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DATE: 13 March 2003

TO: Alan Humphrey, U.S. EPA/ERTC Work Assignment Manager

THROUGH: Gary Newhart, REAC Operations Section Leader
Scott Grossman, REAC Task Leader

FROM: Gordon Shields, REAC Geophysicist

SUBJECT: WATERBORNE GEOPHYSICAL SURVEYS, CENTERDALE MANOR SITE
WORK ASSIGNMENT R1A00270 – PRELIMINARY DRAFT TRIP REPORT

INTRODUCTION

The objective of the field activities described in this Preliminary Draft Trip Report was to map sub-bottom sediments in two ponds at the Centerdale Manor Site in North Providence, Rhode Island. Lockheed Martin personnel were tasked by the United States Environmental Protection Agency (U.S. EPA) Environmental Response Team Center (ERTC) under the Response Engineering and Analytical Contract (REAC) to perform waterborne geophysical surveys.

This Preliminary Draft Trip Report documents the waterborne geophysical surveys performed at the Centerdale Manor Site on 1 through 10 October 2002 and 22 through 24 October 2002. However, only data from the upper, Allendale Pond have been processed to date for presentation in this report.

BACKGROUND

The Centerdale Manor site is located in North Providence, Rhode Island. The areas investigated were the high-water boundaries of the Allendale and Lymansville Ponds. The ponds have been created as impoundments on the Woonasquatucket River. The ponds are downstream and south of the Centerdale Manor Apartments (Figure 1).

Prior to 1936 the properties were occupied by Centerdale Worsted Mills, a woolens mill. Atlantic Chemical began operating on the properties in approximately 1943. Atlantic Chemical Company changed its name in 1953 to Metro-Atlantic, Inc. and continued to operate until the early 1970s. New England Container Company, Inc. operated an incinerator-based drum reconditioning facility on a portion of the site from 1952 until 1971. A major fire in 1972 destroyed most of the structures at the site. The Brook Village Apartments were opened in 1977.

In November 1981, a Notice of Violation and Order was issued by the Rhode Island Department of Environmental Management (RI DEM) to the property owners for violations of the State Hazardous Waste Management Act. This order required that the property owners immediately identify all hazardous material on-site, and dispose of all hazardous wastes off-site. The response of the property owners to the order is unknown.

In February 1982, according to RI DEM records, approximately 400 drums were excavated from the site. About thirty drums had chemical residue that was analyzed. The empty drums were crushed and sent to a solid waste facility and at least eight drums containing hazardous material were manifested as hazardous waste. RI DEM required that soil samples be collected in the area of the building footprint prior to the construction of the Centerdale

Manor Apartments. As a result of the sampling analysis, approximately 6,000 cubic yards of soil were excavated and disposed of as non-hazardous solid waste. The Centerdale Manor Apartments were opened in 1983.

Dioxin was first identified in 1996 in fish collected from the Woonasquatucket River. Since that time, the U.S. EPA has documented elevated levels of several contaminants in soil, sediment, and surface water at the site. The contaminants included dioxin, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals.

In January 1999 the U.S. EPA initiated a time-critical removal action that included sampling, the installation of fencing, and the installation of interim soil caps. The U.S. EPA began the initial remedial investigation activities at the site in August 1999, including a pilot tree-swallow study which was completed in spring 2000. Additional site evaluations for the ecological risk assessments and human fish consumption are currently on-going. In Autumn 2000 through Summer 2001, the U.S. EPA also conducted a source area investigation. This included the installation of groundwater monitoring wells, the collection of surface and downhole geophysical data, and the collection and analyses of soil and groundwater samples. A final report with recommended long-term response action was expected in late 2002.

The U.S. EPA started a non time-critical removal action in February 2000, when the Agency signed an Approval Memorandum approving the performance of two Engineering Evaluation/Cost Analyses (EE/CAs). These two EE/CAs were later combined into one, resulting in an EE/CA report issued in September 2000 recommending restoration of the Allendale Dam and removal of dioxin-impacted soil and flood plain sediment from the residential and recreational-use properties. Following a 60-day public comment period, the EPA issued an action memorandum in January 2001, approving the removal action. The initial phase of the non time-critical removal action plan involved the reconstruction of the Allendale Dam. Rebuilding of the dam began in Summer 2001 and was completed in February 2002. The dam's spill-way was closed completely prior to the waterborne geophysical surveys to achieve the maximum water level.

METHODS

A 16-foot, flat-bottomed, wooden Garvey boat with a 8.0 horsepower outboard motor was used for the waterborne geophysical surveys (Figure 2). The low draft and wide beam of the Garvey boat were ideal for the surveys.

Global Positioning System (GPS) data were collected simultaneously with the geophysical data using a Trimble® Pro XRS receiver. The data were corrected in real-time for differential error. Post processing was also performed using a station located 180 miles away from the site (in Delhi, New York).

Several geophysical methods were attempted to map the sub-bottom sediments at this site (Table 1). However, only one method appeared to be useful and was applied in all areas. The other methods are mentioned only briefly and none of those related data are presented in this Preliminary Draft Trip Report.

Sidescan sonar was attempted in two modes using SeaScan® PC equipment. The first mode was using 600 kilohertz (kHz) antennae in the standard side-looking orientation. This mode was not expected to penetrate the sub-bottom and was only attempted to characterize the pond floor. However, it appeared to not even penetrate a thick organic layer that was present in many places. The second mode was using 300 kHz antennae with a single channel oriented straight down. This did not appear to penetrate the organic layer either.

Sub-bottom profiling was attempted using a Datasonics® Chirp II system. This employed a model DSP-662 transceiver and a DSP-661 processor. The system was capable of operating in two frequencies centered between 2 to 7 kHz and 10 to 20 kHz at a maximum power of 4 kilowatts (kW) per channel and featured a separate hydrophone. Various trigger rates, gains, and chirp rates were attempted. However, this system also did not appear to penetrate the organic layer with either frequency. Another Datasonics transducer model AT-471 that operated in a variable 2 to 7 kHz range was also tried but with similar, negative results. Gas bubbles within the organic layer may have further attenuated the acoustic energy.

Ground penetrating radar (GPR) was the only method that appeared to be useful at this site. It employed a GSSI® 200 megahertz (MHz) antennae deployed in a small rubber raft. A 250 nanosecond (ns) range was used and time varying gains were set at 10, 30, 50, 55, 60, and 65 decibels (dB). A vertical low pass filter was set at 1000 MHz and a high pass filter was set at 125 MHz. The instrument recorded six traces per second. The usual boat speed was about 1.0 knots, which resulted in a sample interval of about eight traces per foot. A trace number was stored on the GPS console with current navigation data once per second.

