WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	Paul Deschaine, David Canada	DATE:	March 15, 2011
FROM:	Rick Davee	PROJECT NO.:	11607B
SUBJECT:	Stratham Water System Investigations		

Groundwater Supply Investigation

The Town requested Wright-Pierce to preliminarily determine if a bedrock groundwater supply was feasible on two separate properties. In order to accomplish this, Task A, Groundwater Geophysical Survey, was completed and is attached for the Town's review.

In summary, the investigation was conducted on two properties in Stratham known as the Scamman and Goodrich properties. Firstly, a photo lineament analysis including hydrogeologist interpretation of aerial photography and side scan at looking airborne radar was completed. The linear features identified were overlayed on a map of the properties to identify areas of intersection. Using this information as a starting point, the on site geophysical investigation was conducted. On site investigations were completed using two techniques; Very Low Frequency (VLF) and electrical resistivity testing. Very Low Frequency testing was completed on both sites but due to budget restraints electrical resistivity was completed on the Goodrich property.

The results of the geophysical survey yielded multiple bedrock drill target locations on each site. A complete set of results and recommendations is included in the attached report.

Water Supply Permitting

The development and permitting for a large groundwater withdrawal (> 57, 600 gallons per day) can be a time consuming and expensive process. In addition, both the Goodrich and Scamman sites are in the vicinity of residential wells which will add to monitoring costs during permitting and may limit the quantity of water that may be withdrawn from the site(s). Based on these facts, the Town may want to consider the option to install groundwater supplies on each property that are < 57,600 gallons per day to fall within the small groundwater withdrawal permitting process (Env- Dw 301). The small groundwater withdrawal process is a relatively straightforward process. In addition, the sanitary protection area around the well may be reduced to 200 feet (verses 400 feet for the large groundwater withdrawal permit). This may be an option to provide potable water to the first phase(s) of the Commercial District. During the early part of this year, the Town should have a meeting with the NHDES Groundwater Bureau to determine the specific permitting requirements of small community wells.

Once the potable water supply has been developed, a source of potable water must be obtained for fire protection (high flows). The two feasible options for fire protection are to either construct a water storage tank or tie into the Exeter public water system. Tying into the Exeter water system would be considered an emergency connection and only used if there was a fire flow demand in Stratham.

Longer term, a larger potable water supply will be needed for Stratham. Review of potential groundwater areas in Stratham has revealed that potential high yielding groundwater supplies can be found just to the north-east of the project area. The long term benefits of these areas are the remoteness of the sites which will reduce the potential impact to private wells.

Water Storage Tank Considerations

The Town has the potential to purchase property at 28 Bunker Hill Road in the vicinity of the Town Office for construction of a proposed 1 million gallon storage tank. The benefit of this property is the ground elevation is approximately 75 feet higher then the proposed tank site on the Town property. This higher ground elevation would allow for a ground level concrete storage tank to be constructed, thereby saving the Town both capital and long term maintenance costs. Additional benefits and concerns are addressed in Table 1.

Table 1: Comparison of Storage Tank Options

Concerns	Ground Level Storage at 28 Bunker Hill Road	Elevated Storage at Town Hall
Materials of Construction	Pre-stressed Concrete	Steel Tank Bowl Concrete Pedestal
Tank Height	30 ft	100 ft
Aesthetics	Less visually obtrusive. Trees should shield most of the tank.	~100' tall tank near the ball field on Town property.
Easements, Property Purchase	Easement needed to cross private property. Tank property needs to be purchased.	Town already owns tank site property.
Maintenance	Virtually zero	Tank bowl needs painting every 15 to 20 years. (~$400,000)
Capital Costs*	~$1,100,000	~$2,000,000

*Does not include easements or land purchase costs.

Figure 1: Examples of a Concrete Ground Level Storage Tank and a Composite Elevated Storage Tank

A) Concrete Ground Level Storage Tank

B) Composite Elevated Storage Tank

The ground elevation on the Town Office property is approximately El. 135. Building a storage tank at this site would require an elevated storage tank. The storage tank would be set on a pedestal approximately 65 feet above the ground (Figure 1) and have an overflow elevation (hydraulic grade line) at El. 230. The ground elevation of the Bunker Hill property behind the Town is approximately El. 200. In this case a concrete storage tank could be built with a 30 foot sidewall and an overflow elevation of El. 230. Locations of the proposed elevated and ground level storage tanks are shown on Figures 2 and 3.

Potential Storage Tank Locations

Water System Investigation

Stratham, NH

PROJ NO: 11607B DATE: Dec 2010 FIGURE: 2

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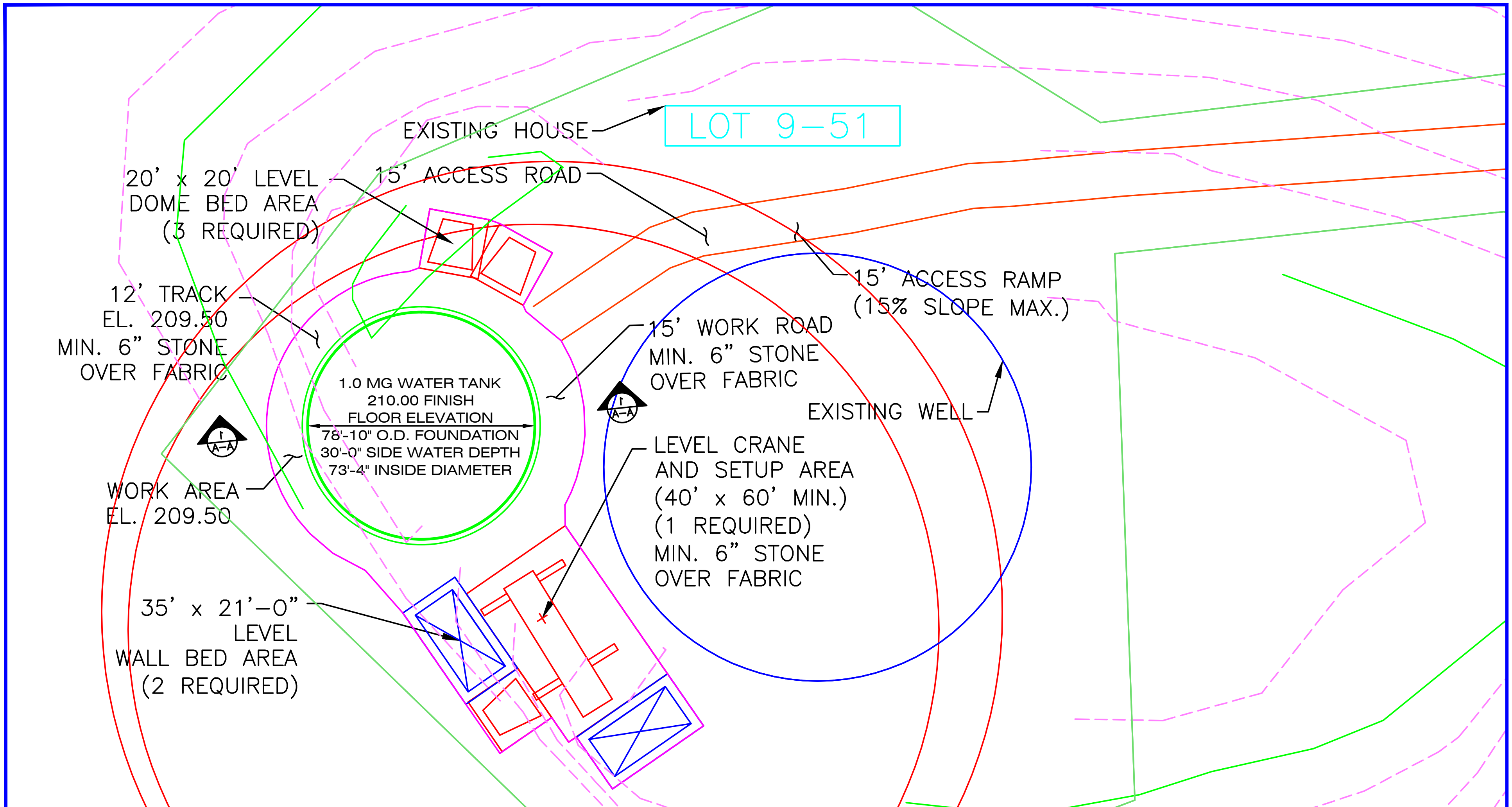


NOTES:

1. PLEASE USE THESE EX-DRAWINGS IN CONJUNCTION WITH THE DETAILED NATGUN SCOPE LETTER AND SUBCONTRACT.
2. FINAL CASTING BED LOCATIONS TO BE DETERMINED BY THE NATGUN FIELD SUPERINTENDENT.
3. LEVEL AREAS MUST BE PROVIDED FOR CASTING BEDS, CRANE AREAS, AND EQUIPMENT AND OFFICE TRAILERS. ALSO PROVIDE ACCESS TO TRACK.
4. BASED ON 210 TON CRANE WITH HEAVY WORKING RADIUS = 135 FT ERECTING 31 FT WALL PANELS.
5. AT A MINIMUM, ALL WORK ROADS, ACCESS ROADS, RAMPS, CRANE AREAS AND THE WINDING TRACK SHALL HAVE 6" OF ROAD BASE OVER GEOTEXTILE FILTER FABRIC, MIRAFI 500X OR EQUAL. REFER TO SCOPE LETTER FOR REQUIREMENTS.

NATGUN PRECAST PRESTRESSED PREFERRED
11 TEAL ROAD WAKEFIELD, MA 01880

1.0 MG PRECAST, PRESTRESSED CONCRETE WATER STORAGE TANK CONSTRUCTION SITE LAYOUT - PLAN

DRAWN BY: AP	DATE: 01/04/11	SCALE: 1" = 50'-0"	DWG# EX-1	REV:
CHECKED:	FILE: T:\ENGINEER\DRAWINGS\LAYOUTS\SITE\2010\STRATHAM, NH 12-27-10.DWG			
SITE LOCATION: STRATHAM, NEW HAMPSHIRE				FIGURE 3

2011 Recommendations

We recommend budgeting for the following work in the next fiscal year:

A. Geophysical Investigation and Bedrock Well Development

1. Perform electrical resistivity surveys on the Scamman site to fine tune potential test well sites. Consideration should be given to evaluating the area to the north and northeast of the Goodrich site, as well as other areas located in the Mill Brook watershed east of Route 108.
2. Obtain permission to perform a field inspection and drill test wells on either/both the Goodrich and Scamman sites.
3. Utilizing the aerial photography and geophysical data, locate and stake potential drill sites.
4. Determine site accessibility and land-use constraints for a 36-ton air-hammer rotary-drilling rig.
5. Provide drill specifications and select a qualified drilling company having equipment capable of drilling in highly fractured water bearing bedrock.
6. Utilizing the air-hammer rotary drilling method, drill up to (4) 6.5-inch diameter test wells to a maximum depth of 600 feet below land surface per site. 8-inch casing will be utilized to allow for the test wells to be "reamed" out and used as production wells if they prove to be a good location.
7. Provide on-site hydrogeologic drill supervision, well logging of fracture depths and aperture and, airlift yield estimates.
8. If suitable airlift yields are obtained, perform a short duration pumping test and analyze for select water chemistry parameters.

9. Meet with NHDES representatives to discuss the Town's options with respect to small community well development and permitting requirements.

B. Water Distribution System Development

1. Conduct ledge probes along the Route 108 pipeline path to estimate ledge quantities in the project area. This information will be used to further refine the construction cost estimates.
2. Conduct soil borings for the ground level storage tank geotechnical analysis.

C. Town Responsibilities

1. Purchase ground level storage tank property.
2. Negotiate easement for water main easement to ground level storage tank.
3. Continue with infrastructure assessment and acquisition plans for the Shaw's fire suppression infrastructure.
4. Continue with fire suppression infrastructure acquisition discussions for all other Phase 1 properties.
5. Determine a location for a water treatment facility for the bedrock wells and gain rights to this property.
6. Develop bylaws for the fire suppression/potable water district.
7. Approach a water system operator regarding operations of the potential water system.

ESTIMATED COST PER TASK

Part	Description	Wright-Pierce	Subcontractor
A. GEOPHYSICAL INVESTIGATION AND BEDROCK WELL DEVELOPMENT			
1	GEOPHYSICAL ANALYSIS	$5,000	$10,000
2-8	BEDROCK WELL DEVELOPMENT	$20,000	$90,000
9	NHDES MEETINGS	$5,000	
	SUBTOTAL	$130,000	
B. WATER DISTRIBUTION SYSTEM DEVELOPMENT			
1	RT 108 LEDGE PROBES	$2,000	$6,000
2	STORAGE TANK BORINGS	$2,000	$8,000
	SUBTOTAL	$18,000	
TOTAL COST		$148,000	

2012 Project Activities

We anticipate the following project activities occurring in 2012:

1. If the bedrock well water chemistry proves acceptable, proceed with NHDES and Town of Stratham permitting requirements.
2. Design a water treatment facility to treat potable water to appropriate levels. Develop construction documents including plans, specifications and construction cost estimates, and potentially bid this project.

3. Design the water main within the Commercial District. Conduct a site survey of the project area. Develop construction documents including plans, specifications and construction cost estimates and potentially bid this project.

4. Design the ground level storage tank. Conduct a site survey of the tank site. Develop construction documents including plans, specifications and construction cost estimates. Develop construction documents including plans, specifications and construction cost estimates and potentially bid this project.

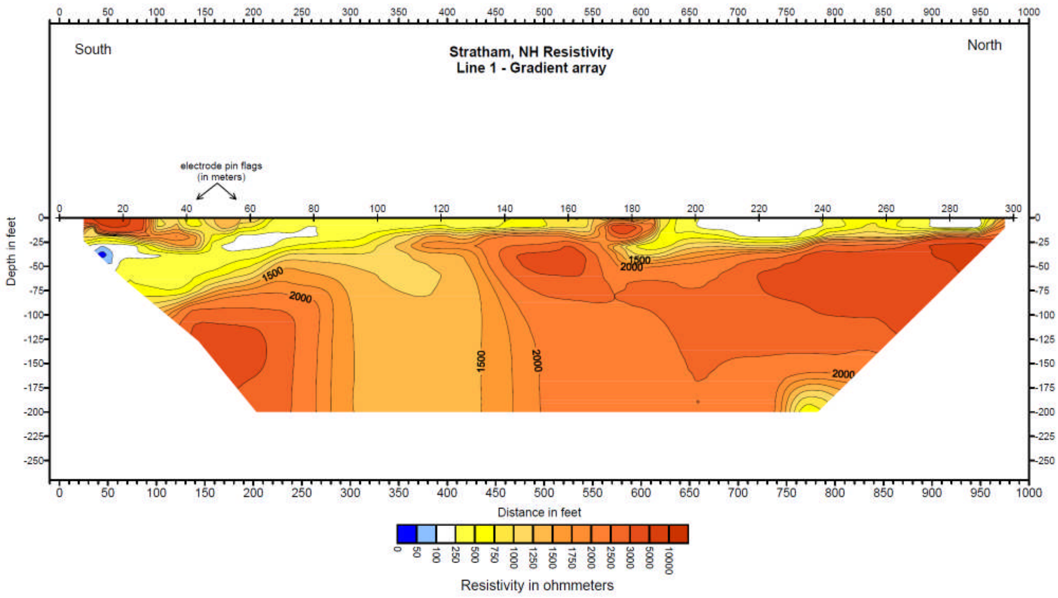
REPORT

Photolineament and Geophysical Analyses To Evaluate the Bedrock Water Supply Potential For the Scamman and Goodrich Sites

Photolineament and Geophysical Analyses to Evaluate the Bedrock Water Supply Potential for the Scamman and Goodrich Sites

Stratham, New Hampshire

December 4, 2010



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PHOTOLINEAMENT AND GEOPHYSICAL ANALYSES TO EVALUATE THE BEDROCK WATER SUPPLY POTENTIAL FOR THE SCAMMAN AND GOODRICH SITE

STRATHAM, NEW HAMPSHIRE

DECEMBER 4, 2010

Prepared By:

Wright-Pierce
230 Commerce Way, Suite 302
Portsmouth, NH 03801

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APPENDIX

LINEAMENT AND GEOPHYSICAL INVESTIGATION

SCAMMAN AND GOODRICH SITES

1.0 INTRODUCTION

At the request of the Town of Stratham, Wright-Pierce has conducted a hydrogeological investigation concerning the potential development of bedrock ground water supplies for Scamman and Goodrich Sites. The site locations are shown on Figures 1 and 2 in Appendix A. The Town presently obtains the majority of its drinking water from individual private and small community wells.

Our work has included an evaluation of existing geologic reports and maps, glacial geomorphology, structural and bedrock geology, a photo-lineament bedrock and geophysical ground water analysis. Our report, including findings, recommendations and conclusions, is presented hereinafter.

1.1 Ground Water Development in Fractured Bedrock Aquifers

The fact that bedrock aquifers may be a source for high yielding wells has been known for sometime. However, only recently, through technological advances, have the tools become available to consistently and accurately direct geologists to the proper locations.

The complexity of a region's geology is a determining factor in the success of employing existing technologies to locate water. The geologic approach, applied in this study by Wright-Pierce, incorporates remote-sensing interpretation, geologic analysis, and field techniques, which were developed for the glaciated Northeast region, one of the most complex geologic terrains in the world.

2.0 PHOTO-LINEAMENT ANALYSIS

The following methodology involving photo-lineament mapping was utilized in this study for locating potential onsite water well locations, which are associated with zones of structural weakness in the earth's crust. Areas of fracture concentration in the underlying bedrock control these zones. The fractures are actually breaks in the bedrock that are clustered in zones five to 100 feet in width and several thousand feet (fracture traces) to more than a mile (lineaments) in length. The fractures are believed to be nearly perpendicular and extend to a depth of at least 500 feet beneath the site. Each fracture zone may contain one, to as many as 200 separate fractures or cracks, and there may be five or ten fractures or zones of fractures in any 100-acre area.

2.1 Interpretation- The hydrogeologist studies black and white or color aerial photographs for clues as to the presence of fracture zones underneath the soil. Due to an unexplained phenomena, the bedrock fracturing manifests itself on the earth's surface in the form of natural straight to curvi-linear stress relief features consisting of light or dark tonal variations in soils, alignment of vegetative patterns, straight stream segments or valleys, aligned depressions, gaps in ridges, or other features showing a linear alignment. In addition, the relative abundance or lack of moisture in the fractures will affect the tree growth diameter and foliage crown. If the water table is deep, the trees growing along the fractures will be healthier due to easier and deeper root penetration. If too much water is available, the roots will be drowned and trees may be stunted or will die along the fracture, forming a linear feature. The soil in recently plowed fields often dries unevenly, leaving a pattern of dark and light areas. The dark areas indicate wetter soil, and this wetter soil often occurs over fracture zones. These features are difficult to distinguish on the ground, but with training, they can be identified from aerial photographs.

