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**TUTU SERVICE STATION INVESTIGATION
WORK PLAN
ST. THOMAS, U.S. VIRGIN ISLANDS**

**PRIVILEGED AND CONFIDENTIAL
ATTORNEY WORK PRODUCT**

Prepared for

Tutu Environmental Investigation Committee
San Juan, Puerto Rico

March 1992

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TUT 003 0530

GERAGHTY & MILLER, INC.

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March 20, 1992

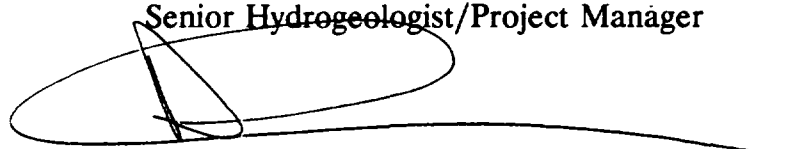
Geraghty & Miller, Inc. is submitting this work plan to Tutu Environmental Investigation Committee for work to be performed at the Tutu Site, St. Thomas, U.S. Virgin Islands. The work plan was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that the work plan meets the highest standards in terms of the methods used and the information presented. If you have any questions or comments concerning this work plan, please contact one of the individuals listed below.

Respectfully submitted,

GERAGHTY & MILLER, INC.

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**TUTU SERVICE STATION INVESTIGATION
WORK PLAN
ST. THOMAS, U.S. VIRGIN ISLANDS**

INTRODUCTION

The Tutu Environmental Investigation Committee (TEIC), which is comprised of Texaco Caribbean, Inc. (Texaco) and Esso Virgin Islands, Inc. (Esso), retained Geraghty & Miller, Inc. in December 1989 to prepare this work plan for the investigation of soil and ground-water conditions in the vicinity of the Tutu Wells Site, Anna's Retreat, St. Thomas, U.S. Virgin Islands (USVI). The work plan was developed to be incorporated as part of the Administrative Order by Consent issued to Texaco and Esso by the United States Environmental Protection Agency (USEPA) Region II, pursuant to Subtitle I of the Resource Conservation and Recovery Act (RCRA). On January 28, 1991 Geraghty & Miller submitted a draft work plan, to the USEPA (Geraghty & Miller, Inc. 1991a). In response to USEPA comments, the work plan was revised and submitted in May 1991 (Geraghty & Miller, Inc. 1991b) and October 1991 (Geraghty & Miller, Inc. 1991c).

A Health and Safety Plan (HASP) and a Quality Assurance Project Plan (QAPP) for the Tutu Service Station Investigation have been developed as separate documents in conjunction with this work plan (Geraghty & Miller, Inc. 1991d; 1992a). The HASP has been prepared for use during the field investigation portion of the study. The QAPP discusses quality assurance/quality control (QA/QC) procedures to be employed for the analytical portion of the study.

Quarterly monitoring of the water quality of the supply wells within the study area is being carried out by Soil Tech of Hato Rey Station, Puerto Rico, and by Geraghty & Miller in accordance with a USEPA-approved work plan, entitled "Sampling, Analysis, and Monitoring Plan for Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands" (Geraghty & Miller, Inc. 1990). A revised Sampling, Analysis, and Monitoring Plan (SAMP) was submitted in September 1991 (Geraghty & Miller, Inc. 1991e) to clarify analytical procedures. The objectives of the original and revised SAMP are to identify, quantify, and

monitor the occurrence of gasoline constituents and tetrachloroethene (and its breakdown products) in supply wells in the vicinity of Route 38 within the Tutu Wells Site. Data from the SAMP (Geraghty & Miller, Inc. 1991f; 1991g; 1991h; 1992b) will be used in conjunction with data generated from this work plan to evaluate hydrogeologic and water quality conditions.

BACKGROUND

The Tutu Wells Site is located in the upper Turpentine Run basin in east central St. Thomas, as shown on Figure 1. Various commercial establishments line the major roads in the area. These establishments include the Texaco Tutu service station at the intersection of Highways 38 and 384 and the Esso Tutu service station on Highway 38. Private homes and multi-family housing, such as the Virgin Islands Housing Authority (VIHA) buildings, generally occupy the less heavily traveled roads. Several water supply wells are located in the Turpentine Run basin (see Figure 2). These wells, which are operated by the VIHA, water purveyors, and private concerns, supply water for domestic and commercial purposes.

The Texaco Tutu service station has been in continuous operation since 1964. The station is a retail outlet for gasoline and diesel fuel and also provides mechanical servicing of automobiles. Over the life of the station, fuel has been stored in underground tanks with the exception of the period from July 1987 to September 1988 when the fuel storage tanks and piping were replaced with new tanks and piping.

The Esso Tutu service station has been in continuous operation since 1970. The station sells gasoline on a retail basis. Fuel has been stored in underground tanks over the life of the station except for a brief period in June 1989 when the tanks and piping were removed and replaced with new tanks and piping. The station has two underground fuel storage tanks; one of the tanks was removed from service from August 1987 to June 1989. The Esso Tutu service station is only open for gasoline sale at the present time. No mechanical repairs have been conducted at the Esso station since 1989.

A brief reconnaissance of the area by Geraghty & Miller in September 1989 revealed the existence of other establishments that represent potential sources of constituents of concern to soil and ground water. These establishments include, but may not be limited to, the following:

- The LAGA building, which formerly housed a textile processing operation.
- A Jeep dealership and repair shop.
- The Ramsay Motor dealership and repair shop.
- The maintenance area of the VIHA complex.
- Tillett Garden, where silk screening and pottery manufacturing and glazing are performed.
- O'Henry dry cleaners.
- The paint store.
- The fire station.
- The Vitelco facility.
- Other small repair shops located on Highway 38.
- Septic tanks.
- The sanitary and storm sewer lines.

The locations of these establishments, with the exception of the septic tanks and sewer lines, are shown on Figure 3.

The following information is derived from the USEPA Draft Administrative Consent Order of June 30, 1989 and from other reports prepared by the USEPA and its consultants. The responding parties have not made an independent determination of these data.

In July 1987, water from the Tillett well was reported to have an unusual odor. Subsequent sampling and analysis of water from that well and other water supply wells in the area by the USEPA Technical Assistance Team (TAT) revealed the presence of volatile organic compounds (VOCs) in the water from the Tillett Well. The compounds detected

included constituents found in gasoline and chlorinated organic compounds. Because of the presence of these constituents, the USVI Department of Planning and Natural Resources (DPNR) closed 18 wells in the area from July through September 1987. The wells have remained closed (with the exception of Four Winds II) and were sampled quarterly through August 1989 under the direction of USEPA Region II. The Four Winds II well has been operating to supply water to a car wash which began operations in early 1991.

PREVIOUS WORK

Previous studies in the vicinity of the Tutu wells site include several regional ground-water resource, use, and quality studies and site-specific investigations at the Texaco and Esso service stations. Water resource studies were performed by the U.S. Geological Survey (USGS) (Jordan and Cosner 1973; Garcia and Canoy 1984; and Graves and Gonzalez 1988) and by Geraghty & Miller for the Government of the U.S. Virgin Islands-Department of Conservation and Cultural Affairs (DCCA) in 1983 (Geraghty & Miller, Inc. 1983a; 1983b). The studies determined that the upper Turpentine Run basin was heavily used for ground-water supply. Although actual ground-water withdrawal rates were not known, it was estimated that withdrawals probably exceeded the estimated safe yield of 300,000 gallons per day (gpd) that was calculated by the USGS in 1973 (Griggs pers. comm. 1978). As of 1982, the Virgin Island Department of Public Works (DPW) had granted ground-water withdrawal appropriations totaling approximately 1,000,000 gpd (Geraghty & Miller, Inc. 1983a).

A potentiometric surface map of the Turpentine River Basin aquifer was prepared by the USGS (Graves and Gonzales 1988) using water-level data obtained on September 11, 1987. A generalized adaption of this map is shown on Figure 4, which indicates that ground-water flow is generally to the southwest through the Tutu site area, parallel to the axis of the valley. At the southern portion of the Tutu site area, ground-water flow is to the south and southeast. The September 11, 1987 water levels for the Demitri, Eglin II, Eglin III, and Steele wells were qualified by the USGS study (Graves and Gonzalez 1988) as

being representative of recovery levels (i.e., previously lowered by pumping) rather than static water levels.

Ground water in the area is generally mineralized with chloride, sodium, calcium, sulfate, and bicarbonate. Such mineralization is common for ground water throughout the Virgin Islands and is attributed to bulk fallout of sea spray onto the land surface (Jordan and Cosner 1973), but may have other sources as well. Nitrate concentrations in excess of the USEPA primary drinking water standard of 10 milligrams per liter (mg/L), expressed as equivalent weight of nitrogen, have consistently been reported in some of the wells in the upper Turpentine Run basin. The high nitrate levels can probably be attributed to contamination by untreated and partially treated sewage. As a part of the ground-water sampling and analysis program performed for Geraghty & Miller's study (1983a), one water sample was collected in May 1982 from one of the VIHA wells (VIHA-I) for analysis of priority pollutant VOCs. The following VOCs were detected: tetrachloroethene, commonly referred to as "perchloroethylene" and abbreviated as PCE, at a concentration of 55 micrograms per liter (ug/L), trans-1,2-dichloroethene (DCE) at 12 ug/L, and trichloroethene (TCE) at 10 ug/L. The location of VIHA-I is shown on Figure 3.

Soil gas surveys were conducted at both the Texaco and Esso service stations and in their vicinities. The Texaco soil gas survey was carried out in November 1987 by Geoscience Consultants, Ltd. Their report to Texaco Caribbean, Inc., entitled "Final Report on Results of Soil Gas Survey, Tutu, St. Thomas, U.S. Virgin Islands," dated January 25, 1988, describes the methodology and results of the survey (Geoscience Consultants 1988). In brief, soil gas samples were collected on the station property, at various locations south and southwest of the property, and at a few locations northeast of the property. Hydrocarbons in soil gas were detected at elevated concentrations in the vicinity of the former underground storage tank area, extending to the southwest toward the intersection of Highways 384 and 38. Another area with moderately elevated hydrocarbon soil gas concentrations was identified within a topographically low area in the southern portion of the Four Winds Shopping Center parking lot. Technical problems precluded the

quantification of individual benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations in some of the samples.

Additionally, nine soil gas sampling points were analyzed for chlorinated compounds. These sampling points were located on and adjacent to the Texaco station, in the vicinity of the LAGA building, and in the vicinity of the Tillett well. Six compounds were analyzed for; however, only PCE, was detected consistently and at significant concentrations. The highest PCE soil gas concentrations were detected in the vicinity of the LAGA building and the Tillett well.

A soil gas survey was performed in the vicinity of the Esso station in April 1988 by Belgodere Associates, Inc. Their report to Esso, entitled "Esso Tutu Service Station Soil Gas Vapor Screening Survey Report, St. Thomas, U.S.V.I., " dated June 14, 1988, describes the methodology and results of the survey (Belgodere & Associates 1988). In summary, soil gas samples were collected and analyzed for BTEX and chlorinated hydrocarbons (PCE, TCE, and DCE) at various locations on the Esso station property and north and south of the property, primarily in the parking lot of the Four Winds Plaza Shopping Center. BTEX was detected in soil gas in the vicinity of the underground storage tank location and the north and southwest portions of the service station. PCE was detected west of the southwest corner of the Esso parcel. PCE and TCE were detected in a soil gas sample collected outside of the northwest corner of the Esso parcel.

SCOPE OF WORK

The objectives of the work plan are to delineate the potential sources, the horizontal and vertical extent, and potential migration pathways of petroleum hydrocarbon products in soil and ground water in the vicinity of Route 38 within the Tutu Wells Site. The USEPA is also concerned about chlorinated hydrocarbon compounds (i.e., PCE and its breakdown products) which have been detected in ground water in the Tutu area (Geraghty & Miller 1991f; 1991g; 1991h; 1992b). To assist the USEPA in evaluating the Tutu area,

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the TEIC has agreed to install deep monitoring wells (i.e., screened below the water table) and analyze all soil and ground-water samples for target compound list (TCL) and other specified VOCs, TCL base neutral and acid extractable compounds (BNAs), target analyte list (TAL) metals, cyanide, and total petroleum hydrocarbons (TPH). To achieve these objectives, the investigation will include three major components:

1. A study of existing geologic, hydrogeologic, and human-made conditions in the area.
2. A soil investigation.
3. A ground-water investigation.

Additionally, if the presence of free hydrocarbon fuel product is detected during the course of the soil and ground-water investigations, a free product investigation and removal will be conducted. Each component of the investigation is described in the following sections.

Once the extent of hydrocarbon fuel constituents in soil and ground water has been delineated, a baseline risk assessment will be performed to determine potential pathways and associated risks to public health and the environment. The results of the risk assessment will be used, in conjunction with an evaluation of the site characteristics and the technical feasibility of achieving remediation levels, to establish site rehabilitation levels (SRLs).

RECONNAISSANCE ACTIVITIES

Reconnaissance activities will be performed to increase the current knowledge of site conditions in order to facilitate and prepare for the field investigation. Reconnaissance activities will include the following:

- The compilation and review of existing geologic and hydrogeologic data for the area. This will include published geologic and hydrogeologic literature, and local studies performed by the USEPA, the Virgin Islands DPNR, Texaco, and Esso.
- The compilation and review of any investigations performed by the USEPA or previous site owners and operators.
- An analysis of aerial photographs to identify the locations of faults and fracture traces.
- An inventory of existing wells in the area. The inventory process will include an effort to compile information regarding well location, age, depth, construction, depth to water, and pumping history.
- The compilation and review of human-constructed structures in the area which may influence hydrocarbon fuel product migration or may preclude drilling in certain locations. Specifically, the presence and construction details of retaining walls, culverts, and underground piping will be examined.
- A magnetometer/metal detector survey in the vicinity of proposed boring locations. The survey will be conducted in areas where the existence of underground structures could not be positively determined. Procedures describing the use and calibration of the magnetometer and metal detector are provided in Appendix A.
- The preparation of an accurate base map of the area. A base map showing surveyed locations of major structures, existing wells, and surface topography will be prepared. Subsequent sampling locations and geologic and hydrogeologic data will be plotted on the base map.

FIELD INVESTIGATION PROGRAM

The field investigation program will consist of the soil investigation and the ground-water investigation. The following sections provide a general explanation of how the project objectives will be fulfilled by the soil and ground-water investigations. Technical details are provided in the section, entitled "Field Investigation Procedure," and the referenced appendices. Depending on site conditions, the investigation may also include a free product investigation. Figure 3 illustrates the investigation area and shows the proposed boring and well locations. Air monitoring during the investigation will consist of HNU readings and if, necessary, OVA readings. Occasional air samples will be collected for field gas chromatographic (GC) analysis at the discretion of the site health and safety officer.

Soil Investigation

The soil investigation has been designed to identify potential sources and delineate the horizontal and vertical extent of hydrocarbon fuel and other potential constituents in soil. The soil investigation will also provide information regarding the distribution of chlorinated hydrocarbon compounds, since soil samples will be analyzed for VOCs. Additional information will be obtained as a part of the soil investigation relating to the thickness, lateral distribution, composition, and physical characteristics of the unconsolidated materials in the study area.

At each of the proposed boring and well locations identified on Figure 3, soil samples will be collected continuously from ground surface to bedrock or to the water table, whichever is encountered first. Each sampling interval will be visually inspected for soil consistency, soil structure, and the potential presence of constituents of concern. Additionally, a portion of each interval will be analyzed for BTEX, PCE, TCE, and DCE using a portable field GC.

A minimum of one sample from each boring will be submitted for laboratory analysis. Samples submitted to the laboratory will be analyzed for TCL VOCs, 1,2-dibromomethane, n-propylbenzene, methyl tert-butyl ether (MTBE), TCL BNAs, TAL metals, cyanide, and TPH. Table 1 summarizes the proposed soil sampling effort. Tables 2 through 4 list the specific compounds that will be analyzed. Selection of samples for laboratory analysis will be based on the GC results and visual evidence. The sample from each boring with the highest GC reading will be submitted to the laboratory. For the purpose of identifying potential migration pathways, additional samples from each boring may also be submitted to the laboratory. These samples will be chosen based on soil consistency, soil structure, visual inspection, HNU/OVA readings, and GC readings. If, on the basis of visual and instrumental evidence, none of the samples from a single boring appears to contain hydrocarbons, a sample from the interval immediately above the seasonally-high water table or above the top of the bedrock (whichever is uppermost) will be submitted for laboratory analysis.

None of the submitted samples will be composited from different split-spoon samples, and sample intervals will not exceed 2 vertical feet. Moreover, individual sample intervals of less than 2 vertical feet will be identified and segregated if soil consistency, structure, and visual inspection of hydrocarbon distribution indicate the intervals are different in physical and/or chemical composition.

A review of the soil analytical data will be conducted by risk assessment personnel at the USEPA. If necessary, additional soil sampling locations will be recommended by the USEPA to provide an adequate database for risk assessment.

Ground-Water Investigation

The ground-water investigation has been developed for the purpose of characterizing hydrogeologic conditions and delineating the extent of petroleum hydrocarbon constituents and chlorinated hydrocarbons in ground water in the vicinity of the study area. Specific data

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to be obtained include the lithology, depth to ground water, magnitude of water-level fluctuations, hydraulic conductivity, effective porosity, hydraulic gradient, recharge and discharge areas, and ground-water quality for the uppermost water-bearing unit. Additionally, the vertical hydraulic gradient and the quality of deeper ground water will be evaluated.

The lithology and other geologic characteristics of the unconsolidated deposits will be identified during soil sampling, as described in the preceding section. Geologic characteristics of the bedrock in the study area will be assessed by obtaining core samples of the bedrock. Coring will also provide evidence regarding the orientation of fractures in the bedrock, which may assist in determining potential pathways of constituent migration.

Approximate monitoring well locations are shown on Figure 3. These locations will be more accurately defined on the basis of an examination of aerial photographs. Prior to monitoring well installation, a technical memorandum will be submitted to the USEPA and the DPNR outlining the results of the utility search and aerial photograph examination and providing more precise recommendations for monitoring well locations. The monitoring wells will be installed after USEPA and DPNR approval of the recommendations.

Hydrogeologic information obtained in the drilling of initial wells may indicate that relocation of other wells may be warranted. Upon completion of a fracture trace analysis and site visit, a technical memorandum recommending well locations will be submitted to the USEPA for approval. If necessary, further decisions for well relocation will be made in the field after consultation with and approval of USEPA and DPNR representatives. These decisions and approvals will be confirmed in written correspondence from TEIC or its representatives to the USEPA.

Shallow Monitoring Wells

Shallow monitoring wells will be installed in 8-inch diameter borings at ten locations, as illustrated on Figure 3. The well locations were chosen so as to provide upgradient and downgradient ground-water quality information around each service station. Additional well locations were chosen to provide water-level and water-quality data over a wider area. Monitoring wells installed in the unconsolidated deposits will be constructed of 4-inch diameter stainless-steel casing and screen with a silica sand pack. Well screens will be installed so that the screens bridge the water table to facilitate the detection of a floating, immiscible layer, if present. Because available information indicates that water levels in the area fluctuate widely, Geraghty & Miller proposes to install well screens 20 feet in length to ensure that the screen will intercept the water table over a wider range of water-level fluctuations.

Monitoring wells installed in competent bedrock will be open-hole construction. The open-hole interval in each well will be 20 feet and will be positioned so that the open interval bridges the water table. The monitoring wells will be installed to document whether the water table fluctuates between the unconsolidated materials and consolidated bedrock. During the initial investigation, wells will be installed straddling the observed water table. If the water table rises above the screened interval, additional shallow wells may be necessary. Because of the thin unconsolidated deposits, shallow wells in the unconsolidated unit may require screen lengths less than 20 feet. Also, due to seasonal water-table fluctuations of approximately 20 feet, it may not be feasible to have monitoring well screens intersecting the water table at all locations during the entire year. Critical areas (i.e., where the potential for floating product exists) will be selected for additional well installation (if necessary), based upon the water-level measurements.

In the event that a well intake interval must straddle the bedrock/overburden boundary, these wells should be completed with well screens. If at all possible, wells that straddle the bedrock/overburden boundary will be avoided. Wells screened across

bedrock/overburden boundaries may give misleading water level readings. However, if the water table does seem to occur or fluctuate in this interval wells will be installed to check for floating product.

Deeper Monitoring Wells

Seven deeper monitoring wells will be installed as part of the drilling program. The proposed locations for the monitoring wells are illustrated on Figure 3. Four deeper monitoring wells will be installed adjacent to four of the shallow monitoring wells in order to evaluate the vertical hydraulic gradient and the ground-water quality conditions at depth. The base of the deeper well will be 40 feet lower than the base of the shallow well, thus allowing a 20-foot vertical separation between the open interval in each well in a monitoring well pair. Three deeper monitoring wells, one upgradient and two downgradient, will be installed without an adjacent shallow well. The deeper wells will be open-hole construction in bedrock. The open-hole interval in each well will not exceed 20 feet. If incompetent rock is encountered, monitoring wells installed in the bedrock unit will be constructed using 4-inch stainless-steel casing and screen with a silica sand pack.

The deeper monitoring wells are intended to provide information regarding vertical hydraulic gradients and the vertical distribution of VOCs in ground water. If the deeper monitoring wells indicate the presence of dissolved VOCs, the need to install monitoring wells at greater depths will be evaluated.

Once all the wells have reached equilibrium with static ground-water levels after development, a minimum of three synoptic rounds of water-level measurements will be taken. Efforts will be made to identify any supply wells that may be pumping in the area. The cooperation of the DPNR will be requested and obtained so that these wells are shut off for at least 12 hours prior to and during the water-level measurement events. If free product is detected in any of the wells, the thickness of the product will be measured at that time.

Pumping Tests

Two pump tests will be performed: one pump test at one well location and another pump test at a different well location. The wells will be selected after evaluation of initial water-quality results. Pumping schedules of nearby wells will be identified to the extent possible, using DPNR records and available information. Prior to conducting the pumping test, a water-level trend will be measured in one of the wells for approximately 72 hours, using a pressure transducer or automatic water-level recorder. The potential impact of nearby pumping wells will be evaluated before starting the test. Geraghty & Miller will request that the DPNR close any pumping wells expected to significantly affect water levels in the new wells prior to and during water-level measurements and the pumping test.

During the pump tests, water-level drawdown will be measured in at least three nearby monitoring wells on a regular pumping test schedule. Periodic rounds of water levels will be measured in all monitoring wells and selected production wells during the test. General pumping test procedures are provided in Appendix H.

The pumping test water will be treated using an air stripper to meet drinking water standards prior to discharge to the sanitary sewer lines. Preliminary approvals from the U.S. Virgin Islands DPNR (temporary operation of air stripper) and the U.S. Virgin Islands Department of Public Works (discharge to sanitary sewer) have been communicated to Geraghty & Miller. Samples will be collected before and after treatment to document VOC concentrations.

Ground-Water Sampling

The monitoring wells will be sampled during two sampling events. Each sampling event will be completed within a 3- to 4-day period. The first sampling event will be performed 2 to 3 weeks after all wells have been developed. The second sampling event will be performed 12 to 14 weeks later. Monitoring wells containing free product will not

be sampled due to the potential for product entrainment in ground-water samples and for false-positive results. If, after product removal, no product enters a well, this well will be sampled during a subsequent sampling event.