Post processing of the GPR data was performed using GSSI's RADAN NT software. This consisted of a 10 times linear gain, followed by a vertical low pass filter of 200 MHz. The data were converted to bit-map (BMP) format, flipped horizontally if the survey direction was west, and then saved in Joint Photographic Experts Group® (JPG) format. The resultant horizontal scale was 1 trace per pixel, and the vertical scale was 250 ns per 1024 pixels. These images were imported into Geosoft® Oasis montaj data processing and mapping software to be displayed as raw pseudosections (Appendix A, available on request). A vertical nomograph for water and sediments was generated for each section based on assumed tow-way travel times (18 ns/foot, and 9 ns/foot, respectively). A horizontal exaggeration was applied to some pseudosections to maintain approximately the same scale for printouts, which was necessary to account for different boat speeds. However, no distance normalization was applied.

The interpretation of the GPR data was based mainly on the assumption that a lack of reflectors in the subbottom indicated "hard sediments". However, even a thin layer of unfavorable electrical properties, one that would reflect most of the energy of the transmitted signal, could create the same impression while not being related to bulk density. Further, the total depth of signal penetration was limited by the cumulative attenuation of the water column plus a limited thickness of soft sediment. Generally, the penetration appeared to be fairly good at this site.

The apparent bottom and sub-bottom reflectors in the GPR data were digitized using raw pseudosection pixel coordinates. These coordinates were transposed to three dimensional, world coordinates in a two step process. The first step used spreadsheet macros to correlate the horizontal pixel (trace) data with the GPS observations in Universal Trans Mercator (UTM) coordinates. The second step used assumed vertical two-way travel times for water of 18 ns/foot and for soft sediment of 9 ns/foot. These assumptions and the interpretation of the reflectors were confirmed in many places using manual probing data.

Manual probing data were collected in a systematic manner on the ponds to determine the actual depth to soft sediments and depth to hard sediments. The probing apparatus consisted of two 10-foot sections of common half-inch steel pipe. The pipes were graduated with feet and inches using duct tape and a marking pen. One pipe was fitted with a three inch diameter flange and lowered gently in order to measure the depth to soft sediments. The other pipe was fitted with a threaded cap, to prevent sediment from becoming trapped, and was pounded into the soft sediments with a sledge hammer until "refusal". Although refusal was somewhat qualitative, this was expected to be a measure of the depth to hard sediments. The two pipes could also be fitted together with a threaded coupling for probing areas deeper than ten feet.

Acoustic depth sounder data were also collected at most times during the geophysical surveys and the manual probing. However, these data did not appear to be accurate, especially in shallow water. Further, the sensor often became fouled with vegetation. The general ability of this acoustic method to penetrate the thick organic layer was in question, given the failure of both the sidescan sonar and sub-bottom profiling acoustic methods.

ACTIVITIES AND OBSERVATIONS

On Allendale Pond, about 2.11 linear miles of GPR data were chosen to provide the most even coverage (Figure 3). In a few places the coverage was sparse due to obstacles and difficulty navigating. The survey area covered was about 12.5 acres. This area was considerably larger than the low-water level area indicated by high resolution aerial photography. At low-water level, the main flow channel was evident down past the middle of the survey area. Several adjacent areas of either erosion or migrating point bars were evident.

The maximum water depth probed was 8.4 feet at the southeastern part of Allendale Pond (Figure 4). The thickest soft sediment probed was 6.8 feet. Thick soft sediments were probed in many areas of the pond. A hard bottom of gravel and coarse sand with little or no soft sediments appeared to characterize the flow channels. Apparent bedrock was observed at the east side of the pond.

Thirty pseudosections were generated for the Allendale Pond (Appendix A, available by request). The pseudosections do not represent actual spatial relationships directly, although they may appear to graphically depict possible features of interest (eg. Figures 5, 6, 7, and 8). Such features may include pockets of soft sediment, paleo flow channels, cross bedding, pinching and thickening of certain strata, and possible chronostratigraphic relationships across many areas.

Features of interest in the pseudosections, which may require further investigation such as sediment coring, must be spatially located using the UTM coordinates posted directly above (eg. Figures 5, 6, 7, and 8). This is necessary due to variations in transect direction, and in boat speed. The latter effect was most dramatic at the beginnings of lines where the boat was slow to reach cruising speed, or where the boat became stuck, and resulted in suspiciously uniform and horizontal stratification. Small features that occur between UTM postings must be located using an interpolation between both northings and eastings. Similarly, depth and sediment thickness can be measured at any location using the nomograph provided. Due to the wide line spacing, the pseudosections appeared to indicate more detailed features than the plan view compilations.

Plan view maps were compiled using interpreted water depth (Figure 9) and sediment thickness (Figure 10) at selected positions from each section. The water depth contours indicated one main flow channel that appeared to have cut into the bottom of the pond. Possible smaller tributary or paleo flow channel scars were also indicated. The sediment thickness contours indicated several areas where the greatest accumulations may have occurred. Generally, thick sediments appeared to occur away from the present flow channel, where the water depths were shallow. However, thick sediments also appear to be coincident with deep water in southern parts of the pond.

CONCLUSIONS AND RECOMMENDATIONS

Acoustic methods such as sidescan sonar and sub-bottom profiling did not appear to yield useful information for mapping sub-bottom sediments at this site. The presence of a thick organic layer that was also filled with gas bubbles probably completely attenuated the transmitted signal. Methods with more powerful sources, such as boomers or sparkers used in seismic exploration, may penetrate this difficult sub-bottom environment. However, these may not be necessary given the apparent success of the GPR method.

The GPR method appeared to achieve about ten feet of soft sediment penetration in most areas and provided numerous detailed pseudosections across the ponds. However, the interpretation of the GPR pseudosections was not simple and some ambiguity can be expected. Often there appeared to be numerous reflectors that could represent the true "hard sediment" surface. The manual probing data were very useful during interpretation in most instances, but occasionally these data were not considered reliable (eg. transect 125).

The GPR pseudosections appeared to indicate several different depositional environments. These included migrating point bars (and associated scour channels), basin-like pools, and small isolated pockets. On some pseudosections, depositional features may represent very focused coring targets. The apparent layering may also have chronostratigraphic significance.

The resultant bathymetric and soft sediment thickness isopach maps appear to have large features that cross several transects. Features such as long paleochannels and large accumulations of sediment may represent general coring targets. However, unfavorable ground or hazards to coring, such as rock, may exist between the transects where no data were collected.

The area most likely to contain sediments from the past 50 years may be restricted to a narrow delta shape that fans out from the northwestern part of Allendale Pond and down towards the dam. A first round of coring may yield the most useful information if it targets areas upstream, and closest to the source of possible contamination. Furthermore, cores oriented across the drainage pattern (eg. transects 137, 128, 125, and 120) may yield more useful information than targeting a single feature such as thick sediments in a paleochannel along the drainage pattern. A few deep cores (to bedrock) may also be useful in a first round.