The accuracy of photo-lineament mapping depends on the skills of the person performing the mapping. Those with the most experience are the most accurate and can map in terrains where surface clues identifying fractures are extremely subtle.

2.2 Remote-Sensing Data

Analysis and interpretation of remotely sensed data were conducted to identify regional and local bedrock structural lineation. Regional photo-lineament analysis was performed on a near and far range composite scan side looking airborne radar (SLAR) images (scales 1:250,000).

The following remotely sensed data was also utilized:

TABLE 1

TYPE	SCALE	DATE	IDENTIFICATION
High Altitude	1:60,000	1986	NHAP Color Infrared
High Altitude	1:60,000	1986	NHAP
Medium Altitude	1:40,000	1992	NAPP
Medium Altitude	1:20,000	1974	FSA
Low Altitude	1:8,000	2006	
Low Altitude	1:8,000	1988	351-10-13

2.3 Photolineament Delineation- The linear features identified on the remote-sensing data were plotted on Mylar baseline overlays. Collection and analysis of all baseline imagery photography was conducted in composite fashion to identify areas that exhibit characteristics favorable for the occurrence of fractured bedrock aquifers. The photolineaments are delineated on **Figures 1 and 2**. The Scamman site appears to have numerous photolineaments trending through the site. The conservation easement shown on Figure 1 constrains siting of test drilling locations and the 400 foot radius NHDES requires around the well head. On the Goodrich site, the property boundary also constrains siting of test drilling locations.

3.0 GEOPHYSICAL SURVEY

A geophysical study was conducted on both the Scamman and Goodrich sites. The survey utilized two types of geophysical techniques. The first technique, Very Low Frequency (VLF), was performed on the Scamman and Goodrich sites. However, due to budget constraints, the second technique, electrical resistivity, was performed solely on the Goodrich Site. The VLF and electrical resistivity profiles can be found in Appendices B and C accordingly.

The VLF utilizes the WADI instrument manufactured by ABEM. The WADI finds structures where useful quantities of groundwater may exist in fractured bedrock and cavities, thus enabling hydrogeologists to select the most promising sites for drilling.

The WADI utilizes the magnetic components of the electromagnetic field generated by existing radio transmitters that use the VLF band (Very Low Frequency, 15-30 kHz). The predominant photolineaments and associated fracture system trend through the sites in northeast and northwest directions; therefore, two radio transmitters (20 and 24 kHz) located in South Dakota and the U.S. Naval Station in Cutler, Maine were utilized. Northwest trending fractures cannot be detected utilizing the Culter station, so the South Dakota station was utilized for those fracture systems. Fractures filled with groundwater affect the direction and strength of the VLF field generated by the transmitted radio signal. A weak secondary field builds up around the geologic structure. This field is detected and measured in the field by the WADI instrument. The WADI measures the field strength and phase displacement around a fracture zone in the bedrock. In order for induction to occur, the structure must be aligned towards the transmitter.

The VLF surveys began in the northeast corners of the Scamman site and progressed southwestward. On the Goodrich Site, the VLF surveys began in the southeast corners and progressed northwestward. Survey lines were oriented perpendicular to the trending photolineaments. On the Scamman site, a total of 7 lines spaced at variable distances apart were performed. The total length of the survey lines was 11,350 feet. On the Goodrich site, a total of 8 lines spaced at variable distances apart were performed. The total length of the survey lines was 8,850 feet. The location of the survey lines are shown in Figures 1 and 2.

The second geophysical technique utilizing a 2-dimensional electrical resistivity survey was completed totaling 2,000 linear feet on the Goodrich Site. The objective of the resistivity survey was to provide additional data on potential fracture zones detected by the VLF survey. Typically, fracture zones filled with water will have a lower electrical resistivity than the surrounding competent bedrock and will appear as areas of relatively low resistivity. The location of the survey lines are shown on Figure 2. Data acquisition for Lines R-1 and R-3 were good with a root-mean-squared difference (RMSD) between the modeled and actual measurements of less than 4%. An RMSD of less than 10% is considered a good match.

4.0 RESULTS

The VLF surveys show multiple potential drill targets on the Scamman and Goodrich sites. The resistivity models for Line R-1 and R-2 on the Goodrich site show zones of low resistivity that penetrate through the model. The low resistivity zones correlate very well where the VLF data shows anomalies on lines L-12 and L-14. Also, several promising locations were identified north of the Goodrich site. Due to dense wetland vegetation and water, the VLF survey could not be performed within the northern portion of the Goodrich site. Potential drill locations are shown on Figures 1 and 2. However, electrical resistivity should be performed on the Scamman site to fine tune the test drilling locations. Since the Scamman site is significantly larger than the Goodrich Site, we would recommend 2 to 3 days of electrical resistivity survey.

5.0 RECOMMENDATIONS

The completion of the hydrogeologic photo-lineament and geophysical surveys analyses has resulted in the selection of priority drilling sites on Figures 1 and 2. Following additional electrical resistivity survey on the Scamman site and access considerations for drilling equipment, locations and ranking of the sites may change slightly.

We recommend commencing in the following sequence:

1. Perform electrical resistivity surveys on the Scamman site. Consideration should be given to evaluating the area to the north and northeast of the Goodrich site, as well as other areas located in the Mill Brook watershed east of Route 108.
2. Obtain permission to perform a field inspection and drill test wells on either or both the Goodrich and Scamman sites.
3. Utilizing the aerial photography and geophysical data, locate and stake potential drill sites.
4. Determine site accessibility and land-use constraints for a 36-ton air-hammer rotary-drilling rig.

5. Provide drill specifications and select a qualified drilling company having equipment capable of drilling in highly fractured water bearing bedrock.
6. Utilizing the air-hammer rotary drilling method, drill 6.5-inch diameter test wells to a maximum depth of 600 feet below land surface.
7. Provide limited on-site hydrogeologic drill supervision, well logging of fracture depths and aperture and, airlift yield estimates.
8. If suitable airlift yields are obtained, perform a short duration pumping test and analyze for select water chemistry parameters.
9. If the water chemistry proves acceptable, proceed with NHDES and Town of Stratham permitting requirements.
10. Drill production wells and perform pumping tests and water quality sampling.

Appendix A

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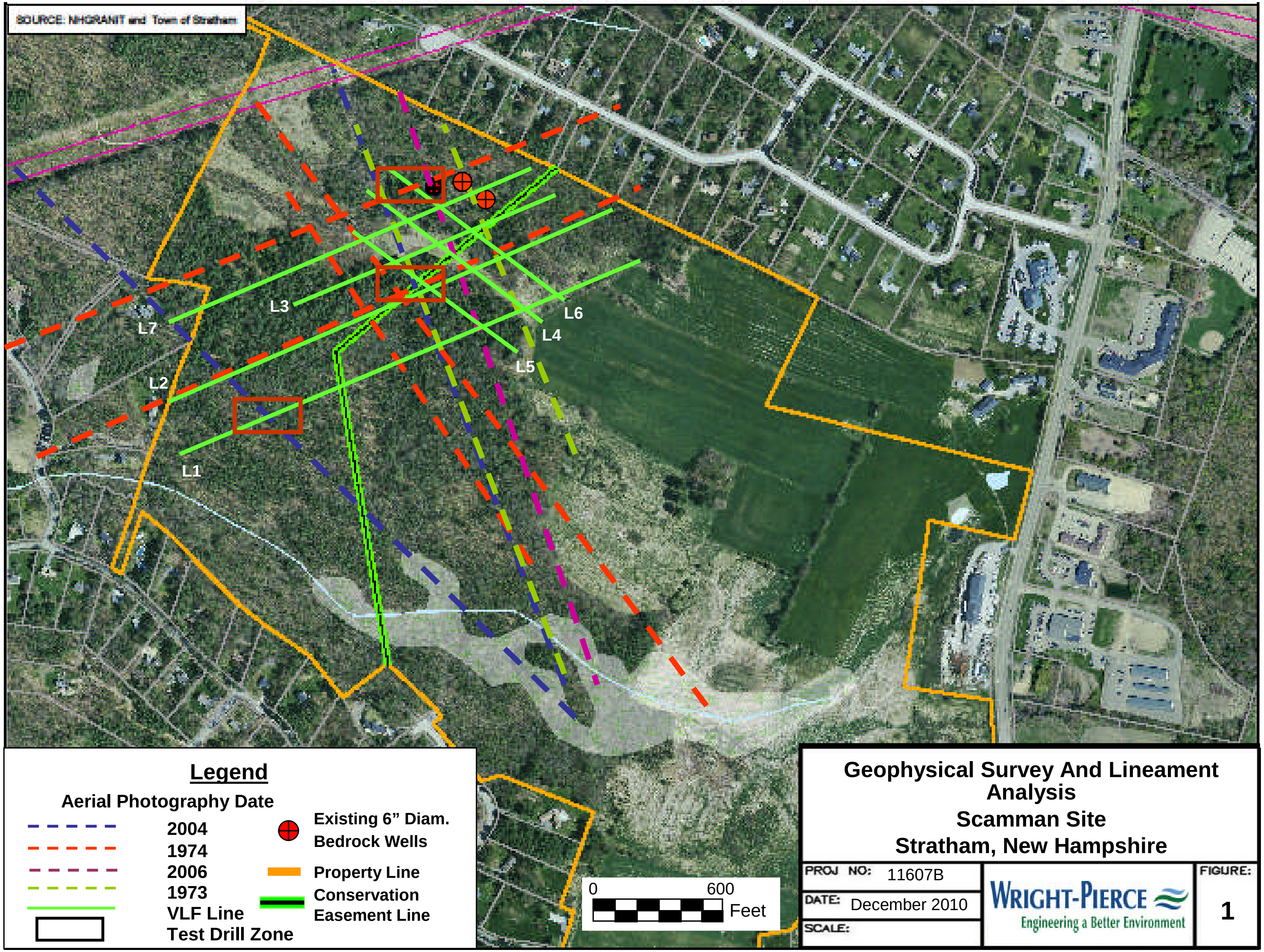

Geophysical Survey And Lineament Analysis
Scamman Site
Stratham, New Hampshire

PROJ NO:	11607B
DATE:	December 2010
SCALE:	

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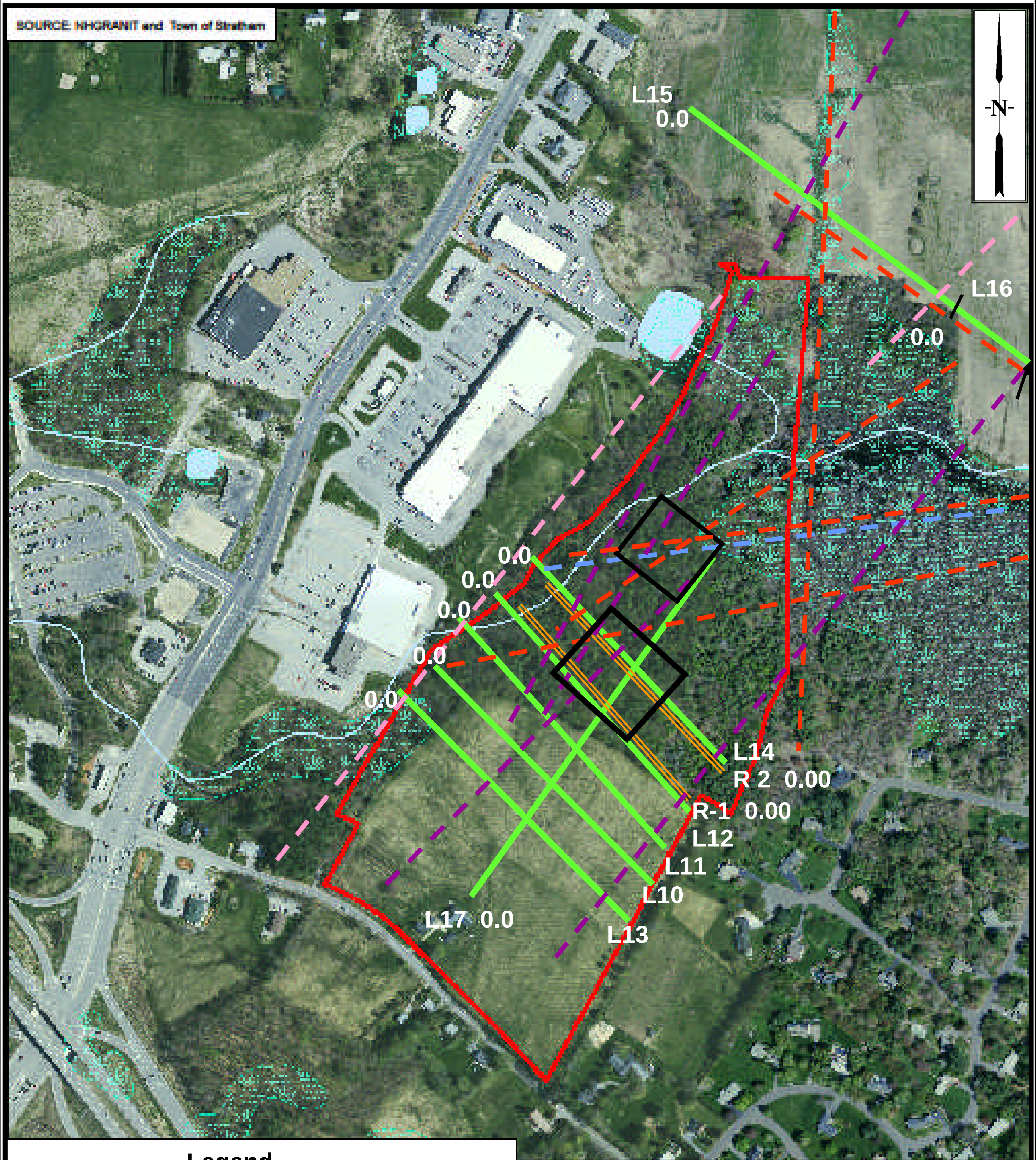
FIGURE: 1



Legend

Aerial Photography Date

- 1986 CIR
- 1986
- 2006
- 1974
- Electrical Resistivity
- VLF Line
- Test Drill Zone
- Property Line

0 500 Feet

Geophysical Survey And Lineament Analysis

Conservation Site

Stratham, New Hampshire

PROJ NO: 11607B

DATE: December 2010

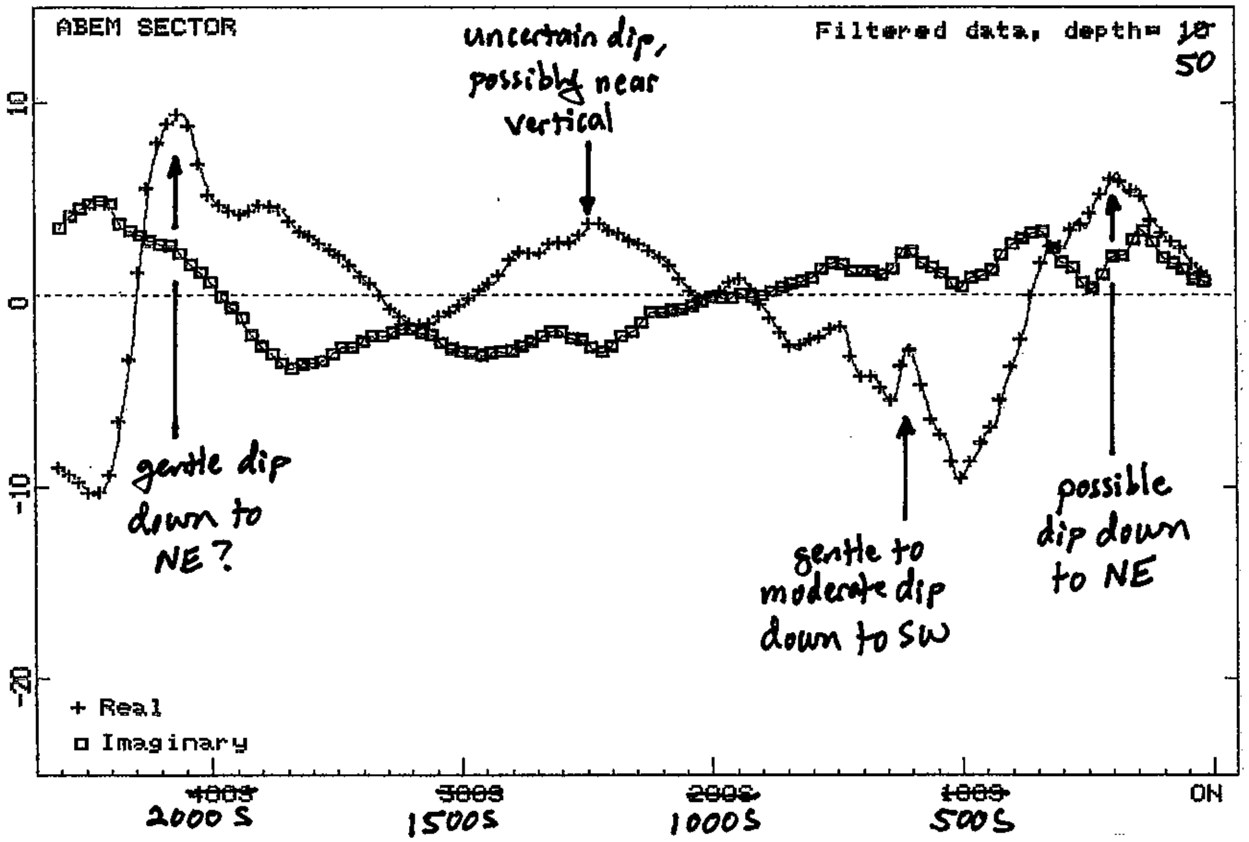
SCALE:

WRIGHT-PIERCE Engineering a Better Environment

FIGURE: 2

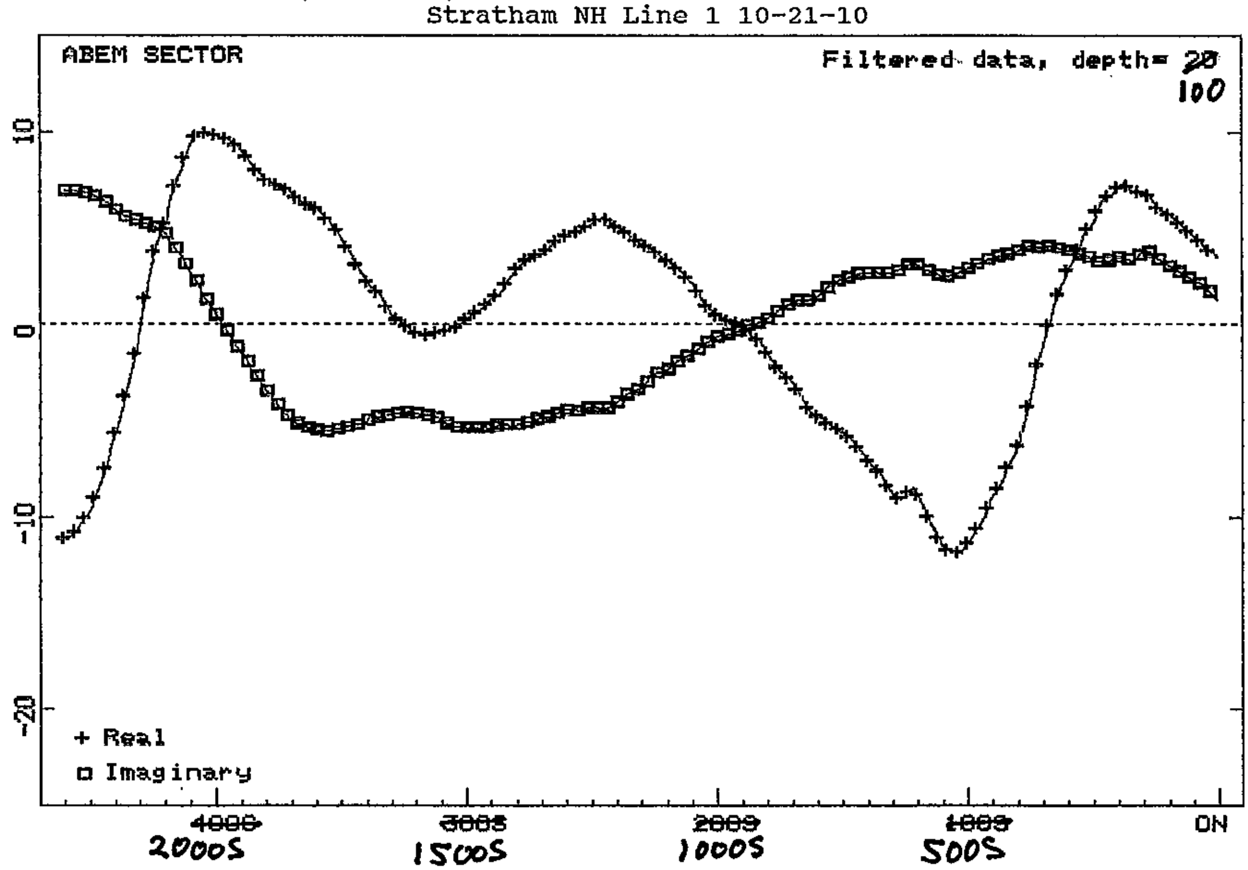
Appendix B

Profile: 0001E (25.2 kHz)
Stratham NH Line 1 10-21-10



SW NE

Profile: 0001E (25.2 kHz)
Stratham NH Line 1 10-21-10



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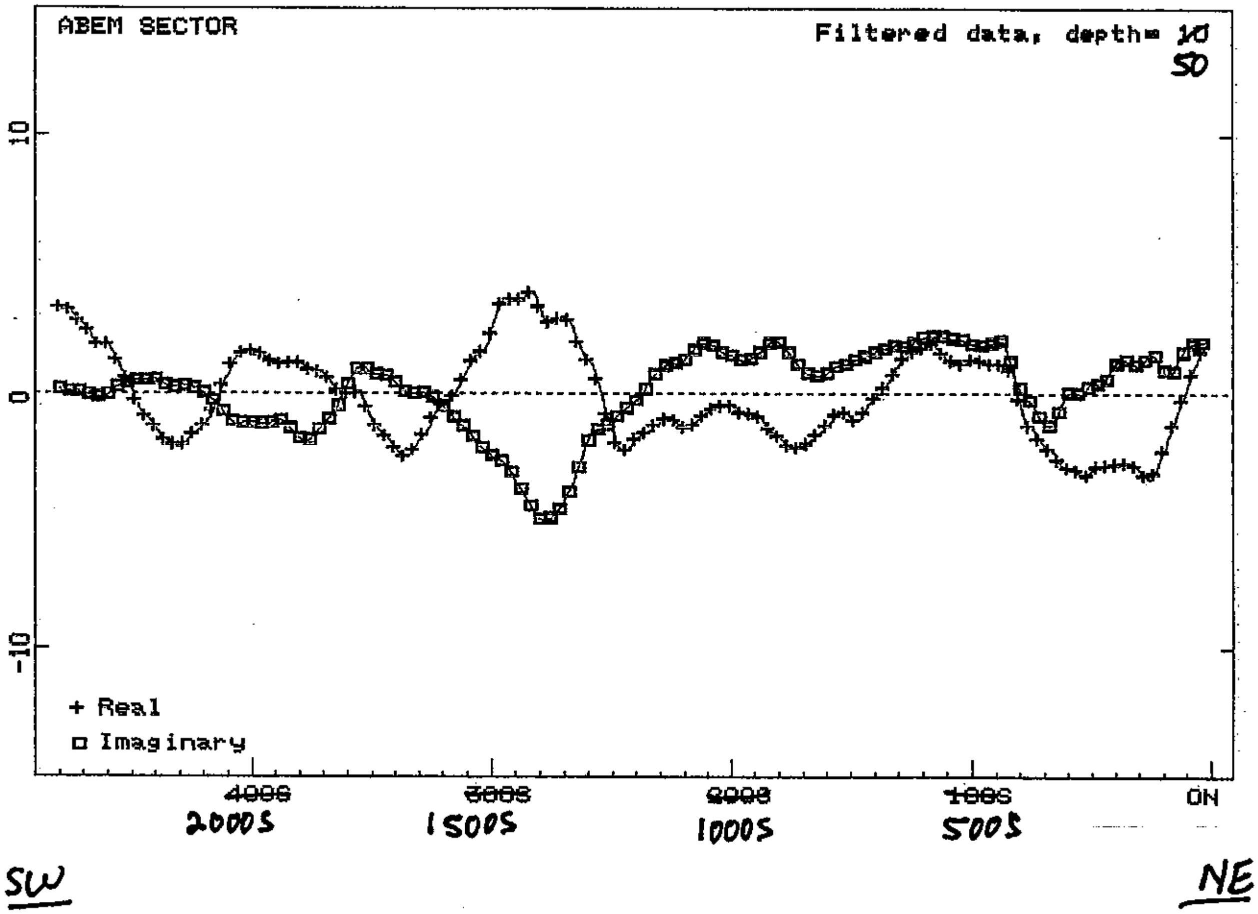

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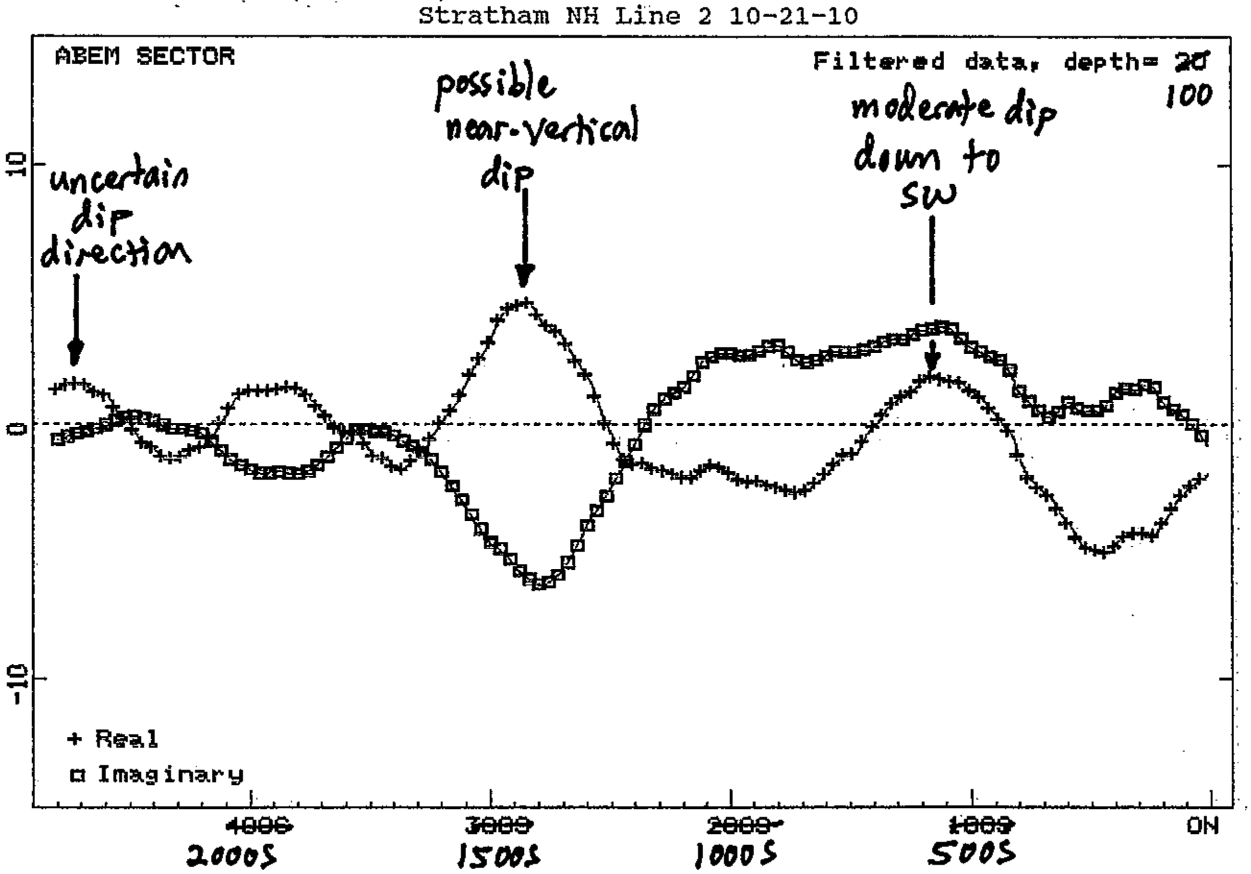

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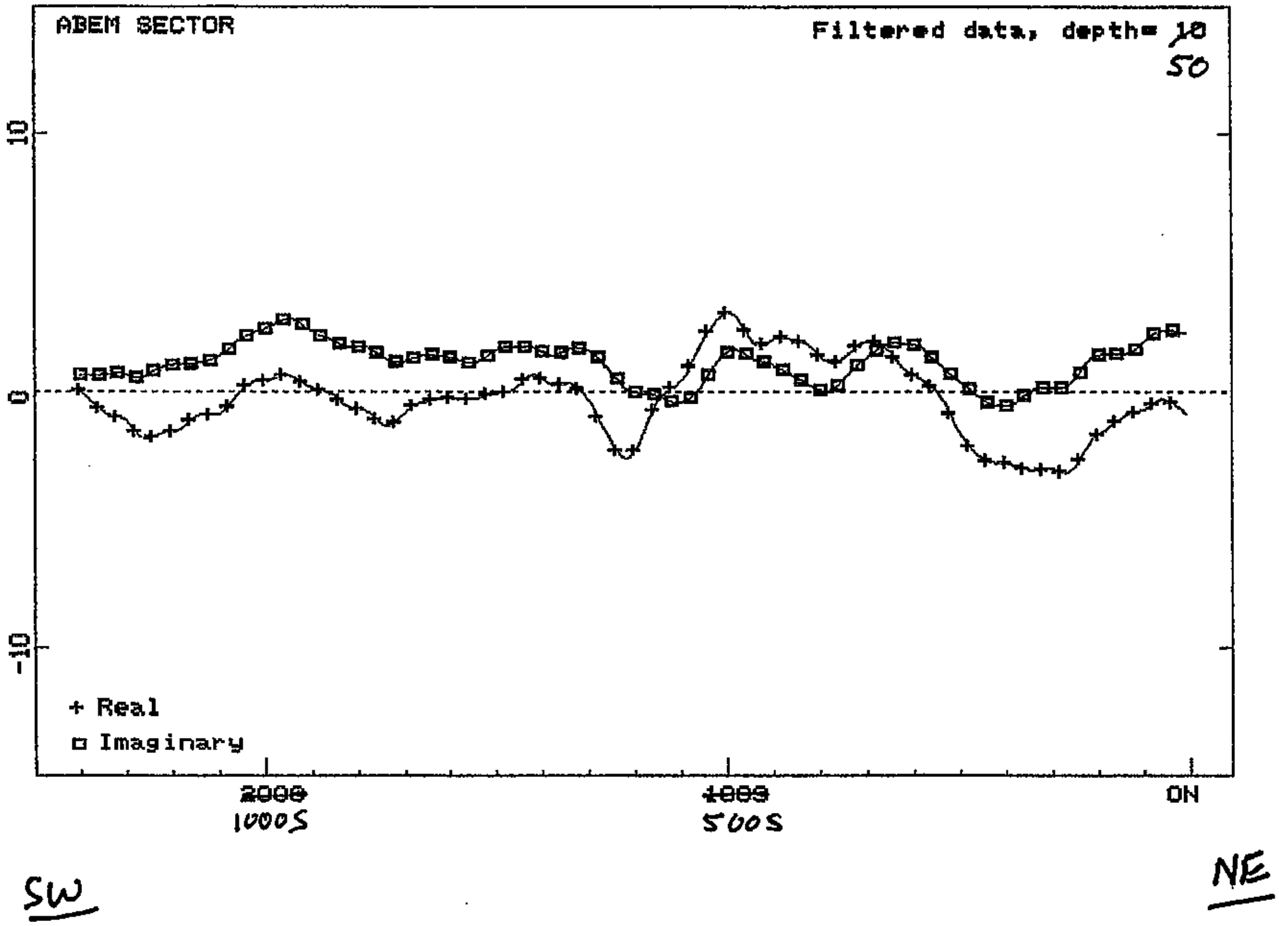
Stratham NH Scamman Line 3



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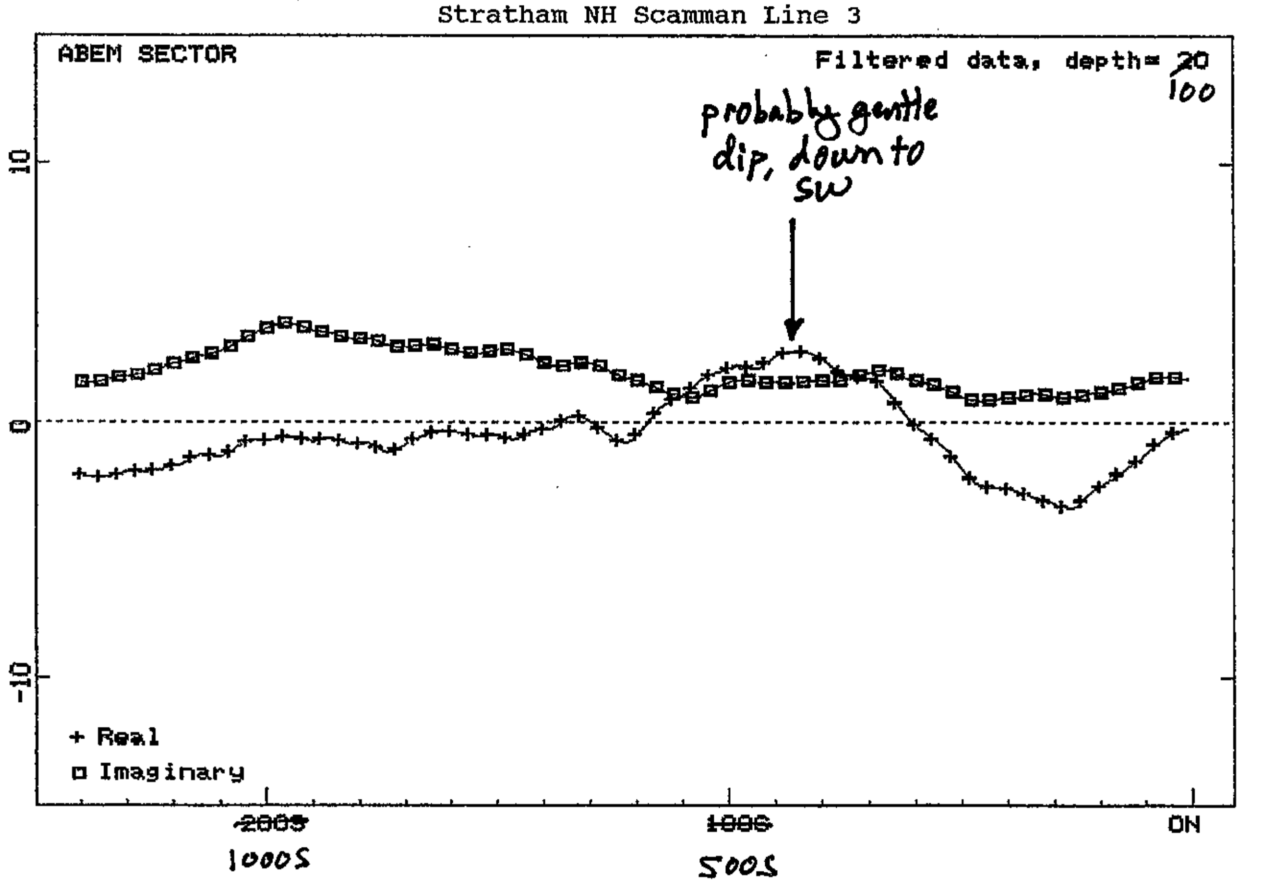
Stratham NH Scamman Line 3



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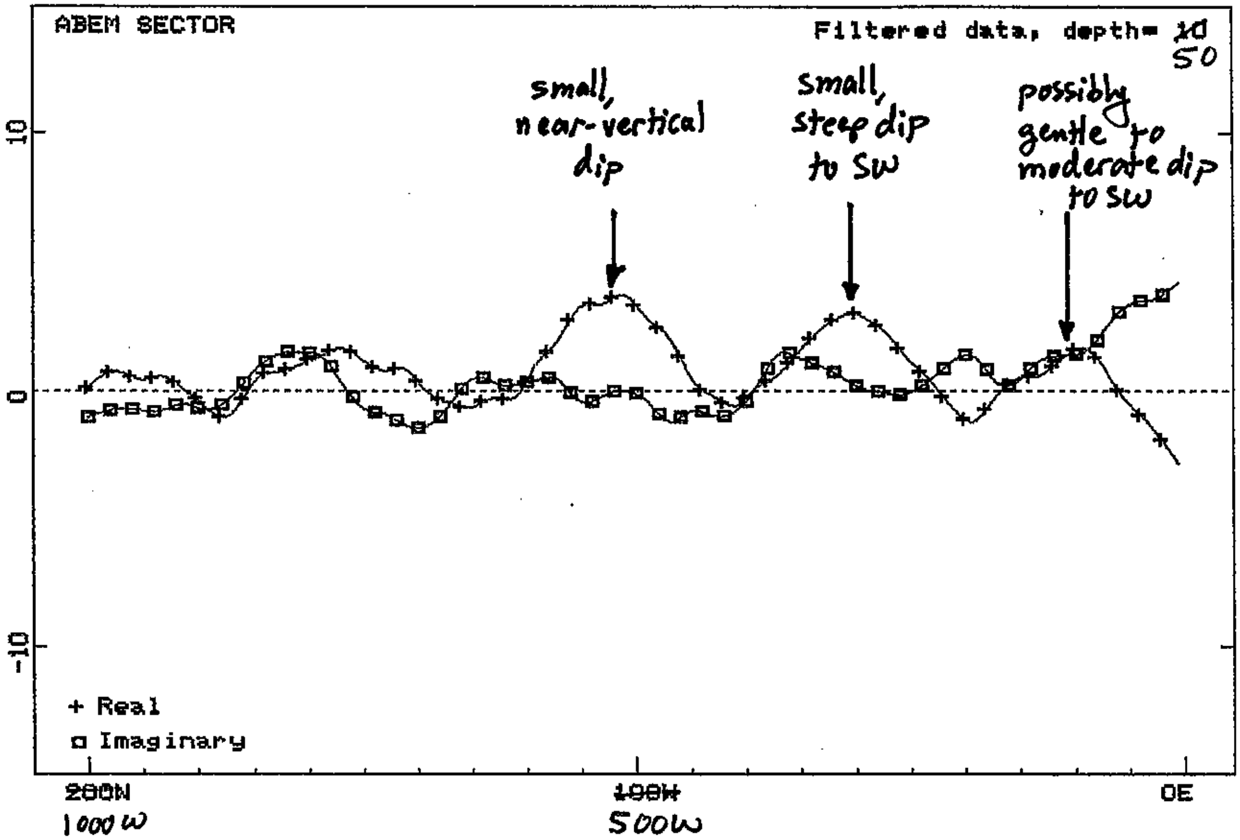

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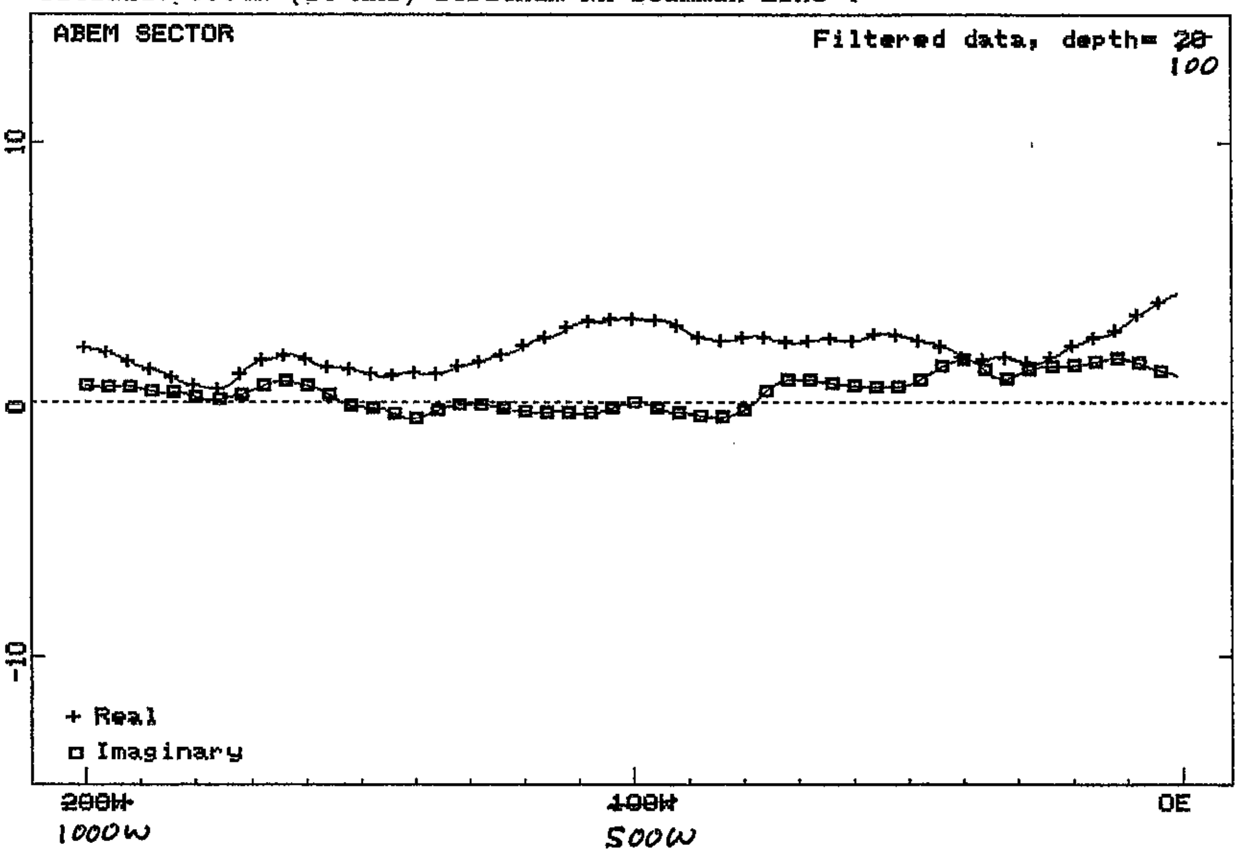

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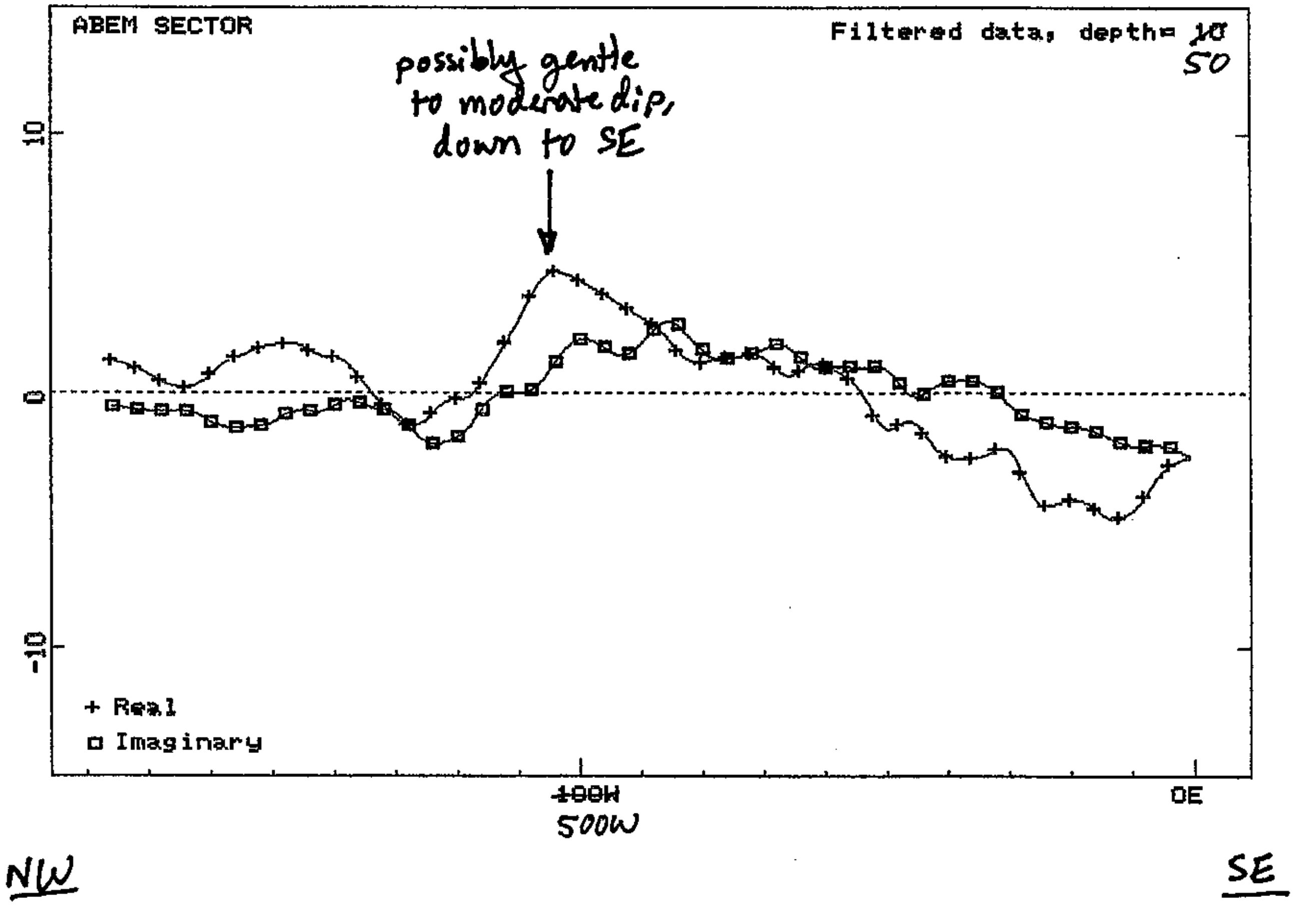

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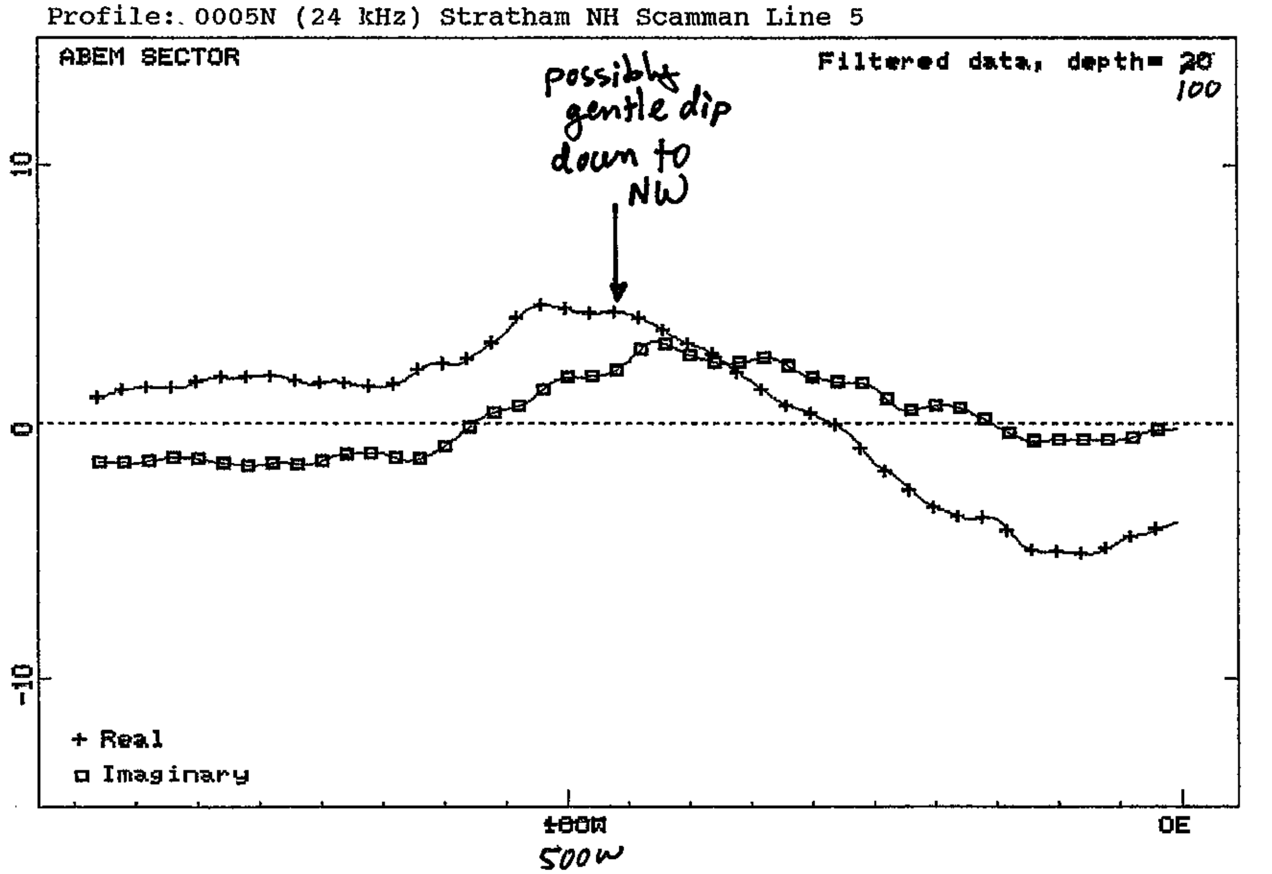

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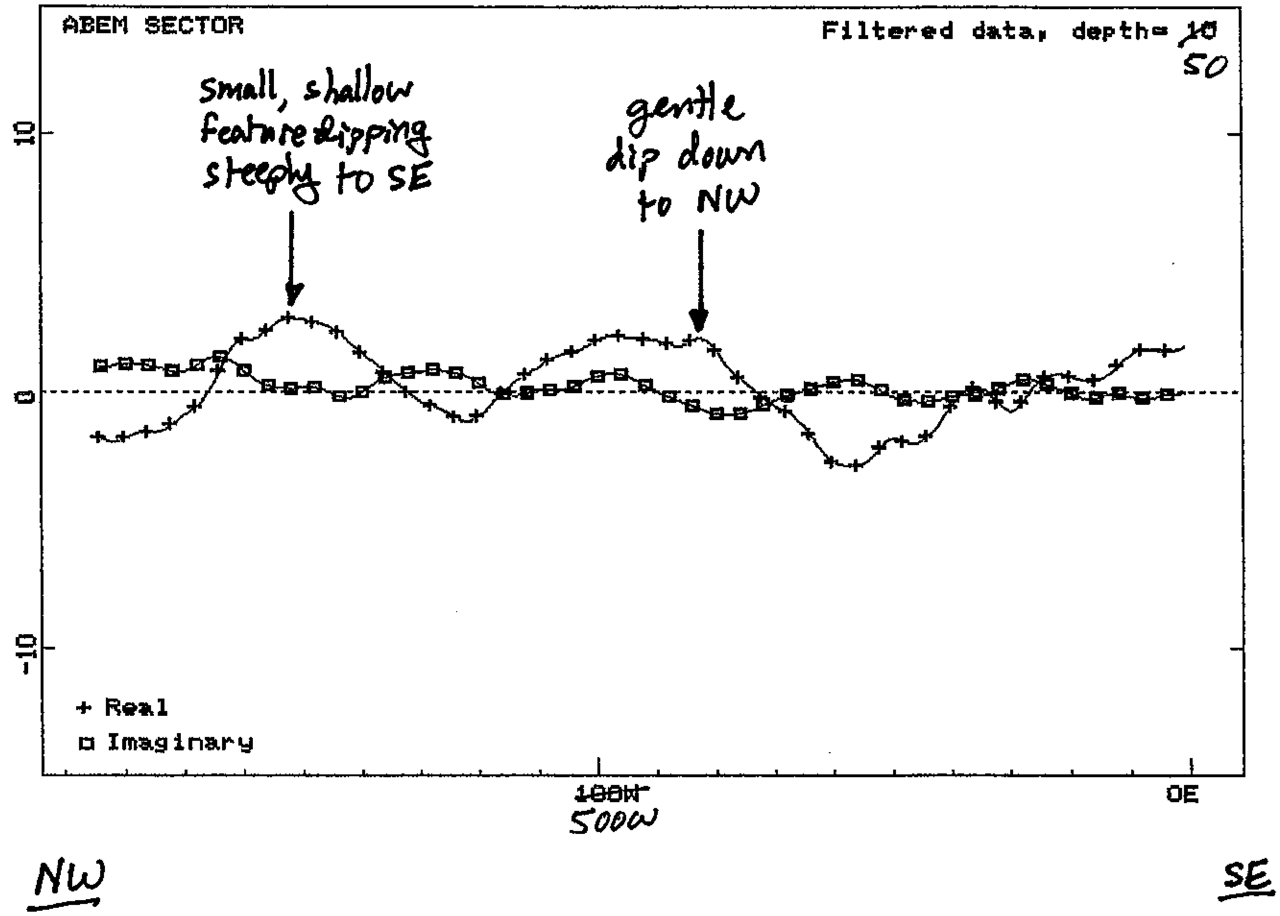

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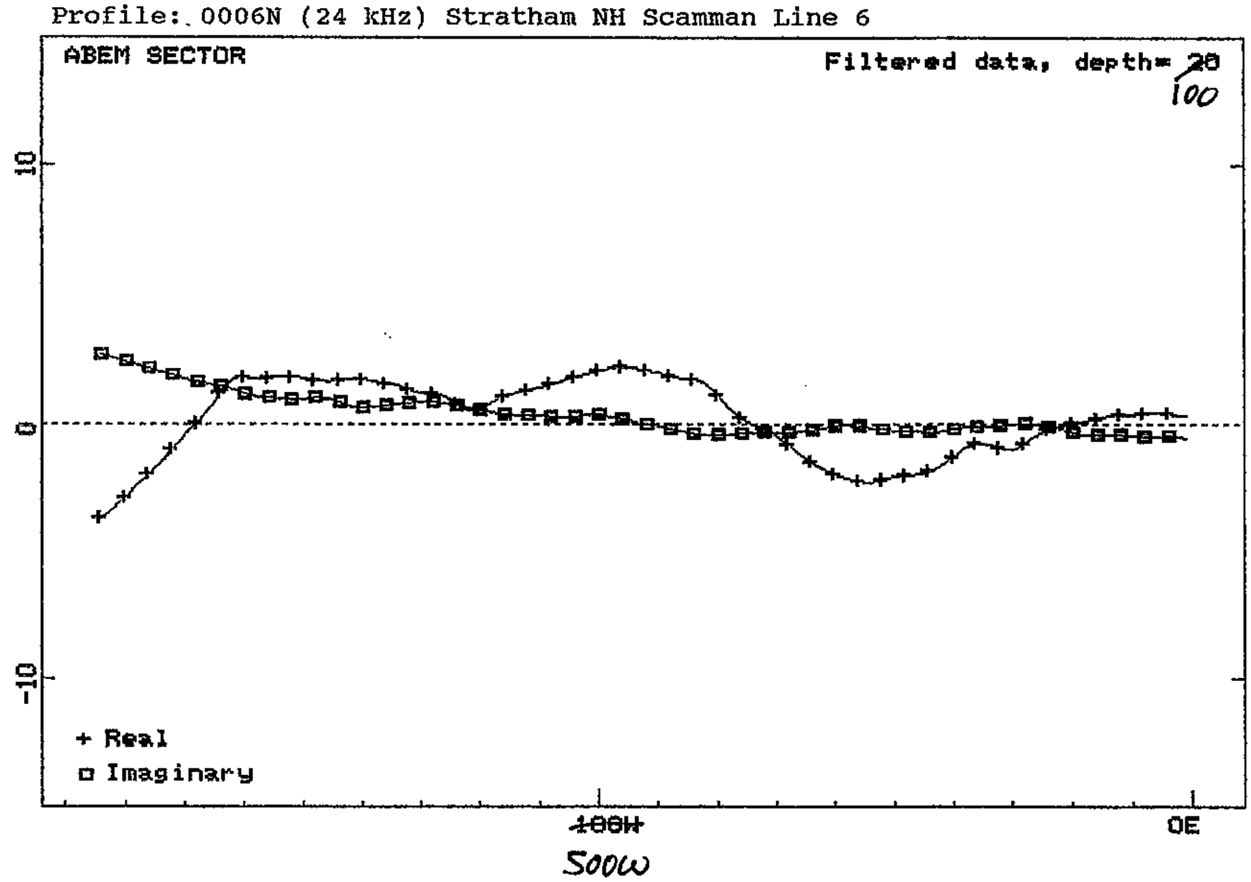

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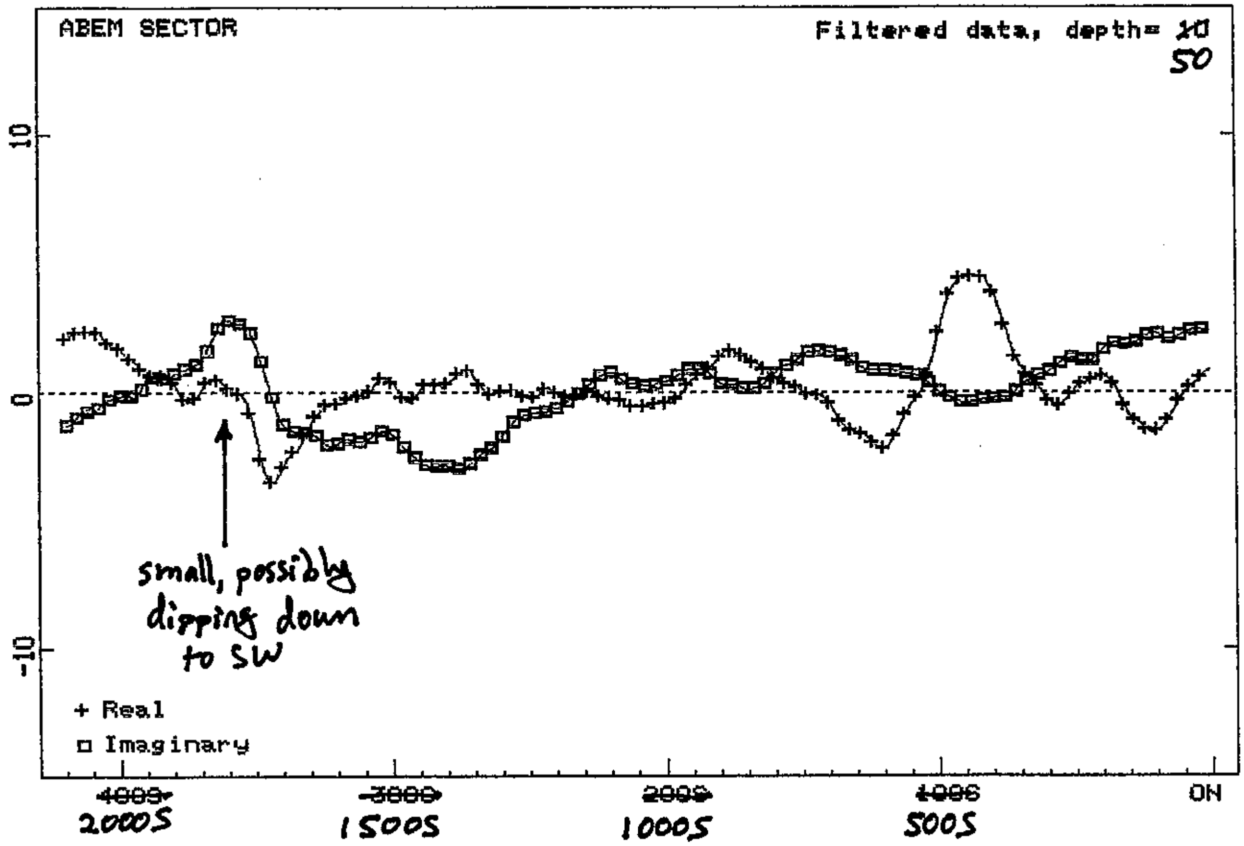
Stratham NH Line 7 10-21-10



SW NE

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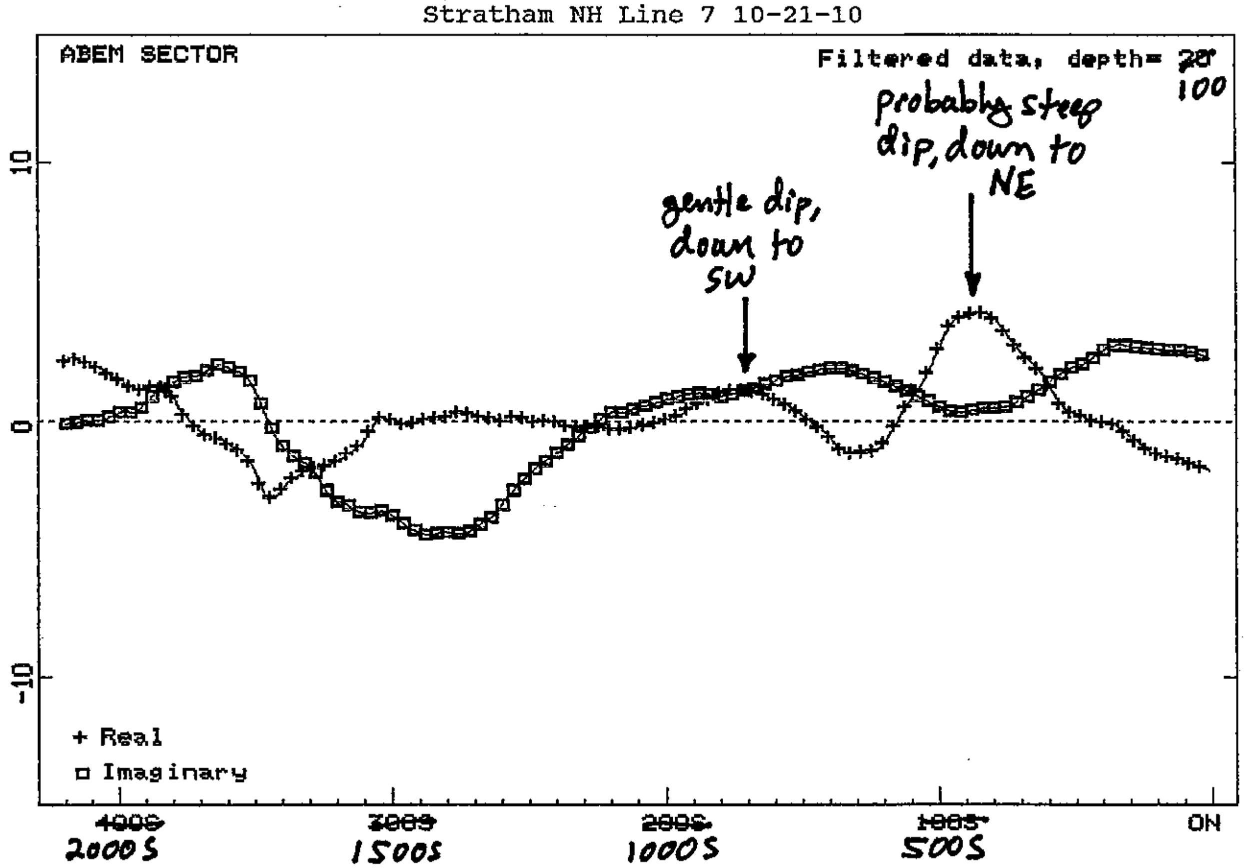
Stratham NH Line 7 10-21-10



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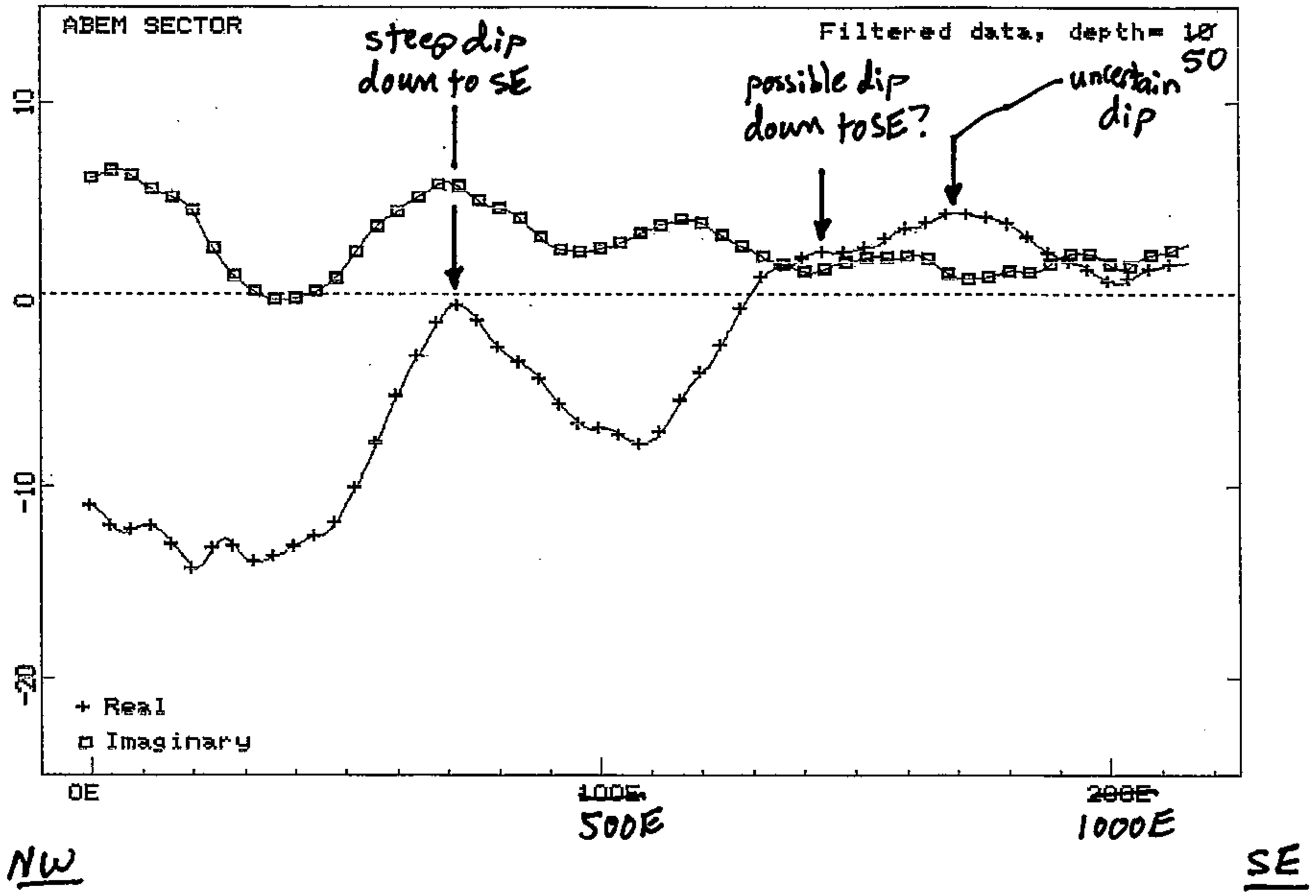

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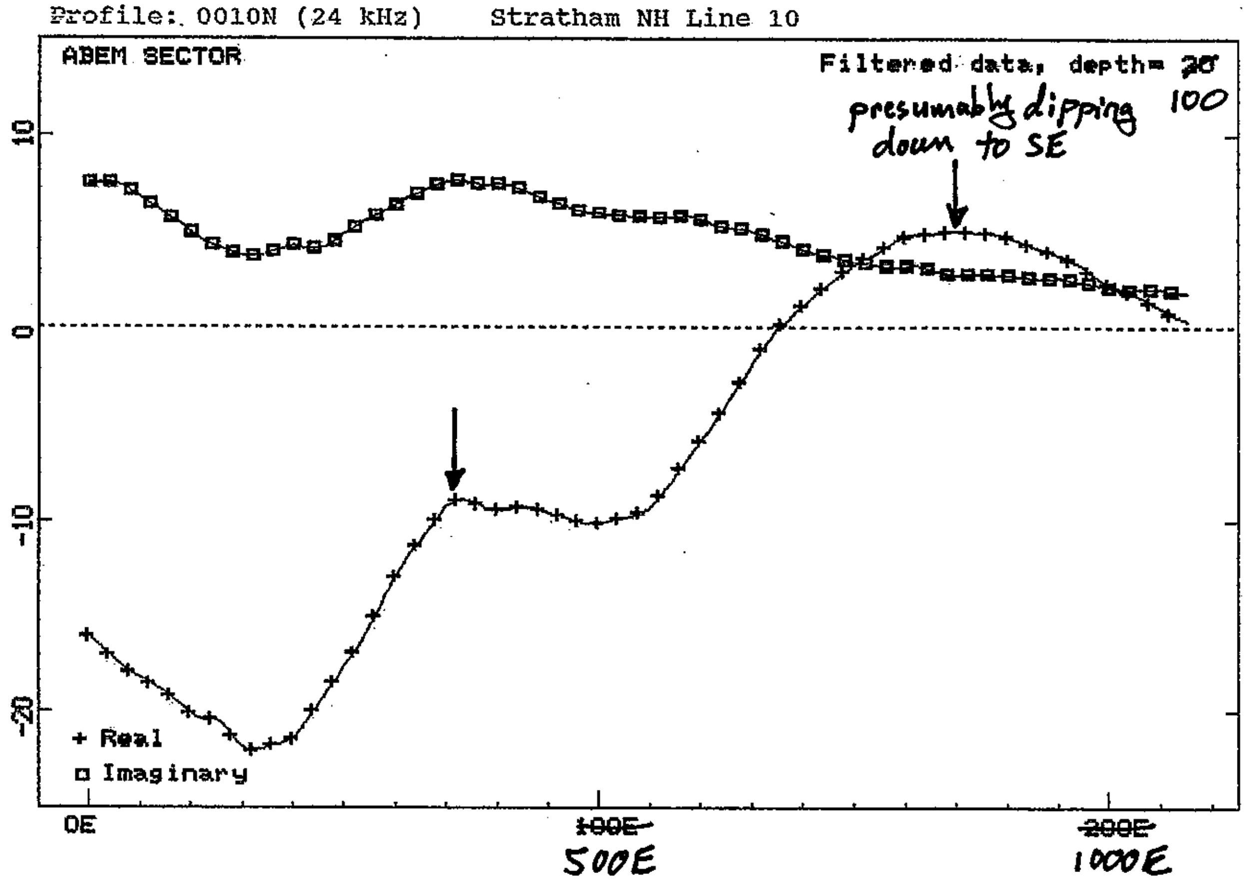

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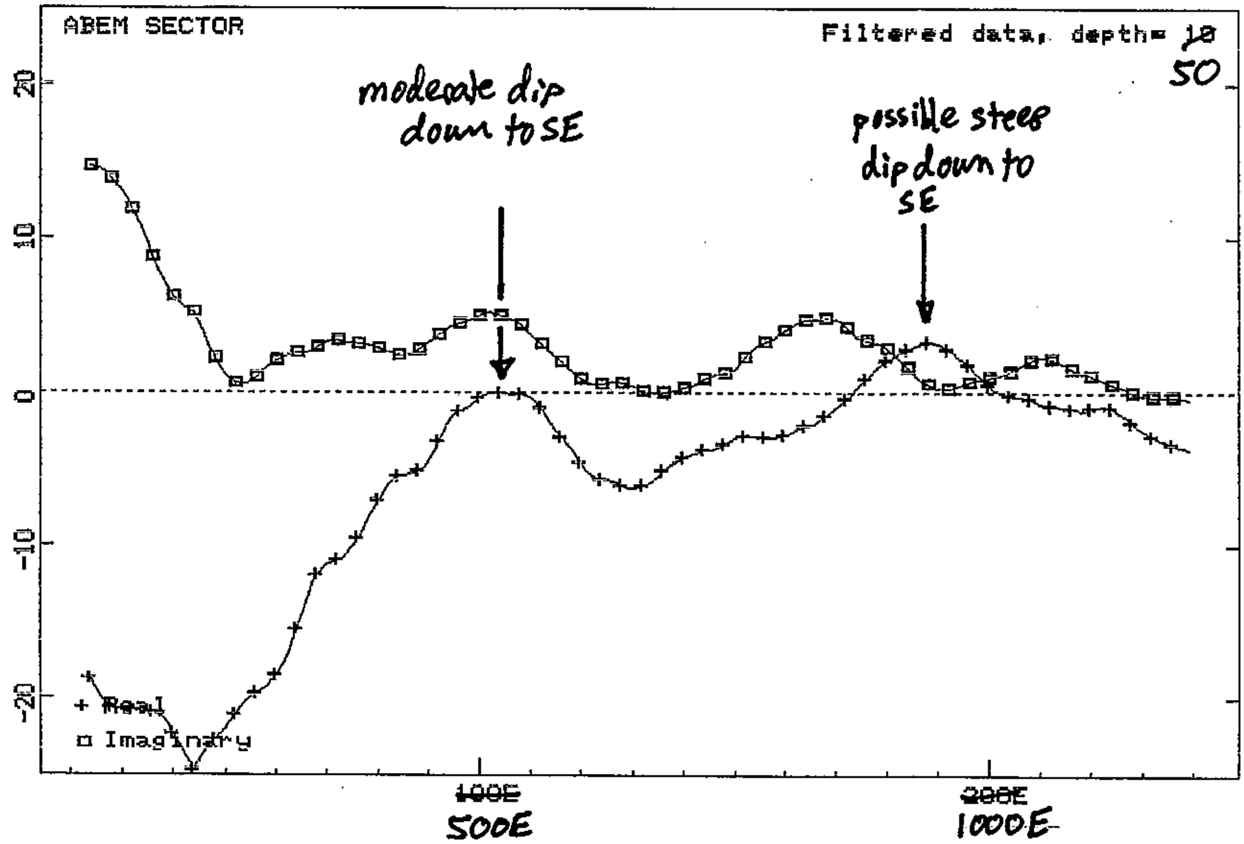
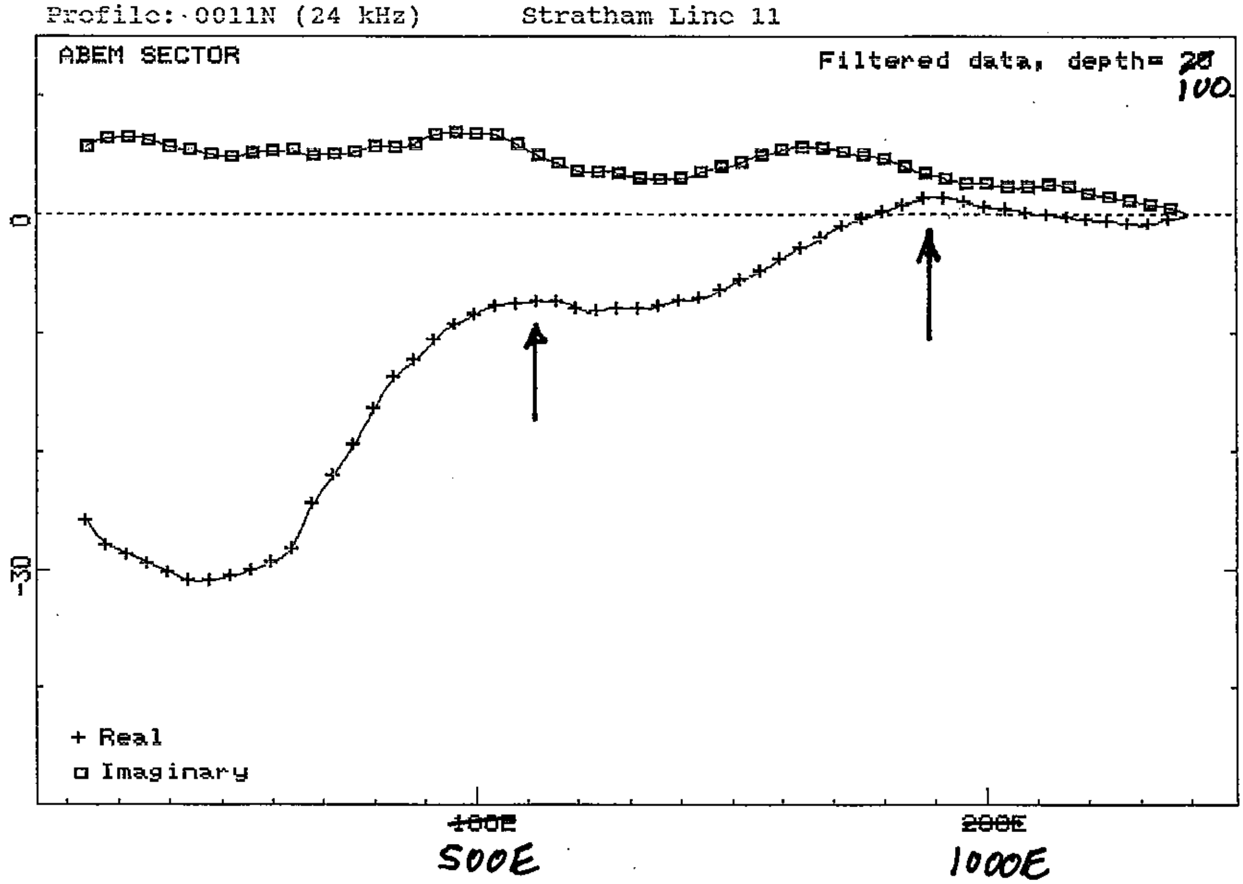


NW SE

Profile: 0011N (24 kHz) Stratham Line 11



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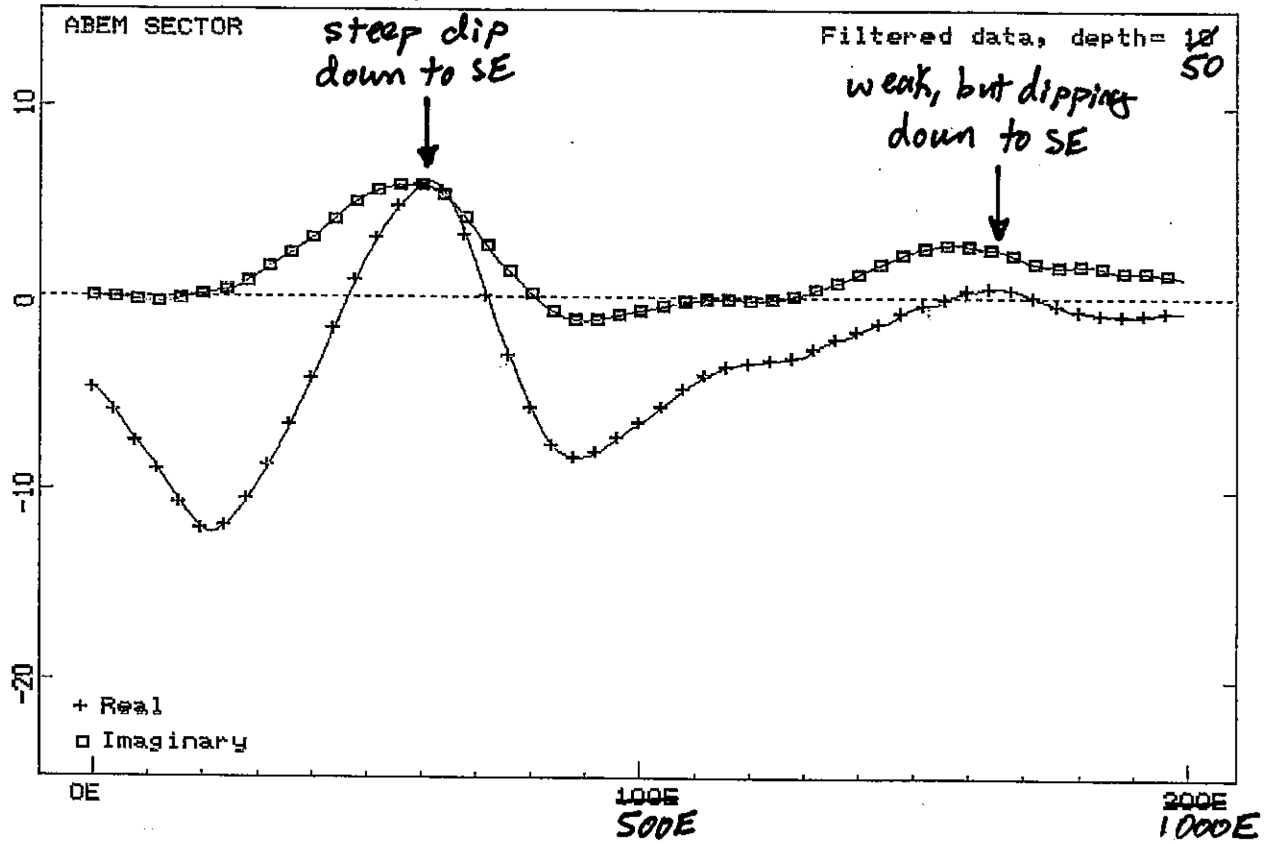

NW

SE

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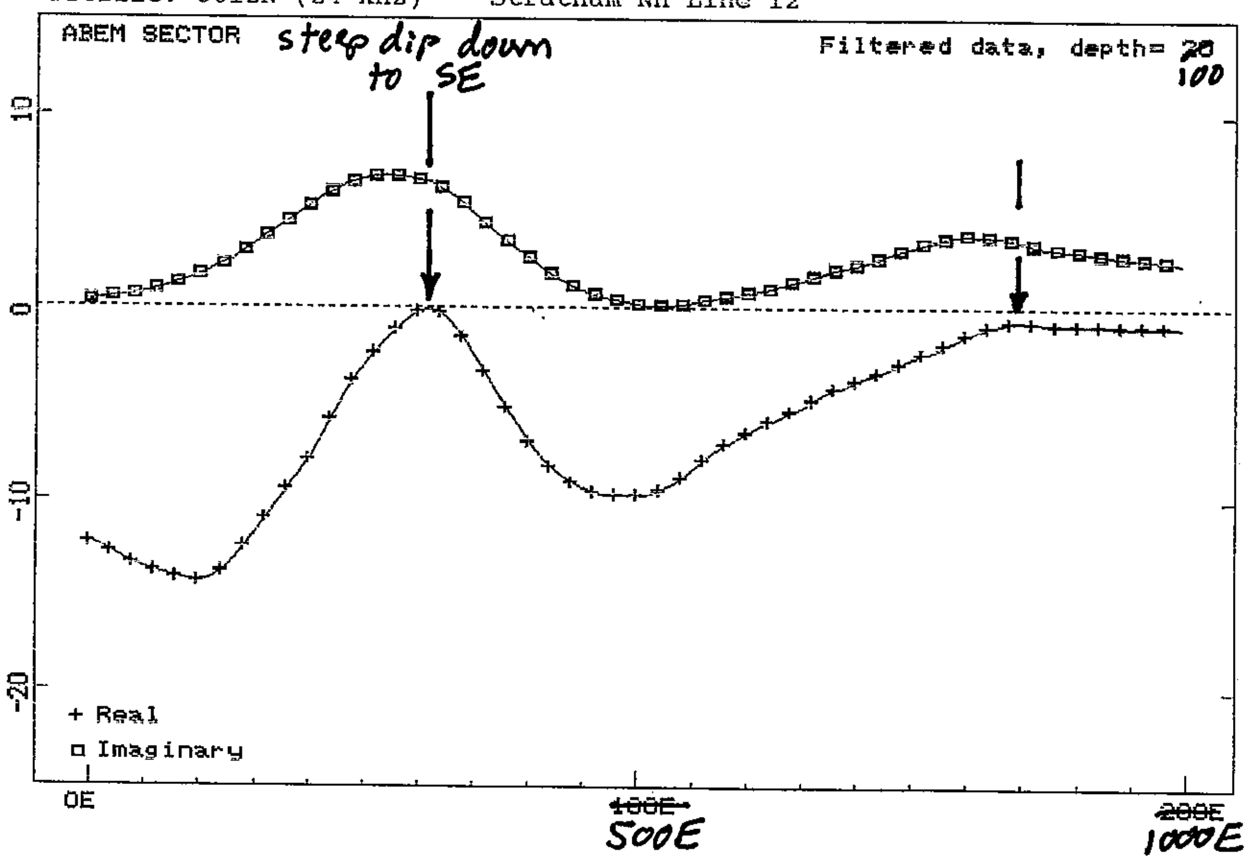
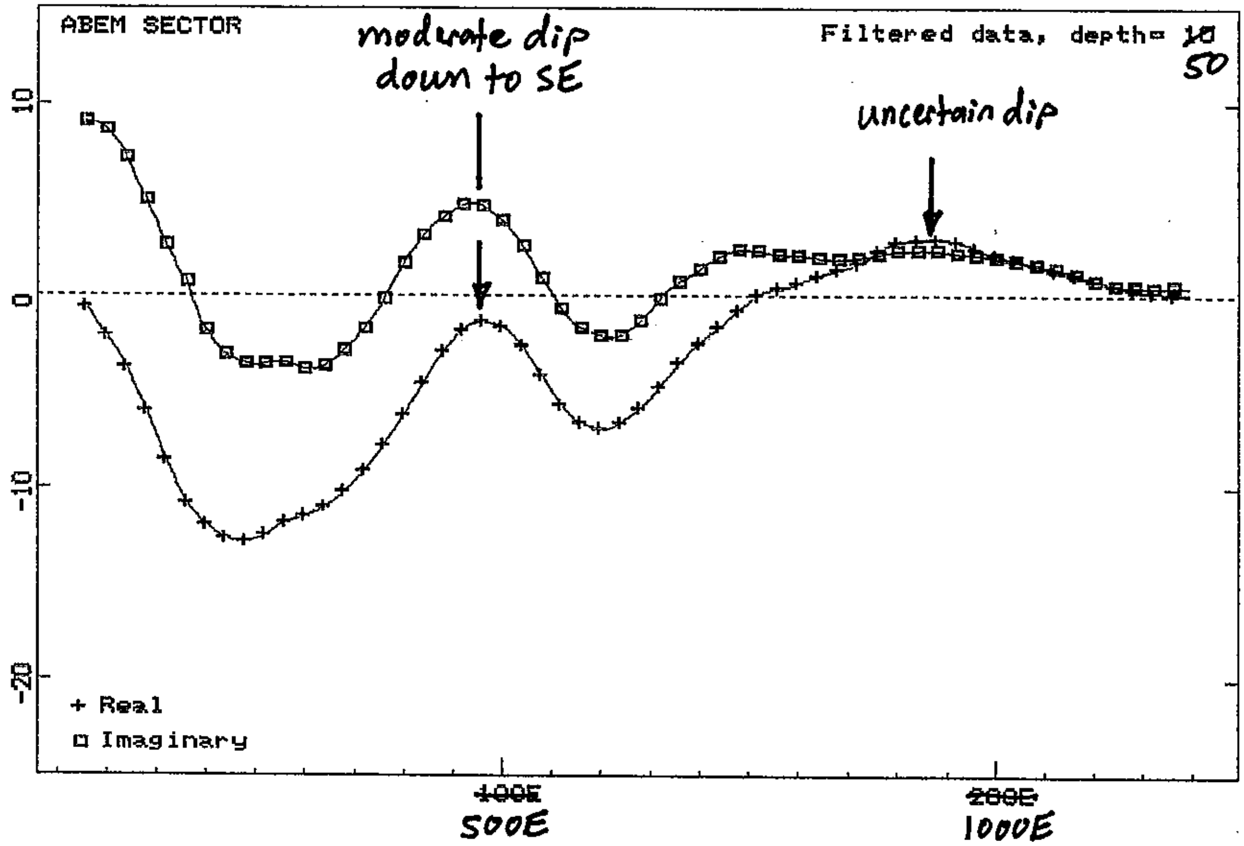


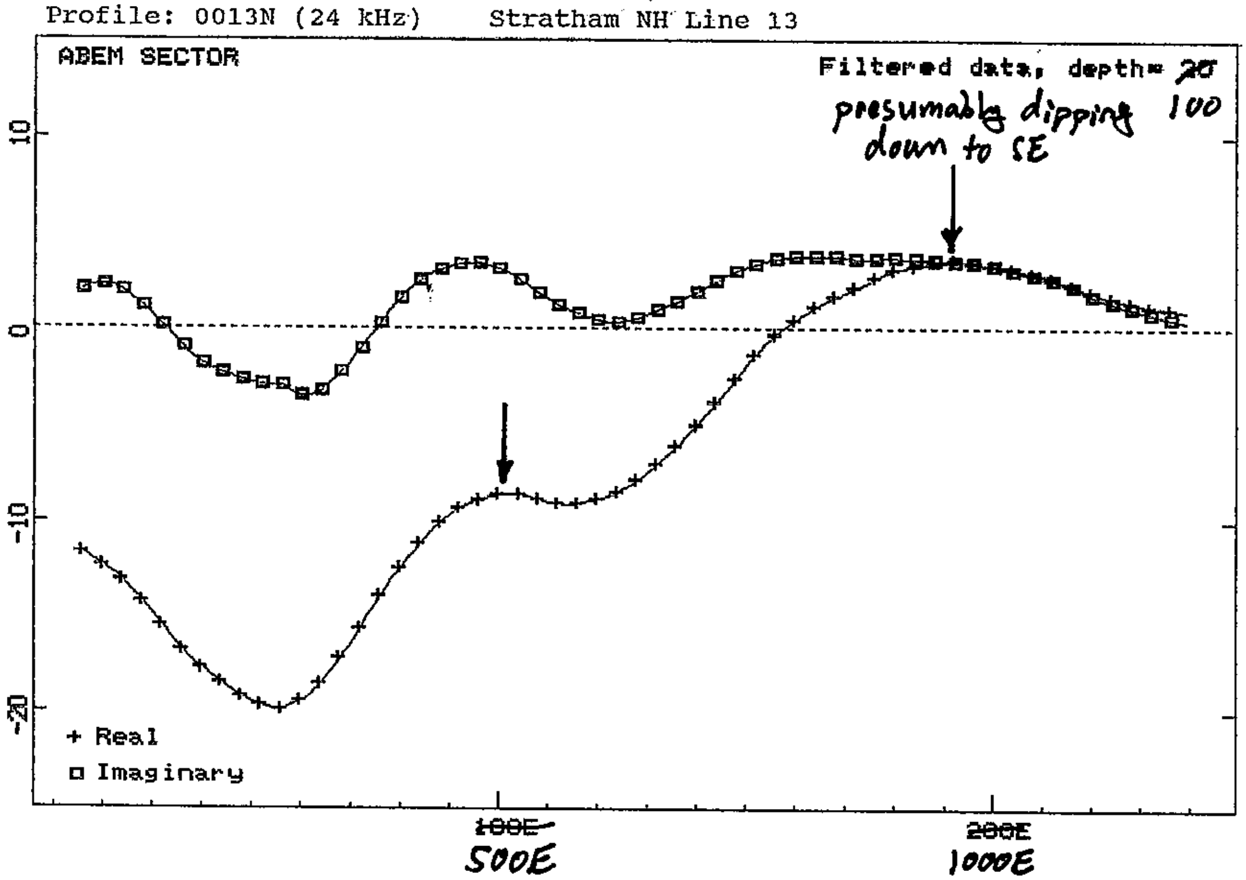
Profile: 0013N (24 kHz) Stratham NH Line 13



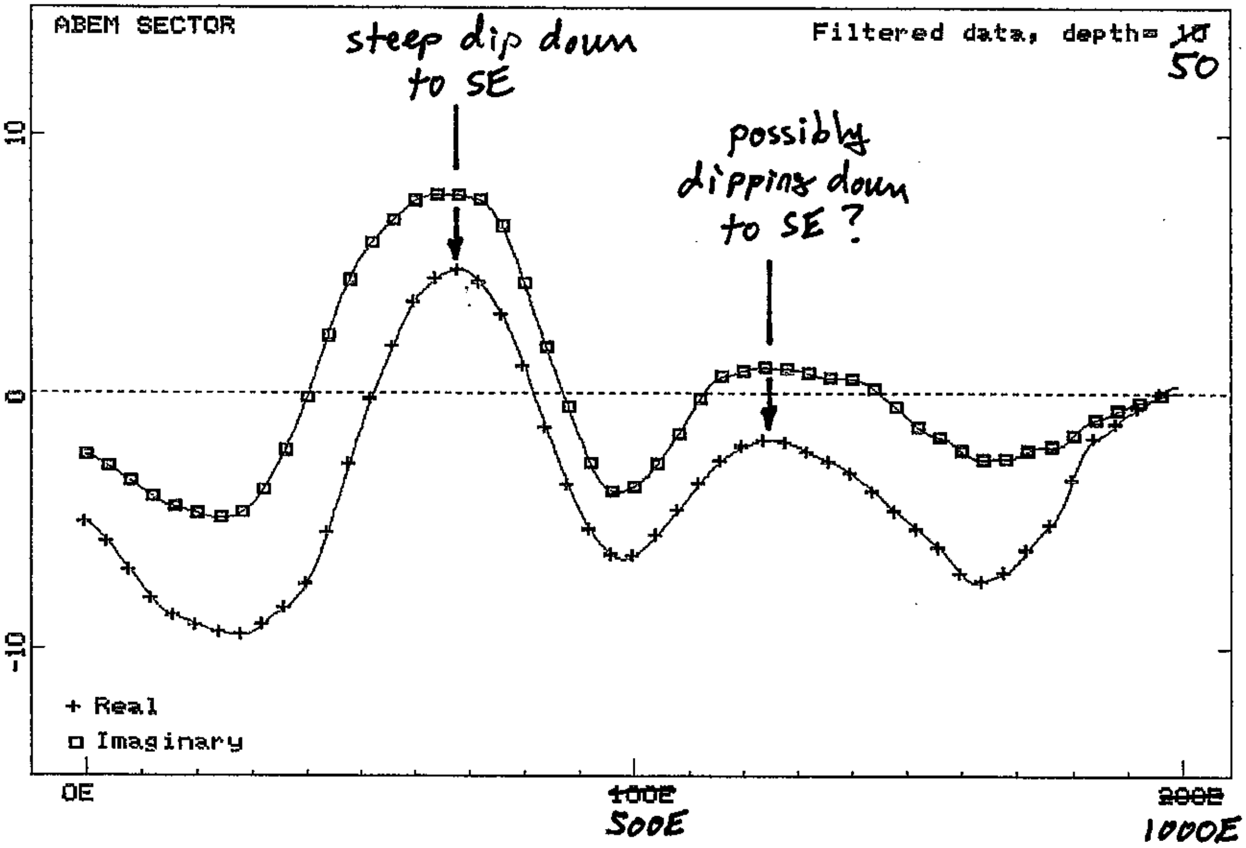
NW

SE

Profile: 0013N (24 kHz) Stratham NH Line 13

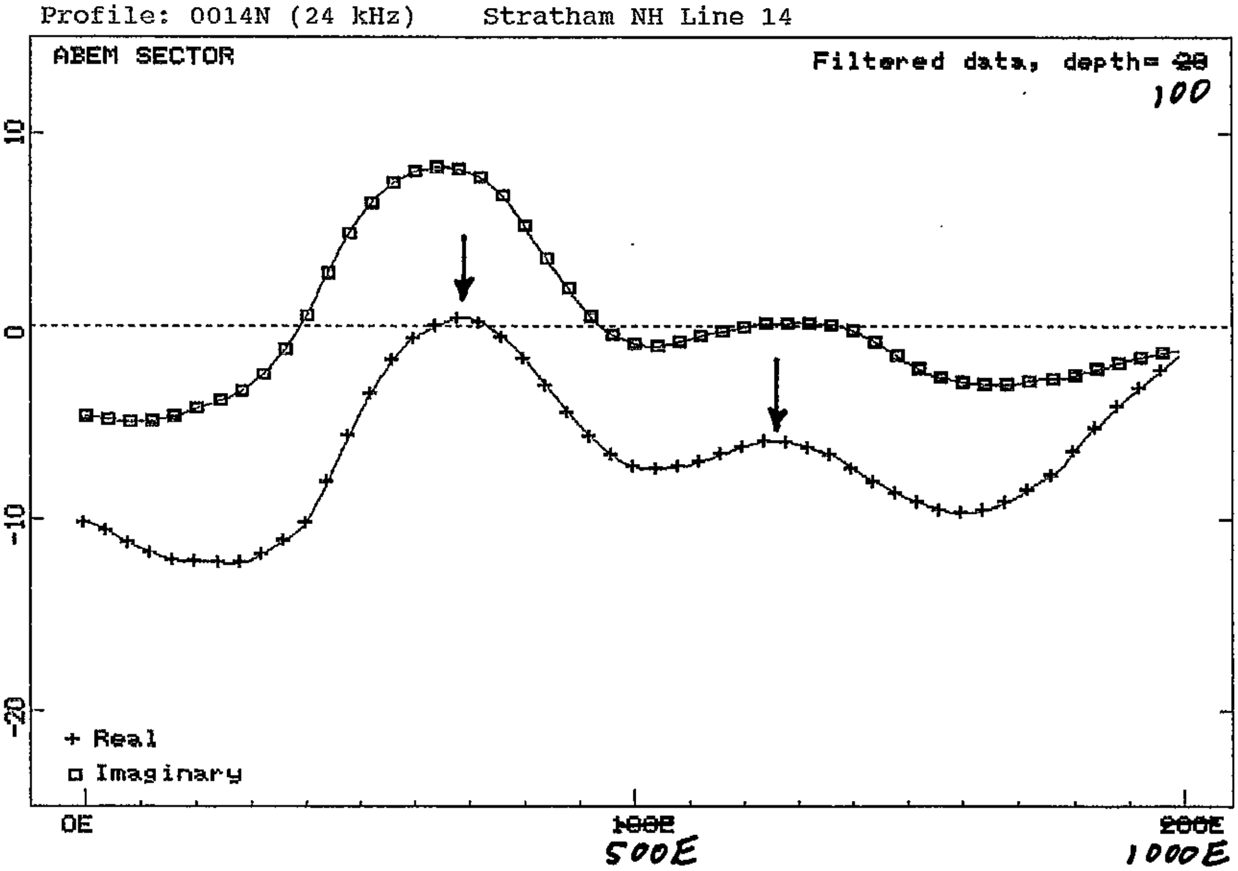


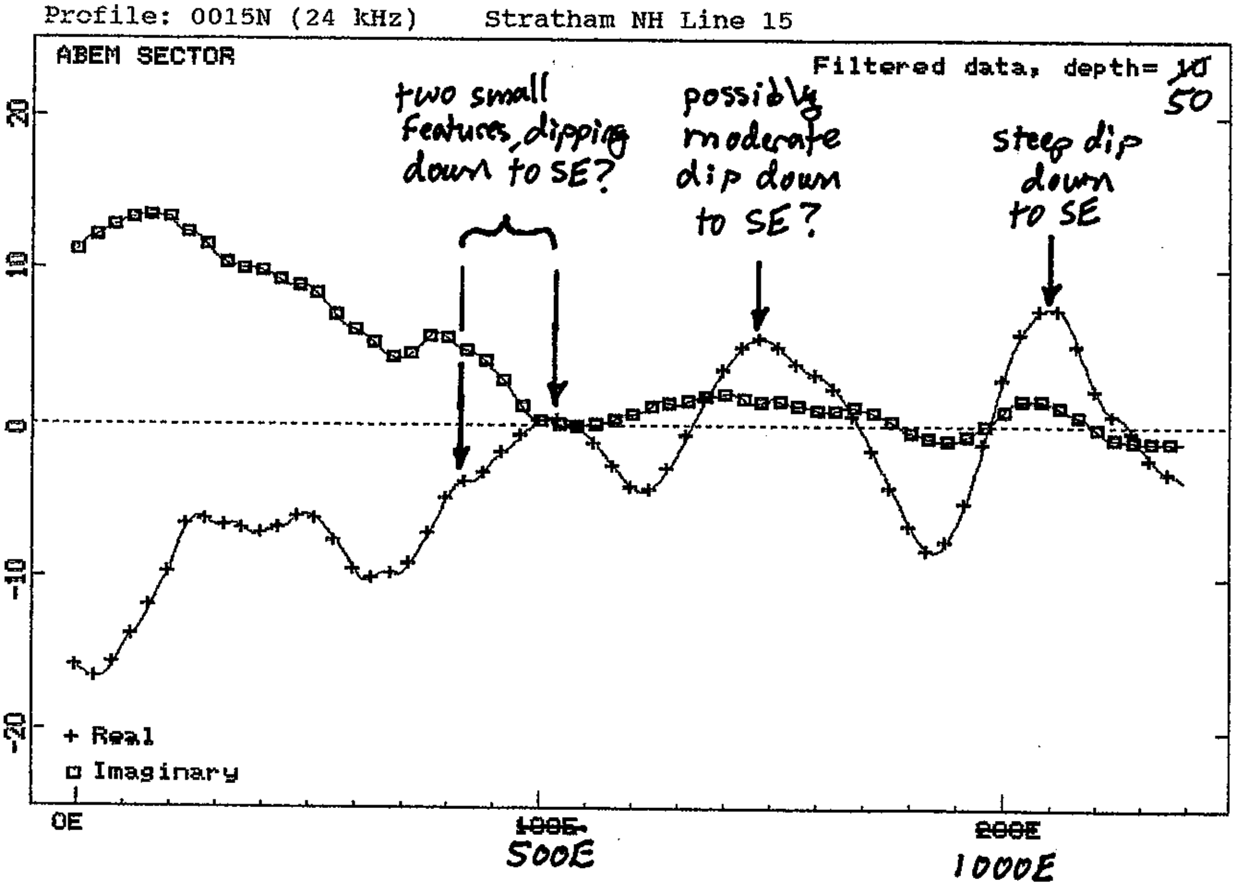
Profile: 0014N (24 kHz)   Stratham NH Line 14



NW   SE

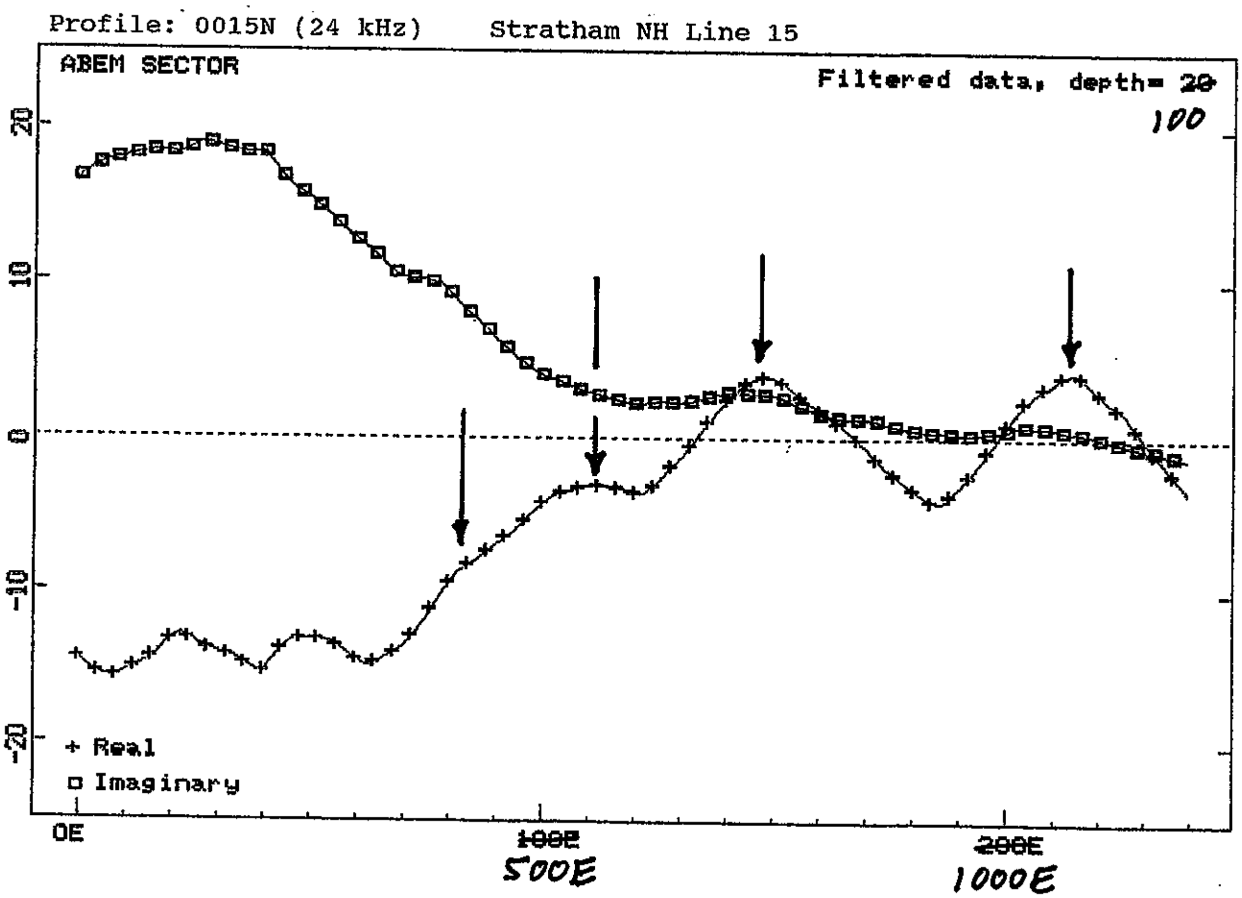
Profile: 0014N (24 kHz)   Stratham NH Line 14



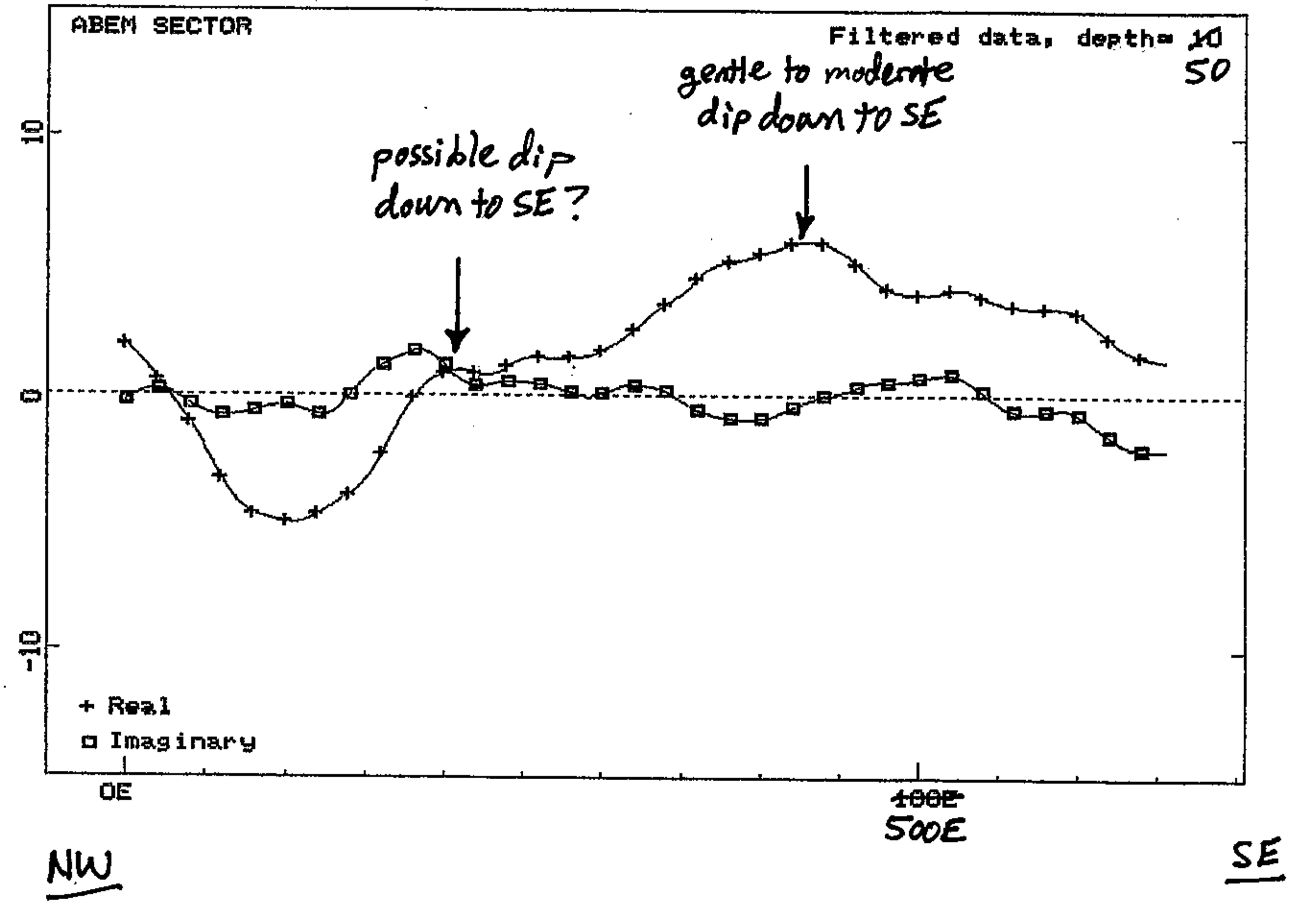

Profile: 0015N (24 kHz)
Stratham NH Line 15
ABEM SECTOR
Filtered data, depth= 10 50
two small features, dipping down to SE?
possibly moderate dip down to SE?
steep dip down to SE
20
10
0
-10
-20
+ Real
□ Imaginary
0E
100E 500E
200E 1000E

NW

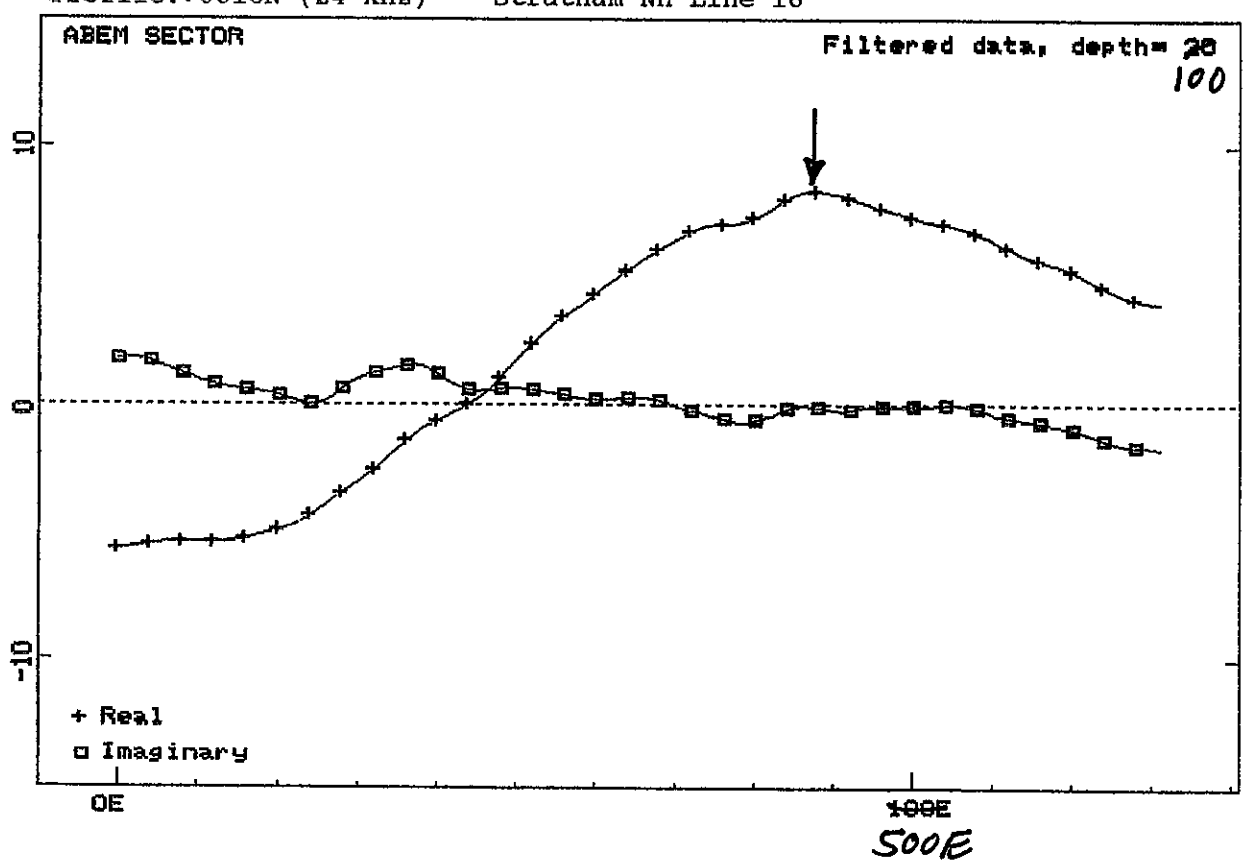
SE


Profile: 0015N (24 kHz)
Stratham NH Line 15
ABEM SECTOR
Filtered data, depth= 20 100
20
10
0
-10
-20
+ Real
□ Imaginary
0E
100E 500E
200E 1000E

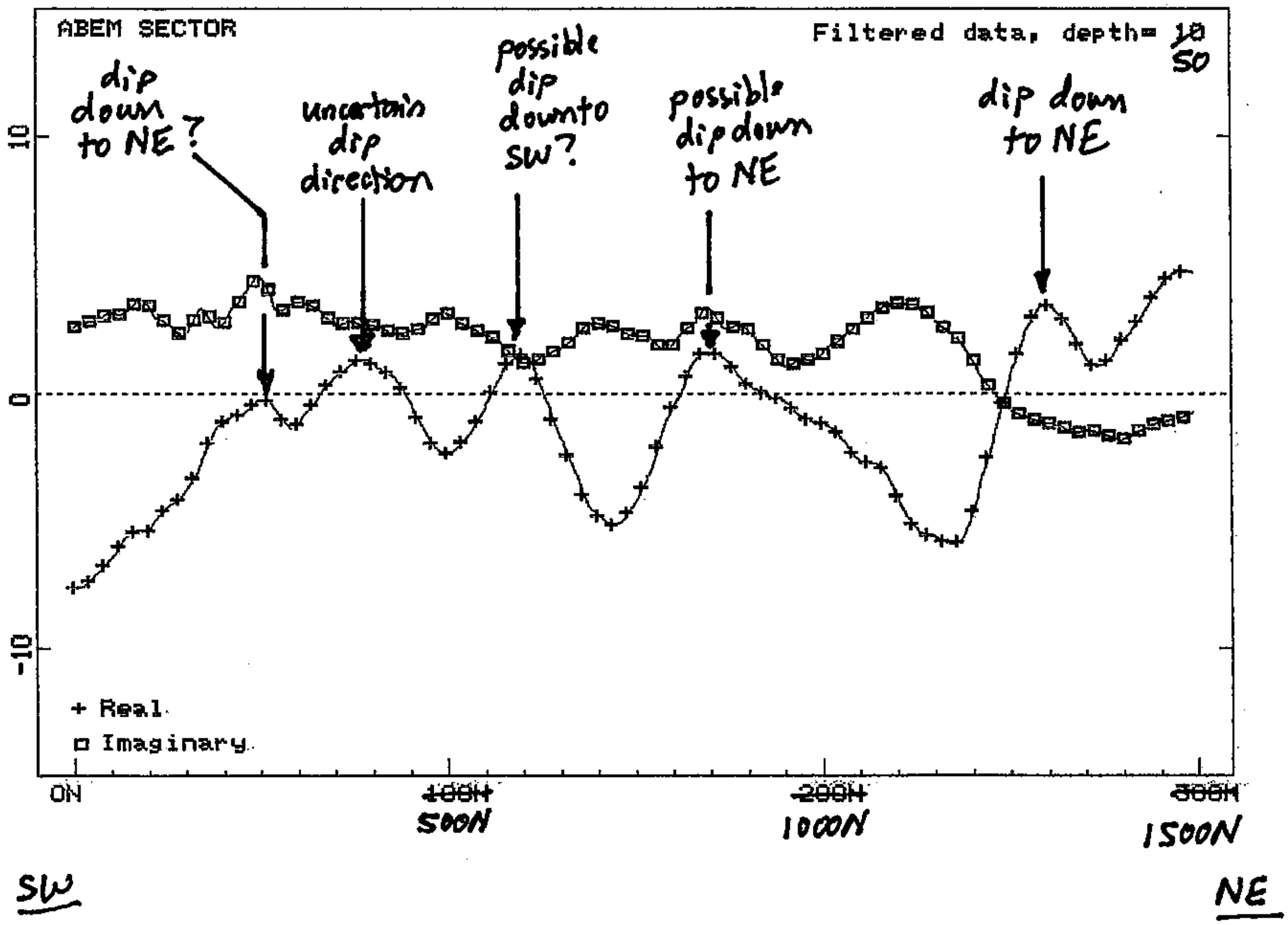
Profile: 0016N (24 kHz) Stratham NH Line 16



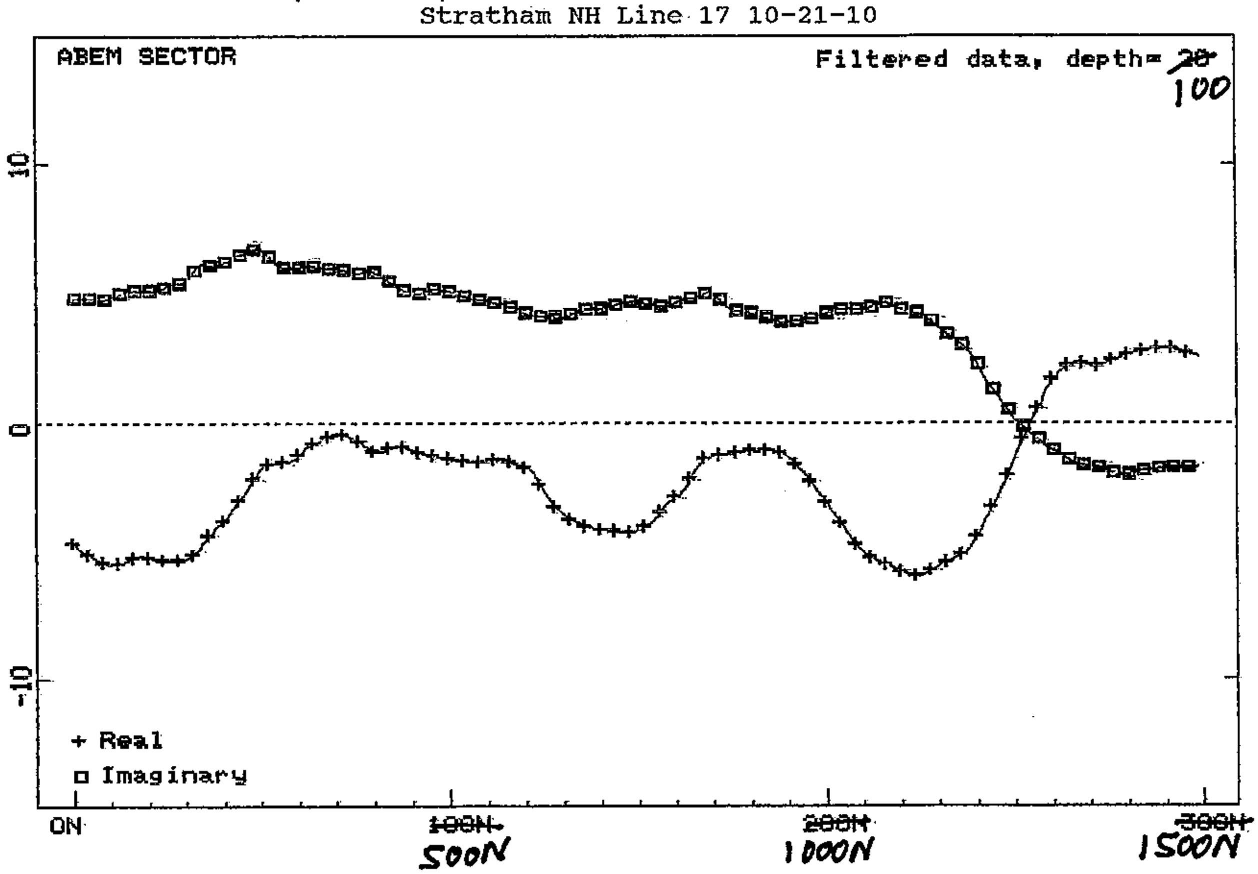
Profile: 0016N (24 kHz) Stratham NH Line 16



Profile: 0017E (25.2 kHz)
Stratham NH Line 17 10-21-10



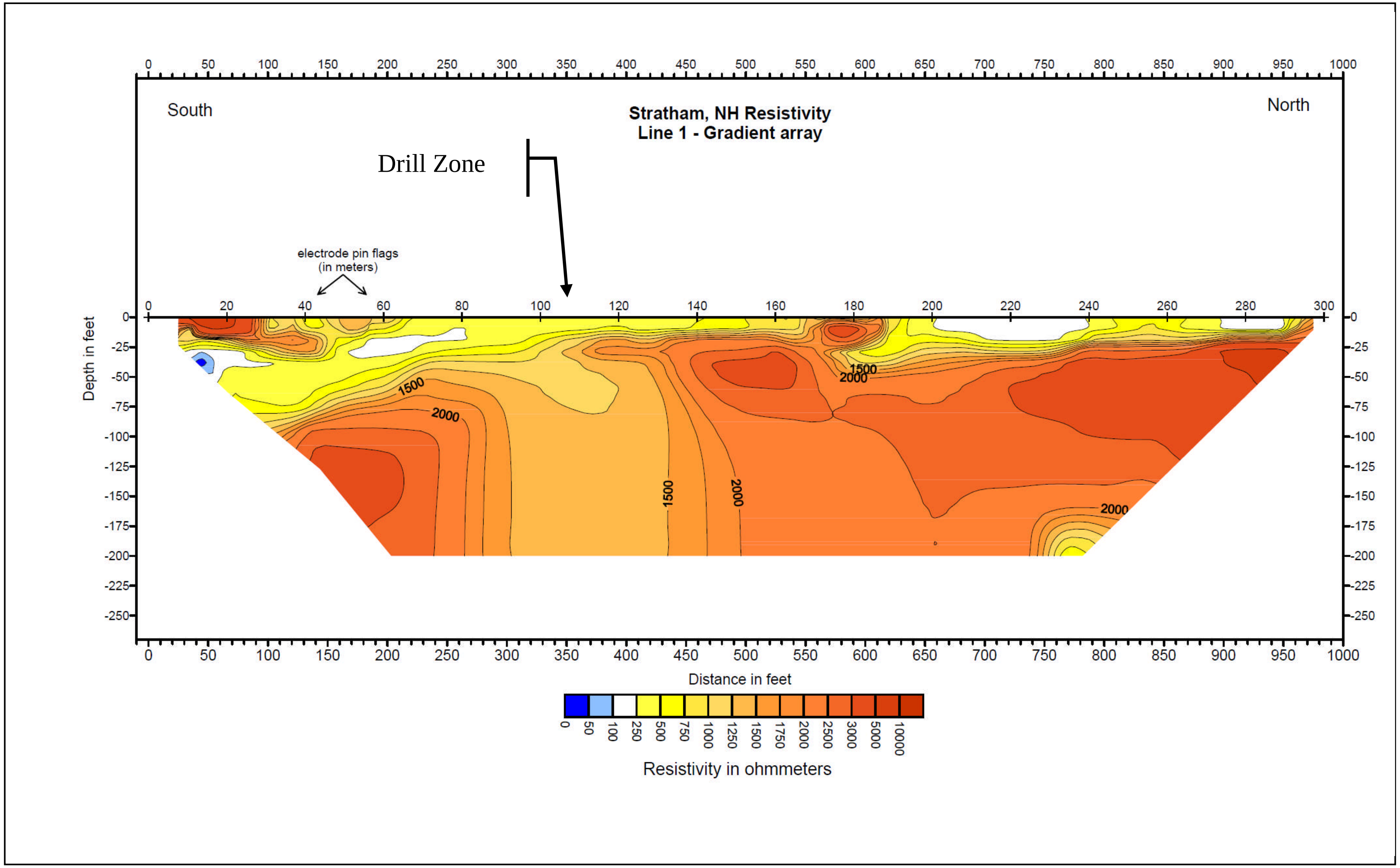
Profile: 0017E (25.2 kHz)
Stratham NH Line 17 10-21-10



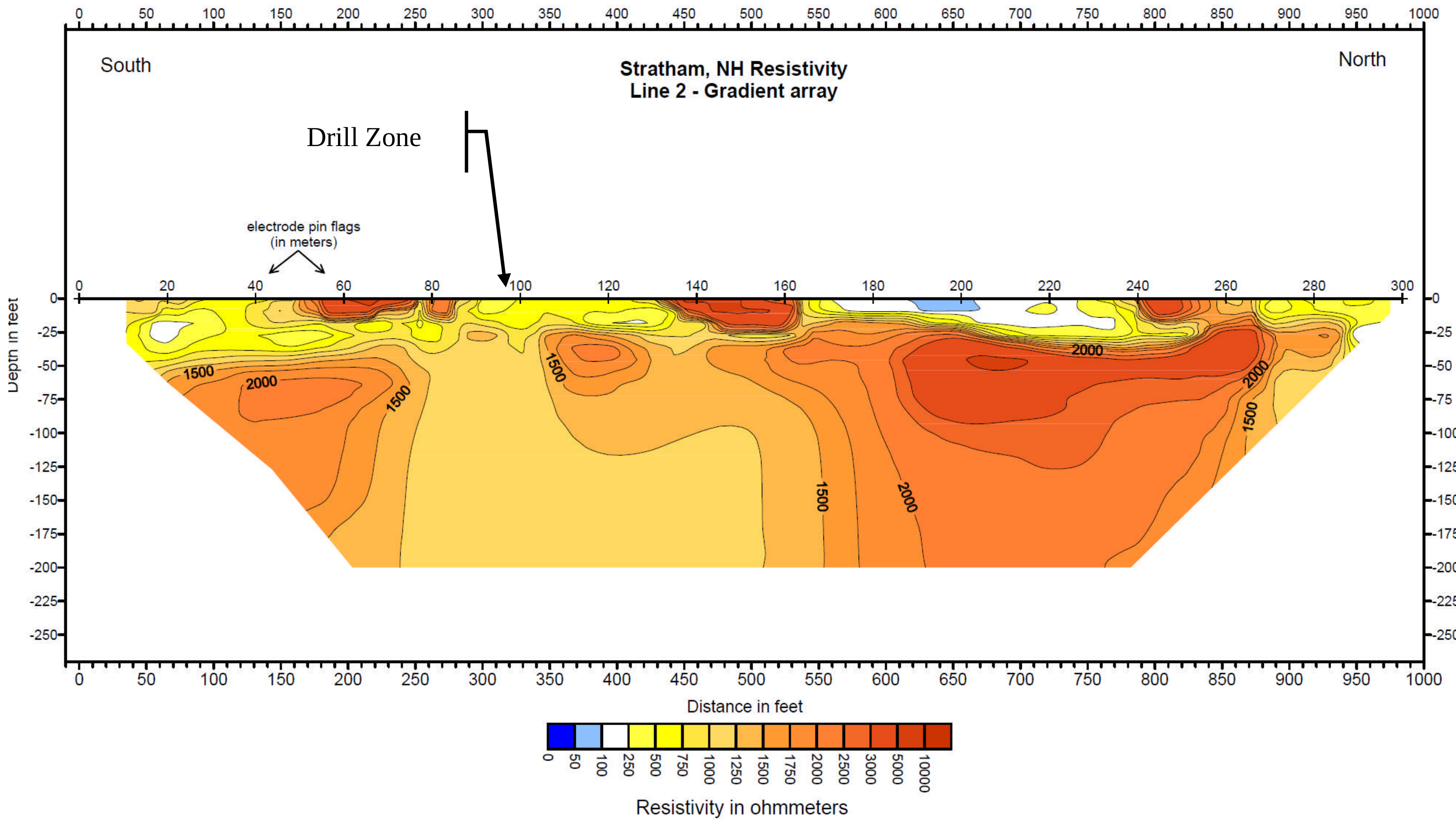
Appendix C

WRIGHT-PIERCE
Engineering a Better Environment

Conservation Land



Conservation Land



WRIGHT-PIERCE
Engineering a Better Environment