Ground-water samples will be analyzed for TCL VOCs, 1,2-dibromomethane, n-propylbenzene, methyl tert-butyl ether (MTBE), TCL BNAs, TAL metals, cyanide, and TPH. At the time of sampling, field measurements of pH, temperature, and specific conductance will also be performed. Table 1 summarizes the proposed ground-water sampling effort. Tables 2 through 4 list the specific compounds which will be analyzed.

The results of the first ground-water sampling round will be evaluated prior to initiating the second round. A technical memorandum will be submitted to the USEPA summarizing the results of the first round sampling, with recommendations for modifications to sampling protocols for the second round, if warranted. Potential modifications could include the utilization of a more sensitive method for analysis of samples from monitoring wells that show low or undetectable VOC concentrations in the first round. Additional modifications may also include reducing the list of sample parameters for analysis.

Free Product Investigation

The purpose of a free product investigation is to determine the thickness, the horizontal extent, and the recoverability of a floating layer of petroleum. The investigation will be conducted if a significant (more than 3 inches) floating hydrocarbon layer is measured in monitoring wells drilled at or near the service stations. The detection of a layer of less than 3 inches thick may also trigger the free product investigation. The decision to initiate specific elements of the free product investigation will depend on the thickness, extent, and persistence of free product in individual wells, and will be made in consultation with the USEPA.

The free product investigation will consist of two procedures. The first procedure will be to examine the monitoring wells for the presence of a floating immiscible layer after the wells have been developed and have reached equilibrium. The second procedure, which will be conducted upon equilibrium, will be product bail tests. A product bail test consists of rapidly removing the free product from a well with a bottom-loading bailer. The rate of recovery of free product into the well is then measured. The recovery data will be used to assess the feasibility of free product recovery.

If the final product thickness measured is greater than 3 inches and the product bail tests indicate a recovery rate of at least approximately 1 gallon per hour, a skimming system will be installed (see the next section - Interim Remedial Measures for details). During the skimming system operation, continued monitoring of product thicknesses and product recovery will be performed. Product will be bailed manually from monitoring wells that show a free product layer of less than 3 inches.

Depending on the permeability of the unconsolidated material, the wells may require from 1 day to 2 weeks to reach equilibrium. Accordingly, the wells will be checked daily for the presence of free product for up to 2 weeks after development. Free product will be measured using an interface probe. Procedures for the use of the probe are described in Appendix A.

If free product accumulations greater than 3 inches in thickness are detected in one or more monitoring wells downgradient of the storage tanks, additional wells will be drilled further downgradient. The detection of product thicknesses of less than 3 inches may also trigger the installation of additional monitoring wells. These decisions will be made in consultation with the USEPA and DPNR.

The exact locations of additional monitoring wells to be drilled as part of the free product investigation will be selected with USEPA and DPNR approval based on an evaluation of the thickness of the free product layer in the initial wells, and in consideration

of constraints imposed by the locations of underground utilities and other obstructions. The installation of monitoring wells will continue over a widening area until the lateral extent of the free product plume has been identified.

INTERIM REMEDIAL MEASURES

To mitigate any potential environmental degradation by fuel products or other constituents, interim remedial measures will be initiated if the free product investigation indicates the need for and feasibility of such measures. As discussed previously, the free product investigation will determine if free product occurs in the site area and if the product is recoverable. If free product is detected in wells at a thickness in excess of 3 inches and if the product bail tests indicate that recovery rates of 1 gallon per hour can be sustained, free product recovery will be initiated.

Free product will be removed utilizing a pneumatically driven skimming system. Figure 5 is a schematic diagram of a proposed skimming system. This system consists of the following components:

- Pneumatic skimmer pump and controller.
- Air supply and transfer lines.
- Product transfer lines.
- Product storage tank.

Skimming systems operate in such a way as to remove only product; the amount of water recovered by the system is minimized. Low-capacity pumps capable of sustaining pumping rates of less than 1 gallon per minute (gpm) allow the system to continue operating when the floating layer becomes thin and the product enters the well slowly. Ground-water collected during the product recovery will be treated using the temporary air stripper and discharged to the sanitary sewer line.

Recovered product will be stored in 55-gallon drums in such a manner as to mitigate fire, vapor, and release hazards. The system will be inspected and free product levels checked on a regular basis to ensure proper functioning of the system. Free product will be recovered on a continuous basis until, at the lowest pump setting, water is pumped into the system.

FIELD INVESTIGATION PROCEDURES

All site activities will be performed in accordance with the health and safety guidelines described in the HASP (Geraghty & Miller, Inc. 1991d). The HASP for the Tutu Service Station Investigation was prepared as a separate document.

SPLIT-SPOON SAMPLING AND ROCK CORING PROCEDURES

All drilling, soil sampling, and well installation will be performed by Soil Tech, using a rotary rig (CME 55). This rig is capable of performing hollow-stem auger drilling and rock coring. An air hammer rig will be used for reaming the bedrock core holes. Geraghty & Miller and/or Soil Tech geologists will collect soil samples and will document drilling, soil sampling, and well installation activities and compile pertinent hydrogeologic data.

Subsurface soil samples will be collected from Borings B-1 through B-12 and from borings drilled through unconsolidated deposits for Monitoring Wells MW-1 through MW-13 (Figure 3). In-place soil samples will be collected in advance of the bit by driving a 3-inch diameter split-spoon using a hammer. The larger diameter split-spoon will help to ensure that there is sufficient sample volume for analytical purposes. Detailed split-spoon sampling procedures are described in Appendix B.

A portion of each sample will be placed in sample containers for analysis of TCL and other specified VOCs, TCL BNAs, TAL metals, cyanide, and TPH. These containers will be preserved on ice immediately and will be retained for potential submission to the

laboratory. A portion of each sample will also be placed immediately in a volatile organic analysis (VOA) vial for eventual field GC analysis. This analysis procedure is described in the Field Gas Chromatograph Analyses Procedures section of the work plan and in Appendix C. The portion of each sample not retained for laboratory or field GC analysis will be stored for future reference. Soil samples will be identified by the boring or well number, followed in parentheses by the specific depth interval from which each sample was obtained.

Drilling through consolidated bedrock will be initially accomplished using wire-line rock coring tools. Rock core of NQ size or greater will be collected continuously throughout the interval drilled. A detailed description of rock coring procedures is provided in Appendix D.

DRILLING AND MONITORING WELL INSTALLATION PROCEDURES

Drilling through unconsolidated deposits will be accomplished using hollow stem auger tools. Wells installed in unconsolidated deposits will be constructed of 4-inch diameter stainless- steel screen and riser pipe. Twenty-foot lengths of 0.020-inch slot, machine-slotted screens will be set so as to bridge the water table. The slot size has been selected to allow for the free flow of floating product if present, into the well. Alternative slot sizes may be selected on the basis of field conditions encountered. Available information indicates that water levels in the area can fluctuate widely. The long screen length was chosen to ensure that the wells will intercept the water table over a wide range of water-level fluctuations. A grade 1 silica sand will be used for the filter pack. Detailed procedures for drilling and monitoring well construction in unconsolidated deposits are described in Appendix E.

Drilling through consolidated bedrock will be initially accomplished by rock coring as described previously and in Appendix D. Core holes will be reamed for monitoring well construction using an air-hammer assembly. After reaming the boreholes, geophysical

logging will be performed in bedrock boreholes. The geophysical logs will include sonic and caliper logs. Sonic and caliper logs will be run prior to casing installation. The sonic log is a recording versus depth, of the time, known as the interval transit time, required for a compressional sound wave to transverse 1 foot of formation. The interval transit time for a given formation depends upon its lithology and porosity. Caliper logs record borehole diameter versus depth, allowing for identification of borehole zones that may be enlarged due to fractures.

Monitoring wells constructed in competent bedrock will be completed as open 4-inch diameter boreholes. The open borehole interval of each well will not exceed 20 feet. The interval above the open portion will consist of 4-inch diameter stainless-steel pipe sealed into an 8-inch diameter borehole with neat cement grout. In bedrock zones that are weathered, friable, or severely fractured, stainless-steel screen and casing will be installed in accordance with the protocols for monitoring wells in unconsolidated deposits.

For shallow wells, the open borehole interval will be chosen so that the water table intersects the open borehole area. For deeper wells, the open borehole interval will occur 40 feet below the interval of the adjacent shallow monitoring well. Detailed procedures for drilling and monitoring well construction in bedrock are provided in Appendix F.

Wherever possible, monitoring wells will be completed above grade to reduce the risk of surface leaking. If completed above grade, a metal protective casing with a locking cap will be set in concrete over each monitoring well riser. If completed below grade, a metal curb box will be set in concrete over the riser so that the curb box is more or less flush with ground surface. To the extent possible, the cement around each curb box will be mounded so that runoff is directed away from the monitoring well. Care will be taken to ensure that there is a seal between the top of the annular slurry and the surface concrete seal.

FIELD GAS CHROMATOGRAPH ANALYSIS PROCEDURES

A Photovac 10S50 portable GC (or equivalent) will be used to document the presence or absence of detectable concentrations of VOCs in soil samples collected at the site. The compound identifications and approximate concentrations can be obtained from the GC within 10 to 15 minutes. Only those compounds initially calibrated for can be identified and quantified. Therefore, prior to the study, the GC will be calibrated with the following standards: benzene, toluene, ethylbenzene, m-xylene, o-xylene, PCE, TCE, and 1,2-trans-DCE. A description of the GC analysis and calibration procedures is provided in Appendix C. Additionally, ground-water samples from the monitoring wells may also be analyzed for VOCs using the field GC to gain a preliminary evaluation of ground-water quality.

GROUND-WATER SAMPLING PROCEDURES

Prior to sampling, the water level, free product thickness (if any), and total depth of each well will be measured. Water levels will be measured using either a steel tape and chalk or a electronic water-level indicator. Free product, if any, will be measured using an interface probe. If free product is detected in a well, that well will not be sampled. Prior to sampling, three to five volumes of standing water will be removed from the well by pumping or bailing. The evacuated water will be examined for the presence of a sheen. A detailed monitoring well sampling protocol is provided in Appendix G.

Monitoring wells that show a thin (less than 3 inches) free product layer or sheen during the first sampling round will be bailed regularly for several weeks. If no product or sheen returns, these wells will be sampled during the second sampling event.

AQUIFER HYDRAULIC CHARACTERISTICS TESTING

To determine the hydraulic characteristics of the uppermost saturated deposits, Geraghty & Miller proposes that a constant rate pumping test be performed on two of the shallow monitoring wells. Without preliminary data regarding the hydraulic conductivity of these deposits, nor of the distribution of constituents of concern, specifics of the pumping test procedure cannot be definitively determined. Accordingly, the following discussion describes the basis upon which the procedures will be chosen. Once the necessary data have been obtained during the course of the field investigation, specifics of the pumping test procedures will be proposed in writing to the USEPA for approval. General pumping test procedures are described in Appendix H.

The wells to be pumped will be chosen based on an evaluation of ground-water quality conditions detected in the monitoring wells; the pumping tests will not be performed upon wells containing free product nor in a well next to a well where free product has been detected. The pumping wells will also be chosen such that at least one monitoring well is within sufficient proximity to each pumping well so that measurable water-level drawdown can be recorded in it during the test. Water-level measurements will be obtained in at least three nearby wells during the pumping tests.

The pumping rate and length of each test will be determined based upon the estimated hydraulic conductivity of the unconsolidated deposits and water-level drawdowns observed during a preliminary step test. The hydraulic conductivity will be estimated based on visual examination of the deposits. At least 1 day prior to each constant rate pumping test, a preliminary step drawdown test will be run on the well. Water-level drawdown observed in the pumping well at various pumping rates during the preliminary step test will help determine the appropriate rate and test length for the constant rate pumping test. Before starting the constant rate pumping test, water levels will be allowed to return to equilibrium conditions.

The method of data analysis will be chosen based upon the hydrogeologic characteristics of the unconsolidated deposits, i.e., unconfined, confined, or leaky confined. The analytical method used will provide for the estimation of aquifer transmissivity and storage. The hydraulic conductivity of the aquifer materials will be estimated by dividing the determined transmissivity by the aquifer thickness, which will be derived from an evaluation of the geologic logs compiled during drilling.

QUALITY ASSURANCE PROGRAM

The objective of the quality assurance program is to ensure that the procedures for sampling and analytical testing provide data of known quality. The quality assurance program consists of three parts: the sampling QA/QC program, the analytical QAPP, and independent data validation. The sampling QA/QC program is discussed below. The analytical QAPP and independent data review are discussed in detail in the Tutu Service Station Investigation QAPP that accompanies this work plan as a companion document (Geraghty & Miller, Inc. 1992a).

SAMPLING QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The sampling QA/QC objectives are to ensure the reliability and integrity of all data and documentation generated as a part of the investigation. Soil and ground-water sampling procedures are described in detail in Appendices B and G, respectively. Quality control sampling, sample custody, sample handling, and data management will be conducted in accordance with USEPA-approved methods. Sampling QA/QC protocols are described in Appendix I.

ANALYTICAL QUALITY ASSURANCE PROJECT PLAN PROGRAM

Laboratory analysis of soil and ground water will be performed by Enseco East (Enseco), a division of Enseco Inc. located in Somerset, New Jersey. Enseco routinely

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participates in laboratory performance evaluations for the USEPA as part of the Water Pollution (WP) program. The laboratory also undergoes annual on-site evaluations and evidentiary audits by the USEPA, as required by the CLP, and has been audited and approved by Geraghty & Miller's Analytical Quality Assurance and Laboratory Control Program (AQA/LCP). Enseco East is a United States Department of Agriculture (USDA)-certified laboratory and may accept samples from the U.S. Virgin Islands.

Analytical methods and major components of the QA/QC program are discussed in the following sections. Details of the QA/QC program are described in the QAPP for the Tutu Service Station Site Investigation (Geraghty & Miller, Inc. 1992a).

Analytical Methods

The analytical methods to be employed for the various analyses and matrices are listed in Table 5. A brief description of each analytical method and method reference is included in the QAPP (Geraghty & Miller, Inc. 1992a), along with the quantitation limits for each matrix. Table 6 lists sample container types, preservation requirements, and holding times for the various analytical parameters for each matrix.

Quality Assurance Objectives

The objectives of the analytical QA/QC program are to provide data of known quality. The QA/QC program is designed to assess the data for precision, accuracy, completeness, representativeness, and comparability. The QAPP (Geraghty & Miller, Inc. 1992a) describes how each of these parameters will be evaluated. Major elements of the plan include the following:

1. **Quality Control Checks.** The specific type and frequency of QC check samples will be as specified by the USEPA CLP SOW, the specified analytical method, and/or as provided in the laboratory QAPP. The QC samples to be

analyzed by the laboratory using the various CLP protocols and methods required in support of this field investigation are described below. A summary of field QC samples to be collected during the field investigation may be found in Table 1.

For TCL VOCs and BNAs, and other specified VOCs, the following QC samples will be analyzed for each sample delivery group (SDG):

- 1 Matrix spike sample.
- 1 Matrix spike duplicate sample.
- 1 Method blank.

For TAL metals and cyanide, the following QC samples will be analyzed for each SDG:

- 1 Matrix spike sample.
- 1 Matrix duplicate sample.
- 1 Preparation blank.

For TPH, the laboratory QC samples for each SDG are as follows:

- 2 Spiked duplicate control samples.
- 1 Matrix spike sample.
- 1 Matrix spike duplicate sample.
- 1 Method blank.

2. Instrument Calibration. Procedures for calibration of the following laboratory instruments are described in the QAPP (Geraghty & Miller, Inc. 1992a).

- Gas chromatograph/mass spectrometer (GC/MS).
- Infrared spectrophotometer (IR).
- Inductively coupled plasma atomic emission spectrometer (ICP).
- Graphite furnace atomic absorption spectrometer (FAA).
- Cold vapor atomic absorption spectrometer (CV).

3. Sample Custody. Procedures for handling and documenting sample custody in the field and the laboratory are described in the QAPP (Geraghty & Miller, Inc. 1992a).
4. Laboratory Performance Audits. A schedule of the laboratory performance audits in which Enseco participates is provided in the laboratory QA Program Plan appended to the QAPP (Geraghty & Miller, Inc. 1992a). Additionally, Enseco has been audited by Geraghty & Miller prior to participation in the AQA/CLP.
5. Data Reduction, Validation, and Reporting. A description of procedures to be used by the laboratory in data reduction, validation, and reporting is provided in the laboratory QA Program Plan.

INDEPENDENT DATA VALIDATION

Geraghty & Miller will perform data validation of the entire data set, independent of the laboratory. Data validation will be performed in accordance with the latest USEPA guidance. In brief, data validation will be accomplished by comparison of the quality control checks associated with the data to the prescribed acceptance criteria. A summary of data review findings and limitations of data use will be included in the investigation report. Specific data validation procedures and references are detailed in the QAPP (Geraghty & Miller, Inc. 1992a).

REPORT PREPARATION

A written report will be prepared after the scope of work described in this work plan has been completed. The report will include a description of site geology and hydrogeology, the investigation objectives, the investigation procedures, the data obtained, data documentation, and an interpretation and discussion of the results. At a minimum the

following information will be presented on maps: monitoring well and private well surveyed locations; top-of-bedrock structure contours; geologic cross sections; and ground-water elevation contours.

Pertinent water-level, aquifer hydraulic properties, soil quality, and ground-water quality data will be summarized in tables. In addition, a set of appendices will be submitted which will contain the raw analytical data, the data validation report, and the raw field data (such as water-level measurements, pumping test data, and boring logs). The draft report will be completed and submitted to the USEPA within 45 days after receipt and independent validation of all of the laboratory analytical data.

FEASIBILITY STUDY

A Feasibility Study (FS) will be conducted based upon the information gathered during the Tutu Service Station Investigation. The FS will consist of three tasks, as follows: (1) development and screening of alternatives, (2) treatability studies, and (3) detailed analysis of alternatives. An outline for the FS is presented in Appendix J.

The FS outline presented in Appendix J is general in nature. Once the field investigation is nearing completion, a more detailed and more site-specific approach for the FS will be developed for USEPA review and approval.

PROJECT MANAGEMENT

A clear understanding of project team responsibilities and project schedule is essential to the timely and efficient completion of large-scale investigations. Of equal importance is the need to maintain good communication between parties, particularly because subsurface conditions have not been well defined. The following sections describe project personnel responsibilities, the proposed project schedule, and notification procedures to the USEPA.

PROJECT TEAM RESPONSIBILITIES

The responsibilities for key project personnel are described below. Key personnel positions are illustrated on the project organization chart shown on Figure 6. All communications from the USEPA or its representatives will be routed through the TEIC Designated Coordinator, Ana Gloria Ramos. The qualifications of key personnel are provided in Appendix K.

- The Designated Coordinator is responsible for overseeing the implementation of the work plan and will make all final decisions regarding technical matters. The designated coordinator will act as the primary communicator for the respondents and their technical consultants with the USEPA and will review and approve all documents prior to submission.
- The Project Coordinator is responsible for the overall technical adequacy of the investigation and reporting activities and conformance to the scope of work. The project coordinator will organize and manage field activities and coordinate field personnel, drilling, sampling, and surveying. The project coordinator will interact with the designated coordinator and the project officer regarding technical issues.
- The Project Officer is responsible for the overall technical adequacy of the investigation and reporting activities, and for conformance to the scope of work. The Project Officer will interact with the designated coordinator and the project coordinator regarding technical issues.
- The Project Manager is responsible for maintaining the project schedule; directing, reviewing, and assessing the adequacy of technical staff and subcontractor performance; preparing the monthly progress reports and the

investigation report; and maintaining complete and orderly project documentation.

- The Project OA Officer is responsible for reviewing work procedures, project documents, and reports for conformance to the scope of work.
- The Field Manager is responsible for daily coordination of field activities, implementing field investigation activities in keeping with the procedures described in the work plan, and documentation of all field activities.
- The Project Chemist/Data Reviewer is responsible for reviewing the laboratory data for compliance with the quality assurance objectives and for preparing a summary of data validation findings for the investigation report.
- The Project Health and Safety Officer is responsible for implementing the site-specific health and safety directives detailed in the HASP (Geraghty & Miller, Inc. 1991d).
- The Principal Investigators are responsible for the technical direction and adequacy of the work in their respective areas of expertise, as required for the investigation objectives. The areas of expertise include hydrogeology, hydrocarbon investigation, and risk assessment.
- The Subcontractor Managers are responsible for the performance of their tasks in accordance with the investigation specifications, interaction with the project manager, and adherence to the project schedule.

PROJECT SCHEDULE

The estimated schedule of project activities is based on our best knowledge of site conditions. Given the logistical difficulties of working in and transporting specialized equipment to the U.S. Virgin Islands, field activities may require greater lengths of time for completion. The anticipated project schedule is illustrated on Figure 7. The schedule will go into effect once written approval of the work plan, QAPP, and HASP has been received from the USEPA and Texaco and Esso have executed a consent decree with the USEPA.

Two technical memorandums will be submitted to the USEPA for review and approval throughout the project duration (Figure 7). Technical Memorandum 1 will document existing supply well locations, sewer line locations, results of the fracture trace analysis, and proposed monitoring well locations. To expedite the drilling program, the soil investigation (i.e., Borings B-1 through B-12) may be initiated while awaiting USEPA approval of the monitoring well locations.

Technical Memorandum 2 will contain data validation report and pertinent hydrogeologic data for the first ground-water sampling event. Geraghty & Miller will provide recommendations regarding sampling and analytical procedures for the second ground-water sampling event for USEPA approval. If non-detectable VOC results are reported for a given monitoring well sample using the March 1990 USEPA CLP Routine Analytical Services (RAS) organic SOW (USEPA 1990a), then Geraghty & Miller may recommend that USEPA Method 524.2 (USEPA 1989) be used for the second sampling event.

NOTIFICATION AND REPORTING TO USEPA

Monthly written progress reports will be submitted to the USEPA as required in the Consent Order after written approval of the work plan has been received. Each progress report will describe project activities for the month and will list anticipated activities for the

following month. Significant deviations in the schedule throughout the course of the investigation will be communicated to the USEPA verbally and in writing within five working days. The USEPA will be notified of all sampling activities to be performed as a part of the investigation at least ten working days prior to initiating such activities.

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REFERENCES

- Belgodere & Associates, Inc. 1988. Esso Tutu Service Station Soil Gas Vapor Screening Survey Report, St. Thomas, U.S.V.I., June 1988.
- Garcia, R. and M. Canoy. 1984. Reconnaissance of Ground-Water Quality in the U.S. Virgin Islands, July 1984. U.S. Geological Survey Water Resources Division Open-File Data Report 84-807.
- Geoscience Consultants, Ltd. 1988. Final Report on Results of Soil Gas Survey, Tutu, St. Thomas, U.S. Virgin Islands, January 1988.
- Geraghty & Miller, Inc. 1983a. Report on Current Ground-Water Conditions in the U.S. Virgin Islands, April 1983.
- Geraghty & Miller, Inc. 1983b. Ground-Water Management Plan for the U.S. Virgin Islands, June 1983.
- Geraghty & Miller, Inc. 1990. Sampling, Analysis, and Monitoring Plan for Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, September 1990.
- Geraghty & Miller, Inc. 1991a. Tutu Service Station Investigation Work Plan (Draft), St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, January 1991.
- Geraghty & Miller, Inc. 1991b. Tutu Service Station Investigation Work Plan, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, May 1991.
- Geraghty & Miller, Inc. 1991c. Tutu Service Station Investigation Work Plan, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, October 1991.
- Geraghty & Miller, Inc. 1991d. Health and Safety Plan, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, September 1991.
- Geraghty & Miller, Inc. 1991e. Revised Sampling, Analysis, and Monitoring Plan for Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, September 1991.

