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Underground Fuel Investigation Tow Way Fuel Farm U.S. Naval Station

Roosevelt Roads, Puerto Rico

Contract No. N62470-90-B-7626

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FINAL REPORT

UNDERGROUND FUEL INVESTIGATION

TOW WAY FUEL FARM

U.S. NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CONTRACT NO. N62470-90-B-7626

NAVAL FACILITIES ENGINEERING COMMAND

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SECTION 1 - INTRODUCTION

1.01 Purpose and Scope

O'Brien & Gere Engineers, Inc. was retained to provide the hydrogeological services necessary to investigate the hydrogeology and to evaluate the extent of sludge disposal and petroleum loss from storage tanks at the Tow Way Fuel Farm, (TWFF) U.S. Naval Station - Roosevelt Roads, Puerto Rico.

The purpose of this report is to present the background information that has been collected regarding the history of fuel losses and to evaluate the hydrogeologic conditions. In addition, the extent of free phased product and dissolved petroleum hydrocarbons in the ground water in the vicinity Tow Way Fuel Farm was evaluated.

1.02 Site Description

The U.S. Naval Station - Roosevelt Roads, Puerto Rico is located on the eastern end of the island of Puerto Rico. The base is bordered by the Caribbean Sea on three sides, and the Commonwealth of Puerto Rico borders the western edge of the base (Figure 1).

The Tow Way Fuel Farm, the specific area of this investigation extends approximately 2100 ft inland. The terrain of the lower fuel facility gently slopes upward toward the upper Tow Way Fuel Facility, and rises only a few feet above sea level. The fuels distribution system, fuels operations offices, and fuel laboratory are located in the lower facility. Forrestal Drive serves as the approximate dividing line between the lower and upper Tow Way Fuel Facility. The upper Tow Way Fuel facility consists of terrain which exhibits moderate relief, it rises approximately 70 ft.

above sea level and extends from approximately 700 ft to 2100 ft inland. The upper facility consists of seven fuel storage tanks containing primarily diesel and JP-5 fuels. (Figure 2)

1.03 Fuel Loss History

Seven fuel storage tanks are located north of Tow Way Road on a hill overlooking Ensenada Honda (Figure 2). As referenced from the NEESA report 12-051, September 1984, spills, leaks, and sludge disposal have occurred here since 1957.

In 1957 or 1958 a fuel line to Tank 82 leaked, resulting in a spill of Bunker C fuel. It is estimated that approximately 420,000 gallons of Bunker C fuel leaked from the storage tank. The oil spill followed a path downhill toward the harbor in a southwesterly direction towards Ensenada Honda, extending to the shoreline and the Ensenada Honda mangrove swamp across the harbor.

It is also estimated that approximately 420,000 gallons of fuel spilled from Tanks 56A and 56B, onto the surrounding soil over a 15- to 20-year period. The tanks were removed in February 1984. A dark fuel-stained soil was present around the old tanks. Isolated pools of oil from the spills and leaks were evident on the ground water that seeped into the holes where the tanks had been removed.

Between 1971 and 1972, Tanks 83 and 1080 were cleaned and the Bunker C fuel-sludge was emptied into two pits dug within a 100-foot radius of the tanks. One pit was dug approximately 100 feet in circumference and 10 to 20 feet in depth near Tank 83; the second pit was 50 feet in circumference and 10 to 20 feet in depth near

Tank 1080. It is estimated that 3,900 to 7,500 cubic yards of Bunker C fuel-sludge were cleaned from the tanks and disposed of at the site in these pits.

In 1978 a leak occurred a Tank 1080, resulting in the release of about 65,000 gallons of diesel fuel from the tank. It is estimated that about 10,000 gallons were recovered during cleanup operations.

In November, 1986 Tank 85 leaked approximately 91,000 gallons of JP-5. Approximately 12,000 gallons were recovered on land and 10,000 gallons were recovered from water. Another 10,000 gallons were trapped in sand under the tank. As a result approximately 59,000 gallons were unaccounted for during the spill (NAVSTA, Roosevelt Roads 1992).

Contaminants could migrate from the site by surface and subsurface flow. Oil-stained ground at the site clearly depicts the surface flow pattern from the bermed fuel farm through culverts to an outlet into Ensenada Honda, where oil booms are left in place to catch the oil that still emerges after rainfall. Diesel fuel was observed on top of water in the holes where Tanks 56A and 56B were removed (NEESA, September 1984).

SECTION 2 - SITE INVESTIGATIONS

2.01 Soil Boring Completion and Sampling

All site investigations were conducted in accordance with procedures, U.S> Navy Specifications, and protocols outlined in the O'Brien & Gere Engineers, Inc. Preliminary Report, Underground Fuel Investigation, January 1991. This report was approved by the Commonwealth of Puerto Rico Environmental Quality Board (EQB) in a letter dated January 28, 1991. In addition, an EQB representative conducted a site visit on Friday, March 8, 1991. The EQB representative approved the investigative approach and methods.

Ten test soil borings were completed to an average depth of 15 ft. Soil boring locations were selected to evaluate the extent of soil contamination associated with the petroleum product loss. The soil borings were completed using hollow-stem auger drilling methods with continuous split spoon sampling techniques per ASTM-D-1586-84. Locations of soil borings are illustrated in Figure 2.

Samples of subsurface materials were collected continuously in 2 ft intervals at each boring. Upon retrieval of the sampling spoon, the sample was screened using a photoionization detector (PID) and visually described by the on-site hydrogeologist. One sample was collected from each split spoon and placed in a precleaned 4 oz sediment jar and stored in a cooler on-site. In soil borings located in the lower fuel facility (B-1 and B-2), soil from the water table to 5 feet above the water table was composited into one sample for laboratory analysis. In the upper fuel facility, where depth to the water table exceeded 20 ft, soil from a depth of 10 to 16 ft in soil borings B-3 to B-10, was composited into one sample for laboratory analysis. Based

on photoionization detector data, two additional samples exhibiting the highest PID reading per soil boring were submitted for laboratory analysis. All soil samples were analyzed for E.P. Toxicity Metals (EPA Method 6010-700 Series, total Halogens (EPA Method 9020), flash point, and total petroleum hydrocarbons (EPA Method 418.1) by Quantum Laboratories of San Juan, Puerto Rico. All soil borings were backfilled with a mixture of auger cuttings and bentonite pellets. The upper six inches was capped with a portland cement/bentonite grout. Soil test boring logs are provided in Appendix A.

2.02 Ground Water Monitoring Well Installations

A total of eighteen ground water monitoring wells were installed throughout the TWFF facility. The wells were installed from February 25 to April 4, 1991 by Jaca & Sierra Testing Laboratories of San Juan, Puerto Rico, under the supervision of an O'Brien & Gere Engineers, Inc. hydrogeologist. The well locations were based upon a preliminary evaluation of the hydrogeologic conditions, location of utility lines in the area, and all newly installed monitoring well results. The placement of the wells, as illustrated on Figure 2, has been selected to provide an assessment of the extent of any product pool floating in the ground water, the extent of dissolved petroleum hydrocarbons in the study area, and an evaluation of the hydrogeologic conditions.

Ground water monitoring wells were installed using conventional hollow stem auger drilling methods. A minimum of 3-3/4-inch ID augers were utilized for drilling of all monitoring wells. During drilling, subsurface samples were obtained in accordance with techniques outlined in ASTM-D-1586-84. Two foot samples were

collected continuously from the upper six feet, and at 5 foot intervals from the remainder of the boring. All soil samples were visually described by the supervising hydrogeologist and screened in the field for volatile compounds using a photo-ionization detector (PID). Borings were advanced 7 ft to 8 ft below first encountered ground water so as to provide a 2 ft to 3 ft section of screen extending above the ground water. Monitoring well soil boring logs and well specification diagrams are included in Appendix A.

Ground water monitoring wells were constructed with 2-inch ID, flush joint, schedule 40 PVC slotted well screens and riser casing. Screens were 10 ft in length with .010 inch slots, with the exception of monitoring wells UGW-5 and UGW-17 which were constructed with 20 and 15 foot long well screens, respectively. A silica sand filter pack was installed into the annular space surrounding the well screen extending to approximately 2 ft above the top of screen. A bentonite pellet seal, at least 1 ft thick, was installed above the filter pack and hydrated if necessary. Finally, a grout mixture of two parts sand and one part cement was thoroughly mixed with the specified amount of potable water and installed above the bentonite seal to the ground surface. To complete each monitoring well, a non-traffic area wellhead was constructed in accordance with Naval UST monitoring well specifications. Monitoring well, UGW-9, was completed with a traffic area type wellhead. Monitoring well specifications are summarized in Table 1.

Following well installations, all wells were developed to clear the well of fine grained materials introduced into the well during installation. Well development also ensures that representative ground water samples and elevations are being transmitted by the well screen. The well development was accomplished by hand

bailing with a bottom-loading stainless steel bailer until discharged ground water became relatively sediment free.

2.03 *Insitu* Hydraulic Conductivity Tests

Insitu hydraulic conductivity tests (k-tests) were performed on the monitoring wells to obtain estimates of the aquifer hydraulic conductivity in the vicinity of the wells. This data is useful in evaluating the horizontal ground water flow velocity.

To complete the k-tests, a potential hydraulic difference was created between the well being monitored and the surrounding aquifer. The k-tests were performed using a rising head test in which, a volume of water was removed from the well, creating a measurable decrease in the water level in the well. The rate of recovery was then measured for an appropriate amount of time until the water level in the well approached equilibrium with the water in the surrounding aquifer. K-tests were not performed on wells that contained a significant amount of product.

The field data was reduced using the Bouwer & Rice Method to estimate the hydraulic conductivity at the screened portion of each well. Table 1 provides a summary of the calculated hydraulic conductivities, and the field test analysis data is included in Appendix B.

2.04 Ground Water Elevation and Product Thickness Monitoring

After completing monitoring well installation efforts, a field instrument survey was performed to determine the horizontal locations and vertical elevations of the monitoring wells. The field instrument survey was performed to provide datum

control and ground water elevation data necessary to evaluate on-site ground water flow conditions. All elevations were tied into the U.S. Geological Survey datum.

A complete round of ground water elevations and product thickness measurements was collected on March 29 and April 4, 1991. Ground water elevation and product thickness data is included in Table 1 and Table 2, respectively. The ground water elevations from the wells that contained free product were corrected for the product thickness. Free product floating on the ground water surface depresses the water table by an amount proportional to the specific gravity of the particular product. The correction calculation typical for a petroleum product is noted on Table 3. Corrected ground water elevations were not used to develop ground water elevation maps due to inaccuracies in the correction factor (i.e., fuel type, degree of fuel degradation, quantity of fuel, etc.).

2.05 Ground Water Sampling

Ground water samples were collected from the newly installed monitoring wells on one occasion, in accordance with the procedures included in Appendix C. The ground water samples were analyzed for Volatile Aromatic and Unsaturated Organic Compounds (EPA Method 503.1) to evaluate the extent of dissolved petroleum hydrocarbons as a result of the free-phased existence of the petroleum product detected on the ground water surface. The analytical parameters and results are summarized on Table 5.

Prior to sampling, three to five well volumes were purged from each well. Ground water samples were collected from each well using a bottom loading stainless steel bailer. Subsequent to collection, custody of the samples were transferred to a

representative of Quantum Laboratories, Inc. in San Juan, Puerto Rico for analysis. Quality assurance/quality control (QA/QC) samples were also submitted for the same analysis, including an equipment blank, trip blanks, and a duplicate sample for the purpose of evaluating the sampling and analytical methods. Ground water sampling field logs are included in Appendix C. Analytical results and chain of custody forms are included in Appendix D.

SECTION 3 - INVESTIGATION RESULTS

3.01 Soil Sampling Results

A subsurface soil sampling program was initiated to evaluate the extent of any soil contamination associated with historic product loss. Soil borings locations were selected based on areas where petroleum product loss and sludge disposal was suspected to have occurred. Tables 3 and 4 summarize organic and inorganic analytical results respectively. Laboratory soils data are included in Appendix D.

A review of these data indicate detectable concentrations of total petroleum hydrocarbons (TPH) exist in all soil borings. Soil borings B-1 through B-5 exhibited elevated concentrations of total petroleum hydrocarbons with respect to the EQB cleanup guideline of 100 ppm (EQB May, 1991). Soil borings B-1 and B-2, which are located in the vicinity of Tanks 56A and 56B exhibit TPH concentrations ranging from 270 parts per million (ppm) in B-1 at 6-8 ft to 2,087 ppm in B-1 at 4-6 ft. Concentrations in boring B-2 ranged from 422 ppm at 4-6 ft to 1816 ppm at 6-10 ft. Soil borings B-3 to B-5 were located adjacent to Tank 83. Soil boring B-3 exhibited the highest levels of TPH concentrations, ranging from 2900 ppm at 12-16 ft to 22,850 ppm at 4-6 ft. The soil boring log for B-3 indicates that a black "tar-like" substance was encountered at a depth of 4-6 ft. TPH levels in boring B-4 were 54 ppm at 6-8 ft to 3,019 ppm at 10-14 ft. Boring B-5 exhibited TPH levels ranging from 6.2 ppm at 2-4 ft to 166.6 ppm at 4-6 ft. TPH concentration in borings B-6 to B-10 were noted in the 2 to 6 foot intervals and ranged from 3.5 ppm in B-7 (2-4 ft) to 54.5 ppm in B-6 (4-6 ft).

The Total Organic Halogen (TOX) analysis results revealed that no detectable concentrations of TOX constituents were observed in the soil samples.

The soils were analyzed for E.P. Toxicity Metals to evaluate if the soil could be characterized as hazardous. The results, summarized in Table 4, reveal that in general no the metal concentrations do not exceed the U.S. EPA maximum concentration of contaminants for the toxicity characteristic (40 CFR 261.4). However, one sample from test boring B-2 detected a cadmium level of 1.7 ppm which is slightly above the EPA maximum level of 1.0 ppm.

Results of the flashpoint analysis indicated that the flashpoint for all soil samples is greater than 140°F. This indicates that the soils do not present an ignitability or explosive hazard.

3.02 Hydrogeologic Conditions

3.02.1 Regional Geology

Puerto Rico is the smallest and easternmost of a group of volcanic islands (Cuba, Jamaica, Hispaniola, and Puerto Rico) called the Greater Antilles[1]. In general, the island is divided into seven physiographic units[2], Monadnock, peneplains, foothills, interior lowlands, playas and alluvial plains, and finally a belted, north-south coast zone, which runs parallel to the north coast and primarily consists of several distinct limestone groups. Outside this northern belted limestone zone, the island geology is predominantly a combination of intrusive and extrusive igneous formations (4).

3.02.2 Site Geology

The geology in the vicinity of the Tow Way Fuel Farm (TWFF) consists of a playa, or a flat, gently sloping alluvial plain, which is located along the coast and rises only a few feet above seal level. This playa appears to consist of marine deposits (i.e. silty sand, seashells, seaweed) ranging in thickness from 15 feet in monitoring well UGW-10, to greater than 22 feet in monitoring well UGW-6 . The playa extends approximately 100 feet inland at monitoring wells UGW-10 and UGW-11, and up to 500 feet inland to monitoring well UGW-6. This playa interfingers with and overlies a highly weathered, predominantly igneous bedrock. The overburden consists of a weathered, poorly sorted, very dense silty, fine to coarse sand and gravel matrix. This weathered overburden extends from between 100 to 500 feet inland to the upper boundaries of the TWFF, and exhibits moderate relief, rising to 70 feet above sea level at soil boring B-9.

3.02.3 Ground Water Flow Conditions

Ground water elevations were collected on two separate occasions March 29 and April 4, 1991 and is summarized on Table 1. A complete set of elevations was collected on April 4, 1991, subsequent to the completion of all monitoring well installations. A ground water elevation map, illustrating representative site ground water elevation and flow conditions has been prepared from both sets of data, and are included as Figures 3 and 4, respectively.

A comparison of the ground water elevation data and the test boring logs reveals that the ground water elevations within the monitoring wells have risen above the zone where saturated soil conditions were encountered. This data is summarized on Table 1. The condition is indicative of a semi-confined aquifer where the static ground water elevation within the wells occur above the top of the aquifer. Under semi-confined aquifer conditions encountered at the site the ground water and any immiscible product layer enters the screened interval of most of the monitoring wells and rises to a static level above the top of the well screen.

The semi-confined aquifer conditions can be demonstrated through the review of the well data for monitoring wells UGW-4 and UGW-14. At these locations saturated soil conditions and petroleum product within the aquifer were encountered within ten feet of the bottom of the borehole, below the top of the well screen. However, a review of the well data reveals that following well installation the static level of the product layer and the corrected ground water elevation is at least ten feet above the well screen. The top of the well screen at each of these wells was set at a minimum of one foot above the top of the aquifer (as indicated on Table 1 as the first encountered saturated condition). This data confirms that the ground water and product are entering the wells below the top of the well screens and rising inside the well. Semi-confined aquifer conditions were also encountered at monitoring wells UGW-1, 3, 4, 8, 9, and 10. At each of these locations the top of the aquifer (first encountered saturated conditions) occurs below the top of the well

screen, however, the water level and/or product layer occurs above the well screen.

As Figures 3 and 4 illustrate, the TWFF ground water flows predominantly southwest towards Ensenada Honda. A slight deflection of ground water flowing towards the south is noted in the southeast corner of the TWFF. This deflection is most likely attributed to topographic effects presented by a bedrock controlled hill bordering the eastern edge of the TWFF. Figure 3, depicting ground water flow derived from the set of data available from March 29, 1991, is consistent with the data and flow conditions present on April 4, 1991.

A hydraulic gradient of .004 ft/ft to .006 ft/ft exists in the vicinity of the TWFF. Review of the *insitu* hydraulic conductivity data summarized in Table 1 indicates a range of hydraulic conductivities of 6.1×10^{-6} cm/sec (.017 ft/day) to 1.4×10^{-4} cm/sec (.4 ft/day).

An estimate of the water transmitting capacity of a geologic formation can be estimated from hydraulic conductivities and gradients at the site. The average linear ground water flow velocity can be approximated using the following equation:

<u>Darcy's Law</u>

$V = Ki/n$

Where

V = velocity (ft/day)

K = hydraulic conductivity (.017 ft/day to .4 ft/day)

i = hydraulic gradient (.004 ft/ft to .006 ft/ft)

n = average porosity (20-45 percent, based on typical values for silty sand and gravel mixtures)

Using Darcy's Equation, it is estimated that the average linear ground water flow velocity in the vicinity of the TWFF is in the range of .0015 to .053 ft/day.

3.03 Ground Water Quality

3.03.1 Free Product Assessment

Product thickness measurements were collected from the monitoring wells on March 29 and April 4, 1991. The product thickness data is summarized on Table 2. This product thickness data was used to develop Free Product Plume Maps (Figures 5 & 6). As depicted on Figures 5 and 6, an extensive free product pool exists, with the center located in the vicinity of monitoring well UGW-1, which contained 14.21 feet of product on March 29, 1991. The major plume axis trends from well UGW-14 downgradient to the southeast approximately 600 ft. Monitoring wells UGW-14 and UGW-17 identifies the approximate edges of the plume axis, and contain 1.11 feet and 2.98 feet of free product, respectively. The plume width is approximately 250 feet, with a bedrock controlled hill controlling the northeastern edge of the plume. Previously installed monitoring well GW-04 identifies the approximate southwestern border of the plume, and contains 2.94 feet of free product. Free product thickness data collected on March 29, 1991 (Figure 5) is

consistent with the data and plume evaluation observed on April 4, 1991 (Figure 6).

3.03.2 Ground Water Analytical Results

A single round of ground water samples were collected from March 28 to April 4, 1991 in accordance with procedures outlined in Appendix C. Field sampling logs are also included in Appendix C. The ground water samples were analyzed for volatile aromatic and unsaturated organic compounds using EPA Method 503.1, and for lead by atomic absorption. Ground water laboratory analytical results are included in Appendix D and summarized in Table 5. Figure 7 illustrates the distribution of total benzene, toluene, ethylbenzene, and xylenes (BTEX) across the TWFF site. Monitoring well UGW-1, which exhibits 283,149 ppb total BTEX, contains free phase product only. Monitoring wells UGW-4, UGW-5, UGW-12, UGW-13, and UGW-14 which all contained free phase product, exhibited total BTEX concentrations ranging from 1890 ppb in UGW-12 to 70,105 ppb in UGW-13. It is likely that the existence of free phase product in ground water samples from these wells resulted in high total BTEX concentrations.

Downgradient monitoring wells UGW-6 and UGW-15 contained 12,273 ppb and 2490 ppb total BTEX respectively. No free phase product was observed in these monitoring wells.

Dissolved lead concentrations in the ground water ranged from 61 ug/L ppb in UGW-17 to 167 ppb in UGW-15. The free phase product sample from UGW-1 exhibited 3,580 ppb lead concentrations. All ground

water samples exhibit lead concentrations which exceed the U.S. EPA maximum contaminant level (MCL) of 0.05 mg/L (50 ppb) in drinking water.

SECTION 4 - REMEDIAL ALTERNATIVES

4.01 General

The following assessment of remedial alternatives focuses on the mitigation of petroleum hydrocarbons in the subsurface at TWFF. When petroleum products impact the ground water, actions are required to clean up the ground water and the affected soils. If the petroleum products reach the ground water in sufficient quantity to form a floating layer, recovery of the free phase product on the ground water should also be considered. Based on the results of the hydrogeologic study conducted at the facility, the *insitu* and non-*insitu* technologies discussed below are deemed to be the most appropriate technologies for consideration by the Navy. In addition to any corrective actions, measures should be taken to alleviate the source of product.

4.02 In-Situ Alternatives

Ground Water Containment

Ground water containment is a process by which an area of concern is separated from the surrounding environment, thereby minimizing the migration of hydrocarbon compounds. This separation may be accomplished by the installation of cut-off walls, grout curtains, and/or slurry walls. A ground water cut-off wall could be installed around the area to collect and prevent further migration of the contaminants. The wall should extend down to a layer of low permeability stratum. In the event that such a stratum is not present at a reasonable depth, a hanging wall could be constructed. A hanging wall would adequately isolate any floating product

but would allow soluble constituents to migrate under the wall. Although ground water containment prevents further migration of the floating product, destruction of compounds in or on the ground water is not accomplished. An additional system would be required to mitigate the compounds within the containment area.

Volatilization

This process removes volatile compounds from the soil by forced or drawn air currents. A system of air injection and extraction pipes are placed over and around the area of the contaminant plume. Volatilization can be used to effectively treat large volumes of soil that would be impracticable to excavate. Air is injected and/or withdrawn from the pipes, treated (if required), and allowed to return to the atmosphere. Volatilization can be effective in removing a wide range of volatile compounds over a wide range of conditions. The controlling mechanisms for vapor diffusion is site-specific and may be easily evaluated through small scale pilot testing.

Aerobic Biodegradation

Biodegradation is a process by which the growth and activity of naturally occurring microorganisms are stimulated to degrade the compounds of interest. Stimulation of microbial growth and activity for hydrocarbon removal is accomplished through the addition of oxygen and nutrients. Ground water is pumped to a mixing tank were the ground water is biologically treated under controlled conditions. After treatment the effluent is either injected back into the ground or sprayed over an infiltration gallery. There are several factors that dictate the appropriateness of biodegradation. These include, but are not limited to the following: 1) availability

of nutrients; 2) type of hydrocarbon available; and 3) concentration of the compound of concern. To evaluate the various site specific parameters, pilot testing would be required to design an efficient biodegradation system for the site.

Soil Leaching

This is a process that is generally used to remove petroleum products that are immobilized in the unsaturated zone. Water is introduced to the soil by means of either gravity (flooding or infiltration galleries) or injection pipes. The water introduced into the soil, remobilizes the product, and the water is subsequently recovered and treated. Surfactants are occasionally introduced along with the water to increase the leaching of the soils. Choosing a surfactant requires laboratory testing and evaluation of the surfactants chemical and environmental properties. This technique is applicable for the treatment of large areas of contaminated soils after the source of contamination has been removed.

4.03 Non-*In-Situ* Alternatives

Product Interceptor Trenches

For shallow contamination problems, particularly in strata with low or highly variable hydraulic conductivity, trenches can be a cost effective option. A trench is excavated across the down gradient front of the contaminant plume. Pumps remove ground water from the trenches influencing the migration of free phase product towards the trenches. The free phase product would be removed, and the contaminated ground water that remains would be collected and treated. Trenches should be installed below the water table, and to be most effective, in areas were the

amount of free product is greatest and were limits to the trenching operations are minimal.

Excavation

Excavation is the process by which affected soils are removed from the site for disposal. Although excavation removes the soil it does not help to remediate the ground water. This technique has been used at numerous sites because it allows an immediate site clean-up of contaminated soils. However, the high costs and issues involving the disposal of the excavated soils generally suggests that other alternatives should be further investigated.

Ground Water Extraction and Treatment

This system requires the installation of a treatment facility and a number of recovery wells within the product plume to collect and treat free phase and/or dissolved hydrocarbons on or in the ground water. The number of wells and the design requirements for the wells would be identified following an evaluation of the aquifer characteristics at the site and the extent of remediation required. The wells commonly screen the water table and extend several feet into the saturated zone. Recovery pumps are installed in the wells; one to remove ground water and induce migration of free phase product towards the wells, and one to remove the free phase product that enters the well. Ground water that is removed generally contains dissolved petroleum hydrocarbons and may require treatment before being either injected back into the ground or discharged. The advantages of this system include

the removal of the highest concentrations of contaminants from the ground water and the prevention of downgradient migration of the contaminant plume.

4.04 Recommended Alternatives

4.04.1 Ground Water Remediation

Review of site hydrogeologic conditions and free-phased product delineation results indicate a ground water extraction and treatment system would provide the most cost-effective remedial alternative for the Tow Way Fuel Farm.

Prior to full scale implementation of this alternative, a test system should be constructed to facilitate incorporation into the complete system at a later date. This test system would consist of a test well and pumping system. At first, an aquifer pump test would be performed to evaluate aquifer characteristics. Based upon these characteristics a full scale system would be designed for the removal of free phase product, as well as dissolved hydrocarbons in the ground water.

4.04.2 Soils Remediation

Although significant total petroleum hydrocarbon (TPH) concentrations were observed in several soil borings, the full extent of TPH concentrations with respect to EQB guidelines should be further defined before initiating soils remediation.

To further define TPH concentrations within the soils it is recommended that additional test borings be installed and soil samples analyzed TPH.

SECTION 5 - CONCLUSIONS AND RECOMMENDATIONS

5.01 Conclusions

Based on the results of the investigations conducted in the vicinity of Tow Way Fuel Farm, the following conclusions can be derived:

- Results of soil borings B-1 and B-2, located in the vicinity of Tanks 56A and 56B indicate petroleum hydrocarbon (TPH) concentrations of the soils to be greater than the EQB cleanup guidelines.
- The results of soil borings B-3, B-4, and B-5 indicate TPH concentrations of soils greater than EQB cleanup guidelines downgradient of Tank 83. In addition, the presence of a tar-like substance in boring B-3 indicates the potential of a sludge pit existing in this vicinity.
- Traces of TPH concentrations exist in shallow soils in borings B-6 through B-10, but below EQB cleanup guidelines.
- With the exception of the cadmium level at B-2, EP Toxicity Metals concentrations for soils were found to be below U.S. EPA maximum concentration limits.
- The site geology consists of alluvial sands and silts near the shore of the Ensenada Honda, and extends between 100 feet and 500 feet inland. These alluvial sands overly and interfinger with highly weathered igneous bedrock, defined by poorly sorted very dense, silty fine to coarse sands, and gravels.
- Site ground water flow is predominantly to the southwest at a rate of .0015 ft/day to .053 ft/day.

- *Insitu* hydraulic conductivity test results indicate hydraulic conductivities at the site range from 6.1×10^{-6} cm/sec (.017 ft/day) to 1.4×10^{-4} cm/sec (.4 ft day).
- A free phase product pool exists in the vicinity of Tanks 56A and 56B, confirming historic losses from these tanks.
- Free phase product measurements indicate that a plume exists in the vicinity of UGW-1, which contains approximately 14 ft of free product.
- Analytical results of ground water samples from downgradient monitoring wells UGW-6 and UGW-15 indicate total BTEX concentrations of 12,273 ppb and 2490 ppb, respectively. These results indicate the presence of dissolved petroleum hydrocarbons in excess of USEPA MCLs in the ground water.
- Total dissolved lead concentrations exceed the U.S. EPA maximum contaminant level (MCL) of 50 ug/L in all of the monitoring wells.

5.02 Recommendations

Based on the conclusions stated above, the following recommendations are made:

1. A recovery well should be installed adjacent to monitoring well UGW-17, and an aquifer performance test should be conducted on this well to evaluate the hydrogeologic characteristics of the aquifer. This will provide the preliminary design data required for the design and installation of a ground water and free phase product recovery and treatment system. At a minimum, two additional recovery wells should

be installed adjacent to monitoring wells UGW-1 and UGW-12. The need for any additional recovery wells should be evaluated based on results of the aquifer performance test.

2. Based on the results of the aquifer performance test, the design and installation of a ground water recovery and treatment system should be implemented to remove the free phase product layer and remediate the dissolved hydrocarbons in the ground water.

3. Additional soil borings should be installed to further define TPH concentrations. Soil samples should be analyzed for TPH and lead.

References

O'BRIEN & GERE

REFERENCES

1. Naval Energy and Environmental Support Activity (NEESA); Initial Assessment Study of Naval Station Roosevelt Roads, Puerto Rico; Port Hueneme, California, Report #13-051, Page 2-9, September 1984.
2. O'Brien & Gere Engineers, Inc. January 1991, Preliminary Report; Underground Fuel Investigation, Tow Way Fuel Farm, U.S. Naval Station, Roosevelt Roads, Puerto Rico.
3. U.S. Army Engineer Waterways Experiment Station, CE, Trafficability Predictions in Tropical Soils: Puerto Rico Study; Vicksburg, Mississippi. Miscellaneous paper No. 4-355, Report 2, February 1960.
4. Mitchell, R.C., A Survey of the Geology of Puerto Rico. Technical Paper No. 13, University of Puerto Rico Agriculture Experiment Station, Rios Piedras, Puerto Rico, June 1954.
5. Soil Total Petroleum Hydrocarbon Cleanup Standard as per phone conversation with Doel Mirenda of the Commonwealth of Puerto Rico Environmental Quality Board (EQB) dated May 30, 1991.

Tables

O'BRIEN & GERE

TABLE 1

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

WELL SPECIFICATION AND ELEVATION DATA

WELL NO.	WELL DEPTH (FT)	GROUND * ELEV. (FT)	CASING * ELEV. (FT)	SCREENED INTERVAL (FT)	HYDRAULIC CONDUCTIVITY (CM/SEC)	GROUND WATER ELEVATION (FT) 3/29/91	GROUND WATER ELEVATION (FT) 4/4/91	ELEVATION FIRST ENCOUNTER SATURATED CONDITIONS FROM BORING LOGS (FT)	DIFFERENCE BETWEEN FIRST ENCOUNTER CONDITIONS AND FINAL ELEVATIONS (FT)	PRODUCT IN WELL (FT)
UGW-1	24.62	115.09	116.85	90.47 - 100.47	(2)	——	——	——	ONLY PRODUCT	15.00
UGW-2	58.35	160.65	162.33	102.30 - 112.30	6.10E-06	106.75	106.61	105.65	0.96	NP
UGW-3	35.44	123.29	125.22	87.85 - 97.85	2.47E-04	104.18	104.12	96.29	7.83	NP
UGW-4	35.26	119.32	120.66	84.06 - 94.06	(2)	104.86 (4)	104.80 (4)	89.32	15.48	13.00
UGW-5	28.57	114.60	116.44	86.03 - 106.03	(2)	103.44 (4)	103.40 (4)	97.90	5.50	12.28
UGW-6	18.37	109.99	111.73	91.62 - 101.62	1.40E-04	101.14	101.08	94.99	6.09	NP
UGW-7	16.27	108.69	110.35	92.42 - 102.42	2.44E-05	101.78	101.69	98.69	3.00	NP
UGW-8	17.53	108.84	110.50	91.31 - 101.31	7.01E-05	102.06	102.02	98.84	3.18	NP
UGW-9	19.93	110.55	110.51	90.62 - 100.62	3.35E-05	102.89	102.68	95.55	7.13	NP
UGW-10	18.86	109.40	110.97	90.54 - 100.54	8.32E-04	100.92	100.87	94.40	6.47	NP
UGW-11	17.45	108.40	110.00	90.95 - 100.95	5.70E-04	100.83	100.80	98.40	2.40	NP
UGW-12	23.14	112.75	114.24	89.61 - 99.61	(2)	103.29 (4)	103.08 (4)	95.75	7.33	9.40
UGW-13	25.88	112.11	113.56	86.23 - 96.23	(2)	101.20 (4)	101.11 (4)	97.11	4.00	5.82
UGW-14	38.83	118.37	119.71	79.54 - 89.54	(2)	103.55 (4)	103.40 (4)	88.37	15.03	1.00
UGW-15	17.92	110.86	112.51	92.94 - 102.94	(3)	100.54	100.51	100.86	-0.35	NP
UGW-16	20.35	112.39	113.98	92.04 - 102.04	7.01E-05	NA	101.18	97.39	3.79	NP
UGW-17	23.70	110.73	112.26	87.03 - 102.03	4.42E-04	NA	100.36 (4)	90.73	9.63	2.98
UGW-18	20.38	113.00	114.53	92.62 - 102.62	1.62E-04	NA	101.24	93.00	8.24	NP
GW-02 (1)	NA	112.14	113.88	NA	NA	102.61	102.53	——	——	——
GW-03 (1)	NA	111.36	113.62	NA	NA	102.43	102.33	——	——	——
GW-04 (1)	NA	NA	113.21	NA	NA	104.94 (4)	105.56 (4)	——	——	——
GW-06 (1)	NA	109.12	111.16	NA	NA	101.69	101.56	——	——	——

NOTES:
NA Data not available
* Elevation data tied to USGS datum + 100 ft.
—— No ground water present in well.
NP No product present in well.
(1) On-site well not installed by O'Brien & Gere Engineers, Inc.
(2) Product layer prevented performance of IN-SITU conductivity test.
(3) Recovery rate defied hand measurement.
(4) Ground water elevation corrected for product layer

GWE + (0.9) (PT) = CGWE

GWE Ground water elevation
PT Product thickness
CGWE Corrected ground water elevation

03-Feb-92

TABLE 2

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

PRODUCT THICKNESS DATA (FT)

WELL NO.	3/29/91	4/4/91
UGW-1	14.43	14.21
UGW-2	----	----
UGW-3	----	----
UGW-4	10.27	9.82
UGW-5	13.34	12.32
UGW-6	----	----
UGW-7	----	----
UGW-8	----	----
UGW-9	----	----
UGW-10	----	----
UGW-11	----	----
UGW-12	9.95	11.44
UGW-13	6.39	6.31
UGW-14	0.87	1.11
UGW-15	----	----
UGW-16	NA	----
UGW-17	NA	2.98
UGW-18	NA	----
GW-02	----	----
GW-03	----	----
GW-04	4.78	2.94
GW-06	----	----

NOTE: NA - Data not available
--- - No product layer detected

TABLE 3

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

SOIL BORING ORGANIC ANALYSES

BORING NO.	DEPTH (FT)	DATE	TOTAL ORGANIC HALOGEN (TOX)	TOTAL PETROLEUM HYDROCARBONS
B-1	4-6'	2/25/91	<.050	2.087
B-1	6-8'	2/25/91	<.050	0.27
B-1	8-15'	2/25/91	<.050	0.53
B-2	2-4'	2/26/91	<.050	0.464
B-2	4-6'	2/26/91	<.050	0.422
B-2	6-10'	2/26/91	<.050	1.816
B-3	4-6'	2/26/91	<.050	22.85
B-3	10-12'	2/26/91	<.050	22.6
B-3	12-16'	2/26/91	<.050	2.9
B-4	6-8'	2/27/91	<.050	0.0539
B-4	8-10'	2/27/91	<.050	0.3338
B-4	10-14'	2/27/91	<.050	3.019
B-5	2-4'	2/27/91	<.050	0.0062
B-5	4-6'	2/27/91	<.050	0.1666
B-5	6-10'	2/27/91	<.050	0.0072
B-6	4-6'	2/28/91	<.050	0.0545
B-6	6-8'	2/28/91	<.050	<.001
B-6	12-16'	2/28/91	<.050	<.001
B-7	2-4'	2/28/91	<.050	0.0035
B-7	4-6'	2/28/91	<.050	<.001
B-7	6-10'	2/28/91	<.050	0.0017
B-8	6-8'	2/28/91	<.050	0.0203
B-8	8-10'	2/28/91	<.050	0.0042
B-8	12-16'	2/28/91	<.050	<.001
B-9	4-6'	3/1/91	<.050	0.0102
B-9	10-12'	3/1/91	<.050	0.0016
B-9	12-16'	3/1/91	<.050	<.001
B-10	4-6'	3/1/91	<.050	0.0102
B-10	6-8'	3/1/91	<.050	<.001
B-10	10-14'	3/1/91	<.050	<.001

NOTES: Results reported in mg/kg (ppm).

