01.01-4/16/99-00859

April 16, 1999

U.S. Environmental Protection Agency
Region II
290 Broadway - 22nd Floor
New York, New York 10007-1866

Attn: Ms. Nicoletta DiForte
Chief, RCRA Caribbean Section

Re: Contract No. N62470-89-D-4814
Navy CLEAN, District III
Contract Task Order (CTO) 0277
U.S. Naval Station Roosevelt Roads, Puerto Rico
RCRA Corrective Action Program
Response to EPA's Comment Letter of March 8, 1999

Dear Ms. DiForte:

Baker Environmental, Inc. (Baker), on behalf of the Navy, is pleased to provide responses to the comments received in your March 8, 1999 letter. Specific comments are addressed pertaining to the following reports:

- Tow Way Fuel Farm Corrective Measures Study (CMS) Task 1 Report (November 30, 1998), and
- Navy's December 16, 1998 Response to EPA's Comments on the June 30, 1998 CMS Investigation Report for the Tow Way Fuel Farm.

Each document is addressed separately below.

Tow Way Fuel Farm Corrective Measures Study (CMS) - Task 1 Report

There were three major issues reflected in the EPA comments:

- The clean-up levels
- The detection of TCE in well 7MW07, and
- The TechLaw comments.

1) Clean-up levels

Attachment 1 to this letter contains a fully revised Section 3.0 and associated appendices of the Task 1 Report. The clean-up goals have been re-calculated based on EPA comments and some re-analysis of the various exposure scenarios. All the EPA comments have addressed.

2) TCE in Well 7WM07

Attachment 2 to this letter is a work plan for specific investigations in the area of well 7MW07 where a significant detection of TCE occurred in a recent groundwater sample. The investigations extend to an adjacent well (7WM08) where a very low level detection of TCE was found. Since there are no intervening wells between 07 and 08, MW08 was included.

The work plan contains a map showing all the TCE sampling results including non-detect locations. TCE detections are indicated in blue. It should be noted that UGW24 contained 2 µg/l TCE. This well is included in the investigations in that a confirmatory sampling in this well will be performed. The detection is thought to be anomalous since there is no apparent potential source in the area of the well, the well is located near the top of the hill in an unlikely location for DNAPL accumulation and there are no other detections of TCE between UGW 24 and 7MW07.

3) TechLaw Comments

The two TechLaw comments pertain to the risk assessment and clean-up goals. These have been addressed in the revised Section 3.0.

Navy's December 16, 1998 Response to EPA Comments on the June 30, 1998 CMS Investigation for the Tow Way Fuel Farm

Insert/replacement pages (3-hole punched) are provided in Attachment 3 to this letter. Also, new report covers and spines are included which designate the report as final.

All of the EPA comments have been addressed. The paragraphs which follow provide a summary of the comments responses. For ease of review, the comments are repeated followed by the response.

MARCH 8, 1999 EPA COMMENT LETTER

Comment

For the responses to EPA's comments #2, 3, 4, and 5, and those given in the TechLaw evaluation included with EPA's October 2, 1998 letter, the Navy indicates they accept EPA's/TechLaw's comments; yet instead of supplying the appropriately revised text or figure, the letter contains numerous statements to the effect that the revised text or figure, etc., will be provided either with the "final submission" or "next submittal". EPA requests that within 45 days of your receipt of this letter, the Navy submit an addendum to the June 1998 CMS Investigation report, which includes all revised text or figures, etc., as indicated in Baker's December 16, 1998 letter. Such an addendum may be combined with the Addendum for the Task 1 report discussed above.

Response
The text and figures corresponding to the comments in question will be revised and submitted as insert/replacement pages into the Corrective Measures Study Investigations report.

The comments from the EPA's comment letter dated October 2, 1998 are listed below with a brief description of where the revised figure or text is located.

OCTOBER 2, 1998 EPA COMMENTS

Comment
2. Please revise Cross Section A-A' and B-B' (Figures 3-2 and 3-3 respectively) to address the following EPA comments:

a) The intersection of the two cross sections should be shown on each.

Response
A symbol identifying the location of the intersection of the cross sections has been added to the replacement Figures 3-2 and 3-3.

Comment
b) It would be very useful to EPA's understanding of the LNAPL/phase separated hydrocarbons (PSH) accumulation at Tow Way Fuel Farm if all such occurrences were reflected in the wells shown on the two cross sections.

Response
Symbols have been added to the figures marked with "FP" to identify the free product level encountered during the groundwater level measurements as shown on replacement Figures 3-2 and 3-3.

Comment
c) For cross section B-B', the relationship between the notation "Gabro Bedrock" on the left half of cross section (between wells UGW-22 and 7MW05) and the "Weathered Zone" east of well MW02, and the depicted "Boundary between weathered and Unweathered Bedrock" apparently is erroneously depicted. Please revise the figure, or explain this anomalous relationship.

Response
The description"Gabbro Bedrock" has been changed to "Weathered Bedrock" on replacement Figure 3-3.

Comment
e) Does well 7MW08 contain unweathered bedrock at the surface, as depicted in B-B'?

Response
Well 7MW08 does not contain unweathered bedrock at the surface, as depicted in B-B'. After reviewing the boring logs for 7MW08, unweathered bedrock was found to have been encountered eight feet below the ground surface. Replacement Figure 3-3 has been corrected to reflect this change.

Comment
3. EPA requests an explanation addressing the following comments/questions regarding the "Corrected Groundwater [Potentiometric] Surface Contour Map", Figure 3-13:

a) What is the cause and significance of the groundwater "sink" depicted in the area of wells UGW-13 and UGW-17 (and also UGW-12)?

Response
It was determined that the wrong values were input into the model for the three mentioned wells. The proper values have been input in the model and the groundwater contour map (replacement Figure 3-13) has been adjusted accordingly.

Comment
4. EPA requests an explanation for the very anomalous relationship between the elevated dissolved BTEX and TPH concentrations measured in the groundwater in wells 470-MW1 and 470-MW3, and the non-detect to very minimal concentrations of those same parameters in the groundwater at well 7MW01A, which is located between those two 470 series wells (refer to Figure 3-14 and Appendix D.3). Also please discuss if there are dissolved BTEX and TPH groundwater measurements in nearby downgradient wells UGW15, UGW20, 7MW05 and 7MW06, and if so, the measured concentrations?

Response
It was determined that the two 470 series wells are screened in the overburden groundwater while 7MW01A was screened in the bedrock. A cross-section showing this has been developed and is attached to this response to comments to assist in viewing the actual conditions. It should be noted that no boring logs are available for the two 470 series wells, the total depth of the wells was determined in the field during the CMS Investigation.
There were no detections of dissolved BTEX in nearby downgradient wells UGW15, UGW20,

7MW05, and 7MW06 as indicated on Table 3-7 and Appendix D.3. UGW15 was the only well of the four listed which detected TPH GRO (110 μg/L). UGW15 and UGW20 were the only two wells of the four listed which detected TPH DRO (0.18 and 0.065 J μg/L, respectively). Replacement Figures 3-14, 3-15, and 3-16 have been modified to include the non-detected values were appropriate to avoid any confusion.

Comment
5. Please quantify the volumes of contaminated soils (both surface and subsurface) as depicted in Figures 3-4 through 3-12 of the report. Since several figures depict the same depth interval (but different constituents/parameters), one composite quantity of contaminated soil for each depth interval may be calculated. Also, the basis for the volumetric calculations must be clearly described (e.g., all soils exceeding the Commonwealth of Puerto Rico's generally applied soil standard of 100 mg/kg total petroleum hydrocarbons [TPH]).

Response
The volumes of contaminated soil above the Commonwealth of Puerto Rico's generally applied soil standard of 100 mg/kg total petroleum hydrocarbons [TPH]) have been calculated and is provided on replacement page 3-4 (Section 3.1.2).

TECHLAW COMMENTS - CMS INVESTIGATIONS REPORT
Comment
3.0 PAGE-SPECIFIC COMMENTS

Page 3-7, Section 3.2.2, Paragraph 4
The text should indicate that the concentration of trichloroethene (TCE) detected above the maximum contaminant level (MCL) was 2,000 ug/L. Since this concentration approaches one criterion for considering the presence of dense non-aqueous phase liquid (DNAPL) (one percent of the aqueous solubility), the facility should consider the potential presence of DNAPL in the vicinity of monitoring well 7MW07. Subsequent subsurface investigation techniques should be carefully conducted in the area of monitoring well 7MW07 to screen for DNAPL and to avoid mobilizing DNAPL.

Response
The text has been modified to reflect the comment and is provided on replacement page 3-7.

Comment
Figure 3-17
Based on information presented in Table 3-10, Figure 3-17 should be corrected to indicate that the free product was detected at monitoring well UGW10 at a thickness of <0.01 feet. Currently, Figure 3-17 indicates that no free product was detected at monitoring well UGW10.

Response
The figure has been modified as requested and is presented on replacement Figure 3-17.

Comment
4.0 EDITORIAL COMMENTS
Figure 3-6, Figure 3-7, Figure 3-9, and Figure 3-12
The units of measure should be modified from mg/kg to ug/kg and the contour intervals revised as appropriate for consistency with data presented in Table 3-1, the text of the report, and other contaminant concentration figures.

Response
The units found in Figure 3-6, Figure 3-9, and Figure 3-12 are correct. The units found in Figure 3-7

were changed to μg/kg as presented in replacement Figure 3-7. Table 3-1 was adjusted to present the TPH DRO in mg/kg as presented on replacement Table 3-1.

Comment
Figure 3-9, 3-11, and Figure 3-12
For clarity, sample locations with no available data should be appropriately annotated. Currently, it is unclear from the figure if results for the following locations are non-detect or not available: 7DP22, 7DP23, 7DP28, 7DP27, and 7DP08.

Response
Figures 3-9, 3-11, and 3-12 have been revised to identify samples which are non-detect or not analyzed as shown on the replacement Figures 3-9, 3-11, and 3-12. The not analyzed locations have been changed to gray color. It should be noted that Figures 3-4 through 3-12 have been modified to this format and are provided as replacements.

Comment
Figure 3-11
The annotation in the legend should be revised to "TPH GRO Concentration" instead of "BTEX Concentration".

Response
The typographical error has been corrected as presented on replacement Figure 3-11.

Please do not hesitate to call me at (412) 269-2065, or Mr. Christopher T. Penny (the Navy's Technical Representative) at (757) 322-4815, if you have any questions or desire further clarification on the points discussed.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Thomas C. Fuller
Activity Coordinator

TCF/lp
Attachment

cc: Mr. Christopher T. Penny - LANTDIV, Code 18231 (w/attachment)
Ms. Madeline Rivera - NSRR (w/attachment)
Mr. Isreal Torres - PREQB (w/attachment)
Mr. John Tomik - CH2M Hill (w/attachment)

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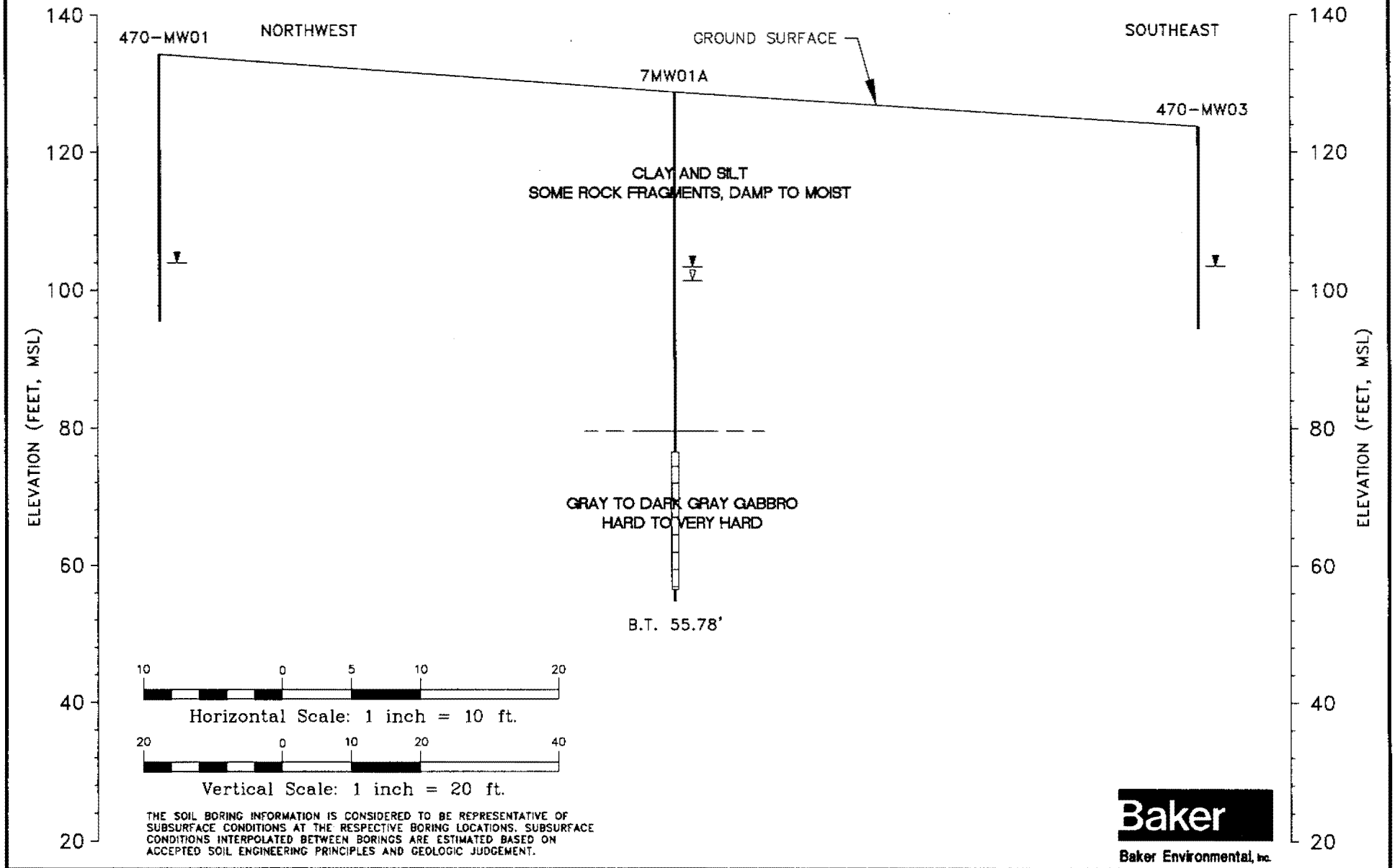


THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

Baker

Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (4/15/98 THROUGH 4/21/98)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. x' — BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

NOTE: DATUM PLAN IS MEAN LOW WATER = 100 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

HYDROGEOLOGIC CROSS-SECTION
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

ATTACHMENT 1

Revised Section 3.0 of the CMS Task 1 Report

3.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

This section of the document establishes the site specific objectives for the corrective action. The objectives are based on public health and environmental criteria, information gathered during the RFI, EPA guidance, and the requirements of any applicable federal statutes. This section determines the potential need for corrective action to mitigate potential risk to human health at the TWFF. Mitigation requires the establishment of chemicals of concern (COCs) from a thorough review of the baseline risk assessment. Once COCs are identified, current and future land use is evaluated to identify receptors and potential exposure routes. COCs, land use and exposure can be distilled to identify site specific corrective action objectives.

3.1 The Process

The corrective action objectives consist of specific goals developed for protecting human health and the environment. The objectives should be as specific as possible, but not so specific that the corrective actions to be developed are limited. Important components in the development of the corrective action objectives include the identification of media of concern/contaminants of concern (COCs), identification of the exposure routes and receptors, the identification of applicable federal statutes, and the development of clean-up goals. These components along with the resulting corrective action objectives are presented below.

3.2 Identification of Media of Concern/Contaminants of Concern (COCs) as Determined by the Human Health Risk Assessment

The baseline RA for the TWFF identified the potential for human health risk to onsite workers and future residents exposed to soil affected by site related activities. Contaminants of concern (COCs) in surface soil include the polynuclear aromatic hydrocarbons (PAHs) benzo(a)pyrene (maximum detected concentration = 17 mg/kg) and benzo(a)anthracene maximum detected concentration = 23 mg/kg). Onsite construction workers exposed to surface soil containing these PAHs exhibit an incremental lifetime cancer risk (ILCR) of 3.4×10^{-4}, which exceeds the upper end of USEPAs generally acceptable risk range. Benzo(a)pyrene and benzo(a)anthracene were responsible for approximately 80 percent of this value (2.8×10^{-4}). Benzo(a) pyrene (maximum detected value = 7.4 mg/kg) and benzo(a)anthracene (maximum detected value = 0.98 mg/kg) were also detected in

subsurface soil at lower concentrations. As a result, the corresponding ILCR value for construction workers falls within USEPA generally acceptable risk range of 1×10^{-6} to 1×10^{-4} for subsurface soil exposure.

PAHs were also responsible for unacceptable ILCR values for both future potential adult (4.7×10^{-4}) and child (2.9×10^{-4}) residents. No other contaminant caused unacceptable carcinogenic or noncarcinogenic human health risks under the scenarios evaluated in the baseline RA.

Groundwater, if used for potable purposes, would also pose unacceptable human health risks. The presence of benzene (maximum detected concentration = 13,500 μg/L) is responsible for 86 percent of the ILCR. Dissolved arsenic detected at a concentration of 6.6 μg/L in one groundwater sample accounted for the remaining 14 percent of the groundwater ILCR value. The presence of toluene, ethylbenzene and total xylenes were detected at maximum concentrations of 34,400, 95,700 and 139,500 μg/L, respectively and produce unacceptable noncarcinogenic risks to both children and adults. Ethylbenzene was responsible for 58 percent of the total hazard indices of 6.6 (children) and 3.4 (adults). Levels of these contaminants evaluated for the inhalation pathway did not produce unacceptable ILCRs or HIs.

Results of the baseline RA identified media and contaminants of concern at TWFF. These include surface soil and groundwater. Because of likely contaminant transport pathways and the presence of PAHs in subsurface soil and groundwater, subsurface soil will also be retained as a medium of concern. COCs in both surface and subsurface soil include benzo(a)pyrene and benzo(a)anthracene. Benzene, toluene, ethylbenzene and xylenes, though not detected in soil at concentrations posing unacceptable risks will be retained for further evaluation in soil.

Groundwater COCs include arsenic, benzene, toluene, ethylbenzene and xylenes. Arsenic will not be retained as a COC because it was detected in only one dissolved groundwater sample and is likely present because of natural conditions at the TWFF. The PAHs benzo(a)pyrene and benzo(a)anthracene will not be considered as groundwater COCs because of their relative immobility in environmental media. The water insolubility of benzo(a)pyrene and benzo(a)anthracene is likely the reason for their detection in surface and subsurface soil but not the groundwater itself. Any soil remediation concerning PAHs will further inhibit their ability to reach groundwater and adversely affect water quality at the TWFF.

3.3 Exposure Routes and Receptors

Exposure routes considered in the baseline RA include dermal contact and accidental ingestion of contaminants in soil. The inhalation of fugitive dust was also considered for both surface soil and subsurface soil in the event that construction activities would bring subsurface soil borne contaminants to the surface where they would be exposed to wind action. Both current construction workers and future potential residents could be exposed to contaminants by these pathways.

Groundwater was evaluated as a potable source for future potential residents. This conservative scenario considered direct dermal contact, ingestion and inhalation of volatiles emanating from showers. Also considered was the potential exposure of construction workers to contaminants in shallow groundwater. Because groundwater can be quite shallow at the TWFF at certain times of the year, construction workers digging to depths of 4 feet may well be exposed to contaminated groundwater. This pathway and a more likely nonpotable residential groundwater use scenario will be evaluated in this CMS Task 1 report to establish potential clean-up levels for the TWFF.