FUTURE ACTIVITIES

The only future geophysical activity planned for this site is to finish the data processing for the lower, Lymansville Pond.

cc: Central File - WA # R1A00270 (w/attachment)
Electronic File - I:/Archive/REAC3/270/D/TR/022803
REAC Program Manager (cover page only)

Table 1. Waterborne Geophysical Surveys Performed
Centerdale Manor Site
North Providence, Rhode Island
March 2003

Allendale Pond
==============

01 Oct.	sonar test runs (all)
01 Oct.	gpr test runs, setting ranges and gains
02 Oct.	gpr on 20 m spaced lines
03 Oct.	pick up and troubleshoot chirp2
04 Oct.	chirp2 several test lines
05 Oct.	chirp2 stopped working, troubleshoot
06 Oct.	chirp2 several test lines
07 Oct.	gpr 10 m spaced in-fill lines
08 Oct.	depth probing with 10/20 ft steel pipe

Lymansville Pond
================

09 Oct.	gpr test runs, then several 10 m spaced lines
10 Oct.	test new transducer for chirp2
23 Oct.	gpr survey
24 Oct.	gpr survey, depth probing

Notes:
sonar = sidescan sonar
gpr = ground penetrating radar
m = metres
chirp2 = sub-bottom profiler
ft = feet

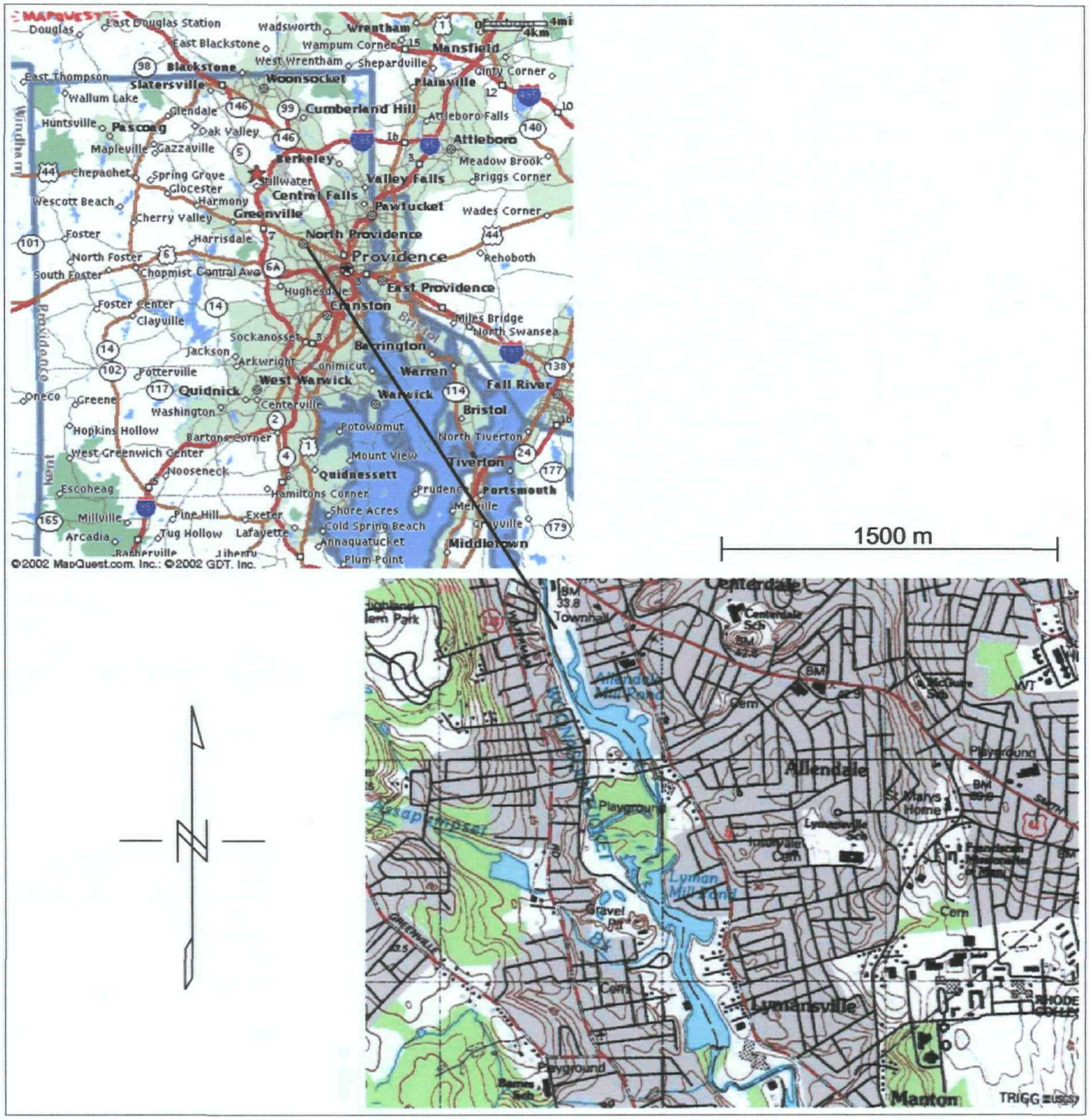

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Figure 1. Location

Centerdale Manor Site

North Providence, Rhode Island

March 2003

200 MHz Ground Penetrating Radar Antennae

Global Positioning System Antenna

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Preliminary

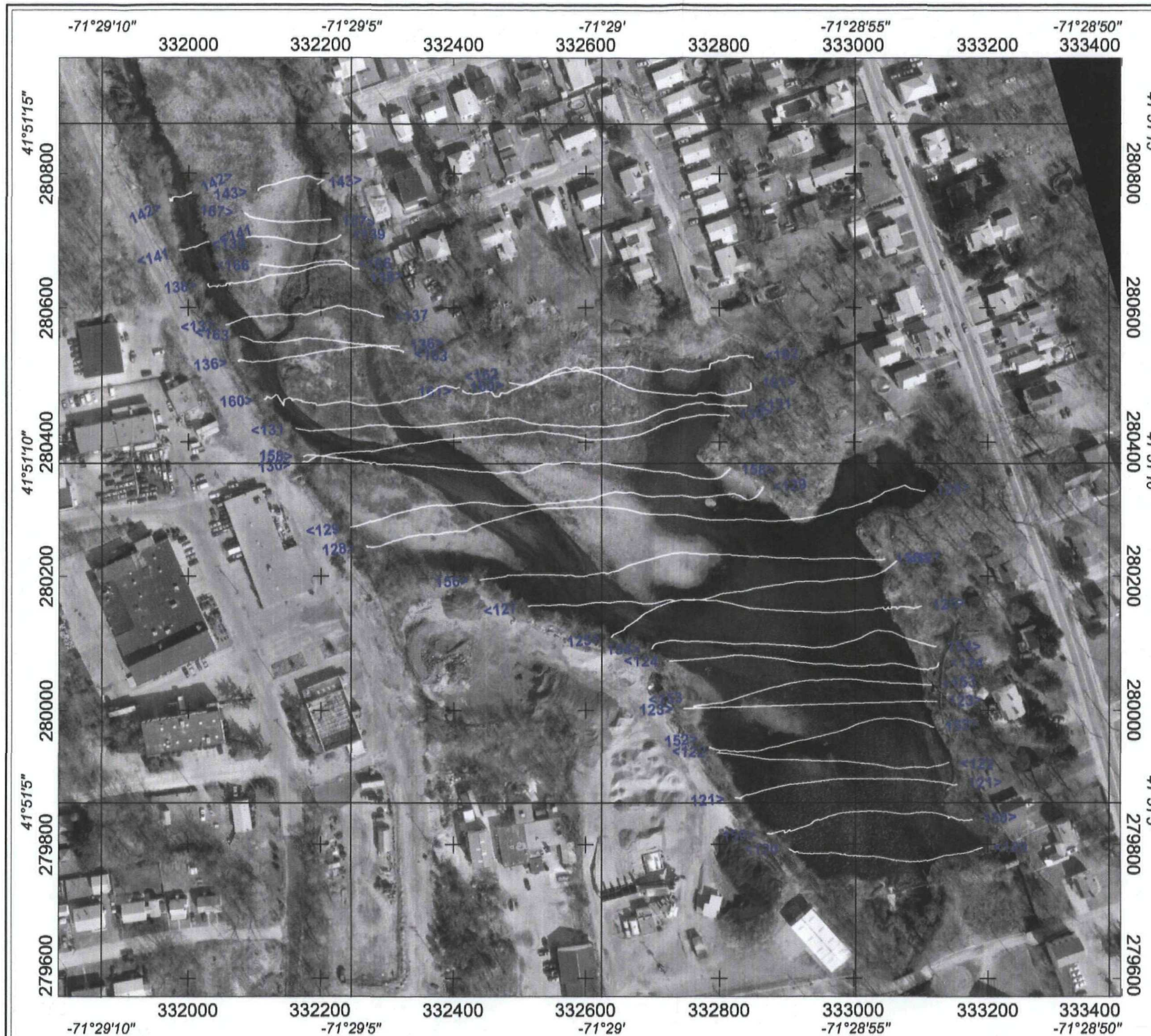
Figure 2. Waterborne Ground Penetrating Radar

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Draft



Scale 1:2400

100 0 100 200

US survey foot

NAD83 / Rhode Island CS83

150> Ground Penetrating Radar Transect (based on differentially corrected, Global Positioning System data)

Aerial Photography, 4 Mar 2002, GEOD Corporation

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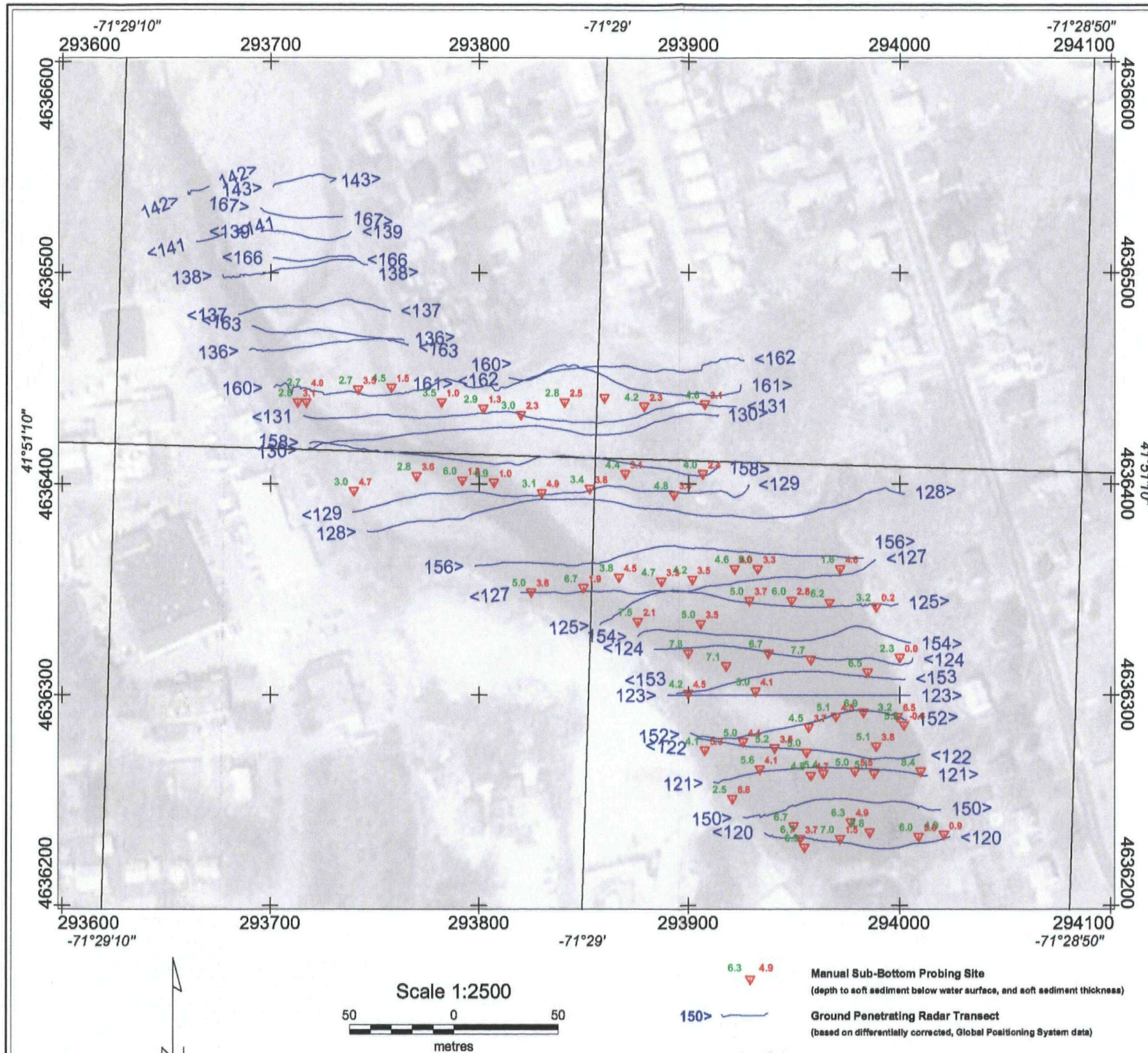
Figure 3. Waterborne GPR Transects, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Preliminary Draft



Aerial Photography, 29 Mar 1995

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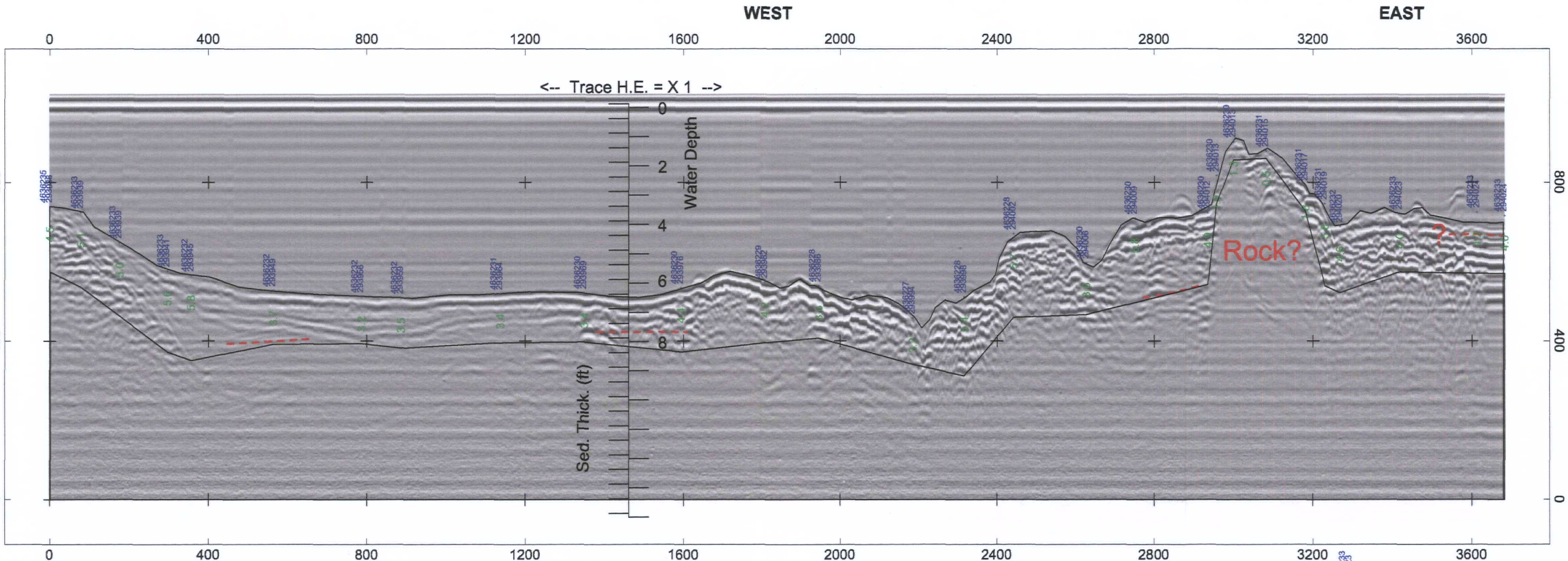
Figure 4. Manual Sub-bottom Probing, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Preliminary Draft



Vertical Nomograph Based On Estimated TWTs:

18 ns / ft (Water) and 9 ns / ft (Soft Sediment)

Vertical Axis Marked as 1024 Pixels (inverted) over a 250 ns Range

Response Amplitude Gained at 10, 30, 50, 55, 60, and 65 dB

Interpreted Bottom Reflector

Interpreted Sub-Bottom Reflector

Sub-Bottom from Nearby Probing

Horizontal Scale by Trace, Exageration as Marked

500 0 500 1000 1500

West-course Lines Flipped on Vertical Axis

4636233 , 294023 Northing and Easting (metres, UTM Zone 19N)

3.5 Estimated Soft Sediment Thickness (feet)

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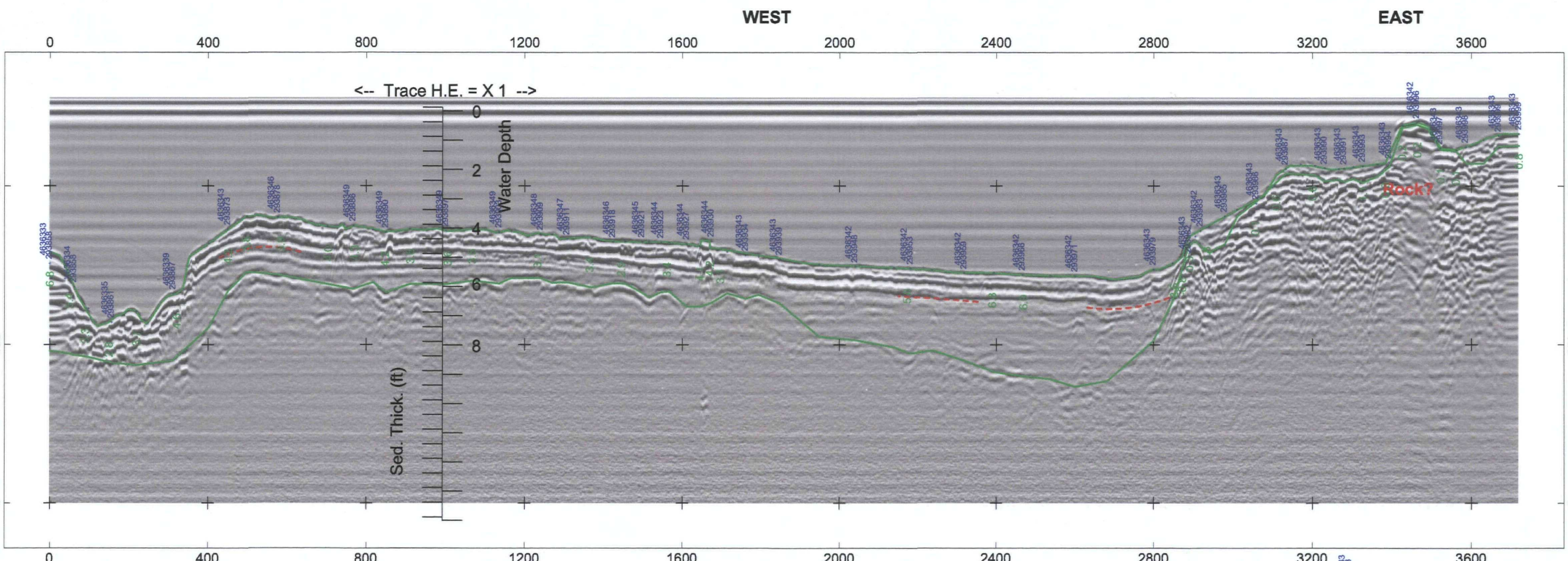
Figure 5. Line 120, GPR Pseudosection, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003



Vertical Nomograph Based On Estimated TWTs:

18 ns / ft (Water) and 9 ns / ft (Soft Sediment)

Vertical Axis Marked as 1024 Pixels (inverted) over a 250 ns Range

Response Amplitude Gained at 10, 30, 50, 55, 60, and 65 dB

Interpreted Bottom Reflector

Interpreted Sub-Bottom Reflector

Sub-Bottom from Nearby Probing

Horizontal Scale by Trace, Exageration as Marked

500 0 500 1000 1500

West-course Lines Flipped on Vertical Axis

4636233 - 294023 Northing and Easting (metres, UTM Zone 19N)

3.5 Estimated Soft Sediment Thickness (feet)

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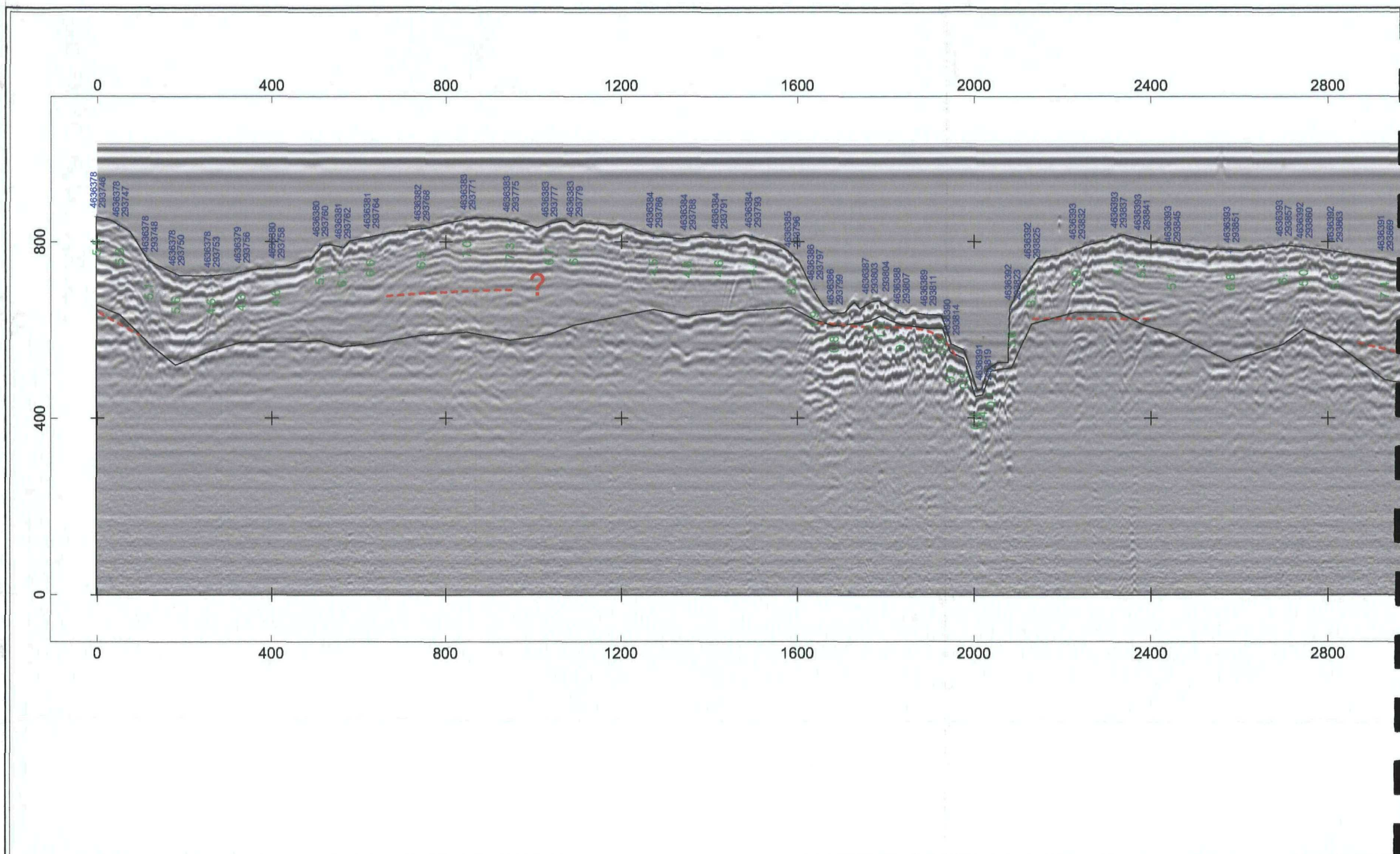
Figure 6. Line 125, GPR Pseudosection, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Preliminary Draft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800
1200
1600
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2800
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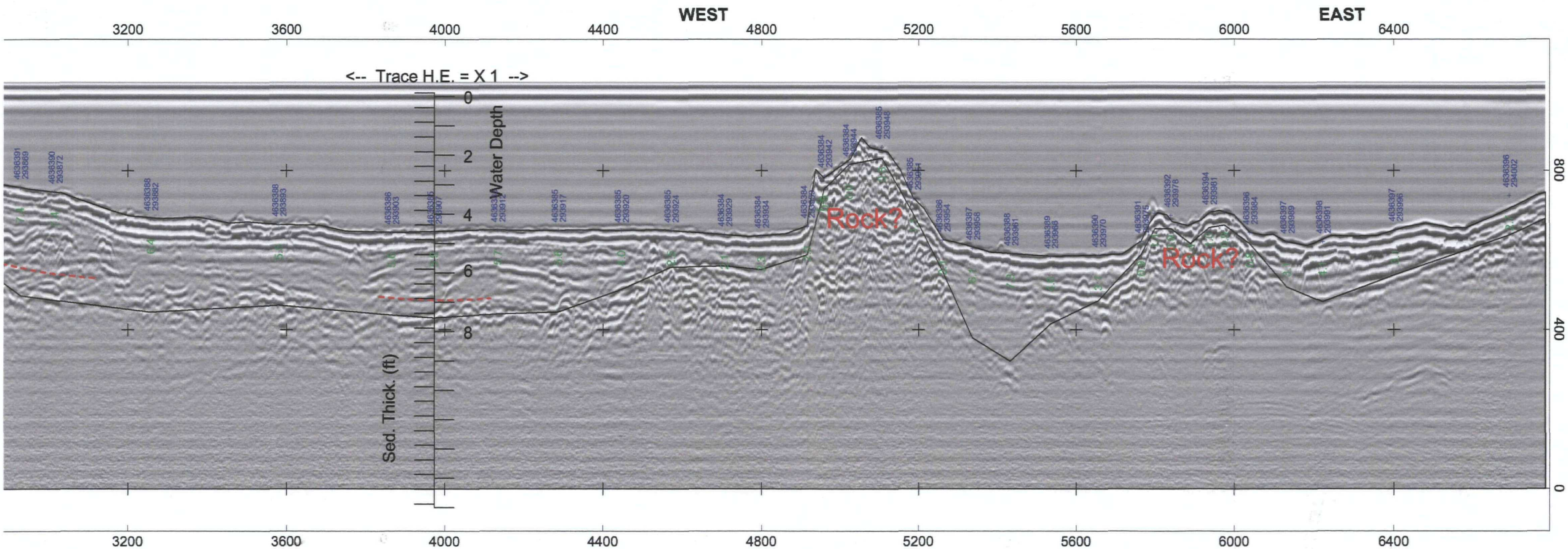

Vertical Nomograph Based On Estimated TWTs:

18 ns / ft (Water) and 9 ns / ft (Soft Sediment)

Vertical Axis Marked as 1024 Pixels (inverted) over a 250 ns Range

Response Amplitude Gained at 10, 30, 50, 55, 60, and 65 dB

Interpreted Bottom Reflector

Interpreted Sub-Bottom Reflector

Sub-Bottom from Nearby Probing

Horizontal Scale by Trace, Exageration as Marked

500 0 500 1000 1500

West-course Lines Flipped on Vertical Axis

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Figure 7. Line 128, GPR Pseudosection, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

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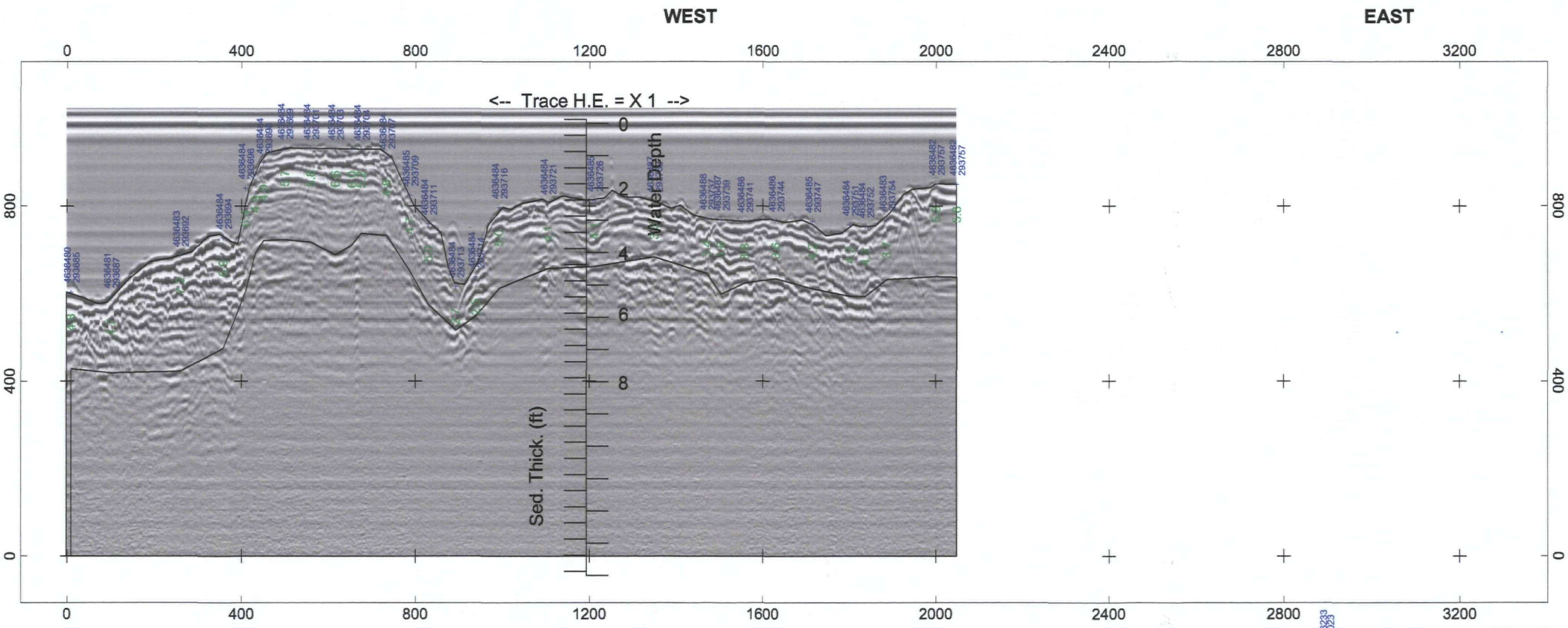

Vertical Nomograph Based On Estimated TWTs:

18 ns / ft (Water) and 9 ns / ft (Soft Sediment)

Vertical Axis Marked as 1024 Pixels (inverted) over a 250 ns Range

Response Amplitude Gained at 10, 30, 50, 55, 60, and 65 dB

Interpreted Bottom Reflector

Interpreted Sub-Bottom Reflector

Sub-Bottom from Nearby Probing

Horizontal Scale by Trace, Exageration as Marked

500 0 500 1000 1500

West-course Lines Flipped on Vertical Axis

Northing and Easting (metres, UTM Zone 19N)

Estimated Soft Sediment Thickness (feet)

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Figure 8. Line 137, GPR Pseudosection, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

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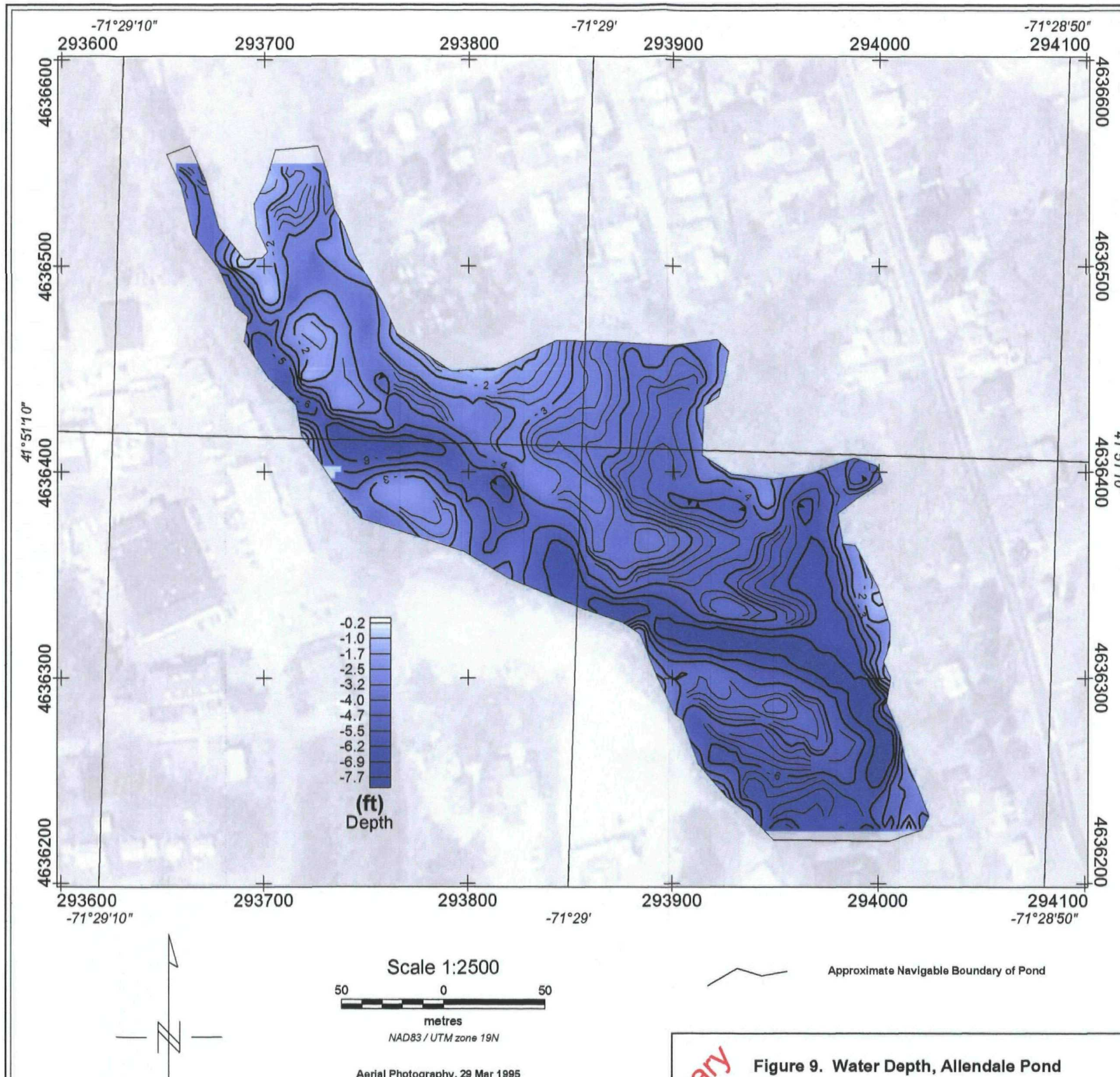

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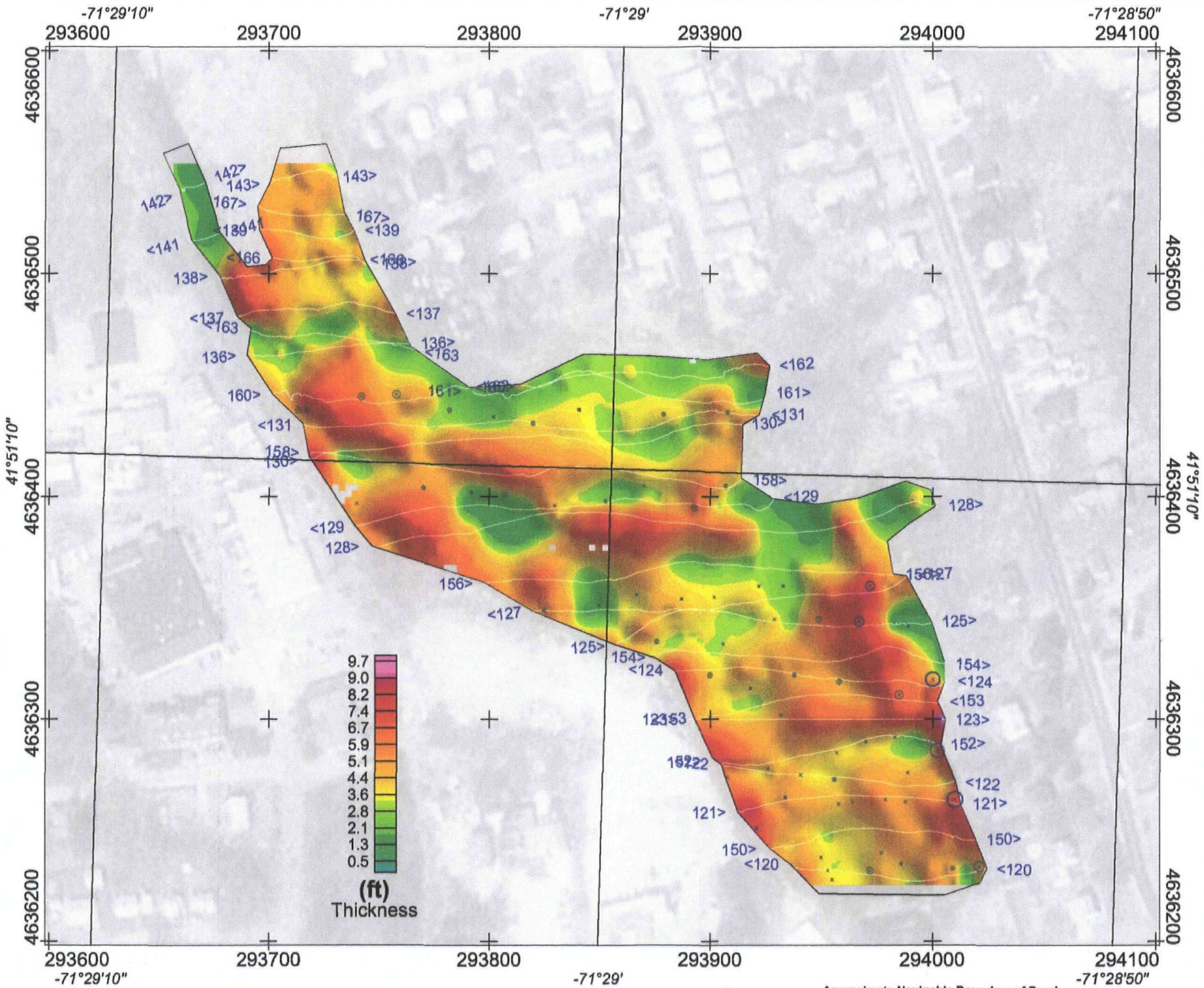
Figure 9. Water Depth, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Preliminary Draft



Approximate Navigable Boundary of Pond

Manual Sub-Bottom Probing Site
(circle proportionate to difference from interpreted thickness, maximum 5.6 ft shown)

150> Ground Penetrating Radar Transect
(based on differentially corrected, Global Positioning System data)

Scale 1:2500

50 0 50

metres

NAD83 / UTM zone 19N

Aerial Photography, 29 Mar 1995

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Figure 10. Apparent Sediment Thickness, Allendale Pond

Centerdale Manor Site

North Providence, Rhode Island

March 2003

Preliminary Draft