REFERENCES (Continued)

- Geraghty & Miller, Inc. 1991f. First Sampling Report September 1990, Tutu Wells Site Sampling, St. Thomas U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, January 1991.
- Geraghty & Miller, Inc. 1991g. Second Sampling Report February 1991, Tutu Wells Site Sampling, St. Thomas U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, May 1991.
- Geraghty & Miller, Inc. 1991h. Third Sampling Report June 1991, Tutu Wells Site Sampling, St. Thomas U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, September 1991.
- Geraghty & Miller, Inc. 1992a. Quality Assurance Project Plan, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, March 1992.
- Geraghty & Miller, Inc. 1992b. Fourth Sampling Report October 1991, Tutu Well Site Sampling, St. Thomas, U.S. Virgin Islands, Prepared for the Tutu Environmental Investigation Committee, January 1992.
- Graves, R.P. and R. Gonzalez. 1988. Potentiometric Surface of the Turpentine Run Basin Aquifer in the Tutu Area, Eastern St. Thomas, U.S. Virgin Islands, September 11, 1987. U.S. Geological Survey Water Resources Investigations Report 88-4131.
- Griggs, D.I. 1978. Interoffice Memorandum re: Land Areas Associated with Public Supply Wells in Upper Tutu. Charlotte Amalie, St. Thomas: Government of the Virgin Islands of the United States, Public Works Department, Division of Solid Waste.
- Jordan, D.G. and O.J. Cosner. 1973. A Survey of the Water Resources of St. Thomas, Virgin Islands. U.S. Geological Survey Water Resources Division, Caribbean District Open-File Report.
- U.S. Environmental Protection Agency (USEPA). 1989. Method 524.2, Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry, Revision 3.0, Environmental Monitoring Systems Laboratory, United States Environmental Protection Agency, Cincinnati, Ohio, 1989.

REFERENCES (Continued)

U.S. Environmental Protection Agency (USEPA). 1990a. USEPA Contract Laboratory Program, Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, Document Number OLM 01.0, Revision December 1990 and February 1991. USEPA Contract Laboratory Program, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1990b. Statement of Work for Inorganics Analysis (Multi-media, Multi-concentration), Document Number ILM01.1, March 1990.

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Table 1. Summary of Proposed Sampling and Laboratory Analysis Effort, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands.

Matrix	Field Task/Sample Source	Estimated Sample Frequency	Estimated Sample Quantity	Analytical Parameters
Ground Water	Development Water	1 sample before and 1 sample after treatment	2	VOCs
	Purge Water	1 sample before and 1 sample after treatment	2	VOCs
	Shallow Monitoring Wells	10 wells 2 sampling rounds	20	VOCs, BNAs, metals cyanide, TPH
	Deep Monitoring Wells	7 wells 2 sampling rounds	14	VOCs, BNAs, metals cyanide, TPH
	Pump Tests	2 wells	8	VOCs
Soil	Soil from Boring	13 borings 1 sample per boring	13	VOCs, BNAs, metals cyanide, TPH
	Soil from Monitoring Well Installation	17 wells 1 sample per well	17	VOCs, BNAs, metals cyanide, TPH
VOCs	Volatile organic compounds.			
BNAs	Base neutral and acid extractable compounds.			
TPH	Total petroleum hydrocarbons.			

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Table 2. Target Compound List and Reporting Limits for Volatile Organic Compounds, to be Analyzed by USEPA CLP Protocols, in Ground-Water and Soil Samples for the Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands.

Parameter	CAS Number	Quantitation Limits *		
		Ground-Water (ug/L)	Soil (Low)** (ug/kg)	Soil (Medium)** (ug/kg)
Chloromethane	74-87-3	10	10	1200
Bromomethane	74-83-9	10	10	1200
Vinyl chloride	75-01-4	10	10	1200
Chloroethane	75-00-3	10	10	1200
Methylene chloride	75-09-2	10	10	1200
Acetone	67-64-1	10	10	1200
Carbon disulfide	75-15-0	10	10	1200
1,1-Dichloroethene	75-35-4	10	10	1200
1,1-Dichloroethane	75-34-3	10	10	1200
1,2-Dichloroethene (total)	540-59-0	10	10	1200
Chloroform	67-66-3	10	10	1200
1,2-Dichloroethane	107-06-2	10	10	1200
2-Butanone	78-93-3	10	10	1200
1,1,1-Trichloroethane	71-55-6	10	10	1200
Carbon tetrachloride	56-23-5	10	10	1200
Bromodichloromethane	75-27-4	10	10	1200
1,2-Dichloropropane	78-87-4	10	10	1200
cis-1,3-Dichloropropene	10061-01-5	10	10	1200
Trichloroethene	79-01-6	10	10	1200
Dibromochloromethane	124-48-1	10	10	1200
1,1,2-Trichloroethane	79-00-5	10	10	1200
Benzene	71-43-2	10	10	1200
trans-1,3-Dichloropropene	10061-02-6	10	10	1200
Bromoform	75-25-2	10	10	1200
4-Methyl-2-pentanone	108-10-1	10	10	1200
2-Hexanone	591-78-6	10	10	1200
Tetrachloroethene	127-18-4	10	10	1200
Toluene	108-88-3	10	10	1200
1,1,2,2-Tetrachloroethane	79-34-5	10	10	1200
Chlorobenzene	108-90-7	10	10	1200
Ethyl benzene	100-41-4	10	10	1200
Styrene	100-42-5	10	10	1200
Xylenes (Total)	1330-20-7	10	10	1200
1,2-Dibromomethane	74-95-3	10	10	1200
Methyl tert-butyl ether	1634-04-4	50	50	6000
n-Propylbenzene	103-65-1	10	10	1200

The above reporting limits are those specified in the USEPA March 1990 CLP SOW protocols.

USEPA U.S. Environmental Protection Agency.

CLP Contract Laboratory Program.

ug/kg Micrograms per kilogram.

CAS Chemical Abstracts Service.

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the CLP contract, will be higher.

** Soil and sediment sample quantitation limits to be used in the final analytical report will be based on the determination of the sample concentration level made from the mandatory pre-screening of the sample matrix.

Table 3. Target Compound List and Reporting Limits for Base Neutral and Acid Extractable Compounds, to be Analyzed by USEPA CLP Protocols, in Ground-Water and Soil Samples for the Tutu Service Station Investigation, St. Thomas, U. S. Virgin Islands.

Parameter	CAS Number	Quantitation Limits*		
		Ground-Water (ug/L)	Soil (Low)** (ug/kg)	Soil (Medium)** (ug/kg)
Phenol	108-95-2	10	330	10000
bis(2-Chloroethyl)ether	11-44-4	10	330	10000
2-Chlorophenol	95-57-8	10	330	10000
1,3-Dichlorobenzene	541-73-1	10	330	10000
1,4-Dichlorobenzene	106-46-7	10	330	10000
1,2-Dichlorobenzene	95-50-1	10	330	10000
2-Methylphenol	95-48-7	10	330	10000
2,2-Oxybis(1-chloropropane)	108-60-1	10	330	10000
4-Methylphenol	106-44-5	10	330	10000
N-Nitroso-di-n-dipropylamine	621-64-7	10	330	10000
Hexachloroethane	67-72-1	10	330	10000
Nitrobenzene	98-95-3	10	330	10000
Isophorone	78-59-1	10	330	10000
2-Nitrophenol	88-75-5	10	330	10000
2,4-Dimethylphenol	105-67-9	10	330	10000
bis(2-Chloroethoxy)methane	111-91-1	10	330	10000
2,4-Dichlorophenol	120-83-2	10	330	10000
1,2,4-Trichlorobenzene	120-82-1	10	330	10000
Naphthalene	91-20-3	10	330	10000
4-Chloroaniline	106-47-8	10	330	10000
Hexachlorobutadiene	87-68-3	10	330	10000
4-Chloro-3-methylphenol	59-50-7	10	330	10000
2-Methylnaphthalene	91-57-6	10	330	10000
Hexachlorocyclopentadiene	77-47-4	10	330	10000
2,4,6-Trichlorophenol	88-06-2	10	330	10000
2,4,5-Trichlorophenol	95-95-4	25	800	25000
2-Chloronaphthalene	91-58-7	10	330	10000
2-Nitroaniline	88-74-4	25	800	25000
Dimethylphthalate	131-11-3	10	330	10000
Acenaphthylene	208-96-8	10	330	10000
2,6-Dinitrotoluene	606-20-2	10	330	10000
3-Nitroaniline	99-09-2	25	800	25000
Acenaphthene	83-32-9	10	330	10000
2,4-Dinitrophenol	51-28-5	25	800	25000
4-Nitrophenol	100-02-7	25	800	25000
Dibenzofuran	132-64-9	10	330	10000
2,4-Dinitrotoluene	121-14-2	10	330	10000
Diethylphthalate	84-66-2	10	330	10000

The above reporting limits are those specified in the USEPA March 1990 CLP SOW protocols.

USEPA U.S. Environmental Protection Agency.

CLP Contract Laboratory Program.

ug/L Micrograms per liter.

ug/kg Micrograms per kilogram.

CAS Chemical Abstracts Service.

* Specific quantitation limits are highly matrix-dependent. The quantitation limits listed are provided for guidance and may not always be achievable. Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the CLP contract, will be higher.

** Soil and sediment sample quantitation limits to be used in the final analytical report will be based on the determination of the sample concentration level made from the mandatory pre-screening of the sample matrix.

Table 3. Target Compound List and Reporting Limits for Base Neutral and Acid Extractable Compounds, to be Analyzed by USEPA CLP Protocols, in Ground-Water and Soil Samples for the Tutu Service Station Investigation, St. Thomas, U. S. Virgin Islands.

Parameter	CAS Number	Quantitation Limits*		
		Ground-Water (ug/L)	Soil (Low)** (ug/kg)	Soil (Medium)** (ug/kg)
4-Chlorophenyl-phenyl ether	7005-72-3	10	330	10000
Fluorene	86-73-7	10	330	10000
4-Nitroaniline	100-01-6	25	800	25000
4,6-Dinitro-2-methylphenol	534-52-1	25	800	25000
N-Nitrosodiphenylamine	86-30-6	10	330	10000
4-Bromophenyl-phenylether	101-55-3	10	330	10000
Hexachlorobenzene	118-74-1	10	330	10000
Pentachlorophenol	87-86-5	25	800	25000
Phenanthrene	85-01-8	10	330	10000
Carbazole	86-74-8	10	330	10000
Anthracene	120-12-7	10	330	10000
Di-n-butylphthalate	84-74-2	10	330	10000
Fluoranthene	206-44-0	10	330	10000
Pyrene	129-00-0	10	330	10000
Butylbenzylphthalate	85-68-7	10	330	10000
3,3-Dichlorobenzidine	91-94-1	10	330	10000
Benzo(a)anthracene	56-55-3	10	330	10000
Chrysene	218-01-9	10	330	10000
bis(2-Ethylhexyl)phthalate	117-81-7	10	330	10000
Di-n-octylphthalate	117-84-0	10	330	10000
Benzo(b)fluoranthene	205-99-2	10	330	10000
Benzo(k)fluoranthene	207-08-9	10	330	10000
Benzo(a)pyrene	50-32-8	10	330	10000
Indeno(1,2,3-cd)pyrene	193-39-5	10	330	10000
Dibenz(a,h)anthracene	53-70-3	10	330	10000
Benzo(g,h,i)perylene	191-24-2	10	330	10000

The above reporting limits are those specified in the USEPA March 1990 CLP SOW protocols.

USEPA U.S. Environmental Protection Agency.

CLP Contract Laboratory Program.

ug/L Micrograms per liter.

ug/kg Micrograms per kilogram.

CAS Chemical Abstracts Service.

* Specific quantitation limits are highly matrix-dependent. The quantitation limits listed are provided for guidance and may not always be achievable. Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the CLP contract, will be higher.

** Soil and sediment sample quantitation limits to be used in the final analytical report will be based on the determination of the sample concentration level made from the mandatory pre-screening of the sample matrix.

Table 4. Target Analyte List and Reporting Limits for Metal Analytes, Cyanide, and Total Petroleum Hydrocarbons to be Analyzed by USEPA CLP Protocols and Other Methodologies, in Ground – Water and Soil Samples for the Tutu Service Station Investigation, St. Thomas, U. S. Virgin Islands.

Parameter	CAS Number	Quantitation Limits*	
		Ground – Water ** (ug/L)	Soil (ug/kg)
Aluminum	7429-90-5	200	200
Antimony	7440-36-0	60	60
Arsenic	7440-38-2	10	10
Barium	7440-39-3	200	200
Beryllium	7440-41-7	5	5
Cadmium	7440-43-9	5	5
Calcium	7440-70-2	5000	5000
Chromium	7440-47-3	10	10
Cobalt	7440-48-4	50	50
Copper	7440-50-8	25	25
Iron	7440-89-6	100	100
Lead	7439-92-1	3	3
Magnesium	7439-95-4	5000	5000
Manganese	7439-96-5	15	15
Mercury	7439-97-6	0.2	0.2
Nickel	7440-02-0	40	40
Potassium	7440-09-7	5000	5000
Selenium	7782-49-2	5	5
Silver	7440-22-4	10	10
Sodium	7440-23-5	5000	5000
Thallium	7440-28-0	10	10
Vanadium	7440-62-2	50	50
Zinc	7440-66-6	20	20
Cyanide	—	10	10
TPH	—	500	20000

USEPA U.S. Environmental Protection Agency.

CLP Contract Laboratory Program.

CAS Chemical Abstracts Service.

ug/L Micrograms per liter.

ug/kg Micrograms per kilogram.

TPH Total petroleum hydrocarbons.

* The quantitation limits for metal analytes and cyanide are equal to the contract required detection limits (CRDLs) in the CLP inorganic statement of work (SOW). The CRDLs are the instrument detection limits obtained in pure water that must be met using the procedure in the CLP SOW for inorganics analysis, March 1990, Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

** The quantitation limits for metal analytes in ground – water samples are for both total and dissolved constituents.

PR01301 – #2/tafTable.wk3

TUT 003 0574

Table 5 . Analytical Methods, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands.

Matrix	Parameter	Analytical Method
Soil	VOCs (a)	March 1990 CLP RAS SOW
Soil	TCL BNAs	March 1990 CLP RAS SOW
Soil	TPH	USACOE CE81-1/USEPA 418.1
Soil	TAL Metals and Cyanide	March 1990 CLP RAS SOW
Water	VOCs (a)	March 1990 CLP RAS SOW
Water	TCL BNAs	March 1990 CLP RAS SOW
Water	TPH	USEPA 418.1
Water (b)	TAL Metals and Cyanide	March 1990 CLP RAS SOW
VOCs CLP RAS SOW	Volatile organic compounds. Contract laboratory program routine analytical services statement of work (Organic SOW Document No. OLM01.0 and revisions; Inorganic SOW Document No. ILM01.0)	
TCL	Target compound list.	
BNAs	Base neutral and acid extractable compounds.	
TPH	Total petroleum hydrocarbons.	
USACOE	Army Corps of Engineers.	
USEPA	U.S. Environmental Protection Agency.	
TAL	Target analyte list.	

(a) VOCs include analyses for TCL VOCs, 1,2-dibromomethane, n-propylbenzene, and methyl tert-butyl ether.

(b) For TAL in water, two samples will be collected (filtered and unfiltered).

Table 6. Requirements for Sample Containers, Preservation, and Recommended Holding Times, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands.

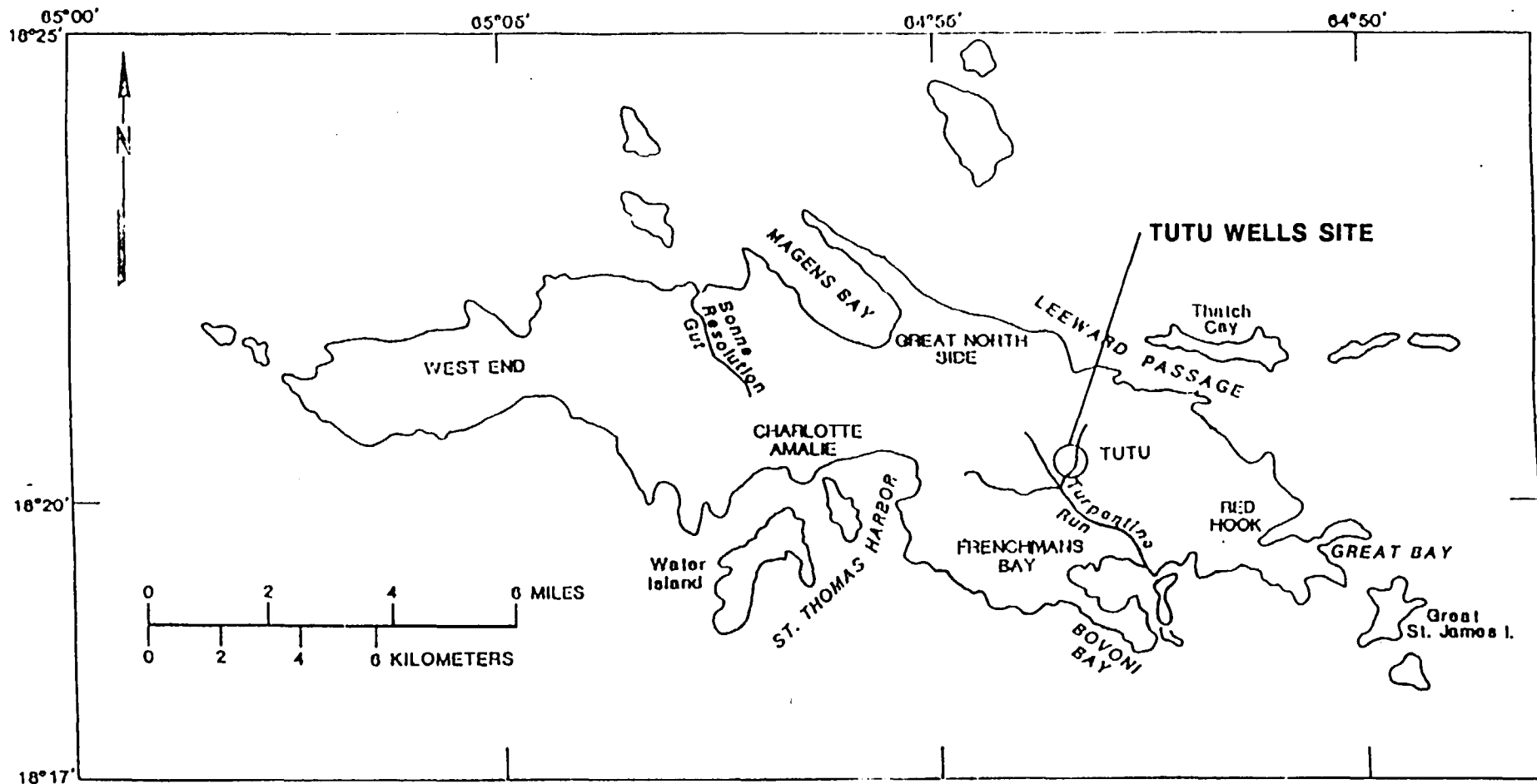
Analytical Parameter	Matrix	Container	Sample Volume	Preservation	Recommended Maximum Holding Time (a)
VOCs	Soil	Glass with Teflon-lined septum	2-40 mL vials	Cool to 4 degrees Celsius	10 days
BNAs	Soil	Glass with Teflon-lined cap	1-250 mL bottle	Cool to 4 degrees Celsius	7 days to extraction 40 days to analysis
Metals	Soil	Glass with Teflon-lined cap	1-250 mL bottle	Cool to 4 degrees Celsius	6 months for all except Hg; 28 days for Hg
Cyanide	Soil	Glass with Teflon-lined cap	1-250 mL bottle	Cool to 4 degrees Celsius	14 days
TPH	Soil	Glass with Teflon-lined cap	1-250 mL bottle	Cool to 4 degrees Celsius	28 days
VOCs	Water	Glass with Teflon-lined septum	2-40 mL vials	Add HCl to pH<2 Cool to 4 degrees Celsius	7 days unpreserved (aromatics only) 14 days preserved (b)
BNAs	Water	Amber glass with Teflon-lined cap	2-1 L bottles	Cool to 4 degrees Celsius	7 days to extraction 40 days to analysis
Metals	Water	Polyethylene with Teflon-lined cap	1-1 L bottle	Add HNO ₃ to pH<2 Cool to 4 degrees Celsius	6 months for all except Hg; 28 days for Hg
Cyanide	Water	Polyethylene with Teflon-lined cap	1-1 L bottle	Add NaOH to pH>12 Cool to 4 degrees Celsius	14 days
TPH	Water	Amber glass with Teflon-lined cap	1-1 L bottle	Add HCl to pH<2 Cool to 4 degrees Celsius	28 days

VOCs Volatile organic compounds.
 BNAs Base neutral and acid extractable compounds.
 TPH Total petroleum hydrocarbons.
 Hg Mercury.
 mL Milliliter.
 L Liter.
 HCl Hydrochloric acid.
 HNO₃ Nitric acid.
 NaOH Sodium hydroxide.

a Holding times measured from time of sample collection.

b If sample acidification causes effervescence, the sample will not be acidified but will be cooled to approximately 4 degrees Celsius.

In this event, the holding time is 7 days from the time of sampling for aromatic compound analysis and 14 days for halogenated VOCs.