TABLE 4

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

SOIL BORING INORGANIC ANALYSES

BORING NO.	DEPTH (FT)	DATE	ARSENIC	BARIUM	CADMIUM	CHROMIUM	LEAD	MERCURY	SELENIUM	SILVER
EPA Maximum Concentration Limi			5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0
B-1	4-6'	2/25/91	<0.01	1.1	0.066	<0.001	0.083	0.001	<0.01	0.035
B-1	6-8'	2/25/91	<0.01	0.7	0.035	<0.001	0.080	0.001	<0.01	0.033
B-1	8-15'	2/25/91	<0.01	<0.5	0.240	<0.001	0.073	<0.001	<0.01	0.030
B-2	2-4'	2/26/91	<0.01	6.4	1.7	0.062	0.166	0.001	<0.01	0.063
B-2	4-6'	2/26/91	<0.01	7.3	0.052	0.064	0.163	0.001	<0.01	0.056
B-2	6-10'	2/26/91	<0.01	<0.5	0.086	<0.001	0.055	0.001	<0.01	0.024
B-3	4-6'	2/26/91	<0.01	10.0	0.073	0.074	0.211	0.001	<0.01	0.088
B-3	10-12'	2/26/91	<0.01	8.6	0.337	0.018	0.098	<0.001	<0.01	0.049
B-3	12-16'	2/26/91	<0.01	0.8	0.027	<0.001	0.055	0.001	<0.01	0.027
B-4	6-8'	2/27/91	<0.01	6.0	0.087	0.144	1.0	<0.001	<0.01	0.106
B-4	8-10'	2/27/91	<0.01	7.5	0.099	0.133	0.602	<0.001	<0.01	0.134
B-4	10-14'	2/27/91	<0.01	1.9	0.060	0.059	0.191	<0.001	<0.01	0.062
B-5	2-4'	2/27/91	<0.01	1.0	0.02	<0.001	0.062	0.001	<0.01	0.017
B-5	4-6'	2/27/91	<0.01	<0.5	0.022	<0.001	0.062	0.001	<0.01	0.016
B-5	6-10'	2/27/91	<0.01	<0.5	0.046	<0.001	0.105	<0.001	<0.01	0.063
B-6	4-6'	2/28/91	<0.01	<0.5	0.047	0.001	0.109	<0.001	<0.01	0.017
B-6	6-8'	2/28/91	<0.01	<0.5	0.015	<0.001	0.103	<0.001	<0.01	0.014
B-6	12-16'	2/28/91	<0.01	<0.5	0.024	<0.001	0.108	<0.001	<0.01	0.018
B-7	2-4'	2/28/91	<0.01	0.5	0.056	<0.001	0.093	0.001	<0.01	0.018
B-7	4-6'	2/28/91	<0.01	0.5	0.024	0.010	0.123	<0.001	<0.01	0.013
B-7	6-10'	2/28/91	<0.01	0.5	0.007	0.002	0.111	<0.001	<0.01	0.020
B-8	6-8'	2/28/91	<0.01	<0.5	0.006	0.233	0.156	0.013	<0.01	0.017
B-8	8-10'	2/28/91	<0.01	<0.5	0.020	0.004	0.090	0.008	<0.01	0.021
B-8	12-16'	2/28/91	<0.01	<0.5	0.011	0.314	0.094	0.008	<0.01	0.020
B-9	4-6'	3/1/91	<0.01	<0.5	0.006	<0.001	0.230	0.004	<0.01	0.014
B-9	10-12'	3/1/91	<0.01	<0.5	0.006	<0.001	0.240	0.004	<0.01	0.017
B-9	12-16'	3/1/91	<0.01	<0.5	0.012	0.024	0.165	0.002	<0.01	0.016
B-10	4-6'	3/1/91	<0.01	<0.5	0.011	<0.001	0.239	0.002	<0.01	0.013
B-10	6-8'	3/1/91	<0.01	<0.5	0.005	<0.001	0.133	0.006	<0.01	0.024
B-10	10-14'	3/1/91	<0.01	<0.5	0.001	<0.001	0.149	0.006	<0.01	0.021

NOTES: All values reported in mg/l (ppm).
* - EPA Publication; 45 Federal Register 33122; May 19, 1980.

TABLE 5

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

GROUND WATER QUALITY DATA

MONITORING WELL NO.	SAMPLE DATE	BENZENE	TOLUENE	ETHYL-BENZENE	XYLENES	TOTAL BTEX	LEAD *
UGW-1 (1)	3/28/91	13,518	34,383	95,702	139,546	283,149	3,580
UGW-2	3/26/91	<1.0	<1.0	<1.0	<1.0	<1.0	142
UGW-3	3/27/91	<1.0	<1.0	<1.0	<1.0	<1.0	122
UGW-4	3/28/91	16	678	7,165	10,697	18,556	80
UGW-5	3/28/91	<1.0	317	3,285	4,233	7,835	107
UGW-6	3/26/91	6,004	2,096	3,719	454	12,273	166
UGW-7	3/26/91	<1.0	<1.0	<1.0	<1.0	<1.0	93
UGW-8	3/28/91	<1.0	<1.0	<1.0	<1.0	<1.0	77
UGW-9	3/26/91	<1.0	<1.0	<1.0	<1.0	<1.0	68
UGW-10	3/27/91	<1.0	<1.0	<1.0	<1.0	<1.0	74
UGW-11	3/27/91	<1.0	<1.0	<1.0	<1.0	<1.0	94
UGW-12	3/28/91	47	8	432	1,403	1,890	82
UGW-13	3/28/91	788	4,713	23,865	40,739	70,105	98
UGW-14	3/28/91	464	2,387	22,804	23,754	49,409	89
UGW-15	3/28/91	1,017	63	1,112	298	2,490	167
UGW-16	3/28/91	<1.0	<1.0	<1.0	<1.0	<1.0	57
UGW-17	4/04/91	<1.0	<1.0	<1.0	<1.0	<1.0	61
UGW-18	4/04/91	<1.0	<1.0	<1.0	<1.0	<1.0	65

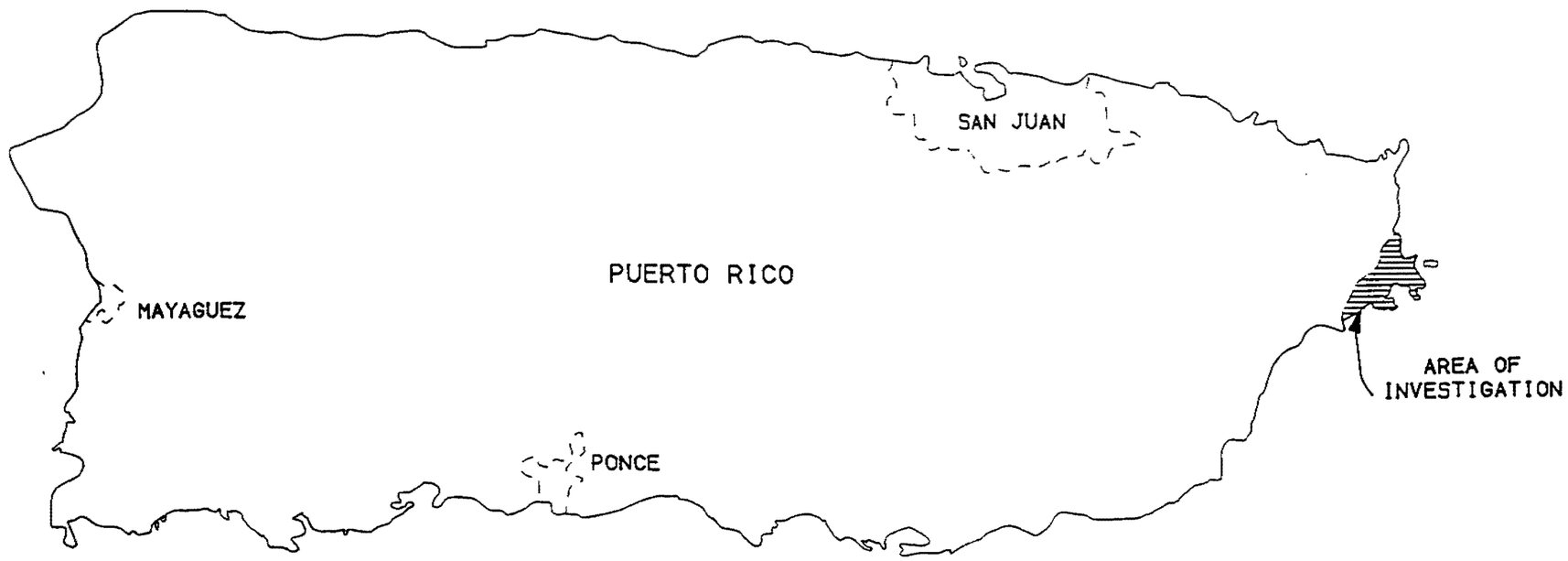
NOTES: Results in ppb.
* - Results in ug/l
(1) - Free phase product sampled.

Figures

O'BRIEN & GERE

FIGURE 1

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO



LEGEND

SITE
LOCATION MAP

10 0 10

APPROX. SCALE IN MILES

3543.020.130

O'BRIEN & GERE
ENGINEERS, INC.

22 MAY 1991

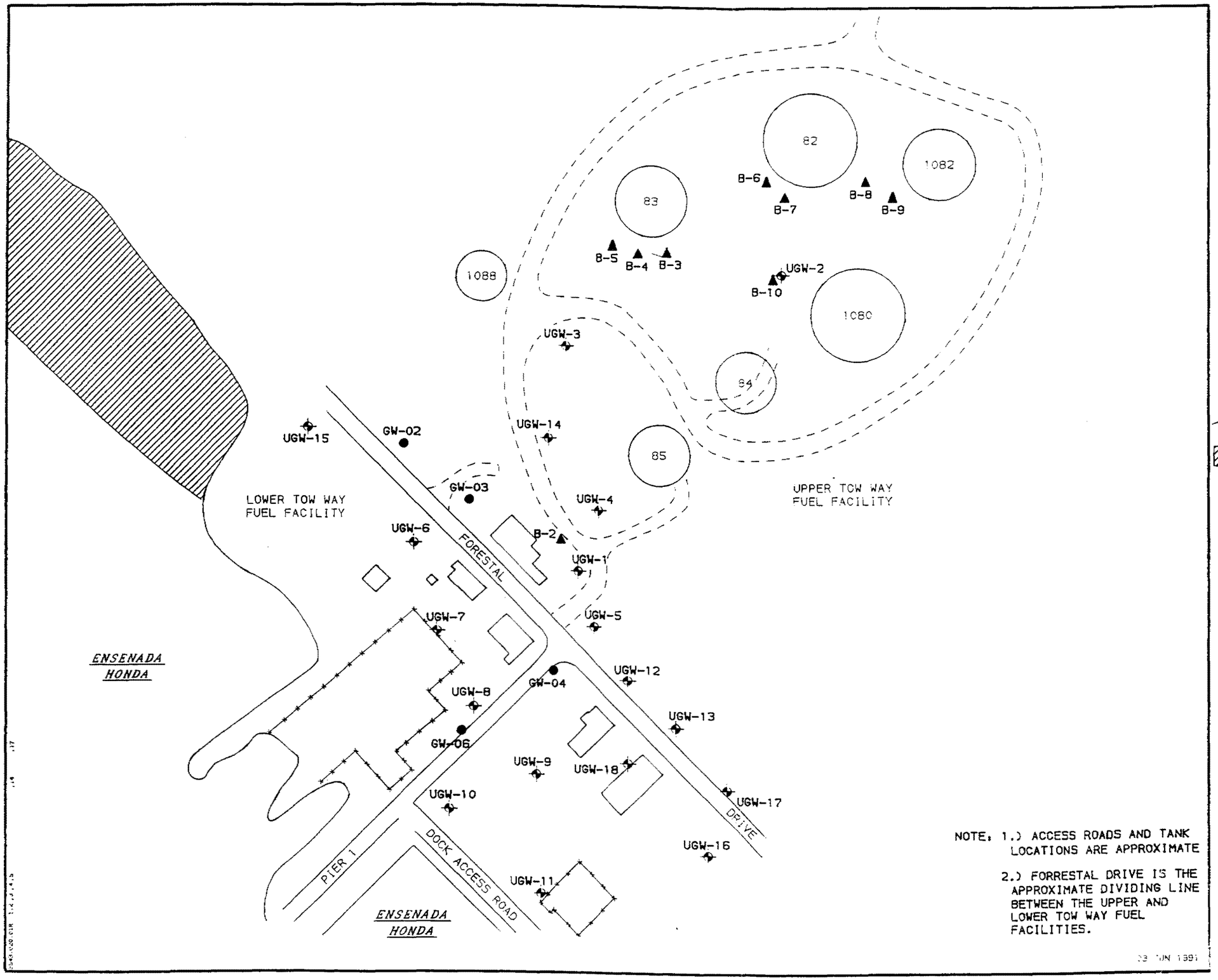


FIGURE 2

TOW WAY FUEL FARM
U.S.NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

LEGEND

- MONITORING WELL LOCATION
- BORING LOCATION
- OLD MONITORING WELL LOCATION
- ACCESS ROAD
- MANGROVE SWAMP

NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

23 JUN 1991

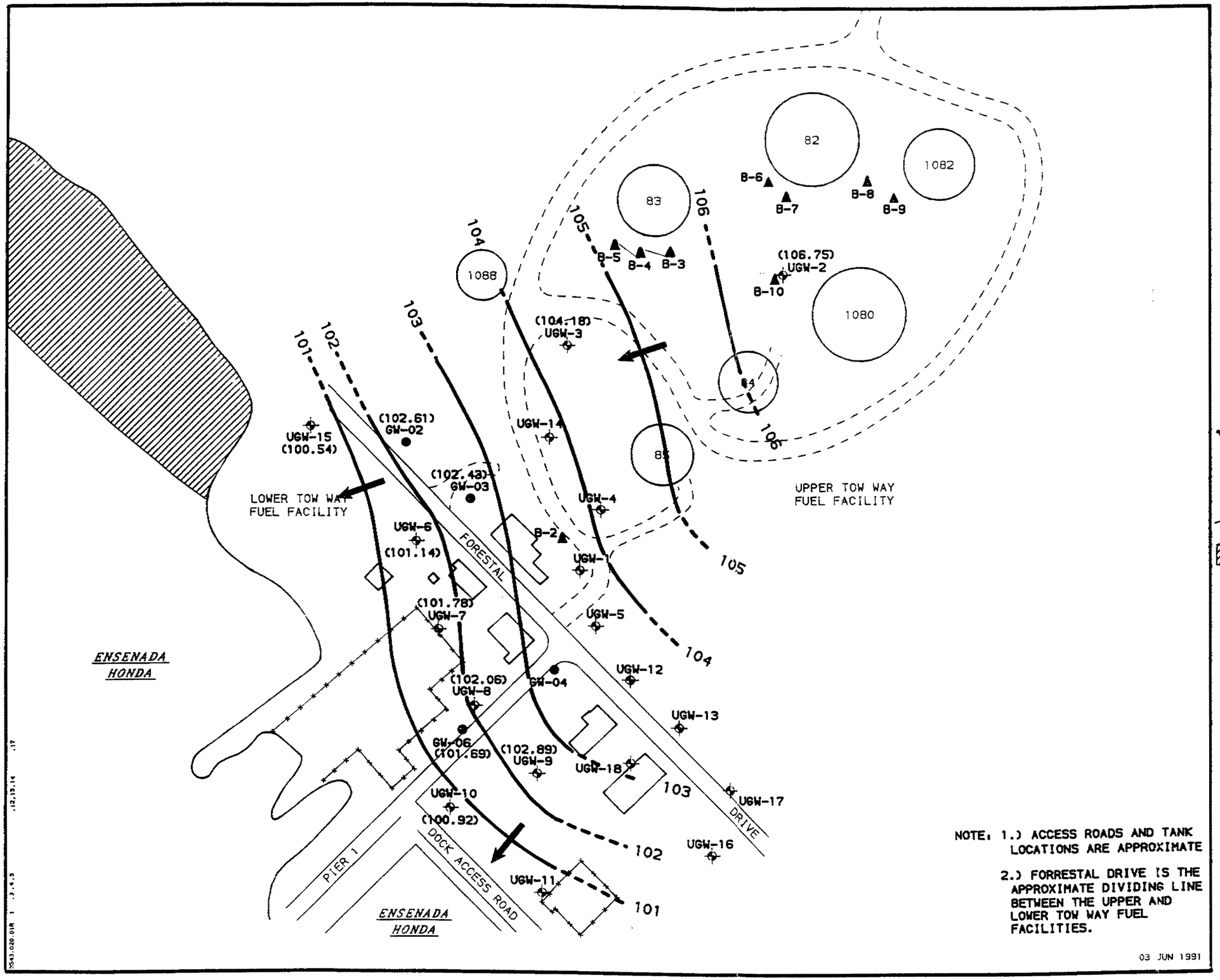
SITE MAP

100 0 100

SCALE IN FEET

4718.005.390

O'BRIEN & GERE ENGINEERS, INC.



NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

03 JUN 1991

FIGURE 3

TOW WAY FUEL FARM
U.S.NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

LEGEND

- MONITORING WELL LOCATION
- BORING LOCATION
- OLD MONITORING WELL LOCATION
- 102 GROUND WATER CONTOUR
- (102.89) GROUND WATER ELEVATION
- GROUND WATER FLOW DIRECTION
- ACCESS ROAD
- MANGROVE SWAMP

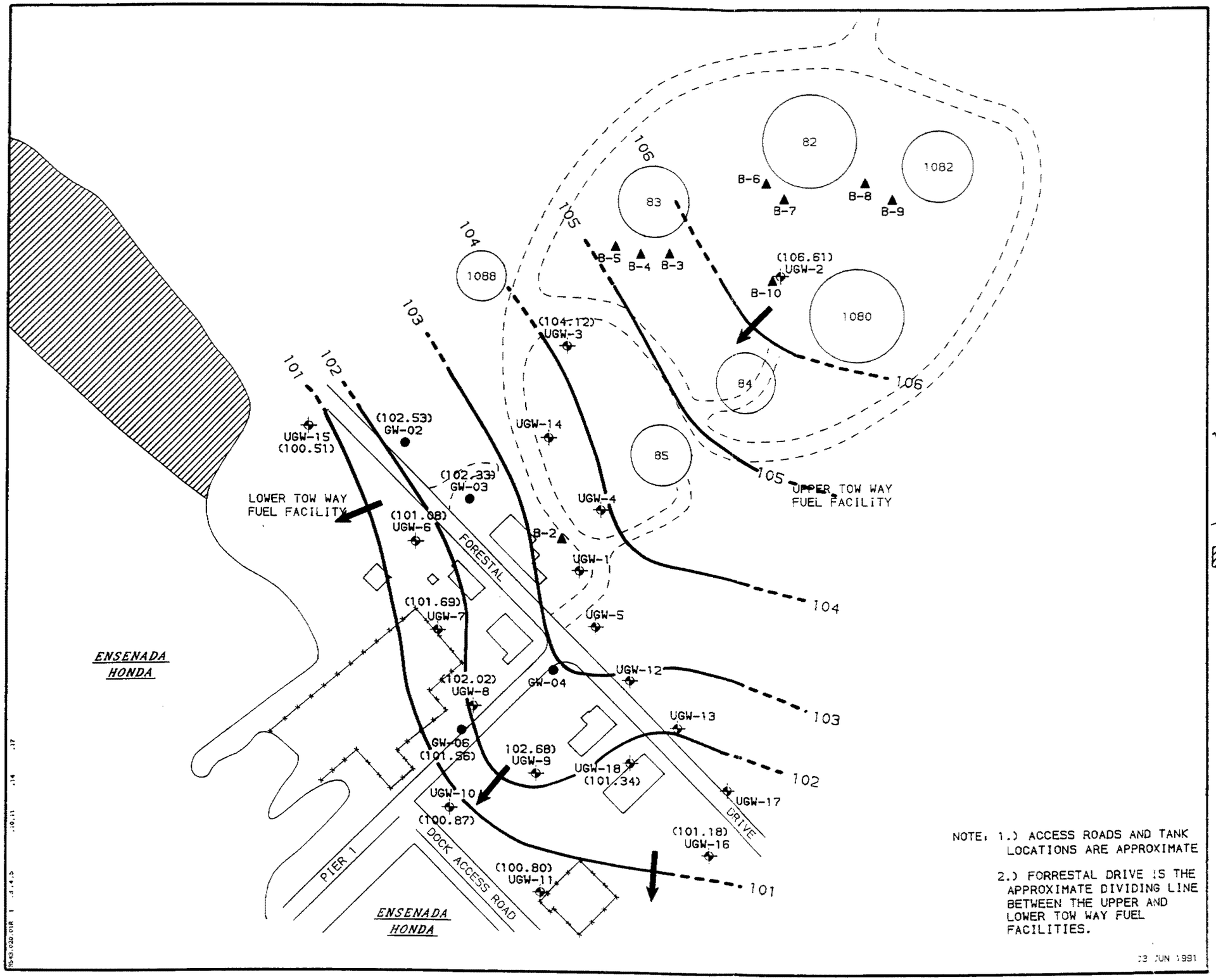
GROUND WATER ELEVATION MAP (3/29/91)

100 0 100

SCALE IN FEET

4718.005.390

O'BRIEN & GERE ENGINEERS, INC.



NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

03 JUN 1991

FIGURE 4

TOW WAY FUEL FARM
U.S.NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

LEGEND

- MONITORING WELL LOCATION
- BORING LOCATION
- OLD MONITORING WELL LOCATION
- 102 GROUND WATER CONTOUR
- (102.68) GROUND WATER ELEVATION
- GROUND WATER FLOW DIRECTION
- ACCESS ROAD
- MANGROVE SWAMP

GROUND WATER ELEVATION MAP (4/4/91)

100 0 100

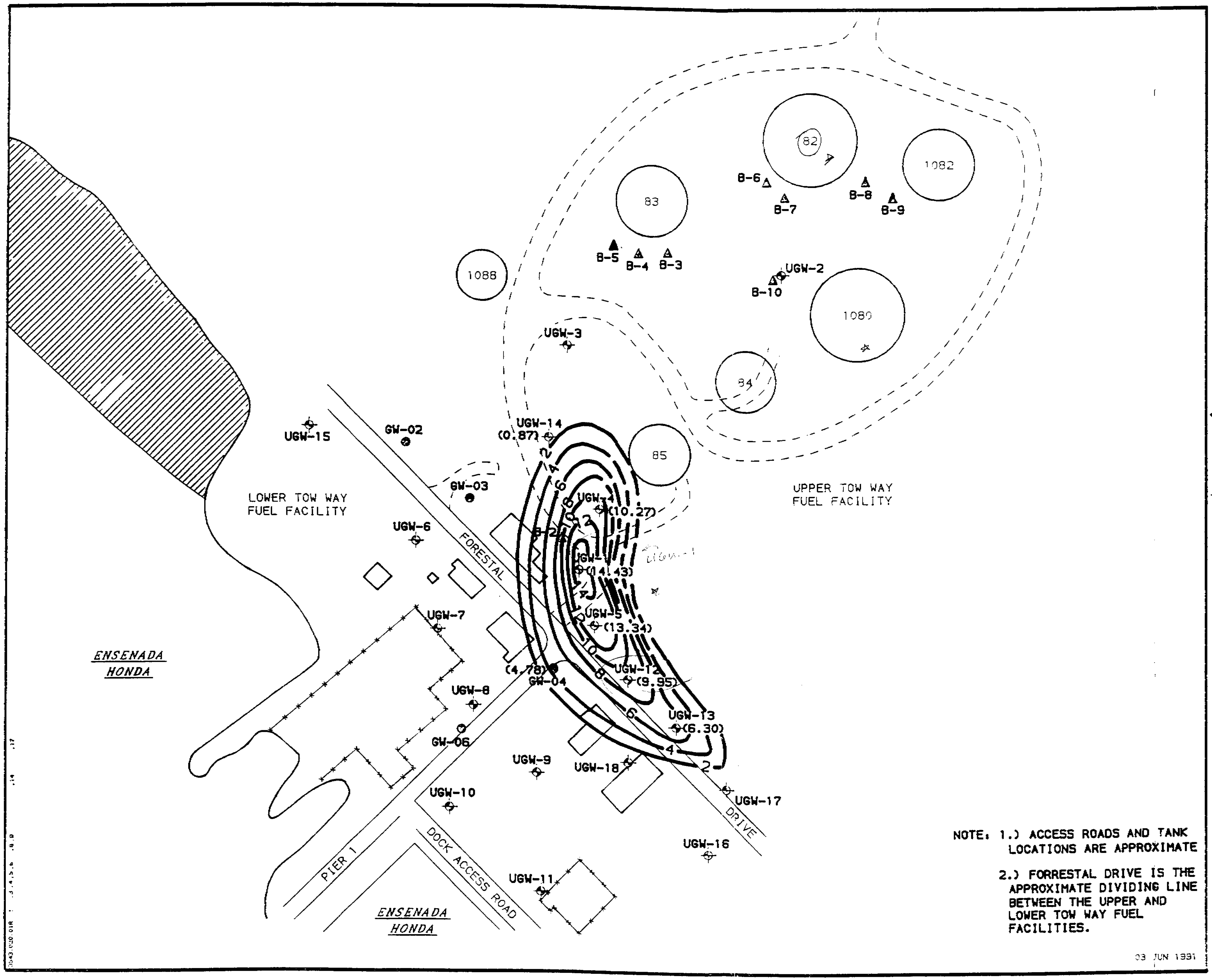
SCALE IN FEET

4718.005.390

O'BRIEN & GERE ENGINEERS, INC.

FIGURE 5

TOW WAY FUEL FARM
U.S. NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO



NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

LEGEND

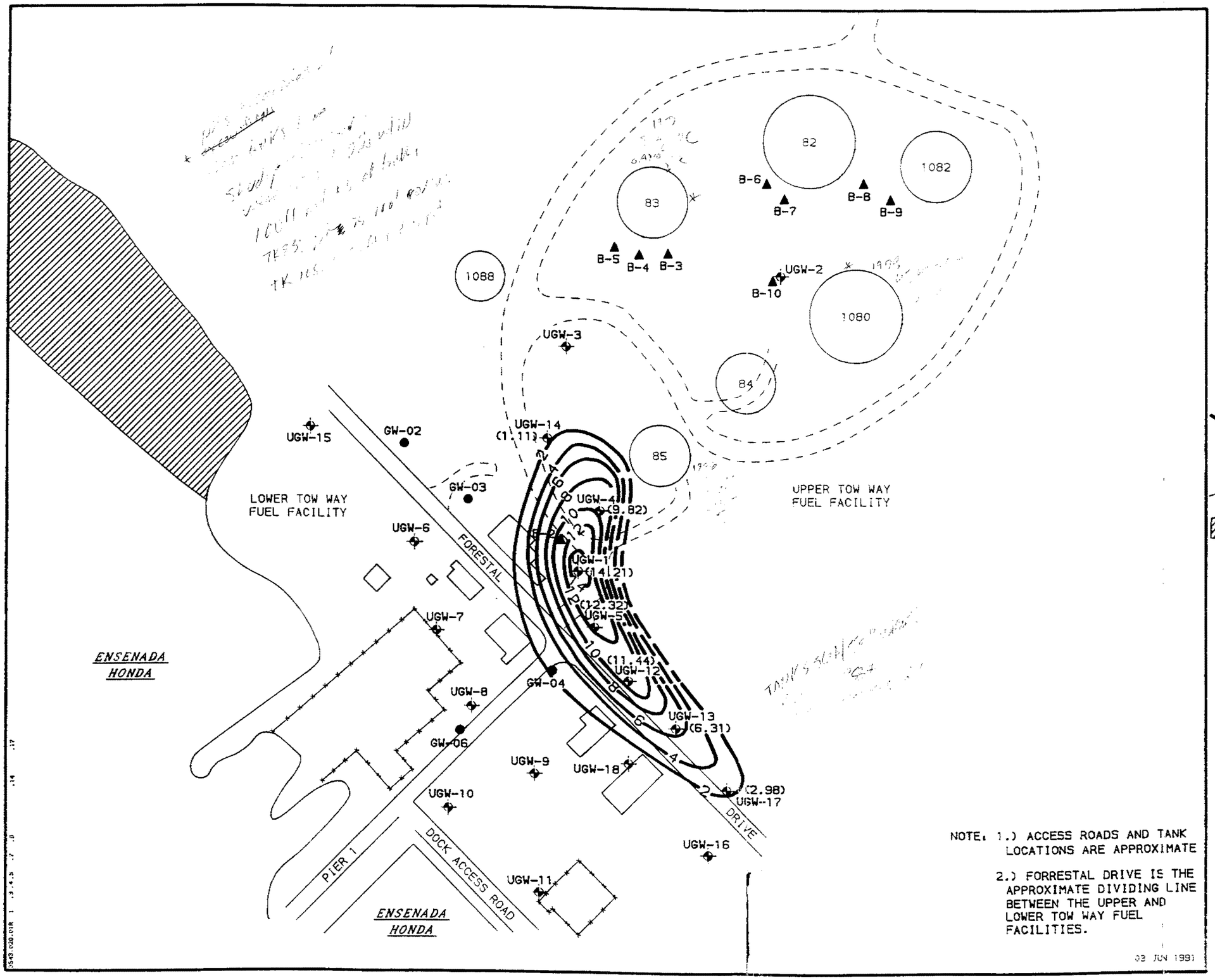
- MONITORING WELL LOCATION
- BORING LOCATION
- OLD MONITORING WELL LOCATION
- 6 PRODUCT THICKNESS CONTOUR (DASHED WHERE INFERRED)
- (6.39) PRODUCT THICKNESS
- ACCESS ROAD
- MANGROVE SWAMP

FREE PRODUCT PLUME MAP
(3/29/91)

100 0 100
SCALE IN FEET

4718.005.390

O'BRIEN & GERE ENGINEERS, INC.



NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

03 JUN 1991

FIGURE 6

TOW WAY FUEL FARM
U.S.NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

LEGEND

- MONITORING WELL LOCATION
- BORING LOCATION
- OLD MONITORING WELL LOCATION
- 2 PRODUCT THICKNESS CONTOUR (DASHED WHERE INFERRED)
- (2.98) PRODUCT THICKNESS
- ACCESS ROAD
- MANGROVE SWAMP

FREE PRODUCT PLUME MAP (4/4/91)

100 0 100

SCALE IN FEET

4718.005.330

O'BRIEN & GERE ENGINEERS, INC.

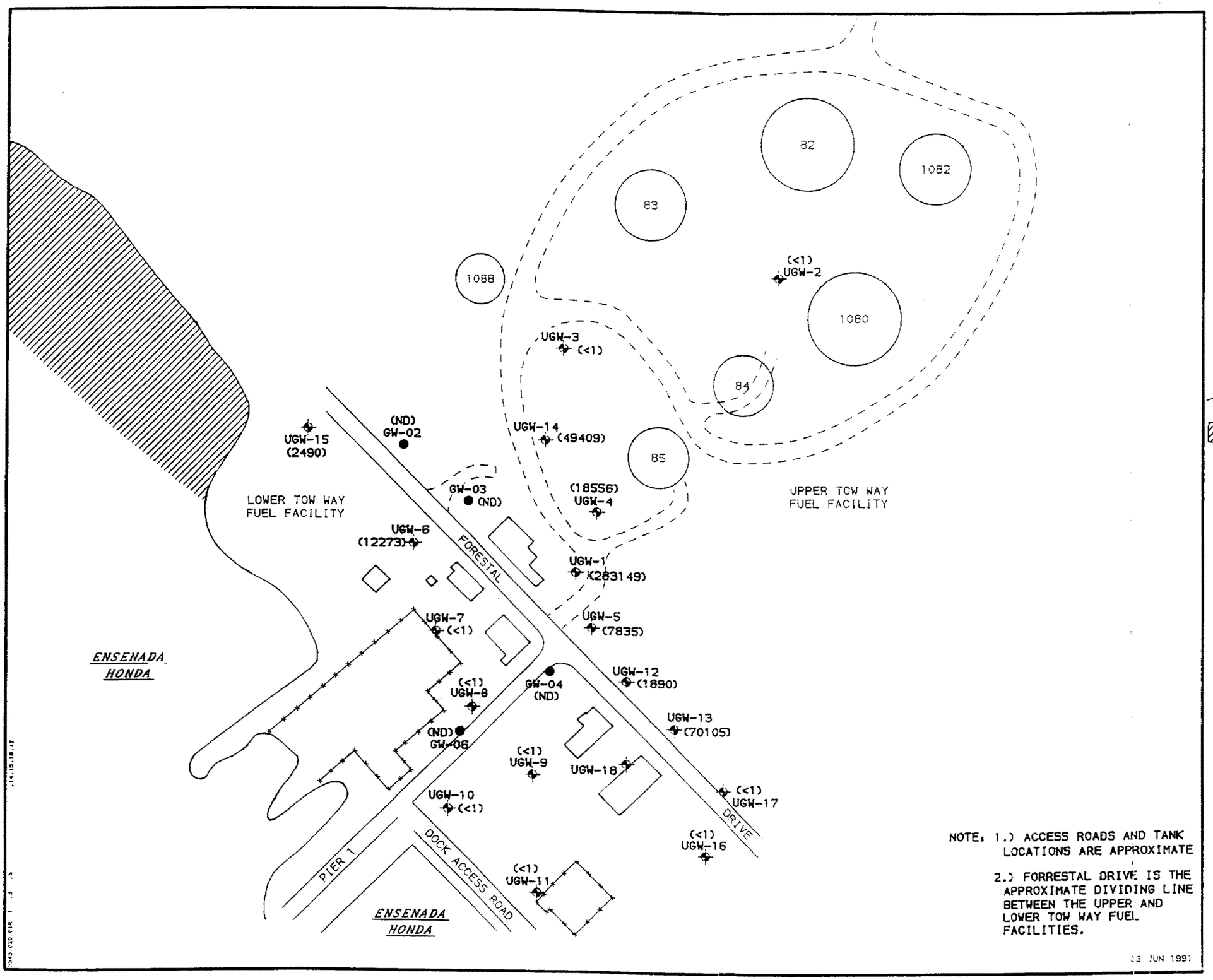


FIGURE 7

TOW WAY FUEL FARM
U.S.NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

LEGEND

- MONITORING WELL LOCATION
- OLD MONITORING WELL LOCATION
- ACCESS ROAD
- MANGROVE SWAMP
- (1890) TOTAL BTEX CONCENTRATIONS (ppb)
- (ND) NO DATA AVAILABLE

NOTE: 1.) ACCESS ROADS AND TANK LOCATIONS ARE APPROXIMATE

2.) FORRESTAL DRIVE IS THE APPROXIMATE DIVIDING LINE BETWEEN THE UPPER AND LOWER TOW WAY FUEL FACILITIES.