3.4 Clean-up Goal Options and Clean-up Levels

The selection of clean-up levels begins with an evaluation of clean-up goals. Clean-up goals can be regulatory criteria, risk-based criteria or a combination of both. This section presents all pertinent risk-based cleanup goals and applicable regulatory criteria for media of concern and COCs identified for the TWFF. The purpose of this section is to insure that all pertinent and applicable criteria are evaluated so that the most reasonable and conservative clean-up levels can be selected to protect human health for current and likely future property use. Clean-up goal options are presented in Table 3-1.

3.4.1 Pertinent Regulatory Criteria

Pertinent regulatory criteria for the TWFF include RBCs and an evaluation of Maximum Contaminant Level (MCL) values. MCLs will be presented for comparative purposes only because groundwater is not currently used as a potable source and is not likely to be used as such in the future because the Station has a dedicated water source in the mountains which is conveyed by pipeline to an on-Station treatment plant which has excess capacity. A description of RBCs and

MCLs are presented in the following paragraphs.

USEPA Region III (Risk Based Concentrations) RBCs - RBC values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. The RBCs for potentially carcinogenic chemicals are based on a target Incremental Cancer Risk (ICR) of 1×10^{-6}. The RBCs for noncarcinogens are based on a target hazard quotient of 1.0. For potential carcinogens, the toxicity criteria applicable to the derivation of RBC values are oral and inhalation cancer slope factors (CSFs); for noncarcinogens, they are chronic oral and inhalation reference doses (RfDs). These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of RBC values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria. The RBC table is issued on a semi-annual basis and was recently updated in October, 1998.

Maximum Contaminant Levels - Federal Groundwater Standards - 40 CFR 161- MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply. Because the uppermost aquifer at the site will not be used for potable purposes, the MCLs do not necessarily apply.

3.4.2 Human Health Risk-Based Preliminary Clean-up Goals

In conjunction with pertinent regulatory criteria, site specific risk-based cleanup levels were developed for TWFF groundwater and soil COCs. The methodology used to derive the risk-based cleanup levels was in accordance with USEPA Risk Assessment Guidance for Superfund, Parts A and B (USEPA, 1989 and USEPA, 1991). For noncarcinogenic effects, risk-based cleanup levels were calculated for significant human exposure pathways that target a Hazard Index (HI) of 1.0, or unity. COC concentrations in a given medium that are less than a corresponding risk-based cleanup level indicate that systemic health effects will not occur subsequent to exposure for even sensitive

populations. For carcinogenic effects, risk-based cleanup levels were calculated that target an ICR range of 1×10^{-6} (one in a million) to 1×10^{-4} (one in ten thousand) that would be expected to result from exposure to a potential carcinogen over a lifetime, from all significant exposure pathways for a given medium. Based on the National Contingency Plan (NCP) (40 CFR 300.430), acceptable exposure levels, for known or suspected carcinogens, are generally concentrations that represent an ICR between 1×10^{-4} and 1×10^{-6}, with the latter ICR representing USEPA's point of departure.

Derivation of site specific cleanup goals involve the identification of the most significant exposure pathways and site specific exposure factors. The following exposure scenarios were considered in determining total site cleanup levels associated with groundwater and soil at the TWFF:

- Accidental ingestion of soil (future adult and child residents, military residents and dependents, current construction workers)
- Dermal contact with soil (future adult and child residents, military residents and dependents, current construction workers)
- Accidental ingestion of groundwater during construction activities (current construction worker)
- Dermal contact with groundwater during construction activities (current construction worker)
- Accidental ingestion of groundwater using a beneficial use scenario (future adult and child residents, military residents and dependents)
- Dermal contact with groundwater using a beneficial use scenario (future adult and child residents, military residents and dependents)

In addition to these scenarios and exposure routes the inhalation pathway was evaluated for commercial workers and future residents using the benzene RGO in a volatilization calculation (Farmer et al., 1980) and dispersion model (Horst, 1979).

It is extremely unlikely that the TWFF would ever be developed into a residential area given the topography of the area and the fact that the presence of the TWFF is critical to the mission of the station. Groundwater is not currently used for potable purposes since a dedicated source of water is available from El Yunque which has redundant capacity to supply all of NSRR present and projected needs. Also, it is known based on investigations performed at the site to date that the yield

of the uppermost aquifer is insufficient to be used as a potable source. Based on these considerations, cleanup levels were calculated for groundwater using: 1) a residential beneficial (nonpotable - i.e., watering lawns and washing cars) use scenario for the future adult and child resident; and 2) a direct contact scenario during construction activities by onsite construction workers.

In accordance with USEPA guidance, noncarcinogenic health effects were estimated as hazard indices for human populations (including sensitive subgroups, that may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety). The cleanup level incorporated the exposure time (hours/day) and/or frequency (days/year) that represented the occurrence of exposure along with averaging time, which was the period over which exposure was averaged. Carcinogenic health effects were calculated as an incremental lifetime cancer risk in the baseline Risk Assessment (RA), expected over the course of a potentially exposed individual's lifetime (70 years).

The risk-based cleanup levels are the most applicable cleanup levels at the TWFF. The risk-based cleanup levels are site-specific, while the RBCs and MCLs are designed to cover a broad range of sites and may be too conservative for the TWFF scenario. In particular, the groundwater MCLs and tap water RBCs are calculated based on a drinking water scenario in which a 70 kg adult drinks two liters of water per day. As previously mentioned, it is unlikely that the TWFF will be developed into a residential area or the uppermost aquifer be used for potable water since the yield is insufficient to be used as a potable source. Additionally, there is currently a dedicated source of water at the TWFF. The use of site-specific cleanup goals is consistent with NCP guidance (40 CFR 300.430).

The estimation methods and models used in this section were consistent with current USEPA risk assessment guidance (USEPA, 1989 and 1991). This evaluation was conducted to assure that media and contamination at the site would be addressed on a site-specific basis. Cleanup levels were developed, with site-specific inputs, for the groundwater and soil COCs. Risk-based cleanup level calculations and calculations for potential inhalation exposure pathways are presented along with exposure inputs in Appendix A.

3.4.3 Selection of Clean-up Levels

Because of the current property use at TWFF and the continued operation of the Station by the DoN, cleanup goals were selected assuming current land use and the most likely current human receptors. Table 3-2 presents the proposed cleanup levels for TWFF. These values were selected to protect on-Station construction workers from contaminants in soil, subsurface soil and groundwater. Selection of residential cleanup goals would be overly conservative because there is currently no on-Station housing at the TWFF, nor is residential use of the property likely to occur in the future. To ensure the protectiveness of any subsequently selected remedy, institutional controls (i.e., restrictions prohibiting future residential property use) must be included as part of the corrective measures alternative.

A comparison of proposed soil cleanup goals to soil RBC values provides an analysis of residual risk associated with the selection of military residential proposed clean-up levels. Benzene at 345 mg/kg exceeds the residential soil RBC value of 22 mg/kg by a factor of approximately 15.7. This is analogous to a future residual risk to residents of approximately 2×10^{-5}, which is within USEPAs generally acceptable risk range. This risk is not significantly increased when exposure to benzene through volatilization is considered. A cleanup goal of 345 mg/kg benzene in soil produces a residual risk to inhabitants of only 2×10^{-9}.

Cleanup goals were also established for the potentially carcinogenic PAHs benzo(a)pyrene and benzo(a)anthracene. A cleanup goal of 1.1 mg/kg benzo(a)pyrene and 10.5 mg/kg benzo(a)ahthracene compared to Region III RBCs would result in a cancer risk of approximately 1.5×10^{-5} for future residents. A cumulative risk to benzene and potentially carcinogenic PAHs for future residents would be approximately 3.5×10^{-5}, a value that falls within USEPA's generally acceptable risk range.

Proposed cleanup goals for noncarcinogens derived for construction workers are higher than residential RBC values or cleanup goals for military residents. Therefore, institutional controls will be necessary to preclude property at the TWFF from future residential usage. Proposed soil cleanup goals were also derived for TPH assuming that the TPH detected in soil is residual JP-5. Although TPH at TWFF may be comprised of other fuels (marine diesel or gasoline), the proposed clean-up goals provides a quantitative benchmark for evaluating TPH results other than disposal limits. A

qualitative goal was established for the remediation of phase-separated hydrocarbons (free product) in groundwater. A goal of 0.1 foot is established based on the limits of technology to recover phase separated hydrocarbons (PSH). Technologies will be discussed in detail in subsequent sections of this CMS Task 1 report and in the CMS Tasks 2 and 3 reports.

Proposed groundwater cleanup goals cannot be compared to residential groundwater RBCs which consider the potable use of groundwater. Because groundwater is not used as a potable supply at TWFF, selected cleanup goals should be compared to other risk-based goals to determine overall protectiveness. Because groundwater is shallow at TWFF, the most likely human receptors would be construction workers who come into contact with affected groundwater during excavation activities. Construction worker cleanup goals are more conservative than residential, nonpotable groundwater use cleanup goals. This is a function of the acute nature of potential exposure by construction workers (180 days per year for a 1 year period) and the duration of potential exposure to contaminated groundwater (1 hour per day). As a result, groundwater clean up goals for potential construction workers will be established for noncarcinogens to ensure that goals are protective for any likely property use at TWFF, precluding potable use.

3.5 Corrective Action Objective

Corrective action objectives are specific goals for protecting human health and the environment. The corrective action objective identified for the TWFF is to establish a remedial action which protects human health and the environment by meeting or exceeding the clean-up goals described in the previous section of this report in a cost effective, economical manner.

TABLES

TABLE 3-1

CLEAN-UP GOAL OPTIONS
CORRECTIVE MEASURES STUDY TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS

Chemical of Concern	Pertinent Criteria					Risk-Based Clean-up Goals								
	Region III RBCs				Federal MCLs	Future On-Site Residents			Military Residents[4]			Construction Workers		
	GW	Air	Soil Ind.	Soil Res.		GW[1]	Air[3]	Soil	GW	Air [3]	Soil	GW	Air[2]	Soil
	µg/L	µg/m³	mg/kg	mg/kg	µg/L	µg/L	µg/m3	mg/kg	µg/L	µg/m3	mg/kg	µg/L	µg/m3	mg/kg
Benzene	0.36	0.11	200	22	5	340	*	25	800	*	37	2,100	*	345
Toluene	750	270	410,000	16,000	1,000	11,000	--	12,500	11,000	--	12,500	5,500	--	28,500
Ethylbenzene	1,300	140	200,000	7,800	700	4,000	--	6,250	4,000	--	6,250	2,300	--	14,000
Total Xylenes	12,000	2,700	--	165,000	10,000	1,092,000	--	125,000	1,092,000	--	125,000	615,000	--	285,000
TPH (JP-5)	--	--	--	--	--	1,000	--	1,100	1,000	--	1,100	340	--	2,100
Benzo (a) pyrene	0.009	0.002	0.78	0.087	0.2	NA	--	0.09	NA	--	0.13	NA	--	1.1
Benzo (a) anthracene	0.09	0.008	7.8	0.87	--	NA	--	1.0	NA	--	1.3	NA	--	10.5

Notes:

– Indicates no value or value is 100% of a given medium
(1) Non-potable use scenario
(2) Volatilization Pathway evaluated using Farmer et at., 1980 and Pasquill & Horst, 1979
(3) Volatilization Pathway evaluated using Farmer et.al.
(4) Assumes a 4-year tour of duty for both military personnel and dependents.
* Air evaluated using the benzene soil cleanup goal for residents and construction workers.

TABLE 3-2

PROPOSED CLEAN-UP LEVELS
CORRECTIVE MEASURES STUDY TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS

Chemical of Concern	Soil Clean-up Level[1]	Groundwater Clean-up Level[2]
	mg/kg	µg/L
Benzene	345	800[1]
Toluene	28,500	5,500
Ethylbenzene	14,000	2,300
Total Xylenes	285,000	615,000
TPH (JP-5)/PSH	2,100	0.1[3]
Benzo (a) pyrene	1.1	NA
Benzo (a) anthracene	10.5	NA

Notes:

[1] Based on the Military Resident Scenario. Volatilization evaluated using the infiltration of foundations from both subsurface soil and groundwater.

[2] Based on construction worker scenario unless otherwise noted.

[3] PSH - Phase Separated Hydrocarbons. Applies to groundwater only and is units of ft.

NA Not Applicable.

APPENDIX A
EXPOSURE INPUTS AND RISK ASSESSMENT CALCULATIONS

APPENDIX A.1

EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS
SURFACE SOIL AND GROUNDWATER
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Input Parameter	Media	Units	Input Values		Comments/References
			Child (1 to 6 years)	Adult	
ED, Exposure Duration	Soil/Groundwater	years	6/4	24/4	USEPA, 1991a/Site Specific Information[5]
EF, Exposure Frequency	Soil/Groundwater	days/year	350	350	USEPA, 1991a
ET, Exposure Time	Groundwater	hrs/day	1.0	1.0	USEPA, 1989a
IR, Ingestion Rate	Groundwater	L/day	0.054	0.054	USEPA, 1991a
	Soil	mg/day	200	100	USEPA, 1989b
SA, Surface Area	Soil/Groundwater	cm^2	2,006[3]	5,300[3]	USEPA, 1989a and 1992a
RR, Respiration Rate	Air (Fugitive Dusts)	m^3/hr	0.83	0.83	USEPA, 1991a
FI, Fraction Ingested	Soil	unitless	1.0	1.0	USEPA, 1989b/ Professional Judgement
ABS, Absorbance Factor	Soil	unitless	Chemical Specific[4]	Chemical Specific[4]	USEPA, 1995a
AF, Adherence Factor	Soil	mg/cm^2	0.2	0.2	USEPA, 1997
BW, Body Weight	Soil/Groundwater	kg	15	70	USEPA, 1989b
PC, Permeability Constant	Groundwater	cm/hr	Chemical-Specific	Chemical-Specific	USEPA, 1992a
AT_{nc}, Averaging Time - Noncarcinogens	Soil/Groundwater	day	2,190/1460	8,760/1460	USEPA, 1989b/Site Specific Information[5]
AT_c, Averaging Time - Carcinogens	Soil/Groundwater	day	25,550	25,550	USEPA, 1989b

Notes:

(1) Frequency conservatively assumes 2 days per weekend, every weekend for 12 months.

(2) Represents total body surface area.

(3) Represents approximately 25% of the total body surface area.

(4) The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

VOCs (Vapor Pressure > 95.2 mmHg) - 0.05%
VOCs (Vapor Pressure < 95.2 mmHg) - 3%
SVOCs - 10%
Arsenic - 3.2%
Inorganics - 1%

(5) Assumes a 4 year tour of duty for enlisted personnel and dependents.

APPENDIX A.1 (Continued)

EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS
SURFACE SOIL AND GROUNDWATER
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

References:

USEPA, 1997. Exposure Factors Handbook, General Factors-Volume I. August, 1997. EPA/600/P-95/002Fa

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

APPENDIX A-2

EXPOSURE INPUT PARAMETERS FOR FUTURE CONSTRUCTION WORKERS
SUBSURFACE SOIL
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Input Parameter	Units	Input Values	Comments/References
ED, Exposure Duration	years	1	USEPA, 1991a
EF, Exposure Frequency	days/year	180	USEPA, 1991a
ET, Exposure Time	hrs/day	8	USEPA, 1991a
IR, Ingestion Rate	mg/day	480	USEPA, 1991a
SA, Exposed Surface Area	cm^2/day	4,100(1)	USEPA, 1992a
RR, Respiration Rate	m^3/hr	1.25	USEPA, 1989a
FI, Fraction Ingested	unitless	1.0	Professional Judgment
ABS, Dermal Absorption Factor	unitless	Chemical-specific(2)	USEPA, 1995a
AF, Adherence Factor	mg/cm^2	1	USEPA, 1991a/1992a
BW, Body Weight	kg	70	USEPA, 1989b
AT_{nc}, Averaging Time - Noncarcinogens	days	365	USEPA, 1989b
AT_c, Averaging Time - Carcinogens	days	25,550	USEPA, 1989b

Notes:

(1) Skin surface area available for contact for an individual wearing a sleeveless shirt, long pants, and shoes.

(2) The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

VOCs (Vapor Pressure > 95.2 mmHg) - 0.05%
VOCs (Vapor Pressure < 95.2 mmHg) - 3%
SVOCs - 10%
Inorganics - 1%; Arsenic - 3.2%

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

FUTURE RESIDENTIAL ADULT
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soi	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	8760	
CF = conversion factor, kg/mg	0.000001	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	24	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	100	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	bsorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day	ermally Adj Slope Facto mg/kg-day)-	Derm. Adj. Ref. Dose (mg/kg-day	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
VOLATILES	✓											✓	
Benzene	1.0E-06	1.0	0.10	2.90E-02	3.00E-03	3.63E-02	2.40E-03	4.70E-07	4.98E-07	1.37E-06	1.45E-06	31.55	942
Toluene		1.0	0.10	--	2.00E-01	--	1.60E-01	4.70E-07	4.98E-07	1.37E-06	1.45E-06	-	62,796
Ethylbenzene		1.0	0.10	--	1.00E-01	--	8.00E-02	4.70E-07	4.98E-07	1.37E-06	1.45E-06	-	31,398
Total Xylenes		1.0	0.10	--	2.00E+00	--	1.60E+00	4.70E-07	4.98E-07	1.37E-06	1.45E-06	-	627,957
JP-5		1.0	0.10	--	2.00E-02	--	1.00E-02	4.70E-07	4.98E-07	1.37E-06	1.45E-06	-	4,679
SEMIVOLATILES													
Benzo(a)pyrene	1.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.09	--
Benzo(a)anthracene	1.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.93	--

$$\text{Dose}_D = \frac{31.55\,\frac{mg}{kg} * 0.2\,\frac{mg}{cm^2 \cdot d} * 5300\,cm^2 * 0.1 * 350\,\frac{d}{yr} * 24\,yrs * 10^{-6}\,\frac{kg}{mg}}{70\,kg * 25550\,d} = 1.57\times10^{-5}\,\frac{mg}{kg\cdot d} * 3.63\times10^{-2}\,\frac{kg\cdot d}{mg} = 5.7\times10^{-7}$$

$$\text{Dose}_I = \frac{31.55\,\frac{mg}{kg} * 100\,\frac{mg}{d} * 350\,\frac{d}{yr} * 24\,yrs * 10^{-6}\,\frac{kg}{mg}}{70\,kg * 25550\,d} = 1.48\times10^{-5}\,mg/kg\cdot d * 2.9\times10^{-2}\,\frac{kg\cdot d}{mg} = 4.3\times10^{-7}$$

FUTURE ON-SITE ADULT RESIDENT
FUTURE BENEFICIAL USE SCENARIO
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO
YORKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm][CSF])
RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)
Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	1.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	8760
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	5300
ED = exposure duration (years)	24
BW = body weight (kg)	70
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-	Dermally Adj Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj Ref Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
VOLATILES													
Benzene	1.0E-06	1.0	0.02	2.90E-02	3.00E-03	3.63E-02	2.40E-03	2.66E-05	5.97E-05	7.83E-05	1.74E-04	0.339	10.13
Toluene	--	1.0	1.00	--	--	2.00E-01	1.60E-01	2.66E-05	2.64E-03	7.83E-05	6.30E-03	-	19
Ethylbenzene	--	1.0	1.20	--	--	1.00E-01	6.00E-02	2.66E-05	3.41E-03	7.83E-05	9.96E-03	-	8
Total Xylenes	--	1.0	0.08	--	--	2.00E+00	1.60E+00	2.66E-05	2.28E-04	7.83E-05	6.64E-04	-	2,203
JP-5	--	1.0	1.00	--	--	2.00E-02	1.00E-02	2.66E-05	2.84E-03	3.65E-04	8.30E-03	-	1
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	1.00	7.40E+00	1.48E+01	--	--	2.66E-05	2.84E-03	7.83E-05	8.30E-03	2.4E-05	--

SITE: Naval Station Roosevelt Roads - Onsite Adults
LOCATION: Tow Way Fuel Farm
JOB # :
DATE: 4/14/99
SCENARIO: CALCULATE THE HYPOTHETICAL VAPOR INTRUSION THROUGH CRACKED FOUNDATIONS FOR FUTURE RESIDENTS.