SUBJECT

**TUTU WELLS SITE
TUTU SERVICE STATION INVESTIGATION,
ST. THOMAS, U. S. VIRGIN ISLANDS**

PREPARED FOR

TEIC

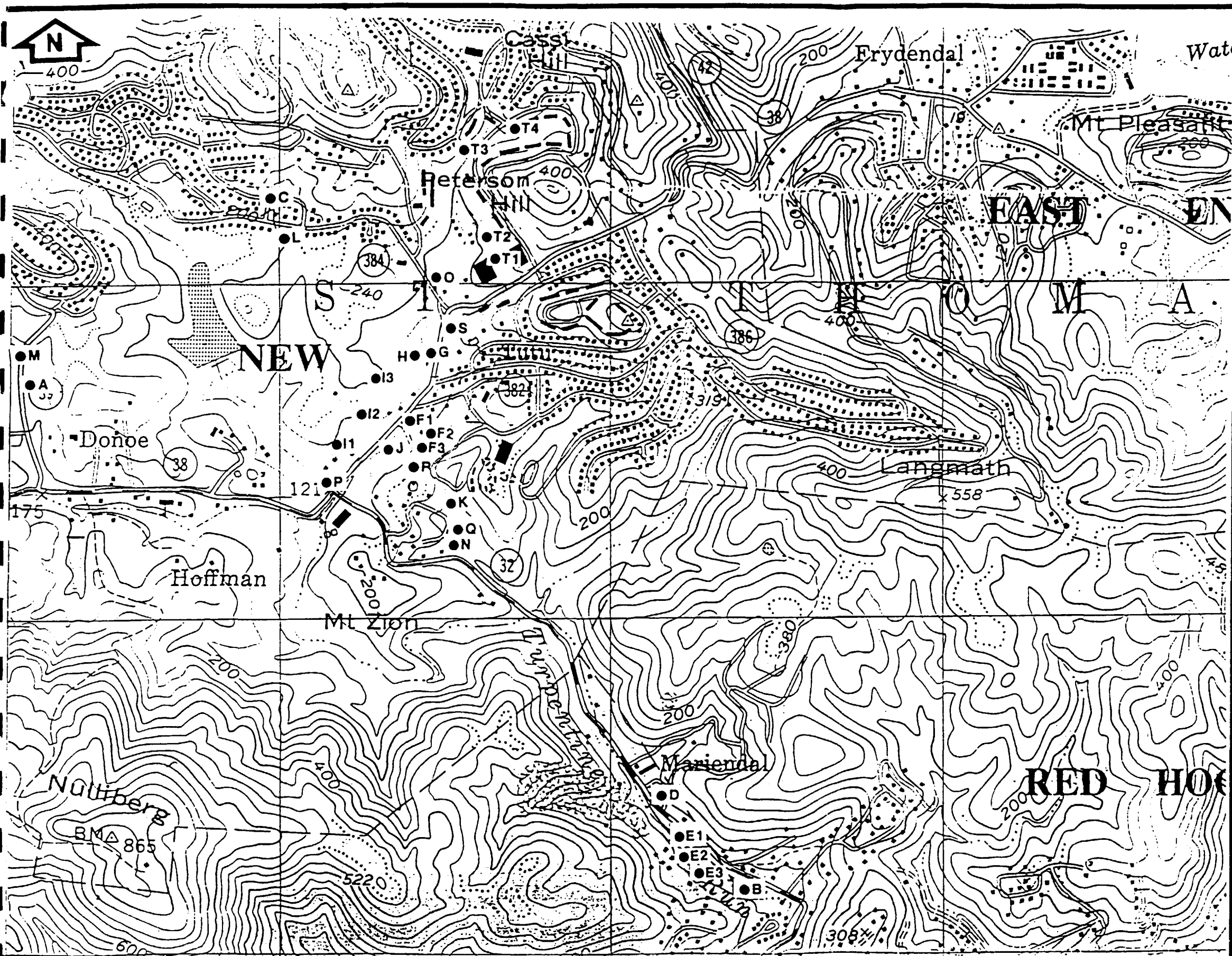
Geraghty
& Miller, Inc.

COMPILED BY **NACHMAN**
PREPARED BY **MESSINGER**
PROJECT MGR **DANAHY**

SCALE
SHOWN
DATE

FIGURE
1

TUT 003 0577



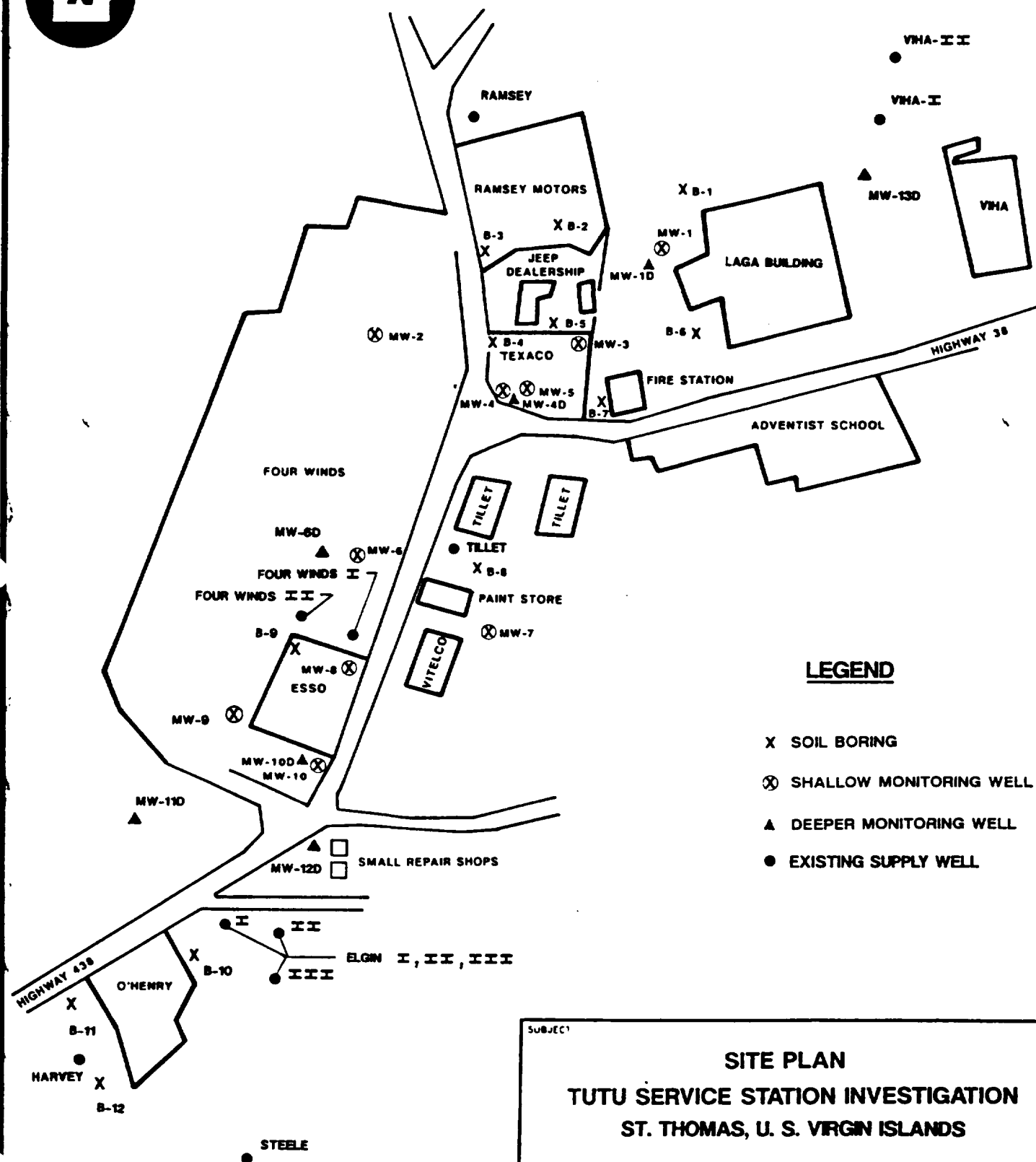
LEGEND

- RESIDENTIAL WELL
- A BRYAN
- B DEDE
- C DEMITRI
- D DENCH
- E1 DEVCON I
- E2 DEVCON II (ALTERNATE)
- E3 DEVCON III
- F1 EGLIN I
- F2 EGLIN II
- F3 EGLIN III
- G FOUR WINDS I
- H FOUR WINDS II
- I1 GASSETT
- I2 HARTMAN II (CRUSHER)
- I3 HARTMAN III (ESTATE)
- J HARVEY
- K LaPLACE
- L LEONARD
- M LOCKHART (ALTERNATE)
- N MATTHIAS
- O RAMSEY
- P RODRIGUES
- Q SMITH
- R STEELE
- S TILLET
- T1 VIHA I
- T2 VIHA II (ALTERNATE)
- T3 VIHA III
- T4 VIHA IV (ALTERNATE)



SOURCE: USGS QUADRANGLE EASTERN ST. THOMAS, V.I. (1964)

SUBJECT			
SUPPLY WELL LOCATIONS TUTU SERVICE STATION INVESTIGATION, ST. THOMAS, U. S. VIRGIN ISLANDS			
PREPARED FOR			
TEIC			
Geraghty & Miller, Inc.	COMPILED BY DANAHY	SCALE SHOWN	FIGURE 2
	PREPARED BY PADULA	DATE 5/90	
	PROJECT MGR DANAHY		



LEGEND

- X SOIL BORING
- ⊗ SHALLOW MONITORING WELL
- ▲ DEEPER MONITORING WELL
- EXISTING SUPPLY WELL

SUBJECT

SITE PLAN TUTU SERVICE STATION INVESTIGATION ST. THOMAS, U. S. VIRGIN ISLANDS

PREPARED FOR

TUT 003 0579

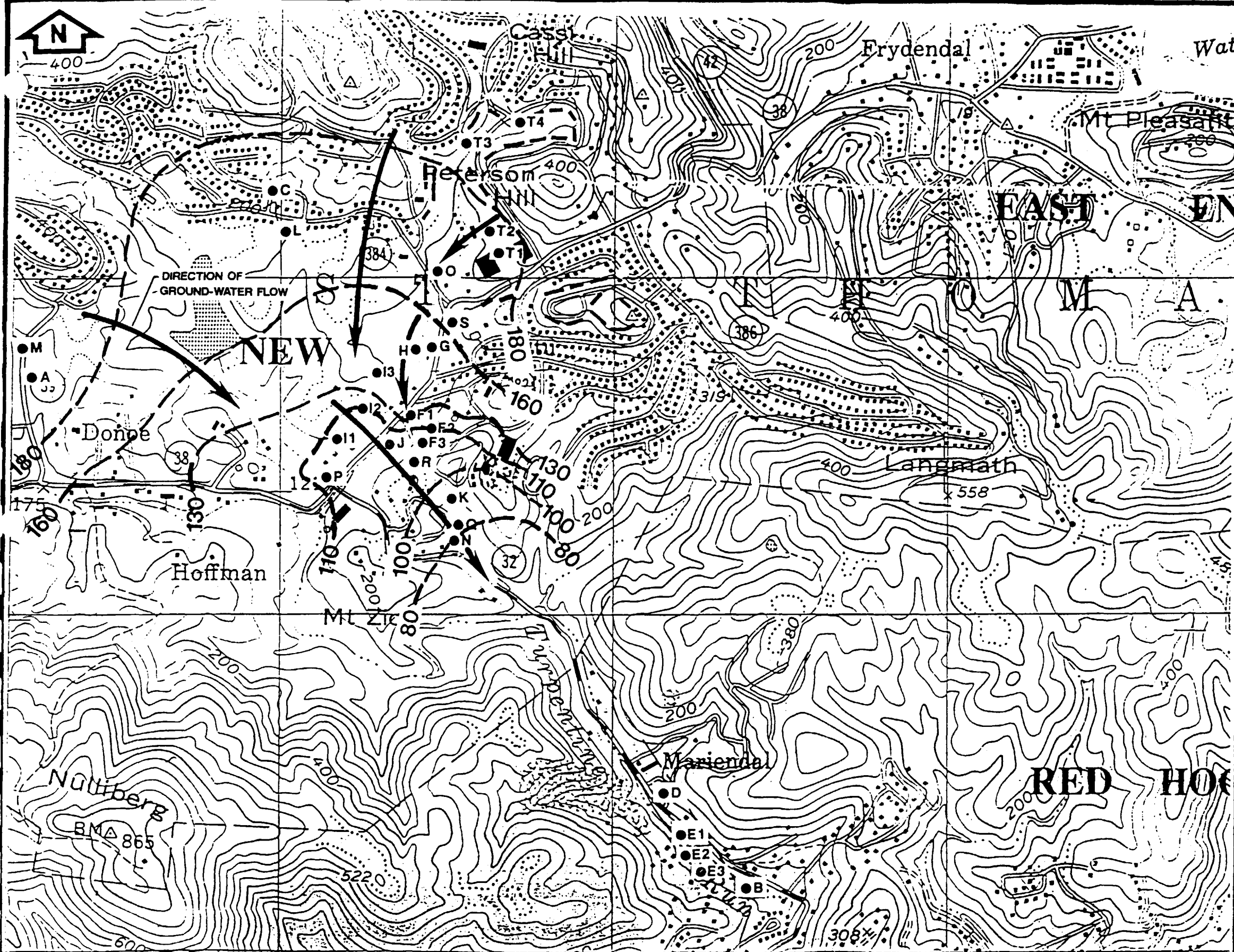
IEIC

Geraghty
& Miller, Inc.

COMPILED BY **DANAHY**
PREPARED BY **PADULA**
PROJECT MGR **DANAHY**

SCALE
SHOWN
DATE
5/4/91

FIGURE
3



LEGEND

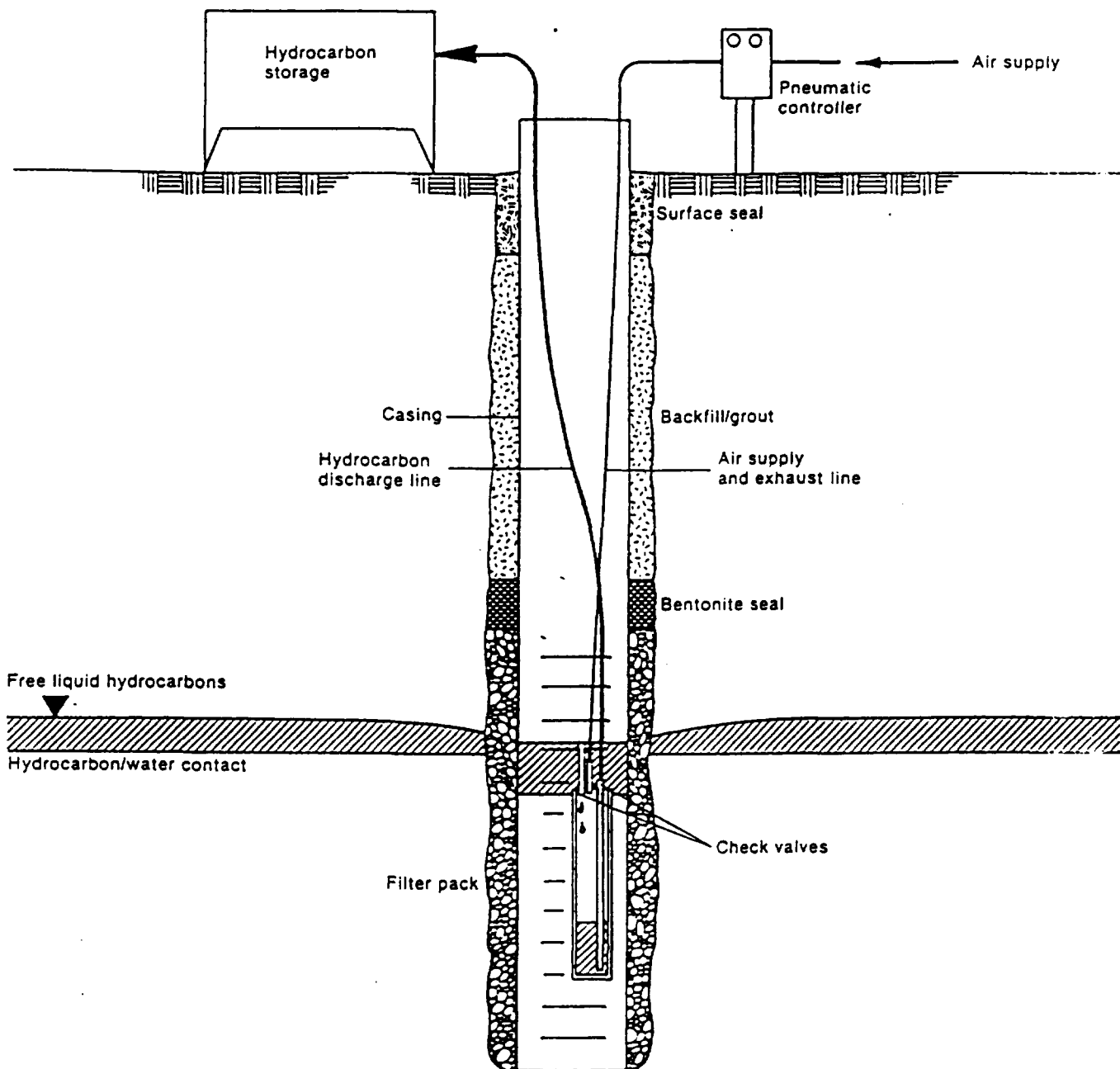
- RESIDENTIAL WELL
- A BRYAN
- B DEDE
- C DEMITRI
- D DENCH
- E1 DEVCON I
- E2 DEVCON II (ALTERNATE)
- E3 DEVCON III
- F1 EGLIN I
- F2 EGLIN II
- F3 EGLIN III
- G FOUR WINDS I
- H FOUR WINDS II
- I1 GASSETT
- I2 HARTMAN II (CRUSHER)
- I3 HARTMAN III (ESTATE)
- J HARVEY
- K LaPLACE
- L LEONARD
- M LOCKHART (ALTERNATE)
- N MATTHIAS
- O RAMSEY
- P RODRIGUES
- Q SMITH
- R STEELE
- S TILLET
- T1 VIHA I
- T2 VIHA II (ALTERNATE)
- T3 VIHA III
- T4 VIHA IV (ALTERNATE)
- LINE OF EQUAL GROUND-WATER LEVEL ELEVATION (FEET ABOVE MEAN SEA LEVEL) (MODIFIED AFTER GRAVES AND GONZALEZ 1988)

SUBJECT
GENERALIZED POTENTIOMETRIC SURFACE (9/11/87) TUTU AREA, ST. THOMAS, U. S. VIRGIN ISLANDS

PREPARED FOR		TEIC	
Geraghty & Miller, Inc.	COMPILED BY DANAHY	SCALE SHOWN	FIGURE 4
	PREPARED BY PADULA	DATE 5/90	
	PROJECT NO. DANAHY		

SOURCE: USGS QUADRANGLE EASTERN ST. THOMAS, V.I. (1954)

0 1000 2000 3000
SCALE FEET



SUBJECT

**FREE PRODUCT SKIMMING SYSTEM
SCHEMATIC DIAGRAM
TUTU SERVICE STATION INVESTIGATION,
ST. THOMAS, U. S. VIRGIN ISLANDS**

PREPARED FOR

TEIC

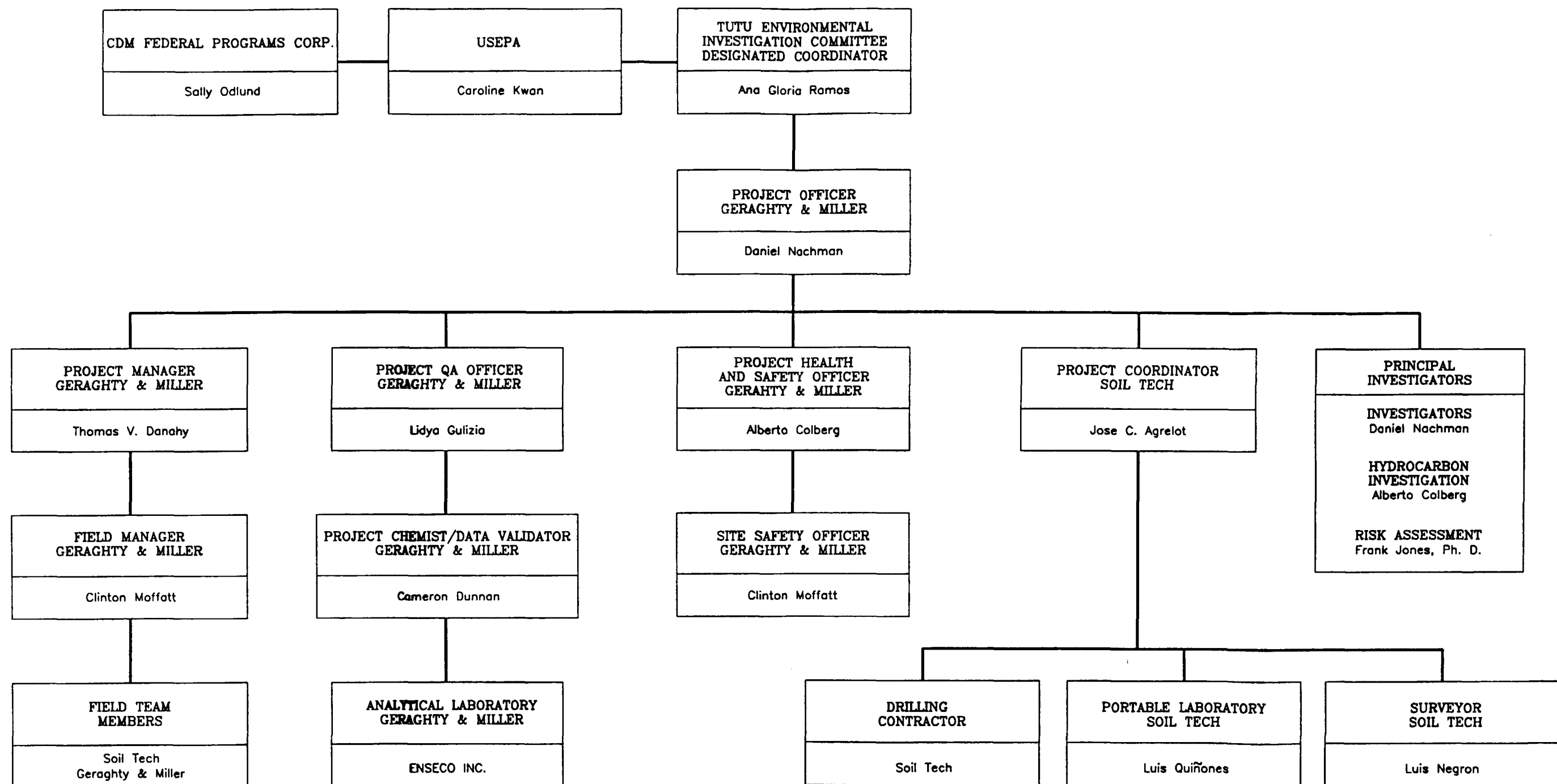
Geraghty
& Miller, Inc.

