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NCBC DAVISVILLE
5090.3a

24 February 1998

Christi Davis
Northern Division, Naval Facilities
Engineering Command (Code 4023/CD)
10 Industrial Highway, Mail Stop 82
Lester, PA 19113-2090

RE: Final Technical Memorandum, Magnetometer and Seismic Reflection Survey, Site 09,
Allen Harbor Landfill, NCBC Davisville, RI
Contract No. N62472-92-D-1296, CTO No. 0067
EA Project No. 29600.67.3293

Dear Christi:

The referenced technical memorandum was submitted as a draft dated 4 March 1997. Because both the US Environmental Protection Agency - Region 1 and the Rhode Island Department of Environmental Management have stated the they will not be providing any review comments, the Technical Memorandum is now considered, via this letter, as Final.

Thank you for your assistance in completion of this task.

Sincerely,

Jim

James A. Shultz, CPG
CTO Manager

JAS/hs
cc: Phil Otis (Northern Division)
Walter Davis (CSO Davisville)
Christine Williams (USEPA-Region 1)
Richard Gottlieb (RIDEM)
Eileen Curry (Dynamac)
Rob Palermo (EA-Boston)
Steven Tyahla (EA-PMO)
File - EA Boston

DRAFT
TECHNICAL MEMORANDUM

Magnetometer and Seismic Reflection Survey
Site 09, Allen Harbor Landfill
NCBC Davisville, Rhode Island
Contract No. N62472-92-D-1296
Contract Task Order No. 0067

March 4, 1997

Introduction

Under Contract No. N624-72-92-D-1296, Northern Division, Naval Facilities Engineering Command Contract Task Order (CTO) No. 0067, dated 23 August 1996, EA Engineering, Science, and Technology (EA) was authorized to perform design services tasks for the Closure of Installation Restoration (IR) Program Site 09, Allen Harbor Landfill at the Naval Construction Battalion Center, Davisville, Rhode Island (NCBC Davisville). This technical memorandum presents the results of two of the CTO No. 0067 tasks, the Magnetometer (Task 3) and Seismic Reflection (Task 2) Surveys performed at Site 09, Allen Harbor Landfill, NCBC Davisville, Rhode Island. Details of the survey methods, equipment used, surveyed locations and results are presented in separate reports included in the Appendices of this Technical Memorandum. A copy of the Magnetometer Survey Report is in Appendix A and the Seismic Reflection Survey Report is in Appendix B.

Survey Objectives

The objective of the Magnetometer and Seismic Reflection Surveys was to evaluate the lateral and vertical extent of Site 09 landfill-related material within the intertidal zone of Allen Harbor.

Summary of Survey Findings

Magnetometer Survey

The Site 09 Magnetometer Survey was successful in evaluating the lateral and vertical extent of landfill-related material (ferrous metal) present in the intertidal zone. Figure 1 attached shows the position and line locations completed for the Site 09 Magnetometer Survey. The magnetic measurements collected during the survey indicated that numerous steel and iron objects were buried in the landfill and along the slope of the landfill facing the harbor. This is supported by the fact that the intensity of the magnetic measurements fall off considerably (decrease in intensity) in the direction of the harbor and increase considerably as they approach the landfill. The results of this survey support that there is little to no indication that buried (ferrous) waste was disposed of in the harbor or that landfilling operations extended into the harbor beyond the existing face of the landfill.

A "deeper" magnetic anomaly was encountered on Line 2 (between Position Locations 0720 and 1440) which were located 30 feet off the shoreline and toe of the landfill but were attributed to magnetic decay or fall off which occur with distance from the source. (Refer to Appendix A, the Magnetometer Survey Report for a further explanation and clarification of deeper magnetic anomaly.) The magnetic field intensity measured at the source decreases proportionally as the distance from the source increases. The magnetic anomalies may also be attributed to potential variations in bedrock surface topography at these locations. Five magnetic anomalies were encountered along Line 4 (at Position Locations 0120, 0870, 1050, 1140 and 1230) which was located 60 feet off the shoreline and toe of the landfill but could not be verified because they are underwater. These five anomalies appear to represent and/or may have resulted from isolated disposal events, material which eroded from the slope of the landfill resulting from wave action or from severe storm conditions, or non-landfill disposal activities.

The visual appearance of the landfill slope along the harbor shoreline revealed a large percentage of metal debris along the entire slope as it abuts the harbor. A large percentage of the debris was ferrous in composition and was observed along the entire landfill slope.

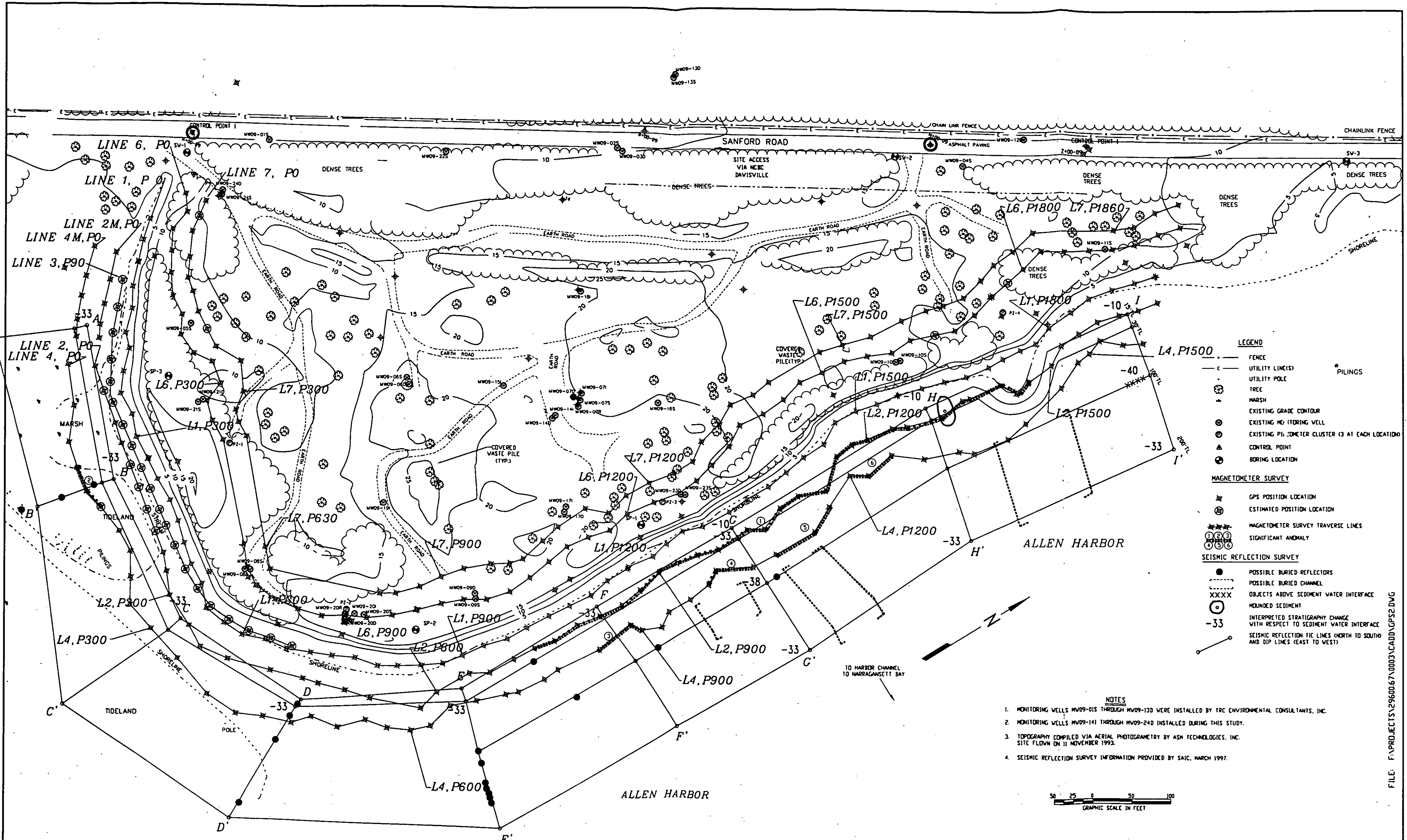
Seismic Reflection Survey

The Seismic Reflection Survey was successful in identifying some of the subsurface geologic structure in Allen Harbor. Figure 1, attached, shows the position and line locations completed for the Site 09 Seismic Reflection Survey. The Seismic Survey lines completed at 15 and 30 feet off the shoreline indicated that the water depth ranged between 2-3 feet for the majority of the lines and 10 feet between Stations E and I. The reflective surface at the sediment water interface appeared to be solid and hard as indicated by dark reflected images shown on the seismic profile printouts. Generally, a deep reflective surface was observed across the entire site at an average depth ranging from 33 to 43 feet below the harbor floor.

The Seismic Reflection Survey did not provide information which could be used to answer the question as to whether the landfill has extended out into the harbor beyond its present boundaries. The hard reflective surface observed along the parallel lines ("tie lines") completed 15 and 30 feet off the shoreline made it difficult to resolve smaller objects at that depth.

<u>Conclusions</u>

Both the Magnetometer and Seismic Reflection Surveys provided needed information which will be used to support the landfill closure design for Site 09. The Magnetometer Survey data indicated that ferrous debris (steel and iron objects) may not have migrated beyond the existing shoreline abutting the landfill. Impact to the intertidal zone from steel and iron objects is limited to locations at the shoreline with the exception of Line 4 where five magnetic anomalies were detected. These anomalies may have no connection with disposal operations which took place on Site 09 or from debris which may have eroded off the landfill. The seismic data did not provide information which could be used by the Magnetometer Survey because the survey lines which overlapped were inconclusive. The Magnetometer Survey included two lines completed in the intertidal zone with a boat at 30 and 60 feet off the shoreline in Allen Harbor. The Seismic Reflection Survey also included lines at 15 and 30 feet off the shoreline so that a comparison could be made of information collected from the two surveys. Since the seismic data for these lines did not provide information which could be used to locate or confirm the presence of buried ferrous debris due to the composition of the harbor bottom at these location (e.g., reflective surfaces), a comparison of data was not possible. The Seismic Reflection Survey, however, provided useful information regarding the topography and geologic structure of the harbor bottom and stratigraphy. The material shown in the seismic cross-sections (Refer to Appendix B, Seismic Reflection Survey Report) may be sand, sandy/silt, clay, or any number of sediment textures. The seismic data did not provide significant subsurface proof that the landfill has extended further than its present boundary. Surficially, it does appear that materials, construction, and otherwise have spilled into the harbor.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.
JAS	JFW	3-4-97	29600.67
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RLA	JAS	AS SHOWN	GPS2.DWG

TECHNICAL MEMORANDUM
SITE 09 ALLEN HARBOR LANDFILL
NCBC DAVISVILLE, RHODE ISLAND

MAGNETOMETER SURVEY TRAVERSES WITH SIESMIC TIE LINES

FIGURE 1

APPENDIX A

Magnetometer Survey Report

EA Engineering, Science and Technology, Inc.

Site 09 - Magnetometer and Seismic Survey Results

PRESENTATION OUTLINE

- Overview of Geophysical Surveys, Site 09, Allen Harbor Landfill
- Discussion of Magnetometer Survey Results by EA
- Discussion of Seismic Reflection Survey Results by SAIC/TG&B

Magnetometers

- How do magnetometers work ?
  - Respond to ferrous objects
  - You walk a line and collect data at established points along the line
  - The regional magnetic is generally stable and does not change unless ... buried objects are encountered
- Prefered method for buried ferrous waste (e.g., steel and iron objects)

The Induced Magnetic Field Depends On Several Variables

- Target Mass
- Target to sensor distance
- Target material and its integrity
- Target geometry
- Target orientation
- Magnitude and direction of permanent magnetism in the object

Difference Between Total Field and Vertical Gradient Measurements

- Total Field Measurements (TFM) are taken to identify deeper magnetic sources
- The intensity of the earth's magnetic field in Boston is 55,000 gammas ... buried objects add to it ... 55,000 plus
- Large magnetic field gradients >600 gammas/ foot prevent accurate measurements

Difference Between Total Field and Vertical Gradient Measurements

- Vertical Gradient Measurements (VGM) more accurately define shallow magnetic sources
- VGM tend to be more specific in delineating individual magnetic properties

Difference Between Total Field and Vertical Gradient Measurements

- *The VGM varies more with distance ($1/d^4$) than the TFM ($1/d^3$) ... all non-local are removed from the VGM*
- *This means that the TFM decreases by a factor of 8 when the distance between the sensor and source is doubled ... and the VGM decreases by a factor of 16 when the distance between the sensor and source is doubled*

Anomaly Depth Dependence

- *Depth is measured from the magnetometer sensor to the target*
- *The deeper the source the broader the anomaly*
- *The anomaly wavelength or width has a direct realtionship with the depth to the traget*

Anomaly Depth Estimates

- *Depth amplitude behavior*
  - The anomaly will appear broader proportionally as the object is deeper or more distant
- *The amplitude of the anomaly decreases inversely as the cube of the distance*

APPENDIX B

Seismic Reflection Survey Report

SEISMIC REFLECTION SURVEY OF WESTERN ALLEN HARBOR ADJACENT TO ALLEN HARBOR LANDFILL

NCBC, Davisville, Rhode Island

March 2, 1997

DRAFT COPY

Prepared for : EA Engineering, Science and Technology
Sharon, MA

Prepared by: Science Applications International Corporation
Narragansett, Rhode Island

and

TG&B Marine Services
Falmouth, Massachusetts

INTRODUCTION

Seismic reflection data was collected by Science Applications International Corporation (SAIC) and TG&B Marine Services in Western Allen Harbor adjacent to the Allen Harbor Landfill in NCBC, Davisville Rhode Island on February 6, 1997. The objective of this program was to use seismic ~~stratigraphy~~ reflection to analyze the marine stratigraphy adjacent to the landfill and determine whether the landfill extends into the harbor.

METHODOLOGY

Each estuary offers different field challenges to the collection of seismic data. In this field area shallow water made collection of usable seismic information challenging. Recent developments in seismic data collection techniques have shown that collection of seismic data using "Chirp" technology improves the probability of gathering good seismic data in these conditions. For this study a Datasonics Chirp II seismic system was deployed from a shallow draft, 20 foot outboard survey vessel. The transducer was mounted over the side of the survey vessel and towed just beneath the water surface.

Seismic Reflection Theory and Equipment

A subbottom seismic system works like a depth finder but utilizes a lower frequency sonar signal. A depth finder transmits a sound wave (~45 KHz) down into the water column by way of a transducer. When this sound wave hits the bottom (sediment/water interface) it bounces back and is received by the transducer. The time that it takes for the sound wave to go to the bottom and return to the depth finder, divided by two, gives the water depth. A subbottom seismic reflection device works in a similar manner. A lower frequency (<20 KHz) sound pulse generated by a subbottom device is sent into the water column. Some of the acoustic energy reflects off of the bottom like a depth finder, but the majority penetrates down into the seafloor/bay bottom. Where stratigraphic layers, such as sand come into contact with other sediment or rock types, for example silts, or clays, some acoustic energy will be reflected back to the receiver. The reflected energy is translated by the seismic receiver and displayed on a computer screen as a dark line (termed a "reflector") that shows the nature of the geologic layers. Older subbottom devices transmitted a pulse at a singular frequency. In order for good geologic information to be recorded the changes in strata had to reflect that specific frequency. This was problematic because some sediment types would allow good data to be collected while in others, especially soft sediments, good seismic information was difficult to collect. Seismic data collection has improved with the introduction of varied frequency transducer and receiver systems.

For this program, a Datasonics FM swept frequency seismic device was utilized. This system emits two different pulses in the frequency range of 2-7 KHz and 10-20 KHz and records the return signal in separate channels. The return signal is processed by the computer and generates cross-sectional images of the geology beneath the sediment/water interface (SWI). The acoustic return received at the hydrophone is filtered with the outgoing FM pulse generating a high resolution image of the subbottom stratigraphy. This system can resolve stratigraphic relationships of 6cm or better. It is ideally suited for determining thicknesses of dredge material lying over native strata. Further, because the FM pulse is generated by a digital to analog converter with a wide dynamic range and a transmitter with linear components, the energy, amplitude, and phase characteristics of the acoustic pulse can be precisely controlled. This precision produces high repeatability and the signal definition required for sediment classification. The seismic data is recorded real time on a magneto-optical disk. Following field data collection the data can be played back on the computer and enhanced using different video gain settings. When the collected data has been optimized to show the most information it is printed out.

Allen Harbor Marine Seismic Field Operations

Prior to the seismic data collection program, buoys were set on the offshore end of prescribed lines and stakes were place into the shore end. At the endpoint of each of these lines differential positioning information was collected (Figure 1). A Differential Global Positioning System was initially fed into the seismic system. However, problems with the differential beacon receiver prevented combining the differential corrected positioning information with the seismic records. Instead, uncorrected satellite positioning coordinates were recorded with the seismic data. Positioning for lines oriented perpendicular to shore ("dip lines") was accomplished by steering the line and marking the time that the seismic transducer passed the buoys or started from the shore based end of the dip line. With the seismic device positioned at "midships" the "end or start of line" was about ten feet from shore.

Data was also collected in lines running parallel ("tie lines") to the landfill at intervals of 15ft, 30ft, 100ft, and 200ft from shore. While collecting data along each tie line a time mark was annotated on the seismic data record at the point that the transducer crossed a dip line. In between the tie lines a time based mark was recorded on the seismic record at regular (20 second) intervals. For the seismic data analysis the annotated marks were tied to the end-of-line DGPS positions and translated to a location map.

DATA

Figure 1 shows the position of specific items identified in the seismic records as discussed in the following section. Nine lines of data were collected perpendicular to the landfill. The dip lines were marked as alpha designations with the alpha "prime" located 200 ft off the landfill shore. For example, in line A-A', the "A" designation was the intertidal stake while "A' " was offshore. Four tie lines of data were collected at 15ft, 30ft, 100ft., and 200ft. distances from the landfill shore. Severe water depth limitations prevented the collection of tie line data between stations A' and D'.

Seismic Data Interpretations

A written interpretation of each seismic cross-section is contained in this report. The raw, interpreted cross sections of these lines are contained in an envelope packaged with the report. Due to the amount of data collected, only the record that exemplifies a line's geologic architecture or details items of particular interest are shown in interpreted transects (Appendix 1). The following interpretations describe the seismic attributes of the record. These interpretations are made based on the presence (or absence) and nature (shape, length, shade) of dark lines (reflectors) recorded on the seismic device. In some instances stratigraphy was inferred from the strength of the reflector, sediment thicknesses over older surfaces was estimated, and specific features are noted. The depth of burial of attributes noted in the data will be relative to the sediment/water interface (SWI).

The sediment/water interface (SWI) is defined as the bottom of a water body, whether an ocean, river, lake or pond. Where the bottom is hard or compact "multiples" or "echoes" are recorded on the seismic record. A normal seismic pulse travels down to the SWI and returns to the transducer where the reflected information is translated into a graphic data picture. When a hard bottom is encountered the initial return signal is so strong that it bounces off of the boat hull, returns to the bottom and is again reflected back to the transducer. Depending upon the bottom type, this "echoing" can occur as many as five times. When the transducer picks up the first "echoed" pulse return it has traveled twice as far as the initial return. The second multiple (echo) will have traveled three times as far as the initial return, the third four times, and so on. Each successive "echo" translates to the seismic record as a dark reflector separated from the previous reflector by a constant distance. These "multiples" of the SWI are recorded over the seismic data making interpretation of the subsurface geology difficult to impossible (see Transect G'-G).

Onshore/Offshore (Dip) Lines

Transect A'- A

Penetration was limited to just over 6ft SWI. The sediment type was soft, verified by probing. Water depth was limited to less than 2 ft. Lack of seismic signal penetration for this run may be related to the outflow and deposit of fine grained/organic materials issuing from the mouth of the tidal creek. Soft sediments can attenuate the seismic pulse and limit the reflection of the signal to the receiver. Better seismic data was collected along Transect C-A, 15' off landfill shore (Appendix I). On this transect a stratigraphy change was noted at -33ft SWI. This reflector was abruptly lost as the boat approached and crossed the A-A' dip line location.

Transect B'- B

In the 2-7KHz pulse data channel three hard, individual reflectors can be seen at -3 and -6 ft SWI. These targets may be larger than a foot in diameter. One is located approximately 40ft offshore of B at a depth between the SWI and -6ft SWI (the deeper reflector may be the multiple of one located nearer to the SWI). The second two are located approximately 150ft and 210ft from shore near to the SWI. In general, continuous reflectors are observed between B and B' at 6ft SWI. This continuous reflector suggests that the bottom below 6ft SWI has not been disturbed. There is insufficient information to determine the mode of deposition or degree of disturbance in the materials above the -6 ft SWI datum. Seismic data collected along Transect C-A, 15' off landfill shore (Appendix I) showed a stratigraphy change at -33ft SWI.

Transect C'- C

The bay bottom appears to be hard, interpreted from the strength of the reflector at the sediment water interface. A reflector runs at approximately -3ft SWI between C and approximately 100ft offshore. There is a slight change in the reflector intensity at -9ft SWI over the length of this cross-section that may be interpreted as a change in stratigraphy. There are no interpretable reflectors deeper than this from this data. However, seismic data collected along Transect C-A, 15' off landfill shore (Appendix I) showed a stratigraphy change at -33ft SWI.

Transect D'- D

Several individual reflectors were identified in the near subsurface (-3 ft SWI) on the shore side of the line (twenty and forty feet from shore) (Figure 1). It should be noted that site D had large slabs of concrete debris lying on the bank. The individual reflectors may be pieces of this debris that have fallen into the harbor. A weak but continuous reflector could be interpreted in the records at about -6ft SWI. A faint strengthening of the return signal was interpreted on the original seismic records to be a change in stratigraphy at approximately -16ft SWI.

Transect E-E'

Data was collected well beyond the marked E line to see whether subsurface data quality improved outside of the project area. Outside of the project area the seismic data was interpretable to depths nearing -33ft SWI. Inside the project area the seismic signal appears to be attenuated. The surface reflector is strong on this line, suggesting a compact, sandy surface substrate. Within the E-E' line a continuous subsurface reflector lies at approximately -8ft SWI. At approximately 33ft from E' a set of four discrete horizontal reflectors lie approximately 2ft above the lower more continuous subsurface reflector. These individual reflectors may not be natural. Based upon the observation of multiple remnant pilings located within Allen Harbor these may be "stumps" of old pilings. Other hard individual reflectors were noted just offshore of the 100' tie line buried to depths between -2 and -5ft SWI.

Line F-F'

This survey line was started well outside of the project area to verify data quality and equipment settings. Subsurface data was interpretable to nearly -45ft SWI. Within the project area a subsurface reflector can be seen running continuously at approximately -13ft SWI. This reflector stops within 33ft of the end of the line. Large concrete slabs were noted on the bank of site F. Similar material lying on the harbor bottom would cause the dark reflector to be recorded at the sediment/water interface.

Line G-G'

The seismic data collection was started outside of the defined line. The penetration of the seismic signal was excellent. The deepest reflector is horizontal with a slightly irregular surface lying about -33ft SWI. Within the survey area just landward of G' this surface rises to -23ft SWI and then dips back to -38ft SWI. Approximately forty feet from shore this irregular surface appears to rise sharply where it intersects/becomes the landfill bank. This rise probably defines the edge of the natural basin that contains Allen Harbor.

Slabs of asphalt and concrete were noted onshore at site G. If materials of this type have spilled into the harbor at this site it would account for the strong surface reflector. However, multiples were recorded beyond the 200' limit of the transect. It is more likely that the bay bottom (SWI) is comprised of a compact sediment.

Transect H' - H

Outside of the designated line subsurface penetration was evident to -33ft SWI. This continuous reflector represents an irregular surface that may be bedrock or an irregular till surface. The hardness of the surface material caused multiples to be recorded. The bank in this vicinity contained slabs of asphalt and concrete. It is likely that this signal was caused by a hard natural bottom. Nearshore, if any of the asphalt/concrete debris has fallen into the harbor it would likely cause multiples to be recorded on the seismic record.

Transect I'- I

An irregular, predominately horizontal surface lies at about -45ft SWI for the length of this record. This reflector was also identified in through lines H-H', G-G', and F-F'. Within the project line the nearshore data was masked by multiples. Similar to the two previous lines this may be due to a hard natural bottom or debris lying on top of it. During the field program a great deal of asphalt and concrete material was noted upon the landfill shore banks. Identical to lines G and H, approximately 50ft from shore this irregular surface appears to rise sharply where it intersects/becomes the landfill bank. The sharp rise probably defines the edge of the natural basin that confines Allen Harbor.

Strike (Tie) Lines

Transect A-I, 15ft & 30ft offshore

Two lines of seismic data were collected at 15ft and 30ft from shore. The limited spacing between these lines accounts for negligible differences in their attributes. Hence, the following interpretation is suitable for both data sets. Water depths ranged between 2 and 3 feet between Stations A and E. Between stations E and I water depth increases to more than ten feet. The data records for the sediment water interface are dark suggesting a hard reflecting surface. There is some definition of strata in the upper nine feet of the subsurface cross section. The shallow reflectors are, for the most part, continuous and slightly irregular. Some shallow individual reflectors were noted near -8ft SWI (Transect G-E, 30' off landfill shore, Appendix I). However, these may also be part of a continuous reflector where the seismic signal has been attenuated and not recorded between windows of data collection. If the "dots" are connected it can be seen that these reflectors appear to be located on a plane. Another "continuous" reflector was noted at -23ft SWI. The irregular surface interpreted to be a major stratigraphic change was noted and varied between -33ft and -40ft SWI.

There is a symmetrical mound of material located between site H and I (Transects I towards G at 15' and 30' offshore from landfill). A concordant reflector is seen just below this mound. This does not appear to be a site of natural deposition. The material interpreted to be lying over the "natural bottom" may have been place there (Figure 1).

A slightly irregular but continuous "deep" reflector can be traced along the entire strike cross-section (Transect C-A, 15' off landfill shore, Transect G-E, 30' off landfill shore) at a depth that averages -33ft SWI. This change in seismic signature represents an abrupt change in sediment type/texture from that which overlies it. This single reflector separates into several reflectors separated by several inches between stations B and C suggesting that it is probably not bedrock but a hard stratified sedimentary material, perhaps a sand or sandy/gravel. Marine vibracoring or water forced jet probing may validate this interpretation.

Tran ect E - I, 100ft off landfill shore

Due to tidal considerations which limited water depth in the project area between D and A offshore data was not collected in lines that ran parallel to this landfill shore. The 100ft tie line was run between station E and I. A strong surface reflector was evident along most of this line, evidence of a bottom type (SWI) that is compact. There is about a foot of softer material blanketing this strong surface reflector (Transect G-E, 100' off landfill shore).

The strong surface reflector is disrupted three times between stations G and F, I and H, and G and H (Transects G-E and G-I, 100' off landfill shore) . The stratigraphic geometry is consistent with what occurs when dredging creates steep sided channels. These interpreted dredged channels have filled with sediment and their tops are flush with the natural level of the sediment water interface (Figure 1). Just west of station I (Transect G-I, 100' off landfill shore) the seismic records revealed four to five discrete reflectors lying several feet above the sediment water interface (Figure 1). These objects may be stumps of remnant pilings examples of which are exposed in other areas of Allen Harbor at low tide. The deepest reflector was identifiable at about -36ft SWI .

Transect E'-I' , 200ft offshore

The data quality for this offshore strike line is of marginal quality. The sediment/water interface reflector was hard and caused multiples except in two areas just to the east of line H and between lines G and H (Transect G' - I', 200' offshore of landfill). In the exceptions, the geology of the subsurface strongly resembled the interpreted buried channels seen in Transect G-I, 100' off landfill shore (Figure 1).

Line A' - D', 125' to 200' offshore

Due to water depth limitations seismic data collection between points A' and D' were limited to less than 200' from the landfill shore. Only the top several feet of strata are interpretable. Aside from the surface reflector there is a continuous reflector located approximately 3 feet into the subsurface.

DISCUSSION

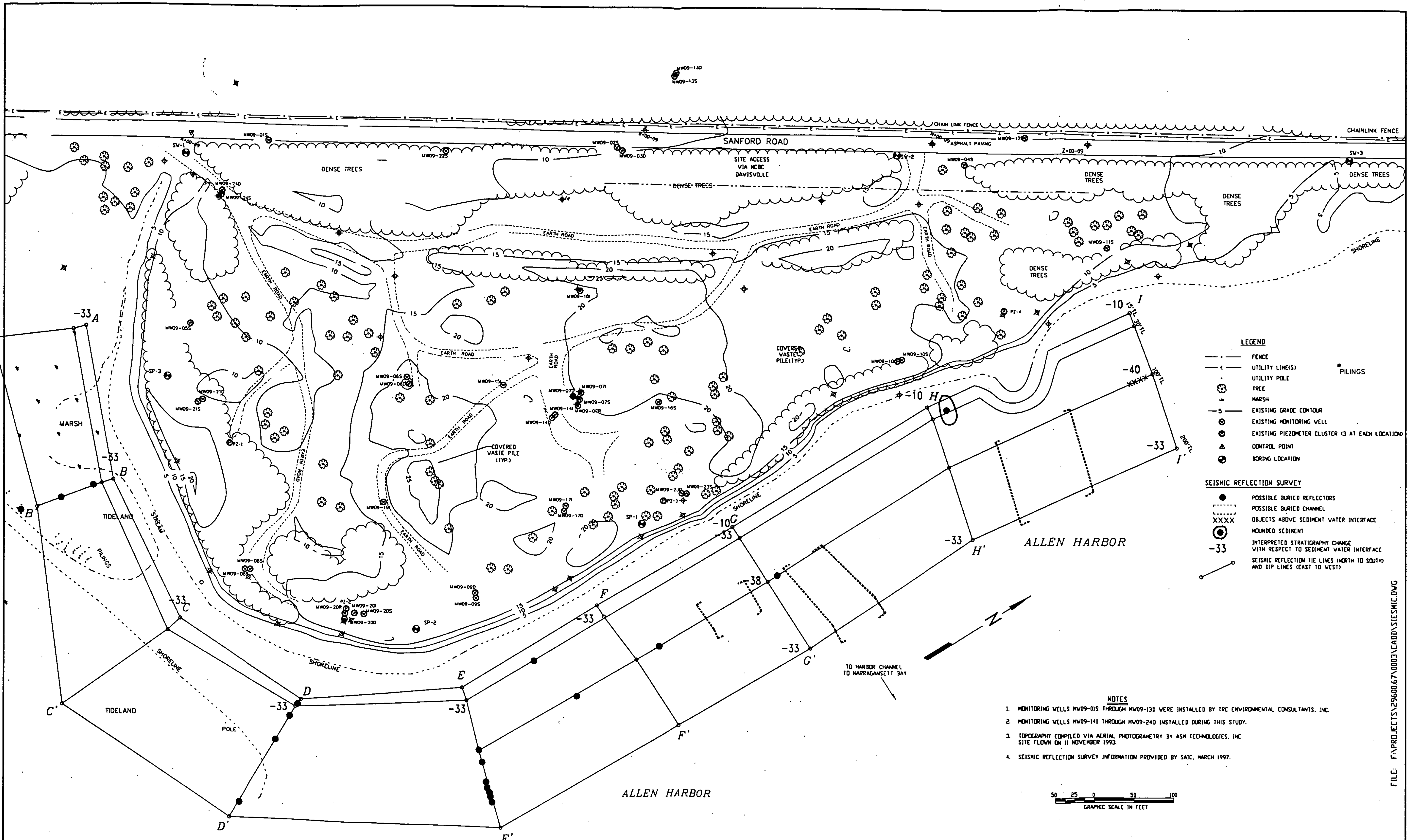
The seismic information collected and interpreted in the nearshore vicinity of the landfill at the Allen Harbor Landfill allowed a cursory evaluation of the subsurface geologic architecture. Generally, a deep reflector was present across the entire site at an average depth of -33 ft SWI (Figure 1). The surface reflector at the sediment water interface was generally strong indicating a hard substrate. Multiples of the surface seismic reflector were noted both offshore and close to shore. In the vicinity of sites I through D the multiples may be causes concrete/asphalt lying on top or just below the natural bottom. In other areas, multiples are probably related to a hard sandy or compact bottom stratigraphy. The seismic data collected along dip lines G,H, and I, showed a steep apron rising from -33 SWI to the present ground surface. This may be the side of the natural basin that contains Allen Harbor. The seismic data collected along the lines A though F did not reveal the nearshore stratigraphy however the stratigraphy change at -33ft SWI was interpreted.

caused by.

CONCLUSION

The material shown in the seismic cross-sections may be sand, sandy/silt, clay, or any of a number of sediment textures. The only way to determine which is prevalent is with direct evidence; that is, to sample or core in the same region that the seismic data was taken. The seismic data did not provide significant subsurface proof that the landfill has extended further than its present boundary. Surficially, it does appear that materials, construction and otherwise have spilled into the harbor. The hard reflector ubiquitous along the nearshore seismic line made it difficult to resolve smaller objects in the near subsurface. To delineate the extent that the seismic information and interpretation is correct, jet probes and/or coring along the data lines is highly recommended.

FIGURES

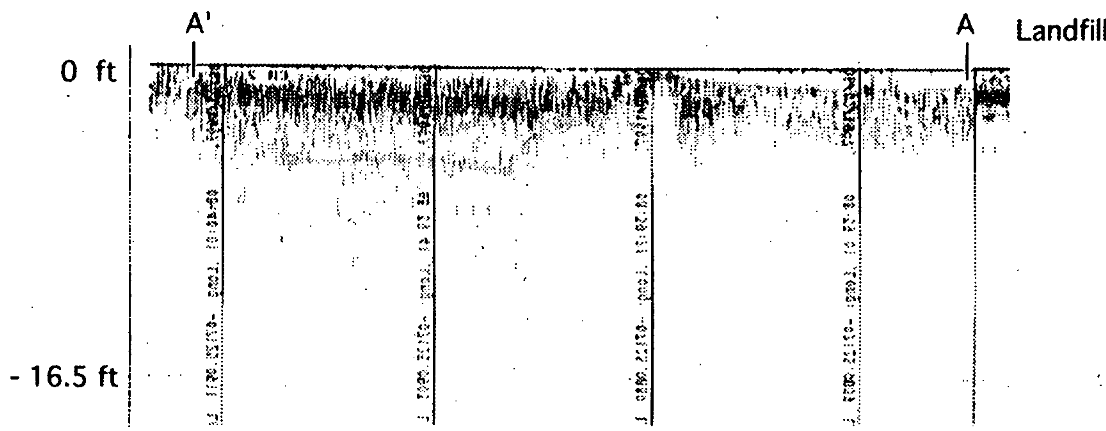


EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	DESIGNED BY: JAS	DRAWN BY: JFW	DATE: 3-4-97	PROJECT NO.: 29600.67	SIESMIC REFLECTION SURVEY SITE 09 ALLEN HARBOR LANDFILL NCBC DAVISVILLE, RHODE ISLAND	SITE 09, ALLEN HARBOR LANDFILL SIESMIC REFLECTION TIE LINES
	CHECKED BY: RLA	PROJECT MGR.: JAS	SCALE: AS SHOWN	FILE NAME: SIESMIC.DWG		FIGURE 1

APPENDIX I
Annotated Transects of Seismic Data Lines

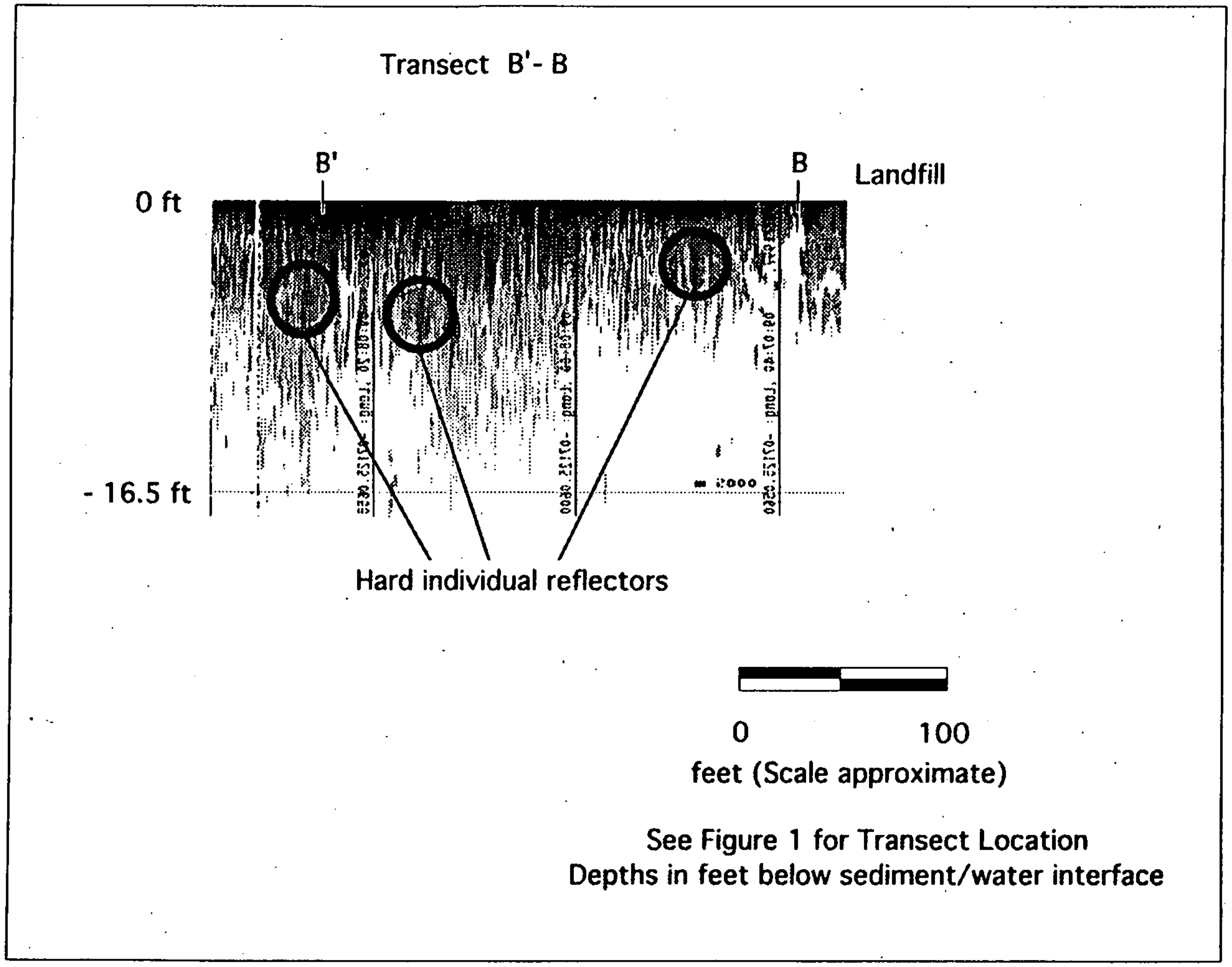
1. Transect A' - A
2. Transect B' - B
3. Transect C' - C
4. Transect D' - D
5. Transect E' - E
6. Transect F' - F
7. Transect G' - G
8. Transect H' - H
9. Transect I' - I
10. Transect C-A, 15' off landfill shore
11. Transect I towards G, 15' off landfill shore
12. Transect G-E, 30' off landfill shore
13. Transect I towards G, 30' off landfill shore
14. Transect G-E, 100' off landfill shore
15. Transect G-I, 100' off landfill shore
16. Transect G'-I', 200' off landfill shore

Transect A'- A

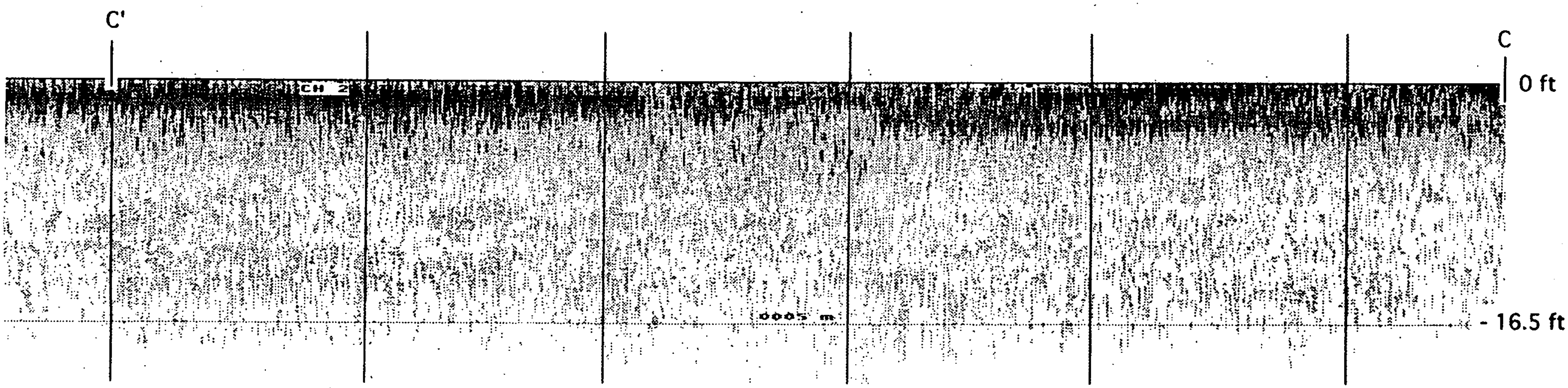


0 feet (Scale approximate) 100

See Figure 1 for Transect Location
Depths in feet below sediment/water interface

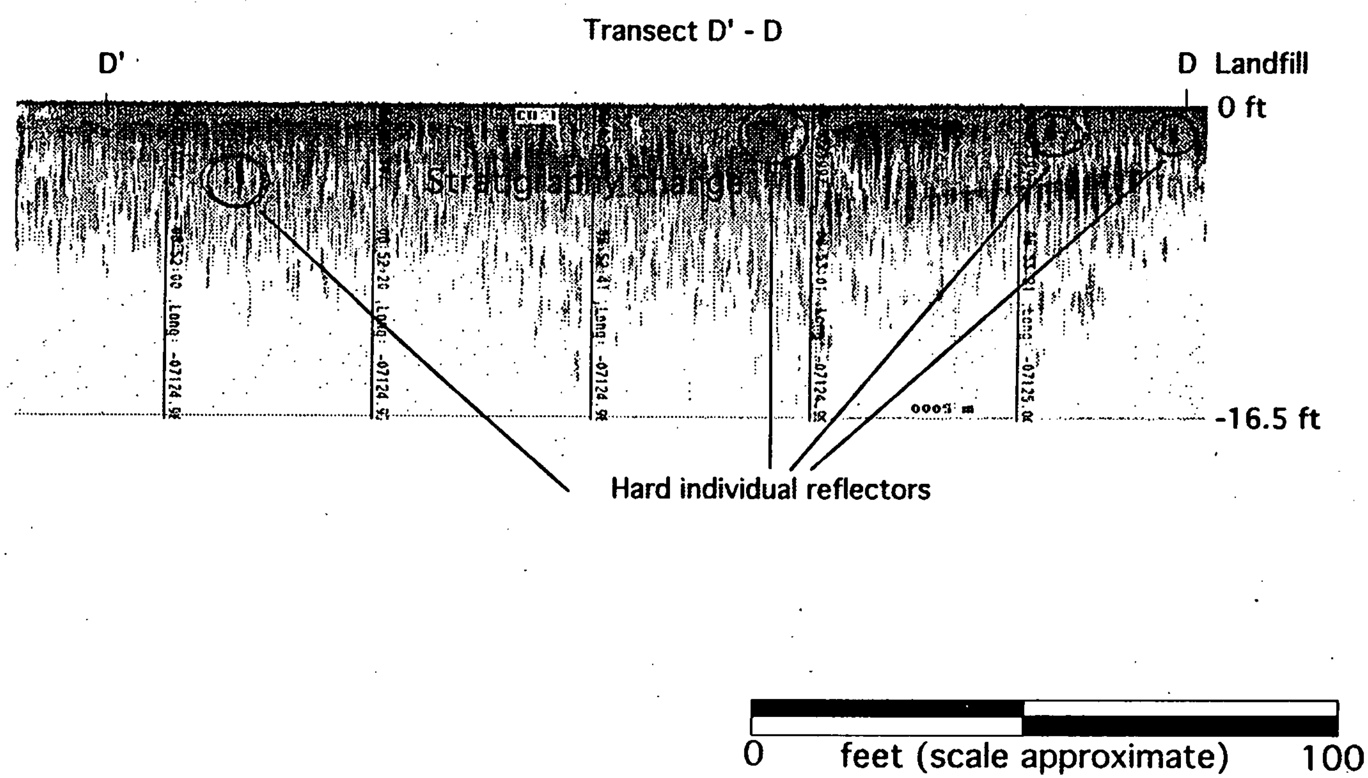

Transect B'- B
B'
B
Landfill
0 ft
- 16.5 ft
Hard individual reflectors
0
100
feet (Scale approximate)
See Figure 1 for Transect Location
Depths in feet below sediment/water interface

Transect C' - C



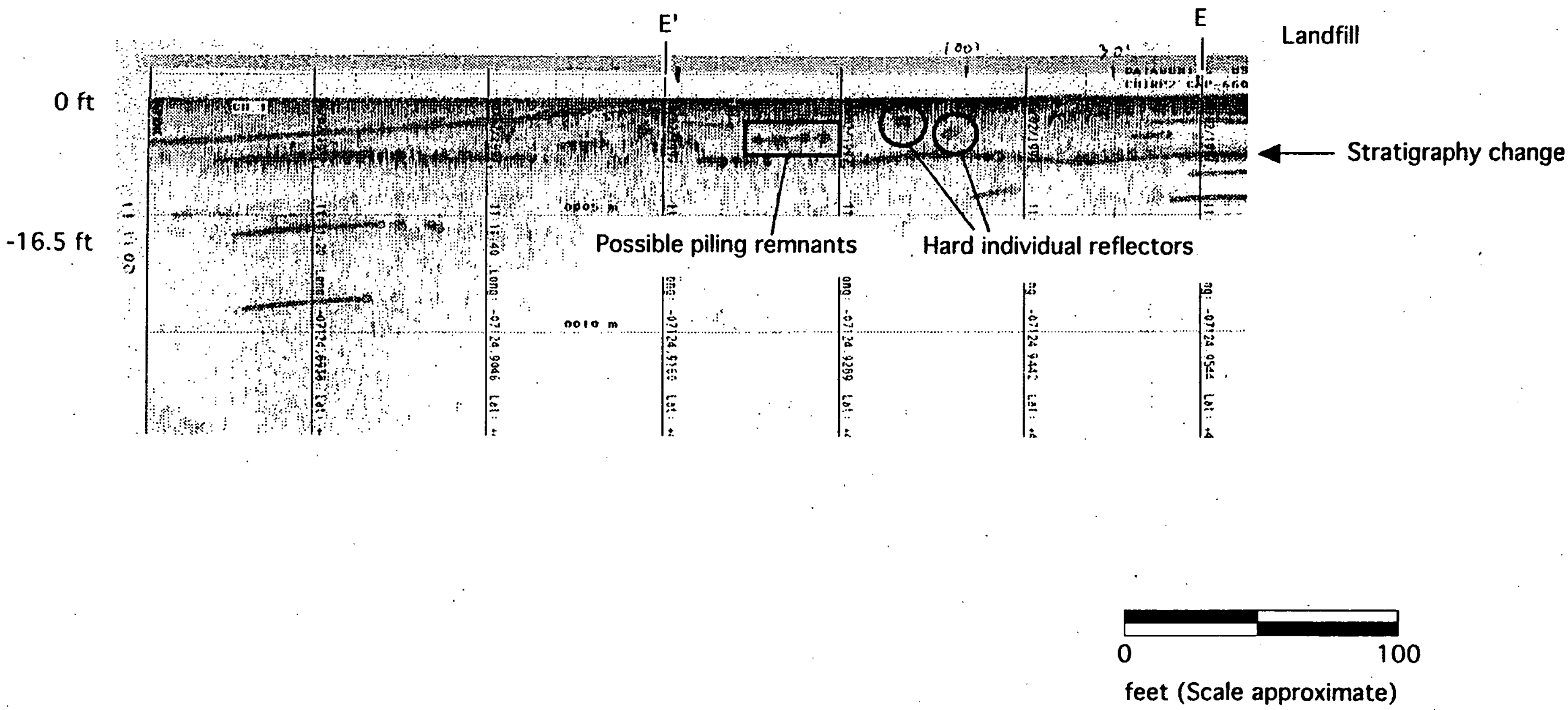
0 feet (Scale approximate) 100

See Figure 1 for Transect Location
Depths in feet below sediment/water interface



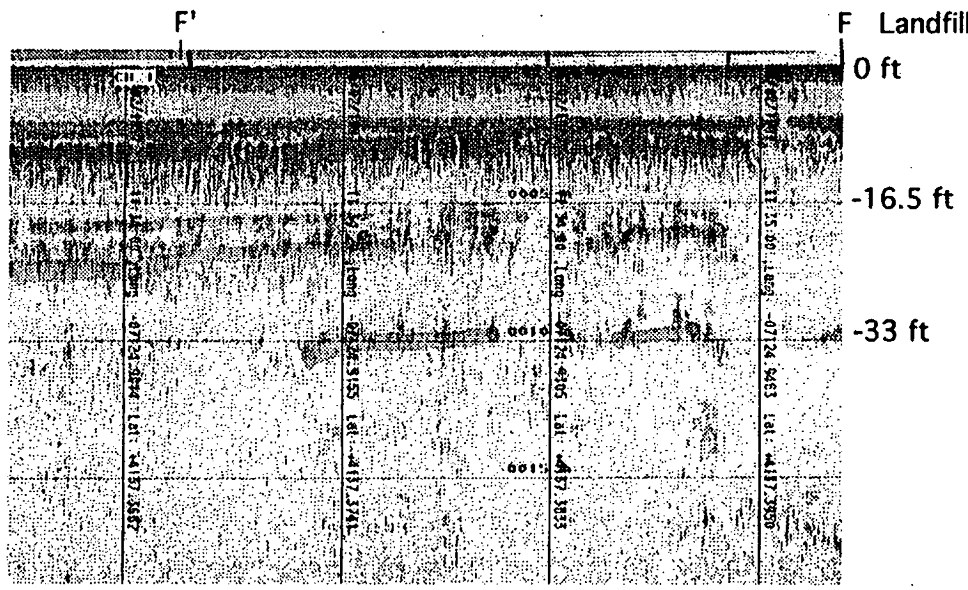
See Figure 1 for Transect Location
Depths in feet below sediment/water interface

Transect E' - E



See Figure 1 for Transect Location
Depths in feet below sediment/water interface

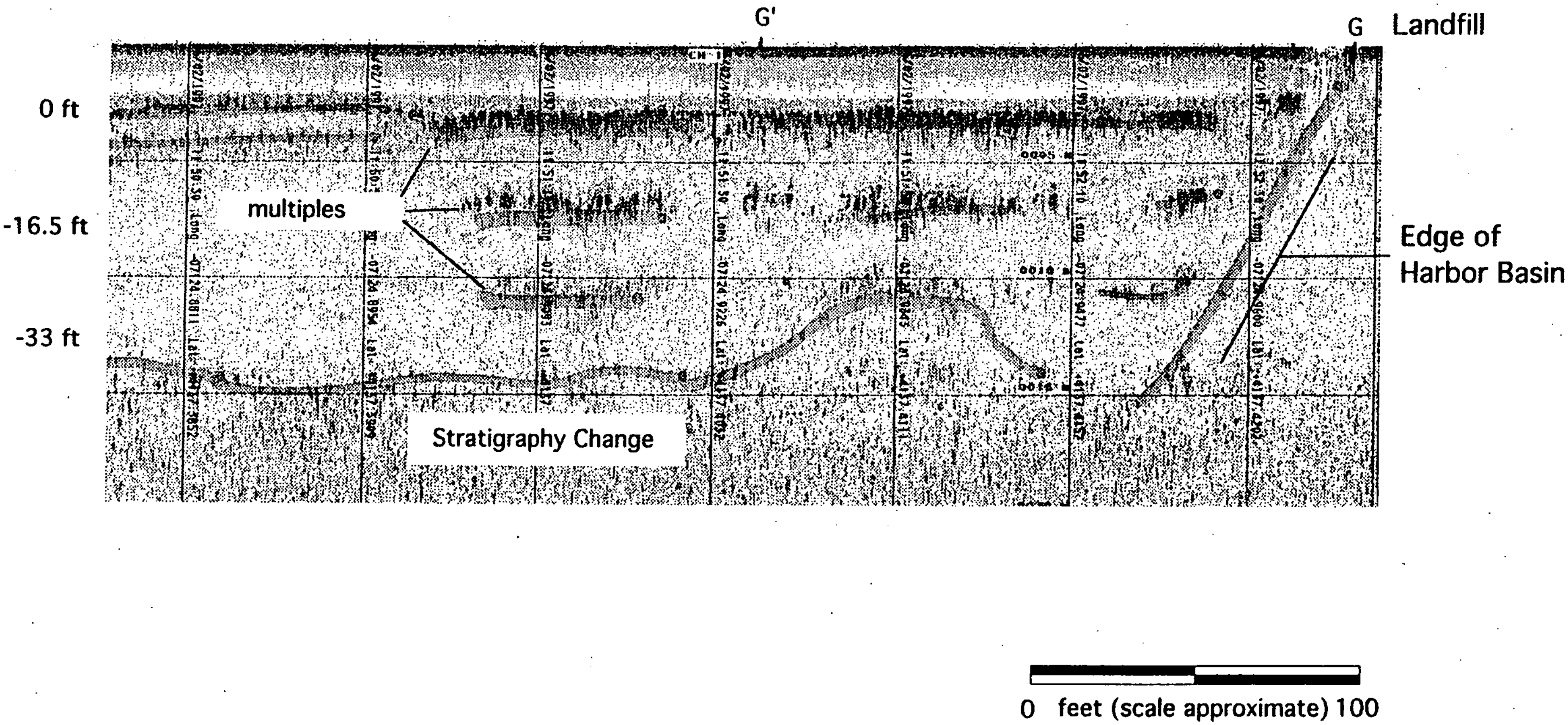
Transect F' - F



0 100
feet (scale approximate)

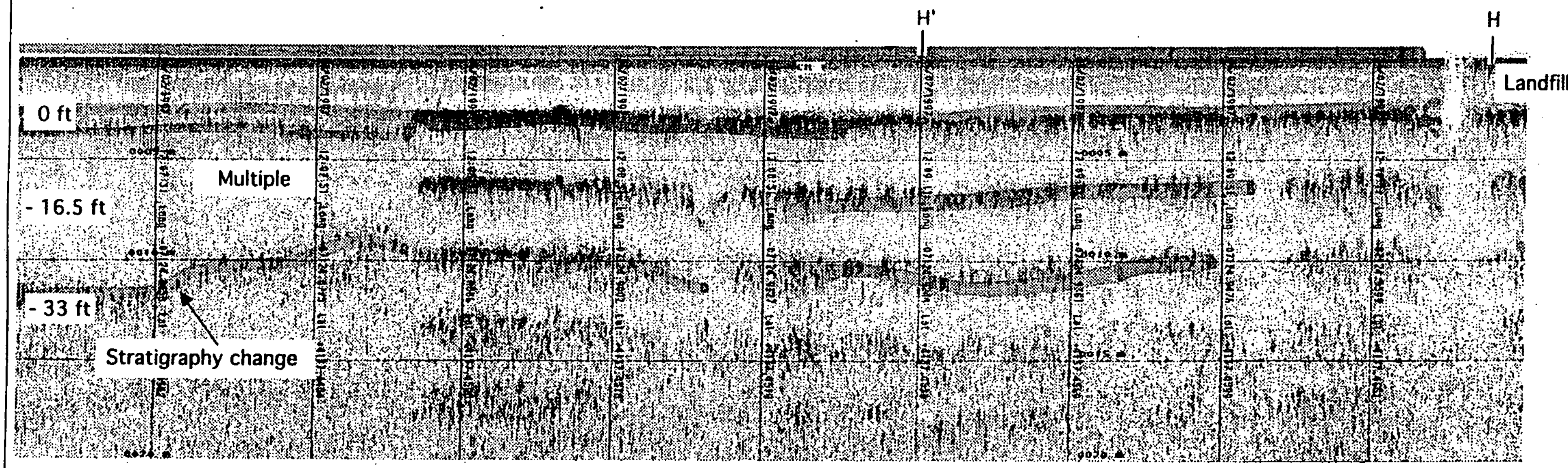
See Figure 1 for Transect Location
Depths in feet below sediment/water interface

Transect G' - G



See Figure 1 for Transect Location
Depths in feet below sediment/water interface

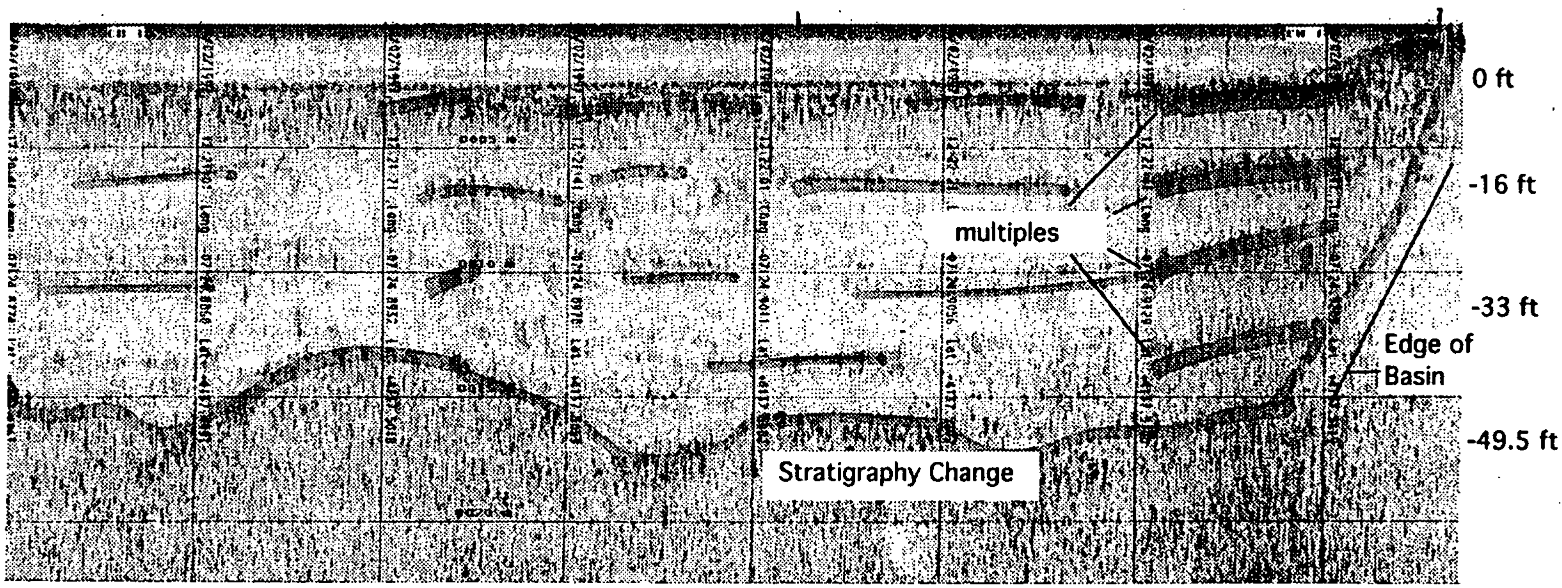
Transect H' - H



0 feet (Scale approximate) 100

See Figure 1 for Transect Location
Depths in feet below sediment/water interface

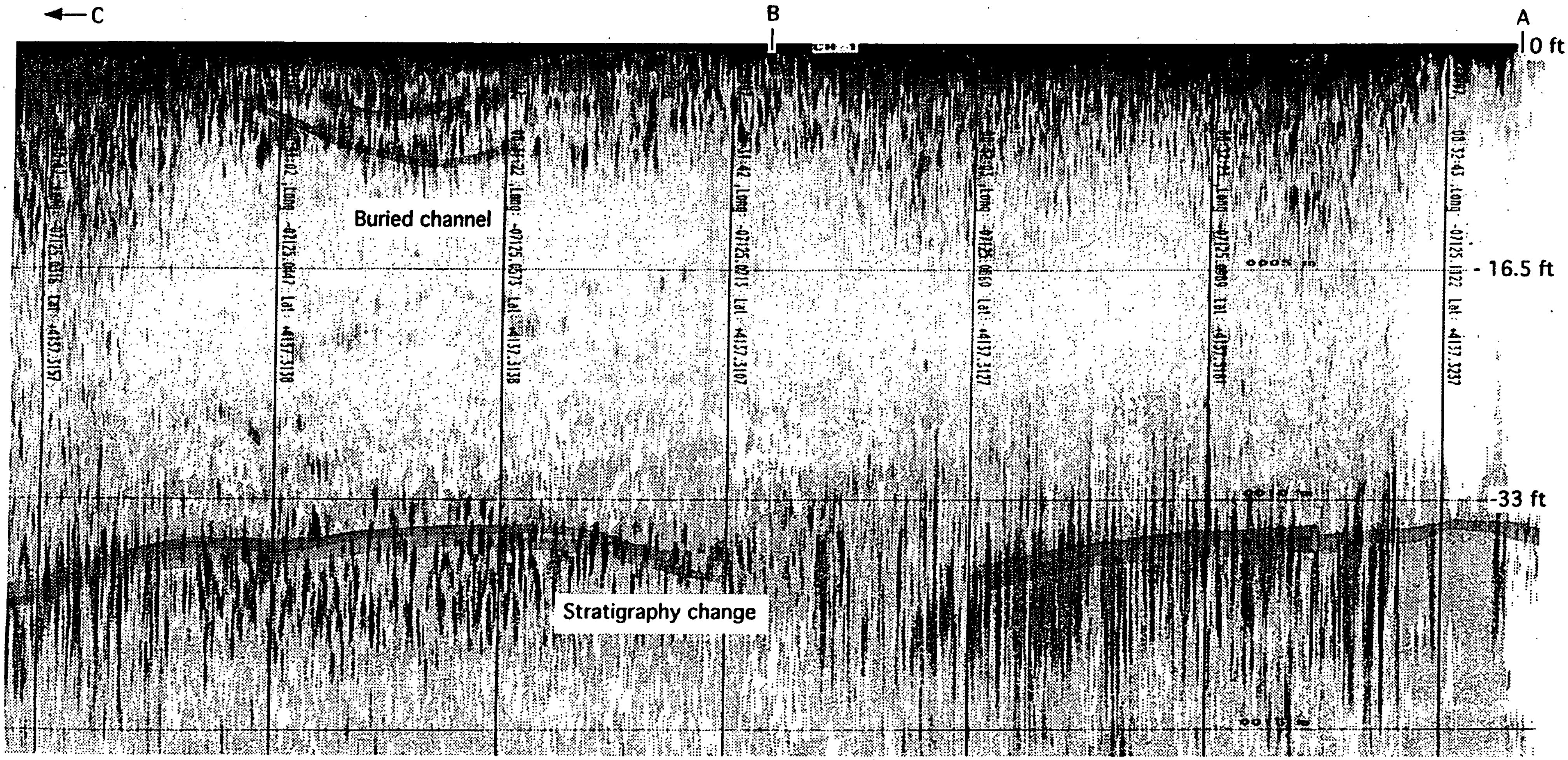
Transect I' - I



0 feet (Scale approximate) 100

See Figure 1 for Transect Location
Depths in feet below sediment/water interface

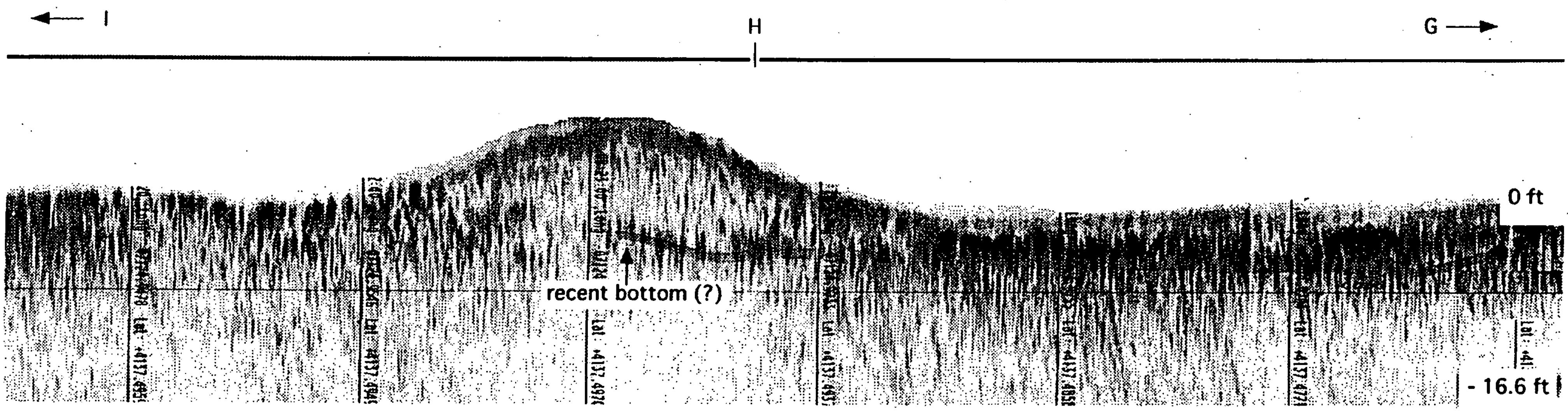
Transect C - A, 15' off landfill shore



Scale is time based
See Figure1 for true position locations

Depths in feet below sediment/water interface

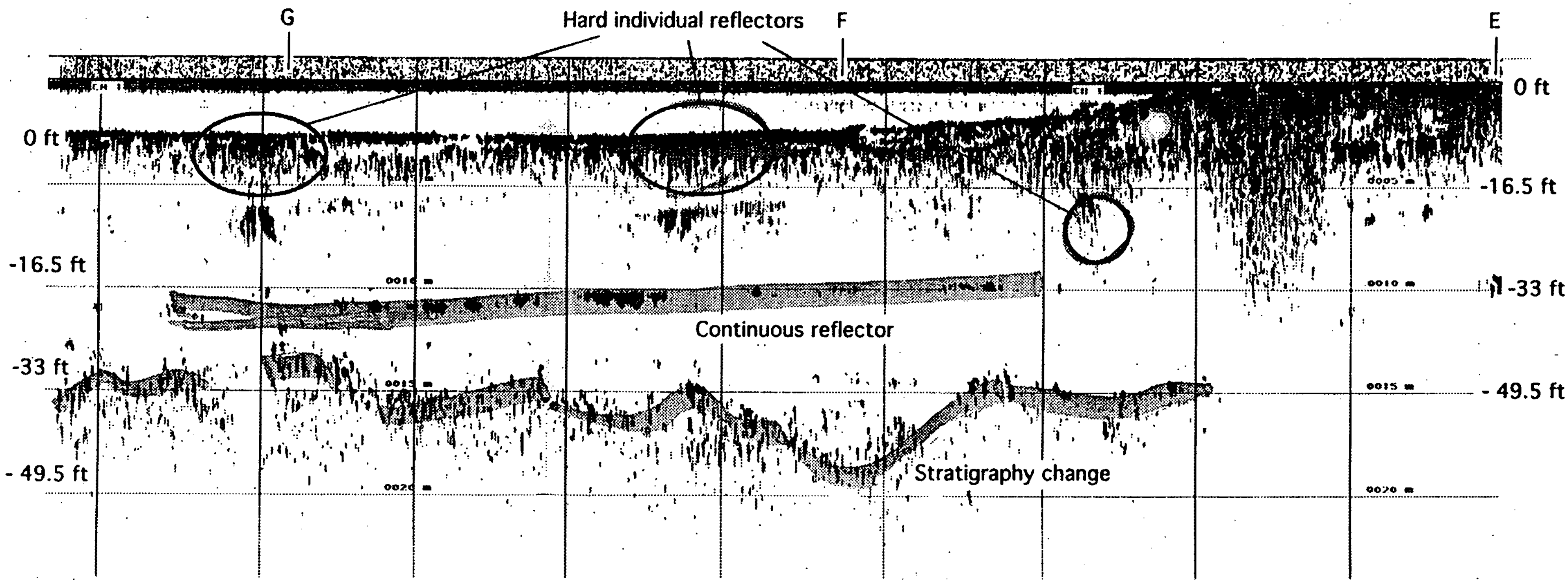
Transect I towards G, 15' offshore from landfill



Scale is time based
See Figure1 for true position locations

Depths in feet below sediment/water interface

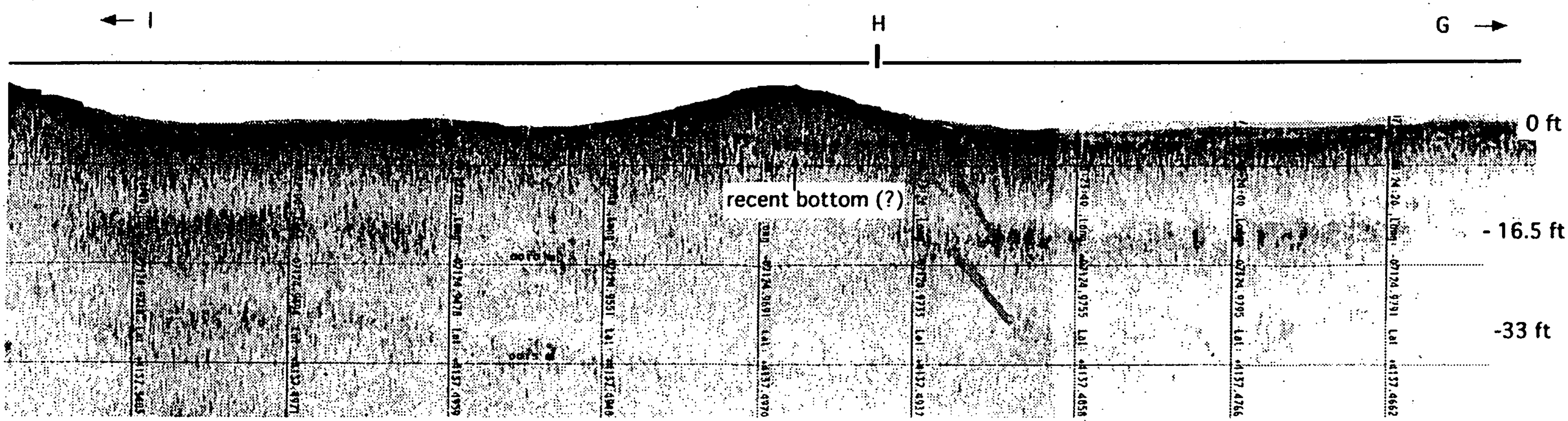
Transect G - E, 30' off landfill shore



Scale is time based
See Figure1 for true position locations

Depths in feet below sediment/water interface

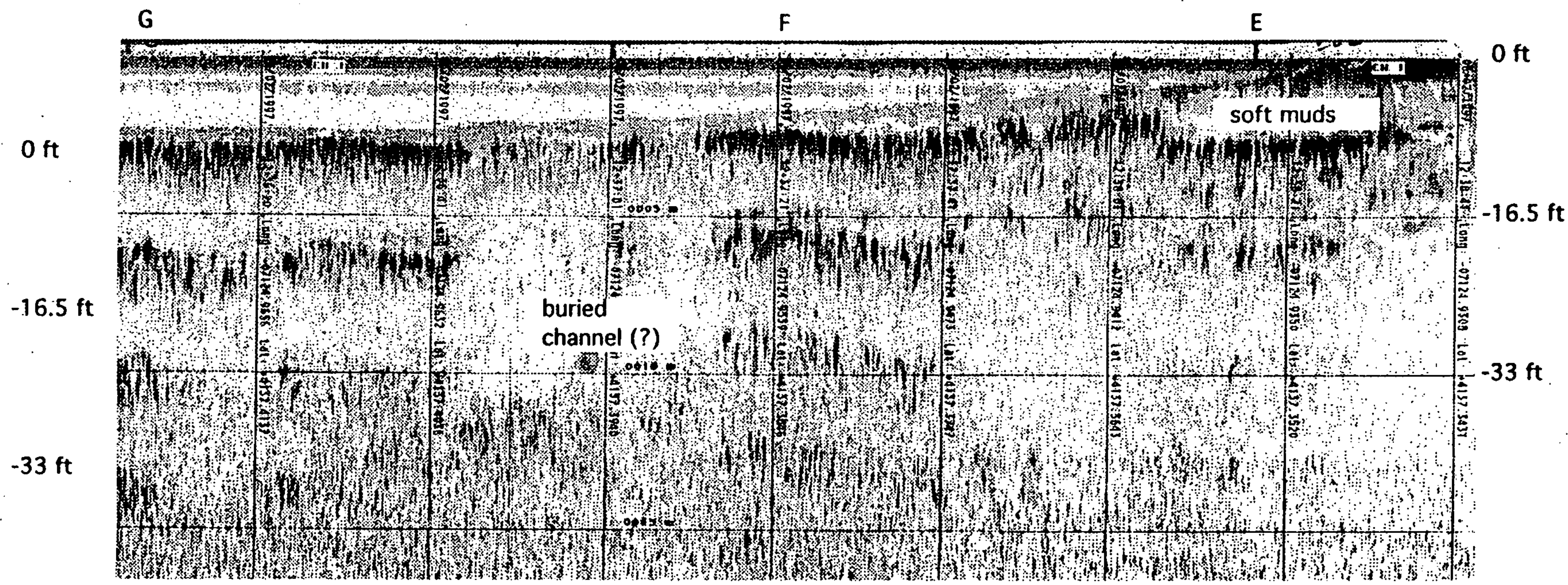
Transect I towards G, 30' offshore of landfill



Scale is time based
See Figure1 for true position locations

Depths in feet below sediment/water interface

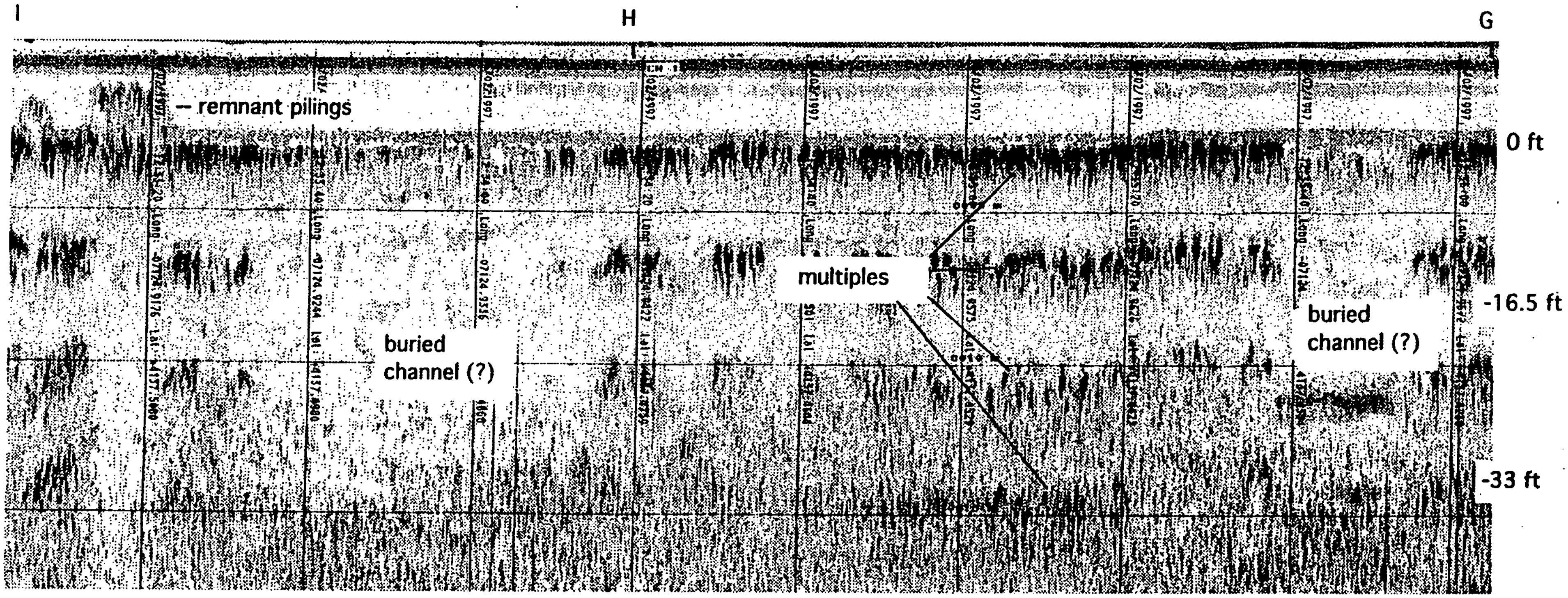
Transect G - E, 100' off landfill shore



Scale is time based
See Figure 1 for true position locations

Depths in feet below sediment/water interface

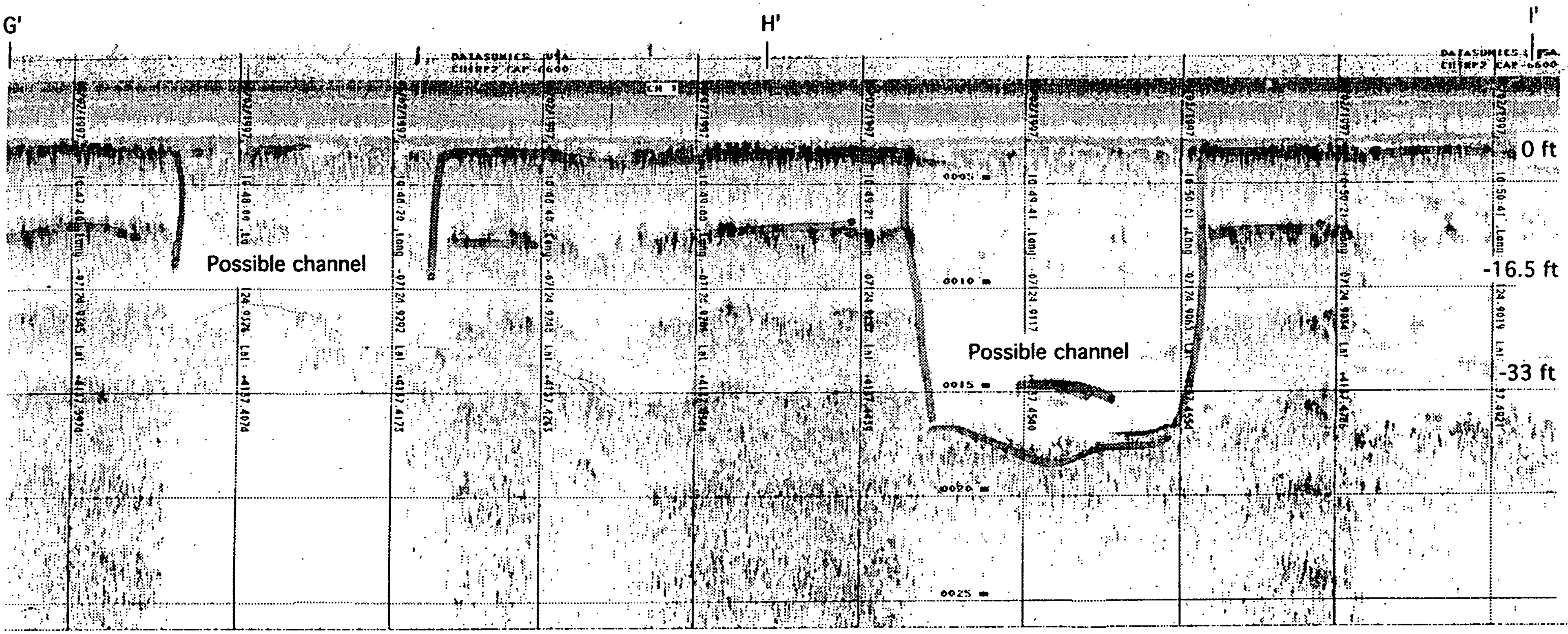
Transect G - I, 100' off landfill shore



Scale is time based
See Figure 1 for true position locations

Depths in feet below sediment/water interface

Transect G' - I', 200' offshore of landfill



Scale is time based
See Figure1 for true position locations

Depths in feet below sediment/water interface