# REPORT OF
# MARINE GEOPHYSICAL SURVEYS: SEISMIC REFRACTION, SUB-AQUEOUS DISPOSAL CELL FEASIBILITY STUDIES, NEW BEDFORD HARBOR-2001
**New Bedford, Massachusetts**

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# 1.0 INTRODUCTION

This "Report of Marine Geophysical Surveys: Seismic Refraction, Sub-aqueous Disposal Cells Feasibility Studies, New Bedford Harbor-2001" was prepared by Apex Environmental, Inc. (Apex) for The Maguire Group, Inc. (Maguire). Apex is supporting Maguire in its completion of feasibility studies concerning proposed Confined Aquatic Disposal (CAD) cells in New Bedford Harbor for Massachusetts Coastal Zone Management (MACZM). MACZM is assessing the feasibility of locating a CAD cell or cells in New Bedford Harbor in order to alleviate the shortage of permanent dredge spoils disposal sites in the area. Two discrete areas of interest within New Bedford Harbor are being assessed by MACZM and Maguire as potential CAD sites: Popes Island North Area, located northeast of Popes Island in New Bedford Harbor; and the Channel Inner Area, located north of Palmer Island in the lower portion of New Bedford Harbor (see Figure 1). The marine geophysical study described in this report covers these two areas.

The results of previous studies (Foster Wheeler, 2001) had indicated that the bedrock surface beneath New Bedford Harbor was somewhat irregular, and that it would be unlikely that drilling data alone would be sufficient to characterize the bedrock surface to the extent desired by design engineers. Therefore, the supplemental geophysical program described in this report was undertaken to provide supporting information and data on the topography and character of the bedrock surface within the survey area.

The objective of this Marine Geophysical Investigation was to detect and map the surface of bedrock beneath the harbor bottom along survey lines in the areas of the proposed CAD cells. The geophysical data on top-of-bedrock was required as part of pre-design feasibility studies, and the data was utilized by Maguire in the determination of the capacity of the proposed cells.

## 1.1 Background

The geologic setting of New Bedford Harbor has been summarized in previous studies by several investigators. Apex reviewed numerous documents prior to commencing geophysical operations in the harbor, in order to obtain background information concerning the general geologic regime present in and around the Site. Among the documents and reports reviewed as part of background information data gathering were: various reports related to the New Bedford Harbor Superfund Site; *The Bedrock Geology of Massachusetts* (Hatch, N.L., ed., 1991); and *The Bedrock Geologic Map of Massachusetts* (Zen, 1983). A full list of the references reviewed by Apex is included as Section 6 of this report.

The bedrock regime of the greater New Bedford Harbor area (including Fairhaven and Acushnet) is composed of the gray granitic gneiss known as Alaskite Gneiss, (Zen, 1983) described as a 'light gray and pinkish-gray to tan, mafic-poor gneissic granite (and granitic gneiss) commonly containing muscovite'. The bedrock encountered in cores within the harbor area (Foster Wheeler, 2001) is a dark to light gray, massive, hard, salt and pepper granitic gneiss similar to other hard bedrock materials found within the Tertiary to Proterozoic Age Milford-Dedham (Geologic) Zone. The gneissic rock encountered in bedrock cores taken from the study area also contained bands and veins of pegmatitic and quartzitic late-stage intrusive materials, evidence that fracturing within the area was followed by late-stage intrusive influx. The Alaskite Gneiss is moderately fractured (Zen, 1983), with the primary fracture orientation north-northeast to south-southwest in this area. Secondary fractures have been noted (Goldsmith, 1978), which trend in an east-westerly direction. The fractures tend to be high angle (between 60 and 90), and are generally filled either with (quartzitic or pegmatitic) solidified late stage fluids (as "healed" fractures), or with silt (as "open" fractures).

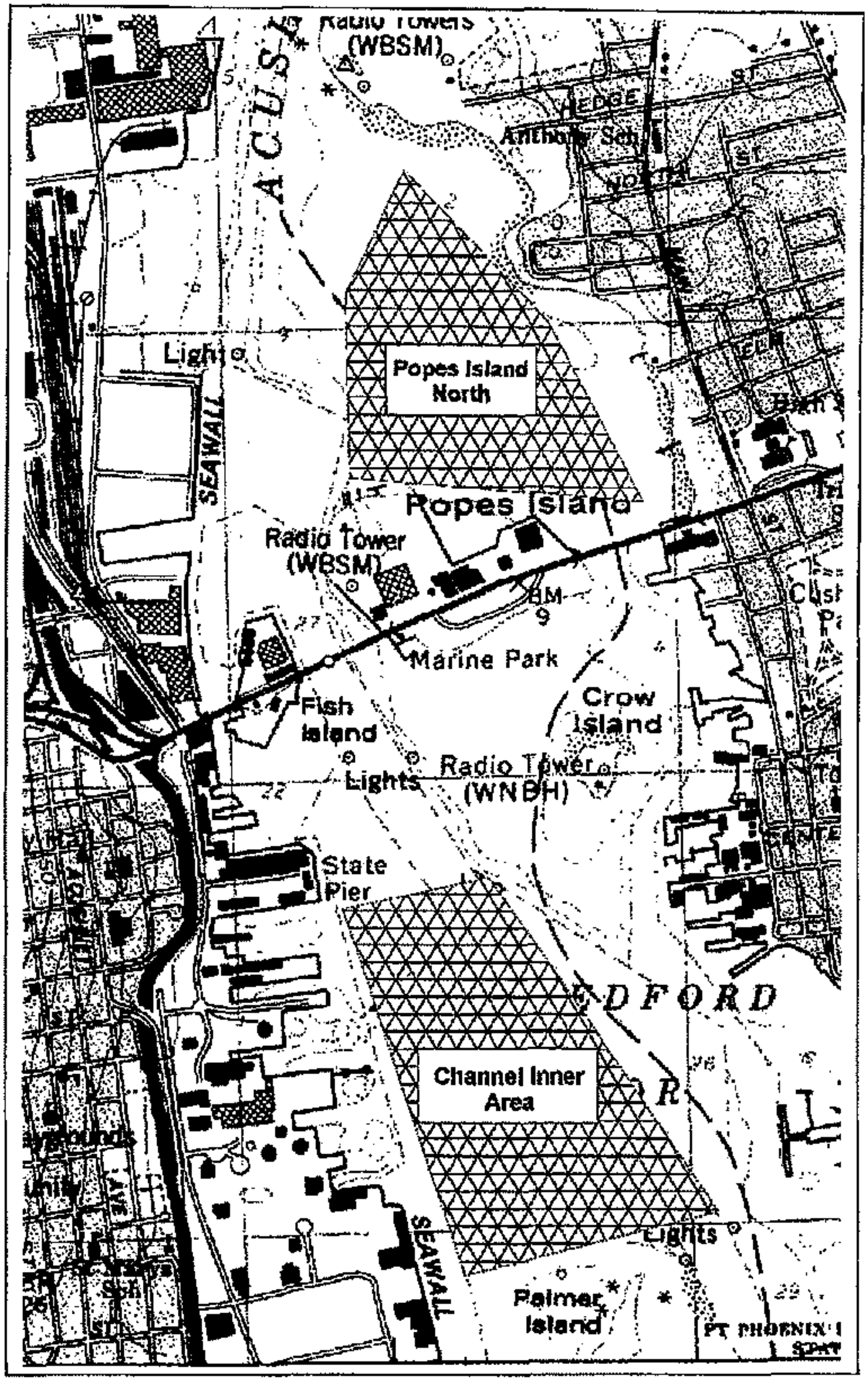



Figure 1. Survey Location Plan

Above the bedrock surface, the sediments of New Bedford Harbor consist of a mixture of marine, glacial, and post-glacial sediments. This area is characteristic of the southern New England marine/glacial sequence that developed upon the retreat of the glaciers at the end of the Pleistocene. The lowest unconsolidated strata in the sequence found at New Bedford Harbor includes a sporadically present glacial till, which consists of a dense mixture of coarse to fine materials with silt, clay, cobbles, and some boulders; and glacial outwash deposits, consisting of coarse to fine sands, silts, and gravels, found above the till (where it exists) and above bedrock (where it does not) throughout the harbor area. The outwash deposits show characteristics of rapidly moving water deposition, evidence of high-energy post-glacial fluvial deposition on a broad scale. Braided stream patterns, cut and fill channels, and filled gullies have been identified throughout the region within the glacio-fluvial sediment column (Goldsmith, 1978). In places, the surface of the glacio-fluvial deposits are separated from the overlying marine deposits by an erosional surface.

The marine sediments (generally found above the glacio-fluvial sediments) consist of poorly graded sands, gravels, silts and clays, sometimes containing shell hash and sometimes displaying seasonal varving. Sandy and gravelly marine deposits represent higher energy beach areas, whereas silts and clays are indicative of deeper and calmer water deposition. These various marine deposits are overprinted on one another throughout the sediment column, suggesting that post-glacial variations in sea level within the harbor area led to complex marine and estuarian depositional regimes.

In some areas, erosional surfaces may exist above the historical marine sediments as well, as evidenced by the presence of peat deposits detected in some borings (conducted by others) in the harbor. The uppermost sedimentary units within the harbor exist as modern estuarian and shallow marine deposits. In deeper water, lower energy areas, these sediments exist as a thick muck layer, consisting of a mixture of silt, fine sand, and decaying organic material (and often contain biogenic "gas" pockets, the residuals of the decomposition process). In shallower areas, the recent bottom sediments may consist of coarser sands and shell hash, indicative of the presence of a higher energy environment.

## 1.2 Purpose

The work conducted as part of the geophysical program was undertaken to characterize the bedrock surface in the two proposed areas for the potential CAD cells. Seismic refraction data was collected in an attempt to better understand the nature and character of the bedrock surface beneath the sediments in the area of the proposed CAD cells. The seismic data was used in conjunction with boring data to develop a model of the shape and character of the bedrock surface below the sediment in the survey areas. Ultimately, the bedrock character data was used by Maguire in assessing the capacity and feasibility of the proposed CAD cells.

## 1.3 Approach to the Report Presentation

This report is organized by sections that provide a functional framework for the presentation of the information that was gathered during the work. The following provides an outline of the approach to the presentation of the information.

Section 1.0 (Introduction) includes introductory information, which describes the contractual framework for the program, and the background information. Section 1.1 includes the historical and published geologic framework of the study area upon which the information gathered as part of this investigation is built.

Section 2.0 (Methods) describes the means and methods by which the information was collected, processed and interpreted. This section includes the equipment used to collect the data, along with a definition of the study area, and a description of the data collection, data processing, and data interpretation procedures undertaken.

Section 3.0 (Results) describes the findings of the Seismic Refraction investigation. This section also includes a discussion of the maps generated as part of the seismic data reduction process.

Section 4.0 presents the conclusions of the investigation, including an assessment of the overall geologic findings for the study area, which describes the big picture as determined from the data collected. Section 5.0 presents the Limitations of the program, and Section 6.0 provides a list of references cited throughout this report.

## 2.0 METHODS

The geophysical method used for this characterization was Marine Seismic Refraction surveying. The survey consisted of a number of seismic lines designed to cover the proposed locations of the two potential CAD sites. The work was performed from survey boats outfitted with the necessary equipment for high quality marine seismic data collection. Apex provided qualified shipboard geophysicists to oversee the collection of the data and operate the seismograph equipment.

Apex geophysicists performed the geophysical survey design, collection oversight, data reduction, and data interpretation for the Marine Seismic Refraction program. Specialty subcontractors with appropriate licenses for the special project requirements assisted in the collection of the geophysical data. The subcontractors utilized to assist with the Seismic Refraction data collection included:

- CR Environmental, Inc. of Falmouth, Massachusetts, providing the survey vessel and US Coast Guard licensed captains for the work, and
- Northeast Geophysical, Inc. of Bangor, Maine, who provided a licensed blaster and assistant for the work.

The survey consisted of 23 seismic refraction spreads: ten refraction spreads collected in the Popes Island North Area; and thirteen spreads in the Channel Inner Area. Each refraction spread consisted of 48 channels, with a nominal hydrophone spacing of 30 feet, such that each spread measured approximately 1410 feet in length. Small seismic charges are emplaced into the sediment of the harbor bottom to provide seismic energy. For this survey seismic energy was generally initiated from both ends of each seismic spread and from "off-set" points off each end of each seismic spread, with three additional shots along the line (located near hydrophones 12, 24, and 36), for a total of seven shot points per seismic spread.

### 2.1 Marine Seismic Refraction

The following sections describe the equipment used for the Seismic Refraction survey, the data collection methods, and the data processing and data interpretation methodologies for all aspects of the marine geophysical survey.

#### 2.1.1 Equipment

For this marine geophysical survey Apex utilized state-of-the-art equipment, including precision marine navigation, Side Scan Sonar, and a digital seismograph for seismic data recording. The equipment specifications are noted below:

<u>Geophysical Equipment Used</u>

- A Digital 48 channel OYO DAS-1 signal enhancement Seismograph with a Mitchum Industries hydrophone bottom sensor array (a "bay" cable), capable of supporting 48 channels of data collection;

- A Trimble Pro XRS Digital Sub-meter Accuracy DGPS;

- Digital Navigation Software for DGPS integration with real-time steer-to navigation for target and way-point navigation capability (HyPak software); and

- An EG&G DF-1000 Digital Side Scan Sonar with the 560 Topside, coupled to a PC running SonarWizz V2.08c data collection and processing software.

HyPak, a digital navigation software package for DGPS integration which allows real-time steer-to navigation and target and waypoint capability, was used during the payout of the hydrophone "bay" cable to ensure accurate cable and shot point positioning.

### 2.1.2 Study Area

Marine geophysical data was collected in two separate areas: Popes Island North located North of Popes Island; and the Channel Inner Area located northwest of the hurricane dike within Lower New Bedford Harbor. These two areas correspond with the potential locations of proposed Confined Aquatic Disposal (CAD) cells. The Seismic Refraction data were collected from stationary vessels via a hydrophone cable stretched out on the bottom of the harbor. Twenty-three spreads were collected in the two areas of the harbor; ten spreads were located in the Popes Island North area, and thirteen spreads were used in the Channel Inner Area. All spreads were located in the area of the possible CAD cells as identified by Maguire engineers (See Figure 2). The following seismic lines were surveyed, for a total of approximately 32,430 lineal feet of data collection:

Ten survey spreads in the Popes Island North area as follows:

- Two survey spreads along the eastern-most edge of the possible CAD cell;
- One survey spread along the western-most edge of the proposed CAD cell; and
- Seven approximately east-west trending survey spreads, spaced 400-600 feet apart.

Thirteen survey spreads in the Channel Inner area as follows:

- Two survey spreads along the eastern-most edge of the possible CAD cell (eastern edge of the navigational channel);
- Two survey spreads along the western-most edge of the possible CAD cell;
- One survey spread along the western edge of the navigational channel north of Palmer Island; and
- Seven east-west trending survey spreads, spaced 400-600 feet apart.

Each survey spread consisted of seven shot points (locations where energy was initiated into the subsurface). The location of the Seismic Refraction survey spreads is shown on Figure 2. Spread locations are depicted as a series of crosses, one cross for each hydrophone.

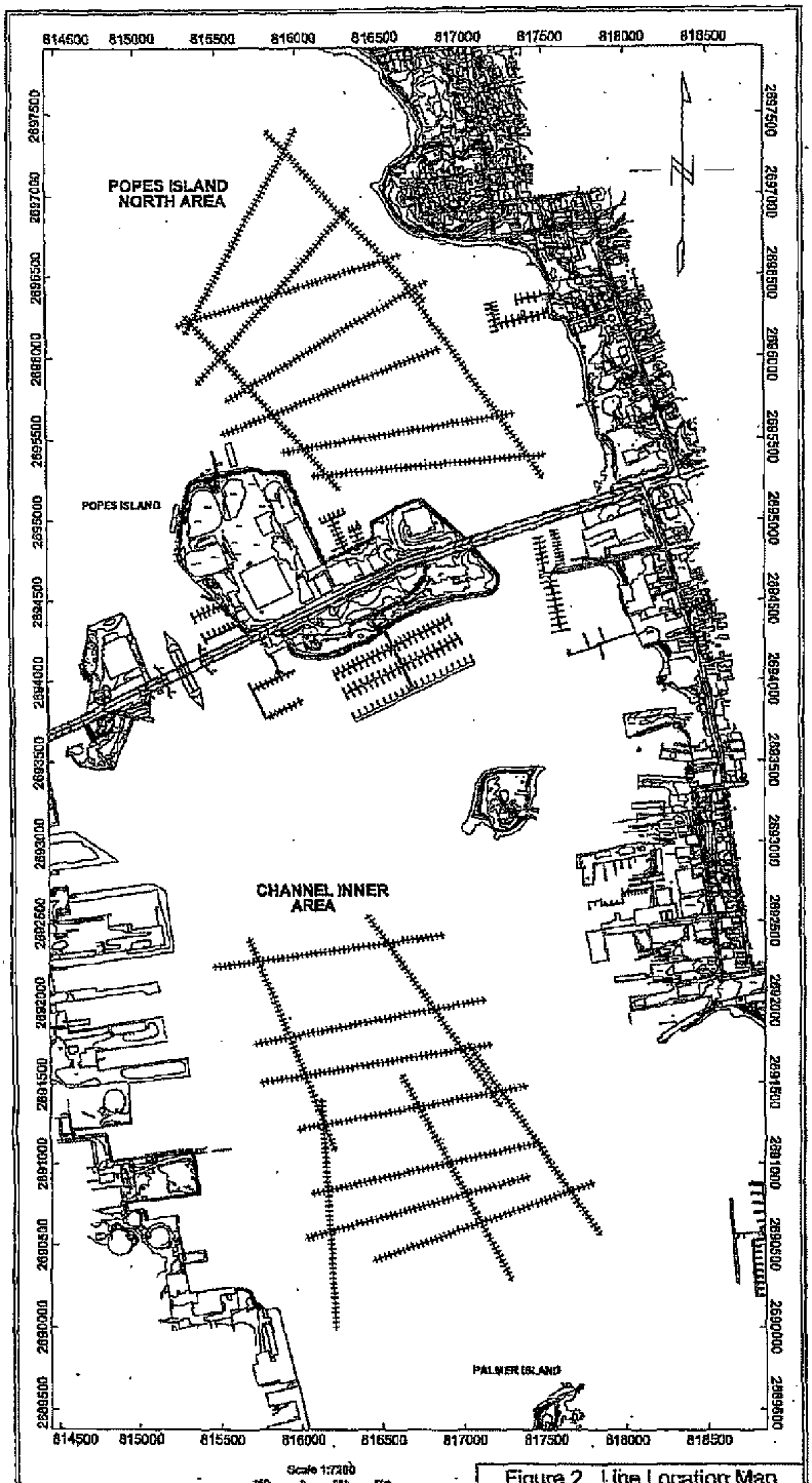



Figure 2. Line Location Map

New Bedford Harbor, MA

## 2.2 Data Collection

Seismic Refraction data was collected over the proposed CAD cell locations from April 19th through May 11th, 2001. The survey set-up in the harbor consisted of laying out the Mitchum Industries 48 channel, 1410 foot long, hydrophone 'bay' cable, with three anchors attached to it (one at each end and one in the middle) to secure it to the bottom. The seismic refraction cable was deployed from the stern of the seismic recording vessel. Position information was collected while laying out the cable using the steer-to navigation system "Hypak." Real-time X,Y position information was fed into a computer system from the DGPS, which logged the position of the cable as it was deployed. The cable also had specially designed sonar reflectors at phones 1, 24 and 48 to aid in the accurate positioning of the cable using the Side Scan Sonar system. The cable head at one end of the cable was kept on the surface of the water using a large buoy for ease of retrieval and hook-up with the seismic recording system located on the recording vessel.

Once the cable had been deployed onto the harbor bottom, Side Scan Sonar data of the cable position was collected in order to accurately locate the hydrophone cable on the bottom of the harbor. A minimum of two passes per spread were collected, one from each side of the cable, at a water-depth-dependent offset distance (a smaller off-set in shallower water, larger in deeper water) between 25 and 75 feet.

Once the cable was successfully deployed on the harbor bottom, the seismic recording vessel anchored at the end of the hydrophone spread, attached to the cable head, and recorded the seismic data. The seismic shot boat emplaced the seismic charges at pre-determined locations on the harbor bottom using an emplacement tool specially designed for the purpose. All cable and shot point locations were surveyed using DGPS.

For this survey, a single 48 channel 'bay' cable was used. The hydrophone array was connected to the 48 channel OYO DAS-1 digital recording seismograph via a cable head adapter. Hydrophones are highly sensitive transducers that generate a voltage that is proportional to changes in pressure caused by the passing of a seismic wave (i.e., a pressure wave propagating through a medium such as the mud of the harbor bottom). The OYO DAS-1 seismograph collects data digitally and prints out records via a built-in thermal printer. A minimum of two copies of each record were printed out in the field as a back up for the digital data, as well as for initial field interpretation. The seismograph recorded the voltage generated by each hydrophone on the harbor bottom immediately after initiation of a seismic "shot", and displayed the result as a "wiggle trace" (or waveform) for each channel, with the amplitude of the waveform proportional to the strength of the seismic pulse received. Ideally, the seismic signals received from the subsurface are stronger than background noise present in the water column in the area. Vibrational background "noise" (from the fishing fleet and on-land machinery working adjacent to the harbor) was common within the Lower New Bedford Harbor survey area, complicating the data processing, as well as the interpretations rendered, in that area. While background noise did affect the data in some areas, in general the data collected was of excellent quality, and in only a few cases did the background noise overwhelm the seismic signal to the point where the data from a particular hydrophone could not be interpreted. These "noisy" hydrophones were "zeroed" out (not used during processing) in the processing of the data.

The seismic energy was provided by small electrically-primed seismic energy charges consisting of an encapsulated, two-stage, chemically accelerated, physically actuated energy source. These energy capsules were buried into the harbor bottom sediments 18" to 36", and were covered by a ½ inch thick steel plate in order to promote maximum coupling of the energy with subsurface. This approach to the energy initiation maximizes the amount of energy that can be transmitted into the subsurface per shot, which overrides the effect of the biogenic gases in the subsurface.

The OYO DAS-1 seismograph was used to collect the data, to store the data digitally on disk, and to produce "hard copy" records of the data, which were printed out in the field via the built-in thermal printer. The seismic records displayed the "wiggle trace" of each hydrophone recording data (in this case 48 hydrophones). The "wiggle trace" voltage fluctuations were recorded with respect to the time (in milliseconds) after the seismic shot was initiated. In this way, the time for the first energy pulse (known as the "first break") occurring at each hydrophone was recorded. Selected example seismograph records are included in Appendix A.

## 2.3 Data Processing

The data processing for this study was performed using state-of-the-art, well-tested software. Processing was completed using the USGS seismic interpretation software known as "SIP" (which stands for 'Seismic Interpretation Program'). This software is a standard recognized by the industry and has been used by the United States Geological Survey (USGS) for many of the seismic refraction applications completed by the government.

### 2.3.1 Side Scan Sonar

One of the first pieces of data to be processed was the Side Scan Sonar data. The results of the Side Scan data processing produced accurate geo-referenced positions of the hydrophone cable lying on the harbor bottom; data that is critical input information for the seismic refraction interpretation program (SIP)

The Side Scan Sonar data was processed using SonarWizz software V 3.07; mosaics of the data were generated with the SonarWeb 3.07 software package. The highest quality Side Scan data were used to create a "mosaic" of the harbor bottom, in which the deployed cable could be seen on the harbor bottom. The Side Scan mosaic image was geo-referenced, and the position of the cable was obtained by digitizing the Side Scan image at short intervals along the sonar image of the cable. Identifying the positions of the cable middle and ends was simplified because custom sonar reflectors had been attached to the seismic cable in the field (see Illustration 1).

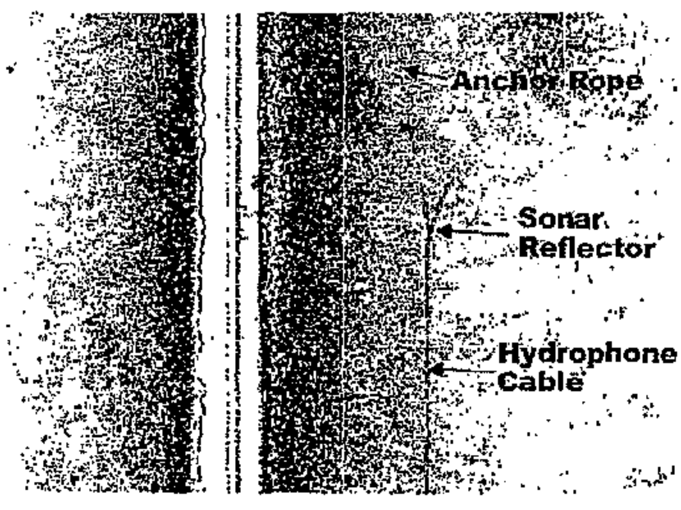



**Illustration 1**

Sample Side Scan Sonar Image

### 2.3.2 Seismic Refraction

Data processing began in the field as the data was collected, which enabled the field geophysicists to make changes to the program in the field in order to maximize data quality. Post-processing of the data, resulting in the creation of initial subsurface models, began immediately upon returning from the field. The following steps were followed in the processing of the Seismic Refraction data:

1. Field seismograms were transferred to digital disc media to enable desktop computer processing.
2. The computer program "First-picks" (a module of "SIP") was utilized to enhance and filter the raw seismogram records, including:
   - The data were filtered using a "band-cut" filter to remove high frequency noise which is imparted onto the data by the pressure wave that travels through the water column after a seismic shot; and
   - The gain controls were adjusted until the first breaks of the seismic waveforms were as clear as possible.
3. The "first breaks" of all of the seismic records were then "picked", and a data file of all of the arrival times of the energy first breaks was created for each hydrophone for every shot conducted (usually seven shots per spread).
4. The lateral distance from the shot points to each of the hydrophones was determined by:
   - Producing maps of the DGPS positions of the shots and the Side Scan Sonar spread location; and
   - Time-distance triangulation, using the travel time to the first breaks multiplied by the velocity of water, as calculated from tests performed in the harbor during the survey.
5. The position of each hydrophone on the harbor bottom was determined by analyzing both the DGPS data collected during the deployment of the cable, Side Scan Sonar data collected once the cable was deployed, and the DGPS positions of buoys attached at the ends of the cable.
6. The elevation of each hydrophone along the 'bay' cable was digitized for each seismic spread. The DGPS and Side Scan Sonar data collected in the field during the data collection phase was integrated with maps of the harbor bathymetry produced (and made publically available) by the U.S. Army Corps of Engineers (USACE).
7. The data was then elevation corrected to the harbor bottom by merging the data sets, including the digitized bathymetry (elevation) files for the hydrophones, and the "picked" seismogram waveform files for each spread.
8. From the elevation corrected data, "Time vs. Distance" (see Illustration 2) plots were created using the SIP program, which allows the interpreter to determine the number of layer responses (apparent in the data), which are used by the program to create "layer models".
9. Layer numbers were then assigned to the various layer segments interpreted from the "Time vs. Distance" plots - these layer numbers form the basis on which the model calculates the seismic velocities that it uses in the production of the resultant "depth models".
10. An initial run of the SIP modeling program was conducted using all of the above as input information, and initial resultant depth profiles were generated.

After completing the preliminary runs of the SIP program, the geophysical interpreters identified where inconsistencies in the data sets existed. Inconsistencies occur in the initial runs of seismic models with all of the processing software packages currently in use. The inconsistencies result from three primary sources:

1. The elevation of a particular sensor (hydrophone) along the sensor string is incorrect, either because the sensor has been located improperly along the string, or the bathymetry data in the area of that hydrophone is insufficient.
2. The first energy "break" of the seismic waveform has been incorrectly picked by the interpreter, either because the waveform was "noisy" due to ambient or background vibrations which had interfered with clear signal production, or because the gain control for the waveform was too high or too low.
3. The seismic velocities that were interpreted from the data and were used by the models to create the layer profiles were inaccurate. This occurs primarily because the velocities used by the initial run of the modeling program are chosen automatically by the computer program, which often cannot differentiate between actual lateral velocity changes in the data and "false" velocity profiles which occur when the harbor bottom is not flat; one of the subsurface layers (i.e., bedrock surface) dips; or faults, fractures or other irregularities are present which cause seismic "low-velocity-zones."

Of these, the inconsistencies in velocity represent the largest area for errors found in initial interpreted profiles. A relatively small change in the bedrock velocity chosen for a spread (such as 15,000 ft/sec as opposed to 16,000 ft/sec), can make a dramatic difference in the depth of bedrock interpreted by the model. In order to alleviate errors due to these issues, the data were processed through SIP several times in an iterative fashion. The velocity issues were studied in the further runs of the modeling program, and the inconsistencies were rectified, as were errors resulting from improper initial "picks" or elevation errors.

### 2.3.3 Calibration Data

Finally, in order to provide the best interpretations possible, calibration data was needed to check the parameters utilized as inputs to the seismic models. The initial un-calibrated models were used to select the best locations for a boring program to provide bedrock elevation calibration data. A geotechnical-drilling program was conducted between June 20 and July 13, 2001 and provided seven calibration points. The geotechnical program involved drilling with a standard drilling rig from a floating barge in the harbor. Samples of soil were collected during drilling using a split-spoon sampler, and rock-core samples were collected of bedrock beneath the sediment using a diamond-bit rock core barrel. Photographs of the rock cores collected are included in Appendix C at the back of this report. Copies of the logs of the borings used for the calibration are included in Appendix D.

Calibration of the SIP models was an iterative process that involved changing the input parameters of layer velocities and "first pick" layer assignments until there was agreement with existing information (boring logs, other SIP models at crossing points, and other geophysical information). The calibration took as many as several dozen iterations to resolve all discrepancies, depending on the data particulars and the line location.

## 2.4 Data Interpretation

The Rimrock Geophysics software package "SIP2" (which includes the latest version of the USGS SIP program) was used to complete the "first picks" and ray tracing inversion of the seismic data.

Interpretation of the data involved refining models and comparing the seismic data with calibration data, until the most likely model (most reasonable interpretation of data given all input) was found. The objective of the data analysis and interpretation phase was to characterize the responses from the geophysical data. An integrated approach to the analysis and interpretation phase was implemented for this project: data were analyzed and interpreted in association with the lithologic and geotechnical sampling data from the drilling campaign. The computer program Geosoft Oasis Montaj (Montaj) V 5.7, a data processing and analysis (DPA) system for earth science applications, was used to produce color contoured maps for the project. The Montaj software was used to integrate the DGPS, bathymetry and bedrock elevation information onto geo-referenced maps.

Data interpretation involved repeating many of the initial data processing steps described in Section 2.3.2 until the most appropriate best-fit model was generated. For some of the records, the "first breaks" of the seismic records were "re-picked", where the initial "first break" interpretation could be improved in order to achieve a better-fit model.

Another adjustment that was made during interpretation was the modification of hydrophone layer assignments on the "Time vs. Distance" plots (an example is shown in illustration 2), which were created using the SIP program. These layer assignments form the basis upon which the model calculates seismic velocities that it uses in the production of the resultant depth models. Changing the layer assignments revises the morphology of the model, both shape and depth of interface. After numerous iterations, it was determined for this data set that the most accurate models required that all the sections be generated using a two layer case when running the SIP program. Three layer models were attempted for some spreads to see if additional layers (such as the organics or clay layers) could be resolved from the other overburden; however, it appeared that the other layers are either not thick enough or of insufficient velocity difference from the surrounding material to be resolved by the SIP program.

## 2.5 Data Synthesis

Once all the data had been interpreted, the process of synthesizing all the data sets into one composite interpretation was undertaken. Several data sets were involved (the seismic refraction results, the boring program results, boring information from previous explorations conducted in the harbor, as well as other published geologic data), and the synthesis of the data involved the fusion of these multiple data sets. A direct merging of the data sets and resulting interpretations was not possible; however, as the data sets each were considered to have different confidence levels. Therefore, the first step in the data fusion process was to create a tiered hierarchy of the confidence of the data sets. Most weight was placed on the data with which the geophysicists had the highest confidence, less weight was placed on data that the geophysicists felt they did not have as high a confidence. The data with the highest confidence became the basis by which the final composite interpretations were made. Other data, having lower confidence factors, were then included in the final interpretations of the data in order to fill in data gaps or to add detail to the interpretations.

As with other phases of the process, the synthesis of all the data (historical, geotechnical and geophysical) into a composite interpretation was conducted in an iterative fashion. A basic interpretation was formed from the data with which the geophysicists had the highest confidence. Contour plans of the bedrock surface were generated based upon this high confidence data. These contour plans were then compared to regional geologic maps in an attempt to identify trends in the data that matched with mapped or known trends in the bedrock geology of the area. Slight modifications were then made to the initial interpretations so that the trends resulting from the data were consistent with published information and made sense geologically and geophysically. Finally, the lower tier confidence level data were folded into the interpretations. In some cases the data points were added to the interpretive maps one at a time, so that their effect on the overall models and interpretations could be gauged.

## 3.0 RESULTS

The following sections describe the results of the Seismic Refraction field survey, as well as the results of the data processing and interpretation of the data collected over the areas of the proposed CAD cells.

### 3.1 Seismic Refraction

The Seismic Refraction survey was successful in profiling bedrock characteristics at the Site. The advantage of having the sensor array and energy source directly on and in the sediment was apparent in the clear "first breaks" on the seismic records (see example instrument printout in Appendix A) that were obtained from the areas that had proven difficult with other geophysical methods.

As part of the interpretation and analysis of the seismic data, Apex geophysicists studied the Time vs. Distance graphs generated from the processed geophysical data to determine the most appropriate layer model to run final interpretations on. An example of a Time vs. Distance graph for one of the seismic spreads collected from the Popes Island North area is depicted in Illustration 2 below. The Time vs. Distance plot is a graphical means of displaying seismic data, allowing an interpreter the ability to identify the correct number of distinct geologic layers that should be incorporated into the computer models used to compute layer depth estimates. Layers are identified on the Time vs. Distance graphs by "inflection points" in the straight line trends, where a segment of points changes slope from longer-time – per-relative-distance to shorter-time-per-relative-distance (see Illustration 2).

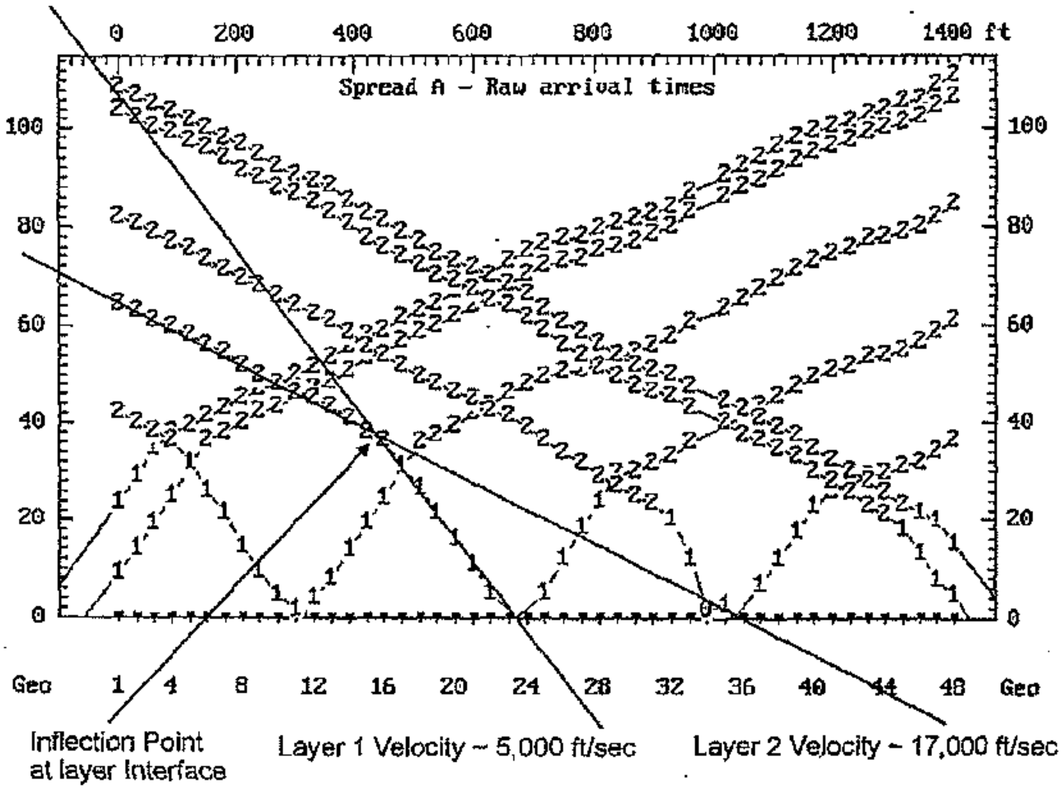



**Illustration 2**
Time-Distance Plot Example

Apex geophysicists reviewed the Time vs. Distance graphs for all of the seismic spreads to see if it was possible to discern a 3-layer geologic model (i.e., clayey marine sediments, glaciofluvial sediments, bedrock) from the data. After review of the Time vs. Distance graphs, it was concluded that the data would support a two-layer model of the geology (i.e., unconsolidated sediments overlying bedrock), but would not support a three-layer model (see Illustration 2 for a depiction of the two layers discernible). The implication of this observation is that the seismic refraction technique in this instance was unable to resolve multiple sub-layers (such as a clay layer within the unconsolidated sediments), but that a reasonable depiction of the depth to bedrock through the unconsolidated zone was resolved.

Profiles generated from the data, using the subsurface modeling software package SIP2, indicated that the bedrock character in both areas of interest is irregular, marked by undulations of the bedrock surface. The results of the seismic refraction program are best conveyed as contoured surface maps of the bedrock as determined from the interpreted seismic data. Figures 3 and 4 depict the results of the seismic data interpretation for Popes Island and Channel Inner area respectively. The figures display the inferred top of bedrock surface as determined from the seismic refraction data as a color-coded contour elevation (referenced to NGVD29), in order to aid in the identification of trends in the surface (i.e., blue areas are deeper and red/pink/orange areas are shallower). The location of borings used to "calibrate" the seismic interpretations is also shown on these figures. The bedrock models were calibrated such that the elevation of bedrock, at any given line crossing, is within three feet at line intersection points.

The "highest" bedrock surface elevation noted in the Popes Island North Area is in the range of –28 feet NGVD29. The "lows" in the bedrock topography, noted from the data within the possible CAD footprint are in the –95 foot range, NGVD29. The mean elevation of the bedrock surface in the Popes Island North area is –65 feet, NGVD29. (See Figure 3). The "highest" bedrock surface elevation noted in the Channel Inner Area is in the range of –35 feet NGVD29. The "lows" in the bedrock topography, noted from the data within the possible CAD footprint are in the –66 foot range, NGVD29. The mean elevation of the bedrock surface in the Channel Inner area is –53 feet, NGVD29. (See Figure 4).

### 3.2 Synthesis of Geophysics with the Geotechnical Boring Program

A limited number of pre-survey borings were available from historic sources (see Section 6.0) within the two survey areas. The geophysical data from the Seismic Refraction program was processed and interpreted with the historical geotechnical boring information, as well as that collected as part of this program within the two areas of interest. Where the seismic lines crossed directly over a boring location, the boring data was utilized to calibrate the depth of bedrock models generated as part of the seismic data processing. Borings were generally not used for calibration of seismic models if the boring data was located some distance from the seismic line (for this project, borings located more than approximately 60 feet from a seismic line were not used in the calibration of that seismic line, but were used by the contouring programs in the generation of the bedrock surface).

The following geotechnical borings collected as part of this program were utilized in the calibration of the following seismic lines (See Figures 3 and 4 for locations).

- Seismic Line 20 & 3 = boring NBH-1 (-90.2 feet)
- Seismic Lines 4 & 5 = boring NBH-2 (-63.8 feet)
- Seismic Lines 1, 2 & 7 = boring NBH-3 (-61.7 feet)
- Seismic Line 11 = boring NBH-4 (-58.5 feet)
- Seismic Lines 13 & 15 = boring NBH-5 (-48.1 feet)
- Seismic Line 16 & 19 = boring NBH-6 (-54.6 feet)

- Seismic Lines 7, 18 & 21 = boring NBH-7 (-62.7 feet)

The calibrated seismic lines and selected borings were incorporated into a single interpretation of the bedrock surface (see Figures 3 and 4). The bedrock surface was created by incorporating lines of bedrock elevation data (along the seismic profiles) with spot elevation data (from the selected borings listed below as well as elevations obtained from the calibration borings noted above), and gridding and contouring the resulting merged data set.

Additional historic boring information (Ebasco, 1988) used in the contouring process to create the bedrock surfaces including the following borings;

- Boring BW-103 (-34 feet)
- Boring BW-104 (-39 feet)
- Boring BW-109 (-52 feet)
- Boring BW-110 (-72 feet)
- Boring BW-111 (-79 feet), and
- Boring BW-112 (-49 feet).

### 3.3 Volume Calculations

Utilizing cell configuration parameters provided by Maguire Group engineers, and the results of the seismic refraction survey, Apex performed preliminary volume calculations for both the Popes Island North and Channel Inner Areas. Calculations were performed using the US Army Corps of Engineers (USACE) bathymetry surface, and the seismic refraction bedrock surface elevation calculated as part of this program. In calculating the volume of each cell, an approximate slope of 3:1 was assumed.

It should be noted that the bathymetry data obtained from the USACE was supplied to Apex as a sorted subset of the shallowest soundings within a 1"=100' paper plot, and as such provides only an approximate pre-engineering cell top elevation surface. Possible artifacts or errors may also exist in the Seismic Refraction surface due to the contouring algorithms that extrapolate the data between successive survey lines. In order to account for these uncertainties, contingency volumes have been incorporated into the various volume estimates. The volume calculations completed for this program, along with the relevant contingency volumes, are presented in the subsections below.

#### 3.3.1 Popes Island Area

Volumes were calculated using five cell configurations in the Popes Island North Area. Cell 1 incorporates all of the area of the Seismic Refraction footprint. Cell 2 and Cell 3 comprise of the eastern, and western halves of the Seismic Refraction footprint respectively. Cell 4 is the northern and Cell 5 the southern portion of the Seismic Refraction footprint. A separation distance of 100 feet was maintained between Cells 2 and 3 and Cells 4 and 5. Figures 5A and 5B show the different cell configurations. A bedrock contingency factor of three feet was assumed, and a loss of volume due to a cap of three feet was also factured into these calculations. Table 1 below summarizes the calculations for the Popes Island North Area.

*Table 1. Volumetric Calculations for the Popes Island North Area*

| POPES ISLAND NORTH | CELL 1 | CELL 2 | CELL 3 | CELL 4 | CELL 5 |
|---|---|---|---|---|---|
| Volume without Contigencies | 3614996 | 1715847 | 1372450 | 1226522 | 1530796 |
| 3' Irregular Bedrock Contigency | 113610 | 37779 | 29997 | 13056 | 31389 |
| 3' Cap Contingency | 235278 | 121389 | 105555 | 87498 | 136386 |
| Total Volume | 3266108 | 1556679 | 1236898 | 1125968 | 1363021 |

All volumes are in cubic yards

### 3.3.2 Channel Inner Area

The Channel Inner Area cell configuration consists of only two cells. Cell 1 comprises the entire Seismic Refraction footprint (see Figure 6); Cell 2 also comprises the Seismic Refraction footprint, but without the southeastern portion of the area.

Irregular bedrock "contingency" (to allow for bedrock irregularities) of three feet was assumed, and a loss of volume due to a cap of three feet was also factored into the calculations. The Channel Inner Area volume calculations are shown in Table 2 below.

*Table 2. Volumetric Calculations for the Channel Inner Area*

| CHANNEL INNER AREA | CELL 1 | CELL2 |
|---|---|---|
| Volume without Contigencies | 1618131 | 1272217.5 |
| 3' Irregular Bedrock Contigency | 175278 | 118611 |
| 3' Cap Contingency | 220278 | 161943 |
| Total Volume | 1222575 | 991664 |

All volumes are in cubic yards

## 4.0 CONCLUSIONS

Marine geophysical investigations were conducted at two locations within New Bedford Harbor during April and May of 2001 as part of pre-design activities undertaken in support of feasibility studies being conducted at two potential Confined Aquatic Disposal (CAD) cells. Seismic Refraction surveying was performed in the study area because it was determined that other geophysical methods (e.g. Uniboom, Sub-bottom Seismic Profiling, etc.) would not yield all the information necessary to support the feasibility effort. The seismic data was augmented by a geotechnical-drilling program conducted in June and July of 2001. The information gained from the geotechnical drilling program was used to calibrate the data profiles generated from the seismic refraction survey.

### 4.1 Geophysics Program

The survey was conducted in and around possible areas for the proposed CAD cells. A Seismic Refraction exploration seismograph system was deployed in order to obtain information on the bedrock surface within the area anticipated to contain possible CAD cells. The following issues were relevant to the data collection and interpretation for the survey areas:

- These techniques were undertaken because previous geophysical methods had been attempted, and while useful for other purposes, were not particularly successful in achieving the desired result for the particular geotechnical design parameters required;
- Biogenic gas in the sediment (remnants of decaying organic matter), precluded other methods from successful implementation for bedrock profiling. This survey was designed and undertaken in an attempt to overcome the "gas" issue; and
- Vibrational background "noise" (associated with equipment operations at the fish fleet) was common at the western side of the Channel Inner Area, complicating the data processing and interpretations rendered in that area.

The marine seismic data was collected in order to assess the depth to bedrock beneath the two areas proposed as locations for possible CAD cells. Profiles generated from the data using subsurface modeling software indicate that the bedrock character in both areas of interest is irregular, marked by undulations of the bedrock surface.

#### 4.1.1 Popes Island Area

The shallowest bedrock encountered in the seismic data was -28.5 feet on Lines 1 at the northeastern end of the survey area. This is within approximately 500 feet of where bedrock outcrops on Marsh Island. The deepest bedrock, at -95.1 feet, is found on Line 20 where it crosses line 5, at the farthest western edge of the survey area. A possible relict bedrock channel trending northwest to southeast runs through the middle of the survey area. This channel inference is further supported by bedrock surface elevation data to the northeast of the survey area collected by another contractor (Foster Wheeler, 2001) in a report submitted to the USACE. In some places the bedrock elevation varies by as much as 36-feet of elevation change over 120-feet of lateral change (or approximately a 25% slope), indicating that there is some relatively steep bedrock topographic variation within the possible CAD footprint.

#### 4.1.2 Channel Inner Area

The presence of several "Low Velocity Zones" (or "LVZs") was noted on several seismic lines in this area. These anomalies in the data occur at locations where the velocity of the energy wave traveling through the bedrock material is reduced, usually because the bedrock is fractured or severely weathered in that zone. LVZs are often indicators of faulted or severely fractured bedrock, and the locations of the LVZs noted in the data during this study are shown in Figures 3. It should be noted that data in the LVZs may be somewhat subjectively interpreted, as the actual velocity within such a zone can only be determined relatively, and can vary dramatically depending upon the material, the amount of fracturing, and the amount of weathering.

In the Channel Inner Area, the presence of LVZs imply that two north-south trending fracture zones may cross through this area. These fracture zones are evident in the Time-Distance plots for most of the east-west refraction spreads (lines 10, 11, 12, 15, 19, 21 and 22). Fracturing in the rock is made evident on Time-Distance plots as a time offset in the linear normal move-out of first breaks. An example of a Time-Distance plot showing the effects of fracturing is shown below in Illustration 3. In areas of fracturing, void spaces or sediment filled fractures (or even highly weathered rock) create a localized Low Velocity Zone (LVZ). Within these zones, the seismic velocity is much slower than that of the surrounding material. Because Seismic Refraction utilizes time and distance measurements to calculate a bedrock geometry, data that contains LVZ's will tend to imply that a bedrock surface is lower than it actually is (increase in time at a fixed velocity increases distance by the geometric relation T=d/v).

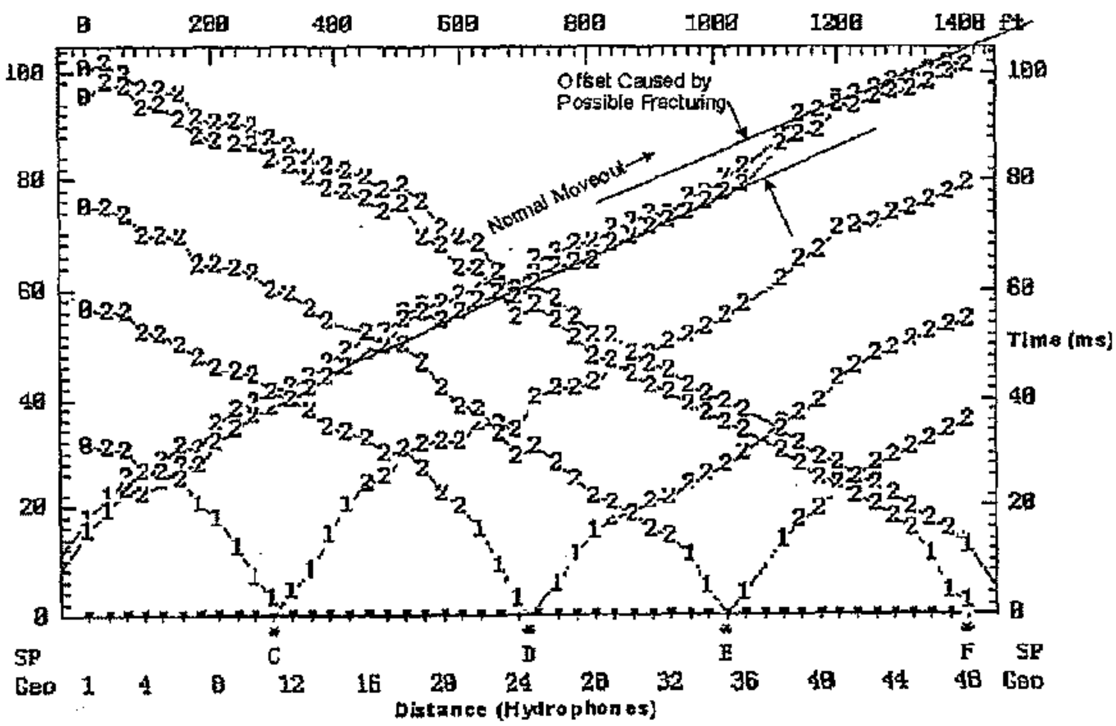



**Illustration 3.**
Time-Distance Plot Showing Areas of Possible Fracturing

## 4.2 The Big Picture

The discussions presented above have thus far concentrated upon providing interpretations of the datasets collected within the study areas during the field program. The following paragraphs attempt to present the results of the geotechnical and geophysical investigations conducted at the possible CAD locations within the context of the larger geological setting of New Bedford Harbor. This section represents a synthesis of the information collected and presented as part of this program, coupled with the available historical geologic information and interpretive insights obtainable. It should be noted that this synthesis of information is based upon the data available at the present time, and the appropriate level of care should be exercised in utilizing the synthesized interpretation for specific information needs.

An overall assessment of the bedrock surface topography is presented in Figures 3 and 4. The results of the geotechnical and geophysical investigations are generally consistent with the findings of regional geological investigators (Zen, et. al., 1978). The geologic map of the area indicates that the geologic setting in the vicinity of the study area is dominated by a Gneissic terrane. The literature makes frequent reference to the fact that the New Bedford Harbor region experienced both glacial, fluvial, and marine influences from the period known as the Pleistocene (glacial period) until the present. The bedrock geology is characterized by several large fold structures that have been mapped in the vicinity of the study area, having relatively symmetrical synclinal limbs and east west to northeast-southwest trending axes. According to the Geologic Map of Massachusetts (Zen, 1978), the study area lies between two such fold structures: one just to the north with its axis at the headwaters of the Harbor near the Acushnet-Fairhaven boundary; and one to the south with its axis trending from the southernmost tip of New Bedford toward South Dartmouth. The Popes Island North study area lies in a zone of granitic gneiss that lies between the two folds, but primarily along the outermost limb of the more southerly of the two folds in the region. The Geologic Map (Zen, 1978) also depicts regional faults that run through the area. One of the regional faults mapped in the area appears to trend through a portion of the study area. This fault is mapped as a north-south trending fault extending from East Freetown (to the north of Acushnet) down to and into New Bedford Harbor (with its trend coinciding with the shape of the harbor from approximately the Middle Harbor southward).

The geologic inferences presented in the literature, and noted above, are supported by the geotechnical and geophysical information collected as part of this program. The bedrock surface topography, as modeled from the seismic line and geotechnical boring data, shows evidence of the glacial and post-glacial fluvial/marine period that predates the current period of marine induration. In studying the Popes Island North Area contour map of the bedrock surface elevation (Figure 3), the feature that is most immediately recognizable is the "relict" channel cut in the bedrock (indicated by blue colors on the contour plan). This lineal feature is approximately 250 to 300 feet wide and runs through the study area from northwest to southeast. At its deepest point, the bedrock channel may extend down to as low as elevation –90 feet. This relict channel likely developed as part of the preglacial drainage pattern in the area, or as a result of syn- or post-glacial meltwater action, and was probably scoured by high energy stream action, which cut through the tough granitic gneiss found in the area by following weaknesses in the rock.

In addition to the channel identified in the bedrock surface, the seismic and geotechnical boring data collected as part of this program indicates that the former channel was bounded on either side by steep-sided bedrock scarps and mounds, which overlooked the central river channel. The highest bedrock elevation identified within the study area is located along the top of these scarps near the eastern shoreline and is found at approximately -28 feet.

The Channel Inner Area data shows similar trends as does the Popes Island North Area. Deeper bedrock depths (to –60-feet NGVD) in the center of the survey area appear to roughly outline a relict channel. The former "channel" is bounded on the east, west, and south by shallower rock (to as high as –34-feet NGDV). The rock actually outcrops at Palmer Island, approximately 500-feet south of the study area. Seismic "Low Velocity Zones" and "time-shift" offsets noted on some of the seismic lines collected from the Channel Inner Area support the interference that a series of roughly north-south trending sub-parallel fractures dictated the location of the relict channel (see Figure 4).

The seismic and boring information obtained from the study area strongly supports this inference, as fractured rock is noted in rock cores and on seismic data in patterns that coincide with the overall trend of the relict channel. A north-south trending fracture zone probably defined the location of the bedrock channel that runs through the area, and ultimately led to the shape of this portion of the harbor.

In summary, the data gathered as part of this program was intended to provide detailed information on the character of the bedrock within the two study areas (Popes Island North Area and Channel Inner Area). Both the geotechnical and geophysical data collected enhanced existing ideas as to the general geologic structure and bedrock character within the study area. Several detailed features (i.e., the channel cut into the bedrock surface) were identified as part of this effort. A contour plan of the bedrock surface was prepared utilizing the calibrated seismic refraction data supplemented by geotechnical drilling data. The bedrock elevation surface plan depicts the variations in the bedrock surface that can be expected within the study areas, and will prove useful in the design of structures which require a knowledge of the elevation and character of the bedrock surface.

## 5.0 LIMITATIONS

The following limitations apply to all geophysical surveys conducted by Apex Environmental, Inc. it's subsidiaries and subcontractors. Every attempt has been made to conduct this survey to maximize the quality of the data collected and the interpretations rendered. However, a geophysical investigation is an indirect method of subsurface exploration whereby subsurface characteristics are inferred or interpreted from measurements collected at the ground or water surface. Many variables may affect these measurements. Due to the indirect, interpretive nature of geophysics, findings are generally considered precursory and subject to verification by more direct methods of investigation such as test borings or test pits. The following limitations are considered when evaluating geophysical data:

1. Subsurface features can be interpreted from the appropriate geophysical methods only insofar as they produce a discernible geophysical signature. They must have adequate homogeneity, size, and appropriate physical or chemical properties sufficient to contrast with the surrounding medium and be within reasonable proximity to the sensors. Additionally, their signature must be distinguishable from and not masked by background noise or interference.

2. Lithologic data inferred on the basis of geophysical data may not be identical to geologic or hydrogeologic data. Lithologies are generally interpreted from some geophysical signature (e.g., velocity differences) that may be the result of many factors (including density, susceptibility, angle to the sensors, amount of weathering, etc.). Lithology divisions based upon seismic velocity for example may not necessarily be identical to lithology changes identified by drilling. The discrepancy is generally related to formation density and/or compaction (i.e., a dense till may have a higher density than a weathered bedrock, and the difference can be difficult to resolve with seismic data).

3. Complex geological configurations may be impossible to resolve with surface geophysical methods. The resolution of geophysical data is limited by the spatial geometry of sensors, strength of signal, and distance of the object or layer of interest from the energy source and the sensor array used. Resulting interpretations are rendered by modeling geophysical response to known or presumed geometric relationships. The complexity of the relationships that can be modeled is limited by the resolution allowed by the method and geometry of equipment layout used, and the limitations of the software used.

4. Apex is not responsible for data quality in areas having excessive "background noise" which affect the specific physical parameters of the subsurface that are being measured by a particular geophysical technique. Examples of background noise include: heavy traffic on a nearby roadway, which induces vibrational energy into the ground which in turn interferes with seismic data collection; heavy machinery (i.e., boat, sand-blaster, or torch) operation adjacent to or in the water near a marine seismic survey line; or underground utilities (such as electric lines, tunnels, sewers, etc.), which can interfere with seismic instrumentation.

No guarantee or warranty (other than that stipulated in the contract under which this work was promulgated), expressly stated or implied, is given concerning the data and interpretations rendered in this report. All information is presented as "for information only." Apex Environmental, Inc., its parent company or any subsidiary, is not liable for any losses resulting from the misuse, misrepresentation, or misinterpretation of any information presented in this report by any person or entity.

## 6.0 REFERENCES


Goldsmith, Richard, 1978, Geologic Map of the Fall River – New Bedford Area, Massachusetts, U.S. Geological Survey Open File Map 78-484, Department of the Interior, U.S. Geological Survey, publications center, Lakewood, CO.

Hatch, N.L., (ed.), 1991, *The Bedrock Geology of Massachusetts*, publication of the U.S. Geological Survey, USGS - Department of the Interior; Reston, VA, 106 p.

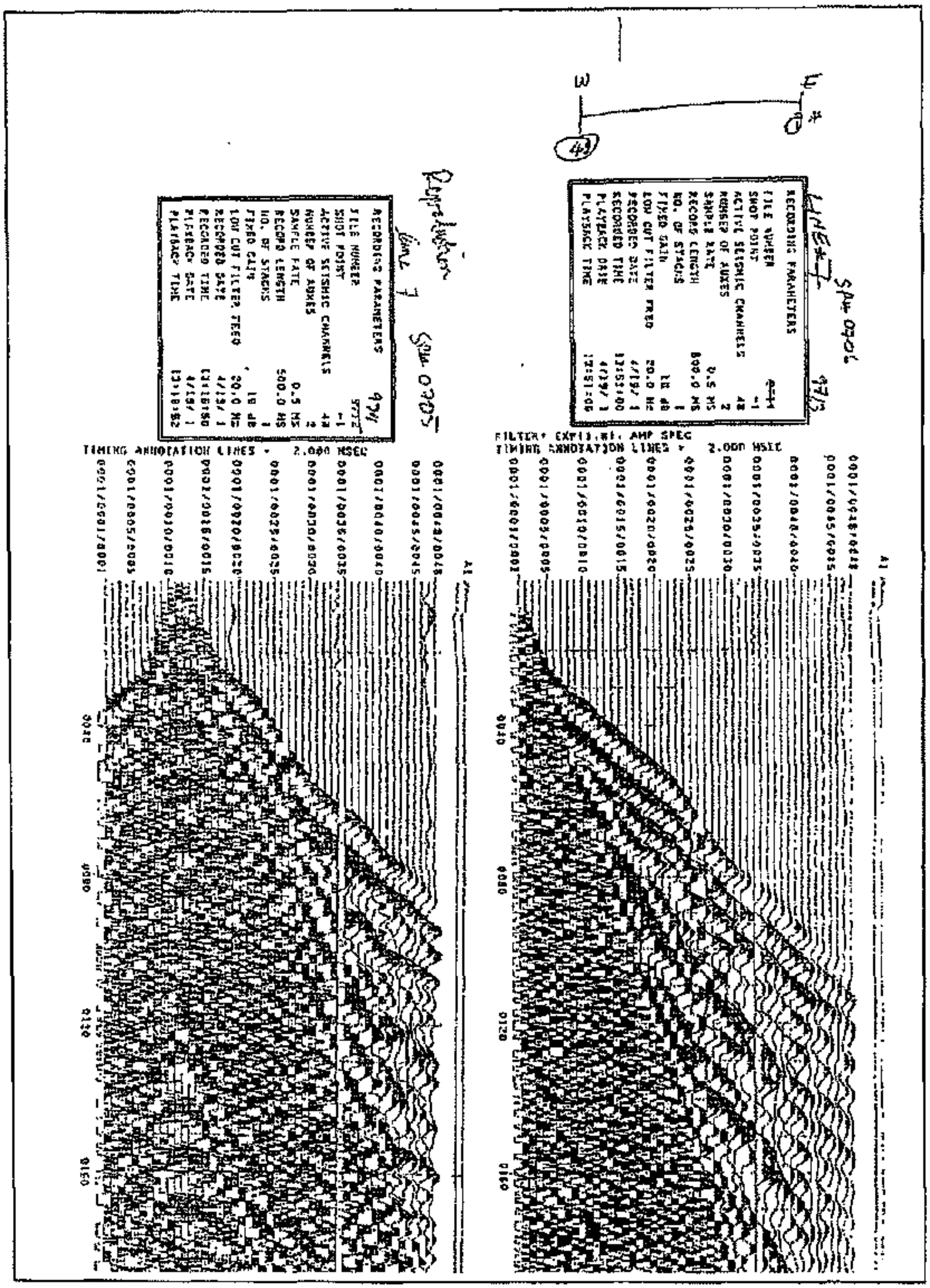
Zen, E-an (editor), 1983, Bedrock Geologic Map of Massachusetts (3 sheets), state Bedrock Geologic Maps publication of the U.S. Geological Survey, U.S. Department of the Interior, U.S. Geological Survey, publications center, Lakewood, CO.

Ebasco Services, Inc. 1988, *Final Draft – Preliminary Geotechnical Investigation of Engineering Properties – New Bedford Harbor*, US Environmental Protection Agency Region I, Records Center, Canal St, Boston, MA.

US Army Corps of Engineers, 1960, *Hurricane Projection Project: New Bedford-Fairhaven Hurricane Barrier (Design Memorandum No.2 Site Geology)*, US Army Corps of Engineers New England District, Waltham, MA.

Foster Wheeler Environmental Corporation, 2001, *Report Of Marine Geophysical Surveys: Phase I Uniboom & Seismic Refraction And Phase II Seismic Refraction, New Bedford Harbor Superfund Site Operable Unit #1*, Foster Wheeler Environmental Corporation, Boston, MA.

# APPENDIX A
## Example Seismograph Record



APPENDIX B

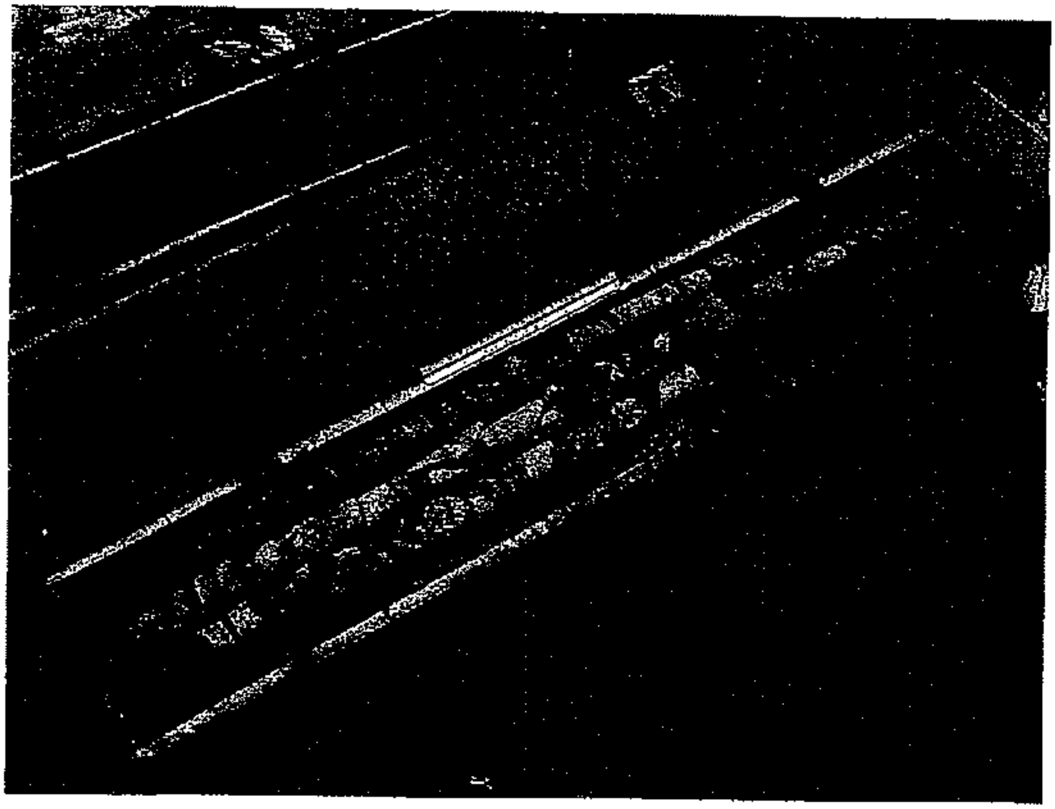
Data CD

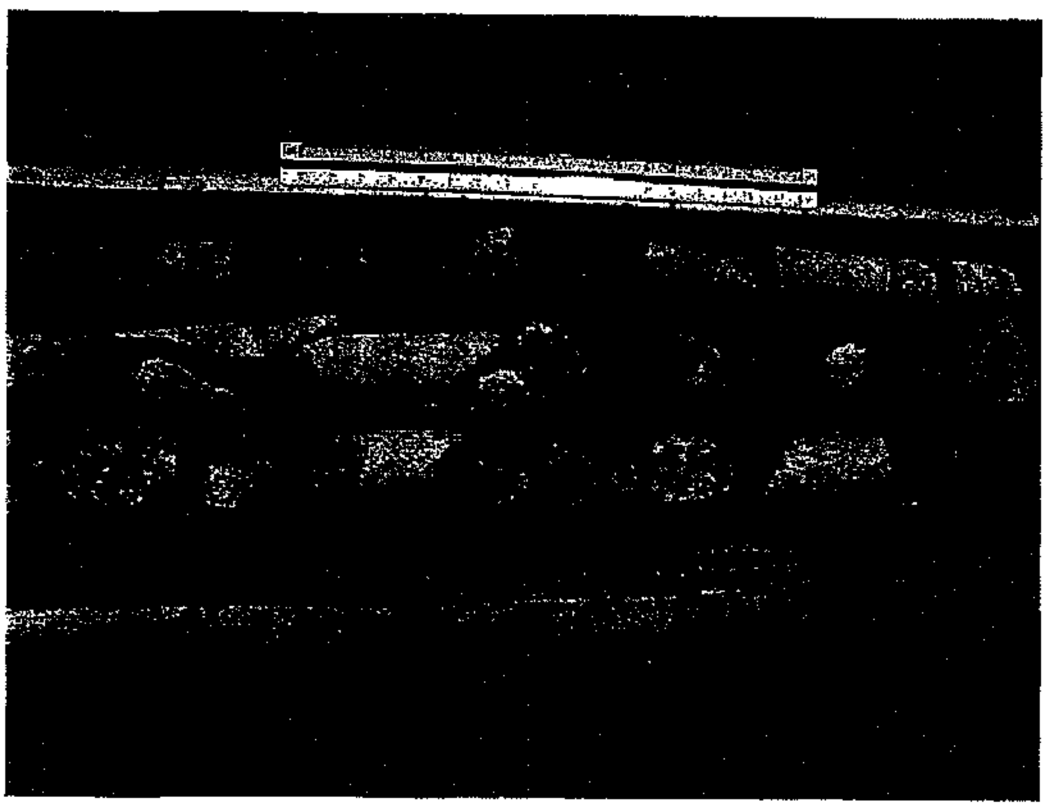
# APPENDIX C

## Photographs of Rock Cores Used for Seismic Calibration

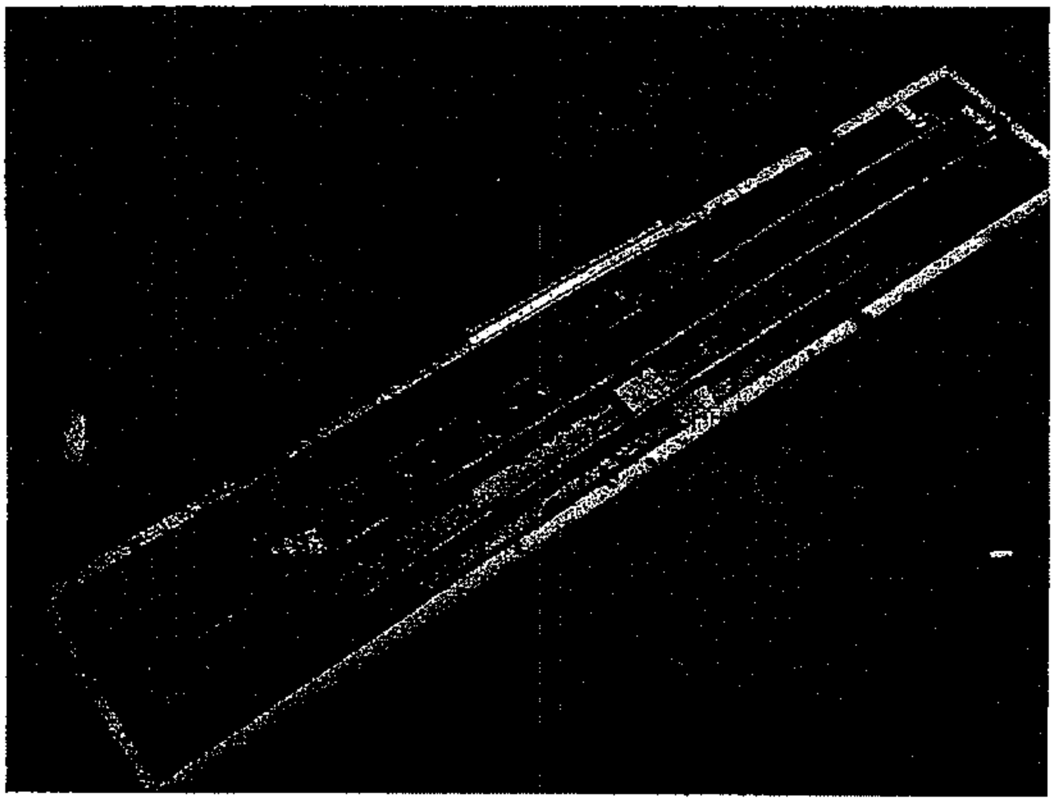
(Borings collected by The Maguire Group as part of the DMMP feasibility study)

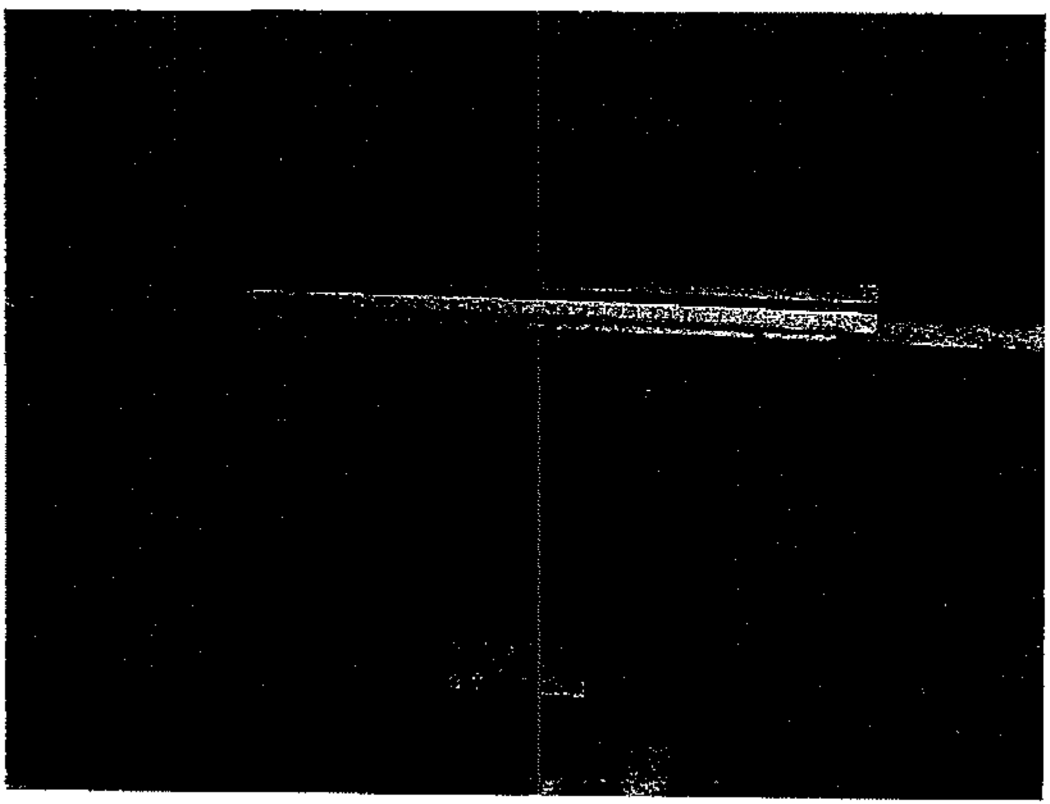
Boring NBH-1



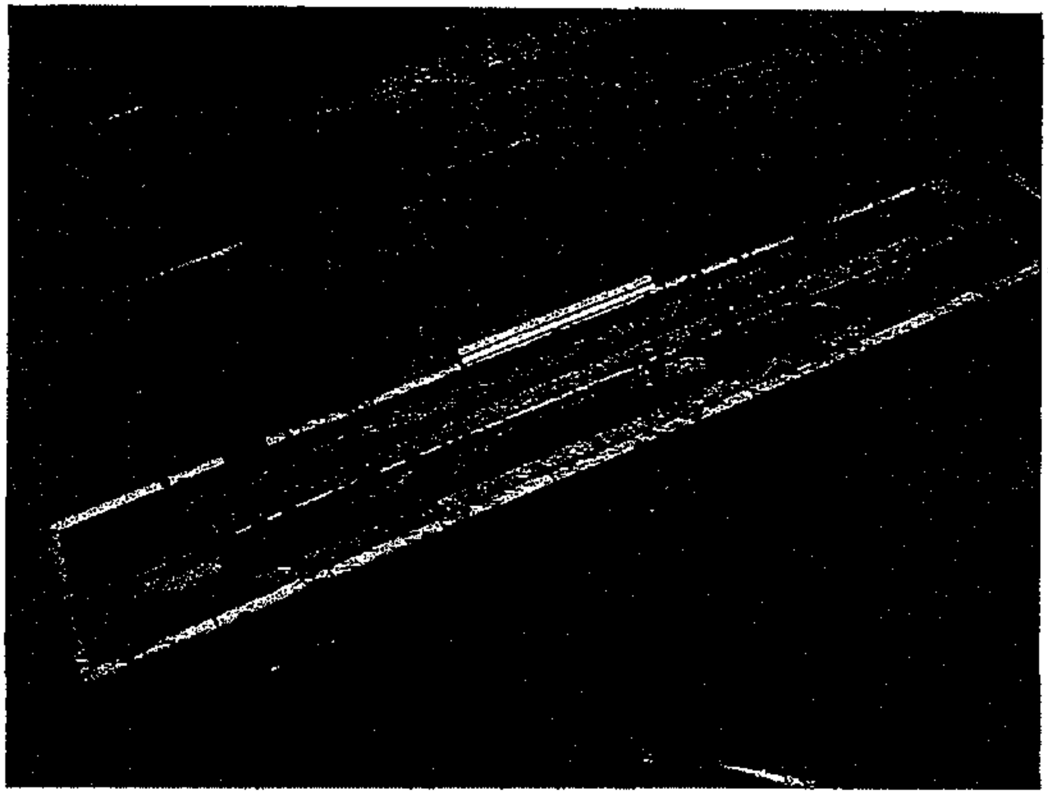


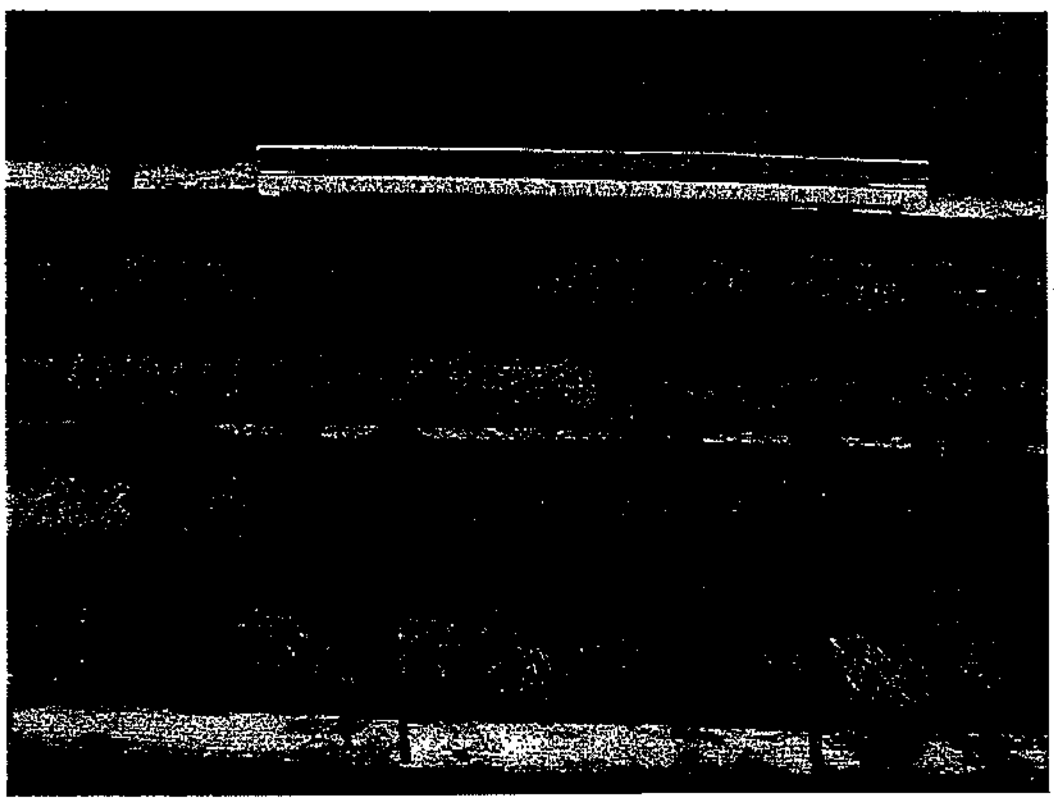
Boring NBH-3



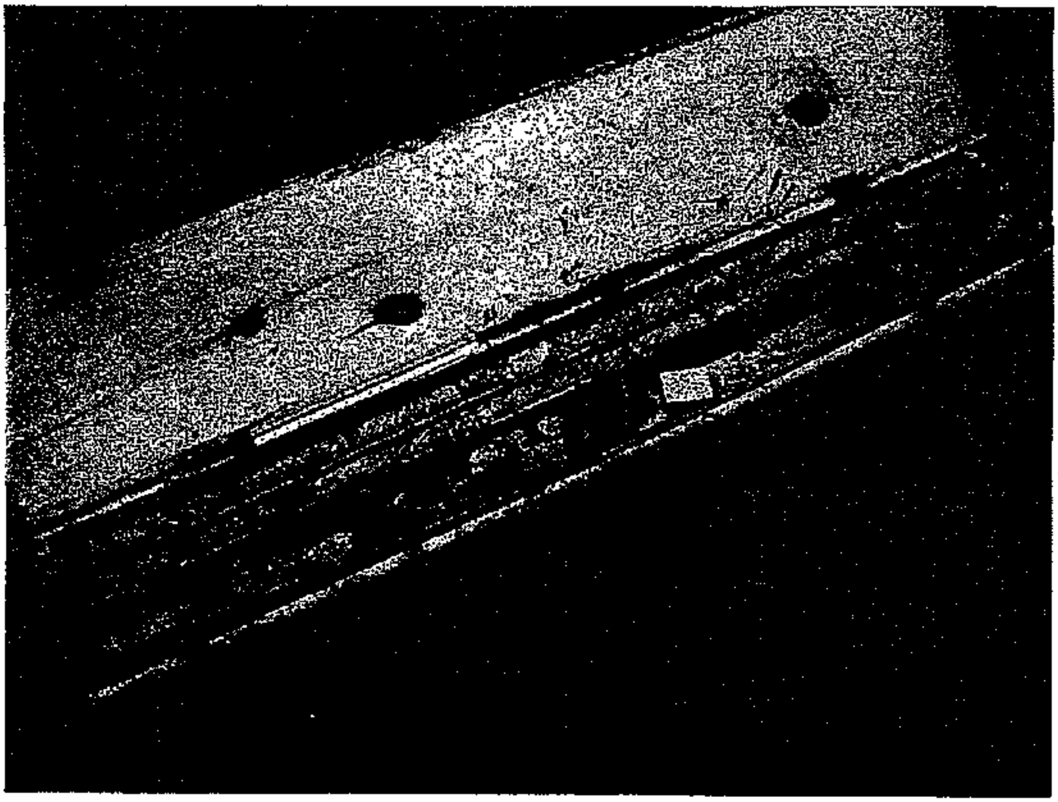


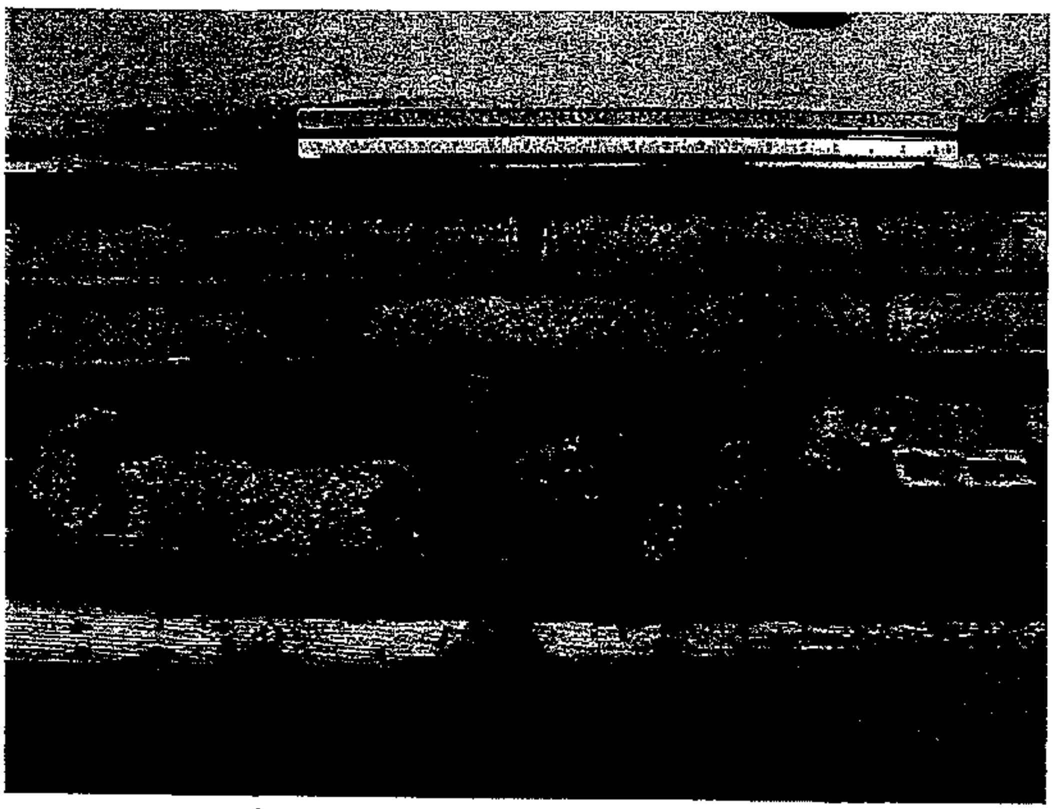
Borings NBH-2 and NBH-4





Borings NBH-6 and NBH-7





# APPENDIX D

## Boring Logs of Borings Used for Seismic Calibration

(Borings collected by The Maguire Group as part of the DMMP feasibility study)

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 3

TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-1
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -6.2' MSL

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | DATE | |
|---|---|---|---|---|---|---|
| At ____ after ____ Hours | Type | HW-NW | S/S | NV-II | Start | 6/20/01 |
| | Size I.D. | 4" 3" | 1-3/8" | | Complete | 6/27/01 |
| At ____ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | Dia. | Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Dark Gray Organic SILT, trace shells | 1 | 24 | 12 |
| 5 | | | | | | | | | | | | |
| | | 7.0-9.0 | D | Wt. | of | Rods | | | | 2 | 24 | 24 |
| 10 | | | | | | | | | | | | |
| | | 12.0-14.0 | D | Wt. | of | Rods | | | | 3 | 24 | 24 |
| 15 | | | | | | | | | | | | |
| | | 17.0-19.0 | D | Wt. | of | Rods | | | | 4 | 24 | 24 |
| 20 | | | | | | | | | | | | |
| | | 22.0-24.0 | D | Wt. | of | Rods | | | | 5 | 24 | 24 |
| 25 | | | | | | | | | | | | |
| | | 27.0-29.0 | D | Wt. | of | Rods | | | | 6 | 24 | 18 |
| | | | | | | | | 28.0 | Dark Brown PEAT, little silt | | | |
| 30 | | | | | | | | | | | | |
| | | 32.0-34.0 | D | Wt. | of | Rods | | | | 7 | 24 | 12 |
| | | 34.0-36.0 | D | 3 | 4 | 4 | | 34.0 | Gray SILT and fine Sand, trace dark brown peat | 8 | 24 | 12 |
| 35 | | | | | | 5 | | | | | | |
| | | 38.5-40.5 | D | 6 | 10 | 10 | | 38.5 | Gray fine SAND and Silt | 9 | 24 | 1 |

OUND SURFACE TO ____ USED ____ CASING: THEN ____

| Sample Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|
| D=Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | Earth Boring 87.5' |
| P=Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft 30 + Hard | Rock Coring 15' |
| T=Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M./Stiff | Samples 17 |
| E = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | |
| 300# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | HOLE NO NBH-1 |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 2 OF 3

TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-1
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -6.2' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 9 | | | Gray fine SAND and Silt | | | |
| | | ~~43.5-46.5~~ | ~~D~~ | ~~5~~ | ~~4~~ | ~~5~~ | | | | ~~10~~ | ~~24~~ | ~~12~~ |
| 45 | | | | | | ~~8~~ | | 44.0 | Gray fine to medium SAND, some silt, trace fine gravel & coarse sand | | | |
| | | 49.0-51.0 | D | 4 | 5 | 6 | | 49.0 | Gray fine to coarse SAND and fine to medium Gravel, little silt | 11 | 24 | 8 |
| 50 | | | | | | 7 | | | | | | |
| | | 54.0-56.0 | D | 9 | 12 | 18 | | 54.0 | Dark Gray & Brown coarse to fine SAND and fine to medium Gravel, little silt (Odor Noted) | 12 | 24 | 12 |
| 55 | | | | | | 20 | | | | | | |
| | | 59.0-61.0 | D | 9 | 4 | 7 | | 59.0 | Grayish Brown medium to coarse SAND, some fine gravel, little silt [illegible] | 13 | 24 | 18 |
| 60 | | | | | | 21 | | | | | | |
| | | 64.0-66.0 | D | 3 | 4 | 4 | | | | 14 | 24 | 8 |
| 65 | | | | | | 9 | | | | | | |
| 70 | | | | | | | | | | | | |
| | | 71.0-73.0 | D | 3 | 3 | 8 | | | | 15 | 24 | 18 |
| | | | | | | 11 | | | | | | |
| 75 | | | | | | | | 75.0 | | | | |
| | | 76.0-78.0 | D | 53 | 29 | 17 | | | Yellow Brown & Gray silty fine to coarse SAND and Gravel | 16 | 24 | 12 |
| | | | | | | 20 | | | | | | |
| 80 | | | | | | | | | (80' to 81' - Boulder) | | | |
| | | 82.0-82.5 | D | 100 | | | | | " some weathered rock | 17 | 6 | 4 |
| | | | | | | | | 84.0 | | | | |
| 85 | | | | | | | | | | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type: D=Drive C=Cored W=Washed; UP=Fixed Piston UT=Shelby Tube; TP=Test Pit A=Auger; O = Open End Rod; 300# hammer

Proportions Used: trace 0 to 10%; little 10 to 20%; some 20 to 35%; and 35 to 50%

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M./Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 87.5'
Rock Coring 15'
Samples 17

HOLE NO NBH-1

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 3 OF 3

TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-1
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -6.2' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler 0-6 | 6-12 | 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION (Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc.) | Sample No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 87.5-92.5 | C | | | | | | Gray GRANITE | C1 | 60 | 36 |
| | | RQD = 0% | | | | | | | | | | 60% |
| 90 | | | | | | | | | | | | |
| | | 92.5-97.5 | C | | | | | | | C2 | 60 | 30 |
| | | RQD = 0% | | | | | | | | | | 50% |
| 95 | | | | | | | | | | | | |
| | | 97.5-102.5 | C | | | | | | | C3 | 60 | 40 |
| | | RQD = 0% | | | | | | | | | | 66.7% |
| 100 | | | | | | | | | | | | |
| | | | | | | | | 102.5 | Bottom of Boring 102.5' | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
P=Fixed Piston UT=Shelby Tube
T=Test Pit A=Auger
O = Open End Rod
300# hammer

| Proportions Used | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M./Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 87.5'
Rock Coring 15'
Samples 17

HOLE NO. NBH-1

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.



| | | | |
|---|---|---|---|
| TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-2 |
| PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO. |
| REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -7.8' MSL |

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | | DATE |
|---|---|---|---|---|---|---|
| At ______ after ____ Hours | Type | HW-NW | S/S | NV-II | Start | 6/29/01 |
| | Size I.D. | 4" 3" | 1-3/8" | | Complete | 7/2/01 |
| At ______ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | Dia. | Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT, trace shells | 1 | 24 | 8 |
| | | ~~3.5-5.5~~ | ~~D~~ | ~~Wt.~~ | ~~of~~ | ~~Rods~~ | | | | ~~2~~ | ~~24~~ | ~~20~~ |
| 5 | | | | | | | | | | | | |
| | | 9.0-11.0 | D | Wt. | of | Rods | | | | 3 | 24 | 24 |
| 10 | | | | | | 11 | | 10.0 | Gray Brown fine SAND, little silt & medium sand | | | |
| | | 14.0-16.0 | D | WOR | 3 | 3 | | 14.0 | Brown fine to medium SAND, trace silt | 4 | 24 | 10 |
| 15 | | | | | | 5 | | | | | | |
| 20 | | | | | | | | | | | | |
| | | 22.0-24.0 | D | Wt. | Rods | 3 | | 22.0 | Gray silty fine SAND | 5 | 24 | 15 |
| | | | | | | 3 | | | | | | |
| 25 | | | | | | | | | | | | |
| | | 27.0-29.0 | D | 3 | 4 | 4 | | | | 6 | 24 | 22 |
| | | | | | | 3 | | | | | | |
| 30 | | | | | | | | | | | | |
| | | 32.0-34.0 | D | 5 | 9 | 13 | | 32.0 | Gray medium to fine SAND, trace silt, coarse sand & fine gravel | 7 | 24 | 10 |
| | | | | | | 12 | | | | | | |
| 35 | | | | | | | | | | | | |
| | | | | | | | | 36.0 | | | | |
| | | 38.0-40.0 | D | 11 | 7 | 7 | | | Gray fine to coarse SAND, some fine to medium gravel, little silt | 8 | 24 | 6 |
| | | | | | | 10 | | | | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
UP=Fixed Piston UT=Shelby Tube
TP=Test Pit A=Auger
OE = Open End Rod
300# hammer

| Proportions Used | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M/Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 59'
Rock Coring 10'
Samples 11

HOLE NO. NBH-2

GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.



TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-2
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -7.8' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./ Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 43.0-45.0 | D | 6 | 9 | 15 | | | Gray Brown silty fine SAND (compact), trace fine gravel | 9 | 24 | 10 |
| | | | | | | 14 | | | | | | |
| 45 | | | | | | | | | | | | |
| | | | | | | | | 46.0 | | | | |
| | | 48.0-50.0 | D | 8 | 5 | 9 | | | Gray silty very fine SAND | 10 | 24 | 12 |
| | | | | | | 7 | | | | | | |
| 50 | | | | | | | | | | | | |
| | | | | | | | | 52.0 | | | | |
| | | ~~53.5-55.5~~ | ~~D~~ | ~~34~~ | ~~15~~ | ~~11~~ | | | TILL | ~~11~~ | ~~24~~ | ~~0~~ |
| 55 | | | | | | ~~11~~ | | | | | | |
| | | | | | | | | 56.0 | | | | |
| | | | | | | | Min/Ft | | | | | |
| | | 59.0-64.0 | C | | | | 5 | | Gray GRANITE | C1 | 60 | 54 |
| 60 | | RQD = 78% | | | | | [illegible] | | | | | 90% |
| | | | | | | | 7 | | | | | |
| | | 64.0-69.0 | C | | | | 6 | | | C2 | 60 | 54 |
| 65 | | RQD = 99% | | | | | 6 | | | | | 90% |
| | | | | | | | 5 | | | | | |
| | | | | | | | 5 | | | | | |
| | | | | | | | 6 | | | | | |
| | | | | | | | | 69.0 | Bottom of Boring 69' | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
UP=Fixed Piston UT=Shelby Tube
TP=Test Pit A=Auger
V = Open End Rod
300# hammer

| Proportions Used | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M./Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 59'
Rock Coring 10'
Samples 11

HOLE NO. NBH-2

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 2

| | | | |
|---|---|---|---|
| TO Maquire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-3A | |
| ROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO. | |
| EPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -7.2' MSL | |

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | | DATE |
|---|---|---|---|---|---|---|
| At ____ after ____ Hours | Type | HW-NW | S/S | NV-II | Start | 7/12/01 |
| | Size I.D. | 4" 3" | 1-3/8" | | Complete | 7/13/01 |
| At ____ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | Dia. | Inspector/Engr. | |

LOCATION OF BORING

| epth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./ Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT | 1 | 24 | 6 |
| 5 | | 4.0-6.0 | D | Wt. | of | Rods | | | " color change to Gray | 2 | 24 | 24 |
| 10 | | 9.0-11.0 | D | Wt. | of | Rods | | | | 3 | 24 | 24 |
| | | | | | | | | 11.0 | PEAT, some organic silt | | | |
| 15 | | | | | | | | | | | | |
| | | 16.5-18.5 | D | 8 | 8 | 20 / 23 | | 16.0 | Brown fine to coarse SAND, some fine to medium gravel, trace silt & shells | 4 | 24 | 2 |
| 20 | | 21.5-23.5 | D | 2 | 3 | 3 / 8 | | 21.5 | Gray fine to coarse SAND, some silt & fine to coarse gravel | 5 | 24 | 5 |
| 25 | | 26.0-28.0 | D | 3 | 2 | 3 / 5 | | 26.0 | Brown coarse to fine SAND, some fine gravel, little silt | 6 | 24 | 4 |
| 30 | | 31.0-33.0 | D | 3 | 3 | 4 / 5 | | 31.0 | Light Brown fine SAND, some silt, little fine gravel | 7 | 24 | 1 |
| 35 | | 37.0-39.0 | D | 5 | 5 | 6 / 8 | | | | 8 | 24 | 0 |

OUND SURFACE TO ____ USED ____ CASING: THEN ____

| Sample Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|---|
| D=Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | | Earth Boring 57.5' |
| UP=Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft | 30 + Hard | Rock Coring 10' |
| =Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M./Stiff | | Samples 12 |
| E = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | | |
| *300# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | | HOLE NO. NBH-3A |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 2 OF 2

TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-3A
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -7.2' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./ Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 41.0-43.0 | D | 2 | 3 | 3 | | | Brown fine SAND, little silt | 9 | 24 | 8 |
| | | | | | | 2 | | | | | | |
| 45 | | | | | | | | | | | | |
| | | 46.0-48.0 | D | 1 | 1 | 2 | | | | 10 | 24 | 12 |
| | | | | | | 3 | | | | | | |
| 50 | | 50.0-52.0 | D | 26 | 30 | 33 | | 50.0 | Brown weathered GRANITE and silty Sand | 11 | 24 | 12 |
| | | | | | | 33 | | | | | | |
| | | 54.0-54.5 | D | 100 | | | | | " color change to Gray with little sand | 12 | 6 | 4 |
| 55 | | | | | | | | | | | | |
| | | | | | | | Min/Ft | | | | | |
| | | 57.5-62.5 | C | | | | 5 | 57.5 | | C1 | 60 | 52 |
| | | RQD = 90% | | | | | 5 | | GRANITE | | | 86.7% |
| 60 | | | | | | | 6 | | | | | |
| | | | | | | | 6 | | | | | |
| | | | | | | | 5 | | | | | |
| | | 62.5-67.5 | C | | | | 5 | | | C2 | 60 | 58 |
| | | RQD = 85% | | | | | 5 | | | | | 96.7% |
| 65 | | | | | | | 5 | | | | | |
| | | | | | | | 5 | | | | | |
| | | | | | | | 5 | | | | | |
| | | | | | | | | 67.5 | Bottom of Boring 67.5' | | | |

UND SURFACE TO ______ USED ______ CASING: THEN ______

| nple Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|
| Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | Earth Boring 57.5' |
| =Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft 30 + Hard | Rock Coring 10' |
| Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M./Stiff | Samples 12 |
| = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | |
| G# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | HOLE NO. NBH-3A |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 2

| | | | |
|---|---|---|---|
| TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-4 |
| PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO. |
| REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -29.5' MSL |

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | | DATE |
|---|---|---|---|---|---|---|
| At ______ after ____ Hours | Type | HW-NW | S/S | NV-II | Start | 7/3/01 |
| | Size I.D. | 4" 3" | 1-3/8" | | Complete | 7/5/01 |
| At ______ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | Dia. | Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler 0-6 | 6-12 | 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT, trace shells | 1 | 24 | 6 |
| 5 | | 5.0-7.0 | D | Wt. | Rods | 3 | | | | 2 | 24 | 24 |
| | | | | | | 4 | | 6.0 | Black & Gray Brown fine to coarse SAND, some silt & gravel | | | |
| | | | | | | | | 8.0 | | | | |
| | | 9.0-11.0 | D | 1 | 2 | 2 | | | Tan fine SAND, little medium sand, trace silt | 3 | 24 | 8 |
| 10 | | | | | | 3 | | | | | | |
| 15 | | | | | | | | | | | | |
| | | 16.0-18.0 | D | 3 | 5 | 8 | | 16.0 | Tan fine to coarse SAND, little silt & fine gravel | 4 | 24 | 8 |
| | | | | | | 9 | | | | | | |
| 20 | | | | | | | | | | | | |
| | | 21.0-23.0 | D | 10 | 9 | 10 | | | | 5 | 24 | 6 |
| | | | | | | 29 | | 22.0 | Brown & Dark Brown coarse to fine SAND and fine to coarse Gravel, little silt | | | |
| 25 | | | | | | | | | | | | |
| | | 27.0-29.0 | D | 29 | 22 | 19 | | | " color change to Yellow Brown | 6 | 24 | 8 |
| | | | | | | 100 | | | | | | |
| | | | | | | | Min/Ft | 29.0 | | | | |
| 30 | | 30.0-35.0 | C | | | | 4 | | QUARTZ & Green Red GRANITE | C1 | 60 | 34 |
| | | RQD = 95% | | | | | 1 | | | | | 56.7% |
| | | | | | | | 5 | | | | | |
| | | | | | | | 6 | | | | | |
| | | | | | | | 7 | | | | | |
| 35 | | 35.0-41.0 | C | | | | 7 | 35.0 | Green Gray GRANITE | C2 | 72 | 72 |
| | | RQD = 85% | | | | | 6 | | | | | 100% |
| | | | | | | | 6 | | | | | |
| | | | | | | | 8 | | | | | |
| | | | | | | | 8 | | | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
UP=Fixed Piston UT=Shelby Tube
TP=Test Pit-A=Auger
OE = Open End Rod
* 300# hammer

| Proportions Used | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M./Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 30'
Rock Coring 11'
Samples 6

HOLE NO. NBH-4

GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 2 OF 2

TO Maguire Group, Inc. ADDRESS Foxborough, MA HOLE NO. NBH-4
PROJECT NAME Harbor Aquatic Disposal Cell LOCATION New Bedford, MA PROJ. NO.
REPORT SENT TO above / Feasibility Study OUR JOB NO. 02-011 SURF. ELEV. -29.5' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./ Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 8 | | | | | |
| | | | | | | | | 41.0 | Bottom of Boring 41' | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
UP=Fixed Piston UT=Shelby Tube
TP=Test Pit A=Auger
OE = Open End Rod
300# hammer

| Proportions Used | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M.Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 30'
Rock Coring 11'
Samples 6

HOLE NO. NBH-4

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 1

TO Maquire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-5

PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.

REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -27.8' MSL

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | | DATE |
|---|---|---|---|---|---|---|
| At ______ after ____ Hours | Type | HW | S/S | | Start | 7/5/01 |
| | Size I.D. | 4" | 1-3/8" | | Complete | 7/5/01 |
| At ______ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | | Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From To 0-6 | 6-12 | 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT | 1 | 24 | 12 |
| 5 | | 4.0-6.0 | D | Wt. | of | Rods | | | | 2 | 24 | 14 |
| 10 | | 9.0-11.0 | D | 5 | 4 | 3 | | 9.0 | Brown fine to coarse SAND, some fine to coarse gravel, little silt | 3 | 24 | 8 |
| | | | | | | 4 | | | | | | |
| | | | | | | | | 12.0 | | | | |
| 15 | | 14.0-16.0 | D | 14 | 9 | 5 | | | Brown silty fine SAND, little fine gravel | 4 | 24 | [illegible] |
| | | | | | | 6 | | | | | | |
| 20 | | 19.0-20.3 | D | 30 | 14 | 100/3" | | | " some coarse sand & fine to medium gravel | 5 | 15 | 3 |
| | | | | | | | | 20.3 | Bottom of Boring 20.3' | | | |

OUND SURFACE TO ______ USED ______ CASING: THEN ______

| mple Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|---|
| Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | | Earth Boring 20.3 |
| =Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft | 30 + Hard | Rock Coring |
| =Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M. Stiff | | Samples 5 |
| = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | | |
| 00# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | | HOLE NO. NBH-5 |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 1

| | | |
|---|---|---|
| TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-6 |
| PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO. |
| REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -28.6' MSL |

| GROUND WATER OBSERVATIONS | | CASING | SAMPLER | CORE BAR. | | DATE |
|---|---|---|---|---|---|---|
| At ______ after ____ Hours | Type | HW-NW | S/S | NV-II | Start | 7/9/01 |
| | Size I.D. | 4" 3" | 1-3/8" | | Complete | 7/9/01 |
| At ______ after ____ Hours | Hammer Wt. | 300# | 140# | BIT | Boring Foreman | J. Medeiros |
| | Hammer Fall | 24" | 30" | Dia. | Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From 0-6 | 6-12 | To 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT | 1 | 24 | 11 |
| | | 4.0-6.0 | D | Wt. | Rods | 3 | | | " trace shells | 2 | 24 | 20 |
| 5 | | | | | | 10 | | | | | | |
| | | | | | | | | 6.0 | Rusty Brown coarse to fine SAND, some fine to medium gravel, trace silt | | | |
| | | 7.5-9.5 | D | 11 | 6 | 6 | | | | 3 | 24 | 7 |
| | | | | | | 8 | | | | | | |
| 10 | | | | | | | | | | | | |
| | | 14.0-16.0 | D | [illegible] | [illegible] | 4 | | | " color change to Brown | 4 | 24 | 6 |
| 15 | | | | | | 6 | | | | | | |
| | | 18.5-20.5 | D | 3 | 2 | 3 | | | " & fine Gravel | 5 | 24 | 2 |
| 20 | | | | | | 5 | | | | | | |
| | | 23.5-25.5 | D | 36 | 30 | 42 | | 23.5 | Brown fine to coarse SAND and Gravel, little silt | 6 | 24 | 7 |
| 25 | | | | | | 31 | | | | | | |
| | | | | | | | Min/Ft | 26.0 | | | | |
| | | 27.0-32.0 | C | | | | 7 | | GRANITE | C1 | 60 | 56 |
| | | RQD = 100% | | | | | 8 | | | | | 93.3% |
| | | | | | | | 8 | | | | | |
| 30 | | | | | | | 8 | | | | | |
| | | | | | | | 8 | | | | | |
| | | 32.0-37.0 | C | | | | 7 | | | C2 | 60 | 54 |
| | | RQD = 92% | | | | | 7 | | | | | 90% |
| | | | | | | | 7 | | | | | |
| 35 | | | | | | | 7 | | | | | |
| | | | | | | | 7 | | | | | |
| | | | | | | | | 37.0 | Bottom of Boring 37' | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

| Sample Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|---|
| D=Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | | Earth Boring 27' |
| UP=Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft | 30 + Hard | Rock Coring 10' |
| TP=Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M./Stiff | | Samples 6 |
| OE = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | | |
| 300# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | | HOLE NO. NBH-6 |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 1 OF 2

| | | |
|---|---|---|
| TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-7 |
| PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO. |
| REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -28.7' MSL |

GROUND WATER OBSERVATIONS

At ______ after ____ Hours

At ______ after ____ Hours

| | CASING | SAMPLER | CORE BAR. |
|---|---|---|---|
| Type | HW-NW | S/S | NV-II |
| Size I.D. | 4" 3" | 1-3/8" | |
| Hammer Wt. | 300# | 140# | BIT |
| Hammer Fall | 24" | 30" | Dia. |

| | DATE |
|---|---|
| Start | 7/10/01 |
| Complete | 7/11/01 |
| Boring Foreman | J. Medeiros |
| Inspector/Engr. | |

LOCATION OF BORING

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler 0-6 | 6-12 | 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec." |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0-2.0 | D | Wt. | of | Rods | | | Black Organic SILT, little shells | 1 | 24 | 22 |
| | | | | | | | | 2.0 | | | | |
| | | 4.0-6.0 | D | 2 | 2 | 4 | | | Gray fine to coarse SAND and fine to medium | 2 | 24 | 20 |
| 5 | | | | | | 8 | | | Gravel, little silt, trace shells (organic) | | | |
| | | 9.0-11.0 | D | 5 | 6 | 7 | | 9.0 | Light Brown silty fine SAND, little fine to medium | 3 | 24 | 12 |
| 10 | | | | | | 10 | | | gravel | | | |
| | | 13.0-15.0 | D | 4 | 6 | 10 | | 13.0 | Brown fine to medium SAND, little silt & coarse sand, | 4 | 24 | 9 |
| | | | | | | 11 | | | trace fine gravel | | | |
| 15 | | | | | | | | | | | | |
| | | 18.0-20.0 | D | 3 | 4 | 8 | | 18.0 | Brown fine SAND, little silt | 5 | 24 | 8 |
| | | | | | | 6 | | | | | | |
| 20 | | | | | | | | | | | | |
| | | 23.0-25.0 | D | 2 | 4 | 3 | | | | 6 | 24 | 12 |
| | | | | | | 5 | | | | | | |
| 25 | | | | | | | | | | | | |
| | | | | | | | | 28.0 | BOULDERS | | | |
| 30 | | | | | | | | | | | | |
| | | | | | | | Min/Ft | 34.0 | | | | |
| 35 | | 35.0-40.0 | C | | | | 5 | | Weathered GRANITE | C1 | 60 | 20 |
| | RQD = 40% | | | | | | 7 | | | | | 33.3% |
| | | | | | | | 8 | | | | | |
| | | | | | | | 3 | | | | | |
| | | | | | | | 3 | | | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

| Sample Type | Proportions Used | | 140 lb. Wt x 30" fall on 2" O.D. Sampler | | | | | SUMMARY: |
|---|---|---|---|---|---|---|---|---|
| D=Drive C=Cored W=Washed | trace | 0 to 10% | Cohesionless | Density | Cohesive | Consistency | | Earth Boring 35' |
| UP=Fixed Piston UT=Shelby Tube | little | 10 to 20% | 0-10 | Loose | 0-4 | Soft | 30 + Hard | Rock Coring 8' |
| TP=Test Pit A=Auger | some | 20 to 35% | 10-30 | Med. Dense | 4-8 | M./Stiff | | Samples 6 |
| E = Open End Rod | and | 35 to 50% | 30-50 | Dense | 8-15 | Stiff | | |
| 300# hammer | | | 50+ | Very Dense | 15-30 | V-Stiff | | HOLE NO. NBH-7 |

# GUILD DRILLING CO., INC.
100 WATER STREET • EAST PROVIDENCE, R.I.

SHEET 2 OF 2

TO Maguire Group, Inc. | ADDRESS Foxborough, MA | HOLE NO. NBH-7
PROJECT NAME Harbor Aquatic Disposal Cell | LOCATION New Bedford, MA | PROJ. NO.
REPORT SENT TO above / Feasibility Study | OUR JOB NO. 02-011 | SURF. ELEV. -28.7' MSL

| Depth | Casing Blows per foot | Sample Depths From - To | Type of Sample | Blows per 6" on Sampler From To 0-6 | 6-12 | 12-18 | Moisture Density or Consist. | Strata Change Elev./Depth | SOIL OR ROCK IDENTIFICATION Remarks include color, gradation, type of soil etc. Rock-color, type, condition, hardness, drilling time, seams, etc. | SAMPLE No. | Pen" | Rec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 40.0-41.5 | C | RQD = 0% | | | 19 | | Weathered GRANITE | C2 | 18 | 6 33.3 |
| | | 41.5-43.0 | C | RQD = 0% | | | 8 | | | C3 | 18 | 6 33.3 |
| | | | | | | | | 43.0 | Bottom of Boring 43' | | | |

GROUND SURFACE TO ______ USED ______ CASING: THEN ______

Sample Type
D=Drive C=Cored W=Washed
UP=Fixed Piston UT=Shelby Tube
TP=Test Pit A=Auger
OE = Open End Rod
300# hammer

Proportions Used

| | |
|---|---|
| trace | 0 to 10% |
| little | 10 to 20% |
| some | 20 to 35% |
| and | 35 to 50% |

140 lb. Wt x 30" fall on 2" O.D. Sampler

| Cohesionless | Density | Cohesive | Consistency | |
|---|---|---|---|---|
| 0-10 | Loose | 0-4 | Soft | 30 + Hard |
| 10-30 | Med. Dense | 4-8 | M./Stiff | |
| 30-50 | Dense | 8-15 | Stiff | |
| 50+ | Very Dense | 15-30 | V-Stiff | |

SUMMARY:
Earth Boring 35'
Rock Coring 8'
Samples 6

HOLE NO. NBH-7