COMPILED BY **DANAHY**
PREPARED BY **MESSINGER**
PROJECT MGR **DANAHY**

SCALE **NONE**
DATE **2/1/88**

FIGURE **5**

DWG DATE: 16MAR92 PRJCT NO.: PR01301 FILE NO.: - DRAWING: TU-2 CHECKED: MOFFATT APPROVED: DANAHY DRAFTER: NICHOL



PROJECT ORGANIZATION CHART

TUTU SERVICE STATION INVESTIGATION
ST. THOMAS, U.S. VIRGIN ISLANDS

FIGURE

6

SYM	REVISIONS	DATE
SCH'D BY: RP	DATE: 10/11/01	
CHK'D BY: TD	DATE: 10/11/01	
APPV'D BY: TD	DATE: 10/11/01	

PROJECT SCHEDULE

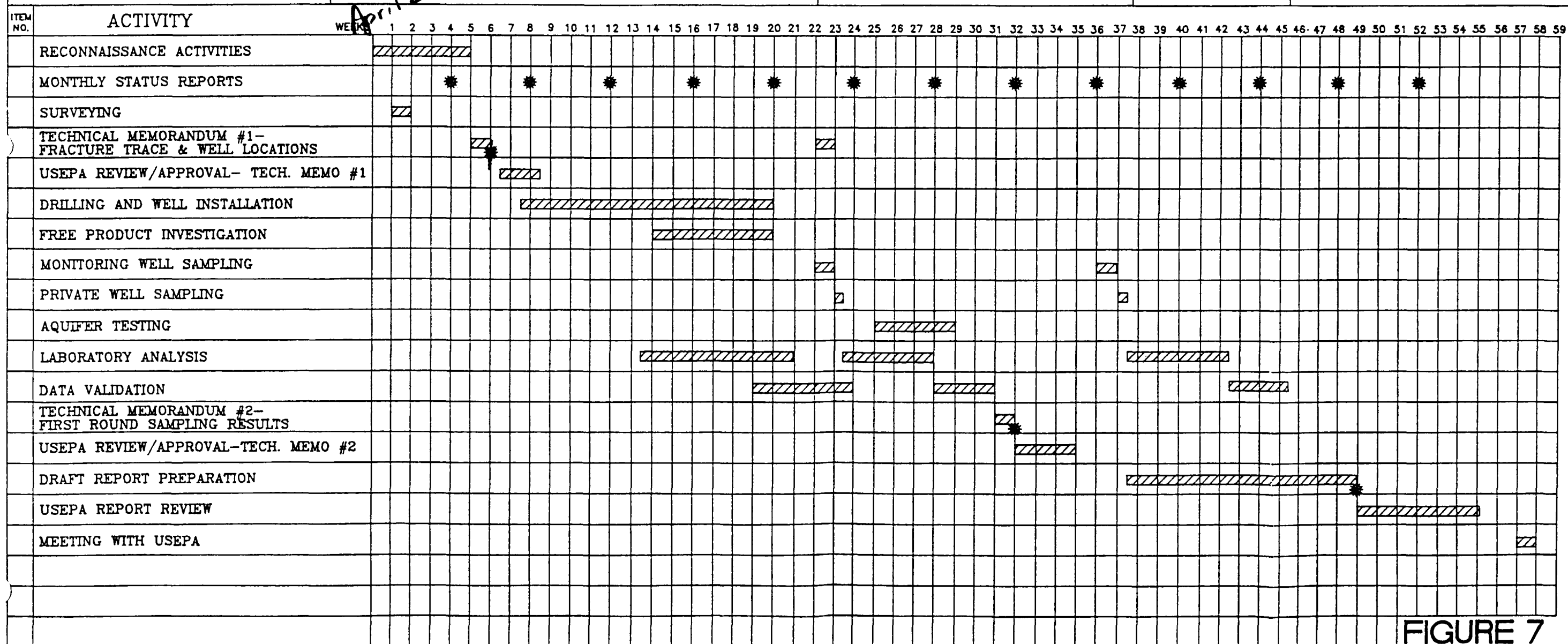


FIGURE 7

APPENDIX A

FIELD INSTRUMENTATION OPERATING PROCEDURES

TUT 003 0584

APPENDIX A
FIELD INSTRUMENTATION OPERATING PROCEDURES

Instruments used as a part of the investigation will be calibrated and operated in accordance with the following procedures and the manufacturer's instructions.

1.0 AIR MONITORING EQUIPMENT

1.1 An HNU Systems Model HW-101 or Model PI-101 photoionization detector (or equivalent) equipped with a 10.2 electron volt (Ev) lamp will be used on a semi-continuous basis during intrusive field operations (e.g., drilling, sampling).

1.2 Calibration of the instrument will be performed prior to use on a daily basis. The calibration gas will consist of a mixture of 100 parts per million (ppm) isobutylene and air. The calibration procedure is as follows:

- A battery check will be performed to ensure that there is sufficient charge in the battery.
- The function switch will be turned to the "standby" position. The "zero adjustment" knob will then be adjusted so that the instrument reading is 0 ppm.
- The tip of the HNU 8-inch extension probe will be fitted into the tubing from the calibration gas container.
- The valve of the calibration gas container will be opened until there is a slight flow of gas.
- The span on the HNU will be adjusted so that the instrument reading is the same as the calibration gas concentration.

- If the adjusted span setting is below the manufacturer's recommendations, appropriate maintenance will be performed.

1.3 Each time the instrument is calibrated the following information will be recorded: serial number of the instrument, time and date, span setting, instrument response, weather conditions, and the name of the person who performed the calibration.

2.0 WATER-LEVEL MONITORING EQUIPMENT

Two types of water-level instrumentation will be used for the project. Weighted steel tapes and electronic water-level indicators will be used to provide instantaneous water-level measurements in wells. A record of continuous water-level fluctuations in wells will be obtained using automated water float and recorder systems and pressure transducer/data logger systems.

2.1 A weighted steel tape, graduated in hundredths of a foot, will be the primary instrument used for measuring the depth to ground water. Blue carpenter chalk will be applied to the bottom 5 feet of tape and the weighted tape will be slowly lowered down the center of the casing. After water is encountered in the well, the tape will be held at the closest even foot marker (which will be recorded) at the premarked surveyed point at the top of the well. The steel tape will then be removed from the well and a record made of the measurement where the tape became wet. The wet measurement will be subtracted from the "held" measurement. This difference is the depth to water.

2.2 The electronic Olympic Model 300 water-level indicator (or equivalent) will be used. The electronic tape is marked at 5-foot intervals. The probe is lowered down the center of the well casing. When the probe encounters water, an audio and visual alarm is triggered. The point on the line is marked at the premarked survey point

on the top of the well casing. The distance is measured between this point and the nearest 5-foot mark below this point. The difference is added to the value of the nearest 5-foot mark. This value is the depth to water.

- 2.3 The Leupold & Stevens Model 68 Type F recorder (or equivalent) automated system will be used. It is necessary to install the proper gears in the recorders to account for the degree of water-level fluctuations over time. Gauge scales in reference to anticipated water-level changes are as follows:

- 1:1, 1.0 ft
- 1:2, 2.0 ft
- 1:5, 5.0 ft
- 1:10, 10.0 ft
- 1:20, 20.0 ft

Recording intervals may be set for the following-total elapsed times:

- 2 hours
- 4 hours
- 8 hours
- 24 hours
- 8 days
- 32 days

The recorder chart, Type F, is installed around the drum. Type F chart paper is calibrated in feet for water-level changes and inches for time scale. The procedure for installing the chart paper is as follows:

- The edges will be pulled together and the turned edge will be laid over the margin.
- The slot in the left chart margin will be checked to ensure that it engages the pin in the chart drum.

- A strip of clean, pressure-sensitive tape will be placed along the overlapping edge of the chart to prevent the pin from catching the seam.

The following information is recorded on the chart:

- Project number
- Well number
- Date
- Time
- Observer
- Description of measuring point
- Depth to water
- Period of record
- Gauge scale

- 2.4 The ORS Data Logger Model DL-120-MCP (or equivalent) and compatible ORS pressure transducers and cables may be used, as follows. The pressure transducer is lowered into the well while the cable is attached to one of the data logger input channels. It is important that the pressure transducer not be subjected to pressure (water depth) greater than it is rated for. Pressure transducer ratings and maximum water depths are as follows:

<u>PSI Rating</u>	<u>Maximum Water Depth (feet)</u>
1	2.30
2	4.61
5	11.53
10	23.07
15	34.60
25	57.67
50	115.3
100	230.7
200	576.7

The data logger is set so that the psi (pounds per square inch) rating of each probe is programmed for each channel being used. The data logger is programmed to

record the pressure due to the column of water above the probe. This measurement is converted to depth to water. These values can be recorded on a linear or semi-logarithmic time scale. Time intervals between data points are programmed in advance or as needed. The data can be read off the screen to confirm that it is functioning. When needed, the data will be transferred to a computer for data analysis and permanent storage.

3.0 FREE PRODUCT MEASUREMENT

An interface probe will generally be used to measure the thickness of free product. However, free product measurements may also be taken using a weighted steel tape, chalk, and hydrocarbon-indicating paste.

- 3.1 The Marine Moisture Control Company Model D-2401-2UI interface probe (or equivalent) can detect down to 0.02 feet thickness of immiscible liquid. The probe is lowered into the well. When the floating layer is encountered, the instrument emits a steady tone. The point where the probe line hits the premarked survey point on the top of the well casing is marked. The probe is then slowly lowered further until the second layer is encountered. At this point the instrument emits a high-pitched chirp. The point where the probe line hits the survey point on the well casing is marked. The distance between the two points on the probe line is the free product thickness.
- 3.2 Free product measurement will be performed with a weighted steel tape by applying blue carpenter chalk to one-half of the bottom 5 feet of the tape. Hydrocarbon indicating paste will be applied to the other half of the tape. The tape will be slowly lowered down the center of the casing. After liquid is encountered, the tape is held at the closest whole number foot marker at the premarked survey point on the top of the well casing. The steel tape will be removed from the well. The hydrocarbon-indicating paste turns pink upon contact with a free product hydrocarbon. The

difference between the pink paste and the point at which water is encountered (indicated by the chalk) is the product thickness.

4.0 FIELD MEASUREMENTS OF WATER SAMPLES

Field measurements of water samples will consist of pH, temperature, and specific conductance. Field instruments for the measurement of pH and specific conductance will be calibrated with standard solutions prior to sampling.

- 4.1 Temperature will be measured with a Taylor pocket thermometer (or equivalent) with a temperature measuring range of -15° C to -105° C.
- 4.2 The pH meter will be an Orion Research, Model 20 (or equivalent), hand-held, digital meter. Calibration will consist of a two buffer standards bracketing the sample pH (nominal pH values of 4 and 11), manufactured by Cole-Palmer Instrument Company (or equivalent) of Chicago, Illinois. Continuing calibration of the meter will be performed using the pH 7 buffer standard immediately prior to analysis of each sample. The probe will be lowered into the sample container and gently stirred to allow equilibration before the reading is taken.
- 4.3 Specific conductance will be measured with a battery-powered Horizon, Model 1484-10, conductivity meter (or equivalent). Calibration will consist of adjusting the meter response to match the 720 or 2000 umhos standard solution prepared by Bioharm Laboratory Solutions and Chemical Reagents (or equivalent) of Anaheim, California. The meter will be calibrated to temperature. The meter will be calibrated daily when in use. The probe will be lowered into a sample container and the reading will be immediately taken.

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5.0 FIELD GAS CHROMATOGRAPH

The procedures for calibration and operation of the field gas chromatograph are provided in Appendix C.

6.0 INSTRUMENT DECONTAMINATION

All instruments that are placed in wells (steel tapes, M-scopes, interface probes) will be decontaminated before use in each well. The portion of the instrument which comes in contact with ground water or the well casing will be decontaminated according to the following sequential procedure: wash in tap water mixed with laboratory-grade detergent; rinse with tap water; rinse with deionized water. Following decontamination, equipment will be wrapped in aluminum foil, with the shiny side facing out.

7.0 MAGNETOMETER SURVEY

A grid will be established in areas where the presence of buried metal objects is suspected. The magnetometer survey will be performed prior to drilling in these areas.

7.1 The grid will be established using a Brunton compass (or equivalent) and fiberglass tape. The four corners of the grid will be staked or otherwise marked. Measurements will be recorded at 10-foot intervals by laying the fiberglass tape along each established line.

7.2 A base station will be established so that diurnal magnetic fluctuations can be monitored. The base station will be located such that no magnetic anomalies are produced at the base station as a result of cultural features. A reading of the magnetic field will be taken at the base station before beginning the survey, every hour during the survey, and at the end of the survey.

TUT 003 0591

- 7.3 The geophysicists will remove all metal from their persons while collecting the magnetic data.
- 7.4 The line number, station number, and station increment will be entered into the memory of the magnetometer.
- 7.5 The magnetic sensor will be oriented towards the north according to the north marking on the top of the sensor.
- 7.6 A magnetic reading will then be taken and observed on the magnetometer instrument console by the geophysicists before the reading is stored in instrument memory. Both total magnetic field data, as well as vertical gradient magnetic data, will be collected and stored.
- 7.7 The geophysicists will proceed to the next measurement station and obtain another reading. The operator will carefully watch the total field magnetic data for erratic data or problems with the survey. Erratic data from station to station indicates either instrument malfunction, a significant magnetic storm, or a station spacing that is too large. If erratic data are noted, the operator should remain stationary and record the magnetic strength several times. This will help identify if a magnetic storm is, in fact, occurring.
- 7.8 If it is determined that a magnetic storm is occurring, the data collection efforts will be suspended until the magnetic storm has abated.
- 7.9 At the end of each survey line, the operator will manually increment or decrement the line number or station number on the instrument as necessary before advancing to the next survey line to collect data.

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- 7.10 If diurnal corrections are being made by revisiting a base station location, the operator will return to the base station approximately every hour.
- 7.11 The location of all ferrous metal objects that may potentially influence the magnetic readings will be recorded relative to the measurement station they are nearest as the magnetometer survey is performed. Information on the approximate size, shape and identity of the objects will be recorded. This information is used later during interpretation of the data to identify those anomalies which are caused by known metal material either on the surface or in the subsurface.
- 7.12 At the end of each survey day, the base station location will be revisited a final time if this method of correcting for diurnal variations was utilized. Data will then be downloaded from the magnetometer to a portable field computer following the specific instrument manufacturer's procedures.
- 7.13 Total field and gradient measurements will be corrected for diurnal variations. Magnetic contour maps will be generated to facilitate the interpretation of the data. The maps will be examined with respect to the magnitude of the anomalies and their location. Drilling will not be performed in the vicinity of areas where there are significant magnetic anomalies.

TUT 003 0593

APPENDIX B

SPLIT-SPOON SAMPLING SPECIFICATIONS AND PROCEDURES

TUT 003 0594

APPENDIX B

SPLIT-SPOON SAMPLING SPECIFICATIONS AND PROCEDURES

Samples of the unconsolidated deposits will be collected using a split-spoon sampler from all of the borings and wells drilled for the field investigation. Specifically, split-spoon samples will be collected from Borings B-1 through B-12 and Monitoring Wells MW-1 through MW-13.

1.0 METHOD OF SAMPLE COLLECTION

- 1.1 Split-spoon samples will be collected in advance of the drill bit using 2-foot long by 3-inch diameter samplers. Samples will be collected continuously to the water table or to the top of bedrock, whichever is encountered first.
- 1.2 The split-spoon samplers will be decontaminated initially and between collecting each sample, according to the following sequential procedure: wash in tap water mixed with laboratory-grade detergent; rinse with tap water; rinse with pesticide-grade methanol; rinse with pesticide-grade hexane; allow to air dry; rinse with deionized water.
- 1.3 Sampling will be accomplished by driving the split-spoon sampler ahead of a 3-1/2 inch inside diameter lead auger via a 150-pound hammer weight dropping a minimum of 3 feet.
- 1.4 Drilling and sampling depths will be measured and recorded. The depth of the boreholes will be periodically measured using a weighted steel tape graduated in hundredths of a foot, and continuously measured by noting the number and lengths of augers used in the drilling operation.
- 1.5 Upon retrieving the sample, the split spoon will be placed onto clean plastic sheeting and opened. The sample identification and a description will be recorded on

Geraghty & Miller, Inc. Sample/Core Log (attached). The sample will be described according to the following criteria: location, depth of sample, amount of sample recovery, lithology, grain size, shape, degree of roundness or angularity, sorting, color, density, moisture content, inclusions, structure, any other secondary characteristics, and the presence of staining, odor or sheen.

- 1.6 The split-spoon core will be trimmed with a clean knife and spatula in order to remove the outer core, which will be discarded. The inner core will be transferred to labelled sample containers with stainless-steel trowels. The sample containers will be filled as much as possible, particularly the volatile organic analysis vials. The trowel, knife, and spatula will be decontaminated initially and between each sample, by the following procedure: wash in tap water mixed with laboratory-grade detergent; rinse with tap water; rinse with pesticide-grade methanol; rinse with pesticide-grade hexane; allow to air dry; rinse with deionized water.
- 1.7 Based on field observations (e.g., staining, odors, and/or geology) and results of field gas chromatographic analysis, a minimum of one sample from each boring will be selected for laboratory analysis of volatile organic compounds, base neutral and acid extractable compounds, metals, cyanide, and total petroleum hydrocarbons. For samples submitted to the laboratory, the procedures described in Appendix I and the quality assurance project plan will be followed.
- 1.8 A portion of each sample, not submitted for laboratory analysis, will be placed in a jar or sealable plastic bag and stored in a secure on-site area for possible future reference.

APPENDIX C

FIELD GAS CHROMATOGRAPH ANALYSIS AND CALIBRATION PROCEDURES

TUT 003 0598

APPENDIX C

FIELD GAS CHROMATOGRAPH ANALYSIS AND CALIBRATION PROCEDURES

All of the soil samples obtained during drilling will be analyzed for volatile organic compounds (VOCs) using a field gas chromatography (GC). Water samples from the monitoring wells may also be analyzed for VOCs using the field GC, in order to provide a preliminary evaluation of ground-water quality.

1.0 SAMPLING AND ANALYSIS

- 1.1 Soil samples to be analyzed using the field GC will be collected from the split-spoon using a stainless-steel trowel. The soil sample will be placed in a 40-ml VOC vial which contains 20 ml of organic-free distilled and deionized water. The sample will be shaken vigorously for 60 seconds. A 300-microliter (ul) headspace sample will be collected from the vial with a gas-tight syringe and injected into the GC.
- 1.2 Water samples to be analyzed using the field GC will be collected by pouring the water from the bailer directly into the 40-ml vial. The vial will be half-filled with water. The sample will be shaken vigorously for 60 seconds. A 300-ul headspace will be collected from the vial with a gas-tight syringe and injected into the GC.
- 1.4 The GC will identify all peak areas greater than 0.1 volt seconds (vs) as unknowns on the GC chromatogram.
- 1.5 The GC operator will match the retention times of the most recent standard with the unknowns. If the retention times match, the compounds will be identified and quantified by multiplying the area (in millivolts) of the compound by the response factor calculated from the initial calibration. The weight of soil added to the 20 ul of water will be multiplied by the aqueous concentration and a final concentration will be reported in micrograms per kilogram (ug/kg).

2.0 QUALITY ASSURANCE/QUALITY CONTROL

- 2.1 GC blank samples will be analyzed to ensure a steady baseline. A blank will be run by starting the GC without injecting a sample. Blanks will be run at the start of each day's sampling.
- 2.2 GC syringe blank samples will be analyzed to determine if there are carry-over effects from previous samples and standards. Syringe blanks will be analyzed following all samples where high VOC concentrations are detected. Contamination of the GC will be removed by purging the GC with ultra-zero air until the contamination is no longer detected. Contamination of the gas-tight syringe will be cleaned using methanol and organic-free water.
- 2.3 A duplicate GC sample will be run once every ten samples to evaluate the precision of the analyses.
- 2.4 Approximately 10 percent of the samples analyzed by the field GC will have field replicates sent to the laboratory for analyses. These analyses will allow for a comparison between field GC and laboratory results. Those samples selected will include samples with both the highest and lowest GC results to confirm the presence and absence of VOC compounds.

3.0 CALIBRATION PROCEDURES

- 3.1 The GC will be calibrated with aqueous standards of the following compounds: benzene, toluene, ethylbenzene, m-xylene, o-xylene, tetrachloroethene (PCE), trichloroethene (TCE), and trans-1,2-dichloroethene (DCE).
- 3.2 The standard will be prepared in the concentration range expected to be present in the samples analyzed on-site. The standard will be prepared by introducing a known volume of the compounds into a known volume of methanol stock solution. Once

the compounds have dissolved, a known volume of the standard will be introduced into a known volume of organic-free water.

- 3.3 A fresh calibration standard will be prepared daily. This daily standard will be prepared from a higher concentration stock of standards which will be kept refrigerated and prepared fresh at a minimum of once per week.
- 3.4 The GC will be calibrated at the beginning of each daily GC analysis event. Initial calibration will be established by five replicate 300 uL injections of the aqueous calibration standard. An average response factor will be calculated for each compound by dividing the concentration of the compound by the average peak area of each standard from the five analyses.
- 3.5 Continuing calibration of the field GC will maintained by the analysis of the aqueous standard every 4 hours or more frequently, at the operator's discretion, in order to ensure accurate calibration of the instrument.

4.0 RECORD KEEPING

- 4.1 The Geraghty & Miller field hydrogeologist will maintain a list of samples collected for field GC analysis using the Sampling List for Field Gas Chromatograph Analyses (attached).
- 4.2 The field GC operator will maintain a list of all analyses performed (including blanks, standards, samples and duplicates) using the Field Gas Chromatograph Analytical Sheet (attached).
- 4.3 Chromatograms of field GC analyses will be attached in a bound notebook. The date and time of analysis, compounds identified, concentrations, sample volume and any other important instrument or interpretation notes will be recorded.

FIELD GAS CHROMATOGRAPH ANALYTICAL SHEET

Site:

Date:

GC Operator:

[illegible]

LIST FOR FIELD GAS CHROMATOGRAPH ANALYSES

Site:

Date:

Sampling Team:

[illegible]

APPENDIX D

ROCK CORING SPECIFICATIONS AND PROCEDURES

TUT 003 0604

APPENDIX D

ROCK CORING SPECIFICATIONS AND PROCEDURES

Rock cores will be obtained from each of the monitoring wells installed in bedrock. Rock cores will be obtained from Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, MW-13D; and may be obtained from one or more of the following: Monitoring Wells MW-1 through MW-10.

1.0 METHOD OF SAMPLE COLLECTION

- 1.1 The rotary method will be used to continuously core the boring. Continuous samples will be collected using a wireline NQ core barrel.
- 1.2 Removal of cuttings and cooling of the bit will be accomplished using air mixed with a small volume of water. A filter will be placed in the system between the air compressor and the down hole air line in order to remove hydraulic fluid or any other contaminant from the air. A sample of the water to be used will be submitted for laboratory analysis of volatile organic compounds (VOCs).
- 1.3 Core samples will be removed from the sampler and the total core recovery in feet will be measured in feet. The rock core will be examined and the following characteristics described: lithology, color, hardness, grain size and shape, sorting, luster, cementation, accessory minerals, inclusions, fossils, bedding, weathering, fracturing, and fracture angle. This information will be recorded on a Geraghty & Miller, Inc. Bedrock Core Log (attached).
- 1.4 A modified core recovery will also be calculated by counting only those pieces of hard and sound core that are 4 inches or greater in length, and dividing that sum by the total length of the run. The modified core recovery will be used to assign a rock

quality designation (RQD) according to the instructions on the log. This information will also be recorded on a Geraghty & Miller, Inc. Bedrock Core Log (attached).

- 1.5 Cores will be transferred from the core barrel into covered wooden boxes and will be arranged by their relative position in the ground.
- 1.6 The top of each core will be clearly marked. Cores will be marked using a waterproof marker with two parallel, red and black colored lines, running from top to bottom of the core. A red line will be placed on the right-hand side when the core is oriented with the top up. The black line will be to the left of the red line. Wooden dowels, noting the cored interval, will be placed between the cores in the box. Intervals of lost core in the sequences will be noted on the annotated wooden dowels.
- 1.7 The following information pertaining to the core stored in each box will be recorded on the inside of each core box:
 - Core run number.
 - Core recovery.
 - Core recovery percentage.
 - Core RQD.

Additionally, the information listed below will be recorded on the inside and outside of each core box:

- Boring number.
 - Core depth.
 - Date.
 - Project number.
 - Box number.
- 1.8 The core boxes will be stored for future reference.

BEDROCK CORE LOG

BORING/WELL _____ PROJECT/NO. _____ PAGE _____ OF _____
 SITE LOCATION _____ DRILLING STARTED _____ DRILLING COMPLETED _____
 TOTAL DEPTH DRILLED _____ FEET HOLE DIAMETER _____ INCHES TYPE OF SAMPLE/
 OF CORING DEVICE _____ SAMPLING INTERVAL _____ FEET
 LENGTH AND DIAMETER
 OF CORING DEVICE _____
 LAND SURFACE ELEV. _____ FEET SURVEYED _____ ESTIMATED _____ DATUM _____
 DRILLING FLUID USED _____ DRILLING METHOD _____
 DRILLING CONTRACTOR _____ DRILLER _____ HELPER _____

PREPARED BY _____

RUN NUMBER	DEPTH (FT.)	CORE RECOVERY (FT.)	A MODIFIED CORE RECOVERY (%)	B ROCK QUALITY DESIGNATION (RQD) AND DESCRIPTION	DRILLING TIME/HYDRAULIC PRESSURE	GEOLOGIC DESCRIPTION

A TOTAL PIECES OF HARD AND SOUND CORE 0.333 FT.(4 INCH) OR
 GREATER IN LENGTH DIVIDED BY THE SUM OF THE TOTAL LENGTH OF RUN.

B 0-25 VERY POOR 25-50 POOR 50-75 FAIR 75-90 GOOD 90-100 EXCELLENT

APPENDIX E

**UNCONSOLIDATED DRILLING AND MONITORING
WELL CONSTRUCTION SPECIFICATIONS AND PROCEDURES**

TUT 003 0608

APPENDIX E

UNCONSOLIDATED DRILLING AND MONITORING WELL CONSTRUCTION SPECIFICATIONS AND PROCEDURES

Drilling through unconsolidated deposits will be performed in all the borings and monitoring wells drilled for the investigation. Depending on the depth to water and the depth to bedrock, some of the monitoring wells may be installed in the unconsolidated deposits. Those wells may include Monitoring Wells MW-1 through MW-10. The monitoring wells will be installed to document whether the water table fluctuates between the unconsolidated materials and consolidated rock. During the initial investigation wells will be installed straddling the observed water table. If the water table rises above the screened interval, additional shallow wells may be necessary. Because of the thin unconsolidated deposits, shallow wells in the unconsolidated unit may require screen lengths less than 20 feet. Due to seasonal water-table fluctuations of approximately 20 feet, it may not be feasible to have monitoring well screens intersecting the water table at all locations during the entire year. Critical areas (i.e., where the potential for floating product exists) will be selected for additional well installation (if necessary), based upon the ground-water level measurements.

1.0 UNCONSOLIDATED DRILLING

- 1.1 The conventional hollow-stem auger method of drilling using 6-1/4-inch inside diameter (ID) augers will be employed. The borehole diameter must be a minimum of 8 inches.
- 1.2 All down-hole equipment and materials, including auger flights, rods, well screens and casing, will be steam cleaned prior to insertion in the borehole.
- 1.3 Any water used during well installation will be obtained from a potable water supply. Prior to its use for project purposes, a sample of the water will be submitted for laboratory analysis of VOCs.

TUT 003 0609

2.0 UNCONSOLIDATED MONITORING WELL INSTALLATION

- 2.1 A 4-inch diameter flush-mounted stainless-steel screen will be installed in the completed borehole. Grease, oil, or glue will not be used when joining the screen sections together. The screen slot size will be 0.020 inch or an alternative slot size as determined by an on-site Geraghty & Miller hydrogeologist.
- 2.2 Four-inch diameter flush-mounted stainless-steel casing will extend from the top of the screen to approximately 2 to 3 feet above land surface. Screens and casings will be threaded. Grease, oil, or glue will not be used when joining the casing sections together.
- 2.3 A clean sand pack consisting of Grade 1 silica sand will be emplaced from approximately 0.5 foot below the bottom of the screen extending above the screen for a minimum vertical distance of 2 feet as measured after placement, or to an alternative thickness as determined by the Geraghty & Miller field hydrogeologist. The filter-pack size may be changed based on actual field conditions. A tremie pipe will be used to apply the sand pack, bentonite seal, and cement/bentonite grout.
- 2.4 A bentonite seal composed of commercially available pellets ranging in size from 1/4- to 1/2-inch in diameter will be placed in the well annulus. The pellets must be dry prior to placement in the well. The pellet seal will be a minimum of 2 vertical feet thick as measured immediately after placement without allowance for swelling, or, if this is impracticable, an alternative thickness as determined by the Geraghty & Miller field hydrogeologist. The bentonite pellets will be allowed to hydrate sufficiently before continuing well construction.
- 2.5 A grout slurry consisting of a mixture of ten parts Portland Type I (or equivalent) cement to one-half part bentonite to 8.5 gallons of water will be placed in the borehole from the top of the pellet seal extending to land surface. The grout seal

will have a 2 vertical foot minimum thickness, or, if this is impracticable, an alternate thickness as determined by the Geraghty & Miller field hydrogeologist.

- 2.6 For above-grade monitoring well completions, 6-inch diameter steel casing with a locking cap will be set in concrete over the riser. A vent hole, approximately 0.50 inches in diameter, will be drilled through the metal protective casing and the stainless-steel well casing, to prevent pressure and suction from interfering with water-level fluctuations.
- 2.7 For monitoring wells completed at grade, a metal curb box with a lock assembly will be set in concrete over the riser so that the curb box is flush with ground surface or slightly (less than 1 inch) raised above ground surface.

- 2.8 Monitoring wells will be affixed with a permanent identification marker.

3.0 UNCONSOLIDATED MONITORING WELL DEVELOPMENT

- 3.1 The development of the monitoring will be performed no sooner than 24 hours after the well has been installed and grouted. Well development will be accomplished using either a submersible or centrifugal pump. Fluids such as dispersing agents, acids, disinfectants, or other additives will not be used during development. Development will continue until the well responds to water-level changes and produces relatively clear, sediment-free water. A 1-pint sample of the last water to be removed during development will be obtained and inspected for clarity to determine if development is adequate. The well development water will be treated to drinking water standards and discharged into the sanitary sewer.
- 3.2 The following data shall be recorded on a Geraghty & Miller, Inc. Unconsolidated Well Construction Log (attached) as part of development:

- Static water level before and 24 hours after development.
- Volume of water standing in the well prior to development.
- Measured depth of well before and after development.
- Physical characteristics of discharged water.
- Type and capacity of pump.
- Volume of water removed during development.

4.0 UNCONSOLIDATED MONITORING WELL CONSTRUCTION DIAGRAMS

4.1 The well construction details will be documented on a Geraghty & Miller, Inc. Unconsolidated Well Construction Log (attached) including the following items:

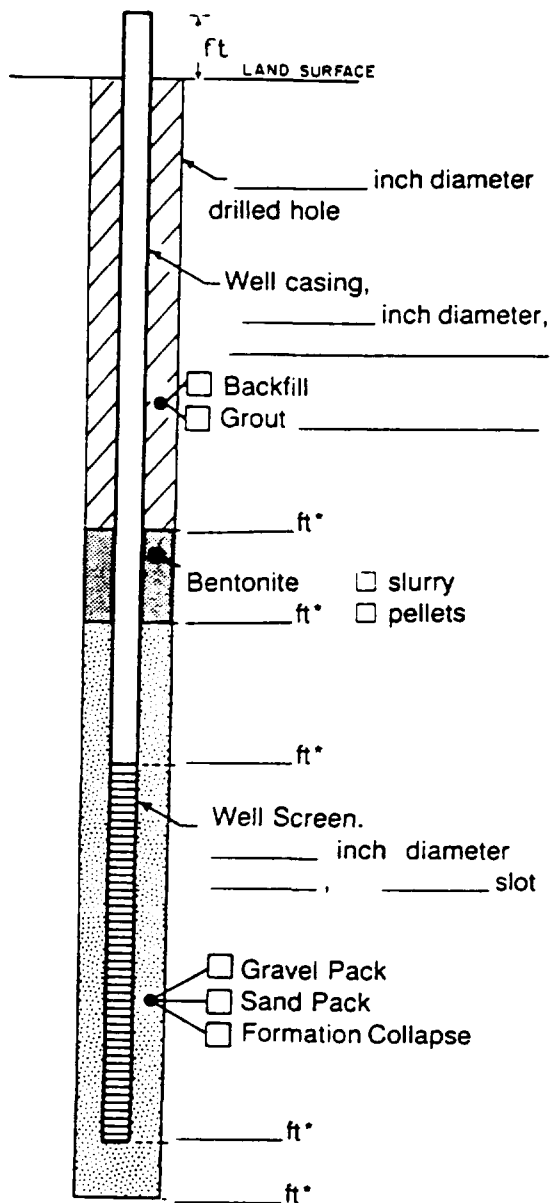
- Borehole depth.
- Screen setting.
- Gravel pack interval.
- Bentonite seal.
- Grout seal.
- Borehole and casing diameter.
- Height and riser without cap (referenced above ground surface).
- Protective casing details.

5.0 SURVEYING

5.1 The ground surface and vertical measuring point elevations of each newly installed unconsolidated monitoring well, relative to the National Geodetic Vertical Datum, will be established to the nearest hundredth of a foot by a Virgin Islands-licensed surveyor. The vertical measuring point will be marked at the top of the well inner casing.

- 5.2 The horizontal location of each newly installed monitoring well, relative to an established project coordinate origin point, will be established to the nearest tenth of a foot by a Virgin Islands-licensed surveyor.

WELL CONSTRUCTION LOG (UNCONSOLIDATED)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

*Depth Below Land Surface

Project _____ Well _____

Town/City _____

County _____ State _____

Permit No. _____

Land-Surface Elevation _____

and Datum _____ feet ☐ Surveyed

_____ ☐ Estimated

Installation Date(s) _____

Drilling Method _____

Drilling Contractor _____

Drilling Fluid _____

Development Technique(s) and Date(s) _____

Fluid Loss During Drilling _____ gallon

Water Removed During Development _____ gallon

Static Depth to Water _____ feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose _____

Remarks _____

Prepared by _____ TLT 003 0614 _____

APPENDIX F

**BEDROCK DRILLING AND MONITORING WELL CONSTRUCTION
SPECIFICATIONS AND PROCEDURES**

TUT 003 0615

APPENDIX F

BEDROCK DRILLING AND MONITORING WELL CONSTRUCTION SPECIFICATIONS AND PROCEDURES

Depending on the depth to water and the depth to bedrock, some of the monitoring wells may be installed in bedrock. Those wells include Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D, and may also include one or more of the following: Monitoring Wells MW-1 through MW-10.

1.0 BEDROCK MONITORING WELL DRILLING AND INSTALLATION

- 1.1 All down-hole equipment and materials, including the well casing, will be steam cleaned prior to insertion in the borehole.
- 1.2 Bedrock core holes will be reamed using an air hammer assembly for open-hole monitoring well construction.
- 1.3 The core hole will be reamed to 10 inches in diameter from the top of bedrock to the top of the open hole interval.
- 1.4 Six-inch diameter stainless-steel casing will be installed through the unconsolidated material to the top of the open-hole interval, and the annular space will be sealed with a cement-bentonite grout.
- 1.5 After the cement-bentonite grout has set a minimum of 12 hours, the open-hole interval will be reamed to a diameter of 6 inches to the bottom of the open-hole interval (20 feet).
- 1.6 Close attention will be paid to the drilling time and downhole pressures applied on the drill stem. The rate of water discharge at discrete intervals will be measured and

TUT 003 0616

recorded. These observations and measurements will yield valuable information regarding changes in lithology and the nature of the formations penetrated, and will help identify water-bearing zones and weathered intervals. Borehole geophysical logging (caliper and sonic) will also be used to identify fracture zones. These geophysical logs will run before setting casing.

- 1.7 The depth of the borehole will be checked and recorded by measuring the drill string and hammer/bit assembly. Special attention will be paid to the height of the drill rig above land surface and measurements will be adjusted accordingly.
- 1.8 The cement grout will be composed by weight of ten parts Portland Type I (or equivalent) cement to one-half part bentonite with 8.5 gallons of water. For example, each 94-lb bag of Portland Type I (or equivalent) cement, will be mixed with 4.7 lbs of bentonite and 8.5 gallons of approved water. The mixed grout will be pumped between the well casing and borehole by means of a tremie pipe, which will be withdrawn as the annulus between the casing and borehole fills with grout. The grout will be pumped into the borehole until grout flows at ground surface. After 24 hours, the grout will be checked for settlement and grout will be added as necessary.
- 1.9 For above-grade monitoring well completions, 6-inch diameter low carbon steel casing with a locking cap will be set in concrete over the riser. A vent hole, approximately 0.50 inch in diameter, will be drilled through the metal protective casing and the stainless steel well casing, to prevent pressure and suction from interfering with water-level fluctuations.
- 1.10 For monitoring wells completed at grade, a metal curb box with a lock assembly will be set in concrete over the riser so that the curb box is flush with ground surface or slightly raised above ground surface.

- 1.11 Monitoring wells will be affixed with a permanent identification marker.
- 1.12 All water used during drilling and installation will be obtained from a potable water supply. Prior to its use for project purposes, a sample of the water will be submitted for laboratory analysis of volatile organic compounds (VOCs).

2.0 BEDROCK MONITORING WELL DEVELOPMENT

- 2.1 The development of the monitoring wells will be performed no sooner than 24 hours after installation and grouting. Surge blocks, centrifugal pumps and/or submersible pumps may be used for developing the wells. No water, dispersing agents, acids, disinfectants, or other additives will be used during development. Water will be removed throughout the entire column of water standing in the well by periodically lowering and raising the drill stem. Development will continue until the well responds to water-level changes and produces clear, relatively sediment-free water. A 1-pint sample of the last water to be removed during the development will be obtained. The water will be inspected for relative clarity to determine whether development is adequate. The well development water will be treated to drinking water standards and discharged into the sanitary sewer.
- 2.2 The following data will be recorded as part of development on a Geraghty & Miller, Inc. Bedrock Well Construction Log (attached):
- Static water-level before and 24 hours after development.
 - Volume of water standing in the well prior to development.
 - Physical characteristics of discharge water.
 - Volume of water removed during development.

TUF 003 0618

3.0 BEDROCK MONITORING WELL CONSTRUCTION DIAGRAMS

3.1 The well construction details will be documented on a Geraghty & Miller, Inc. Bedrock Well Construction Log (attached) including the following items:

- Borehole diameter.
- Well casing diameter.
- Depth to top of bedrock.
- Depth of well casing.
- Borehole depth.
- Grout consistency and amount of material used.
- Fracture zones.

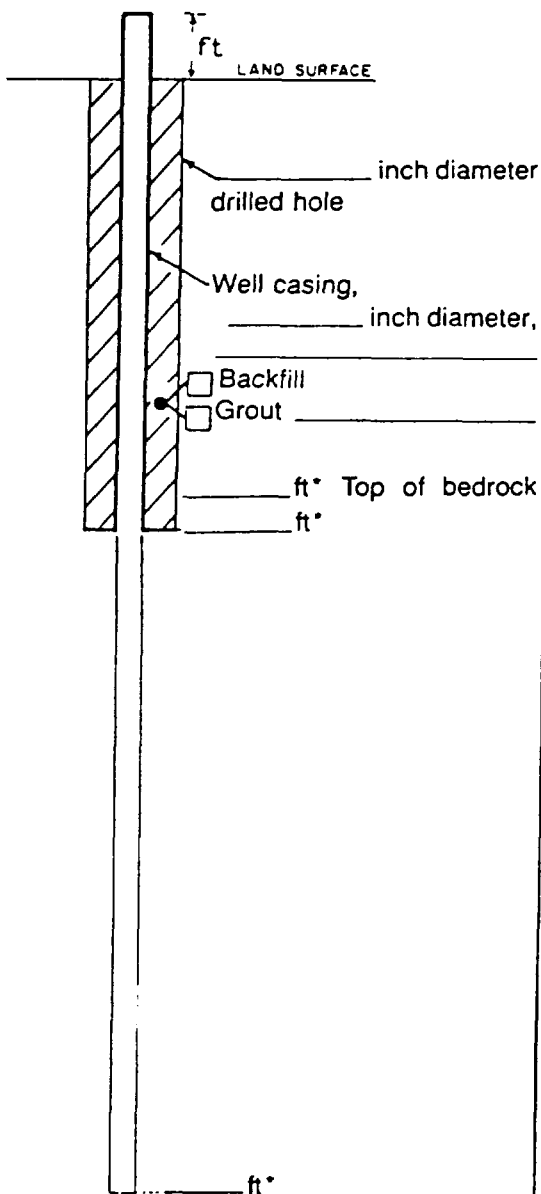
4.0 SURVEYING

4.1 The ground surface and vertical measuring point elevations of each of the new and existing bedrock monitoring wells, relative to the National Geodetic Vertical Datum, will be established to the nearest hundredth of a foot by a Virgin Islands-licensed surveyor. The vertical measuring point will be marked in the inside of the top of the well casing.

4.2 The horizontal location of each new and existing bedrock monitoring well, relative to an established project coordinate origin point, will be established to the nearest tenth of a foot by a Virgin Islands-licensed surveyor.

TUT 003 0619

WELL CONSTRUCTION LOG (BEDROCK)



Measuring Point is Top of
Well Casing Unless Otherwise
Noted.

*Depth Below Land Surface

Project _____ Well _____

Town/City _____

County _____ State _____

Permit No. _____

Land-Surface Elevation _____

and Datum _____ feet ☐ Surveyed

_____ ☐ Estimated

Installation Date(s) _____

Drilling Method _____

Drilling Contractor _____

Drilling Fluid _____

Development Technique(s) and Date(s) _____

Fluid Loss During Drilling _____ gallons

Water Removed During Development _____ gallons

Static Depth to Water _____ feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose _____

Fracture Zones _____

Remarks _____

FUT 003 0620

Prepared by _____

APPENDIX G

MONITORING WELL SAMPLING PROTOCOL

TUT 003 0621

APPENDIX G
MONITORING WELL SAMPLING PROTOCOL

The 17 monitoring wells (MW-1 through MW-10 and MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D) will be sampled during two sampling events. Ground-water samples will be submitted for laboratory analysis of volatile organic compounds (VOCs), base neutral and acid (BNAs) extractable compounds, metals, cyanide, and total petroleum hydrocarbons (TPH). The wells will not be sampled until at least 2 weeks after the initial development.

1.0 WELL EVACUATION PROCEDURES

- 1.1 The well number, sample designation, and other pertinent data will be recorded on the Geraghty & Miller, Inc. Water Sampling Log (attached).
- 1.2 Clean plastic sheeting will be placed on the ground surface adjacent to the well. Equipment and supplies to be used for sampling will be stored on the plastic sheeting.
- 1.3 The well cap or plug will be removed and the inside of the casing will be wiped with a clean cloth. The cap will be placed on the plastic sheeting.
- 1.4 The water level will be measured using either a steel tape or an electronic water-level indicator. If present, the thickness of a floating, immiscible layer will be measured using an immiscibility probe. The depth to water from the survey point at the top of the well casing will be measured and recorded on the Geraghty & Miller, Inc. Water Sampling Log. The bottom of the well will also be sounded and recorded.
- 1.5 The volume of water in the well will be computed and recorded on the log according to the following:

TUT 003 0622

For a 4-inch diameter well: height of water column x 0.65 gallon/foot

For a 6-inch diameter well: height of water column x 1.46 gallons/foot

- 1.6 Three to five times the volume of standing water in the well will be removed using either a submersible pump, peristaltic pump, or a clean bailer. Temperature, pH, and specific conductance will be measured initially and after the removal of each well volume. If one or more of these parameters continues to change after the evacuation of three well volumes, evacuation will continue until two consistent (less than 20 relative percent difference) readings are obtained.
 - 1.6.1 The intake opening of the pump will be positioned and maintained just below the water surface in the well casing to ensure that the well is properly flushed. If there is a slight decrease in the well's water level as a result of pumping, the intake will be lowered as needed. After three to five volumes have been evacuated, the pump will be quickly removed from the well while the pump is still operating to prevent backwash from reentering the well.
 - 1.6.2 For those wells in which there is a rapid and pronounced decline in the water level, the pump will be placed near the bottom of the well. If the well is pumped dry during the procedure and shows essentially complete recovery within 15 minutes, removal of the water will continue for two additional pump down and recovery periods. If recovery is less than 75 percent during the 15 minutes after complete evacuation, sampling may begin.
- 1.7 Pumps will be decontaminated prior to use by washing in tap water mixed with laboratory-grade detergent. The detergent-water mix will be run through the pump to decontaminate the internal components. Next, the pump will be washed/pumped with tap water, followed by a final wash/pump with deionized water.

2.0 WELL SAMPLING PROCEDURE

- 2.1 Ground-water samples will be collected using dedicated Teflon bailers and bailer cord composed of stainless-steel wire, Teflon coated wire, or polypropylene monofilament.
- 2.2 Bailer and bailer cord will be decontaminated prior to use by the following procedure: washing with laboratory-grade detergent (Micro or equivalent); rinse with tap water; rinse with pesticide-grade methanol; rinse with pesticide-grade hexane; allowed to air dry; wrap in aluminum foil.
- 2.3 Sampling personnel will wear surgical gloves when handling sampling equipment and containers. The gloves will be disposed after sampling is completed at each well.
- 2.4 The monitoring wells will be sampled within 3 hours of purging.
- 2.5 The first bailer full of water from each well will be discarded. The bailer will then be refilled for sampling. The purged water and the first bailer of water will be treated to drinking water standards and discharged into the sanitary sewer.
- 2.6 Samples will be collected by pouring the water from the bailer directly into pre-labeled sample containers provided by the laboratory. VOC samples will be collected first.
- 2.7 Samples will be preserved immediately upon collection, with the exception of BNAs, which do not require preservation. VOC and TPH samples will be preserved using ultra-pure grade 1:1 hydrochloric acid (HCl) to pH less than 2. Metals will be preserved with ultra pure grade concentrated nitric acid (HNO₃) to pH less than 2. Cyanide samples will be preserved with sodium hydroxide (NaOH) to pH greater than 12. In order to determine if each sample is sufficiently preserved, the samples

will be tested using pH paper. If the acidification of the VOC sample causes effervescence, the sample will not be acidified, but will be cooled to 4° Celsius.

2.8 Sample containers will be labeled prior to sample collection. The following information will be recorded on each sample label:

- Project name.
- Sample identification.
- Sample matrix.
- Requested analysis.
- Chemical preservation and pH achieved (if applicable).
- Date and time of sample collection.
- Sampler signature.

3.0 FIELD ANALYSES

3.1 After the laboratory containers are filled, approximately 0.5 gallon of sample will be collected in clean, unpreserved glass container and its color, odor, and appearance will be noted. The pH, temperature, and specific conductance of the sample will be measured.

3.2 Temperature will be measured immediately after collection of the sample with a mercury-filled Celsius thermometer in order to calibrate the pH and specific conductance meters.

3.3 The pH will be measured with a glass hydrogen-ion electrode compared against a reference electrode of known potential by means of a pH meter. Calibration of the pH meter will be completed before analysis with two buffer solution standards bracketing the sample pH (nominal pH values of 4 and 11). Continuing calibration of the meter will be performed using the pH 7 buffer standard immediately prior to

each sample analysis. The probe will be lowered into the sample and gently stirred to allow equilibration before the reading is taken.

- 3.4 Specific conductance will be measured with a battery-powered specific conductance meter. The probe will be lowered into the sample and the reading will be immediately taken.
- 3.5 The field analyses and sample descriptions will be recorded on a Geraghty & Miller, Inc. Water Sampling Log (attached).
- 3.6 All parts of the field instrumentation which come in contact with the sample will be cleaned initially and between samples with a stream of deionized or distilled water.