03 JUN 1991

TOTAL BTEX
DISTRIBUTION MAP

100 0 100

SCALE IN FEET

4718.005.390

O'BRIEN & GERE
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Appendices

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APPENDIX A

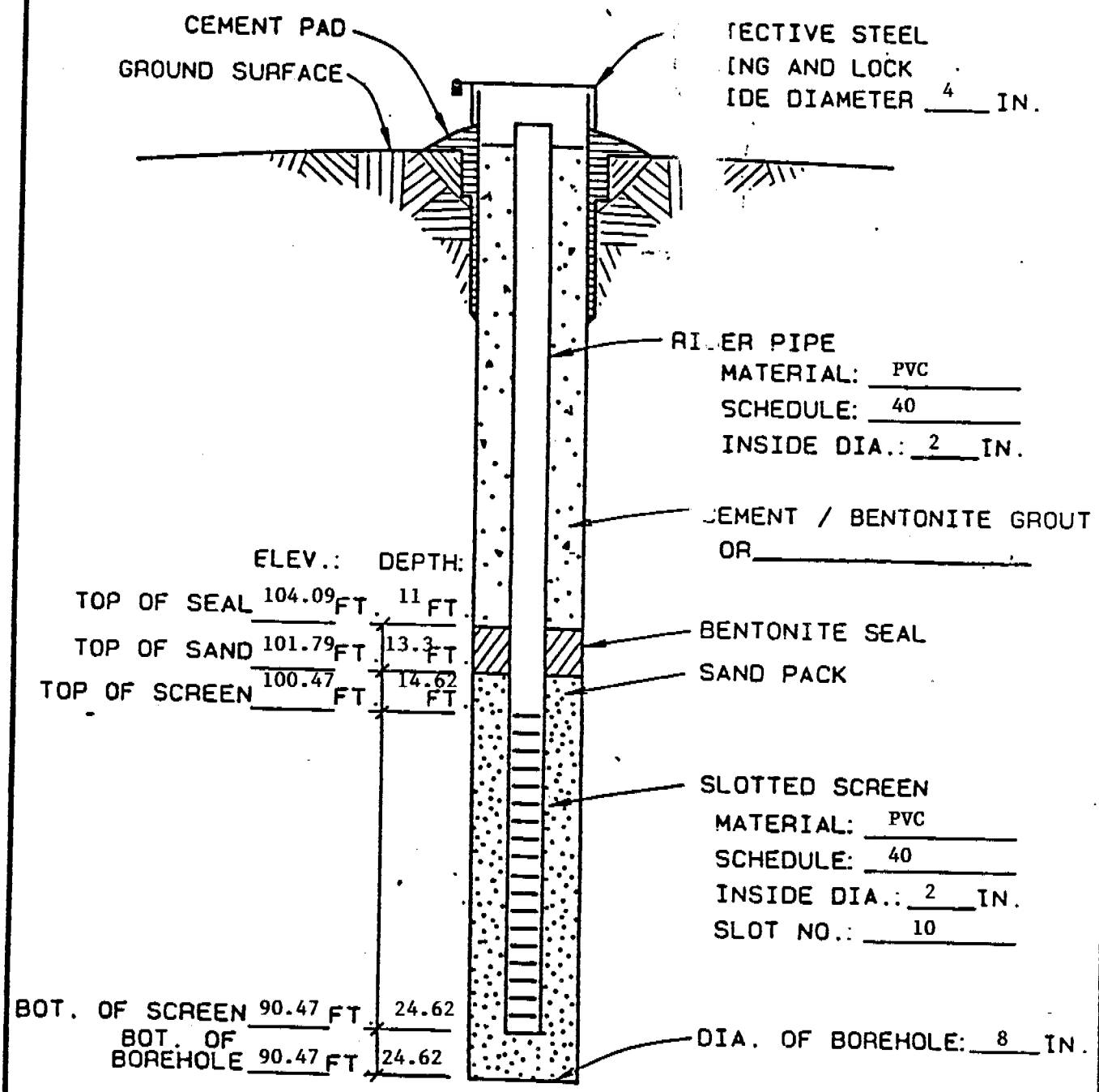
BORING LOGS AND WELL SPECIFICATIONS

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-1 / UGW-1 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 2/25/91	Ended: 2/26/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	5-9-8-5	2'/0.4'	17	Brown, damp, medium dense, fine to coarse SAND, little fine to medium gravel, trace silt and clay					2.4	*
	2	2-4'	5-5-7-14	2'/0.1'	12	Same as above					3.2	
	3	4-6'	3-9-19-23	2'/2'	28	Green, moist, very stiff CLAY, some silt, little fine to coarse sand, trace fine to medium gravel					70.0	
5												
	4	6-8'	11-29- 49-50/0.3	1.8/1.8'	78	Very dense, green-brown, mottled appearance fine to medium SAND, some fine to coarse gravel, little silt and clay					10.0	
	5	8-10'	53-77	1'/0.8'	—	Very dense, aqua-green, fine to medium gravelly, SAND, little silt and clay					0.4	
10	6	10-12'	37-64	1'/0.8'	—	Same as above					3.0	
	7	12-14'	84/0.2'	0.2'/0'	—	No sample obtained					—	
15	8	15-17'	93/0.1'	0.1/0.1'	—	Very dense, aqua-green, moist, fine to medium gravelly SAND, little silt and clay					2.0	
						Water encountered at 20 ft.						
20	9	20-22'	100/0.3'	0.3/0.3'	—	Very dense, wet, brown-green, fine to coarse SAND, trace silt					100.0	
25	10	25-27'	100/0.3'	0.3/0.3'	—	Very dense, wet, brown, fine to coarse SAND, some fine to medium gravel, little silt and clay					100.0	
							27.0'					
						Bottom of boring 27.0 ft.						

* - HNU readings reported in ppm.

B1.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-2 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 2/26/91	Ended: 2/26/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	5-7-6-6	2'/1.6'	13	Brown, damp, some green, fine to medium SAND, some silt and clay, trace fine to medium gravel					20	
	2	2-4'	3-4-4-3	2'/1.5'	8	Dark green, medium stiff, wet SILT, some fine to medium sand, little fine to medium gravel					30	
	3	4-6'	1-1-7-15	2'/1.3'	8	Dark gray and aqua-green, mottled appearance, fine to medium SAND, some silt and clay, little fine to medium gravel					90	
5												
	4	6-8'	11-14-19-31	2'/1.3'	33	Same as above to 6.5', then, brown, dense, fine to coarse SAND, some fine to coarse gravel, little silt					130	
	5	8-10'	18-22-32-41	2'/1.9'	54	Same as above to 9.4', then, mottled brown and dark green appearance, moist, very dense Water encountered at 10 ft.					60	
10	6	10-12'	19-36-50-46	2'/1.9'	86	Dark, wet (free product) fine to coarse SAND, some fine to medium gravel, trace silt	12'				---	
						Bottom of boring 12 ft.						
15												

* - HNU readings reported in ppm.

B2.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-3 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

Boring Co.: JACA & Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 2/26/91 Ended: 2/27/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	5-5-6-6	2'/0.5'	11	Moist, brown, medium dense, fine to coarse SAND, some silt, trace fine to medium gravel, trace organics					50	*
	2	2-4'	3-6-4-4	2'/0.1'	10	Moist, brown with trace red, medium stiff SILT, little fine to medium sand, trace clay, trace fine to medium gravel					17	
	3	4-6'	10-3-5-8	2'/1.1'	8	Same grading to black tar-like appearance moist SILT, little fine to medium sand to 5.9', then fine to coarse sand, trace fine gravel					80	
5												
	4	6-8'	7-5-5-5	2'/0.8'	10	Damp, light gray, fine to medium SAND, trace fine to medium gravel, medium dense					30	
	5	8-10'	2-2-1-1	2'/1'	3	Moist, light gray, very loose, fine to medium SAND, little silt, trace gravel					50	
10	6	10-12'	1-3-5-9	2'/1'	8	Dark brown with trace black, moist SILT, some clay, little fine to medium gravel, trace fine to medium sand					3.0	
	7	12-14'	11-20-35-48	2'/1'	55	Moist, dark brown-green, very dense fine to coarse SAND, some silt, trace fine to medium gravel, turning light brown at 13.4'					0	
	8	14-16'	14-20-22-32	2'/1'	42	Dense, light brown with tinge orange, moist fine to coarse SAND, some silt, trace fine gravel					0	
15												
	9	16-18'	9-13-22-27	2'/1'	35	Same as above					0	
	10	18-20'	20-41-49-54	2'/1'	90	Same as above, very dense					0	
20	11	20-22'	30-50	2'/0.9'	—	Same as above					0.3	
25	12	25-27'	22-27-50-100	2'/0.7'	77	Same as above					0	
30	13	30-32'	21-32-50-74	2'/0.8'	82	Same as above, grading to white, medium to coarse SAND, little silt, trace fine gravel					0	

* - HNU reading reported in ppm.

Bottom of boring 35.0 ft.

B3.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-4 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 2/27/91	Ended: 2/27/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	7-9-28-21	2'/0.2'	37	Damp, brown-gray SILT, little fine to medium sand, trace organics, clay and fine gravel					1	
	2	2-4'	24-39-	2'/0.4'	63	Damp, gray, very dense, fine to medium SAND, little fine to coarse gravel, trace silt					30	
			24-9									
	3	4-6'	5-5-5-4	2'/1.2'	10	Damp, dense, fine to coarse SAND, little silt, trace fine gravel					10	
5												
	4	6-8'	3-2-2-1	2'/0.3'	4	Same as above, wet, very loose					60	
	5	8-10'	2-2-1-2	2'/0.7'	3	Same to 9.8', then moist, black SILT, trace fine to medium sand					20	
10	6	10-12'	6-15-	2'/1'	32	Wet, very dense, gray, silty, fine to medium SAND, grading to moist, brown-green to light brown, fine to coarse SAND, little fine to medium gravel, little silt at 11.5'					7	
			17-17									
	7	12-14'	9-14-	2'/2'	36	Damp, very dense, light brown-orange, fine to coarse SAND, little silt and fine gravel					5	
			22-37									
	8	14-16'	13-14-	2'/2'	38	Same as above					1	
15			24-50									
							16.0'					
						Bottom of boring 16.0 ft.						

* - HNU readings reported in ppm.

B4.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-5 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

Boring Co.: JACA & Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 2/27/91 Ended: 2/28/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	3-7-54-54	2'/1'	61	Moist, red, stiff SILT, little fine gravel, trace fine to medium sand, grading to gray-green, angular gravel at 1'					3.5	*
	2	2-4'	19-22-60	1.5/1.3'	82	Moist, very dense, light brown-gray silty fine to coarse SAND, some fine to coarse gravel					2	
	3	4-6'	22-54-	1.3'/1'	—	DRY, very dense, gray-light green, fine to medium SAND, some angular fine to coarse gravel, trace silt					13	
5			75/0.3									
	4	6-8'	54-44-	2'/1'	91	Dry, very dense, gray-light brown, fine to coarse gravelly SAND, trace silt					80	
			47-59									
	5	8-10'	100/0.4'	0.4/0.2'	—	Dry, very dense, fine to medium SAND, some fine to coarse gravel, trace silt					50	
							10.0'					
10						Bottom of boring 10.0 ft.						

* - HNU readings reported in ppm.

B5.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-6 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 2/28/91	Ended: 2/28/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Remarks*
0	1	0-2'	3-4-2-2	2'/0.3'	6	Moist, loose, brown SILT, some fine to medium sand, trace organics					1	
	2	2-4'	2-7-12-20	2'/0.3'	19	Moist, stiff, brown-light brown SILT, little clay, trace fine to medium sand					30	
	3	4-6'	8-18-	2'/2'	46	Light brown-orange, very dense SILT and fine to medium SAND					11	
5			28-38									
	4	6-8'	8-16-	2'/2'	35	Damp, light brown with white spots, fine to medium SAND, little silt, trace fine to medium gravel					100	
			19-21									
	5	8-10'	10-26-	2'/2'	50	Same, very dense					0	
			24-20									
10	6	10-12'	7-12-	2'/2'	30	Same, dense, grading to gray at 10.8'					0.2	
			18-26									
	7	12-14'	10-17-	2'/2'	42	Same as above					0.2	
			25-32									
	8	14-16'	10-19-	2'/2'	51	Same as above					0.2	
15			32-57									
							16.0'					
						Bottom of boring 16.0 ft.						

* - HNU readings reported in ppm.

BS.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-7 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

Boring Co.: JACA & Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 2/28/91 Ended: 2/28/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	13-11-	2'/0.1'	24	Moist, brown, stiff SILT, trace fine to medium sand and fine to coarse gravel					100	
			13-24									
	2	2-4'	2-3-3-4	2'/0.9'	6	Moist, brown, medium stiff SILT, little fine to medium gravel, trace silt					10	
	3	4-6'	5-57/0.4'	0.9/0.7'	—	Same grading to fine to coarse SAND, little silt, trace fine to medium gravel at 4.5'					4	
5												
	4	6-8'	11-29-	2'/1'	59	Very dense, brown-orange, silty, fine to coarse SAND, some fine to medium gravel, grading to light gray at 7.6'					30	
			30-20									
	5	8-10'	72-43-	1.5/0.5'	—	Very dense, brown-light gray, fine to coarse gravelly SAND, white speckled appearance, trace silt					1	
			73/0.5'				10.0'					
10						Bottom of boring 10.0 ft.						
15												

* - HNU readings reported in ppm.

B7.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-8 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 2/28/91	Ended: 3/1/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	3-3-4-3	2'/0.9'	7	Moist, brown, medium stiff SILT, little fine to coarse gravel, trace fine to medium sand					50	
	2	2-4'	2-4-9-17	2'/1.5'	13	Moist, brown-green, medium stiff SILT, little fine to coarse gravel and fine to medium sand to 3.3', then, orange-brown damp fine to medium SAND, trace silt					12.5	
	3	4-6'	15-20-	2'/1.9'	49	Damp, very dense, reddish-brown, fine to medium SAND, little silt to 5.4', then, green-tan trace fine to medium gravel					20	
5			29-34									
	4	6-8'	12-18-	2'/2.2'	44	Damp, green-tan, dense, fine to medium SAND, little silt, trace fine to medium gravel					60	
			26-35									
	5	8-10'	15-27-	2'/2'	65	Same as above					100	
			38-60									
10	6	10-12'	36-80/0.5	1'/1.5'	---	Same					60	
	7	12-14'	26-37-	1.4/1.4'	---	Same, to 13.9', then, reddish-brown appearance					30	
			65/0.4									
	8	14-16'	26-32-	2'/2'	61	Damp very dense, reddish-brown mottled with light green, fine to medium SAND, little silt and fine to medium gravel					15	
15			29-35				16.0'					
						Bottom of boring 16.0 ft.						

* - HNU readings reported in ppm.

B8.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-9 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/1/91	Ended: 3/1/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	1-2-2-1	2'/0.3'	4	Moist, dark brown, soft SILT, trace organic debris, fine to medium gravel and sand					20	
	2	2-4'	1-2-3-10	2'/2'	5	Same to 3.3' then, brown-orange, moist SILT, some fine to medium sand, little clay, trace fine to medium gravel					30	
	3	4-6'	5-15-	2'/2'	43	Wet, dark brown, stiff SILT to 4.5' then, brown, dense, fine to medium SAND, little silt, trace fine gravel, reddish at 5.4'					20	
5			28-37									
	4	6-8'	4-15-	2'/2'	43	Damp, dense, brown with white and green speckled appearance, fine to medium SAND, little silt, trace fine gravel					7	
			28-37									
	5	8-10'	34-70/0.3	0.8/0.8'	---	Same, very dense					50	
10	6	10-12'	20-30-	2'/1.5'	69	Same, reddish brown at 11.8'					300	
			39-70									
	7	12-14'	19-56-	2'/1.6'	116	Damp, extremely dense, brown, fine to medium SAND, little silt, trace fine to coarse gravel					500	
			60-64									
	8	14-16'	23-16-	1.5/0'	---	Same, turning to olive green-brown, some silt, moist					300	
15			70/0.5									
						Bottom of boring 16.0 ft.	16.0'					

* - HNU readings reported in ppm.

B9.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-10 / UGW-2 Sheet 1 of 2
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

Boring Co.: JACA & Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/1/91 Ended: 3/5/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	4-4-3-3	2'/0.7'	7	Moist, medium stiff, dark brown SILT, some fine to medium sand grading to silt at 1.6'					20	*
	2	2-4'	4-12-20-25	2'/1.3'	32	Same, grading to brown, dense, fine to coarse SAND, little silt, trace fine to medium gravel					30	
5	3	4-6'	19-27-31-35	2'/0.8'	64	Damp, very dense, brown, fine to medium SAND, little silt, trace fine to medium gravel					70	
	4	6-8'	15-38-63	1.5'/1'	101	Same as above					90	
	5	8-10'	6-17-29-44	2'/1.7'	46	Damp, light brown with mottled, gray-green appearance, dense, fine to medium SAND, little silt, trace fine gravel					10	
10	6	10-12'	11-25-29-34	2'/1.7'	54	Same as above					3	
	7	12-14'	45-70/0.5	1'/0.8'	—	Damp, brown-light brown, fine to coarse SAND, some silt, little fine gravel					10	
	8	14-16'	100/0	0.2/0.1'	—	No sample recovery					—	
15												
20	9	20-22'	70-70/0.1	0.6/0.4'	—	Very dense, gray-green, fine to coarse SAND little silt, trace fine to medium gravel					8	
25	10	25-27'	50/0.3'	0.3/0.3'	—	Moist, very dense, fine to coarse gravelly fine to coarse SAND, little silt					150	
30	11	30-32'	70/0.5'	0.5/0.3'	—	Same as above					200	

* - HNU readings reported in ppm.

1B10.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. B-10 / UGW-2 Sheet 2 of 2
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

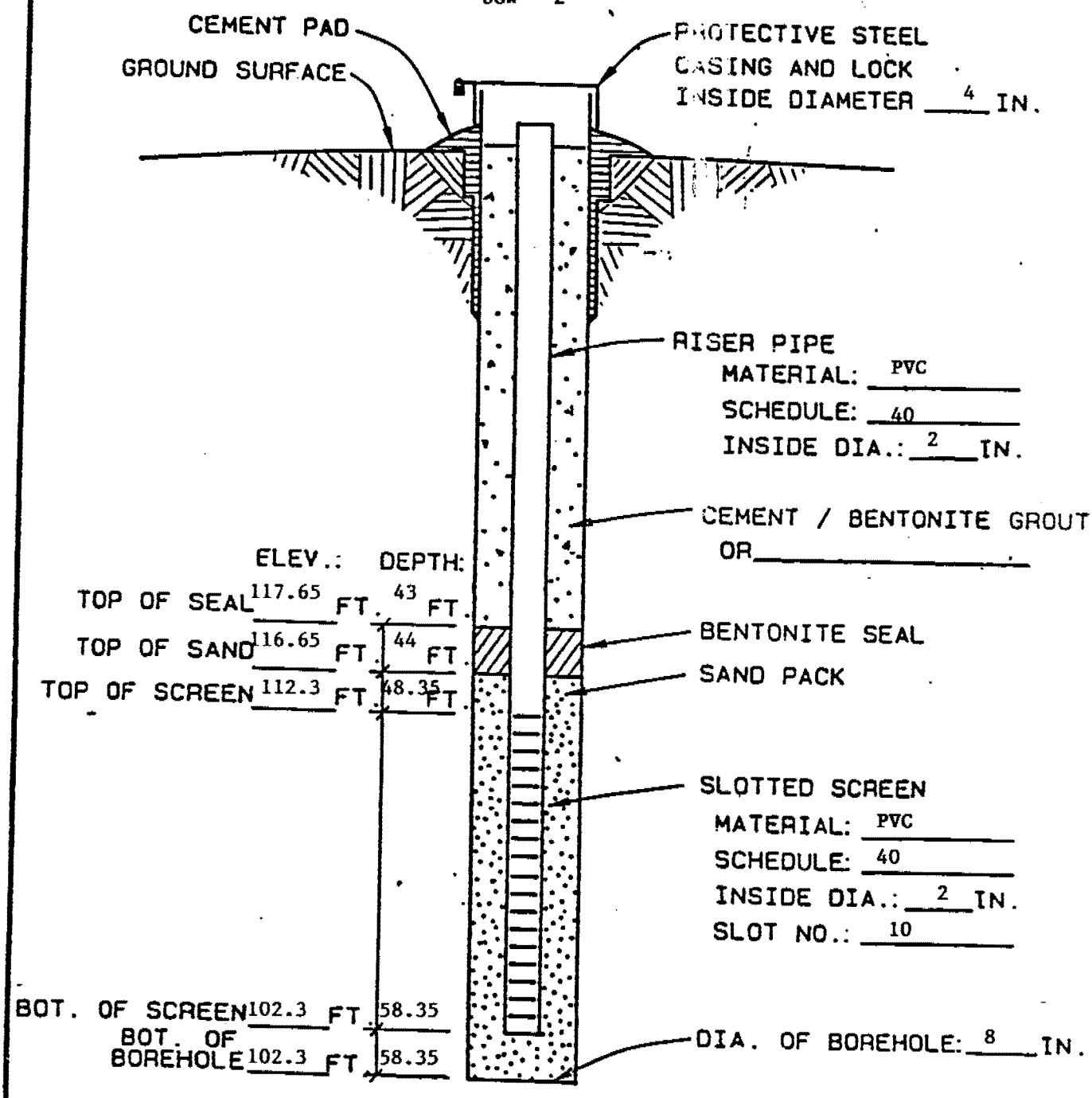
Boring Co.: JACA & Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/1/91 Ended: 3/5/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
35	12	35-40'	50/0.1'	0.1/0.1'	---	Damp, very dense, tan-olive green, fine to medium SAND, some silt, little fine to medium gravel						
40	13	40-45'	50/1'	1'/0.4'	---	Same as above					16	*
45	14	45-50'	50/1'	1'/0.5'	---	Same, gray					6	
50	15	50-55'	50/0.3'	0.3/0.3'	---	Damp, very dense, gray, fine to medium SAND, some fine to coarse gravel, little silt					50	
55	16	55-60'	50/1'	1'/0.5'	---	Wet, very dense, gray, fine to medium SILT and SAND, little fine to medium gravel					30	
						Bedrock encountered at 56.5'						
							58'					
						Bottom of boring 58.0 ft.						

* - HNU readings reported in ppm.

2B10.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-3 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/5/91	Ended: 3/6/91

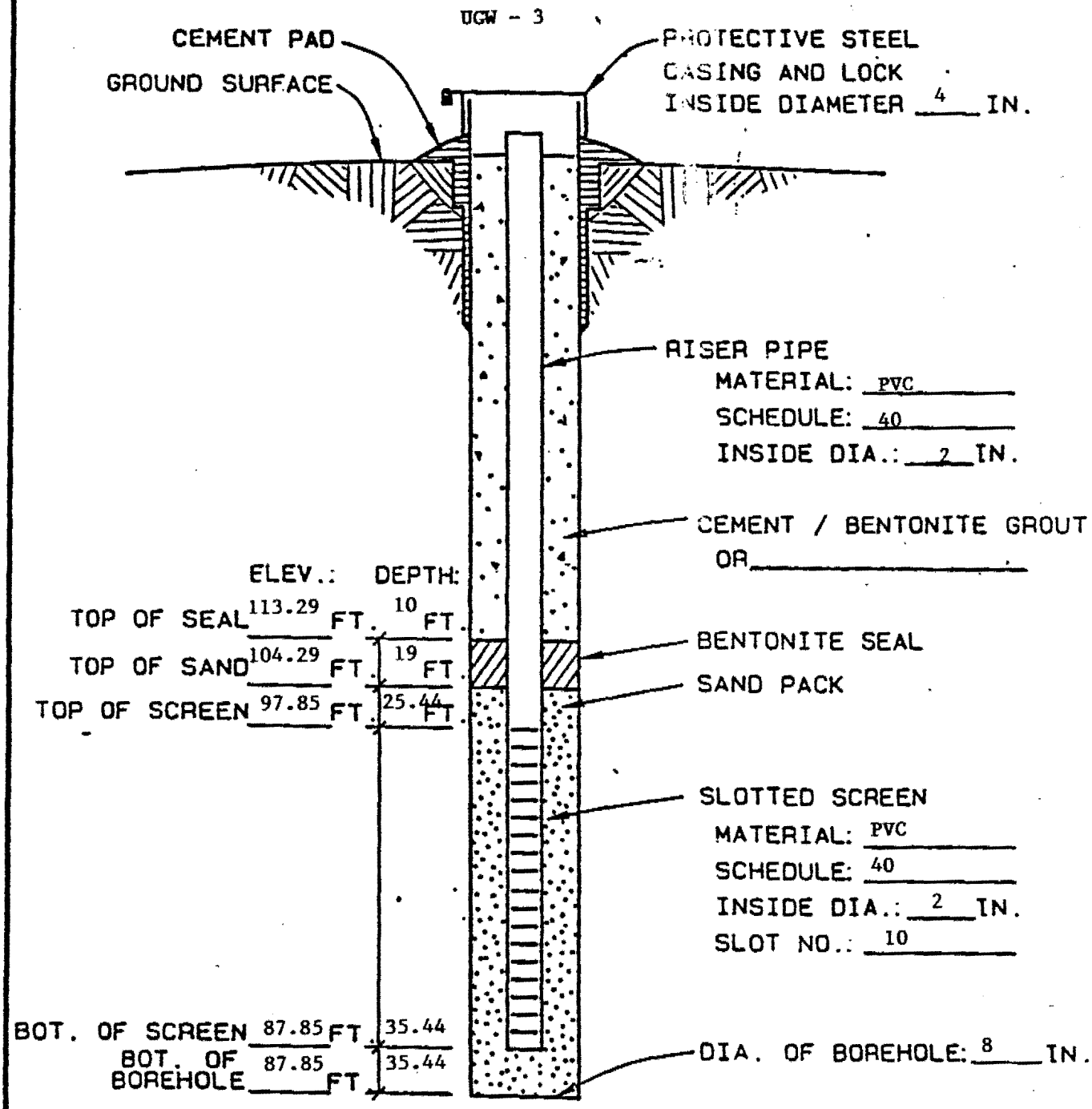
Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	3-4-5-8	2'/1'	9	Moist, brown/green/black, medium stiff SILT little fine to medium gravel, trace clay					30	*
	2	2-4'	3-4-8-7	2'/2'	12	Moist, brown and gray mottled, stiff CLAY, some silt, trace fine to medium sand					40	
	3	4-6'	5-5-8-2	2'/1.8'	13	Same as above					40	
5												
10	4	10-12'	27-38- 18-21	2'/1.6'	56	Damp, brown/orange/green, fine to medium SAND, some silt, trace fine to medium gravel					1	
15	5	15-17'	10-50/0.5	1'/1'	---	Damp, very dense, brown-gray, silty, fine to coarse SAND, trace fine to medium gravel					6	
20	6	20-22'	25-50/0.3	0.8/0.8'	---	Very dense, brown slight green, fine to coarse SAND, some silt, trace fine to medium gravel					100	
25	7	25-27'	47-50/0.3	0.8/0.8'	---	Very dense, brown, fine to coarse SAND, little silt and fine to medium gravel 25-25.3 Wet with petroleum product					7	
30	8	30-32'	84/0.5'	0.5/0.5'	---	Wet, brown, very dense, silty, fine to coarse SAND, little fine to medium gravel					140	

* - HNU readings reported in ppm.

Bottom of boring 33.0 ft

MW3.KJF

UGW - 3



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

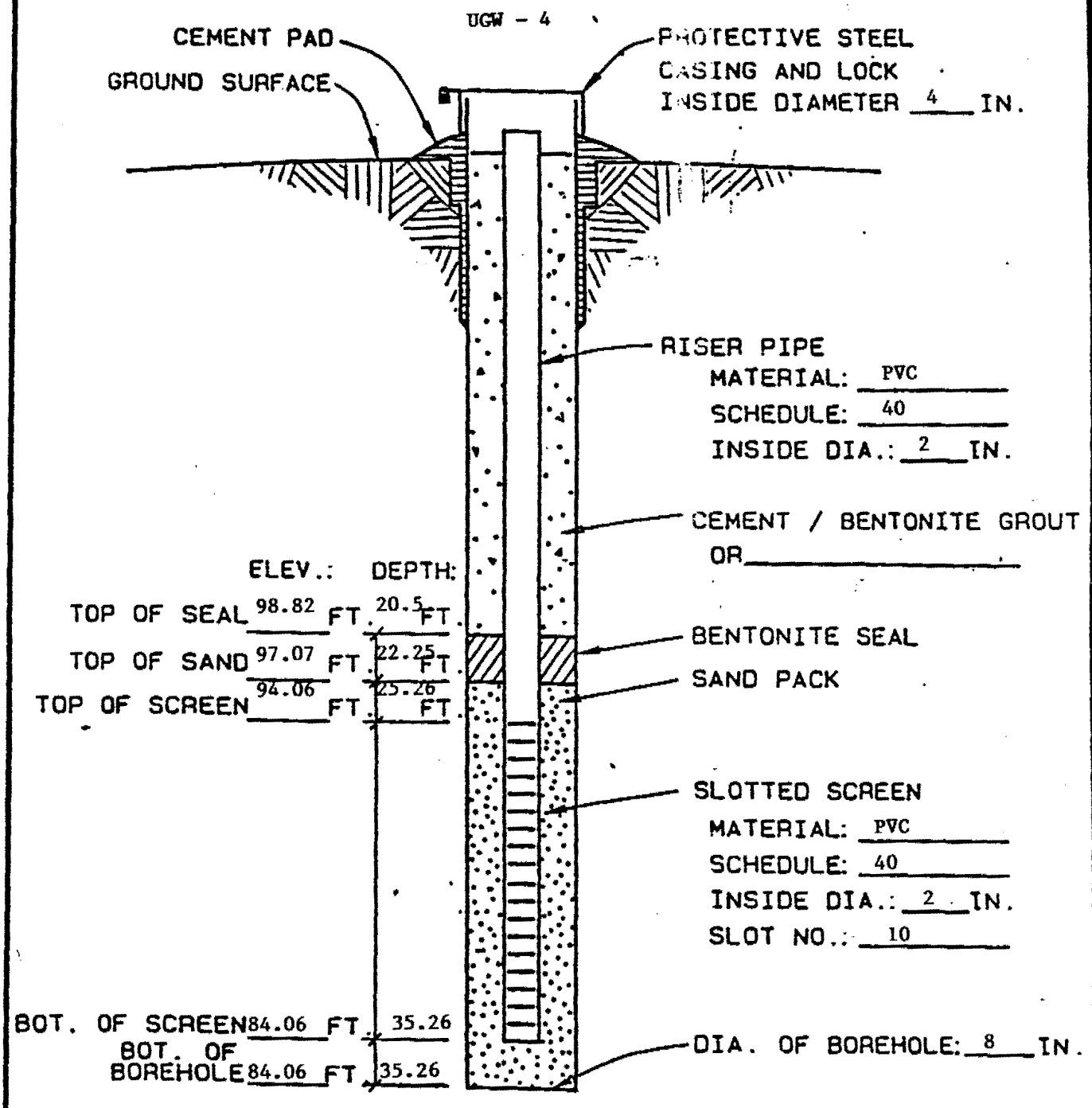
O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-4 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/6/91	Ended: 3/7/91

Depth	Sample No	Sample Depth	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Remarks*
0	1	0-2'	5-5-13-12	2'/1'	18	Moist, brown, stiff SILT little fine to coarse sand, trace fine to coarse gravel					1	*
	2	2-4'	6-9-8-11	2'/1.1'	17	Same to 3.5', then, damp, brown-orange fine to medium SAND, little silt, trace fine to medium gravel					12	
	3	4-6'	9-13-	2'/1.4'	29	Same as above					11	
5			16-21									
10	4	10-12'	31-45-60	1.5/1.3'	110	Damp, brown-orange, very dense, fine to medium SAND, some silt, trace fine to medium gravel					50	
15	5	15-17'	7-10-	2'/2'	31	Moist, green-gray, stiff SILT, some fine to medium sand, trace fine to medium gravel Petroleum odor					7	
			21-27									
20	6	20-22'	19-22-	2'/2'	50	Same, grading to brown and green mottled with white speckles at 20.9'					30	
			28-35									
25	7	25-27'	16-34-	1.8/1.8'	77	Same, wet with petroleum product					60	
			43-50/0.3									
30	8	30-32'	70/0.3'	0.3/0.2'	—	Wet, brown-gray very dense, silty, fine to coarse silty SAND, trace fine gravel					8	

* - HNU readings reported in ppm.