PURPOSE: THIS SPREADSHEET CALCULATED THE HYPOTHETICAL INFILTRATION OF VAPOR PHASE CONSTITUENTS FROM GROUNDWATER THROUGH A FOUNDATION WITH SOME CRACKING AND THE CORRESPONDING RISKS ASSOCIATED WITH THIS EXPOSURE PATHWAY. CONSERVATIVE ASSUMPTIONS ARE USED IN THIS SCENARIO WHICH IS DESIGNED TO REPRESENT FUTURE RESIDENTS. INHALATION RATES, BODY WEIGHTS, AND EXPOSURE DURATIONS ARE TAKEN FROM THE MOST RECENT LITERATURE

PERTINENT EQUATIONS:

Q = [28*(b^3)*(l)/(F)]*(P1-P2)*(Csg) (MURPHY 1985 & 1986)

where: Q = THE CONTAMINANT EMISSION THROUGH A CRACKED FOUNDATION (mg/s)
b = THE CRACK WIDTH (0.5mm)
l = THE TOTAL CRACK LENGTH (cm)
F = THE FOUNDATION THICKNESS (10-20cm)
(P1-P2) = THE PRESSURE DIFFERENCE BETWEEN THE INSIDE AND THE OUTSIDE (DYNES/cm^2)
Csg = THE CONSTITUENT CONCENTRATION IN SOIL GAS (mg/cm^3)

Csg = (H/RT)*Cg (MURPHY 1985 & 1986)

where: H = HENRY'S CONSTANT (atm*m^3/mol.)
R = THE IDEAL GAS CONSTANT (L*atm/mol.* K)
T = THE TEMPERATURE OF THE SOIL (293 K)
Cg = THE CONSTITUENT CONCENTRATION IN THE GROUND WATER (mg/ml)

(P1-P2) = 1.176E-2*(d)*(T-TO/TO) (MURPHY 1985 & 1986)

where: d = THE DISTANCE TO A POINT OF NEUTRAL PRESSURE (m)
T,TO = THE INDOOR AND OUTDOOR TEMPERATURES (K)

Ca = (Q/K*Qa)*(1-e^(-K/V)*(Qa)*(t)) + Cs*e-(K/V)*(Qa)*(t) (WADDEN et al. 1983)

where: Qa = THE AIR FLOW RATE THROUGH THE DWELLING (m^3/hr)
K = THE MIXING FACTOR
V = THE ROOM VOLUME (m^3)
Cs = THE BASELINE INDOOR AIR CONCENTRATION (mg/m^3)
t = TIME (s)

as time approaches infinity, a steady state is approached and the equation reduces to...

Ca = Q/Qa

where: Qa = Vd*AE

and: Vd = THE ROOM VOLUME (m^3)
AE = THE AIR EXCHANGE RATE (hr^-1)
Ca = THE AMBIENT AIR CONCENTRATION (mg/m^3)

CARCINOGENIC CONSTITUENTS

DOSE = Ca*RR*D*EV*ED*AB/BW*70yrs*365d/yr (USEPA 1988)

where: RR = THE RESPIRATION RATE (m3/hr)
D = THE WORKDAY LENGTH (hr/d)
EV = THE NUMBER OF EXPOSURES PER YEAR
ED = THE EXPOSURE DURATION (yrs)
AB = THE ABSORBED FRACTION OF THE CONSTITUENTS
BW = THE RECEPTOR BODY WEIGHT (Kg)

NONCARCINOGENIC CONSTITUENTS

DOSE = Ca*RR*D*AB/BW (USEPA 1988)

where: RR = THE RESPIRATION RATE (m3/hr)
D = THE WORKDAY LENGTH (hr/d)
AB = THE ABSORBED FRACTION OF THE CONSTITUENTS
BW = THE RECEPTOR BODY WEIGHT (Kg)

CONSTITUENTS	Cg mg/mL	H atm*m^3/mol	RT L*atm/mol	Csg mg/cm^3	b mm	F cm	L m	d m	(P1-P2) dynes/cm^2	Q mg/s	Vd m^3	AE hr^-1	Qa m^3/hr	Ca mg/m^3
benzene	8.00E-04	5.50E-03	24.055	1.83E-04	0.5	15	114000	15	2.96E-03	1.44E-02	34200	0.5	17100	8.42E-07

CONSTITUENTS	RR m^3/hr	D hr/d	EV d/yr	ED yr	AB	BW Kg	CARC. DOSE mg/Kg/d	NONCARC. DOSE mg/Kg/d	CPF Kg-d/mg	RfD mg/Kg/d	ICR	HI	COMMENTS
benzene	0.8	24	350	24	1	70	7.59E-08	0.00E+00	0.029	0	2.20E-09	0.00E+00	
TOTAL											2.20E-09	0.00E+00	

Volatilization Emissions Analysis - Onsite Resident Adults
Farmer et al. (USEPA, 1980)

Volatiles Emissions from toxic landfills

Ei is emission rate of chemical i given the chemical, temperature of subsurface environment (T), depth of contamination (d), and concentration in soil (Cw).
Area of the site is (A).

CONTAMINANTS	Mol. Wght. (g/mol)	P (mmHg)	Dc(10o C) (cm2/sec)	pt (unitless)	T (K)	Csi (g/cm3)	A (cm2)	d (cm)	Cw (mg/Kg)	cf (Kg/mg)	Ei (g/sec)
Benzene	78	95	8.20E-02	0.3	283	0.00042	2.E+08	152	*345*	1.00E-06	**2.56E-03**

Naer Field Box Model
Pasquill, 1975 and Horst, 1979

Takes Emission Rate to the breathing zone. Input width of contaminated area and annual mean wind speeds.

CONTAMINANTS	Hb (m)	u10 (m/sec)	um (m/sec)	Wb (m)	Ca (g/m3)
Benzene	1.4	1	0.127560069	15240	**9.408E-07**

CONTAMINANTS	RR m^3/hr	D hr/d	EV d/yr	ED yr	AB unitless	BW Kg	CARC. DOSE mg/Kg/d	NONCARC. DOSE mg/Kg/d	CPF Kg-d/mg	RfD mg/Kg/d	ICR	HI
Benzene	0.8	24	350	24	1	70	8.48E-08	0.00E+00	0.029	0	2.46E-09	-
											---	---
TOTAL											2.46E-09	0.00E+00

FUTURE RESIDENTIAL CHILD
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	2190	
CF = conversion factor, kg/mg	0.000001	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	6	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	200	
BW = body weight, kg	15	
SA = skin surface area available for contact, cm2	2006	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Absorption Factor (unitless)	Slope Factor g/kg-day)	Reference Dose (mg/kg-day	ermally Adj Slope Facto mg/kg-day)-	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
VOLATILES													
Benzene	1.0E-06	1.0	0.10	2.90E-02	3.00E-03	3.63E-02	2.40E-03	1.10E-06	2.20E-07	1.28E-05	2.56E-06	25.15	188
Toluene	--	1.0	0.10	--	2.00E-01	--	1.60E-01	1.10E-06	2.20E-07	1.28E-05	2.56E-06	-	12,507
Ethylbenzene	--	1.0	0.10	--	1.00E-01	--	8.00E-02	1.10E-06	2.20E-07	1.28E-05	2.56E-06	-	6,253
Total Xylenes	--	1.0	0.10	--	2.00E+00	--	1.60E+00	1.10E-06	2.20E-07	1.28E-05	2.56E-06	-	125,068
JP-5	--	1.0	0.10	--	2.00E-02	--	1.00E-02	1.10E-06	2.20E-07	1.28E-05	2.56E-06	-	1,116
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.09	--
Benzo(a)anthracene	1.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.89	--

FUTURE ON-SITE CHILD RESIDENT
FUTURE BENEFICIAL USE SCENARIO
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO
YORKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm][CSF])
RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)
Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	1.00E-05
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	2190
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	2006
ED = exposure duration (years)	6
BW = body weight (kg)	15
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-1	Dermally Adj. Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
VOLATILES													
Benzene	1.0E-06	1.0	0.02	2.90E-02	3.00E-03	3.63E-02	2.40E-03	3.13E-05	2.64E-05	3.65E-04	3.08E-04	0.536	4.00
Toluene	--	1.0	1.00	--	--	2.00E-01	1.60E-01	3.13E-05	1.26E-03	3.65E-04	1.47E-02	-	11
Ethylbenzene	--	1.0	1.20	--	--	1.00E-01	8.00E-02	3.13E-05	1.51E-03	3.65E-04	1.76E-02	-	4
Total Xylenes	--	1.0	0.08	--	--	2.00E+00	1.60E+00	3.13E-05	1.00E-04	3.65E-04	1.17E-03	-	1,040
JP-5	--	1.0	1.00	--	--	2.00E-02	1.00E-02	3.13E-05	1.26E-03	3.65E-04	1.47E-02	-	1
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	1.00	7.30E+00	1.46E+01	--	--	3.13E-05	1.25E-03	3.65E-04	1.47E-02	5.4E-05	--
Benzo(a)anthracene	1.00E-06	--	1.00	7.30E-01	1.46E+00	--	--	3.13E-05	1.26E-03	3.65E-04	1.47E-02	5.4E-04	--

SITE: Naval Station Roosevelt Roads - Onsite Childem
LOCATION: Tow Way Fuel Farm
JOB # :
DATE: 4/14/99
SCENARIO: CALCULATE THE HYPOTHETICAL VAPOR INTRUSION THROUGH CRACKED FOUNDATIONS FOR FUTURE RESIDENTS

PURPOSE: THIS SPREADSHEET CALCULATED THE HYPOTHETICAL INFILTRATION OF VAPOR PHASE CONSTITUENTS FROM GROUNDWATER THROUGH A FOUNDATION WITH SOME CRACKING AND THE CORRESPONDING RISKS ASSOCIATED WITH THIS EXPOSURE PATHWAY. CONSERVATIVE ASSUMPTIONS ARE USED IN THIS SCENARIO WHICH IS DESIGNED TO REPRESENT FUTURE RESIDENTS INHALATION RATES, BODY WEIGHTS, AND EXPOSURE DURATIONS ARE TAKEN FROM THE MOST RECENT LITERATURE.

PERTINENT EQUATIONS:

Q = [28*(b^3)*(l)/(F)]*(P1-P2)*(Csg) (MURPHY 1985 & 1986)

where: Q = THE CONTAMINANT EMISSION THROUGH A CRACKED FOUNDATION (mg/s)
b = THE CRACK WIDTH (0.5mm)
l = THE TOTAL CRACK LENGTH (cm)
F = THE FOUNDATION THICKNESS (10-20cm)
(P1-P2) = THE PRESSURE DIFFERENCE BETWEEN THE INSIDE AND THE OUTSIDE (DYNES/cm^2)
Csg = THE CONSTITUENT CONCENTRATION IN SOIL GAS (mg/cm^3)

Csg = (H/RT)*Cg (MURPHY 1985 & 1986)

where: H = HENRY'S CONSTANT (atm*m^3/mol.)
R = THE IDEAL GAS CONSTANT (L*atm/mol.* K)
T = THE TEMPERATURE OF THE SOIL (293 K)
Cg = THE CONSTITUENT CONCENTRATION IN THE GROUND WATER (mg/ml)

(P1-P2) = 1.176E-2*(d)*(T-TO/TO) (MURPHY 1985 & 1986)

where: d = THE DISTANCE TO A POINT OF NEUTRAL PRESSURE (m)
T,TO = THE INDOOR AND OUTDOOR TEMPERATURES (K)

Ca = (Q/K*Qa)*{1-e^(-K/V)*(Qa)*(t)} + Cs*e-(K/V)*(Qa)*(t) (WADDEN et al. 1983)

where: Qa = THE AIR FLOW RATE THROUGH THE DWELLING (m^3/hr)
K = THE MIXING FACTOR
V = THE ROOM VOLUME (m^3)
Cs = THE BASELINE INDOOR AIR CONCENTRATION (mg/m^3)
t = TIME (s)

as time approaches infinity, a steady state is approached and the equation reduces to...

Ca = Q/Qa

where: Qa = Vd*AE

and: Vd = THE ROOM VOLUME (m^3)
AE = THE AIR EXCHANGE RATE (hr^-1)
Ca = THE AMBIENT AIR CONCENTRATION (mg/m^3)

|::

CARCINOGENIC CONSTITUENTS

DOSE = Ca*RR*D*EV*ED*AB/BW*70yrs*365d/yr (USEPA 1988)

where: RR = THE RESPIRATION RATE (m3/hr)
D = THE WORKDAY LENGTH (hr/d)
EV = THE NUMBER OF EXPOSURES PER YEAR
ED = THE EXPOSURE DURATION (yrs)
AB = THE ABSORBED FRACTION OF THE CONSTITUENTS
BW = THE RECEPTOR BODY WEIGHT (Kg)

NONCARCINOGENIC CONSTITUENTS

DOSE = Ca*RR*D*AB/BW (USEPA 1988)

where: RR = THE RESPIRATION RATE (m3/hr)
D = THE WORKDAY LENGTH (hr/d)
AB = THE ABSORBED FRACTION OF THE CONSTITUENTS
BW = THE RECEPTOR BODY WEIGHT (Kg)

CONSTITUENTS	Cg mg/mL	H atm*m^3/mol	RT L*atm/mol	Csg mg/cm^3	b mm	F cm	L m	d m	(P1-P2) dynes/cm^2	Q mg/s	Vd m^3	AE hr^-1	Qa m^3/hr	Ca mg/m^3
benzene	8.00E-04	5.50E-03	24.055	1.83E-04	0.5	15	114000	15	2.96E-03	1.44E-02	34200	0.5	17100	8.42E-07

CONSTITUENTS	RR m^3/hr	D hr/d	EV d/yr	ED yr	AB	BW Kg	CARC. DOSE mg/Kg/d	NONCARC. DOSE mg/Kg/d	CPF Kg-d/mg	RfD mg/Kg/d	ICR	HI	COMMENTS
benzene	0.8	24	350	6	1	15	8.86E-08	0.00E+00	0.029	0	2.57E-09	0.00E+00	
TOTAL											2.57E-09	0.00E+00	

Volatilization Emissions Analysis - Onsite Resident Children
Farmer et al. (USEPA, 1980)

Volatiles Emissions from toxic landfills

Ei is emission rate of chemical i given the chemical, temperature of subsurface environment (T), depth of contamination (d), and concentration in soil (Cw).
Area of the site is (A).

CONTAMINANTS	Mol. Wght. (g/mol)	P (mmHg)	Dc(10o C) (cm2/sec)	pt (unitless)	T (K)	Csi (g/cm3)	A (cm2)	d (cm)	Cw (mg/Kg)	cf (Kg/mg)	Ei (g/sec)
Benzene	78	95	8.20E-02	0.3	283	0.00042	2.E+08	152	***345***	1.00E-06	**2.56E-03**

Naer Field Box Model
Pasquill, 1975 and Horst, 1979

Takes Emission Rate to the breathing zone. Input width of contaminated area and annual mean wind speeds.

CONTAMINANTS	Hb (m)	u10 (m/sec)	um (m/sec)	Wb (m)	Ca (g/m3)
Benzene	1.4	1	0.127560069	15240	**9.408E-07**

CONTAMINANTS	RR m^3/hr	D hr/d	EV d/yr	ED yr	AB unitless	BW Kg	CARC. DOSE mg/Kg/d	NONCARC. DOSE mg/Kg/d	CPF Kg-d/mg	RfD mg/Kg/d	ICR	HI
Benzene	0.8	24	350	6	1	15	9.90E-08	0.00E+00	0.029	0	2.87E-09	-
											---	---
TOTAL											2.87E-09	0.00E+00

CHILD MILITARY RESIDENT
FUTURE BENEFICIAL USE SCENARIO
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO
YORKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm]*CSF])

RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)

Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where	INPUTS
ICR = incremental cancer risk (unitless)	1.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	1460
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	2006
ED = exposure duration (years)	4
BW = body weight (kg)	15
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-1	Dermally Adj. Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
VOLATILES													
Benzene	1.0E-06	1.0	0.02	2.90E-02	3.00E-03	3.63E-02	2.40E-03	2.09E-05	1.76E-05	3.65E-04	3.08E-04	0.804	4.00
Toluene	--	1.0	1.00	--	--	2.00E-01	1.60E-01	2.09E-05	8.37E-04	3.65E-04	1.47E-02	-	11
Ethylbenzene	--	1.0	1.20	--	--	1.00E-01	8.00E-02	2.09E-05	1.00E-03	3.65E-04	1.76E-02	-	4
Total Xylenes	--	1.0	0.08	--	--	2.00E+00	1.60E+00	2.09E-05	6.70E-05	3.65E-04	1.17E-03	-	1.092
JP-5	--	1.0	1.00	--	--	2.00E-02	1.00E-02	2.09E-05	8.37E-04	3.65E-04	1.47E-02	-	1
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	1.00	7.30E+00	1.46E+01	--	--	2.09E-05	8.37E-04	3.65E-04	1.47E-02	8.1E-05	--
Benzo(a)anthracene	1.00E-06	--	1.00	7.30E-01	1.46E+00	--	--	2.09E-05	8.37E-04	3.65E-04	1.47E-02	8.1E-04	--

FUTURE RESIDENTIAL CHILD
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	1460	
CF = conversion factor, kg/mg	0.000001	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	4	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	200	
BW = body weight, kg	15	
SA = skin surface area available for contact, cm2	2006	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Calc (mg/kg)	RGO Noncarc (mg/kg)
VOLATILES													
Benzene	1.0E-06	1.0	0.10	2.90E-02	3.00E-03	3.63E-02	2.40E-03	7.31E-07	1.47E-07	1.28E-05	2.56E-06	37.73	188
Toluene	--	1.0	0.10	--	2.00E-01	--	1.60E-01	7.31E-07	1.47E-07	1.28E-05	2.56E-06	-	12,507
Ethylbenzene	--	1.0	0.10	--	1.00E-01	--	8.00E-02	7.31E-07	1.47E-07	1.28E-05	2.56E-06	-	6,253
Total Xylenes	--	1.0	0.10	--	2.00E+00	--	1.60E+00	7.31E-07	1.47E-07	1.28E-05	2.56E-06	-	125,068
JP-5	--	1.0	0.10	--	2.00E-02	--	1.00E-02	7.31E-07	1.47E-07	1.28E-05	2.56E-06	-	[illegible]
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	0.10	7.30E+00	--	1.46E+01	--	7.31E-07	1.47E-07	1.28E-05	2.56E-06	0.13	--
Benzo(a)anthracene	1.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	7.31E-07	1.47E-07	1.28E-05	2.56E-06	1.34	--

RESIDENTIAL ADULT - MILITARY ASSIGNMENT
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	1460	
CF = conversion factor, kg/mg	0.000001	
CSFo = oral cancer slope factor (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	4	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	100	
BW = body weight, kg	70	
SA = skin surface area available for contact cm2	5900	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note. Inputs are scenario and site specific

Contaminant	ICR	HQ	bsorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	ermally A lope Fact g/kg-day)	Derm. Adj Ref. Dose mg/kg-da	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
VOLATILES													
Benzene	1.0E-06	1.0	0.10	2.90E-02	3.00E-03	3.63E-02	2.40E-03	7.83E-08	8.30E-08	1.37E-06	1.45E-06	189.32	942
Toluene		1.0	0.10	--	2.00E-01	--	1.60E-01	7.83E-08	8.30E-08	1.37E-06	1.45E-06	-	62,796
Ethylbenzene		1.0	0.10	--	1.00E-01	--	8.00E-02	7.83E-08	8.30E-08	1.37E-06	1.45E-06	-	31,398
Total Xylenes		1.0	0.10	--	2.00E+00	--	1.60E+00	7.83E-08	8.30E-08	1.37E-06	1.45E-06	-	627,957
JP-5		1.0	0.10	--	2.00E-02	--	1.00E-02	7.83E-08	8.30E-08	1.37E-06	1.45E-06	-	4,679
SEMIVOLATILES													
Benzo(a)pyrene	1.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	7.83E-08	8.30E-08	1.37E-06	1.45E-06	0.56	--
Benzo(a)anthracene	1.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	7.83E-08	8.30E-08	1.37E-06	1.45E-06	5.61	--

ADULT MILITARY RESIDENT
FUTURE BENEFICIAL USE SCENARIO
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO
YORKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/(Ing + Derm)[CSF])

RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)

Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	1.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	1460
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	5300
ED = exposure duration (years)	4
BW = body weight (kg)	70
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-1	Dermally Adj Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
VOLATILES													
Benzene	1.0E-06	1.0	0.02	2.90E-02	3.00E-03	3.53E-02	2.40E-03	4.47E-06	9.96E-06	7.83E-05	1.74E-04	2.036	10.13
Toluene	--	1.0	1.00	--	--	2.00E-01	1.60E-01	4.47E-06	4.74E-04	7.83E-05	8.30E-03	-	19
Ethylbenzene	--	1.0	1.20	--	--	1.00E-01	8.00E-02	4.47E-06	5.69E-04	7.83E-05	9.96E-03	-	8
Total Xylenes	--	1.0	0.08	--	--	2.00E+00	1.60E+00	4.47E-06	3.79E-05	7.83E-05	6.64E-04	-	2,203
JP-5	--	1.0	1.00	--	--	2.00E-02	1.00E-02	4.47E-06	4.74E-04	3.65E-04	8.30E-03	-	*
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	1.00	7.30E+00	1.46E+01	--	--	4.47E-06	4.74E-04	7.83E-05	8.30E-03	1.4E-04	--
Benzo(a)anthracene	1.00E-06	--	1.00	7.30E-01	1.46E+00	--	--	4.47E-06	4.74E-04	7.83E-05	8.30E-03	1.4E-03	--

CURRENT CONSTRUCTION WORKERS
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

RGOs from accidental ingestion and dermal contact with soil are calculated as follows.