TUT 003 0626

WATER SAMPLING LOG

Project/No. _____ Page _____ of _____

Site Location _____

Site/Well No. _____ Coded/
Replicate No. _____ Date _____

Weather _____ Time Sampling
Began _____ Time Sampling
Completed _____

EVACUATION DATA

Description of Measuring Point (MP) _____

Height of MP Above/Below Land Surface _____ MP Elevation _____

Total Sounded Depth of Well Below MP _____ Water-Level Elevation _____

Held _____ Depth to Water Below MP _____ Diameter of Casing _____

Wet _____ Water Column in Well _____ Gallons Pumped/Bailed
Prior to Sampling _____

Gallons per Foot _____

Gallons in Well _____ Sampling Pump Intake Setting
(feet below land surface) _____

Evacuation Method _____

SAMPLING DATA/FIELD PARAMETERS

Color _____ Odor _____ Appearance _____ Temperature _____ °F/°C

Other (specific ion; OVA; HNU; etc.) _____

Specific Conductance,
umhos/cm _____ pH _____

Sampling Method and Material _____

Constituents Sampled	Container Description From Lab _____ or G&M _____	Preservative
----------------------	--	--------------

Remarks _____

Sampling Personnel _____

		WELL CASING VOLUMES			
GAL./FT.	1-1/4" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65	
	1-1/2" = 0.09	2-1/2" = 0.26	3-1/2" = 0.50	6" = 1.47	

APPENDIX H

PUMPING TEST PROCEDURES

APPENDIX H

PUMPING TEST PROCEDURES

Present knowledge regarding the hydraulic characteristics of the unconsolidated deposits and shallow bedrock at the Tutu site is limited. For this reason, it is difficult to determine which well(s) is to be pumped, the pumping rate, length of the pumping test, pump setting, and the method of data analysis. After the monitoring wells have been installed, these and any other pertinent details will be proposed in writing to USEPA Region II for approval. The following sections describe general pumping test procedures that will be followed.

1.0 PRELIMINARY ACTIVITIES

- 1.1 A preliminary step test will be performed at the well(s) to be pumped in order to select an optimal pumping rate for the constant rate test.
- 1.2 Three to five steps, each of increasing pump rates, will be performed for 1-hour each (if sustainable). The water level in the pumping well will be measured at regular intervals throughout each step.
- 1.3 Efforts will be made to determine the locations, pumping schedule, and pumping rates of nearby water supply wells.
- 1.4 Automatic water-level recorders will be placed on the pumping well, the observation well and other nearby wells for several days prior to the test to provide data regarding water-level fluctuations.

2.0 PUMPING TEST EQUIPMENT

- 2.1 Submersible pumps will be used to pump water from the pumping well(s). Pumps will be suspended in the wells using a nylon safety rope and 1-inch diameter flexible polyethylene pipe.
- 2.2 Small-diameter threaded, flush-joint or flexible PVC pipe will be installed as a drop line for measuring water levels in the bedrock wells. The PVC pipe will be installed to just above the top of the pump and will provide for accurate water-level measurement in the event that water trickles or cascades from dewatered portions of the bedrock.
- 2.3 The pump will be equipped with an in-line valve to adjust the flow rate. A flow regulator will be installed to maintain a constant discharge rate. An in-line flow meter will be installed after the flow regulator to measure the actual flow rate.
- 2.4 Electric power will be supplied to the pump, if possible. If it is not possible, power will be supplied by a gasoline-powered generator.
- 2.5 Prior to each test, the submersible pump will be decontaminated by rinsing the interior and exterior of the pump with Micro solution (or equivalent), followed by a rinse with potable water. A minimum of 20 gallons of potable water will be run through the pump.
- 2.6 New polyethylene discharge pipe and nylon safety rope will be used for each test. The PVC drop pipe will be decontaminated by steam cleaning before use.
- 2.7 An electronic water-level indicator will be used to measure the water level in the pumping well. An electronic water-level indicator or an automatic water-level

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recorder will be used to measure water levels in the observation well. Automatic water-level recorders will be placed on other nearby wells.

- 2.8 Water-level measurement probes and any other nondisposable equipment that enters the well will be decontaminated in sequence by washing in Micro solution (or equivalent), followed by a potable water rinse and a final distilled water rinse.

3.0 PUMPING TEST

- 3.1 Immediately prior to the test, project personnel will synchronize their timepieces and the automatic water-level recorders. Water levels in the pumping well, the observation well, and other nearby wells will be recorded immediately prior to starting the test.
- 3.2 The pump will be run at a constant rate throughout the entire test.
- 3.3 Water levels will be recorded in the pumping well according to the schedule shown below. If water levels in the nearest observation well(s) are measured with an electronic water-level indicator, they will also be measured according to the schedule shown below. Water levels and other pertinent data will be recorded on the Geraghty & Miller Water/Level Pumping Test Record (attached).

<u>Pumping Well</u>		<u>Observation Well</u>	
<u>Elapsed Time</u> <u>(Minutes)</u>	<u>Frequency of</u> <u>Measurement</u>	<u>Elapsed Time</u> <u>(Minutes)</u>	<u>Frequency of</u> <u>Measurement</u>
0-5	Every 30 seconds	0-5	Every 30 seconds
5-10	Every minute	5-15	Every minute
10-30	Every 2 minutes	15-60	Every 5 minutes
30-60	Every 5 minutes	60-120	Every 10 minutes
60-120	Every 10 minutes	120-480	Every 30 minutes
120-180	Every 20 minutes	480-840	Every hour
180-360	Every 30 minutes	Greater than 840	Every 2 hours
360-720	Every hour		
Greater than 720	Every 2 hours		

- 3.4 After the pumping has stopped, recovery water levels will be measured in the pumping well, the observation well, and in the other nearby wells. In wells fitted with automatic water-level recorders, water levels will be monitored at least until they have returned to equilibrium. Water levels in the pumping well and the observation wells will be measured according to the schedules shown above until at least 90 percent recovery has occurred.
- 3.5 Water samples will be collected from the pumping well initially and every hour throughout the duration of the test. The water samples will be tested for temperature, pH, and specific conductance using field meters. Additionally, the initial and final water sample will be submitted for laboratory analysis of volatile organic compounds (VOCs). The discharged ground-water will be temporarily stored in settling tanks on-site prior to treatment via an air stripper and carbon adsorption, followed by discharge to the sanitary sewer lines. Samples will be collected before and after treatment to document VOC concentrations. Drinking water standards will be documented prior to release to the sewer lines.

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PROJECT _____ WELL _____ SITE _____

SCREEN _____ MEASURING POINT _____ HEIGHT ABOVE _____
 SETTING _____ DESCRIPTION _____ GROUND SURFACE _____

STATIC _____ MEASURED WITH _____ DATE/TIME _____
 WATER LEVEL _____

DRAWDOWN ☐ START OF TEST _____ PUMPING _____
 RECOVERY ☐ END OF TEST _____ WELL _____

DISTANCE FROM WELL _____
 MEASURED TO PUMPING _____
 WELL (r) _____ DISCHARGE RATE _____ ORIFICE _____

[illegible]

1) Dewatering Correction 2) Equivalent Artesian Drawdown 3) pH, Spec. Cond., Temp., Weather, S

G&M Form 10 6-86

TUT 003 0633

Southprint 89-249

APPENDIX I

SAMPLING QUALITY ASSURANCE/QUALITY CONTROL PROTOCOLS

TUT 003 0634

APPENDIX I

SAMPLING QUALITY ASSURANCE/QUALITY CONTROL PROTOCOLS

The objective of the sampling quality assurance/quality control (QA/QC) program is to ensure the reliability and integrity of all data and documentation generated as part of the monitoring program. Major elements of the program are quality control sampling, sample custody and handling, and field-generated data management.

1.0 QUALITY CONTROL SAMPLING

1.1 Field Replicate Samples

1.1.1 One field replicate ground-water and soil sample will be collected and analyzed for every ten samples of that matrix submitted to the laboratory. Care will be taken to ensure that each sample and sample replicate pair can be considered as a homogenous sample split in two.

1.1.2 Each field replicate sample will be given a different sample identification so that it is not identified in the laboratory as a replicate sample.

1.2 Blank Samples

1.2.1 One equipment blank sample will be collected on every day that sampling for laboratory analysis occurs. The equipment blank sample will be analyzed for every parameter analyzed on that day for each matrix. The equipment blank sample will be collected by pouring deionized water through the pre-cleaned bailer so that the rinsate flows directly into the sample container(s). Equipment blanks will be collected for soil samples by preparing a daily rinse of the split spoon. All equipment blanks will be preserved in the same manner as the environmental samples.

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1.2.2 Trip blank samples will be provided by the laboratory and will accompany each cooler of volatile organic analysis vials shipped. Trip blank samples will be analyzed for volatile organic compounds (VOCs) only.

1.2.3 The deionized water used for field and trip blanks will be analyzed immediately prior to beginning field activities to document whether it is free of VOCs, base neutral and acid extractables (BNAs), metals, cyanide, and total petroleum hydrocarbons (TPH) contaminants.

1.3 Spike Samples

1.3.1 Matrix spike/matrix spike duplicate (MS/MSD) samples will be analyzed for VOCs, BNAs, and TPH for each sample delivery group (SDG). One sample volume will be collected for the analysis of the MS sample parameters. One sample volume will also be collected for the analysis of the MSD sample parameters.

1.3.2 Matrix spike and matrix duplicate (MS/MD) samples will be analyzed for metals and cyanide for each SDG. One sample volume will be collected for the analysis of the MS sample parameters and one sample volume will be collected for the analysis of the MD sample parameters.

1.4. Drilling Water

1.4.1 One sample of the water to be used during drilling and well installation will be analyzed for VOCs, BNAs, TAL metals, cyanide, and TPH prior to use.

2.0 SAMPLE CUSTODY

2.1 The sampling team will be responsible for maintaining custody of the samples until they are delivered to the courier for shipment to the laboratory. All samples shipped to the laboratory will be accompanied by the Geraghty & Miller, Inc. chain-of-custody record and by the Geraghty & Miller Laboratory Task Order (LTO). Both forms are attached. The chain-of-custody record will be completed in the field; the original form will accompany the shipment and a copy will be retained in the field project file. The chain-of-custody form will include the project name, the signatures of the sampling team members who participated in collecting the samples, and the following corresponding sample information for each container:

- Date and time of sample collection.
- Sample identification.
- Sample matrix.
- Requested analysis.
- Chemical preservation and pH achieved (if applicable).
- Any special instructions required.

The LTO will be completed prior to the sampling event. A copy of the LTO will accompany the shipment to the laboratory and a copy will be retained in the project file. The LTO will specify to the laboratory the estimated sample number, the type of analyses for each sampling matrix, and the required quantitation limits. In addition, the LTO will specify the required report deliverables format, the anticipated sampling period, the Geraghty & Miller and laboratory contacts, and any other instructions or information relating to the sampling event.

2.2 The copies of the chain-of-custody record and LTO forms will be placed in a plastic bag and taped to the underside of the lid of the cooler.

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- 2.3 Samples will be placed in a clean, dry, undamaged cooler such that there is sufficient packaging material (vermiculite and/or bubble wrap) to prevent bottle breakage. Sufficient ice will be placed in each cooler to ensure that sample temperature is maintained at approximately 4° Celsius until arrival at the laboratory. Ice will be placed in double Ziplock plastic bags. The ice-filled bags will be evenly distributed in the cooler, in order to ensure that all samples are maintained at approximately 4° Celsius. The cooler will be sealed by wrapping nylon-reinforced packing tape entirely around the cooler.
- 2.4 To provide a means of detecting any potential tampering during shipment, all shipment containers (coolers) will be affixed with signed Geraghty & Miller, Inc. sample custody seals (attached). Two seals will be affixed to each cooler, on opposite ends.
- 2.5 The courier service utilized for sample shipment and the number which identifies each shipment will be recorded on the chain-of-custody form. A receipt from the courier service or copy of the airbill that identifies each shipment will be retained in the field project file. Shipment will be arranged such that samples arrive at the laboratory within 48 hours of collection. All samples will be shipped within 24 hours of collection via an overnight courier.

3.0 FIELD-GENERATED DATA MANAGEMENT

- 3.1 Field data and documentation will be recorded in serialized sheets for every day during which activities occur at the site.
- 3.2 Field procedures, measurements, and observations will be described in sufficient detail, so as to enable others to easily reconstruct the field events.

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3.3 The project manager will maintain all project documentation in a central project file. This file will include the following:

- Project plans and specifications.
- Field data and documentation.
- Chain-of-custody record documentation.
- LTO documentation.
- Sample identification documents.
- Laboratory data packages.
- Data review notes.
- Report notes and calculations.
- Final maps and drawings.

4.0 ANALYTICAL DATA MANAGEMENT

- 4.1 Analytical data packages received from the contract laboratory will be compared with the list of analyses requested on the chain-of-custody record to ensure all analyses were performed.
- 4.2 Analytical data received from the contract laboratory (magnetic media or hardcopy) will be validated, reduced, and reported by Geraghty & Miller. Further details are provided in the QAPP (Geraghty & Miller, Inc. 1992a).

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LABORATORY TASK ORDER

Task Order No. _____

Geraghty & Miller Office: _____ Phone: _____ Date: _____
 Address: _____ Project Number: _____
 Laboratory Reporting Level: ☐ I ☐ II ☐ III ☐ IV
 Project Name: _____ Location: _____
 Laboratory: _____ Phone: _____ Contact: _____
 Lab Provides Sample Containers? ☐ Yes ☐ No Date Required: _____ Ship To: _____
 Estimated Date Of Sample Receipt By Laboratory: _____ Report Due: _____
 Reports Delivered To: _____ Number Of Reports: _____
 Work Description: _____
 Send Invoice To: _____

PHYSICAL PROPERTIES	#	Water	Method	Det	#	Soil	Method	Det	NON-METALLICS	#	Water	Method	Det	#	Soil	Method	Det
pH									Acidity								
Spec. Cond									Alkalinity (Total)								
Hardness (Total)									Carbonate								
TDS									Bicarbonate								
TSS									Bromide								
Temperature									Chloride								
Turbidity									Cyanide								
Ignitability									Fluoride								
Corrosivity									Ammonia								
Reactivity									Nitrate								
E.P. Tox. Extraction									TOX								
TCLP Extraction									Nitrite								
E.P. Tox. Complete									Phosphorus								
TCLP Complete									Silica								
METALS*									Sulfate								
Aluminum									Sulfide								
Antimony									Surfactants (MS&S)								
Arsenic									ORGANICS								
Barium									BOD								
Beryllium									COD								
Cadmium									Oil & Grease								
Calcium									TOC								
Chromium									TOX								
Hex Chromium									TRPH								
Copper									Purg. Halocarbons*								
Iron									Non-Halogenated VOCs*								
Lead									Purgeable Arom.*								
Magnesium									Phenols*								
Manganese									Pesticides/PCPs*								
Mercury									PNAs*								
Nickel									Org. Phos. Pest.*								
Potassium									Dioxins								
Selenium									Chlor. Herb.*								
Silver									Volatile Organics*								
Sodium									Semi Volatile Organics*								
Thallium									APPENDIX D*								
Tin									RADIONUCLIDES								
Vanadium									Gross Alpha								
Zinc									Gross Beta								
Priority Pollutant Metals*									Radium 226								
TCL (HSL) Metals*									Radium 228								

* Metals are Total Metals Unless Specified as Dissolved Under Special Instructions * Attach Table of Elements or Compounds to be Analyzed * Includes All Organic and Inorganic Compounds

Special Instructions Or Other: _____

G&M Project Manager Signature: _____ Date: _____ G&M QA Officer Signature: _____ Date: _____
 Laboratory Acceptance: _____ Date: _____ G&M Form 107

☐ No Changes

LABORATORY TASK ORDER AMENDMENTS

Required Change: _____

G&M Representative Signature: _____ Date: _____

TUT 003 0642

APPENDIX J

FEASIBILITY STUDY OUTLINE

TUT 003 0643

APPENDIX J

FEASIBILITY STUDY OUTLINE

1. INTRODUCTION
 - 1.1 General
 - 1.2 Site description and history
2. SUMMARY OF THE TUTU SERVICE STATION INVESTIGATION
 - 2.1 Field investigation
 - 2.2 Investigation results
 - 2.3 Contamination extent summary
 - 2.4 Risk assessment (To be performed by USEPA).
3. OBJECTIVE AND GENERAL REMEDIAL GOALS
 - 3.1 Objectives
 - 3.2 General remedial goals
4. GENERAL RESPONSE ACTIONS
 - 4.1 Overview of transport pathways and exposure routes
 - 4.2 Identification of general response actions
 - 4.3 Identification of applicable remedial technologies
 - 4.4 Prescreening of technologies
 - 4.5 Evaluation of process options
 - 4.5.1 Effectiveness
 - 4.5.2 Implementability
 - 4.5.3 Cost
 - 4.5.4 Innovative technologies
5. DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES
 - 5.1 Alternative 1: No action/limited action
 - 5.2 Alternative 2: Ground-water extraction, treatment, and discharge to surface water
 - 5.3 Alternative 3: Ground-water extraction, pretreatment, and discharge to the Publically Owned Treatment Works

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- 5.4 Alternative 4: Ground-water extraction, treatment, and reinjection
- 5.5 Alternative 5: Other
- 6. SCREENING OF REMEDIAL ACTION ALTERNATIVES
 - 6.1 Treatment Option Screening
 - 6.1.1 Organic chemical treatment Option 1: Granular Activated Carbon (GAC) adsorption
 - 6.1.2 Organic chemical treatment Option 2: Air stripping
 - 6.1.3 Organic chemical treatment Option 3: Air stripping followed by GAC adsorption
 - 6.2 Screening of Ground-Water Migration Control Alternatives
 - 6.2.1 Alternative 1:
 - 6.2.2 Alternative 2:
 - 6.2.3 Alternative 3:
 - 6.3 Summary of screening
- 7. TREATABILITY INVESTIGATIONS
 - 7.1 Introduction
 - 7.2 Data requirements
 - 7.3 Treatability testing - bench scale study
 - 7.4 Summary
- 8. ANALYSIS OF RETAINED REMEDIAL ACTION ALTERNATIVES
 - 8.1 Non-cost criteria analysis
 - 8.1.1 Alternative 1:
 - 8.1.2 Alternative 2:
 - 8.1.3 Alternative 3:
 - 8.2 Cost Criteria Analysis
 - 8.2.1 Capital costs
 - 8.2.2 Operational maintenance costs
 - 8.2.3 Present worth analysis
 - 8.2.4 Sensitivity analysis
 - 8.2.5 Summary of cost evaluation
- 9. REMEDY SELECTION

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APPENDIX K

RESUMES OF KEY PERSONNEL

TUT 003 0646

Ana Gloria Ramos
Zaragoza #2
Villa España
Bayamón, Puerto Rico 00619

Home: (809) 780-5577
Office: (809) 792-2920

Environmental/Safety/Health/Project Engineer

Twenty years of Environmental Protection Safety and Health Management, and all Phases of Project Engineering and Coordination.

EMPLOYMENT HISTORY

Esso Standard Oil Company (Puerto Rico)

Environmental Protection, Safety and Health Coordinator

1985 To Present

- Coordinate all environmental, safety and health efforts and procedures for Esso's Central Caribbean operations which includes Puerto Rico, U.S. Virgin Islands, Dominican Republic and Haiti
- Direct supervision and evaluation of UST assessments and corrective actions under the EPA Underground Storage Tank Regulations for the Esso service stations in Puerto Rico and U.S. Virgin Islands
- In charge of corporate environmental compliance audits at Esso's bulk terminal facilities and service stations
- Corporate coordinator for environmental, safety and health local and federal regulatory affairs, including the following governmental agencies: U.S. Environmental Protection Agency, Puerto Rico Environmental Quality Board, Department of Planning and Natural Resources of the U.S. Virgin Islands; OSHA, OSHO, among other .
- Direct coordinator for all environmental, safety and health consultants retained by Esso for its Central Caribbean operations

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- Responsible for environmental reporting and record-keeping requirements under all applicable federal and local environmental laws and regulations

Union Carbide Caribe Inc. (UCCI) - Ponce, P.R.

Safety & Health Coordinator

1980 to 1985

- Control of annual department budget of \$1MM which led to the reduction of \$300M annually
- Direct Supervision and evaluation of two exempt (Safety and Health Supervisor) and four technicians
- Developed and recommended annual Safety & Health Program, new Safety & Health Procedures, and Mandatory Training program
- Coordinated test, inspection and maintenance of fire and respiratory protection equipment
- Prepared report and analysis of safety statistics, i.e., on-the-job and off-the-job injury analysis, unsafe condition reports, accidents and incident reports, OSHA Form 200 report and Chemical Manufacturers Association injuries report, also classification of injuries in accordance with ANSI.
- Member of multidivision Fire Protection, Process & Personnel Safety and Occupational Health Audit Team
- Conducted in-house safety and health audits every year
- Screened, interpreted and procured line management action of OSHA and PROSHO regulations also of Corporate Safety and Health procedures

Senior Project Engineer

1978 to 1980

- Designed, cost estimated and field inspected a total of \$3MM in capital projects, a partial list follows:
 - Internal Floating Roof installation
 - Unit Control Room building expansion
 - Demineralized water Neutralization System
 - Energy conservation projects (heat exchangers)

- Environmental Protection and Fire Protection related projects

Advanced Project Engineer

1974 to 1978

- ° Designed, cost estimated and field inspected and controlled engineering projects for:
 - Utilities unit including sewer revisions and raw water storage and transfer facilities
 - Wastewater effluent pipe - fiberglass installation
 - Purchased and installed 10 high-speed surface aerators (\$400M) at wastewater Treatment Plant
 - Designed and installed distillation column

Area Project Engineer

1971 to 1974

- ° Designed, cost estimated and implementation of engineering projects

Area Process Engineer

1970 to 1971

- ° Supervised and improved efficiency of operational units (training purposes)

Area Process Engineer

1969 to 1970

- ° Trainee at the Plant Engineering Department becoming familiar with cost estimate procedures, preparation of projects for drafting, reading of troop, electrical, piping and instrument drawings

EDUCATION

- ° B.S. in Chemical Engineering, 1969 - University of Puerto Rico
- ° Radiation Protection Officers West Virginia - 1983 - Obtained License
- ° Construction Supervisors and OSHA New Developments Safety Seminar - 1981

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Ana Gloria Ramos
Resume
Page 4

- ° Interaction Management, (1980); Time Management (1979); Professional Management (Louis A. Allen Associates, 1974)
- ° Fundamentals of Fire Explosion Hazards, AICHE, Charleston, w.Va., 1980
- ° Management and Control of Toxic and Hazardous Substances, CIA, 1979
- ° Advanced Water Pollution Control, University of Texas at Austin, 1974
- ° Process Design in Water Quality, Vanderbilt University, 1973
- ° Annual Environmental Update Seminar of the Puerto Rico Manufacturers Association (PRMA) - (1986, 1987, 1988, 1989)

LANGUAGES English and Spanish

ASSOCIATIONS

- ° Association of Engineers and Surveyors of Puerto Rico P.E. License #5891
- ° Sociedad Profesionales de Prevención de Accidentes de Puerto Rico - 1984
- ° Industrial Hygiene Association of P.R.
- ° Chairperson of the Safety & Health Committee of the Puerto Rico Manufacturing Association (PRMA)
- ° Member of the Environmental Committee of PRMA

TUT 003 0650

SOIL TECH

RESUME

NAME : José C. Agrelot-Peña

ADDRESS : P.O. Box 1704
Hato Rey Station
Hato Rey, P.R. 00919

SOCIAL SECURITY NO. : 583-50-9762

DATE AND PLACE OF BIRTH : July 1, 1951 - Santurca, Puerto Rico

TITLE : Master of Science in Civil Engineering

LICENSE : Puerto Rico No. 7362 - Issued: July, 1975

ACADEMIC PREPARATION :

High School : San José School - Río Piedras, P.R.
1966 - 1969 - General Diploma

University : U.P.R. Mayaguez Campus - Mayaguez, P.R.
1969 - 1974 - Bachelor of Science in
Civil Engineering

U.P.R. Mayaguez Campus - Mayaguez, P.R.
1974 - 1977 - Master of Science in
Civil Engineering, specialized in Soil
Mechanics and Foundations

PROFESSIONAL EXPERIENCE :

1. Soil Tech Corporation

Address: Corner of Amir and Duina Street
Reparto Landrau
Río Piedras, Puerto Rico 00927

Telephone: 792-8900

Responsibilities:

1. President of Soil Tech Corporation
2. Administrative Coordination
3. Report writing, invoicing and personnel supervision.

RESUME

(José C. Agrelot)

2. Partner - Ortiz, Agrelot & Cardona

Address: State Road #838 - Monacillos Ward #1757
Río Piedras, Puerto Rico 00928

Telephones: 751-4994 / 763-4753 / 751-4639

Responsibilities:

1. Report writing and invoicing. Field personnel supervision.

2. Secretary/Treasurer of Corporación Geotec

3. Partner - Paniagua, Rodríguez, García, Crumley & Solum de Puerto Rico, Inc.

Address: Mayaguez Street No. 70
Hato Rey, Puerto Rico 00917

Time Employed: May 1977 until November 1978

Position: Soils and Foundation Engineer

Responsibilities:

Report writing and invoicing. Performance of special laboratory tests. Field personnel supervision.

4. Employer - University of Puerto Rico - Mayaguez Campus

Address: Civil Engineering Department - R.U.M.
Mayaguez, Puerto Rico

Time Employed: August 1974 until May 1977

Position: Instructor

Director of the Soil Mechanics Laboratory
(June 30, 1976 until June 30, 1977)

RESUME

(José C. Agrelot)

Responsibilities:

Teaching Soil Mechanics I - (INCI 441)
 Soil Mechanics Lab. I - (INCI 443)
 Soil Mechanics Advanced Lab. - (INCI 643)
 Soil Mechanics II - (INCI 542)

Director of the Soil Mechanics Laboratories

5. Employer - University of Puerto Rico - Mayaguez Campus

Address: Technical Institute
 Mayaguez Campus
 Mayaguez, Puerto Rico

Time Employed: August 1976 until May 1977

Position: Instructor

Responsibilities:

Teaching Advanced Mathematics

RESUME

(José C. Agralot)

MEMBERSHIP IN PROFESSIONAL SOCIETIES:

1. Associate Member - (American Society of Civil Engineers)
(Section President)
2. Member - "Colegio de Ingenieros y Agrimensores de Puerto Rico"
3. Member - TAU BETA PI Honorary Society
4. Member - American Concrete Institute
5. Member - Home Builders Association
6. Member - Association of General Contractors
7. Member - "Sociedad de Ingenieros Geotécnicos de Puerto Rico"
Past President (1981 - 1983)
8. Member - National Water Works Association
9. Member - Asociación de Recursos de Agua de P.R.
(Past President 1986-1987)

PUBLICATIONS:

1. "Análisis de la Hincia de Pilotes por la Ecuación de Propagación de Onda"
Biblioteca de la U.P.R. - Recinto de Mayaguez - 1977
2. Grouting Caverns and Soft Zones by Concrete Pumps
American Society of Civil Engineers, Grouting in Geotechnical Engineering Specialty Conference - 1982
3. Vacuum: Defense System for Ground Water VOC Contamination
Proceedings of Fifth National Symposium and Exposition of Aquifer Restoration and Ground Water Monitoring, May 21-24 1985.

RESUME

(José C. Agrelot)

4. Investigation, Analysis and Remedial Actions taken for the containment of groundwater contamination in a karst environment. (International Symposium on Tropical Hydrology and Second Caribbean Islands Water Resources Congress, 1985).
5. Run-Off Disposal in the Limestone Region of Northern P.R.
(International Symposium on Tropical Hydrology and Second Caribbean Islands Water Resources Congress, 1985.)

TUT 003 0655



DANIEL A. NACHMAN

Vice President

CREDENTIALS/REGISTRATION

B.S. Geology, New York University, 1973

M.S. Geology, Oregon State University, 1977

Certified Professional Geologist: AIPG No. 6524

Registered Geologist, Commonwealth of Virginia No. 000425

PROFESSIONAL AFFILIATIONS

National Water Well Association

Geologic Association of New Jersey

FIELDS OF SPECIALIZATION

- Regional hydrogeologic assessments and management programs, well head and aquifer protection strategies.
- Exploration and development of ground-water resources.
- Design of test-well and production-well drilling programs.
- Development of well field maintenance and rehabilitation programs.
- Ground-water contamination investigations and design of monitoring programs.
- Evaluation of ground-water flow regimes in complex alluvial, glacial, and other sedimentary depositional environments.
- Interpretation of ground-water quality data.
- Expert testimony.

EXPERIENCE SUMMARY

Mr. Nachman has over 12 years of experience in hydrogeology. He has directed and implemented a wide variety of ground-water supply and contamination studies throughout the United States, particularly in New Jersey, New York, and Puerto Rico. He has developed regional aquifer assessment and ground-water exploration programs for industries, private water companies, and public utilities. He has extensive experience in the design and implementation of remedial investigations under Superfund, RCRA, and state regulations.

Mr. Nachman has lectured at graduate level courses in hydrogeology at Stevens College in Hoboken, New Jersey and at the New Jersey Institute of Technology in Newark, New Jersey. He has also presented several talks on ground-water contamination and aquifer protection at seminars sponsored by various agencies and associations. Mr. Nachman has served as the manager of Geraghty & Miller's Hackensack, New Jersey office and is presently manager of the firm's office in Santurce, Puerto Rico.



DANIEL A. NACHMAN/2

KEY PROJECTS

- Carried out field investigations and supervised test drilling and pumping operations for expansion of the ground-water supply system for the Puerto Rico Water Resources Authority power plant in Aguirre, Puerto Rico. Responsible for data collection and supervision of test drilling at several proposed power-plant sites in Puerto Rico.
- Coordinated and supervised an extensive investigation of existing and potential ground-water resources for the government of the U. S. Virgin Islands.
- Contributed to the preparation of a ground-water management plan and a strategy for assessment of Class V underground injection wells for the U. S. Virgin Islands.
- Coordinated and managed a Remedial Investigation/Feasibility Study (RI/FS) at an industrial facility in northwestern New Jersey, under an Administrative Consent Order issued by the New Jersey Department of Environmental Protection (NJDEP). Study involved geophysical surveys, monitoring well installation, and sampling of ground water, soils, surface water, and surrounding domestic wells, to define contaminant extent and assess the feasibility of remedial alternatives. Served as project officer/senior technical advisor for the Phase II RI.
- Conducted a ground-water contamination and remedial investigation in Morris County, New Jersey. Studies included delineation of two separate contaminant plumes, the design of recovery-well networks for the removal of contaminated water, and the design of injection-well networks for the reinjection of treated ground water. Project involved the preparation of permit applications for working in designated wetlands, injecting treated water, and long-term remediation and monitoring.
- Implemented several projects at an oil refinery in Puerto Rico, including ground-water exploration programs to augment the refinery's water supply; the modification and regular sampling of a RCRA monitoring well network; and a subsurface investigation associated with a fuel spill.
- Assisted property owners and a New Jersey township in evaluating the suitability of a site designated for a hazardous waste incinerator within the hydrogeologic parameters specified in the New Jersey Hazardous Waste Facility Siting Act. The project included field data collection, interpretation of hydrogeologic and climatological data, and the presentation of findings at public hearings. As a result of this study, the site was delisted as a possible incinerator location.

TUT 003 0657



DANIEL A. NACHMAN/3

KEY PROJECTS (Continued)

- Conducted a soil and ground-water quality study at an industrial facility as part of a Superfund investigation at a site in western New York State. Project included collection of soil samples for chemical analysis, monitoring well installation, slug tests, and long-term pumping tests to define the plant production well's capture zone. Coauthored report that assessed the facility's potential as a source of contamination to a municipal well field, and participated in negotiations with the USEPA on the need for additional investigative and remedial work.
- Assisted a township in Sussex County, New Jersey in assessing the state's plan to blend and dispose radium-contaminated soils at a sand and gravel quarry. The project involved preparing an independent environmental site assessment and identifying potential impacts to ground-water quality from the proposed disposal.
- Coordinated a study to identify alternative sources of water for a water company in Burlington County, New Jersey. Project was initiated in response to the state's plan to curtail pumpage from the Potomac-Raritan-Magothy aquifer system. Tasks included identification of sources of ground water and surface water, the selection of test-drilling sites, and predictions of long-term yields from well fields.
- Coordinated an extensive well-field rehabilitation program for a private water company in Essex County, New Jersey. Project included selection of well-development techniques and design of pumping tests to evaluate effectiveness of well redevelopment.
- Responsible for preliminary assessment of ground- and surface-water resources for a resort complex on St. Croix.
- Coordinated a complex seismic investigation on an undeveloped site in Dutchess County, New York. The project included mapping of buried bedrock surface, siting of monitoring wells, and interpretation of subsurface hydrogeologic conditions.
- Assisted with a complex study of ground-water contamination at the Rocky Mountain Arsenal in Denver, Colorado. Compiled geologic and water-quality data, and prepared contaminant distribution maps, cross sections, and water-level maps. Investigated regional aquifer conditions in the area.

TUT 003 0658



DANIEL A. NACHMAN/4

KEY PROJECTS (Continued)

- Supervised drilling operations and prepared reports in connection with ground-water contamination investigations in Pittsfield, Massachusetts, Fort Edward, New York, Baton Rouge, Louisiana, and Rockford, Illinois.
- Designed and managed several projects at industrial properties carried out in compliance with New Jersey's Environmental Cleanup Responsibility Act. Projects involved soil sampling, monitoring well installation and sampling, pumping tests, assessment of remedial alternatives, preparation of cleanup plans, and negotiation with the NJDEP to establish cleanup levels.
- Responsible for several litigation-related projects. Work included evaluation of reports prepared by other consultants, identification of key hydrogeologic and water-quality issues, preparation of expert reports, and presentation of testimony at depositions, public hearings, and court proceedings.

5/91

TUT 003 0659

GERAGHTY & MILLER, INC.



THOMAS V. DANAHY

Senior Scientist

CREDENTIALS/REGISTRATION

B.S. Chemistry and Geology, State University of New York at Cortland, 1982

M.S. Geology, East Carolina University, 1986

Health and Safety at Hazardous Waste Sites - 40-Hour, 1987 and 8-Hour Supervisor, 1990

Registered Professional Geologist: State of North Carolina No. 1039

PROFESSIONAL AFFILIATIONS

National Water Well Association

Geological Society of America

Sigma Gamma Epsilon National Geology Honor Society

FIELDS OF SPECIALIZATION

- Ground-water contamination investigations.
- Assessment of potential NPL hazardous waste sites.
- Regional hydrogeological studies.
- Soil-gas and geophysical surveys.
- Exploration and development of ground-water resources.
- Remedial design for ground-water contamination.

EXPERIENCE SUMMARY

Mr. Danahy has 7 years of experience in hydrogeology and geotechnical engineering. Since joining Geraghty & Miller in 1991, he has been the project manager for a Remedial Investigation and Feasibility Study (RI/FS) in St. Thomas, U.S. Virgin Islands. Mr. Danahy was previously a consultant hydrogeologist with Dunn Geoscience Corporation in Albany, New York. He has also been employed with Law Engineering Testing Company in Greenville, North Carolina and Soil and Material Engineering, Inc. in Raleigh, North Carolina.

Mr. Danahy's experience has been in the fields of geology, chemistry, hydrology, and geotechnical engineering. He has conducted several field investigations, including aquifer evaluations, hazardous waste site assessments, solid waste landfill siting and closure studies, RI/FS projects, and ground-water monitoring programs.

KEY PROJECTS

- Project Manager of a \$1.5 million contract with the New York State Department of Environmental Conservation. Included development of project tasks and budgeting and implementation of hazardous-waste investigations at nine sites.
- Project Manager of an investigation of PCB content and geotechnical characteristics of Hudson River bottom sediment for a proposed hydroelectric facility.



THOMAS V. DANAHY/2

KEY PROJECTS (Continued)

- Project Hydrogeologist/Principal Investigator for a hydrogeologic assessment of a manufacturing facility in Central New Jersey. The assessment demonstrated that the facility was not the source of contamination at a nearby municipal water-supply wellfield.
- Project Manager/Project Hydrogeologist for a hydrogeologic investigation and Closure Design of a solid waste landfill in northeastern New York. Hydrogeologic characterization of the site formed the basis for negotiation of an approved Closure Plan with the New York State Attorney General's Office and New York State Department of Environmental Conservation. Provided technical review of remedial alternatives, closure report preparation, and regulatory liaison/negotiations.
- Project Manager of a hydrogeologic investigation in support of a Petition to Delist a landfill from the New York State Registry of Inactive Hazardous Waste Sites.
- Project Hydrogeologist for a Superfund site in central New York. Conducted a subsurface investigation for the remedial design of groundwater control at this PCB-contaminated site.
- Project Hydrogeologist for a RI/FS of a public-water supply well field contaminated with trichloroethene and tetrachloroethene.
- Project Manager of a closure investigation for a municipal sanitary landfill. The investigation included leachate outbreak mapping, landfill gas evaluation, landfill cover evaluation, leachate and groundwater sampling.

PUBLICATIONS

Danahy, T.V., Howard, W.O. and Wolterding, D.J., 1988, Hydrogeologic and Soil Gas Evaluation of Groundwater Contamination at a Municipal Landfill in New York State, Proceedings of Focus Conference Eastern Regional Ground Water Issues, National Water Well Association pp. 613-633.

Howard, W.O., Danahy, T.V. and Ianniello, M., 1988, An Air-Lift Development System for Deep Wells, Proceedings of Focus Conference Eastern Regional Ground Water Issues, National Water Well Association pp. 559-564.

Danahy, T.V., 1986, Petrology, Depositional Environment and Diagenesis of the Hillsdale Limestone (Mississippian, Meramecian) in Washington County, Virginia, M.S. Thesis, East Carolina University. (Included trace element and stable isotope analysis).

5/91

TUT 003 0661



ALBERTO COLBERG NEVARES

Project Scientist

CREDENTIALS/REGISTRATION

A.D. Liberal Arts, Boston University, 1979

B.S. Geology, University of Puerto Rico, 1985

License for purchase, transport, and use of explosives

SHORT COURSES/SEMINARS

Hazardous Waste Site Activities Health and Safety Training, 1987; Refresher Program 1989

Analysis of Groundwater Data, Oklahoma State University, 1988

PROFESSIONAL AFFILIATIONS

National Water Well Association

Geological Society of Puerto Rico

Puertorican Water Resource Association

FIELDS OF SPECIALIZATION

- Design and implementation of ground-water contamination investigations.
- Monitoring well installation and sampling.
- Specialized product and ground-water recovery systems.
- Field gas chromatography studies; interpretation of ground-water quality data.
- Health and safety procedures for hazardous waste sites.
- RCRA closure plans.

EXPERIENCE SUMMARY

Prior to joining Geraghty & Miller, Inc., Mr. Colberg was employed by Terra Vac, Inc. of San Juan, Puerto Rico for 5 years as a hydrogeologist, project manager, and Health and Safety Officer. He has been involved in ground-water contamination and remediation projects in a wide variety of geologic terrains in Puerto Rico and the United States. He has conducted hydrogeologic investigations at gasoline service stations, has managed a subsurface product recovery project at a petroleum refinery in Puerto Rico, and has extensive experience in the design and implementation of in-situ vacuum extraction systems. Mr. Colberg has prepared and implemented RCRA closure plans for container storage areas and wastewater lagoons for several industrial facilities in Puerto Rico.



CAMERON S. DUNNAN

Staff Scientist

CREDENTIALS/REGISTRATION

B.S. Biochemistry, Brown University, 1985

M.B.A. Rutgers University Graduate School of Management, 1991

PROFESSIONAL AFFILIATIONS

American Chemical Society

National Alumni Schools Program

FIELDS OF SPECIALIZATION

- Analytical chemistry.
- Gas and liquid chromatography.
- Statistical analysis.
- Data validation.
- Data management.
- Technical editing.

EXPERIENCE SUMMARY

Mr. Dunnan has been part of the newly created data validation group at Geraghty & Miller, Inc. since October 1990. He has been involved in the streamlining of the validation process and the standardization of validation reports.

Prior to joining Geraghty & Miller, Inc., Mr. Dunnan was employed as an analytical chemist at a major pharmaceutical corporation. While in the pharmaceutical industry, he was responsible for raw material, finished product, and stability analyses, as well as instrument maintenance and calibration. His other duties included the evaluation, purchasing and set-up of laboratory equipment to support the newly created biotechnology division.

KEY PROJECTS

- Carried out domestic well resampling project for an ECRA site in Warren County, Great Meadows, New Jersey.
- Authored organic and inorganic data validation reports in accordance with USEPA Functional Guidelines for a proposed municipal pool site in Newark, New Jersey.
- Coordinated data management and authored technical memorandum in conjunction with an outside environmental consultant for a ground-water project in Vega Alta, Puerto Rico.



CAMERON S. DUNNAN/2

KEY PROJECTS (Continued)

- Authored multiple organic and inorganic data validation reports in accordance with USEPA-Region III guidelines for water and soil samples from a landfill in South Whitehall Township, Pennsylvania.
- Authored organic and inorganic data validation report in accordance with USEPA Functional Guidelines for a non-regulated environmental site in Dos Campos, Brazil.
- Authored inorganic data validation report in accordance with NJDEP guidelines for a chemical production facility in Morristown, New Jersey.

7/91

TUT 003 0664



LIDYA GULIZIA

Project Scientist
Data Quality Assurance Manager

CREDENTIALS/REGISTRATION

B.S. Microbiology, Rutgers University, 1980

FIELDS OF SPECIALIZATION

- Supervision and administration of environmental laboratories.
- Program management of environmental investigations in laboratories.
- Evaluation of laboratory data.
- Quantitative chemical analysis.

EXPERIENCE SUMMARY

Ms. Gulizia has over 10 years of experience in environmental analysis. Since joining Geraghty & Miller, Inc., Ms. Gulizia is responsible for evaluating data and the capability of laboratories used in support of environmental investigations. Prior to joining Geraghty & Miller, Ms. Gulizia was employed as a project manager at a leading environmental laboratory in New Jersey and worked on federal and state projects for industrial and engineering clients. She has also worked at other leading environmental and toxicology laboratories in California and New Jersey as a program manager and analytical chemist.

KEY PROJECTS

- Participated in administration, marketing and management of large-volume, high-production laboratories and related support services for two environmental laboratories located in California and New Jersey. Tasks included sales promotion, contract review, proposal preparation, staff recruitment and training, identification and allocation of resources, scheduling, tracking and supervision.
- Administered quality assurance/quality control (QA/QC) program for environmental laboratory facility in New Jersey. Responsibilities included monitoring of laboratory operations for adherence to QA/QC program, identifying deficiencies, implementing corrective actions, preparation of laboratory standard operating procedures and performing audits. Maintained laboratory certifications and pursued new accreditations for expansion of laboratory services and capabilities.
- Administered environmental, health and safety program for environmental laboratory facility in New Jersey. Performed safety and hazard communication training for all personnel in compliance with the Resource, Conservation and Recovery Act (RCRA) and the Occupational Health and Safety Act (OSHA) requirements. Managed on-site chemical inventory including hazardous waste and materials. Manifested waste off-site for treatment or disposal. Participated in various facility audits and inspections conducted by local, state and federal agencies.

TUT 003 0665



LIDYA GULIZIA/2

KEY PROJECTS (Continued)

- Coordinated laboratory operations in support of environmental assessments for federal, state and private sectors. Provided daily and long-term program management on several National Priority List (NPL) site investigations, federal facilities, and both active and closed industrial sites. Evaluated laboratory deliverables for adherence to client requirements and regulatory agencies using the USEPA Contract Laboratory Protocols (CLP), the Department of Energy's (DOE) Hazardous Waste Remedial Actions Program (HAZWRAP), the US Navy Installation Restoration Quality Assurance Program (NEESA) and various state guidelines.
- Performed a preliminary assessment to evaluate overall data quality and compliance to program objectives on an ECRA site in Great Meadows, New Jersey.
- Evaluated environmental data using USEPA Functional Guidelines for data validation for a site in St. Thomas, U.S. Virgin Islands. Assessed laboratory capability to provide analyses in support of drinking water supply investigations.
- Coordinated review of and response to a NJDEP BEECRA data evaluation for an ECRA site in Hudson County, New Jersey. Provided recommendations and justifications for incorporation into future sampling plan revisions.

8/91



CLINTON MOFFATT

Staff Scientist

CREDENTIALS/REGISTRATION

N.1 Industrial Wastewater Treatment Operator
New Jersey Professional Weighmaster No. 24657

FIELDS OF SPECIALIZATION

- Wastewater treatment.
- Development and implementation of site health and safety plans.
- Industrial hygiene surveys.
- Aquifer and air monitoring instrumentation.
- Superfund remedial action oversight.
- Administration of ASTM Standard Tests.
- Field inspection and documentation.

EXPERIENCE SUMMARY

Since joining Geraghty & Miller, Inc., Mr. Moffatt has been involved in ground-water treatment, aquifer pumping tests, installation of monitoring wells, soil borings, development and implementation of site health and safety plans, report preparation and review of contractor proposals.

Prior to joining Geraghty & Miller, Inc., Mr. Moffatt was employed as a Health and Safety Officer at a leading environmental consulting firm. His responsibilities included developing and implementing health and safety plans, conducting industrial hygiene surveys, and providing Superfund remedial action oversight.

Mr. Moffatt was previously employed as a laboratory and field technician with a leading geotechnical engineering firm, where his responsibilities included site coordination during foundation distress investigations and administering ASTM Standard Tests.

KEY PROJECTS

- Served as health and safety officer during a Superfund Remedial Action project in Bridgeport, New Jersey. Project involved the incineration of on-site contamination, backfilling and grading to natural topography, and water treatment.
- Served as Health and Safety Officer and field inspector on a Superfund Remedial Action Project in Marlboro, New Jersey. Project involved excavation of contaminated soil, solidification of lagoon sludge, hauling of contaminated material to landfills, backfilling, grading, construction of clay cap, and vegetation.



CLINTON MOFFATT/2

KEY PROJECTS (Continued)

- Assisted in field investigations of sites throughout New Jersey, New York, Virginia, Nevada, Pennsylvania and Colorado. Activities included air quality surveys, aquifer pumping tests, geophysical investigations, in-place density testing, and soil, ground-water and lagoon sampling.

9/91

TUT 003 0668