Bottom of boring 34.0 ft

MW4.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

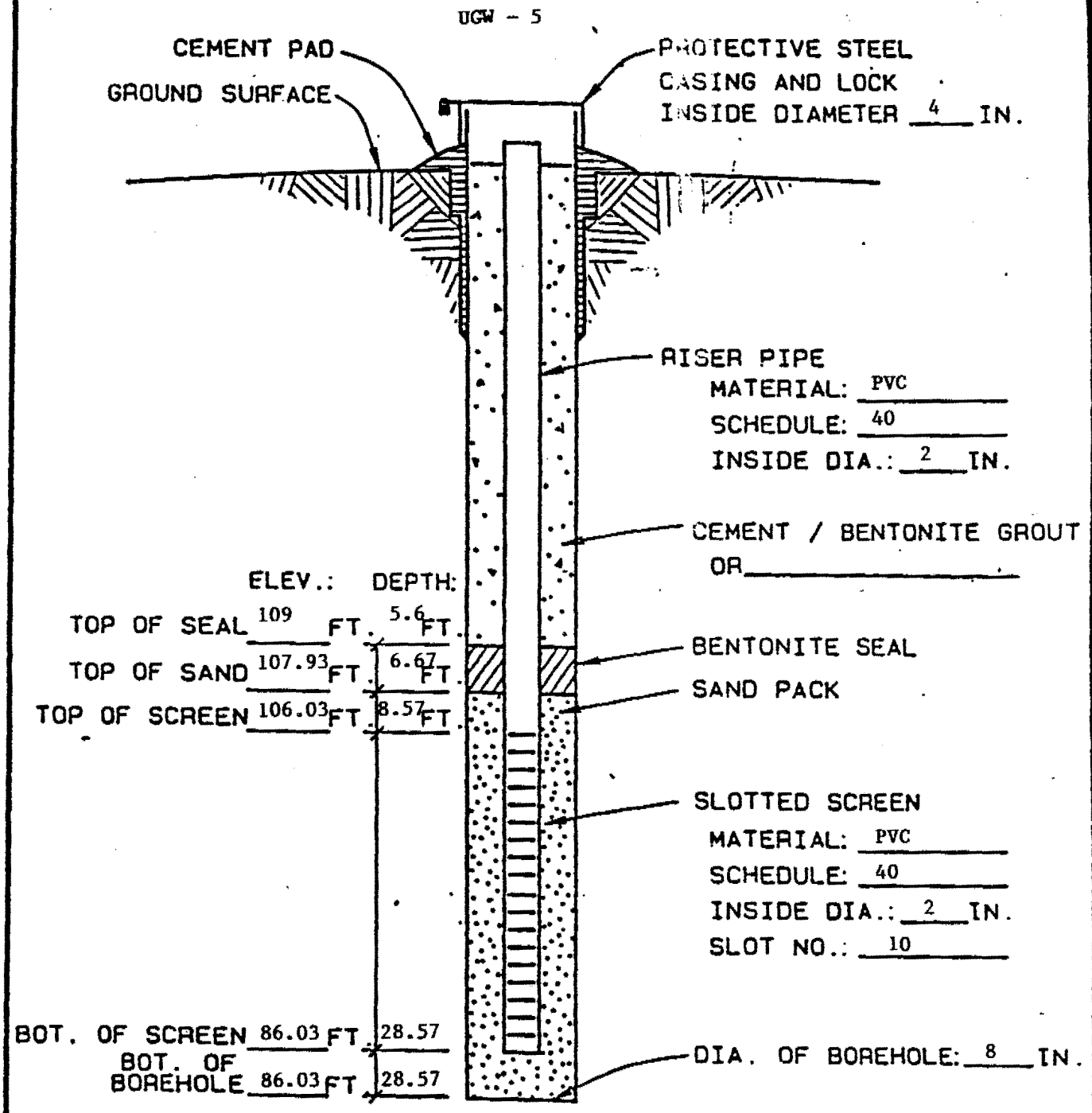
O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-5 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd. Puerto Rico Client: Naval Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: JACA & Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/7/91	Ended: 3/7/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2'	6-12-	2'/0.7'	29	Damp, brown, stiff SILT, little fine to coarse sand and gravel					3	*
			17-9									
	2	2-4'	7-8-9-10	2'/0.9'	17	Same grading to orange-brown, fine to medium SAND, some silt to 2.3' then brown green stiff SILT, little sand and gravel					200	
	3	4-6'	6-7-8-6	2'/1.4'	15	Same, petroleum odor					16	
5												
10	4	10-12'	7-32-70	1.5/1.5'	102	Brown/green/blue hard wet with petroleum SILT, little fine to medium sand and fine to coarse gravel					15	
15	5	15-17'	15-24-	1.8/1.8'	66	Brown/green/red, very dense, fine to coarse SAND, some silt, little fine to coarse gravel, petroleum odor, wet at 16.7'					10	
			45-50/0.3									
20	6	20-22'	21-46-57	1.5/1.5'	103	Same, mottled green and dark brown, grading to brown-orange, medium to coarse SAND, some silt at 21.5'					18	
25	7	25-27'	43-50/0.1	0.6/0.6'	—	Damp, very dense, brown-orange, fine to medium SAND, some silt, trace fine gravel					70	
	8	28-30'	70/0.3'	0.3/0.3'	—	Same as above					3	
							30'					
30						Bottom of boring 30.0 ft.						

* - HNU readings reported in ppm.

MW5.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-6 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

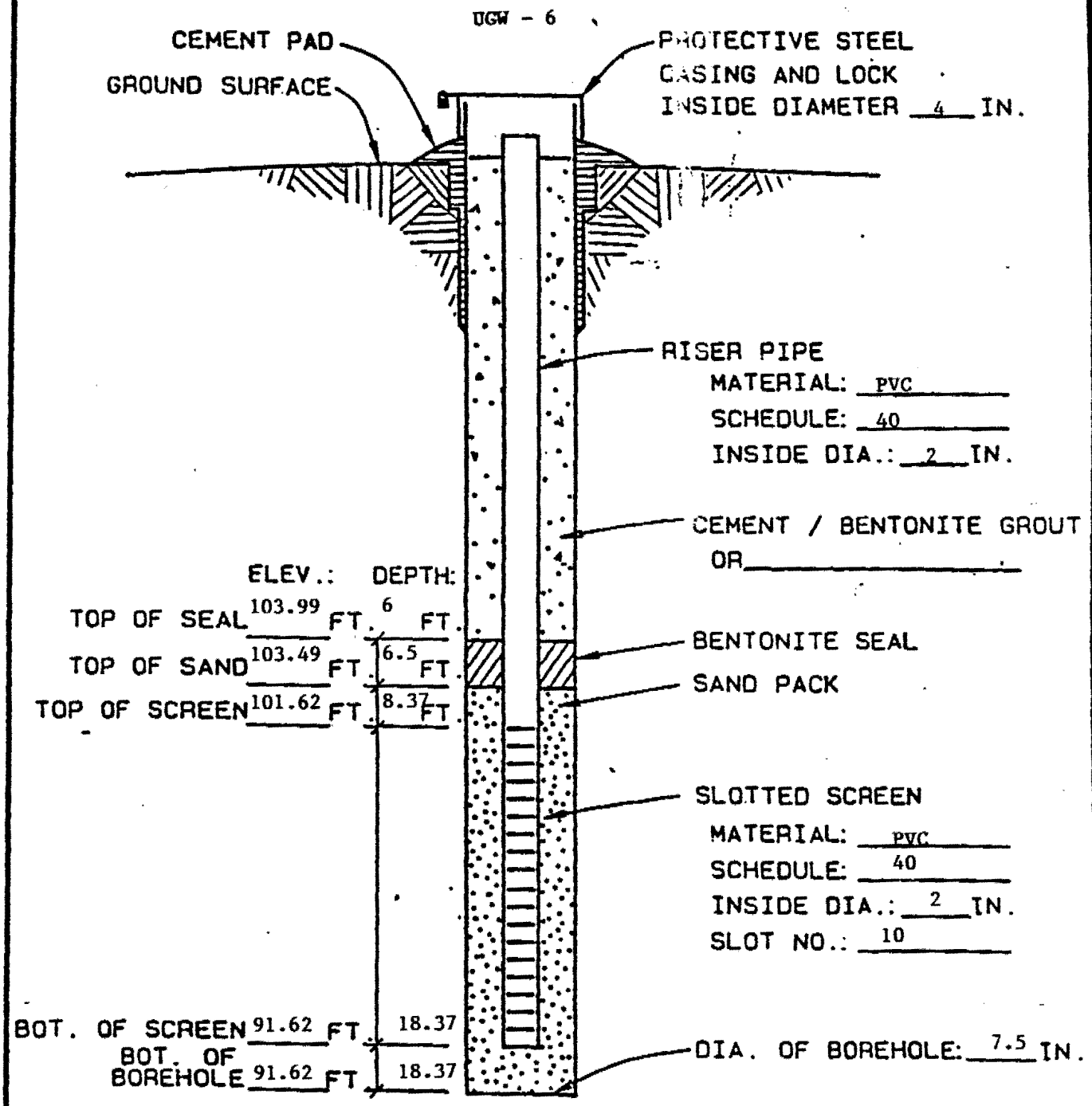
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/19/91 Ended: 3/20/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	20-14-16-20	2'/1.1'	30	Dry, brown, dense, fine to coarse silty SAND, trac fine to medium gravel					2.0	*
	2	2-4'	9-14-21-21	2'/1.4'	35	Damp, reddish brown, stiff silty CLAY, some fine to medium sand, trace fine to coarse gravel to 2.6 ft., then, dense fine to coarse sand, some silt, trace gravel					3.0	
	3	4-6'	9-5-4-5	2'/1.6'	9	Same to 5.6', then, medium stiff CLAY, some silt, trace fine to medium sand					3.0	
5												
10	4	10-12'	3-4-7-5	2'/0.3'	11	Gray glistening, medium stiff SILT, petroleum odor, some clay, little fine to coarse sand, trace fine gravel					140	
15	5	15-17'	0-1-0-1	2'/2'	1	Wet, very soft, red-brown, organic peat to 16 ft., then, gray SILT, some fine to medium sand, sulfur odor					10	
	6	18-20'	1-0-1-0	2'/2'	1	Wet, very soft, gray SILT, some fine sand, trace organics (seaweed), trace seashells, sulfur odor					2.0	
20						Bottom of boring 20 ft.	20.0'					

* - HNU readings reported in ppm

UGW6.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-7 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

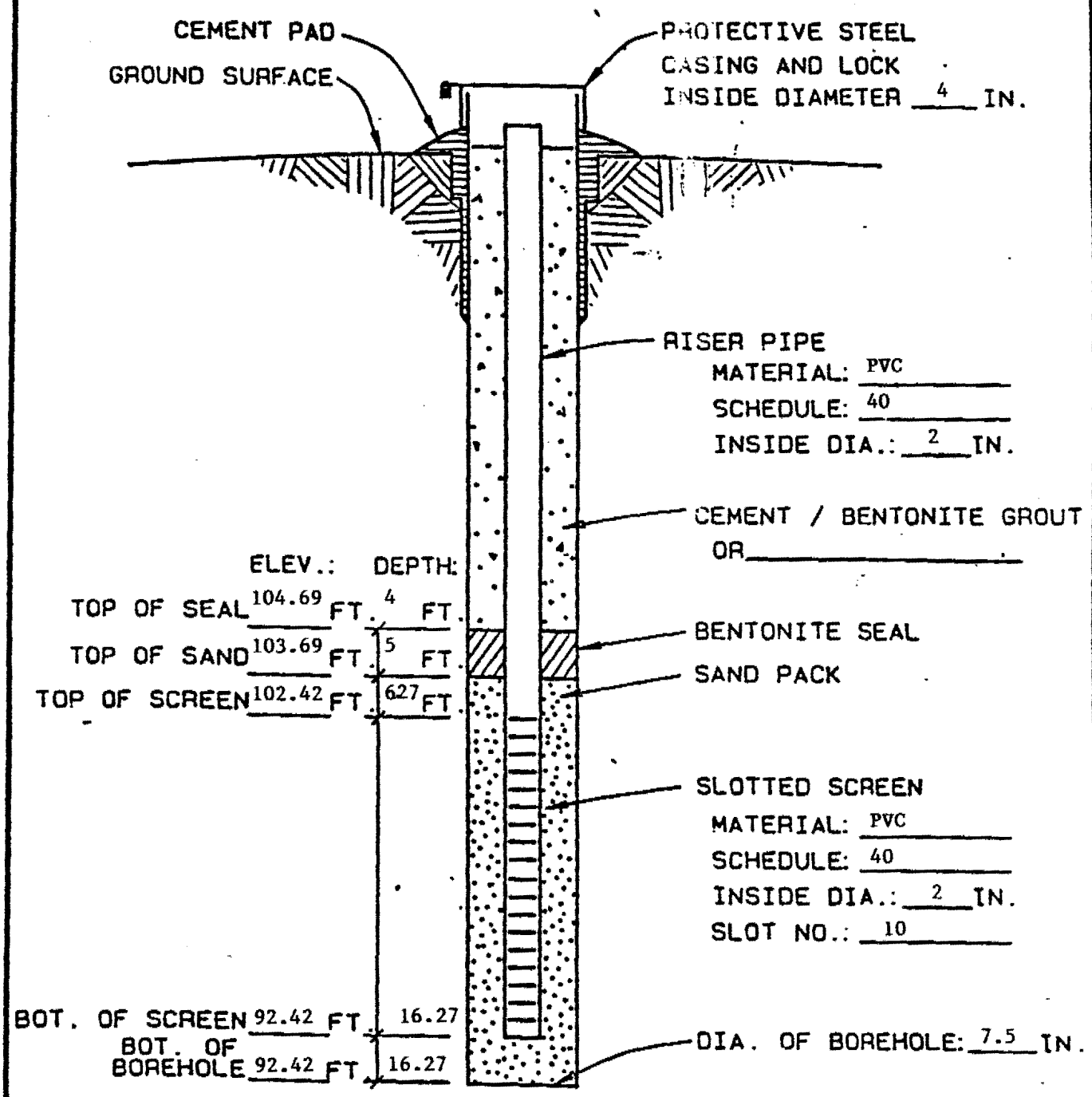
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/20/91 Ended: 3/20/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	4-11-11-6	2'/1.6'	22	Brown-white, damp, fine to medium SAND, little silt, grading to silty with trace clay at 1.2'					3.6	*
	2	2-4'	4-3-3-4	2'/2'	6	Brown-white, moist, medium stiff SILT, little clay, little fine to medium sand, trace organics at 3.6', trace fine gravel					7.0	
	3	4-6'	2-1-2-1	2'/2'	3	As above, soft					2.6	
5												
10	4	10-12'	3-2-4-10	2'/0.8'	6	Gray, wet, soft SILT, little fine to medium sand, little clay, trace sea shells and organics, trace fine to coarse gravel					30.0	
15	5	15-17'	1-1-1	2'/2'	3	Very soft, wet, brown-green SILT, trace clay, organics and seashells					60.0	
							17.0'					
						Bottom of boring 17.0 ft.						

* - HNU readings reported in ppm.

UGW7.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-8 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

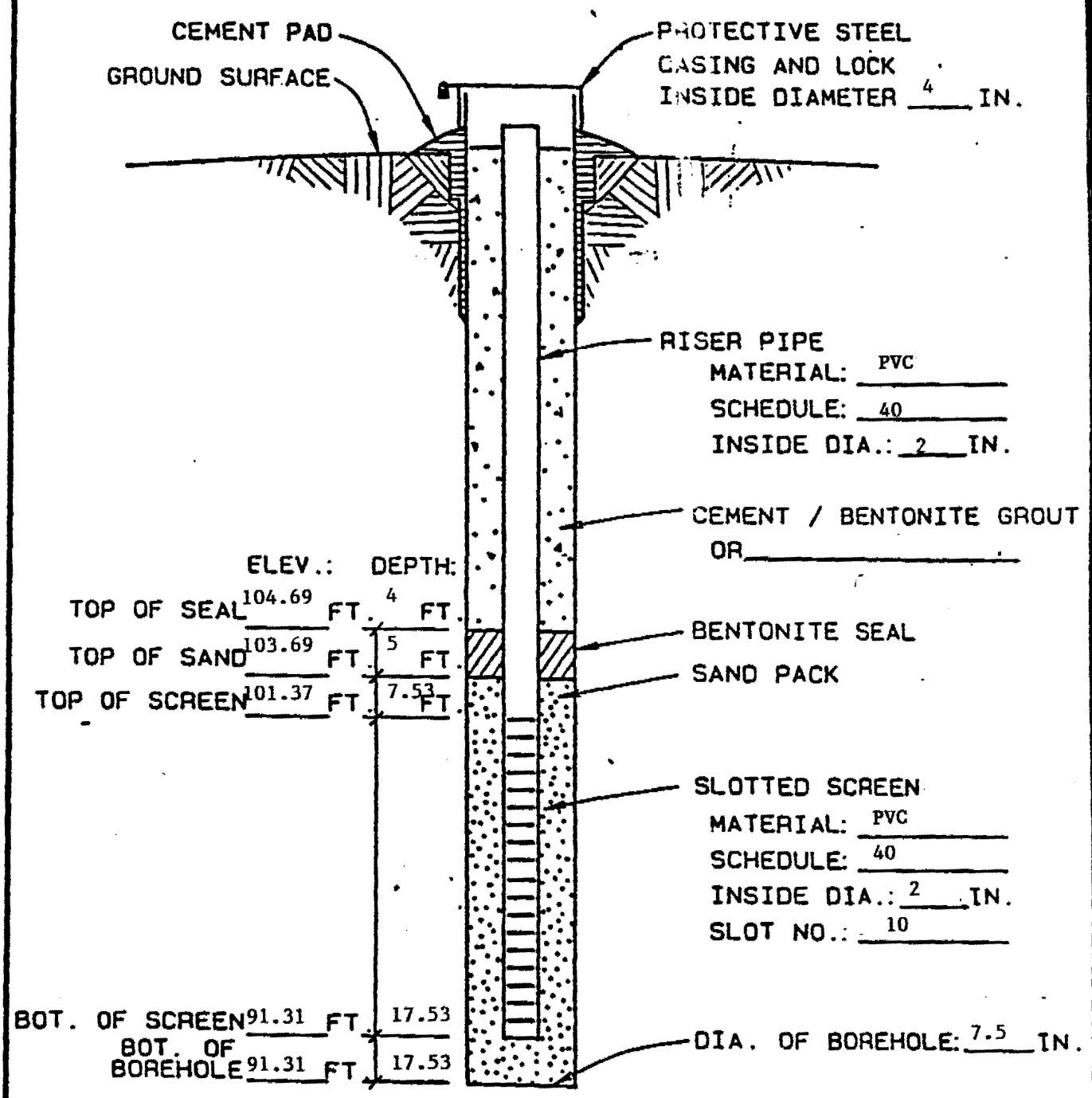
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/21/91 Ended: 3/21/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	16-17-	2'/0.8'	35	Brown, damp, dense, fine to coarse SAND, some silt, little fine to medium gravel, trace organics					10.0	*
			18-19									
	2	2-4'	19-15-	2'/1'	28	As above with trace clay					15.6	
			13-10									
	3	4-6'	4-8-4-3	2'/1'	12	Reddish brown, medium stiff, damp, fine to medium sandy SILT, little clay, trace fine to medium gravel, moist at 5.7'					35.0	
5												
10	4	10-12'	15-25-50	1.5/0.9'	75	Wet, green, brown and orange mottled appearance, very dense, fine to coarse SAND, some apparent weathered rock, little silt and clay					13.0	
15	5	15-17'	13-66	1'/0.7'	—	Wet, greenish brown, very dense, fine to coarse SAND, some fine to coarse gravel, little silt and clay					0.3	
							17.5'					
						Bottom of boring 17.5 ft.						
20												

* - HNU readings reported in ppm.

UGW8.KJF



TYPICAL OVERBURDEN MONITORING WELL

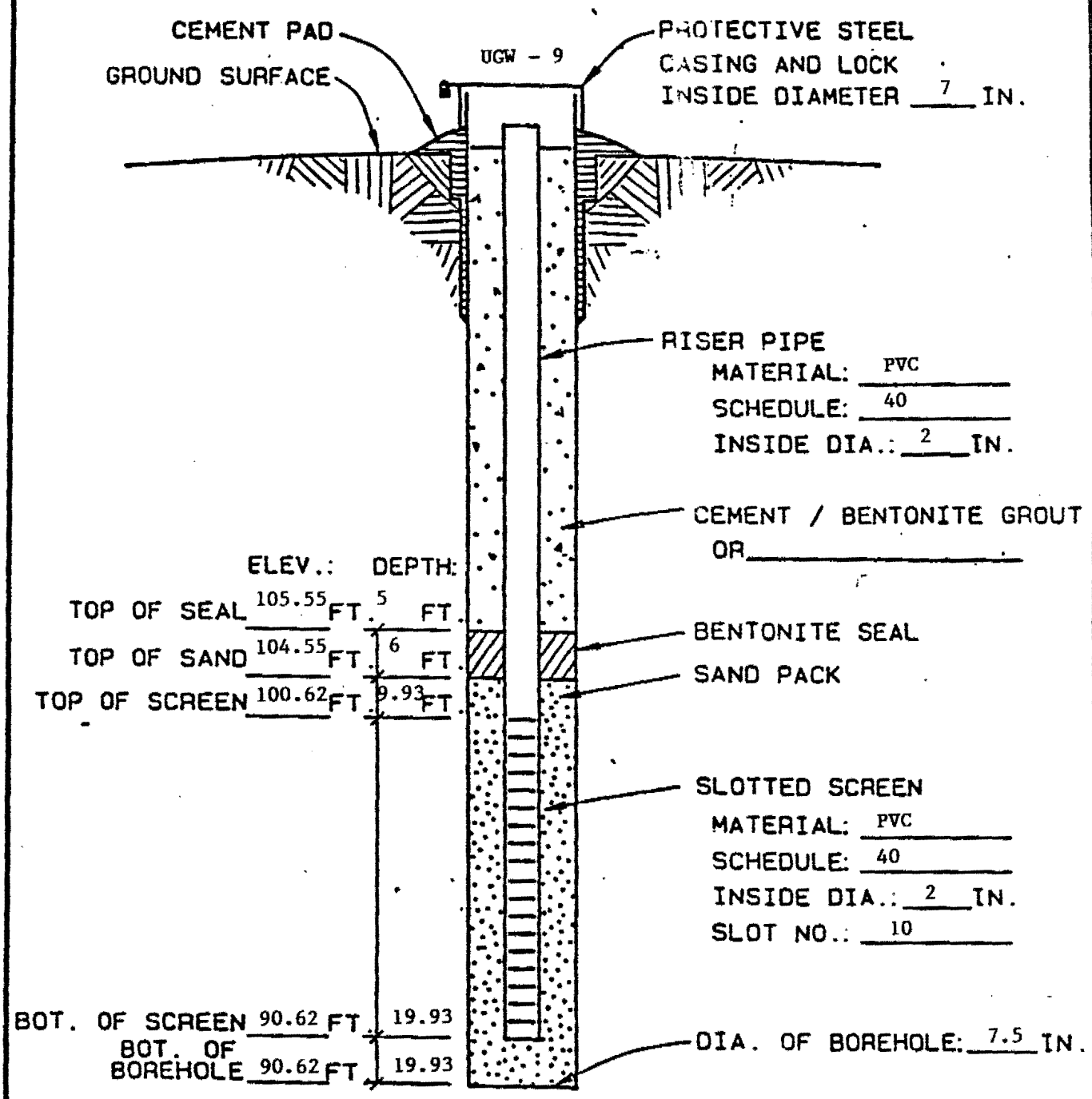
N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-9 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: Jaca and Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/22/91	Ended: 3/22/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	13-17-	2'/1.3'	33	Light brown, damp, very dense, fine to coarse SAND, some silt, little fine to coarse gravel					140.	*
			16-15									
	2	2-4'	9-6-5-6	2'/1.8'	11	As above, moist, medium dense					1.0	
	3	4-6'	5-8-10-28	2'/1.8'	18	Brown-tan, brown, medium dense, fine to medium silty SAND, trace fine to medium gravel, turning to reddish brown at 5.6'					50.0	
5												
10	4	10-12'	13-17-	2'/2'	37	Very dense, moist, light brown with white speckles, fine to coarse SAND, some silt, trace fine gravel					1.2	
			20-14									
15	5	15-17'	22-25-	2'/2'	55	Reddish brown, wet, very stiff SILT, little fine to coarse sand, apparent weathered bedrock					0.6	
			30-31									
20	6	20-22'	17-34-	1.3/0.8'	---	As above					0	
			50/0.3'									
							22.0'					
						Bottom of boring 22.0 ft.						

* - HNU readings reported in ppm.

UGW9.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-10 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

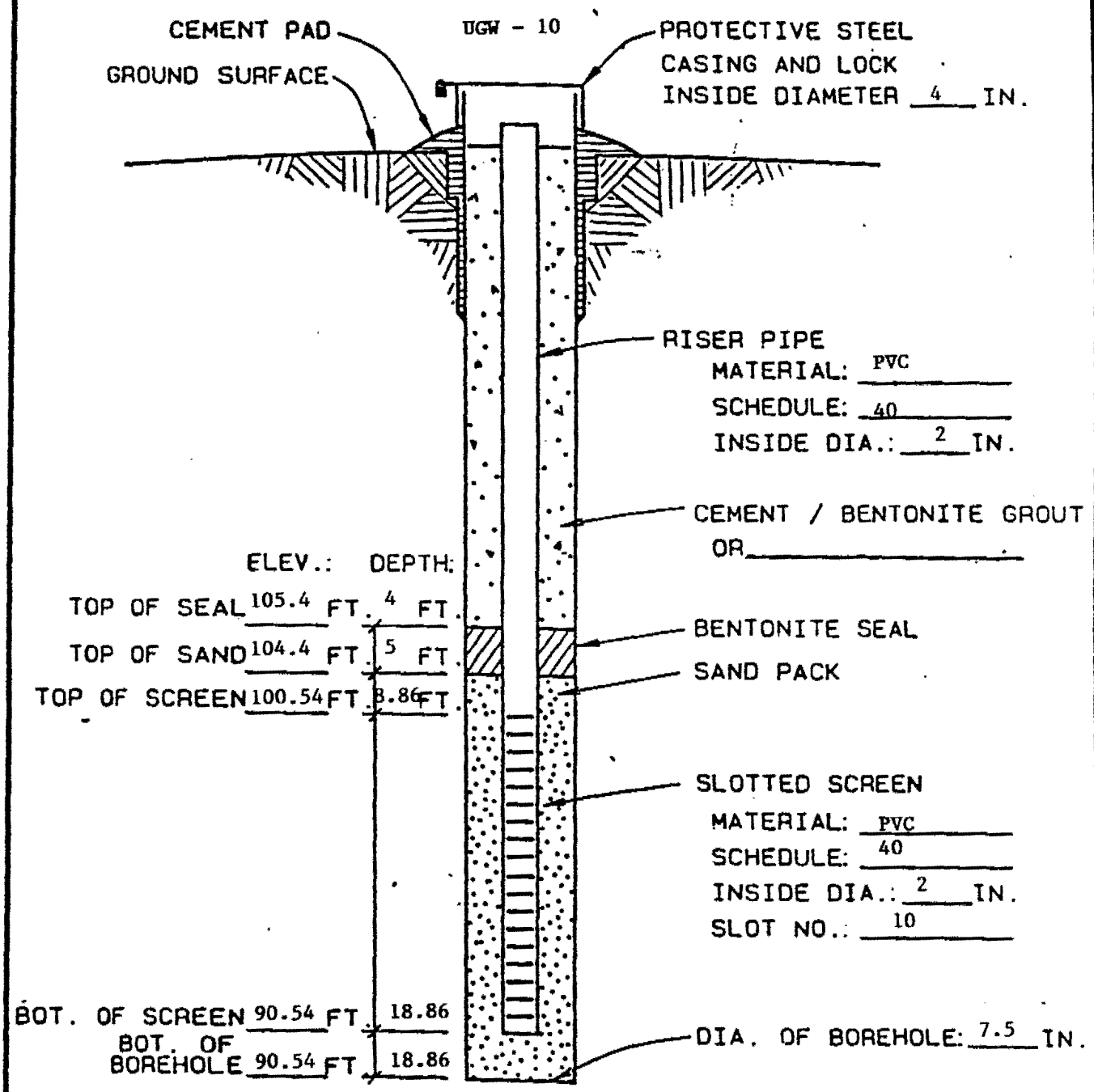
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/25/91 Ended: 3/25/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	14-12-8-14	2'/1.8'	20	Light tan, damp, medium dense, fine to medium SAND, trace fine to coarse gravel, some silt, little clay at 1.4'					80.0	*
	2	2-4'	12-5-7-5	2'/1.5'	12	Moist, brown orange, medium stiff SILT, little clay, little fine to medium sand, trace fine to medium gravel					18.0	
	3	4-6'	3-2-2-2	2'/1.3'	4	As above, soft, very poorly sorted					12.0	
5												
10	4	10-12'	1-0-1-2	2'/0.5'	1	As above, wet to 11', gray, then fine to coarse white SAND, very loose					30.0	
15	5	15-17'	14-26-36-34	2'/1.8'	62	Hard, wet, orange brown SILT, some clay, trace fine to coarse sand, trace fine to medium gravel					35.0	
						Bottom of boring 17.0 ft.	17.0'					
20												

* - HNU readings reported in ppm.

UGW10.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-11 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

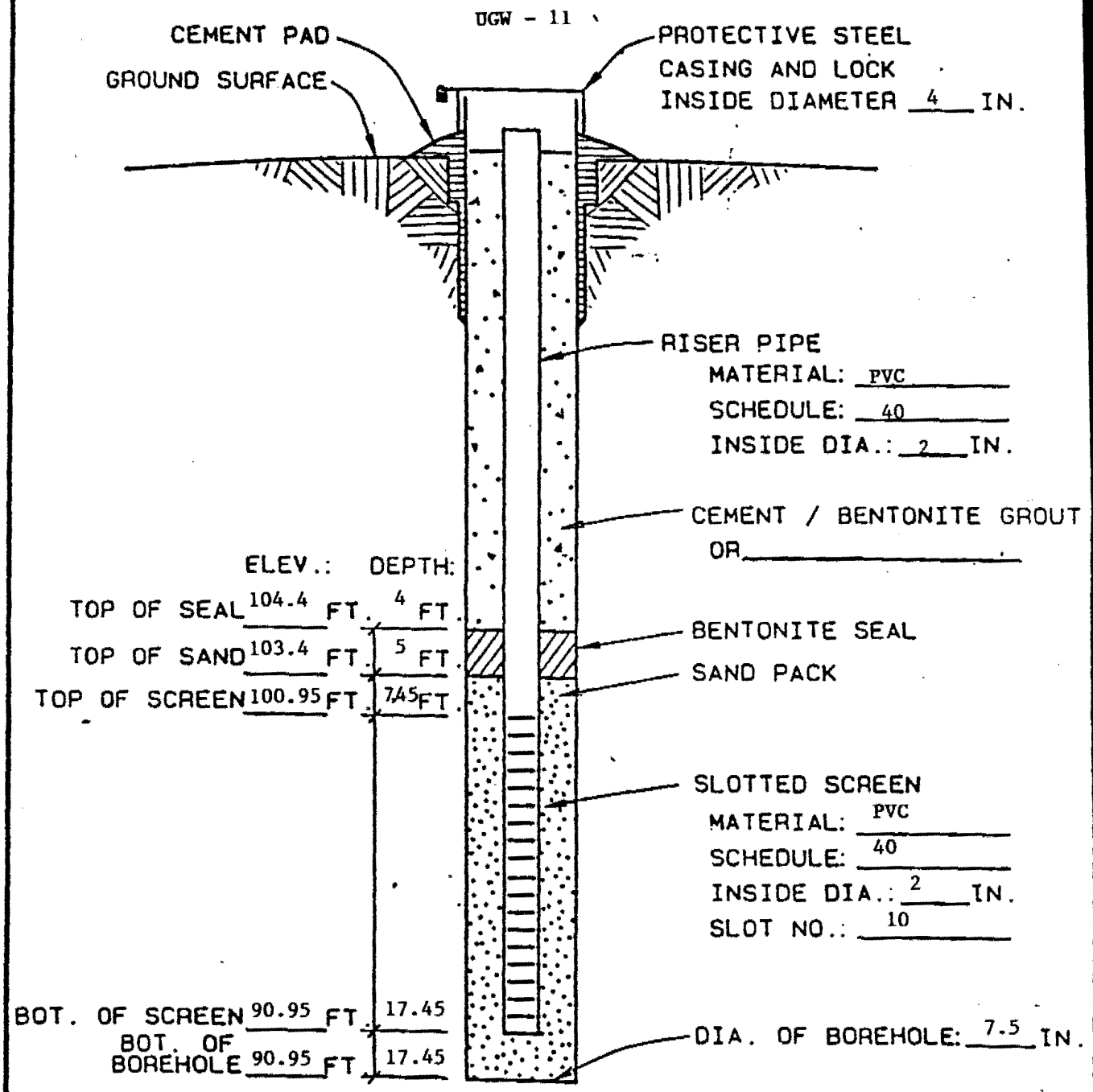
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/25/91 Ended: 3/25/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	11-22-	2'/1.5'	47	Brown, damp, silty, fine to medium SAND, little fine to medium gravel to 0.5', then white, very dense					7.5	*
			25-26									
	2	2-4'	19-20-	2'/1.5'	36	As above					110.	
			16-13									
	3	4-6'	14-11-9-9	2'/1.6'	20	White, moist, medium dense, fine to medium SAND, little fine to coarse gravel, trace sea shell pieces					130.	
5												
10	4	10-12'	2-2-1-1	2'/2'	3	Wet, very loose, white, fine to coarse SAND, slight sulfur odor					2.0	
15	5	15-17'	2-8-8-6	2'/1'	16	As above, grading to dark gray, stiff, wet SILT, trace fine to medium gravel at 16'					7.0	
							17.0'					
						Bottom of boring 17.0 ft.						

* - HNU readings reported in ppm.

UGW11.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-12 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

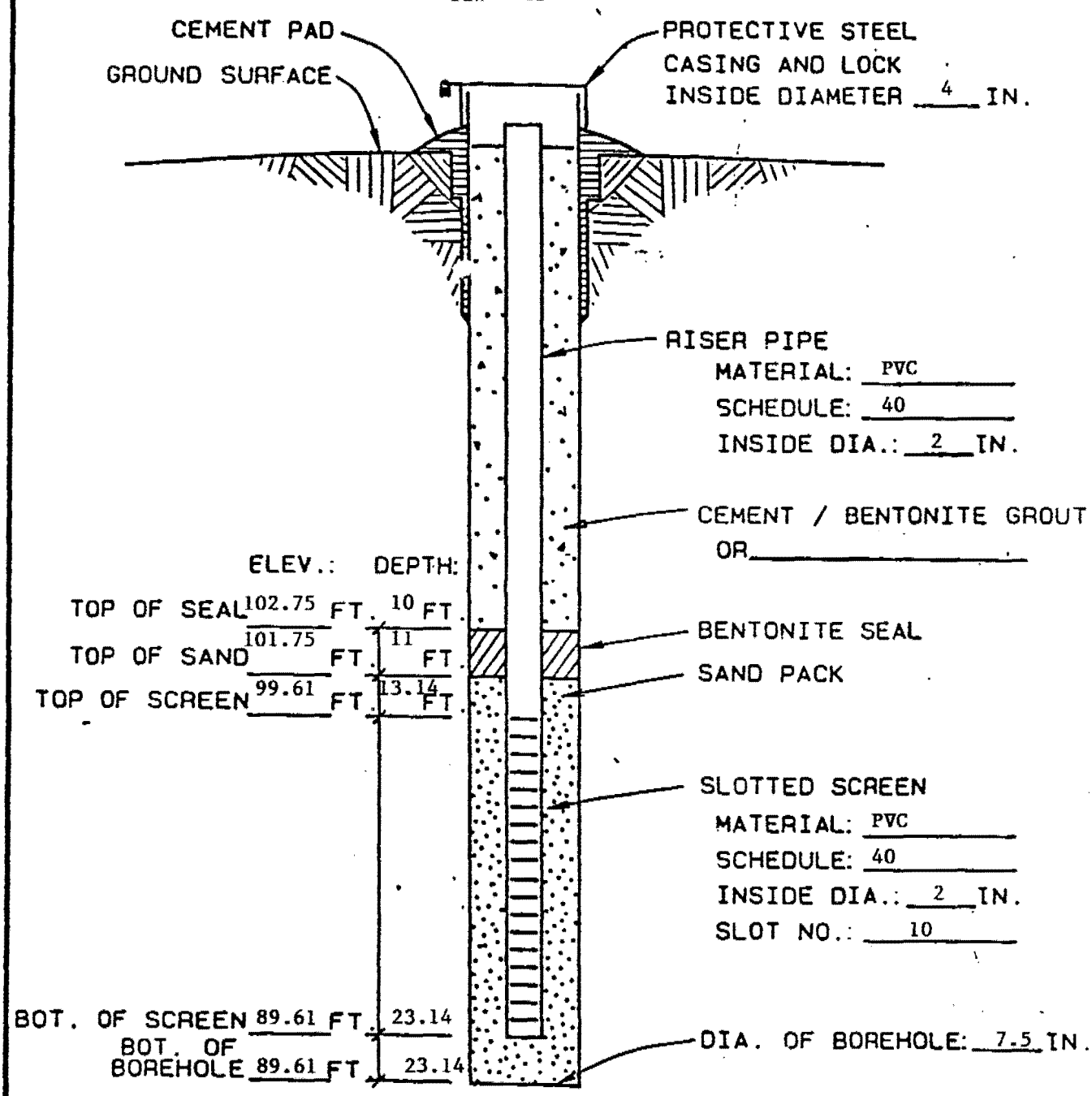
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/26/91 Ended: 3/26/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	6-7-13-19	2'/1'	20	Dry, stiff, brown SILT, little fine to medium gravel, little fine to medium sand					7.0	*
	2	2-4'	15-19-	2'/0.3'	33	Dry, whitesh brown, dense, silty fine to medium SAND, little fine to medium gravel					10.0	
			14-16									
	3	4-6'	11-60/0.3	0.8/0.5'	—	Very dense, damp, orange-brown, fine to medium silty SAND, little fine to medium gravel					1.0	
5												
10	4	10-12'	18-19-	1.8/1.8'	53	Hard, moist, brown orange SILT, little clay trace fine to medium gravel and sand					46.0	
			34-55/0.3									
15	5	15-17'	42-60	1'/0.7'	60	Very dense, partially saturated, fine to coarse SAND, some silt, little fine to medium gravel, petroleum odor					150.	
20	6	20-22'	70/0.3	0/0.3'	—	Very dense, wet, brown, silty fine to medium SAND, some angular gravel, trace clay					12.0	
							23.0'					
						Bottom of boring 23.0 ft.						

* - HNU readings reported in ppm.

UGW12.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-13 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

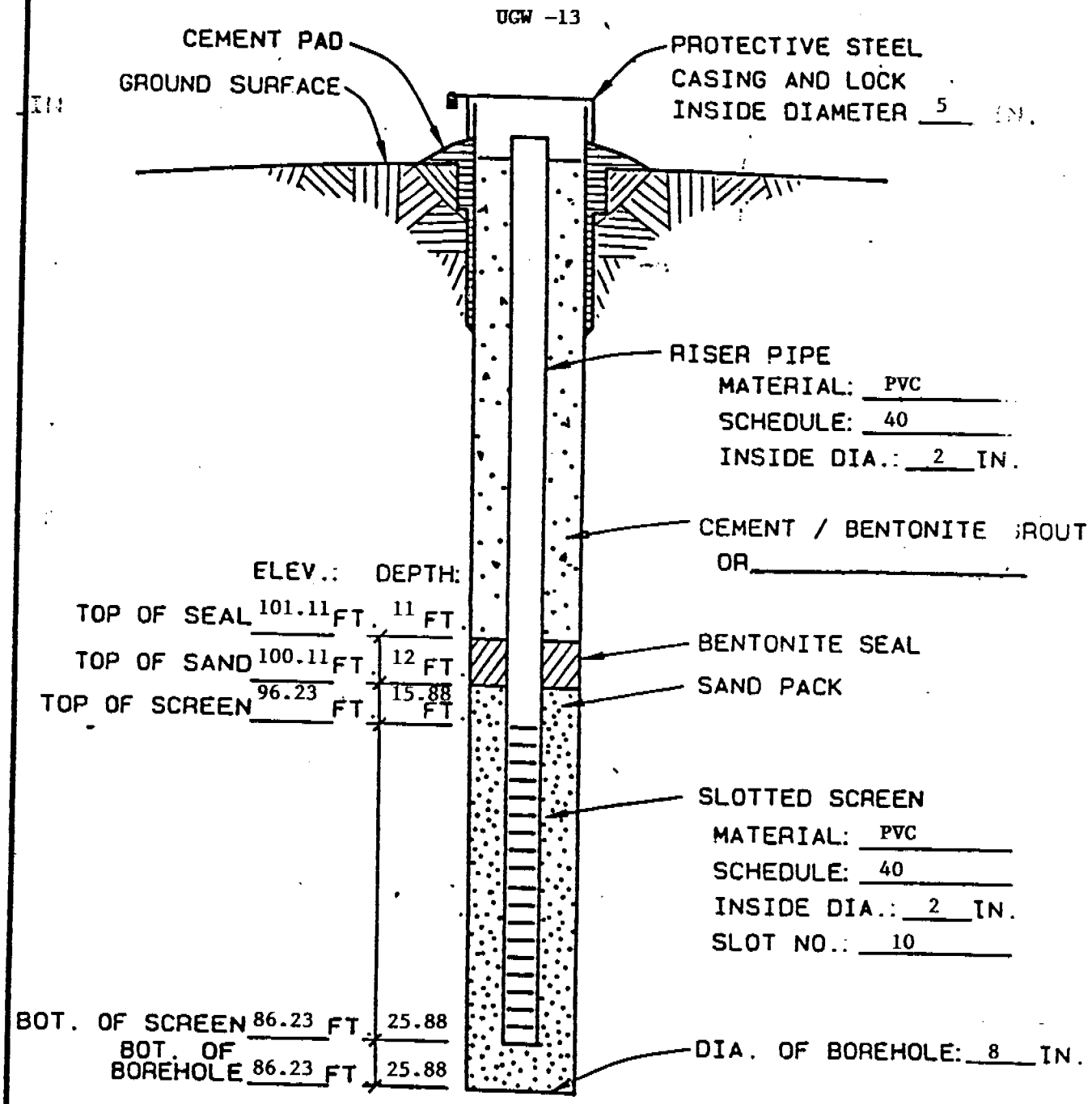
Boring Location:
Ground Elevation:
Dates: Started: 3/26/91 Ended: 3/26/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	6-10-	2'/1.3'	27	Brown, dry, medium dense, silty, fine to medium SAND, little fine to medium gravel, trace clay					0.6	*
			17-18									
	2	2-4'	14-16-	2'/1.6'	40	Dry, brown, dense silty, fine to medium SAND, little fine to coarse gravel, greenish tinge at 4'					2.0	
			24-34									
	3	4-6'	32-50/0.1	0.6/0.2'	—	Dry, brown, very dense, silty, fine to medium SAND, little fine to coarse gravel					5.0	
5												
10	4	10-12'	60/0.3'	0.3/0.3'	—	Hard, slight petroleum odor, damp, brown-green SILT, some fine to medium sand, trace fine to medium gravel					146.	
15	5	15-17'	16-60/0.3	0.8/0.8'	—	Very dense, wet, petroleum odor, dark brown-dark green, fine to coarse SAND, some silt, little fine to medium gravel					158.	
20	6	20-22'	19-50/0.3	0.8/0.8'	—	Hard, wet, orange-brown SILT, some clay, little fine to medium angular gravel, trace fine to medium sand					4.0	
							24'					
						Bottom of boring 24.0 ft.						

* - HNU readings reported in ppm.

UGW13.KJF

UGW -13



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-14 Sheet 1 of 2
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: Jaca and Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/27/91	Ended: 3/27/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	6-10-	2'/1.3'	21	Brown-white, damp, medium dense SILT and fine to coarse SAND, little clay and medium to coarse gravel, trace corral					4.0	*
			11-11									
	2	2-4'	17-11-	2'/1'	24	Moist, brown, medium dense, fine to coarse silty SAND, trace fine to medium gravel, trace clay					96.0	
			13-10									
	3	4-6'	4-6-7-7	2'/1.8'	13	Brown, moist, medium dense, silty, fine to coarse SAND, little clay, trace fine to medium gravel, green at 5.8 ft.					13.0	
5												
10	4	10-12'	1-2-3-3	2'/2'	5	Moist, soft, green-brown, clayey SILT, trace fine to medium sand, grading to red and gray at 11.3 ft.					20.0	
15	5	15-17'	14-22-	2'/1'	45	Brown-gray, moist, very stiff, clayey SILT, little fine to coarse gravel, trace fine to coarse sand					50.0	
			23-16									
20	6	20-22'	11-23-	2'/1.7'	49	Green-brown, petroleum odor, moist, dense, silty, fine to coarse SAND, little fine to medium gravel, trace clay					130.	
			26-31									
25	7	25-27'	12-16-	2'/2'	34	Moist, brown, stiff, clayey SILT, little fine to coarse sand, trace fine to medium gravel					12.6	
			18-19									
30	8	30-32'	26-33-	1.5/1.5'	67	Orange-brown, wet, very stiff, clayey SILT, some fine to coarse sand, little fine to medium gravel					10.0	
			80-50/0.5									

* - HNU readings reported in ppm.

1UGW14.KJF

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-14 Sheet 2 of 2
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

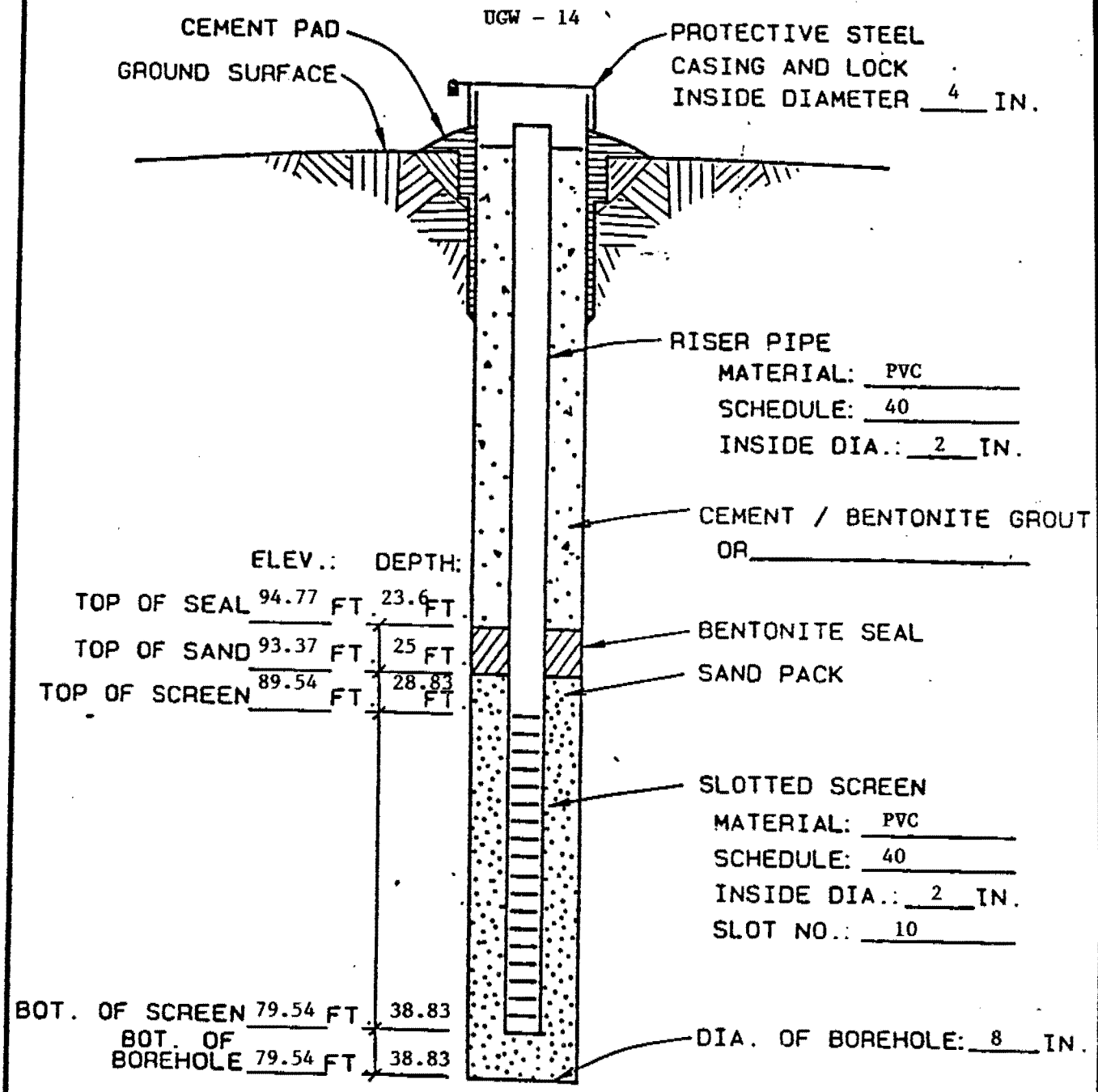
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 3/27/91 Ended: 3/27/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
35	9	35-37'	31-63	1'/0	—	Medium, saturated, brown SILT, little fine to coarse sand, little clay, little fine to medium gravel					30.0	*
							37.0'					
						Bottom of boring 37.0 ft.						

* - HNU readings reported in ppm.

2UGW14.KJF



TYPICAL OVERBURDEN MONITORING WELL

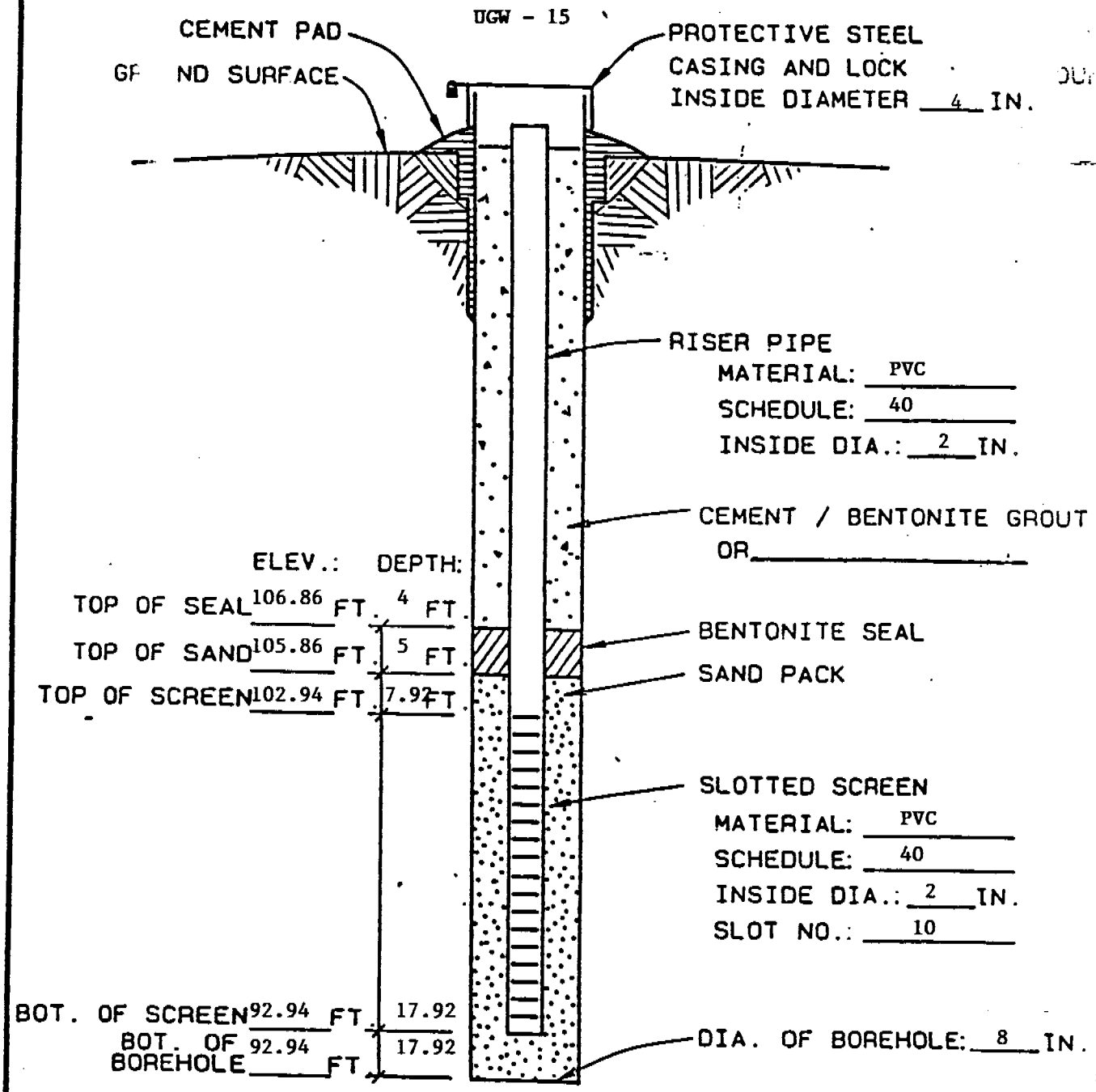
N.T.S.

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-15 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: Jaca and Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 3/28/91	Ended: 3/28/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	16-23-	2'/1'	38	Brown, damp, dense, silty, fine to medium SAND, little fine to medium gravel					8.0	*
			15-12									
	2	2-4'	8-11-	2'/1.3'	23	Brown, moist, medium dense, fine to coarse SAND, little silt and fine to medium gravel					2.8	
			12-13									
	3	4-6'	7-7-5-7	2'/0.9'	12	As above					1.2	
5												
10	4	10-12'	4-5-5-4	2'/0.3'	10	Gray, brown, saturated, fine to coarse SAND some fine to coarse gravel, little silt					30.0	
15	5	15-17'	10-26-	2'/1.3'	64	Saturated, brown-orange, gray, hard SILT, some clay, little fine to coarse sand, little fine to medium gravel					4.6	
			38-41				17'					
						Bottom of boring 17.0 ft.						
20												

* - HNU readings reported in ppm.

UGW15.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

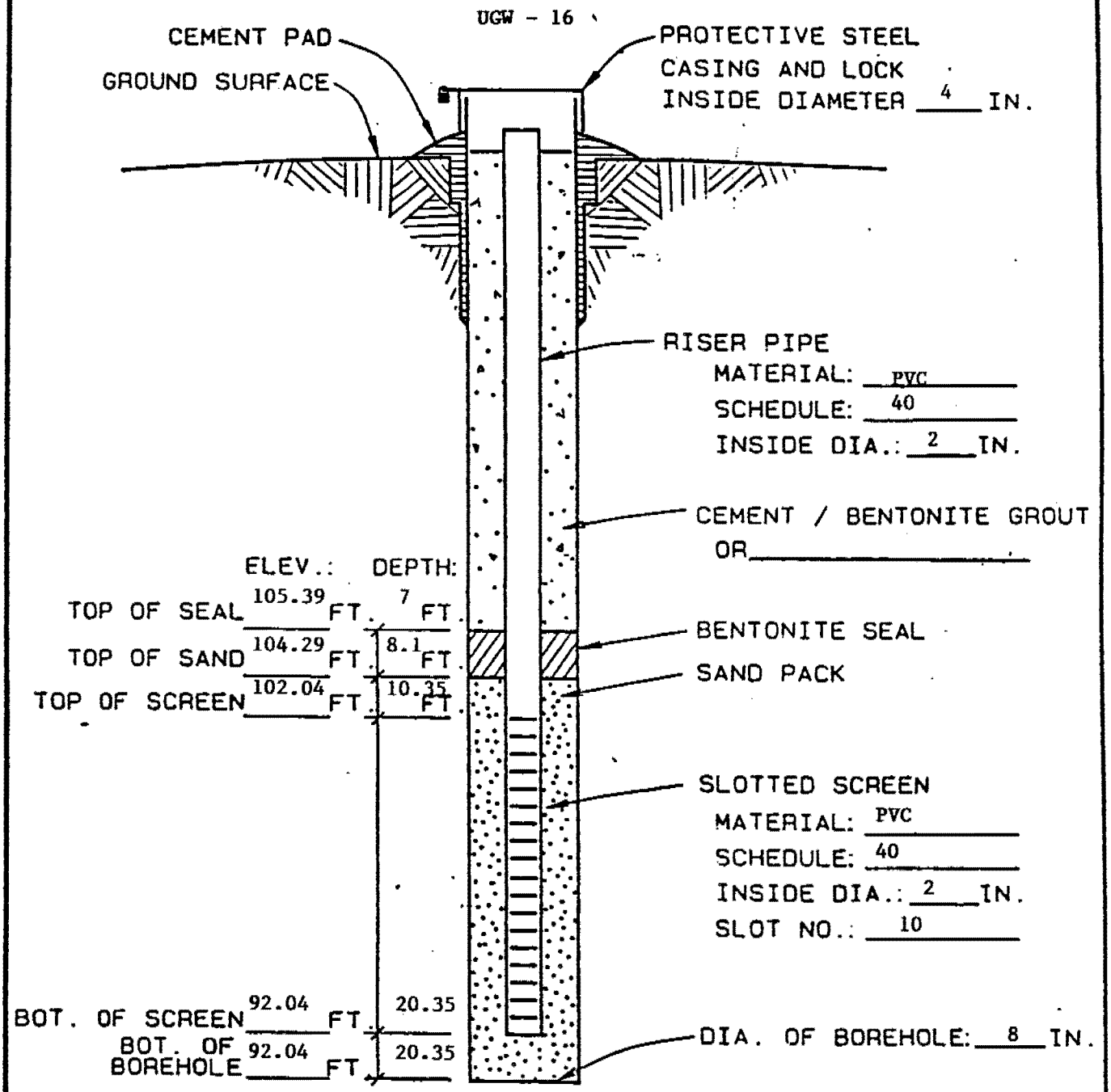
O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-16 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130
Boring Co.: Jaca and Sierra Testing Laboratories Foreman: Angel Ferrer OBG Geologist: Tim Eddy	Boring Location: Ground Elevation: Dates: Started: 4/2/91	Ended: 4/2/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	11-9-7-4	2'/1'	16	Brown, dry, medium dense, fine to coarse SAND, little silt and fine to medium gravel					2.2	*
	2	2-4'	6-3-3-3	2'/0.8'	6	Damp, loose, orange-brown, fine to coarse SAND, little silt nad fine to medium gravel					1.8	
	3	4-6'	5-39-	1.3'/1'	—	Very dense, orange brown, silty, fine to medium SAND, trace fine to medium gravel, cobble at 5.8 ft.					2.4	
5			60/0.3'									
10	4	10-12'	47-51/0.4	0.9/0.4'	—	Very dense, greenish gray, damp, fine to coarse SAND, some silt, little fine to medium gravel					0.8	
15	5	15-17'	76/0.2'	0.2/0.2'	—	Brown, wet, very dense, silty, fine to coarse SAND, some angular broken gravel, little clay					3.0	
20	6	20-22'	60/0.5'	0.5/0.3'	—	As above					0.8	
							22.0'					
						Bottom of boring 22.0 ft.						

* - HNU readings reported in ppm.

UGW16.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-17 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

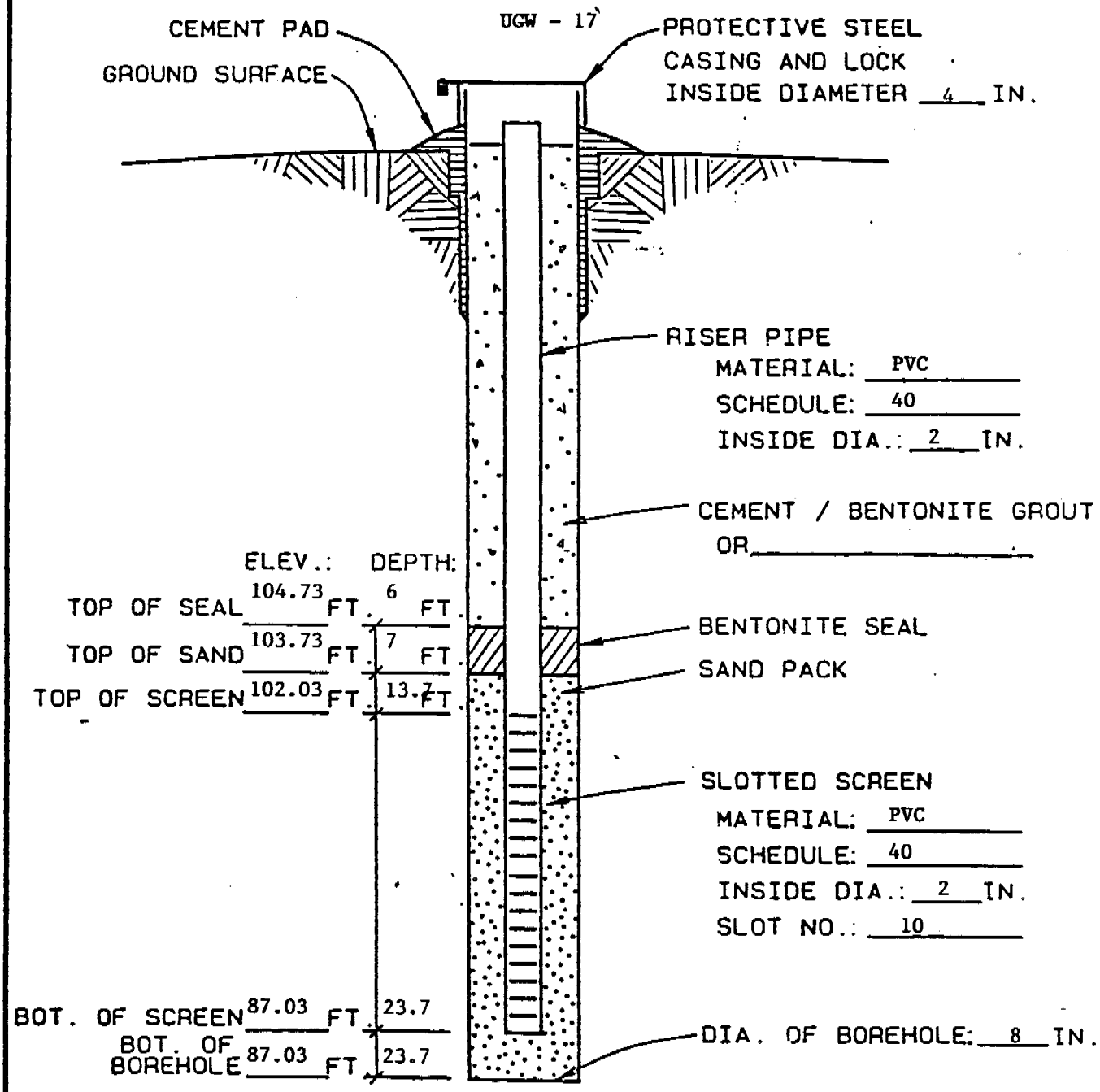
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 4/2/91 Ended: 4/2/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	10-13-	2'/1.1'	29	Dry, stiff, brown-gray SILT, some fine to medium sand, little fine to medium gravel, trace clay					10.4	*
			16-18									
	2	2-4'	19-41-	2'/1.8'	75	Very dense, damp, brown-orange with green tinge, medium to coarse SAND, some silt, trace clay, and fine to medium gravel					4.2	
			34-39									
	3	4-6'	60/0.5	0.5/0.5'	—	Very dense, greenish brown, fine to coarse silty SAND, some fine to medium angular gravel, little clay					2.0	
5												
10	4	10-12'	15-19-	2'/1.6'	40	Brown-tan, damp, dense silty, fine to coarse SAND, little fine to medium gravel, trace clay, diesel odor, moist at 11.9 ft.					130.	
			21-30									
15	5	15-17'	9-16-	2'/1'	30	Brown-orange, moist, dense, silty, fine to medium SAND, little fine to medium gravel, trace clay, less odorous					2.0	
			14-18									
20	6	20-22'	40-60/0.3	0.8/0.8'	—	Very dense, wet, slight odor, fine to coarse SAND, some fine to medium gravel, little silt					1.0	
						Bedrock at 25.0 ft.	25.0'					

* - HNU readings reported in ppm.

UGW17.KJF



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

O'BRIEN & GERE

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No. UGW-18 Sheet 1 of 1
Project Location: U.S. Naval Station Roosevelt Rd., Puerto Rico Client: Facilities Engineering Command	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30"	Ground Water Depth Date Depth Date File No.: 3543.020.130

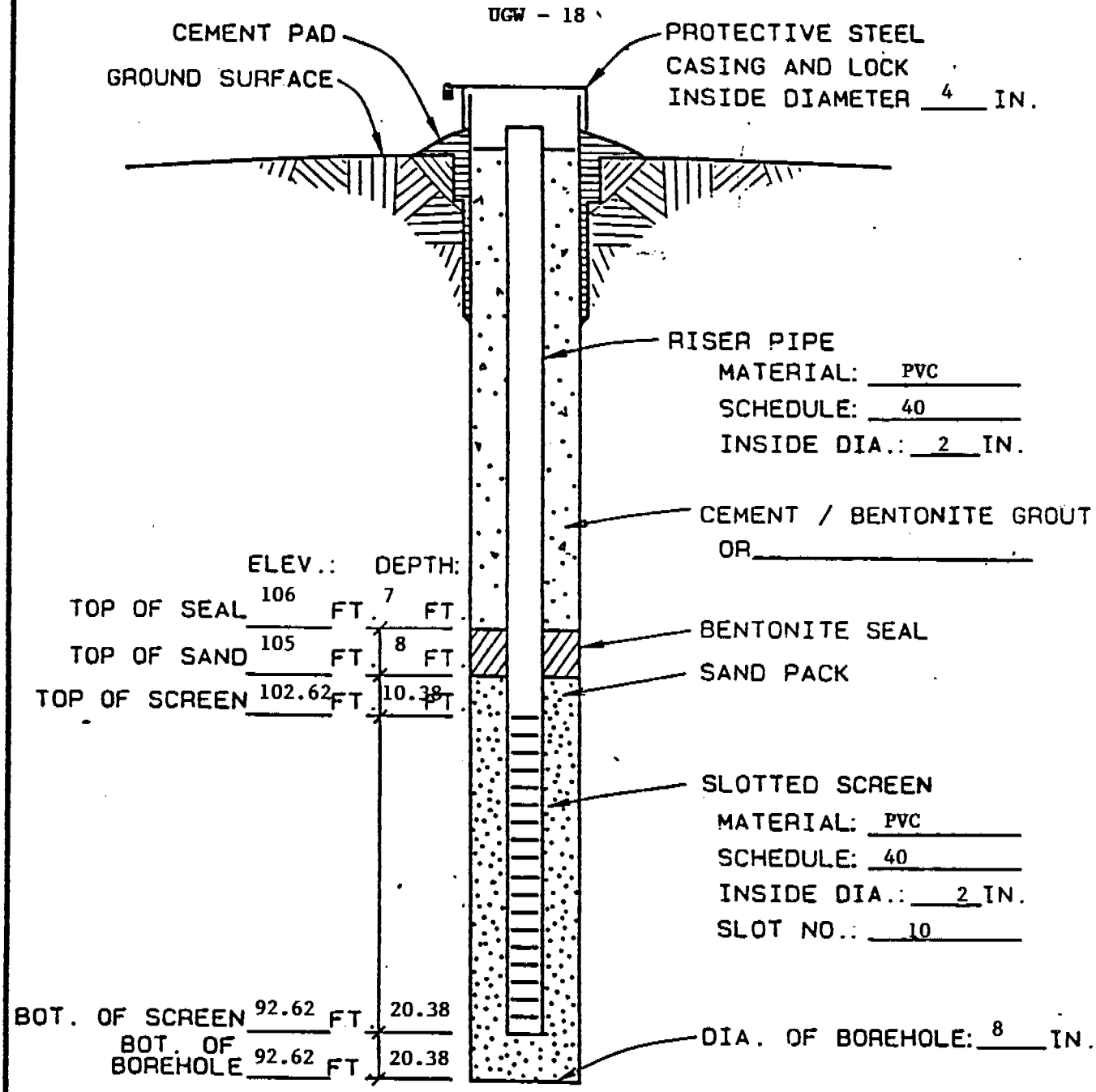
Boring Co.: Jaca and Sierra Testing Laboratories
Foreman: Angel Ferrer
OBG Geologist: Tim Eddy

Boring Location:
Ground Elevation:
Dates: Started: 4/3/91 Ended: 4/3/91

Depth	Sample No	Sample Depth	Blows /6"	Penetr/ Recovry	"N" Valve	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2'	10-20-20-24	2'/1.8'	40	Brown, tan, orange, greenish, dry, very dense, fine to coarse SAND, some silt, trace fine to medium gravel					1.0	*
	2	2-4'	15-24-21-38	2'/1.8'	45	Brown-orange, tan mottled appearance, very dense, damp, fine to coarse SAND, some silt trace fine to medium gravel, trace clay					2.5	
5	3	4-6'	25-54	1'/1'	—	Very dense, damp, gray-greenish gray silty fine to medium SAND, trace fine to medium gravel, trace clay					2.0	
10	4	10-12'	22-57	1'/1'	—	Very dense, light brown, damp, silty, fine to medium SAND, browken cobble at 10.5 to 10.8 ft., trace fine gravel					4.2	
15	5	15-17'	35-60/0.3	0.8/0.5'	—	Greenish gray, damp, fine to medium sandy SILT, trace fine to medium gravel, trace clay					3.8	
20	6	20-22'	60/0.2'	0.2/0.2'	—	Wet, very dense, angular, fine to medium GRAVEL, suspect cobble remains	20.0'				—	
						Bottom of boring 20.0 ft.						

* - HNU readings reported in ppm.

UGW18.KJF

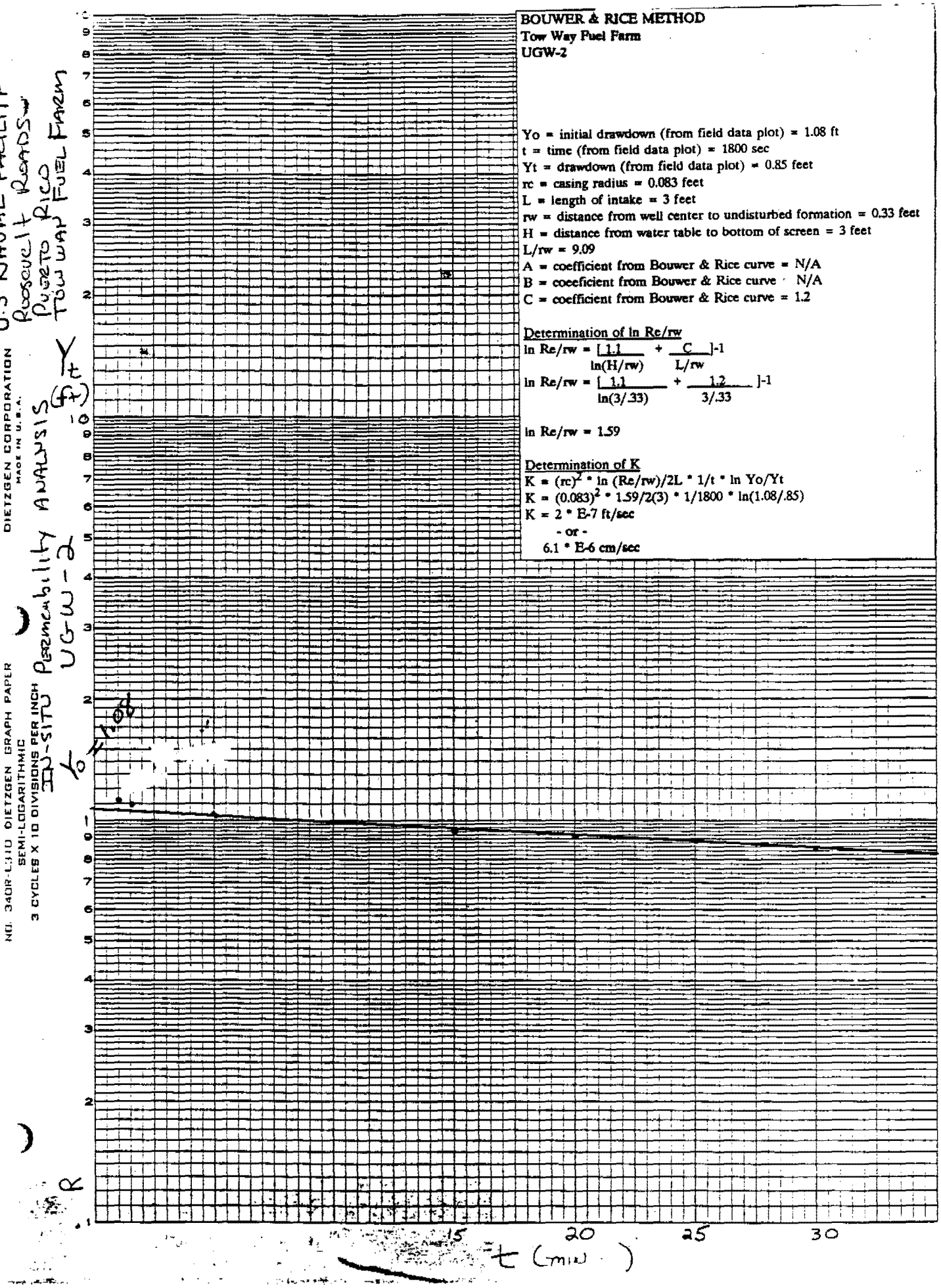


TYPICAL OVERBURDEN MONITORING WELL

N.T.S.

APPENDIX B

IN-SITU HYDRAULIC CONDUCTIVITY TEST ANALYSIS



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-2

Yo = initial drawdown (from field data plot) = 1.08 ft
t = time (from field data plot) = 1800 sec
Yt = drawdown (from field data plot) = 0.85 feet
rc = casing radius = 0.083 feet
L = length of intake = 3 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 3 feet
L/rw = 9.09
A = coefficient from Bouwer & Rice curve = N/A
B = coeeficient from Bouwer & Rice curve N/A
C = coefficient from Bouwer & Rice curve = 1.2

Determination of ln Re/rw

$$\ln Re/rw = \left[\frac{1.1}{\ln(H/rw)} + \frac{C}{L/rw}\right]^{-1}$$

$$\ln Re/rw = \left[\frac{1.1}{\ln(3/.33)} + \frac{1.2}{3/.33}\right]^{-1}$$

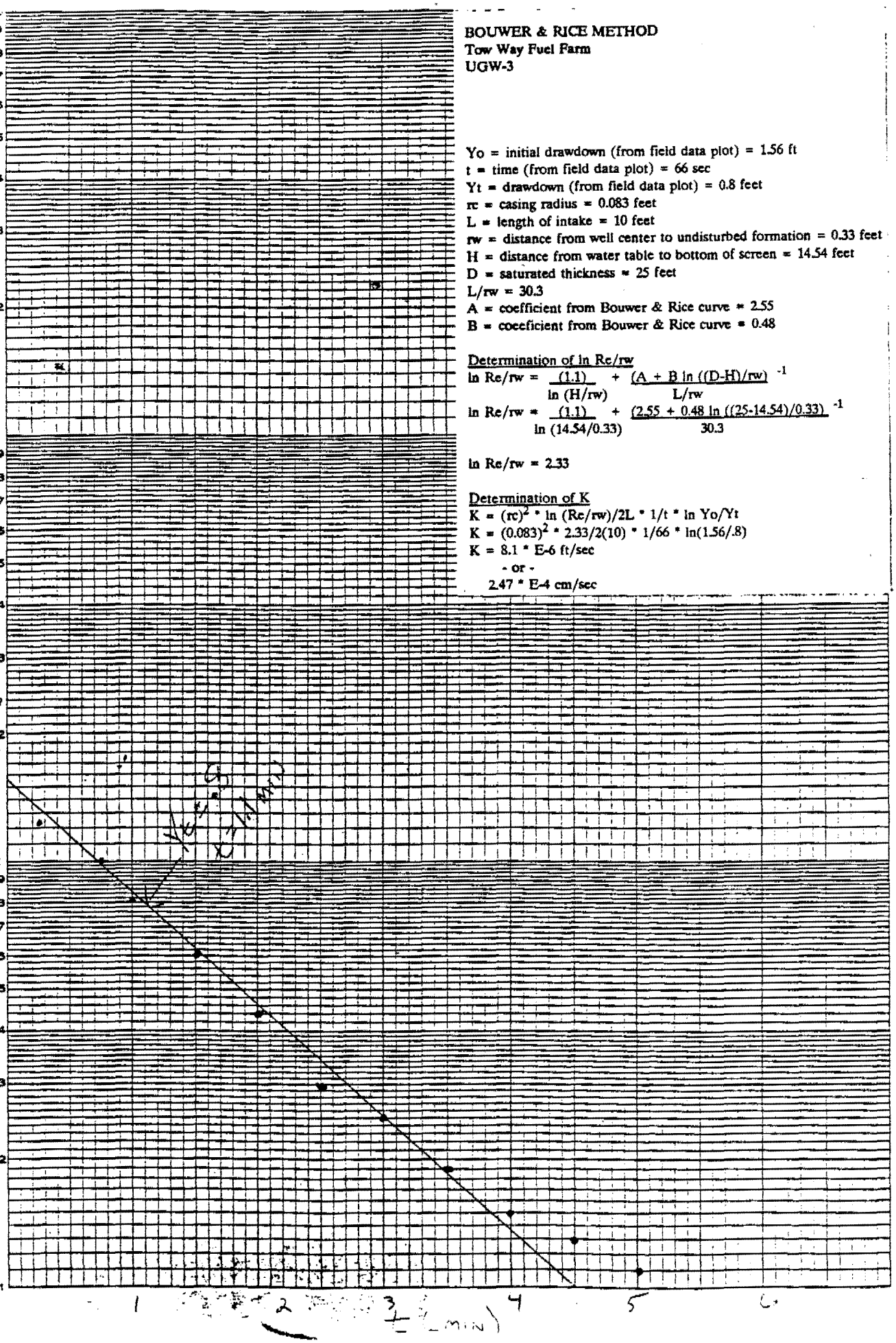
ln Re/rw = 1.59

Determination of K

$K = (rc)^2 * \ln(Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 1.59/2(3) * 1/1800 * \ln(1.08/.85)$
K = 2 * E-7 ft/sec
- or -
6.1 * E-6 cm/sec

U.S. NAVAL FACILITY
ROOSEVELT ROADS
PUERTO RICO
TOW WAY FUEL FARM

IN-SITU PERMEABILITY ANALYSIS
UGW-3



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-3

Yo = initial drawdown (from field data plot) = 1.56 ft
t = time (from field data plot) = 66 sec
Yt = drawdown (from field data plot) = 0.8 feet
rc = casing radius = 0.083 feet
L = length of intake = 10 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 14.54 feet
D = saturated thickness = 25 feet
L/rw = 30.3
A = coefficient from Bouwer & Rice curve = 2.55
B = coeeficient from Bouwer & Rice curve = 0.48

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (14.54/0.33)} + \frac{(2.55 + 0.48 \ln ((25-14.54)/0.33)}{30.3}^{-1}$$

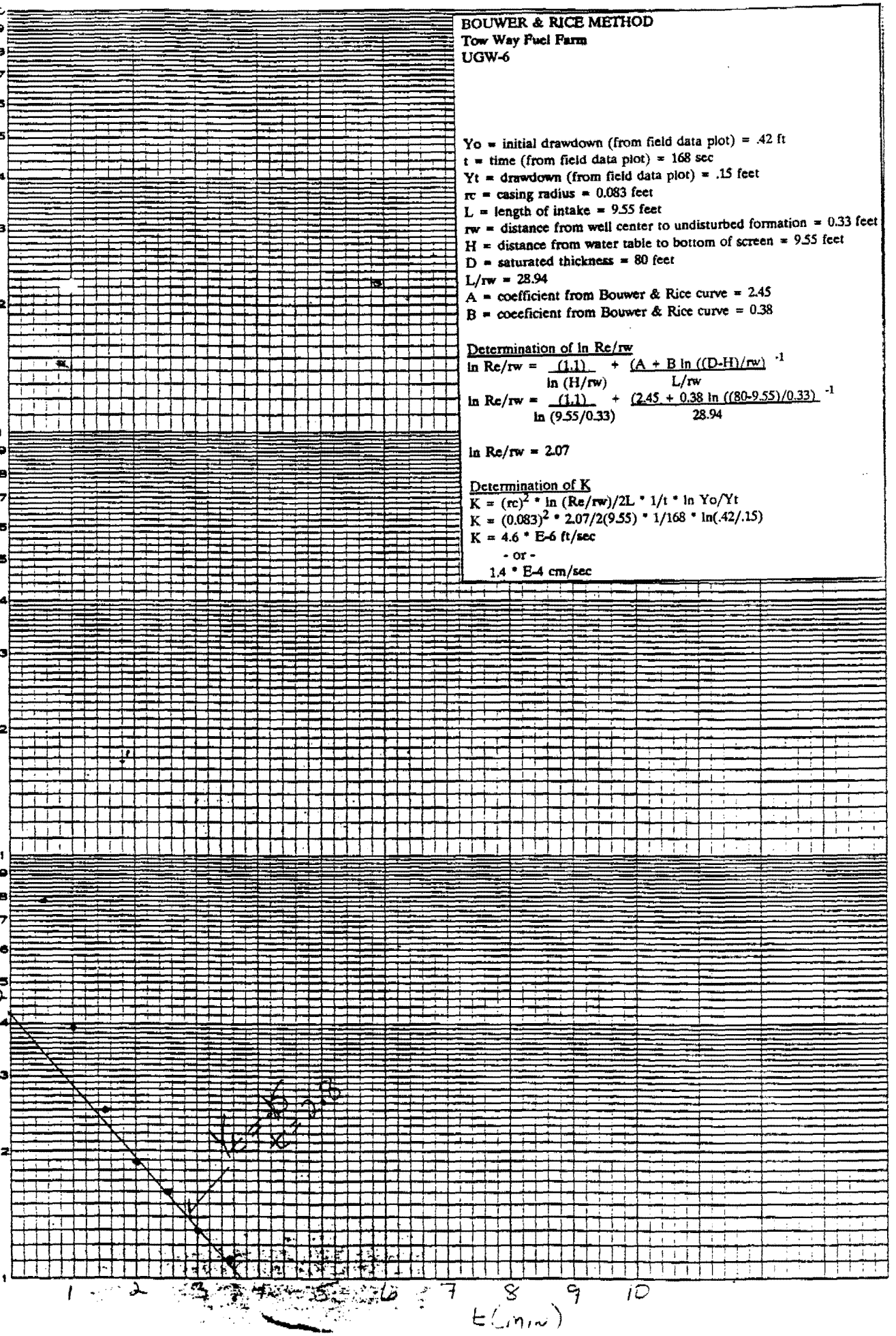
ln Re/rw = 2.33

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.33/2(10) * 1/66 * \ln(1.56/.8)$
K = 8.1 * E-6 ft/sec
- or -
2.47 * E-4 cm/sec

U.S. NAVAL FACILITY ROOSEVELT ROADS PUERTO RICO TOW WAY FUEL FARM

IN-SITU PERMEABILITY ANALYSIS UGW-6



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-6

Yo = initial drawdown (from field data plot) = .42 ft
t = time (from field data plot) = 168 sec
Yt = drawdown (from field data plot) = .15 feet
rc = casing radius = 0.083 feet
L = length of intake = 9.55 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 9.55 feet
D = saturated thickness = 80 feet
L/rw = 28.94
A = coefficient from Bouwer & Rice curve = 2.45
B = coeeficient from Bouwer & Rice curve = 0.38

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (9.55/0.33)} + \frac{(2.45 + 0.38 \ln ((80-9.55)/0.33)}{28.94}^{-1}$$

ln Re/rw = 2.07

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.07/2(9.55) * 1/168 * \ln(.42/.15)$
K = 4.6 * E-6 ft/sec
- or -
1.4 * E-4 cm/sec

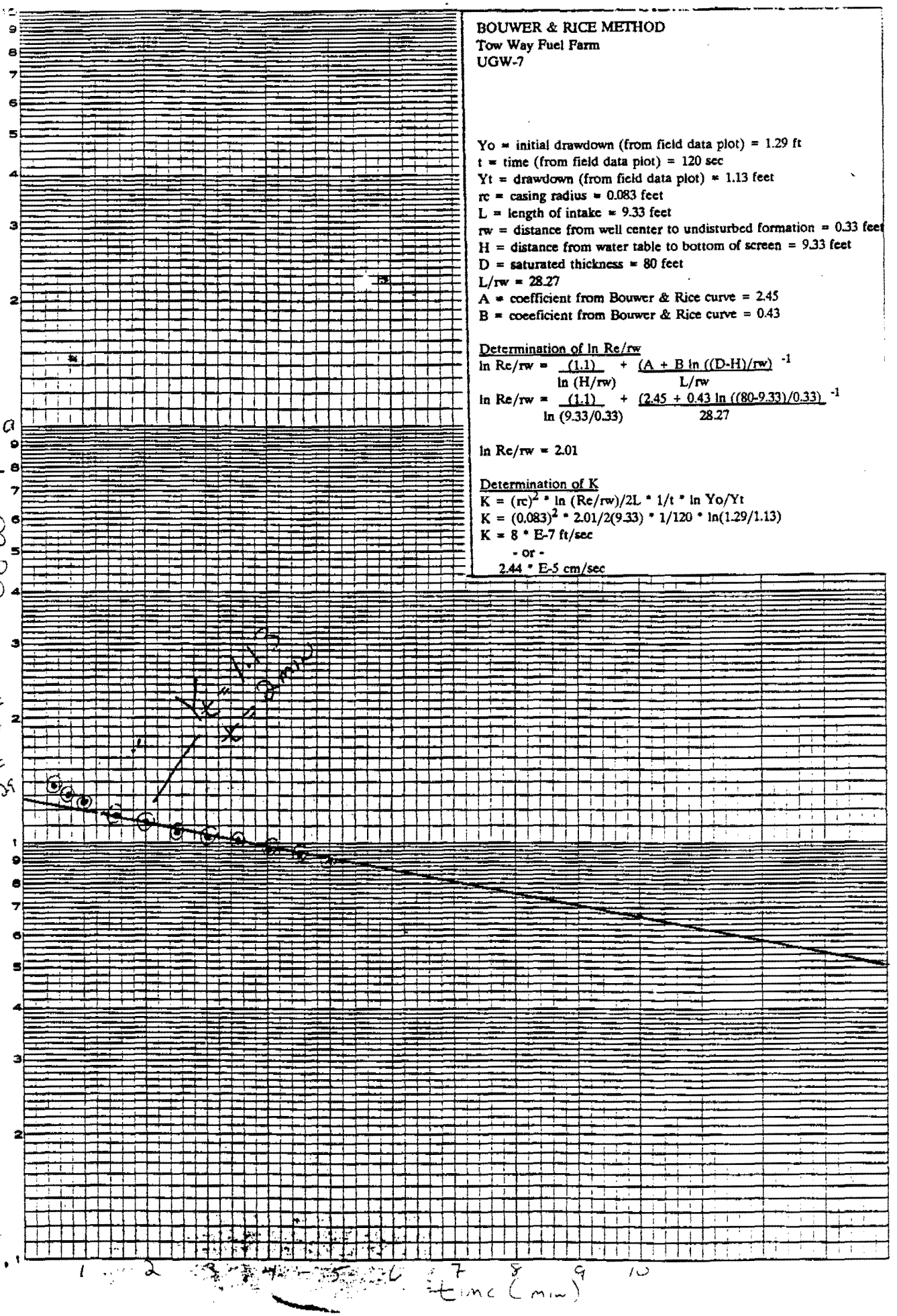
DIETZGEN CORPORATION MADE IN U.S.A.
NO. 340R-L310 DIETZGEN GRAPH PAPER SEMI-LOGARITHMIC 3 CYCLES X 10 DIVISIONS PER INCH

U.S NAVAL FACILITY ROOSEVELT ROADS PUERTO RICO TOW WAY FUEL FARM

DIETZGEN CORPORATION MADE IN U.S.A.

In-situ Permeability Analysis UGW-7

NO. 340R-L310 DIETZGEN GRAPH PAPER SEMI-LOGARITHMIC 3 CYCLES X 10 DIVISIONS PER INCH



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-7

Yo = initial drawdown (from field data plot) = 1.29 ft
t = time (from field data plot) = 120 sec
Yt = drawdown (from field data plot) = 1.13 feet
rc = casing radius = 0.083 feet
L = length of intake = 9.33 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 9.33 feet
D = saturated thickness = 80 feet
L/rw = 28.27
A = coefficient from Bouwer & Rice curve = 2.45
B = coeeficient from Bouwer & Rice curve = 0.43

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (9.33/0.33)} + \frac{(2.45 + 0.43 \ln ((80-9.33)/0.33)}{28.27}^{-1}$$

ln Re/rw = 2.01

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$

$K = (0.083)^2 * 2.01/2(9.33) * 1/120 * \ln(1.29/1.13)$

K = 8 * E-7 ft/sec

- or -

2.44 * E-5 cm/sec

U.S. Naval Facility
Roosevelt Roads
Puerto Rico
Tow Way Fuel Farm

BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-8

Yo = initial drawdown (from field data plot) = .458 ft
t = time (from field data plot) = 60 sec
Yt = drawdown (from field data plot) = .38 feet
rc = casing radius = 0.083 feet
L = length of intake = 10 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 10.66 feet
D = saturated thickness = 30 feet
L/rw = 30.3
A = coefficient from Bouwer & Rice curve = 2.55
B = coeeficient from Bouwer & Rice curve = 0.48

Determination of ln Re/rw

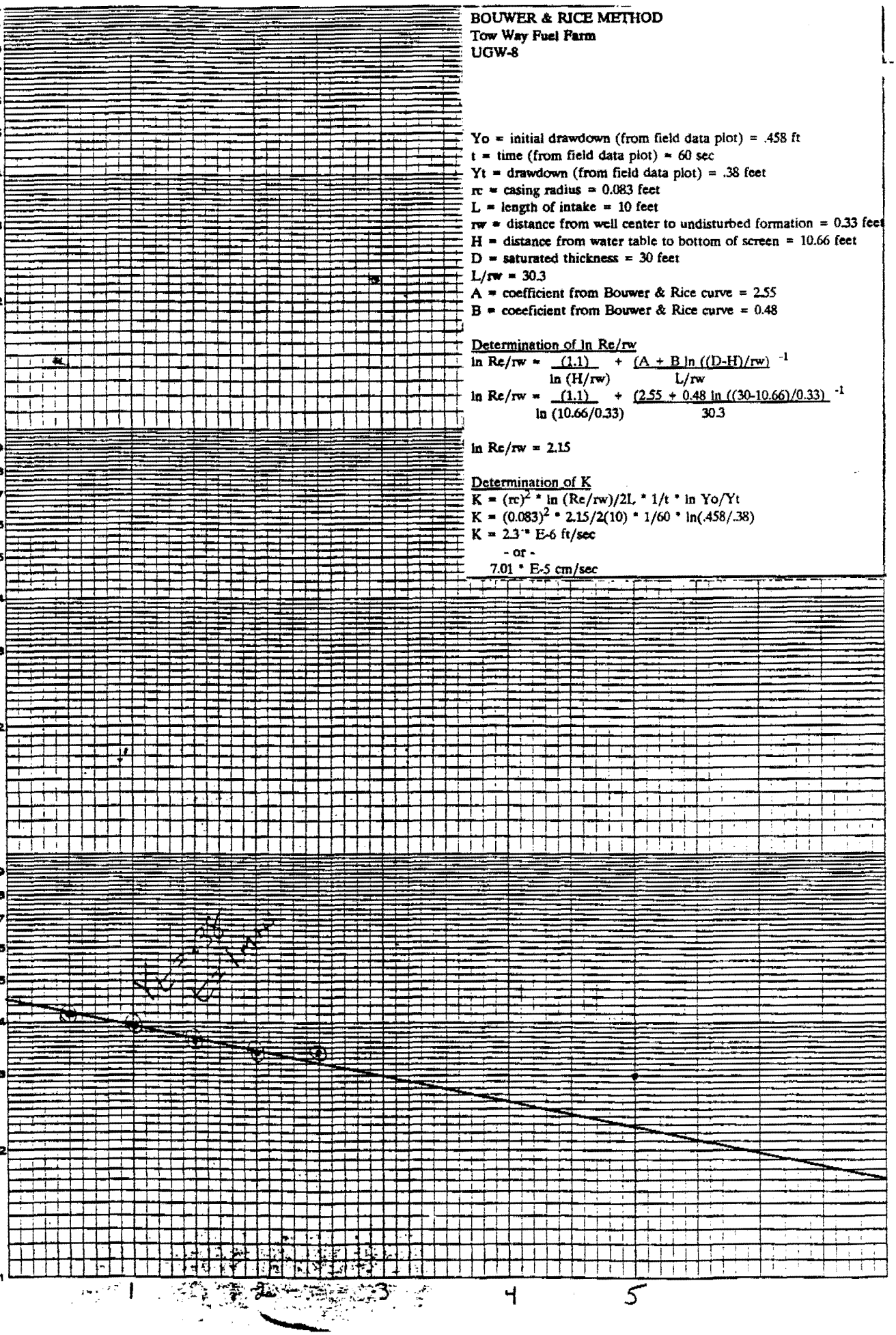
$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (10.66/0.33)} + \frac{(2.55 + 0.48 \ln ((30-10.66)/0.33)}{30.3}^{-1}$$

ln Re/rw = 2.15

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.15/2(10) * 1/60 * \ln(.458/.38)$
K = 2.3 * E-6 ft/sec
- or -
7.01 * E-5 cm/sec



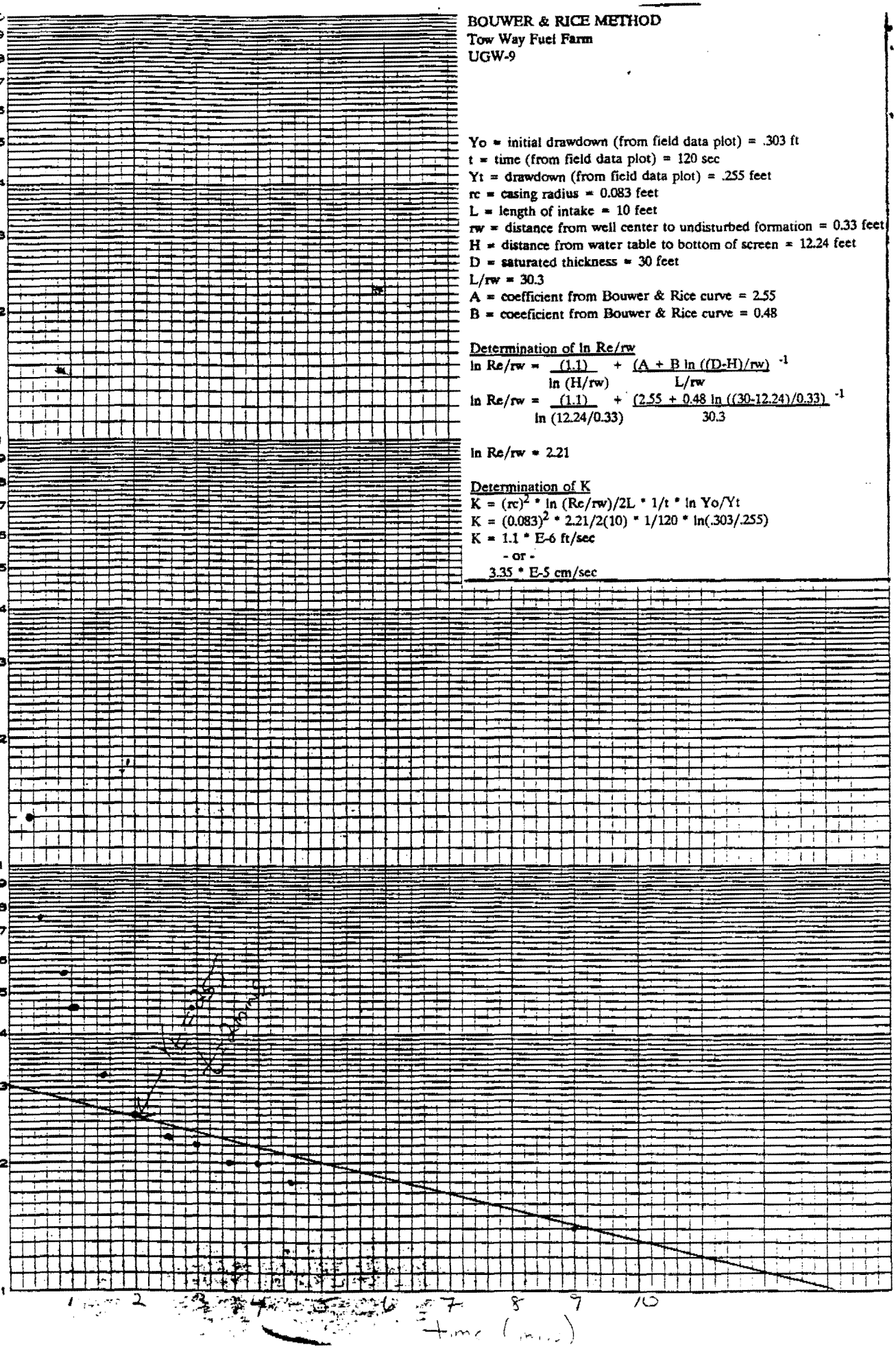
U.S. Naval Facility
Roosevelt Roads
Puerto Rico
Tow Way Fuel Farm

DIETZGEN CORPORATION
MADE IN U.S.A.

In-situ Permeability Analysis
UGW-9

NO. 340R-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH

Yt (ft)



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-9

Yo = initial drawdown (from field data plot) = .303 ft
t = time (from field data plot) = 120 sec
Yt = drawdown (from field data plot) = .255 feet
rc = casing radius = 0.083 feet
L = length of intake = 10 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 12.24 feet
D = saturated thickness = 30 feet
L/rw = 30.3
A = coefficient from Bouwer & Rice curve = 2.55
B = coeeficient from Bouwer & Rice curve = 0.48

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (12.24/0.33)} + \frac{(2.55 + 0.48 \ln ((30-12.24)/0.33)}{30.3}^{-1}$$

ln Re/rw = 2.21

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$

$K = (0.083)^2 * 2.21/2(10) * 1/120 * \ln(.303/.255)$

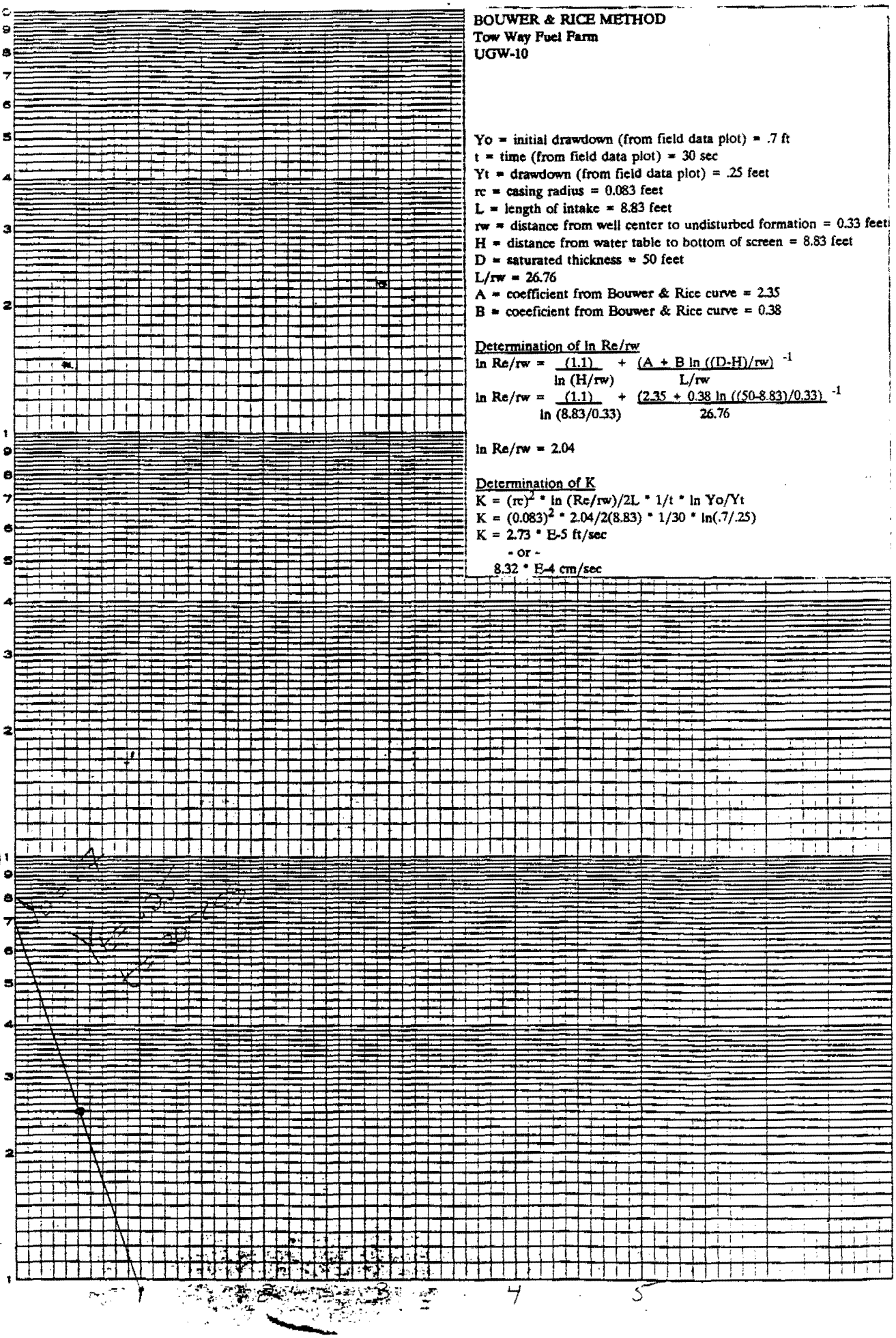
K = 1.1 * E-6 ft/sec

- or -

3.35 * E-5 cm/sec

US Naval Facility
Roosevelt Roads
Puerto Rico
Tow Way Fuel Farm

IN-SITU Permeability Analysis
UGW-10



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-10

Yo = initial drawdown (from field data plot) = .7 ft
t = time (from field data plot) = 30 sec
Yt = drawdown (from field data plot) = .25 feet
rc = casing radius = 0.083 feet
L = length of intake = 8.83 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 8.83 feet
D = saturated thickness = 50 feet
L/rw = 26.76
A = coefficient from Bouwer & Rice curve = 2.35
B = coeeficient from Bouwer & Rice curve = 0.38

Determination of ln Re/rw

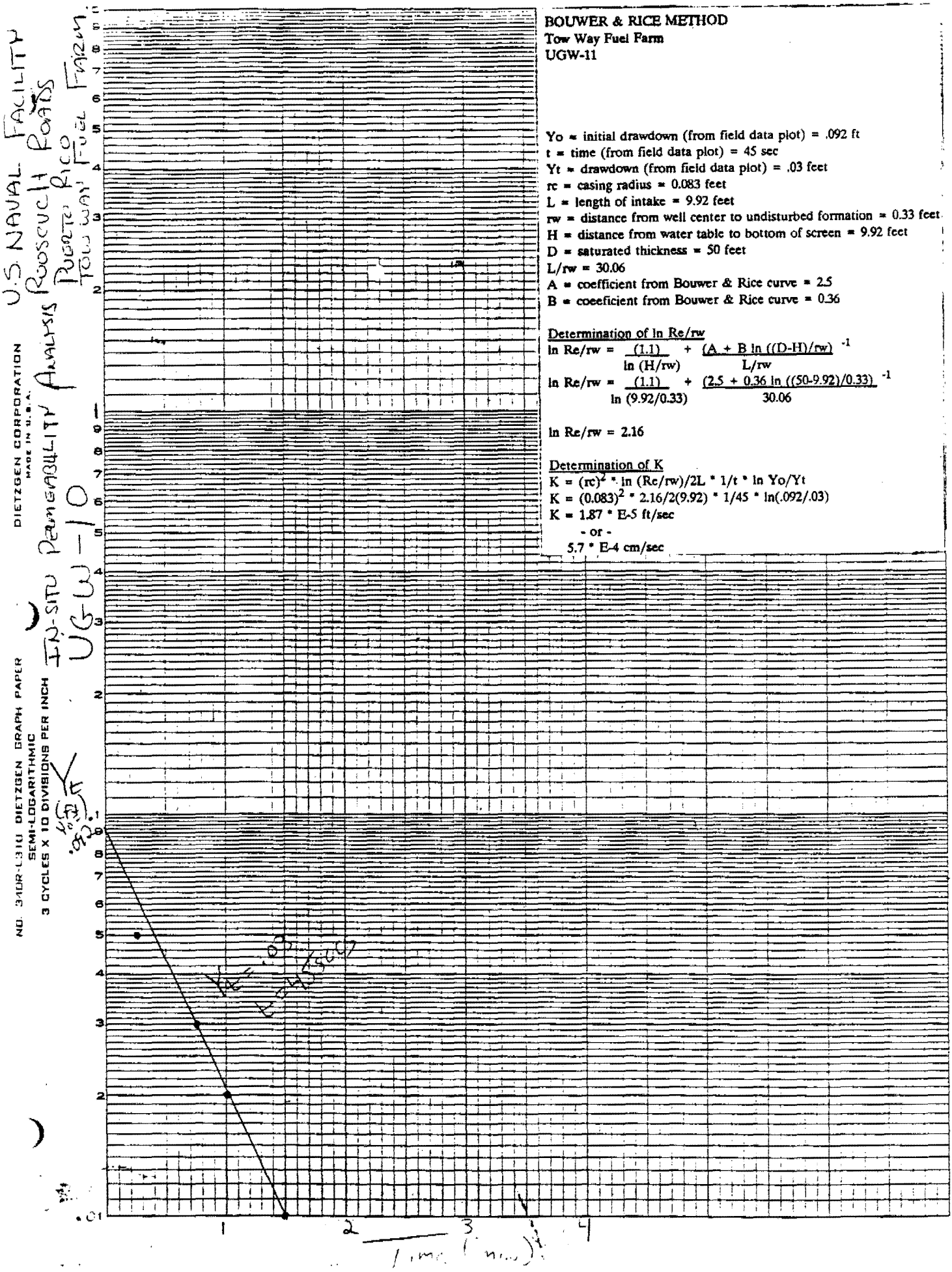
$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (8.83/0.33)} + \frac{(2.35 + 0.38 \ln ((50-8.83)/0.33)}{26.76}^{-1}$$

ln Re/rw = 2.04

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.04/2(8.83) * 1/30 * \ln(.7/.25)$
K = 2.73 * E-5 ft/sec
- or -
8.32 * E-4 cm/sec



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-11

Yo = initial drawdown (from field data plot) = .092 ft
t = time (from field data plot) = 45 sec
Yt = drawdown (from field data plot) = .03 feet
rc = casing radius = 0.083 feet
L = length of intake = 9.92 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 9.92 feet
D = saturated thickness = 50 feet
L/rw = 30.06
A = coefficient from Bouwer & Rice curve = 2.5
B = coeeficient from Bouwer & Rice curve = 0.36

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (9.92/0.33)} + \frac{(2.5 + 0.36 \ln ((50-9.92)/0.33)}{30.06}^{-1}$$

ln Re/rw = 2.16

Determination of K

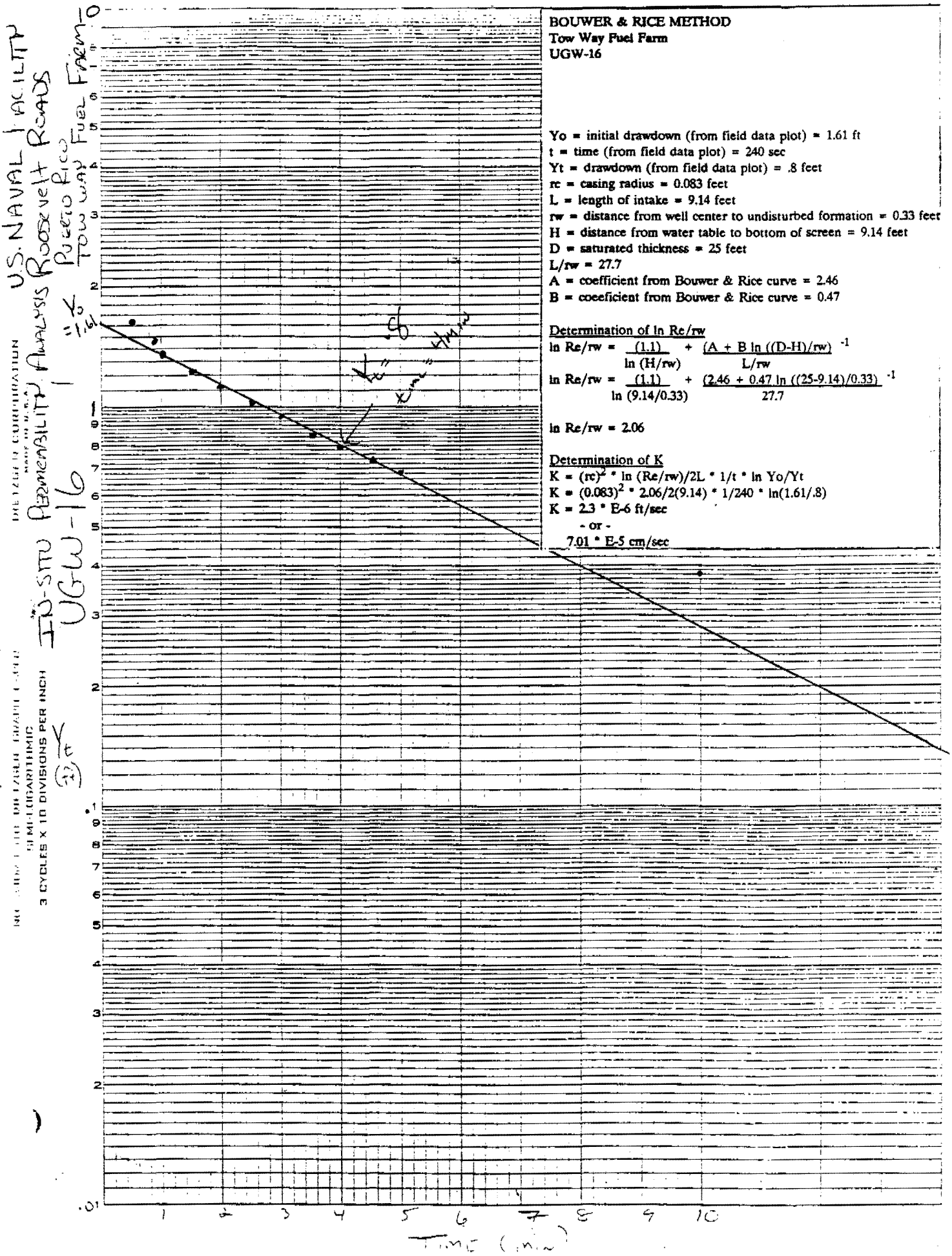
$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$

$K = (0.083)^2 * 2.16/2(9.92) * 1/45 * \ln(.092/.03)$

K = 1.87 * E-5 ft/sec

- or -

5.7 * E-4 cm/sec



BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-16

Yo = initial drawdown (from field data plot) = 1.61 ft
t = time (from field data plot) = 240 sec
Yt = drawdown (from field data plot) = .8 feet
rc = casing radius = 0.083 feet
L = length of intake = 9.14 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 9.14 feet
D = saturated thickness = 25 feet
L/rw = 27.7
A = coefficient from Bouwer & Rice curve = 2.46
B = coeeficient from Bouwer & Rice curve = 0.47

Determination of ln Re/rw

$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (9.14/0.33)} + \frac{(2.46 + 0.47 \ln ((25-9.14)/0.33)}{27.7}^{-1}$$

ln Re/rw = 2.06

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$

$K = (0.083)^2 * 2.06/2(9.14) * 1/240 * \ln(1.61/.8)$

K = 2.3 * E-6 ft/sec

- or -

7.01 * E-5 cm/sec

BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-17

Yo = initial drawdown (from field data plot) = .48 ft
t = time (from field data plot) = 120 sec
Yt = drawdown (from field data plot) = 0.05 feet
rc = casing radius = 0.083 feet
L = length of intake = 12.12 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 12.12 feet
L/rw = 36.73
A = coefficient from Bouwer & Rice curve = N/A
B = coeeficient from Bouwer & Rice curve = N/A
C = coefficient from Bouwer & Rice curve = 2.35

Determination of ln Re/rw

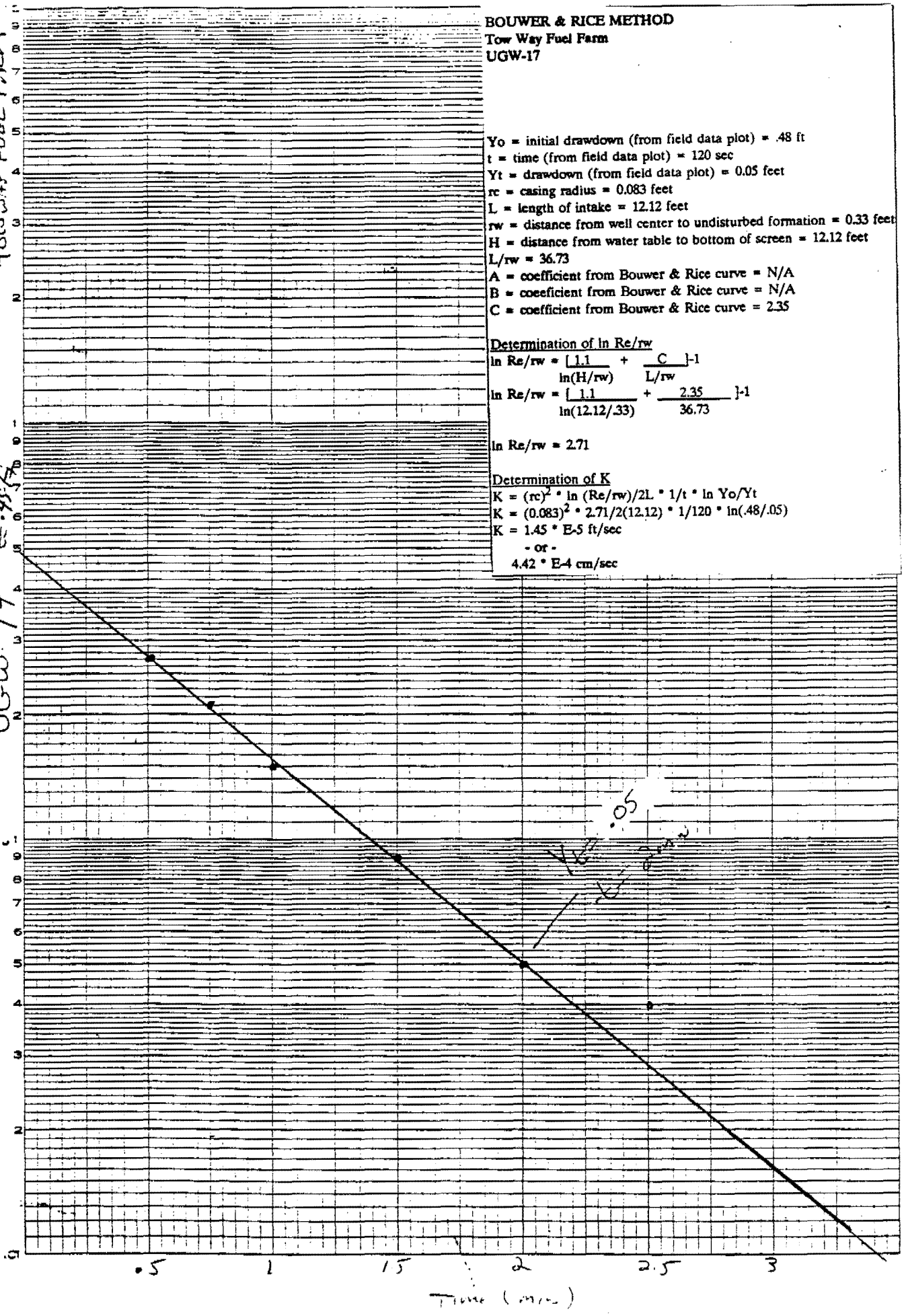
$$\ln Re/rw = \left[\frac{1.1}{\ln(H/rw)} + \frac{C}{L/rw}\right]^{-1}$$

$$\ln Re/rw = \left[\frac{1.1}{\ln(12.12/.33)} + \frac{2.35}{36.73}\right]^{-1}$$

ln Re/rw = 2.71

Determination of K

$K = (rc)^2 * \ln(Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.71/2(12.12) * 1/120 * \ln(.48/.05)$
K = 1.45 * E-5 ft/sec
- or -
4.42 * E-4 cm/sec



J.S. Navy Facility
Roosevelt Roads
Puerto Rico
Tow Way Fuel Farm

BOUWER & RICE METHOD
Tow Way Fuel Farm
UGW-18

Yo = initial drawdown (from field data plot) = 1.59 ft
t = time (from field data plot) = 150 sec
Yt = drawdown (from field data plot) = .6 feet
rc = casing radius = 0.083 feet
L = length of intake = 8.62 feet
rw = distance from well center to undisturbed formation = 0.33 feet
H = distance from water table to bottom of screen = 8.62 feet
D = saturated thickness = 25 feet
L/rw = 26.12
A = coefficient from Bouwer & Rice curve = 2.46
B = coeeficient from Bouwer & Rice curve = 0.40

Determination of ln Re/rw

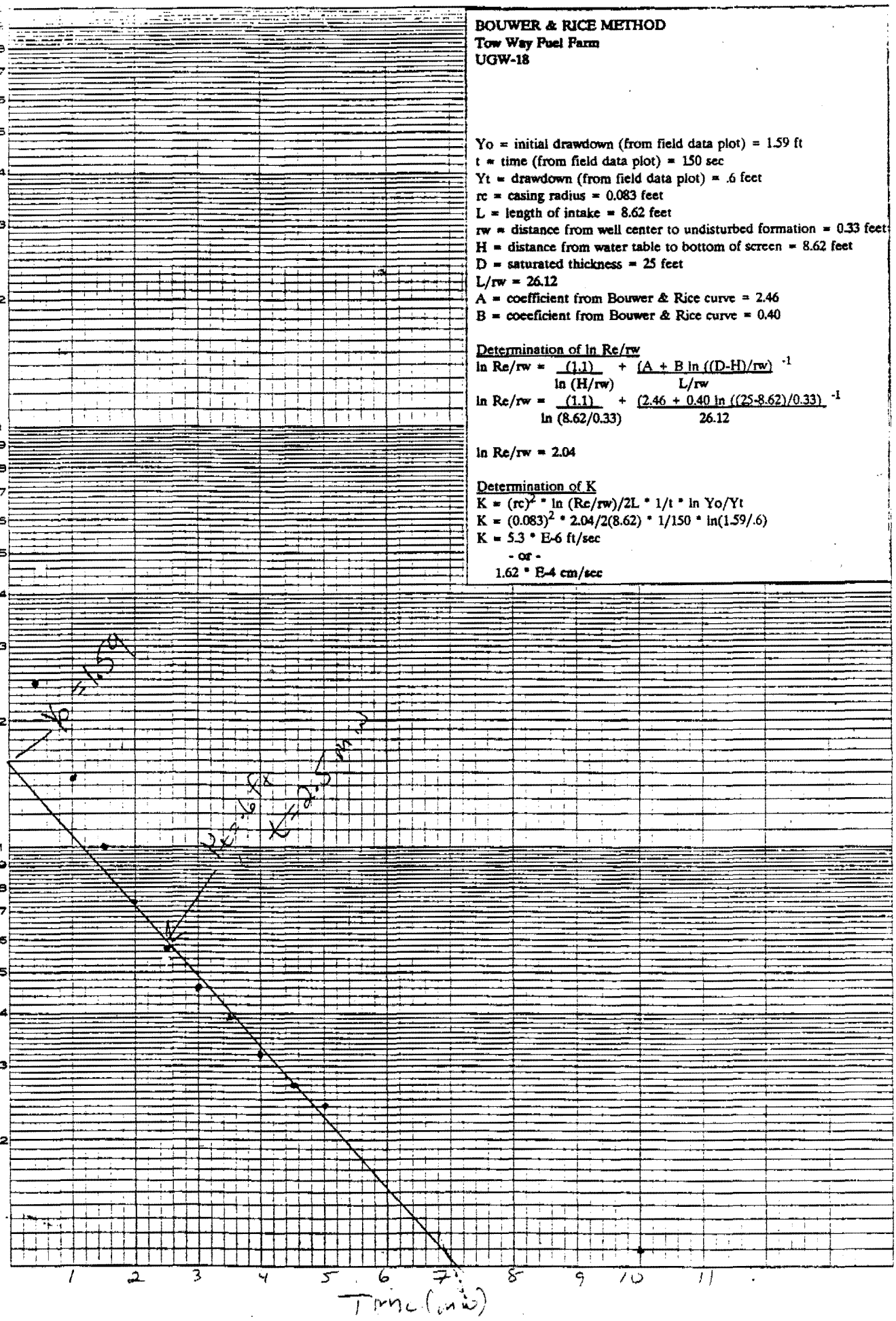
$$\ln Re/rw = \frac{(1.1)}{\ln (H/rw)} + \frac{(A + B \ln ((D-H)/rw)}{L/rw}^{-1}$$

$$\ln Re/rw = \frac{(1.1)}{\ln (8.62/0.33)} + \frac{(2.46 + 0.40 \ln ((25-8.62)/0.33)}{26.12}^{-1}$$

ln Re/rw = 2.04

Determination of K

$K = (rc)^2 * \ln (Re/rw)/2L * 1/t * \ln Yo/Yt$
$K = (0.083)^2 * 2.04/2(8.62) * 1/150 * \ln(1.59/.6)$
K = 5.3 * E-6 ft/sec
- or -
1.62 * E-4 cm/sec



In-Situ Permeability Analysis
UGW-18

DIETZGEN CORPORATION MADE IN U.S.A.
NEW ... DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH

APPENDIX C

GROUND WATER SAMPLING PROTOCOLS AND FIELD SAMPLING LOGS

GROUND WATER SAMPLING PROTOCOL

Prior to obtaining ground water samples for laboratory analysis, all monitoring wells must be developed as described in the Well Development Protocol.

Sampling Procedures

Use of the following procedures for the sampling of ground water observation wells is dependent upon the size and depth of the well to be sampled and the volume of ground water in the well. To obtain representative ground water samples from wells containing only a few gallons of ground water, the bailing procedures is preferred. To obtain representative ground water samples from wells containing more than a few gallons, the pumping procedure generally facilitates more rapid sampling. Each of these procedures is explained in detail below.

1. Identify the well and record the location on the Ground Water Sampling Field Log, Attachment A.

2. Put on a new pair of disposable gloves.

3. Cut a slit in the center of the plastic sheet, and slip it over the well creating a clean surface onto which the sampling equipment can be positioned.

4. Clean all meters, tools, equipment, etc., before placing on the plastic sheet.

5. Using an electric well probe, measure the depth to the water table and the bottom of the well. If free-phase product is present, use an oil-water interface probe or a clear bottom-valve bailer to determine the thickness of the free product. Record this information in the Ground Water Sampling Field Log.

6. Clean the well depth probe and rinse it with distilled water after use.

7. Compute the volume of water in the well, and record this volume on the Ground Water Sampling Field Log.

8. Attach enough polypropylene rope to a bailer to reach the bottom of the well, and lower the bailer slowly into the well making certain to submerge it only far enough to fill one-half full. The purpose of this is to recover any oil film, if one is present on the water table.

9. Pull the bailer out of the well keeping the polypropylene rope on the plastic sheet. Empty the ground water from the bailer into a glass quart container and observe its appearance. NOTE: This sample will not undergo laboratory analysis, and

is collected to observe the physical appearance of the ground water only.

10. Record the physical appearance of the ground water on the Ground Water Sampling Field Log.

11. Lower the bailer to the bottom of the well, and agitate the bailer up and down to resuspend any material settled in the well.

12. Initiate bailing the well from the well bottom making certain to keep the polypropylene rope on the plastic sheet. All ground water should be dumped from the bailer into a graduate pail to measure the quantity of water removed from the well.

13. Continue bailing the well throughout the water column and from the bottom until a sufficient volume of ground water in the well has been removed, or until the well is bailed dry. If the well is bailed dry, allow sufficient time for the well to recover before proceeding with Step 14. Record this information on the Ground Water Sampling Field Log.

14. Remove the sampling bottles from their transport containers, and prepare the bottles for receiving samples. Inspect all labels to insure proper sample identification. Sample bottles should be kept cool with their caps on until they are ready to receive samples. Arrange the sampling containers to allow for convenient filling. Always fill the containers labeled purgeable priority pollutant first. Filter and add preservatives to appropriate samples.

15. To minimize agitation of the water in the well, initiate sampling by lowering the bailer slowly into the well making certain to submerged it only far enough to fill it completely. Fill each sample container following the instructions listed in the Sample Containerization Procedures, Attachment B. Return each sample bottle to its proper transport container.

16. If the sample bottle cannot be filled quickly, keep them cool with the caps on until they are filled. The vials (3) labeled purgeable priority pollutant analysis should be filled from one bailer then securely capped. NOTE: Samples must not be allowed to freeze.

17. Record the physical appearance of the ground water observed during sampling on the Ground Water Sampling Field Log.

18. After the last sample has been collected, record the date and time, and, and if required, empty one bailer of water from the surface of the water in the well into the 200 ml beaker and measure and record the pH, conductivity and temperature of the ground water following the procedures outlined in the equipment operation manuals. Record this information on the

Ground Water Sampling Field Log. The 200 ml beaker must then be rinsed with distilled water prior to reuse.

19. Begin the Chain of Custody Record.

20. Replace the well cap, and lock the well protection assembly before leaving the well location.

21. Place the polypropylene rope, gloves, rags, and plastic sheeting into a plastic bag for disposal.

22. Clean the bailer by rinsing with control water and then distilled water. Store the clean bailer in a fresh plastic bag.

Sampling Procedures (PUMP)

1. Identify the well and record the location on the Ground Water Sampling Field Log.

2. Put on a new pair of disposable gloves.

3. Cut a slit in the center of the plastic sheet, and slip it over the well creating a clean surface onto which the sampling equipment can be positioned.

4. Clean all meters, tools, equipment, etc., before placing on the plastic sheet.

5. Using an electric well probe, measure the depth to the water table and the bottom of the well. If free-phase product is present use an oil water interface probe or a clean bottom-valve bailer to determine the thickness of the free product. Record this information in the Ground Water Sampling Field Log.

6. Clean the well depth probe and rinse it with distilled water after use.

7. Compute the volume of water in the well, and record this volume on the Ground Water Sampling Field Log.

8. Attach enough polypropylene rope to a bailer to reach just below the surface of the water table, and lower the bailer slowly into the well making certain to submerge it only far enough to fill it one-half full. The purpose of this is to recover any oil film, if one is present on the water table.

9. Pull the bailer out of the well keeping the polypropylene rope on the plastic sheet. Empty the ground water from the bailer into a glass quart container and observe its appearance. NOTE: This sample will not undergo laboratory analysis, and is collected to observe the physical appearance of the ground water only.

10. Record the physical appearance of the ground water on the Ground Water Sampling Field Log.

11. Prepare the submersible pump for operation.

12. Lower the pump to just below the top of the water column and pump the ground water into a graduated pail. Pumping should continue until sufficient well volumes have been removed or the well is pumped dry. If the well is pumped dry, allow sufficient time for the well to recover before proceeding with Step 16. Record this information on the Ground Water Sampling Field Log.

13. Remove the sampling bottles from their transport containers, and prepare the bottles for receiving samples. Inspect all labels to insure proper sample identification. Sample bottles should be kept cool with their caps on until they are ready to receive samples. Arrange the sampling containers to allow for convenient filling. Always fill the vials labelled purgeable priority pollutant first. Filter and add preservatives to appropriate samples.

14. With submersible pump raised to a level just below the surface of the water in the well, fill each sample container following the instructions listed in the Sample Containerization Procedures. Return each sampling bottle to its proper transport container. NOTE: A clean bottom loading stainless steel or Teflon bailer should be used to collect the sample used to fill the sample vials labeled purgeable priority pollutant analysis. Gently lower the bailer into the water to minimize agitation of the water. The vials (2) should be filled from one bailer.

15. If the sample bottle cannot be filled quickly, keep them cool with the caps on until they are filled. NOTE: Samples must not be allowed to freeze.

16. Record the physical appearance of the ground water observed during sampling on the Ground Water Sampling Field Log.

17. After the last sample has been collected, record the date and time, and if required, place a sample of well water into a 200 ml beaker and measure and record the pH, conductivity and temperature of the ground water following the procedures outlined in the equipment operation manuals. Record this information on the Ground Water Sampling Field Log. The 200 ml beaker must then be rinsed with distilled water prior to reuse.

18. Begin the Chain of Custody Record.

19. Remove the submersible pump from the well and clean the pump and necessary tubing both internally and externally. Cleaning is comprised of rinses with a source water and acetone or methanol mixture, and distilled water using

GROUND WATER SAMPLING FIELD LOG

.mple Location U.S. NAVAL STATION - Roosevelt Roads, Puerto Rico Well No. UG-W-1

Sampled By Jim Eddy Date 3/28/90 Time 1500

Weather Hot, Sunny Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 26.38 ft.

Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) No water ft.

Water table elevation: ____ ft.

Length of water column (LWC) ____ ft.

Volume of water in well:

2" diameter wells = 0.163 x (LWC) = ____ gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color ____ Odor ____ Turbidity ____

Was an oil film or layer apparent? ____

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ____ gallons.

Did well go dry? ____

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color ____ Odor ____ Turbidity ____

Was an oil film or layer apparent? ____

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

Did not evacuate due to no presence of H2O detected in well

H. WELL SAMPLING NOTES:

Product 10' 1 1/4"

No water Detected

Free phase product SAMPLED

GROUND WATER SAMPLING FIELD LOG

ie Location U.S. NAVAL STATION - Roosevelt Roads PUERTO RICO Well No. UGW-2

.mpled By Tim Eth Date 3/26/91 Time 1708

Weather HOT, SUNNY Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 58.35 ft. SOLID WIST

Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 55.54 ft.

Water table elevation: ____ ft.

Length of water column (LWC) 2.76 ft.

Volume of water in well: x3 = 1.5 = 5 BAILS

2" diameter wells = 0.163 x (LWC) = .5 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color GRAY Odor SLIGHT PETRO. Turbidity HIGH

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ~1 gallons.

Did well go dry? Yes

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color GRAY Odor PETRO ? Turbidity HIGH

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

NO PRODUCT ~~INTERFACE~~ OIL-WATER 55.53

WATER LEVEL BOTTOM

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads Puerto Rico Well No. UGW-3

Sampled By Jim Eth Date 3/27/91 Time 1418

Weather HOT, SUNNY Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 35.41 ft. Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 20.99 ft. Water table elevation: ____ ft.

Length of water column (LWC) 13.45 ft.

Volume of water in well: x3 = 6.58 gals ≈ 22 BATCHES

2" diameter wells = 0.163 x (LWC) = 2.19 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color TAN Odor NOWHERE SOMETHING Turbidity LOW

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 6.6 gallons.

Did well go dry? ALMOST

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color TAN Odor Yes Turbidity med

Was an oil film or layer apparent? BARELY 1/8"

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

NO OIL ON ACT OIL WATER INTERFACE PROBE

WATER-TABLE 2 FT ABOVE TOP OF SCREEN

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads, Puerto Rico Well No. UGW-4

Sampled By Jim Eth Date 3/28/91 Time 1305

Weather Hot Sunny Sampled with Bailer ____ Pump ____ Submersible

A. WATER TABLE:

Well depth: (below top of casing) 35.26 ft. Well elevation: (top of casing) _____ ft.

Depth to water table: (below top of casing) 27.46 ft. Water table elevation: _____ ft.

Length of water column (LWC) 7.8 ft.

Volume of water in well: 3.81 ≈ 12.7 BAILS

2" diameter wells = 0.163 x (LWC) = 1.27 gallons
4" diameter wells = 0.653 X (LWC) = _____ gallons
6" diameter wells = 1.469 X (LWC) = _____ gallons

B. PHYSICAL APPEARANCE AT START:

Color Brown Odor Diesel Turbidity High

Was an oil film or layer apparent? Yes

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ~4 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color Brown Odor Diesel Turbidity High

Was an oil film or layer apparent? Yes

E. CONDUCTIVITY _____

F. pH _____

G. TEMPERATURE _____

H. WELL SAMPLING NOTES:

Product 14'8" 7/8" = 14.74 ft

Water 27' 5 1/2" 27.46 ft

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads, P.R. Well No. UGW-5

Sampled By Jim Eth Date 3/28/91 Time 1336

Weather HOT SUNNY Sampled with Bailer ____ Pump ____ WATERRA

A. WATER TABLE:

Well depth: (below top of casing) 30.41 ft. Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 23.92 ft. Water table elevation: ____ ft.

Length of water column (LWC) 6.49 ft. = 3.17

Volume of water in well:

2" diameter wells = 0.163 x (LWC) = 1.06 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color Brown-orange Odor Diesel Turbidity High

Was an oil film or layer apparent? Yes

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 2.4 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color orange Odor Diesel Turbidity High

Was an oil film or layer apparent? Yes

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

Product 11' 7 2/3" = 11.64 Ft

Water 23' 11" = 23.92 Ft

20 Ft Screen

GROUND WATER SAMPLING FIELD LOG

U.S. NAVAL STATION - Roosevelt Roads
Puerto Rico — Well No. UGW-6

Eddy — Date 3/26/91 — Time 1347

Sunny, Hot — Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 20.11 ft.

Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 10.54 ft.

Water table elevation: ____ ft.

Length of water column (LWC) 9.57 ft.

Volume of water in well:

V3 = 4.68 ≈ 16 BAILS

2" diameter wells = 0.163 x (LWC) = 1.56 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color Cloudy Odor Strong Turbidity Low

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 12 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color Greyish Odor Sulfur or Petro Turbidity Low - Med

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

NO PRODUCT during evacuation on 3/25/91
Appears Great Appearance, Strong odor

GROUND WATER SAMPLING FIELD LOG

~ ~~STATION~~ - Roosevelt Roads Well No. UGW-7

Date 3/26/91 Time 1336

Sampled with Bailer ✓ Pump ____

of casing) 17.93 ft. Well elevation: (top of casing) ____ ft.

water table: ow top of casing) 8.55 ft. Water table elevation: ____ ft.

Length of water column (LWC) 9.38 ft.

Volume of water in well: x3 = 4.55 ≈ 5 gals

2" diameter wells = 0.163 x (LWC) = 1.53 gallons ≈ 17 GALLS

4" diameter wells = 0.653 X (LWC) = ____ gallons

6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color clear Odor none Turbidity low

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 5.1 gallons.

Did well go dry? almost

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color ~~dark brown~~ clear Odor ~~sulphur~~ slight sulphur Turbidity ~~high~~ low

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

Dark brown sulphur smell and high turbidity during development on 3/25/91

GROUND WATER SAMPLING FIELD LOG

U.S. NAVAL STATION - Roosevelt Roads PUERTO RICO — Well No. UR-W-8

Eth — Date 3/28/92 — Time 1217

HOT, SUNNY — Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 19.19 ft.

Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 8.37 ft.

Water table elevation: ____ ft.

Length of water column (LWC) 10.82 ft.

Volume of water in well:

2" diameter wells = 0.163 x (LWC) = 1.76 gallons x3 = 5.29 gals ≈ 18 BAILS

4" diameter wells = 0.653 X (LWC) = ____ gallons

6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color GREENISH-GRAY Odor — Turbidity med

Was an oil film or layer apparent? POSSIBLE slight oil film

. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 6 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color GRAY Odor — Turbidity LOW

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads PUERTO RICO Well No. UGW-9

Sampled By Jim Eth Date 3/26/91 Time 1300

Weather HOT, SUNNY Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 19.93 ft.

Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 7.69 ft.

Water table elevation: ____ ft.

Length of water column (LWC) 12.24 ft.

Volume of water in well: ≈ 6 galls = 20 BAILS

2" diameter wells = 0.163 x (LWC) = 1.99 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color CLEAR Odor NONE Turbidity LOW

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ≈ 7.5 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color CLEAR Odor NONE Turbidity LOW

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

NO PRODUCT Detected

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads, Puerto Rico Well No. UGW-10

Sampled By Jim Eth Date 3/27/91 Time 1639

Weather HOT, SUNNY Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) 18.86 ft. Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) 10.03 ft. Water table elevation: ____ ft.

Length of water column (LWC) 8.83 ft.

Volume of water in well: x3 = 4.32 ≈ 15 BAILS

2" diameter wells = 0.163 x (LWC) = 1.44 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color greenish-brown Odor — Turbidity high

Was an oil film or layer apparent? 1/8-inch

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 6 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color GRAY Odor — Turbidity med

Was an oil film or layer apparent? 1/8 inch

E. CONDUCTIVITY —

pH ____

TEMPERATURE ____

WELL SAMPLING NOTES:

2 1/8-inch oil water

GROUND WATER SAMPLING FIELD LOG

U.S. NAVAL STATION - Roosevelt Roads PUERTO RICO — Well No. UGW-11

Eth — Date 3/27/91 — Time 1620

PT, SUNNY — Sampled with Bailer ___ ✓ Pump ___

A. WATER TABLE:

Well depth: (below top of casing) 19.05 ft. — Well elevation: (top of casing) ___ ft.

Depth to water table: (below top of casing) 9.13 ft. — Water table elevation: ___ ft.

Length of water column (LWC) 9.92 ft. = 48.5 gal

Volume of water in well: x3 ≈17 Bails

2" diameter wells = 0.163 x (LWC) = 1.62 gallons
4" diameter wells = 0.653 X (LWC) = ___ gallons
6" diameter wells = 1.469 X (LWC) = ___ gallons

B. PHYSICAL APPEARANCE AT START:

Color GRAYISH WHITE Odor ? Turbidity LOW

Was an oil film or layer apparent? MAYBE

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 6 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color GRAY Odor — Turbidity LOW

Was an oil film or layer apparent? NO

E. CONDUCTIVITY /

F. pH ___

G. TEMPERATURE ___

H. WELL SAMPLING NOTES:

POSSIBLE MINISCULE PRODUCT LAYER PRESENT

CONDUCTIVITY METER MALFUNCTIONING

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads Route 2100 Well No. UGW-12

Sampled By Jim Eth Date 3/28/91 Time 1110

Weather HOT, SUNNY Sampled with Bailer ____ Pump ____ WATARA

A. WATER TABLE:

Well depth: (below top of casing) ~~25.13~~ 24.63 ft. Well elevation: (top of casing) _____ ft.

Depth to water table: (below top of casing) 19.53 ft. Water table elevation: _____ ft.

Length of water column (LWC) 5.1 ft.

Volume of water in well: 2.49

2" diameter wells = 0.163 x (LWC) = .83 gallons
4" diameter wells = 0.653 X (LWC) = _____ gallons
6" diameter wells = 1.469 X (LWC) = _____ gallons

B. PHYSICAL APPEARANCE AT START:

Color Brown Odor Petro Turbidity Hiell

Was an oil film or layer apparent? Yes

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 2.3 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color Brown Odor Diesel Turbidity Hiell

Was an oil film or layer apparent? Yes

E. CONDUCTIVITY _____

F. pH _____

G. TEMPERATURE _____

H. WELL SAMPLING NOTES:

Product 10' 1 1/2" = 10.13'

WATER 19' 6 3/4" = 19.53

UNPOCO Free Product Present in Sample

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads, Puerto Rico Well No. UG-W-13

Sampled By Tim Eddy Date 3/28/91 Time 1428

Weather HOT, SUNNY Sampled with Bailer ____ Pump ____ WATERRA

A. WATER TABLE:

Well depth: (below top of casing) 25' 10½" ft. (25.88) Well elevation: (top of casing) _____ ft.

Depth to water table: (below top of casing) 17.59 ft. Water table elevation: _____ ft.

Length of water column (LWC) 8.29 ft.

Volume of water in well:

2" diameter wells = 0.163 x (LWC) = 1.35 (4.05) gallons
4" diameter wells = 0.653 X (LWC) = _____ gallons
6" diameter wells = 1.469 X (LWC) = _____ gallons

B. PHYSICAL APPEARANCE AT START:

Color ORANGE - BROWN Odor Diesel Turbidity HIGH

Was an oil film or layer apparent? Yes

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ≈ 5 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color ORANGE - BROWN Odor Diesel Turbidity HIGH

Was an oil film or layer apparent? Yes

E. CONDUCTIVITY _____

F. pH _____

G. TEMPERATURE _____

H. WELL SAMPLING NOTES:

PRODUCT 11' 9¼" 11.72

WATER 17' 7⅛" 17.59

Despite Development very silty

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads Puerto Rico Well No. UGW-14

Sampled By Jim Eddy Date 3/28/91 Time 1646

Weather SUNNY HOT Sampled with Bailer ____ Pump ____

L Cuatterry

A. WATER TABLE: 38.83

Well depth: (below top of casing) 38' 10" ft. Well elevation: (top of casing) _____ ft.

Depth to water table: (below top of casing) 16.95 ft. Water table elevation: _____ ft.

Length of water column (LWC) 21.88 ft.

Volume of water in well: ~10.7 gals

2" diameter wells = 0.163 x (LWC) = 3.57 gallons 2.36 liters

4" diameter wells = 0.653 X (LWC) = _____ gallons

6" diameter wells = 1.469 X (LWC) = _____ gallons

B. PHYSICAL APPEARANCE AT START:

Color Brown Odor Petro Turbidity HIGH

Was an oil film or layer apparent? Yes

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling 2 11 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color Brown Odor Petro Turbidity Mod

Was an oil film or layer apparent? Yes

E. CONDUCTIVITY _____

F. pH _____

G. TEMPERATURE _____

Product 16.05
water 16.95

H. WELL SAMPLING NOTES:

Developed with Bailer, sampled with Waterra allowed well to sit for 15 min to allow oil & water to separate ~ 3ft of product prior to Development

GROUND WATER SAMPLING FIELD LOG

Sample Location U.S. NAVAL STATION - Roosevelt Roads PUERTO RICO Well No. UGW-15

Sampled By Tim Eddy Date 3/28/91 Time 1730

Weather SUNNY cooling Sampled with Bailer ✓ Pump ____

A. WATER TABLE:

Well depth: (below top of casing) ~~11.97~~ 19.57 ft. Well elevation: (top of casing) ____ ft.

Depth to water table: (below top of casing) ~~19.57~~ 11.97 ft. Water table elevation: ____ ft.

Length of water column (LWC) 7.6 ft.

Volume of water in well: x3 = 37.2 ≈ 13 BAILS

2" diameter wells = 0.163 x (LWC) = 1.24 gallons
4" diameter wells = 0.653 X (LWC) = ____ gallons
6" diameter wells = 1.469 X (LWC) = ____ gallons

B. PHYSICAL APPEARANCE AT START:

Color GREEN GRAY Odor Yes Turbidity mod

Was an oil film or layer apparent? NO

C. PREPARATION OF WELL FOR SAMPLING:

Amount of water removed before sampling ≈ 6 gallons.

Did well go dry? NO

D. PHYSICAL APPEARANCE DURING SAMPLING:

Color GREEN GRAY Odor Yes Turbidity Hiol

Was an oil film or layer apparent? NO

E. CONDUCTIVITY ____

F. pH ____

G. TEMPERATURE ____

H. WELL SAMPLING NOTES:

APPENDIX D

LABORATORY ANALYSIS REPORT

QUANTUM LABORATORIES, INC.

ANALYTICAL SERVICES
G.P.O. BOX 361629 • SAN JUAN, PUERTO RICO 00936-1629
(809) 793-7288

ANALYSIS REPORT

SUBMITTED TO

O'BRIEN & GERE ENGINEERS INC

ATTN. MR. TIMOTHY M. EDDY

5000 BRITTONFIELD PARKWAY

SYRACUSE, NJ 13221

PROJECT: Soil and water analysis

Tow Way Fuel Facility

U.S. Naval Station

Roosevelt Roads

Ceiba, Puerto Rico

May 17, 1991

QUANTUM LABORATORIES, INC.

ANALYTICAL SERVICES
G.P.O. BOX 361629 • SAN JUAN, PUERTO RICO 00936-1629
(809) 793-7288

O'BRIEN & GERE ENGINEERS INC
Attn: Mr. Timothy Eddy
5000 Brittonfield Parkway
Syracuse, NJ 13221

Re: Tow Way Fuel Facility Project
US Naval Station Roosevelt Roads
Ceiba, Puerto Rico

Introduction

Soil samples were received from T. Eddy by J.R. Ramirez on March 1, 1991. The transfer was performed at Roosevelt Roads. Samples were entered at the laboratory on the same day and identified by numbers 41,447 to 41,478.

Water samples were transferred on two ocassions. Samples identified by numbers 41,611 to 41,647 were received and entered on March 29, 1991. These were received from T. Eddy by J.R. Ramirez at the San Juan airport. A second group was received on April 5, 1991 at the Travel Lodge Hotel. These were identified by numbers 41,644 to 41,647.

Sampling logs and Chain of Custody records are attached.

At the laboratory samples were kept under refrigeration until analysis.

ANALYTICAL RESULTS/METHODOLOGY

The analytical results for this report are presented by sample. Each set of data will include complete sample identification information and the analytical results. The results are arranged by the numbering or identification sequence chosen by the sampler and not by the laboratory numbering sequence.

Water samples were analyzed for Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) by EPA Method 503.1. The analysis was performed by Purge and Trap on a Tracor LSC-2 sample concentrator followed by gas chromatography with a photoionization detector (Tracor 540 model gc). The column used was a 0.085" ID SS with

5% SP-1200 and 1.75% Bentone 34 packing set isothermally at 90°C.

Some samples had a considerable content of BTEX and these chromatograms exhibited additional peaks. Identification and quantification of BTEX, however, was achieved. Samples were submitted in 40mL vials in sets of two. Each vial was analyzed independently. Two vials were found broken on removal form the foam-holder: these corresponded to samples 41,624 and 41,625. Asteriks in the report reflect this matter.

Water samples were also analyzed for Lead content. A Varian flame atomic absorption spectrometer was used with excellent results. Samples contained nitric acid as preservative. Results are reported in micrograms per liter.

Soil samples were analyzed for total recoverable petroleum hydrocarbons by EPA Method 418.1. The method consists of extraction with Freon followed by IR determination at $2930cm^{-1}$. The exceptional concentration exhibited by some samples forced the use of smaller aliquots thus lowering the detection limit to 1.0mg/Kg. Results, however are definite.

Flashpoint determinations met with some difficulty due to the nature of the samples. Most samples were hard packed and bound clay. Moisture determinations in some samples showed a range of 10 to 20 percent moisture. None of the samples could be ignited.

Leachate metal analysis following SW-846 protocols presented no particular difficulties. Results are reported in mg/L so as to compare with SW-846 limits.

TOX analysis were performed according to Method 9020 in SW-846. Detection limit obtained was 50mg/Kg. All samples resulted in less than 50mg/Kg.

QUALITY CONTROL

Gas chromatography of water samples was monitored by periodic blanks and standards. Linearity and reproducibility were established before and after analysis of each set. Sample blanks were intermingled with samples.

Similary linearity and reproducibility were established for method 418.1 for hydrocarbons. A calibration curve was constructed for each day of analysis using benzene, isoctane and hexadecane as the protocol dictates. Sample weights were lowed to allow results to fall within the calibration curve. Each

extract was measured three times and the average absorbance used for the determination.

Metal analysis and TOX were subjected to normal quality control procedures. No difficulties were experienced. Standard deviations in the metal analysis were within the 0.5% range.

May 17, 1991

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41.447
FIELD DESCRIPTION:	Soil, B-1, 4' to 6'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 25, 1991 , 11:21 AM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	1.1
Cadmium	mg/L	0.066
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.083
Selenium	mg/L	< 0.01
Silver	mg/L	0.035
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	2,087
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41.448
FIELD DESCRIPTION:	Soil, B-1, 6´ to 8´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 25, 1991 , 11:35 AM
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	0.7
Cadmium	mg/L	0.035
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.080
Selenium	mg/L	< 0.01
Silver	mg/L	0.033
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	270
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,449
FIELD DESCRIPTION:	Soil, B-1, 8' to 15'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 25, 1991 , 2:09 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.240
Chromium	mg/L	< 0.001
Mercury	mg/L	< 0.001
Lead	mg/L	0.073
Selenium	mg/L	< 0.01
Silver	mg/L	0.030
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	530
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,450
FIELD DESCRIPTION:	Soil, B-2, 2' to 4'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 2:39 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	6.4
Cadmium	mg/L	1.700
Chromium	mg/L	0.062
Mercury	mg/L	0.001
Lead	mg/L	0.166
Selenium	mg/L	< 0.01
Silver	mg/L	0.063
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	464
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,451
FIELD DESCRIPTION:	Soil, B-2. 4' to 6'
DATE SAMPLE SUBMITTED:	March 1. 1991
DATE SAMPLED:	Feb. 26, 1991 , 2:48 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	7.3
Cadmium	mg/L	0.052
Chromium	mg/L	0.064
Mercury	mg/L	0.001
Lead	mg/L	0.163
Selenium	mg/L	< 0.01
Silver	mg/L	0.056
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	422
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,452
FIELD DESCRIPTION:	Soil, B-2, 6' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 3:45 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.086
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.055
Selenium	mg/L	< 0.01
Silver	mg/L	0.024
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	1,816
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,453
FIELD DESCRIPTION:	Soil, B-2, 6' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 3:45 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil (Matrix Spike)

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.175
Chromium	mg/L	0.018
Mercury	mg/L	0.001
Lead	mg/L	0.218
Selenium	mg/L	< 0.01
Silver	mg/L	0.033
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	4,029
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,454
FIELD DESCRIPTION:	Soil, B-2, 6' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 3:45 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil (Matrix Spike Duplicate)

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.072
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.074
Selenium	mg/L	< 0.01
Silver	mg/L	0.024
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	3,560
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,455
FIELD DESCRIPTION:	Soil, B-3, 4' to 6'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 3:55 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	10.0
Cadmium	mg/L	0.073
Chromium	mg/L	0.074
Mercury	mg/L	0.001
Lead	mg/L	0.211
Selenium	mg/L	< 0.01
Silver	mg/L	0.088
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	22,850
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,456
FIELD DESCRIPTION:	Soil, B-3, 10´ to 12´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 26, 1991 , 5:20 PM
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	8.6
Cadmium	mg/L	0.337
Chromium	mg/L	0.018
Mercury	mg/L	< 0.001
Lead	mg/L	0.098
Selenium	mg/L	< 0.01
Silver	mg/L	0.049
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	22,600
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,457
FIELD DESCRIPTION:	Soil, B-3, 12' to 16'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991 , 10:40 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	0.8
Cadmium	mg/L	0.027
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.055
Selenium	mg/L	< 0.01
Silver	mg/L	0.027
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	2,900
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,458
FIELD DESCRIPTION:	Soil, B-4, 6' to 8'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991 , 1:11 PM
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	6.0
Cadmium	mg/L	0.087
Chromium	mg/L	0.144
Mercury	mg/L	< 0.001
Lead	mg/L	1.000
Selenium	mg/L	< 0.01
Silver	mg/L	0.106
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	53.9
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,459
FIELD DESCRIPTION:	Soil, B-4, 8´ to 10´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991 , 1:20 PM
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	7.5
Cadmium	mg/L	0.099
Chromium	mg/L	0.133
Mercury	mg/L	< 0.001
Lead	mg/L	0.602
Selenium	mg/L	< 0.01
Silver	mg/L	0.134
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	333.8
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,460
FIELD DESCRIPTION:	Soil, B-4, 10´ to 14´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991 , 2:01 PM
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	1.9
Cadmium	mg/L	0.060
Chromium	mg/L	0.059
Mercury	mg/L	< 0.001
Lead	mg/L	0.191
Selenium	mg/L	< 0.01
Silver	mg/L	0.062
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	3,019
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,461
FIELD DESCRIPTION:	Soil, B-5, 2' to 4'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	1.0
Cadmium	mg/L	0.020
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.062
Selenium	mg/L	< 0.01
Silver	mg/L	0.017
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	6.2
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,462
FIELD DESCRIPTION:	Soil, B-5, 4' to 6'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.022
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.062
Selenium	mg/L	< 0.01
Silver	mg/L	0.016
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	166.6
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,463
FIELD DESCRIPTION:	Soil, B-5, 6' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 27, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.046
Chromium	mg/L	< 0.001
Mercury	mg/L	< 0.001
Lead	mg/L	0.105
Selenium	mg/L	< 0.01
Silver	mg/L	0.063
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	7.2
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,464
FIELD DESCRIPTION:	Soil, B-6, 4' to 6'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.047
Chromium	mg/L	0.001
Mercury	mg/L	< 0.001
Lead	mg/L	0.109
Selenium	mg/L	< 0.01
Silver	mg/L	0.017
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	54.5
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,465
FIELD DESCRIPTION:	Soil, B-6, 6' to 8'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.015
Chromium	mg/L	< 0.001
Mercury	mg/L	< 0.001
Lead	mg/L	0.103
Selenium	mg/L	< 0.01
Silver	mg/L	0.014
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,466
FIELD DESCRIPTION:	Soil, B-6, 12´ to 16´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, Composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.024
Chromium	mg/L	< 0.001
Mercury	mg/L	< 0.001
Lead	mg/L	0.108
Selenium	mg/L	< 0.01
Silver	mg/L	0.018
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,467
FIELD DESCRIPTION:	Soil, B-7, 2' to 4'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	0.5
Cadmium	mg/L	0.056
Chromium	mg/L	< 0.001
Mercury	mg/L	0.001
Lead	mg/L	0.093
Selenium	mg/L	< 0.01
Silver	mg/L	0.018
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	3.5
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,468
FIELD DESCRIPTION:	Soil, B-7, 4' to 6'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	0.5
Cadmium	mg/L	0.024
Chromium	mg/L	0.010
Mercury	mg/L	< 0.001
Lead	mg/L	0.123
Selenium	mg/L	< 0.01
Silver	mg/L	0.013
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,469
FIELD DESCRIPTION:	Soil, B-7, 6' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	0.5
Cadmium	mg/L	0.007
Chromium	mg/L	0.002
Mercury	mg/L	< 0.001
Lead	mg/L	0.111
Selenium	mg/L	< 0.01
Silver	mg/L	0.020
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	1.7
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,470
FIELD DESCRIPTION:	Soil, B-8, 6' to 8'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.006
Chromium	mg/L	0.233
Mercury	mg/L	0.013
Lead	mg/L	0.156
Selenium	mg/L	< 0.01
Silver	mg/L	0.017
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	20.3
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,471
FIELD DESCRIPTION:	Soil, B-8, 8' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	February 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.020
Chromium	mg/L	0.004
Mercury	mg/L	0.008
Lead	mg/L	0.090
Selenium	mg/L	< 0.01
Silver	mg/L	0.021
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	4.2
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,472
FIELD DESCRIPTION:	Soil, B-8, 12' to 16'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	Feb. 28, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.011
Chromium	mg/L	0.314
Mercury	mg/L	0.008
Lead	mg/L	0.094
Selenium	mg/L	< 0.01
Silver	mg/L	0.020
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,473
FIELD DESCRIPTION:	Soil, B-9, 4´ to 6´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.006
Chromium	mg/L	< 0.001
Mercury	mg/L	0.004
Lead	mg/L	0.230
Selenium	mg/L	< 0.01
Silver	mg/L	0.014
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	10.2
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41.474
FIELD DESCRIPTION:	Soil, B-9, 10' to 12'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.006
Chromium	mg/L	< 0.001
Mercury	mg/L	0.004
Lead	mg/L	0.240
Selenium	mg/L	< 0.01
Silver	mg/L	0.017
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	1.6
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,475
FIELD DESCRIPTION:	Soil, B-9, 12´ to 16´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.012
Chromium	mg/L	0.024
Mercury	mg/L	0.002
Lead	mg/L	0.165
Selenium	mg/L	< 0.01
Silver	mg/L	0.016
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O´BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,476
FIELD DESCRIPTION:	Soil, B-10, 4´ to 6´
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O´Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.011
Chromium	mg/L	< 0.001
Mercury	mg/L	0.002
Lead	mg/L	0.239
Selenium	mg/L	< 0.01
Silver	mg/L	0.013
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	10.2
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,477
FIELD DESCRIPTION:	Soil, B-10, 6' to 8'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Grab

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.005
Chromium	mg/L	< 0.001
Mercury	mg/L	0.006
Lead	mg/L	0.133
Selenium	mg/L	< 0.01
Silver	mg/L	0.024
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,478
FIELD DESCRIPTION:	Soil, B-10, 10' to 10'
DATE SAMPLE SUBMITTED:	March 1, 1991
DATE SAMPLED:	March 1, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Soil, Composite

PARAMETER	UNITS	RESULT
Arsenic	mg/L	< 0.01
Barium	mg/L	< 0.5
Cadmium	mg/L	0.001
Chromium	mg/L	< 0.001
Mercury	mg/L	0.006
Lead	mg/L	0.149
Selenium	mg/L	< 0.01
Silver	mg/L	0.021
Total Organic Halogen	mg/Kg	< 50
Petroleum Hydrocarbons	mg/Kg	< 1.0
Flashpoint	Deg F.	> 140

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,625
FIELD DESCRIPTION:	UGW-1
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	13,517.8
Toluene	ppb	34,382.9
Ethylbenzene	ppb	95,702.4
Xylenes	ppb	139,546.8
Lead	ug/L	3,580
Benzene, dup	ppb	*
Toluene, dup	ppb	*
Ethylbenzene, dup	ppb	*
Xylenes, dup	ppb	*

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,614
FIELD DESCRIPTION:	UGW-2
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	142
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,615
FIELD DESCRIPTION:	UGW-3
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	122
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzen, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,621
FIELD DESCRIPTION:	UGW-4
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	15.8
Toluene	ppb	677.7
Ethylbenzene	ppb	7,164.6
Xylenes	ppb	10,697.1
Lead	ug/L	80
Benzene, dup	ppb	349.8
Toluene, dup	ppb	6,068.7
Ethylbenzene, dup	ppb	7,016.1
Xylenes, dup	ppb	7,898.4

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,622
FIELD DESCRIPTION:	UGW-5
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	316.9
Ethylbenzene	ppb	3,285.4
Xylenes	ppb	4,232.7
Lead	ug/L	107
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	1,077.3
Ethylbenzene, dup	ppb	6,677.2
Xylenes, dup	ppb	1,768.6

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,613
FIELD DESCRIPTION:	UGW-6
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Waste water

PARAMETER	UNITS	RESULT
Benzene	ppb	6003.9
Toluene	ppb	2095.6
Ethylbenzene	ppb	3719.0
Xylenes	ppb	453.7
Lead	ug/L	166
Benzene, dup	ppb	3080.1
Toluene, dup	ppb	240.0
Ethylbenzene, dup	ppb	1166.3
Xylenes, dup	ppb	129.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,612
FIELD DESCRIPTION:	UGW-7
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	93
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,620
FIELD DESCRIPTION:	UGW-8
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	77
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,611
FIELD DESCRIPTION:	UGW-9
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	68
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzen, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41.619
FIELD DESCRIPTION:	UGW-10
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	74
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,618
FIELD DESCRIPTION:	UGW-11
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	94
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,623
FIELD DESCRIPTION:	UGW-12
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	47.2
Toluene	ppb	7.5
Ethylbenzene	ppb	432.3
Xylenes	ppb	1,402.9
Lead	ug/L	82
Benzene, dup	ppb	11.6
Toluene, dup	ppb	4.0
Ethylbenzene, dup	ppb	524.5
Xylenes, dup	ppb	1,275.4

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,624
FIELD DESCRIPTION:	UGW-13
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	788.3
Toluene	ppb	4,712.6
Ethylbenzene	ppb	23,864.6
Xylenes	ppb	40,739.2
Lead	ug/L	98
Benzene, dup	ppb	*
Toluene, dup	ppb	*
Ethylbenzene, dup	ppb	*
Xylenes, dup	ppb	*

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,626
FIELD DESCRIPTION:	UG-14
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	464.0
Toluene	ppb	2,387.1
Ethylbenzene	ppb	22,803.7
Xylenes	ppb	23,754.2
Lead	ug/L	89
Benzene, dup	ppb	745.7
Toluene, dup	ppb	1,987.4
Ethylbenzene, dup	ppb	18,341.1
Xylenes, dup	ppb	36,905.3

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,627
FIELD DESCRIPTION:	UGW-15
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	1,017.4
Toluene	ppb	62.9
Ethylbenzene	ppb	1,112.1
Xylenes	ppb	297.7
Lead	ug/L	167
Benzene, dup	ppb	3,111.4
Toluene, dup	ppb	1,032.8
Ethylbenzene, dup	ppb	1,509.2
Xylenes, dup	ppb	1,095.0

O'BRIEN & GERE/NAVAL B PROJECT

SAMPLE ID:	41,644
FIELD DESCRIPTION:	UGW-16
DATE SAMPLE SUBMITTED:	April 5, 1991
DATE SAMPLED:	April 4, 1991, 11:54
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Waste water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	57
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,645
FIELD DESCRIPTION:	UGW-17
DATE SAMPLE SUBMITTED:	April 5, 1991
DATE SAMPLED:	April 4, 1991, 12:20
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Waste water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	61
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,646
FIELD DESCRIPTION:	UGW-18
DATE SAMPLE SUBMITTED:	April 5, 1991
DATE SAMPLED:	April 4, 1991, 16:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Waste water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	65
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,616
FIELD DESCRIPTION:	Duplicate
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	125
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,617
FIELD DESCRIPTION:	Field Blank
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Well water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	76
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,628
FIELD DESCRIPTION:	Trip Blank
DATE SAMPLE SUBMITTED:	March 29, 1991
DATE SAMPLED:	March 26, 1991, 13:00
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	N/A
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

O'BRIEN & GERE/NAVAL BASE PROJECT

SAMPLE ID:	41,647
FIELD DESCRIPTION:	Trip Blank
DATE SAMPLE SUBMITTED:	April 5, 1991
DATE SAMPLED:	April 1, 1991
SAMPLER:	O'Brien & Gere
SAMPLE TYPE:	Waste water

PARAMETER	UNITS	RESULT
Benzene	ppb	< 1.0
Toluene	ppb	< 1.0
Ethylbenzene	ppb	< 1.0
Xylenes	ppb	< 1.0
Lead	ug/L	N/A
Benzene, dup	ppb	< 1.0
Toluene, dup	ppb	< 1.0
Ethylbenzene, dup	ppb	< 1.0
Xylenes, dup	ppb	< 1.0

QUANTUM LABORATORIES, INC.

ANALYTICAL SERVICES
G.P.O. BOX 361629 • SAN JUAN, PUERTO RICO 00936-1629
(809) 793-7288

May 17, 1991

C E R T I F I C A T I O N

The analysis reported herein have been performed following approved methods found in "Standard Methods for the Examination of Water and Wastewater " (APHA) and/or in "Methods for Chemical Analysis of Water and Wastes" (EPA).

Instruments, solutions and regeants have been prepared, standardized and/or calibrated according to the applicable methods.

All tests have been performed by or under the supervision of licensed chemist.

J. Roberto Ramirez, Ph. D.

A 186300

O'BRIEN & GERE ENGINEERS, INC.

Job No. 3543 [illegible]

Sheet 1 of 3

Office: Syracuse NY 70

Address: Brittonfield Syracuse

Phone: 315-437-6100 Ext 2467

CHAIN OF CUSTODY

CLIENT: U S Navy Roosevelt Roads

LOCATION: Puerto Rico

COLLECTED BY: Timothy M Eddy

(Signature) Timothy Eddy

SAMPLE DESCRIPTION	Date	Time	Sample Matrix[1]	Sample Type[2]	No. of Containers	ANALYSIS REQUESTED
B-1 4'-6'	2/25/91	1121	SOIL	GRAB	1	EPA 6010-7000 EPA 9020
B-1 6'-8'	2/25/91	1135	SOIL	GRAB	1	EPA 415.1 FLASHPOINT
B-1 8'-15'	2/25/91	1409	SOIL	COMPOSITE	1	
B-2 2'-4'	2/26/91	1439	SOIL	GRAB	1	
B-2 4'-6'	2/26/91	1448	SOIL	GRAB	1	
B-2 6'-10'	2/26/91	1545	SOIL	COMPOSITE	1	
B-2 6'-10' MATRIX SPIKE	2/26/91	1545	SOIL	COMPOSITE	1	
B-2 6'-10' MATRIX SPIKE DUP	2/26/91	1545	SOIL	COMPOSITE	1	
B-3 4'-6'	2/26/91	1555	SOIL	GRAB	1	
B-3 10'-12'	2/26/91	1720	SOIL	GRAB	1	
B-3 12'-16'	2/27/91	1040	SOIL	COMPOSITE	1	
B-4 6'-8'	2/27/91	1311	SOIL	GRAB	1	
B-4 8'-10'	2/27/91	1320	SOIL	GRAB	1	
B-4 10'-14'	2/27/91	1401	SOIL	COMPOSITE ~~GRA~~	1	✓

[1] Matrix = water, wastewater, air, sludge, sediment, etc.
[2] Type = grab, composite

Relinquished by:	Date	Time	Received by:	Date	Time
Timothy Eddy	3/1/90	1700	[illegible]	3/1/90	1700
of: O'Brien & Gere Engineers, Inc			of: Quan Sum Laboratories		
Relinquished by:	Date	Time	Received by:	Date	Time
of:			of:		
Relinquished by:	Date	Time	Received by:	Date	Time
of:			of:		
Use this space if shipped via courier (e.g., Fed Ex) Relinquished by:	Date	Time	Courier Name:	Date	Time

*Attach delivery/courier receipt to Chain of Custody

O'BRIEN & GERE ENGINEERS, INC.

Job No. 3543 02013

Sheet 2 of 3

Office: SYRACUSE

Address: 5000 SENTRY PARK

Phone: 315-437-6100 x 2467

CHAIN OF CUSTODY

CLIENT: U.S NAVY

LOCATION: Roosevelt Roads Puerto Rico

COLLECTED BY: Timothy M Eddy

(Signature) Timothy M Eddy

SAMPLE DESCRIPTION	Date	Time	Sample Matrix[1]	Sample Type[2]	No. of Containers	ANALYSIS REQUESTED
B-5 2'-4'	2/27/91	1605	SOIL	GRAB	1	EPA 6010-700 EPA 9070
B-5 4'-6'	2/27/91	1617	SOIL	GRAB	1	EPA 418.1 FLASHPOINT
B-5 6'-10'	2/27/91	1710	SOIL	COMPOSITE	1	
B-6 4'-6'	2/28/91	1012	SOIL	GRAB	1	
B-6 6'-8'	2/28/91	1022	SOIL	GRAB	1	
B-6 12'-16'	2/28/91	1115	SOIL	COMPOSITE	1	
B-7 2'-4'	2/28/91	1326	SOIL	GRAB	1	
B-7 4'-6'	2/28/91	1335	SOIL	GRAB	1	
B-7 6'-10'	2/28/91	1443	SOIL	COMPOSITE	1	
B-8 6'-8'	2/28/91	1604	SOIL	GRAB	1	
B-8 8'-10'	2/28/91	1617	SOIL	GRAB	1	
B-8 12'-16'	2/28/91	1700	SOIL	COMPOSITE	1	
B-9 4'-6'	3/1/91	0936	SOIL	GRAB	1	
B-9 10'-12'	3/1/91	1028	SOIL	GRAB	1	

[1] Matrix = water, wastewater, air, sludge, sediment, etc.
[2] Type = grab, composite

Relinquished by:	Date	Time	Received by:	Date	Time
Timothy M Eddy	3/1/90	1700	M Manning	3/1/90	17:00
of: O'BRIEN & GERE ENGINEERS INC			of: Quantum Laboratories		
Relinquished by:	Date	Time	Received by:	Date	Time
of:			of:		
Relinquished by:	Date	Time	Received by:	Date	Time
of:			of:		
Use this space if shipped via courier (e.g., Fed Ex) Relinquished by:	Date	Time	Courier Name:	Date	Time
			*Attach delivery/courier receipt to Chain of Custody		

O'BRIEN & GERE ENGINEERS, INC.

Job No. 3442 020120

Sheet 3 of 3

Office: SYRACUSE P O Box 4873

Address: 5000 BRITTONFIELD PKWY 13221

Phone: 315-437-6100 x 2467

CHAIN OF CUSTODY

CLIENT: U S NAVY

LOCATION: Roosevelt Roads Puerto Rico

COLLECTED BY: Timothy M Edelly

(Signature) Timothy Edelly

SAMPLE DESCRIPTION	Date	Time	Sample Matrix[1]	Sample Type[2]	No. of Containers	ANALYSIS REQUESTED
B-9 12'-16'	3/1/91	1110	SOIL	COMPOSITE	1	EPA 6010-7000 SERIES EPA 9020
B-10 4'-6'	3/1/91	1305	SOIL	~~COMP~~ GRAB	1	EPA 415.1 EXTRACT
B-10 6'-8'	3/1/91	1323	SOIL	GRAB	1	↓
B-10 ~~[illegible]~~ 10'-14'	3/1/91	1439	SOIL	COMPOSITE	1	↓

[1] Matrix = water, wastewater, air, sludge, sediment, etc.

[2] Type = grab, composite

Relinquished by:	Date	Time	Received by:	Date	Time
Timothy M Edelly of: O'Brien & Gere Engineers Inc	3/1/90	1700	M Mann of: Quanterra Laboratories	3/1/90	1710
Relinquished by: of:			Received by: of:		
Relinquished by: of:			Received by: of:		
Use this space if shipped via courier (e.g., Fed Ex) Relinquished by:			Courier Name: *Attach delivery/courier receipt to Chain of Custody		

CHAIN OF CUSTODY RECORD

LABORATORIES, INC.

SURVEY: U.S. NAVY Roosevelt Roads Naval Station

LOCATION: Puerto Rico

SAMPLED BY: Timothy M Eddy

ORGANIZATION: O'Brien & Gere Engineers, Inc. (Div 7)

STATION NUMBER	SAMPLE LOCATION	DATE COLLECTED	TIME COLLECTED	SAMPLE MATRIX	COMP. OR GRAB	NO. OF CONTAINERS	ANALYSIS REQUIRED
	UGW-9	3/26/91	1300	H_2O	GRAB	3	EPA METHOD 503.1 BTEX LEAD by AA
	UGW-7	3/26/91	1336	H_2O	GRAB	3	
	UGW-6	3/26/91	1347	H_2O	GRAB	3	
	UGW-2	3/26/91	1705	H_2O	GRAB	3	
	UGW-3	3/27/91	1418	H_2O	GRAB	3	
	Field Blank	3/27/91	1422	H_2O	GRAB	3	
	Duplicate	3/27/91	—	H_2O	GRAB	3	
	UGW-11	3/27/91	1620	H_2O	GRAB	3	
	UGW-10	3/27/91	1635	H_2O	GRAB	3	
	UGW-8	3/28/91	1212	H_2O	GRAB	3	
	UGW-4	3/28/91	1305	H_2O	GRAB	3	
	UGW-5	3/28/91	1336	H_2O	GRAB	3	✓

Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Timothy Eddy	3/29/91	1257	Mami	3/29/91	12:57
Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Relinquished By:	DATE	TIME	Received by Laboratory:	DATE	TIME

COMMENTS:

METHOD OF SHIPMENT:

Rental Car to San Juan Airport

CHAIN OF CUSTODY RECORD

LABORATORIES, INC.

SURVEY: U.S NAVY Roosevelt Roads NAVAL STATION

LOCATION: Puerto Rico

SAMPLED BY: Timothy M Eddy

ORGANIZATION: CDM Federal Services Engineers Inc

STATION NUMBER	SAMPLE LOCATION	DATE COLLECTED	TIME COLLECTED	SAMPLE MATRIX	COMP. OR GRAB	NO. OF CONTAINERS	ANALYSIS REQUIRED
	UGW-12	3/28/91	1410	H_2O	GRAB	3	EPA METHOD 503-1 LEAD BY AA
	UGW-13	3/28/91	1428	H_2O	GRAB	3	↑
	UGW-1 Freedom Power	3/28/91	1500	—	GRAB	3	↑
	UGW-14	3/28/91	1646	H_2O	GRAB	3	↑
	UGW-15	3/28/91	1730	H_2O	GRAB	3	↑
	TRIP BLANK	1/16/91	—	H_2O	—	1	✓

Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Timothy M Eddy	3/29/91	1157	[illegible]	3/29/91	12:57
Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Relinquished By:	DATE	TIME	Received by Laboratory:	DATE	TIME

COMMENTS:

METHOD OF SHIPMENT:

Rental Car to San Juan for Transfer

CHAIN OF CUSTODY RECORD

DCG LABORATORIES, INC.

SURVEY: U/S NAVAL STATION Roosevelt Roads

LOCATION: Puerto Rico

SAMPLED BY: Timothy M Kelly

ORGANIZATION: Offshore Engineers, Inc. Div 7

STATION NUMBER	SAMPLE LOCATION	DATE COLLECTED	TIME COLLECTED	SAMPLE MATRIX	COMP. OR GRAB	NO. OF CONTAINERS	ANALYSIS REQUIRED
	UGW-16	4/4/91	1154	H_2O	GRAB	3	EPA 503.1 LEAD BY AA
	UGW-17	4/4/91	1220	H_2O	GRAB	3	
	UGW-18	4/4/91	1600	H_2O	GRAB	3	
	TRIP BLANK	4/4/91	-	H_2O	-	1	

Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Timothy M Kelly	4/4/91	2000	[illegible]	4/4/91	
Relinquished By:	DATE	TIME	Received By:	DATE	TIME
Relinquished By:	DATE	TIME	Received by Laboratory:	DATE	TIME

COMMENTS:

METHOD OF SHIPMENT: