FINAL REPORT

RESULTS OF GEOTECHNICAL EXPLORATION AND TESTING
NORTH ANNA ESP PROJECT
LOUISA COUNTY, VIRGINIA

February 11, 2003

Prepared By

MACTEC ENGINEERING AND CONSULTING
RALEIGH NORTH CAROLINA

MACTEC PROJECT NUMBER 30720-2-5400

Submitted To

BECHTEL POWER CORPORATION
FREDERICK, MD

BECHTEL SUBCONTRACT NUMBER 24830-006-HC4-CY00-00001

24830-006-VOA-CY00-00004-002

BECHTEL
SUPPLIER DOCUMENT REVIEW STATUS

STATUS NO.
1 ☑ Work may proceed.
2 ☐ Revise and resubmit. Work may proceed subject to incorporation of changes indicated.
3 ☐ Revise and resubmit. Work may not proceed.
4 ☐ Review not required. Work may proceed.

Permission to proceed does not constitute acceptance or approval of design details, calculations, analyses, test methods or materials developed or selected by the supplier and does not relieve supplier from full compliance with contractual obligations.

Reviewed	Civil	Elec./CS	Nuc./Mech.	Plant Design	QS	M&QS	Arch.	GeHES
								TRP

BY Richard Baker DATE 6/18/03

GA-41258SM Rev. 10/95

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SECTION 1
INTRODUCTION

MACTEC Engineering and Consulting (MACTEC) was retained by Bechtel Power Corporation (BECHTEL) to conduct a geotechnical exploration and associated laboratory testing at the North Anna Power Station in Louisa County, Virginia. MACTEC executed its services per BECHTEL Subcontract Number 24830-006-HC4-CY00-00001.

The geotechnical services were completed as part of the Early Site Permitting (ESP) project for Dominion Power. The field work commenced on November 18, 2002 and was completed on December 18, 2002. Surveying activities to locate the actual test locations were completed on January 8, 2003.

The Scope of Work was defined in Exhibit D of the Subcontract which included BECHTEL Technical Specification 24830-006-SR9-CY00-00001-000, and is briefly described below.

- Locate exploration points by survey.
- Coordinate the location of underground utilities with plant personnel prior to advancing any exploratory activities.
- Drill geotechnical exploratory borings at locations specified by BECHTEL, adjusting as necessary to accommodate access and utility conflicts. Geotechnical borings were completed at seven locations identified as B-801 through B-807.
- Conduct Standard Penetration Testing (SPT) to obtain samples of soil, undisturbed sampling of soil as directed by BECHTEL field representatives, and rock coring to obtain samples of rock.
- Prepare field logs for all drilling and sampling and transfer all samples to a secure, on-site sample storage facility.
- Seal all boreholes by grouting.
- Complete drilling, with selective soil sampling, for the installation of water level observation wells at nine locations identified as OW-841 through OW-849. Soil sampling was not included in the technical specifications but was requested by BECHTEL's field representatives.
- Develop observation wells and conduct field permeability testing using slug testing methods.
- Install locking well covers and concrete well pads at observation well locations.
- Conduct cone penetrometer testing (CPT) at specified locations. The project specifications called for CPT testing at seven locations. However, due to site access issues and shallow refusal, the CPT testing program was modified to include testing at eight locations (not including offset tests). Test numbers for completed CPT locations are as follows: CPT-821 to CPT-825, CPT-827, CPT-828, and CPT-830.

- Conduct cross-hole seismic tests at one location (B-802) using a three hole array. Due to subsurface conditions encountered at the B-802 location, BECHTEL approved additional cross-hole testing at a second location (B-805).
- Conduct laboratory testing on soil and rock samples as assigned by Bechtel.
- Provide a summary report for all testing.
- Provide daily reports of all field activities.
- The Technical Specifications included provisions for test pits. However, no test pits were assigned or completed.

Sampling and testing related to the geotechnical exploration was designated as "Safety-Related" by BECHTEL. As such, the work was completed under a Quality Assurance Program meeting the Code of Federal Regulations 10CFR50, Appendix B and conforming to the provisions of ANSI/ASME N45.2-1977.

This data report describes the field and laboratory testing methods and presents the results.

SECTION 2
TEST METHODS

2.1 Surveying

The surveying for the project was conducted in two phases. The initial phase was to complete preliminary boring layout based on initial coordinates for test locations provided by BECHTEL. After completing an initial assessment of test locations and potential utility and access conflicts, it was determined that the test points in the central plant area would be identified by MACTEC and BECHTEL personnel by locating them relative to existing site features and structures. Preliminary test locations away from the central plant area and in wooded areas were located by the surveyor (Stantec Consulting, a MACTEC subcontractor) using conventional survey methods.

The second phase was done after completion of all testing. The surveyor returned to the site and determined locations and elevations of the actual test points. Elevations were referenced to NAVD 88. BECHTEL requested that all horizontal locations be provided in Commonwealth of Virginia Grid coordinates. During project startup, it was found that the grid coordinates shown on original plant drawings were referenced to the 1927 plane grid. Since the plant construction, Virginia has adopted a revised grid (the 1983 grid). No drawings were located which linked plant features to the 1983 grid, and the plant itself has its own coordinate grid. Available current Virginia reference monuments are tied to the 1983 grid system; however, it is possible to convert 1983 grid points to the older 1927 grid system. BECHTEL requested that the survey use the 1983 grid references and that a table for all points be prepared showing both the 1983 and the 1927 coordinates. In addition, two existing plant monuments were located by survey to provide a link to previous surveys and coordinates. Survey reference points linked to the current 1983 Virginia grid could not be identified on the plant site. Therefore, the surveyors ran a traverse into the plant from Louisa County Monuments TR 2001 and TR 22 to establish control points.

Prior to the completion of the survey, several markers identifying test locations were removed or damaged. The test locations impacted included: CPT-821, CPT-821A, CPT-821B, B-802 (geotechnical boring only), and CPT-823. Approximate locations for each of these test points were reestablished by MACTEC personnel and located by the surveyors. The locations for these subject points are noted as approximate in the Survey Results Table included in Appendix B. A plan showing the locations of all test locations is also included in Appendix B.

2.2 Utility Location

Representatives of MACTEC and BECHTEL used preliminary survey locations and physical features to mark planned locations of borings, wells, cross-hole test sites, and CPT probes. These preliminary locations were provided to Dominion Power plant personnel for utility clearance.

Dominion personnel used electromagnetic and ground penetrating radar methods to check the planned test locations for the presence of underground utilities. The planned locations were adjusted as required by Dominion Power to provide the necessary utility clearances.

A Digging, Drilling, and Cutting (DD&C) permit for the boring and testing operations was written by Dominion Power and provided to MACTEC for field use. The DD&C was appended to include each new test location as utility clearance was provided. A representative of Dominion Power was present at each test location until the drilling had advanced to a depth of at least ten feet.

2.3 Drilling Equipment/Methods

Drilling equipment mobilized to the site included the following:

- CME 550 Drill Rig mounted on an ATV carrier
- CME 45 Drill Rig mounted on a trailer
- Deitrich D-50 Drill Rig mounted on a tracked carrier
- Ingersoll Rand Model T3W truck mounted air-rotary rig

In addition, a rubber tired ATV with a 300-gallon water tank was mobilized to the site and used to haul materials and supply water to the drill rigs.

Borings were advanced in soil using rotary wash drilling techniques until SPT refusal (defined as the physical inability to advance the hole using wash drilling procedures or 50 blows for one inch or less of penetration, whichever occurred first) was encountered. Once SPT refusal was encountered, a steel casing was set, and the holes were advanced using wire-line rock coring equipment and procedures described in ASTM D 2113. A five foot long "NQ" core barrel with a split inner barrel was use for all rock coring. Fresh water obtained from Lake Anna was used for all drilling and coring operations. In Boring B-805, a slurry formed by mixing bentonite with fresh water was used. Four inch diameter casing was used to stabilize the upper portions of each boring as necessary.

Hollow stem augers, with a 4.25-inch inside diameter and a nominal 8-inch outside diameter, were used to advance all observation well holes except for OW-845. Soil samples were obtained at 2.5-foot and 5-foot intervals in the augered holes as described in Section 2.4. OW-845 was drilled using the rotary air percussion rig in order to advance into rock. No soil samples were obtained in OW-845.

The holes required for cross-hole testing in rock, B-802A, B-802B and B-802C, were advanced using the rotary air percussion drill rig. A 10-inch diameter bit was used through soil and weathered rock zones and a 6-inch diameter bit was used in rock. No sampling was done in these holes.

The holes for the cross-hole testing in soil, B-805A, B-805B and B-805C, were advanced using rotary wash techniques. A 6-inch diameter bit was used to advance these holes to the top of rock. No sampling was done in these holes.

Specific equipment used at each borehole is included on the borehole logs included in Appendix C.

All boreholes and the cross-hole casings were filled prior to demobilizing from the site using a cement-bentonite grout. The cross-hole casing at B-802B was left open for possible additional testing. As required in specification section 4.1.2, the grout was placed by pumping through a tremie pipe inserted to the bottom of the borehole. The grout mixture specified in 4.1.2 (7 gallons of water and 5 pounds of bentonite per 94-pound sack of cement) proved too thick to pump with conventional pumps. MACTEC proposed and BECHTEL's field representative approved use of the same grout mix used for observation well installation for sealing the boreholes.

2.4 Sampling in Geotechnical Borings

Soil sampling in the geotechnical borings (B-801 through B-807) was conducted at intervals ranging from 2.5 feet to 5 feet using equipment and methods described in ASTM D 1586. The sampler was typically driven a minimum of 18 inches in soil with blows recorded for each six inch interval of penetration. In very hard soils and weathered rock, driving was terminated at 100 blows and the actual penetration recorded, (e.g., 100 blows / 3 inches).

The split spoon sampler was opened at the drill site and the recovered materials were visually described and classified by MACTEC's rig geologist. A selected portion of the sample (typically the material for the lower portion of the sample) was placed in a glass sample jar with a moisture proof lid. Sample jars were labeled, placed in cardboard boxes, and transported to an on-site storage area.

The technical specifications defined SPT refusal as 50 blows for 6 inches or less of penetration. For the purposes of determining the depth at which to begin rock coring procedures, BECHTEL agreed that refusal to soil drilling would be defined as physical inability to advance the hole using wash drilling procedures or 50 blows for one inch or less of penetration, whichever occured first. In practice, the sampler was typically struck with 100 blows and the actual penetration measured and recorded on the boring logs.

Rock recovered by the coring process was carefully removed from the split inner barrel and placed in wooden core boxes with wooden blocks used to mark ends of runs. When core recovery was less than 100%, the rig geologist placed foam spacers in the core box to mark the estimated locations for the missing material. Filled core boxes were taken to the on-site sample storage facility. Photographs of the cores were taken at the sample storage facility. Core Photographs are included in Appendix C.

The rig geologist visually described the core and noted the presence of joints and fractures, distinguishing mechanical breaks from natural breaks where possible. The rig geologist also calculated percent recovery and Rock Quality Designation, (RQD) prior to moving the core from the drill site. Core descriptions as well as drilling data, recovery data and RQD are shown on the Core Boring Report for each borehole included in Appendix C.

2.5 Observation Wells

2.5.1 Well Installation

Nine observation wells were installed on the site as part of this project – eight screened in the soil/weathered rock zone and one screened in the rock. The wells were installed per section 5.3 of the specification.

Boreholes for all observation wells except OW-845 were advanced using hollow stem augers with a 4.25-inch inside diameter and a nominal 8-inch outside diameter. The holes were advanced to depths specified by BECHTEL's field representative. Although not required in the specifications, BECHTEL requested that samples be obtained at approximately 5-foot intervals during the drilling for soil classification purposes (except at well OW-845). A split spoon sampler was driven by an automatic hammer for sampling purposes. The driving resistances obtained with automatic hammers are known to be typically lower than those obtained with manually operated hammers due to differences in energy delivered to the drill rods. Manually operated hammers using rope and cathead were used in the geotechnical borings, and are believed to have been used in previous explorations done at the site in the 1970's.

As agreed with BECHTEL representatives, the driving resistances for the samples obtained using the automatic hammer in the observation well boreholes are not to be relied upon for use in correlations based on standard penetration test values or for comparisons with data obtained using manually operated hammers. Therefore, driving resistance data has not been included on the borehole logs for the observation wells which are included in Appendix D. The driving data was recorded, however, and is included on the field logs maintained by the rig geologist.

Borehole depths shown on the borehole logs indicate the total depth drilled and sampled. Due to small amounts of drill spoil at the base of the augers, or due to the sampler advancing beyond the augered depth, the total depth shown on the borehole log may be slightly greater than the well depth reported on the companion well installation record.

Soil samples obtained from the split spoon sampler in the observation well boreholes were placed in glass sample jars with moisture-proof lids. The jars were labeled and placed in cardboard boxes and transported to the on-site sample storage facility.

One observation well, OW-845, extended into rock. The hole for this well was advanced using the rotary air percussion drill rig. No samples of soil or rock were obtained from this borehole.

Upon reaching the designated depth for a well, slotted PVC casing connected to solid sections was set. A sand pack and bentonite seal were then placed. A grout plug was placed from the top of the bentonite seal to the ground surface in each borehole. The grout mix specified in specifications was found too thick to pump with the equipment on site. A modified grout mix consisting of one bag of Portland Cement (94 pounds), 2.5 pounds of bentonite and 7 gallons of water was proposed by MACTEC and accepted by BECHTEL's field representative. The modified mix was used for all well installations.

The depth of the screened interval, length of the screen and general well configuration were designated in the field for each well by BECHTEL's field representative. Since the ground surface elevations at the well sites were not determined until after the well pads were placed, the top of the PVC casing elevation, less the casing stickup above ground surface as measured at the time of installation, was used to back-calculate the ground surface elevation shown on well installation records and the well borehole logs. All water depth measurements are referenced to the top of the PVC casing. The elevation of the top of the casing was also used along with measurements of the well sections to calculate elevations for the well monitoring interval. Well installation logs showing the details of the construction for all wells are included in Appendix D. A summary table with pertinent observation well information is shown in the Summary Table in Appendix A.

All wells were capped with a locked steel well cover extending approximately two feet above grade. A concrete pad, two feet square and six inches thick, was also placed around each well cover per the specification.

2.5.2 Well Development

After well installation was completed, wells were developed by pumping. The development procedure agreed to with BECHTEL was to remove 2 to 3 standing well volumes of water initially by pumping, cycling the pump on and off to create a surging effect. After initial pumping, the procedure called for removal of 6 standing well volumes while monitoring pH and conductivity with a field meter and visually observing the turbidity. The wells were considered developed when the pH and conductivity stabilized and the pumped water was reasonably free of suspended sediment.

Well development records are attached in Appendix D. These records indicate most wells produced moderate to high inflows of water. All wells were developed satisfactorily using the planned procedure.

2.5.3 Field Permeability Tests

Field permeability testing was conducted in each observation well using procedures described in Section 8 of ASTM D 4044. This procedure is commonly termed the slug test method. Slug testing involves establishing a static water level, lowering a solid cylinder into the well to cause an increase of water level in the well and monitoring the time rate for the well water level to return to the pre-test static level. This method is commonly called the "slug-in" method. After that stabilization, the slug is rapidly removed to create a lowering of the water level in the well, and the time rate for water to recover to the pre-test static level is recorded. This method is commonly called the "slug-out" method. Electronic transducers and data loggers are used for measuring the water levels and times during the test. Due to the rates of recovery and adverse weather conditions at the time of testing, the slug-in and slug-out tests were conducted at different times in some wells.

A summary sheet with the calculated coefficients of permeability from the slug tests is included in Appendix A. The field records, data logger output sheets, and analysis/calculations are attached as Appendix E.

2.5.4 Water Level Measurements

On December 17, 2002, after completion of the field permeability testing, MACTEC representatives checked water levels in all wells installed plus additional wells designated by BECHTEL. Measurements were made using an electric water level meter and referenced to the top of the casing. Some of the previously-existing wells had no reference mark at the top of the casing; in these cases, the higher side of the casing, if applicable, was used as the reference point. The water levels recorded are shown on the table in Appendix A. For two of the wells - WP-3 and WP-4 – no elevations of the tops of the casings were available from Dominion. These two wells are not part of the normal network monitored by Dominion personnel.

2.6 Cone Penetometer Testing

Locations for seven Cone Penetrometer Tests, (CPT) were included in the original scope of work for this project. Specified probe depths ranged from 30 to 40 feet below ground surface. MACTEC personnel staked the probes at the specified locations; however, due to soft, wet ground conditions, several of the probes were relocated to more accessible locations. All test locations were approved by the BECHTEL field representative and cleared by plant utility personnel prior to pushing.

CPT testing was completed by Applied Research Associates, Inc. (ARA), a subcontractor to MACTEC. ARA utilized a 30-ton self-contained truck rig to complete the work. Each probe was advanced to cone refusal, (the limit of the pushing capacity of the rig). Seismic testing was completed at intervals of five feet in CPT-822 and CPT-825. Pore pressure dissipation tests were completed in CPT-827 and 823. All testing was done in accordance with project specifications and ASTM-5778

Refusal was encountered at a depth of less than 10 feet at three test locations, CPT-821, CPT-824 and CPT-828. At CPT-821, two offset probes were attempted which also refused at a shallow depth. Utility conflicts prevented an offset test location at CPT-824.

CPT tests were numbered from CPT-821 to CPT-830; however, CPT-826 and CPT-829 were not completed due to utility and site access issues. Results for all CPT testing are included in Appendix F

2.7 Cross-Hole Testing

Cross-hole testing was conducted at two locations - B-802 and B-805. The methods of ASTM D 4438/D 4428M were specified in section 8.1 of the specifications. Section 8.1 called for one borehole in each cross-hole array to be sampled in accordance with section 4.8.2 of the specifications. After reviewing the planned depth of the cross-hole testing (90 feet) and based on the anticipated presence of rock above the assigned depth, MACTEC proposed and Bechtel approved drilling and sampling to be done in an offset boring. The drilled and sampled borings are identified as B-802 and B-805. The cross-hole test holes are identified as B-802A, B-802B and B-802C and B-805A, B-805B and B805C.

The provisions of ASTM D 4428/D 4428M call for a maximum borehole size of six inches for cross-hole testing. The cross-hole equipment needs a minimum diameter of 2-7/8 inches to accommodate the geophones. These considerations require an outside casing diameter of about 4 inches maximum to assure adequate space for grout placement; thus the 6-inch diameter hole is also practically the minimum hole size. Standard rock coring bits used in geotechnical exploratory work do not produce a 6-inch diameter borehole. In order to advance a borehole through soil and into rock, the soil portion of the hole must be larger than the desired hole in the rock to prevent collapse of the soil. Thus, it was concluded that cross-hole testing in soil and in rock could not be accomplished in the same set of casings.

MACTEC proposed that two sets of cross-hole casings be installed at location B-802 with one set for testing below the soil-rock interface and one set for testing above the soil-rock interface. However, it was found that the depth to rock at location B-802 was very shallow, approximately 8 to 10 feet. Discussions with Grumman Exploration, MACTEC's subcontract geophysicist, indicated that with such a shallow depth to rock, cross-hole testing in the soil would yield limited, if any, reasonable results due to refraction of the seismic waves off the rock surface causing interference. Options considered were to reduce the spacing between the casings or to relocate the soil test casings to another spot where the depth to rock was greater. Because geotechnical boring B-805, located in the general vicinity of B-802 and at a similar elevation, had indicated a depth to rock of about 30 feet, BECHTEL approved conducting the soil cross-hole testing at location B-805.

For location B-802, the air percussion drill was used to advance boreholes for the cross-hole tests. A 10-inch diameter borehole was advanced slightly into rock and an 8-inch diameter PVC casing set to stabilize the soil portion of the hole. A 6-1/8 inch diameter bit was used to extend the boreholes to the assigned termination depths of 90 feet.

For location B-805, rotary wash drilling with one of the geotechnical drill rigs using a 6-inch diameter bit was used to advance the boreholes to approximately 30 feet.

Because the specification required a deviation survey of the cross-hole casings, inclinometer casing as manufactured by The Slope Indicator Company was installed in each borehole. Centralizers were placed on the casing, and the annular space between the casing and the borehole was filled with Portland cement grout.

Installation of the cross-hole casings encountered minor difficulties during the grout placement at B-802A. Excessive grout take was noted. During the drilling of B-802A, a relatively large inflow of water had been noted. MACTEC concluded the large grout take was due to grout flowing into open fractures in the rock. Grouting was suspended and resumed the following day with successful completion. Grout losses were not noted in the other two boreholes at the B-802 location.

ASTM D 4428/4428M calls for a grout unit weight in rock of 140 pounds per cubic foot (pcf). To achieve this unit weight, a cement-water mix with a water-reducing admixture was planned due to concerns about the ability to pump the mix. Field work found that a unit weight of about 128 pcf was the maximum that could be achieved and still maintain a mix fluid enough to pump. Since the primary concern with the grout was to achieve a continuous fill of the annular space, the lower unit weight was considered acceptable. Discussions with Grumman indicated the difference in unit weight considered over an approximate 1-inch layer would not affect the seismic velocity measurements.

After setting the casings, and after the cross-hole testing, a deviation survey was conducted in each of the inclinometer casings. The survey was done with a Slope Indicator Digitilt probe, and the data was recorded by a Slope Indicator DataMate recorder. The surveyor later established the grid coordinates for the center of each casing as well as the bearing of the inclinometer reference groove. Horizontal distances between each pair of cross-hole receiver casings were computed at 2-foot increments from the top down using the deviation survey results. These distances were furnished to Grumman for their use in analyzing the cross-hole velocity data. Appendix G contains a drawing showing the orientation of the cross-hole casings, the results of the deviation survey and the computed distances.

The cross-hole velocity measurements were performed on December 12, 2002 by Grumman. MACTEC, in consultation with Grumman, reviewed the available borehole data to select one end of each array as the energy source hole with the other two casings used for the receiver geophones. Due to the large amount of grout used in B-802A, this casing was used for the energy source. Casings for the energy source were pumped/bailed prior to testing to remove water.

The cross-hole measurements were made using a manually-actuated, reversible polarity, shear wave impulse source to create a shock wave at each test depth. Triaxial geophones were lowered into each receiver casing and positioned such that for each test, the impulse source and the geophones were at the same depth relative to the ground surface. Tests were conducted at 5-foot intervals in the rock test location (B-802) as required by the specifications. At location B-805, due to the relatively short length of the casings, tests were conducted at 2.5-foot intervals to 21 feet, then at 5-foot intervals to obtain more data points.

The cross-hole testing was conducted in accordance with ASTM D4428/D4428M ("preferred method") with the following minor deviations:

- A timing accuracy test was not performed at the site as the system had been calibrated within two weeks prior to the filed testing.
- Separate tests for P-wave and S-wave were not conducted as the equipment used has an adequate sampling rate to allow proper interpretation.
- Arrival times were visually observed at the site on the computer monitor, but arrival times were not determined in the field as it is more accurate to evaluate the data and determine arrival times using computer assistance later.

The signals produced by the impulse sources and received by the geophones were recorded by a Geometrics Model S12 signal enhancement seismograph. The data were analyzed by Grumman to produce estimated values for Vp (compression wave velocity) and Vs (shear wave velocity) at the test depths. The results are presented in the figures and tables in Appendix H.

During the analysis, it was found that a background high frequency noise signal was present at the B-802 location. The source of the noise was judged as external to the test equipment. As a result of the interference, estimated values for Vp could not be obtained, and Vs values could not be interpreted at test depths below 45 feet. Grumman believes that downhole testing using one of the casings may have a potential for improved data quality in light of the interference signal. One casing (B-802B) was left open to allow for possible future testing.

Subsequent to the original field work, downhole seismic testing was conducted in Boring B-802B. Reasonable data were obtained for Vp. The shear wave was reasonably well-defined to a depth of 45 feet, but less well-defined to 65 feet. Below approximately 65 feet, the shear wave appeared to be absent. The results of the test are presented in the report, figures and tables in Appendix J.

SECTION 3
SAMPLE STORAGE

3.1 On-Site Sample Storage Facility

At the request of BECHTEL and consistent with MACTEC's quality requirements, an on-site sample storage facility was established. The sample storage facility was located within the "A Level" area of the plant's warehouse facility. The "A Level" has limited access and is climate controlled. MACTEC personnel erected sections of chain link fence, six feet high, to form the approximately 12-foot square area. A locking gate was included in one of the side sections.

Upon sample transport to the warehouse facility, MACTEC personnel first logged each sample container, (boxes of glass jars or rock core boxes) into the plant's "Non-Stock" inventory system. The non-stock inventory number was then placed on the sample container. The sample containers were then placed into the secured sample storage area and logged into the project sample inventory log book.

Any samples removed from the facility were noted in the sample inventory log book. A chain of custody form was also completed for all samples removed from the facility.

SECTION 4
LABORATORY TESTING

Laboratory testing of soil and rock samples was completed based on the BECHTEL Geotechnical Laboratory Test Assignment sheet dated December 18, 2002. Laboratory testing of soil included moisture content, Atterberg Limits, grain size and chemical analysis. Nineteen pieces of rock core were tested for unconfined compressive strength. Six of the test specimens were instrumented with strain gages to allow measurement of stress-strain curves and calculation of modulus of elasticity.

All testing of soil samples except for chemical analysis, was completed in MACTEC's Raleigh, NC laboratory. All rock testing was completed at MACTEC's Atlanta, GA laboratory. Testing was completed in accordance with Section 10.0 – Laboratory Testing, of the project specifications.

For the rock testing, MACTEC's field geologist obtained intact sections of core from the depth intervals designated on the assignment sheet in all but one case. Core pieces were longer than would be required for testing to allow for preparation. Due to insufficient intact length of rock in one assigned interval (B-804, 35-38'), MACTEC's field geologist selected a piece of rock of the same type from the next core run for testing. The substitute piece was from 38.9 to 39.9 feet. Mr. John Davie of Bechtel was advised of the substitution and concurred.

Chemical testing for pH, sulfates and chlorides in selected soil samples as assigned by Bechtel was conducted using EPA methods SW9045 and 9056/300.0. The testing was done by Severn Trent Laboratory (STL) of Savannah, Georgia, a subcontractor to MACTEC.

All soil and rock samples were shipped under Chain-of-Custody from the site storage area to MACTEC's Raleigh, North Carolina laboratory. If required, samples were further divided and/or shipped to the appropriate testing laboratory under Chain-of Custody.

The rock core specimens were prepared in accordance with ASTM D 4543-01. The testing was done at the "as-received" moisture content. The unconfined compressive strength tests were conducted in accordance with ASTM D 2938—95 with minor modifications as noted on the summary sheet. The testing with stress-strain measurements was conducted in accordance with ASTM D 3148-96. Two of the test specimens had length to diameter ratios that were less than the 2.0 minimum recommended by ASTM. The actual ratios were 1.8 and 1.9. In addition, two samples had diameters that were very slightly less (.006") than the minimum recommended in the ASTM standard. The diameter deviation is not significant relative to the test results.

Modulus of elasticity values for the rock cores tested with stress-strain measurements were calculated using the average slope method, with the Poisson's ratios computed over the same interval used for the modulus. For one sample, this method yielded a value of Poisson's ratio of 0.54, which suggests the core was deforming plastically over the interval chosen. The stress-strain curve for this test also exhibited two distinct slope portions. The modulus value and Poisson's ratio for the portion of the curve in the initial stress range were calculated and resulted in a more reasonable value for Poisson's ratio. For completeness, both results are included in Appendix I.

Summary sheets for the laboratory testing results are included in Appendix A. Copies of the Laboratory Assignment sheets and the results of all soil and rock testing are included in Appendix I.

A summary sheet showing the unconfined compressive strengths and moduli of elasticity is attached in Appendix A. Full reports for the tests are included in Appendix I.

LIST OF APPENDICIES

APPENDIX A
TABLES OF SUMMARY TEST DATA

OBSERVATION WELL SUMMARY NORTH ANNA ESP PROJECT BECHTEL SUBCONTRACT NO. 24830-006-HC4-CY00-00001 MACTEC JOB NO. 30720-2-5400				
Well Number	Total Depth, ft *	Top of Casing Elevation, ft**	Measurement Interval Elevations, ft ***	Water Level Elevation, ft (Date) ****
OW-841	34.3	251.6	215.8 – 230.0	249.2 (12-13-02)
OW-842	49.6	336.7	285.6 - 299.9	307.4 (12-12-02)
OW-843	49.2	320.6	269.9 - 282.7	284.9 (12-12-02)
OW-844	24.6	273.5	247.4 - 259.3	265.0 (12-13-02)
OW-845	55.0	297.3	240.8 - 256.1	272.6 (12-12-02)
OW-846	32.7	297.3	263.1 - 275.5	272.5(12-12-02)
OW-847	49.8	319.7	268.4 - 283.2	285.3 (12-12-02)
OW-848	47.3	284.5	235.7 – 243.9	241.9 (12-13-02)
OW-849	49.8	298.5	247.2 – 261.4	265.4 (12-13-02)

* Measured relative to ground surface.
** Casing is 1.5 ft above ground surface at time of drilling.
*** Includes interval from bottom of well casing to top of sand pack.
**** Water level measured immediately prior to slug testing, after well development.

Prepared by: CA9 Date: 2-4-03
Checked by: MAL Date: 2-4-03

First Quarterly Water Level Summary (12-17-02)
North Anna ESP Project

Observation Point	Depth to Water below Ref. Pt. (ft)	Elevation (ft) Ref. Pt.	Elevation (ft) Water	Remarks: Time, Weather Conditions Observation Point Condition, etc.
				Partly Cloudy, low 40's
OW-841	2.7	251.6	248.9	No cap on PVC casing inside locking cover
OW-842	29.2	336.7	307.5	
OW-843	35.5	320.6	285.1	
OW-844	8.0	273.5	265.5	
OW-845	24.6	297.3	272.7	
OW-846	24.8	297.3	272.5	
OW-847	34.3	319.7	285.4	
OW-848	42.8	284.5	241.7	
OW-849	33.0	298.5	265.5	No cap on PVC casing inside locking cover
P-10	12.0	286.4	274.4	Ref Pt. mark is fading
P-14	55.5	327.1	271.6	No mark for Ref Pt.
P-18	43.3	329.0	285.7	No mark for Ref Pt.
P-19	38.0	322.3	284.3	
P-20	45.7	320.6	274.9	
P-21	Dry to 58	319.2		No mark for Ref Pt.
P-22	43.7	320.5	276.8	
P-23	35.3	296.4	261.1	
P-24	17.0	293.4	276.4	
WP-3	18.2	*		Sediment in bottom at 43.4'; No mark for Ref Pt.
WP-4	NA	*		Water level is below pump; No mark for Ref Pt.

* No elevation available for top of casing

Service Water Reservoir Elevation 314.6 ft.
Lake Level Elevation 248.1 ft.

Wells labeled OW were installed by MACTEC in November and December, 2002.
All other wells listed were installed by others at unknown times.

Elevations for OW points obtained by Stantec as part of current project.
Elevations for other points furnished by Dominion.

Field Measurements by M. Howe
Sheet Prepared by: [illegible] Date: [illegible]
Checked by: [illegible] Date: 1/3/03

North Anna ESP Project
Summary Table of Hydraulic Conductivity (K) Results
MACTEC Job Number: 30720-2-5400

WELL ID	DATE OF TEST	K VALUE RESULTS				COMMENTS
		SLUG IN		SLUG OUT		
		FT/DAY	CM/SEC	FT/DAY	CM/SEC	
OW-841	12/13/2002	2.2E+00	7.8E-04	2.3E+00	8.2E-04	
OW-842	12/12/2002			9.3E-01	3.3E-04	
	12/17/2002	9.3E-01	3.3E-04			
OW-843	12/12/2002			1.4E+00	4.9E-04	
	12/17/2002	1.3E+00	4.5E-04			
OW-844	12/13/2002	2.5E-01	8.9E-05	2.8E-01	9.9E-05	
OW-845	12/12/2002	1.8E+00	6.3E-04	3.1E+00	1.1E-03	K values are questionable (see graph)
	12/17/2002	NA	NA			Recovery to quick to calculate K values (see graph)
OW-846	12/12/2002	1.9E+00	6.8E-04	3.4E+00	1.2E-03	
OW-847	12/13/2002	5.8E-01	2.1E-04			
	12/17/2002			6.6E-01	2.3E-04	
OW-848	12/13/2002	3.4E+00	1.2E-03	2.8E+00	9.9E-04	K value may be overestimated due to H2O level below top of screen
OW-849	12/13/2002	2.0E+00	7.0E-04	3.2E+00	1.1E-03	

Notes:
Prepared by / date: BWJ / 12-20-02 BWJ
Checked by / date: WSL / 12-27-02

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC.
RALEIGH, NORTH CAROLINA
REPORT OF STANDARD TEST METHOD FOR
LABORATORY DETERMINATION OF WATER CONTENT OF SOIL AND ROCK BY MASS
(ASTM D 2216)

PROJECT NAME: North Anna ESP
MACTEC PROJECT NUMBER: 30720-2-5400
BECHTEL JOB NO: 24830
DATE: 2/11/03

SAMPLE IDENTIFICATION			NATURAL	LIQUID & PLASTIC LIMITS			% FINER				USCS
BORING	TYPE	DEPTH (feet)	MOISTURE (%)	LL	PL	PI	#200 SIEVE	pH	CHLORIDES mg/kg	SULFATES mg/kg	CLASSIFICATION
B-801	SS-1	0-1.5	22.2	39	29	10		6.3	130.0	< 27	
B-801	SS-5	8.5-10					39.9				
B-801	SS-6	13.5-15					55.1				
B-802	SS-2	3.7-5.2					19.5				
B-803	SS-3	6.1-7.6	18.9	30	26	4					
B-803	SS-4	8.6-10.1	23.2				24.4				
B-803	SS-6	13.7-15.3					20.9	5.7	100.0	< 23	
B-803	SS-8	23.6-25.1					18.5				
B-804	SS-3	3.5-5					54.2				
B-804	SS-6	11-12.5					46.1				
B-804	SS-8	18.5-20					22.1				
B-805	SS-4	7.5-9	27.2	NP	NP	NP	27.5				SM
B-805	SS-7	18.5-20					25.1				
B-806	SS-3	5.6-7.1					27.1	6.7	920.0	< 24	
B-807	SS-3	4.5-6	40.1	49	45	4					
B-807	SS-6	12.3-13.8	42.8	46	40	6		5.7	170.0	< 28	
B-807	SS-8	21.8-23.3	28.9	41	34	7	42.6				SM-SC
B-807	SS-10	31.5-33	26.7				37.7				
B-807	SS-12	41.4-42.9	21.8				44.2				

PREPARED BY: [signature]
Trudy L. Mullins, Laboratory Manager

REVIEWED BY: [signature]
Stephen J. Criscenzo
Principal Professional

APPROVED BY: [signature]
J. Allan Tice, P.E.
Principal Engineer/Project Manager
Registered Virginia, 5264

TESTING EQUIPMENT:

SCALES: 3.1.99
OVEN: 5.1.10
WASH SIEVE: 5.4.39

TECHNICIAN: JLB
CALCULATIONS: JLB
CHECKED BY: TLM

MACTEC

Summary of Laboratory Rock Core Tests on Intact Specimens
Unconfined Compressive Strength and Modulus of Elasticity

Project No.: 30720-2-5400
Project Name: North Anna ESP

Boring No.	Depth (ft)	MACTEC Lab ID #	Unconfined Compressive Strength (psi)	Modulus of Elasticity, psi	Poisson's Ratio
B-805	41.3-41.9	001639	3,400	336,000*	0.15*
B-804	38.9-39.9	001640	27,150		
B-804	43.5-44.9	001641	25,200		
B-805	80.8-81.6	001642	4,430		
B-801	48.7-49.7	001644	28,420	8,670,000	0.27
B-804	49.9-50.5	001645	12,300	3,190,000	0.43
B-801	24.1-24.8	001646	27,210		
B-806	42.6-43.2	001648	2,720		
B-802	20.4-21.0	001649	8,640		
B-802	66.0-66.7	001650	14,710	4,613,000	0.24
B-806	25.1-25.8	001651	610		
B-803	54.1-54.7	001652	13,010		
B-803	129.4-130.1	001653	26,730		
B-802	85.3-85.9	001654	9,370		
B-803	70.4-71.1	001655	23,210	7,133,000	0.34
B-803	90.3-91.0	001656	27,590		
B-803	155.6-156.4	001657	22,030	7,173,000	0.33
B-802	44.9-45.6	001658	11,760		
B-806	64.1-64.5	001659	27,360		

Modulus of Elasticity and Poisson's ratio computed using average slope method.

* These values represent low-stress portion of stress-strain curve. Values computed over middle portion of curve indicate E = 522,000 and Poisson's Ratio of 0.54. A value of .54 suggests plastic behavour of the core at the higher stress levels.

Prepared by: [illegible] Date: 2/5/03

Checked by: SJZ Date: 2/5/03

APPENDIX B
SURVEY DATA AND TEST LOCATION PLAN

North Anna Survey Data Table

02-03-03

BORING	DONE	NAVD88 DATUM: ELEV. TO TOP OF BLUE CAP	NAVD88 DATUM: GROUND ELEVATION	BEARING (TO A END)	STATE PLANE COORDINATES (NAD83) SOUTH ZONE: NORTHING	STATE PLANE COORDINATES (NAD83) SOUTH ZONE: EASTING	STATE PLANE COORDINATES (NAD27) NORTH ZONE: NORTHING	STATE PLANE COORDINATES (NAD27) NORTH ZONE: EASTING
B-801	✓		248.9		3910351.5739	11686737.9892	144033.5657	2203739.9220
B-802	✓		271.5		3909956.9016	11686380.8110	143638.8229	2203382.8334
B-802A	✓	271.222	271.1	N 71°36'22" W	3909943.5519	11686399.2814	143625.4774	2203401.3062
B-802B	✓	271.356	271.2	N 39°11'34" W	3909945.4028	11686389.7511	143627.3262	2203391.7756
B-802C	✓	271.446	271.4	S 80°00'35" E	3909947.3175	11686379.7512	143629.2387	2203381.7756
B-803	✓		292.4		3909921.5113	11685763.7633	143603.3008	2202765.8066
B-804	✓		320.0		3909497.2390	11685134.7547	143178.9007	2202136.8990
B-805	✓		271.1		3910361.5788	11686246.9595	144043.4649	2203248.9012
B-805A	✓	271.028	271.2	S 59°19'30" E	3910364.0260	11686236.6888	144045.9099	2203238.6302
B-805B	✓	271.126	271.4	N 73°02'24" E	3910354.9867	11686240.7396	144036.8716	2203242.6828
B-805C	✓	271.016	271.3	N 77°19'54" E	3910345.9275	11686244.7671	144027.8134	2203246.7121
B-806	✓		299.2		3909416.2434	11683977.2831	143097.6599	2200979.4688
B-807	✓		310.6		3909849.0828	11683980.4378	143530.4933	2200982.5350
CPT			GROUND ELEVATION					
CPT-821 *	✓		271		3909965	11686353	143647	2203355
CPT-821A *	✓		271		3909957	11686348	143639	2203350
CPT-821B *	✓		271		3909966	11686367	143648	2203369
CPT-822	✓		271.1		3910375.4066	11686237.2013	144057.2904	2203239.1404
CPT-823 **	✓		296.3		3909850.0235	11685756.1761	143531.8125	2202758.2343
CPT-824	✓		276.1		3910054.2670	11686009.5911	143736.1071	2203011.6016
CPT-825	✓		332.5		3909477.9442	11685267.2998	143159.6345	2202269.4452
CPT-827	✓		277.1		3910688.2442	11683569.4372	144369.5540	2200571.3722
CPT-828	✓		270.0		3910652.8241	11683066.3705	144334.0281	2200068.3241
CPT-830	✓		307.5		3909848.9822	11686000.3856	143530.8236	2203002.4386
OBS. WELL		ELEV. TOP OF PVC CASING						
OW-841	✓	251.622			3910556.1514	11686804.1141	144238.1541	2203806.0030
OW-842	✓	336.740			3909034.7635	11685149.1315	142716.4352	2202151.3705
OW-843	✓	320.580			3909725.1724	11685056.8319	143406.8139	2202058.9310
OW-844	✓	273.507			3909908.8159	11686589.6454	143590.7828	2203591.6732
OW-845	✓	297.309			3909858.6642	11685741.1107	143540.4499	2202743.1674
OW-846	✓	297.270			3909845.0918	11685721.8162	143526.8736	2202723.8761
OW-847	✓	319.720			3908945.4511	11686447.6923	142627.4022	2203449.9225
OW-848	✓	284.512			3910853.3688	11686272.7632	144535.2523	2203274.6027
OW-849	✓	298.536			3910786.2446	11684731.0221	144467.7996	2201732.9106

* These points were not field located but placed by MACTEC's estimated location, the elevations were established from a field survey of the surrounding area.
** This is a field located point of the estimated location of CPT 823.
*** Virginia State Plane NAD83 (South Zone) coordinates converted to State Plane NAD27 (North Zone) using Corpscon for Windows version 5.11.08

I hereby certify that field surveys were performed in accordance with applicable project specifications (11/22/02 – 12/30/02) under my supervision to determine the values listed in this table except where noted. All data was collected directly from Louisa County Survey Control Monuments (pair # 14, monuments 2001 to 22) using the coordinates provided in Virginia State Plane, NAD83 – South Zone (U.S. Survey Foot) and the reference datum of NAVD 88. The NAD27 coordinates were derived via office computations as noted.

David R. Gardy, LS # 001751

COMMONWEALTH OF VIRGINIA
DAVID R. GARDY
No. 1751
02/03/03
LAND SURVEYOR

APPENDIX C
GEOTECHNICAL BORING LOGS, CORE BORING REPORTS, AND PHOTOGRAPHS

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of material is LARGER than No. 200 sieve size)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	GW	Well graded gravels, gravel - sand mixtures, little or no fines.
			GP	Poorly graded gravels or grave - sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel - sand - silt mixtures.
			GC	Clayey gravels, gravel - sand - clay mixtures.
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 Sieve Size)	CLEAN SANDS (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand - silt mixtures
			SC	Clayey sands, sand - clay mixtures.
FINE GRAINED SOILS (More than 50% of material is SMALLER than No. 200 sieve size)	SILTS AND CLAYS (Liquid limit LESS than 50)		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts and with slight plasticity.
			CL	Inorganic lays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (Liquid limit GREATER than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils.

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

No.200 No.40 No.10 No.4 3/4" 3" 12"

U.S. STANDARD SIEVE SIZE

Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)

	GROUP SYMBOLS	TYPICAL NAMES
ROCK	WR	Weathered Rock
	HR	Hard Rock

▽ Water Table at time of drilling ▼ Water Table after 24 hours

Correlation of Penetration Resistance with Relative Density and Consistency

SAND & GRAVEL		SILT & CLAY	
No. of Blows	Relative Density	No. of Blows	Consistency
0 - 4	Very Loose	0 - 1	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 20	Firm	5 - 8	Firm
21 - 30	Very Firm	9 - 15	Stiff
31 - 50	Dense	16 - 30	Very Stiff
Over 50	Very Dense	Over 31	Hard

KEY TO SYMBOLS AND DESCRIPTIONS

MACTEC

MACTEC
3301 Atlantic Avenue
Raleigh, NC 27604

GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-801			0 HR. 1.3
COLLAR ELEV. 248.9 ft (NAVD 88)	NORTHING 3,910,351.57 (NAD 83)	EASTING 11,686,737.99 (NAD 83)	24 HR. 1.0
TOTAL DEPTH 49.8 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 12/3/02	COMPLETED 12/4/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 20 40 60 80 100)	SAMP. NO.	SOIL AND ROCK DESCRIPTION
248.9	0.0				Ground Surface		248.9 0.00
248.9	0.0	3	3	7	10	SS-1	Fill: Orange, brown, and tan, stiff, fine to coarse sandy, silty, CLAY (CL)
247.4	1.5	5	4	6	10	SS-2	246.9 2.0 Fill: Brown, stiff, micaceous, slightly fine sandy, SILT (ML)
245.4	3.5	4	4	6	10	SS-3	245.4 3.5 Fill: Brown and tan, loose to firm, micaceous, silty, fine to coarse SAND (SM)
242.9	6.0	5	7	9	16	SS-4	
240.4	8.5	7	7	8	15	SS-5	236.9 12.0 Fill: Brown and tan, firm, micaceous, clayey, fine to coarse sandy SILT (ML)
235.4	13.5	3	3	3	6	SS-6	
230.4	18.5	10	43	57/0.1ft	100/0.6ft	SS-7	229.9 19.0 Weathered Rock: Gray, QUARTZ GNEISS
228.9	20.0	50/0.0ft			100/0.0ft	SS-8	228.9 20.0 Hard Rock: Gray, slightly weathered to fresh, closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and trace magnetite
211.5	37.4						

MACTEC
3301 Atlantic Avenue
Raleigh, NC 27604

GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER: 30720-2-5400**	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear				
PROJECT NAME NORTH ANNA ESP						**WATER LEVEL (ft)**	
BORING NO. B-801						**0 HR.**	1.3
COLLAR ELEV. 248.9 ft **(NAVD 88)**	**NORTHING** 3,910,351.57 **(NAD 83)**	**EASTING** 11,686,737.99 **(NAD 83)**				**24 HR.**	1.0
TOTAL DEPTH 49.8 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5				
DATE STARTED 12/3/02	**COMPLETED** 12/4/02	**SURFACE WATER DEPTH** N/A					

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
211.5	37.4				Continued from previous page				
									Hard Rock: Gray, slightly weathered to fresh, closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and trace magnetite *(continued)*
199.1	49.8								Boring and Coring terminated at 49.8 ft in Hard Rock: Very slightly weathered to fresh, moderately closely fractured, very hard, Quartz Gneiss with biotite (5%) and trace magnetite Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/13/02
174.1	74.8								

BECHTEL 5400. NC DOT.GDT 2/4/03

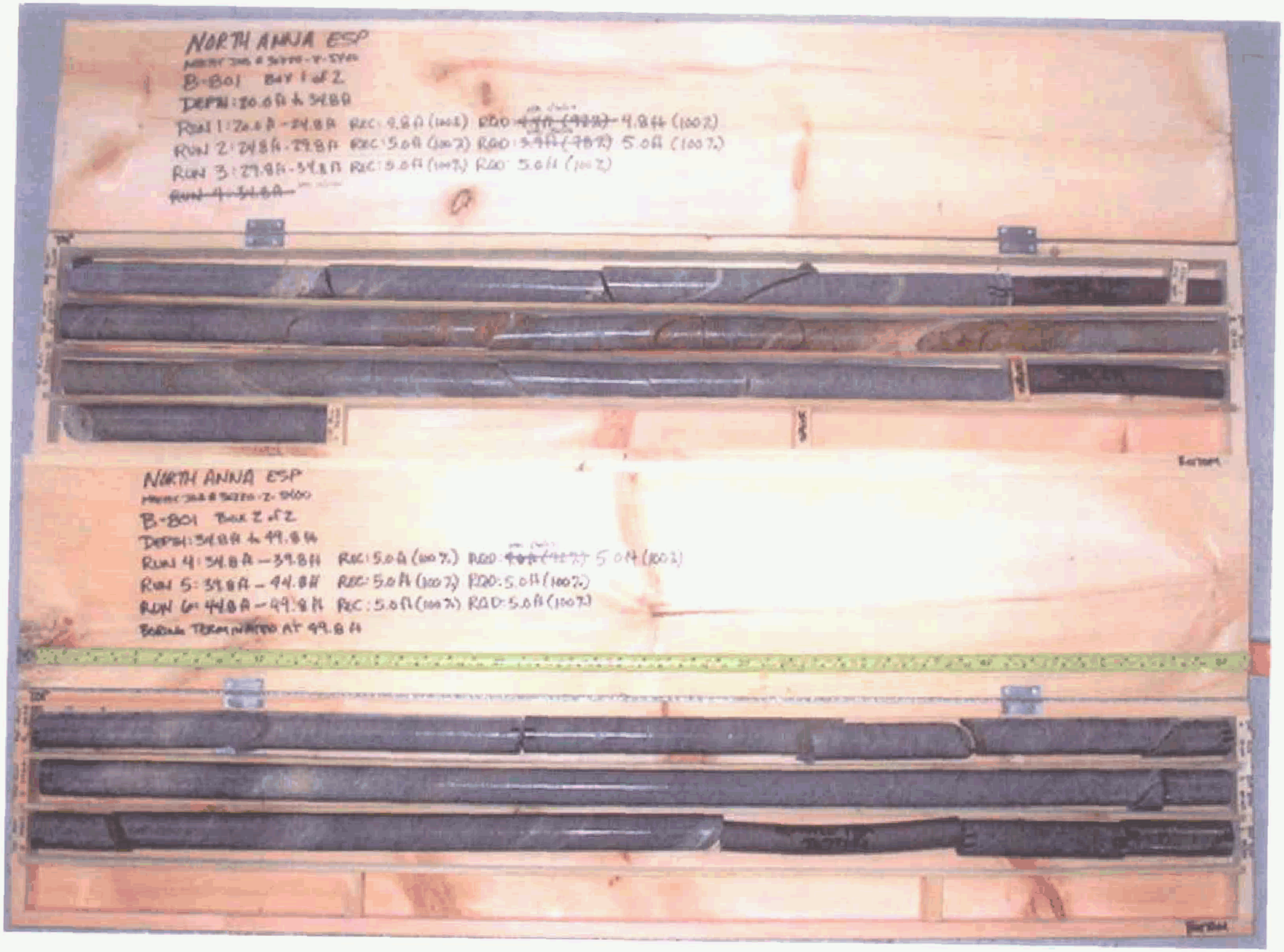
MACTEC
3301 ATLANTIC AVENUE
RALEIGH, NC 27604

CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-801			**0 HR.** 1.3
COLLAR ELEV. 248.9 ft **(NAVD 88)**	**NORTHING** 3,910,351.57 **(NAD 83)**	**EASTING** 11,686,737.99 **(NAD 83)**	**24 HR.** 1.0
TOTAL DEPTH 49.8 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/3/02	**COMPLETED** 12/4/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 29.8 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 20.0 ft
228.9	20.0	4.8	3:36 4:19 5:54 5:17 2:51/0.8	(4.8) 100%	(4.8) 100%	RUN 1				228.9 Hard Rock: Gray, slightly weathered to fresh, closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and trace magnetite (2 joints at 30-35° with trace clay; 1 joint at 70° with trace clay; 2 coarse quartz and potassic feldspar veins at 60° with gradational margins from 20.9ft to 21.3ft and 22.2ft to 22.8ft) 20.0
224.1	24.8	5.0	3:19 3:18 3:31 3:35 3:40	(5.0) 100%	(5.0) 100%	RUN 2				(4 joints at 70° with clay and orange Fe stain; 1 joint at 30° with orange Fe stain)
219.1	29.8	5.0	3:55 4:01 5:50 5:51 8:26	(5.0) 100%	(5.0) 100%	RUN 3				(5 joints at 40-50° with trace clay; 1 joint at 20° with trace clay)
214.1	34.8	5.0	13:12 9:34 3:26 3:29 5:25	(5.0) 100%	(5.0) 100%	RUN 4				(2 joints at 40° with clay, quartz, and orange Fe stain; 2 joints at 60-70° with trace clay)
209.1	39.8	5.0	4:26 3:50 3:58 3:40 3:55	(5.0) 100%	(5.0) 100%	RUN 5				(1 joint at 40° with trace clay)
204.1	44.8	5.0	3:49 4:51 4:23 5:00 6:14	(5.0) 100%	(5.0) 100%	RUN 6				(2 joints at 30-40° with trace clay and orange Fe stain)
199.1	49.8									199.1 49.8
										Boring and Coring terminated at 49.8 ft in Hard Rock: Very slightly weathered to fresh, moderately closely fractured, very hard, Quartz Gneiss with biotite (5%) and trace magnetite Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/13/02


NORTH ANNA ESP
B-B01
DEPTH: 20.0 ft to 34.8 ft
RUN 1: 20.0 ft - 24.8 ft REC: 4.8 ft (100%) RQD: 4.8 ft (100%)
RUN 2: 24.8 ft - 29.8 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 3: 29.8 ft - 34.8 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
NORTH ANNA ESP
B-801 Box 2 of 2
DEPTH: 34.8 ft to 49.8 ft
RUN 4: 34.8 ft - 39.8 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 5: 39.8 ft - 44.8 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 6: 44.8 ft - 49.8 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
BORING TERMINATED AT 49.8 ft

MACTEC
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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER: 30720-2-5400**	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-802			**0 HR.** 5.2
COLLAR ELEV. 271.5 ft **(NAVD 88)**	**NORTHING** 3,909,956.90 **(NAD 83)**	**EASTING** 11,686,380.81 **(NAD 83)**	**24 HR.** 3.4
TOTAL DEPTH 90.0 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/9/02	**COMPLETED** 12/10/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0–100)	SAMP. NO.
271.5	0.0				Ground Surface	
270.5	1.0	26	22	14	36	SS-1
267.8	3.7	15	22	22	44	SS-2
265.5	6.0	12	38	62/0.2ft	100/0.7ft	SS-3
263.2	8.3	50/0.0ft			100/0.0ft	SS-4
234.1	37.4					

SOIL AND ROCK DESCRIPTION

271.5 — 0.00
Fill: Gray, dense, silty, fine to coarse sandy, GRAVEL (GM)

268.5 — 3.0
Residual: Tan and gray, dense, slightly micaceous, silty, fine to coarse SAND (SM)

265.5 — 6.0
Weathered Rock: Brown, BIOTITE QUARTZ GNEISS

263.2 — 8.3
Hard Rock: Gray with tan, orange, and brown Fe stain, moderately severe to moderately weathered, very closely to closely fractured, moderately hard to hard, BIOTITE QUARTZ GNEISS

245.9 — 25.6
Hard Rock: Dark gray, slightly weathered to fresh, very closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS

BECHTEL 5400A C DOT.GDT 2/4/03

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear	
PROJECT NAME NORTH ANNA ESP				WATER LEVEL (ft)
BORING NO. B-802				0 HR. 5.2
COLLAR ELEV. 271.5 ft (NAVD 88)	NORTHING 3,909,956.90 (NAD 83)	EASTING 11,686,380.81 (NAD 83)		24 HR. 3.4
TOTAL DEPTH 90.0 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5	
DATE STARTED 12/9/02	COMPLETED 12/10/02	SURFACE WATER DEPTH N/A		

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
234.1	37.4				Continued from previous page				
									Hard Rock: Dark gray, slightly weathered to fresh, very closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS *(continued)*
215.5	56.0								Hard Rock: Gray and pink, locally with orange Fe stain, slightly weathered, very closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
200.2	71.3								Hard Rock: Dark gray, very slightly weathered to fresh, closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS
196.7	74.8								

BECHTEL 5400. NC DOT.GDT 2/4/03

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-802			**0 HR.** 5.2
COLLAR ELEV. 271.5 ft (NAVD 88)	**NORTHING** 3,909,956.90 (NAD 83)	**EASTING** 11,686,380.81 (NAD 83)	**24 HR.** 3.4
TOTAL DEPTH 90.0 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/9/02	**COMPLETED** 12/10/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
196.7	74.8				Continued from previous page				
									Hard Rock: Dark gray, very slightly weathered to fresh, closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS *(continued)*
									186.6 — 84.9
									Hard Rock: Gray, slightly to very slightly weathered, closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
									181.5 — 90.0
									Boring and Coring terminated at 90.0 ft in Hard Rock: Slightly to very slightly weathered, closely to moderately closely fractured, hard, Quartz Gneiss with biotite (5%)
159.3	112.2								

Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated)

Drilling Fluid: Water

Borehole filled by grouting 12/13/02

BECHTEL 5400A DOT.GDT 2/4/03

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RALEIGH, NC 27604

CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-802			**0 HR.** 5.2
COLLAR ELEV. 271.5 ft (NAVD 88)	**NORTHING** 3,909,956.90 (NAD 83)	**EASTING** 11,686,380.81 (NAD 83)	**24 HR.** 3.4
TOTAL DEPTH 90.0 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/9/02	**COMPLETED** 12/10/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 81.7 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 8.3 ft
263.2 261.6	8.3 9.9	1.6	2:29 1:19/0.6	(1.6) 100%	(0.5) 31%	RUN 1				263.2 Hard Rock: Gray with tan, orange, and brown Fe stain, moderately severe to moderately weathered, very closely to closely fractured, moderately hard to hard, BIOTITE QUARTZ GNEISS 8.3 (5 joints at 50-60° with clay and orange Fe stain)
256.6	14.9	5.0	1:43 1:40 2:03 1:53 1:48	(4.3) 86%	(2.1) 42%	RUN 2				(11 joints at 50-60° with clay and orange Fe stain; 5 joints at 0-10° with clay and orange Fe stain; Severely weathered fracture zone with no recovery from 11.3ft to 12.0ft)
251.6	19.9	5.0	1:15 1:22 1:05 1:17 1:15	(4.0) 80%	(2.3) 46%	RUN 3				(9 joints at 50-60° with clay and orange Fe stain; Severely weathered fracture zone with no recovery from 17.6ft to 18.6ft)
246.6	24.9	5.0	1:04 1:00 1:11 1:20 1:45	(4.5) 90%	(3.6) 72%	RUN 4				(5 joints at 50-60° with brown Fe stain; 2 joints at 0-10° with brown Fe stain; Severely weathered fracture zone with no recovery from 24.4ft to 24.9ft)
241.6	29.9	5.0	2:11 1:32 1:24 1:24 1:30	(4.8) 96%	(3.9) 78%	RUN 5				245.9 (5 joints at 50-60° with brown and orange Fe stain; 1 joint at 70-80° with orange Fe stain) 25.6 Hard Rock: Dark gray, slightly weathered to fresh, very closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS
236.6	34.9	5.0	1:31 1:38 1:33 1:53 1:56	(5.0) 100%	(4.4) 88%	RUN 6				(10 joints at 40-50° with trace orange Fe stain)
231.6	39.9	5.0	1:17 1:19 1:34 1:50 1:33	(4.4) 88%	(4.2) 84%	RUN 7				(1 joint at 68° with clay and quartz; Severely weathered fracture zone with no recovery from 37.9ft to 38.5ft)
226.6	44.9	5.0	1:27 1:55 1:45 2:01 1:53	(5.0) 100%	(3.3) 66%	RUN 8				(11 joints at 0-10° with trace clay and brown Fe stain; 4 joints at 50-60° with trace clay; 1 joint at 70° with clay and chlorite)
		5.0	1:54	(5.0)	(4.8)	RUN 9				(3 joints at 40-50° with trace clay, chlorite, and red and orange Fe stain)

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CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-802			**0 HR.** 5.2
COLLAR ELEV. 271.5 ft **(NAVD 88)**	**NORTHING** 3,909,956.90 **(NAD 83)**	**EASTING** 11,686,380.81 **(NAD 83)**	**24 HR.** 3.4
TOTAL DEPTH 90.0 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/9/02	**COMPLETED** 12/10/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 81.7 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
			1:42	100%	96%					Hard Rock: Dark gray, slightly weathered to fresh, very closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS *(continued)*
			1:43							
			1:48							
			1:56							
221.6	49.9	5.0	1:32	(5.0) 100%	(5.0) 100%	RUN 10				(1 joint at 60°)
			1:34							
			1:39							
			1:36							
			1:43							(4 joints at 50-60° with brown Fe stain; 4 joints at 30-40° with brown Fe stain)
216.6	54.9	5.0	1:14	(5.0) 100%	(4.0) 80%	RUN 11				215.5 56.0
			1:42							Hard Rock: Gray and pink, locally with orange Fe stain, slightly weathered, very closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
			1:58							
			2:17							
			2:15							
211.6	59.9	5.0	1:37	(5.0) 100%	(3.6) 72%	RUN 12				(6 joints at 30-40° with trace clay; 2 joints at 50-60° with brown Fe stain; 1 joint at 70° with clay, quartz, and red Fe stain)
			1:43							
			1:40							
			2:20							
			2:51							
206.6	64.9	5.0	2:40	(5.0) 100%	(4.0) 80%	RUN 13				(5 joints at 30-40° with orange Fe stain; 4 joints at 0-10° with trace clay; 1 joint at 60° with clay, quartz, and orange Fe stain)
			2:45							
			2:43							
			2:36							
			2:55							(3 joints at 40-50° with trace clay)
201.6	69.9	5.0	2:35	(5.0) 100%	(4.8) 96%	RUN 14				200.2 71.3
			2:52							Hard Rock: Dark gray, very slightly weathered to fresh, closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS
			2:43							
			2:45							
			2:15							
196.6	74.9	5.0	1:23	(5.0) 100%	(3.6) 72%	RUN 15				(11 joints at 30-40° with brown Fe stain; 2 joints at 50-60° with trace clay)
			1:27							
			1:21							
			1:18							
			1:05							
191.6	79.9	5.0	1:13	(5.0) 100%	(4.5) 90%	RUN 16				(4 joints at 30-40° with trace clay and orange Fe stain; 2 joints at 60-70° with trace clay and chlorite)
			1:18							
			1:19							

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CORE BORING REPORT

BECHTEL

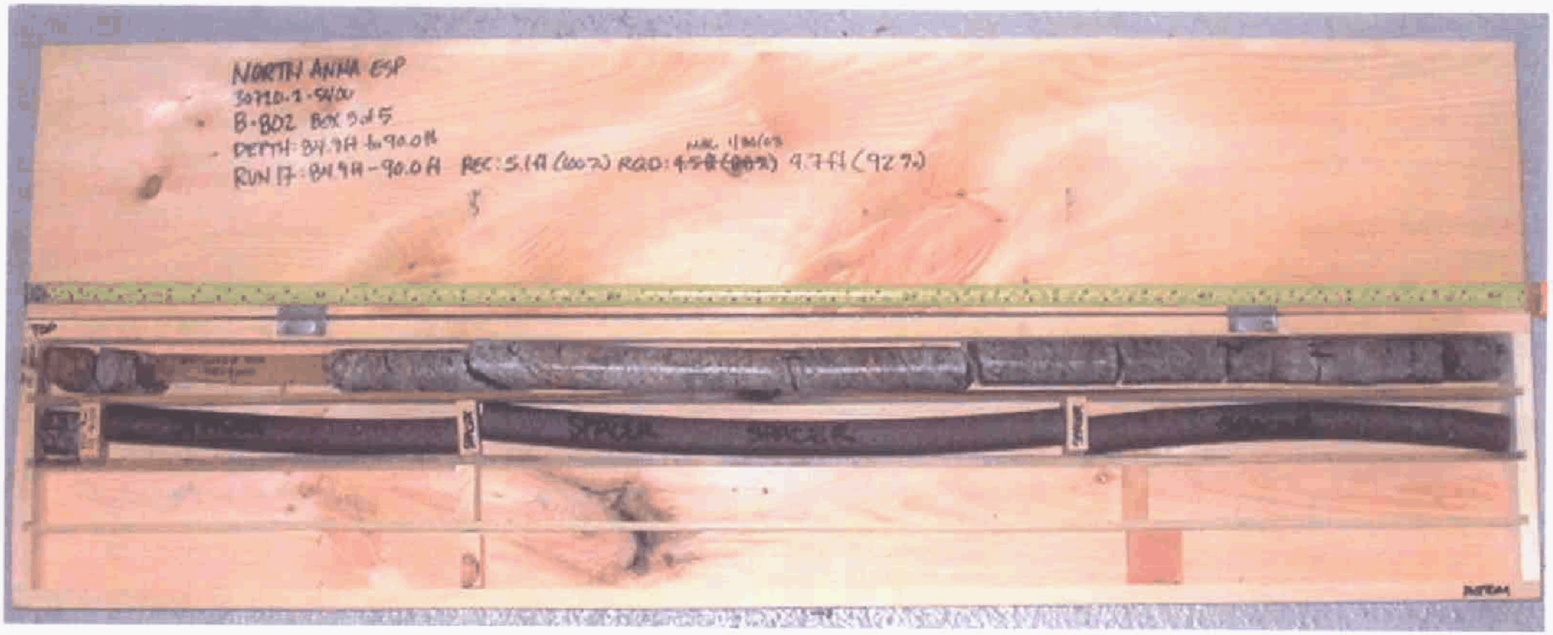
BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-802			**0 HR.** 5.2
COLLAR ELEV. 271.5 ft **(NAVD 88)**	**NORTHING** 3,909,956.90 **(NAD 83)**	**EASTING** 11,686,380.81 **(NAD 83)**	**24 HR.** 3.4
TOTAL DEPTH 90.0 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/9/02	**COMPLETED** 12/10/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 81.7 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
186.6	84.9		1:20 1:20							Hard Rock: Dark gray, very slightly weathered to fresh, closely to moderately closely fractured, hard, BIOTITE QUARTZ GNEISS *(continued)* 186.6 84.9
181.5	90.0	5.1	1:24 1:21 1:23 1:30 1:57/1.1	(5.1) 100%	(4.7) 92%	RUN 17				Hard Rock: Gray, slightly to very slightly weathered, closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%) (4 joints at 30-40°; 1 joint at 70° with chlorite) 181.5 90.0
										Boring and Coring terminated at 90.0 ft in Hard Rock: Slightly to very slightly weathered, closely to moderately closely fractured, hard, Quartz Gneiss with biotite (5%) Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/13/02

BECHTEL CORE1 LC ...A.GPJ NC DOT.GDT 2/3/03


NORTH ANNA ESP
30790-7-5400
B-802 BOX 1 of 5
DEPTH: 8.3ft to 24.9ft
RUN 1: 8.3ft - 9.9ft REC: 1.6ft (100%) RQD: 0.5ft (31%)
RUN 2: 9.9ft - 14.9ft REC: 4.3ft (86%) RQD: 2.1ft (42%)
RUN 3: 14.9ft - 19.9ft REC: 4.0ft (80%) RQD: 2.3ft (46%)
RUN 4: 19.9ft - 24.9ft REC: 4.5ft (90%) RQD: 3.6ft (72%)
TOP
BOTTOM
NORTH ANNA ESP
30790-7-5400
B-802 BOX 2 of 5
DEPTH: 24.9ft to 44.9ft
RUN 5: 24.9ft - 29.9ft REC: 4.8ft (96%) RQD: ~~3.9ft (90%)~~ 3.9ft (78%)
RUN 6: 29.9ft - 34.9ft REC: 5.0ft (100%) RQD: 4.4ft (88%)
RUN 7: 34.9ft - 39.9ft REC: 4.4ft (88%) RQD: 4.2ft (82%)
RUN 8: 39.9ft - 44.9ft REC: 5.0ft (100%) RQD: ~~2.7ft (54%)~~ 3.3ft (66%)
TOP
BOTTOM


NORTH ANNA ESP
30720-2-5400
B-802 BOX 3 of 5
DEPTH: 44.9 ft to 64.9 ft
RUN 9: 44.9 ft – 49.9 ft REC: 5.0 ft (100%) RQD: 4.8 ft (96%)
RUN 10: 49.9 ft – 54.9 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 11: 54.9 ft – 59.9 ft REC: 5.0 ft (100%) RQD: 4.0 ft (80%)
RUN 12: 59.9 ft – 64.9 ft REC: 5.0 ft (100%) RQD: 3.6 ft (72%)
TOP
BOTTOM
NORTH ANNA ESP
30720-2-5400
B-802 BOX 4 of 5
DEPTH: 64.9 ft to 84.9 ft
RUN 13: 64.9 ft – 69.9 ft REC: 5.0 ft (100%) RQD: 4.0 ft (80%)
RUN 14: 69.9 ft – 74.9 ft REC: 5.0 ft (100%) RQD: 4.8 ft (96%)
RUN 15: 74.9 ft – 79.9 ft REC: 5.0 ft (100%) RQD: 3.6 ft (72%)
RUN 16: 79.9 ft – 84.9 ft REC: 5.0 ft (100%) RQD: 4.5 ft (90%)
TOP
BOTTOM



NORTH ANNA ESP
B-802 BOX 5 of 5
DEPTH: 84.9 ft to 90.0 ft
RUN 17: 84.9 ft - 90.0 ft REC: 5.1 ft (100%) RQD: 4.7 ft (92%)

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft (NAVD 88)	**NORTHING** 3,909,921.51 (NAD 83)	**EASTING** 11,685,763.76 (NAD 83)	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 20 40 60 80 100)	SAMP. NO.	SOIL AND ROCK DESCRIPTION
292.4	0.0				Ground Surface		292.4 — 0.00
292.4	0.0	3	5	7	12	SS-1	Residual: Brown, orange, and tan, loose, clayey, gravelly, coarse SAND (SC)
							289.9 — 2.5 Residual: Tan, dense, slightly clayey, fine to coarse sandy, GRAVEL (GP)
288.8	3.6	16	19	12	31	SS-2	
							286.9 — 5.5 Residual: Orange and tan, firm, slightly gravelly, clayey, fine to coarse SAND (SC)
286.3	6.1	5	7	7	14	SS-3	
							284.4 — 8.0 Residual: Orange, tan, whitish tan, and grayish white, firm to dense, micaceous, silty, fine to coarse SAND (SM)
283.8	8.6	11	13	9	22	SS-4	
281.3	11.1	6	6	7	13	SS-5	
278.7	13.7	10	12	11	23	SS-6	
273.8	18.6	10	9	9	18	SS-7	
268.8	23.6	14	14	17	31	SS-8	
263.8	28.6	17	14	16	30	SS-9	
							261.4 — 31.0 Weathered Rock: Gray and orange Fe stained, BIOTITE QUARTZ GNEISS
258.8	33.6	43	57/0.4ft		100/0.9ft	SS-10	
255.0	37.4						

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-803			0 HR. 20.9
COLLAR ELEV. 292.4 ft (NAVD 88)	NORTHING 3,909,921.51 (NAD 83)	EASTING 11,685,763.76 (NAD 83)	24 HR. 21.0
TOTAL DEPTH 170.3 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 11/22/02	COMPLETED 12/2/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
255.0	37.4				Continued from previous page				
253.8	38.6	50/0.5ft			100/0.5ft	SS-11			Weathered Rock: Gray and orange Fe stained, BIOTITE QUARTZ GNEISS *(continued)*
248.8	43.6	50/0.2ft			100/0.2ft	SS-12			
243.6	48.8	50/0.0ft			100/0.0ft	SS-13			243.6 — 48.8 Hard Rock: Grayish white, slightly to very slightly weathered, closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
									233.9 — 58.5 Hard Rock: Gray, very slightly weathered, closely to moderately closely fractured, very hard, QUARTZITE
									232.0 — 60.4 Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite
217.6	74.8								

BECHTEL 5400. NC DOT.GDT 2/4/03

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-803			0 HR. 20.9
COLLAR ELEV. 292.4 ft (NAVD 88)	NORTHING 3,909,921.51 (NAD 83)	EASTING 11,685,763.76 (NAD 83)	24 HR. 21.0
TOTAL DEPTH 170.3 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 11/22/02	COMPLETED 12/2/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
217.6	74.8				Continued from previous page				
									Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
180.2	112.2								

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft (NAVD 88)	**NORTHING** 3,909,921.51 (NAD 83)	**EASTING** 11,685,763.76 (NAD 83)	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
180.2	112.2				Continued from previous page				
									Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
142.8	149.6								

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GEOTECHNICAL BORING LOG

SHEET 5 OF 5

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear	
PROJECT NAME NORTH ANNA ESP				**WATER LEVEL (ft)**
BORING NO. B-803				**0 HR.** 20.9
COLLAR ELEV. 292.4 ft (NAVD 88)	**NORTHING** 3,909,921.51 (NAD 83)	**EASTING** 11,685,763.76 (NAD 83)		**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5	
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A		

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
142.8	149.6				Continued from previous page				
									Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
122.1	170.3								Boring and Coring terminated at 170.3 ft in Hard Rock: Fresh, very widely fractured, very hard, Quartz Gneiss with biotite (5%), magnetite (1%) and trace pyrite Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/9/03
105.4	187.0								

BECHTEL 5400. BECIC DOT.GDT 2/4/03

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CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft **(NAVD 88)**	**NORTHING** 3,909,921.51 **(NAD 83)**	**EASTING** 11,685,763.76 **(NAD 83)**	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 121.5 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 48.8 ft
243.6 242.0	48.8 50.4	1.6	2:38 1:08/0.6	(1.3) 81%	(1.3) 81%	RUN 1				243.6 — 48.8 Hard Rock: Grayish white, slightly to very slightly weathered, closely to moderately closely fractured, hard, QUARTZ GNEISS with Biotite (5%) (2 joints at 45° with trace clay and white mica)
237.0	55.4	5.0	2:12 1:48 2:12 2:21 2:44	(5.0) 100%	(5.0) 100%	RUN 2				(2 joints at 20° with trace clay; 1 joint at 50° with clay and orange Fe stain; 1 joint at 70° with clay and brown Fe stain)
232.0	60.4	5.0	3:02 2:24 1:10 3:18 6:17	(4.4) 88%	(3.3) 66%	RUN 3				(1 joint at 50° with clay and brown Fe stain; Severely weathered fracture zones with no recovery from 56.9ft to 57.3ft and 58.3ft to 58.5ft - **Severe water loss in these zones for duration of drilling)** 233.9 — 58.5 Hard Rock: Gray, very slightly weathered, closely to moderately closely fractured, very hard, QUARTZITE 232.0 — 60.4
227.0	65.4	5.0	1:53 2:40 3:52 4:25 5:00	(5.0) 100%	(5.0) 100%	RUN 4				Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite (1 joint at 60° with trace clay, white mica, and brown Fe stain; 2 joints at 30-35° with white mica and orange Fe stain)
222.0	70.4	5.0	4:13 4:33 5:16 4:56 5:59	(5.0) 100%	(4.4) 88%	RUN 5				(7 joints at 0-10° with white mica and orange Fe stain; 1 joint at 30° with white mica)
217.1	75.3	4.9	6:27 5:40 5:44 6:02 8:21/0.9	(4.9) 100%	(4.5) 92%	RUN 6				(3 joints at 0-10° with white mica and orange Fe stain; 2 joints at 30-35° with white mica and orange Fe stain; 1 joint at 60° with clay and brown Fe stain)
212.1	80.3	5.0	6:36 7:43 7:55 10:05 12:53	(5.0) 100%	(5.0) 100%	RUN 7				(1 joint at 40° with clay and orange Fe stain; 2 joints at 70° with clay, orange Fe stain, and Mn oxide; 1 joint at 80-85° with orange Fe stain)
207.1	85.3	5.0	1:45 1:53 3:00 2:56 2:25	(4.9) 98%	(4.4) 88%	RUN 8				(3 joints at 0-10° with white mica, clay, and brown Fe stain; 1 joint at 45° with brown Fe stain; 1 joint at 75° orange Fe stain; Severely weathered fracture zone from 81.0ft to 81.3ft)
		5.0	2:41	(5.0)	(5.0)	RUN 9				(1 joint at 70° with trace clay)

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft **(NAVD 88)**	**NORTHING** 3,909,921.51 **(NAD 83)**	**EASTING** 11,685,763.76 **(NAD 83)**	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 121.5 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
202.1	90.3		2:58 2:21 3:35 3:53	100%	100%					Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
197.1	95.3	5.0	3:04 3:47 7:56 6:05 6:26	(5.0) 100%	(5.0) 100%	RUN 10				(1 joint at 75° with clay and chlorite)
192.1	100.3	5.0	7:13 8:11 8:09 9:45 15:22	(5.0) 100%	(5.0) 100%	RUN 11				(1 joint at 80-90° with trace clay and brown Fe stain; 1 joint at 50° with brown Fe stain)
191.1	101.3	1.0	29.20	(1.0) 100%	(1.0) 100%	RUN 12				(No joints)
187.1	105.3	4.0	3:07 2:08 2:07 2:08	(4.0) 100%	(4.0) 100%	RUN 13				(1 joint at 50°)
182.1	110.3	5.0	2:05 2:10 2:22 2:34 2:31	(5.0) 100%	(5.0) 100%	RUN 14				(No joints)
177.1	115.3	5.0	2:55 3:05 3:06 3:50 4:28	(5.0) 100%	(5.0) 100%	RUN 15				(1 joint at 30° with coarse white mica)
172.1	120.3	5.0	3:49 7:09 11:48 22:34 7:35	(5.0) 100%	(5.0) 100%	RUN 16				(Coarse quartz and potassium feldspar vein/zone from 115.3ft to 116.3ft at 65°)
		5.0	3:45 2:03 2:06	(5.0) 100%	(5.0) 100%	RUN 17				(1 joint at 55° with chlorite mineralization)

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CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft **(NAVD 88)**	**NORTHING** 3,909,921.51 **(NAD 83)**	**EASTING** 11,685,763.76 **(NAD 83)**	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 121.5 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
			2:38 3:04							Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
167.1	125.3	5.0	3:32 4:07 5:04 7:35 13:00	(5.0) 100%	(5.0) 100%	RUN 18				(No joints)
162.1	130.3	5.0	3:15 3:45 3:57 4:25 4:15	(5.0) 100%	(5.0) 100%	RUN 19				(No joints)
157.1	135.3	5.0	4:30 5:51 7:19 10:29 17:14	(5.0) 100%	(5.0) 100%	RUN 20				(Coarse quartz, potassium feldspar, and white mica vein/zone from 137.8ft to 138.3ft at 60° with gradational margins)
152.1	140.3	5.0	14:21 18:42 9:26 2:18 2:22	(5.0) 100%	(5.0) 100%	RUN 21				(Coarse quartz, potassium feldspar, and white mica vein/zone from 144.3ft to 144.8ft at 65° with gradational margins)
147.1	145.3	5.0	2:03 2:34 2:36 2:40 2:47	(5.0) 100%	(5.0) 100%	RUN 22				(Coarse quartz, potassium feldspar, and white mica vein/zone from 147.0ft to 147.1ft at 60° with gradational margins)
142.1	150.3	5.0	3:31 3:39 4:14 4:45 6:16	(5.0) 100%	(5.0) 100%	RUN 23				(No joints)
137.1	155.3	3.0	3:20 7:56 10:54	(3.0) 100%	(3.0) 100%	RUN 24				(No joints)
134.1	158.3	2.0	3:53 2:55	(2.0) 100%	(2.0) 100%	RUN 25				(No joints)
132.1	160.3	5.0	2:47	(5.0)	(5.0)	RUN 26				(No joints)

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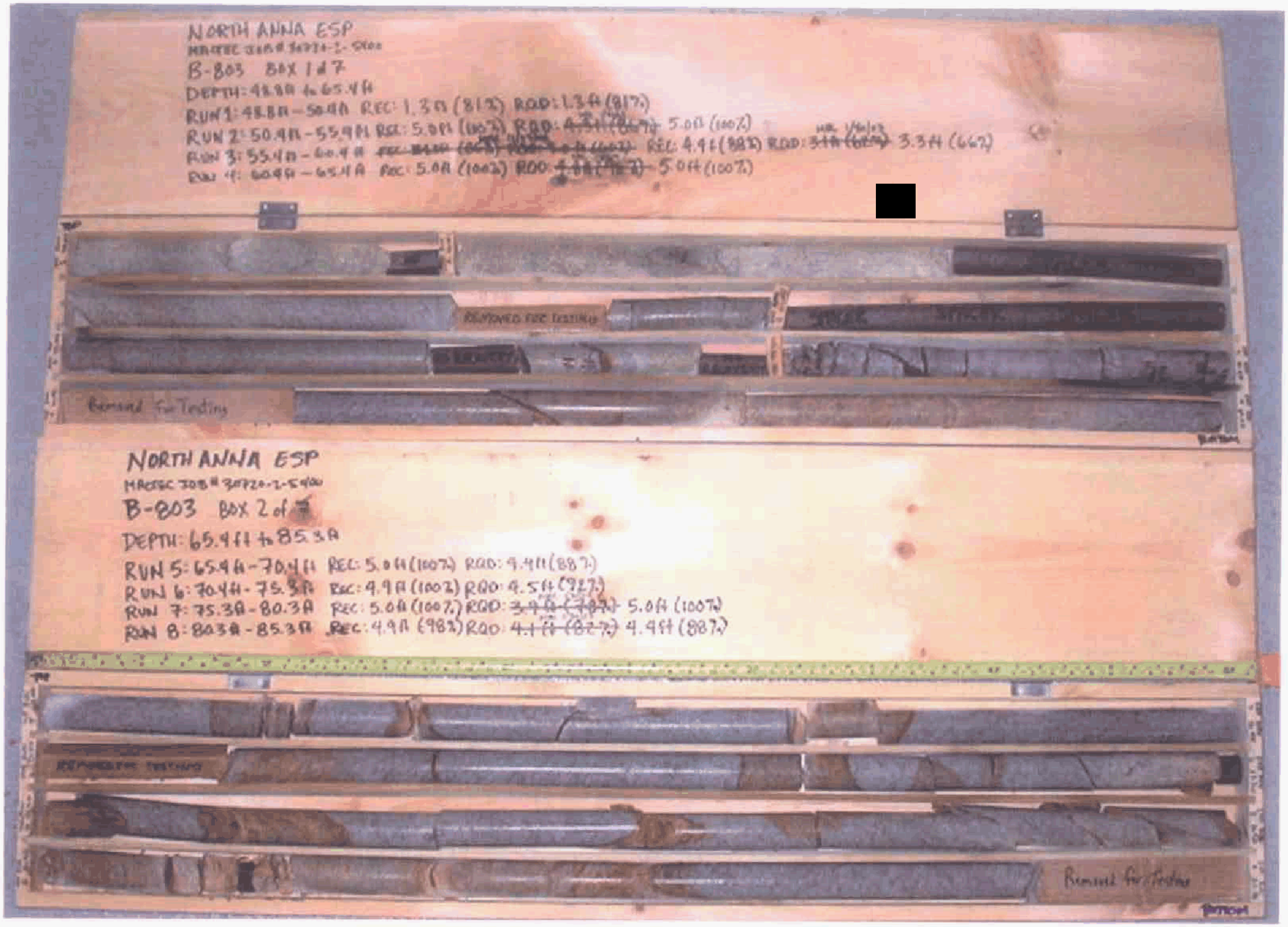
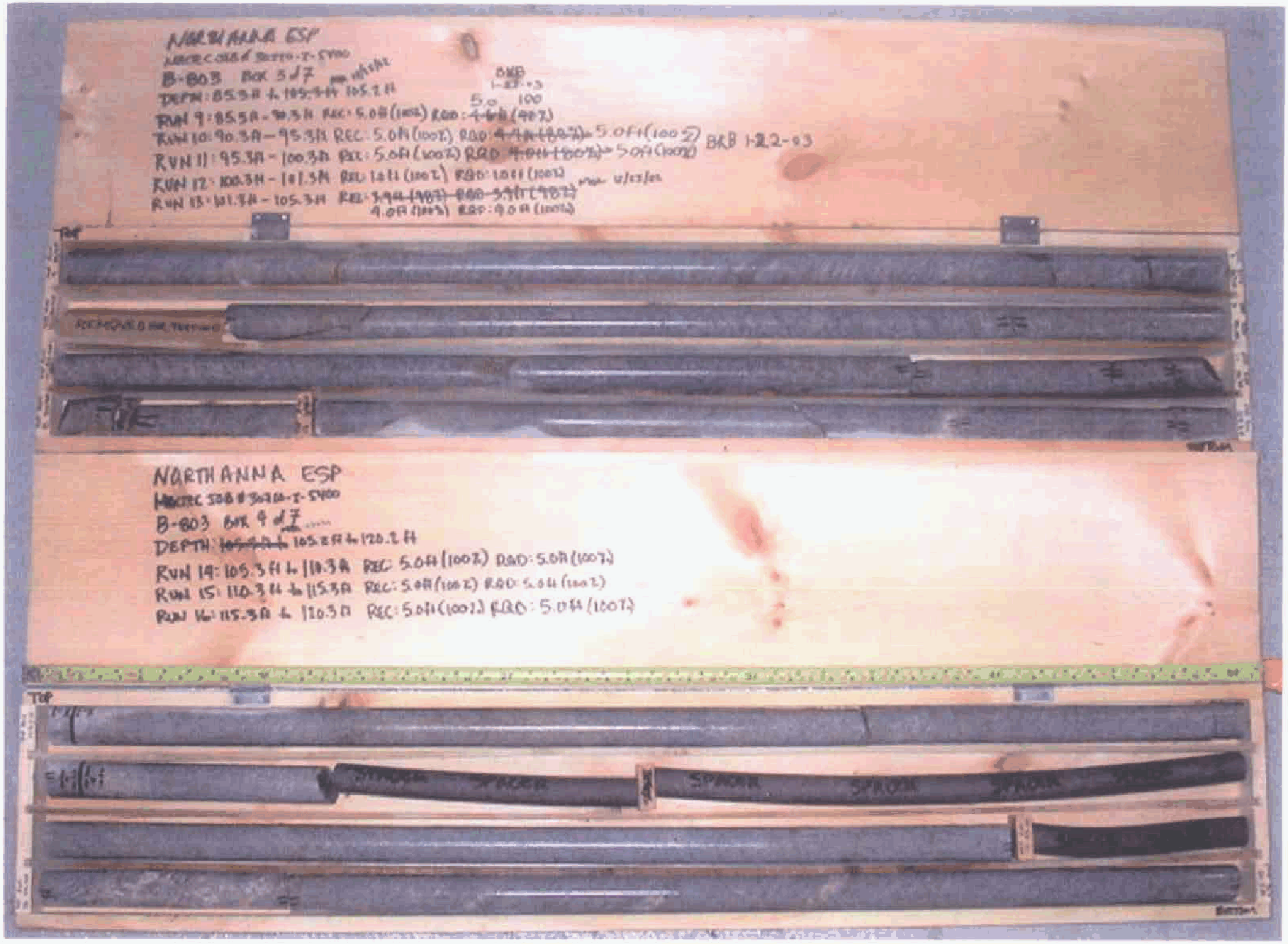
RALEIGH, NC 27604

BECHTEL

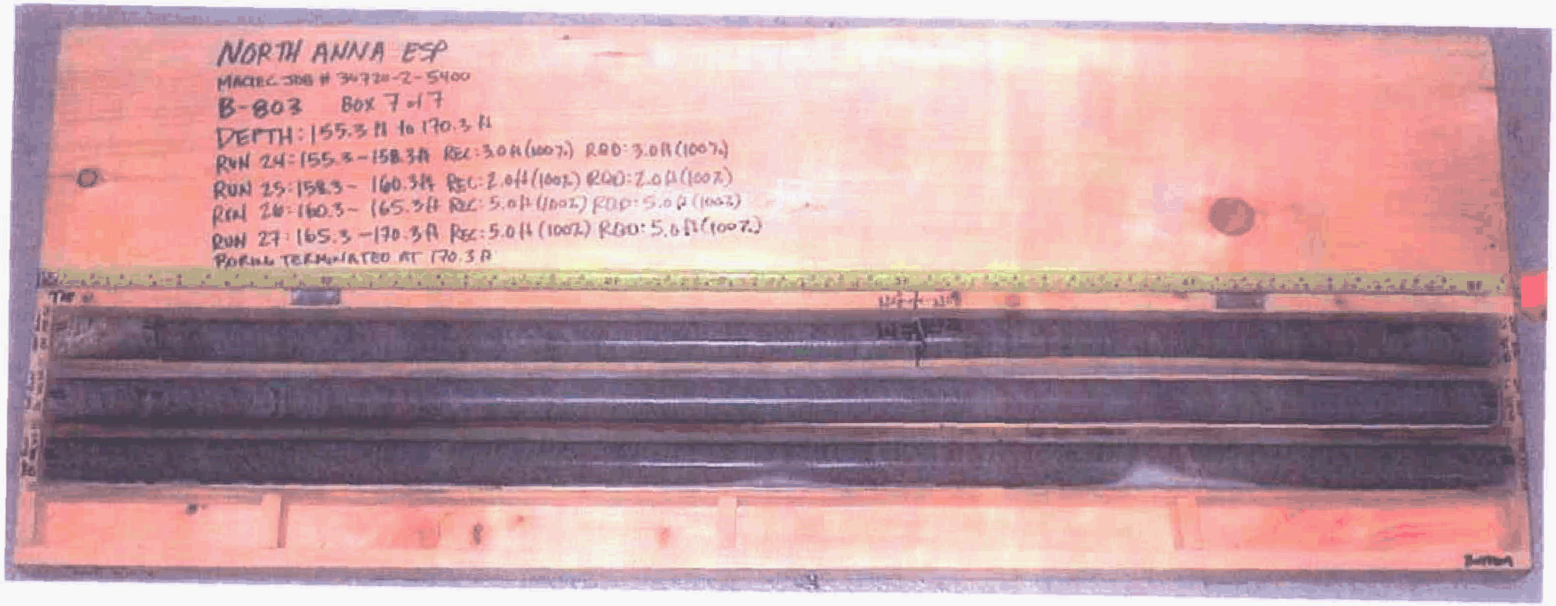
BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-803			**0 HR.** 20.9
COLLAR ELEV. 292.4 ft **(NAVD 88)**	**NORTHING** 3,909,921.51 **(NAD 83)**	**EASTING** 11,685,763.76 **(NAD 83)**	**24 HR.** 21.0
TOTAL DEPTH 170.3 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/22/02	**COMPLETED** 12/2/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 121.5 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
			2:22	100%	100%					Hard Rock: Gray and pink, locally with orange Fe stain, very slightly weathered to fresh, very closely to very widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) and trace pyrite *(continued)*
			2:19							
			2:41							
127.1	165.3		2:40							
		5.0	2:53	(5.0) 100%	(5.0) 100%	RUN 27				(No joints)
			2:57							
			3:31							
			3:45							
122.1	170.3		3:31							122.1 170.3
										Boring and Coring terminated at 170.3 ft in Hard Rock: Fresh, very widely fractured, very hard, Quartz Gneiss with biotite (5%), magnetite (1%) and trace pyrite
										Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated)
										Drilling Fluid: Water
										Borehole filled by grouting 12/9/03


NORTH ANNA ESP
B-803 BOX 1 of 7
DEPTH: 48.8ft to 65.4ft
RUN 1: 48.8ft - 50.4ft REC: 1.3ft (81%) RQD: 1.3ft (81%)
RUN 2: 50.4ft - 55.4ft REC: 5.0ft (100%) 5.0ft (100%)
RUN 3: 55.4ft - 60.4ft REC: 4.4ft (88%) 3.3ft (66%)
RUN 4: 60.4ft - 65.4ft REC: 5.0ft (100%) 5.0ft (100%)
REMOVED FOR TESTING
Removed for Testing
NORTH ANNA ESP
B-803 BOX 2 of 7
DEPTH: 65.4ft to 85.3ft
RUN 5: 65.4ft - 70.4ft REC: 5.0ft (100%) RQD: 4.4ft (88%)
RUN 6: 70.4ft - 75.3ft REC: 4.9ft (100%) RQD: 4.5ft (92%)
RUN 7: 75.3ft - 80.3ft REC: 5.0ft (100%) RQD: 5.0ft (100%)
RUN 8: 80.3ft - 85.3ft REC: 4.9ft (98%) RQD: 4.4ft (88%)
REMOVED FOR TESTING
Removed for Testing




NORTH ANNA ESP
B-803 Box 5 of 7
DEPTH: 120.2 ft to 135.3 ft
RUN 17: 120.3 ft - 125.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 18: 125.3 ft - 130.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 19: 130.3 ft - 135.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
NORTH ANNA ESP
MACTEC JOB # 30720-2-5400
B-803 Box 6 of 7
DEPTH: 135.3 ft to 155.3 ft
RUN 20: 135.3 - 140.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 21: 140.3 - 145.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 22: 145.3 - 150.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 23: 150.3 - 155.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)


NORTH ANNA ESP
MACTEC JOB # 34720-2-5400
B-803 BOX 7 of 7
DEPTH: 155.3 ft to 170.3 ft
RUN 24: 155.3 - 158.3 ft REC: 3.0 ft (100%) RQD: 3.0 ft (100%)
RUN 25: 158.3 - 160.3 ft REC: 2.0 ft (100%) RQD: 2.0 ft (100%)
RUN 26: 160.3 - 165.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
RUN 27: 165.3 - 170.3 ft REC: 5.0 ft (100%) RQD: 5.0 ft (100%)
BORING TERMINATED AT 170.3 ft
BOTTOM

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GEOTECHNICAL BORING LOG

SHEET 1 OF 2

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-804			0 HR. 26.3
COLLAR ELEV. 320.0 ft (NAVD 88)	NORTHING 3,909,497.24 (NAD 83)	EASTING 11,685,134.75 (NAD 83)	24 HR. 28.6
TOTAL DEPTH 59.9 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 12/4/02	COMPLETED 12/6/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 20 40 60 80 100)	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
320.0	0.0				Ground Surface				320.0 0.00
320.0	0.0	4	5	8	13	SS-1			Residual: Reddish brown, stiff, slightly gravelly, slightly sandy, CLAY (CL)
318.5	1.5	7	6	7	13	SS-2			318.5 1.5 Residual: Brown, stiff, micaceous, fine sandy, SILT (ML)
316.5	3.5	4	3	3	6	SS-3			
314.0	6.0	2	3	3	6	SS-4			315.0 5.0 Residual: Brown, orangish brown, gray, and tan, loose to very firm, micaceous, slightly clayey, silty, fine to medium SAND (SM) with relict rock fabric
311.5	8.5	2	2	3	5	SS-5			
309.0	11.0	3	2	3	5	SS-6			
306.5	13.5	2	3	6	9	SS-7			
301.5	18.5	11	12	12	24	SS-8			
296.5	23.5	50/0.4ft			100/0.4ft	SS-9			297.5 22.5 Weathered Rock: Gray, QUARTZ GNEISS
291.5	28.5	50/0.3ft			100/0.3ft	SS-10			
286.6	33.4	50/0.0ft			100/0.0ft	SS-11			286.6 33.4 Hard Rock: Tan and gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, QUARTZ GNEISS with Biotite (5%)
									285.4 34.6 Weathered Rock: No recovery - Interpreted as QUARTZ GNEISS
									284.7 35.3 Hard Rock: Gray, locally with tan and orange
282.6	37.4								

BECHTEL 5400 NC DOT.GDT 2/4/03

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-804			**0 HR.** 26.3
COLLAR ELEV. 320.0 ft **(NAVD 88)**	**NORTHING** 3,909,497.24 **(NAD 83)**	**EASTING** 11,685,134.75 **(NAD 83)**	**24 HR.** 28.6
TOTAL DEPTH 59.9 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/4/02	**COMPLETED** 12/6/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
282.6	37.4				Continued from previous page				
									Fe stain, very slightly weathered to fresh, moderately closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) Hard Rock: Gray, locally with tan and orange Fe stain, very slightly weathered to fresh, moderately closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) *(continued)*
260.1	59.9								Boring and Coring terminated at 59.9 ft in Hard Rock: Very slightly weathered to fresh, widely fractured, very hard, Quartz Gneiss with biotite (5%) and magnetite (1%) Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/17/02
245.2	74.8								

BECHTEL 5406 NC DOT.GDT 2/4/03

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RALEIGH, NC 27604

CORE BORING REPORT
SHEET 1 OF 1

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME: NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-804			0 HR. 26.3
COLLAR ELEV. 320.0 ft (NAVD 88)	NORTHING 3,909,497.24 (NAD 83)	EASTING 11,685,134.75 (NAD 83)	24 HR. 28.6
TOTAL DEPTH 59.9 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 12/4/02	COMPLETED 12/6/02	SURFACE WATER DEPTH N/A	
CORE SIZE NQ	TOTAL RUN 26.5 ft	DRILLER K. Pendley	

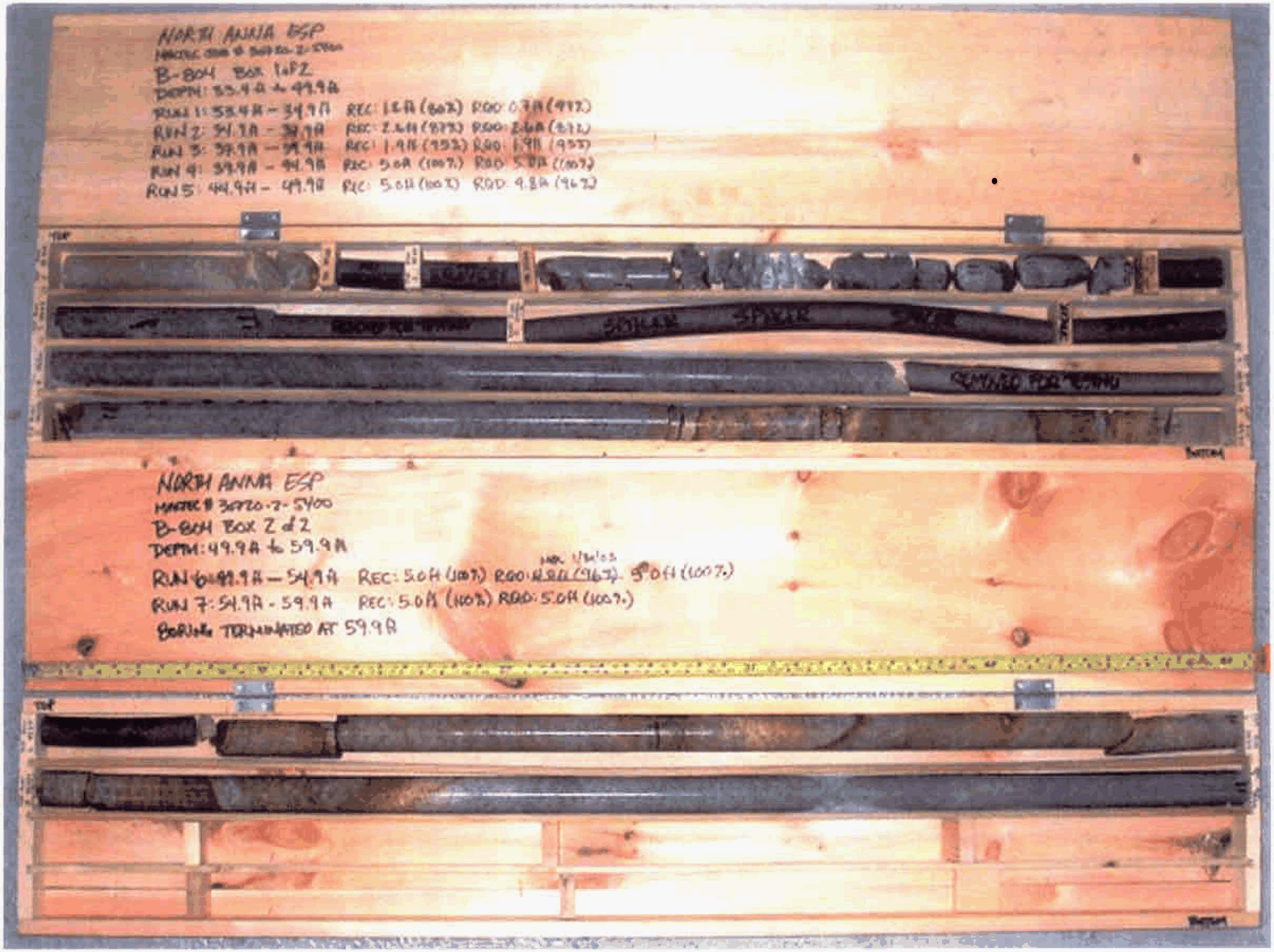
ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 33.4 ft
286.6	33.4	1.5	1:43	(1.2) 80%	(0.7) 47%	RUN 1				286.6 Hard Rock: Tan and gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, QUARTZ GNEISS with Biotite (5%) 33.4
285.1	34.9		0:50/0.5							285.4 Weathered Rock: No recovery - Interpreted as QUARTZ GNEISS 34.6
		3.0	2:50 2:53 3:01	(2.6) 87%	(2.6) 87%	RUN 2				284.7 Hard Rock: Gray, locally with tan and orange Fe stain, very slightly weathered to fresh, moderately closely to widely fractured, hard to very hard, QUARTZ GNEISS with Biotite (5%) and Magnetite (trace to 1%) 35.3
282.1	37.9	2.0	2:19 2:37	(1.9) 95%	(1.9) 95%	RUN 3				(No Joints)
280.1	39.9	5.0	1:25 1:25 1:29 1:44 1:40	(5.0) 100%	(5.0) 100%	RUN 4				(2 joints at 40-50° with trace clay, white mica, and orange Fe stain)
275.1	44.9	5.0	2:07 2:31 2:14 1:43 1:33	(5.0) 100%	(4.8) 96%	RUN 5				(5 joints at 0-10° with trace clay and orange Fe stain)
270.1	49.9	5.0	1:21 1:35 1:34 1:52 1:54	(5.0) 100%	(5.0) 100%	RUN 6				(2 joints at 55° with orange Fe stain)
265.1	54.9	5.0	1:45 2:04 1:54 2:00 2:14	(5.0) 100%	(5.0) 100%	RUN 7				(1 joint at 10° with trace clay)
260.1	59.9									260.1 59.9

Boring and Coring terminated at 59.9 ft in Hard Rock: Very slightly weathered to fresh, widely fractured, very hard, Quartz Gneiss with biotite (5%) and magnetite (1%)

Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated)

Drilling Fluid: Water

Borehole filled by grouting 12/17/02


NORTH ANNA ESP
B-804 BOX 1 of 2
NORTH ANNA ESP
MACTEC # 30720-2-5400
B-804 BOX 2 of 2
DEPTH: 49.9ft to 59.9ft
RUN 7: 54.9ft - 59.9ft REC: 5.0ft (100%) RQD: 5.0ft (100%)
BORING TERMINATED AT 59.9ft

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-805			0 HR. 10.6
COLLAR ELEV. 271.1 ft (NAVD 88)	NORTHING 3,910,361.58 (NAD 83)	EASTING 11,686,246.96 (NAD 83)	24 HR. 9.6
TOTAL DEPTH 90.1 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Mud Rotary/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 11/20/02	COMPLETED 11/22/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	BLOWS PER FOOT	SAMP. NO.
271.1	0.0				Ground Surface	
271.1	0.0	3	6	6	12	SS-1
268.6	2.5	8	11	9	20 (No Recovery)	SS-2
266.2	4.9	6	7	7	14	SS-3
263.6	7.5	5	7	10	17	SS-4
260.5	10.6	12	12	13	25	SS-5
257.6	13.5	18	19	19	38	SS-6
252.6	18.5	11	14	20	34	SS-7
247.6	23.5	44	56/0.2ft		100/0.7ft	SS-8
242.7	28.4	50/0.05ft			100/0.05ft	SS-9
233.7	37.4					

SOIL AND ROCK DESCRIPTION

Elev.	Description	Depth
271.1	Residual: Orange and tan, stiff to very stiff, micaceous, slightly sandy, SILT (ML)	0.00
266.6	Residual: Black, red, orange and white, micaceous, stiff to hard, slightly sandy, SILT (ML) with relict rock fabric	4.5
263.6	Residual: Black, orange, and white, dense to very dense, micaceous, silty, fine SAND (SM) with relict rock fabric	7.5
242.7	Weathered Rock: Black and orange Fe stained, BIOTITE GNEISS	28.4
240.0	Hard Rock: Black and white, slightly weathered, closely fractured, moderately hard, BIOTITE GNEISS	31.1
238.9	Weathered Rock: Partial recovery, BIOTITE GNEISS	32.2
235.5	Hard Rock: Black and white, moderately weathered, very closely to closely fractured, medium to moderately hard, BIOTITE GNEISS	35.6
234.3		36.8

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BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-805			0 HR. 10.6
COLLAR ELEV. 271.1 ft (NAVD 88)	NORTHING 3,910,361.58 (NAD 83)	EASTING 11,686,246.96 (NAD 83)	24 HR. 9.6
TOTAL DEPTH 90.1 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Mud Rotary/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 11/20/02	COMPLETED 11/22/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
233.7	37.4				Continued from previous page				
									Weathered Rock: No recovery - Interpreted as BIOTITE GNEISS *(continued)*
									232.4 ——— 38.7
									Hard Rock: Gray, black, and white, moderately to very slightly weathered, very closely to moderately closely fractured, moderately hard to hard, locally slightly schistose, BIOTITE GNEISS
196.3	74.8								196.5 ——— 74.6

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GEOTECHNICAL BORING LOG

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BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-805			0 HR. 10.6
COLLAR ELEV. 271.1 ft (NAVD 88)	NORTHING 3,910,361.58 (NAD 83)	EASTING 11,686,246.96 (NAD 83)	24 HR. 9.6
TOTAL DEPTH 90.1 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Mud Rotary/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 11/20/02	COMPLETED 11/22/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
196.3	74.8				Continued from previous page				
									195.4 Weathered Rock: No recovery - Interpreted as BIOTITE GNEISS *(continued)* 75.7
									Hard Rock: Gray, black, and white, moderately weathered to fresh, very closely to widely fractured, moderately hard to hard, slightly schistose, BIOTITE GNEISS
									181.0 90.1
									Boring and Coring terminated at 90.1 ft in Hard Rock: Slightly weathered to fresh, closely to moderately closely fractured, hard, slightly schistose, Biotite Gneiss Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water/Bentonite (weight unknown) Borehole filled by grouting 12/6/02
158.9	112.2								

BECHTEL 5400 NC_DOT.GDT 2/4/03

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RALEIGH, NC 27604

CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-805			**0 HR.** 10.6
COLLAR ELEV. 271.1 ft **(NAVD 88)**	**NORTHING** 3,910,361.58 **(NAD 83)**	**EASTING** 11,686,246.96 **(NAD 83)**	**24 HR.** 9.6
TOTAL DEPTH 90.1 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Mud Rotary/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/20/02	**COMPLETED** 11/22/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 61.6 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 28.5 ft
242.6	28.5	1.6	1:25	(0.0) 0%	(N/A)	RUN 1				Weathered Rock: No recovery - Interpreted as BIOTITE GNEISS
241.0	30.1		0:52/0.6							
		5.0	1:45	(2.9) 58%	(1.1) 22%	RUN 2				240.0 — 31.1
			1:08							Hard Rock: Black and white, slightly weathered, closely fractured, moderately hard, BIOTITE GNEISS — 238.9 — 32.2
			1:06							Weathered Rock: Partial recovery, BIOTITE GNEISS
			1:09							
			0:41							
236.0	35.1									
		5.0	1:40	(2.6) 52%	(0.4) 8%	RUN 3				235.5 — (2 joints at 0-10° with trace clay; 2 joints at 30-35° with trace clay; 1 joint at 20° with Quartz and Biotite; 1 joint at 50° with Quartz and Biotite) — 35.6
			1:22							234.3 — Hard Rock: Black and white, moderately weathered, very closely to closely fractured, medium to moderately hard, BIOTITE GNEISS — 36.8
			1:37							Weathered Rock: No recovery - Interpreted as BIOTITE GNEISS
			1:31							232.4 — 38.7
			2:10							Hard Rock: Gray, black, and white, moderately to very slightly weathered, very closely to moderately closely fractured, moderately hard to hard, locally slightly schistose, BIOTITE GNEISS
231.0	40.1									(14 joints at 30-35° with trace clay and Fe stain; 2 joints at 0-10°)
		5.0	1:12	(5.0) 100%	(2.8) 56%	RUN 4				
			1:28							
			1:37							
			1:45							
			1:49							
226.0	45.1									
		5.0	1:25	(4.0) 80%	(2.1) 42%	RUN 5				(7 joints at 30-35° with trace clay and Fe stain; 5 joints at 10-20°; Severely weathered fracture zone with no recovery from 48.1ft to 49.1ft)
			1:21							
			1:22							
			1:18							
			1:31							
221.0	50.1									
		5.0	1:35	(4.5) 90%	(4.1) 82%	RUN 6				(5 joints at 30-35° with trace clay; Severely weathered fracture zone with no recovery from 53.ft to 53.6ft)
			1:18							
			0:57							
			1:16							
			1:37							
216.0	55.1									
		5.0	1:12	(4.5) 90%	(3.6) 72%	RUN 7				(1 joint at 30°; 3 joints at 15-20° with trace clay and Fe stain; 0.2ft wide Quartz vein at 56.2ft; Severely weathered fracture zone with no recovery from 56.8ft to 57.3ft)
			1:00							
			1:10							
			1:39							
			1:53							
211.0	60.1									
		5.0	1:45	(4.1) 82%	(3.7) 74%	RUN 8				(5 joints at 30° with trace clay and Fe stain; 0.2ft wide coarse Quartz and Hornblende vein at 60°; Severely weathered fracture zone with no recovery from 62.9ft to 63.8ft)
			2:11							
			1:33							
			1:53							
			2:06							
206.0	65.1									
		5.0	1:56	(5.0)	(3.5)	RUN 9				(11 joints at 10-15° with clay and Fe stain; 1 joint at 60°)

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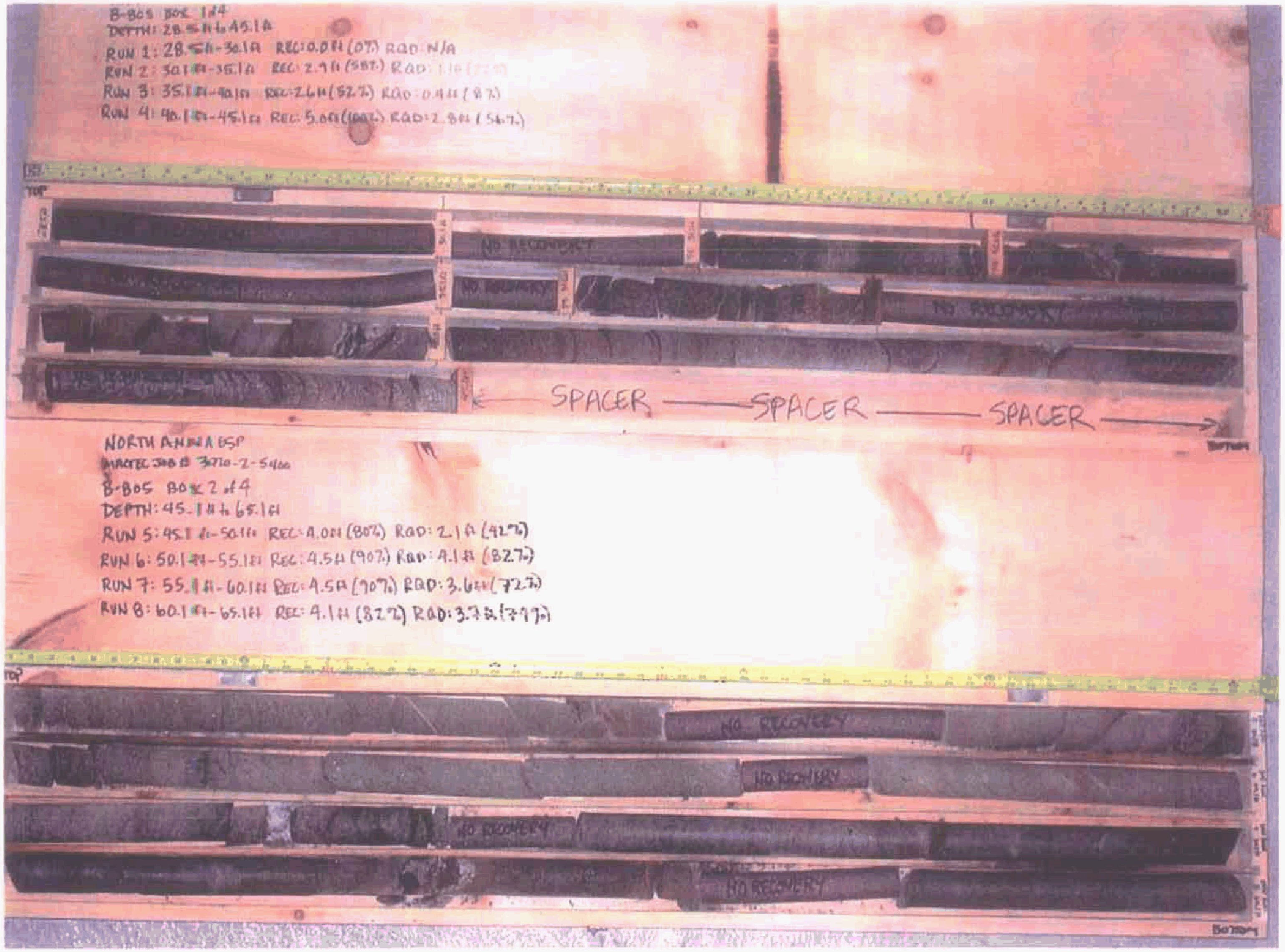
CORE BORING REPORT

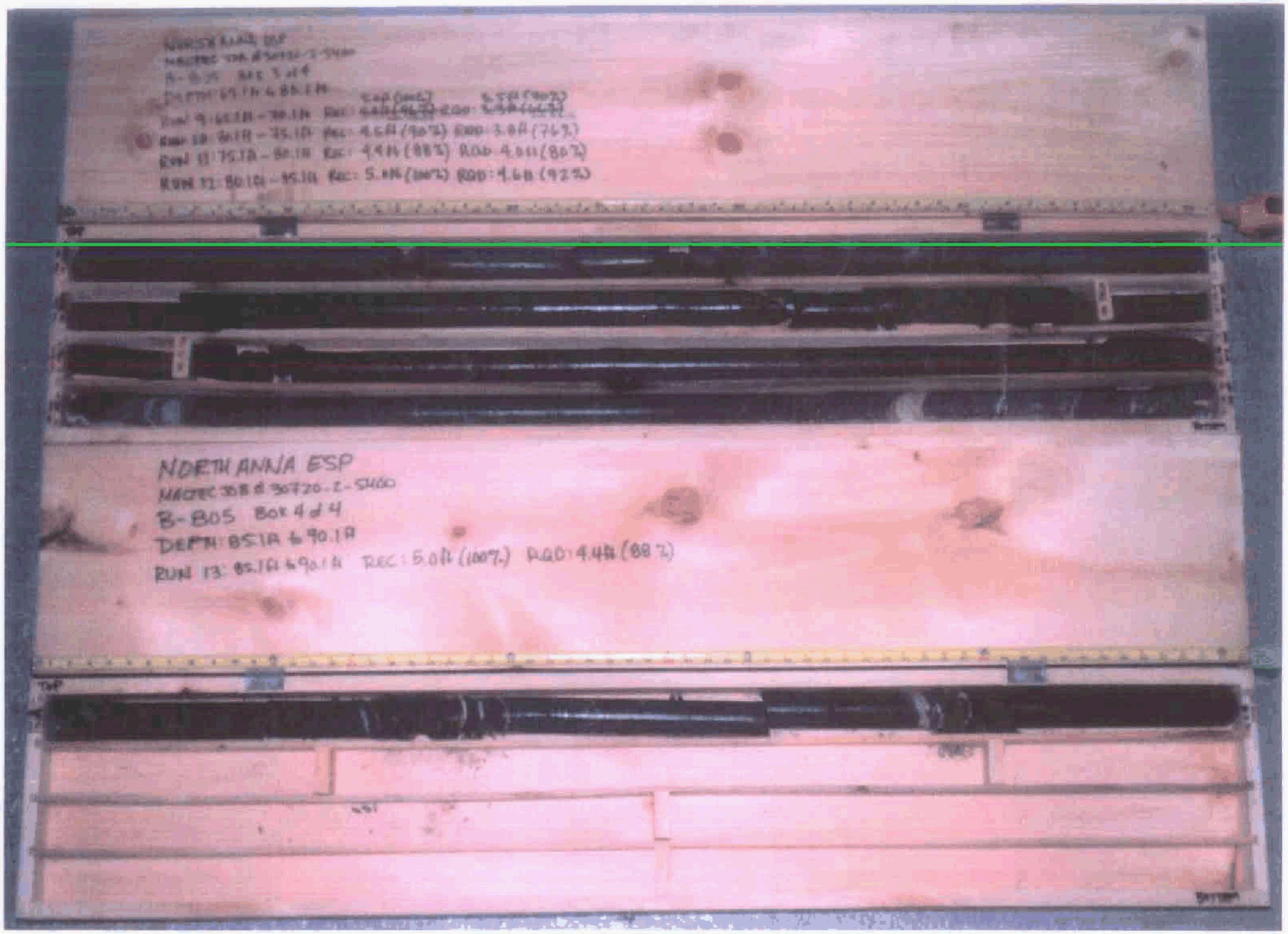
BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-805			**0 HR.** 10.6
COLLAR ELEV. 271.1 ft **(NAVD 88)**	**NORTHING** 3,910,361.58 **(NAD 83)**	**EASTING** 11,686,246.96 **(NAD 83)**	**24 HR.** 9.6
TOTAL DEPTH 90.1 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Mud Rotary/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 11/20/02	**COMPLETED** 11/22/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 61.6 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
			1:42 1:38 1:41 1:58	100%	70%					Hard Rock: Gray, black, and white, moderately to very slightly weathered, very closely to moderately closely fractured, moderately hard to hard, locally slightly schistose, BIOTITE GNEISS *(continued)*
201.0	70.1	5.0	1:34 1:58 2:07 2:02 1:12	(4.5) 90%	(3.8) 76%	RUN 10				(2 joints at 50° with clay and Fe stain; 4 joints at 30-35° with clay and Fe stain)
										196.5 — 74.6
										Weathered Rock: No recovery - Interpreted as BIOTITE GNEISS
196.0	75.1	5.0	1:10 2:16 2:08 2:12 2:16	(4.4) 88%	(4.0) 80%	RUN 11				195.4 — 75.7 Hard Rock: Gray, black, and white, moderately weathered to fresh, very closely to widely fractured, moderately hard to hard, slightly schistose, BIOTITE GNEISS
191.0	80.1	5.0	1:44 1:37 1:56 1:33 1:57	(5.0) 100%	(4.6) 92%	RUN 12				(4 joints at 50° with trace clay and Quartz; 0.1ft wide Quartz vein at 50° at 84.0ft)
186.0	85.1	5.0	2:05 2:19 2:39 1:52 1:51	(5.0) 100%	(4.4) 88%	RUN 13				(5 joints at 30-35° with clay, Quartz, and Fe stain; 2 joints at 60-65° with clay, Quartz, and Fe stain; 3 joints at 0-10° with trace clay)
181.0	90.1									181.0 — 90.1
										Boring and Coring terminated at 90.1 ft in Hard Rock: Slightly weathered to fresh, closely to moderately closely fractured, hard, slightly schistose, Biotite Gneiss Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water/Bentonite (weight unknown) Borehole filled by grouting 12/6/02

BECHTEL CORE1 LC ·A.GPJ NC DOT.GDT 2/3/03


B-B05 BOX 1 of 4
DEPTH: 28.5 ft to 45.1 ft
RUN 1: 28.5 ft - 30.1 ft REC: 0.0 ft (0%) RQD: N/A
RUN 2: 30.1 ft - 35.1 ft REC: 2.9 ft (58%)
RUN 3: 35.1 ft - 40.1 ft REC: 2.6 ft (52%) RQD: 0.4 ft (8%)
RUN 4: 40.1 ft - 45.1 ft REC: 5.0 ft (100%) RQD: 2.8 ft (56%)
NO RECOVERY
NO RECOVERY
NO RECOVERY
SPACER
SPACER
SPACER
BOTTOM
NORTH ANNA ESP
MACTEC JOB # 3770-2-5400
B-B05 BOX 2 of 4
DEPTH: 45.1 ft to 65.1 ft
RUN 5: 45.1 ft - 50.1 ft REC: 4.0 ft (80%) RQD: 2.1 ft (42%)
RUN 6: 50.1 ft - 55.1 ft REC: 4.5 ft (90%) RQD: 4.1 ft (82%)
RUN 7: 55.1 ft - 60.1 ft REC: 4.5 ft (90%) RQD: 3.6 ft (72%)
RUN 8: 60.1 ft - 65.1 ft REC: 4.1 ft (82%) RQD: 3.7 ft (74%)
TOP
NO RECOVERY
NO RECOVERY
NO RECOVERY
NO RECOVERY
BOTTOM


NORTH ANNA ESP
MACTEC JOB # 30720-2-5400
B-805 Box 4 of 4
DEPTH: 85.1ft to 90.1ft
RUN 13: 85.1ft to 90.1ft REC: 5.0ft (100%) RQD: 4.4ft (88%)

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830		**MACTEC PROJECT NUMBER:** 30720-2-5400		**COUNTY** LOUISA, VA		**GEOLOGIST** M. Lear	
PROJECT NAME NORTH ANNA ESP						**WATER LEVEL (ft)**	
BORING NO. B-806						**0 HR.**	6.3
COLLAR ELEV. (NAVD 88)		**NORTHING** 3,909,416.24 (NAD 83)		**EASTING** 11,683,977.28 (NAD 83)		**24 HR.**	FIAD
TOTAL DEPTH 64.5 ft	**DRILL MACHINE** CME-550, ATV		**DRILL METHOD** Rotary Wash/Core			**HAMMER TYPE** 140 lb. Manual, #5	
DATE STARTED 12/12/02		**COMPLETED** 12/13/02		**SURFACE WATER DEPTH** N/A			

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
299.2	0.0				Ground Surface		
298.7	0.5	14	27	15	42	SS-1	
296.0	3.2	9	7	15	22	SS-2	
293.6	5.6	9	10	8	18	SS-3	▽
291.2	8.0	50/0.3ft			100/0.3ft	SS-4	
289.0	10.2	50/0.0ft			100/0.0ft	SS-5	
261.8	37.4						

SOIL AND ROCK DESCRIPTION

Elev.	Description	Depth
299.2		0.00
	Fill: Tan, dense, silty, sandy, GRAVEL (GM) (Railroad Bed)	
296.7	Residual: Brown and dark gray, firm to very firm, micaceous, clayey, fine to coarse SAND (SC)	2.5
291.7	Weathered Rock: BIOTITE GNEISS	7.5
288.4	Hard Rock: Dark gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, BIOTITE GNEISS with Epidote (5%)(7 joints at 40-50° with clay; Severely weathered fracture zone with no recovery from 10.8ft to 11.4ft)	10.8
284.7	Hard Rock: Grayish white, moderately weathered, very close to closely fractured, moderately hard, QUARTZ GNEISS with Biotite (5%)	14.5
283.9	Weathered Rock: Partial recovery - Interpreted as BIOTITE GNEISS	15.3
278.2	Hard Rock: Dark gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, BIOTITE GNEISS with Epidote (5%)	21.0
273.4	Weathered Rock: Partial recovery - Interpreted as BIOTITE GNEISS	25.8
265.8	Hard Rock: Dark to light gray, locally with orange Fe stain, moderately to slightly weathered, very closely to moderately closely fractured, moderately hard to hard, BIOTITE GNEISS	33.4

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GEOTECHNICAL BORING LOG

SHEET 2 OF 2

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-806			**0 HR.** 6.3
COLLAR ELEV. (NAVD 88)	**NORTHING** 3,909,416.24 (NAD 83)	**EASTING** 11,683,977.28 (NAD 83)	**24 HR.** FIAD
TOTAL DEPTH 64.5 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/12/02	**COMPLETED** 12/13/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
261.8	37.4				Continued from previous page				
									Hard Rock: Dark to light gray, locally with orange Fe stain, moderately to slightly weathered, very closely to moderately closely fractured, moderately hard to hard, BIOTITE GNEISS *(continued)*
									243.4 — 55.8
									Weathered Rock: Partial recovery - Brown, BIOTITE GNEISS
									238.8 — 60.4
									Hard Rock: Dark gray, moderately weathered, v. close to closely fractured, moderately hard, BIOTITE GNEISS
									235.6 — 63.6
									Hard Rock: Gray, slightly weathered to fresh, closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
									234.7 — 64.5
									Boring and Coring terminated at 64.5ft in Hard Rock: Slightly weathered to fresh, closely fractured, hard, Quartz Gneiss with Biotite (5%) Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water Borehole filled by grouting 12/12/02
224.4	74.8								

BECHTEL 5400 NC DOT.GDT 2/4/03

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RALEIGH, NC 27604

CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Lear
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-806			**0 HR.** 6.3
COLLAR ELEV. (NAVD 88)	**NORTHING** 3,909,416.24 (NAD 83)	**EASTING** 11,683,977.28 (NAD 83)	**24 HR.** FIAD
TOTAL DEPTH 64.5 ft	**DRILL MACHINE** CME-550, ATV	**DRILL METHOD** Rotary Wash/Core	**HAMMER TYPE** 140 lb. Manual, #5
DATE STARTED 12/12/02	**COMPLETED** 12/13/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 54.3 ft	**DRILLER** K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 10.2 ft
289.0	10.2	4.3	2:02	(3.7) 86%	(2.8) 65%	RUN 1				288.4 — 10.8
			1:34							Hard Rock: Dark gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, BIOTITE GNEISS with Epidote (5%)(7 joints at 40-50° with clay; Severely weathered fracture zone with no recovery from 10.8ft to 11.4ft)
			2:05							
			2:03							
284.7	14.5		0:25/0.3							284.7 — 14.5
		2.6	1:23	(0.8) 31%	(0.6) 23%	RUN 2				Hard Rock: Grayish white, moderately weathered, very close to closely fractured, moderately hard, QUARTZ GNEISS with Biotite (5%)
										283.9 — 15.3
			1:34							Weathered Rock: Partial recovery - Interpreted as BIOTITE GNEISS
282.1	17.1		0:57/0.6							
			0:45/0.4							
281.5	17.7	2.4	1:54	(0.4) 17%	(0.0) 0%	RUN 3				
			1:31							
279.7	19.5									
279.1	20.1	5.0	1:09	(3.5) 70%	(1.2) 24%	RUN 4				
			0:57							278.2 — 21.0
			1:22							Hard Rock: Dark gray, moderately to slightly weathered, very closely to closely fractured, moderately hard to hard, BIOTITE GNEISS with Epidote (5%)
			1:15							
			1:19							
274.7	24.5									
		1.8	1:14	(1.4) 78%	(1.2) 67%	RUN 5				
			0:57/0.8							273.4 — 25.8
272.9	26.3									Weathered Rock: Partial recovery - Interpreted as BIOTITE GNEISS
		3.2	1:03/0.2	(0.3) 9%	(0.0) 0%	RUN 6				
			1:48							
			1:47							
			1:45							
269.7	29.5									
		3.6	1:52	(0.0) 0%	(0.0) 0%	RUN 7				
			1:01							
			1:45							
266.1	33.1		1:22/0.6							
		1.4	1:02/0.4	(1.1) 79%	(0.4) 29%	RUN 8				265.8 — 33.4 (3 Joints at 30-40° with trace clay)
			1:36							Hard Rock: Dark to light gray, locally with orange Fe stain, moderately to slightly weathered, very closely to moderately closely fractured, moderately hard to hard, BIOTITE GNEISS
264.7	34.5									
		5.0	1:39	(5.0) 100%	(3.4) 68%	RUN 9				(6 Joints at 30-40° with trace clay and orange Fe stain; 1 joint at 80-90° with clay, quartz and orange Fe stain)
			1:34							
			1:40							
			1:31							
			1:21							
259.7	39.5									
		5.0	1:41	(5.0) 100%	(3.9) 78%	RUN 10				(13 Joints at 30-40° with trace clay and orange Fe stain)
			1:31							
			1:23							
			1:30							
			1:27							
254.7	44.5									
		5.0	1:24	(4.7) 94%	(4.0) 80%	RUN 11				(5 Joints at 30-40° with orange Fe stain; Severely weathered fracture zone with partial recovery from 49.0ft to 49.5ft)
			1:21							
			1:20							

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CORE BORING REPORT

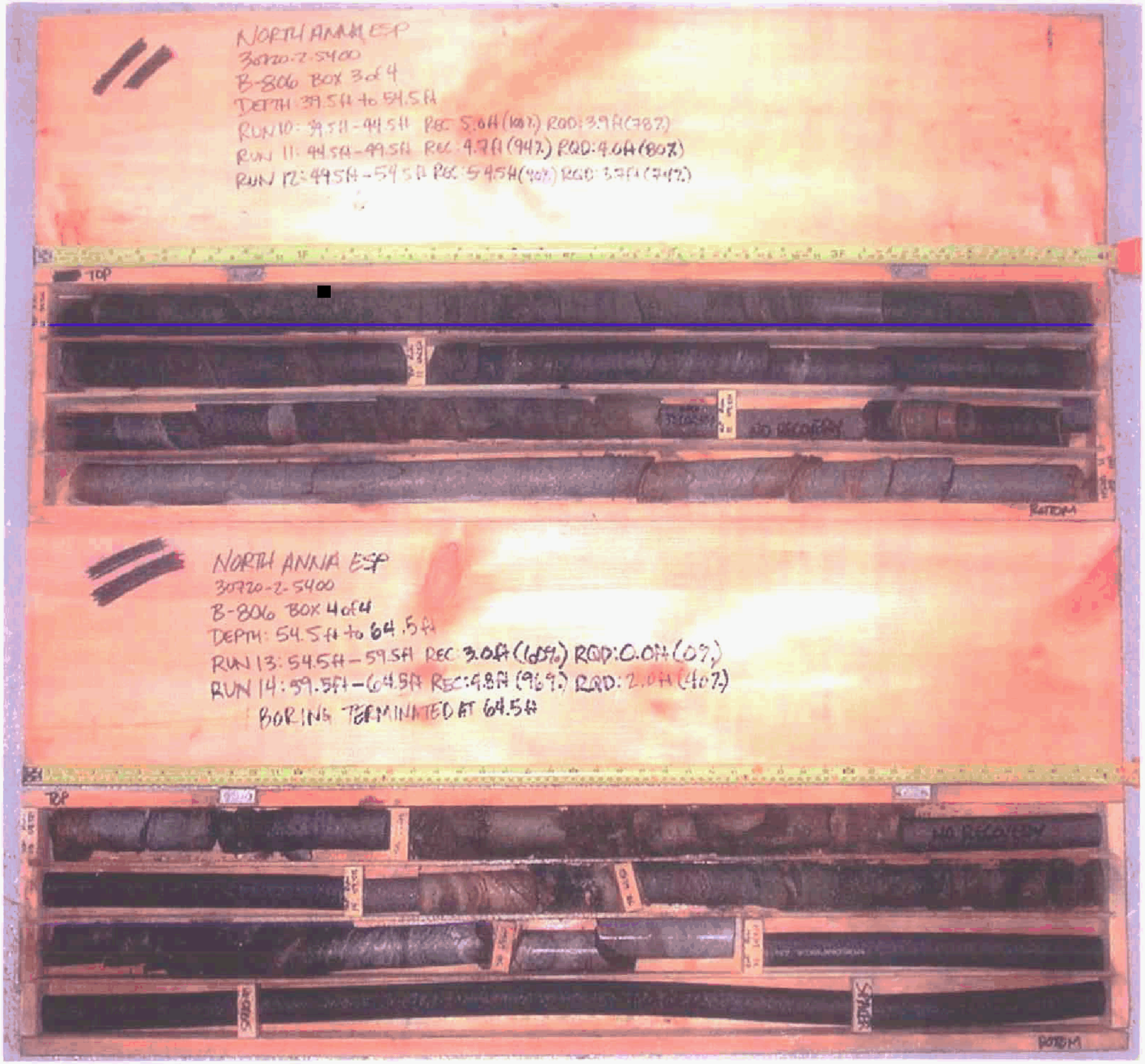
BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Lear
PROJECT NAME: NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-806			0 HR. 6.3
COLLAR ELEV. (NAVD 88)	NORTHING 3,909,416.24 (NAD 83)	EASTING 11,683,977.28 (NAD 83)	24 HR. FIAD
TOTAL DEPTH 64.5 ft	DRILL MACHINE CME-550, ATV	DRILL METHOD Rotary Wash/Core	HAMMER TYPE 140 lb. Manual, #5
DATE STARTED 12/12/02	COMPLETED 12/13/02	SURFACE WATER DEPTH N/A	
CORE SIZE NQ	TOTAL RUN 54.3 ft	DRILLER K. Pendley	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Continued from previous page
			1:15							Hard Rock: Dark to light gray, locally with orange Fe stain, moderately to slightly weathered, very closely to moderately closely fractured, moderately hard to hard, BIOTITE GNEISS *(continued)*
249.7	49.5		1:20							
		5.0	1:31	(4.5) 90%	(3.7) 74%	RUN 12				(7 joints at 30-40° with trace clay and orange Fe stain; Severely weathered fracture zone with no recovery from 49.5ft to 50.0ft)
			1:34							
			1:25							
			1:30							
244.7	54.5		1:41							
		5.0	2:15	(3.0) 60%	(0.0) 0%	RUN 13				(3 Joints at 30-40° with clay; 2 joints at 0-10° with clay and Fe stain)
243.4	55.8		2:16							Weathered Rock: Partial recovery - Brown, BIOTITE GNEISS
			1:35							
			1:34							
239.7	59.5		2:30							
		5.0	2:19	(4.8) 96%	(2.0) 40%	RUN 14				
238.8	60.4		1:55							Hard Rock: Dark gray, moderately weathered, v. close to closely fractured, moderately hard, BIOTITE GNEISS
			1:35							
			2:11							
235.6	63.6		5:46							Hard Rock: Gray, slightly weathered to fresh, closely fractured, hard, QUARTZ GNEISS with Biotite (5%)
234.7	64.5									Boring and Coring terminated at 64.5ft in Hard Rock: Slightly weathered to fresh, closely fractured, hard, Quartz Gneiss with Biotite (5%)
										Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated)
										Drilling Fluid: Water
										Borehole filled by grouting 12/12/02

BECHTEL CORE1 LC A.GPJ NC DOT.GDT 2/3/03

NORTH ANNA ESP
30720-2-5400
B-806 BOX 1 of 4
DEPTH: 10.2 ft to 24.5 ft
RUN 1: 10.2 ft - 14.5 ft REC: 3.7 ft (86%) RQD: 2.8 ft (65%)
RUN 2: 14.5 ft - 17.1 ft REC: 0.8 ft RQD: 0.6 ft (23%)
RUN 3: 17.1 ft - 19.5 ft REC: 0.4 ft (17%) RQD: 0.0 ft (0%)
RUN 4: 19.5 ft - 24.5 ft REC: 3.5 ft (70%) RQD: 1.2 ft (24%)
TOP
NO RECOVERY
NO RECOVERY
NO RECOVERY
NO RECOVERY
BOTTOM
NORTH ANNA ESP
30720-2-5400
B-806 BOX 2 of 4
DEPTH: 24.5 ft to 39.5 ft
RUN 5: 24.5 ft - 26.3 ft REC: 1.4 ft (78%) RQD: 1.2 ft (67%)
RUN 6: 26.3 ft - 29.5 ft REC: 0.3 ft (9%) RQD: 0.0 ft (0%)
RUN 7: 29.5 ft - 33.1 ft REC: 0.0 ft (0%) RQD: 0.0 ft (0%)
RUN 8: 33.1 ft - 34.5 ft REC: 1.1 ft (79%) RQD: 0.4 ft (29%)
RUN 9 34.5 ft - 39.5 ft REC: 5.0 ft (100%) RQD: 3.4 ft (68%)
TOP
NO RECOVERY
NO RECOVERY
BOTTOM


NORTH ANNA ESP
30720-2-5400
B-806 BOX 3 of 4
DEPTH 39.5ft to 54.5ft
RUN 10: 39.5ft - 44.5ft REC 5.0ft (100%) RQD: 3.9ft (78%)
RUN 11: 44.5ft - 49.5ft REC 4.7ft (94%) RQD: 4.0ft (80%)
RUN 12: 49.5ft - 54.5ft REC 4.5ft (90%) RQD: 3.7ft (74%)
TOP
NO RECOVERY
BOTTOM
NORTH ANNA ESP
30720-2-5400
B-806 BOX 4 of 4
DEPTH: 54.5ft to 64.5ft
RUN 13: 54.5ft - 59.5ft REC 3.0ft (60%) RQD: 0.0ft (0%)
RUN 14: 59.5ft - 64.5ft REC: 4.8ft (96%) RQD: 2.0ft (40%)
BORING TERMINATED AT 64.5ft
TOP
NO RECOVERY
SPACER
SPACER
BOTTOM

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER: 30720-2-5400**	**COUNTY** LOUISA, VA	**GEOLOGIST** B. Deobald
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-807			**0 HR.** ND
COLLAR ELEV. (NAVD 88)	**NORTHING** 3,909,849.08 (NAD 83)	**EASTING** 1,163,980.43 (NAD 83)	**24 HR.** FIAD
TOTAL DEPTH 72.1 ft	**DRILL MACHINE** CME-45C, Trailer	**DRILL METHOD** Mud Rotary/Core	**HAMMER TYPE** 140 lb. Manual
DATE STARTED 12/12/02	**COMPLETED** 12/13/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0–100)	SAMP. NO.	SOIL AND ROCK DESCRIPTION
310.6	0.0				Ground Surface		
310.6	0.0	2	5	7	12	SS-1	310.6 — 0.00 Residual: Orange, tan, and white, stiff to very stiff, micaceous, clayey, fine sandy, SILT (ML), locally with rock fragments
308.3	2.3	3	7	10	17	SS-2	
306.1	4.5	2	7	8	15	SS-3	
303.6	7.0	3	5	7	12	SS-4	
300.9	9.7	3	5	8	13	SS-5	
298.3	12.3	3	5	8	13	SS-6	
295.8	14.8	4	9	12	21	SS-7	
							289.6 — 21.0 Residual: Orange, tan, and white, very stiff, micaceous, clayey, silty, fine SAND (SM), locally with rock fragments
288.9	21.7	2	8	14	22	SS-8	
							285.6 — 25.0 Residual: Gray, white, and orange, very dense, micaceous, silty, fine to coarse SAND (SM) with rock fragments
284.1	26.5	20	30	70		SS-9	
279.2	31.4	45	40	40	80	SS-10	
							275.6 — 35.0 Weathered Rock: Interpreted as QUARTZ GNEISS
274.2	36.4						
273.2	37.4	50/0.2ft			100/0.2ft	SS-11	

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GEOTECHNICAL BORING LOG

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BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** B. Deobald
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-807			**0 HR.** ND
COLLAR ELEV. (NAVD 88)	**NORTHING** 3,909,849.08 (NAD 83)	**EASTING** 1,163,980.43 (NAD 83)	**24 HR.** FIAD
TOTAL DEPTH 72.1 ft	**DRILL MACHINE** CME-45C, Trailer	**DRILL METHOD** Mud Rotary/Core	**HAMMER TYPE** 140 lb. Manual
DATE STARTED 12/12/02	**COMPLETED** 12/13/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0–100)	SAMP. NO.	MOI	SOIL AND ROCK DESCRIPTION
273.2	37.4				Continued from previous page			Weathered Rock: Interpreted as QUARTZ GNEISS *(continued)*
269.3	41.3	38	35	65/0.4ft	100/0.9ft	SS-12		
264.3	46.3	90	10/0.1ft		100/0.6ft	SS-13		261.6 — 49.0
								Residual: No recovery - Interpreted as very dense, silty, SAND (SM)
259.3	51.3	30	50	37	87	SS-14		254.6 — 56.0
254.4	56.2	50/0.1ft			100/0.1ft	SS-15		Weathered Rock: Interpreted as QUARTZ GNEISS
								253.5 — 57.1
								Hard Rock: Tan, pink, and black, Fe stained, moderately severe to moderately weathered, very closely to closely fractured, moderately hard, QUARTZ GNEISS
								238.5 — 72.1
235.8	74.8							Boring and Coring terminated at 72.1ft in Hard Rock: Moderately severe to moderately weathered, very closely to closely fractured, moderately hard, Quartz Gneiss

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GEOTECHNICAL BORING LOG

SEE ATTACHED CORE BORING REPORT FOR CORING DETAILS

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST B. Deobald
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. B-807			0 HR. ND
COLLAR ELEV. (NAVD 88)	NORTHING 3,909,849.08 (NAD 83)	EASTING 1,163,980.43 (NAD 83)	24 HR. FIAD
TOTAL DEPTH 72.1 ft	DRILL MACHINE CME-45C, Trailer	DRILL METHOD Mud Rotary/Core	HAMMER TYPE 140 lb. Manual
DATE STARTED 12/12/02	COMPLETED 12/13/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
235.8	74.8				Continued from previous page				
									Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated) Drilling Fluid: Water/Mud (weight unknown) Borehole filled by grouting 12/17/02
198.4	112.2								

BECHTEL 5400.[illegible]C DOT.GDT 2/4/03

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CORE BORING REPORT

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** B. Deobald
PROJECT NAME: NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. B-807			**0 HR.** ND
COLLAR ELEV. (NAVD 88)	**NORTHING** 3,909,849.08 (NAD 83)	**EASTING** 1,163,980.43 (NAD 83)	**24 HR.** FIAD
TOTAL DEPTH 72.1 ft	**DRILL MACHINE** CME-45C, Trailer	**DRILL METHOD** Mud Rotary/Core	**HAMMER TYPE** 140 lb. Manual
DATE STARTED 12/12/02	**COMPLETED** 12/13/02	**SURFACE WATER DEPTH** N/A	
CORE SIZE NWD4	**TOTAL RUN** 15.0 ft	**DRILLER** D. White	

ELEV. (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
										Begin Coring @ 57.1 ft
253.5	57.1	5.0	3:08 2:10 2:15 2:20 2:40	(0.5) 10%	(0.0) 0%	RUN 1				253.5 Hard Rock: Tan, pink, and black, Fe stained, moderately severe to moderately weathered, very closely to closely fractured, moderately hard, QUARTZ GNEISS 57.1
248.5	62.1	5.0	2:00 2:10 2:30 2:40 2:50	(3.7) 74%	(0.5) 10%	RUN 2				
243.5	67.1	5.0	2:20 2:20 1:40 2:00 2:00	(0.9) 18%	(0.0) 0%	RUN 3				
238.5	72.1									238.5 72.1

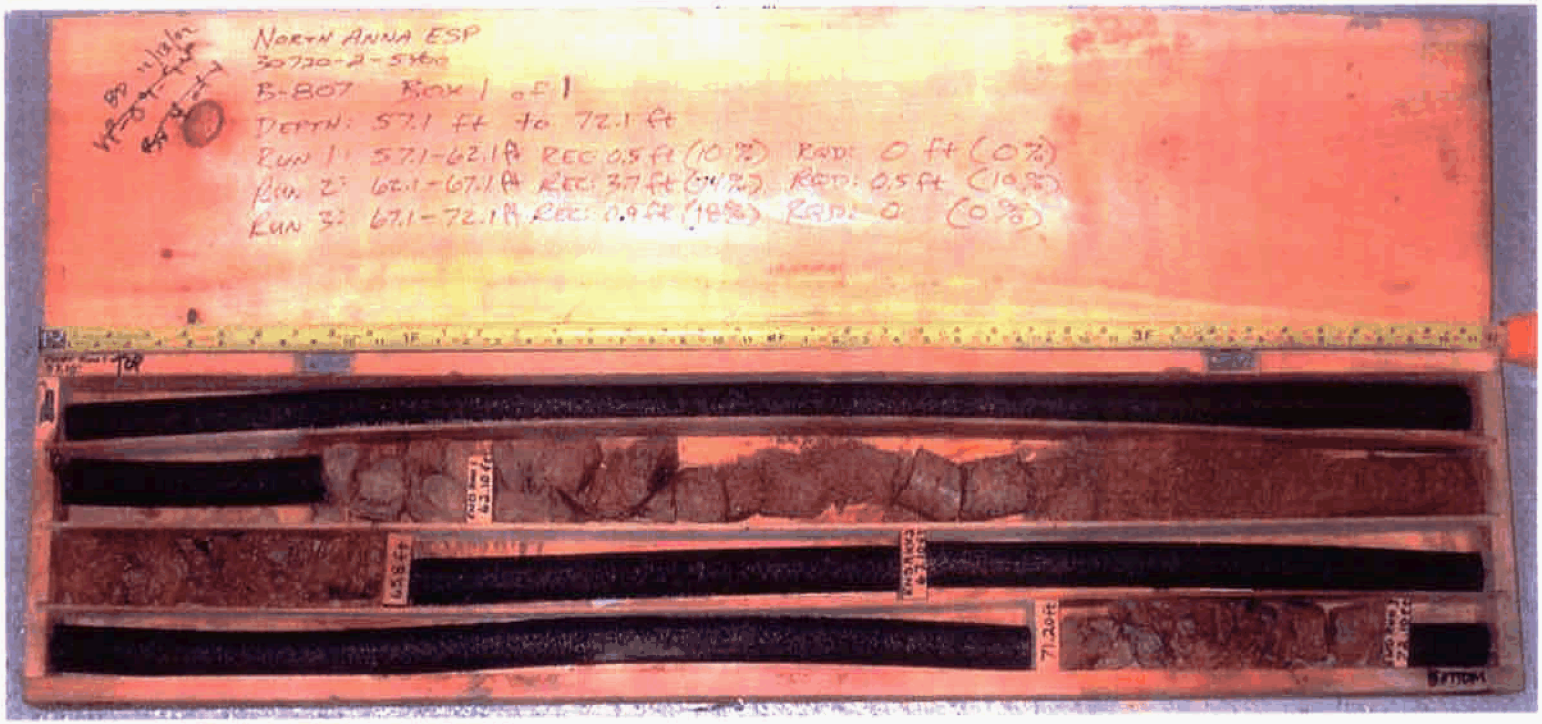
Boring and Coring terminated at 72.1ft in Hard Rock: Moderately severe to moderately weathered, very closely to closely fractured, moderately hard, Quartz Gneiss

Bits Used: 3" Roller cone; N-size core bit (Face discharge, diamond impregnated)

Drilling Fluid: Water/Mud (weight unknown)

Borehole filled by grouting 12/17/02

BECHTEL CORE1 LC A.GPJ NC DOT.GDT 2/3/03


NORTH ANNA ESP
B-807 BOX 1 of 1
DEPTH: 57.1 ft to 72.1 ft
RUN 1: 57.1-62.1 ft REC 0.5 ft (10%) RQD: 0 ft (0%)
RUN 2: 62.1-67.1 ft REC: 3.7 ft (74%) RQD: 0.5 ft (10%)
RUN 3: 67.1-72.1 ft REC: 0.9 ft (18%) RQD: 0 (0%)
TOP
71.20 ft
BOTTOM

APPENDIX D
OBSERVATION WELL LOGS
OBSERVATION WELL INSTALLATION RECORDS
WELL DEVELOPMENT RECORDS

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OBSERVATION WELL BORING LOG

SHEET 1 OF 1

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Howe
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. OW-841			**0 HR.** ND
COLLAR ELEV. 250.1 ft **(NAVD 88)**	**NORTHING** 3,910,556.15 **(NAD 83)**	**EASTING** 11,686,804.11 **(NAD 83)**	**24 HR.** ND
TOTAL DEPTH 35.6 ft	**DRILL MACHINE** Diedrich D-50	**DRILL METHOD** HSA 4.25"	**HAMMER TYPE** 140 lb. Automatic
DATE STARTED 11/25/02	**COMPLETED** 11/26/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
250.1					Ground Surface				
250.1	0.0					1			250.1 — 0.00 Fill: Orange, tan, and brown mottled, loose, micaceous, silty, fine to coarse SAND (SM)
245.3	4.8					2			
240.3	9.8				Samples were obtained for descriptive purposes only	3			
235.4	14.7					4			233.1 — 17.0 Residual: Tan and orange mottled, very dense, silty, fine to coarse SAND (SM) with relict rock fabric
230.2	19.9					5			228.1 — 22.0 Weathered Rock: GNEISS sampled as tan to orange mottled, very dense, silty, fine to coarse SAND (SM) with relict rock fabric
224.9	25.2					6			223.1 — 27.0 Residual: Tan to orange mottled, very dense, silty, fine to coarse SAND (SM) with relict rock fabric
220.3	29.8					7			218.1 — 32.0 Weathered Rock: GNEISS sampled as orange to tan mottled, very dense, silty, fine to coarse SAND (SM)
216.4	33.7					8			214.5 — 35.6 Boring terminated at 35.6 ft in Weathered Rock: GNEISS sampled as very dense, silty, fine to very coarse SAND (SM)

BECHTEL OBS OG 5400A.GPJ NC_DOT.GDT 2/3/03

See Well Installation Record for well construction details

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Howe
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. OW-842			**0 HR.** ND
COLLAR ELEV. 335.2 ft **(NAVD 88)**	**NORTHING** 3,909,034.76 **(NAD 83)**	**EASTING** 11,685,149.13 **(NAD 83)**	**24 HR.** ND
TOTAL DEPTH 51.0 ft	**DRILL MACHINE** Diedrich D-50	**DRILL METHOD** HSA 4.25"	**HAMMER TYPE** 140 lb. Automatic
DATE STARTED 12/3/02	**COMPLETED** 12/3/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
335.2					Ground Surface				
335.2	0.0					1			335.2 — 0.00 Fill: Brown, firm, slightly fine to medium sandy, clayey, SILT (ML)
									332.7 — 2.5 Residual: Tan, brown, green, black, and white mottled, firm to dense, locally micaceous, silty, fine to medium SAND (SM) with relict rock fabric and locally with manganese oxide staining
330.7	4.5					2			
325.7	9.5				**Samples were obtained for descriptive purposes only**	3			
320.7	14.5					4			
315.7	19.5					5			
310.7	24.5					6			
305.7	29.5					7			
300.7	34.5					8			

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-842			0 HR. ND
COLLAR ELEV. 335.2 ft (NAVD 88)	NORTHING 3,909,034.76 (NAD 83)	EASTING 11,685,149.13 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.0 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 12/3/02	COMPLETED 12/3/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
297.8					Continued from previous page				
295.7	39.5					9			Residual: Tan, brown, green, black, and white mottled, firm to dense, locally micaceous, silty, fine to medium SAND (SM) with relict rock fabric and locally with manganese oxide staining *(continued)*
290.7	44.5				Samples were obtained for descriptive purposes only	10			
287.0	48.2					11			
									284.2 — 51.0
									Boring terminated at 51.0 ft in Residual: Very firm, micaceous, silty, fine SAND (SM) with relict rock fabric See Well Installation Record for well construction details

BECHTEL OBS OG 5400A.GPJ NC DOT.GDT 2/3/03

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OBSERVATION WELL BORING LOG

SHEET 1 OF 2

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-843			0 HR. ND
COLLAR ELEV. 319.1 ft (NAVD 88)	NORTHING 3,909,725.17 (NAD 83)	EASTING 11,685,056.83 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.0 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 12/4/02	COMPLETED 12/4/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
319.1					Ground Surface				319.1 0.00
319.1	0.0					1			Residual: Dark green to yellow, firm to dense, very slightly micaceous, silty, fine SAND (SM) with relict rock fabric
314.6	4.5					2			
									312.1 7.0
					Samples were obtained for descriptive purposes only				Residual: Orange, brown, and pink mottled, stiff, very slightly fine sandy, SILT (ML) with relict rock fabric and manganese oxide stain
309.6	9.5					3			
304.6	14.5					4			
									302.1 17.0
									Residual: Orange, brown, dark green, and yellow mottled, firm to dense, locally micaceous, silty, fine SAND (SM) with relict rock fabric and manganese oxide stain
299.6	19.5					5			
294.6	24.5					6			
289.6	29.5					7			
284.6	34.5					8			

BECHTEL OBS \ OG 5400A.GPJ NC DOT.GDT 2/3/03

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER: 30720-2-5400**	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Howe
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. OW-843			**0 HR.** ND
COLLAR ELEV. 319.1 ft **(NAVD 88)**	**NORTHING** 3,909,725.17 **(NAD 83)**	**EASTING** 11,685,056.83 **(NAD 83)**	**24 HR.** ND
TOTAL DEPTH 51.0 ft	**DRILL MACHINE** Diedrich D-50	**DRILL METHOD** HSA 4.25"	**HAMMER TYPE** 140 lb. Automatic
DATE STARTED 12/4/02	**COMPLETED** 12/4/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
281.7					Continued from previous page				
									Residual: Orange, brown, dark green, and yellow mottled, firm to dense, locally micaceous, silty, fine SAND (SM) with relict rock fabric and manganese oxide stain *(continued)*
279.6	39.5					9			
274.6	44.5				**Samples were obtained for descriptive purposes only**	10			
271.1	48.0					11			
									268.1 51.0
									Boring terminated at 51.0 ft in Residual: Firm, micaceous, silty, fine SAND (SM) with relict rock fabric and manganese oxide stain See Well Installation Record for well construction details

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Raleigh, NC 27604

OBSERVATION WELL BORING LOG

SHEET 1 OF 1

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER: 30720-2-5400**	**COUNTY** LOUISA, VA	**GEOLOGIST** M. Howe
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. OW-844			**0 HR.** 18.7
COLLAR ELEV. 272.0 ft **(NAVD 88)**	**NORTHING** 3,909,908.82 **(NAD 83)**	**EASTING** 11,686,589.64 **(NAD 83)**	**24 HR.** ND
TOTAL DEPTH 26.2 ft	**DRILL MACHINE** Diedrich D-50	**DRILL METHOD** HSA 4.25"	**HAMMER TYPE** 140 lb. Automatic
DATE STARTED 11/23/02	**COMPLETED** 11/23/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
272.0					Ground Surface				272.0 — 0.00
272.0	0.0					1			Fill: Orange and brown, firm to loose, silty, fine SAND (SM) with trace quartz rock fragments and abandoned conduit/construction debris
267.5	4.5					2			
									265.0 — 7.0 Residual: Black and white, dense to very dense, silty, fine SAND (SM) with relict rock fabric
262.5	9.5				Samples were obtained for descriptive purposes only	3			
257.5	14.5					4			
252.5	19.5					5	▽		
									249.5 — 22.5 Weathered Rock: BIOTITE GNEISS sampled as gray to black, very dense, silty, fine SAND (SM) Auger refusal at 24.6ft
248.1	23.9					6			
									245.8 — 26.2 Boring terminated at 26.2 ft in Weathered Rock: BIOTITE GNEISS sampled as very dense, silty, fine SAND (SM) See Well Installation Record for well construction details

BECHTEL OBS W... LOG 5400A.GPJ NC DOT.GDT 2/3/03

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	**MACTEC PROJECT NUMBER:** 30720-2-5400	**COUNTY** LOUISA, VA	**GEOLOGIST** S. Criscenzo
PROJECT NAME NORTH ANNA ESP			**WATER LEVEL (ft)**
BORING NO. OW-845			**0 HR.** ND
COLLAR ELEV. 295.8 ft **(NAVD 88)**	**NORTHING** 3,909,858.66 **(NAD 83)**	**EASTING** 11,685,741.11 **(NAD 83)**	**24 HR.** ND
TOTAL DEPTH 35.0 ft	**DRILL MACHINE** Ingersol Rand T3W	**DRILL METHOD** Air Rotary 6 1/8"	**HAMMER TYPE** N/A
DATE STARTED 12/3/02	**COMPLETED** 12/3/02	**SURFACE WATER DEPTH** N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
295.8					Ground				295.8 0.00
									0 - 55 feet drilled without sampling
									240.8 55.5
									Boring terminated at 55.0 ft

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BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-846			0 HR. ND
COLLAR ELEV. 295.8 ft (NAVD 88)	NORTHING 3,909,845.09 (NAD 83)	EASTING 11,685,721.82 (NAD 83)	24 HR. ND
TOTAL DEPTH 33.5 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 11/22/02	COMPLETED 11/22/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 20 40 60 80 100)	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
295.8					Ground Surface				
295.8	0.0					1			295.8 — 0.00 Residual: Orange, yellow, tan, and brown, loose to very dense, silty, fine to coarse SAND (SM) locally with gravel and relict rock fabric
291.8	4.0					2			
286.3	9.5				Samples were obtained for descriptive purposes only	3			
281.3	14.5					4			
276.3	19.5					5			
271.3	24.5					6			
266.3	29.5					7			
									262.3 — 33.5 Boring terminated at auger refusal 33.5 ft on Hard Rock: QUARTZ GNEISS See Well Installation Record for well construction details

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BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-847			0 HR. ND
COLLAR ELEV. 318.2 ft (NAVD 88)	NORTHING 3,908,945.45 (NAD 83)	EASTING 11,686,447.69 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.8 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 11/26/02	COMPLETED 11/26/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
318.2					Ground Surface				
318.2	0.0					1			318.2 — 0.00 Residual: Orange, brown, and tan mottled, firm to stiff, micaceous, locally medium to coarse sandy, clayey, SILT (ML) locally with manganese oxide stain
313.4	4.8					2			
308.6	9.6				Samples were obtained for descriptive purposes only	3			
303.4	14.8					4			
298.3	19.9					5			
									296.2 — 22.0 Residual: Orange, yellow, tan, and brown mottled, loose to very firm, micaceous, silty, fine to coarse SAND (SM) with relict rock fabric and locally with manganese oxide stain and trace angular quartz rock fragments
293.1	25.1					6			
288.0	30.2					7			
283.0	35.2					8			

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-847			0 HR. ND
COLLAR ELEV. 318.2 ft (NAVD 88)	NORTHING 3,908,945.45 (NAD 83)	EASTING 11,686,447.69 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.8 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 11/26/02	COMPLETED 11/26/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
280.8					Continued from previous page				
									280.2 — 38.0 Residual: Yellow, green, tan, brown, and white mottled, stiff to very stiff, micaceous, SILT (ML) with relict rock fabric and locally with manganese oxide stain
278.0	40.2					9			
272.8	45.4				**Samples were obtained for descriptive purposes only**	10			
269.9	48.3					11			
									266.4 — 51.8 Boring terminated at 51.8 ft in Residual: Very stiff, micaceous, SILT (ML) with relict rock fabric See Well Installation Record for well construction details

BECHTEL OBS W LOG 5400A.GPJ NC DOT.GDT 2/3/03

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-848			0 HR. ND
COLLAR ELEV. 283.0 ft (NAVD 88)	NORTHING 3,910,853.37 (NAD 83)	EASTING 11,686,272.76 (NAD 83)	24 HR. ND
TOTAL DEPTH 47.4 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 11/24/02	COMPLETED 11/24/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
283.0					Ground Surface				
283.0	0.0					1			283.0 Fill: Brown, loose, silty, fine SAND (SM) with trace quartz rock fragments 0.00
278.2	4.8					2			
									276.0 Residual: Gray to brown, firm, very slightly fine sandy, clayey, SILT (ML) 7.0
					Samples were obtained for descriptive purposes only				
272.7	10.3					3			
									270.5 Residual: Gray, brown, and tan, locally mottled, dense to very dense, micaceous, silty, fine to medium SAND (SM) with relict rock fabric 12.5
268.2	14.8					4			
263.0	20.0					5			
257.9	25.1					6			
252.9	30.1					7			
									252.0 Weathered Rock: BIOTITE GNEISS sampled as brown, gray, tan, and black mottled, very dense, micaceous, silty, fine SAND (SM) with relict rock fabric 31.0
247.9	35.1					8			

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BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-848			0 HR. ND
COLLAR ELEV. 283.0 ft (NAVD 88)	NORTHING 3,910,853.37 (NAD 83)	EASTING 11,686,272.76 (NAD 83)	24 HR. ND
TOTAL DEPTH 47.4 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 11/24/02	COMPLETED 11/24/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	▼/MOI	LOG	SOIL AND ROCK DESCRIPTION
245.6					Continued from previous page				
									Weathered Rock: BIOTITE GNEISS sampled as brown, gray, tan, and black mottled, very dense, micaceous, silty, fine SAND (SM) with relict rock fabric *(continued)*
242.9	40.1					9			
237.7	45.3				**Samples were obtained for descriptive purposes only**	10			
									235.6 47.4
									Boring terminated at auger refusal at 47.4ft in Weathered Rock: BIOTITE GNEISS sampled as very dense, silty, fine SAND (SM) with relict rock fabric See Well Installation Record for well construction details

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-849			0 HR. ND
COLLAR ELEV. 297.0 ft (NAVD 88)	NORTHING 3,910,786.24 (NAD 83)	EASTING 11,684,731.02 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.0 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 12/6/02	COMPLETED 12/6/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
297.0					Ground Surface				
297.0	0.0					1			297.0 — 0.00 Residual: Ornage, stiff, slightly clayey, SILT (ML) with root fragments
									294.5 — 2.5 Residual: Orange and tan mottled, loose to firm, locally micaceous, silty, fine to coarse SAND (SM) with relict rock fabric, quartz rock fragments, and trace Fe staining
292.5	4.5					2			
287.5	9.5				Samples were obtained for descriptive purposes only	3			
282.5	14.5					4			
277.5	19.5					5			
272.5	24.5					6			
267.5	29.5					7			
									265.0 — 32.0 Residual: Tan and orange mottling, very firm to very dense, micaceous, slightly clayey, slightly silty, poorly graded, fine to coarse SAND (SP) with relict rock fabric
262.5	34.5					8			

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OBSERVATION WELL BORING LOG

BECHTEL

BECHTEL PROJECT NO. 24830	MACTEC PROJECT NUMBER: 30720-2-5400	COUNTY LOUISA, VA	GEOLOGIST M. Howe
PROJECT NAME NORTH ANNA ESP			WATER LEVEL (ft)
BORING NO. OW-849			0 HR. ND
COLLAR ELEV. 297.0 ft (NAVD 88)	NORTHING 3,910,786.24 (NAD 83)	EASTING 11,684,731.02 (NAD 83)	24 HR. ND
TOTAL DEPTH 51.0 ft	DRILL MACHINE Diedrich D-50	DRILL METHOD HSA 4.25"	HAMMER TYPE 140 lb. Automatic
DATE STARTED 12/6/02	COMPLETED 12/6/02	SURFACE WATER DEPTH N/A	

ELEV. (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 20 40 60 80 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
259.6					Continued from previous page				
257.5	39.5					9			Residual: Tan and orange mottling, very firm to very dense, micaceous, slightly clayey, slightly silty, poorly graded, fine to coarse SAND (SP) with relict rock fabric *(continued)*
252.5	44.5				Samples were obtained for descriptive purposes only	10			
248.7	48.3					11			
246.0	51.0								Boring terminated at 51.0 ft in Residual: Very firm, slightly micaceous, slightly clayey, slightly silty, poorly graded, fine to coarse SAND (SP) with relict rock fabric See Well Installation Record for well construction details

OBSERVATION WELL INSTALLATION RECORD

JOB NAME **NORTH ANNA ESP** JOB NUMBER **37020-2-5400**

WELL NUMBER **OW-841** INSTALLATION DATE **11/26/02**

LOCATION (NAD83) **3910556.15N 11686804.11E**

GROUND SURFACE ELEVATION (NAVD88) **250.1 ft** REFERENCE POINT ELEVATION * (NAVD88) **251.6 ft**

GRANULAR BACKFILL MATERIAL **#2 Well Gravel** SLOT SIZE **0.010 in.**

SCREEN MATERIAL **PVC Schd. 40-Standard** SCREEN DIAMETER **2 in.**

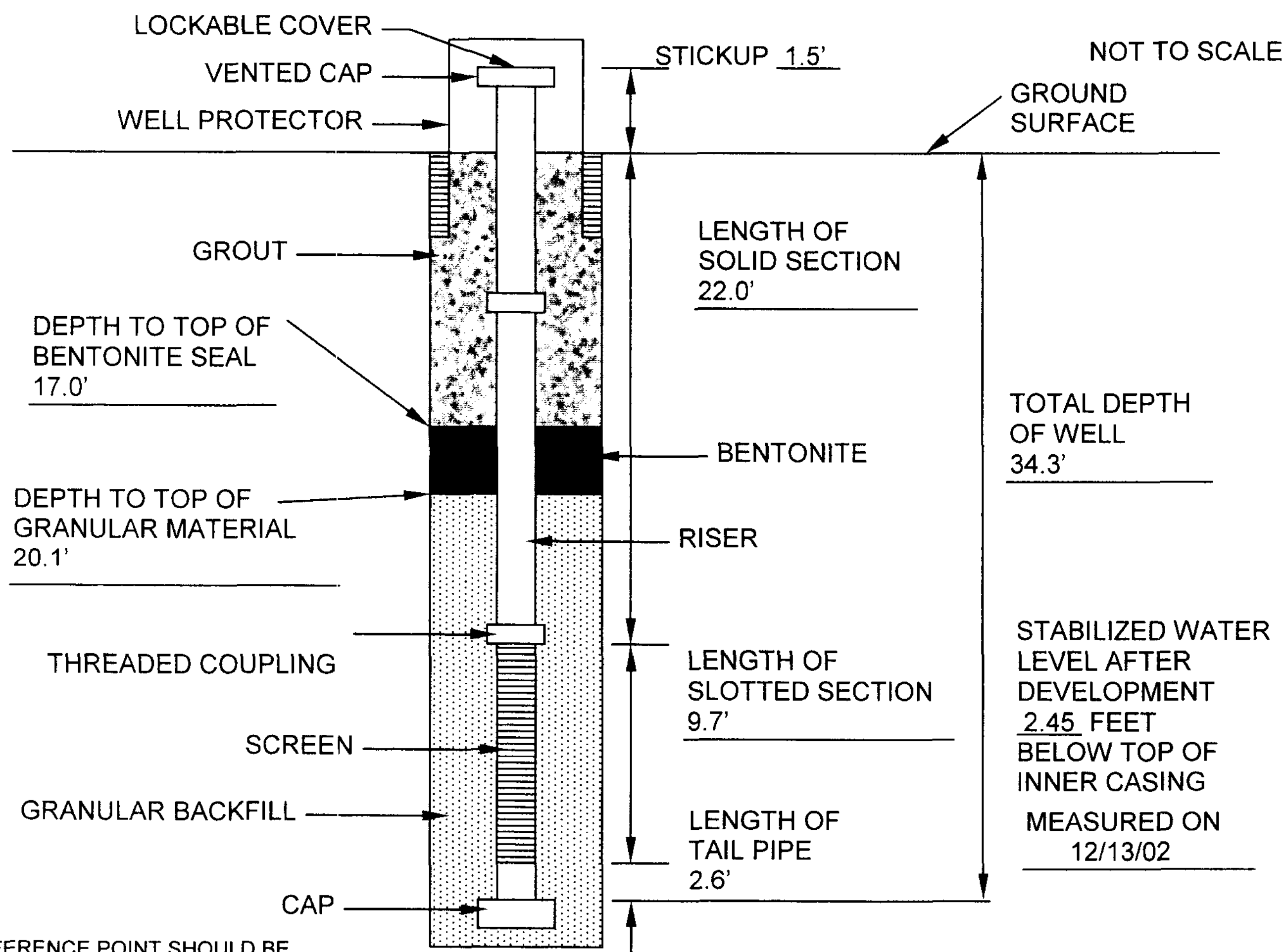
RISER MATERIAL **PVC Schd. 40-Standard** RISER DIAMETER **2 in.**

DRILLING TECHNIQUE **HSA $4^{1/4}$ in. I.D.** DRILLING CONTRACTOR **MACTEC – Atlanta, GA**

BOREHOLE DIAMETER **8 in.** MACTEC FIELD REPRESENTATIVE **Matt Howe**

LOCK BRAND **Masterlock** SIZE/MODEL **N/A**

KEY CODE/COMBINATION **0536**



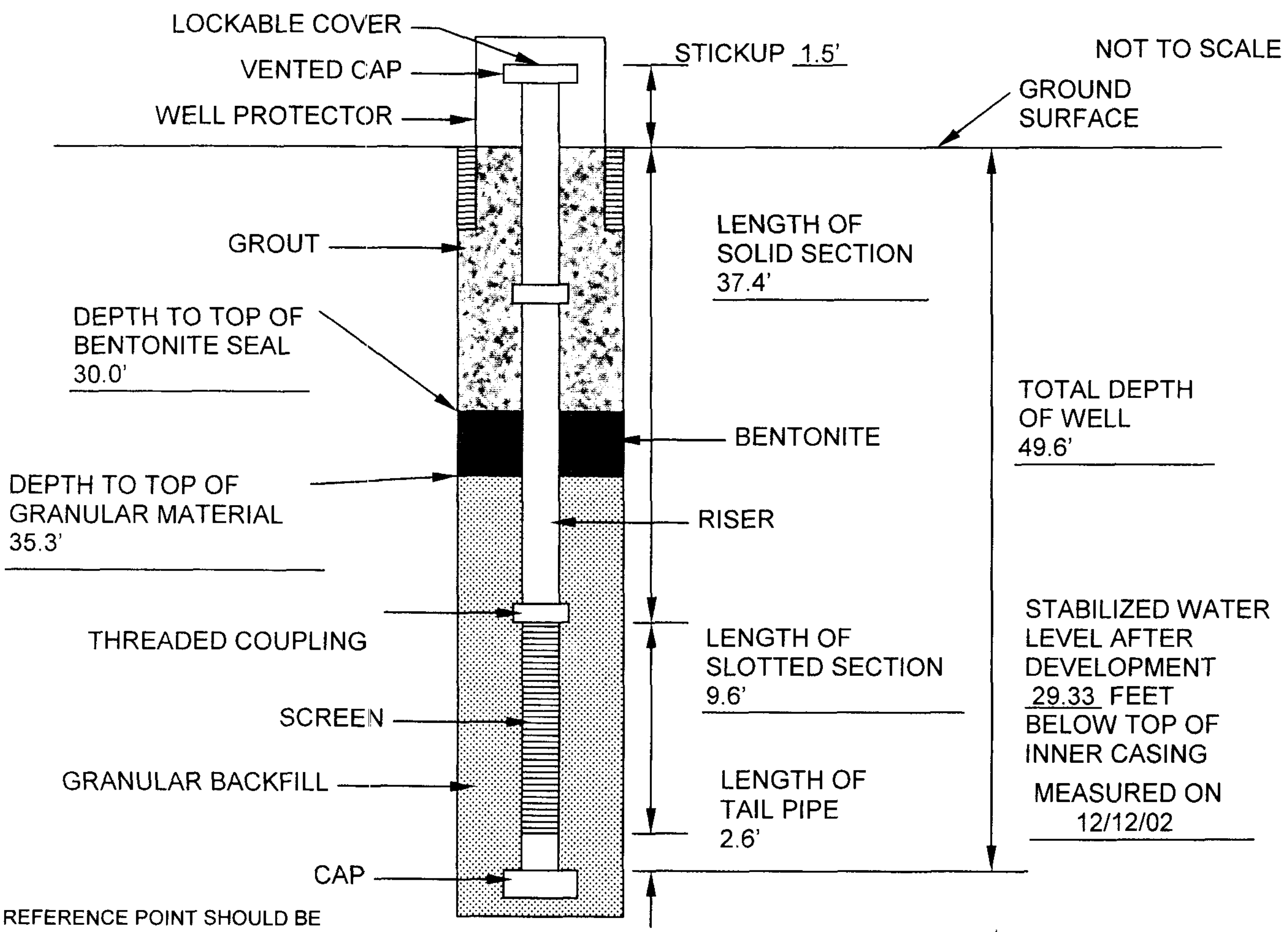
* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

KJ 2-3-03

NORTH ANNA POWER STATION MINERAL, VIRGINA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	NORTH ANNA ESP	JOB NUMBER	37020-2-5400
WELL NUMBER	OW-842	INSTALLATION DATE	12/03/02
LOCATION (NAD83)	3909034.76N 11685149.13E		
GROUND SURFACE ELEVATION (NAVD88)	335.2 ft	REFERENCE POINT ELEVATION * (NAVD88)	336.7 ft
GRANULAR BACKFILL MATERIAL	#2 Well Gravel	SLOT SIZE	0.010 in.
SCREEN MATERIAL	PVC Schd. 40-Standard	SCREEN DIAMETER	2 in.
RISER MATERIAL	PVC Schd. 40-Standard	RISER DIAMETER	2 in.
DRILLING TECHNIQUE	HSA $4^{1/4}$ in. I.D.	DRILLING CONTRACTOR	MACTEC – Atlanta, GA
BOREHOLE DIAMETER	8 in.	MACTEC FIELD REPRESENTATIVE	Matt Howe
LOCK BRAND	Masterlock	SIZE/MODEL	N/A
KEY CODE/COMBINATION	0536		



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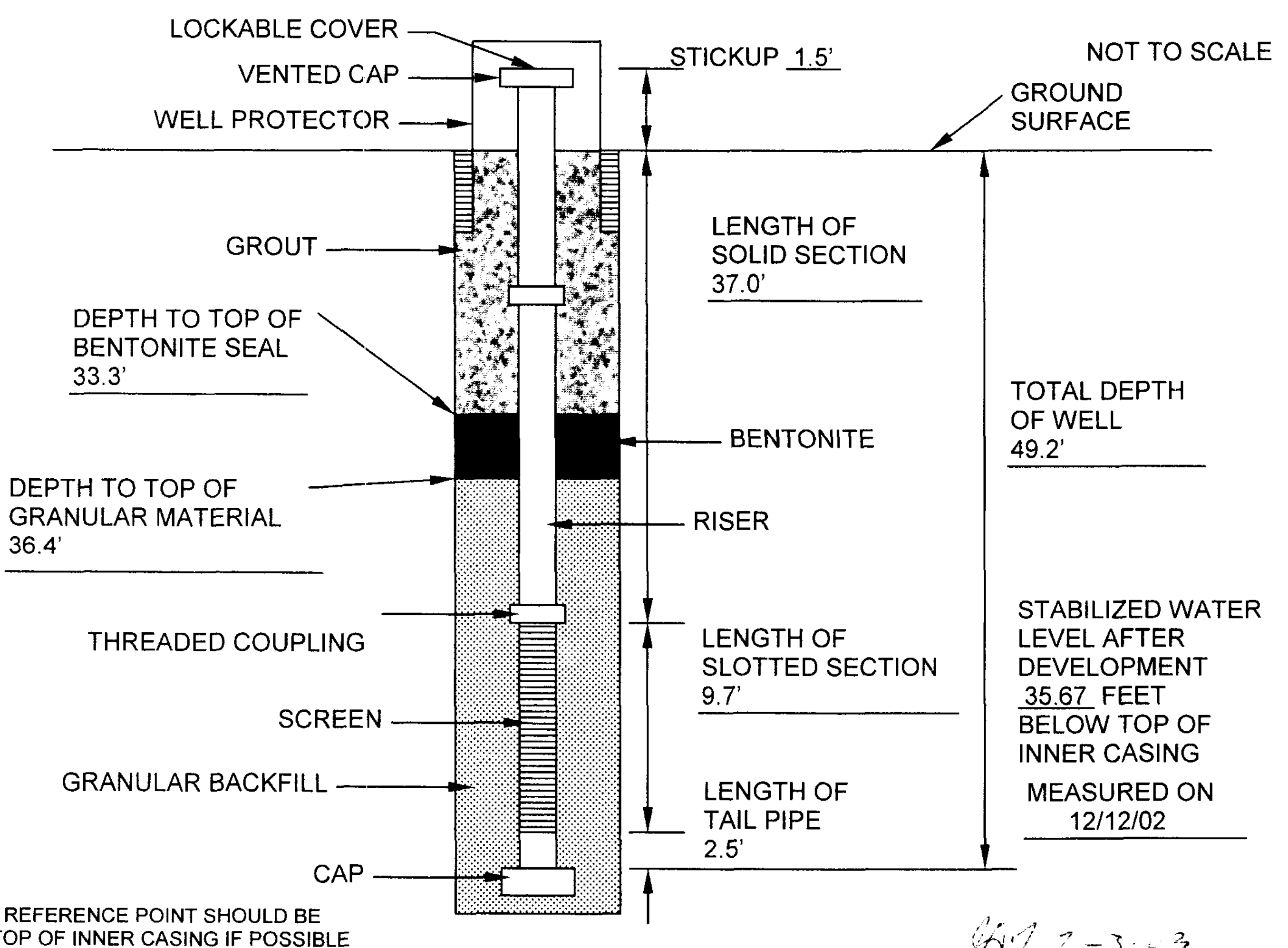
NORTH ANNA POWER STATION MINERAL, VIRGINA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME **NORTH ANNA ESP**
JOB NUMBER **37020-2-5400**
WELL NUMBER **OW-843**
INSTALLATION DATE **12/04/02**
LOCATION (NAD83) **3909725.17N 11685056.83E**
GROUND SURFACE ELEVATION (NAVD88) **319.1 ft**
REFERENCE POINT ELEVATION * (NAVD88) **320.6 ft**
GRANULAR BACKFILL MATERIAL **#2 Well Gravel**
SLOT SIZE **0.010 in.**
SCREEN MATERIAL **PVC Schd. 40-Standard**
SCREEN DIAMETER **2 in.**
RISER MATERIAL **PVC Schd. 40-Standard**
RISER DIAMETER **2 in.**
DRILLING TECHNIQUE **HSA $4^{1/4}$ in. I.D.**
DRILLING CONTRACTOR **MACTEC – Atlanta, GA**
BOREHOLE DIAMETER **8 in.**
MACTEC FIELD REPRESENTATIVE **Matt Howe**
LOCK BRAND **Masterlock**
SIZE/MODEL **N/A**
KEY CODE/COMBINATION **0536**



* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

MH 2-3-03

NORTH ANNA POWER STATION
MINERAL, VIRGINA
ESP PROJECT
Bechtel Subcontract
24830-006-HC4-CY00-00001

MACTEC

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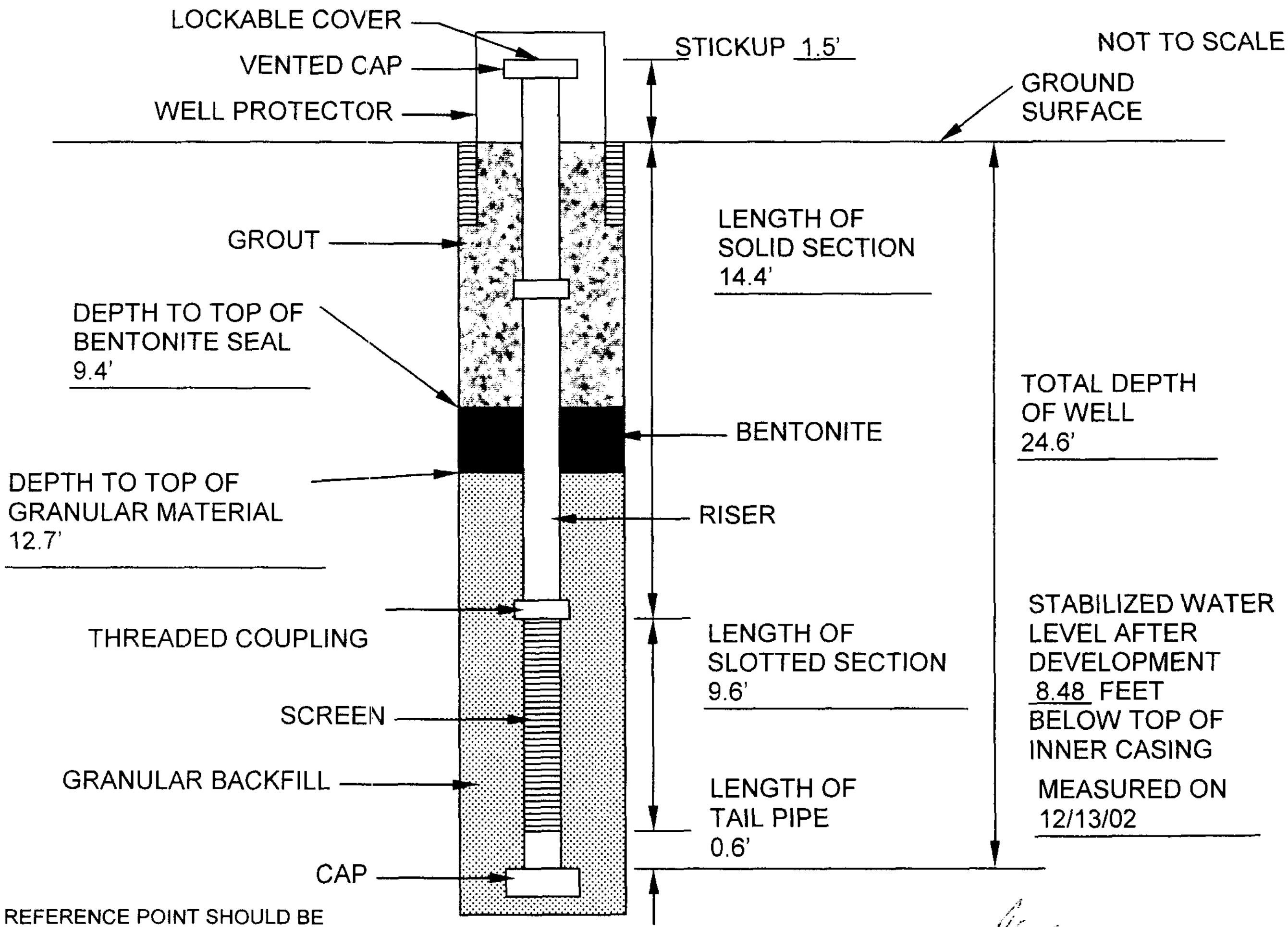
OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	**NORTH ANNA ESP**	JOB NUMBER	**37020-2-5400**
WELL NUMBER	**OW-844**	INSTALLATION DATE	**11/24/02**
LOCATION (NAD83)	**3909908.82N 11686589.65E**		
GROUND SURFACE ELEVATION (NAVD88)	**272.0 ft**	REFERENCE POINT ELEVATION * (NAVD88)	**273.5 ft**
GRANULAR BACKFILL MATERIAL	**#2 Well Gravel**	SLOT SIZE	**0.010 in.**
SCREEN MATERIAL	**PVC Schd. 40-Standard**	SCREEN DIAMETER	**2 in.**
RISER MATERIAL	**PVC Schd. 40-Standard**	RISER DIAMETER	**2 in.**
DRILLING TECHNIQUE	**HSA $4^{1/4}$ in. I.D.**	DRILLING CONTRACTOR	**MACTEC – Atlanta, GA**
BOREHOLE DIAMETER	**8 in.**	MACTEC FIELD REPRESENTATIVE	**Matt Howe**
LOCK BRAND	**Masterlock**	SIZE/MODEL	**N/A**
KEY CODE/COMBINATION	**0536**		



* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

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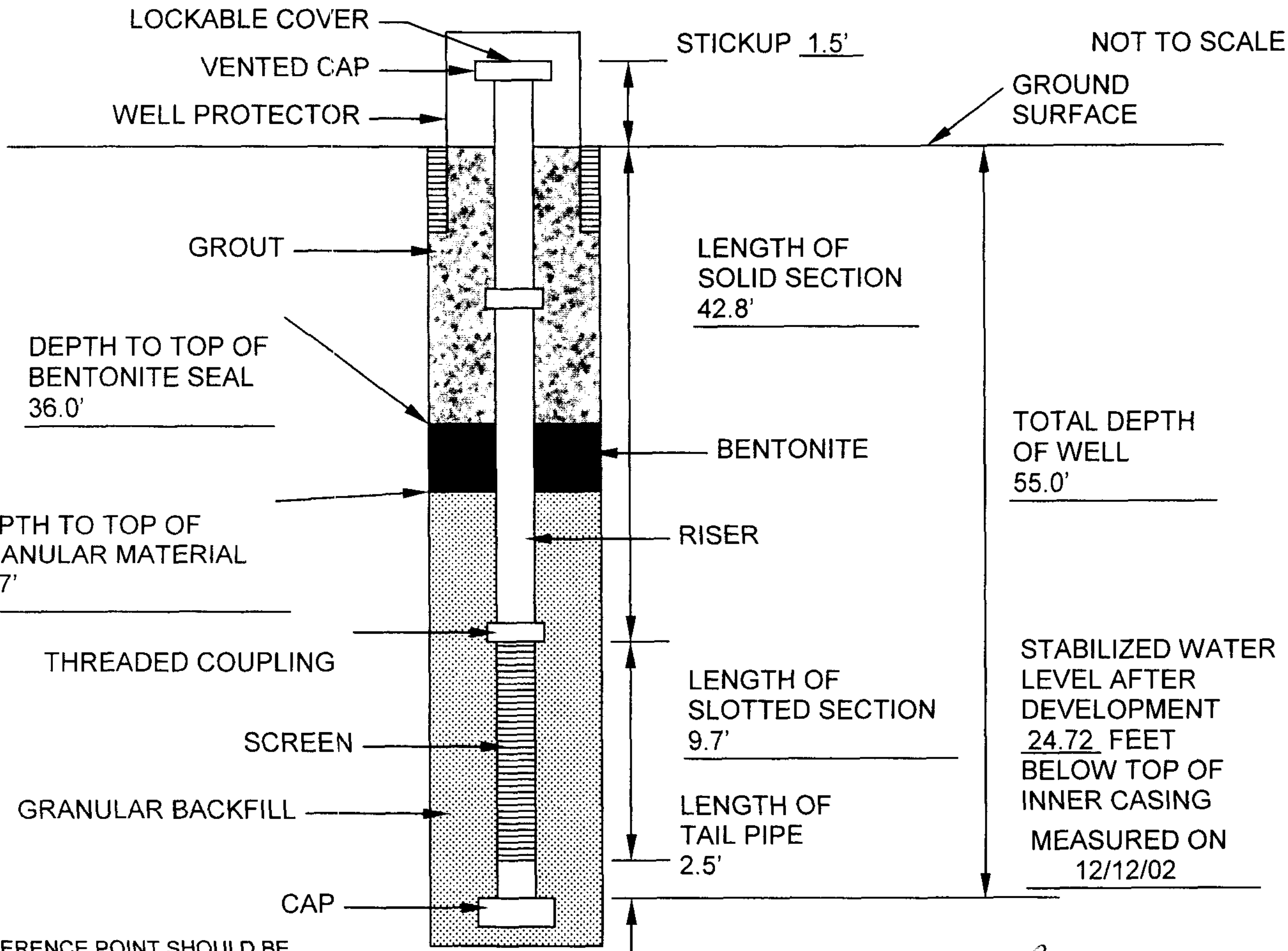
NORTH ANNA POWER STATION MINERAL, VIRGINIA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	**NORTH ANNA ESP**	JOB NUMBER	**37020-2-5400**
WELL NUMBER	**OW-845**	INSTALLATION DATE	**12/03/02**
LOCATION (NAD83)	**3909858.66N 11685741.11E**		
GROUND SURFACE ELEVATION (NAVD88)	**295.8 ft**	REFERENCE POINT ELEVATION * (NAVD88)	**297.3 ft**
GRANULAR BACKFILL MATERIAL	**#2 Well Gravel**	SLOT SIZE	**0.010 in.**
SCREEN MATERIAL	**PVC Schd. 40-Standard**	SCREEN DIAMETER	**2 in.**
RISER MATERIAL	**PVC Schd. 40-Standard**	RISER DIAMETER	**2 in.**
DRILLING TECHNIQUE	**Air Rotary**	DRILLING CONTRACTOR	**Bedford Well Drilling**
BOREHOLE DIAMETER	**6 1/8 in.**	MACTEC FIELD REPRESENTATIVE	**S. Criscenzo – MACTEC** **L. Matthews – Bechtel**
LOCK BRAND	**Masterlock**	SIZE/MODEL	**N/A**
KEY CODE/COMBINATION	**0536**		



* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

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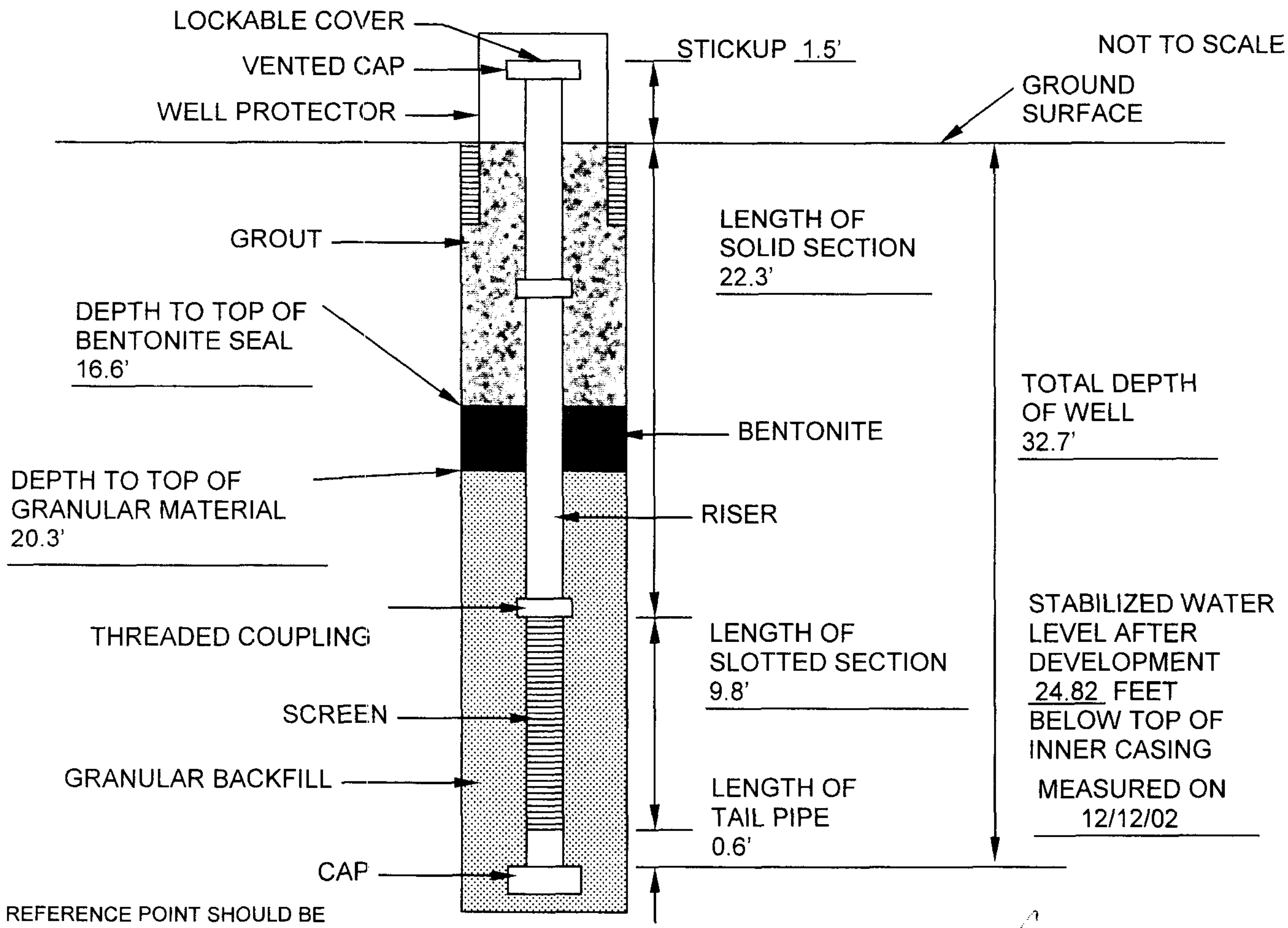
NORTH ANNA POWER STATION MINERAL, VIRGINIA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	**NORTH ANNA ESP**	JOB NUMBER	**37020-2-5400**
WELL NUMBER	**OW-846**	INSTALLATION DATE	**11/23/02**
LOCATION (NAD83)	**3909845.09N 11685721.82E**		
GROUND SURFACE ELEVATION (NAVD88)	**295.8 ft**	REFERENCE POINT ELEVATION * (NAVD88)	**297.3 ft**
GRANULAR BACKFILL MATERIAL	**#2 Well Gravel**	SLOT SIZE	**0.010 in.**
SCREEN MATERIAL	**PVC Schd. 40-Standard**	SCREEN DIAMETER	**2 in.**
RISER MATERIAL	**PVC Schd. 40-Standard**	RISER DIAMETER	**2 in.**
DRILLING TECHNIQUE	**HSA $4^{1/4}$ in. I.D.**	DRILLING CONTRACTOR	**MACTEC – Atlanta, GA**
BOREHOLE DIAMETER	**8 in.**	MACTEC FIELD REPRESENTATIVE	**Matt Howe**
LOCK BRAND	**Masterlock**	SIZE/MODEL	**N/A**
KEY CODE/COMBINATION	**0536**		



* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

NORTH ANNA POWER STATION MINERAL, VIRGINIA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME **NORTH ANNA ESP** | JOB NUMBER **37020-2-5400**

WELL NUMBER **OW-847** | INSTALLATION DATE **12/03/02**

LOCATION (NAD83) **3908945.45N 11686447.69E**

GROUND SURFACE ELEVATION (NAVD88) **318.2 ft** | REFERENCE POINT ELEVATION * (NAVD88) **319.7 ft**

GRANULAR BACKFILL MATERIAL **#2 Well Gravel** | SLOT SIZE **0.010 in.**

SCREEN MATERIAL **PVC Schd. 40-Standard** | SCREEN DIAMETER **2 in.**

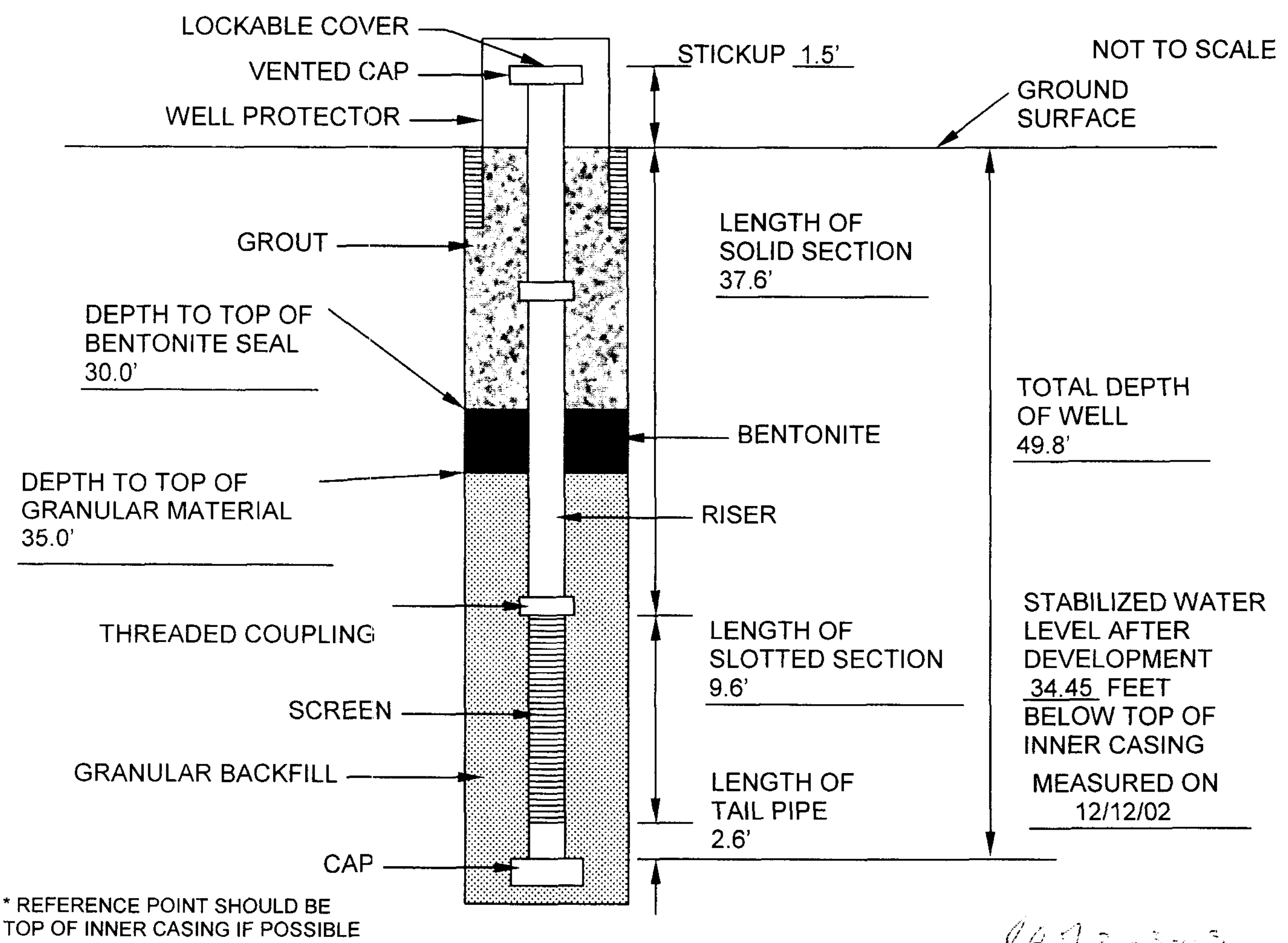
RISER MATERIAL **PVC Schd. 40-Standard** | RISER DIAMETER **2 in.**

DRILLING TECHNIQUE **HSA 4 1/4 in. I.D.** | DRILLING CONTRACTOR **MACTEC – Atlanta, GA**

BOREHOLE DIAMETER **8 in.** | MACTEC FIELD REPRESENTATIVE **Matt Howe**

LOCK BRAND **Masterlock** | SIZE/MODEL **N/A**

KEY CODE/COMBINATION **0536**



* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

2-3-03

NORTH ANNA POWER STATION
MINERAL, VIRGINA
ESP PROJECT
Bechtel Subcontract
24830-006-HC4-CY00-00001

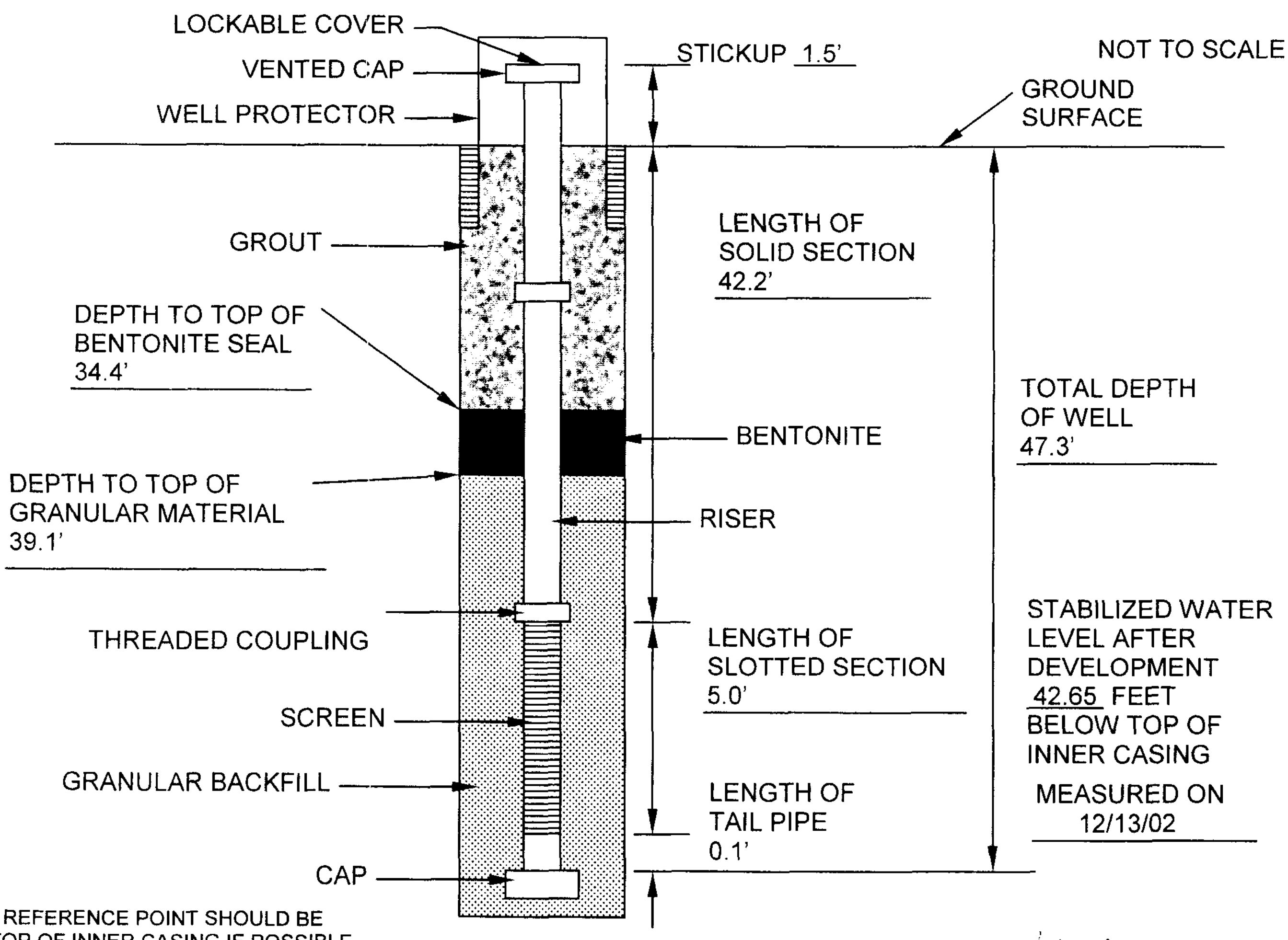
MACTEC

MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, North Carolina 27604

OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	**NORTH ANNA ESP**	JOB NUMBER	**37020-2-5400**
WELL NUMBER	**OW-848**	INSTALLATION DATE	**11/25/02**
LOCATION (NAD83)	**3910853.37N 11686272.76E**		
GROUND SURFACE ELEVATION (NAVD88)	**283.0 ft**	REFERENCE POINT ELEVATION * (NAVD88)	**284.5 ft**
GRANULAR BACKFILL MATERIAL	**#2 Well Gravel**	SLOT SIZE	**0.010 in.**
SCREEN MATERIAL	**PVC Schd. 40-Standard**	SCREEN DIAMETER	**2 in.**
RISER MATERIAL	**PVC Schd. 40-Standard**	RISER DIAMETER	**2 in.**
DRILLING TECHNIQUE	**HSA $4^{1/4}$ in. I.D.**	DRILLING CONTRACTOR	**MACTEC – Atlanta, GA**
BOREHOLE DIAMETER	**8 in.**	MACTEC FIELD REPRESENTATIVE	**Matt Howe**
LOCK BRAND	**Masterlock**	SIZE/MODEL	**N/A**
KEY CODE/COMBINATION	**0536**		



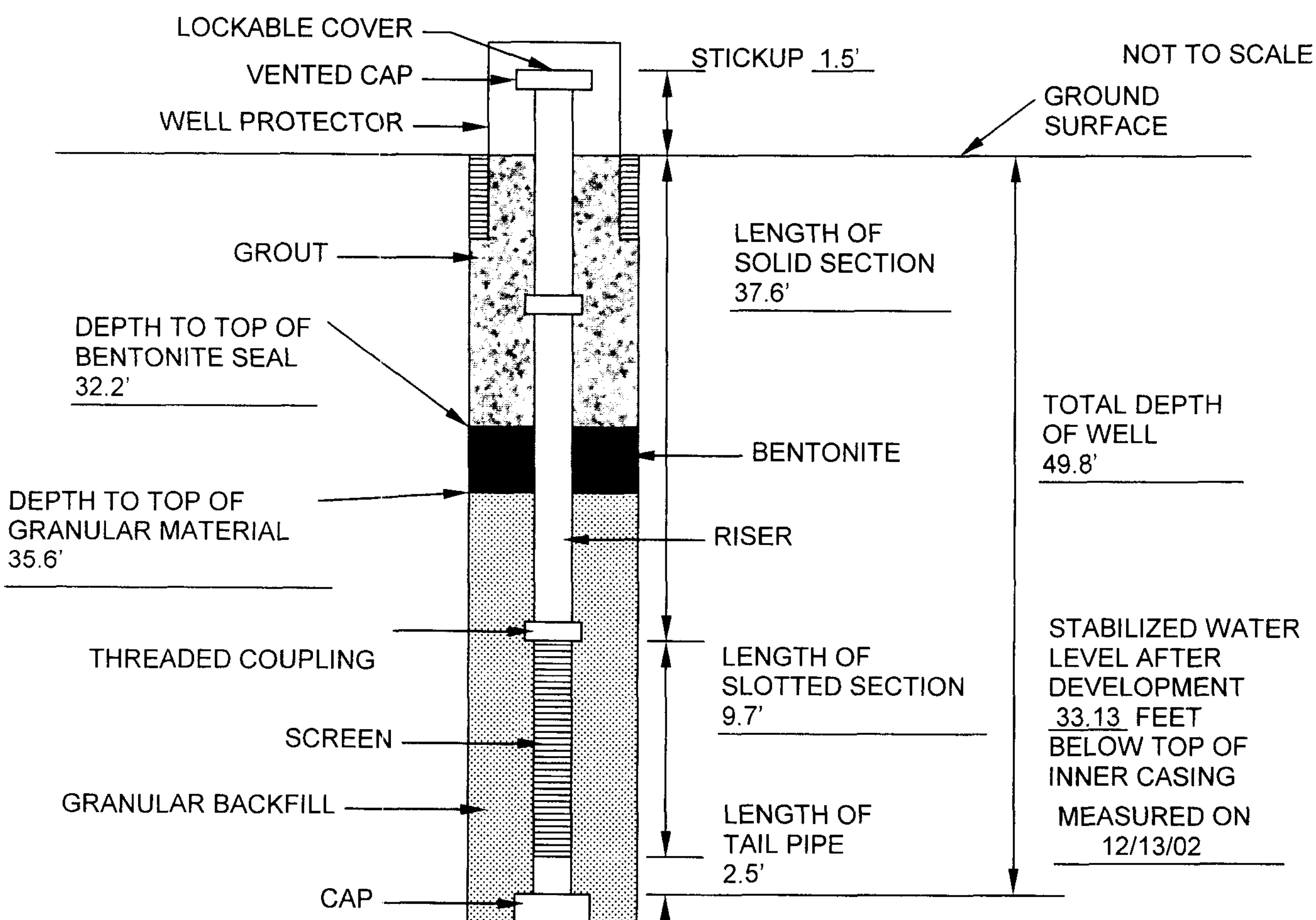
* REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

[illegible] 6-3-03

NORTH ANNA POWER STATION MINERAL, VIRGINA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

OBSERVATION WELL INSTALLATION RECORD

JOB NAME	NORTH ANNA ESP	JOB NUMBER	37020-2-5400
WELL NUMBER	OW-849	INSTALLATION DATE	12/06/02
LOCATION (NAD83)	3910786.24N 11684731.02E		
GROUND SURFACE ELEVATION (NAVD88)	297.0 ft	REFERENCE POINT ELEVATION * (NAVD88)	298.5 ft
GRANULAR BACKFILL MATERIAL	#2 Well Gravel	SLOT SIZE	0.010 in.
SCREEN MATERIAL	PVC Schd. 40-Standard	SCREEN DIAMETER	2 in.
RISER MATERIAL	PVC Schd. 40-Standard	RISER DIAMETER	2 in.
DRILLING TECHNIQUE	HSA $4^{1/4}$ in. I.D.	DRILLING CONTRACTOR	MACTEC – Atlanta, GA
BOREHOLE DIAMETER	8 in.	MACTEC FIELD REPRESENTATIVE	Matt Howe
LOCK BRAND	Masterlock	SIZE/MODEL	N/A
KEY CODE/COMBINATION	0536		



*REFERENCE POINT SHOULD BE TOP OF INNER CASING IF POSSIBLE

2-3-03

NORTH ANNA POWER STATION MINERAL, VIRGINA ESP PROJECT Bechtel Subcontract 24830-006-HC4-CY00-00001	MACTEC MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604	OBSERVATION WELL INSTALLATION RECORD

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Raleigh, North Carolina 27604

Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-841

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/10/02 TIME (MILITARY) 0815

FIELD PERSONNEL Grimes + Howe

WEATHER CONDITIONS Cloudy + Low 30's

TOTAL WELL DEPTH (TWD) ~~35.60~~ wsh 12/11/02 35.80 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5 FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) ~~35.60~~ wsh 12/10/02 2.63 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED 33 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER N/A

SCREENED INTERVAL (FROM ID PLATE) 23.5 – 33.2 (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☒ NO ☐ COMMENTS purged 5 gallons and let rest

LOCKING CAP YES ~~☒~~ wsh 12/10/02 NO ☒ 5 minutes, Purged another

PROTECTIVE POST/ABUTMENT YES ☐ NO ☒ 5 gallons and let rest

NONPOTABLE LABEL YES ☐ NO ☒ 5 minutes. Started w/development

ID PLATE YES ☐ NO ☒

WELL INTEGRITY SATISFACTORY YES ☒ NO ☐

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☒ COMMENTS

GROUNDWATER PARAMETERS wsh 12/10/02

VOLUME (GAL.)	5	10	15	20	25	30	~~30~~ 33
pH (S.U.)	6.94	6.68	6.52	6.66	6.67	6.67	6.98
12/10/02 wsh mS SP. COND. (µ~~MHOS~~/CM)	0.312	0.229	0.240	0.199	0.202	0.217	0.258
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TURBIDITY*	(3)	(2)	(2)	(1)	(1)	(1)	(1)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

TWD - DGW × 0.167 × 6 = development amount in gallons

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Observation Well Development Woksheet

MACTEC JOB NUMBER **30720-2-5400** OBSERVATION WELL NUMBER OW-842

SITE NAME **North Anna Power Station**

DATE (MO/DAY/YR) 12/10/02 TIME (MILITARY) 1530

FIELD PERSONNEL Grimes + Howe

WEATHER CONDITIONS cloudy low 30's

TOTAL WELL DEPTH (TWD) 51.16 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5' FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 29.14 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED 22 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER ~~2~~ mcH 12/10/02

SCREENED INTERVAL (FROM ID PLATE) 37.4 – 45.3 (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☒ NO ☐

LOCKING CAP YES ☒ NO ☐

PROTECTIVE POST/ABUTMENT YES ☐ NO ☒

NONPOTABLE LABEL YES ☐ NO ☒

ID PLATE YES ☐ NO ☒

WELL INTEGRITY SATISFACTORY YES ☒ NO ☐

COMMENTS Purged 3 gallons and let rest 5 gallons. Purged 3 more gallons and let rest 5 minutes. Started purging development volumes.

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☒ COMMENTS

GROUNDWATER PARAMETERS

			mcH 12/10/02	mcH 12/10/02	mcH 12/10/02	mcH 12/10/02	
VOLUME (GAL.)	3	6	~~12~~ 9	~~18~~ 12	~~18~~ 15	~~22~~ 18	22
pH (S.U.)	7.30	7.28	7.15	7.13	7.04	7.04	7.03
mS/cm 12/10/02 mS SP. COND. (µ~~MHOS~~/CM)	0.210	0.205	0.192	0.181	0.174	0.167	0.163
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TURBIDITY*	(2)	(2)	(2)	(2)	(1)	(1)	(2)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

TWD - DGW × 0.167 × 6 = development volume in gallons

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Observation Well Development Woksheet

MACTEC JOB NUMBER **30720-2-5400** OBSERVATION WELL NUMBER OW-843

SITE NAME **North Anna Power Station**

DATE (MO/DAY/YR) 12/10/02 TIME (MILITARY) 1625

FIELD PERSONNEL Gaines + Howe

WEATHER CONDITIONS Cloudy + low 30's

TOTAL WELL DEPTH (TWD) ~~51.00~~ wsr 12/11/02 50.90 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5 FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 35.74 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED ~~16~~ wsr 12/10/02 30 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER n/a

SCREENED INTERVAL (FROM ID PLATE) 40.2 - 49.9 (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☒ NO ☐ COMMENTS Purged 2.5 gallons, let rest 5 minutes. Purged 2.5 more gallons, let rest 5 minutes, started development. Purged 14 additional gallons to stabilize pH

LOCKING CAP YES ~~☒~~ wsr 12/10/02 NO ☒

PROTECTIVE POST/ABUTMENT YES ☐ NO ☒

NONPOTABLE LABEL YES ☐ NO ☒

ID PLATE YES ☐ NO ☒

WELL INTEGRITY SATISFACTORY YES ☒ NO ☐

WELL YIELD LOW ☐ MODERATE ☒ HIGH ☐ COMMENTS

GROUNDWATER PARAMETERS

	wsr 12/10/02	wsr 12/10/02	wsr 12/10/02	wsr 12/10/02	wsr 12/10/02	12/10/02	
VOLUME (GAL.)	~~3~~ 2.5	~~6~~ 5.0	~~9~~ 7.5	~~12~~ 10.0	~~15~~ 12.5	15 ~~16.~~	17.5
pH (S.U.)	9.90	9.87	9.72	9.46	9.20	8.62	8.19
wsr 12/11/02 mS SP. COND. (~~µMHOS~~/CM)	0.187	0.182	0.177	0.172	0.171	0.172	0.167
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A	NA
TURBIDITY*	(2)	(2)	(2)	(2)	(2)	(1)	(1)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH wsr 12/11/02 ~~[illegible]~~ →

TWD - DGW * 0.167 * 6 = development amount in gallons OK [signature] See continuation sheet

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Observation Well Development Wokshеet

MACTEC JOB NUMBER 30720-2-5400   OBSERVATION WELL NUMBER OW-843 continuation

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) ______   TIME (MILITARY) ______

FIELD PERSONNEL ______

WEATHER CONDITIONS ______

TOTAL WELL DEPTH (TWD) ______ FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE ______ FT.

DESCRIPTION OF MEASURING POINT ______

DEPTH TO GROUNDWATER (DGW) see 12/11/07 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION   DISPOSABLE BAILER ☐   OTHER: ______

TOTAL VOLUME OF WATER REMOVED ______ GAL.   CASING DIAMETER ______ IN.

CASING MATERIAL   PVC ☐   S.S. ☐   TEFLON ☐   OTHER ______

SCREENED INTERVAL (FROM ID PLATE) ______ (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING   YES ☐   NO ☐   COMMENTS ______

LOCKING CAP   YES ☐   NO ☐

PROTECTIVE POST/ABUTMENT   YES ☐   NO ☐

NONPOTABLE LABEL   YES ☐   NO ☐

ID PLATE   YES ☐   NO ☐

WELL INTEGRITY SATISFACTORY   YES ☐   NO ☐

WELL YIELD   LOW ☐   MODERATE ☐   HIGH ☐   COMMENTS ______

GROUNDWATER PARAMETERS

VOLUME (GAL.)	20	22.5	25	27.5	30	
pH (S.U.)	7.82	7.66	7.55	7.49	7.41	
12/11/07 SP. COND. (~~µMHOS~~ mS/CM)	0.165	0.164	0.163	0.161	0.160	
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	
TURBIDITY*	(1)	(1)	(1)	(1)	(1)	

* VISUAL DETERMINATION ONLY   (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH   OK [illegible]

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Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-844

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/10/02 TIME (MILITARY) 1120

FIELD PERSONNEL Grimes & Howe

WEATHER CONDITIONS Cloudy, low 30's

TOTAL WELL DEPTH (TWD) ~~25.82~~ 26.10 use 12/11/02 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5 FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 8.95 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED 17 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER

SCREENED INTERVAL (FROM ID PLATE) 14.4 - 24.0 (DEPTHS BELOW LAND SURFACE - FT.)

			COMMENTS
STEELGUARD PIPE AROUND CASING	YES ☒	NO ☐	purged 3 gallons let rest
LOCKING CAP	YES ☒	NO ☐	5 minutes, Purged another 3.5 gallons
PROTECTIVE POST/ABUTMENT	YES ☐	NO ☒	& well dried up, let rest
NONPOTABLE LABEL	YES ☐	NO ☒	Dried up ~ 14.25 gallons, let
ID PLATE	YES ☐	NO ☒	rest. Dried up @ 19.75 gallons
WELL INTEGRITY SATISFACTORY	YES ☒	NO ☐	let rest. 1250-1730 @ 1730

WELL YIELD LOW ☒ MODERATE ☒ use 12/10/02 HIGH ☐ COMMENTS DGW = 8.41. DGW @ 0935 on 12/11/02 = 8.83, well dry @ 3.2 gallons

GROUNDWATER PARAMETERS

VOLUME (GAL.)	3	6	9	12	15	17
pH (S.U.)	8.47	7.97	8.38	7.82	7.40	7.46
use 12/11/02 SP. COND. (~~µMHOS~~ mS/CM)	0.202	0.195	0.223	0.190	0.185	0.187
WATER TEMP. (°C)	n/a	n/A	n/A	n/A	n/A	n/A
TURBIDITY*	(3)	(3)	(4)	(3)	(3)	(2)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH use 12/11/02 ~~temp readings~~

TWD - DGW * 0.167 * 6 = development amount in gallons

OK JAH

See continuation sheet

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Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-844 Continuation

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) ______ TIME (MILITARY) ______

FIELD PERSONNEL ______

WEATHER CONDITIONS ______

TOTAL WELL DEPTH (TWD) ______ FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE ______ FT.

DESCRIPTION OF MEASURING POINT ______

DEPTH TO GROUNDWATER (DGW) ______ FT. (DEPTH BELOW MEASURING POINT)

12/11/07

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: ______

TOTAL VOLUME OF WATER REMOVED ______ GAL. CASING DIAMETER ______ IN.

CASING MATERIAL PVC ☐ S.S. ☐ TEFLON ☐ OTHER ______

SCREENED INTERVAL (FROM ID PLATE) ______ (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☐ NO ☐ COMMENTS ______

LOCKING CAP YES ☐ NO ☐

PROTECTIVE POST/ABUTMENT YES ☐ NO ☐

NONPOTABLE LABEL YES ☐ NO ☐

ID PLATE YES ☐ NO ☐

WELL INTEGRITY SATISFACTORY YES ☐ NO ☐

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☐ COMMENTS ______

GROUNDWATER PARAMETERS

VOLUME (GAL.)	20	23	26	29	32	
pH (S.U.)	7.63	7.72	7.67	7.66	7.62	
12/11/07 SP. COND. (~~µMHOS~~ mS/CM)	0.201	0.207	0.199	0.209	0.200	
WATER TEMP. (°C)	n/a	n/a	n/a	n/a	n/a	
TURBIDITY*	(2)	(2)	(2)	(2)	(2)	

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK [signature]

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Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-845

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/9/02 TIME (MILITARY) 1530

FIELD PERSONNEL Grimes v Howe

WEATHER CONDITIONS Partly Sunny ~30's

TOTAL WELL DEPTH (TWD) ~~55.72~~ 56.50 vsc 12/10/02 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5' FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 24.69 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Whale submersible pump

TOTAL VOLUME OF WATER REMOVED 31 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER N/A

SCREENED INTERVAL (FROM ID PLATE) 43.6 - 53.3 (DEPTHS BELOW LAND SURFACE - FT.)

			COMMENTS
STEEL GUARD PIPE AROUND CASING	YES ☒	NO ☒ vsc 12/10/02	
LOCKING CAP	YES ☒	NO ☐	- purged 2.5 gallons and shut pump off for 15 minutes.
PROTECTIVE POST/ABUTMENT	YES ☒ vsc 12/10/02	NO ☒	- Purged 2.5 gallons, let rest
NONPOTABLE LABEL	YES ☐	NO ☒	15 minutes. Purged 5 gallons
ID PLATE	YES ☐	NO ☒	let sit overnight vsc 12/10/02
WELL INTEGRITY SATISFACTORY	YES ☒	NO ☐	before purging development volume. 12/10/02 - DGW - 24.69 @ 1310

WELL YIELD LOW ☐ MODERATE ☒ HIGH ☐ COMMENTS

GROUNDWATER PARAMETERS

	12/10/02 vsc	12/10/02 vsc	12/10/02 vsc	12/10/02 vsc	12/10/02 vsc	
VOLUME (GAL.)	~~6~~ 5	~~12~~ 10	~~18~~ 15	~~24~~ 20	~~31~~ 25	31
pH (S.U.)	5.87	5.83	5.87	5.83	5.81	5.80
12/10/02 vsc SP. COND. (µ~~MHOS~~ mS/CM)	0.89	0.098	0.095	0.096	0.095	0.096
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A
TURBIDITY*	(1)	(1)	(1)	(1)	(1)	(1)
DGW 12/10/02	24.72 @ 0730					

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK JAJ

TD - DGW * 0.167 * 6 = development amount in gallons

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Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-846

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/6/07 TIME (MILITARY) 1615

FIELD PERSONNEL Grimes & Howe

WEATHER CONDITIONS Partly Sunny and in the 30's

TOTAL WELL DEPTH (TWD) ~~33.60~~ 34.30 12/11/07 wsr FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE ______ FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 24.82 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED wsr 12/10/07 ~~9~~ 33 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER N/A

SCREENED INTERVAL (FROM ID PLATE) ______ (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING	YES ☒	NO ☐	COMMENTS	purged 1 gallon, let rest 5	
LOCKING CAP	YES ☒	NO ☐		minutes, purged another gallon	
PROTECTIVE POST/ABUTMENT	YES ☐	NO ☒		let rest 5 minutes. Purged	
NONPOTABLE LABEL	YES ☐	NO ☒		1, let rest 5 minutes. Purged 1	
ID PLATE	YES ☐	NO ☒		gallon let rest 5 minutes.	
WELL INTEGRITY SATISFACTORY	YES ☒	NO ☐		-removed development volume	

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☒ COMMENTS + additional 24 gallons to clear up sediment.

GROUNDWATER PARAMETERS

VOLUME (GAL.)	1.5	3.0	4.5	6.0	7.5	9.0
pH (S.U.)	5.01	5.19	5.16	5.09	5.16	5.07
12/10/07 wsr SP. COND. (µ~~MHOS~~ mS/CM)	0.245	0.226	0.229	0.233	0.228	0.227
WATER TEMP. (°C)	n/a	n/a	n/a	n/a	n/a	n/a
TURBIDITY* visual	(4)	(4)	(4)	(3)	(3)	(3)
~~DTW~~ DGW on	12/10/07	= 24.93				

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK JAJ

TD - DGW × 0.167 × 6 = development amount

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Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-847

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/6/02 TIME (MILITARY) 1410

FIELD PERSONNEL Ostimus & Howe

WEATHER CONDITIONS Cloudy & Low 30's

TOTAL WELL DEPTH (TWD) ~~50.87~~ 51.30 wsc 12/11/02 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5 FT.

DESCRIPTION OF MEASURING POINT T.O.C

DEPTH TO GROUNDWATER (DGW) 34.18 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED ~~17~~ 28 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER N/A

SCREENED INTERVAL (FROM ID PLATE) 37.6' - 45.5 (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☒ NO ☐

LOCKING CAP YES ☒ NO ☐

PROTECTIVE POST/ABUTMENT YES ☐ NO ☒

NONPOTABLE LABEL YES ☐ NO ☒

ID PLATE YES ☐ NO ☒

WELL INTEGRITY SATISFACTORY YES ☒ NO ☐

WELL YIELD LOW ☐ MODERATE ☒ HIGH ☐

COMMENTS Pumped 3 gallons and let rest 5 minutes, Pumped 3 more gallons, let rest 5 minutes. Started pumping development volumes, pulled 11 additional gallons to clear up sediment.

GROUNDWATER PARAMETERS

VOLUME (GAL.)	3	6	9	12	15	17
pH (S.U.)	7.48	7.11	7.10	7.16	7.25	7.04
SP. COND. (~~µMHOS~~/CM) written ms	0.134	0.103	0.101	0.102	0.119	0.107
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A
TURBIDITY*	(4)	(4)	(3)	(3)	(2)	(2)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH wsc 12/11/02 More readings →

TWD - DGW × 0.167 × 8 = well development amount in gallons

OK JAD

See continuation sheet

MACTEC

MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, North Carolina 27604

Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-847 continuation

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) ______ TIME (MILITARY) ______

FIELD PERSONNEL ______

WEATHER CONDITIONS ______

TOTAL WELL DEPTH (TWD) ______ FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE ______ FT.

DESCRIPTION OF MEASURING POINT ______

DEPTH TO GROUNDWATER (DGW) VSB 12/11/02 ______ FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: ______

TOTAL VOLUME OF WATER REMOVED ______ GAL. CASING DIAMETER ______ IN.

CASING MATERIAL PVC ☐ S.S. ☐ TEFLON ☐ OTHER ______

SCREENED INTERVAL (FROM ID PLATE) ______ (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☐ NO ☐ COMMENTS ______

LOCKING CAP YES ☐ NO ☐ ______

PROTECTIVE POST/ABUTMENT YES ☐ NO ☐ ______

NONPOTABLE LABEL YES ☐ NO ☐ ______

ID PLATE YES ☐ NO ☐ ______

WELL INTEGRITY SATISFACTORY YES ☐ NO ☐ ______

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☐ COMMENTS ______

GROUNDWATER PARAMETERS

VOLUME (GAL.)	20	23	26			
pH (S.U.)	6.94	7.05	7.04			
12/11/02 VSB SP. COND. (~~µMHOS~~ mS/CM)	0.092	0.096	0.112			
WATER TEMP. (°C)	n/a	n/a	n/a			
TURBIDITY*	(2)	(1)	(1)			

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK

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Raleigh, North Carolina 27604

Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-848

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/10/02 TIME (MILITARY) 0920

FIELD PERSONNEL Grimes & Howe

WEATHER CONDITIONS Cloudy in low 30's

TOTAL WELL DEPTH (TWD) ~~49.50~~ 48.87 wsb 12/11/02 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5' FT.

DESCRIPTION OF MEASURING POINT T.O.C

DEPTH TO GROUNDWATER (DGW) 42.79 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ wsb 12/11/02 OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED ~~6.5~~ 8.5 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☑ S.S. ☐ TEFLON ☐ OTHER n/A

SCREENED INTERVAL (FROM ID PLATE) 42.2 - 47.22 (DEPTHS BELOW LAND SURFACE - FT.)

	YES	NO
STEEL GUARD PIPE AROUND CASING	☒	☐
LOCKING CAP	☒	☐
PROTECTIVE POST/ABUTMENT	☐	☒
NONPOTABLE LABEL	☐	☒
ID PLATE	☐	☒
WELL INTEGRITY SATISFACTORY	☒	☐

COMMENTS Removed 1 gallon & let rest 5 minutes. Removed 1 gallon & let rest for 5 minutes. Removed 1 gallon & let sit with turbine rest 5 minutes prior to developing. pulled an additional 2 gallons

WELL YIELD LOW ☐ MODERATE ☒ HIGH ☐ COMMENTS to clean up sediment

GROUNDWATER PARAMETERS

VOLUME (GAL.)	1	2	3	4	5	6	6.5
pH (S.U.)	8.87	8.60	9.38	8.78	8.43	8.25	7.88
SP. COND. (~~µMHOS~~ mS/CM) 12/11/02 wsb	0.200	0.230	0.186	0.281	0.293	0.307	0.314
WATER TEMP. (°C)	N/A ~~(3)~~ ~~(4)~~ 12/11/02	n/a wsb 12/11/02	n/A	n/A	n/A	n/A	n/A
TURBIDITY*	(4)	(4)	(4)	(4)	(4)	(3)	(3)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH wsb 12/11/02 ~~Moderate~~

TWD - DGW + 0.167 × 6 = development amount in gallons

OK JCL

see continuation sheet →

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Raleigh, North Carolina 27604

Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-848 continuation

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) ______ TIME (MILITARY) ______

FIELD PERSONNEL ______

WEATHER CONDITIONS ______

TOTAL WELL DEPTH (TWD) ______ FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE ______ FT.

DESCRIPTION OF MEASURING POINT ______

DEPTH TO GROUNDWATER (DGW) WAV 11/11/08 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: ______

TOTAL VOLUME OF WATER REMOVED ______ GAL. CASING DIAMETER ______ IN.

CASING MATERIAL PVC ☐ S.S. ☐ TEFLON ☐ OTHER ______

SCREENED INTERVAL (FROM ID PLATE) ______ (DEPTHS BELOW LAND SURFACE - FT.)

STEEL GUARD PIPE AROUND CASING YES ☐ NO ☐ COMMENTS ______

LOCKING CAP YES ☐ NO ☐

PROTECTIVE POST/ABUTMENT YES ☐ NO ☐

NONPOTABLE LABEL YES ☐ NO ☐

ID PLATE YES ☐ NO ☐

WELL INTEGRITY SATISFACTORY YES ☐ NO ☐

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☐ COMMENTS ______

GROUNDWATER PARAMETERS

VOLUME (GAL.)	7.5	8.5				
pH (S.U.)	7.49	7.42				
11/11/08 WAV SP. COND. (~~µMHOS~~ mS/CM)	0.353	0.368				
WATER TEMP. (°C)	n/a	n/a				
TURBIDITY*	(2)	(1)				

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK JAJ

MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, North Carolina 27604

Observation Well Development Woksheet

MACTEC JOB NUMBER 30720-2-5400 OBSERVATION WELL NUMBER OW-849

SITE NAME North Anna Power Station

DATE (MO/DAY/YR) 12/11/02 TIME (MILITARY) 1350

FIELD PERSONNEL Grimes + Deobald

WEATHER CONDITIONS rainy and Low 30's

TOTAL WELL DEPTH (TWD) 51.30 FT. (DEPTH BELOW MEASURING POINT)

HEIGHT OF MEASURING POINT ABOVE LAND SURFACE 1.5 FT.

DESCRIPTION OF MEASURING POINT T.O.C.

DEPTH TO GROUNDWATER (DGW) 33.15 FT. (DEPTH BELOW MEASURING POINT)

METHOD OF WELL EVACUATION DISPOSABLE BAILER ☐ OTHER: Submersible whale pump

TOTAL VOLUME OF WATER REMOVED 18.5 GAL. CASING DIAMETER 2 IN.

CASING MATERIAL PVC ☒ S.S. ☐ TEFLON ☐ OTHER N/A

SCREENED INTERVAL (FROM ID PLATE) 37.6 - 47.3 (DEPTHS BELOW LAND SURFACE - FT.)

	YES	NO
STEEL GUARD PIPE AROUND CASING	☒	☐
LOCKING CAP	☐	☐
PROTECTIVE POST/ABUTMENT	☐	☒
NONPOTABLE LABEL	☐	☒
ID PLATE	☐	☒
WELL INTEGRITY SATISFACTORY	☒	☐

COMMENTS Pumped 3 gallons, let rest 5 minutes, pumped 5 more gallons, let rest 5 minutes, started pumping development volume

WELL YIELD LOW ☐ MODERATE ☐ HIGH ☒ COMMENTS

GROUNDWATER PARAMETERS

VOLUME (GAL.)	3	6	9	12	15	18.5
pH (S.U.)	6.95	6.84	6.80	6.74	6.74	6.62
use 12/11/02 mS SP. COND. (~~µMHOS~~/CM)	0.117	0.099	0.089	0.084	0.083	0.078
WATER TEMP. (°C)	N/A	N/A	N/A	N/A	N/A	N/A
TURBIDITY*	(2)	(2)	(2)	(1)	(1)	(1)

* VISUAL DETERMINATION ONLY (1) CLEAR (2) SLIGHT (3) MODERATE (4) HIGH

OK

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APPENDIX E
WELL PERMEABILITY TEST RESULTS

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/13/02	**Time:** 0820	**Observation Well No.:**	OW-841
Weather Conditions:	cloudy in upper 30's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	35.80 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	22.0 - 31.7 ft
Depth to Groundwater:	2.45 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
~~Final 35.80~~ 2.63	12-06-02
2.99	12-09-02

Comments/Remarks

Slug 1 volume = 0.08 ft^3

(Slug 2 volume = 0.08 ft^3)

Transducer s/n → 6497

Hermit s/n → 45749

Set transducer @ 20' below TOC

WSW

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Vell: OW-841
est Date: 12/13/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: [illegible] 12/20/02

WELL DATA

SWL =	2.45	(ft BTOC)
WD =	35.80	(ft BTOC)
WD =	34.30	(ft BGS)
DTSP =	20.10	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	33.35	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.425	(ft) from plot
yt =	0.472	(ft) from plot
t =	0.644	(minutes) from plot
ln(Re/rw) =	2.70	
K =	**2.2E+00**	**(ft/day)**
K =	**7.8E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.70

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 3.23

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

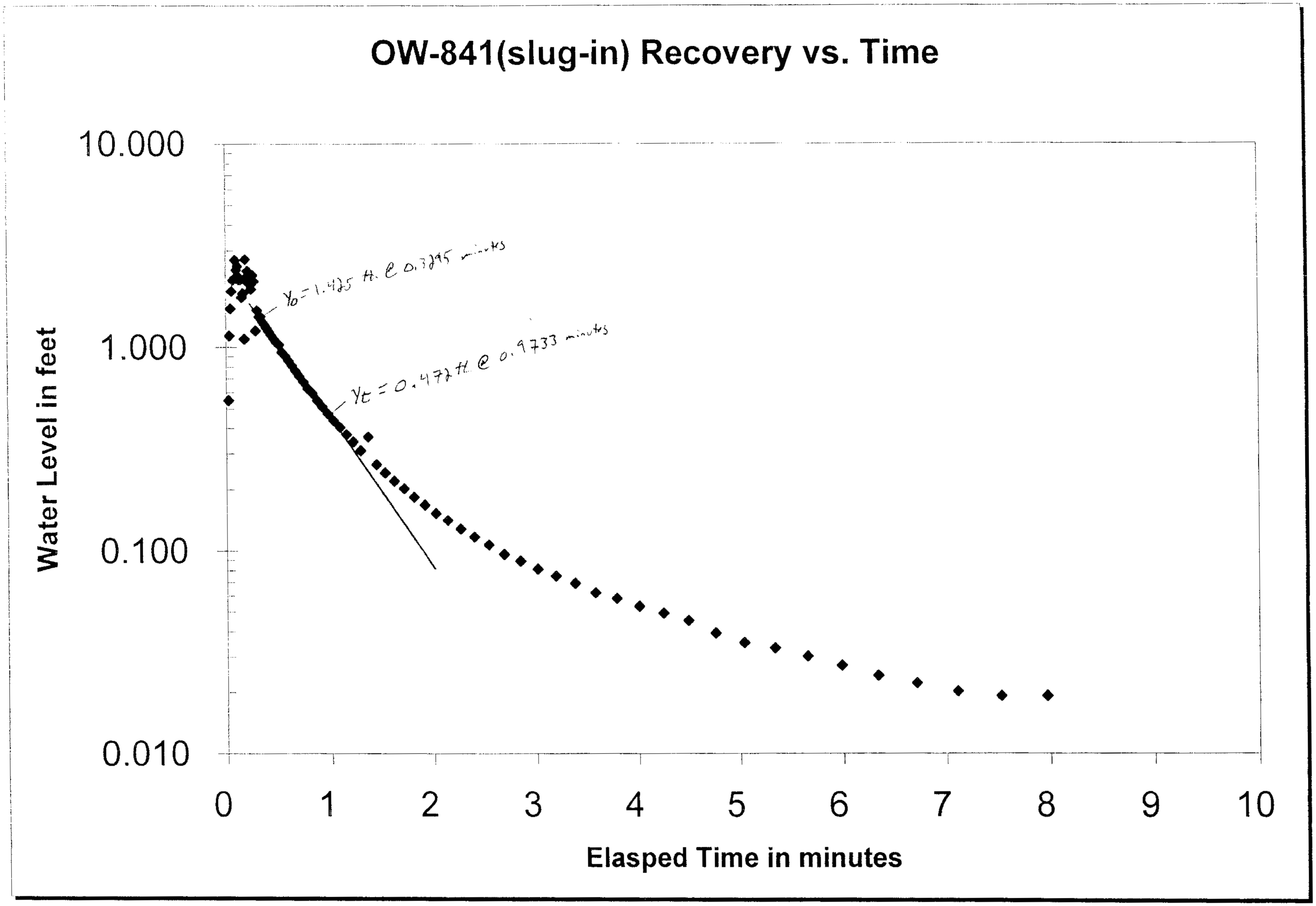
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	2.45	0
0.011	-3.00	0.001	2.449	-0.001
0.022	-0.26	0.550	1.9	-0.55
0.033	0.06	1.142	1.308	-1.142
0.044	0.19	1.561	0.889	-1.561
0.055	0.28	1.901	0.549	-1.901
0.066	0.33	2.157	0.293	-2.157
0.077	0.34	2.175	0.275	-2.175
0.088	0.43	2.708	-0.258	-2.708
0.099	0.38	2.423	0.027	-2.423
0.11	0.40	2.533	-0.083	-2.533
0.121	0.34	2.169	0.281	-2.169
0.132	0.35	2.223	0.227	-2.223
0.143	0.33	2.157	0.293	-2.157
0.154	0.25	1.776	0.674	-1.776
0.165	0.27	1.854	0.596	-1.854
0.176	0.04	1.102	1.348	-1.102
0.187	0.44	2.726	-0.276	-2.726
0.198	0.35	2.233	0.217	-2.233
0.209	0.38	2.396	0.054	-2.396
0.22	0.32	2.076	0.374	-2.076
0.231	0.32	2.083	0.367	-2.083
0.2427	0.29	1.946	0.504	-1.946
0.2552	0.36	2.286	0.164	-2.286
0.2683	0.33	2.129	0.321	-2.129
0.2823	0.08	1.210	1.24	-1.21
0.2972	0.18	1.530	0.92	-1.53
0.3128	0.15	1.419	1.031	-1.419
0.3295	0.15	1.425	1.025	-1.425
0.3472	0.13	1.341	1.109	-1.341
0.3658	0.11	1.295	1.155	-1.295
0.3857	0.10	1.249	1.201	-1.249
0.4067	0.08	1.201	1.249	-1.201
0.4288	0.06	1.152	1.298	-1.152
0.4523	0.04	1.106	1.344	-1.106
0.4772	0.02	1.059	1.391	-1.059
0.5035	0.01	1.033	1.417	-1.033
0.5315	-0.02	0.948	1.502	-0.948
0.5612	-0.04	0.909	1.541	-0.909
0.5925	-0.06	0.861	1.589	-0.861
0.6257	-0.09	0.814	1.636	-0.814
0.6608	-0.12	0.766	1.684	-0.766
0.6982	-0.14	0.722	1.728	-0.722
0.7377	-0.17	0.675	1.775	-0.675
0.7795	-0.20	0.625	1.825	-0.625
0.8238	-0.23	0.595	1.855	-0.595
0.8708	-0.26	0.549	1.901	-0.549
0.9207	-0.29	0.510	1.94	-0.51
0.9733	-0.33	0.472	1.978	-0.472
1.0292	-0.36	0.436	2.014	-0.436
1.0883	-0.39	0.405	2.045	-0.405
1.151	-0.43	0.373	2.077	-0.373
1.2173	-0.46	0.344	2.106	-0.344
1.2877	-0.51	0.311	2.139	-0.311
1.3622	-0.44	0.363	2.087	-0.363
1.4412	-0.58	0.265	2.185	-0.265
1.5248	-0.62	0.241	2.209	-0.241
1.6133	-0.66	0.220	2.23	-0.22
1.7072	-0.69	0.202	2.248	-0.202
1.8065	-0.74	0.184	2.266	-0.184
1.9118	-0.77	0.168	2.282	-0.168
2.0233	-0.82	0.153	2.297	-0.153
2.1415	-0.85	0.141	2.309	-0.141
2.2667	-0.89	0.128	2.322	-0.128
2.3992	-0.93	0.117	2.333	-0.117
2.5397	-0.97	0.107	2.343	-0.107
2.6885	-1.02	0.096	2.354	-0.096
2.846	-1.05	0.089	2.361	-0.089
3.0128	-1.09	0.081	2.369	-0.081
3.1897	-1.12	0.075	2.375	-0.075
3.377	-1.16	0.069	2.381	-0.069
3.5753	-1.21	0.062	2.388	-0.062
3.7855	-1.24	0.058	2.392	-0.058
4.0082	-1.28	0.053	2.397	-0.053
4.244	-1.31	0.049	2.401	-0.049
4.4938	-1.35	0.045	2.405	-0.045
4.7585	-1.41	0.039	2.411	-0.039
5.0388	-1.46	0.035	2.415	-0.035
5.3357	-1.48	0.033	2.417	-0.033
5.6502	-1.52	0.030	2.42	-0.03
5.9833	-1.57	0.027	2.423	-0.027
6.3362	-1.62	0.024	2.426	-0.024
6.71	-1.66	0.022	2.428	-0.022
7.106	-1.70	0.020	2.43	-0.02
7.5253	-1.72	0.019	2.431	-0.019
7.9697	-1.72	0.019	2.431	-0.019



CHK'D: BWS 12/20/02

Slug-out

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

MACTEC

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12-13-02	**Time:** 0835	**Observation Well No.:**	OW-841
Weather Conditions:	cloudy, calm, upper 30s		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	35.50 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	22.0-31.70 ft
Depth to Groundwater:	2.45 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
~~35.50~~ 2.63	12/6/02
2.59	12/09/02

Comments/Remarks

LSW

Slug #2 → volume = 0.08 ft³

Transducer S/N = 6407

Maxi-t S/N = 45449

Set transducer @ 20' below TOC

LSW

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-841
Test Date: 12/13/2002
Test Type: Recovery (slug out)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: [signature] 12/20/02

WELL DATA

SWL =	2.45	(ft BTOC)
WD =	35.80	(ft BTOC)
WD =	34.30	(ft BGS)
DTSP =	20.10	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	33.35	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.180	(ft) from plot
yt =	0.829	(ft) from plot
t =	0.540	(minutes) from plot
ln(Re/rw) =	2.70	
K =	**2.3E+00**	**(ft/day)**
K =	**8.2E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1= 2.70

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(C/(Le/rw))]^-1 = 3.23

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

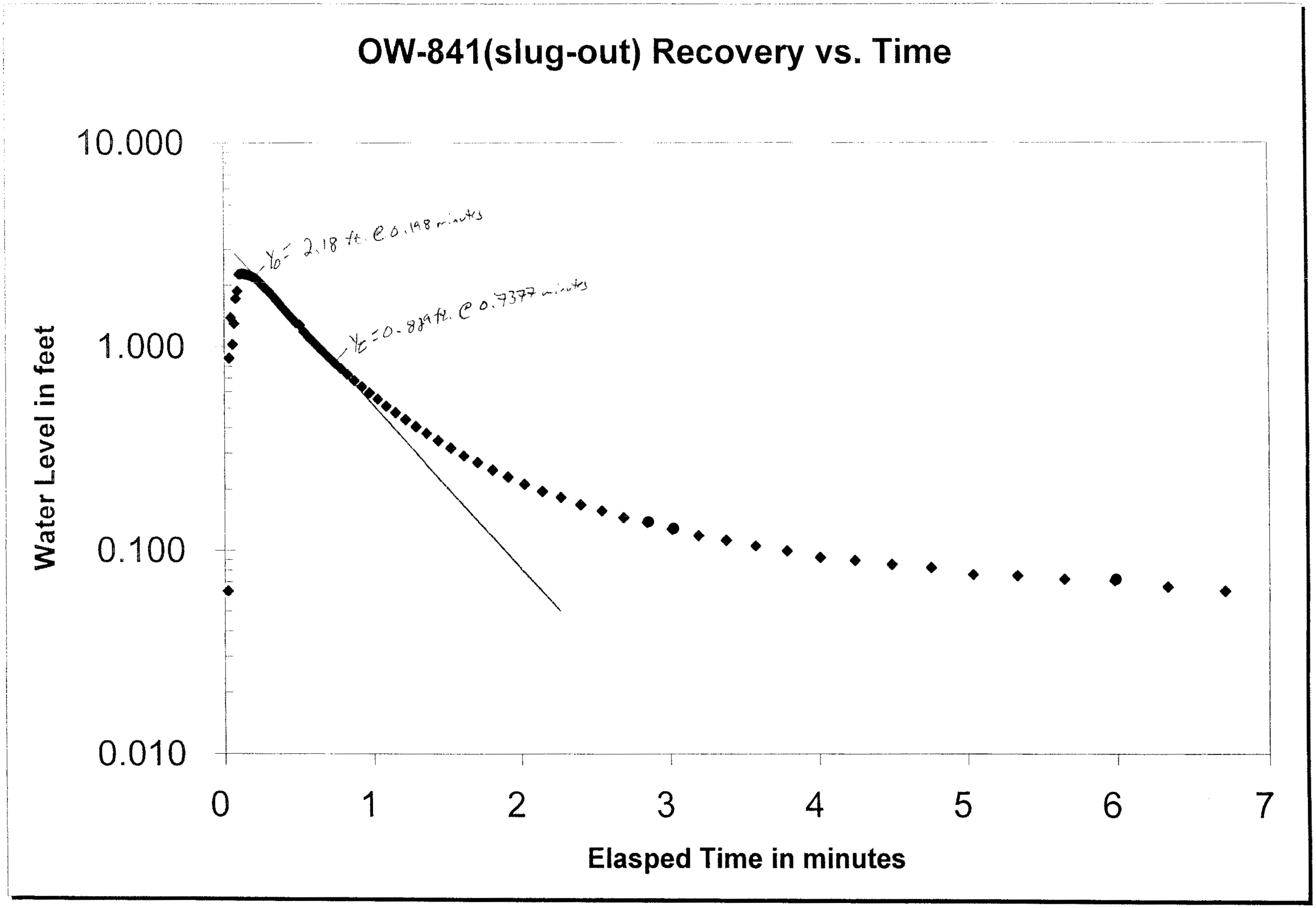
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	2.45	0
0.011	#NUM!	0.000	2.45	0
0.022	-1.20	0.063	2.513	0.063
0.033	-0.06	0.877	3.327	0.877
0.044	0.14	1.385	3.835	1.385
0.055	0.01	1.024	3.474	1.024
0.066	0.11	1.299	3.749	1.299
0.077	0.23	1.716	4.166	1.716
0.088	0.27	1.870	4.32	1.87
0.099	0.35	2.259	4.709	2.259
0.11	0.36	2.269	4.719	2.269
0.121	0.36	2.280	4.73	2.28
0.132	0.36	2.267	4.717	2.267
0.143	0.35	2.262	4.712	2.262
0.154	0.35	2.249	4.699	2.249
0.165	0.35	2.236	4.686	2.236
0.176	0.35	2.223	4.673	2.223
0.187	0.34	2.206	4.656	2.206
0.198	0.34	2.180	4.63	2.18
0.209	0.33	2.160	4.61	2.16
0.22	0.33	2.128	4.578	2.128
0.231	0.32	2.086	4.536	2.086
0.2427	0.31	2.046	4.496	2.046
0.2552	0.30	1.995	4.445	1.995
0.2683	0.29	1.949	4.399	1.949
0.2823	0.28	1.911	4.361	1.911
0.2972	0.27	1.860	4.31	1.86
0.3128	0.26	1.804	4.254	1.804
0.3295	0.24	1.746	4.196	1.746
0.3472	0.23	1.687	4.137	1.687
0.3658	0.21	1.626	4.076	1.626
0.3857	0.19	1.561	4.011	1.561
0.4067	0.18	1.500	3.95	1.5
0.4288	0.16	1.437	3.887	1.437
0.4523	0.14	1.375	3.825	1.375
0.4772	0.12	1.312	3.762	1.312
0.5035	0.11	1.281	3.731	1.281
0.5315	0.07	1.185	3.635	1.185
0.5612	0.05	1.119	3.569	1.119
0.5925	0.02	1.058	3.508	1.058
0.6257	0.00	0.998	3.448	0.998
0.6608	-0.03	0.942	3.392	0.942
0.6982	-0.05	0.884	3.334	0.884
0.7377	-0.08	0.829	3.279	0.829
0.7795	-0.11	0.780	3.23	0.78
0.8238	-0.14	0.732	3.182	0.732
0.8708	-0.17	0.681	3.131	0.681
0.9207	-0.20	0.636	3.086	0.636
0.9733	-0.23	0.593	3.043	0.593
1.0292	-0.26	0.552	3.002	0.552
1.0883	-0.29	0.511	2.961	0.511
1.151	-0.32	0.474	2.924	0.474
1.2173	-0.36	0.438	2.888	0.438
1.2877	-0.39	0.405	2.855	0.405
1.3622	-0.42	0.376	2.826	0.376
1.4412	-0.46	0.346	2.796	0.346
1.5248	-0.50	0.318	2.768	0.318
1.6133	-0.53	0.292	2.742	0.292
1.7072	-0.57	0.271	2.721	0.271
1.8065	-0.60	0.249	2.699	0.249
1.9118	-0.64	0.230	2.68	0.23
2.0233	-0.67	0.212	2.662	0.212
2.1415	-0.71	0.196	2.646	0.196
2.2667	-0.74	0.183	2.633	0.183
2.3992	-0.77	0.168	2.618	0.168
2.5397	-0.80	0.157	2.607	0.157
2.6885	-0.84	0.145	2.595	0.145
2.846	-0.86	0.137	2.587	0.137
3.0128	-0.90	0.127	2.577	0.127
3.1897	-0.93	0.118	2.568	0.118
3.377	-0.95	0.112	2.562	0.112
3.5753	-0.98	0.105	2.555	0.105
3.7855	-1.00	0.099	2.549	0.099
4.0082	-1.04	0.092	2.542	0.092
4.244	-1.05	0.089	2.539	0.089
4.4938	-1.07	0.085	2.535	0.085
4.7585	-1.09	0.082	2.532	0.082
5.0388	-1.12	0.076	2.526	0.076
5.3357	-1.12	0.075	2.525	0.075
5.6502	-1.14	0.072	2.522	0.072
5.9833	-1.15	0.071	2.521	0.071
6.3362	-1.18	0.066	2.516	0.066
6.71	-1.20	0.063	2.513	0.063



CHK'D: BWD 12/20/02.

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name: North Anna ESP		**MACTEC Job Number:** 30720-2-5400	
Date: 12/12/02	**Time:** 1215	**Observation Well No.:** OW 842	
Weather Conditions: [illegible]			
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen: 2 in.		**Diameter of Casing:** 2 in.	
Total Well Depth: 57.16 ft below reference point		**Reference Point:**	Permanent mark on top of casing
Length of Screened Section: 7.9 ft		**Depth interval of screened portion:**	37.4-45.3 ft
Depth to Groundwater: 39.33 ft below reference point			

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
39.14	12/10/02
39.32	12/11/02
39.33	12/12/02

Comments/Remarks

[illegible]

[illegible]

[illegible]

[illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-842
Test Date: 12/17/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: WSG/12/18/2002
Checked/date: [signature] 12/20/02

WELL DATA

SWL =	29.23	(ft BTOC)
WD =	51.16	(ft BTOC)
WD =	49.66	(ft BGS)
DTSP =	35.30	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	7.9	(ft)
Lw =	21.93	(ft)
Le/rw =	23.94	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.670	(ft) from plot
yt =	0.589	(ft) from plot
t =	2.343	(minutes) from plot
ln(Re/rw) =	2.38	

K = 9.3E-01 (ft/day)

K = 3.3E-04 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1= 2.38

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(C/(Le/rw))]^-1 = 2.94

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
20	2.23	0.29	1.75
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

23.94	2.34	0.31	1.89

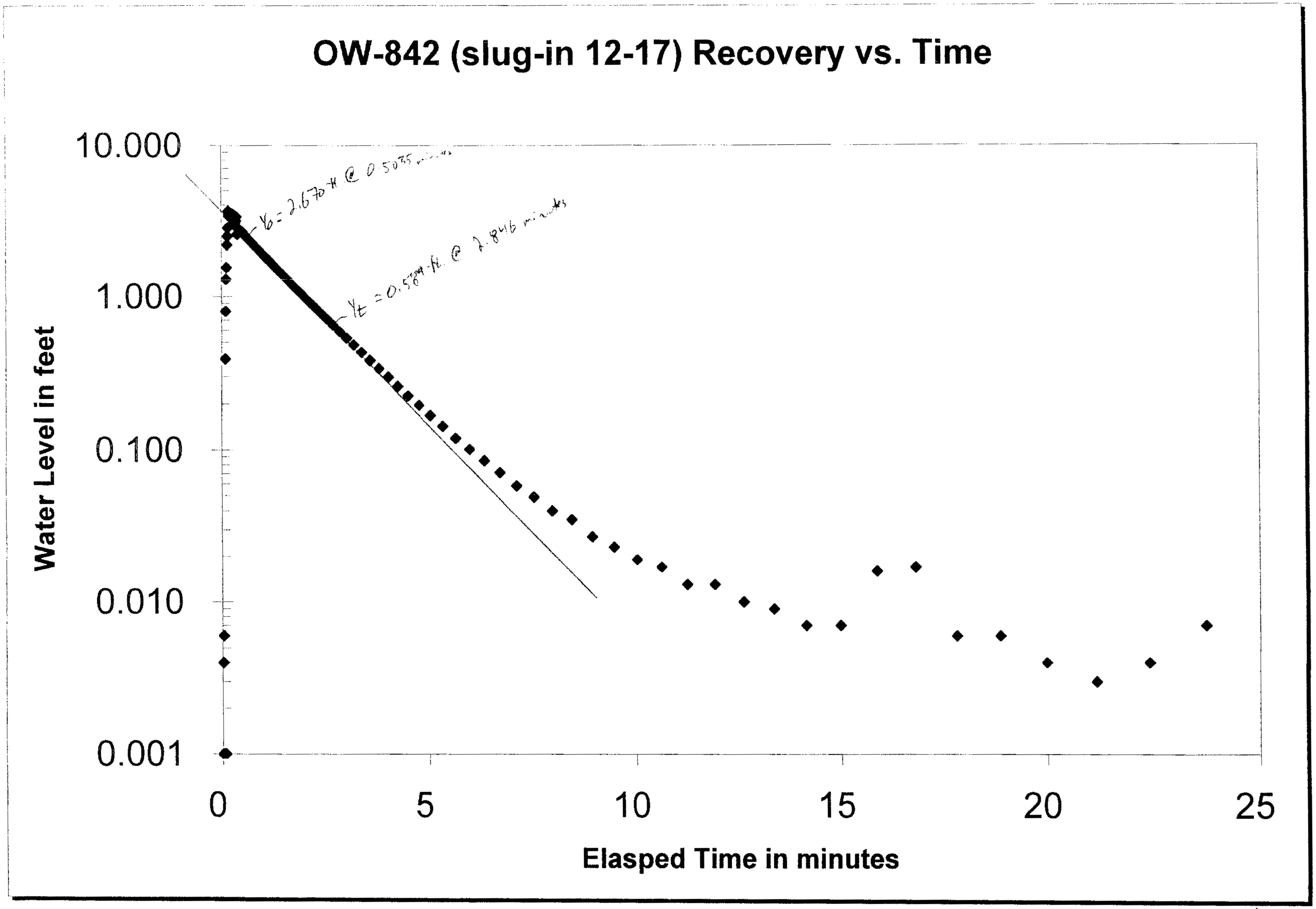
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	29.23	0
0.011	-3.00	0.001	29.229	-0.001
0.022	-2.40	0.004	29.226	-0.004
0.033	-2.22	0.006	29.224	-0.006
0.044	-3.00	0.001	29.229	-0.001
0.055	-3.00	0.001	29.229	-0.001
0.066	#NUM!	0.000	29.23	0
0.077	-3.00	0.001	29.229	-0.001
0.088	-0.41	0.390	28.84	-0.39
0.099	-0.10	0.800	28.43	-0.8
0.11	0.11	1.299	27.931	-1.299
0.121	0.19	1.552	27.678	-1.552
0.132	0.34	2.184	27.046	-2.184
0.143	0.40	2.501	26.729	-2.501
0.154	0.45	2.841	26.389	-2.841
0.165	0.56	3.651	25.579	-3.651
0.176	0.53	3.390	25.84	-3.39
0.187	0.55	3.535	25.695	-3.535
0.198	0.55	3.586	25.644	-3.586
0.209	0.53	3.411	25.819	-3.411
0.22	0.55	3.547	25.683	-3.547
0.231	0.55	3.522	25.708	-3.522
0.2427	0.53	3.422	25.808	-3.422
0.2552	0.53	3.350	25.88	-3.35
0.2683	0.54	3.502	25.728	-3.502
0.2823	0.52	3.282	25.948	-3.282
0.2972	0.54	3.463	25.767	-3.463
0.3128	0.49	3.079	26.151	-3.079
0.3295	0.49	3.079	26.151	-3.079
0.3472	0.50	3.149	26.081	-3.149
0.3658	0.53	3.360	25.87	-3.36
0.3857	0.41	2.569	26.661	-2.569
0.4067	0.45	2.793	26.437	-2.793
0.4288	0.44	2.773	26.457	-2.773
0.4523	0.44	2.737	26.493	-2.737
0.4772	0.43	2.693	26.537	-2.693
0.5035	0.43	2.670	26.56	-2.67
0.5315	0.41	2.589	26.641	-2.589
0.5612	0.40	2.533	26.697	-2.533
0.5925	0.40	2.484	26.746	-2.484
0.6257	0.38	2.425	26.805	-2.425
0.6608	0.37	2.371	26.859	-2.371
0.6982	0.36	2.312	26.918	-2.312
0.7377	0.35	2.256	26.974	-2.256
0.7795	0.34	2.190	27.04	-2.19
0.8238	0.33	2.129	27.101	-2.129
0.8708	0.31	2.060	27.17	-2.06
0.9207	0.30	1.994	27.236	-1.994
0.9733	0.28	1.925	27.305	-1.925
1.0292	0.27	1.860	27.37	-1.86
1.0883	0.25	1.782	27.448	-1.782
1.151	0.24	1.725	27.505	-1.725
1.2173	0.22	1.643	27.587	-1.643
1.2877	0.19	1.566	27.664	-1.566
1.3622	0.17	1.491	27.739	-1.491
1.4412	0.15	1.421	27.809	-1.421
1.5248	0.13	1.346	27.884	-1.346
1.6133	0.10	1.271	27.959	-1.271
1.7072	0.08	1.198	28.032	-1.198
1.8065	0.05	1.124	28.106	-1.124
1.9118	0.02	1.054	28.176	-1.054
2.0233	-0.01	0.980	28.25	-0.98
2.1415	-0.04	0.911	28.319	-0.911
2.2667	-0.07	0.844	28.386	-0.844
2.3992	-0.11	0.776	28.454	-0.776
2.5397	-0.15	0.713	28.517	-0.713
2.6885	-0.19	0.649	28.581	-0.649
2.846	-0.23	0.589	28.641	-0.589
3.0128	-0.27	0.534	28.696	-0.534
3.1897	-0.32	0.481	28.749	-0.481
3.377	-0.37	0.430	28.8	-0.43
3.5753	-0.42	0.381	28.849	-0.381
3.7855	-0.47	0.338	28.892	-0.338
4.0082	-0.53	0.297	28.933	-0.297
4.244	-0.59	0.259	28.971	-0.259
4.4938	-0.65	0.225	29.005	-0.225
4.7585	-0.71	0.196	29.034	-0.196
5.0388	-0.77	0.168	29.062	-0.168
5.3357	-0.84	0.143	29.087	-0.143
5.6502	-0.92	0.119	29.111	-0.119
5.9833	-1.00	0.101	29.129	-0.101
6.3362	-1.07	0.085	29.145	-0.085
6.71	-1.15	0.071	29.159	-0.071
7.106	-1.24	0.058	29.172	-0.058
7.5253	-1.31	0.049	29.181	-0.049
7.9697	-1.40	0.040	29.19	-0.04
8.4403	-1.46	0.035	29.195	-0.035
8.9388	-1.57	0.027	29.203	-0.027
9.4668	-1.64	0.023	29.207	-0.023
10.0262	-1.72	0.019	29.211	-0.019
10.6187	-1.77	0.017	29.213	-0.017
11.2462	-1.89	0.013	29.217	-0.013
11.911	-1.89	0.013	29.217	-0.013
12.6152	-2.00	0.010	29.22	-0.01
13.361	-2.05	0.009	29.221	-0.009
14.151	-2.15	0.007	29.223	-0.007
14.9878	-2.15	0.007	29.223	-0.007
15.8743	-1.80	0.016	29.214	-0.016
16.8133	-1.77	0.017	29.213	-0.017
17.808	-2.22	0.006	29.224	-0.006
18.8617	-2.22	0.006	29.224	-0.006
19.9777	-2.40	0.004	29.226	-0.004
21.1598	-2.52	0.003	29.227	-0.003
22.412	-2.40	0.004	29.226	-0.004
23.7385	-2.15	0.007	29.223	-0.007



CHK'D: BWJ 12/20/02

-[illegible]

MACTEC	MACTEC Engineering and Consulting 3301 Atlantic Avenue Raleigh, North Carolina **Slug Test Data Sheet**

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/12/02	**Time:** 0755	**Observation Well No.:**	OW-847
Weather Conditions:	Foggy in the 40's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	57.16 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	~~x~~7.9 ft [illegible]	**Depth interval of screened portion:**	37.4-45.3 ft
Depth to Groundwater:	29.33 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
29.14	12/11/02
29.22	12/06/02

Comments/Remarks

[illegible] used

Slug 2 → volume = 0.025 ft³

Transducer SN = 6467

Hermit SN = 45469

WSF

Set transducer 45' below TOC

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-842
Test Date: 12/12/2002
Test Type: Recovery (slug out)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BWJones 12/20/02

WELL DATA

SWL =	29.33	(ft BTOC)
WD =	51.16	(ft BTOC)
WD =	49.66	(ft BGS)
DTSP =	35.30	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	7.9	(ft)
Lw =	21.83	(ft)
Le/rw =	23.94	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.548	(ft) from plot
yt =	0.771	(ft) from plot
t =	1.857	(minutes) from plot
ln(Re/rw) =	2.38	
K =	**9.3E-01**	**(ft/day)**
K =	**3.3E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+{A+Bln((H Lw)/rw)}/(Le/rw)]^-1= 2.38

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+{C/(Le/rw)}]^-1 = 2.94

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
20	2.23	0.29	1.75
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

23.94	2.34	0.31	1.89

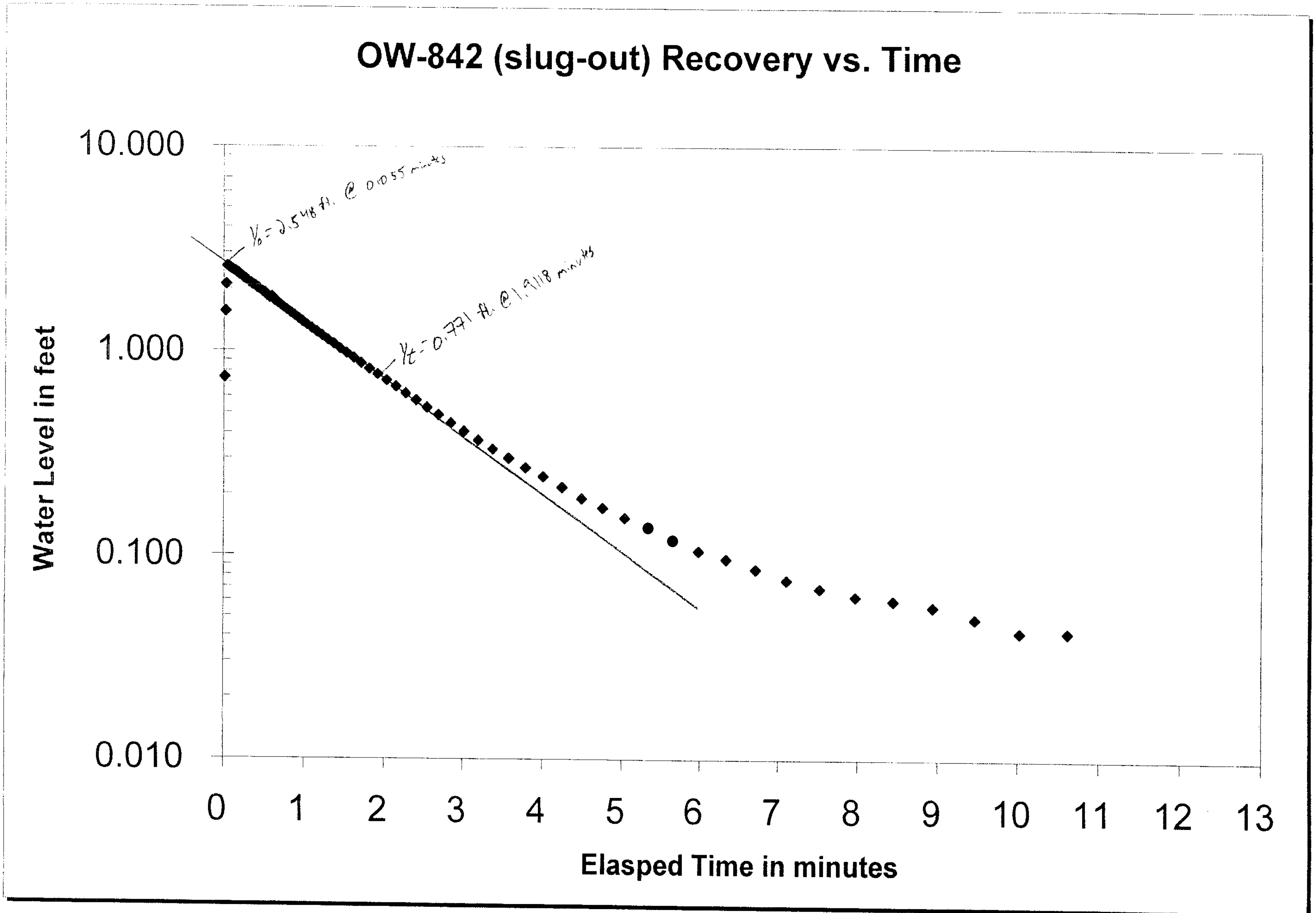
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	29.33	29.33
0.011	-0.13	0.741	30.071	30.071
0.022	0.19	1.546	30.876	30.876
0.033	0.32	2.089	31.419	31.419
0.044	0.41	2.561	31.891	31.891
0.055	0.41	2.548	31.878	31.878
0.066	0.40	2.519	31.849	31.849
0.077	0.40	2.524	31.854	31.854
0.088	0.40	2.486	31.816	31.816
0.099	0.39	2.468	31.798	31.798
0.11	0.39	2.468	31.798	31.798
0.121	0.39	2.442	31.772	31.772
0.132	0.39	2.432	31.762	31.762
0.143	0.39	2.436	31.766	31.766
0.154	0.38	2.390	31.72	31.72
0.165	0.38	2.378	31.708	31.708
0.176	0.38	2.384	31.714	31.714
0.187	0.37	2.330	31.66	31.66
0.198	0.37	2.322	31.652	31.652
0.209	0.37	2.318	31.648	31.648
0.22	0.36	2.299	31.629	31.629
0.231	0.36	2.266	31.596	31.596
0.2427	0.35	2.246	31.576	31.576
0.2552	0.35	2.232	31.562	31.562
0.2683	0.35	2.216	31.546	31.546
0.2823	0.34	2.193	31.523	31.523
0.2972	0.34	2.168	31.498	31.498
0.3128	0.33	2.143	31.473	31.473
0.3295	0.33	2.131	31.461	31.461
0.3472	0.32	2.094	31.424	31.424
0.3658	0.32	2.072	31.402	31.402
0.3857	0.31	2.059	31.389	31.389
0.4067	0.30	2.015	31.345	31.345
0.4288	0.30	2.003	31.333	31.333
0.4523	0.29	1.961	31.291	31.291
0.4772	0.28	1.927	31.257	31.257
0.5035	0.28	1.912	31.242	31.242
0.5315	0.27	1.843	31.173	31.173
0.5612	0.26	1.802	31.132	31.132
0.5925	0.26	1.827	31.157	31.157
0.6257	0.24	1.744	31.074	31.074
0.6608	0.23	1.704	31.034	31.034
0.6982	0.22	1.662	30.992	30.992
0.7377	0.21	1.617	30.947	30.947
0.7795	0.20	1.574	30.904	30.904
0.8238	0.18	1.530	30.86	30.86
0.8708	0.17	1.482	30.812	30.812
0.9207	0.16	1.435	30.765	30.765
0.9733	0.14	1.386	30.716	30.716
1.0292	0.13	1.335	30.665	30.665
1.0883	0.11	1.287	30.617	30.617
1.151	0.09	1.236	30.566	30.566
1.2173	0.07	1.184	30.514	30.514
1.2877	0.05	1.133	30.463	30.463
1.3622	0.03	1.082	30.412	30.412
1.4412	0.01	1.028	30.358	30.358
1.5248	-0.01	0.977	30.307	30.307
1.6133	-0.03	0.925	30.255	30.255
1.7072	-0.06	0.872	30.202	30.202
1.8065	-0.09	0.820	30.15	30.15
1.9118	-0.11	0.771	30.101	30.101
2.0233	-0.14	0.720	30.05	30.05
2.1415	-0.17	0.671	30.001	30.001
2.2667	-0.21	0.623	29.953	29.953
2.3992	-0.24	0.576	29.906	29.906
2.5397	-0.27	0.531	29.861	29.861
2.6885	-0.31	0.489	29.819	29.819
2.846	-0.35	0.448	29.778	29.778
3.0128	-0.39	0.409	29.739	29.739
3.1897	-0.43	0.370	29.7	29.7
3.377	-0.47	0.335	29.665	29.665
3.5753	-0.52	0.302	29.632	29.632
3.7855	-0.57	0.271	29.601	29.601
4.0082	-0.61	0.245	29.575	29.575
4.244	-0.66	0.217	29.547	29.547
4.4938	-0.72	0.191	29.521	29.521
4.7585	-0.77	0.171	29.501	29.501
5.0388	-0.82	0.153	29.483	29.483
5.3357	-0.86	0.137	29.467	29.467
5.6502	-0.92	0.119	29.449	29.449
5.9833	-0.98	0.105	29.435	29.435
6.3362	-1.02	0.096	29.426	29.426
6.71	-1.07	0.086	29.416	29.416
7.106	-1.12	0.076	29.406	29.406
7.5253	-1.16	0.069	29.399	29.399
7.9697	-1.20	0.063	29.393	29.393
8.4403	-1.22	0.060	29.39	29.39
8.9388	-1.25	0.056	29.386	29.386
9.4668	-1.31	0.049	29.379	29.379
10.0262	-1.38	0.042	29.372	29.372
10.6187	-1.38	0.042	29.372	29.372
11.2462	-1.38	0.042	29.372	29.372
11.911	-1.38	0.042	29.372	29.372
12.6152	-1.38	0.042	29.372	29.372



CHK'D: BWA 12/20/02

Slug - 2 [illegible]

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12-17-02	**Time:** 11:30	**Observation Well No.:**	MW-813
Weather Conditions:	[illegible]		
Method of Slug Withdrawl (circle one):	**water, mechanical, or pressure**	**Test Method:**	**Rising Head** or **Falling Head** (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	50.50 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	40.2 - 49.9 ft
Depth to Groundwater:	35.53 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
35.74	12/10/02
35.63	12/13/02
35.67	12/14/02

Comments/Remarks

[illegible] Slug #1 [illegible] 0.058 ft³

Transducer [illegible] = 40.7

[illegible] = 35.49

[illegible]

[illegible] slug #1

[illegible]

[illegible]

[illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-843
Test Date: 12/17/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: WSG/12/18/2002
Checked/date: BWatring 12/20/02

WELL DATA

SWL =	35.53	(ft BTOC)
WD =	50.90	(ft BTOC)
WD =	49.40	(ft BGS)
DTSP =	36.40	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	15.37	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.569	(ft) from plot
yt =	0.518	(ft) from plot
t =	0.993	(minutes) from plot
ln(Re/rw) =	2.33	
K =	**1.3E+00**	**(ft/day)**
K =	**4.5E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.33

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.78

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

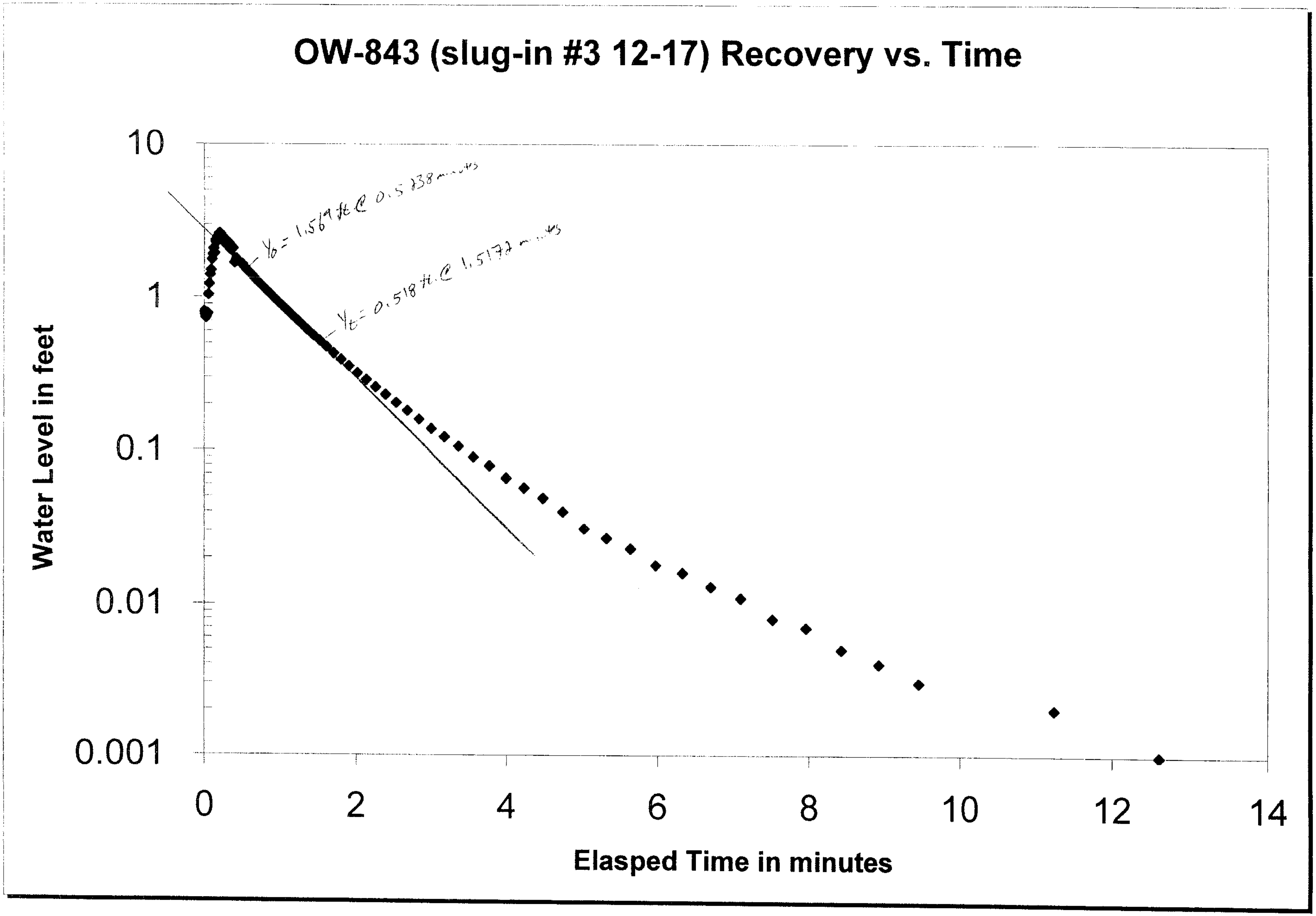
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y Adjusted (ft)	WL (ft BTOC)	Data Logger results
0	-0.10	0.803	34.727	0
0.0112	-0.12	0.766	34.764	0.037
0.0223	-0.13	0.733	34.797	0.07
0.0335	-0.12	0.758	34.772	0.045
0.0447	-0.11	0.779	34.751	0.024
0.0558	0.02	1.036	34.494	-0.233
0.067	0.09	1.221	34.309	-0.418
0.0782	0.15	1.398	34.132	-0.595
0.0893	0.18	1.502	34.028	-0.699
0.1005	0.25	1.762	33.768	-0.959
0.1117	0.28	1.908	33.622	-1.105
0.1228	0.32	2.078	33.452	-1.275
0.134	0.29	1.937	33.593	-1.134
0.1452	0.37	2.355	33.175	-1.552
0.1563	0.36	2.275	33.255	-1.472
0.1675	0.39	2.472	33.058	-1.669
0.1787	0.39	2.483	33.047	-1.68
0.1898	0.42	2.611	32.919	-1.808
0.201	0.42	2.63	32.9	-1.827
0.2122	0.41	2.596	32.934	-1.793
0.2233	0.40	2.531	32.999	-1.728
0.235	0.39	2.447	33.083	-1.644
0.2475	0.38	2.4	33.13	-1.597
0.2607	0.38	2.426	33.104	-1.623
0.2747	0.35	2.258	33.272	-1.455
0.2895	0.36	2.265	33.265	-1.462
0.3052	0.34	2.196	33.334	-1.393
0.3218	0.36	2.266	33.264	-1.463
0.3395	0.31	2.054	33.476	-1.251
0.3582	0.31	2.032	33.498	-1.229
0.378	0.32	2.094	33.436	-1.291
0.399	0.22	1.677	33.853	-0.874
0.4212	0.25	1.785	33.745	-0.982
0.4447	0.24	1.732	33.798	-0.929
0.4695	0.23	1.687	33.843	-0.884
0.4958	0.22	1.658	33.872	-0.855
0.5238	0.20	1.569	33.961	-0.766
0.5535	0.18	1.512	34.018	-0.709
0.5848	0.16	1.454	34.076	-0.651
0.618	0.15	1.397	34.133	-0.594
0.6532	0.13	1.335	34.195	-0.532
0.6905	0.11	1.277	34.253	-0.474
0.73	0.09	1.22	34.31	-0.417
0.7718	0.07	1.162	34.368	-0.359
0.8162	0.04	1.102	34.428	-0.299
0.8632	0.02	1.046	34.484	-0.243
0.913	-0.01	0.983	34.547	-0.18
0.9657	-0.03	0.928	34.602	-0.125
1.0215	-0.06	0.871	34.659	-0.068
1.0807	-0.09	0.82	34.71	-0.017
1.1433	-0.12	0.763	34.767	0.04
1.2097	-0.15	0.711	34.819	0.092
1.28	-0.18	0.661	34.869	0.142
1.3545	-0.21	0.61	34.92	0.193
1.4335	-0.25	0.562	34.968	0.241
1.5172	-0.29	0.518	35.012	0.285
1.6057	-0.32	0.475	35.055	0.328
1.6995	-0.36	0.432	35.098	0.371
1.7988	-0.41	0.393	35.137	0.41
1.9042	-0.45	0.356	35.174	0.447
2.0157	-0.49	0.32	35.21	0.483
2.1338	-0.54	0.289	35.241	0.514
2.259	-0.59	0.258	35.272	0.545
2.3915	-0.64	0.231	35.299	0.572
2.532	-0.69	0.204	35.326	0.599
2.6808	-0.74	0.181	35.349	0.622
2.8383	-0.80	0.159	35.371	0.644
3.0052	-0.86	0.138	35.392	0.665
3.182	-0.91	0.122	35.408	0.681
3.3693	-0.97	0.106	35.424	0.697
3.5677	-1.05	0.09	35.44	0.713
3.7778	-1.10	0.079	35.451	0.724
4.0005	-1.18	0.066	35.464	0.737
4.2363	-1.24	0.057	35.473	0.746
4.4862	-1.31	0.049	35.481	0.754
4.7508	-1.40	0.04	35.49	0.763
5.0312	-1.51	0.031	35.499	0.772
5.328	-1.57	0.027	35.503	0.776
5.6425	-1.64	0.023	35.507	0.78
5.9757	-1.74	0.018	35.512	0.785



CHK'D: BAH 12/20/22

Slug-wt

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/11/02	**Time:** 1245	**Observation Well No.:**	OW-843
Weather Conditions:	Partly Sunny in 40's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	50.90 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	40.2-49.9 ft
Depth to Groundwater:	35.79 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
35.74	12/10/02

Comments/Remarks

Used Slug 2 → [illegible]

Transducer → SN = 64407

Head → 45449
5.9

[illegible] USE [illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-843
Test Date: 12/12/2002
Test Type: Recovery (slug out)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BW Jones 12/20/02

WELL DATA

SWL =	35.69	(ft BTOC)
WD =	50.90	(ft BTOC)
WD =	49.40	(ft BGS)
DTSP =	36.40	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	15.21	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.873	(ft) from plot
yt =	0.817	(ft) from plot
t =	0.692	(minutes) from plot
ln(Re/rw) =	2.33	
K =	**1.4E+00**	**(ft/day)**
K =	**4.9E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.33

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.78

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

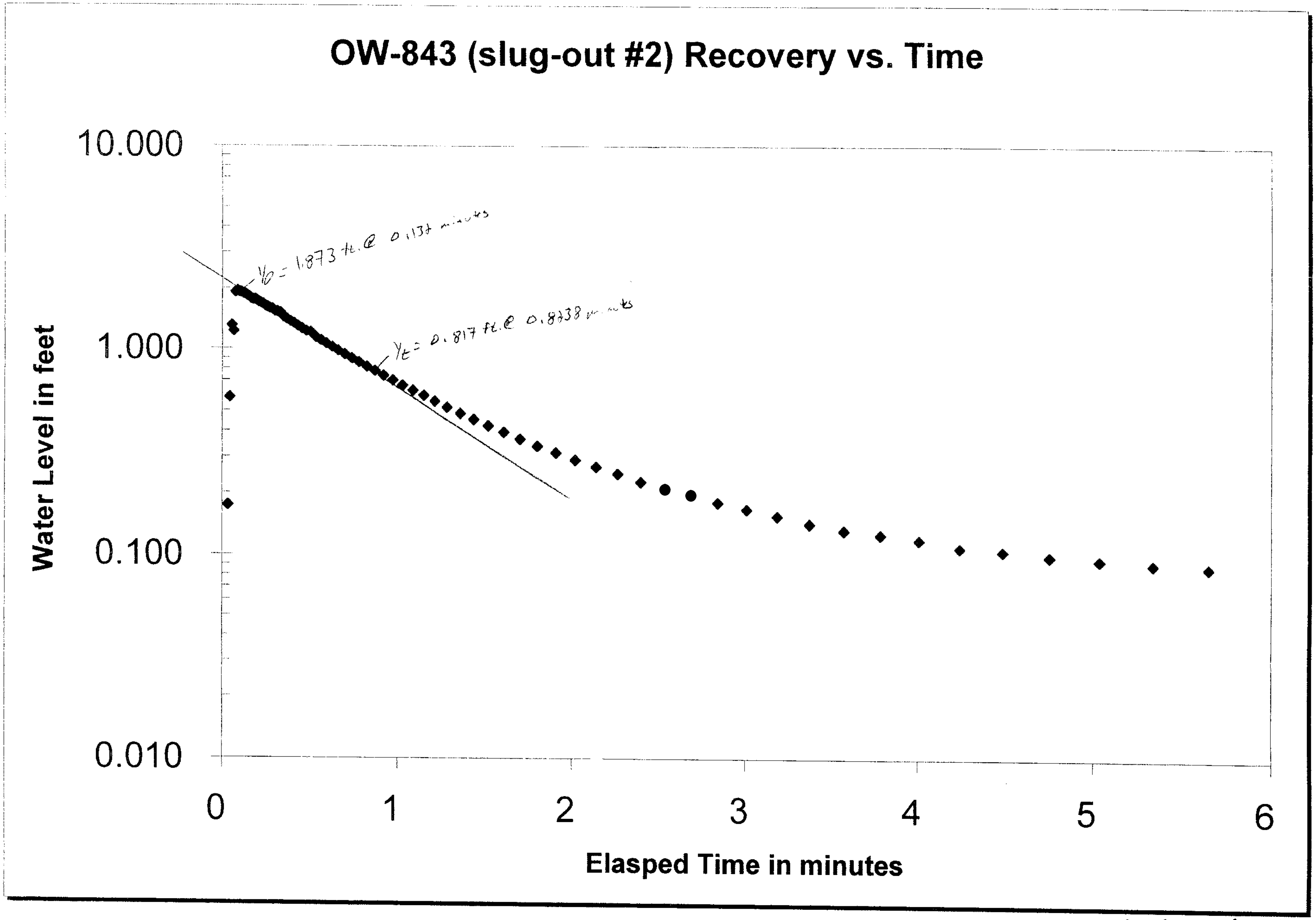
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	35.69	35.69
0.011	-2.40	0.004	35.694	35.694
0.022	-2.22	0.006	35.696	35.696
0.033	-0.76	0.174	35.864	35.864
0.044	-0.24	0.578	36.268	36.268
0.055	0.12	1.307	36.997	36.997
0.066	0.09	1.223	36.913	36.913
0.077	0.28	1.912	37.602	37.602
0.088	0.29	1.941	37.631	37.631
0.099	0.28	1.918	37.608	37.608
0.11	0.28	1.906	37.596	37.596
0.121	0.27	1.882	37.572	37.572
0.132	0.27	1.873	37.563	37.563
0.143	0.26	1.839	37.529	37.529
0.154	0.26	1.813	37.503	37.503
0.165	0.25	1.778	37.468	37.468
0.176	0.25	1.761	37.451	37.451
0.187	0.25	1.760	37.45	37.45
0.198	0.24	1.738	37.428	37.428
0.209	0.23	1.709	37.399	37.399
0.22	0.23	1.689	37.379	37.379
0.231	0.22	1.666	37.356	37.356
0.2427	0.21	1.636	37.326	37.326
0.2552	0.21	1.616	37.306	37.306
0.2683	0.20	1.592	37.282	37.282
0.2823	0.20	1.579	37.269	37.269
0.2972	0.19	1.540	37.23	37.23
0.3128	0.18	1.530	37.22	37.22
0.3295	0.18	1.508	37.198	37.198
0.3472	0.16	1.441	37.131	37.131
0.3658	0.15	1.406	37.096	37.096
0.3857	0.14	1.372	37.062	37.062
0.4067	0.13	1.343	37.033	37.033
0.4288	0.11	1.299	36.989	36.989
0.4523	0.10	1.264	36.954	36.954
0.4772	0.09	1.227	36.917	36.917
0.5035	0.08	1.210	36.9	36.9
0.5315	0.06	1.141	36.831	36.831
0.5612	0.04	1.105	36.795	36.795
0.5925	0.03	1.062	36.752	36.752
0.6257	0.01	1.021	36.711	36.711
0.6608	-0.01	0.980	36.67	36.67
0.6982	-0.03	0.940	36.63	36.63
0.7377	-0.05	0.898	36.588	36.588
0.7795	-0.07	0.858	36.548	36.548
0.8238	-0.09	0.817	36.507	36.507
0.8708	-0.11	0.779	36.469	36.469
0.9207	-0.13	0.738	36.428	36.428
0.9733	-0.15	0.700	36.39	36.39
1.0292	-0.18	0.662	36.352	36.352
1.0883	-0.20	0.625	36.315	36.315
1.151	-0.23	0.592	36.282	36.282
1.2173	-0.26	0.555	36.245	36.245
1.2877	-0.28	0.519	36.209	36.209
1.3622	-0.31	0.486	36.176	36.176
1.4412	-0.34	0.455	36.145	36.145
1.5248	-0.37	0.424	36.114	36.114
1.6133	-0.40	0.395	36.085	36.085
1.7072	-0.44	0.366	36.056	36.056
1.8065	-0.47	0.339	36.029	36.029
1.9118	-0.50	0.315	36.005	36.005
2.0233	-0.54	0.290	35.98	35.98
2.1415	-0.57	0.269	35.959	35.959
2.2667	-0.60	0.249	35.939	35.939
2.3992	-0.64	0.227	35.917	35.917
2.5397	-0.68	0.211	35.901	35.901
2.6885	-0.71	0.197	35.887	35.887
2.846	-0.74	0.180	35.87	35.87
3.0128	-0.78	0.167	35.857	35.857
3.1897	-0.81	0.155	35.845	35.845
3.377	-0.85	0.142	35.832	35.832
3.5753	-0.88	0.132	35.822	35.822
3.7855	-0.90	0.126	35.816	35.816
4.0082	-0.92	0.119	35.809	35.809
4.244	-0.96	0.109	35.799	35.799
4.4938	-0.98	0.105	35.795	35.795
4.7585	-1.00	0.099	35.789	35.789
5.0388	-1.02	0.095	35.785	35.785
5.3357	-1.04	0.091	35.781	35.781
5.6502	-1.06	0.088	35.778	35.778



CHK'D: BWJ 12/20/02

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name: North Anna ESP **MACTEC Job Number:** 30720-2-5400

Date: 12/13/07 **Time:** 0710 **Observation Well No.:** ~~[illegible]~~ OW-844

Weather Conditions: [illegible] 30's 12/11/07

Method of Slug Withdrawl (circle one): water, mechanical, or pressure

Test Method: Rising Head or Falling Head (circle)

Diameter of Screen: 2 in. **Diameter of Casing:** 2 in.

Total Well Depth: 24.0 ft below reference point **Reference Point:** Permanent mark on top of casing

Length of Screened Section: 9.6 ft **Depth interval of screened portion:** [illegible]-24.0 ft

Depth to Groundwater: 8.48 ft below reference point

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
8.95	12/10/07
8.91	12/10/07
8.83	12/11/07
8.90	12/06/07

Comments/Remarks

Used slug #2 volume 0.08 ft^3

Transducer S/N → 5407

Baro S/N → 45449

Set transducer @ 20' below TOC.

WSR

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-844
Test Date: 12/13/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: 12/20/02

WELL DATA

SWL =	8.48	(ft BTOC)
WD =	26.10	(ft BTOC)
WD =	24.60	(ft BGS)
DTSP =	12.70	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.6	(ft)
Lw =	17.62	(ft)
Le/rw =	29.09	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	3.022 (ft) from plot
yt =	2.000 (ft) from plot
t =	1.868 (minutes) from plot
ln(Re/rw) =	2.38
K =	**2.5E-01 (ft/day)**
K =	**8.9E-05 (cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.38

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.86

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.09	2.48	0.34	2.06

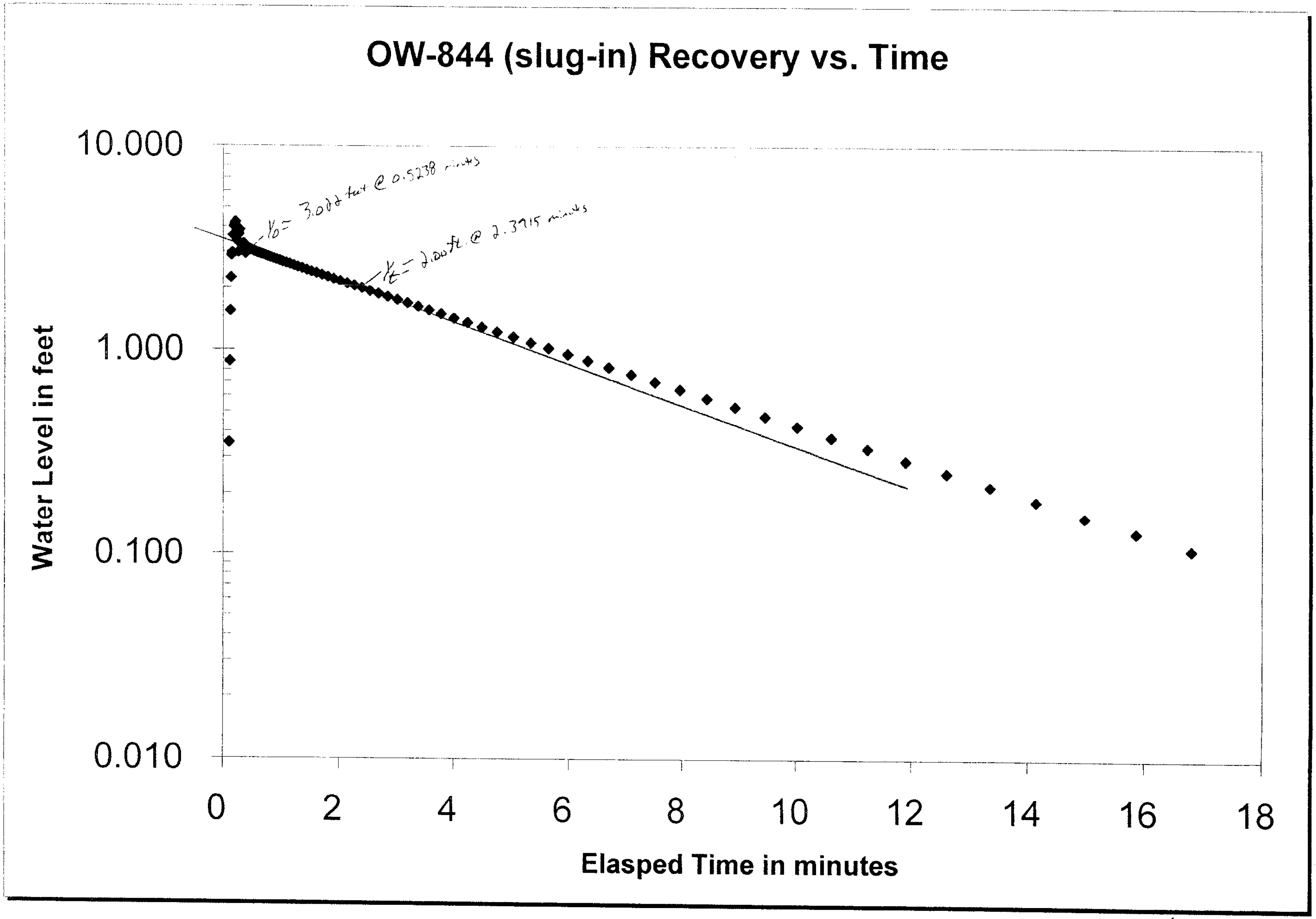
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	8.48	0
0.0112	-3.00	0.001	8.479	0.001
0.0223	#NUM!	0.000	8.48	0
0.0335	-3.00	0.001	8.479	-0.001
0.0447	-2.40	0.004	8.476	-0.004
0.0558	-2.40	0.004	8.476	-0.004
0.067	-2.22	0.006	8.474	-0.006
0.0782	-2.22	0.006	8.474	-0.006
0.0893	-2.22	0.006	8.474	-0.006
0.1005	-0.45	0.352	8.128	-0.352
0.1117	-0.06	0.879	7.601	-0.879
0.1228	0.19	1.537	6.943	-1.537
0.134	0.35	2.235	6.245	-2.235
0.1452	0.46	2.874	5.606	-2.874
0.1563	0.47	2.973	5.507	-2.973
0.1675	0.56	3.609	4.871	-3.609
0.1787	0.60	4.000	4.48	-4
0.1898	0.60	4.025	4.455	-4.025
0.201	0.62	4.124	4.356	-4.124
0.2122	0.63	4.229	4.251	-4.229
0.2233	0.57	3.697	4.783	-3.697
0.235	0.53	3.382	5.098	-3.382
0.2475	0.59	3.859	4.621	-3.859
0.2607	0.47	2.980	5.5	-2.98
0.2747	0.56	3.671	4.809	-3.671
0.2895	0.59	3.859	4.621	-3.859
0.3052	0.49	3.072	5.408	-3.072
0.3218	0.49	3.097	5.383	-3.097
0.3395	0.52	3.292	5.188	-3.292
0.3582	0.52	3.287	5.193	-3.287
0.378	0.47	2.940	5.54	-2.94
0.399	0.48	3.019	5.461	-3.019
0.4212	0.49	3.068	5.412	-3.068
0.4447	0.49	3.072	5.408	-3.072
0.4695	0.49	3.088	5.392	-3.088
0.4958	0.48	3.046	5.434	-3.046
0.5238	0.48	3.022	5.458	-3.022
0.5535	0.48	3.002	5.478	-3.002
0.5848	0.47	2.976	5.504	-2.976
0.618	0.47	2.953	5.527	-2.953
0.6532	0.47	2.928	5.552	-2.928
0.6905	0.46	2.904	5.576	-2.904
0.73	0.46	2.874	5.606	-2.874
0.7718	0.45	2.845	5.635	-2.845
0.8162	0.45	2.818	5.662	-2.818
0.8632	0.45	2.790	5.69	-2.79
0.913	0.44	2.756	5.724	-2.756
0.9657	0.44	2.723	5.757	-2.723
1.0215	0.43	2.687	5.793	-2.687
1.0807	0.42	2.648	5.832	-2.648
1.1433	0.42	2.615	5.865	-2.615
1.2097	0.41	2.574	5.906	-2.574
1.28	0.40	2.534	5.946	-2.534
1.3545	0.40	2.494	5.986	-2.494
1.4335	0.39	2.446	6.034	-2.446
1.5172	0.38	2.407	6.073	-2.407
1.6057	0.37	2.359	6.121	-2.359
1.6995	0.36	2.311	6.169	-2.311
1.7988	0.35	2.261	6.219	-2.261
1.9042	0.34	2.212	6.268	-2.212
2.0157	0.33	2.159	6.321	-2.159
2.1338	0.32	2.100	6.38	-2.1
2.259	0.31	2.054	6.426	-2.054
2.3915	0.30	2.000	6.48	-2
2.532	0.29	1.934	6.546	-1.934
2.6808	0.27	1.877	6.603	-1.877
2.8383	0.26	1.813	6.667	-1.813
3.0052	0.24	1.753	6.727	-1.753
3.182	0.23	1.687	6.793	-1.687
3.3693	0.21	1.624	6.856	-1.624
3.5677	0.19	1.560	6.92	-1.56
3.7778	0.17	1.494	6.986	-1.494
4.0005	0.15	1.425	7.055	-1.425
4.2363	0.13	1.360	7.12	-1.36
4.4862	0.11	1.291	7.189	-1.291
4.7508	0.09	1.222	7.258	-1.222
5.0312	0.06	1.158	7.322	-1.158
5.328	0.04	1.087	7.393	-1.087
5.6425	0.01	1.021	7.459	-1.021
5.9757	-0.02	0.955	7.525	-0.955
6.3285	-0.05	0.889	7.591	-0.889
6.7023	-0.08	0.825	7.655	-0.825
7.0983	-0.12	0.762	7.718	-0.762
7.5177	-0.15	0.700	7.78	-0.7
7.962	-0.19	0.644	7.836	-0.644
8.4327	-0.24	0.582	7.898	-0.582
8.9312	-0.28	0.528	7.952	-0.528
9.4592	-0.32	0.474	8.006	-0.474
10.0185	-0.37	0.423	8.057	-0.423
10.611	-0.43	0.374	8.106	-0.374
11.2385	-0.48	0.331	8.149	-0.331
11.9033	-0.54	0.289	8.191	-0.289
12.6075	-0.60	0.252	8.228	-0.252
13.3533	-0.67	0.216	8.264	-0.216
14.1433	-0.74	0.183	8.297	-0.183
14.9802	-0.82	0.152	8.328	-0.152
15.8667	-0.89	0.128	8.352	-0.128
16.8057	-0.98	0.105	8.375	-0.105



CHKD: BLH 12/20/06

Slug - DT

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: ~~12/12/02~~ 12/13/02	**Time:** 0750	**Observation Well No.:**	OW-844
Weather Conditions:	Cloudy, upper 30's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	26.10 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.6 ft	**Depth interval of screened portion:**	14.4-24.0 ft
Depth to Groundwater:	8.48 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
8.95	12/12/02
8.91	12/10/02
8.83	12/11/02
8.90	12/06/02

Comments/Remarks

Slug #1 → Volume = 0.05 ft³

Transducer s/n → 06972

Baro s/n → 45444

File header labeled as OW-841 and should be OW-844

LSD

2.5.4B-135

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-844	Conducted by:	Grimes and Howe
Test Date:	12/13/2002	Entered/date:	12/15/02
Test Type:	Recovery (slug out)	Checked/date:	BWL 12/20/02

WELL DATA

SWL =	8.48	(ft BTOC)
WD =	26.10	(ft BTOC)
WD =	24.60	(ft BGS)
DTSP =	12.70	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.6	(ft)
Lw =	17.62	(ft)
Le/rw =	29.09	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	3.318	(ft) from plot
yt =	2.052	(ft) from plot
t =	1.966	(minutes) from plot
ln(Re/rw) =	2.38	

K = 2.8E-01 (ft/day)

K = 9.9E-05 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H;	
ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1=	2.38
Where: Lw = H;	
ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(C/(Le/rw))]^-1 =	2.86

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.09	2.48	0.34	2.06

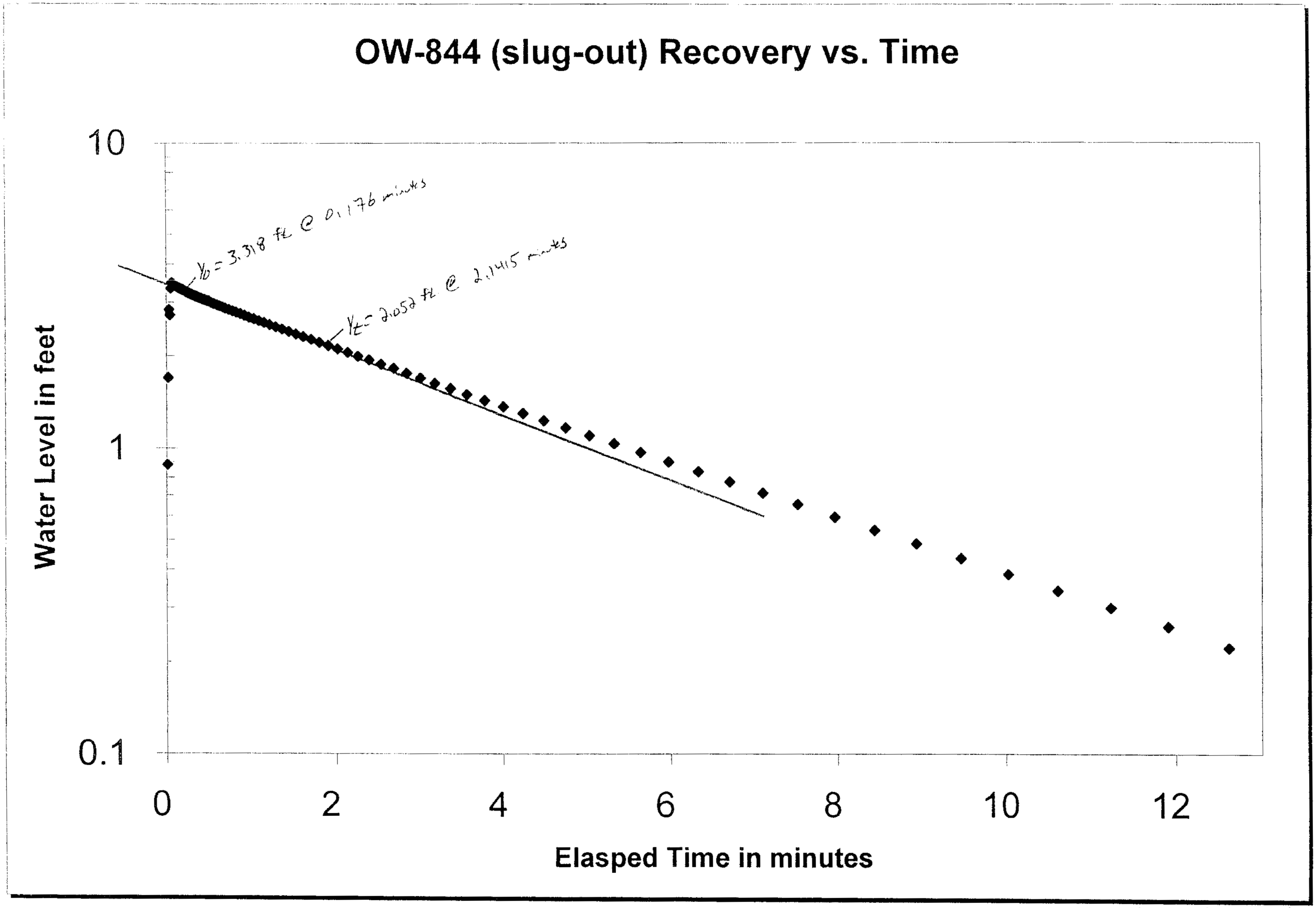
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	8.48	0
0.011	-0.06	0.881	9.361	0.881
0.022	0.23	1.7	10.18	1.7
0.033	0.45	2.844	11.324	2.844
0.044	0.44	2.726	11.206	2.726
0.055	0.52	3.327	11.807	3.327
0.066	0.54	3.479	11.959	3.479
0.077	0.54	3.459	11.939	3.459
0.088	0.54	3.44	11.92	3.44
0.099	0.53	3.419	11.899	3.419
0.11	0.53	3.396	11.876	3.396
0.121	0.53	3.38	11.86	3.38
0.132	0.53	3.365	11.845	3.365
0.143	0.53	3.352	11.832	3.352
0.154	0.52	3.341	11.821	3.341
0.165	0.52	3.328	11.808	3.328
0.176	0.52	3.318	11.798	3.318
0.187	0.52	3.307	11.787	3.307
0.198	0.52	3.302	11.782	3.302
0.209	0.52	3.282	11.762	3.282
0.22	0.51	3.263	11.743	3.263
0.231	0.51	3.251	11.731	3.251
0.2427	0.51	3.24	11.72	3.24
0.2552	0.51	3.228	11.708	3.228
0.2683	0.51	3.215	11.695	3.215
0.2823	0.51	3.202	11.682	3.202
0.2972	0.50	3.187	11.667	3.187
0.3128	0.50	3.174	11.654	3.174
0.3295	0.50	3.16	11.64	3.16
0.3472	0.50	3.144	11.624	3.144
0.3658	0.50	3.128	11.608	3.128
0.3857	0.49	3.11	11.59	3.11
0.4067	0.49	3.094	11.574	3.094
0.4288	0.49	3.077	11.557	3.077
0.4523	0.49	3.057	11.537	3.057
0.4772	0.48	3.039	11.519	3.039
0.5035	0.48	3.029	11.509	3.029
0.5315	0.48	2.991	11.471	2.991
0.5612	0.47	2.97	11.45	2.97
0.5925	0.47	2.946	11.426	2.946
0.6257	0.47	2.923	11.403	2.923
0.6608	0.46	2.896	11.376	2.896
0.6982	0.46	2.868	11.348	2.868
0.7377	0.45	2.841	11.321	2.841
0.7795	0.45	2.812	11.292	2.812
0.8238	0.44	2.782	11.262	2.782
0.8708	0.44	2.751	11.231	2.751
0.9207	0.43	2.719	11.199	2.719
0.9733	0.43	2.683	11.163	2.683
1.0292	0.42	2.649	11.129	2.649
1.0883	0.42	2.611	11.091	2.611
1.151	0.41	2.574	11.054	2.574
1.2173	0.40	2.534	11.014	2.534
1.2877	0.40	2.492	10.972	2.492
1.3622	0.39	2.45	10.93	2.45
1.4412	0.38	2.406	10.886	2.406
1.5248	0.37	2.36	10.84	2.36
1.6133	0.36	2.311	10.791	2.311
1.7072	0.35	2.264	10.744	2.264
1.8065	0.34	2.213	10.693	2.213
1.9118	0.33	2.162	10.642	2.162
2.0233	0.32	2.108	10.588	2.108
2.1415	0.31	2.052	10.532	2.052
2.2667	0.30	1.996	10.476	1.996
2.3992	0.29	1.939	10.419	1.939
2.5397	0.27	1.879	10.359	1.879
2.6885	0.26	1.82	10.3	1.82
2.846	0.24	1.756	10.236	1.756
3.0128	0.23	1.695	10.175	1.695
3.1897	0.21	1.63	10.11	1.63
3.377	0.20	1.567	10.047	1.567
3.5753	0.18	1.499	9.979	1.499
3.7855	0.16	1.433	9.913	1.433
4.0082	0.14	1.367	9.847	1.367
4.244	0.11	1.299	9.779	1.299
4.4938	0.09	1.23	9.71	1.23
4.7585	0.07	1.164	9.644	1.164
5.0388	0.04	1.097	9.577	1.097
5.3357	0.01	1.031	9.511	1.031
5.6502	-0.02	0.965	9.445	0.965
5.9833	-0.05	0.898	9.378	0.898
6.3362	-0.08	0.834	9.314	0.834
6.71	-0.11	0.771	9.251	0.771
7.106	-0.15	0.709	9.189	0.709
7.5253	-0.19	0.65	9.13	0.65
7.9697	-0.23	0.591	9.071	0.591
8.4403	-0.27	0.536	9.016	0.536
8.9388	-0.32	0.484	8.964	0.484
9.4668	-0.36	0.433	8.913	0.433
10.0262	-0.42	0.384	8.864	0.384
10.6187	-0.47	0.339	8.819	0.339
11.2462	-0.53	0.298	8.778	0.298
11.911	-0.59	0.259	8.739	0.259
12.6152	-0.66	0.221	8.701	0.221



CHK'D: BWA 12/20/02

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	MACTEC Job Number:	30720-2-5400
Date: 12/12/02	Time: 1530	Observation Well No.:	OW-945
Weather Conditions:	partly sunny in 50's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	Test Method:	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	Diameter of Casing:	2 in.
Total Well Depth:	56.50 ft below reference point	Reference Point:	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	Depth interval of screened portion:	43.6-53.3 ft
Depth to Groundwater:	24.72 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
24.69	12/09/02
24.69	12/10/02
24.72	12/06/02

Comments/Remarks

Slug #2 volume = 0.08 ft3
transducer s/n = 6407
datalogger s/n = 45299

Sensor set at 45' below TOC

WSG

[illegible] 12/13/02 @ 1145
Depth to water 20.17
Transducer s/n 257
Datalogger s/n = 45449
Slug #2 volume = 0.08 ft3

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-845
Test Date: 12/12/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BWJones 12/20/02

WELL DATA

SWL =	24.72	(ft BTOC)
WD =	56.50	(ft BTOC)
WD =	55.00	(ft BGS)
DTSP =	39.70	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	31.78	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo = 0.048 (ft) from plot
yt = 0.025 (ft) from plot
t = 0.470 (minutes) from plot
ln(Re/rw) = 2.70

* **K = 1.8E+00 (ft/day)**

* **K = 6.3E-04 (cm/sec)**

* DATA IS QUESTIONABLE (SEE GRAPH)

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.70

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 3.23

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

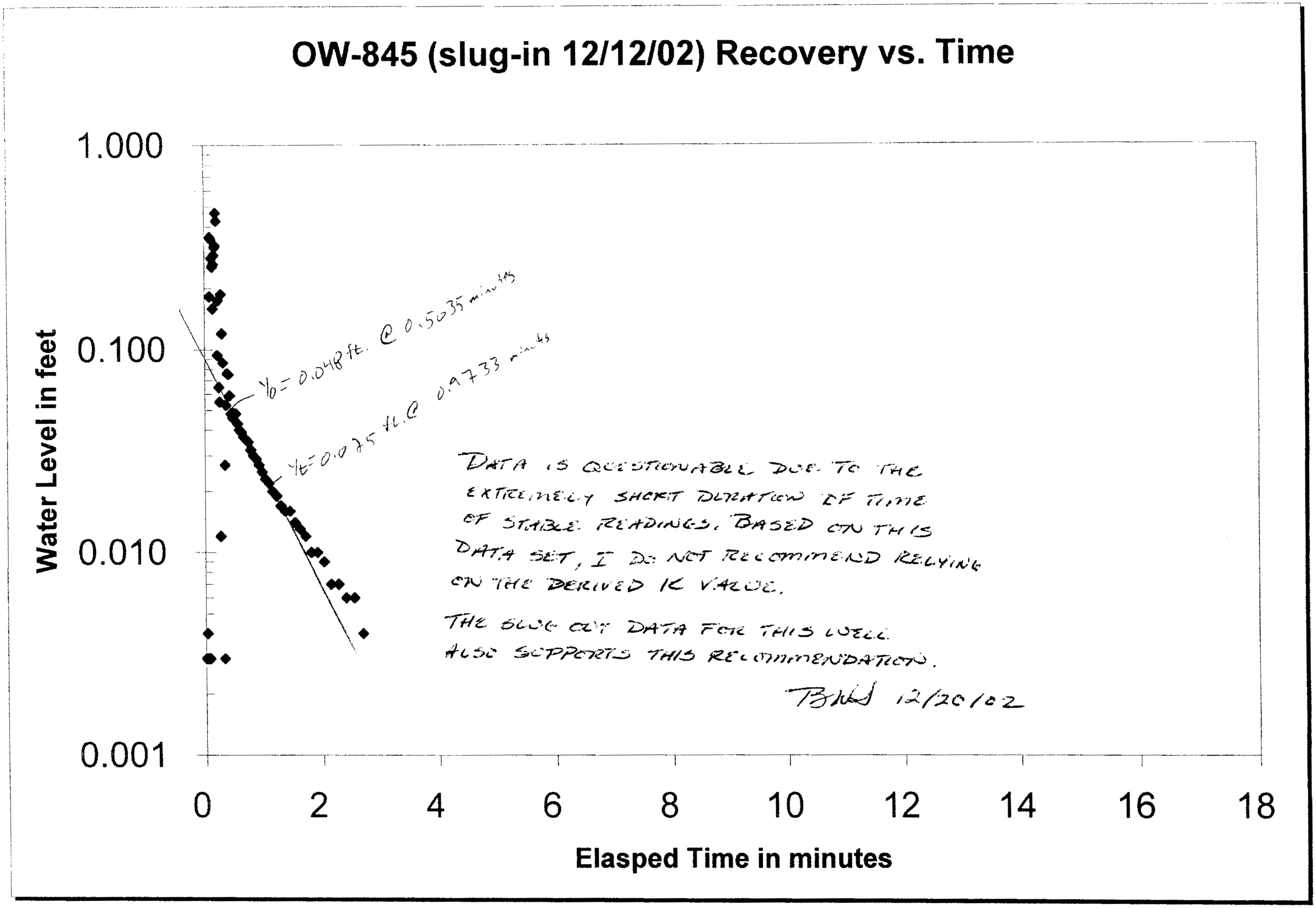
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	24.72	0
0.011	-2.52	0.003	24.717	-0.003
0.022	-2.52	0.003	24.717	-0.003
0.033	-2.40	0.004	24.716	-0.004
0.044	-2.52	0.003	24.717	-0.003
0.055	-2.52	0.003	24.717	-0.003
0.066	-2.52	0.003	24.717	-0.003
0.077	-2.52	0.003	24.717	-0.003
0.088	-0.74	0.182	24.538	-0.182
0.099	-0.45	0.356	24.364	-0.356
0.11	-0.46	0.349	24.371	-0.349
0.121	-0.55	0.281	24.439	-0.281
0.132	-0.59	0.255	24.465	-0.255
0.143	-0.80	0.159	24.561	-0.159
0.154	-0.58	0.262	24.458	-0.262
0.165	-0.54	0.291	24.429	-0.291
0.176	-0.50	0.317	24.403	-0.317
0.187	-0.49	0.324	24.396	-0.324
0.198	-0.33	0.467	24.253	-0.467
0.209	-0.37	0.427	24.293	-0.427
0.22	-1.03	0.094	24.626	-0.094
0.231	-0.76	0.174	24.546	-0.174
0.2427	-1.19	0.065	24.655	-0.065
0.2552	-1.26	0.055	24.665	-0.055
0.2683	-1.92	0.012	24.708	-0.012
0.2823	-0.73	0.187	24.533	-0.187
0.2972	-0.92	0.120	24.6	-0.12
0.3128	-1.07	0.086	24.634	0.086
0.3295	-2.52	0.003	24.717	0.003
0.3472	-1.57	0.027	24.693	0.027
0.3658	-1.28	0.053	24.667	-0.053
0.3857	-1.12	0.076	24.644	-0.076
0.4067	-1.12	0.075	24.645	-0.075
0.4288	-1.23	0.059	24.661	-0.059
0.4523	-1.32	0.048	24.672	-0.048
0.4772	-1.34	0.046	24.674	-0.046
0.5035	-1.32	0.048	24.672	-0.048
0.5315	-1.32	0.048	24.672	-0.048
0.5612	-1.37	0.043	24.677	-0.043
0.5925	-1.40	0.040	24.68	-0.04
0.6257	-1.41	0.039	24.681	-0.039
0.6608	-1.43	0.037	24.683	-0.037
0.6982	-1.44	0.036	24.684	-0.036
0.7377	-1.46	0.035	24.685	-0.035
0.7795	-1.49	0.032	24.688	-0.032
0.8238	-1.52	0.030	24.69	-0.03
0.8708	-1.54	0.029	24.691	-0.029
0.9207	-1.57	0.027	24.693	-0.027
0.9733	-1.60	0.025	24.695	-0.025
1.0292	-1.64	0.023	24.697	-0.023
1.0883	-1.66	0.022	24.698	-0.022
1.151	-1.70	0.020	24.7	-0.02
1.2173	-1.72	0.019	24.701	-0.019
1.2877	-1.77	0.017	24.703	-0.017
1.3622	-1.80	0.016	24.704	-0.016
1.4412	-1.80	0.016	24.704	-0.016
1.5248	-1.85	0.014	24.706	-0.014
1.6133	-1.89	0.013	24.707	-0.013
1.7072	-1.92	0.012	24.708	-0.012
1.8065	-2.00	0.010	24.71	-0.01
1.9118	-2.00	0.010	24.71	-0.01
2.0233	-2.05	0.009	24.711	-0.009
2.1415	-2.15	0.007	24.713	-0.007
2.2667	-2.15	0.007	24.713	-0.007
2.3992	-2.22	0.006	24.714	-0.006
2.5397	-2.22	0.006	24.714	-0.006
2.6885	-2.40	0.004	24.716	-0.004

Reference: Bouwer(1989), Bouwer and Rice(1976)



OW-845 (slug-in 12/12/02) Recovery vs. Time
1.000
0.100
0.010
0.001
Water Level in feet
0
2
4
6
8
10
12
14
16
18
Elasped Time in minutes
Yo = 0.048 ft. @ 0.5035 minutes
Yt = 0.0075 ft. @ 0.9733 minutes
DATA IS QUESTIONABLE DUE TO THE EXTREMELY SHORT DURATION OF TIME OF STABLE READINGS. BASED ON THIS DATA SET, I DO NOT RECOMMEND RELYING ON THE DERIVED K VALUE.
THE SLUG OUT DATA FOR THIS WELL ALSO SUPPORTS THIS RECOMMENDATION.
12/20/02

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: [illegible]	**Time:** [illegible]5	**Observation Well No.:** [illegible]	
Weather Conditions: [illegible]			
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	[illegible] ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	[illegible] ft	**Depth interval of screened portion:**	[illegible] 53.3 ft
Depth to Groundwater:	[illegible] ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
24.69	12/09/02
24.9	12/10/02
24.72	12/10/02
24.72	12/11/02
24.62	12/13/02

Comments/Remarks

[illegible]

WSR

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-845
Test Date: 12/17/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: WSG/12/18/02
Checked/date: [illegible] 12/20/02

WELL DATA

SWL =	24.65	(ft BTOC)
WD =	56.50	(ft BTOC)
WD =	55.00	(ft BGS)
DTSP =	39.70	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	31.85	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =		(ft) from plot
yt =		(ft) from plot
t =		(minutes) from plot
ln(Re/rw) =	2.70	
K =	**#DIV/0!**	**(ft/day)**
K =	**#DIV/0!**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1 = 2.70

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(C/(Le/rw))]^-1 = 3.23

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

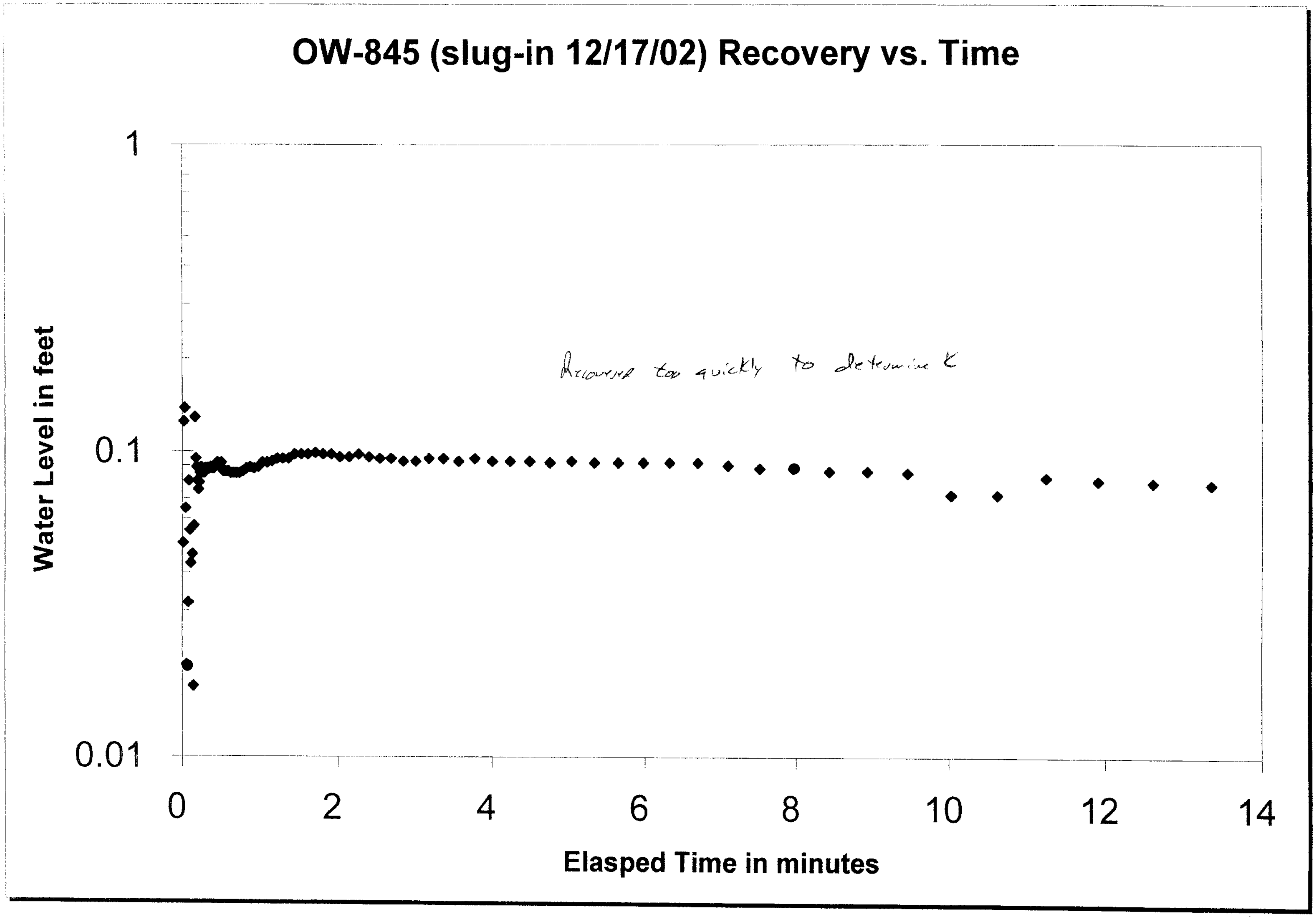
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	24.65	0
0.011	-1.30	0.05	24.6	0.05
0.022	-0.90	0.125	24.525	0.125
0.033	-0.86	0.138	24.512	0.138
0.044	-1.19	0.065	24.585	0.065
0.055	-1.70	0.02	24.63	0.02
0.066	#NUM!	-0.01	24.66	-0.01
0.077	-1.49	0.032	24.618	0.032
0.088	-1.10	0.08	24.57	0.08
0.099	-1.26	0.055	24.595	0.055
0.11	-1.37	0.043	24.607	0.043
0.121	-3.00	0.001	24.649	0.001
0.132	-1.34	0.046	24.604	0.046
0.143	-1.77	0.017	24.633	0.017
0.154	-1.24	0.057	24.593	0.057
0.165	-0.89	0.129	24.521	0.129
0.176	-1.02	0.095	24.555	0.095
0.187	-1.05	0.089	24.561	0.089
0.198	-1.10	0.08	24.57	0.08
0.209	-1.12	0.075	24.575	0.075
0.22	-1.10	0.079	24.571	0.079
0.231	-1.07	0.085	24.565	0.085
0.2427	-1.05	0.089	24.561	0.089
0.2552	-1.06	0.088	24.562	0.088
0.2683	-1.07	0.085	24.565	0.085
0.2823	-1.07	0.085	24.565	0.085
0.2972	-1.06	0.088	24.562	0.088
0.3128	-1.06	0.088	24.562	0.088
0.3295	-1.06	0.088	24.562	0.088
0.3472	-1.06	0.088	24.562	0.088
0.3658	-1.05	0.089	24.561	0.089
0.3857	-1.06	0.088	24.562	0.088
0.4067	-1.06	0.088	24.562	0.088
0.4288	-1.05	0.09	24.56	0.09
0.4523	-1.04	0.092	24.558	0.092
0.4772	-1.05	0.09	24.56	0.09
0.5035	-1.04	0.092	24.558	0.092
0.5315	-1.07	0.086	24.564	0.086
0.5612	-1.07	0.086	24.564	0.086
0.5925	-1.07	0.086	24.564	0.086
0.6257	-1.07	0.085	24.565	0.085
0.6608	-1.07	0.085	24.565	0.085
0.6982	-1.07	0.085	24.565	0.085
0.7377	-1.07	0.085	24.565	0.085
0.7795	-1.07	0.086	24.564	0.086
0.8238	-1.06	0.088	24.562	0.088
0.8708	-1.05	0.089	24.561	0.089
0.9207	-1.06	0.088	24.562	0.088
0.9733	-1.05	0.089	24.561	0.089
1.0292	-1.04	0.092	24.558	0.092
1.0883	-1.04	0.092	24.558	0.092
1.151	-1.03	0.093	24.557	0.093
1.2173	-1.02	0.095	24.555	0.095
1.2877	-1.02	0.095	24.555	0.095
1.3622	-1.02	0.095	24.555	0.095
1.4412	-1.01	0.098	24.552	0.098
1.5248	-1.01	0.098	24.552	0.098
1.6133	-1.01	0.098	24.552	0.098
1.7072	-1.00	0.099	24.551	0.099
1.8065	-1.01	0.098	24.552	0.098
1.9118	-1.01	0.098	24.552	0.098
2.0233	-1.02	0.096	24.554	0.096
2.1415	-1.02	0.096	24.554	0.096
2.2667	-1.01	0.098	24.552	0.098
2.3992	-1.02	0.096	24.554	0.096
2.5397	-1.02	0.095	24.555	0.095
2.6885	-1.02	0.095	24.555	0.095
2.846	-1.03	0.093	24.557	0.093
3.0128	-1.03	0.093	24.557	0.093
3.1897	-1.02	0.095	24.555	0.095
3.377	-1.02	0.095	24.555	0.095
3.5753	-1.03	0.093	24.557	0.093
3.7855	-1.02	0.095	24.555	0.095
4.0082	-1.03	0.093	24.557	0.093
4.244	-1.03	0.093	24.557	0.093
4.4938	-1.03	0.093	24.557	0.093
4.7585	-1.04	0.092	24.558	0.092
5.0388	-1.03	0.093	24.557	0.093
5.3357	-1.04	0.092	24.558	0.092
5.6502	-1.04	0.092	24.558	0.092
5.9833	-1.04	0.092	24.558	0.092
6.3362	-1.04	0.092	24.558	0.092
6.71	-1.04	0.092	24.558	0.092
7.106	-1.05	0.09	24.56	0.09
7.5253	-1.06	0.088	24.562	0.088
7.9697	-1.06	0.088	24.562	0.088
8.4403	-1.07	0.086	24.564	0.086
8.9388	-1.07	0.086	24.564	0.086
9.4668	-1.07	0.085	24.565	0.085
10.0262	-1.14	0.072	24.578	0.072
10.6187	-1.14	0.072	24.578	0.072
11.2462	-1.09	0.082	24.568	0.082
11.911	-1.10	0.08	24.57	0.08
12.6152	-1.10	0.079	24.571	0.079
13.361	-1.11	0.078	24.572	0.078



CHK'D: BWS 12/20/02

Slug-out

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/12/02	**Time:** 1510	**Observation Well No.:**	OW-845
Weather Conditions:	Partly sunny in 90s used 12/12/02		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	56.50 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	43.6-53.3 ft
Depth to Groundwater:	24.72 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
24.69	12/09/02
24.69	12/11/02

Comments/Remarks

c 2x
Slug #2 → Volume = 0.0893
Transducer SN = 2467
Head SN = 45449

Set transducer @ 45' below TOC

water

Reran Test on 12/15/02 ~ 1130
used slug #2 → volume 0.0893
Trans SN = 257
Head SN = 45449

Depth to water = 24.67

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-845	Conducted by:	Grimes and Howe
Test Date:	12/12/2002	Entered/date:	12/15/02
Test Type:	Recovery (slug out)	Checked/date:	BWehrnes 12/20/02

WELL DATA

SWL =	24.72	(ft BTOC)
WD =	56.50	(ft BTOC)
WD =	55.00	(ft BGS)
DTSP =	39.70	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	31.78	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	0.065 (ft) from plot
yt =	0.027 (ft) from plot
t =	0.369 (minutes) from plot
ln(Re/rw) =	2.70
K =	**3.1E+00 (ft/day)**
K =	**1.1E-03 (cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.70

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 3.23

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

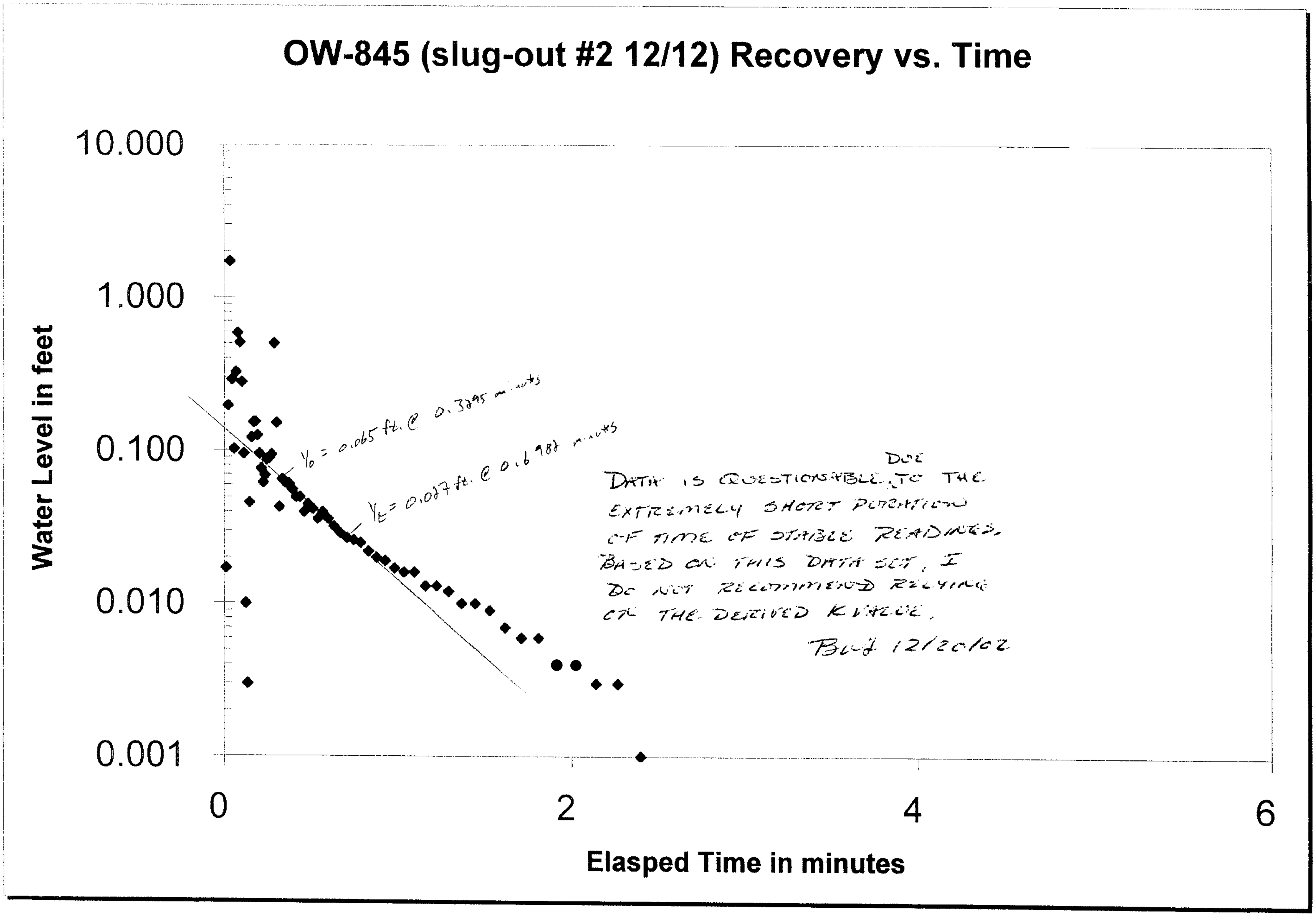
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	24.72	24.72
0.011	-1.77	0.017	24.737	24.737
0.022	-0.71	0.196	24.916	24.916
0.033	0.24	1.720	26.44	26.44
0.044	-0.54	0.290	25.01	25.01
0.055	-0.99	0.102	24.822	24.822
0.066	-0.49	0.324	25.044	25.044
0.077	-0.23	0.585	25.305	25.305
0.088	-0.30	0.506	25.226	25.226
0.099	-0.55	0.280	25	25
0.11	-1.02	0.095	24.815	24.815
0.121	-2.00	0.010	24.73	24.73
0.132	-2.52	0.003	24.723	24.723
0.143	-1.34	0.046	24.766	24.766
0.154	-0.92	0.121	24.841	24.841
0.165	-0.82	0.153	24.873	24.873
0.176	-0.81	0.154	24.874	24.874
0.187	-0.90	0.125	24.845	24.845
0.198	-1.02	0.095	24.815	24.815
0.209	-1.12	0.076	24.796	24.796
0.22	-1.21	0.062	24.782	24.782
0.231	-1.16	0.069	24.789	24.789
0.2427	-1.06	0.088	24.808	24.808
0.2552	-1.05	0.089	24.809	24.809
0.2683	-1.03	0.094	24.814	24.814
0.2823	-0.30	0.501	25.221	25.221
0.2972	-0.82	0.151	24.871	24.871
0.3128	-1.37	0.043	24.763	24.763
0.3295	-1.19	0.065	24.785	24.785
0.3472	-1.21	0.062	24.782	24.782
0.3658	-1.21	0.061	24.781	24.781
0.3857	-1.25	0.056	24.776	24.776
0.4067	-1.30	0.050	24.77	24.77
0.4288	-1.30	0.050	24.77	24.77
0.4523	-1.40	0.040	24.76	24.76
0.4772	-1.35	0.045	24.765	24.765
0.5035	-1.38	0.042	24.762	24.762
0.5315	-1.44	0.036	24.756	24.756
0.5612	-1.40	0.040	24.76	24.76
0.5925	-1.44	0.036	24.756	24.756
0.6257	-1.49	0.032	24.752	24.752
0.6608	-1.54	0.029	24.749	24.749
0.6982	-1.57	0.027	24.747	24.747
0.7377	-1.59	0.026	24.746	24.746
0.7795	-1.60	0.025	24.745	24.745
0.8238	-1.66	0.022	24.742	24.742
0.8708	-1.70	0.020	24.74	24.74
0.9207	-1.72	0.019	24.739	24.739
0.9733	-1.77	0.017	24.737	24.737
1.0292	-1.80	0.016	24.736	24.736
1.0883	-1.80	0.016	24.736	24.736
1.151	-1.89	0.013	24.733	24.733
1.2173	-1.89	0.013	24.733	24.733
1.2877	-1.92	0.012	24.732	24.732
1.3622	-2.00	0.010	24.73	24.73
1.4412	-2.00	0.010	24.73	24.73
1.5248	-2.05	0.009	24.729	24.729
1.6133	-2.15	0.007	24.727	24.727
1.7072	-2.22	0.006	24.726	24.726
1.8065	-2.22	0.006	24.726	24.726
1.9118	-2.40	0.004	24.724	24.724
2.0233	-2.40	0.004	24.724	24.724
2.1415	-2.52	0.003	24.723	24.723
2.2667	-2.52	0.003	24.723	24.723
2.3992	-3.00	0.001	24.721	24.721
2.5397	#NUM!	0.000	24.72	24.72
2.6885	#NUM!	0.000	24.72	24.72
2.846	#NUM!	-0.001	24.719	24.719
3.0128	#NUM!	-0.001	24.719	24.719
3.1897	#NUM!	-0.001	24.719	24.719
3.377	#NUM!	-0.003	24.717	24.717
3.5753	#NUM!	-0.003	24.717	24.717
3.7855	#NUM!	-0.004	24.716	24.716
4.0082	#NUM!	-0.003	24.717	24.717
4.244	#NUM!	-0.004	24.716	24.716
4.4938	#NUM!	-0.004	24.716	24.716
4.7585	#NUM!	-0.004	24.716	24.716
5.0388	#NUM!	-0.004	24.716	24.716

Reference: Bouwer(1989), Bouwer and Rice(1976)



OW-845 (slug-out #2 12/12) Recovery vs. Time
10.000
1.000
0.100
0.010
0.001
Water Level in feet
0
2
4
6
Elasped Time in minutes
Y_0 = 0.065 ft. @ 0.3295 minutes
Y_t = 0.027 ft. @ 0.6982 minutes
DATA IS QUESTIONABLE DUE TO THE EXTREMELY SHORT DURATION OF TIME OF STABLE READINGS. BASED ON THIS DATA SET, I DO NOT RECOMMEND RELYING ON THE DERIVED K VALUE.
BLJ 12/20/02

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/12/02	**Time:** 1025	**Observation Well No.:**	OW-846
Weather Conditions:	partly sunny in 50's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	34.32 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.45 ft	**Depth interval of screened portion:**	22.4-31.45 ft
Depth to Groundwater:	24.82 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
24.82	~~11/19/02~~ 12/09/02
24.87	12/06/02

Comments/Remarks

wsc 12/12/02

used slug #2 → volume = 0.0843

Transducer S/N → 6407

Hermit S/N → 45299

2 ft transducer @ 32 below TOC

wsc

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-846
Test Date: 12/12/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: [illegible] 12/20/02

WELL DATA

SWL =	24.82	(ft BTOC)
WD =	34.30	(ft BTOC)
WD =	32.80	(ft BGS)
DTSP =	20.30	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.19	(ft)
Le =	9.75	(ft)
Lw =	9.48	(ft)
Le/rw =	29.55	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	0.704	(ft) from plot
yt =	0.495	(ft) from plot
t =	1.069	(minutes) from plot
ln(Re/rw) =	2.13	

K = 1.9E+00 (ft/day)

K = 6.8E-04 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1 = 2.13

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.50

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.55	2.49	0.35	2.08

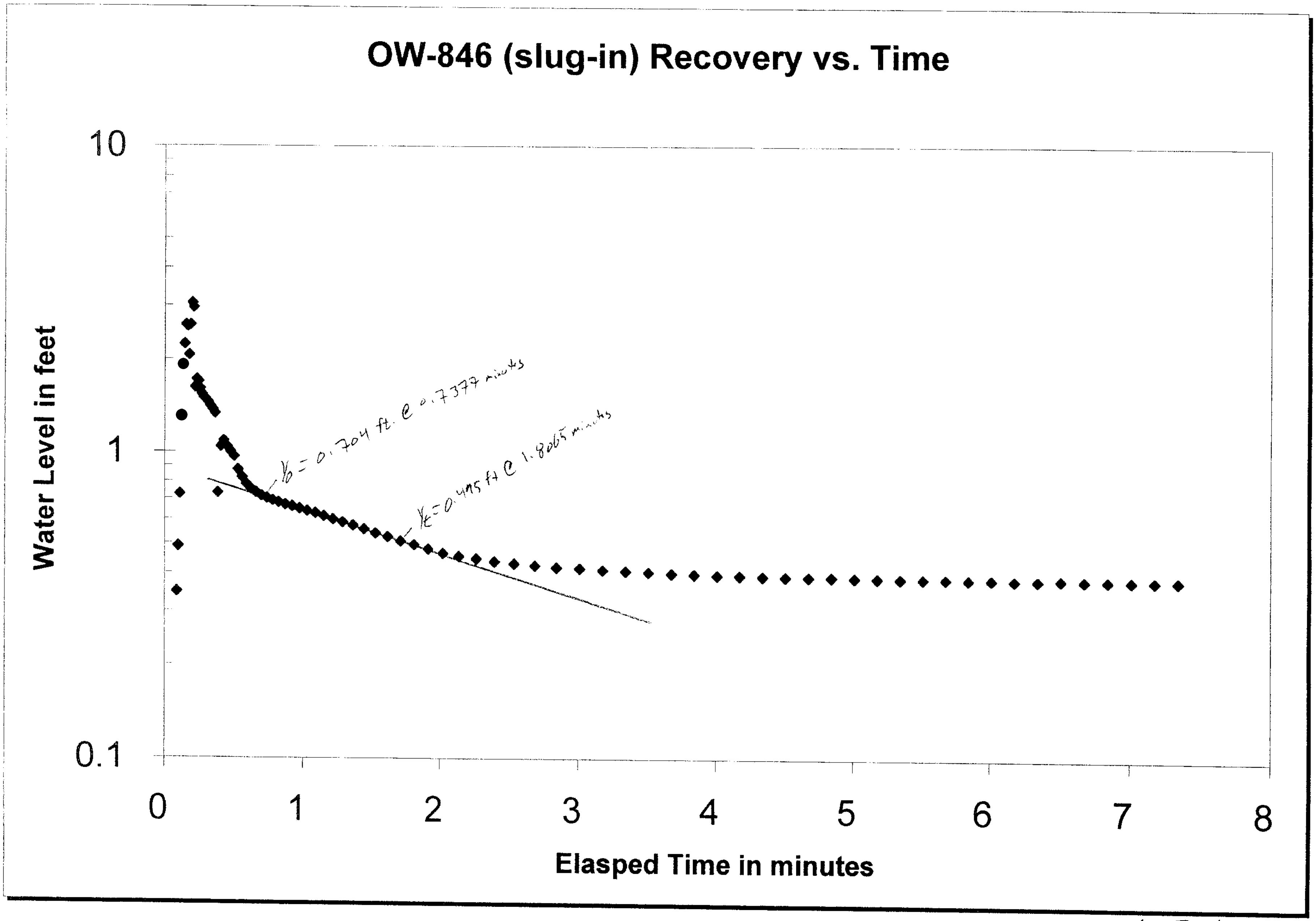
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	24.82	0
0.011	-3.00	0.001	24.819	0.001
0.022	-3.00	0.001	24.819	0.001
0.033	-2.52	0.003	24.817	0.003
0.044	-2.40	0.004	24.816	0.004
0.055	-2.40	0.004	24.816	0.004
0.066	-2.40	0.004	24.816	0.004
0.077	-2.52	0.003	24.817	0.003
0.088	-0.46	0.347	24.473	-0.347
0.099	-0.31	0.488	24.332	-0.488
0.11	-0.14	0.725	24.095	-0.725
0.121	0.12	1.308	23.512	-1.308
0.132	0.28	1.91	22.91	-1.91
0.143	0.35	2.238	22.582	-2.238
0.154	0.41	2.593	22.227	-2.593
0.165	0.41	2.558	22.262	-2.558
0.176	0.31	2.062	22.758	-2.062
0.187	0.41	2.593	22.227	-2.593
0.198	0.49	3.061	21.759	-3.061
0.209	0.47	2.96	21.86	-2.96
0.22	0.21	1.617	23.203	-1.617
0.231	0.24	1.718	23.102	-1.718
0.2427	0.23	1.692	23.128	-1.692
0.2552	0.20	1.6	23.22	-1.6
0.2683	0.19	1.538	23.282	-1.538
0.2823	0.18	1.501	23.319	-1.501
0.2972	0.17	1.478	23.342	-1.478
0.3128	0.16	1.449	23.371	-1.449
0.3295	0.15	1.407	23.413	-1.407
0.3472	0.14	1.374	23.446	-1.374
0.3658	0.13	1.336	23.484	-1.336
0.3857	-0.14	0.732	24.088	-0.732
0.4067	0.02	1.04	23.78	-1.04
0.4288	0.04	1.087	23.733	-1.087
0.4523	0.02	1.04	23.78	-1.04
0.4772	0.00	1.002	23.818	-1.002
0.5035	-0.02	0.964	23.856	-0.964
0.5315	-0.06	0.872	23.948	-0.872
0.5612	-0.08	0.823	23.997	-0.823
0.5925	-0.11	0.783	24.037	-0.783
0.6257	-0.12	0.754	24.066	-0.754
0.6608	-0.13	0.734	24.086	-0.734
0.6982	-0.14	0.717	24.103	-0.717
0.7377	-0.15	0.704	24.116	-0.704
0.7795	-0.16	0.692	24.128	-0.692
0.8238	-0.17	0.682	24.138	-0.682
0.8708	-0.17	0.671	24.149	-0.671
0.9207	-0.18	0.662	24.158	-0.662
0.9733	-0.19	0.65	24.17	-0.65
1.0292	-0.19	0.639	24.181	-0.639
1.0883	-0.20	0.629	24.191	-0.629
1.151	-0.21	0.615	24.205	-0.615
1.2173	-0.22	0.6	24.22	-0.6
1.2877	-0.23	0.587	24.233	-0.587
1.3622	-0.24	0.573	24.247	-0.573
1.4412	-0.25	0.557	24.263	-0.557
1.5248	-0.27	0.541	24.279	-0.541
1.6133	-0.28	0.526	24.294	-0.526
1.7072	-0.29	0.508	24.312	-0.508
1.8065	-0.31	0.495	24.325	-0.495
1.9118	-0.32	0.48	24.34	-0.48
2.0233	-0.33	0.465	24.355	-0.465
2.1415	-0.34	0.455	24.365	-0.455
2.2667	-0.35	0.447	24.373	-0.447
2.3992	-0.36	0.438	24.382	-0.438
2.5397	-0.37	0.431	24.389	-0.431
2.6885	-0.37	0.425	24.395	-0.425
2.846	-0.38	0.419	24.401	-0.419
3.0127	-0.38	0.416	24.404	-0.416
3.1793	-0.39	0.411	24.409	-0.411
3.346	-0.39	0.408	24.412	-0.408
3.5127	-0.39	0.405	24.415	-0.405
3.6793	-0.40	0.401	24.419	-0.401
3.846	-0.40	0.399	24.421	-0.399
4.0127	-0.40	0.396	24.424	-0.396
4.1793	-0.40	0.395	24.425	-0.395
4.346	-0.41	0.393	24.427	-0.393
4.5127	-0.41	0.392	24.428	-0.392
4.6793	-0.41	0.391	24.429	-0.391
4.846	-0.41	0.391	24.429	-0.391
5.0127	-0.41	0.389	24.431	-0.389
5.1793	-0.41	0.388	24.432	-0.388
5.346	-0.41	0.386	24.434	-0.386
5.5127	-0.41	0.386	24.434	-0.386
5.6793	-0.41	0.386	24.434	-0.386
5.846	-0.41	0.385	24.435	-0.385
6.0127	-0.41	0.385	24.435	-0.385
6.1793	-0.42	0.383	24.437	-0.383
6.346	-0.42	0.383	24.437	-0.383
6.5127	-0.41	0.385	24.435	-0.385
6.6793	-0.42	0.383	24.437	-0.383
6.846	-0.42	0.383	24.437	-0.383
7.0127	-0.42	0.382	24.438	-0.382
7.1793	-0.42	0.382	24.438	-0.382
7.346	-0.42	0.382	24.438	-0.382



CHK'D: BWJ 12/20/02

Slug-out

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/12/02	**Time:** ~~1335~~ 1535	**Observation Well No.:**	OW-846
Weather Conditions: partly sunny ~50's 12/12/02 - sun			
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	34.36 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.75 ft	**Depth interval of screened portion:**	24.4-34.15 ft
Depth to Groundwater:	24.82 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date ~~12/09/02~~
24.82	~~12/9/02~~ 12/12/02

Comments/Remarks

Slug [illegible]
Transducer = [illegible]
[illegible] Slug = [illegible]

Set transducer @ 32' below TOC

[illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number 30720-2-5400

Well: OW-846
Test Date: 12/12/2002
Test Type: Recovery (slug-out)

Conducted by: Grimes&Howe
Entered/date: Grimes/12/15/02
Checked/date: BHJones 12/20/02

WELL DATA

SWL =	24.82	(ft BTOC)
WD =	34.30	(ft BTOC)
WD =	32.80	(ft BGS)
DTSP =	20.30	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.19	(ft)
Le =	9.75	(ft)
Lw =	9.48	(ft)
Le/rw =	29.55	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.707	(ft) from plot
yt =	1.162	(ft) from plot
t =	0.652	(minutes) from plot
ln(Re/rw) =	2.13	

K = 3.4E+00 (ft/day)

K = 1.2E-03 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H:

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1= 2.13

Where: Lw = H:

ln(Re/rw) = [(1.1/(ln(Lw/rw))+(C/(Le/rw))]^-1 = 2.50

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.55	2.49	0.35	2.08

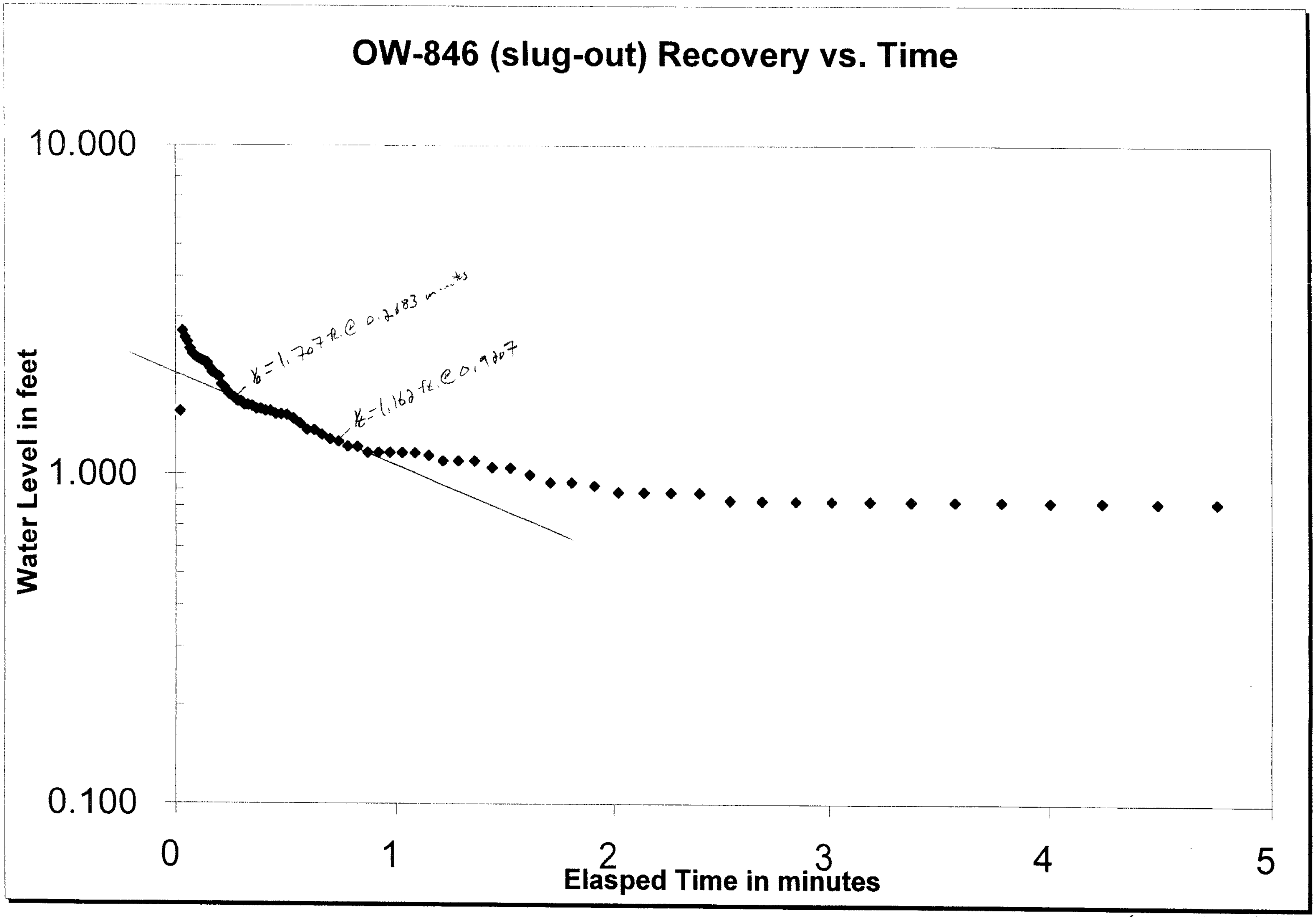
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	24.82	24.82
0.011	-3.00	0.001	24.821	24.821
0.022	0.19	1.552	26.372	26.372
0.033	0.44	2.727	27.547	27.547
0.044	0.42	2.604	27.424	27.424
0.055	0.40	2.528	27.348	27.348
0.066	0.38	2.412	27.232	27.232
0.077	0.37	2.334	27.154	27.154
0.088	0.36	2.293	27.113	27.113
0.099	0.35	2.262	27.082	27.082
0.11	0.35	2.238	27.058	27.058
0.121	0.35	2.218	27.038	27.038
0.132	0.34	2.201	27.021	27.021
0.143	0.34	2.185	27.005	27.005
0.154	0.32	2.113	26.933	26.933
0.165	0.31	2.043	26.863	26.863
0.176	0.31	2.033	26.853	26.853
0.187	0.30	1.997	26.817	26.817
0.198	0.30	1.981	26.801	26.801
0.209	0.27	1.874	26.694	26.694
0.22	0.27	1.842	26.662	26.662
0.231	0.25	1.796	26.616	26.616
0.2427	0.24	1.752	26.572	26.572
0.2552	0.24	1.729	26.549	26.549
0.2683	0.23	1.707	26.527	26.527
0.2823	0.22	1.665	26.485	26.485
0.2972	0.22	1.664	26.484	26.484
0.3128	0.21	1.621	26.441	26.441
0.3295	0.21	1.621	26.441	26.441
0.3472	0.21	1.611	26.431	26.431
0.3658	0.20	1.576	26.396	26.396
0.3857	0.20	1.576	26.396	26.396
0.4067	0.19	1.556	26.376	26.376
0.4288	0.19	1.556	26.376	26.376
0.4523	0.18	1.522	26.342	26.342
0.4772	0.18	1.520	26.34	26.34
0.5035	0.18	1.512	26.332	26.332
0.5315	0.17	1.475	26.295	26.295
0.5612	0.15	1.424	26.244	26.244
0.5925	0.13	1.364	26.184	26.184
0.6257	0.13	1.361	26.181	26.181
0.6608	0.12	1.317	26.137	26.137
0.6982	0.11	1.276	26.096	26.096
0.7377	0.10	1.255	26.075	26.075
0.7795	0.08	1.213	26.033	26.033
0.8238	0.08	1.212	26.032	26.032
0.8708	0.07	1.163	25.983	25.983
0.9207	0.07	1.162	25.982	25.982
0.9733	0.07	1.162	25.982	25.982
1.0292	0.06	1.160	25.98	25.98
1.0883	0.06	1.159	25.979	25.979
1.151	0.06	1.139	25.959	25.959
1.2173	0.04	1.097	25.917	25.917
1.2877	0.04	1.097	25.917	25.917
1.3622	0.04	1.096	25.916	25.916
1.4412	0.02	1.045	25.865	25.865
1.5248	0.02	1.042	25.862	25.862
1.6133	0.00	0.994	25.814	25.814
1.7072	-0.03	0.943	25.763	25.763
1.8065	-0.03	0.942	25.762	25.762
1.9118	-0.04	0.922	25.742	25.742
2.0233	-0.06	0.880	25.7	25.7
2.1415	-0.06	0.879	25.699	25.699
2.2667	-0.06	0.877	25.697	25.697
2.3992	-0.06	0.876	25.696	25.696
2.5397	-0.08	0.829	25.649	25.649
2.6885	-0.08	0.827	25.647	25.647
2.846	-0.08	0.826	25.646	25.646
3.0128	-0.08	0.824	25.644	25.644
3.1897	-0.08	0.823	25.643	25.643
3.377	-0.09	0.821	25.641	25.641
3.5753	-0.09	0.820	25.64	25.64
3.7855	-0.09	0.820	25.64	25.64
4.0082	-0.09	0.818	25.638	25.638
4.244	-0.09	0.817	25.637	25.637
4.4938	-0.09	0.814	25.634	25.634
4.7585	-0.09	0.814	25.634	25.634
5.0388	-0.09	0.811	25.631	25.631
5.3357	-0.10	0.793	25.613	25.613
5.6502	-0.11	0.768	25.588	25.588
5.9833	-0.12	0.764	25.584	25.584
6.3362	-0.12	0.762	25.582	25.582
6.71	-0.12	0.761	25.581	25.581
7.106	-0.12	0.760	25.58	25.58
7.5253	-0.12	0.757	25.577	25.577
7.9697	-0.12	0.755	25.575	25.575
8.4403	-0.12	0.752	25.572	25.572
8.9388	-0.12	0.751	25.571	25.571
9.4668	-0.12	0.750	25.57	25.57
10.0262	-0.13	0.747	25.567	25.567
10.6187	-0.13	0.745	25.565	25.565
11.2462	-0.13	0.742	25.562	25.562
11.911	-0.13	0.738	25.558	25.558
12.6152	-0.13	0.737	25.557	25.557
13.361	-0.14	0.732	25.552	25.552
14.151	-0.14	0.729	25.549	25.549
14.9878	-0.14	0.725	25.545	25.545
15.8743	-0.14	0.719	25.539	25.539
16.8133	-0.15	0.715	25.535	25.535
17.808	-0.15	0.711	25.531	25.531
18.8617	-0.15	0.706	25.526	25.526
19.9777	-0.15	0.704	25.524	25.524



CHK'D: BWS 12/20/02

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	MACTEC Job Number:	30720-2-5400
Date: 12/11/02	Time: 1310	Observation Well No.:	OW-847
Weather Conditions:	partly cloudy 50's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	Test Method:	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	Diameter of Casing:	2 in.
Total Well Depth:	77.30 ft below reference point	Reference Point:	Permanent mark on top of casing
Length of Screened Section:	7.9 ft	Depth interval of screened portion:	37.6-45.5 ft
Depth to Groundwater:	34.45 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
34.18	12/10/02
34.36	12/06/02
34.31	12/13/02
34.45	12/11/02

Comments/Remarks

Slug Volume = 0.08 ft³

Slug volume = 0.08 ft³

USGS

Transducer S/N → 6107

Hermit S/N → 45449

Set transducer 45' below TOC

USGS

Redo test on 12/13/02 @ 1055

Using same equipment

Depth to water = 34.31

Set transducer at 45' below TOC

Use this test for calculations

USGS 12/16/02

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-847
Test Date: 12/13/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BhJones 12/20/02

WELL DATA

SWL =	34.31	(ft BTOC)
WD =	51.30	(ft BTOC)
WD =	49.80	(ft BGS)
DTSP =	35.00	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	7.9	(ft)
Lw =	16.99	(ft)
Le/rw =	23.94	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.480	(ft) from plot
yt =	1.195	(ft) from plot
t =	1.620	(minutes) from plot
ln(Re/rw) =	2.27	

K = 5.8E-01 (ft/day)

K = 2.1E-04 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.27

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.78

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
20	2.23	0.29	1.75
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

23.94	2.34	0.31	1.89

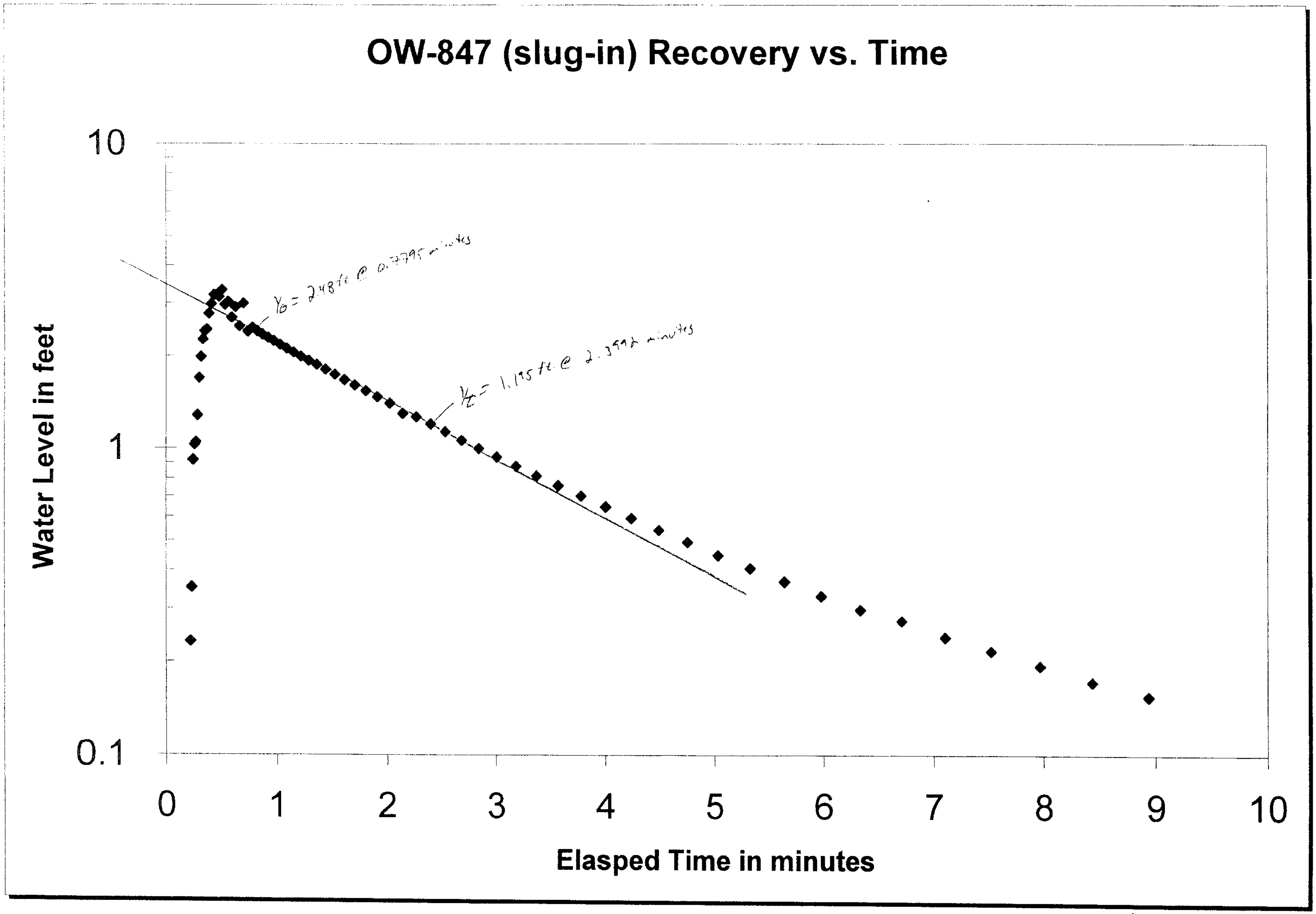
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	34.31	0
0.011	-2.40	0.004	34.306	0.004
0.022	-2.40	0.004	34.306	0.004
0.033	-2.40	0.004	34.306	0.004
0.044	-2.40	0.004	34.306	0.004
0.055	-2.52	0.003	34.307	0.003
0.066	-3.00	0.001	34.309	0.001
0.077	-2.40	0.004	34.306	0.004
0.088	-2.52	0.003	34.307	0.003
0.099	-3.00	0.001	34.309	0.001
0.11	#NUM!	0	34.31	0
0.121	-2.52	0.003	34.307	0.003
0.132	-2.52	0.003	34.307	0.003
0.143	-3.00	0.001	34.309	0.001
0.154	-3.00	0.001	34.309	0.001
0.165	-3.00	0.001	34.309	0.001
0.176	-3.00	0.001	34.309	0.001
0.187	#NUM!	0	34.31	0
0.198	-3.00	0.001	34.309	0.001
0.209	#NUM!	0	34.31	0
0.22	-0.63	0.233	34.077	-0.233
0.231	-0.45	0.352	33.958	-0.352
0.2427	-0.04	0.916	33.394	-0.916
0.2552	0.01	1.028	33.282	-1.028
0.2683	0.02	1.045	33.265	-1.045
0.2823	0.11	1.277	33.033	-1.277
0.2972	0.23	1.692	32.618	-1.692
0.3128	0.30	1.986	32.324	-1.986
0.3295	0.36	2.269	32.041	-2.269
0.3472	0.38	2.418	31.892	-2.418
0.3658	0.39	2.447	31.863	-2.447
0.3857	0.44	2.764	31.546	-2.764
0.4067	0.47	2.975	31.335	-2.975
0.4288	0.50	3.189	31.121	-3.189
0.4523	0.50	3.194	31.116	-3.194
0.4772	0.50	3.149	31.161	-3.149
0.5035	0.52	3.318	30.992	-3.318
0.5315	0.47	2.966	31.344	-2.966
0.5612	0.48	3.028	31.282	-3.028
0.5925	0.43	2.679	31.631	-2.679
0.6257	0.46	2.905	31.405	-2.905
0.6608	0.40	2.508	31.802	-2.508
0.6982	0.48	2.991	31.319	-2.991
0.7377	0.38	2.41	31.9	-2.41
0.7795	0.39	2.48	31.83	-2.48
0.8238	0.38	2.417	31.893	-2.417
0.8708	0.37	2.359	31.951	-2.359
0.9207	0.36	2.299	32.011	-2.299
0.9733	0.35	2.243	32.067	-2.243
1.0292	0.34	2.181	32.129	-2.181
1.0883	0.33	2.119	32.191	-2.119
1.151	0.31	2.057	32.253	-2.057
1.2173	0.30	1.993	32.317	-1.993
1.2877	0.29	1.931	32.379	-1.931
1.3622	0.27	1.868	32.442	-1.868
1.4412	0.26	1.8	32.51	-1.8
1.5248	0.24	1.734	32.576	-1.734
1.6133	0.22	1.665	32.645	-1.665
1.7072	0.20	1.599	32.711	-1.599
1.8065	0.19	1.533	32.777	-1.533
1.9118	0.17	1.464	32.846	-1.464
2.0233	0.14	1.396	32.914	-1.396
2.1415	0.11	1.292	33.018	-1.292
2.2667	0.10	1.261	33.049	-1.261
2.3992	0.08	1.195	33.115	-1.195
2.5397	0.05	1.13	33.18	-1.13
2.6885	0.03	1.061	33.249	-1.061
2.846	0.00	0.999	33.311	-0.999
3.0128	-0.03	0.937	33.373	-0.937
3.1897	-0.06	0.875	33.435	-0.875
3.377	-0.09	0.815	33.495	-0.815
3.5753	-0.12	0.758	33.552	-0.758
3.7855	-0.15	0.701	33.609	-0.701
4.0082	-0.19	0.647	33.663	-0.647
4.244	-0.23	0.592	33.718	-0.592
4.4938	-0.27	0.542	33.768	-0.542
4.7585	-0.31	0.494	33.816	-0.494
5.0388	-0.35	0.447	33.863	-0.447
5.3357	-0.39	0.405	33.905	-0.405
5.6502	-0.44	0.367	33.943	-0.367
5.9833	-0.48	0.329	33.981	-0.329
6.3362	-0.53	0.296	34.014	-0.296
6.71	-0.57	0.272	34.038	-0.272
7.106	-0.62	0.24	34.07	-0.24
7.5253	-0.67	0.216	34.094	-0.216
7.9697	-0.71	0.193	34.117	-0.193
8.4403	-0.77	0.171	34.139	-0.171
8.9388	-0.81	0.154	34.156	-0.154



CHK'D: BLG 12/20/02

Slug out

MACTEC | **MACTEC Engineering and Consulting**
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name: North Anna ESP		**MACTEC Job Number:** 30720-2-5400	
Date: 12-17-02	**Time:** 0820	**Observation Well No.:** OW-847	
Weather Conditions: Sunny [illegible]			
Method of Slug Withdrawl (circle one):	water, **mechanical**, or pressure	**Test Method:**	**Rising Head** or **Falling Head** (circle)
Diameter of Screen: 2 in.		**Diameter of Casing:** 2 in.	
Total Well Depth: 58.3 ft below reference point		**Reference Point:**	Permanent mark on top of casing
Length of Screened Section: 9.9 ft		**Depth interval of screened portion:**	38.6 - 48.5 ft
Depth to Groundwater: 34.34 ft below reference point			

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
34.18	12/10/02
34.36	12/06/02
34.31	12/13/02
34.35	12-17-02

Comments/Remarks

[illegible]

[illegible]

[illegible]

[illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-847
Test Date:	12/17/2002
Test Type:	Recovery (slug out)

Conducted by:	Grimes and Howe
Entered/date:	WSG/12/18/02
Checked/date:	BHJones 12/20/02

WELL DATA

SWL =	34.34	(ft BTOC)
WD =	51.30	(ft BTOC)
WD =	49.80	(ft BGS)
DTSP =	35.00	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	7.9	(ft)
Lw =	16.96	(ft)
Le/rw =	23.94	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	3.543	(ft) from plot
yt =	2.387	(ft) from plot
t =	0.761	(minutes) from plot
ln(Re/rw) =	2.27	
K =	**6.6E-01**	**(ft/day)**
K =	**2.3E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)}]^-1 = 2.27

Where: Lw = H,

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.78

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
20	2.23	0.29	1.75
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

23.94	2.34	0.31	1.89

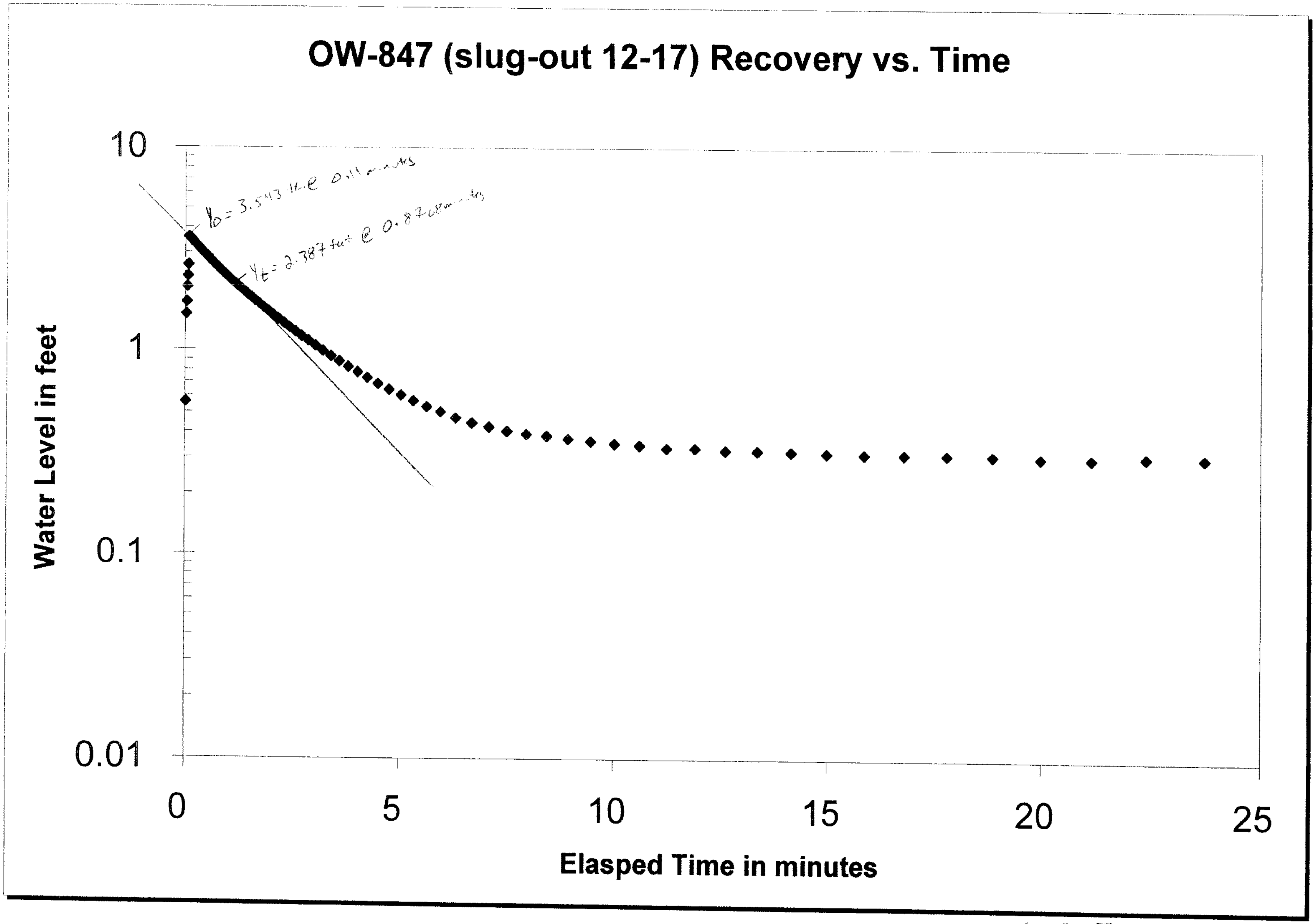
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	34.34	0
0.011	#NUM!	-0.001	34.339	-0.001
0.022	-0.25	0.562	34.902	0.562
0.033	0.17	1.487	35.827	1.487
0.044	0.23	1.706	36.046	1.706
0.055	0.31	2.024	36.364	2.024
0.066	0.36	2.294	36.634	2.294
0.077	0.41	2.6	36.94	2.6
0.088	0.55	3.576	37.916	3.576
0.099	0.55	3.554	37.894	3.554
0.11	0.55	3.543	37.883	3.543
0.121	0.55	3.513	37.853	3.513
0.132	0.54	3.484	37.824	3.484
0.143	0.54	3.46	37.8	3.46
0.154	0.54	3.438	37.778	3.438
0.165	0.53	3.427	37.767	3.427
0.176	0.53	3.406	37.746	3.406
0.187	0.53	3.388	37.728	3.388
0.198	0.53	3.368	37.708	3.368
0.209	0.52	3.346	37.686	3.346
0.22	0.52	3.32	37.66	3.32
0.231	0.52	3.303	37.643	3.303
0.2427	0.52	3.277	37.617	3.277
0.2552	0.51	3.254	37.594	3.254
0.2683	0.51	3.234	37.574	3.234
0.2823	0.51	3.207	37.547	3.207
0.2972	0.50	3.187	37.527	3.187
0.3128	0.50	3.162	37.502	3.162
0.3295	0.50	3.131	37.471	3.131
0.3472	0.49	3.096	37.436	3.096
0.3658	0.49	3.064	37.404	3.064
0.3857	0.48	3.033	37.373	3.033
0.4067	0.48	3	37.34	3
0.4288	0.47	2.962	37.302	2.962
0.4523	0.47	2.928	37.268	2.928
0.4772	0.46	2.892	37.232	2.892
0.5035	0.46	2.875	37.215	2.875
0.5315	0.45	2.811	37.151	2.811
0.5612	0.44	2.77	37.11	2.77
0.5925	0.44	2.728	37.068	2.728
0.6257	0.43	2.682	37.022	2.682
0.6608	0.42	2.636	36.976	2.636
0.6982	0.41	2.59	36.93	2.59
0.7377	0.41	2.544	36.884	2.544
0.7795	0.40	2.494	36.834	2.494
0.8238	0.39	2.442	36.782	2.442
0.8708	0.38	2.387	36.727	2.387
0.9207	0.37	2.336	36.676	2.336
0.9733	0.36	2.282	36.622	2.282
1.0292	0.35	2.223	36.563	2.223
1.0883	0.34	2.166	36.506	2.166
1.151	0.32	2.107	36.447	2.107
1.2173	0.31	2.047	36.387	2.047
1.2877	0.30	1.988	36.328	1.988
1.3622	0.28	1.926	36.266	1.926
1.4412	0.27	1.863	36.203	1.863
1.5248	0.26	1.801	36.141	1.801
1.6133	0.24	1.737	36.077	1.737
1.7072	0.22	1.673	36.013	1.673
1.8065	0.21	1.609	35.949	1.609
1.9118	0.19	1.546	35.886	1.546
2.0233	0.17	1.48	35.82	1.48
2.1415	0.15	1.417	35.757	1.417
2.2667	0.13	1.352	35.692	1.352
2.3992	0.11	1.29	35.63	1.29
2.5397	0.09	1.228	35.568	1.228
2.6885	0.07	1.167	35.507	1.167
2.846	0.04	1.108	35.448	1.108
3.0128	0.02	1.049	35.389	1.049
3.1897	0.00	0.991	35.331	0.991
3.377	-0.03	0.935	35.275	0.935
3.5753	-0.05	0.882	35.222	0.882
3.7855	-0.08	0.83	35.17	0.83
4.0082	-0.11	0.783	35.123	0.783
4.244	-0.13	0.734	35.074	0.734
4.4938	-0.16	0.688	35.028	0.688
4.7585	-0.19	0.646	34.986	0.646
5.0388	-0.22	0.607	34.947	0.607
5.3357	-0.24	0.57	34.91	0.57
5.6502	-0.27	0.534	34.874	0.534
5.9833	-0.30	0.505	34.845	0.505
6.3362	-0.33	0.472	34.812	0.472
6.71	-0.35	0.446	34.786	0.446
7.106	-0.37	0.427	34.767	0.427
7.5253	-0.39	0.407	34.747	0.407
7.9697	-0.40	0.394	34.734	0.394
8.4403	-0.41	0.386	34.726	0.386
8.9388	-0.43	0.374	34.714	0.374
9.4668	-0.44	0.364	34.704	0.364
10.0262	-0.45	0.355	34.695	0.355
10.6187	-0.46	0.348	34.688	0.348
11.2462	-0.47	0.337	34.677	0.337
11.911	-0.47	0.337	34.677	0.337
12.6152	-0.48	0.329	34.669	0.329
13.361	-0.48	0.328	34.668	0.328
14.151	-0.49	0.324	34.664	0.324
14.9878	-0.50	0.319	34.659	0.319
15.8743	-0.50	0.316	34.656	0.316
16.8133	-0.50	0.315	34.655	0.315
17.808	-0.50	0.314	34.654	0.314
18.8617	-0.51	0.312	34.652	0.312
19.9777	-0.52	0.304	34.644	0.304
21.1598	-0.52	0.302	34.642	0.302
22.412	-0.51	0.308	34.648	0.308
23.7385	-0.51	0.306	34.646	0.306
25.1435	-0.52	0.302	34.642	0.302



CHKD: BLB 12/20/02

Slug - 7n

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	MACTEC Job Number:	30720-2-5400
Date: 12/12/02	Time: 1310	Observation Well No.:	OW-848
Weather Conditions:	Rainy & upper 30's		
Method of Slug Withdrawl (circle one):	water, ~~mechanical~~, or pressure	Test Method:	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	Diameter of Casing:	2 in.
Total Well Depth:	45.87 ft below reference point	Reference Point:	Permanent mark on top of casing
Length of Screened Section:	5.02 ft	Depth interval of screened portion:	42.2-47.2 ft
Depth to Groundwater:	42.65 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
42.79	12/10/02
43.02	12/06/02

Comments/Remarks

used slug #2 → volume = 0.08 ft³

Transducer S/n = 6407

Hermit S/n = 45279

used 12/13/02

set transducer @ 45' below TOC

48' — [illegible]

[illegible]

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-848
Test Date: 12/13/2002
Test Type: Recovery (slug in)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BWJones 12/20/02

WELL DATA

SWL =	42.65	(ft BTOC)
WD =	48.87	(ft BTOC)
WD =	47.37	(ft BGS)
DTSP =	39.10	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.19	(ft)
Le =	5.02	(ft)
Lw =	6.22	(ft)
Le/rw =	15.21	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.537	(ft) from plot
yt =	0.953	(ft) from plot
t =	1.255	(minutes) from plot
ln(Re/rw) =	1.67	
K =	**3.4E+00**	**(ft/day)**
K =	**1.2E-03**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 1.67

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.13

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
15	2.1	0.27	1.5
25	2.4	0.31	1.9

Interpolated values of A, B and C for Le/rw

15.21	2.11	0.27	1.51

Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

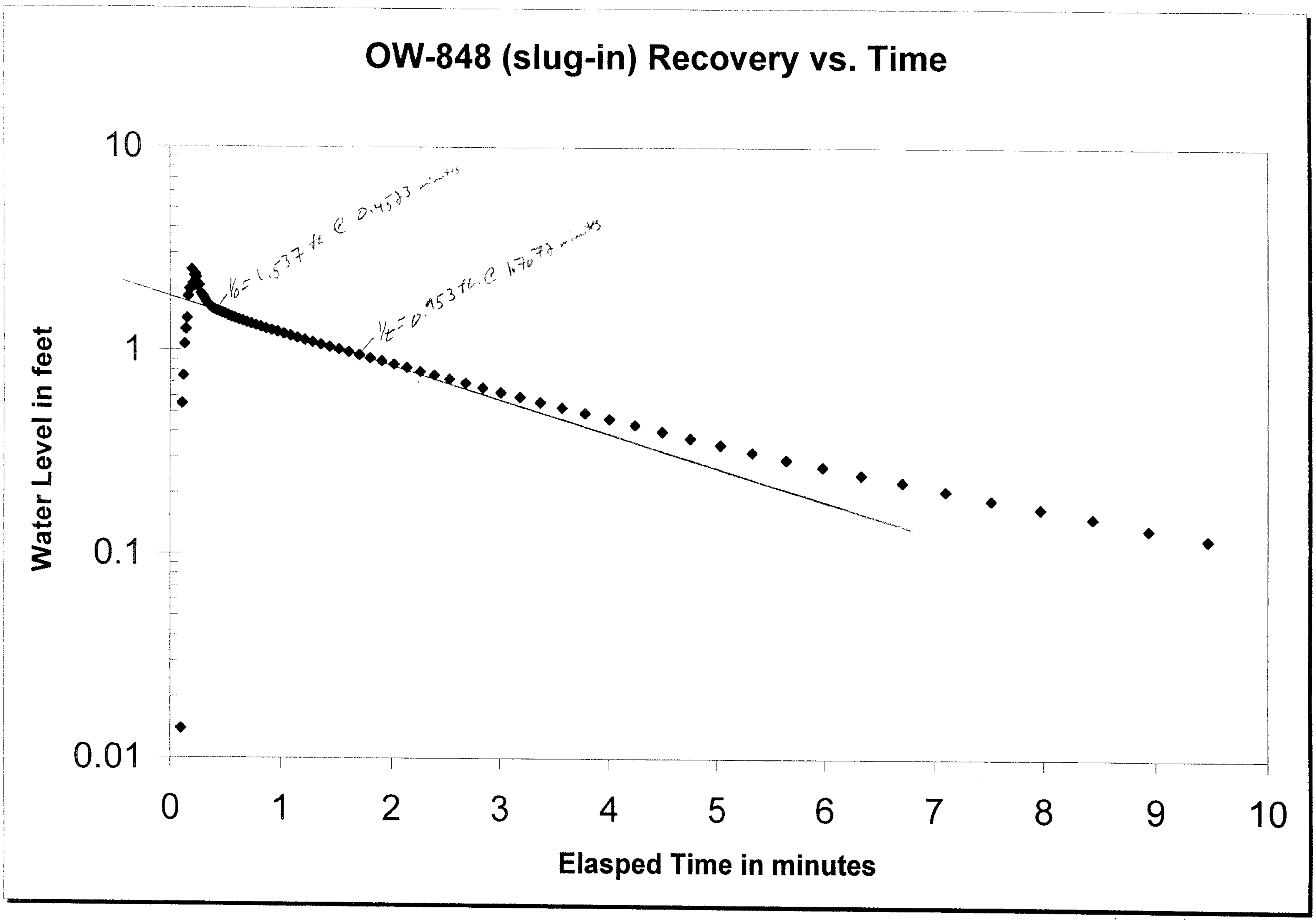
Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	42.65	0
0.011	-3.00	0.001	42.649	0.001
0.022	-2.52	0.003	42.647	0.003
0.033	-3.00	0.001	42.649	0.001
0.044	-3.00	0.001	42.649	0.001
0.055	#NUM!	0	42.65	0
0.066	-2.52	0.003	42.647	0.003
0.077	-3.00	0.001	42.649	0.001
0.088	-3.00	0.001	42.649	0.001
0.099	-1.85	0.014	42.636	-0.014
0.11	-0.26	0.55	42.1	-0.55
0.121	-0.12	0.752	41.898	-0.752
0.132	0.03	1.073	41.577	-1.073
0.143	0.10	1.261	41.389	-1.261
0.154	0.16	1.429	41.221	-1.429
0.165	0.26	1.831	40.819	-1.831
0.176	0.30	1.991	40.659	-1.991
0.187	0.30	1.995	40.655	-1.995
0.198	0.39	2.48	40.17	-2.48
0.209	0.33	2.128	40.522	-2.128
0.22	0.37	2.318	40.332	-2.318
0.231	0.37	2.358	40.292	-2.358
0.2427	0.36	2.266	40.384	-2.266
0.2552	0.31	2.042	40.608	-2.042
0.2683	0.32	2.078	40.572	-2.078
0.2823	0.28	1.893	40.757	-1.893
0.2972	0.26	1.837	40.813	-1.837
0.3128	0.25	1.778	40.872	-1.778
0.3295	0.24	1.718	40.932	-1.718
0.3472	0.22	1.672	40.978	-1.672
0.3658	0.21	1.633	41.017	-1.633
0.3857	0.20	1.603	41.047	-1.603
0.4067	0.20	1.577	41.073	-1.577
0.4288	0.19	1.557	41.093	-1.557
0.4523	0.19	1.537	41.113	-1.537
0.4772	0.18	1.518	41.132	-1.518
0.5035	0.18	1.508	41.142	-1.508
0.5315	0.17	1.478	41.172	-1.478
0.5612	0.16	1.457	41.193	-1.457
0.5925	0.16	1.437	41.213	-1.437
0.6257	0.15	1.414	41.236	-1.414
0.6608	0.14	1.392	41.258	-1.392
0.6982	0.14	1.372	41.278	-1.372
0.7377	0.13	1.349	41.301	-1.349
0.7795	0.12	1.329	41.321	-1.329
0.8238	0.12	1.304	41.346	-1.304
0.8708	0.11	1.28	41.37	-1.28
0.9207	0.10	1.257	41.393	-1.257
0.9733	0.09	1.233	41.417	-1.233
1.0292	0.08	1.208	41.442	-1.208
1.0883	0.07	1.182	41.468	-1.182
1.151	0.06	1.155	41.495	-1.155
1.2173	0.05	1.128	41.522	-1.128
1.2877	0.04	1.101	41.549	-1.101
1.3622	0.03	1.073	41.577	-1.073
1.4412	0.02	1.043	41.607	-1.043
1.5248	0.01	1.013	41.637	-1.013
1.6133	-0.01	0.984	41.666	-0.984
1.7072	-0.02	0.953	41.697	-0.953
1.8065	-0.04	0.921	41.729	-0.921
1.9118	-0.05	0.89	41.76	-0.89
2.0233	-0.07	0.858	41.792	-0.858
2.1415	-0.08	0.827	41.823	-0.827
2.2667	-0.10	0.792	41.858	-0.792
2.3992	-0.12	0.761	41.889	-0.761
2.5397	-0.14	0.728	41.922	-0.728
2.6885	-0.16	0.695	41.955	-0.695
2.846	-0.18	0.659	41.991	-0.659
3.0128	-0.20	0.626	42.024	-0.626
3.1897	-0.23	0.593	42.057	-0.593
3.377	-0.25	0.56	42.09	-0.56
3.5753	-0.28	0.527	42.123	-0.527
3.7855	-0.31	0.495	42.155	-0.495
4.0082	-0.33	0.463	42.187	-0.463
4.244	-0.36	0.433	42.217	-0.433
4.4938	-0.39	0.403	42.247	-0.403
4.7585	-0.43	0.374	42.276	-0.374
5.0388	-0.46	0.347	42.303	-0.347
5.3357	-0.49	0.32	42.33	-0.32
5.6502	-0.53	0.294	42.356	-0.294
5.9833	-0.57	0.271	42.379	-0.271
6.3362	-0.61	0.247	42.403	-0.247
6.71	-0.64	0.227	42.423	-0.227
7.106	-0.69	0.205	42.445	-0.205
7.5253	-0.73	0.185	42.465	-0.185
7.9697	-0.77	0.168	42.482	-0.168
8.4403	-0.82	0.151	42.499	-0.151
8.9388	-0.88	0.133	42.517	-0.133
9.4668	-0.92	0.119	42.531	-0.119
10.0262	-0.97	0.106	42.544	-0.106

not valid, H2O below top of Screen

overestimates K



CHK'D: BWJ 12/20/02

Slug-out

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name: North Anna ESP **MACTEC Job Number:** 30720-2-5400

Date: 12/12/02 **Time:** 1425 1345 **Observation Well No.:** OW-848

Weather Conditions:

Method of Slug Withdrawl (circle one): water, mechanical, or pressure **Test Method:** Rising Head or Falling Head (circle)

Diameter of Screen: 2 in. **Diameter of Casing:** 2 in.

Total Well Depth: 58.7 ft below reference point **Reference Point:** Permanent mark on top of casing

Length of Screened Section: 5.0 ft **Depth interval of screened portion:** ft

Depth to Groundwater: 42.65 ft below reference point

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
42.79	12/10/02
43.02	12/ /02

Comments/Remarks

Transducer SN →
Recorder SN →

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well: OW-848
Test Date: 12/13/2002
Test Type: Recovery (slug out)

Conducted by: Grimes and Howe
Entered/date: 12/15/02
Checked/date: BNHmes 12/20/02

WELL DATA

SWL =	42.65	(ft BTOC)
WD =	48.87	(ft BTOC)
WD =	47.37	(ft BGS)
DTSP =	39.10	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.19	(ft)
Le =	5.02	(ft)
Lw =	6.22	(ft)
Le/rw =	15.21	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.229 (ft) from plot
yt =	0.785 (ft) from plot
t =	1.426 (minutes) from plot
ln(Re/rw) =	1.67
K =	**2.8E+00 (ft/day)**
K =	**9.9E-04 (cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(A+Bln((H-Lw)/rw))/(Le/rw)]^-1= 1.67

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw)))+(C/(Le/rw))]^-1 = 2.13

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
15	2.1	0.27	1.5
25	2.4	0.31	1.9

Interpolated values of A, B and C for Le/rw

15.21	2.11	0.27	1.51

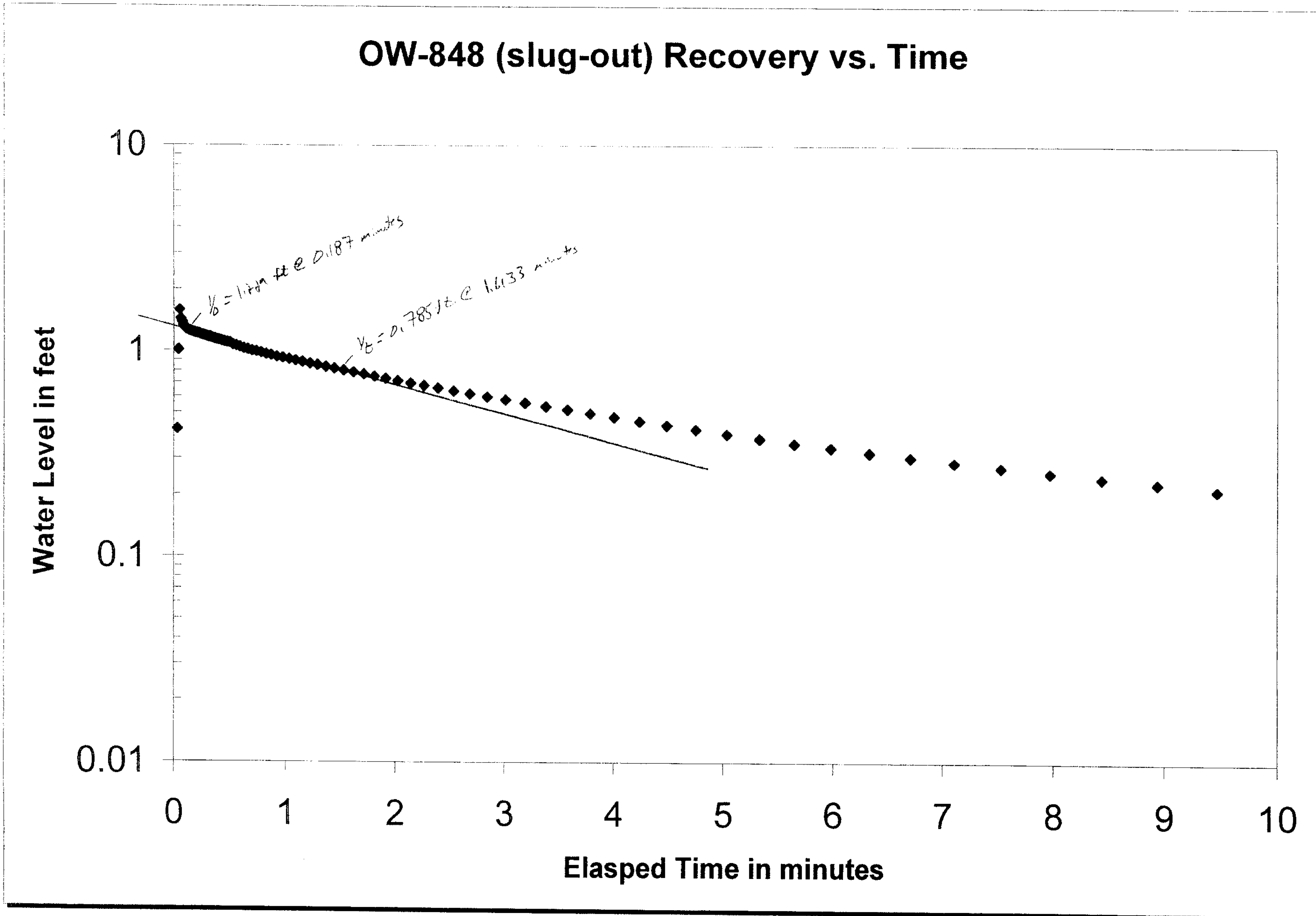
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	42.65	0
0.011	-3.00	0.001	42.651	0.001
0.022	-2.52	0.003	42.653	0.003
0.033	-0.38	0.415	43.065	0.415
0.044	0.00	1.01	43.66	1.01
0.055	0.20	1.582	44.232	1.582
0.066	0.16	1.433	44.083	1.433
0.077	0.14	1.38	44.03	1.38
0.088	0.12	1.33	43.98	1.33
0.099	0.11	1.3	43.95	1.3
0.11	0.11	1.28	43.93	1.28
0.121	0.10	1.268	43.918	1.268
0.132	0.10	1.258	43.908	1.258
0.143	0.10	1.254	43.904	1.254
0.154	0.10	1.245	43.895	1.245
0.165	0.09	1.239	43.889	1.239
0.176	0.09	1.232	43.882	1.232
0.187	0.09	1.229	43.879	1.229
0.198	0.09	1.221	43.871	1.221
0.209	0.09	1.219	43.869	1.219
0.22	0.08	1.212	43.862	1.212
0.231	0.08	1.209	43.859	1.209
0.2427	0.08	1.201	43.851	1.201
0.2552	0.08	1.194	43.844	1.194
0.2683	0.08	1.189	43.839	1.189
0.2823	0.07	1.182	43.832	1.182
0.2972	0.07	1.176	43.826	1.176
0.3128	0.07	1.168	43.818	1.168
0.3295	0.07	1.165	43.815	1.165
0.3472	0.06	1.155	43.805	1.155
0.3658	0.06	1.145	43.795	1.145
0.3857	0.06	1.136	43.786	1.136
0.4067	0.05	1.129	43.779	1.129
0.4288	0.05	1.118	43.768	1.118
0.4523	0.05	1.11	43.76	1.11
0.4772	0.04	1.1	43.75	1.1
0.5035	0.04	1.096	43.746	1.096
0.5315	0.03	1.07	43.72	1.07
0.5612	0.02	1.057	43.707	1.057
0.5925	0.02	1.043	43.693	1.043
0.6257	0.01	1.029	43.679	1.029
0.6608	0.01	1.017	43.667	1.017
0.6982	0.00	1.001	43.651	1.001
0.7377	0.00	0.993	43.643	0.993
0.7795	-0.01	0.98	43.63	0.98
0.8238	-0.02	0.963	43.613	0.963
0.8708	-0.02	0.951	43.601	0.951
0.9207	-0.03	0.935	43.585	0.935
0.9733	-0.03	0.924	43.574	0.924
1.0292	-0.04	0.911	43.561	0.911
1.0883	-0.05	0.895	43.545	0.895
1.151	-0.06	0.881	43.531	0.881
1.2173	-0.06	0.865	43.515	0.865
1.2877	-0.07	0.851	43.501	0.851
1.3622	-0.08	0.835	43.485	0.835
1.4412	-0.09	0.819	43.469	0.819
1.5248	-0.10	0.802	43.452	0.802
1.6133	-0.11	0.785	43.435	0.785
1.7072	-0.11	0.769	43.419	0.769
1.8065	-0.12	0.75	43.4	0.75
1.9118	-0.13	0.733	43.383	0.733
2.0233	-0.15	0.714	43.364	0.714
2.1415	-0.16	0.696	43.346	0.696
2.2667	-0.17	0.677	43.327	0.677
2.3992	-0.18	0.659	43.309	0.659
2.5397	-0.20	0.637	43.287	0.637
2.6885	-0.21	0.618	43.268	0.618
2.846	-0.22	0.597	43.247	0.597
3.0128	-0.24	0.578	43.228	0.578
3.1897	-0.25	0.557	43.207	0.557
3.377	-0.27	0.535	43.185	0.535
3.5753	-0.29	0.516	43.166	0.516
3.7855	-0.31	0.495	43.145	0.495
4.0082	-0.32	0.475	43.125	0.475
4.244	-0.34	0.453	43.103	0.453
4.4938	-0.36	0.433	43.083	0.433
4.7585	-0.38	0.413	43.063	0.413
5.0388	-0.41	0.393	43.043	0.393
5.3357	-0.43	0.374	43.024	0.374
5.6502	-0.45	0.354	43.004	0.354
5.9833	-0.47	0.337	42.987	0.337
6.3362	-0.50	0.319	42.969	0.319
6.71	-0.52	0.303	42.953	0.303
7.106	-0.54	0.286	42.936	0.286
7.5253	-0.57	0.27	42.92	0.27
7.9697	-0.59	0.255	42.905	0.255
8.4403	-0.62	0.24	42.89	0.24
8.9388	-0.64	0.227	42.877	0.227
9.4668	-0.68	0.211	42.861	0.211



CHK'D: BWH 12/20/02

Slug - In

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name: North Anna ESP		MACTEC Job Number: 30720-2-5400	
Date: 12/13/02	Time: 0915	Observation Well No.: OW-849	
Weather Conditions: cloudy mid upper 30's			
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	Test Method:	Rising Head or Falling Head (circle)
Diameter of Screen: 2 in.		Diameter of Casing: 2 in.	
Total Well Depth: 57.36 ft below reference point		Reference Point:	Permanent mark on top of casing
Length of Screened Section: 9.7 ft		Depth interval of screened portion: 37.6-47.3ft	
Depth to Groundwater: 33.13 ft below reference point			

Depth to Groundwater	Date
33.15	12/12/02

Groundwater Measurements Collected Prior to Slug Test

Comments/Remarks

Used Slug # 2 → volume = 0.08 ft³

Transducer SN → 6407

Hermit SN → 45449

Set Transducer @ 45' below TOC

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-849	Conducted by:	Grimes and Howe
Test Date:	12/13/2002	Entered/date:	12/15/02
Test Type:	Recovery (slug in)	Checked/date:	BWJones 12/20/02

WELL DATA

SWL =	33.13	(ft BTOC)
WD =	51.30	(ft BTOC)
WD =	49.80	(ft BGS)
DTSP =	35.60	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	18.17	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	1.493	(ft) from plot
yt =	0.542	(ft) from plot
t =	0.588	(minutes) from plot
ln(Re/rw) =	2.44	

K = 2.0E+00 (ft/day)

K = 7.0E-04 (cm/sec)

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.44

Where: Lw = H;

ln(Re/rw) = [(1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 2.94

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

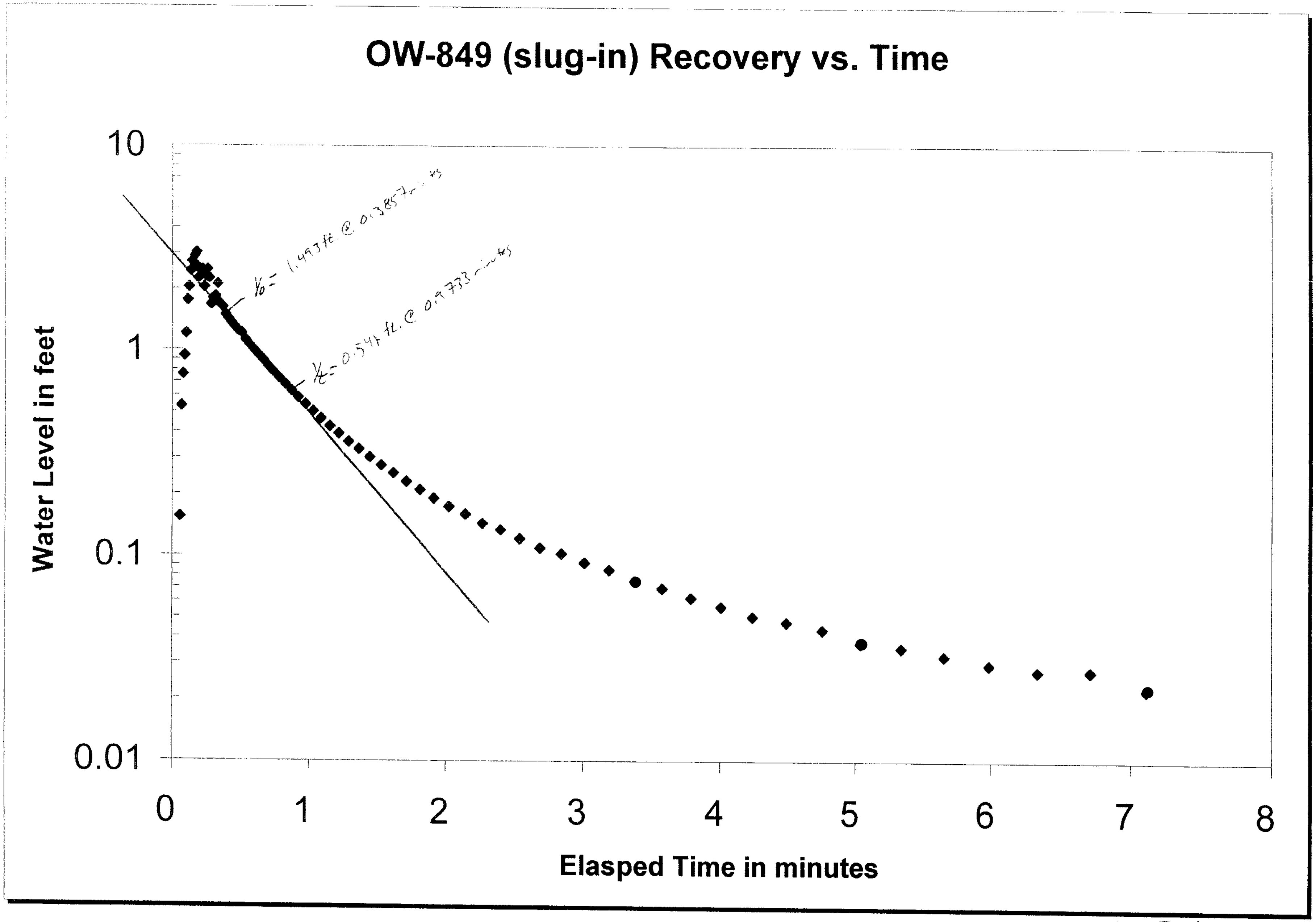
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	33.13	0
0.011	-3.00	0.001	33.129	0.001
0.022	#NUM!	0	33.13	0
0.033	-3.00	0.001	33.129	0.001
0.044	-2.52	0.003	33.127	0.003
0.055	-0.81	0.155	32.975	-0.155
0.066	-0.27	0.533	32.597	-0.533
0.077	-0.12	0.759	32.371	-0.759
0.088	-0.03	0.935	32.195	-0.935
0.099	0.08	1.205	31.925	-1.205
0.11	0.24	1.757	31.373	-1.757
0.121	0.31	2.039	31.091	-2.039
0.132	0.39	2.449	30.681	-2.449
0.143	0.43	2.72	30.41	-2.72
0.154	0.40	2.517	30.613	-2.517
0.165	0.46	2.903	30.227	-2.903
0.176	0.48	3.028	30.102	-3.028
0.187	0.41	2.546	30.584	-2.546
0.198	0.36	2.281	30.849	-2.281
0.209	0.39	2.436	30.694	-2.436
0.22	0.39	2.483	30.647	-2.483
0.231	0.31	2.042	31.088	-2.042
0.2427	0.36	2.307	30.823	-2.307
0.2552	0.40	2.49	30.64	-2.49
0.2683	0.35	2.249	30.881	-2.249
0.2823	0.22	1.674	31.456	-1.674
0.2972	0.25	1.798	31.332	-1.798
0.3128	0.26	1.837	31.293	-1.837
0.3295	0.32	2.113	31.017	-2.113
0.3472	0.22	1.674	31.456	-1.674
0.3658	0.21	1.628	31.502	-1.628
0.3857	0.17	1.493	31.637	-1.493
0.4067	0.15	1.425	31.705	-1.425
0.4288	0.14	1.365	31.765	-1.365
0.4523	0.12	1.304	31.826	-1.304
0.4772	0.10	1.245	31.885	-1.245
0.5035	0.08	1.214	31.916	-1.214
0.5315	0.05	1.12	32.01	-1.12
0.5612	0.03	1.06	32.07	-1.06
0.5925	0.00	1.002	32.128	-1.002
0.6257	-0.02	0.945	32.185	-0.945
0.6608	-0.05	0.892	32.238	-0.892
0.6982	-0.08	0.833	32.297	-0.833
0.7377	-0.11	0.779	32.351	-0.779
0.7795	-0.14	0.729	32.401	-0.729
0.8238	-0.17	0.679	32.451	-0.679
0.8708	-0.20	0.631	32.499	-0.631
0.9207	-0.23	0.585	32.545	-0.585
0.9733	-0.27	0.542	32.588	-0.542
1.0292	-0.30	0.502	32.628	-0.502
1.0883	-0.33	0.464	32.666	-0.464
1.151	-0.37	0.426	32.704	-0.426
1.2173	-0.41	0.393	32.737	-0.393
1.2877	-0.44	0.359	32.771	-0.359
1.3622	-0.48	0.331	32.799	-0.331
1.4412	-0.52	0.303	32.827	-0.303
1.5248	-0.56	0.276	32.854	-0.276
1.6133	-0.60	0.253	32.877	-0.253
1.7072	-0.64	0.23	32.9	-0.23
1.8065	-0.68	0.21	32.92	-0.21
1.9118	-0.72	0.191	32.939	-0.191
2.0233	-0.76	0.174	32.956	-0.174
2.1415	-0.80	0.16	32.97	-0.16
2.2667	-0.84	0.144	32.986	-0.144
2.3992	-0.87	0.134	32.996	-0.134
2.5397	-0.92	0.121	33.009	-0.121
2.6885	-0.96	0.109	33.021	-0.109
2.846	-0.99	0.102	33.028	-0.102
3.0128	-1.04	0.092	33.038	-0.092
3.1897	-1.07	0.085	33.045	-0.085
3.377	-1.12	0.075	33.055	-0.075
3.5753	-1.16	0.069	33.061	-0.069
3.7855	-1.21	0.062	33.068	-0.062
4.0082	-1.25	0.056	33.074	-0.056
4.244	-1.30	0.05	33.08	-0.05
4.4938	-1.33	0.047	33.083	-0.047
4.7585	-1.37	0.043	33.087	-0.043
5.0388	-1.43	0.037	33.093	-0.037
5.3357	-1.46	0.035	33.095	-0.035
5.6502	-1.49	0.032	33.098	-0.032
5.9833	-1.54	0.029	33.101	-0.029
6.3362	-1.57	0.027	33.103	-0.027
6.71	-1.57	0.027	33.103	-0.027
7.106	-1.66	0.022	33.108	-0.022



CHKD: BWJ 12/20/02

Slug test

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/13/02	**Time:** 09:35	**Observation Well No.:**	OW 549
Weather Conditions:	Cloudy in upper 30's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	51.30 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	37.6 - 47.3 ft
Depth to Groundwater:	33.13 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
33.15	12/11/02

Comments/Remarks

Used Slug #2 → volume = 0.05ft³

Transducer S/N → 6107

Logger S/N = 45449

Set transducer @ 45 ft bel. TOC

Did additional slug out test on 12/13/02 Start @ 1546. Used Slug #2 = volume = 0.05ft³

Transducer S/N → 6107

Logger S/N → 45449

Depth to water 33.06

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-849
Test Date:	12/13/2002
Test Type:	Recovery (slug out)

Conducted by:	Grimes and Howe
Entered/date:	12/15/02
Checked/date:	12/20/02

WELL DATA

SWL =	33.06	(ft BTOC)
WD =	51.30	(ft BTOC)
WD =	49.80	(ft BGS)
DTSP =	35.60	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	18.24	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.895 (ft) from plot
yt =	1.695 (ft) from plot
t =	0.194 (minutes) from plot
ln(Re/rw) =	2.44
K =	**3.2E+00 (ft/day)**
K =	**1.1E-03 (cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;	
ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1=	2.44
Where: Lw = H;	
ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 =	2.94

Calculation of Coefficients
Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

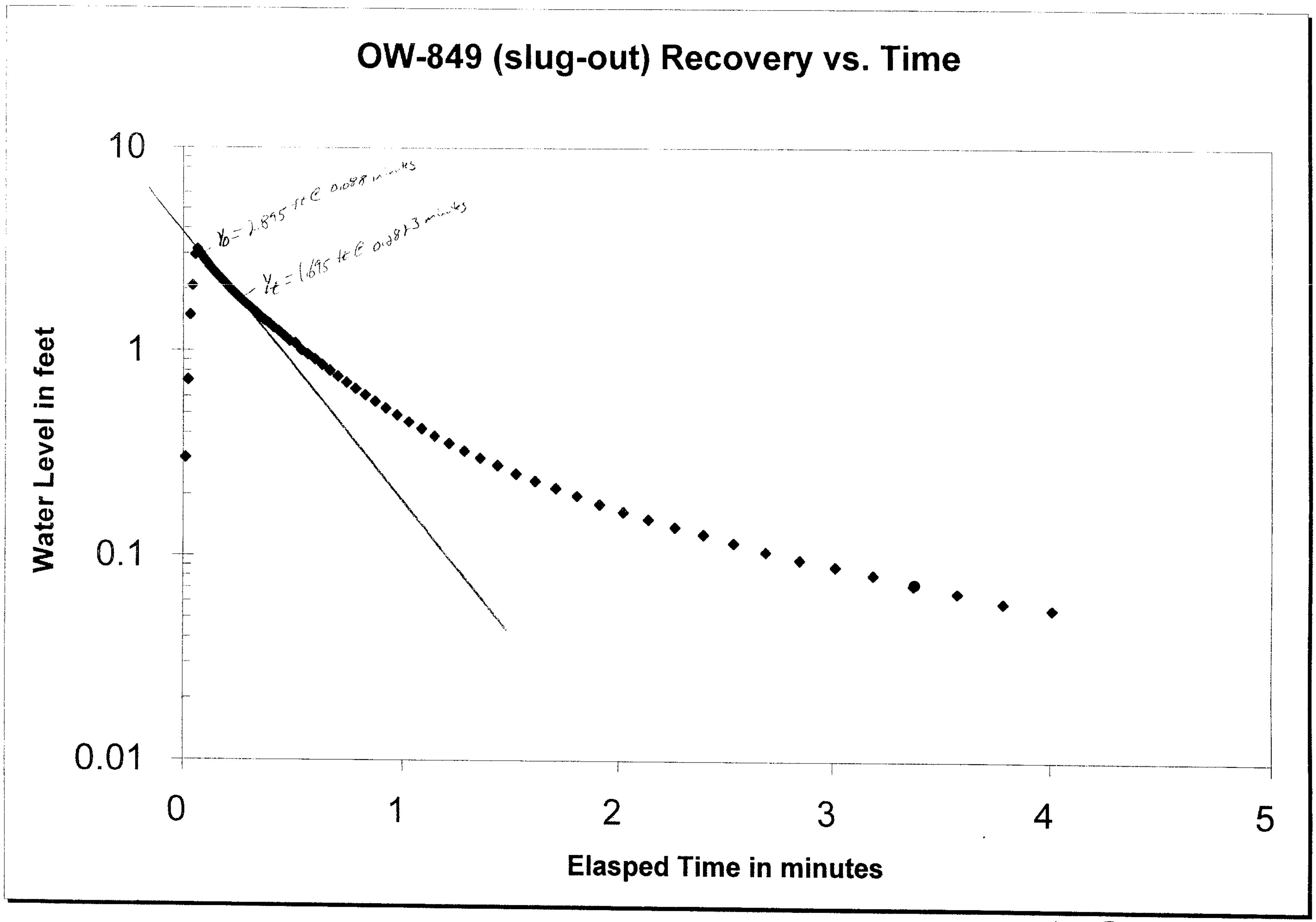
Coefficients Table

Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0	33.06	0
0.011	-0.52	0.303	33.363	0.303
0.022	-0.14	0.722	33.782	0.722
0.033	0.17	1.491	34.551	1.491
0.044	0.32	2.08	35.14	2.08
0.055	0.47	2.964	36.024	2.964
0.066	0.50	3.153	36.213	3.153
0.077	0.48	3.015	36.075	3.015
0.088	0.46	2.895	35.955	2.895
0.099	0.44	2.784	35.844	2.784
0.11	0.43	2.692	35.752	2.692
0.121	0.41	2.59	35.65	2.59
0.132	0.40	2.512	35.572	2.512
0.143	0.39	2.429	35.489	2.429
0.154	0.37	2.354	35.414	2.354
0.165	0.36	2.283	35.343	2.283
0.176	0.35	2.218	35.278	2.218
0.187	0.33	2.15	35.21	2.15
0.198	0.32	2.083	35.143	2.083
0.209	0.31	2.027	35.087	2.027
0.22	0.29	1.968	35.028	1.968
0.231	0.28	1.916	34.976	1.916
0.2427	0.27	1.862	34.922	1.862
0.2552	0.26	1.804	34.864	1.804
0.2683	0.24	1.749	34.809	1.749
0.2823	0.23	1.695	34.755	1.695
0.2972	0.22	1.643	34.703	1.643
0.3128	0.20	1.583	34.643	1.583
0.3295	0.18	1.525	34.585	1.525
0.3472	0.17	1.466	34.526	1.466
0.3658	0.15	1.412	34.472	1.412
0.3857	0.13	1.359	34.419	1.359
0.4067	0.11	1.298	34.358	1.298
0.4288	0.10	1.245	34.305	1.245
0.4523	0.07	1.182	34.242	1.182
0.4772	0.05	1.118	34.178	1.118
0.5035	0.04	1.09	34.15	1.09
0.5315	0.00	1.006	34.066	1.006
0.5612	-0.02	0.96	34.02	0.96
0.5925	-0.04	0.907	33.967	0.907
0.6257	-0.07	0.854	33.914	0.854
0.6608	-0.10	0.801	33.861	0.801
0.6982	-0.12	0.752	33.812	0.752
0.7377	-0.15	0.702	33.762	0.702
0.7795	-0.18	0.656	33.716	0.656
0.8238	-0.21	0.611	33.671	0.611
0.8708	-0.24	0.569	33.629	0.569
0.9207	-0.28	0.529	33.589	0.529
0.9733	-0.31	0.489	33.549	0.489
1.0292	-0.34	0.453	33.513	0.453
1.0883	-0.38	0.42	33.48	0.42
1.151	-0.41	0.387	33.447	0.387
1.2173	-0.45	0.357	33.417	0.357
1.2877	-0.48	0.328	33.388	0.328
1.3622	-0.52	0.303	33.363	0.303
1.4412	-0.55	0.279	33.339	0.279
1.5248	-0.60	0.254	33.314	0.254
1.6133	-0.63	0.234	33.294	0.234
1.7072	-0.67	0.216	33.276	0.216
1.8065	-0.70	0.198	33.258	0.198
1.9118	-0.74	0.18	33.24	0.18
2.0233	-0.78	0.165	33.225	0.165
2.1415	-0.82	0.152	33.212	0.152
2.2667	-0.86	0.139	33.199	0.139
2.3992	-0.89	0.128	33.188	0.128
2.5397	-0.94	0.116	33.176	0.116
2.6885	-0.98	0.105	33.165	0.105
2.846	-1.02	0.096	33.156	0.096
3.0128	-1.05	0.089	33.149	0.089
3.1897	-1.09	0.081	33.141	0.081
3.377	-1.14	0.072	33.132	0.072
3.5753	-1.18	0.066	33.126	0.066
3.7855	-1.23	0.059	33.119	0.059
4.0082	-1.26	0.055	33.115	0.055



CHK'D: BWJ 12/20/02

LAW
RESOURCES CREATING SOLUTIONS
LAW Engineering and Environmental Services, Inc.
5710 Oleander Drive
Suite 110
Wilmington, NC 28403

JOB NO. 30770-2-5400 SHEET 1 OF 2
PHASE ______ TASK ______
JOB NAME North Anna ESP Project
BY BWL DATE 12/18/02
CHECKED BY [signature] DATE 12/20/02

SPREADSHEET VERIFICATION

WELL: OW-841 (SLUG OUT)
TEST DATE: 12/13/02
TEST TYPE: RECOVERY (SLUG OUT)

CONDUCTED BY: GRIMES & HOWE
ENTERED/DATE: 12/15/02

DATA COLLECTED USING HERMIT 3000

HAND CALC'S TO VERIFY SPREAD SHEET FORMULAS

SPREAD SHEET USES BOUWER & RICE METHOD

Le/rw VALUES FOR A, B & C OBTAINED FROM SPREAD SHEET CALC'S

WELL DATA

SWL = 2.45' (BTOC)
WD = 35.80' (BTOC)
WD = 34.30' (BGS)
DTSP = 20.10' (BGS)
rc = 0.08' (2" WELL)
N = 0.30

RW = 0.33' (RADIUS OF 8" BOREHOLE)
RC (ADJ) = 0.08'

$$(1)\quad K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e}\left(\frac{1}{t}\right)\left(\ln\frac{Y_0}{Y_t}\right)$$

$\ln(R_e/r_w) = 2.70$ (FROM SPREADSHEET)
CALCS NEXT PAGE

Le = 9.7' (LENG. OF WELL)
Lw = 33.35' (WD SWL)
Le/rw = 29.39'
H = 50' (EST. AQUIFER THICKNESS)
t = 0.7377 − 0.198 (MINUTES) = 0.5397 (FROM COMPUTER GRAPH)

$$K = \left(\frac{0.0064\,ft^2 \times 2.7}{19.4'}\right)\frac{1}{0.54\,m}\left(\ln\frac{2.18}{0.829}\right) \leftarrow 0.96686$$

Yo = 2.18
Yt = 0.829
FROM COMPUTER GRAPH/ BEST FIT LINE

$$K = \frac{0.00089\,ft}{32.4\ sec}(0.96686)$$

$K = 2.66 \times 10^{-5}$ ft/sec ×30.48 cm/ft — 2.66×10^{-5} ft/s ✓

K = 2.29 ft/d — 2.29 ft/d ✓

K = 8.2E-04 cm/sec ✓ — 8.2×10^{-4} cm/s ✓

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Suite 110
Wilmington, NC 28403

JOB NO. 30770-2-5400 SHEET 2 OF 2
PHASE ______ TASK ______
JOB NAME NORTH ANNA ESP PROJECT
BY BWJ DATE 12/18/02
CHECKED BY [signature] DATE 12/20/02

SPREADSHEET VERIFICATION CON'T

WELL: OW-841 (SLUGOUT)

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(L_e/r_w)} + \frac{A + B\ \ln[(H-L_w) \div r_w]}{L_e/r_w}\right]^{-1}$$

COMPUTER
A = 2.49
B = 0.35

$$= \left[\frac{1.1}{3.38} + \frac{(2.49 + (0.35 \times 3.912))}{29.39}\right]^{-1}$$

$$= [0.3254 + 0.1314]^{-1}$$

$$= 0.457^{-1}$$

$$= 2.189 \text{ or } 2.2$$

COMPUTER $\ln(R_e/r_w) = 2.7$

DIFFERENCE IN CALC'S & COMPUTER

HAND GENERATED GRAPH

$Y_0 = 2.16' \ /\ 0.209$ (t)
$Y_t = 0.552' \ /\ 1.0292$

0.82 MIN = 49.2 sec

BOUWER & RICE CURVES (BY HAND)

A = 2.49
B = 0.45

$$\ln(R_e/r_w) = \left[\frac{1.1}{3.38} + \frac{(2.49 + (0.45 \times 3.912))}{29.39}\right]^{-1} = 0.47^{-1} = 2.128$$

2.127 ✓

$$K = \left(\frac{0.0064\ ft^2 \times 2.128}{19.4'}\right)\left(\frac{1}{49.2\ sec}\right) \ln\left(\frac{2.16}{0.552}\right)$$

$$K = (0.00070202')(0.02033/sec)(1.36431)$$

= 0.000019467 ft/sec

0.00001947 ft/s ✓

= 1.682 ft/d

× 30.48 cm/sec

= 5.93 E-04 cm/sec

0.0006 cm/sec ✓

Slug-out

MACTEC

MACTEC Engineering and Consulting
3301 Atlantic Avenue
Raleigh, North Carolina

Slug Test Data Sheet

MACTEC Job Name:	North Anna ESP	**MACTEC Job Number:**	30720-2-5400
Date: 12/13/07	**Time:** 0835	**Observation Well No.:**	OW-841
Weather Conditions:	cloudy in upper 30's		
Method of Slug Withdrawl (circle one):	water, mechanical, or pressure	**Test Method:**	Rising Head or Falling Head (circle)
Diameter of Screen:	2 in.	**Diameter of Casing:**	2 in.
Total Well Depth:	35.30 ft below reference point	**Reference Point:**	Permanent mark on top of casing
Length of Screened Section:	9.7 ft	**Depth interval of screened portion:**	22.0-31.70 ft
Depth to Groundwater:	2.45 ft below reference point		

Groundwater Measurements Collected Prior to Slug Test

Depth to Groundwater	Date
~~35.80~~ 2.63	12/10/07
2.89	12/09/07

Comments/Remarks

USE
Slug #2 → volume = 0.08 ft³

Transducer S/N = 6407
Mini-t S/N = 45449

Set transducer @ 20' below TOC

North Anna ESP Project
Hydraulic Conductivity (K) Calculation Worksheet
MACTEC Job Number: 30720-2-5400

Well:	OW-841	Conducted by:	Grimes and Howe
Test Date:	12/13/2002	Entered/date:	12/15/02
Test Type:	Recovery (slug out)	Checked/date:	

WELL DATA

SWL =	2.45	(ft BTOC)
WD =	35.80	(ft BTOC)
WD =	34.30	(ft BGS)
DTSP =	20.10	(ft BGS)
rc =	0.08	(ft)
n =	0.30	
rw =	0.33	(ft)
rc (adjusted) =	0.08	(ft)
Le =	9.7	(ft)
Lw =	33.35	(ft)
Le/rw =	29.39	
H =	50.00	(ft)

CALCULATION OF K

K = [(rc^2 ln(Re/rw))/2Le]*(1/t)ln(yo/yt)

yo =	2.180	(ft) from plot
yt =	0.829	(ft) from plot
t =	0.540	(minutes) from plot
ln(Re/rw) =	2.70	
K =	**2.3E+00**	**(ft/day)**
K =	**8.2E-04**	**(cm/sec)**

Calculation of ln(Re/rw)

Where: Lw < H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{A+Bln((H-Lw)/rw)}/(Le/rw)]^-1= 2.70

Where: Lw = H;

ln(Re/rw) = [{1.1/(ln(Lw/rw))}+{C/(Le/rw)}]^-1 = 3.23

Calculation of Coefficients

Value range for Le/rw from Table of Coefficients

Le/rw	A	B	C
25	2.4	0.31	1.9
30	2.5	0.35	2.1

Interpolated values of A, B and C for Le/rw

29.39	2.49	0.35	2.08

Coefficients Table

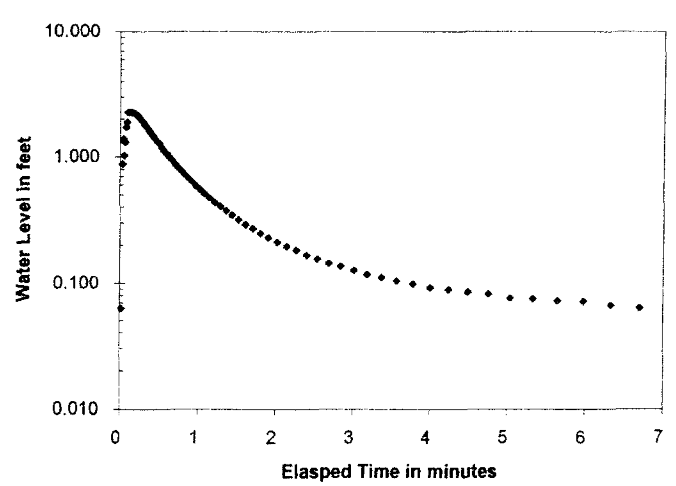
Le/rw	A	Le/rw	B	Le/rw	C
4	1.75	4	0.25	4	0.75
5	1.76	5	0.25	5	0.85
6	1.77	6	0.25	6	0.90
7	1.80	7	0.25	7	1.00
8	1.83	8	0.25	8	1.10
9	1.90	9	0.25	9	1.20
10	1.95	10	0.25	10	1.30
15	2.10	15	0.27	15	1.50
20	2.23	20	0.29	20	1.75
25	2.40	25	0.31	25	1.90
30	2.50	30	0.35	30	2.10
40	2.75	40	0.45	40	2.45
50	3.00	50	0.50	50	2.70
60	3.45	60	0.52	60	3.00
70	3.70	70	0.60	70	3.40
80	3.90	80	0.65	80	3.60
90	4.20	90	0.70	90	3.85
100	4.50	100	0.75	100	4.20
150	5.45	150	0.98	150	5.70
200	6.10	200	1.20	200	7.00
250	6.70	250	1.30	250	8.00
300	7.10	300	1.50	300	8.80
400	7.75	400	1.90	400	9.90
500	8.20	500	2.20	500	10.60
600	8.50	600	2.33	600	11.10
700	8.70	700	2.50	700	11.50
800	8.90	800	2.70	800	11.80
900	9.00	900	2.75	900	12.00
1000	9.20	1000	2.83	1000	12.40
1500	9.50	1500	3.18	1500	12.90

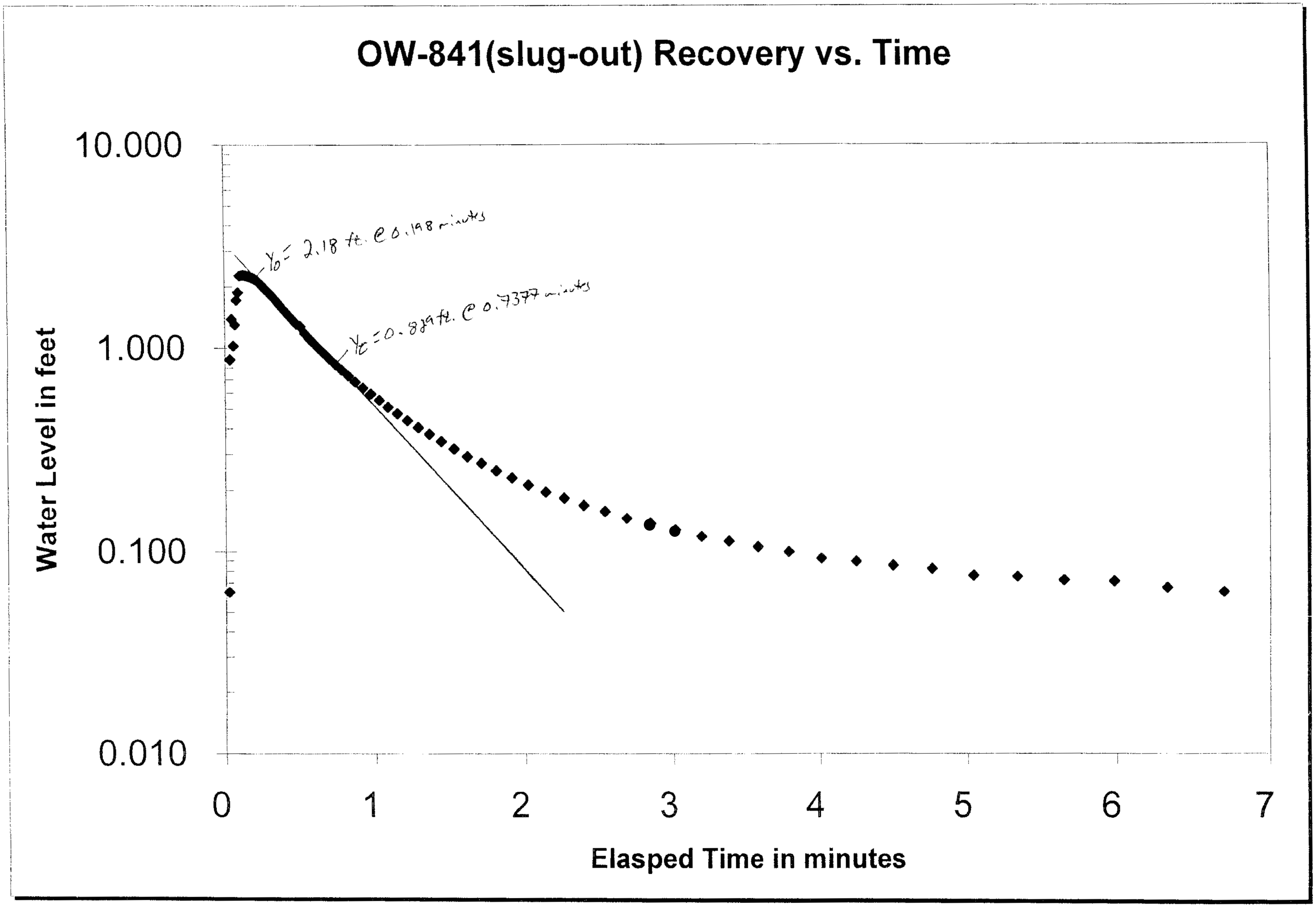
Reference: Bouwer(1989), Bouwer and Rice(1976)

TEST DATA

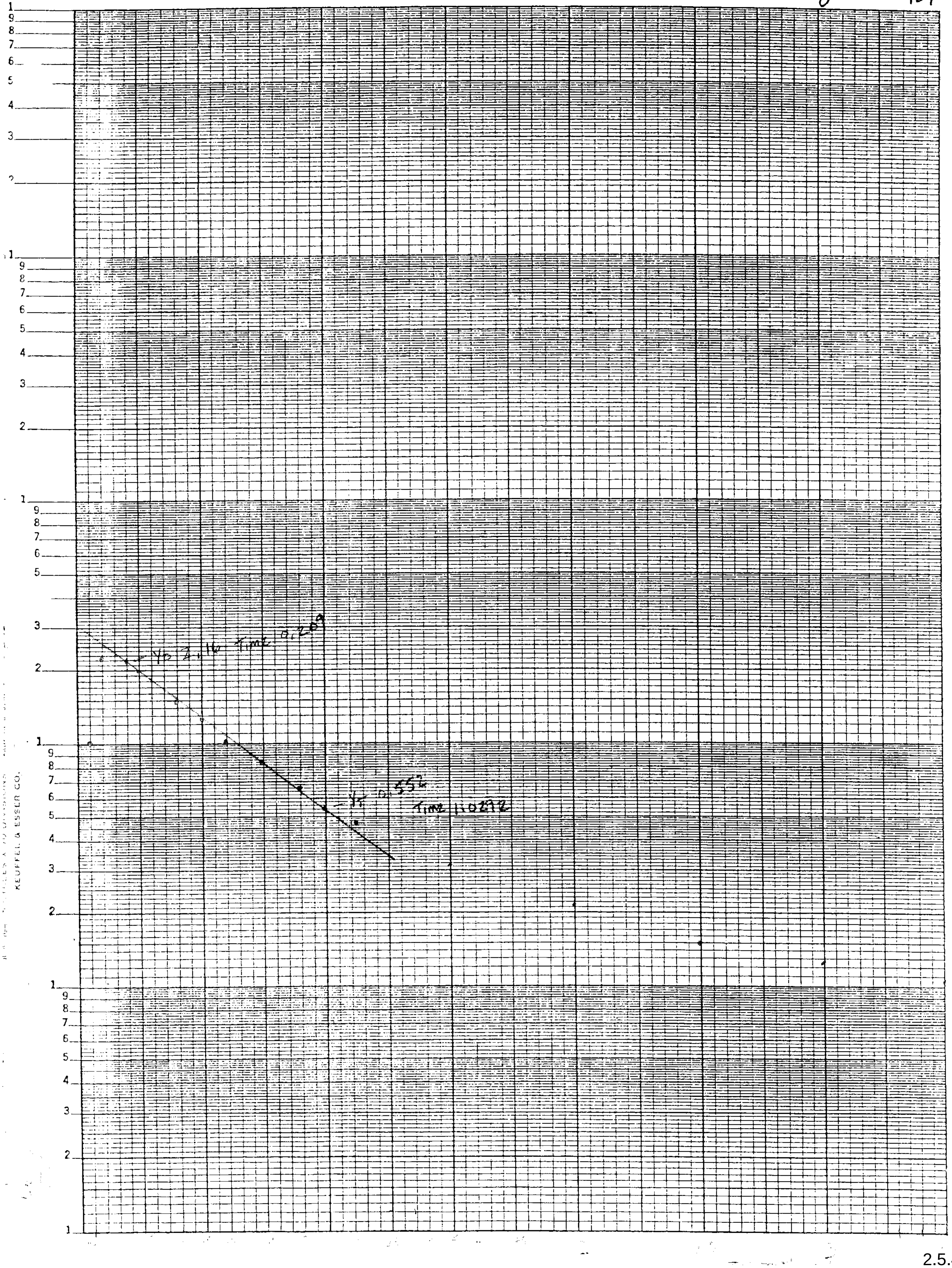
Elapsed time (min)	Log y	y (ft)	WL (ft BTOC)	Data Logger results
0	#NUM!	0.000	2.45	0
0.011	#NUM!	0.000	2.45	0
0.022	-1.20	0.063	2.513	0.063
0.033	-0.06	0.877	3.327	0.877
0.044	0.14	1.385	3.835	1.385
0.055	0.01	1.024	3.474	1.024
0.066	0.11	1.299	3.749	1.299
0.077	0.23	1.716	4.166	1.716
0.088	0.27	1.870	4.32	1.87
0.099	0.35	2.259	4.709	2.259
0.11	0.36	2.269	4.719	2.269
0.121	0.36	2.280	4.73	2.28
0.132	0.36	2.267	4.717	2.267
0.143	0.35	2.262	4.712	2.262
0.154	0.35	2.249	4.699	2.249
0.165	0.35	2.236	4.686	2.236
0.176	0.35	2.223	4.673	2.223
0.187	0.34	2.206	4.656	2.206
0.198	0.34	2.180	4.63	2.18
0.209	0.33	2.160	4.61	2.16
0.22	0.33	2.128	4.578	2.128
0.231	0.32	2.086	4.536	2.086
0.2427	0.31	2.046	4.496	2.046
0.2552	0.30	1.995	4.445	1.995
0.2683	0.29	1.949	4.399	1.949
0.2823	0.28	1.911	4.361	1.911
0.2972	0.27	1.860	4.31	1.86
0.3128	0.26	1.804	4.254	1.804
0.3295	0.24	1.746	4.196	1.746
0.3472	0.23	1.687	4.137	1.687
0.3658	0.21	1.626	4.076	1.626
0.3857	0.19	1.561	4.011	1.561
0.4067	0.18	1.500	3.95	1.5
0.4288	0.16	1.437	3.887	1.437
0.4523	0.14	1.375	3.825	1.375
0.4772	0.12	1.312	3.762	1.312
0.5035	0.11	1.281	3.731	1.281
0.5315	0.07	1.185	3.635	1.185
0.5612	0.05	1.119	3.569	1.119
0.5925	0.02	1.058	3.508	1.058
0.6257	0.00	0.998	3.448	0.998
0.6608	-0.03	0.942	3.392	0.942
0.6982	-0.05	0.884	3.334	0.884
0.7377	-0.08	0.829	3.279	0.829
0.7795	-0.11	0.780	3.23	0.78
0.8238	-0.14	0.732	3.182	0.732
0.8706	-0.17	0.681	3.131	0.681
0.9207	-0.20	0.636	3.086	0.636
0.9733	-0.23	0.593	3.043	0.593
1.0292	-0.26	0.552	3.002	0.552
1.0883	-0.29	0.511	2.961	0.511

OW-841(slug-out) Recovery vs. Time




OW-841(slug-out) Recovery vs. Time
10.000
1.000
0.100
0.010
Water Level in feet
0
1
2
3
4
5
6
7
Elasped Time in minutes
Yo = 2.18 ft. @ 0.198 minutes
Yt = 0.829 ft. @ 0.7377 minutes

checked by: SCP 12/20/02



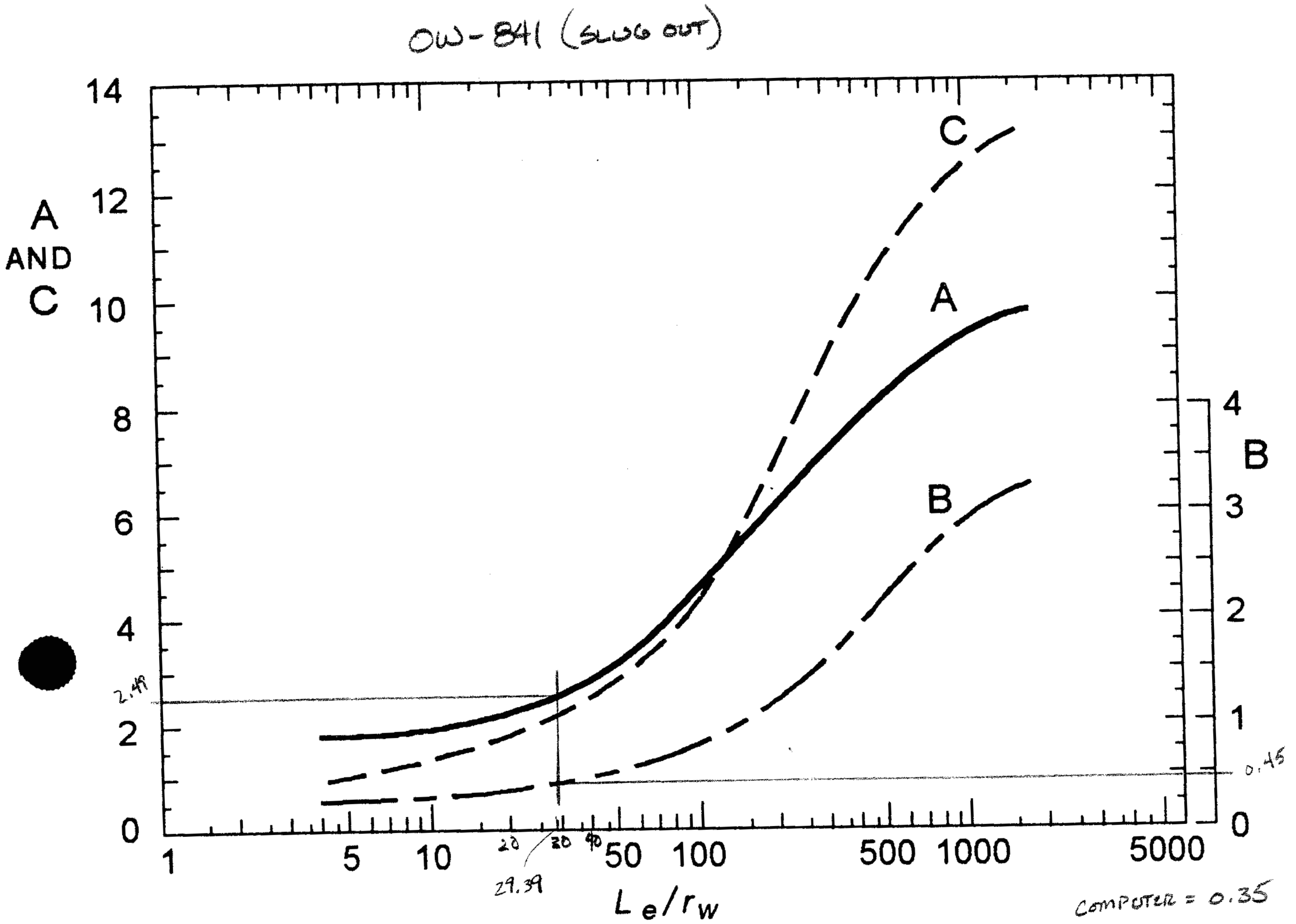


Figure 31.5 Dimensionless parameters A, B, and C as a function of L_e/r_w for calculation of $\ln(R_e/r_w)$ in the Bouwer and Rice slug test. (Bouwer, H., 1989: The Bouwer and Rice slug test. *Ground Water*, 27(3), p. 304–309. Reprinted by permission of Ground Water Publishing Company. Copyright 1989. All rights reserved.)

HYDRAULIC CONDUCTIVITY

Since time (t) and displacement (s) are the only variables in logarithmic equation), the plot of t versus s on a semi-log paper must show a straight line. However, the drawdown of the water table in the aquifer becomes more significant during iter part of the test, the basic assumption of equation (31.4) does not hold any more lata points start to deviate from the straight line.

The slope of the best-fitting straight line through field data is found as:

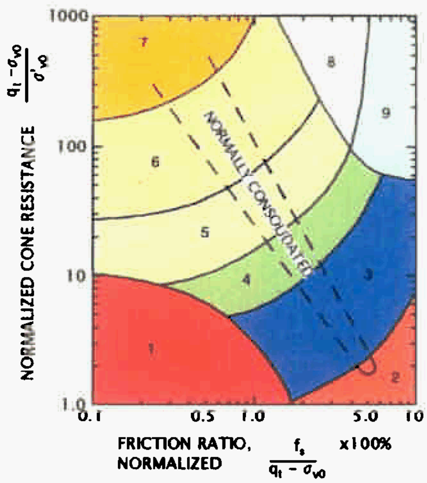
APPENDIX F
CONE PENTROMETER TEST RESULTS

CPT Soil Classification Legend

Zone		Q_t/N	Description
1		2	Sensitive, Fine Grained
2		1	Organic Soils-Peats
3		1.5	Clays-Clay to Silty Clay
4		2	Silt Mixtures-Clayey Silt to Silty Clay
5		3	Sand Mixtures-Silty Sand to Sandy Silt
6		4.5	Sands-Clean Sand to Silty Sand
7		6	Gravelly Sand to Sand
8		1	Very Stiff Sand to Clayey Sand *
9		2	Very Stiff, Fine Grained *

(*) *Heavily Overconsolidated or Cemented*

Normalized Friction Ratio Classification Chart



(Ref. Robertson, 1990)

Coefficient of Permeability (cm/s)

Zone	Description	Permeability
1	Sensitive Fines	10^{-5}
2	Organic Soils-Peats	10^{-5}
3	Clays	10^{-7}
4	Silt Mixtures	10^{-6}
5	Sand Mixtures	10^{-4}
6	Sands	10^{-2}
7	Gravelly Sands	10^{-1}
8	Very Stiff Sands	10^{-5}
9	Very Stiff Fines	10^{-6}

Applied Research Associates, Inc., South Royalton, Vermont 05068
(802) 763-8348, cpt@ara.com, http://www.ara.com

The classification profiles can be very detailed due to the high spatial resolution afforded by collecting one sample every 2 cm (0.8 in) for CPT profiles. Frequently significant variability in soil types over small changes in elevation can be observed in the profiles. To provide a simplified soil stratigraphy for comparison to standard boring logs, a layering and generalized classification system was implemented. Layer thicknesses are determined based on the variability of the SBT profile. The layer sequence begins at the ground surface and layer thicknesses are determined based upon changes in the standard deviation of the SBT number. Whenever an additional 6-inch increment deviates from the previous increment, a new layer is started, otherwise, this material is added to the layer above and the next 6-inch section is evaluated. The soil type for the layer is determined by the mean value for the complete layer.

The lithology text seen on the plots is determined according to the following conditions:

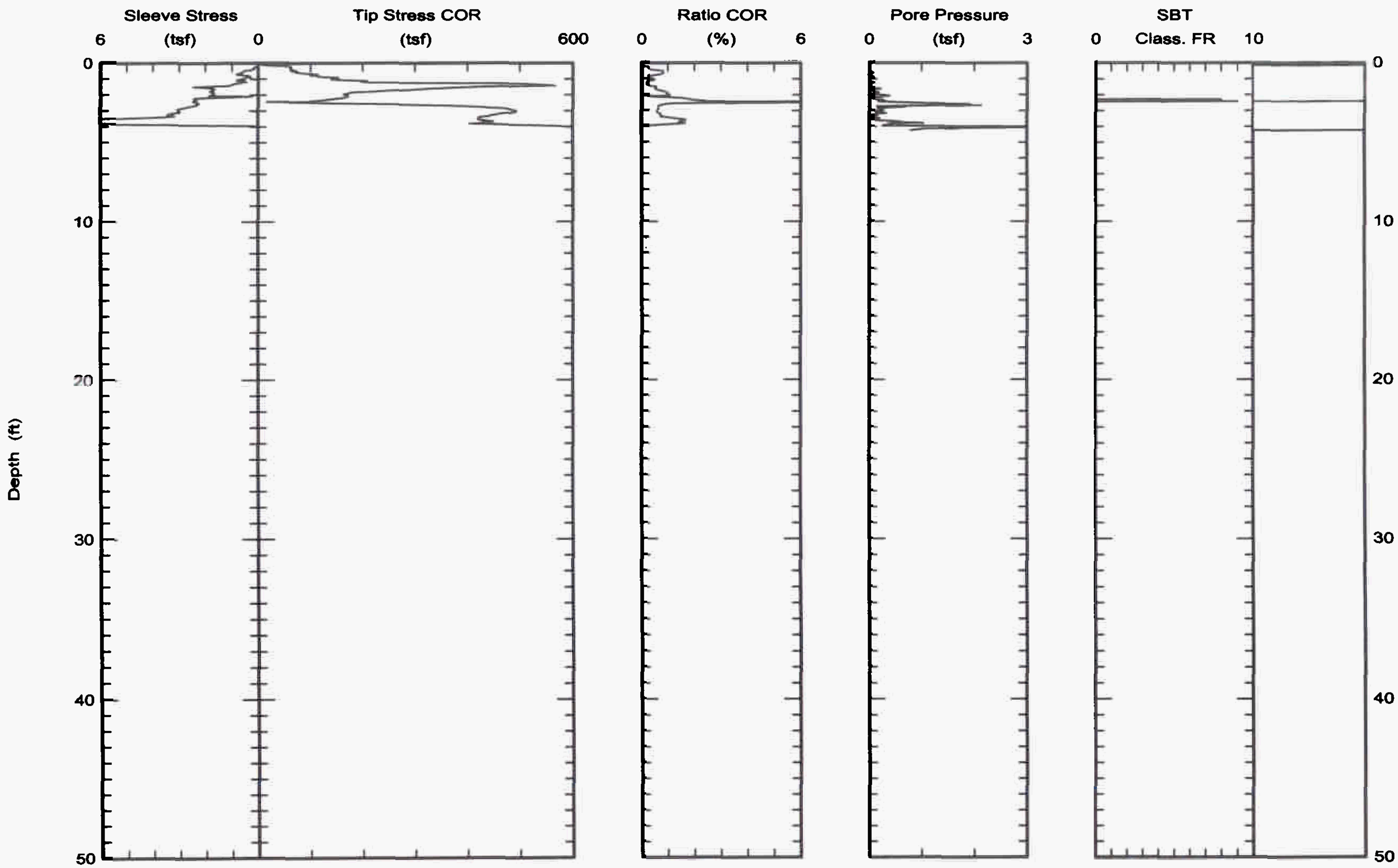
Mean Value	Abbreviation	Description
1 – 2.25	Sen Clay	Sensitive Clay
>2.25 – 2.75	Soft Clay	Soft Clay
>2.75 – 3.25	Clay	Clay
>3.25 – 3.75	Si Clay	Silty Clay
>3.75 – 4.25	Cl Silt	Clayey Silt
>4.25 – 4.75	Sa Fine Gr	Sand – Fine Grained
>4.75 – 5.75	Sand Mix	Sand Mix
>5.75 – 6.75	Sand	Sand
>6.75 – 7.5	Gr Sand	Gravelly Sand
>7.5 – 8.5	OC	Over Consolidated
>8.5 – 9	OC-Clay	Over Consolidated-Clay

Applied Research Associates
South Royalton, VT 05068
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3909965
Easting: 11686353
Elevation: 271

Date: 11/Dec/2002
Test ID: CPT-821
Project: 5737

Client: MACTEC
Site: NORTH ANNA ESP



Maximum depth: 4.25 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-821
File: 311D0201C.ECP

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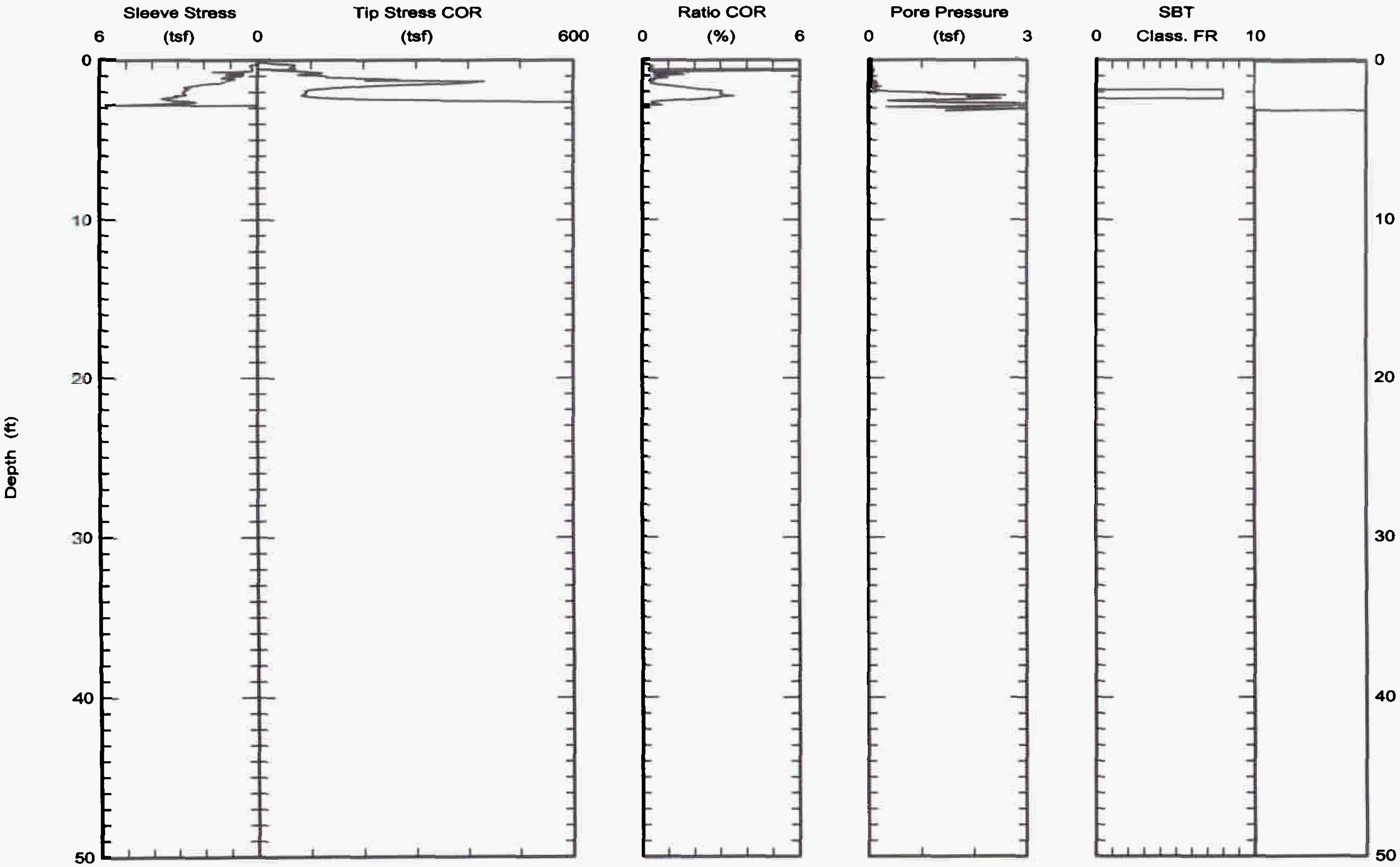
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3909957		Date: 11/Dec/2002
Easting: 11686348		Test ID: CPT-821A
Elevation: 271		Project: 5737
Client: MACTEC		
Site: NORTH ANNA ESP		

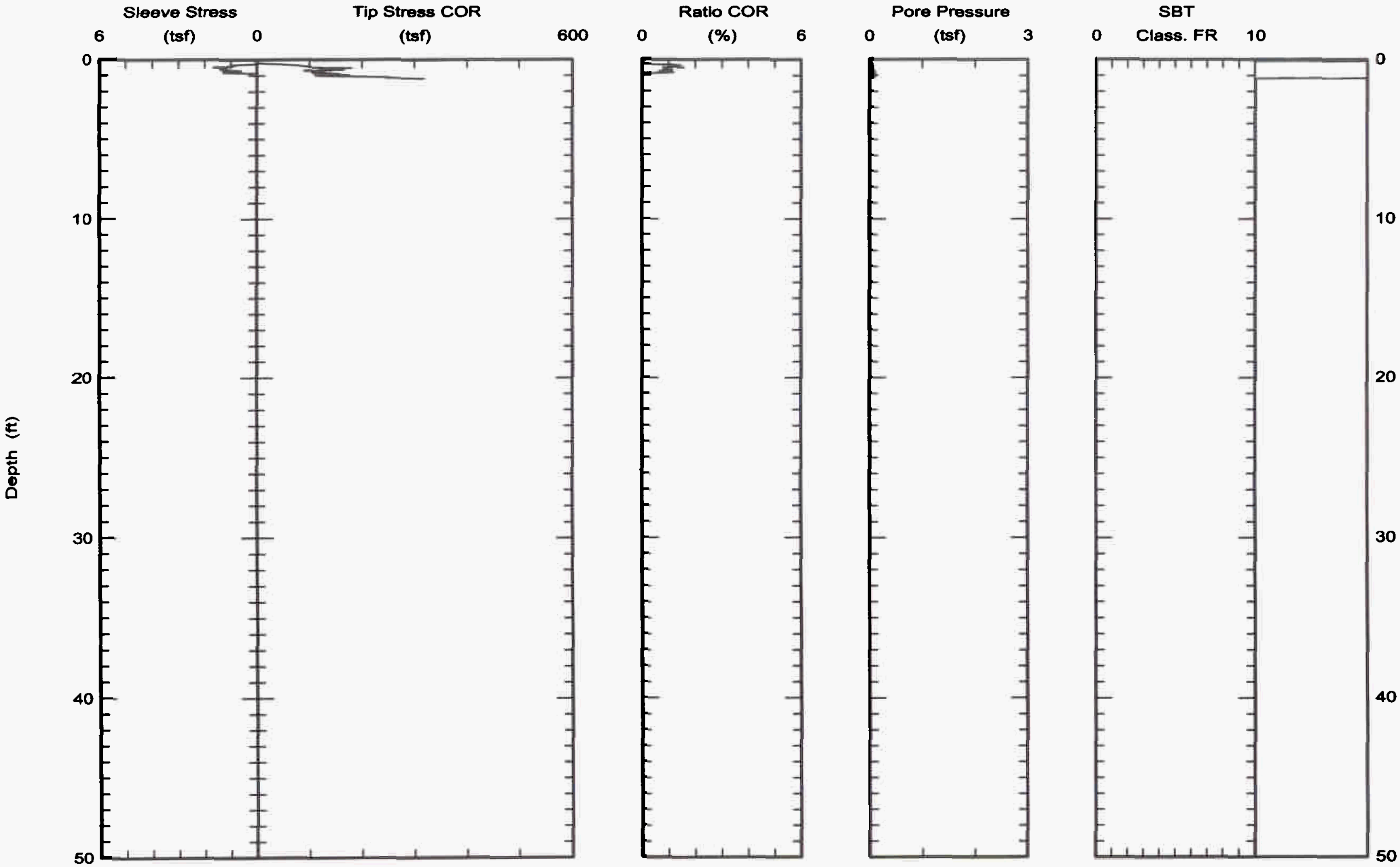


Maximum depth: 3.18 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-821A
File: 311D0202C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3909966 Easting: 11686367 Elevation: 271	Date: 11/Dec/2002 Test ID: CPT-821B Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	

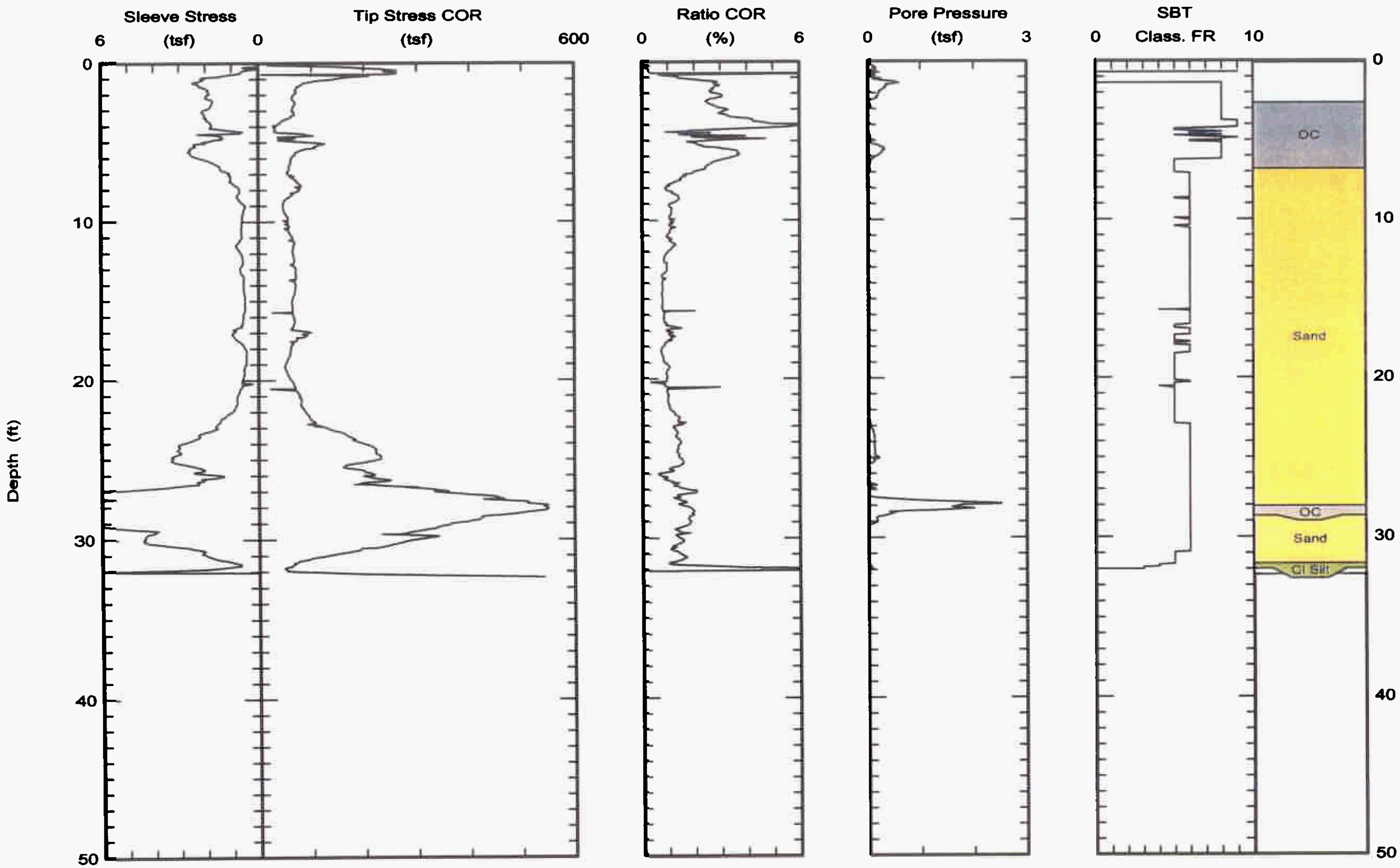


Maximum depth: 1.19 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-821B
File: 311D0203C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3909850.0235 Easting: 11685756.1761 Elevation: 296.3	Date: 11/Dec/2002 Test ID: CPT-823 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	

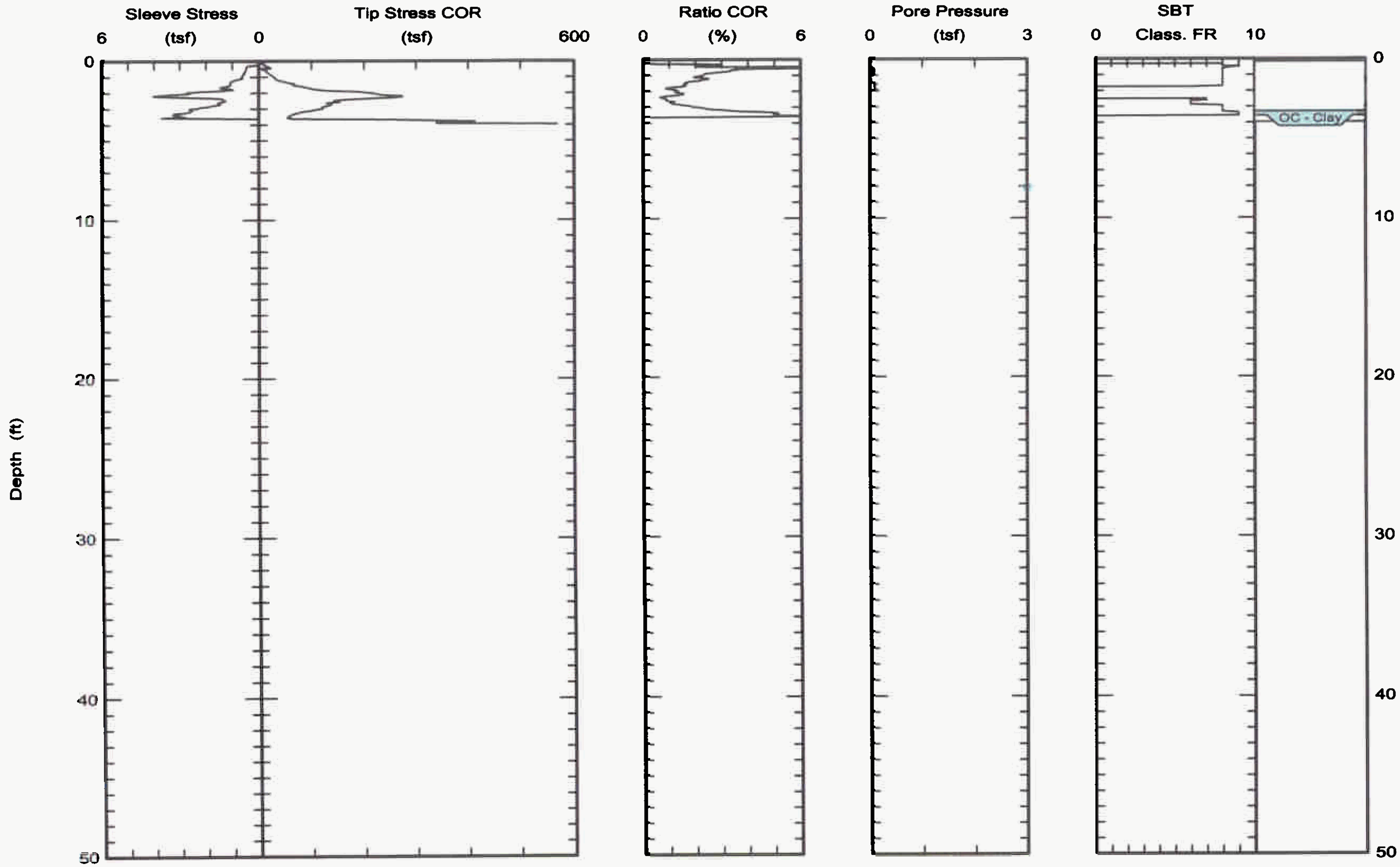


Maximum depth: 32.35 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-823
File: 311D0204C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3910054.2670 Easting: 11686009.5911 Elevation: 276.1	Date: 11/Dec/2002 Test ID: CPT-824 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	

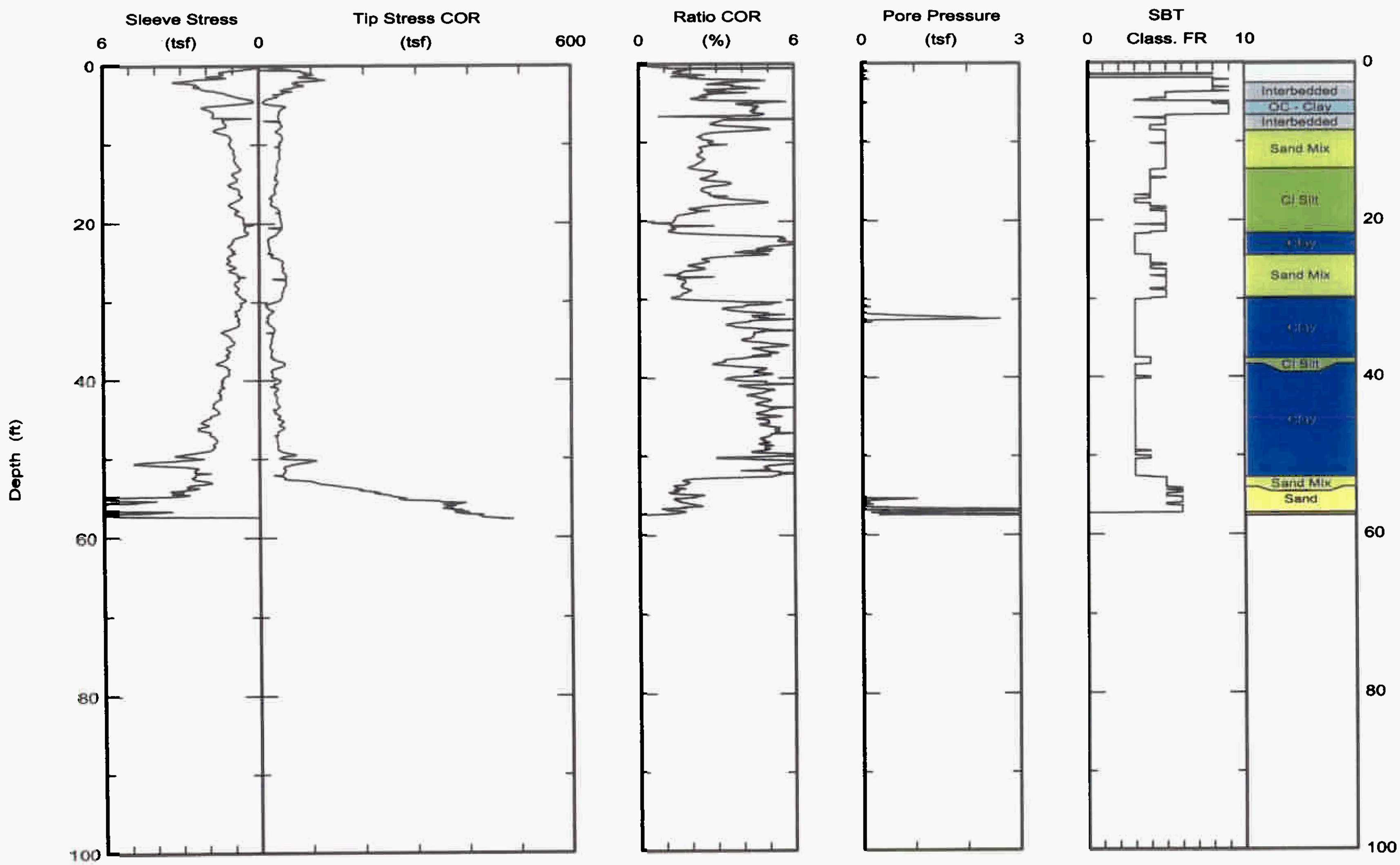


Maximum depth: 3.98 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-824
File: 311D0205C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3910688.2442 Easting: 11683569.4372 Elevation: 277.1	Date: 12/Dec/2002 Test ID: CPT-827 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	

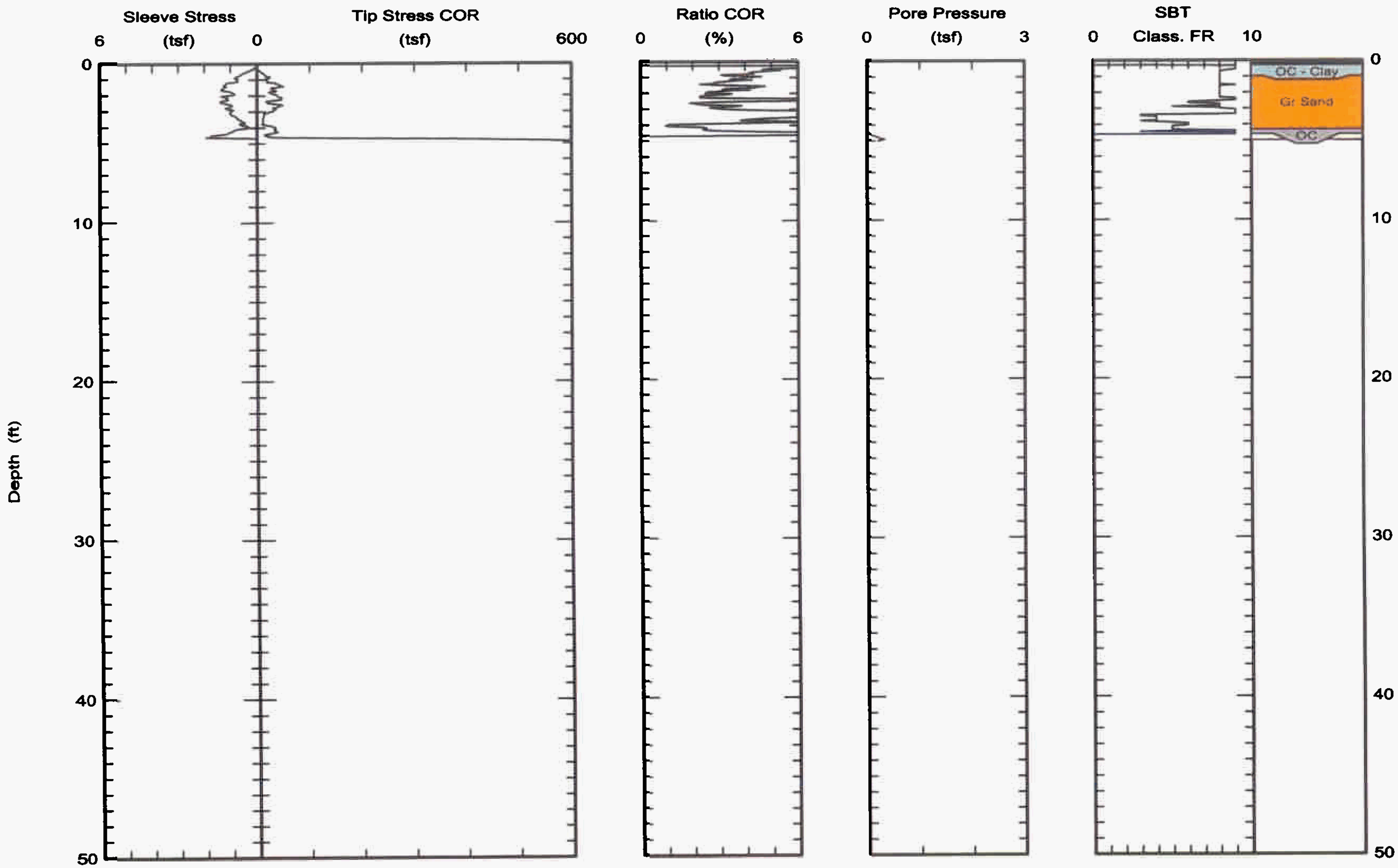


Maximum depth: 57.69 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-827
File: 312D0201C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3910652.8241 Easting: 11683066.3705 Elevation: 270.0	Date: 12/Dec/2002 Test ID: CPT-828 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	



Maximum depth: 5.01 (ft)

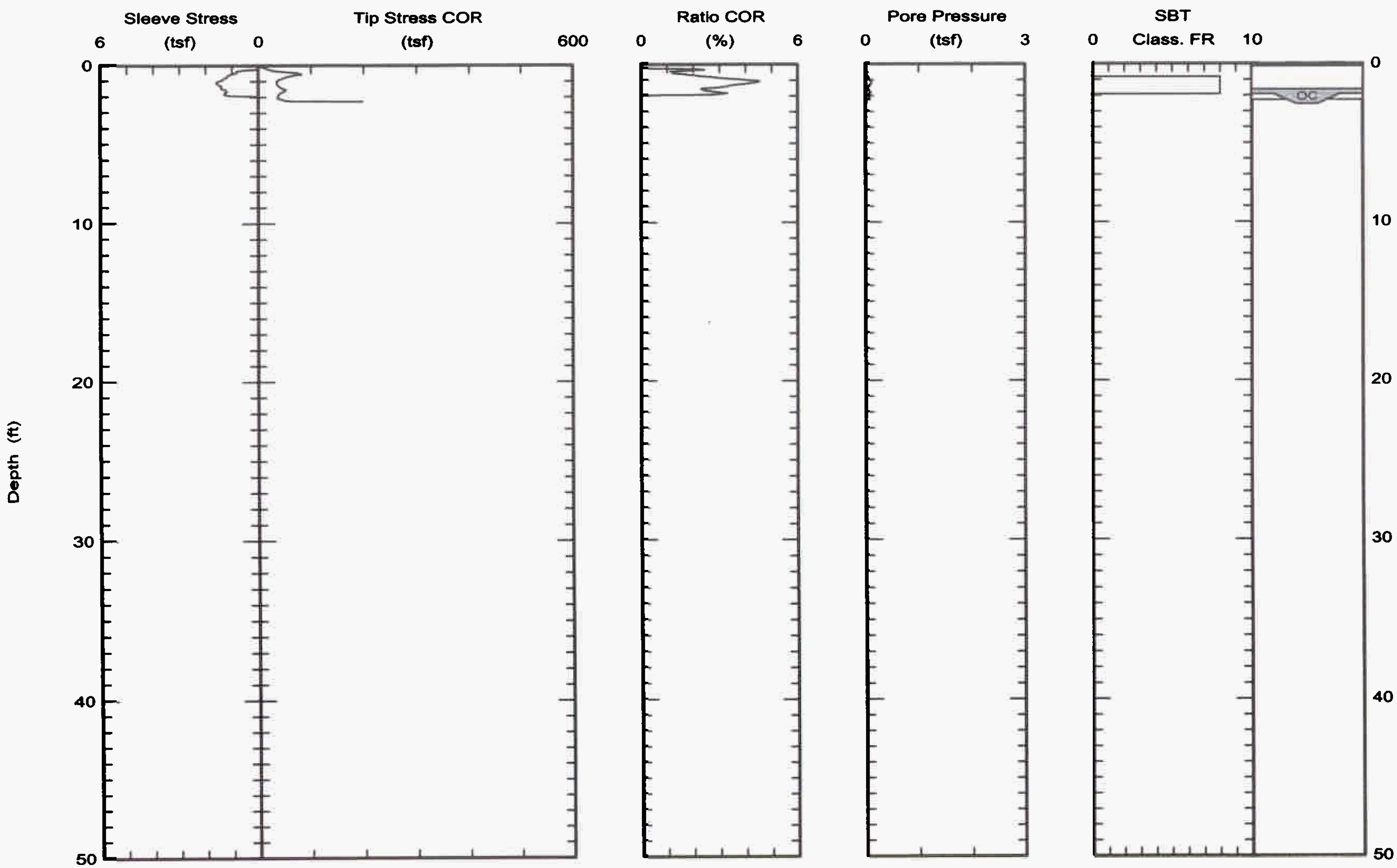
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Applied Research Associates
South Royalton, VT 05068
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3910652.8241
Easting: 11683066.3705
Elevation: 270.0

Date: 12/Dec/2002
Test ID: CPT-828
Project: 5737

Client: MACTEC
Site: NORTH ANNA ESP



Maximum depth: 2.29 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

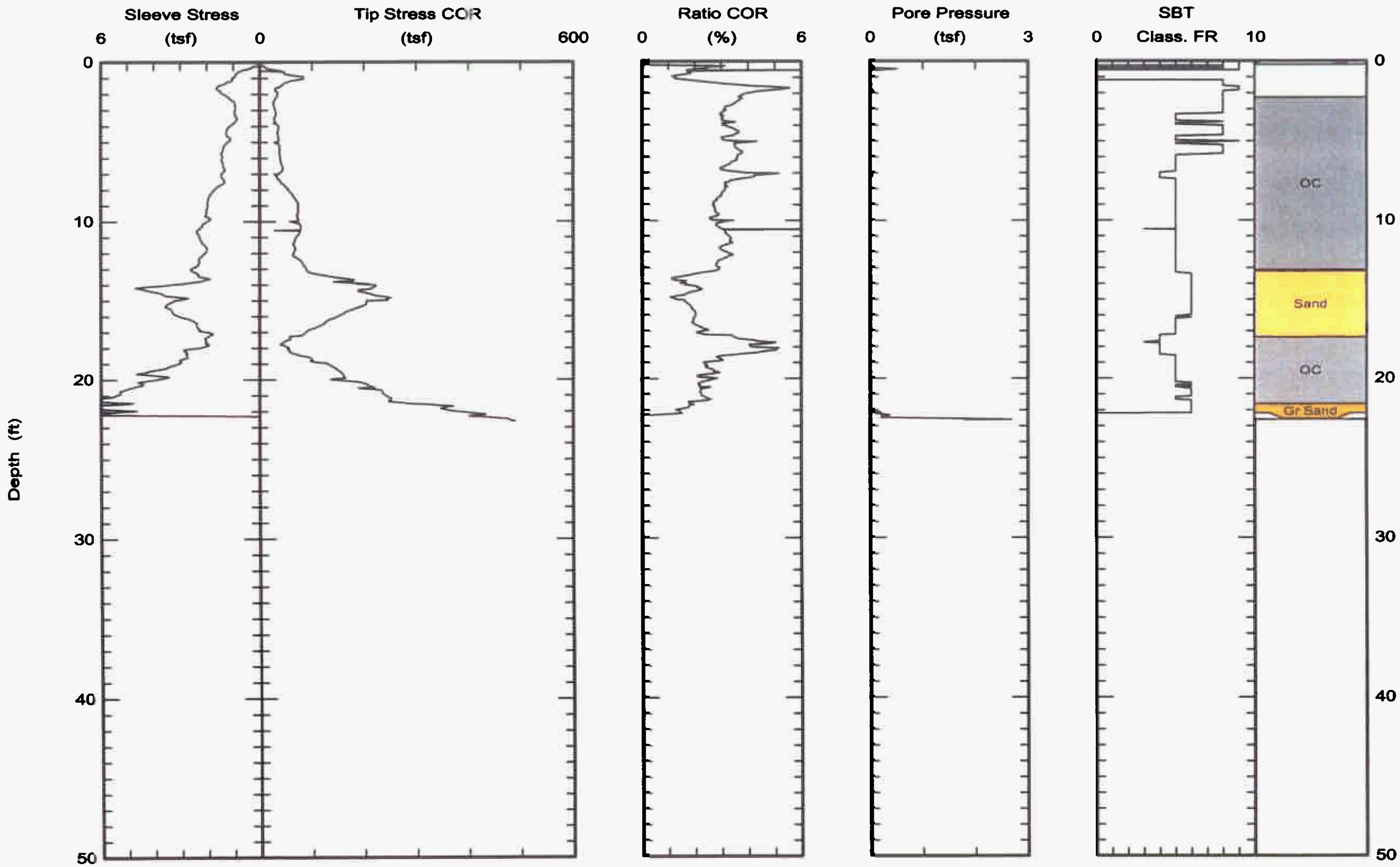
Test ID: CPT-828
File: 312D0203C.ECP

Applied Research Associates
South Royalton, VT 05068
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3910375.4066
Easting: 11686237.2013
Elevation: 271.1

Date: 12/Dec/2002
Test ID: CPT-822
Project: 5737

Client: MACTEC
Site: NORTH ANNA ESP

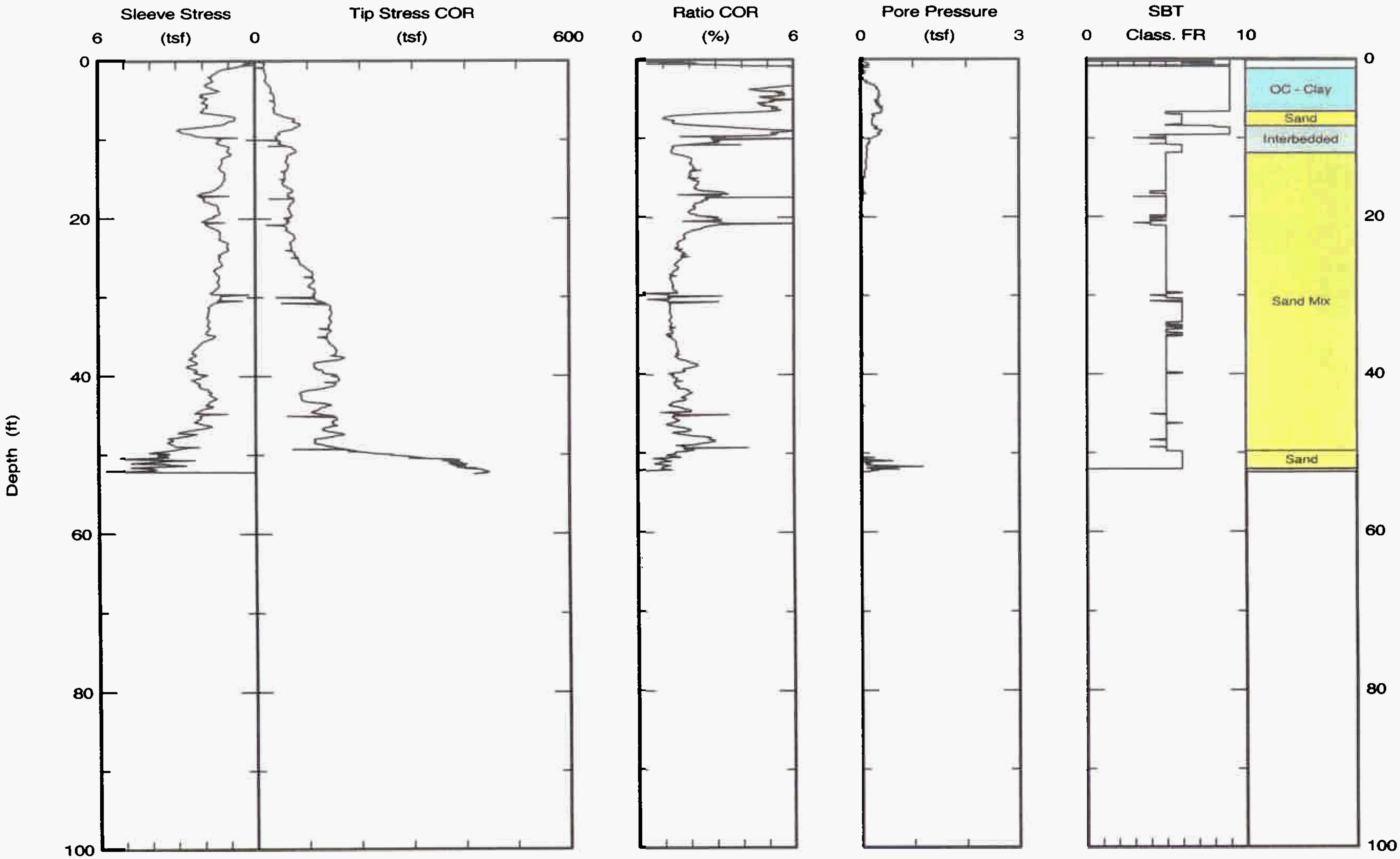


Maximum depth: 22.61 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-822
File: 312D0206C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3909477.9442 Easting: 11685267.2998 Elevation: 332.5	Date: 12/Dec/2002 Test ID: CPT-825 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	

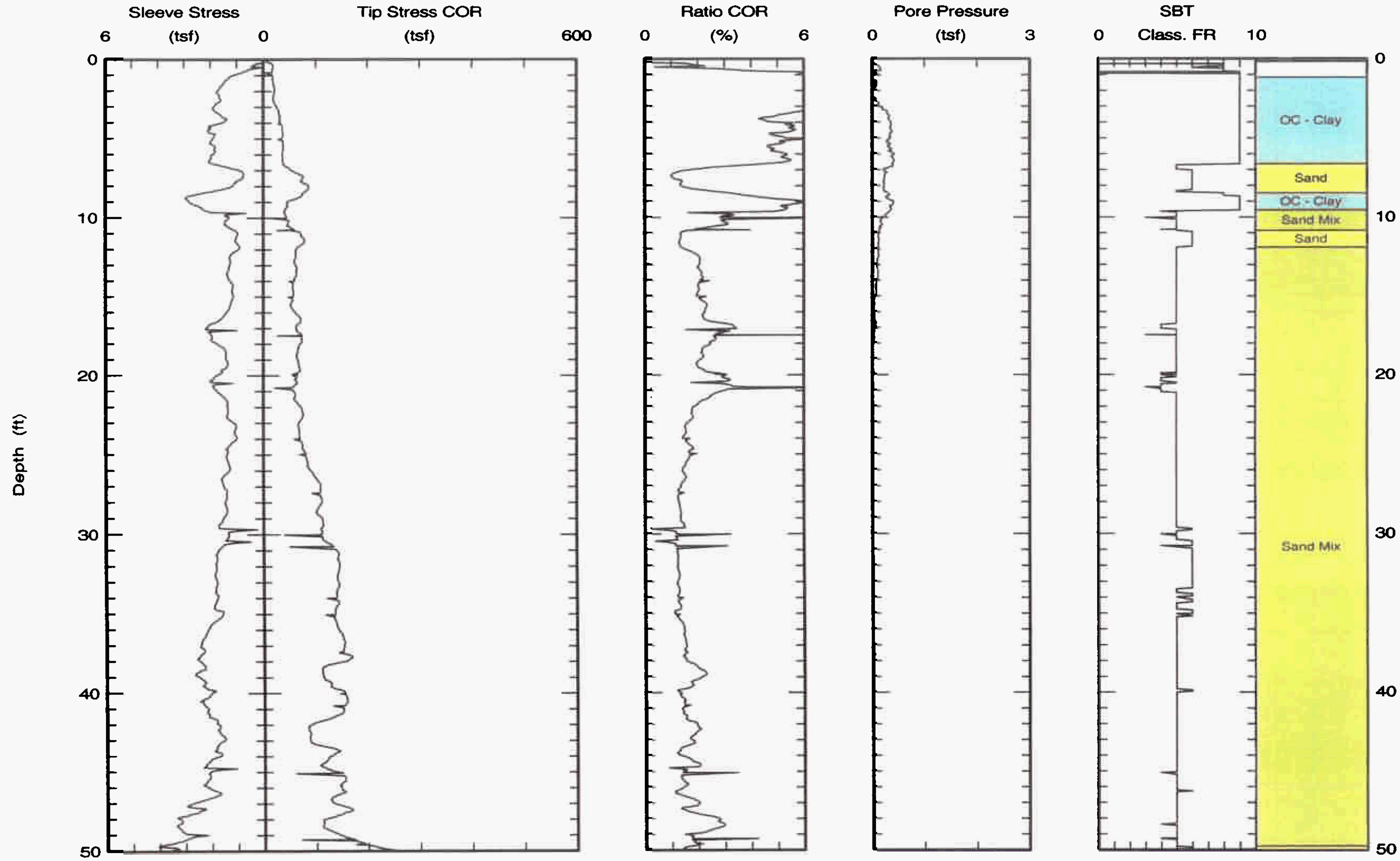


Maximum depth: 52.47 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-825
File: 312D0207C.ECP

Applied Research Associates South Royalton, VT 05068 802-763-8348 Email: cpt@ned.ara.com http://www.ara.com	Northing: 3909477.9442 Easting: 11685267.2998 Elevation: 332.5	Date: 12/Dec/2002 Test ID: CPT-825 Project: 5737
	Client: MACTEC Site: NORTH ANNA ESP	



Maximum depth: 52.47 (ft)
Page 1 of 2

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

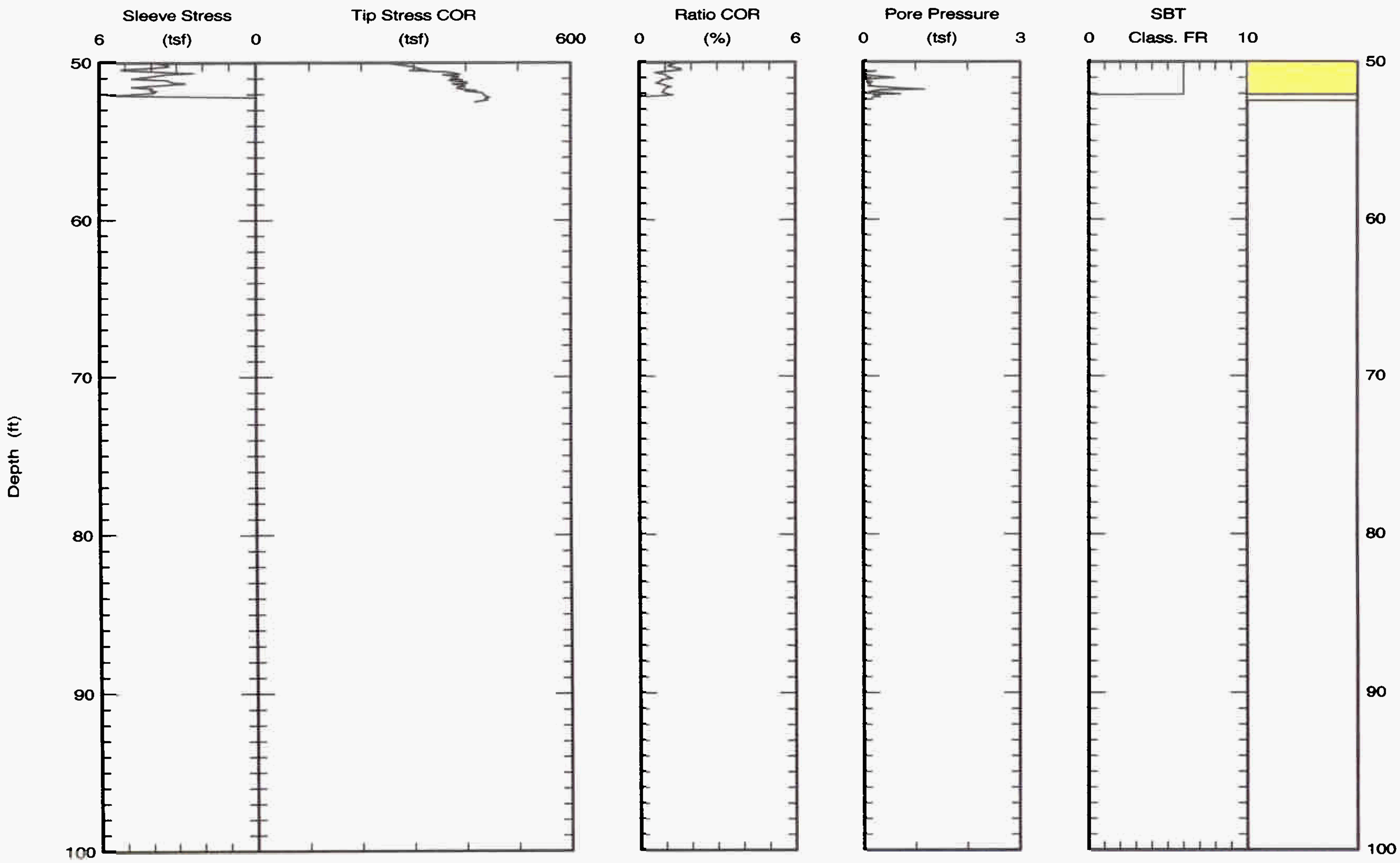
Test ID: CPT-825
File: 312D0207C.ECP

Applied Research Associates
South Royalton, VT 05068
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3909477.9442
Easting: 11685267.2998
Elevation: 332.5

Date: 12/Dec/2002
Test ID: CPT-825
Project: 5737

Client: MACTEC
Site: NORTH ANNA ESP



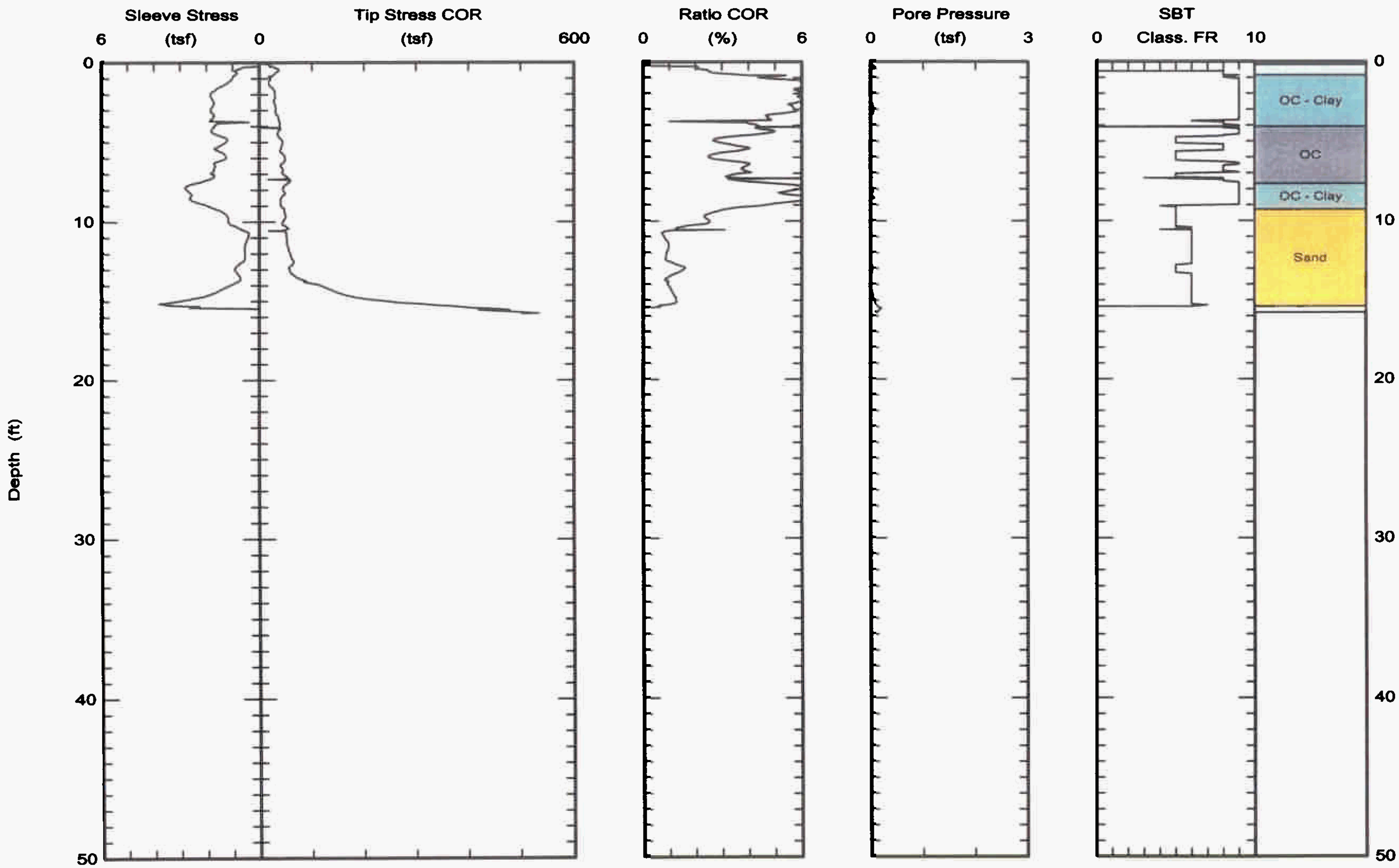
Maximum depth: 52.47 (ft)
Page 2 of 2

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-825
File: 312D0207C.ECP

Applied Research Associates
South Royalton, VT 05068
802-763-8348
Email: cpt@ned.ara.com
http://www.ara.com

Northing: 3909848.9822		Date: 12/Dec/2002
Easting: 11686000.3856		Test ID: CPT-830
Elevation: 307.5		Project: 5737
Client: MACTEC		
Site: NORTH ANNA ESP		

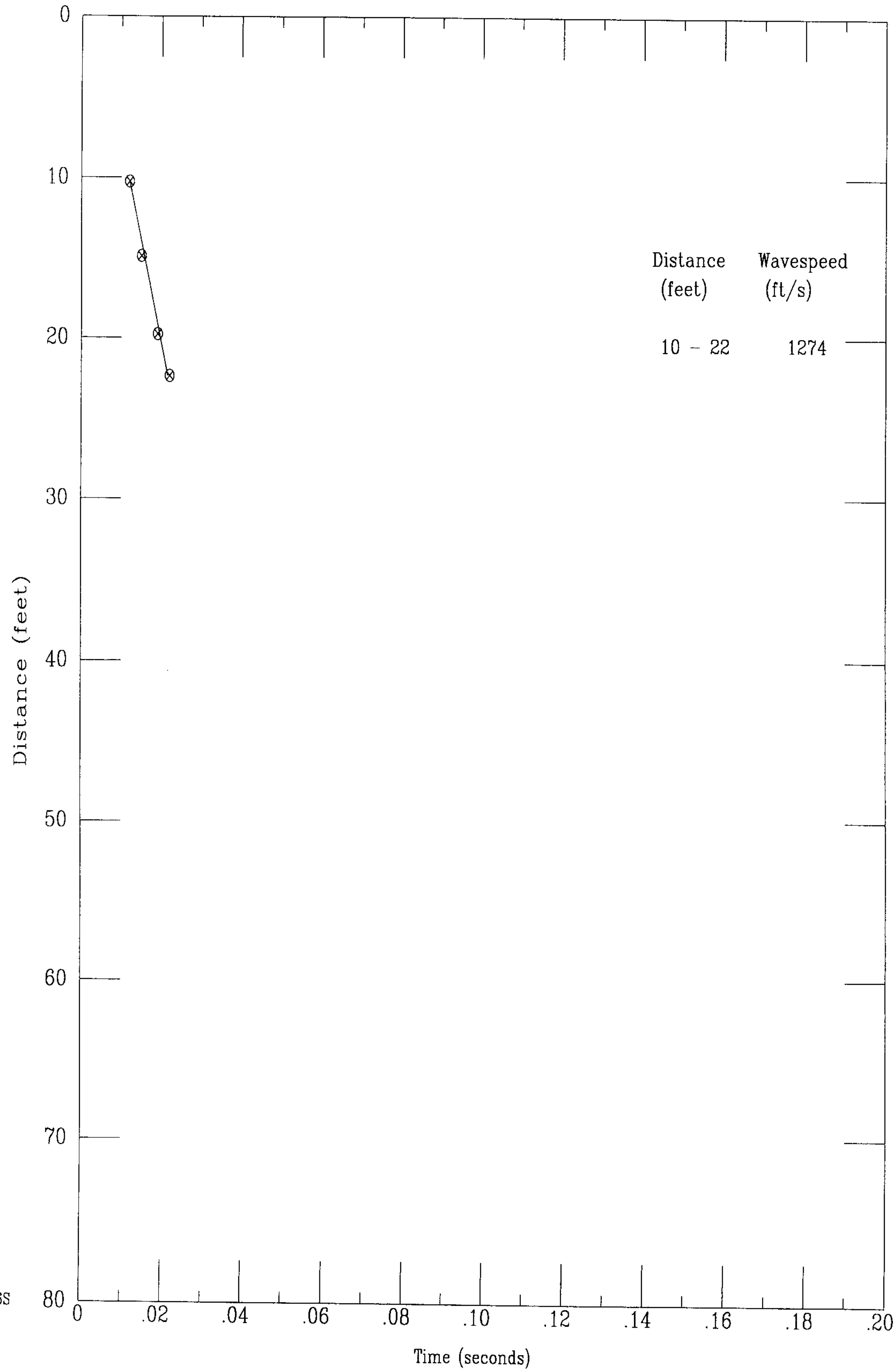


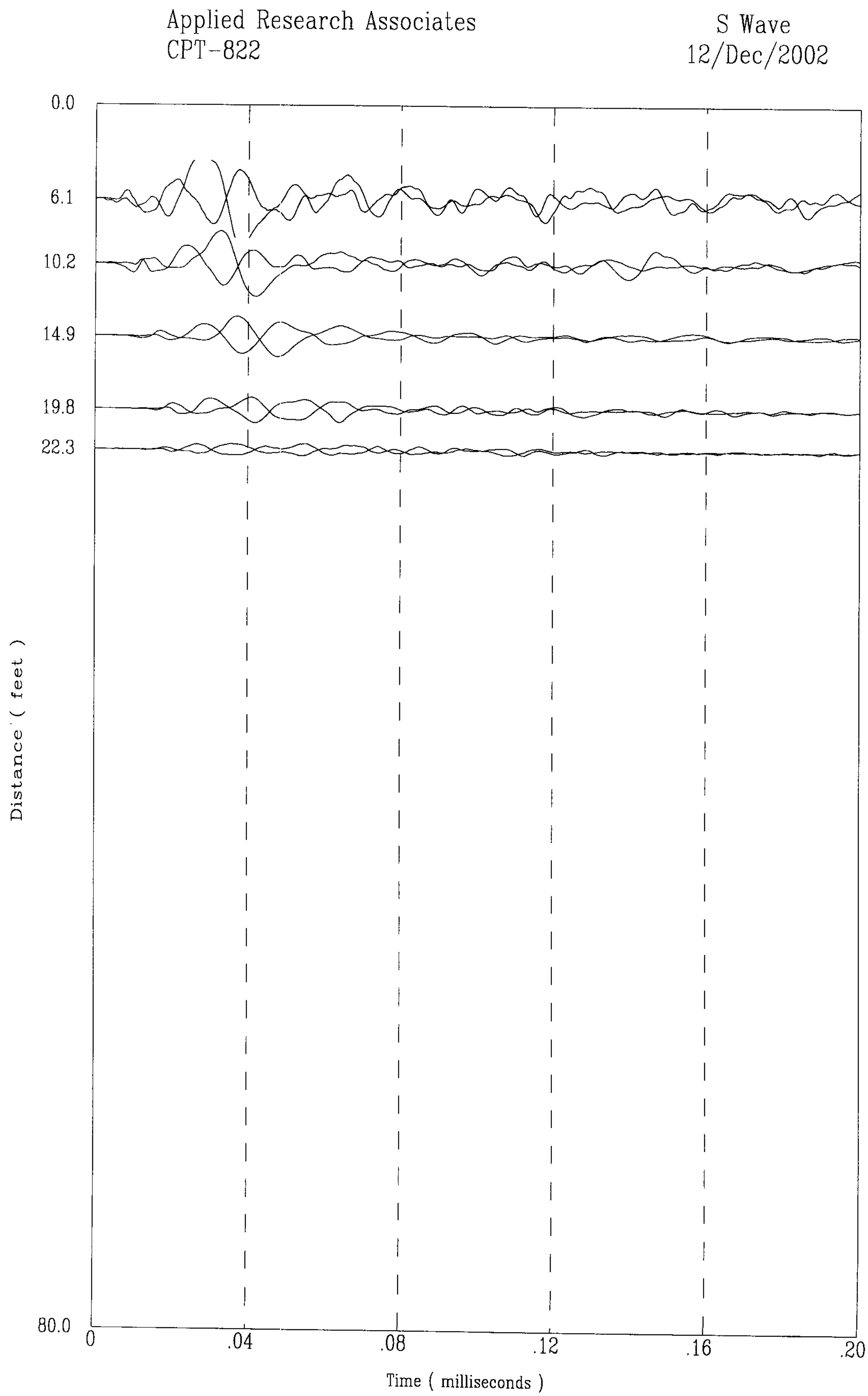
Maximum depth: 15.79 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

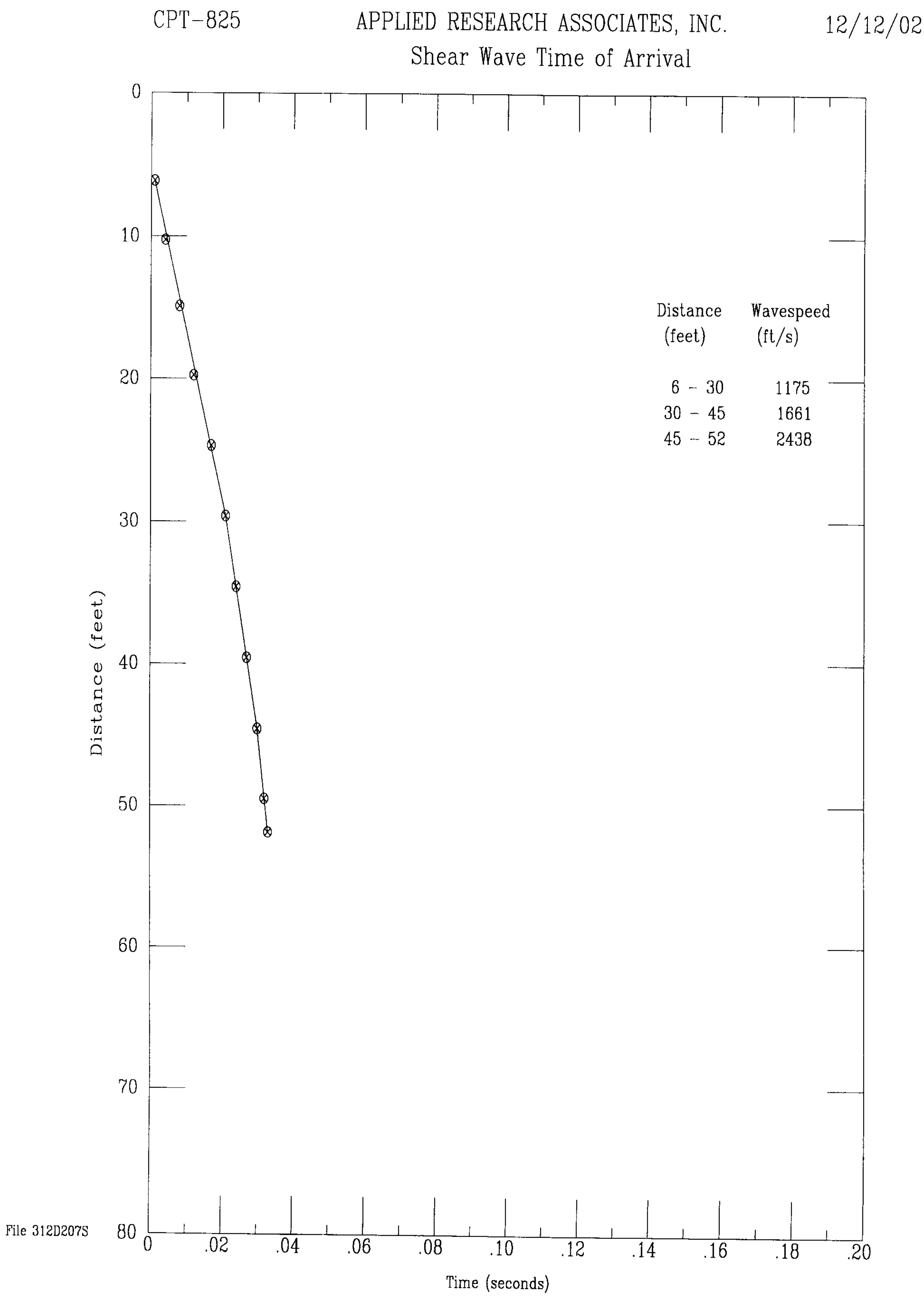
CPT-822 APPLIED RESEARCH ASSOCIATES, INC. 12/Dec/2002

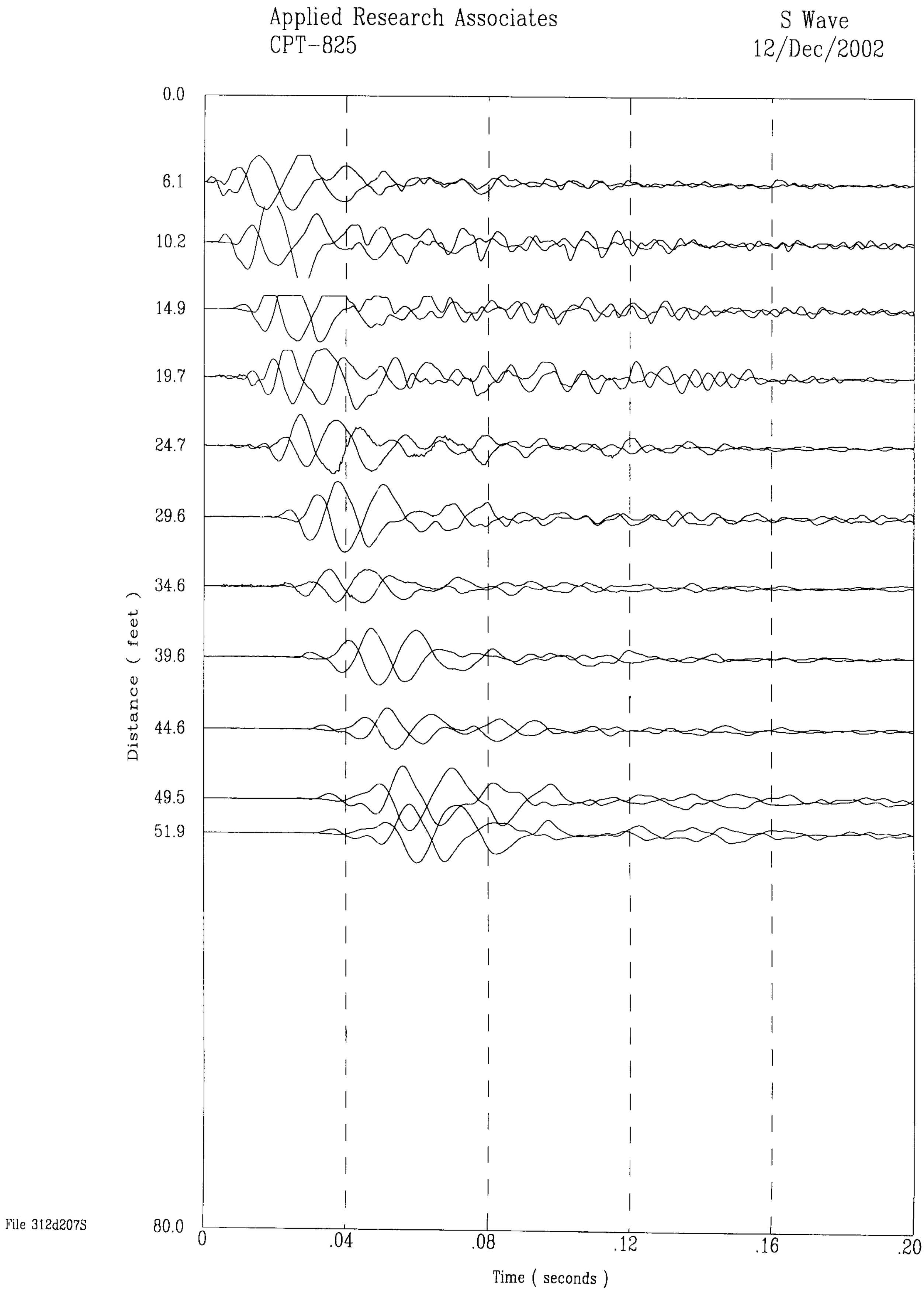
Shear Wave Time of Arrival



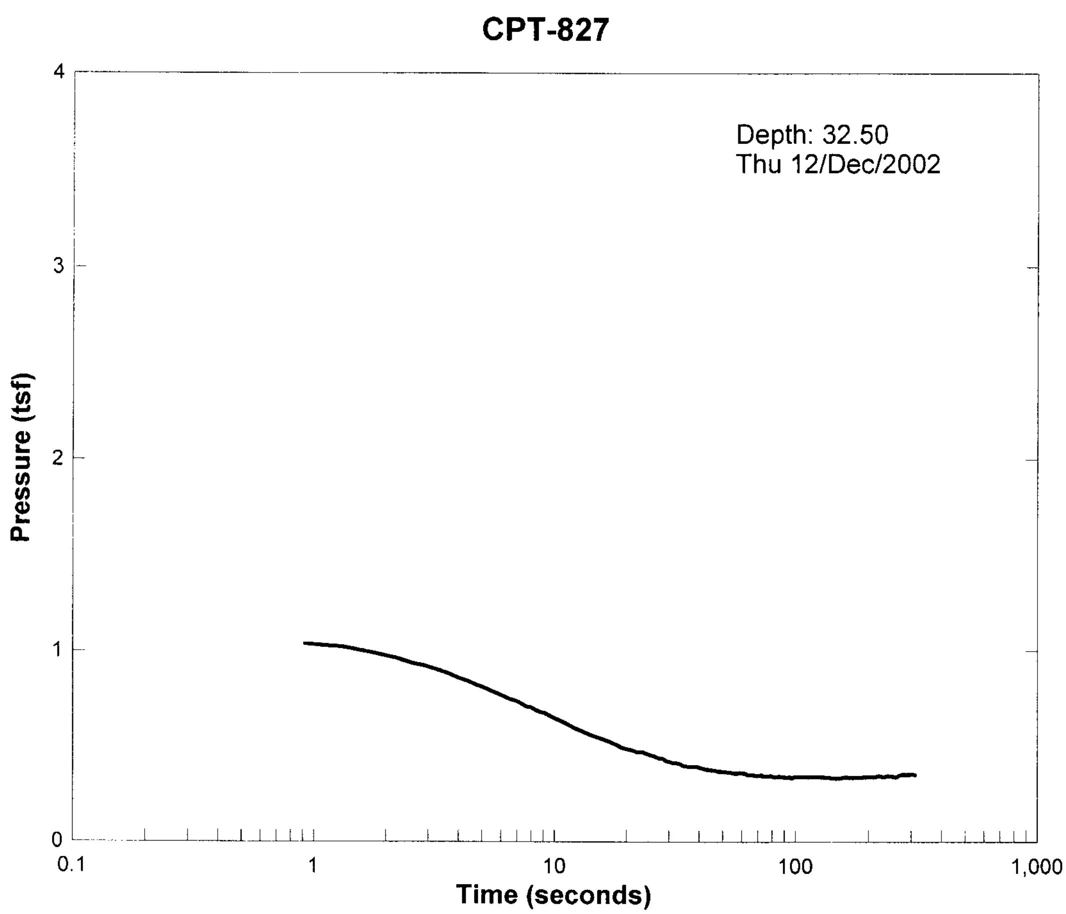


File 312d206S

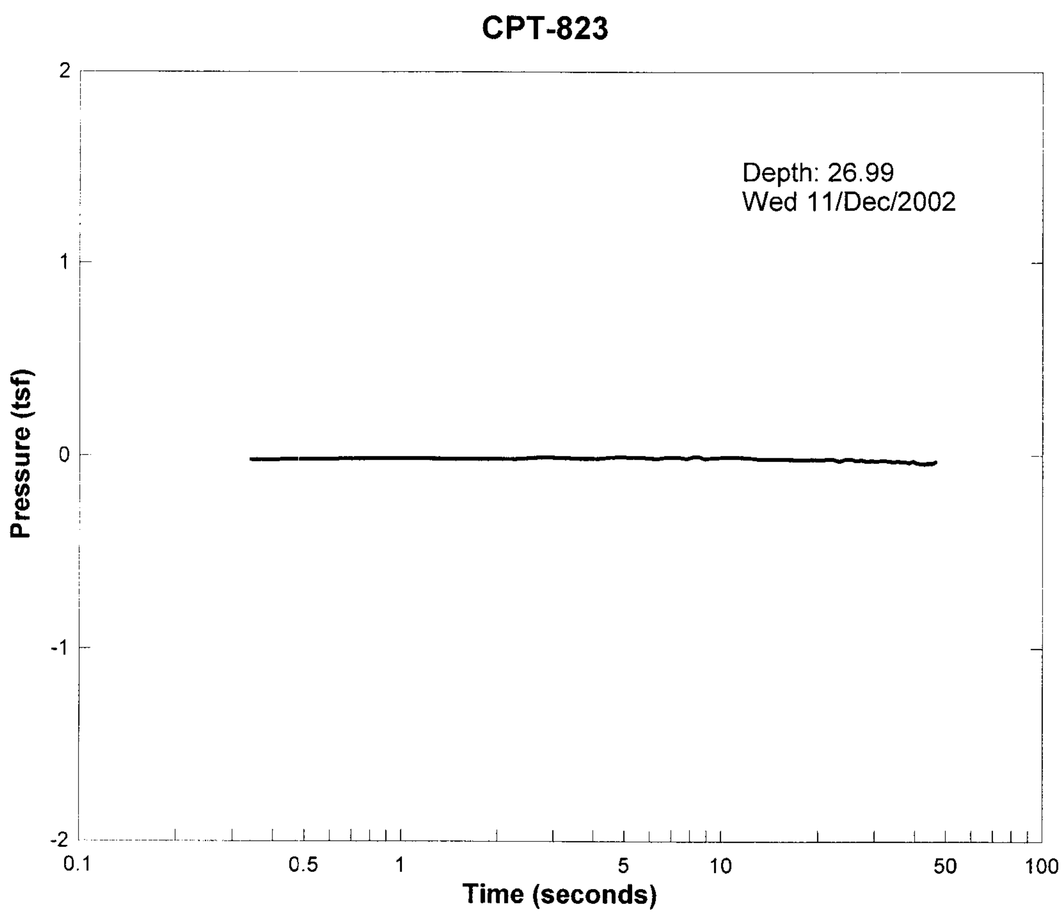

CPT-825
APPLIED RESEARCH ASSOCIATES, INC.
12/12/02
Shear Wave Time of Arrival
Distance (feet)
Time (seconds)
0
10
20
30
40
50
60
70
80
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
Distance (feet)
Wavespeed (ft/s)
6 - 30
1175
30 - 45
1661
45 - 52
2438
File 312D207S



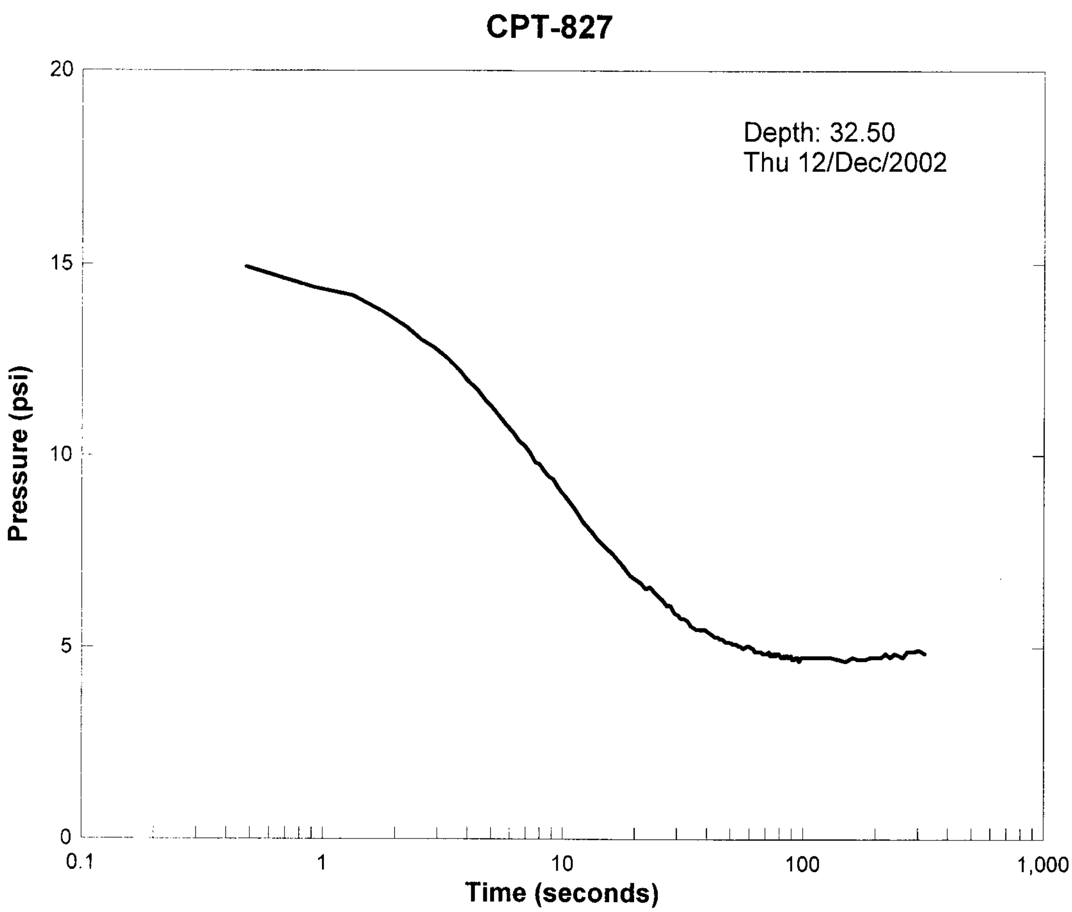
Applied Research Associates
CPT-825
S Wave
12/Dec/2002
0.0
6.1
10.2
14.9
19.7
24.7
29.6
34.6
39.6
44.6
49.5
51.9
80.0
Distance (feet)
0
.04
.08
.12
.16
.20
Time (seconds)
File 312d207S

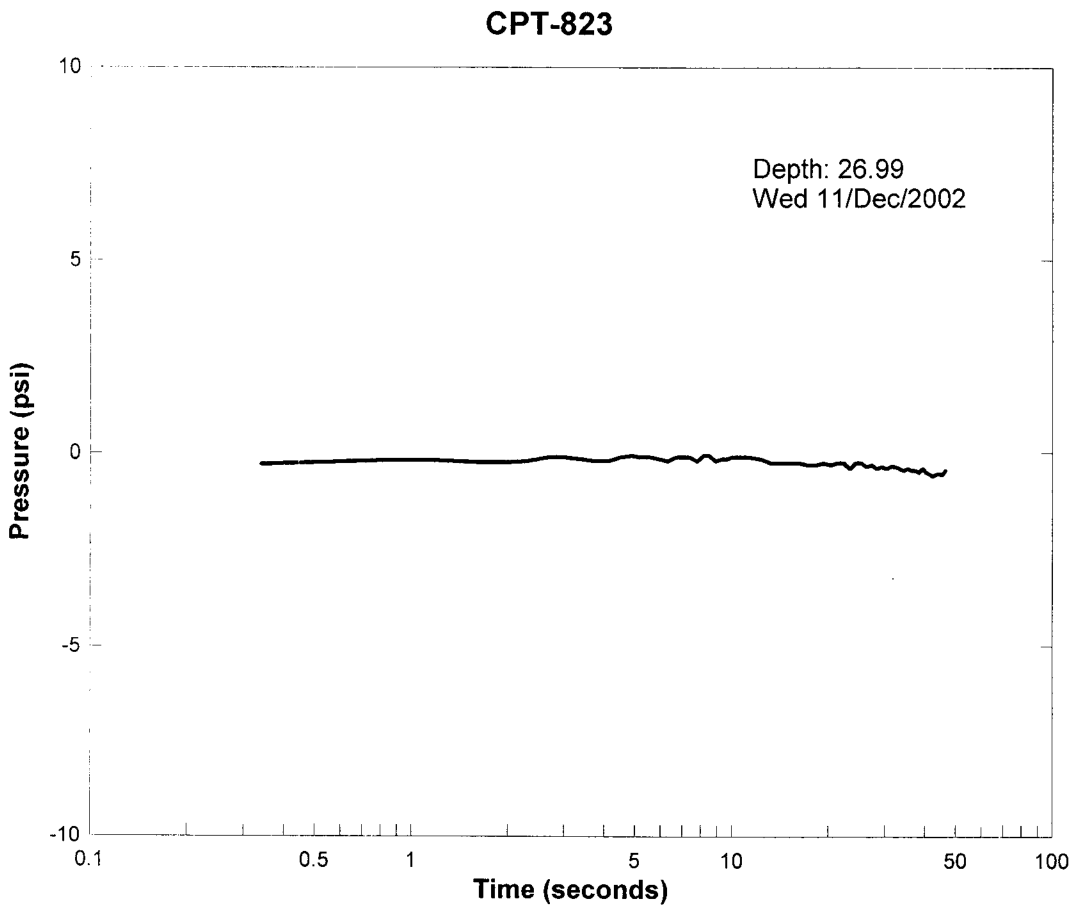


CPT-827
Depth: 32.50
Thu 12/Dec/2002
Pressure (tsf)
4
3
2
1
0
0.1
1
10
100
1,000
Time (seconds)



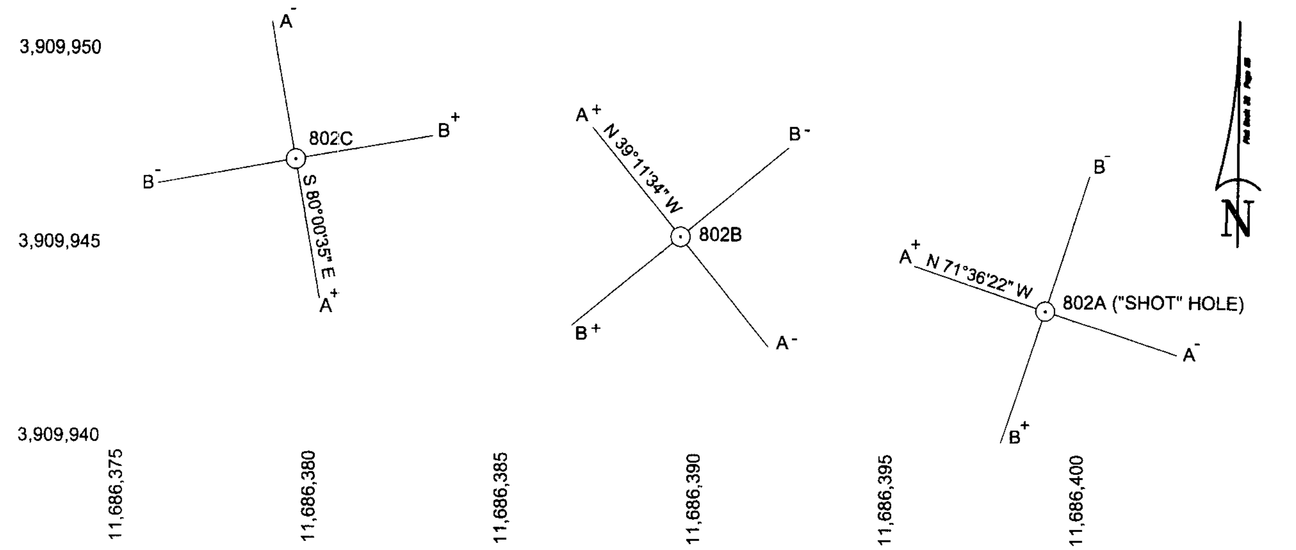
CPT-823
Depth: 26.99
Wed 11/Dec/2002
Pressure (tsf)
2
1
0
-1
-2
0.1
0.5
1
5
10
50
100
Time (seconds)


CPT-827
Depth: 32.50
Thu 12/Dec/2002
Pressure (psi)
20
15
10
5
0
0.1
1
10
100
1,000
Time (seconds)

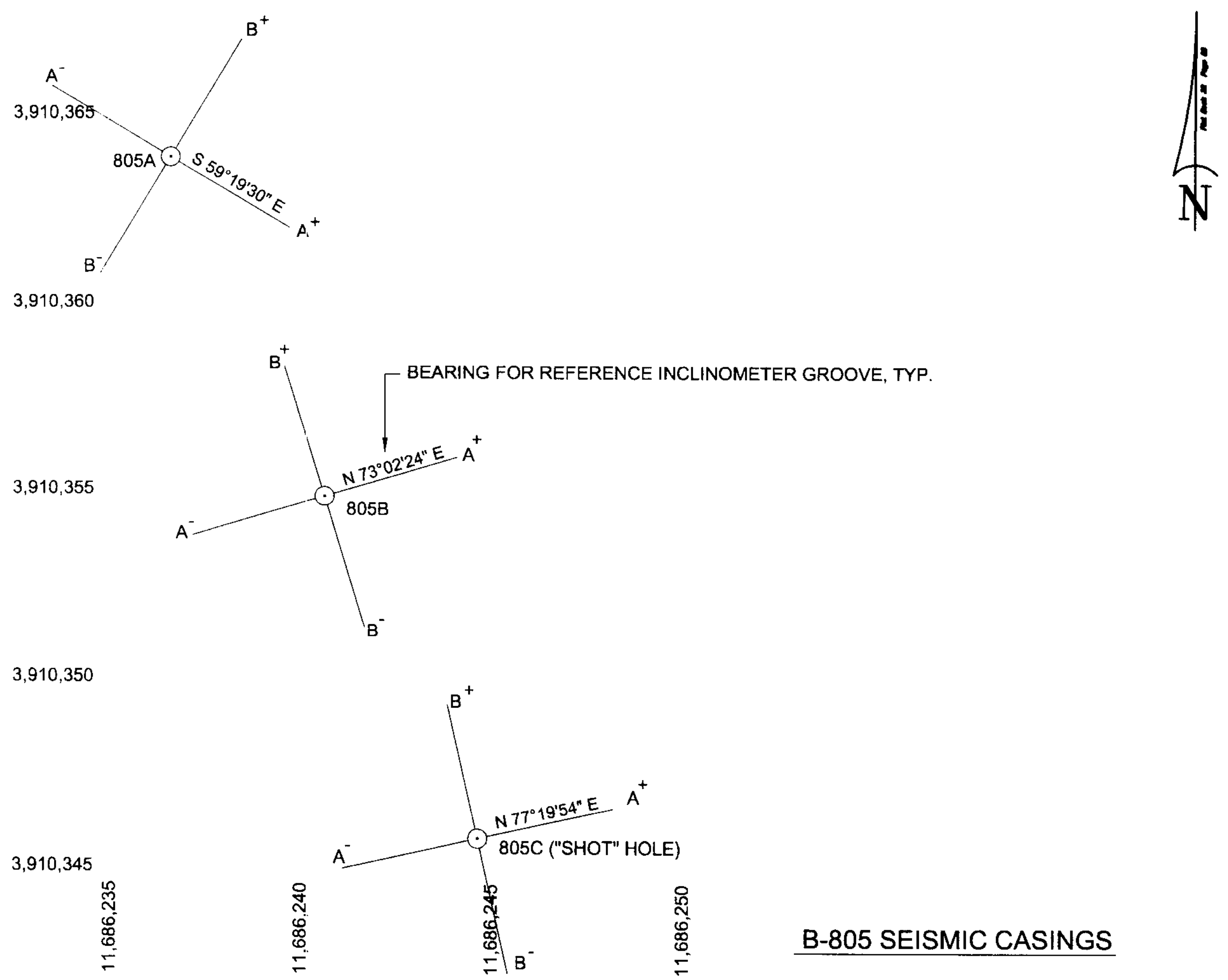


CPT-823
Depth: 26.99
Wed 11/Dec/2002
Pressure (psi)
Time (seconds)
10
5
0
-5
-10
0.1
0.5
1
5
10
50
100

APPENDIX G
DEVIATION SURVEY CROSSHOLE CASINGS



B-802 SEISMIC CASINGS



B-805 SEISMIC CASINGS

P:\30720\PROJECTS\5400 North Anna\POINTS.DWG

MACTEC

MACTEC ENGINEERING AND CONSULTING OF GEORGIA INC.
3301 ATLANTIC AVENUE RALEIGH, NORTH CAROLINA

ORIENTATION OF
INCLINOMETER GROOVES
B-802 & B-805 SEISMIC CASINGS
NORTH ANNA ESP

DRAWN: R.R.	DATE: FEB, 2003
DFT CHECK:	SCALE: 1"=5'
ENG CHECK:	JOB: 30720-2-5400
APPROVAL:	DRAWING: DEV-1

REFERENCE: Survey by Stantec, Inc. with NAD 83 grid coordinates

CROSSHOLE CASING DISTANCE CALCULATION SHEET

NORTH ANNA ESP PROJECT Prepared by: [signature] Date: 1/8/03

MACTEC JOB NO. 30720-2-5400 Checked by: [signature] Date: 1/8/03

	B-802B		B-802C				
Depth, ft	N	E	N	E	Delta N	Delta E	Distance
0	3909945.4	11686389.75	3909947.32	11686379.75	-1.92	10	10.18
2	3909945.37	11686389.78	3909947.351	11686379.78	-1.9804829	10.00133	10.20
4	3909945.349	11686389.82	3909947.38	11686379.81	-2.0309254	10.00289	10.21
6	3909945.34	11686389.85	3909947.411	11686379.84	-2.0708418	10.00788	10.22
8	3909945.34	11686389.89	3909947.444	11686379.87	-2.1047587	10.01786	10.24
10	3909945.345	11686389.93	3909947.482	11686379.9	-2.1366617	10.03111	10.26
12	3909945.355	11686389.97	3909947.524	11686379.92	-2.1682145	10.04924	10.28
14	3909945.369	11686390.02	3909947.568	11686379.94	-2.1990804	10.07537	10.31
16	3909945.385	11686390.06	3909947.613	11686379.96	-2.2278018	10.10417	10.35
18	3909945.4	11686390.11	3909947.659	11686379.98	-2.2598641	10.13585	10.38
20	3909945.408	11686390.17	3909947.708	11686380	-2.3001778	10.17056	10.43
22	3909945.416	11686390.23	3909947.759	11686380.02	-2.3423062	10.20679	10.47
24	3909945.425	11686390.28	3909947.812	11686380.04	-2.3868399	10.24617	10.52
26	3909945.433	11686390.34	3909947.865	11686380.06	-2.4316464	10.2854	10.57
28	3909945.44	11686390.4	3909947.919	11686380.07	-2.4795983	10.32441	10.62
30	3909945.443	11686390.45	3909947.974	11686380.09	-2.5308555	10.36344	10.67
32	3909945.445	11686390.51	3909948.034	11686380.11	-2.5890269	10.40188	10.72
34	3909945.438	11686390.57	3909948.101	11686380.14	-2.6631264	10.43323	10.77
36	3909945.43	11686390.64	3909948.175	11686380.17	-2.7453954	10.46598	10.82
38	3909945.424	11686390.71	3909948.254	11686380.21	-2.8292467	10.5041	10.88
40	3909945.425	11686390.78	3909948.332	11686380.24	-2.9073323	10.54328	10.94
42	3909945.432	11686390.86	3909948.412	11686380.26	-2.9801422	10.59473	11.01
44	3909945.439	11686390.94	3909948.492	11686380.29	-3.0523317	10.64779	11.08
46	3909945.452	11686391.01	3909948.573	11686380.31	-3.1217929	10.70229	11.15
48	3909945.464	11686391.08	3909948.656	11686380.32	-3.1918497	10.75848	11.22
50	3909945.474	11686391.16	3909948.736	11686380.34	-3.2619055	10.8181	11.30
52	3909945.486	11686391.24	3909948.816	11686380.35	-3.3298867	10.88116	11.38
54	3909945.5	11686391.32	3909948.892	11686380.37	-3.3921496	10.94756	11.46
56	3909945.516	11686391.4	3909948.967	11686380.38	-3.4506326	11.01946	11.55
58	3909945.534	11686391.49	3909949.043	11686380.39	-3.5093853	11.09775	11.64
60	3909945.552	11686391.59	3909949.122	11686380.41	-3.5704056	11.18126	11.74
62	3909945.573	11686391.69	3909949.208	11686380.42	-3.6342864	11.26986	11.84

64	3909945.594	11686391.8	3909949.308	11686380.44	-3.713479	11.35945	11.95
66	3909945.614	11686391.91	3909949.414	11686380.47	-3.8003499	11.44776	12.06
68	3909945.633	11686392.02	3909949.523	11686380.49	-3.8891598	11.53719	12.18
70	3909945.652	11686392.13	3909949.633	11686380.51	-3.9805984	11.62695	12.29
72	3909945.669	11686392.24	3909949.741	11686380.53	-4.0722546	11.71166	12.40
74	3909945.688	11686392.35	3909949.845	11686380.55	-4.1567401	11.79414	12.51
76	3909945.706	11686392.45	3909949.943	11686380.58	-4.2371288	11.87528	12.61
78	3909945.721	11686392.56	3909950.042	11686380.6	-4.3204107	11.9564	12.71
80	3909945.734	11686392.66	3909950.14	11686380.62	-4.4058201	12.03837	12.82
82	3909945.746	11686392.76	3909950.237	11686380.64	-4.4905526	12.12202	12.93
84	3909945.758	11686392.86	3909950.33	11686380.66	-4.5722656	12.20489	13.03
86	3909945.772	11686392.97	3909950.421	11686380.68	-4.6490619	12.28451	13.13
88	3909945.792	11686393.07	3909950.509	11686380.7	-4.7176571	12.36482	13.23
90	3909945.816	11686393.16	3909950.594	11686380.72	-4.7776835	12.44622	13.33

CALCULATION OF DEVIATION AT INCREMENTAL DEPTHS FOR CROSSHOLE CASINGS

Casing No. B-802B Prepared by: ZOZ Date: 1/8/03
Checked by: BKB Date: 1/8/03

Depth, ft	A Deviatior	B Deviatior	Resultant	Angle y	calc angle	Delta N(in)	delta E (in)	N (ft)	E(ft)
0	0	0	0	0				3909945.4	11686389.75
2	-0.5338	-0.0922	0.54	9.80	41.00	-0.36	0.41	3909945.37	11686389.78
4	-0.9816	-0.2414	1.01	13.82	36.98	-0.61	0.81	3909945.349	11686389.82
6	-1.3363	-0.4968	1.43	20.39	30.41	-0.72	1.23	3909945.34	11686389.85
8	-1.6147	-0.8318	1.82	27.25	23.55	-0.73	1.67	3909945.34	11686389.89
10	-1.8586	-1.2389	2.23	33.69	17.11	-0.66	2.13	3909945.345	11686389.93
12	-2.0798	-1.705	2.69	39.34	11.46	-0.53	2.64	3909945.355	11686389.97
14	-2.303	-2.2378	3.21	44.18	6.62	-0.37	3.19	3909945.369	11686390.02
16	-2.5229	-2.8099	3.78	48.08	2.72	-0.18	3.77	3909945.385	11686390.06
18	-2.7706	-3.3878	4.38	50.72	0.08	-0.01	4.38	3909945.4	11686390.11
20	-3.0994	-3.9571	5.03	51.93	1.13	0.10	5.03	3909945.408	11686390.17
22	-3.4507	-4.5432	5.71	52.78	1.98	0.20	5.70	3909945.416	11686390.23
24	-3.8198	-5.1557	6.42	53.47	2.67	0.30	6.41	3909945.425	11686390.28
26	-4.176	-5.7562	7.11	54.04	3.24	0.40	7.10	3909945.433	11686390.34
28	-4.5437	-6.3283	7.79	54.32	3.52	0.48	7.78	3909945.44	11686390.4
30	-4.9435	-6.8842	8.48	54.32	3.52	0.52	8.46	3909945.443	11686390.45
32	-5.376	-7.4366	9.18	54.14	3.34	0.53	9.16	3909945.445	11686390.51
34	-5.8906	-7.9354	9.88	53.41	2.61	0.45	9.87	3909945.438	11686390.57
36	-6.469	-8.4998	10.68	52.73	1.93	0.36	10.68	3909945.43	11686390.64
38	-7.0603	-9.1205	11.53	52.26	1.46	0.29	11.53	3909945.424	11686390.71
40	-7.6118	-9.8093	12.42	52.19	1.39	0.30	12.41	3909945.425	11686390.78
42	-8.1154	-10.559	13.32	52.45	1.65	0.38	13.31	3909945.432	11686390.86
44	-8.6227	-11.3222	14.23	52.71	1.91	0.47	14.22	3909945.439	11686390.94
46	-9.0677	-12.096	15.12	53.14	2.34	0.62	15.10	3909945.452	11686391.01
48	-9.5069	-12.8702	16.00	53.55	2.75	0.77	15.98	3909945.464	11686391.08
50	-9.9854	-13.6574	16.92	53.83	3.03	0.89	16.89	3909945.474	11686391.16
52	-10.4726	-14.4691	17.86	54.10	3.30	1.03	17.83	3909945.486	11686391.24
54	-10.9574	-15.3298	18.84	54.44	3.64	1.20	18.81	3909945.5	11686391.32
56	-11.4547	-16.2494	19.88	54.82	4.02	1.39	19.83	3909945.516	11686391.4
58	-11.9717	-17.2171	20.97	55.19	4.39	1.60	20.91	3909945.534	11686391.49
60	-12.5328	-18.2544	22.14	55.53	4.73	1.83	22.07	3909945.552	11686391.59
62	-13.1165	-19.3733	23.40	55.90	5.10	2.08	23.30	3909945.573	11686391.69

64	-13.7554	-20.5507	24.73	56.20	5.40	2.33	24.62	3909945.594	11686391.8
66	-14.4144	-21.7363	26.08	56.45	5.65	2.57	25.95	3909945.614	11686391.91
68	-15.071	-22.9109	27.42	56.66	5.86	2.80	27.28	3909945.633	11686392.02
70	-15.7339	-24.0763	28.76	56.84	6.04	3.02	28.60	3909945.652	11686392.13
72	-16.3771	-25.1914	30.05	56.97	6.17	3.23	29.87	3909945.669	11686392.24
74	-17.005	-26.3155	31.33	57.13	6.33	3.45	31.14	3909945.688	11686392.35
76	-17.6395	-27.4416	32.62	57.27	6.47	3.67	32.41	3909945.706	11686392.45
78	-18.2861	-28.5245	33.88	57.34	6.54	3.86	33.66	3909945.721	11686392.56
80	-18.9504	-29.5824	35.13	57.36	6.56	4.01	34.90	3909945.734	11686392.66
82	-19.6205	-30.6288	36.37	57.36	6.56	4.15	36.14	3909945.746	11686392.76
84	-20.2944	-31.6766	37.62	57.35	6.55	4.29	37.37	3909945.758	11686392.86
86	-20.9304	-32.7283	38.85	57.40	6.60	4.47	38.59	3909945.772	11686392.97
88	-21.5011	-33.7978	40.06	57.54	6.74	4.70	39.78	3909945.792	11686393.07
90	-22.0306	-34.9133	41.28	57.75	6.95	4.99	40.98	3909945.816	11686393.16

CALCULATION OF DEVIATION AT INCREMENTAL DEPTHS FOR CROSSHOLE CASINGS

Casing No. B-802C

Prepared by: CQJ Date: 1-8/03

Checked by: BKB Date: 1/8/03

Depth, ft	A Deviation	B Deviation	Resultant	Angle y	calc angle	Delta N(in)	Delta E(in)	N (ft)	E (ft)
0	0	0	0	0				3909947.32	11686379.75
2	0.3226	0.433	0.54	53.31	43.31	0.37	0.39	3909947.351	11686379.78
4	0.6355	0.8462	1.06	53.09	43.09	0.72	0.77	3909947.38	11686379.81
6	0.9288	1.2691	1.57	53.80	43.80	1.09	1.14	3909947.411	11686379.84
8	1.1698	1.7208	2.08	55.79	45.79	1.49	1.45	3909947.444	11686379.87
10	1.3973	2.219	2.62	57.80	47.80	1.94	1.76	3909947.482	11686379.9
12	1.5893	2.7624	3.19	60.09	50.09	2.44	2.04	3909947.524	11686379.92
14	1.7333	3.3302	3.75	62.50	52.50	2.98	2.29	3909947.568	11686379.94
16	1.8734	3.899	4.33	64.34	54.34	3.51	2.52	3909947.613	11686379.96
18	1.9973	4.4875	4.91	66.01	56.01	4.07	2.75	3909947.659	11686379.98
20	2.124	5.1077	5.53	67.42	57.42	4.66	2.98	3909947.708	11686380
22	2.257	5.7442	6.17	68.55	58.55	5.27	3.22	3909947.759	11686380.02
24	2.3784	6.4109	6.84	69.65	59.65	5.90	3.46	3909947.812	11686380.04
26	2.4835	7.0805	7.50	70.67	60.67	6.54	3.68	3909947.865	11686380.06
28	2.5747	7.7587	8.17	71.64	61.64	7.19	3.88	3909947.919	11686380.07
30	2.6726	8.4427	8.86	72.43	62.43	7.85	4.10	3909947.974	11686380.09
32	2.7854	9.1856	9.60	73.13	63.13	8.56	4.34	3909948.034	11686380.11
34	2.976	10.0373	10.47	73.49	63.49	9.37	4.67	3909948.101	11686380.14
36	3.2242	10.9906	11.45	73.65	63.65	10.26	5.08	3909948.175	11686380.17
38	3.4522	11.9856	12.47	73.93	63.93	11.20	5.48	3909948.254	11686380.21
40	3.694	12.9878	13.50	74.12	64.12	12.15	5.89	3909948.332	11686380.24
42	3.8054	13.9795	14.49	74.77	64.77	13.11	6.18	3909948.412	11686380.26
44	3.9106	14.9683	15.47	75.36	65.36	14.06	6.45	3909948.492	11686380.29
46	3.9643	15.9706	16.46	76.06	66.06	15.04	6.68	3909948.573	11686380.31
48	3.9926	16.9805	17.44	76.77	66.77	16.03	6.88	3909948.656	11686380.32
50	4.0186	17.9674	18.41	77.39	67.39	17.00	7.08	3909948.736	11686380.34
51	4.031	18.9355	19.36	77.98	67.98	17.95	7.26	3909948.816	11686380.35
54	4.0459	19.8677	20.28	78.49	68.49	18.86	7.43	3909948.892	11686380.37
56	4.0517	20.7802	21.17	78.97	68.97	19.76	7.60	3909948.967	11686380.38
58	4.0277	21.7061	22.08	79.49	69.49	20.68	7.74	3909949.043	11686380.39
60	4.0162	22.6718	23.02	79.95	69.95	21.63	7.89	3909949.122	11686380.41
62	4.009	23.7077	24.04	80.40	70.40	22.65	8.06	3909949.208	11686380.42

64	4.0382	24.9307	25.26	80.80	70.80	23.85	8.31	3909949.308	11686380.44
66	4.0872	26.2402	26.56	81.15	71.15	25.13	8.58	3909949.414	11686380.47
68	4.1098	27.5635	27.87	81.52	71.52	26.43	8.83	3909949.523	11686380.49
70	4.1218	28.9061	29.20	81.88	71.88	27.75	9.08	3909949.633	11686380.51
72	4.1453	30.2366	30.52	82.19	72.19	29.06	9.33	3909949.741	11686380.53
74	4.2043	31.5038	31.78	82.40	72.40	30.30	9.61	3909949.845	11686380.55
76	4.2941	32.7226	33.00	82.52	72.52	31.48	9.91	3909949.943	11686380.58
78	4.3589	33.935	34.21	82.68	72.68	32.66	10.19	3909950.042	11686380.6
80	4.4064	35.1403	35.42	82.85	72.85	33.84	10.44	3909950.14	11686380.62
82	4.4323	36.3216	36.59	83.04	73.04	35.00	10.67	3909950.237	11686380.64
84	4.4774	37.4674	37.73	83.19	73.19	36.12	10.92	3909950.33	11686380.66
86	4.5451	38.5896	38.86	83.28	73.28	37.21	11.18	3909950.421	11686380.68
88	4.584	39.6696	39.93	83.41	73.41	38.27	11.40	3909950.509	11686380.7
90	4.6267	40.7078	40.97	83.52	73.52	39.29	11.63	3909950.594	11686380.72

CROSSHOLE CASING DISTANCE CALCULATION SHEET

NORTH ANNA ESP PROJECT — Prepared by: JAS — Date: 1-9-03

MACTEC JOB NO. 30720-2-5400 — Checked by: BKB — Date: 1/8/03

	B-805A		B-805B		Delta N	Delta E	Distance, ft
Depth, ft	N	E	N	E			
0	3910364.026	11686236.69	3910354.987	11686240.74	9.039	-4.051	9.91
2	3910364.048	11686236.68	3910354.982	11686240.73	9.066090599	-4.048924	9.93
4	3910364.064	11686236.67	3910354.973	11686240.71	9.091124818	-4.041354	9.95
6	3910364.074	11686236.66	3910354.968	11686240.69	9.106526772	-4.034219	9.96
8	3910364.07	11686236.64	3910354.968	11686240.67	9.10207588	-4.031221	9.95
10	3910364.049	11686236.62	3910354.979	11686240.65	9.070460818	-4.031622	9.93
12	3910364.017	11686236.58	3910354.989	11686240.63	9.028436542	-4.044928	9.89
14	3910363.971	11686236.53	3910354.98	11686240.6	8.990443387	-4.061367	9.87
16	3910363.911	11686236.48	3910354.969	11686240.56	8.942413297	-4.076217	9.83
18	3910363.843	11686236.43	3910354.963	11686240.52	8.880154132	-4.090536	9.78
20	3910363.767	11686236.37	3910354.97	11686240.48	8.796807952	-4.104496	9.71
22	3910363.681	11686236.32	3910354.989	11686240.43	8.691540767	-4.111241	9.61
24	3910363.582	11686236.26	3910355.026	11686240.35	8.556378063	-4.087378	9.48
26	3910363.47	11686236.2	3910355.078	11686240.24	8.391564746	-4.039951	9.31
28	3910363.348	11686236.14	3910355.152	11686240.12	8.196011243	-3.978371	9.11
	0						

CALCULATION OF DEVIATION AT INCREMENTAL DEPTHS FOR CROSSHOLE CASINGS

Casing No. B-805B

Prepared by: JAZ Date: 1-9-03

Checked by: BKB Date: 1/8/03

Depth, ft	A Deviatior	B Deviatior	Resultant	Angle y	calc angle	Delta N, in	Delta E, in	N, ft	E, ft
0	0	0	0	0				3910354.987	11686240.74
2	-0.1464	-0.0211	0.147913	8.201318	25.16132	-0.0628878	-0.1338779	3910354.982	11686240.73
4	-0.3782	-0.0581	0.382637	8.733639	25.69364	-0.1658956	-0.3448036	3910354.973	11686240.71
6	-0.6029	-0.059	0.60578	5.589188	22.54919	-0.2323024	-0.5594685	3910354.968	11686240.69
8	-0.8122	0.012	0.812289	0.846466	16.11353	-0.2254439	-0.7803768	3910354.968	11686240.67
10	-1.0296	0.2098	1.050758	11.51739	5.442607	-0.0996629	-1.0460208	3910354.979	11686240.65
12	-1.2893	0.4128	1.353772	17.7537	0.793701	0.01875279	-1.353642	3910354.989	11686240.63
14	-1.681	0.4306	1.735274	14.36778	2.592219	-0.0784818	-1.7334988	3910354.98	11686240.6
16	-2.1408	0.4267	2.18291	11.27236	5.687645	-0.2163377	-2.1721638	3910354.969	11686240.56
18	-2.6179	0.4992	2.665071	10.79596	6.164036	-0.2861628	-2.6496626	3910354.963	11686240.52
20	-3.0605	0.7224	3.144602	13.281	3.679	-0.2017783	-3.1381217	3910354.97	11686240.48
22	-3.5659	1.1131	3.73559	17.33582	0.375817	0.02450245	-3.7355099	3910354.989	11686240.43
24	-4.3709	1.8226	4.735677	22.63541	5.675407	0.4683236	-4.7124633	3910355.026	11686240.35
26	-5.4053	2.795	6.08517	27.34281	10.38281	1.09669397	-5.9855288	3910355.078	11686240.24
28	-6.5424	4.0685	7.704264	31.8761	14.9161	1.98311109	-7.4446599	3910355.152	11686240.12
30	-7.6099	5.7158	9.517402	36.91023	19.95023	3.24737374	-8.9462568	3910355.258	11686239.99

CALCULATION OF DEVIATION AT INCREMENTAL DEPTHS FOR CROSSHOLE CASINGS

Casing No. B-805A | Prepared by: JBJ | Date: 1-8-03
Checked by: BKB | Date: 1/8/03

Depth, ft	A Deviation	B Deviation	Resultant	Angle x	calc angle	Delta N, in	Delta E in	N, ft	E, ft
0	0	0	0	0				3910364.026	11686236.689
2	-0.2275	0.1699	0.283941	36.75286	67.43286	0.262199	-0.108967	3910364.048	11686236.680
4	-0.4315	0.2784	0.513516	32.82975	63.50975	0.459602	-0.229052	3910364.064	11686236.670
6	-0.6029	0.3144	0.679953	27.54112	58.22112	0.578019	-0.358092	3910364.074	11686236.659
8	-0.7382	0.18	0.759828	13.70339	44.38339	0.531467	-0.543031	3910364.07	11686236.644
10	-0.8414	-0.1761	0.859631	11.82103	18.85897	0.277867	-0.813483	3910364.049	11686236.621
12	-1.0464	-0.7464	1.285327	35.50037	4.820368	-0.108009	-1.280781	3910364.017	11686236.582
14	-1.2605	-1.5166	1.972038	50.26883	19.58883	-0.661161	-1.857903	3910363.971	11686236.534
16	-1.4266	-2.4456	2.83128	59.74356	29.06356	-1.375378	-2.474769	3910363.911	11686236.483
18	-1.5682	-3.4795	3.816565	65.73906	35.05906	-2.192313	-3.124089	3910363.843	11686236.429
20	-1.6651	-4.6018	4.893784	70.10802	39.42802	-3.108083	-3.780072	3910363.767	11686236.374
22	-1.7194	-5.8397	6.087564	73.59383	42.91383	-4.145008	-4.458401	3910363.681	11686236.317
24	-1.7122	-7.2053	7.405942	76.6327	45.9527	-5.32314	-5.148996	3910363.582	11686236.260
26	-1.6291	-8.725	8.875787	79.42373	48.74373	-6.672529	-5.852943	3910363.47	11686236.201
28	-1.5034	-10.3483	10.45694	81.73391	51.05391	-8.132754	-6.573115	3910363.348	11686236.141

DEVIATION SURVEY RECORDS FOR ALL THREE CASINGS
(ONLY SURVEYS FOR RECEIVER CASINGS USED IN CALCULATIONS)

SITE : NANPP
INSTALLATION : 802A
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 1:35:39 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 1:52:48 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	113	-126	0.1147	-0.1147
4	80	-88	0.0806	-0.1954
6	23	-33	0.0269	-0.2222
8	-1	-7	0.0029	-0.2251
10	-18	10	-0.0134	-0.2117
12	-48	41	-0.0427	-0.1690
14	-106	94	-0.0960	-0.0730
16	-129	123	-0.1210	0.0480
18	-155	143	-0.1430	0.1910
20	-178	169	-0.1666	0.3576
22	-214	204	-0.2006	0.5582
24	-238	229	-0.2242	0.7824
26	-261	251	-0.2458	1.0282
28	-267	258	-0.2520	1.2802
30	-278	271	-0.2635	1.5437
32	-292	284	-0.2765	1.8202
34	-310	301	-0.2933	2.1134
36	-299	292	-0.2837	2.3971
38	-261	253	-0.2467	2.6438
40	-233	222	-0.2184	2.8622
42	-209	197	-0.1949	3.0571
44	-147	140	-0.1378	3.1949
46	-148	137	-0.1368	3.3317
48	-151	145	-0.1421	3.4738
50	-149	140	-0.1387	3.6125
52	-127	116	-0.1166	3.7291
54	-110	103	-0.1022	3.8314
56	-92	83	-0.0840	3.9154
58	-88	80	-0.0806	3.9960
60	-105	97	-0.0970	4.0930
62	-130	119	-0.1195	4.2125
64	-122	112	-0.1123	4.3248
66	-146	135	-0.1349	4.4597
68	-157	151	-0.1478	4.6075
70	-194	182	-0.1805	4.7880
72	-227	216	-0.2126	5.0006
74	-269	263	-0.2554	5.2560
76	-320	307	-0.3010	5.5570
78	-330	322	-0.3130	5.8699
80	-353	343	-0.3341	6.2040
82	-382	370	-0.3610	6.5650
84	-385	377	-0.3658	6.9307

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	-441	428	-0.4171	7.3478
88	-496	488	-0.4723	7.8202
90	-573	561	-0.5443	8.3645

SITE : NANPP
INSTALLATION : 802A
DESCRIPTION : Entered Manually

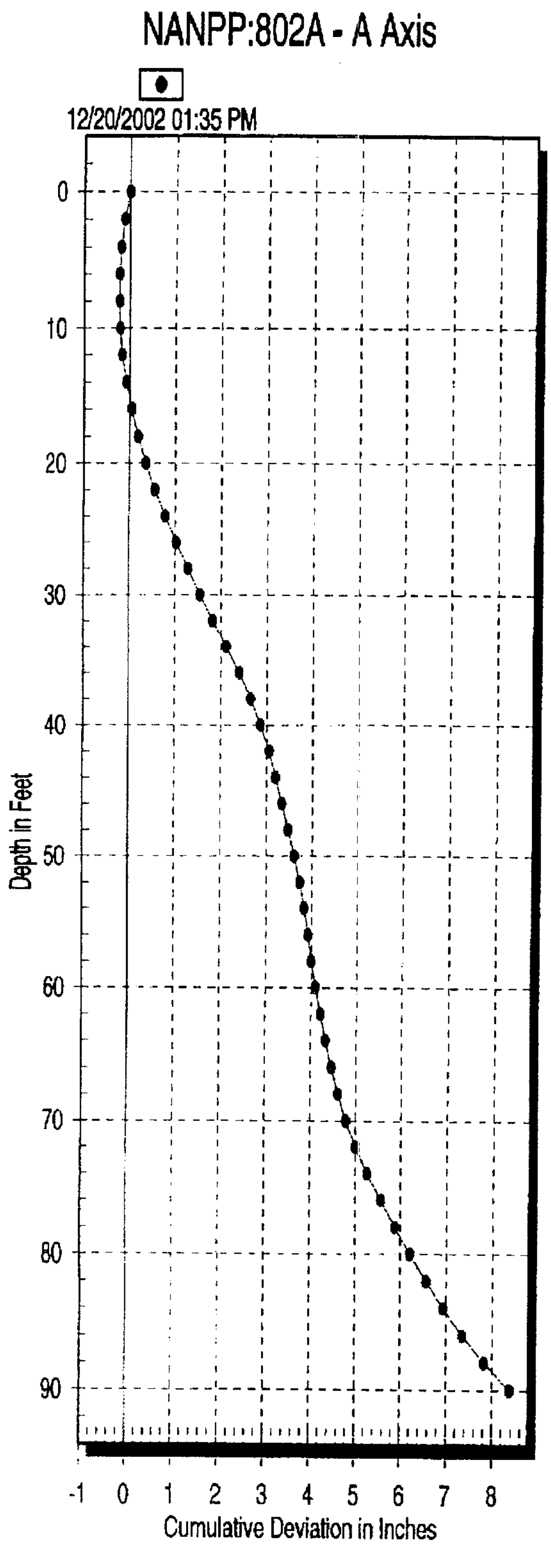
CURRENT SURVEY : 12/20/2002 1:35:39 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 1:52:48 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	344	-348	0.3322	-0.3322
4	306	-312	0.2966	-0.6288
6	221	-239	0.2208	-0.8496
8	108	-117	0.1080	-0.9576
10	8	-17	0.0120	-0.9696
12	-91	85	-0.0845	-0.8851
14	-72	73	-0.0696	-0.8155
16	-58	54	-0.0538	-0.7618
18	-31	28	-0.0283	-0.7334
20	-12	6	-0.0086	-0.7248
22	-27	21	-0.0230	-0.7018
24	-14	12	-0.0125	-0.6893
26	-34	27	-0.0293	-0.6600
28	-66	63	-0.0619	-0.5981
30	-89	83	-0.0826	-0.5155
32	-99	97	-0.0941	-0.4214
34	-80	84	-0.0787	-0.3427
36	-64	58	-0.0586	-0.2842
38	-34	31	-0.0312	-0.2530
40	-8	3	-0.0053	-0.2477
42	28	-30	0.0278	-0.2755
44	92	-96	0.0902	-0.3658
46	108	-113	0.1061	-0.4718
48	147	-153	0.1440	-0.6158
50	198	-200	0.1910	-0.8069
52	210	-208	0.2006	-1.0075
54	246	-239	0.2328	-1.2403
56	272	-276	0.2630	-1.5034
58	276	-280	0.2669	-1.7702
60	250	-256	0.2429	-2.0131
62	216	-219	0.2088	-2.2219
64	266	-268	0.2563	-2.4782
66	267	-278	0.2616	-2.7398
68	258	-264	0.2506	-2.9904
70	251	-257	0.2438	-3.2342
72	235	-241	0.2285	-3.4627
74	214	-208	0.2026	-3.6653
76	164	-179	0.1646	-3.8299
78	152	-155	0.1474	-3.9773
80	142	-146	0.1382	-4.1155
82	119	-125	0.1171	-4.2326
84	114	-116	0.1104	-4.3430

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	84	-89	0.0830	-4.4261
88	16	-23	0.0187	-4.4448
90	-24	18	-0.0202	-4.4246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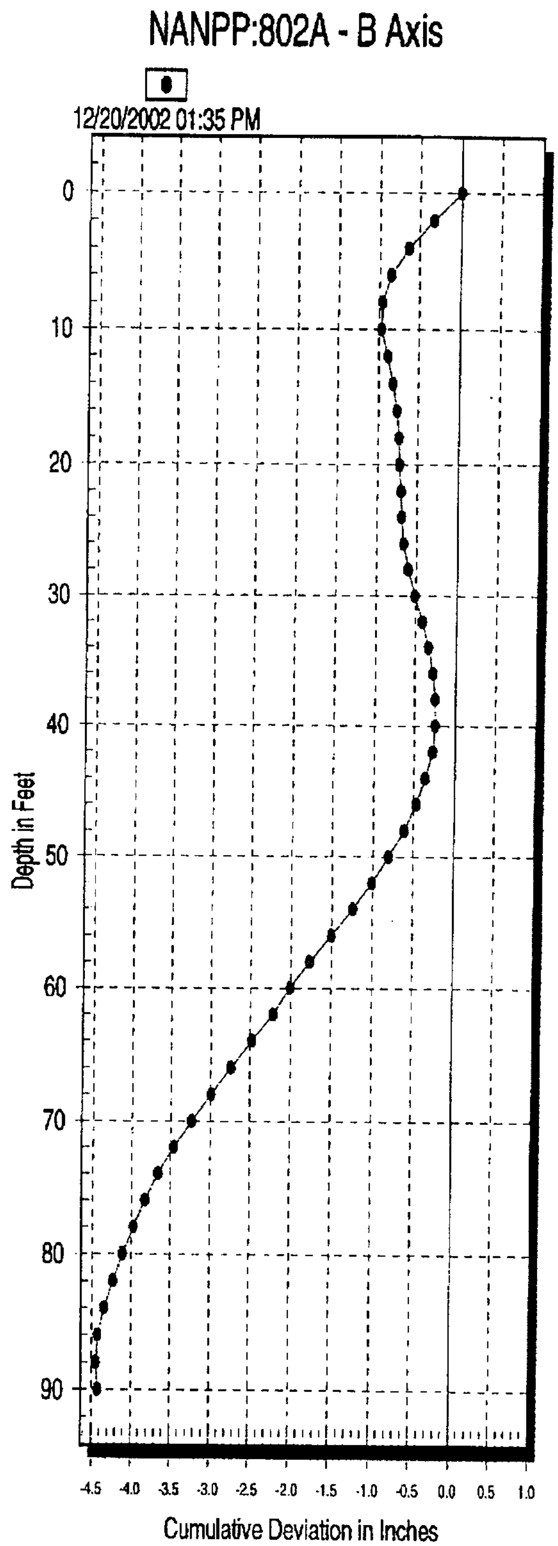
12/20/2002 01:35 PM
Depth in Feet
Cumulative Deviation in Inches


NANPP:802A - B Axis
12/20/2002 01:35 PM
Depth in Feet
Cumulative Deviation in Inches

SITE : NANPP
INSTALLATION : 802B
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 1:54:55 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:03:40 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	545	-567	0.5338	-0.5338
4	461	-472	0.4478	-0.9816
6	364	-375	0.3547	-1.3363
8	282	-298	0.2784	-1.6147
10	248	-260	0.2438	-1.8586
12	225	-236	0.2213	-2.0798
14	227	-238	0.2232	-2.3030
16	223	-235	0.2198	-2.5229
18	254	-262	0.2477	-2.7706
20	336	-349	0.3288	-3.0994
22	360	-372	0.3514	-3.4507
24	379	-390	0.3691	-3.8198
26	367	-375	0.3562	-4.1760
28	378	-388	0.3677	-4.5437
30	411	-422	0.3998	-4.9435
32	446	-455	0.4325	-5.3760
34	528	-544	0.5146	-5.8906
36	597	-608	0.5784	-6.4690
38	609	-623	0.5914	-7.0603
40	570	-579	0.5515	-7.6118
42	512	-537	0.5035	-8.1154
44	523	-534	0.5074	-8.6227
46	456	-471	0.4450	-9.0677
48	450	-465	0.4392	-9.5069
50	493	-504	0.4786	-9.9854
52	500	-515	0.4872	-10.4726
54	501	-509	0.4848	-10.9574
56	516	-520	0.4973	-11.4547
58	533	-544	0.5170	-11.9717
60	580	-589	0.5611	-12.5328
62	602	-614	0.5837	-13.1165
64	658	-673	0.6389	-13.7554
66	681	-692	0.6590	-14.4144
68	677	-691	0.6566	-15.0710
70	685	-696	0.6629	-15.7339
72	667	-673	0.6432	-16.3771
74	646	-662	0.6278	-17.0050
76	654	-668	0.6346	-17.6395
78	667	-680	0.6466	-18.2861
80	686	-698	0.6643	-18.9504
82	692	-704	0.6701	-19.6205
84	695	-709	0.6739	-20.2944

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	659	-666	0.6360	-20.9304
88	590	-599	0.5707	-21.5011
90	549	-554	0.5294	-22.0306

SITE : NANPP
INSTALLATION : 802B
DESCRIPTION : Entered Manually

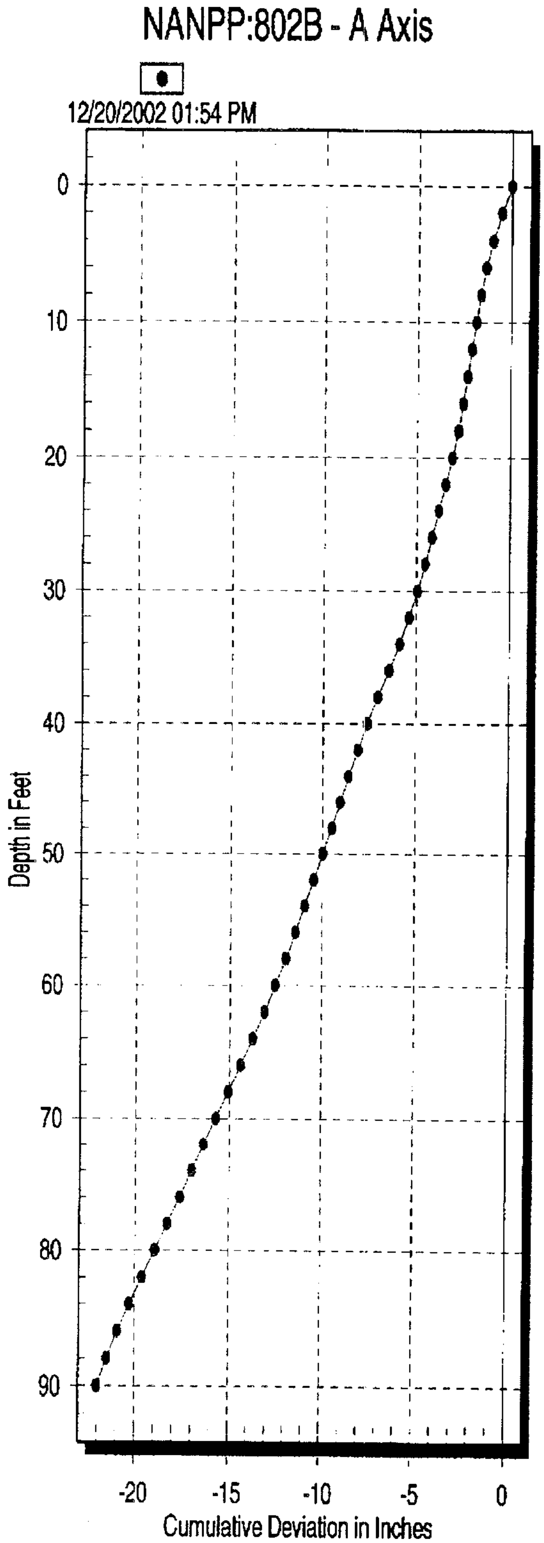
CURRENT SURVEY : 12/20/2002 1:54:55 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:03:40 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	93	-99	0.0922	-0.0922
4	156	-155	0.1493	-0.2414
6	264	-268	0.2554	-0.4968
8	346	-352	0.3350	-0.8318
10	423	-425	0.4070	-1.2389
12	483	-488	0.4661	-1.7050
14	554	-556	0.5328	-2.2378
16	596	-596	0.5722	-2.8099
18	600	-604	0.5779	-3.3878
20	593	-593	0.5693	-3.9571
22	613	-608	0.5861	-4.5432
24	639	-637	0.6125	-5.1557
26	624	-627	0.6005	-5.7562
28	593	-599	0.5722	-6.3283
30	578	-580	0.5558	-6.8842
32	574	-577	0.5525	-7.4366
34	516	-523	0.4987	-7.9354
36	588	-588	0.5645	-8.4998
38	645	-648	0.6206	-9.1205
40	716	-719	0.6888	-9.8093
42	778	-784	0.7498	-10.5590
44	803	-787	0.7632	-11.3222
46	810	-802	0.7738	-12.0960
48	805	-808	0.7742	-12.8702
50	820	-820	0.7872	-13.6574
52	847	-844	0.8117	-14.4691
54	898	-895	0.8606	-15.3298
56	954	-962	0.9197	-16.2494
58	1004	-1012	0.9677	-17.2171
60	1077	-1084	1.0373	-18.2544
62	1144	-1187	1.1189	-19.3733
64	1225	-1228	1.1774	-20.5507
66	1235	-1235	1.1856	-21.7363
68	1222	-1225	1.1746	-22.9109
70	1211	-1217	1.1654	-24.0763
72	1161	-1162	1.1150	-25.1914
74	1170	-1172	1.1242	-26.3155
76	1172	-1174	1.1261	-27.4416
78	1126	-1130	1.0829	-28.5245
80	1101	-1103	1.0579	-29.5824
82	1096	-1084	1.0464	-30.6288
84	1092	-1091	1.0478	-31.6766

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	1092	-1099	1.0517	-32.7283
88	1110	-1118	1.0694	-33.7978
90	1154	-1170	1.1155	-34.9133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12/20/2002 01:54 PM
Depth in Feet
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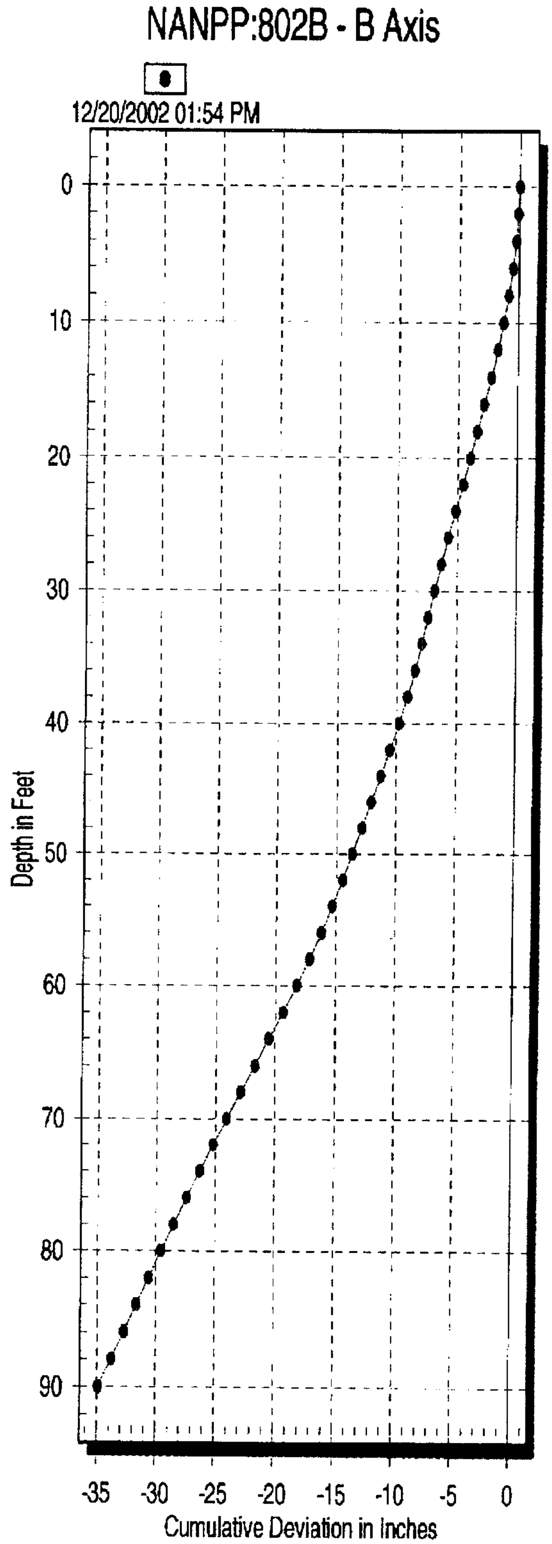
30
40
50
60
70
80
90
-20
-15
-10
-5
0
Cumulative Deviation in Inches


NANPP:802B - B Axis
12/20/2002 01:54 PM
Depth in Feet
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10
20
30
40
50
60
70
80
90
-35
-30
-25
-20
-15
-10
-5
0
Cumulative Deviation in Inches

SITE : NANPP
INSTALLATION : 802C
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 2:04:16 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:12:11 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	-347	325	-0.3226	0.3226
4	-331	321	-0.3130	0.6355
6	-311	300	-0.2933	0.9288
8	-256	246	-0.2410	1.1698
10	-243	231	-0.2275	1.3973
12	-204	196	-0.1920	1.5893
14	-155	145	-0.1440	1.7333
16	-151	141	-0.1402	1.8734
18	-133	125	-0.1238	1.9973
20	-136	128	-0.1267	2.1240
22	-146	131	-0.1330	2.2570
24	-131	122	-0.1214	2.3784
26	-115	104	-0.1051	2.4835
28	-99	91	-0.0912	2.5747
30	-109	95	-0.0979	2.6726
32	-123	112	-0.1128	2.7854
34	-204	193	-0.1906	2.9760
36	-266	251	-0.2482	3.2242
38	-246	229	-0.2280	3.4522
40	-212	199	-0.1973	3.6494
42	-169	156	-0.1560	3.8054
44	-117	102	-0.1051	3.9106
46	-60	52	-0.0538	3.9643
48	-38	21	-0.0283	3.9926
50	-30	24	-0.0259	4.0186
52	-18	8	-0.0125	4.0310
54	-19	12	-0.0149	4.0459
56	-10	2	-0.0058	4.0517
58	19	-31	0.0240	4.0277
60	5	-19	0.0115	4.0162
62	1	-14	0.0072	4.0090
64	-36	25	-0.0293	4.0382
66	-60	42	-0.0490	4.0872
68	-30	17	-0.0226	4.1098
70	-20	5	-0.0120	4.1218
72	-34	15	-0.0235	4.1453
74	-65	58	-0.0590	4.2043
76	-100	87	-0.0898	4.2941
78	-74	61	-0.0648	4.3589
80	-55	44	-0.0475	4.4064
82	-34	20	-0.0259	4.4323
84	-53	41	-0.0451	4.4774

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	-79	62	-0.0677	4.5451
88	-36	45	-0.0389	4.5840
90	-50	39	-0.0427	4.6267

SITE : NANPP
INSTALLATION : 802C
DESCRIPTION : Entered Manually

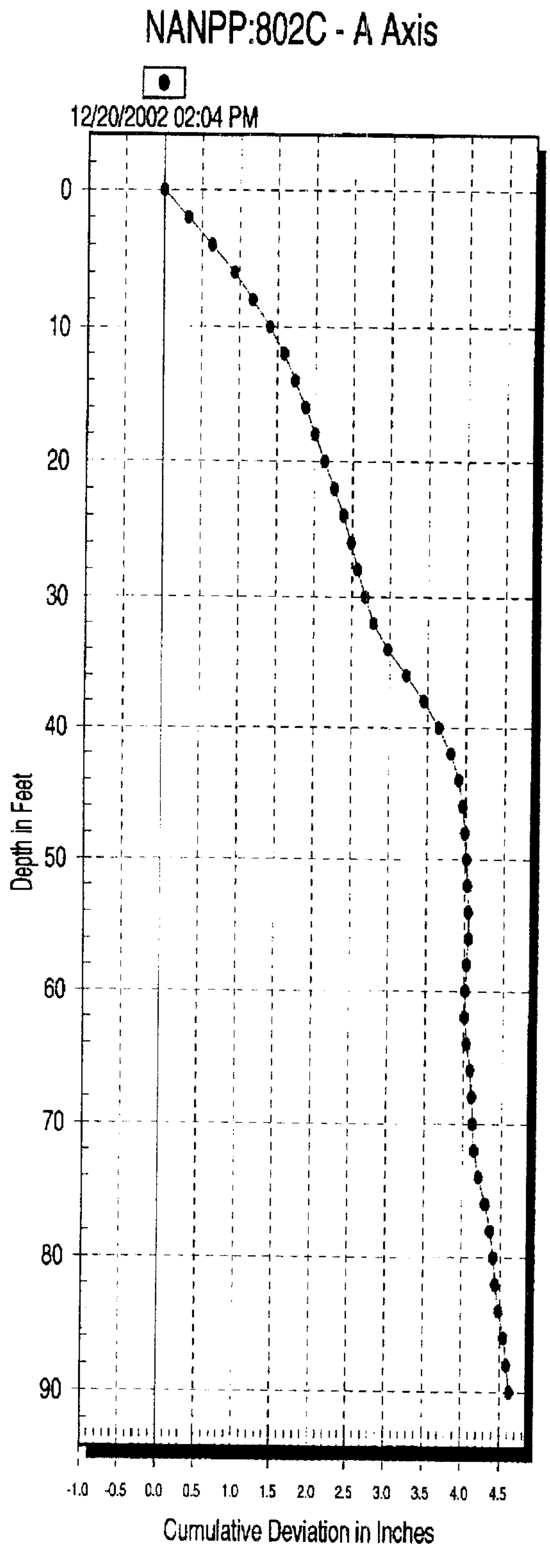
CURRENT SURVEY : 12/20/2002 2:04:16 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:12:11 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	-452	450	-0.4330	0.4330
4	-430	431	-0.4133	0.8462
6	-440	441	-0.4229	1.2691
8	-470	471	-0.4517	1.7208
10	-520	518	-0.4982	2.2190
12	-565	567	-0.5434	2.7624
14	-592	591	-0.5678	3.3302
16	-593	592	-0.5688	3.8990
18	-614	612	-0.5885	4.4875
20	-648	644	-0.6202	5.1077
22	-662	664	-0.6365	5.7442
24	-692	697	-0.6667	6.4109
26	-696	699	-0.6696	7.0805
28	-706	707	-0.6782	7.7587
30	-715	710	-0.6840	8.4427
32	-755	751	-0.7229	9.1656
34	-905	911	-0.8717	10.0373
36	-995	991	-0.9533	10.9906
38	-1039	1034	-0.9950	11.9856
40	-1044	1044	-1.0022	12.9878
42	-1031	1035	-0.9917	13.9795
44	-1028	1032	-0.9888	14.9683
46	-1040	1048	-1.0022	15.9706
48	-1053	1051	-1.0099	16.9805
50	-1027	1029	-0.9869	17.9674
52	-1006	1011	-0.9682	18.9355
54	-969	973	-0.9322	19.8677
56	-951	950	-0.9125	20.7802
58	-964	965	-0.9259	21.7061
60	-1010	1002	-0.9658	22.6718
62	-1080	1078	-1.0358	23.7077
64	-1274	1274	-1.2230	24.9307
66	-1365	1363	-1.3094	26.2402
68	-1378	1379	-1.3234	27.5635
70	-1398	1399	-1.3426	28.9061
72	-1387	1385	-1.3306	30.2366
74	-1323	1317	-1.2672	31.5038
76	-1272	1267	-1.2187	32.7226
78	-1263	1263	-1.2125	33.9350
80	-1256	1255	-1.2053	35.1403
82	-1230	1231	-1.1813	36.3216
84	-1192	1195	-1.1458	37.4674

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
86	-1170	1168	-1.1222	38.5896
88	-1122	1128	-1.0800	39.6696
90	-1082	1081	-1.0382	40.7078



NANPP:802C - A Axis
12/20/2002 02:04 PM
Depth in Feet
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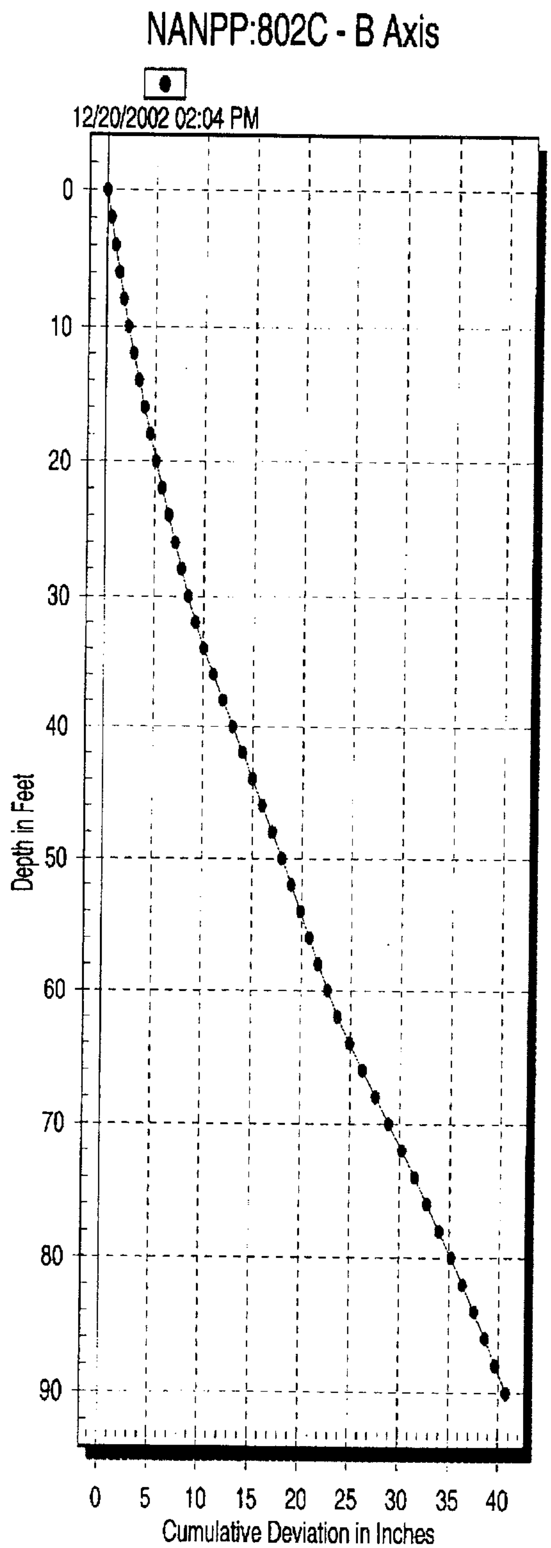
10
20
30
40
50
60
70
80
90
-1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Cumulative Deviation in Inches



NANPP:802C - B Axis
12/20/2002 02:04 PM
Depth in Feet
0
10
20
30
40
50
60
70
80
90
0 5 10 15 20 25 30 35 40
Cumulative Deviation in Inches

SITE : NANPP
INSTALLATION : 805A
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/19/2002 5:28:37 PM
Probe Serial No : 2591

DATE PRINTED : 1/14/2003 1:27:11 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	230	-244	0.2275	-0.2275
4	209	-216	0.2040	-0.4315
6	172	-185	0.1714	-0.6029
8	137	-145	0.1354	-0.7382
10	104	-111	0.1032	-0.8414
12	210	-217	0.2050	-1.0464
14	218	-228	0.2141	-1.2605
16	168	-178	0.1661	-1.4266
18	144	-151	0.1416	-1.5682
20	97	-105	0.0970	-1.6651
22	53	-60	0.0542	-1.7194
24	-13	2	-0.0072	-1.7122
26	-92	81	-0.0830	-1.6291
28	-135	127	-0.1258	-1.5034

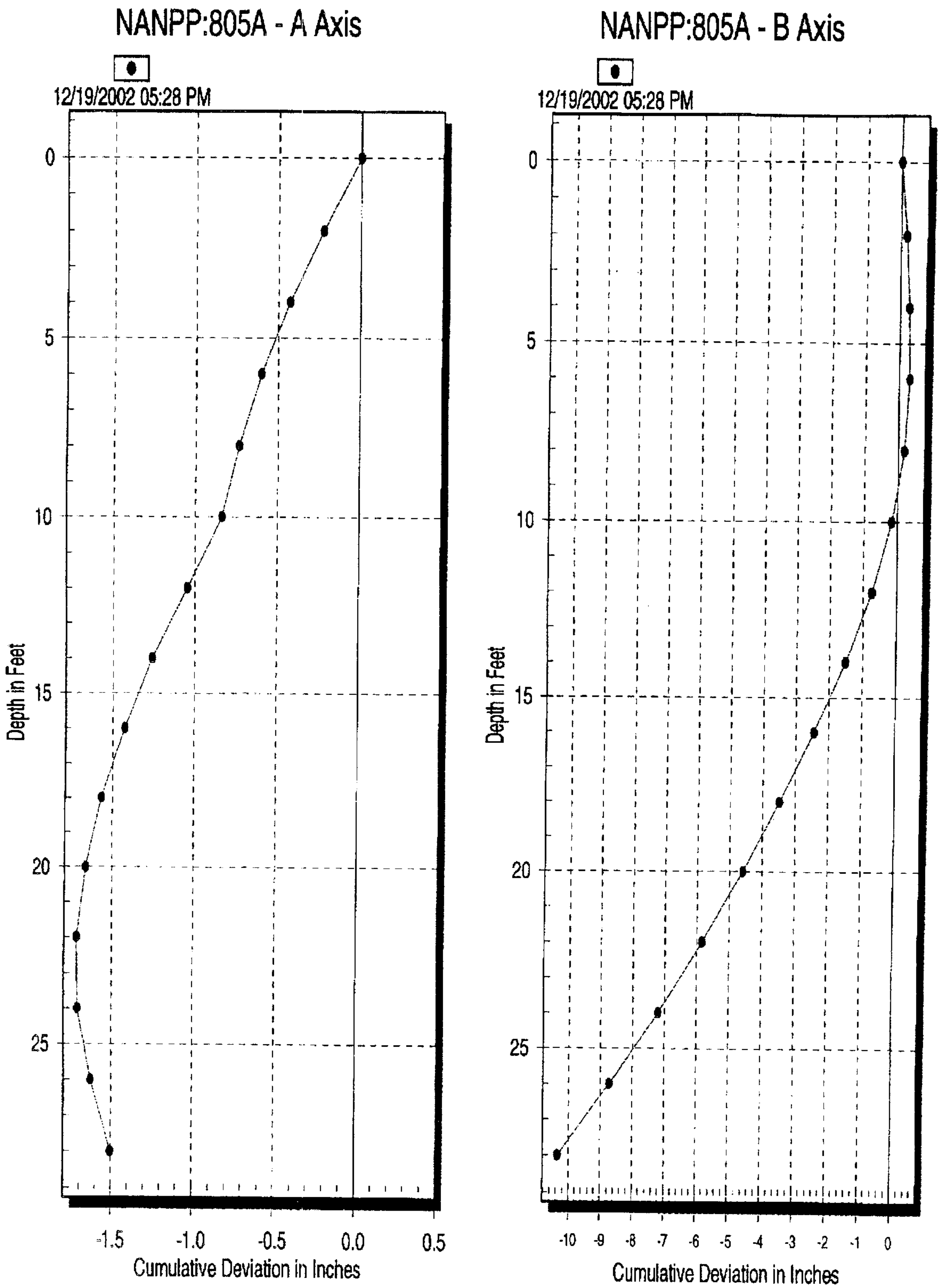
SITE : NANPP
INSTALLATION : 805A
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/19/2002 5:28:37 PM
Probe Serial No : 2591

DATE PRINTED : 1/14/2003 1:27:11 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (In)
0	0	0	0.0000	0.0000
2	-178	176	-0.1699	0.1699
4	-116	110	-0.1085	0.2784
6	-42	33	-0.0360	0.3144
8	134	-146	0.1344	0.1800
10	366	-380	0.3581	-0.1781
12	586	-598	0.5683	-0.7464
14	796	-809	0.7704	-1.5168
16	964	-971	0.9288	-2.4456
18	1073	-1081	1.0339	-3.4795
20	1166	-1172	1.1222	-4.6018
22	1285	-1294	1.2379	-5.8397
24	1419	-1426	1.3656	-7.2053
26	1576	-1590	1.5197	-8.7250
28	1687	-1695	1.6234	-10.3483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12/19/2002 05:28 PM
Depth in Feet
0
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10
15
20
25
-1.5
-1.0
-0.5
0.0
0.5
Cumulative Deviation in Inches
NANPP:805A - B Axis
12/19/2002 05:28 PM
Depth in Feet
0
5
10
15
20
25
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
Cumulative Deviation in Inches

SITE : NANPP
INSTALLATION : 805B
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 12:14:33 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:18:14 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	144	-161	0.1464	-0.1464
4	237	-246	0.2318	-0.3782
6	228	-240	0.2246	-0.6029
8	213	-223	0.2093	-0.8122
10	222	-231	0.2174	-1.0296
12	264	-277	0.2597	-1.2893
14	402	-414	0.3917	-1.6810
16	475	-483	0.4598	-2.1408
18	491	-503	0.4771	-2.6179
20	457	-465	0.4426	-3.0605
22	523	-530	0.5054	-3.5659
24	831	-846	0.8050	-4.3709
26	1072	-1083	1.0344	-5.4053
28	1178	-1191	1.1371	-6.5424
30	1107	-1117	1.0675	-7.6099

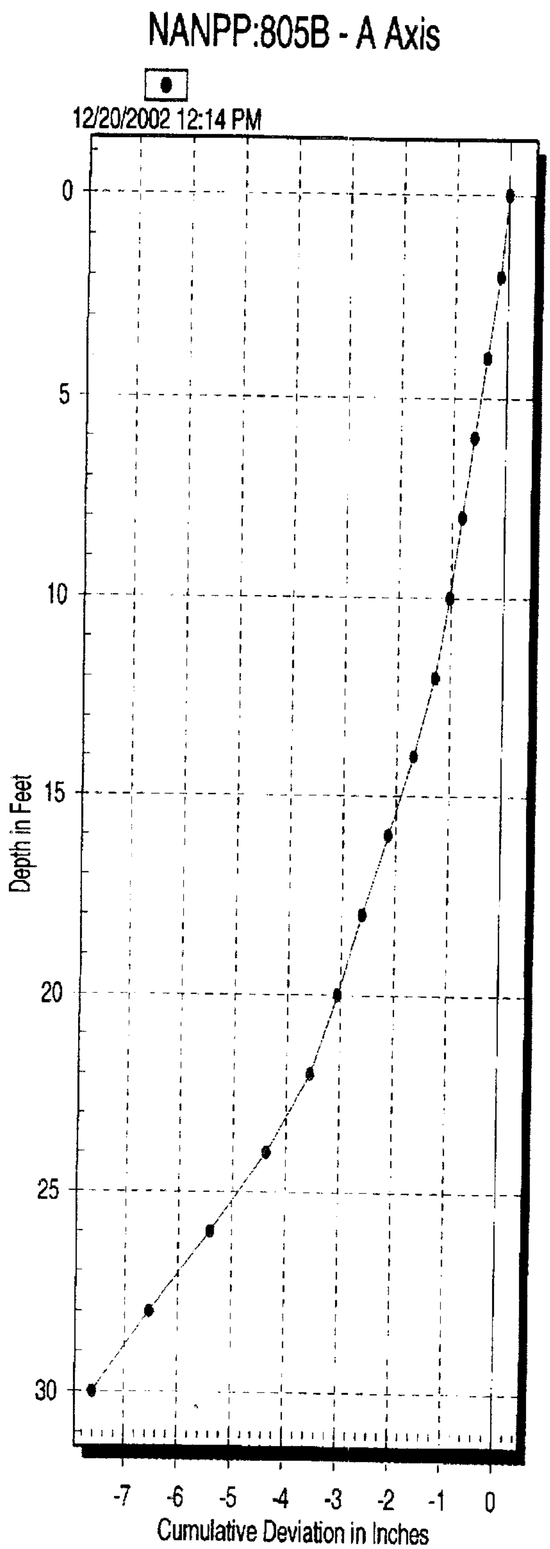
SITE : NANPP
INSTALLATION : 805B
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 12:14:33 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 2:18:14 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	24	-20	0.0211	-0.0211
4	39	-38	0.0370	-0.0581
6	1	-1	0.0010	-0.0590
8	-78	70	-0.0710	0.0120
10	-207	205	-0.1978	0.2098
12	-218	205	-0.2030	0.4128
14	-19	18	-0.0178	0.4306
16	5	-3	0.0038	0.4267
18	-78	73	-0.0725	0.4992
20	-235	230	-0.2232	0.7224
22	-409	405	-0.3907	1.1131
24	-741	737	-0.7094	1.8226
26	-1017	1009	-0.9725	2.7950
28	-1329	1324	-1.2734	4.0685
30	-1715	1717	-1.6474	5.7158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12/20/2002 12:14 PM
Depth in Feet
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25
30
-7
-6
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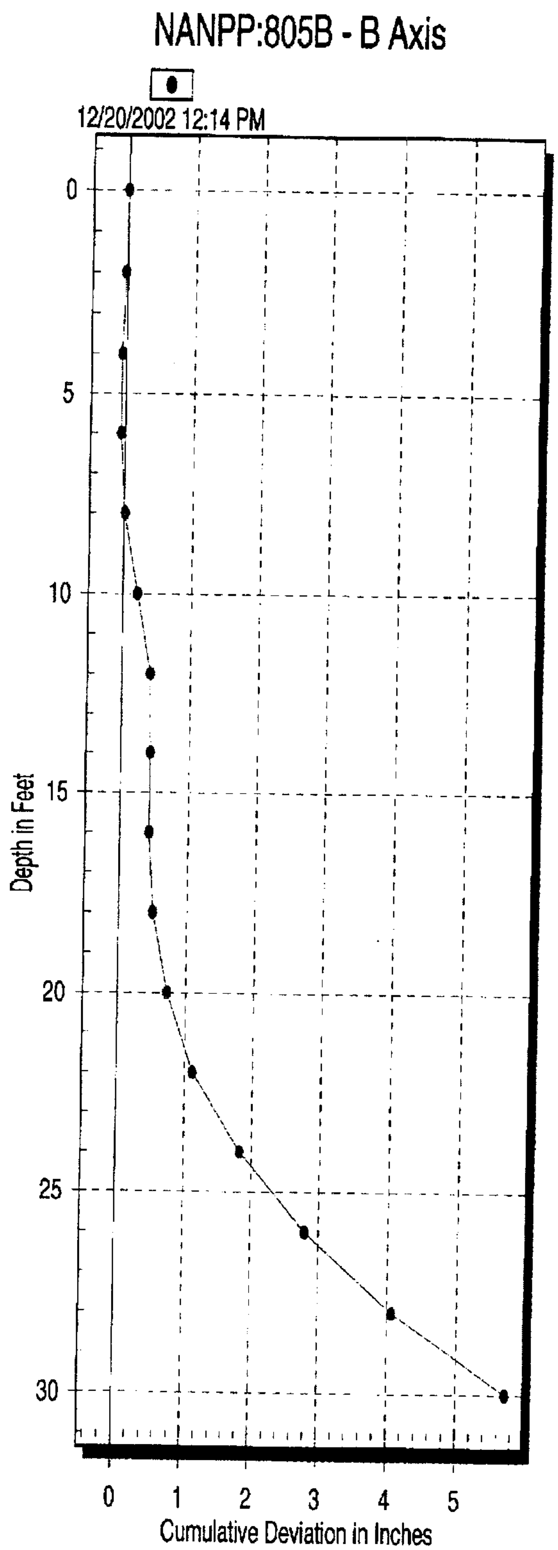
-4
-3
-2
-1
0
Cumulative Deviation in Inches


NANPP:805B - B Axis
12/20/2002 12:14 PM
Depth in Feet
0
5
10
15
20
25
30
0
1
2
3
4
5
Cumulative Deviation in Inches

SITE : NANPP
INSTALLATION : 805C
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 12:27:39 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 1:32:57 PM

Data Reduction for A Axis:

Depth (ft)	Current A0	Current A180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	-82	62	-0.0691	0.0691
4	-63	49	-0.0538	0.1229
6	-42	28	-0.0336	0.1565
8	10	-21	0.0149	0.1416
10	9	-19	0.0134	0.1282
12	-101	92	-0.0926	0.2208
14	-280	270	-0.2640	0.4848
16	-438	430	-0.4166	0.9014
18	-433	420	-0.4094	1.3109
20	-210	198	-0.1958	1.5067
22	-62	52	-0.0547	1.5614
24	61	-77	0.0662	1.4952
26	101	-110	0.1013	1.3939
28	205	-204	0.1963	1.1976
30	303	-316	0.2971	0.9005

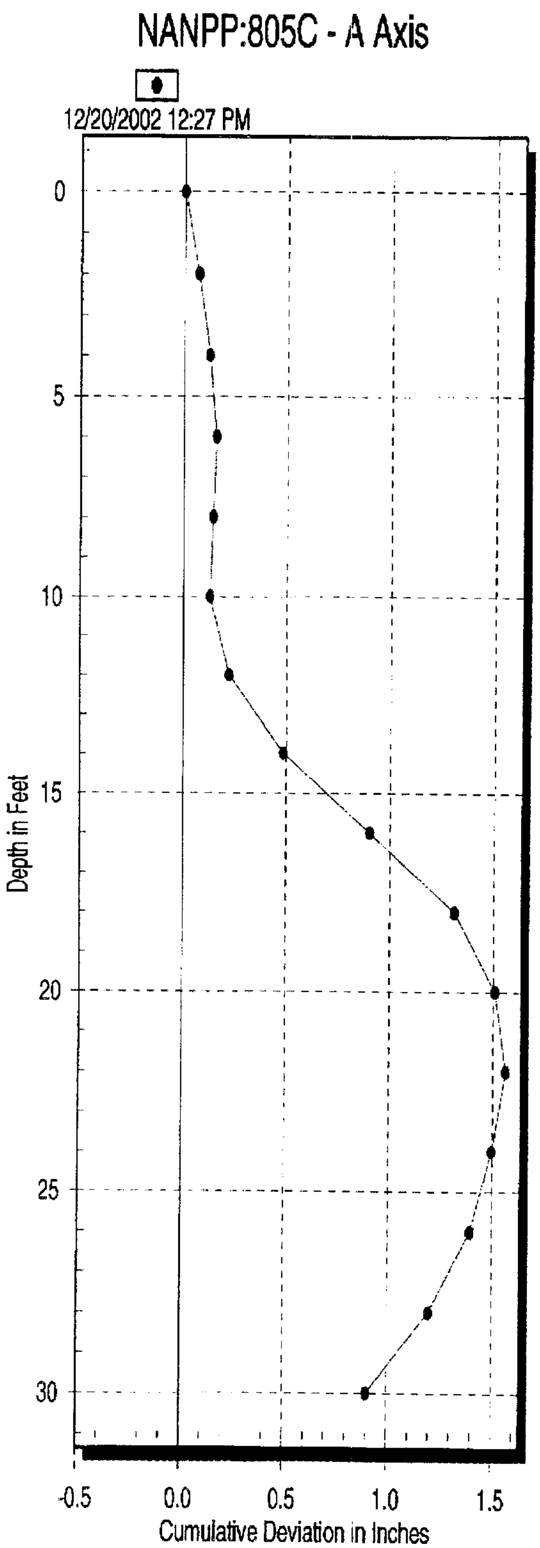
SITE : NANPP
INSTALLATION : 805C
DESCRIPTION : Entered Manually

CURRENT SURVEY : 12/20/2002 12:27:39 PM
Probe Serial No : 2591

DATE PRINTED : 12/20/2002 1:32:57 PM

Data Reduction for B Axis:

Depth (ft)	Current B0	Current B180	Current Incr. Dev. (in)	Cum. Dev. (in)
0	0	0	0.0000	0.0000
2	-75	77	-0.0730	0.0730
4	4	1	0.0014	0.0715
6	41	-40	0.0389	0.0326
8	29	-34	0.0302	0.0024
10	-11	16	-0.0130	0.0154
12	-86	84	-0.0816	0.0970
14	-194	206	-0.1920	0.2890
16	-336	332	-0.3206	0.6096
18	-484	481	-0.4632	1.0728
20	-610	599	-0.5803	1.6531
22	-796	791	-0.7618	2.4149
24	-1062	1059	-1.0181	3.4330
26	-1222	1209	-1.1669	4.5998
28	-1488	1476	-1.4227	6.0226
30	-1869	1848	-1.7842	7.8067


NANPP:805C - A Axis
12/20/2002 12:27 PM
Depth in Feet
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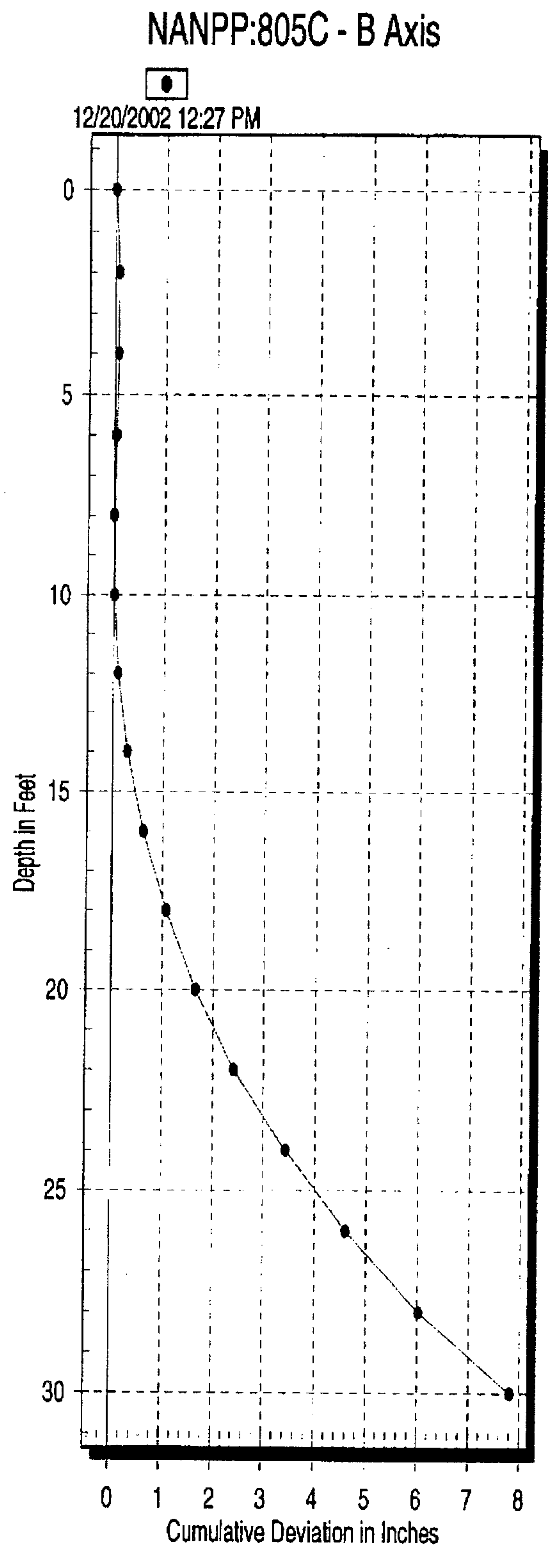
5
10
15
20
25
30
-0.5
0.0
0.5
1.0
1.5
Cumulative Deviation in Inches


NANPP:805C - B Axis
12/20/2002 12:27 PM
Depth in Feet
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
Cumulative Deviation in Inches

APPENDIX H
CROSSHOLE SEISMIC REPORT AND DATA

Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221
(614) 488-7860 tel; (614) 488-8945 fax

Non-destructive Subsurface Exploration
Near-surface Geophysics

January 14, 2003

Mr. J. Allan Tice
Mactec Engineering and Consulting Services, Inc.
3301 Atlantic Avenue
Raleigh, NC 22080

RE: Report of Cross-hole Seismic Testing, North Anna ESP Project, North Anna Nuclear Facility, Lake Anna, Virginia, GEI Project No. 01-22089, MACTEC JOB NO. 30720-2-5400

Dear Al:

Grumman Exploration, Inc. has completed the cross-hole seismic testing at the above referenced site located on Lake Anna, Virginia. This letter-report summarizes the field procedures used and results of the tests performed at this site. The attached spreadsheets and plots summarize the estimated seismic velocities for the boreholes tested.

Project Description

Mactec Engineering and Consulting Services, Inc. is engaged in geotechnical investigations at the above referenced site. Cross-hole seismic testing was requested to assist in the evaluation and design of possible structures and foundations proposed for this location. Among the requirements and assumptions of the cross-hole testing procedure are: homogeneous isotropic subsurface materials, horizontal layering of subsurface materials, receiver hole verticality, minimal lateral stratigraphic variability and low ambient noise. Estimating a P or S wave arrival time onset can be complicated by the presence of noise and other interfering wave trains.

Field Procedures

Grumman Exploration, Inc. conducted cross-hole seismic tests using boreholes B-805a, b, and c , and B-802a, b and c on December 12, 2002 as specified by Mactec Engineering and Consulting Services, Inc. The cross-hole seismic tests were performed in accordance with D-ASTM D4428/D4428M, with minor, approved exceptions noted on the field log. The depth of the two sets of test borings was approximately 29-ft and 92-ft for borings B-805 and B-802 respectively. The cross-hole tests in B-802 was performed in the bedrock portion of the hole (deeper than ~25-ft), while the testing performed in B-805 was performed entirely in the unconsolidated portion of the overburden. The receiver borings were lined with 2.875" diameter PVC inclinometer casing that were grouted in-place using a cement bentonite grout. Borehole deviation surveys were performed by Mactec Engineering and Consulting Services, Inc.

The following field equipment and procedures were used to conduct the tests:

- Geometrics, Inc. SmartSeis S-12, 12 channel, digital signal enhancement seismograph,
- Dual triaxial geophones, with mechanical sidewall clamping mechanisms [receiver holes], and
- Reversible polarity, dowhole impulse hammer source with trigger [shot hole]

In B-805 (soil/weathered rock boring), the tests were performed at intervals that corresponded to the approximate centers of the soil sampling intervals. In B-802, the tests were performed at 5-ft intervals to the end of the boring. The nominal receiver hole separation at the ground surface was approximately 10-ft however borehole deviation surveys were performed by Mactec Engineering and Consulting Services, Inc. The test preparation procedures consisted of lowering each geophone to the desired test depth in each receiver hole. The impulse source was placed in the shot hole to the corresponding testing depth. The impulse source was activated multiple times until a satisfactory signal response was obtained. Two separate tests were performed at each depth. Between 2 and 6 impacts per test were stacked to help enhance the P and S-wave signatures and cancel spurious noise effects. Sampling intervals of 0.03125 and 0.064 milli-seconds [msec] and record lengths (sweep-times) of between 64 and 128 milli-seconds were used. A total of 2048 samples were digitally recorded per channel per shot and no filtering was used during acquisition. The seismograph was calibrated by the manufacturer two-weeks prior to the tests and the geophones were also manufactured and purchased new within three weeks of the tests. Sources of possible noise and other interfering vibrations included vehicle traffic, construction activity, heavy machinery operation and nearby concrete cutting operations.

The data were observed and recorded in the field during acquisition and later returned to the offices of Grumman Exploration, Inc. for further review and analysis. The analysis consisted of estimating the earliest onset of the P-wave and S wave for each depth level tested. Some of the S-waves were analyzed by comparing similar S-wave onsets, peaks and/or zero crossings across the seismic traces. A computer program developed by Grumman Exploration, Inc. was used to extract and display the raw, unfiltered P and S-wave traces for each test interval. No alteration (e.g. filtering, processing) of the raw signals was performed. Using the arrival time estimates and the measured ground-level receiver-hole separation distance, P and S wave velocities were calculated for each depth interval. The vertically aligned geophones (channels 1 and 4) were used primarily for the S-wave analysis and the lateral geophones for the compressional (p-wave) assessment. Copies of the seismic waveforms used in the interpretation are attached.

Cross-hole Seismic Testing Results

The attached spreadsheets summarizes the cross-hole seismic testing results for test hole locations B-802 and B-805 at the North Anna ESP Project site. Each spreadsheet represents a separate test performed at each depth. The spreadsheets include summaries of the P and S-wave arrival times, the calculated estimates of apparent P-wave and S-wave velocity and poisson's ratio for each test interval. Graphs illustrating these results are also included with each spreadsheet and as separate figures.

B-805 (soil/unconsolidated overburden)

The cross-hole seismic waveforms were reasonably clear and uncomplicated by noise interference with the exception of the deepest test intervals, near the bedrock contact. The downhole seismic impulse source is optimized for the Shear (S)-wave and the S-wave onset was more readily apparent than the earlier P-wave on the waveforms for B-805. The compressional (P)-wave onset was complicated by high-frequency noise, particularly at the deepest test intervals. The computed compressional wave velocities (Vp) generally appear higher than would be anticipated given the observed soil/overburden profile. Possible explanations for the elevated Vp include the presence of higher velocity weathered bedrock within the overburden, saturation of the deeper test intervals, and possible P-wave arrival time estimation inaccuracies caused by excessive noise interference.

B-802 (bedrock)

Severe high frequency noise appears to have severely degraded the overall quality of the B-802 results and complicated the interpretation of these results. A possible shear wave arrival was apparent only on the tests performed from 27-ft to approximately 45-ft. Deeper than 45-ft, no apparent shear-wave could be discerned from the results. Although excessive high-frequency noise severely complicated all of the recorded waveforms, no clear late-time waveforms (e.g. possible shear-waves) were apparent on the deeper records (>~45-ft). No compressional wave waves could be clearly interpreted on the seismic records. The compressional waveforms, if present, may have been obscured by the high-frequency noise. The observation of the P-wave onset may have been further complicated by the anticipated high Vp in the bedrock interval and resultant very small arrival time differential between receiver locations. The bedrock within the test area appears to readily transmit high-frequency noise from various noise sources throughout the site. An attempt to filter the seismic traces was performed, however, the results did not appear to improve the interpretation of the waveforms.

General Qualifications

It is considered possible that one or more of the circumstances noted below may have affected the P and S-wave velocities or their estimation through various regions of the subsurface. Bias in the arrival time picks and consequently the velocity estimates may be the result of one or more possible circumstances including: inaccuracies in the wave arrival time picks, irregular or incomplete borehole annular space filling, refraction effects, lateral stratigraphic changes, limitations on the resolution of the digitized signal, and the presence of interfering noise and other wavetrains.

The cross-hole seismic data presented herein represent estimates of subsurface properties in the interval between the two receiver boreholes tested using the measurement procedures described above. No warranty, certification, or statement of fact, either expressed or implied, regarding actual subsurface properties surrounding the borehole tested is contained herein. If questions or uncertainties exist regarding the actual parameter values, supplemental in-situ or laboratory tests or other invasive explorations should be conducted to document actual subsurface material properties. No inference of subsurface properties can be made for depth intervals not tested.

Grumman Exploration, Inc. has appreciated this opportunity to be of service again to Mactec Engineering and Consulting Services, Inc. If you have any questions or comments regarding this report, please feel free to contact us.

Sincerely,

Grumman Exploration, Inc.

David L. Grumman, Jr.
President/Geophysicist

Attachments:

Spreadsheets: B802 Xhole Seismic.xls
B805 Xhole Seismic.xls
Figure 1 (B-805)
Figure 2 (B-802)
Field data acquisition logs for B-802 and B-805

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
(614) 488-7860 tel, (614) 488-8945 fax

Cross-Hole Seismic Testing Summary Table

Test/Well ID: B-802
Project: **Noth Anna ESP Project**
Location: North Anna Power Station, Mineral, Virginia
Client/Owner: Mactec
Well Descr.: 2.875" PVC/inclinometer, grouted, ~92' depth

Test Date: 12/12/2002
Calc. Date: 1/14/2003
Field Staff: dlg
Data Proc by: dlg

Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221-3145
(614) 488-7860 tel

Test Interval Depth (ft)	Interval Velocity (ft/sec) V_p	V_s	Soil Density (pcf) γ	Shear Modulus G	Bulk Modulus K	Young's Modulus E	Poisson's Ratio υ	Depth (ft)	Material Descr/Class
27.00		4508						27.00	
30.00		5334						30.00	
30a		5204						30a	
35.00		5997						35.00	
40.00		5208						40.00	
40a		5468						40a	
45.00		5556						45.00	
50.00								50.00	
55.00								55.00	
60.00								60.00	
60a								60a	
65.00								65.00	

Downhole Seismic Testing Field Data Spreadsheet

Test/Well ID: B-802

Project: **Noth Anna ESP Project**

Location: North Anna Power Station, Mineral, Virginia

Client/Owner: Mactec

Grumman Exploration, Inc.

Nominal Test Hole Separation: ~10 ft

Test Depth	Notes	Est'd Velocity (fps) V_P	V_S	Esimated Wave Arrival Time (msec) P_{805B}	P_{805A}	S_{805B}	S_{805A}	receiver separation (ft)[1]
27.0			4508	n/a	n/a	2.25	4.60	10.593
30.0			5334	n/a	n/a	2.00	4.00	10.668
30a	repeat		5204	n/a	n/a	1.95	4.00	10.668
35.0			5997	n/a	n/a	1.50	3.30	10.794
40.0			5208	n/a	n/a	2.10	4.20	10.937
40a	repeat		5468	n/a	n/a	2.05	4.05	10.937
45.0			5556	n/a	n/a	2.50	4.50	11.112
50.0				n/a	n/a	n/a	n/a	11.299
55.0				n/a	n/a	n/a	n/a	11.504
60.0				n/a	n/a	n/a	n/a	11.737
60a	repeat			n/a	n/a	n/a	n/a	11.737
65.0				n/a	n/a	n/a	n/a	12.007
70.0				n/a	n/a	n/a	n/a	12.289
75.0				n/a	n/a	n/a	n/a	12.557
80.0				n/a	n/a	n/a	n/a	12.819
80a	repeat			n/a	n/a	n/a	n/a	12.819
85.0				n/a	n/a	n/a	n/a	13.084
89.00				n/a	n/a	n/a	n/a	13.283

Field Equipment: EG&G SmartSeis S-12, 12-channel, signal enhancement siesmograph

Two Triaxial Geophones, 10-ft nominal surface separation distance centered at depth indicated

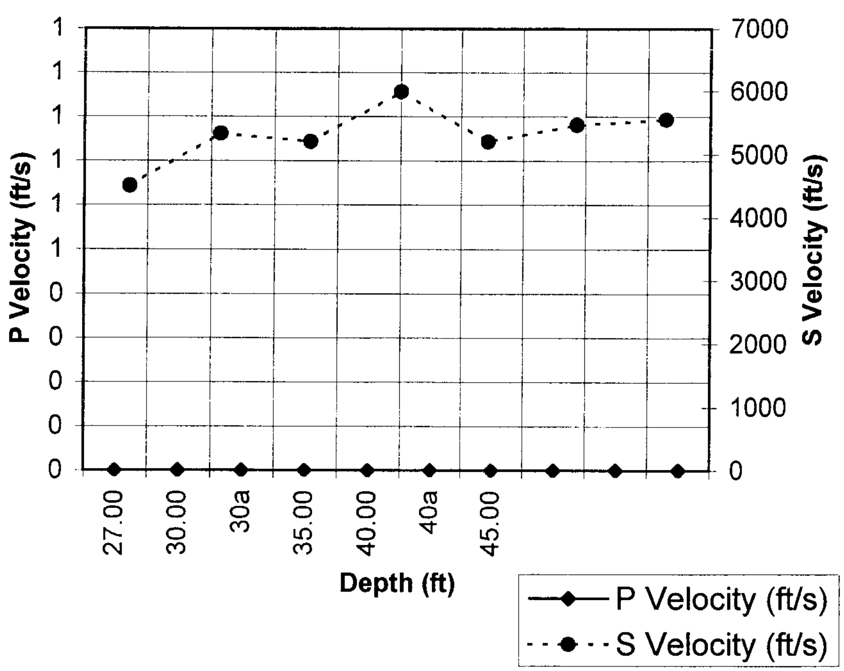
Downhole, reversible polarity hammer source

[1] Per checked deviation survey provded by Mactec

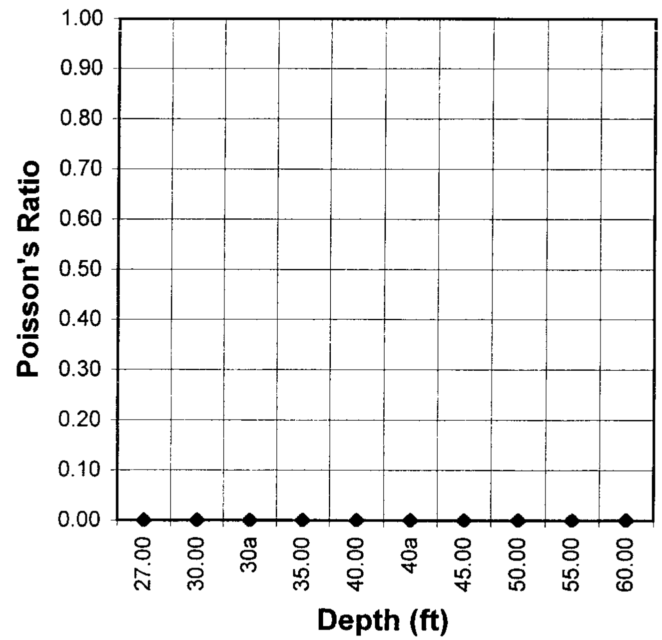
n/a uninterpretable/poor quality waveform

Test/Well ID: B-802
Project: **Noth Anna ESP Project**
Location: North Anna Power Station, Mineral, Virginia
Client/Owner: Mactec

P and S Velocity vs Depth



Poisson's Ratio vs Depth



Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221-3145
(614) 488-7860 tel

Cross-Hole Seismic Testing Summary Table

Test/Well ID: B-805
Project: **Noth Anna ESP Project**
Location: North AnnaPower Station, Mineral, Virginia
Client/Owner: Mactec
Well Descr.: 2.875" PVC/inclinometer, grouted, ~29' depth

Test Date: 12/12/2002
Calc. Date: 1/14/2003
Field Staff: dlg
Data Proc by: dlg

Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221-3145
(614) 488-7860 tel

Test Interval Depth (ft)	Interval Velocity (ft/sec) V_p	V_s	Soil Density (pcf) γ	Shear Modulus G	Bulk Modulus K	Young's Modulus E	Poisson's Ratio υ	Depth (ft)	Material Descr/Class
3.50	1243	612					0.340	3.50	
6.00	1245	701					0.268	6.00	
6.00	1660	604					0.424	6.00	
8.50	1658	650					0.409	8.50	
11.00	1652	748					0.371	11.00	
13.50	4936	977					0.480	13.50	
16.00	6552	936					0.490	16.00	
18.50	5741	1072					0.482	18.50	
21.00	5683	1380					0.469	21.00	
26.00	5478	1023					0.482	26.00	
26.00		1150						26.00	
27.00		1047						27.00	

Downhole Seismic Testing Field Data Spreadsheet

Test/Well ID: B-805

Project: **Noth Anna ESP Project**

Location: North AnnaPower Station, Mineral, Virginia

Client/Owner: Mactec

Grumman Exploration, Inc.

Nominal Test Hole Separation: ~10 ft

Test Depth	Notes	Est'd Velocity (fps) V_P	V_S	Esimated Wave Arrival Time (msec) P_{805B}	P_{805A}	S_{805B}	S_{805A}	receiver separation (ft)[1]
3.5		1243	612	13.00	21.00	19.50	35.75	9.94398
6.0		1245	701	11.00	19.00	17.40	31.60	9.96011
6.0	repeat	1660	604	11.50	17.50	20.50	37.00	9.96011
8.5		1658	650	10.00	16.00	15.60	30.90	9.94764
11.0		1652	748	11.50	17.50	19.50	32.75	9.90961
13.5		4936	977	10.00	12.00	15.50	25.60	9.87221
16.0		6552	936	3.50	5.00	15.00	25.50	9.82763
18.5		5741	1072	1.50	3.20	10.60	19.70	9.75956
21.0		5683	1380	2.80	4.50	13.00	20.00	9.66105
26.0		5478	1023	2.20	3.90	11.40	20.50	9.31341
26.0	repeat		1150	3.60	n/a	11.40	19.50	9.31341
27.0			1047	3.00	n/a	10.70	19.50	9.21198

Field Equipment: EG&G SmartSeis S-12, 12-channel, signal enhancement siesmograph

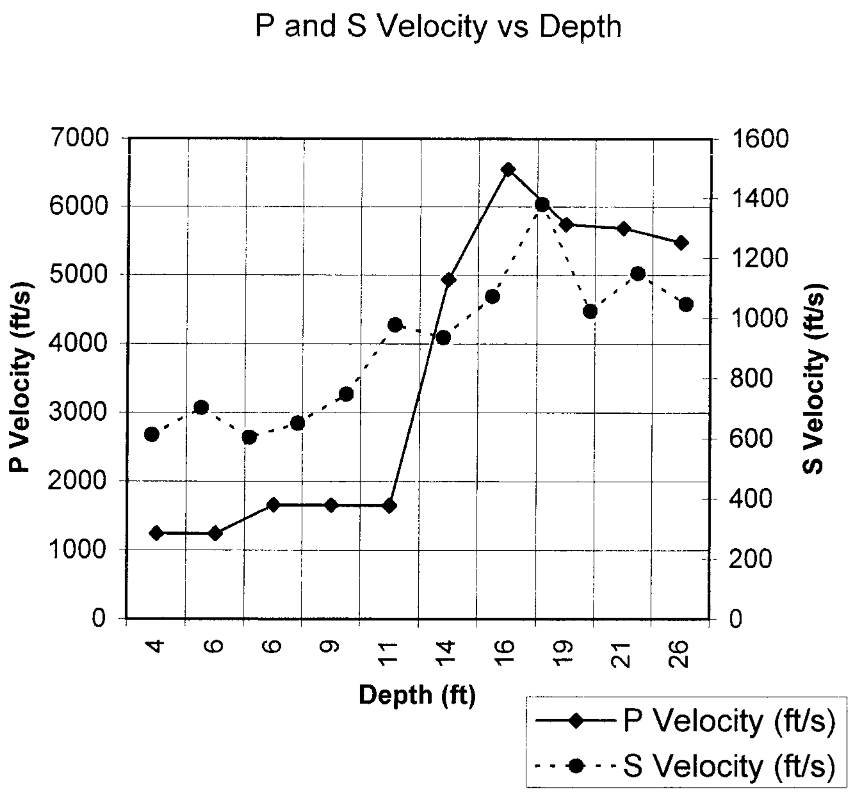
Two Triaxial Geophones, 10-ft nominal surface separation distance centered at depth indicated

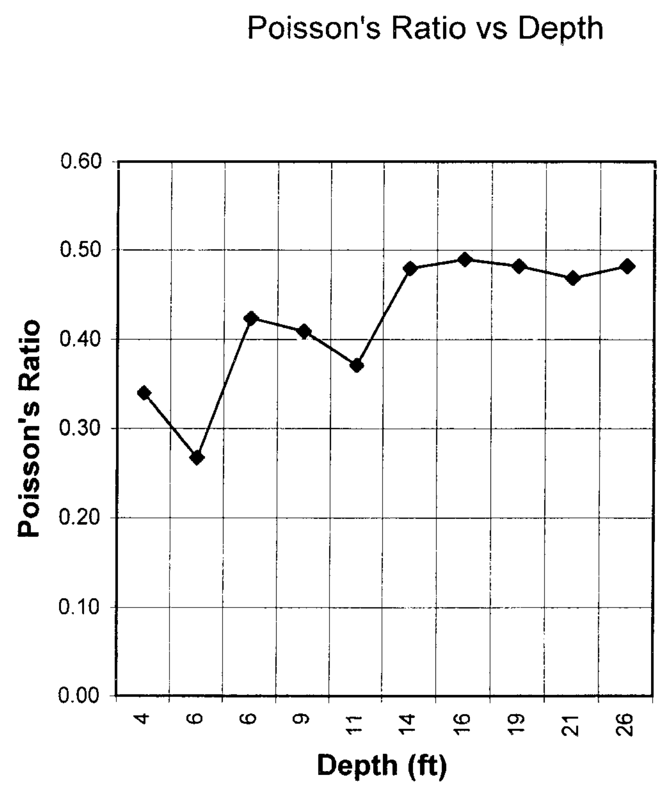
Downhole, reversible polarity hammer source

[1] Per checked deviation survey provded by Mactec

n/a uninterpretable/poor quality waveform

Test/Well ID: B-805
Project: **Noth Anna ESP Project**
Location: North AnnaPower Station, Mineral, Virginia
Client/Owner: Mactec





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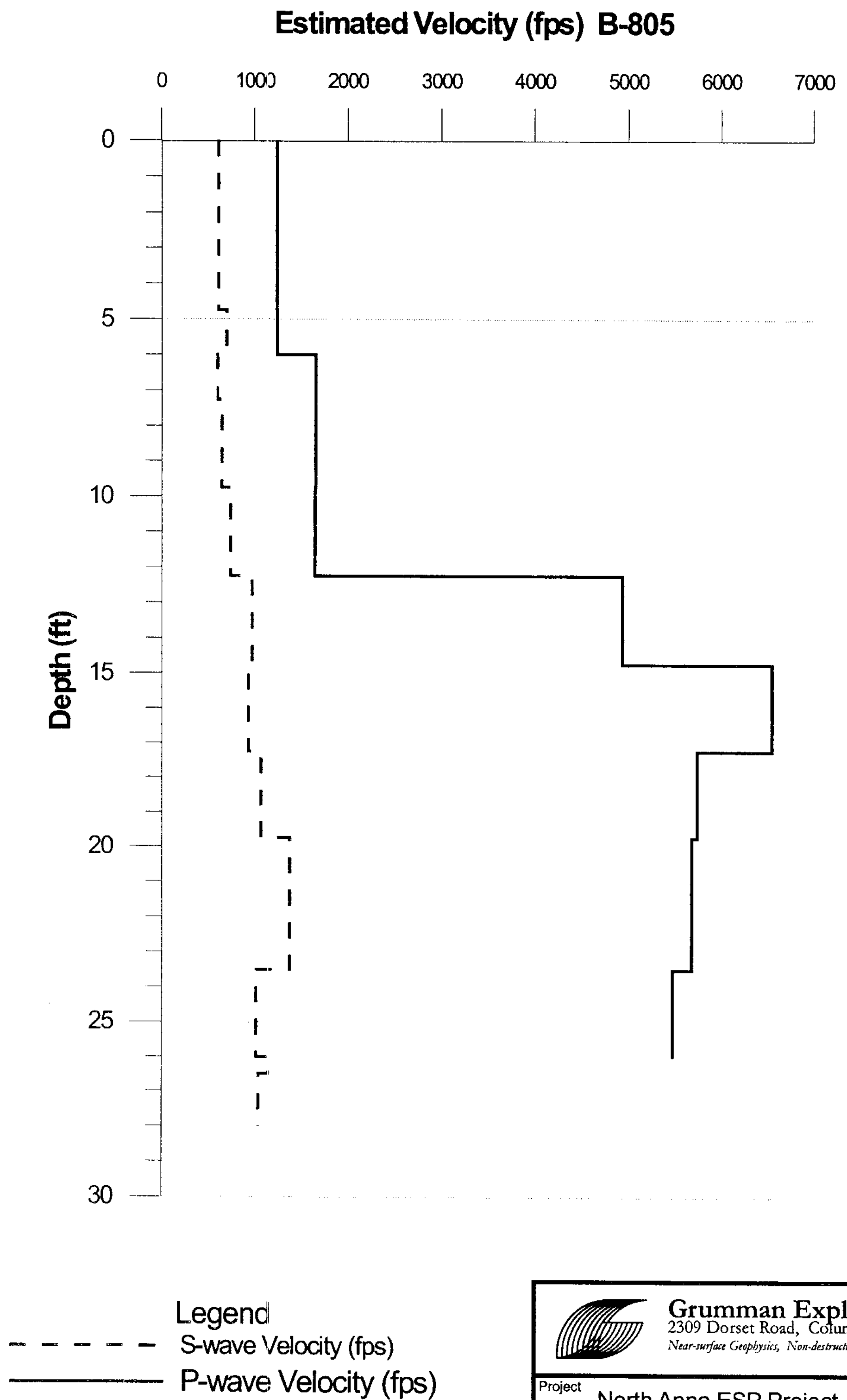
Columbus, Ohio 43221-3145
(614) 488-7860 tel



Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
Near-surface Geophysics, Non-destructive Subsurface Exploration

Project: North Anna ESP Project		
Location: North Anna power Station, Mineral, Virginia		
Client: Mactec Eng. Svcs.	By: dlg	Date: 1/10/03
Project No.: 01-22089	Checked:	Scale: nts

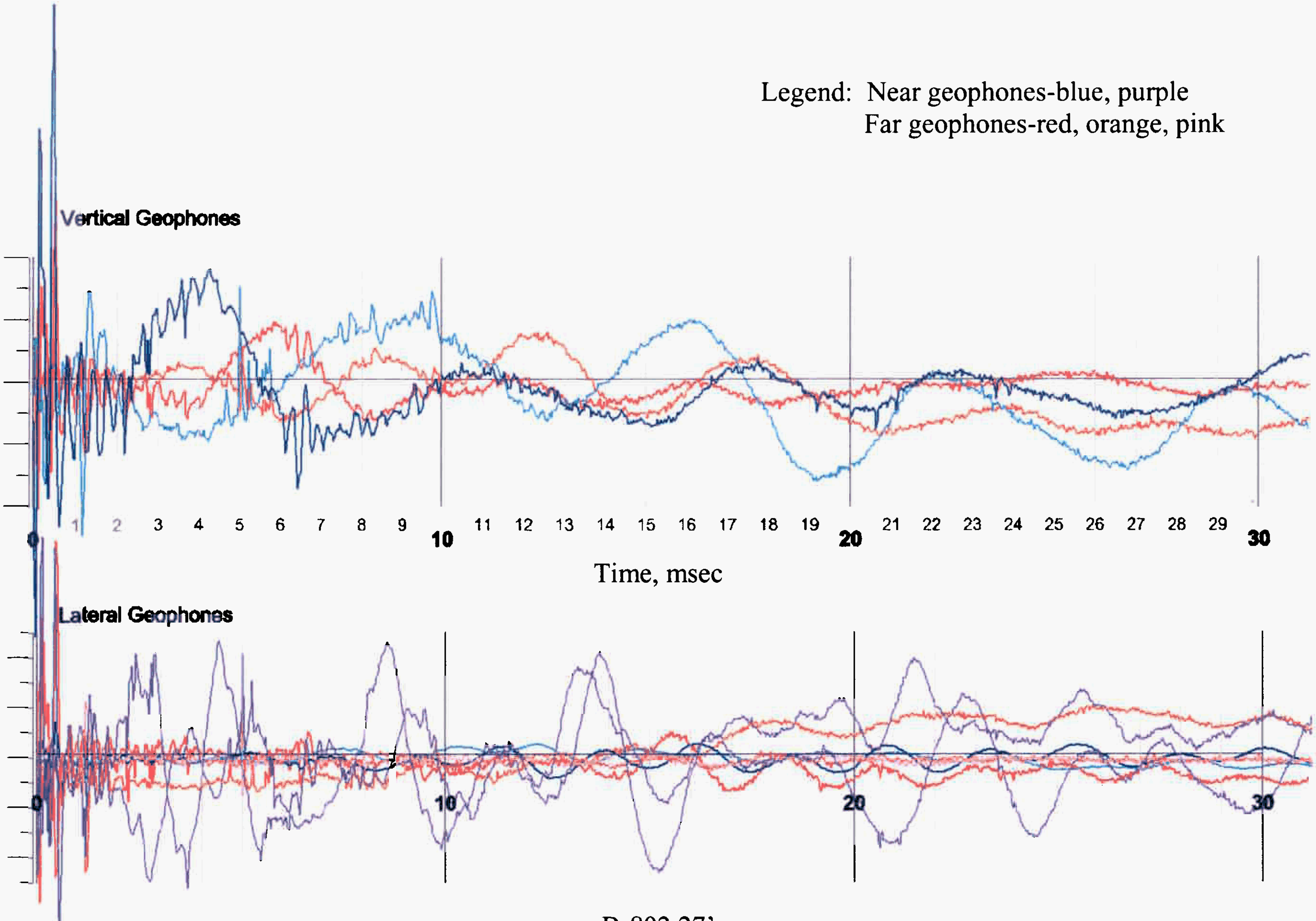
Figure: 1	Title: B-805, Estimated Velocity vs. Depth

WAVE FORMS FROM FIELD DATA

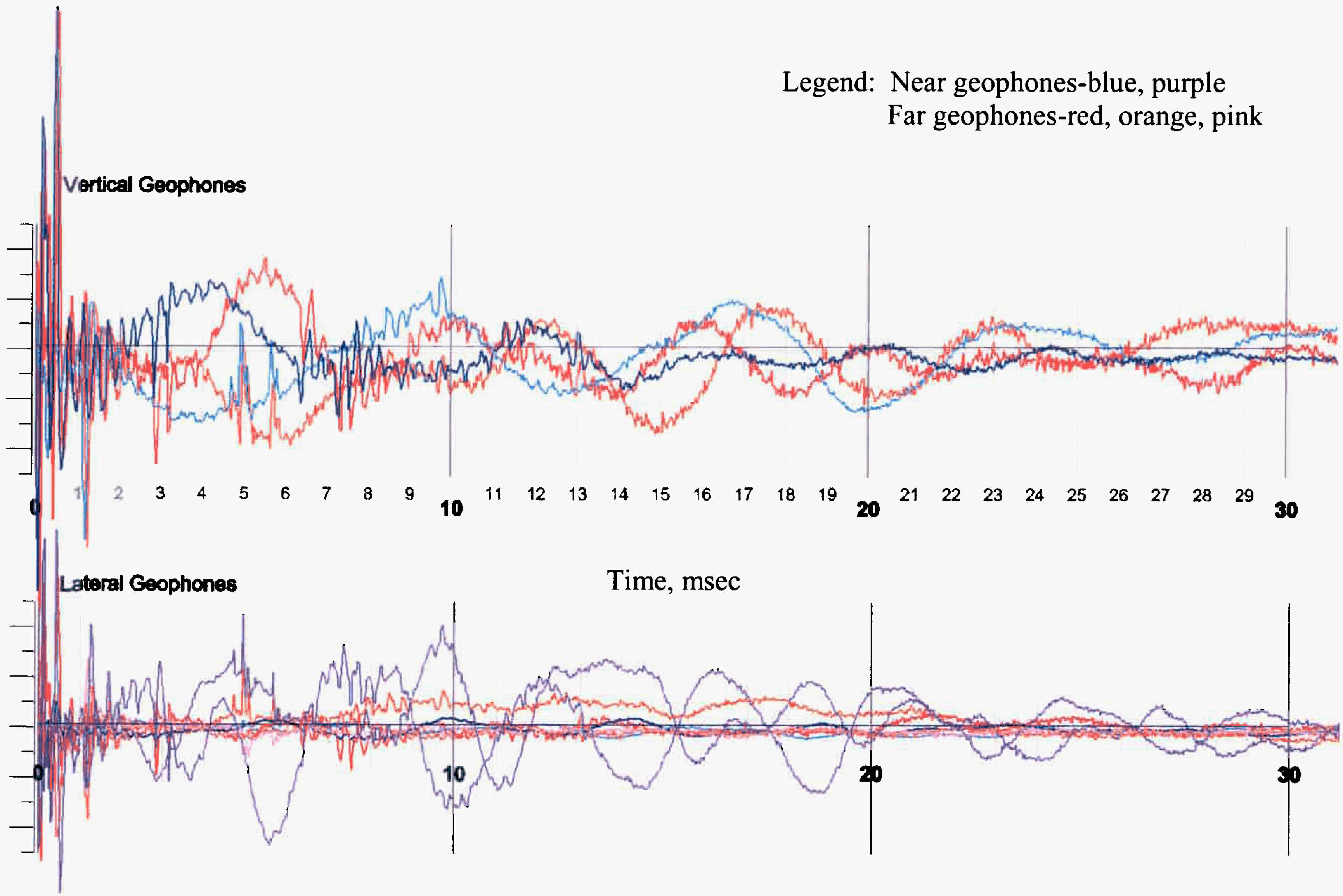
B-802 INCLUDES BOTH VERTICAL AND LATERAL GEOPHONES
B-805 INCLUDES ONLY THE VERTICAL GEOPHONES

GRAPHS ARE CAPTIONED BY BOREHOLE LOCATION AND DEPTH
AN "a" AFTER THE DEPTH INDICATES A REPEAT READING

Legend: Near geophones-blue, purple
Far geophones-red, orange, pink

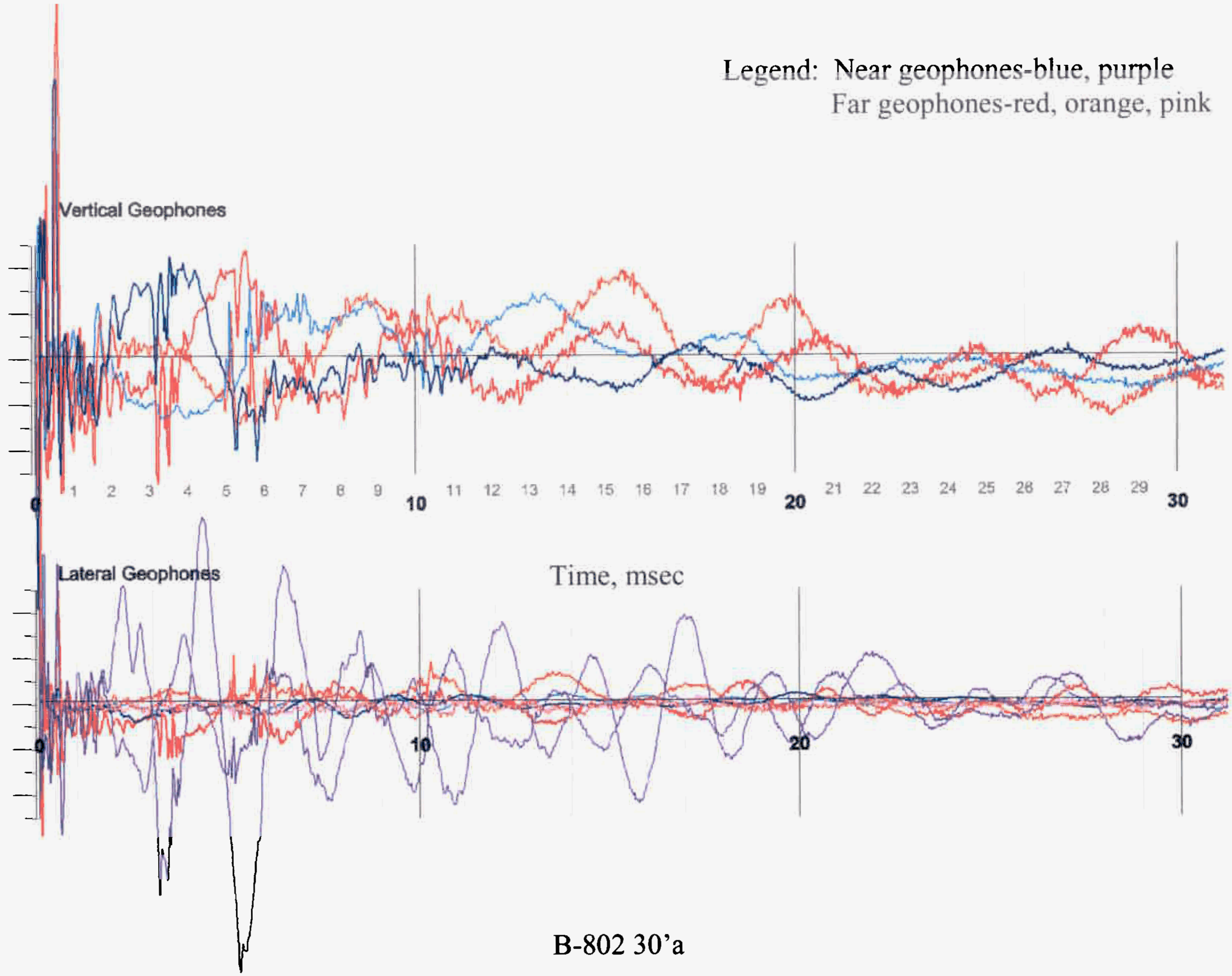


B-802 27'



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Time, msec
Lateral Geophones
0 10 20 30

B-802 30'


Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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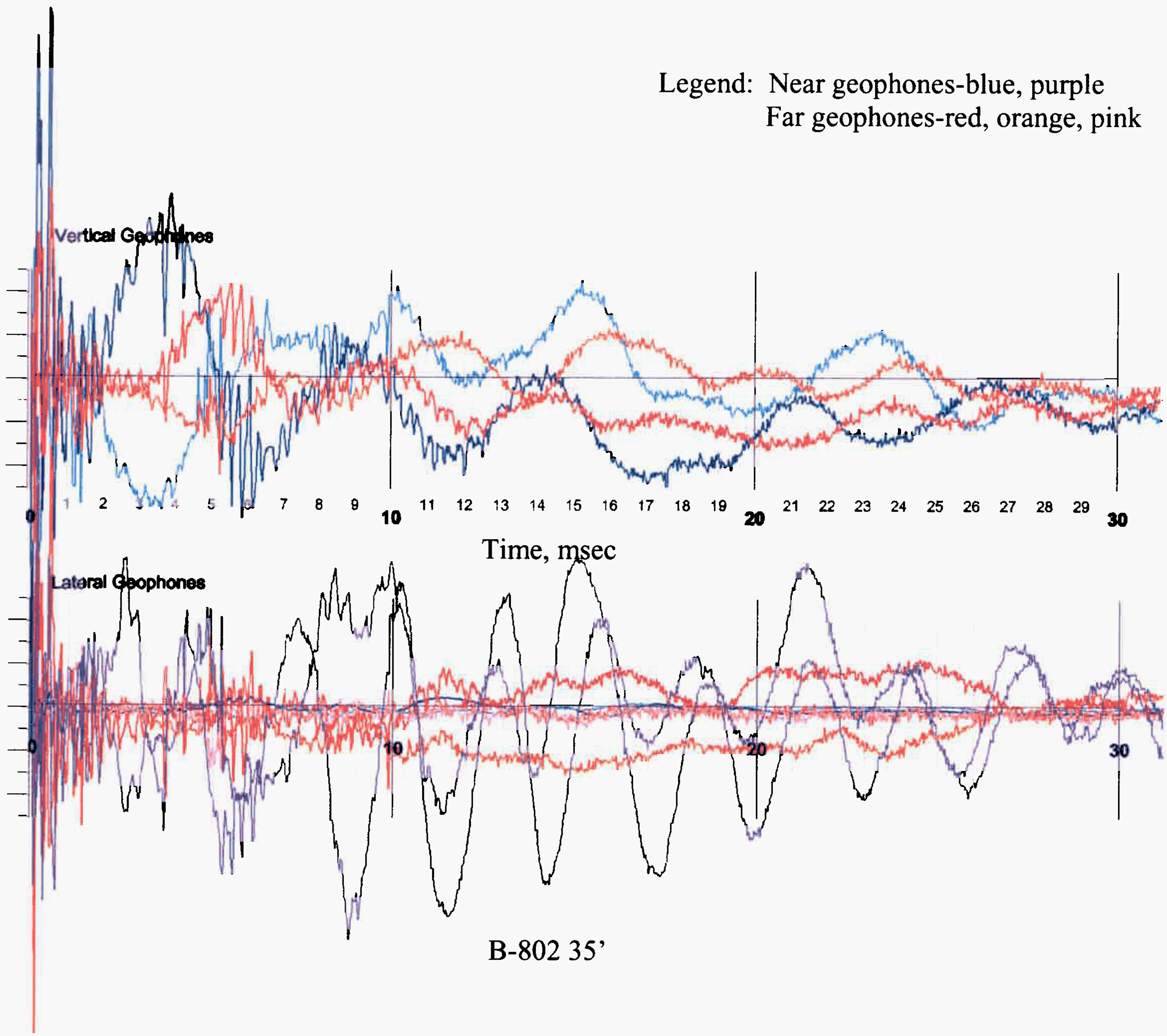
B-802 30'a



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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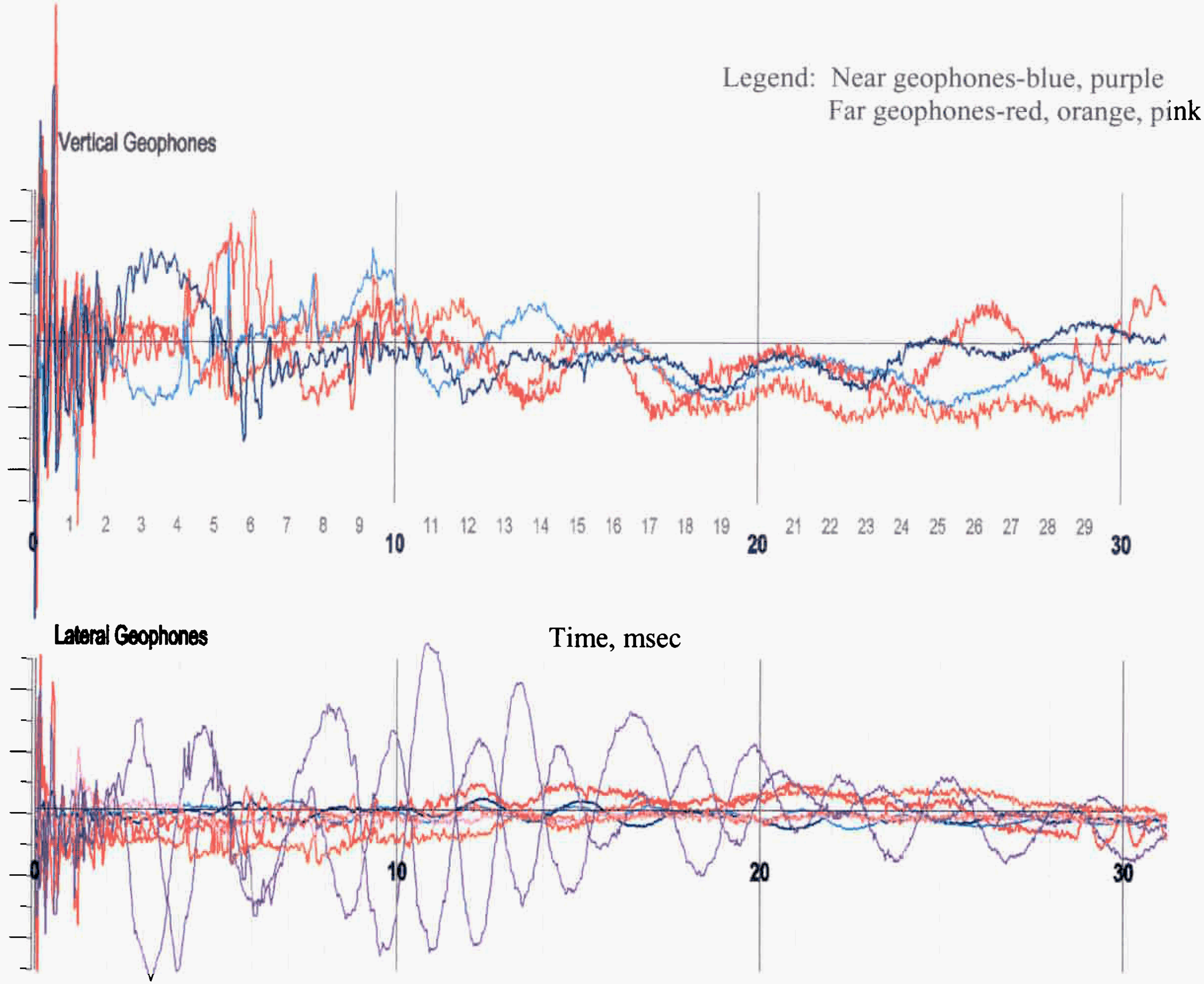
Time, msec
Lateral Geophones
0 10 20 30

B-802 35’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Far geophones-red, orange, pink
Vertical Geophones
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Time, msec
Lateral Geophones
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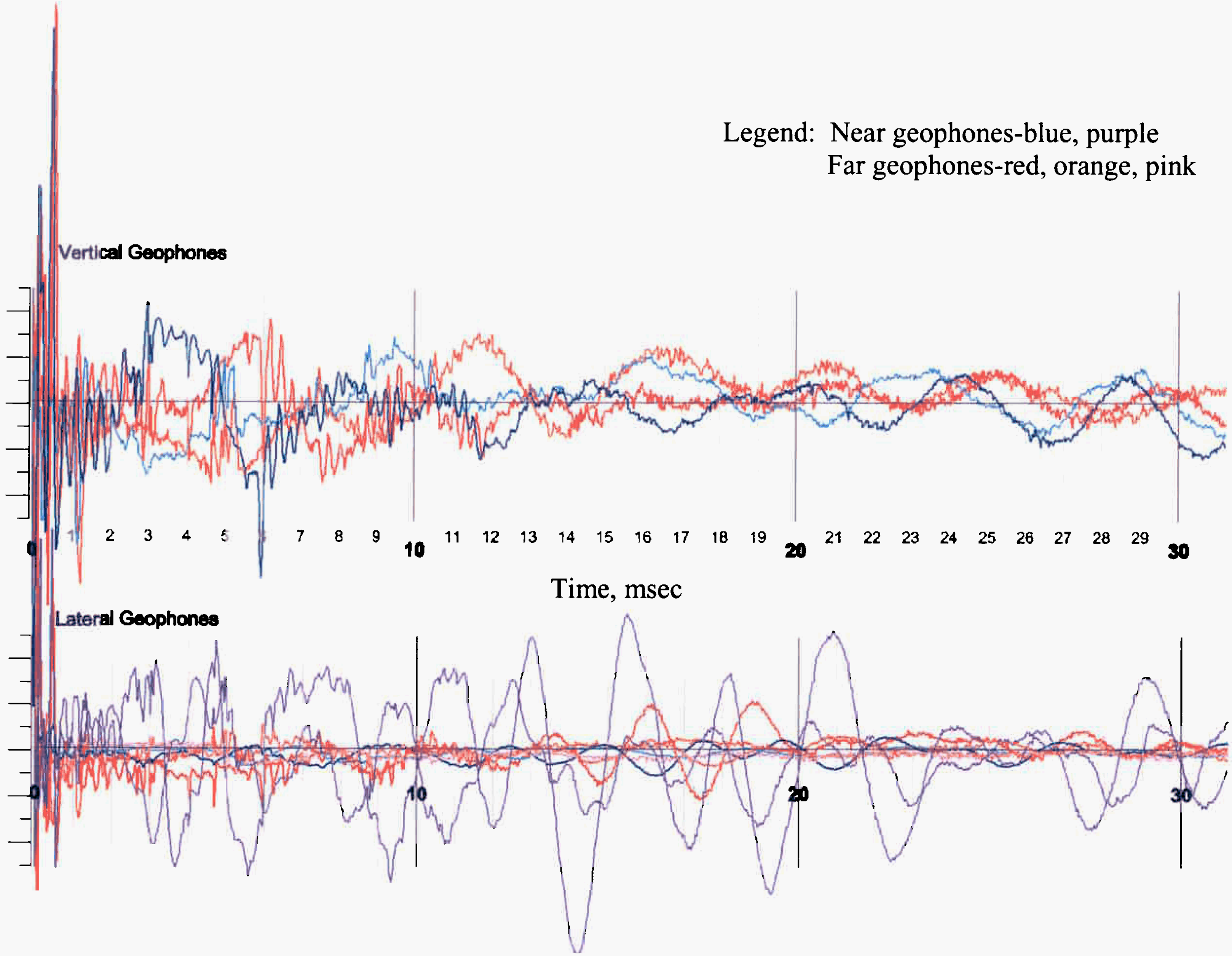
B-802 40’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Far geophones-red, orange, pink
Vertical Geophones
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Time, msec
Lateral Geophones
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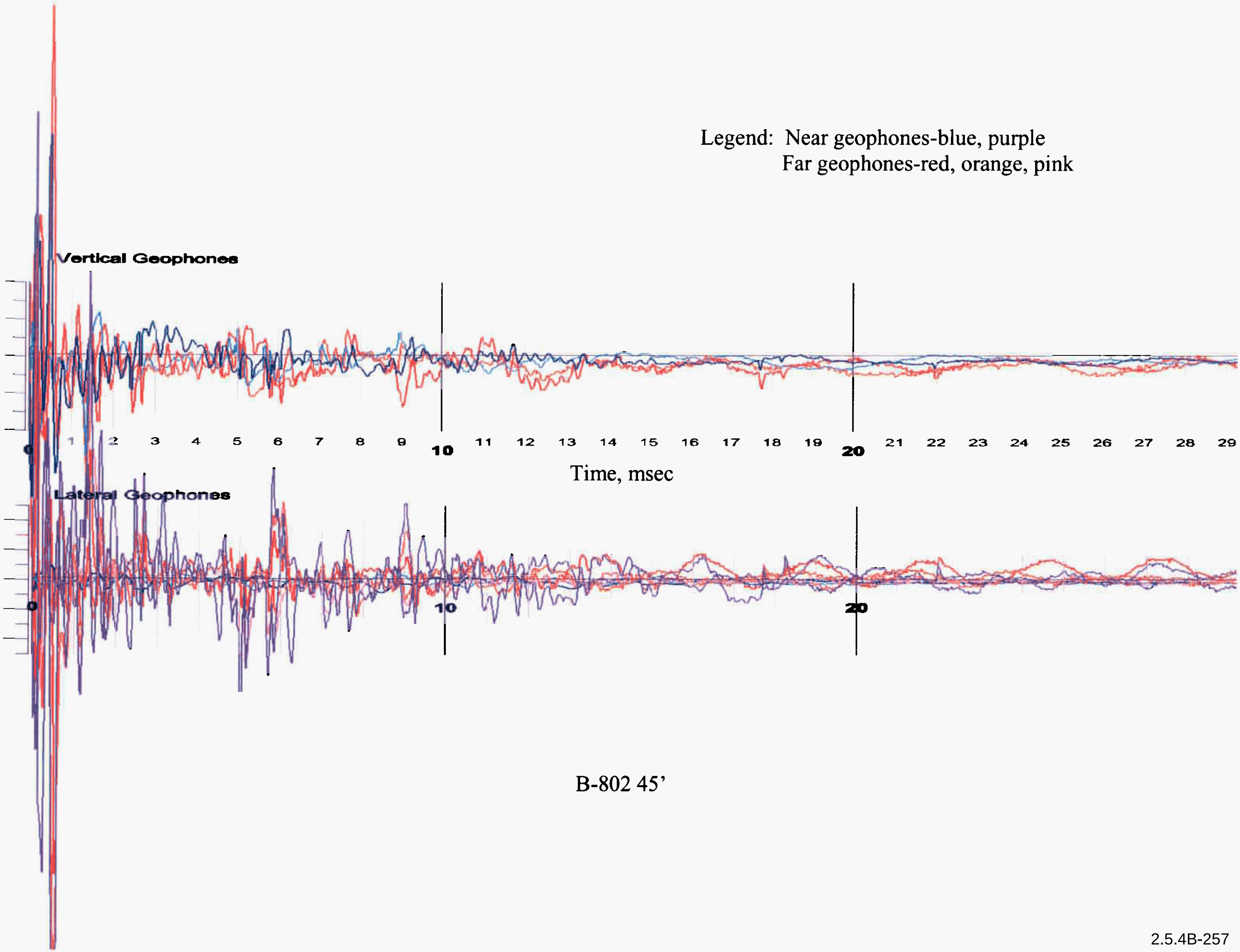
B-802 40'a



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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Time, msec
Lateral Geophones
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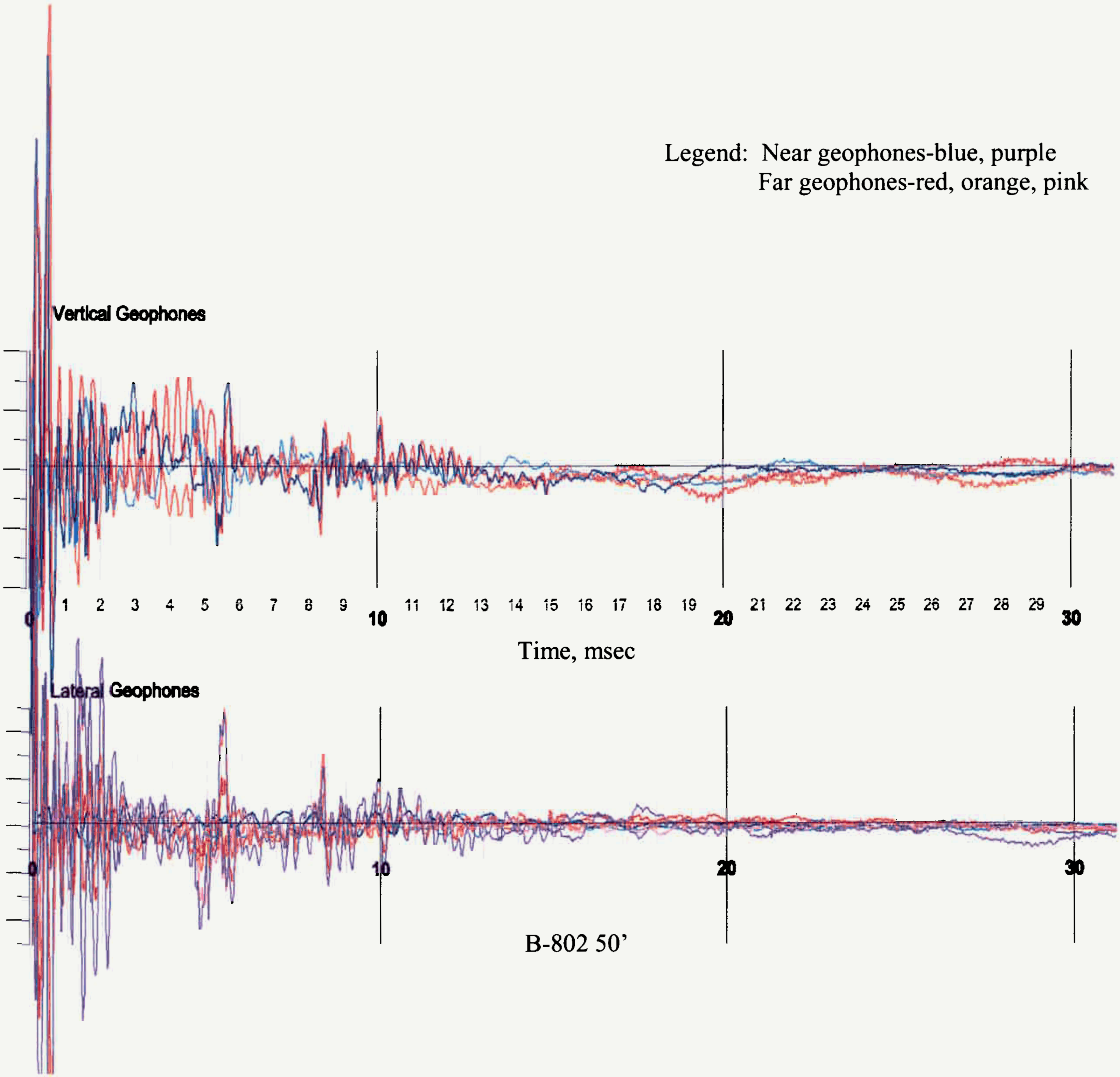
B-802 45'



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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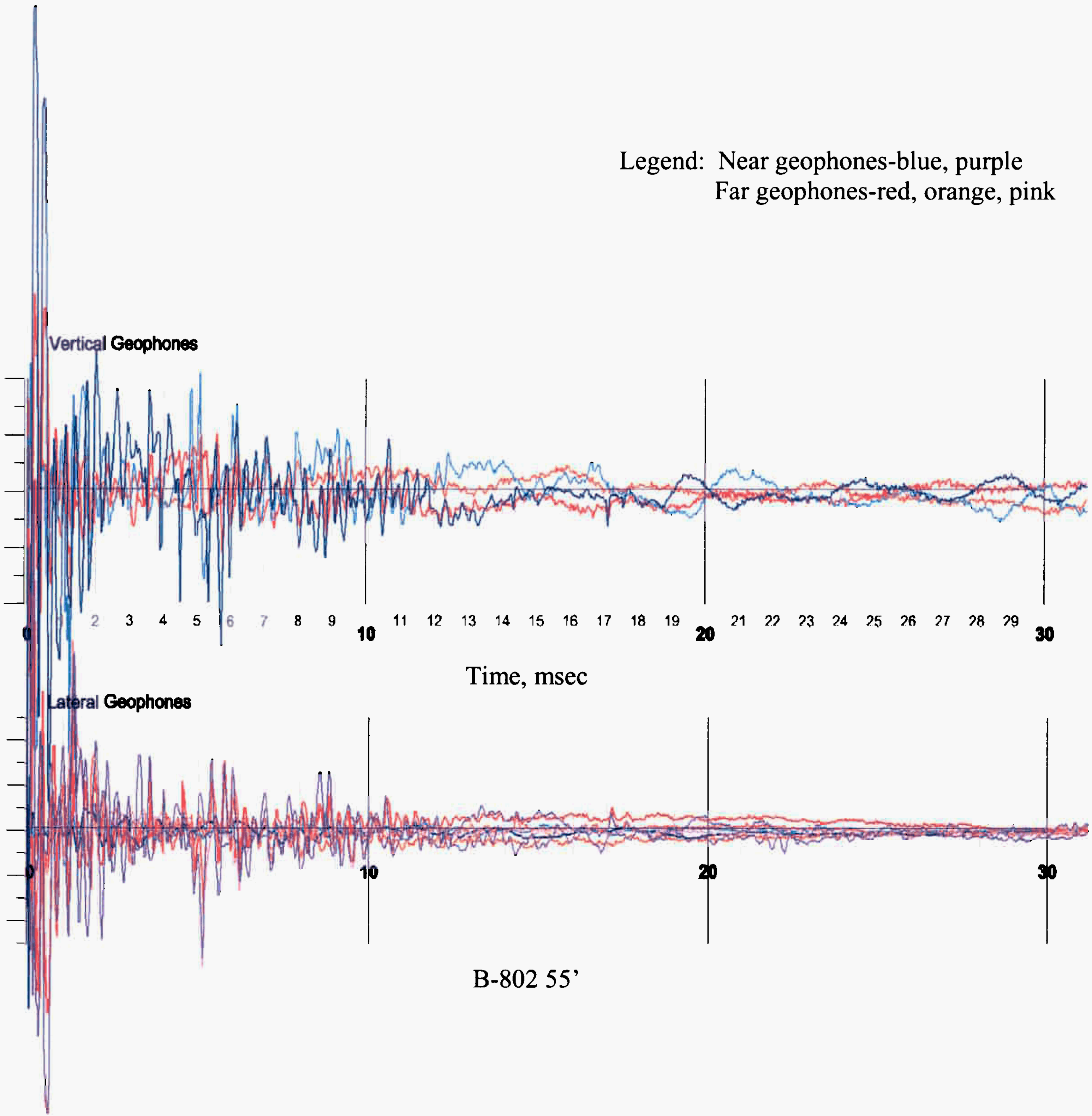
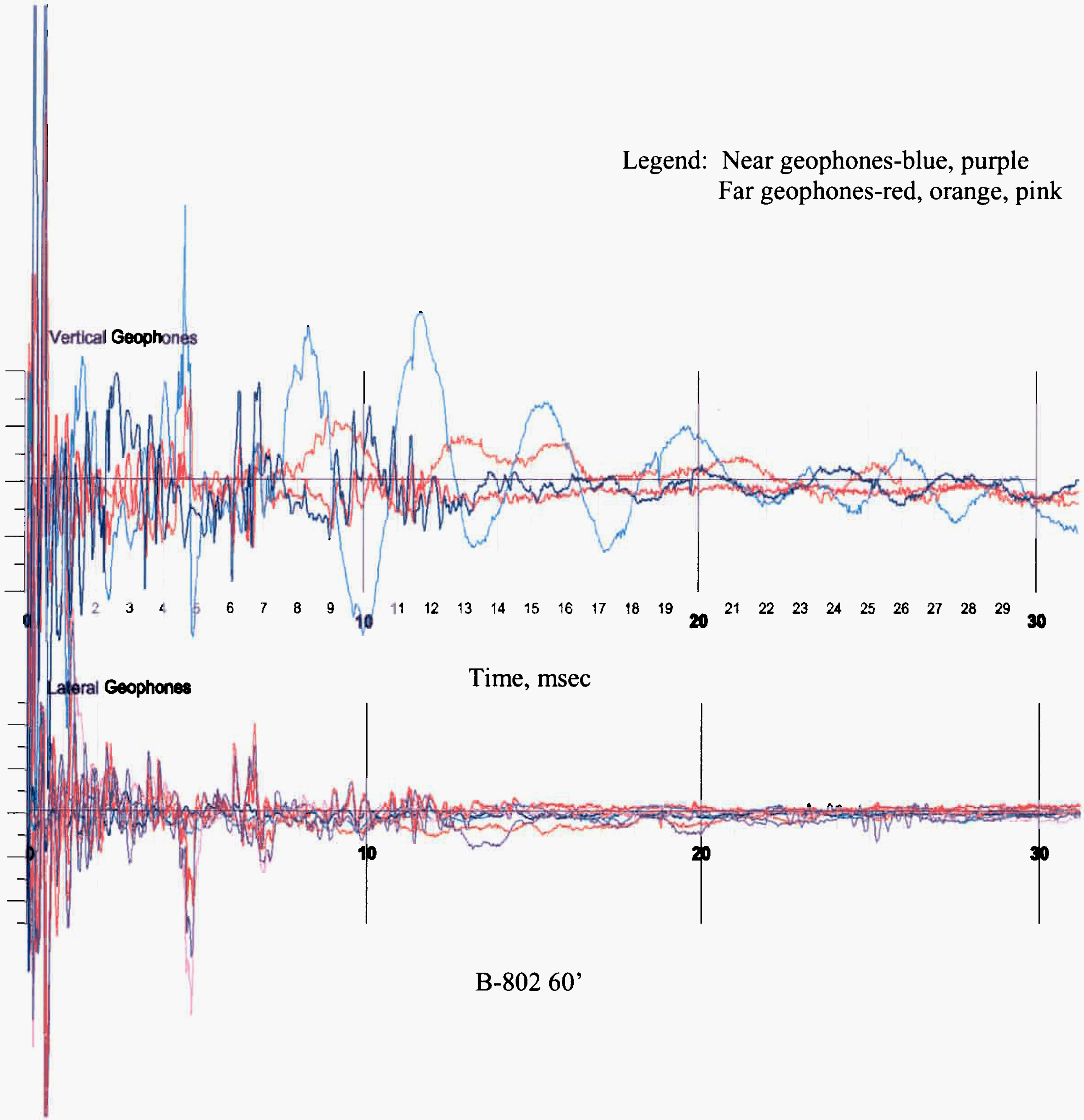
Time, msec
Lateral Geophones
0 10 20 30

B-802 50’

Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



B-802 55'


Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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Time, msec
Lateral Geophones
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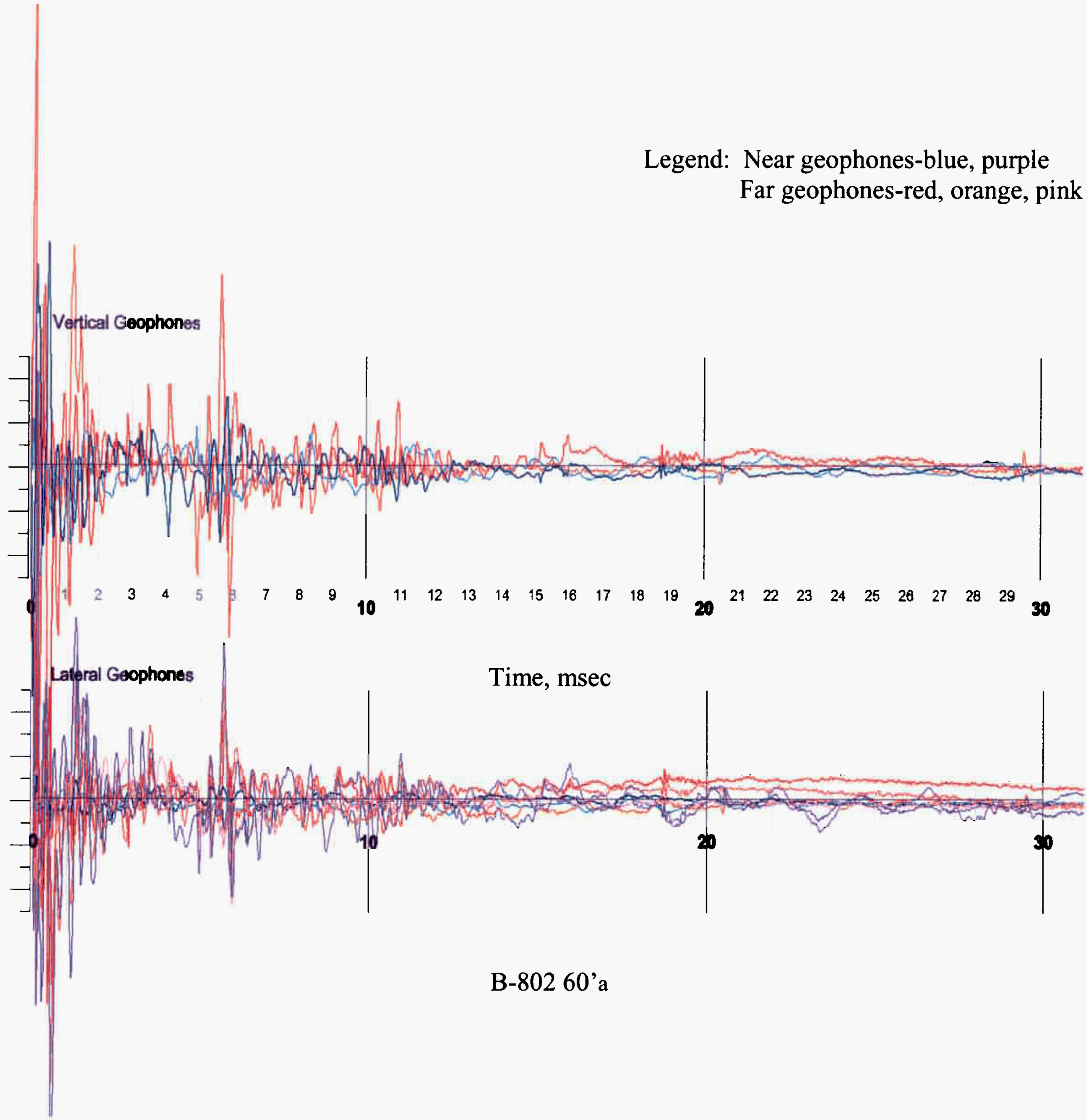
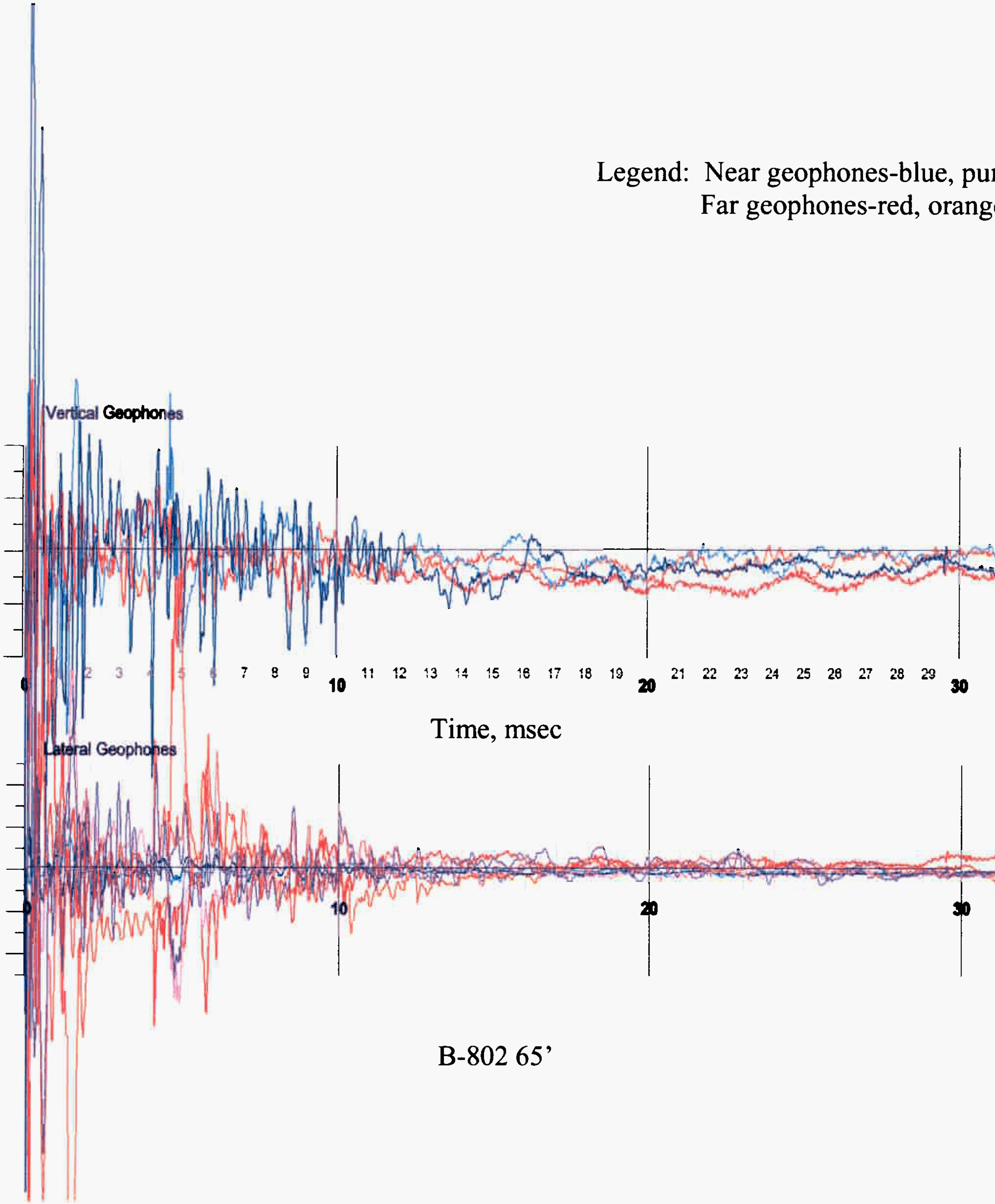
B-802 60’

Legend: Near geophones-blue, purple
Far geophones-red, orange, pink

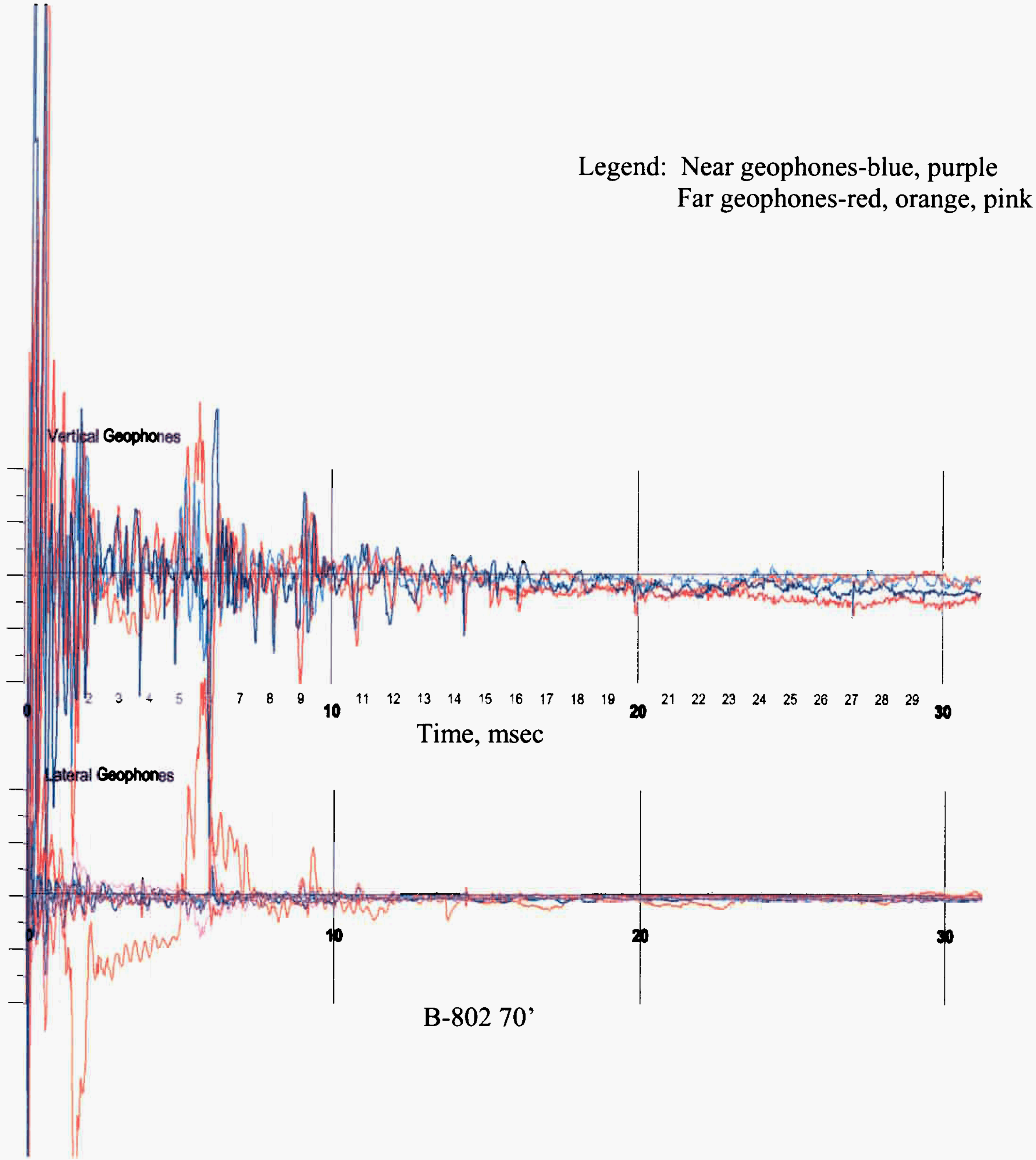


B-802 60'a

Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



B-802 65’


Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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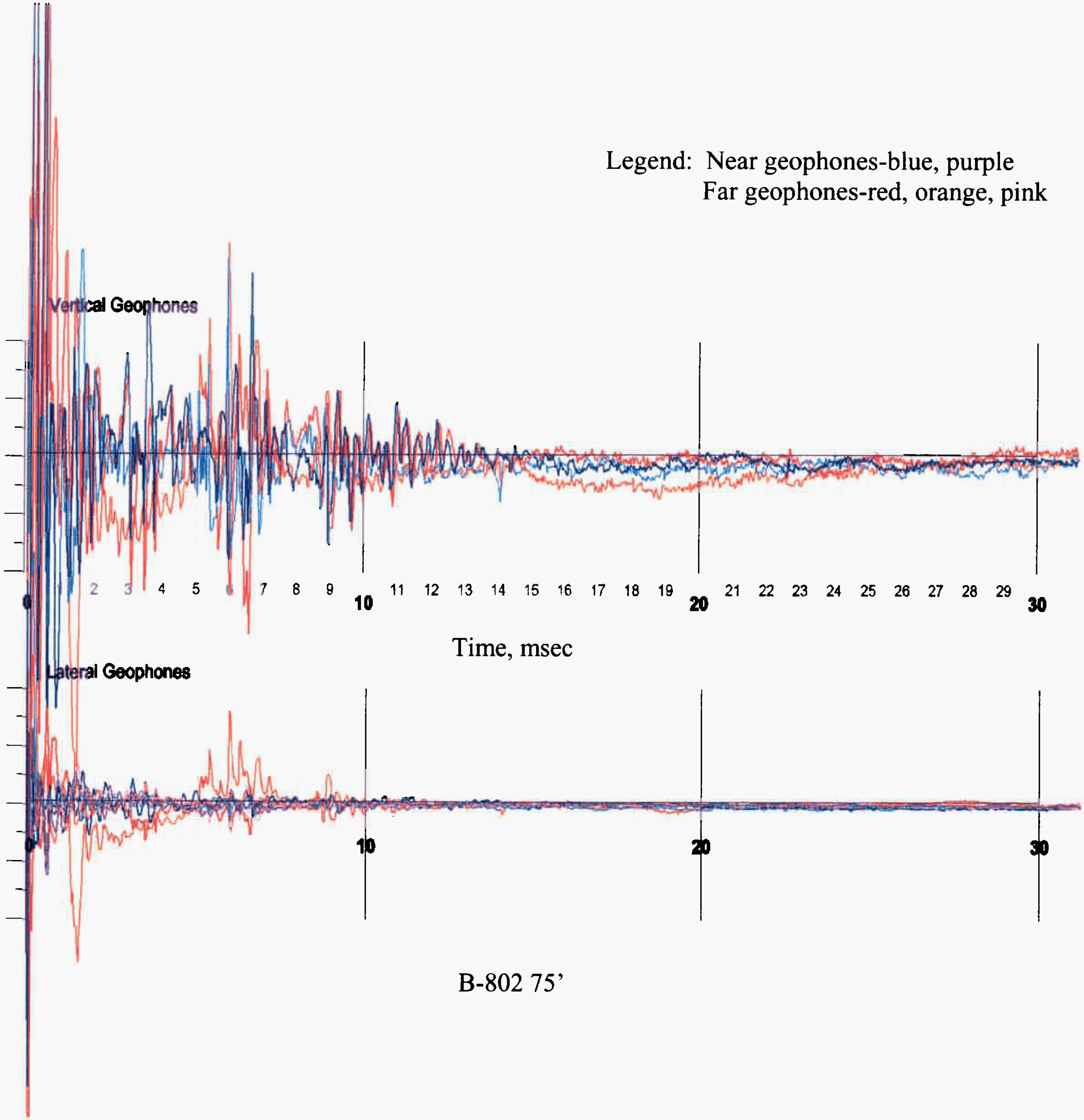
Time, msec
Lateral Geophones
0 10 20 30

B-802 70'



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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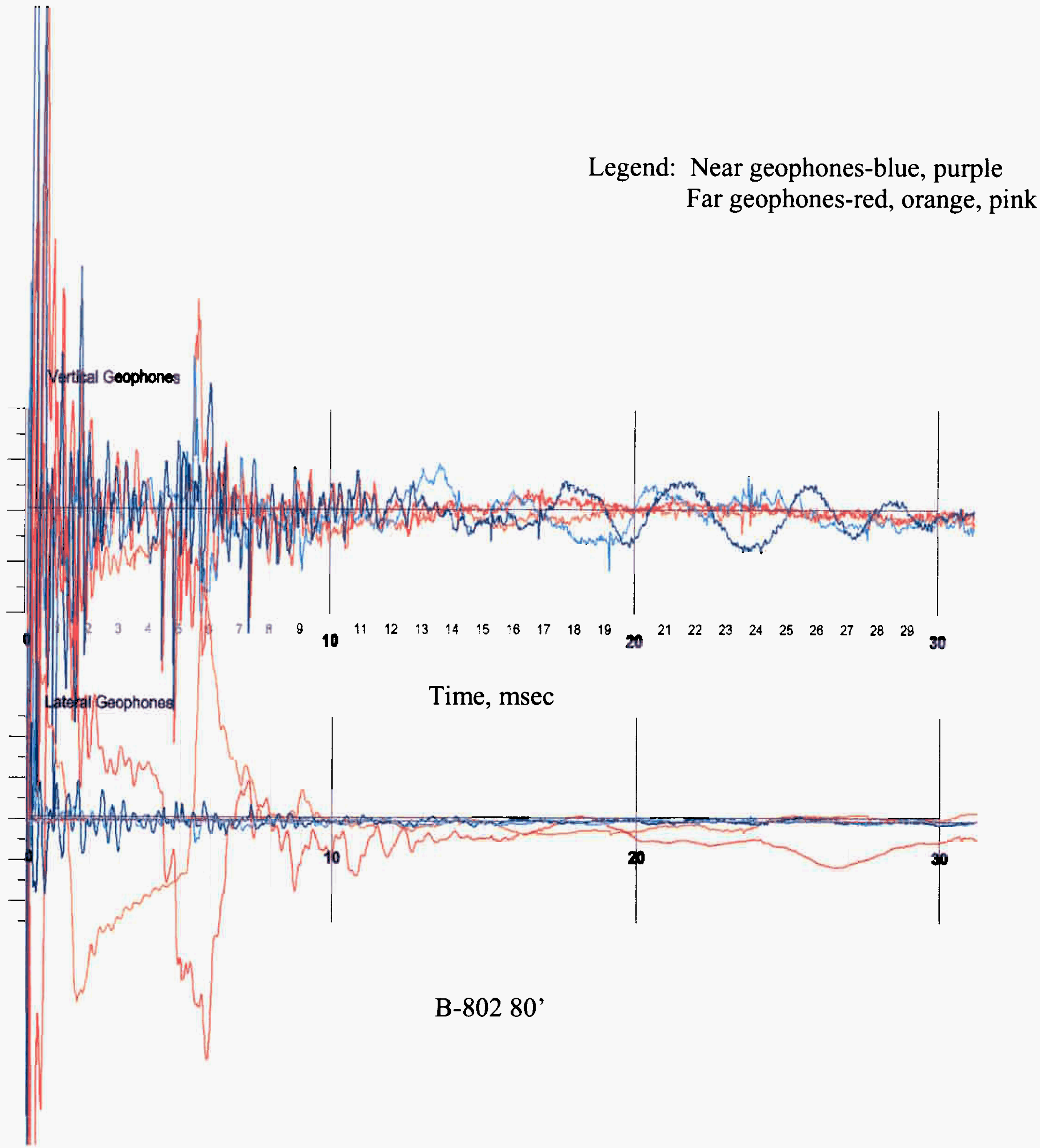
Time, msec
Lateral Geophones
0 10 20 30

B-802 75’



Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
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Time, msec
Lateral Geophones
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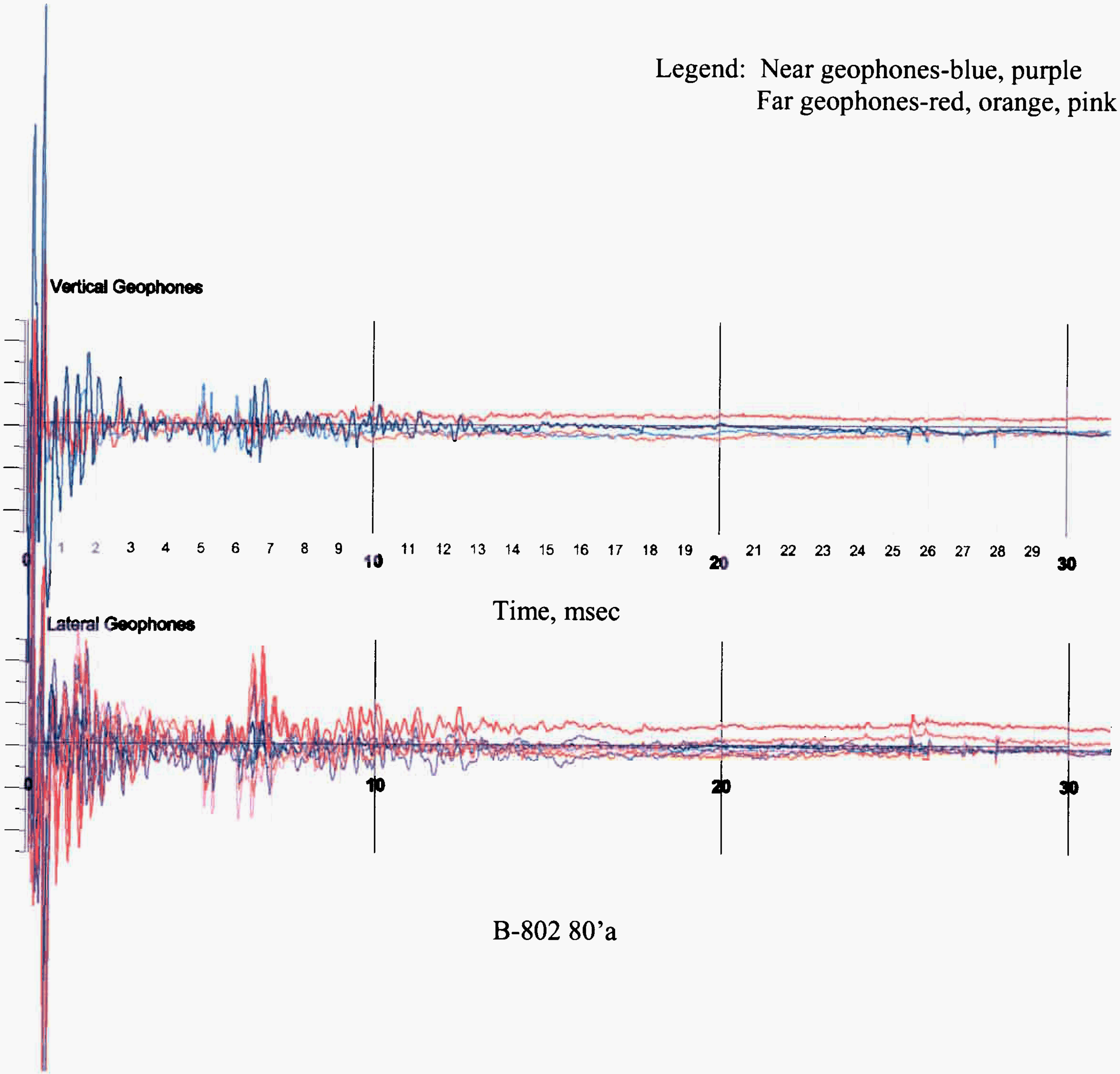
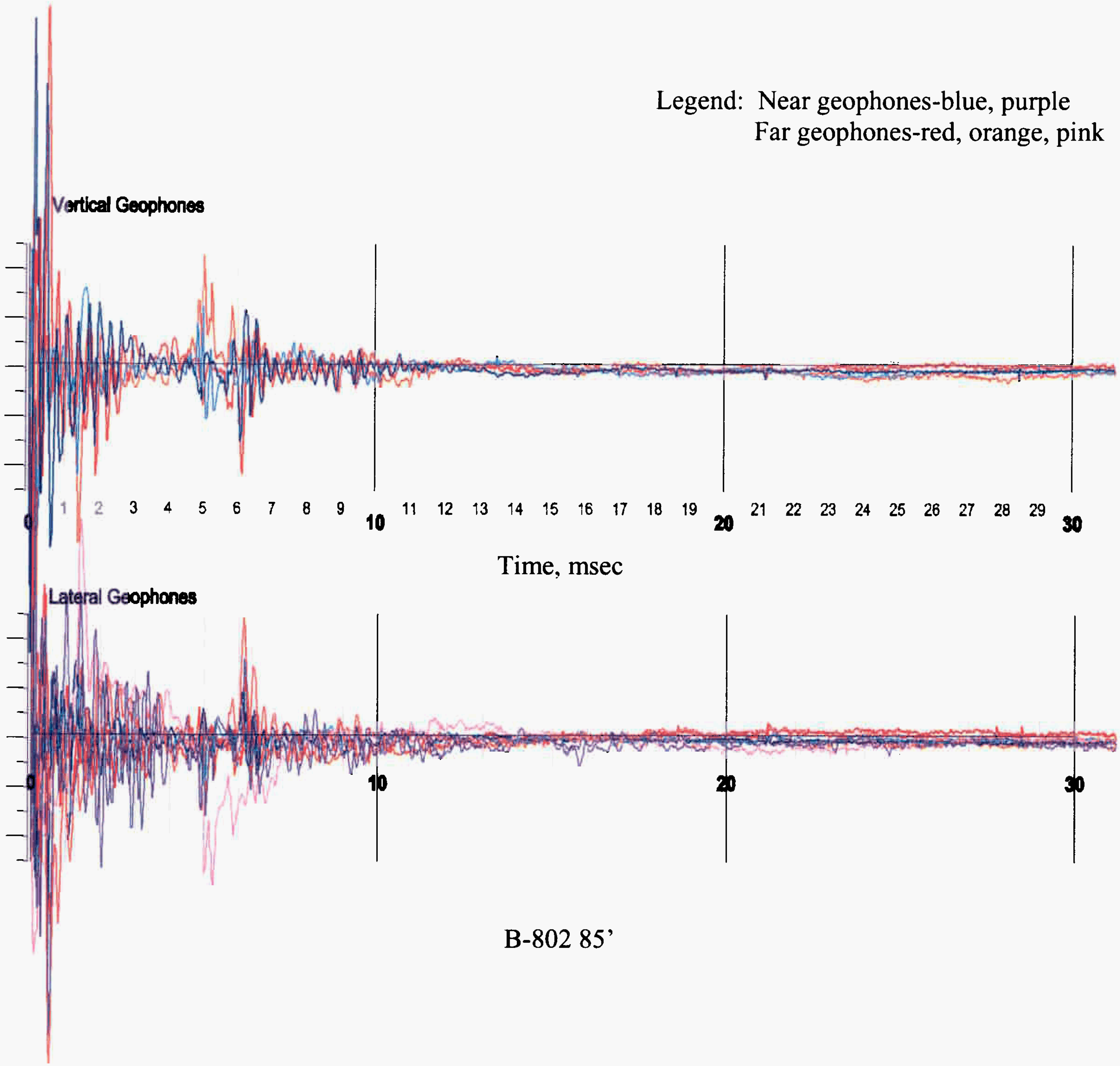
10
20
30

B-802 80’

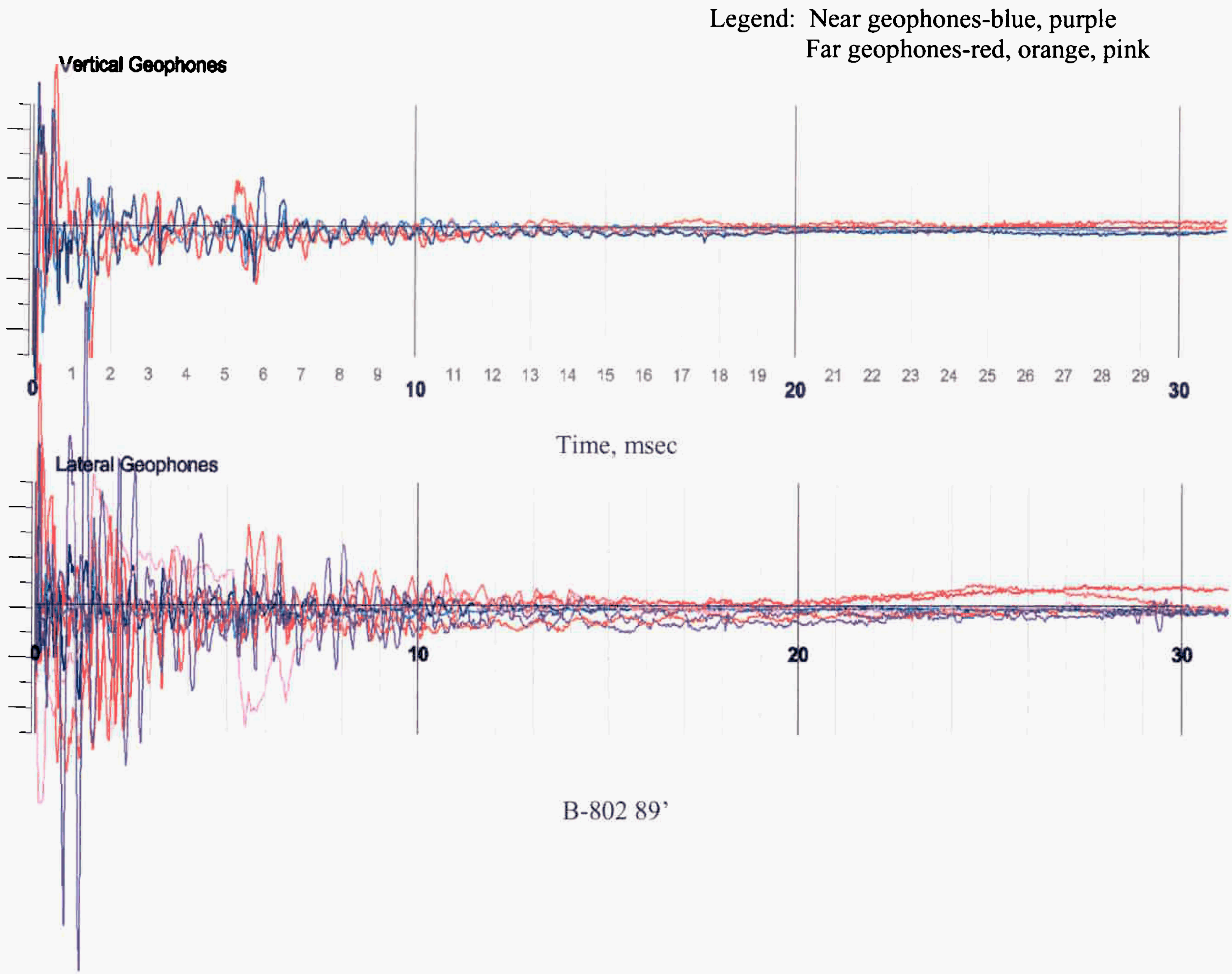
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



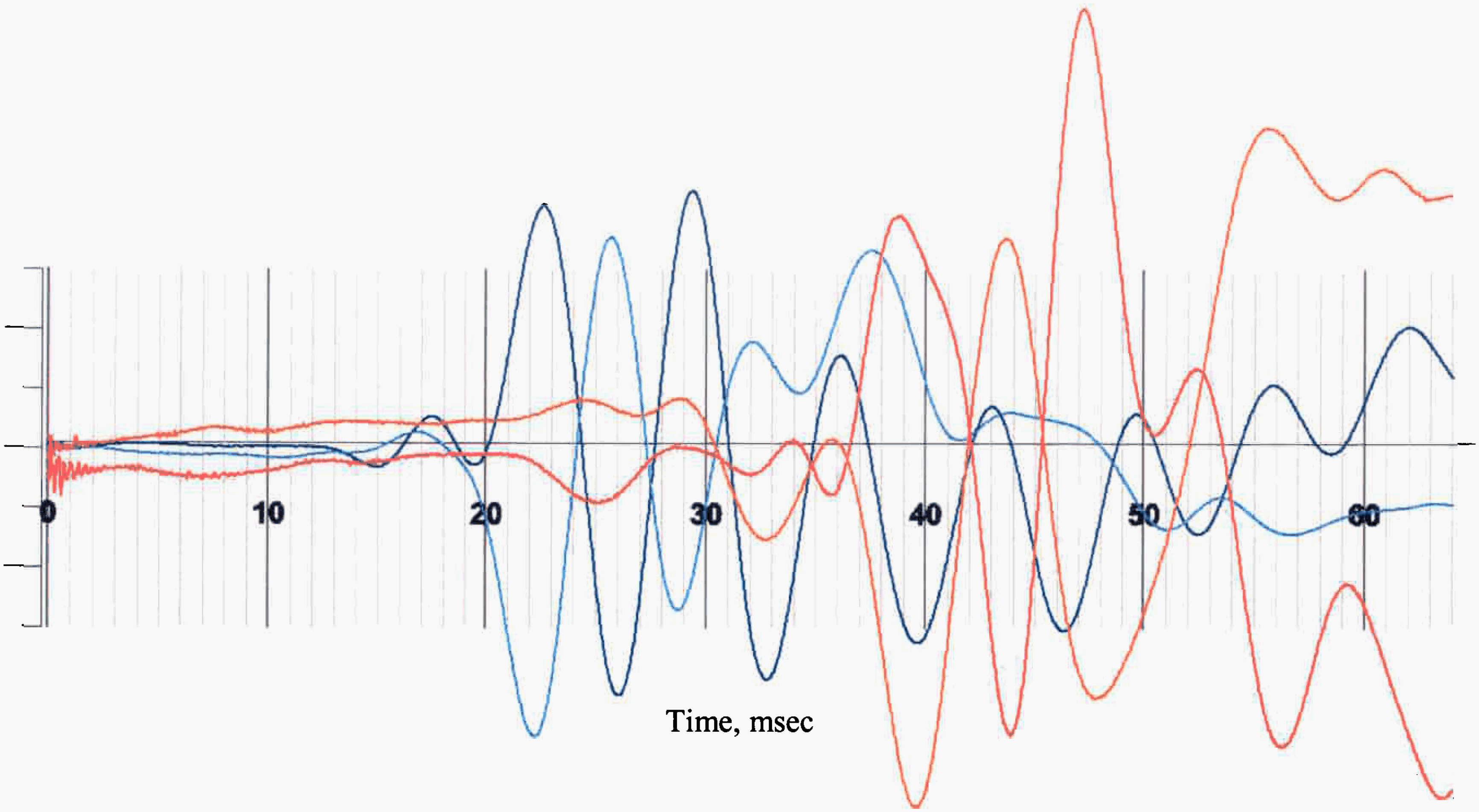
B-802 80'a


Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Time, msec
Lateral Geophones
0
10
20
30

B-802 85’


Legend: Near geophones-blue, purple
Far geophones-red, orange, pink
Vertical Geophones
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Time, msec
Lateral Geophones
0 10 20 30
B-802 89'

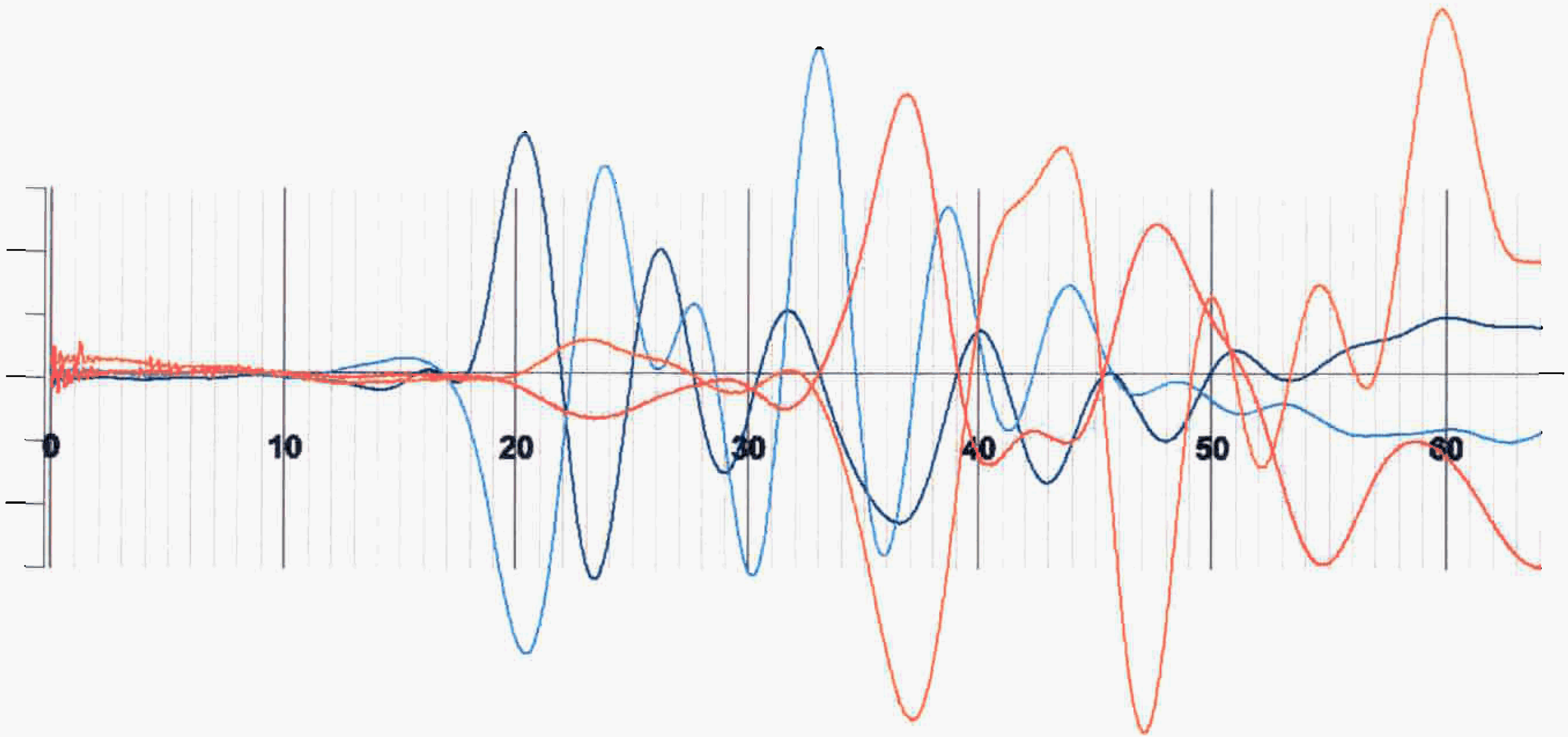
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 03’

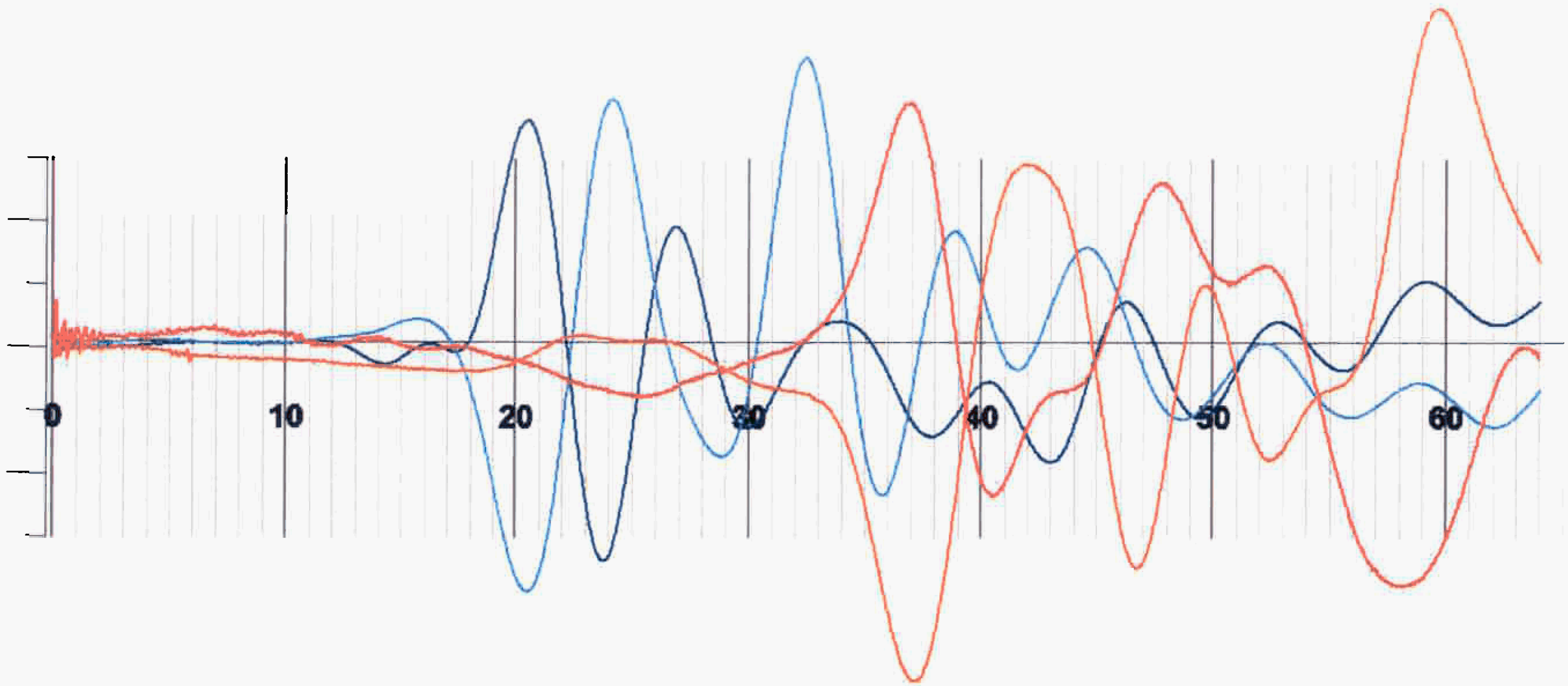
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 06'

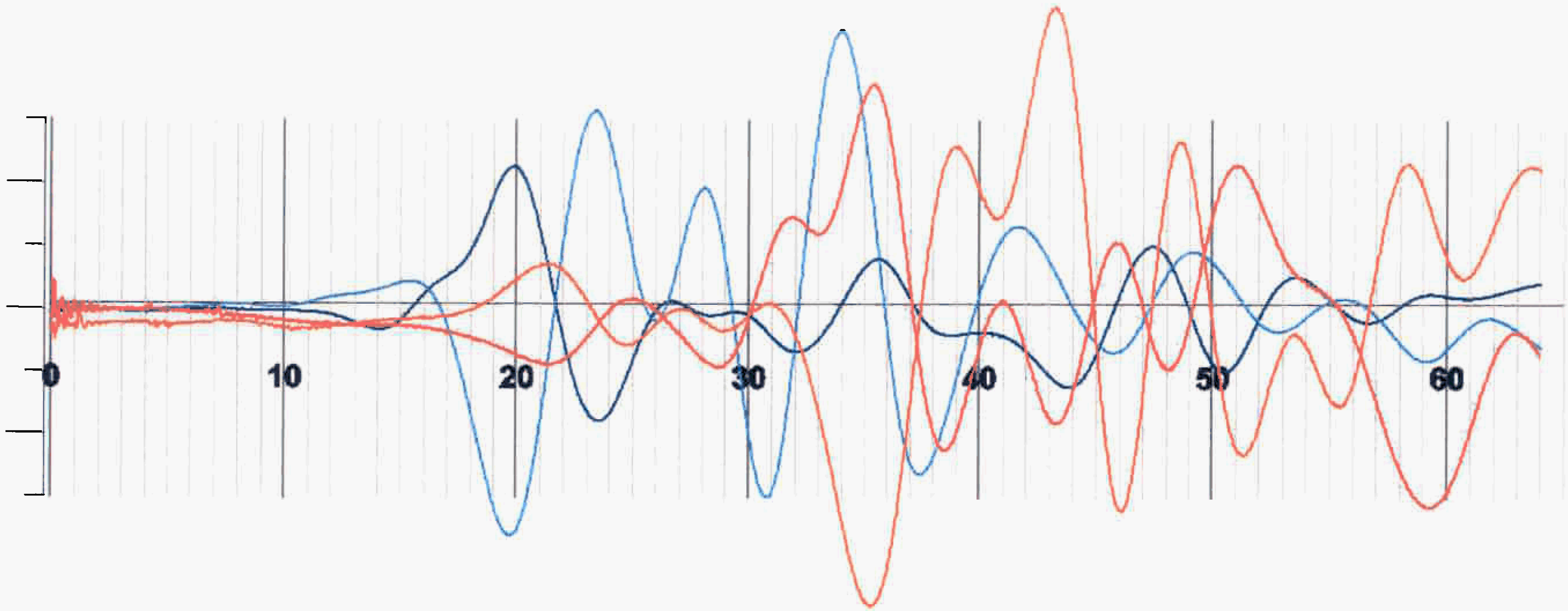
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 06'a

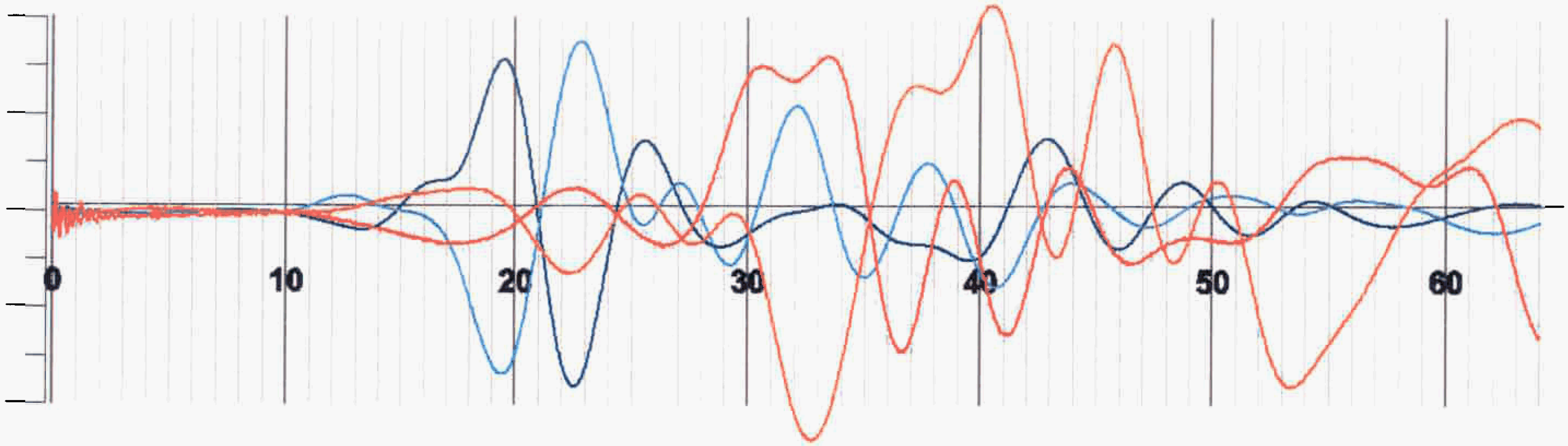
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 08.5’

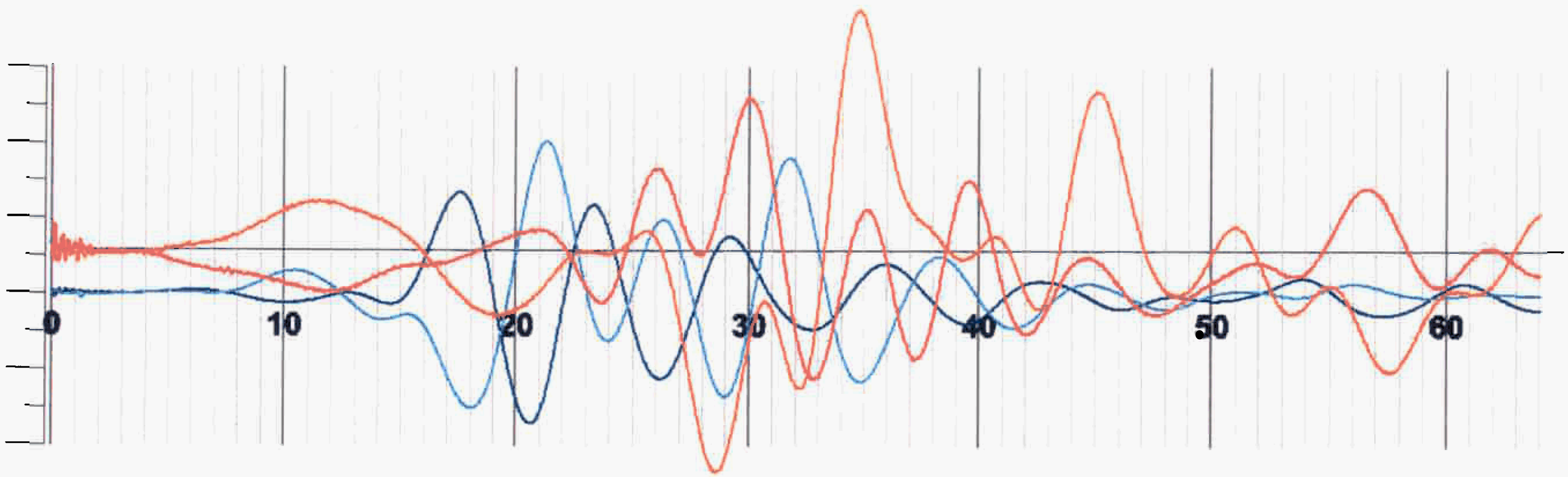
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 11'

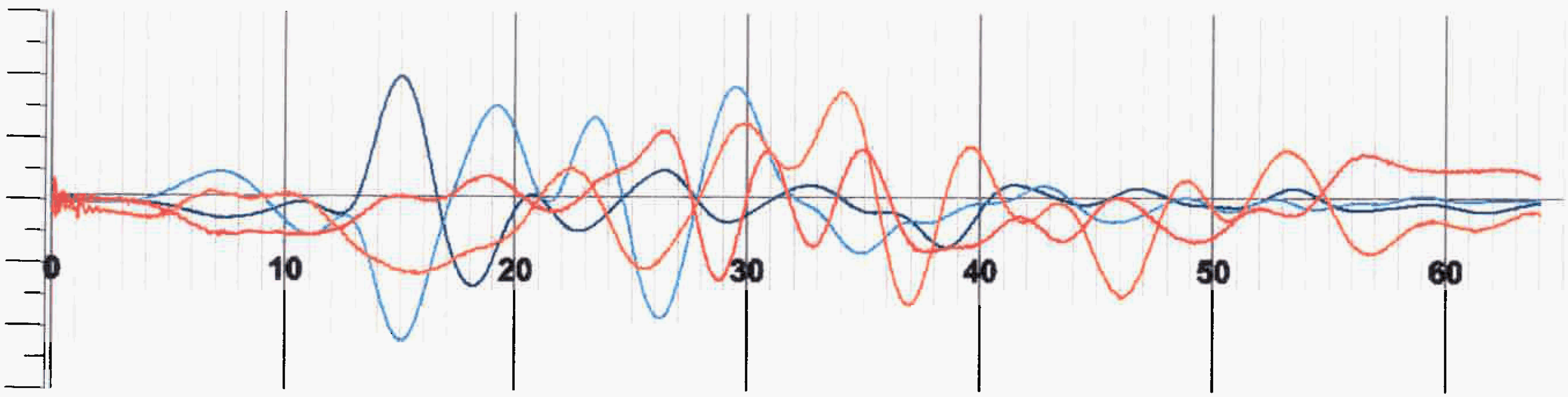
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 13'

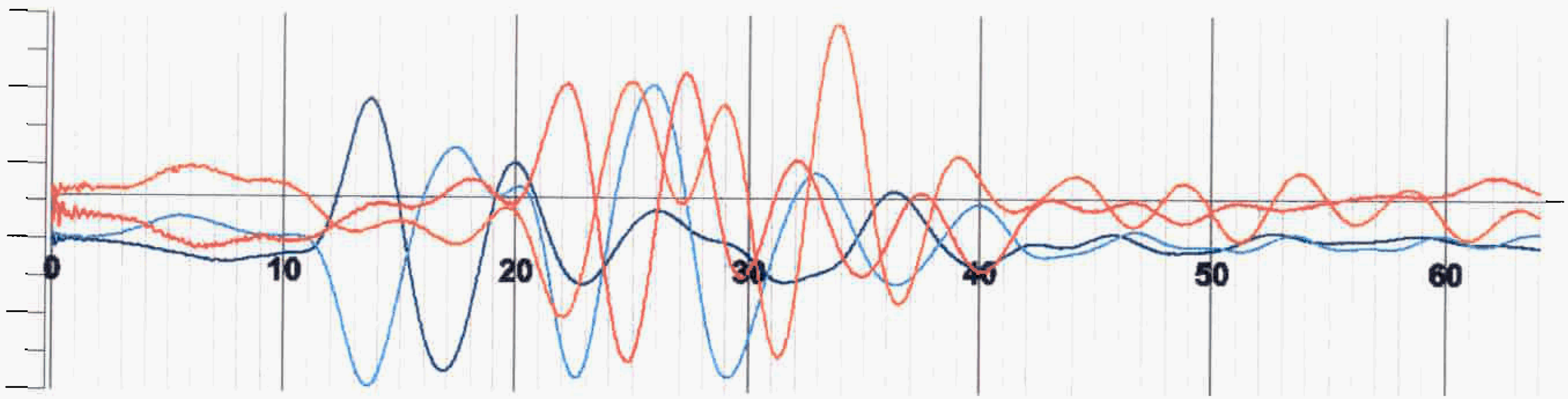
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 16'

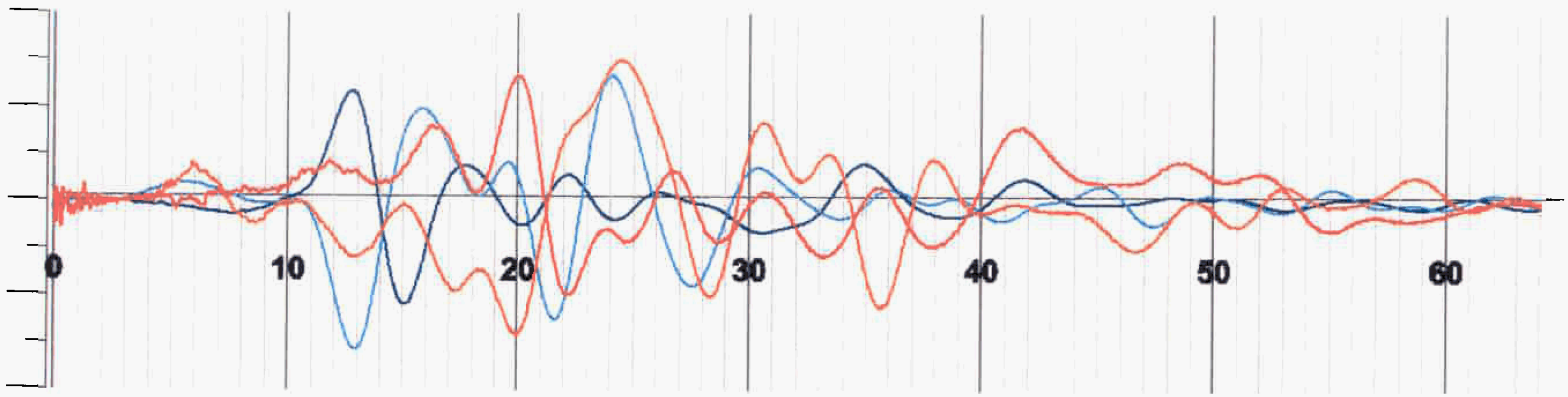
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 18.5’

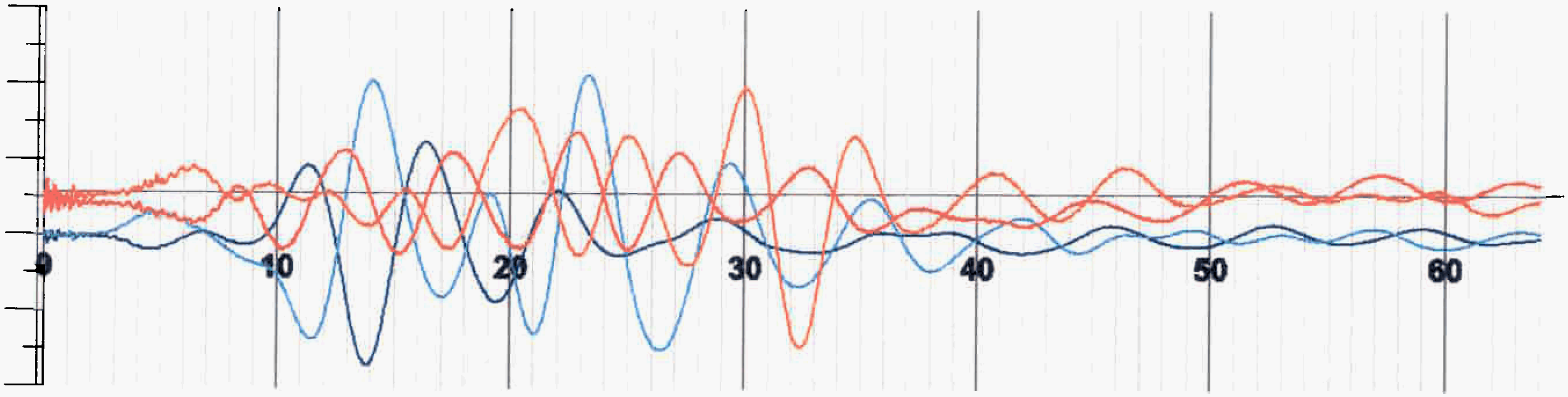
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 21'

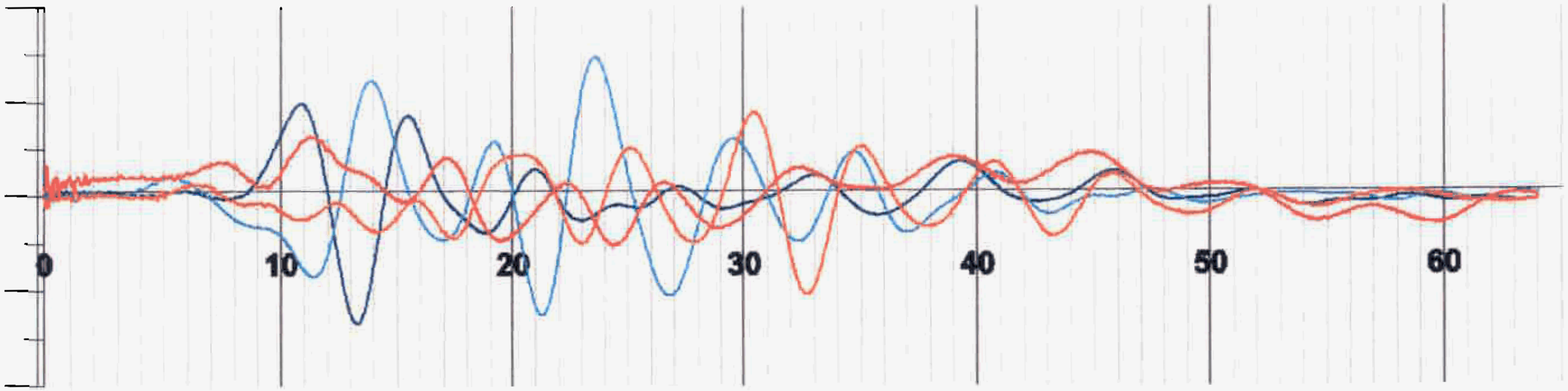
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 26'

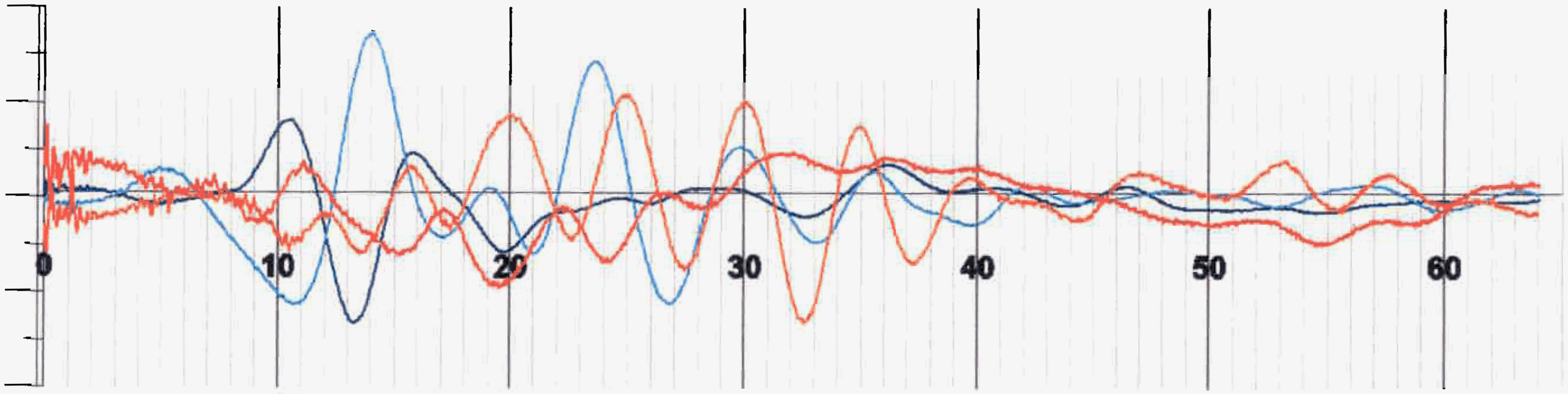
Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 26'a

Legend: Near geophones-blue, purple
Far geophones-red, orange, pink



Time, msec

B-805 27’

APPENDIX I
LABORATORY TESTING DATA

GEOTECHNICAL LABORATORY TEST ASSIGNMENT

Date 11/27/2002-12/18/02 Job Name North Anna ESP Job No. 24830 Requested By John Davie

SAMPLE LOCATION				PHYSICAL PROPERTIES										STRENGTH TESTS							COM-PACTION			CONSOLIDATION
								Grain Size Analysis																NOTE: Stress increments and rebound cycles, ksf.
Boring No.	Sample Type/No.	Sample Depth, Ft	Sample Number	Moisture Content	Unit Weight	Specific Gravity	Atterberg Limits	Sieve Only	Sieve + Hydrometer	Chemical Analysis (pH, chloride, sulphate)	Organic Content			Unconsolidated-Undrained Triaxial	Consolidated-Undrained Triaxial (3-stage w/pore-pressure meas.)	Unconfined Compression (rock) w/stress-strain	Unconfined Compression (rock) without stress-strain curve	Confining Pressure	Direct Shear	Point Load Test	Standard (A, B, C, D)	Modified (A, B, C, D)	CBR	
805	jar	7.5-9	SS4	x			x		x															
"	"	18.5-20	SS7					x																
"	core	40-45	run4													x								
"	core	80-85	run12														x							
803	jar	6.1-7.6	SS3	x			x																	
"	jar	8.6-10.1	SS4					x																
"	jar	13.7-15.	SS6						x	x														
"	jar	23.6-25.	SS8					x																
"	core	50-55	run2														x							
"	core	70-75	run6													x								
"	core	90-95	run10														x							
"	core	125-130	run18														x							
"	core	155-158	run24													x								
801	jar	0-1.5	SS1	x			x																	
"	jar	8.5-10	SS5					x																

REMARKS: Please contact John Davie of Bechtel if there are any questions: Phone (301) 228-7647; Fax (301) 682-6415; e-mail JDAVIE@BECHTEL.COM. For unconfined compression testing of rock cores, select typical rock core samples.

GEOTECHNICAL LABORATORY TEST ASSIGNMENT

Date 11/27/2002-12/18/02 Job Name North Anna ESP Job No. 24830 Requested By John Davie

SAMPLE LOCATION				PHYSICAL PROPERTIES										STRENGTH TESTS							COM-PACTION			CONSOLIDATION						
								Grain Size Analysis																NOTE: Stress increments and rebound cycles, ksf.						
Boring No.	Sample Type/No.	Sample Depth, Ft	Sample Number	Moisture Content	Unit Weight	Specific Gravity	Atterberg Limits	Sieve Only	Sieve + Hydrometer	Chemical Analysis (pH, chloride, sulphate)	Organic Content			Unconsolidated-Undrained Triaxial	Consolidated-Undrained Triaxial (3-stage w/pore-pressure meas.)	Unconfined Compression (rock) w/stress-strain	Unconfined Compression (rock) without stress-strain curve	Confining Pressure	Direct Shear	Point Load Test	Standard (A, B, C, D)	Modified (A, B, C, D)	CBR							
801	jar	13.5-15	SS6						x	x																				
"	core	20-25	run1														x													
"	core	45-50	run6													x														
804	jar	3.5-5	SS3					x																						
"	jar	11-12.5	SS6					x																						
"	jar	18.5-20	SS8					x																						
[illegible]	core	38-40 35-38	run3 ~~run2~~	1/6/03													x													
"	core	40-45	run4														x													
"	core	50-55	run6													x														
802	jar	3.7-5.2	SS2					x																						
"	core	20-25	run4														x													
"	core	45-50	run9														x													
"	core	65-70	run13													x														
"	core	85-90	run17														x													

REMARKS: Please contact John Davie of Bechtel if there are any questions: Phone (301) 228-7647; Fax (301) 682-6415; e-mail JDAVIE@BECHTEL.COM. For unconfined compression testing of rock cores, select typical rock core samples.

GEOTECHNICAL LABORATORY TEST ASSIGNMENT

Date 11/27/2002-12/18/02 Job Name North Anna ESP Job No. 24830 Requested By John Davie

SAMPLE LOCATION				PHYSICAL PROPERTIES										STRENGTH TESTS							COM-PACTION			CONSOLIDATION						
								Grain Size Analysis																NOTE: Stress increments and rebound cycles, ksf.						
Boring No.	Sample Type/No.	Sample Depth, Ft	Sample Number	Moisture Content	Unit Weight	Specific Gravity	Atterberg Limits	Sieve Only	Sieve + Hydrometer	Chemical Analysis (pH, chloride, sulphate)	Organic Content			Unconsolidated-Undrained Triaxial	Consolidated-Undrained Triaxial (3-stage w/pore-pressure meas.)	Unconfined Compression (rock) w/stress-strain	Unconfined Compression (rock) without stress-strain curve	Confining Pressure	Direct Shear	Point Load Test	Standard (A, B, C, D)	Modified (A, B, C, D)	CBR							
806	jar	5.6-7.1	SS3						x	x																				
"	core	24.5-26	run5														x													
"	core	40-45	run10														x													
"	core	60-65	run14														x													
807	jar	4.5-6	SS4	x			x																							
"	jar	12.3-13.	SS6	x			x			x																				
"	jar	21.8-23.	SS-8	x			x		x																					
"	jar	31.5-33	SS10					x																						
"	jar	41.4-42.	SS12					x																						

REMARKS: Please contact John Davie of Bechtel if there are any questions: Phone (301) 228-7647; Fax (301) 682-6415; e-mail JDAVIE@BECHTEL.COM. For unconfined compression testing of rock cores, select typical rock core samples.

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC.
RALEIGH, NORTH CAROLINA

REPORT OF STANDARD TEST METHOD FOR
LABORATORY DETERMINATION OF WATER CONTENT OF SOIL AND ROCK BY MASS
(ASTM D 2216)

PROJECT NAME: North Anna ESP
MACTEC PROJECT NUMBER: 30720-2-5400
BECHTEL JOB NO: 24830
DATE: 2/11/03

SAMPLE IDENTIFICATION			NATURAL	LIQUID & PLASTIC LIMITS			% FINER				USCS
BORING	TYPE	DEPTH (feet)	MOISTURE (%)	LL	PL	PI	#200 SIEVE	pH	CHLORIDES mg/kg	SULFATES mg/kg	CLASSIFICATION
B-801	SS-1	0-1.5	22.2	39	29	10		6.3	130.0	< 27	
B-801	SS-5	8.5-10					39.9				
B-801	SS-6	13.5-15					55.1				
B-802	SS-2	3.7-5.2					19.5				
B-803	SS-3	6.1-7.6	18.9	30	26	4					
B-803	SS-4	8.6-10.1	23.2				24.4				
B-803	SS-6	13.7-15.3					20.9	5.7	100.0	< 23	
B-803	SS-8	23.6-25.1					18.5				
B-804	SS-3	3.5-5					54.2				
B-804	SS-6	11-12.5					46.1				
B-804	SS-8	18.5-20					22.1				
B-805	SS-4	7.5-9	27.2	NP	NP	NP	27.5				SM
B-805	SS-7	18.5-20					25.1				
B-806	SS-3	5.6-7.1					27.1	6.7	920.0	< 24	
B-807	SS-3	4.5-6	40.1	49	45	4					
B-807	SS-6	12.3-13.8	42.8	46	40	6		5.7	170.0	< 28	
B-807	SS-8	21.8-23.3	28.9	41	34	7	42.6				SM-SC
B-807	SS-10	31.5-33	26.7				37.7				
B-807	SS-12	41.4-42.9	21.8				44.2				

TESTING EQUIPMENT:

SCALES: 3.1.99
OVEN: 5.1.10
WASH SIEVE: 5.4.39

TECHNICIAN: JLB
CALCULATIONS: JLB
CHECKED BY: TLM

PREPARED BY: Trudy L. Mullins
Trudy L. Mullins, Laboratory Manager

REVIEWED BY:
Stephen J. Criscenzo
Principal Professional

APPROVED BY: J. Allan Tice
J. Allan Tice, P.E.
Principal Engineer/Project Manager
Registered Virginia, 5264

GRAIN SIZE DISTRIBUTION TEST REPORT

	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.3	59.8	39.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.56	0.24	0.15					

MATERIAL DESCRIPTION	USCS	AASHTO
● B-801 SS-5 8.5-10'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-801 SS-5 8.5-10'

Date: 1/2/2003

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Figure No. 4

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 4

D·te: 1/2/2003
 ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-801 SS-5 8.5-10'
Sample Description: B-801 SS-5 8.5-10'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-4   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 4

Mechanical Analysis Data

	Initial
Dry sample and tare=	150.96
Tare =	0.00
Dry sample weight =	150.96

Tare for cumulative weight retained= 0

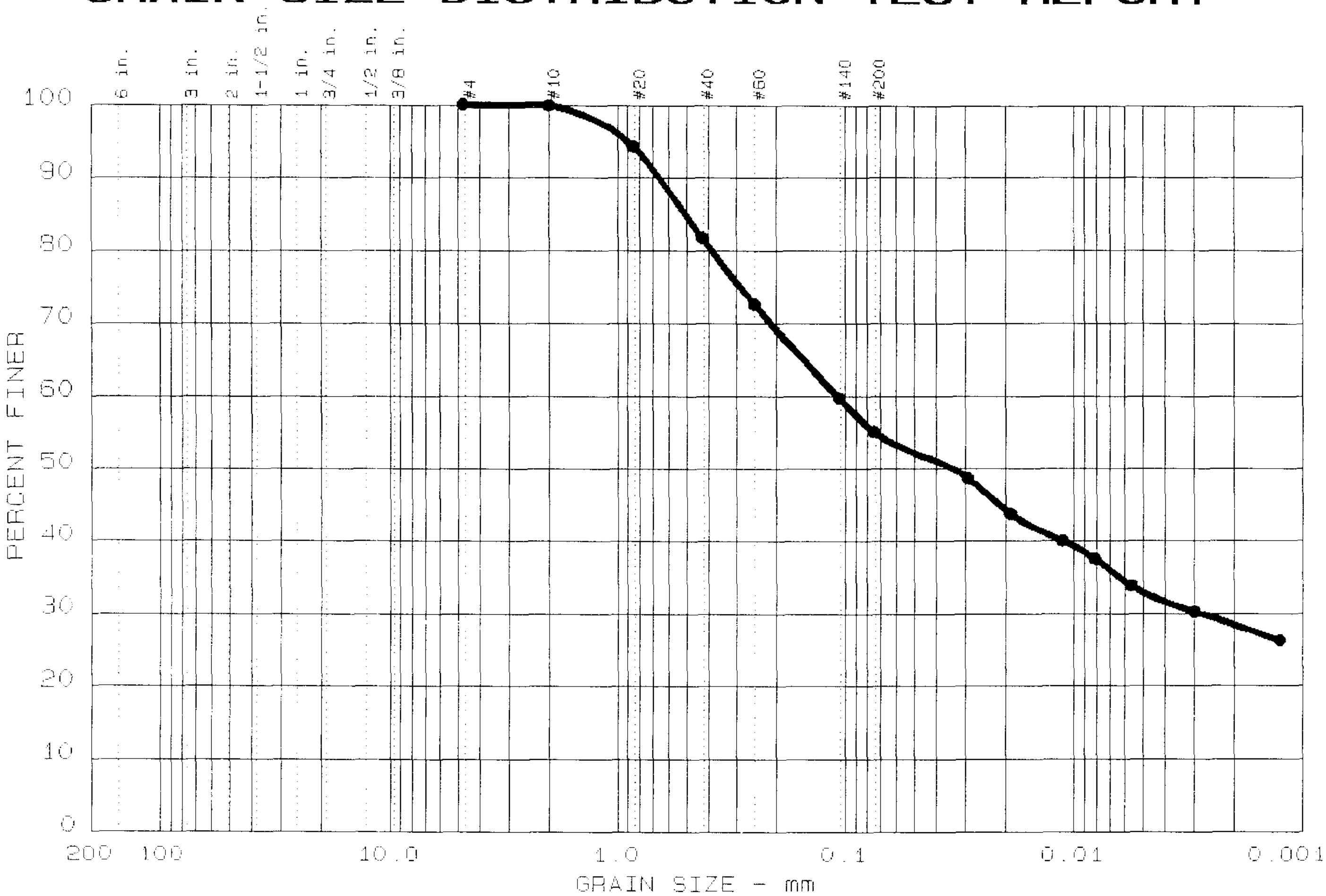
·ieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.46	99.7
# 20	6.52	95.7
# 40	33.55	77.8
# 60	58.58	61.2
# 140	84.15	44.3
# 200	90.76	39.9

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0   % GRAVEL = 0.3   % SAND = 59.8
% FINES = 39.9

D85= 0.56 D60= 0.239 D50= 0.151

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.1	44.8	22.3	32.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.50	0.11	0.03	0.003				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-801 SS-6 13.5-15'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-801 SS-6 13.5-15'

Date: 1/2/2003

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Figure No. 3

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 3

D-te: 1/2/2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-801 SS-6 13.5-15'
Sample Description: B-801 SS-6 13.5-15'
USCS Class: ML Liquid limit: ND
AASHTO Class: A-4(0) Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 3

Mechanical Analysis Data

	Initial
Dry sample and tare=	91.60
Tare =	0.00
Dry sample weight =	91.60

Sample split on number 10 sieve
S-lit sample data:
ample and tare = 81.22 Tare = 0 Sample weight = 81.22
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.08	99.9
# 20	4.54	94.3
# 40	14.71	81.8
# 60	22.21	72.6
# 140	32.68	59.7
# 200	36.40	55.1

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 99.9
Weight of hydrometer sample: 81.22
Calculated biased weight= 81.29
Table of composite correction values:
Temp, deg C: 15.3 20.3 27.1
Comp. corr:

- 6.5 - 5.0 - 3.0
Meniscus correction only=-1
Specific gravity of solids= 2.63
S ecific gravity correction factor= 1.005
 rometer type: 152H   Effective depth L= 16.294964 - 0.164 x Rm

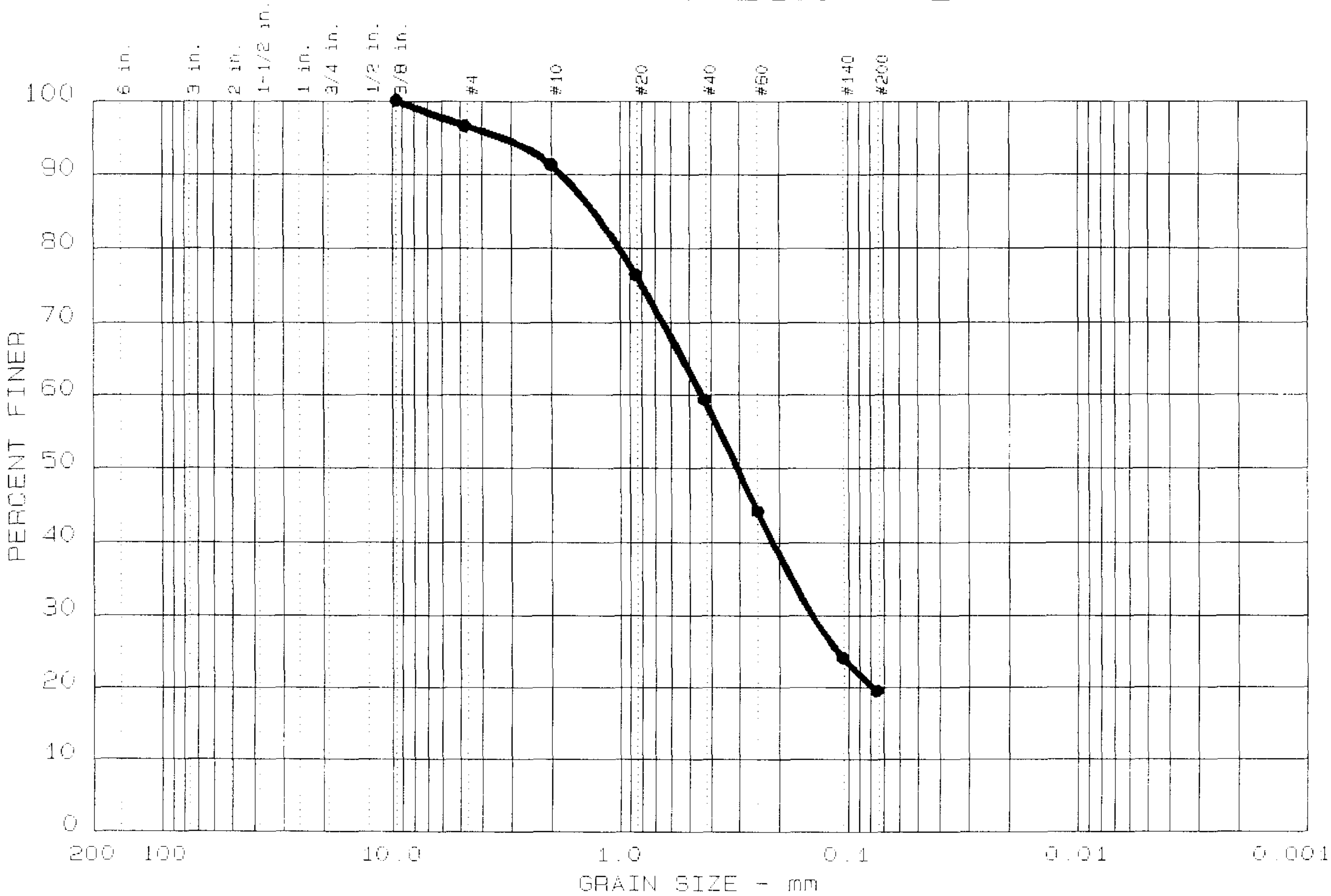
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	21.4	44.0	39.3	0.0135	43.0	9.2	0.0290	48.6
5.0	21.4	40.0	35.3	0.0135	39.0	9.9	0.0190	43.7
15.0	21.4	37.0	32.3	0.0135	36.0	10.4	0.0112	39.9
30.0	21.4	35.0	30.3	0.0135	34.0	10.7	0.0081	37.5
65.0	21.3	32.0	27.3	0.0135	31.0	11.2	0.0056	33.7
240.0	21.7	29.0	24.4	0.0134	28.0	11.7	0.0030	30.2
1440.0	21.0	26.0	21.2	0.0136	25.0	12.2	0.0012	26.2

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0   % GRAVEL = 0.1   % SAND = 44.8
% SILT = 22.3   % CLAY = 32.8

D85= 0.50 D60= 0.107 D50= 0.033
D30= 0.0028

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	8.7	71.8	19.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	1.29	0.44	0.31	0.143				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-802 SS-2 3.7-5.2'		

Project No.: 30720-2-5400

Project: NORTH ANNA ESP

● Location: B-802 SS-2 3.7-5.2'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT

LAW ENGINEERING, INC.

Remarks:

ND=NOT DETERMINED.

SPECIFIC GRAVITY IS ASSUMED

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 15

e: 1-2-2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-802 SS-2 3.7-5.2'
Sample Description: B-802 SS-2 3.7-5.2'
USCS Class: SM Liquid limit: ND
AASHTO Class: A-2-4(0) Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	174.16
Tare =	0.00
Dry sample weight =	174.16

Tare for cumulative weight retained= 0

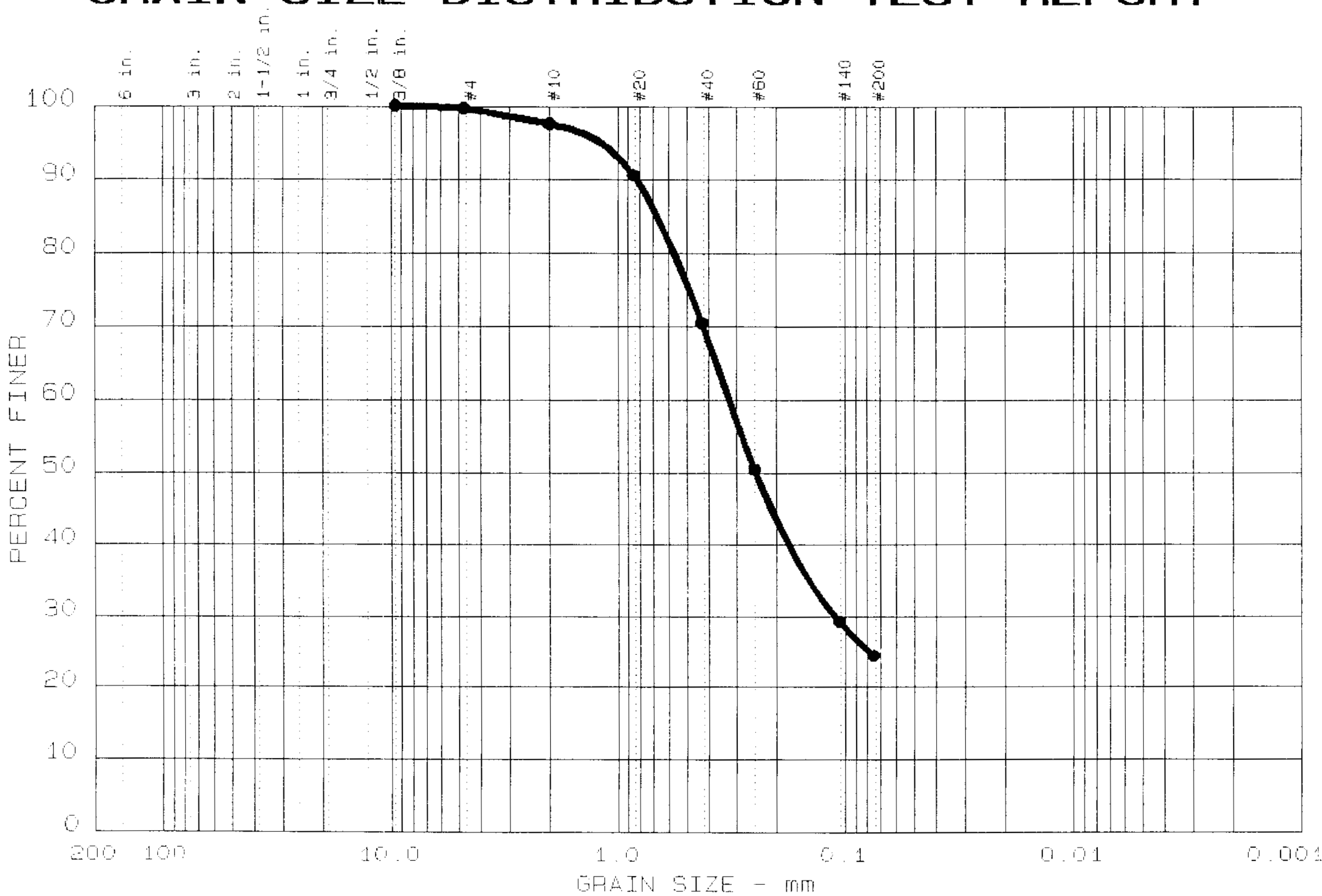
ieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	5.93	96.6
# 10	15.16	91.3
# 20	41.13	76.4
# 40	71.05	59.2
# 60	97.38	44.1
# 140	132.15	24.1
# 200	140.21	19.5

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 8.7 % SAND = 71.8
% FINES = 19.5

D85= 1.29 D60= 0.437 D50= 0.305
D30= 0.1429

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	2.5	73.1	24.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.67	0.32	0.25	0.111				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-803 SS-4 8.5-10.1'		

Project No.: 30720-2-540C
Project: NORTH ANNA ESP
● Location: B-803 SS-4 8.6-10.1'

Date: 1/2/2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED.
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 5

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 5

ᵀ ᵗe: 1/2/2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-803 SS-4 8.6-10.1'
Sample Description: B-803 SS-4 8.6-10.1'
USCS Class: SM Liquid limit: ND
AASHTO Class: A-2-4 Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 5

Mechanical Analysis Data

	Initial
Dry sample and tare=	112.71
Tare =	0.00
Dry sample weight =	112.71

Tare for cumulative weight retained= 0

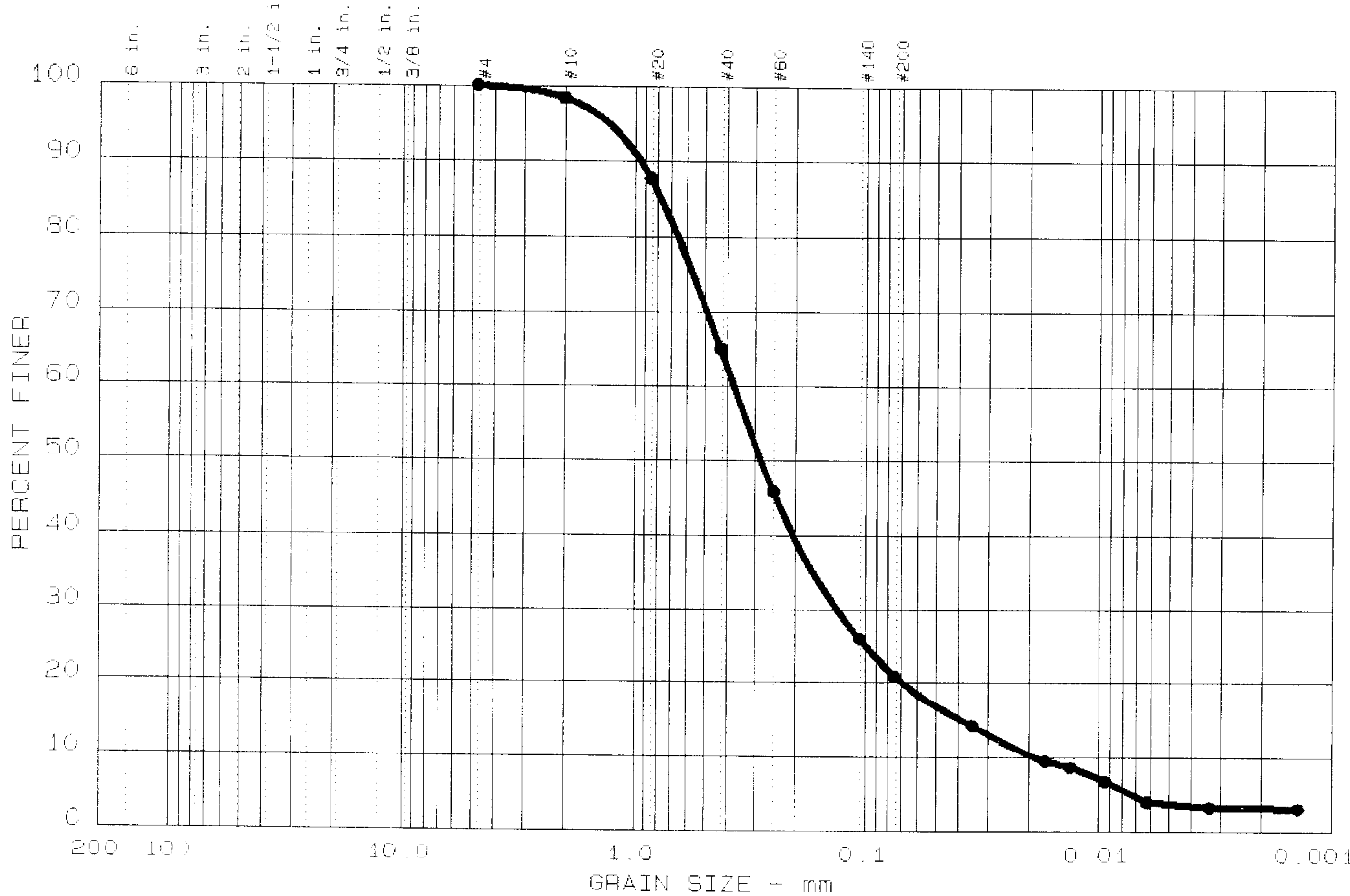
ˈieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	0.36	99.7
# 10	2.78	97.5
# 20	10.58	90.6
# 40	33.34	70.4
# 60	55.82	50.5
# 140	79.83	29.2
# 200	85.21	24.4

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 2.5 % SAND = 73.1
% FINES = 24.4

D85= 0.67 D60= 0.322 D50= 0.246
D30= 0.1113

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	1.7	77.4	17.2	3.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.76	0.37	0.28	0.132	0.0386	0.0187	2.51	20.0

MATERIAL DESCRIPTION	USCS	AASHTO
● B-803 SS-6 13.7-15.3		

Project No.: 30720-2-5400

Project: NORTH ANNA ESP

● Location: B-803 SS-6 13.7-15.3'

Date: 1/2/2003

GRAIN SIZE DISTRIBUTION TEST REPORT

LAW ENGINEERING, INC.

Remarks:

ND=NOT DETERMINED

SPECIFIC GRAVITY

IS ASSUMED

Figure No. 2

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 2

Date: 1/2/2003
Project No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-803 SS-6 13.7-15.3'
Sample Description: B-803 SS-6 13.7-15.3'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-2-4(0)   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 2

Mechanical Analysis Data

	Initial
Dry sample and tare=	174.53
Tare =	0.00
Dry sample weight =	174.53

Sample split on number 10 sieve
Split sample data:
Sample and tare = 105.59 Tare = 0 Sample weight = 105.59
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	2.96	98.3
# 20	11.36	87.7
# 40	35.82	65.0
# 60	56.40	45.8
# 140	77.72	25.9
# 200	83.16	20.9

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 98.3
Weight of hydrometer sample: 105.59
Calculated biased weight= 107.41
Table of composite correction values:
Temp, deg C: 15.3 20.3 27.1
Comp. corr:

- 6.5 - 5.0 - 3.0

Meniscus correction only=-1

Specific gravity of solids= 2.63

ecific gravity correction factor= 1.005

rometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	20.9	20.0	15.2	0.0136	19.0	13.2	0.0348	14.2
9.0	20.9	15.0	10.2	0.0136	14.0	14.0	0.0169	9.5
15.0	21.0	14.0	9.2	0.0136	13.0	14.2	0.0132	8.6
30.0	20.9	12.0	7.2	0.0136	11.0	14.5	0.0094	6.7
71.0	20.9	9.0	4.2	0.0136	8.0	15.0	0.0062	3.9
246.0	21.7	8.0	3.4	0.0134	7.0	15.1	0.0033	3.2
1440.0	21.1	8.0	3.2	0.0135	7.0	15.1	0.0014	3.0

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #200 sieve

% + 75mm. = 0.0 % GRAVEL = 1.7 % SAND = 77.4

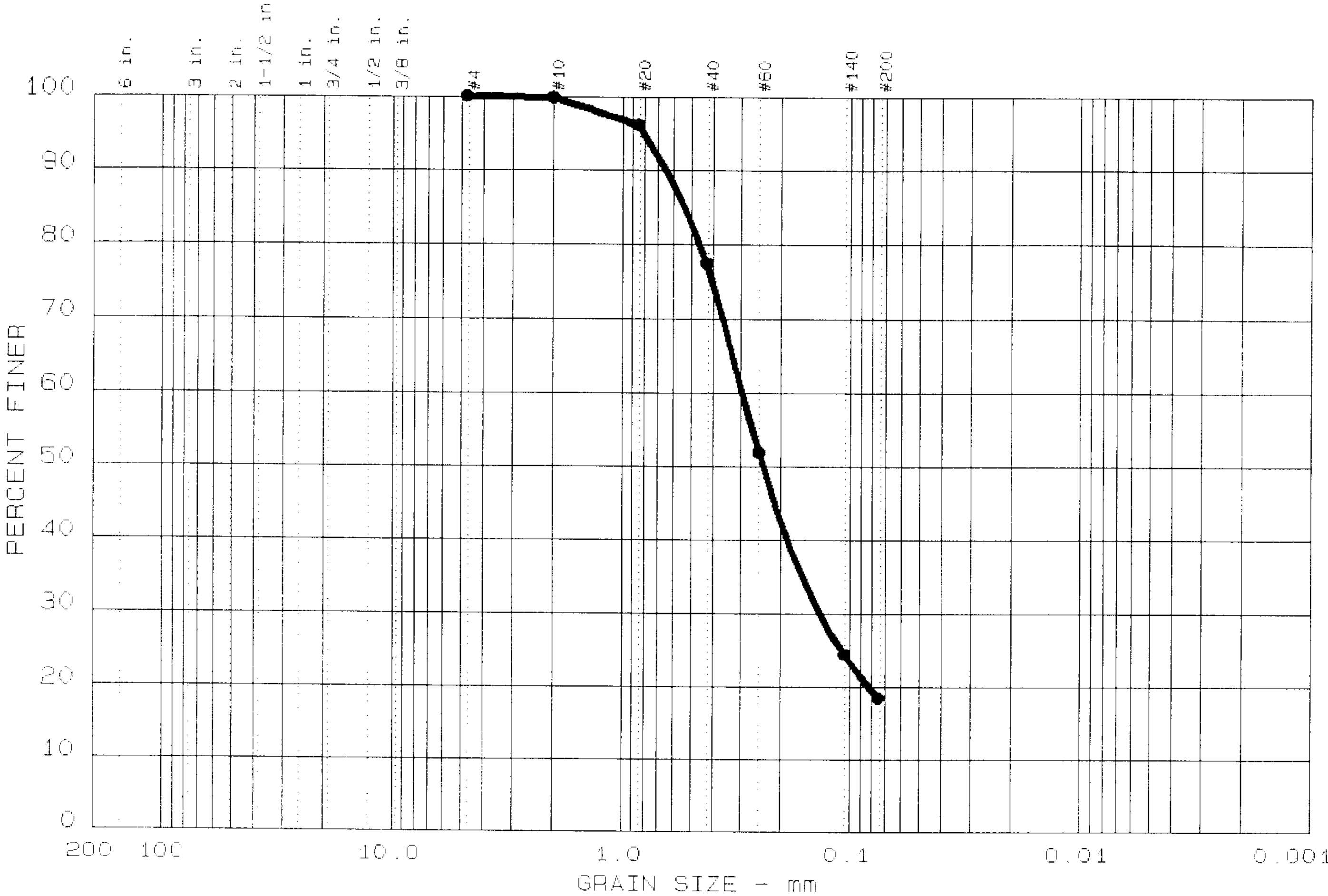
% SILT = 17.2 % CLAY = 3.7

D85= 0.76 D60= 0.373 D50= 0.283

D30= 0.1323 D15= 0.03859 D10= 0.01869

Cc = 2.5119 Cu = 19.9526

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.2	81.3	18.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.53	0.30	0.24	0.135				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-803 SS-8 23 6-25.1'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-803 SS-8 23.6-25.1'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 6

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 10

te: 1-2-2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-803 SS-8 23.6-25.1'
Sample Description: B-803 SS-8 23.6-25.1'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-2-4   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 6

Mechanical Analysis Data

	Initial
Dry sample and tare=	142.55
Tare =	0.00
Dry sample weight =	142.55

Tare for cumulative weight retained= 0

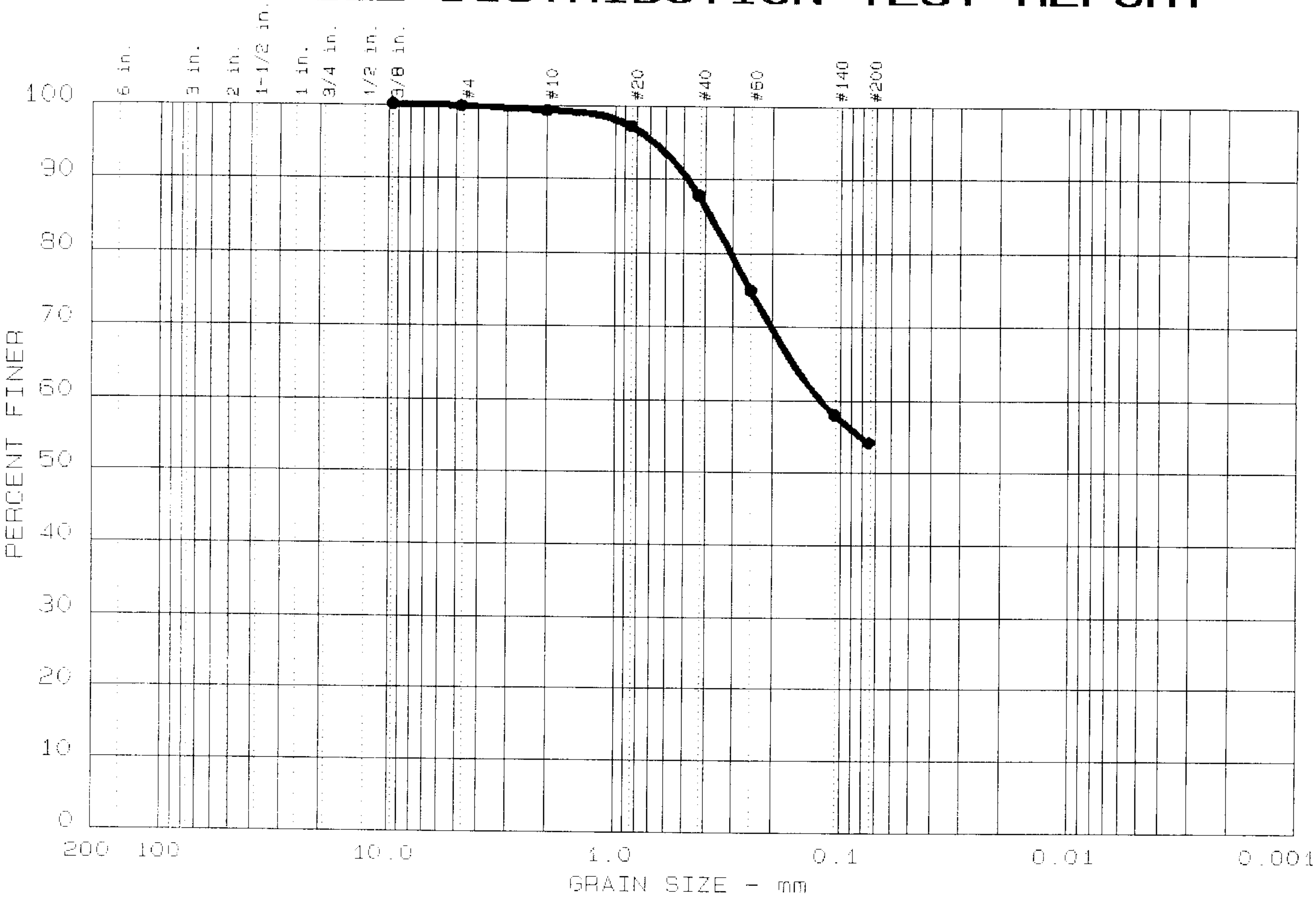
ieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.26	99.8
# 20	5.41	96.2
# 40	32.09	77.5
# 60	68.56	51.9
# 140	107.81	24.4
# 200	116.12	18.5

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 0.2 % SAND = 81.3
% FINES = 18.5

D85= 0.53 D60= 0.295 D50= 0.240
D30= 0.1347

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.7	45.1	54.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.37	0.12						

MATERIAL DESCRIPTION	USCS	AASHTO
● B-804 SS-3 3.5-5'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-804 SS-3 3.5-5'

Date: 1-2-2003

Remarks:
ND=NOT DETERMINED.
SPECIFIC GRAVITY
IS ASSUMED

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Figure No. 7

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 11

e: 1-2-2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-804 SS-3 3.5-5'
Sample Description: B-804 SS-3 3.5-5'
USCS Class: ML Liquid limit: ND
AASHTO Class: A-4 Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 7

Mechanical Analysis Data

	Initial
Dry sample and tare=	135.24
Tare =	0.00
Dry sample weight =	135.24

Tare for cumulative weight retained= 0

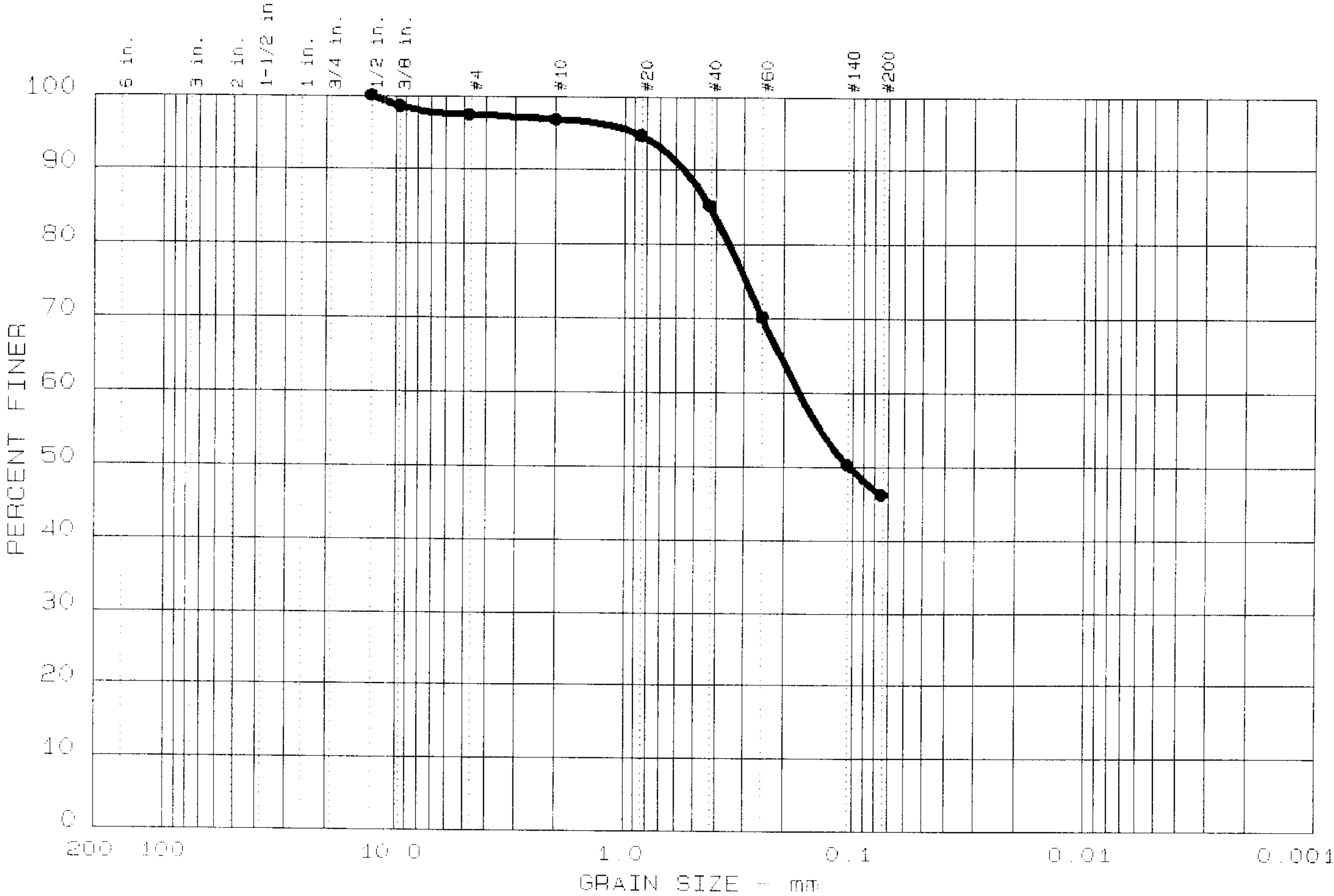
ieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	0.22	99.8
# 10	1.00	99.3
# 20	3.84	97.2
# 40	16.42	87.9
# 60	33.97	74.9
# 140	56.91	57.9
# 200	62.03	54.1

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 0.7 % SAND = 45.1
% FINES = 54.2

D85= 0.37 D60= 0.122

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	3.3	50.6	46.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.42	0.17	0.10					

MATERIAL DESCRIPTION	USCS	AASHTO
● B-804 SS-6 11-12.5'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-804 SS-6 11-12.5'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 8

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 12

Date: 1-2-2003
Project No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-804 SS-6 11-12.5'
Sample Description: B-804 SS-6 11-12.5'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-4   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 8

Mechanical Analysis Data

	Initial
Dry sample and tare=	176.24
Tare =	0.00
Dry sample weight =	176.24

Tare for cumulative weight retained= 0

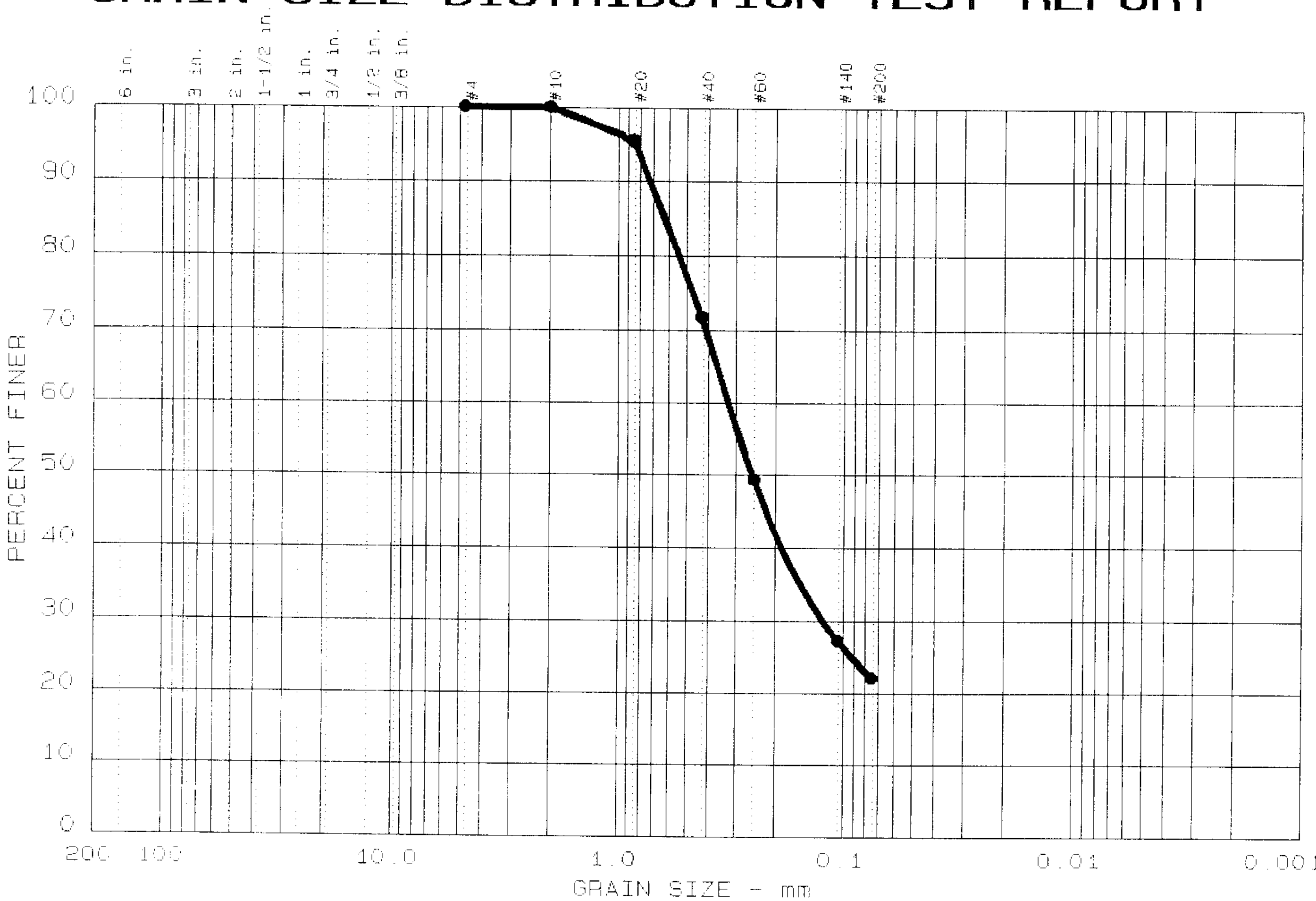
Sieve	Cumul. Wt. retained	Percent finer
0.5 inches	0.00	100.0
0.375 inches	2.58	98.5
# 4	4.58	97.4
# 10	5.74	96.7
# 20	9.55	94.6
# 40	26.11	85.2
# 60	52.51	70.2
# 140	87.74	50.2
# 200	94.90	46.2

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0   % GRAVEL = 3.3   % SAND = 50.6
% FINES = 46.1

D85= 0.42 D60= 0.172 D50= 0.103

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	77.9	22.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.62	0.32	0.25	0.123				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-804 SS-8 18.5-20'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-804 SS-8 18.5-20'

Date: 1-2-2003

Remarks:
ND=NOT DETERMINED.
SPECIFIC GRAVITY
IS ASSUMED

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Figure No. 9

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 13

e: 1-2-2003
. oject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-804 SS-8 18.5-20'
Sample Description: B-804 SS-8 18.5-20'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-2-4   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 9

Mechanical Analysis Data

Initial
Dry sample and tare= 133.91
Tare = 0.00
Dry sample weight = 133.91
Tare for cumulative weight retained= 0

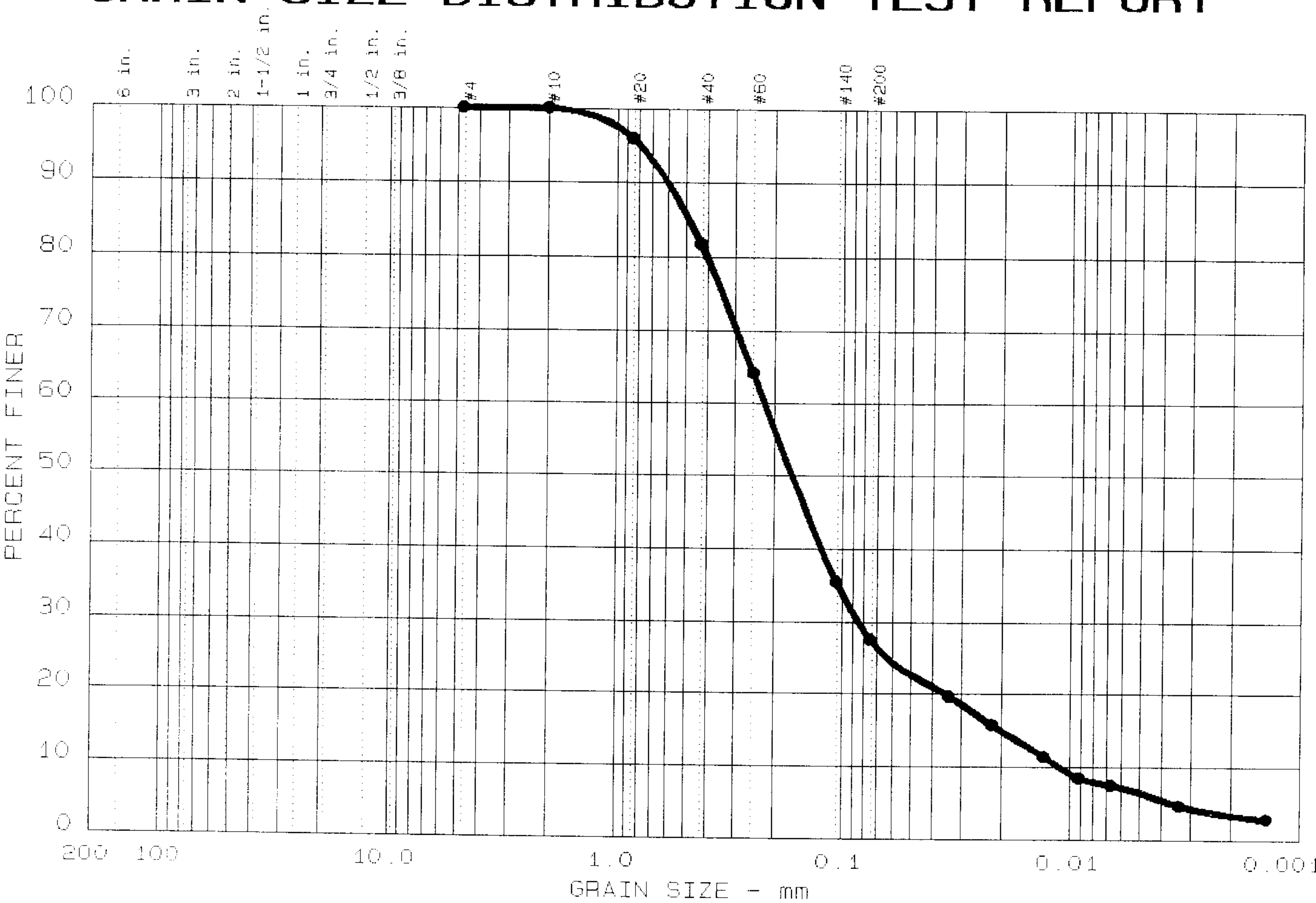
ieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.04	100.0
# 20	5.94	95.6
# 40	37.80	71.8
# 60	67.88	49.3
# 140	97.44	27.2
# 200	104.29	22.1

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 0.0 % SAND = 77.9
% FINES = 22.1

D85= 0.62 D60= 0.324 D50= 0.254
D30= 0.1230

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	76.9	16.7	6.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	NP	NP	0.48	0.22	0.17	0.085	0.0201	0.0112	2.91	19.7

MATERIAL DESCRIPTION	USCS	AASHTO
● B-805 SS-4 7.5-9'	SM	A-2-4 (0)

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-805 SS-4 7.5-9'

Date: 1/2/2003

Remarks:
ND=NOT DETERMINED.
SPECIFIC GRAVITY
IS ASSUMED

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 1

te: 1/2/2003
oject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-805 SS-4 7.5-9'
Sample Description: B-805 SS-4 7.5-9'
USCS Class: SM   Liquid limit: NP
AASHTO Class: A-2-4(0)   Plasticity index: NP

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	168.13
Tare =	0.00
Dry sample weight =	168.13

Sample split on number 10 sieve
it sample data:
ample and tare = 99.56 Tare = 0 Sample weight = 99.56
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

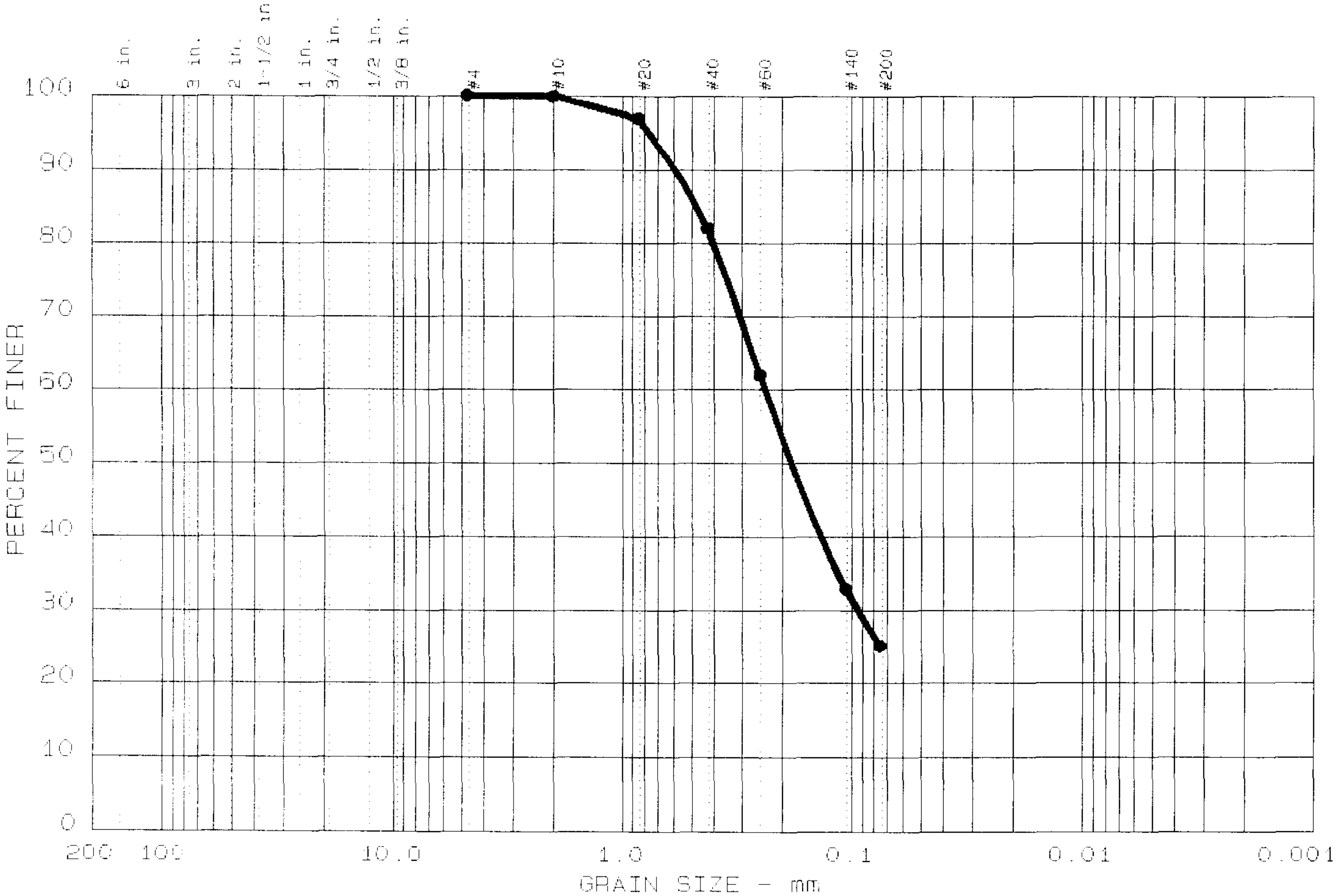
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.02	100.0
# 20	4.08	95.9
# 40	18.13	81.8
# 60	35.61	64.2
# 140	64.22	35.5
# 200	72.15	27.5

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 100.0
Weight of hydrometer sample: 99.56
Calculated biased weight= 99.57
Table of composite correction values:

Temp, deg C:	15.3	20.3	27.1
Comp. corr:			

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.1	74.8	25.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.47	0.24	0.18	0.094				

MATERIAL DESCRIPTION	USCS	AASHTO
● B-805 SS-7 18.5-20'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-805 SS-7 18.5-20'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 10

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 14

e: 1-2-2003
jject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-805 SS-7 18.5-20'
Sample Description: B-805 SS-7 18.5-20'
USCS Class: SM — Liquid limit: ND
AASHTO Class: A-2-4 — Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 10

Mechanical Analysis Data

	Initial
Dry sample and tare=	120.52
Tare =	0.00
Dry sample weight =	120.52

Tare for cumulative weight retained= 0

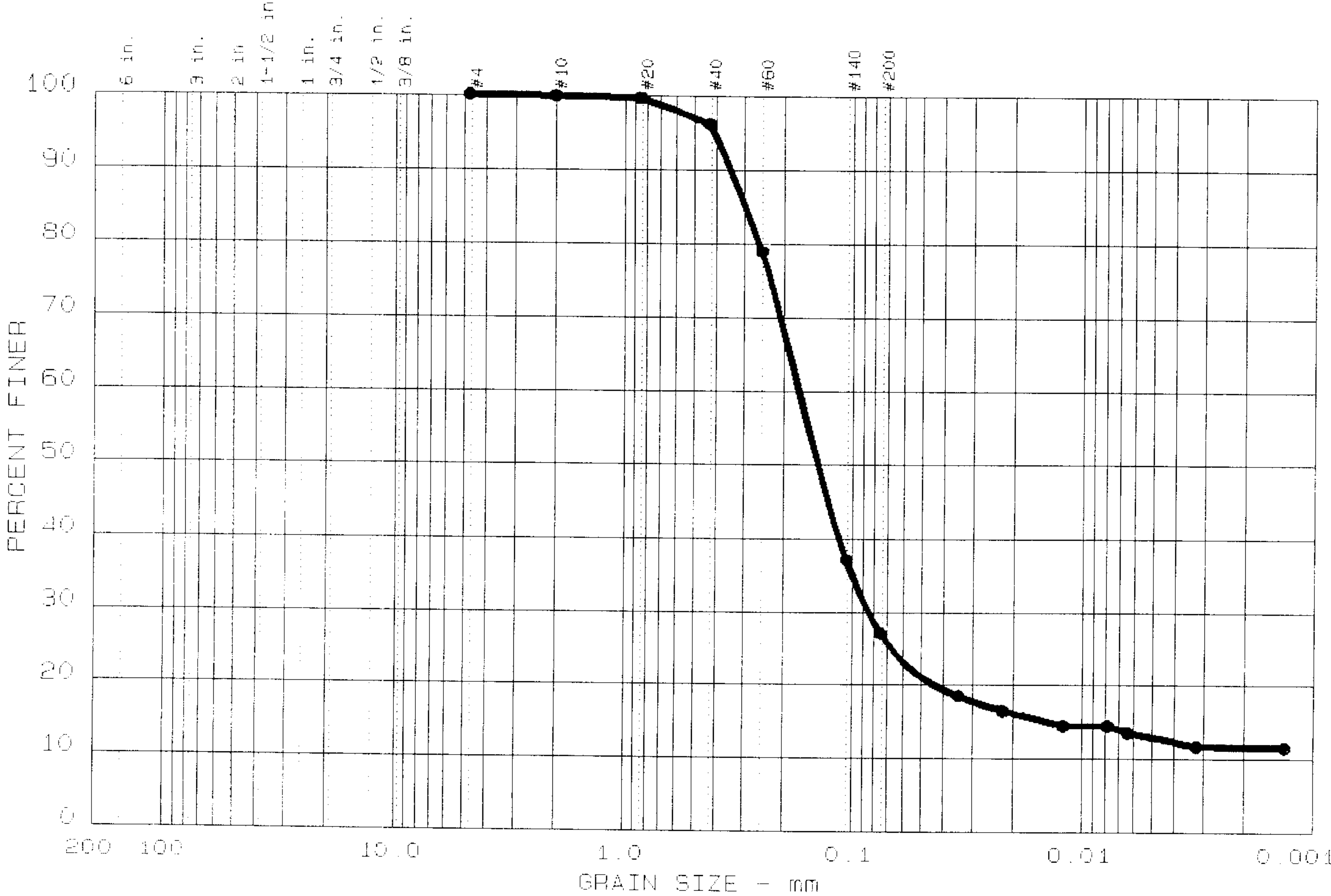
ieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.11	99.9
# 20	3.76	96.9
# 40	21.65	82.0
# 60	45.83	62.0
# 140	80.96	32.8
# 200	90.24	25.1

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 0.1 % SAND = 74.8
% FINES = 25.1

D85= 0.47 D60= 0.237 D50= 0.182
D30= 0.0942

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.2	72.7	14.3	12.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.29	0.17	0.14	0.084	0.0138			

MATERIAL DESCRIPTION	USCS	AASHTO
● B-806 SS-3 5.6-7.1'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-806 SS-3 5.6-7.1'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 2

==

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 16

" te: 1-2-2003
,ject No.: 30720-2-5400
Project: NORTH ANNA ESP

==

Sample Data

Location of Sample: B-806 SS-3 5.6-7.1'
Sample Description: B-806 SS-3 5.6-7.1'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-2-4(0)   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 2

Mechanical Analysis Data

	Initial
Dry sample and tare=	120.73
Tare =	0.00
Dry sample weight =	120.73

Sample split on number 10 sieve
" "it sample data:
ample and tare = 98.05 Tare = 0 Sample weight = 98.05
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.21	99.8
# 20	0.21	99.6
# 40	3.62	96.1
# 60	20.51	78.9
# 140	61.66	37.0
# 200	71.41	27.1

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 99.8
Weight of hydrometer sample: 98.05
Calculated biased weight= 98.22
Table of composite correction values:

Temp, deg C:	15.3	20.3	27.1
Comp. corr:			

- 6.5 - 5.0 - 3.0
Meniscus correction only=-1
Specific gravity of solids= 2.63
Specific gravity correction factor= 1.005
Hydrometer type: 152H   Effective depth L= 16.294964 - 0.164 x Rm

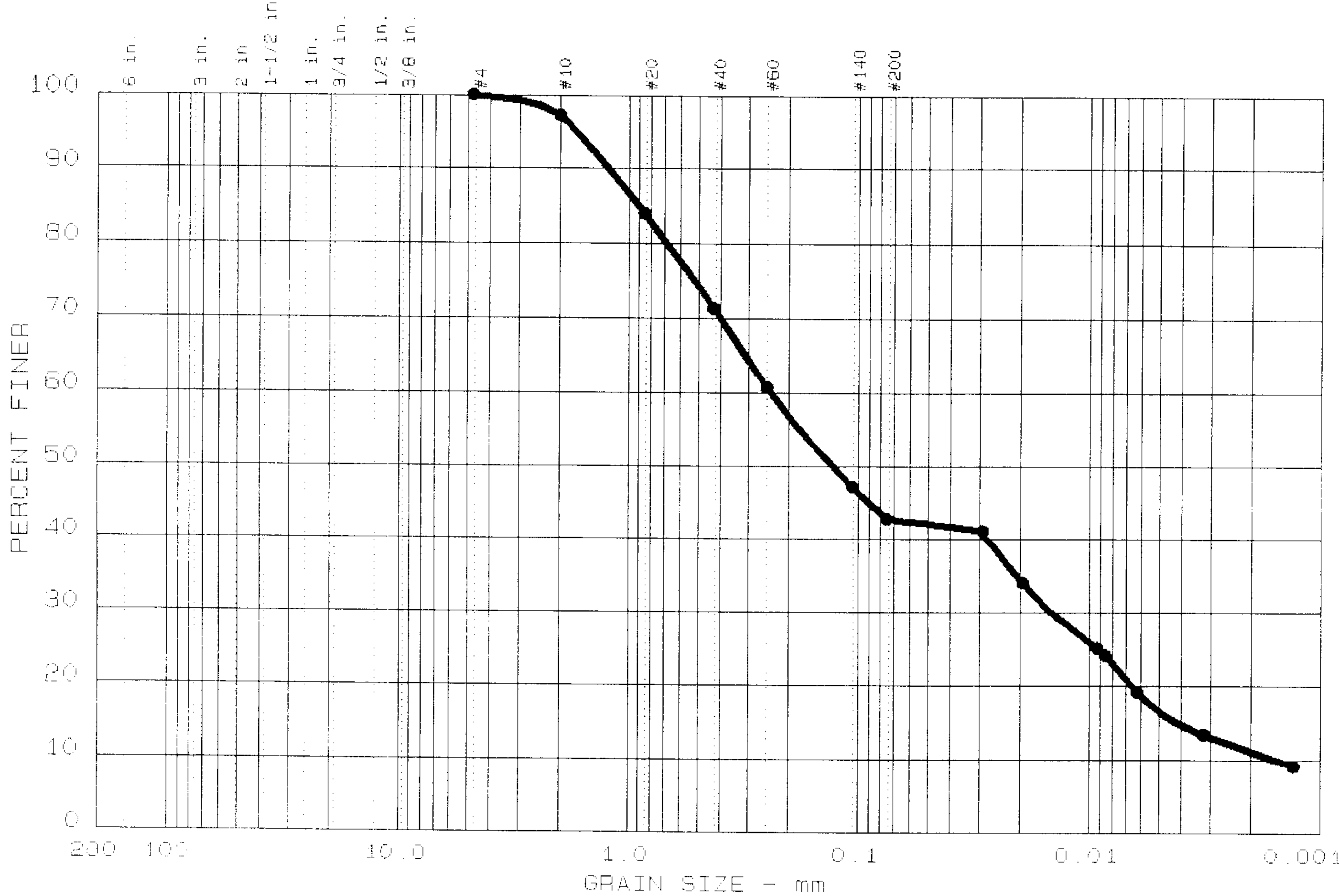
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	20.5	23.0	18.1	0.0136	22.0	12.7	0.0344	18.5
5.0	20.5	21.0	16.1	0.0136	20.0	13.0	0.0220	16.4
17.0	20.6	19.0	14.1	0.0136	18.0	13.3	0.0121	14.4
41.0	20.6	19.0	14.1	0.0136	18.0	13.3	0.0078	14.4
62.0	20.9	18.0	13.2	0.0136	17.0	13.5	0.0063	13.5
244.0	21.6	16.0	11.4	0.0135	15.0	13.8	0.0032	11.6
1440.0	21.1	16.0	11.2	0.0135	15.0	13.8	0.0013	11.5

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0   % GRAVEL = 0.2   % SAND = 72.7
% SILT = 14.3   % CLAY = 12.8

D85= 0.29 D60= 0.171 D50= 0.141
D30= 0.0842 D15= 0.01382

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	2.7	54.6	26.1	16.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	41	7	0.90	0.24	0.13	0.015	0.0041	0.0015	0.58	154.9

MATERIAL DESCRIPTION	USCS	AASHTO
● B-807 SS-8 21.8-23.3'	SM-SC	A-5(1)

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-807 SS-8 21.8-23.3'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 3

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 17

e: 1-2-2003
ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-807 SS-8 21.8-23.3'
Sample Description: B-807 SS-8 21.8-23.3'
USCS Class: SM-SC   Liquid limit: 41
AASHTO Class: A-5(1)   Plasticity index: 7

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 3

Mechanical Analysis Data

	Initial
Dry sample and tare=	183.66
Tare =	0.00
Dry sample weight =	183.66

Sample split on number 10 sieve
it sample data:
Sample and tare = 97.65 Tare = 0 Sample weight = 97.65
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	5.04	97.3
# 20	13.34	84.0
# 40	26.07	71.3
# 60	36.65	60.8
# 140	50.37	47.1
# 200	54.83	42.6

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 97.3
Weight of hydrometer sample: 97.65
Calculated biased weight= 100.41
Table of composite correction values:
Temp, deg C: 15.3 20.3 27.1
Comp. corr:

- 6.5 - 5.0 - 3.0
Meniscus correction only=-1
Specific gravity of solids= 2.63
Specific gravity correction factor= 1.005
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

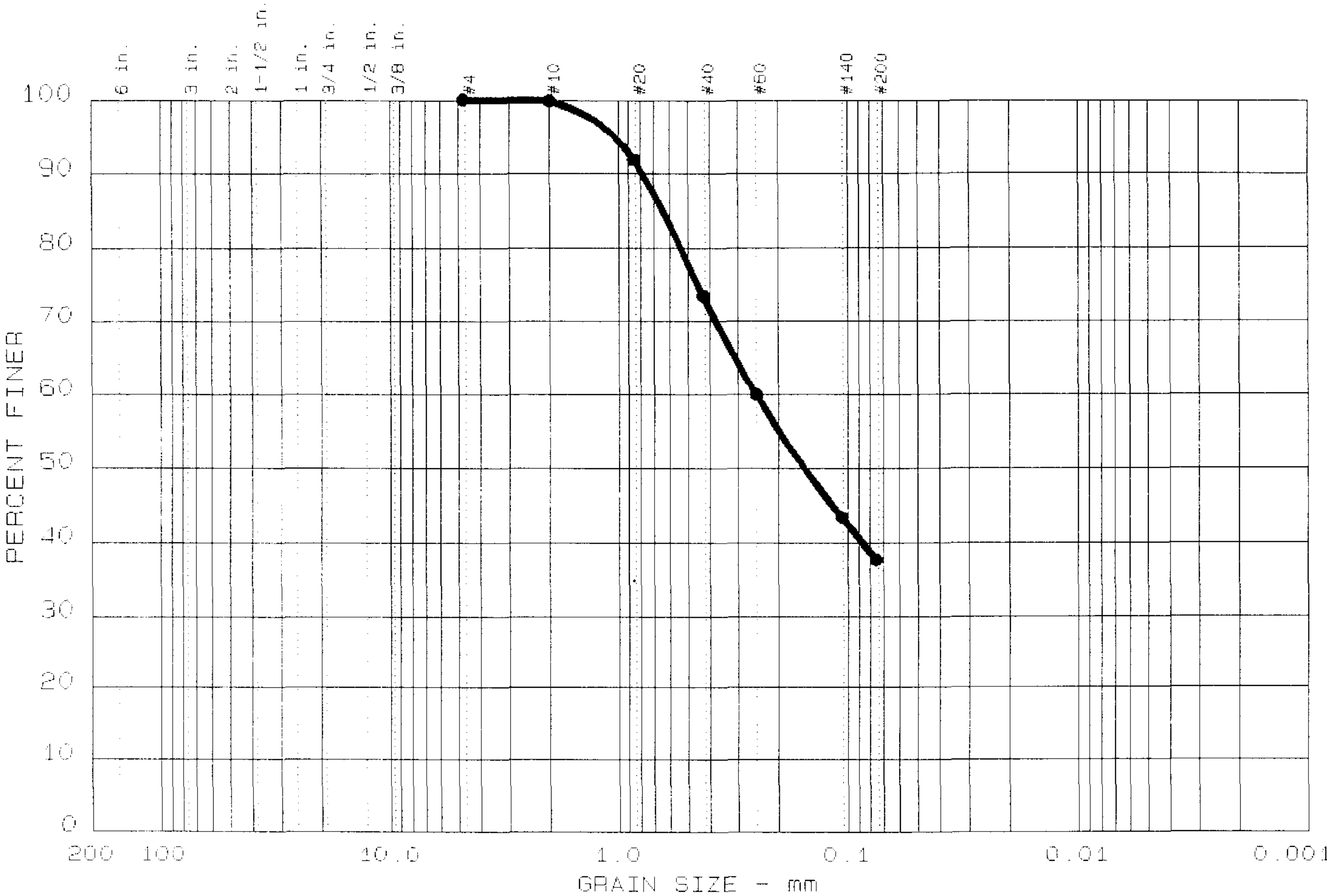
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
2.0	20.3	46.0	41.0	0.0137	45.0	8.9	0.0289	41.0
5.0	20.3	39.0	34.0	0.0137	38.0	10.1	0.0194	34.0
25.0	20.4	30.0	25.0	0.0137	29.0	11.5	0.0093	25.0
30.0	20.4	29.0	24.0	0.0137	28.0	11.7	0.0085	24.0
60.0	20.8	24.0	19.1	0.0136	23.0	12.5	0.0062	19.2
240.0	21.6	18.0	13.4	0.0135	17.0	13.5	0.0032	13.4
1539.0	21.0	14.0	9.2	0.0136	13.0	14.2	0.0013	9.2

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 2.7 % SAND = 54.6
% SILT = 26.1 % CLAY = 16.6

D85= 0.90 D60= 0.240 D50= 0.129
D30= 0.0146 D15= 0.00412 D10= 0.00155
Cc = 0.5754 Cu = 154.8817

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.1	62.2	37.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.64	0.25	0.15					

MATERIAL DESCRIPTION	USCS	AASHTO
● B-807 SS-10 31.5-33'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-807 SS-10 31.5-33'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 4

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 18

e: 1-2-2003
. ject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-807 SS-10 31.5-33'
Sample Description: B-807 SS-10 31.5-33'
USCS Class: SM
Liquid limit: ND
AASHTO Class: A-4(0)
Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY IS ASSUMED
Fig. No.: 4

Mechanical Analysis Data

	Initial
Dry sample and tare=	180.87
Tare =	0.00
Dry sample weight =	180.87

Tare for cumulative weight retained= 0

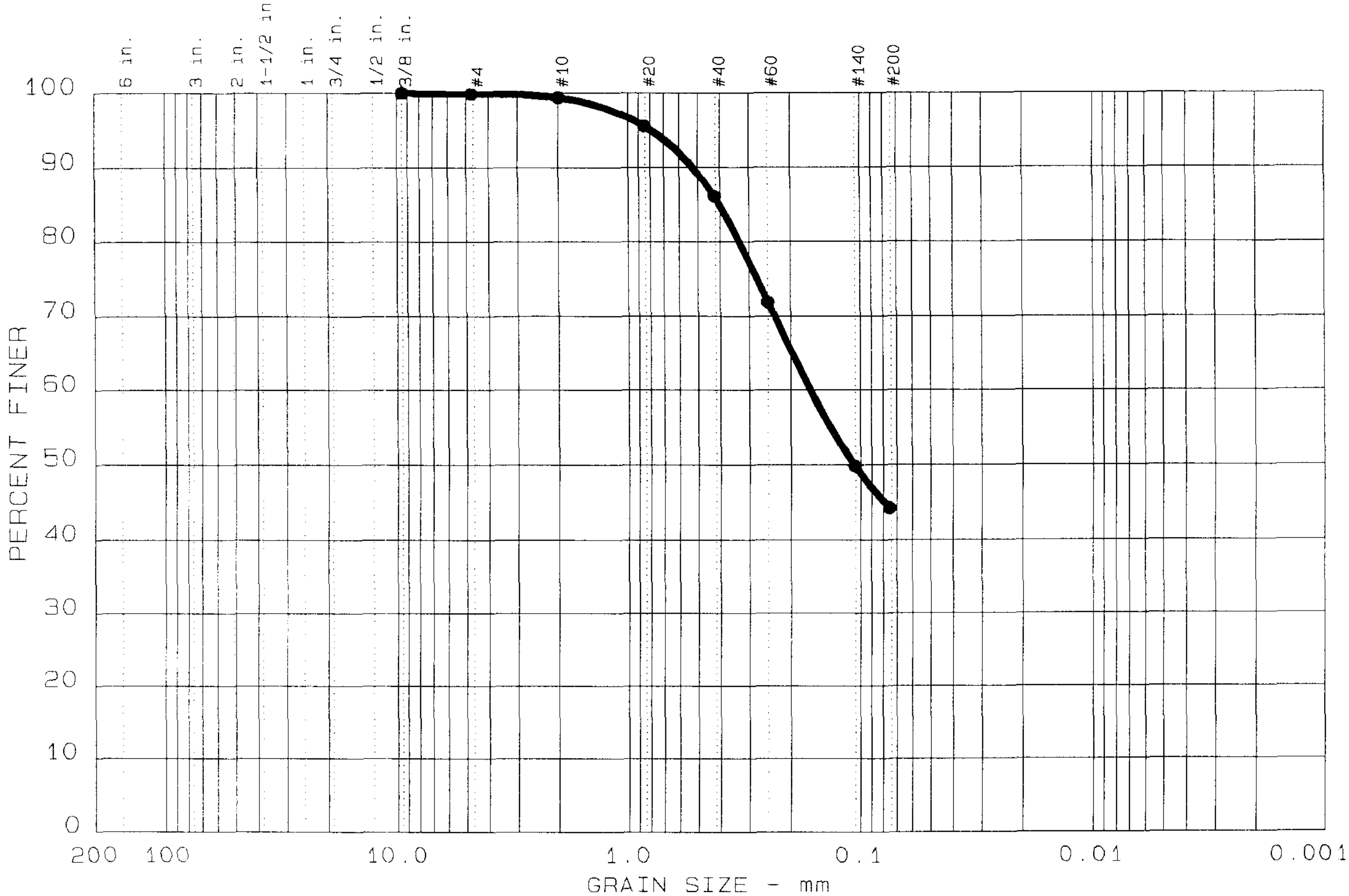
ieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.25	99.9
# 20	14.68	91.9
# 40	47.99	73.5
# 60	72.48	59.9
# 140	102.54	43.3
# 200	112.82	37.6

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0 % GRAVEL = 0.1 % SAND = 62.2
% FINES = 37.7

D85= 0.64 D60= 0.251 D50= 0.155

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.6	55.2	44.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	ND	ND	0.40	0.16	0.11					

MATERIAL DESCRIPTION	USCS	AASHTO
● B-807 SS-12 41.4-42.9'		

Project No.: 30720-2-5400
Project: NORTH ANNA ESP
● Location: B-807 SS-12 41.4-42.9'

Date: 1-2-2003

GRAIN SIZE DISTRIBUTION TEST REPORT
LAW ENGINEERING, INC.

Remarks:
ND=NOT DETERMINED.
SPECIFIC GRAVITY
IS ASSUMED

Figure No. 5

GRAIN SIZE DISTRIBUTION TEST DATA   Test No.: 19

e: 1-2-2003
. oject No.: 30720-2-5400
Project: NORTH ANNA ESP

Sample Data

Location of Sample: B-807 SS-12 41.4-42.9'
Sample Description: B-807 SS-12 41.4-42.9'
USCS Class: SM   Liquid limit: ND
AASHTO Class: A-4(0)   Plasticity index: ND

Notes

Remarks: ND=NOT DETERMINED. SPECIFIC GRAVITY
IS ASSUMED
Fig. No.: 5

Mechanical Analysis Data

	Initial
Dry sample and tare=	151.70
Tare =	0.00
Dry sample weight =	151.70

Tare for cumulative weight retained= 0

ieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	0.15	99.9
# 10	0.87	99.4
# 20	6.70	95.6
# 40	21.05	86.1
# 60	42.60	71.9
# 140	76.12	49.8
# 200	84.59	44.2

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #200 sieve
% + 75mm. = 0.0   % GRAVEL = 0.6   % SAND = 55.2
% FINES = 44.2

D85= 0.40 D60= 0.164 D50= 0.106

MACTEC

Unconfined Compressive Strength of Intact Rock Core Specimens
(ASTM D2938-95) (Modified[1,3])

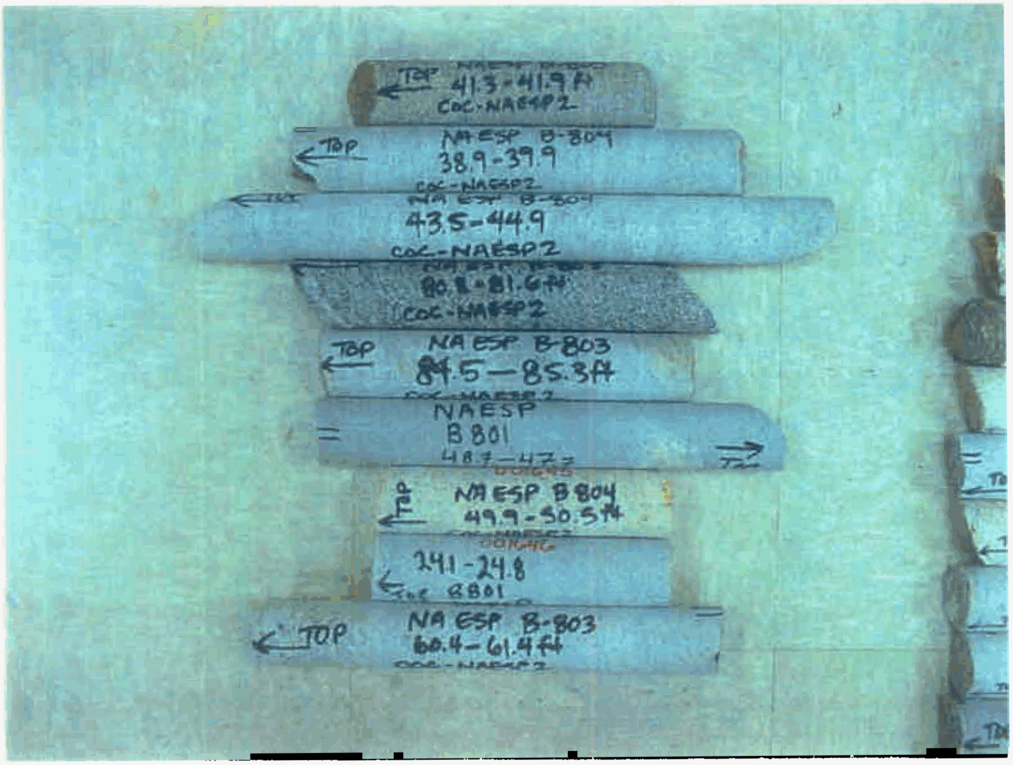
Project No.: 30720-2-5400.07.800
Project Name: North Anna ESP

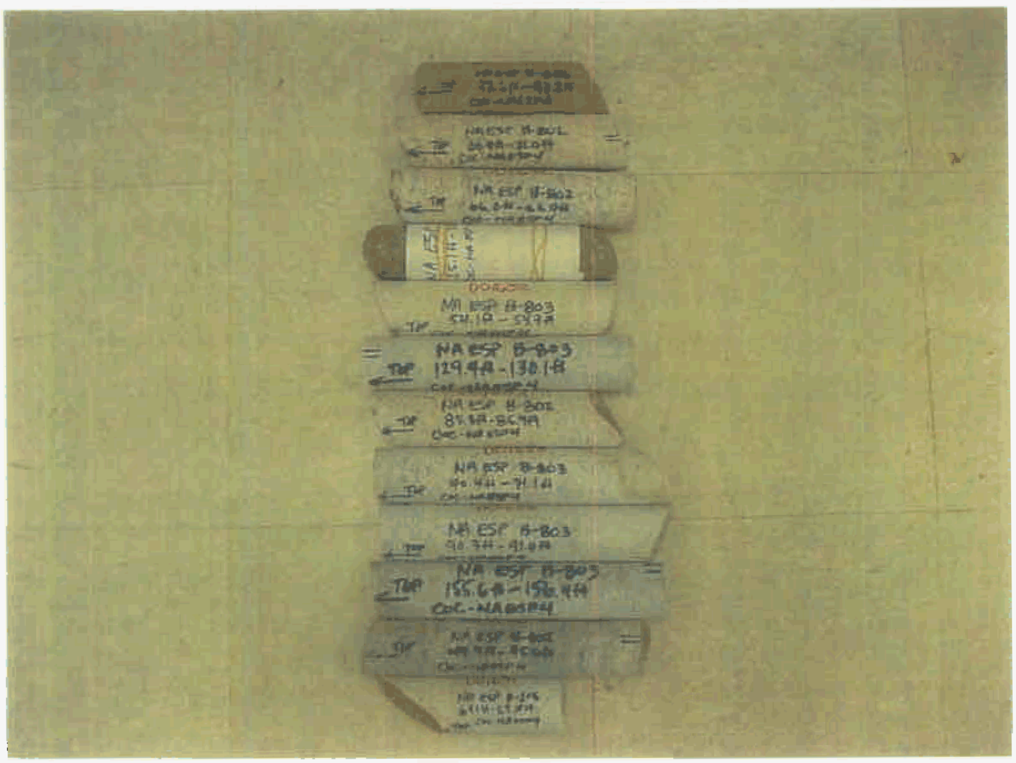
Tested By: Daniel Johnson
Test Date: 1/21/2003
Reviewed By: Thomas Dobras
Review Date: 1/27/2003

Specimen Specifications:
[2] Minimum diameter - 47mm (1.85")
[3] L/D ratio 2.0<L/D<2.5
[4] Straightness: 0.02" maximum gap
[5] Flatness: 0.0015" difference between maximum and minimum readings

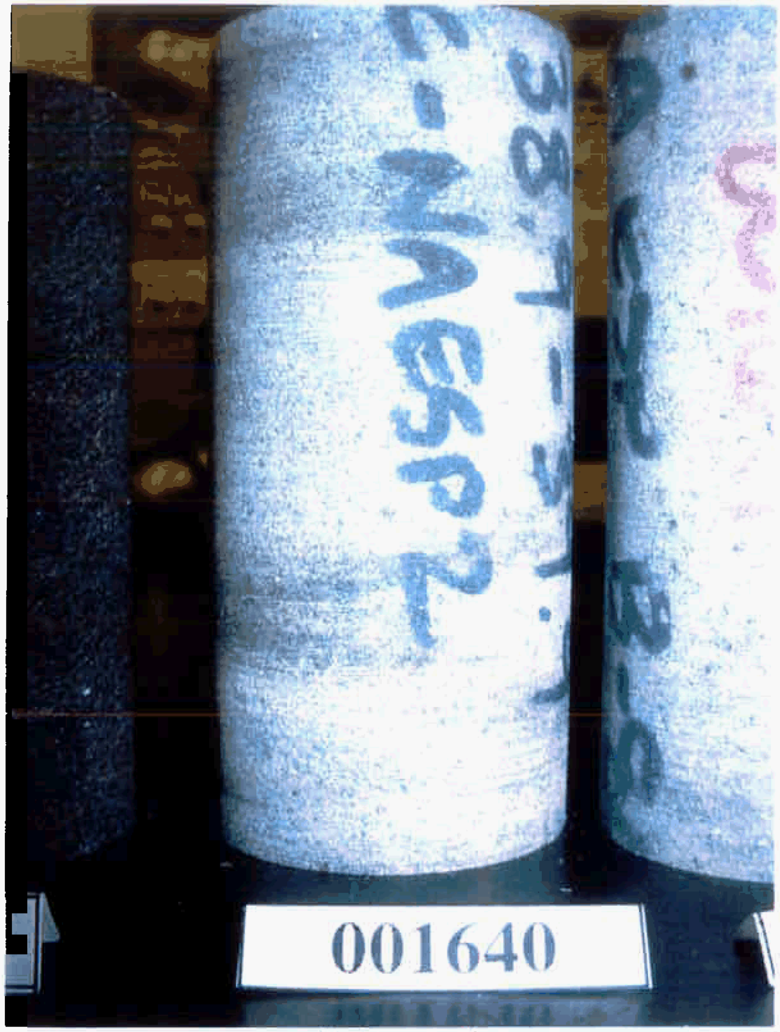
Boring No.	Depth (ft)	MACTEC Lab ID #	Moisture Content (%)	Dry Density (pcf)	Specimen Diameter (D) (in)	Specimen Length (L) (in)	L/D Ratio	Type of Break	Rate of Loading (lbs/min)	Unconfined Compressive Strength (psi)
B-805	41.3-41.9	001639	0.2	169.6	1.859	3.685	2.0	Shear	800	3,400
B-804	38.9-39.9	001640	0.1	162.5	1.868	3.986	2.1	Cone	15,000	27,150
B-804	43.5-44.9	001641	0.1	163.0	1.868	4.000	2.1	Cone	14,000	25,200
B-805	80.8-81.6	001642	0.2	181.3	1.854	3.774	2.0	Shear	6,000	4,430
B-801	48.7-49.7	001644	0.1	164.0	1.863	4.051	2.2	Cone	10,000	28,420
B-804	49.9-50.5	001645	0.1	162.3	1.863	3.943	2.1	Cone & Shear	5,000	12,300
B-801	24.1-24.8	001646	0.1	164.0	1.864	4.010	2.2	Cone	14,000	27,210
B-806	42.6-43.2	001648	0.3	169.4	1.853	3.264	1.8	Cone & Shear	4,000	2,720
B-802	20.4-21.0	001649	0.2	160.8	1.861	3.973	2.1	Shear	6,000	8,640
B-802	66.0-66.7	001650	0.3	160.4	1.859	3.757	2.0	Cone & Split	5,000	14,710
B-806	25.1-25.8	001651	1.2	144.5	1.844	3.918	2.1	Crumbled	800	610
B-803	54.1-54.7	001652	0.1	162.4	1.858	3.830	2.1	Shear	12,000	13,010
B-803	129.4-130.1	001653	0.1	164.3	1.868	4.096	2.2	Shear	14,000	26,730
B-802	85.3-85.9	001654	0.3	161.8	1.859	3.773	2.0	Cone & Shear	10,000	9,370
B-803	70.4-71.1	001655	0.1	163.4	1.866	4.168	2.2	Cone & Shear	10,000	23,210
B-803	90.3-91.0	001656	0.1	163.0	1.872	3.903	2.1	Shear	14,000	27,590
B-803	155.6-156.4	001657	0.1	164.2	1.873	3.910	2.1	Cone & Shear	10,000	22,030
B-802	44.9-45.6	001658	0.1	175.5	1.862	4.105	2.2	Cone & Shear	8,000	11,760
B-806	64.1-64.5	001659	0.1	163.6	1.844	3.589	1.9	Cone & Shear	15,000	27,360

Comments:
[1] Top bearing plate to specimen diameter ratio was 1.67 (Per Section 5.4 of ASTM D2938, max. allow. is 1.1)
[2] All specimen diameters except as shaded met the minimum requirements per ASTM D4543-01.
[3] Specimens shown were outside the allowable tolerance for L/D ratio or were less than the minimum diameter
[4] Straightness of elements was determined by Procedure A as referenced in ASTM D4543-01, Section 5.1.1.
[5] Flatness of the specimen was determined by Procedure B as referenced in ASTM D4543-01, Section 5.2.2.
Physical description of the samples is listed on a separate report.
Test temperature was room temperature, 20-22 ^{0} C. Lab Id#s 001643 and 001647 not assigned.





SAMPLES FOR STRENGTH TESTING AS RECEIVED IN LAB

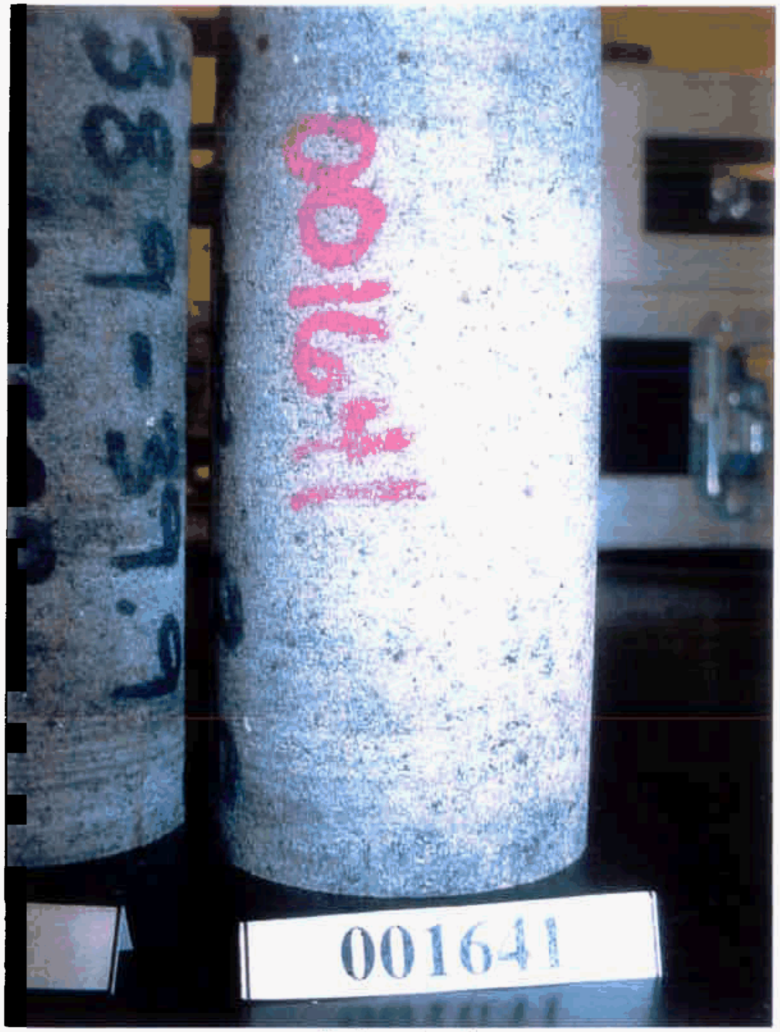


Before testing

After Testing

B-804 **Depth (ft): 38.9-39.9**

Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

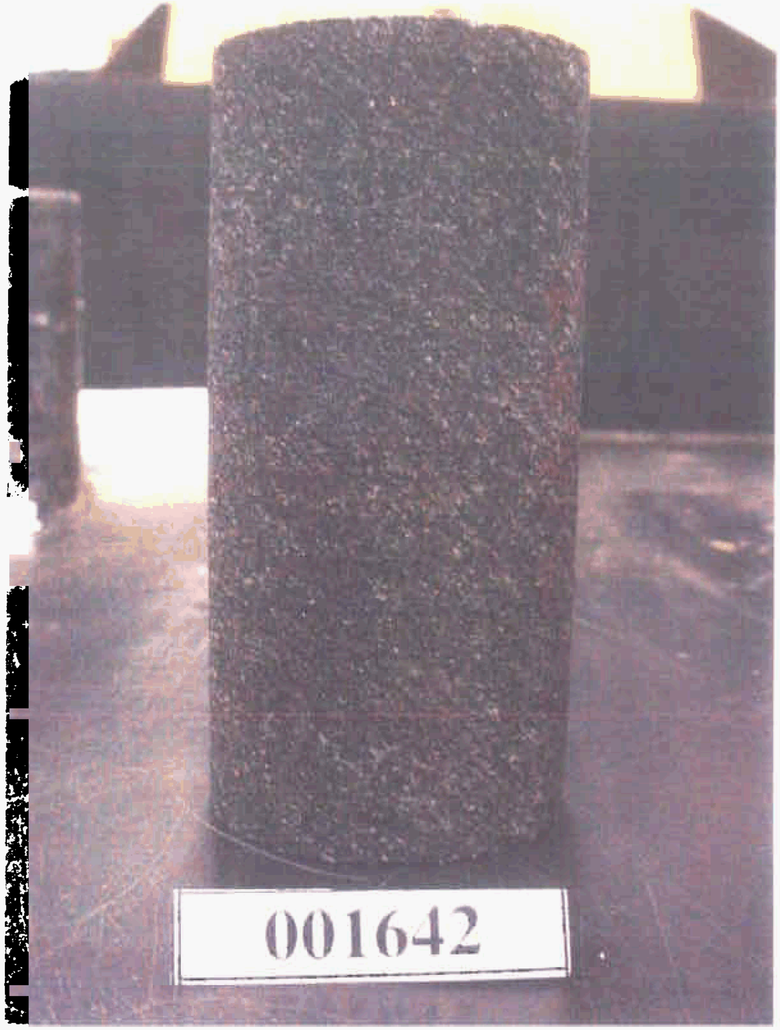


Before testing

After testing

B-804 **Depth (ft): 43.5-44.9**

Physical Description: Very slightly weathered, hard, Quartz Gneiss with weak foliation at 50-60°



Before testing

After testing

B-805 **Depth (ft): 80.8-81.6**

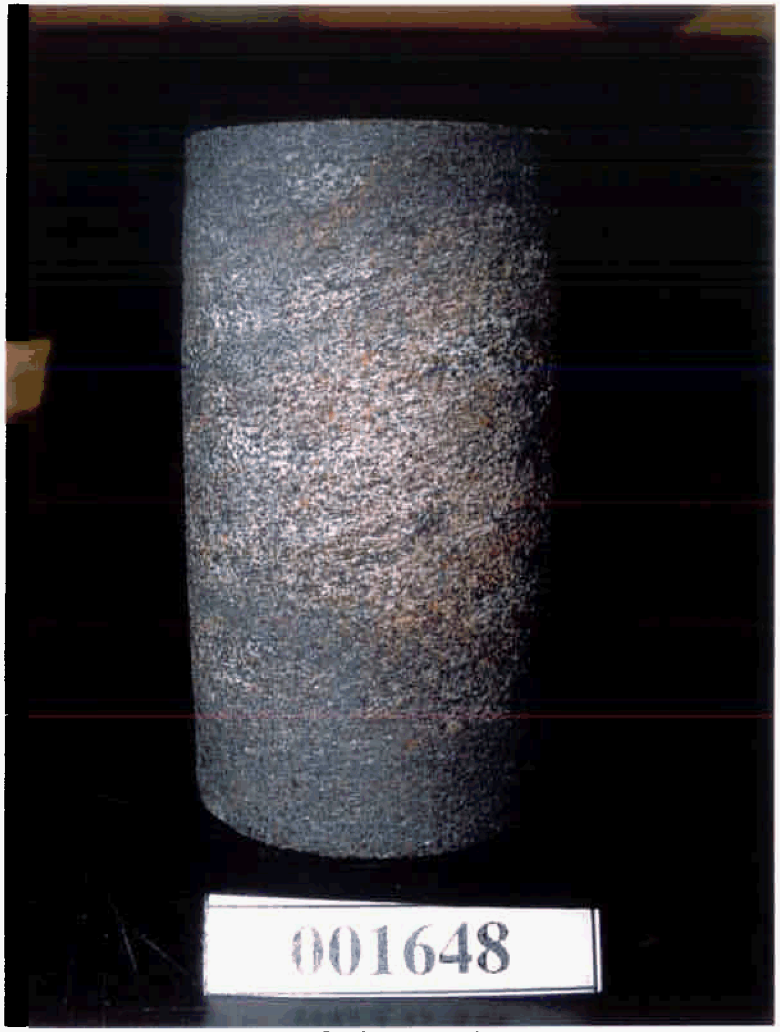
Physical Description: Fresh, hard, Biotite Gneiss with strong foliation at 50-60°

Before testing

After testing

B-801 **Depth (ft): 24.1-24.8**

Physical Description: Very slightly weathered, hard, Quartz Gneiss with weak foliation at 50-60^{o}



Before testing

After testing

B-806 **Depth (ft): 42.6-43.2**

Physical Description: Moderately weathered, moderately hard, Biotite Gneiss with strong foliation at 30-40°

Before testing

After testing

B-802 **Depth (ft): 20.4-21.0**

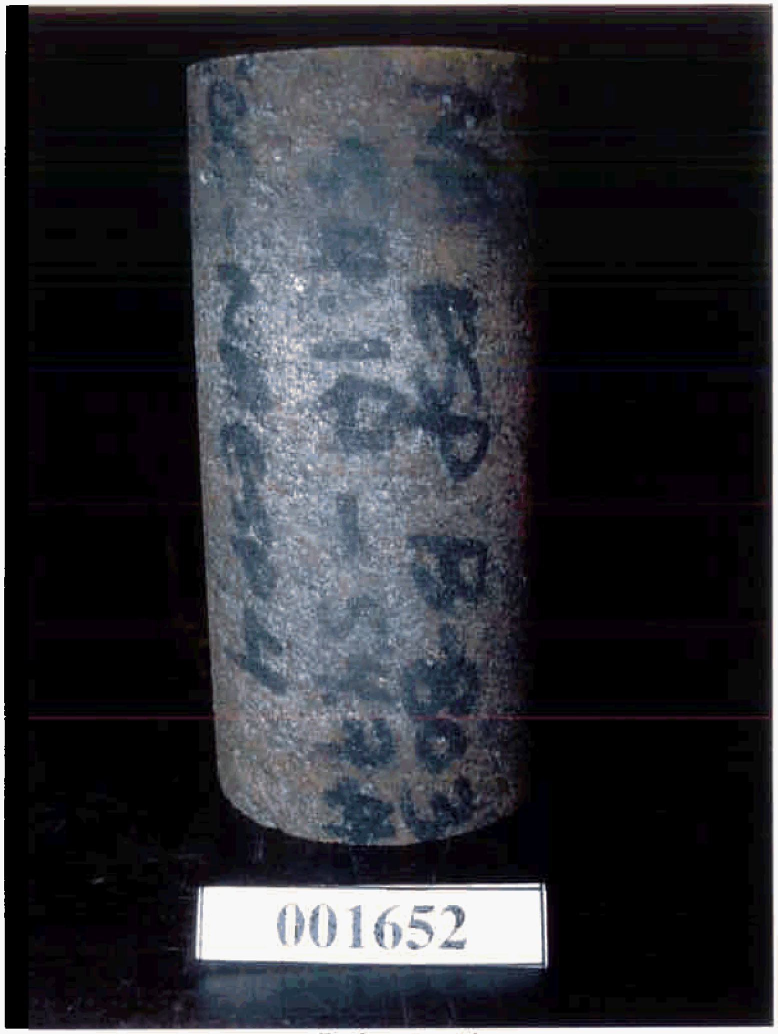
Physical Description: Moderately weathered, hard, Quartz Gneiss with strong foliation at 50-60°

Before testing

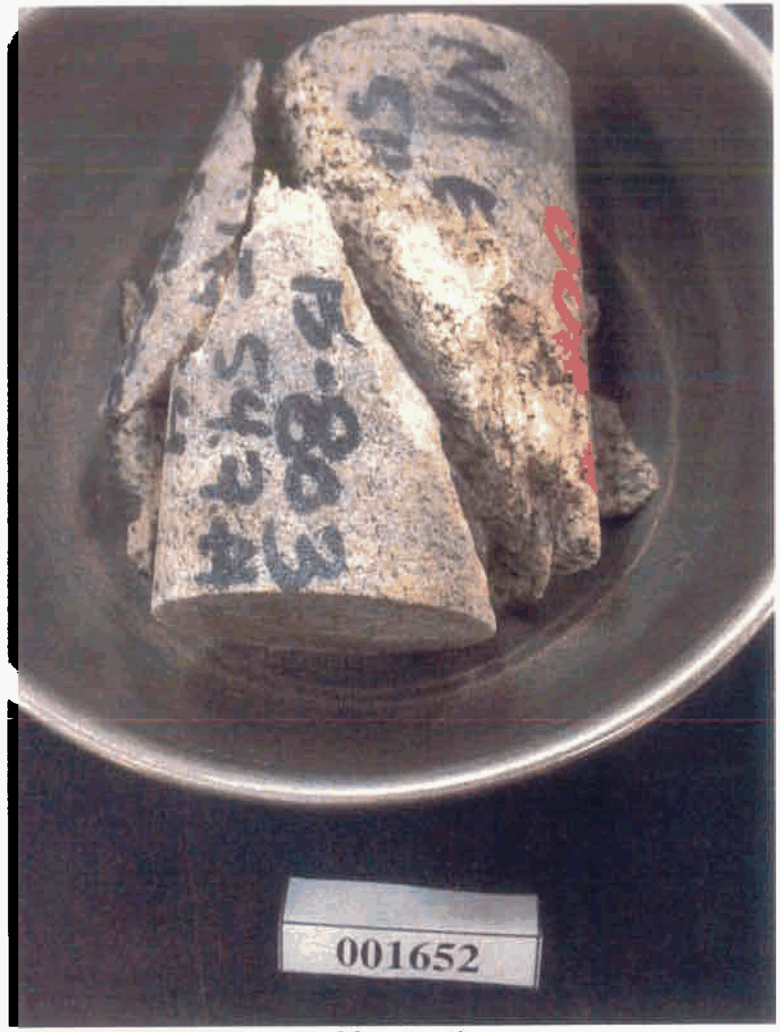
After testing

B-806　　**Depth (ft): 25.1-25.8**

Physical Description: Moderately weathered, moderately hard, Biotite Gneiss with strong foliation at 30-40°



Before testing



After testing

B-803 **Depth (ft): 54.1-54.7**

Physical Description: Slightly weathered, hard, Quartz Gneiss with weak foliation at 50-60°

Before testing

After testing

B-803 **Depth (ft): 129.4-130.1**

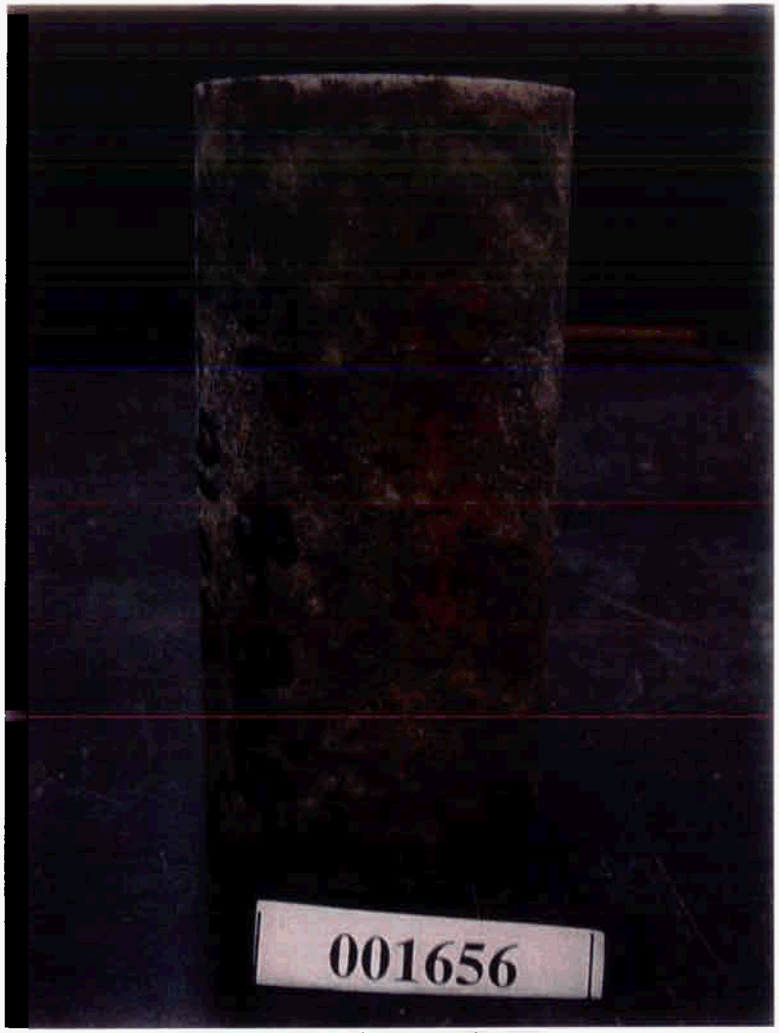
Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

Before testing

After testing

B-802 **Depth (ft): 85.3-85.9**

Physical Description: Slightly weathered, hard, Quartz Gneiss with weak foliation at 50-60°



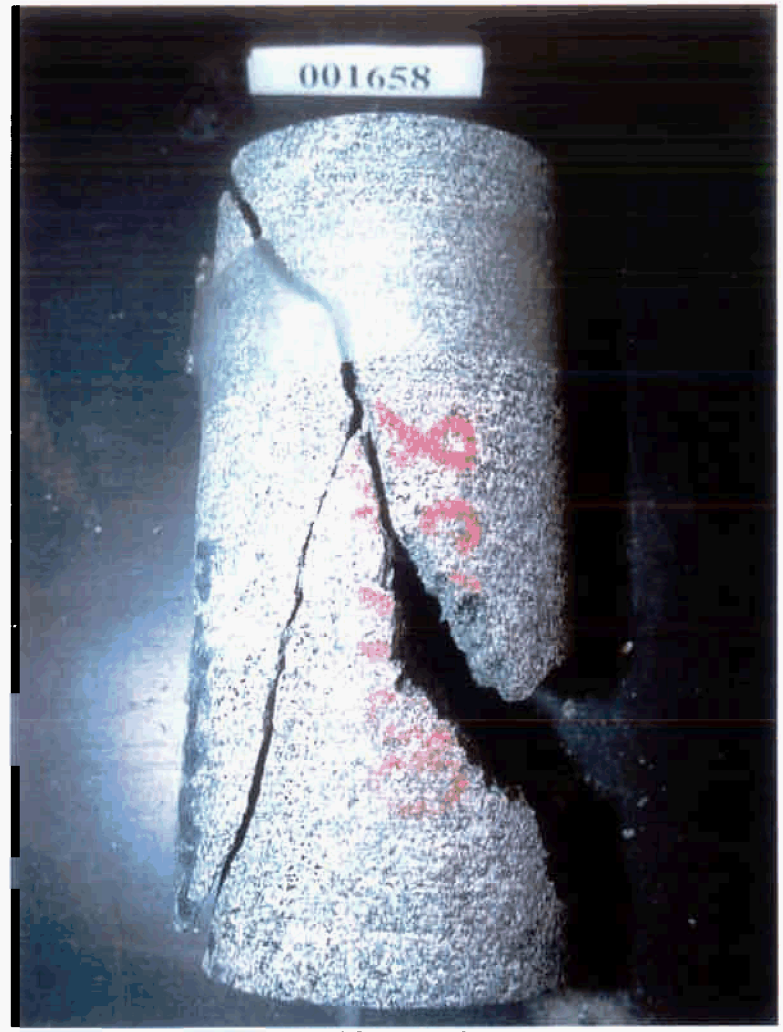
Before testing

After testing

B-803 **Depth (ft): 90.3-91.0**

Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

Before testing



After testing

B-802 **Depth (ft): 44.9-45.6**

Physical Description: Slightly weathered, hard, Biotite Quartz Gneiss with strong foliation at 50-60°

Before testing

After testing

B-806 **Depth (ft): 64.1-64.5**

Physical Description: Fresh, Quartz Gneiss with weak foliation at 50-60°

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001639	**Gage Factor:**	2.090
Sample I.D.:	B-805 Depth 41.3-41.9 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	1/28/2003

Specimen Information	
Average Diameter, inch	1.859
Average Height, inch	3.685
Moisture Content (%)	0.2
Ultimate Load, lb_f	9222

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-11	11
400	-550	19
800	-969	24
1,200	-1426	69
1,600	-1865	125
2,000	-2283	220
2,400	-2624	340
2,800	-2948	470
3,200	-3272	600
3,600	-3578	755
4,000	-3850	915
4,400	-4144	1109
4,800	-4425	1319
5,200	-4701	1560
5,600	-4966	1818
6,000	-5251	2119
7,000	-5967	2990
8,000	-6803	4240
9,000	-7966	6300

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001639	**Gage Factor:**	2.09
Sample I.D.:	B-805 Depth 41.3-41.9 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

Average Diameter, inch	1.859
Average Length, inch	3.685
Length/Diameter ratio	2.0
Specimen Area, $inch^2$	2.714
Moisture Content (%)	0.2
Rate of loading (lbs/min)	800
Compressive Strength, psi	**3,400**
Longitudinal e Correction, inch/inch	-0.000011
Transverse e Correction, inch/inch	0.000011
Modulus of Elasticity, psi	**522,000**
Poisson's Ratio	**0.54**

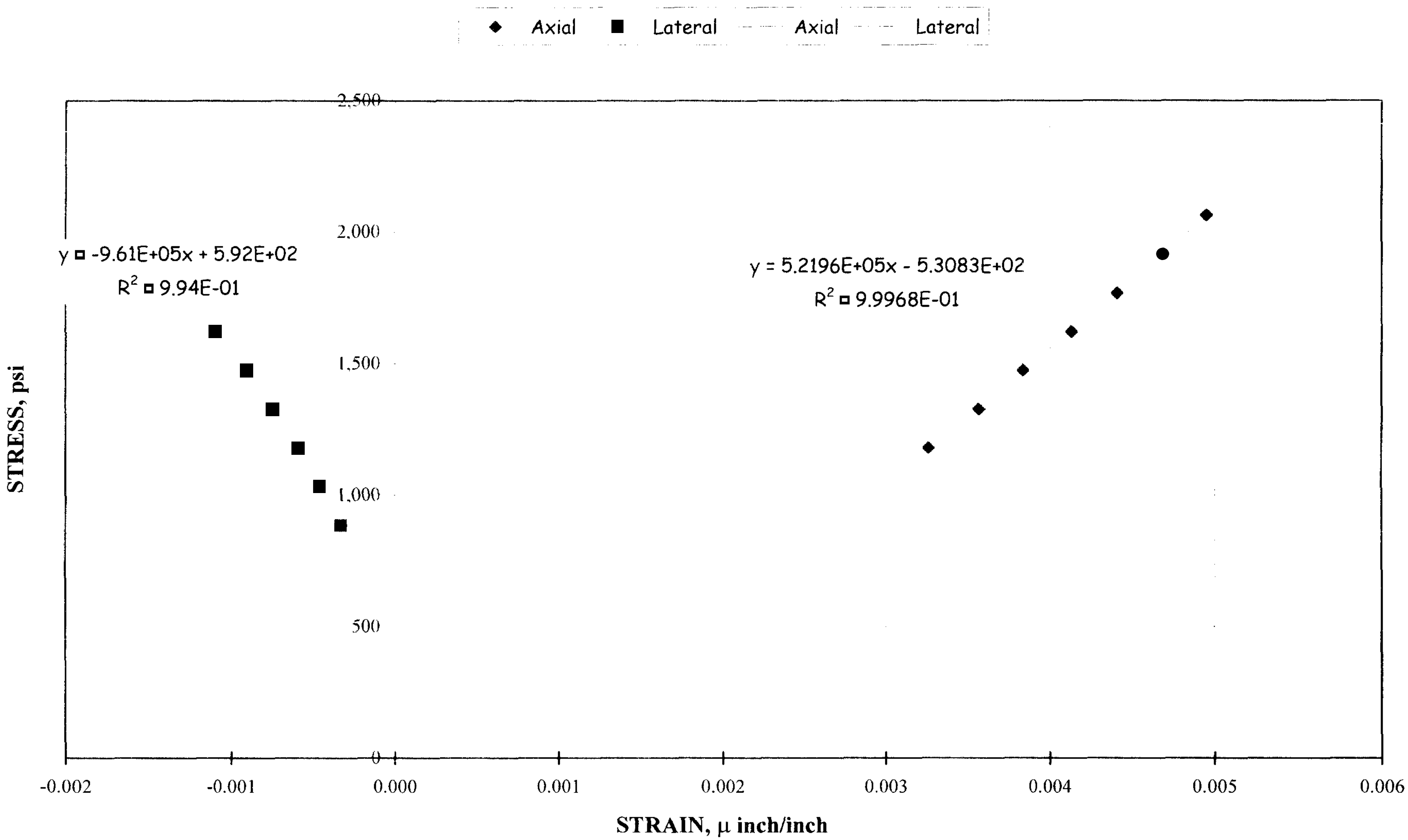
RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
147	0.000539	-0.000008
295	0.000958	-0.000013
442	0.001415	-0.000058
589	0.001854	-0.000114
737	0.002272	-0.000209
884	0.002613	**-0.000329**
1,032	0.002937	-0.000459
1,179	**0.003261**	-0.000589
1,326	0.003567	-0.000744
1,474	0.003839	-0.000904
1,621	0.004133	**-0.001098**
1,768	0.004414	-0.001308
1,916	0.004690	-0.001549
2,063	**0.004955**	-0.001807
2,211	0.005240	-0.002108
2,579	0.005956	-0.002979
2,947	0.006792	-0.004229
3,316	0.007955	-0.006289

Note : Points chosen are in Bold.

Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 ^{0}C
Analysis using middle portion of curve. Poisson's ratio indicates plastic deformation
Analysis was rerun using lower portion of curve. See attached sheet.

MACTEC

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001639 Boring No. B-805 (41.3-41.9 ft)



MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001639	**Gage Factor:**	2.09
Sample I.D.:	B-805 Depth 41.3-41.9 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	J. A. Tice ~~Thomas N. Dobras~~ JAJ 2-5-03
Test Date:	01/24/03	**Review Date:**	01/28/03

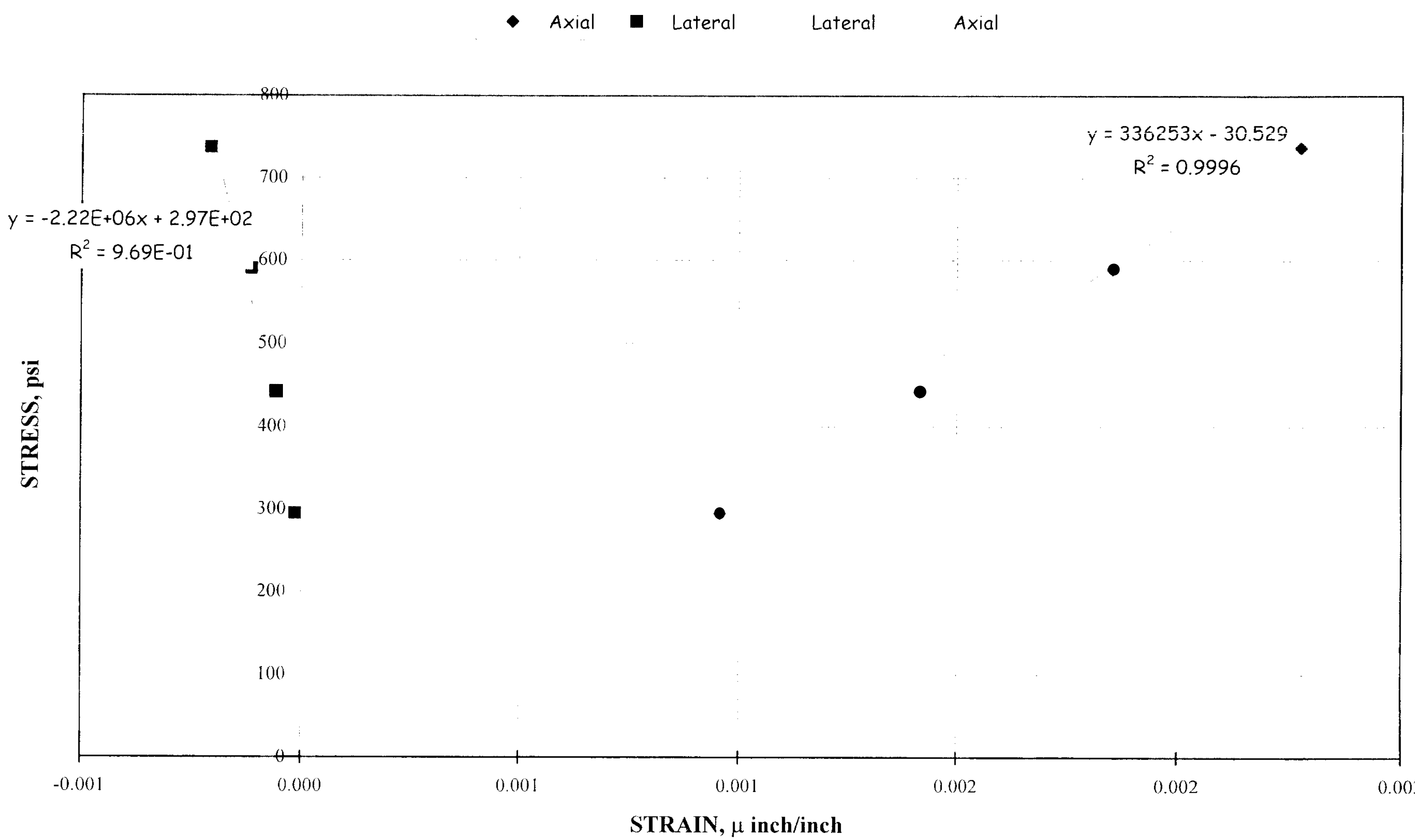
Average Diameter, inch	1.859
Average Length, inch	3.685
Length/Diameter ratio	2.0
Specimen Area, inch^2	2.714
Moisture Content (%)	0.2
Rate of loading (lbs/min)	800
Compressive Strength, psi	**3,400**
Longitudinal e Correction, inch/inch	-0.000011
Transverse e Correction, inch/inch	0.000011
Modulus of Elasticity, psi	**336,000**
Poisson's Ratio	**0.15**

RUN # 2						
Stress, psi	**Longitudinal e inch/inch**	**Transverse e inch/inch**	Longitudinal Modulus	Transverse Modulus	Poisson's Ratio	Volumetric Strain ε_v
0	0.000000	0.000000	273415.144	-18421345.31	0.014842	0
147	0.000539	-0.000008	351720.197	-29474152.49	0.011933	0.000523
295	**0.000958**	**-0.000013**	322474.316	-3274905.832	0.098468	0.000932
442	0.001415	-0.000058	335696.498	-2631620.758	0.127563	0.001299
589	0.001854	-0.000114	352561.633	-1551271.184	0.227273	0.001626
737	**0.002272**	**-0.000209**	432172.324	-1228089.687	0.351906	0.001854
884	0.002613	-0.000329	454848.032	-1133621.25	0.401235	0.001955
1,032	0.002937	-0.000459	454848.032	-1133621.25	0.401235	0.002019
1,179	0.003261	-0.000589	481603.799	-950779.1126	0.506536	0.002083
1,326	0.003567	-0.000744	541804.274	-921067.2653	0.588235	0.002079
1,474	0.003839	-0.000904	501261.097	-759643.1054	0.659864	0.002031
1,621	0.004133	-0.001098	524451.112	-701765.5355	0.747331	0.001937
1,768	0.004414	-0.001308	533952.038	-611496.9396	0.873188	0.001798
1,916	0.004690	-0.001549	556116.085	-571204.5056	0.973585	0.001592
2,063	0.004955	-0.001807	517090.395	-489603.8619	1.05614	0.001341
2,211	0.005240	-0.002108	514562.718	-422993.0036	1.21648	0.001024
2,579	0.005956	-0.002979	440702.041	-294741.5249	1.495215	-2E-06
2,947	0.006792	-0.004229	316790.117	-178848.0127	1.771281	-0.001666
3,316	0.007955	-0.006289				-0.004623

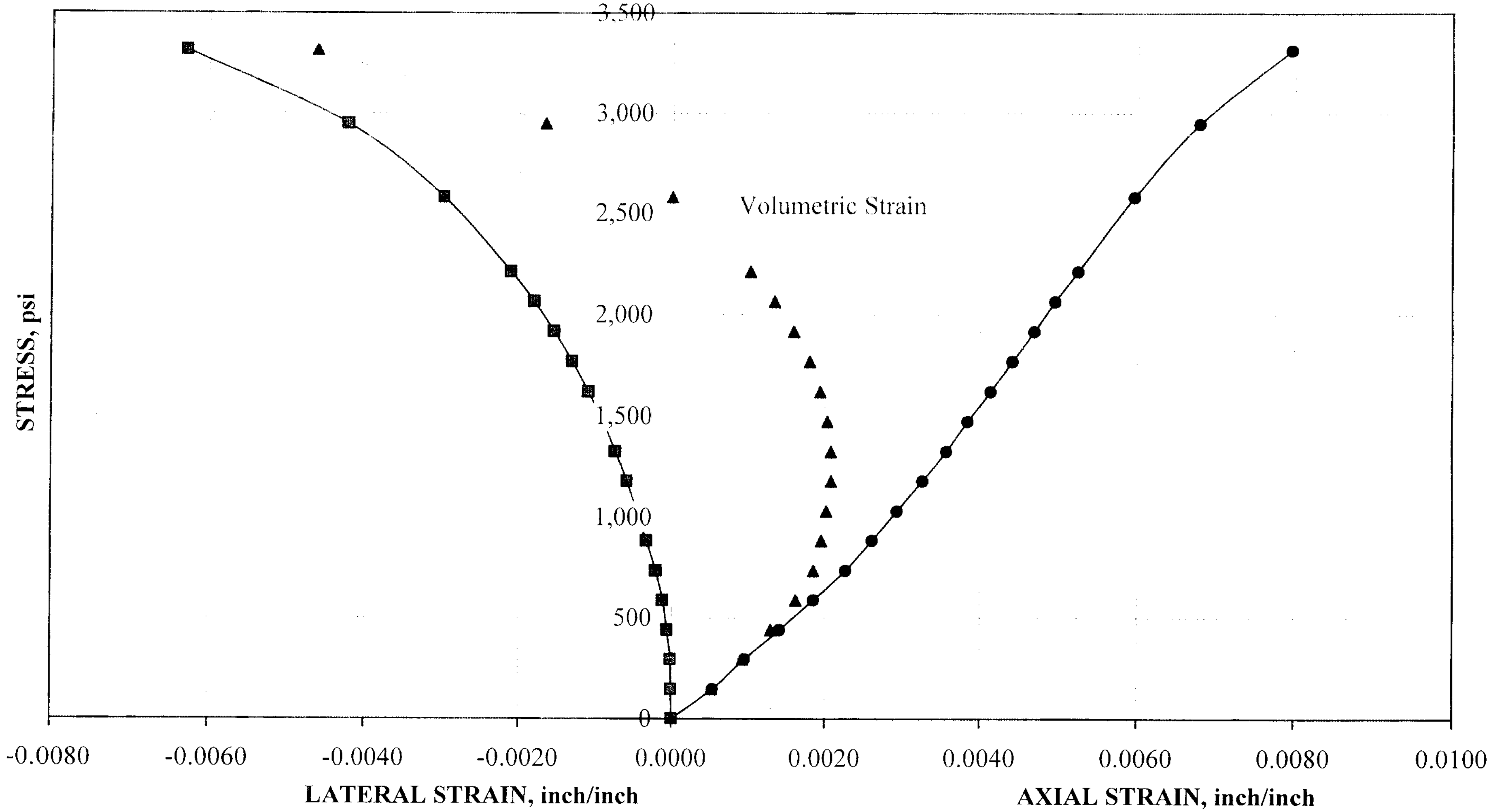
Note : Points chosen are in Bold.

Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 $^{\circ}$C
Analysis using lower portion of curve JAJ 2-5-03

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001639 Boring No. B-805 (41.3-41.9 ft)



North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001639 Boring No. B-805 (41.3-41.9) (ft)



Before testing

Before testing with strain gauges attached


After testing

B-805 **Depth (ft): 41.3-41.9**

Physical Description: Slightly weathered, moderately hard, Biotite Gneiss with strong foliation at 50-60°

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001644	**Gage Factor:**	2.090
Sample I.D.:	B-801 Depth 48.7-49.7 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	1/28/2003

Specimen Information	
Average Diameter, inch	1.863
Average Height, inch	4.051
Moisture Content (%)	0.1
Ultimate Load, lb_f	77,484

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-15	24
5,000	-301	65
10,000	-539	112
15,000	-768	161
20,000	-983	214
25,000	-1196	268
30,000	-1406	330
35,000	-1618	400
40,000	-1827	473
45,000	-2034	551
50,000	-2248	644
55,000	-2459	759
60,000	-2677	910
65,000	-2898	1128
70,000	-3126	1499
75,000	-3328	2300

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001644	**Gage Factor:**	2.09
Sample I.D.:	B-801 Depth 48.7-49.7 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

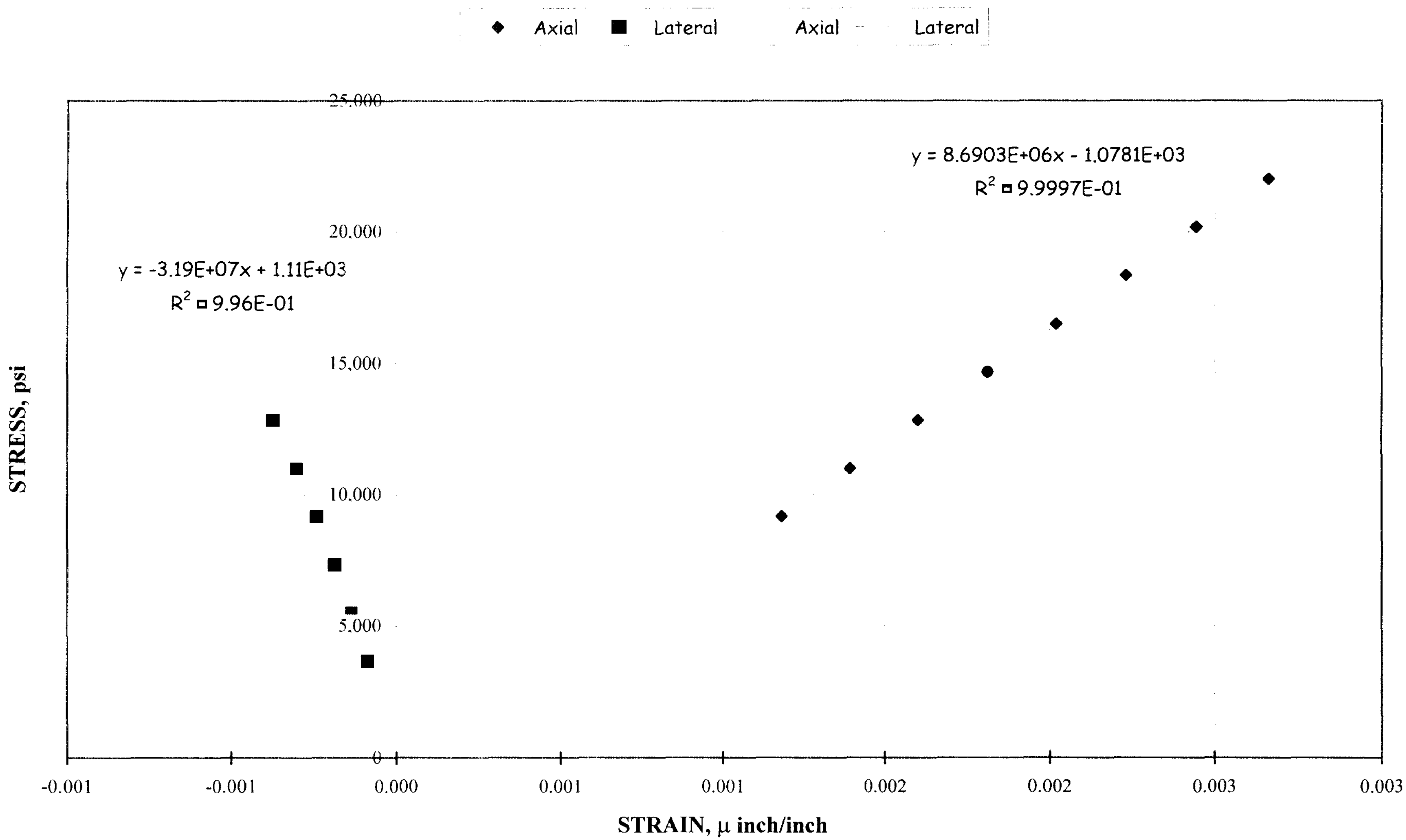
Average Diameter, inch	1.863
Average Length, inch	4.051
Length/Diameter ratio	2.2
Specimen Area, $inch^2$	2.726
Moisture Content (%)	0.1
Rate of loading (lbs/min)	10,000
Compressive Strength, psi	**28,420**
Longitudinal e Correction, inch/inch	-0.000015
Transverse e Correction, inch/inch	0.000024
Modulus of Elasticity, psi	**8,670,000**
Poisson's Ratio	**0.27**

RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
1,834	0.000286	-0.000041
3,668	0.000524	**-0.000088**
5,503	0.000753	-0.000137
7,337	0.000968	-0.000190
9,171	**0.001181**	-0.000244
11,005	0.001391	-0.000306
12,840	0.001603	**-0.000376**
14,674	0.001812	-0.000449
16,508	0.002019	-0.000527
18,342	0.002233	-0.000620
20,177	0.002444	-0.000735
22,011	**0.002662**	-0.000886
23,845	0.002883	-0.001104
25,679	0.003111	-0.001475
27,513	0.003313	-0.002276

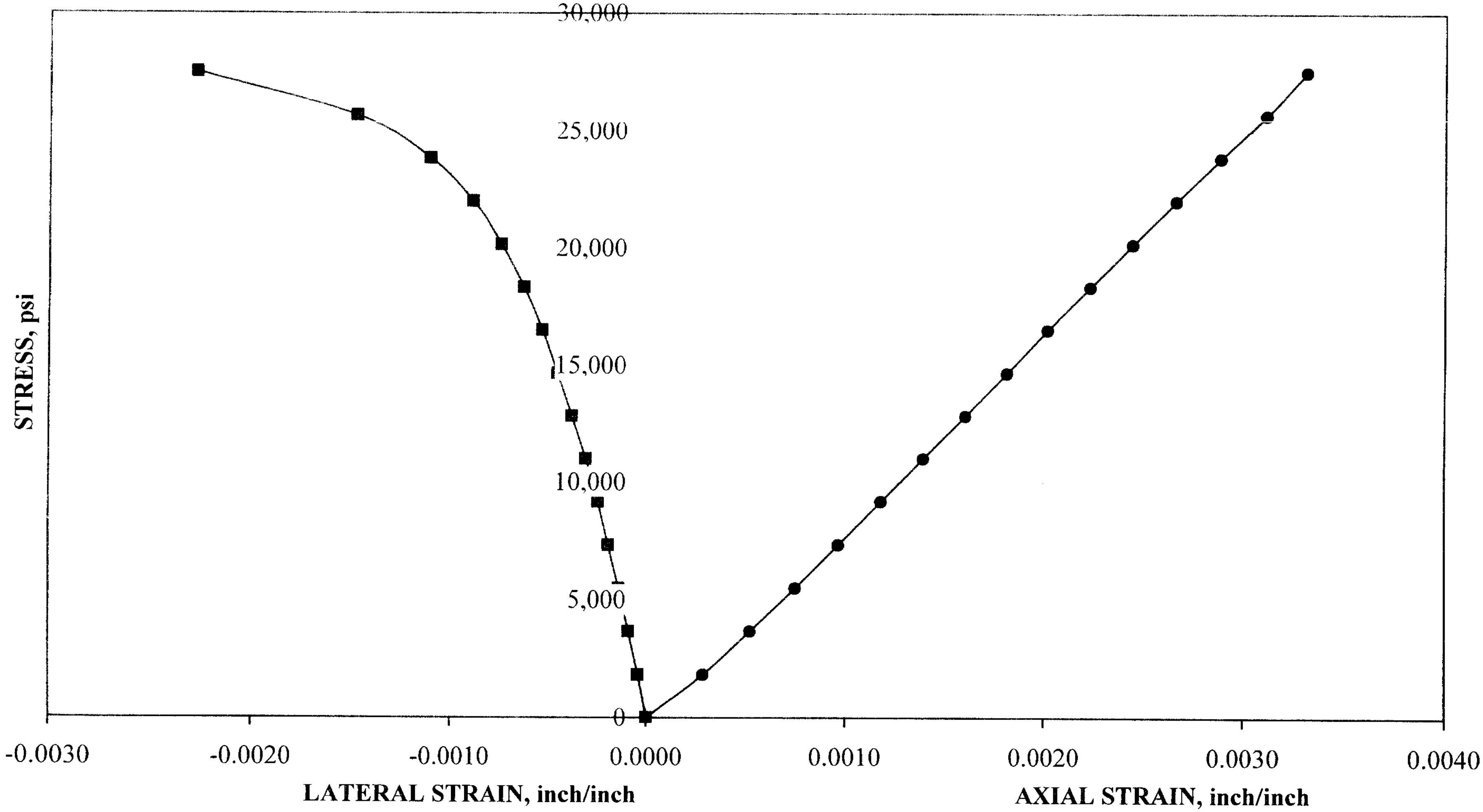
Note : Points chosen are in Bold.

Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 ^0C

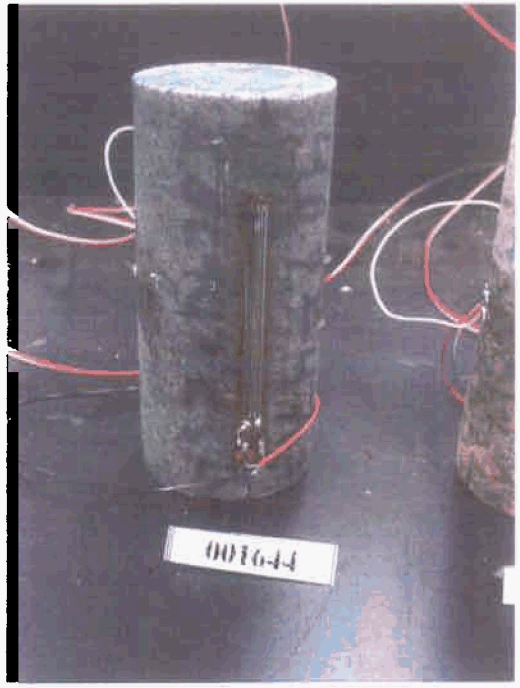
North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001644 Boring No. B-801 (48.7-49.7 ft)



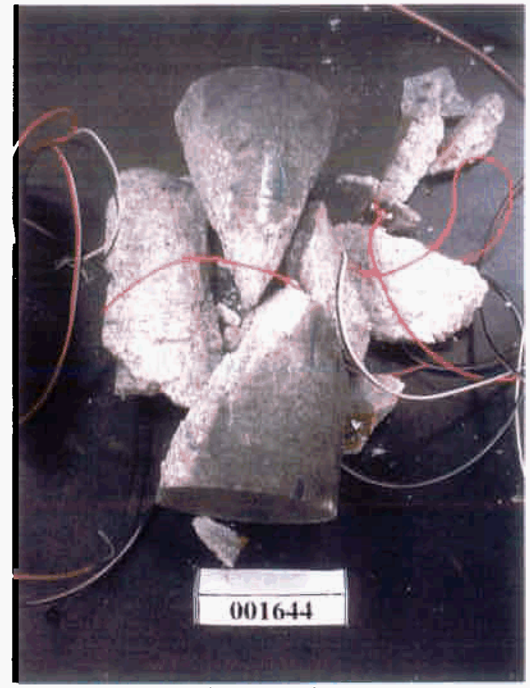
North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001644 Boring No. B-801 (48.7-49.7 ft)



Before testing



Before testing with strain gauges attached



After testing

B-801 **Depth (ft): 48.7-49.7**

Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001645	**Gage Factor:**	2.090
Sample I.D.:	B-804 Depth 49.9-50.5 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	1/28/2003

Specimen Information	
Average Diameter, inch	1.863
Average Height, inch	3.943
Moisture Content (%)	0.1
Ultimate Load, lb_f	33,532

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-8	10
2,000	-641	80
4,000	-1065	180
6,000	-1423	279
8,000	-1718	380
10,000	-1980	476
12,000	-2211	573
14,000	-2443	673
16,000	-2670	802
18,000	-2938	998
20,000	-3198	1235
22,000	-3461	1514
24,000	-3735	1855
26,000	-4012	2287
28,000	-4298	2824
30,000	-4609	3582
32,000	-4960	4737

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001645	**Gage Factor:**	2.09
Sample I.D.:	B-804 Depth 49.9-50.5 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

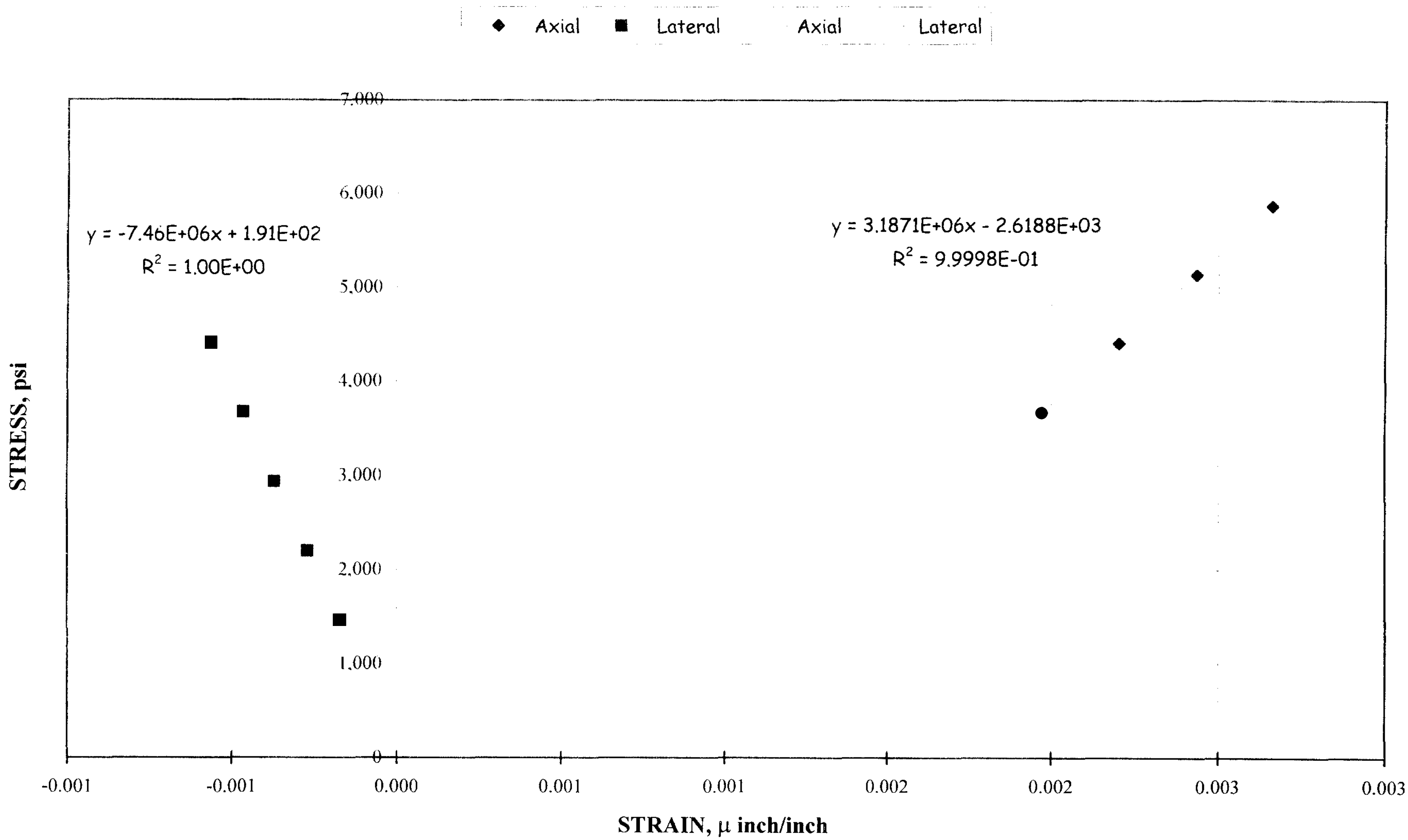
Average Diameter, inch	1.863
Average Length, inch	3.943
Length/Diameter ratio	2.1
Specimen Area, inch^2	2.726
Moisture Content (%)	0.1
Rate of loading (lbs/min)	5000
Compressive Strength, psi	**12,300**
Longitudinal e Correction, inch/inch	-0.000008
Transverse e Correction, inch/inch	0.000010
Modulus of Elasticity, psi	**3,190,000**
Poisson's Ratio	**0.43**

RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
734	0.000633	-0.000070
1,467	0.001057	**-0.000170**
2,201	0.001415	-0.000269
2,935	0.001710	-0.000370
3,668	**0.001972**	-0.000466
4,402	0.002203	**-0.000563**
5,136	0.002435	-0.000663
5,870	**0.002662**	-0.000792
6,603	0.002930	-0.000988
7,337	0.003190	-0.001225
8,071	0.003453	-0.001504
8,804	0.003727	-0.001845
9,538	0.004004	-0.002277
10,272	0.004290	-0.002814
11,005	0.004601	-0.003572

Note : Points chosen are in Bold.

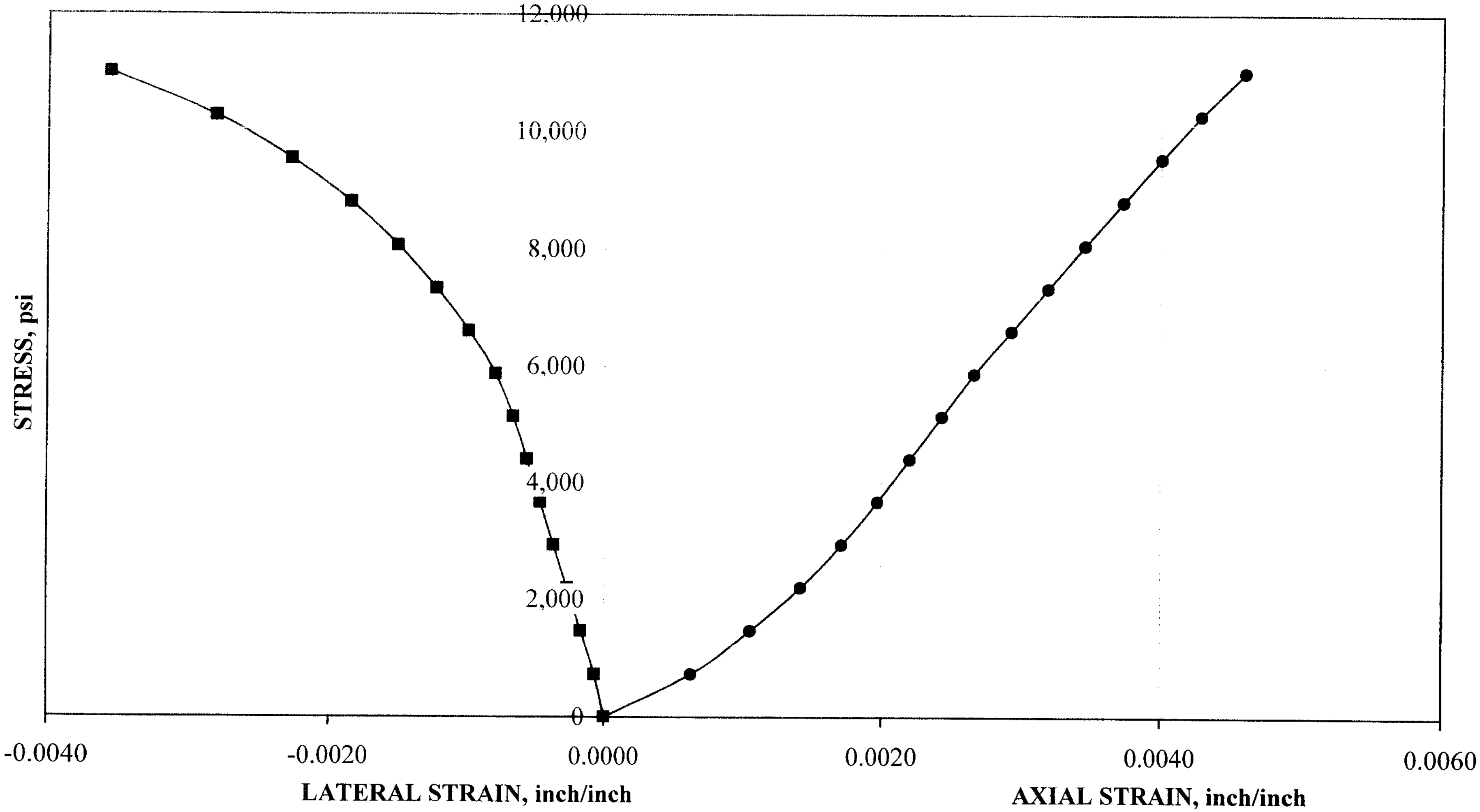
Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 ^{0}C

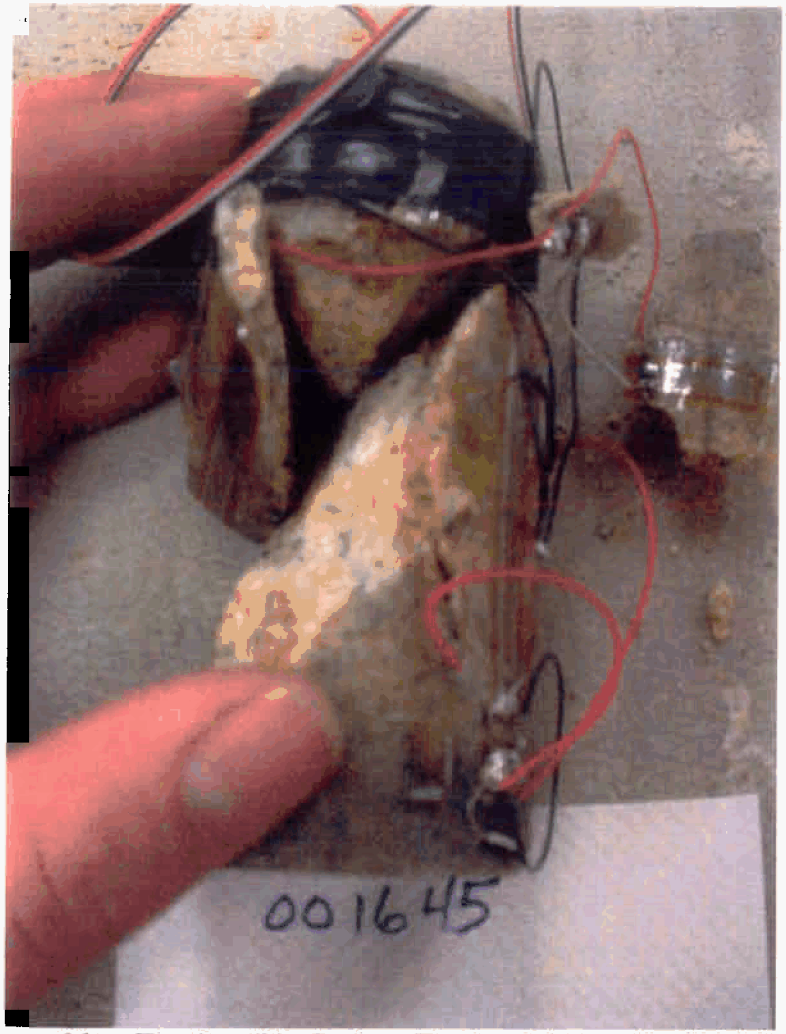
North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001645 Boring No. B-804 (49.9-50.5 ft)



MACTEC

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001645 Boring No. B-804 (49.9-50.5 ft)





After Testing (No Before Testing Picture Available)

B-804 **Depth (ft): 49.9-50.5**

Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001650	**Gage Factor:**	2.090
Sample I.D.:	B-802 Depth 66.0-66.7 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	1/28/2003

Specimen Information	
Average Diameter, inch	1.859
Average Height, inch	3.757
Moisture Content (%)	0.3
Ultimate Load, lb_f	39,933

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-11	10
1,000	-193	17
2,000	-374	24
3,000	-535	39
4,000	-678	45
5,000	-798	56
6,000	-912	68
7,000	-1020	81
8,000	-1122	97
9,000	-1221	111
10,000	-1316	127
12,000	-1503	161
14,000	-1677	196
16,000	-1844	233
18,000	-1995	271
20,000	-2142	312
25,000	-2500	424
30,000	-2830	565
35,000	-3139	761

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001650	**Gage Factor:**	2.09
Sample I.D.:	B-802 Depth 66.0-66.7 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

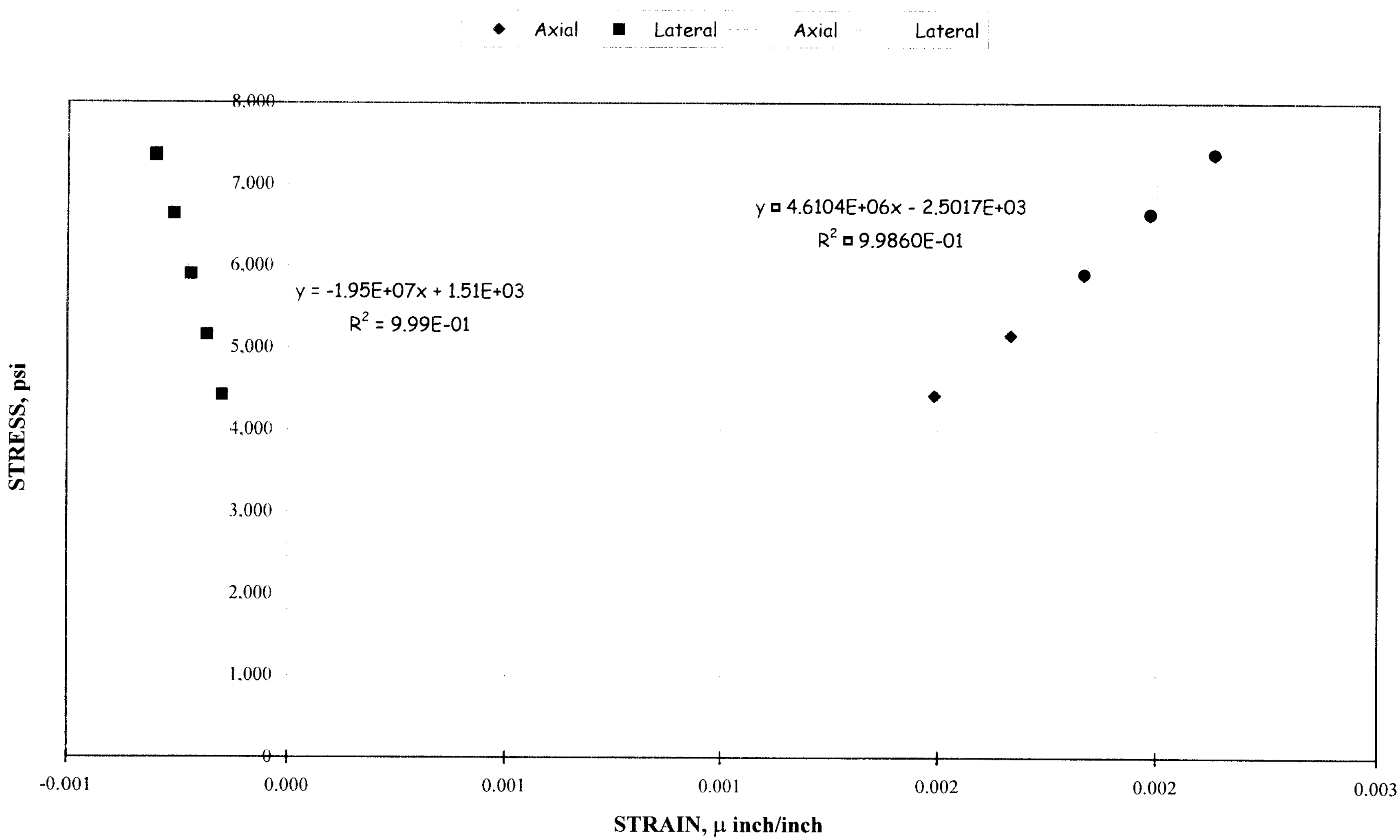
Average Diameter, inch	1.859
Average Length, inch	3.757
Length/Diameter ratio	2.0
Specimen Area, inch^2	2.714
Moisture Content (%)	0.3
Rate of loading (lbs/min)	5000
Compressive Strength, psi	**14,710**
Longitudinal e Correction, inch/inch	-0.000011
Transverse e Correction, inch/inch	0.000010
Modulus of Elasticity, psi	**4,613,000**
Poisson's Ratio	**0.24**

RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
368	0.000182	-0.000007
737	0.000363	-0.000014
1,105	0.000524	-0.000029
1,474	0.000667	-0.000035
1,842	0.000787	-0.000046
2,211	0.000901	-0.000058
2,579	0.001009	-0.000071
2,947	0.001111	-0.000087
3,316	0.001210	-0.000101
3,684	0.001305	-0.000117
4,421	**0.001492**	**-0.000151**
5,158	0.001666	-0.000186
5,895	0.001833	-0.000223
6,632	0.001984	-0.000261
7,369	**0.002131**	**-0.000302**
9,211	0.002489	-0.000414
11,053	0.002819	-0.000555
12,895	0.003128	-0.000751

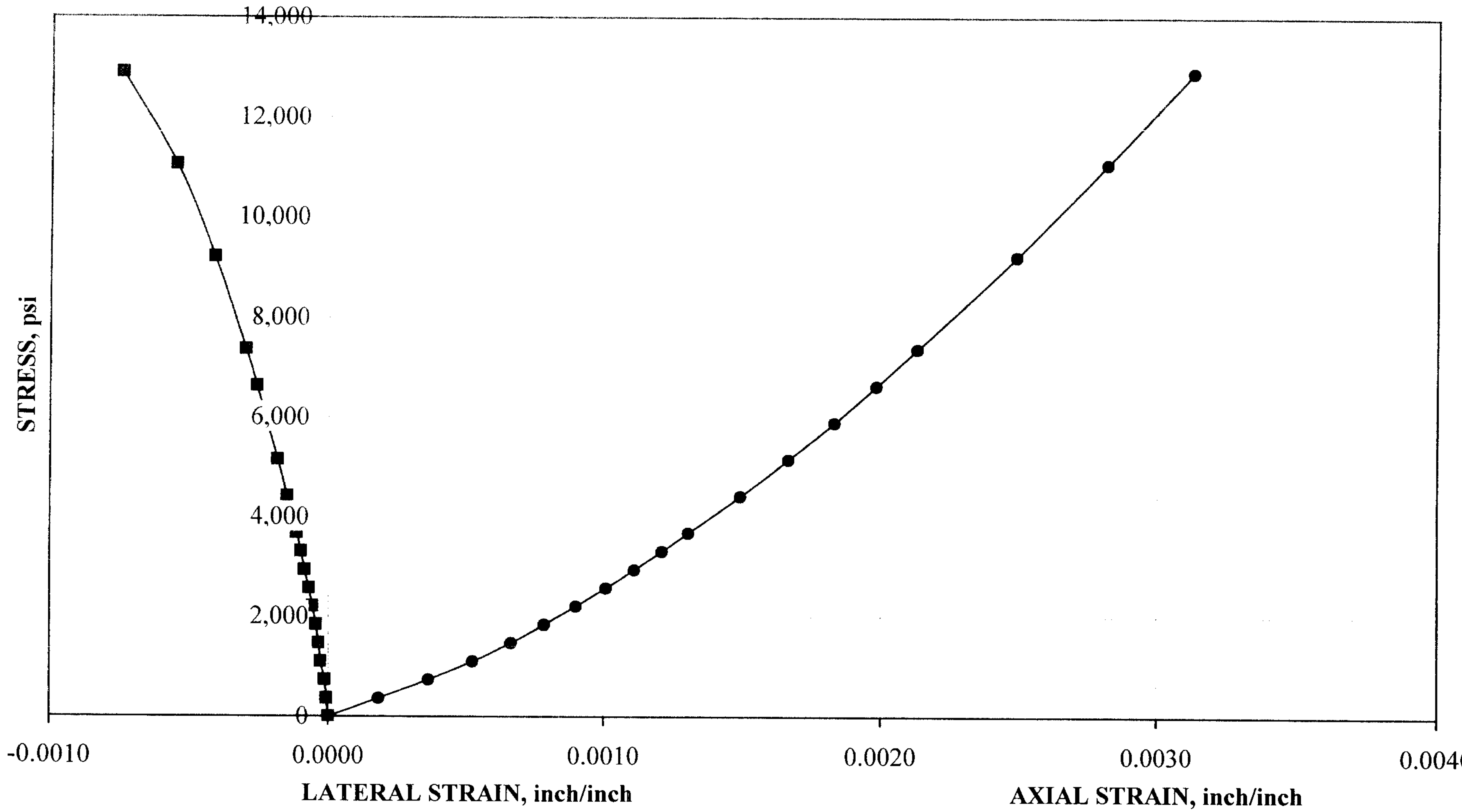
Note : Points chosen are in Bold.

Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 ^{0}C

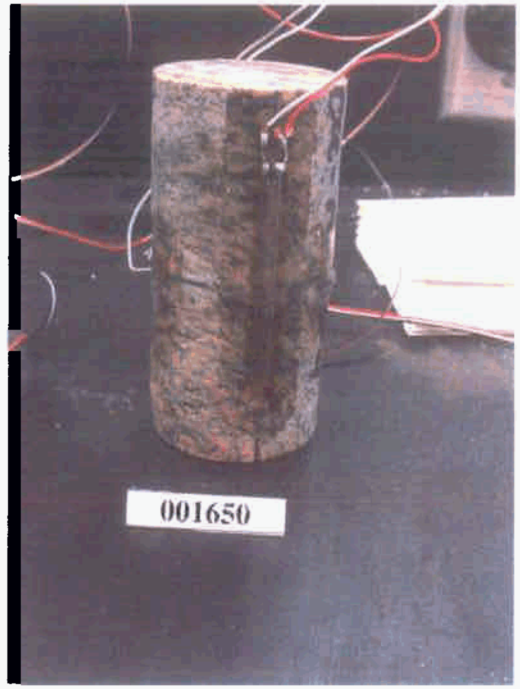
North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001650 Boring No. B-802 (66.0-66.7 ft)



North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001650 Boring No. B-802 (66.0-66.7 ft)



Before testing



Before testing with strain gauges attached

After testing

B-802 **Depth (ft): 66.0-66.7**

Physical description: Slightly weathered, hard, Quartz Gneiss with strong foliation at 30-40^{o}

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001655	**Gage Factor:**	2.090
Sample I.D.:	B-803 Depth 70.4-71.1 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	1/28/2003

Specimen Information	
Average Diameter, inch	1.866
Average Height, inch	4.168
Moisture Content (%)	0.1
Ultimate Load, lb_f	63,464

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-8	8
1,000	-110	16
2,000	-233	24
3,000	-348	34
4,000	-462	43
5,000	-572	55
6,000	-673	67
7,000	-770	81
8,000	-859	94
9,000	-945	107
10,000	-1023	123
12,000	-1177	152
14,000	-1317	183
16,000	-1448	216
18,000	-1572	248
20,000	-1692	282
25,000	-1971	371
30,000	-2237	468
35,000	-2494	580
40,000	-2741	713
45,000	-2988	883
50,000	-3230	1120
55,000	-3468	1520
60,000	-3689	2223

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001655	**Gage Factor:**	2.09
Sample I.D.:	B-803 Depth 70.4-71.1 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

Average Diameter, inch	1.866
Average Length, inch	4.168
Length/Diameter ratio	2.2
Specimen Area, $inch^2$	2.735
Moisture Content (%)	0.1
Rate of loading (lbs/min)	10,000
Compressive Strength, psi	**23,210**
Longitudinal e Correction, inch/inch	-0.000008
Transverse e Correction, inch/inch	0.000008
Modulus of Elasticity, psi	**7,133,000**
Poisson's Ratio	**0.34**

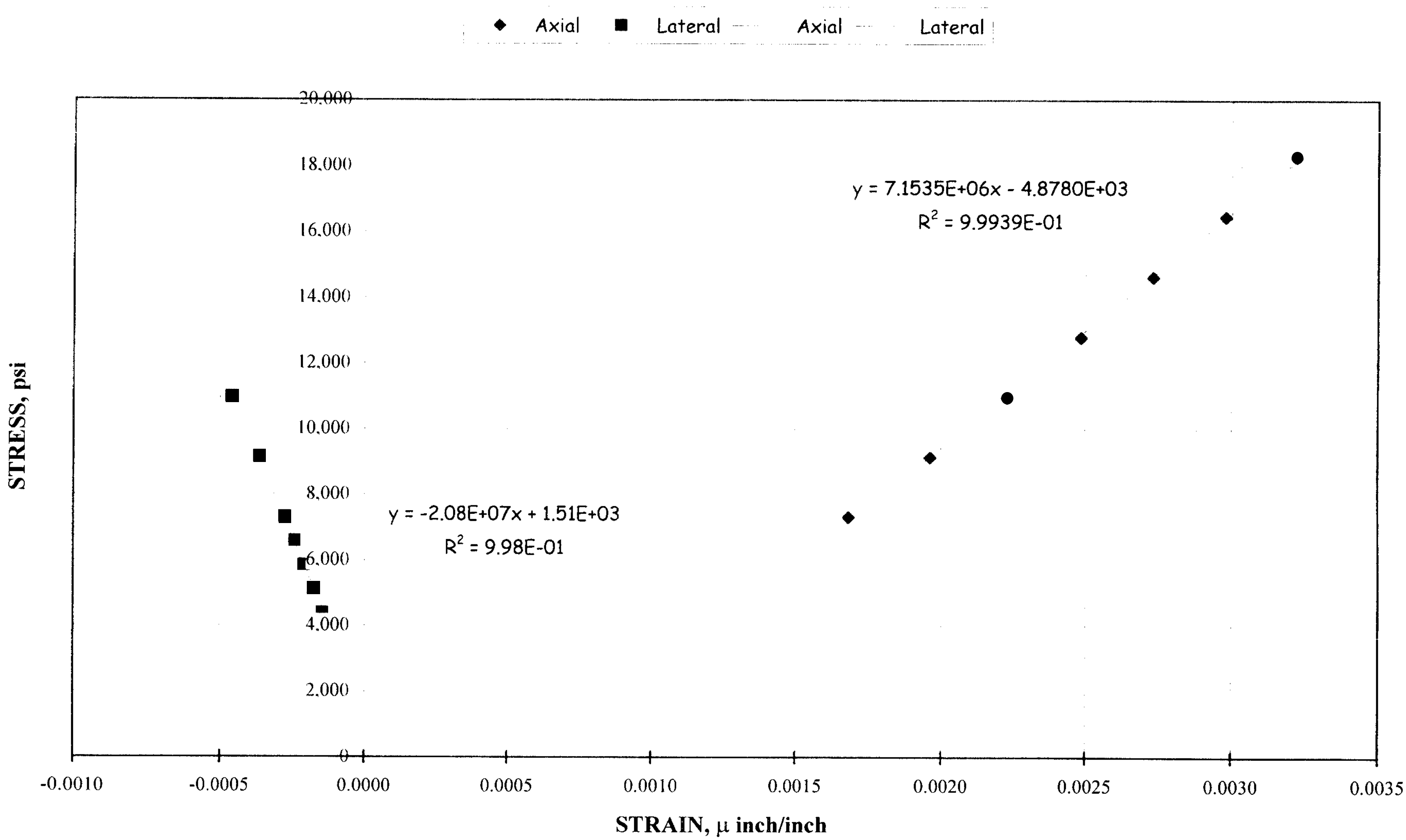
RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
366	0.000102	-0.000008
731	0.000225	-0.000016
1,097	0.000340	-0.000026
1,463	0.000454	-0.000035
1,828	0.000564	-0.000047
2,194	0.000665	-0.000059
2,560	0.000762	-0.000073
2,925	0.000851	-0.000086
3,291	0.000937	-0.000099
3,657	0.001015	-0.000115
4,388	0.001169	**-0.000144**
5,119	0.001309	-0.000175
5,851	0.001440	-0.000208
6,582	0.001564	-0.000240
7,313	**0.001684**	-0.000274
9,142	0.001963	-0.000363
10,970	0.002229	**-0.000460**
12,798	0.002486	-0.000572
14,627	0.002733	-0.000705
16,455	0.002980	-0.000875
18,283	**0.003222**	-0.001112
20,112	0.003460	-0.001512
21,940	0.003681	-0.002215

Note : Points chosen are in Bold.

Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22°C

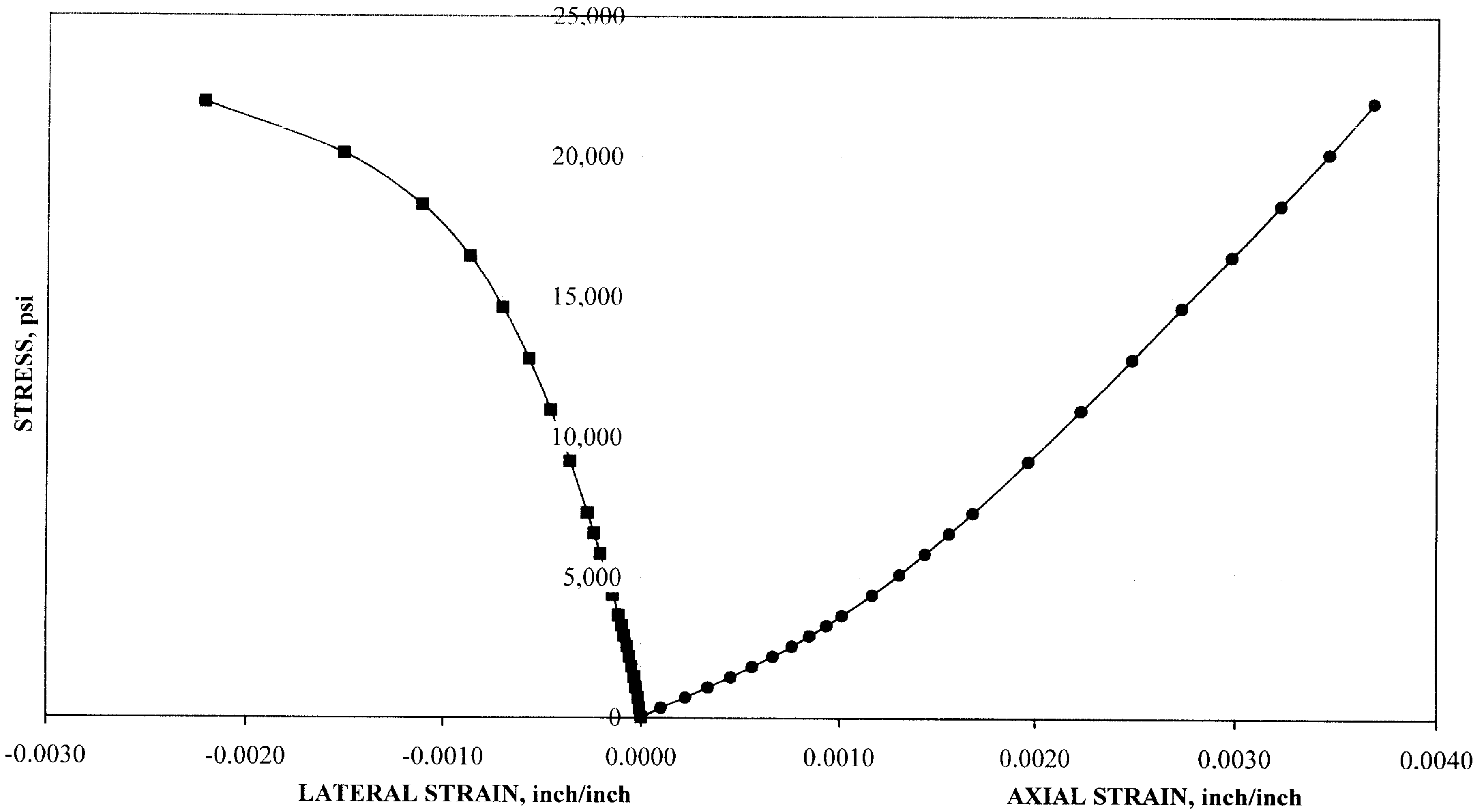
MACTEC

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001655 Boring No. B-803 (70.4-71.1 ft)



MACTEC

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001655 Boring No. B-803 (70.4-71.1 ft)



Before testing

Before testing with strain gauges attached

After testing

B-803 **Depth (ft): 70.4-71.1**

Physical Description: Very slightly weathered, hard, Quartz Gneiss with weak foliation at 50-60°

MACTEC

Elastic Modulii of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP
Project Number:	30720-2-5400.07.800
MACTEC Lab ID:	001657
Sample I.D.:	B-803 Depth 155.6-156.4 ft
Tested By:	David Jensen
Test Date:	01/24/03
Transverse Strain Gage Series:	EA-06-20CBW-120
Longitudinal Strain Gage Series:	EA-06-500BH-120
Gage Factor:	2.090
Excitation Voltage:	2.0 V
Reviewed by:	Thomas N. Dobras
Review Date:	1/28/2003

Specimen Information	
Average Diameter, inch	1.873
Average Height, inch	3.91
Moisture Content (%)	0.1
Ultimate Load, lb_f	60,698

RUN # 2		
Load, lb_f	**Longitudinal ε** μ inch/inch	**Transverse ε** μ inch/inch
0	-9	10
5,000	-469	57
10,000	-815	114
15,000	-1130	179
20,000	-1420	250
25,000	-1688	325
30,000	-1945	411
35,000	-2197	504
40,000	-2447	610
45,000	-2700	730
50,000	-2958	874
55,000	-3227	1064
60,000	-3554	1366

MACTEC

Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D 3148-96

Project Name:	North Anna ESP	**Transverse Strain Gage Series:**	EA-06-20CBW-120
Project Number:	30720-2-5400.07.800	**Longitudinal Strain Gage Series:**	EA-06-500BH-120
MACTEC Lab ID:	001657	**Gage Factor:**	2.09
Sample I.D.:	B-803 Depth 155.6-156.4 ft	**Excitation Voltage:**	2.0 V
Tested By:	David Jensen	**Reviewed by:**	Thomas N. Dobras
Test Date:	01/24/03	**Review Date:**	01/28/03

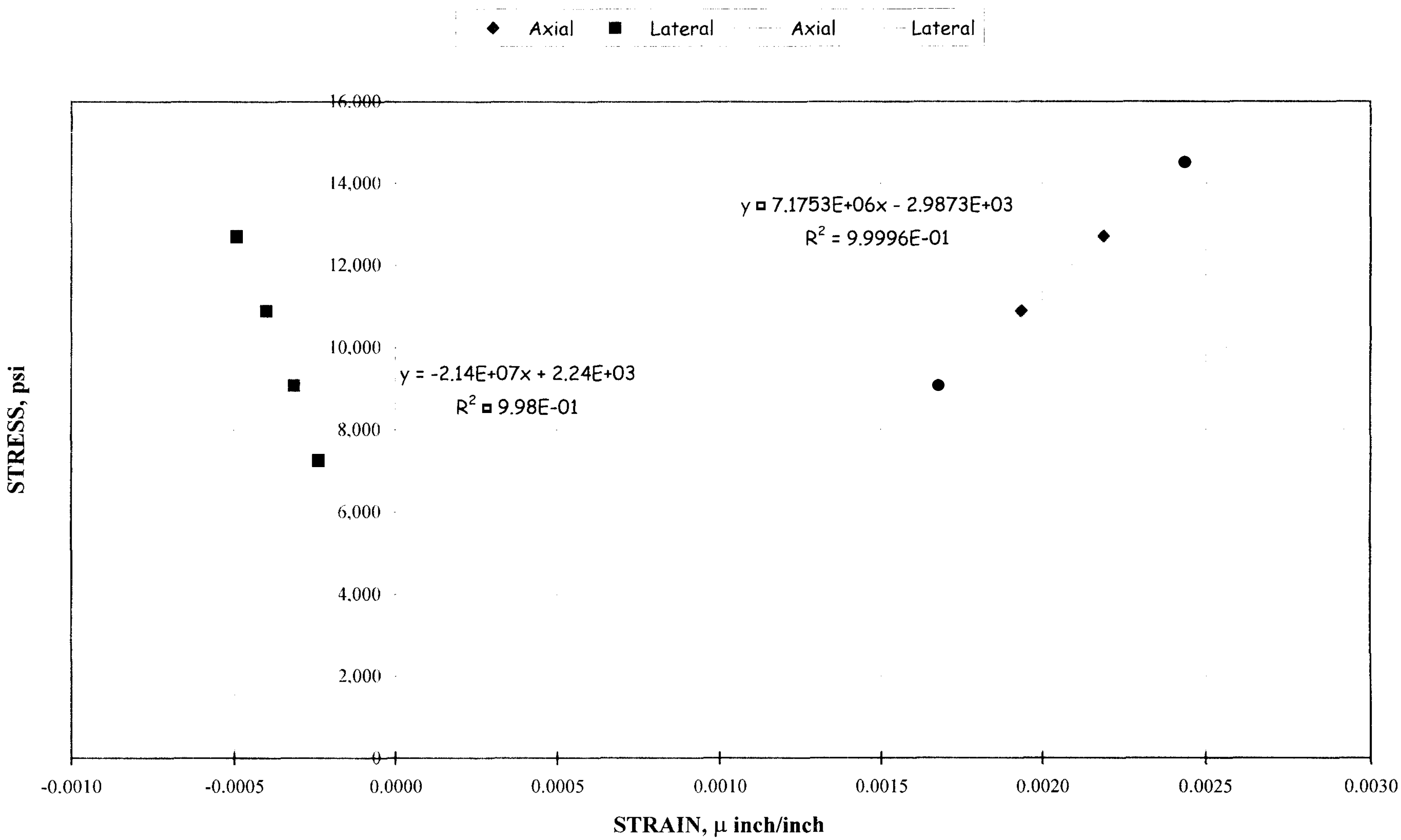
Average Diameter, inch	1.873
Average Length, inch	3.910
Length/Diameter ratio	2.1
Specimen Area, inch^2	2.755
Moisture Content (%)	0.1
Rate of loading (lbs/min)	10,000
Compressive Strength, psi	**22,030**
Longitudinal e Correction, inch/inch	-0.000009
Transverse e Correction, inch/inch	0.000010
Modulus of Elasticity, psi	**7,173,000**
Poisson's Ratio	**0.33**

RUN # 2		
Stress, psi	**Longitudinal e** inch/inch	**Transverse e** inch/inch
0	0.000000	0.000000
1,815	0.000460	-0.000047
3,629	0.000806	-0.000104
5,444	0.001121	-0.000169
7,259	0.001411	**-0.000240**
9,073	**0.001679**	-0.000315
10,888	0.001936	-0.000401
12,703	0.002188	**-0.000494**
14,518	**0.002438**	-0.000600
16,332	0.002691	-0.000720
18,147	0.002949	-0.000864
19,962	0.003218	-0.001054
21,776	0.003545	-0.001356

Note : Points chosen are in Bold.

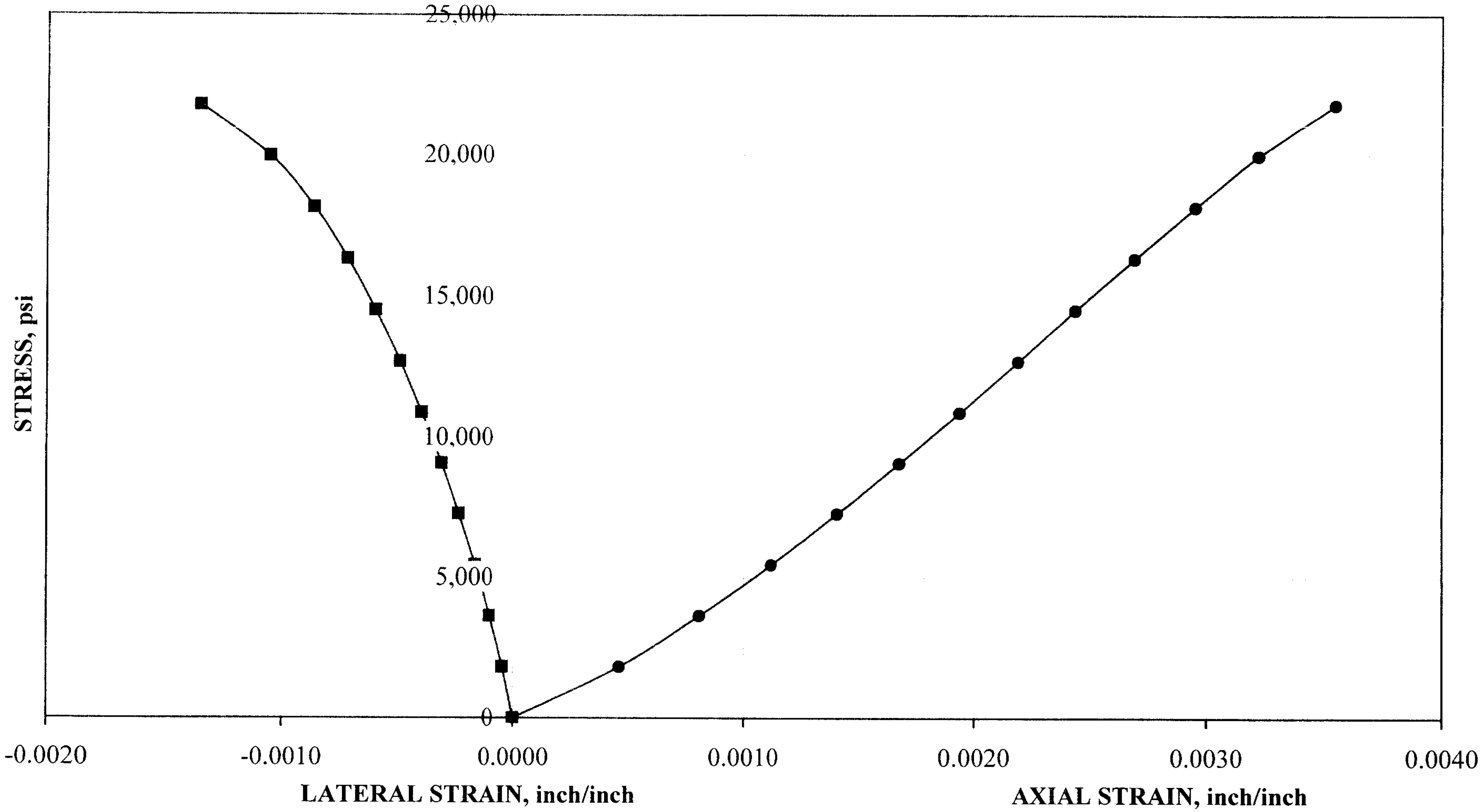
Comments: Material description and photographs submitted in separate report
Test temperature was room temperature at 20-22 ^{0}C

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001657 Boring No. B-803 (155.6-156.4 ft)

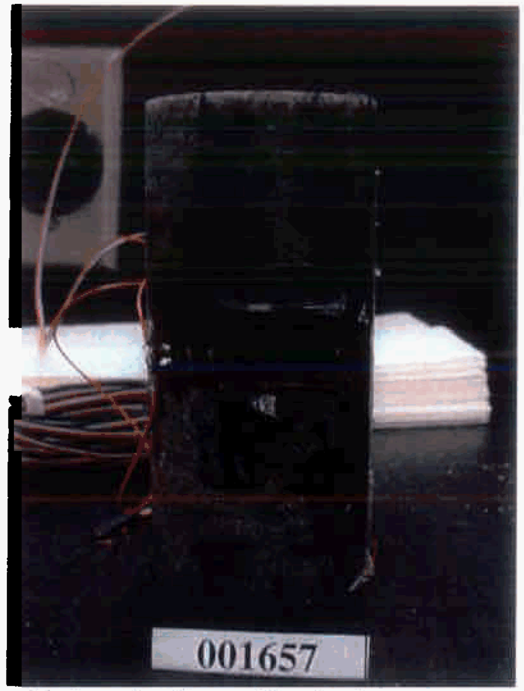


MACTEC

North Anna ESP Project 30720-2-5400
MODULUS OF ELASTICITY
MACTEC Lab ID 001657 Boring No. B-803 (155.6-156.4 ft)



Before testing



Before testing with strain gauges attached

After testing

B-803 **Depth (ft): 155.6-156.4**

Physical Description: Fresh, very hard, Quartz Gneiss with weak foliation at 50-60°

APPENDIX J
DOWNHOLE SEISMIC REPORT AND DATA

Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221
(614) 488-7860 tel; (614) 488-8945 fax

Non-destructive Subsurface Exploration
Near-surface Geophysics

March 17, 2003

Mr. J. Allan Tice
Mactec Engineering Services, Inc.
3301 Atlantic Avenue
Raleigh, NC 22080

RE: Report of Supplemental Downhole Seismic Testing at the North Anna Power Station ESP, Mineral Virginia, GEI Project No. 01-22089, MACTEC JOB NO. 30720-2-5400

Dear Al:

Grumman Exploration, Inc. has completed the downhole seismic testing at the above referenced project site located near Mineral, Virginia. This letter-report summarizes the field procedures used and results of the tests performed at this site. The attached spreadsheets and plots summarize the estimated seismic velocities and derived parameters for the borehole tested.

Project Description

Mactec Engineering Services, Inc. is engaged in geotechnical investigations at the site. Downhole seismic testing of a single borehole was requested to supplement an earlier cross-hole seismic test that may have yielded inconclusive results. Among the requirements and assumptions of the downhole testing procedure are: homogeneous isotropic subsurface materials, consistent annular space material, filling and diameter, and minimal ambient noise.

Field Procedures

Grumman Exploration, Inc. conducted downhole seismic tests at borehole B-802b on February 12, 2003 as specified by Mactec Engineering Services, Inc. B-802b was part of a three borehole set that was originally installed for cross-hole seismic tests. The borehole was lined with approximately 92-ft of 2.875" diameter inclinometer casing and was grouted in-place using a cement bentonite grout according to ASTM D4428/D4428M. Approximately 50-ft of water in the cased hole was removed prior to testing.

The following field equipment and procedures were used to conduct the tests:

- Geometrics, Inc. SmartSeis S-12, 12 channel, digital signal enhancement seismograph,
- Four triaxial downhole geophones, 10-ft separation with leaf-spring sidewall clamping mechanisms, and
- Sledge hammer source, steel plate and weighted wood plank.

Tests were performed at 5-ft intervals from approximately 10-ft to 84-ft. Note that a 10-ft geophone separation was used to provide a longer measurement time interval between geophones in the anticipated high velocity bedrock. The seismograph sampling rate was 64 microseconds (0.064 msec) with a total sweep time of 128 milliseconds. A total of 2048 samples for each of the 12-channels were acquired for each shot. A pre-trigger delay of 5-msec was used to provide additional data in a brief time window just prior to the initiation of the test. The test preparation procedures consisted of lowering the geophones to the desired test depth and releasing the sidewall clamping mechanism on each geophone. Three tests were performed at each test depth using multiple impacts from a sledgehammer striking an aluminum plate. The attached summary sheet describes the test nomenclature and test positions. The impact plate was struck from three positions: ground-surface (vertical, P-wave) and opposite sides of the horizontal plank (lateral, S wave, opposing polarities). The impacts from opposite sides of the plank were used to help identify the onset of the shear wave by observing the reversal in wave polarity. Between 2 and 7 impacts were stacked to help enhance the compressional (P) and shear (S) wave signatures and cancel spurious noise effects. A 4WD vehicle was used to weight the plank.

The data were observed and recorded in the field during acquisition. Both low and high-pass digital filters (250 Hz and 10 Hz, respectively) were used to help reduce interfering noise effects within the borehole. A preliminary assessment of the first five interval tests was performed in the field to observe the processed initial test results and adjust the acquisition parameters as needed. Upon the completion of the testing, the data were returned to the offices of Grumman Exploration, Inc. for further review and analysis.

A computer program developed by Grumman Exploration, Inc. was used to extract and display the P and S-wave traces for the geophones used for each test interval. Using the arrival time estimates, P and S wave velocities were calculated for each depth interval. The velocity calculation was based on the difference in arrival times and an assumed straight-line travel distances to each geophone using the in-hole depth to each geophone and the ground-level offset distance of the seismic impulse. An attachment summarizes the velocity calculation methodology.

The analysis consisted of estimating P-wave and S wave arrivals for each depth level tested. Three general approaches were used to estimate the compressional and shear wave arrival times:

- Composite plots illustrating all the results from all geophones at all test depths to observe general data trends;
- Multi-geophone arrival time assessment: examining the arrival time differences between successive geophones for each test position, repeated for all test positions; and
- Single-geophone assessment: examining the arrival time differences between individual geophones for different test depths, repeated for all four geophones.

The criteria for selecting arrival times included (1) observing the apparent first onset of the P or S-wave, and/or (2) identifying a characteristic waveform, peak, polarity reversal, zero-crossing or shape that was consistently present between successive records. Apparently erroneous or unrealistically high or low velocity estimates were eliminated from the data summary tables. Because four geophones were used for each test, multiple velocity estimates for some of the test intervals were available.

Downhole Seismic Testing Results

The attached spreadsheets summarize the downhole seismic testing results for test borehole B-802b at the North Anna Power Station ESP site in Mineral, Virginia. The spreadsheet includes a summary of the compressional wave velocity (Vp) and the shear wave velocity (Vs). Some of the interval velocity estimates were averaged if multiple test results were available for that interval. Plots of these results are also included. The following paragraphs summarize some of the results of the downhole seismic tests:

- High Compressional wave velocities: The estimated compressional wave velocities ranged between 10,000 feet-per-second (fps) to over 16,000 fps. It is not clear why significantly lower Vp estimates occurred in the 70-ft to 85-ft depth interval. For very high velocity materials, such as occur at the North Anna ESP site, small variations in the arrival time estimates (on the order of 0.1 millisecond) can cause large changes in the Vp estimates (e.g. >1,500 fps for every 0.1 msec arrival time difference for material with Vp over 12,000 fps). Consequently, signal resolution limitations, interfering noise and slight biases in the arrival time estimates can all contribute to disproportionate, large variations in the Vp estimates. Other possible explanations for the apparent lower velocity levels may be attributable to geologic factors such as the possible presence of fracture zones and fracture filling, changes in lithology, enhanced weathering, and anisotropy.

- Shear Wave velocities were correspondingly high and were estimated in the range of 3,500 to 6,300 fps in the areas were reliable shear wave information was available. The

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
(614) 488-7860 tel, (614) 488-8945 fax

shear wave information appeared less reliable and thus more inconclusive below approximately 45-ft.

- Compressional waveforms: The compressional wave onset was fairly clear throughout the borehole. P-wave arrival times became more inconsistent and unreliable below approximately 65-ft where more coincident p-wave arrivals occurred (i.e. approx. same arrival time for different depths). Possible refraction effects, geologic conditions and noise interference may be responsible for some of the irregular P-wave arrivals.

- Shear waveforms: the shear-wave was generally well defined to a depth of approximately 45-ft. Although well-defined S-wave waveforms appeared to be present below 45-ft, the waveforms below this depth tended to provide more unrealistic velocity estimates and consequently fewer of the S-wave results were used below 45-ft. Below approximately 65-ft, the S-wave appears to be absent. The higher amplitude signals with the appearance of an S-wave may actually represent noise wavetrains because (a) maximum seismograph amplification of the waveforms and (b) the signal peaks all occur at approximately the same time. Ambient vibrations in the 30 to 40 Hz range are apparent in the records from bottom 20-ft of B-802b. Possible explanations for the apparent loss of signal in the lowermost sections of the borehole include excessive interfering ambient noise and possible incomplete grout filling or grout set-up within the annular space near the hole bottom.

Bias in the arrival time picks and consequently the velocity estimates could result from one or more possible circumstances including: difficulty in estimating the S and P wave arrival times, irregular or incomplete borehole annular space filling, refraction effects (non-straight line travel path), limitations on the resolution of the digitized signal, and the presence of interfering noise and other wavetrains.

<u>General Qualifications</u>
The downhole seismic data presented herein represent estimates of subsurface properties in the immediate vicinity of the boreholes tested using the measurement procedures described above. No warranty, certification, or statement of fact, either expressed or implied, regarding actual subsurface properties surrounding the borehole tested is contained herein. If questions or uncertainties exist regarding the actual parameter values, supplemental in-situ or laboratory tests or other invasive explorations should be conducted to document actual subsurface material properties. No inference of subsurface properties can be made for depth intervals not tested.

Grumman Exploration, Inc. has appreciated this opportunity to be of service again to Mactec Engineering Services, Inc. If you have any questions or comments regarding this report, please feel free to contact us.

Sincerely,

Grumman Exploration, Inc.

David L. Grumman, Jr.
President/Geophysicist

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
(614) 488-7860 tel, (614) 488-8945 fax

Downhole Seismic Testing Summary Table

Test/Well ID: B-802b
Project: **North Anna ESP**
Location: Mineral, VA
Client/Owner: Mactec
Well Descr.: 2.875" PVC, grouted, ~91' depth

Test Date: 2/12/2003
Calc. Date: 3/17/2003
Field Staff: dlg
Data Proc by: dlg

Grumman Exploration, Inc.
2309 Dorset Road
Columbus, Ohio 43221-3145
(614) 488-7860 tel

Eqp: Geometrics S-12 Seismograph
4 triaxial geophones
sledge hammer impulse source

Test Interval Depth (ft)	Interval Velocity (ft/sec) V_p	V_s	Soil Density (pcf) γ	Shear Modulus G	Bulk Modulus K	Young's Modulus E	Poisson's Ratio υ	Depth (ft)	Material Descr/Class
2.50	4526	385					0.496	2.50	
7.50	6603	854					0.491	7.50	
12.50		3435						12.50	
17.50	11813	1482					0.492	17.50	
22.50	13798	5278					0.414	22.50	
27.50	10854	3398					0.446	27.50	
32.50	14047	4513					0.442	32.50	
37.50	14106							37.50	
42.50	16502	6364					0.413	42.50	
47.50	14468	6382					0.379	47.50	
52.50	16559	5371					0.441	52.50	
55.00	13623							55.00	
57.00	13260							57.00	
57.50	16576	5835					0.429	57.50	
62.50	16590							62.50	
67.00	13280							67.00	
67.50	16601	6030					0.424	67.50	
77.00	9970							77.00	
87.00	9976							87.00	

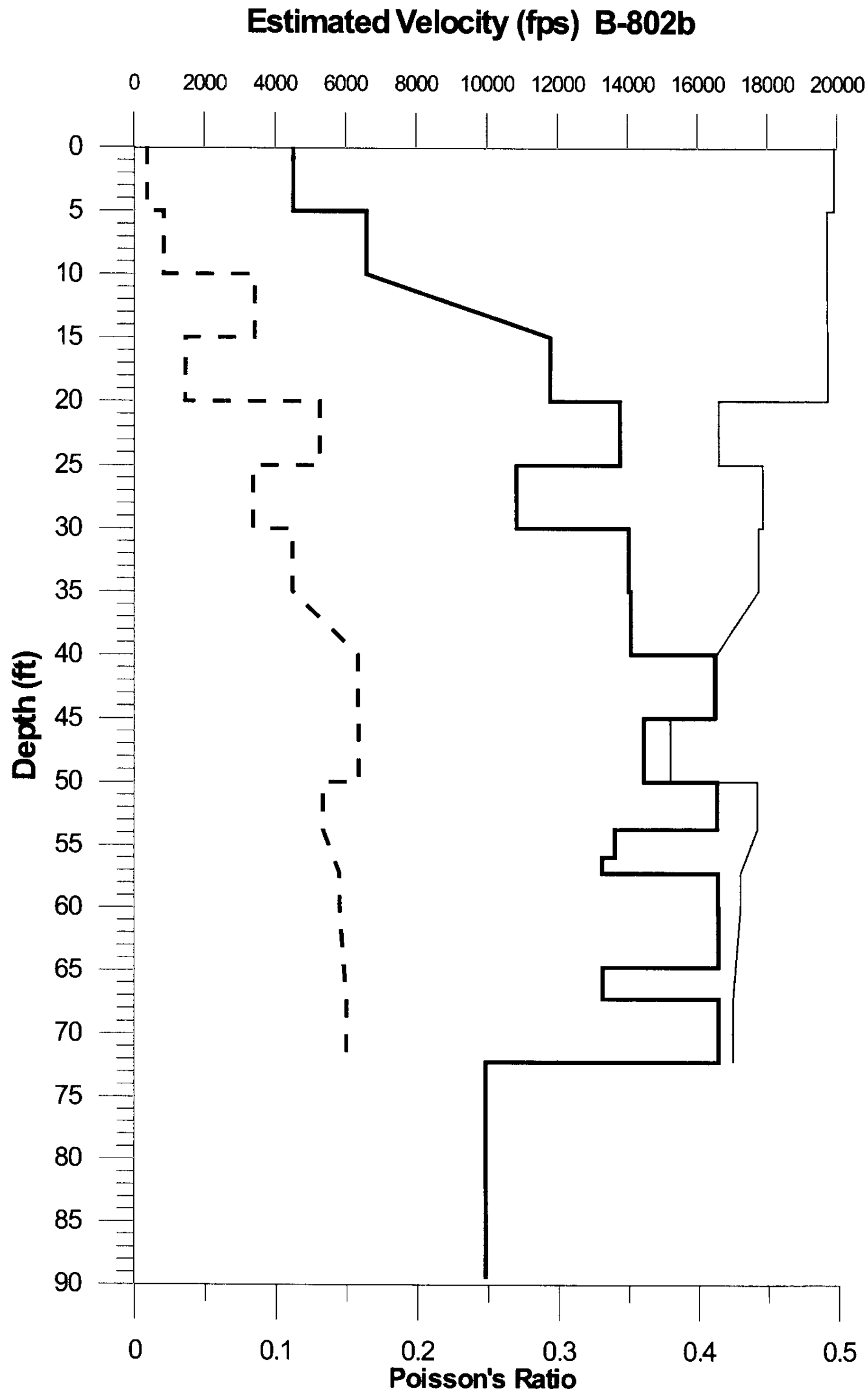
Notes: Blank value denotes uninterpretable data

S	Project:	North Anna ESP				Grumman Exploration, Inc. 2003				
	Borehole:	B-802b		Location:	Mineral, VA					
				Wave Type :		Shear				
				Ground Offset		7.35	ft			
	Arrival Time Est's, Geophones A, B, C and D						Velocity			
Depth	A.1	A.2	B.1	C.1	C.2	D.1	D.2	Avg (fps)	Depth	
0.0	15.00								0.0	
2.5	385							385	2.5	
5.0	19.00		19.00						5.0	
7.5	880		828					854	7.5	
10.0	23.00		23.25						10.0	
12.5			3435					3435	12.5	
15.0	22.40		24.50	15.00					15.0	
17.5	1123		1842					1482	17.5	
20.0	26.50		27.00	20.30					20.0	
22.5	5278							5278	22.5	
25.0	27.40		27.05	23.00		25.00			25.0	
27.5	3577			3219				3398	27.5	
30.0	28.75		29.25	24.50		25.90			30.0	
32.5	3901		3901			5737		[illegible]	32.5	
35.0	30.00		30.50	25.25		26.75			35.0	
37.5									37.5	
40.0	32.00		30.90	27.00		27.20			40.0	
42.5				6569		6158		6364	42.5	
45.0	31.00	35.00	30.80	27.75		28.00			45.0	
47.5		6176		6588				6382	47.5	
50.0	26.00	35.80	31.50	28.50		30.50	29.40		50.0	
52.5						7074	3668	[illegible]	52.5	
55.0	28.25		31.60		30.00	31.20	30.75		55.0	
57.5							5835	5835	57.5	
60.0	29.90		32.10		36.60	31.70	31.60		60.0	
62.5									62.5	
65.0			31.50		37.50		32.25		65.0	
67.5			6213				5848	[illegible]	67.5	
70.0			32.30		41.75		33.10		70.0	
72.5									72.5	
75.0					41.00				75.0	
77.5									77.5	
80.0									80.0	
82.5									82.5	
85.0									85.0	
87.5									87.5	
90.0									90.0	

Notes: Shaded cells are geophone locations w/ est'd arrival times (msec),
Red values are velocity estimates (fps) for depth interval
questionable/erroneous velocity estimates blanked

P	Project:	North Anna ESP					Grumman Exploration, Inc. 2003			
	Borehole:	B-802b		Location:		Mineral, VA				
					Wave Type :Compression					
					Ground Offset		6.00	ft		
	Arrival Time Est's, Geophones A, B, C and D							Velocity		
Depth	A	B	C	D	Avg (fps	Depth				
0.0	6.90					0.0				
2.5	4526				4526	2.5				
5.0	7.30	7.50				5.0				
7.5	5502	7703			6603	7.5				
10.0	8.00	8.00				10.0				
12.5						12.5				
15.0	11.00	11.60	10.60			15.0				
17.5			11813		11813	17.5				
20.0	12.20	11.80	11.00			20.0				
22.5			13798		13798	22.5				
25.0	14.80	11.40	11.35	11.70		25.0				
27.5				10854	10854	27.5				
30.0	16.30	12.15	12.30	12.15		30.0				
32.5				14047	14047	32.5				
35.0	12.40	12.00	11.90	12.50		35.0				
37.5	14106				14106	37.5				
40.0	12.75	12.75	12.80	13.10		40.0				
42.5			16502		16502	42.5				
45.0	12.00	13.40	12.90	13.00		45.0				
47.5		12401	16535		14468	47.5				
50.0	12.60	13.60	13.20	13.75		50.0				
52.5			16559		16559	52.5				
55.0	[illegible]	12.75	13.50			55.0				
57.5	16576				16576	57.5				
60.0	13.10	13.50	[illegible]	[illegible]		60.0				
62.5				16590	16590	62.5				
65.0		13.60	[illegible]	14.30		65.0				
67.5		16601			16601	67.5				
70.0		13.90	[illegible]	[illegible]		70.0				
55.0	12.80			13623	13623	55.0				
57.0	13260			13.90	13260	57.0				
59.0	13.10					59.0				
				14.70		0.0				
65.0		13.60				65.0				
67.0		13280			13280	67.0				
69.0		13.90				69.0				
						0.0				
75.0			14.40			75.0				
77.0			9970		9970	77.0				
79.0			14.80			79.0				
						0.0				
85.0				14.80		85.0				
87.0				9976	9976	87.0				
89.0				15.20		89.0				
						0.0				

Notes: Shaded cells are geophone locations w/ est'd arrival times (msec),
Red values are velocity estimates (fps) for depth interval
questionable/erroneous velocity estimates blanked

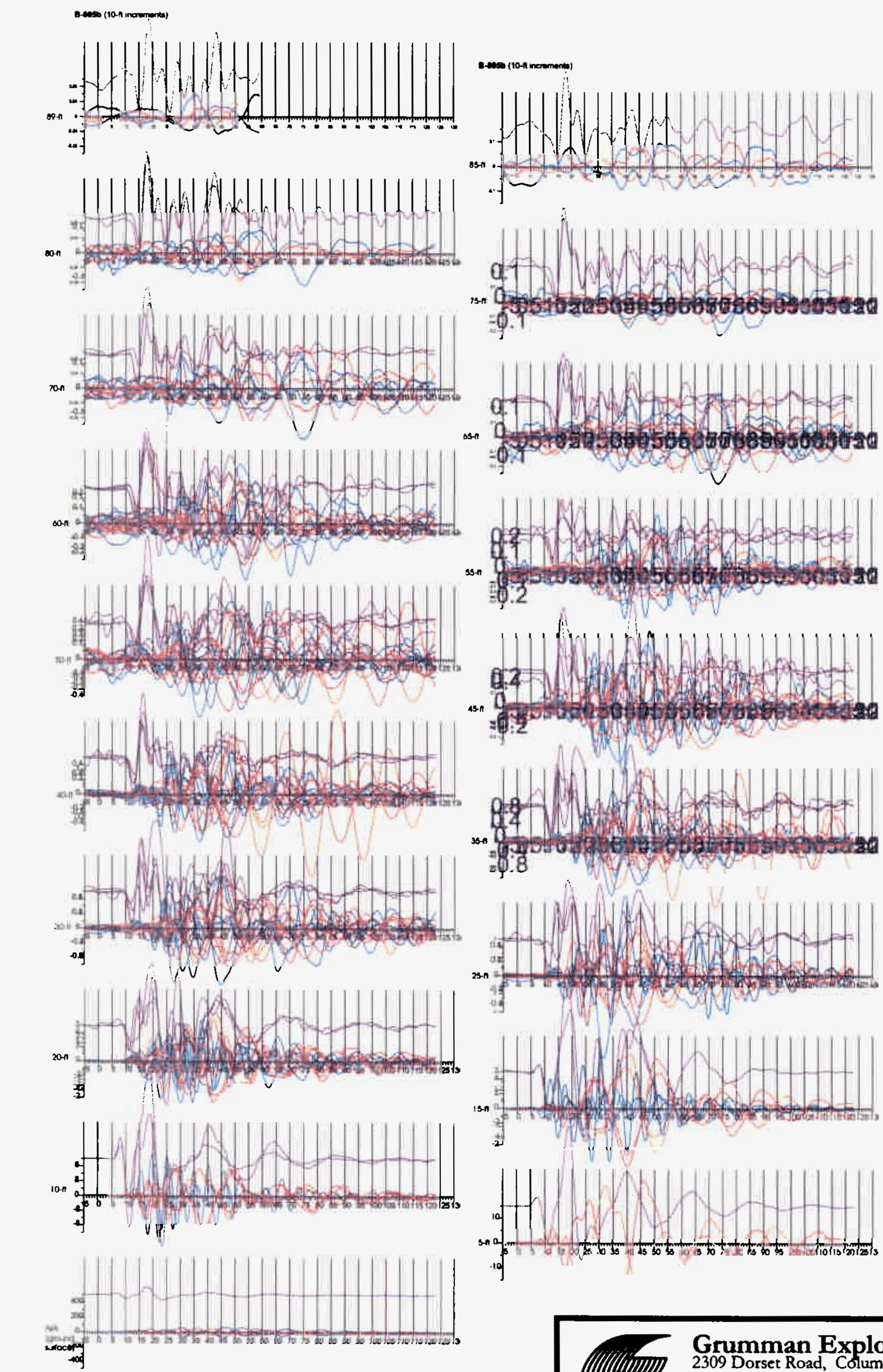


Legend

- P-wave Velocity (fps)
- S-wave Velocity (fps)
- Poisson's Ratio

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
Near-surface Geophysics, Non-destructive Subsurface Exploration

Project: North Anna ESP Project - Downhole Seismic			
Location: North Anna Power Station, Mineral, Virginia			
Client: Mactec Eng. Svcs.	By: dlg	Date: 2/20/03	
Project No.: 01-22089	Checked:	Scale: nts	
Figure: 1	Title: B-802b, Estimated Velocity vs. Depth		



Legend

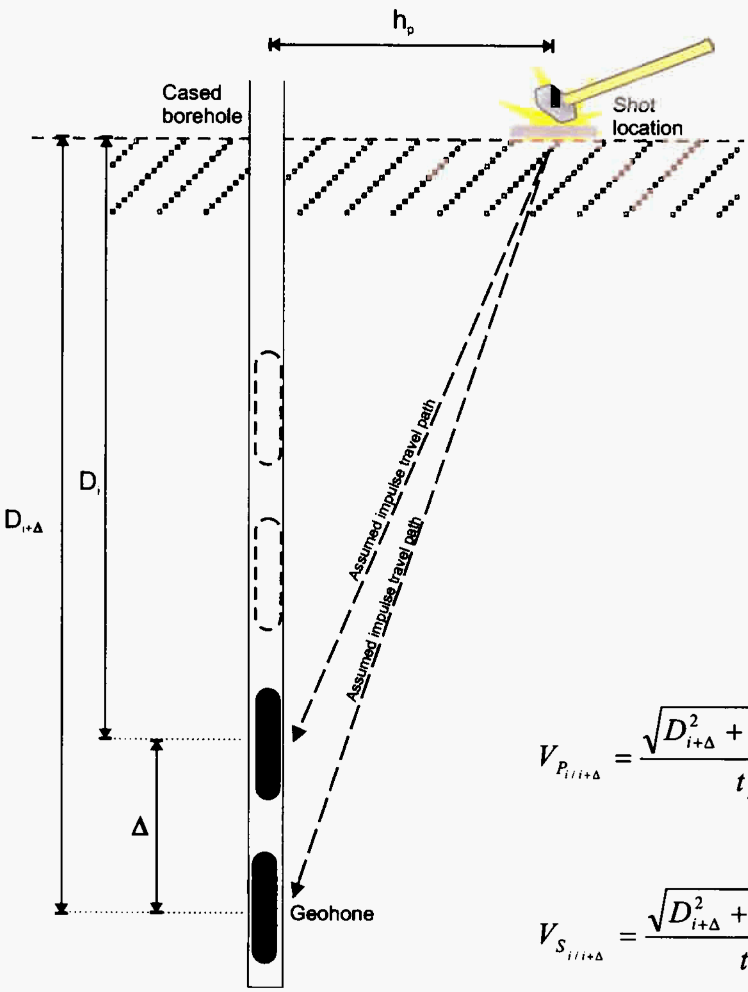
Vertical Geophone (compressional)

Lateral Geophone #1 (opposing polarities)

Lateral Geophone #2 (opposing polarities)

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
Near-surface Geophysics, Non-destructive Subsurface Exploration

Project: North Anna ESP Project - Downhole Seismic			
Location: North Anna Power Station, Mineral, Virginia			
Client: Mactec Eng. Svcs.	By: dlg	Date: 2/20/03	
Figure: 2	Title: B-802b, Recorded Downhole Waveforms		
Project No.: 01-22089	Checked:	Scale: nts	



$$V_{P_{i/i+\Delta}} = \frac{\sqrt{D_{i+\Delta}^2 + h_p^2} - \sqrt{D_i^2 + h_p^2}}{t_{P_{i+\Delta}} - t_{P_i}}$$

$$V_{S_{i/i+\Delta}} = \frac{\sqrt{D_{i+\Delta}^2 + h_s^2} - \sqrt{D_i^2 + h_s^2}}{t_{S_{i+\Delta}} - t_{S_i}}$$

$V_{P_{i/i+\Delta}}$	=	Compressional wave velocity for the depth interval *i* to *i*+**Δ**
$V_{S_{i/i+1}}$	=	Shear wave velocity for the depth interval *i* to *i*+**Δ**
Δ	=	Vertical distance/separation between successive geophones
D_i , $D_{i+\Delta}$	=	Geophone depth at test depth i, Geophone depth at test depth i+**Δ**
t_{S_i} , $t_{S_{i+\Delta}}$	=	Estimated arrival times for the shear wave for successive geophones
h_p , h_s	=	Ground offset distance between shot location and center of borehole for the compressional and shear wave shots, respectively

Grumman Exploration, Inc.
2309 Dorset Road, Columbus, Ohio 43221
Near-surface Geophysics, Non-destructive Subsurface Exploration

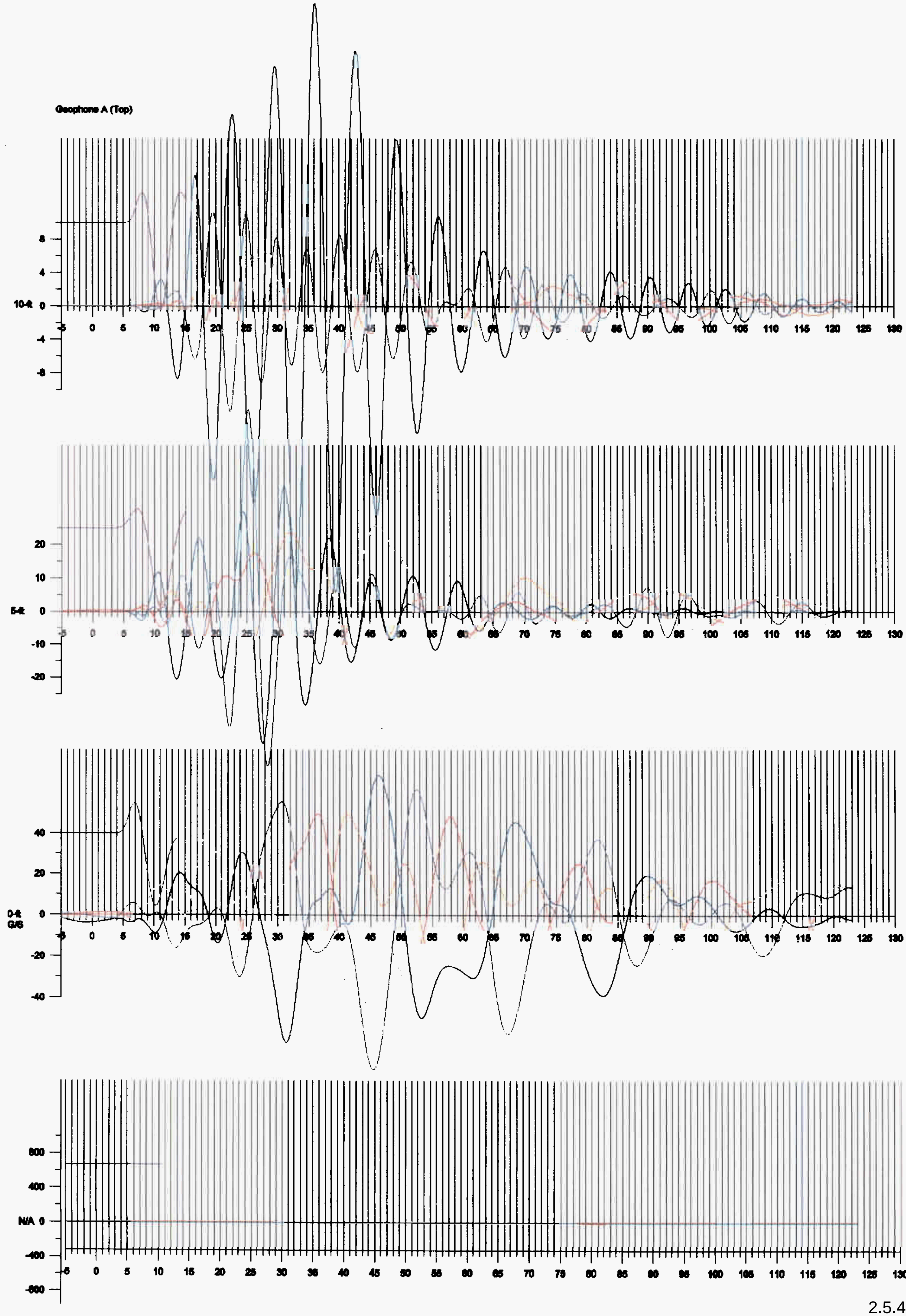
Project: DOWNHOLE SEISMIC CALCULATIONS			
Location			
Client		By: dlg	Date: 3/01/03
Figure	Title: Schematic Downhole Computations		
Project No.		Checked	Scale: nts

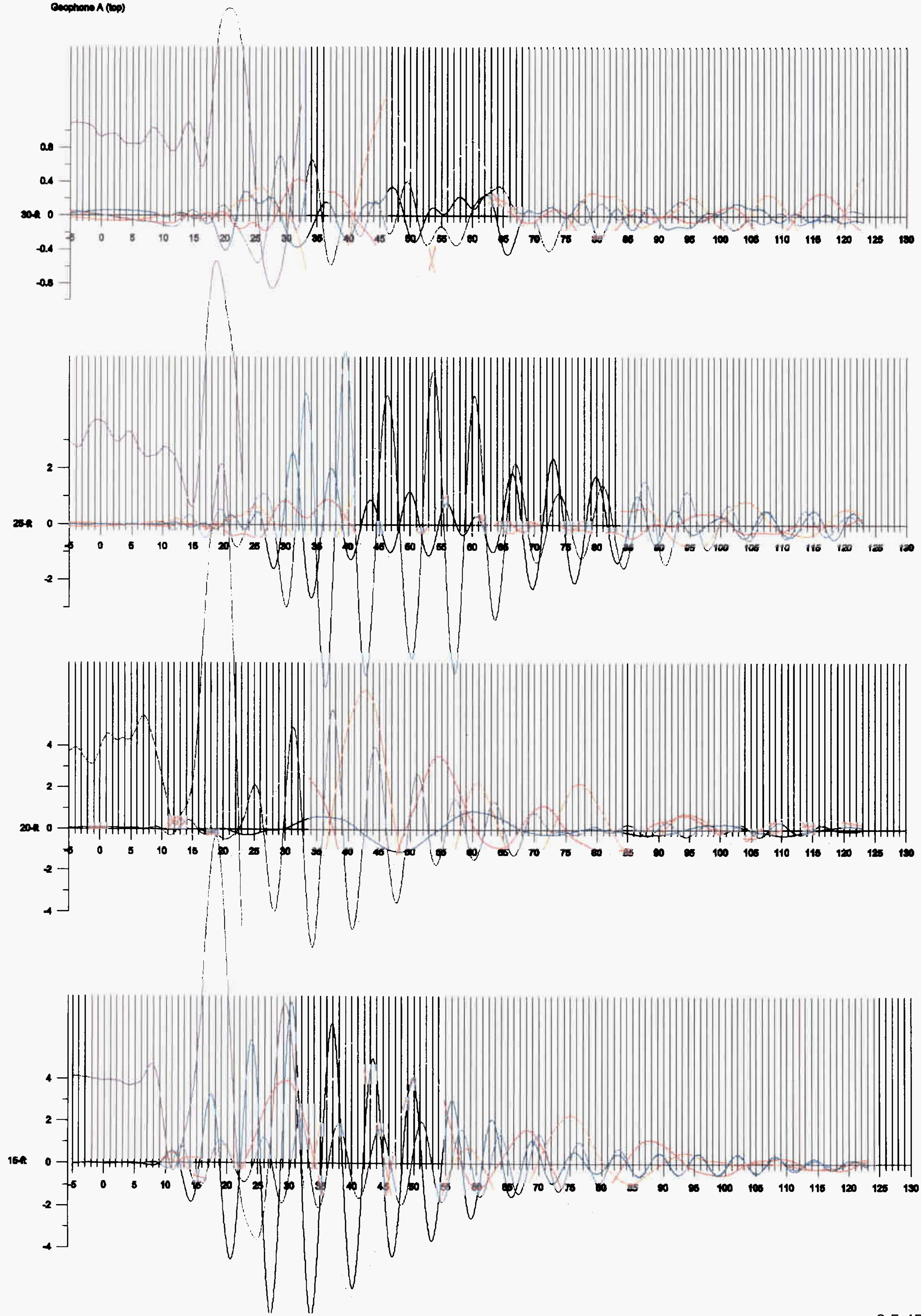
WAVE FORMS FROM FIELD DATA

Wave forms from each geophone are presented on a series of sheets. Each sheet shows data from the indicated geophone at different depths below the surface as shown on the left side of the sheet, reading from bottom to top of the sheet. There are four geophones – A (at the top of the array), B (at the top middle of the array), C (at the bottom middle of the array) and D (at the bottom of the array). The horizontal axis is time in milliseconds. The vertical axis is amplitude of the signal and has a variable scale.

The color plots are coded as follows:

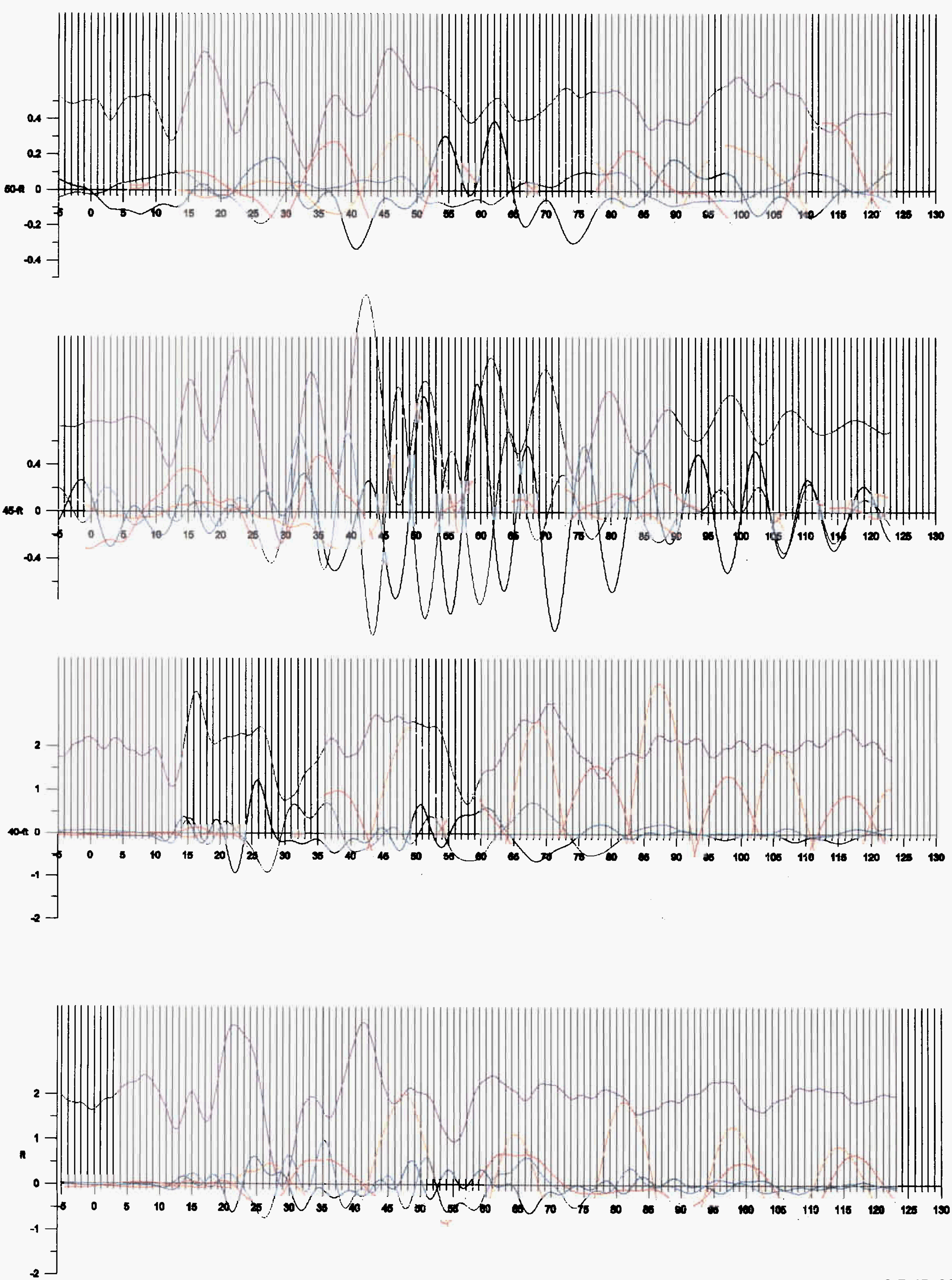
Purple	- vertical signal
Red	- lateral signal geophone 1
Orange	- lateral signal geophone 1, opposite polarity
Light Blue	- lateral signal geophone 2
Dark Blue	- lateral signal geophone 2, opposite polarity


Geophones A (Top)
10-ft
5-ft
0-ft
G/S
N/A

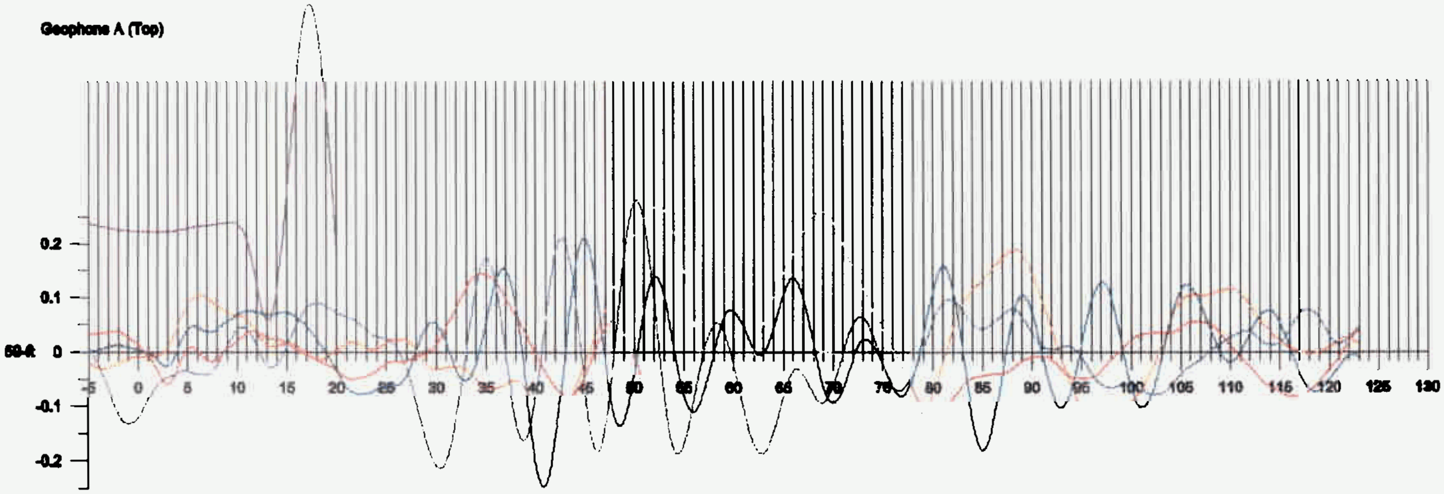


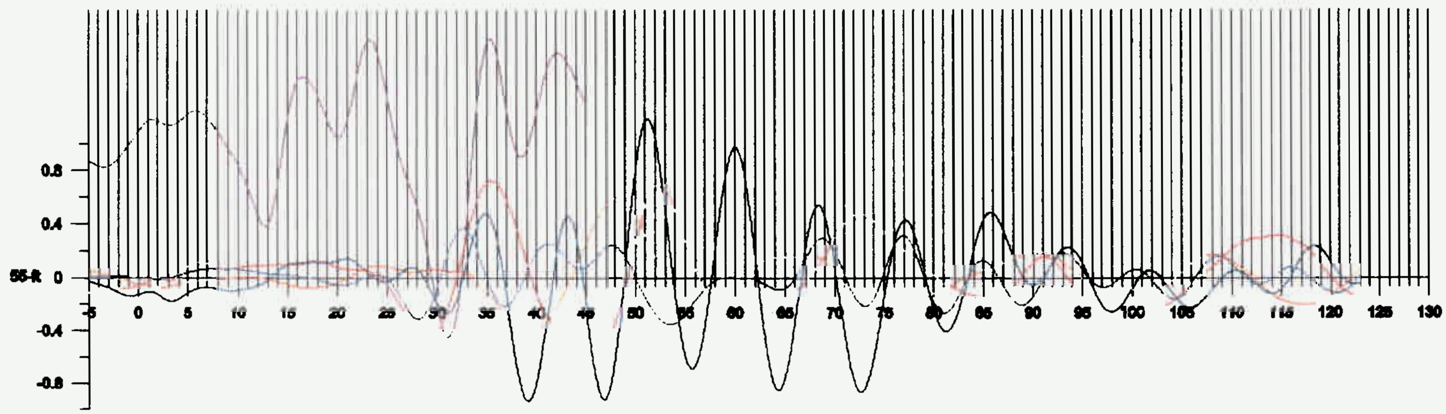
Geophone A (top)
30-ft
25-ft
20-ft
15-ft

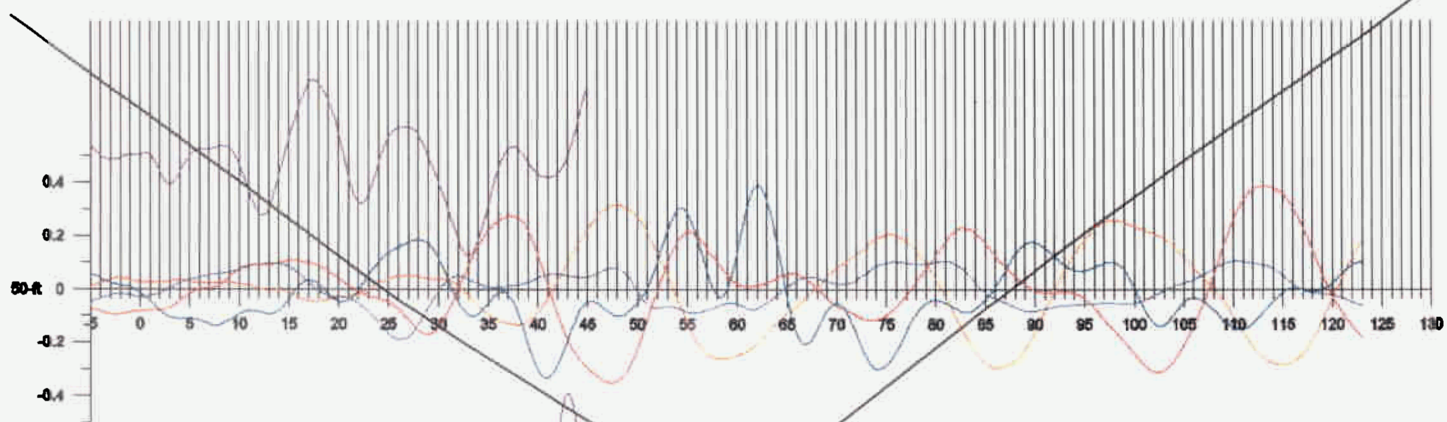
Geophone A (Top)



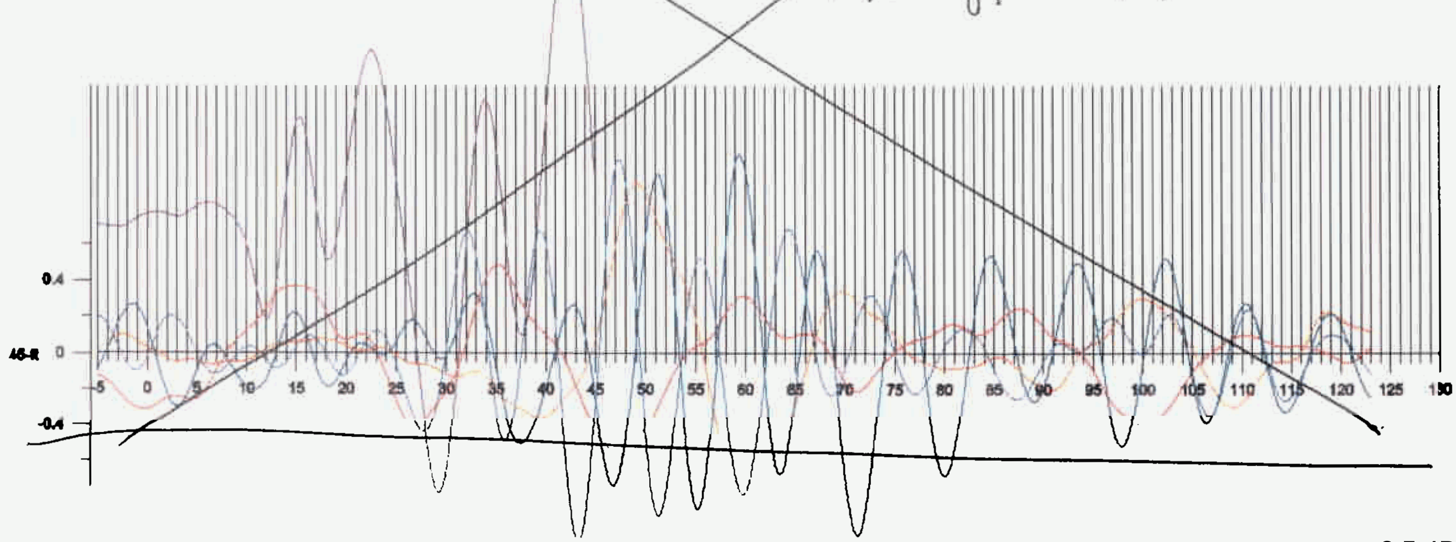
Geophone A (Top)



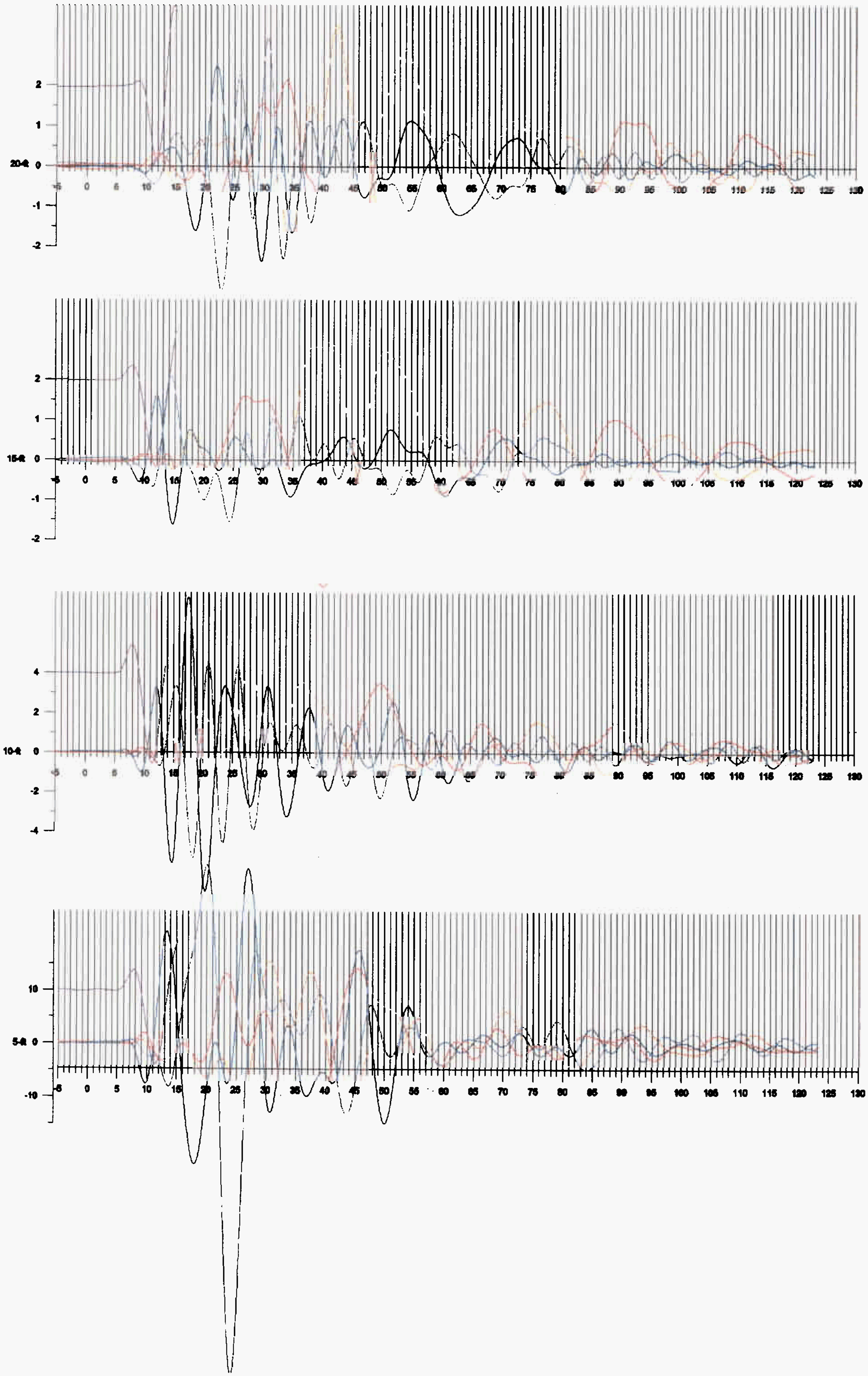




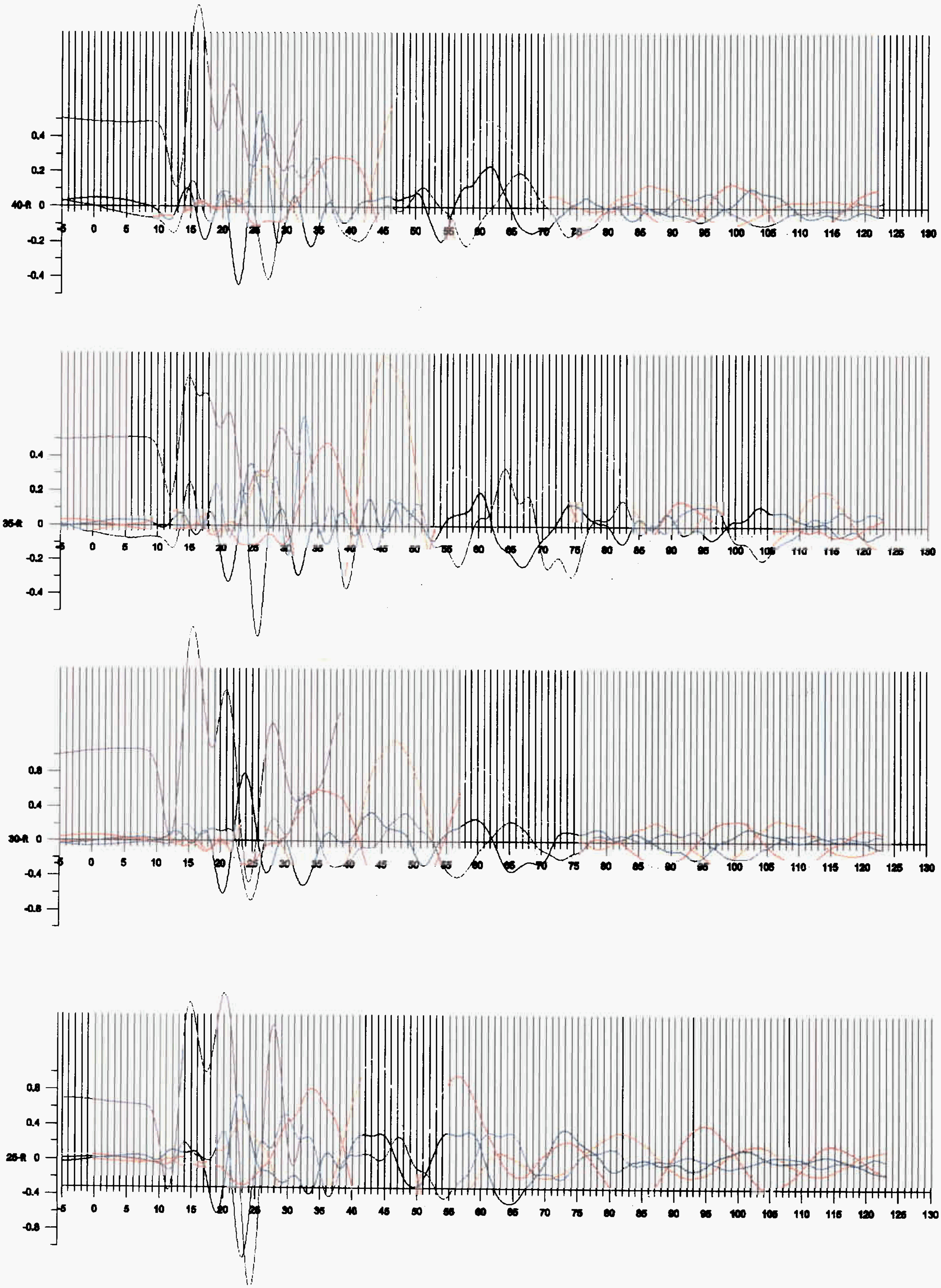
repeat of previous page



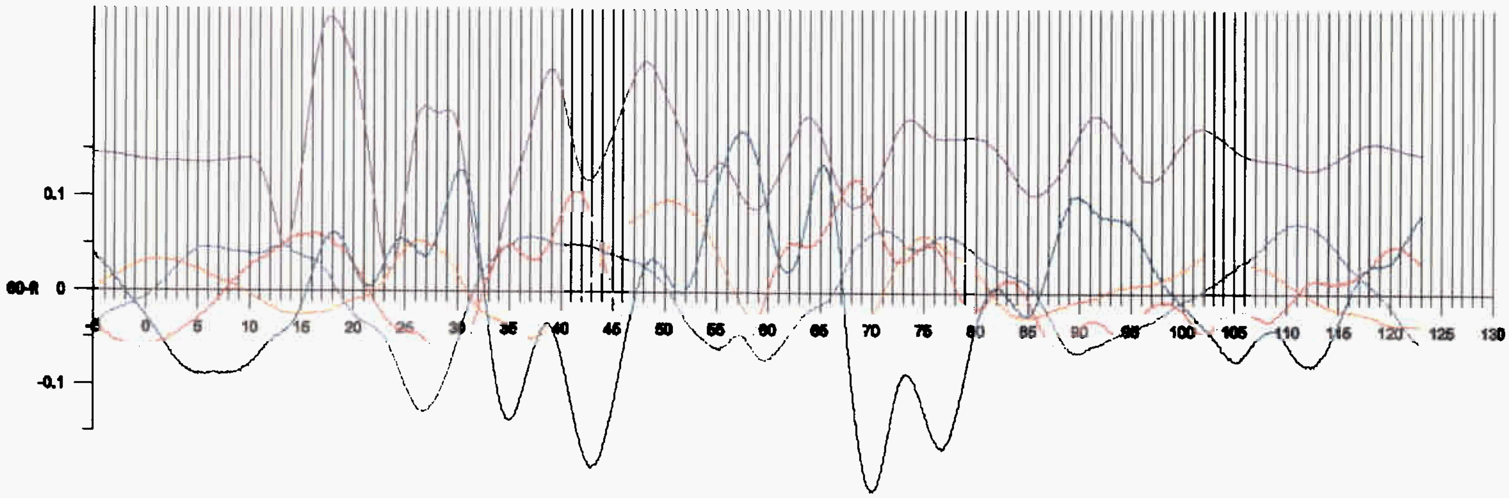
Geophone B (mid-ht)

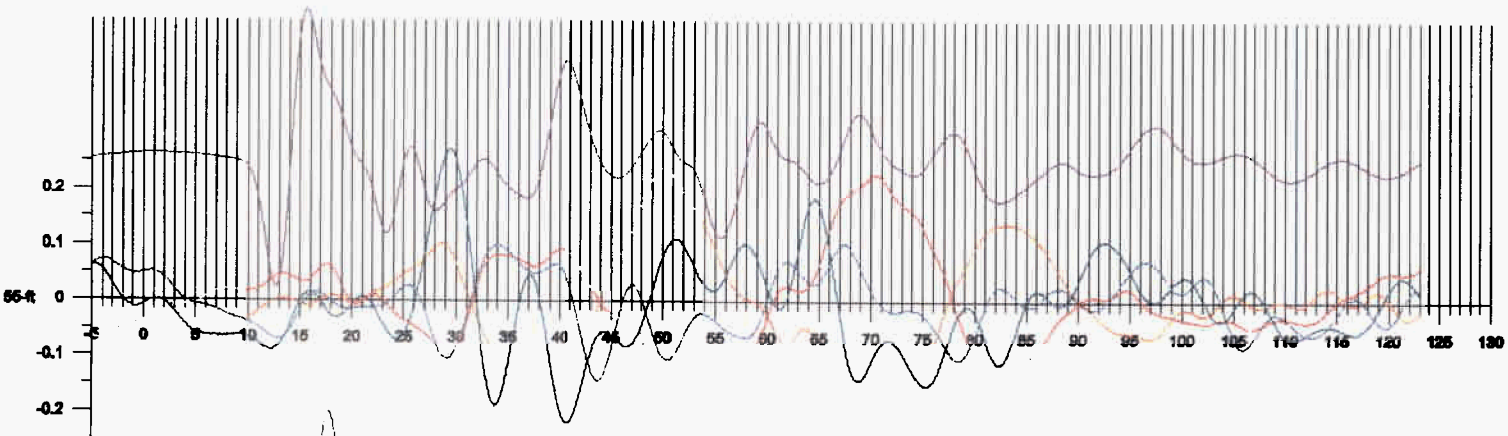


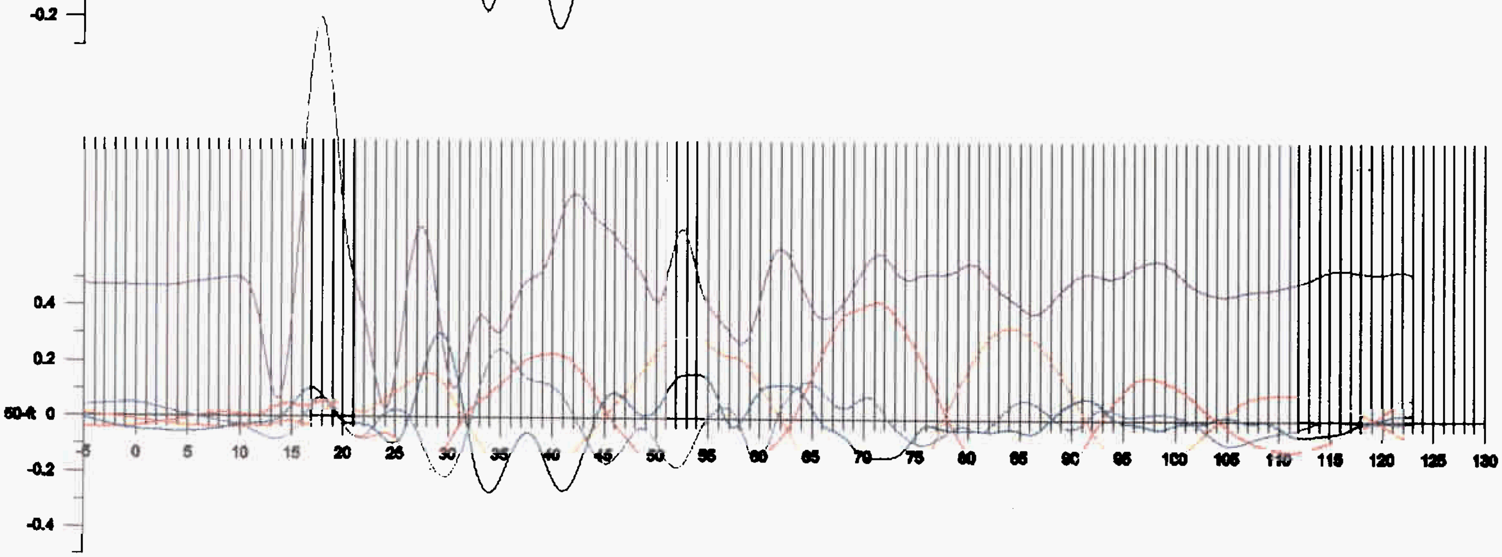
Geophone B (mid-hi)

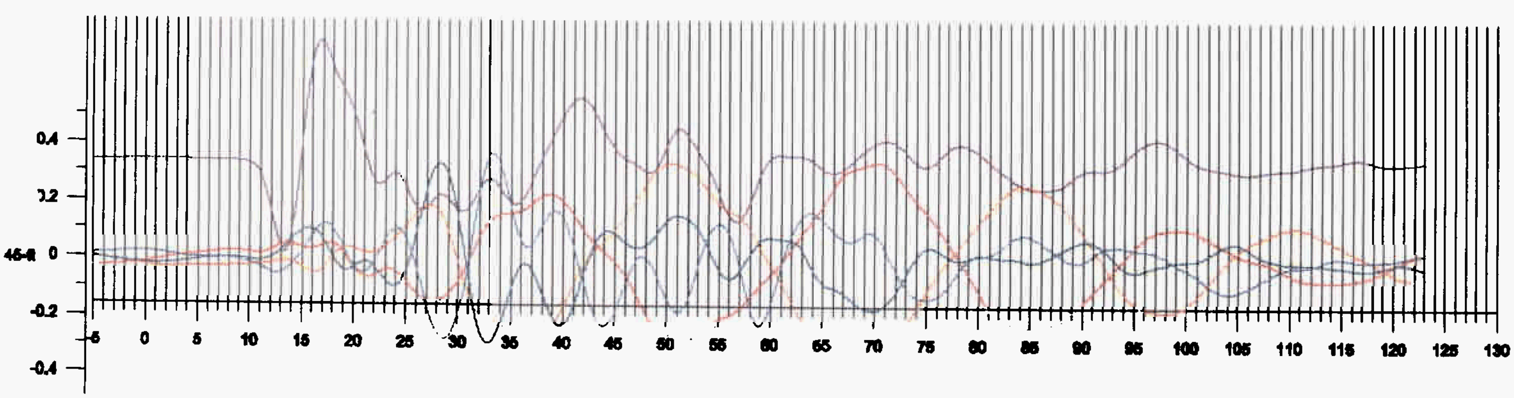


Geophone B (Mid-hi)

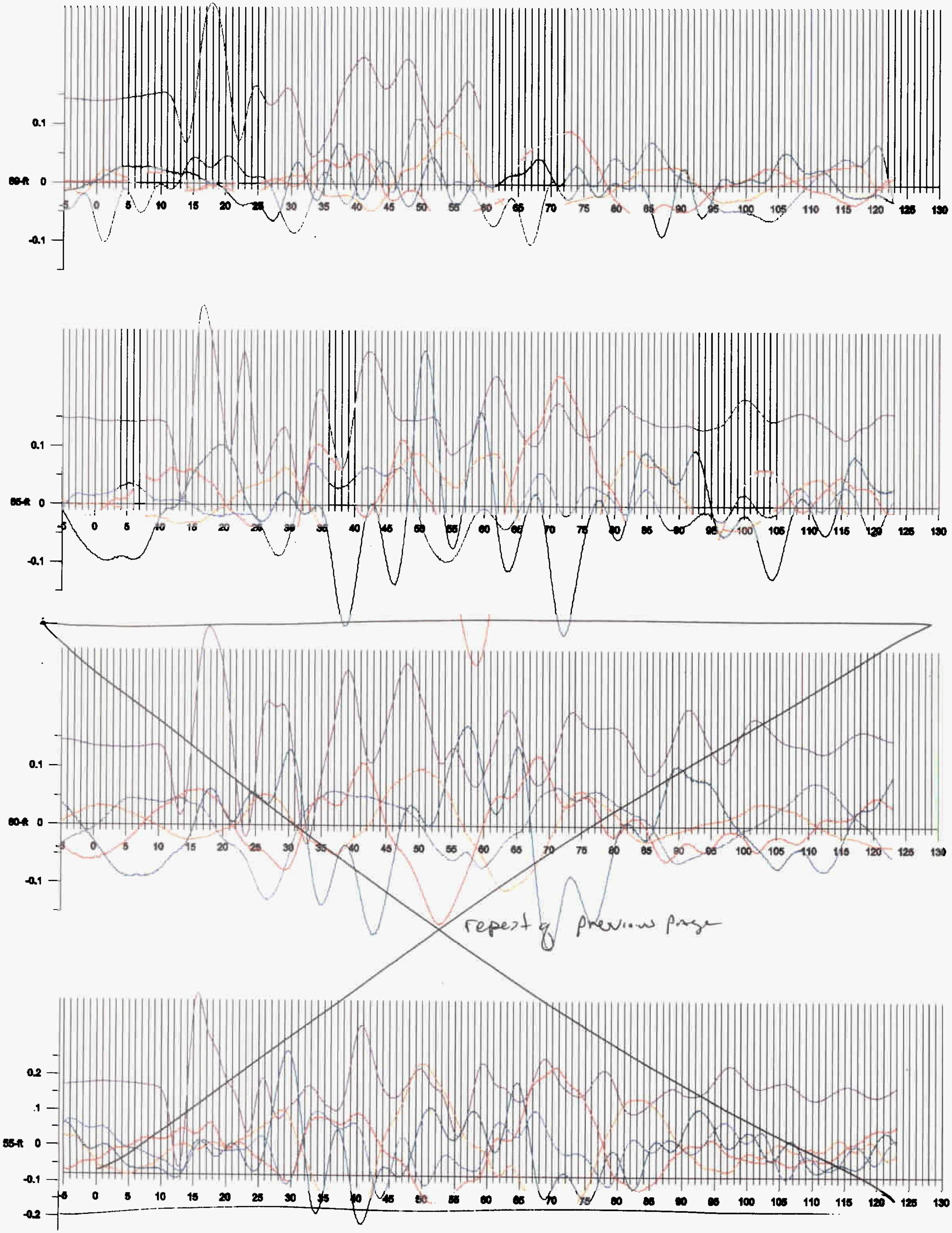




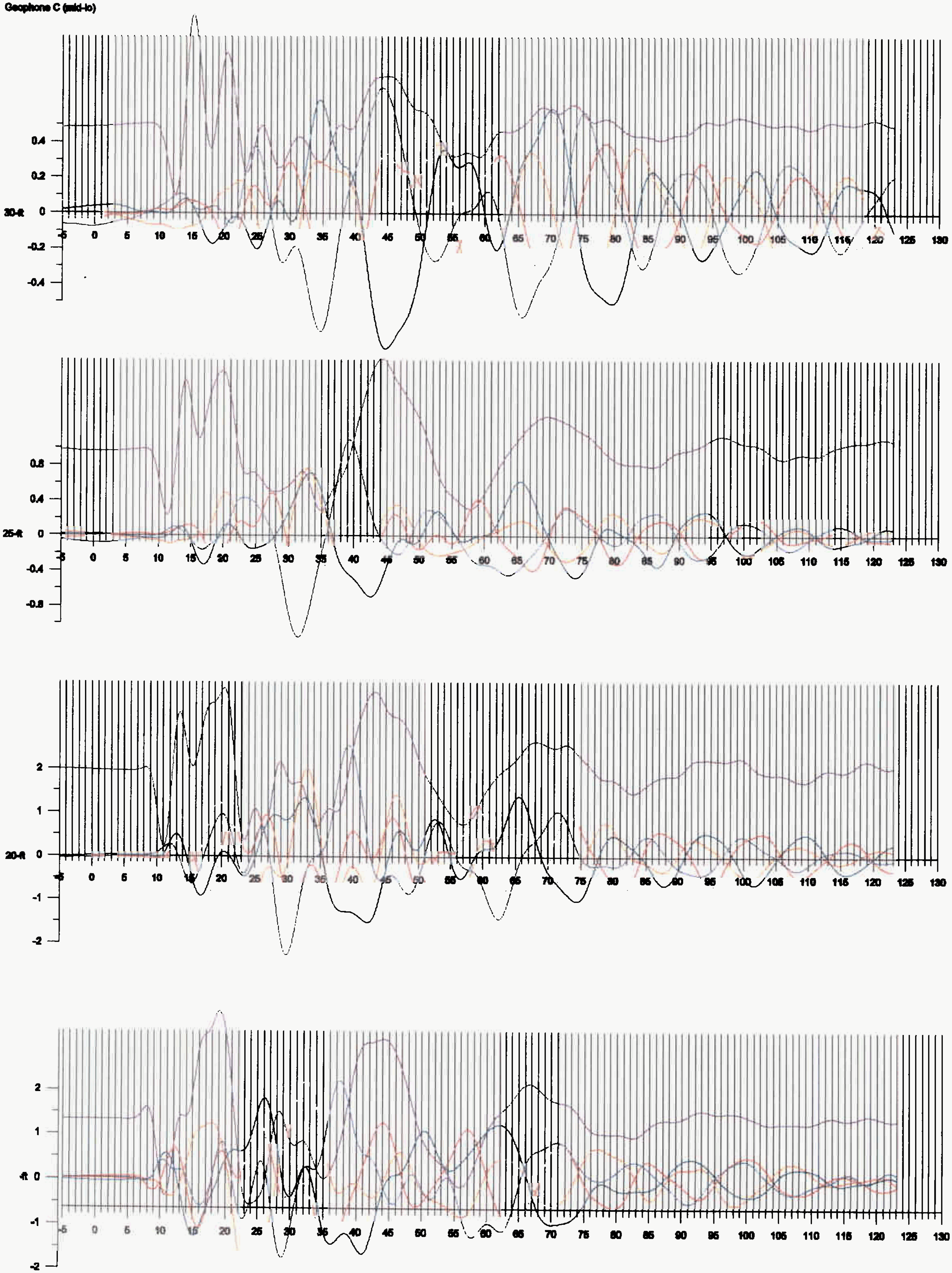


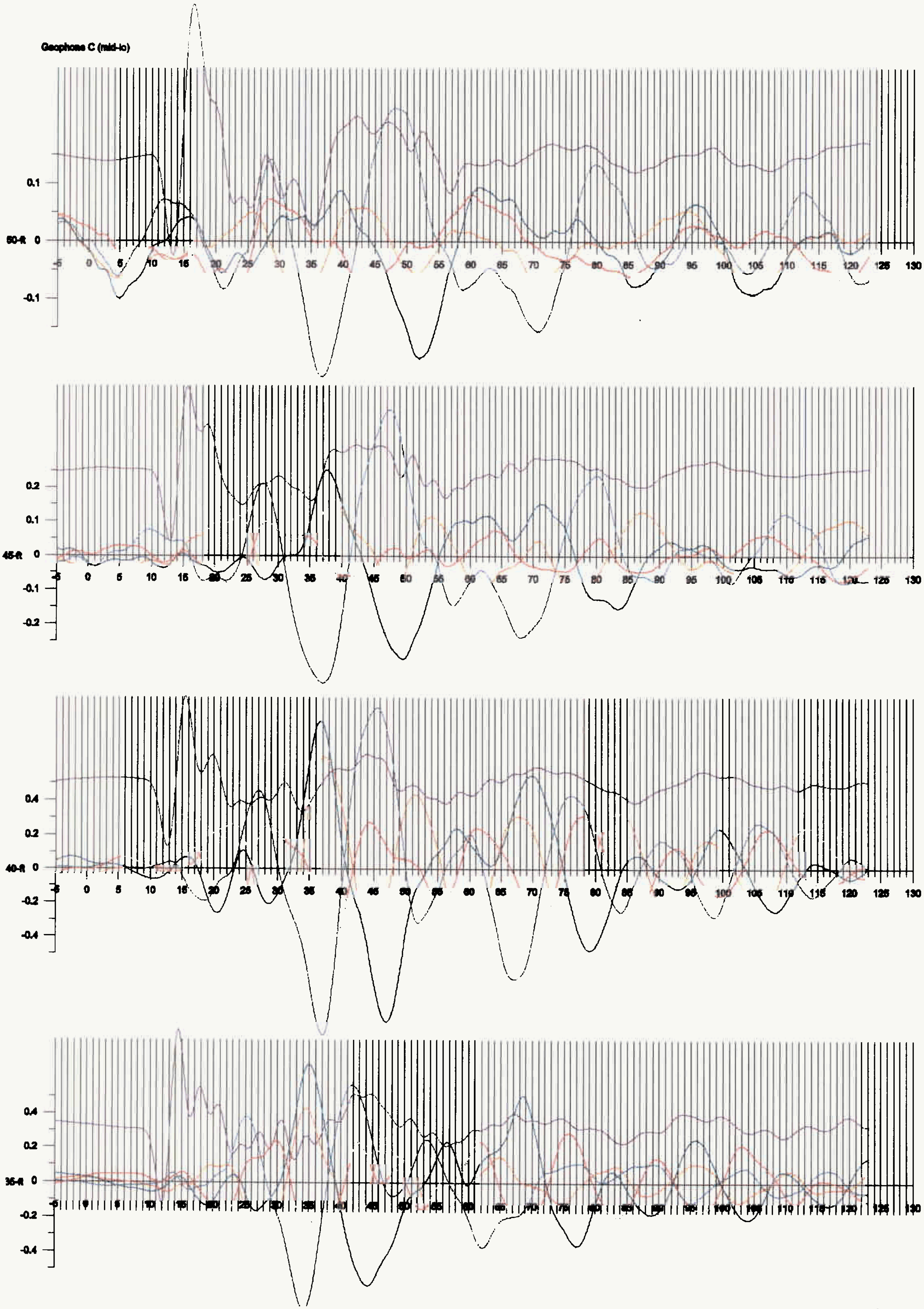


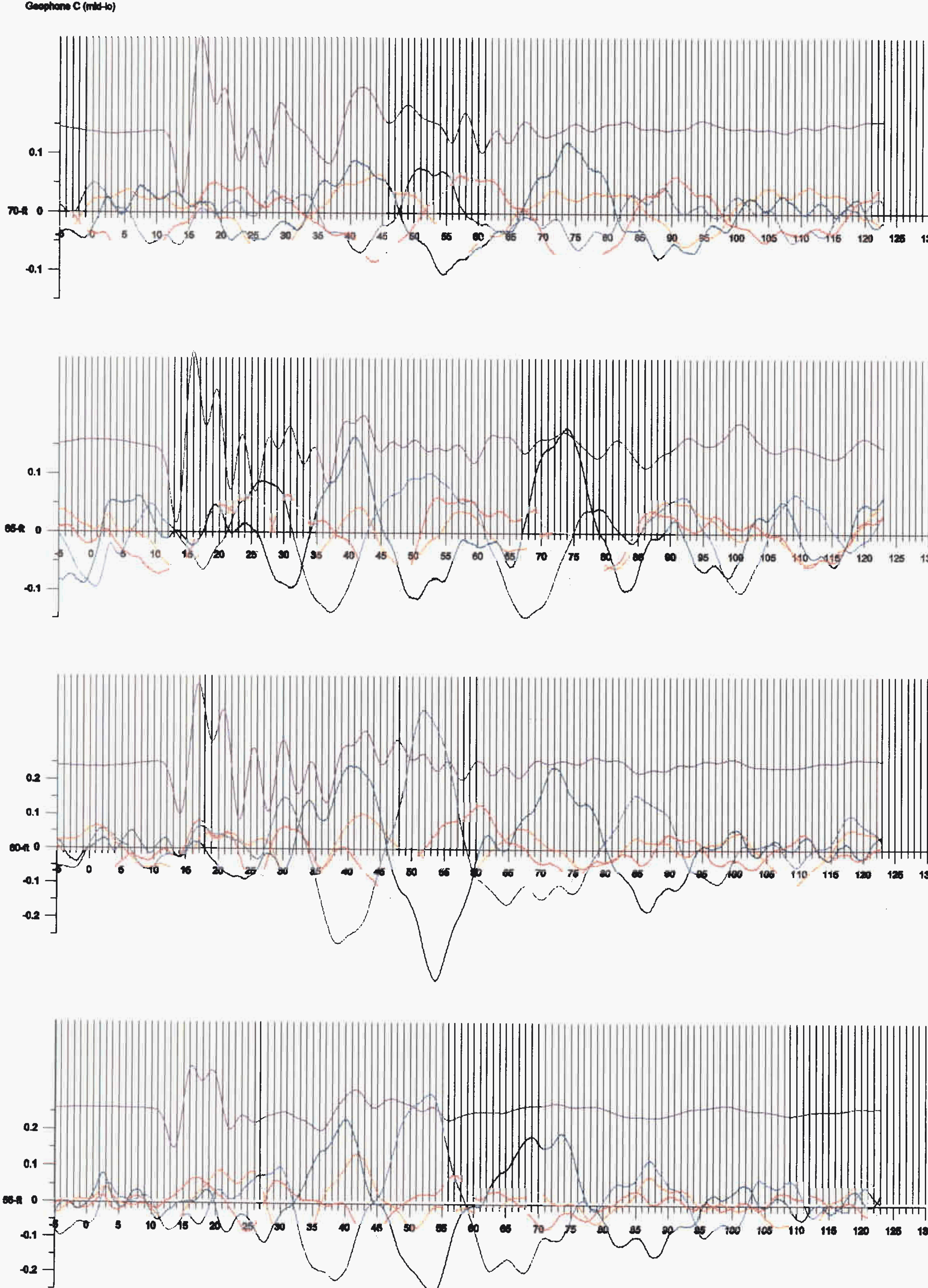
Geophone B (mid hi)

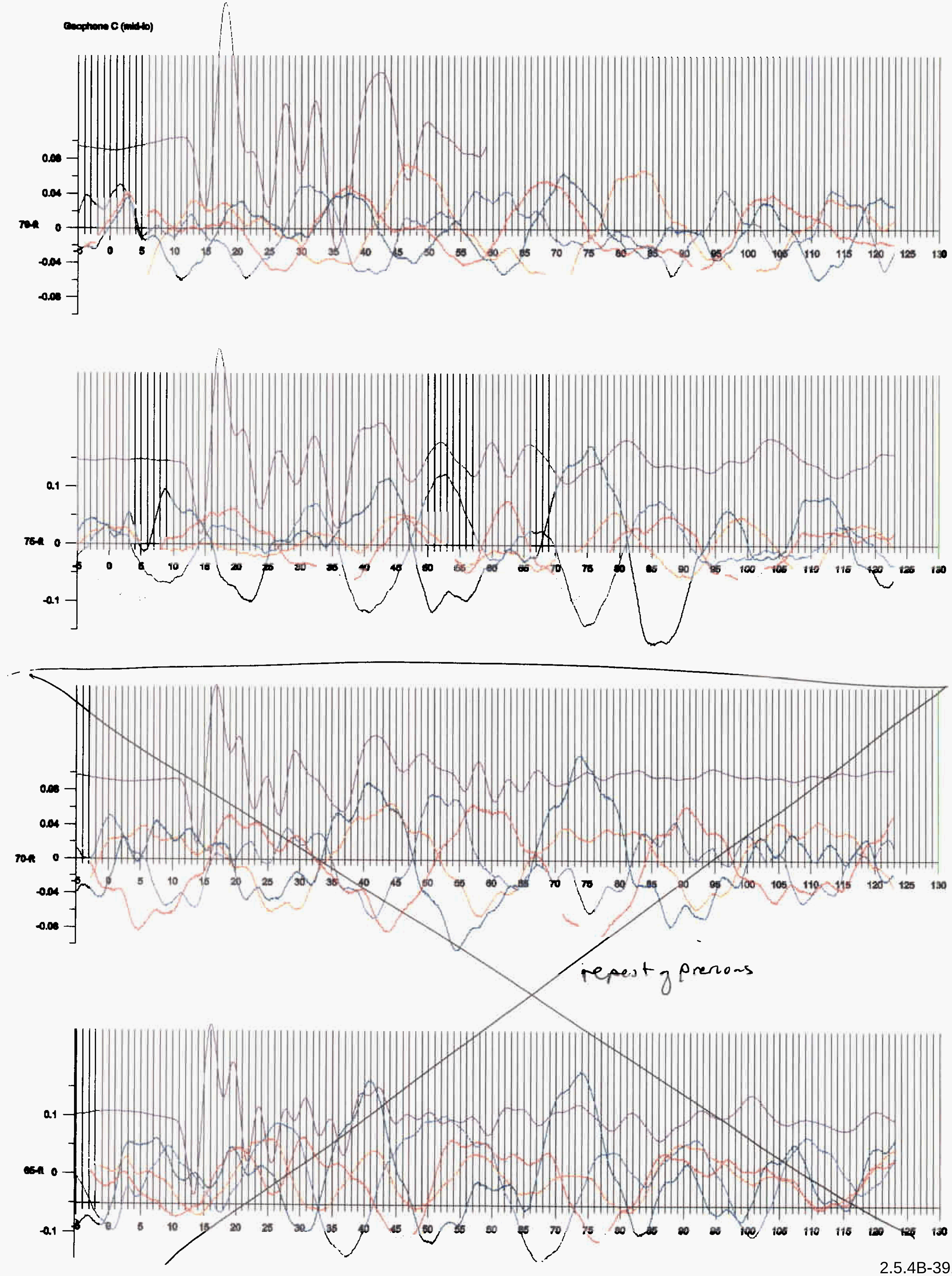


Geophone C (mid-lo)

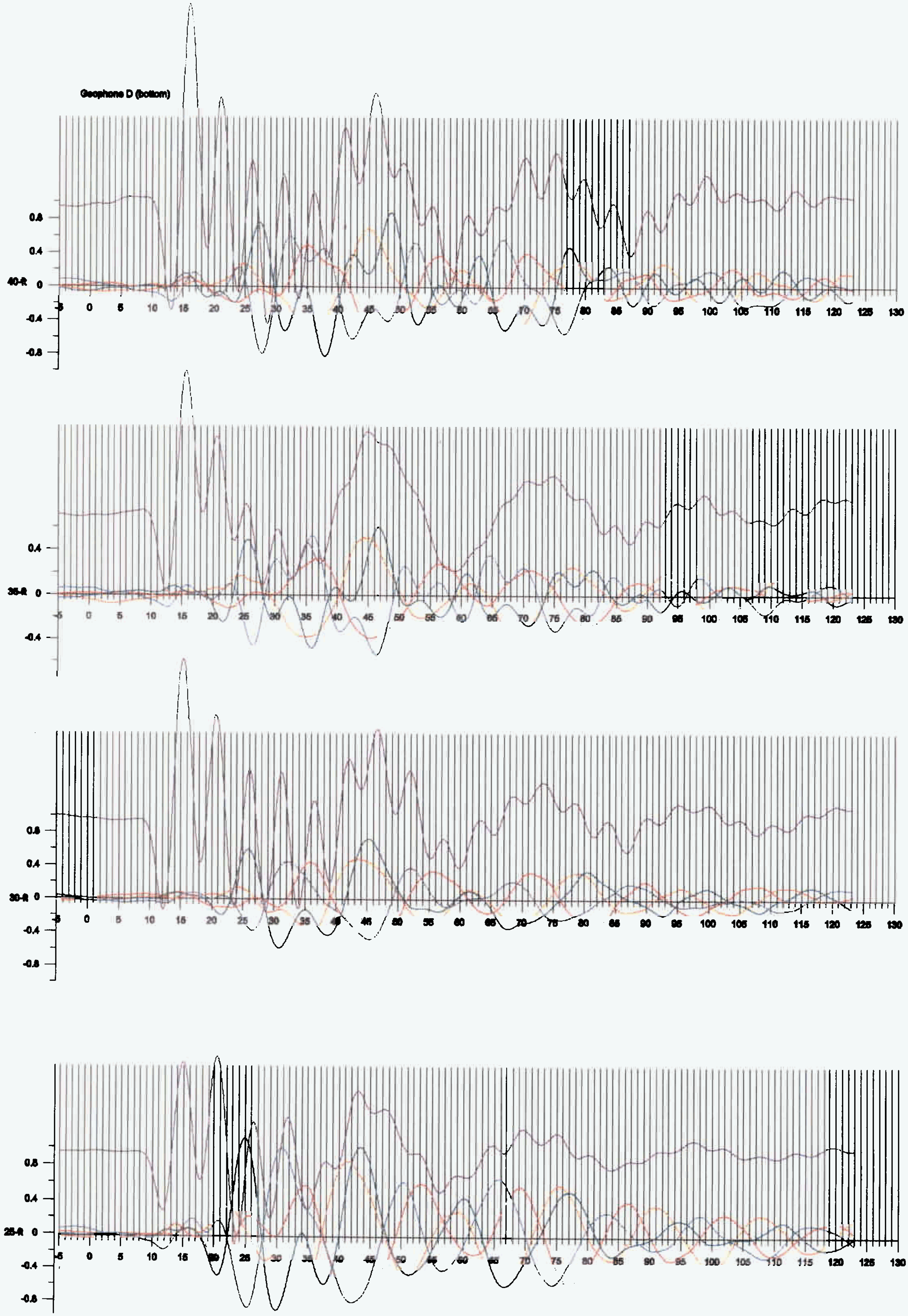



Geophone C (mid-ic)
50-ft
45-ft
40-ft
35-ft

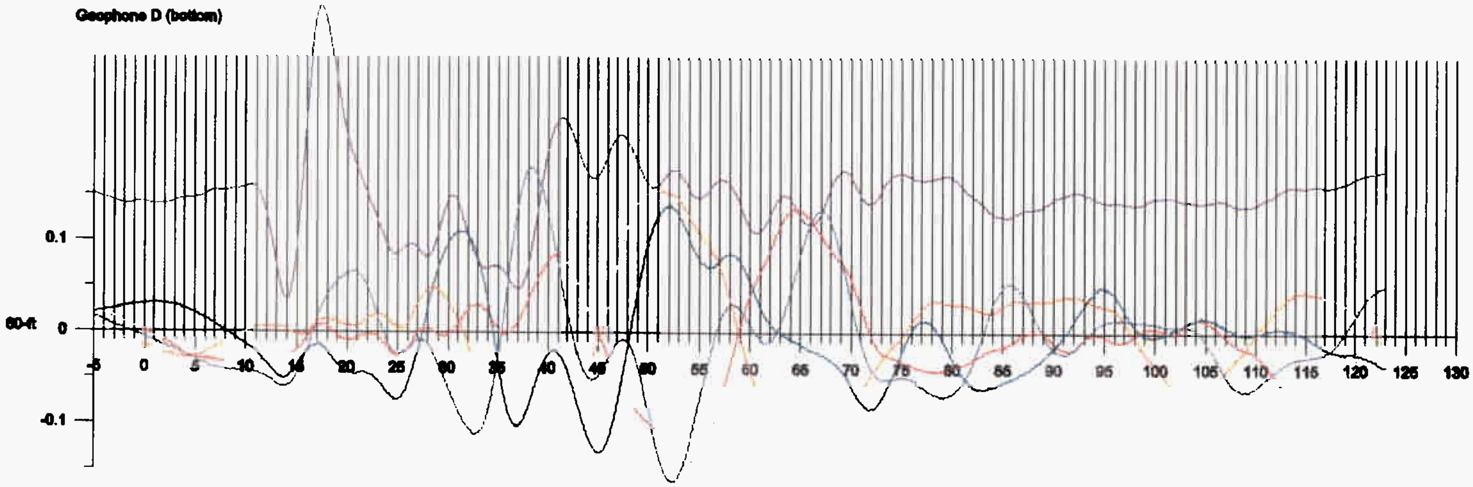

Geophone C (mid-lo)
70-ft
65-ft
60-ft
55-ft

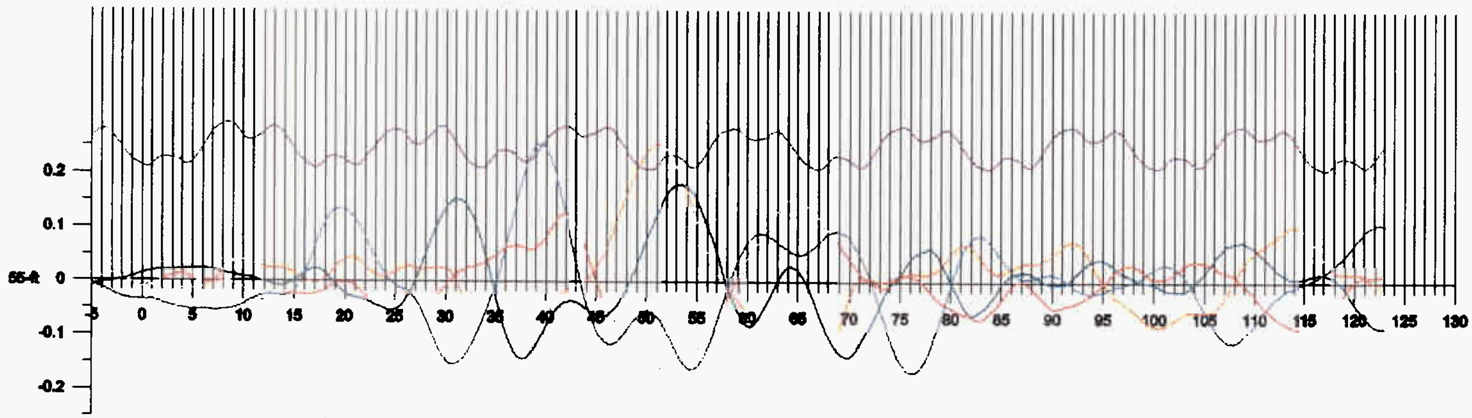


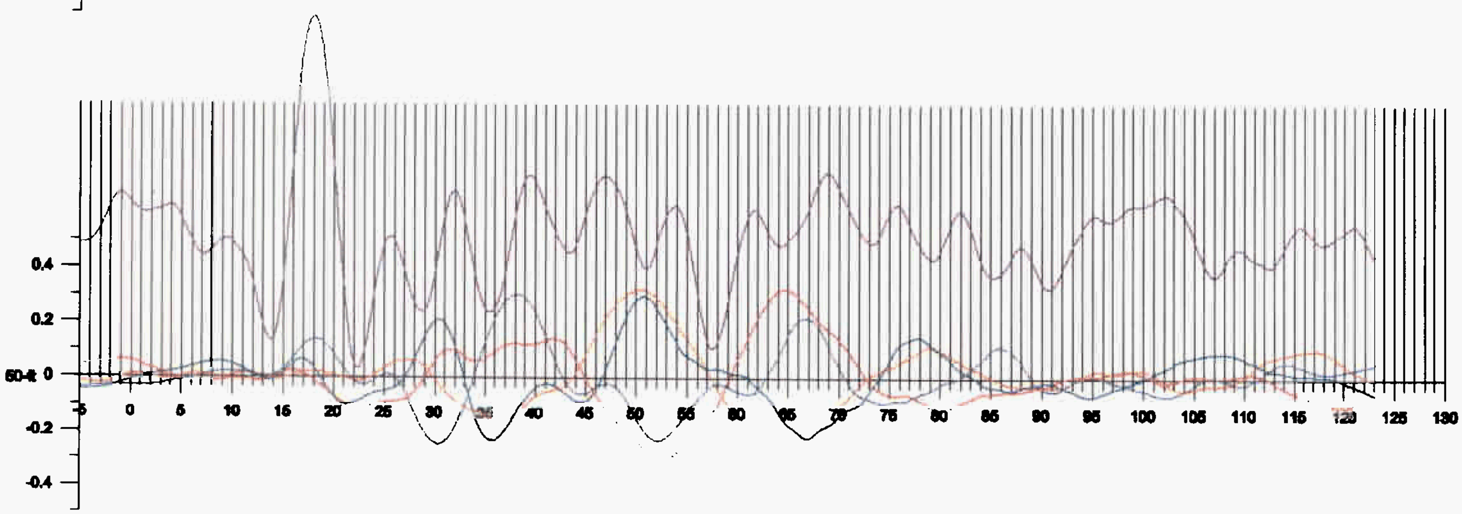
Geophone C (mid-lo)
75-ft
70-ft
65-ft
repeat of previous

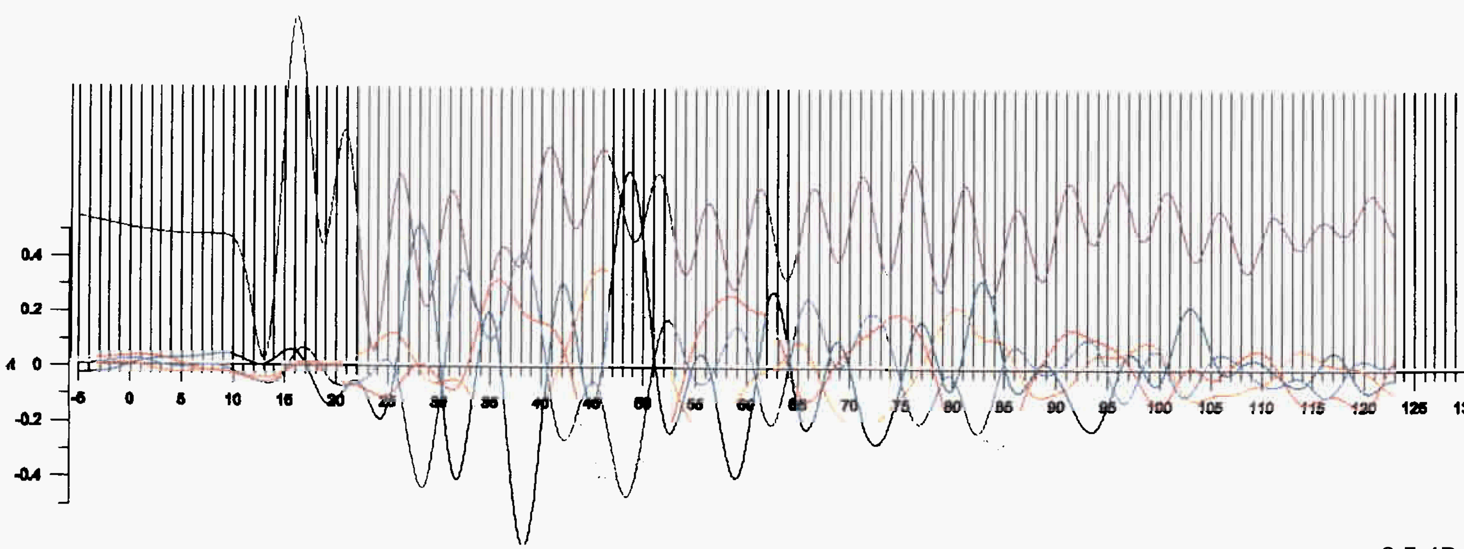

Geophone D (bottom)
40-ft
35-ft
30-ft
25-ft

Geophone D (bottom)

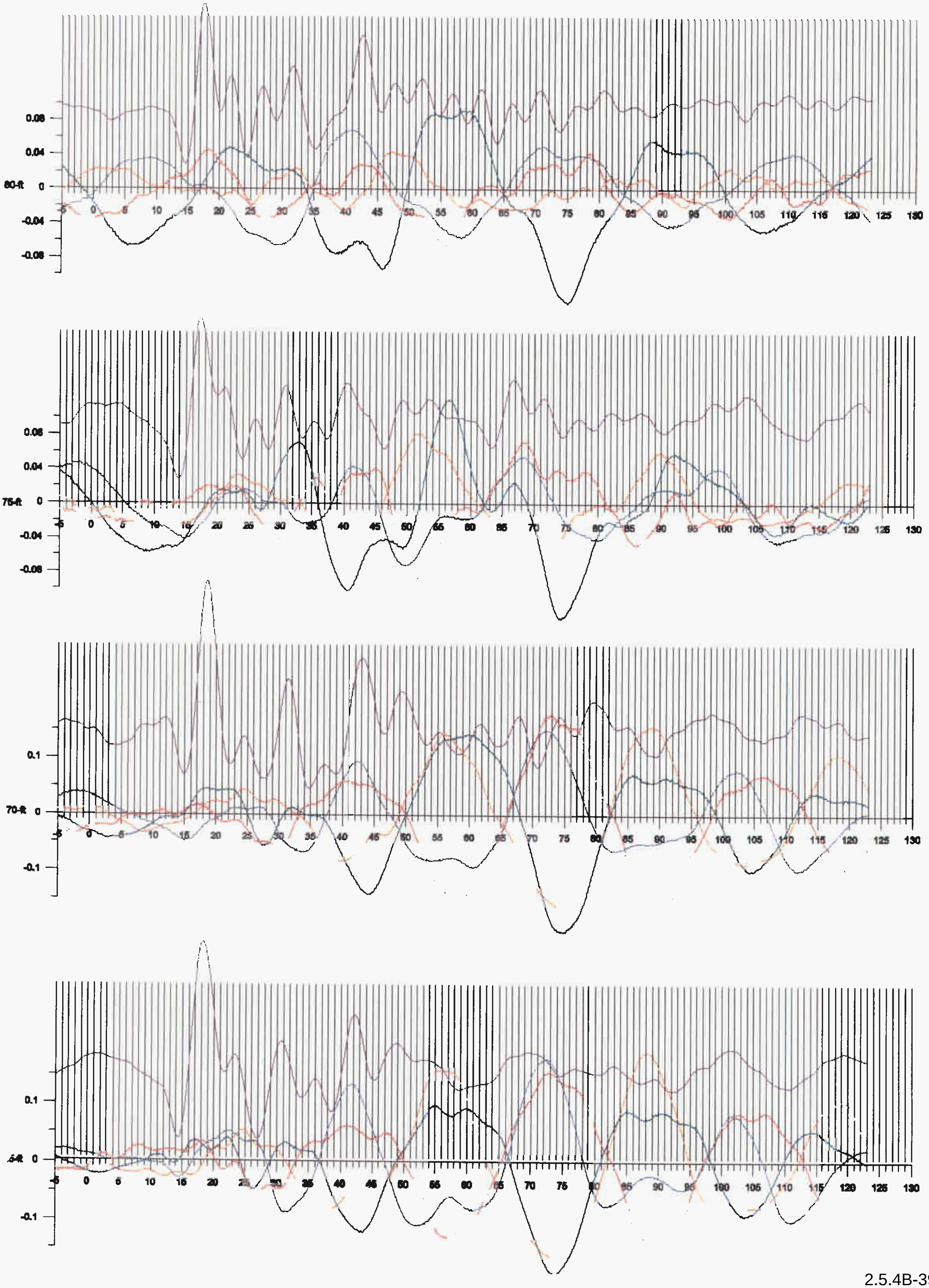




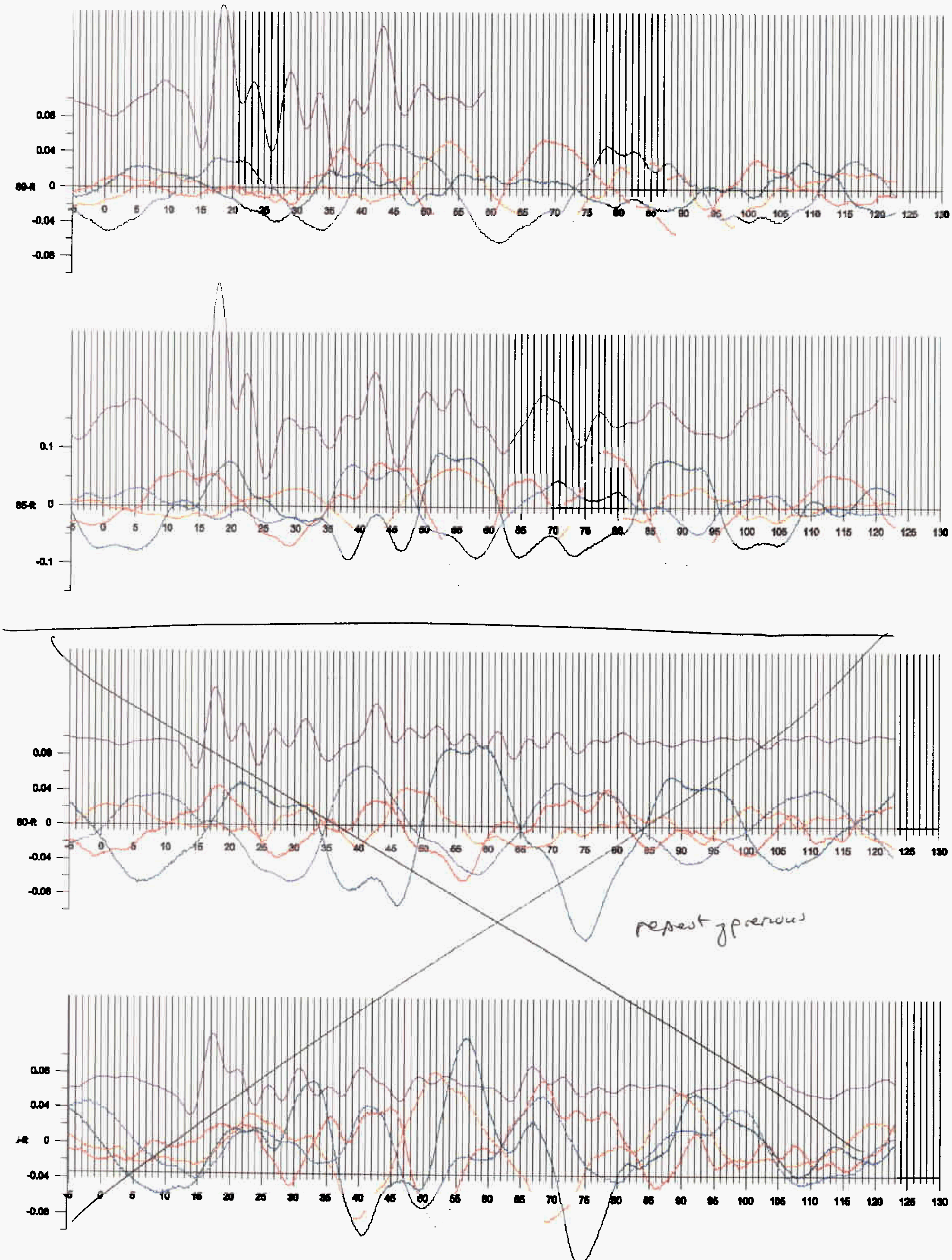




Geophone D (bottom)



Geophone D (bottom)



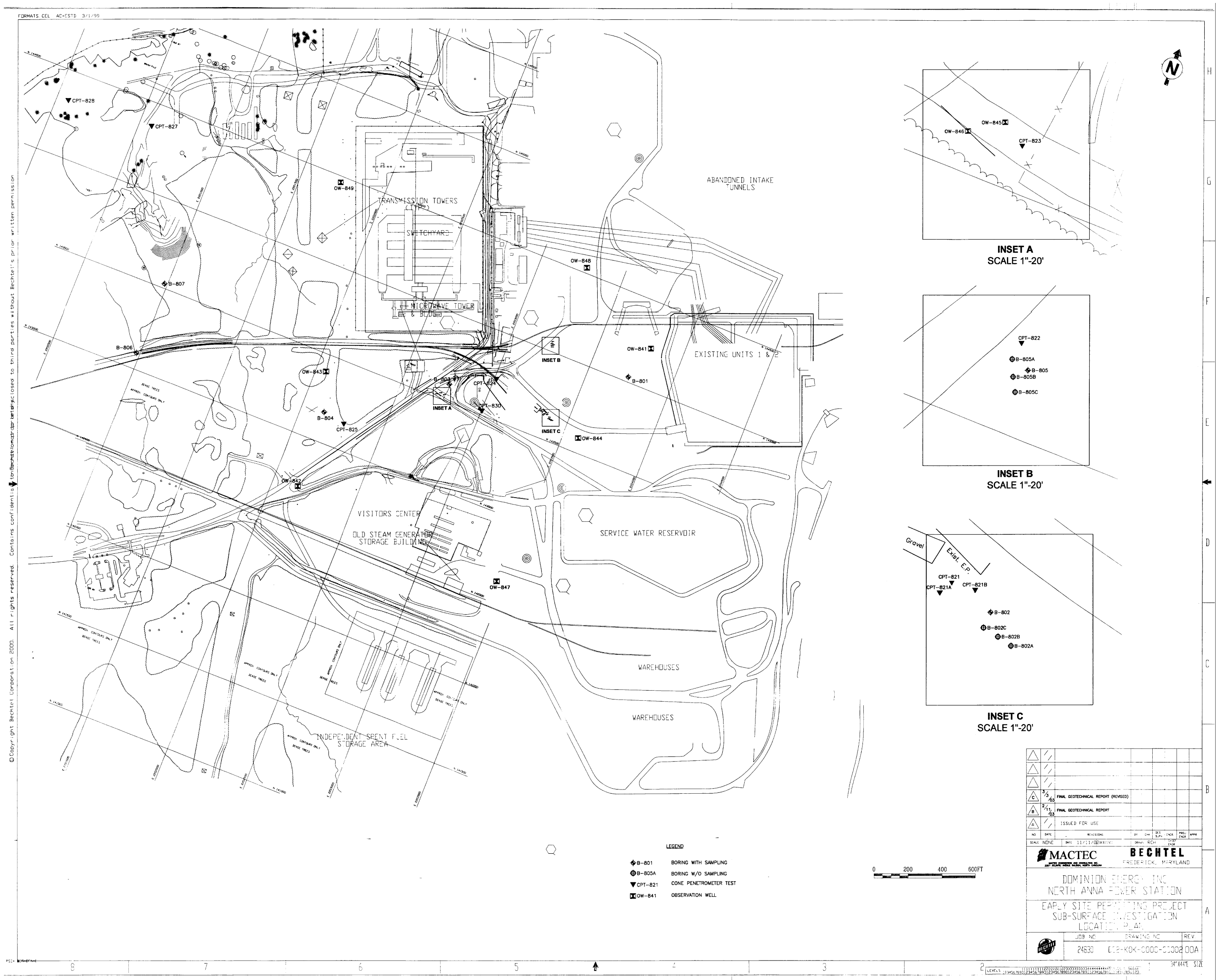


Figure 2.5-4B-1 Sub-Surface Investigation Location Plan