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Micro Survey - Acoustic Core and Physical Core Inter-Relations with Spatial Variation, Trenton Channel of the Detroit River

Volumes I, II and III

MICRO SURVEY
ACOUSTIC CORE AND PHYSICAL CORE
INTER - RELATIONSHIP WITH SPATIAL VARIATION,
TRENTON CHANNEL OF THE DETROIT RIVER

PROJECT SUMMARY

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INTRODUCTION

Historic practices of discharging toxics into our harbors and rivers have created the problem of in-place pollutants in sediments. These sediments exhibit elevated concentrations of contaminants which may have adverse effects on the local biota as well as humans. The managers of these harbors and rivers are faced with the task of making decisions regarding sediment remediation. In order to facilitate the decision-making process, the managers must evaluate the degree of contamination, the potential for sediment resuspension and the ecological effects of the contaminated sediments.

A cost effective and rapid means of mapping the distribution of sediments in harbors and rivers is required to facilitate the remedial decisions facing environmental managers. Models are being developed to predict the potential for sediment erosion in harbors and rivers. These models require an accurate mapping of sediments.

The development of an acoustical subbottom profiling system will provide three main products that will assist in bringing sites around the Great Lakes basin closer to remediation:

1. On the assessment side, it will help focus sediment sampling work at those areas where soft sediments are situated and thus, where the contaminants are located. Rather than sampling in the hopes of finding sediments, this technology will pinpoint exactly where and how deep the soft sediment deposits are. Thus, much time and money can be saved in the sediment assessment and characterization phase of a project.

2. At the remediation phase of a project, the use of this equipment will provide accurate volume information for development of remedial scenarios. Because the remediation of contaminated

sediments is very expensive, it is very important to accurately delineate the vertical and horizontal extent of sediment "hot spots" prior to initiating a clean-up action.

3. Additionally, this system will provide the technology to evaluate post-remediation conditions.

In 1988, the U.S. Army Corps of Engineers Waterways Experiment Station (WES), began development of a waterborne seismic acoustic impedance technique for the characterization of bottom and subbottom sediments in marine waters as it relates to removal by dredging. In 1994, WES working with Caulfied Engineering, completed the development of this rapid geophysical technique using acoustics to characterize bottom and subbottom conditions. The results of this technique were statistically within 10 percent of the results obtained from sediment core analyses.

The USEPA, through an interagency agreement, requested WES to optimize this acoustical technique for mapping in shallow water (2 -30 feet), where sediments exhibit a high degree of spatial variation, contamination and micro gas bubbles. The WES working with Caulfield Engineering optimized the technique, as requested, and demonstrated the acoustical impedance technique at two locations in the Trenton Channel, Detroit River, Michigan.

PROCEDURE / METHODOLOGY

The acoustic impedance technique utilizes an empirical model which classifies sediment stratigraphy according to established relationships between acoustical impedance and geotechnical properties. Classical multi layer reflective mathematics are used to compute reflection coefficients which are converted to acoustical impedance values using basic sonar equations. The relationships between acoustical impedance and geotechnical properties have been established in the literature (Hamilton, 1970, 1980) and form the data base used in the model. The model is corrected for local conditions; for example, micro gas bubbles and contaminants in the sediments, and computes estimates of sediment density at the surface and at depth. These density estimates are then placed in density categories, such as rock, sand, silt, clay, etc.

Once computed, sediment density categories, were plotted as surface contour maps and also as cross sectional plots along the survey lines showing sediment density group distribution at depth. These density data could also be plotted by three dimensional plotting software using the ASCII files generated, which provide state plane coordinates for each density data point.

Two demonstration sites, each 100 meters by 100 meters, in the Trenton Channel were selected for water depth and spatial variations in sediment distribution. The water depth ranged from a few feet to 30 feet and the sediments in the study areas exhibited a high degree of spatial variability, contamination and gas. Survey lines in the study area were established at 10 meter offsets.

A key component leading to the accuracy of this technique is the calibration and monitoring of all instruments used to collect the acoustic data. Sediment cores were also collected to correct for local conditions which may differ from the standard marine sediment library. In addition, cores were collected at precisely known locations of acoustic data for comparison of acoustically estimated geotechnical properties and the measured geotechnical properties in the cores.

RESULTS and CONCLUSIONS

Two sites in the Trenton Channel, Detroit River were surveyed during this demonstration project. Sediment deposits of the Elizabeth Park site were very localized and exhibited extreme lateral variability. Hard compact sediment is often exposed with depositional sediment thickness ranging from 0 to about 1 meter with a volume of approximately 530 m^3.

Depositional sediment dominates the surface area of the Black Lagoon site with some areas of exposed rock and hard compact sediment. Sediment is less localized and exhibits less spatial variability than the Elizabeth Park site. Depositional sediment thickness ranged from 0 to about 2.25 meters with a volume of approximately 3,070 m^3.

The project demonstrated the existence of sediment fluff or foam over-laying some of the surface sediments. This fluff was found both by the piston cores and in the high frequency acoustic records. The role of this fluff in the transport of contaminants and the effect on sediment resuspension should be further studied.

The Acoustic Core© System was shown to be capable of mapping in shallow water where sediments exhibit a high degree of spatial variation. Existing software was modified and additional software written to meet the challenge of acoustically mapping sediments in shallow waters where sediments exhibit spatial variability and contain micro gas bubbles.

At sites where sediment cores were collected, sediment core statrigraphy was compared to the acoustically-estimated stratigraphy and good agreement was generally observed. In addition, there was agreement between acoustical data and cores collected the year before.

The Caulfield Engineering plotting software demonstrated the ability to create cross sectional plots of acoustical data expressed as sediment density groups (sand, silt, clay, etc). The cross sectional plots provide a tool, usable by managers, for the visualization of sediment distribution and volume. This type of surveying and mapping provides the reconnaissance tool needed in designing and implementing cost efficient assessment of contaminated sediments.

FINAL REPORT
MICRO SURVEY - ACOUSTIC CORE AND PHYSICAL CORE INTER - RELATIONS WITH SPATIAL VARIATION, TRENTON CHANNEL OF THE DETROIT RIVER
VOLUME I
FIELD ACTIVITIES AND CALIBRATION DOCUMENTATION

Prepared

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1.0 INTRODUCTION

Significant deposits of contaminated sediment occur in many waterways near urban centers, including those of the Great Lakes basin. Some of these deposits have accumulated for decades and reflect historic loadings of pollution from cities, industry and agricultural runoff. These deposits continue to contaminate benthic and pelagic organisms through various transport and fate processes. The removal, treatment and disposal of these contaminants may be extremely costly.

A cost effective and rapid means of mapping the distribution of sediments in harbors and rivers is required to facilitate the remediation decisions facing environmental managers. Models are being developed to predict the potential for sediment erosion in harbors and rivers. An accurate prediction of sediment resuspension by these models requires accurate mapping of sediments.

This final report has been prepared in three volumes. Each volume was originally delivered as an interim project report. Upon completion of the final volume the interim reports were edited and a final report consisting of a three volume set and executive summary was prepared. The three volumes include:

Volume I: Field Activities and Calibration Documentation (December 30, 1995). This volume summarizes field acquisition and calibration procedures. Highlights of the field activities, associated field logs and corrected file navigation, and the results of an extended calibration program are provided.

Volume II: Core Analysis and Summary Findings (Documentation (Caulfield Engineering Report March 23, 1996). This volume relates the acoustic properties of the sediments to the physical properties of the cores at selected sites.

Volume III: Normal and Contaminated Sedimentary Distribution Maps (Documentation (Caulfield Engineering Report May, 1997). Volume III provides final outputs identifying contaminated layer cross-sections as well as estimated dredging volumes. Also presented are new spatial analysis techniques developed to accommodate the spatial variations and contaminants/gas content of the Trenton Channel sediments.

2.0 PROJECT DESCRIPTION

2.1 Background

Both the Army Corps of Engineers/Water Ways Experimental Station (USACE-WES) and the U.S. Environmental Protection Agency/Office of Research and Development/Mid-Continent Ecology Division/Community Based Science Support Staff (USEPA/MED/CBSSS) have research interest in mapping sediment in harbors and rivers by acoustic profiling. In 1994 the Great Lakes National Program Office, The Michigan Department of Natural Resources and USEPA/MED/CBSSS conducted a sediment survey by contract with Caulfield Engineering using the Acoustic Core© system. The survey of the Detroit River's Trenton Channel demonstrated that the Acoustic Core© system has the potential for mapping the sediment in harbors and rivers of the Great Lakes. The 1994 survey results identified high spatial variance in sediment distribution and possible gas content in these sediments. The acoustic method required optimization for use in shallow water (2 ft. to 30 ft.) and areas which exhibit a high degree of sediment spatial variability.

The USEPA requested that USACE-WES optimize the Acoustic Corer. Two sites on the Trenton Channel, Elizabeth Park and Black Lagoon, were selected for micro-surveys to demonstrate the Acoustic Corer and to confirm the 1994 observations. The request required survey grids of very closely spaced (5-10 meters) observation lines with high ping repetition rates. In addition, ground truth piston cores were to be taken at calibration sites and other sites of interest. The data were to be acquired and processed with the Caulfield Engineering Acoustic Core suite of software. Final project outputs were to include identification of the location and volume of depositional sediment, survey line cross section plots of horizontal and vertical sediment distribution by density group, and to specify the acoustic properties of the possible contaminated sediments.

2.2 Site Overview

The Detroit River has been identified by the International Joint Commission as an Area of Concern due to a number of water quality problems, including contaminated sediments and degraded benthic communities. In addition, the river is also listed under the Michigan Environmental Response Act (P.A. 307, 1982 as amended) due to contaminated sediments.

Sediment studies conducted under the Upper Great Lakes Connecting Channels Study (USEPA and EC, 1988) and other research activities, documented sediments contaminated with metals, PCBs, and oil and grease (Farara and Burt, 1993) in multiple locations in the Detroit River and Trenton Channel. Impaired uses relating to contaminated sediments, as identified in the Detroit River Stage 1 Remedial Action Plan (MDEQ, 1987), include restrictions on dredging activities, degraded benthic communities, exceeding Michigan Water Quality Criteria for fish consumption advisories, and increased incidence of fish tumors.

The Trenton Channel is located in the lower Detroit River between Grosse Ile and the Michigan mainland, Figure 2-1. It is approximately nine miles in length and carries 21 percent of the total river flow, with an average velocity of 1.08 to 1.9 ft/sec. The Detroit River and Trenton Channel, a heavily industrialized area and a major navigation route, has been identified as severely degraded in terms of water and sediment quality and benthic communities (USEPA and EC, 1988). Numerous point sources in the area include steel plants, waste water treatment plants and chemical and automotive manufacturing industries. Concentration of arsenic, nickel, PCBs, and oil and grease in Trenton Channel sediments have been found to exceed the recommended guidelines for sediments (Long and Morgan, 1990; Persaud et al., 1993). Data from various sediment Toxicity tests conducted showed sever impacts compared to other Detroit River locations and reference stations for a number of biota tested (Giesy et al., 1988).

2.3 Project Objectives

The primary objective of the USEPA-USACE-Caulfield Engineering effort was the acquisition of micro-survey data using the Acoustic Core© system and the processing and analysis of selected results and sites to determine the sediment stratigraphy in near shore areas of the Trenton Channel. Two specific sites were chosen to demonstrate soft sediment mapping, allowing the calculation of volume estimates.

This project uses the Acoustic Core© suite of software to identify and map the gross distribution of these sediments as presented in this report. Piston core data was required to calibrate the acoustic process. It is important to note that the exact engineering geo-acoustic properties of the marine sediments versus the various types of pollutants is not known. It is only known that pollutants and or micro-gas bubbles contained in sediment change the acoustic properties, and in some cases radically, from standard marine sediments. Data shows (volume II) that as the gross contaminants (observed from the chemical analysis of the USEPA vibra-cores collected in 1994) increase the deviation of the bottom loss from similar non-contaminated marine sediments increases.

TRENTON CHANNEL STUDY AREA

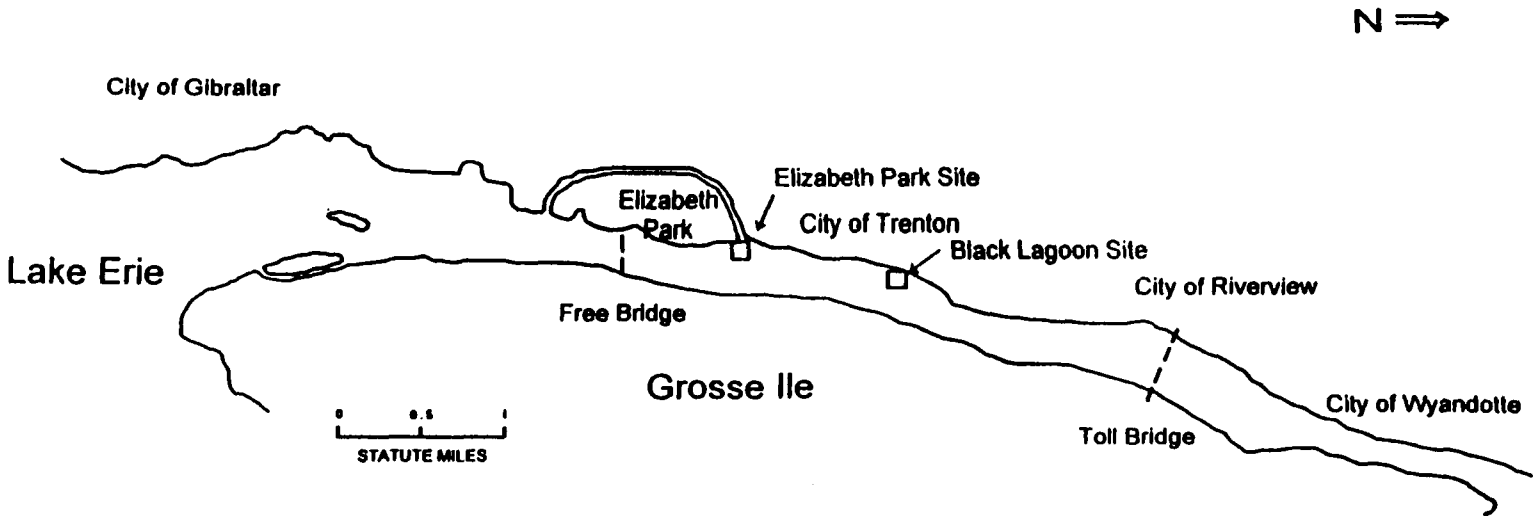


Figure 2-1

Trenton Channel
Study Area

The tasks listed in the interagency agreement between EPA and ACOE included:

> Optimize the Acoustic Corer for use mapping, in shallow water (2ft-30ft), where sediments exhibit a high degree of heterogeneity .

> Demonstrate the accuracy of the Acoustic Corer to characterize sediment type and map the distribution of sediment type at depth. The demonstration should take place at three sites (shallow, medium and deeper water depths) in the Trenton Channel, Detroit River.

> Collect and conduct the necessary geophysical characterization of sediment cores needed for calibration and validation of the acoustic corer.

> At the demonstration sites provide mapping of the distribution of the soft sediment.

> Provide a written report on the Acoustic Corer Optimization, describing the rational, approach and results.

> Provide a survey report on the demonstration site surveys. This report is to include:

1. A description of the Acoustic Corer and the fundamentals of operation
2. The survey design
3. Results of the survey
4. Graphical mapping of the sediment distribution for each site
5. A calculation of the volume of soft sediment at each site

Without the detailed Quality Assurance Program carried out during the field exercises this project would not have succeeded. The Quality Assurance Program enabled absolute calibrations of the sound sources, which in turn allowed for the quantitative identification of the sediment types.

2.3.1 Experimental Design

The data acquisition procedures encompass standard shallow subbottom profiling techniques in which a sound source emanates a sound signal (source) and the reflection from the bottom and subbottom are received on an array or transducer (receiver). Various sound sources and receivers are used with different amplifiers to format the data for proper digitizing and data storage. The selection of source and receiver combinations are a function of the soil types, the depths of sound penetration and vertical resolution required. Based on the experience of the previous year's Trenton Channel survey, a

number of different systems were made available. The following list summarizes the equipment supplied and by which organization:

1) ORE 7.0/3.5 KHz Pinger (CE) - Medium and high frequency sound data. Provides good resolution of the surface reflection coefficients and penetration into soft sediments.

2) Boomer and Towed Array (CE) - Low frequency sound data. Provides deeper penetration into polluted and sand materials. Resolution is limited.

3) CE-1000 Amplifiers (CE) - Provides analog amplification of the received data to condition the data for optimum digitizing. Amplifier calibration provides for the gain value for the calibration sonar equation and as input to the Acoustic Core© system.

4) Khron-Hite Filter (CE) - Provides for noise isolation in the frequency domain.

5) CE Calibration Hydrophones (CE) - Provides for direct measurement of source level and bottom reflectivity.

6) 386 Computers (CE) - For the digital acquisition of the data, system calibration, and data processing. These computers had have a standard printer and math coprocessor. Caulfield Engineering will supply one 230 Mega-byte Magneto-Optical hard drive for data storage.

7) Navigation (USEPA) - Positioning was provided by real time differentially corrected GPS.

8) Ground Penetrating Radar (CE) - Used to measure shallow water layering as a calibration input into the Acoustic systems which have difficulty determining water depths in very shallow water.

9) Piston Core (CE) - Standard 3" piston core was provided by Caulfield Engineering and operated with the aid of the USEPA staff. Nineteen cores sites were acquired.

10) Prototype Core Velocimeter - A prototype core velocimeter was provided by Caulfield Engineering so that the sound velocity and absorption could be measured immediately after the core was brought to the surface. This would allow testing for gas content before the gas could dissipate. Gas content was confirmed.

11) Precision Core Velocimeter - The USACE provided, at WES, a precision core velocimeter that was built to near National Bureau of Standards precision. These measurements confirmed the in-field absorption measurements for the presence of gas.

The prime data acquisition mode is digital and is controlled by the CE DF25 Digital Acquisition software. This software has the ability to ensure quality by indicating that the data is not clipped and that the S/N exceeds 5 db. The data was stored on 230 Mega-byte disks.

Data are processed with the Acoustic Core AC50 and AC60, and the new CAL1, programs to produce bottom reflectivity and impedance, and subbottom reflectivity and impedance. Caulfield Engineering also developed a new Acoustic Core Reflection/Sign program, ACRS1, which generates ASCII files of the best estimate of the reflection sign and the bottom loss for the ping data.

The Digital Spectral Analysis software (DSA10) is used to confirm frequency content and to examine absorption. As long as the data is not clipped the data is of high quality.

System source calibration is obtained with the calibration hydrophone in combination with the DF25 program and the new CAL1 Windows program. Results were computed and statistically processed over 8000 pings or traces and provide the source and receiver levels in decibels (db). The mean measurements are accurate to within 97% for source and receiver levels after correcting for the vessel handling and electrical problems.

The exact accuracy of the acoustic subbottom stratigraphy cannot be specified until data acquired over the reference cores is processed in full. The acoustic data was collected simultaneously with the coring to get detailed analytical correlation and has been processed and presented in Volume II. Detailed explanations, accuracies, procedures, of the final results are presented in subsequent Sections and Volumes II and III.

The step by step method for the mathematical computation of the impedance and depth estimates are given in 'Prediction of Shallow Subbottom Sediment Acoustic Impedance while Estimating Absorption and other Losses', D.D. Caulfield and Yung-Chang Yim, CSEG, Vol. 19, No. 1(Dec. 1983) P. 44-50.

2.4 Project Field Schedule

The project was scheduled to commence on July 24, 1995. The project was started

on time and Table 2-1 summarizes the major activities daily along with the survey and calibration stations by file names. Appendix A provides the detailed data acquisition field log. The following items highlight the major milestones to be undertaken by Caulfield Engineering.

1) Equipment Mobilization July 24-25, 1995. This includes equipment testing and shipping of the survey equipment to the site and the setup aboard the survey vessel.

2) Field Collection - June 26, 1995 to August 4, 1995. This included system calibration at the multiple core locations, collection of survey data at the Elizabeth Park and Black Lagoon sites, and in-field calibrations over specific areas of interest with nineteen cores taken.

3) Data Processing - Preliminary processing to verify system linearity and data quality was carried out on the research vessel "Mudpuppy" by Caulfield Engineering. Individual site calibration were of low standard deviation. It was only on the completion of the field effort that it was discovered that there was a small site to site variance with the pinger data. Noise problems affected the calibration of the boomer and limited field time did not allow for the exact determination of the cause. These variance problems will be discussed in detail in subsequent sections.

3.0 QUALITY ASSURANCE PROCEDURES SUMMARY

The key to a successful survey is the development and adherence to a detailed quality assurance plan. Such a plan was developed prior to the implementation of the Trenton channel survey. The Quality Assurance Project Plan comprised the following steps: General area geology and sediment distribution was estimated; expected optimum sound sources were chosen; reconnaissance surveys were undertaken; engineering and calibration specifications were selected, reconnaissance surveys were executed and initial data processing was undertaken. Using these initial results a detailed Quality Assurance Plan was developed which met the study objectives.

The Acoustic Core© method utilizes a strict engineering approach applied to solving the basic sonar equations. The key to success is the calibration and monitoring of all system components. Utilizing these calibration procedures, together with data exhibiting high signal to noise ratio and seismic reflection data (bottom Loss), data were processed and an accurate density and sediment type classification produced. Use of the Acoustic Core© system by untrained personnel is an invitation to disaster because of the high requirement for quality control and expert analysis and interpretation.

One of the main functions of the Acoustic Core© system was to act as a quality control monitor. It did this in several ways. First, it maximized the dynamic range and Signal-to-Noise (S/N) of the data acquired while preventing clipping. Second, correct field procedures ensured the prevention of aliasing, the digital sampling of data at to low a sample rate, by ensuring that the proper sampling rates (greater than Nyquist) were employed. This section is included in the final report so that the resulting data from the field exercise can be compared to the desired goals. In all cases tested to date, the goals have been met, albeit with great difficulty due to ship handling and noise, with the exception of very shallow water where either the multiples or the direct wave contaminated the data. Alternate data acquisition procedures (move-outs) were carried out to eliminate these problems and sample data was provided at the Elizabeth Park Canal site to show how these problems can be over come. It is important to note that these problems were not the result of the Acoustic Core© system limitation, but rather were related to the physics of propagating sound levels of sufficient power in shallow water to obtain penetration.

3.1 Measurement Quality Procedures

Caulfield Engineering carried out the following procedures to ensure the highest possible data quality:

- Testing and optimization of equipment during mobilization.
- Filtering and correct amplification of data to ensure maximum dynamic range and to prevent aliasing.
- Choice of correct source and source configuration, to image the desired depth.
- Source/receiver separation to reduce multiple contamination.
- Electrical isolation to reduce noise.
- Use of correlation to improve S/N and resolution during processing.
- Integration of new processing flows as developed, the CAL1 Windows program.
- Careful calibration procedures in the field, to double check functioning of the system and to calibrate the impedance system. In this program this was also augmented with the acquisition of acoustic data while taking cores.

It is important to note that the Acoustic Core subroutine and the Digital Field Acquisition System digitally stored all of the calibration and actual field results. This provided a permanent log versus time of all events, allowing legal documentation of the quality assurance steps outlined above. In addition to the digitally stored data, complete field log and analysis forms were completed to provide a permanent backup of events. See Appendices.

With any present subbottom digital system, the major quality control items are to ensure that data is not clipped (ensured by the DF25 software), S/N is optimum and the amplifier gains and source levels are exact. Clipping occurs when the amplifier gains are improperly set and the dynamic range of the Analog/Digital (A/D) converters is exceeded. Color coded display information allows the operator to detect such clipping. All other parameters are derived or computed. The accuracy of the model used to predict the sediments is verified by plotting predicted densities against the observed densities at the core sites. In the Trenton Channel sediment, the match was not identical due to the anomalous sediments perhaps related to pollution content and/or presence of micro gas bubbles. It is important to note that if the absorption due to pollution or gas is too great, some fine structure in the cores might not be seen at all.

For the purposes of this work, the following definitions for QA objectives are outlined in the following table and defined along with their practical and economic limits.

DATA QUALITY OBJECTIVE FOR ACOUSTIC SURVEY

DQOS	Parameter	Frequency	Acceptance Criteria (Accuracy)	Units	Corrective Action
	Precision as RPD	10% of survey distance	+/- 10 %	ratio	DQO reported as not met
	Accuracy	See MQO cal. parameters	See MQO parameters		Repeated until conditions met
	Completeness	NA	90 % of survey area	m^2	DQO reported as not met

Precision - The ultimate measurement precision of the DF25 system is 0.024 percent. This converts to a precision in voltage measurement of +/- 0.00244 volts or +/- 0.0068 db. All measurements are made in voltage and major computations performed in decibels. The above precision converts to a theoretical precision for the determination of the reflection coefficients of +/- 0.3 percent. For the duplicate survey lines a minimum of 10 % of the survey area was duplicated. For this effort, precision is defined as Relative Percent Difference (RPD). Due to USEPA boat handling personnel this criteria was not always met. However, software generation and processing procedures were completed to compensate and correct for this problem.

$$RPD = (X1-X2)*100/[X1+X2/2]$$

A RPD of < 10 % meets data quality acceptance.

Accuracy - The accuracy of the system must be divided into a discussion of the observable (measurements) and computations. Each is discussed in detail below.

Measurement Accuracy - Each component of the system can be measured to the above precision. However, in the real world of operation, boat motion, boat noise and spatial parameters limit the in situ accuracy. The ultimate accuracy is dependent on the time spent in calibration of the system at each calibration site. For this survey, multiple acoustic samples (hundreds) were acquired at the calibration sites and averaged to obtain a minimum standard deviation of the measurements. Examples of this processing is given in subsequent sections.

For this survey, when the standard deviation of the source level was less than or equal to 3 percent of the measured value, the calibration was deemed satisfactory. The amount of time spent was economically limited and was not equipment limited. For this

survey sufficient time was spent to provide the required system accuracy at each calibration site. Judgment factors were employed because of the refusal of the boat operator to anchor at some locations. A further limiting function during normal surveying along survey lines was the spatial variation of the subbottom layering. For normal surveys, it can generally be assumed that the bottom geology and layer structure is constant over the beam pattern of the systems employed. For example, given a 30 foot water depth the bottom would not change radically in the horizontal direction for a distance of 30 feet. If the structures do change more rapidly than this, boat speed must be reduced, and/or special hydrophone and receiver array geometry's must be developed. For river and harbor surveys, the later case is a rare exception. However, the control of the boat speed does occur often and is related to the economics of the survey, as slow boat speed limits the total area to be covered, unless additional resources are added. For this preliminary survey, the number of lines were increased and boat speed was slowed below 2 knots which proved sufficient with high speed ping repetition rates.

Computational Accuracy - All the terms of the sonar equation and hence the bottom surface refection coefficient (impedance) can be computed directly from the observables and are as accurate (+/- 3 percent) as the source level. However, subbottom material and density predictions are based on a model of the geology and material types. The absorption and impedance to density relationships are derived from the calibration cores. Again, if sufficient core data is available, these parameters can be derived. It was impossible to predict before hand the absolute accuracy of this model in the Detroit River because the pollution parameters were not known in detail, but sufficient data was acquired to start the required data base. However, for normal marine sediments, accuracy's of +/- 3 to 5 percent are standard. The accuracies of the system are affected by the signal to noise (S/N) and the Acoustic Core© system (AC60) provides indications on the data validity by allowing the setting of the S/N threshold. With the exception of coherent ringing noise in very shallow water, the S/N was excellent. Refer to the MQO table below.

Completeness - This is a measure of the number of valid subbottom survey samples obtained compared to the amount that is needed to meet the program objectives. For this program it has been decided that at least two major sites be examined. At each major site, multiple soundings were acquired with each of the three sound sources at 5 and 10 meter spaced survey lines. This provided detailed saturation of the survey site. During the survey, ten major calibration sites were implemented. The survey lines were chosen to pass over both the new and older core sites.

The scope of the work was chosen to gather sufficient technical information to understand the study area and meet available resources. It is important to note that the layer strata distribution and its spatial variation was even more complex than assumed; however, volumes of data were acquired was be processed in detail. For this effort:

completeness = v/n*100

where v = coverage of area in survey
n = total area

Detectability - A subbottom signal is classified as being detectable if the Signal-to-Noise (S/N) is greater than 5 db. In this survey these limits were exceeded in the majority of the cases providing good signals to analyze. The sediment absorption limits the depth of penetration as a function of frequency. Therefore the deepest detectable signals will be a function of the source frequency. For this survey, source frequencies from 600 Hz to 7000 Hz were available and were selected to give the best resolution of the strata for the depth to the hardpan in the study areas. The DF25 software provides continuous monitoring of the signal and the noise level (by color display) so that this 5 db S/N level was maintained for the layers to be detected. It is important to emphasize that the Precision Acoustic Core processing allowed the editing of the data predictions based on S/N. Detailed studies by the USACE have shown that all density predictions with S/N above 5 db are valid if the system is fully calibrated and the sediments are not polluted.

Representativeness - A calibrated system, with a precisely known sound source, receiver sensitivity, and receiver gain, which was calibrated at a core site provides good representation of the physical properties of the subbottom materials based on standard marine sediment tables. With the core data collected from sites which were representative of the channel depositional zones, the standard marine sediment tables were corrected for local site variations. Appendix A4 provides the Trenton Channel site core information and logs. In the field, the grain size information was used to classify the material type, and the core density was used to confirm the Acoustic Core densities. If they did not match exactly, the Acoustic Core absorption parameters were modified for the new subbottom type, and this new absorption was then used for the rest of the survey. The other core locations were used to confirm this absorption selection. Again, because of the high variability, only average data were derived.

Comparability - Same as Representativeness for density comparison and material type. In addition, the Digital Spectral Analysis and the new CAL1 Windows software was used to compare results on a selected ping to ping basis proving, in the field that all systems were operating properly and that the data quality was proper and within specifications. These tests were conducted on adjacent calibration ping sets. Hard copy output was maintained both in the field logs and in the final report to demonstrate this comparability.

Also typical tables of bottom loss predicted versus measured core density derived bottom losses are provided in Volumes II. In a standard marine sediment area, previous work has shown that the standard deviation is less than 5 percent (Hamilton, 1970). Comparability was made with selected Trenton Channel non-contaminated core data and

the standard marine data base. See Volume II, Appendix B3 and Figure 4-7 in Volume II. The mean core densities for non-contaminated sediments in the Trenton Channel was 2.08 with a standard deviation of 0.098. The mean bottom loss for standard marine sediments of this density range is 7.92 with a standard deviation of 0.343. The observed mean bottom loss for these non-contaminated in the Trenton Channel sediments was 9.274 with a standard deviation of 0.703.

It is important to note that with the detailed calibration procedures carried out at the nineteen core sites and selected source level calibration at the end of major lines, all parameters were derived even if they changed during the survey. This is possible as the DF25 software maintained a complete log of events and program settings.

Based on the above discussion a Measurement Quality Objectives Table was constructed for the project, as follows:

MEASUREMENT QUALITY OBJECTIVES FOR ACOUSTIC SURVEY

MQOs	Parameter	Frequency	Accept. Criteria (Accuracy)	Units	Corrective Action
On reference core sites (2 min.)	1. Impedance	As desired	Data Accepted if parameter 3 to 7 acceptable	g/cm^2*s	Repeated until conditions met
	2. Sound Vel.	Same as above	Derived	m/sec	Same as above
	3. Density	Same as above	Optimal +/- 1 % +/- 4 % Acceptable	gm/cm^2	Same as above
	4. Density	At other core sites	Optimal +/- 5 % From Den. Vs Den. Plot	Same	Same as above
	5. Surface Reflect. Coef.	Same as above	+/- 5 % for 7.0 % 3.5 KHz Systems	Ratio	Same as above
Pre-survey run/ Post-survey run	6. Source level	Beginning & end of each run	+/- 2.5 %	db's	Survey rerun if out of compliance
	7. Amplifier Gain	Same as above	+/- 1.0 %	db's	Same as above
	8. Receiv. /array Gain	Same as above	+/- 2.5 %	db's	Same as above
	9. Signal/Noise	Continuous	> 5db	ratio	If not immediately corrected, survey is rerun

Note that the Amplifier Gain and the Receiver/Arrays are permanent type fixtures in that they should not change their characteristics unless an unforeseen mechanical or electrical shock damages the equipment. Hence, only a few points of the calibration have to be rerun to ensure the system is operating properly. If all gains and settings are identical to the previous day these elements do not have to be completely re-calibrated.

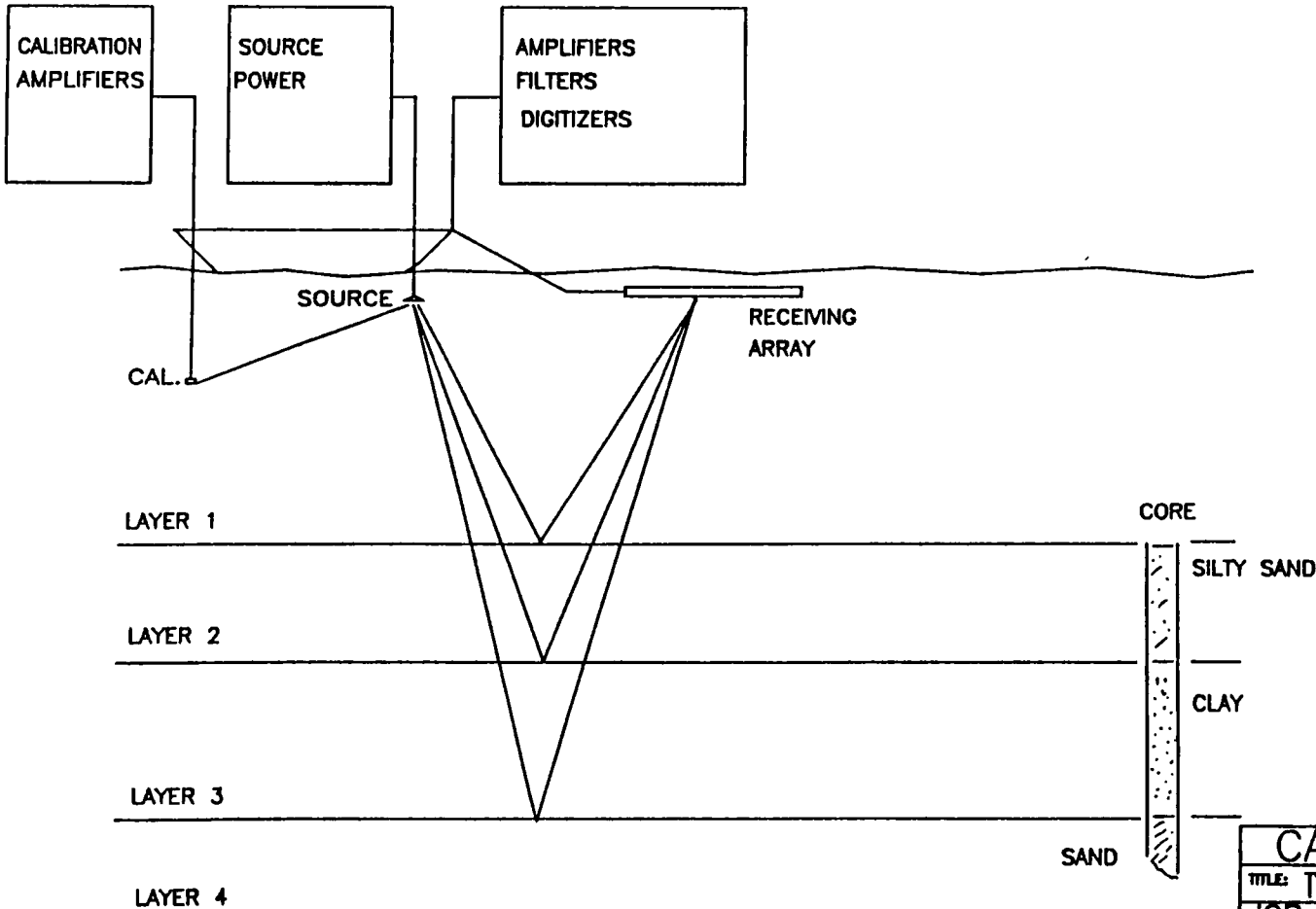
In all cases tested to date, the quality control parameters have been met, This report provides detailed examples on how these quality control parameters were met. In order to fully understand and relate the measurements to the systems parameters, the following subsections review models and the mathematical background for the work.

3.2 The Survey Reflection Coefficient, Calibration Model, and Acoustic Impedance

Figure 3-1 illustrates the typical form of a shallow reflection seismic reflection system with a calibration phone inserted. The reflections from the bottom and subbottom, as well as the reflection to the calibration phone, are depicted.

Reflections occur at changes in acoustic impedance (Z), which is the product the density and velocity. Acoustical impedance can be thought of as the acoustical hardness of the sediment (Anstey, 1977). At these layers of differing acoustical impedance, part of the incident sound wave energy is reflected back to the surface and part of the energy is transmitted downward toward lower layers. The strength of the reflection is directly related to the contrast of the acoustical impedance across the boundary. The strength of the reflection can be quantified as the reflection coefficient. The right portion of the Figure illustrates the stratigraphy. At each change in material type there is a reflection. Usually the largest change is between the water and the bottom. Since the sound velocity of water and its density can be readily measured, the absolute impedance of the water can be calculated. This absolute impedance can also be independently computed from the multiple reflection; i.e., the second bounce off the water surface. Knowledge of the reflection coefficient from the water-bottom interface allows direct computation of the absolute impedance and density estimate of the first layer of the bottom.

To do this, it is necessary to know either the absolute source level, or to have a calibration hydrophone and compute the source level. The calibration phone allows the calculation of the source level by solving the basic sonar equation. Likewise, if multiples are present, the sonar equation for the multiples can be solved for an independent verification of the source level. A new Windows program, CAL1, was created to solve these equations for various known inputs and to process large amounts of data to get statistical results. Previously the data was processed semi-manually using the Spectral data output and Matlab.



CAULFIELD ENGINEERING			
TITLE: TYPICAL SHALLOW SEISMIC SYSTEM CONFIGURATION			
JOB:	1868	DATE: 9/4/93	SCALE:
DWN:	DDC	SHEET:	REV:
ENG:			
DWG NO. 1868-1001			

Figure 3-1

3.2.1 The Sonar Equation

The general sonar equation is given as follows:

$$S_{sig} = S_{source} - N_w - N_{hyd} + N_A + N_{DI} + BL \qquad (1)$$

where

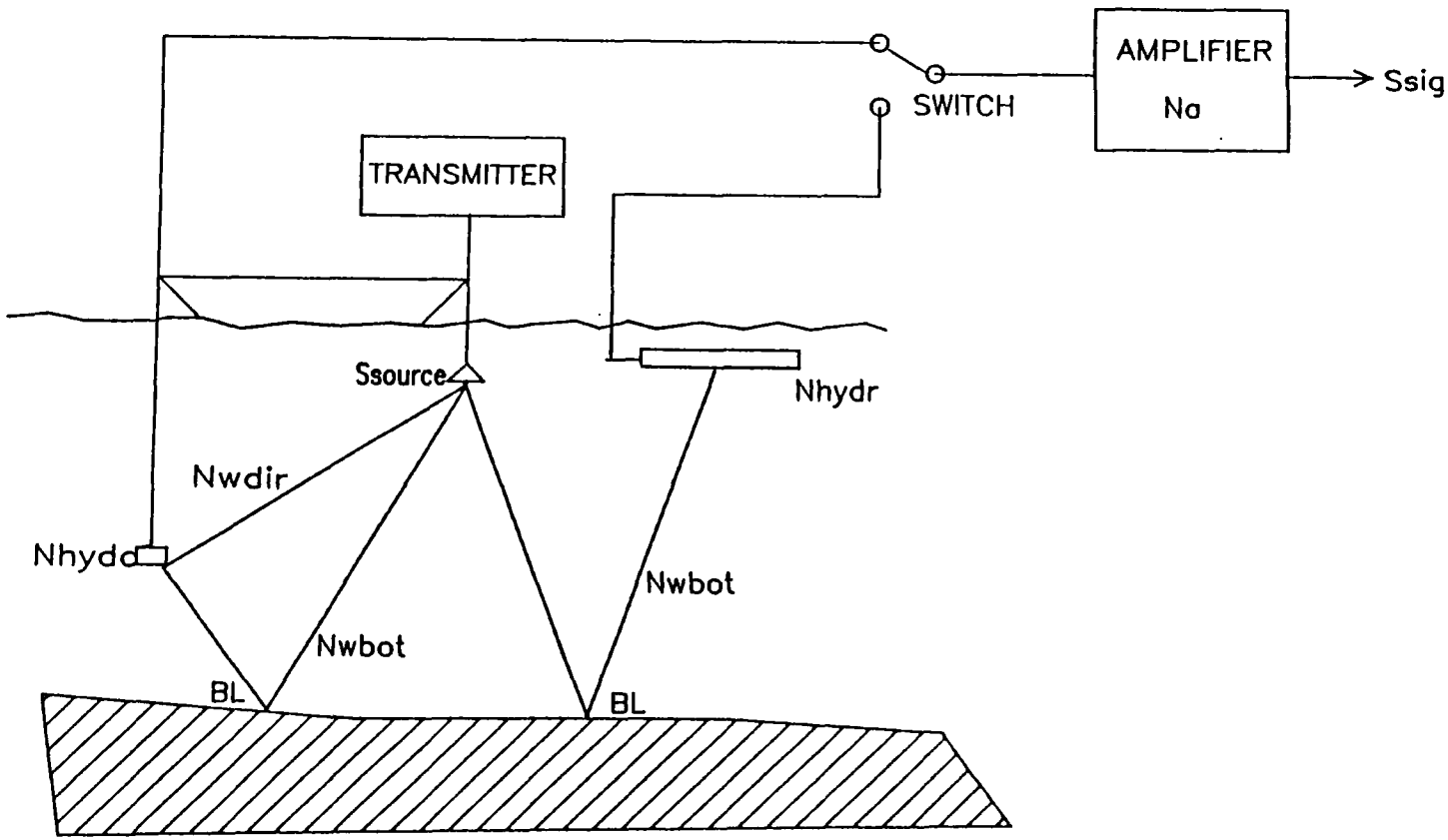
S_{sig} = Received signal level decibels (db)
S_{source} = Source level (db)
N_w = Transmission loss (20* log Range(D)) (db)
N_{hyd} = Hydrophone receive sensitivity (db)
N_A = Amplifier Gain (db)
N_{DI} = Directory factor (beam pattern) (db)
BL = Bottom loss (20* log (R)) (db)
R = Reflection Coefficient

All source levels, receiving hydrophone levels and receiving hydrohone sensitivities are referenced to one volt per microbar, not in the new Pascal's. The difference is 100 db. The new CAL1 program allows inputs of various beam pattern terms, as the calibration phone was not normal to the direct field due to the boat movements and currents.

Figure 3-2 is a detailed depiction of the physical elements in a normal calibration and bottom reflection sonar equation solution case. The horizontal exaggeration of the transmitter, receiver, and calibration hydrophone is for clarity purposes only. The Amplifier gain (N_A) value includes all preamplifiers and amplifiers and is obtained from the electrical calibration of the receiving equipment. The calibration hydrophone sensitivity (N_{hyd}) and receiving array sensitivity are available from manufacturers of the hydrophone and arrays. The symbolic switch in Figure 3-2, is set so that calibration data is gathered first and then sent to the receiving array during production data acquisition. The transmission loss term (N_w) is obtained from precise geometrical measurements of the calibration test. The signal level (S_{sig}) is obtained from the precision CE-Digital Field Spectral Analysis amplitude plot of the raw data.

The first step is to find the source level term. Source levels are usually defined in decibels (db) and are an efficient method to describe the pressure level at one meter from the source relative to a microbar. Some sonars have this data available from the manufacturer. However, most seismic systems do not readily have this information available, and field conditions vary to such an extent that the published levels are not sufficient for precise reflection computations.

Setting up the sonar equation to solve for the direct wave calibration (S_{sigdir}) of the sonar source level gives the following equation:



CAULFIELD ENGINEERING			
TITLE: GRAPHICS OF SONAR EQUATION TERMS			
JOB:	1868	DATE: 8/30/93	SCALE:
DWN:	DDC	SHEET:	REV:
ENG:			
DWG NO. 1868-1000			

Figure 3-2

$$S_{sigdir} = S_{source} - N_{wdir} - N_{hyd} + N_A \qquad (2)$$

All the terms in equation 2, except the source level, are absolutely known. Therefore, the absolute source level for the particular seismic system can be found. Normally, calibration data is taken at various depths (variation in transmission loss) to ensure that beam pattern and signal level clipping is not a problem. This step provides the source level of the system.

The next step in the process is the computation of the bottom reflection coefficient at the calibration site. The sonar equation for this case is:

$$S_{sigbot} = S_{source} - N_{wbot} - N_{hyd} + N_A + BL \qquad (3)$$

S_{sigbot} = The amplitude of the signal in the seismic trace from the bottom interface. This is usually the first signal after the transmit pulse.

Again, in equation 3 all the terms, except the bottom loss, are precisely known. Therefore, the absolute bottom loss (BL) value can be computed. The bottom loss term is related to reflectivity by the equation:

$$BL = 20 * \log(R)$$

where

R = Reflection Coefficient

Solution of equation 3 provides a precise bottom loss term and the corresponding reflection and acoustic impedance of the surface layer at this location. It is important to note that these values can be compared to core data at the calibration site to learn if the marine sediments are "standard" or local data bases must be constructed relating acoustic impedance to density. It has already been determined that the bottom loss from polluted sediments is lower than a “standard” marine sediment with the same density.

An alternate solution for the bottom loss can be derived from the calibration case by setting up two simultaneous linear equations. These two equations are for the case where the calibration hydrophone has been placed at a sufficient depth to obtain both the direct wave from the source and the bottom reflected signal. These equations would appear as:

$$S_{sigdir} = S_{source} - N_{wdir} \quad N_{hyd} + N_A$$

$$S_{sigbot} = S_{source} - N_{wbot} - N_{hyd} + N_A + BL$$

Subtracting the second equation above from the first and re-arranging the terms yields:

$$-BL = S_{sigdir} - S_{sigbot} + N_{wdir} - N_{wbot} \quad (4)$$

All the terms on the right side of equation 4 are known exactly, therefore, the absolute bottom loss and surface reflection coefficients can be obtained.

If the bottom is reasonably hard, clays through sands, the multiples can also be recorded. When corrected for spherical spreading, the ratio of the first multiple reflection to the first bottom reflection is a measure of the reflection coefficient and the actual bottom loss. This data can be used as verification of the calibration procedures. The use of multiple reflections to calculate the reflection coefficient is normally not as accurate. This is because the multiple signal strength is normally small, and the ambient and background noise has a negative effect. However, for this program the S/N was sufficiently high for more than 60 percent of the data, which allowed the verification of the calibration results and processing of the data even though there were the ship problems as noted above.

Finally, once the source and bottom reflection coefficients are calculated at a given location, the system receiving array can be calibrated. This is done by replacing the calibration hydrophone with the receive hydrophone and again applying the sonar equation. The resultant array sensitivity data can be compared to the manufacturers specifications and corrections applied accordingly.

The practical limitations in production surveys are the actual system beam patterns, total Signal-to-Noise (S/N), and the linearity and dynamic range of the systems involved.

3.2.2 Acoustic Impedance

Knowing the reflection coefficient and the impedance of the water allows the solution of the equation:

$$R_{bot} = (Z_{bot} - Z_{wat})/(Z_{bot} + Z_{wat}) \quad (5)$$

Z_{bot} = acoustical impedance of the bottom surface
Z_{wat} = acoustical impedance of the water
R_{bot} = bottom reflection coefficient

Knowledge of the absolute subbottom surface acoustic impedance allows the calibration of the Caulfield Engineering Acoustic Core software. This software computes an estimate of the impedance for each subsequent layer into the bottom until the S/N becomes too low to provide meaningful data. These impedances are based on estimated absorption through the bottom. The general absorptive properties of bottom sediments

are provided in the literature.

The CE Digital Spectral Analysis software is used to verify the literature absorption data (Hamilton, E.L, 1972). If very precise results are desired, several deep core logs can be taken to identify the deepest layer. The absorption can then be adjusted until the impedance of this deeper layer matches that of the core data. These deep cores were not taken on this exercise.

Most subbottom systems insonifies an area of the bottom and not a point. This area is analogous to the illuminated area produced by a flashlight held above a floor and pointed straight down at the floor. Therefore, geotechnical parameters derived from seismic data are averages over the insonified area. The size of this area can be controlled by the beam pattern (the angle of the beam), although some aerial extent is always involved. This average lower limit of the insonified area for the Trenton Channel survey, with a mean water depth of 8 meters and a beam angle of 30 degrees, is 14.4 square meters. The diameter of this area is 4.28 meters.

3.3 Transmission Loss Model for Linearity

Once the sound source has been derived from a number of calibration locations, the calibration data as a function of depth can be corrected for amplifier gains and plotted on a ideal spherical spreading plot. This plot will confirm the linearity of the system and ensure that the calibration data were all acquired within the main beam pattern.

This simple procedure, if positive, provides a quick check that all systems and acquisition procedures meet the overall Quality Assurance Project Plan. Results indicated that all quality assurance objectives where met.

4.0 MOBILIZATION ACTIVITIES AND EQUIPMENT CONFIGURATION

Starting on Monday morning, July 24, 1995, the Acoustic Core© system was set up on the "R/V Mudpuppy" and the equipment was checked to ensure that no damage occurred during shipment. The Digital Field Acquisition System sampling period was verified and calibrated. It was determined that because of the high resolution required, a sampling period of 30 microseconds would be used. This is a sampling rate of 33333 Hz. The following subsections outline the system installation parameters and provide block diagrams of all systems configurations. The sonar equipment layout was exactly the same as occurred the year before with the exception that the received signals were fed directly to the filter without proceeding through a preamplifier. Preamplifiers are part of the standard Acoustic Core acquisition package and are used to match the electrical characteristics of the various different available receiving arrays. Also, because of the large storage disks now available, EPC records and tape backup were not required. After each run multiple copies of the data were backed up on these 230 Mega-byte disks. Because the same setup was utilized, Caulfield Engineering took the liberty of using the same drawings as previously used.

4.1 Vessel Layout, Transducer Placement, and Equipment Configuration

Figure 4-1 illustrates the general vessel layout and the placement of the equipment. The 3.5/7.0 KHz transducers were mounted from the forward catwalk on specially constructed wooden reinforced frames. The critical dimensions were a spacing between the transducers of 34 inches and a depth below the water of 20 inches. Note that Figure 4-1 has a typographic error and reports this depth as 28 inches. This mounting provided excellent Signal-to-Noise conditions and virtually no engine or ship noise was detected during the entire survey. The boomer and receiving array phone was towed off the port side aft of the vessel. A 10 foot boom provided separation between the boomer tow cable and the receiver tow cable. During the survey activities the tow distances were adjusted to optimize the boomer signal. Each tow configuration was recorded in the field logs and will be given, when appropriate, during the analysis. Since the boomer is a low frequency device the separation between the receiver and the boomer only has to be known within +/- 1 foot. The precise separation is recorded by the direct arrival on the acoustic data.

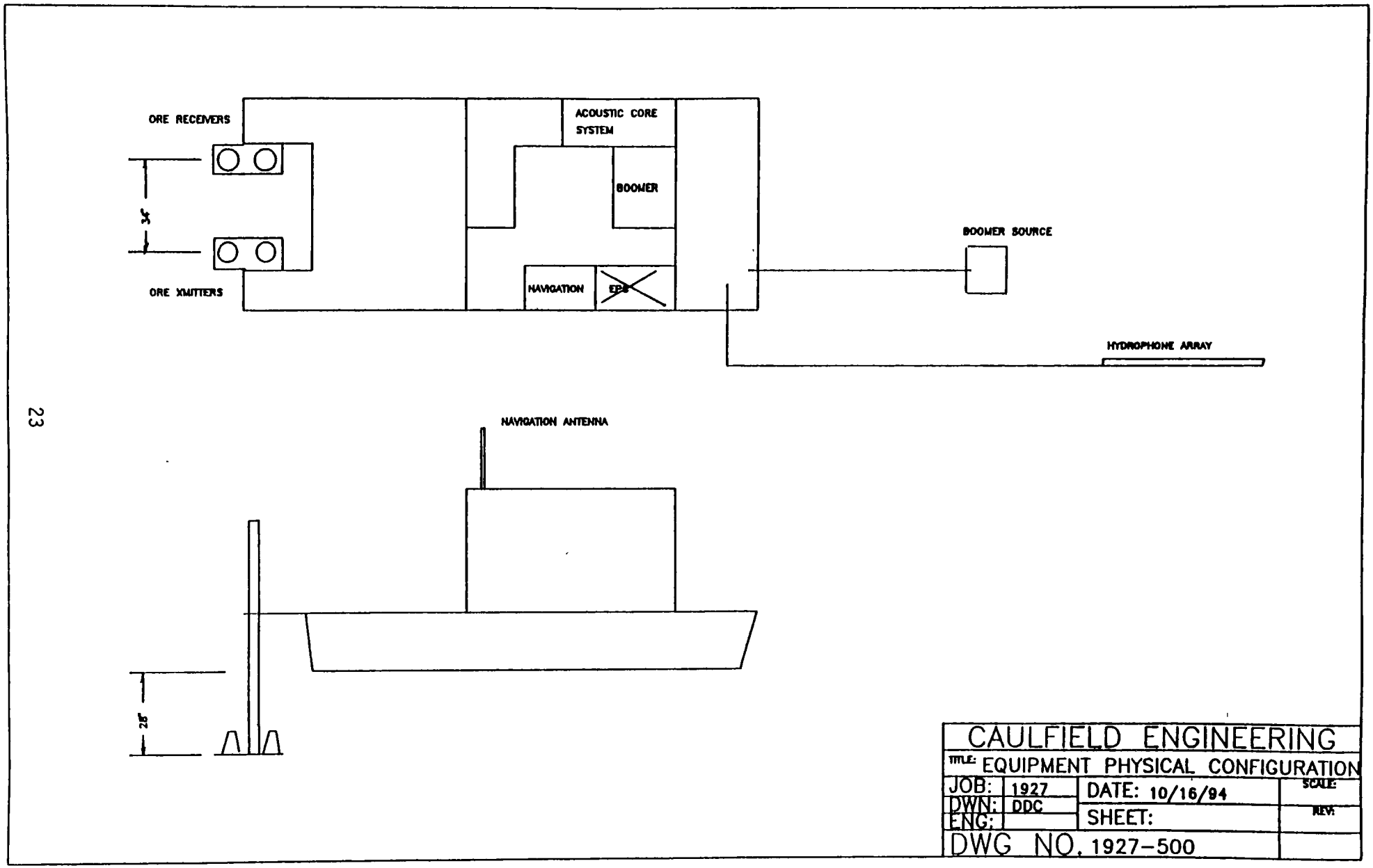

ORE RECEIVERS
3'
ORE XMITTERS
ACOUSTIC CORE SYSTEM
BOOMER
NAVIGATION
EPC
BOOMER SOURCE
HYDROPHONE ARRAY
NAVIGATION ANTENNA
28'
CAULFIELD ENGINEERING
TITLE: EQUIPMENT PHYSICAL CONFIGURATION
JOB: 1927
DWN: DDC
ENG:
DATE: 10/16/94
SHEET:
SCALE:
REV:
DWG NO. 1927-500

Figure 4-1

The Acoustic Core computer and receiver components were located in the rear starboard side of the vessel cabin with the computer console located on a table above the boomer power supply. The EPC data logging unit shown located on the port aft part of the boat was not needed. The navigation receiver and processing computer was located on the starboard side of the vessel cabin as the cabin configuration had changed from the previous year. All data times logged utilized the UTC time provided by the GPS satellite receiver. As the weeks of data acquisition progressed, a small linear time difference developed between the Acoustic Core computer and the navigation time. This difference was logged in the field records. A computer program was used to co-relate the file numbers and subfiles to the correct times. Appendix A3 provides the detailed listing of these corrected navigation files.

During the afternoon of Tuesday, July 25, 1995, initial field tests and calibrations were carried out to determine optimum ping lengths and proper transducer impedance matching to obtain the best resolution with the ORE system. These optimizations were logged and equipment configuration finalized. The next sections delineate the equipment configurations arrived at as optimum for this survey.

4.2 3.5/7.0 KHz ORE Equipment Organization

Figure 4-2 provides the block diagram of the 3.5/7.0 KHz ORE equipment configuration for this survey. The transmit cycle was initiated by a signal generator rather than the key of the EPC, which then triggered the CE-1000 Key Generator (which has precision pulse width control) and then the Model 140 transmitter. This transmitter has an output power level that is continuously adjustable from 0 to 10 kilowatts. 5.0 kW was used throughout most of the survey. The same key initiates the digital recording of the ping trace in the acquisition computer.

The receive transducer is loaded with an attenuater (100 ohms) to minimize transducer ringing. The received signal is then passed through a high-pass (HP) filter to the CE-1000 gain amplifier. The data is recorded in the digital acquisition system and stored on the 230 Mega-byte disks, and monitored on a Textronic Oscilloscope.

Data was digitized with a sampling period of 30 microseconds which is four times the highest frequency range of interest. This sample rate of 4 times the highest frequency insures that any wave form distortion is correctly digitized.

4.3 Boomer Equipment Organization

Figure 4-3 provides a block diagram of the boomer recording configuration. The only difference from the ORE configuration was that the attenuater was not used and an IO (InterOcean) single element array was used as a receiver. The key (trigger) fired the

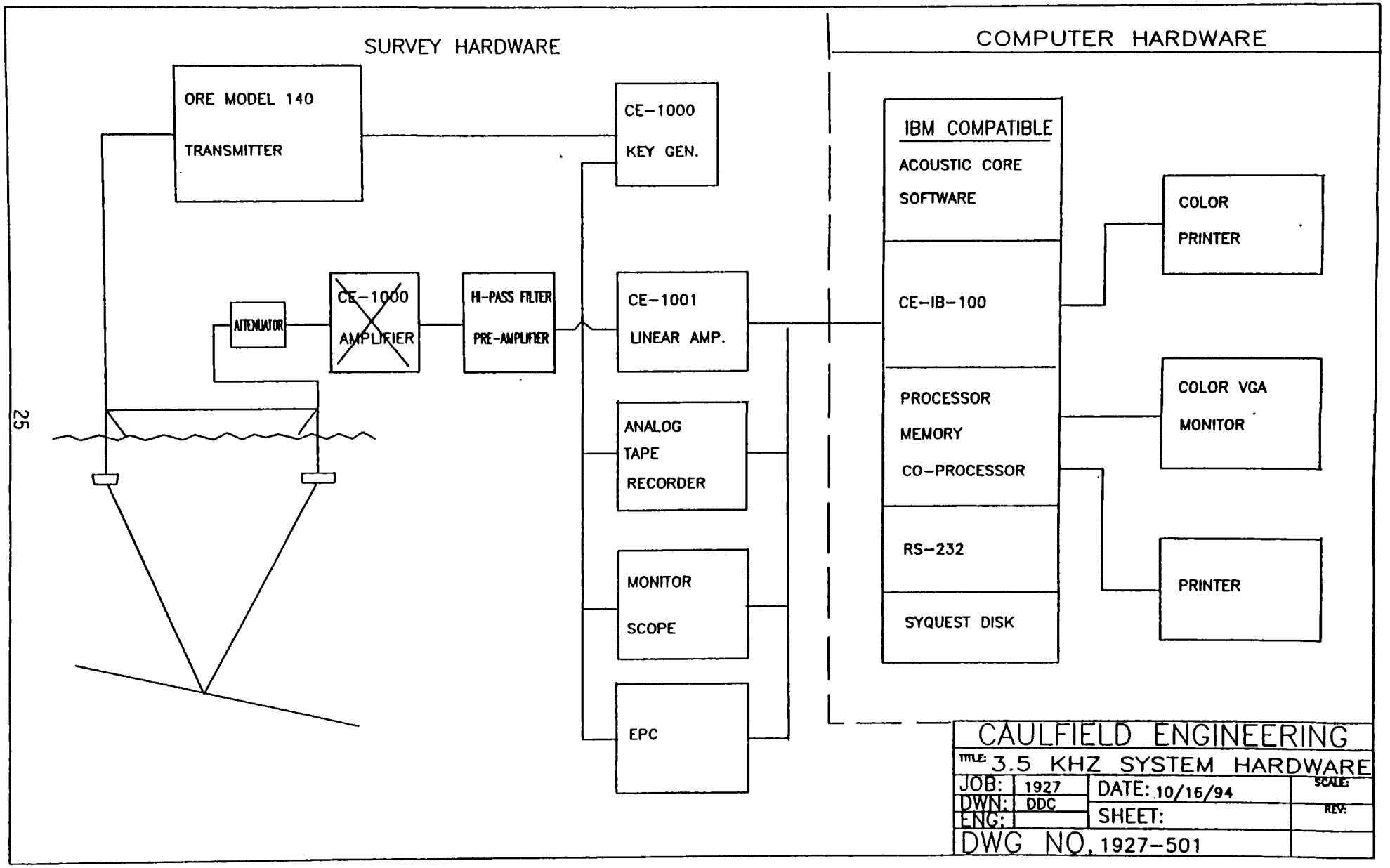

SURVEY HARDWARE
COMPUTER HARDWARE
ORE MODEL 140
TRANSMITTER
CE-1000
KEY GEN.
IBM COMPATIBLE
ACOUSTIC CORE
SOFTWARE
COLOR
PRINTER
ATTENUATOR
CE-1000
AMPLIFIER
HI-PASS FILTER
PRE-AMPLIFIER
CE-1001
LINEAR AMP.
CE-IB-100
ANALOG
TAPE
RECORDER
PROCESSOR
MEMORY
CO-PROCESSOR
COLOR VGA
MONITOR
MONITOR
SCOPE
RS-232
PRINTER
SYQUEST DISK
EPC
CAULFIELD ENGINEERING
TITLE: 3.5 KHZ SYSTEM HARDWARE
JOB: 1927
DWN: DDC
ENG:
DATE: 10/16/94
SHEET:
SCALE:
REV:
DWG NO. 1927-501

Figure 4-2

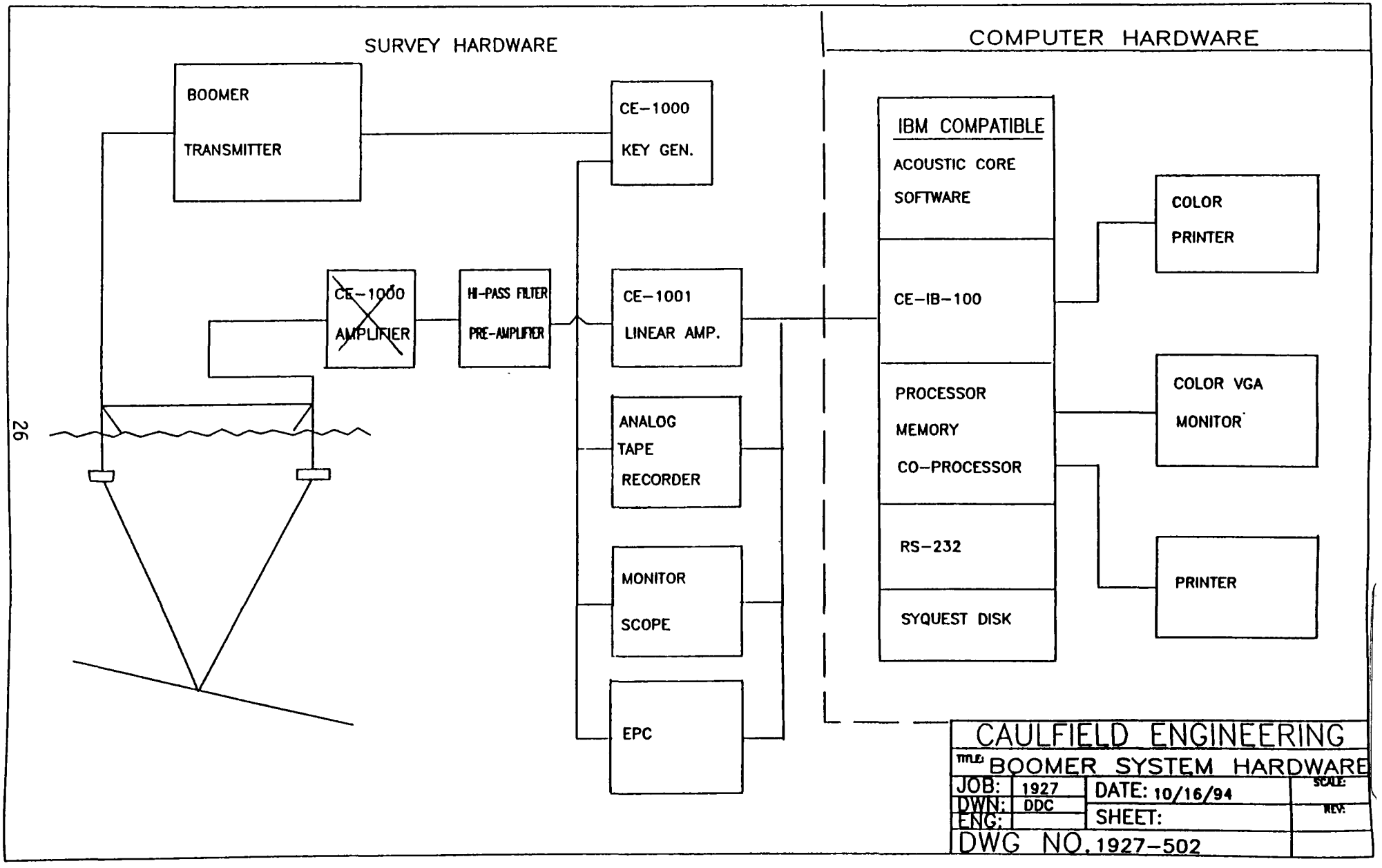

SURVEY HARDWARE
COMPUTER HARDWARE
BOOMER
TRANSMITTER
CE-1000
KEY GEN.
CE-1000
AMPLIFIER
HI-PASS FILTER
PRE-AMPLIFIER
CE-1001
LINEAR AMP.
ANALOG
TAPE
RECORDER
MONITOR
SCOPE
EPC
IBM COMPATIBLE
ACOUSTIC CORE
SOFTWARE
CE-IB-100
PROCESSOR
MEMORY
CO-PROCESSOR
RS-232
SYQUEST DISK
COLOR
PRINTER
COLOR VGA
MONITOR
PRINTER
CAULFIELD ENGINEERING
TITLE: BOOMER SYSTEM HARDWARE
JOB: 1927
DWN: DDC
ENG:
DATE: 10/16/94
SHEET:
SCALE:
REV:
DWG NO. 1927-502

Figure 4-3

boomer rather than the ORE transmitter. The boomer energy level was 100 joules. This provided the broadest band transmit signal. In this configuration the filter was used as a band-pass filter rather than a high-pass filter. Filter settings are recorded in the field logs. In Figures 4-2 and 4-3 the preamplifier boxes have been crossed out to indicate that separate boxes were not used for pre-amplification. The filters employed had the ability to provide pre-amplification when needed. However, the crossed out boxes have been left to indicate that there was modification to the standard set up.

Unfortunately, the variation in ship position during the initial calibration of the boomer, caused the Caulfield Engineering team to erroneously select the IO receive transducer that had only a maximum output voltage of +/- 2 volts. This prohibited optimum calibration of the source level of the boomer. This further caused the clipping of some of the boomer data in shallow water and made the boomer data unreliable for absolute reflection computations. However, the data were still useful for determining layer thickness. There was sufficient other data at the 7.0 and 3.5 kHz to overcome this limitation. The reason that this receiver was selected was its the maximum sensitivity and good S/N data generated in heavily polluted areas, such as the Elizabeth Park Channel.

4.4 Radar Systems

A GSSI ground penetrating radar was employed as an additional sensor, in an attempt to gain additional information on polluted sediments in very shallow water. The system used a GSR-3 transceiver with a selection of 100 MHZ and 300 MHZ antennas. The larger 100 MHZ antenna was placed in a rubber boat, while the 300 MHZ antenna was lowered by the forward deck winch. The GSR-3 receiver output was coupled directly to the filter input of the Acoustic Core© system electronics which allowed digital logging of the data.

The system was extremely noisy, in part due to the loading of the antenna by the higher than normal water conductivity, and the ship's generator noise. Data quality was poor and time did not allow for acquisition of all planned data as the boat operator backed onto the tow cable cutting it. It required several days to get a replacement and so only limited data was acquired.

Even with these setbacks some important observations were obtained. Primarily, in polluted sediment areas, the water conductivity above the sediments was higher than normal clean water. Further, the actual sediment conductivity was higher than unpolluted sediments. Appendix A4 provides this information. The radar system also provided an excellent way to precisely measure the water depths and shallow sediments thickness in very shallow, less than 3 feet, water depths. At these depths, it is extremely hard to use normal incident acoustic waves, as the receive signal is still within the time domain of the transmit pulse. Move outs are used in acoustics to get around this problem, but because

of the large reflection angles involved the depth measurements are not as accurate as desired.

Since some of the radar noise was coherent, statistical noise removal computer programs can be generated. Contract time and budget limitations prohibited detailed processing of the radar data.

4.5 Core Velocimeter Systems

Caulfield Engineering manufactured a prototype Core Velocimeter System to measure the sound velocity and sound absorption across the core tube as soon as the core was brought on board the vessel. This procedure was important for the detection of in-situ gas in the core. Since the core is no longer underwater, the gases quickly dissipate and are not detected in the geotechnical laboratory. The results of these measurements confirmed the presence of gas by the high absorption of the 300 Khz signal used in the velocity measurements. Appendix A4 provides this information along with the core data.

The Core Velocimeter System consisted of a 4 foot high steel frame that contained a mounting block to center the core in the unit. On each side of the core was a 300 Khz transmitting and receiving transducer that could be precisely placed at different elevations along the core tube. This allowed the direct measurement of the travel time through the core tube. At this time the system only obtained relative measurements, as time did not allow for precise calibration of the system. The only calibration was to measure the water in the top of the core and relate the amplitude and velocity measurements to the speed of sound in the water. In most cases the absorption was so great, due to the gas content, that no data was acquired.

The USACE-WES has a precision system for performing the same type measurements. The cores were carefully capped and taped securely and shipped to WES for analysis. The USACE staff found the same results, complete absorption due to gas.

5.0 SURVEY ACTIVITIES SUMMARY

The base of daily operations was a dock located at Elizabeth Park just north of the main car bridge to Grosse Ile. The area just north of the dock and extending out from the Elizabeth Park Canal is known as the Elizabeth Park site. Further to the north is the Black Lagoon site. It is located just south of a small indentation or miniature bay in the river. It is important to note precise satellite navigation was used at all times and detailed logs of boat position as a function of time were generated by USEPA. Appendix A2 provides these logs.

5.1 Area Overview

These main survey areas are on the west bank of the Trenton Channel portion of the Detroit River. This channel is between the mainland and Grosse Ile. Figures 5-1 and 5-2 provides maps for the channel indicating the Elizabeth Park and Black Lagoon study areas. Running three different sound sources over these areas provided 100 percent of the planned coverage. At each of the areas multiple surveillance lines were taken. Ten detailed calibration sets of data were taken for each sound source.

5.2 Summary of Field Logs

Appendix A1 provides a complete summary of all survey lines and calibration stations (actual field log). This field log provides the reference 4 character start of the file name and the 4 character file number which constitutes the entire file name. Also provided are comments on the significant activities occurring at given data subfiles. For reference to the navigation, the file navigation time is given as well as the file start time. The latter is given because of the slight growing deviation between the Acoustic Core computer time and the satellite time. The type of sound source employed and gain setting are also annotated.

5.3 Quality Assurance Logging Procedures (Examples)

To ensure that all quality assurance criteria were met, detailed manual logs were kept in addition to the digital logging of events in both the navigation and Acoustic Core© system. This section provides examples of the raw logs as follows:

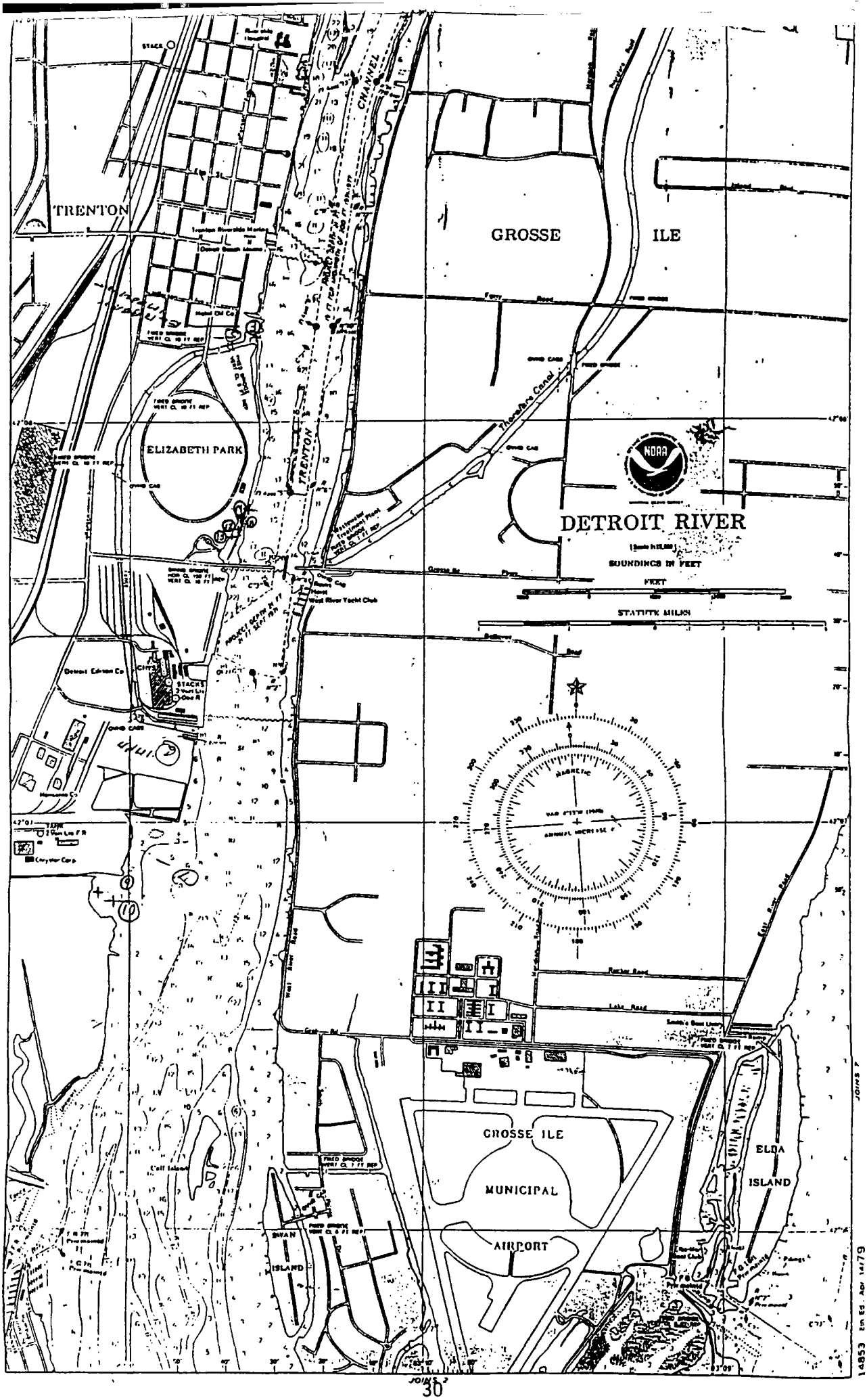

TRENTON
GROSSE ILE
ELIZABETH PARK
TRENTON CHANNEL
Thorofare Canal
DETROIT RIVER
SOUNDINGS IN FEET
FEET
STATUTE MILES
West River Yacht Club
Detroit Edison Co
STACKS
GROSSE ILE MUNICIPAL AIRPORT
ELBA ISLAND
SWAN ISLAND
Calf Island
Rocker Road
Lake Road
West River Road
East River Road
JOINS 2
JOINS 7

Figure 5-1

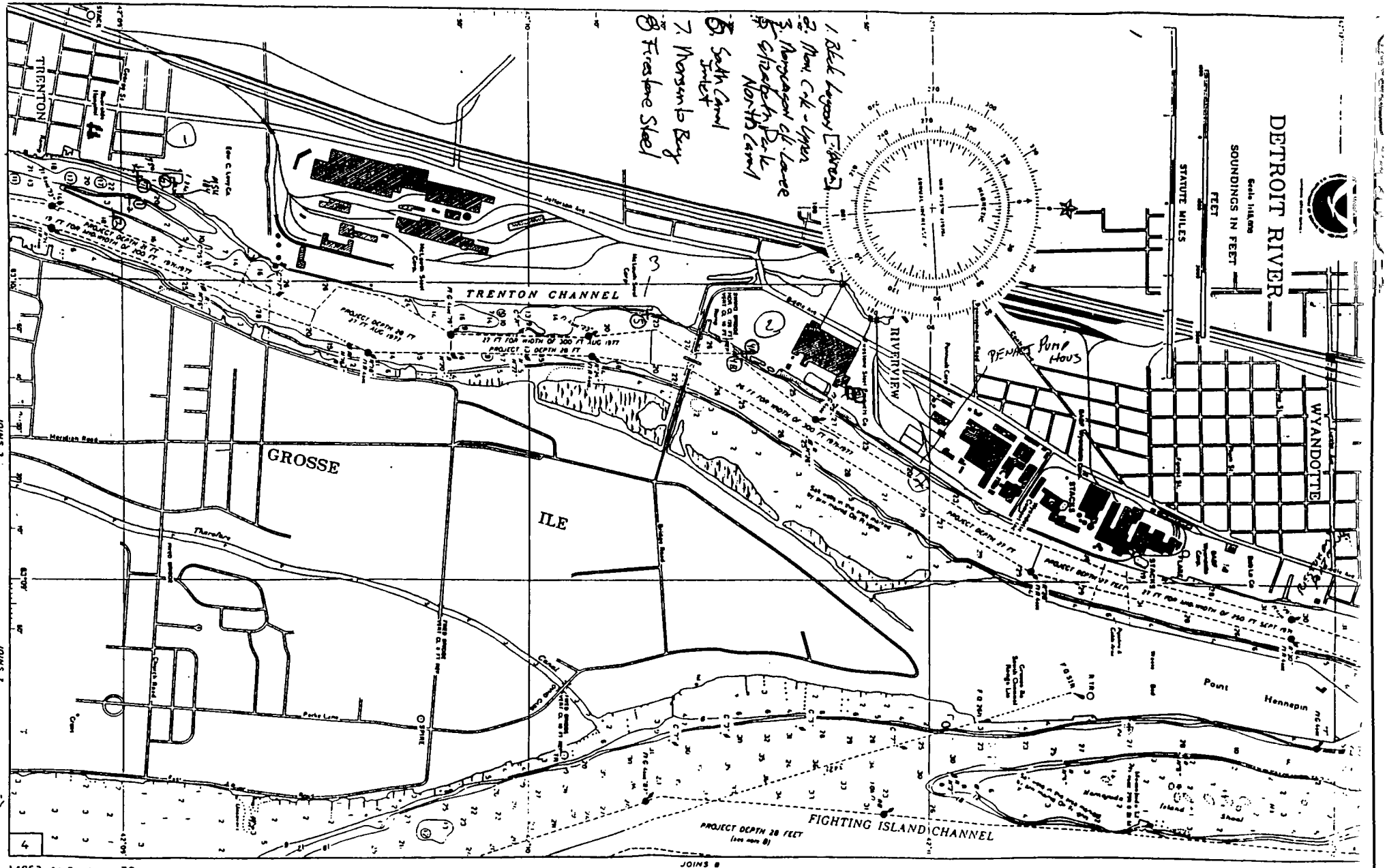

DETROIT RIVER
SOUNDINGS IN FEET
STATUTE MILES
TRENTON
TRENTON CHANNEL
RIVERVIEW
WYANDOTTE
GROSSE
ILE
FIGHTING ISLAND CHANNEL
Point Hennepin
PROJECT DEPTH 28 FEET
JOINS 8
JOINS 3
JOINS 7
14853 8th Ed., Apr. 14/79

Figure 5-2

1. Digital Field Acquisition input parameters (DFAS) Computer Log - Each time the DFAS system was run in the field a print out sheet was generated with all the important sampling rate information and acquisition parameters. See Figure 5-3.

2. Subbottom Survey Field Notes - A manual field log of events was maintained with subfile information versus time, gain settings, and general events. The time logged on this form is the GMT or Universal Time Constant (UTC) from the satellite navigation system. See Appendix A1.

3. Navigation Manual Log - In addition to all of the digital logging of the navigation system, a manual log of navigation events was taken to ensure complete tie in of the navigation with the Acoustic Core© system. See Appendix A2.

4. Field Core Log - Appendix A4 provides the field log of the coring program along with the sound velocity field logs and conductivity (resistivity) measurements made.

5. DFAS Playback Log - For each record played back the computer prints out all the key parameters. This log was checked with item 1 above to ensure consistency in the critical parameters. See Figure 5-4.

6. Playback File, Date and Time - During each playback the computer can generate the exact file and subfile date and time. This data is used to verify the manual logs and to cross check the Acoustic Core position with the navigation versus time. See Figure 5-5.

All field records were played back and all computer logs checked with the manual logs and navigation logs. This comparison showed that noise interfered with the Caulfield Engineering DF25 acquisition software causing the acquisition computer to lose time. These logs were used to construct computer programs to recreate the exact positions and times to each file and subfile. Appendix A3 provides this information.

5.4 Navigation Procedures and Interface to Data

A complete computer controlled DGPS navigation acquisition system was installed on the vessel and recorded the vessel position every 3 seconds, as well as providing the master timing for all events. At the time of the survey, differentially corrected positions were available in real time, however time was not available to establish a direct link between the Acoustic Core© system (ACS) and the navigational computer. Such an interface would facilitate the incorporation of navigational data into the Acoustic Core© system. For this survey the USEPA provided a complete set of ASCII files of differentially corrected position versus time to Caulfield Engineering, which were incorporated into the Acoustical Core System. The vessel position were then

DIGITAL FIELD ACQUISITION INPUT PARAMETERS

Job Title: eliz park cal at core site 8
Line num.: ec01
Start coords: 7`1365
Seismic source: 4098449
Comments:

Print Variables (1=Y,0=N):	1
Tape startup delay?:	50
Tape Speed factor? (1,2,4,8):	1
Original Tape Speed?:	2
A/D Sampling Rate? (20-1000):	30
Cent. freq. of system?:	7000
Water Column delay?:	0
Offset value in ms?:	0
Traces to stack? (1,2,4,8):	8
Enter trace length :	700
Ampl. Spher.Corr. (1=Y,0=N):	0
Spher. Time Delay (ms.):	10
Enter Gain Factor (1000=1):	1000

FIELD ACQUISITION COMPUTER LOG

Figure 5-3

DIGITAL FIELD ACQUISITION INPUT PARAMETERS

Job Title: eliz park canal cal
Line num.: ec01
Start coords: 0000
Seismic source:
Comments: calibration

Print Variables (1=Y,0=N):	1
Tape startup delay?:	50
Tape Speed factor? (1,2,4,8):	1
Original Tape Speed?:	2
A/D Sampling Rate? (20-1000):	30
Cent. freq. of system?:	3500
Water Column delay?:	0
Offset value in ms?:	0
Traces to stack? (1,2,4,8):	2
Enter trace length :	700
Ampl. Spher.Corr. (1=Y,0=N):	0
Spher. Time Delay (ms.):	10
Enter Gain Factor (1000=1):	1000

PLAYBACK COMPUTER LOG

Figure 5-4

accurately post plotted versus time.

The plots of vessel position were generated by Caulfield Engineering for each analysis set of data and are supplied with each specific set of data presented in Volume 3. In fact, the excellent quality of the navigation data enabled Caulfield Engineering to perform the required statistics for each calibration area to correct for those locations where the ship drifted during the calibration procedure.

6.0 SITE CORE INFORMATION

In order to rapidly gather actual physical core samples for correlation with the acoustic surveying, Caulfield Engineering acquired and modified a Benthos Boomerang Corer to function as a drop piston corer. The core tube diameter was approximately 3 inches in diameter and provided sufficient sediment to classify the sediment and obtain precision in-situ densities. Modifications to the corer included adding steel handles for rigging, installation of a piston sealer (to prevent core drop out), and the addition of more weights. The system worked extremely well and 19 cores locations were sampled. In a few locations, the bottom was rocky and no sample was obtained. In these situations a ponar dredge was used to verify bottom type, providing useful information. Also, the ponar dredge was used to select potential core site locations.

The coring system was small enough so that the corer could be deployed between the forward 3.5 KHz transducers allowing continuous subbottom profiling to occur during coring activities. The only problem encountered was the boat operating personnel who at times refused to anchor or provided poor anchoring at some sites. The latter caused some difficulty in analysis. Statistical processing, as discussed for the calibration data, was undertaken for those cases.

It is important to note that this coring system does not remove the requirement to take vibra-cores in the future. However, it does provide a rather inexpensive system for rapid coring to confirm the acoustic measurements and to map softer depositional sediments.

6.1 Field Core Logging

Figure 6-1 is a typed copy of the typical field core log. The core length was measured and the distances to the top of the water level and the top sediment-water interface were measured from the bottom of the core. These dimensions allowed for the computation of the volume of sediment in the core. The core was then weighed using an electronic scale. The scale had a sling attached to keep the core vertical. The tare weight is the weight of the scale rigging. The offset weight is the scale reading empty. For the particular scale being used the tare weight and the offset weight were not the same. Later it was found how to zero the electronic scale so that only the core weight was measured directly. With the known dimensions of the core and the distances to each medium, the water, empty core tube, tare, and offset are subtracted from the total weight

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG6

CORE NO: 6

STATUS (CUT/NOT CUT): CUT

SITE: Eliz. Park Cove - Same loc. as Core #5

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT: 101.5

WEIGHT TOTAL CORE: 13.312 lbs

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.18 gm/cm^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Sediment							
	71.5	71.5	1500	5	144		
		73.0		4	136		
		73.0			140		
		74.0		2	152		
		70.7		3	142		
		70.0			168		
		69.5			164		
					250		
		68.4			180		
	89.0	87.8	1400	5	160		
		89.0			164		

TYPICAL FIELD CORE LOG

Figure 6-1

and the resultant average density of the core is computed. The repeatability of this technique was very good. After the core was measured the water was removed and the unused portion of the core tube core was removed. Next the core was capped and sealed for storage and shipment. After cutting, the core was weighed again to confirm the first density measurements.

A portable velocimeter was used to measure the travel time of a sound wave across the core at selected depths. The lower portion of Figure 6-1 shows the logged travel time for the sound wave traveling though the sediment and core tube. To eliminate core tube effects, data was taken at various offsets. An offset of zero would place the measuring transducer directly across from each other. Other offsets were generated by keeping one transducer fixed and moving the other transducer either up or down, creating offsets. Velocity measurements were taken along the core tube at various distances, in centimeters, from the sediment core surface.

Early in the program some dielectric measurements were also taken for use in the analysis of the radar data. The same dielectric plates were also used to obtain the in-situ conductivity. Unfortunately, the bottom sediments were such that the epoxy holding the system together was eaten away destroying the dielectric measurement system. Those dielectric measurements obtained are included in the core log, Appendix A4.

It is very important to note that these core analysis procedures are preliminary. The primary goal was to obtain the gross density for calibration of the acoustic measurements and to note gross anomalies from standard marine sediments and to begin optimizing field procedures. The more data available from many different sensors improves the analysis conclusions.

An important visual observation in almost all cores collected in polluted areas was the existence of a ½ to 3 inch foam layer at the sediment-water interface. This indication of low velocity at the sediment water interface should be confirmed using current meters. The existence of surface foam would suggest that re-suspension as a result of current velocity must be low. In these areas, gas transport may be a more suitable model than sediment re-suspension, to explain the re-entry of contaminants into the water column. It is strongly suggested that detailed chemical analysis be carried out on the foam during the next survey. This might shed additional information on the re-suspension of the pollutants.

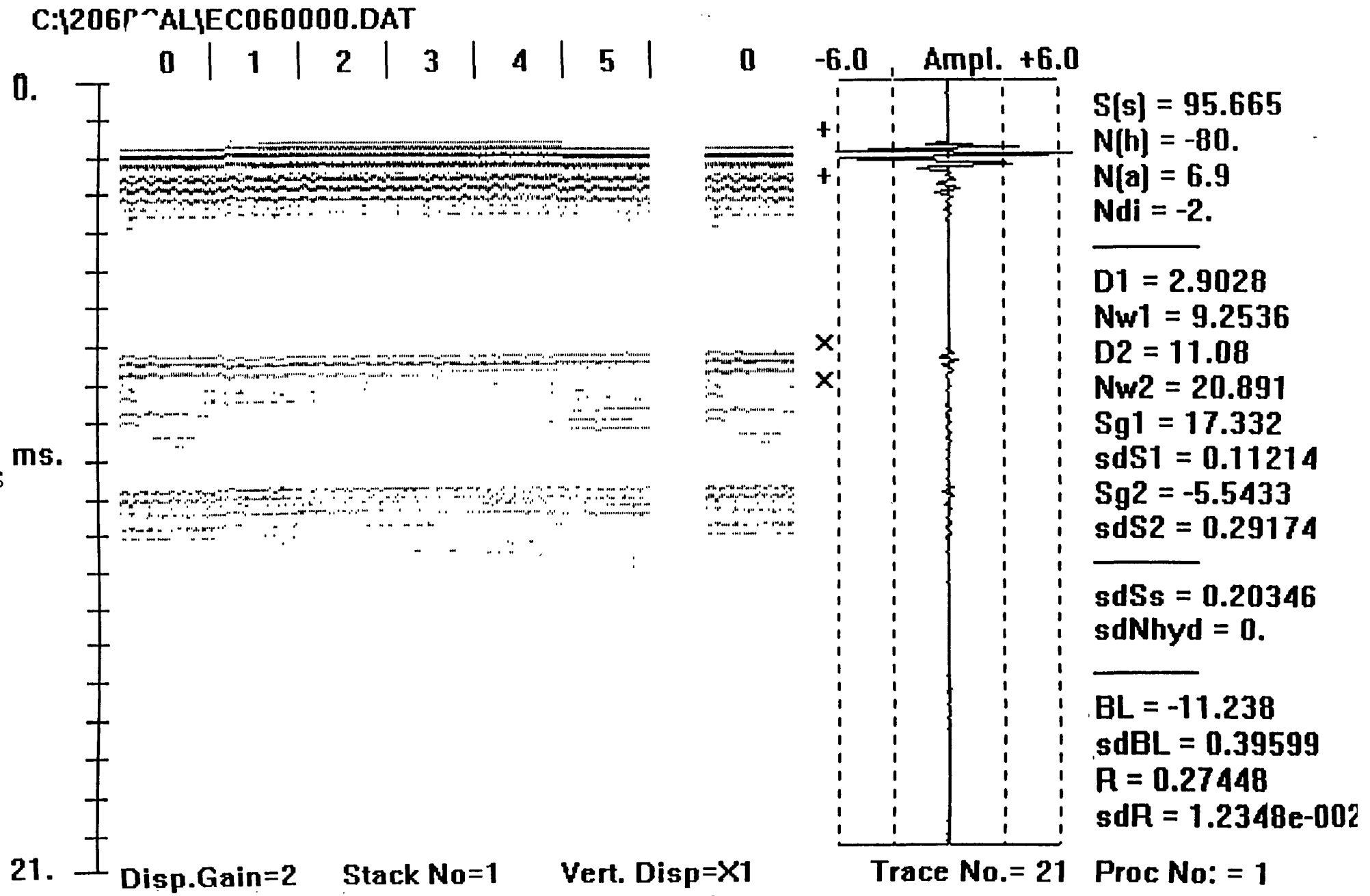
7.0 DETAILED CALIBRATION ANALYSIS

The calibration procedures utilized in the Acoustic Core methodology were critical in obtaining engineering data on bottom marine sediments and polluted sediments. A description of technical terms and software display descriptions can be found in appendix A3 in volume 3. Absolute knowledge of the mean source levels and their spatial variance allows absolute computation of the bottom reflection coefficients (Bottom Loss), reflection sign, and variance of the bottom. In addition, absolute knowledge of the bottom reflection aids in estimating the subbottom acoustic parameters and ensures the overall quality of the program. In previous surveys, the calibration procedures were processed using the Digital Field Acquisition System (DF25), Digital Spectral Analysis Software (DSA10), and Matlab. The effort was labor intensive and time consuming as color prints had to be generated and files had to loaded for each step of the processing. Caulfield Engineering, working with the USACE, integrated these steps into a Windows program with higher speed, black and white laser printing to speed up the processing. This new Windows program has been designated 'CAL1'.

The 'Cal1' program allowed the bulk processing of over 8000 traces (pings) in order to solve and develop procedures to overcome the problems caused by boat positioning and generator noise which occurred during this survey. This section will review the features of this new calibration software and then apply this software in a step by step manner to the Trenton Channel calibration data. Appendix A5 provides the complete calibration analysis sheets and logs, Appendix A6 provides the amplifier gain curves, and Appendix A7 supplies the idealized sediment properties Table. This table enabled comparison of the acoustic properties of "standard" marine sediments with polluted sediments found in the Trenton Channel.

7.1 'CAL1' Windows Program

The calibration programs perform the solutions of the Sonar Equation mathematical procedures outlined in Section 3 of this report. Figure 7-1 shows a typical 'CAL1' output. This particular figure is for calibration site EC06 and it shows the calibration hydrophone located at approximately 8 feet water depth. The first arrival is the direct wave to the calibration hydrophone, and the second arrival is the bottom reflection. The right side of the figure displays the computed results. Referring to this figure a summary of the features of the program will be given. An additional description of this calibration output is provided in volume 3, Appendix A3, A3.5. This description



TYPICAL "CAL!" OUTPUT
Figure 7-1

is provided to aid in understanding the extended calibration procedures undertaken for the Trenton Channel work.

The major program features and inputs are:

- File Selection - Allows the opening of any calibration or data file on any disk or server. This feature takes full advantage of Windows directory handling and file reading. An option will also be provided for reading in navigation and gain information. Time did not allow the completion of this feature.

- Vertical Scale - The time scale in milliseconds is given on the left of Figure 7-1. This scale can be expanded in steps of 2 to a 4 times expansion. In addition, an offset can be introduced to allow detailed examination of the wave form from a particular reflector. This feature is used to show the phase reversal when reflections occur from gas bearing sediments.

- Gain - It is often necessary to elevate the gain in order to look at weaker reflections. Gain steps of 1, 2, 4, 8 are available. This gain factor is incorporated into the sonar equation solutions and is normalized so that the solutions are independent of this display gain.

- Stacking - In noisy environments it is often desirable to stack sequential traces to improve the signal-to-noise. In the particular data shown in the figure this was not necessary. Stack steps available are 1,2,4,8.

- Function Inputs - Often in solutions of the Sonar Equation, it is necessary to input various terms such as receiver sensitivity and gain. The function inputs allow input of Source Level, Receiver Level, System Gain, Directivity Index, and Bottom Loss. The input functions depend on which Sonar Equation is being solved with the program's compute mode. In the example shown in Figure 7-1, the input parameters would be calibration hydrophone receive sensitivity, system gain, and directivity index. The output would then be the source level, transmission losses, and bottom loss (reflectivity). The statistical properties of each observation are also shown for evaluation of the quality of the computation. As an example the direct signal, reflecting the source, has a standard deviation of only 0.2917, while the bottom signal has a standard deviation of 2.533. This reflects the bottom loss variation at this point illustrating that even for this small sample the bottom exhibits a high degree of spatial variance.

- SubFile Selection - Computation is performed on either single traces in a subfile or on the entire subfile which represents 40 traces. In Figure 7-1 subfile '0' was selected and is shown just right of center in the figure. The subfile selection

corresponds to a physical navigation point in the subsequent detail analysis described in the next sections.

- Signal Selection The signal selection allows the selection of the particular trace to display in the amplitude plot. The program normally selects a trace near the center of the subfile. This function also allows the cursor selection of the location of the wave forms to be processed, namely, the direct wave and bottom. The direct wave in Figure 7-1 is shown by the '+' marks and the bottom reflection is selected with the 'x' marks.

- Computation - There are 5 solutions of the sonar equations. These are:

    1) - Compute *Source* level direct from known receiver, gain, directivity index. This is output shown in Figure 7-1.
    2) - Compute *Receiver* level direct from known source, gain, directivity index.
    3) - Compute *Bottom Loss* from known source, gain, receiver.
    4) - Compute *Receiver* level from known source, bottom loss, gain.
    5) - Compute *Bottom Loss* from multiples. Independent verification of computations.

The given computation process is indicated on the Figure by the Proc. No. given on the bottom right of the Figure 7-1. See Section 3.0 for the detailed sonar equations.

- Save Function - This operation allows the saving of the computed data to ASCII files. Two options are provided; computed data and computed data plus signals selected. The latter being used as the reference signal in the Acoustic Core Reflection/Sign software (ACRS1) used in Volume II analysis. Figure 7-2 illustrates the computed data save file. The ASCII file extension is '.cXs' where the X is the computational process number discussed above.

- Print Function - The print function allows the selection of a gray scale (dynamic range 32 db) as shown in Figure 7-1 or a draft print out without the gray scale, Figure 7-3. This latter output only takes one-third of the time to print and when doing bulk processing is adequate for documentation.

7.2 Detailed Calibration Statistical Analysis

Normal calibration procedures, as bid under this contract, required the selection of 40 or 50 subfiles (points) and computation of source levels of the various systems. The means and standard deviation was compared to the Quality Assurance criteria discussed earlier in this report. This was done in early October and each calibration location standard deviation just met the Quality Assurance criteria for the 3.5 and 7.0 Khz, but not

CAULFIELD ENGINEERING
Source, Receiver, Bottom Loss Calibration

CAL1 - Version 1.00

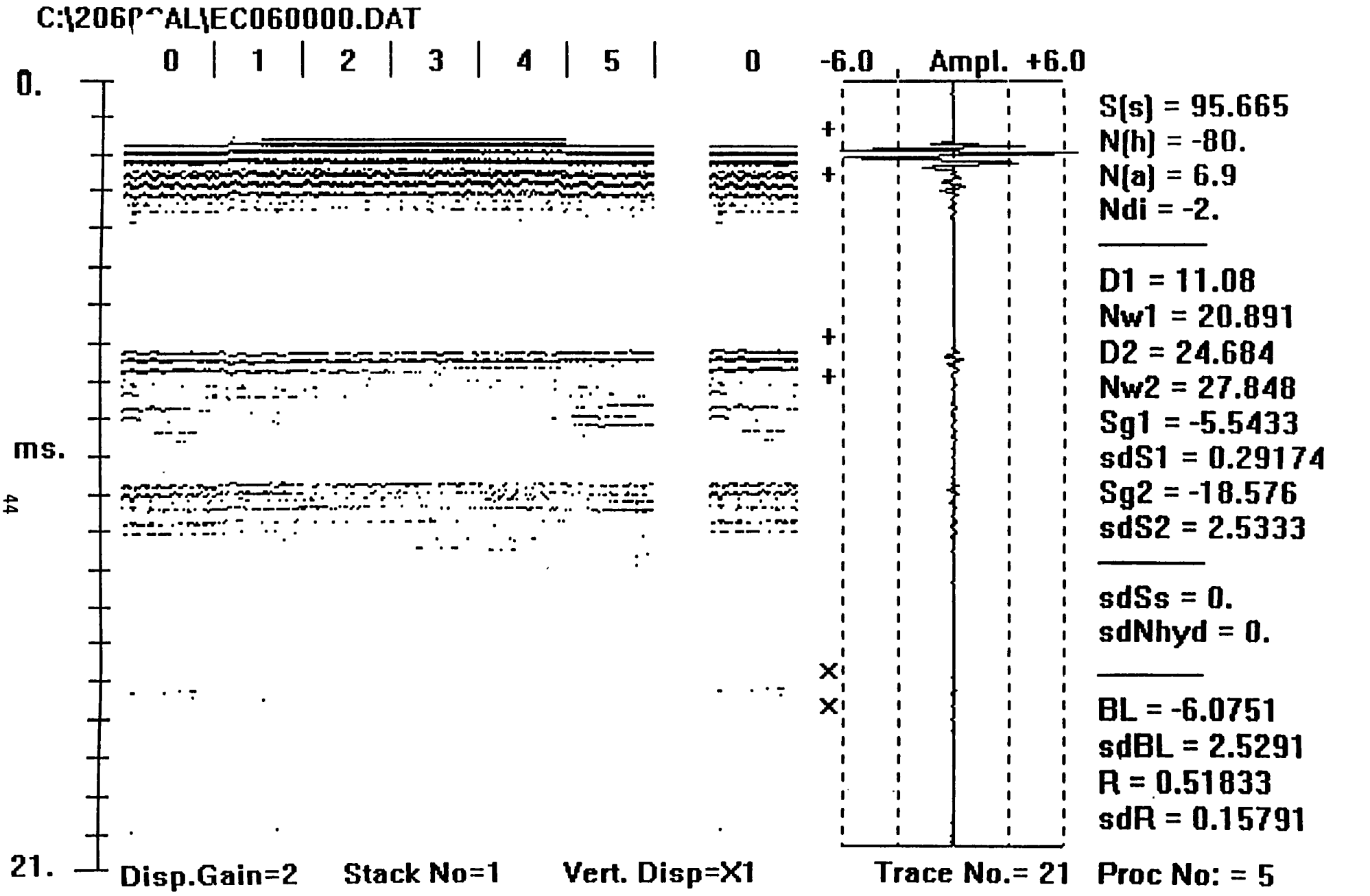
Position Northing - XXXXXXXX.XX
Position Easting - XXXXXXXX.XX

Original Path/File: C:\BJ\CAL\ELPRKCAL\EC010003.DAT
Sub File No.: 2
This File Path/File: C:\BJ\CAL\ELPRKCAL\EC010032.cd1
Process Type 1 - Source Direct, Known Receiver

Stack No.	= 2
Display Gain (db)	= 6.02
Source (db)- S(s)	= 80.37
Receiver Hyd. (db)- N(h)	= -80.00
System Gain (db)- N(a)	= 20.76
Beam Pattern (db)- Ndi	= 0.00
---	---
Depth 1 (m)- D1	= 3.83
Trans. Loss 1 (db)- Nw1	= 11.67
Depth 2 (m)- D2	= 7.91
Trans. Loss 2 (db)- Nw2	= 17.96
Signal 1 (volts)- S1	= 15.4817
Std. Signal 1- sdS1	= 0.1105
Signal 2 (volts)- S2	= -2.0416
Std. Signal 2- sdS2	= 3.0307
Std. Source- sdNs	= 0.1185
Std. Receiver- sdNhyd	= 0.0000
---	---
Bottom Loss (db)- BL	= -11.237
Std. Bottom Loss - sdBL	= 2.6933
Reflectivity- R	= 0.2875
Std. Reflectivity- sdR	= 0.0902

COMPUTED DATA ASCII FILE

Figure 7-2



TYPICAL "CAL!" DRAFT OUTPUT

Figure 7-3

for the boomer. Further, the source level values varied slightly from site to site exceeding the quality assurance criteria and the time loss in the acquisition computer was unexplainable. It was assumed that a quick examination of the data would explain the differences and the program could continue.

The first problem was identified while plotting out the ship's position recorded during calibration. Figure 7-4 illustrates the ship position for calibration site EC01 at the Elizabeth Park. The deviation from center is +/- 7.77 meters or a total extend of over 50 feet. Not only does the bottom reflection change, but the boat accelerating from point to point caused random position changes in the location of the calibration phone. In order to correct for this problem, it was determined that if the multiple reflection analysis gave approximately the same value as the direct calibration procedures, the answer was best. This required much more analysis than was normally done. Over 207 subfiles or points were processed to correct for this unstable position problem. This corresponds to over 8000 traces. The complete set of calibration records with their supporting notes is given in Appendix A5, along with computations.

The complete raw and processed data for each calibration site is summarized in Appendix A5. This Appendix A5 has reproductions of the field logs, a black and white copy of the colored playback seismic cross sections (with indicated calibration analysis numbers when appropriate), summary processing sheet, and all the 'CAL1' output sheets. Figure 7-5A and 7-5B are the actual draft working summary sheets of all observations. The headings are summarized as:

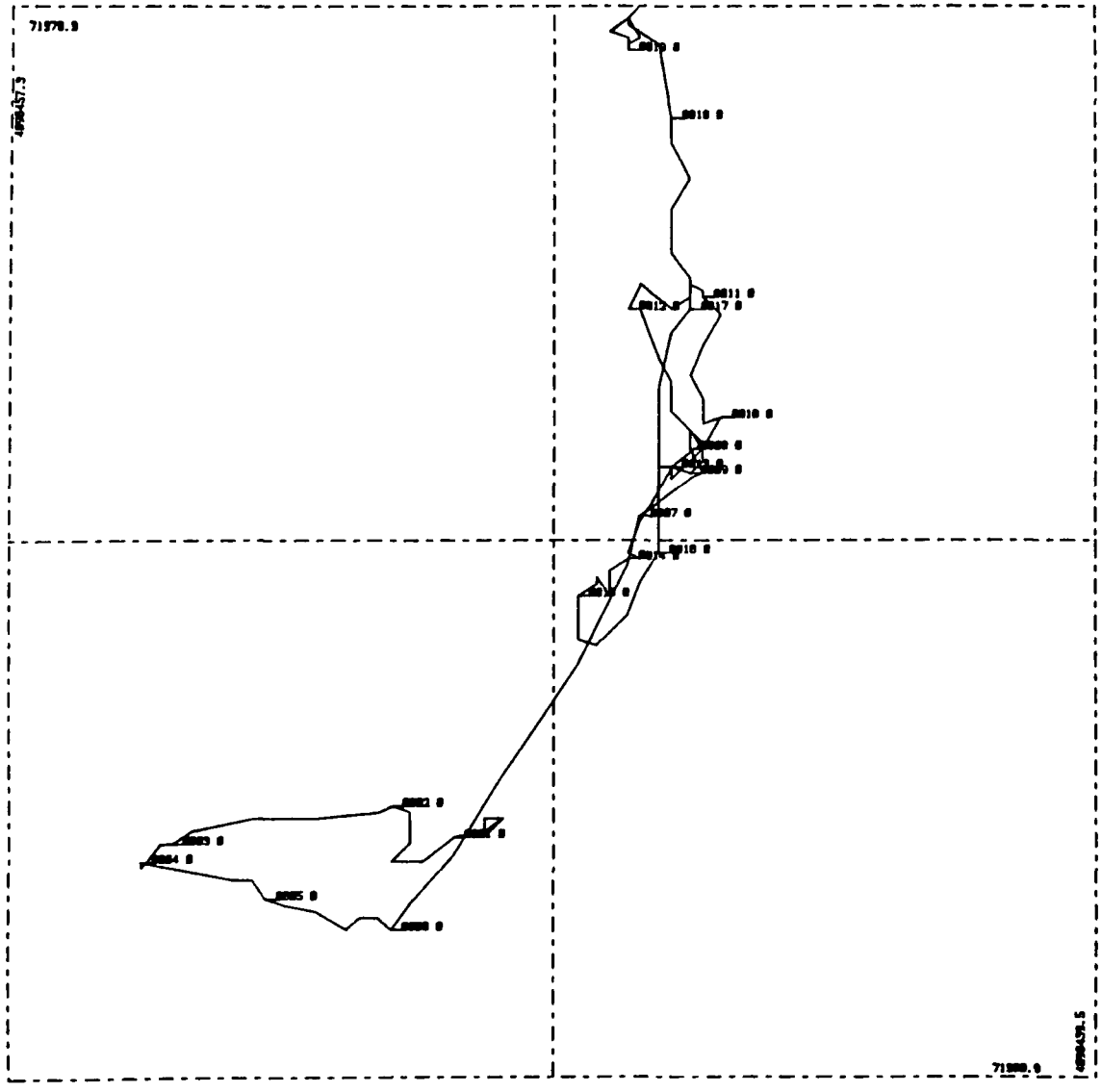
1) Event - This is the general site of the calibration and is given by the first 4 characters of the data file name. In event number one this is EC01. In this example E stands for Elizabeth Park and the C stands for calibration.

2) Location - The location is provided in State Plane coordinates of Northing and Easting and represents the mid-point of the navigation of the geographical areas delineated by the navigational data, and is not necessarily the mid-point of the observations. The convoluted movement of the ship, while on station, makes computing a true center point difficult.

3) Drift/Deviation - This is the maximum extent about the mid-point location. Values varied from +/- 60.9 meters to 1.58 meters. The latter is good survey practice. Only three sites out of the ten calibration sites met this criteria. This observation demonstrates the need for precise stable anchoring of the vessel during calibration.

4) System - The particular source or receiver under calibration. For example, the Massa (MS) as a source.

5) Frequency - The center frequency of calibration. Note that the 7 Khz system



SHIP'S POSITION AT SITE EC01

Figure 7-4

SUMMARY OF ALL CALIBRATION EVENTS

TRENTON CHANNEL SURVEY - 1995

JOB 2060 CAL PHONE SENSITIVITY -80.00 DB

EVENT	LOCATION NORTHING	LOCATION EASTING 489*	DRIFT DEVIATION METERS	LOCATION NAME	SYSTEM	FREQ.	SOURCE /RECEIVER	STD. DEV.	NO POINTS OBSERVED	MEAN B.L.	DEVIATION B.L.	COMMENTS
E7C4	71407.90	8515.40	+/- 60.9	ELZ. PRK	MS XMIT	7KC	93.06	1.42	12.00	-12.40	2.50	REFUSED ANCHORING
					CAL SURF.	7KC	93.06		4.00	-9.41	2.17	CAL PHONE AT SURFACE
					CRYSTAL	7KC	-105.49	2.67	6.00	-9.85	1.72	CRYSTAL SOURCE 93.06
					MS REC.	7KC	-91.57	1.04	4.00	-9.17	0.99	MASSA REC. SOURCE 93.06
					MS XMIT	3.5KC	100.60	3.29	3.00	-7.17	2.54	SOURCE MASSA 3.5
				✓	CRYSTAL	3.5KC	-96.60	2.00	5.00	-10.97	1.54	CRYSTAL SOURCE 100.6
					MS REC.	3.5KC	-77.77	4.00	2.00	-11.83	1.92	MASSA REC. SOURCE 100.6
EC01	71369.60	8448.50	+/- 7.77	ELZ. PRK	MS XMIT	7KC	85.26	1.72	6.00	-7.83	1.71	REFUSED ANCHOR, POW.1.2KW
					MS XMIT		91.26					COMPUTE POW 5.0 KW
					MS REC.	7KC	-80.26	6.00	5.00	-9.04	1.81	MASS REC. SOURCE 85.25
				✓	CRYSTAL	7KC	-95.00	3.20	2.00	-11.10	0.48	CRYSTAL REC. SOURCE 85.25
					MS XMIT	3.5KC	90.29	3.86	6.00	-9.03	1.99	MASS XMIT @ 1.2 KW
					MS XMIT		96.29					COMPUTE XMIT @ 5.0 KW
					MS REC	3.5KC	-81.00		1.00	-9.94		MASSA REC.
EC02	71368.50	8447.20	+/-8.25	ELZ. PRK	MS XMIT	3.5KC	91.97	1.89	6.00	-8.84	2.15	XMIT @1.2KW, NO ANCHOR
						3.5KC	96.97					COMPUTED @ 5.0 KW
					MS XMIT	3.5KC	103.61	0.29	3.00	-8.68	2.28	XMIT 3.5 @ 5.0 KW MEAS.
					MS XMIT	7KC	97.81	0.23	3.00	-8.54	1.48	XMIT LEVEL 5 KW
EC03	71365.40	8449.25	+/-2.80	ELZ. PRK	EDO REC.	7KC	-108.40	3.87	10.00	-7.72	2.70	SOURCE LVL 97.81
				✓	EDO REC.	3.5KC	-106.70	0.25	3.00	-9.77	1.68	SOURCE LVL 103.61
					MS REC.	3.5KC	-86.79	0.01	2.00	-9.71	0.30	MASS REC SOURCE@ 103.61
EC04	ATTEMPT TO CALIBRATE INTEROCEAN RECEIVER SEVERE NOISE - CANNOT PROCESS											
	EC05 ALSO WAS SUBJECT TO FLUCTUATING SEVERE NOISE											
EC05	71367.00	8448.05	+/-3.7	ELZ. PRK	BOOMER	0.8-3KC	62.08		1.00	-0.75		VERY NOISEY -80 CAL PHN.
					BOOMER	0.8-3KC	86.89	0.95	3.00	-5.19	0.08	BASED ON EDO @ -106 DB
					MS REC.	0.8-3KC	-90.10	0.00	2.00	-5.20	0.02	MASS REC. BOOMER
					CR REC.	0.8-3KC	-112.80		1.00	-5.22		CR REC. BOOMER

SUMMARY CALIBRATION OBSERVATIONS

FIGURE 7-5A

SUMMARY OF ALL CALIBRATION EVENTS PART - 2

TRENTON CHANNEL SURVEY - 1995

JOB 2060 CAL PHONE SENSITIVITY -80.00 DB

EVENT	LOCATION NORTHING	LOCATION EASTING 489*	DRIFT DEVIATION METERS	LOCATION NAME	SYSTEM	FREQ.	SOURCE /RECEIVER	STD. DEV.	NO POINTS OBSERVED	MEAN B.L.	DEVIATION B.L.	COMMENTS
EC06	71486.00	8535.88	+/-3.85	ELZ. PRK.	MS XMIT ✓	7KC	95.43	0.51	5.00	-8.86	2.77	SOURCE, ANCHORED PRT
					MS REC.	7KC	-80.43	1.07	2.00	-11.66	0.44	MS. REC. SOURCE 95.
					✓ CRYSTAL	7KC	-106.33	5.54	2.00	-10.41	2.33	CRYSTAL REC, SOUR. 9
					✓✓ CRYSTAL	3.5KC	-95.03	3.46	3.00	-8.37	1.10	CRYSTAL REC 3.5 SR100
					✓ MS REC	3.5KC	-80.70	2.10	2.00	-9.37	0.52	MS REC. 3.5 SOR. 100
					MS XMIT	3.5KC	100.38	2.18	8.00	-9.75	2.55	MS XMT CAL @ -80 DB
				INTEROCEAN RECEIVER - NOW LINEAR								
					IO REC	3.5KC	-79.95	5.11	4.00	-4.82	4.17	IO REC. SOURCE 100.
BCR4/19-24	72942.40	8815.00	+/-1.58	BLK. LAG.	MS XMIT	7KC	96.83	0.86	7.00	-4.29	1.65	XMT CAL 7.0KC, CAL -8
												CORE SITE 17/18 DEP 1
												IDEAL RL = -12.1 DB
					MS XMIT	3.5KC	96.30	0.83	3.00	-7.16	3.67	XMT CAL 3.5KC, CAL -8
					✓ MS REC.	3.5KC	-81.81	1.50	2.00	-10.95	0.99	MS REC 3.5 SOR 100.
BCR4/37-40	84.6M SOL/2.6 M PORT			BLK. LAG.	MS XMIT	7KC	94.83	0.59	3.00	-6.59	3.35	XMT CAL 7KC, CAL -9
												CORE SITE 19, DEP -1
												IDEAL RL = -20.9
					MS XMIT	3.5KC	97.86	0.09	3.00	-3.54	2.01	XMT CAL 3.5KC, CAL -9
					✓ MS REC	7KC	-78.23	0.75	3.00	-4.76	0.31	MS REC SOURCE - 96.
BLC5	72925.40	8737.65	+/-1.59	BLK. LAG.	MS XMIT	7KC	97.19	2.49	14.00	-10.59	3.83	XMT CAL 7KC CAL -8
					MS REC	7KC	-77.35	1.19	3.00	-10.83	0.94	MS REC CAL, SOURCE 9
					✓ CRYSTAL	7KC	-99.83	1.80	3.00	-10.91	1.46	CRYSTAL REC. SOURCE 9
					✓ EDO REC	7KC	-107.05	1.04	5.00	-11.45		
					MS XMIT	3.5KC	101.52	0.64	10.00	-9.80	3.37	XMT CAL 3.5KC,CAL -8
					✓ MS REC	3.5KC	-80.02	3.11	5.00	-10.52	1.98	MS REC 3.5KC SOURCE
					✓ CRYSTAL	3.5KC	-111.05	1.72	5.00	-10.19	1.37	CRYSTAL 3.5KC,SOUR 10
					✓ EDO REC	3.5KC	-100.47	0.40	11.00	-12.39	4.28	EDO REC 3.5KC,SOUR 10
BCB5	NOT AVAILABLE			BLK. LAG.	BOOM XMIT	0.8-3KC	96.95	2.34	8.00	-8.35	1.81	BOOMER CAL, EDO @ 10
					BOOM XMIT	1-3KC	95.33		1.00	-7.33		BOOMER CAL FIL 1-3 K
					BOOM XMIT	1-10KC	99.59		1.00	-6.37		BOOMER CAL FIL 1-10 K
	DATA NOISEY - NOW LINEAR				BOOM XMIT	0.4-1KC	89.00		1.00	-12.02		BOOMER CAL FIL 0.4-1 K
					IO REC	0.8-3KC	-69.63	0.13	3.00	-9.76	1.66	IO REC CAL SOURCE 1

SUMMARY CALIBRATION OBSERVATIONS

FIGURE 7-5B

had a center frequency of 5.8 Khz but did have energy from 3 Khz to 8 Khz.

6) Source/Receiver Level - The mean observed source or receiver level for that site observation.

7) Standard Deviation - The standard deviation for the source or receiver level for that site observation.

8) Number Points Observed - This is the number of subfiles used to compute the statistics of each site observation. Note that each subfile normally had 40 traces.

9) Mean Bottom Loss This is the mean bottom loss observed at the site computed over each subfile for the number of points (subfiles) indicated. Each navigation point represents one subfile.

10) Standard Deviation Bottom Loss - The observed standard deviation of the bottom loss over each subfile for the number of points (subfiles) indicated.

11) Comments - Highlights decisions made for the computations and values used that impacted the results.

All data was grouped by function, that is, source level or receiver levels at a given frequency. Within each group, the group statistics and the weighted statistics were computed. In this analysis the means and standard deviation numbers were weighted by the number of observations (labeled No. Points at the top of the summary Figures 7-10 through 7-17) taken for that reading. The following subsections provides the findings for each system and compares the results with the manufacturers specifications when available. The data in groups BCR4 were taken while anchored for coring and show generally lower standard deviations than the other data sets.

7.2.1 Transmit Levels

Figure 7-6 summarizes the observations for 3.5 Khz. The source level observed from each site is noted with its standard deviation. Also noted is the number of points (subfiles) used to obtain the data. The weighted mean and weighted standard deviation is obtained by multiplying each event by the number of points, summing and dividing by the total number of point observations. The minimum and maximum value from each site is provided.

The local mean (group mean) is the average of the source levels and standard deviations from each site without weighting. The local standard deviation is computed from the mean values of each event. Except for the first event (E7C4) all events by themselves meet the accuracy requirements of the quality assurance program and the

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
3.5 KC TRANSMIT LEVEL

EVENT	SOURCE	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	100.60	3.29	5.00	503.00	16.45
				0.00	0.00
EC01	90.29	3.86	6.00	541.74	23.16
				0.00	0.00
EC02	103.61	0.29	3.00	310.83	0.87
	96.97	1.89	6.00	581.82	11.34
EC06	100.38	2.18	8.00	803.04	17.44
				0.00	0.00
BCR4/19-24	96.30	0.53	3.00	288.90	1.59
				0.00	0.00
BCR4/37-40	97.86	0.09	3.00	293.58	0.27
				0.00	0.00
BLC5	101.52	0.64	10.00	1015.20	6.40
LOCAL MEAN	98.44	1.60			
LOCAL STD.	3.84	1.34			
TOTAL NUMBER OBSERVATIONS			44.00		

WEIGHTED SOURCE MEAN ---------- 98.59

WEIGHTED SOURCE STD. DEVIATIONS ---------- 1.76

RANGE SOURCE VALUES (MIN - MAX) ------ 90.29 103.61

3.5 KHZ TRANSMIT LEVEL
Figure 7-6

overall weighted source and standard deviation meets the quality assurance standards. It is believed that the variance between events is due to the wide range of ship movement and the electrical induced noise which will be discussed at the end of this subsection.

Figures 7-7 and 7-8 provide the same statistical analysis of the 7Khz source level and the boomer source level, respectively. It is interesting to note that the difference between the weight means and the local group means increased as the power level increased, which shows a relationship to the generator. The transmit power increased because the effective pulse lengths increased as the frequency was lowered drawing more power from the generator. Figure 7-9 illustrate the observed group standard deviations and mean individual observed standard deviations versus pulse length. The boomer has the longest pulse length (right center of Figure 7-9) and the 7 Khz system the smallest (left most data points of Figure 7-9). This suggests that the generator had some sort of grounding problem and the movement of cables on deck and/or power surges may have caused variance. After finding these relationships, it was confirmed that the generator and ship wiring was modified from the previous year, when no such variation was encountered. This observation further identified the generator as a cause of variation. Ground surges or pulses would also explain the computer clock missing counts. It is important to note that the known vessel movement, while anchored, also contributed to the variances, but with the statistical schemes employed, these movements were mostly averaged out. This was confirmed by the low standard deviation of the 7 Khz data.

This graph shows that by using the 7 Khz data to calibrate the surface reflection, and that calculation was confirmed by the calculation of surface reflection using reflection multiples (see Volume 3 appendix A3 section A3.4), that all of the 7 Khz and 3.5 Khz data was recoverable. Likewise some of the Boomer data could be recovered. In any event, the boomer data was used to measure the deeper layers only and this travel time information was recovered.

7.2.2 Receiver Levels

The same group analysis was conducted on data from each of the receivers. Figures 7-10 and 7-11 provide the receiver levels and statistics for the Massa transducers at 3.5 Khz and 7.0 Khz respectively. Figures 7-12 and 7-13 provides statistics for the crystal receiver at 3.5 Khz and 7.0 Khz, and Figures 7-14 and 7-15 provides statistics for the receiver levels for the Edo hydrophone.

Figure 7-16 provides the approximate statistics for receive levels for the Interocean hydrophone. Due to the confusion of ship movement, Caulfield Engineering failed to notice that this very sensitive hydrophone has an absolute output limit of four (4) volts peak to peak at its terminals. This meant that some source level measurements were clipped which limited the number of points for calibration. The Boomer used this unit for most of its receive data, hence, care had to be taken to make sure that no clipped

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
7 KC TRANSMIT LEVEL

EVENT	SOURCE	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	93.06	1.42	12.00	1116.72	17.04
				0.00	0.00
EC01	91.26	1.72	6.00	547.56	10.32
				0.00	0.00
EC02	97.81	0.23	3.00	293.43	0.69
				0.00	0.00
EC06	95.43	0.51	5.00	477.15	2.55
				0.00	0.00
BCR4/19-24	96.83	0.86	7.00	677.81	6.02
				0.00	0.00
BCR4/37-40	94.83	0.59	3.00	284.49	1.77
				0.00	0.00
BLC5	97.19	2.49	14.00	1360.66	34.86
LOCAL MEAN	95.20	1.12			
LOCAL STD.	2.19	0.74			
TOTAL NUMBER OBSERVATIONS			50.00		
WEIGHTED SOURCE MEAN ----------				95.16	
WEIGHTED SOURCE STD. DEVIATIONS ----------					1.47
RANGE SOURCE VALUES (MIN-MAX) ------				91.26	97.81

NOTE: 7KHZ DATA PEAKS AT 5.8 KHZ DUE TO RESONANCE CHARACTERISTICS TRANSDUCERS AND SHORT PING LENGTH. DATA AVAILABLE AT 7 KHZ

7.0 KHZ TRANSMIT LEVEL

Figure 7-7

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
BOOMER TRANSMIT LEVEL (0.8 - 1 KC)

EVENT	SOURCE	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
EC05	62.08	0.00	1.00	62.08	0.00
				0.00	0.00
EC05	86.89	0.95	3.00	260.67	2.85
				0.00	0.00
BCB5	96.95	2.24	8.00	775.60	17.92
				0.00	0.00
LOCAL MEAN	81.97	1.06			
LOCAL STD.	14.65	0.92			
TOTAL NUMBER OBSERVATIONS			12.00		
WEIGHTED SOURCE MEAN ----------				91.53	
WEIGHTED SOURCE STD. DEVIATIONS ----------					1.73
RANGE SOURCE VALUES (MIN-MAX) ------				62.08	96.95

NOTE: THESE VALUES BASED ON EDO AND CAL PHONES
NOT ON THE INTEROCEANS.

BOOMER TRANSMIT LEVEL
Figure 7-8

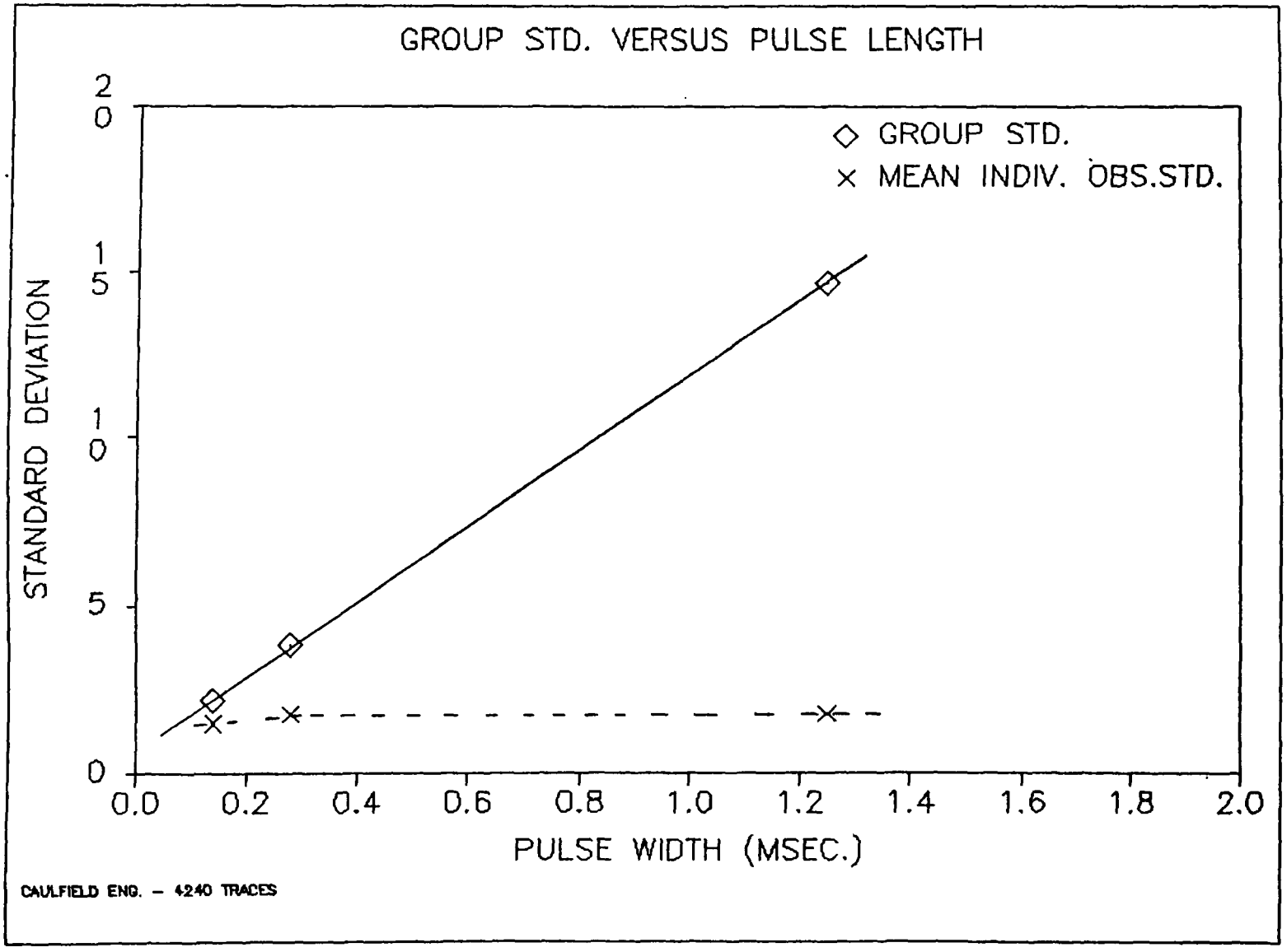

GROUP STD. VERSUS PULSE LENGTH
◇ GROUP STD.
× MEAN INDIV. OBS.STD.
STANDARD DEVIATION
2
0
1
5
1
0
5
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
PULSE WIDTH (MSEC.)
CAULFIELD ENG. - 4240 TRACES

Figure 7-9

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
3.5 KC MASSA RECEIVER SENSITIVITY

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	-77.77	4.00	2.00	-155.54	8.00
				0.00	0.00
EC01	-81.00	0.00	1.00	-81.00	0.00
				0.00	0.00
EC03	-86.79	0.01	2.00	-173.58	0.02
EC06	-80.70	2.10	2.00	-161.40	4.20
				0.00	0.00
BCR4/19-24	-81.81	1.50	2.00	-163.62	3.00
				0.00	0.00
BLC5	-80.02	3.11	5.00	-400.10	15.55

LOCAL MEAN	-81.35	1.79			
LOCAL STD.	2.74	1.48			
TOTAL NUMBER OBSERVATIONS			14.00		
WEIGHTED RECEIVER MEAN ----------				-81.09	
WEIGHTED RECEIVER STD. DEVIATION ----------					2.20
RANGE RECEIVER VALUES (MIN - MAX) ------				-86.79	-77.77

3.5 KHZ MASSA RECEIVER

Figure 7-10

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
7 KC MASSA RECEIVER SENSITIVITY

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	-91.57	1.04	4.00	-366.28	4.16
				0.00	0.00
EC01	-80.26	6.00	5.00	-401.30	30.00
				0.00	0.00
EC06	-80.43	1.07	2.00	-160.86	2.14
				0.00	0.00
BCR4/37-40	-78.23	0.75	3.00	-234.69	2.25
				0.00	0.00
BLC5	-77.35	1.19	3.00	-232.05	3.57
LOCAL MEAN	-81.57	2.01			
LOCAL STD.	5.14	2.00			
TOTAL NUMBER OBSERVATIONS			17.00		

WEIGHTED RECEIVER MEAN ---------- -82.07

WEIGHTED RECEIVER STD. DEVIATION ---------- 2.48

RANGE RECEIVER VALUES (MIN-MAX) -------- -91.57 -77.35

7.0 KHZ MASSA RECEIVER

Figure 7-11

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
CRYSTAL RECEIVER SENSITIVITY 3.5 KC

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	-96.60	4.00	2.00	-193.20	8.00
				0.00	0.00
EC06	-95.03	3.46	3.00	-285.09	10.38
				0.00	0.00
BLC5	-111.05	1.72	5.00	-555.25	8.60
LOCAL MEAN	-100.89	3.06			
LOCAL STD.	7.21	0.97			
TOTAL NUMBER OBSERVATIONS			10.00		

WEIGHTED RECEIVER MEAN ---------- -103.35

WEIGHTED RECEIVER STD. DEVIATION ---------- 2.70

RANGE RECEIVER VALUES (MIN - MAX) ------ -111.05 -95.03

3.5 KHZ - CRYSTAL RECEIVER

Figure 7-12

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
CRYSTAL RECEIVER SENSITIVITY 7 KC

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
E7C4	-105.49	2.67	6.00	-632.94	16.02
				0.00	0.00
EC01	-95.00	3.20	2.00	-190.00	6.40
				0.00	0.00
EC06	-106.33	5.54	2.00	-212.66	11.08
				0.00	0.00
BLC5	-99.83	1.80	3.00	-299.49	5.40
LOCAL MEAN	-101.66	3.30			
LOCAL STD.	4.59	1.39			
TOTAL NUMBER OBSERVATIONS			13.00		
WEIGHTED RECEIVER MEAN ----------				-102.70	
WEIGHTED RECEIVER STD. DEVIATION ----------					2.99
RANGE RECEIVER VALUES (MIN - MAX) ------				-106.33	-95.00

7.0 KHZ - CRYSTAL RECEIVER

Figure 7-13

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
EDO RECEIVER SENSITIVITY 3.5 KC

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
EC03	-106.70	0.25	3.00	-320.10	0.75
				0.00	0.00
BLC5	-100.47	0.40	11.00	-1105.17	4.40
LOCAL MEAN	-103.59	0.33			
LOCAL STD.	3.12	0.08			
TOTAL NUMBER OBSERVATIONS			14.00		
WEIGHTED RECEIVER MEAN ----------				-101.81	
WEIGHTED RECEIVER STD. DEVIATIONS -----					0.37
RANGE RECEIVER VALUES (MIN-MAX)				-106.70	-100.47

3.5 KHZ - EDO RECEIVER

Figure 7-14

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY
EDO RECEIVER SENSITIVITY 7KC

EVENT	RECEIVER	STD. DEV.	NO.POINTS	ACC. SOR.	ACC.STD.
EC03	-108.40	3.87	10.00	-1084.00	38.70
				0.00	0.00
BLC5	-99.83	1.80	3.00	-299.49	5.40
LOCAL MEAN	-104.12	2.84			
LOCAL STD.	4.28	1.04			
TOTAL NUMBER OBSERVATIONS			13.00		
WEIGHTED RECEIVER MEAN ----------				-106.42	
WEIGHTED RECEIVER STD. DEVIATIONS -----					3.39
RANGE RECEIVER VALUES (MIN-MAX)				-108.40	-99.83

7.0 KHZ - RECEIVER (EDO)

Figure 7-15

CAULFIELD ENGINEERING
TRENTON CHANNEL SURVEY 1995
SUMMARY

INTEROCEANS RECEIVER
LIMITED SAMPLES DUE TO NOISE
RESULTS ARE ONLY APPROXIMATE

EVENT	FREQ.	RECEIVER	STD.
EC06	3.5KC	-79.95	5.11
BCB5	0.8-3 KC	-69.63	0.13

INTEROCEANS RECEIVER

Figure 7-16

reflected signals were used.

7.2.3 Performance Summary

Figure 7-17 provides a summary of the weighted mean levels, standard deviations and manufacturers specifications for all the sources and receivers used for this project. This figure shows that all systems except the boomer and the InterOceans hydrophone fall within or very near the 2.50 percent quality control specification in the quality assurance specifications. The EDO receiver was not used for processing data. The crystal 3.5 and 7.0 KHz variances were slightly above the quality control specifications. However, mean bottom loss predictions with these units closely matched the Massa data, and it was assumed that this slight increase over the quality control specifications did not degrade these system overall performance. This indicates that the Caulfield Engineering hardware systems operated to specifications.

Even more important, the new CAL1 calibration program provides a way to verify compliance of all survey lines, by checking the mean source and receiver values computations against computation derived from reflection the multiples. This allowed the rest of the program to be satisfactorily completed.

7.3 Initial Reflection (Bottom Loss) Results

Two of the small calibration runs were undertaken at core locations in Black Lagoon while coring operations were underway. These initial measurements clearly showed that the bottom loss of polluted or gas containing sediments is considerably less than for the same non-polluted or non-gas containing sediment. The following table summarizes these initial result.

Event	Location	Observed BL DB	Measured Density	Ideal BL BL
BCR4/19-24	Core 18	-4.298	1.53	-12.1
BCR4/37-40	Core 19	-6.596	1.18	-20.9
BCL5	Core 16 (1)	-10.900	1.22	-20.6

Note 1: Boat was to be over Core 16 but navigation puts boat 24 feet away.

It is interesting to note that the air-water interface corresponds to a zero (0) db bottom loss, that is, perfect reflection. Therefore, the lower bottom loss numbers in the

CAULFIELD ENGINEERING

COMPOSITE SUMMARY OF CALIBRATION

UNIT	FUNCTION	FREQ.	WEIGHTED MEAN LEVEL	STD. DEV.	MANUFACT. SPECIF.
MASSA	SOURCE	3.5 KC	98.59	1.76	102.48
MASSA	SOURCE	7.0 KC	95.16	1.47	95.45
BOOMER	SOURCE	0.8-3 KC	91.53	1.73	88.00
	NOTE: BOOMER DATA ONLY APPROXIMATE				
MASSA	RECEIVER	3.5 KC	-81.09	2.20	-75.00
MASSA	RECEIVER	7 KC(5.8)	-82.07	2.48	-82.00
EDO	RECEIVER	3.5 KC	-101.81	0.37	NA
EDO	RECEIVER	7.0 KC	-106.42	3.39	NA
CRYSTAL	RECEIVER	3.5 KC	-103.35	2.70	-103.00
CRYSTAL	RECEIVER	7.0 KC	-102.70	2.99	-93.00
IO	RECEIVER	3.5 KC	-79.95	5.11	NA
IO	RECEIVER	0.8-3 KC	-69.63	0.13	NA
	NOTE: IO CHARACTERISTICS BASED ON LIMITED SAMPLES				

COMPOSITE CALIBRATION SUMMARY

Figure 7-17

above table also confirm that the sediments must contain gas. It is premature to speculate on the amount of bottom loss deviation due to the gas and the amount caused by the pollutants. The Core 18 and Core 19 sites had phase reversal at the bottom also indicating gas content.

7.4 Spectral Results

Spectral plots were generated for 16 traces from site E7C4. The colored records do not reproduce clearly in black and white so are not included in this report. However, the spectral plots confirmed that each source was transmitting the desired frequencies. The 7 Khz system used a very short pulse length (0.14 milliseconds). Since the resonant frequency of the transducer was 4 Khz, some lower frequency energy was also transmitted giving a mean frequency of 5.8 Khz. However, when receiving this data on the crystals, most of this lower frequency energy is filtered, because the peak response of the crystals is at 8 Khz.

A spectral plot is generated by computing the Fourier Transform (frequency analysis) terms for the bottom reflections and each subbottom event. The energy at each frequency is proportional to the sum of the squares of the Fourier coefficients. The Spectral plots are a composite plot of the energy component at each frequency for the bottom reflection and each layer. These computations are carried out to ensure that the desired frequency is being transmitted and received for each one of the seismic sources.

8.0 INITIAL CONCLUSIONS

Even though boat operations caused severe constraints on the calibration and operating conditions, software and statistical processing techniques and procedures were developed and carried out to overcome the majority of the problems. This allowed the full processing of the data set. In future operations it is imperative that the vessel be anchored in a stationary manner. During the period of time anchored it is necessary for the position to be plotted graphically using GPS and the vessel drift monitored and scientific personnel alerted to any potential problems.

It is essential that all ships electrical power be inspected by a trained marine electrician after any major work or modification to the ship's electrical system. During ship operation, methods should be developed to monitor the ships electrical system for any spikes or other problems.

Both the coring and seismic calibration analysis steps carried out confirmed the presence of gas in the polluted sediments. The two initial core sites where preliminary bottom reflectivity studies were carried out indicated a decrease in the bottom loss compared to equivalent non-polluted sediment.

The expanded calibration analysis indicated that all 3.5 Khz and 7.0 Khz systems functioned properly and according to the quality assurance requirements. The crystal receiver had variances slightly above the quality assurance requirements, but subsequent analysis showed that the means from the crystals were close to the Massa transducers allowing the data to be used. The Boomer system has a limitation in that the signal strength from the bottom must be under four (4) volts peak to peak at the transducer. This is the case in the majority of survey areas because of the separation (move-out) between the transducer and the receiving hydrophone.

The new 'CAL1' calibration program allowed for dynamic calibration of all survey lines through the use of reflectivity calculations using reflection multiples to compensate for the ship operating problems.

The new Caulfield Engineering piston core rig proved to be an economical method to verify spatial variance, obtain sufficient sediments for system calibration and provide adequate near surface density estimates.

Both the Caulfield Engineering Core Velocimeter and the USACE Precision Core Velocimeter confirmed the presence of gas in the sediments.

9.0 ACKNOWLEDGMENTS

The staff of USEPA-GLNPO, USEPA-CBSSS, and the USACE all contributed to the success of the engineering and scientific findings of this work. Special mention to Dr. Lloyd Breslau of the Caulfield Engineering staff for his extra work.

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APPENDIX A1

DAILY FIELD LOG

DAILY LOG INDEX

INIT	DATE
PREP	/ /
APP	/ /

		1 FILE NAME	2 FILE NAME	3 AWS	4 X.ALG	5 PRINTED	
1	1	CLOC	LOG CLOC	✓	✓	✓	1
2	2	CLOD	LOG CLOD	DOES NOT INVOKE			2
3							3
4	3	RCØA	LOG RCØA	✓	✓	✓	4
5	4	RCØB	LOG RCØB	✓	✓	✓	5
6	5	RCØC	LOG RCØC	✓	✓	✓	6
7							7
8	6	ETO1	LOG ETO1	✓	✓	✓	8
9	7	ETC4	LOG ETC4	✓	✓	✓	9
10	8	ETC5	LOG ETC5	✓	✓	✓	10
11							11
12	9	CRS1	LOG CRS1	✓	✓	✓	12
13	10	CRS2	LOG CRS2	✓	✓	✓	13
14	11	CRS3	LOG CRS3	✓	✓	✓	14
15	12	CRS4	LOG CRS4	✓	✓	✓	15
16							16
17	13	EBØ1	LOG EBØ1	✓	✓	✓	17
18	14	EBØ2	LOG EBØ2	✓	✓	✓	18
19	15	EBØ3	LOG EBØ3	✓	✓	✓	19
20							20
21	16	ECØ1	LOG ECØ1	✓	✓	✓	21
22	17	ECØ2	LOG ECØ2	✓	✓	✓	22
23	18	ECØ3	LOG ECØ3	✓	✓	✓	23
24	19	ECØ4	LOG ECØ4	✓	✓	✓	24
25	20	ECØ5	LOG ECØ5	✓	✓	✓	25
26	21	ECØ6	LOG ECØ6	✓	✓	✓	26
27							27
28	22	EBØ5	LOG EBØ5	✓	✓	✓	28
29							29
30	23	BPØ1	LOG BPØ1	✓	✓	✓	30
31	24	BPØ2	LOG BPØ2	✓	✓	✓	31
32	25	BPO3	LOG BPO3	✓	✓	✓	32
33							33
34	26	BCR1	LOG BCR1	✓	✓	✓	34
35	26A	BCR1A	LOG BCR1A	✓	✓	✓	35
36	27	BRC2	LOG BRC2	✓	✓	✓	36
37	28	BCR4	LOG BCR4	✓	✓	✓	37
38							38
39							39
40							40

DAILY LOG

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INIT.	DATE
PREP.	/ /
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		FILE NAME	FILE NAME	*.WS	*.ALG	PRINT
1	29	BB01	LOG BB01	✓	✓	✓
2	30	BB02	LOG BB02	✓	✓	✓
3	31	BB03	LOG BB03	✓	✓	✓
4	32	BB04	LOG BB04	✓	✓	✓
5						
6	33	RD01	LOG RD01	✓	✓	✓
7	34	RD02	LOG RD02	✓	✓	✓
8	35	RD04	LOG RD04	✓	✓	✓
9						
10	36	BP22	LOG BP22	✓	✓	✓
11						
12	37	BLC5 (CAL)	LOG BLC5	✓	✓	✓
13	37A	BLC5A (EDO)	LOG BLC5A	✓	✓	✓
14	37B	BLC5-B (I°)	LOG BLC5B	✓	✓	✓
15						
16	38	BCB5	LOG BCB5	✓	✓	✓
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
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DAILY LOG

CL0C

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		174920		020		0		MS	1.5		7.0	5	1	20	1	30	3.5	Start vert hard clay
0	4				020		20		CR										
			175600																Good spt. Post stone pr
			175700																good spt.
9	3																		good spt.
9	4																		good spt.
10	0	825	180100																good spt.
11	1	845	180200																good spt.
12	1	865	180300																good spt.
13	4	905	180500																
18	4		181050				20		MS										CHG. TO MASSA WITH + 20
19	0						0		MS										MASSA FIL 0 DB
20	2	1051	181220																
22	2	1095	181436		020		20		CR										BACK TO XTAL
24	4	1145	181700																SHOAL
28	0						0												TURN GAIN DOWN NOT CAL.

DAILY LOG

CL0D

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		190900		020		0		CR	1.5		7.0	5	1	20	1	30	3.5	At Sample Site 2

does not tie to record original log cl0e check latter if time allows
problems with disk drive on computer

DATE: [illegible]

RC0A

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		131000	0A	6		0		CR	1.5	0	7.0	5	1	20	1	30	3.5	Start line
0	1				020		0												
1	4		131152																Stopped to reset scale
2	0		131224		020		20												Restarted
2	2		131250																mud bottom ?
																			Gibralta boat basin
3	2	24	131353																Very Shallow
4	5				010		20												
5	2				050		20												
6	0	80	131657																Soft Bottom
6	4	100	131739		090		20												
7	5	127	131858																
11	1	202	132244																
12	1	225	132354																
12	2		132400				20		MS										CONFIRMS FILTER GAIN 20 D

LOCAL TIME

DAILY LOG

RCOB

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		132844		090	19.4	0	19.4	MS	1.5	0	7.0	5	1	20	1	30	3.5	power on massa
1	2	24	133002																
2	4	54	133133																
4	0	87	133310																Nor of perpend from site
5	2	119	133446																Turning into island
8	1				050	15.9	0	15.9	MS										Shoaling fast
8	4	190	133820		050	15.9	0	15.9											
9	2	206	133907		050	15.9	20	35.9	CR										Switch to CRy + 20 db
10	3	234	134033		030	11.1	20	31.1											
11	2	250	134120		050	15.9	20	35.9											
12	0	266	134208		090	19.4	20	39.4											Hove to Grab Sample Mud
14	2	344	134400		090	19.4	0	19.4	MS										Switch Massa 0 db filter
17	0	380	134750																Hove to for sample
18	2	406	134908									3.5							Change freq, same gain
19	9	422	134955		090	19.4	0	19.4											

DAILY LOG

RC0C

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	480	135250		090	19.4	0	19.4	MS	1.5	0	7.0	5	1	20	1	30	3.5	Celeron Isl North recon
1	5		135455		090	19.4	20	39.4	CR										Switch to Crystal
4	4	582	135800																Hard Bottom ?
			135830																Lost Power
6	0	1	140600		090	19.4	20	39.4											Restart line
11	2	129	141222																
12	3		141320																Boat Speed Increased
15	1		141637																
17	4		141937		050	15.9	20	35.9											
20	1	320	142233																Line into Mud E.Side Isl
22	1		142447		050	15.9	0	15.9											Switch to Massa 0 db fil
24	1	410	142639																Sample 65675-4099239
25	2		142829		050	15.9	20	35.9	CR										Switch to CR + 20 Ponar sample 440 N65663- E 4099242
30	4	568	143432																Start Steaming
34	2		143843																Stop Samp. Tim Celeronis
35	4	678	144000																N65803 -E2079015
36	0	687	144030		050	15.9	0	15.9	MS										Switch Massa fil 0 db
37	4		144230																Steam to Crysler Bay
40	0	780	144510		090	19.4	0	19.4											
42	0																		Chg. Detph Rng. 4.8 55.2
43	0		144800																Stght. Up N. End Island
43	5				050	15.9	0	15.9											
46	2	926	145228																
50	3				090	19.4	0	19.4											
52	2	1057	145900		090	19.4	20	39.4	CR										Switched to CR 20 db
59	4		150730																South Side Chrysler Bay
61	3	1267	150930																
63	1	1305	151125																
70	5	1480	152020																Heading into Chrys.Bay
71	5		152128																Wat Del=0 0 51.5
72	1		152140		050	15.9	20	39.4											Gain Change
73	1	1540	152300																Stop Sample Silty Sand
75	2	1588	152535		090	19.4	20	39.4											Till End of Record

DAILY LOG

E701

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				090	19.4	0	19.4	MS	1.5	0	7.0	5	1	20	1	30	3.5	Start lines in Eliz Prk
0	4	1996	174124																Pract line run 1
2	2																		Change rep. rate 0.15s
6	0		174545																Going to str. line 1
7	2	2101	174640	S01N															
9	4	2136	174820	E01															
11	1		174930																Going to next line
15	0	2215	175220																Stop survey while plan details of line runs

DAILY LOG

E703

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	2639	181305	3	090	19.4	0	19.4	MS	1.5	0	7.0	5	1	20	1	30	3.5	heading N. line 3
1	2	2660	181408																Power Prob. Comp. Stopd
5	0	2694	181545																Going to line 3
7	2	2726	181730	S3N															Str. Line 3N, Sp 1.5knts
9	14	2782	182020	E3															End line 3
12	4		182130																Heading to line 5
20	0	2920	182655	S5N	090	19.4	0	19.4											Start Line 5
25	0	2988	183040	E5															End Line 5
27	2		183215																Heading Line 7
33	1	3111	183630	S7N															Start Line 7
34	5		183750																Lump Mater. on Bottom
39	0	3197	184055	E7															End line 7 Head 9
46	2	3306	184620	S9N															Start Line 9
50	4		184930	E9															End line 9
57	4	3470	185438	S11N															Str. 11, Should Sample
61	2		185730																Soft 20 yds of N chan dk
63	3	3560	185855	E11															End line 11, go to 13
70	0		190300		050	15.4	0	15.4											Gain Change
70	3	3662	190410	S13N															Start Line 13 North
73	1	3710	190607	E13															End line 13 go to 14
80	0	3802	191120	S14N															Start line 14
82	1	3838	191241	E14															End Line 14 - Soft byPr.
83	4	3861	191350																Start Stght. into Cove
85	3	3890																	High Absorption
88	0	3910	191700																Back out of Cove

DAILY LOG

E7C4

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
2	0		192400		080	16.8	20	36.8	CR	1.5	0	7.0	5	1	20	1	30	3.5	Eliz. Pkr. Crystal Rec.
4	2		192533		020	6.9	20	26.9											Entering cove
5	3		192634		010	0.7	20	20.7											Gain Change
8	3	4072	192850																Str. Backing Out of Cove
13	0				040	14.0	20	34.0											Gain Change
15	0	4164	193320	S14N															Start Line 14 N
17	4	4203	193530	E14															End Line 14
18	2				060	17.2	20	37.2											Gain Change
23	0				100	19.9	20	39.9											Gain change
25	1	4215	193943	S13N															Start line 13
28	3	4364	194056	E13															End 13
33	0																		Heading to line 9
36	3	4480	194916	S09N															Start Line 9
42	5	4577	195355	E09															End line 9
46	0																		Heading line 5
48	0	4670	195845	S05N															Start Line 5
54	3	4748	200222	E05															End Line 5
61	0	4842	200720	S01N															Start Line 01
67	0	4936	201140	E01															End Line 1
70	0	4982	201351																Hove to for cal
																			Echo Sound 22 ft.
73	0		201600	cal	020	6.9	0	6.9	cal										9' of cable out
73	4																		15' of cable out
74	3				040	14.0	0	14.0											
75	0	5053	201722	cal	030	11.2	0	11.2											Gain changes
75	4		201800																21' of cable out
76	2																		Pull cal up
78	3		202036	cal															Cal @ Receiv. MS & CR
79	1		202036	cal	220	25.0	0	25.0	cal										Cal @ Receivers
79	5				220	25.0	20	45.0	CR										Switch to CRystal
80	4				220	25.0	0	25.0	MS										Switch to Massa
83	4				100	19.9	0	19.9	cal			3.5							Pul.Width 0.14 to 0.28
																			Had to move ship to shal
90	0								cal										Cal @ 16' out
91	2				030	11.2	0	11.2	cal										
92	2				010	0.7	0	0.7	cal										Cal @ 10' and then surf
93	1	5322	203050																
93	5				050	15.9	20	35.9	CR										Change CR and going Lin
96	3				050	15.9	0	15.9	MS										Change Massa
97	1						20	35.9	CR										Change Crystal
101	3	5442	203655	S01N															Start line 1 north
108	0	5540	204145	E01															End Line 1 go to 5
117	2	5680	204840	S05N															Start line 5
119	2				080	18.8	20	38.8											Change Gain
122	5	5761	205245	E05															End line 5
129	1	5855	205725	S09N															Start line 9
131	1	5890	205855	BD09															Stop 09 Computer prob

DAILY LOG

E7cS

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
3	2	5967	210245		080	18.8	20	38.8	CR	1.5	0	3.5	5	1	20	1	30	3.5	Going to line 13 CR Rec.
6	5	6017	210525	S13N															Start line 13 go north
9	5	6064	210740	E13															End of line 13
15	0				050	15.9	20	35.9											Gain Change
15	3	6142	211200	S14N	020	6.9	20	26.9											Str. 14, gain change
18	4	6192	211400	E14															End Line 14
20	1																		Steaming into Cove
21	5	6235																	Prop. core 1
22	2	6244	211640																Prop. core 2
23	3	6262	211730																Prop. core 3
24	3																		Prop. core 4 absorp
25	3	6290																	End of Line Grass Bot.

DAILY LOG

CR51

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0			CR5	014	3.5	20	23.5	CR	1.5		7.0	5	1	20	1	30	3.5	Coring Eliz.Prk. Cove
1	3	1	122200		030	11.1	20	31.1											Core 5 N4208' 11.7401'
																			083 10' 37.3885' W
																			weight = 14 lbs 133.7 cm
																			to water top
																			93.8 cm sediment
																			Small air pocket 10.5 cm
																			Black Silty Clay
																			Gas content

DAILY LOG

CR52

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		152217	CR7	030	11.1	20	31.1	CR	1.5		7.0	5	1	20	1	30	3.5	Core #7 Elz. Prk cove
1	2	200	152312																Core location Medium Hard gaseous
5	2	253	152554																end of record

DAILY LOG

CR53

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
			195400																Core # 8
																			N71376 E4098447
																			Hard
0	1	500	195840	CR8	060	17.2	20	37.2	CR	1.5	0	7.0	5	1	20	1	30	3.5	
0	5	515	195905																
1	2	523	195930																
5	1		200219		060	17.2	0	17.2	MS	1.5									Changed to Massa Rec
		618																	Core Taken # 8 again
																			N 71376 E4098447
																			Retained 1" Sand Gravel
																			Sample in Sample Bag
7	5	622	200426																
8	1	624																	Actual Location of Core
																			on seismic record
																			Did not anchor for these
																			so off by a meter etc.
26	4	898	201815																
27	1	906	201840																Getting Ready Core 9

DAILY LOG

CR54

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	1	975	202207	CR9	050	15.9	0	15.9	MS	1.5	0	3.5	5	1	20	1	30	3.5	Getting read core # 9
2	3	1010	202350																
3	1	1020	202420																Core 9 Dropped North ch. N71477 E4098481 1/2" Sand Gravel
5	1	1049	202548		050	15.9	20	35.9	CR										Changed Crystal
18	2	1245	203621		150	22.0	20	42.0											Changed Gain
19	4	1263	203621		150	22.0	0	22.0	MS										Changed Massa
23	2	1318	203905																Droped Core 10 N71490.8 E4098539.9 Silty Sand Den 1.56 Oil Odor North End Line 1
24	2	1332	203947																

Core 5+6 — Clay Silt
- NORM Ref Low
- Core Velocity HIGH
- Core dielectric High
- measured density 1.2

Core 7 - Silty Clay
- NORM Ref low
- Core Velocity medium High
- Core dielectric medium high
- measured density 1.3

Core 8
Gravel +
HRD BTM Rocky

Core 9
Gravel +
HARD BTM Rocky

Core 10
Silty Sand & Sandy Silt
- low diesel odor
- measured density 1.56 or 1.57

Core Velocity
Core dielectric low

- SHIP Measured Reflectivity
- Ship Inferred absorption
- Core measured velocity
- Core Measured absorption ?
- Core measured dielectric characteristics
- Core Gas / Petroleum Content
- Core Sediment Characteristics
- Core measured density

- Geographic Situational Expectation

DAILY LOG

EB01

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	29	133200		300	26.9	0	26.9	AR	1		1	100	0.7	20	1	3	15	Boomer 20' aft
0	2		133242		200	24.4	0	24.4											Steaming arnd line 1 set
2	0				100	19.9	0	19.9											change gain
6	4	116	133613																
11	3				060	17.2	0	17.2											Chg. Gain Rep Rate 0.25
13	4	188	133950		80	18.8	0	18.8											Chg. Gain
35	3	400	135025	S01N															Start Line 01
46	0	496		E01															end Line 01
																			Going line 5
55	0					18.8	40	58.8										40	Crystal Very weak
56	0					18.8	20	38.8										40	Massa receiver
57	2					18.8	40	58.8										40	Gain Change
58	0					18.8	20	38.8										40	Gain Change Massa
59	3					18.8	0	18.8											Back to Array 0db
63	2				110	20.5	0	20.5											gain change
71	4	755	140805	S02N															Start of line 5
74	0																		Source Sparking
84	0																		Terminate Line to repair

DAILY LOG

EB02

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		143000		110	20.5	0	20.5	AR	1		1.0	100	0.7	20	1	3	15	Boomer 20' aft boat
4	1				080	18.8	0	18.8											Change Gain
9	0	1284	143428	S05N															Start line 05
14	4	1335	143705	E05															End Line 05
16	1				070	18.1	0	18.1											Restart Acquisitin sys.
20	0	1488	144439	S09N															Start line 09
25	5	1540	155715	E09															End line 09
25	5																		10 meter from end line
																			Boat turning away dock
27	2																		System off Resting Boom
27	4	1637	145200		060	17.2	0	17.2											Restart system
31	2	1671	145343	S13N															Start of line 13
34	3	1701	145512	E13															End 13
34	5	1705	145527																10 meter past line
																			Echo from wall
37	2	1730																	System off
38	0	1798	150000																Restart to line 14
41	4	1831	150140	S14N															Start line 14
44	2	1854	150250	E14															End line 14
45	0																		Next stell pier North
46	1																		System Off
48	0			NEL	050	15.9	0	15.9											In Cove Run Out North La
51	5																		Near Core #6 (2nd core)
54	4	2094	151440																Hyd. @ outer core posit.
56	3																		Out of cannal into deep
57	1															1.5	4.0		Change Filter 1.5-4k
58	2		151630																System off
60	4	2140	152300																Start Boom. Head Out E.
64	0		152325																@ 2nd core position
65	3																		Entrance cove
66	4	2200	152624																
68	0				100	19.9	0	19.9								0.4	1.0		Change Gain & Filter
68	5																		Go back into cove
																			Not transmitting
73	4	2328	153250																Start data go out east
75	1																		First Core - Absorption

DA... ...

EB03

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				100	19.9	0	19.9	AR	1		1.0	100	0.4	20	0.4	1.0	15	Working in El Prk Cove
																			Steam In and Profile out
																			Boomer next to boat
2	1	2452	153940																Start goin east
4	0	2485	154040																1st core site
																			boat in Cent/Line chan
6	0	2533	154230																2nd core site
8	1																		3rd core site
12	0						20	39.9	MS										Xmit Boom, Rec. Massa
																		25	Sep 25-30 ft
17	0																		
					100	19.9	20	39.9	MS					0.8	20	0.8	3.0		Change Filters
																			Go back into channel
23	0	2749	155352																Str. Line Going East Out
25	0																		Core #1
27	0	2767	155545																2nd Core Site
29	1																		3rd Core Site
30	0				030	11.1	20	31.1	MS										Change Gain
34	4						0	11.1											Filter gain out
35	3				100	19.9	0	19.9											Ghange gain
39	0	2904																	10' South Bouy E. Elz.
																			Cove

DAILY LOG

EC01

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	PIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0			cal	030	11.1	0	11.1	MS	1.5		7.0	1.2	0.7	20	3	20	3.5	Start of Cal at Elz. Pt
0	2				030	11.1	20	31.1	MS										Change of gain
1	3			cal				31.1	Cal										Cal Phone 6'
2	1	3169	182752																
2	5	3187	182850																Cal Phone 10'
4	4	3229																	Cal Phone 14' 45 deg.
5	2																		Cal Phone up slow
6	0	3255																	
6	4				060	17.2	20	37.2	Cal										Cal next Receivers
																			Pulse length 0.14
7	3								MS										Change to Massa Receiver
8	1				020	6.9	20	26.9	MS										Change Gain
9	0								CR										Change to Crystal Array
9	3	3338	183522																
10	3																		End this Cal
																			Note: Confusion on 20 db
																			Check when processing.
11	1								CR			3.5							3.5 khz Crystal phone
11	5	3400	10		020	6.9	0	6.9	MS										Change to Massa
12	3								Cal										Cal 8'. Gain not logged
13	4	3436	184115		055	16.6	0	16.6	Cal										
15	2	3474																	Cal 10' angle 25 deg
15	1	3494	184411																Cal Up to surface slow
17	3	3525	184540		100	19.9	0	19.9	Cal										Cal Next to Receivers
18	2	3545	184642						MS										Massa receiver
19	0	3560	184728				20	39.9	CR										Crystal Receiver
																			Note: found out latter
																			1.2 kw not 5 kw.

DAILY LOG

EC02

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	1			cal	030	11.1	0	11.1	cal	6		3.5	1.2	1	20	1	30		Start Cal again cal 6'
1	3																		Cal Phone next to receiv
1	4	3678	185319		130	26.7	0	26.7	cal	0									Cal Next to Rec. Gain Cg
2	1																		End Discov. Power 1.2KW
2	5	3753	185704	cal	020	6.9	0	6.9	cal	6			5						Power at 5kw gain change
3	2				010	0.7	0	0.7	cal	6									gain change
3	3	3767	185749																
4	0											7.0	5	3	20	1	30		Change to 7.0 KHz
4	2				030	11.1	0	11.1	cal	6									Change gain
5	0				020	6.9	0	6.9	cal	6									Change gain
																			Note This 7KHz
																			Pulse width = 0.28
																			Not 0.14

DAILY LOG

EC03

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	1	3920	190500	CAL	020	6.9	20	26.9	EDO	10		7.0	5	3	20	1	30		Cal with EDO
1	1	3947	190649		040	14.0	20	34.0											Gain Change
2	1	3976	190816																Lower to 14 feet
2	5	3991	190816																Move up to surface
3	2	3998			040	14.0	20	34.0	EDO										Next to receiv phones
4	0				070	18.1	20	38.1											Change gain
4	4				070	18.1	20	38.1	Edo			3.5							Change Frequency 3.5
5	0													1	20	1	30		Change Filter
6	0						0	18.1	MS										Change to Massa phone
7	3				050	15.9	0	15.9	EDO										Next to receivers
8	3	4122	195031		110	20.5	0	20.5	EDO			3.5							Edo 6' Pul Length 0.2 Power 5 kw

DAILY LOG

EC04

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				110	20.5	0	20.5	IO	6		3.5	5	1	20	1	30		InterOcean Phone Noisey found bad battery Pulse Length 0.28

DAILY LOG

EC05

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	4423	193210		100	19.9	20	39.9	Cal	7		1	100	0.8	3	0.8	30		Cal Boomer Cal Phone
																			Boomer just aft strboar
0	4								MS										Massa Rec. Noise Prob.
0	5								Cal										Back to Cal Phone
5	5																		Playing with filters
6	1	4564	193912																Depth 7 feet
7	2																		Depth 4 feet
7	4	4619	194156						EDO	4				0.8	3	0.8	30		Change to edo
8	3	4839	194258							14									Depth 14 feet
9	1	4639																	Depth 18 feet
9	3	4661	194406																Start up
10	1	4678	194456						MS										Change Massa phone
11	1				100	19.9	40	59.9	CR										Change Crystal Rec.
11	4				050	15.9	40	55.9											Change Gain
12	0																		Shut down

DAIL

EC06

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
																			Changed Preamp Battery
0	0	5149	200824		020	6.9	0	6.9	Cal	8		7.0	5	3	20	1	30		Cal At Station 10
																			Pulse Width 0.14
1	2	5182	201004		030	11.1	0	11.1		12									Gain Chg. Depth 12'
2	1	5201	201101							16									Depth 16' angle 10 deg
2	5	5215	201145																Raise to surface
3	4																		Next to Receivers
4	0	5242	201306		030	11.1	20	31.1	Cal	1.5									Change Gain next rec.
5	0	5265							MS										Massa receivers
5	5								CR										Crystal Receivers
6	1				030	11.1	40	51.1	CR										Increase gain
7	0																		Stop
7	4	5327	201720		030	11.1	20	31.1	CR			3.5	5	1	20	1	30		Change 3.5 kHz 0.28 pl
8	4				100	19.9	0	19.9	MS										Change Massa
10	0								Cal										Cal Phone Next Receiver
11	1	5408	202130		010	0.7	0	0.7	Cal	8									Cal Phone 8'
11	5																		Depth 12'
12	2	5435	202246		030	11.1	0	11.1	cal	12									Gain Chg. Depth 12'
13	0	5451	202333							16									Depth 16'
15	4	5513																	Up to surface
16	3	5596	203045						IO										Change to Inter Oceans
16	4																		Unknown gain change
18	2				005	-3.3	0	-3.3	IO										Gain Change
19	1	5640	203259		010	0.7	0	0.7				7.0	5	1	20	1	30		Change 7.0 khz pulse0.1
20	0	5654	203259		005	-3.3	0	-3.3											Depth 14' gain change
20	4	5665	203415		010	0.7	0	0.7											Up 4' gain change
21	1													3	20	1	30		Filter change
21	5	5701			005	-3.3	0	-3.3											Gain change
22	3	5710	203601																up to surface

DAILY LOG

EB05

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				005	-3.3	0	-3.3	IO	1		1	100	0.8	3	0.8	30	10	Boomer & IO in El.Pk Cov
1	2	6015	205144		010	0.7	0	0.7											gain change
2	3	6027																	Core st 1
4	0	6038	205300																Core St. 2 going east
6	1	6059																	Core St. 3
9	2	6090	205540																Out to buoy and line
14	2	6185	210010		020	6.9	0	6.9	IO					0.4	0.8	0.4	30		Change freq. run E. out
16	0	6197																	Core St. 1
17	3	6212	210146																Core St. 2 ?Hard Bot.
19	0	6234	210249																Core St. 3
22	0	6259	210357		090	19.4	0	19.4											Gain Change
23	1																		data clipped
25	4				040	14.0	0	14.0											gain chg. @ green buoy
26	4				30	11.1	0	11.1						0.8	3	0.4	30		gain chg. filter change
30	3	6340	210759																Buoy Heading west
32	3																		End of line

DAILY LOG

BP01

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	17	122352		030	11.1	0	11	MS	1.5		7.0	5	3	20	0.7	20	3.5	Gibralter Water lv -36'
																			Black Lagoon Lower
																			AS01AugA Navigation
0	3	30	122440	S02N															Str. L. 2 CoreSite 70m
1	2	67	122627	E02															
3	5																		Scale 2.4 53.5
6	2	161	123112	S04	040	14.0	0	14.0	MS										Start line 4
7	1	177																	core site 1 ?
8	0	202	123300	E04															end line 4
11	1				050	15.9	0	15.9											gain change
13	3	325	123920	S06N															Str. 06 speed 1.3 kts
14	3																		possible core site
16	0	377	124200	E06															end line 06
17	2																		Scale 4.8 - 55.9
17	5	412	124339		060	17.2	0	17.2											gain change
23	0	494	124704	S08N															Start Line 08
27	5	569	125120	E08															End line 08
28	3				070	18.1	0	18.1											Change gain
36	3	706	125816	S10N															Str. line 10 0.9 knts
38	1	733																	possible core site
42	0	793	130238	E10															end line 10
50	0	921	130900	S12N															str. line 12
51	4	948																	possible core line
56	0	1015	131344	E12															end line 12
56	4				080	18.8	0	18.8											gain change
65	1	1163	132100	S14N															start line 14
70	4	1259	132520	E14															end line 14
75	2	1330																	Bottom Pile above bot.
78	4	1378	133140	S16N															Str. line 16
79	5	1397																	Poss. Core Soft
82	3	1440																	Hard Bottom ?
84	3	1468	133610	E16															End line 16 - Soft bott
94	3	1629	134417	S18N															Str. line 18 - 0.8 knts
100	0	1716	134836	E18															End line 18
103	5				070	18.1	0	18.1											gain change
108	3	1851	135520	S20N															str. line 20 1.0 knts
113	1	1925	135520	E20															end line 20
114	1				060	17.2	0	17.2											gain change
120	1																		depth scale 0 51
122	0		140600	S22N															start line 22
126	0	2129																	old station #7
126	3																		end line 22

DAILY LOG

BP02

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				060	17.2	20	37.2	CR	1.5		7.0	5	3	20	0.7	20	3.5	Crystal black lagoon
																			Pulse width 0.14
1	2	2239	142155	S02N															Str. 02 wat depth 2'
4	1	2201																	wat. depth 9' weeds
4	2	2290	142420	E02															end line weeds
5	1				080	18.8	20	38.8											change gain
8	2																		scale chg. 4.8 - 55.2
13	2	2429	143120	S06															start line 06
17	1	2489	143420	E06															End line 06
19	2				100	19.9	20	39.9											Gain Change
27	0	2647	144214	S10N															Start line 10
33	1	2742	144645	E10															End line 10
38	3	2832																	Raised soft spot
43	4	2906	145500	S14N															Start line 14
50	0	3007	150010																End line 14
57	4	3133																	raised soft material
58	4	3146	150700	S18N															Str. line 18
63	2																		one line out old Sta #7
64	1	3230	151120	E18															End line 18
64	4																		Scale 0 51.2
68	1																		Shut down data collection
68	2																		Start again
68	4				090	19.4	20	39.4											Change gain
71	1	3349	151940	S22															Start line 22
75	1				060	17.2	20	37.2											Chg. gain Possible clip
75	2																		Old Sta. #7
75	3	3415	152258	E22															End line 22
																			Computer time 141106
																			UTC time 152430

DAILY LOG

BP03

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC AMG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
					030	11.1	0	11.1	MS	1.5		3.5	5	0.7	20	1	20	3.5	Black Lagoon 3.5 kHz
																			Pulse length 0.28
0	0	3509		S02N															Start Line 02
3	0	3550		E02															End line 02
6	3				040	14.0	0	14.0											Gain change
12	5	3710	172050	S04N															Str. Line 04
16	1	3761	172325	E04															End Line 04
25	5				050	15.9	0	15.9											gain change
26	5	3929	173147	S10N															Start line 10
28	5	3959	172325																hard spot
32	4	4021	173625																End line 10
43	3	4189	174450	S14N															start line 14
45	3	4221	174625																hard spot
46	5	4244																	Power surge - noise
49	5	4290	175000	E14															End line 14
57	4	4416	175606	S18N															Start Line 18
63	4	4511	180100	E18															End line 18
65	0																		Turn fast down stream
																			lighting storm
67	0	4560	180330																System shut down

DAILY LOG

BCR1

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
					050	15.9	0	15.9	MS	1.5	0	3.5	5	1	20	1	20	3.5	Recon for core sites
																			along line 16 rep 0.15
0	0	17	124020																175 yds from Str. line
9	1																		15 yds SOL
10	4	180	124846	S16N															Str. line 16
																			20 meters in pos. core
13	0		125043																35 meters in pos. Hard
																			60 - 67 mtr. pos. Soft
16	0	265																	76 - 80 mtr. pos. Hard
19	0																		110 mtr. pos soft
20	0																		Moving to a possible s
20	5																		stop recording riggi
21	0	537	130600	C11					MS										Anchored core 11 start
24	3	586																	Rep. rate = 0.25 wait
26	1	618	131036	C11					MS										Core Down N73002
																			E4098765
27	3			C11					CR										change to crystal
28	0	666			150	23.2	20	43.2	CR										change gain
29	0											7.0							change freq. 7 khz
30	1						0	23.2	MS										change Massa 7 khz
32	1	757	131722	C11															● 105 meter from line
																			pulse length 0.14
33	0																		● 95 mtr. Ponar - Bla
																			clay/silt with gravel
34	1	1006	132950																Start again
35	1	1024	133048	C12															Core 12 In, 95.7 meter
																			N72993 E4098757.9
38	0						20	43.2	CR					1	20	1	20		Switch Crystal
46	0													3	20	1	20		change filter
46	2	1278	134332	C12	150	23.2	0	23.2	MS										switch Massa
46	4													1	20	1	20		changed filter
48	0				150	23.2	0	23.2	MS			3.5							change freq. 3.5 khz
49	2	1344	134647		150	23.2	20	43.2	CR										change to crystal
																			Fluff on top of core

DAILY LOG

BCR1A

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
					150	23.2	0	23.2	MS	1.5		3.5	5	1	20	1	20	3.5	Core Site 13 - 71.8 mtr.
51	0	1789	140900	C13															Massa 3.5 khz
52	0																		Stop Pinging - Ponar dwn
																			Very Hard - Rock/Gravel
52	2	1948	141634	C13															Massa start again C13
52	5	1963			150	23.2	20	43.3	CR										Switch crystal 3.5 khz
53	3				200	24.4	20	44.4	CR										gain change
54	2	2000	141900																chg. freq 7.0 pl=0.14
55	3				200	24.4	0	24.4	MS			7.0							chg Massa, chg. gain
57	3																		Stop moving boat back
58	2																		Ponar Sand Gravel Clay
59	5	2210	143124		150	23.2	0	23.2	MS										Getting ready for C14
61	2																		Core 14 down - Sand fine
																			pea gravel 6" length
																			could not save
61	4				150	23	20	43.2	CR										Switch to crystal
																			End Disk
																			note: record 4.8 55.2

DAILY LOG

BRC2

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
					150	23.2	20	43.2	CR	1.5		7.0	5	1	20	1	20	3.5	Cont' C14 site
0	0	2365	143917																Crystal 7.0 khz
1	1	2390	144000						CR			3.5							Crystal 3.5 khz
2	0	2410			150	23.2	0	23.2	MS										Change to massa 3.5 khz
3	2																		Move to 30 meter point
10	4																		Stop @ 27.2 offset 6.1s
11	3	2862	150359									7.0							Massa 7.0 khz
																			Ponar - Mud - soft
14	0	2910	150630	C15															Core 15 N72928 E4098736.3
																			Moving back and forth
17	5								MS										Massa 7 khz
17	5	3107			200	24.4	20	44.4	CR										Change to Crystal
20	4				200	24.4	0	24.4	MS			3.5							Change to Massa 3.5 khz
21	0	3176	151945																
23	0																		Moving back to 17.6 sec; Note Nav 14' aft of Rec.
26	1	3453							MS			7.0							change freq 7.0 khz
																			Ponar clay silt iron tr
28	2																		stop rig core
28	3	3552	153829						MS										str. data again
30	1																		Core 72917.9 E4098738.0 PL = 0.14
31	4	3625			200	24.4	20	44.4	CR			7.0							Crystal Rec. 7 khz
33	5	3681										3.5							Crystal Rec. 3.5 khz 17 meters 0 offset
35	0	3692	144518		200	24.4	0	24.4	MS			3.5							Change Massa 3.5 khz

DAILY LOG

BCR4

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	PIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	4051	180850	C17	200	24.4	0	24.4	MS	1.5	0	7.0	1.2	1	20	1	20	3.5	Core 17 Last year #1
																			Black Lagoon Lower
																			Echo sounder 10'
																			Pulse width 0.14
																			Ponar clay/silt/sand
																			56.0 meter on line 2.7of
6	5	4207	181615	C17															Core down N72942.2
																			E4098817.2
8	2	4241			200	24.4	20	44.4	CR										Crystal, change gain
9	1				400	29.5	20	49.5											Gain Change
10	3				200	24.4	20	44.4	CR			3.5	1.2						Freq. chg.
10	5												5						Power chg to 5 kw
12	1	4326			070	18.1	0	18.1	MS			3.5							Change to Massa rec.
13	3				060	17.2	0	17.2	MS			7.0							Freq chg 3.5, gain chg.
14	3	4378	182455	C17	060	17.2	20	37.2	CR										Change to crystal
15	3	4723										7.0							Getting ready core 18
16	3	4738	184300	C18															Core 18 55.2mtr, 1.0 off
17	0	4759			060	17.2	0	17.2	MS										Massa rec.
19	4	5214		Cal	020	6.9	0	6.9	Cal	8									CALIBRATION 8' depth
20	5																		Raise Cal phone
21	4				010	0.7	0	0.7	Cal										Gain chg.
22	2				030	11.1	0	11.1	Cal										Gain chg.
22	4				020	6.95	0	6.9	Cal										gain chg.
23	1											3.5							Freq chg. to 3.5 khz
23	5				030	11.1	0	11.1	Cal										Gain Chg. PL = 0.28ms
24	4	5520			020	6.9	0	6.9	MS										Going to line 22 3.5 khz
25	2				045	15.0	0	15.0	MS										gain chg.
25	5	5547	192310	S22N															start line 22
27	3	5583	192500		060	17.2	0	17.2	MS										gain chg.
28	4																		stop anchor for Core19
30	5																		moving still old core 7
																			84.9 metr. 2.3 m offset
31	4	5800																	Lower core 19
32	5				050	15.9	0	15.9	MS										chg. gain
34	1				050	15.9	20	35.9	CR										chg to crystal, chg gain
34	4	5880	193930		100	19.9	20	39.9	CR										gain chg.
35	4											7.0							freq. chg. 7.0 khz
36	4	5921			100	19.9	0	19.9	MS										chg. massa
37	0	5929			050	15.9	0	15.9	MS										chg. gain pul wid.0.14
38	1	6133		CAL	015	4.1	0	4.1	Cal										CALIBRATION CAL PHONE
38	4	6154	195330	CAL	030	11.1	0	11.1	Cal										gain chg.
39	3	6172			015	4.1	0	4.1	Cal			3.5							freq. chg. 3.5 gain chg.
40	2				030	11.1	0	11.1	Cal										gain chg.
40	4				015	4.1	0	4.1	Cal										gain Chg.
																			Compact Mud Core Bottom

BB01

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				020	6.9	0	6.9	IO	1.5		1	100	0.8	3	0.7	20	15	Boomer black lagoon
																			boomer 15' aft
																			Receiver 15' further aft
3	5	150	121300	S02N															Start line 02
6	5	208	121607	E02															End line
21	5	347	122247	S03N															Start line 3
24	3	372	122400																core location 17,18
27	5	404	122536	E03															End line 3
45	0	567	123332	S04	030	11.1	0	11.1											Str. line 4, gain change
50	5	623	123637	E04															End line 4
72	5	836	124715	S06															Str. line 6
85	1	956	125310	E06															End line 6
87	2		125425																Put float on rec hyd.
																			Stoped data acq. momentar
100	0	1137	130215	S08															Str. line 8
113	2	1266	130835	E08															End of line 8

DAILY LOG

BB02

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	1312	131952		040	14.0	0	14.0	IO	1.5		1	100	0.8	3	0.7	20	15	Cont. Boomer Blk. Lagoon
																			Heading south to line 10
15	2	1429	130215	S10N															Str. line 10
30	0	1542	132230	E10															End line 10
44	3	1658	132814	S12N															Str. line 12
57	5	1762	133330	E12															End line 12
73	5	1880	133948	S14N															Str. line 14
87	3	1995	134501	E14															End line 14
88	3																		Here in turn out to S.
104	1	2112	135137	S16N															Str. line 16
117	4	2220	135656	E16															End line 16
120	5																		Turn east to south
																			going to line 18
																			file bb03

DAILY LOG

BB03

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0		135945		040	14.0	0	14.0	IO	1.5		1	100	0.8	3	0.7	20	15	Cont Boomer Blk. Lagoon
																			Boomer 20' aft
11	0	2358	140345	S18N															Str. line 18 Occ. grass
24	1	2498	140854	E18															End line 18
29	0				030	11.1	0	11.1											Gain Chg.
39	5	2584	141508	S20N															Str. line 20
51	2	2671	141941	E20															End line 20
54	3				020	6.9	0	6.9											Gain chg. Turn S. out
																			Blank at Gain chg.
70	4	2810	142715	S22N															Str. 22
78	1	2871	143019																Core site 19
79	4	2884	143055	E22															End line 19
																			Going Blk Lagoon north
91	3	2979																	Start turn in west 15'
93	0																		9'
93	5																		2.5'
94	3																		2.5' and heavy weeds
96	4																		4'
97	0																		7' heading south
98	3																		8' depth echo sounder
100	2																		6.5'
102	3																		3' weeds
105	2																		6.5' weeds
109	0	3121																	Stop clean off weeds
112	2				030	11.1	0	11.1											Heading north on 22
																			Boomer 10' aft 15' sep ff
127	2	3349	145402	E22															heading north blk lag.N.
134	0	3399																	18' echo sounder
138	5																		4' turn in
139	2																		2.5'
141	0																		4'
144	0																		8.5'
147	3																		2.5' weeds
151	1	3513																	11'
153																			rough reverse line 16
																			till end of record

DAILY LOG

BB04

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				030	11.1	0	11.1	IO	1.5		1	100	0.4	1	0.7	20	20	Boomer low frequency
																			black lagoon lower
4	3	3639	150953	S02N	040	14.0	0	14.0											Str. line 02
7	4																		very shallow 3'
14	4	3720	151330	E02															end line 02 turn south
19	2				060	17.2	0	17.2											gain change
29	0	3834	151923	S03N															Str. line 03
33	0	3865	152115																Core look 55m C17,18
37	3	3904	152315	E03															End line 3
52	0	4021	152900		100	19.9	0	19.9											gain chg.
56	0													0.4	1	0.4	20		Reset filters
57	0	4061	143100	S08	080	18.8	0	18.8											str. line 08
74	3	4199	153756	E08															end line 08
84	0																		lost nav momentarily
97	1	4335	154709	S16N															str line 16
112	0	4452	155303	E16															end line 16
119	1				060	17.2	0	17.2											gain change
123	1				080	18.8	0	18.8											gain change
128	5				070	18.3	0	18.3											gain change
129	1	4594	155954	S22N															str line 22
135	4																		core location
137	0	4655	160259	E22															end line 22

DAILY LOG

RD01

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				050	15.9	0	15.9											Radar data Eliz. Park
																			This data experimental
																			only. lrate 100 micr/sec
																			1400 samples
																			Amplitude is non linear
28	2																		x4 line 7 N
34	0																		Eliz Park Cove move out
35	1																		Bow over soft spot
																			G = 4 + 0 linear
																			= 6 + 0 TVG
37	5																		middle core
39	1																		Core 3 going out
																			Antenna 20' aft boat
43	0																		Playing w/ filters
45	5																		bottom rising rapidly
47	3																		water depth 2.5 ft
48	4																		boat backing in cove
51	2																		Filter 100 Hz 500 Hz
52	3																		Inner Core
54	2																		middle core
53	5	5045	182400																
57	0																		third core 4.7' echo sou
58	0																		8' dept
60	1																		4'
60	4																		2.5'
70	1																		Inner Core (20' aftboat
73	0																		4.5' depth out core
77	3																		3.0' depth
80	0																		turn around and go back
83	4	5326																	str out of cannal
88	3																		4.5'
89	4	5389																	12' water
94	3	5440																	1st steel pier
96	0	5457	184518																2nd steel pier

DAILY LOG

RD02

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0				050	15.9	0	15.9	RD					100	500			20	Radar Black Lagoon
																			Only experimental
																			Gains not linear
7	0			L22															Line 22 out of range
																			of scale
14	1			E22															End line 22
15	3	5872																	depth 4.3'
17	4																		2.5'
19	0																		turning
20	1	5920																	2.5 weeds
24	0																		6.5'
25	0																		3- 2.5'
27	1																		Filter 35 - 500 Hz
32	2																		Changed zero position
37	4	6102																	8'
40	5	6132																	3.5'
43	0																		Filter 100-500 Hz
51	0																		Ant. to side of boat
																			All data at 100 MHZ
																			till here.

DAILY LOG

RD04

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0																		Radar 900 MHZ Blk. Lag Non linear no gains
2	0		194513																
7	0	5229	194745																Entering Blk Lagoon
8	2	6224	194850																Stationary
9	0	6253	154844																
11	3																		On sand bottom
17	5	6342	195309																Stationary at Pole to
19	2																		slow up mud bottom
21	0																		down and up again
23	3																		at bottom again
24	3	6408	195638																on surface
																			finished

DAILY LOG

BP22

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	20	124649		080	18.8	0	18.8	MS	1.5		3.5	5	0.7	20	1	20	3.5	Pinger Blk Lagoon
																			Pulse length 0.28ms
3	3				050	15.9	0	15.9	MS										gain change
5	0	110	125125	S22N															Str. Line 22 North
6	3				022	7.9	0	7.9											gain change
6	4	144	125300																Old core #7
7	1		125340	E22															End line 22
9	0																		Nav not logging
12	0	209	125825	S03N															Str. Line 3
13	3	240																	Core Sites 17,18
14	3	260																	End line 3 3.5 Khz
15	3											7.0		1	20	1	20		Freq. chg. pl=0.14
16	0				040	14.0	0	14.0	MS										chg. gain
19	0	350	130503	S03N															Str. Line 03
20	0	370																	core 18
21	2	394	130718	E03															End of line 03 3.5 khz
22	0																		go to cal sites line 16
25	2	476	131120																16 meters from SOL
26	0																		missed some pings
26	2																		30 meter from SOL 16

DAILY LOG

BCLS

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	0	650	132015	Cal	040	14.0	0	14.0	CAL	8	0	7	5	1	20	1	20		Cal at line 16
																			24.2. mtr. from start
																			2.8 mtr. offset
1	0				020	6.9	0	6.9	CAL										gain chg. 8 ft out
1	4				015	4.1	0	4.1											gain chg.
2	2	690	122230																lower 4', angle 30 deg
3	1				020	6.9	0	6.9											gain change
4	3																		24.7 meter from SOL
																			5.8 Meter offset
5	4																		lower 4' angle 45 deg
7	2				030	11.1	0	11.1											gain change
7	5																		up 4'
8	4	817			020	6.9	0	6.9											gain change
9	3	831			015	4.1	0	4.1											gain change
10	5																		Cal next to receivers
11	3				100	19.9	0	19.9	Cal										Cal next to recedivers
12	4	890	133235						MS										change to Massa 7 khz
14	3	929			100	19.9	20	39.9	CR										change to Crystal
18	0					?			CAL	8		35	5						chg. cal 3.5 khz
18	4	1013	133815		010	0.7	0	0.7											gain chg.
19	2	1024	133849																down 4'
19	5				017	5.3	0	5.3											gain change
21	1	1054	134034																down 4' angle 45 deg
21	5				020	6.9	0	6.9											gain chg.
22	3	1080																	up 4' angle 30 deg
23	0				015	4.1	0	4.1											gain change
24	1	1116	134320		010	0.7	0	0.7	CAL										gain chg.
26	0	1161			100	19.9	0	19.9	CAL										Cal next to receivers
																			24.8 m from SOL 2.3m of
28	0	1201							MS										Massa 24.8mSOL, 2.7m of
29	2																		24.9 m SOL, 3.9 m offpo
29	4																		24.7m SOL, 4.1 m off po
30	2	1249	135000		100	19.9	20	39.9	CR										Chg. to Crystal
31	1				200	24.4	20	44.4											gain chg.
32	4																		24.6 SOL 3.0 m off por

DAILY LOG

BLCSA

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
33	3	1309		cal	200	24.4	20	44.4	EDO	8		3.5	5	1	20	1	20		Cal Cont' EDO 3.5 khz
34	4	1329	135114		080	18.8	0	18.8											change gain
35	2																		down 4' angle 30 deg.
36	0	1363			150	23.2	0	23.2											gain change
36	5																		down 4' angle 45 deg
37	2				200	24.4	0	24.4											gain change
38	1																		up 4'
39	0	1415																	up 4'
39	3				100	19.9	0	19.9											gain chg.
40	1				010	0.7	20	20.7											gain chg. see lin. filter
41	0																		next to receivers
41	2				100	19.9	20	39.9											gain chg. next receivers
42	1				800	38.8	0	38.8											gain chg. check fil. lin.
44	0	1518			520	32.4	0	32.4	EDO			7.0							Chg. Freq. EDO 8'
45	0																		down 4'
46	0																		down 4' angle 45 deg
47	0																		up 4' angle 30 deg.
47	4				075	18.5	20	38.5											gain change
48	3	1601	140745		050	15.9	20	35.9											gain change
49	3																		up 4'
50	4				030	11.1	20	31.1											gain chg.
51	2				030	11.1	0	11.1											gain chg.
51	5				400	29.5	0	29.5											gain chg. ck. filter
53	2																		next to receivers
54	0				400	29.5	20	49.5											gain chg.
																			24.4 m SOL, 5.4 m Offprt

56 To 64 - InterOcean
Not Processed Clipped

DAILY LOG

BLCSB

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
56	0	1845	141950	CAL	006	-2.4	0	-2.4	IO	8		7.0	5	1	20	1	20		Cal of Interoceans
57	1																		down 4'
57	5				010	0.7	0	0.7		12									gain chg
58	2																		down 3'
58	4				005	-5.1	0	-5.1		15									gain chg
59	0									11									up 4'
59	4									7									up 4'
60	0																		varied pulse len +/-0.05
61	2																		next to receivers
62	0				020	6.9	0	6.9											change gain
62	3				030	11.1	0	11.1											change gain
																			last gain in ?
64	2	2000	142750		005	-5.1	0	-5.1		8		3.5	5	0.7	20	1	20		chg. Gain, chg. Freq 3.5
65	1									12									down 4'
65	3				010	0.7	0	0.7											gain chg.
66	1				005	-5.1	0	-5.1											gain chg.
66	3									16									down 4'
67	0									12									up 4'
67	4									8									up 4'
68	1				010	0.7	0	0.7											gain change
69	1																		next to receivers
69	5				005	-5.1	0	-5.1											gain change
70	3				100	19.9	0	19.9											Massa receiver

DAILY LOG

BCBS

FILE NO.	SUB FILE	FIX	TIME GMT	LINE NO.	REC. SET.	REC. GAIN	FIL GAIN	TOT. GAIN	REC. TYPE	REC. DPTH	REC ANG.	XMT FREQ	XMT PWR	F1 LOW	F1 HI	F2 LOW	F2 HI	SEPR FT	COMMENTS
0	3	2362	144852	16	020	6.9	0	6.9	IO	12		1	100	0.7	20	0.8	3		Boomer cal @ line16 cal
																			Boom @ stb. stern boat
1	0									16									lower 4'
1	3				010	0.7	0	0.7											gain chg.
1	5									12									up 4'
2	2									8									up 4'
2	4																		slowly down 4'
3	1																		up 4'
3	3													0.4	20	0.4	1		filter change
4	2													0.7	20	0.4	1		filter change
5	0																		down 4'
5	2				030	11.1	0	11.1											gain change
6	0													0.4	20	0.4	1		filter change
6	2																		up 4'
																			end
8	1								EDO										Change Edo Phone ?
8	3	2580																	
9	0				030	11.1	20	31.1											gain chg.
9	2																		down 4'
10	1	2616	150136											0.7	20	0.8	3		filter chg.
11	0				020	6.9	20	26.9											gain chg.
11	3				020	6.9	0	6.9											gain chg.
11	5				100	19.9	0	19.9											gain chg.
12	0																		up 4'
12	4				020	6.9	20	26.9											gain chg.
13	1																		up 4'
14	0																		on bottom
14	2																		pull up
15	0													0.7	20	1	3		filter change
15	2													0.7	20	1	10		filter change
																			end
																			Note: cal phones insert
																			just forward house

TRENTON CHANNEL CONDUCTIVITY MEASUREMENTS

PURPOSE: PROVIDE DATA FOR EVALUATION OF RADAR INFORMATION

APPARATUS: Unit consisted of 2 1.5*3* plates with a mean separation of 9.5*. The leads connected to a high impedance ohmmeter.

REFERENCE: Normal clean water = 10,000 ohms

Area	Location	Obs -1	Obs-2	Obs-3	Obs-4	Obs -5	Mean Obs
Dock	Surface	2564					2564
Immediate	Mid Point	2487					2487
after	Bottom	1992					1992
storm	Air-Wet	90000					90000
							0
Q.E.Prk	Surface	1080					1080
	Bottom	1077					1077
	Mid Point	1150					1150
	Air-Wet	300000					300000
							0
Blk. L.Up	Air-Dry	1700000					1700000
	Surface	2500	2600	2700	2680	2650	2626
	Bottom	2650	2630	2625	2616	2604	2625
							0
Blk.L.Upp							0
over sand	Air -Dry	3000000					3000000
	Surface	2400	2700	2600			2567
	Bottom	6000	6000	7000			6333
Center(mud							0
	Surface	2800	2900	3200	2000		2725
	Bottom	2000	1500	2000	7000		3125
Dock							
Next day	Air	1700000					1700000
	Surface	10000	11000	12000	11000		11000
	Bottom	10000	9000	10000	10200		9800

APPENDIX A2

DETAILED NAVIGATION LOGS
(USEPA-LLRS)

TRANSCRIPTION OF JULY 1995 TRENTON CHANNEL FIELD BOOK NOTES

BY ROBERT L. GREGORY 29 SEPTEMBER 1995

THE FIELD BOOK PAGE WILL BE LISTED, DATA WILL BE TRANSCRIBED LINE BY LINE AS ENTERED , FROM TOP DOWN.

PAGE 15 [FIRST PAGE OF NOTE BOOK ADDRESSING TRENTON CHANNEL]
Trimble UTC Time Standard
File AS26JULA
Runline AS(B/N)6
15:01:47 start log 001 [Trimble generated fix number]
turn off @ 090
Runline ASN6001
91 @ 10:21:46
Start @ FIX 100
End ASN001 Fix 132 15:25:xx
stop data 15:48:30 Fix 594

ADDED NOTES BY JOHN FILKINS

ESTABLISHED A JOB TCI as
Trenton Channel Study Clean Site
[Point Monlee']
Transfers AM Position data file AS26JULA
to DATA BASE in TCI

Set computer time to UTC

FIX 600 Time 17:49:30
FILE AS26JULB
Started data collection
[maybe stayed in "A']
N56649.8 E4,097,853.5
****
PAGE 16
[BLANK]
****
PAGE 17

POSSIBLE SITE	N	700.9	OFF SPUR DIKE
	E	794.9	
POSSIBLE SITE		60.1	OFF RANGE LIGHT
		52.8	
POSSIBLE SITE	N	58.	ALTERNATE
	E	76	
REF. POINT.	N	57,209	MOUTH
	E	4,098,286	app.. # 925

One foot wave on lake

```
                  N      57,223            centerline jetties
                  E      4,098,305   entrance

ref. Point.                    553   marker on north ch.
                  235
                  Appro. #1150
**************************************************************************

PAGE 18

                  N      587         2nd wood pile
                         280
sample      "Grab"       @
HOLD POSITION
@     N      57,583             TIME  18:22:50
             4,098,279
      2nd try                   fix   1285
             N      57,505             about 18:30
             E      4,098,285          LOSS SAMPLER

ANCHOR SAMPLE            [SAMPLE SITE]
FOUND PEAT @ About same site

SECOND SAMPLE
      N      56,734                   FIX 1790 @ 18:48
      E      4,097,722

DRAG ANCHOR SAMPLE SITE 2
      NORTH EAST OF PILE
      SOUTH SPUR DIKE
      WEST SIDE OF CHANNEL
      4 INCH "CLAY"
**************************************************************************

PAGE 19

            CORE SAMPLE
FIX START # 2014         N 56,752
TIME 19:00               E 4,097,724
FIX END   #2747          N 56,747
                         E 4,097,724

DOCK @ 19:52             FIX   3078
--------------------------------------------------------------------------

DATA FROM ART
STA 8              PEAT        0-43cm      12.9% clay

                                           41.5% silt
50% sed silt or clay
                               43-74cm     53.1 silt\31.0% clay
                               74-107cm    51.1 silt\19.0% clay
```

COMPUTER SET TO UTC 27 JULY 95

NEW FILE AS27JULA
FIX 001
START TIME 13:13
FIX 1 MARK OUTLET GIBRALTAR BOAT BASIN

FIX 73 MARK N 66,730 2nd MARK
E 4,097,815

****** LOSS POWER & RESTORED about 13:26**********

NEW FILE AS27JULB
FIX 1 @ 13:29 [FIX CHANGE TO 1 AUTOMATIC]

FIX 84 INTERESTING SITE
N 65,075 E 4,098,088

FIX 114 START INWARD RUN @ SITE

FIX 177 [INTERESTING SITE] N 65,023 E 4,098,300

FIX 200 N 65,023 E 4,098,375
TURN AROUND HEAD OUT PARALLEL TO LINE

********* TEMPORARY LOSS POSITION**********
****
PAGE 21

FIX 257 N 65,029 E 4,098,239

HOLD FOR GRAB SAMPLE

*FIX 296 N 65,017 E 4,098,238 CENTER FOR POSITION
ACTUAL SAMPLE LOCATION
HOLDING ON SITE

FIX approx. 500 MOVE OFF SITE CELERON ISLAND
FIX 582
****
*****POWER OFF**********
BREAK IN RECORD
NEW FILE AS27JULC about 14:06
FIX 1 STARTING AROUND ISLAND
****
FIX about 290 N 65,815 E 4,098,955 TAKE GRAB
****
FIX 320 N 65,663 E 4,098,129 TURNED END OF RUN
SURVEY START
****

PAGE 22

+ 40 INCHES

FIX 366 N 65,681 E 4,098,284
INBOUND END OF LINE RUN
OUTBOUND RUN
FIX 410 N 65,675 E 4,099,239 END OF RUN
****
**GRAB SAMPLE HEAD OF ISLAND NE CONNER
FIX 444 N 65,663 E 4,099,242 [FOR CORE]
[GO N E]
****
GRAB SAMPLE
FIX 651 N 65,812 E 4,099,980
FIX 678 N 65,803 E 4,099,015 FOR CORE
****
FIX 1222 N 67,635 E 4,098,848
POSSIBLE SITE
****

PAGE 23

RUN INTO CHRYSLER BAY
FIX 1461 N 68,701 E 4,098,171
LINE
****
FIX 1511 N 68,720 E 4,098,020
END
****
SAMPLE TIME 15:23
FIX 1540 N 68,736 E 4,098,020 #
FIX 1704 MOVING OFF SITE
****
SHUT DOWN DATA COLLECTION @ FIX 1920 15:42
@ FREE BRIDGE
****

PAGE 24

THURSDAY PM 1:20
NEW FILE AS27JULD
[START] FIX 1921

TEST RUN THRU FIX 2025

RUN 4N001 OUTSIDE
FIX START 2100
FIX END 2133

RUN 4N003
FIX START 2726
FIX END 2782

RUN 4N005

FIX START 2914
FIX END 2988

INTERESTING POINT FIX 2947
****

PAGE 25

REFERENCE [18:34:25\FIX 3072]

RUN 4N007
FIX START 3111
FIX END 3197

RUN 4N009
FIX START 3306
FIX END 3371

RUN 4N011 SAMPLE START ON LINE FIX 3540
FIX START 3470
FIX END 3560

RUN 4N013
FIX START 3662
FIX END 3710

RUN 4N014
FIX START 3802
FIX END 3838
****OFF LINE*****
****

PAGE 26

FREE RUNLINE
FIX START 3861 STRIGHT IN
FIX END 3910
UP CHANNEL TO FIRST BRIDGE FIX 3890

NEW FILE AS27JULE
FIX START 4017

RUN UP CHANNEL
FIX START 4021 [LATE START]
FIX END 4072

RUN N 014 SECOND PASS
FIX START 4164
FIX END 4203
RUNNING AROUND CONNER
PARALLEL TO SHORE TO FIX 4231
****

PAGE 27

RUN N013 [SECOND PASS]
FIX START 4315
FIX END 4364

RUN N009 [SECOND PASS]
FIX START 4480
FIX END 4577

RUN N005 [SECOND PASS]
FIX START 4670
FIX END 4748

RUN N001 [SECOND PASS]
FIX START 4842
FIX END 4936

HOLD ON STATION FOR TEST
FIX 4948 N 71,489 E 4,098,535

DRIFT UNTIL
****

PAGE 28

RUN N4001 [THIRD TRIAL]
FIX START 5442
FIX END 5540

RUN N4005 [THIRD TRIAL]
FIX START 5680
FIX END 5761

RUN N009 [THIRD TRIAL]
FIX START 5855
FIX END about 5935
BAD LINE [TERMINATED INCOMPLETE]

RUN N013 [THIRD TRIAL]
FIX START 6017
FIX END 6064

RUN N4014 [THIRD TRIAL]
FIX START 6142
FIX END 6192

****

PAGE 29

CHANNEL RUN [THIRD TRIAL]

FIX START 6217
FIX END 6290
positions calculated by Filkins for navigation to possible sampling points
SPECIAL FIXES 6235 [ROCK MAYBE]
SPECIAL FIXES 6344 [SECOND POINT]
SPECIAL FIXES 6262 [THIRD POINT]
SPECIAL FIXES 6277 [FOURTH POINT]*

****

FIX 6235 42` 08' 12.21" 71,423.28 N [(`) USED FOR DEGREE]
83` 10' 33.40" 4,098,435.77 E

FIX 6236 42` 08' 12.23" 71,423.87 N
83` 18' 33.47" 4,098,434.11 E

FIX 6244 42` 08' 12.42" 71,429.57 N
83` 10' 34.04" 4,098,421.04 E

FIX 6262 42` 08' 12.25" 71,423.57 N
83` 10' 35.24" 4,098,393.51 E

****

PAGE 30

FIX 6277 42` 08' 11.95" 71.413.68 N
83` 10' 36.37" 4,098,367.56 E

****

PAGE 31

JULY 28 1995

MUD PUPPY ANTENNA 4.30 METERS MIDSHIP FROM `CORE' [BOOM], CENTERLINE VESSEL 12 FEET 4 INCHES FROM WATER LINE

NEW FILE AS28JULA
FIX START 001

CORE SITE CHANNEL U\S FIRST BRIDGE ELISABETH PARK ISLAND
RUN FILE FIX 1-200
NAME STATION 5 ELIZ PARK INNER
42` 08' 11.7474 N 083` 10' 37.3896 W
N 71,407.2 E 4,098,345.6
VESSEL BEARING 101.9`

CORE 7 STATION
FIX 201-236
****

PAGE 32

42` 08' 12.2378" 83` 10'35.3178

N 71,422.8 E 4,098,392.8
MAG BEARING 128.8

****

SITE OFF CHANNEL
FIX 236 284 TO ABOUT 350
****ABORTED******

SECOND TRY
FIX 500

CORE DOWN FIX 618
CORE UP FIX 628
SAMPLE 8.**
N 71,376 E 4,098,447
LAT 42` 08' 10.9651" LONG 83` 10' 32.7639
[SOUTH SIDE OF CHANNEL]
OFF SITE FIX 761
****GRAVEL ONLY**********

****

PAGE 33

SAMPLE CORE TRY
SAMPLE #9 NORTH SIDE CHANNEL
CORE DOWN FIX 1016
CORE UP FIX 1040
N 71,477 E 4,098,481
LAT 42` 08' 13.86 LONG 83` 10' 31.3143"
SAND & GRAVEL about 2 INCHES

SAMPLE CORE TRY
SAMPLE #10
CORE DOWN FIX 1316
CORE UP FIX 1346
N 71,489 E 4,098,540
LAT 42` 08' 14.125" LONG 83` 10' 28.8185"
about NORTH END LINE 1
***POWER DOWN AT 5:00 PM FIX 1806
****

PAGE 34

CALCULATION to digitize a sampling grid

GIBRALTAR BAY
BEARING 310`
AREA 300 METERS X 500 METERS

FOUR POINT DRAWING FOLLOWING LENGTHS AND BEARINGS:

A to B 300 METERS AT BEARING OF 40`
B to C 500 METERS AT BEARING OF 310`
C to D 300 METERS AT BEARING OF 220`
D to A 500 METERS AT BEARING OF 130`

POINT A [STARTING POINT] IS 42` 04' 58" N 83` 10' 05" W
USING "ROBBIN DIRECT
POINT B 42` 05' 05.4" N  83` 09' 56.6" W
POINT C 42` 05' 15.8" N  83` 10' 13.3" W
POINT D 42` 05' 08.4" N  83` 10' 21.7" W
POINT A 42` 05' 18.8" N  83` 10' 05.04 W

EDITORIAL NOTE: THIS TRAVERSE DOES NOT CLOSE, MAY BE COMPUTATIONAL ERROR OR COPYING ERROR. SINCE WE DID NOT USE, I DID NOT RECHECK.
****

PAGE 35

SAT. 29 JULY `95
ELIZ PARK [THIRD DAY]

NEW FILE AS29JULA FIX 001

****
SUNDAY 30 JUL 95 *collecting cores for Lick sediment flume*

0855 STA # 7 SOUTH OF BLACK LAGOON 9'3" WATER
42` 09' 03.4920" N  83` 10' 19.5675" W
1 SQ CORE 1 2" ROUND CORE

1020 STA #3 INNER ELIZ PARK CANAL 4' WATER
42` 08' 11.9120" N  83` 10' 36.8720" W
1 SQ CORE 1 2" ROUND CORE

1120 STA #3 MIDDLE ELIZ PARK CANAL 5 Feet water
42` 08' 12.2525"" n  83`10'36.3200" w [maybe 35" or 33"]
1 square core 1 -2 inch round core

12:15 STATION # 3 OUTER ELIZ PARK CANAL 5 Feet Water
42` 08' 12.4300" N  83` 10' 33.9100 W
REPOSITIONED TO
42` 08' 12.4450"  N  83` 10' 34.0300" W

****
PAGE 36
MONDAY 31 JULY 1995

BOOMER 20' AFT STERN
OFF SET 10' PORT OF CENTERLINE

FILE AS31JULA FIX 001
BOOMER RUN OF ELIZ PARK
FILE ON TIME 13:30:34

RUNLINE ASN4001
FIX START 29 CENTERLINE CHANNEL FIX 77
CENTER LINE ELIZ PARK CHANNEL FIX 77
FIX END 116

REDO ASN4001
FIX START 400 TIME 13:35:03
CENTER LINE ELIZ PARK CHANNEL 451
FIX END 496

RUNLINE ASN4005 VELOCITY [0.7]
FIX START 755
**TERMINATE RUN FIX 778

****

PAGE 37

RUNLINE ASN4005 SECOND TRY
VELOCITY 1.2 KNOTS
FIX START 1284
FIX CENTER LINE ELIZ PARK CHANNEL
FIX END 1335

RUNLINE ASN4009 FIRST TRY
VELOCITY 1.3\1.4 KNOTS
FIX START 1489
FIX CENTER LINE ELIZ PARK CHANNEL 1512
FIX END 1540

RUNLINE ASN4013
VELOCITY 1.5 KNOTS
FIX START 1671
FIX CENTERLINE ELIZ PARK CHANNEL 1690
FIX END 1781

RUNLINE ASN4 0014
VELOCITY 1.6 KNOTS
FIX START 1831
FIX CENTER LINE ELIZ PARK CHANNEL 1855
FIX END 1856

****

PAGE 38

BEARING 114
RUN CENTER LINE ELIZ PARK CANAL
TO MOUTH [FIRST BRIDGE]

NORTH SIDE
FIX START 2029
FIX END [CANAL] 2094
OVER RUN FIX 2119
****
END FILE 2135

NEW FILE AS31JULB FIX 2136

SECOND PASS CENTER LINE ELIZ PARK CANAL
FIX START 2140
END CANAL
END OVERRUN 2212

THIRD PASS CENTER LINE ELIZ PARK CANAL
FIX START 2327
END CANAL 2346 FIRST CORE
END OVER RUN 2361 SECOND
END RUN
DATA DOWN
****

PAGE 39

GAGE READING +3.4 11:30 AM

FOURTH PASS CENTER LINE ELIZ PARK CANAL
FIX START 2482
FIRST CORE SITE 2500
SECOND CORE SITE 2519
THIRD CORE SITE 2541 [END CHANNEL]
END OVER RUN 2572

****
BOOMER TEST 2621 OMIT
****

RUN DOWN ELIZ PARK CANAL
FIX START 2746
FIRST CORE SITE 2766 [2756 FIX CORE]
SECOND CORE SITE 2766
THIRD CORE SITE 2806
END OVER RUN 2869

FIX @ BUOY [SOL 1] [START OF LINE]
[FIX 2904
TEN FEET SOUTH BUOY
FILE OFF @ 29:30
****

PAGE 40

FILE AS31JULC
ANCHORED ON STATION 8
FIX START 3085 ABOUT 18:25

N 71,365 E 4,098,449
MAG BEARING 18.2 @FIX 3224

MAG BEARING 22 @FIX 3247

SAMPLE 17 FEET FORWARD OF ANTENNA
8 FEET DEPTH
BEARING 43 degrees FIX 3400
                     FIX 3442
****
FIX 3472 BOTTOM TEN FEET 25 DEGREE ANGLE
****
FIX 3480
CLOSE FILE @ FIX 4385

NEW FILE AS31JULD START FIX 4386
START ON STATION @ FIX 4386
****

NEW PAGE 41

STATION 10
START FIX 4992 @ 20:00:46
END STATION 5794
****
INTER OCEAN & BOOMER

RUN INTO CANAL about 20:47:00

FIX NEAR FIRST BRIDGE
START FIX 6000
STATION #2 FIX 6038
STATION #3 FIX 6059
END OF OVER RUN FIX 6090

SECOND RUN
START FIX 6185
STATION # 1 6197
STATION #2 6212
STATION #3 6234
END OF OVERRUN 6278
CIRCILE
END FIX 6348

****

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*****NOTE BROKE CONVENTION AND NAMED THIS SERIES AS"C"3"S"

1 AUG 1995

FILE AS01AUGA FIX 001
RUNLINE ASN3A

```
SELECTION
            ASC3A02             OUTER RUNLINE
            ASC3A022            INTER RUNLINE

START DATA COLLECTION AT 12:23:15

RUNLINE     02
START FIX   30    [about 2.0 KNOTS]
END FIX     63

RUNLINE     04
START FIX   161   [about 2.0 knots]
END FIX     196

RUNLINE     06
START FIX   325   [about 1.3 KNOTS]
END FIX     377

************************************************************

PAGE 43

RUNLINE 08
START FIX   494
END FIX     568

RUNLINE 10
START FIX   706
END FIX     793

RUNLINE 12
START FIX   921
END FIX     1015

RUNLINE 14
START FIX   1163
END FIX     1250

RUNLINE 16
START FIX   1376
END FIX     1468
************************************************************



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RUNLINE 18
START FIX   1629
END FIX     1716

RUNLINE 20
START FIX   1851
```

```
END FIX     1925

RUNLINE 22
START FIX   2066
END FIX     2132

END FILE    FIX   2158

*****************************************
NEW FILE          AS31AUGB    START FIX 2159
*************NOTE FILE SHOULD READ AS"01"AUGB,  NOT "31" ************

*********************************************************************************

PAGE 45

SUGGEST CORE ON RUNLINE 14

RUNLINE 2   SECOND PASS
START FIX   2239
END FIX     2296

RUNLINE 06  SECOND PASS
START FIX   2429
END FIX     2489

RUNLINE 10  SECOND PASS
START FIX   2647
END FIX     2742

RUNLINE 14  SECOND PASS
START FIX   2906
END FIX     3007

RUNLINE  18 second pass
START FIX   3146
END FIX     3230

*********************************************************************

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RUNLINE 22  SECOND PASS
START FIX   3349
END FIX     3415

END FILE          FIX   3463

NEW FILE    AS01AUGC
```

START DATA LOGGING @ 17:08:40

RUNLINE 02 THIRD PASS
START FIX   3509
END FIX   3550

RUNLINE 06 THIRD PASS
START FIX   3710
END FIX   3761

RUNLINE 10 THIRD PASS
START FIX   3929   TIME 17:31:42
END FIX   4021

****

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RUNLINE 14 THIRD PASS
START FIX   4189
END FIX   4290

RUNLINE 18 THIRD PASS
START FIX   4416
END FIX   4511

ABOUT FIX 4560 **********SYSTEM   DOWN**********

****

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2 AUGUST 1995
FILE AS02AUGA   START FIX   001

12:39:47 STARTED DATA COLLECTION
PICKING CORE SITE ON RUNLINE ASC3S-16

START FIX   180   TIME 12:48:44
#25 METERS FIX   207
#20
#55   24
#60
#70   FIX   253
#76   FIX   266   [TARGET CORE SITE]
#90
#100
END FIX   302   TIME 12:54:46

**EDITORIAL NOTE MY SUPPLEMENTARY RECALL IS "# 55 IS STATION NUMBER OR DISTANCE IN METERS FROM THE START OF RUNLINE ASC3S-16. THE STATED PURPOSE OF THIS PASS WAS TO LOOK AT BOTTOM CONDITIONS.

I WOULD SUGGEST WE APPEND THESE NOTES WITH A PRINTOUT OF THE RUNLINE DIRECTORY AND SELECTED RUNLINE FILES.

****

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CORE #11 About END OF LINE [EOL]

START CORE FIX 485 N 73,002 E 4,098,765
42` 09' 03.236 N 83` 10' 18.138 W
DROP SAMPLER FIX 618
PULL SAMPLER FIX 659
NO SOIL [TOO HARD]

GRAB SAMPLE FIX 774
PULL STONE
OFF STATION FIX 824

SECOND CORE SITE #12 FIX 871
GRAB about FIX 900 N 72,993.6 E 4,098,758.4
OUT @ FIX 939
CLAY\SILT\GRAVEL FILLED 42` 09' 02.96 N 83` 10' 18.429"
FROM BLACK LAGOON

DROPPED CORE FIX 1006 N 72,993.7 E 4,098,757.9
PULL CORE FIX 1052 42` 09' 02.98 N 83` 10' 18.45"

SYSTEM TEMPORARILY OFF @ FIX 1579

****

PAGE 50

CORE SAMPLE # 13

ON STATION FIX 1794 N 72,971.2 E 4,098,747.8
42` 09' 02.242 N 83` 10' 18.890 W
GRAB SAMPLE @ FIX 1844

NEW FILE AS02AUGB START FIX 2077

NEW CORE SITE # 14

ON SITE FIX 2087 [NOTES SAY FIX 2187 BUT INCONSISTENT]
GRAB SAMPLE FIX 2136
DROP CORE FIX 2210 N 72,963.5 E 4,098,740.5
PULL CORE FIX 2231 42` 09' 02.00"N 83` 10' 19.22" E
BAD CORE
SMALL AMOUNT OF SAND AND GRAVEL IN CATCHER
ONLY WATER ON TOP OF STIFF MUD

****

PAGE 51

CORE SITE # 15

ON SITE FIX 2750 N 72,928.5 E 4,098,735.6
GRAB FIX 2782
FIX 2799 42` 09' 00.86" N 83` 10' 19.41" W
MUD
DROPPED CORE FIX 2908
PULLED CORE FIX 2913

ABOUT 10 CENTIMETERS OF MATERIAL IN TUBE
OFF STATION @ FIX 3332
****

CORE SITE # 16

ON`SITE @ FIX 3384
GRAB SAMPLE FIX 3454 N 72,918.5 E 4,098,738.2
FIX 3468 42` 09' 00.54"N 83` 10' 19.34" W

CORE FIX 3585 N 72,917.9 E 4,098,738.9
STOPPED DATA LOGGING @ FIX 3887
****

PAGE 52

RUNLINE 003 WITH PINGER & BOOMER

PM 2 AUG 1995

FILE AS02AUGC START FIX 3888
START TIME 18:00:13
ON RUNLINE 03 /55 METERS FROM START OF LINE [OLD CORE SITE # 1]
[[EDITORIAL NOTE: THIS RUNLINE FAMILY WAS DEVELOPED OFF OF OLD SITE #1 LAT. & LONG]]
CORE SITE # 17

FIX 4060 N 72,943.2 E 4,098,816.7
TRIPLE ANCHOR 42` 09' 01.30" N 83` 10' 15.93"
DROPPED CORE FIX 4207
PULLED CORE FIX 4221
****

CORE SITE # 18

DROPPED CORE FIX 4738 N 72,942.4 E 4,098,815.5
PULLED CORE FIX 4796

OFF STATION FIX 5334
****

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RUNLINE 22 FOR IDENTIFICATION OF CORE SITE

START OF LINE FIX 5547
[OLD CORE FIX 5600]
ON STATION FIX 5682

CORE SITE # 19 N 72,988.4 E 4,098,726.4
42` 09' 02.81N 83` 10' 19.80 W
DROPPED CORE FIX 5797
PULLED FIX 5830

WEIGHT 17# 9 oz
TARE 1# 2 oz LITTLE SETTLEMENT ON WOOD
TOTAL LENGTH 57 1/4 INCHES
SEDIMENT LENGTH 27 1/4 INCHES
0-4 1/4 INCHES DISCONTINUOUS
LOTS OF OIL IN SEDIMENT

END CALIBRATION @ FIX 6214
STOPPED DATA COLLECTION AT FIX 6225
****

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4 SECONDS BEHIND UTC

NEW FILE AS03AUGA START FIX 001

RUNLINE ASC3S-02
DEPLOY BOOMER START DATA @ 12:05:29
START FIX 147 TIME 12:12:57
END FIX 202 TIME 12:15:48

RUN LINE 03
START FIX 340 TIME 12:22:10

```
55 M  FIX   373
END FIX     404          TIME  12:26:27

RUNLINE 04
START FIX   567          TIME  12:33:53
END FIX     623          TIME  12:36:57

RUNLINE 06
START FIX   837          TIME  12:47:19
END FIX     955          TIME  12:53:10

*************************************************************************

PAGE 55            HIGHPACK

RUNLINE     08
START FIX   1135         TIME  13:02:15
END FIX     1262         TIME  13:08:35

RUNLINE 10
START FIX   1430         TIME  13:16:50
END FIX     1542         TIME  13:22:30

RUNLINE 12
START FIX   1657         TIME  13:28:14
END FIX     1762         TIME  13:33:30

RUNLINE 14
START FIX   1889         TIME  13:39:40
END FIX     1994         TIME  13:45:01

NEW FILE AS03AUGB        START FIX 2014

RUNLINE 16
START FIX   2112         TIME  13:51:37
END FIX     2216         TIME  13:56:56
*************************************************************************



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RUNLINE 18
START FIX   2353         TIME  14:03:45
END FIX     2458         TIME  14:09:XX

RUNLINE 20
START FIX   2581         TIME  14:15:08
END FIX     2672         TIME  14:19:42

RUNLINE 22
START FIX   2814
END FIX     2881
```

****
CIRCLE INTO BLACK LAGOON

DEPTH 15 ft. FIX 2981
TURNING WEST
DEPTH 10 ft. FIX 2989
DEPTH 8 ft. FIX
DEPTH 5 ft. FIX 2991
DEPTH 4 ft. FIX 2993
DEPTH FIX 2995
DEPTH 3.5ft. FIX 2996
****
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DEPTH 2.5	FEET	FIX	2999	
DEPTH 2.5	FEET	FIX	3003	
DEPTH 4	FEET	FIX	3014	
DEPTH 6	FEET	FIX	3019	
DEPTH 7	FEET	FIX	3021	
DEPTH 8	FEET	FIX	3023	
DEPTH 9	FEET	FIX	3025	
DEPTH 8.5	FEET	FIX	3030	
DEPTH 8	FEET	FIX	3034	SOUTH
DEPTH 7.5	FEET	FIX	3039	
DEPTH 7	FEET	FIX	3043	
DEPTH 6.5	FEET	FIX	3048	
DEPTH 6	FEET	FIX	3051	
DEPTH 5.5	FEET	FIX	3054	
DEPTH 4	FEET	FIX	3056	
DEPTH 4	FEET	FIX	3058	
DEPTH 4.5	FEET	FIX	3060	
DEPTH 4	FEET	FIX	3061	
DEPTH 3.5	FEET	FIX	3062	
DEPTH 2.5	FEET	FIX	3064	

****

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DEPTH 5	FEET	FIX	3067
DEPTH 10	FEET	FIX	3070
DEPTH		FIX	3072
DEPTH 6.5	FEET	FIX	3086

OUT RETURN TO RUNLINE 22
[COMPLETED RUN THRU LAGOON]

SECOND PASS RUNLINE 22
START FIX 3289 TIME 14:51:11
END FIX 3346 TIME 14:54:02

TURNED INTO BLACK LAGOON

```
DEPTH 18     FEET   FIX    3399
DEPTH 4      FEET   FIX    3436
DEPTH 3.5    FEET   FIX    3440
DEPTH 2.5    FEET   FIX    3442
      WEEDS         FIX    3445
SHALLOW\WEEDS      FIX    3453
DEPTH 4      FEET   FIX    3459
      XXXX          FIX    3461
BLACK LAGOON
DEPTH 9      FEET   FIX    3473

*****************************************

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DEPTH 8.5    FEET   FIX    3480
DEPTH 8.0    FEET   FIX    3482        NO DATA LOGGED
DEPTH 7.0    FEET   FIX    3481        NO DATA LOGGED
DEPTH 6.5    FEET   FIX    3482        NO DATA LOGGED
DEPTH 4.5    FEET   FIX    3487
DEPTH 3.0    FEET   FIX    3488
DEPTH 2.5    FEET   FIX    3491
      WEEDS         FIX    3493
DEPTH 11     FEET   FIX    3513

END LINE           FIX    3546
*************************************************************************

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RUNLINE 02  SECOND PASS
START FIX   3637          TIME  15:09:53
LOSS DIRECT XXXX 61             [NOT SURE OF NOTES BELIEVE THEY INDICATED]
                                [A TEMPORARY LOSS OF POSITION ]
END   FIX   3710          TIME  15:13:49

RUNLINE 03
START FIX   3834          TIME  15:19:23
END FIX     3904          TIME  15:23:13
[CORE] MID-POINT 55 METERS      FIX   3865

RUNLINE     08
START FIX   4060          TIME  15:31:00
END FIX     4199          TIME  15:37:56

END FILE   FIX 4210

**********************************

NEW FILE AS03AUGD         START FIX   4211

*******SYSTEM WHEN DOWN**********

*************************************************************
```

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RUNLINE 16
START FIX 4335 TIME 15:47:04
END FIX 4452 TIME 15:53:52

RUNLINE 22
START FIX 4594 TIME 15:59:54
END FIX 4655 TIME 16:02:59

****

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NEW FILE AS03AUGE approx. FIX 4700

STARTED @ TIME 18:09:00

TESTING RADAR
START FIX 4814 TIME 18:13:13
GOING OUT ELIZ PARK CANAL
FIX 4823 #3 INNER CORE
FIX 4851 #3 MIDDLE
FIX 4869 #3 OUTER

INBOUND FIX 4939 CHANNEL ENTRANCE
OUTBOUND FIX 4988 ABOUT TWENTY FEET DOWN STREAM BRIDGE
FIX 5007 #3 INNER
FIX 5016 **********LARGE SIGNAL**********
FIX 5024 #3 MIDDLE
FIX 5051 #3 OUTER
FIX 5066 *********13 FEET DEPTH**********

RETURNED FOR ANOTHER PASS UP CHANNEL
FIX 5086 *****4 FEET DEPTH ********

****

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FIX 5135
FIX 5162 OUT BOUND TIME 18:30:39
FIX 5289 #3 INNER
FIX 5209 #3 MIDDLE
FIX 5217 FOUR & ONE HALF FEET
FIX 5223 #3 OUTER

RETURNED FOR ANOTHER PASS

FIX 5265 THREE FEET INBOUND
FIX 5290 TURNING
FIX 5326 OUT BOUND
FIX 5378 FOUR & ONE HALF FEET
FIX 5389

UP BOUND TOWARD BLACK LAGOON

RUNLINE AS3CS22
START FIX 5798 TIME 19:01:54
FIX 5860 TIME 19:02:04
FIX 5872 WATER DEPTH
FIX 5897 PASS FROM BLACK LAGOON

****

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TURN INTO BLACK LAGOON	FIX	5910
CHANGE OF DEPTH	FIX	5920
RETURN PASS BLACK LAGOON	FIX	5990
TURN INTO BLACK LAGOON	FIX	6273
ON POLE IN BLACK LAGOON	FIX	6342
OFF	FIX	6408

N 73,221.4 E 4,098,745.8 about 8.5 feet deep

****

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GIBRALTAR GAGE +35 INCHES

FRIDAY 4 AUG 1995

NEW FILE AS04AUGA START FIX 001

RUNLINE AS3CS 0022
START 200 FEET DOWN STREAM START OF LINE @ time 12:46:xx

START FIX 110 TIME 12:55:25
ON STATION FIX 144
END FIX 151 TIME 12:53:34

SHUT OWN TEMPORARILY about FIX . 200

RUNLINE 03

START FIX 209 TIME 12:58:23
MID POINT FIX 240
END FIX 260

RUNLINE 03 SECOND PASS
START FIX 350 TIME 13:05:03
55 METER FIX 370
END FIX 394 TIME 13:07:16

****

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ANCHOR ON RUNLINE 016 @ 30 METERS PASS START OF LINE
CORE SITE
START FIX 568 TIME 13:16:12
END FIX 2150

NEW FILE AS04AUGB START FIX 2151
START TIME 14:38:40
STOPPED TIME 15:08:20 @FIX 2746

BLACK LAGOON [NOT OUT BOUND]
START FIX 2750 TIME 15:16:56 FOR CONDUCTIVITY
END FIX 2770 [MOVED OFF SITE]
****

SECOND SITE [POST]
START FIX 2801 TIME 15:19:21
DEEP FIX 2811
END FIX 2825 TIME 15:20:51

STOP LOG FIX 2841 TIME 15:21:30
****

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4 AUG 1995

QUALITY CONTROL CHECK @ ELIZ PARK
CORPS OF ENGINEERS MONUMENT

START TIME 15:52:56

READING 42` 07' 55.5556 N 83` 10' 32.9684 W
N 70,909.2 E 4,098,453.6 [.8]

START FIX 001
END FIX 148

1.231 METERS FROM MONUMENT TO BASE OF ANTENNA

****

APPENDIX A3

COMPLETE CORRECTED NAVIGATION LOGS AVAILABLE FOR REVIEW AT U.S.EPS/CBSSS, GROSSE ILE, MI.

APPENDIX A4

FIELD CORE LOGS, VELOCITY LOGS, AND RESISTIVITY MEASURMENTS

CORE LOG.

INIT.	DATE
PREP	
APP	

	CORE	LOCATION/NOTES	FILE NAME	*.WS	PRINT	DENSITY GM/cm³
1						
2						
3						
4						
5						
6	5	QE.P. COVE	CRLOG5	↵	↵	
7			5A	↵	↵	
8			5B	↵	↵	1.249
9		DIELECTRIC	5C			
10						
11	6	QE.P. COVE (SAME)	CRLOG6	↵	↵	1.48
12		DIELECTRIC	CRLOG6B	↵	↵	
13						
14	7	QEP. COVE	CRLOG7	↵	↵	1.39.
15			CRLOG7B	↵	↵	
16						
17	8	Q.E.P. OUT SOUTH	CRLOG8	↵	↵	2.30.
18		ROCKS				
19						
20	9	QEP. OUT NORTH	CRLOG9	↵	↵	2.30
21		ROCKS GRAVEL				
22						
23	10	QEP OUT	CRLOG10	↵	↵	1.58
24		NORTH END LINE 1	CRLOG10A			
25						
26						
27	11	BLACK LAGOON LINE 6	CRLOG11	↵	↵	2.30
28						
29	12	BLACK LAGOON LINE 6	CRLOG12	↵	↵	
30		CUT	CRLOG12A	↵	↵	1.23
31	13	BLACK LAGOON LINE 6	CRLOG13	↵	↵	2.30
32		7T.6M. ROCK GRAVEL				
33						
34	14	BLACK LAGOON LINE 6	CRLOG14			2.10
35		6" STAND PEA GRAVEL				
36						
37						
38						
39						
40						

CORE LOG (PART 2)

	INIT	DATE
PREP.		/ /
APP.		/ /

CORE	LOCATION/NOTES	FILE NAME	*.WS	PRINT	DENSITY
15	BLACK LAGOON NOT CUT	CRLOG 15	✓	✓	
	27M, 6M PORT			CALC	2.20
	CUT	CRLOG 15A	✓	EST	2.80
	NOTE	THAT WAS CONSOLIDATED.			
16	BLACK LAGOON CUT	CRLOG 16	✓	✓	1.22
	17M FROM ST				
17	BLACK LAGOON	CRLOG 17	✓	✓	1.33-1.40
	LINE 3 - OLD #1				
18	BLACK LAGOON	CRLOG 18	✓	✓	
	LINE 3 · OLD #1	CRLOG 18A	✓	✓	1.53
19	BLACK LAGOON	CRLOG 19	✓	✓	
	LINE 22 OLD #7.	CRLOG 19A			1.18

CORE 5 DENSITY COMPUTATION

1 KG = 2.2046 lb.

	lb	Kg.
TOTAL WEIGHT	= 12.75	5.783
LESS TARE	= 1.25	- 0.566
		5.216
LESS OFFSET	= 0.125	- 0.056
		5.159
LESS WT CORE 92.5 x 0.01176		- 1.087
		4.0712 Kg

I.D. = 6.7 cm

AREA = $(3.35)^2 \pi$

= 35.238

VOL = 35.238 x 92.5 = 3259 cm^3

$$\text{DENSITY} = \frac{4071.2 \text{ gm}}{3259 \text{ cm}^3}$$

$$= 1.249 \text{ GM/CM}^3$$

CORE 6 DENSITY COMPUTATIONS

	lb.	KGMS.
TOTAL WEIGHT	13,3125	6.0364
LESS TARE	1.25	- .566
		5,4724
LESS OFSET	0.25	0.056
		5.4164
LESS WT CORE TUBE 101.5 x 0.01176		1.1936
		4.2227 Kgm

VOLUME

$35.238 \times 101.5 = 3576.65$

$$\text{DENSITY} = \frac{4222.7}{3576.6}$$

$$= 1.118 \text{ GM/cm}^3$$

CORE #7 DENSITY

	lb	kg
TOTAL WEIGHT –	18.125	8.221
LESS CATCHER/TOP	2.00	0.901
		7.313
LESS TARE	1.250	0.566
		6.747
LESS OFF-SET		0.056
		6.691
LESS WT CORE TUBE – 142 X .0116		1.669
		5.022
LESS VOL. WAT 32,238 X 50		1.611
		3.411

VOLUME CORE

$32{,}238 \times (86 - 10) = 2450{,}08$

(10 = CORE CATCHER)

$$\text{DENSITY} = \frac{3411}{2450} = 1{,}39 \text{ gm/cm}^3$$

Cor #7 Density
(After Cutting)

		KG
Cut Weight -	10.750 lb	= 4.876
Less Core Tube Wt.	76.3 x 0.01176	= .897
		3.978

Volume
32.238 x 76.3 = 2459.

Density = $\frac{3978}{2459.}$ = 1.61

Correct

	lbs	Kg
Core Weight -	10.750	
Less Tare	1.250	
	9.500	
Less Of	.125	
	9.375	= 4.252
less core Tube Weight		0.897
		3.355

Density = $\frac{3355}{2459}$ = 1.36

CORE 10 DENSITY COMPUTATION

	lbs	Kg
TOTAL WEIGHT	16,250	7,3708
LESS TARE (NO OFFSET)		0,566
		6.804
LESS CORE CATCHER		.100
		6.704
LESS LENGTH CORE		
142 x 0.01176		1,6699
		5,1349
LESS WATER		
128 − 39 =		
(89) (35.238) =		3.1361
		1998.8

VOLUME CORE

37 x 35,238 = 1303.8

$$\text{DENSTY} = \frac{1.9986}{1.3038} = 1,533$$

COMPUTATION DENSITY CORE #12

	lbs	Kg
TOTAL WT	15.5	7,030
LESS TARE	1.0	0.453
		6,576
OFFSET = 0.0		
LESS CONDUIT - 136.2 × 0.01178		1,599
		4,976

LESS WATER

35,238 * (128.6 - 52.7)

35,238 * 75.9 = 2,674

2,302

VOLUME SEDIMENT

35,238 × 52.7 = 1857.0

DENSITY = $\frac{2302}{1857}$

= 1.23 GM/cm^3

DENSITY COMPUTATION CORE #15

	lbs	kg
TOTAL WEIGHT -	13.8125	6.2652
LESS TARE	1.000	0.4536
		5.8116
LESS CORE TUBE 66.5 x .01176	—	0.6055
		5.0061
LESS WATER 35.238 x (10.1)	—	0.3559
		4.6502

VOLUME CORE

35.238 x 58.4 = 2057.89

DENSITY = 2.20

NOTE DENSITY HIGH
BUT LOG NOTED CONSOLIDATED

DENSITY COMPUTATION CORE #16

	LBS	KG
TOTAL WEIGHT -	3.00	1.3607
LESS TARE	1.00	0.4535
		0.9071

NO WATER
LESS CORE WEIGHT
16.5 x 0.01176 — 0.1940
0.71306

VOLUME
35.236 x 16.5 = 0.5814

$$\text{DENSITY} = \frac{0.71306}{0.5814}$$

$$= 1.22 \text{ GM/CM}^3$$

NOTE SUCH A THIN LAYER MIGHT NOT BE SEEN BY LOW FREQ SUB BOTTOM.

DENSITY COMPUTATIONS CORE #17

	LBS.	KG.
TOTAL WEIGHT.	19.5	8.8450
LESS TARE	1.0 LB	0.4535
		8.3915
LESS PISTON CORE CATCHER	2.0	0.9071
		7.4843
LESS CORE TUBE - 142.2 X 0.01176		1.6722
		5.8120
LESS WATER 35.238 X 52.1		1.8359
		3.9761

VOL SEDIMENT
35.238 X (90.1 - 5.0)
= 2.9967

$$\text{DENSITY} = \frac{3.9761}{2.9967}$$

$$= 1.32 - 1.40$$

COMPUTATION CORE #18 DENSITY

	LB	Kgm.
TOTAL CUT WEIGHT	17.437	7.9092
LESS TARE	1.000	.4535
		7.4556
LESS CORE TUBE		
130.8 x 0.01176		1.5380
		5.9174
LESS WATER		
35.238 x (150.8 - 75.2) x (55.6)		= 1.9592
		3.9581

VOLUME CORE SED

35.238 (75.2 - 1.9) = 2.582

/

SMALL AIRGAP

DENSITY = 1.53 GM/cm^3

COMPUTATION CORE #19 DENSITY

	LB	KGS.
TOTAL CUT WEIGHT	14.625	6.6337
LESS TARE	1.125	0.5102
		6.1234
LESS CORE TUBE 131.4 × 0.01176		1.5452
		4.5781
LESS WT WATER 35.238 × (121.9 − 44.45) × 77.45		2.7291
		1.8489

VOLUME CORE

35.238 × 44.45 = 1.566

DENSITY = 1.18 GM/cm^3.

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG5

CORE NO: 5

STATUS (CUT/NOT CUT) not cut

SITE:

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 120 cm

CORE LENGTH SEDIMENT: 93.5 cm

WEIGHT TOTAL CORE: measured after cutting

TARE WEIGHT:

OFFSET WEIGHT:

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
water	103.5	103.5	0630	5	100		
103.5		101.5			110		
		102.0			60		When have two readings
					100		First closest, etc.
		102.5			80		
		104.0			140		
		105.0			90		
					160		
		106.0			145		
		107.0			144		
Sediment							
89.0	89.0	89.0	1500	5	36		
					96		
					160		
		90.0		2.5	36		
					60		
					100		
					176		
		91.0			36		
					60		
					100		
					179		
		89.0			36		
					108		
					160		
	87.5	90.0			36		
					96		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG5A

CORE NO: 5 -CONT.

STATUS (CUT/NOT CUT):

SITE:

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT:

OFFSET WEIGHT:

EMPTY CORE: 11.76 gm/cm^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Sediment							
65.5	65.5	65.5	1500	5	136		
		66.0			170		
		64.0		4	176		
		63.5			150		
					180		
		63.0			170		
					210		
		62.5			140		
					180		
		68.5		1	170		
					210		
		68.3		3	170		
					150		
		67.3			150		
		66.7			140		
		66.0	1700	4	135		
				5	240		
		65.5		4	150		
				5	205		
		65.0		5	140		
Sediment							
33.0	33.0	32.0	1500	5	100		
				1	195		
		34.0		1	160		
		35.3		1	200		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOGSB

CORE NO: 5 CONT'

STATUS (CUT/NOT CUT). CUT

SITE:

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 92.5

CORE LENGTH - SEDIMENT: ALL

WEIGHT TOTAL CORE: 12.75 LB

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.249 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Water							
99.5	99.5	97.0	1500	5	100		
		98.0			92		
		99.5			89		
		101.0			94		
		102.0			100		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOGSC

CORE NO: 5 CONT' DIELECTRIC OBSERVATIONS

STATUS (CUT/NOT CUT): CUT

SITE:

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 92.5

CORE LENGTH - SEDIMENT: ALL

WEIGHT TOTAL CORE: 12.75 LB

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect pfd.	Comments
Empty leads meter offset						53.7	
	68.5					111	
	43.0					110	
	15.0					114	
Empty core tube for normalization							
	68.5					103	
	43.0					102	
	15.0					107	

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG6

CORE NO: 6

STATUS (CUT/NOT CUT): CUT

SITE: Eliz. Park Cove - Same loc. as Core #5

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT: 101.5

WEIGHT TOTAL CORE: 13.312 lbs

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.18 gm/cm^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Sediment							
	71.5	71.5	1500	5	144		
		73.0		4	136		
		73.0			140		
		74.0		2	152		
		70.7		3	142		
		70.0			168		
		69.5			164		
					250		
		68.4			180		
	89.0	87.8	1400	5	160		
		89.0			164		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG6B

CORE NO: 6 CONT' DIELECTRIC MEASUREMENTS

STATUS (CUT/NOT CUT): CUT

SITE:

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect pfd	Comments
Empty leads meter offset						52.3	
	85.0					112	
	54.0					110	
	20.0					112	
Empty core for normalization							
	85.0					103	
	54.0					102	
	20.0					103	

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG7

CORE NO: 7

STATUS (CUT/NOT CUT): NOT CUT

SITE: QUEEN ELIZ PARK COVE ACOUSTIC MEDIUM HARD

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 136 CM

CORE LENGTH - SEDIMENT: 86 CM INCLUDES CORE CATCHER

WEIGHT TOTAL CORE: 18.125 LBS

TARE WEIGHT: 1.25 LB + PISTON/CORE CATCHER 2 LBS

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3 TOTAL 142 CM OF CORE TUBE

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Water							
	93.8	93.0	0900	5	88		
					96		
	94.7	92.0			92		
	92.5				86		
	91.0				92		
	89.8				100		
	86.7				120		
	97.8				108		
Top Sed	82.0	81.0	1700	4	72		
					112		
	79.9			4	110		
					210		
	79.4			2	70		
					112		
					144		
	78.3			2	140		
	64.0	65.0		2	68		
					128		
	64.7				60		
					144		
	67.8				72		in series first low
					250		second bigger
	63.1				138		
					180		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG7B

CORE NO: 7 CONT' VELOCITY AND DIELECTRIC

STATUS (CUT/NOT CUT) CUT

SITE: ELIZ. PARK CANAL

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT: 76.3 CM

WEIGHT TOTAL CORE: 10.75 cut 76.3 cm length

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.39 gm/cm^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect pfd	Comments
Sediment							
	36.7	40.0	1700 max	<1	60		
	39.0				60		
					80		
					112		
	28.0	23.0		<0.5	70		
					90		
					160		
	19.0	21.0		<0.5	50		
					80		

DIELECTRIC

Zero leads	53.3	
22.0		113
41.5		115
62.0		112
79.5		112
95.5		113
Empty core tube		102

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG8

CORE NO: 8

STATUS (CUT/NOT CUT): CUT

SITE: QUEEN ELIZ. PARK OUTSIDE LOWER

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 2.40 GM/CM^3 ESTIMATED

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NO CORE RETENTION ROCKS AND SAND ABSOLUTELY NO PENETRATION

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG9

CORE NO: 9

STATUS (CUT/NOT CUT): CUT

SITE: QUEEN ELIZ. PARK OUTSIDE LOWER

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 2.40 GM/CM^3 ESTIMATED

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NO CORE RETENTION ROCKS AND SAND ABSOLUTELY NO PENETRATION

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG10

CORE NO: 10

STATUS (CUT/NOT CUT) NOT CUT

SITE: QUEEN ELIZ. PARK NORTH END LINE 1

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 128 cm Saturated cloth in bottom

CORE LENGTH - SEDIMENT: 37 cm sediment + 4 cm fluff

WEIGHT TOTAL CORE: 16.25 lbs (includes core catcher and 142 core tube)

TARE WEIGHT: 1.25 LB Core Catcher = 100 gms.

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
Water	50.0	50.0	0	5	93		
	52.2			4	101		
					104		
	48.1				190		
Fluff	36.5	36.5			92		
	37.2				82		
Sediment	30.1	29.4	1300	4	52		
					94		
	26.2				56		
					94		
					120		
					160		
	31.0			3	52		
				5	94		
	15.0	13.0		2	52		
					70		
					116		
	12.5		1300	2	52		
					100		
	27.5	25.0			48		
					96		
					150		
	25.0			5	42		
					98		

Note: Appears to be at least a 14 microsec system delay

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG10A

CORE NO: 10 CONT'

STATUS (CUT/NOT CUT) NOT CUT

SITE: QUEEN ELIZ. PARK END LINE 1

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.533 GM/CM^3 TO 1.56 COMPENSATE FOR CLOTH

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect pfd	Comments
DIELECTRIC							
ZERO LEADS						50.2	
Water	67.0					107	
	50.0					107	
Foam	39.0					105	
Core Sed	28.0					106	
	16.0					107	
EMPTY CORE TUBE							
	28.0					101	
	16.0					100	

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG11

CORE NO: 11

STATUS (CUT/NOT CUT)

SITE: BLACK LAGOON LOWER

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: NONE

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

BOTTOM - GRAVEL AND ROCK NO RECOVERY AT ALL

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG12

CORE NO: 12

STATUS (CUT/NOT CUT) NOT CUT

SITE: BLACK LAGOON LINE 16 94 METERS INTO LINE

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 139.7 CM

CORE LENGTH - SEDIMENT: 66.04 CM

WEIGHT TOTAL CORE: 17.5 LB

TARE WEIGHT: 1.00 LB + TOP DEVICE AND CORE CATCHER 2 LB

OFFSET WEIGHT: 0.000

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
NOTE: 3/16" OF WHITE CHALK LIKE SUBSTANCE ON SEDIMENT SURFACE							
WATER	60.0	61.0	1100	5	93		
	62.8			4	96		
	61.8				94		
	59.5				92		
	57.8				104		
SEDIMENT							
	42.5	42.0	1700	3	96		
	42.0				120		
	40.5			2	100		
	39.0			1	120		
	20.5	22.0		0.1	120		
	22.0			0.1	120		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG12A

CORE NO: 12

STATUS (CUT/NOT CUT): CUT

SITE: BLACK LAGOON LOWER 94 METER ON LINE 16

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 128.6 CM TOTAL CORE 136.2

CORE LENGTH - SEDIMENT: 52.7 CM

WEIGHT TOTAL CORE: 15.5

TARE WEIGHT: 1.00

OFFSET WEIGHT: 0.00

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.23 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: BOTTOM CORE BLACK GRANULAR MATERIAL

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG13

CORE NO: 13

STATUS (CUT/NOT CUT) NO SAMPLE ROCK AND GRAVEL

SITE: BLACK LAGOON - LINE 16 71.8 METERS FROM START

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: PONAR SAMPLE - ROCK AND GRAVEL NO RETENTION

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG14

CORE NO: 14

STATUS (CUT/NOT CUT) NO RETENTION 6" SAND/GRAVEL

SITE: BLACK LAGOON LOWER LINE 16 62.4 METERS FROM START

POSITION: N: 72963.5 E: 4098740.5

CORE LENGTH - WATER+SEDIMENT: NO RETENTION 6" SAND/GRAVEL

CORE LENGTH - SEDIMENT:

WEIGHT TOTAL CORE:

TARE WEIGHT: 1.25 LB

OFFSET WEIGHT: 0.125 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 2.10 (EST)

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: HARD BOTTOM SAND/PEA GRAVEL 6" CORE - NO RETENTION

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG15

CORE NO: 15

STATUS (CUT/NOT CUT) CUT

SITE: BLACK LAGOON LOWER - 27 METERS STR. 6 METERS PORT

POSITION: N: 72928 E: 4098736.3

CORE LENGTH - WATER+SEDIMENT: 68.5

CORE LENGTH - SEDIMENT: 58.4

WEIGHT TOTAL CORE: 13. 8125

TARE WEIGHT: 1.00 LBS

OFFSET WEIGHT: 0.00 LBS

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY: 2.00 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: NO VELOCITY DATA TAKEN ON THIS CORE
CORE TO SHORT

NOTE: THIS WAS A DISTURBED CORE DENSITY ESTIMATE SLIGHTLY HIGH

NOTE: UNCUT CORE DATA NOT GIVEN.

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG16

CORE NO: 16

STATUS (CUT/NOT CUT): CUT

SITE: BLACK LAGOON LINE 16

POSITION: N: 72917.9 E: 4098738.9

CORE LENGTH - WATER+SEDIMENT:

CORE LENGTH - SEDIMENT: 16.5 CM

WEIGHT TOTAL CORE: 3 LB

TARE WEIGHT: 1.00 LB

OFFSET WEIGHT: 0.00 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.22 GM/CM3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: ONLY A VERY SHORT CORE WAS OBTAINED.
DENSITY BASED ON CUT CORE ONLY

NOTE: BECAUSE OF THE SHORT CORE NO VELOCITY MEASUREMENTS TAKEN

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG17

CORE NO: 17

STATUS (CUT/NOT CUT) NOT CUT

SITE: BLACK LAGOON LOWER OLD CORE #1 56.0 METERS SOL 2.7 M STB.

POSITION: N: 72942.2 E: 4098817.2

CORE LENGTH - WATER+SEDIMENT: 142.2 CM

CORE LENGTH - SEDIMENT: 90.1 CM WITH 5 CM OF AIR

WEIGHT TOTAL CORE: 19.5 LBS

TARE WEIGHT: 1.00 B\LBS

OFFSET WEIGHT: 0.000 LB WITH TOP PLUNGER AND CORE CATCHER 2 LBS

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.33 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: CORE HAD 4 CM OF FOCULENT MATERIAL ON TOP

NOTE: BECAUSE OF AIR CORE REDONE AS #18 AND NO VELOCITY TAKEN
VELOCITY REPEATED IN LABORATORY COMPLETE ABSORPTION
CONFIRMED BY USACE.

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG18

CORE NO: 18

STATUS (CUT/NOT CUT): NOT CUT

SITE: BLACK LAGOON LOWER ● OLD CORE SITE #1
REPEAT OF CORE # 17 52.2 METERS SOL - 1METER STB.

POSITION: N: 72941.4 E: 4098813.9

CORE LENGTH - WATER+SEDIMENT: 142.2 CM.

CORE LENGTH - SEDIMENT: 92.0 CM. + 5 CM FOAM
HAVE 7.6 CM SPACE ON BOTTOM CORE

WEIGHT TOTAL CORE: 20.125 LB

TARE WEIGHT: 1.00 LB

OFFSET WEIGHT: 0.00 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
WATER	82.0	81.3	1000	5	104		
					100		
	83.0		1100	5	100		
					130		
	79.0				130		
	81.4				96		
SEDIMENT							
	66.2	66.6	1700	2	88		
			MAX		90		
	65.2				94		
	64.2				96		
	47.6	46.7	1700	1	94		
	46.7			0.5	96		
	42.5			0.2	100		
	26.7	26.7	1700	0.4	96		
					145		
	26.0				95		
					175		
	23.0				100		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG18A

CORE NO: 18

STATUS (CUT/NOT CUT): CUT

SITE: BLACK LAGOON LOWER @ OLD CORE SITE #1
REPEAT OF CORE #17 52.2 METERS SOL, 1 METER STB.

POSITION: N: 72941.4 E: 4098813.9

CORE LENGTH - WATER+SEDIMENT: 130.8 CM.

CORE LENGTH - SEDIMENT: 75.2 CM.

WEIGHT TOTAL CORE: 17.437 LB

TARE WEIGHT: 1.00 LB

OFFSET WEIGHT: 0.00 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:___ 1.53 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments

NOTE: THIS DATA USED FOR DENSITY CALCULATIONS

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG19

CORE NO: 19

STATUS (CUT/NOT CUT) NOT CUT

SITE: BLACK LAGOON LOWER LINE 22 OLD CORE # 7

84.6 METERS FROM SOL 2.4 METERS PORT

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 142.2 CM. 3-4 CM OF FOAM ON TOP

CORE LENGTH - SEDIMENT: 69.2 CM CORE CATCHER STILL ON

PENETRATION BY WEIGTH OF CORE

WEIGHT TOTAL CORE: 17.56 LB

TARE WEIGHT: 1.125 LB

OFFSET WEIGHT: 0.00 LB

CORE TUBE WEIGHT: 0.01176 GM/CM^3

COMPUTED DENSITY:_____

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
NOTE: VELOCITY MEASUREMENTS ON CUT CORE							
WATER	53.1	53.0	1130	4	94		
					140		
	53.6		1300	4	98		
					140		
	54.1		1400	4	98		
					136		
	54.7				100		
					136		
	53.6				96		
					134		
	52.2				94		
					140		
	51.4				104		
					175		
AIR TEST					245		
	50.6		1700	3	120		
					170		
	50.6	51.1	1500	5	108		
	49.8				108		
	48.8	49.6			92		
	48.4				120		
					179		

FIELD CORE OBSERVATIONS AND VELOCITY MEASUREMENTS

FILE NAME: CRLOG19A

CORE NO: 19

STATUS (CUT/NOT CUT): CUT

SITE: BLACK LAGOON LOWER LINE 22 OLD CORE #7
84.6 METERS FROM SOL 2.4 METERS PORT

POSITION: N:_____ E:_____

CORE LENGTH - WATER+SEDIMENT: 121.9 CM CORE TUBE LENGTH 131.4

CORE LENGTH - SEDIMENT: 44.45 CM.

WEIGHT TOTAL CORE: 14.625

TARE WEIGHT: 1.125 LB

OFFSET WEIGHT: 0.000 LB

CORE TUBE WEIGHT: 0.01176 GM/CM

COMPUTED DENSITY:___ 1.18 GM/CM^3

VELOCITY/DIELECTRIC

Dist From Bottom-cm	Rec. Pos. cm	Xmit Pos. cm	Rec. Gain	Rec. Ampl.	Delay Microsec	Dielect mic.farad	Comments
NOTE: CONTINUATION OF VELOCITY ON CUT CORE							
SEDIMENT	41.7	38.5	1100	5	92		ON CUT CORE 40.5 SED TOP
					170		IN MEASUREMENT OF TAPE
1/2 WAT.	39.0				92		MEASURE.
					150		
	37.0				96		
					150		
	37.0	36.7	1700	5	90		
					145		
	36.2			3	112		
	35.1			1	138		
	33.4	33.2		5	100		
	30.8			1	110		
	32.0				130		
	28.2	29.9		0			NO SIGNAL
	27.6	26.7	1700	0.1	150		
	26.2				125		
	20.6	20.5		0.2	100		
					140		
	20.6	19.5			102		
					150		
		18.5		0.1	108		
	12.5	13.5		0.1	110		
	13.5			1	124		

TRENTON CHANNEL CONDUCTIVITY MEASUREMENTS

PURPOSE: PROVIDE DATA FOR EVALUATION OF RADAR INFORMATION

APPARATUS: Unit consisted of 2 1.5*3* plates with a mean separation of 9.5*. The leads connected to a high impedance ohmmeter.

REFERENCE: Normal clean water = 10,000 ohms

Area	Location	Obs -1	Obs-2	Obs-3	Obs-4	Obs -5	Mean Obs
Dock	Surface	2564					2564
Immediate	Mid Point	2487					2487
after	Bottom	1992					1992
storm	Air-Wet	90000					90000
							0
Q.E.Prk	Surface	1080					1080
	Bottom	1077					1077
	Mid Point	1150					1150
	Air-Wet	300000					300000
							0
Blk. L.Up	Air-Dry	1700000					1700000
	Surface	2500	2600	2700	2680	2650	2626
	Bottom	2650	2630	2625	2616	2604	2625
							0
Blk.L.Upp							0
over sand	Air -Dry	3000000					3000000
	Surface	2400	2700	2600			2567
	Bottom	6000	6000	7000			6333
Center(mud							0
	Surface	2800	2900	3200	2000		2725
	Bottom	2000	1500	2000	7000		3125
Dock							
Next day	Air	1700000					1700000
	Surface	10000	11000	12000	11000		11000
	Bottom	10000	9000	10000	10200		9800

APPENDIX A5

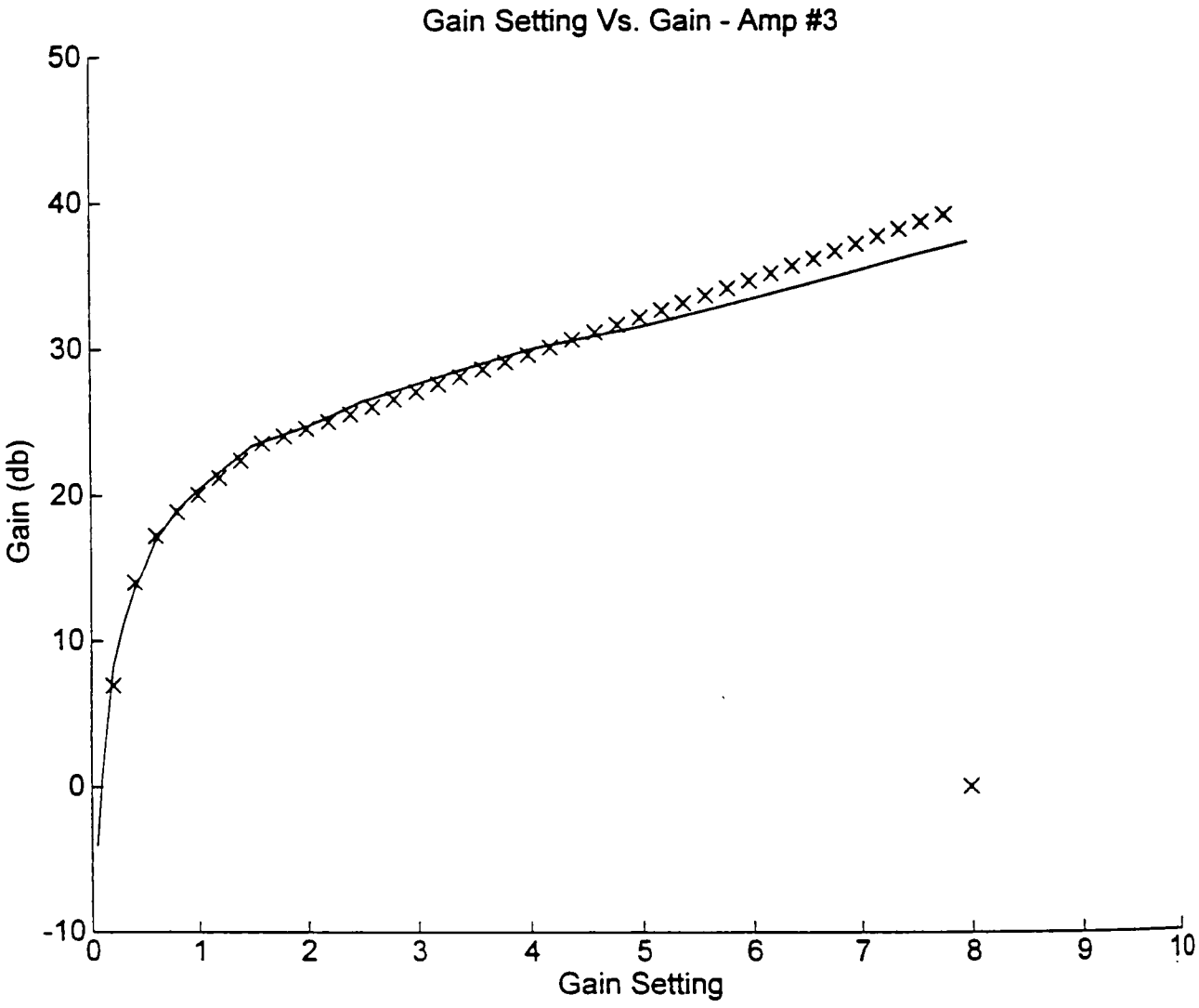
SELECTED CALIBRATION ANALYSIS SHEETS AND LOGS AVAILABLE FOR REVIEW AT U.S.EPS/CBSSS, GROSSE ILE, MI.

APPENDIX A6

AMPLIFIER GAIN CURVES

```
% program name gaincomp.m
% version 1.00
% written by ddc 10/4/95
% compute gain and check with actual gain.

p(1) = 0.0017;
p(2) = -0.0600;
p(3) =  0.8815;
p(4)=  -7.0764;
p(5) =  33.884;
p(6) =  -99.2424;
p(7) =  175.9008;
p(8) = -181.6657;
p(9) = 105.5041;
p(10) = -8.1394;
pf(1) = 2.5057;
pf(2) = 2.2370;
%load p;
%load pf;

for w = 1:30;
gnset = input('Input gain setting value x.xx = ');


if gnset <= 1.40
        gn = polyval(p,gnset);
end

if gnset > 1.40
        x = gnset-1.40;
        gn = polyval(pf,x) + 20.7433;
end
if gnset > 5.00
        gn = gn - ((gnset-5)*0.22);
end
load gain;
load gainset;
```

```
axis([0 10 -10 40]);
hold on;

plot(gainset,gain,gnset,gn,'x');
title(['Gain versus Gain Setting ']);
xlabel('Gain Setting');
ylabel('Gain (db)');
text(7,20,num2str(gn));
pause;
hold off;
clf;
if gnset == 11
        break;
end

end
```


Gain Setting Vs. Gain - Amp #3
Gain (db)
50
40
30
20
10
0
-10
0
1
2
3
4
5
6
7
8
9
10
Gain Setting

APPENDIX A7

STANDARD SEDIMENT PROPERTIES TABLE

STANDARD MARINE UNCONSOLIDATED
GEOTECHNICAL AND ACCOUSTIC PROPERTIES

SPECIFIC GRAVITY SOILS ASSUMED = 2.70 GM/CM^3

ITEM	MATERIAL TYPE	BULK DENSITY	WET DENSITY	DRY DENSITY	POROSITY X	MEDIAN GRAIN SZ.	IMPED. Z	REFLECT. R	BOTTOM LOSS-DB	WATER CONT. X	WATER CNT X CHECK	POROSITY CHECK	WET DEN. CHECK
1	COARSE SAND	2.70	2.05	1.658	38.60	0.520	3740	0.410	7.8	23.284	23.658	38.600	2.044
2	MEDIUM SAND	2.700	2.010	1.628	39.700	0.356	3510	0.385	8.3	24.384	23.457	39.700	2.025
3	FINE SANDS	2.700	1.980	1.515	43.900	0.153	3440	0.375	8.6	28.983	30.719	43.900	1.954
4	VERY FINE SANDS	2.700	1,910	1.420	47.400	0.090	3265	0.352	9.1	33.376	34.488	47.400	1.894
5	SILTY SANDS	2.700	1.830	1.274	52.800	0.073	3060	0.320	9.9	41.431	43.597	52.800	1.802
6	SANDY SILT	2.700	1.600	0.856	68.300	0.036	2500	0.214	13.5	79.799	86.938	68.300	1.539
7	SAND-SILT-CLAY	2.700	1.560	0.891	67.000	0.018	2490	0.250	12.1	75.196	75.084	67.000	1.561
8	CLAYEY SILT	2.700	1.430	0.675	75.000	0.006	2200	0.177	15.2	111.111	111.852	75.000	1.425
9	SILTY CLAY	2.700	1.400	0.621	77.000	0.003	2150	0.159	16.1	123.994	125.443	77.000	1.391
10	CLAYEY SILT	2.700	1.380	0.578	78.600	0.006	2110	0.150	16.7	136.033	138.837	78.600	1.364
11	CLAY	2.700	1.260	0.383	85.800	0.001	1890	0.090	20.6	223.787	228.638	85.800	1.241

G = SPECIFIC GRAVITY
n = POROSITY
w = WATER CONTENT
DD = DRY DENSITY
WD = WET DENSITY

DRY DENSITY = G*(N-1)
WET DENSITY(CHECK) = (1-n)*G + n
w = (1/DD - 1/G)*100
w(CHECK) = (WD/DD -1)*100 = (n/DD)*100
n(CHECK) = (1-DD/G)*100

STANDARD MARINE SEDIMENTS GEOTECHNICAL PROPERTIES

FINAL REPORT
MICRO SURVEY - ACOUSTIC CORE AND PHYSICAL CORE INTER - RELATIONS WITH SPATIAL VARIATION, TRENTON CHANNEL OF THE DETROIT RIVER
VOLUME II
CORE ANALYSIS AND SUMMARY FINDINGS

prepared

March 23, 1996

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1.0 INTRODUCTION

Significant deposits of contaminated sediment occur in many waterways near urban centers, including those of the Great Lakes basin. Some of these deposits have accumulated for decades and reflect historic loadings of pollution from cities, industry and agricultural runoff. These deposits continue to contaminate benthic and pelagic organisms through various transport and fate processes. The removal, treatment and disposal of these contaminants may be extremely costly.

A cost effective and rapid means of mapping the distribution of sediments in harbors and rivers is required to facilitate the remedial decisions facing environmental managers. Models are being developed to predict the potential for sediment erosion in harbors and rivers. An accurate prediction of sediment resuspension by these models requires accurate mapping of sediments.

This final report has been prepared in three volumes. Each volume was originally delivered as an interim project report. Upon completion of the final volume the interim reports were edited and a final report consisting of a three volumes set and executive summary was prepared. The three volumes include:

Volume I: Field Activities and Calibration Documentation (December 30, 1995). This volume summarizes field acquisition and calibration procedures. Highlights of the field activities, associated field logs and corrected file navigation, and the results of an extended calibration program are provided.

Volume II: Core Analysis and Summary Findings (March 23, 1996). This volume relates the acoustic properties of the sediments to the physical properties of the cores at selected sites.

Volume III: Normal and Contaminated Sediment Distribution Maps (May, 1997). Volume III provides final outputs identifying contaminated layer cross-sections as well as estimated dredging volumes. Also presented are new spatial analysis techniques developed to accommodate the spatial variations and contaminants/gas content of the Trenton Channel sediments.

2.0 PROJECT DESCRIPTION

2.1 Background

Both the Army Corps of Engineers/Water Ways Experimental Station (USACE-WES) and the U.S. Environmental Protection Agency/Office of Research and Development/Mid-Continent Ecology Division/Community Based Science Support Staff (USEPA/MED/CBSSS) have research interest in mapping sediment in harbors and rivers by acoustic profiling. In 1994, the Great Lakes National Program Office, The Michigan Department of Natural Resources and USEPA/MED/CBSSS conducted a sediment survey by contract with Caulfield Engineering using the Acoustic Core© system. The survey of the Detroit River's Trenton Channel demonstrated that the Acoustic Core© system has the potential for mapping the sediment in harbors and rivers of the Great Lakes. The 1994 survey results identified high spatial variance in sediment distribution and possible gas content in these sediments. The acoustic method required optimization for use in shallow water (2 ft. to 30 ft.) and areas which exhibit a high degree of sediment spatial variability.

The USEPA requested that USACE-WES optimize the Acoustic Corer. Two sites on the Trenton Channel, Elizabeth Park and Black Lagoon, were selected for micro-surveys to demonstrate the Acoustic Corer and to confirm the 1994 observations. The request required survey grids of very closely spaced (5-10 meters) observation lines with high ping repetition rates. In addition, ground truth piston cores were to be taken at calibration sites and other sites of interest. The data were to be acquired and processed with the Caulfield Engineering Acoustic Core suite of software. Final project outputs were to include identification of the location and volume of depositional sediment, survey line cross section plots of horizontal and vertical sediment distribution by density group, and to specify the acoustic properties of the possible contaminated sediments.

2.2 Site Overview

The Detroit River has been identified by the International Joint Commission as an Area of Concern due to a number of water quality problems, including contaminated sediments and degraded benthic communities. In addition, the river is also listed under the Michigan Environmental Response Act (P.A. 307, 1982 as amended) due to contaminated sediments.

Sediment studies conducted under the Upper Great Lakes Connecting Channels Study (USEPA and EC, 1988) and other research activities, documented sediments contaminated with metals, PCBs, and oil and grease (Farara and Burt, 1993) in multiple locations in the Detroit River and Trenton Channel. Impaired uses relating to contaminated sediments, as identified in the Detroit River Stage 1 Remedial Action Plan (MDEQ, 1987), include restrictions on dredging activities, degraded benthic communities, exceeding Michigan Water Quality Criteria for fish consumption advisories, and increased incidence of fish tumors.

The Trenton Channel is located in the lower Detroit River between Grosse Ile and the Michigan mainland, Figure 2-1. It is approximately nine miles in length and carries 21 percent of the total river flow, with an average velocity of 1.08 to 1.9 ft/sec. The Detroit River and Trenton Channel, a heavily industrialized area and a major navigation route, has been identified as severely degraded in terms of water and sediment quality and benthic communities (USEPA and EC, 1988). Numerous point sources in the area include steel plants, waste water treatment plants and chemical and automotive manufacturing industries. Concentration of arsenic, nickel, PCBs, and oil and grease in Trenton Channel sediments have been found to exceed the recommended guidelines for sediments (Long and Morgan, 1990; Persaud et al., 1993). Data from various sediment Toxicity tests conducted showed sever impacts compared to other Detroit River locations and reference stations for a number of biota tested (Giesy et al., 1988).

2.3 Project Objectives

The primary objective of the USEPA-USACE-Caulfield Engineering effort was the acquisition of micro-survey data using the Acoustic Core© system and the processing and analysis of selected results and sites to determine what the sediment stratigraphy in near shore areas of the Trenton Channel. Two specific sites were chosen to demonstrate soft sediment mapping, allowing the calculation of volume estimates.

This project uses the Acoustic Core© suite of software to identify and map the gross distribution of these sediments as presented in this report. Piston core data is required to calibrate the acoustic process. It is important to note that the exact relationship engineering geo-acoustic properties of the marine sediments versus the various types of pollutants is not known. It is only known that pollutants and or micro-gas bubbles contained in sediment change the acoustic properties, and in some cases radically, from standard marine sediments. Data shows (Volume II) that as the gross contaminants (observed from the chemical analysis of the USEPA vibra-cores collected in 1994) increase the deviation of the bottom loss for similar non-contaminated marine sediments increases.

The tasks listed in the interagency agreement between EPA and ACOE included:

> Optimize the Acoustic Corer for use mapping, in shallow water (2ft-30ft), where sediments exhibit a high degree of heterogeneity .

> Demonstrate the accuracy of the Acoustic Corer to characterize sediment type and map the distribution of sediment type at depth. The demonstration should take place at three sites (shallow, medium and deeper water depths) in the Trenton Channel, Detroit River.

> Collect and conduct the necessary geophysical characterization of sediment cores needed for calibration and validation of the acoustic corer.

> At the demonstration sites provide mapping of the distribution of the soft sediment.

> Provide a written report on the Acoustic Corer Optimization, describing the rational, approach and results.

> Provide a survey report on the demonstration site surveys. This report is to include:

1. A description of the Acoustic Corer and the fundamentals of operation
2. The survey design
3. Results of the survey
4. Graphical mapping of the sediment distribution for each site
5. A calculation of the volume of soft sediment at each site

Without the detailed quality assurance program carried out during the field exercises this project would not have succeeded. The quality assurance program enabled absolute calibrations of the sound sources, which in turn allowed for the quantitative identification of the sediment types.

2.4 Experiment Design

The data acquisition procedures encompass standard shallow subbottom profiling techniques in which a sound source emanates a sound signal (source) and the reflection from the bottom and subbottom are received on an array or transducer (receiver). Various sound sources and receivers are used with different amplifiers to format the data for proper digitizing and data storage. The selection of source and receiver combinations are a function of the soil types, the depths of penetration and vertical resolution required. Based on the experience of the previous years survey, a number of different systems were

made available. Volume I provides an extensive review of all the acquisition systems, field procedures, sonar equation solutions, and calibration.

A new Caulfield Engineering program, Acoustic Core Reflection/Sign (ACRS1) was utilized to automatically obtain water bottom depth and depths to each strong subbottom layer, bottom reflection sign, and to compute bottom loss for the file being analyzed. This program is in addition to the standard Acoustic Core routines discussed in Volume I, the latter being also used in the preparation of this report.

2.5 Project Schedules

The project was scheduled to commence on July 24, 1995. The project was started on time and Volume I provides a detailed description of all activities, equipment and calibration procedures and results. The field acquisition was completed on schedule. During the field operation, severe boat handling problems were encountered that severely complicated the data processing. In many cases the boat was not anchored well, or not anchored at all. This required trace by trace processing to obtain the proper representation of the bottom. These problems and the solutions to them, are discussed in detail in Volume I. Some of the same problems were encountered when relating the core data to the seismic data in this report. The solutions outlined in Volume I were applied to this core/seismic data with the same positive results.

2.6 Quality Assurance Procedures

The success of the entire program results from the implementation of a detailed quality assurance procedure program. This QA program presented all system operating specifications, tolerances, and calibration programs. These in field calibration programs allowed verification of all results and, more importantly, allowed correction for boat handling problems. Volume I provides complete descriptions of the QA procedure program, along with the detailed individual system specifications and accuracy. The same procedures established and documented in volume I were used to obtain the results presented in this volume. Results are presented showing that, with the calibrated source and receiver sensitivity values obtained, predicted non-polluted sediment bottom loss values equaled, within 1.32 db, the theoretical bottom loss values for these sediments.

The Quality Assurance Procedure Section of Volume I also presented the main mathematical equations used in data analysis. These are namely, the sonar equation, reflection model, and transmission model. A complete discussion of the mathematical procedures and equations used in the preparation of this volume can be found in Volume I.

3.0 TECHNICAL APPROACH AND ANALYSIS PROCEDURES

The acquisition of seismic data and core data simultaneously was specifically designed to accomplish the following:

- Physical Verification of Spatial Variability - The 1994 seismic survey of the Trenton Channel indicated high spatial variability in sediment type and pollution variability. The physical cores, along with grab samplers, confirmed this variability.

- Confirmation of Seismic Predictions - The availability of multiple sediment cores, characterized for material type and physical density, allowed for verification of the acoustic core predictions. Bottom loss predictions were within 1.32 db of theoretical bottom loss for non-polluted sediments.

- Acoustic Properties of Polluted Sediments - The long term goal of the project is to start to build a library of the relationship of the physical properties of polluted sediments in relation to the observed acoustic properties of these sediments. This program provided an initial step, and acoustic parameters can be related to gross pollution measurements. Even more importantly, the results provide a confirmed procedure for surveying and delineating these highly variable depositional Trenton Channel sediments in an analytical manner.

The 'R/V Mudpuddy' provided an excellent platform for performing this first experiment in pollution classification with the Caulfield Engineering Acoustic Core patented procedures. The transmitter and receivers were mounted in the front of the hull on extended platforms, while a special Caulfield Engineering piston corer could be dropped directly between the transducers. This ensured that when the boat was properly anchored, the transducers were directly over the core location, allowing absolute calibration of the bottom loss with physical samples. Unfortunately, the boat was not always anchored properly or was not anchored at all. However, the statistical processing to overcome these problems, developed in Volume I, was successfully used in this core/seismic study.

3.1 Field Procedures

Core location sites were at the same locations that previous detailed chemical analysis cores were taken by the USEPA, and sites chosen from review of the seismic records and a test grab sampler. The boat was then positioned over the desired spot and sometimes anchored. While seismic acquisition with either the 3.5 KHz or 7.0 KHz system running, the core was dropped. After retrieving the core, the core sample was weighed, measured, and the general characteristics and sediment interfaces noted. If time allowed, this core was then placed in the Caulfield Engineering Field Core Velocity/Absorption System prototype unit. This unit measured the gross sound velocity and absorption by placing a 330 KHz transmitter on one side of the core and a corresponding receiver on the other side. Peaks travel time and amplitude were recorded in the core logs. The latter being only rough estimates as this unit was a prototype and was not part of the contract deliverables.

After the above measurements were properly recorded, the surface water was removed, the cores cut, sealed, and the cores were again weighed and measured. The empty weight of the core tube and its dimensions allowed in the field computation of the average density. This information was useful for optimizing survey procedures. Rough dielectric measurements were occasionally taken, however, the number of samples taken was insufficient to make any conclusions. Some resistivity measurements were also taken. The data suggest the bottom conductivity increased as the gross pollution increased.

At the majority of core sites, data was acquired at both 3.5 KHz and 7.0 KHz with additional calibration procedures performed. This allowed absolute checking of the calibration procedures developed and discussed in Volume I.

At the completion of the survey effort, the packaged cut cores were shipped to USACE-WES where precision absorption and density measurements were repeated. Gross density measurements obtained agreed with the field measurements as presented in Appendix B3. However, the precision velocity/absorption portion of the system could not obtain data due to the extremely high sound absorption of the sediments. The operating frequency of this precision system was approximately twice as high as the Caulfield Engineering prototype unit. As frequency increases, so does the absorption in marine sediments (Hamilton, E.L. 1972), explaining why the USACE-WES unit could not get any data. These negative results confirm the high acoustic absorption in these sediments.

3.2 Analysis Procedures

The 'standard' Acoustic Core© system measures the bottom reflection coefficients

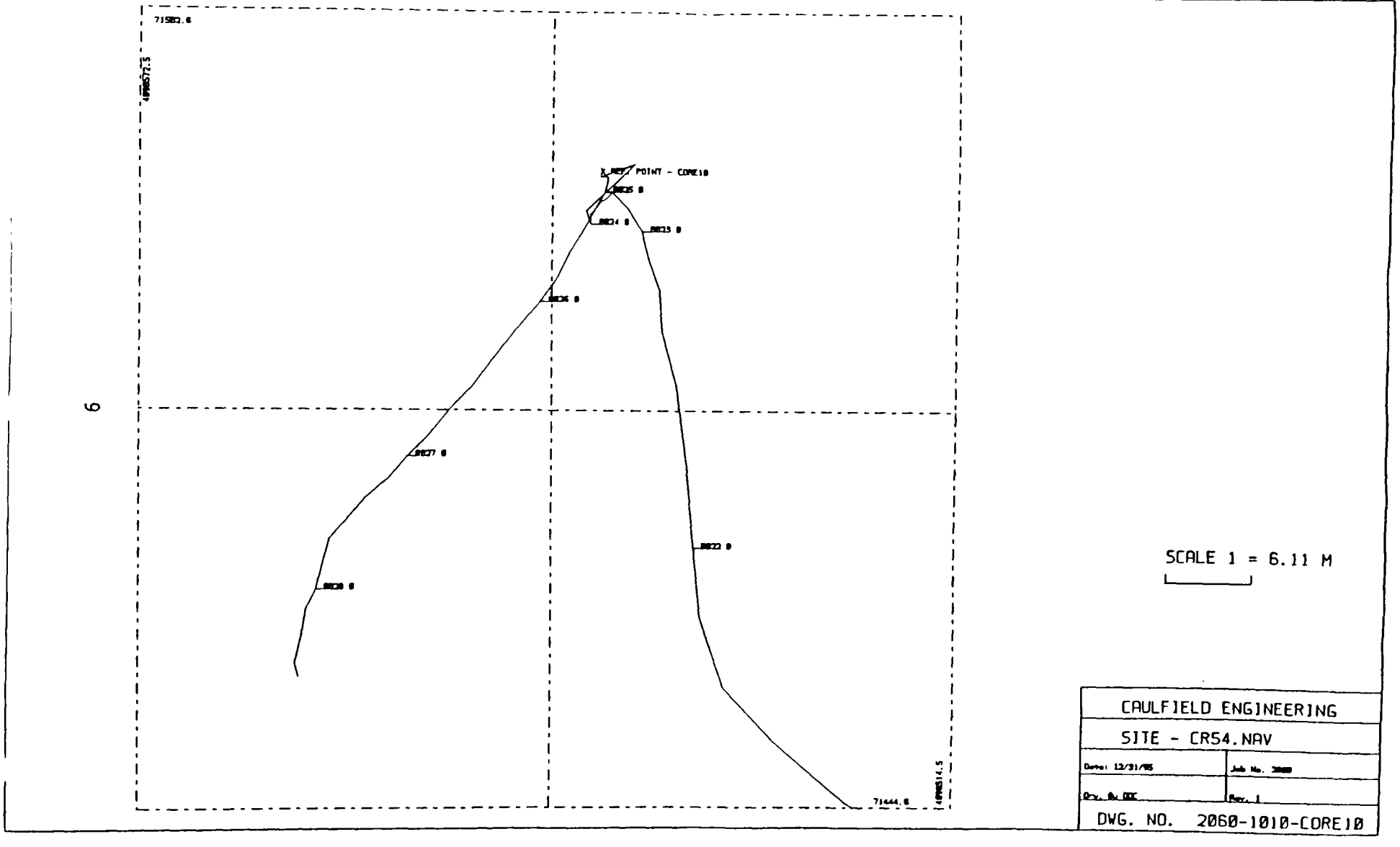
(Bottom Loss (BL)), estimates the absorption (for standard marine sediments) and computes the impedance of the various layers. From historical tables embedded in the software, the density is estimated from the impedance. In the case of polluted sediments, this historical data base does not exist and a different approach must be undertaken.

The approach taken was to generate a new Windows based Acoustic Core Reflection/Sign (ACRS1) program that performed all the normal computations of the standard Caulfield Engineering's Acoustic Core software, but did not perform the density predictions. In addition, a reflection sign output algorithm had to be added to detect and measure the observed phase reversals caused by micro gas bubbles in the sediments. Because of the large amount of data to be processed due to the high spatial variability of the sediments, and ship handling problems, a gray-scale display was developed for use with Laser printers, which increases the processing speed compared to conventional color plotters. This ACRS1 program was combined with the new Calibration Program discussed in Volume I to process the data. Appendix B1, contained in an Addendum, provides complete examples of processing for each core site. The following outline summarizes step by step the process for relating the seismic data to the core information at each location:

- Step 1) Position Plots - At each core site location the precise position is plotted from the navigational data. Figure 3-1 illustrates such a plot. This plot demonstrates the movement of the boat when coring is attempted while unanchored. The data nearest the core point were identified using the navigational plots and chosen for analysis.

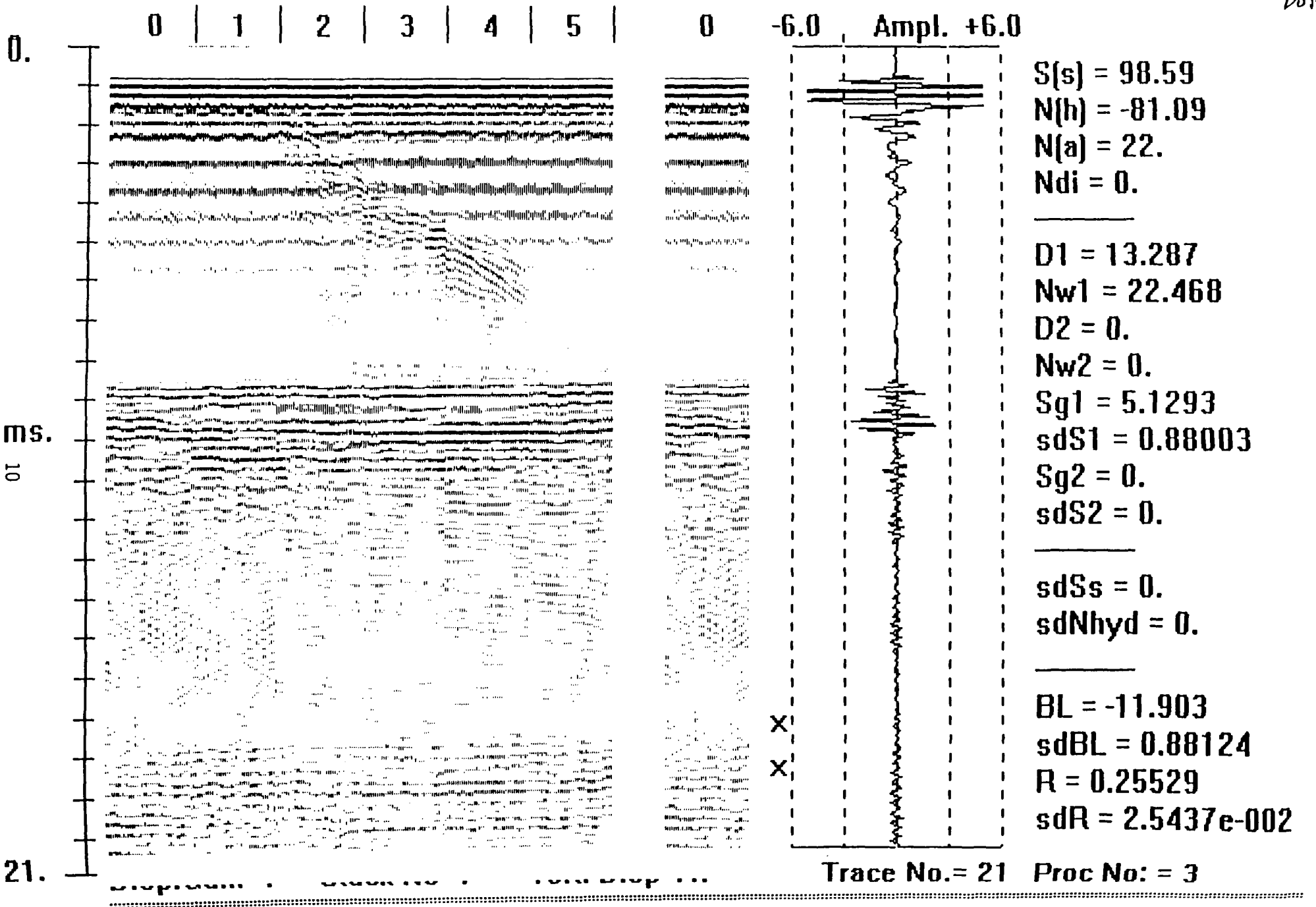
- Step 2) CAL1 Processing - For several sub-files the CAL1 calibration program is run to generate bottom and subbottom signal levels and to compute the bottom loss and refection coefficients. This particular plot, Figure 3-2, is from the 3.5 KHz Massa receiver data set. Data from the 7.0 KHz and the crystal receivers were collected at the same position and analyzed, providing four (4) independent observations at each core site. In addition to providing the bottom loss calculations, the plots were used for sediment layer identification. In this particular case, the surface layer is clearly identified and is approximately 0.7 meters thick. The piston core obtained approximately 0.4 meters of sediment. Data output from this processing is provided in an ASCII file and is included with this report on separate disks. The source and receiver levels were those determined during the calibration program reported in Volume I.

- Step3) ACRS1 Processing - The ACRS1 processing provides layer depths, the layer sign (a measure of the phase of the reflected signal, positive for non gas containing sediments and negative for gas containing sediments), and plots of the bottom loss for the entire subbottom file. Volume III, Appendix A3.6 provides a detailed discussion of the ACRS1 programs and descriptions of the

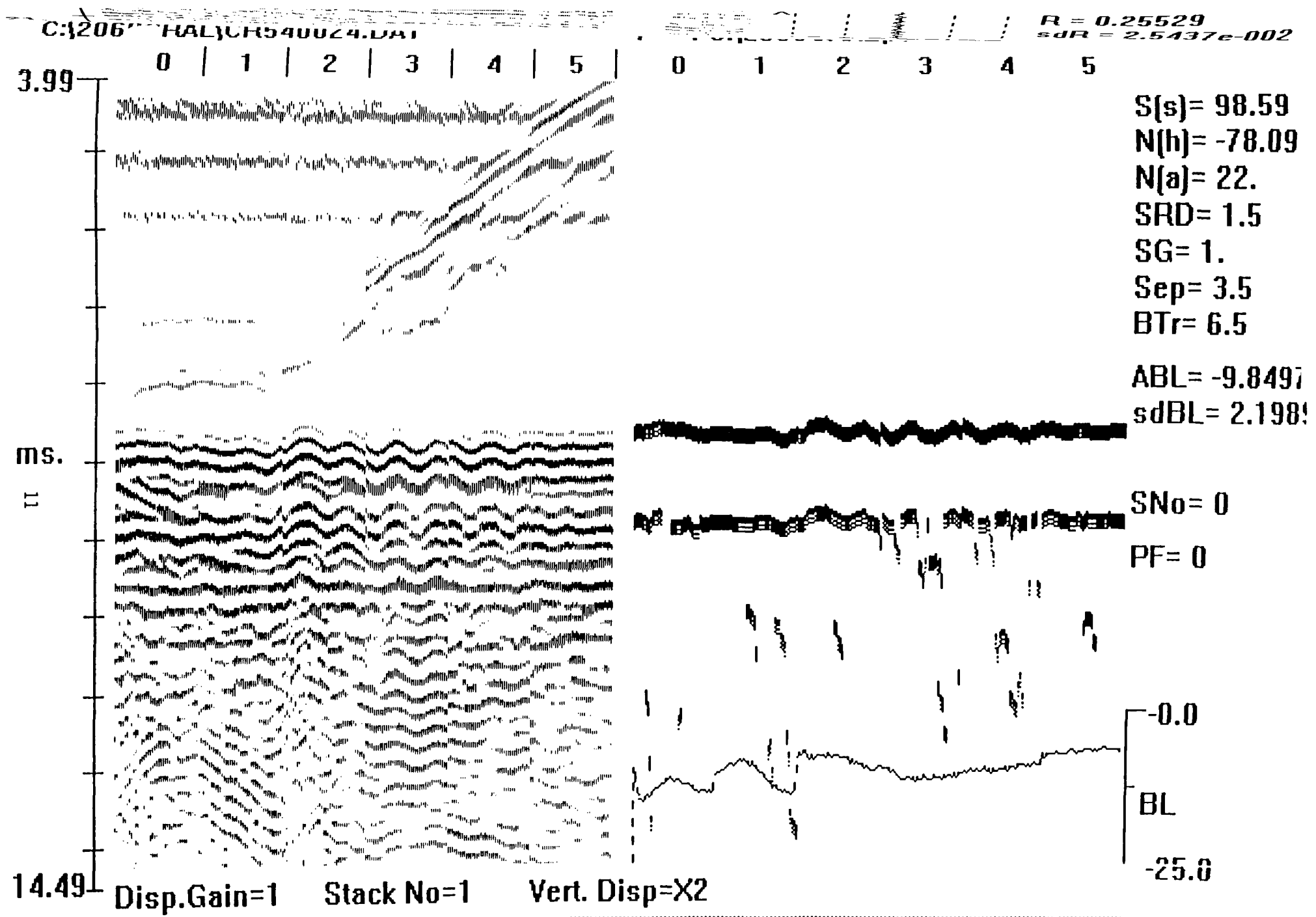


Typical Navigation Plot at Core Site

Figure 3-1



Typical CAL1 Output Plot



Typical ACRS1 Processing Output

Figure 3-3

graphic symbols in the display. The left hand side of Figure 3-3 is the raw seismic data. In this particular case the echo from the coring devise rising from the sediment to the water surface is clearly shown. The ability to see the corer on the acoustic records enabled certain identification of the seismic records associated with the cored site. The right hand side of the same Figure presents the layers and the bottom loss plots. Solid black thick lines indicate a negative reflection coefficient, and dashed thick lines indicate positive reflection coefficients. The average bottom loss (ABL) for all the traces processed is presented in the data table on the right. The standard deviation is also presented. Even though this was an extremely stable region (apparent uniform bottom based on the seismic display), the standard deviation is still quite large. This is representative of the spatial variation observed in Trenton Channel. As above, the source and receiver levels were those determined during the calibration program reported in Volume I. The detailed trace by trace results of the processing is provided in ASCII files and is supplied on the attached disks. In this example two major layers are detected. The third possible layer was weak and below the ambient Signal-to-Noise and is only partially detected.

- Step 4) Site Data Summary - The principal observation from each file and sub-file is summarized in Figure 3-4. This figure records the receiver levels, source levels, transducer depths, directivity index, and the system gain. These are all the parameters for solving the sonar equation to determine the bottom loss, which is given on the right side of Figure 3-4. The type of processing undertaken by the CAL1 program is also listed. The bottom loss is computed by using the basic sonar equation, knowing the receiver and source strength and solving the sonar equation for the bottom loss. This bottom loss computation can also be confirmed using the multiple refection values. The latter solution has higher variance due to bottom scattering. These calculations are described in volume 1 and also in volume III, appendix A3. The top of Figure 3-4 shows the outputs for the CAL1 processing and the bottom of figure 3-4 shows the results of the ACRS1 processing. These data sets are averaged and presented latter in the section on results.

- Step 5) Amplitude Decay Ratio - The amplitude ratio is a gross estimate of the absorption. Figure 3-5 illustrates the form used to record the amplitude decay ratio (Ampl. Ratio). The amplitude decay ratio is the second prominent layer amplitude divided by the bottom (surface sediment) amplitude. It has been assumed that the region can be approximated as a one layer model.

- Step 6) Reflection Sign Data Form - The reflection sign, when negative indicates phase reversal, a phenomenon indicative of gas containing sediment. Figure 3-6 presents the form used to record and generate the plus (+) sign percentage seen over the entire file. The data is generated graphically by

CORE 10

DENSITY = 1,533 LENGTH = 37CM = 14.56" = 1.21 FT.

	No	FREQ	FILE No/COMMENT	PROC	SUB FILE	REC DB	DEPTH S	DEPTH R	DI	GAIN	SOURCE	B.L.
1	1	3.5	23 B.L.KNREC	3	Ø	-78.09	1.5	1.5	Ø	22	98.59	-19.90 σ=0.88
2	2		23 MUL	5	Ø			MUL				-11.863 σ=2.3
3	3		23 B.L.KNREC	3	Ø	-81.09	1.5	1.5	Ø	22	98.59	-11.908 σ=0.8
4	4		23 BLKNREC	3	1	-78.09	1.5	1.5	Ø	22	98.59	-9.3707
5	5		23 MUL	5	1			MUL				-12.827
6	6		23 B.L.KNREC	3	2	-78.09	1.5	1.5	Ø	22	98.59	-11.377 σ=1.02
7	7		23 MUL	5	2			MUL				-15.626 σ=3.6
8	8		23 BL KNREC	3	3	-78.09	1.5	1.5	Ø	22	98.59	-14.93 σ=0.3
9	9		23 MUL	5	3			MUL				-11.067 σ=2.4
10	10		24 B.L.KNRE	3	1	-78.09	1.5	1.5	Ø	22	98.59	-11.08 σ=1.02
11	11		24 MUL	5	1		MUL					-11.701
12	12		24 B.L.KNRE	3	3	-78.09	1.5	1.5	Ø	22	98.59	-11.244
13	13		24 MUL	5	3			MUL				-13.187 σ=2.72
14	14		24 B.L.KNRE	3	5	-78.89	1.5	1.5	Ø	22	98.59	-7.3665
15	15		24 MUL	5	5			MUL				-13.94
16	16		25 B.L.KNRE	3	Ø	-78.89	1.5	1.5	Ø	22	98.59	-11.911
17	17		25 MUL ~~B.L.KNR~~	5	Ø			MUL				-16.205 σ=2.70
18	18		25 B.L.KNREC	3	1	-78.89	1.5	1.5	Ø	22	98.59	-14.928
19	19		25 MUL	5	1			MUL				-13.28 σ=1.97
25			ACRS 2									
26	1	3.5	23 MASSA			-78.09	1.5	1.5	Ø	22	98.59	-13.107 σ=2.73
28	2		24 MASS									-9.8497 σ=2.19
30	3		25 MASSA			-78.09	1.5	1.5	Ø	22	98.59	-11.875 σ=2.82

Bottom Loss Summary Sheet

Figure 3-4

AMPLITUDE DECAY RATIO DATA FORM

Core Site 10

File Header CR54

Frequency 3.5 CAL1 - Data

Receiver MS

Number	File Num.	SubFile	P-P Amplitude Bottom Volts	P-P Ampl. Next Lay Volts	Decay Ratio	Comments
1	23	0	2.4	3.1	1.29	
2	23	1	6.9	2.7	0.39	
3	23	2	5	5.0	1.00	
4	23	3	3	4.5	1.50	
5	24	1	6.8	4.0	0.58	
6	24	3	4.4	1.9	0.431	
7	24	5	8.5	3.0	0.35	
8	25	0	5.0	3.0	0.60	
9	25	1	3.3	2.4	0.73	

Mean Value 0.763 ← 0.388

Figure 3-5

REFLECTION SIGN DATA FORM
ESTIMATE ONLY

Core Site 10

File Header CR54

Frequency 3.5 KHz ACRS1 - Data

Receiver MASSA

				P-P			
Number	File Num.	SubFile	Plus	Minus	Total	Pecentage	Comments
			cm.	cm.	cm.	+/-	
1	24	—	0.5	9.7	10.2	4.90	
2	23	—	2.8	7.9	10.2	27.45	
3	23	—	3.7	6.5	10.2	36.27	

Mean Value 22.80 $\bar{T}$ = 13.30

Note: Precision data available from *.asl files. This form for estimate only.

Figure 3-6

measuring the gross amount of plus and minus data. The data is also provided in ASCII format on the core analysis disks provided with this report. It is important to note that in the ASCII file generation program there was an error, and the plus and minus signs are interchanged.

The above processing steps provided literally thousands of observations for statistically comparing the acoustic data to the core information. The next section will review and summarize these findings. A quick review of Appendix A in the Addendum will confirm that the spatial variations exist. The processing of such a large amount of data was necessary to ensure that the ship handling and electrical problems were removed.

4.0 DISCUSSION OF RESULTS

The following subsections summarize the processed results from the Addendum - Appendix B1. Each major finding is broken out as a separate subsection. Only core sites 5 through 19 were processed as these were in the major areas of interest.

4.1 Core Densities and Core Locations

The core densities measured by the USACE-WES by weight and volume are given in Figure 4-1 along with the field core densities obtained immediately on the vessel. Volume I contains the complete raw core field log from which the field core densities were derived. Note that Core 15 density obtained by USACE-WES is out of range. This core was damaged during shipping from Detroit to Vicksburg. The table given in Figure 4-1 shows how the average densities are computed from the core length and volume.

Literature-derived densities were used for the cores that did not have good retention. In particular, the sand material ran out the bottom of the core when the core tube was raised out of the water. Sufficient material was recovered to classify the material type. These cores were namely sand, or sand with gravel, or sand with rocks. Refer to Volume I for complete reference material to standard densities for non-polluted sediments and to the next sub-section for a summary of density and acoustic properties of these standard marine sediments.

Figures 4-2 and 4-3 provide the locations of cores 5 through 19. Note that the Northing (N) was mislabeled as an Easting (E) at core site 19 in Figure 4-3. Cores 5 through 10 were taken in the Elizabeth Park region, Figure 4-2, and Cores 11 through 19, Figure 4-3, were taken in the Black Lagoon region. The core locations are given in the Northing and Easting as observed by the USEPA staff.

4.2 Standard Marine Acoustic Properties

For purposes of comparison, Figure 4-4 is presented to summarize standard marine sediments versus acoustic properties, developed by Hamilton. Refer to Volume I for complete references. The graph at the bottom of the figure shows the analytical function used to relate density to bottom loss (BL). The slight deviations from the curve are negligible in comparison to the deviations for anomalous sediments which were polluted and contained gas.

Trenton Channel Core Densities
Second Laboratory Measurements

Core Tube = 8.683 gm/cm
I.D Core = 6.69 cm.

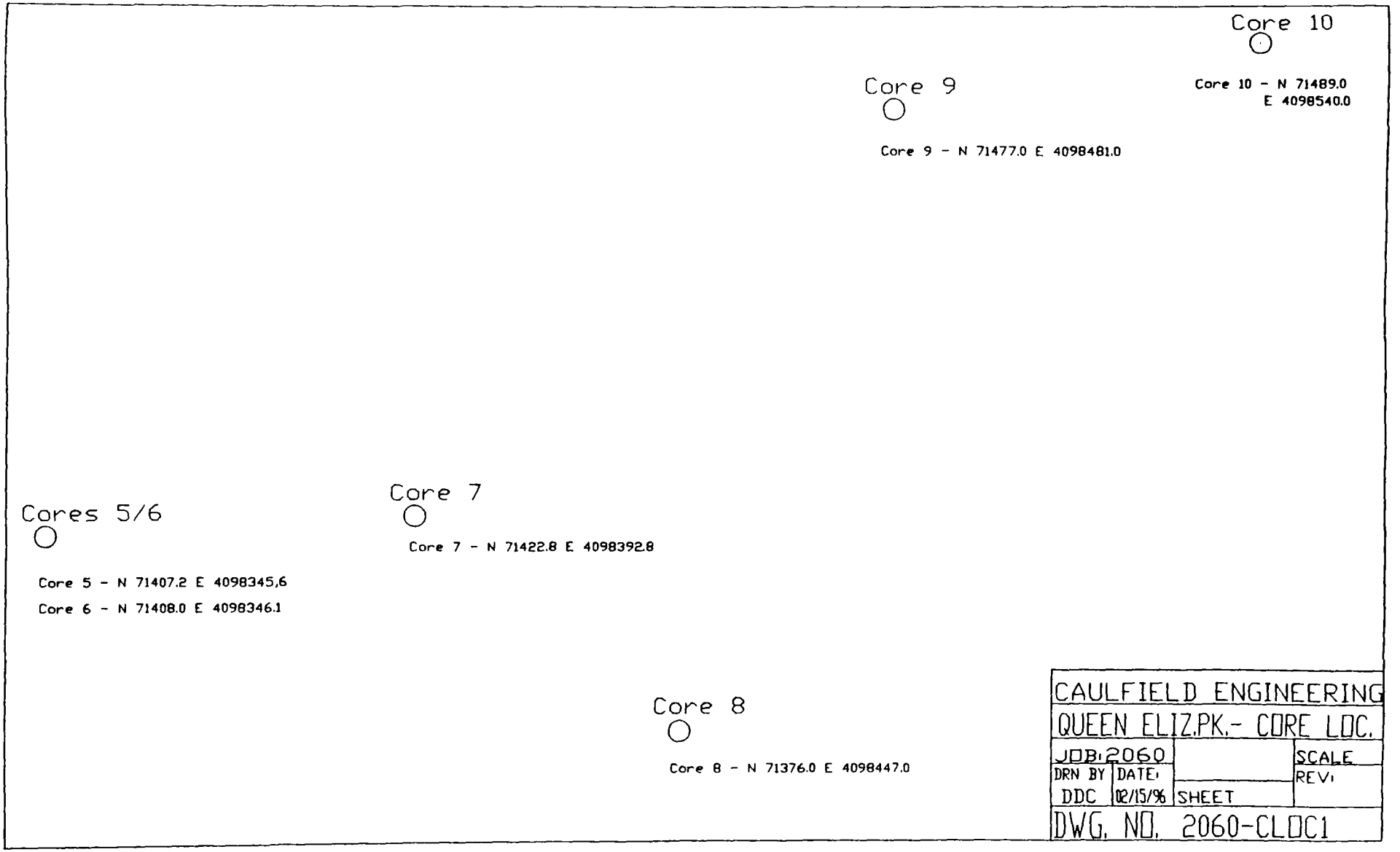
Core Number	Location	Material	Weight(lb)	gms.	Length-cm	Volume cm^3	Weight - Core Tube	Density gm/cm^3	Field Density gm/cm^3	Pollution Factor
Core 1	Celeron		4.65	2109.800	29.84	1048.719	1850.7	1.7647		
Core 2	Celeron					0				
Core 3	Crys. Bay		3	1361.162	23.49	825.5496	1157.198	1.4017		
Core 4	Crys. Bay		3	1361.162	22.22	780.9158	1168.225	1.4960		
Core 5	Q.E. Inner		10.4	4718.693	92.5	3250.887	3915.516	1.2044	1.249	10
Core 6	Q.E. Inner	Clay/Silty	10.6	4809.437	100.33	3526.071	3938.272	1.1169	1.18	10
Core 7	Q.E. Inner	Silt/Clay	9	4083.485	76.53	2689.626	3418.975	1.2712	1.39	10
Core 8	Q.E. Outer	Gravel/Sand	hard					2.1000	2.10	0
Core 9	Q.E. Outer	Rock/Gr.	hard					2.2000	2.20	0
Core 10	Q.E. Outer	Silty-Sand	4.1	1860.254	27.002	948.9779	1625.796	1.7132	1.533	5
Core 11	Blk. Lagoon	Gravel	hard					2.0000	2	0
Core 12	Blk. Lagoon	Clay/Tr.Gr.	6.4	2903.811	66.04	2320.958	2330.386	1.0041	1.23	7
Core 13	Blk. Lagoon	Rock/Gr.	hard					2.2000	2.20	0
Core 14	Blk. Lagoon	Sand-SmGr	0.75	340.290	7.62	267.8028	274.1259	1.0236	2.10	0
Core 15	Blk. Lagoon	Silty-Clay	12	5444.646	58.4	2052.452	4937.559	2.4057	1.45	3
Core 16	Blk. Lagoon	Clay	2	907.441	16.5	579.888	764.1715	1.3178	1.22	7
Core 17	Blk. Lagoon	Sandy Silt	9.625	4367.060	72.39	2544.127	3738.498	1.4695	1.33	9
Core 18	Blk. Lagoon	Sandy Silt	10.2	4627.949	73.66	2588.761	3988.359	1.5406	1.53	9
Core 19	Blk. Lagoon	Clay-Silt	5.4	2450.091	41.91	1472.916	2086.186	1.4164	1.18	10

Note: Pollution Factor is arbitary scale based on in field/laboratory absorption measurements, site observations, and 1994 core analysis.

Note: Core 15 weight seem to be in error. Penetration of core eliminates calculated density

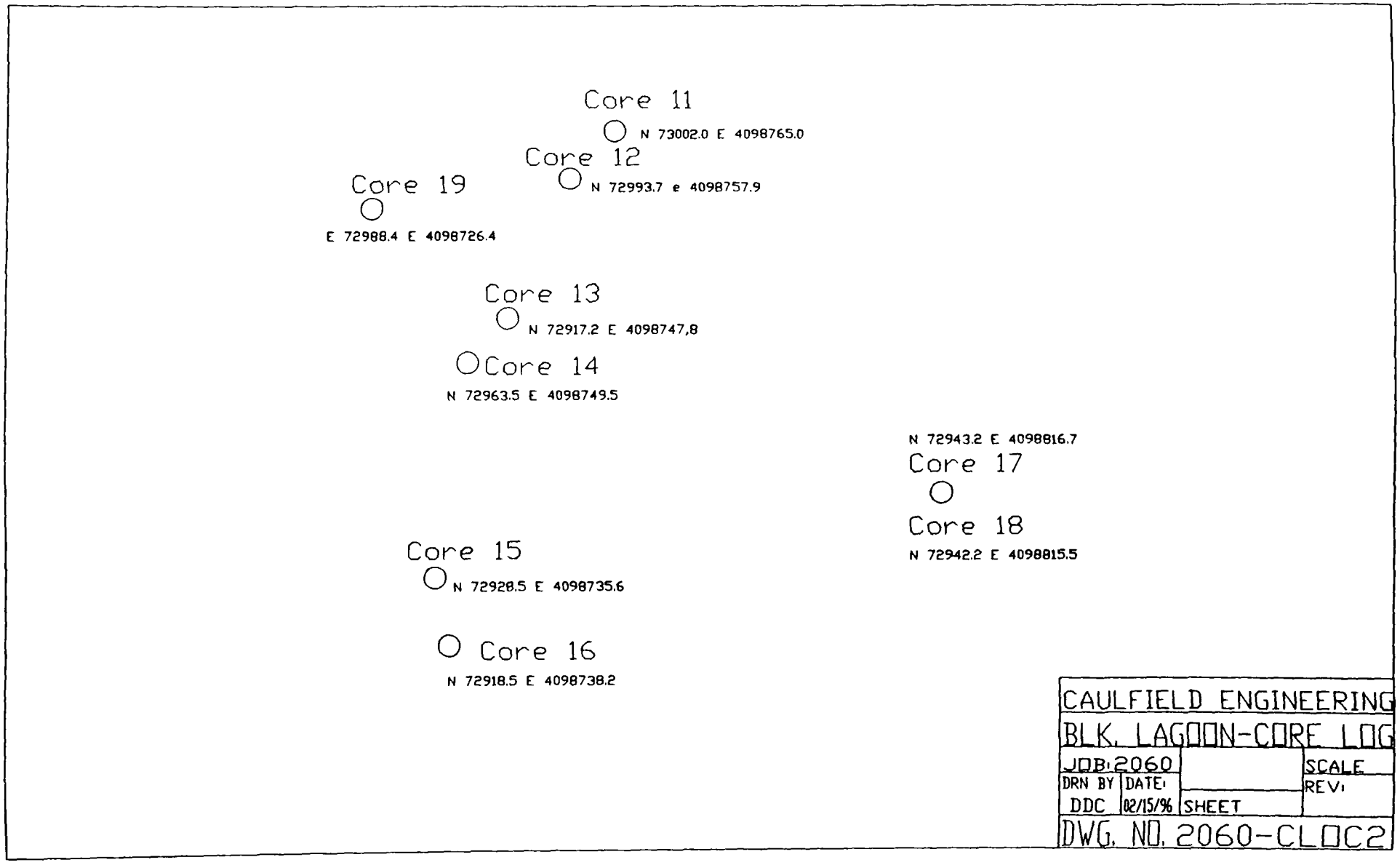
Density Summary

Figure 4-1



Core Locations

Figure 4-2



Core Location

Figure 4-3

Bottom Loss - Standard Marine Sediments

Material	Density	Bottom Loss	Impedance
Sand-Coarse	2.03	7.8	3734.7
Sand-Medium	2.01	8.3	3508.7
Sand-Fine	1.98	8.6	3443.3
Sand-Very Fine	1.91	9.1	3254.5
Silty-Sand	1.83	9.9	3063.3
Silt	1.6	12	2611.1
Sand-Silt-Clay	1.58	12.1	2493.9
Sandy-Silt	1.56	13.5	2420.1
Clayey-Silt	1.43	15.2	2198.9
Silty- Clay	1.42	16.1	2157.1
Clay	1.26	20.6	1891.1
Fluff	1.1	23	1600

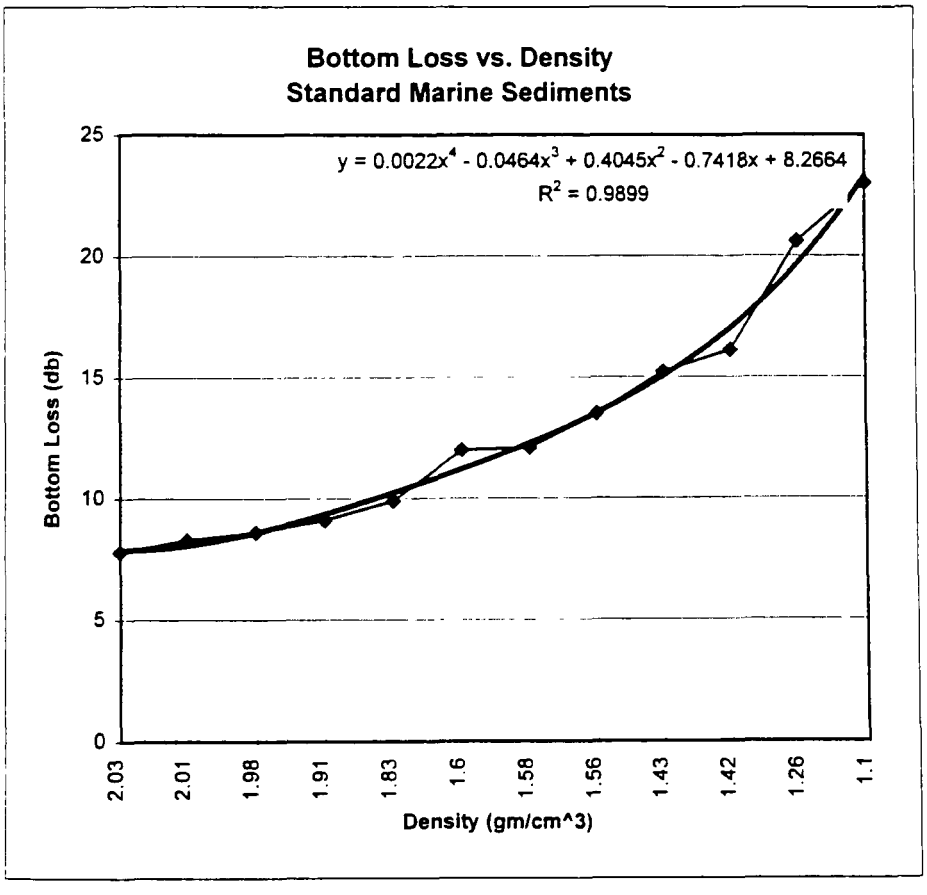


Figure 4-4

4.3 Processed Seismic Data Summary

The processed seismic data at each core site, partially given in Addendum - Appendix B1, has been summarized in tabular format data sheets for each core site. Figure 4-5 provides an example of such a data sheet. The top of the figure gives the prominent physical properties such as density and core length. The standard marine bottom loss for the specified density is given along with a 'Pollution Factor' term. This term has arbitrary values from 0 to 10, where 10 represents severely polluted. This pollution factor term is only a rough estimate, for Trenton Channel sediments, based on the chemical analysis performed on the cores taken at 1994 core sites. Future research should examine the acoustic effects of pollutants under laboratory conditions when specific pollutants are added to clay sediments in known amounts. This 'Pollution Factor' was assigned by reviewing the USEPA cores taken prior to the 1994 survey and assigning a factor of 10 to the core sets which chemical analysis showed to chemically contaminated. Lower numbers were assigned to cores which had lower levels of contaminates relative to the selected highest contaminated ones. Cores that had no contaminates were assigned a factor of zero. This factor has been derived based on this site only and care should be employed in using this factor in other sites without having detailed chemically analyzed cores to establish base line references.

Each frequency and receiver type is given on the left side of Figure 4-5 with the observed bottom loss and standard deviation for each observation. The amplitude decay ratio is only determined from the CAL1 calibration output data, and the plus sign percentage is only available from the ACRS1 program. The ACRS1 program generates symbols representing if the reflection sign is plus or minus. For reporting purposes, only the positive sign percentage (the number of plus signs divided by the total number of traces in a file) is used. Refer to Volume III, Appendix 3 for detailed description of the operation and symbols used in the ACRS1 program.

The bottom of the chart in Figure 4-5, presents the overall means and standard deviation for each type of observation. In some cases the Massa receiver data means and standard deviations were broken out as separate items. The beam pattern for the Massa receivers is more focused on the bottom than the omni-directional crystal phones. The Massa receiver data were used for comparison of the amplitude decay and the signs.

Appendix B2 provides the complete set of acoustic property tables for each core site.

Figure 4-6 provides an overall composite summary of the acoustic parameters versus core number and density. The table in Figure 4-6 is derived from the tables in Appendix B. It is important to note that cores 5 through 10 were taken without the boat being anchored. Great care was taken during data processing to select only data near the core site. The table in Figure 4-6 also presents the difference of observed bottom loss

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 19

Density = 1.20 Std. Marine B. L. = 21
Core Leng 69.2 cm. Pollution Factor = 10

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	5.45	2.64	0.221			
3.5-crys.	4.32	5.956	0.26			
7.0 -ms	3.26	1.184	0.142			
7.0-crys.	4.43	2.074	0.205			
ACRS1						
3.5 - ms	7.016	0.796			11.76	
3.5 - crys.	7.812				60.78	
7.0 - ms	3.125				8.33	
7.0 - crys	5.4687				47.05	
Means	5.110213	2.53	0.207		31.98	
Set Stdev.	1.674478	2.047925	0.049105		25.97894	
Massa Means			0.1815		10.045	
Massa Setdev.			0.055861		2.425376	

Typical Core Site Sheet

Figure 4-5

SUMMARY OF BOTTOM LOSS FINDINGS
VERSUS AMPL. RATIO & SIGN PERCENTAGE

Core Site	Density	Mean Observ.	Bottom Loss Difference	Massa Ampl.	Massa + Sign	Overall Ampl.	Overall + Sign	Pollution
	gm/cm^3	B.L.(db)	St.Mar-Obs	Ratio	Percent	Ratio	Percent	Factor
Core 5	1.29	11.377	8.62	0.141	27.43	0.141	27.43	10
Core 6	1.18	11.377	10.62	0.141	27.43	0.141	27.43	10
Core 7	1.39	6.646	10.85	0.171	13.23	0.171	13.23	10
Core 8	2.00	8.882	-0.68	0.874	50.62	0.874	50.62	0
Core 9	2.20	9.63	-2.13	0.507	46.21	0.507	46.21	0
Core 10	1.53	12.045	1.96	0.763	22.80	0.763	22.80	5
Core 11	2.00	8.323	-0.12	0.542	82.95	0.551	67.21	0
Core 12	1.23	7.121	13.88	0.409	67.08	0.390	67.48	7
Core 13	2.20	10.4	-2.90	0.494	87.61	0.898	70.00	0
Core 14	2.00	9.138	-0.94	0.594	82.93	0.631	71.26	0
Core 15	1.45	12.8	2.20	0.789	32.47	0.789	41.25	3
Core 16	1.22	12.607	8.39	0.716	66.14	0.670	60.79	7
Core 17	1.40	6.578	11.42	0.149	31.37	0.265	44.58	9
Core 18	1.53	6.578	7.42	0.149	31.37	0.265	44.58	9
Core 19	1.20	5.11	15.89	0.185	10.045	0.207	31.98	10

Note: Cores 5-10 have only one sensor as input. Boat would not anchor.

Overall Acoustic Parameter Summary Chart

Figure 4-6

from 'standard marine sediments' bottom loss. The data for the 'standard marine sediments' is provided in Section 4.2. The data in Figure 4-6 is used as the basis for establishing relationships between the various parameters and is discussed in the following subsections.

4.3.1 Calibration Procedure Verification

All the computed acoustic parameters were based on the source and receiver levels derived during the calibration program reported on in Volume I. See Figure 7-17 in Volume I. All levels checked out except for the crystal receiver. The receive level should have been 108.35 rather than the 103.35 reported. The proper levels were used for the data processed in this Volume II and Volume III.

Figure 4-7 compares the theoretical bottom loss for the non-polluted core locations with the observed bottom loss. The mean deviation is only -1.354 db with a standard deviation of 1.132 db. Considering all the problems that occurred, this result is remarkable. It confirms the validity of the quality assurance procedures and the Acoustic Core processing procedures. Further, it clearly establishes that the variation due to pollution/gas that is observed are in fact very real.

4.3.2 Bottom Loss Analysis

The table given in Figure 4-8 shows the computation of the difference in the observed bottom loss compared to 'standard marine sediment' bottom loss. The difference in bottom loss between 'standard' and the observed are much greater than the standard deviation of the data.

Figure 4-9 is a comparison of bottom loss to the core physical density. Series 1 represent the theoretical 'standard marine sediments' The point distributions about the curve presented is what is normally seen in non polluted sediments. From region to region in the country the curve sometimes has to be adjusted for specific gravity of the material itself. However, this is normally well within 5 percent. Series 2 shows the data for the Trenton Channel. It can be seen that the higher density material is very close to standard marine case. As the density decreases, the deviation from normal increases and is scattered. This deviation correlates with the gas and pollution content of the material. This plot supports the hypothesis that contaminants are generally associated with the "soft fine grained sediments which have lower densities.

Figure 4-10 is a comparison of the bottom loss difference between observed and standard marine sediments to the qualitative pollution factor. It is important to note that determining the exact causes of these deviations from normal as a function of the gas and particular pollutants is beyond the scope of this work. However, the existence of this

COMPARISON NON-POLLUTED SITES TO STD. MARINE SEDIMENT BOTTOM LOSS

Core Number	Density	Std. B.L.	Obs. B.L.	Difference
Core 8	2.00	8.2	8.8825	-0.6825
Core 9	2.20	7.5	9.63	-2.13
Core 11	2.00	8.2	8.323	-0.123
Core 13	2.20	7.5	10.4	-2.9
Core 14	2.00	8.2	9.138	-0.938

Mean Difference	-1.3547
Standard Deviation Difference	1.132654

Note: Indicates the goodness of Calibration and Computation Procedures.

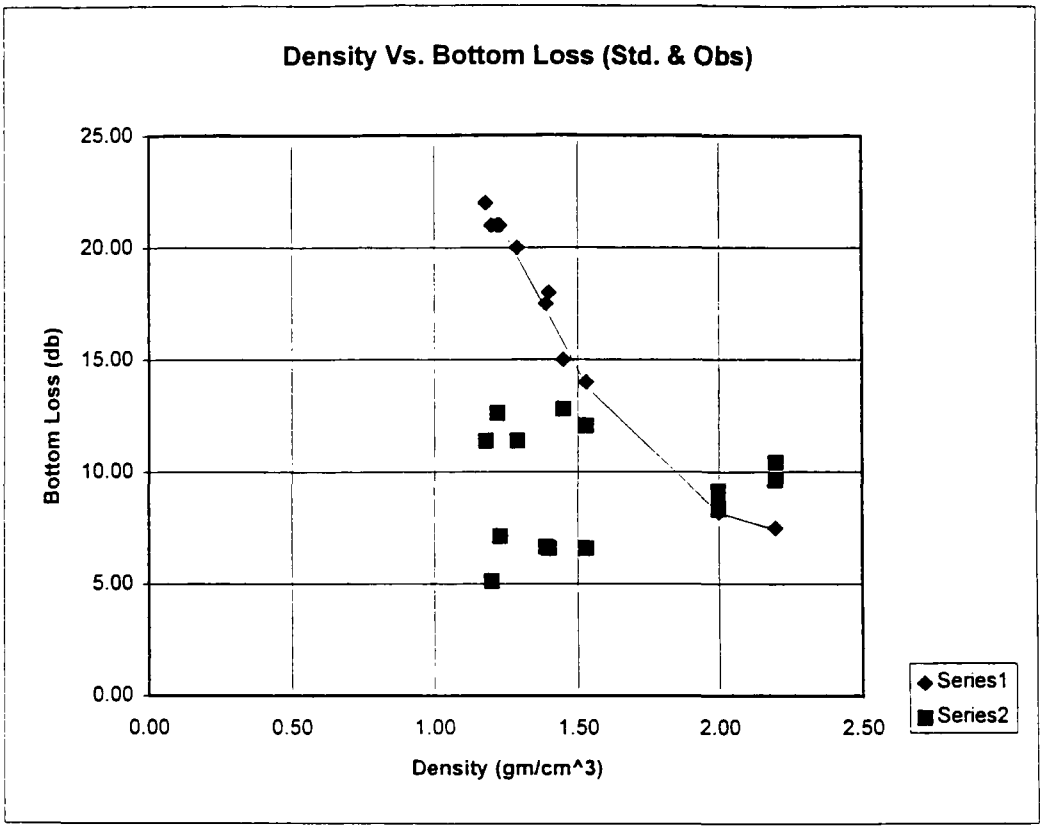
Figure 4-7

SUMMARY OF BOTTOM LOSS FINDINGS
TRENTON CHANNEL 1995

Core Site No.	Density gm/cm^3	Std. Mar. B.L.(db)	Mean Observ. B.L.(db)	Mean Observ. Std.	Difference St.Mar-Obs.	Pollution Factor
Core 5	1.29	20.00	11.377	2.0325	8.62	10
Core 6	1.18	22.00	11.377	2.0325	10.62	10
Core 7	1.39	17.50	6.646	1.444	10.85	10
Core 8	2.00	8.20	8.882	2.444	-0.68	0
Core 9	2.20	7.50	9.63	2.13	-2.13	0
Core 10	1.53	14.00	12.045	2.38	1.96	5
Core 11	2.00	8.20	8.323	1.399	-0.12	0
Core 12	1.23	21.00	7.121	2.108	13.88	7
Core 13	2.20	7.50	10.4	1.299	-2.90	0
Core 14	2.00	8.20	9.138	3.424	-0.94	0
Core 15	1.45	15.00	12.8	2.68	2.20	3
Core 16	1.22	21.00	12.607	3.331	8.39	7
Core 17	1.40	18.00	6.578	2.197	11.42	9
Core 18	1.53	14.00	6.578	2.19	7.42	9
Core 19	1.20	21.00	5.11	2.53	15.89	10

Diff. Bottom Loss Derivation Table

Figure 4-8



Series 1 = Standard Marine Sediments

Series 2 = Trenton Channel Sediments

Figure 4-9

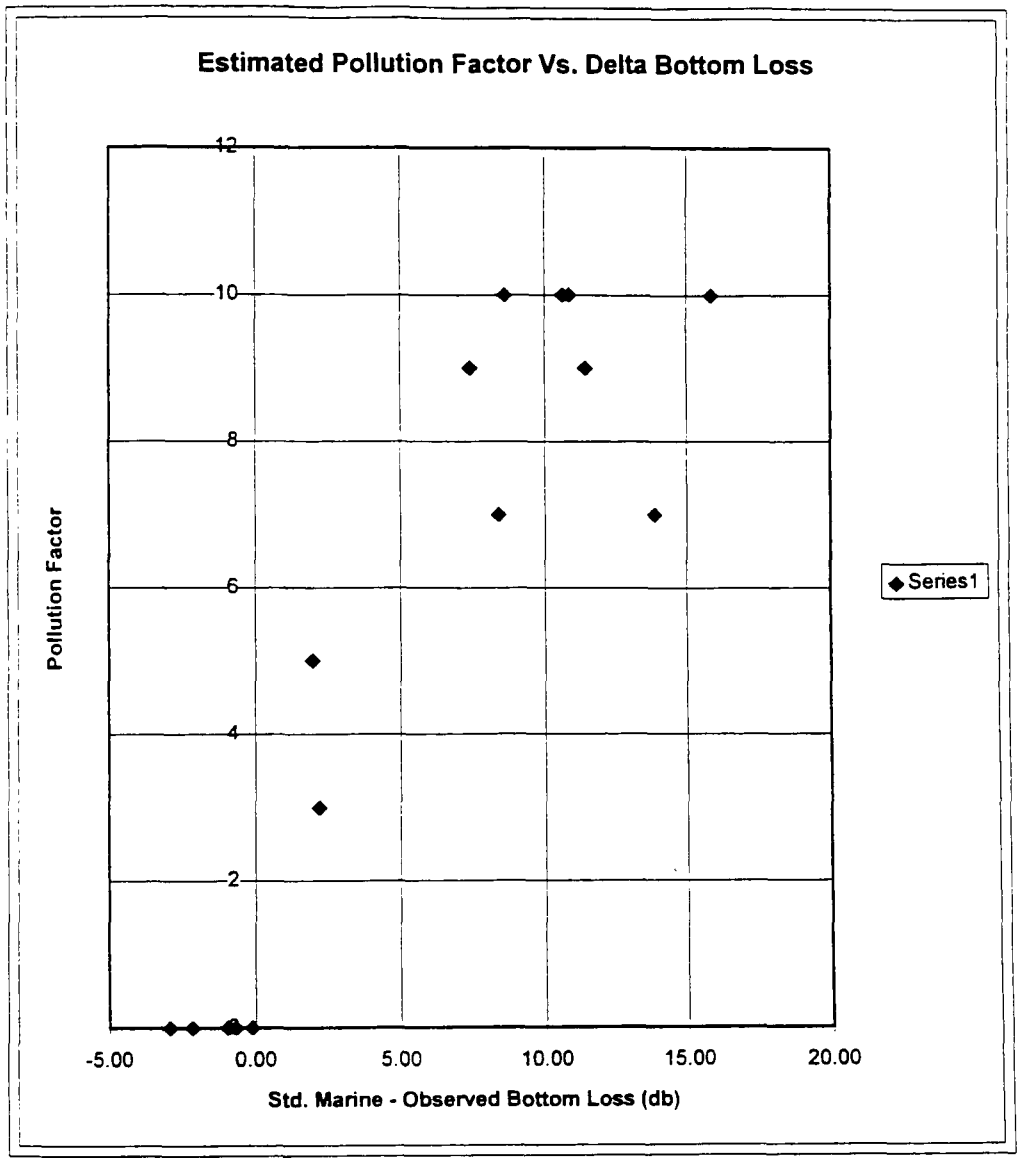

Estimated Pollution Factor Vs. Delta Bottom Loss
Pollution Factor
12
10
8
6
4
2
-5.00
0.00
5.00
10.00
15.00
20.00
Std. Marine - Observed Bottom Loss (db)
Series1

Figure 4-10

deviation allowed classification of potentially polluted sediments. This finding has only been examined for the Trenton Channel study and must not be assumed valid for other sites.

4.3.3 Amplitude Decay Ratio

The Amplitude Decay Ratio is a gross measure of absorption. When plotted against difference in bottom loss, Figure 4-11, a linear approximation is indicated. The straight line on the plot is a linear fit of the data points. It is important to recognize that this result is only considered as a general trend. The large variance in boat position, hence sediment type, explains some of the variance. In addition, examination of the ping to ping variance could also be attributed to different amounts of gas. The higher absorption (lower amplitude ratios) correspond to more polluted clay layers.

Figure 4-12 is a three dimensional plot of the amplitude ratio (vertical axis) versus pollution factor by core number. The left portion is for normal non-polluted sediments and the right, low values, are for the heavily polluted sediments. The middle bars are slightly higher than expected. It is believed that this is due to the fact that the data were not corrected for layer thickness. Time did not allow for this correction. The black squares in the legend plot are an anomaly of the plotting routine and have no significance. Spectral analysis tools, such as the Caulfield Engineering 'Digital Spectral Analysis System (DSA10),' are available to refine these gross trends identified. However, the amount of data processing is quite large and was beyond the scope of this contract.

4.3.4 Plus Sign Percentage

The plus sign percentage is lowest when the gas content is highest and there is a phase reversal of the bottom reflection. Phase reversal occurs when the boundary is a pressure release surface, where the reflecting layer is less dense than the incident layer. The best example is the water-air surface where there is always a 180 degree phase shift. Figure 4-13 compares the plus percentage to the difference in bottom loss (defined above). This curve, like the amplitude ratio, shows that the largest deviation in bottom loss, highest gas content, has the lowest plus sign percentage or the largest negative reflection coefficients. The line plotted through the data is a linear fit of the data points.

Figure 4-14 is a three dimensional bar graph of the plus percentage (vertical axis) versus the pollution factor by core numbers. The data on the left is the non-polluted sediments and the data on the right is the highest polluted clay samples. Again, time did not allow for correction for slight deviations in layer thickness, which would have corrected the middle points. The black and white squares in the legend block are an anomaly of the plotting routine and have no significance. The Plus Sign Axis is the vertical axis in this Figure 4-14.

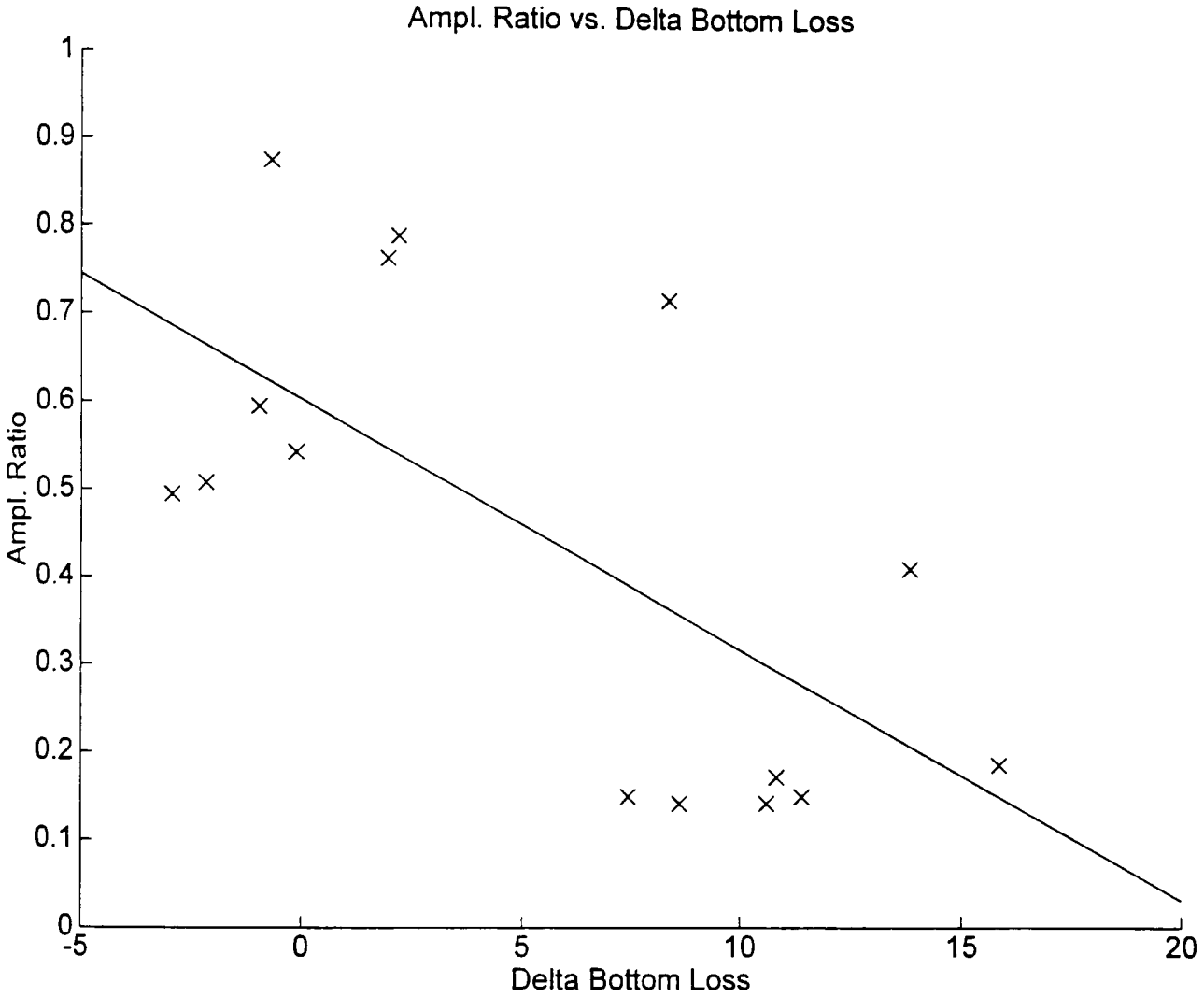
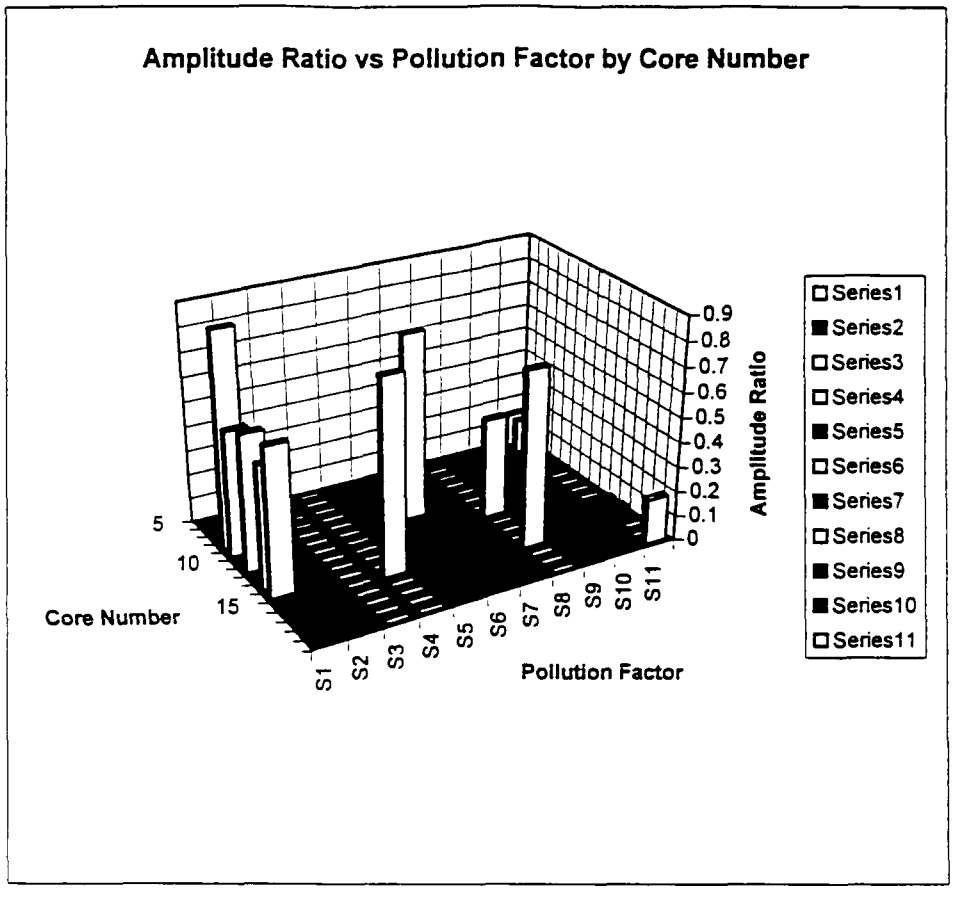

Ampl. Ratio vs. Delta Bottom Loss
Ampl. Ratio
Delta Bottom Loss
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
0
5
10
15
20

Figure 4-11



Series 1-11 represents Pollution Factor 0 - 10

Figure 4-12

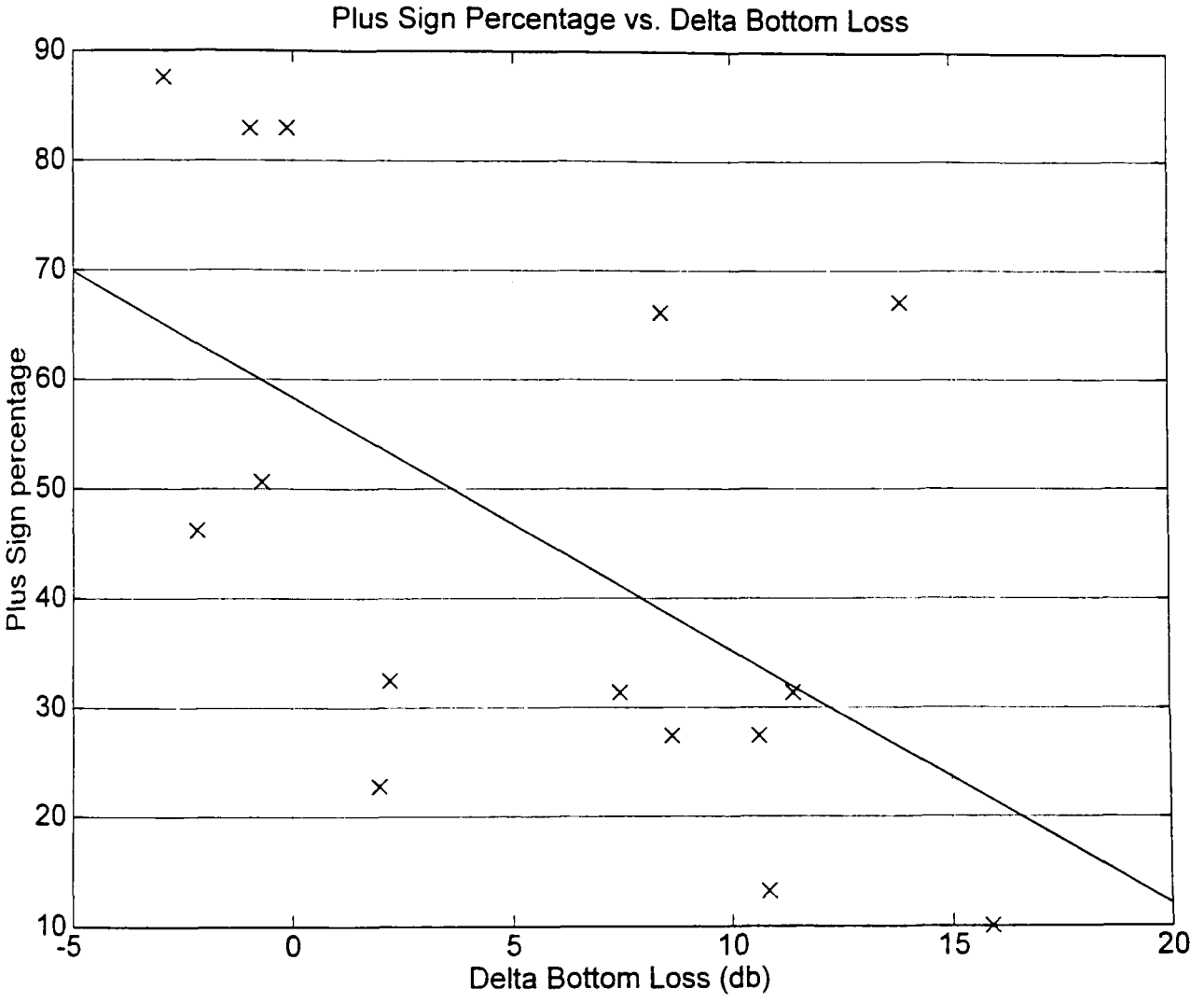

Plus Sign Percentage vs. Delta Bottom Loss
Plus Sign percentage
Delta Bottom Loss (db)
90
80
70
60
50
40
30
20
10
-5
0
5
10
15
20

Figure 4-13

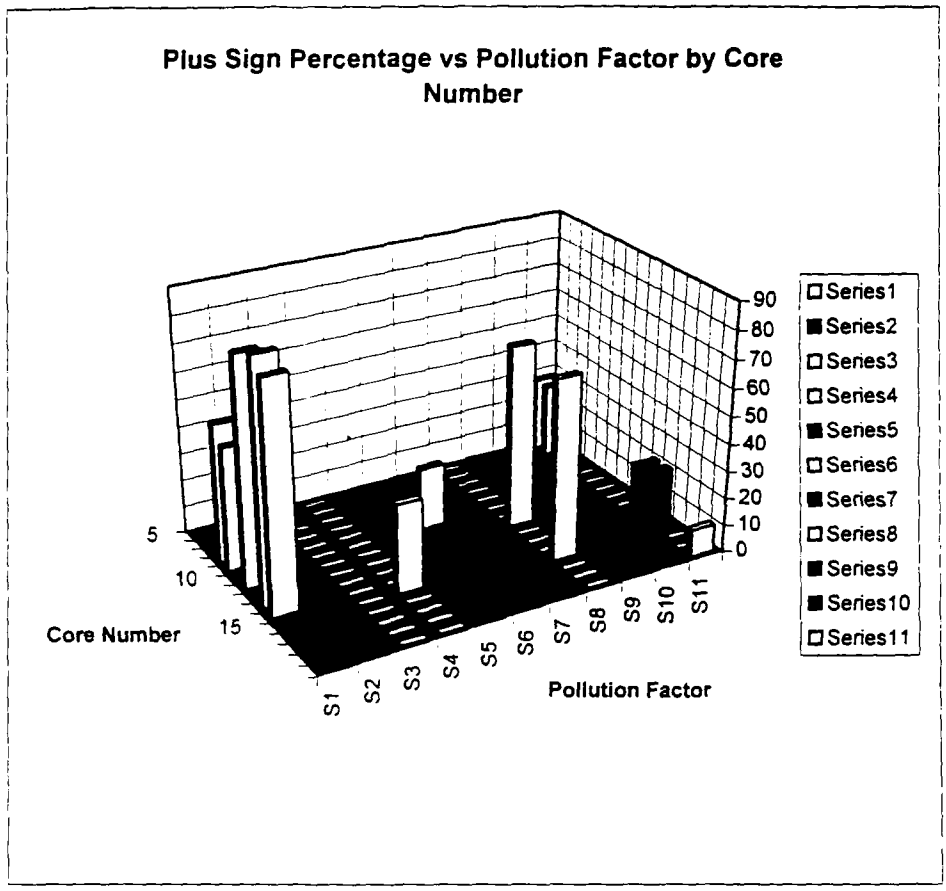


Figure 4-14

Series 1-11 represents Pollution Factor 0 - 10

4.3.5 Acoustic Parameters Summary

The data presented above should be considered only as general trends due to the electrical and boat handling problems encountered during the survey. However, the trends do suggest the potential for identifying polluted and/or gas containing sediments in the Trenton Channel. In application, when the bottom loss is low, more sound is being reflected back to the receiver, one normally would assume a very hard or rocky bottom. In a normal marine case of a hard or rocky bottom the reflection sign would be positive (plus percentage high). However, when the plus percentage is low, indicating negative reflection coefficients (indicating gas), one can readily assume the that low bottom loss is due to gas/polluted sediments. Cross referencing with the absorption can then provide a rough classification of the sediment type and the potential for pollution/gas. The ability to have some geotechnical data on the cores while in the field confirms the process.

The data processed to date has concentrated on the 3.5 KHz and 7.0 KHz data. The boomer low frequency data, which was used to aid in layer identification, can also be used for classification. Time did not allow for processing the boomer data in the same detail as above.

ACOUSTIC PARAMETERS SUMMARY AS A FUNCTION OF BOTTOM STATE

Sediment Type	Density (g/cm^3)	Bottom Loss (db)	Reflection Sign	Absorption (db/m)
Clean Clay	1.3	-20 (High)	+ (High +%)	Low
Polluted Clay	1.3	-8 (Low)	- (Low +%)	Very High
Clean Sand/Rock	2.1	-8 (Low)	+ (High +%)	Medium

It is also important to note that most pollutants lodge in clays and silty-sands and do not lodge in sands.

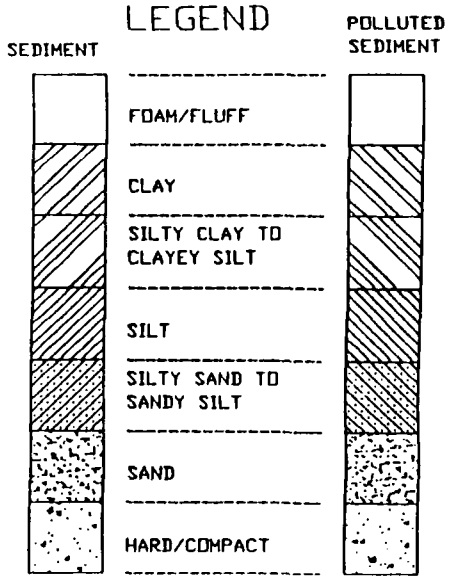
5.0 DETAILED CROSS-SECTIONS AT CORE SITES

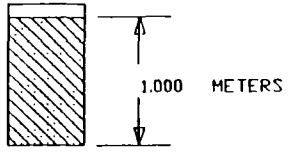
At each core site detailed cross-sections were generated providing material identification by layer and depth. All core site cross-sections are provided in Appendix B3. Note that Cores 5 and 6 were at the same seismic site. Likewise, Cores 17/18 were at the same seismic site.

Figure 5-1 provides an example of the core site cross-section. For this site, two cores were taken. The material legend is given in the upper-right hand corner of the drawing. Potentially polluted materials have the hatching rotated 90 degrees with respect to non-polluted sediments. The depth, in meters, below the water surface is provided. The major layering is indicated with the hatching defining layer type. The actual core stratigraphy is plotted on the left-hand side.

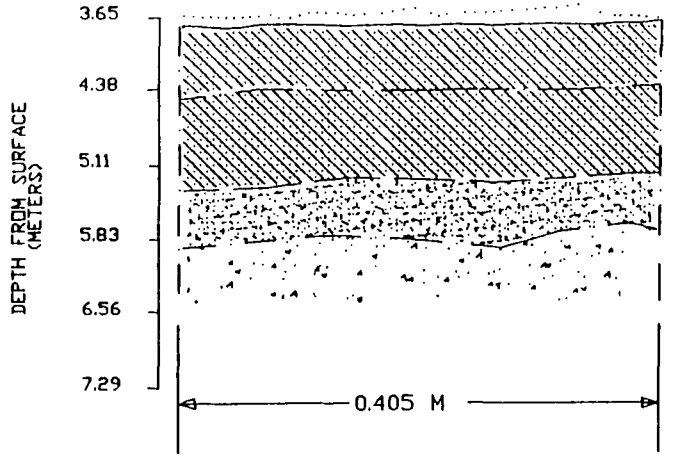
In this particular example, the predominant material is sandy/silt with fluff on the bottom surface. The location, physical properties, and major acoustic parameters are provided in the tables located at the top left of the drawing. A relative pollution factor comment is provided to the right of the bottom cross-section. The amount of drift of the boat is provided in meters. Even with a drift of only 0.405 meters, the bottom structure is beginning to vary, confirming the spatial resolution required to fully understand these complex structures.

OBSERVATION	CORE 17	CORE 18
NORTHING	72943.2	72942.2
EASTING	4098816.7	4098815.5
CORE LENGTH	0.90 M	0.97 M
DENSITY	1.40 g/cm^3	1.53 g/cm^3
BOT. LOSS	6.578 db	6.578 db
AMPL. DECAY	0.265	0.265
+ PERCENT.	44.58	44.58





CORE 17/18



CAULFIELD ENGINEERING

CORE 17/18 SUMMARY SHEET

JOB: 2060			SCALE
DRN BY: DDC	DATE: 2/25/96	SHEET	REV:

DWG. NO. 2060-CR17/18

Typical Core Site Cross-Section

Figure 5-1

6.0 DIRECT CORE VELOCITY/ABSORPTION

Caulfield Engineering provided, at no cost and not as part of the contract, a new prototype Direct Core Velocity/Absorption System for use in confirming and aiding in calibration of the polluted/gas containing sediments. This system allowed the direct measurement of both velocity and absorption in the core as soon as it was brought on board the boat. This allows verification of gas content, which normally would have escaped by the time normal laboratory geotechnical analysis was carried out. Because of the prototype nature of this system, data had to logged manually. Therefore, the data should be reviewed for trends and not absolute values.

The system consisted of a steel frame that allowed the core to be firmly mounted in the center. A transmitter and receiver crystal was mounted on sliding rods on each side of the core. The position of the water-sediment interface with respect to the bottom of the core was logged and the positions of the measuring transducer with respect to the bottom were also logged. Data acquired at each position included the travel time (velocity), the amplitude setting and the gain setting (absorption). At each core layer multiple readings were taken so that statistical processing could be undertaken. The operating frequency of the system was 330 KHz. A similar production system was used by USACE-WES to confirm the results. Unfortunately, this production system operated at 600 KHz and the absorption at this frequency was so large that no data were acquired. This was actually a positive result as it confirmed the high absorption parameters that were observed by the Caulfield system and by the seismic data in polluted areas. These measurements were only taken on seven (7) cores due to time limits and insufficient sample volume for some of the cores.

The original field log for this data was reported in Volume I. The analysis sheets for the velocity and absorption observations for all processed cores are provided in Appendices B3 and B4, respectively. The following sub-sections will review the observations obtained in detail for cores 5, 6, 7, 10, 12, 18, and 19.

6.1 Core Velocity Measurement Review

Figure 6-1 shows the form developed to estimate the velocity across the core at the various location along the core. Note that all position point measurements were referenced to the bottom of the core in the field. For reporting purposes the position (depth) down the core from the water sediment interface is also presented in Column 2 of Figure 6-1. The actual field positions of the transmitter and receiver, referenced to the

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 5 Page 1

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-10	103.5	103.5	7.3	100			10	811.1111		
		103.5	101.5	7.569016	110			10	756.9016		
		103.5	102	7.452516	60	100		10	1490.503	2484.172	
		103.5	102.5	7.368175	80			10	1052.596		
		103.5	104	7.317103	mov->	140		10		1688.562	
		103.5	105	7.452516	90	160		10	931.5645	1490.503	
		103.5	106	7.716217	mov->	145		10		1714.715	
		103.5	107	8.095678	mov->	144		10		1812.465	
							Mean velocity			1423.309	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	5	89	89	7.3	36	96	160	10	2807.692	2546.512	2433.333
		89	90	7.368175	60	100	176	10	1473.635	2456.058	2219.33
		89	91	7.569016	36	100	179	10	2911.16	2523.005	2239.354
		89	89	7.3	36	108	160	10	2807.692	2234.694	2433.333
		87.5	90	7.716217	36	96		10	2967.776	2691.703	
							Mean Velocity			2481.806	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********

Figure 6-1

bottom of the core, are also given. Knowing the diameter of the core, and after correction for wall thickness, the actual transmission path was computed (Distance Xmt-Rec., Column 5, Figure 6-1).

Because of the high frequency and short time intervals involved, the standard Acoustic Core digitizer could not be used for this prototype. The data was displayed on an oscilloscope and the travel time to the various peaks was read along with the amplitude of the peak signal and the gain setting. These latter items are discussed in the following absorption sub-section. The multiple peaks existed because of multiple echoes inside of the tube. These multiples are called the 1st arrival (direct), the 2nd arrival and so forth. The various reading, in microseconds, were placed in the appropriate columns on the chart shown in Figure 6-1. It is important to note that because of the weak signal levels and the prototype nature of the system, these placement may not always be correct. However, by taking many observation, the approximate estimate can be determined through averaging all of the possible velocities computed from the data. These computed velocity estimates are shown in the leftmost three columns. For example, in the example in Figure 6-1, the mean velocity of water came out to be 1423.3 meter/second. Slightly low from the normal velocity of water, which is 1459.2 meter/second. The lower value is expected due to migrating gas from the core into the water column. The tests at the multiple compensated for any arrivals coming from the plastic tube. The velocity of the plastic is much higher than water and would raise observed velocities if the plastic had any effect on the readings.

To ensure an independent calibration of the velocity system, the core tube was removed and the velocity of the air gap was measured. Figure 6-2 presents the table for the air calibration. The air velocity was 317.39 meters/second. The ideal velocity for air is 330 meters/second at ideal temperature and humidity. This measurement showed that the system was working properly.

Figure 6-3 provides a summary table for the velocity reading taken from seven (7) cores. The second column is the water velocity observed. As was noted, this velocity is slightly low. Part of this can be explained by the gas escaping into the water from the core and part is the prototype nature of the device. The third column provides the mean velocities observed and the fourth column the ideal velocity of standard marine sediments for the density measured. The next columns present the difference from ideal and the absolute difference from ideal. Also shown is the observed bottom loss and the difference in bottom loss from ideal. The ideal bottom loss data was obtained by using the core data density and using Hamilton's 1970 data for average bottom loss for standard marine sediments. The plus percentage and amplitude decay ratio are also presented. These latter numbers are taken from the tables presented in Section 4.0.

Figure 6-3B shows the ideal sediment plot of velocity versus density, while Figure 6-4 shows the observed velocity versus density measured with the core velocimeter system. The general trend of both plots shows that velocity increases as

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

AIR CALIBRATION

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Air	0	50	50	7.3	240			10	317.3913		
					Published Air Velocity = 330 m/sec.						
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********

Core Velocimeter Calibration - Air

Figure 6-2

CORE VELOCITY ANALYSIS SUMMARY SHEET

Core No	Water Vel.m/sec	Density g/cm^3	Mean Sediment Vel.m/sec	Ideal Sediment Vel.m/sec	Diff. Std. Velocity m/sec	Abs. Diff Velocity m/sec	Observed Bot. Loss db	Seismic Diff. Std. Bot. Loss db	Plus Percent Sign	Ampl. Ratio
5	1423.3	1.29	1531.3	1510	21.3	21.3	11.37	8.62	27.43	0.141
6		1.18	1623.4	1500	123.4	123.4	11.41	10.62	27.51	0.144
7	893.7	1.39	1842.9	1540	302.9	302.9	6.64	10.85	13.23	0.171
10	1351.9	1.53	2130.9	1677	453.9	453.9	9.64	1.96	22.8	0.763
12	1303.6	1.23	1940.6	1505	435.6	435.6	7.12	13.88	67.08	0.409
18	1342.1	1.53	1487.9	1600	-112.1	112.1	6.57	7.42	31.37	0.149
19	1280.2	1.20	1252.2	1505	-252.8	252.8	5.11	15.89	10.04	0.185

Means	1265.8
Stdev.	188.7516
Theorectical	1450.0

Figure 6-3

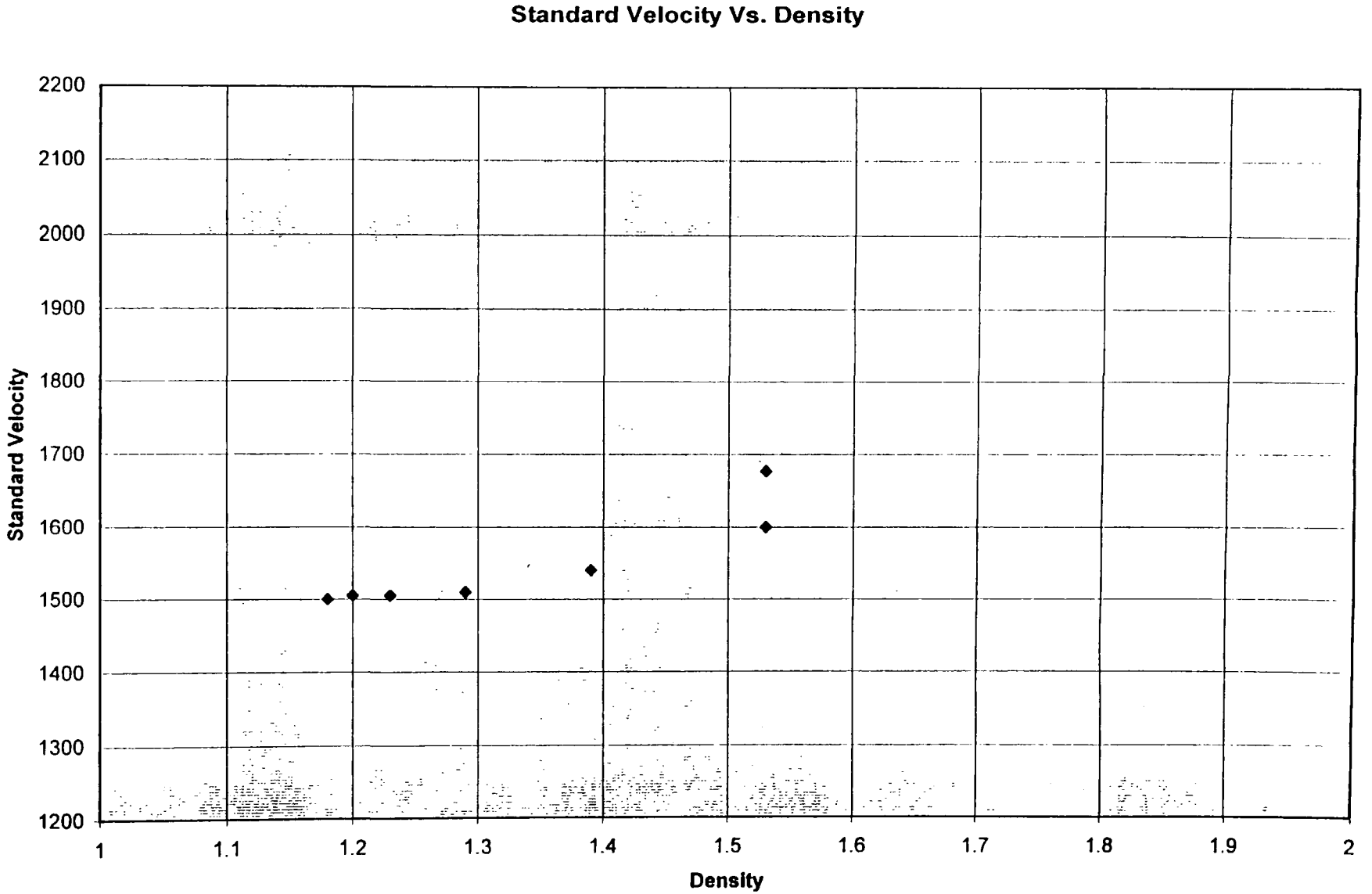


Figure 6-3 B

corvelsum - std. vel vs. density

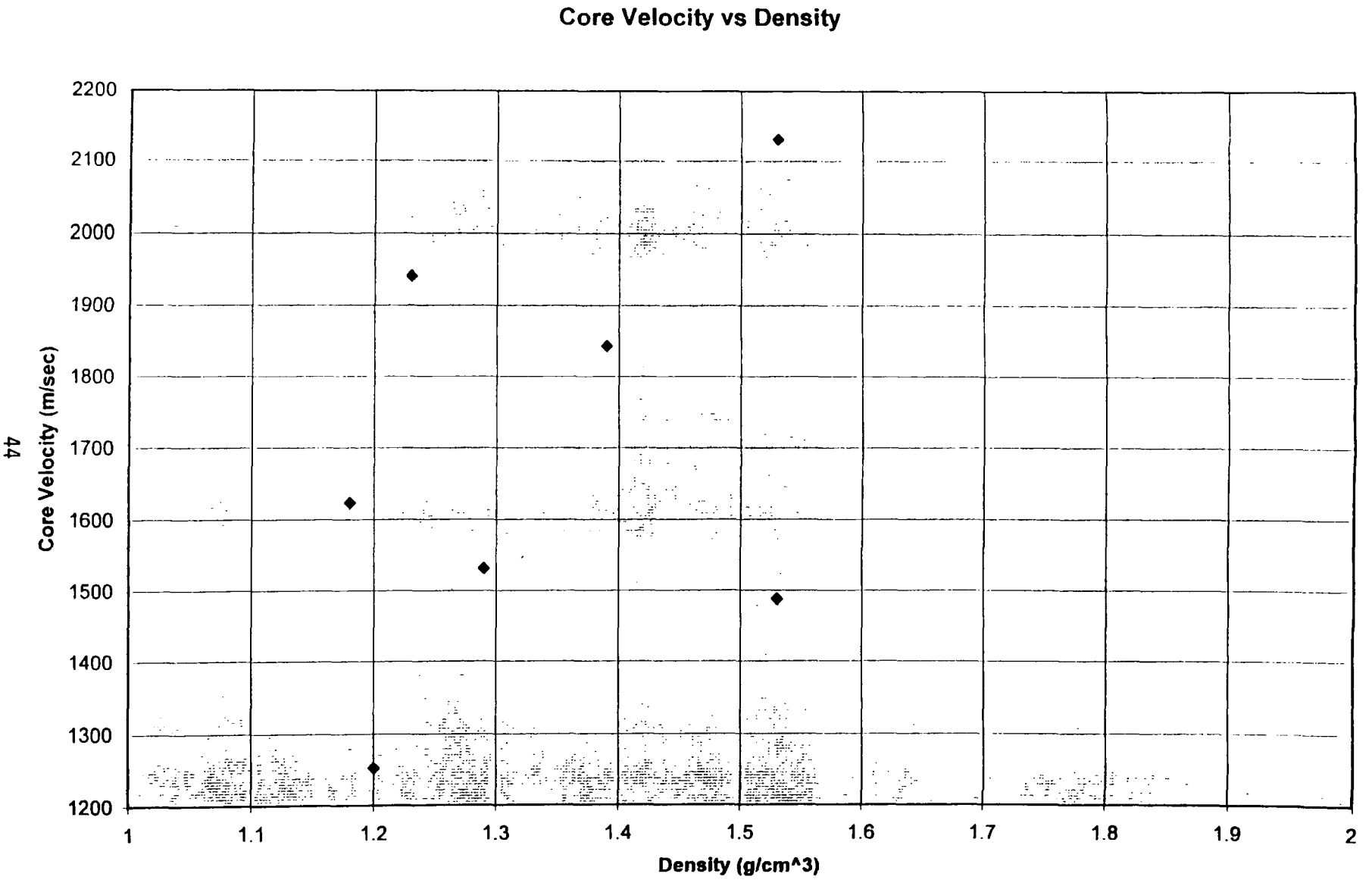


Figure 6-4

corvelsum - core vel.vs density

density increases. The high variance of cores exhibiting anomalous standard marine sediments is in part due to the prototype system and in part due to variations in other geophysical properties or chemical contamination. The curves presented in this section must be reviewed for gross trends only. This variance in observed velocity explains in part the high spatial variance seen in the Trenton Channel sediments and is possibly due to different concentrations of gas and or pollutants.

Figure 6-5 shows the difference between observed and standard marine sediment velocities plotted against the difference between observed and standard marine sediment bottom loss. The general trend is for delta velocity to increase as delta bottom loss increases. This plot further confirms the hypothesis that increased pollution/gas may cause increased deviation of the Trenton Channel sediment acoustic properties from those of standard marine sediments.

6.2 Core Absorption Observations

The relative amplitude and gain levels of the traverse signal through the core were recorded while taking the velocity data. Figure 6-6 shows the compilation of this data on an analysis sheet. The gain settings were logged along with the signal levels in volts. The corrected levels referenced to 1 volt were computed and this data was normalized to 0 db absorption for water. The last column converted these values into decibels (db) per meter. It is important to note that these db/meter values are extremely high. The absolute values should not be considered final because of the prototype nature of the system. Only the general trends should be reviewed. Appendix B4 provides the analysis sheets for the seven (7) cores examined.

Figure 6-7 provides a summary of the absorption values observed along with the acoustic properties for each core site processed. Figure 6-8 presents the observed relative absorption versus the observed difference in bottom loss from 'standard marine sediments.' The linear fit curve demonstrates the direct relationship between absorption and deviation in bottom loss. An increase in absorption is associated with an increase in delta bottom loss, which corresponds to increased pollution and or gas in the sediment. Again, the deviation from the line are due in part to the prototype nature of the measuring device and possibly the variations in gas and pollution.

Figure 6-9 displays the relationship between absorption and plus sign percentage. The plot of these data demonstrates that almost all the cores contained gas. Low plus sign percentages correspond to negative reflection coefficients, which indicates the presence of gas in the sediment.

Figure 6-10 shows the plot of absorption versus amplitude decay ratio. This data set confirms that those areas of high absorption observed in the seismic data also have high absorption as observed with the independent core absorption monitoring system.

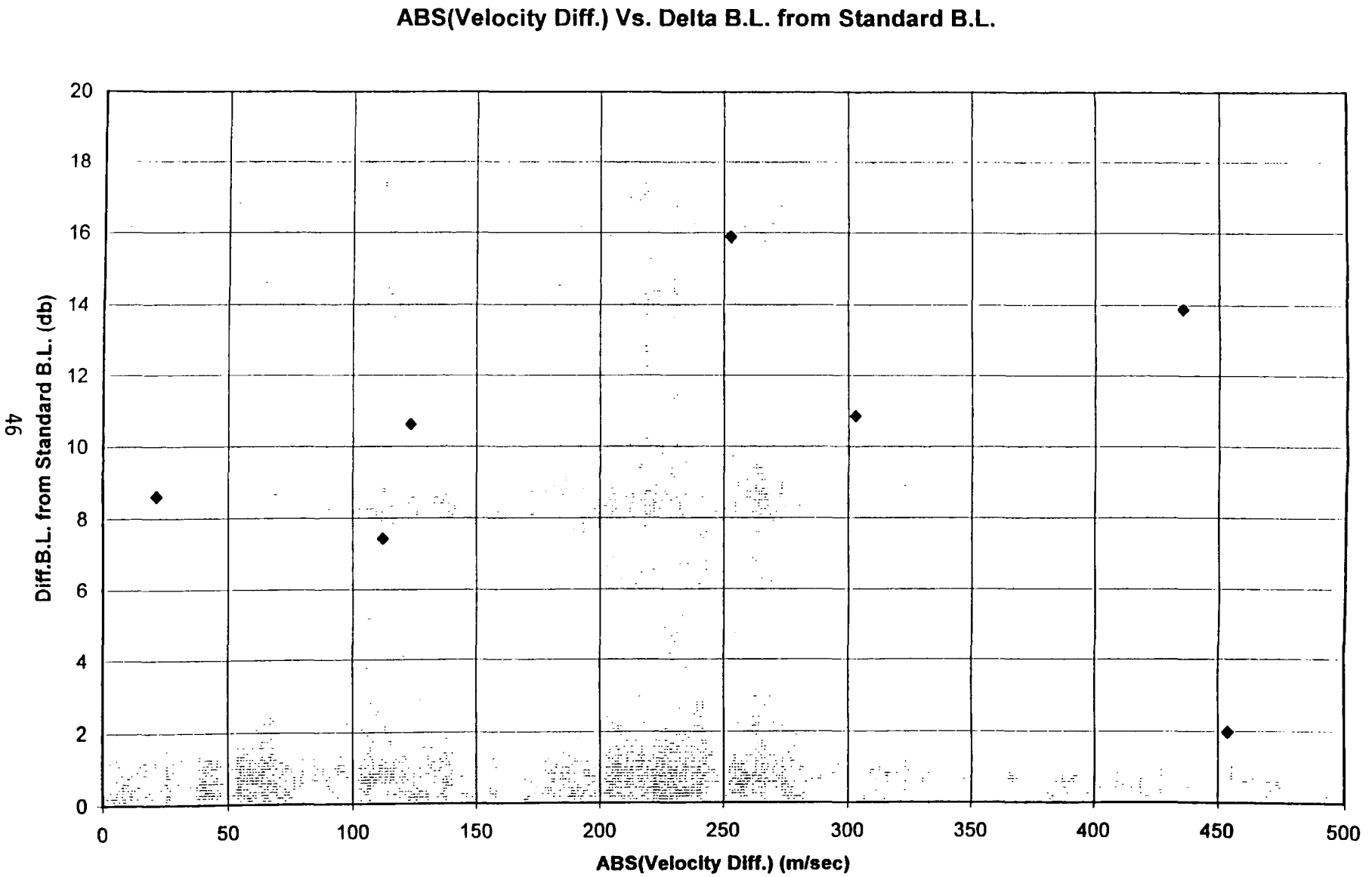


Figure 6-5

corvelwum - vel.diff vs. BL diff

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 5

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-10	630	66	.5	13.9	52.1	0	0
Sediment	5	1500	83.4	3.75	11.5	71.9	19.8	271.2329
Sediment	30	1500	83.4	3.25	10.2	73.2	21.1	289.0411
Sediment	33	1700	84	4.6	13.3	70.7	18.6	254.7945
Sediment	60	1500	83.4	1	0	83.4	31.3	428.7671

Mean Loss 22.7

Mean Absorption/Meter 310.9589

Analysis Log for Absorption Analysis

Figure 6-6

CORE ABSORPTION SUMMARY SHEET

Cores missing were sand or two short for analysis.

Core No.	Mean Absorp Core Tube	Mean Absorb db/m	Density g/cm^3	Bot. Loss db	Diff. B.L db	+ Sign Percent.	Ampl. Ratio	Pollution Factor
5	22.7	310.9	1.29	11.37	8.62	27.43	0.141	10
6	18.7	256.1	1.18	11.37	10.62	27.51	0.15	10
7	22.5	308.4	1.39	6.65	10.85	13.23	0.171	10
10	21.4	292.8	1.53	12.04	1.96	22.80	0.763	5
12	32.4	443.2	1.23	7.12	13.88	67.08	0.39	7
18	29.5	404.1	1.53	6.57	7.42	31.37	0.265	10
19	27.7	379.4	1.20	5.11	15.89	10.04	0.207	10

Figure 6-7

corabsum

Delta Bottom Loss Vs. Observed Absorption

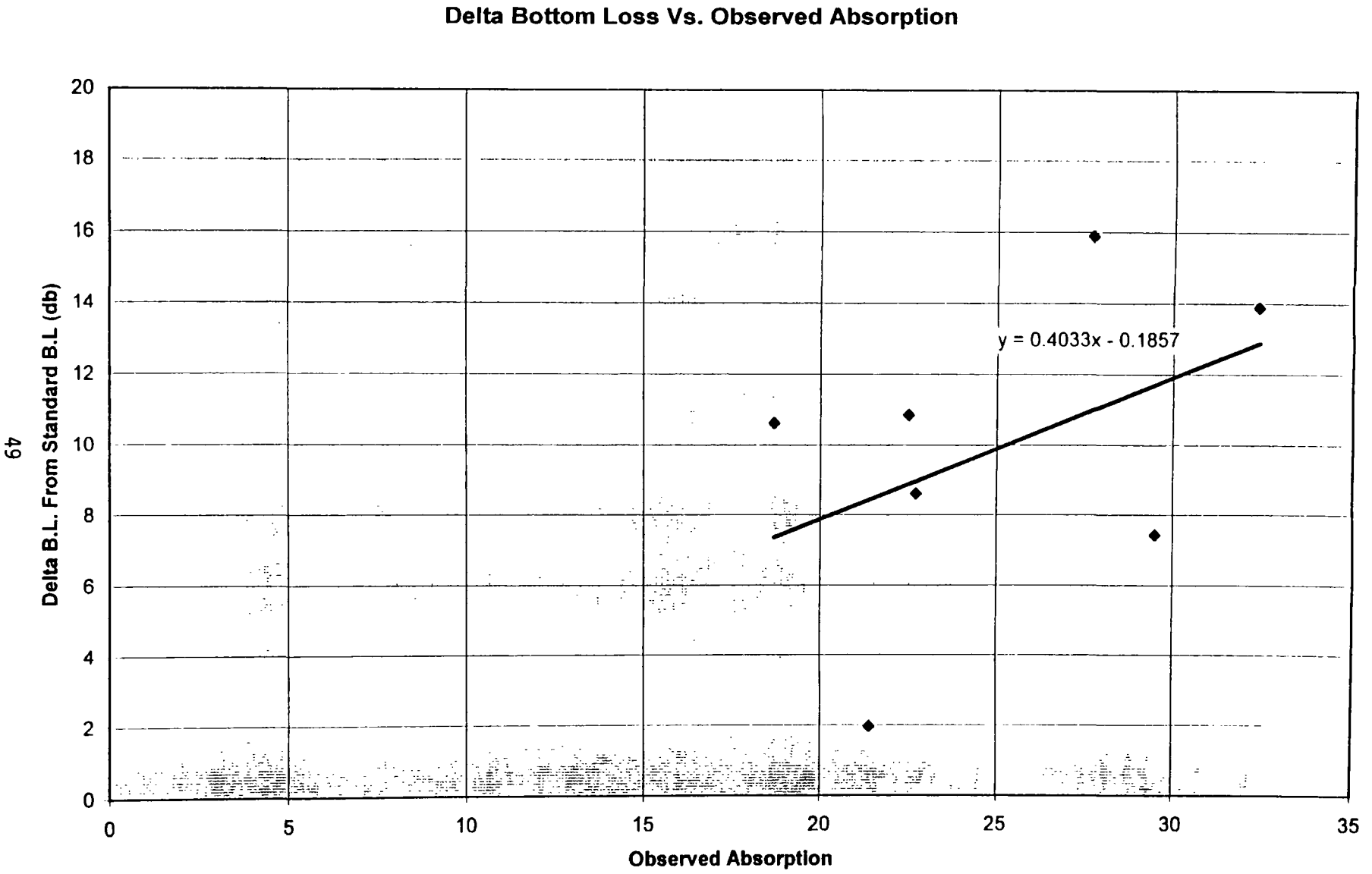


Figure 6-8

corabssum - dev from std.B.L.

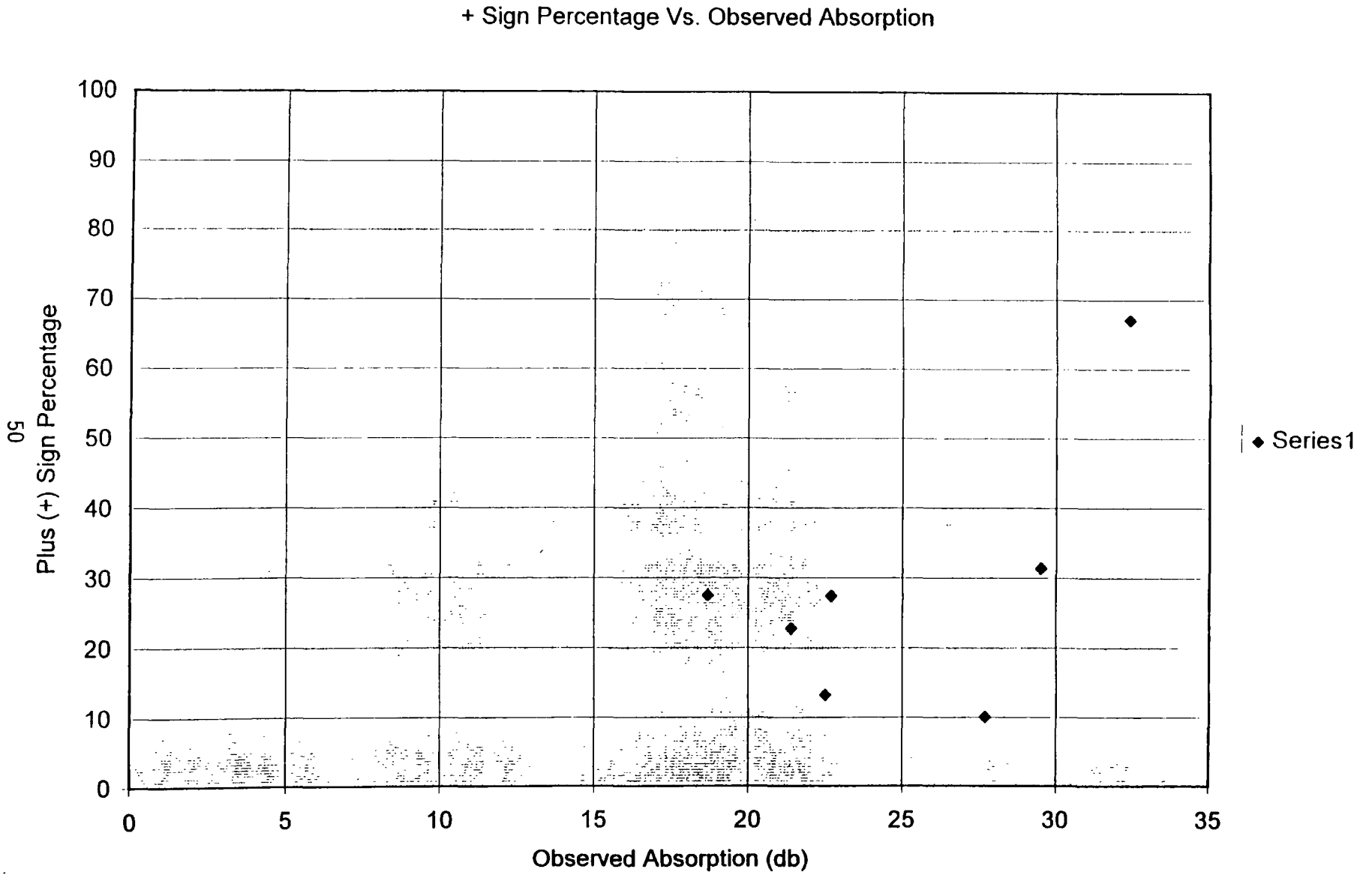


Figure 6-9

corabssum- ampl. ratio

Ampl. Ratio Vs. Observed Absorption

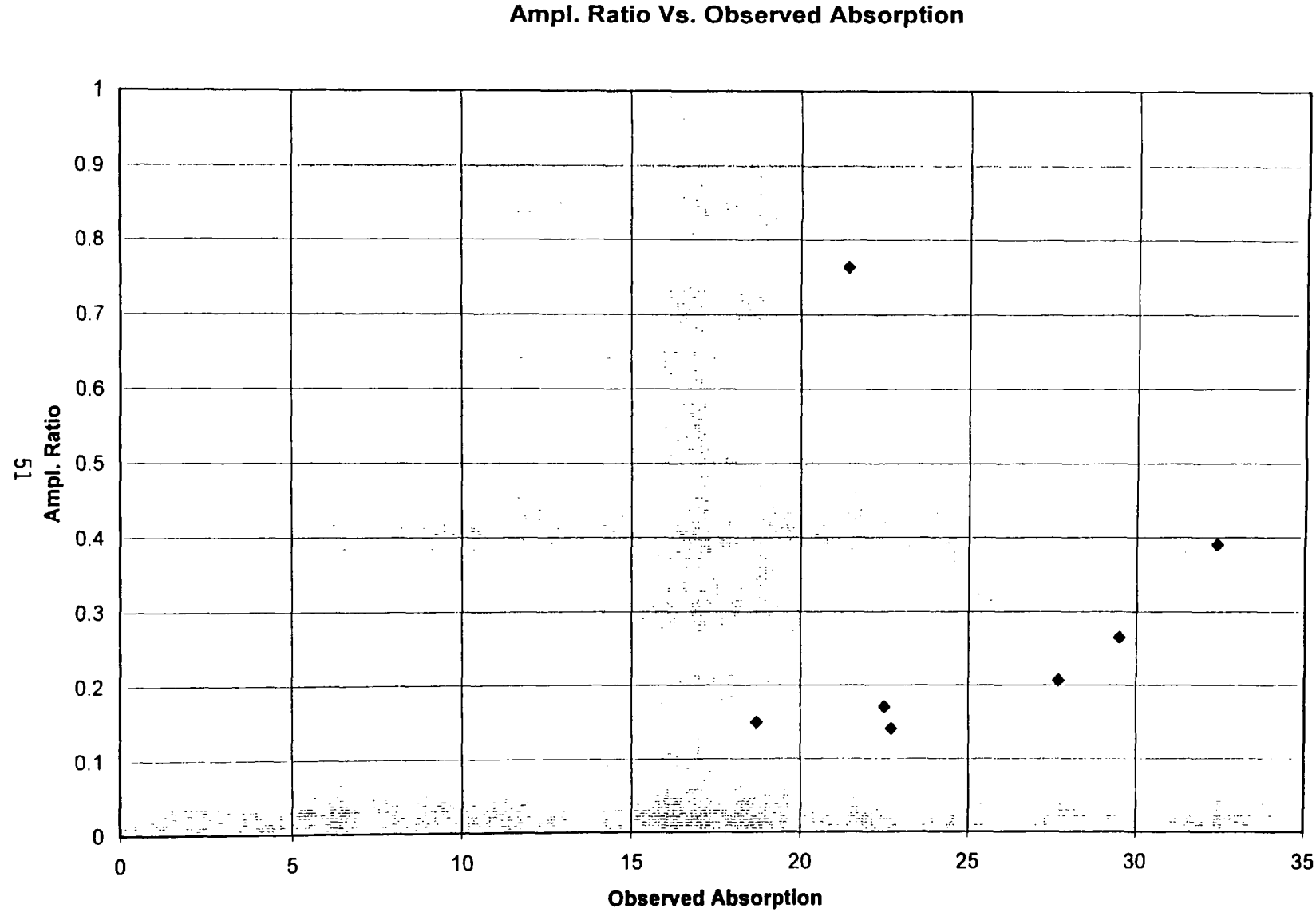


Figure 6-10

corabssum - ampl. ratio

7.0 PRELIMINARY AREA FINDINGS

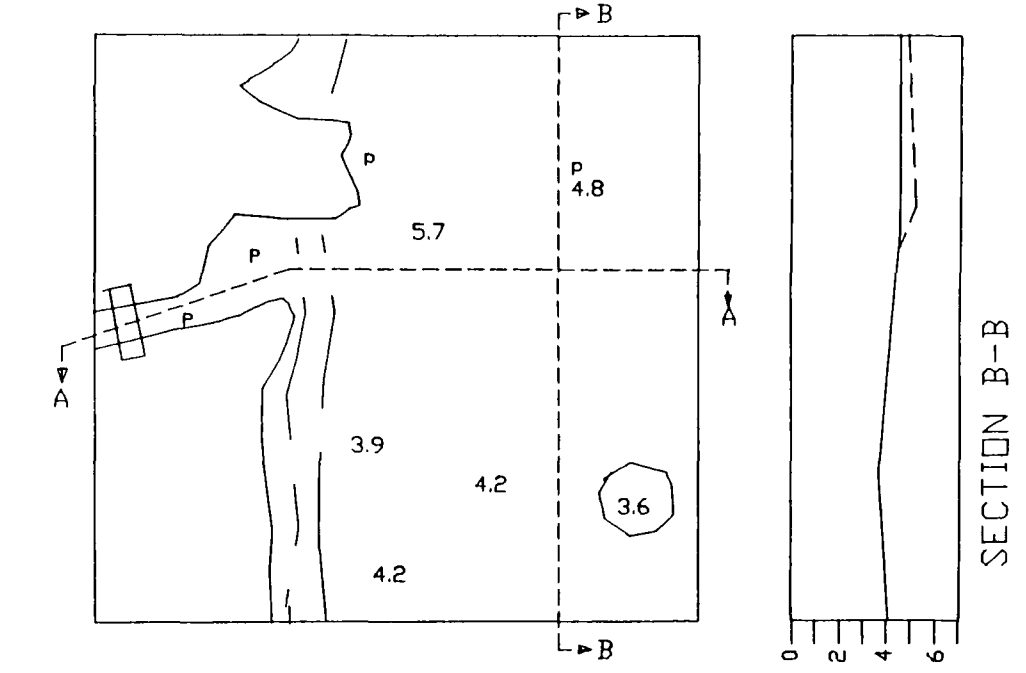
At the completion of the calibration (Volume I), and core analysis (Volume II), sufficient data existed to prepare initial summarized cross-section and area plots of depositional sediment distribution with indications of areas of possible pollution/gas distribution in the Elizabeth Park and Black Lagoon survey areas. The following subsections will provide this summary. Final cross sectional survey line plots of the study areas describing sediment distribution by density grouping (sand, silt, clay etc.) are presented in Volume III. Also presented in Volume III are estimates of the volume and location of depositional sediment. The information presented illustrates the form of preliminary site data before extensive data interpretation of the seismic cross-sections was undertaken.

7.1 Elizabeth Park Summary

Figure 7-1 is the summary overview of Elizabeth Park survey area. The plan view was digitized from the NOAA maps for the region. The dot-dashed lines represent the water depth contours, the water depth contour interval is 1.82 meter. Areas of high 'Pollution Factor' have 'P' and areas of medium 'Pollution Factor' have a small 'p'. Areas of high fluff are designated by 'F', and thin layers of fluff by 'f'. Note that a small 'f' is missing from drawing to the top right of the intersection of sectional lines 'A and B'. The sectional plots are shown on the bottom and to the right of the plan view. In the cross-sectional views, the bottom depth profile is given as a solid line and the depositional sediment depths are shown with a dashed line. The difference in depth between the solid and dashed lines indicates the depositional sediment thickness. All depths are in meters.

The main deep water portion is almost free of depositional sediment, with only a thin layer on the top right and top left of the plan view. In the top right area there is a thin layer of fluff on top indicating that the shoaling at the bottom portion of the plan view forms a river current void allowing the particles to settle to the bottom forming depositional sediment.

The Elizabeth Park channel is polluted, as shown by sediment core analysis. There is a sand and rock shoal at the entrance of the channel which effectively forms a water current void allowing the contaminated sediment to settle behind the shoal.



NOTE 4: C = CLAY
SS = SILTY/SAND
SL = SILT

NOTE 3: Fluff (F-High,f-Low)

NOTE 2: Pollution (P-High,p-Med.)

NOTE 1: CONTOURS @ 1,82 M INTRV

CAULFIELD ENGINEERING			
Q.E. PARK - SUMMARY			
JOB:2060			SCALE
DRN BY: DDC	DATE: 3/19/96	SHEET	REV:
DWG. NO. 2060-QESM			

Figure 7-1

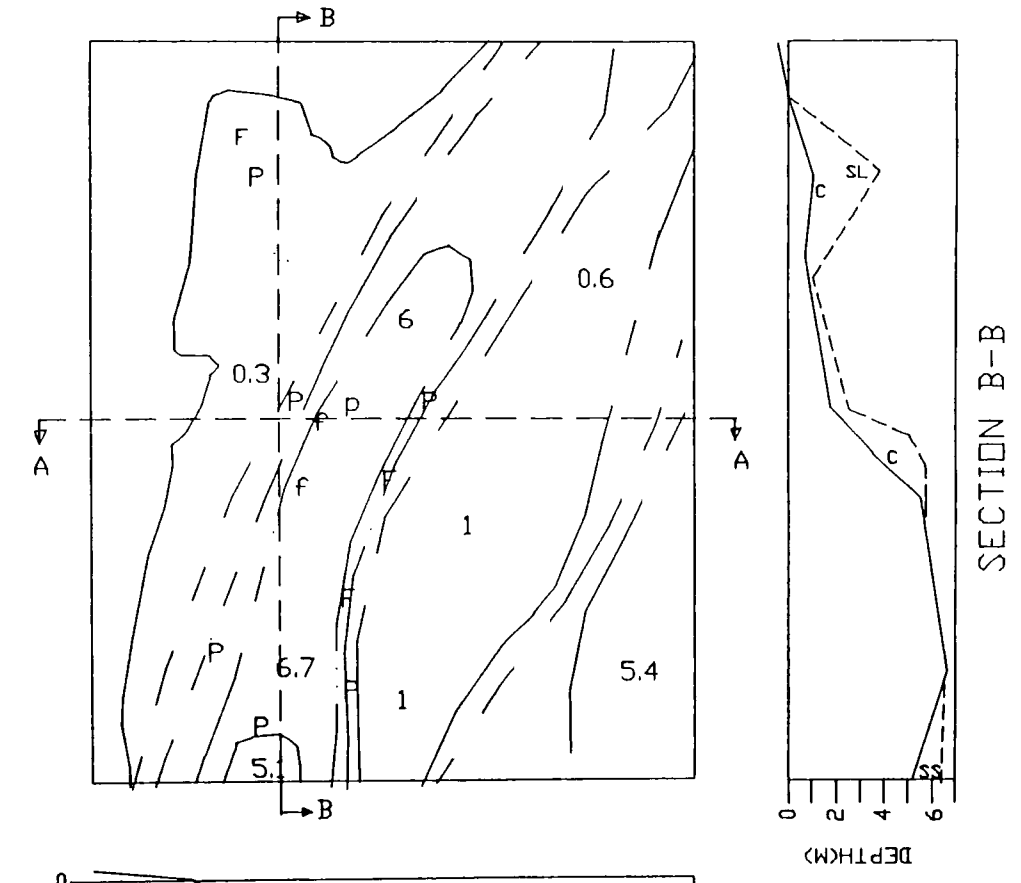
7.2 Black Lagoon Summary

Figure 7-2 is the summary overview of Black Lagoon survey area. The plan view was digitized from the NOAA maps for the region. The dot-dashed lines represent the water bottom contours, the water bottom contour interval is 1.82. Areas of high 'Pollution Factor' have 'P' and areas of medium 'Pollution Factor' have a small 'p'. Areas of high fluff are designated by 'F', and thin layers of fluff by 'f'. The sectional plots are shown on the bottom and to the right of the plan view. The water bottom depth profile and shoreline is given as a solid line and the polluted sediment zones are shown with a dashed line. The difference between the solid and dashed lines is the depositional sediment thickness. All depths are in meters.

The area consists of a large sand shoal in the middle right of the plan view. This shoal effectively makes the portion to the left of the shoal a settling pond. This hypothesis is confirmed by the existence of fluff on the bottom. The heavier particles, sand and silt, predominantly settle just to the left of the sand shoal. The lighter clay particles are deposited along the shore and in the small bay on the top left of the plan view. This small bay is surrounded with a sand ridge (dotted line) which traps the contaminated depositional sediment within the small bay. Eddy currents cause the clay particles to be carried into this small bay.

In the center and deeper area, there are various pockets of depositional sediments. These pockets are on the north side of shallower bottom features. An example of this is the bottom rise at the intersection of the Sectional B line with the bottom of the plan. This variation in depositioal sediment pockets was confirmed by the detailed coring program. There is no deposition on the deeper side of the shoal that is adjacent to the main channel. Currents must be sufficient to flush any deposits in this area.

The discovery of fluff on the bottom is extremely important in understanding the sedimentation rates of the pollutants. It is strongly suggested that micro-current meter surveys be conducted to confirm the settling pond concept. These fluff deposits exhibited in the seismic records and were confirmed in the cores.



NOTE 4: C = CLAY
SS = SILTY/SAND
SL = SILT

NOTE 3: Fluff (F-High,f-Low)

NOTE 2: Pollution (P-High,p-Med.)

NOTE 1: CONTOURS @ 1,82 M INTRV.

CAULFIELD ENGINEERING			
BLK. LAGOON - OVERVIEW			
JOB:2060			SCALE
DRN BY: DDC	DATE: 3/19/96	SHEET	REV:
DWG. NO. 2060-BLKSUM			

Figure 7-2

8.0 CONCLUSIONS AND RECOMMENDATIONS

The detailed analysis carried out has confirmed the following:

- Calibration Verification - The calibration procedures carried out in Volume I of this project were confirmed. The observed bottom loss at non-polluted sites matched theoretical bottom loss for these sediment types within the quality assurance program criteria. The offset from theoretical bottom loss was only -1.35 db with a standard deviation of 1.326 db.

- Acoustic Properties - The acoustic properties derived from the observations confirmed relationships between these properties and the gross pollution/gas content. The deviation of observed bottom loss from standard marine sediment bottom loss appeared proportional to the amount of pollutant and/or gas in the sediment. Further research is needed before this hypothesis can be confirmed.

  Gas content affected the reflection sign of the bottom signal. The percentage of phase reversal was grossly proportional to the level of pollution/gas in the Trenton Channel sediments, suggesting that the areas of high pollution had higher gas content. In addition, it was observed that gas containing sediments had a higher reflection coefficient (bottom loss) than the same sediment without gas.

- Independent On-Site Core Velocity and Absorption - These independent measurements confirmed the acoustic property relationships. A gross measure of absorption is the energy loss from the first to the second layer corrected for reflection coefficients. This has been approximated by a term called the amplitude decay ratio in this report. Areas of high pollution had a lower amplitude ratio, with the amplitude of the second layer being much smaller than the first. Absorption losses are caused primarily by gas content and by changes in the bonding of the grains of the sediments (pollution) and the sediment porosity (water content) (Hamilton, 1972)

  A prototype core velocity/absorption system was used in the field on the cores immediately after retrieval of the cores from the bottom. These measurements independently confirmed the observed trends seen in the seismic data. A second independent Core Velocity/Absorption System used by the USACE confirmed that the absorption was abnormally high.

- Spatial Variability - The spatial variability of sediments in the Trenton Channel was confirmed. The variation was as small as two meters in some cases. This core/seismic analysis confirmed sediment structure changes spatially, within meters, in the Trenton Channel. This variation was due in part to the complex current structures and geology, and in part to the anomalous sediments. This variation led to extensive additional processing of the data in order to obtain meaningful results.

- Sediment Deposition Mechanism The discovery of fluff on top of the sediments suggests possible deposition. Detailed processing of the acoustic data confirmed the existence of suspended fluff just above and on the bottom. This strongly suggested that current patterns in areas such as Black Lagoon generated a settling pond, concentrating sediment particles that are suspended in the river flow. These fluff and suspended sediments occurred in all depositional areas and were most prevalent in Black Lagoon.

Analysis of these data indicate that special arrays should be assembled for future surveys to narrow the effective beam pattern. This would allow better handling of the spatial variation problems. Also, a higher frequency system, such as 24 KHz would allow better definition of the fluff layers.

The large amount of data processing required, even eliminating the boat handling and electrical problems, was due to the high spatial variation in these sediments. The Acoustic Core© procedure, discussed in this report, is a method for the economical definition of these sediments. The cost of coring at the close spacing required, due to spatial variation, would be enormous.

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APPENDIX B1

DETAILED EXAMPLES OF ANALYSIS AT EACH CORE SITE

AVALIABLE FOR REVIEW AT U.S.EPA/CBSSS, Grosse Ile, Mi.

APPENDIX B2

SUMMARY OF ACOUSTIC PROPERTIES AT EACH CORE SITE

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 5

Density = 1.249 Std. Marine B. L. = 20
Core Leng 92.5 cm. Pollution Factor = 10

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms						
3.5-crys.						
7.0 -ms	11.129	2.922				Only one observat.
7.0-crys.			0.141			frequency/receiver
ACRS1						
3.5 - ms						
3.5 - crys.						
7.0 - ms	11.625	1.143				
7.0 - crys					27.43	

Means	11.377	2.0325	0.141		27.43	
Set Stdev.	0.350725	1.257943				

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 6

Density = 1.18 Std. Marine B. L. = 22
Core Leng 101.5 cm. Pollution Factor = 10

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms						
3.5-crys.						
7.0 -ms	11.129	2.922				Only one observat.
7.0-crys.			0.141			frequency/receiver
ACRS1						
3.5 - ms						
3.5 - crys.						
7.0 - ms	11.625	1.143				
7.0 - crys					27.43	

Means	11.377	2.0325	0.141		27.43	
Set Stdev.	0.350725	1.257943				

Note: Same data as for Core 5

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 7

Density = 1.39 Std. Marine B. L. = 17.5
Core Leng 85.85 cm. Pollution Factor = 10

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms						
3.5-crys.						
7.0 -ms	7.2911	0.6875				Only one observat.
7.0-crys.			0.171			frequency/receiver
ACRS1						
3.5 - ms						
3.5 - crys.						
7.0 - ms	6.002	2.2015				
7.0 - crys					13.23	

Means	6.64655	1.4445	0.171		13.23	
Set Stdev.	0.911531	1.07056				

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 8

Density = 2.00 Std. Marine B. L. = 8.2
Core Leng 0 Pollution Factor = 0

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms						
3.5-crys.						
7.0 -ms	8.954	1.843	0.874			Only one observat.
7.0-crys.						frequency/receiver
ACRS1						
3.5 - ms						
3.5 - crys.						
7.0 - ms	8.811	3.046			50.62	
7.0 - crys						

Means	8.8825	2.4445	0.874		50.62	
Set Stdev.	0.101116	0.850649				

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 9

Density = 2.20 Std. Marine B. L. = 7.50
Core Leng 0 Pollution Factor = 0

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	10.07	2.39	0.507			
3.5-crys.						
7.0 -ms						Only one observat.
7.0-crys.						frequency/receiver
ACRS1						
3.5 - ms	9.19	1.87			30.17	
3.5 - crys.					62.25	
7.0 - ms						
7.0 - crys						

Means	9.63	2.13	0.507		46.21	
Set Stdev.	0.622254	0.367696			22.68399	

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 10

Density = 1.53 Std. Marine B. L. = 14.0
Core Leng 37.0 cm. Pollution Factor = 5

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	12.48	2.16	0.763			
3.5-crys.						
7.0 -ms						Only one observat.
7.0-crys.						frequency/receiver
ACRS1						
3.5 - ms	11.61	2.6			22.8	
3.5 - crys.						
7.0 - ms						
7.0 - crys						

Means	12.045	2.38	0.763		22.8	
Set Stdev.	0.615183	0.311127				

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 11

Density =	2.00	Std. Marine B. L. =	8.2
Core Leng	0	Pollution Factor =	0

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	9.68	2.69	0.537			
3.5-crys.	8.66	0.854	0.469			
7.0 -ms	8.49	1.398	0.548			
7.0-crys.	7.691	2.81	0.638			
ACRS1						
3.5 - ms	6.53	0.727			96.31	
3.5 - crys.	7.99				29.41	Sign Noisy
7.0 - ms	10.57	1.21			69.6	
7.0 - crys	8.33				73.52	

Means	8.323	1.3998	0.551667		67.21	
Set Stdev.	1.218994	0.832954	0.08456		27.81593	

Massa Means	0.5425		82.955
Massa Setdev.	0.007778		18.88682

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 12

Density = 1.23 Std. Marine B. L. = 21
Core Leng 66.04 cm. Pollution Factor = 7

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	9.49	2.47	0.475			
3.5-crys.						
7.0 -ms	7.56	2.99	0.343			
7.0-crys.	4.95	3.18	0.352			
ACRS1						
3.5 - ms	11.41	1.43			73.52	
3.5 - crys.						
7.0 - ms	5.528	1.92			60.65	
7.0 - crys	3.792	0.66			68.29	

Means	7.121667	2.108333	0.39		67.48667	
Set Stdev.	2.916626	0.964353	0.07375		6.472498	

Massa Means	0.409		67.085
Massa Setdev.	0.093338		9.100464

ACOUSTIC PROPERTIES AT CORE SITES

Core Site 13

Density =	2.20	Std. Marine B. L. =	7.5
Core Leng	0	Pollution Factor =	0

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	8.94	1.5	0.433			
3.5-crys.	13.24	1.54	1.00			
7.0 -ms	8.26	0.63	0.555			
7.0-crys.	13.44	0.78	1.606			
ACRS1						
3.5 - ms	9.042	0.30			95.09	
3.5 - crys.	8.5					0 - Very Noisy
7.0 - ms	8.811	3.046			80.13	
7.0 - crys	13.00				34.78	

Means	10.40413	1.299333	0.8985		70	
Set Stdev.	2.353033	0.98645	0.530893		31.4052	

Massa Means	0.494		87.61
Massa Setdev.	0.086267		10.57832

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 14

Density = 2.00 Std. Marine B. L. = 8.2
Core Leng 7.62 cm. Pollution Factor = 0

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	10.127	4.32	0.661			
3.5-crys.	9.507	4.37	0.684			
7.0 -ms	9.322	3.62	0.433			
7.0-crys.	8.66	2.217	0.747			
ACRS1						
3.5 - ms		2.595			83.33	17.95(Boat Moved
3.5 - crys.	10.5				39.21	for bottom loss
7.0 - ms	6.48				82.53	
7.0 - crys	9.375				79.98	

Means	9.138714	3.4244	0.63125		71.2625	
Set Stdev.	1.31357	0.984916	0.137075		21.41603	

Massa Means	0.547		82.93
Massa Setdev.	0.16122		0.565685

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 15

Density =	1.45	Std. Marine B. L. =	15.0
Core Leng	58.4	Pollution Factor =	5

System/	Bot.Loss	Std. Dev.	Ampl.	Absorp.	Sign	Comments
Process			Decay	per meter	+/- %	
	(db)		(ratio)	(db)		
CAL1						
3.5 -ms	12.80	5.46	0.747			
3.5-crys.	11.78	4.4	0.888			
7.0 -ms	10.58	2.3	0.832			
7.0-crys.	10.86	3.46	0.6915			
ACRS1						
3.5 - ms	16.96	1.03			34.55	
3.5 - crys.	13.00					no sign - noisy
7.0 - ms	11.88	1.05			30.39	
7.0 - crys	14.54	1.057			58.82	

Means	12.80	2.68	0.789625		41.25333	
Set Stdev.	2.102787	1.800608	0.087405		15.35471	

Massa Means	0.7895		32.47
Massa Setdev.	0.060104		2.941564

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 16

Density = 1.22 Std. Marine B. L. = 21
Core Leng 16.5 cm. Pollution Factor = 7

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						soft spot small
3.5 -ms	12.87	1.22	0.803			hard spot near
3.5-crys.	12.79	5.96	0.460			boat movement
7.0 -ms	11.031	4.832	0.629			causes high variance
7.0-crys.	12.664	3.125	0.789			plus gas content
ACRS1						
3.5 - ms	13.14	0.40			53.42	
3.5 - crys.	13.25				48.14	
7.0 - ms	12.823	4.57			78.86	
7.0 - crys	12.29	3.21			62.74	

Means	12.60725	3.331	0.67025		60.79	
Set Stdev.	0.700445	1.991813	0.160863		13.47426	

Massa Means	0.716		66.14
Massa Setdev.	0.123037		17.9888

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 17

Density = 1.40 Std. Marine B. L. = 18.0
Core Leng 90.1 cm. Pollution Factor = 9

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						Site 17 sameSite 18
3.5 -ms	6.502	3.011	0.14			for acoustic data
3.5-crys.	7.92	3.5	0.425			
7.0 -ms	3.0428	0.736	0.159			
7.0-crys.	8.794	2.99	0.338			
ACRS1						
3.5 - ms	8.543	1.569			35.29	
3.5 - crys.	7.03				55.81	
7.0 - ms	2.208	1.38			27.45	
7.0 - crys	8.59				59.8	

Means	6.578725	2.197667	0.2655		44.5875	
Set Stdev.	2.575311	1.112263	0.138791		15.6791	

Massa Means	0.1495		31.37
Massa Setdev.	0.013435		5.543717

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 18

Density = 1.53 Std. Marine B. L. = 14.0
Core Leng 92.0 cm. Pollution Factor = 9

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						Site 18 same Site 17
3.5 -ms	6.502	3.011	0.14			for acoustic data
3.5-crys.	7.92	3.5	0.425			
7.0 -ms	3.0428	0.736	0.159			
7.0-crys.	8.794	2.99	0.338			
ACRS1						
3.5 - ms	8.543	1.569			35.29	
3.5 - crys.	7.03				55.81	
7.0 - ms	2.208	1.38			27.45	
7.0 - crys	8.59				59.8	

Means	6.578725	2.197667	0.2655		44.5875	
Set Stdev.	2.575311	1.112263	0.138791		15.6791	

Massa Means	0.1495		31.37
Massa Setdev.	0.013435		5.543717

ACOUSTIC PROPERTIES AT CORE SITES
Core Site 19

Density = 1.20 Std. Marine B. L. = 21
Core Leng 69.2 cm. Pollution Factor = 10

System/ Process	Bot.Loss (db)	Std. Dev.	Ampl. Decay (ratio)	Absorp. per meter (db)	Sign +/- %	Comments
CAL1						
3.5 -ms	5.45	2.64	0.221			
3.5-crys.	4.32	5.956	0.26			
7.0 -ms	3.26	1.184	0.142			
7.0-crys.	4.43	2.074	0.205			
ACRS1						
3.5 - ms	7.016	0.796			11.76	
3.5 - crys.	7.812				60.78	
7.0 - ms	3.125				8.33	
7.0 - crys	5.4687				47.05	

Means	5.110213	2.53	0.207		31.98	
Set Stdev.	1.674478	2.047925	0.049105		25.97894	

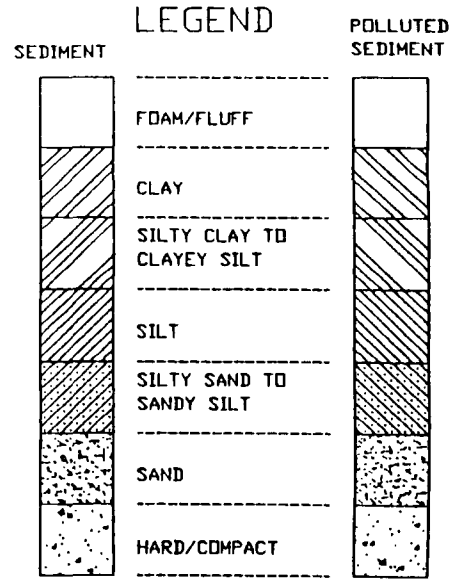
Massa Means	0.1815		10.045
Massa Setdev.	0.055861		2.425376

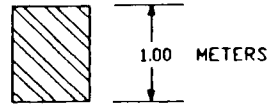
APPENDIX B3

CORE SITES CROSS-SECTIONS

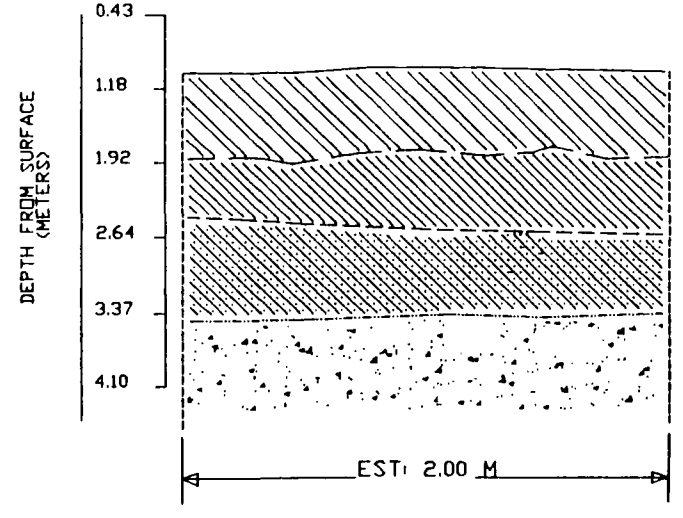
B3-2

OBSERVATION	CORE 5	CORE 6
NORTHING	71407.2	71408.0
EASTING	4098345.6	4098346.1
CORE LENGTH	0.925 M	1.015 M
DENSITY	1.29 g/cm^3	1.18 g/cm^3
BOT. LOSS	11.37 db	11.37 db
AMPL. DECAY	0.141	0.141
+ PERCENT.	27.43	27.43





CORE 5/6



POLLUTION FACTOR HIGH

Ref.File: CR510001

CAULFIELD ENGINEERING

CORE 05/06-SUMMARY SHEET

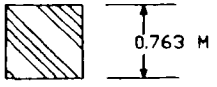
JOB: 2060 | SCALE

DRN BY: DDC | DATE: 2/26/96 | SHEET | REV:

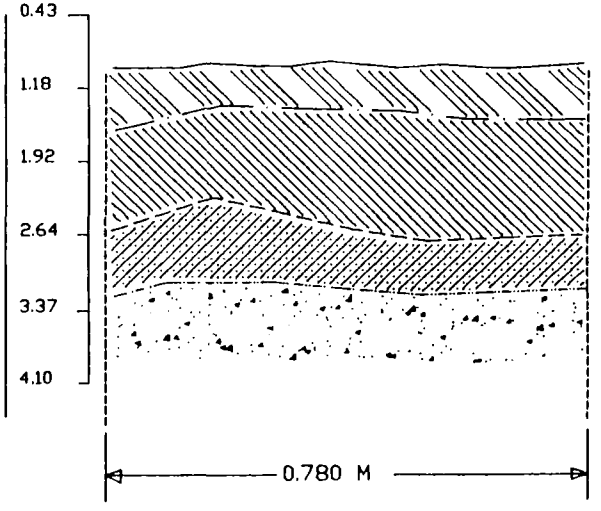
DWG. NO. 2060-CR5/6

B3-3

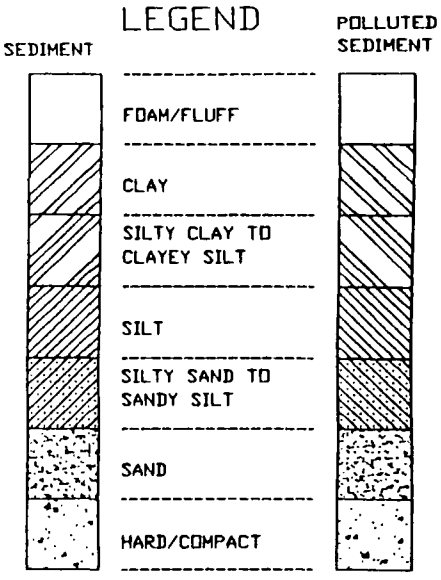
OBSERVATION	CORE 7
NORTHING	71422.8
EASTING	4098392.8
CORE LENGTH	0.763
DENSITY	1.39 g/cm^3
BOT. LOSS	6.65 db
AMPL. DECAY	0.171
+ PERCENT.	13.23



CORE 7



POLLUTION FACTOR HIGH

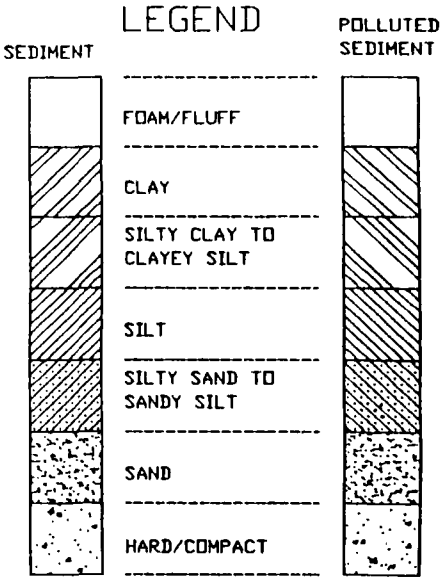


CAULFIELD ENGINEERING			
CORE 07 - SUMMARY SHEET			
JOB: 2060			SCALE
DRN BY	DATE:		REV:
DDC	2/26/96	SHEET	
DWG. NO. 2060-CR05			

Ref. File: CR520003

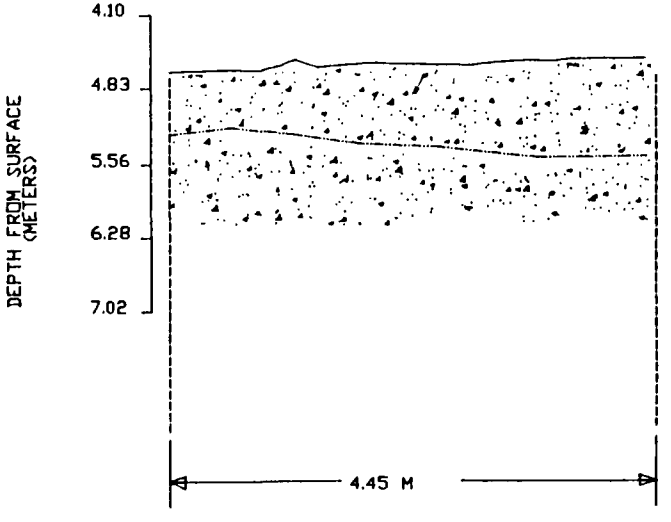
B3-4

OBSERVATION	CORE 8
NORTHING	71376.0
EASTING	4098447.0
CORE LENGTH	0.0 M
DENSITY	2.00 g/cm^3
BOT. LOSS	8.20 db
AMPL. DECAY	0.874
+ PERCENT.	50.62



NO CORE
SAND & GRAVEL

CORE 8



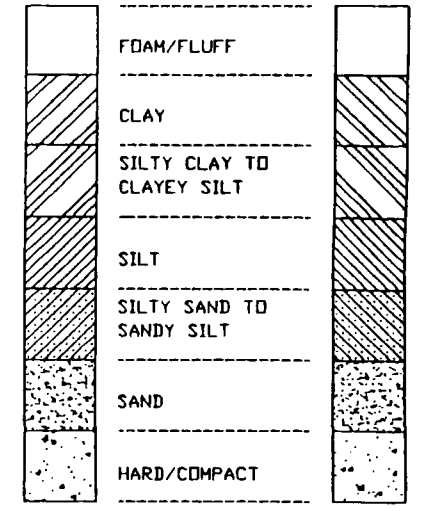
Ref. File: CR530007

CAULFIELD ENGINEERING		
CORE 08 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CR08		

B3-5

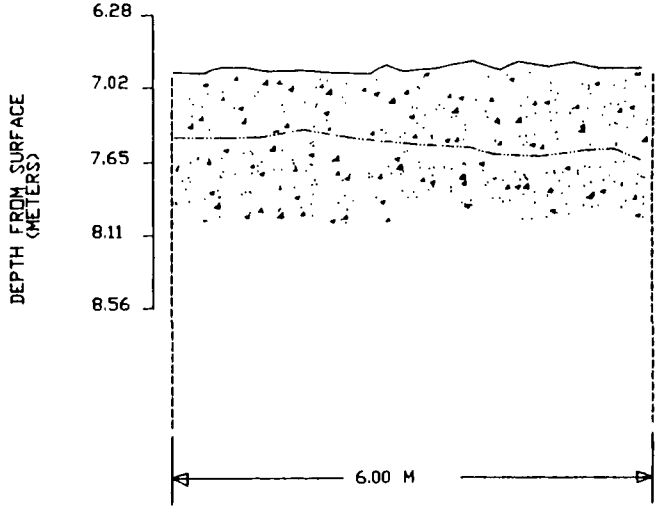
OBSERVATION	CORE 9
NORTHING	71477.0
EASTING	4098481.0
CORE LENGTH	0.0 M
DENSITY	2.20 g/cm^3
BOT. LOSS	9.63 db
AMPL. DECAY	0.507
+ PERCENT.	46.21

LEGEND



NO CORE
SAND & GRAVEL

CORE 9



NON-CONSOLIDATED SAND,GRAVEL,ROCK,CLAY
NO POLLUTION

CONSOLIDATED MATERIALS

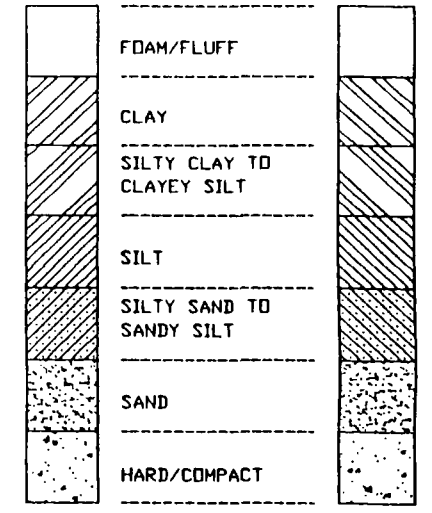
Ref. File: CR540003

CAULFIELD ENGINEERING		
CORE 09 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CR09		

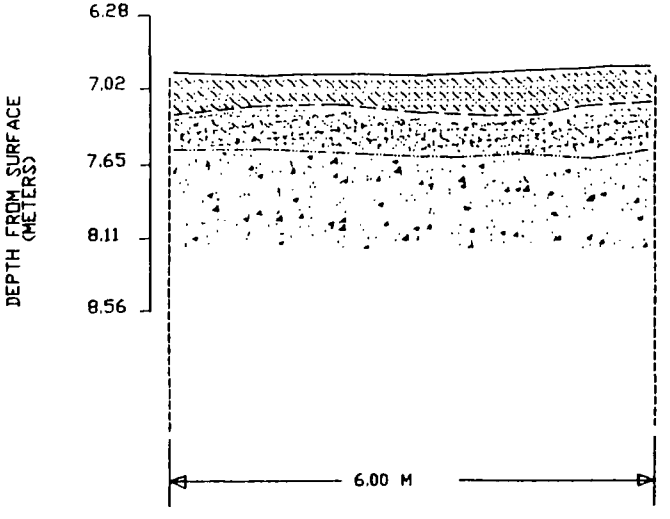
B3-6

OBSERVATION	CORE 10
NORTHING	71489.0
EASTING	4098540.0
CORE LENGTH	0.37 M
DENSITY	1.53 g/cm^3
BOT. LOSS	12.04 db
AMPL. DECAY	0.763
+ PERCENT.	22.80

LEGEND



CORE 10

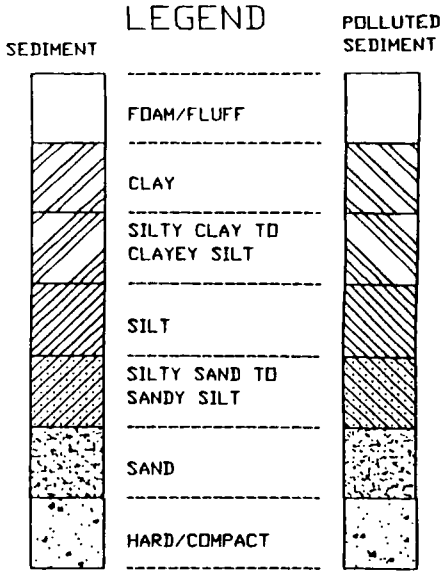


Ref. File: CR540023

CAULFIELD ENGINEERING		
CORE 10 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CR10		

B3-7

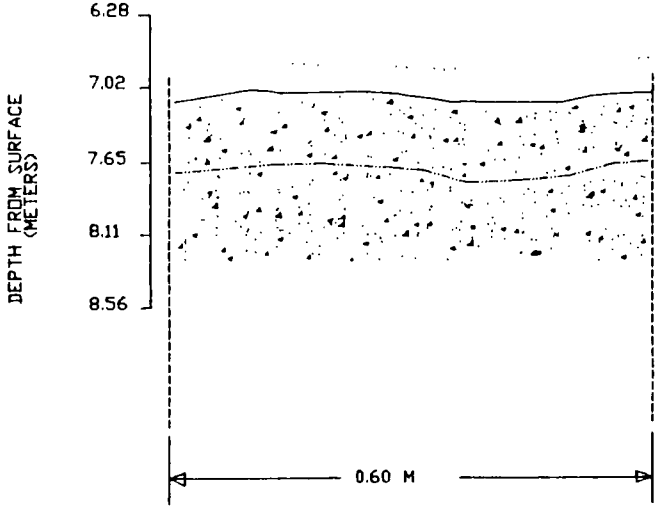
OBSERVATION	CORE 11
NORTHING	73002.0
EASTING	4098765.0
CORE LENGTH	0.0 M
DENSITY	2.00 g/cm^3
BOT. LOSS	8.323 db
AMPL. DECAY	0.551
+ PERCENT.	67.21



FLUFF

NO CORE ONLY SAND GRAVEL

CORE 11

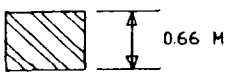


CAULFIELD ENGINEERING		
CORE 11 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CR11		

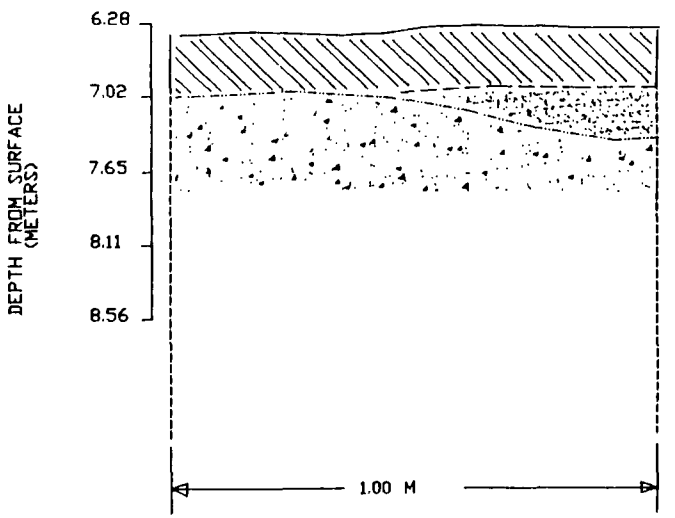
Ref. File: BCR10031

B3-8

OBSERVATION	CORE 12
NORTHING	72993.7
EASTING	4098757.9
CORE LENGTH	0.66 M
DENSITY	1.23
BOT. LOSS	7.121 db
AMPL. DECAY	0.409
+ PERCENT.	67.08



CORE 12

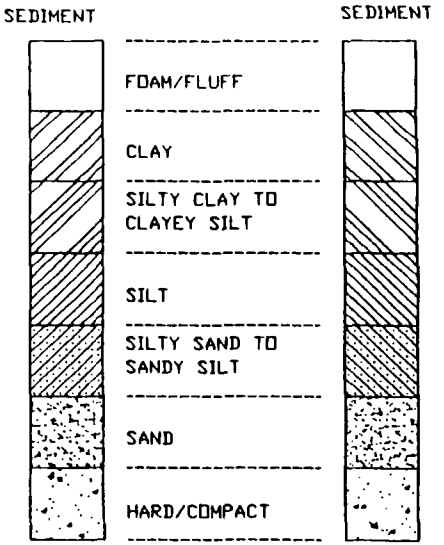


MEDIUM POLLUTED CLAY

NON CONSOLIDATED MATERIALS
NO POLLUTION

CONSOLIDATED MATERIALS

LEGEND



CAULFIELD ENGINEERING

CORE 12 - SUMMARY SHEET

JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	

DWG. NO. 2060-CR12

Ref. File: BCR10036

OBSERVATION	CORE 13
NORTHING	72971.2
EASTING	4098747.8
CORE LENGTH	0.0 M
DENSITY	2.20 g/cm^3
BOT. LOSS	10.4 db
AMPL. DECAY	0.898
+ PERCENT.	70.0

LEGEND

SEDIMENT

POLLUTED SEDIMENT

FOAM/FLUFF

CLAY

SILTY CLAY TO CLAYEY SILT

SILT

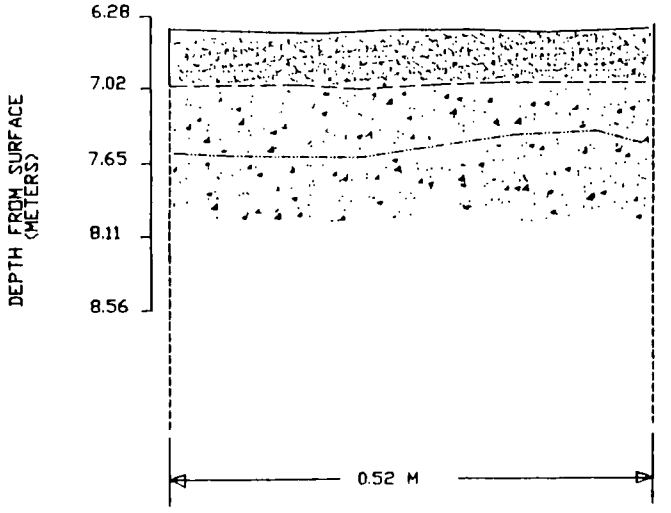
SILTY SAND TO SANDY SILT

SAND

HARD/COMPACT

NO CORE ROCK/GRAVEL

CORE 13



Ref. File: BCR10056

CAULFIELD ENGINEERING

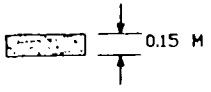
CORE 13 - SUMMARY SHEET

JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	

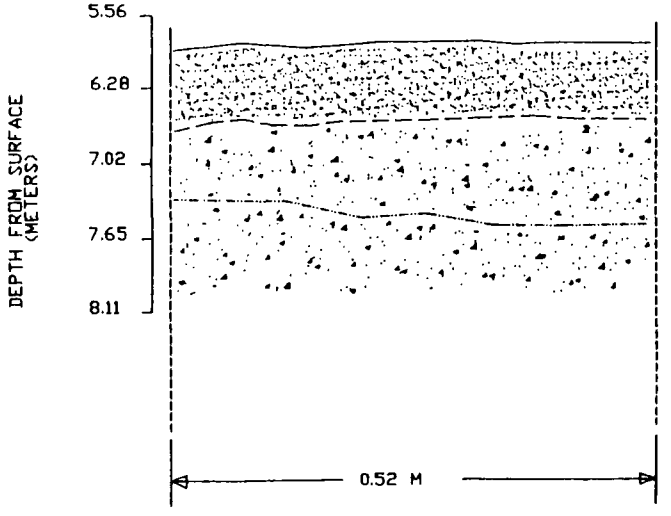
DWG. NO. 2060-CR13

B3-10

OBSERVATION	CORE 14
NORTHING	72963.5
EASTING	4098740.5
CORE LENGTH	0.15 M
DENSITY	2.00 g/cm^3
BOT. LOSS	9.138
AMPL. DECAY	0.631
+ PERCENT.	71.26



CORE 14

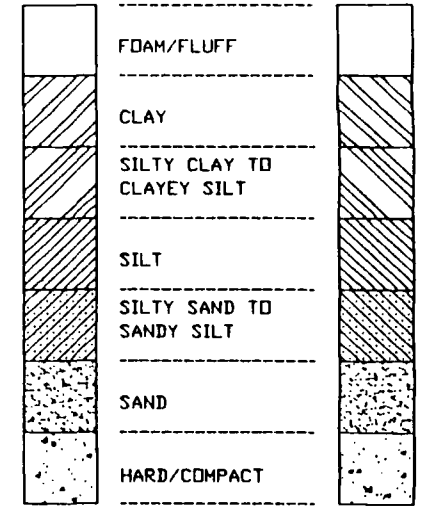


SAND/GRAVEL

NO POLLUTION

NON CONSOLIDATED MATERIALS

CONSOLIDATED MATERIALS

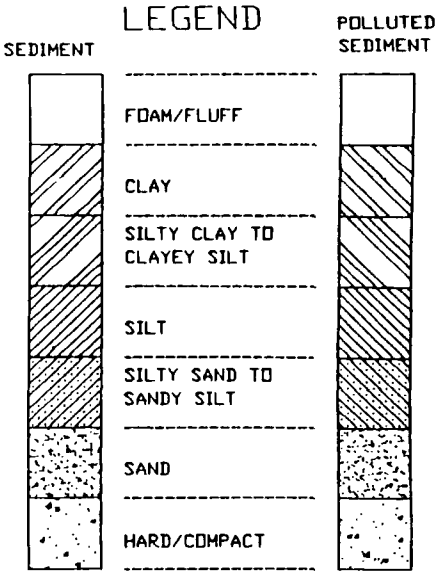


CAULFIELD ENGINEERING		
CORE 14 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CR14		

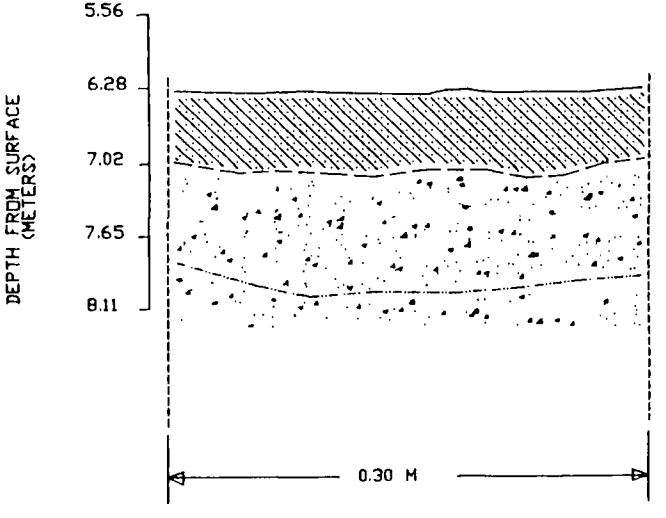
Ref. File: BCR10060

B3-11

OBSERVATION	CORE 15
NORTHING	72928.5
EASTING	4098735.6
CORE LENGTH	0.58 M
DENSITY	1.45 g/cm^3
BOT. LOSS	12.8 db
AMPL. DECAY	0.789
+ PERCENT.	32.47



CORE 15



Ref. File: BRC20014

CAULFIELD ENGINEERING

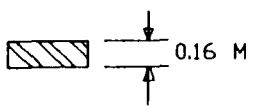
CORE 15 - SUMMARY SHEET

JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/28/96	REV:
	SHEET	

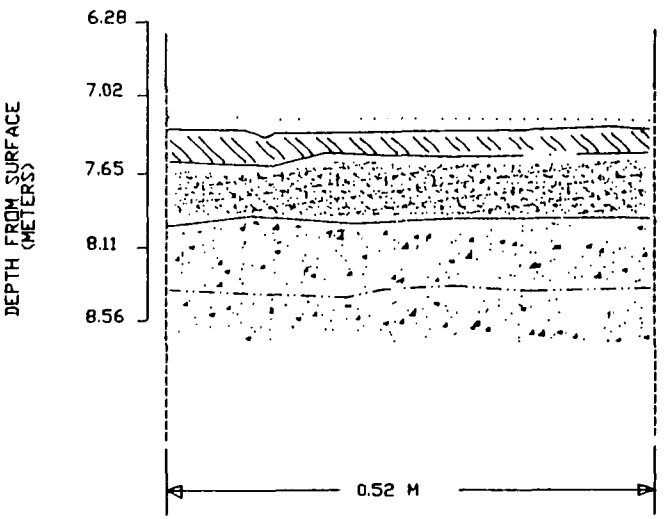
DWG. NO. 2060-CR15

B3-12

OBSERVATION	CORE 16
NORTHING	72918.5
EASTING	4098738.2
CORE LENGTH	0.16 M
DENSITY	1.22 g/cm^3
BOT. LOSS	12.60 db
AMPL. DECAY	0.716
+ PERCENT.	66.14



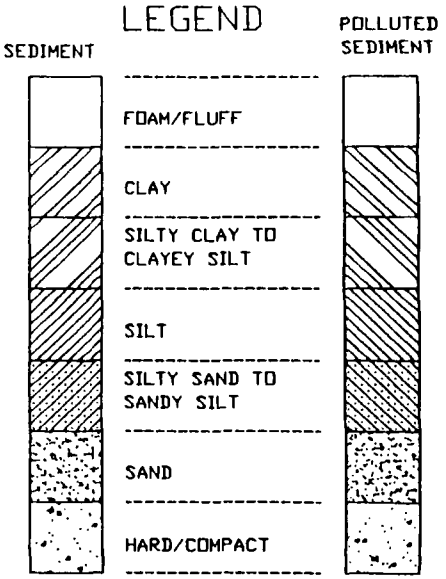
CORE 16



POLLUTION WITH FLUFF

NO POLLUTION - ADDITIONAL ROCKS

NON CONSOLIDATED

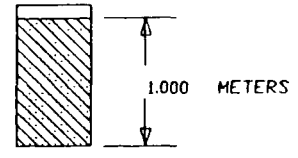


CAULFIELD ENGINEERING		
CORE 16 - SUMMARY SHEET		
JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/26/96	REV:
	SHEET	
DWG. NO. 2060-CORE16		

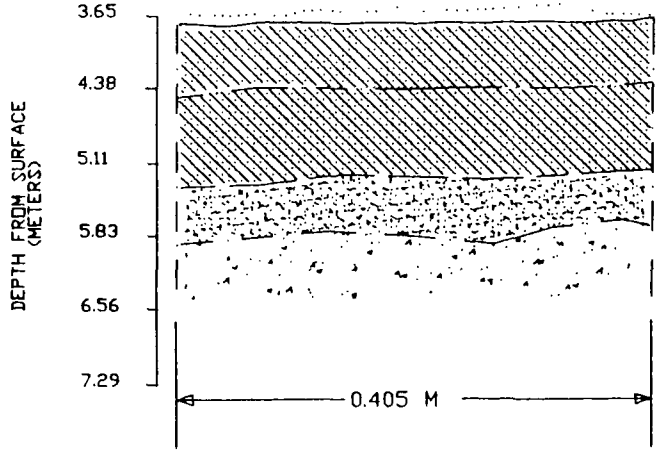
Ref File: BRC20030

B3-13

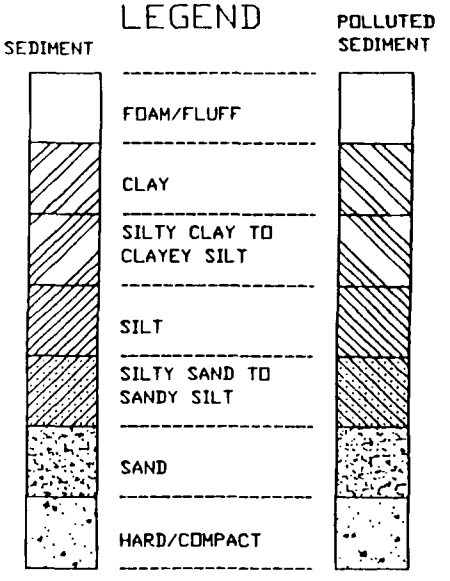
OBSERVATION	CORE 17	CORE 18
NORTHING	72943.2	72942.2
EASTING	4098816.7	4098815.5
CORE LENGTH	0.90 M	0.97 M
DENSITY	1.40 g/cm^3	1.53 g/cm^3
BOT. LOSS	6.578 db	6.578 db
AMPL. DECAY	0.265	0.265
+ PERCENT.	44.58	44.58



CORE 17/18



POLLUTION FACTOR HIGH



CAULFIELD ENGINEERING

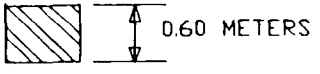
CORE 17/18 SUMMARY SHEET

JOB: 2060		SCALE
DRN BY: DDC	DATE: 2/25/96	REV:
	SHEET	

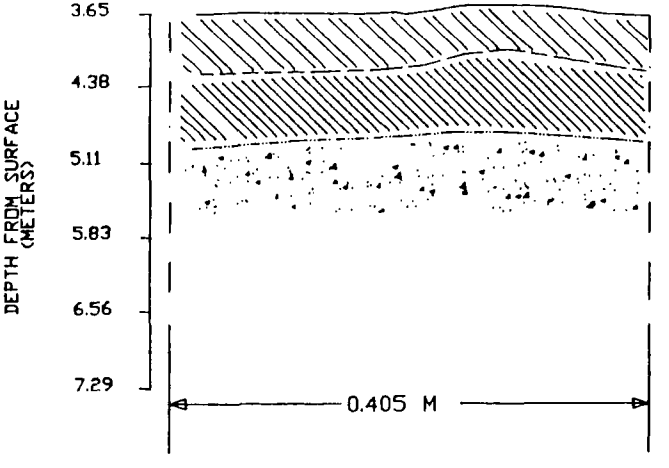
DWG. NO. 2060-CR17/18

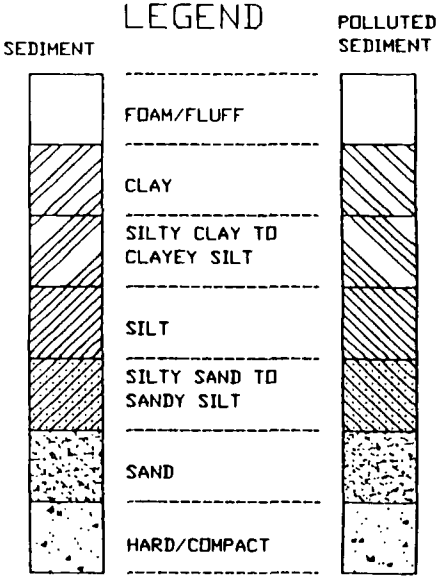
B3-14

OBSERVATION	CORE 19
NORTHING	72988.4
EASTING	4098726.4
CORE LENGTH	0.60 M
DENSITY	1.20 g/cm^3
BOT. LOSS	5.11 db
AMPL. DECAY	0.207
+ PERCENT.	31.98



CORE 19





CAULFIELD ENGINEERING

CORE 19 - SUMMARY SHEET

JOB: 2060		SCALE
DRN BY: DDC	DATE: 3/18/96	REV:
	SHEET	

DWG. NO. 2060-CORE19

Ref. File: BCR40034

APPENDIX B4

IN FIELD CORE VELOCIMETER DATA

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 5 Page 1

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-10	103.5	103.5	7.3	100			10	811.1111		
		103.5	101.5	7.569016	110			10	756.9016		
		103.5	102	7.452516	60	100		10	1490.503	2484.172	
		103.5	102.5	7.368175	80			10	1052.596		
		103.5	104	7.317103	mov->	140		10		1688.562	
		103.5	105	7.452516	90	160		10	931.5645	1490.503	
		103.5	106	7.716217	mov->	145		10		1714.715	
		103.5	107	8.095678	mov->	144		10		1812.465	
							Mean velocity			1423.309	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	5	89	89	7.3	36	96	160	10	2807.692	2546.512	2433.333
		89	90	7.368175	60	100	176	10	1473.635	2456.058	2219.33
		89	91	7.569016	36	100	179	10	2911.16	2523.005	2239.354
		89	89	7.3	36	108	160	10	2807.692	2234.694	2433.333
		87.5	90	7.716217	36	96		10	2967.776	2691.703	
							Mean Velocity			2481.806	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 5 Page 2

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Sediment	35	65.5	64	7.452516		176		10			
		65.5	63.5	7.569016	150	180		10	540.644	1335.709	
		65.5	63	7.716217	170	210		10	482.2635		
		65.5	62.5	7.892401	140	180		10		1392.777	
		65.5	68.5	7.892401	170	210		10	493.2751	1183.86	
		65.5	66	7.317103	135	240		10		954.4048	
		65.5	65.5	7.3	150	205		10		1123.077	
							Mean velocity			938.2512	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	60	33	32	7.368175	100	195		10	818.6861	1194.839	
		33	34	7.368175		160		10		1473.635	
		33	35.3	7.653757		200		10		1208.488	
							Mean Velocity			1173.912	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
							Core Mean Velocity			1531.321	

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 6 Page 1

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.18
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Sediment	30	71.5	71.5	7.3	mov->	144		10		1634.328	
		71.5	73	7.452516	mov->	136		10		1774.409	
		71.5	73	7.452516	mov->	140		10		1719.811	
		71.5	74	7.716217	mov->	152		10		1630.187	
		71.5	70.7	7.343705	mov->	142		10		1669.024	
		71.5	70	7.452516		168		10		1415.035	
		71.5	69.5	7.569016	mov->	164	250	10		1474.484	1576.878
							Mean velocity			1796.08	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	10	89	87.8	7.397973		160		10		1479.595	
		89	89	7.3		164		10		1422.078	
							Mean Velocity			1450.836	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
							Core Mean Velocity			1623.458	

B4-4

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 7 Page 1

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.39
Core Material: Silt/Clay

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	From Core Bot. Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-10	93.8	93	7.343705	88			10	941.5006		
& Fluff		92	94.7	7.783315	96			10	905.0367		
		92	92.5	7.317103	92			10	892.3297		
		92	91	7.368175	92			10	898.5579		
		92	89.8	7.624303	100			10	847.1448		
		92	86.7	9.021086	120			10	820.0988		
		92	97.8	9.323626	108			10	951.3904		
							Mean velocity			893.7227	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	5	81	82	7.368175	72	112		10	1188.415	2167.11	
		81	79.9	7.382412	110	210		10	738.2412	1107.362	
		81	79.4	7.473286	70	144		10	1245.548	1673.124	
		81	78.3	7.783315	mov->	140		10		1796.15	
							Mean Velocity			1416.564	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********

B4-5

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 7 Page 2

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.39
Core Material: Silt/Clay

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Sediment	20	65	64	7.368175	68	128		10	1270.375	1873.265	
		65	64.7	7.306162	60	144		10	1461.232	1635.708	
		65	67.8	7.818568	72	mov->	250	10	1261.059		1628.868
		65	63.1	7.543209	mov->	138	180	10		1767.94	2218.591
							Mean velocity			1639.63	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	40	40	36.7	8.011242	60			10	1602.248		
		40	39	7.368175	60	112		10	1473.635	2167.11	
							Mean Velocity			1747.665	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	55	19	21	7.569016	50	80		10	1892.254	3243.864	
							Mean Velocity			2568.059	
							Core Mean Velocity			1842.978	
					Core Mean Velocity Without Last Layer					1601.285	

B4-6

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 10 Page 1

POLLUTION FACTOR: 5
Sample Diameter: 0.073

Core Dens ity: 1.53
Core Material: Silty/Sand

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-15	50	50	7.3	93			10	879.5181		
Some		50	52.2	7.624303	101	104		10	837.8355	2433.288	
Fluff		50	48.1	7.543209		190		10		1257.201	
							Mean velocity			1351.961	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	8	29.4	30.1	7.333485	52	94		10	1746.068	2619.102	
		29.4	26.2	7.970571	56	160		10	1732.733	1594.114	
		29.4	31	7.473286	52	94		10	1779.354	2669.031	
		25	27.5	7.716217	48	96		10	2030.583	2691.703	
		25	25	7.3	42	98		10	2281.25	2488.636	
							Mean Velocity			2163.257	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	20	13	15	7.569016	48	150		10	1991.846	1621.932	
		13	12.5	7.317103	42	98		10	2286.595	2494.467	
							Mean Velocity			2098.71	
							Core Mean Velocity			2130.984	

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 12 Page 1

POLLUTION FACTOR: 7
Sample Diameter: 0.073

Core Dens ity: 1.23
Core Material: Clay/Tr. Gravel

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-10	61	60	7.368175	93			10	887.7319		
+ Chalk		61	62.8	7.518643	96			10	874.2609		
Material		61	59.5	7.452516	92			10	908.8435		
		61	57.8	7.970571		104		10		2543.799	
								Mean Velocity		1303.659	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	22	42	42.5	7.317103	96			10	850.826		
		42	42	7.3		120		10		1990.909	
		42	40.5	7.452516		100		10		2484.172	
		42	39	7.892401		120		10		2152.473	
							Mean Velocity			1869.595	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	42	22	20.5	7.452516		120		10		2032.504	
		22	22	7.3		120		10		1990.909	
							Mean Velocity			2011.707	
							Core Mean Velocity			1940.651	

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 18 Page 1

POLLUTION FACTOR: 9
Sample Diameter: 0.073

Core Dens ity: 1.53
Core Material: Sandy/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-10	81.3	82	7.333485	100	104		10	814.8316	2340.474	
+ Chalk		81.3	83	7.495332	100	130		10	832.8147	1873.833	
Material		81.3	79	7.653757		130		10			
		81.3	81.4	7.300685	96			10	848.9168		
								Mean Velocity		1342.174	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	28	66.6	66.2	7.310951	88	90		10	937.3014	2741.607	
		66.6	65.2	7.433034	94	120		10	884.885	2027.191	
		66.6	64.2	7.6844	96			10	893.5349		
							Mean Velocity			1496.904	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	66	26.7	26.7	7.3	96	145		10	848.8372	1622.222	
		26.7	26	7.333485	95	175		10	862.7629	1333.361	
		26.7	23	8.184131		100		10		2728.044	
							Mean Velocity			1479.045	
							Core Mean Velocity			1487.975	

ESTIMATED IN FIELD CORE VELOCITY ANALYSIS

CORE NO: 19 Page 1

POLLUTION FACTOR: 10
Sample Diameter: 0.073

Core Dens ity: 1.2
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Est. Depth Below Bot cm.	From Core Bot. Xmit Position cm.	Receiver Position cm.	Distance Xmt-Rec. cm.	1st Arr. Delta T micro-sec.	2nd Arr. Delta T micro-sec	3rd Arr. Delta T micro-sec	System Offset micro-sec	1st Arr. Velocity m/sec	2nd Arr. Velocity m/sec	3rd Arr. Velocity m/sec
Water	-8	53	53.1	7.300685	94	140		10	869.1292	1684.773	
		53	53.6	7.324616	98	140		10	832.3427	1690.296	
		53	54.1	7.382412	98	136		10	838.9104	1757.717	
		53	52.2	7.343705	94	140		10	874.2506	1694.701	
								Mean Velocity		1280.265	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	5	38.5	41.7	7.970571	92	170		10	972.0208	1494.482	
		38.5	39	7.317103	92	150		10	892.3297	1567.951	
		38.5	37	7.452516	96	150		10	866.5717	1596.968	
							Mean Velocity			1231.72	
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Sediment	25	20.5	20.6	7.300685	102	140		10	793.5527	1684.773	
		20.6	19.5	7.382412	102	150		10	802.436	1581.945	
		20.6	18.5	7.596052	108	124		10	775.1073	1998.961	
							Mean Velocity			1272.796	
							Core Mean Velocity			1252.258	

APPENDIX B5

IN FIELD CORE ABSORPTION DATA

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 5

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-10	630	66	5	13.9	52.1	0	0
Sediment	5	1500	83.4	3.75	11.5	71.9	19.8	271.2329
Sediment	30	1500	83.4	3.25	10.2	73.2	21.1	289.0411
Sediment	33	1700	84	4.6	13.3	70.7	18.6	254.7945
Sediment	60	1500	83.4	1	0	83.4	31.3	428.7671

Mean Loss 22.7

Mean Absorption/Meter 310.9589

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 6

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.29
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	from core 5	630	66	5	13.9	52.1	0	0
Sediment	30	1500	83.4	3.5	10.8	72.6	20.5	280.8219
Sediment	10	1400	82.9	5	13.9	69	16.9	231.5068

Mean Loss 18.7

Mean Absorption/Meter 256.1644

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 7

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.39
Core Material: Silt/Clay

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-10	900	74.9	5	13.9	61	0	0
Sediment	5	1730	84.3	3	9.5	74.8	13.8	189.0411
Sediment	20	1730	84.3	2	6	78.3	17.3	236.9863
Sediment	44	1730	84.3	0.8	-1.9	86.2	25.2	345.2055
Sediment	60	1730	84.3	0.3	-10.5	94.75	33.75	462.3288

Mean Loss 22.5125

Mean Absorption/Meter 308.3904

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 10

POLLUTION FACTOR 5
Sample Diamter: 0.073 meters

Core Density: 1.53
Core Material: Silty/Sand

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-11	630	66	5	13.9	52.1	0	0
Sediment	9	1300	82.5	4	12.04	70.46	18.36	251.5068
Sediment	24	1300	82.5	2	6	76.5	24.4	334.2466

Mean Loss 21.38

Mean Absorption/Meter 292.8767

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 12

POLLUTION FACTOR 7

Sample Diamter: 0.073 meters

Core Density: 1.23

Core Material: Clay/Tr Gravel

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-6	730	72	4.5	13.06	58.94	0	0
Sediment	22	1700	84.3	2	6	78.3	19.36	265.2055
Sediment	42	1700	84.3	0.1	-20	104.3	45.36	621.3699

Mean Loss 32.36

Mean Absorption/Meter 443.2877

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 18

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.53
Core Material: Sandy/Silt

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-10	730	75	5	13.9	61.1	0	0
Sediment	10	1730	84.3	2	6	78.3	17.2	235.6164
Sediment	20	1730	84.3	0.56	-4.9	89.2	28.1	384.9315
Sediment	45	1730	84.3	0.1	-20	104.3	43.2	591.7808

Mean Loss 29.5

Mean Absorption/Meter 404.1096

CORE RELATIVE ABSORPTION ANALYSIS

CORE NO: 19

POLLUTION FACTOR 10
Sample Diamter: 0.073 meters

Core Density: 1.2
Core Material: Clay/Silt

Frequency - 330 KHz

Material	Depth Below Bot. cm.	Gain Setting hrs.	Gain Level db	Signal Level volts	Signal db	Level Cor. 1 volt db	Normalized Relative To Water db	Absorp. db/meter
Water	-10	1130	80	5	13.9	66.1	0	0
Sediment	5	1730	84.3	2.5	7.9	76.4	10.3	141.0959
Sediment	15	1730	84.3	0.15	-16.4	100.7	34.6	473.9726
Sediment	28	1730	84.3	0.1	-20	104.3	38.2	523.2877

Mean Loss 27.7

Mean Absorption/Meter 379.4521

FINAL REPORT
MICRO SURVEY - ACOUSTIC CORE AND PHYSICAL CORE INTER - RELATIONS WITH SPATIAL VARIATION, TRENTON CHANNEL OF THE DETROIT RIVER
VOLUME III
NORMAL AND CONTAMINATED SEDIMENT DISTRIBUTION MAPS

Prepared

June 25, 1997

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PREFACE

This document is Volume III of a series of reports on portions of the Detroit River's Trenton Channel sediment distribution. The previous volumes covered the following:

- Volume I Field Data Acquisition and Calibration (Caulfield Engineering, December 30, 1995). This report summarizes field acquisition and calibration procedures.

- Volume II - Core Analysis and Summary Findings (Caulfield Engineering, March 23, 1996). This report relates the acoustic properties of the sediments to the physical properties of the cores at selected sites.

Volume III provides final outputs identifying depositional sediment layer cross-sections as well as estimated dredging volumes for depositional sediments thicker than 1 meter and as an option, thicker than 0.5 meters. This is done for the two major sites, Black Lagoon and Elizabeth Park. Also provided are bathymetric contours and depositional sediment thickness contours. A critical result of this study shows that some depositional sediments are very thin, less than 0.5 meters, and bounded by rocks and sand. These layers may be too thin to dredge and are not included in the volume estimates.

Because of the spatial variation and contaminated nature of the sediments, and the many thin layers found, new special analysis techniques were required. This volume summarizes these new analysis techniques necessary to extract information regarding the nature and distribution of the sediment.

The overall mapping and analysis program was carried out under the supervision of Darla McVan and Terry Waller, Hydraulic Analysis Branch (HAB), of the Hydraulic Structure Division (HSD) of the Waterways Experimental Station, U.S. Army Corps of Engineers, Vicksburg, MS. This project was a cooperative effort with the U.S. Environmental Protection Agency, Mid-Continental Ecology Division-Duluth, Community Based Science Support Staff, Grosse Ile, MI. John Filkins provided technical review and guidance for the USEPA.

1.0 INTRODUCTION

1.1 Background

Significant deposits of contaminated sediment occur in many waterways near urban centers, including those of the Great Lakes basin. Some of these deposits have accumulated for decades and reflect historic loadings of pollution from cities, industry and agricultural runoff. These deposits continue to contaminate benthic and pelagic organisms through various transport and fate processes. The removal, treatment and disposal of these contaminants may be extremely costly.

A cost effective and rapid means of mapping the distribution of sediments in harbors and rivers is required to facilitate the remedial decisions facing environmental managers. Models are being developed to predict the potential for sediment erosion in harbors and rivers. An accurate prediction of sediment resuspension by these models requires accurate mapping of sediments.

Both the Army Corps of Engineers/Water Ways Experimental Station (USACE-WES) and the U.S. Environmental Protection Agency/Office of Research and Development/Mid-Continent Ecology Division/Community Based Science Support Staff (USEPA/MED/CBSSS) have research interest in mapping sediment in harbors and rivers by acoustic profiling. In 1994 the Great Lakes National Program Office, The Michigan Department of Natural Resources and USEPA/MED/CBSSS conducted a sediment survey by contract with Caulfield Engineering using the Acoustic Core© system. The survey of the Detroit River's Trenton Channel demonstrated that the Acoustic Core© system has the potential for mapping the sediment in harbors and rivers of the Great Lakes. The 1994 survey results identified high spatial variance in sediment distribution and possible gas content in these sediments. The acoustic method required optimization for use in shallow water (2ft to 30 ft) and areas which exhibit a high degree of sediment spatial variability.

The USEPA requested that USACE-WES optimize the Acoustic Core© system. Two sites in the Trenton Channel, Elizabeth Park and Black Lagoon, were selected for micro-surveys to demonstrate the Acoustic Core© system and to confirm the 1994 observations. The request required survey grids of very closely (5-10 meters) spaced observation lines with high ping repetition rates. In addition, ground truth piston cores were to be taken at calibration sites and other sites of interest. The data were to be acquired and processed with the Caulfield Engineering Acoustic Core suite of software.

Final project outputs were to include identification of the location and volume of depositional sediment, survey line cross section plots of horizontal and vertical sediment distribution by density group, and to specify the acoustic properties of the possible contaminated sediments.

Volume I of this report summarizes the field acquisition and system calibration procedures, and Volume II of this report provides the relationship of the sediment's acoustic properties and the properties to the cores taken at selected sites. Volume III provides final outputs identifying sediment layer cross-sections, surface contour plots and estimated dredging volumes for the thicker sediment layers.

The standard Acoustic Core© analysis software (AC60) which predicts acoustic impedance was inadequate to delineate the differences between hard packed sediments and possible contaminated sediments. New analysis procedures and software, Windows-based Calibration and Acoustic Core Reflection/Sign, were necessary to identify the differences. This report will summarize the procedures used in identifying the layering. Final results closely match the piston cores taken by Caulfield Engineering and the earlier vibra-cores taken by the USEPA.

The high spatial variation was also confirmed and is illustrated in the accompanying cross-section drawings. Detailed discussion is provided on both the analysis procedures and the spatial variance problems.

1.2 Site Overview

The Detroit River has been identified by the International Joint Commission as an Area of Concern due to a number of water quality problems, including contaminated sediments and degraded benthic communities. In addition, the river is also listed under the Michigan Environmental Response Act (P.A. 307, 1982 as amended) due to contaminated sediments.

Sediment studies conducted under the Upper Great Lakes Connecting Channels Study (USEPA and EC, 1988) and other research activities, documented sediments contaminated with metals, PCBs, and oil and grease (Farara and Burt, 1993) in multiple locations in the Detroit River and Trenton Channel. Impaired uses relating to contaminated sediments, as identified in the Detroit River Stage 1 Remedial Action Plan (MDEQ, 1987), include restrictions on dredging activities, degraded benthic communities, exceeding Michigan Water Quality Criteria for fish consumption advisories, and increased incidence of fish tumors.

The Trenton Channel is located in the lower Detroit River between Grosse Ile and the Michigan mainland, Plate 33. It is approximately nine miles in length and carries 21 percent of the total river flow, with an average velocity of 1.08 to 1.9 ft/sec. The Detroit River and Trenton Channel, a heavily industrialized area and a major navigation route,

has been identified as severely degraded in terms of water and sediment quality and benthic communities (USEPA and EC, 1988). Numerous point sources in the area include steel plants, waste water treatment plants and chemical and automotive manufacturing industries. Concentration of arsenic, nickel, PCBs, and oil and grease in Trenton Channel sediments have been found to exceed the recommended guidelines for sediments (Long and Morgan, 1990; Persaud et al., 1993). Data from various sediment Toxicity tests conducted showed sever impacts compared to other Detroit River locations and reference stations for a number of biota tested (Giesy et al., 1988).

1.3 Project Objectives

The primary objective of the USEPA-USACE-Caulfield Engineering effort was the acquisition of micro-survey data using the Acoustic Core© System and the processing and analysis of selected results and sites to determine what the sediment stratigraphy in near shore areas of the Trenton Channel. Two specific sites were chosen to demonstrate soft sediment mapping, allowing the calculation of volume estimates. Volume III provides the cross-sectional plots for these data, maps identifying surficial sediment deposition by density group and contours of sediment thickness with estimates of depositional sediment volumes. Volume II of this series of reports provided the geo-acoustic relationships with the core data.

This project uses the Acoustic Core© suite of software to identify and map the gross distribution of these sediments as presented in this report. Piston core data is required to calibrate the acoustic process. It is important to note that the exact relationship of engineering geo-acoustic properties of the sediments to the various types of pollutants is not known. It is only known that pollutants and or micro-gas bubbles contained in sediment may change the acoustic properties, and in some cases radically, from standard marine sediments. Volume II has shown that as the gross contaminants (observed from the chemical analysis of the USEPA vibra-cores collected in 1994) increase, the deviation of the bottom loss for similar non-contaminated marine sediments also increases.

The tasks listed in the interagency agreement between EPA and ACOE included:

> Optimize the Acoustic Corer for use mapping, in shallow water (2ft-30ft), where sediments exhibit a high degree of heterogeneity .

> Demonstrate the accuracy of the Acoustic Corer to characterize sediment type and map the distribution of sediment type at depth. The demonstration should take place at three sites (shallow, medium and deeper water depths) in the Trenton Channel, Detroit River.

> Collect and conduct the necessary geophysical characterization of sediment cores needed for calibration and validation of the acoustic corer.

> At the demonstration sites, provide mapping of the distribution of the soft sediment.

> Provide a written report on the Acoustic Corer Optimization, describing the rational, approach and results.

> Provide a survey report on the demonstration site surveys. This report is to include:

1. A description of the Acoustic Corer and the fundamentals of operation
2. The survey design
3. Results of the survey
4. Graphical mapping of the sediment distribution for each site
5. A calculation of the volume of soft sediment at each site

All requests summarized were met. Because of some boat logistics problems during data acquisition, data formatting of the final results in GIS type ASCII formats was impossible under the project scope. However, all Auto-Cad, Matlab, and Acoustic Core Reflection/Sign files were supplied.

Without the detailed quality assurance program carried out during the field exercises this project would not have succeeded. The quality assurance program enabled absolute calibrations of the sound sources, which in turn allowed for the quantitative identification of the sediment types.

2.0 DATA INTERPRETATION PROCEDURES - LAYER SELECTION

Due to the many unique aspects of the sediment found in the study sites as well as operational problems encountered with the survey vessel, data interpretation procedures required significant manual participation in application of the Acoustic Core sediment identification programs. These unique aspects and problems are summarized as follows:

- Acoustic Impedance (Appendix A3.1) - The acoustic impedance of contaminated sediments is higher than the same non -contaminated sediment. The impedance of severely contaminated clays is approximately the same as sand. This means that the material identification with impedance alone (the standard Acoustic Core AC50/60 program) will not work in contaminated sediments.

- Spatial Variability - In normal marine sediments, the horizontal spatial variation is usually measured in tens of meters (McGee et al., 1995, Figure 45). However in this riverine site, the contaminated sediment structures exhibited horizontal spatial variation measured in meters. An entirely new method to handle computation of bottom loss (impedance) and the signal properties on a trace-by-trace basis rather than a subfile basis was needed. Two new Windows-based programs were developed by Caulfield Engineering to handle these variations. They are the CAL1 (Expanded Calibration Routine, Appendix A3.5) and the ACRS1 (Acoustic Core Reflection/Sign routine, Appendix A3.6). The application of these programs to the generation of cross-sections is covered in this report. Minor problems occurred with the ship handling during data acquisition. These problems prevented full integration of navigation data with the seismic files, causing extensive manual data collation to tie these sets of data together during data reduction. Also, steering difficulties prevented the survey lines from overlapping properly, which necessitated further manual review of the data to compare the results from the different seismic frequencies. Detailed processing corrected for all ship handling effects on data variability.

- Large Variation in Sediment Layer Thickness - In both survey sites, the layer thickness varied from tenths of meters (0.1m) to several meters (2.0 m). High frequency pingers were required for the thin layers and a low frequency boomer was necessary to penetrate the highly sound absorbing contaminated/gas containing sediment layers. Center sound source

frequencies used were 700 Hz (Boomer), 3500 Hz and 7000 Hz (ORE Pinger). At 7000 Hz, the ping length was longer in time than the acoustic travel time for the layer thickness of the very thin layers, which prevents these very thin sediment layers from being easily resolved. In such cases manual layer identification was required, as outlined in Appendix A3.8. The procedures used are discussed in this report.

- Hard Pan Characteristics - Glacial till type structures became exposed on the sediment surface when there was no overlying sediment cover. The glacial till was composed of packed sand and varying size rocks. These rocks caused seismic scattering and generated diffraction which added to the spatial variation. These phenomena were identified and separated from the layer data. At this time automated programs do not exist to handle this case and manual interpretation is required.

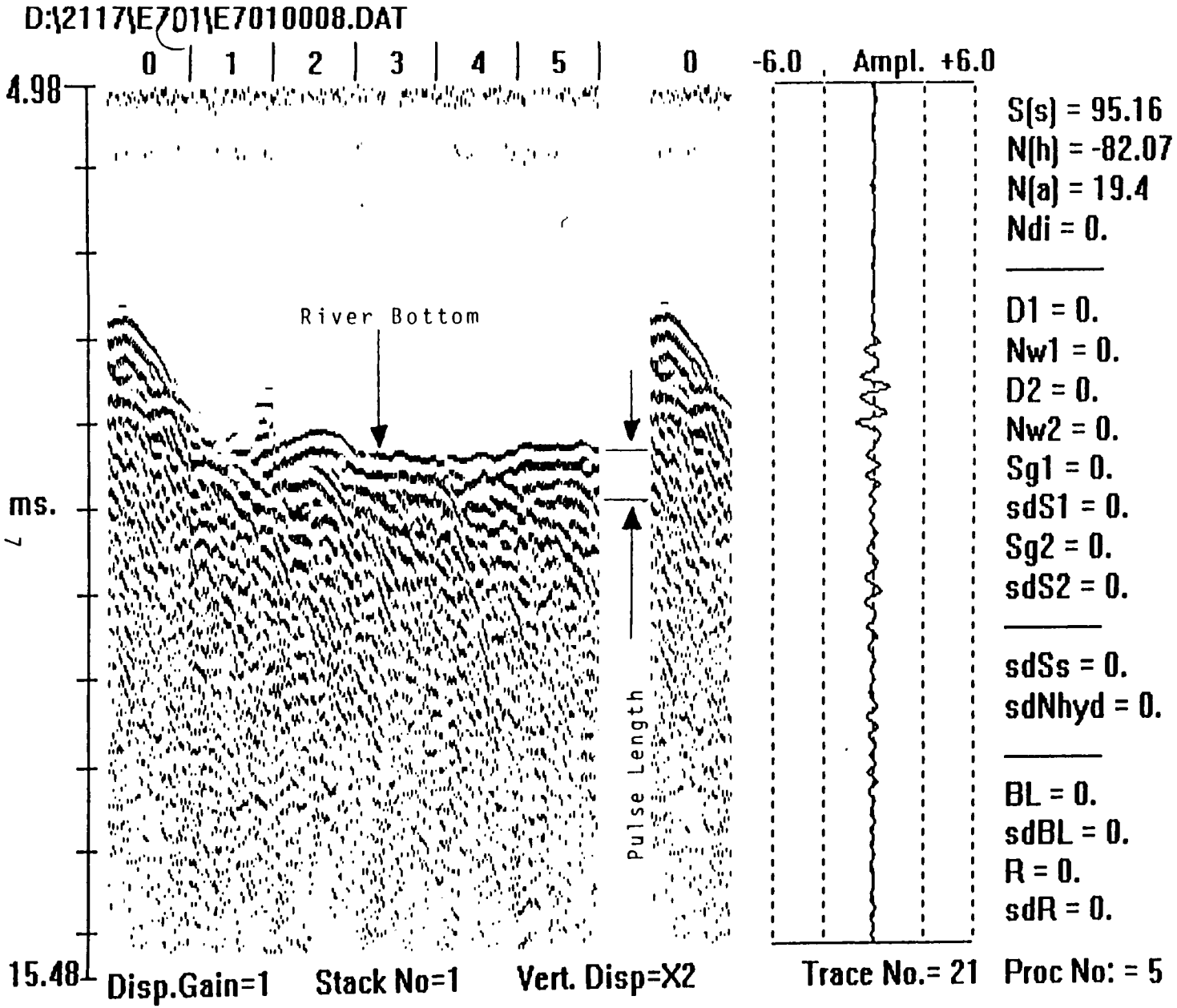
Many of the interpretation techniques used in this work were based on extensions of standard geophysical procedures used in deep seismic interpretation and integrated with the Caulfield Engineering material identification algorithms. With much diligence each problem was identified, addressed, and the results were verified with the calibration procedure and new Acoustic Core routines.

2.1 Layer Identification Steps

The first step in the generation of the area cross-section plots is to pick the major layers. As discussed above, there were several problems associated with identification of these layers. This section delineates the various procedures and phenomena used in isolating the true layers. These procedures overcame all the major problems. For discussion purposes, the 7 KHz data were used. The 3.5 KHz and boomer data were used selectively to confirm deeper layers in high absorptive contaminated areas.

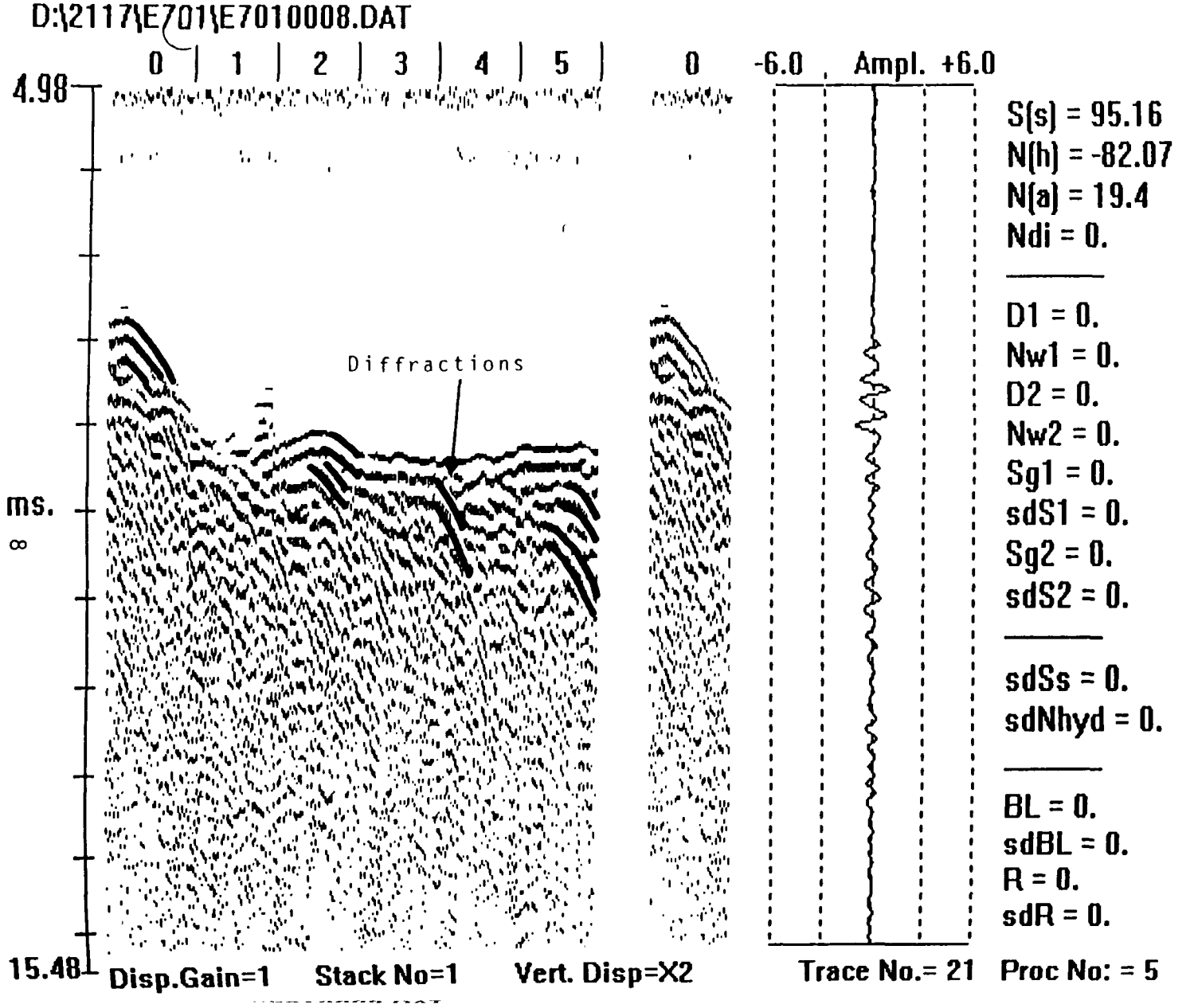
2.1.1 Step 1: Diffractions

Rocks often act as point reflectors and scatter the acoustic energy in all directions. This is shown by "diffraction tails" which show up in the acoustic records. Figure 1 is the CAL1 software display of a data set that has strong diffractions. Refer to Appendix A3.8 for a review of diffraction patterns on seismic cross-sections. Some of these diffractions have been highlighted in Figure 2. Figure 3 highlights further steeply dipping coherent energy diffractions in this acoustic record. This coherent "apparent noise" is due to diffraction tails originating earlier in time. These diffractions are generated because of the beam width of the seismic source receiver combination coupled with the forward motion of the boat. These diffractions, if there are many rock scatters, forms this apparent noise chatter in the seismic cross-section. With many rocks one has overlapping diffractions patterns that generates a noisy looking record. See Appendix A3.8 for a discussion of diffraction.



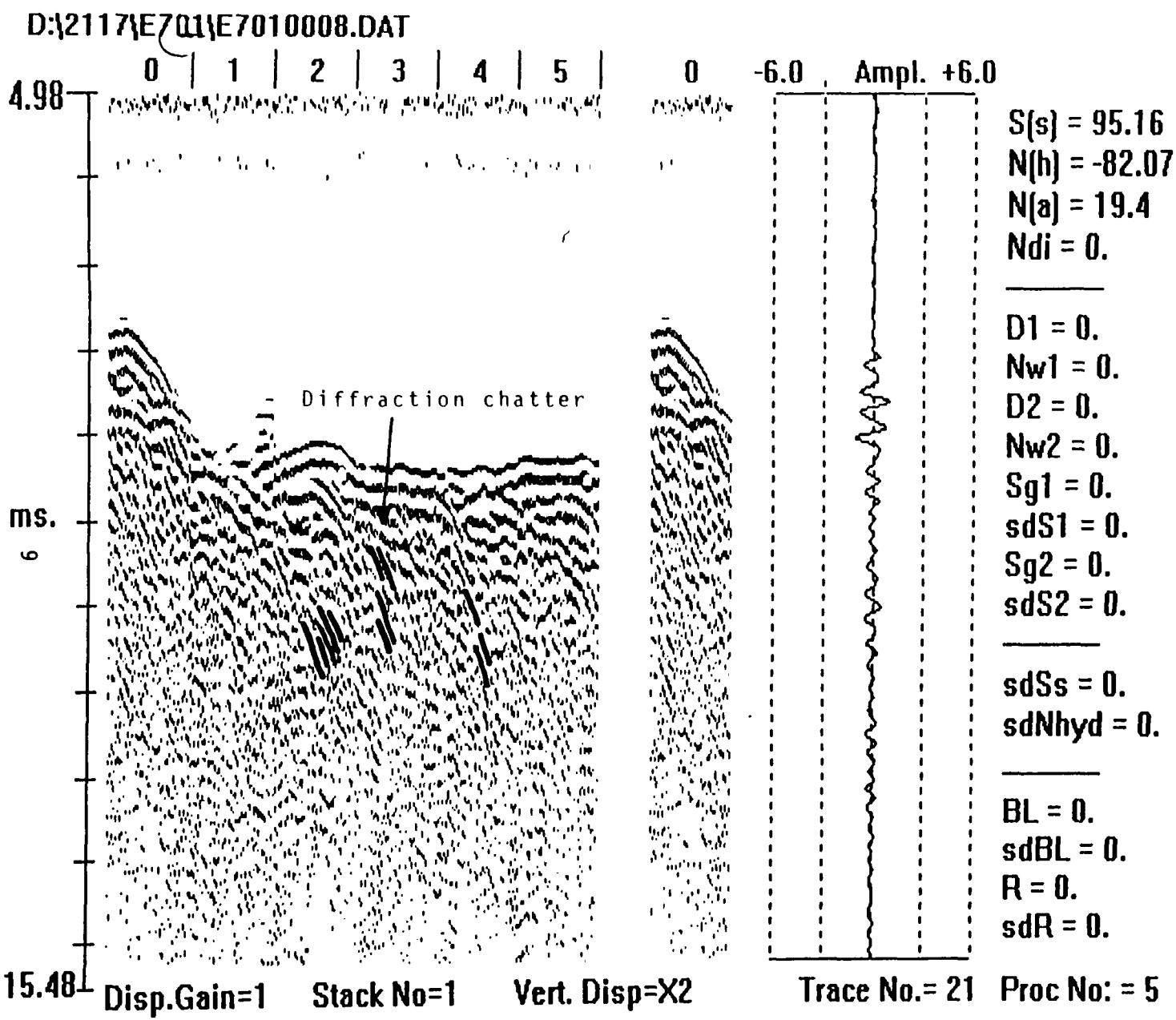
Calibration software output display for region with strong diffractions

Figure 1



Calibration output as for Figure 1
Start of diffractions highligted

Figure 2



Calibration output as for Figure 1 Diffraction chatter highlighted

Figure 3

Figure 4 is the ACRS software "pick" plot display of the same data set. The "pick" plot displays the layers identified through the use of correlation techniques. Appendix A3.6.1 discusses the generation of these "pick" plots. The Bottom Losses (BL), Appendix A3.3, are plotted at the bottom right of the Figure. In the acoustic data, a strong and isolated diffraction is marked and the corresponding severe bottom loss variation is highlighted. Notice the extreme variation in bottom loss of 20 db within a few traces.

The existence of rocks at the surface is indicated by the characteristic parabolic shape of the diffraction and the correspondingly widely varying bottom losses. Further, the lower extent of sediment, the upper surface of the hard pan, can be found by noticing where, in time (time representing depth), the rocks appear.

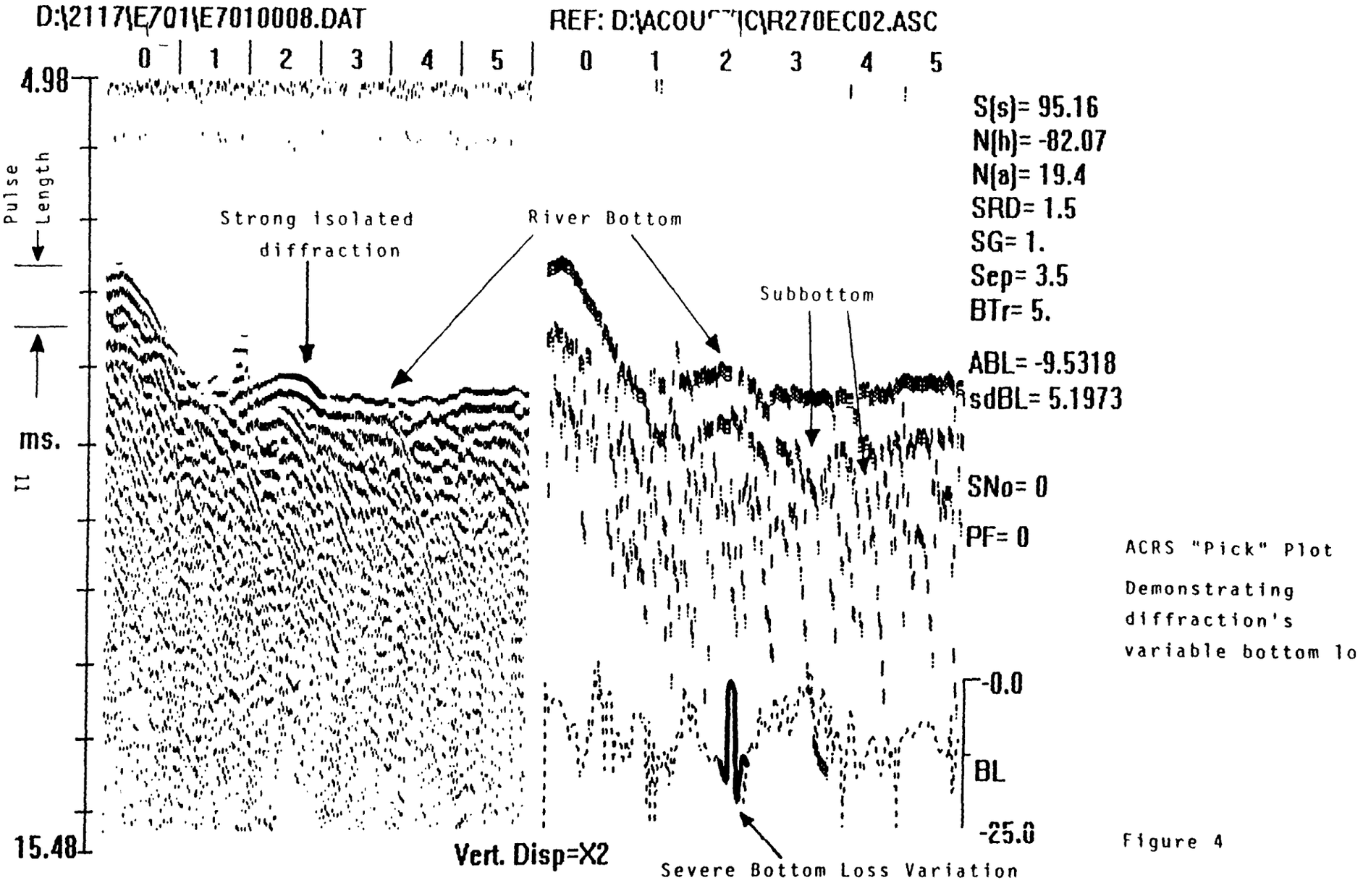
Figure 5 is the CAL1 software plot of the seismic data nearest where Core 9 hit rocks. The acoustic data has been highlighted to show some high lighted interpreted diffractions. Figure 6 is the ACRS software "pick" plot for the same data set which exhibits the severe bottom loss variation indicative of rocks and hard pan. The non-highlighted seismic records can be seen in this figure, for comparison.

While the diffractions on the cross-section display in Figure 5 are much weaker than in Figure 1, they are also more abundant. Interpreting them is more difficult, in part because they interfere with each other, and the diffraction signal tails are weaker than the normal incidence bottom signal. However, the basic diffraction shapes, the deep coherent chatter, and the rapidly varying bottom loss allow identification of the hard pan either on the surface or below the sediment layer.

2.1.2 Step 2: Amplitude Analysis

The envelope of an acoustic trace can be found by rectifying the trace and connecting the peaks of the signal. Appendix A3.8 provides a step by step example for the trace envelope construction. An alternate procedure is taking the value of each positive and negative peak and plotting them on both sides of the trace as shown in Figure 7. The envelope is found by smoothly connecting all the peaks, indicated by a + on the amplitude plot, from both sides of the trace. See Figure 8. Figures 7 and 8 are CAL1 software plots of a simple trace where the only significant reflection is the reflection from the sediment surface (labeled S) and its multiple (labeled M) on Figure 8.

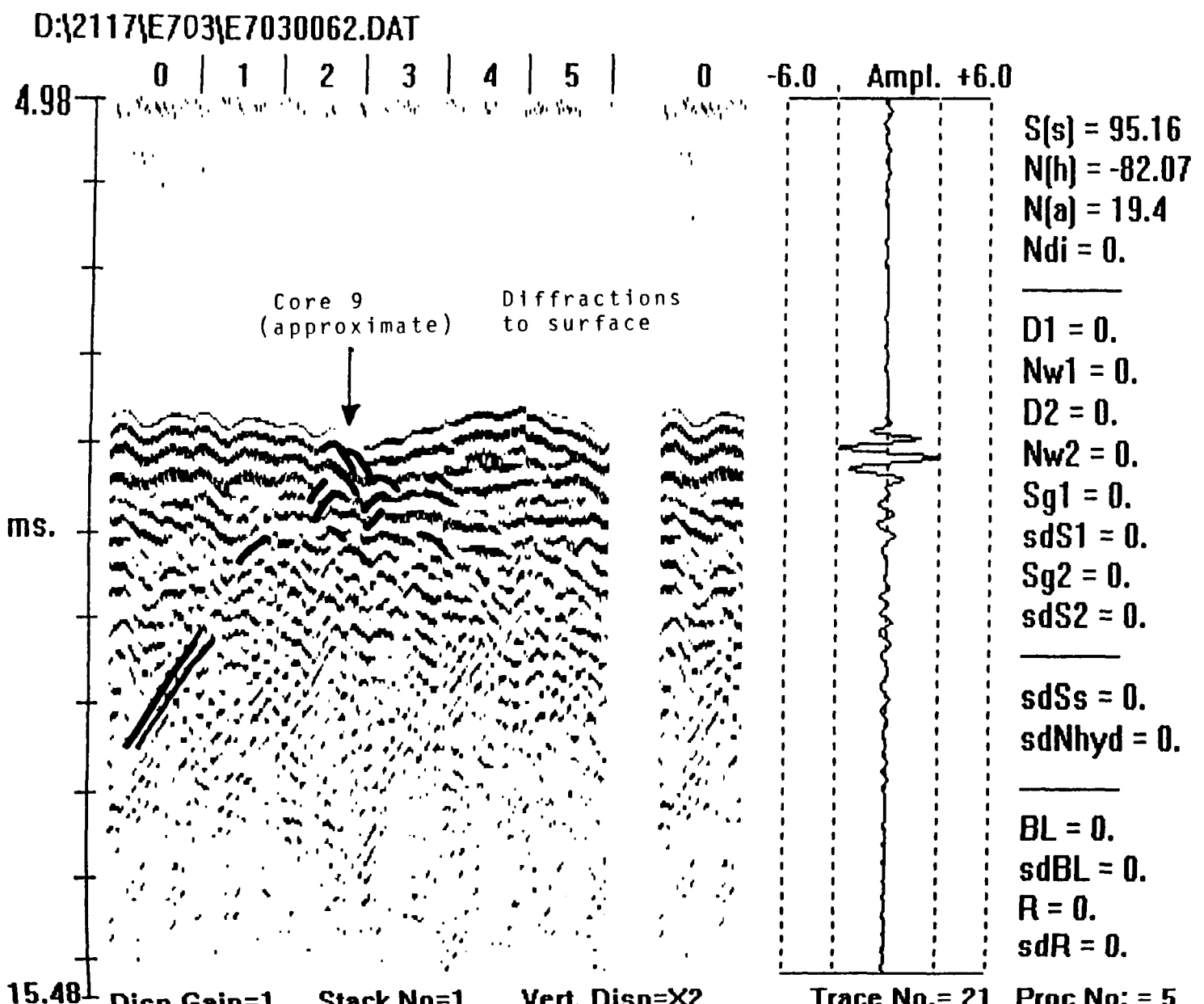
In practice, this is seldom the case. Usually, there is more than one reflection produced by the bottom and sub-bottom layers. Because the source has a narrow band width, the wavelets are relatively long and unable to resolve thin layers. With thin layers there are two significant reflections and the reflections overlap within the acoustical travel time of the source sound wavelet. See Appendix A3.8 Figure A3.8-5. Even though the interference effects complicate determining when the second reflection begins, the layers can be resolved with detailed effort. In future projects it is recommended that



ACRS "Pick" Plot

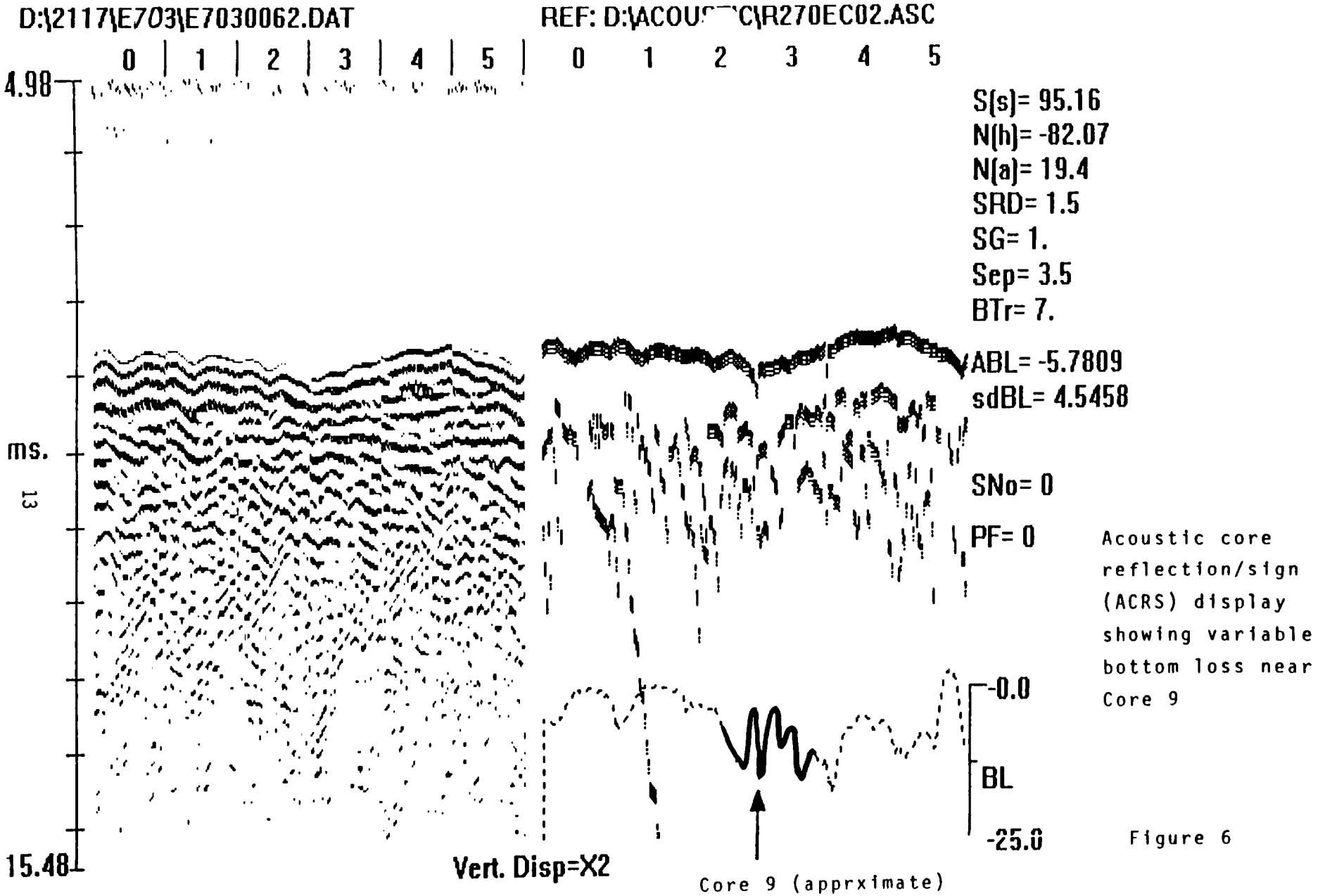
Demonstrating diffraction's variable bottom lo

Figure 4



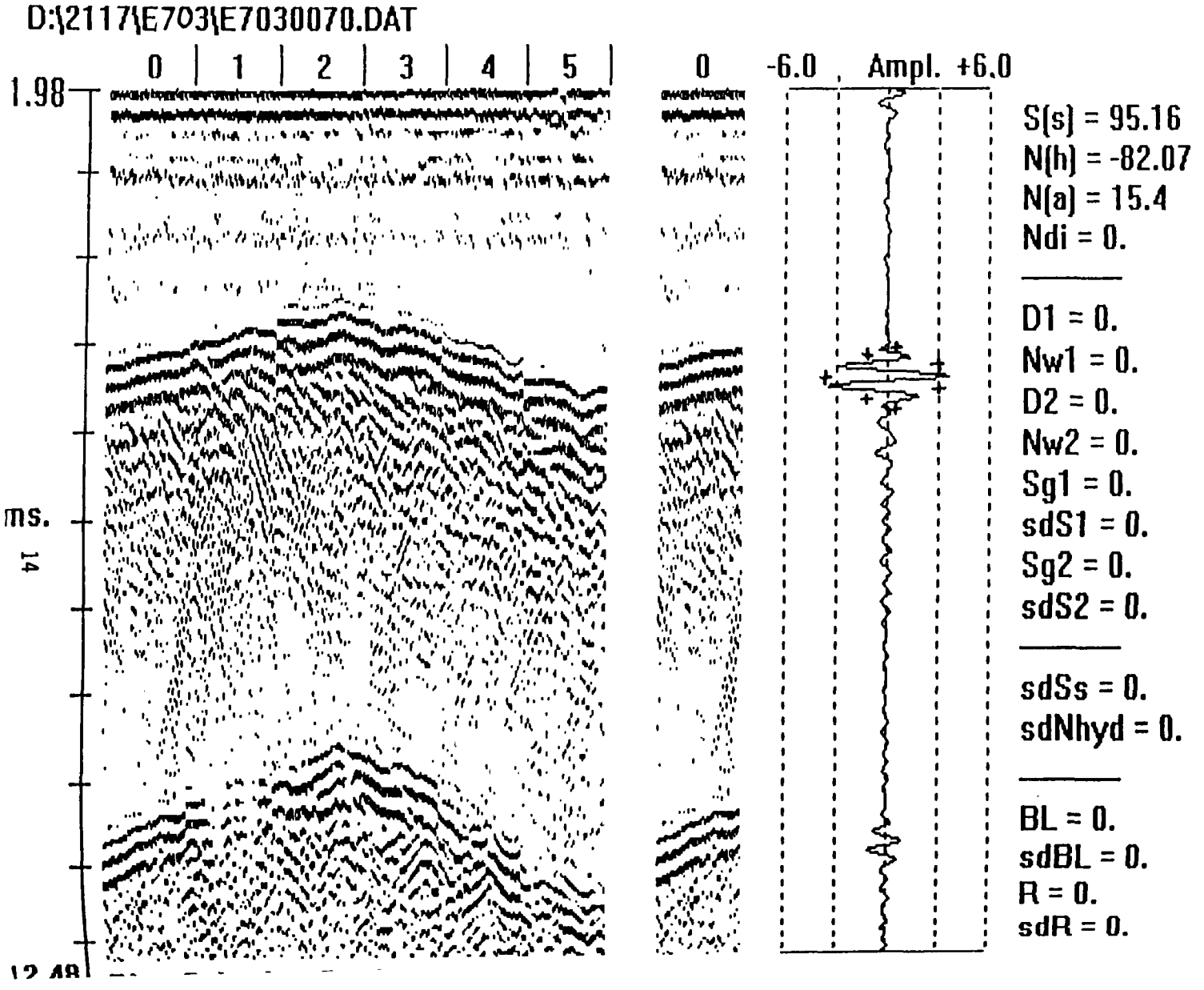
CAL display for production data near Core 9, which hit rocks

Figure 5



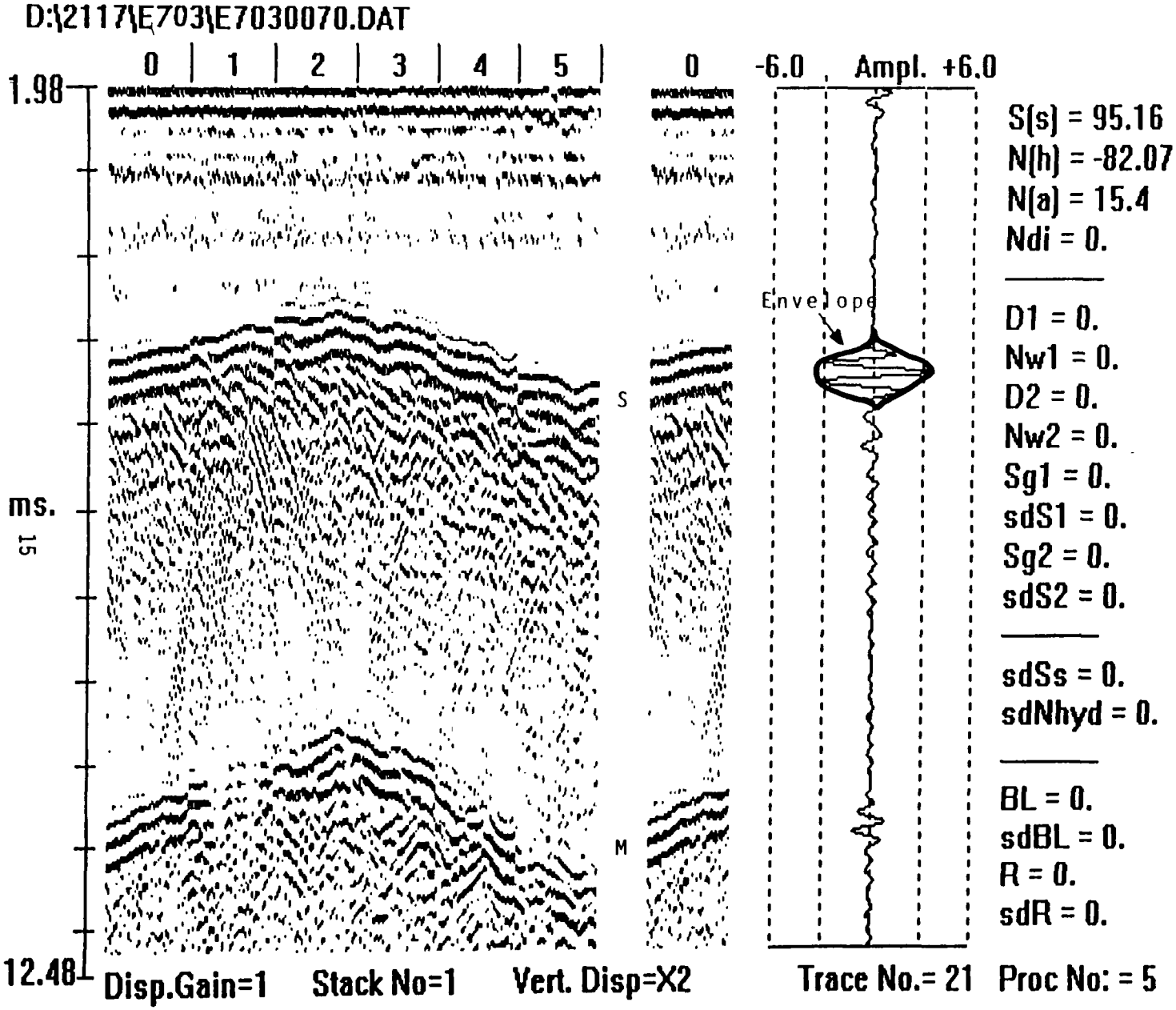
Acoustic core reflection/sign (ACRS) display showing variable bottom loss near Core 9

Figure 6



CAL plot of simple trace

Peaks plotted on both sides of trace



CAL plot showing envelope of simple reflection

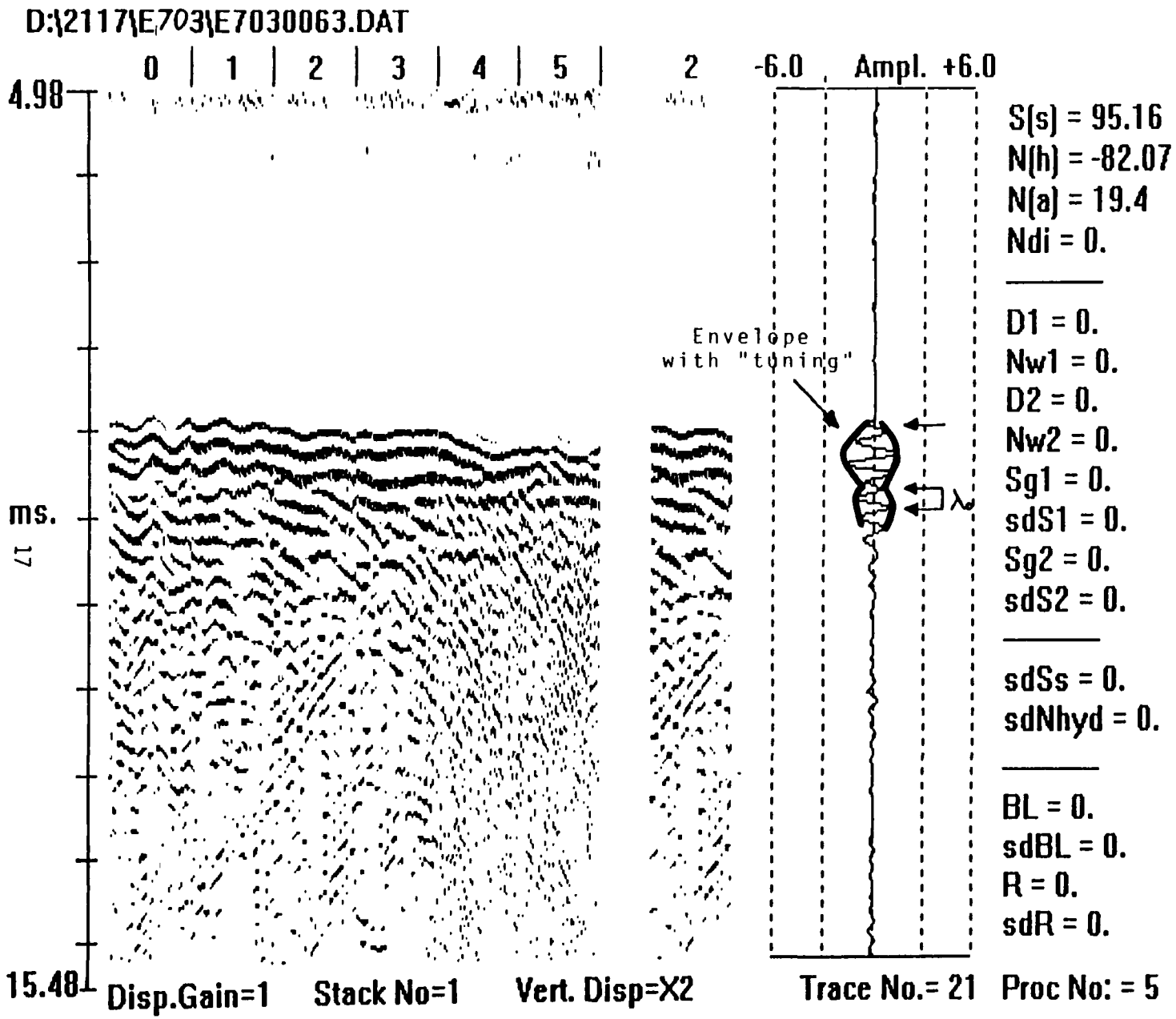
Figure 8

a higher frequency source (12 kHz or 24 kHz) with shorter wave lengths be used when thin layers are expected. This will minimize the work required to resolve these thin layers. It is important to note that the data from cores collected prior to this survey suggested thicker deeper layers. Based on the pre-survey core analysis, very thin layers were not anticipated and source wavelets and frequencies were chosen to resolve both the thin and deep layers but not the very thin layers.

The envelope of a trace with two reflections is shown in Figure 9. The envelope collapses where they touch because of the interference. The beginning of the second reflection was taken to be one wavelength (equivalent time) before the first positive maxima in the second envelope. Appendix A3.8 Figure A3.8-1 illustrates the need for this correction for the proper wavelet onset (start) time. In cases of more severe tuning, individual estimates were made by referring to the source wavelet as an aid in determining peak locations.

For each data file, the beginning of each reflection was determined for the central trace of three sub-files (remember that each sub-file equals 40 pings) 0, 2, and 4. In practice, the reflections were picked and marked at the dominant wavelength after the start of the wavelet. These picks or marks were shifted a constant wavelength distance up later in the analysis. This shift of one wavelength was required as the pick was at the maximum and not the weaker start of the wavelet. See Figure 10 and Appendix A3.8. The diffractions and the bottom loss were also noted. See Figure 11. Usually the interpretation was made by connecting the beginning of the reflections using the coherence of the wave fronts as much as possible and while noting the length of the wavelet. There were four (4) major cycles in each wavelet allowing identification of the wavelet. In Figure 12, the coherence of the wave fronts in adjacent traces were of little assistance in determining the upper layer thickness because the surface reflection was much stronger than the second reflection. The truncation of the upper layer was taken at the lateral position where the fourth wave front of the wavelet faded out due to interference effects. The coherence was much more useful in mapping the second layer because of the similar strength of the second and third reflections. The point of termination of the second layer was partly determined by the bottom losses which started to exhibit diffraction style behavior as the observable diffraction hyperbolas approached the surface. In essence, knowing the shape of the reference wavelet (Figure A3.8-1), both in number of cycles and envelope shape, one can use this reference and compare it to the actual seismic trace. Coherence between the reference and the actual trace allowed selection of the layer travel time. When wavelet overlapping occurs in thin sediments, wave form distortion also helped in identifying the travel time.

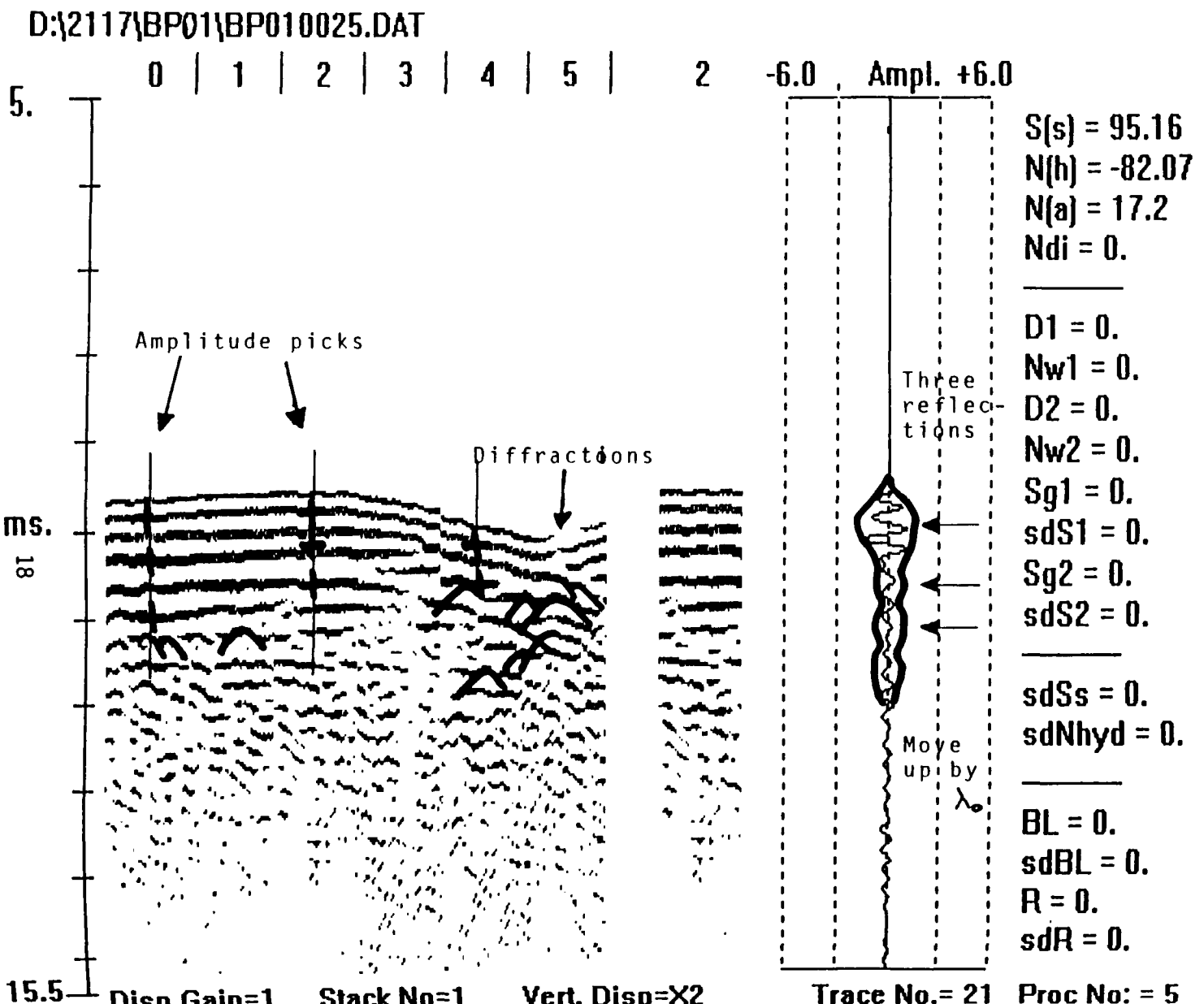
The above discussion demonstrates the need to use higher frequency sound sources in future surveys to help resolve thin layers. At higher frequencies where the wavelength is short compared to the layer thickness the trace envelope will look like Figure A3.8-4 allowing easier identification of the thin layers. At higher frequencies the pulse length is shorter and the travel time (distance) is smaller between the wave front cycles of the pulse allowing easier definition of thin layers.



CAL plot demonstrati
wavelet interference

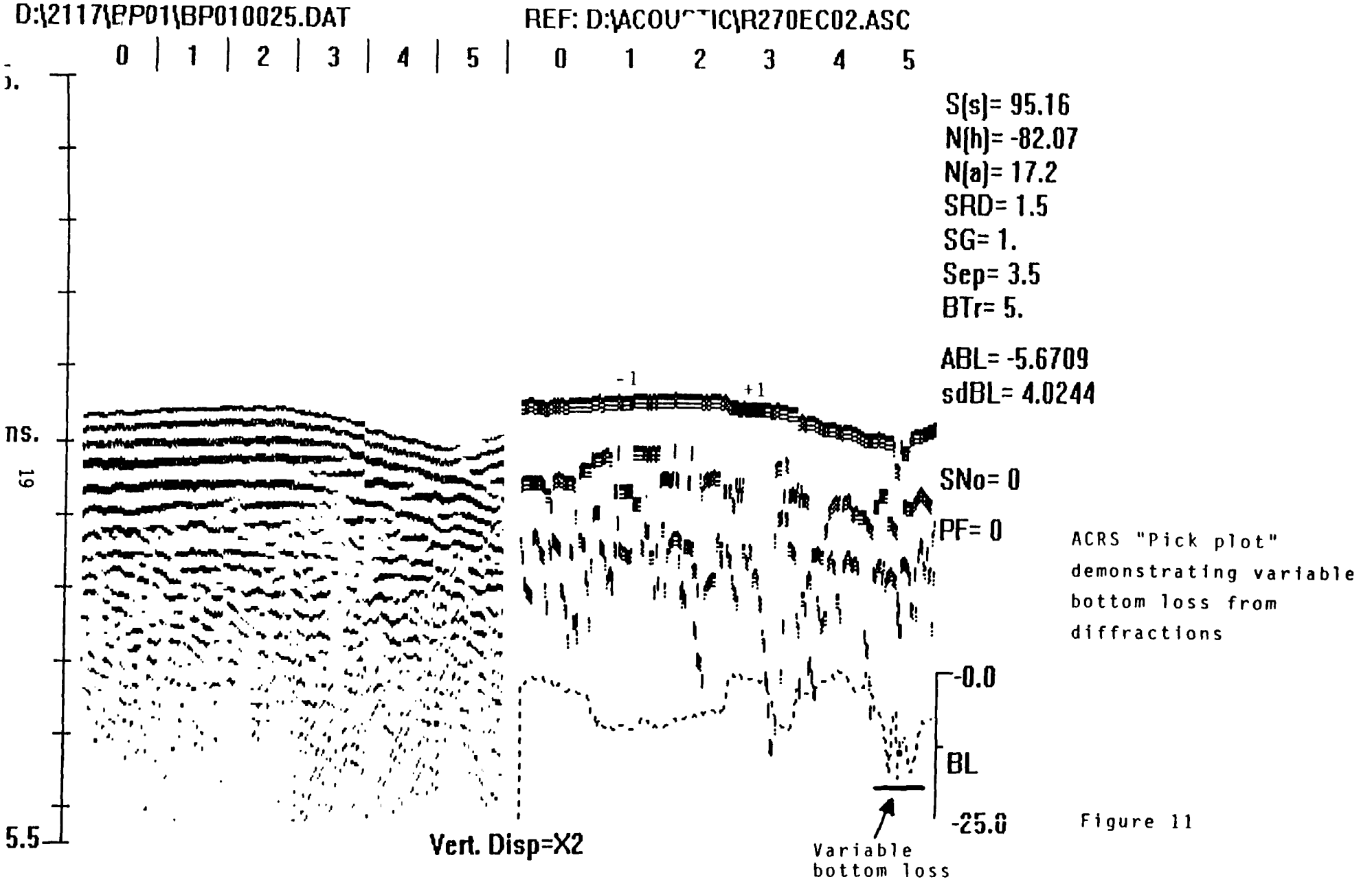
Dominant wavelength
is λ_o

Figure 9



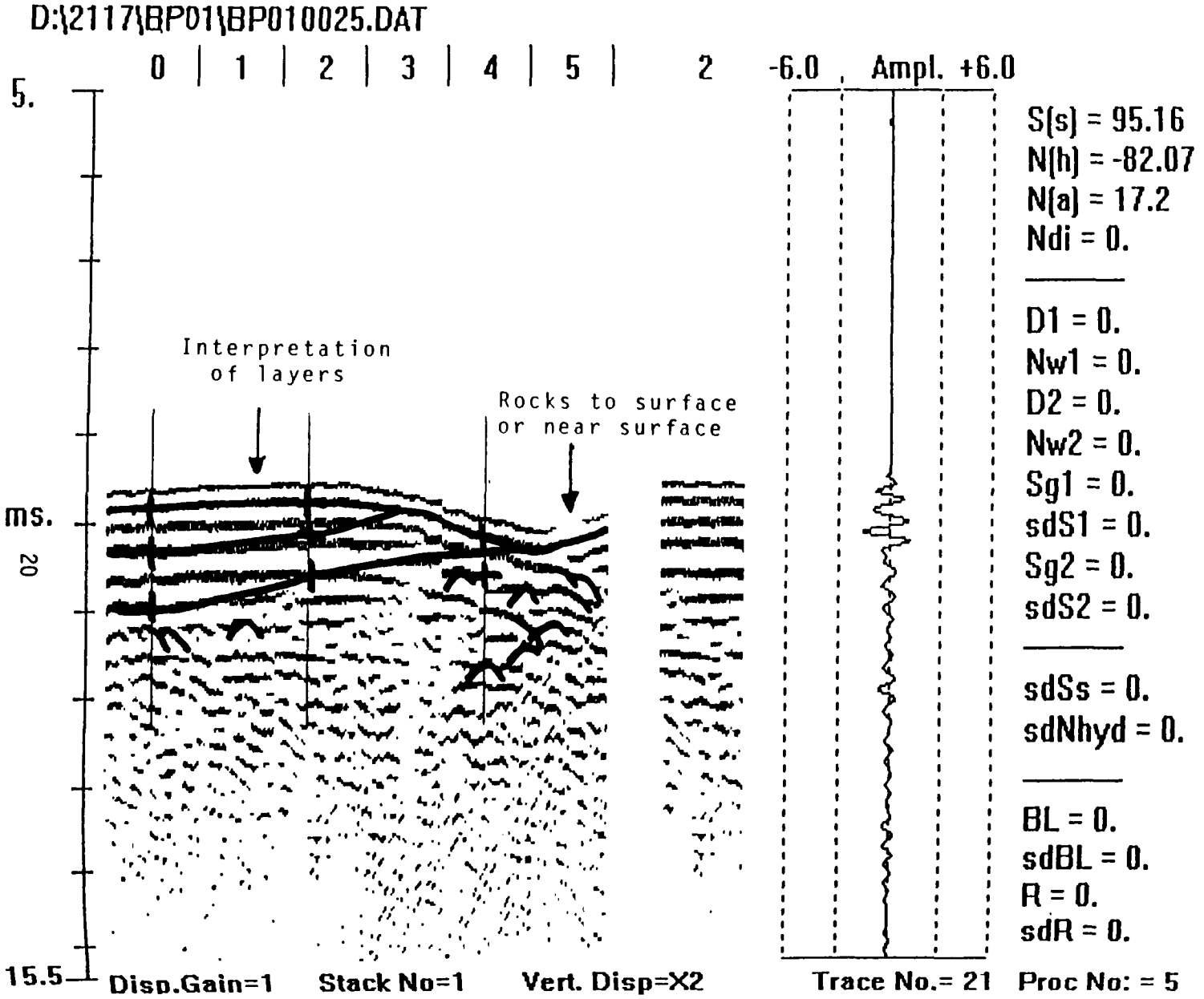
CAL plot demonstrating amplitude picks and diffractions

Figure 10



ACRS "Pick plot" demonstrating variable bottom loss from diffractions

Figure 11



CAL plot interpretation using amplitude picks, coherence and diffractions

Figure 12

2.1.3 Step 3: ACRS Plots

Caulfield Engineering's ACRS program generates two kinds of plots (Appendix A3.6.1 and A3.6.2). The first uses a correlation algorithm to pick three events on each trace (refer back to Figure 11). Each pick is found versus time and evaluated for phase inversion, a + 1 indicates that the reflection has experienced no phase inversion and -1 indicates that it has. The plot is a display of the picks in time along with the phase value. The phase value is shown by either a solid bar (-1) or a hatched bar (+1). See Figure A3.6-1 in Appendix A3.6. The bottom loss is also calculated and displayed, as already introduced in the diffractions discussion. The numeric data from this display is saved to an ASCII computer file. The second plot, Figure 13, displays the full wave rectified trace envelopes (Figure A3.6-2), in a gray scale display. These two displays are called the ACRS Pick plot and the ACRS Envelope plot, which will now be described in summary. The details of both plots are discussed in Appendix A3.6 Both these plots were interpreted separately to verify the amplitude layer detection interpretation.

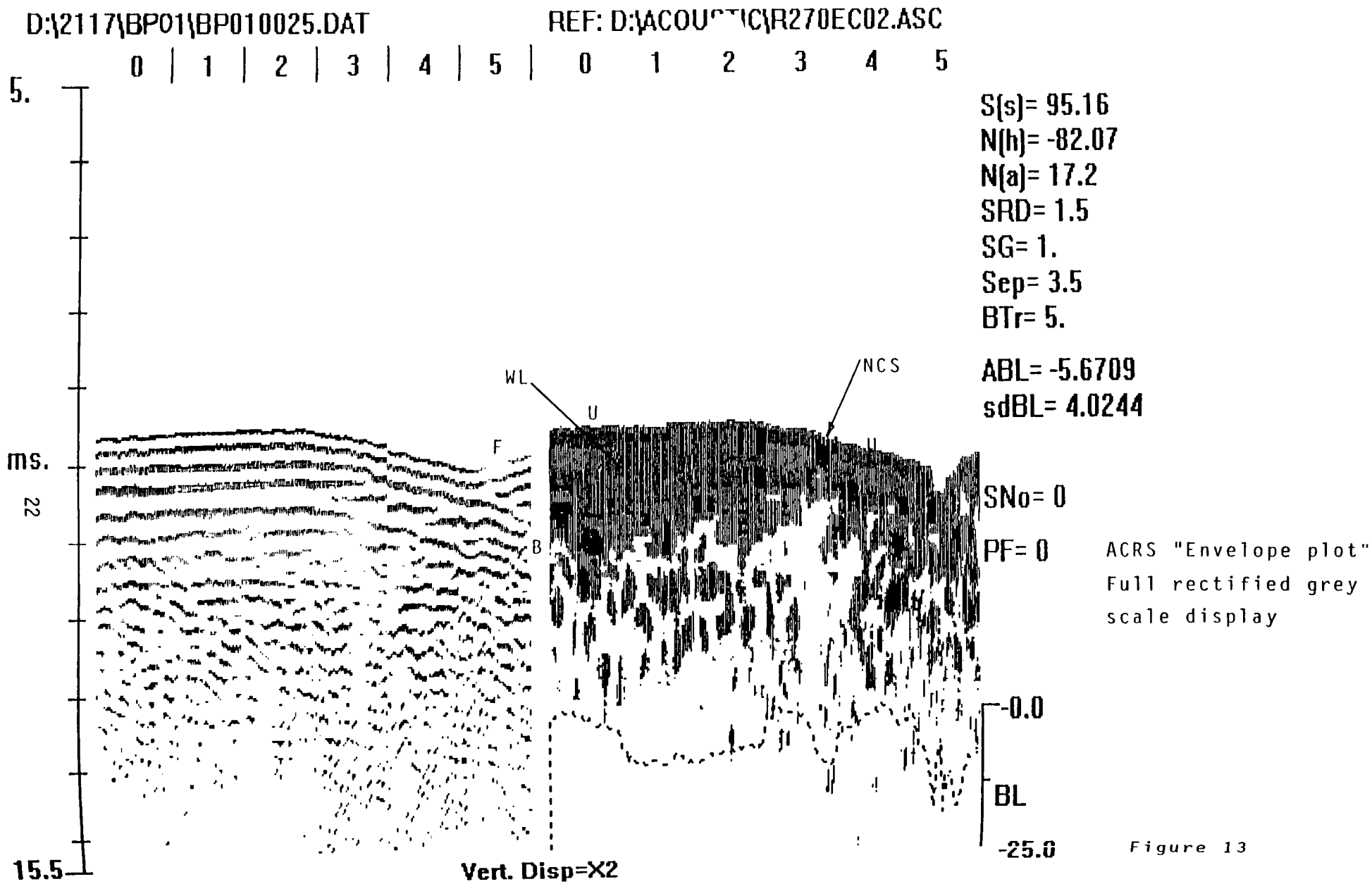
2.1.3.1 Step 3.1: ACRS Envelope Plot

The ACRS envelope plot, Figure 13 right hand cross-section, offers assistance in showing the existence of surface sediment deposits and their lateral termination. When the surface envelope is very consistent over many traces, this indicates a uniform layering effect (label U), and indicates a sediment deposit. The left side cross-section of both displays in Figures 13 and 14 demonstrate that the seismic cross-section is also uniform for sediment layering. The compacted materials, in contrast, produce an inconsistent "broken" effect (labeled B). In addition, fluff deposits showed as a weak signal above the bottom (labeled F).

The envelope plot is limited as the display is biased to a wavelet envelope length. See Appendix A3.8 for the shape of the envelope wavelet. When the indicated sediment layer shows as the thickness of the wavelet envelope, it may be quite thin. Also, if the surface reflection is quite strong, the ACRS Envelope plot will not provide a clear lower second layer (labeled NCS in Figure 13). If the layer is thicker than a wavelength, it is displayed, but is a weak signal as is shown in Figure 13 (labeled WL). The manual layer interpretation results, as described in Appendix A3.8, are highlighted in Figure 14. The data does not suggest a gradual surface pinch out, but it does show the end of both layers. Also, the consistency of the upper region is broken when the bottom loss data plot indicates diffraction behavior, wide bottom loss variation.

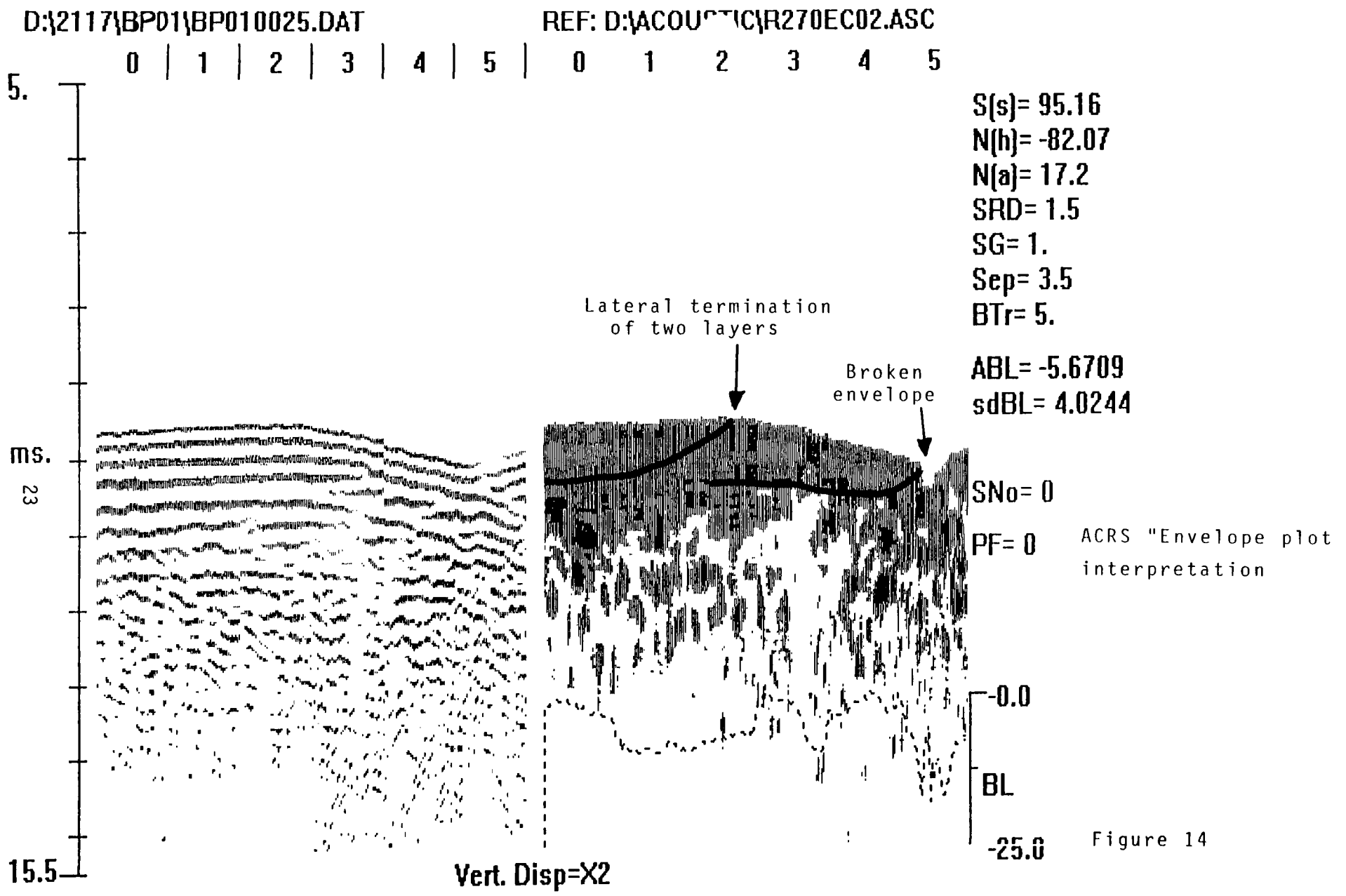
2.1.3.2 Step 3.2: ACRS Pick Plot

The ACRS Pick plot picks the top of sediment layers if the layer is thicker than the wavelet, and it is very effective at picking diffractions (labeled D in Figure 15). In fact, a diffraction hyperbola that is weak enough to be in doubt in the seismic record, can often be detected with the picked data by the ACRS Pick plot.



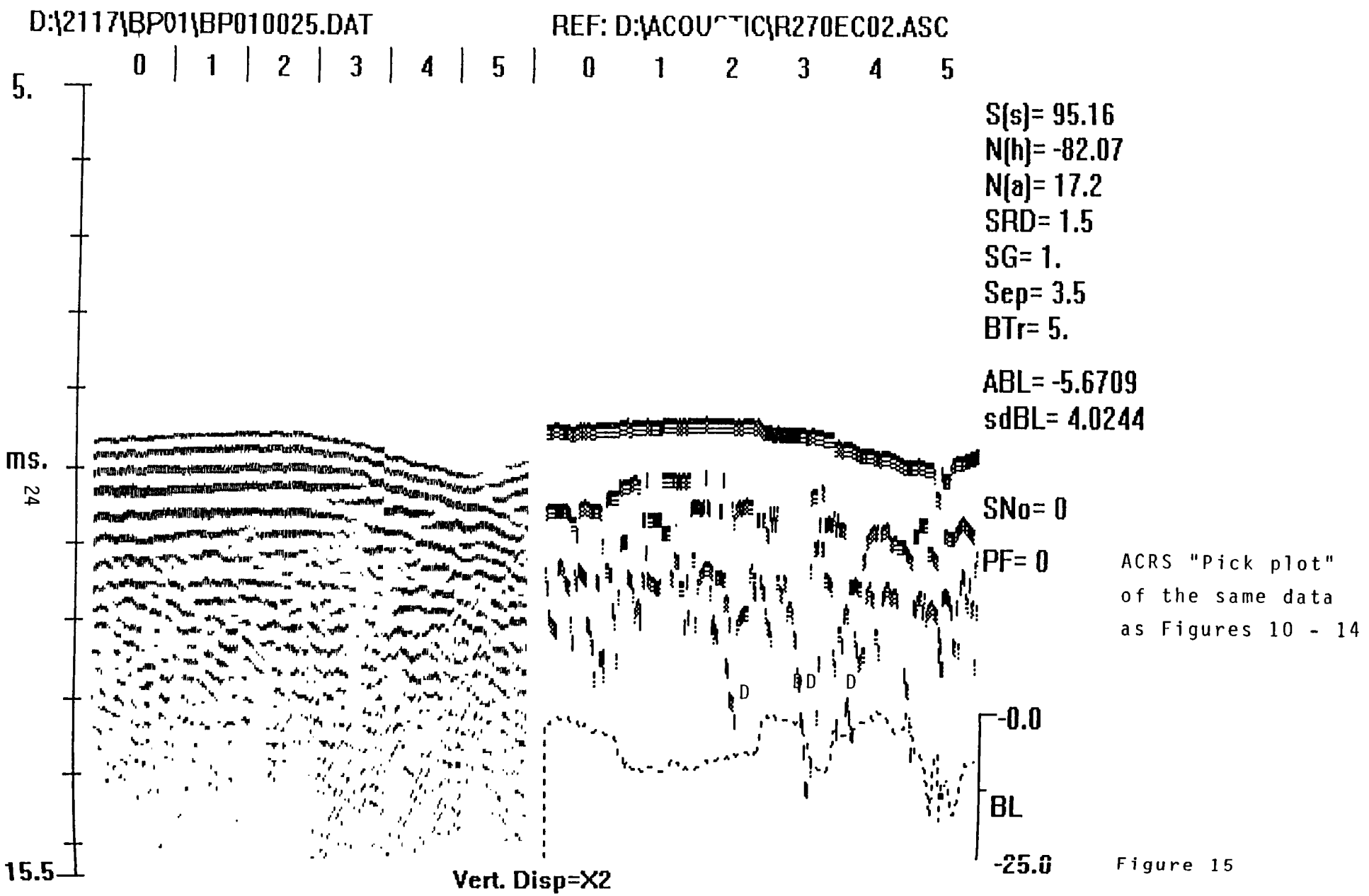
ACRS "Envelope plot"
Full rectified grey
scale display

Figure 13



ACRS "Envelope plot interpretation

Figure 14



ACRS "Pick plot" of the same data as Figures 10 - 14

Figure 15

This ACRS Pick plot has a similar limitation as the ACRS Envelope plot. It cannot pick within twice the dominant wavelength equivalent distance. This limitation was due solely to the project time available and was not a theoretical limit. The ACRS Pick plot is effective in establishing a second deeper layer and following the diffractions to the surface. Figures 15 and 16 are examples of this case. The upper layer is seen to be thinning out during subfile 0 (layer labeled "Top of the 2nd...." in Figure 16), but the display does not follow it afterwards. The diffractions can be followed to the surface on the right of Figure 16 (labeled SD). The variance in the bottom loss confirms this observation.

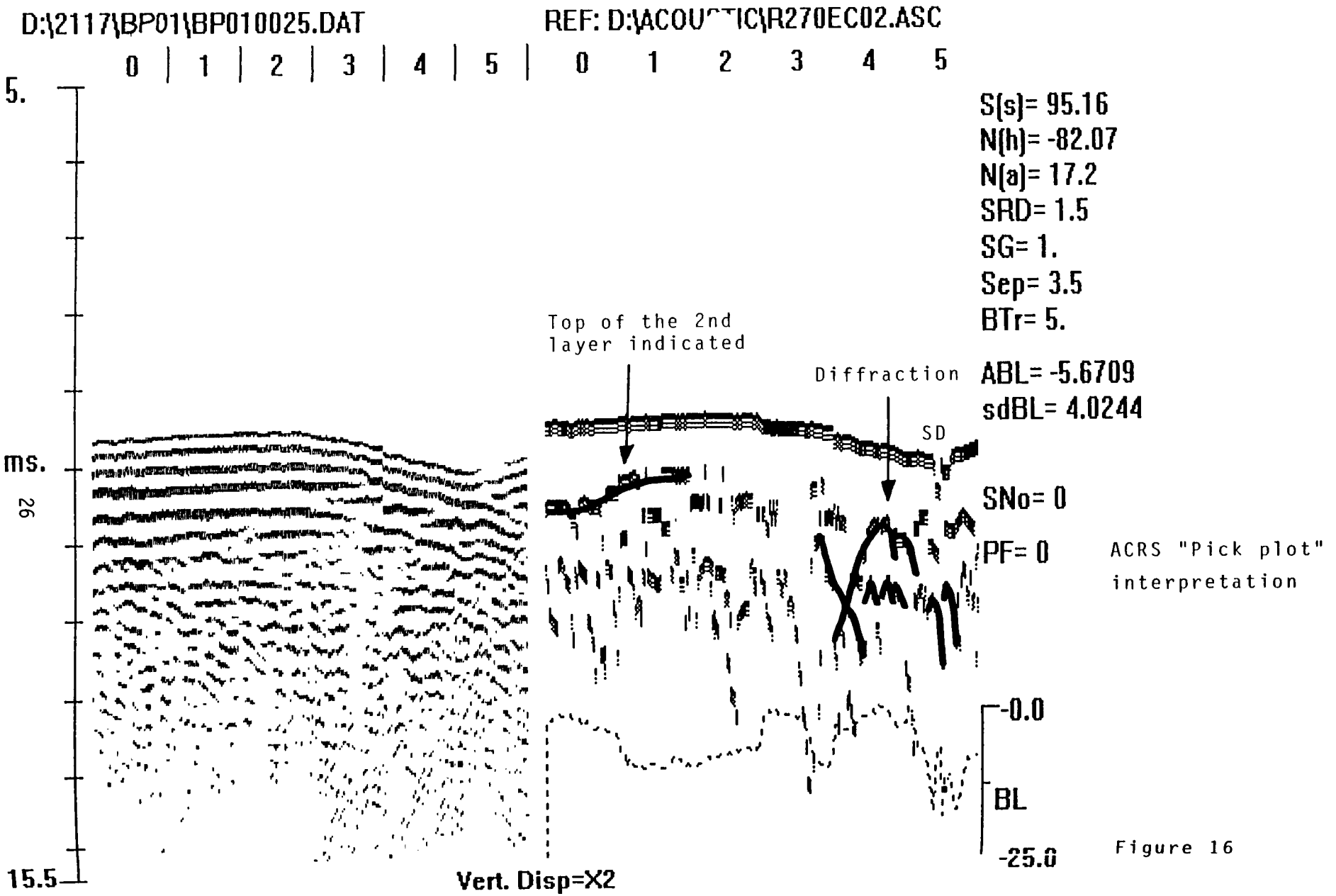
2.1.4 Step 4: Integrating the Three Layer Picking Techniques

Each of the three interpretations is traced onto a grid of the same scale created on a transparent sheet. At this time, the wavelength correction is made to the amplitude analysis interpretation to correct for the peak offset (see Appendix A3.8). Figure 17 shows the equivalent distance (time) of one wavelength (lambda sub zero). Figure 18 shows the three integrated interpretations. The solid line is the amplitude analysis and the cross marks the amplitude picks corrected for the one wavelength effect. The dashed line is from the ACRS envelope plot, and the dotted line from the ACRS pick plot.

The final layer identification was made by integrating all of three interpretations and is the result of interpretation by an experienced technician. Step 5 provides the reference for relating Figure 18 to the final cross-section. Consistency was used to suggest correctness and small differences were averaged. This plot represents one file of one line. The process is repeated for all the files on a given survey line in the chosen survey site. The Bottom Loss was also traced, in its own box, just below the combined plot as a reference interpretation aid.

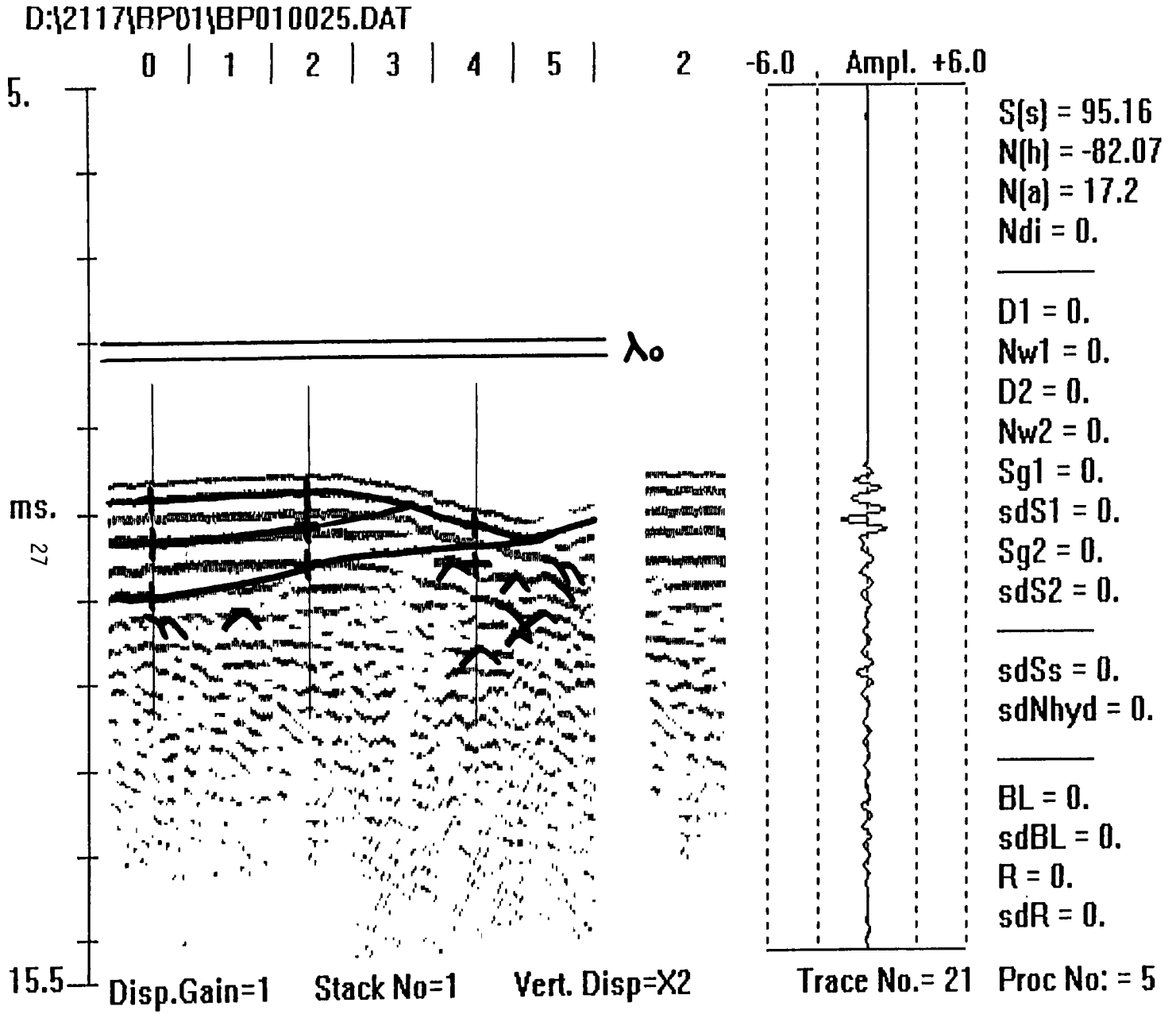
2.1.5 Step 5: Survey Line Layer Cross-Section

When the layer identification for all the files for one line was completed, each file layer interpretation was digitized and placed in an AutoCad drawing to produce the line layer cross-section. The layer data in Figure 19 plotted between BP010025 and BP10026 is an example of a cross-section layer drawing, without the material type being identified, and developed from the examples given in Figures 11 through 17. The material type was then processed and inserted. Section 3 of this report summarizes the steps for material classification.



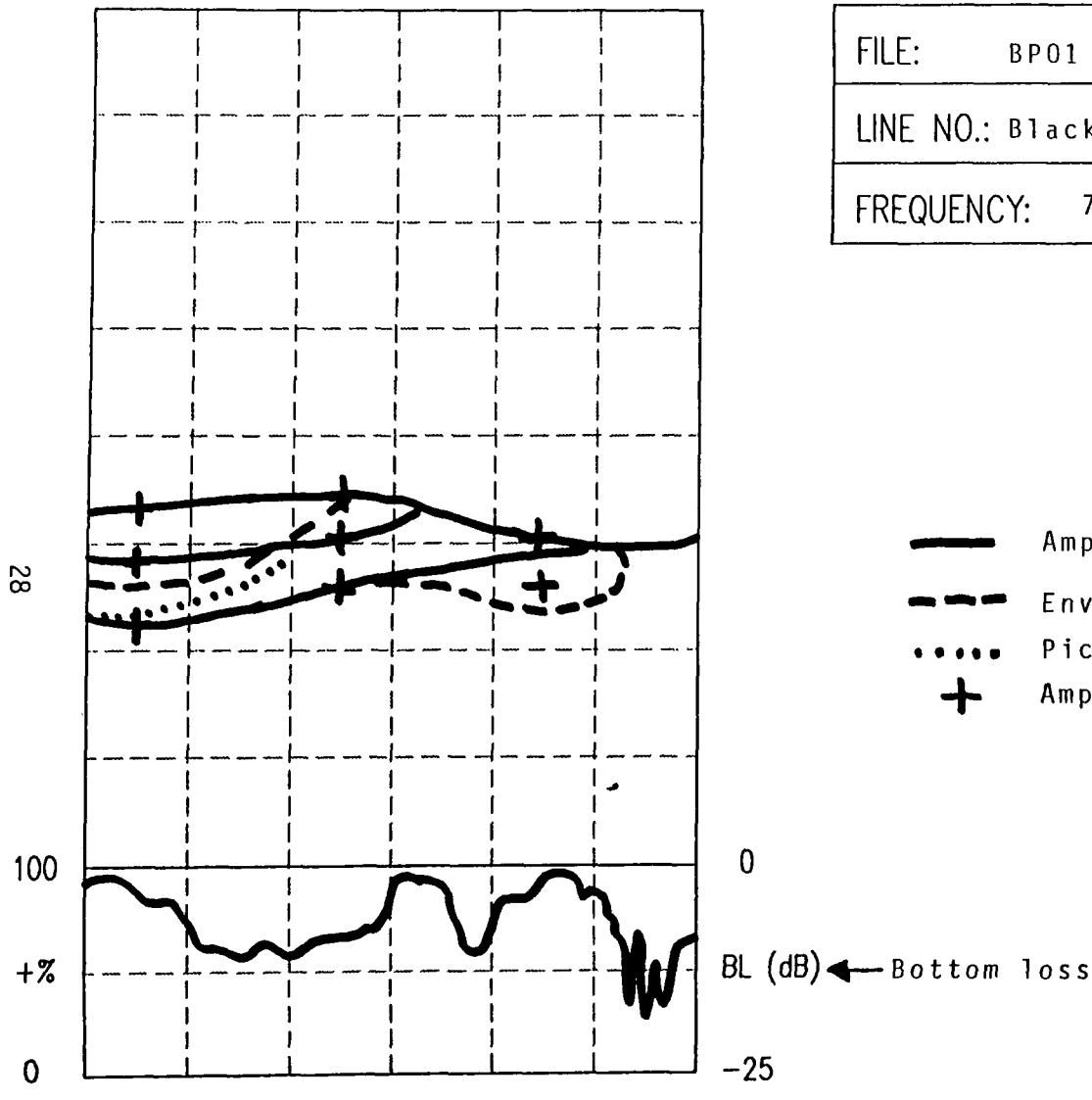
ACRS "Pick plot" interpretation

Figure 16



CAL plot displaying adjustment of amplitude pick times

Figure 17



FILE:	BP01 0025
LINE NO.:	Black Lagoon 8
FREQUENCY:	7 kHz

Amplitude analysis

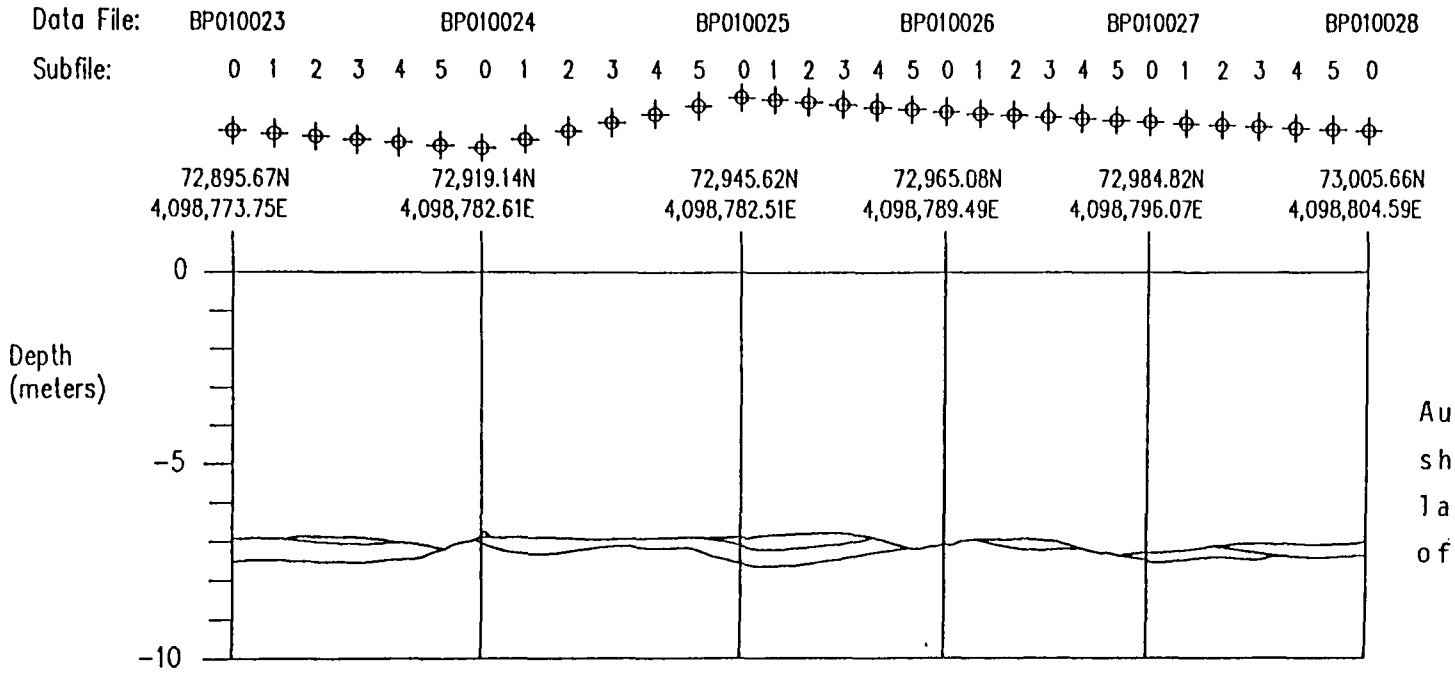
Envelope

Pick plot

Amplitude Picks

Display showing integration of the 3 interpretations and bottom loss

Figure 18



Autocad plot showing the final layer determination of line 8

Ref. File: BP01
Line no: 08

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

SCALE
0 5 10m

CAULFIELD ENGINEERING
TITLE: BLACK LAGOON, BP01/LINE 8

DRN BY:	SCALE:	DATE:
HV	1:500	22/11/96
JOB NO: 2117	DWG NO:	CAD FILE: pBP01-8

Figure 19

3.0 DATA INTERPRETATION PROCEDURES - SEDIMENT IDENTIFICATION

The final procedure in the generation of the site cross-sections was identification of the sediment type (material) and estimation of the selected sediment potential contamination. A set of data from Elizabeth Park site has been chosen to illustrate the procedures for sediment identification. As a precursor to these final procedures, the calibration process was completed (volume 1), and the regional data base was generated from the core data and simultaneous acoustic survey data (volume 2). These documents should be reviewed and referred to while reading this section. The final sediment type selection was determined by the following steps.

3.1 Step 1: Matching the Sediment Layers to the Cores

The sediment layer types were first selected from core information, and the data base generated in the core analysis (volume 2). The layers determined from acoustic interpretation nearest the cores were made to have the same sediment type as observed in these cores. These changes were then extrapolated, by review of the acoustic records, to the layers in adjacent lines. This approach is the historical interpretation procedure, and works well when the sediment deposits extend laterally and are of a uniform nature. However this technique requires many cores.

At the Elizabeth Park site, the number of cores which could be collected were limited, the sediment deposits were very localized, and exhibited extreme lateral variations. What would normally have been a reasonable horizontal distance (10 to 20 meters) in a normal delta type sediment was, for this project, too great a distance. Black Lagoon and Elizabeth Park were both affected by this problem of high spatial variances.

As a result of the high spatial variance at the Elizabeth Park site, a 100 square meter site, five attempts were made to collect sediment samples and only one core exhibited a sediment layer. Three piston cores (8, 9 and 10) were collected inside the actual boundaries of the outer Elizabeth Park survey site. Cores 8 and 9 exhibited only hardpan in the core nose cone and no sediments layers were found. Core 10 was the only core which exhibited a sediment layer.

The lack of more detailed core information in Elizabeth Park necessitated the full application of the new acoustic patented sediment identification procedures first shown in the Core Analysis Report, (volume 2). At this site the new software was put to the test

using fully the bottom loss and sign information from the ACRS software (Appendix A3.6) to classify the sediments. These same procedures were also used at the Black Lagoon site. However, at this site more cores were available and the analysis was easier.

3.2 Step 2: Bottom Loss Processing

The bottom loss measurements were full of random fluctuations depending on site location. This is because the layers were variable both in thickness and lateral extent, and the acoustic energy was diffracted by rocks at some locations. To make matters more complex, normal averaging over a subfile (40 traces) or a full data file (240 traces) was not adequate at these sites to resolve the mixed bottom losses of the various materials resulting from the spatial variation. This spatial variation was often exhibited by combinations of two different sediments or, more often, the sediment next to the hard pan. There were seldom enough similar sequential traces to get a good estimate by using brute force statistical techniques alone. Occasionally during the collection of data for the core data base program the boat was correctly anchored and normal statistical processes worked well for the generation of the data base information.

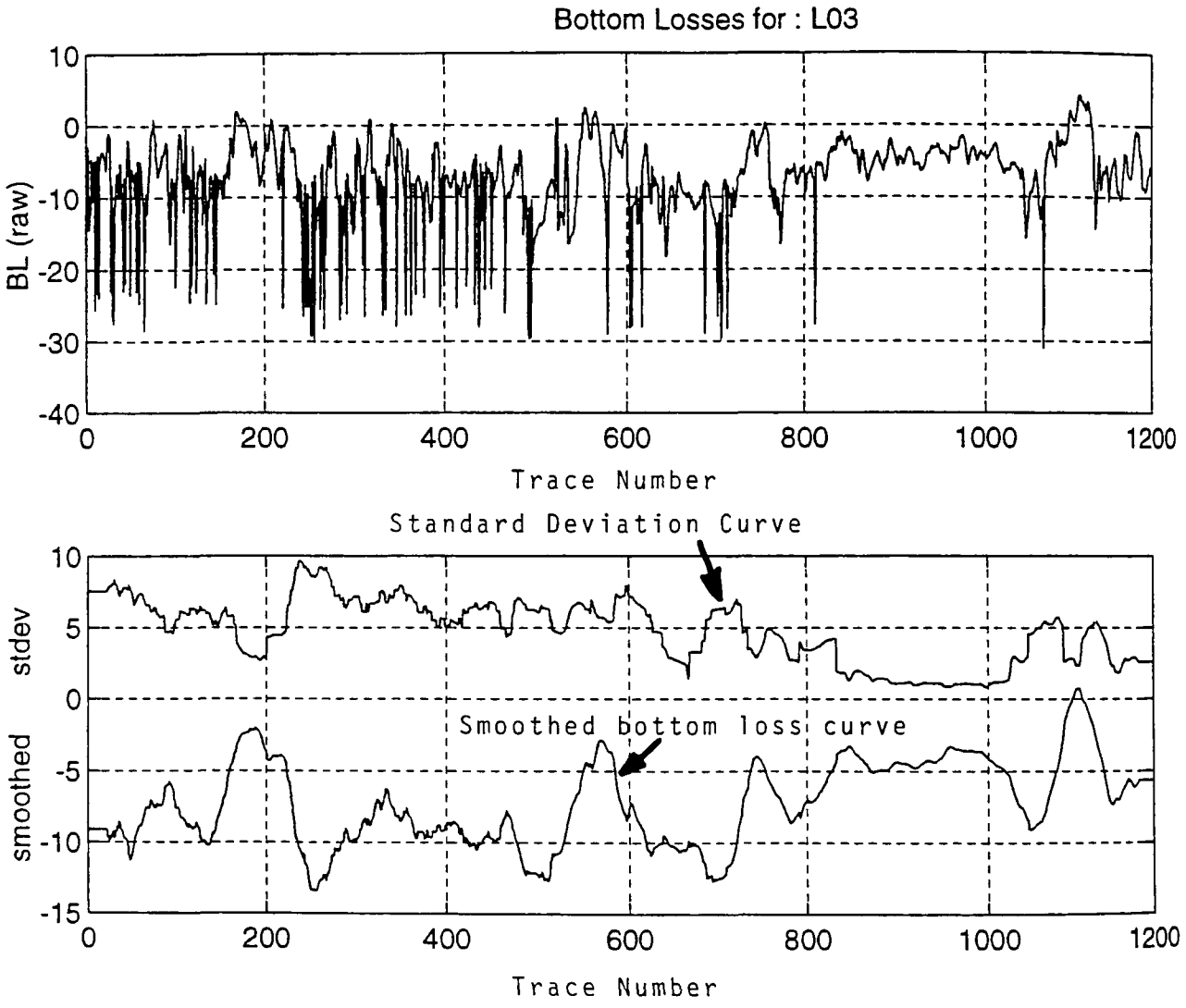
To solve the problem for these cases of high spatial variation a moving average filter was generated. This filter allowed derivation of a bottom loss measurement from each trace weighted by its nearest trace neighbors. The process is also a valid statistical procedure but more memory and computational intensive. What was new in this analysis is that every trace received a bottom loss value. The extreme redundancy in this approach resulted in a smoothed and stable curve (Figure 20).

The process of obtaining this data was as follows:

- Bottom Loss The bottom loss was calculated by Caulfield Engineering's ACRS (Appendix A3.6) program and the output text file was saved for each data file.

- Line Data These bottom loss ASCII files were grouped together so that there was one file with all the bottom loss values for each line. A program was written which reads these values into Matlab for processing. See Program Listings 1 and 2, Appendix A2.1.

- Smoothing Filter - The "smoothing" process, Program Listing 2, averaged the Bottom Loss value in question with the 20 traces before it, for the desired trace position in the line, and the 20 traces after it. This average is output as the smoothed bottom loss value for that position in the line was used in the calculation. This approach outputs as many averaged bottom loss values as the number of values in the input data set. At the ends of the line, this symmetry is broken because of no further data, so from trace 21 to trace 41 in the last subfile bottom losses for each of these traces are filled with the mean



Bottom Loss Display
Smoothed bottom losses wi
standard deviation calcul
by moving average techniq

Figure 20

value of Bottom Loss at trace 21. This number of 41 traces for the smoothing, found by trial and error, provided the optimum smoothing for these sites. Note that other sites might require different smoothing functions depending on the sonar equipment employed and the regional spatial variations. Refer to Figure 20 to view the display of this process output.

- Standard Deviation Analysis - This smoothing was not quite sufficient in itself for the sediment classification, because the lateral variations were so extreme. The program also calculated the average standard deviation of the same bottom loss values. The average standard deviation was useful for differentiating hardpan from sediment deposits and was not influenced by the thinness of the bed, a few rocks within the layer, or similar random factors. In essence the layer "irregularities" were used as additional data points to augment the sediment classification process. Refer to Figure 20 to view the bottom loss standard deviation.

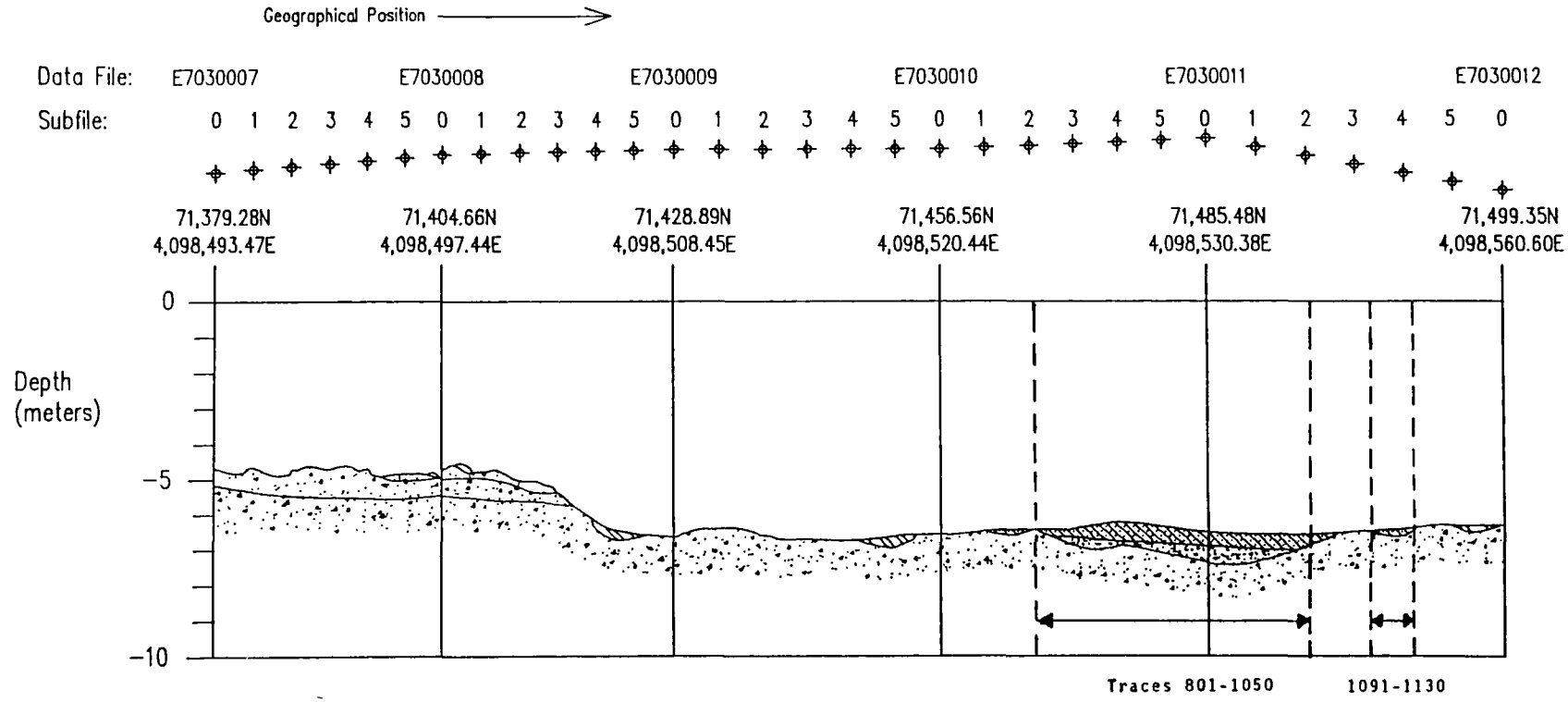
An example of the application of these procedures is provided in Figure 21 and Figure 22. Figure 21 is a draft cross-section and Figure 22 is the bottom loss working analysis sheet used to provide the deposited sediment identification. The process which used both sedimental and textural differences for analysis can be summarized for this example as follows:

- The lateral extent of the layer was determined from the cross-section (traces 801 -1050).
- This range of the lateral extent was found on the Bottom Loss Graph (Figure 22) and indicated by the bold line on the bottom curve between the two vertical dark lines.
- The standard deviation was studied and its local minimum point found.
- The standard deviation curve should have a flat spot here.
- The smoothed bottom loss, again on the bottom curve between the two vertical dark lines in Figure 22, corresponding to this local range of flat minimum standard deviation values was the best estimate of a deposited sediment.

This technique allowed the identification of depositional sediment layers though they were thin and spotty. The severe scattering of the sound from the hard pan allowed for identification of these layers.

3.3 Step 3: Contamination, Bottom Loss, and Plus Sign Percentage

The existence of contamination (pollution) and/or gas bubbles may affect the bottom loss as established in the volume II, section 4.3.2. The summary data from this report is reproduced in Figure 23 and illustrates the deviation of study site sediment



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.8	
	SILTY SAND TO SANDY SILT	1.8 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

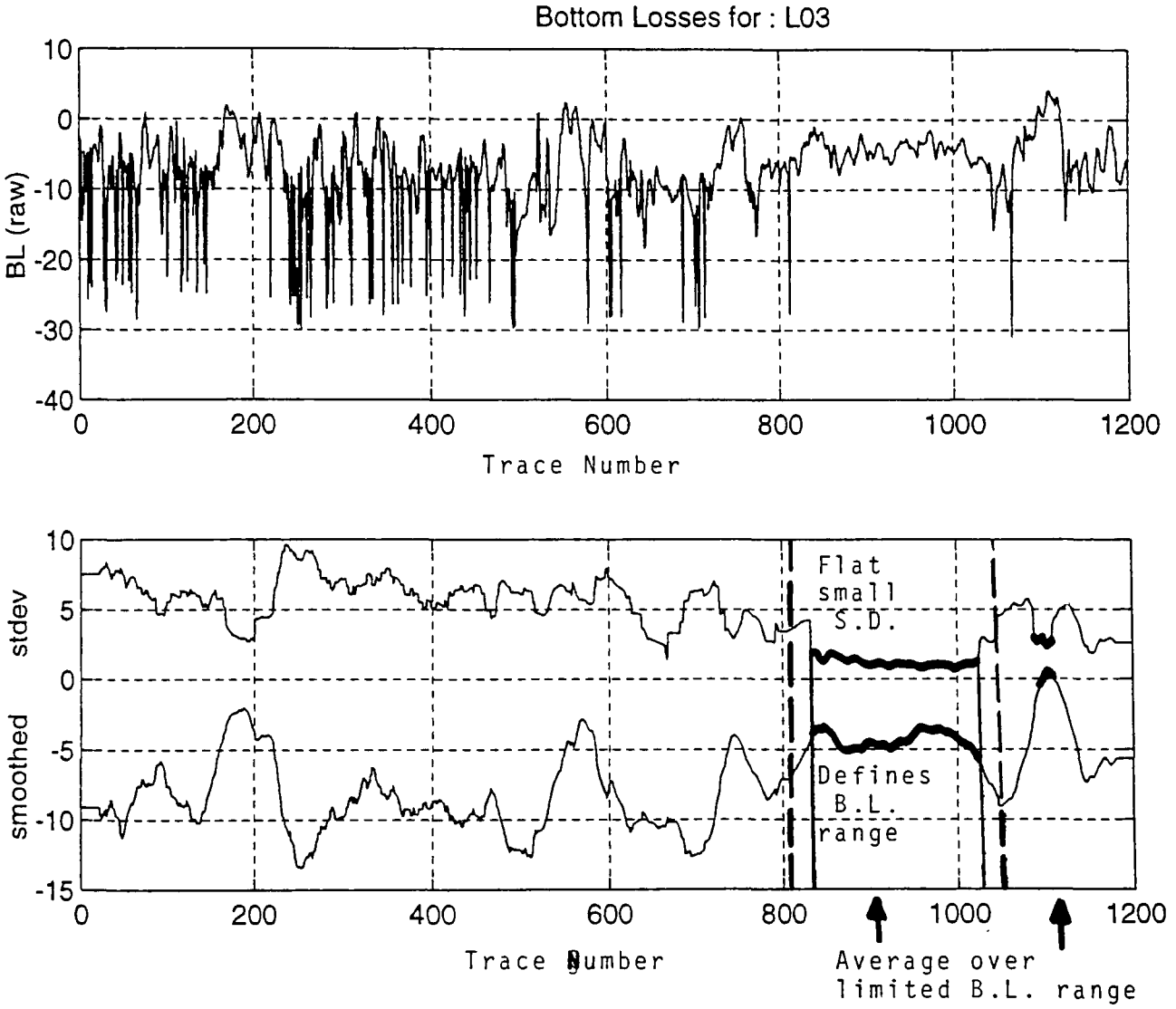
LATERAL DISTANCE SCALE

Ref. File: E703
Line no: 03

CAULFIELD ENGINEERING		
TITLE: ELIZABETH PARK, E703/LINE 3		
DRN BY: HV	SCALE: 1:500	DATE: 16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-3

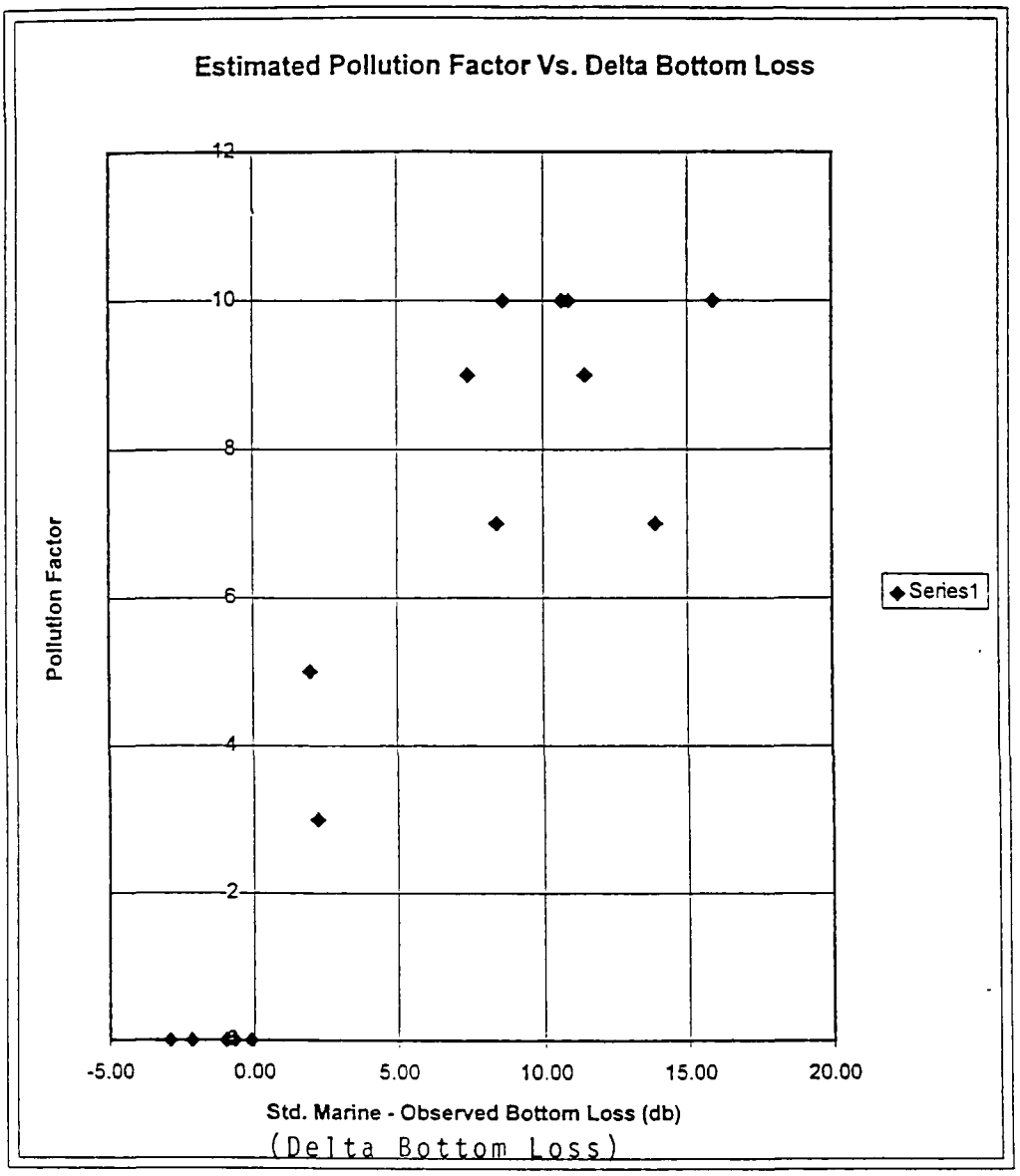
Cross section showing lateral limits of sediment layers.

Figure 21



Bottom loss plot showing lateral limits of sediments. Valid range of bottom loss is subset with small stable S.D.

Figure 22



Graph showing effect of pollution on bottom loss.

Figure 23

bottom loss values from standard marine sediment bottom loss values plotted versus gross pollution level found in the Trenton Channel USEPA cores. This gross pollution level is an arbitrary value derived by assuming the USEPA core with the highest quantity and diversity of foreign elements of chemical, oils, and metals had the highest pollution level and then scaling down as fewer foreign elements were found in the cores. With the bottom loss smoothing and standard deviation approach described above, site depositional sediment areas were determined and located. Noting that these anomalous sediments in the Detroit River differ from standard marine sediments by varying degrees, calculated bottom loss magnitude values, in themselves, are not enough to decide the type of sediment, only differentiation of depositional sediment from hard pan. The variation of bottom loss within that sediment made it impossible for proper sediment identification unless additional information was available.

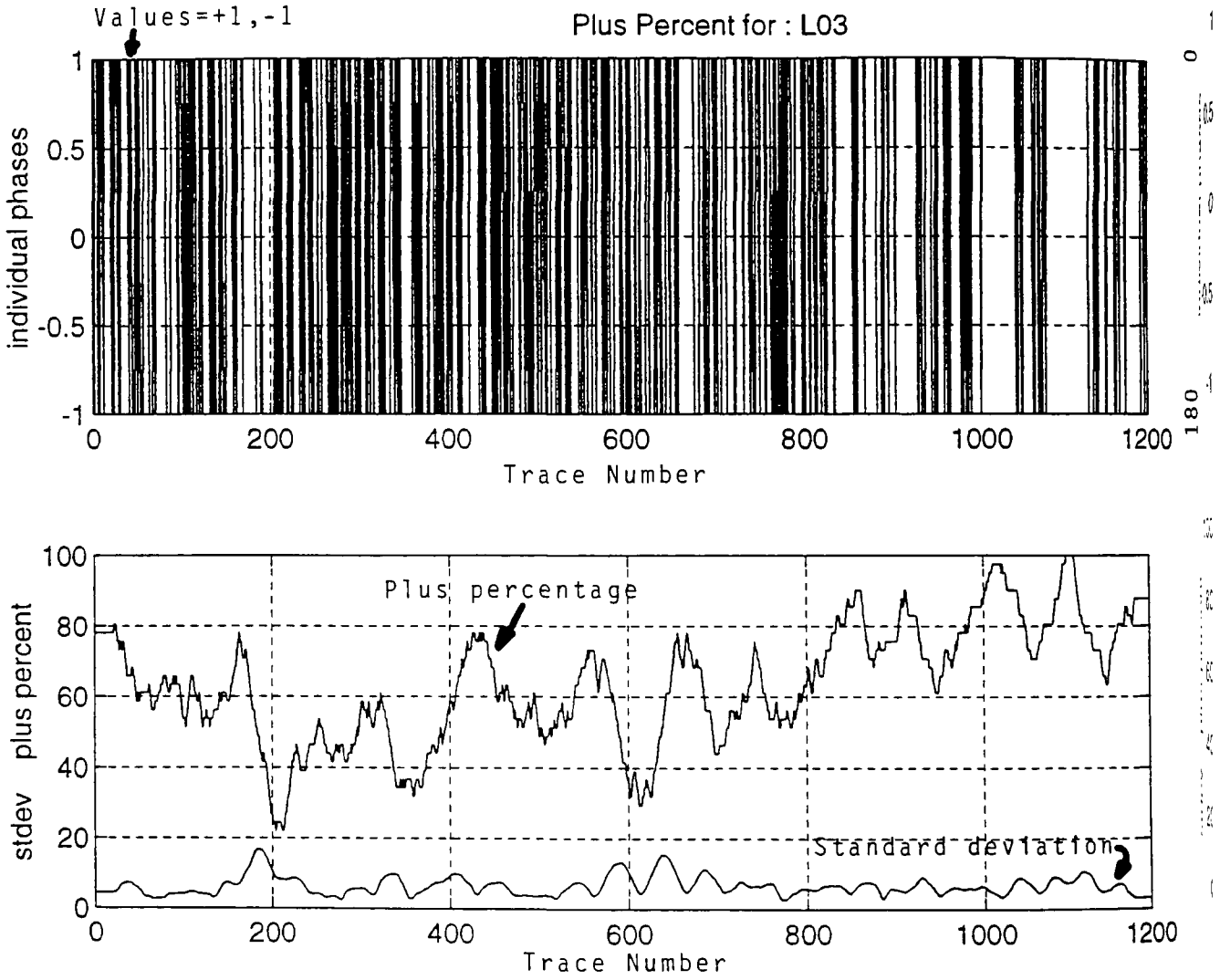
Caulfield Engineering's ACRS program also measured the phase value of each major reflector in the trace, in terms of +1 or -1, where the values were determined from doing the cross-correlation of the source wavelet with bottom trace (Appendix A3.6). The sign shows that the first reflection was reflected normally, as in the non anomalous case, or with a 180-degree phase inversion as with the anomalous sediment case. The phase shift occurred because of the gas content of the sediments. These values became meaningful by using statistics over a number of traces to calculate the plus sign percentage, the calculation of the percentage of traces which are NOT phase inverted. The smoothing approach used in the bottom losses calculations was modified slightly to produce a similar plot of the plus sign percentage and its standard deviation (Figure 24). See Program Listings 3 and 4, Appendix A2.2, and Figure 24. This example uses the same range of traces (41) to compute the moving average of the plus sign percentage along the survey line used to filter the bottom loss measurements. Figure 25 shows the Plus Sign Percentage output (darken line between traces 800 and 1000) for the surface layer discussed in the bottom loss computations discussed above.

The Core Analysis Report (volume 2, section 4.3.4) shows the plot of Plus Sign Percentage versus Change in Bottom Loss and the plot of Pollution Factor versus Change in Bottom Loss. Figures 26 and 27 reproduce these figures from that report. Linear Regression was used with these data sets to determine the minimum squared error relationships to develop functional relationships (equations) for the data in each of these Figures. These equations were then represented as functions of the Plus Sign Percentage:

$$\text{DeltaBL} = 25.23 - 0.4325 * \text{PSP}$$
$$\text{PF} = 17.7765 - 0.2746 * \text{PSP}$$

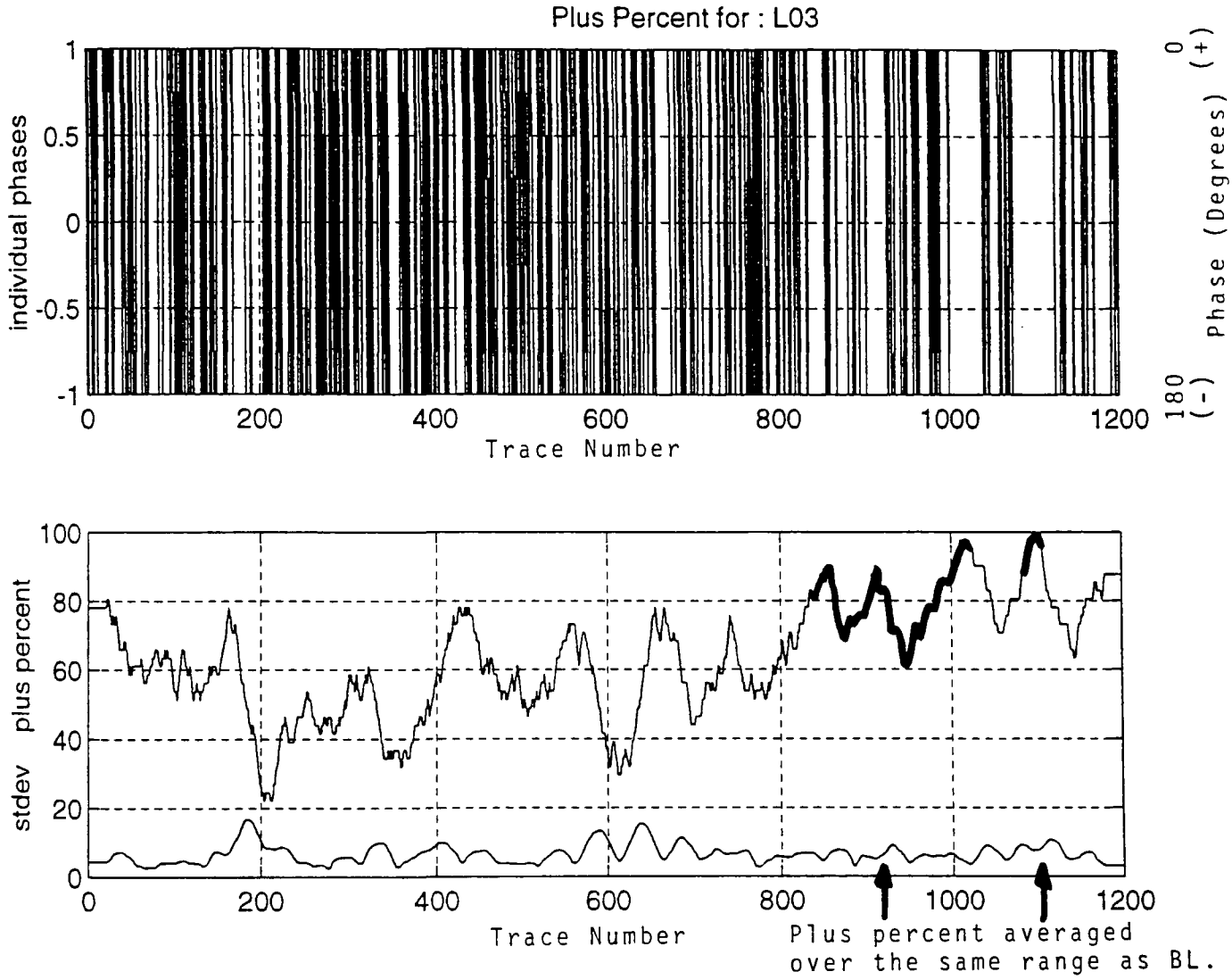
where:

DeltaBL = Change in Bottom Loss of study site sediments
PSP = Plus Sign Percentage
PF = Pollution Factor



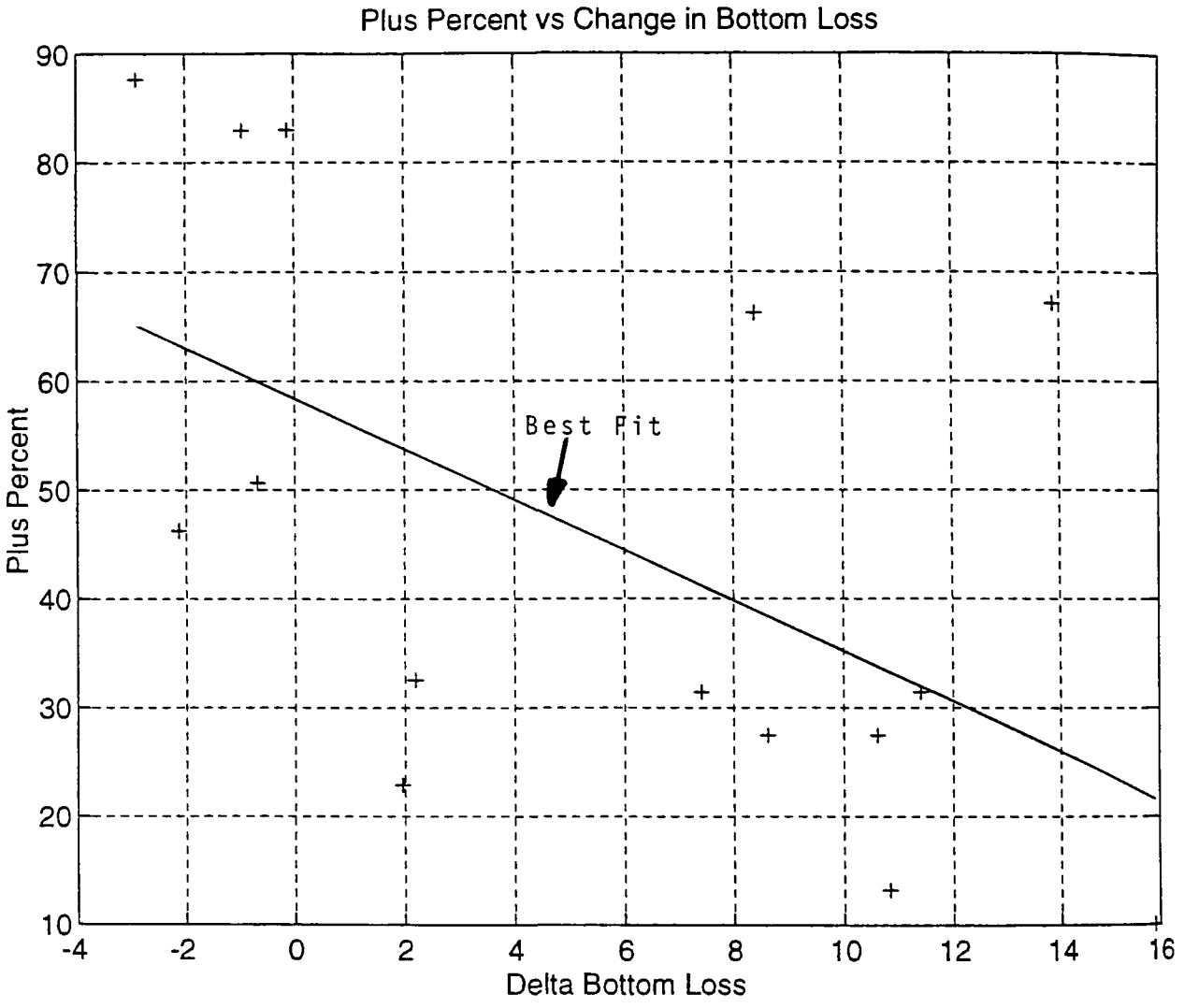
Plus percentage display calculat
from moving average process.

Figure 24



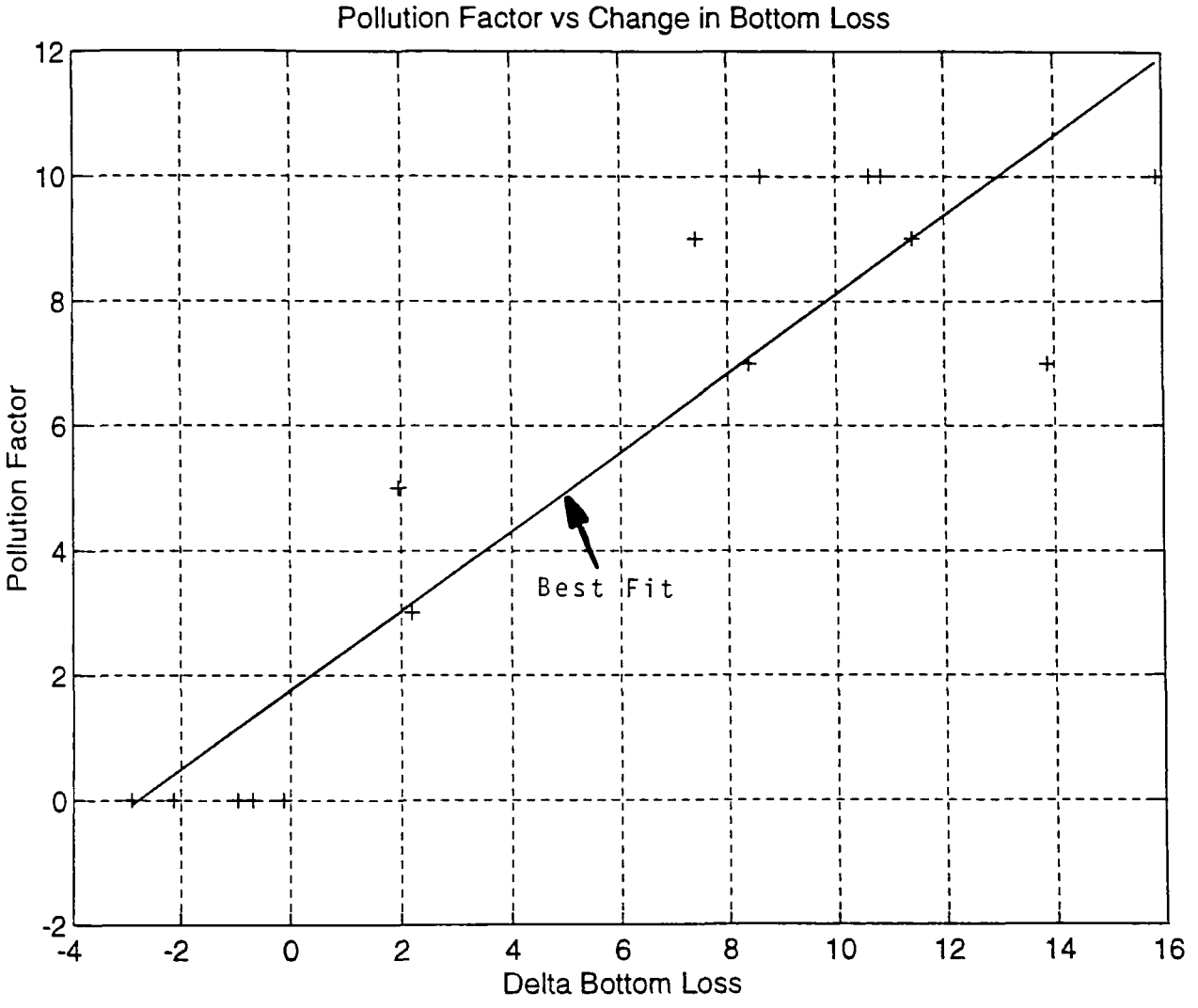
Plus percentage plot showing same restriction in trace number as in bottom loss determination.

Figure 25



Graph demonstrating relationship between plus percentage and change in bottom loss.

Figure 26



Graph demonstrating relationship between pollution factor and change in bottom loss.

Figure 27

The Plus Sign Percentage, the Change in Bottom Loss and the Pollution Factor were then calculated for each layer in each line. The percentage of traces which are not phase inverted is inversely proportional to the change in bottom loss. The measured bottom loss was then corrected, by this change in bottom loss to determine an estimate of the non-anomalous bottom loss (BL)o. Table 1 presents these summarized computations for the lines at Elizabeth Park, a 100 meter square site. Note that the arithmetic complement of the plus sign percentage (100 - PSP) is the correct value for PSP used because of a small sign bug in the ACRS program.

The non-anomalous bottom loss value, bottom loss corrected for changes in study site bottom loss allows the sediments to be identified, as to type, by comparing it with the standard marine sediments curve, developed by Hamilton (see Table 2). Table 2 has been reproduced from Volume 2. These approaches produced layer type determination. These estimated sediment types matched the independent interpretation in adjacent survey lines. Also, the estimated sediment types agreed with the cores and seemed reasonable given the flow and currents of the river.

The calculation of the pollution factor itself was a useful double check, because some values were outside the established range from 0 to 10. These outliers were reset to the extreme edge of the range (either 0 or 10) and a correction was made to the calculated non-pollution bottom loss value based on the slope of the regression curve. Such values were given an unconfidence level (Unconf) reflecting the amount they exceeded the range. This was considered when making the sediment type assignment. The unconfidence level is listed in Table 1 on the far left column headed as Unconf. These out of range values only arose due to the extremely small data set available for the generation of the functional relationships between acoustic variables and the core information.

3.4 Analysis Summary

The results discussed in this report are based on the calibration and core analysis carried out in Volumes 1 and 2 of the project. Therefore, it is important to note that the procedures and equations developed are site dependent. As further data is acquired at additional core sites, the relationships discussed can be improved. The success of the project was the result of the piston cores and acoustic data being acquired simultaneously under strict quality assurance programs.

An additional parameter, the absorption as a function of frequency, could not be used in an analytical manner for the final sediment identification. The difficulty with the vessel handling prevented production data position overlap at the different source frequencies. This added information would have provided further confidence in the sediment type selection.

Table 1	Zero Pollution Bottom Loss and Pollution Factor calculations								
Queen Elizabeth Park									
Line 01									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
161-200	65	35	0.00	10.09	-10.09	8.17	8.17	-10.09	
371-400	65	35	-5.50	10.09	-15.59	8.17	8.17	-15.59	
415-465	65	35	-10.50	10.09	-20.59	8.17	8.17	-20.59	
466-500	65	35	-7.50	10.09	-17.59	8.17	8.17	-17.59	
521-561	80	20	-5.50	16.58	-22.08	12.28	10.00	-16.80	3
635-650	55	45	-6.00	5.77	-11.77	5.42	5.42	-11.77	
Line 03									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
181-240	40	60	-2.50	-0.72	-1.78	1.30	1.30	-1.78	
401-440	67	33	-9.00	10.96	-19.96	8.71	8.71	-19.96	
641-690	73	27	-10.00	13.55	-23.55	10.36	10.00	-22.72	1
761-800	60	40	-5.00	7.93	-12.93	6.79	6.79	-12.93	
951-1020	85	15	-4.00	18.74	-22.74	13.66	10.00	-14.29	4
1091-1130	95	5	-0.50	23.07	-23.57	16.40	10.00	-8.76	7
1161-1200	85	15	-6.00	18.74	-24.74	13.66	10.00	-16.29	4
Line 05									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
1-40	65	35	-4.50	10.09	-14.59	8.17	8.17	-14.59	
121-160	75	25	-4.00	14.42	-18.42	10.91	10.00	-16.31	1
381-561	55	45	-3.00	5.77	-8.77	5.42	5.42	-8.77	
601-680	22	78	-4.50	-8.51	4.01	-3.64	0.00	-4.42	4
871-980	92	8	-3.00	21.77	-24.77	15.58	10.00	-11.87	6
1071-1100	65	35	-1.50	10.09	-11.59	8.17	8.17	-11.59	
1161-1200	57	43	-7.00	6.63	-13.63	5.97	5.97	-13.63	
Line 07									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
1-40	85	15	-2.00	18.74	-20.74	13.66	10.00	-12.29	4
201-240	75	25	-6.00	14.42	-20.42	10.91	10.00	-18.31	1
281-320	65	35	1.00	10.09	-9.09	8.17	8.17	-9.09	
541-600	50	50	-2.50	3.61	-6.11	4.05	4.05	-6.11	
641-680	30	70	-4.50	-5.05	0.54	-1.45	0.00	-2.80	
721-760	40	60	-11.00	-0.72	-10.28	1.30	1.30	-10.28	
801-840	65	35	-11.00	10.09	-21.09	8.17	8.17	-21.09	
881-960	75	25	-9.00	14.42	-23.42	10.91	10.00	-21.31	1
990-1050	77	23	-4.00	15.28	-19.28	11.46	10.00	-15.91	2
1101-1140	93	7	-9.00	22.20	-31.20	15.85	10.00	-17.67	6
1201-1240	83	17	-5.00	17.88	-22.88	13.11	10.00	-15.69	4
1351-1440	60	40	-8.00	7.93	-15.93	6.79	6.79	-15.93	

TABLE 1 concluded

Line 09									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
41-120	45	55	-0.50	1.44	-1.94	2.67	2.67	-1.94	
361-440	55	45	0.00	5.77	-5.77	5.42	5.42	-5.77	
521-660	50	50	-2.50	3.61	-6.11	4.05	4.05	-6.11	
691-720	55	45	-6.00	5.77	-11.77	5.42	5.42	-11.77	
721-820	65	35	-2.00	10.09	-12.09	8.17	8.17	-12.09	
861-920	57	43	-3.50	6.63	-10.13	5.97	5.97	-10.13	
961-1000	80	20	-6.50	16.58	-23.08	12.28	10.00	-17.80	3
1041-1080	73	27	-7.50	13.55	-21.05	10.36	10.00	-20.22	1
1121-1160	80	20	-5.50	16.58	-22.08	12.28	10.00	-16.80	3
Line 11									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
201-240	80	20	-3.00	16.58	-19.58	12.28	10.00	-14.30	3
401-480	75	25	-5.00	14.42	-19.42	10.91	10.00	-17.31	1
1081-1120	66	34	-1.00	10.53	-11.53	8.44	8.44	-11.53	
1241-1280	60	40	-2.00	7.93	-9.93	6.79	6.79	-9.93	
1521-1560	70	30	-6.00	12.26	-18.26	9.54	9.54	-18.26	
Line 13									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
1-40	95	5	1.00	23.07	-22.07	16.40	10.00	-7.26	7
91-200	95	5	1.00	23.07	-22.07	16.40	10.00	-7.26	7
211-240	80	20	-4.00	16.58	-20.58	12.28	10.00	-15.30	3
271-400	75	25	-1.50	14.42	-15.92	10.91	10.00	-13.81	1
811-850	65	35	-3.00	10.09	-13.09	8.17	8.17	-13.09	
901-960	52	48	-1.50	4.47	-5.97	4.60	4.60	-5.97	
Line 14									
Trace Range	PSP	PSP'	BL	DeltaBL	(BL)o	PF	PF'	(BL)o'	Unconf
The reflections of the data at the beginning of the line were clipped.									
601-720	60	40	-2.00	7.93	-9.93	6.79	6.79	-9.93	

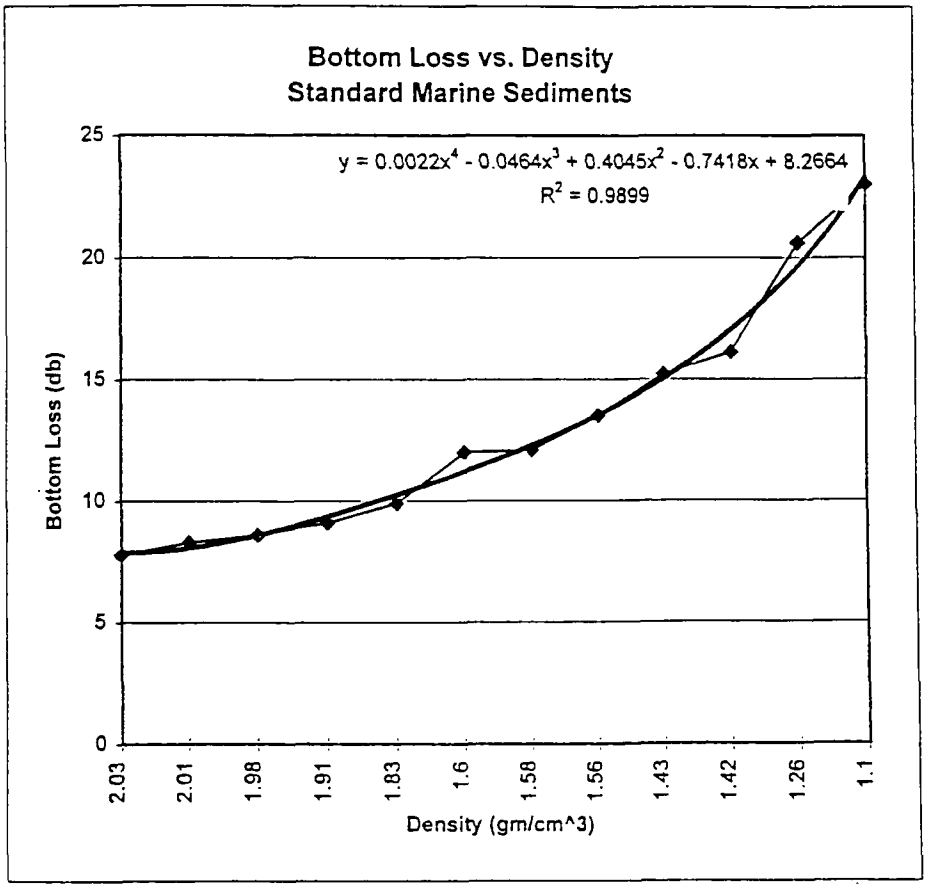
Table 1 Symbols

PSP - Plus Sign Percentage
PSP' - Complement PSP
BL - Bottom Loss (db)
Delta BL - Observed BL minus Normal Sediment (NS) BL
(BL)o - Normal Sediment BL extracted from Observed BL
(BL)o' - Corrected for end points
PF - Pollution Factor
PF' - Pollution Factor corrected for end points
Unconf - Unconfidence factor

TABLE 2

Bottom Loss - Standard Marine Sediments

Material	Density	Bottom Loss	Impedance
Sand-Coarse	2.03	7.8	3734.7
Sand-Medium	2.01	8.3	3508.7
Sand-Fine	1.98	8.6	3443.3
Sand-Very Fine	1.91	9.1	3254.5
Silty-Sand	1.83	9.9	3063.3
Silt	1.6	12	2611.1
Sand-Silt-Clay	1.58	12.1	2493.9
Sandy-Silt	1.56	13.5	2420.1
Clayey-Silt	1.43	15.2	2198.9
Silty- Clay	1.42	16.1	2157.1
Clay	1.26	20.6	1891.1
Fluff	1.1	23	1600



4.0 DISCUSSION OF RESULTS

The cross-sections for the Black Lagoon and Elizabeth Park, each a 100 meter square site, are presented along with a transect running into Elizabeth Park Channel. Bathymetric and sediment layer thickness contours are provided with estimates of volumes of depositional sediment which might be dredged. The results are presented for each major site and then an example is given on the procedures used for the computations of sediment volumes. The wide variations in spatial distribution are confirmed.

4.1 Cross-Sections for Black Lagoon Site

Plates 1 and 2, Appendix A1, are the ship navigation tracks for the Black Lagoon Site. Two plates were used to display the survey lines, as the number of survey lines were too many to place on one plot. Each survey line is identified by a four character code (BP01) and a line number. In Plate 1, the circle with a cross in the center represents the location, along each survey line of the zero subfile number of each data file. Plates 3 through 17 are the cross-sections plots of the survey line acoustical data displaying sediment type and layer identification. Each subfile position is indicated on the top of the plate by a circle with a cross through it. The navigation location for all zero subfiles is also given. The 7 KHz data and tracks were used as the prime data source. If core data was available along a track, two plates are presented. The first plate of the set plots the cross-section with the core position indicated (see Plate 3), and the second plate shows the cross-section with the core stratigraphy superimposed on the cross-section (see Plate 4). A comparison of the core stratigraphy superimposed on the acoustical stratigraphy provides a visual demonstration of the close agreement between acoustical data and physical core characterization.

The Eastern most survey line on Plate 3 (data file BP010001-subfile 1) shows considerable fluff on the seismic record. This was confirmed by the core data. This area had the most fluff of any site surveyed. Not all of the fluff appeared on the seismic records. For this fluff to exist there must be a very low current flow. It is suggested that as the current flows, the shadow of the sandbar causes an interruption in the flow allowing the sediments to deposit. Further, because of these phenomena, it is hypothesized that Black Lagoon could be a settling pond for the river flow. All of this pollution and sediments could not have originated at this site. Small amounts of fluff were also detected along the center line of this site above the polluted sediments.

In summary, the survey line cross section illustrates a thin sediment layer near the surface, often less than a meter in thickness, often demonstrating a high degree of spatial

variation. Layers of silt, silty sand, sandy silt, sand, clay and foam/fluff at the water sediment interface were observed. In some locations the hard compacted sediment, hard pan, is exposed at the surface. The overlay of core stratigraphy on the acoustical stratigraphy demonstrated close agreement.

Plate 18 is a distribution map of surface depositional sediments by density group types. Figure 28 is a color printout of this same distribution map. The spatial variations in sediment type are confirmed showing sediment deposition in various pockets. Fine grain soft sediment, silt or clay, seem to have been deposited along the shore line. The heavier sediments, silty-sands are deposited along the Eastern side of the site out toward the center of the channel in areas of stronger current.

The depth and surface area of potentially dredgeable sediments have been estimated for Black Lagoon as follows:

Sediment Layer Greater Than	Volume of Dredgeable Sediment
1 meter	3070 cubic meters
0.5 meters	5430 cubic meters

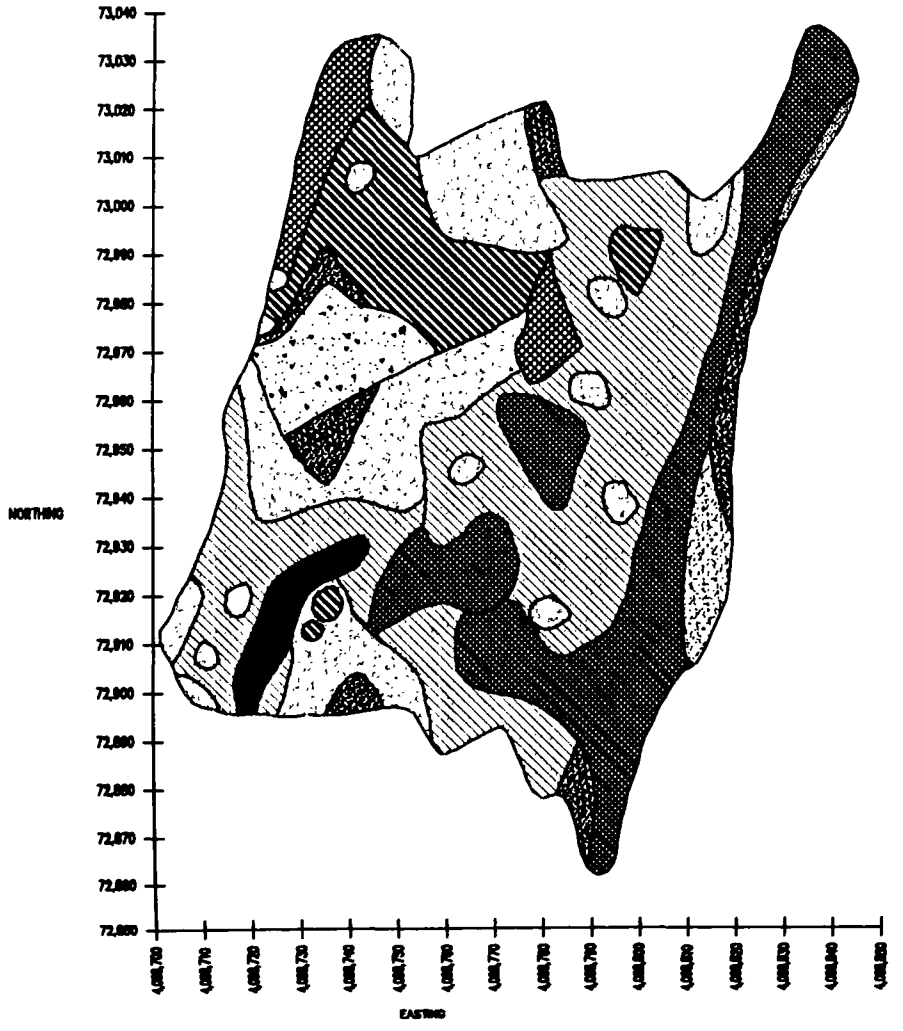
4.2 Cross-Sections for Elizabeth Park Site

Several seismic survey lines were run in the Elizabeth Park site using different frequencies. Plate 19, Appendix A1 displays these survey line. Plates 20 through 29 show the survey line cross section plots of acoustically characterized sediment layers. Again, the 7 kHz data were used as the prime data source with the other frequencies being used to aid interpretation. Cross sectional plots of survey lines with core data are again presented in sets with the second plate showing the core stratigraphy as an overlay of the acoustically developed stratigraphy.

The northern portion of this site contained anomalous depositional sediment of silty-sands and clay. However this site exhibited less anomalous depositional sediment than Black Lagoon as measured by the deviation of site sediment bottom loss values from the standard marine sediment bottom loss values. This is reasonable as the river floor is more uniform in this area as compared to Black Lagoon indicating the potential for more uniform sediment erosion by water current and less tendency for pockets of sediment deposition to form. As in Black Lagoon, thin layers of fluff were again found in the northeast portion of the site.

In general the east survey lines exhibited large areas of hard compacted sediment exposed at the sediment surface with some sediment deposition occurring where depressions in the hard pan provided a protected area for deposition. Such a case is

Color map of Black Lagoon sediment classifications. Figure 28



exemplified in plate 20 "E7010009" subfile 04 and 05 at the location of core 10. Movement west towards shore exhibited an increase in the number of sediment pockets and an increase of depositional sediment surface area. The Elizabeth park site on the whole exhibited fewer and thinner layers of depositional sediment than Black Lagoon.

Plate 30 is a distribution map of depositional surface sediments. Figure 29 is a colored version of the same map. The spatial variations are confirmed with depositional sediments located in various pockets. However, a comparison with the surface map for Black lagoon shows the increased presence of surface hard pan. Along the southwestern shore line, the fine grained sediments seem to have been sparsely deposited with most of the depositional sediments being silts or clays. The heavier sediments, silty-sands are deposited along the northern and northeastern side of the site. The depositional sediments are also relatively thin in this site with most of the sediments being trapped in bottom depressions.

The estimated dredge volumes for Elizabeth Park were as follows:

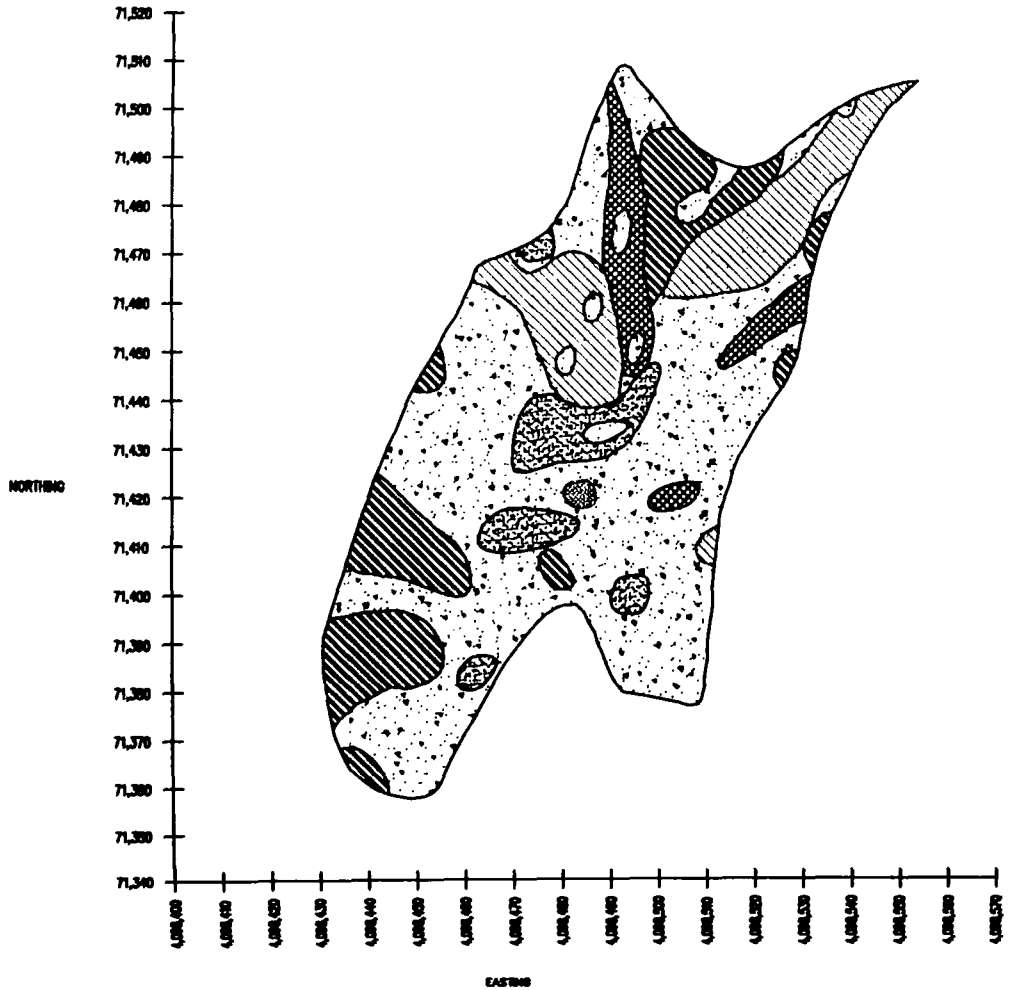
Sediment Layer Greater Than	Volume of Dredgeable Sediment
0.5 meters	210 cubic meters
0.25 meters	530 cubic meters

4.3 Cross-Sections for Elizabeth Park Channel

Several seismic survey lines were run down the center of the Elizabeth Park North Channel site using different frequencies. The channel is a shallow narrow tributary entering the Trenton Channel. The shallow water depth and the narrowness of the channel width allowed only multiple passes over a center line running down the channel. The boomer, 700 Hz frequency, data were used to obtain the cross-section for the Channel (Plate 31). The boomer was needed to provide sufficient energy to penetrate the sediments which exhibited a high degree of sound adsorption possibly due to high concentrations of contaminants/gas in the sediment areas from file EB030023 to EB030029 on Plate 31. The intermediate sediment layering in areas away from the cores is estimated from the low frequency, low resolution data. The navigation map for this line is shown in Plate 19.

The channel has a very shallow hard pan section at the mouth where the channel enters into the Trenton Channel. This exposure of hard pan is the result of the erosion by the higher current velocity. Plate 31 file EB030029 - file EB030031 displays the location of the hard pan. Moving up the Elisabeth Park channel the effects of the Trenton Channel current decrease and sediment deposition occurs. Deposits of clay overlying silt which overlies silty sand represents the primary layering. However, one area of silt exposed at the surface over lying silty sand was also encountered. This decrease in current velocity has allowed the fines, contaminated silt and clays, to accumulate in the Channel as shown

Color map of Elizabeth Park sediment classifications. Figure 29



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF	
	SILTY CLAY	
	CLAY	
	SILT	
	SILTY SAND	
	SAND	
	ROCK, HARD/COMPACT	

0 10 20m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING		
TITLE: ELIZABETH PARK SEDIMENTS		
DRN BY: DC	SCALE: 1:1000	DATE: 20/1/97

in Plate 31. The cores for the site are shown in the adjacent plate, Plate 32. A comparison of core stratigraphy to acoustically estimated density group stratigraphy once again demonstrates close agreement.

Depositional sediment volume estimates where made by noting that the available surveyed Channel length, where sediment deposits occurred, is approximately 18 meters long. Also, it was assumed that there was a linear change of hard pan depth to each of the nearby shorelines, which averaged 10 meters on each side of the survey line. The mean sediment thickness of 2.1 meters occurred along the center of the survey line between files EB030023 and EB030029. These assumptions yielded a calculated total dredgeable volume of 378 cubic meters.

4.4 Estimating Sediment Volumes - Black Lagoon

Because this is the first time for the application of the techniques discussed in this report and combined with the ship handling problems, many of the procedures were accomplished through semi-manual processing. Using Black Lagoon as an example, the step by step procedures used and the results are presented in the following subsections.

4.4.1 Step 1: Data Sampling and Contour Plots Generation

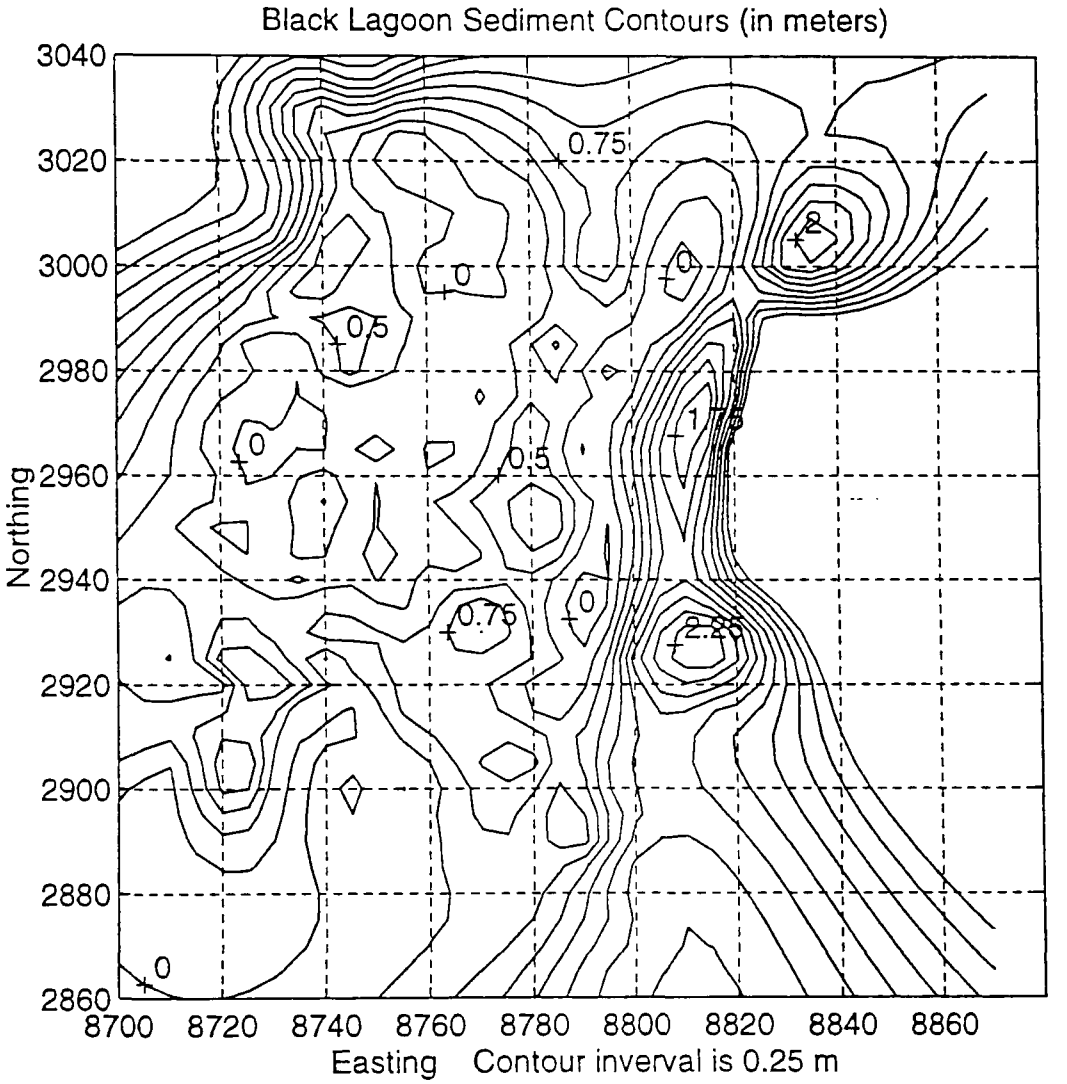
The AutoCAD plots were used to construct ASCII (TEXT) files, Figure 30, containing the position coordinates and the water depth and thickness of sediment in meters at that position. In Figure 30 "Top" refers to the water depth to the sediment surface and "Bottom" is the depth from the surface to the bottom of the depositional sediment layer. A data set for each of the cross-sections in the Black Lagoon site was constructed following this format. These data sets were then used to create several plots.

A Matlab program, FLAYER3.M, was constructed to generate the contour plots of the sediment thickness. Appendix A2.3 provides a listing for this program. The data is first interpolated onto a grid and then plotted as contours. Figure 31 shows the output plot with all the contours of sediment thickness shown in quarter meter increments. For ease of plotting computations, the Northing and Easting position coordinates were adjusted to show only the last 4 digits. To convert to the true Northing scale, add 70,000 meters to the listed Northing, and to convert to the true Easting scale, add 4,090,000 meters to the listed Easting. A five-meter increment was chosen for the interpolated grid size of the plot. This grid size generated coupled with the mean depositional sediment thickness in the grid generated a cube with a given volume. Summing the volumes in each grid, cube produced the total computed dredgeable volumes. Smaller grid spacing values produced no significant improvement in resolution; however, larger grid spacing values degraded the detail.

Northing	Easting	Top	Bottom
72863.75	4098790.87	5.3	6.7
72868.16	4098793.02	4.9	6.3
72872.56	4098795.17	4.6	5.9
72879.09	4098796.34	4.5	5.9
72885.62	4098797.51	4.4	5.8
72891.48	4098800.42	4.3	5.6
72897.33	4098803.33	4.0	5.3
72906.55	4098809.52	3.8	5.1
72915.77	4098815.71	3.5	4.8
72927.81	4098816.77	2.9	5.4
72939.85	4098817.83	1.9	2.5
72952.83	4098818.42	1.1	1.1
72965.80	4098819.00	1.0	1.0
72977.70	4098822.01	1.1	1.1
72989.60	4098825.02	1.6	1.6
73001.25	4098831.25	2.0	4.1
73012.87	4098837.49	2.5	4.3
73015.44	4098839.58	3.0	4.5
73018.00	4098841.67	3.3	4.6
73022.15	4098842.44	3.7	4.7
73026.31	4098843.21	4.0	5.0
73029.86	4098841.72	4.1	5.1
73033.41	4098840.24	4.2	5.2
73034.68	4098836.85	4.2	5.3
73035.96	4098833.45	4.3	5.4

List of geographic coordinates and top & bottom of sediments for line 2

Figure 30



Add 70,000 m to Northing

Add 4,090,000 m to Easting

Contour map of Black Lagoon sediment thickness.

Contours from 0.00 to2.25 m

Figure 31

As an aid in planning dredging activities, the above plot was re-plotted for sediment thickness contours greater than 1 meter, Figure 32, and for sediment thickness contours greater than 0.5 meter, Figure 33. These two minimum depths were targeted as probable practical dredging limits.

Only the contours within the survey boundary have correct values. The extrapolation techniques produce some data corruption outside of the survey area. Another Matlab program, FLINES.M (Appendix A2.4), was generated to display the extent of the survey lines on the same scale as the contours. Figure 34 shows this output. The extent of the valid contour data is determined by connecting adjacent ends of lines to enclose the area of the survey as shown in Figure 35. The extent of the valid contours is displayed by superimposing the outer bound data of Figure 35 onto the contour plots as shown in Figures 36 and 37.

4.4.2 Step 2: Dealing with Extrapolated Grid Values.

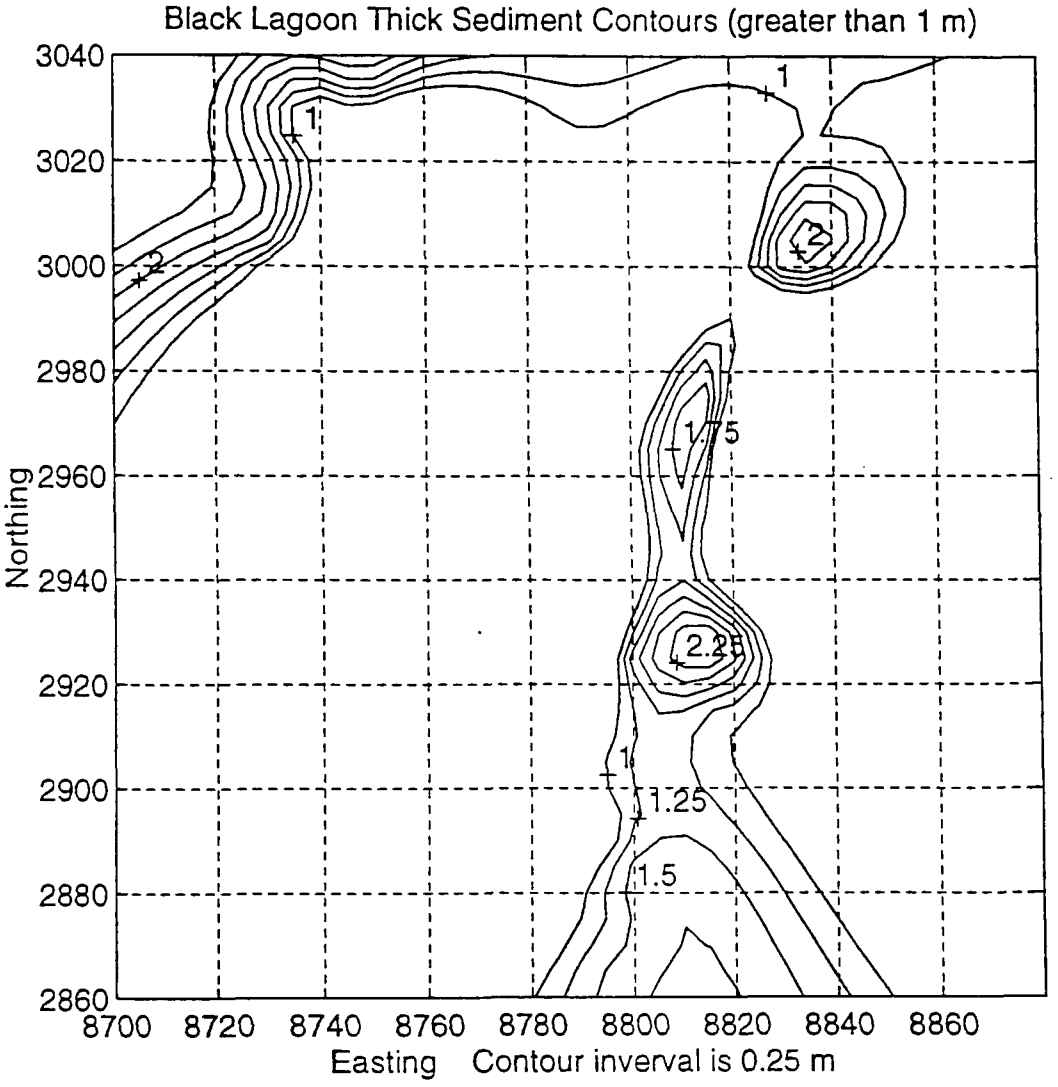
The dredging volume estimates are calculated from the interpolated grid values saved to disk by Program Listing 5, Appendix A2.3. Figure 38 illustrates a listing of some of these values, as output by MATLAB, in ASCII format. The information is the Easting, Northing, and sediment thickness on a regularly spaced grid line. The data set was reformatted as shown in Figure 39. The data has been changed from exponential format into fixed decimal for easier reading. More importantly a fourth value is added to indicate whether the point was inside or outside of the survey area. A value of 1 means that the position is inside the survey area, whereas a zero indicates an extrapolated data point. Data was accumulated in these formats for the entire site and then used to compute the volumes of sediment.

4.4.3 Step 3: Two Volume Estimates for Black Lagoon

Sediment thickness contouring using a depositional sediment thickness criteria of 1 meter or greater identified 3 depositional areas. In Figure 40 these areas are labeled 1a, 1b, and 2. Figure 41 shows 7 depositional areas selected using a sediment thickness contour interval criteria of greater than a 0.5 meter. Volume estimates were calculated for each of these areas using the Matlab program, Listing 7 (Appendix A2.5). This program calculates the total volume subject to the following constraints:

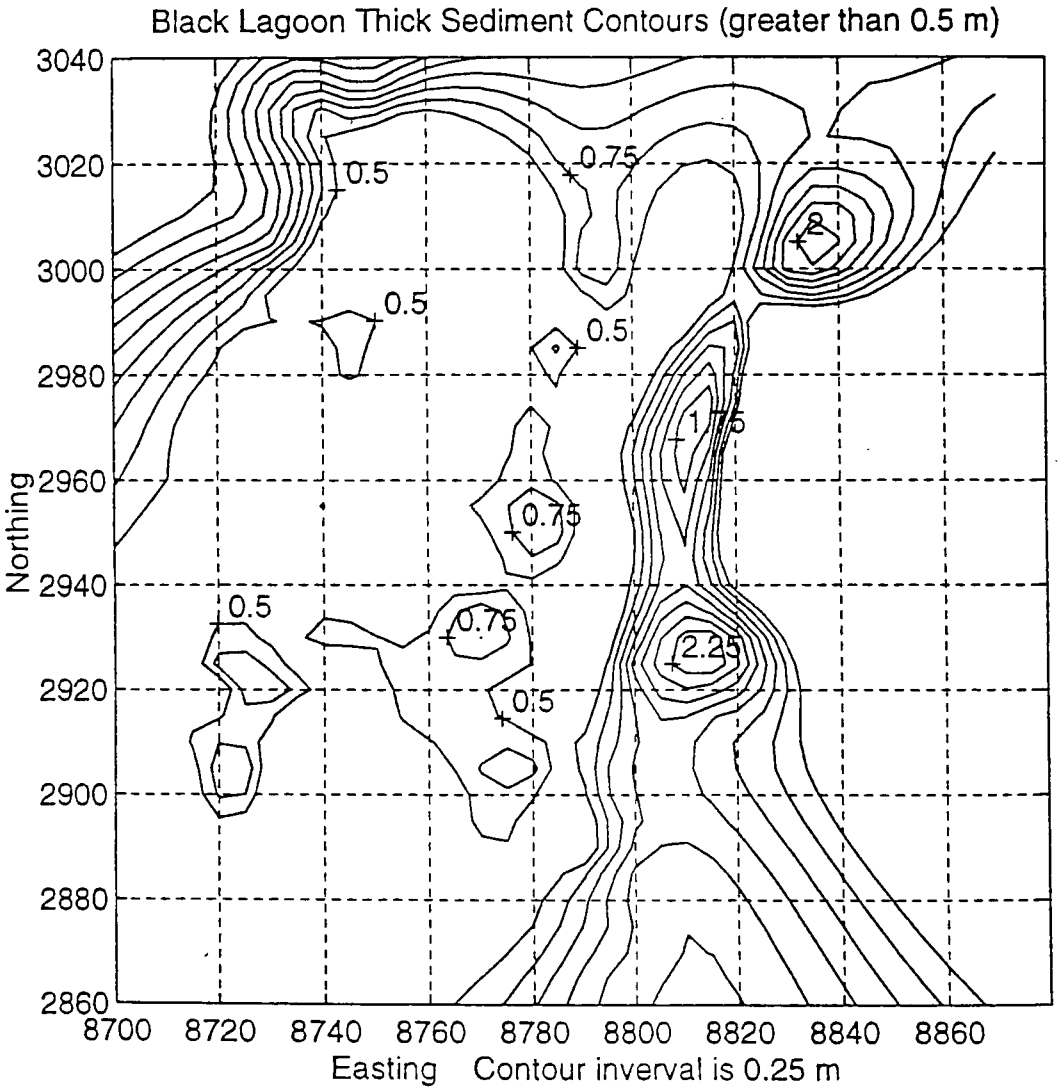
- A specified range of Northing values.
- A specified range of Easting values.
- The thickness must be greater than the minimum contour interval criteria selected.

The program uses the flag encoded information in the input data set to automatically reject values outside of the survey area. When a given data point satisfies the criteria, the sediment depth is added to a running total. Finally, when there are no



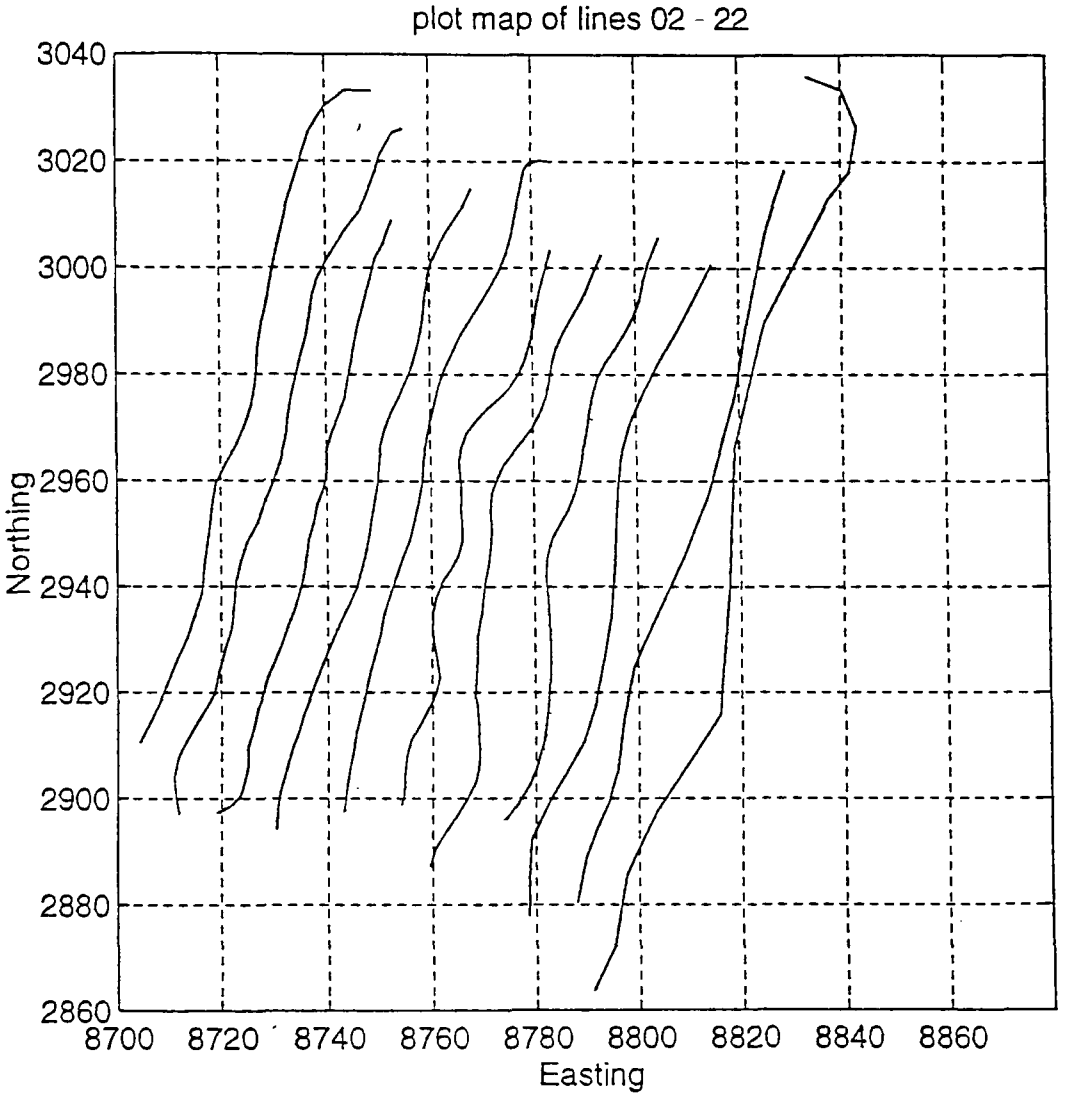
Contour map of Black Lagoon.
Sediment depth of 1.0 m or more

Figure 32



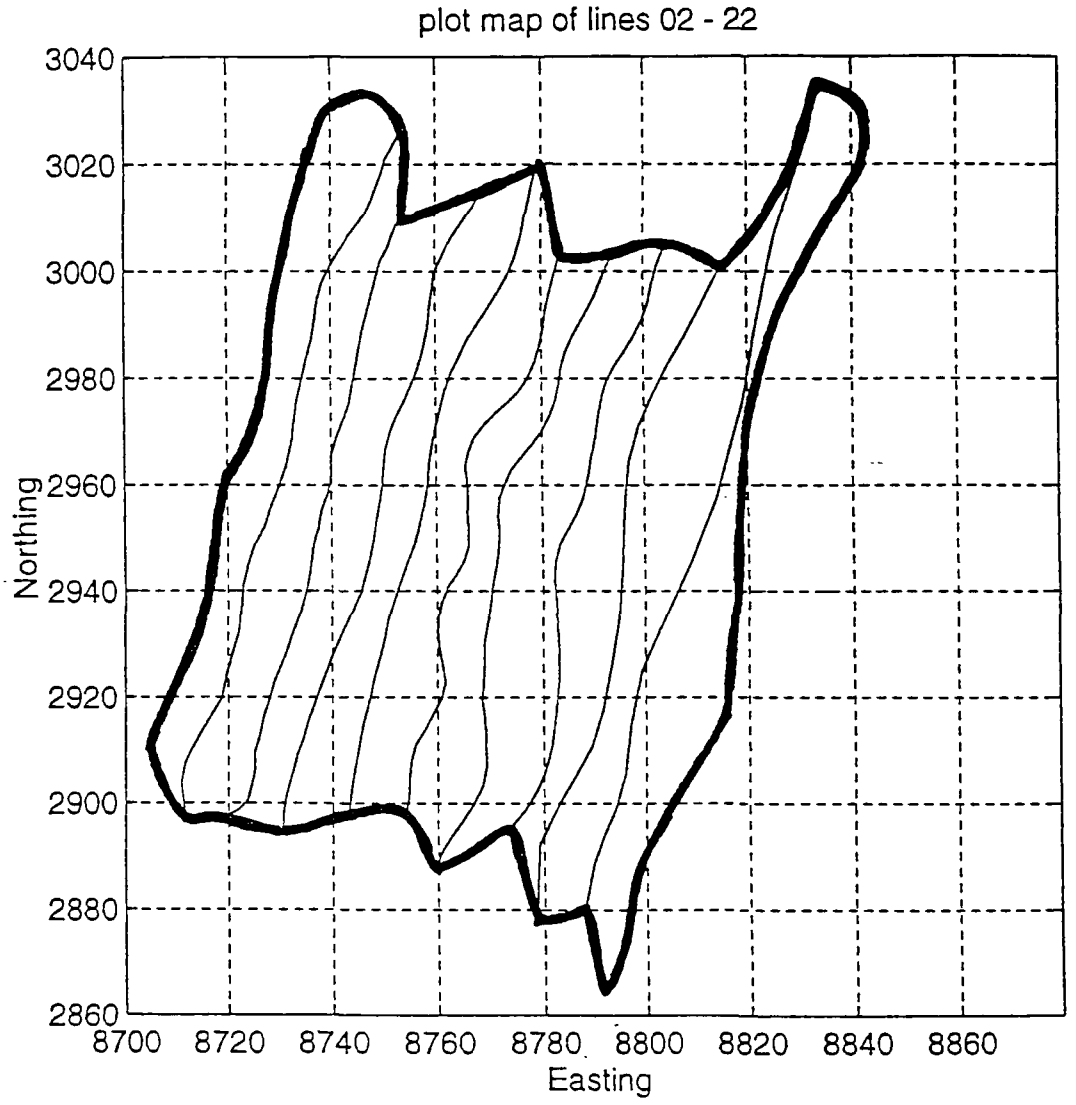
Contour map of Black Lagoon.
Sediment depth of 0.5m or more

Figure 33



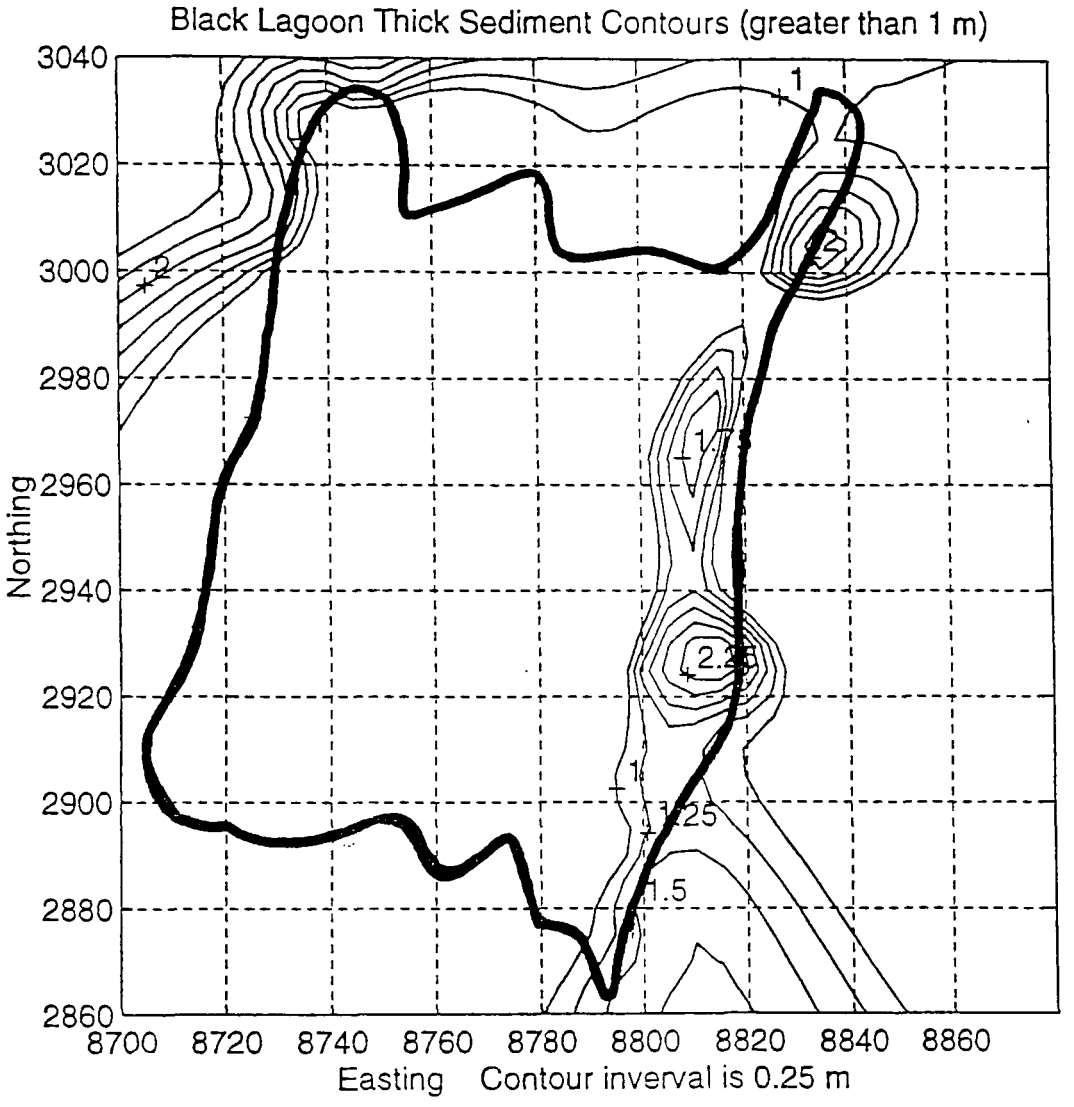
Geographical extent of Black Lagoon Survey Lines.

Figure 34



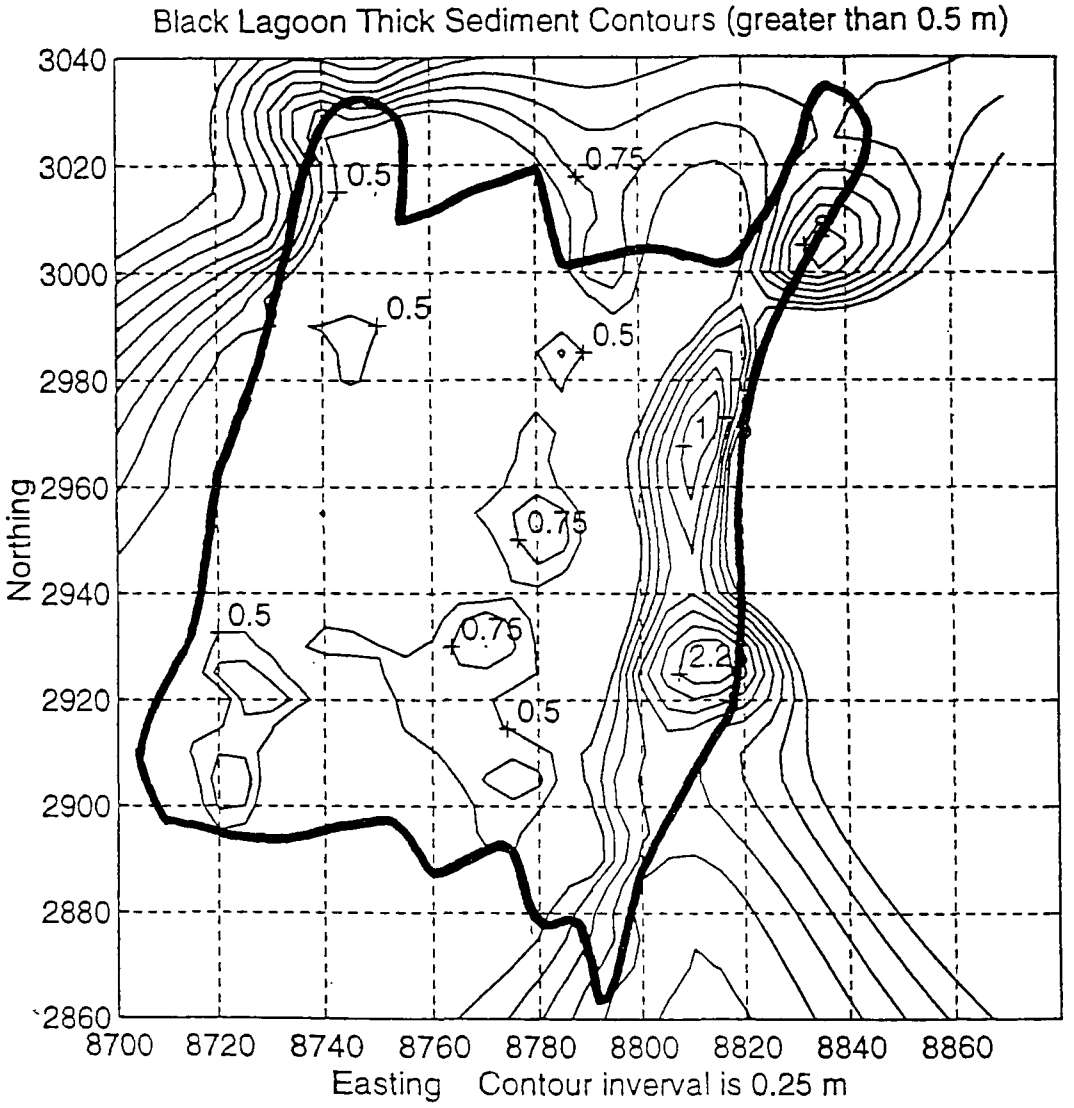
Geographical extent of data integrity.

Figure 35



Geographical extent of valid contours, 1m and greater.

Figure 36



Geographical extent of valid contours greater than 0.5m.

Figure 37

Easting	Northing	Layer Thickness
8.7350000e+003	2.9900000e+003	4.7742731e-001
8.7350000e+003	2.9950000e+003	1.8752866e-001
8.7350000e+003	3.0000000e+003	4.3373187e-001
8.7350000e+003	3.0050000e+003	9.7079171e-001
8.7350000e+003	3.0100000e+003	1.3096406e+000
8.7350000e+003	3.0150000e+003	1.4364769e+000
8.7350000e+003	3.0200000e+003	1.3634478e+000
8.7350000e+003	3.0250000e+003	9.7386564e-001
8.7350000e+003	3.0300000e+003	9.7317738e-001
8.7350000e+003	3.0350000e+003	1.4457003e+000
8.7350000e+003	3.0400000e+003	2.0303591e+000
8.7400000e+003	2.8600000e+003	1.3103892e-001
8.7400000e+003	2.8650000e+003	7.3050225e-002
8.7400000e+003	2.8700000e+003	3.3442422e-002

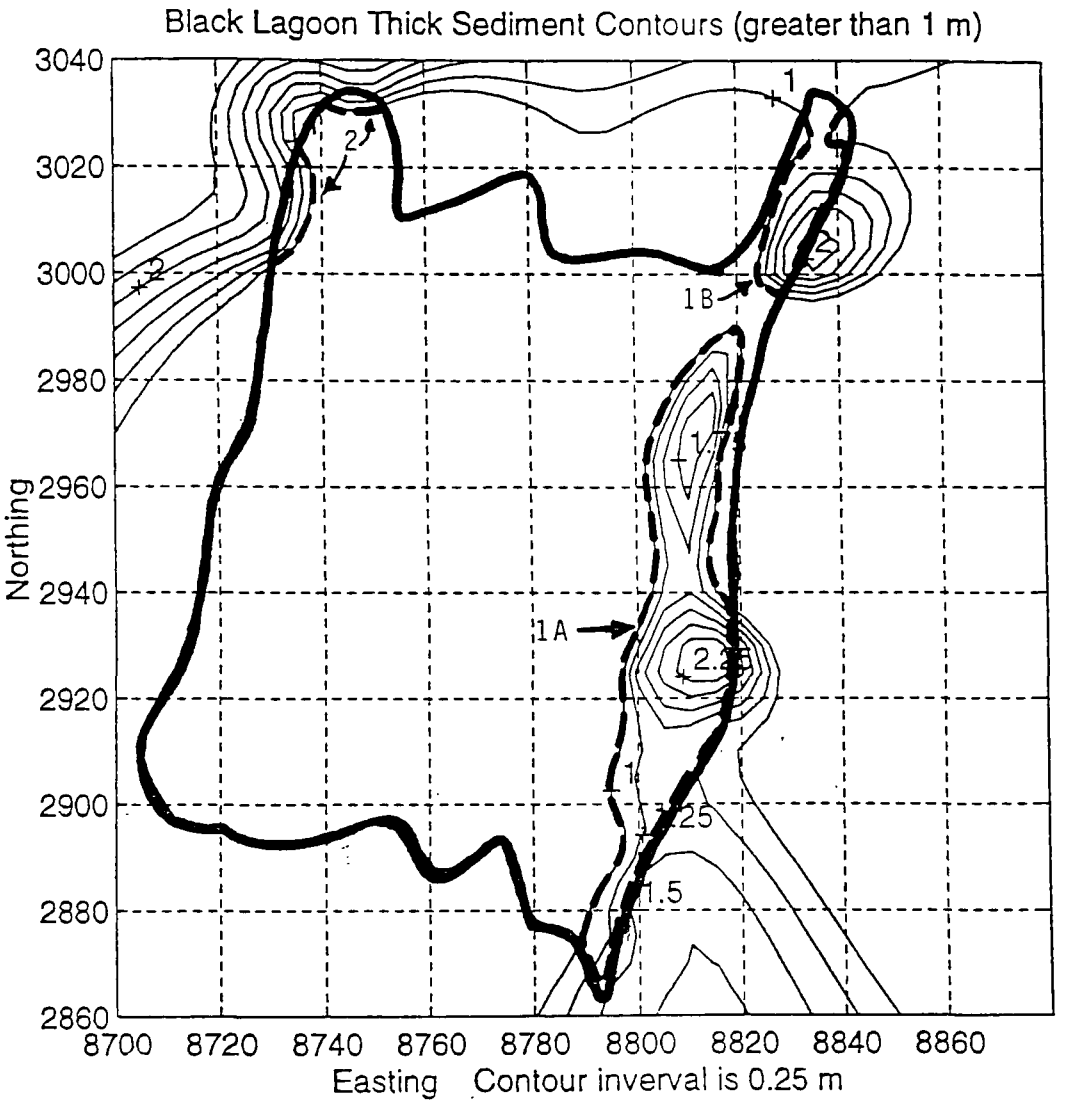
List of MATLAB output.
Thickness interpolated/extrapolated into a uniform grid.

Figure 38

Easting	Northing	Thickness	Inside/Outside Flag
8735.00	2990.00	0.48	1
8735.00	2995.00	0.19	1
8735.00	3000.00	0.43	1
8735.00	3005.00	0.97	1
8735.00	3010.00	1.31	1
8735.00	3015.00	1.44	1
8735.00	3020.00	1.36	1
8735.00	3025.00	0.97	0
8735.00	3030.00	0.97	0
8735.00	3035.00	1.45	0
8735.00	3040.00	2.03	0
8740.00	2860.00	0.13	0
8740.00	2865.00	0.07	0
8740.00	2870.00	0.03	0

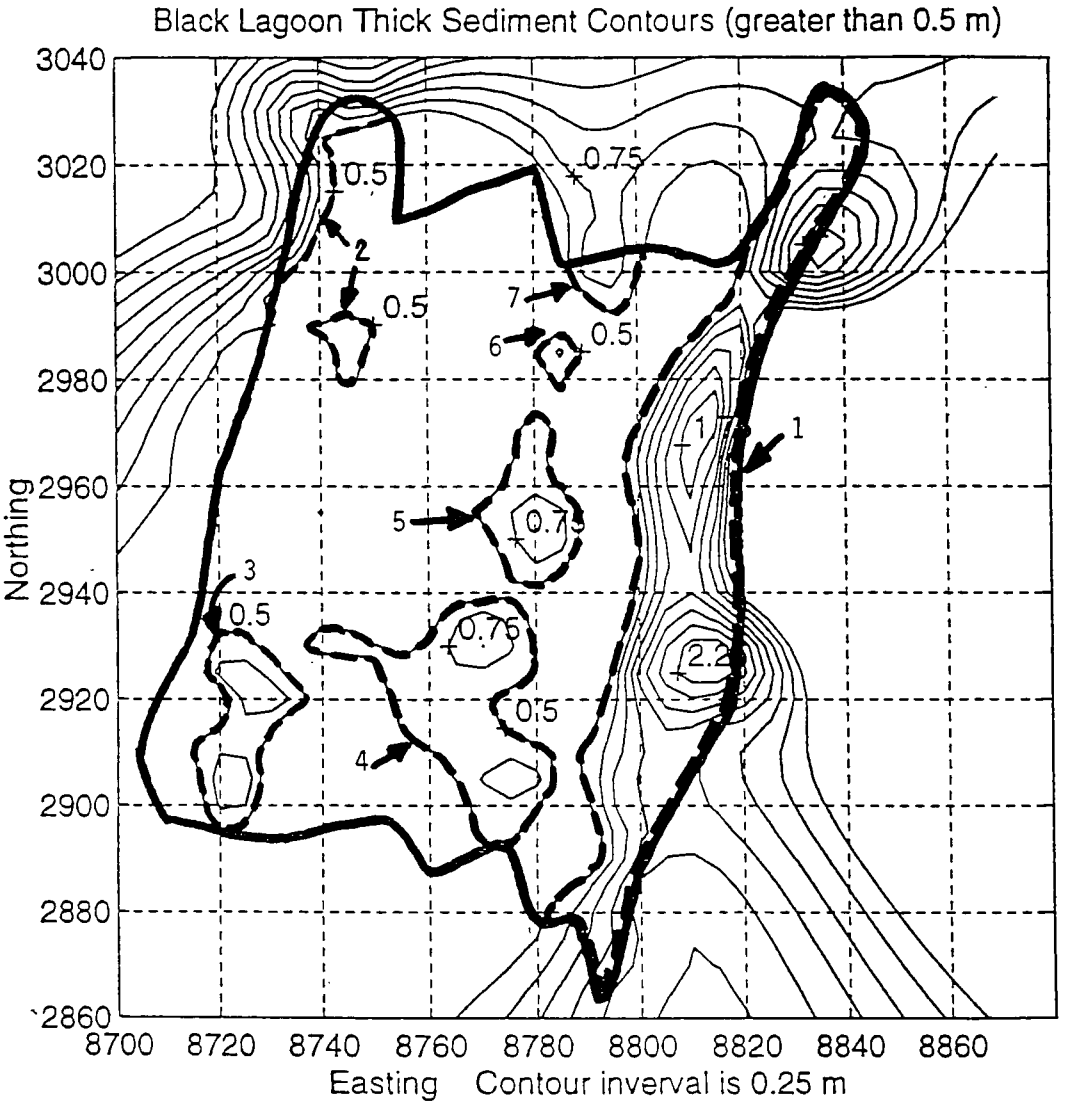
Regular grid data in fixed decimal format with a validity flag.
Valid data is inside the survey.

Figure 39



Suggested dredging sites based on 1.0m minimum depth.

Figure 40



Suggested dredging sites based on 0.5m minimum depth.

Figure 41

more points to consider, the sum total depth is multiplied by the grid increment in both the Northing and Easting directions to give the volume estimate. The results are echoed back to the MATLAB Command window where they were printed as shown in Figure 42. A safety margin of 10 percent was added and the numbers were then rounded off. This safety margin was used to compensate for the fact that an interpolation cube consisting of grid size and sediment thickness might have missed some sediments because of the high spatial variability in the sediment structures. Figures 43 and 44 show estimated volumes using, 1 meter and 0.5meter contour criteria, respectively.

For discussions above, the volume estimates were prepared in a semi-manual manner. With better ship handling in the future and improved navigation interfaces, much of this semi-manual work can be automated. However, the present manual data base and procedures will allow calibrations of future automated programs. The correct automation procedures will depend on the spatial variations expected and knowledge of the optimum grid size before hand. As shown earlier in this report, the spatial variations were much greater than expected and prevented the immediate use of off the shelf software.

Figure 45 illustrates the bathymetry for the Black Lagoon site a product of the Matlab program. The Matlab program, FWDEP.M (Appendix A2.6), was used to generate these contours. The bathymetry of the Black Lagoon study site illustrates the sand bar located in the north east corner which the sediment density group analysis identified as silty sand over slightly more compacted silty sand and sand. Moving in toward shore, deeper water and sediment depositional areas are encountered .

4.5 Estimating Sediment Volumes - Elizabeth Park

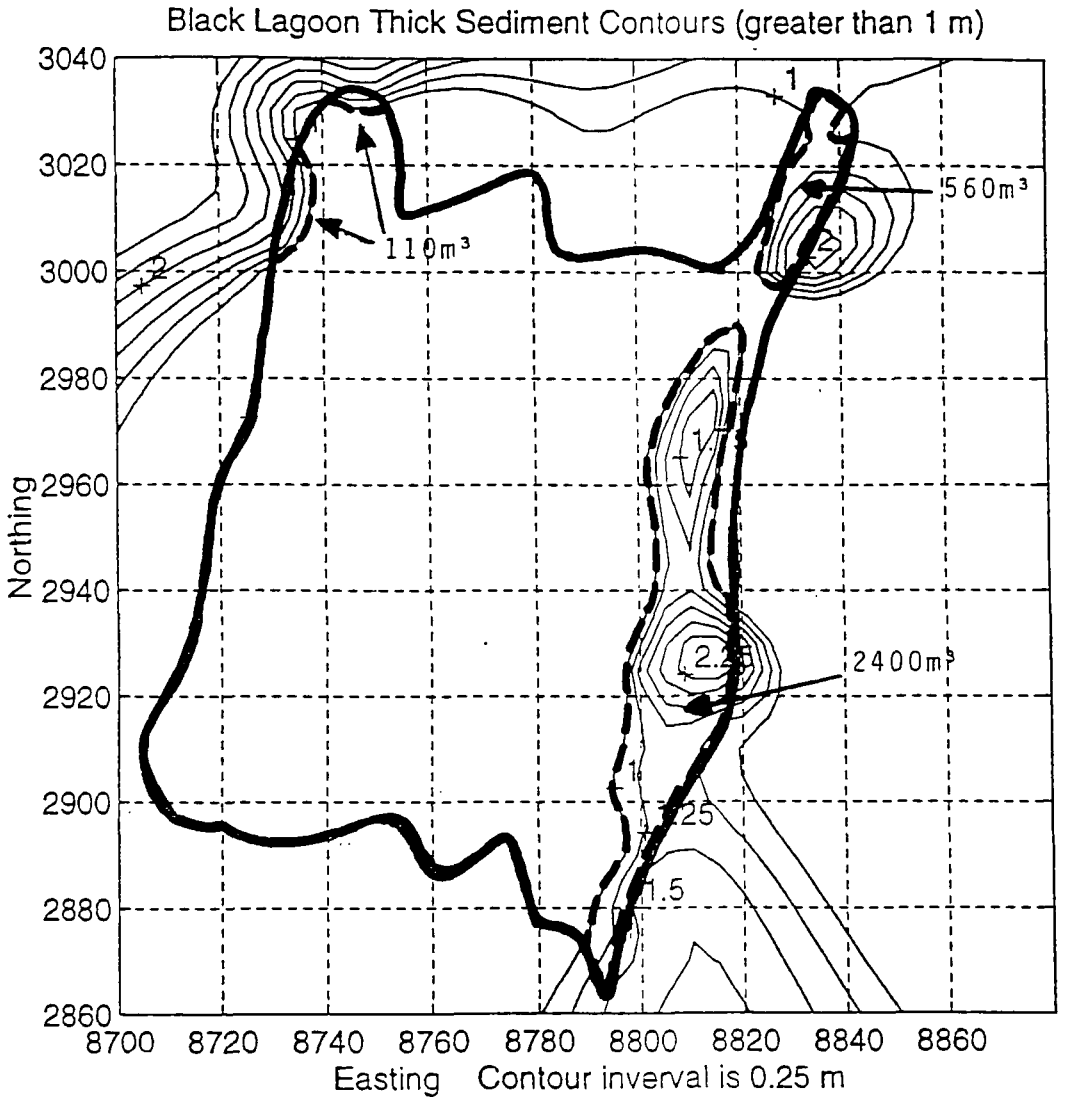
The Matlab programs developed above for Black Lagoon were only modified for the different data set names, and then used to generate the estimated sediment volumes for the Elizabeth Park site. Program Listing 9 is provided in Appendix A2.7 to illustrate the different data set name changes. No sediment thickness contours greater than 1 meter were found at the Elizabeth Park site, therefore a minimum contour interval of 0.25 meter and 0.5 meter were selected. The sediment contour plots for these contour intervals are shown in Figures 46 and 47. It is expected that dredging a layer of thickness 0.25 meters is unrealistic. The plot was provided to give a better understanding of the area. The actual survey line positions, shown in Figure 48, were plotted to determine the site for contouring boundary.

Figures 49 and 50 shows the contours within the limits of the actual survey data for both the minimum 0.5 meter and 0.25 meter minimum thickness contouring respectively. The areas of sediment deposition are highlighted and the volume estimates calculated. The 0.25 contour criteria, Figure 50, identified a small number of sediment deposits in the center of the survey site that are not highlighted. These deposits were identified as sand and not included in the dredging volume computations.

```
» fvol
northmin2 =
        2890
northmax2 =
        2935
eastmin2 =
        8710
eastmax2 =
        8735
minthick2 =
    0.5000
thick2 =
   12.5900
vol3 =
  314.7500 ⟹  350m³
```

Output from program fvol for Area 3 of Black Lagoon and target thickness of 0.5m. 10% is added and result is rounded off.

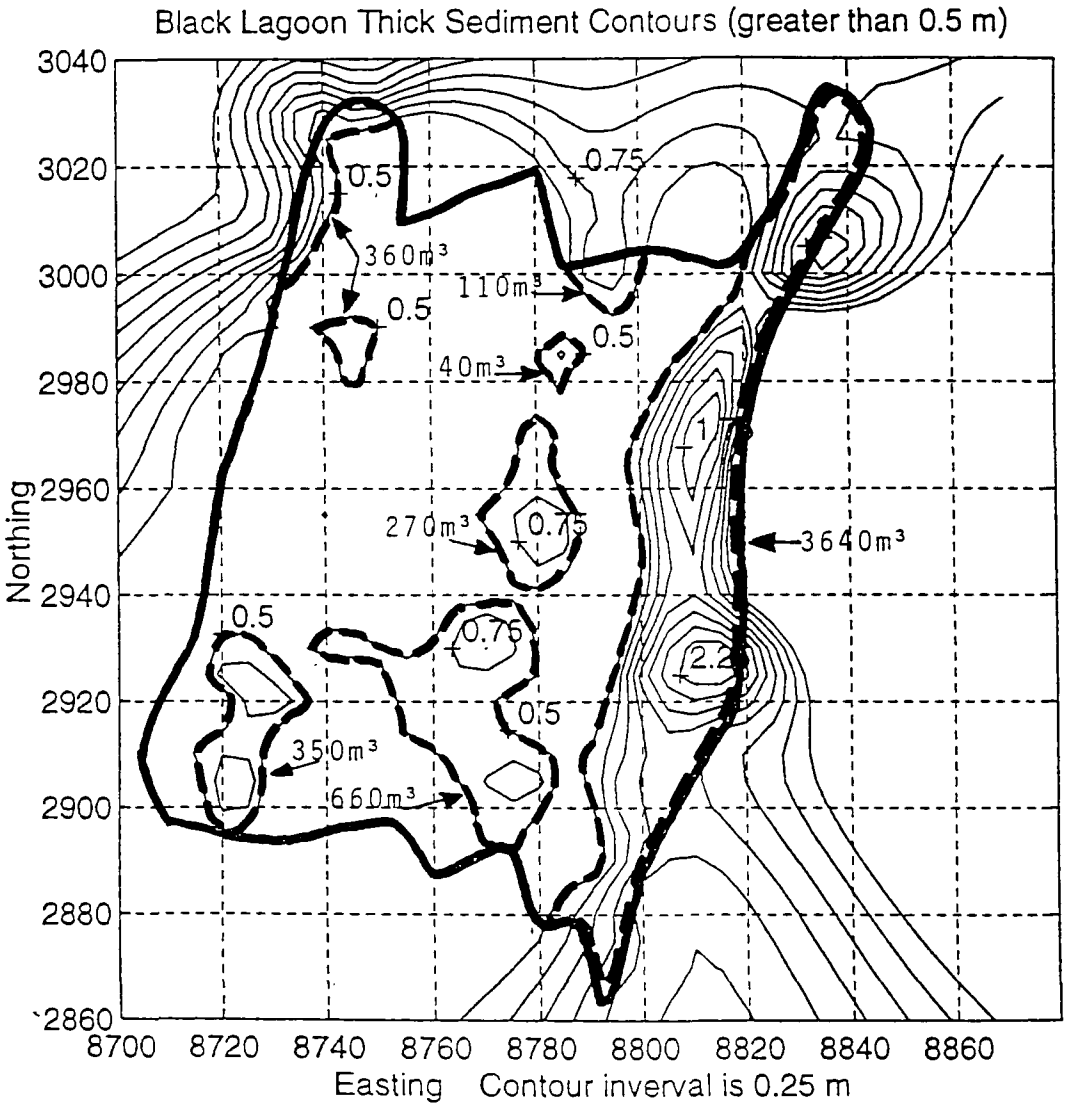
Figure 42



Total value = 3070m³

Volume estimates for suggested dredging sites. (Based on 1m target.)

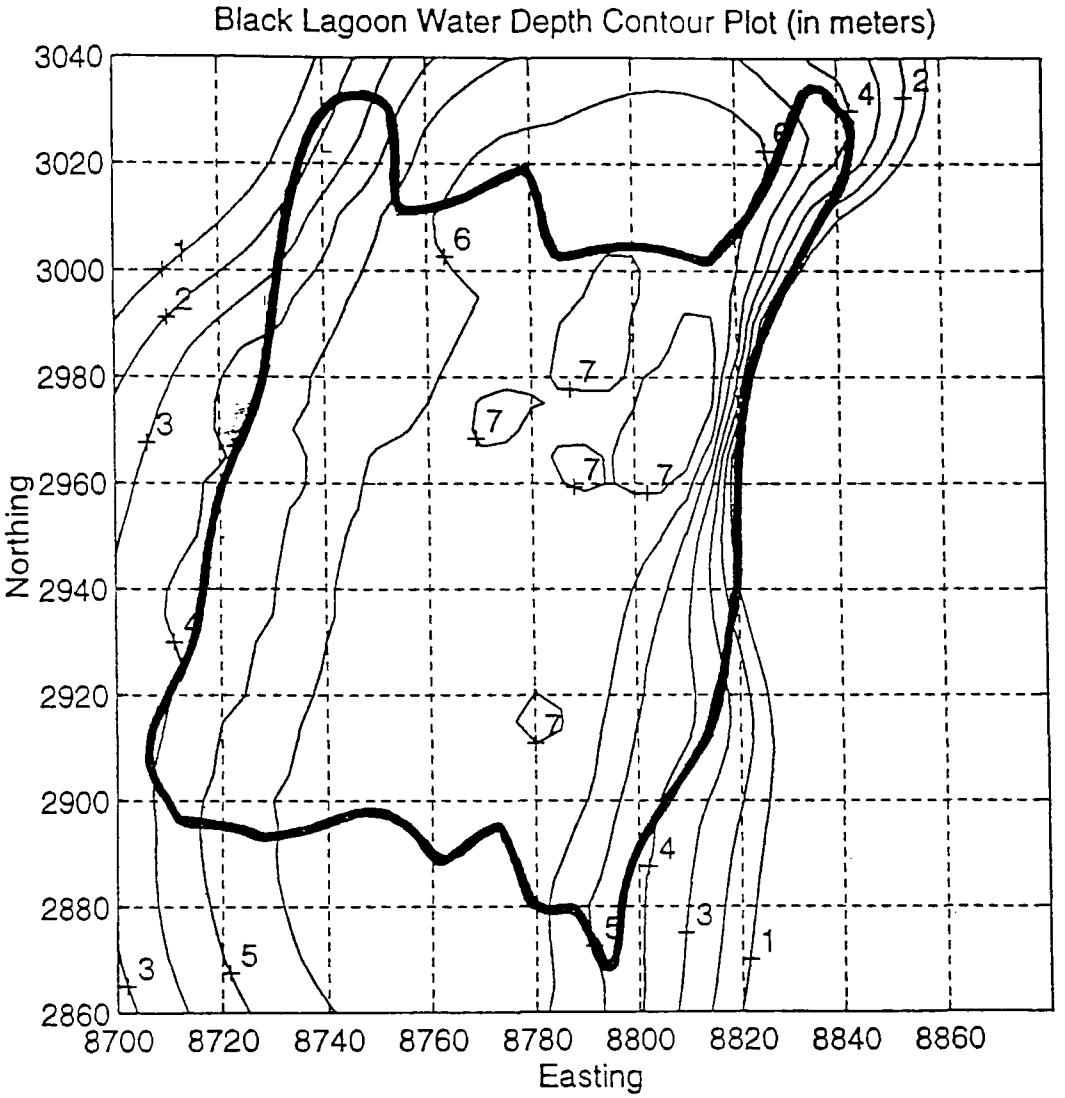
Figure 43



Total volume = 5430m³

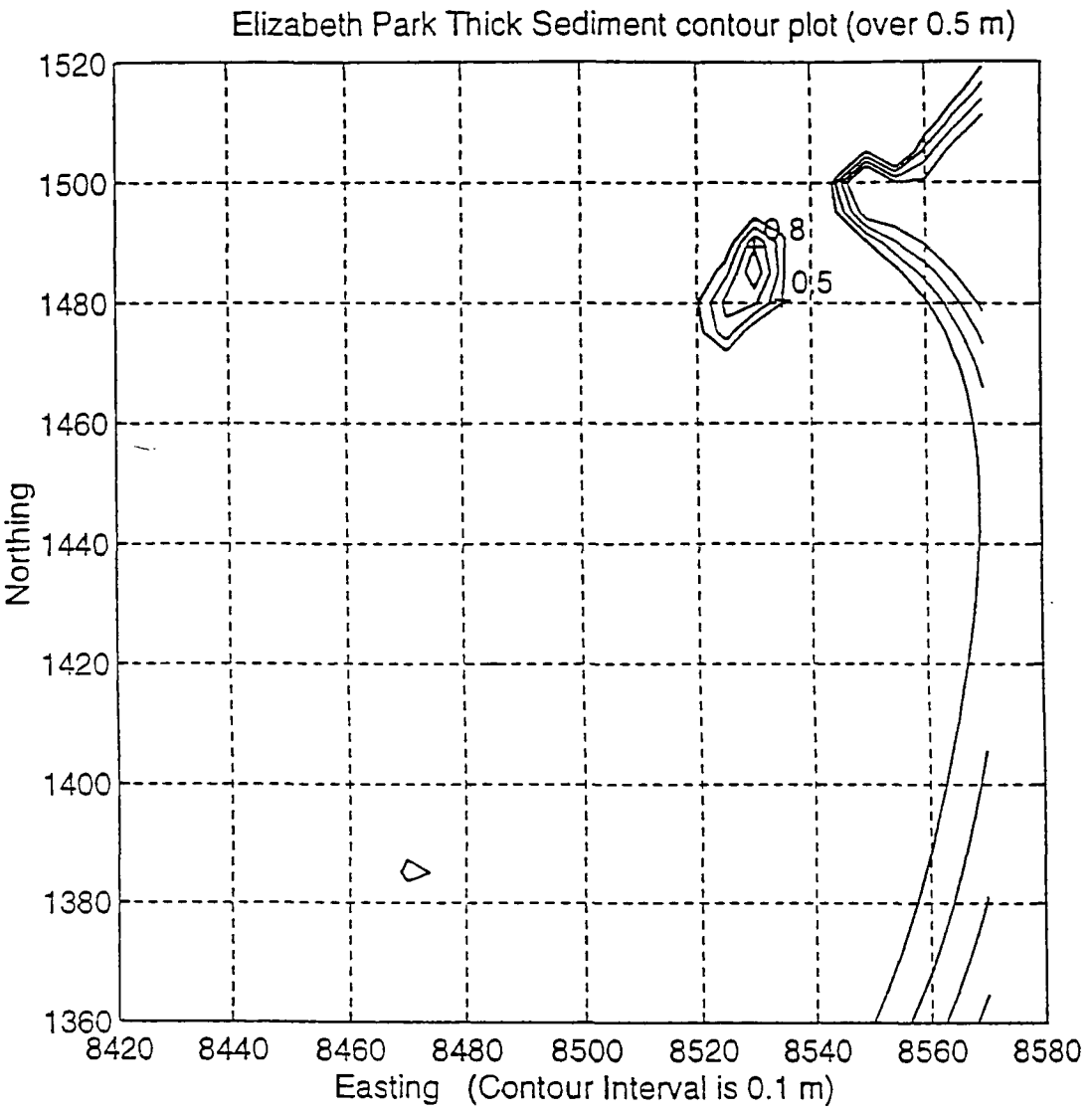
Volume estimates for suggested dredging sites. (Based on 0.5m target depth.)

Figure 44



Black Lagoon Bathymetric Contours.

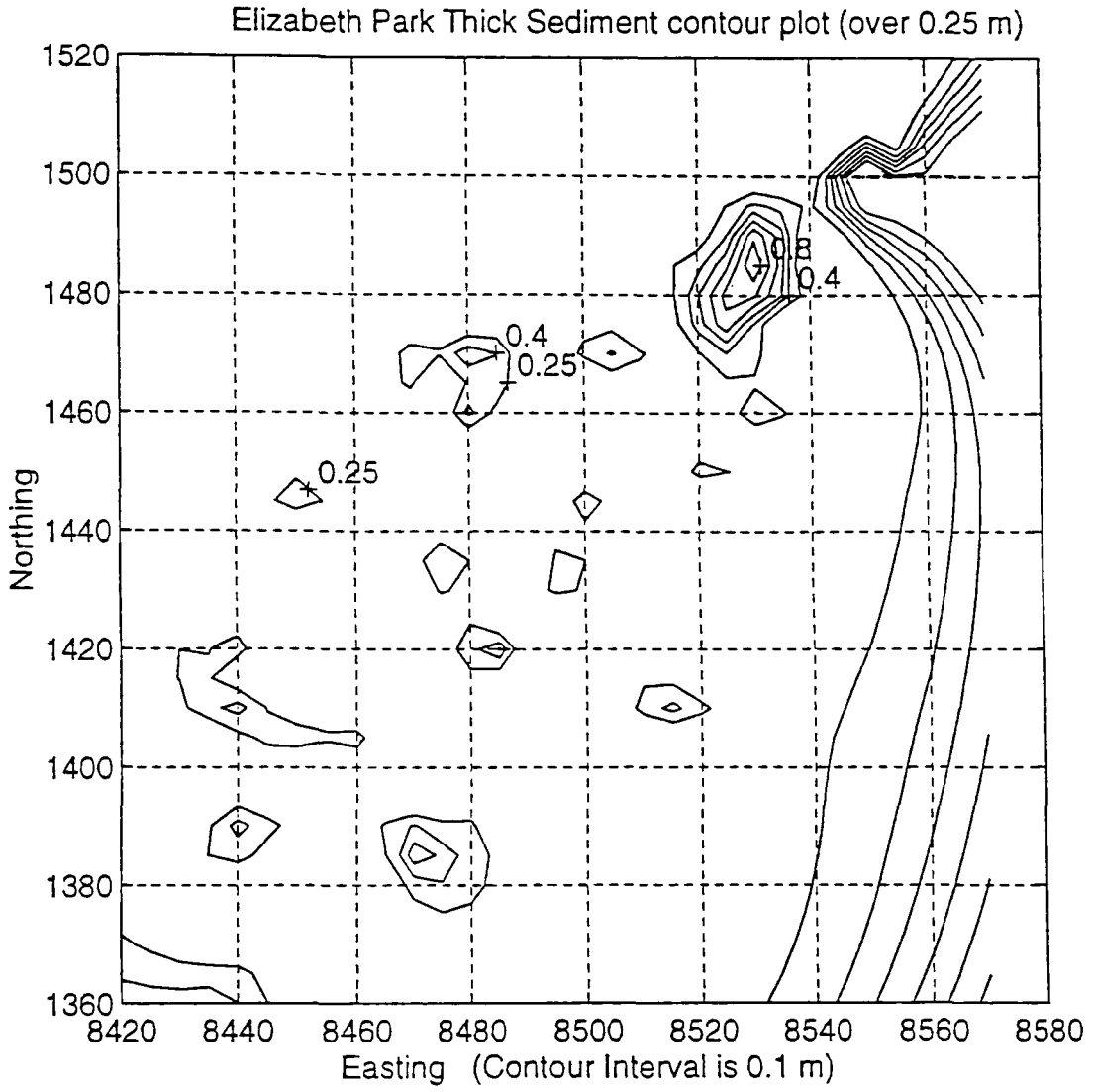
Figure 45



Contour map of Elizabeth Park.

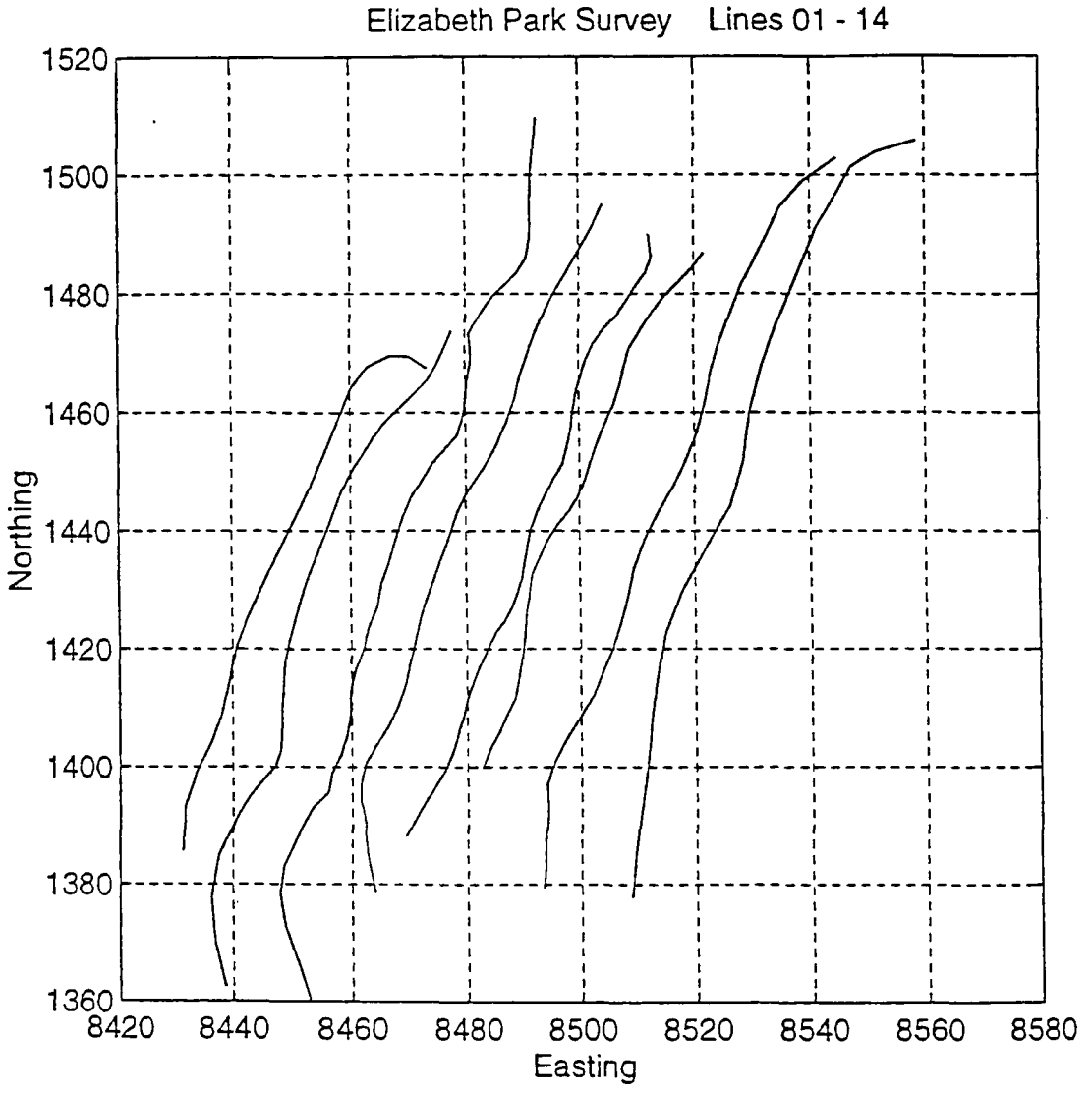
Sediment depth over 0.5 meters.

Figure 46



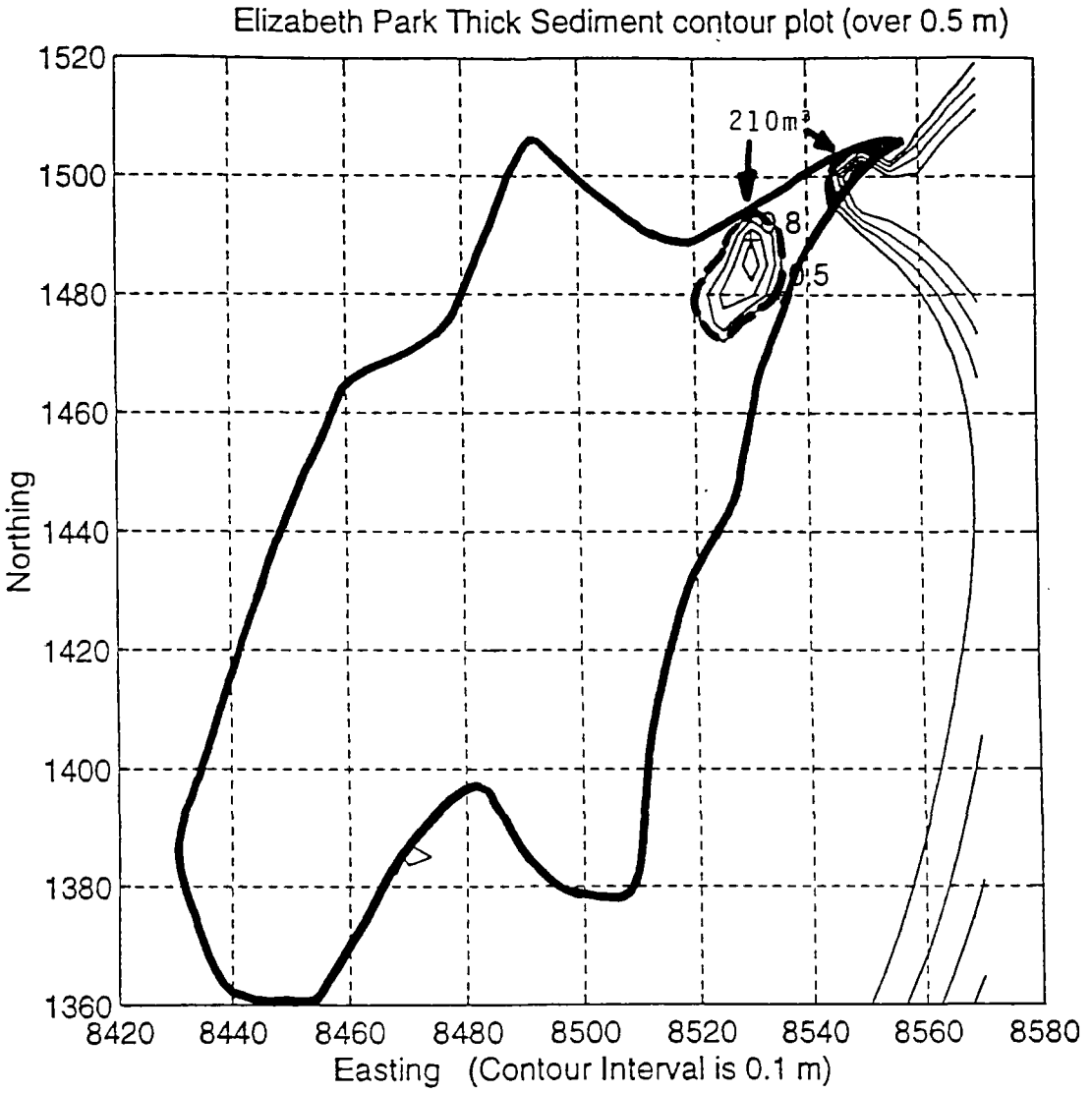
Contour map of Elizabeth Park.
Sediment depth over 0.25 m.

Figure 47



Geographical extent of Elizabeth Park survey lines.

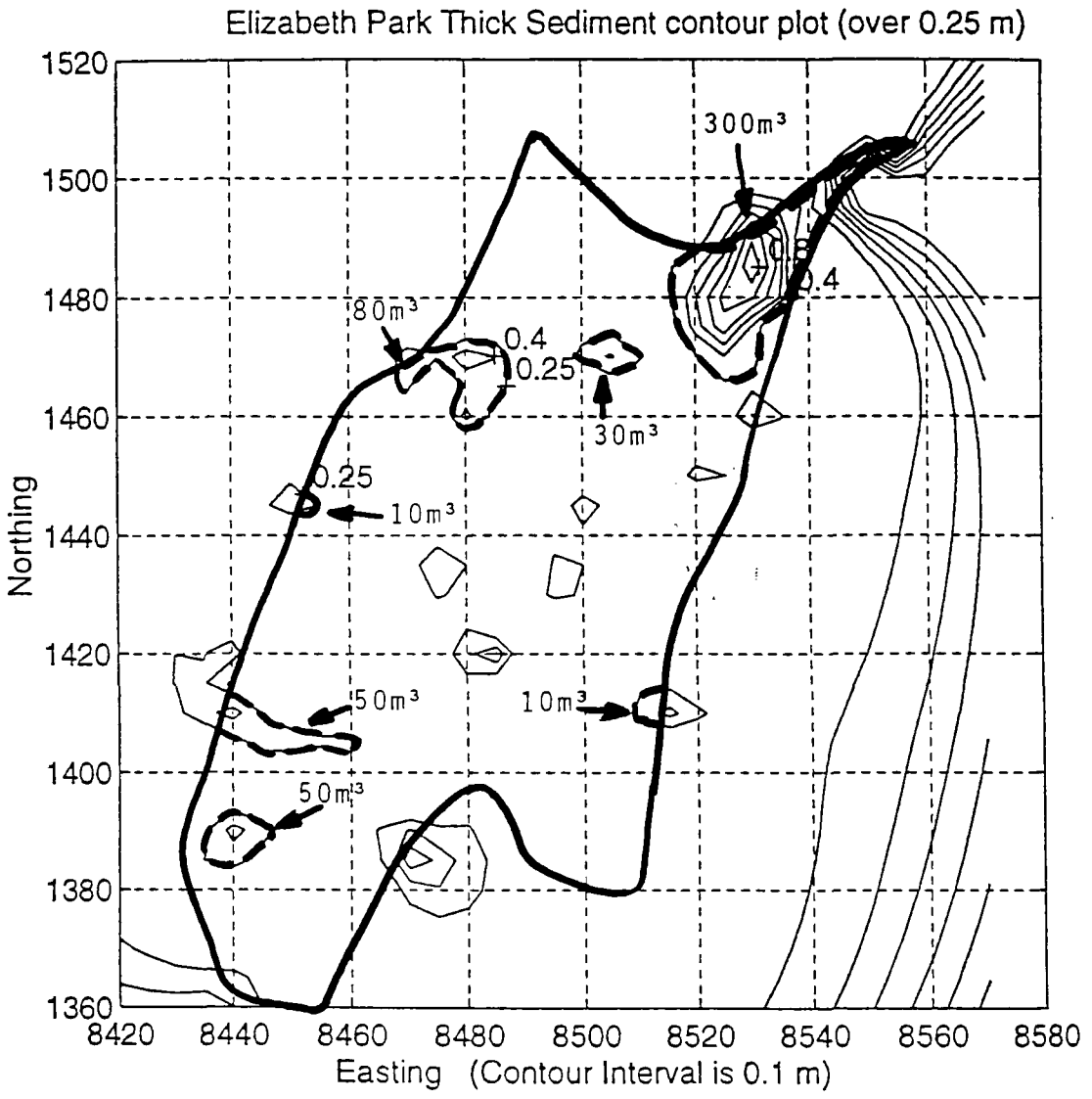
Figure 48



Total volume = 210m³

Suggested dredging sites with volume estimate, based on target thickness of 0.5m.

Figure 49

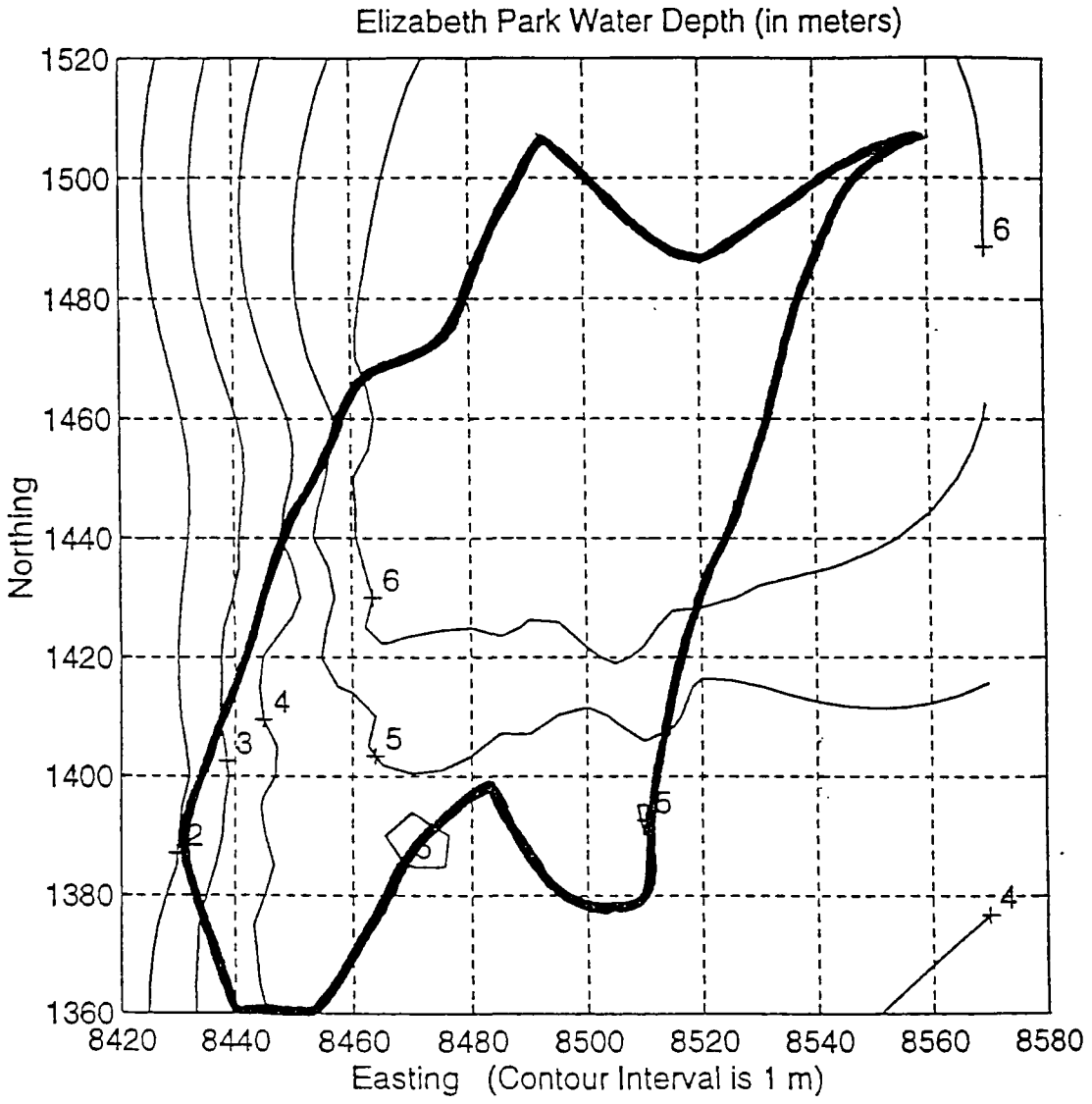


Total volume = 530m³

Suggested dredging sites with volume estimate, based on target depth of 0.25m.

Figure 50

The water depth contours for the Elizabeth Park survey area are displayed in Figure 51. The bathymetry of this site indicates a relatively uniform decrease in water depth moving to the southwest.



Elizabeth Park Bathymetric Contours.

Figure 51

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Acoustic Core© System is capable of mapping in shallow water where sediments exhibit a high degree of spatial variation. Existing software was modified and additional software written to meet the challenge of acoustically mapping sediments in shallow waters where sediments exhibit spatial variability and contain micro gas bubbles.

In future surveys it is recommended that a higher frequency source be used as an aid in resolving the thin layers. Also, it is recommended that wider bandwidth sources, such as chirps or sparkers, be used to better resolve the bottom reflection sign. This will accelerate the data reduction procedures. The low frequency sound sources employed on this survey will still have to be used to determine the depth of thicker potentially contaminated gas containing sediments, as these sediments are extremely absorptive.

At sites where sediment cores were collected, sediment core stratigraphy was compared to the acoustically estimated density group stratigraphy and generally good agreement was seen. There was agreement between acoustical data and cores collected the year before.

The Caulfield Engineering plotting software demonstrated the ability to create cross section plots of acoustical data expressed as sediment density groups (sand, silt, clay etc.). The cross section plots provide a tool, usable by managers, for the visualization of depositional sediment distribution and volume. This type of survey and mapping provides the reconnaissance tool needed in designing and implementing cost efficient assessment of contaminated sediments.

Two sites on the Detroit River, Trenton Channel were surveyed during this demonstration project. Sediment deposits of the Elizabeth Park site were very localized and exhibited extreme lateral variability. Hard compact sediment is often exposed with depositional sediment thickness ranging from 0 to about 1 meter with a volume of around 530 m^3.

Depositional sediment dominates the surface area of the Black Lagoon site with some areas of exposed rock and hard compact sediment. Depositional sediment is less localized and exhibits less spatial variability than the Elizabeth Park site. Depositional sediment thickness ranged from 0 to about 2.25 meters with a volume of about 3,070 m^3.

The project demonstrated the existence of sediment fluff or foam overlaying some of the surface sediments. This fluff was found both by the piston cores and in the high

frequency acoustic records. The role of this fluff in the transport of contaminants and its' effect on sediment resuspension should be further studied.

The deviation of contaminated sediment acoustical properties from standard marine sediments may provide a tool for the acoustical identification of contaminated sediments. With the availability of selected core sites in which the contamination has been chemically measured and the physical geotechnical soil properties have been determined, a data base relating the acoustic properties of the sediments to the physical and chemical sediment properties can be constructed. With additional research this data base might be used to quantitatively determine the thickness and lateral distribution of the contaminated sediments. It is critical for the success of such a program that the data be acquired with a detailed quality assurance program which allows absolute determination of the source level and the source wavelet shape. Additional research is needed in this area.

For long term research, it is suggested that a laboratory procedure be assembled to start measuring the acoustic properties of each type of contaminant when combined in marine clays. This will enable the construction of more detailed data bases of acoustic properties versus the types of contaminants.

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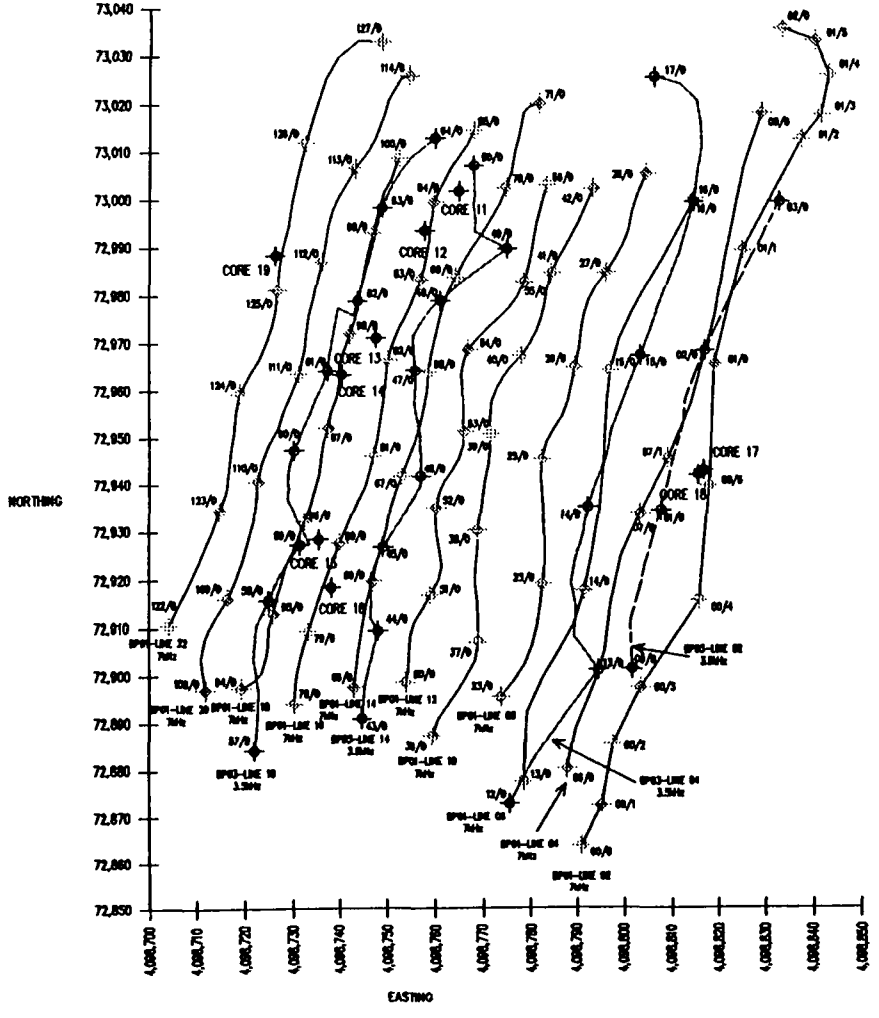
APPENDIX A1

CROSS-SECTION PLATES

All Auto-Cad Drawing Prepared for this Report are Contained in this Appendix

Plate 1



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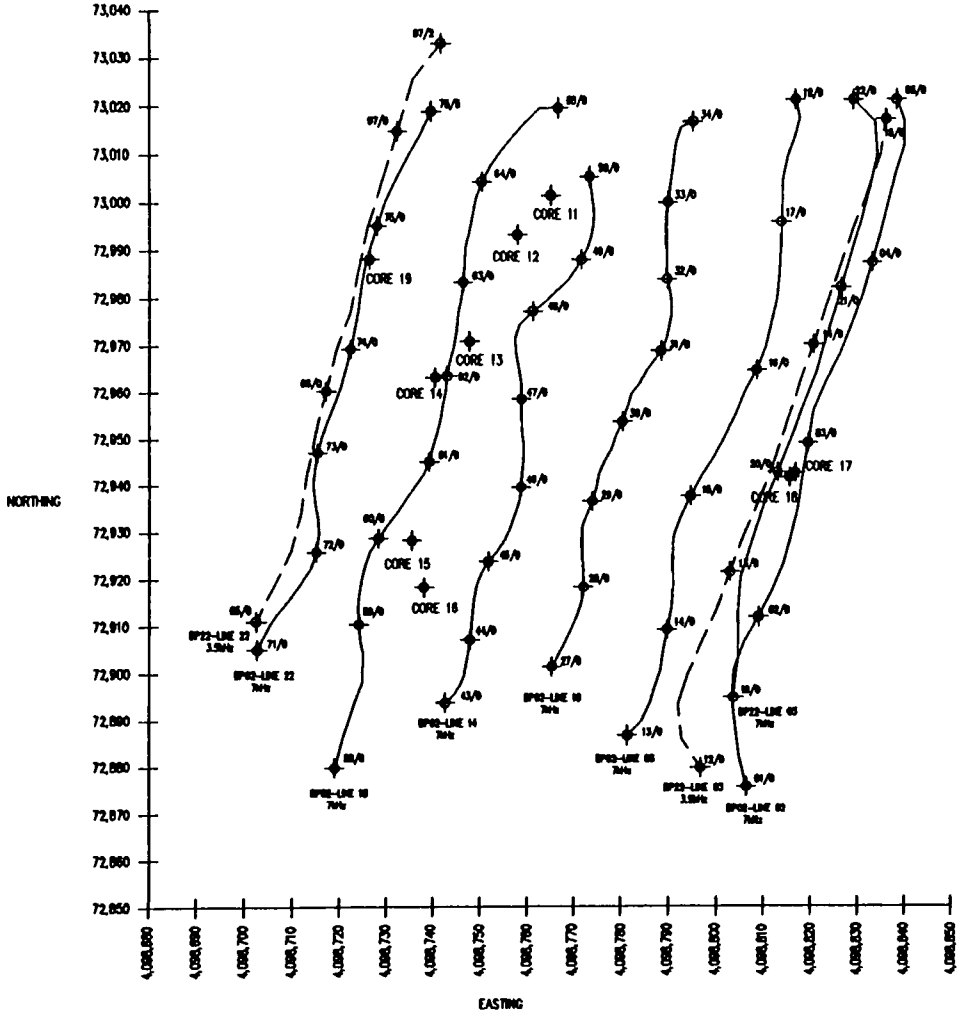

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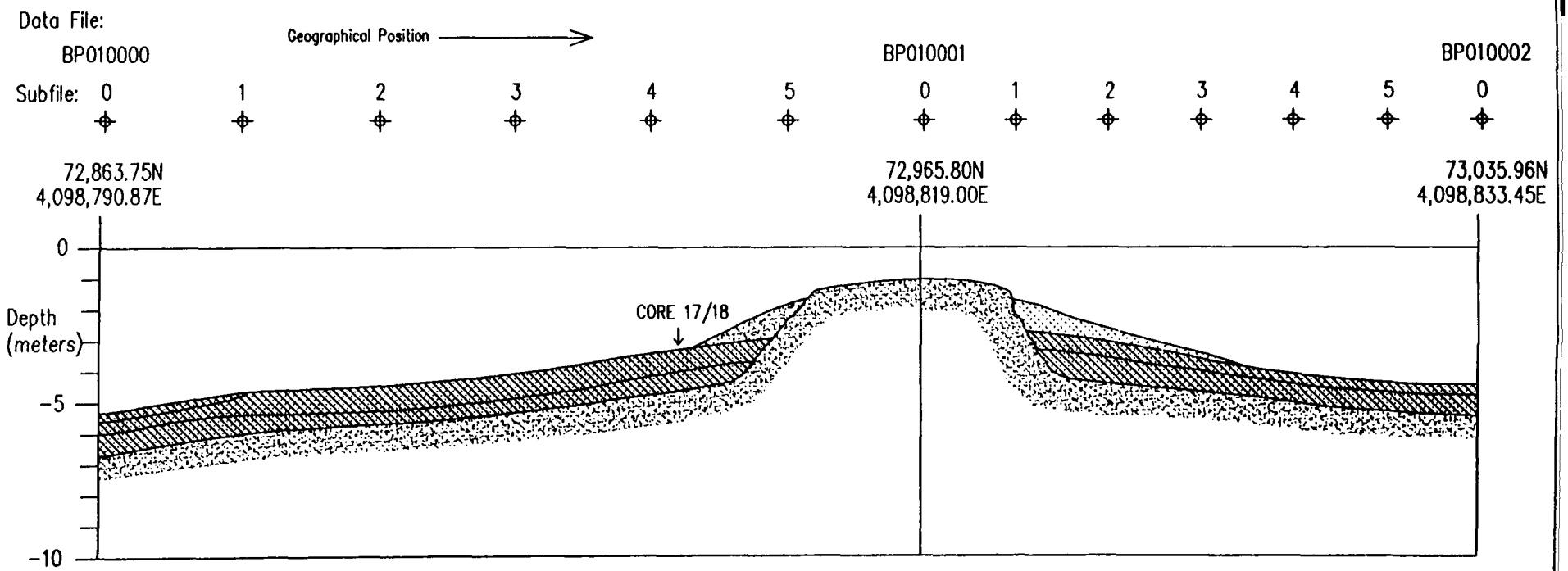

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	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

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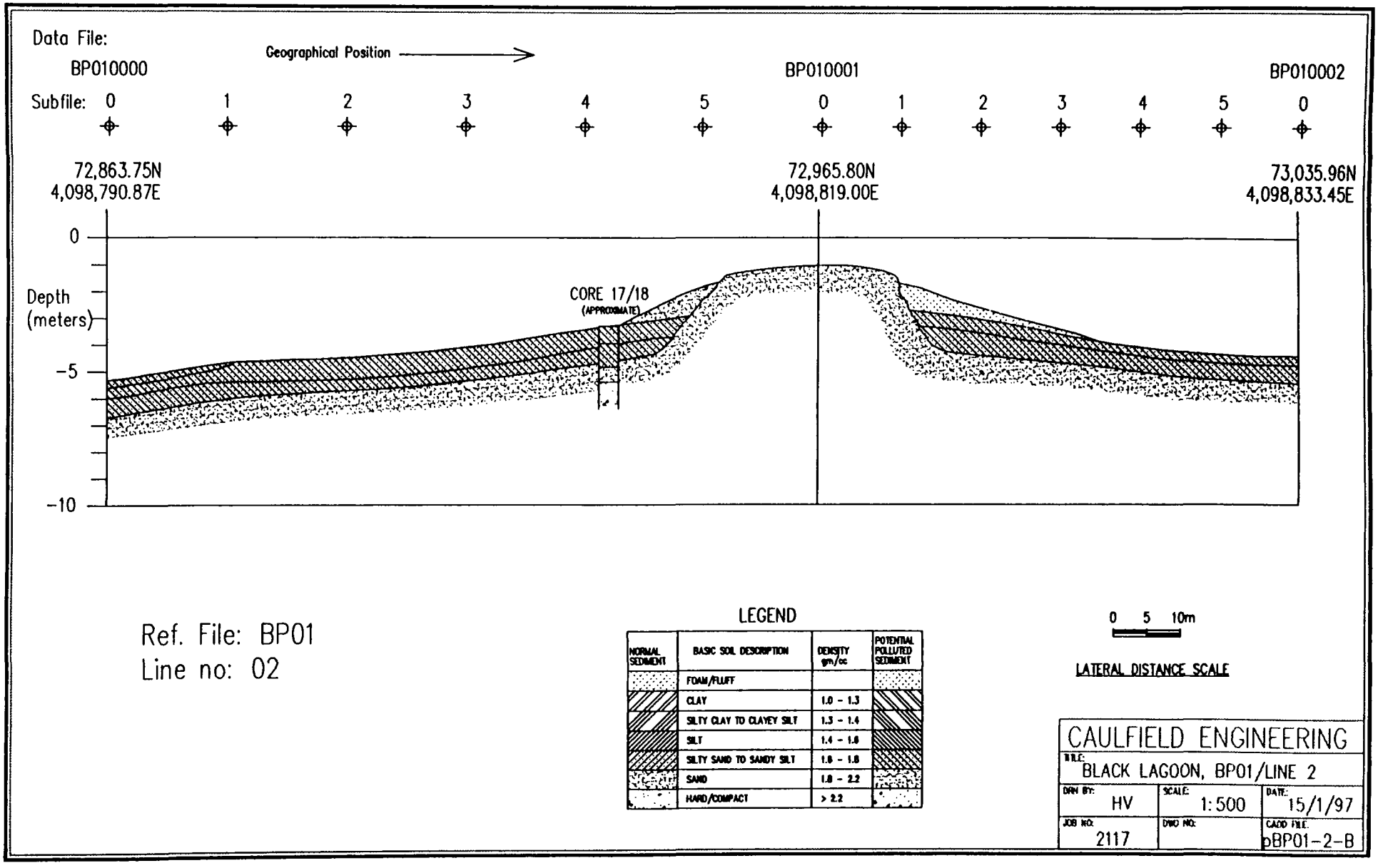
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BP010001
BP010002
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72,965.80N
4,098,819.00E
73,035.96N
4,098,833.45E
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Depth
(meters)
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-10
CORE 17/18
(APPROXIMATE)
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NORMAL SEDIMENT
BASIC SOIL DESCRIPTION
DENSITY gm/cc
POTENTIAL POLLUTED SEDIMENT
FOAM/FLUFF
CLAY 1.0 - 1.3
SILTY CLAY TO CLAYEY SILT 1.3 - 1.4
SILT 1.4 - 1.8
SILTY SAND TO SANDY SILT 1.8 - 1.8
SAND 1.8 - 2.2
HARD/COMPACT > 2.2
0 5 10m
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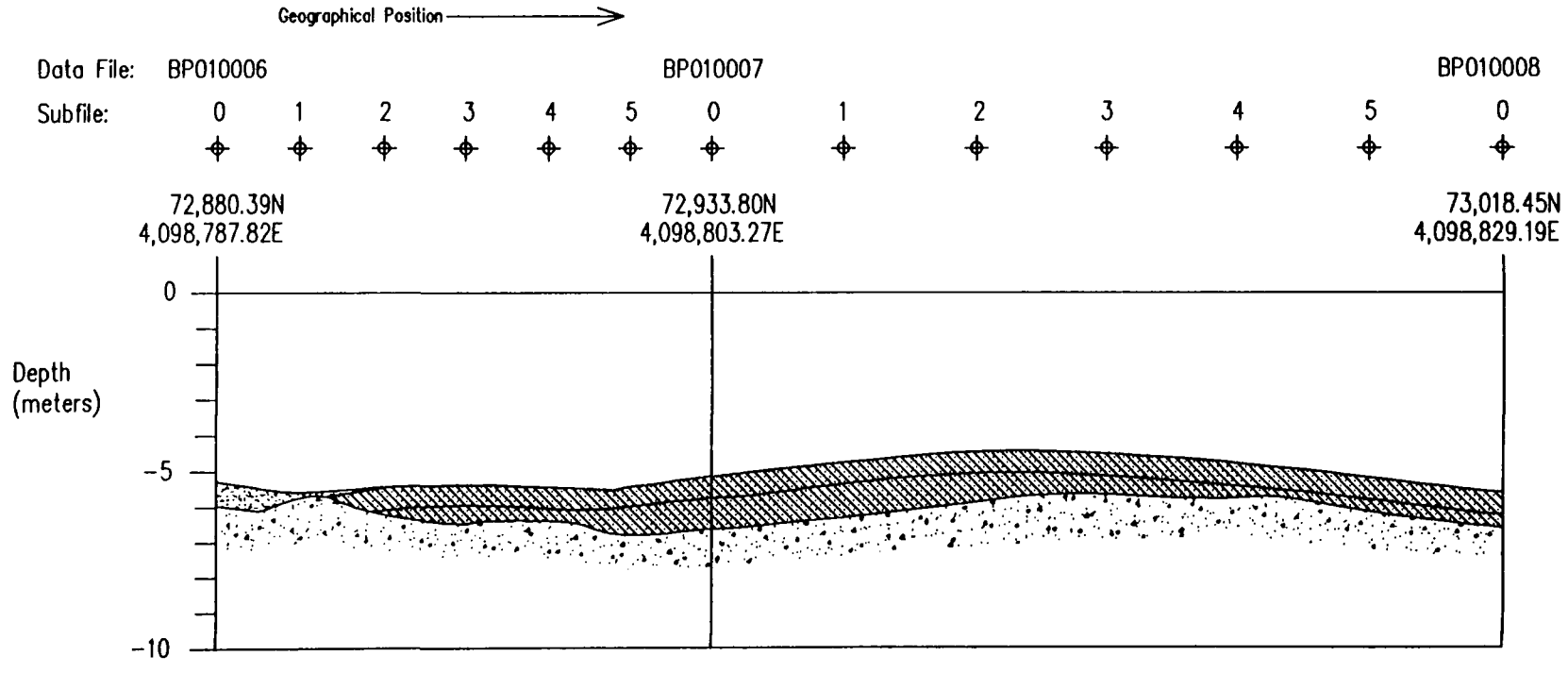

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	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

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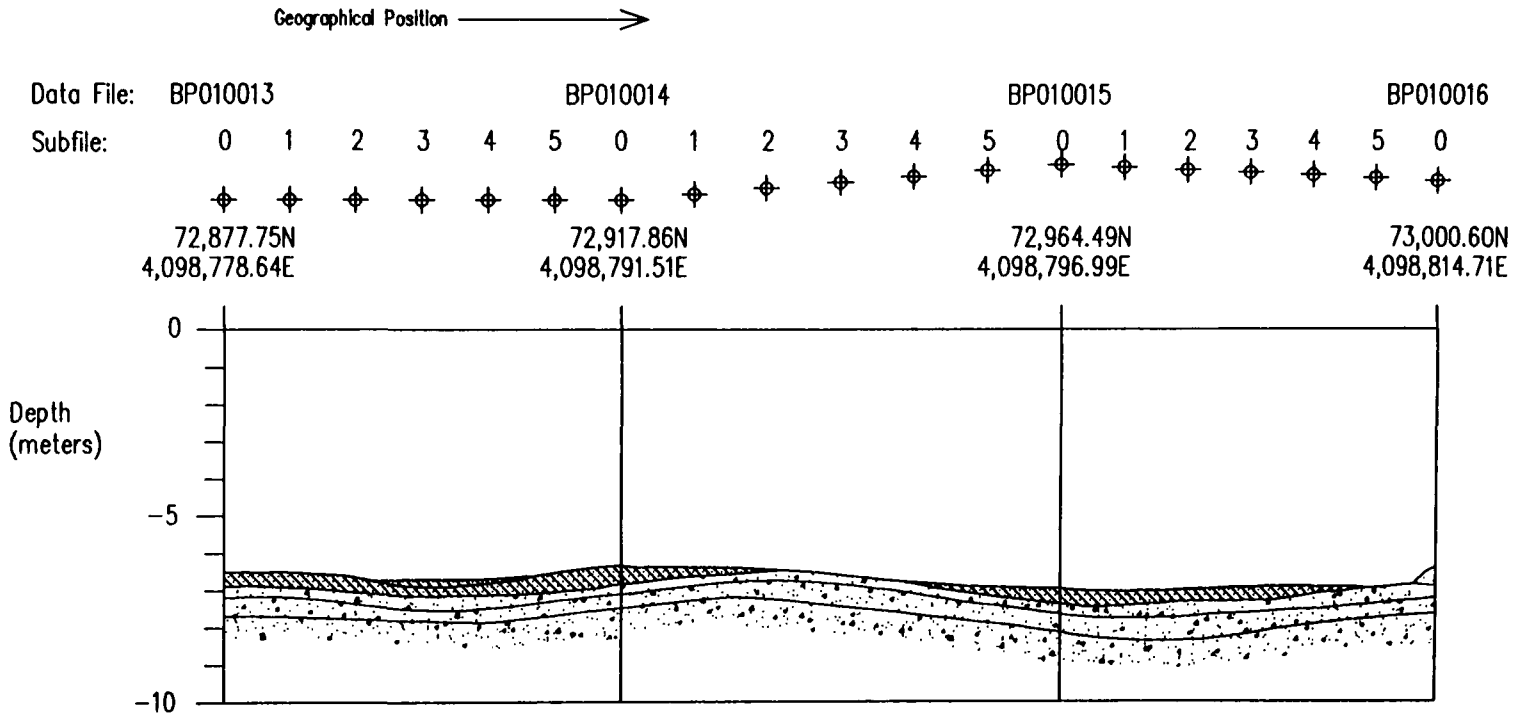

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	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

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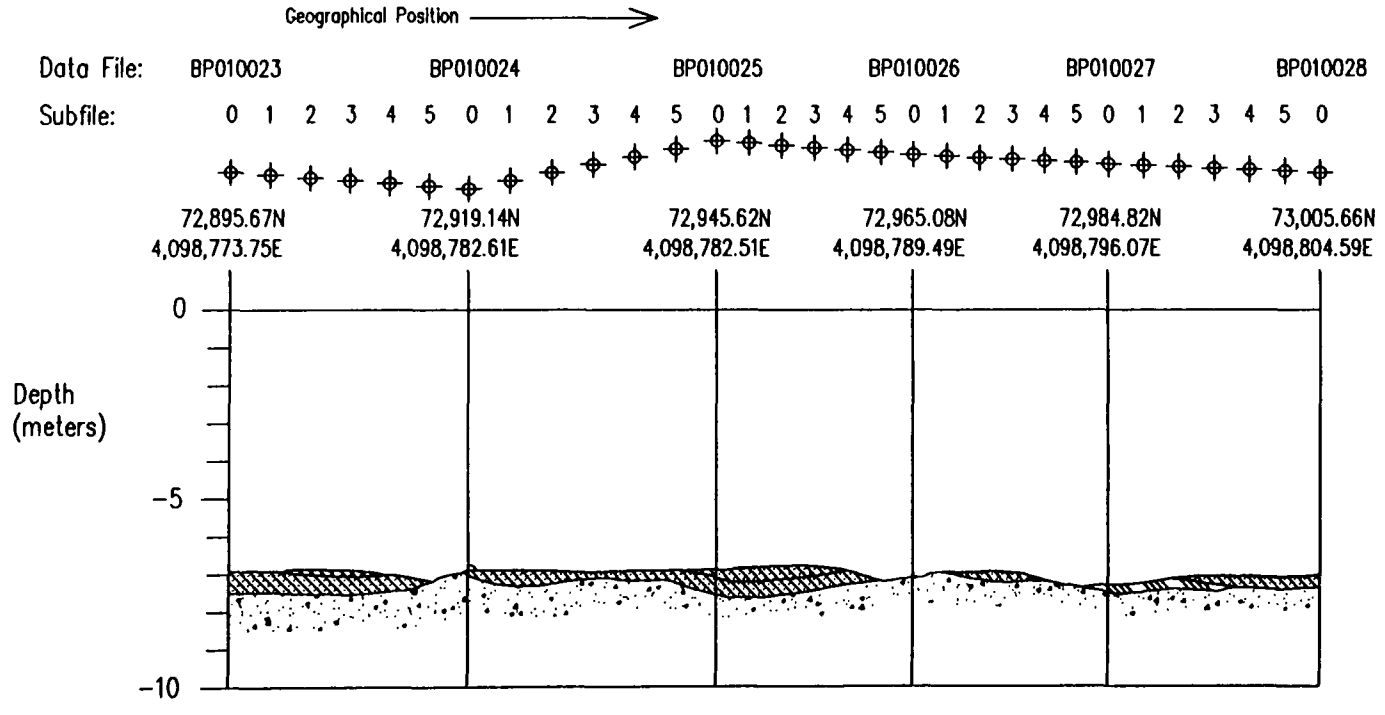

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	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.8	
	SILTY SAND TO SANDY SILT	1.8 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

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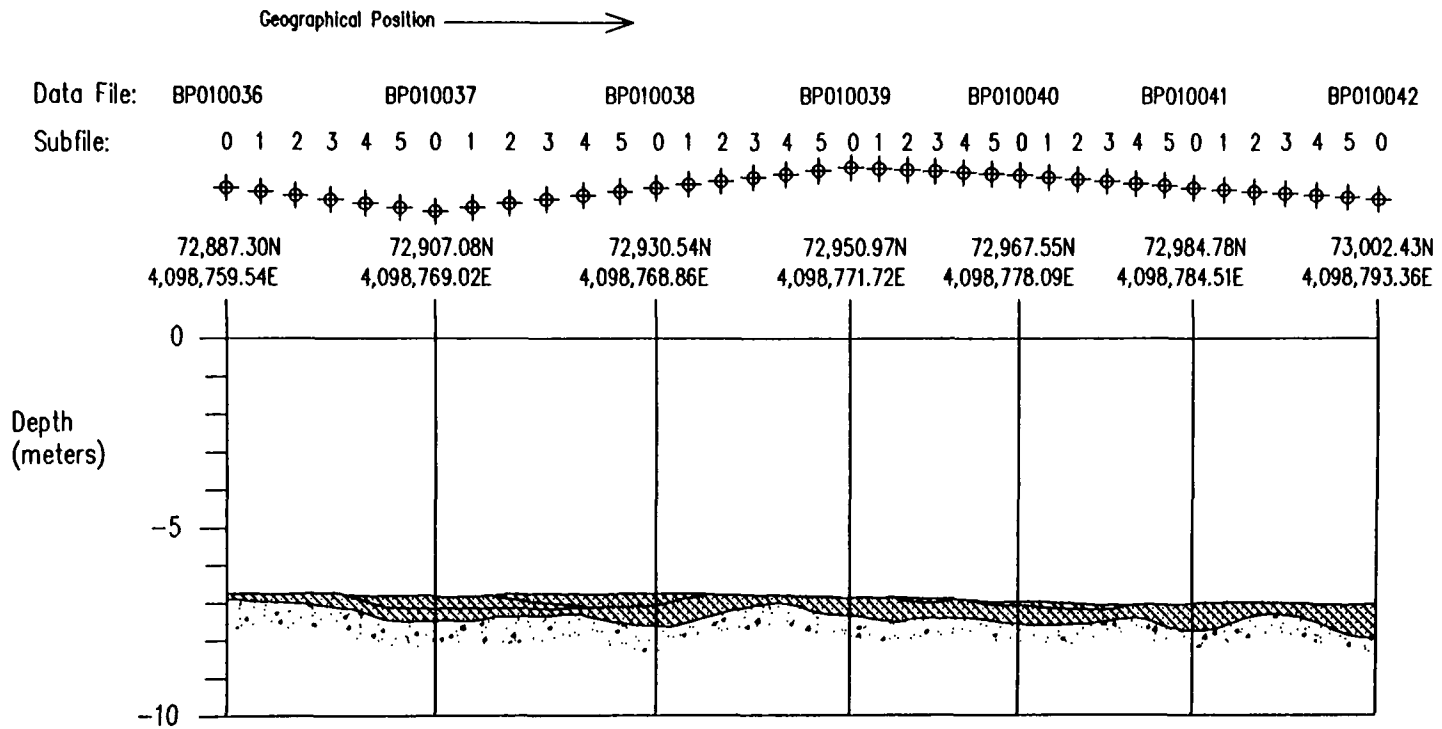

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	FOAM/FLUFF		
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	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.8	
	SILTY SAND TO SANDY SILT	1.8 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

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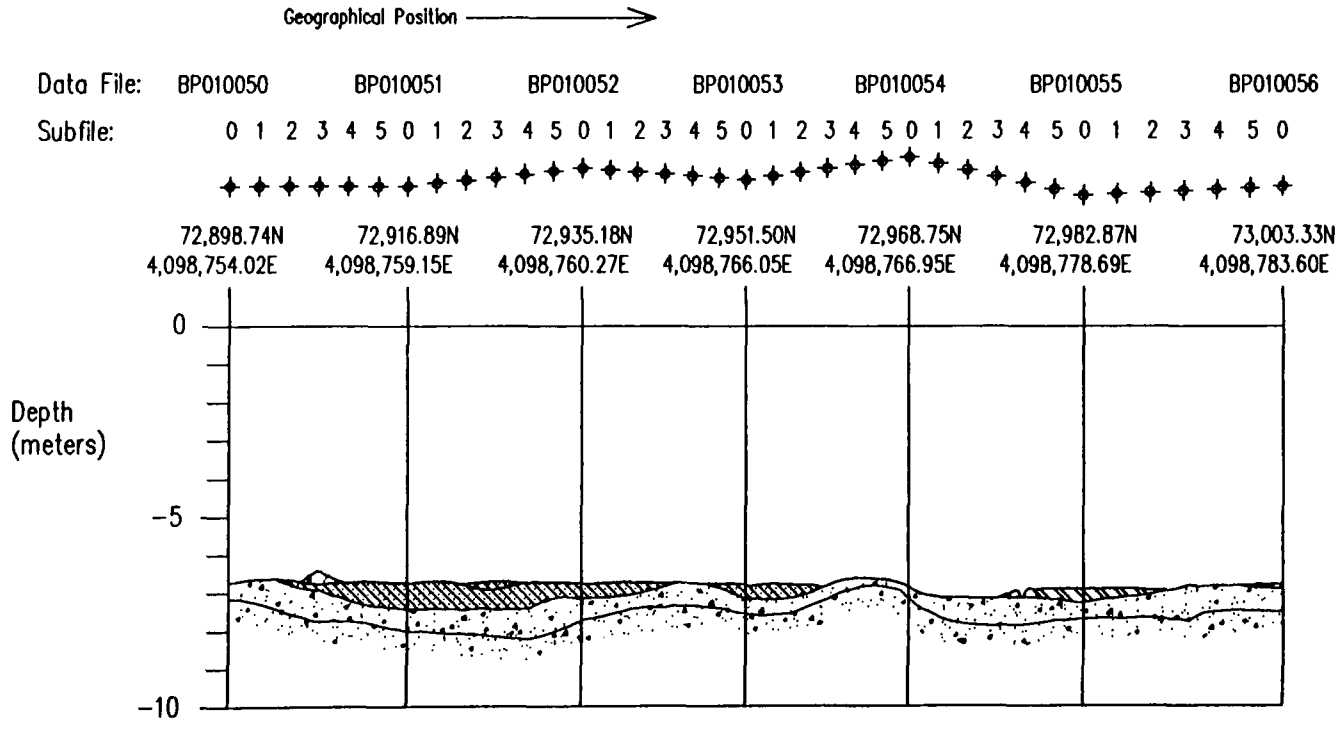

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	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

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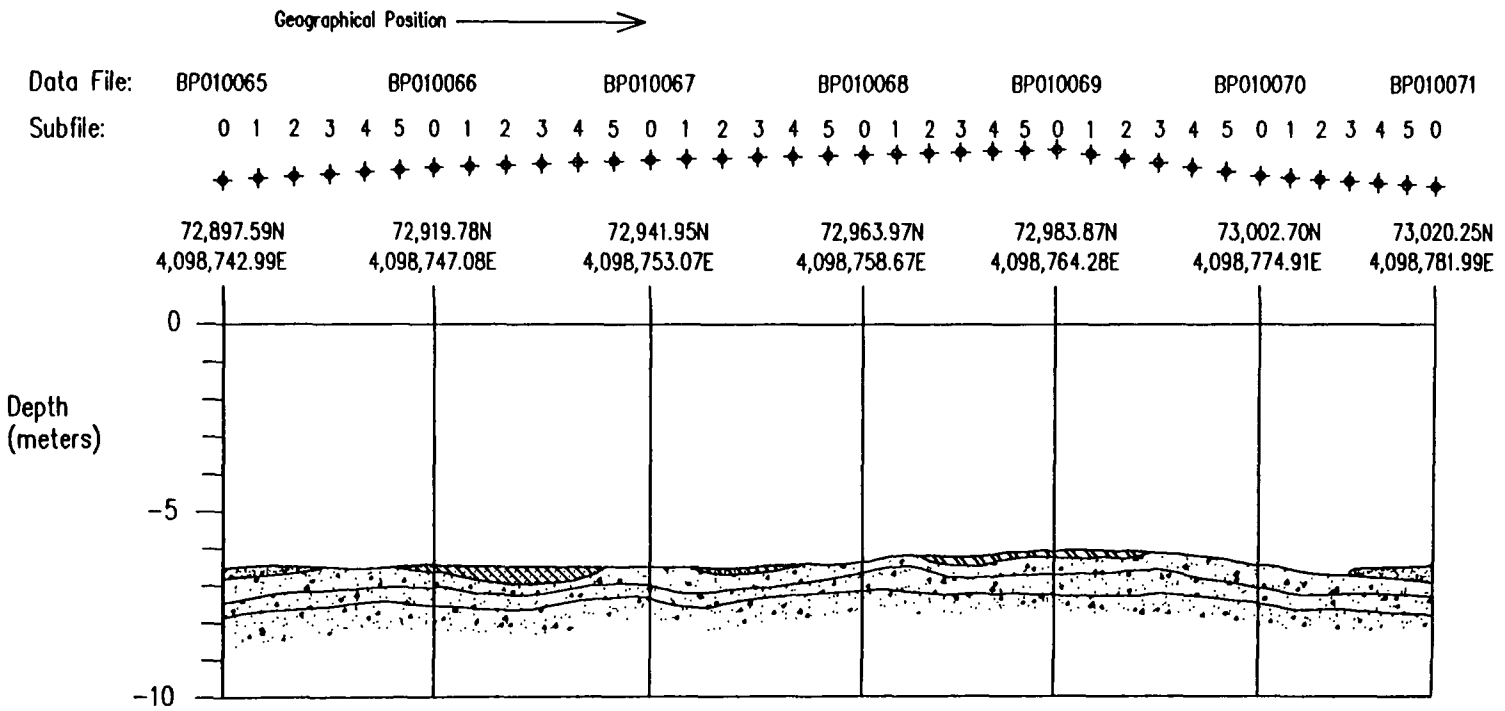

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LEGEND

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	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

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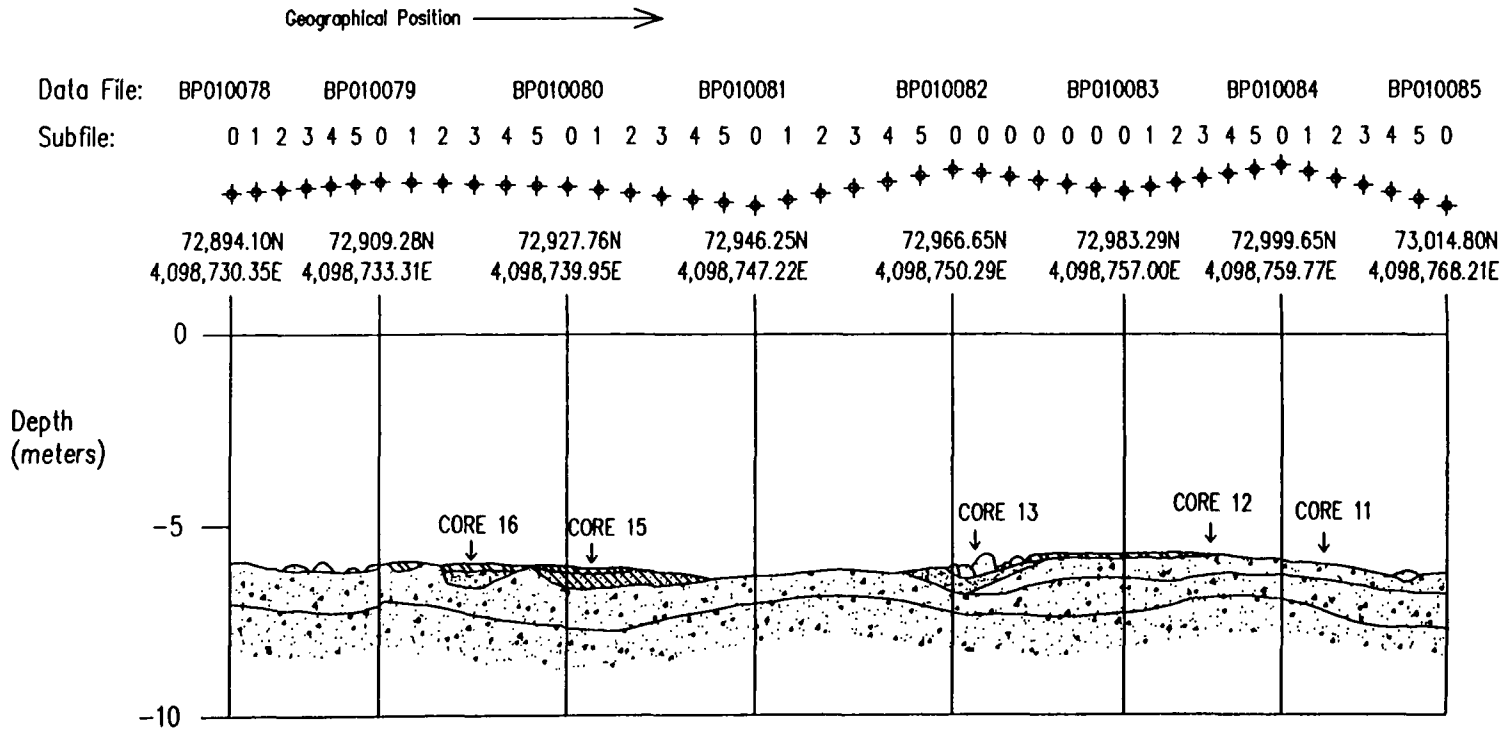

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
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	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.6	
	SILTY SAND TO SANDY SILT	1.6 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: BP01
Line no: 16

0 5 10m

LATERAL DISTANCE SCALE

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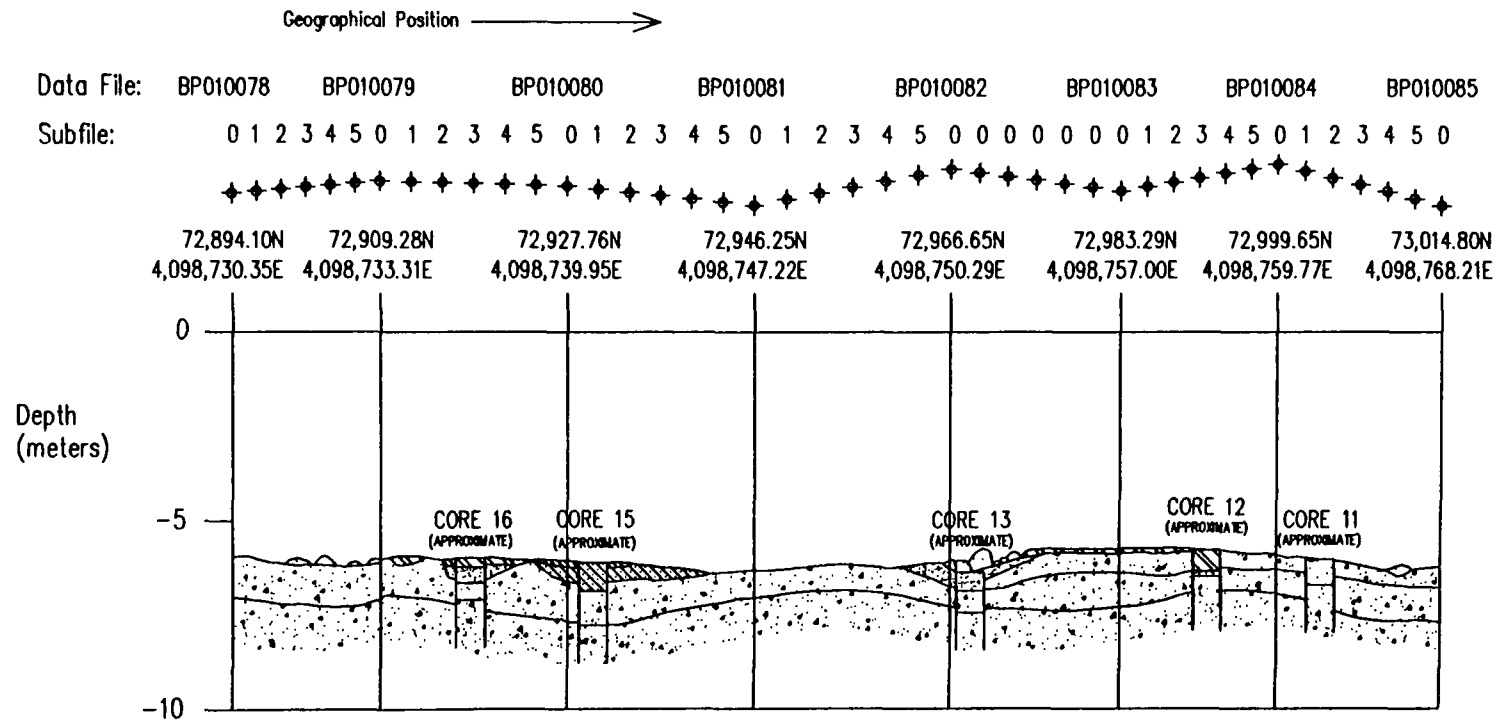
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-16A

A1-12



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

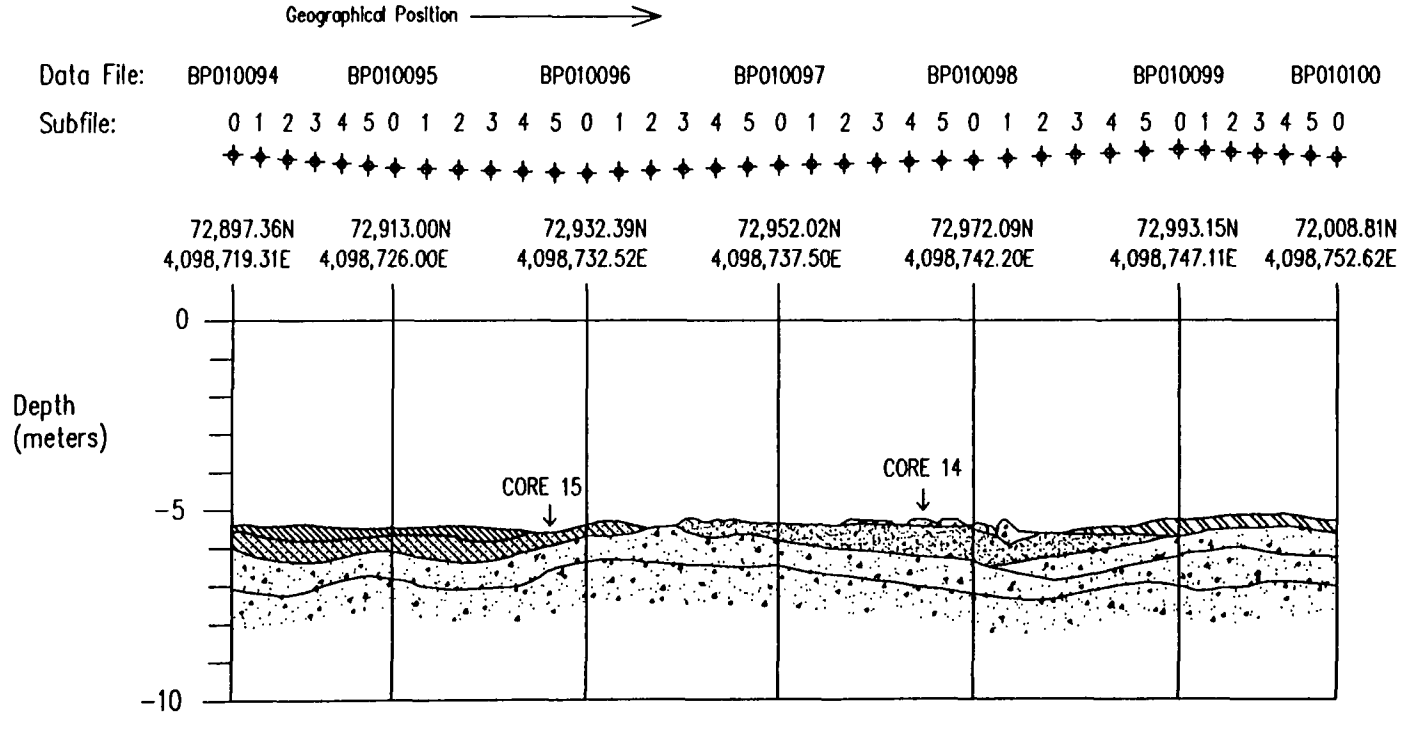
Ref. File: BP01
Line no: 16

0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 16		
DRN BY: HV	SCALE: 1:500	DATE: 16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-16B



Ref. File: BP01
Line no: 18

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

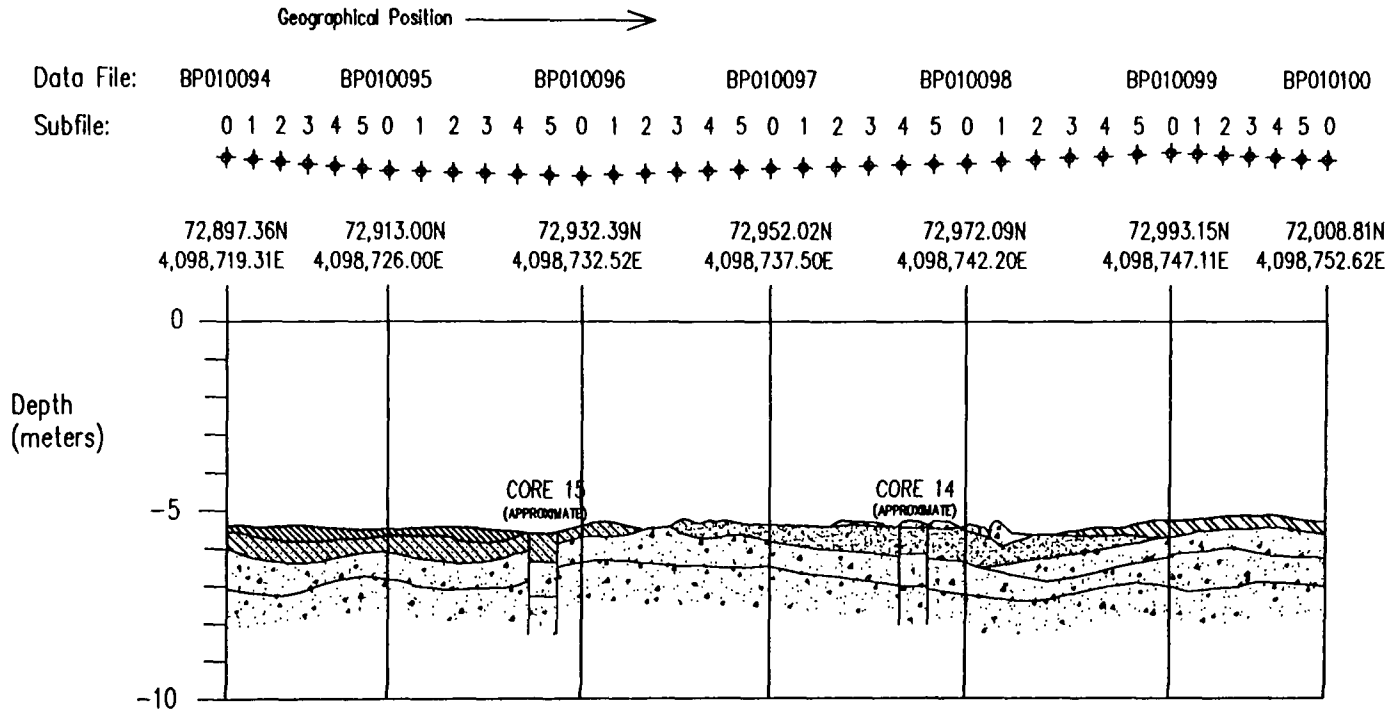
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 18

DRN BY: HV	SCALE: 1:500	DATE: 16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-18A



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: BP01
Line no: 18

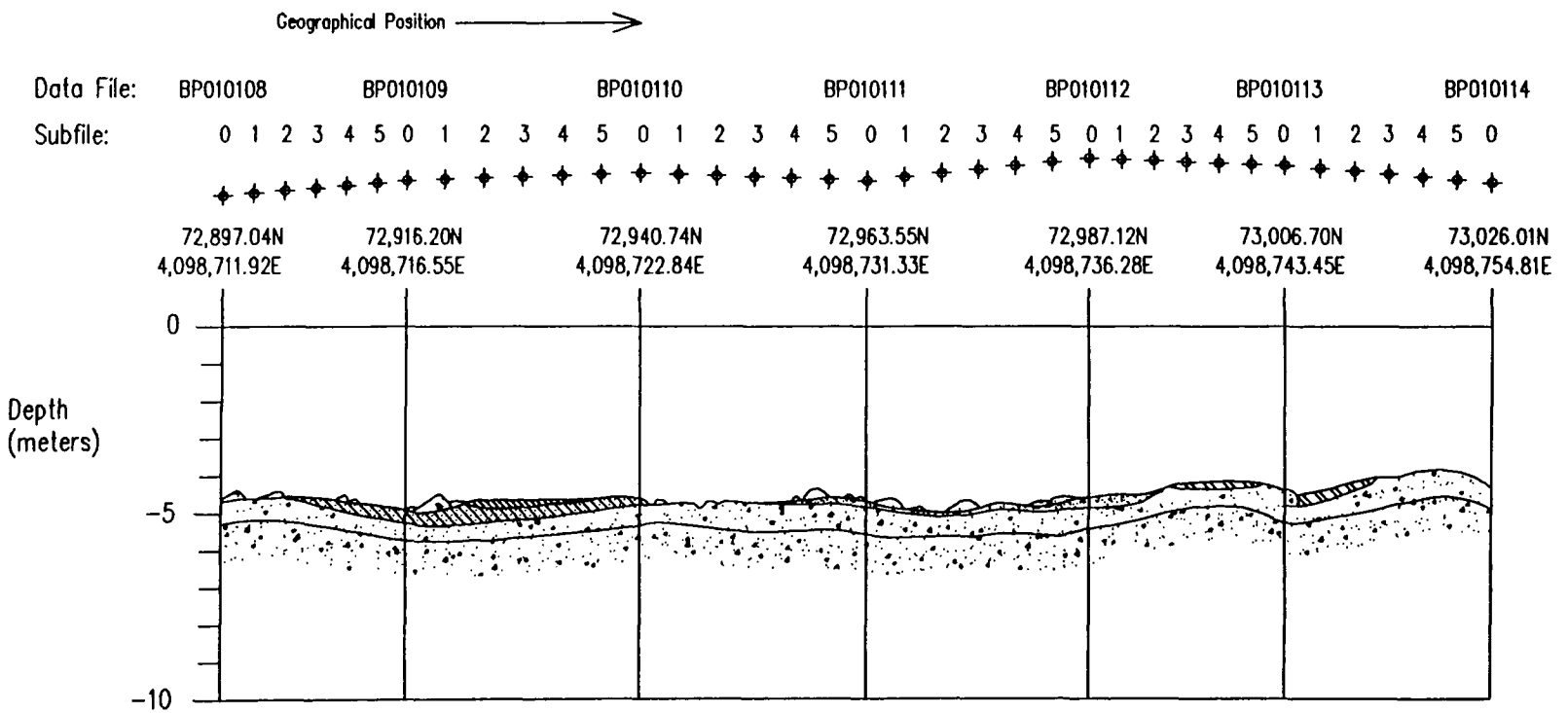
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 18

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-18B



AL-16

Ref. File: BP01
Line no: 20

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

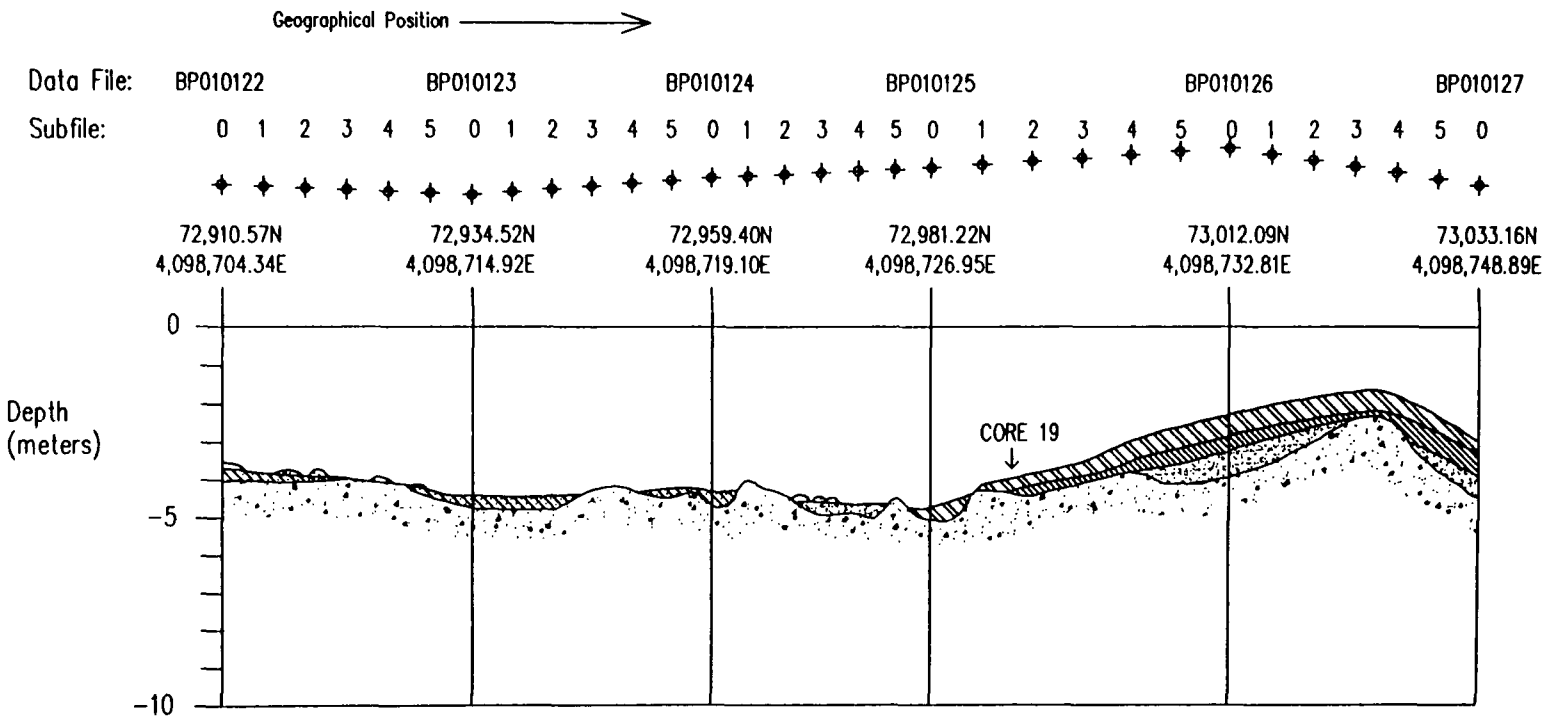
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 20

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-20



Ref. File: BP01
Line no: 22

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

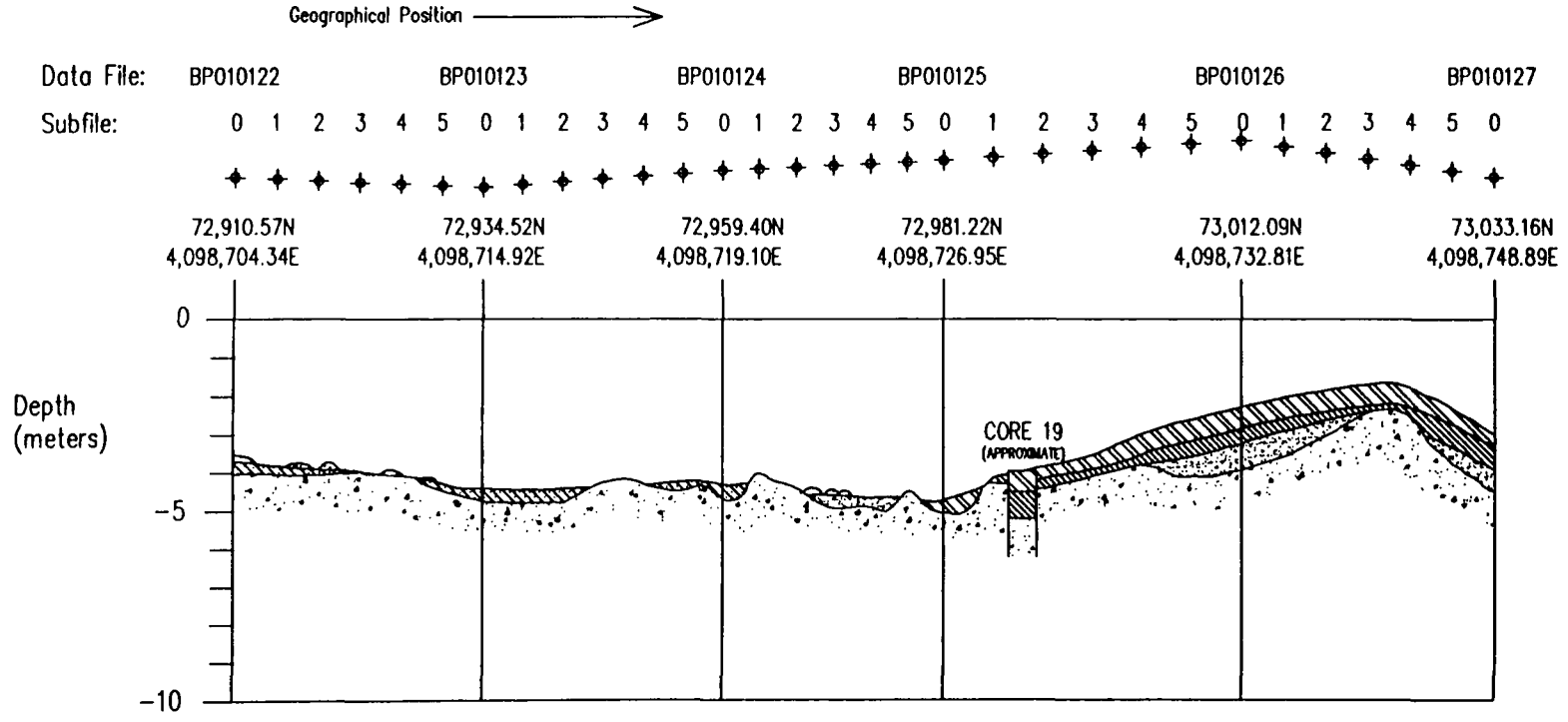
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 22

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-22A



Ref. File: BP01
Line no: 22

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

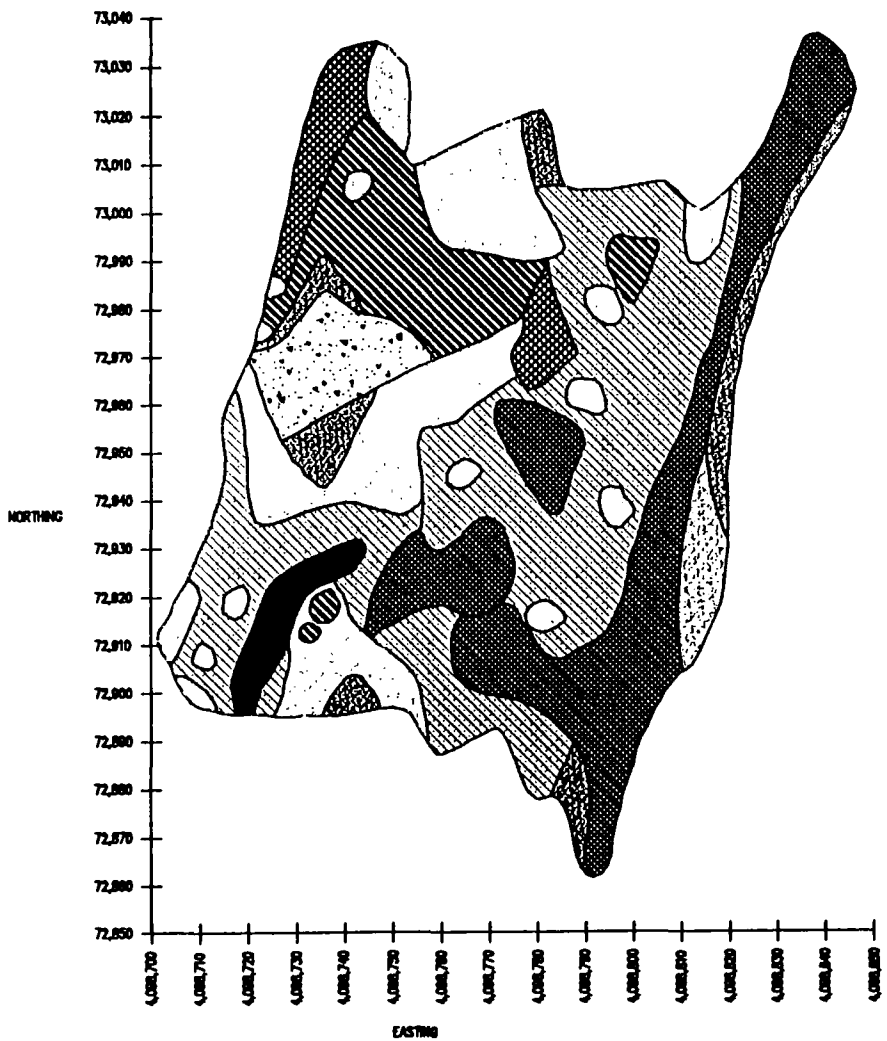
LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: BLACK LAGOON, BP01/LINE 22

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: pBP01-22B

A1-18



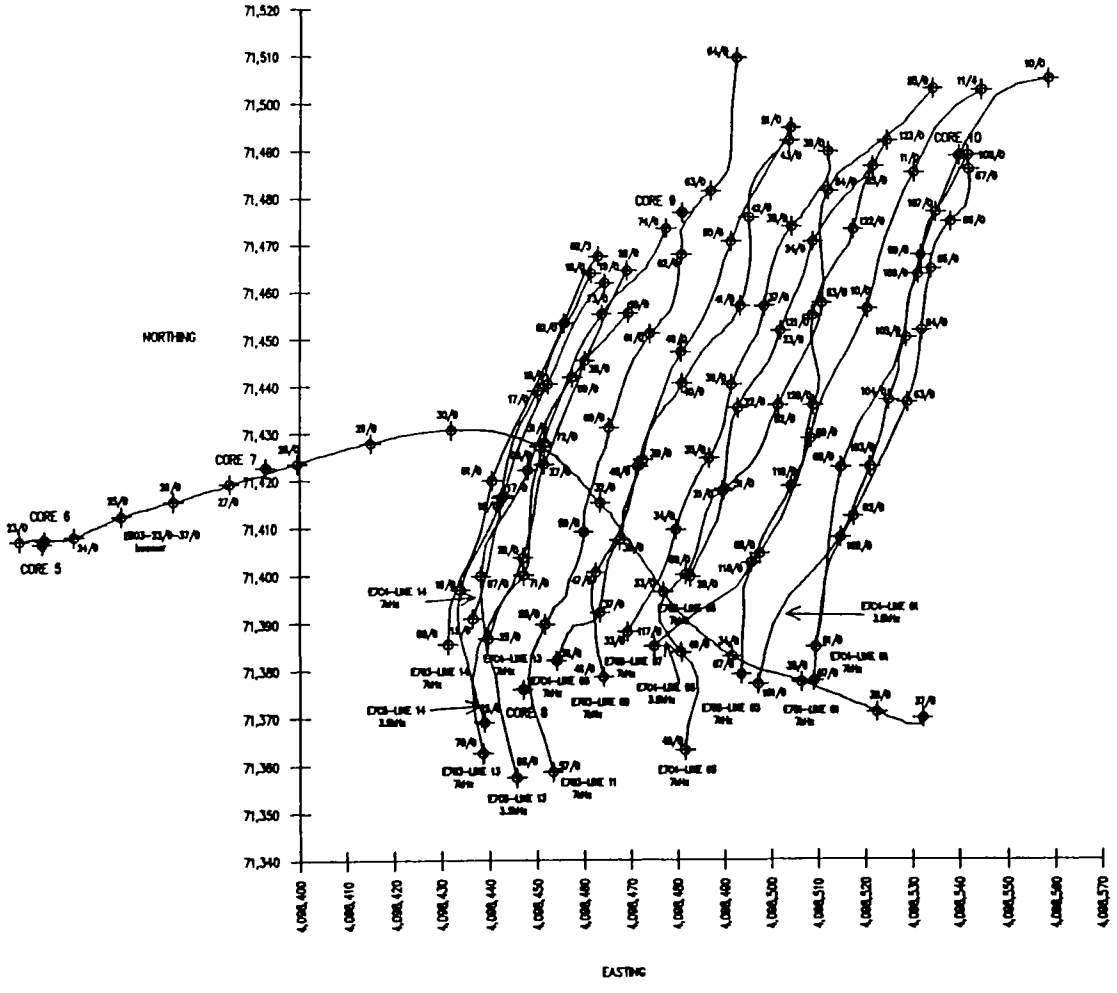
LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF	
	CLAY/SILTY CLAY	
	CLAY ON SILT/SILTY SAND	
	SILT	
	SILTY SAND TO SANDY SILT	
	SAND	
	HARD/COMPACT	
	SILTY SAND ON SILTY SAND	
	SURFACE ROCK	
	SAND ON SILTY SAND	

0 10 20m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING		
TITLE: BLACK LAGOON SEDIMENTS		
DRN BY: HV	SCALE: 1:1000	DATE: 15/1/97
JOB NO: 2117	DRG NO:	CADD FILE: color-map

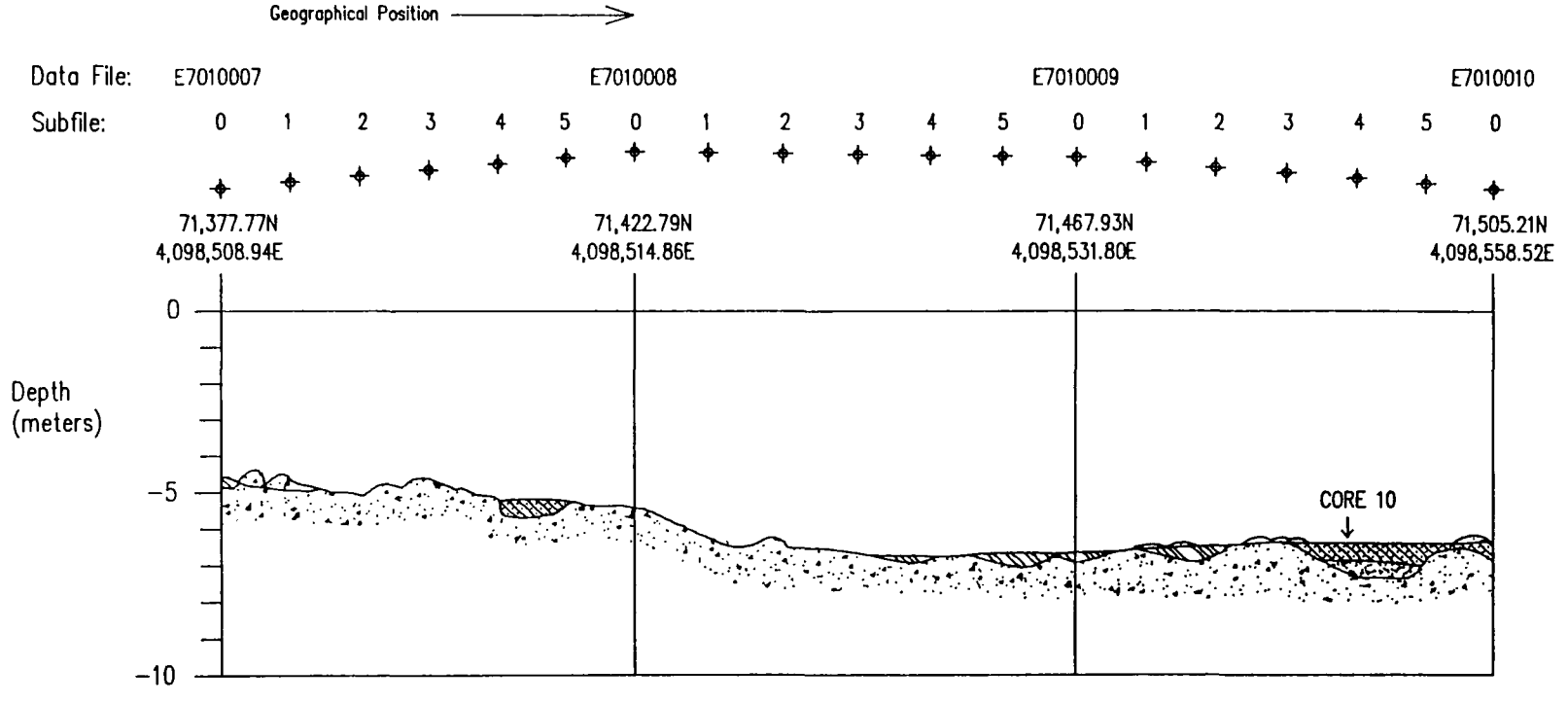


0 10 20m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING		
TITLE: Elizabeth Park		
DRN BY: HV	SCALE: 1:1000	DATE: 17/1/97
JOB NO: 2117	DWG NO:	CADD FILE: Elizamap

Plate 20



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.8	
	SILTY SAND TO SANDY SILT	1.8 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: E701
Line no: 01

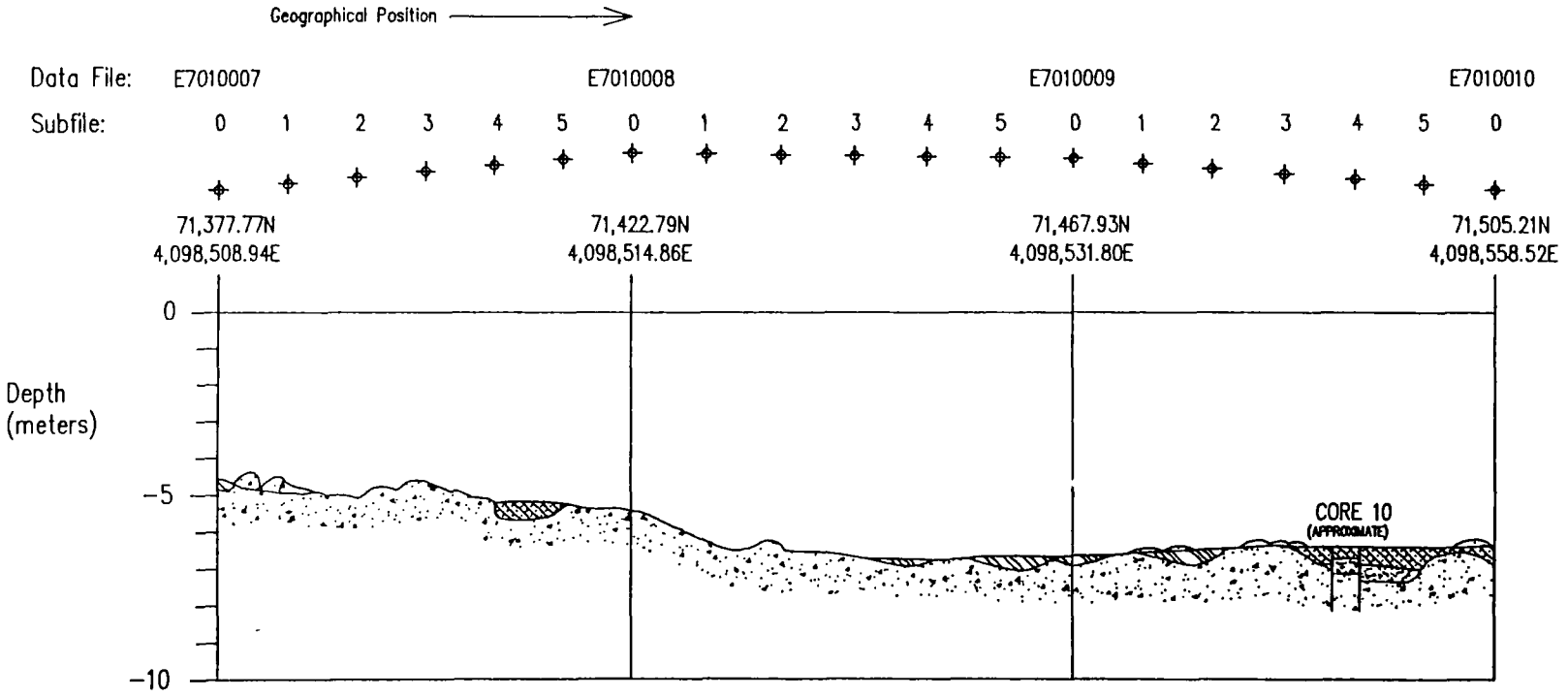
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E701/LINE 1

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE701-1A



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.8	
	SILTY SAND TO SANDY SILT	1.8 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: E701
Line no: 01

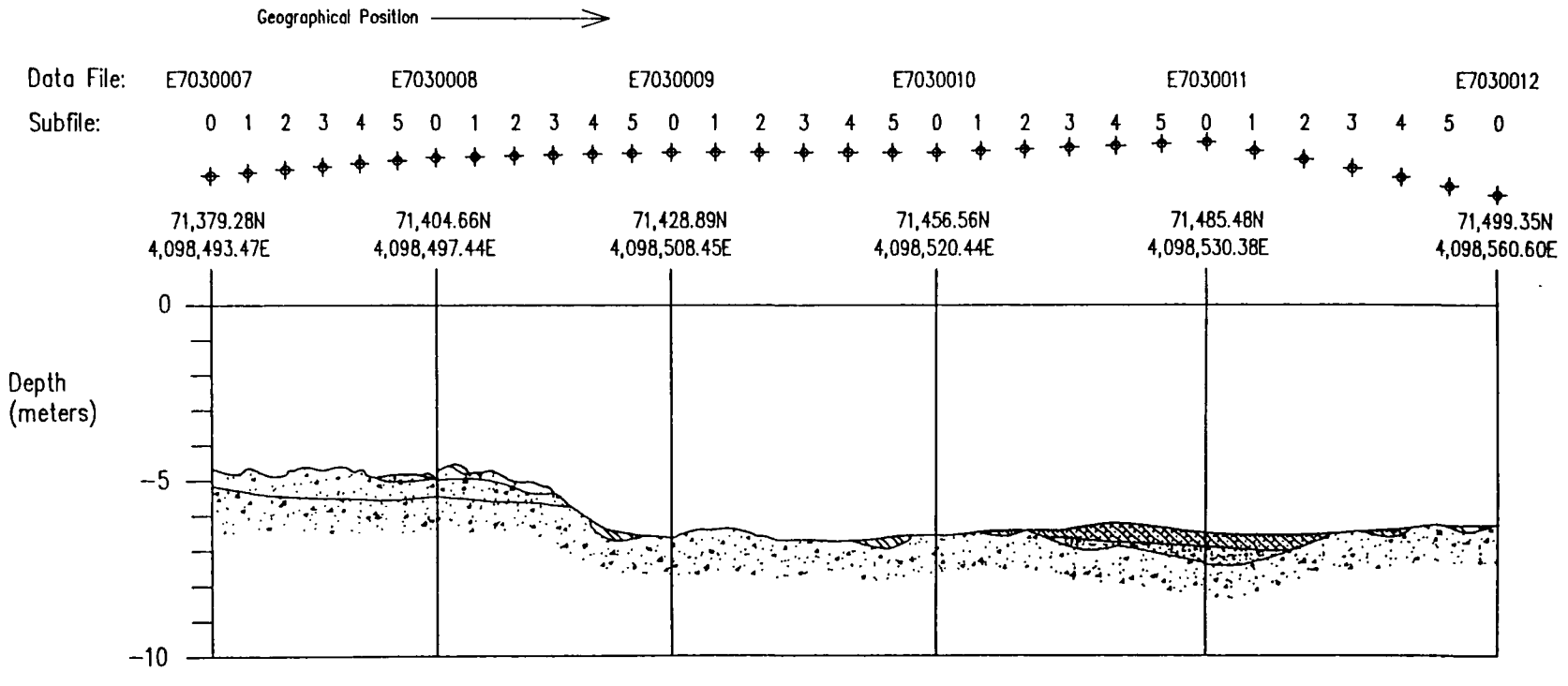
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E701/LINE 1

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE701-1B



Ref. File: E703
Line no: 03

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.6	
	SILTY SAND TO SANDY SILT	1.6 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

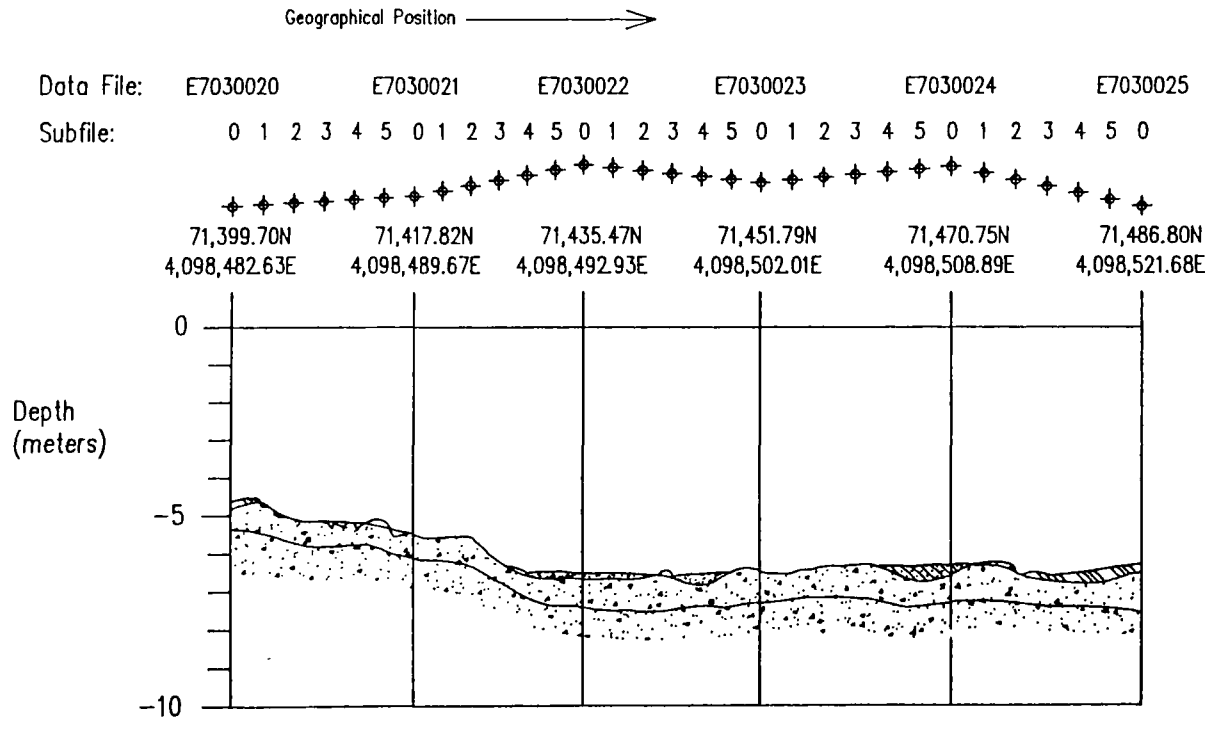
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 3

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-3



Ref. File: E703
Line no: 05

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

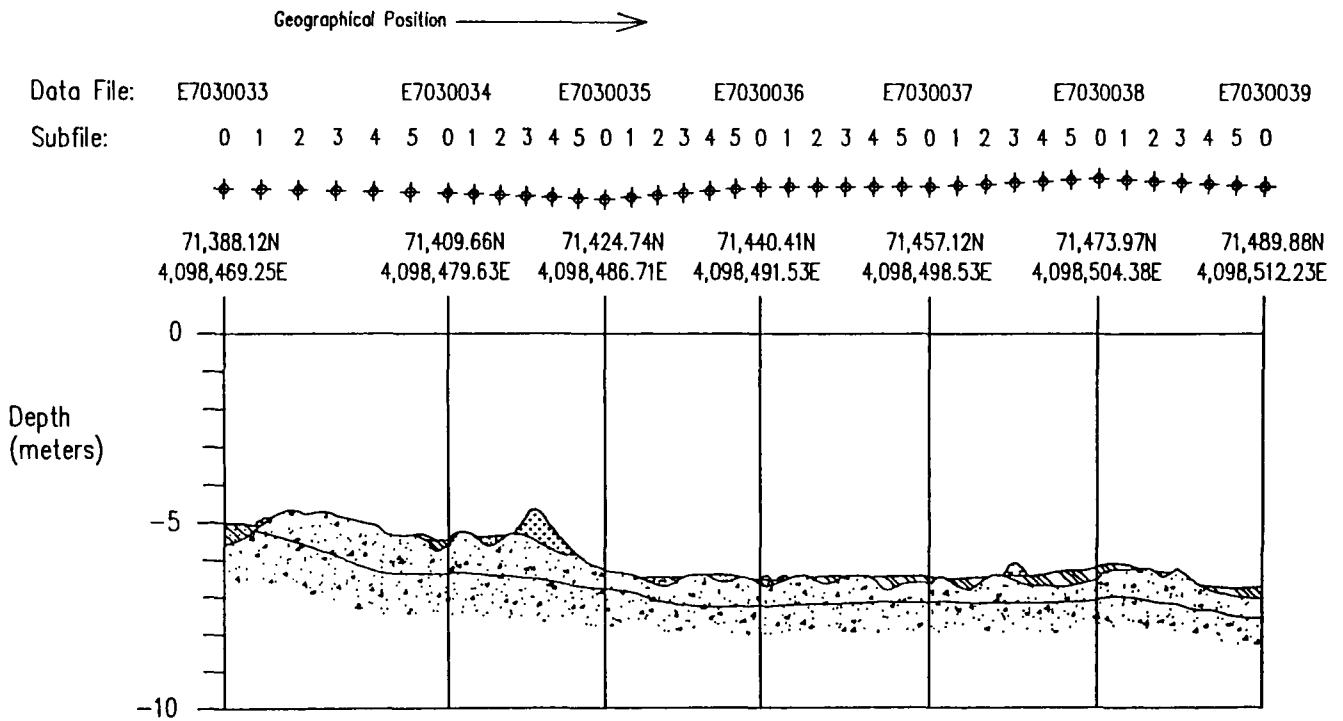
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 5

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: gE703-5



Ref. File: E703
Line no: 07

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.8	
	SILTY SAND TO SANDY SILT	1.8 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

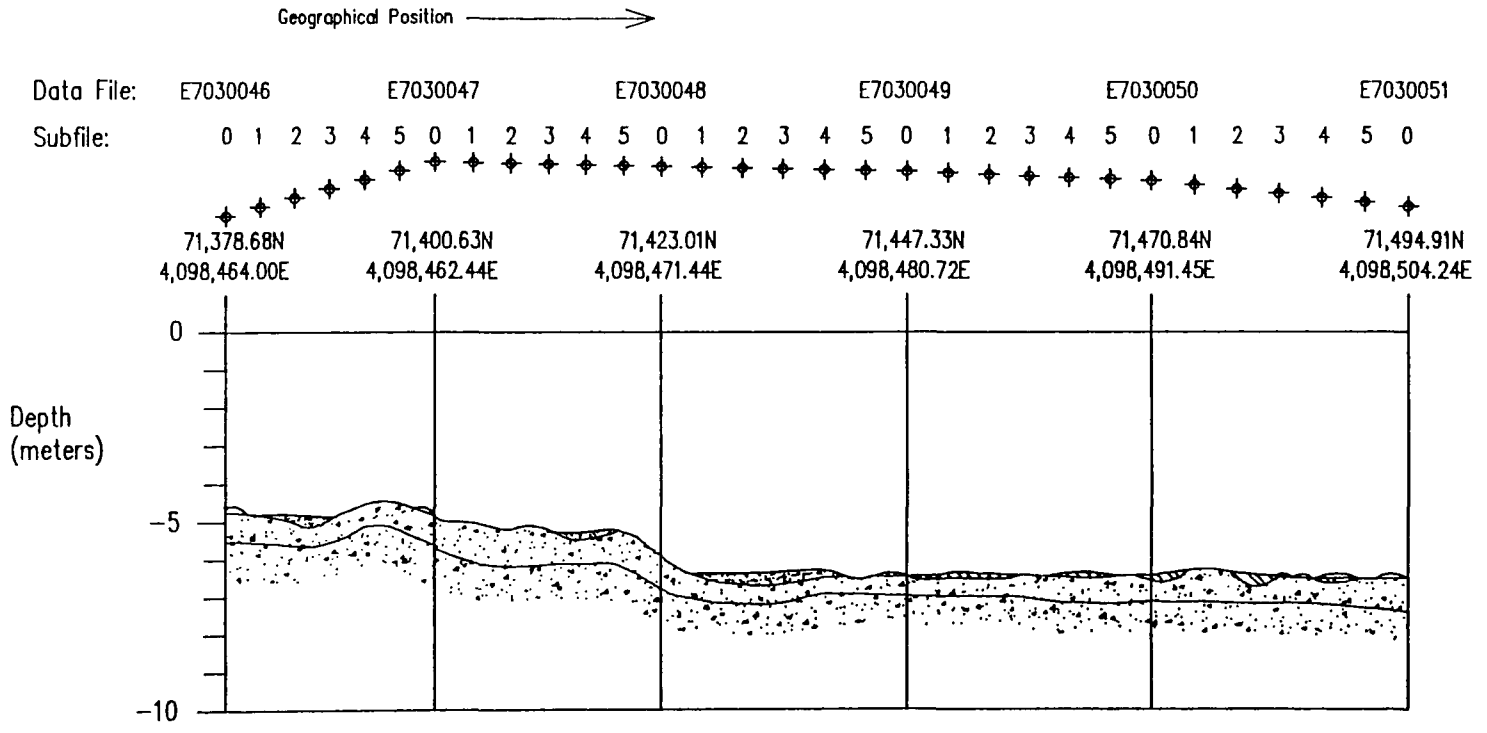
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 7

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: aE703-7



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.6	
	SILTY SAND TO SANDY SILT	1.6 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: E703
Line no: 09

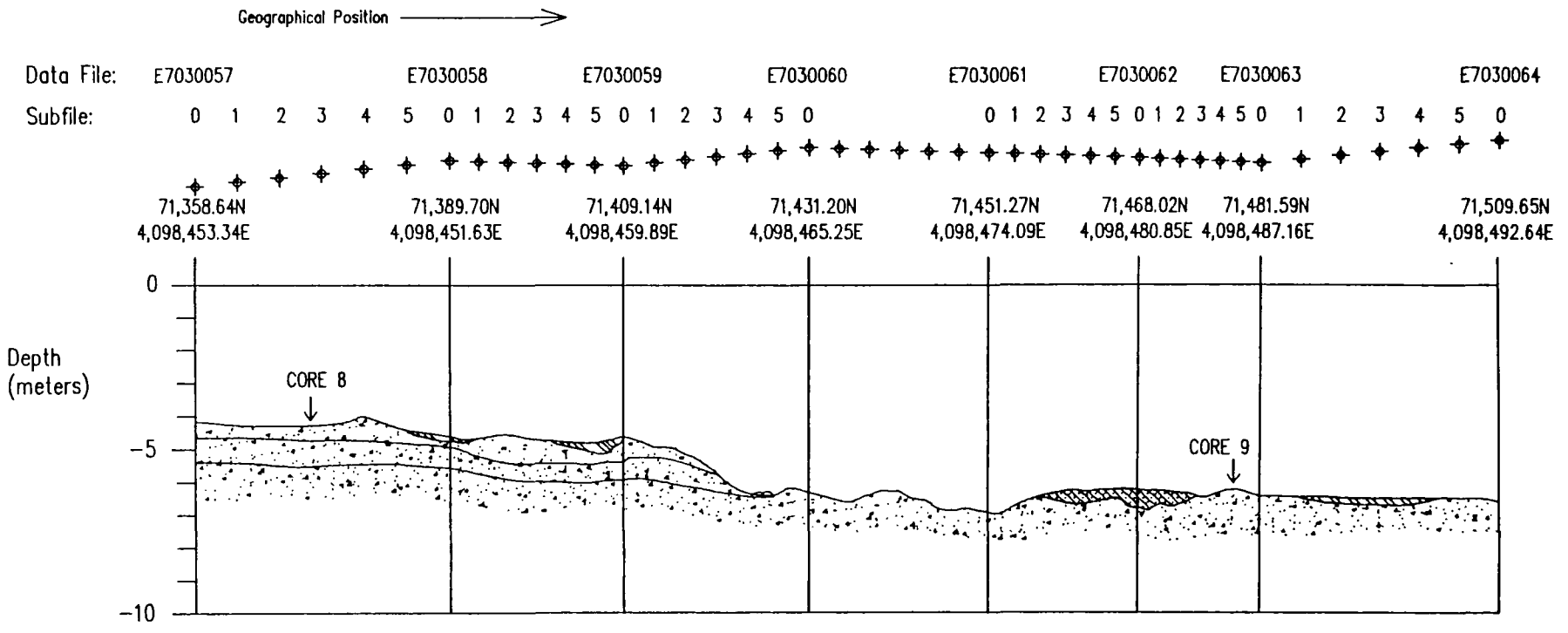
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 9

DRN BY:	SCALE:	DATE:
HV	1:500	16/1/97
JOB NO: 2117	DWG NO:	CADD FILE: gE703-9



LEGEND

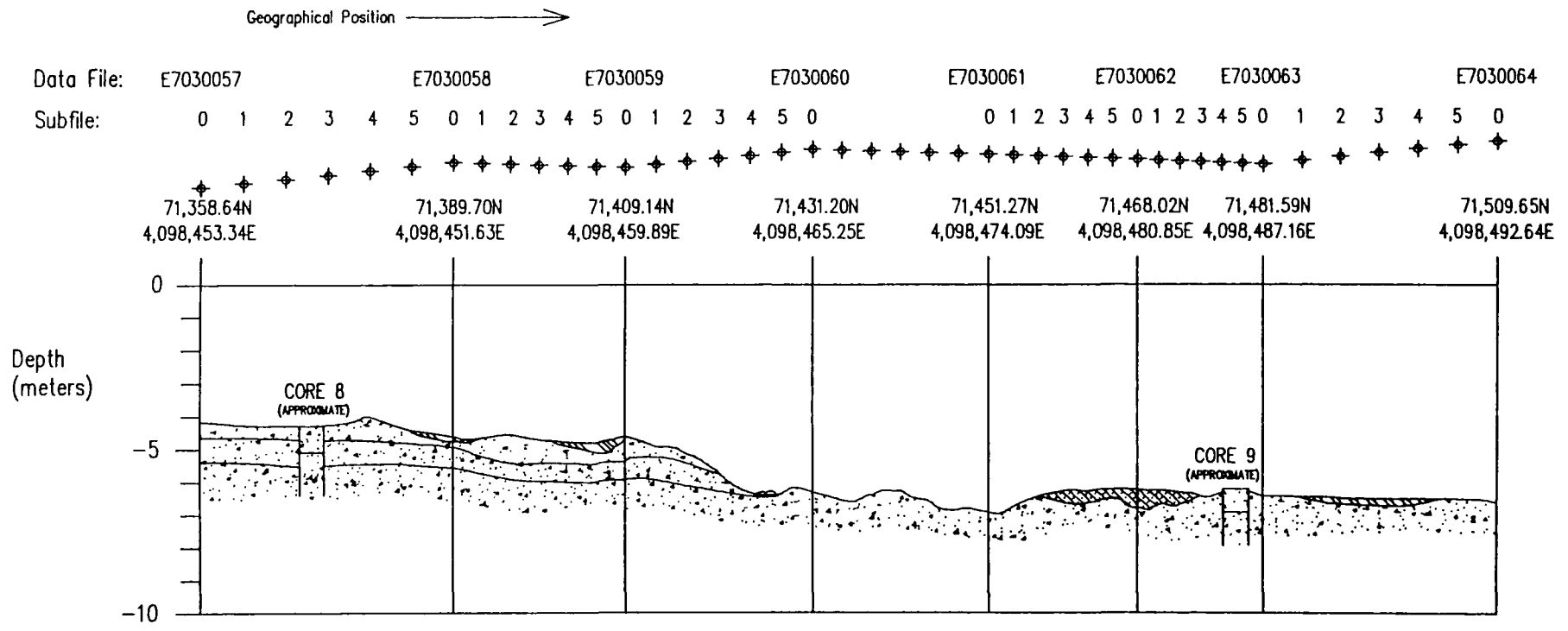
NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

Ref. File: E703
Line no: 11

CAULFIELD ENGINEERING		
TITLE: ELIZABETH PARK		
DRN BY: HV	SCALE: 1:500	DATE: 17/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-11A



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

Ref. File: E703
Line no: 11

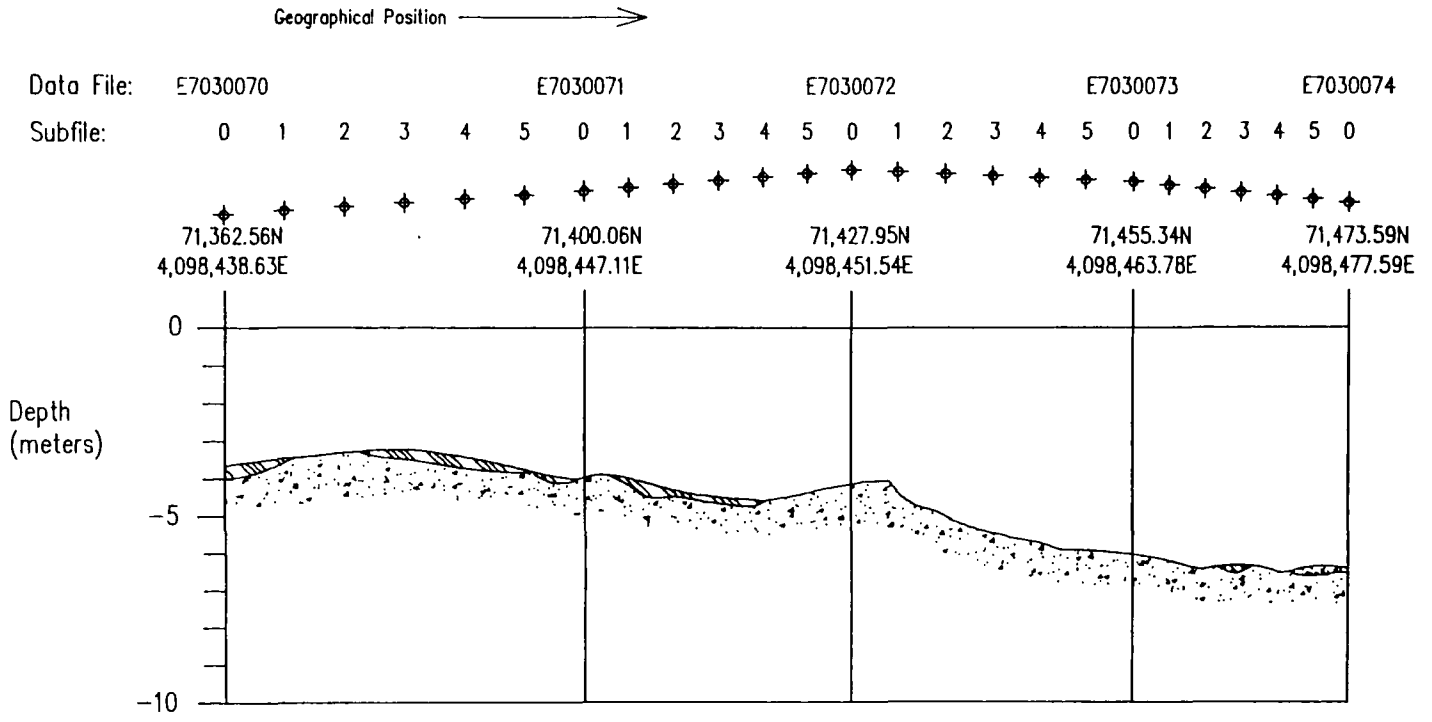
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 11

DRN BY:	SCALE:	DATE:
HV	1:500	17/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-11B



Ref. File: E703
Line no: 13

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

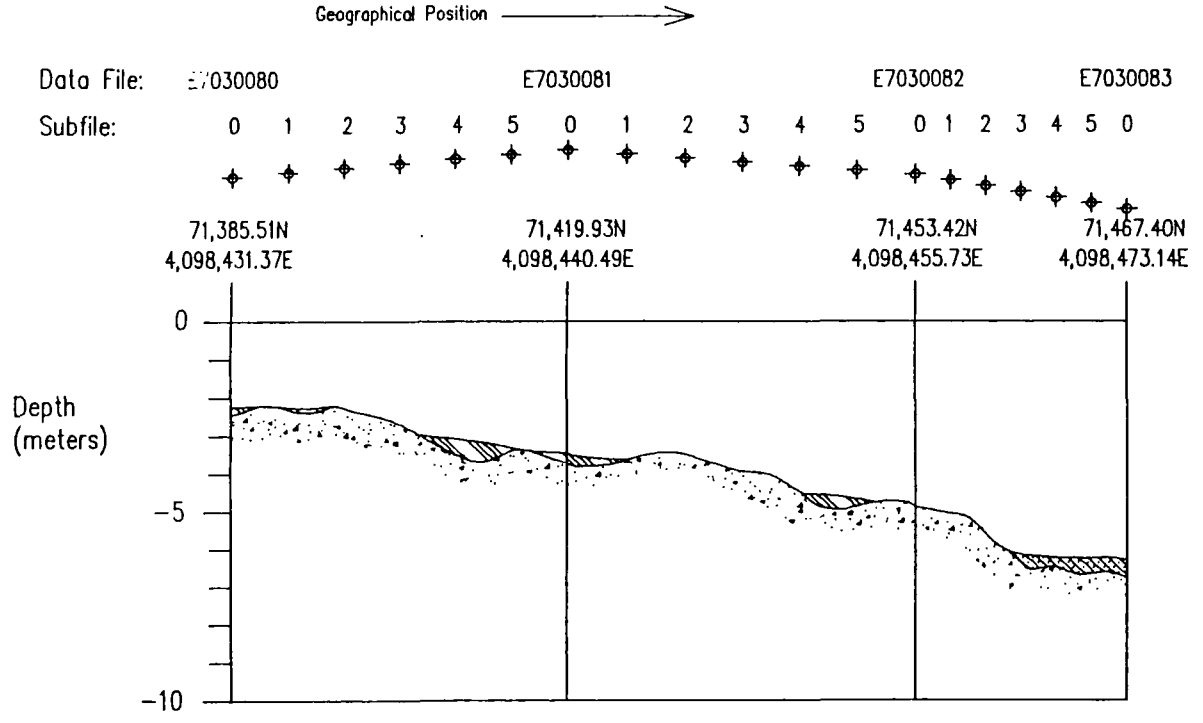
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK, E703/LINE 13

DRN BY:	SCALE:	DATE:
HV	1:500	17/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-13



Ref. File: E703
Line no: 14

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

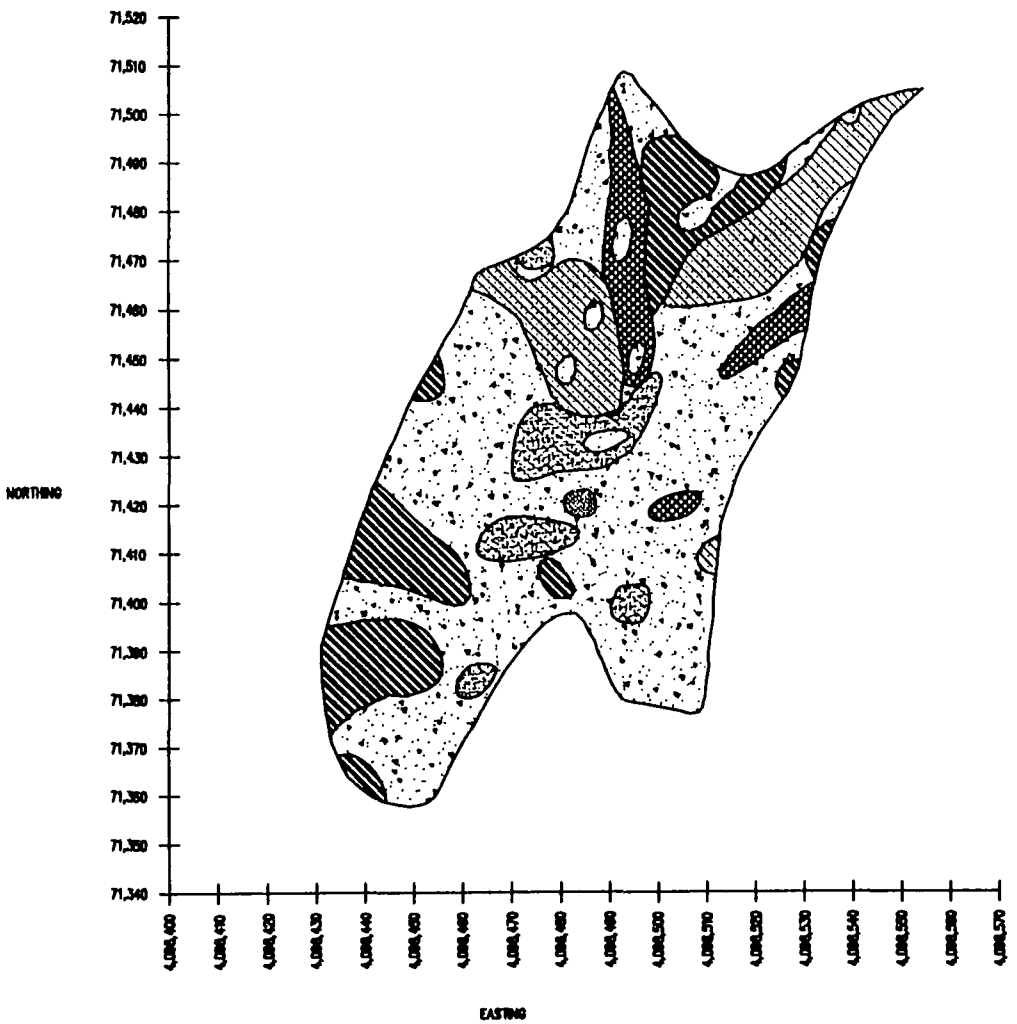
0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK,E703/LINE 14

DRN BY:	SCALE:	DATE:
HV	1:500	17/1/97
JOB NO: 2117	DWG NO:	CADD FILE: qE703-14



LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF	
	SILTY CLAY	
	CLAY	
	SILT	
	SILTY SAND	
	SAND	
	ROCK, HARD/COMPACT	

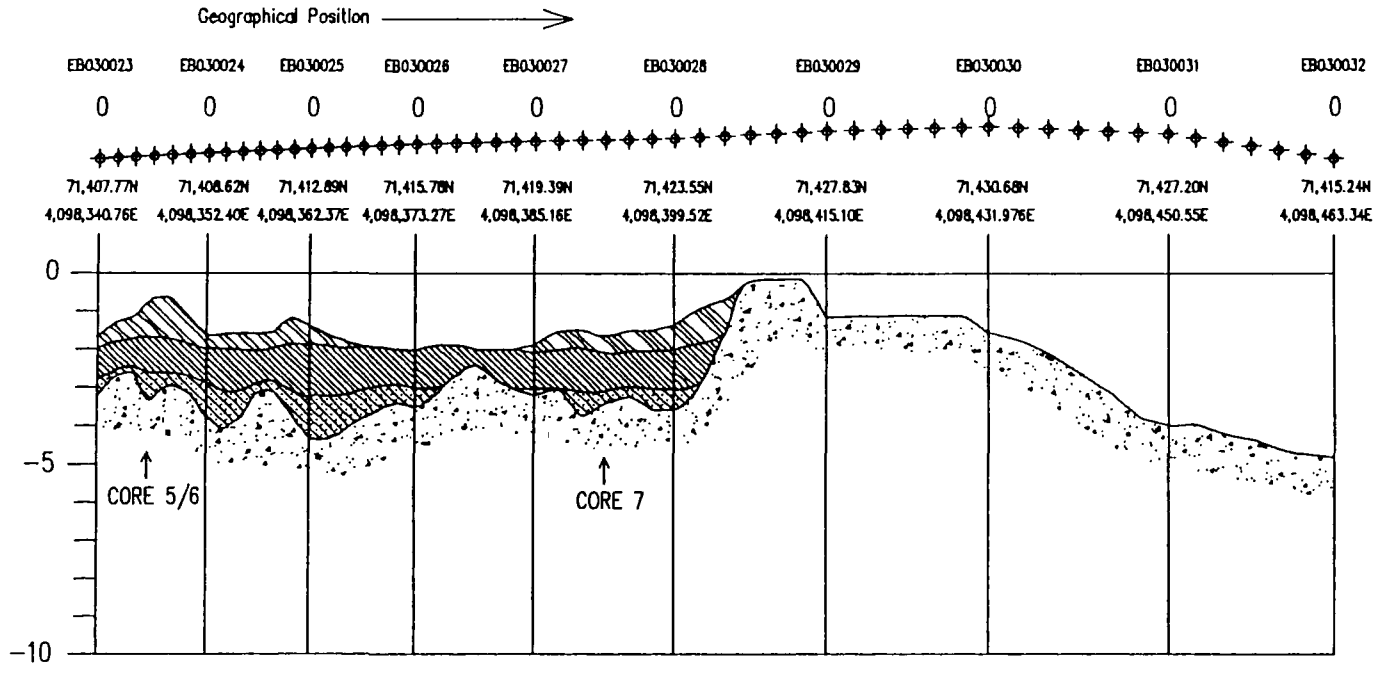
0 10 20m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK SEDIMENTS

DRWN BY:	SCALE:	DATE:
DC	1:1000	20/1/97
JOB NO. 2117	DWG NO:	FILE: ELIZCOLM



Ref. File: EB03
BOOMER LINE

NOTE:
LOW FREQUENCY BOOMER DATA
SEDIMENT LAYERS INTERPRETTED
FROM CORES

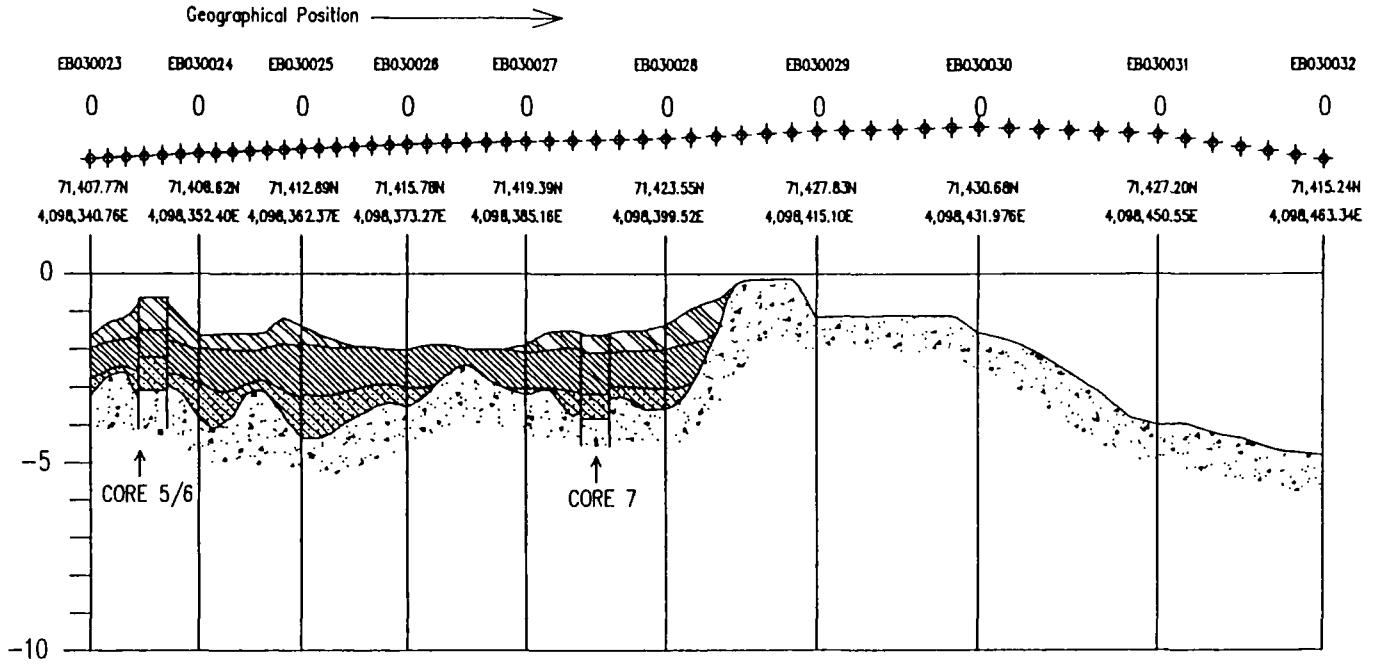
LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 – 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 – 1.4	
	SILT	1.4 – 1.6	
	SILTY SAND TO SANDY SILT	1.6 – 1.8	
	SAND	1.8 – 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING		
TITLE: ELIZABETH PARK/BOOMRE LINE		
DRN BY: HV	SCALE: 1:500	DATE: 24/1/97
JOB NO: 2117	DWG NO:	CADD FILE: rpEB03-A



Ref. File: EB03
BOOMER LINE

NOTE:
LOW FREQUENCY BOOMER DATA
SEDIMENT LAYERS INTERPRETTED
FROM CORES

LEGEND

NORMAL SEDIMENT	BASIC SOIL DESCRIPTION	DENSITY gm/cc	POTENTIAL POLLUTED SEDIMENT
	FOAM/FLUFF		
	CLAY	1.0 - 1.3	
	SILTY CLAY TO CLAYEY SILT	1.3 - 1.4	
	SILT	1.4 - 1.6	
	SILTY SAND TO SANDY SILT	1.6 - 1.8	
	SAND	1.8 - 2.2	
	HARD/COMPACT	> 2.2	

0 5 10m

LATERAL DISTANCE SCALE

CAULFIELD ENGINEERING

TITLE: ELIZABETH PARK/BOOMER LINE

DRN BY:	SCALE:	DATE:
HV	1:500	27/1/97
JOB NO: 2117	DWG NO:	CADD FILE: rpBE03-B

TRENTON CHANNEL STUDY AREA

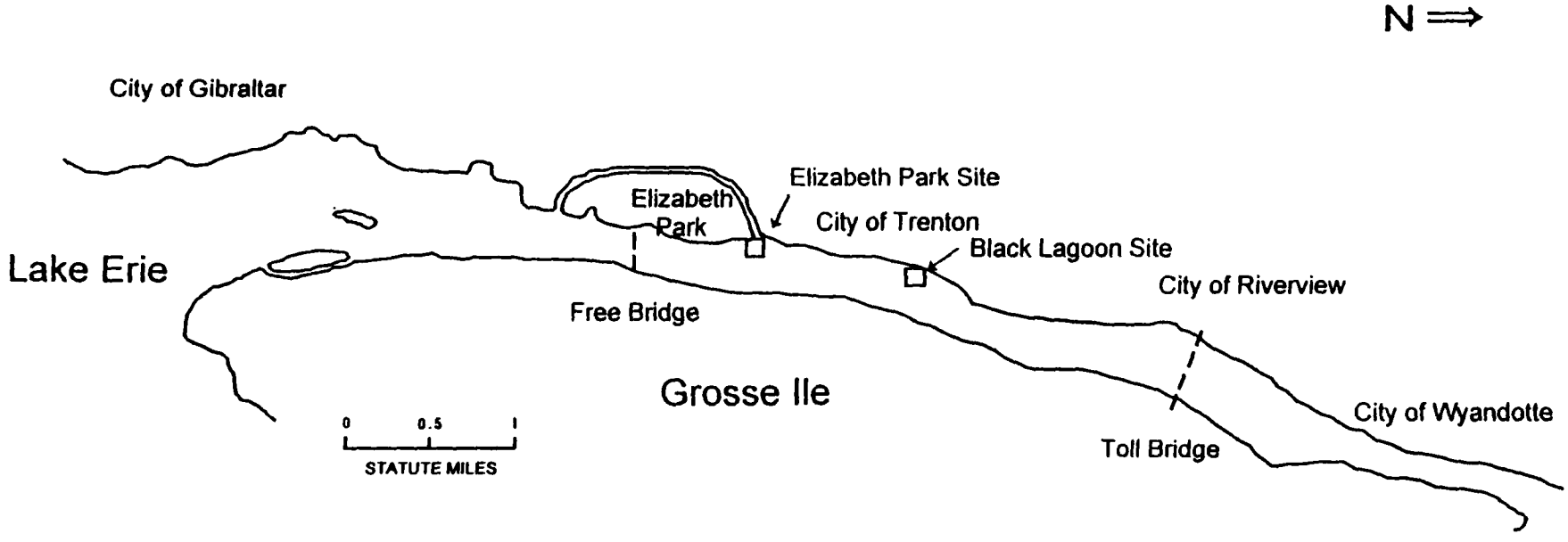


Plate 33
Trenton Channel
Study Area

APPENDIX A2

METLAB ANALYSIS PROGRAMS

The Major Metlab Program Listings Prepared for the Analysis of the Data is Contained in This Appendix. These Program Listings have been Broken into Sub-Appendices for Easier Reference

Appendix A2.1

Bottom Loss Computations

Program Listing 1 - Bottom Loss Batch File
Program Listing 2 - Bottom Loss Plotting Routine

PROGRAM LISTING #1
BLS.M

```
% program name  : bls
% program       : bottom loss plots
% comments      : this is the batch engine driver
%                 to produce various bottom loss plots
%                 any number can be run with printing

% define constants
m = 20;
pf = 0;

% program runs
a = 'L03';
fbls2(a,m,pf);

%a = 'L01';
%fbls2(a,m,pf);
%a = 'L03';
%fbls2(a,m,pf);
%a = 'L05';
%fbls2(a,m,pf);
%a = 'L07';
%fbls2(a,m,pf);
%a = 'L09';
%fbls2(a,m,pf);
%a = 'L11';
%fbls2(a,m,pf);
%a = 'L13';
%fbls2(a,m,pf);
%a = 'L14';
%fbls2(a,m,pf);

% end of batch engine driver
```

PROGRAM LISTING #2
FBLS2.M

```
function fbls2(a,m,pf)
% function name : fbls
% function      : bottom loss
% description   : this function generates bottom loss
%                 plots for one line

% load the bottom loss data data
eval(['load c:\brian\e70x\' a '.bls ;']);
eval(['bl = ' a ';']);
bl = bl';
[temp n] = size(bl);
xbl = 1 : n;

% calculate average and standard deviation for
%   every point except at the edges.
for i = m + 1 : n   m;
 bltemp(1 : 2 * m + 1) = bl(i - m : i + m);
 blav(i) = mean(bltemp);
 blsd(i) = std(bltemp);
end;
% for the both edges use the closest symmetric calculation
% this is the same as using the 2*m + 1 values starting at
%   the edge
for i = 1 : m;
 blav(i) = blav(m + 1);
 blsd(i) = blsd(m + 1);
end;
for i = n - m + 1 : n;
 blav(i) = blav(n - m);
 blsd(i) = blsd(n - m);
end;

% plot bottom losses and processed bottom losses
figure(2);
grid;
subplot(2,1,1), plot(xbl,bl);
title(['Figure XXX  Bottom Losses for : ' a]);
ylabel('BL (raw)');
grid;
```

```
subplot(2,1,2), plot(xbl,blav,xbl,blsd);
ylabel('smoothed      stdev');
grid;
xlabel('x');
if pf == 1;
 print;
end;

% end of function
```

Appendix A2.2

Phase Computations

Program Listing 3 - Phase Batch File
Program Listing 4 - Phase Plotting Routine

PROGRAM LISTING #3
PHP.M

```
% program name  : php
% program       : phase plus plots
% comments      : this is the batch engine driver
%                to produce various phase plus plots
%                any number can be run with printing

% constants
m = 20;
pf = 0;

% program runs
a = 'L03';
fphp2(a,m,pf);

%a = 'L01';
%fphp2(a,m,pf);
%a = 'L03';
%fphp2(a,m,pf);
%a = 'L05';
%fphp2(a,m,pf);
%a = 'L07';
%fphp2(a,m,pf);
%a = 'L09';
%fphp2(a,m,pf);
%a = 'L11';
%fphp2(a,m,pf);
%a = 'L13';
%fphp2(a,m,pf);
%a = 'L14';
%fphp2(a,m,pf);

% end of batch engine driver
```

PROGRAM LISTING #4
FPHP2.M

```
function fphp2(a,m,pf)
% function name : fphp2
% function      : phase plus
% description   : this function generates phase plus
%                 plots for one line

% load the phase plus data
eval(['load c:\brian\e70x\' a '.php ;']);
eval(['pp = ' a ';']);
pp = pp';
[temp n] = size(pp);
xpp = 1 : n;
pp2(1 : n) = pp(1, 1 : n);
clear pp;
pp = pp2;

% process the phases +- where there is symmetical data
for i = m + 1 : n - m;
 pptemp(1 : 2 * m + 1) = pp(i - m : i + m);
 ppav(i) = mean(pptemp);
 temp = ppav(i);
% adjust so the range is 0 to 100.
 temp = temp/2 + 0.5;
 temp = temp * 100;
 ppav(i) = temp;
end
% use the nearest symmetric value for edges.
for i = 1 : m;
 ppav(i) = ppav(m + 1);
end;
for i = n - m + 1 : n;
 ppav(i) = ppav(n - m);
end;
% calculate the standard deviation too
for i = m + 1 : n - m;
 pptemp(1 : 2 * m + 1) = ppav(i - m : i + m);
 ppsd(i) = std(pptemp);
end;
```

```
% edge effects for SD
for i = 1 : m;
 ppsd(i) = ppsd(m + 1);
end;
for i = n - m + 1 : n;
 ppsd(i) = ppsd(n - m);
end;

% plot phase sign percents
figure(1);
grid;
subplot(2,1,1), plot(xpp,pp);
title(['Figure XXX   Plus Percent for : ' a]);
ylabel('individual phases');
grid;
subplot(2,1,2), plot(xpp,ppav,xpp,ppsd);
ylabel('stdev    plus percent');
grid;
xlabel('x');
if pf == 1;
 print;
end;

% end of function
```

Appendix A2.3

Layer Thickness Contour Routines

Program Listing 5 - Layer Thickness Contour Plot Routine

PROGRAM LISTING #5
FLAYERS3.M

```
function flayers3
% function name : flayers3
% function      : layers contour
% description   : this function generates a contour plot
%               for the layers
%               it also writes the interpolated grid
%               to an ascii (text) file

% first read the data from disk and store in arrays

% load line 02
load c:\brian\autocadt\bl02bj.txt
hld = bl02bj;
hld = hld';
[temp n02] = size(hld);
north02(1 : n02) = hld(1, 1 : n02);
north02 = north02 - 70000;
east02(1 : n02) = hld(2, 1 : n02);
east02 = east02 - 4090000;
top02(1 : n02) = hld(3, 1 : n02);
bot02(1 : n02) = hld(4, 1 : n02);
dpth02 = bot02 - top02;
clear hld;

% load line 04
load c:\brian\autocadt\bl04bj.txt
hld = bl04bj;
hld = hld';
[temp n04] = size(hld);
north04(1 : n04) = hld(1, 1 : n04);
north04 = north04 - 70000;
east04(1 : n04) = hld(2, 1 : n04);
east04 = east04 - 4090000;
top04(1 : n04) = hld(3, 1 : n04);
bot04(1 : n04) = hld(4, 1 : n04);
dpth04 = bot04 - top04;
clear hld;
```

```
% load line 06
load c:\brian\autocadt\bl06bj.txt
hld = bl06bj;
hld = hld';
[temp n06] = size(hld);
north06(1 : n06) = hld(1, 1 : n06);
north06 = north06 - 70000;
east06(1 : n06) = hld(2, 1 : n06);
east06 = east06 - 4090000;
top06(1 : n06) = hld(3, 1 : n06);
bot06(1 : n06) = hld(4, 1 : n06);
dpth06 = bot06 - top06;
clear hld;

% load line 08
load c:\brian\autocadt\bl08bj.txt
hld = bl08bj;
hld = hld';
[temp n08] = size(hld);
north08(1 : n08) = hld(1, 1 : n08);
north08 = north08 - 70000;
east08(1 : n08) = hld(2, 1 : n08);
east08 = east08 - 4090000;
top08(1 : n08) = hld(3, 1 : n08);
bot08(1 : n08) = hld(4, 1 : n08);
dpth08 = bot08 - top08;
clear hld;

% load line 10
load c:\brian\autocadt\bl10bj.txt
hld = bl10bj;
hld = hld';
[temp n10] = size(hld);
north10(1 : n10) = hld(1, 1 : n10);
north10 = north10 - 70000;
east10(1 : n10) = hld(2, 1 : n10);
east10 = east10 - 4090000;
top10(1 : n10) = hld(3, 1 : n10);
bot10(1 : n10) = hld(4, 1 : n10);
dpth10 = bot10 - top10;
clear hld;

% load line 12
load c:\brian\autocadt\bl12bj.txt
hld = bl12bj;
```

```
hld = hld';
[temp n12] = size(hld);
north12(1 : n12) = hld(1, 1 : n12);
north12 = north12 - 70000;
east12(1 : n12) = hld(2, 1 : n12);
east12 = east12 - 4090000;
top12(1 : n12) = hld(3, 1 : n12);
bot12(1 : n12) = hld(4, 1 : n12);
dpth12 = bot12 - top12;
clear hld;

% load line 14
load c:\brian\autocadt\bl14bj.txt
hld = bl14bj;
hld = hld';
[temp n14] = size(hld);
north14(1 : n14) = hld(1, 1 : n14);
north14 = north14 - 70000;
east14(1 : n14) = hld(2, 1 : n14);
east14 = east14 - 4090000;
top14(1 : n14) = hld(3, 1 : n14);
bot14(1 : n14) = hld(4, 1 : n14);
dpth14 = bot14 - top14;
clear hld;

% load line 16
load c:\brian\autocadt\bl16bj.txt
hld = bl16bj;
hld = hld';
[temp n16] = size(hld);
north16(1 : n16) = hld(1, 1 : n16);
north16 = north16 - 70000;
east16(1 : n16) = hld(2, 1 : n16);
east16 = east16 - 4090000;
top16(1 : n16) = hld(3, 1 : n16);
bot16(1 : n16) = hld(4, 1 : n16);
dpth16 = bot16 - top16;
clear hld;

% load line 18
load c:\brian\autocadt\bl18bj.txt
hld = bl18bj;
hld = hld';
[temp n18] = size(hld);
north18(1 : n18) = hld(1, 1 : n18);
```

```
north18 = north18 - 70000;
east18(1 : n18) = hld(2, 1 : n18);
east18 = east18 - 4090000;
top18(1 : n18) = hld(3, 1 : n18);
bot18(1 : n18) = hld(4, 1 : n18);
dpth18 = bot18 - top18;
clear hld;

% load line 20
load c:\brian\autocadt\bl20bj.txt
hld = bl20bj;
hld = hld';
[temp n20] = size(hld);
north20(1 : n20) = hld(1, 1 : n20);
north20 = north20 - 70000;
east20(1 : n20) = hld(2, 1 : n20);
east20 = east20 - 4090000;
top20(1 : n20) = hld(3, 1 : n20);
bot20(1 : n20) = hld(4, 1 : n20);
dpth20 = bot20 - top20;
clear hld;

% load line 22
load c:\brian\autocadt\bl22bj.txt
hld = bl22bj;
hld = hld';
[temp n22] = size(hld);
north22(1 : n22) = hld(1, 1 : n22);
north22 = north22 - 70000;
east22(1 : n22) = hld(2, 1 : n22);
east22 = east22 - 4090000;
top22(1 : n22) = hld(3, 1 : n22);
bot22(1 : n22) = hld(4, 1 : n22);
dpth22 = bot22 - top22;
clear hld;

% put all the data into 3 long vectors

nn04 = n02 + n04;
nn06 = nn04 + n06;
nn08 = nn06 + n08;
nn10 = nn08 + n10;
nn12 = nn10 + n12;
nn14 = nn12 + n14;
nn16 = nn14 + n16;
```

```
nn18 = nn16 + n18;
nn20 = nn18 + n20;
nn22 = nn20 + n22;
x(1 : n02) = east02(1 : n02);
x(n02 + 1 : nn04) = east04(1 : n04);
x(nn04 + 1 : nn06) = east06(1 : n06);
x(nn06 + 1 : nn08) = east08(1 : n08);
x(nn08 + 1 : nn10) = east10(1 : n10);
x(nn10 + 1 : nn12) = east12(1 : n12);
x(nn12 + 1 : nn14) = east14(1 : n14);
x(nn14 + 1 : nn16) = east16(1 : n16);
x(nn16 + 1 : nn18) = east18(1 : n18);
x(nn18 + 1 : nn20) = east20(1 : n20);
x(nn20 + 1 : nn22) = east22(1 : n22);
y(1 : n02) = north02(1 : n02);
y(n02 + 1 : nn04) = north04(1 : n04);
y(nn04 + 1 : nn06) = north06(1 : n06);
y(nn06 + 1 : nn08) = north08(1 : n08);
y(nn08 + 1 : nn10) = north10(1 : n10);
y(nn10 + 1 : nn12) = north12(1 : n12);
y(nn12 + 1 : nn14) = north14(1 : n14);
y(nn14 + 1 : nn16) = north16(1 : n16);
y(nn16 + 1 : nn18) = north18(1 : n18);
y(nn18 + 1 : nn20) = north20(1 : n20);
y(nn20 + 1 : nn22) = north22(1 : n22);
z(1 : n02) = dpth02(1 : n02);
z(n02 + 1 : nn04) = dpth04(1 : n04);
z(nn04 + 1 : nn06) = dpth06(1 : n06);
z(nn06 + 1 : nn08) = dpth08(1 : n08);
z(nn08 + 1 : nn10) = dpth10(1 : n10);
z(nn10 + 1 : nn12) = dpth12(1 : n12);
z(nn12 + 1 : nn14) = dpth14(1 : n14);
z(nn14 + 1 : nn16) = dpth16(1 : n16);
z(nn16 + 1 : nn18) = dpth18(1 : n18);
z(nn18 + 1 : nn20) = dpth20(1 : n20);
z(nn20 + 1 : nn22) = dpth22(1 : n22);
clear east02;
clear east04;
clear east06;
clear east08;
clear east10;
clear east12;
clear east14;
clear east16;
clear east18;
```

```
clear east20;
clear east22;
clear north02;
clear north04;
clear north06;
clear north08;
clear north10;
clear north12;
clear north14;
clear north16;
clear north18;
clear north20;
clear north22;
clear top02;
clear top04;
clear top06;
clear top08;
clear top10;
clear top12;
clear top14;
clear top16;
clear top18;
clear top20;
clear top22;
clear bot02;
clear bot04;
clear bot06;
clear bot08;
clear bot10;
clear bot12;
clear bot14;
clear bot16;
clear bot18;
clear bot20;
clear bot22;
clear dpth02;
clear dpth04;
clear dpth06;
clear dpth08;
clear dpth10;
clear dpth12;
clear dpth14;
clear dpth16;
clear dpth18;
clear dpth20;
```

```
clear dpth22;

%for i = 1 : 86;
% xi(i) = i*2;
%end;
%for i = 1 : 91;
% yi(i) = i*2;
%end;
%xi = 8698 + xi;
%yi = 2858 + yi;

% defined desired regular grid coordinates
for i = 1 : 35;
 xi(i) = i*5;
end;
for i = 1 : 37;
 yi(i) = i*5;
end;
xi = 8695 + xi;
yi = 2855 + yi;

% interpolate the data onto the regular grid
zi = griddata(x,y,z,xi,yi);

%% save the resampled data to disk
%for i = 1 : 35;
% for j = 1 : 37;
%  k = j + (i - 1) * 37;
%  a(1,k) = xi(i);
%  a(2,k) = yi(j);
%  a(3,k) = zi(k);
% end;
%end;
%a = a'
%save c:\brian\code\thick.txt a -ascii

% make contour plot
v = [0.5 0.75 1 1.25 1.5 1.75 2 2.25 2.5];
figure(1);
grid;
cs = contour(xi,yi,zi,v);
axis('square');
axis([8700,8880,2860,3040]);
title('Black Lagoon Thick Sediment Contours (greater than 0.5 m)');
ylabel('Northing');
```

```
grid;
xlabel('Easting    Contour inverval is 0.25 m');
clabel(cs,'manual');

% end of function
```

Appendix A2.4

Scaled Survey Lines Routine

Program Listing 6 - Sealed Survey Line Map Routine

PROGRAM LISTING #6
FLINES.M

```
function flines
% function name : flines
% function      : lines
% description   : this function generates a map plot
%                 of all the lines

% load line 02
load c:\brian\autocadt\bl02bj.txt
hld = bl02bj;
hld = hld';
[temp n02] = size(hld);
no02(1 : n02) = hld(1, 1 : n02);
no02 = no02 - 70000;
ea02(1 : n02) = hld(2, 1 : n02);
ea02 = ea02 - 4090000;
clear hld;

% load line 04
load c:\brian\autocadt\bl04bj.txt
hld = bl04bj;
hld = hld';
[temp n04] = size(hld);
no04(1 : n04) = hld(1, 1 : n04);
no04 = no04 - 70000;
ea04(1 : n04) = hld(2, 1 : n04);
ea04 = ea04 - 4090000;
clear hld;

% load line 06
load c:\brian\autocadt\bl06bj.txt
hld = bl06bj;
hld = hld';
[temp n06] = size(hld);
no06(1 : n06) = hld(1, 1 : n06);
no06 = no06   70000;
ea06(1 : n06) = hld(2, 1 : n06);
ea06 = ea06 - 4090000;
clear hld;
```

```
% load line 08
load c:\brian\autocadt\bl08bj.txt
hld = bl08bj;
hld = hld';
[temp n08] = size(hld);
no08(1 : n08) = hld(1, 1 : n08);
no08 = no08 - 70000;
ea08(1 : n08) = hld(2, 1 : n08);
ea08 = ea08 - 4090000;
clear hld;

% load line 10
load c:\brian\autocadt\bl10bj.txt
hld = bl10bj;
hld = hld';
[temp n10] = size(hld);
no10(1 : n10) = hld(1, 1 : n10);
no10 = no10 - 70000;
ea10(1 : n10) = hld(2, 1 : n10);
ea10 = ea10 - 4090000;
clear hld;

% load line 12
load c:\brian\autocadt\bl12bj.txt
hld = bl12bj;
hld = hld';
[temp n12] = size(hld);
no12(1 : n12) = hld(1, 1 : n12);
no12 = no12 - 70000;
ea12(1 : n12) = hld(2, 1 : n12);
ea12 = ea12 - 4090000;
clear hld;

% load line 14
load c:\brian\autocadt\bl14bj.txt
hld = bl14bj;
hld = hld';
[temp n14] = size(hld);
no14(1 : n14) = hld(1, 1 : n14);
no14 = no14 - 70000;
ea14(1 : n14) = hld(2, 1 : n14);
ea14 = ea14 - 4090000;
clear hld;

% load line 16
```

```
load c:\brian\autocadt\bl16bj.txt
hld = bl16bj;
hld = hld';
[temp n16] = size(hld);
no16(1 : n16) = hld(1, 1 : n16);
no16 = no16 - 70000;
ea16(1 : n16) = hld(2, 1 : n16);
ea16 = ea16 - 4090000;
clear hld;

% load line 18
load c:\brian\autocadt\bl18bj.txt
hld = bl18bj;
hld = hld';
[temp n18] = size(hld);
no18(1 : n18) = hld(1, 1 : n18);
no18 = no18 - 70000;
ea18(1 : n18) = hld(2, 1 : n18);
ea18 = ea18 - 4090000;
clear hld;

% load line 20
load c:\brian\autocadt\bl20bj.txt
hld = bl20bj;
hld = hld';
[temp n20] = size(hld);
no20(1 : n20) = hld(1, 1 : n20);
no20 = no20 - 70000;
ea20(1 : n20) = hld(2, 1 : n20);
ea20 = ea20 - 4090000;
clear hld;

% load line 22
load c:\brian\autocadt\bl22bj.txt
hld = bl22bj;
hld = hld';
[temp n22] = size(hld);
no22(1 : n22) = hld(1, 1 : n22);
no22 = no22 - 70000;
ea22(1 : n22) = hld(2, 1 : n22);
ea22 = ea22 - 4090000;
clear hld;

% make map plot
figure(1);
```

```
grid;
plot(ea02,no02,ea04,no04,ea06,no06,ea08,no08,ea10,no10,ea12,no12,ea14,no14,ea16,no16,ea18
,no18,ea20,no20,ea22,no22);
title('plot map of lines 02 - 22');
axis('square');
axis([8700,8880,2860,3040]);
ylabel('Northing');
grid;
xlabel('Easting');
pf = 0;
if pf == 1;
 print;
end;

% end of function
```

Appendix A2.5

Volume Estimate Routine

Program Listing 7 - Sediment Thickness and Position Information Converted to Volume Estimates

PROGRAM LISTING #7
FVOL.M

```
function fvol
% function name : fvol
% function      : volume calculation
% description   : this function calculates the volume of
%                 sediment within a given range of Northings
%                 and Eastings.  The sediments must also
%                 be thicker than a practical dregging minimum
%                 and be within the actual survey boundries.
%
%                 the result is simply echoed to the matlab
%                 command window.
%

% load thicknesses
load c:\brian\code\thick3.txt
hld = thick3;
hld = hld';
[temp n] = size(hld);
north(1 : n) = hld(2, 1 : n);
east(1 : n) = hld(1, 1 : n);
thick(1 : n) = hld(3, 1 : n);
inflg(1 : n) = hld(4, 1 : n);
clear hld;

% set range data
minthick = 1.0;
eastinc = 5;
northinc = 5;
eastmin = 8750;
eastmax = 8810;
northmin = 2990;
northmax = 3040;

% calcuate the volume
vol = 0;
for i = 1 : n;
 if inflg(i) == 1;
  if east(i) >= eastmin;
```

```
   if east(i) <= eastmax;
    if north(i) >= northmin;
     if north(i) <= northmax;
      if thick(i) >= minthick;
       vol = vol + thick(i);
      end;
     end;
    end;
   end;
  end;
 end;
end;

% echoing to matlab window
northmin2 = northmin
northmax2 = northmax
eastmin2 = eastmin
eastmax2 = eastmax
minthick2 = minthick
thick2 = vol
vol = vol * northinc * eastinc;
vol3 = vol

% end of function
```

Appendix A2.6

Depth Contour Routine

Program Listing 8 - Bathymetric Contour Generation

PROGRAM LISTING #8
FWDEP.M

```
function fwdep
% function name : fwdep
% function      : water depth
% description   : this function generates a contour plot
%                 for the water depths

% load line 02
load c:\brian\autocadt\bl02bj.txt
hld = bl02bj;
hld = hld';
[temp n02] = size(hld);
north02(1 : n02) = hld(1, 1 : n02);
north02 = north02 - 70000;
east02(1 : n02) = hld(2, 1 : n02);
east02 = east02 - 4090000;
top02(1 : n02) = hld(3, 1 : n02);
clear hld;

% load line 04
load c:\brian\autocadt\bl04bj.txt
hld = bl04bj;
hld = hld';
[temp n04] = size(hld);
north04(1 : n04) = hld(1, 1 : n04);
north04 = north04 - 70000;
east04(1 : n04) = hld(2, 1 : n04);
east04 = east04 - 4090000;
top04(1 : n04) = hld(3, 1 : n04);
clear hld;

% load line 06
load c:\brian\autocadt\bl06bj.txt
hld = bl06bj;
hld = hld';
[temp n06] = size(hld);
north06(1 : n06) = hld(1, 1 : n06);
north06 = north06 - 70000;
east06(1 : n06) = hld(2, 1 : n06);
```

```
east06 = east06 - 4090000;
top06(1 : n06) = hld(3, 1 : n06);
clear hld;

% load line 08
load c:\brian\autocadt\bl08bj.txt
hld = bl08bj;
hld = hld';
[temp n08] = size(hld);
north08(1 : n08) = hld(1, 1 : n08);
north08 = north08 - 70000;
east08(1 : n08) = hld(2, 1 : n08);
east08 = east08 - 4090000;
top08(1 : n08) = hld(3, 1 : n08);
clear hld;

% load line 10
load c:\brian\autocadt\bl10bj.txt
hld = bl10bj;
hld = hld';
[temp n10] = size(hld);
north10(1 : n10) = hld(1, 1 : n10);
north10 = north10 - 70000;
east10(1 : n10) = hld(2, 1 : n10);
east10 = east10 - 4090000;
top10(1 : n10) = hld(3, 1 : n10);
clear hld;

% load line 12
load c:\brian\autocadt\bl12bj.txt
hld = bl12bj;
hld = hld';
[temp n12] = size(hld);
north12(1 : n12) = hld(1, 1 : n12);
north12 = north12 - 70000;
east12(1 : n12) = hld(2, 1 : n12);
east12 = east12 - 4090000;
top12(1 : n12) = hld(3, 1 : n12);
clear hld;

% load line 14
load c:\brian\autocadt\bl14bj.txt
hld = bl14bj;
hld = hld';
[temp n14] = size(hld);
```

```
north14(1 : n14) = hld(1, 1 : n14);
north14 = north14 - 70000;
east14(1 : n14) = hld(2, 1 : n14);
east14 = east14 - 4090000;
top14(1 : n14) = hld(3, 1 : n14);
clear hld;

% load line 16
load c:\brian\autocadt\bl16bj.txt
hld = bl16bj;
hld = hld';
[temp n16] = size(hld);
north16(1 : n16) = hld(1, 1 : n16);
north16 = north16 - 70000;
east16(1 : n16) = hld(2, 1 : n16);
east16 = east16 - 4090000;
top16(1 : n16) = hld(3, 1 : n16);
clear hld;

% load line 18
load c:\brian\autocadt\bl18bj.txt
hld = bl18bj;
hld = hld';
[temp n18] = size(hld);
north18(1 : n18) = hld(1, 1 : n18);
north18 = north18 - 70000;
east18(1 : n18) = hld(2, 1 : n18);
east18 = east18 - 4090000;
top18(1 : n18) = hld(3, 1 : n18);
clear hld;

% load line 20
load c:\brian\autocadt\bl20bj.txt
hld = bl20bj;
hld = hld';
[temp n20] = size(hld);
north20(1 : n20) = hld(1, 1 : n20);
north20 = north20 - 70000;
east20(1 : n20) = hld(2, 1 : n20);
east20 = east20 - 4090000;
top20(1 : n20) = hld(3, 1 : n20);
clear hld;

% load line 22
load c:\brian\autocadt\bl22bj.txt
```

```
hld = bl22bj;
hld = hld';
[temp n22] = size(hld);
north22(1 : n22) = hld(1, 1 : n22);
north22 = north22 - 70000;
east22(1 : n22) = hld(2, 1 : n22);
east22 = east22 - 4090000;
top22(1 : n22) = hld(3, 1 : n22);
clear hld;

nn04 = n02 + n04;
nn06 = nn04 + n06;
nn08 = nn06 + n08;
nn10 = nn08 + n10;
nn12 = nn10 + n12;
nn14 = nn12 + n14;
nn16 = nn14 + n16;
nn18 = nn16 + n18;
nn20 = nn18 + n20;
nn22 = nn20 + n22;
x(1 : n02) = east02(1 : n02);
x(n02 + 1 : nn04) = east04(1 : n04);
x(nn04 + 1 : nn06) = east06(1 : n06);
x(nn06 + 1 : nn08) = east08(1 : n08);
x(nn08 + 1 : nn10) = east10(1 : n10);
x(nn10 + 1 : nn12) = east12(1 : n12);
x(nn12 + 1 : nn14) = east14(1 : n14);
x(nn14 + 1 : nn16) = east16(1 : n16);
x(nn16 + 1 : nn18) = east18(1 : n18);
x(nn18 + 1 : nn20) = east20(1 : n20);
x(nn20 + 1 : nn22) = east22(1 : n22);
y(1 : n02) = north02(1 : n02);
y(n02 + 1 : nn04) = north04(1 : n04);
y(nn04 + 1 : nn06) = north06(1 : n06);
y(nn06 + 1 : nn08) = north08(1 : n08);
y(nn08 + 1 : nn10) = north10(1 : n10);
y(nn10 + 1 : nn12) = north12(1 : n12);
y(nn12 + 1 : nn14) = north14(1 : n14);
y(nn14 + 1 : nn16) = north16(1 : n16);
y(nn16 + 1 : nn18) = north18(1 : n18);
y(nn18 + 1 : nn20) = north20(1 : n20);
y(nn20 + 1 : nn22) = north22(1 : n22);
z2(1 : n02) = top02(1 : n02);
z2(n02 + 1 : nn04) = top04(1 : n04);
z2(nn04 + 1 : nn06) = top06(1 : n06);
```

```
z2(nn06 + 1 : nn08) = top08(1 : n08);
z2(nn08 + 1 : nn10) = top10(1 : n10);
z2(nn10 + 1 : nn12) = top12(1 : n12);
z2(nn12 + 1 : nn14) = top14(1 : n14);
z2(nn14 + 1 : nn16) = top16(1 : n16);
z2(nn16 + 1 : nn18) = top18(1 : n18);
z2(nn18 + 1 : nn20) = top20(1 : n20);
z2(nn20 + 1 : nn22) = top22(1 : n22);

for i = 1 : 35;
 xi(i) = i*5;
end;
for i = 1 : 37;
 yi(i) = i*5;
end;
xi = 8695 + xi;
yi = 2855 + yi;

%for i = 1 : 18;
% xi(i) = i*10;
%end;
%for i = 1 : 19;
% yi(i) = i*10;
%end;
%xi = 8690 + xi;
%yi = 2850 + yi;

z2i = griddata(x,y,z2,xi,yi);

v2 = [1 2 3 4 5 6 7];

% make contour plot
figure(1);
grid;
cs = contour(xi,yi,z2i,v2);
axis('square');
axis([8700,8880,2860,3040]);
title('Black Lagoon Water Depth Contour Plot (in meters)');
ylabel('Northing');
grid;
xlabel('Easting');
clabel(cs,'manual');

% end of function
```

Appendix A2.7

Elizabeth Park Layer-Contour Routine

Program Listing 9 - Example of Program Changes for Site Input

PROGRAM LISTING #9
FLAYERQE.M

```
function flayerqe
% function name : flayerqe
% function      : layers contour qe park
% description   : this function generates a contour plot
%               for the layers
%               for queen elizabeth park

% read the data from disk

% load line 01
load c:\brian\autocadt\qe01bj.txt
hld = qe01bj;
hld = hld';
[temp n01] = size(hld);
no01(1 : n01) = hld(3, 1 : n01);
no01 = no01 - 70000;
ea01(1 : n01) = hld(4, 1 : n01);
ea01 = ea01 - 4090000;
top01(1 : n01) = hld(5, 1 : n01);
bot01(1 : n01) = hld(6, 1 : n01);
diff01 = bot01 - top01;
clear hld;

% load line 03
load c:\brian\autocadt\qe03bj.txt
hld = qe03bj;
hld = hld';
[temp n03] = size(hld);
no03(1 : n03) = hld(3, 1 : n03);
no03 = no03 - 70000;
ea03(1 : n03) = hld(4, 1 : n03);
ea03 = ea03 - 4090000;
top03(1 : n03) = hld(5, 1 : n03);
bot03(1 : n03) = hld(6, 1 : n03);
diff03 = bot03 - top03;
clear hld;

% load line 05
```

```
load c:\brian\autocadt\qe05bj.txt
hld = qe05bj;
hld = hld';
[temp n05] = size(hld);
no05(1 : n05) = hld(3, 1 : n05);
no05 = no05 - 70000;
ea05(1 : n05) = hld(4, 1 : n05);
ea05 = ea05 - 4090000;
top05(1 : n05) = hld(5, 1 : n05);
bot05(1 : n05) = hld(6, 1 : n05);
diff05 = bot05 - top05;
clear hld;

% load line 07
load c:\brian\autocadt\qe07bj.txt
hld = qe07bj;
hld = hld';
[temp n07] = size(hld);
no07(1 : n07) = hld(3, 1 : n07);
no07 = no07 - 70000;
ea07(1 : n07) = hld(4, 1 : n07);
ea07 = ea07 - 4090000;
top07(1 : n07) = hld(5, 1 : n07);
bot07(1 : n07) = hld(6, 1 : n07);
diff07 = bot07 - top07;
clear hld;

% load line 09
load c:\brian\autocadt\qe09bj.txt
hld = qe09bj;
hld = hld';
[temp n09] = size(hld);
no09(1 : n09) = hld(3, 1 : n09);
no09 = no09 - 70000;
ea09(1 : n09) = hld(4, 1 : n09);
ea09 = ea09 - 4090000;
top09(1 : n09) = hld(5, 1 : n09);
bot09(1 : n09) = hld(6, 1 : n09);
diff09 = bot09 - top09;
clear hld;

% load line 11
load c:\brian\autocadt\qe11bj.txt
hld = qe11bj;
hld = hld';
```

```
[temp n11] = size(hld);
no11(1 : n11) = hld(3, 1 : n11);
no11 = no11 - 70000;
ea11(1 : n11) = hld(4, 1 : n11);
ea11 = ea11 - 4090000;
top11(1 : n11) = hld(5, 1 : n11);
bot11(1 : n11) = hld(6, 1 : n11);
diff11 = bot11 - top11;
clear hld;

% load line 13
load c:\brian\autocadt\qe13bj.txt
hld = qe13bj;
hld = hld';
[temp n13] = size(hld);
no13(1 : n13) = hld(3, 1 : n13);
no13 = no13 - 70000;
ea13(1 : n13) = hld(4, 1 : n13);
ea13 = ea13 - 4090000;
top13(1 : n13) = hld(5, 1 : n13);
bot13(1 : n13) = hld(6, 1 : n13);
diff13 = bot13 - top13;
clear hld;

% load line 14
load c:\brian\autocadt\qe14bj.txt
hld = qe14bj;
hld = hld';
[temp n14] = size(hld);
no14(1 : n14) = hld(3, 1 : n14);
no14 = no14 - 70000;
ea14(1 : n14) = hld(4, 1 : n14);
ea14 = ea14 - 4090000;
top14(1 : n14) = hld(5, 1 : n14);
bot14(1 : n14) = hld(6, 1 : n14);
diff14 = bot14 - top14;
clear hld;

nn03 = n01 + n03;
nn05 = nn03 + n05;
nn07 = nn05 + n07;
nn09 = nn07 + n09;
nn11 = nn09 + n11;
nn13 = nn11 + n13;
nn14 = nn13 + n14;
```

```
x(1 : n01) = ea01(1 : n01);
x(n01 + 1 : nn03) = ea03(1 : n03);
x(nn03 + 1 : nn05) = ea05(1 : n05);
x(nn05 + 1 : nn07) = ea07(1 : n07);
x(nn07 + 1 : nn09) = ea09(1 : n09);
x(nn09 + 1 : nn11) = ea11(1 : n11);
x(nn11 + 1 : nn13) = ea13(1 : n13);
x(nn13 + 1 : nn14) = ea14(1 : n14);
clear ea01;
clear ea03;
clear ea05;
clear ea07;
clear ea09;
clear ea11;
clear ea13;
clear ea14;

y(1 : n01) = no01(1 : n01);
y(n01 + 1 : nn03) = no03(1 : n03);
y(nn03 + 1 : nn05) = no05(1 : n05);
y(nn05 + 1 : nn07) = no07(1 : n07);
y(nn07 + 1 : nn09) = no09(1 : n09);
y(nn09 + 1 : nn11) = no11(1 : n11);
y(nn11 + 1 : nn13) = no13(1 : n13);
y(nn13 + 1 : nn14) = no14(1 : n14);
clear no01;
clear no03;
clear no05;
clear no07;
clear no09;
clear no11;
clear no13;
clear no14;

z1(1 : n01) = top01(1 : n01);
z1(n01 + 1 : nn03) = top03(1 : n03);
z1(nn03 + 1 : nn05) = top05(1 : n05);
z1(nn05 + 1 : nn07) = top07(1 : n07);
z1(nn07 + 1 : nn09) = top09(1 : n09);
z1(nn09 + 1 : nn11) = top11(1 : n11);
z1(nn11 + 1 : nn13) = top13(1 : n13);
z1(nn13 + 1 : nn14) = top14(1 : n14);
clear top01;
clear top03;
clear top05;
```

```
clear top07;
clear top09;
clear top11;
clear top13;
clear top14;

z2(1 : n01) = bot01(1 : n01);
z2(n01 + 1 : nn03) = bot03(1 : n03);
z2(nn03 + 1 : nn05) = bot05(1 : n05);
z2(nn05 + 1 : nn07) = bot07(1 : n07);
z2(nn07 + 1 : nn09) = bot09(1 : n09);
z2(nn09 + 1 : nn11) = bot11(1 : n11);
z2(nn11 + 1 : nn13) = bot13(1 : n13);
z2(nn13 + 1 : nn14) = bot14(1 : n14);
clear bot01;
clear bot03;
clear bot05;
clear bot07;
clear bot09;
clear bot11;
clear bot13;
clear bot14;

z3(1 : n01) = diff01(1 : n01);
z3(n01 + 1 : nn03) = diff03(1 : n03);
z3(nn03 + 1 : nn05) = diff05(1 : n05);
z3(nn05 + 1 : nn07) = diff07(1 : n07);
z3(nn07 + 1 : nn09) = diff09(1 : n09);
z3(nn09 + 1 : nn11) = diff11(1 : n11);
z3(nn11 + 1 : nn13) = diff13(1 : n13);
z3(nn13 + 1 : nn14) = diff14(1 : n14);
clear diff01;
clear diff03;
clear diff05;
clear diff07;
clear diff09;
clear diff11;
clear diff13;
clear diff14;

for i = 1 : 31;
 xi(i) = i*5;
end;
for i = 1 : 33;
 yi(i) = i*5;
```

```
end;
xi = 8420 - 5 + xi;
yi = 1360 - 5 + yi;

zi = griddata(x,y,z3,xi,yi);

for i = 1 : 31;
 for j = 1 : 33;
  k = j + (i   1) * 33;
  a(1,k) = xi(i);
  a(2,k) = yi(j);
  a(3,k) = zi(k);
 end;
end;
a = a';
save c:\brian\code\thickqe.txt a -ascii
clear a;

v = [.5 .6 .7 .8 ];

% make contour plot
figure(1);
grid;
cs = contour(xi,yi,zi,v);
axis('square');
axis([8420,8580,1360,1520]);
title('Queen Elizabeth Park Thick Sediment contour plot (over 0.5 m)');
ylabel('Northing');
grid;
xlabel('Easting   (Contour Interval is 0.1 m)');
%clabel(cs,'manual');

% end of function
```

APPENDIX A3

TECHNICAL TERMS AND SOFTWARE DISPLAY DESCRIPTIONS

This Appendix Provides the Definitions of Technical Terms and Software Display Layouts in Their Order of Occurrence in the Report

A3.1 Acoustic Impedance

Acoustic Impedance (Z) is defined as:

$$Z = rho^* c \qquad \text{(A3.1-1)}$$

where

rho = density (gm/cm^3)
c = velocity (m/second)

The Acoustic Impedance is related to the reflectivity (R) by:

$$Z = (1+R)/(1-R) \qquad \text{(A3.1-1)}$$

This equation assumes that the sound wave is plane and is normal (perpendicular) incident to the reflecting layer.

A3.2 Reflectivity

The layer reflectivity is a measure of the ratio of the signal amplitude reflected back from a given layer. For normal incidence (perpendicular) cases the reflectivity (R) is a function of the two layers Impedance's (Z). The equation of normal incidence is:

$$R = (Z_2 \quad Z_1)/ (Z_2 + Z_1) \qquad \text{(A3.2-1)}$$

where

Z_1 = Impedance of the incident layer
Z_2 = Impedance of the reflecting layer

A3.3 Bottom Loss

The bottom reflectivity is often expressed in decibels for ease of reference in data tables and because the sonar equation for bottom reflectivity is easier to handle when the terms are in decibels. The equation of bottom loss (BL) is :

$$BL = 20^*\log(R) \qquad \text{(A3.3-1)}$$

where

R = bottom - water interface reflectivity.

Note that the term bottom loss is normally used to refer to the water-bottom interface, hence the term bottom loss. The subbottom layer reflectivities can also be expressed in decibels. See Sonar Equation (Section A3.4). The bottom loss is often

reported as a positive number in text and tables. However, it is important to note that it is a negative number as the log of a fraction (reflectivity) is negative.

A3.4 Sonar Equation

The Sonar Equation is used in the survey system calibration routines and for the computation of bottom loss. The general sonar equation for the computation of bottom loss (BL) in decibels (db) is:

$$BL = SL - S_R \quad N_w - N_{hyd} + N_A + DI \qquad \text{(A3.4-1)}$$

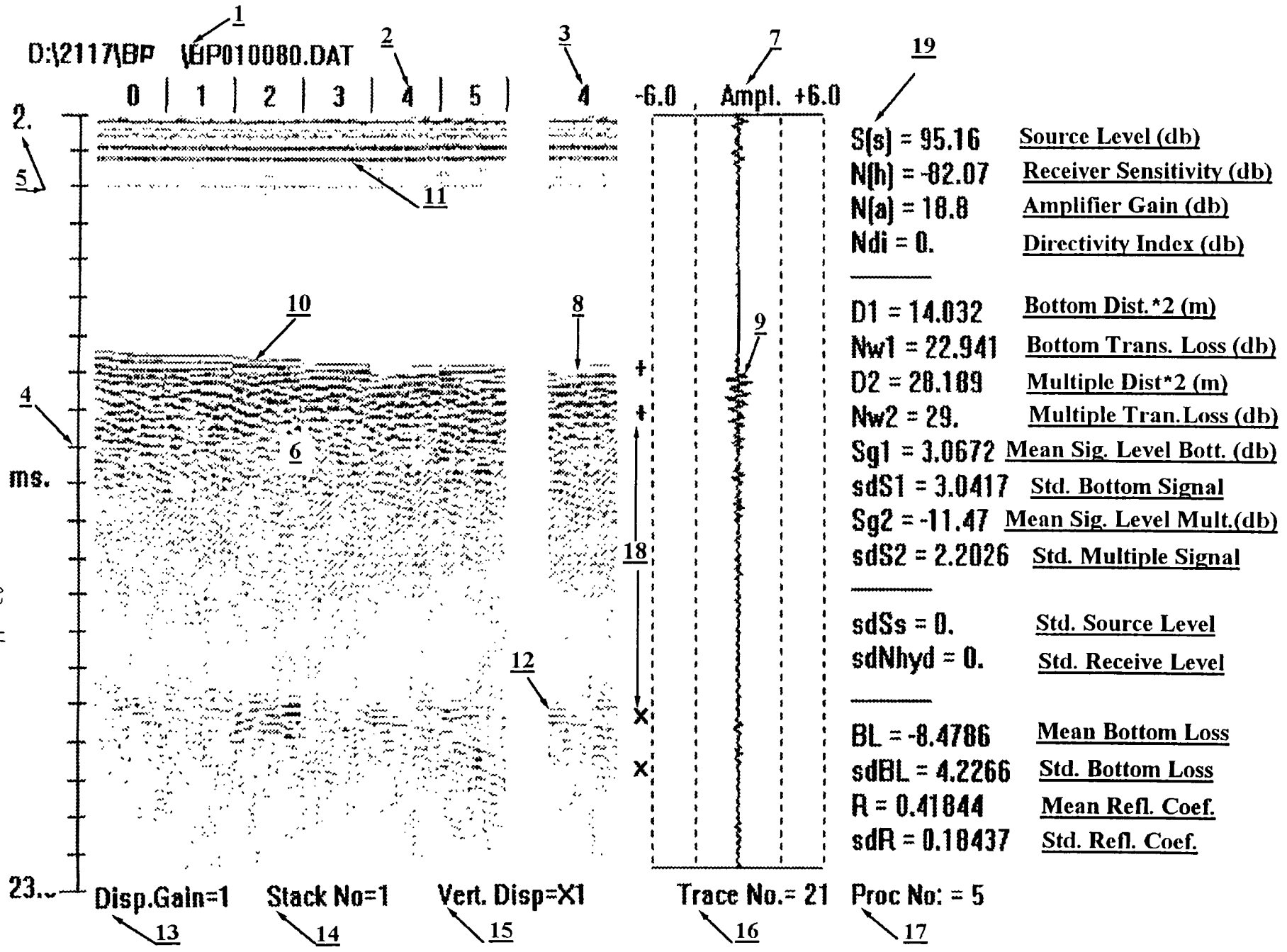
where

SL = sound source level of the survey pinger
S_R = signal received at the output of the survey receiver
N_w = 20 * log (Range, meters), db (transmission loss due to spherical spreading along the path of sound propagation)
N_{hyd} = survey receiver sensitivity, db
N_A = receiver amplifier gain, db
DI = directivity index, db

A3.5 Windows CAL1 Routine

Besides providing source and receiver system calibration, the CAL1 calibration routine is useful during layer identification and material verification steps. In particular, the wave form of a given trace in a subfile can be displayed allowing confirmation of the proper selection of a given layer. Also, independent verification of bottom loss (reflectivity) can be obtained. Figure A3.5-1 provides a summary of the CAL1 display. Each major element of the display is numbered and described below.

1. File Name - The file name being processed is displayed here. The file consists of 6 subfiles labeled 0 to 5. Each file subfile contains the navigation data at the start (left side) of the subfile. These navigation points are noted on the final cross sections with a circle with a cross through it.
2. SubFile Number Label - Each subfile is given a label number of 0 to 5.
3. Current Processed SubFile - The current subfile being processed by the Sonar Equation (Section A3.4) is replicated in this column with the amplitude for the selected trace number being shown to the right of this column (7).
4. Time Scale Lines - The time scale lines (in milliseconds) is given on the left of the figure.
5. Time Offset - The program has the ability to offset the start time by a given millisecond offset. In this case the offset is 2 milliseconds from the key start time. This offset is provided so that the bottom display can be moved up and down.



A3-4

CAL1 Routine Display

6. Seismic Cross Section - The positive half wave rectified total file cross section is provided. This total display covers all the subfiles in the file.
7. Amplitude Trace - The actual wave form of the Trace No. 21 is displayed. The program can display any selected trace in the subfile from trace 1 to trace 40. The positive side of the wave form is to the right and the negative portion of the wave form is to the left. This display is useful when attempting to resolve closely spaced layers.
8. Bottom Arrival Time - Showing the strongest bottom reflection signal for the selected subfile which corresponds to the start of the amplitude signal (9).
9. Bottom Amplitude Signal Provided to reference the bottom signal discussed in item (8).
10. Water-Bottom Interface - Showing the point of selection of the water-bottom interface for the total file cross-section.
11. Source Ringing - This coherent signal is part of the ringing from the source ping. Its only use is to confirm that the timing is consistent.
12. Multiple - The bottom multiple occurs because the bottom signal has reflected twice off the bottom. This multiple signal and the bottom signal data can be entered into the software by selecting these respective signals "++" and "xx" (18) and solving the Sonar Equation (column (19)) for bottom loss and reflectivity. This procedure is used to calibrate the Acoustic Core Reflection/Sign (ACRS) routine.
13. Display Gain - The display gain can be varied to improve visual review of the amplitude data shown in the center of the Figure.
14. Stack Number - The stacking of up to 8 adjacent traces can be accomplished to improve the Signal-to-Noise. In this particular case, the bottom spatial variance is high and stacking is not used.
15. Vertical Display - The time scale can be expanded to examine in more detail various sections of the seismic cross-section. In this particular display no vertical expansion was done.
16. Trace Number - The amplitude of any one of the subfile traces can be displayed. In this particular case, trace 21 is displayed. There are 40 traces in each of these subfiles.
17. Process Number - There are five different possible solutions of the sonar equation. That is for source level, receiver level, etc. In this particular display we are solving for bottom loss (reflectivity) by way of process number 5.
18. Signal Selection Marks - The first reflection signal "+ +" and the second reflection signal "x x" marks are used to indicate the travel time regions where the computer program searches for the largest signal for current computation. In this particular case the bottom and multiple signals are selected.
19. Sonar Equation Terms - This column of the display shows the processed results from the sonar equation solution. Each term is identified and mean and standard deviation of the computations are provided. The computations

are done for all traces in the selected subfile. The source and receiver standard deviations are zero for this case as these were input into the sonar equations as known values.

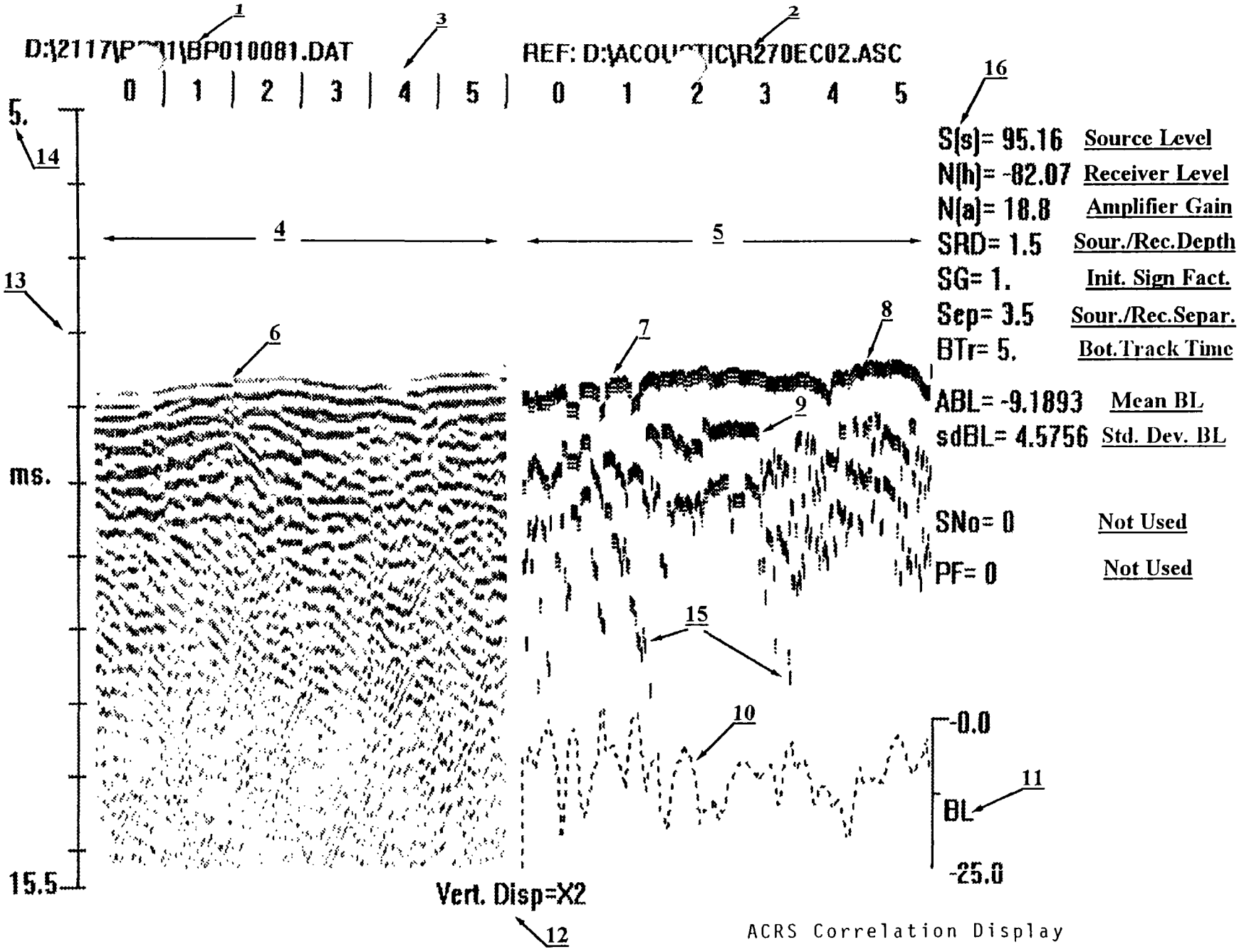
A3.6 Acoustic Core Reflection/Sign (ACRS) Routine

The ACRS program is used to identify layers in complex structures and as an aid in bottom classification (material type). The program uses the Sonar Equation for the computation of the bottom loss terms. For the Trenton Channel study two display modes were used, correlation display and full wave rectified display. These displays are discussed in the following sub-sections.

A3.6.1 Correlation Display

Figure A3.6-1 illustrates the output display for the correlation mode of operation of the ACRS routine. The right portion of the display, the correlation output, is also called the pick plot. The correlation display (5) is generated by performing the cross-correlation of the source wavelet with each seismic trace. When the correlation level is above the mean noise, a layer pick is made. The sign of the pick is dependent on the phase of the signal at that layer with respect to the wavelet phase. A negative phase is shown with dashed lines (7) and a solid line (8) is for positive phase. The phase changes if there is gas content in the bottom. The routine also solves the Sonar Equation in Section A3.4 and generates the bottom loss value for each trace as well as the overall file mean and standard deviation bottom loss values. The keyed number items are as follows:

1. File Name - The file name being processed is displayed here. The file consists of 6 subfiles labeled 0 to 5. Each file subfile contains the navigation data at the start (left side) of the subfile. These navigation points are noted on the final cross sections with a circle with a cross through it.
2. Wavelet Reference File Name - This file was originally generated by the CAL1 routine during the calibration of the source. It contains an exact replica the source wave form.
3. SubFile Number Label - Each subfile is given a label number of 0 to 5.
4. Normal Cross-Section - The left hand portion of the display is the normal seismic half wave rectified seismic cross-section.
5. Correlation Cross-Section - The right half seismic display is of the correlation pick plots of the bottom layers with optimum signal-to-noise. The automated correlation processing has a vertical resolution limit of one wavelet. That is, if a layer is identified it cannot pick another layer within the equivalent travel time of the ping transmit period. This is not a theoretical limitation, but rather a software limitation at the present time. This display is of great help when spatial variance is high as is shown in this plot.
6. Water-Bottom Interface - Water bottom interface for standard cross-section.



ACRS Correlation Display

Figure A3.6-1

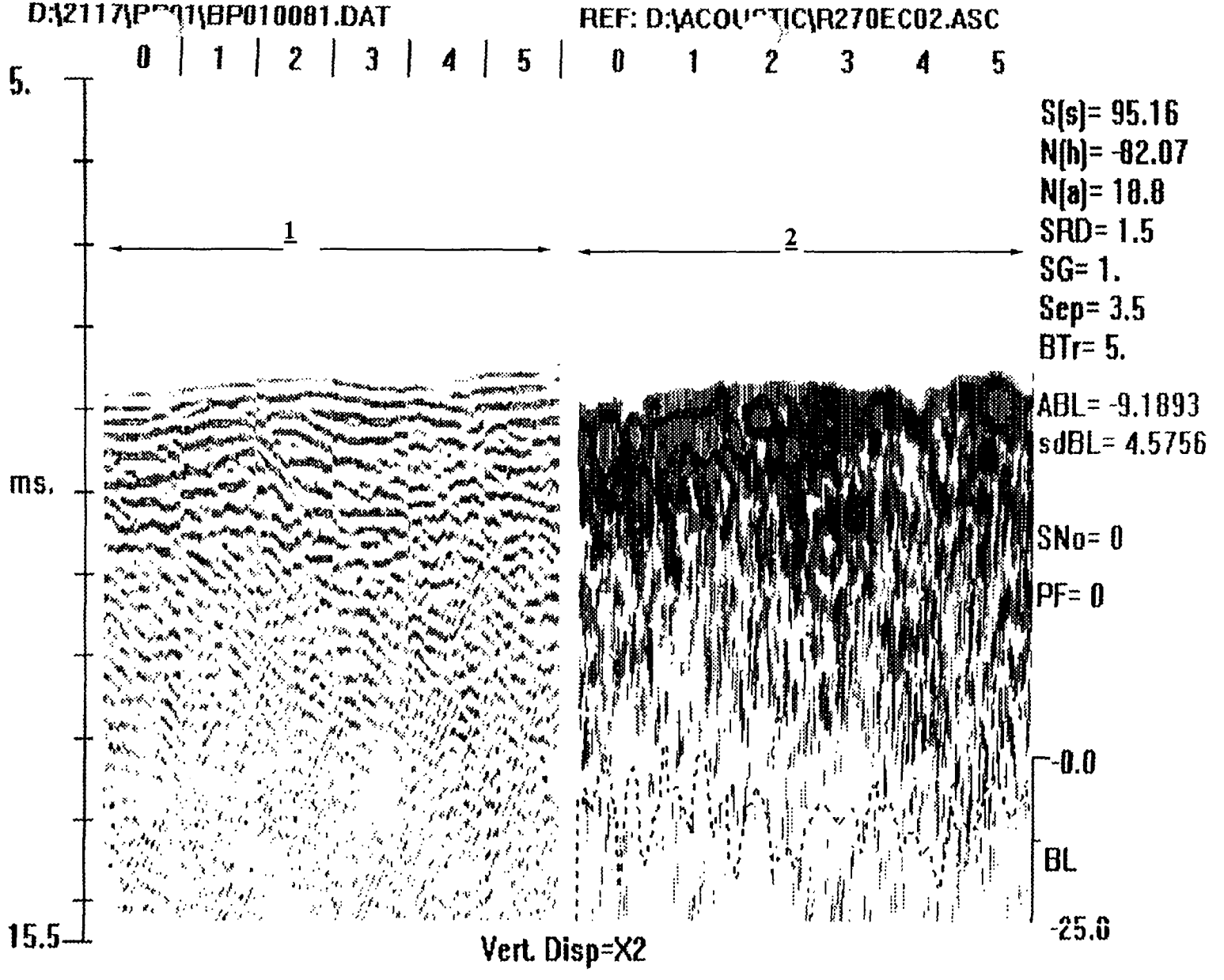
7. Water-Bottom Interface (Correlation Negative Sign) - The water bottom interface with the broken lines indicating a negative phase change at the layer interface.
8. Water-Bottom Interface (Correlation Positive Sign) - The water bottom interface with the solid line indicating a positive phase at the layer interface. The phase sign displays are also available on the subbottom layers.
9. Subbottom Layer - Illustrating the identification of a subbottom layer with the correlation pick plot routine. Another subbottom layer exists and is picked below this layer. If diffraction signals or if the signal to noise is bad the record appears incoherent (15). Incoherent data is ignored during interpretation.
10. Bottom Loss Plot - The bottom loss for each trace in the entire file (all subfiles) is computed and plotted. Note the typical high variance of the bottom loss due to spatial variance.
11. Bottom Loss Scale - The bottom loss scale ranges from 0 to -25 db.
12. Vertical Display As in the CAL1 routine the seismic section can be expanded and displayed. This particular display has been expanded by a factor of two from the original.
13. Time Scale - The time scale (depth) is given in milliseconds increments.
14. Time Scale Offset - The entire display can be shifted vertically by changing the Time Scale Offset with respect to the transmit key (time zero). An offset of 5 milliseconds is shown in the Figure.
15. Diffraction and Incoherent Reflectors - See Item 9 above.
16. Sonar Equation Processing - This column presents the solutions for the bottom loss and the input variables used in the computation of the bottom loss. Each variable is labeled. The average bottom loss (ABL) is the mean bottom loss for all traces in all subfiles. Likewise, the standard deviation bottom loss is over all traces for all subfiles.

All processed data including bottom loss, travel time to picked layers, and reflection sign values are stored in ACSII data for processing at a later time.

A3.6.2 ACRS Full Wave Envelope Display

Figure A3.6-2 is the second ACRS display used for layer identification. Item (1) is the normal half wave cross-section as shown on the left hand portion of the Figure. Item (2) is the same data displayed as a full wave rectified envelope traces. The individual traces are constructed by full wave rectifying the seismic trace (moving the negative signals to the positive side of the trace) and then connecting the peaks of this resultant signal. The latter being referred to as the envelope.

All other parameters on Figure A3.6-2 are identical to the data presented in Figure A3.6-1 and have not been reproduced on Figure A3.6-2.



ACRS Full Wave Envelope Display

Figure A3.6-2

The full wave envelope is helpful in confirming layer identification. It also is an excellent confirmation of the acoustic complexity of the bottom due to spatial variance.

A3.7 Diffraction Examples

Diffractions are caused by the combination of wide beam patterns on the seismic systems and very hard concentrated reflection targets (rocks). The Trenton Channel hard pan consisted of compact clay, sand and rocks of various sizes. These rocks on the surface of the hard pan generated diffraction patterns across the seismic record.

Figure A3.7-1 illustrates how the diffraction pattern is generated by a wide beam pattern source as the ship moves across a hard target. The top portion of the figure shows the ship in three positions. Position 1 is when the beam pattern first intersects the hard target (rock). Because the reflection from the rock is so hard, the reflection is high even though it is on the fringe of the beam pattern. Position 2 shows the ship directly over the target, and Position 3 shows the ship with the back end of the beam pattern just leaving the target.

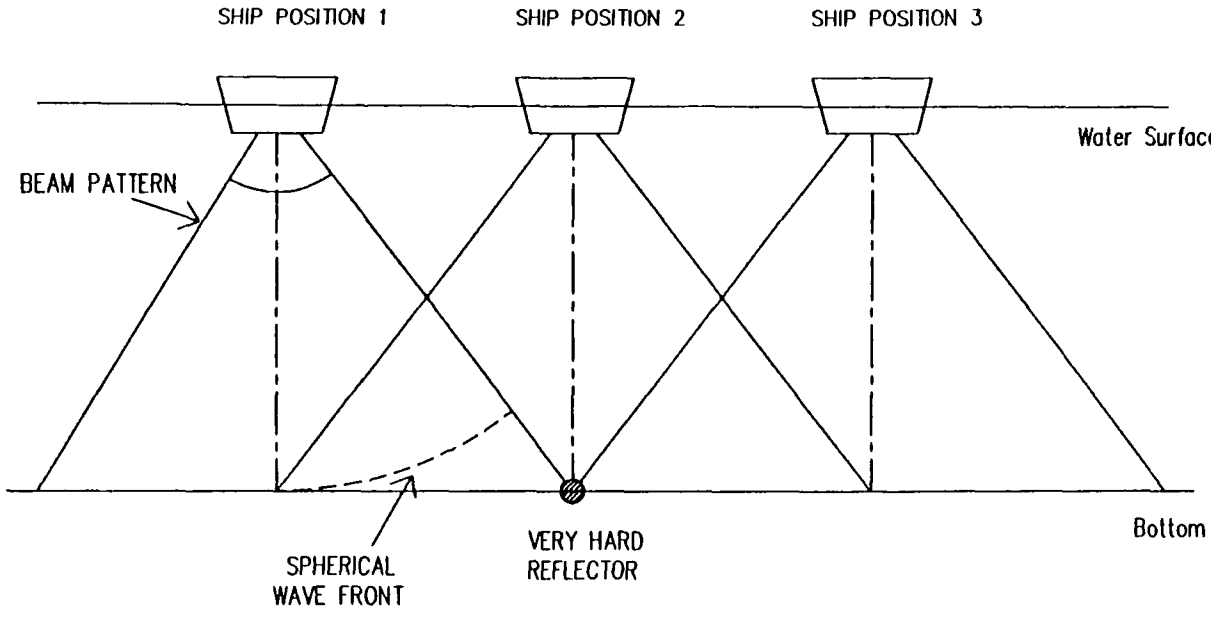
The bottom portion of Figure A3.7-1 shows a simplified seismic cross-section generated as the ship moves over the target. The normal bottom is shown which replicates the true bottom, and the diffraction pattern generated because of the hard target is also shown. In many cases of Trenton Channel there were many rocks on the bottom making a noise pattern of diffraction patterns. The top of the diffraction pattern will be of course the top of the hard pan for the Trenton Channel. This information was used to confirm the hard pan during interpretation.

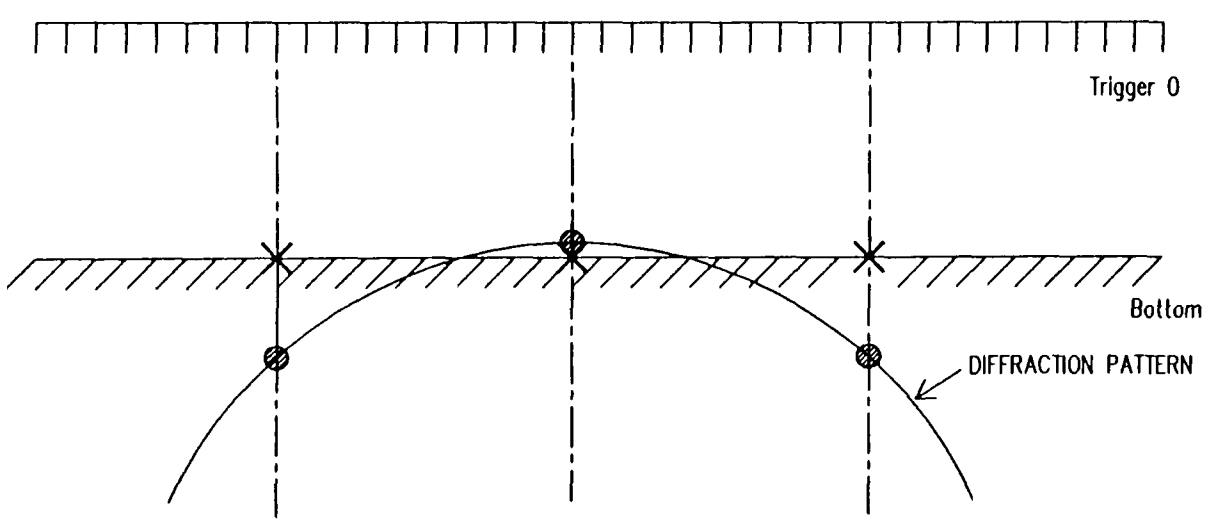
In a normal harbor survey that does not exhibit high spatial variations, the data can be stacked which suppresses the diffraction patterns. This could not be undertaken in the Trenton Channel because of the high spatial variance. Another, more expensive solution for minimizing diffraction patterns is to use much narrower beam patterns. However, the low frequencies involved when doing subbottom profiling has prohibited using these narrow beam patterns because of high cost of large arrays. Consideration should be given to these narrower beam patterns to aid in resolving the bottom because of spatial variation observed when encountering contaminated sediments.

A3.8 Envelope Layer Detection

The resolution of thin layers can be aided through wave form envelope analysis. A thin layer is defined as any layer whose thickness converted to travel time is thinner than the transmit wavelet. This section will review the generation of the trace envelope and illustrate the resulting envelopes from a thick and thin layer.

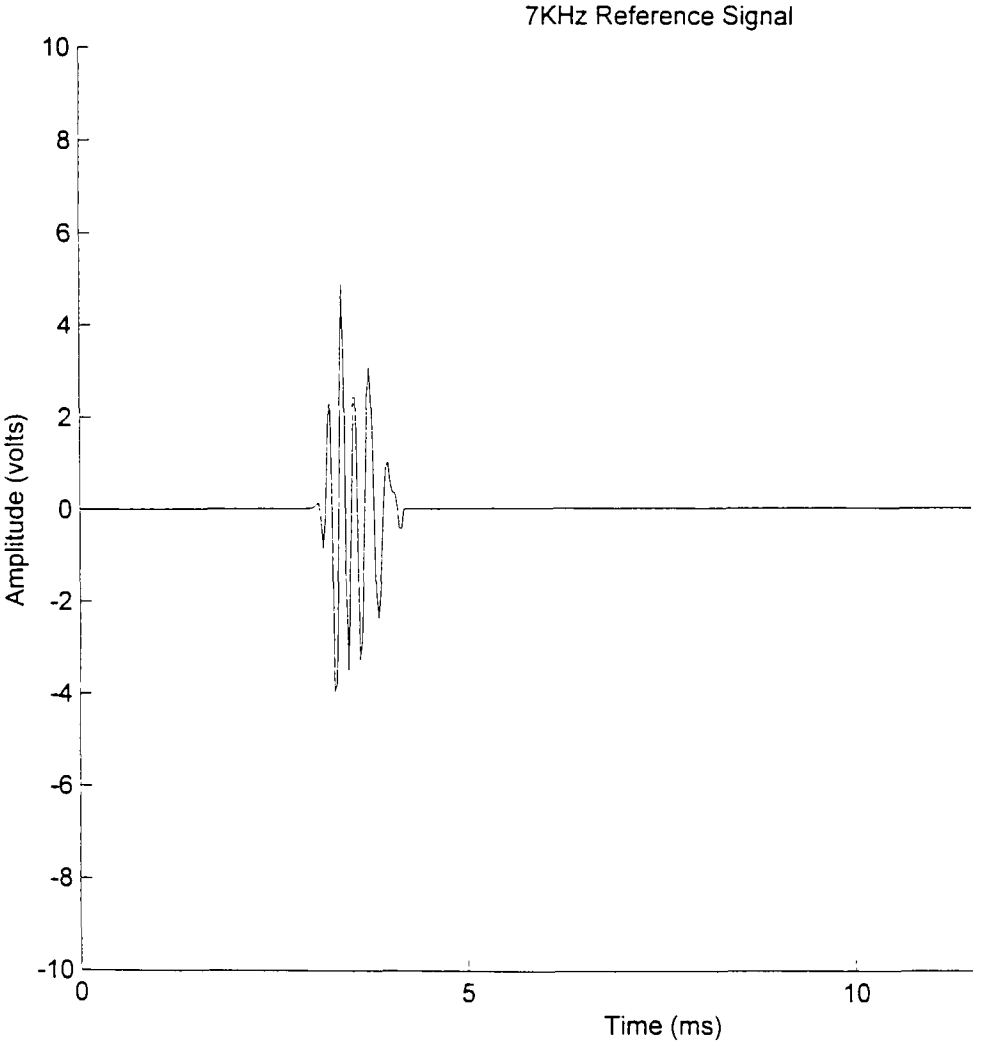
Figure A3.8-1 illustrates the calibrate source wavelet for 7 KHz used for the Trenton Channel survey. The travel time length of the wavelet is approximately 1 millisecond that corresponds to a normal minimum layer resolution of 0.75 meters. This





CAULFIELD ENGINEERING		
TITLE: DIFFRACTION EXAMPLE		
DRN BY: H.V.	SCALE:	DATE: 24/3/97
JOB NO: 2117	DRAWING NO:	CADD FILE:

Figure A3.7-1



7 KHz Reference Wavelet

Figure A3.8-1

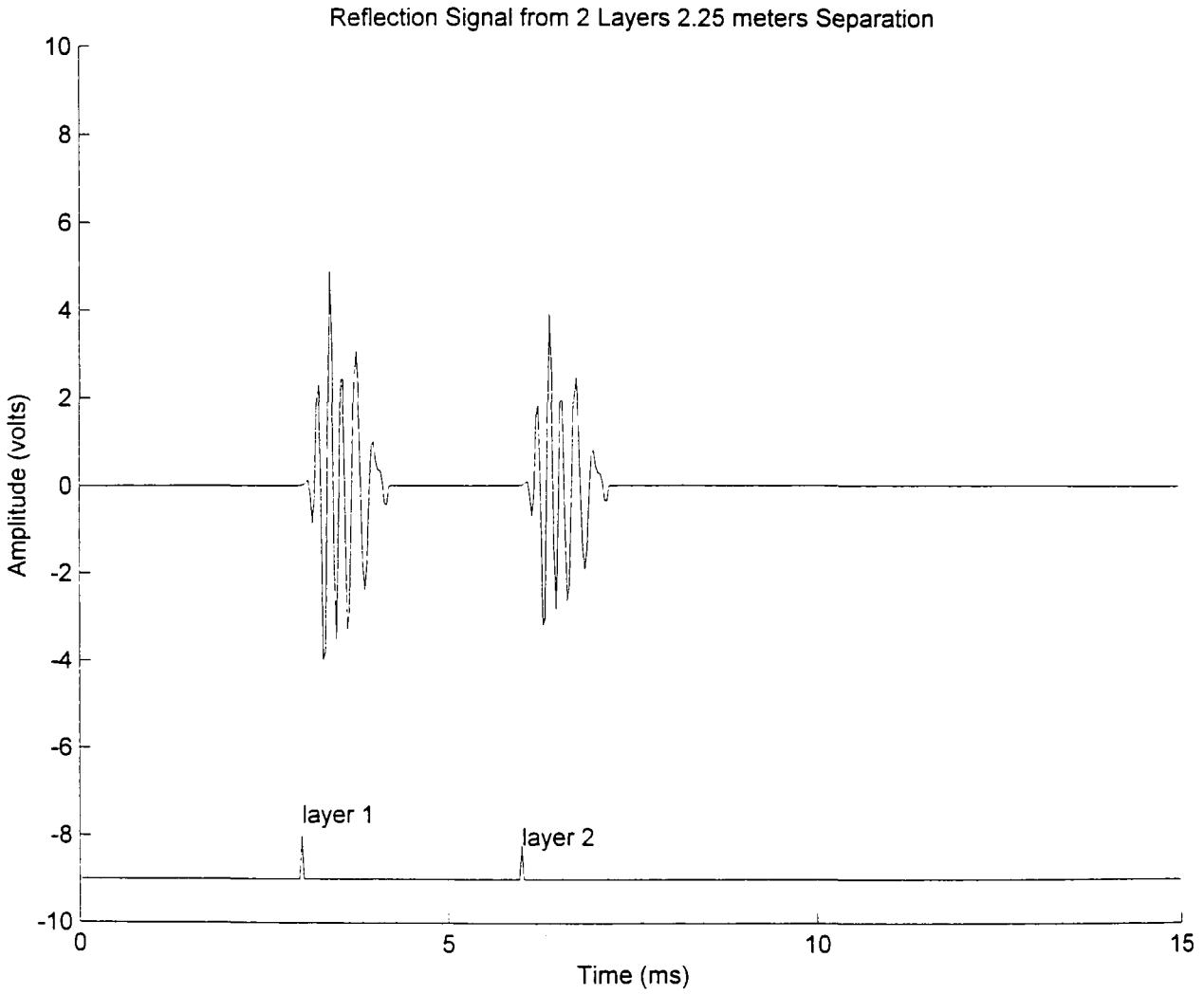
wavelet is the reference signal employed in the generation of the correlation displays in the ACRS routines.

A simulated seismic trace, Figure A3.8-2, was constructed by convoluting the reference wavelet with ideal reflecting layers shown on the bottom of this Figure. Note that the signal peaks about 1.5 wavelengths from its onset. For interpretation purposes, a one (1) wave length shift from the peak to the actual bottom travel time was employed and is noted in the text. See Figure 17 of the main report.

For the next step in preparation for the generation of the signal envelope, the seismic trace is full wave rectified as illustrated in Figure A3.8-3. As can be seen from this Figure the full wave rectified trace is constructed by moving the negative portion of the signal to the positive side of the trace.

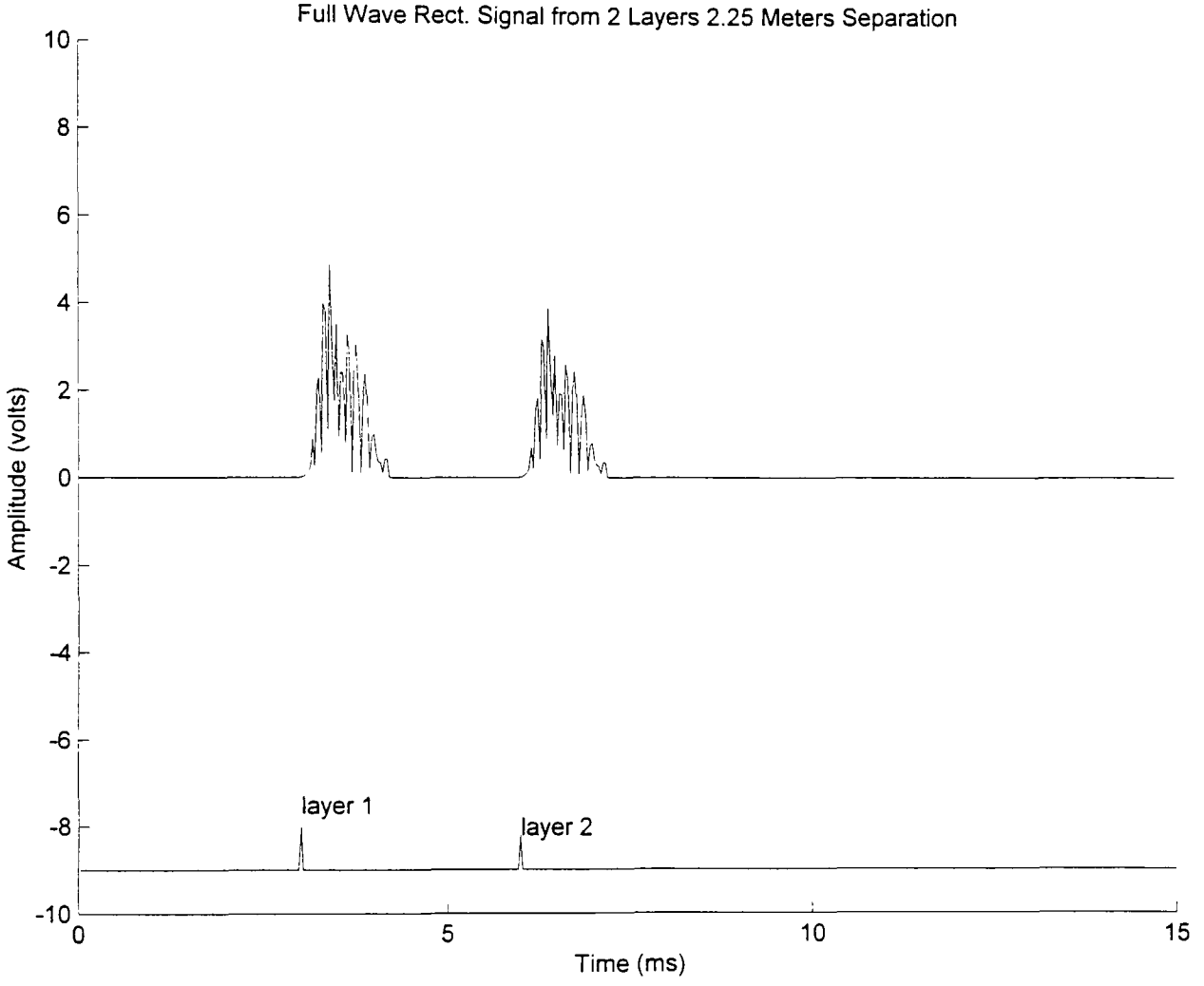
Figure A3.8-4 illustrates the trace envelope that can be derived from the rectified trace by either low pass filtering (the technique employed here) or by peak detection. These techniques are well established and are used in AM radio signal detection. It is clear that for this Case 1, a 2.25 meter thick layer, that the layers are identified and do not overlap.

The same procedure was used for a 0.33 meter thick layer (approximately 1 foot), Case 2, and the results from the envelope detection for these two layers is shown in Figure A3.8-5. As can be seen from this Figure a resolution of even 0.5 feet is not unreasonable. This technique was employed to aid in the resolution of overlapping layers. The ACRS correlation program could not employ these techniques as the prime purpose of the ACRS program was to recover the reflection sign. For these overlapping layers the sign computations are uncertain with the present program. Project time was not available to fully automate the procedures discussed here into the ACRS program.



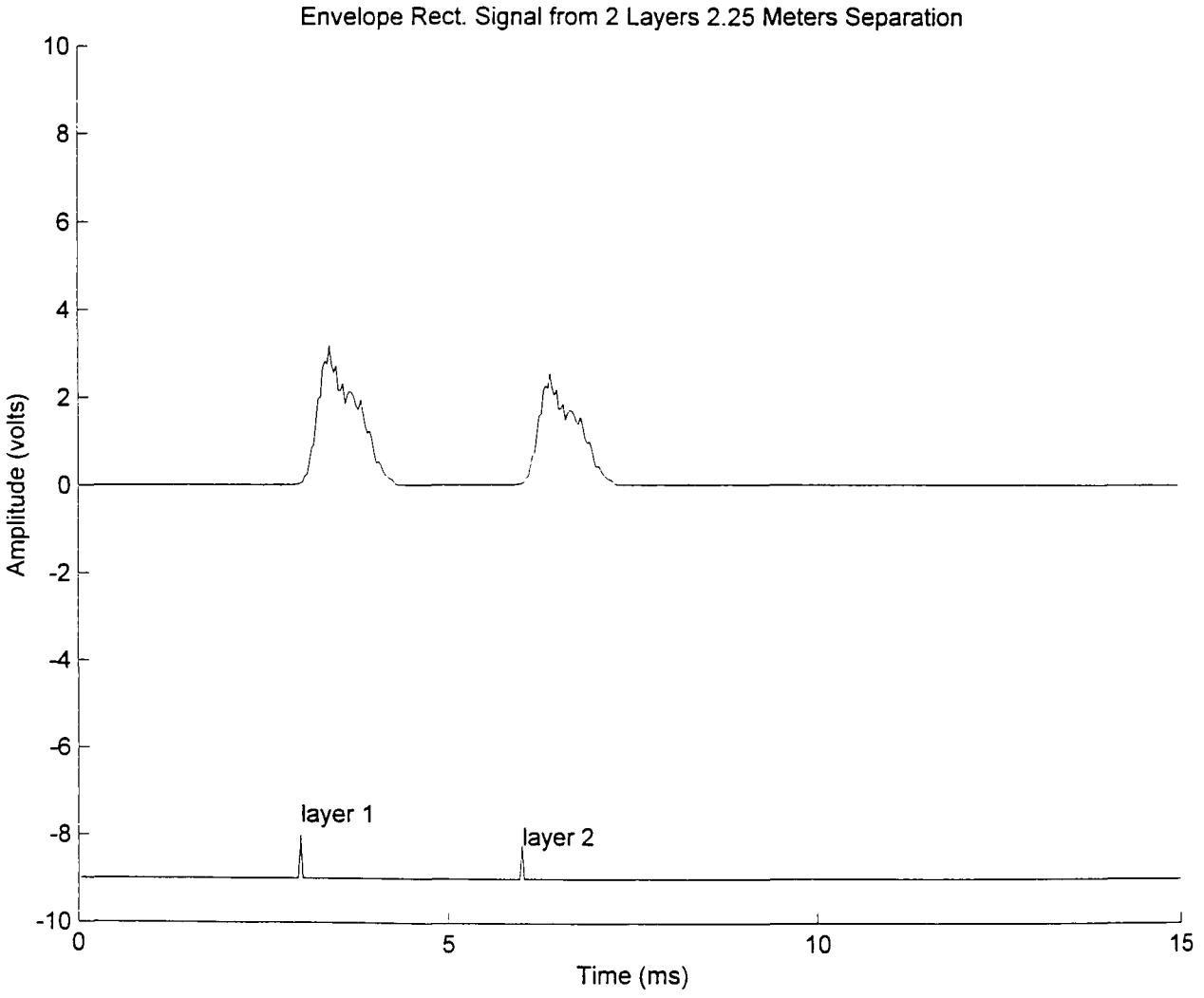
Simulated Seismic Trace from Ideal Reflectors

Figure A3.8-2



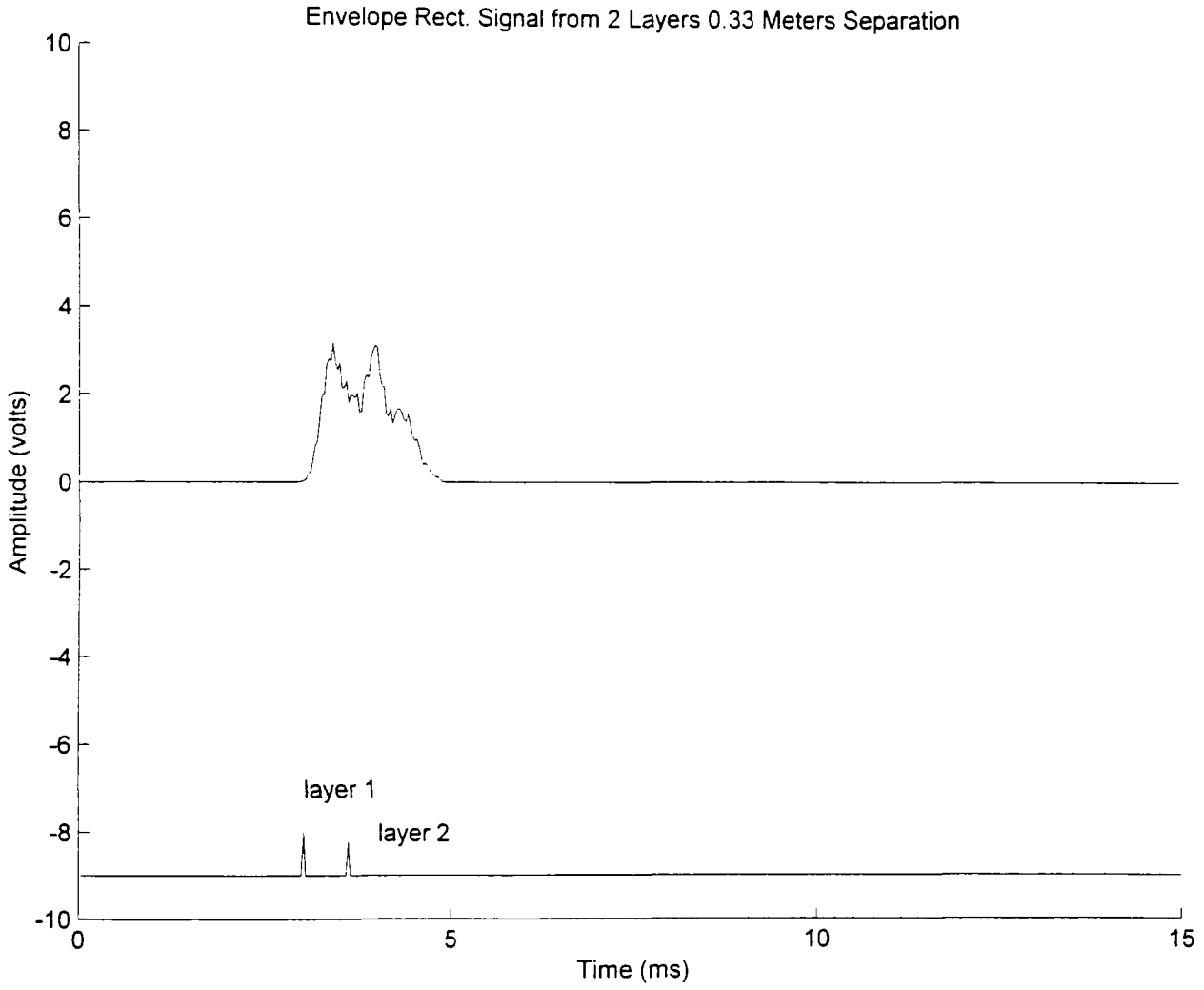
Trace Full Wave Rectification

Figure A3.8-3



Trace Envelope - Case 1

Figure A3.8-4



Trace Envelope - Case 2

Figure A3.8-5

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