*RGOc (mg/kg) = ICR/[(Ing*CSFo) + (Derm*CSFd)]*
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

*Ing = IR*ED*EF*CF/ATc or ATnc*BW*
*Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW*

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	365	
CF = conversion factor, kg/mg	0.000001	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	1	
EF = exposure frequency, days/year	180	
IR = ingestion rate, mg/day	480	
Fi = Fraction Ingested, unitless	1	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	4100	
AF = soil to skin adherence factor, mg/cm2	1	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Absorption Factor (unitless)	Slope Factor (Kg/day-mg	Reference Dose (mg/kg-day	Dermally Adj. Slope Factor (Kg/day-mg)	Derm Adj. Ref. Dose (mg/kg-day	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
VOLATILES													
Benzene	1.00E-06	1.0	0.10	2.90E-02	3.00E-03	3.83E-02	2.40E-03	4.83E-08	4.13E-08	3.38E-06	2.89E-06	344.97	429
Toluene	--	1.0	0.10	--	2.00E-01	--	1.60E-01	4.83E-08	4.13E-08	3.38E-06	2.89E-06	-	28,603
Ethylbenzene	--	1.0	0.10	--	1.00E-01	--	8.00E-02	4.83E-08	4.13E-08	3.38E-06	2.89E-06	-	14,302
Total Xylenes	--	1.0	0.10	--	2.00E+00	--	1.60E+00	4.83E-08	4.13E-08	3.38E-06	2.89E-06	-	286,034
JP-5	--	1.0	0.10	--	2.00E-02	--	1.00E-02	4.83E-08	4.13E-08	3.38E-06	2.89E-06	-	2,184
SEMIVOLATILES													
Benzo(a)pyrene	1.00E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.83E-08	4.13E-08	3.38E-06	2.89E-06	1.05	--
Benzo(a)anthracene	1.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.83E-08	4.13E-08	3.38E-06	2.89E-06	10.47	--

ON-SITE CONSTRUCTION WORKER
DIRECT CONTACT WITH GROUNDWATER
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
CORRECTIVE MEASURES STUDY-TASK I, TOW WAY FUEL FARM
US NAVAL STATION ROOSEVELT ROADS
PUERTO RICO
YORKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm][CSF])
RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)
Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	1.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	365
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	180
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	4100
ED = exposure duration (years)	1
BW = body weight (kg)	70
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-	Dermally Adj. Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
VOLATILES													
Benzene	1.0E-06	1.0	0.02	2.90E-02	3.00E-03	3.63E-02	2.40E-03	5.03E-06	8.67E-06	3.52E-04	6.07E-04	2.172	2.7
Toluene	--	1.0	1.00	--	--	2.00E-01	1.60E-01	5.03E-06	4.13E-04	3.52E-04	2.89E-02	-	5.5
Ethylbenzene	--	1.0	1.20	--	--	1.00E-01	8.00E-02	5.03E-06	4.95E-04	3.52E-04	3.47E-02	-	2.3
Total Xylenes	--	1.0	0.08	--	--	2.00E+00	1.60E+00	5.03E-06	3.30E-05	3.52E-04	2.31E-03	-	617.1
JP-5	--	1.0	1.00	--	--	2.00E-02	1.00E-02	5.03E-06	4.13E-04	3.52E-04	2.89E-02	-	0.3
SEMIVOLATILES													
Benzo(a)pyrene	1.0E-06	--	1.00	7.30E+00	1.46E+01	--	--	5.03E-06	4.13E-04	3.52E-04	2.89E-02	1.6E-04	--

Volatilization Emissions Analysis - CONSTRUCTION WORKER
Farmer et al. (USEPA, 1980)

Volatiles Emissions from toxic landfills

Ei is emission rate of chemical i given the chemical, temperature of subsurface environment (T), depth of contamination (d), and concentration in soil (Cw).
Area of the site is (A).

CONTAMINANTS	Mol. Wght. (g/mol)	P (mmHg)	Dc(10o C) (cm2/sec)	pt (unitless)	T (K)	Csi (g/cm3)	A (cm2)	d (cm)	Cw (mg/Kg)	cf (Kg/mg)	Ei (g/sec)
Benzene	78	95	8.20E-02	0.3	283	0.00042	2.E+08	152	***345***	1.00E-06	**2.56E-03**

Naer Field Box Model
Pasquill, 1975 and Horst, 1979

Takes Emission Rate to the breathing zone. Input width of contaminated area and annual mean wind speeds.

CONTAMINANTS	Hb (m)	u10 (m/sec)	um (m/sec)	Wb (m)	Ca (g/m3)
Benzene	1.4	1	0.127560069	15240	**9.408E-07**

CONTAMINANTS	RR m^3/hr	D hr/d	EV d/yr	ED yr	AB unitless	BW Kg	CARC. DOSE mg/Kg/d	NONCARC. DOSE mg/Kg/d	CPF Kg-d/mg	RfD mg/Kg/d	ICR	HI
Benzene	1.2	8	180	1	1	70	9.09E-10	0.00E+00	0.029	0	2.64E-11	-
											---	---
TOTAL											2.64E-11	0.00E+00

ATTACHMENT 2
TCE Investigations Work Plan

WORK PLAN
FOR
TOW WAY FUEL FARM INVESTIGATIONS RELATED TO DETECTIONS OF TCE IN GROUNDWATER

CONTRACT TASK ORDER 0277

APRIL 20, 1999

Prepared for:

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

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Comprehensive Long-Term Environmental Action Navy

1.0 INTRODUCTION

The Tow Way Fuel Farm (TWFF) has been the subject of numerous investigations extending back beyond the advent of RCRA corrective action requirements. A full RCRA Facility Investigation (RFI) was performed at the site and the subsequent report for which was approved by the EPA. It was recommended in the report that a Corrective Measures Study (CMS) be performed at the site to select the appropriate corrective measure. The first step in the CMS was to perform certain additional investigations designed to fill data gaps remaining from the RFI. Groundwater samples were obtained during the additional investigations.

The most recent sampling indicated the presence of a significant level of TCE in monitoring well 7MW07. Based on this detection, its possible ramification in terms of a potential Dense Non-Aqueous Phase Liquid (DNAPL) plume and the historic use of the area surrounding the well, focused investigations of the TCE occurrence are warranted. This work plan describes the elements of the investigatory program.

2.0 CURRENT CONDITIONS

2.1 Sampling Results

Groundwater samples were obtained from the wells at the TWFF during the CMS investigations which were analyzed for, among other constituents, TCE. The results of the sampling are shown on Figure 1. It should be noted that this figure shows all the TCE detection and non-detection points. As can be seen, TCE was detected in three wells:

- UGW 24 at 2 μg/l
- 7MW07 at 2,000J μg/l (J=estimated), and
- 7MW08 at 3 μg/l.

It is the significant concentration seen at 7MW07 which has prompted the need for focused investigations.

2.2 Historical Building Use

The building immediately northeast of 7MW07 (between Forrestal Drive and the well) was comprised of a half-cylindrical structure constructed of cloth over a frame which was anchored to a concrete slab. The building was destroyed during hurricane Georges. A previous, more substantial, structure which was on the same pad was destroyed during hurricane Hugo.

The buildings which have occupied the area have been used for the storage and maintenance of small craft used in various harbor operations. This information is based on conversations with long-term station employees. While the repair activities have apparently been somewhat limited, the fact that maintenance was performed indicates the potential for cleaning and degreasing operations which could have resulted in a release of solvents. Also, it is unclear to what extent the buildings were used for storage and what was stored. The potential of stored material release can not be discounted.

3.0 SCOPE OF INVESTIGATIONS

The "TCE" investigations at the TWFF will consist of confirmatory sampling, off-set drilling, installation of temporary wells and groundwater grab sampling with on-site screening. The various investigatory elements are described in detail in the subsections which follow.

3.1 Confirmatory Sampling

TCE was detected in wells 7MW07, 7MW08 and UGW 24. These wells will be resampled to ascertain if the TCE occurrence is persistent at these locations. Samples will be obtained without purging the well using a bottom filling bailer. Purging is generally employed to ensure that fresh, formation water is sampled. In this case, the intent is to maximize the ability of the sampling to detect a DNAPL layer which could be present in the well bottom. The bailer will be emptied from the bottom into sampling containers.

Each sample will be analyzed in a local laboratory for VOCs on a rapid turnaround basis so the information is available to make field decisions. The samples will also be subjected to field screening using QuickTest® test kits which provide a Method Detection Limit of 4 parts per billion (ppb).

Appendix A to this work plan contains technical information related to the QuickTest® screening tool. Using both the laboratory and screening test on these samples will:

- Provide data from the laboratory which is comparable to that from previous sampling events, and
- Provide data to "calibrate" the screening tests.

This step will serve to confirm if TCE is still present in the wells and increase the utility of the screening test.

3.2 Boring and Temporary Well Program

Three borings will be made near well 7MW07 (designated A, B and C) and two more (designated D and E) will be placed in the vicinity of 7MW08. The borings will be 50 feet from the monitoring wells and will be placed in the pattern shown on Figure 1. The purpose of the borings is to provide information near the wells which contained TCE. Boring placement is skewed in the downgradient direction: however sidegradient locations are included since DNAPL do not necessarily follow groundwater in terms of flow direction.

The borings will be advanced using hollow-stemmed augers. Initially, the hole will be drilled to the same depth as the monitoring well (either 7MW07 or 7MW08 as appropriate). Split-spoon soil samples will be obtained at five foot intervals to verify stratigraphy; no soil samples will be analyzed. A boring log will be maintained indicating, among other things, lithology and water occurrence. The logs of 7MW07 and 7MW08 are provided in Appendix B for information.

Once the borings reach depth, a temporary well will be installed in the hole. This installation will consist of two-inch diameter, schedule 40 PVC, riser with a five foot screen that extends to the bottom. The temporary well will be sealed at the surface to prevent inflow of surface water or accidental introduction of foreign material into the hole.

A groundwater sample will be obtained from the temporary well after allowing sufficient time for the groundwater to enter the screen. Samples will be obtained using the techniques described for

confirmatory sampling. Each sample will be screened using the Quick Test® technique. This will provide immediate information regarding the presence of TCE.

Once the initial sampling is performed, the temporary well will be removed and the boring will be advanced another five feet. Split-spoon samples will obtained at two foot intervals to the bottom of the boring to provide information on the lithology in this zone. A temporary well, as previously described, will be installed in the boring. This temporary well will be sampled and analyzed as described previously. Upon completion of the sampling, the temporary well will be removed and the hole backfilled with drill cuttings placed in the hole at approximately the same depth as that from which they were derived.

TCE detections in the temporary wells will trigger the following responses:

- If TCE is detected in temporary well "A"
  - Contingent temporary wells 1 and 2 will be installed
  - UGW 16 will be sampled and screened for TCE

- If TCE is detected in temporary well "B"
  - Contingent temporary wells 1, 2 and 3 will be installed

- If TCE is detected in temporary well "C"
  - Contingent temporary wells 3 and 4 will be installed

- If TCE is detected in any two temporary wells A, B and C
  - Contingent temporary wells 1-4 will be installed

- If TCE is detected in temporary well "D"
  - Contingent temporary wells 4 and 5 will be installed

- If TCE is detected in temporary well "E"
  - Contingent temporary wells 5 and 6 will be installed.

Each of the contingent temporary wells will be drilled, installed (including the two depths) and sampled in the same manner as the initial temporary wells. They will be placed 150 feet away from the original wells.

The detection of TCE in any of the contingent temporary wells will immediately be brought to the attention of the project manager who, in consultation with the Navy and EPA, will assess what, if any, further steps should be taken while the investigation team is in the field.

3.3 Other Investigation Considerations

Investigation Derived Wastes (IDW)

The generation of IDW is not anticipated since wells will not be purged and drill cuttings will be returned to the boring.

Decontamination

Disposal, single use, bailers will be employed for the sampling. New riser and screen will be used for each temporary well. The drill rig will be decontaminated in accordance with the EPA approved RCRA Facility Investigation Work Plans between each use.

Surveying

The borings for temporary well installation will be surveyed by field measurements to permanent objects.

4.0 REPORTING

A full report on the investigations described herein will be prepared and submitted. Included will be a description of the field activities, boring logs, all screening and laboratory analytical results and an interpretation of the information obtained.

5.0 SCHEDULE

A schedule for the investigations will be developed upon work plan approval. The schedule will need to take into account Navy budgetary constraints.

UGW24

82

1082

83

1080

84

1088

85

PALAU STREET

FORRESTAL DRIVE

SEE ENLARGED VIEW A

JUNCTION VAULT

ENSENADA
HONDA

PALAU STREET

A
7MW07
C
B
1
2
3
4
7MW08
D
E
CARD STREET
5
6

200 0 100 200
1 inch = 200 ft.

2" RISER

JUNCTION VAULT

VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277828WP

LEGEND
- MONITORING WELL LOCATION WITHOUT TCE DETECTION
- MONITORING WELL LOCATION WITH TCE DETECTION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- INITIAL BORING LOCATION
- CONTINGENT BORING LOCATION

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 1
SWMU 7/8 – TOW WAY FUEL FARM
TRICHLOROETHENE (ug/L) IN GROUNDWATER
SAMPLE RESULTS AND BORING LOCATION

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

APPENDIX A
QUICKTEST® TECHNICAL INFORMATION

QuickTest® For Volatile Organic Halides in Water

Including: Trichloroethylene (TCE), Perchloroethylene (PCE), Trihalomethanes (THMs), and Carbon Tetrachloride (CCl_4)

Quick Test for Volatile Organic Halides Water Test Method Performance:

Performance Parameters:

Dynamic Range	5-2,000 ppb
Number of False Positives[1]	0
Number of False Negatives[1]	0
Method Detection Limit (MDL):	
Trichloroethylene (TCE)	4 ppb
Perchloroethylene (PCE)	4 ppb
Carbon Tetrachloride (CCl_4)	3 ppb
Chloroform ($CHCl_3$)	5 ppb
Method Quantitation Limit (MQL):	
Trichloroethylene (TCE)	9 ppb
Perchloroethylene (PCE)	8 ppb
Carbon Tetrachloride (CCl_4)	7 ppb
Chloroform ($CHCl_3$)	10 ppb

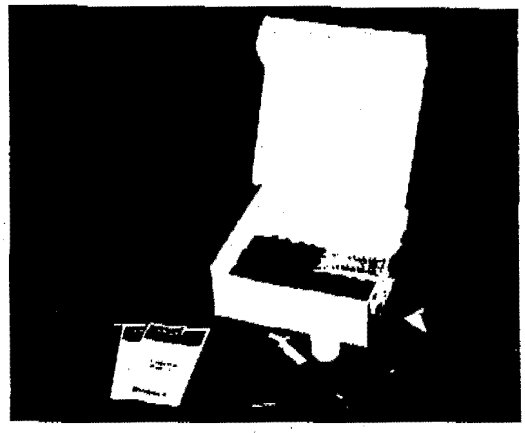
Other Volatile Organic Halides:	Relative Sensitivity Compared to:			
	TCE	PCE	CCl_4	$CHCl_3$
Trichloroethylene (TCE)	**100%**	122%	88%	122%
Perchloroethylene (PCE)	82%	**100%**	72%	100%
Carbon Tetrachloride (CCl_4)	114%	139%	**100%**	139%
Chloroform ($CHCl_3$)	82%	100%	72%	**100%**
1,1-Dichloroethene	69%	84%	61%	84%
Vinyl Chloride	0.8%	1.0%	0.7%	1.0%
trans-1,2-Dichloroethene	61%	74%	54%	74%
cis-1,2-Dichloroethene	43%	52%	38%	52%
Dichloromethane	20%	24%	18%	24%
1,1,1-Trichloroethane	112%	137%	98%	137%
1,1,2-Trichloromethane	80%	98%	70%	98%
1,2-Dichloroethane	15%	18%	13%	18%
Bromoform	77%	94%	68%	94%
Bromodichloromethane	75%	91%	65%	91%
Chlorodibromomethane	71%	87%	63%	87%

[1] False positive and false negative study conducted on TCE only

Interferences[1]

	Concentration Required for a Detectable Interference (ppm)
Benzene	>2,000
Methanol	>2,000
Toluene	>2,000
Oxalic Acid	>2,000
Glyoxylic Acid	>2,000
Sodium Trichloroacetate	>2,000
Sodium Dichloroacetate	>2,000
2,2,2-trichloroethanol	>200
Vinyl Chloride	>200
Pentachlorophenol	>20

[1] Initial Trichloroethylene concentration was 20 ppb.



Complete Volatile Organic Halides in Water Test Kit

ENVIROL INC.
1770 Research Park Way · Suite 160
North Logan, Utah 84341
435-753-7946 · FAX: 435-787-2878
E-mail: envirol@mtwest.net

To place an order or have technical questions answered, please call 1-800-748-3548

QuickTest® For Volatile Organic Halides in Water

Including: Trichloroethylene (TCE), Perchloroethylene (PCE), Trihalomethanes (THMs), and Carbon Tetrachloride (CCl_4)

The QuickTest field analytical test kit for volatile organic halides in water contains materials for analyzing ten water samples. Two sets of standard solutions and calibration checks, specific to the organic halide of interest, are provided with each kit to ensure accurate, reliable results.

PROCEDURES:

Sample Extraction

A water sample is taken and mixed with a solvent to extract the analyte from the sample

Removal of Extract

Teflon™ tape is used in the extraction process to separate the extraction solvent from the water sample and minimize volatization of the analyte. The teflon tape is removed and the extraction solvent containing the analyte is forced from the tape by the syringe.

Sample Quantification

The extract containing the analyte is mixed with a reagent and exposed to ultra-violet light in the Envirometer™. The concentration of the analyte is quantitatively displayed in parts per billion (ppb) on the Envirometer display.

FEATURES:

Inexpensive	• *Low cost compared to standard methods*
Ease of Use	• *Easy to follow layout minimizes operator error*
Quantitative	• *Envirometer gives a quantitative reading in parts per billion (ppb)*
Rapid	• *Samples can be analyzed in 20 minutes or less*
Recyclable	• *Foam insert is recyclable*
Reliable	• *Quick Test results have excellent correlation with standard methods*
Ease of Standardization	• *Internal standard curve stored electronically in the instrument eliminates the need to run a standard with each test*

APPLICATIONS:

Testing During Remediation and Treatment
Monitoring Wastewater Discharge
Site Characterization or Assessment
Screening Samples
Testing of Stormwater Runoff
Testing of Groundwater Monitoring Wells

Quick Test® for Volatile Organic Halides
Including: Trichlorethylene (TCE), Perchloroethylene (PCE), Trihalomethanes (THMs), and Carbon Tetrachloride (CCl_4)

Abstract: Halogenated volatile organic compounds such as trichloroethylene (TCE), perchloroethylene (PCE), trihalomethanes (THMs), carbon tetrachloride (CCl4) and others can be found as pollutants in a variety of environmental samples. Since these compounds present serious health risks, the Environmental Protection Agency (EPA) has mandated the clean-up of waters containing such compounds. Currently, laboratory methods exist for the detection and quantitation of these compounds, but on-site field methods have been desired. Envirol, Inc. has developed a quick, reliable and sensitive analytical field test procedure for the analysis of these compounds in water. This procedure is called the Quick Test® Volatile Organic Halides Water Test.

The Quick Test Volatile Organic Halides Water Test Kit for on-site and laboratory analysis is designed to give the user quick, reliable screening results for environmental decision making. The Quick Test Volatile Organic Halides Water Test Kit can be used for site characterization and mapping, ground water monitoring, selecting samples for laboratory analysis, and monitoring remediation processes.

The Quick Test Volatile Organic Halides Water Test system is based on a photochemical reaction that produces coloration proportional to the concentration of the contaminate in water. A water sample is taken and mixed with a solvent to extract the analyte from the sample. Teflon® Tape is used in the extraction process to separate the extraction solvent from the water sample and minimize analyte volatilization. The Teflon Tape is removed and the extraction solvent containing the analyte is forced from the Teflon Tape and mixed with a reagent. The reagent-analyte complex is then exposed to ultra-violet (UV) light.

An instrument (Envirometer™) is used to expose the sample to UV light and measure the absorbance produced by the reagent-analyte complex. The absorbance is compared to an internal standard curve that is stored electronically within the instrument. The concentration of the analyte in water is then displayed in $\mu g/l$ or parts per billion (ppb). The user should note that if multiple organic halides are present in the water sample the result will be a total of all organic halides. Optimal agreement with standard methods is obtained by establishing a correlation between the Quick Test Volatile Organic Halides test and standard methods.

Standard solutions and calibration checks are provided with each Quick Test Volatile Organic Halides Water Test Kit to ensure that quality control standards are met. The standard curve for the instrument should be set at the beginning of each testing period. The Quick Test Volatile Organic Halides Water Test Kit standard curve can be set and checked with one of four standard compounds: perchloroethylene (PCE), trichloroethylene (TCE), trihalomethanes (THMs), and carbon tetrachloride (CCl_4).

Quick Test® Demonstration

Step 1: Extraction

A. Fill the Extraction Container (1) with the Water Sample to the blue mark on the neck of the Extraction Container (1).
B. Pour all of the clear solution from the Extraction Solvent Vial (2) into the Extraction Container (1). Leave the red crystals in the Extraction Solvent Vial (2).
C. Shake for 3 minutes.

Step 2: Extraction Solvent Transfer

A. Remove the cap of the Extraction Solvent Vial (2). Remove the plunger from the barrel of the Extraction Solvent Transfer Syringe (3).
B. Remove the Teflon® Tape, using the plastic fork device, from the Extraction Container (1) and place it in the Extraction Solvent Transfer Syringe (3).
C. Place the tip of the Extraction Solvent Transfer Syringe (3) in the Extraction Solvent Vial (2). Replace the plunger in the barrel of the Extraction Solvent Transfer Syringe (3). Force the plunger of the Extraction Solvent Transfer Syringe (3) to the blue line on the barrel of the Extraction Solvent Transfer Syringe (3). This will allow for adequate removal of the extraction solvent from the Teflon Tape.
D. Invert the Extraction Solvent Vial (2) three or four times. Allow separation of the two layers.

Step 3: Drying

A. Remove the cap from the Drying Vial (4). Place a new disposable tip on the pipette. Adjust the pipette volume to 0.6 ml (600 μl). Use the pipette to transfer all of the clear top solution (which contains the TCE and/or PCE) from the Extraction Solvent Vial (2) to the Drying Vial (4).

Note: Be careful to remove only the clear top solution from the Extraction Solvent Vial (2). Removal of the red colored layer can negatively effect the result of the test.

Step 4: Liquid/Liquid Transfer

A. Place a new disposable tip on the pipette. Adjust the pipette volume to 0.6 ml (600 μl). Using the pipette, transfer all of the solution from the Drying Vial (4) to the Liquid/Liquid Transfer Vial (5).
B. Cap the Liquid/Liquid Transfer Vial (5). Shake vigorously for approximately 1 minute.
C. Allow the contents to separate into two layers.
D. Place a new disposable tip on the pipette. Adjust the pipette volume to 0.6 ml (600 μl). Using the pipette, transfer all of the upper layer from the Liquid/Liquid Transfer Vial (5), into the Drying Vial (4) and cap for discard.
E. Place a new disposable tip on the pipette. Adjust the pipette volume to 0.6 ml (600 μl). Transfer 0.6 ml (600 μl) of the remaining layer from the Liquid/Liquid Transfer Vial (5) to the Reaction Vial (6). Do this by placing the pipette tip on the bottom of the Liquid/Liquid Transfer Vial (5) and then drawing up the solution.

Note: Be careful to remove only the upper layer from the Liquid/Liquid Transfer Vial (5). When approaching the meniscus between the two layers, the user may pipette up some of the bottom layer into the pipette tip. Separation of the two solvents will be visible in the pipette tip. Carefully force the bottom layer back into the Liquid/Liquid Transfer Vial (5). This technique may be used to ensure that all of the top layer is removed from the Liquid/Liquid transfer Vial (5).

If the user removes too much of the lower layer, or leaves too much of the upper layer in the Liquid/Liquid Transfer Vial (5), the final concentration reading may be effected and result in a low or diluted reading.

Step 5: Reaction/Reading Concentration

A. Cap the Reaction Vial (6).
B. Invert the Reaction Vial (6) three or four times.
C. Place the Reaction Vial (6) in the Envirometer™.
D. After exposure is complete, read the sample concentration from the Envirometer display.
E. If "OL" (over limit) appears on the Envirometer display, the sample concentration is greater than 200 ppb.
F. After exposure is complete and the user has recorded the displayed concentration, remove the Reaction Vial (5) from the Envirometer.

APPENDIX B
MONITORING WELL LOGS

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm SWMU 7
CTO NO.: 0277 BORING NO.: 7MW07
COORDINATES: EAST: NORTH:
ELEVATION: SURFACE: TOP OF PVC CASING:

RIG: Mobil B-90	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT.)	WEATHER	WATER DEPTH (FT.)	TIME
SIZE (DIAM.)	3"		8 1/4"		10/21/97	20' 10/21 10' 10/22	mostly sunny 85-90°	10.3'	10/22 24hr.
LENGTH	2'		5'						
TYPE	STD		HSA						
HAMMER WT.	140 lbs								
FALL	30"								
STICK UP									

REMARKS: Located South of Bldg. # 2314

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

Well Information	Diam.	Type	Top Depth (ft.)	Bottom Depth (ft.)
Riser	6"	PVC	-2.5 Stick-up	5
Screen 0.020 slot	6"	PVC	5	25

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm) BG/PS	Visual Description	Well Installation Detail	Elevation (ft. MSL)
1, 2, 3	AN					Auger to 3' bgs No Sample	Bentonite @ 1' bgs; Sand @ 3' bgs	
4, 5	S-1 1621	0.5/2.0 25%	9 8 4 4		0.5/0.5	Lt. Brn/Gray Rock, angular to sltly. Rounded. Some silt. Dry to wet @ tip of sample. water @ 5.0' bgs *	Top of screen @ 5' bgs	
6, 7, 8	AN							
9, 10	S-2 1645	0.83/2.0 42%	3 1 5 9/5"		0.5/0.5	Lt. Brn. Rock and Silt. moist to wet. Sample 7MW07-02 TPH DRO/GRO Grain size		

Match to Sheet 2

DRILLING CO.: Soil Tech BAKER REP.: J. Tepsic
DRILLER: Jorge Diaz BORING NO.: 7MW07 SHEET 1 OF 2

* Alot of rain @ NSRR last week, Possibly Perched Zone, Probably Not True Watertable

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm SWMU 7
CTO NO.: 0277 BORING NO.: 7MW07

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586)(Blows/0.5')
RQD = Rock Quality Designation (%)
Lab. Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-328
Lab. Moist. = Moisture Content (ASTM D-2216) Dry Weight Basi

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm) BG/PS	Visual Description	Well Installation Detail	Elevat (ft. MS
						Continued from Sheet 1		
11								
12	AN							
13								
14	S-3	1.25 / 2.0	12 37		0.5/0.5	Lt. Brn Rock w/ some silt and Trace clay and Trace Sand. wet. 7MW07-03 TPH DRO/GRO Grain size		
15	1710	63%	50/5"					
16								
17								
18								
19	S-4	1.67 / 2.0	20 21			Lt. Brn. Rock, angular to Subangular w/ Some silt Trace clay. wet. 7MW07-04 TPH DRO/GRO		
20	1755	83%	50/6"					
21								
22								
23								
24	S-5	0.83 / 2.0	28 40		0.5/2.0	Lt. Brn/Gray Rock, angular to Subangular, Fragmented w/ Some clay wet. 7MW07-05 TPH DRO/GRO		
25	10/22 0800	42%	50/3"					Bottom of Screen @ 25' bgs
26								
27								
28								
29	S-6	0.83 / 2.0	26 25 16 7		0.5/0.5	Lt. Brn. Rock w/ Trace to Little clay & Trace Sand, wet. RX. is angular to subangular. 7MW07-06 TPH DRO/GRO		
30	10/22 0905	42%						

END OF BORING 30'

DRILLING CO.: Soil Tech BAKER REP.: J. Tepsic
DRILLER: Jorge' Diaz BORING NO.: 7MW07 SHEET 2

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm
CTO NO.: 0277 BORING NO.: 7MW08
COORDINATES: EAST: NORTH:
ELEVATION: SURFACE: TOP OF PVC CASING:

RIG: Mobil B-90

	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT.)	WEATHER	WATER DEPTH (FT.)	TIME
SIZE (DIAM.)	3"		8 1/4"		10/27/97 10/28/97	10 20	clear 90°	11'	
LENGTH	2'		5						
TYPE	STD		HSA						
HAMMER WT.	140 lbs								
FALL	30"								
STICK UP									

REMARKS: Auger Refusal @ 8.0' Finish boring by Air Hammer Located on Forrestal Dr.

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

Well Information	Diam.	Type	Top Depth (ft.)	Bottom Depth (ft.)
Riser	6"	PVC	0.5	8
Screen 0.020 Slot	6"	PVC	8	28

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm)	Visual Description	Well Installation Detail	Elevation (ft. MSL)
1, 2, 3	AN					Attempted 2 holes, Can't Advance augers b/c of RX. V. hard. Chg to new cutter head, attempt 3rd hole.		
4, 5	S-1 1110	0.83 / 2.0 42%	28 18 13 15		0.5/0.5	Lt Brn Fragmented RX, w/ Some Silt. Dry. Lab Sample 7MW08-01 TPH DRO/GRO Grain Size 7MW08-01D Dup Collected		
6, 7, 8	AN						Top of Screen @ 8' bgs	
9, 10	S-2 1133	0.83 / 2.0 42%	13 5 8 50/5"		0.5/0.5	Same Material as above, Dry to slthly. moist 7MW08-02 TPH DRO/GRO 7MW08-02D Dup collected MS/MSD. Cannot advance augers any further, Switch to Air Hammer		

Match to Sheet 2

DRILLING CO.: Soil Tech BAKER REP.: J. Tepsic
DRILLER: Jorge' Diaz BORING NO.: 7MW05 SHEET 1 OF 2

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm

CTO NO.: 0277 BORING NO.: 7MW08

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586)(Blows/0.5')
RQD = Rock Quality Designation (%)
Lab. Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-328
Lab. Moist. = Moisture Content (ASTM D-2216) Dry Weight Basi

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm)	Visual Description	Well Installation Detail	Elevat (ft. M
						Continued from Sheet 1		
11						Begin Air Hammer @ 8' bgs @ 0800 10/28/97		
12	Downhole Air Hammer							
13								
14								
15								
16						Water encountered @ 16' bgs Nearby existing MW has water @ 11' bgs		
17								
18								
19								
20						20' V. Hard Rx. Advance Air Hammer 1' for 5 min.		
21								
22								
23								
24								
25								
26								
27								
28						28' Alot of water! Produced From MW V. "clean" ie. Sediment free.	Bottom of Screen @ 28' bgs	
29								
30						END of Boring 30'		

DRILLING CO.: Soil Tech BAKER REP.: J. Tepsic

DRILLER: Jorge' Diaz BORING NO.: 7MW08 SHEET

ATTACHMENT 3
CMS Investigation Report
Tow Way Fuel Farm Replacement Pages

Directions for Insert/Replacement Text, Tables and Figures
Corrective Measures Study Investigation Report
Tow Way Fuel Farm
Naval Station Roosevelt Roads
June 30, 1998

Description	Remove	Insert
Cover/Spines	Draft Cover/Spines	Final Cover/Spines
Section 3.0 Text	Pages 3-3, 3-4, and 3-7	Revised Pages 3-3, 3-4, 3-4a, and 3-7
Section 3.0 Tables	Table 3-1	Revised Table 3-1
Section 3.0 Figures	Figures 3-2 through 3-17	Revised Figures 3-2 through 3-17

located close to Ensenada Honda indicate the presence of naturally deposited sediments. These sediments were encountered at monitoring well UGW10 (on the southwestern end of Cross-section A-A') and are primarily silt with lesser amounts of sand and clay. In other borings close to Ensenada Honda, but not on the cross-section, the sediments were observed to contain coral and shell fragments, which are indicative of a marine origin. The particle size sample from 7DP03 is an example of the particle size distribution of the marine sediments.

The information used to develop the cross-sections came from this investigation and from RCRA Facility Investigation Report (Baker, June 1996). Information was also taken from the Additional Well Installation Interim Corrective Measure Report (Baker, March 1998).

3.1.2 Subsurface Soil Analytical Results

A total of 68 subsurface soil samples were submitted for laboratory analysis from the TWFF during the CMS investigation.

At least one of the four constituents in the BTEX analysis were detected in 34 of the 60 samples as presented in Table 3-1. None of the detected levels exceeded the residential or industrial RBCs. Sample 7DP15-02 contained the maximum detections for three of the four BTEX constituents, including benzene (150 J µg/kg), toluene (680 µg/kg), and xylene (2,300 µg/kg). The location of the maximum detection of ethylbenzene was 7DP07-04, with a concentration of 12,000 µg/kg.

TPH (DRO and GRO) were detected in 43 of the 60 samples as shown in Table 3-1. There were a total of 14 samples which exceeded the EPA Region III RBCs for TPH DRO (100 mg/kg) with concentrations ranging from 270J mg/kg (7DP07-06) to 22,000 mg/kg (7DP15-04). A total of ten samples exceeded the screening criteria for TPH GRO (100,000 µg/kg) with concentrations ranging from 180,000 µg/kg (7DP10-05) to 1,100,000 J µg/kg (7DP25-06).

Isopleth maps of the BTEX and TPH (DRO and GRO) concentrations were developed on five foot intervals to a total depth of 15 feet bgs. A minimum of three positive detections were required in

each interval for the respective constituent to generate the isopleth maps. This yielded a BTEX, TPH (DRO and GRO) isopleth from the three five foot intervals for a total of nine isopleth maps. Figures 3-4, 3-5, and 3-6 provide the BTEX, TPH GRO, and TPH DRO isopleth maps for the 0-5 ft bgs interval. Figure 3-7, 3-8, and 3-9 correspond to the 5-10 ft bgs interval while Figures 3-10, 3-11, and 3-12 provide the BTEX, TPH GRO, and TPH DRO isopleths. An estimated volume of contaminated soil was determined utilizing the isopleth maps. This volume was calculated for those soils which exceeded 100 mg/kg (Commonwealth of Puerto Rico's generally applied soil standard for TPH in soil). It was estimated that 146,000 cubic yards of soil is in excess of 100 mg/kg TPH.

TOC was detected in eight of the 68 samples submitted for analysis as presented in Table 3-1. The concentrations ranged from 0.046 µg/kg (7DP23-02) to 0.77 µg/kg (7DP03-02).

A total of five samples (7DP02/10, 7DP03-02, 7DP04-03, 7DP05-02, and 7DP08-01) were submitted for analysis of bulk density. The density of the samples ranged from one gram per milliliter (g/ml) in sample 7DP08-01 to 1.4 g/ml (7DP03-02).

3.1.3 Soil Gas Analytical Results

A total of ten soil gas samples were submitted for laboratory analysis as summarized on Table 3-2. These samples were submitted for analysis of TPH (DRO and GRO), percent carbon dioxide, and percent oxygen.

TPH GRO was detected in four of the ten samples with a minimum detection of 5.6 parts per million by volume (ppmV) in sample 7SG10, and a maximum detection of 45 ppmV in sample 7SG06. TPH DRO was not detected in any of the ten samples. Carbon dioxide was detected in nine samples with a minimum concentration of 0.9% from sample 7SG02, and a maximum concentration of 20.8% from sample 7SG01. The concentration of oxygen detected in the subsurface soils ranged from 7.6% (7SD01) to 25.4% (7SG06) as indicated in Table 3-2.

3.1.4 Vertical Permeability Test Results

A total of three vertical permeability tests were performed at the TWFF at the locations shown on Figure 2-2. The results of the tests are presented in Tables 3-3 through 3-5. The tests were conducted according to the EPA approved work plan, and utilized the "flush bottom in uniform soil with variable head" calculation to determine the mean coefficient of permeability (Winterkorn and Fang, 1975). The formula used consists of the following:

centimeter (g/cc). The apparent elevation of groundwater was obtained by measuring depth to groundwater from the top of the PVC casing with a known elevation.

The corrected groundwater elevations are provided in Table 3-6. A corrected groundwater surface contour map was developed as shown on Figure 3-13. The groundwater at the site generally follows the topographic surface down the TWFF hillside in a southwest direction toward Ensenada Honda.

3.2.2 Groundwater Analytical Results

A total of 41 groundwater samples were collected from the TWFF during the CMS investigation.

Twenty one VOCs were detected in the groundwater samples collected. Only fourteen of the detected VOCs were in excess of either or both of the screening criteria as shown in Table 3-7. 1,1-Dichloroethene, chloroform, bromodichloromethane, and 1,1,2-Trichloroethane exceed the EPA Region III Tap Water RBCs in one sample each. 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, n-Propylbenzene, Sec-butylbenzene, and n-butylbenzene all exceeded their respective tap water RBCs. A total of five constituents exceeded both of the listed criteria. Trichloroethene with a MCL of 5 μg/l was detected in three samples ranging in concentration of 2-2,000J μg/l. An isopleth map providing the BTEX concentrations in the groundwater at the TWFF is shown on Figure 3-14.

TPH GRO was detected in 26 out of 41 samples ranging from 29 J to 420,000 J µg/L. An isopleth map of the TPH GRO concentrations in groundwater at the TWFF is provided on Figure 3-15. TPH DRO was detected in 33 of 41 samples with concentrations from 65 J to 960,000 µg/L. An isopleth map of the TPH DRO concentrations in groundwater at the TWFF is provided on Figure 3-16.

Methane was detected in 33 of the 41 samples with concentrations ranging from 0.05 to 55 µg/L as provided in Table 3-7. The alkalinity of the groundwater samples ranged from 156,000 to 1,400,000 µg/L. Nitrate was detected in 17 out of 41 samples ranging in concentration from 110 to 3,200 µg/L. Sulfate detections ranged from 260 to 681,000 µg/L in 38 of the 41 groundwater samples. Chloride which was detected in all of the groundwater samples ranged from 14,100 to 8,340,000 µg/L, while ferrous iron was detected in 39 of the 41 samples ranging from 80 to 28,000 µg/L as shown in Table 3-7.

TABLE 3-1

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III Industrial RBC	EPA Region III Residential RBC	7DP-TWFF-U	7DP-TWFF-U1	7DP01	7DP01-05	7DP01-08	7DP01-11	7DP01-13	7DP01-14	7DP02-05	7DP02/10
Sample Date			04/21/98	04/21/98	04/14/98	04/14/98	04/14/98	04/14/98	04/14/98	04/14/98	04/15/98	04/16/98
Depth Range (ft.)					0.00-29.00	8.00-10.00	14.00-16.00	20.00-22.00	24.00-26.00	27.00-28.50	9.00-10.00	
BTEX (ug/kg)												
Benzene	200,000	22,000	NA	NA	NA	1.2 U	1.2 U	1.1 U	1.1 U	1.1 U	1.1 U	NA
Ethylbenzene	200,000,000	7,800,000	NA	NA	NA	1.2 U	1.2 U	1.1 U	1.1 U	1.1 U	1.1 U	NA
Toluene	410,000,000	16,000,000	NA	NA	NA	1.2 U	1.2 U	1.1 U	1.1 U	1.1 U	1.1 U	NA
Xylenes	4,100,000,000	160,000,000	NA	NA	NA	1.2 U	1.2 U	3.4	1.1 U	0.82 J	0.6 J	NA
TPH												
Diesel Range Organics (mg/kg)	100	100	NA	NA	NA	12	11	5.3 J	6.9 U	15	26	NA
Gasoline Range Organics (ug/kg)	100,000	100,000	NA	NA	NA	58 U	32 J	79	55 U	65	54 U	NA
Grain-size												
% Clay	NE	NE	12.2	63	23.8	NA	NA	NA	NA	NA	NA	NA
% Silt	NE	NE	25.9	24.7	25.9	NA	NA	NA	NA	NA	NA	NA
% Gravel	NE	NE	8.4	2.1	4.1	NA	NA	NA	NA	NA	NA	NA
% Sand	NE	NE	53.5	10.2	46.2	NA	NA	NA	NA	NA	NA	NA
Engineering Properties												
Total organic carbon (ug/kg)	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Density												
Density (g/ml)	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.05

Data Qualifiers:
J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III Industrial RBC	EPA Region III Residential RBC	7DP03-01	7DP03-02	7DP04-01	7DP04-03	7DP05-02	7DP05-01	7DP05-05	7DP06-01	7DP06-05	7DP07-01	7DP07-04	7DP07-06
Sample Date			04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98	04/15/98
Depth Range (ft.)			1.00-2.00	3.00-4.00	1.00-3.00	5.00-7.00	3.00-5.00	2.00-3.00	9.00-11.00	0.00-4.00	8.00-12.00	0.00-4.00	4.00-8.00	12.00-14.00
BTEX (ug/kg)														
Benzene	200,000	22,000	1.2 U	1.3 U	1.2 U	1.2 U	NA	1.1 U	1.1 U	1.2 U	4.5	1.2 U	28 J	6.2 U
Ethylbenzene	200,000,000	7,800,000	1.2 U	1.3 U	1.2 U	10	NA	1.1 U	1.1 U	1.2 U	3.8	1.2 U	12,000	31 J
Toluene	410,000,000	16,000,000	1.2 J	0.68 J	1.2 U	2.3	NA	1.1 U	1.1 U	1.2 U	0.92 J	1.2 U	37 J	24 J
Xylenes	4,100,000,000	160,000,000	2.7	1.2 J	1.2 U	10	NA	1.1 U	1.1 U	1.2 U	9	1.9	560	53 J
TPH														
Diesel Range Organics (mg/kg)	100	100	7.3 U	8.1 U	7.3 U	6.9 U	NA	6.6 U	6.9 U	7.6 U	13 J	35	**5,700**	**270 J**
Gasoline Range Organics (ug/kg)	100,000	100,000	59 U	66 U	61 U	1,100 J	NA	29 J	57 U	61 U	2,100	110	**730,000**	60,000
Grain-size														
% Clay	NE	NE	NA	31.3	NA	NA	NA	NA	NA	NA	NA	15.6	NA	NA
% Silt	NE	NE	NA	32.7	NA	NA	NA	NA	NA	NA	NA	56.8	NA	NA
% Gravel	NE	NE	NA	0.7	NA	NA	NA	NA	NA	NA	NA	0.3	NA	NA
% Sand	NE	NE	NA	35.3	NA	NA	NA	NA	NA	NA	NA	27.3	NA	NA
Engineering Properties														
Total organic carbon (ug/kg)	NE	NE	NA	0.77	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Density														
Density (g/ml)	NE	NE	NA	1.4	NA	1.37	1.1	NA	NA	NA	NA	NA	NA	NA

Data Qualifiers:

J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III Industrial RBC	EPA Region III Residential RBC	7DP08-01	7DP08-04	7DP09	7DP09-03	7DP10-01	7DP10-03	7DP10-05	7DP11-02	7DP11-05	7DP12-01	7DP13-02
Sample Date			04/15/98	04/15/98	04/16/98	04/16/98	04/16/98	04/16/98	04/16/98	04/16/98	04/16/98	04/16/98	04/16/98
Depth Range (ft.)			0.00-4.00	4.00-8.00	0.00-9.00	5.00-7.00	1.00-2.00	5.00-7.00	10.00-12.00	4.00-6.00	10.00-12.00	1.00-3.00	4.00-5.50
BTEX (ug/kg)													
Benzene	200,000	22,000	1.1 U	1.1 U	NA	2.5 U	1.2 U	12 U	6 U	1.2 U	10 J	1.1 U	1.2 U
Ethylbenzene	200,000,000	7,800,000	1.1 U	1.1 U	NA	2.5 U	1.2 U	180 J	41	1.2 U	140 J	1.1 U	1.2 U
Toluene	410,000,000	16,000,000	1.1 U	1.1 U	NA	2.5 U	1.2 U	190 J	8.4	1.2 U	15 J	1.1 U	1.2 U
Xylenes	4,100,000,000	160,000,000	0.75 J	1.1 U	NA	1.7 J	1.2	450 J	54	1.2 U	170 J	1.1 U	0.7 J
TPH													
Diesel Range Organics (mg/kg)	100	100	6.7 UJ	6.7 U	NA	7.9 U	7.1 U	**8,400**	**2,300**	93	**1,100**	19	5.8 J
Gasoline Range Organics (ug/kg)	100,000	100,000	54 U	56 U	NA	640	51 J	**220,000**	**180,000**	62 U	**280,000**	56 U	58 U
Grain-size													
% Clay	NE	NE	NA	NA	15.3	NA	NA	NA	NA	NA	NA	NA	NA
% Silt	NE	NE	NA	NA	38	NA	NA	NA	NA	NA	NA	NA	NA
% Gravel	NE	NE	NA	NA	7.6	NA	NA	NA	NA	NA	NA	NA	NA
% Sand	NE	NE	NA	NA	39.1	NA	NA	NA	NA	NA	NA	NA	NA
Engineering Properties													
Total organic carbon (ug/kg)	NE	NE	0.34	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Density													
Density (g/ml)	NE	NE	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Data Qualifiers:

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U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III	EPA Region III	7DP14-01	7DP15-02	7DP15-04	7DP15-07	7DP16-03	7DP16-05	7DP17-02	7DP17-04	7DP18-02	7DP19-03	7DP19-06	7DP19-08
Sample Date	Industrial	Residential	04/16/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98	04/17/98
Depth Range (ft.)	RBC	RBC	1.00-3.00	3.00-5.00	6.00-8.00	12.00-14.00	2.00-6.00	10.00-12.00	3.00-6.00	7.00-9.00	4.00-6.00	5.00-7.00	12.00-14.00	16.00-18.00
BTEX (ug/kg)														
Benzene	200,000	22,000	1.2 U	150 J	340 U	140 U	2.8 U	1.1 U	1.3 U	1.2 U	1.2 U	6.2 U	1.2 J	1.3 U
Ethylbenzene	200,000,000	7,800,000	1.2 U	2,300	3,400	140 U	2.8 U	1.1 U	1.3 U	1.2 U	1.2 U	6.2 U	7.4	0.79 J
Toluene	410,000,000	16,000,000	1.2 U	680	340 U	140 U	2.8 U	1.1 U	1.3 U	1.2 U	1.2 U	6.2 U	2.8	0.81 J
Xylenes	4,100,000,000	160,000,000	0.17 J	2,300	2,000	910 J	9.5	0.82 J	1.8	1.2 U	0.82 J	12	35	3.9
TPH														
Diesel Range Organics (mg/kg)	100	100	7.5 U	**7,900 J**	**22,000**	**9,400**	**9,500**	3.8 J	5.5 J	5.5 J	7.4 U	**3,200**	15	8.1 U
Gasoline Range Organics (ug/kg)	100,000	100,000	60 U	**540,000**	**660,000**	**340,000**	1,200	46 J	95	60 U	61 U	3,600	3,800	71
Grain-size														
% Clay	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
% Silt	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
% Gravel	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
% Sand	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Engineering Properties														
Total organic carbon (ug/kg)	NE	NE	0.09	NA	NA	NA	NA	NA	NA	0.053	NA	NA	NA	NA
Density														
Density (g/ml)	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Data Qualifiers:

J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III Industrial RBC	EPA Region III Residential RBC	7DP20	7DP20-02	7DP20-05	7DP21-01	7DP22-01	7DP23-02	7DP24-02	7DP24-01	7DP24-03	7DP24-05	7DP25-01
Sample Date			04/17/98	04/17/98	04/17/98	04/18/98	04/18/98	04/18/98	04/18/98	04/18/98	04/18/98	04/18/98	04/19/98
Depth Range (ft.)			0.00-9.00	3.00-5.00	0.00-12.0	1.00-3.00	0.00-4.00	3.00-4.00	3.00-5.00	3.00-5.00	5.00-7.00	10.00-11.00	0.00-4.00
BTEX (ug/kg)													
Benzene	200,000	22,000	NA	1.2 U	1.2 U	1.3 U	1.1 U	1.1 U	NA	1.1 U	1.2 R	1.4 U	160 U
Ethylbenzene	200,000,000	7,800,000	NA	1.2 U	1.2 U	1.3 U	1.1 U	1.1 U	NA	1.1 U	1.2 R	1.4 U	1,300 J
Toluene	410,000,000	16,000,000	NA	1.2 U	1.2 U	1.3 U	1.1 U	1.1 U	NA	1.1 U	1.2 R	1.4 U	160 U
Xylenes	4,100,000,000	160,000,000	NA	1.2 U	1.2 U	0.71 J	1.1 U	1.1 U	NA	1.1 U	1.2 R	1.4 U	820 J
TPH													
Diesel Range Organics (mg/kg)	100	100	NA	7.1 U	5.3 J	8 U	6 J	6.5 U	NA	5.8 J	7.6 U	8.5 U	**3,600**
Gasoline Range Organics (ug/kg)	100,000	100,000	NA	59 U	58 U	49 J	54 U	53 U	NA	57 U	62 R	160	**1,000,000 J**
Grain-size													
% Clay	NE	NE	34.6	NA	NA	NA	NA	NA	24.4	NA	NA	NA	NA
% Silt	NE	NE	32.3	NA	NA	NA	NA	NA	32.8	NA	NA	NA	NA
% Gravel	NE	NE	1.5	NA	NA	NA	NA	NA	10.6	NA	NA	NA	NA
% Sand	NE	NE	31.6	NA	NA	NA	NA	NA	32.2	NA	NA	NA	NA
Engineering Properties													
Total organic carbon (ug/kg)	NE	NE	NA	NA	NA	0.17	NA	0.046	NA	NA	NA	NA	NA
Density													
Density (g/ml)	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Data Qualifiers:

J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample ID	EPA Region III	EPA Region III	7DP25-03	7DP25-06	7DP26-02	7DP26-04	7DP26-06	7DP27-01	7DP27-04	7DP28-01	7DP29-01	7DP29-04	7DP30-01	7DP30-03
Sample Date	Industrial	Residential	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98	04/19/98
Depth Range (ft.)	RBC	RBC	4.00-7.00	10.00-13.00	2.00-4.00	6.00-10.00	12.00-14.00	0.00-4.00	7.00-8.00	1.00-3.00	1.00-3.00	7.00-8.00	1.00-3.00	5.00-6.00
BTEX (ug/kg)														
Benzene	200,000	22,000	5.3 U	140 U	1.2 U	24 J	1.3 U	1.2 U	1.5 U	1.1 U	1.3 U	1.3 U	1.1 U	1.1 U
Ethylbenzene	200,000,000	7,800,000	17	1,700 J	1.2 U	87 J	1.3 U	1.2 U	1.5 U	1.1 U	1.3 U	1.3 U	1.1 U	1.1 U
Toluene	410,000,000	16,000,000	2.7 J	140 U	1.2 U	29 J	1.3 U	1.2 U	1.5 U	1.1 U	1.3 U	1.3 U	1.1 U	1.1 U
Xylenes	4,100,000,000	160,000,000	43	1,200 J	2.4	370 J	1.3 U	1.2 U	1.5 U	1.1 U	1.3 U	1.3 U	1.1 U	1.1 U
TPH														
Diesel Range Organics (mg/kg)	100	100	280 J	**4,000**	7.6 U	**2,500** J	20 U	7.2 U	9.1 U	15	14	8.2 U	6.8 U	7.1 UJ
Gasoline Range Organics (ug/kg)	100,000	100,000	64,000	**1,100,000** J	720 J	**310,000**	290	58 U	73 U	54 U	65 U	67 U	55 U	36 J
Grain-size														
% Clay	NE	NE	NA	NA	NA	NA	NA	NA	NA	29.2	28.2	NA	NA	NA
% Silt	NE	NE	NA	NA	NA	NA	NA	NA	NA	35.9	54.7	NA	NA	NA
% Gravel	NE	NE	NA	NA	NA	NA	NA	NA	NA	2.2	2.7	NA	NA	NA
% Sand	NE	NE	NA	NA	NA	NA	NA	NA	NA	32.7	14.4	NA	NA	NA
Engineering Properties														
Total organic carbon (ug/kg)	NE	NE	NA	NA	NA	NA	NA	NA	0.39	0.051	NA	NA	NA	NA
Density														
Density (g/ml)	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Data Qualifiers:
J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

TABLE 3-1 (continued)

SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
CMS INVESTIGATION
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

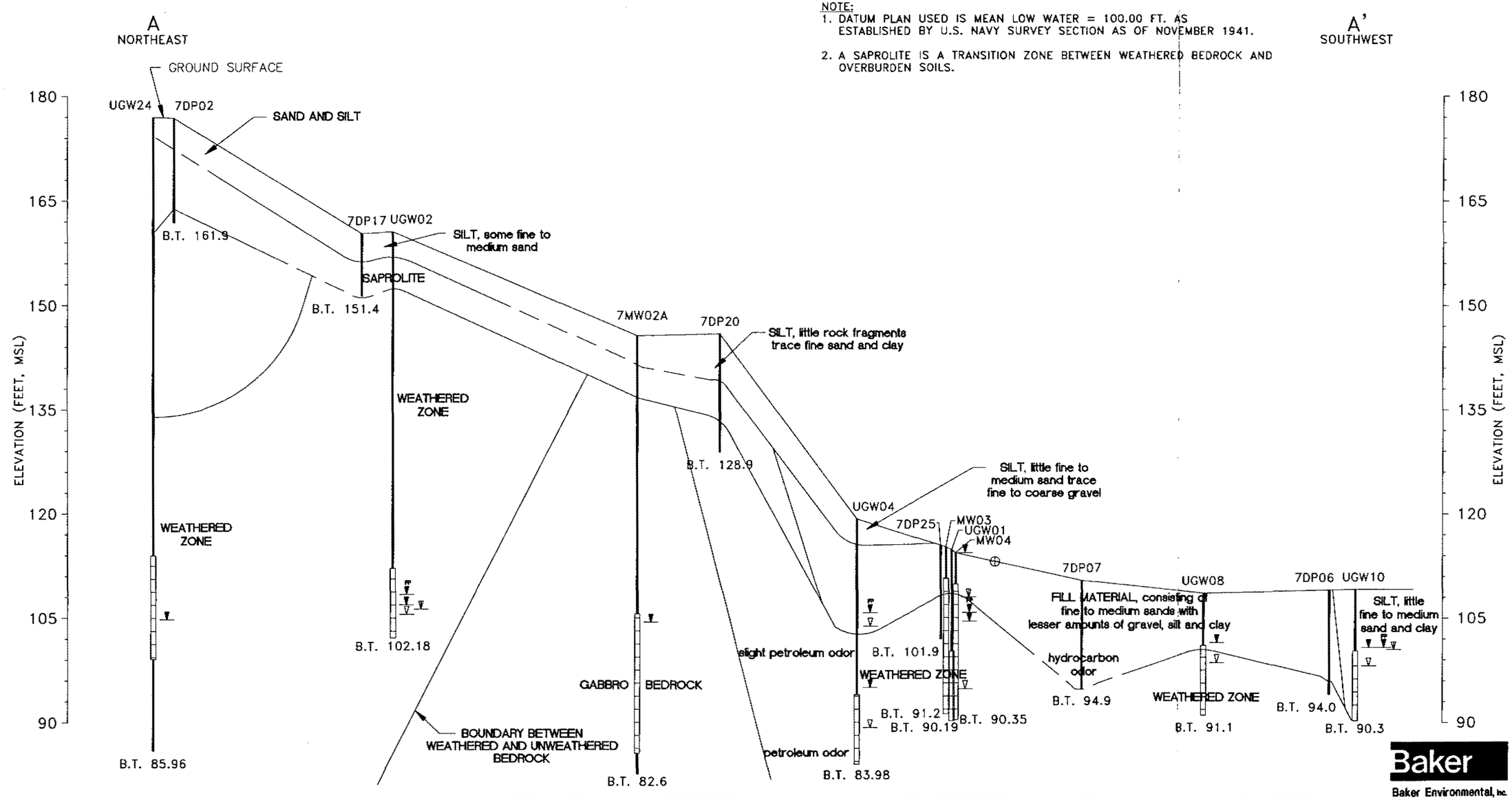
Sample ID Sample Date Depth Range (ft.)	EPA Region III Industrial RBC	EPA Region III Residential RBC	Number Exceeding EPA Region III Industrial RBC	Range Exceeding EPA Region III Industrial RBC	Number Exceeding EPA Region III Residential RBC	Range Exceeding EPA Region III Residential RBC	Location Maximum Detect
BTEX (ug/kg)							
Benzene	200,000	22,000	0/60		0/60		7DP15-02
Ethylbenzene	200,000,000	7,800,000	0/60		0/60		7DP07-04
Toluene	410,000,000	16,000,000	0/60		0/60		7DP15-02
Xylenes	4,100,000,000	160,000,000	0/60		0/60		7DP15-02
TPH							
Diesel Range Organics (mg/kg)	100	100	14/60	270J-22,000	14/60	270J-22,000	7DP15-04
Gasoline Range Organics (ug/kg)	100,000	100,000	10/60	180,000-1,100,000J	1060	180,000-1,100,000J	7DP25-06
Grain-size							
% Clay	NE	NE	NE		NE		7DP-TWFF-U1
% Silt	NE	NE	NE		NE		7DP07-01
% Gravel	NE	NE	NE		NE		7DP24-02
% Sand	NE	NE	NE		NE		7DP-TWFF-U
Engineering Properties							
Total organic carbon (ug/kg)	NE	NE	NE		NE		7DP03-02
Density							
Density (g/ml)	NE	NE	NE		NE		7DP03-02

Data Qualifiers:

J - Analyte present. Reported value may not be accurate or precise.
U - Not detected. The associate number indicates the approximate sample concentration necessary to be detected.
UJ - Not detected, quantitation limit may be inaccurate or imprecise.
NE - Not established.
NA - Not analyzed.

277807WP

NOTE:
1. DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.
2. A SAPROLITE IS A TRANSITION ZONE BETWEEN WEATHERED BEDROCK AND OVERBURDEN SOILS.



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (4/15/98 THROUGH 4/21/98)
- CORRECTED GROUNDWATER ELEVATION (4/21/98)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- FREE PRODUCT ELEVATION (4/15/98 THROUGH 4/21/98)
- B.T. X' — BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- INTERSECTION OF CROSS-SECTION B-B'
- ESTIMATED — — — PROJECTED

150 0 75 150 300
Horizontal Scale: 1 inch = 150 ft.

15 0 7.5 15 30
Vertical Scale: 1 inch = 15 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-2
HYDROGEOLOGIC CROSS-SECTION A-A'
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

277808WP

B
NORTHWEST

B'
SOUTHEAST

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

ELEVATION (FEET, MSL)

120
115
110
105
100
95
90

GROUND SURFACE

FILL MATERIAL consisting of fine to coarse sands with lesser amounts of gravel, silt, and clay

7MW05
MW02
UGW22
UGW12
UGW13
UGW17
7DP30
UGW19
UGW21
7MW08

silt, some gravel FILL

medium sand FILL

light green staining

B.T. 104.9

hydrocarbon odor

slight petroleum odor

WEATHERED ZONE

B.T. 98.15

WEATHERED BEDROCK

slight hydrocarbon odor

B.T. 92.0

B.T. 89.5

B.T. 88.56

B.T. 87.6

petroleum odor

B.T. 87.2

B.T. 86.2

BOUNDARY BETWEEN WEATHERED AND UNWEATHERED BEDROCK

B.T. 82.14

B.T. 81.58

Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (4/15/98 THROUGH 4/21/98)
- CORRECTED GROUNDWATER ELEVATION (4/21/98)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- FREE PRODUCT ELEVATION (4/15/98 THROUGH 4/21/98)
- B.T. X' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- INTERSECTION OF CROSS-SECTION A-A'
- ESTIMATED — — — PROJECTED

160 0 80 160 320
Horizontal Scale: 1 inch = 160 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

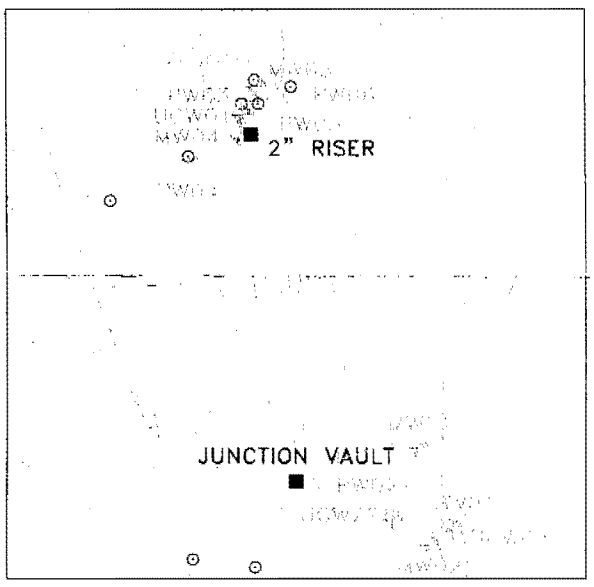
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTION B-B'
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
83
7DP16
7DP13
7DP15
1080
84
7DP14
1088
7DP05
7DP12
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07
JUNCTION VAULT
7DP03
7DP10
ENSENADA
HONDA
PALAU STREET
7DP22
7DP06
7DP23
7DP28
7DP08
7DP27
CARD STREET

200 0 100 200
1 inch = 200 ft.



VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277821WP

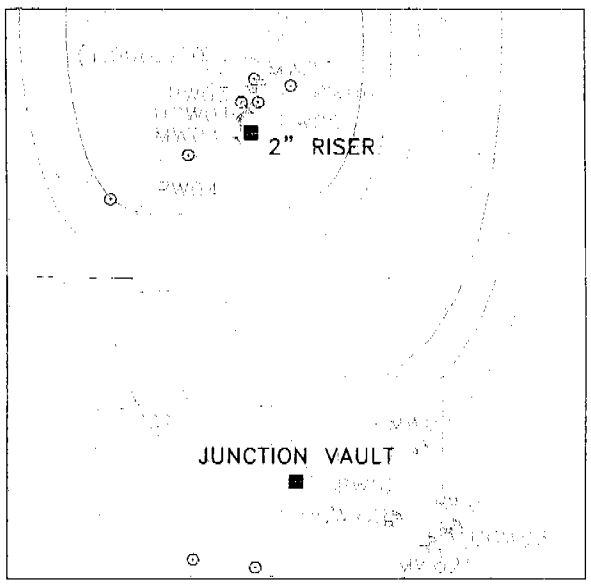
LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- BTEX CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-4
BTEX IN SOIL ISOPLETH MAP 0-5' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
83
7DP16
7DP13
7DP15
1080
84
7DP14
1088
7DP05
7DP12
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07
JUNCTION VAULT
7DP03
7DP10
ENSENADA
HONDA
PALAU STREET
7DP22
7DP06
7DP23
7DP28
7DP08
7DP27
CARD STREET



VIEW A

200 0 100 200
1 inch = 200 ft.

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

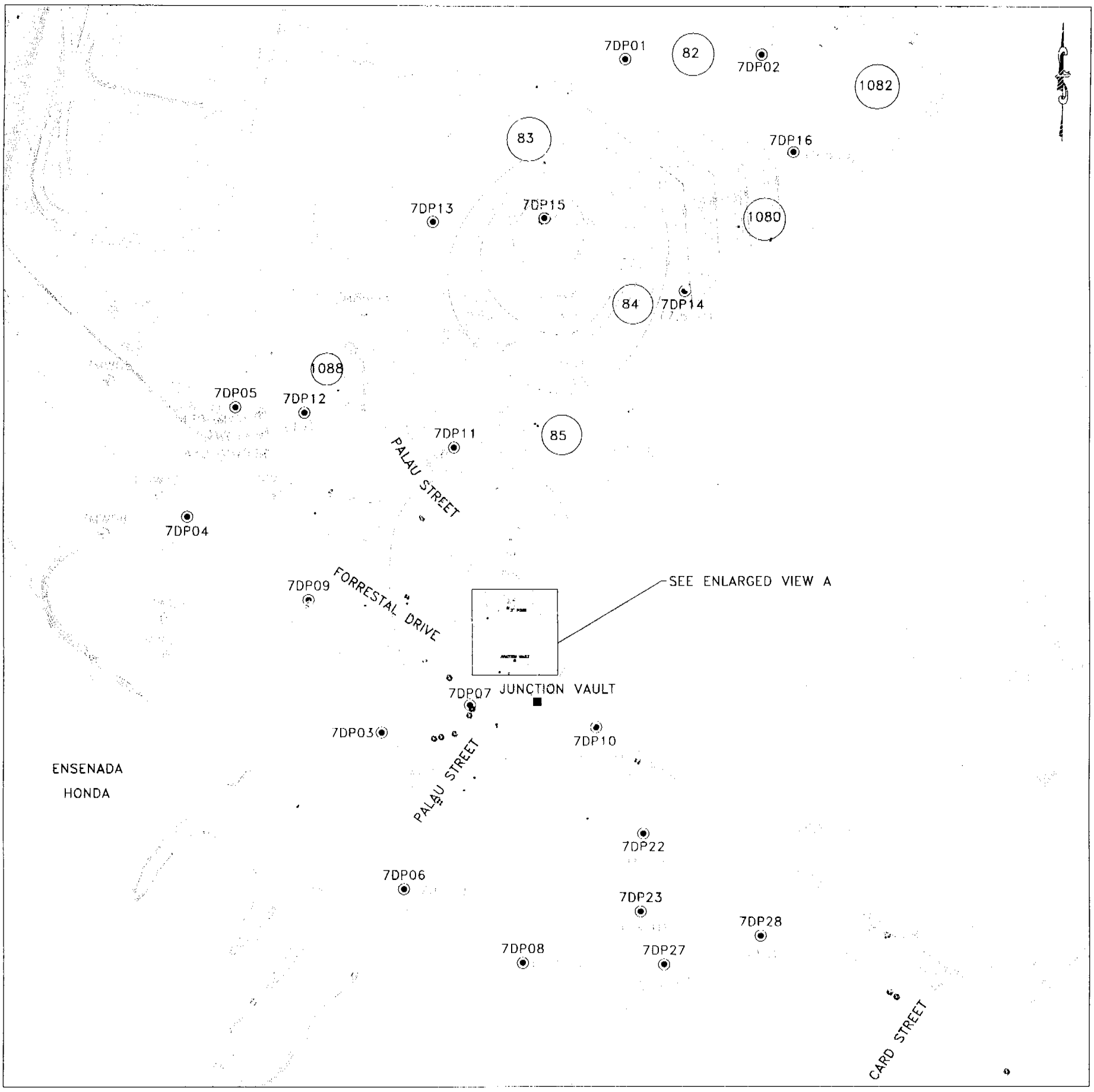
277818WP

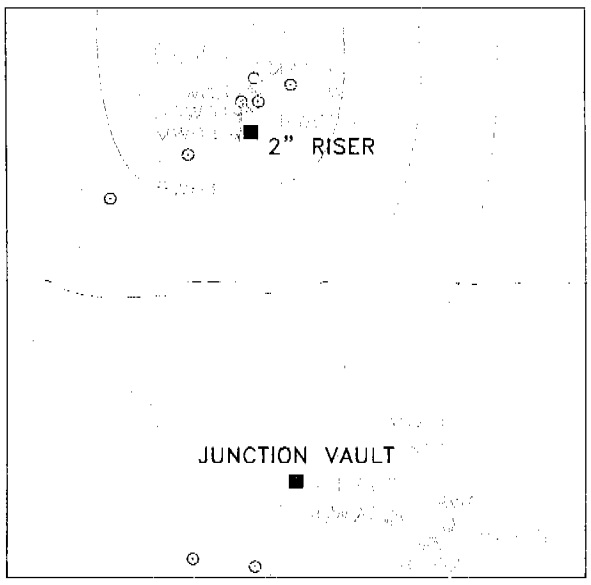
LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH GRO CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-5
TPH GRO IN SOIL ISOPLETH MAP 0-5' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO





VIEW A

200 0 100 200
1 inch = 200 ft.

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277813WP

LEGEND

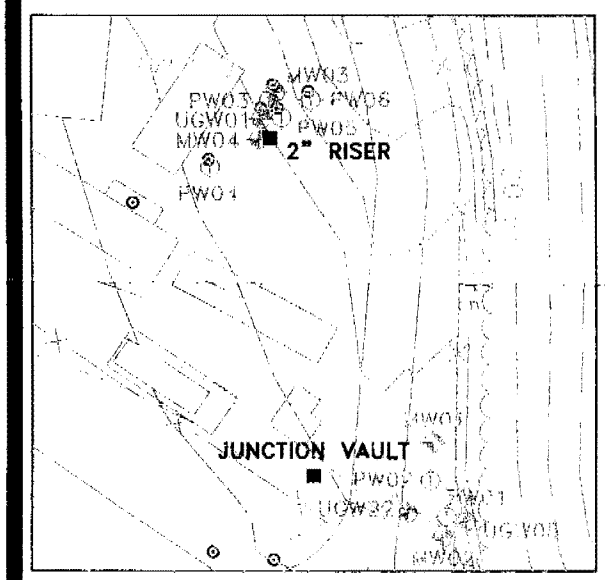
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH DRO CONCENTRATION (mg/kg) IN SOILS
- ISOCONCENTRATION LINE (mg/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-6
TPH DRO IN SOIL ISOPLETH MAP 0-5' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
83
7DP16
7DP13
7DP15
1080
84
7DP14
1088
7DP05
7DP12
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07
JUNCTION VAULT
7DP03
7DP10
ENSENADA
HONDA
PALAU STREET
7DP22
7DP06
7DP23
7DP28
7DP08
7DP27
CARD STREET



VIEW A

200 0 100 200
1 inch = 200 ft.

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277820WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- BTEX CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

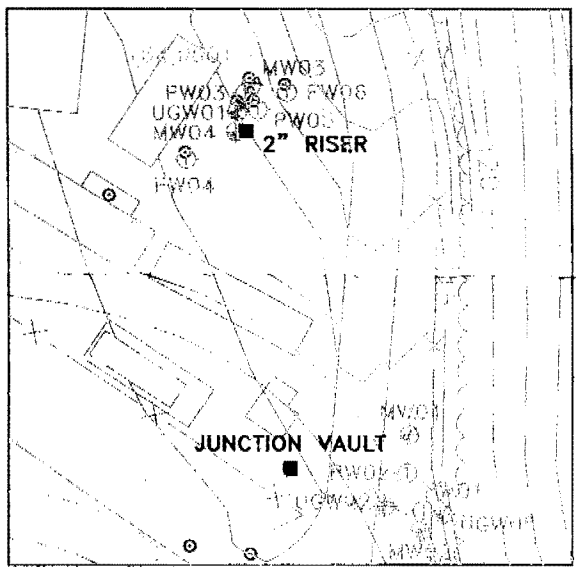
SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-7
BTEX IN SOIL ISOPLETH MAP 5-10' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
83
7DP16
7DP13
7DP15
1080
84
7DP14
1088
7DP05
7DP12
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07 JUNCTION VAULT
7DP03
7DP10
(220,000)
ENSENADA
HONDA
7DP22
7DP06
7DP23
7DP28
7DP08
7DP27
CARD STREET

200 0 100 200
1 inch = 200 ft.



VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277817WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH GRO CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-8
TPH GRO IN SOIL ISOPLETH MAP 5-10' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
83
7DP15
1080
84
1088
7DP05
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07
JUNCTION VAULT
7DP10
ENSENADA
HONDA
PALAU STREET
7DP06
7DP08
7DP27
CARD STREET

200 0 100 200
1 inch = 200 ft.

2" RISER
JUNCTION VAULT

VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

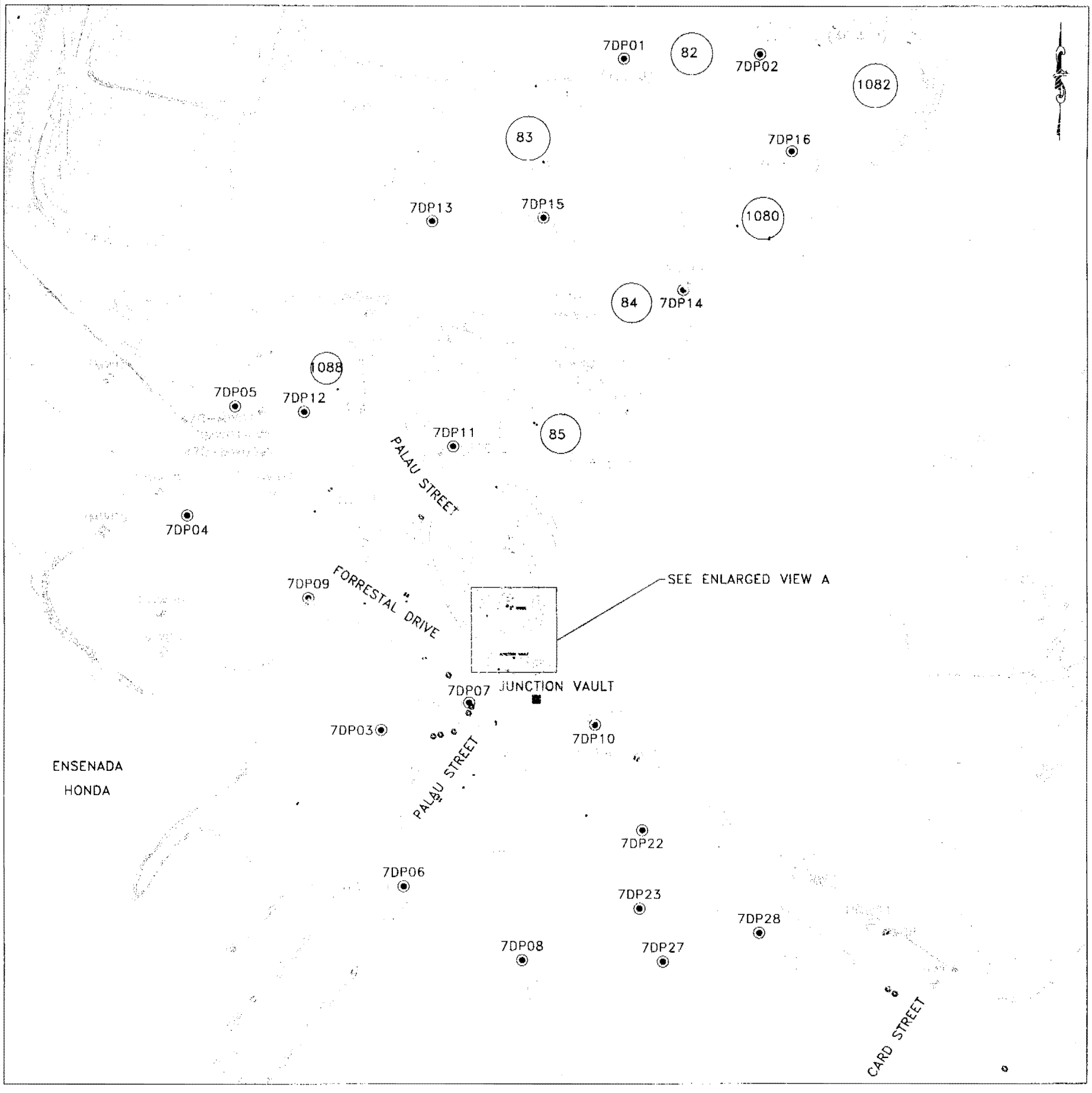
277819WP

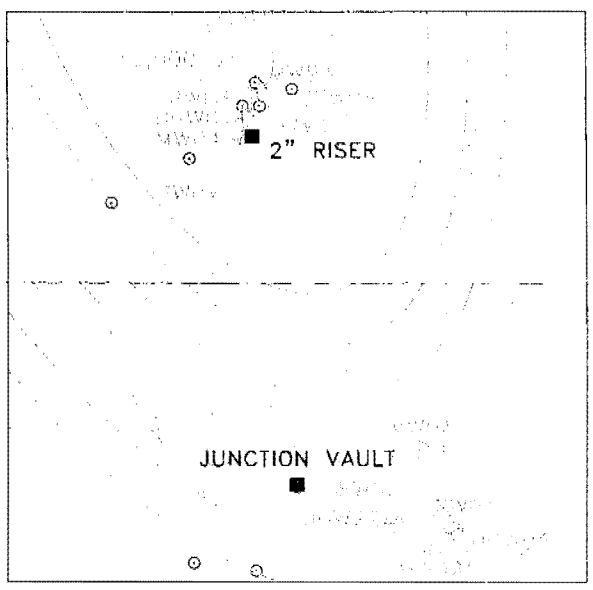
LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH DRO CONCENTRATION (mg/kg) IN SOILS
- ISOCONCENTRATION LINE (mg/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-9
TPH DRO IN SOIL ISOPLETH MAP 5-10' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO





VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277816WP

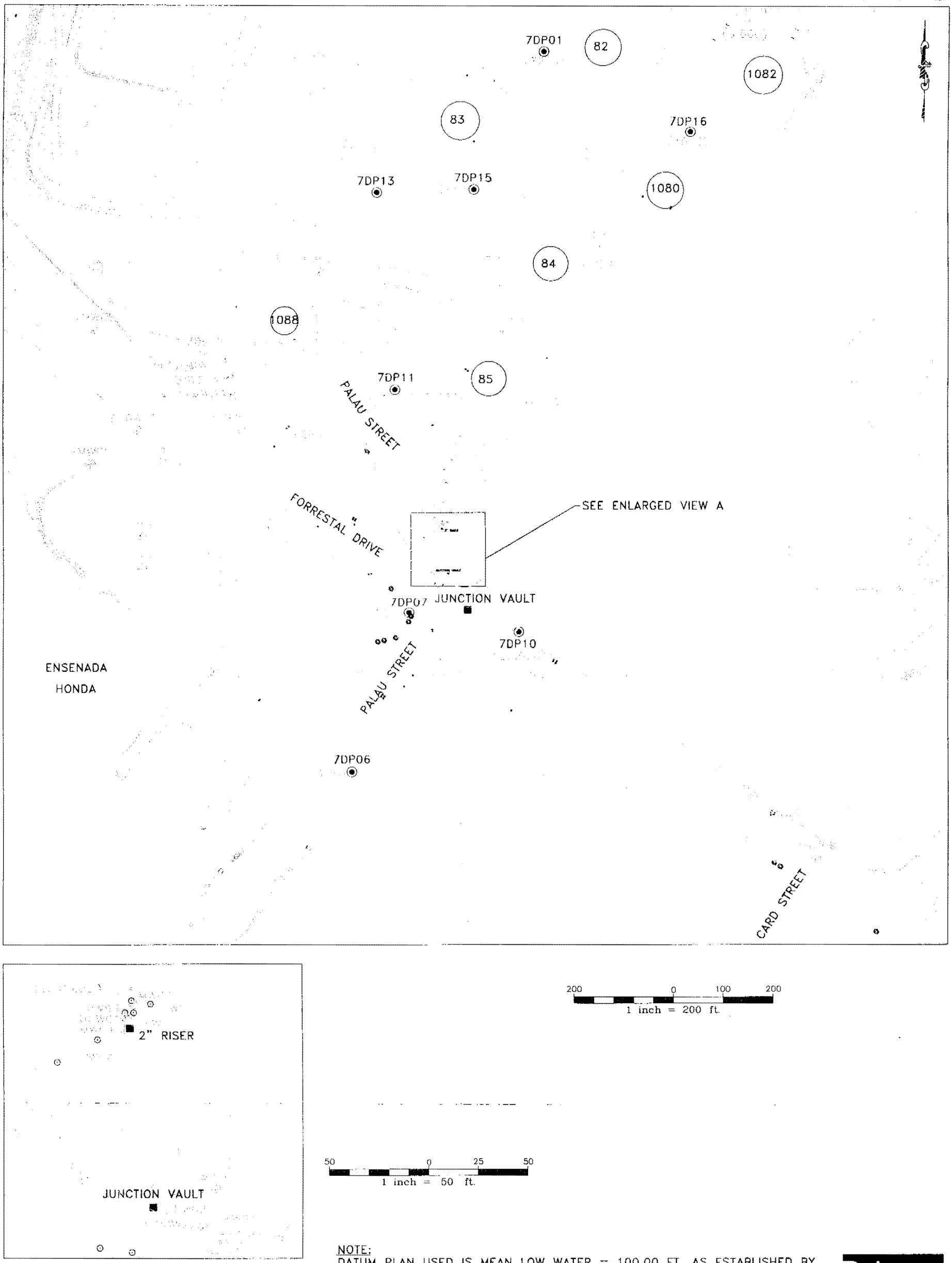
LEGEND

- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- BTEX CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-10
BTEX IN SOIL ISOPLETH MAP 10-15' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



VIEW A

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277814WP

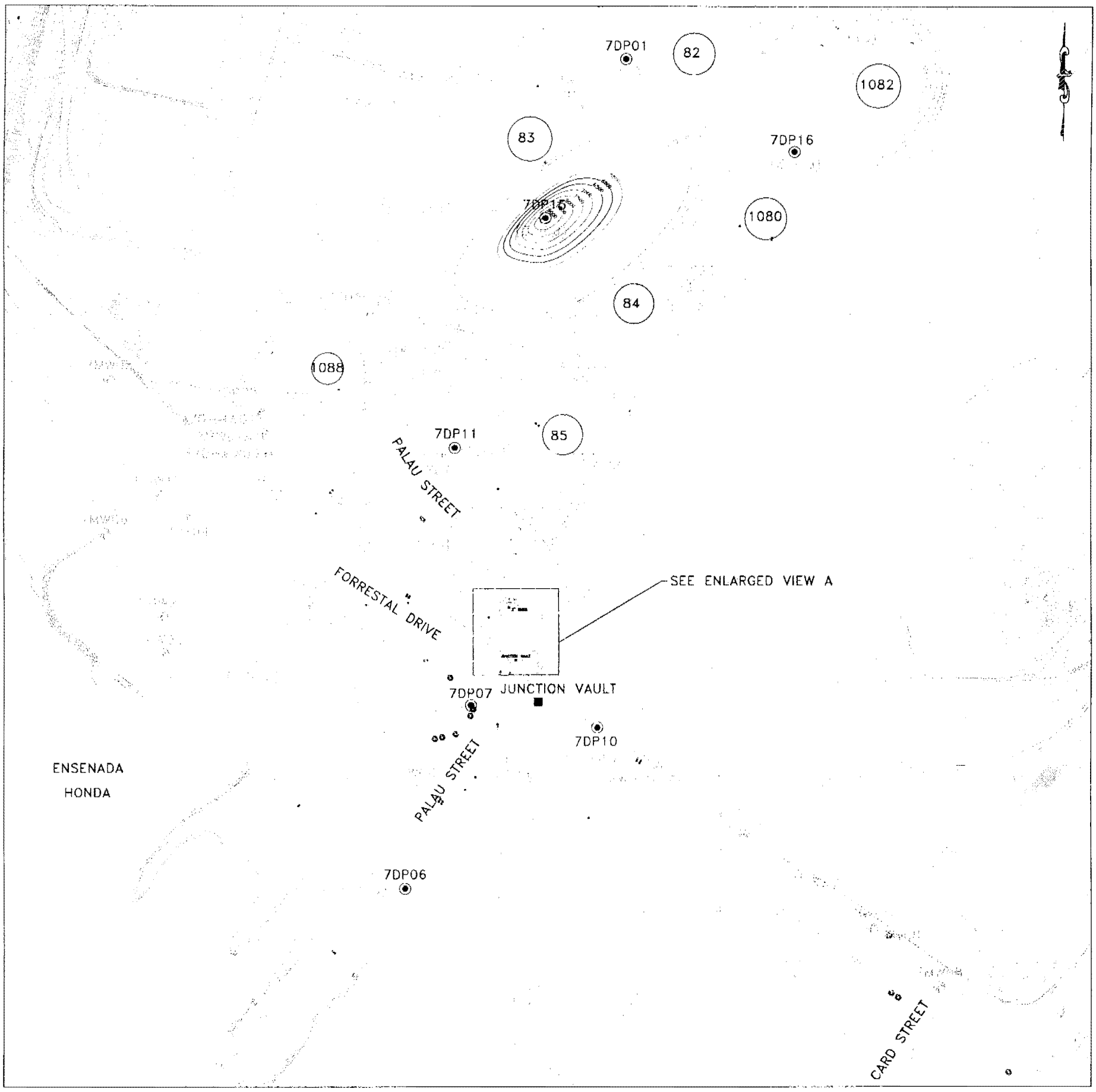
LEGEND

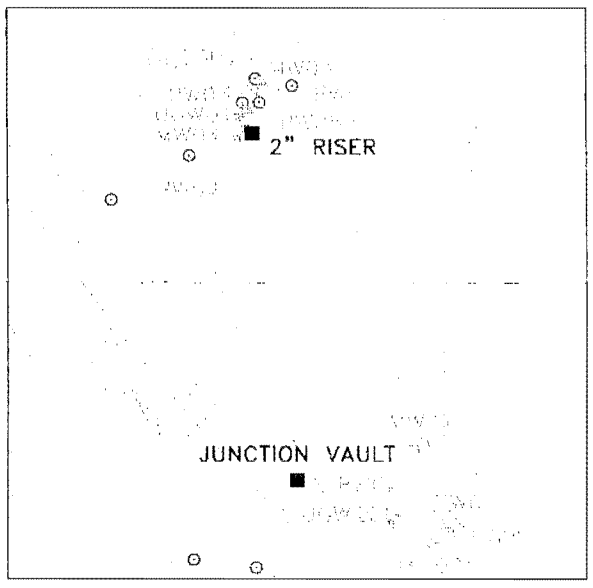
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH GRO CONCENTRATION (ug/kg) IN SOILS
- ISOCONCENTRATION LINE (ug/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-11
TPH GRO IN SOIL ISOPLETH MAP 10-15' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO





VIEW A

200 0 100 200
1 inch = 200 ft.

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

27781SWP

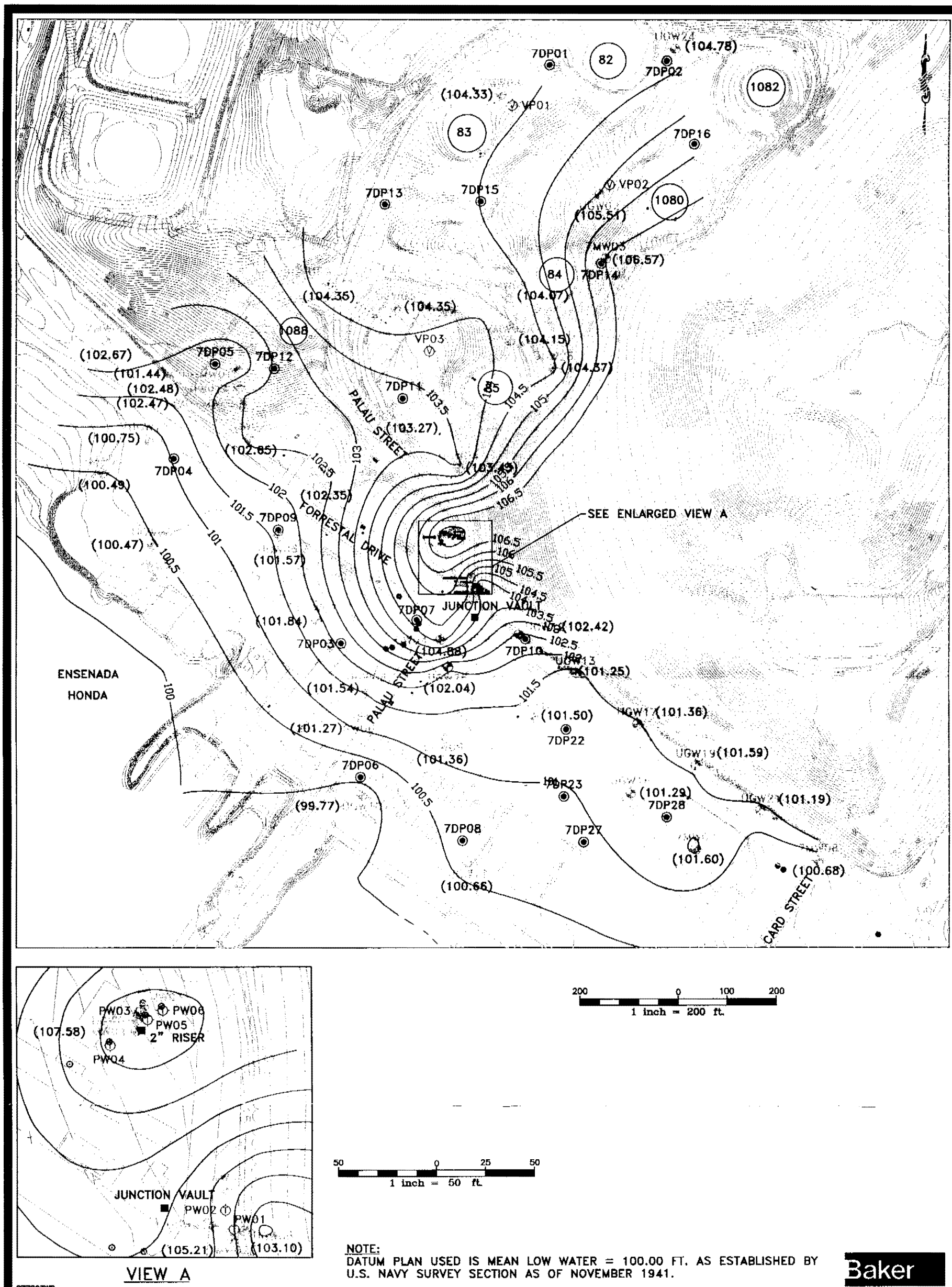
LEGEND

- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH DRO CONCENTRATION (mg/kg) IN SOILS
- ISOCONCENTRATION LINE (mg/kg)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-12
TPH DRO IN SOIL ISOPLETH MAP 10-15' BGS
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



VIEW A

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277823WP

LEGEND

- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- —103— CORRECTED GROUNDWATER SURFACE CONTOUR

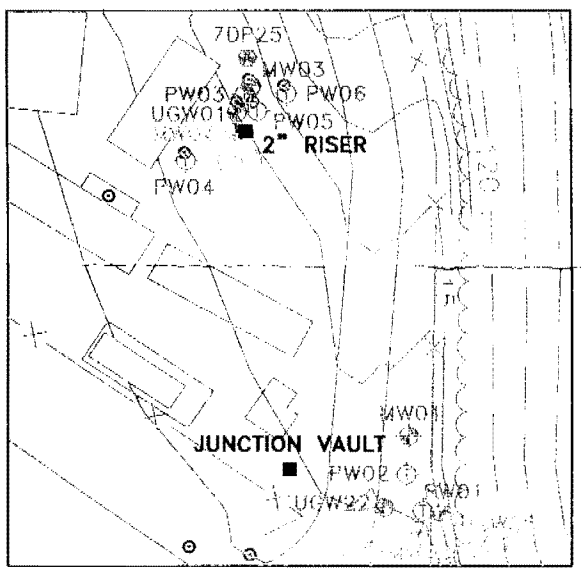
SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-13
CORRECTED GROUNDWATER SURFACE CONTOUR MAP
APRIL 21, 1998
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

82
1082
83
1080
7MW03
84
1088
85
PALAU STREET
FORRESTAL DRIVE
SEE ENLARGED VIEW A
JUNCTION VAULT
ENSENADA
HONDA
PALAU STREET
CARD STREET

200 0 100 200
1 inch = 200 ft.



VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277810WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- BTEX CONCENTRATION (ug/L) IN GROUNDWATER
- ISOCONCENTRATION LINE (ug/L)

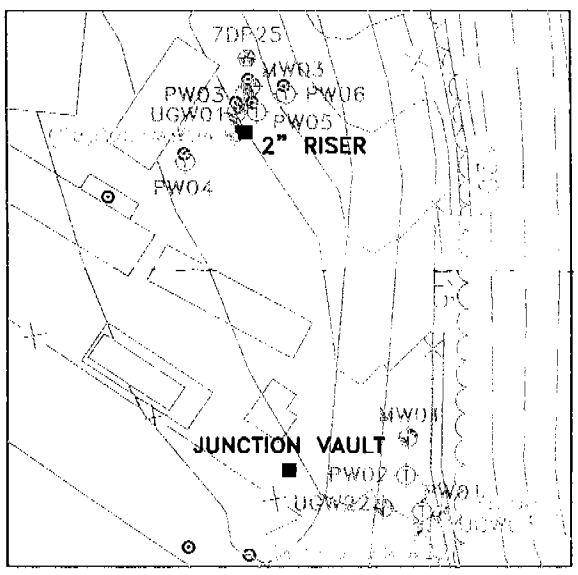
SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-14
BTEX IN GROUNDWATER ISOPLETH MAP
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

82
1082
83
1080
84
1088
85
PALAU STREET
FORRESTAL DRIVE
SEE ENLARGED VIEW A
JUNCTION VAULT
ENSENADA
HONDA
PALAU STREET
UGW13(15,000 J)
CARD STREET

200 0 100 200
1 inch = 200 ft.



VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

Z77812WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH GRO CONCENTRATION (ug/L) IN GROUNDWATER
- ISOCONCENTRATION LINE (ug/L)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-15
TPH GRO IN GROUNDWATER ISOPLETH MAP
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

82
1082
83
1080
84
1088
85
PALAU STREET
FORRESTAL DRIVE
SEE ENLARGED VIEW A
JUNCTION VAULT
ENSENADA
HONDA
PALAU STREET
CARD STREET

200 0 100 200
1 inch = 200 ft.

2" RISER
JUNCTION VAULT

VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277811WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TPH DRO CONCENTRATION (mg/L) IN GROUNDWATER
- ISOCONCENTRATION LINE (mg/L)

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-16
TPH DRO IN GROUNDWATER ISOPLETH MAP
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7DP01
82
7DP02
1082
VP01
83
7DP16
7DP13
7DP15
VP02
1080
84
7DP14
1088
VP03
7DP05
7DP12
7DP11
85
PALAU STREET
7DP04
7DP09
FORRESTAL DRIVE
SEE ENLARGED VIEW A
7DP07
JUNCTION VAULT
7DP03
7DP10
ENSENADA
HONDA
PALAU STREET
7DP22
7DP06
7DP23
7DP28
7DP08
7DP27
CARD STREET

200 0 100 200
1 inch = 200 ft.

PW03
PW06
PW05
2" RISER
PW04
JUNCTION VAULT
PW02
PW01

VIEW A

50 0 25 50
1 inch = 50 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

277822WP

LEGEND
- MONITORING WELL LOCATION
- VERTICAL PERMEABILITY SAMPLE LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- FREE PRODUCT THICKNESS

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-17
FREE PRODUCT THICKNESS AND EXTENT MAP
APRIL 1998
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO