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REPORT OF FINDINGS AND RECOMMENDATIONS LIGHT NON-AQUEOUS PHASE LIQUID PLUME DELINEATION RECOVERY WELL PLACEMENT NS NORFOLK VA

10/20/1994

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

GROUNDWATER
TECHNOLOGY
GOVERNMENT SERVICES

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REPORT OF FINDINGS AND RECOMMENDATIONS

LIGHT NON-AQUEOUS PHASE LIQUID PLUME DELINEATION RECOVERY WELL PLACEMENT

PIERS 2-12 AND 20-25, NAVAL BASE NORFOLK, VIRGINIA

NEESA RAC NO: N47408-92-D-3044
DELIVERY ORDER NO. 0037

October 20, 1994

Prepared for:
John Wollenburg
NFESC Code 112E4
1000 23rd Street
Port Hueneme, California 93043-4201

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES, INC.
Prepared by:

William L. Hughes
Lead Geologist

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES, INC.
Reviewed by:

William L. Hughes for
Paul Farrington, P.E.
Project Manager

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October 20, 1994

Mr. John Wollenburg
NFESC Code 112E4
1000 23rd Street
Port Hueneme, CA 93043-4201

830012037.031

RE: Report of Findings and Recommendations from a Light Non-Aqueous Phase Liquid Plume Delineation, Recovery Well Placement, Piers 2-12 and 20-25, Naval Base, Norfolk, Virginia, NEESA RAC No. N47408-92-D-3044, Delivery Order 0037

Dear Mr. Wollenburg:

Groundwater Technology Government Services, Inc. (GSI) has been contracted by the government to implement a Corrective Action Plan for the recovery of light non-aqueous phase liquid (LNAPL) at the above referenced site. Pursuant to earlier discussions, a modification to the delivery order was approved for the determination of the delineation of the LNAPL plume or plumes at the site and for determination of the optimal locations for the proposed recovery wells. Enclosed is a report covering the results of field activities and groundwater modeling conducted at the site. We look forward to a discussion of the findings and recommendations in this report during our meeting in Norfolk, Virginia, on October 27, 1994.

If you should have any questions, please do not hesitate to call William Hughes at (804) 436-7881 or myself at (617) 769-7600.

Respectfully,

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES, INC.

William L. Hughes for

Paul Farrington, P.E.
Project Manager

William L. Hughes

William L. Hughes
Lead Geologist

Enclosures: Report

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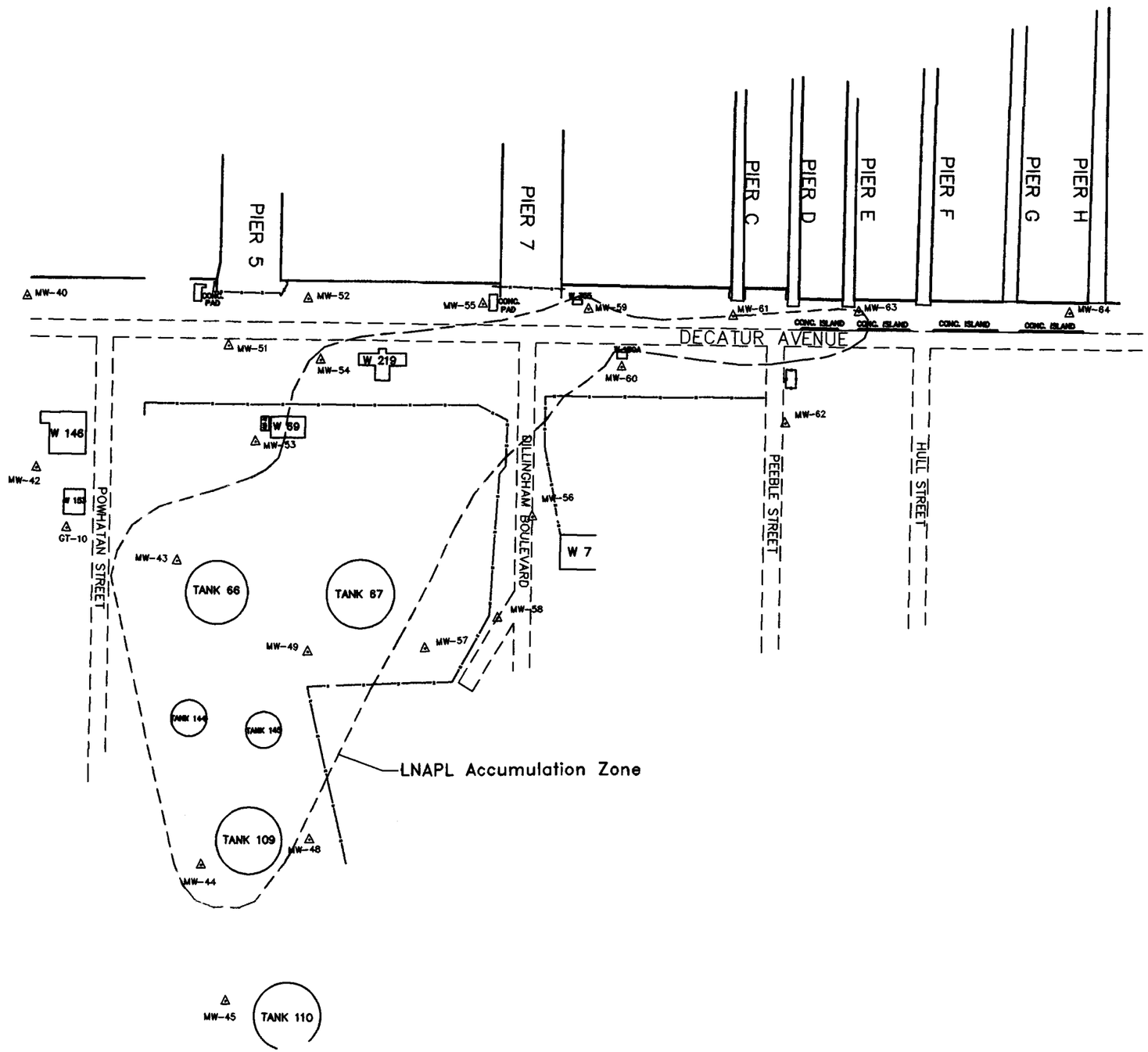
1.0 INTRODUCTION

Groundwater Technology Government Services, Inc. (GSI) has been contracted by the government to implement a Corrective Action Plan for the recovery of light non-aqueous phase liquid (LNAPL) at Piers 2 through 12 and 20 through 25, Norfolk Naval Base, Norfolk, Virginia. Pursuant to earlier discussions, a modification to the delivery order was approved for the determination of the delineation of the LNAPL plume or plumes at the site and for determination of the optimal locations for the proposed recovery wells. These determinations would be based on groundwater modeling of various scenarios and a geophysical survey of part of the site (Figure 1).

During meetings with representatives of the Navy, it was reported that abandoned bulkheads are present beneath the site. The bulkheads may have an affect on the distribution and migration of the LNAPL and constitute a barrier between the proposed recovery wells and the LNAPL plume. It was also determined that none of the monitoring wells installed during the site assessment were surveyed with respect to a vertical datum. Therefore liquid-level measurements collected from the monitoring wells could not be used in any groundwater modeling until a common datum was established.

Our efforts related to determining the plume location and optimal recovery well locations included:

- Drilling and installation of six (6) monitoring wells in the vicinity of Piers 21 and 22 and four (4) monitoring wells in the vicinity of Piers 2 through 4;
- Collection of soil samples for laboratory analysis of petroleum hydrocarbons;
- Collection of liquid-level measurements from all of the monitoring wells at the site;
- Surveying monitoring wells to tie them to a single vertical datum;
- Conducting rising-head permeability tests in ten monitoring wells;
- Performing hydrogeologic modeling of the groundwater at the site using the above data to evaluate the proposed location of the interceptor trench and recovery wells; and
- Conducting a geophysical survey using vertical induction profiling of the area located between the tank farm and Piers 6 and 7 on the north side of the site to ascertain plume limits;
- Disposal of soil cuttings generated during soil boring activities and treatment and discharge of water generated during well development and groundwater sampling.



LEGEND

△ MONITORING WELL

N

0 200 400

SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG1
PROJECT MGR. PF	SITE AREA AND LNAPL ACCUMULATION ZONE	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 1

2.0 INVESTIGATIVE METHODS

2.1 Rising Head Permeability Tests

On July 12 and 13, 1994, rising-head permeability tests were performed in monitoring wells MW-7, MW-32, MW-14, MW-39, MW-42 MW-51, MW-52, MW-53, MW-57 and MW-64 to evaluate the hydraulic characteristics of the water table aquifer (Figure 1). A rising-head permeability test involves the rapid removal of a volume (slug) of water from a well to lower the level of the water table below that of measured at static conditions. The rate at which the water level returns to static conditions is then observed by periodically measuring the water level in the test well and recording the elapsed time since the removal of the slug. The measured rate of recovery of the water level is a function of the hydraulic conductivity of the aquifer material in the vicinity of the test well. Data was collected from each monitoring well and processed so that the hydraulic conductivity can be reported for each monitor well. The data was processed using a software package, SLUGIX, developed by Interpex Limited. SLUGIX is an inverse modeling formulation by Bouwer and Rice (1976).

2.2 Soil Boring/Monitoring Well Installation

On August 1 through 5, 1994, ten soil borings were installed to help delineate the LNAPL plume at the site. During drilling, a geologist logged soil samples and drill cuttings for soil classification. Collection of split-spoon soil samples occurred at each of the following depths: 2 to 4 feet (ft.), 4 to 6 ft., 6 to 8 ft., 10 to 12 ft., and 15 to 17 ft., below ground surface (bgs). A portion of each soil sample was scanned with an organic vapor meter (OVM) to measure volatile organic constituents in parts per million (ppm). All OVM readings were recorded on the drill logs. The soil samples collected at the water table (4 to 6 ft.) in each boring were submitted to a laboratory for analysis.

Upon completion of all of the soil borings, monitoring wells were installed to a depth of 18-feet bgs. Each well was constructed of 4.0-inch diameter Schedule 40 poly-vinyl chloride (PVC) 0.010 inch factory slot screen which extended approximately 3 feet above the static water table level. Drill cuttings were stored in labelled DOT-approved, 55-gallon drums pending classification for disposal options. To counter the effects of drilling and maximize the hydraulic connection between the well and the surrounding aquifer, each well was developed using a pump. Development water was stored in 55-gallon drums staged at three locations approved by the Naval Technical

Representative (NTR).

The top of the casing of each new and existing monitoring well was surveyed to within 0.01 foot vertical and 0.1 foot horizontal accuracy using a series of temporary benchmarks. The temporary benchmarks were tied to a U.S. Geological Survey benchmark at the Base and to horizontal mapping controls.

2.3 Groundwater Monitoring

The 41 existing and 10 newly installed monitoring wells were gauged once between August 8 and 12, 1994. Liquid-levels in the monitoring wells were measured to 0.01 foot accuracy from a permanently marked survey point on top of each well casing. This allows measured values to be directly compared to a common datum and each other. Measurements made in the field included depth to water, depth to liquid-phase hydrocarbons (if present), and thickness of liquid-phase hydrocarbons (if present).

2.4 Geophysical Survey

From August 22 through 24, 1994, vertical induction profiling (VIP) geophysical survey was conducted in the vicinity of Piers 6 and 7 and adjacent to the tank farm. The objective of the VIP survey was to locate areas in the subsurface with anomalously high electrical resistivities, indicating the potential presence of released petroleum hydrocarbons. The VIP involves placing a transmitter coil on the ground surface which generates a primary, alternating electromagnetic field. For each monitoring well within the VIP survey area, a receiver coil is configured in a slim hole probe allowing data collection from a 2-inch diameter, or greater, PVC cased hole. A profile is measured by raising a receiver coil in a nearby monitoring well at a slow rate and recording voltages induced by the primary and secondary electromagnetic fields. The signal profile at the receiver probe may be interpreted as a "relative resistivity" log of the section below the transmitter and receiver. Data was collected from monitoring wells MW-53, MW-54, and MW-60.

Changes in the resistivity may indicate the presence of hydrocarbon contaminants, salt water, buried metals, and changes in lithology, etc. In many cases, to ensure the collection of valid electromagnetic readings, the site was logged more than once to confirm that the data collected was repeatable. The effective depth "profiled" is from 1 foot above the bottom of the monitoring well, approximately 22 feet deep, to 4 feet below the ground surface.

2.5 Groundwater Modeling

Data gathered during soil boring activities, groundwater monitoring and compiled during the rising-head permeability tests were incorporated so that groundwater modeling scenarios could be performed. The model was used to depict groundwater flow in the vicinity of Piers 4, 5, and 7 and Piers C through H, and the petroleum terminal. Once the groundwater flow direction and magnitude were determined (within modeling parameters), a specific conceptual model was generated for the site. The model was used to evaluate the proposed locations for the recovery trench and subsequent recovery wells. Initial placement of the recovery trench was based on the CAP. Several scenarios were evaluated including:

- Groundwater flow under static (non-pumping) conditions;
- Groundwater flow under passive conditions with a recovery trench and inactive (non-pumping) recovery wells;
- Groundwater flow under pumping conditions with a recovery trench and five active (pumping) groundwater recovery wells;
- Groundwater flow under passive conditions, with five inactive (non-pumping) recovery wells located perpendicular to groundwater flow along the downgradient edge of the LNAPL zone, adjacent to the bulkheads;
- Groundwater flow under pumping conditions with five active (pumping) recovery wells located perpendicular to groundwater flow along the downgradient edge of the LNAPL zone, adjacent to the bulkheads; and
- Groundwater flow under pumping conditions with nine active (pumping) recovery wells located throughout the extent of the LNAPL accumulation zone.

The FLOWPATH model was used to simulate groundwater flow conditions associated with the various groundwater extraction/LNAPL recovery scenarios evaluated. FLOWPATH, developed by the Waterloo Hydrogeologic Software Group, is a numerical model capable of evaluating steady-state, two-dimensional flow in anisotropic and heterogeneous porous media. Zones of varying hydraulic conductivity (i.e., natural soils, trench backfill, etc.) and varying vertical infiltration were incorporated into the model for predictive analysis.

Using existing site specific information contained in the Corrective Action Plan (Versar, 1993) and data obtained from rising head permeability tests and monitoring well gauging events conducted by Groundwater Technology Government Services, Inc., in July and August 1994, model input parameters and assumptions were established as follows:

- Static groundwater elevations were simulated to represent the August 8 through 12, 1994 data. The influence of tidal fluctuations on groundwater levels was not incorporated in the modeling due to the fact that tidal fluctuation field data have not been collected. The tidal influence may effect the ability of a groundwater extraction system to control and collect LNAPL at the site.

- A constant head groundwater elevation boundary of five feet above sea level was initialized along the waterfront area. This was based on groundwater elevations greater than five feet recorded at monitoring wells along the waterfront adjacent to the piers.

- The hydraulic conductivities of the site soils were assigned based on the results of the July 1994 rising head permeability tests. Values input to the model ranged from 5 feet per day (ft/day) to 47.5 ft/day. For the area along the bulkhead, a hydraulic conductivity of 0.5 ft/day was established to represent a reduced flow condition in this area. This hydraulic conductivity value is one order magnitude lower than the lowest rising head permeability test value.

  For trench simulation, a hydraulic conductivity of 500 ft/day was used to represent the backfill material of the trench. This value is two orders of magnitude greater than the lowest hydraulic conductivity value determined from the on-site rising head permeability tests.

- The porosity of the natural soils was set a 0.25 with the exception of the area along the bulkhead which was initialized at 0.6 to represent the more impermeable flow conditions in this area.

- A vertical recharge component of 0.004 ft/day was initialized in the center of the tank farm area to account for the higher groundwater elevations and slight mounding of groundwater observed in this area during the groundwater gauging measurements. Vertical recharge was excluded from all other areas of the model.

- The initial saturated thickness of the site model was set at approximately 25 to 27 feet with the bottom of the modeled zone established at an elevation of 20 feet below sea level.

- Vertical extraction wells and the trench depth were set as fully penetrating the thickness of the flow zone. Due to the two dimensional nature of the flow model that was used, the vertical depth of the extraction points and trench could not be less than the vertical thickness of the flow zone.

- Due to the fact that FLOWPATH is a groundwater simulation model only, the interaction of multi-phase flow (groundwater and LNAPL) could not be evaluated. Therefore, an assumption has been made that the area of influence approximated by modeling of the various groundwater extraction systems is equal to the area of influence that would effectively control and recover the LNAPL. This is a generally accepted assumption.

2.6 Drill Cuttings and Purge Water Disposal

During the drilling of the monitoring wells, drill cuttings were stored in twenty (20) 55-gallon drums. A composite soil sample was collected from the drill cuttings and submitted to a laboratory analysis. The soils were disposed in compliance with contract, state, federal and local regulations. Prior to transport, a completed material characterization form and the soil sample analytical results were provided to the remediation contractor for acceptance of the soils. On October 14, 1994, the drums were transported with a waste manifest to a thermal remediation facility located in Chesapeake, Virginia. A copy of the completed material characterization form, composite soil sample analytical results and non-hazardous waste manifest is presented in Appendix A.

During monitoring well development and drilling equipment decontamination activities, development and decontamination water was stored in ten (10) 55-gallon drums on the site. On September 27, 1994, the water was treated using a portable carbon adsorption unit and discharged on the ground at the site in accordance with state permits.

3.0 INVESTIGATIVE RESULTS

3.1 Soil Boring

The stratigraphy directly beneath the site is characterized by interbedded sandy clay, sandy silt and clay as determined by the soil borings for monitoring well installation. Soil beds are approximately 6 inches to 6 feet thick and do not appear to be continuous across the site. Sands are various shade of grey, medium to very fine-grained and loose. A copy of the drill logs including the well construction are presented in Appendix B.

3.2 Soil Sample Analytical Results

The TPH concentration in all of the soil samples collected was less than the laboratory's 20 micrograms per kilogram (mg/kg) method detection limit with the exception of the samples collected from monitoring wells GT-4, GT-5 and GT-6. The soil samples collected from monitoring wells GT-4, GT-5 and GT-6 were 29 mg/kg, 12,000 mg/kg and 29 mg/kg, respectively. A summary of the soil sample analytical results is presented in Table 1 and a copy of the analytical report is presented in Appendix C.

TABLE 1
SUMMARY OF SOIL SAMPLE ANALYTICAL RESULTS

Monitoring Well	Depth (ft)	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Xylenes (mg/kg)	TPH (mg/kg)
GT-1	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-2	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-3	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-4	4-6	<0.05	<0.10	<0.10	<0.20	29
GT-5	4-6	<0.05	<0.10	0.56	1.8	12,000
GT-6	4-6	<0.05	<0.10	<0.10	<0.20	39
GT-7	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-8	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-9	4-6	<0.05	<0.10	<0.10	<0.20	<20
GT-10	4-6	<0.05	<0.10	<0.10	<0.20	<20

TPH = Total Petroleum Hydrocarbons
mg/kg= micrograms per kilogram

3.3 Groundwater Monitoring

During the drilling of the soil borings, saturated soils were encountered at depths ranging from 5- to 8-feet. The groundwater at the site is under unconfined hydraulic conditions. Well gauging data recorded on August 8 through 12, 1994, were used to prepare a potentiometric surface map indicating that the potentiometric surface is relatively flat with a slight mounding in the vicinity of the tank farm. This mounding at the tank farm may be a result of additional vertical recharge in the tank farm due to the existence of a gravel surface cover which is more permeable than the asphalt, concrete and structural cover throughout the other areas of the site.

Light non-aqueous phase liquids (LNAPL) were detected in monitoring wells MW-11, MW-12, MW-13, MW-15, MW-37, MW-43, MW-44, MW-49, MW-54, MW-59, MW-63, and GT-5. The thickness of LNAPL ranged from 0.19 feet in monitoring well MW-37 to 3.77 feet in monitoring well MW-49 (Table 2). A copy of the liquid-level measurements collected is presented in Appendix D.

TABLE 2
SUMMARY OF LIGHT NON-AQUEOUS PHASE LIQUID MEASUREMENTS
AUGUST 8-12, 1994

MONITORING WELL	LNAPL THICKNESS (ft)
MW-11	1.15
MW-12	0.80
MW-13	1.06
MW-15	1.45
MW-37	0.19
MW-43	3.05
MW-44	0.29
MW-49	3.77
MW-54	0.98
MW-59	0.67
MW-63	0.30
GT-5	0.77

LNAPL = Light Non-Aqueous Phase Liquid

3.4 Rising-Head Permeability Tests

Based upon the modeling results using the SLUGIX software, hydraulic conductivity values at the site ranged from 1.29 feet per day (ft/dy) in monitoring well MW-32 to 47.58 ft/dy in monitoring well MW-64. The transmissivity ranged from 23.43 feet per day (ft/day) in monitoring well MW-32 to 563.77 ft/day to monitoring well MW-57. These hydraulic values are within the measured range of fine-grained sand (Freeze and Cherry, 1976). A summary of the results from the rising head permeability tests is presented in Table 3 and a copy of the results of the rising head permeability tests are presented in Appendix E.

TABLE 3
SUMMARY OF RISING-HEAD PERMEABILITY RESULTS

MONITORING WELL	HYDRAULIC CONDUCTIVITY (ft/day)	TRANSMISSIVITY (ft/day)
MW-7	6.68	126.78
MW-14	29.30	477.65
MW-32	1.29	23.43
MW-39	5.39	99.34
MW-42	6.86	58.00
MW-51	2.96	48.77
MW-52	5.06	92.88
MW-53	6.16	110.11
MW-57	23.22	563.77
MW-64	47.58	347.84

3.5 Geophysical Survey

The results of the vertical induction profiles show no indication of a relative high resistivity anomaly at the top of the water table that would be indicate the presence of LNAPL. A relatively high resistivity anomaly is present at approximately 20-feet bgs in the surveyed area. The cause of this anomaly is unknown and it is doubtful that this anomaly can be attributed to dissolved-phase petroleum hydrocarbons since floating LNAPL was not detected floating on the water table.

The results of the geophysical survey show that no resistivity decrease is apparent with an increase in depth, which would be indicative of salt water intrusion. Salt water has a lower resistivity than groundwater and its presence should increase with depth due to its greater density.

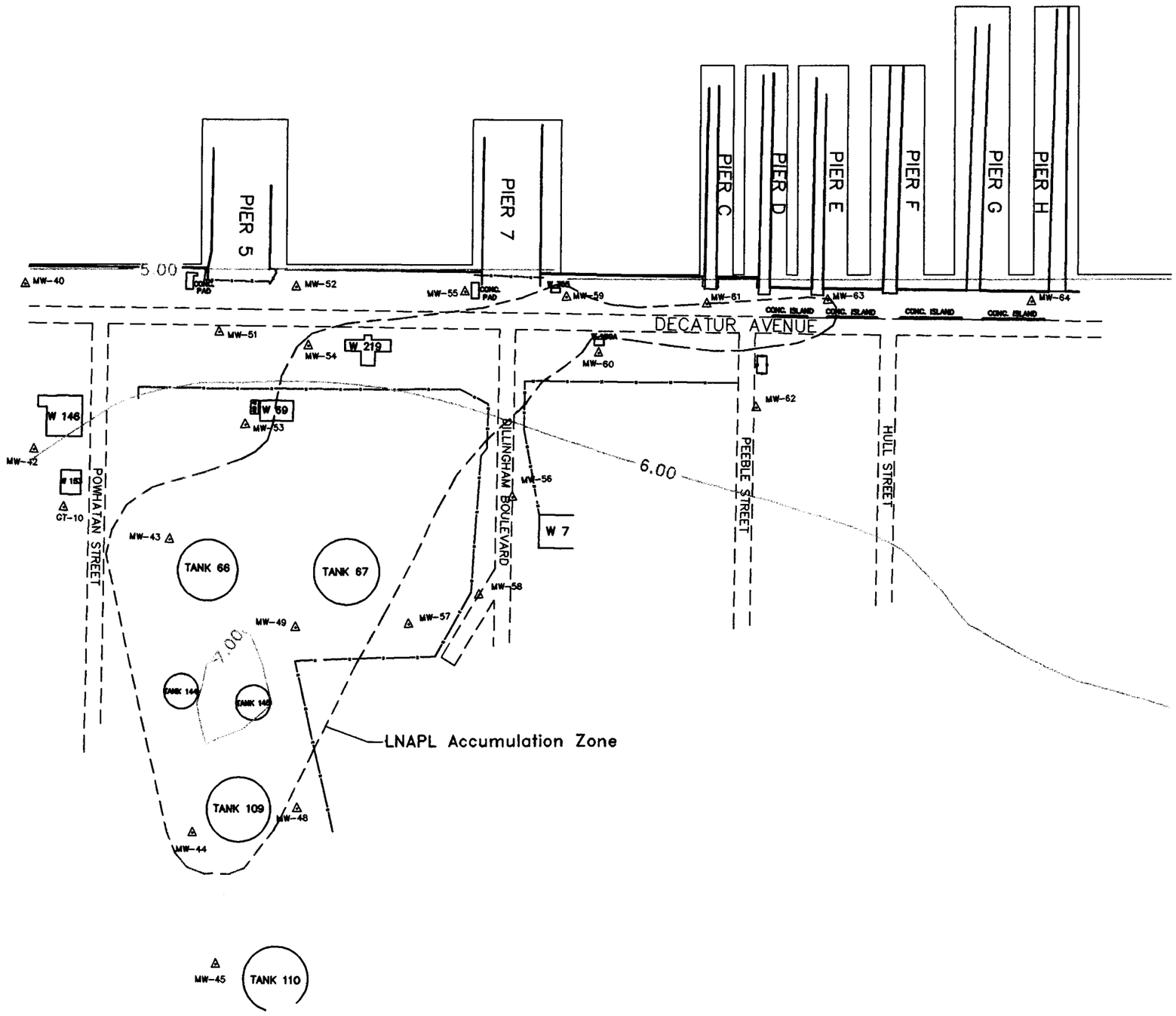
Higher relative resistivity features at depth may be an artifact of the VIP data processing algorithms, which do not compensate for the geometry of the dipolar electromagnetic field which decreases with depth in the monitoring well. Normalizing the data collected at the site with respect to the primary electromagnetic field might reduce the deep relative resistivity features, but would probably not develop any shallow anomalies corresponding to a LNAPL plume.

The LNAPL plume delineated during previous assessment activities was not identified during the geophysical survey. Liquid-level measurements collected from monitoring wells (MW-51, MW-52, MW-53, MW-54, and MW-55) located within the geophysical survey area of investigation indicate that LNAPL is present. More than one factor may be influencing the results of the geophysical survey and masking the hydrocarbon plume. A combination of salt water intrusion, reworking of the subsurface soils through the expansion of the Base or installation of subsurface utilities may have influenced the resistive properties of the subsurface at the site. A copy of the geophysical report is presented in Appendix F.

3.6 Groundwater Modeling

Several LNAPL recovery scenarios were evaluated during the modeling process, five of which are presented. Static groundwater elevations representative of the August 8 through 12, 1994, gauging event are depicted in Figure 2 as a basis of comparison. This scenario reflects no remedial action at the site. Groundwater flow was modeled under the following scenarios:

- Static (non-pumping) conditions;
- Passive conditions with a recovery trench and inactive (non-pumping) recovery wells;
- Pumping conditions with a recovery trench and five active (pumping) groundwater extraction recovery wells;
- Passive conditions, with five inactive (non-pumping) recovery wells located perpendicular to groundwater flow along the downgradient edge of the LNAPL zone, adjacent to the bulkheads;
- Pumping conditions with five active (pumping) recovery wells located perpendicular to groundwater flow along the downgradient edge of the LNAPL zone, adjacent to the bulkheads; and



LEGEND

- MONITORING WELL
- 6.00 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION

N

0 200 400

SCALE FEET

GROUNDWATER TECHNOLOGY	100 RIVER RIDGE DRIVE NORWOOD, MA 02062 (617) 769-7600	
	DRAWING DATE: 10/13/94	ACAD FILE: FIG2
PROJECT MGR. PF	MODELED STATIC GROUNDWATER HEAD ELEVATIONS REPRESENTING AUGUST 8-12, 1994 GAUGING DATA	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 2

- Pumping conditions with nine active (pumping) recovery wells located throughout the extent of the LNAPL accumulation zone.

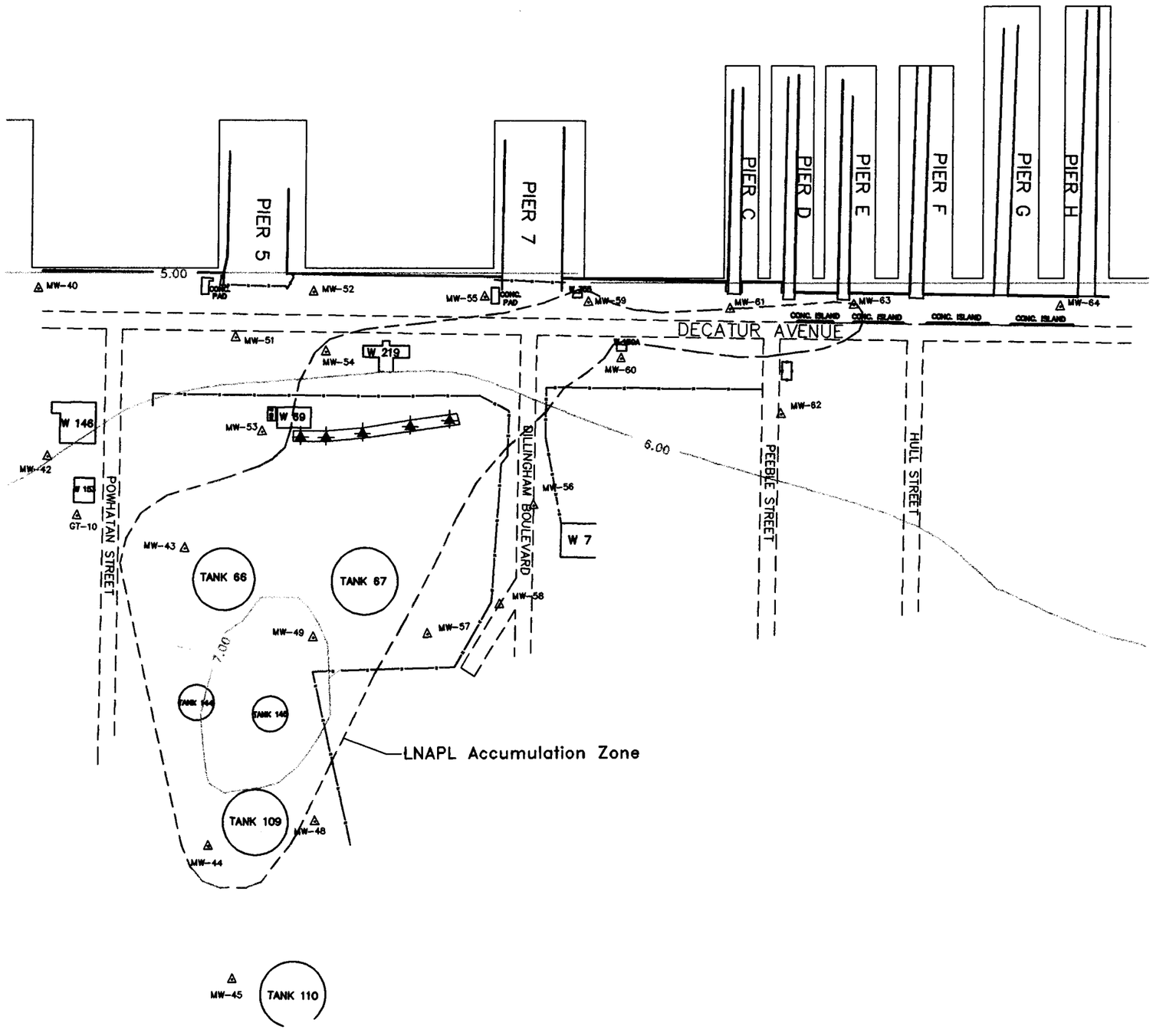
A passive trench system (i.e., no groundwater extraction to control groundwater gradients) is depicted in Figure 3. The hydraulic heads for this scenario match the static elevations as would be expected for a simulation that does not include active pumping. A passive recovery trench system would only recover LNAPL that migrates into the trench. The hydraulic gradient at the site is relatively flat, so there is no natural driving force that will assist the migration of LNAPL towards the trench. Potential LNAPL recovery would be minimal under this scenario.

Steady-state groundwater elevations for the proposed recovery trench equipped with a groundwater extraction system are shown in Figure 4. The trench is modeled as operating at a total extraction rate of 15 gallons per minute (gpm). A one-year travel time capture zone is approximated at each recovery well. The flow lines in Figure 4 show the length of the travel paths over one-year at each well assuming continuous steady-state operation. This configuration, using a recovery trench system, does not address major regions of the LNAPL plume.

Steady-state groundwater elevations for the proposed passive five well recovery system located along the downgradient LNAPL zone, adjacent to the bulkhead are depicted in Figure 5. The hydraulic heads for this scenario match the static elevations as would be expected for a simulation that does not include active pumping. The system would only recover LNAPL that happens to migrate to the wells. Potential recovery would be minimal under this scenario.

Steady-state groundwater elevations for the proposed active five well recovery system located along the downgradient edge of the LNAPL zone, adjacent to the bulkhead, as shown in Figure 6. Each well is equipped with a groundwater extraction pump and is modeled as operating at 10 gpm. A one-year travel time capture zone is approximated at each recovery well based on the modeled steady-state pumping configuration. Only a small area of the most downgradient portion of the LNAPL zone is addressed under these operational parameters as modeled.

Steady-state groundwater elevations for an active well recovery system with nine wells located throughout the LNAPL accumulation area as shown in Figure 7. The wells are modeled as operating at 2 to 5 gpm each. A one-year travel time capture zone is approximated at each recovery well based on the modeled steady-state groundwater pumping configuration. A more complete coverage of the LNAPL zone is approximated by this modeling scenario under these operational parameters.



LEGEND

- MONITORING WELL
- TRENCH WITH RECOVERY WELLS
- 6.00 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION

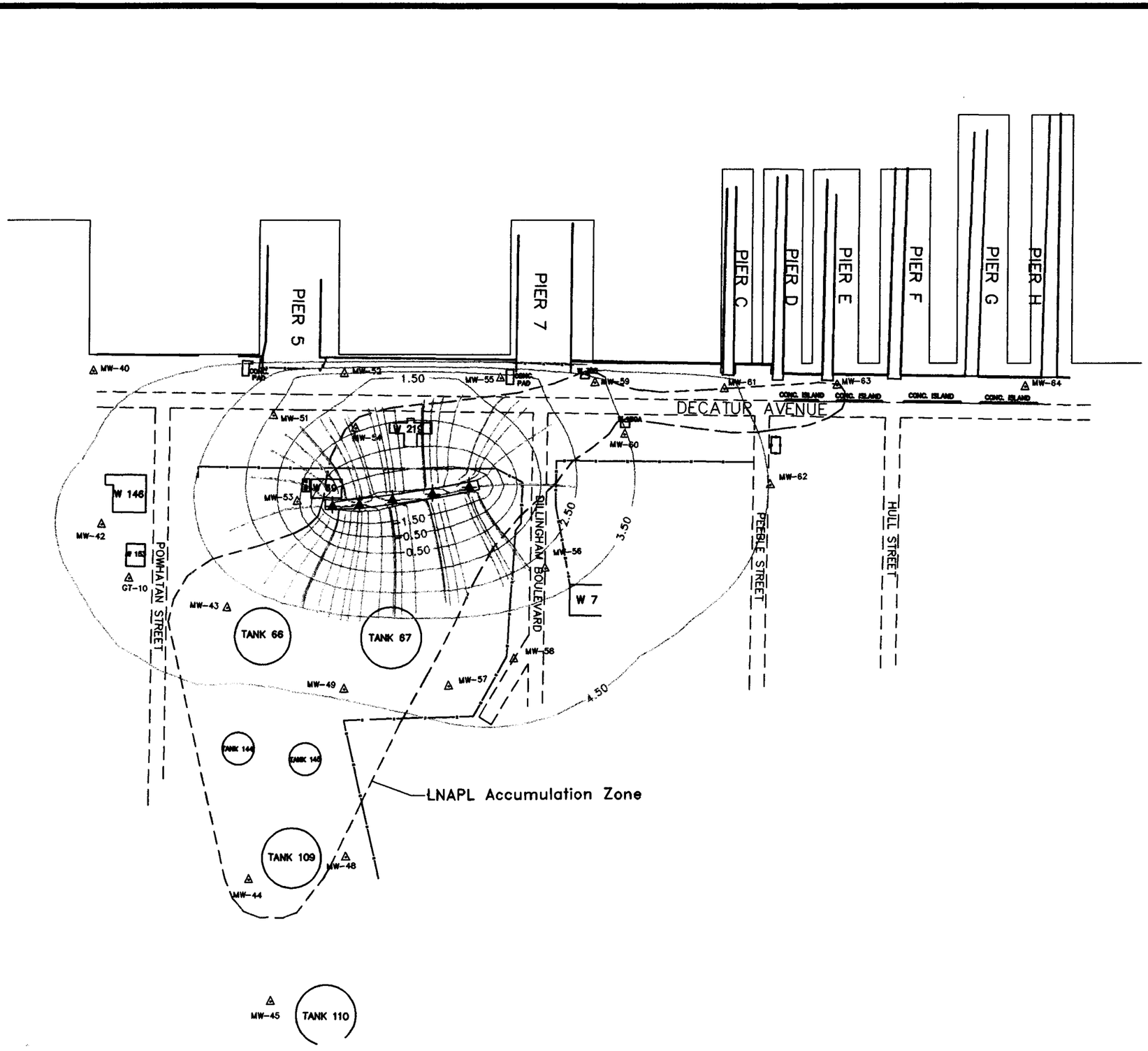
N

0 200 400

SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG3
PROJECT MGR. PF	MODELED STEADY-STATE GROUNDWATER HEAD ELEVATIONS FOR PASSIVE TRENCH SYSTEM	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 3



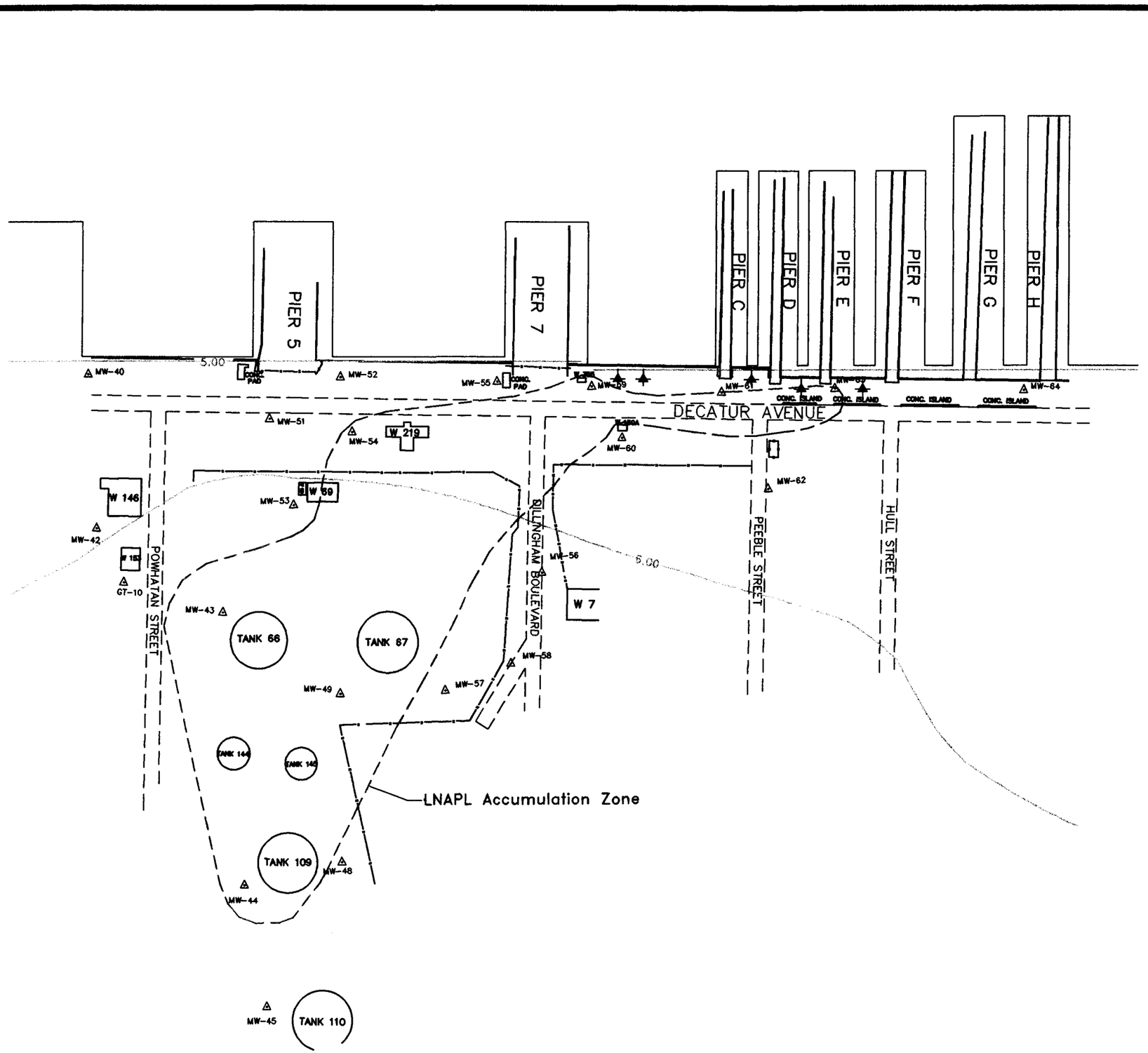
LEGEND

- MONITORING WELL
- TRENCH WITH RECOVERY WELLS
- 1.50 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION
- MODELED ONE YEAR CAPTURE ZONE FLOW LINES BASED UPON STEADY-STATE PUMPING GROUNDWATER HEAD ELEVATIONS

0 200 400
SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG4
PROJECT MGR. PF	MODELED STEADY-STATE GROUNDWATER HEAD ELEVATIONS AND ONE YEAR CAPTURE ZONE FLOW LINES FOR ACTIVE TRENCH SYSTEM	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 4



LEGEND

- MONITORING WELL
- RECOVERY WELL
- 5.00 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION

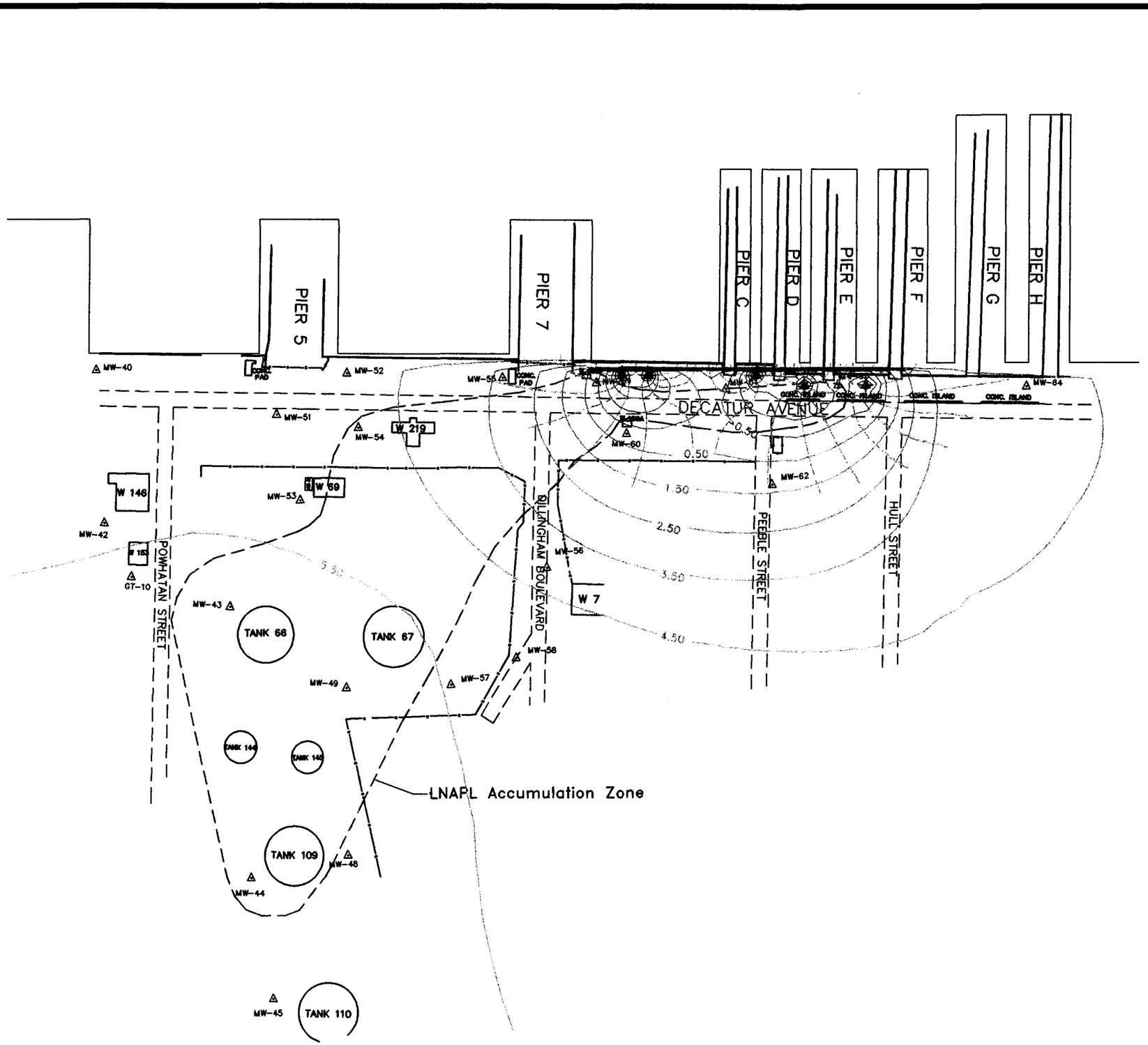
N

0 200 400

SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG5
PROJECT MGR. PF	MODELED STEADY-STATE GROUNDWATER HEAD ELEVATIONS FOR PASSIVE DOWNGRADIENT RECOVERY WELL SYSTEM	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 5



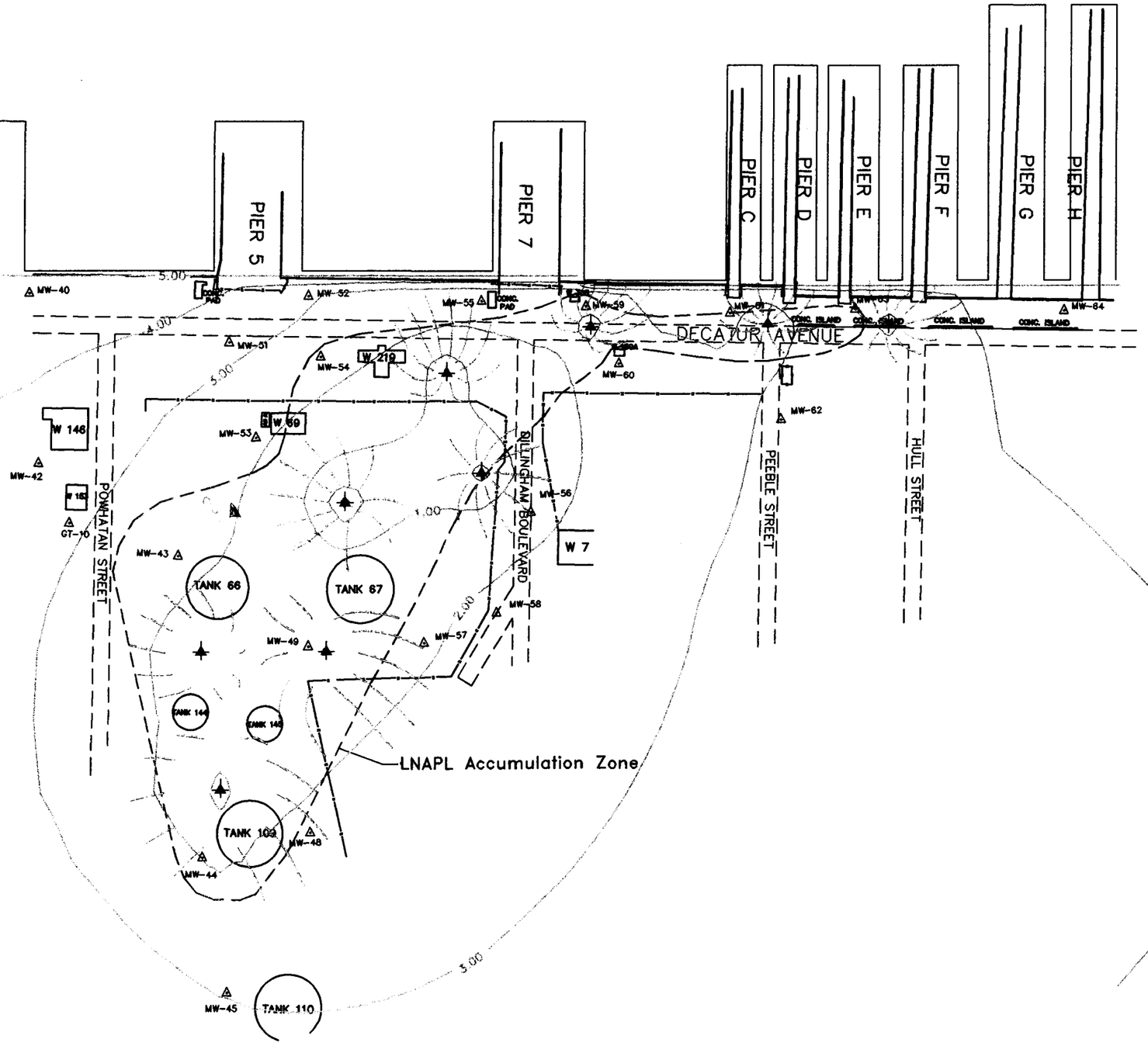
LEGEND

- MONITORING WELL
- RECOVERY WELL
- 1.50 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION
- MODELED ONE YEAR CAPTURE ZONE FLOW LINES BASED UPON STEADY-STATE PUMPING GROUNDWATER HEAD ELEVATIONS

0 200 400
SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG6
PROJECT MGR.: PF	MODELED STEADY-STATE GROUNDWATER HEAD ELEVATIONS AND ONE YEAR CAPTURE ZONE FLOW LINES FOR ACTIVE DOWNGRADIENT RECOVERY WELL SYSTEM	
PROJECT GEO.: RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 6



LEGEND

- MONITORING WELL
- RECOVERY WELL
- 2.00 — MODELED STEADY-STATE GROUNDWATER HEAD ELEVATION
- MODELED ONE YEAR CAPTURE ZONE FLOW LINES BASED UPON STEADY-STATE PUMPING GROUNDWATER HEAD ELEVATIONS

0 200 400
SCALE FEET

GROUNDWATER TECHNOLOGY
100 RIVER RIDGE DRIVE
NORWOOD, MA 02062
(617) 769-7600

	DRAWING DATE: 10/13/94	ACAD FILE: FIG7
PROJECT MGR. PF	MODELED STEADY-STATE GROUNDWATER HEAD ELEVATIONS AND ONE YEAR CAPTURE ZONE FLOW LINES FOR ACTIVE RECOVERY WELL SYSTEM LOCATED THROUGHOUT LNAPL ACCUMULATION ZONE	
PROJECT GEO. RJF	CLIENT: U.S. NAVY	PROJECT NO.: 830012037
DRAWN BY: MAT	LOCATION: NORFOLK NAVAL BASE	FIGURE NO.: 7

4.0 RECOMMENDATIONS

Based upon the results of the field activities and groundwater modeling, GSI recommends that present proposed recovery trench and recovery well locations not be used in the recovery of LNAPL at the site. The proposed recovery trench and recovery wells will not address a sufficient area of the LNAPL plume. There is no benefit associated with the installation of a recovery trench at the tank farm. The cost of a recovery trench would be higher than vertical recovery wells due to: 1) the need for shoring of the trench walls during excavation; 2) the relatively high number of subsurface utilities that will be encountered may result in disruption of service; 3) space constraints which will result in site congestion; and 4) excavated soil must be sampled, characterized and disposed.

The results of the above groundwater modeling simulations indicate that the potentially most effective and feasible groundwater extraction/LNAPL collection system is a multiple vertical well system located throughout the major zone of LNAPL accumulation. By placing the extraction wells close to the LNAPL areas, the ability to recover the LNAPL material is increased. The placement of extraction wells strategically throughout the LNAPL plume may result in lower groundwater extraction rates in some areas.

This type of strategy for recovery well placement is of particular importance due to the apparent subsurface control on LNAPL migration. As shown on each of the attached figures, the LNAPL accumulation zone appears to migrate perpendicular to groundwater flow along the downgradient bulkhead area. This may be a result of the bulkheads restricting LNAPL flow to some degree, and/or the presence of subsurface utilities and backfill that create preferred paths for migration.

The passive collection scenarios offer no benefit to LNAPL collection beyond what may migrate into the collection points (inactive/LNAPL only recovery wells) due to natural/static groundwater flow conditions. This is represented by the modeled hydraulic head configurations for these two scenarios (Figures 3 and 5) which closely match the static head configuration of Figure 2. Therefore, LNAPL collection under passive operating conditions would not achieve the objective of LNAPL recovery over the impacted area. The other two extraction scenarios evaluated (active trench with recovery wells and active downgradient recovery wells) do not appear to influence a sufficient area of the LNAPL for effective or timely collection. As shown on Figures 4 and 6, the one-year groundwater capture zones approximated from the steady-state head configurations for these scenarios, do not encompass major portions of the LNAPL accumulation zone.

Eliminating the above alternatives, the nine well collection scenario presented in Figure 7 offers the best approach to achieve LNAPL collection across the impacted area of the site based on the available data and assumptions used. The nine well collection system can provide more coverage of the irregular shaped LNAPL plume and may require a lower total rate of groundwater extraction. With a greater coverage of the LNAPL plume by the nine well system, the clean-up objectives may be attained in a shorter period of time. Recovery well separation may result in higher construction costs for connecting piping and wiring, but this may also be compensated for by elimination of the trench installation and reduced length of system operation.

The strategically place nine recovery well system offers the best approach, however, due to the lack of site specific characterization and performance data (i.e., tidal fluctuations, site specific aquifer pump testing, LNAPL recovery rates, etc.), a phased approach to final design and installation of the LNAPL collection system should be considered. Once these data are collected, a more detailed design evaluation can be conducted that would enhance the operational success of the recommended strategy of nine recovery wells located throughout the LNAPL zone. To enhance the present evaluation, an approach that can be taken would be to install one LNAPL collection recovery well, and conduct a tidal fluctuation study followed by an aquifer pumping test and LNAPL recovery test. This information can then be used to further optimize the suggested well locations and the groundwater pumping rates.

This type of phased approach could also reduce overall costs by enabling a better determination of site specific flow rates and LNAPL collection rates which, in turn, determines the design of the water treatment and LNAPL collection systems. This flow rate information is currently unavailable and is possibly resulting in overdesign of other components of the remediation system. Examples of potential overdesign include the selection of recovery well pumps; the types and size of LNAPL storage tanks; and the size of the water treatment system equipment. In addition, unsubstantiated flow rate data may impact operation and maintenance costs by ultimately requiring more frequent adjustments to equipment to compensate for engineering conservatism.

The amount of additional time necessary for conducting a phased installation approach would be approximately 4 weeks of field activities and additional groundwater modeling. This work could be performed as part of the revised project to install a groundwater and LNAPL recovery system using nine strategically placed active recovery wells.

The results of the modeling conducted indicate that vertical extraction wells located throughout the LNAPL area is the most feasible method for LNAPL recovery at the site. Therefore, the use of vertical recovery wells at the revised locations is recommended.

The phased approach to recovery well installation and additional field testing to enhance the final design and operational capability of the recommended recovery system, should also be considered.

APPENDIX A

Soil Disposal Documentation

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Northeast Region
Meadowbrook Industrial Park
Milford, NH 03055
(603) 672-4835
(603) 673-8105 (FAX)

September 9, 1994

Paul Farrington
Groundwater Technology Government
Services, Inc.
100 River Ridge Drive
Norwood, MA 02062

RE: GTEL Client ID: 830012037
Login Number: M4080675
Project ID (number): 830012037
Project ID (name): NAVAL BASE PIERS NORFOLK, VA

Dear Paul Farrington:

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 08/27/94 under Chain-of-Custody Number(s) 65637.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the State of Virginia under certification #00155.

If you have any questions regarding this analysis, or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Susan C. Uhler
Laboratory Director

GTEL Client ID: 830012037
Login Number: M4080675
Project ID (number): 830012037
Project ID (name): NAVAL BASE PIERS NORFOLK, VA

ANALYTICAL RESULTS

Volatile Organics
Method: EPA 8020
Matrix: Soil

GTEL Sample Number	M4080675-01	--	--	--	--
Client ID	COMP	--	--	--	--
Date Sampled	08/26/94	--	--	--	--
Date Analyzed	08/30/94	--	--	--	--
Dilution Factor	1.00	--	--	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Benzene	0.05	mg/kg	0.05 U	--	--	--
Toluene	0.10	mg/kg	0.10 U	--	--	--
Ethylbenzene	0.10	mg/kg	0.10 U	--	--	--
Xylenes (total)	0.20	mg/kg	0.80	--	--	--
Percent Solids	--	%	87.9			

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 8020:

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods". SW-846. Third Edition. Revision 1. US EPA July 1992. "U" indicates that the compound was analyzed for but not detected at or above the reporting limit indicated.

M4080675-01:

> 6 deg C on receipt.

Client Number: 830012037
Project ID: NAVAL BASE PIERS
NORFOLK, VA
Login Number: M4-08-0675

ANALYTICAL RESULTS

Polychlorinated Biphenyls in Soil
EPA Method 8080[a]

GTEL Sample Number		080675-01[c]	--	--	--
Client Identification		COMP	--	--	--
Date Sampled		08/26/94	--	--	--
Date Extracted		08/30/94	--	--	--
Date Analyzed		09/07/94	--	--	--
Analyte	Detection Limit, ug/kg	Concentration, ug/kg			
Aroclor-1221	40	44 U	--	--	--
Aroclor-1232	40	44 U	--	--	--
Aroclor-1242 (1016)	40	44 U	--	--	--
Aroclor-1248	40	44 U	--	--	--
Aroclor-1254	40	44 U	--	--	--
Aroclor-1260	40	44 U	--	--	--
Detection Limit Multiplier[b]		1.11	--	--	--
Percent Solids, %		87.9	--	--	--

a Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986; Extraction by EPA Method 3550 (low level sonication). Results are reported on a dry weight basis.

b The detection limit multiplier indicates the adjustments made to the data and detection limits as a result of dilutions and percent solids.

c > 6°C on receipt.

U Indicates compound was analyzed for but not detected.

Client Number: 830012037
Project ID: NAVAL BASE PIERS
NORFOLK, VA
Login Number: M4-08-0675

ANALYTICAL RESULTS

Metals in TCLP Leachate[a]

GTEL Sample Number			080675-01	--	--	--
Client Identification			COMP	--	--	--
Date Sampled			08/26/94	--	--	--
Dates Leached			08/29/94-08/30/94	--	--	--
Extraction Fluid			1	--	--	--
Date Analyzed (Method 7470)			08/31/94	--	--	--
Date Analyzed (Method 6010A)			09/01/94	--	--	--
Dilution Factor (Method 6010A)[b]			1	--	--	--
Analyte (Regulatory Level, mg/L)	Method[c]	Reporting Limit, mg/L	Concentration, mg/L			
Arsenic (5.0)	6010A	0.50	0.50 U	--	--	--
Barium (100)	6010A	1.0	1.0 U	--	--	--
Cadmium (1.0)	6010A	0.050	0.050 U	--	--	--
Chromium (5.0)	6010A	0.050	0.050 U	--	--	--
Lead (5.0)	6010A	0.50	0.50 U	--	--	--
Mercury (0.2)	7470	0.002	0.002 U	--	--	--
Selenium (1.0)	6010A	0.20	0.20 U	--	--	--
Silver (5.0)	6010A	0.050	0.050 U	--	--	--

a TCLP performed as per 40 CFR, Part 261, Appendix II - Method 1311. These data are presented in accordance with the Federal Register, 57, p. 55114, November 24, 1992.

b The dilution factor indicates the adjustments made for dilutions.

c Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 1, US EPA, July 1992. Digestion by Method 3010A for Method 6010A analytes and Method 7470 for mercury.

U Indicates compound was analyzed for but not detected.

GTEL Client ID: 830012037
Login Number: M4080675
Project ID (number): 830012037
Project ID (name): NAVAL BASE PIERS NORFOLK, VA

ANALYTICAL RESULTS

Extractable Organic Halides
Method: EPA 600/AP
Matrix: Soil

GTEL Sample Number	M4080675-01	--	--
Client ID	COMP	--	--
Date Sampled	08/26/94	--	--
Date Analyzed	08/30/94	--	--
Date Prepped	08/30/94		
Dilution Factor	1.00	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Extractable Organic Halides	70.	mg/kg	70. U	--	--	--
Percent Solids	--	%	87.9			

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 600/APPX D:

"Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79-020, USEPA EMSL, Cincinnati, OH, Revised, March 1983. "U" indicates that the compound was analyzed for but not detected at or above the reporting limit indicated.

M4080675-01:

> 6 deg C on receipt.

Client Number: 830012037
Project ID: NAVAL BASE PIERS
NORFOLK, VA
Login Number: M4-08-0675

ANALYTICAL RESULTS

Percent Moisture
EPA CLP Method[a]

Sample Identification		Date Sampled	Date Analyzed	Percent Moisture
GTEL No.	Client ID	--	--	--
080675-01	COMP	08/25/94	08/30/94	**12.1**

a EPA CLP Statement of Work, ILM 01.01, Section IV, Part F.

Client Number: 830012037
Project ID: NAVAL BASE PIERS
NORFOLK, VA
Login Number: M4-08-0675

ANALYTICAL RESULTS

Total Recoverable Petroleum Hydrocarbons In Soil
by Infrared Spectrometry
Modified EPA Method 418.1[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Percent Solids, %	Reporting Limit, mg/kg	Concentration, mg/kg
GTEL No.	Client ID	--	--	--	--	--	--
080675-01[b,c,d]	COMP	08/26/94	09/02/94	09/06/94	87.9	40	**1500**

a EPA 600/4-79-020, March 1983 revision. Extraction modified for soils (Soxhlet). Concentration calculated on a dry weight basis.
b Dilution Factor = 10.0.
c Sample anomaly. Not appropriate for evaluation. Spike diluted out. Due to Sample > spike. Supporting data LS090294-01 demonstrates accuracy.
d > 6°C on receipt.

EnviroTech

EnviroTech Mid-Atlantic
P.O. Drawer 72
108 S. Main Street
Chatham, Virginia 24531
(804) 432-1901

Mid-Atlantic

MATERIAL CHARACTERIZATION FORM

EMA NO. _____

GENERATOR IDENTIFICATION:

BUSINESS NAME COMNAVBASE CODE N4

MAILING ADDRESS 1530 GILBERT ST STE 200 CITY NORFOLK STATE VA

JOB LOCATION NAVAL BASE PIERS 21 THRU 5 CITY NORFOLK STATE VA

AUTHORIZED AGENT GARY ROPER TITLE NTR PHONE 444-3967

TYPE OF CONTAMINANT IN SOIL ☐Gasoline ☒Diesel/#2 Oil ☐Other Fuel Oil ☒Other Oil JP-5

TYPE OF PROCESS GENERATING THIS MATERIAL ☒Leaking Underground Storage Tank (POTENTIALLY) ☐Surface Spill**

MATERIAL CHARACTERIZATION: **Analysis Attached** YES

Arsenic*	<0.50 ppm	Selenium*	<0.20 ppm	Benzene**	<50 ppb
Barium*	<1.0 ppm	Silver*	<0.050 ppm	Toluene	<100 ppb
Cadmium*	<0.050 ppm	PCB	<44 ppb	Ethyl/benzene	<100 ppb
Chromium*	<0.050 ppm	Moisture	12.1 %	Total Xylenes	800 ppb
Lead*	<0.5 ppm	[redacted]	°F	TOX	<70 ppm
Mercury*	<0.002 ppm	TPH	1500 ppm		

*By TCLP method **By TCLP method if surface spill

PHYSICAL STATE: ☑Solid ☐Liquid/Slurry ☐Slurry

PACKING: ☐Bulk ☑Drums Number 20 Type 55-GALLON

BULK VOLUME: ☐Tons _____ Cubic Yards _____

REFERRAL INFORMATION:

SUBCONTRACTOR ~~BROKER~~ NAME GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES INC.

ADDRESS 1244-B EXECUTIVE BLVD SUITE 106 CITY CHESAPEAKE STATE VA

TELEPHONE (804) 436-7881

PROJ MGR ~~SALESPERSON~~ TAYLOR SWORD for PAUL FARRINGTON

AUTHORIZATION:

*If the above described soil was generated from a surface spill, I certify that the spilled material was entirely non-hazardous fuel petroleum.

Signature of Authorized Agent _____

Printed Name _____ Title _____ Date _____

The analyses above were performed on a representative sample composite of this soil collected by approved EPA methods such as those outlined in manual SW 846, chapter 9. This is a complete and accurate description of this soil and I hereby certify this material is not hazardous as defined by U.S. Department of Transportation (DOT), U.S. Environmental Protection Agency (EPA), State or local regulations.

Signature of Authorized Agent _____

Printed Name _____ Title _____ Date _____

If you have any questions, please call one of our offices.
Chatham, VA (804) 432-1901
Blacksburg, VA (703) 231-3983
Fredericksburg, VA (703) 371-7494

Please sign and return this form to Mr. Ricky Harris at the above address or fax number (804) 432-0278. Thank you.

EnviroTech Mid-Atlantic

XXXXXXXXXXXX P. O. BOX 1219
P. O. Drawer 72
108 S. Main Street
Chatham, Virginia 24531

NON HAZARDOUS SHIPPING MANIFEST

MANIFEST NO. 013706

ENSCI Environmental Inc. dba EnviroTech Mid-Atlantic

ENERATOR IDENTIFICATION:

Business Name: COMNAVBASE CODE N4
Mailing Address: 1530 GILBERT ST. SUITE 200 City/State: NORFOLK, VA
hipment Origin: NAVAL BASE PIERS 21 THRU 5 City/State: NORFOLK, VA
uthorized Agent: GARY ROFER Title:
Emergency Tel #: 804-444-3967 Type of Process Generating Material: UST
escription of Material: 10 DRUMS CONTAINING SOIL CONTAMINATED WITH DIESEL & JP5

MATERIAL CHARACTERIZATION: Analysis Attached: ON FILE **EMA Code #:** EMAC-484

. Arsenic	_____ppm	E. Silver	_____ppm	I. TPH	_____ppm
. Barium	_____ppm	F. Lead	_____ppm	J. TOX	_____ppm
C. Mercury	_____ppm	G. Selenium	_____ppm	K. PCB	_____ppm
. Chromium	_____ppm	H. Cadmium	_____ppm	L. Total BTEX	_____ppm

BULK VOLUME: Tons _____ Cubic Yards _____ Other _____

ONTAINERS: Drums No. _____ Size: 55 gal

Special Handling Instructions: NON-HAZARDOUS
ire or Spill Instructions: NON-FLAMMABLE
auler Identification: HIGGERSON-BUCHANAN, INC.
Site Destination: HIGGERSON-BUCHANAN, INC., CHESAPEAKE, VA

The materials described above were consigned to the carrier designated below. I certify the foregoing is true to the best of my knowledge.

Gary Rofer — 10.14.24
ignature of Generator or Authorized Agent — **Date Of Shipment Release**

AULER IDENTIFICATION:

Name & Address: HIGGERSON-BUCHANAN, INC. 5300 BAINBRIDGE ROAD CHESAPEAKE, VA
Telephone No: 804-545-4665 Hauler Registration No: State:
ork Order No: Tractor No: Trailer No: Tank No: Box No: Other:

I certify that the materials in quantity described above were received by me or shipment and delivered to the destination indicated below.

Date Received _____ Time: _____ AM PM — Signature of Hauler
ate Delivered _____ Time: _____ AM PM

SITE IDENTIFICATION:

ame & Address: HIGGERSON-BUCHANAN, 5300 BAINBRIDGE RD., CHESAPEAKE, VA 23327
elephone No: 804-545-4665 Site Permit No:
Work Order No: Trailer No: Driver:
uantity Measured at Site:

HANDLING PROCEDURE
Describe In Detail: UNLOAD AND STORE AT HIGGERSON-BUCHANAN STORAGE FACILITY PENDING THERMAL RECLAMATION.

INAL ON-SITE LOCATION
I certify that the material described above were received by me. I further ertify that this facility has received all permits and approval for handling his material.

EnviroTech Mid-Atlantic
~~P. O. Drawer 72~~ P. O. BOX 1219
108 S. Main Street
Chatham, Virginia 24531

NON HAZARDOUS SHIPPING MANIFEST

MANIFEST NO. 013707

ENSCI Environmental Inc. dba EnviroTech Mid-Atlantic

GENERATOR IDENTIFICATION:

Business Name: COMNAVBASE CODE N4
Mailing Address: 1530 GILBERT ST. SUITE 200 City/State: NORFOLK, VA
Shipment Origin: NAVAL BASE PIERS 21 THRU 5 City/State: NORFOLK, VA
Authorized Agent: GARY ROFER Title:
Emergency Tel #: 804-444-3967 Type of Process Generating Material: UST
Description of Material: 10 DRUMS CONTAINING SOIL CONTAMINATED WITH DIESEL & JP5

MATERIAL CHARACTERIZATION: Analysis Attached: (ON FILE) **EMA Code #:** EMAC-484

A.	Arsenic	_____ ppm	E.	Silver	_____ ppm	I.	TPH	_____ ppm
B.	Barium	_____ ppm	F.	Lead	_____ ppm	J.	TOX	_____ ppm
C.	Mercury	_____ ppm	G.	Selenium	_____ ppm	K.	PCB	_____ ppm
D.	Chromium	_____ ppm	H.	Cadmium	_____ ppm	L.	Total BTEX	_____ ppm

BULK VOLUME: Tons _____ Cubic Yards _____ Other _____

CONTAINERS: Drums No. _____ Size: 55 gal

Special Handling Instructions: NON-HAZARDOUS
Fire or Spill Instructions: NON-FLAMMABLE
Hauler Identification: HIGGERSON-BUCHANAN, INC.
Site Destination: HIGGERSON-BUCHANAN, INC., CHESAPEAKE, VA

The materials described above were consigned to the carrier designated below. I certify the foregoing is true to the best of my knowledge.

Gary S Rofer — 10-14-94
Signature of Generator or Authorized Agent **Date Of Shipment Release**

HAULER IDENTIFICATION:

Name & Address: HIGGERSON-BUCHANAN, INC. 5300 BAINBRIDGE ROAD CHESAPEAKE, VA
Telephone No: 804-545-4665 Hauler Registration No: State:
Work Order No: Tractor No: Trailer No: Tank No: Box No: Other:

I certify that the materials in quantity described above were received by me for shipment and delivered to the destination indicated below.

Richard Wright
Date Received _____ Time: _____ AM PM **Signature of Hauler**
Date Delivered _____ Time: _____ AM PM

SITE IDENTIFICATION:

Name & Address: HIGGERSON-BUCHANAN, 5300 BAINBRIDGE RD., CHESAPEAKE, VA 23327
Telephone No: 804-545-4665 Site Permit No:
Work Order No: Trailer No: Driver:
Quantity Measured at Site:

HANDLING PROCEDURE
Describe In Detail: UNLOAD AND STORE AT HIGGERSON-BUCHANAN STORAGE FACILITY PENDING THERMAL RECLAMATION.

FINAL ON-SITE LOCATION
I certify that the material described above were received by me. I further certify that this facility has received all permits and approval for handling this material.

APPENDIX B

Drill Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

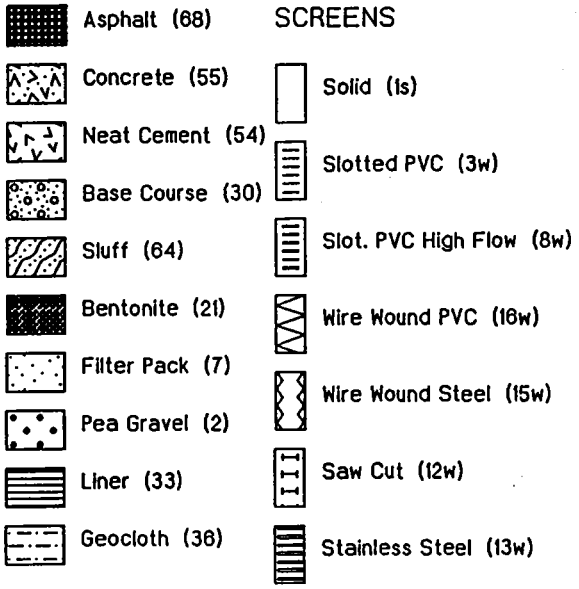
CLASSIFICATION CHART

MAJOR DIVISIONS		SYMBOLS		TYPICAL NAMES	GTGS FILL PATTERN
COARSE GRAINED SOILS OVER 50%>No.200 SIEVE SIZE	GRAVELS MORE THAN 1/2 OF COARSE FRACTION> NO.4 SIEVE SIZE	GW		Well graded gravels or gravel-sand mixtures, little or no fines	26
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines	25
		GM		Silty gravels, gravel-sand mixtures	26=11
		GC		Clayey gravels, gravel-sand-clay mixtures	26=14
	SANDS MORE THAN 1/2 OF COARSE FRACTION< NO.4 SIEVE SIZE	SW		Well graded sands or gravelly sands, little or no fines	8
		SP		Poorly graded sands or gravelly sands, little or no fines	6
		SM		Silty sands, sand-silt mixtures	9
		SC		Clayey sands, sand-clay mixtures	10
FINE GRAINED SOILS OVER 50%<No.200 SIEVE SIZE	SILTS & CLAYS LL<50	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	11
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	14
		OL		Organic silts and organic silty clays of low plasticity	18
	SILTS & CLAYS LL>50	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	12
		CH		Inorganic clays of high plasticity, fat clays	15
		OH		Organic clays of medium to high plasticity, organic silty clays, organic silts	35
HIGHLY ORGANIC SOILS		Pt		Peat and other highly organic soils	20

GRAIN SIZE CHART

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL COARSE FINE	3" to No.4 3" to 3/4" 3/4" to No.4	76.2 to 4.75 76.2 to 19.1 10.1 to 4.75
SAND COARSE MEDIUM FINE	No.4 to No.200 No.4 to No.10 No.10 to No.40 No.40 to No.200	4.75 to 0.074 4.76 to 2.00 2.00 to 0.420 0.420 to 0.074
SILT & CLAY	Below No.200	Below No.0.074

WELL CONSTRUCTION MATERIALS



SAMPLE TYPES

SS - Split Spoon
CC - Continuous Core
CG - Cuttings Grab

SYMBOLS

Initial Water Level
Static Water Level

GROUNDWATER TECHNOLOGY

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

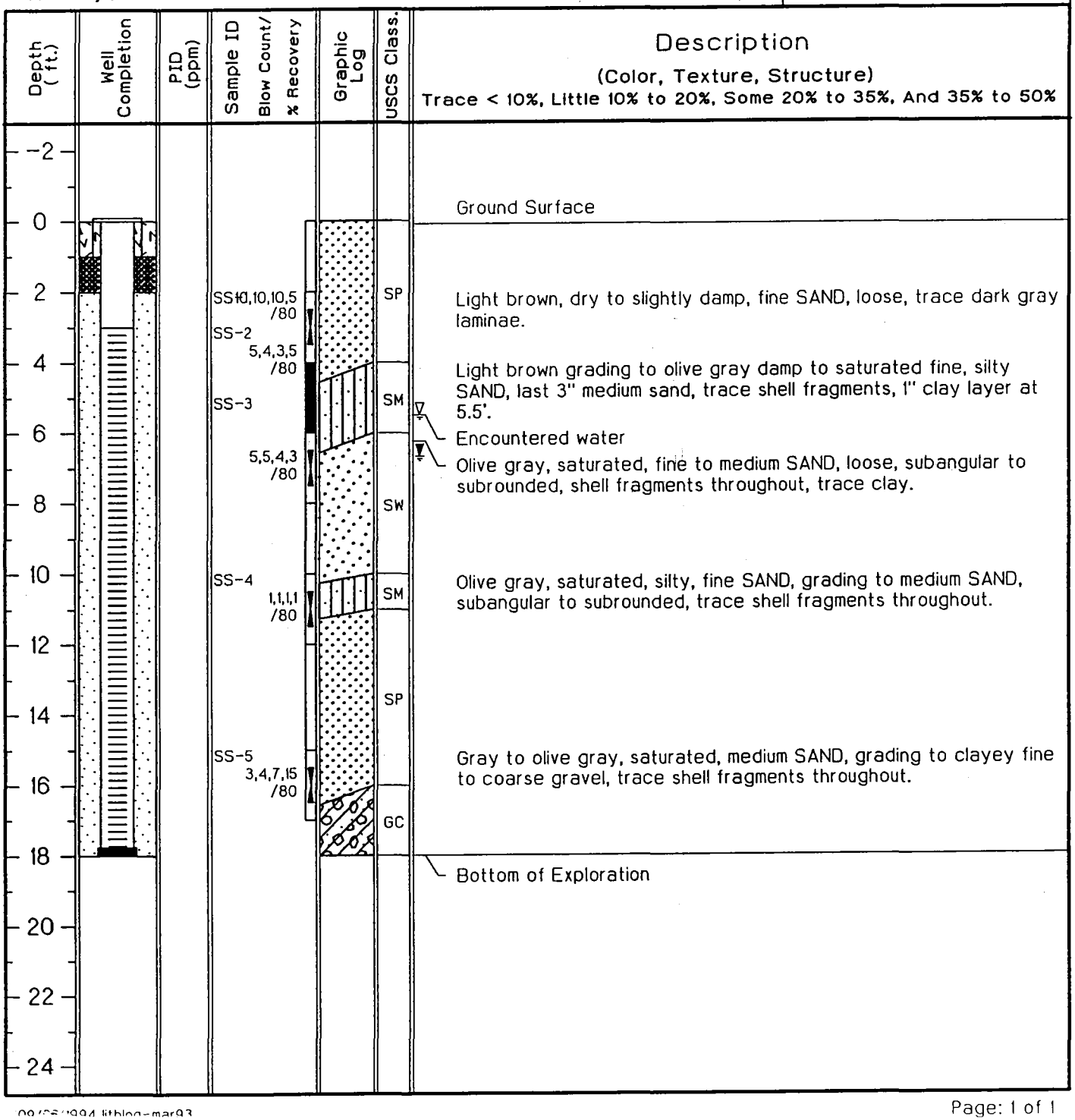
Monitoring Well GT-1

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 12.06 ft. Water Level Initial 5.5 ft. Static 6.68 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/03/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.



Description

(Color, Texture, Structure)
Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%

Ground Surface

Light brown, dry to slightly damp, fine SAND, loose, trace dark gray laminae.

Light brown grading to olive gray damp to saturated fine, silty SAND, last 3" medium sand, trace shell fragments, 1" clay layer at 5.5'.

Encountered water

Olive gray, saturated, fine to medium SAND, loose, subangular to subrounded, shell fragments throughout, trace clay.

Olive gray, saturated, silty, fine SAND, grading to medium SAND, subangular to subrounded, trace shell fragments throughout.

Gray to olive gray, saturated, medium SAND, grading to clayey fine to coarse gravel, trace shell fragments throughout.

Bottom of Exploration

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

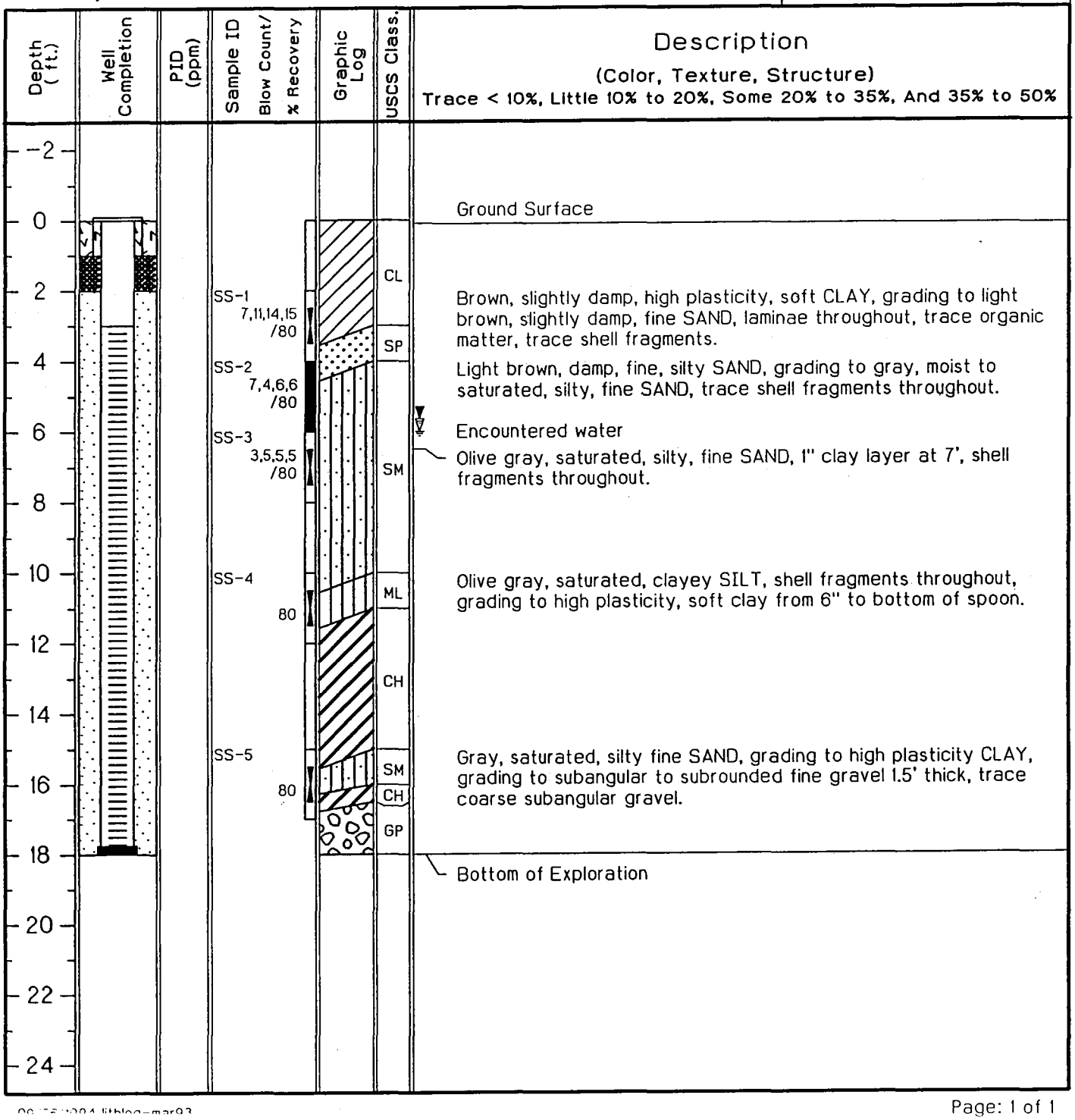
Monitoring Well GT-2

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 11.33 ft. Water Level Initial 6.0 ft. Static 5.64 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/02/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.



Description

(Color, Texture, Structure)
Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%

Ground Surface

Brown, slightly damp, high plasticity, soft CLAY, grading to light brown, slightly damp, fine SAND, laminae throughout, trace organic matter, trace shell fragments.

Light brown, damp, fine, silty SAND, grading to gray, moist to saturated, silty, fine SAND, trace shell fragments throughout.

Encountered water

Olive gray, saturated, silty, fine SAND, 1" clay layer at 7', shell fragments throughout.

Olive gray, saturated, clayey SILT, shell fragments throughout, grading to high plasticity, soft clay from 6" to bottom of spoon.

Gray, saturated, silty fine SAND, grading to high plasticity CLAY, grading to subangular to subrounded fine gravel 1.5' thick, trace coarse subangular gravel.

Bottom of Exploration

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

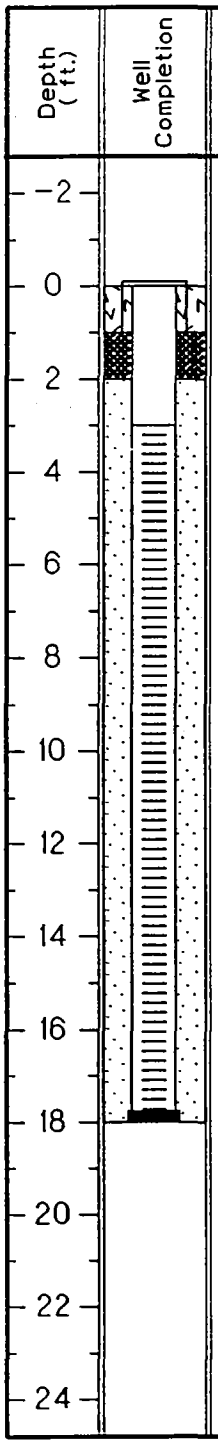
Monitoring Well GT-3

Project *Naval Base Piers NEESA RAC* Owner *US NAVY*
Location *Norfolk, VA* Proj. No. *830012037*
Surface Elev. _____ Total Hole Depth *18 ft.* Diameter *12 in.*
Top of Casing *11.87 ft.* Water Level Initial *6.5 ft.* Static *6.57 ft.*
Screen: Dia *4 in.* Length *15.0 ft.* Type/Size *0.010 in.*
Casing: Dia *4 in.* Length *3 ft.* Type *PVC*
Fill Material *#2 Morie Sand* Rig/Core *Mobile B-40/Split Spoon*
Drill Co. *Rock Ray Drilling* Method *Hollow Stem Auger*
Driller *Matt Marquedant* Log By *Lori Reuther* Date *08/02/94* Permit # _____
Checked By _____ License No. _____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.



Description

(Color, Texture, Structure)
Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%

Ground Surface

Light brown and light gray mottled, dry to slightly damp, silty SAND, trace dark gray laminae.

Light brown grading to gray, damp to very moist, fine, silty SAND, grading to fine SAND, little shell fragments throughout, trace organic matter.

Encountered water

Olive gray, saturated, fine, silty SAND, trace shell fragments, grading to 4" layer, olive gray, high plasticity, soft CLAY, grading to gray fine SAND, little medium sand.

Gray to light brown, saturated fine to medium SAND, trace shell fragments.

Gray, saturated, fine to medium SAND, grading to gray, fine SAND.

Bottom of Exploration

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

Monitoring Well GT-4

Project *Naval Base Piers NEESA RAC* Owner *US NAVY*
Location *Norfolk, VA* Proj. No. *830012037*
Surface Elev. ____ Total Hole Depth *18 ft.* Diameter *12 in.*
Top of Casing *11.12 ft.* Water Level Initial *6.5 ft.* Static *6.00 ft.*
Screen: Dia *4 in.* Length *15.0 ft.* Type/Size *0.010 in.*
Casing: Dia *4 in.* Length *3 ft.* Type *PVC*
Fill Material *#2 Morie Sand* Rig/Core *Mobile B-40/Split Spoon*
Drill Co. *Rock Ray Drilling* Method *Hollow Stem Auger*
Driller *Matt Marquedant* Log By *Lori Reuther* Date *08/01/94* Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / Blow Count / % Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%
-2						
0						Ground Surface
2			SS-1 7,6,7,7 /60		SM	Light brown to dark gray, dry to slightly damp, loose, silty, fine SAND, shell fragments throughout.
4			SS-2 7,6,4,4 /80			Light brown to gray, damp, loose, silty, fine SAND.
6			SS-3 1,3,4,2 80		SW	Light brown, damp, loose, fine to medium SAND, grading to moist to saturated, olive gray, silty, fine SAND, organic matter, shell fragments throughout.
8					SM	Encountered water
10			SS-4 4,3,2,2 80			Gray, saturated, loose, fine and medium SAND, little coarse sand.
12					SW	
14						
16			SS-5 2,2,1,2 80		CH	Dark gray, saturated, high plasticity, soft CLAY, grading to silty, fine SAND, grading to coarse SAND.
18					SW	Bottom of Exploration
20						
22						
24						

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

Monitoring Well GT-5

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 11.96 ft. Water Level Initial 7.5 ft. Static 6.90 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/01/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / Blow Count / % Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%
-2						
0						Ground Surface
2		5.7	SS-1 5,12,12,8 /80		SP	Yellowish orange, dry to damp, fine SAND, clay layer 2" thick, mottled dark gray and light brown, high plasticity, soft CLAY, trace medium sand.
4		4.7	SS-2 7,7,6,7 /60			Light brown, damp, fine SAND, some medium, subrounded sand, trace shell fragments.
6		185	SS-3 5,6,6,8 /80			Light brown to dark gray, moist, fine and medium SAND, trace shell fragments, strong hydrocarbon odor, sheen on split spoon.
8					SW	Encountered water
10						
12						
14		31	SS-4 4,3,1,1 /80			Olive gray, saturated, silty, fine, subrounded medium SAND, clay layer at 14', 4" thick, hydrocarbon odor until 14', then dark gray, saturated, fine SAND, no hydrocarbon odor.
16					SP	
18		3.6	SS-5 2,2,6,19 /60		CH	Olive gray, saturated, high plasticity, soft CLAY, grading to fine SAND, grading to subrounded medium SAND, little subrounded fine gravel.
20					SW	
22						Bottom of Exploration
24						

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

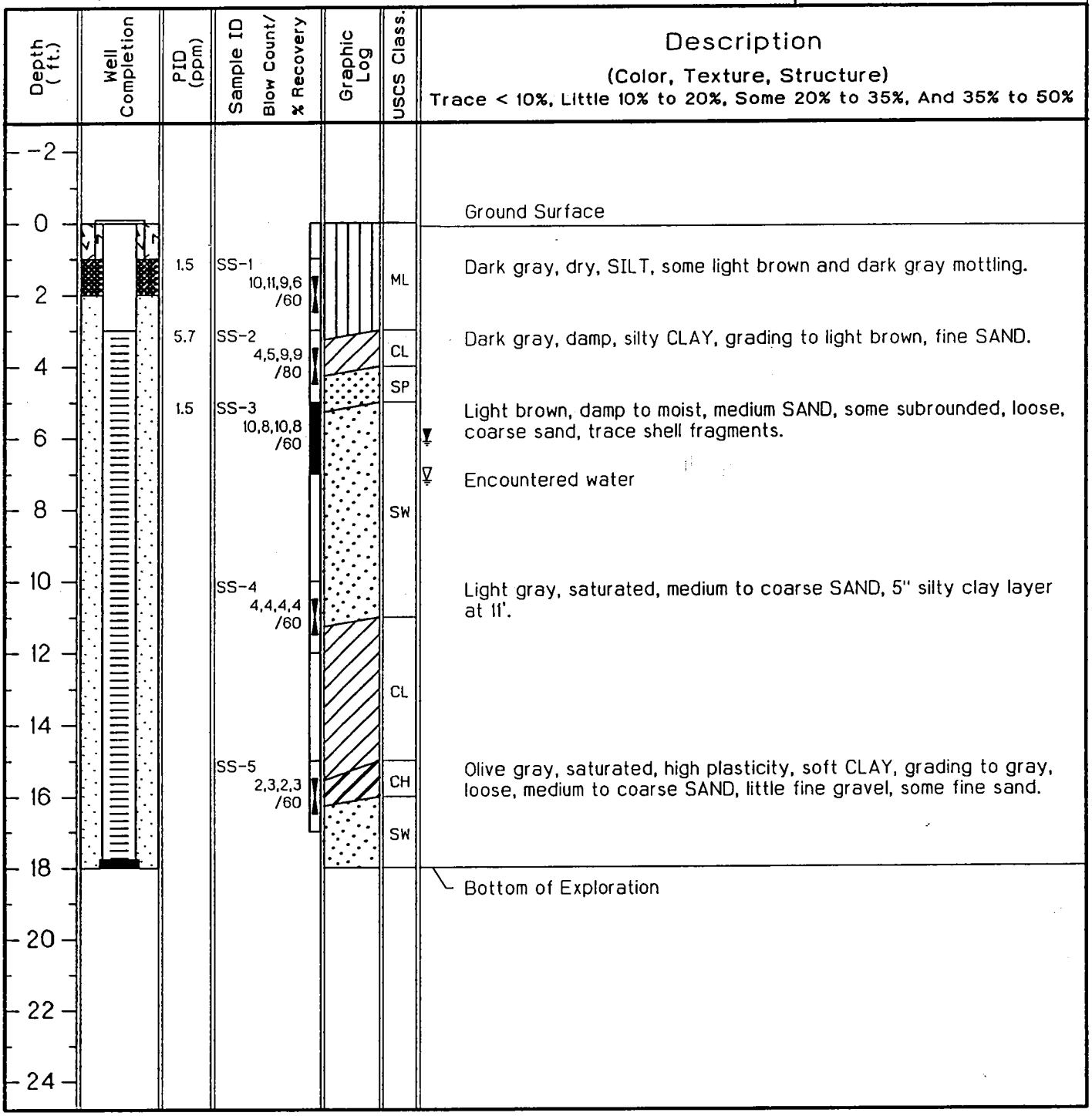
Monitoring Well GT-6

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 10.93 ft. Water Level Initial 7.2 ft. Static 6.10 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/01/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for the 10-12 ft. depth sample and the 15-17 ft. depth sample.



Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

Monitoring Well GT-10

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 11.64 ft. Water Level Initial 5.5 ft. Static 5.57 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/05/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector.

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / Blow Count / % Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%
-2						
0						Ground Surface
2		1.6	SS-1 3,6,7,5 /80		GC	Dark gray, slightly damp, fine to coarse, gravelly CLAY, grading to light brown, slightly damp, loose, silty fine SAND.
		2.1	SS-2 3,3,2,2 /50		SM	
4						Olive gray, damp to saturated, loose, fine SAND, shell fragments throughout, thin shell layer at 5.5', trace dark gray laminae.
		0.5	SS-3 1,1,1,1 /80		SP	Encountered water
6						Olive gray, with trace dark gray, saturated, high plasticity, very soft, fat CLAY, trace organic matter.
8						
10		1.6	SS-4 0/24 /80		OH	Olive gray, saturated, high plasticity, very soft, fat CLAY, trace organic matter.
12						
14						
16		0	SS-5 6,9,8,8 /60		SM / OH / GW	Olive gray, saturated, loose, silty, fine SAND, grading to dark gray, organic CLAY, grading to very light gray, saturated, medium SAND and coarse gravel.
18						Bottom of Exploration
20						
22						
24						

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

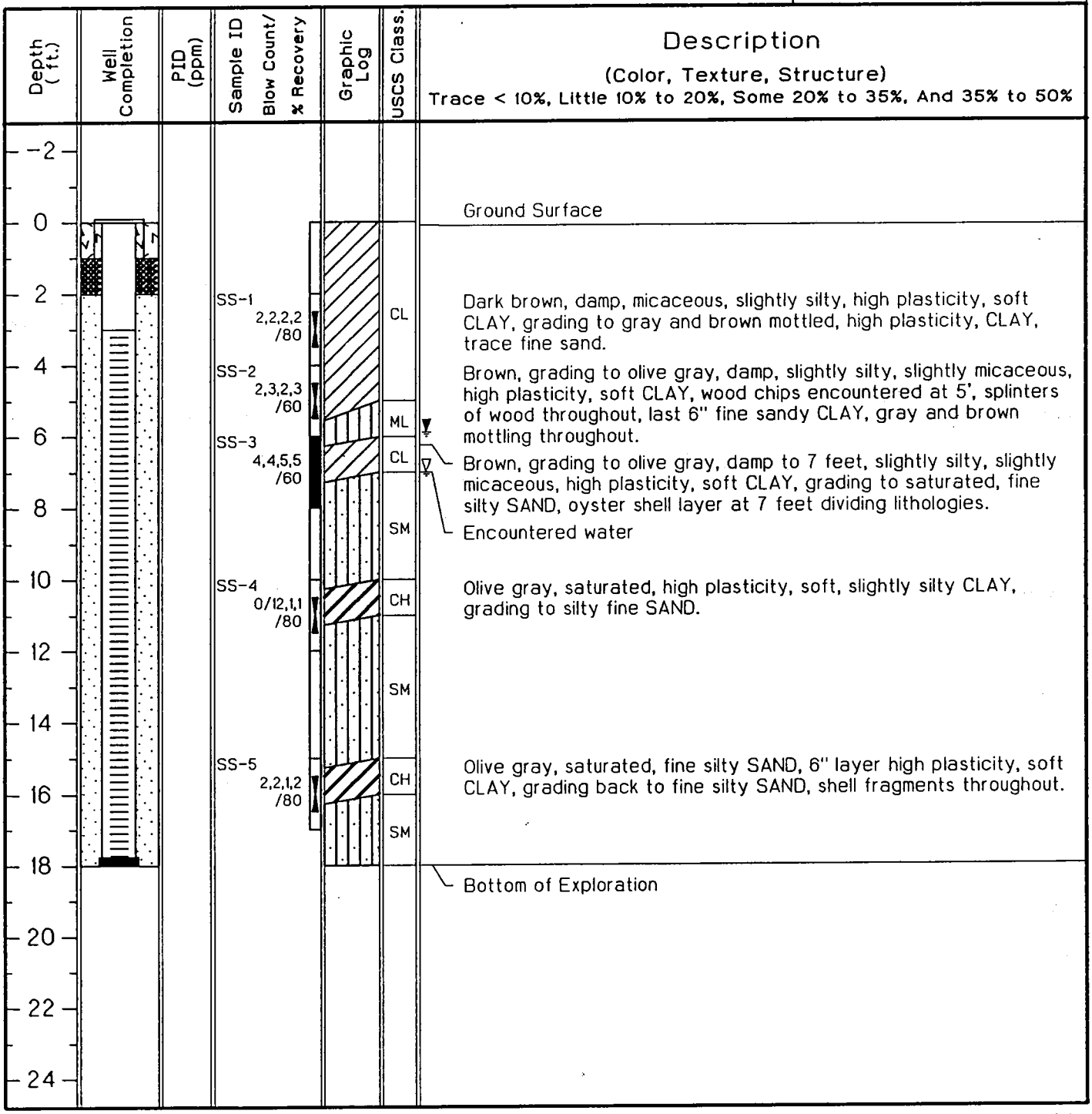
Monitoring Well GT-7

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 11.38 ft. Water Level Initial 7.0 ft. Static 5.88 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/04/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.



Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

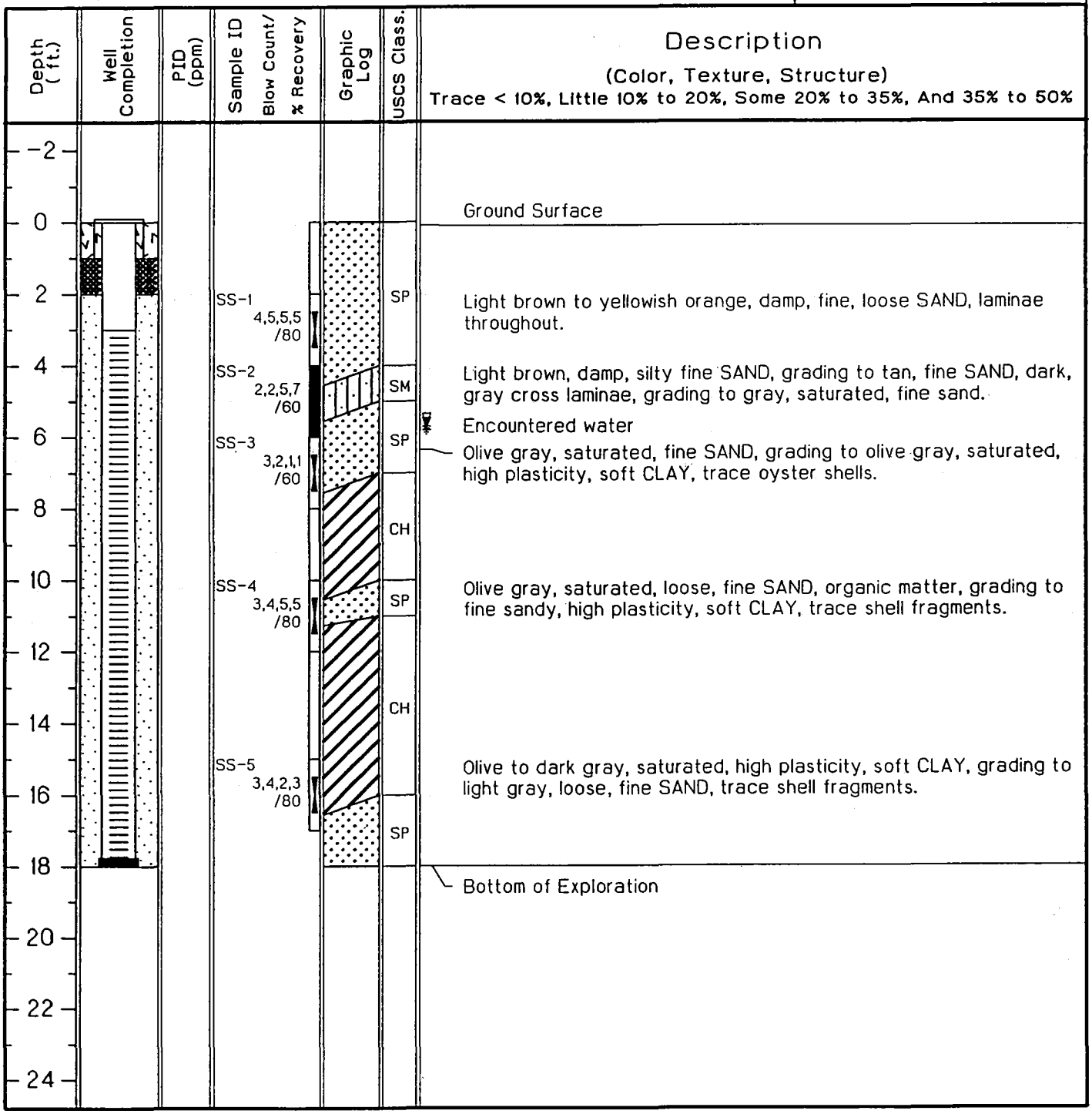
Monitoring Well GT-8

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 12.30 ft. Water Level Initial 5.7 ft. Static 5.81 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/04/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector. Due to equipment malfunction, PID field readings were not obtained for this monitoring well.



Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

Monitoring Well GT-9

Project Naval Base Piers NEESA RAC Owner US NAVY
Location Norfolk, VA Proj. No. 830012037
Surface Elev. ____ Total Hole Depth 18 ft. Diameter 12 in.
Top of Casing 12.29 ft. Water Level Initial 6.2 ft. Static 6.65 ft.
Screen: Dia 4 in. Length 15.0 ft. Type/Size 0.010 in.
Casing: Dia 4 in. Length 3 ft. Type PVC
Fill Material #2 Morie Sand Rig/Core Mobile B-40/Split Spoon
Drill Co. Rock Ray Drilling Method Hollow Stem Auger
Driller Matt Marquedant Log By Lori Reuther Date 08/05/94 Permit # ____
Checked By ____ License No. ____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector.

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / Blow Count / % Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%
0						Ground Surface
2		1.0	SS-1 3,4,3,4 /70			Light brown, damp, loose, silty, fine SAND, trace clay, shell fragments throughout, oyster shell layer 3" thick at 3.5'.
4		2.1	SS-2 4,7,8,8 /80		SM	Light brown, damp to moist, loose, silty, fine SAND, clay lens at 5.5', shell fragments throughout.
6		1.0	SS-3 3,2,3,3 /60			Encountered water Light brown grading to olive gray, saturated, loose, silty, fine SAND, shell fragments throughout, trace clay.
10		0	SS-4 0/12,1,1 /80			Olive gray, saturated, silty CLAY, grading to high plasticity, soft CLAY.
14					CH	
16		0	SS-5 3,3,3,4 /80			Olive gray, saturated, high plasticity, soft CLAY, grading at 16' to light gray, loose, fine SAND.
18					SP	Bottom of Exploration
20						
22						
24						

Drilling Log

GROUNDWATER TECHNOLOGY GOVERNMENT SERVICES

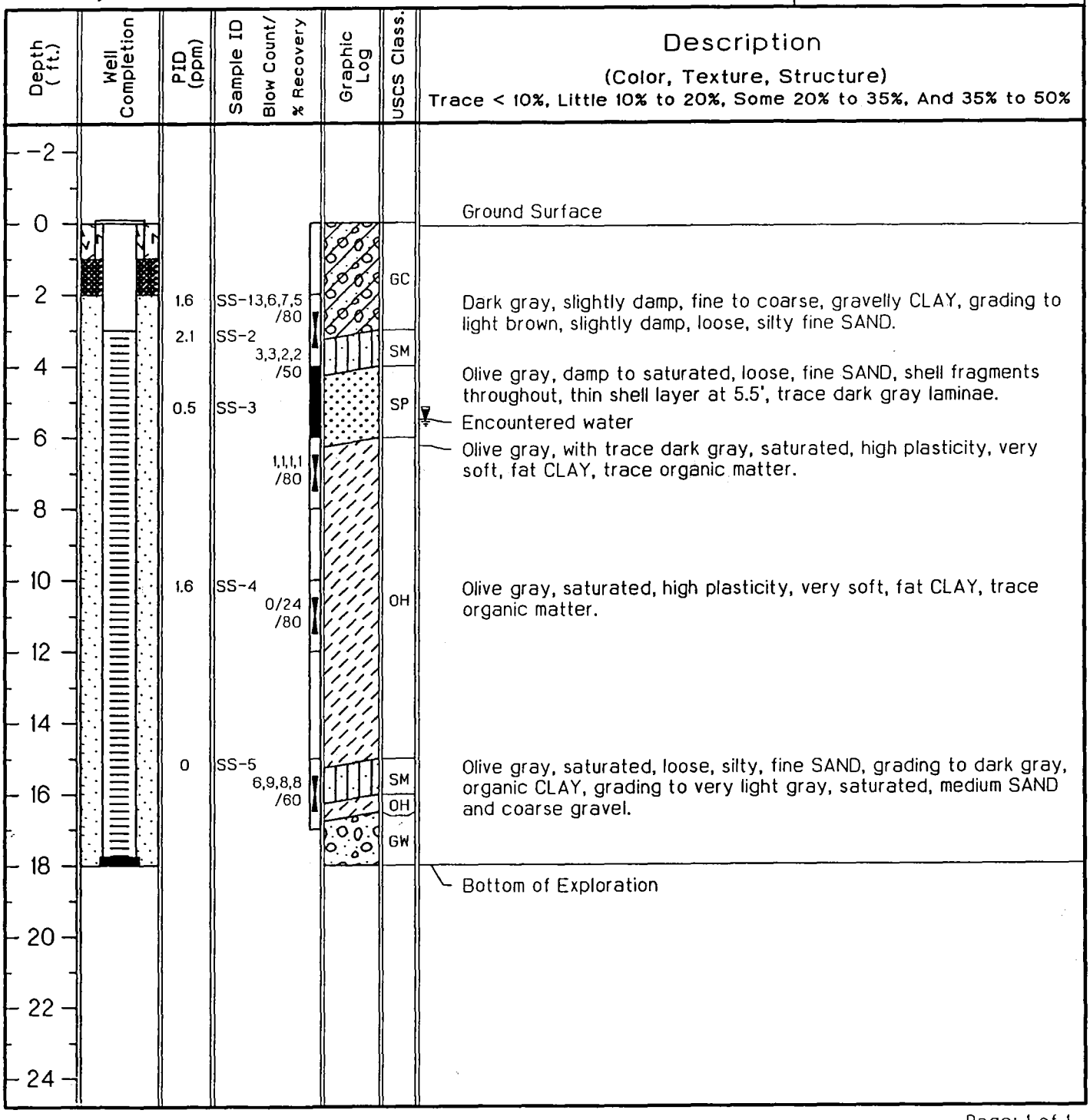
Monitoring Well GT-10

Project *Naval Base Piers NEESA RAC* Owner *US NAVY*
Location *Norfolk, VA* Proj. No. *830012037*
Surface Elev. _____ Total Hole Depth *18 ft.* Diameter *12 in.*
Top of Casing *11.64 ft.* Water Level Initial *5.5 ft.* Static *5.57 ft.*
Screen: Dia *4 in.* Length *15.0 ft.* Type/Size *0.010 in.*
Casing: Dia *4 in.* Length *3 ft.* Type *PVC*
Fill Material *#2 Morie Sand* Rig/Core *Mobile B-40/Split Spoon*
Drill Co. *Rock Ray Drilling* Method *Hollow Stem Auger*
Driller *Matt Marquedant* Log By *Lori Reuther* Date *08/05/94* Permit # _____
Checked By _____ License No. _____

See Site Map For Boring Location

COMMENTS:

Printed using the Unified Soil Classification System (USCS). PID= Photo-Ionization Detector.



APPENDIX C

Analytical Report

GTEL Client ID: 830012037
Login Number: M4080169
Project ID (number): 830012037
Project ID (name): NAVY NORFOLK, VA

ANALYTICAL RESULTS

Volatile Organics
Method: EPA 8020
Matrix: Soil

GTEL Sample Number	M40B0169-01	M4080169-02	--	--
Client ID	GT-9	GT-10	--	--
Date Sampled	08/05/94	08/05/94	--	--
Date Analyzed	08/10/94	08/10/94	--	--
Dilution Factor	1.00	1.00	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Benzene	0.05	mg/kg	0.05 U	0.05 U	--	--
Toluene	0.10	mg/kg	0.10 U	0.10 U	--	--
Ethylbenzene	0.10	mg/kg	0.10 U	0.10 U	--	--
Xylenes (total)	0.20	mg/kg	0.20 U	0.20 U	--	--
Percent Solids	--	%	93.2	93.6		

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 8020:

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Revision 1, US EPA July 1992. "U" indicates that the compound was analyzed for but not detected.

Client Number: 830012037
Project ID: NAVY PIERS NAVAL BASE NORFOLK, VA
Login Number: M4-08-0169

ANALYTICAL RESULTS

Total Recoverable Petroleum Hydrocarbons in Soil
by Infrared Spectrometry
Modified EPA Method 418.1[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Percent Solids, %	Detection Limit, mg/kg	Concentration, mg/kg
GTEL No.	Client ID	–	–	–	–	–	–
080169-01	GT-9	08/05/94	08/09/94	08/10/94	93.2	20	20 U
080169-02	GT-10	08/05/94	08/09/94	08/10/94	93.6	20	20 U

a EPA 600/4-79-020, March 1983 revision. Extraction modified for soils (Soxhlet). Concentration calculated on a dry weight basis.
U Indicates compound was analyzed for but not detected.

GTEL ENVIRONMENTAL LABORATORIES, INC.

MEADOWBROOK INDUSTRIAL PARK
MILFORD, NH 03055
(603) 672-4835
(800) LAB-GTEL

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

62423

Company Name: GROUNDWATER TECH GOV'T SERVICES

Phone #: 804-436-7881

FAX #: 804-436-2312

Company Address: 1244-B EXECUTIVE BLVD. SUITE 106 CHESAPEAKE, VA 23320

Site location: NAVY PIERS NAVAL BASE NORFOLK, VA

Project Manager: PAUL FARRINGTON

Client Project ID: (#) 830012037

(NAME)

I attest that the proper field sampling procedures were used during the collection of these samples. [signature]

Sampler Name (Print): L. REUTHER

Field Sample ID	GTEL Lab # (Lab use only)	# Containers	Matrix: WATER	Matrix: SOIL	Matrix: AIR	Matrix: SLUDGE	Matrix: PRODUCT	Matrix: OTHER	Method Preserved: HCl	Method Preserved: HNO_3	Method Preserved: H_2SO_4	Method Preserved: ICE	Method Preserved: UNPRESERVED	Method Preserved: OTHER (SPECIFY)	Sampling: DATE (94)	Sampling: TIME
GT-9	1	4		X								X			8/5	10:00
GT-10	2	5		X								X			8/5	11:45

Field Sample ID	BTEX/602 ☐ 8020 ☒ with MTBE ☐	BTEX/Gas Hydrocarbons PID/FID ☐ with MTBE ☐	Hydrocarbons GC/FID Gas ☐ Diesel ☐ Screen ☐	Hydrocarbon Profile (SIMDIS) ☐	Oil and Grease 413.1 ☐ 413.2 ☐ SM 503 ☐	TPH/IR 418.1 ☐ SM 503 ☐	EDB by 504 ☐ DBCP by 504 ☐	EPA 503.1 ☐ EPA 502.2 ☐	EPA 601 ☐ EPA 8010 ☐	EPA 602 ☐ EPA 8020 ☐	EPA 608 ☐ 8080 ☐ PCB only ☐	EPA 624/PPL ☐ 8240/TAL ☐ NBS (+15) ☐	EPA 625/PPL ☐ 8270/TAL ☐ NBS (+25) ☐	EPA 610 ☐ 8310 ☐	EP TOX Metals ☐ Pesticides ☐ Herbicides ☐	TCLP Metals ☐ VOA ☐ Semi-VOA ☐ Pest ☐ Herb ☐	EPA Metals - Priority Pollutant ☐ TAL ☐ RCRA ☐	CAM Metals TTLC ☐ STLC ☐	Lead 239.2 ☐ 200.7 ☐ 7420 ☐ 7421 ☐ 6010 ☐	Organic Lead ☐	Corrosivity ☐ Flash Point ☐ Reactivity ☐	TRPH 418.1		
GT-9	X																					X		
GT-10	X																					X		

TAT

Priority (24 hr) ☐
Expedited (48 hr) ☐
7 Business Days ☐
Other ________
Business Days ☐

Special Handling

GTEL Contact ________
Quote/Contract # ________
Confirmation # ________
PO # ________

QA / QC LEVEL

BLUE ☐ CLP ☐ OTHER ________

SPECIAL DETECTION LIMITS

SPECIAL REPORTING REQUIREMENTS

FAX ☐

REMARKS

Lab Use Only Lot #

Storage Location: 231A 103B

Work Order #: [illegible]5069

CUSTODY RECORD

Relinquished by	Date	Time	Received by
Relinquished by Sampler: [signature]	8/5/94	5:10	Received by:
Relinquished by:	Date	Time	Received by:
Relinquished by:	Date [illegible]	Time [illegible]	Received by Laboratory: [signature]

Waybill #

Rev. 7/91

000002

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Meadowbrook Industrial Park
Milford, N.H. 03055
(603) 672-4835
(800) 441-4835
FAX (603) 673-8105

October 6, 1994

P. Farrington
Groundwater Technology Government
Services, Inc.
100 River Ridge Drive
Norwood, MA 02062

RE: GTEL Client ID: 830012037
Login Number: M4080025
Project ID (number): 830012037
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA

Dear P. Farrington:

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 08/02/94 under Chain-of-Custody Number(s) 62416.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the State of Virginia under certification #00155.

If you have any questions regarding this analysis, or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Susan C. Uhler
Laboratory Director

Client Number: 830012037
Project ID: NAVY PIERS NAVAL BASE NORFOLK, VA
Login Number: M4-08-0025

ANALYTICAL RESULTS

Volatile Organics in Soil
EPA Method 8020[a]

GTEL Sample Number		080025-01	080025-02[d]	080025-03	--
Client Identification		GT-6	GT-5	GT-4	--
Date Sampled		08/01/94	08/01/94	08/01/94	--
Date Analyzed		08/04/94	08/05/94	08/04/94	--
Analyte	Reporting Limit, mg/kg	Concentration, mg/kg[c]			
Benzene	0.05	0.05 U	0.05 U	0.05 U	--
Toluene	0.10	0.10 U	0.10 U	0.10 U	--
Ethylbenzene	0.10	0.10 U	**0.56**	0.10 U	--
Xylenes (total)	0.20	0.20 U	**1.8**	0.20 U	--
Dilution Factor[b]		1.00	4.00	1.00	--
Percent Solids		79.6	91.5	78.6	--

a Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986; Methanolic extraction by EPA Method 5030 (purge and trap). Method modified to include additional compounds.

b The dilution factor indicates the adjustments made to the data as a result of dilutions.

c Results reported reflect dry weight concentration.

d Sample was analyzed diluted due to large amounts of non-target peaks.

U Indicates compound was analyzed for but not detected above the reporting limit indicated.

Client Number: 830012037
Project ID: NAVY PIERS NAVAL BASE NORFOLK, VA
Login Number: M4-08-0025

ANALYTICAL RESULTS

Total Recoverable Petroleum Hydrocarbons in Soil
by Infrared Spectrometry
Modified EPA Method 418.1[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Percent Solids, %	Reporting Limit, mg/kg	Concentration, mg/kg
GTEL No.	Client ID	--	--	--	--	--	--
080025-01	GT-6	08/01/94	08/03/94	08/04/94	79.6	20	**39**
080025-02	GT-5	08/01/94	08/03/94	08/04/94	91.5	20	**12000**
080025-03	GT-4	08/01/94	08/03/94	08/04/94	78.6	20	**29**

a EPA 600/4-79-020, March 1983 revision. Extraction modified for soils (Soxhlet). Concentration calculated on a dry weight basis.

GTEL ENVIRONMENTAL LABORATORIES, INC.

MEADOWBROOK INDUSTRIAL PARK
MILFORD, NH 03055
(603) 672-4835
(800) LAB-GTEL

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

62416

Company Name: GROUNDWATER TECH GOVT SERV. Phone #: 804-436-7884 FAX #: 804-436-2312

Company Address: SUITE 106, 244-B EXECUTIVE BLVD CHESAPEAKE VA 23320

Site location: NAVY PIERS, NAVAL BASE NORFOLK, VA

Project Manager: P. FARRINGTON

Client Project ID: (#) 8200.20.37

(NAME)

I attest that the proper field sampling procedures were used during the collection of these samples.

Sampler Name (Print): L. REITHER

Field Sample ID	GTEL Lab # (Lab use only)	# Containers	Matrix: WATER	SOIL	AIR	SLUDGE	PRODUCT	OTHER	Method Preserved: HCl	HNO_3	H_2SO_4	ICE	UNPRESERVED	OTHER (SPECIFY)	Sampling '94 DATE	TIME
GT-6	1			X								X			8/1	1:00
GT-5	2			X								X			8/1	11:00
GT-4	3			X								X			8/1	4:30

BTEX/602 ☐ 8020 ☐ with MTBE ☐
BTEX/Gas Hydrocarbons PID/FID ☐ with MTBE ☐
Hydrocarbons GC/FID Gas ☐ Diesel ☐ Screen ☐
Hydrocarbon Profile (SIMDIS) ☐
Oil and Grease 413.1 ☐ 413.2 ☐ SM 503 ☐
TPH/IR 418.1 ☐ SM 503 ☐
EDB by 504 ☐ DBCP by 504 ☐
EPA 503.1 ☐ EPA 502.2 ☐
EPA 601 ☐ EPA 8010 ☐
EPA 602 ☐ EPA 8020 ☐
EPA 608 ☐ 8080 ☐ PCB only ☐
EPA 624/PPL ☐ 8240/TAL ☐ NBS (+15) ☐
EPA 625/PPL ☐ 8270/TAL ☐ NBS (+25) ☐
EPA 610 ☐ 8310 ☐
EP TOX Metals ☐ Pesticides ☐ Herbicides ☐
TCLP Metals ☐ VOA ☐ Semi-VOA ☐ Pest ☐ Herb ☐
EPA Metals - Priority Pollutant ☐ TAL ☐ RCRA ☐
CAM Metals TTLC ☐ STLC ☐
Lead 239.2 ☐ 200.7 ☐ 7420 ☐ 7421 ☐ 6010 ☐
Organic Lead ☐
Corrosivity ☐ Flash Point ☐ Reactivity ☐
418.1 TRPH
BTEX 8020

TAT
Priority (24 hr) ☐
Expedited (48 hr) ☐
7 Business Days ☐
Other ____
Business Days ☐

Special Handling
GTEL Contact ____
Quote/Contract # ____
Confirmation # ____
PO # ____

QA / QC LEVEL
BLUE ☐ CLP ☐ OTHER ____

SPECIAL DETECTION LIMITS

SPECIAL REPORTING REQUIREMENTS
FAX ☐

REMARKS
PLEASE NOTE! 3 oz JARS SAY BTEX 602. — PLEASE ANALYZE FOR BTEX 8020 INSTEAD! Thank You

Lab Use Only Lot #

Storage Location: D3L4 W/B

Work Order #

CUSTODY RECORD

	Date	Time	
Relinquished by Sampler:	8/1/94	5:15	Received by:
Relinquished by:	Date	Time	Received by:
Relinquished by:	8/2/94	10:30	Received by Laboratory:

Waybill #

Rev. 7/91

200002

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Meadowbrook Industrial Park
Milford, N.H. 03055
(603) 672-4835
(800) 441-4835
FAX (603) 673-8105

October 6, 1994

Paul Farrington
Groundwater Technology Government
Services, Inc.
100 River Ridge Drive
Norwood, MA 02062

RE: GTEL Client ID: 830012037
Login Number: M4080061
Project ID (number): 830012037
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA

Dear Paul Farrington:

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 08/03/94 under Chain-of-Custody Number(s) 62417.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the State of Virginia under certification #00155.

If you have any questions regarding this analysis, or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Susan C. Uhler
Laboratory Director

GTEL Client ID: 830012037 ANALYTICAL RESULTS
Login Number: M4080061 Volatile Organics
Project ID (number): 830012037 Method: EPA 8020
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA Matrix: Soil

GTEL Sample Number	M4080061-01	M4080061-02	--	--	
Client ID	GT-3	GT-2	--	--	
Date Sampled	08/02/94	08/02/94	--	--	
Date Analyzed	08/06/94	08/06/94	--	--	
Dilution Factor	1.00	1.00	--	--	

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Benzene	0.05	mg/kg	0.05 U	0.05 U	--	--
Toluene	0.10	mg/kg	0.10 U	0.10 U	--	--
Ethylbenzene	0.10	mg/kg	0.10 U	0.10 U	--	--
Xylenes (total)	0.20	mg/kg	0.20 U	0.20 U	--	--
Percent Solids	--	%	82.1	80.1		

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 8020:

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Revision 1, US EPA July 1992. "U" indicates that the compound was analyzed for but not detected.

Client Number: 830012037
Project ID: NAVY PIERS NAVAL BASE NORFOLK, VA
Login Number: M4-08-0061

ANALYTICAL RESULTS

Total Recoverable Petroleum Hydrocarbons in Soil by Infrared Spectrometry Modified EPA Method 418.1[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Percent Solids, %	Reporting Limit, mg/kg	Concentration, mg/kg
GTEL No.	Client ID	--	--	--	--	--	--
080061-01	GT-3	08/02/94	08/04/94	08/05/94	82.1	20	< 20
080061-02	GT-2	08/02/94	08/04/94	08/05/94	80.1	20	< 20

a EPA 600/4-79-020, March 1983 revision. Extraction modified for soils (Soxhlet). Concentration calculated on a dry weight basis.

GTEL ENVIRONMENTAL LABORATORIES, INC.

MEADOWBROOK INDUSTRIAL PARK
MILFORD, NH 03055
(603) 672-4835
(800) LAB-GTEL

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

62417

Company Name: GROUNDWATER TECH GOV'T SERVICES
Phone #: 804-436-7881
FAX #: 804-436-2312
Company Address: 1441-B EXECUTIVE BLVD. SUITE 106 CHESAPEAKE, VA 23320
Site location: NAVY PIERS NAVAL BASE NORFOLK, VA
Project Manager: PAUL FARRINGTON
Client Project ID: (#) 830012037
(NAME)
I attest that the proper field sampling procedures were used during the collection of these samples.
Sampler Name (Print): L. REUTHER

Analyses requested: BTEX/602 ☐ 8020 ☒ with MTBE ☐; BTEX/Gas Hydrocarbons PID/FID ☐ with MTBE ☐; Hydrocarbons GC/FID Gas ☐ Diesel ☐ Screen ☐; Hydrocarbon Profile (SIMDIS) ☐; Oil and Grease 413.1 ☐ 413.2 ☐ SM 503 ☐; TPH/IR 418.1 ☐ SM 503 ☐; EDB by 504 ☐ DBCP by 504 ☐; EPA 503.1 ☐ EPA 502.2 ☐; EPA 601 ☐ EPA 8010 ☐; EPA 602 ☐ EPA 8020 ☐; EPA 608 ☐ 8080 ☐ PCB only ☐; EPA 624/PPL ☐ 8240/TAL ☐ NBS (+15) ☐; EPA 625/PPL ☐ 8270/TAL ☐ NBS (+25) ☐; EPA 610 ☐ 8310 ☐; EP TOX Metals ☐ Pesticides ☐ Herbicides ☐; TCLP Metals ☐ VOA ☐ Semi-VOA ☐ Pest ☐ Herb ☐; EPA Metals - Priority Pollutant ☐ TAL ☐ RCRA ☐; CAM Metals TTLC ☐ STLC ☐; Lead 239.2 ☐ 200.7 ☐ 7420 ☐ 7421 ☐ 6010 ☐; Organic Lead ☐; Corrosivity ☐ Flash Point ☐ Reactivity ☐; TRPH 418.1

Field Sample ID	GTEL Lab # (Lab use only)	# Containers	Matrix: WATER	SOIL	AIR	SLUDGE	PRODUCT	OTHER	Method Preserved: HCl	HNO₃	H₂SO₄	ICE	UNPRESERVED	OTHER (SPECIFY)	Sampling: DATE (94)	TIME	BTEX/602 8020	TRPH 418.1
GT-3	1	5		X								X			8/2	10:45	X	X
GT-2	2	5		X								X			8/2	12:15	X	X

TAT
Priority (24 hr) ☐
Expedited (48 hr) ☐
7 Business Days ☐
Other ____ Business Days ☐

Special Handling
GTEL Contact ____
Quote/Contract # ____
Confirmation # ____
PO # ____

QA / QC LEVEL
BLUE ☐ CLP ☐
OTHER ____

SPECIAL DETECTION LIMITS

SPECIAL REPORTING REQUIREMENTS
FAX ☐

REMARKS

Lab Use Only Lot #
Storage Location: W-10
Work Order # A4080011 23LP

CUSTODY RECORD

Relinquished by	Date	Time	Received by
Relinquished by Sampler: L Reuther	8/2/94	5:55	Received by:
Relinquished by:			Received by:
Relinquished by:	8/3/94	15:20	Received by Laboratory: [signature]

000002

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Meadowbrook Industrial Park
Milford, N.H. 03055
(603) 672-4835
(800) 441-4835
FAX (603) 673-8105

October 6, 1994

Paul Farrington
Groundwater Technology Government
Services, Inc.
100 River Ridge Drive
Norwood, MA 02062

RE: GTEL Client ID: 830012037
Login Number: M4080134
Project ID (number): 830012037
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA

Dear Paul Farrington:

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 08/05/94 under Chain-of-Custody Number(s) 62419.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the State of Virginia under certification #00155.

If you have any questions regarding this analysis, or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Susan C. Uhler
Laboratory Director

GTEL Client ID: 830012037 ANALYTICAL RESULTS
Login Number: M4080134 Total Petroleum Hydrocarbons
Project ID (number): 830012037 Method: EPA 418.1
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA Matrix: Soil

GTEL Sample Number	M4080134-01	M4080134-02	--	--
Client ID	GT-7	GT-8	--	--
Date Sampled	08/04/94	08/04/94	--	--
Date Analyzed	08/10/94	08/10/94	--	--
Date Prepped	08/09/94	08/09/94		
Dilution Factor	1.00	1.00	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Total Petroleum Hydrocarbons	20.	mg/kg	20. U	20. U	--	--
Percent Solids	--	%	75.1	77.2		

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 418.1 Modified:

"Methods for Chemical Analysis of Water and Wastes". EPA 600/4-79--020. USEPA EMSL. Cincinnati. OH. Revised. March 1983. "U" indicates that the compound was analyzed for but not detected at or above the reporting limit indicated. Extraction modified for soils using EPA 3550 (sonication).

GTEL Client ID: 830012037 ANALYTICAL RESULTS
Login Number: M4080134 Volatile Organics
Project ID (number): 830012037 Method: EPA 8020
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA Matrix: Soil

GTEL Sample Number	M4080134-01	M4080134-02	--	--
Client ID	GT-7	GT-8	--	--
Date Sampled	08/04/94	08/04/94	--	--
Date Analyzed	08/10/94	08/10/94	--	--
Dilution Factor	1.00	1.00	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Benzene	0.05	mg/kg	0.05 U	0.05 U	--	--
Toluene	0.10	mg/kg	0.10 U	0.10 U	--	--
Ethylbenzene	0.10	mg/kg	0.10 U	0.10 U	--	--
Xylenes (total)	0.20	mg/kg	0.20 U	0.20 U	--	--
Percent Solids	--	%	75.1	77.2		

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 8020:

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods". SW-846, Third Edition, Revision 1, US EPA July 1992. "U" indicates that the compound was analyzed for but not detected.

GTEL ENVIRONMENTAL LABORATORIES, INC.

MEADOWBROOK INDUSTRIAL PARK
MILFORD, NH 03055
(603) 672-4835
(800) LAB-GTEL

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

62419

Company Name: Groundwater Tech Gov't Services
Phone #: 804-436-7881
FAX #: 804 436-2312

Company Address: 4-B Executive Blvd. Suite 106, Chesapeake, VA 23320
Site location: NAVY PIERS, NAVAL BASE, NORFOLK, VA

Project Manager: Paul Farrington
Client Project ID: (#) 830012037
(NAME)

I attest that the proper field sampling procedures were used during the collection of these samples.
Sampler Name (Print): L Reuther

Field Sample ID	GTEL Lab # (Lab use only)	# Containers	Matrix: WATER	Matrix: SOIL	Matrix: AIR	Matrix: SLUDGE	Matrix: PRODUCT	Matrix: OTHER	Method Preserved: HCl	Method Preserved: HNO_3	Method Preserved: H_2SO_4	Method Preserved: ICE	Method Preserved: UNPRESERVED	Method Preserved: OTHER (SPECIFY)	Sampling: DATE 94	Sampling: TIME
GT-7	1	5		X								X			8/4	10:45
GT-8	2	5		X								X			8/4	12:45

Field Sample ID	BTEX/602 ☐ 8020 ☒ with MTBE ☐	BTEX/Gas Hydrocarbons PID/FID ☐ with MTBE ☐	Hydrocarbons GC/FID Gas ☐ Diesel ☐ Screen ☐	Hydrocarbon Profile (SIMDIS) ☐	Oil and Grease 413.1 ☐ 413.2 ☐ SM 503 ☐	TPH/IR 418.1 ☐ SM 503 ☐	EDB by 504 ☐ DBCP by 504 ☐	EPA 503.1 ☐ EPA 502.2 ☐	EPA 601 ☐ EPA 8010 ☐	EPA 602 ☐ EPA 8020 ☐	EPA 608 ☐ 8080 ☐ PCB only ☐	EPA 624/PPL ☐ 8240/TAL ☐ NBS (+15) ☐	EPA 625/PPL ☐ 8270/TAL ☐ NBS (+25) ☐	EPA 610 ☐ 8310 ☐	EP TOX Metals ☐ Pesticides ☐ Herbicides ☐	TCLP Metals ☐ VOA ☐ Semi-VOA ☐ Pest ☐ Herb ☐	EPA Metals - Priority Pollutant ☐ TAL ☐ RCRA ☐	CAM Metals TTLC ☐ STLC ☐	Lead 239.2 ☐ 200.7 ☐ 7420 ☐ 7421 ☐ 6010 ☐	Organic Lead ☐	Corrosivity ☐ Flash Point ☐ Reactivity ☐	TRPH 418.1
GT-7	X																					X
GT-8	X																					X

TAT
- Priority (24 hr) ☐
- Expedited (48 hr) ☐
- Business Days ☐
- Other ______ Business Days ☐

Special Handling
- GTEL Contact ______
- Quote/Contract # ______
- Confirmation # ______
- PO # ______

QA / QC LEVEL
BLUE ☐ CLP ☐ OTHER ______

SPECIAL DETECTION LIMITS

REMARKS

SPECIAL REPORTING REQUIREMENTS
FAX ☐

Lab Use Only Lot #
Storage Location: 2 ... WIID
Work Order # 1194080134

CUSTODY RECORD		Date	Time	
	Relinquished by Sampler: L Reuther	8/4/94	4:45	Received by:
	Relinquished by:	Date	Time	Received by:
	Relinquished by:	Date	Time	Received by Laboratory:
				Waybill #

Rev. 7/91

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Meadowbrook Industrial Park
Milford, N.H. 03055
(603) 672-4835
(800) 441-4835
FAX (603) 673-8105

October 6, 1994

Paul Farrington
Groundwater Technology Government
Services, Inc.
100 River Ridge Drive
Norwood, MA 02062

RE: GTEL Client ID: 830012037
Login Number: M4080092
Project ID (number): 830012037
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA

Dear Paul Farrington:

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 08/04/94 under Chain-of-Custody Number(s) 62418.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the State of Virginia under certification #00155.

If you have any questions regarding this analysis, or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Susan C. Uhler
Laboratory Director

GTEL Client ID: 830012037 ANALYTICAL RESULTS
Login Number: M4080092 Volatile Organics
Project ID (number): 830012037 Method: EPA 8020
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA Matrix: Soil

GTEL Sample Number	M4080092-01	--	--	--
Client ID	GT-1	--	--	--
Date Sampled	08/03/94	--	--	--
Date Analyzed	08/09/94	--	--	--
Dilution Factor	1.00	--	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Benzene	0.05	mg/kg	0.05 U	--	--	--
Toluene	0.10	mg/kg	0.10 U	--	--	--
Ethylbenzene	0.10	mg/kg	0.10 U	--	--	--
Xylenes (total)	0.20	mg/kg	0.20 U	--	--	--
Percent Solids	--	%	82.0			

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 8020:

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Revision 1, US EPA July 1992. "U" indicates that the compound was analyzed for but not detected.

GTEL Client ID: 830012037 ANALYTICAL RESULTS
Login Number: M4080092 Total Petroleum Hydrocarbons
Project ID (number): 830012037 Method: EPA 418.1
Project ID (name): NAVY PIERS NAVAL BASE NORFOLK, VA Matrix: Soil

GTEL Sample Number	M4080092-01	--	--	--
Client ID	GT-1	--	--	--
Date Sampled	08/03/94	--	--	--
Date Analyzed	08/10/94	--	--	--
Date Prepped	08/09/94			
Dilution Factor	1.00	--	--	--

Analyte	Reporting Limit	Units	Concentration:Dry Weight			
Total Petroleum Hydrocarbons	20.	mg/kg	20. U	--	--	--
Percent Solids	--	%	82.0			

Notes:

Dilution Factor:

The dilution factor indicates the adjustments made by the laboratory to results and sample reporting limits for dilutions.

EPA 418.1 Modified:

"Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79--020. USEPA EMSL, Cincinnati, OH. Revised, March 1983. "U" indicates that the compound was analyzed for but not detected at or above the reporting limit indicated. Extraction modified for soils using EPA 3550 (sonication).

GTEL ENVIRONMENTAL LABORATORIES, INC.

MEADOWBROOK INDUSTRIAL PARK
MILFORD, NH 03055
(603) 672-4835
(800) LAB-GTEL

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST 62418

Company Name: GROUNDWATER TECH GOV'T SERVICES
Phone #: 804·436·7881
FAX #: 804·436·2312
Company Address: 1244-B EXECUTIVE BLVD SUITE 106 CHESAPEAKE, VA 23320
Site location: NAVY PIERS NAVAL BASE NORFOLK, VA
Project Manager: PAUL FARRINGTON
Client Project ID: (#) 830012037
(NAME)
I attest that the proper field sampling procedures were used during the collection of these samples. [signature]
Sampler Name (Print): L. REUTHER

Field Sample ID	GTEL Lab # (Lab use only)	# Containers	Matrix: WATER	SOIL	AIR	SLUDGE	PRODUCT	OTHER	Method Preserved: HCl	HNO_3	H_2SO_4	ICE	UNPRESERVED	OTHER (SPECIFY)	Sampling: DATE '94	TIME	BTEX/602 ☐ 8020 ☒ with MTBE ☐	BTEX/Gas Hydrocarbons PID/FID ☐ with MTBE ☐	Hydrocarbons GC/FID Gas ☐ Diesel ☐ Screen ☐	Hydrocarbon Profile (SIMDIS) ☐	Oil and Grease 413.1 ☐ 413.2 ☐ SM 503 ☐	TPH/IR 418.1 ☐ SM 503 ☐	EDB by 504 ☐ DBCP by 504 ☐	EPA 503.1 ☐ EPA 502.2 ☐	EPA 601 ☐ EPA 8010 ☐	EPA 602 ☐ EPA 8020 ☐	EPA 608 ☐ 8080 ☐ PCB only ☐	EPA 624/PPL ☐ 8240/TAL ☐ NBS (+15) ☐	EPA 625/PPL ☐ 8270/TAL ☐ NBS (+25) ☐	EPA 610 ☐ 8310 ☐	EP TOX Metals ☐ Pesticides ☐ Herbicides ☐	TCLP Metals ☐ VOA ☐ Semi-VOA ☐ Pest ☐ Herb ☐	EPA Metals - Priority Pollutant ☐ TAL ☐ RCRA ☐	CAM Metals TTLC ☐ STLC ☐	Lead 239.2 ☐ 200.7 ☐ 7420 ☐ 7421 ☐ 6010 ☐	Organic Lead ☐	Corrosivity ☐ Flash Point ☐ Reactivity ☐	TKPH 418.1	
GT-1	1	5		X								X			8/3	12:15	X																					X	

TAT
Priority (24 hr) ☐
Expedited (48 hr) ☐
7 Business Days ☐
Other ____
Business Days ☐

Special Handling
GTEL Contact ____
Quote/Contract # ____
Confirmation # ____
PO # ____

QA / QC LEVEL
BLUE ☐ CLP ☐ OTHER ____

SPECIAL DETECTION LIMITS

SPECIAL REPORTING REQUIREMENTS
FAX ☐

REMARKS

Lab Use Only Lot #
Storage Location: 023LB 101B
Work Order # 0108009 ?

CUSTODY RECORD

Relinquished by Sampler:	Date	Time	Received by:
[signature]	8/3/94	4:45	
Relinquished by:	Date	Time	Received by:
Relinquished by:	Date	Time	Received by Laboratory:
			Waybill #

Rev. 7/91

000002

APPENDIX D

Liquid-Level Data

GROUNDWATER
TECHNOLOGY
GOVERNMENT SERVICES

Groundwater Technology Government Services, Inc.
1244 B Executive Boulevard, Suite 106, Chesapeake, VA 23320
Tel: (804) 436-7881 Fax: (804) 436-2312

LIQUID LEVEL MEASUREMENTS
CLIENT: U.S. Navy, Atlantic Division
LOCATION: Piers, Norfolk Naval Base, Norfolk, Virgina
DATE: August 8-12, 1994

MONITORING WELLS

No.	DTW	DTP	PT	TOC ELEV	ELEV-W	CORRECTED ELEV-W	COMMENTS
MW-1	5.12	-	-				
MW-2	5.54	-	-				
MW-3	NG						Not Gauged
MW-4	NG						Not Gauged
MW-5	NG						Not Gauged
MW-6	NG						Not Gauged
MW-7	5.17	-	-				
MW-8	NG						Not Gauged
MW-9	NG						Not Gauged
MW-10	5.62	-	-				
MW-11	7.77	6.62	1.15				
MW-12	7.62	6.82	0.80				
MW-13	7.43	6.37	1.06				
MW-14	6.42	-	-				
MW-15	6.95	5.50	1.45				
MW-16	6.31	-	-				
MW-17	7.01	-	-				
MW-18	5.94	-	-				
MW-19	7.36	-	-				

DEPTH TO WATER MEASURED RELATIVE TO LIP OF PVC

DTW = Depth to Water
DTP = Depth to Product
PT = Product Thickness
TOC = Top of Casing

Elev-W = Elevation of Water
Corrected Elev-W = Corrected water elevation for the presence of hydrocarbon floating on the Water table
= TOC ELEV - DTW + (PT x 0.88)

PIERPROJ.LL1

GROUNDWATER
TECHNOLOGY
GOVERNMENT SERVICES

Groundwater Technology Government Services, Inc.
1244 B Executive Boulevard, Suite 106, Chesapeake, VA 23320
Tel: (804) 436-7881 Fax: (804) 436-2312

LIQUID LEVEL MEASUREMENTS
CLIENT: U.S. Navy, Atlantic Division
LOCATION: Piers, Norfolk Naval Base, Norfolk, Virgina
DATE: August 8-12, 1994

MONITORING WELLS

No.	DTW	DTP	PT	TOC ELEV	ELEV-W	CORRECTED ELEV-W	COMMENTS
MW-20	7.18	-	-				
MW-21	NG						
MW-22	8.77	-	-				
MW-23	7.32	-	-				
MW-24	6.33	-	-				
MW-25	7.57	-	-				
MW-26	10.87	-	-				No cap or cover
MW-27	NG						Not Gauged
MW-28	NG						Not Gauged
MW-29	NG						Not Gauged
MW-30	NG						Not Gauged
MW-31	NG						Not Gauged
MW-32	NG						Not Gauged
MW-33	NG						Not Gauged
MW-34	NG						Not Gauged
MW-35	6.09	-	-				
MW-36	6.13	-	-				
MW-37	6.13	5.94	0.19				
MW-38	NG						Paved Over

DEPTH TO WATER MEASURED RELATIVE TO LIP OF PVC

DTW = Depth to Water
DTP = Depth to Product
PT = Product Thickness
TOC = Top of Casing
Elev-W = Elevation of Water
Corrected Elev-W = Corrected water elevation for the presence of hydrocarbon floating on the Water table
= TOC ELEV - DTW + (PT x 0.88)

PIERPROJ.LL2

GROUNDWATER
TECHNOLOGY
GOVERNMENT SERVICES

Groundwater Technology Government Services, Inc.
1244 B Executive Boulevard, Suite 106, Chesapeake, VA 23320
Tel: (804) 436-7881 Fax: (804) 436-2312

LIQUID LEVEL MEASUREMENTS
CLIENT: U.S. Navy, Atlantic Division
LOCATION: Piers, Norfolk Naval Base, Norfolk, Virgina
DATE: August 8-12, 1994

MONITORING WELLS

No.	DTW	DTP	PT	TOC ELEV	ELEV-W	CORRECTED ELEV-W	COMMENTS
MW-39	6.06	-	-				
MW-40	NG						Not Gauged
MW-41	NG						Not Gauged
MW-42	6.07	-	-				
MW-43	8.60	5.55	3.05				
MW-44	7.59	7.30	0.29				
MW-45	6.51	-	-				
MW-46	NG						Not Gauged
MW-47	NG						Wasp Nest
MW-48	6.13	-	-				
MW-49	10.13	6.36	3.77				
MW-50	NG						Not Gauged
MW-51	6.69	-	-				
MW-52	5.79	-	-				
MW-53	6.92	-	-				
MW-54	6.82	5.84	0.98				
MW-55	5.76	-	-				
MW-56	NG						Well Demolished
MW-57	8.42	-	-				

DEPTH TO WATER MEASURED RELATIVE TO LIP OF PVC

DTW = Depth to Water
DTP = Depth to Product
PT = Product Thickness
TOC = Top of Casing
Elev-W = Elevation of Water
Corrected Elev-W = Corrected water elevation for the presence of hydrocarbon floating on the Water table
= TOC ELEV - DTW + (PT x 0.88)

PIERPROJ.LL3

GROUNDWATER
TECHNOLOGY
GOVERNMENT SERVICES

Groundwater Technology Government Services, Inc.
1244 B Executive Boulevard, Suite 106, Chesapeake, VA 23320
Tel: (804) 436-7881 Fax: (804) 436-2312

LIQUID LEVEL MEASUREMENTS
CLIENT: U.S. Navy, Atlantic Division
LOCATION: Piers, Norfolk Naval Base, Norfolk, Virgina
DATE: August 8-12, 1994

MONITORING WELLS

No.	DTW	DTP	PT	TOC ELEV	ELEV-W	CORRECTED ELEV-W	COMMENTS
MW-58	5.65	-	-				
MW-59	6.59	5.92	0.67				
MW-60	NG						Not Gauged
MW-61	6.00	-	-				
MW-62	6.11	-	-				
MW-63	6.37	6.07	0.30				
MW-64	6.12	-	-				
GT-1	6.47	-	-				
GT-2	5.61	-	-				
GT-3	6.47	-	-				
GT-4	5.84	-	-				
GT-5	7.57	6.80	0.77				
GT-6	5.97	-	-				
GT-7	5.88	-	-				
GT-8	5.83	-	-				
GT-9	6.65	-	-				
GT-10	5.57	-	-				

DEPTH TO WATER MEASURED RELATIVE TO LIP OF PVC

DTW = Depth to Water
DTP = Depth to Product
PT = Product Thickness
the TOC= Top of Casing

Elev-W = Elevation of Water
Corrected Elev-W = Corrected water elevation for the presence of hydrocarbon floating on Water table
= TOC ELEV - DTW + (PT x 0.88)

PIERPROJ.LL4

APPENDIX E

Rising Head Permeability Test Results

DATA SET: PIERS7

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	13 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-7
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.51 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	5.550 ft
AQUIFER:	Endless	THICKNESS:	18.96 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	5.550 ft	SCREEN BASE:	24.51 ft
INITIAL HEAD:	0.875 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

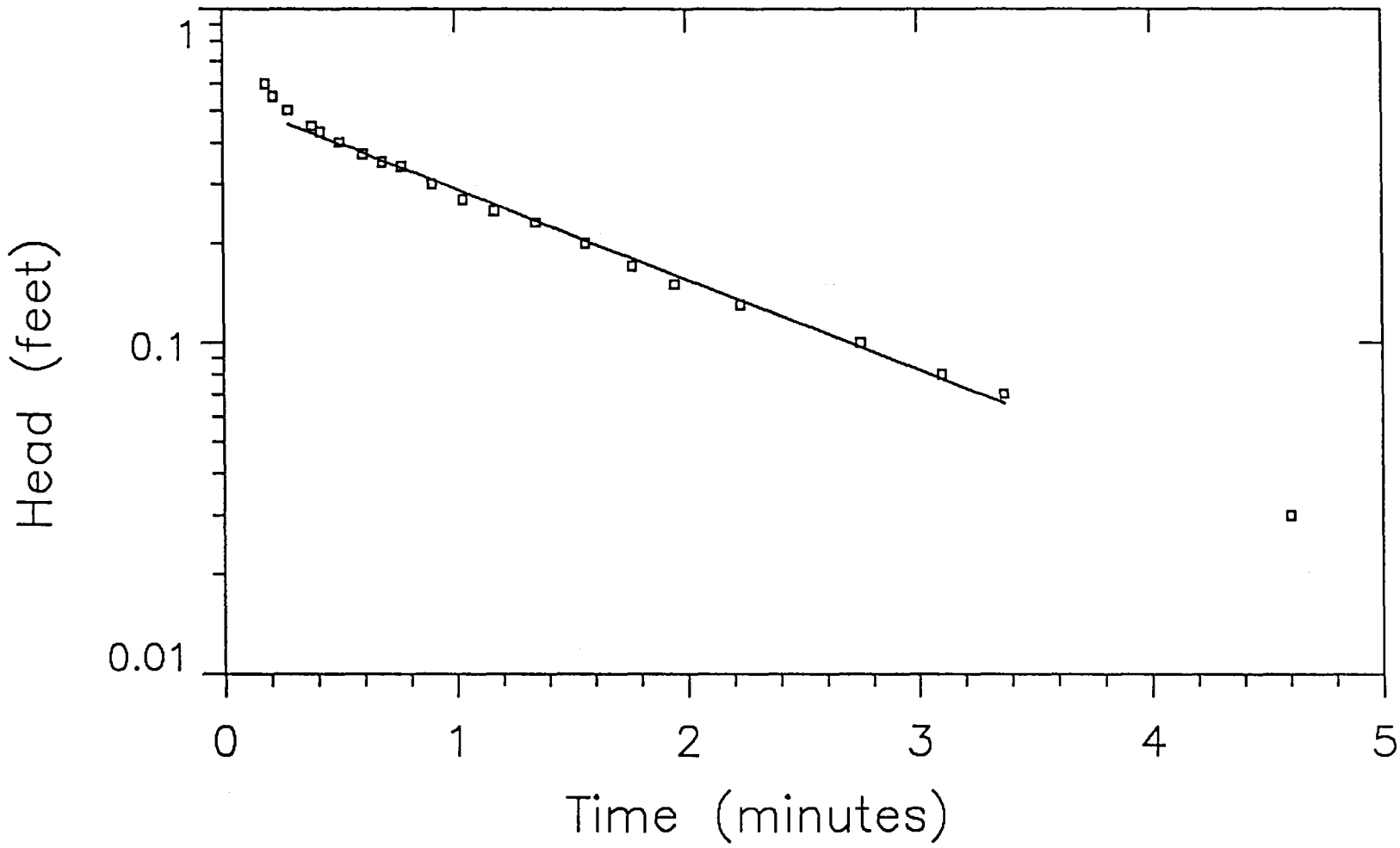
TRANSMISSIVITY: 126.77982square ft/day

CONDUCTIVITY: 6.68670 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.184	0.600		
2	0.217	0.550		
3	0.283	0.500	0.455	8.97
4	0.383	0.450	0.427	5.01
5	0.417	0.430	0.418	2.69
6	0.500	0.400	0.397	0.707
7	0.600	0.370	0.373	-0.811
8	0.684	0.350	0.353	-1.09
9	0.767	0.340	0.335	1.21
10	0.900	0.300	0.308	-2.99
11	1.03	0.270		
12	1.16	0.250		
13	1.35	0.230		
14	1.56	0.200		
15	1.76	0.170		
16	1.95	0.150		
17	2.23	0.130		
18	2.75	0.1000		
19	3.10	0.0800		
20	3.36	0.0700		
21	4.60	0.0300		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 6.687 ft/day	by: Groundwater Technology, Inc.	
TRANSMISSIVITY: 126.7 sq. ft/day	WELL DATA: Units: ft	Well: MW-7
INITIAL HEAD: .8750 ft	AQUIFER: Endless	NAVAL BASE
	THICKNESS: 18.96	NORFOLK, VA
Data Set: PIERS7 / Date: 13 JULY 94	SCREEN: top: 5.550 base: 24.51	
	DIAMETER: casing: .5620 intake: .8340	
	DEPTH: Water Table: 5.550 TD: 24.51	

DATA SET: PIERS14

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	13 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-14
COUNTY:	NORFOLK, VA	WELL DEPTH:	23.44 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	7.140 ft
AQUIFER:	Endless	THICKNESS:	16.30 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	7.140 ft	SCREEN BASE:	23.44 ft
INITIAL HEAD:	2.660 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

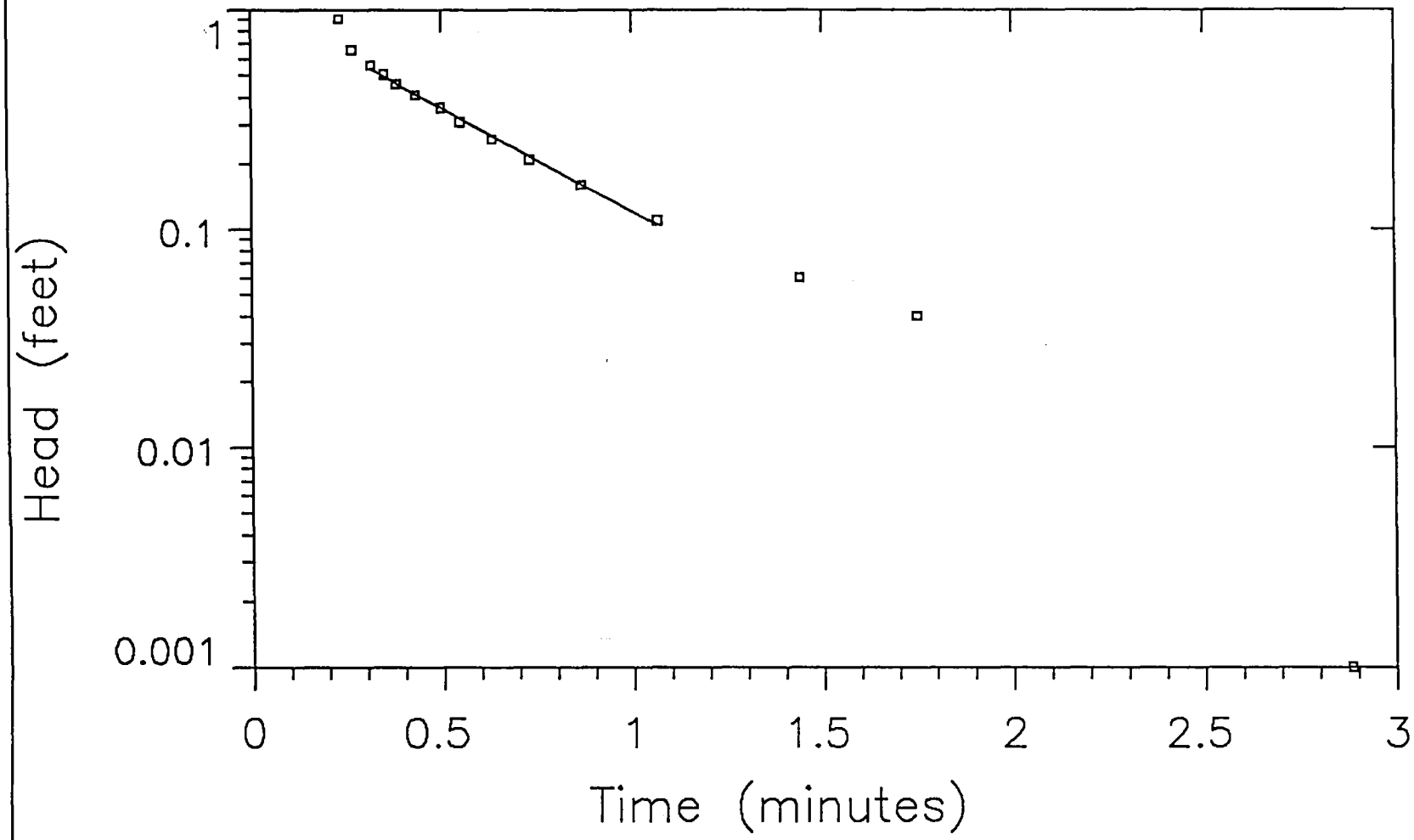
TRANSMISSIVITY: 477.64822square ft/day

CONDUCTIVITY: 29.30357 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.233	0.910		
2	0.267	0.660		
3	0.317	0.560	0.533	4.68
4	0.350	0.510	0.496	2.57
5	0.383	0.460	0.462	-0.543
6	0.433	0.410	0.414	-1.19
7	0.500	0.360	0.358	0.358
8	0.550	0.310	0.321	-3.80
9	0.633	0.260	0.268	-3.35
10	0.733	0.210	0.216	-2.97
11	0.867	0.160	0.161	-1.02
12	1.06	0.110	0.104	4.83
13	1.44	0.0600		
14	1.75	0.0400		
15	2.88	0.00100		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: 29.30 ft/day

TRANSMISSIVITY: 477.6 sq. ft/day

INITIAL HEAD: 2.660 ft

Data Set: PIERS14 | Date: 13 JULY 94

for: LANTDIV NAVFACENGCOM

by: Groundwater Technology, Inc.

WELL DATA: Units: ft

AQUIFER: Endless

THICKNESS: 16.30

SCREEN: top: 7.140 base: 23.44

DIAMETER: casing: .5620 Intake: .8340

DEPTH: Water Table: 7.140 TD: 23.44

PIERS PROJECT

Well: MW-14

NAVAL BASE

NORFOLK, VA

DATA SET: PIERS32

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-32
COUNTY:	NORFOLK, VA	WELL DEPTH:	25.13 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.970 ft
AQUIFER:	Endless	THICKNESS:	18.16 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.970 ft	SCREEN BASE:	25.13 ft
INITIAL HEAD:	0.682 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

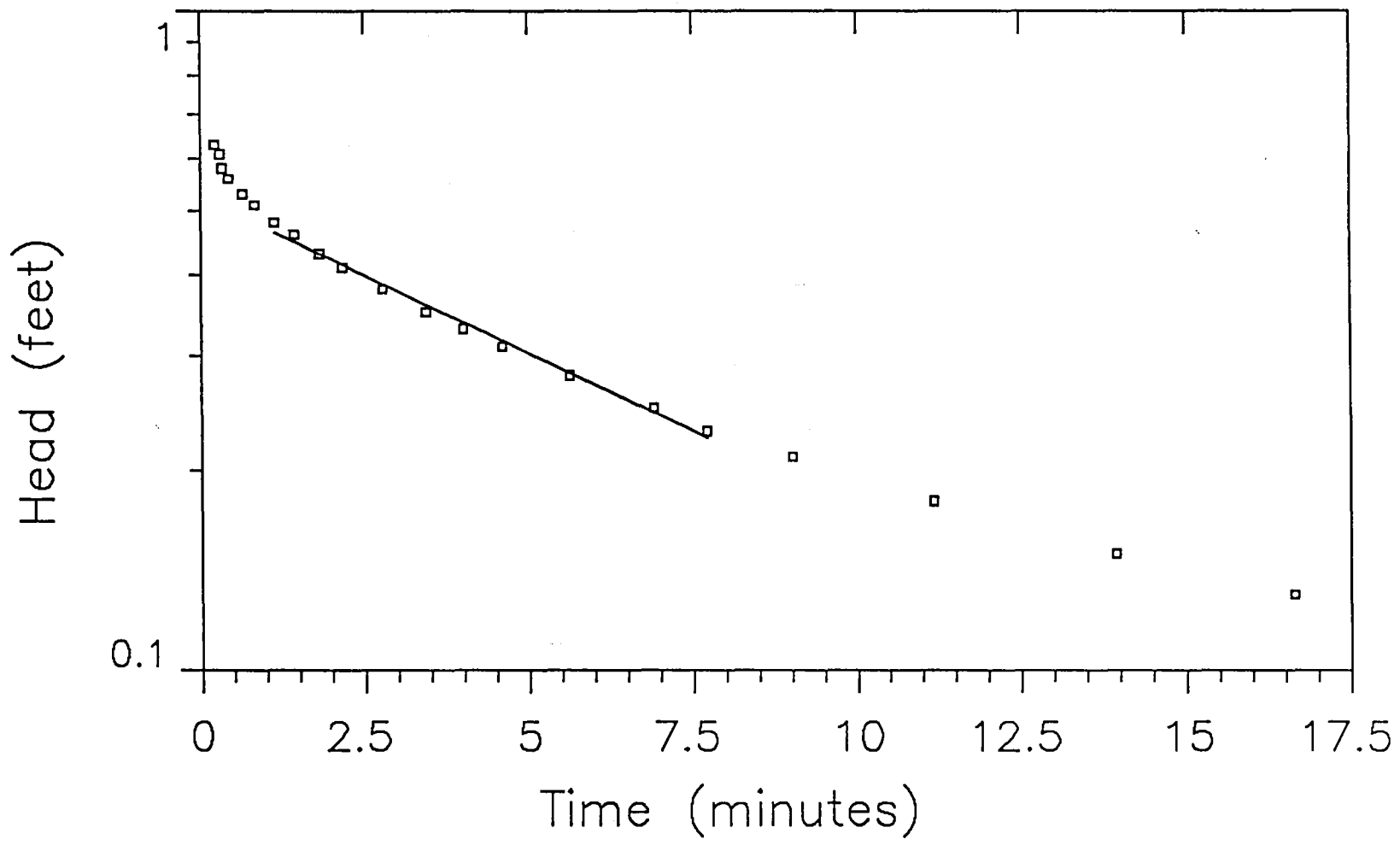
TRANSMISSIVITY: 23.42637square ft/day

CONDUCTIVITY: 1.29000 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.217	0.630		
2	0.300	0.610		
3	0.333	0.580		
4	0.433	0.560		
5	0.650	0.530		
6	0.833	0.510		
7	1.13	0.480	0.463	3.46
8	1.44	0.460	0.447	2.61
9	1.81	0.430	0.429	0.0506
10	2.16	0.410	0.413	-0.865
11	2.78	0.380	0.386	-1.69
12	3.44	0.350	0.359	-2.71
13	4.00	0.330	0.338	-2.43
14	4.60	0.310	0.316	-2.07
15	5.63	0.280	0.282	-0.869
16	6.91	0.250	0.245	1.90
17	7.71	0.230	0.224	2.36
18	9.01	0.210		
19	11.16	0.180		
20	13.93	0.150		
21	16.63	0.130		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: 1.290 ft/day

TRANSMISSIVITY: 23.42 sq. ft/day

INITIAL HEAD: .6820 ft

Data Set: PIERS32 | Date: 12 JULY 94

for: LANTDIV NAVFACENGCOM

by: Groundwater Technology, Inc.

WELL DATA: Units: ft

AQUIFER: Endless

THICKNESS: 18.16

SCREEN: top: 6.970 base: 25.13

DIAMETER: casing: .5620 intake: .8340

DEPTH: Water Table: 6.970 TD: 25.13

PIERS PROJECT

Well: MW-32

NAVAL BASE

NORFOLK, VA

DATA SET: PIERS39

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-39
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.56 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.150 ft
AQUIFER:	Endless	THICKNESS:	18.41 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.150 ft	SCREEN BASE:	24.56 ft
INITIAL HEAD:	0.688 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

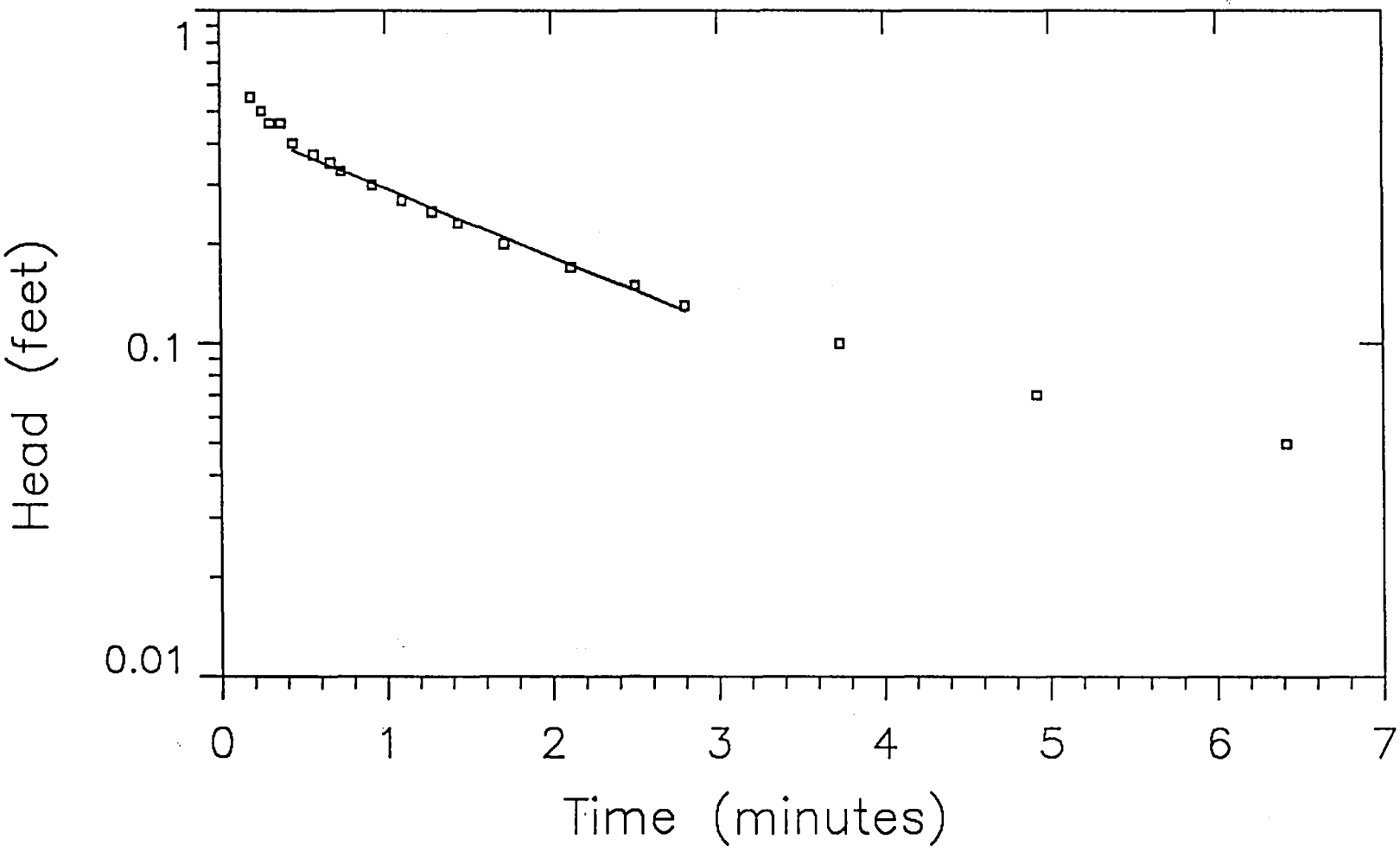
TRANSMISSIVITY: 99.33665square ft/day

CONDUCTIVITY: 5.39580 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	Head, H (ft) SYNTHETIC	DIFFERENCE (percent)
1	0.184	0.550		
2	0.250	0.500		
3	0.300	0.460		
4	0.367	0.460		
5	0.440	0.400	0.381	4.74
6	0.567	0.370	0.358	2.99
7	0.667	0.350	0.342	2.17
8	0.733	0.330	0.331	-0.584
9	0.917	0.300	0.304	-1.46
10	1.10	0.270	0.279	-3.42
11	1.28	0.250	0.256	-2.47
12	1.43	0.230	0.238	-3.59
13	1.71	0.200	0.208	-4.42
14	2.11	0.170	0.172	-1.76
15	2.50	0.150	0.144	3.70
16	2.80	0.130	0.125	3.52
17	3.73	0.1000		
18	4.91	0.0700		
19	6.41	0.0500		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: 5.396 ft/day

TRANSMISSIVITY: 99.34 sq. ft/day

INITIAL HEAD: .6880 ft

Data Set: PIERS39 | Date: 12 JULY 94

for: LANTDIV NAVFACENGCOM

by: Groundwater Technology, Inc.

WELL DATA: Units: ft
AQUIFER: Endless
THICKNESS: 18.41
SCREEN: top: 6.150 base: 24.56
DIAMETER: casing: .5620 intake: .8340
DEPTH: Water Table: 6.150 TD: 24.56

PIERS PROJECT

Well: MW-39
NAVAL BASE
NORFOLK, VA

DATA SET: PIERS42

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-42
COUNTY:	NORFOLK, VA	WELL DEPTH:	14.77 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.320 ft
AQUIFER:	Endless	THICKNESS:	8.45 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.320 ft	SCREEN BASE:	14.77 ft
INITIAL HEAD:	0.860 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: 57.99990square ft/day

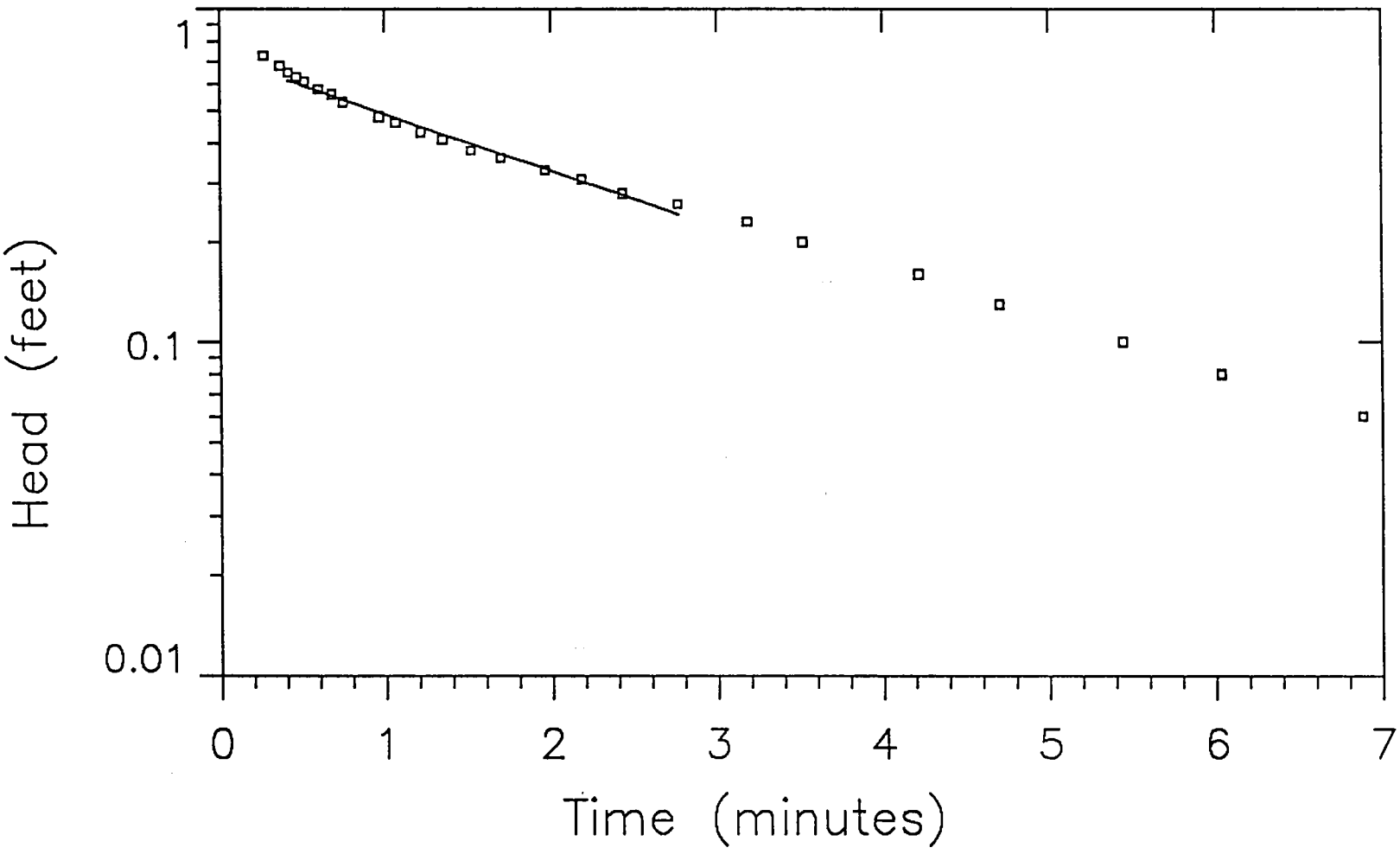
CONDUCTIVITY: 6.86389 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.267	0.730		
2	0.367	0.680		
3	0.417	0.650	0.615	5.33
4	0.467	0.630	0.603	4.24
5	0.517	0.610	0.591	3.04
6	0.600	0.580	0.572	1.31
7	0.684	0.560	0.553	1.13
8	0.750	0.530	0.539	-1.76
9	0.967	0.480	0.495	-3.12
10	1.06	0.460	0.475	-3.43
11	1.21	0.430	0.448	-4.27
12	1.35	0.410	0.425	-3.75
13	1.51	0.380	0.398	-4.78
14	1.70	0.360	0.370	-2.88
15	1.96	0.330	0.333	-0.986
16	2.18	0.310	0.305	1.34
17	2.43	0.280	0.277	1.01
18	2.76	0.260	0.242	6.60
19	3.18	0.230		
20	3.51	0.200		
21	4.21	0.160		
22	4.70	0.130		
23	5.44	0.1000		

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
24	6.03	0.0800		
25	6.88	0.0600		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 6.864 ft/day	by: Groundwater Technology, Inc.	
TRANSMISSIVITY: 58.00 sq. ft/day	WELL DATA: Units: ft	Well: MW-42
INITIAL HEAD: .8600 ft	AQUIFER: Endless	NAVAL BASE
	THICKNESS: 8.450	NORFOLK, VA
Data Set: PIERS42 / Date: 12 JULY 94	SCREEN: top: 6.320 base: 14.77	
	DIAMETER: casing: .5620 Intake: .8340	
	DEPTH: Water Table: 6.320 TD: 14.77	

DATA SET: PIERS51

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-51
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.90 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.800 ft
AQUIFER:	Endless	THICKNESS:	18.10 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.800 ft	SCREEN BASE:	24.90 ft
INITIAL HEAD:	0.720 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

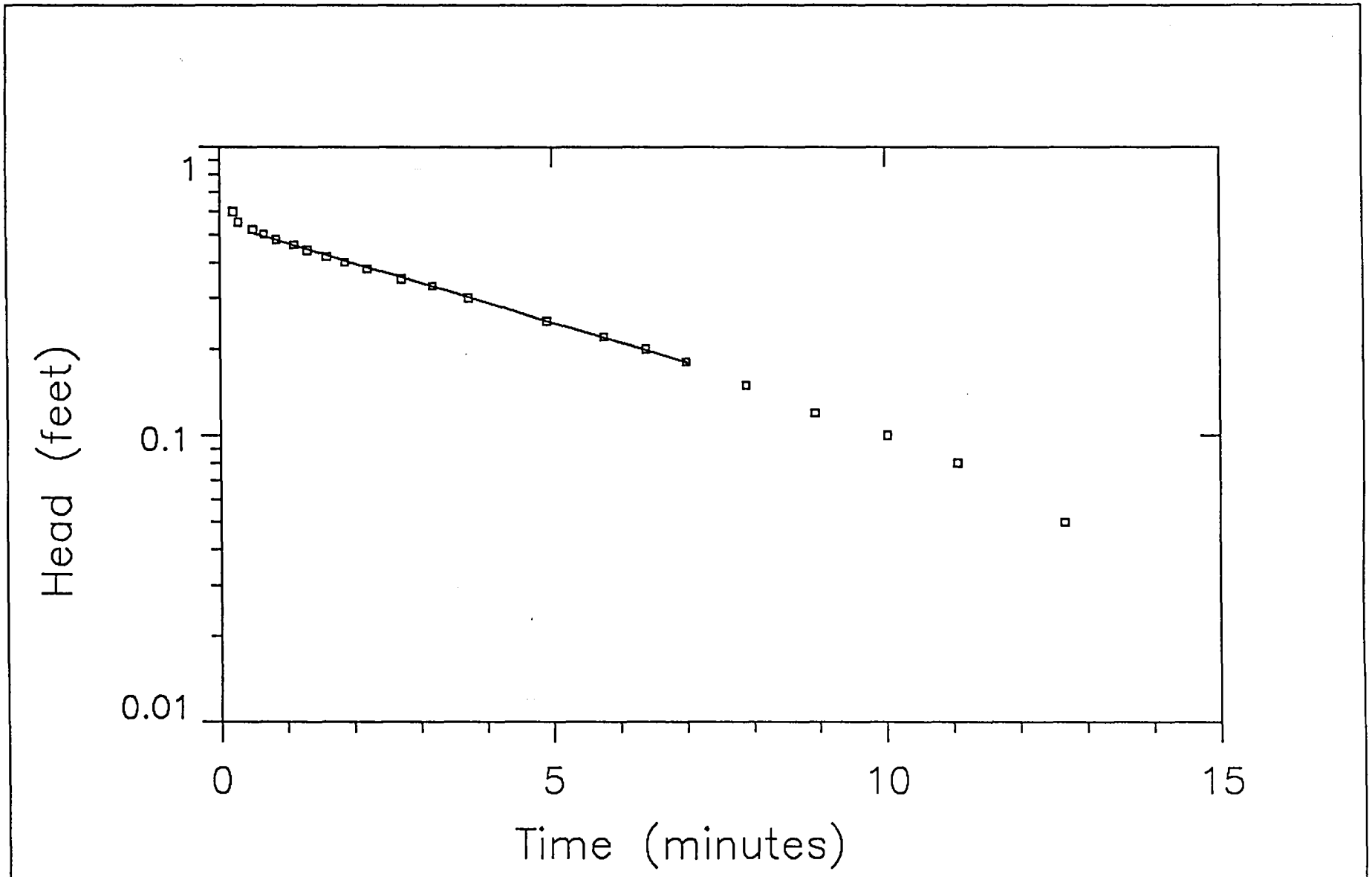
TRANSMISSIVITY: 48.77488square ft/day

CONDUCTIVITY: 2.69474 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.200	0.600		
2	0.283	0.550		
3	0.500	0.520	0.505	2.70
4	0.667	0.500	0.492	1.46
5	0.850	0.480	0.478	0.310
6	1.11	0.460	0.458	0.306
7	1.31	0.440	0.444	-0.957
8	1.60	0.420	0.424	-1.10
9	1.88	0.400	0.405	-1.48
10	2.21	0.380	0.384	-1.28
11	2.73	0.350	0.354	-1.29
12	3.20	0.330	0.329	0.265
13	3.73	0.300	0.302	-0.780
14	4.91	0.250	0.250	-0.153
15	5.76	0.220		
16	6.40	0.200		
17	7.00	0.180		
18	7.90	0.150		
19	8.93	0.120		
20	10.01	0.1000		
21	11.06	0.0800		
22	12.66	0.0500		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 2.694 ft/day	by: Groundwater Technology, Inc.	
TRANSMISSIVITY: 48.77 sq. ft/day	WELL DATA: Units: ft	Well: MW-51
INITIAL HEAD: .7200 ft	AQUIFER: Endless	NAVAL BASE
	THICKNESS: 18.10	NORFOLK, VA
Data Set: PIERS51 / Date: 12 JULY 94	SCREEN: top: 6.800 base: 24.90	
	DIAMETER: casing: .5620 Intake: .8340	
	DEPTH: Water Table: 6.800 TD: 24.90	

DATA SET: PIERS52

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-52
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.88 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.520 ft
AQUIFER:	Endless	THICKNESS:	18.36 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.520 ft	SCREEN BASE:	24.88 ft
INITIAL HEAD:	0.750 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: 92.88194square ft/day

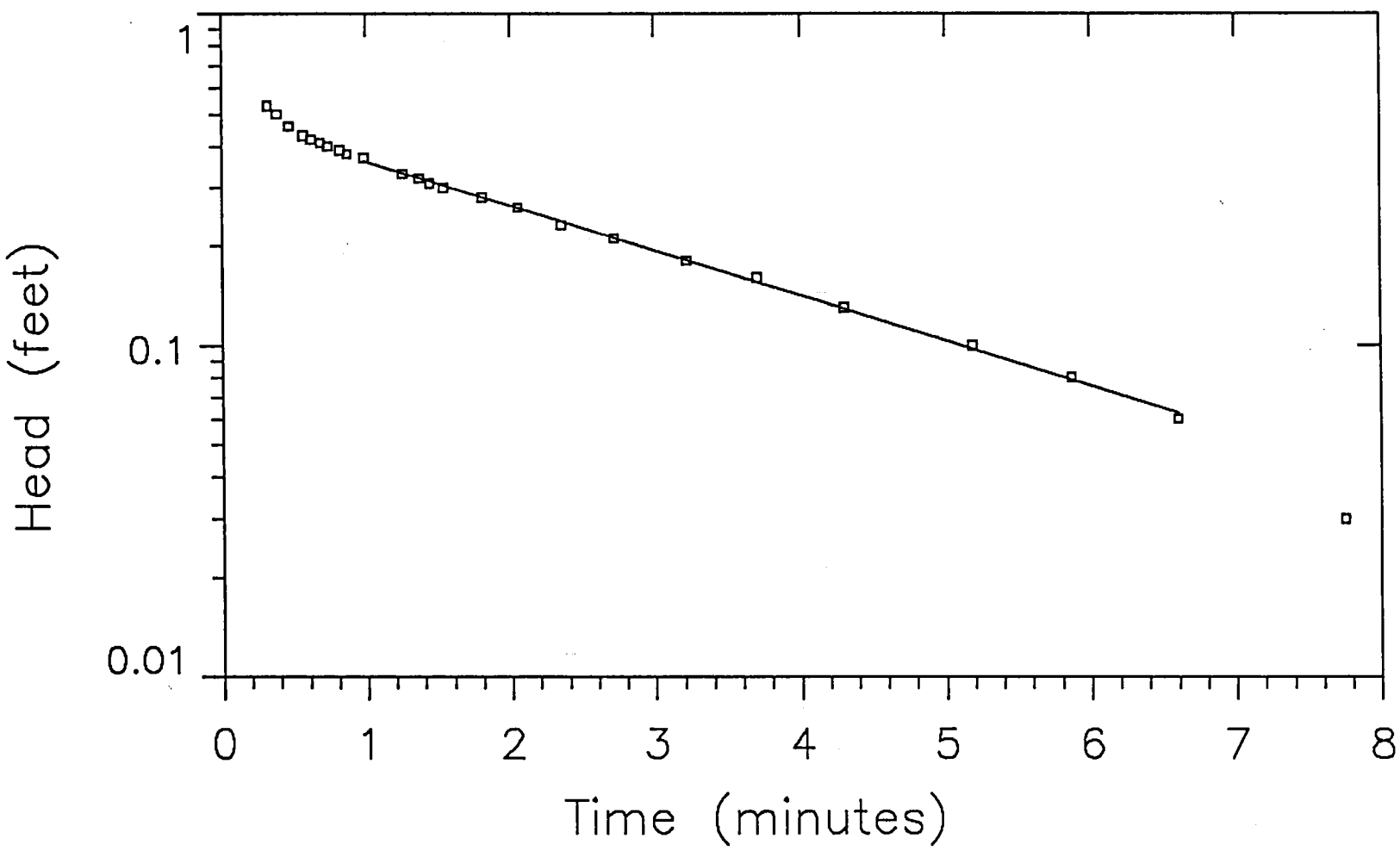
CONDUCTIVITY: 5.05893 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.317	0.530		
2	0.383	0.500		
3	0.467	0.460		
4	0.567	0.430		
5	0.617	0.420		
6	0.684	0.410		
7	0.733	0.400		
8	0.817	0.390		
9	0.867	0.380		
10	0.983	0.370	0.361	2.29
11	1.25	0.330	0.332	-0.791
12	1.36	0.320	0.320	-0.217
13	1.44	0.310	0.313	-1.12
14	1.53	0.300	0.304	-1.50
15	1.80	0.280	0.280	-0.0675
16	2.05	0.260	0.259	0.317
17	2.35	0.230	0.236	-2.62
18	2.71	0.210	0.210	-0.240
19	3.21	0.180	0.180	-0.0638
20	3.70	0.160	0.154	3.16
21	4.30	0.130	0.128	1.15
22	5.18	0.1000	0.0975	2.46
23	5.86	0.0800	0.0788	1.46

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
24	6.60	0.0600	0.0627	-4.53
25	7.75	0.0300		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 5.059 ft/day	by: Groundwater Technology, Inc.	
TRANSMISSIVITY: 92.88 sq. ft/day	WELL DATA: Units: ft	Well: MW-52
INITIAL HEAD: .7500 ft	AQUIFER: Endless	NAVAL BASE
	THICKNESS: 18.36	NORFOLK, VA
Data Set: PIERS52 / Date: 12 JULY 94	SCREEN: top: 6.520 base: 24.88	
	DIAMETER: casing: .5620 Intake: .8340	
	DEPTH: Water Table: 6.520 TD: 24.88	

DATA SET: PIERS53

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-53
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.83 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.960 ft
AQUIFER:	Endless	THICKNESS:	17.87 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.960 ft	SCREEN BASE:	24.83 ft
INITIAL HEAD:	1.030 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: 110.11537square ft/day

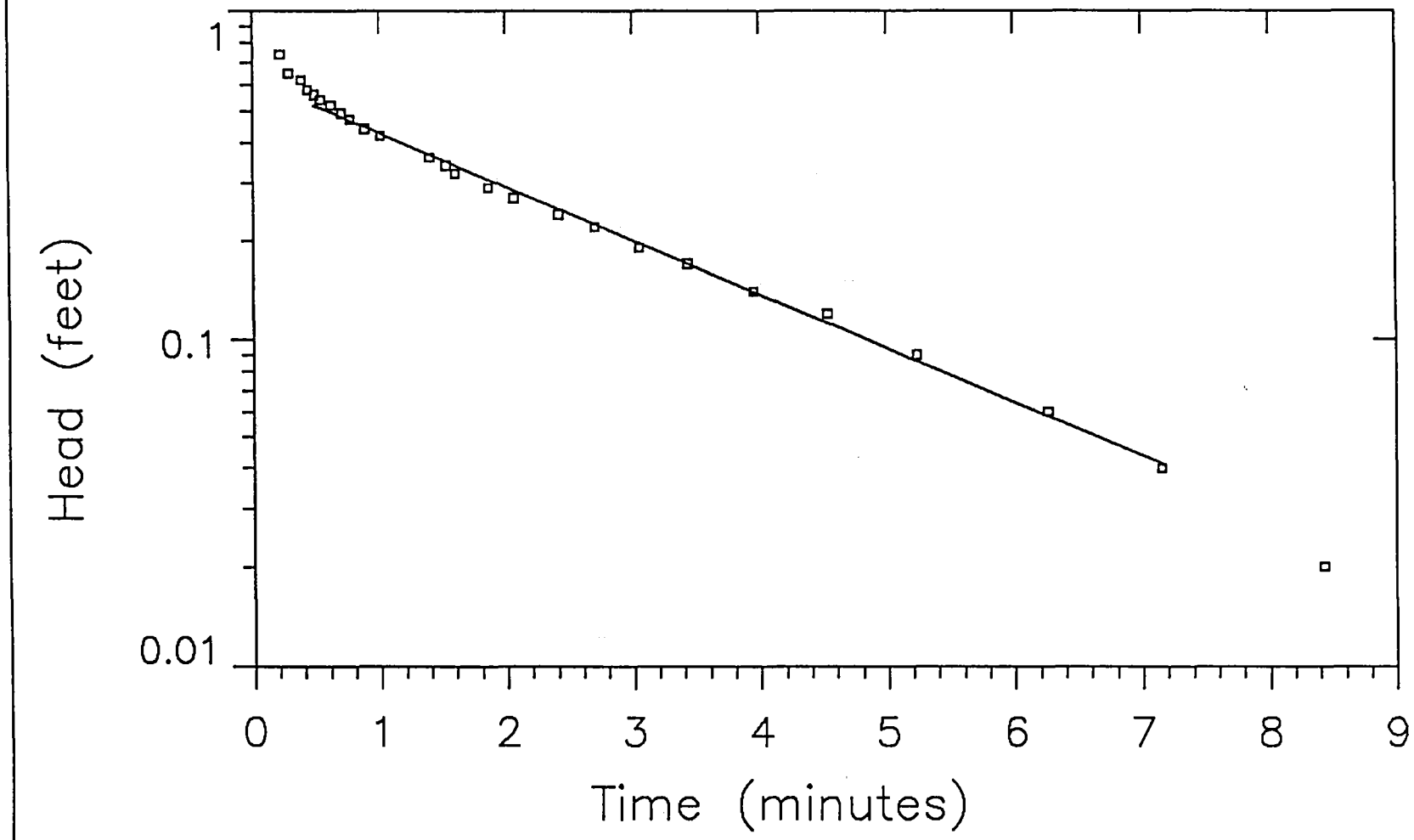
CONDUCTIVITY: 6.16202 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	Head, H (ft) SYNTHETIC	DIFFERENCE (percent)
1	0.217	0.740		
2	0.283	0.650		
3	0.383	0.620		
4	0.433	0.580		
5	0.484	0.560	0.519	7.31
6	0.533	0.540	0.509	5.65
7	0.617	0.520	0.493	5.09
8	0.700	0.490	0.478	2.40
9	0.767	0.470	0.466	0.804
10	0.883	0.440	0.446	-1.39
11	1.01	0.420	0.425	-1.23
12	1.40	0.360	0.366	-1.86
13	1.53	0.340	0.349	-2.67
14	1.60	0.320	0.339	-6.23
15	1.86	0.290	0.308	-6.21
16	2.06	0.270	0.285	-5.75
17	2.41	0.240	0.250	-4.18
18	2.70	0.220	0.224	-1.81
19	3.05	0.190	0.196	-3.24
20	3.43	0.170	0.169	0.0975
21	3.95	0.140	0.139	0.400
22	4.53	0.120	0.111	6.74
23	5.23	0.0900	0.0858	4.64

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
24	6.26	0.0600	0.0580	3.21
25	7.15	0.0400	0.0414	-3.59
26	8.43	0.0200		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 6.162 ft/day	by: Groundwater Technology, Inc.	Well: MW-53
TRANSMISSIVITY: 110.1 sq. ft/day	WELL DATA: Units: ft	NAVAL BASE
INITIAL HEAD: 1.030 ft	AQUIFER: Endless	NORFOLK, VA
Data Set: PIERS53 / Date: 12 JULY 94	THICKNESS: 17.87	
	SCREEN: top: 6.960 base: 24.83	
	DIAMETER: casing: .5620 intake: .8340	
	DEPTH: Water Table: 6.960 TD: 24.83	

DATA SET: PIERS57

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	12 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-57
COUNTY:	NORFOLK, VA	WELL DEPTH:	24.28 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	5.590 ft
AQUIFER:	Endless	THICKNESS:	24.28 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	5.590 ft	SCREEN BASE:	24.28 ft
INITIAL HEAD:	1.500 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

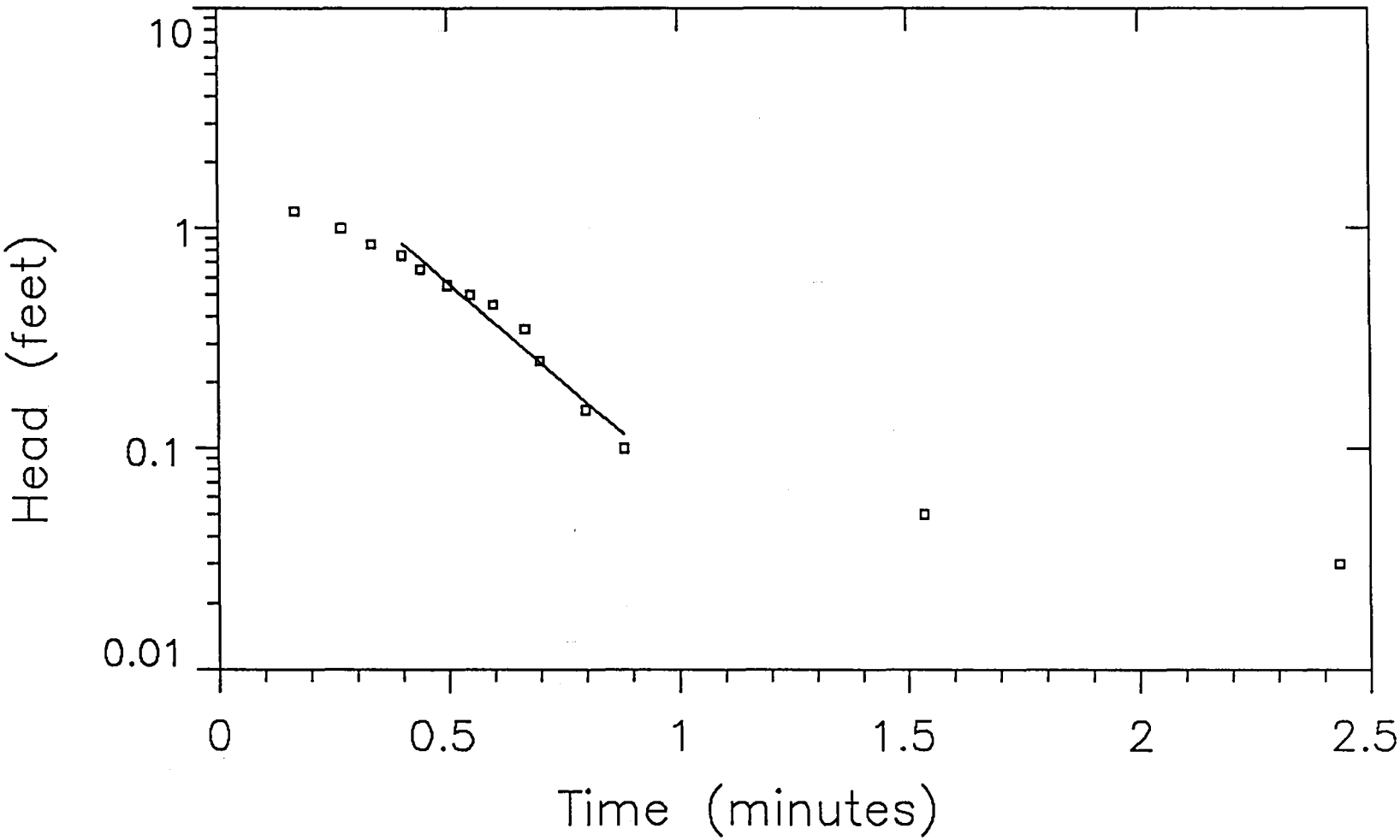
TRANSMISSIVITY: 563.76715square ft/day

CONDUCTIVITY: 23.21940 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	Head, H (ft) SYNTHETIC	DIFFERENCE (percent)
1	0.167	1.20		
2	0.267	1.00		
3	0.333	0.850		
4	0.400	0.750	0.855	-14.05
5	0.440	0.650	0.724	-11.50
6	0.500	0.550	0.565	-2.77
7	0.550	0.500	0.459	8.10
8	0.600	0.450	0.373	17.00
9	0.667	0.350	0.282	19.15
10	0.700	0.250	0.246	1.28
11	0.800	0.150	0.163	-8.71
12	0.883	0.1000	0.115	-15.61
13	1.53	0.0500		
14	2.43	0.0300		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE	for: LANTDIV NAVFACENGCOM	PIERS PROJECT
CONDUCTIVITY: 23.22 ft/day	by: Groundwater Technology, Inc.	
TRANSMISSIVITY: 563.7 sq. ft/day	WELL DATA: Units: ft	Well: MW-57
INITIAL HEAD: 1.500 ft	AQUIFER: Endless	NAVAL BASE
Data Set: PIERS57 / Date: 12 JULY 94	THICKNESS: 24.28	NORFOLK, VA
	SCREEN: top: 5.590 base: 24.28	
	DIAMETER: casing: .5620 Intake: .8340	
	DEPTH: Water Table: 5.590 TD: 24.28	

DATA SET: PIERS64

CLIENT:	LANTDIV NAVFACENGCOM	DATE:	13 JULY 94
LOCATION:	NAVAL BASE	WELL NO.:	MW-64
COUNTY:	NORFOLK, VA	WELL DEPTH:	13.63 ft
PROJECT:	PIERS PROJECT	WATER TABLE:	6.320 ft
AQUIFER:	Endless	THICKNESS:	7.31 ft
INTAKE RADIUS:	0.417 ft	CASING RADIUS:	0.281 ft
SCREEN TOP:	6.320 ft	SCREEN BASE:	13.63 ft
INITIAL HEAD:	0.513 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

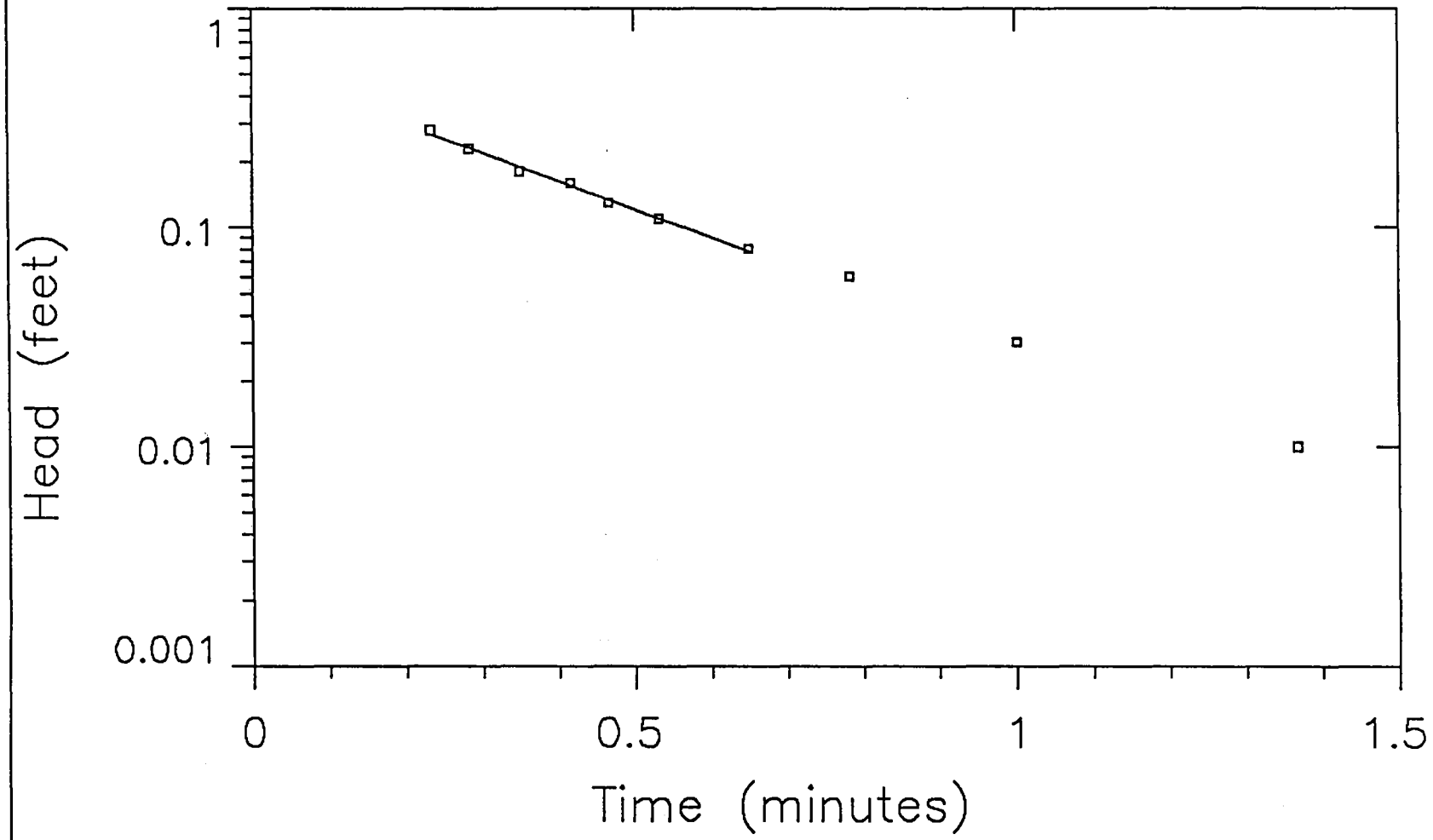
TRANSMISSIVITY: 347.84113square ft/day

CONDUCTIVITY: 47.58429 ft/day

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.233	0.280	0.268	4.19
2	0.283	0.230	0.231	-0.594
3	0.350	0.180	0.189	-5.42
4	0.417	0.160	0.155	2.72
5	0.467	0.130	0.134	-3.25
6	0.533	0.110	0.110	-0.377
7	0.650	0.0800	0.0781	2.36
8	0.783	0.0600		
9	1.00	0.0300		
10	1.36	0.01000		

CURRENT RESOLUTION MATRIIX NOT AVAILABLE



MODEL TYPE: BOUWER and RICE

CONDUCTIVITY: 47.58 ft/day

TRANSMISSIVITY: 347.8 sq. ft/day

INITIAL HEAD: .5130 ft

Data Set: PIERS64

Date: 13 JULY 94

for: LANTDIV NAVFACENGCOM

by: Groundwater Technology, Inc.

WELL DATA: Units: ft

AQUIFER: Endless

THICKNESS: 7.310

SCREEN: top: 6.320 base: 13.63

DIAMETER: casing: .5620 Intake: .8340

DEPTH: Water Table: 6.320 TD: 13.63

PIERS PROJECT

Well: MW-64

NAVAL BASE

NORFOLK, VA

APPENDIX F

Geophysical Report

VERTICAL INDUCTION PROFILING
GEOPHYSICAL SURVEY
NORFOLK NAVAL PIERS SITE
NORFOLK, VIRGINIA

Prepared for:

Groundwater Technology Government Services, Inc.
1244-B Executive Boulevard, Suite 106
Chesapeake, Virginia 23320

October 6, 1994

Prepared by:

North American Exploration of Virginia, Inc.
Post Office Box 7584
Charlottesville, Virginia 22906
(804) 973-4328
(804) 973-9791 Fax

INTRODUCTION

Groundwater Technology Government Services, Inc. (GSI) requested North American Exploration of Virginia, Inc. (NAEVA) to conduct a vertical induction profiling (VIP) geophysical survey at the Norfolk Naval Piers Site, Norfolk, Virginia. The objective of the survey was to locate areas in the subsurface with anomalously high electrical resistivities, indicating the potential presence of petroleum hydrocarbon contaminants.

VIP METHODOLOGY

VIP surveys are conducted as follows: A transmitter coil is placed on the surface, which generates a primary, alternating electromagnetic field. For each well, a receiver coil is configured in a slim hole probe allowing data collection from a 2" diameter, or greater, PVC cased hole. A profile is measured by raising a receiver coil in a nearby monitor well at a slow rate and recording voltages induced by the primary and secondary electromagnetic fields. The signal profile at the receiver probe may be interpreted as a "relative resistivity" log of the section below the transmitter and receiver. Changes in resistivity may indicate the presence of hydrocarbon contaminants, salt water, buried metals, and changes in lithology, etc. The effective depth "profiled" is from 1 foot above the bottom of the hole to 4 feet from surface.

SITE AND SURVEY CONFIGURATION

The area of investigation, as defined by GSI at the pre-proposal conference, was a rectangular area approximately 650 feet north-south by 250 feet east-west as shown in Figure 1.

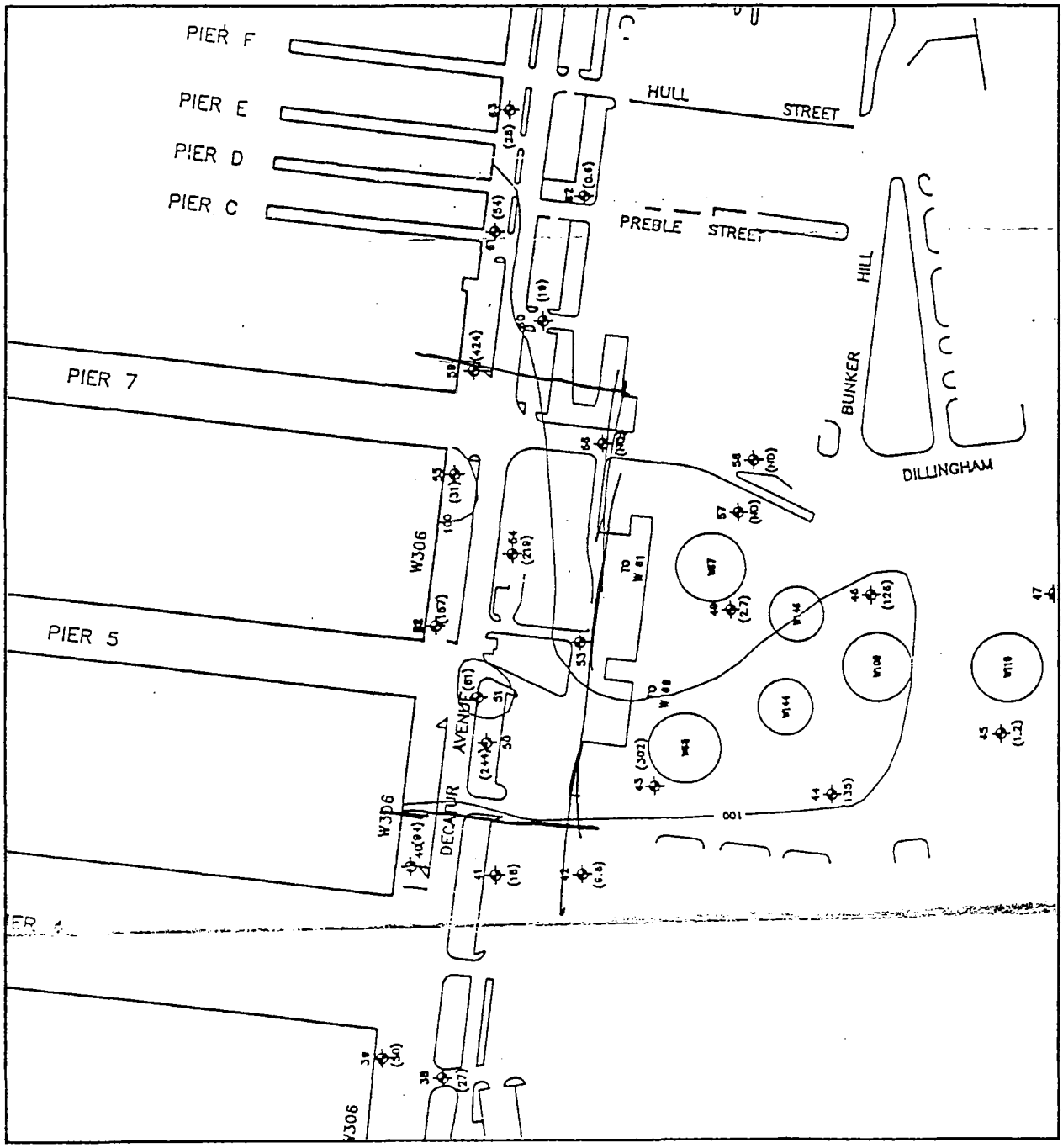


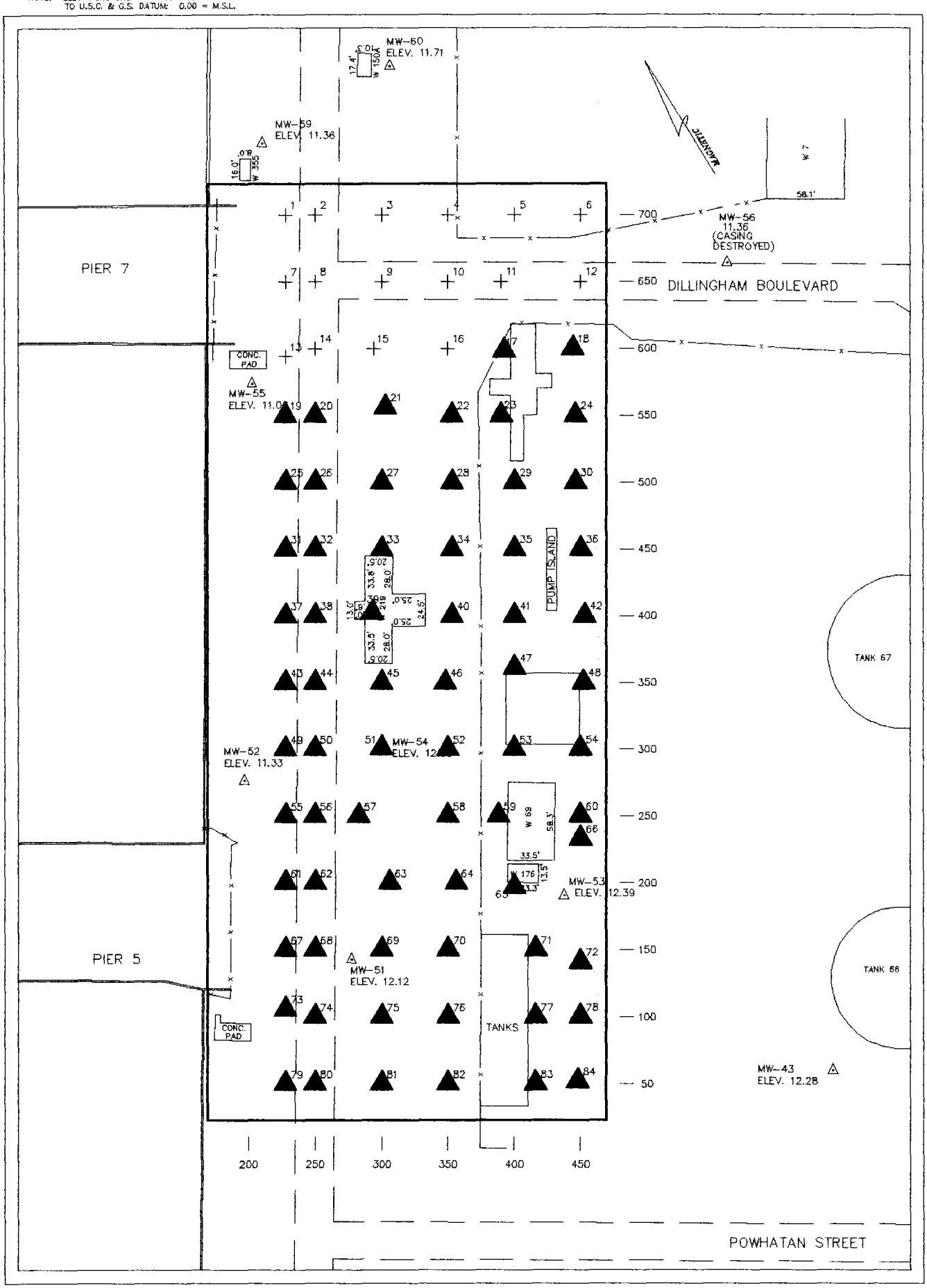
Figure 1: Area of Investigation

A grid was established over the area of investigation on a 50-foot by 50-foot spacing, centered on monitor well (MW) 54, which was designated with grid coordinates 300 EAST (X) and 300 NORTH (Y). The grid was oriented to be parallel with the edge of the wharf, west of the monitor well. Locations of the monitor wells and significant landmarks such as roads and buildings were surveyed and provided to NAEVA by GSI. This was the basis for the generation of the site plan on which the grid points are located. Each grid station was a transmitter site, and 84 sites were established to cover the area of investigation. These sites were given number designations as shown in the site plan. Some transmitter sites had to be offset in the field from the ideal coordinates due to cultural features such as buildings, parked cars, etc. In other cases, during data collection the transmitter sites may have been offset again to attempt to avoid interference from subsurface metallic or electrical features. The actual coordinates for each transmitter station are listed in Appendix A.

Waste Microbes, Inc. was subcontracted to provide the necessary equipment and operator to collect the raw data. They have conducted approximately 20 VIP surveys previously. Typically, data can be collected at a receiver in a monitor well to a maximum distance of 250 to 300 feet from the surface transmitter. Data collection was initiated at MW-54 and transmitter sites were occupied north, south, and west of this well. In many cases, to ensure the collection of valid electromagnetic readings, the site was logged more than once to confirm repeatability. In general, signal strength was good and the data appeared repeatable. Electrical interference was encountered at several sites in front of pier 5 on line 200E which caused repeatability problems. Consequently, the sites were offset 28 feet east to the edge of the road and the sites were relogged. Thus the 200E line was continued north at 228E to avoid further interference.

Some problems were encountered when logging sites east and southeast of MW-54, where signal strength appeared abnormally low. These sites were relogged from MW-53 after moving there in order to log site 51 (MW-54). Data collected at sites from MW-53 were repeatable although several sites north of MW-53 had abnormal curves, suggesting the presence of strong conductors between the transmitter and receiver, probably due to underground pipelines or powerlines.

After completion of logging from MW-53, the receiver was moved to MW-60 to complete the logging of the stations at the north end of the property. MW-55 and MW-59 were not useable due to the lack of an accessible AC power source near these wells. Data collected using transmitter stations from MW-60 were found, in general, to be erratic with repeatability problems. Repeated attempts were made to collect valid data at many of these sites. Various equipment checks were also conducted in several instances and all was found to be in proper working order. Significant variations in the received electrical voltages were even encountered with the receiver probe stationary, whether the transmitter was energized or not. The conclusion was that significant and sporadic electrical interference from outside sources such as powerlines, telephone cables, radio and radar transmissions was occurring. These fluctuations were so dramatic at some transmitter sites that logging could not be completed. The data collected from the north end of the survey were used but required extensive editing and should be viewed with a lesser degree of confidence. Figure 2 indicates which transmitter stations were logged from each monitor well.



GRAPHIC SCALE

(IN FEET)
1 inch = 100 ft.

SITES LOGGED FROM:

MW-60

MW-53

MW-54

NORFOLK NAVAL BASE PIERS
NORFOLK, VIRGINIA

Figure 2: Transmitter Stations by Monitor Well Receiver Locations

DATA ANALYSIS

Editing of Raw Data

Raw profile data (mv) were plotted on linear and semi-log scales and inspected. Where more than one profile was recorded for the same transmitter site, repeatability was verified. Obvious noise "spikes" or gaps in the profiles were corrected manually by interpolation, where necessary, in order to avoid spurious relative resistivity responses.

During surveying in the northern part of the area (from MW-60), a different type of disturbance was noted. Profiles were offset abruptly $\pm$ approx. 0.01-0.02 millivolts, at random intervals. This problem persisted despite numerous attempts to measure undisturbed profiles. In order to avoid loss of coverage in the northern portion, these dislocated segments of the profiles were corrected using a scaling factor as seemed appropriate, at sites 2, 3, 7, 9, 10, 11, 12, 14, 15, and 16.

Data Processing

Edited field data (mv) files were sent to Mr. Ron Bell of Earth 'n' Ware, Inc. for processing using computer software originally developed by Earth 'n' Ware in cooperation with Dr. James Pritchard in the early 1990's. The sequence of steps involved in this software is described more particularly in a memorandum by Mr. Bell (Appendix B). Note that several steps, involving the calculation of "resistivity" and the "circuit correction" are only described in general terms, because they are proprietary. Mr. Bell has considerable experience processing VIP data for Waste Microbes, Inc. and others.

The processed profiles, expressed as "relative resistivity" units, are presented in north-south fence diagrams and as color coded 2-D and 3-D graphical plots. It should be noted that "relative resistivity" is not the same as actual resistivity measured in units of ohm-meters.

VIP SURVEY RESULTS

Presentation of Results

The results of the VIP downhole EM survey are presented in two ways. Firstly, a series of north-south "fences" or vertical cross-sections between 228E and 450E are enclosed in Appendix C. Each section shows the VIP relative resistivity profiles as calculated by Earth 'n' Ware for each transmitter site, with color-coded contours superimposed. Blue and green colors denote low relative resistivity response (0-30), while yellow, orange, red, and purple denote higher values. More detailed fence diagrams (1"=50') are also enclosed in a back pocket to this report.

Survey results are also presented in Appendix D as a series of color-coded 2-D and 3-D diagrams generated by Dynamic Graphics, Inc., using Earth 'n' Ware's processed data base. These diagrams include the following types of images:

1) One profile location, an oblique 3-D image.

2) Five 2-D horizontal cuts at depths of 6', 10', 15', 17', and 20', as requested, with an extended cultural overlay of surface features including piers, tanks, roads, and buildings (to aid in visual orientation).

3) Four 3-D images, looking almost straight down, showing the envelopes of the +10, +20, +30, and +40 relative resistivity unit contour surfaces. These also carry the extended cultural overlay.

No resistivity decrease at or below the water table is apparent. This is surprising, because the groundwater at the site is reportedly brackish (actual salinity not mentioned in the Versar site report), and the dissolved phase contamination is described as "low". It is doubtful that the deep relative resistivity features are related to weak dissolved phase hydrocarbons since free product was not detected at the water table.

Stratigraphic logs from numerous borings show mostly sands, with minor silt, clay, and gravel, and no systematic increase in more resistive units downward. This could be confirmed by obtaining actual electrical or induction resistivity logs from the monitor wells directly. Higher relative resistivity features at depth may be an artifact of the VIP data processing algorithms, which do not compensate for the geometry of the dipolar field which decreases with depth in the monitor well. Normalizing the field data with respect to the primary field might reduce the deep relative resistivity features, but would probably not develop any shallow anomalies correlative with a free product plume.

It is important to keep in mind that the VIP or "offset induction logging" method of downhole EM data analysis is recently developed. The algorithm for calculating relative resistivity response is proprietary, and important details are un-disclosed. It has not been subjected to peer review through publication. The dimensional units of relative resistivity are not specified. It is not clear how secondary fields are separated from the primary transmitted field (especially since phase is not measured), or exactly what aspects of the secondary field variations produce relative resistivity anomalies. Finally, it is probable that secondary fields arising from surface conductors or magnetization also contribute to the computed relative resistivity response (near surface or at depth). Therefore, it is probably best not to base

remediation plans solely on VIP data, without corroborating data from other investigations on site.

APPENDIX A

Transmitter Stations

With

Grid Coordiantes

TRANSMITTER STATIONS WITH GRID COORDINATES

Station #	East X	North Y	Station #	East X	North Y
1	228	700	43	228	350
2	250	700	44	250	350
3	300	700	45	300	350
4	350	700	46	348	350
5	400	700	47	400	361
6	450	700	48	452	350
7	228	650	49	228	300
8	250	650	50	250	300
9	300	650	51	300	300
10	350	650	52	350	300
11	390	650	53	400	300
12	450	650	54	450	300
13	228	594	55	228	250
14	250	600	56	250	250
15	296	600	57	283	250
16	350	600	58	350	250
17	392	598	59	388	250
18	444	600	60	450	250
19	228	550	61	228	200
20	250	550	62	250	200
21	303	556	63	306	200
22	353	550	64	356	200
23	390	550	65	400	197
24	446	550	66	450	233
25	228	500	67	228	150
26	250	500	68	250	150
27	300	500	69	300	150
28	353	500	70	350	150
29	400	500	71	416	150
30	446	500	72	450	141
31	228	450	73	228	106
32	250	450	74	250	100
33	300	450	75	300	100
34	353	450	76	350	100
35	400	450	77	416	100
36	450	450	78	450	100
37	228	400	79	228	50
38	250	400	80	250	50
39	293	402	81	300	50
40	353	400	82	350	50
41	400	400	83	416	50
42	453	400	84	448	52

APPENDIX B

VIP Data Processing

Procedure

Earth'N'Ware, Inc.
P.O. Box 10618, Golden, CO 80401-0618
TEL: (303)237-9891 FAX: (303)237-9892

MEMORANDUM

September 19, 1994

to: Hunter Ware / John Allan
North American Exploration, Inc.

from: Ron Bell

ref: VIP Data Processing / Norfolk Naval Base

Following are the processing steps applied to the data from Norfolk:

1) 7 point median filter
2) resample to .25 ft interval
3) flipped data
4) calculate Apparent Resistivity (Pritchard's Terminology)
I believe the formula to be:

$$\mathbf{RHOA = -1*\log_{10}(1/x^2)}$$

4) Normalize by the average of the entire log.
5) Take antilog

basic processing
6) make circuit correction
7) apply 3 pt average filter
8) create data file: RHO1.DAT

basic processing with filter
6) apply 5pt average filter.
7) make circuit correction
8) apply 3 pt average filter
9) create data file: RHO2.DAT

APPENDIX C

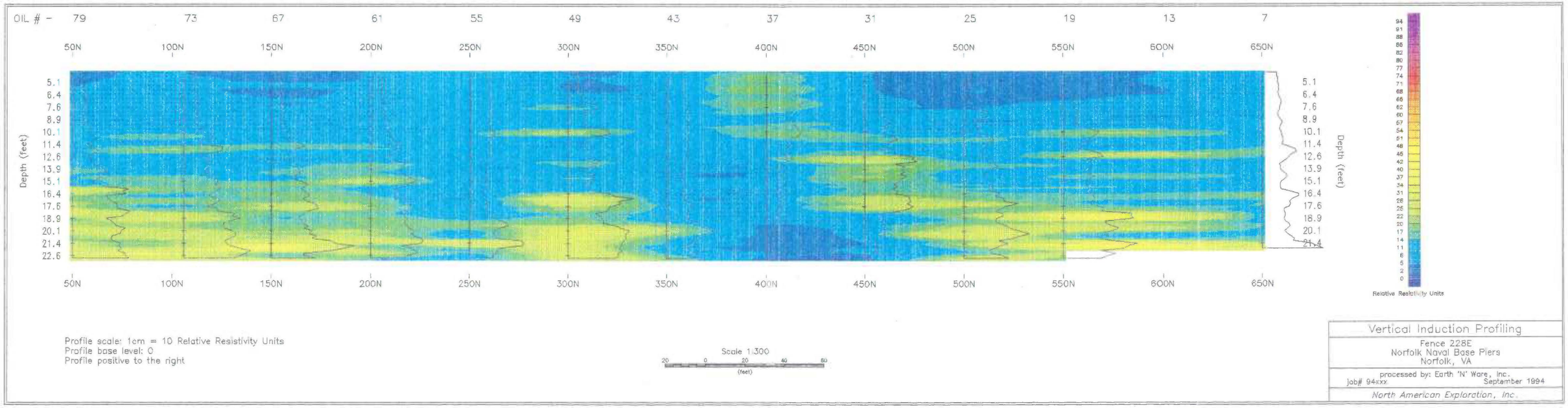
North-South Fence

Diagrams Showing

Relative Resistivity Profiles

And

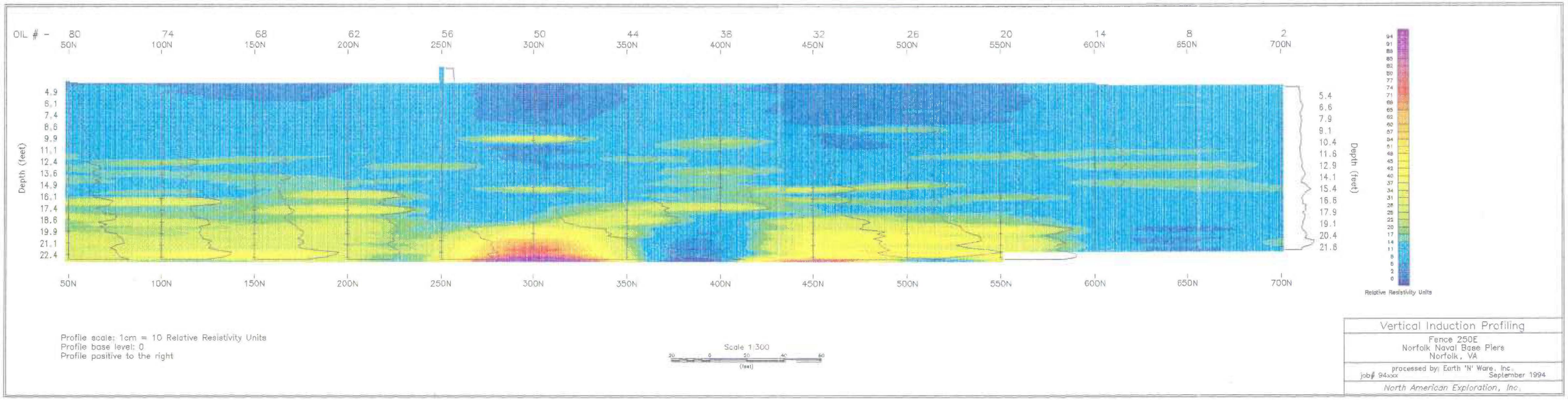
Color Contours

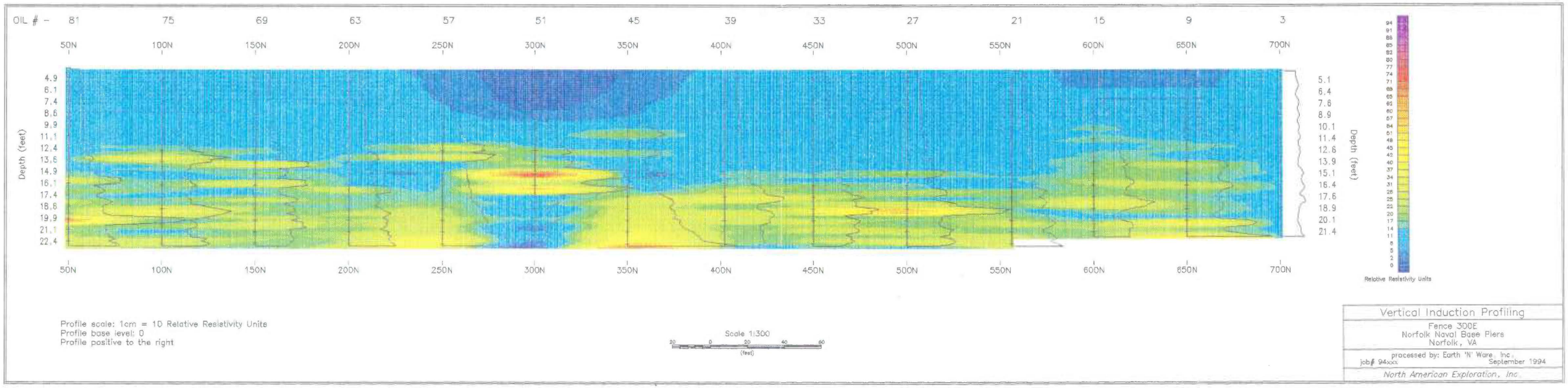


FENCE DIAGRAMS REDUCED TO

1:600

1cm=20 relative resistivity units

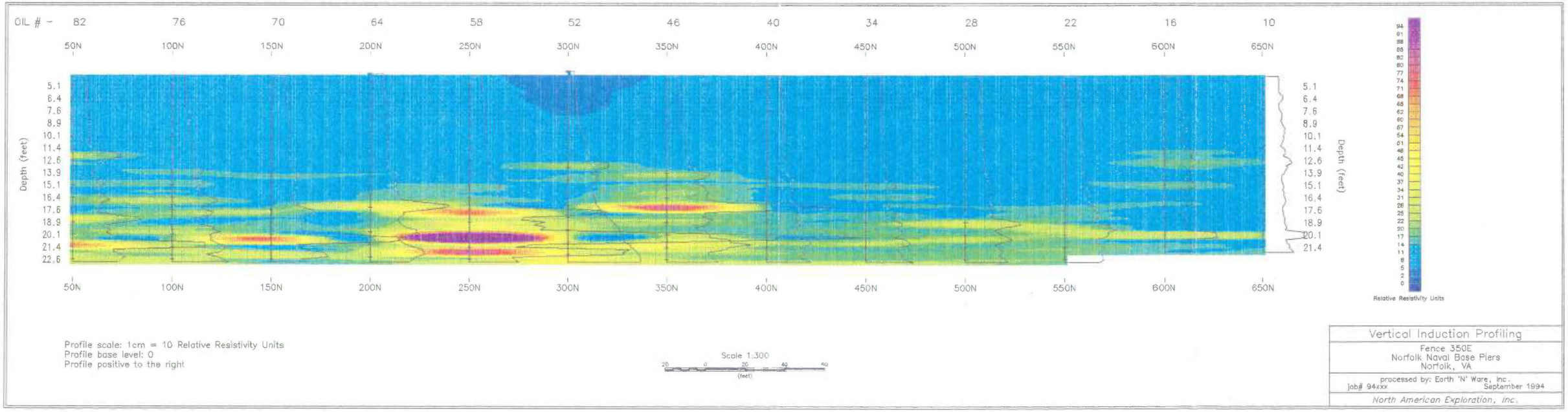


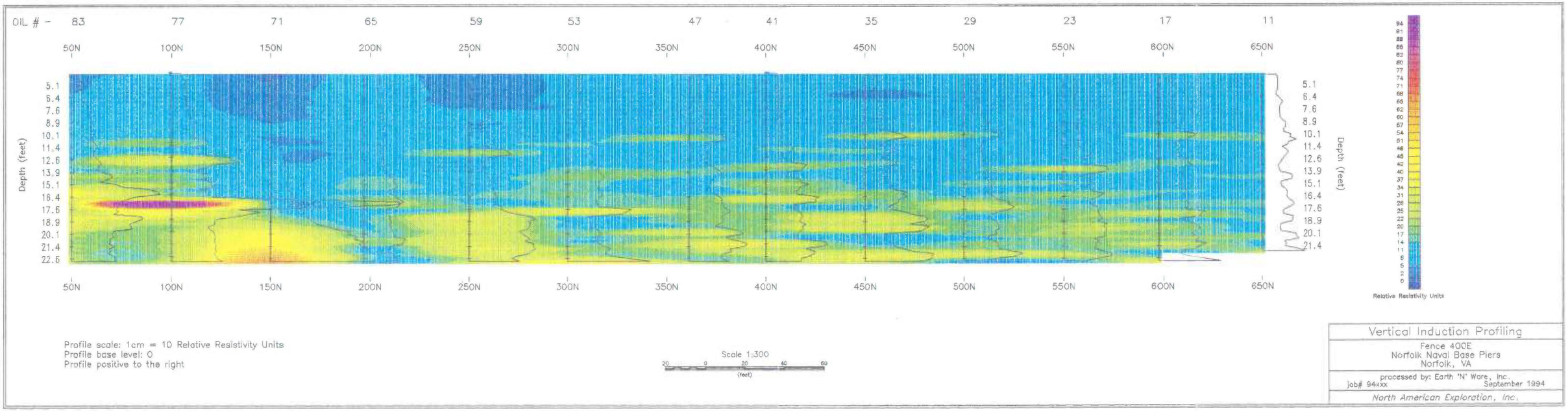


FENCE DIAGRAMS REDUCED TO

1:600

1cm=20 relative resistivity units

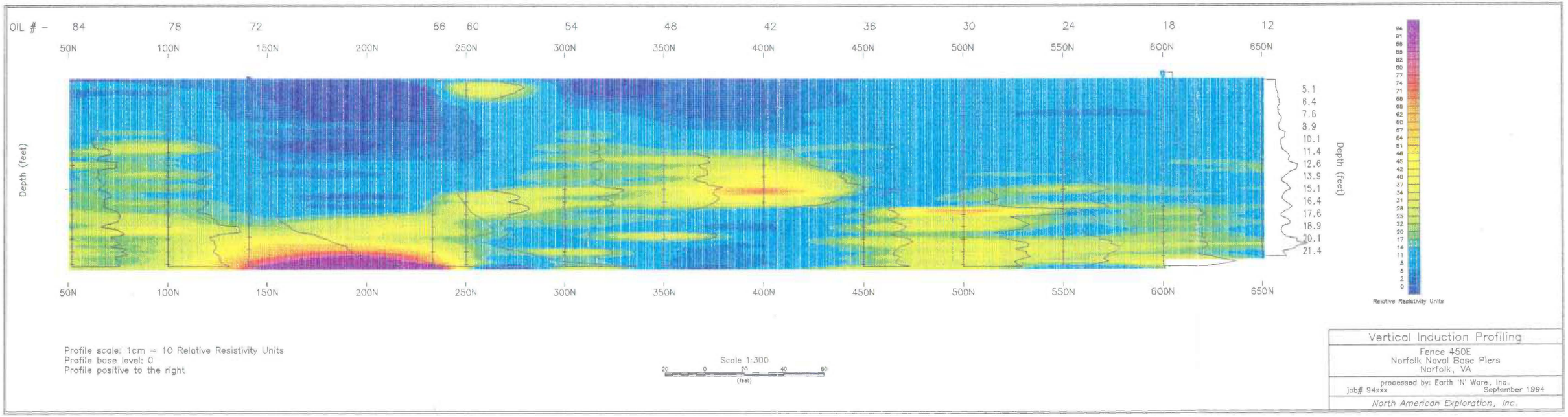




FENCE DIAGRAMS REDUCED TO

1:600

1cm=20 relative resistivity units



APPENDIX D

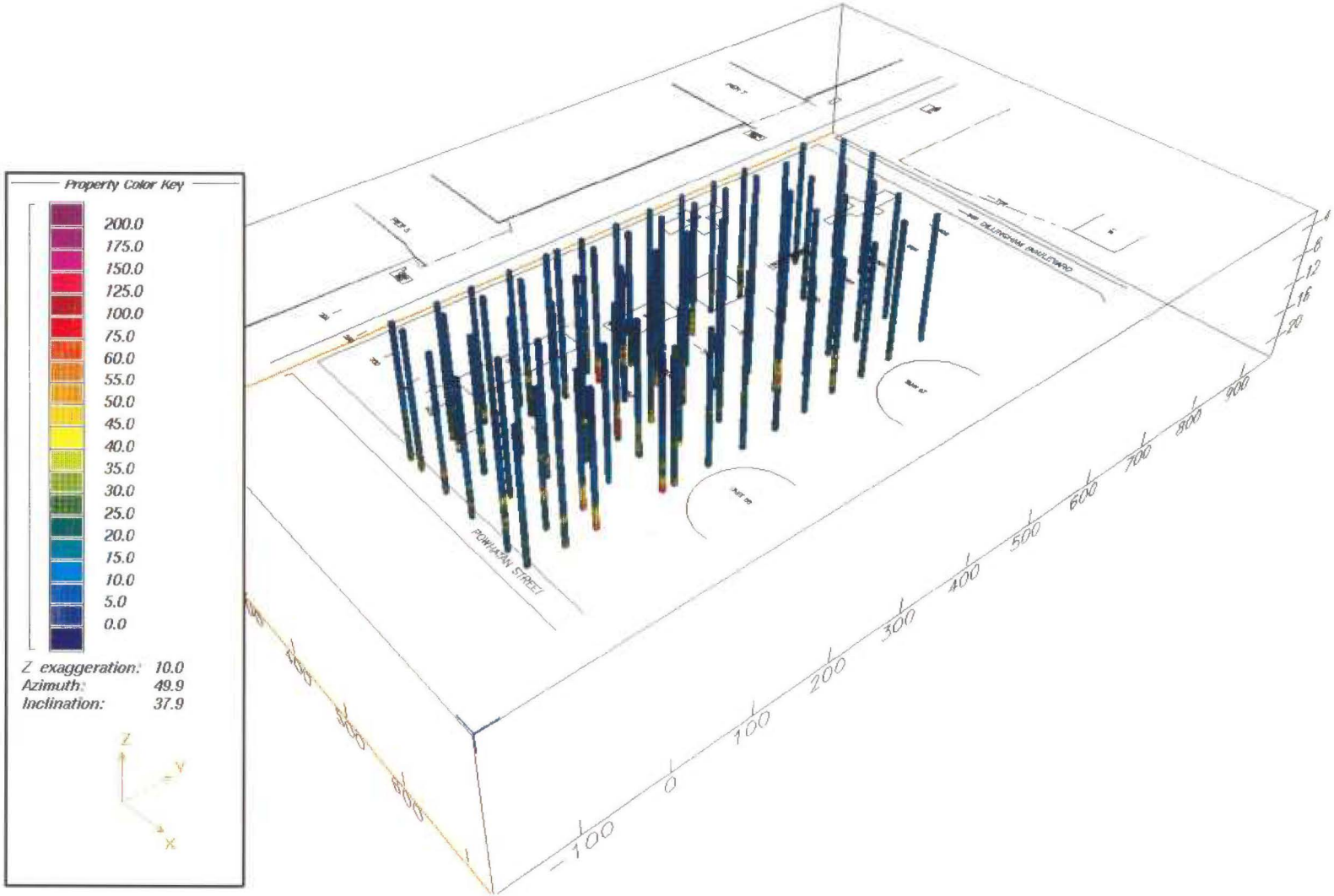
Color-Coded

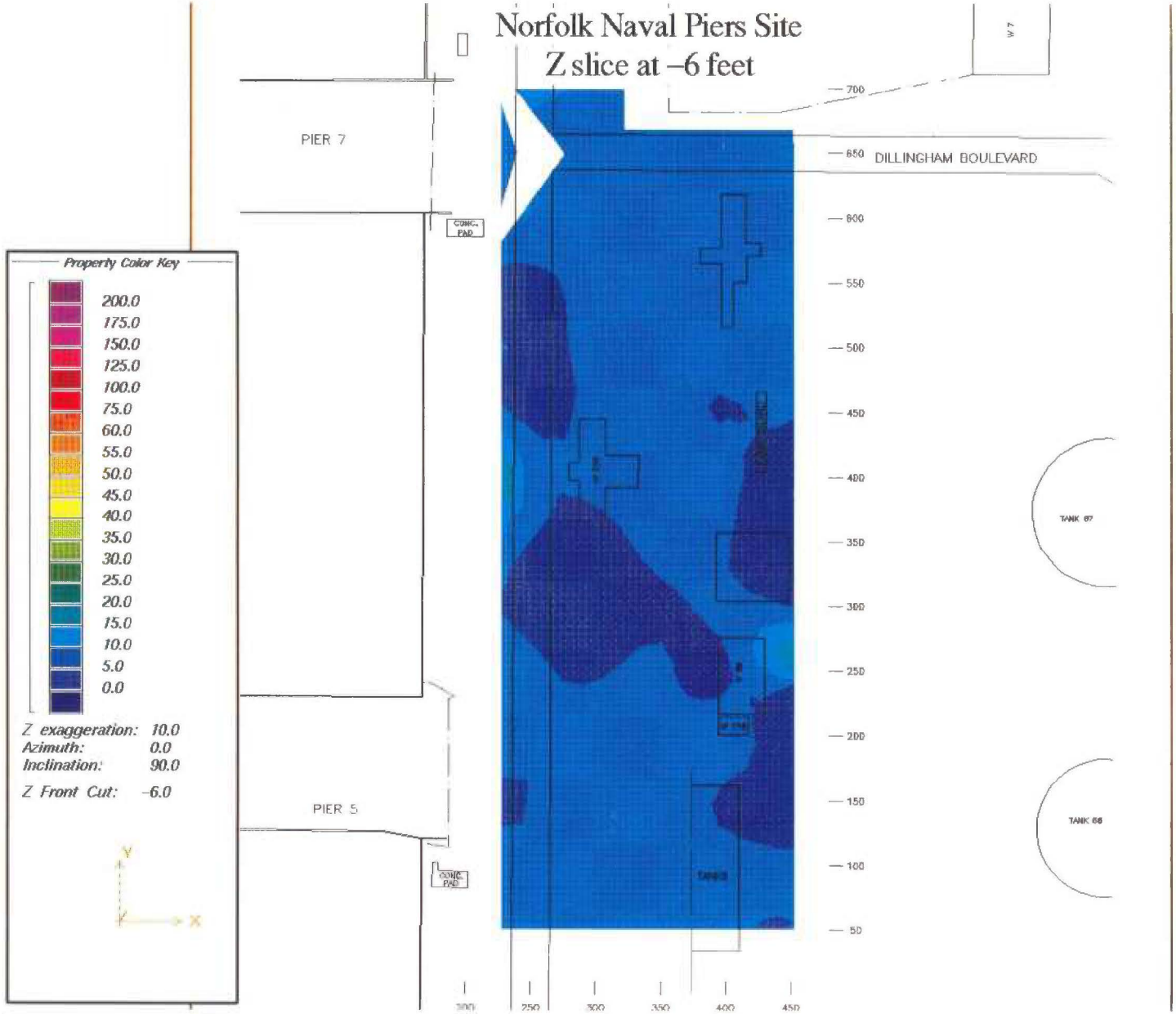
2-D and 3-D

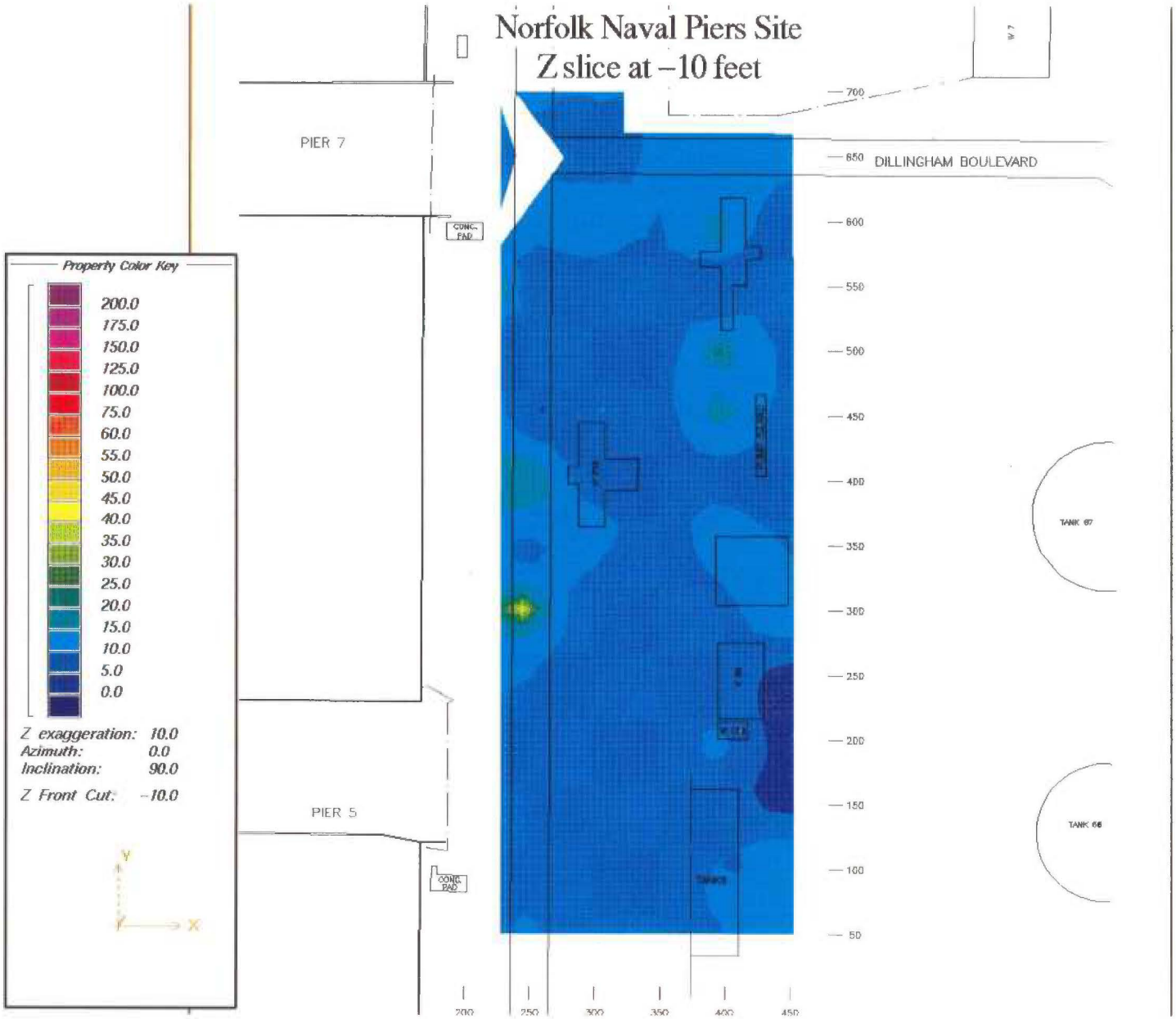
Graphic Images of

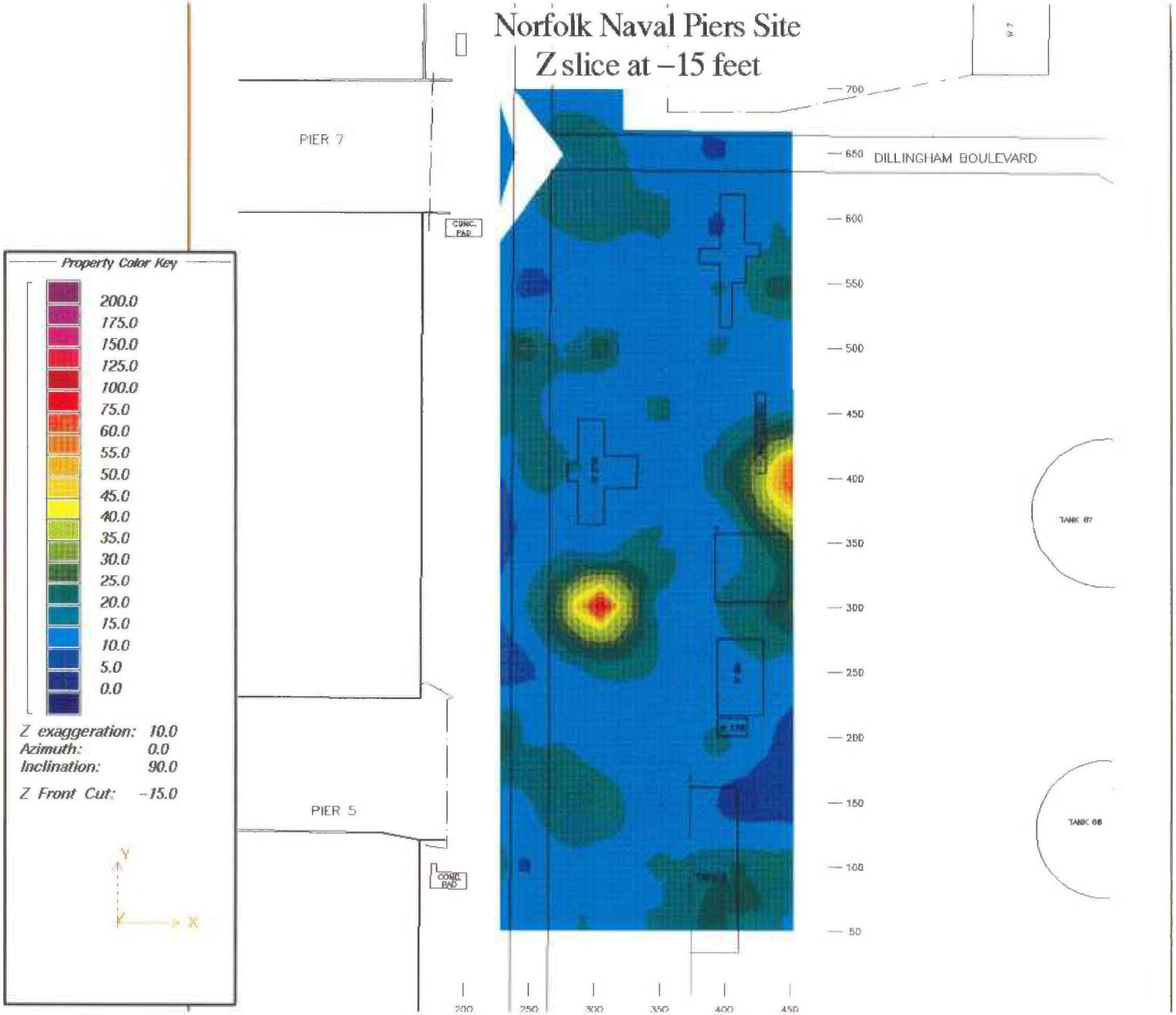
Relative Resistivity Data

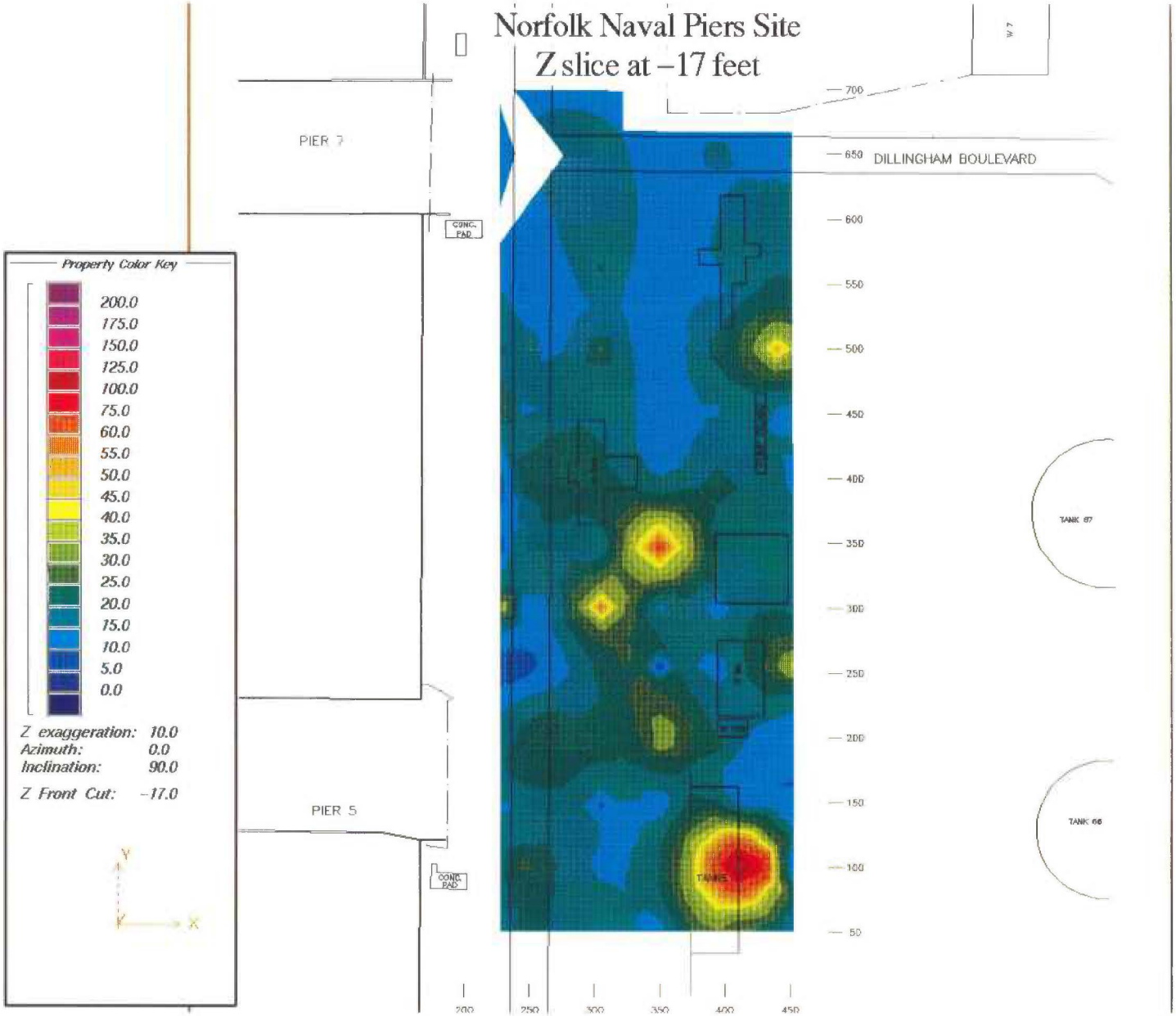
Norfolk Naval Piers Site
Profile Locations

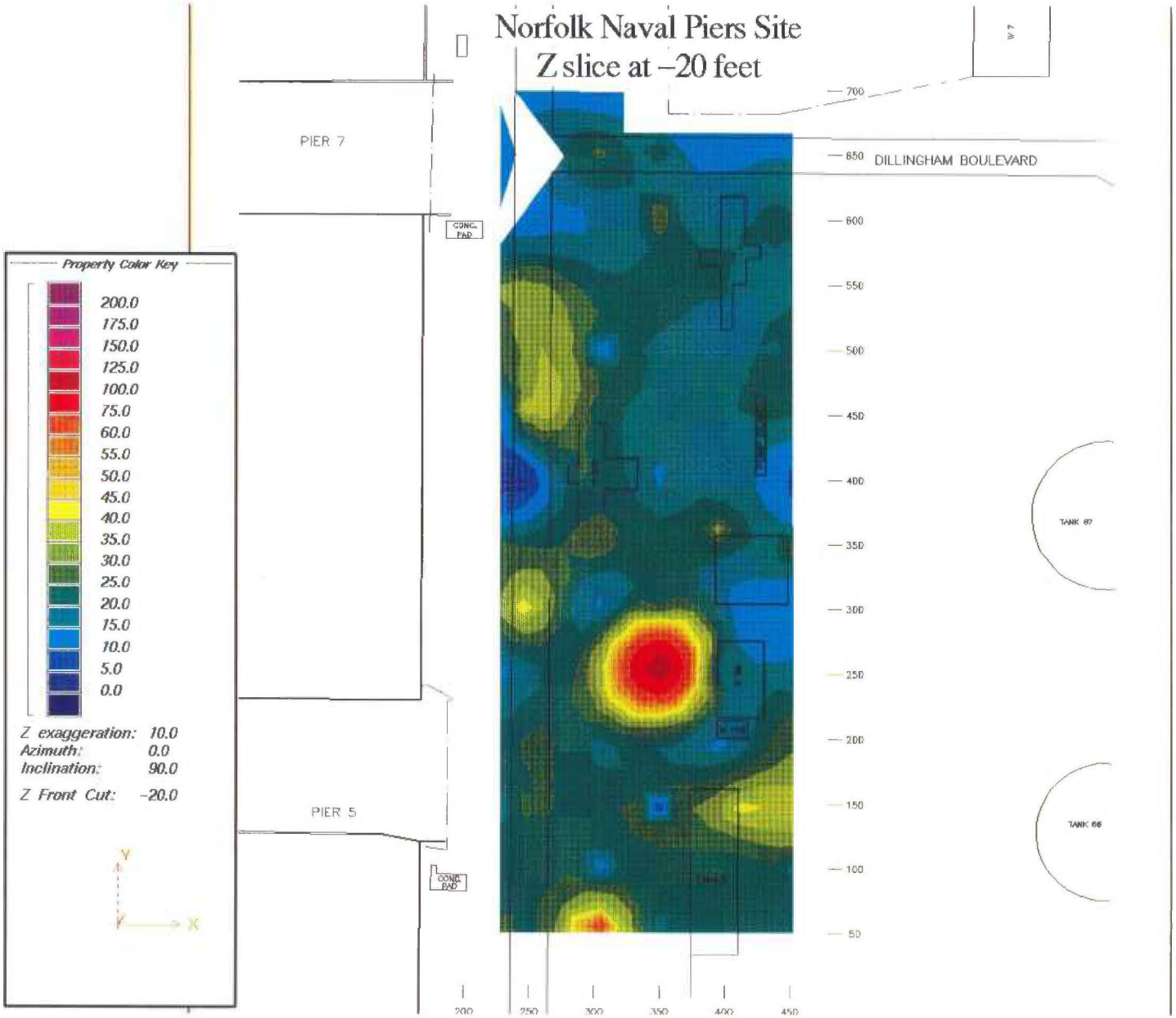



Norfolk Naval Piers Site
Z slice at –6 feet
PIER 7
PIER 5
DILLINGHAM BOULEVARD
CONC. PAD
CONC. PAD
TANK 67
TANK 68
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 0.0
Inclination: 90.0
Z Front Cut: -6.0
Y
X
700
650
600
550
500
450
400
350
300
250
200
150
100
50
200
250
300
350
400
450

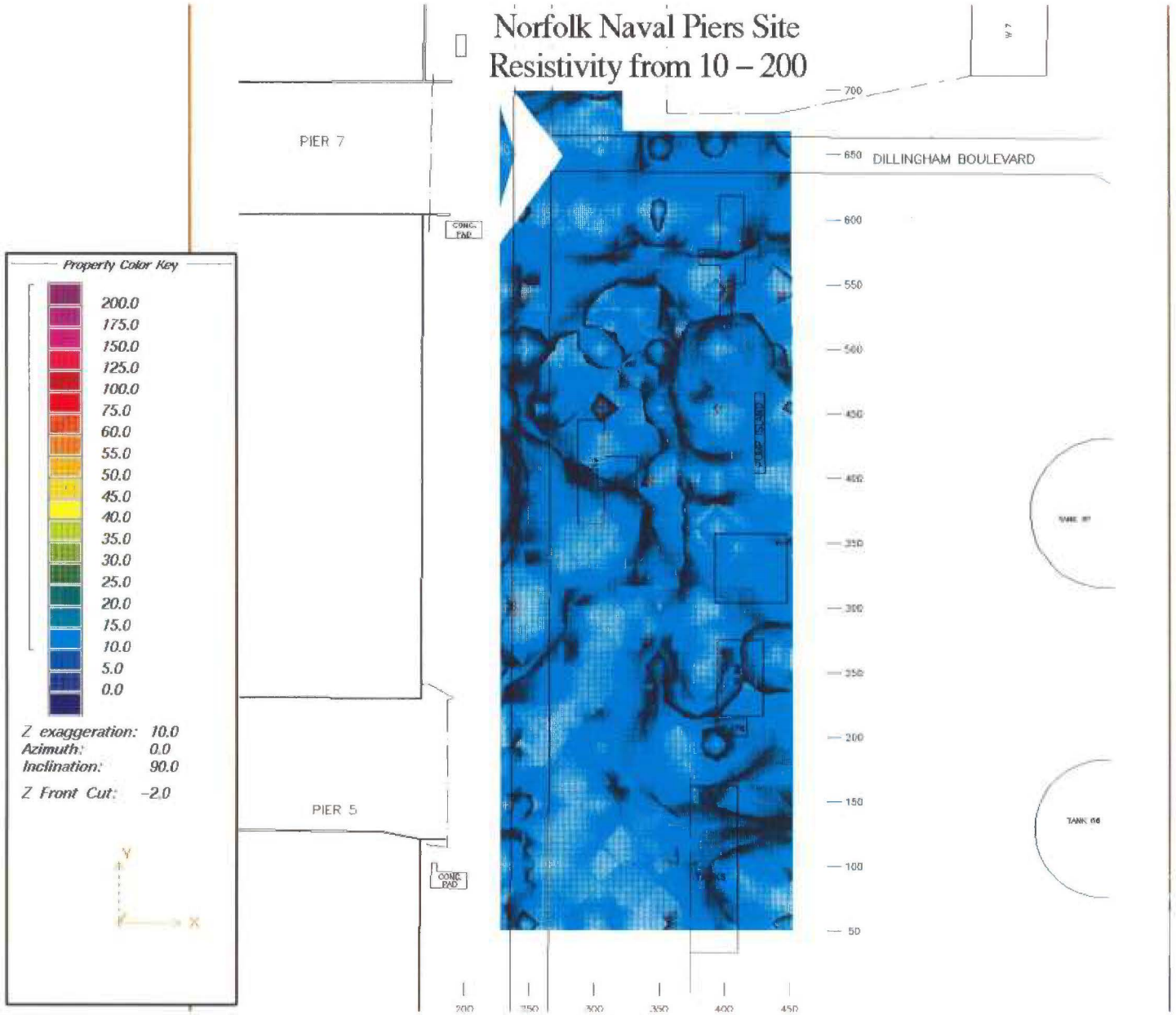

Norfolk Naval Piers Site
Z slice at –10 feet
PIER 7
PIER 5
DILLINGHAM BOULEVARD
CONC. PAD
CONC. PAD
TANK 67
TANK 66
700
650
600
550
500
450
400
350
300
250
200
150
100
50
200
250
300
350
400
450
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 0.0
Inclination: 90.0
Z Front Cut: –10.0
Y
X


Norfolk Naval Piers Site
Z slice at –15 feet
PIER 7
PIER 5
DILLINGHAM BOULEVARD
CONC. PAD
CONC. PAD
TANK 67
TANK 66
700
650
600
550
500
450
400
350
300
250
200
150
100
50
200
250
300
350
400
450
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 0.0
Inclination: 90.0
Z Front Cut: –15.0
Y
X

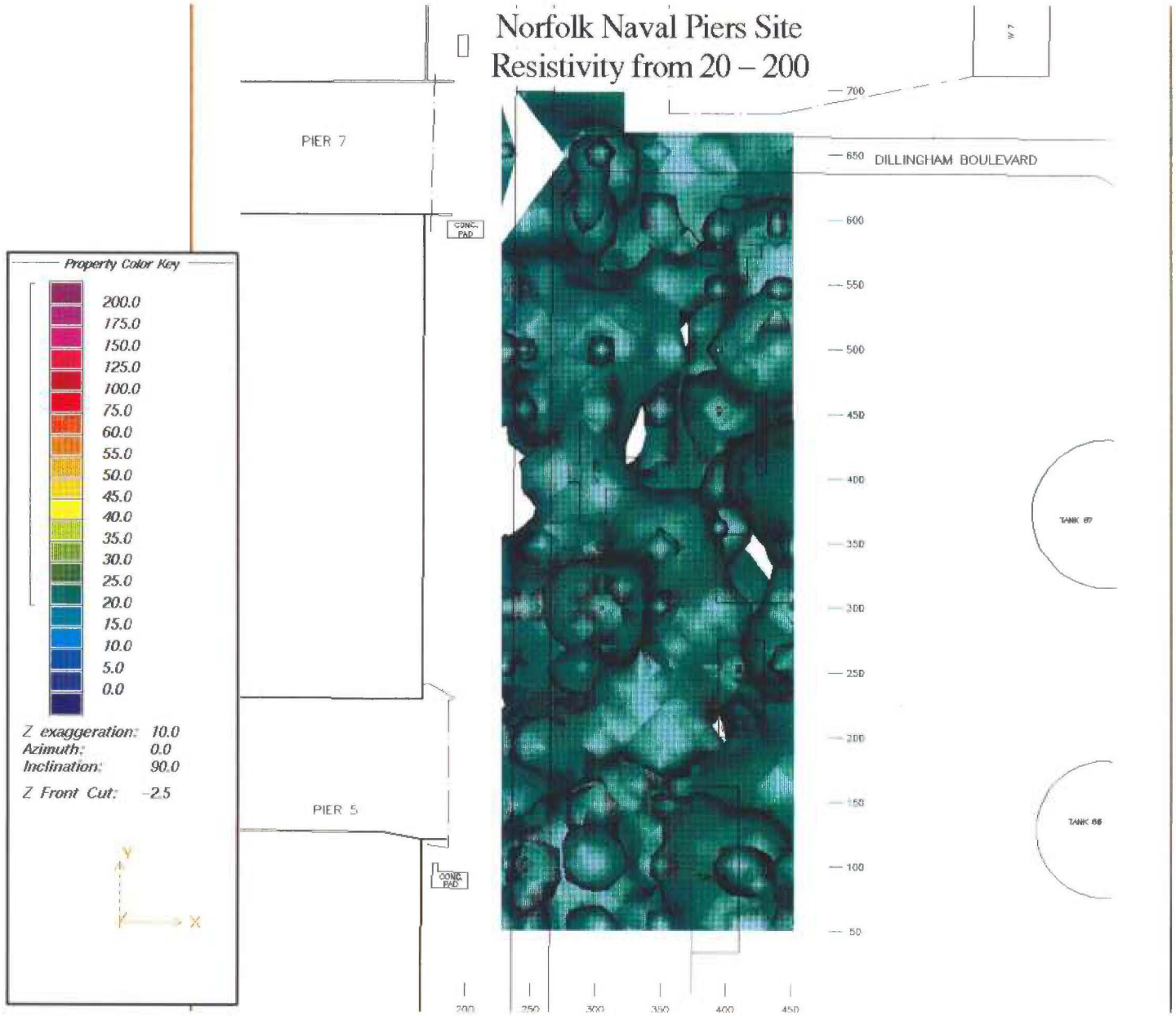

Norfolk Naval Piers Site
Z slice at –17 feet
PIER 7
PIER 5
DILLINGHAM BOULEVARD
CONC. PAD
CONC. PAD
TANK 67
TANK 66
TANK 5
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 0.0
Inclination: 90.0
Z Front Cut: –17.0
Y
X
700
650
600
550
500
450
400
350
300
250
200
150
100
50
200
250
300
350
400
450


Norfolk Naval Piers Site
Z slice at –20 feet
PIER 7
PIER 5
DILLINGHAM BOULEVARD
CONC. PAD
CONC. PAD
TANK 67
TANK 68
700
650
600
550
500
450
400
350
300
250
200
150
100
50
200
250
300
350
400
450
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 0.0
Inclination: 90.0
Z Front Cut: -20.0
Y
X

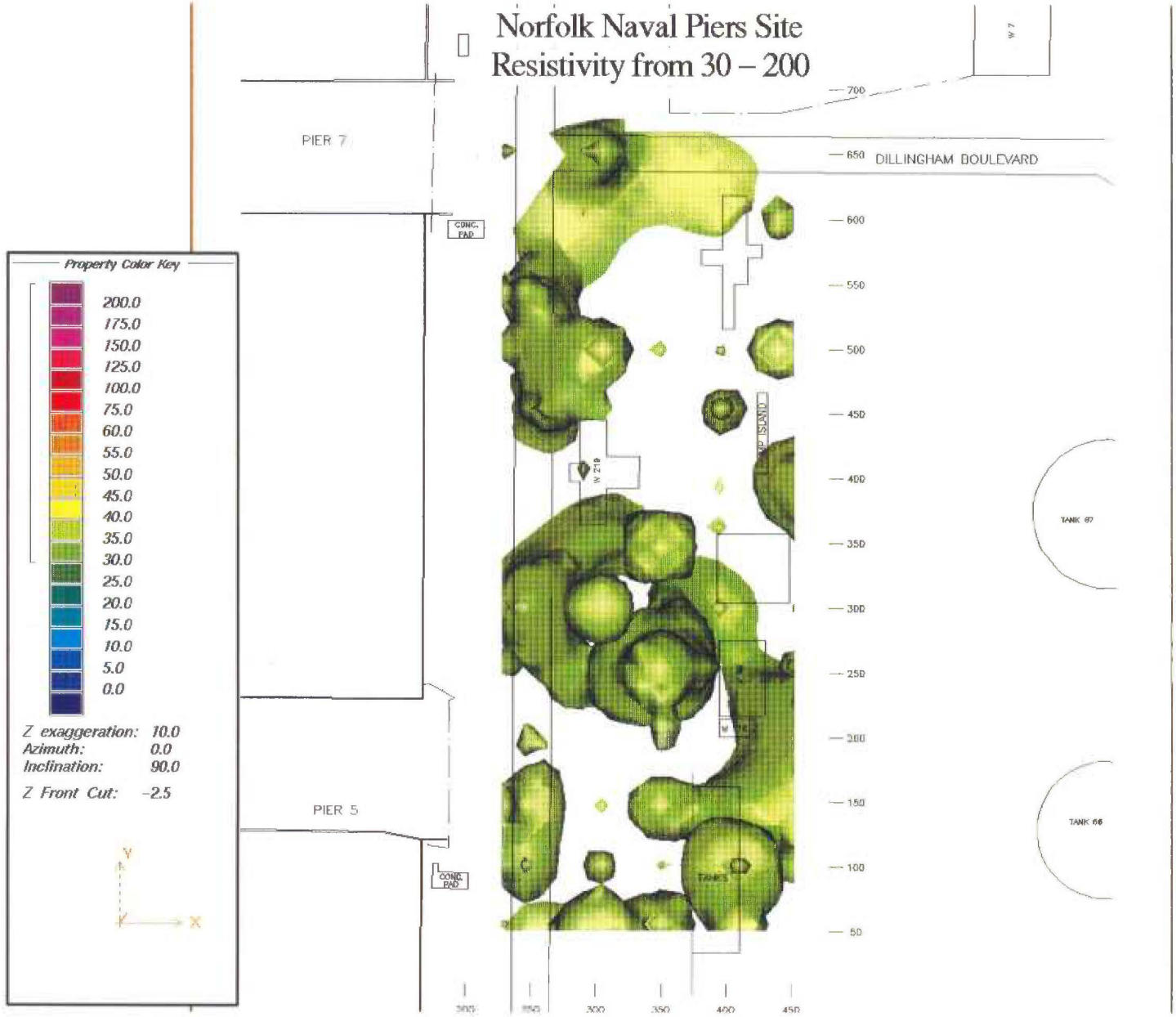
Norfolk Naval Piers Site
Resistivity from 10 – 200



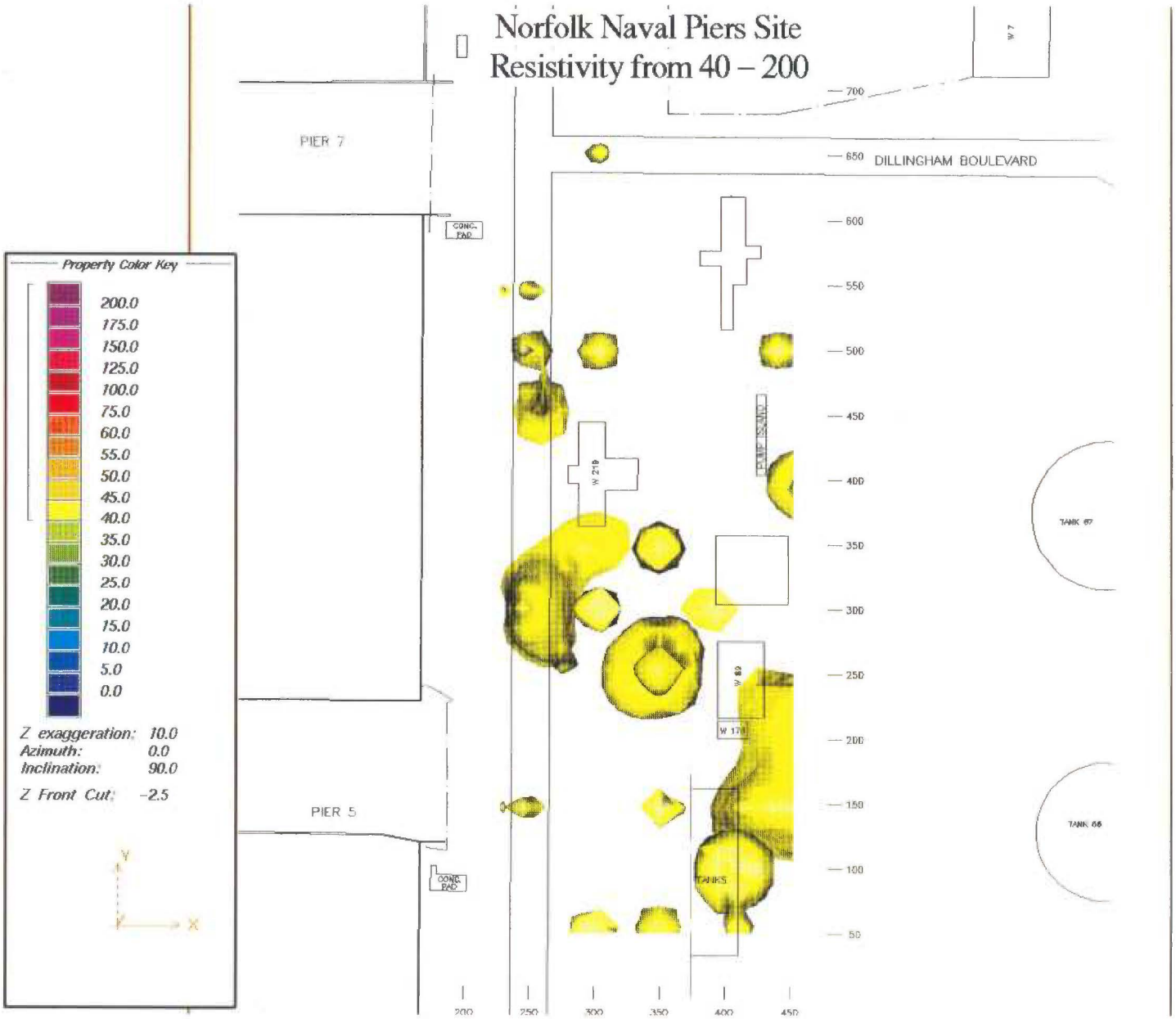
Norfolk Naval Piers Site
Resistivity from 20 – 200

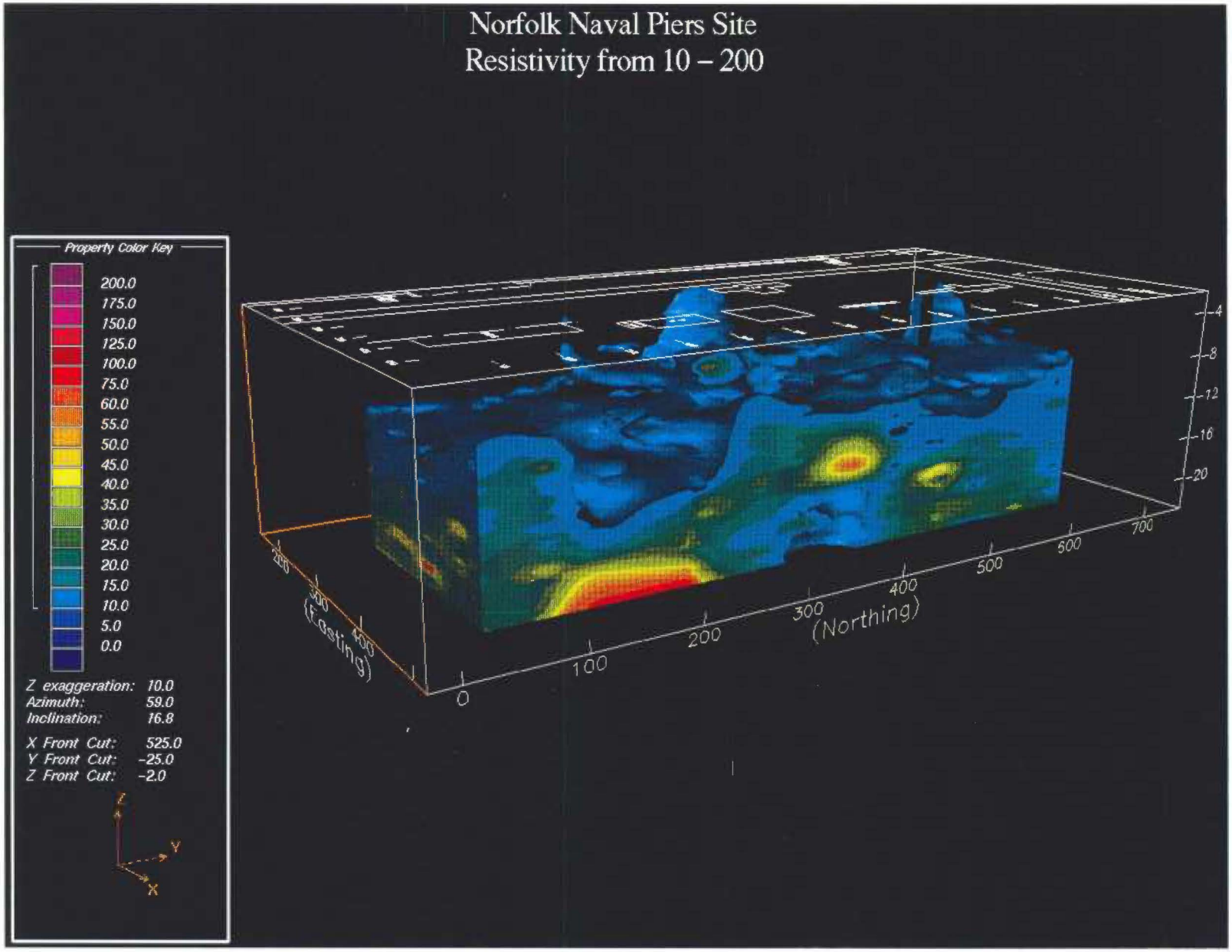


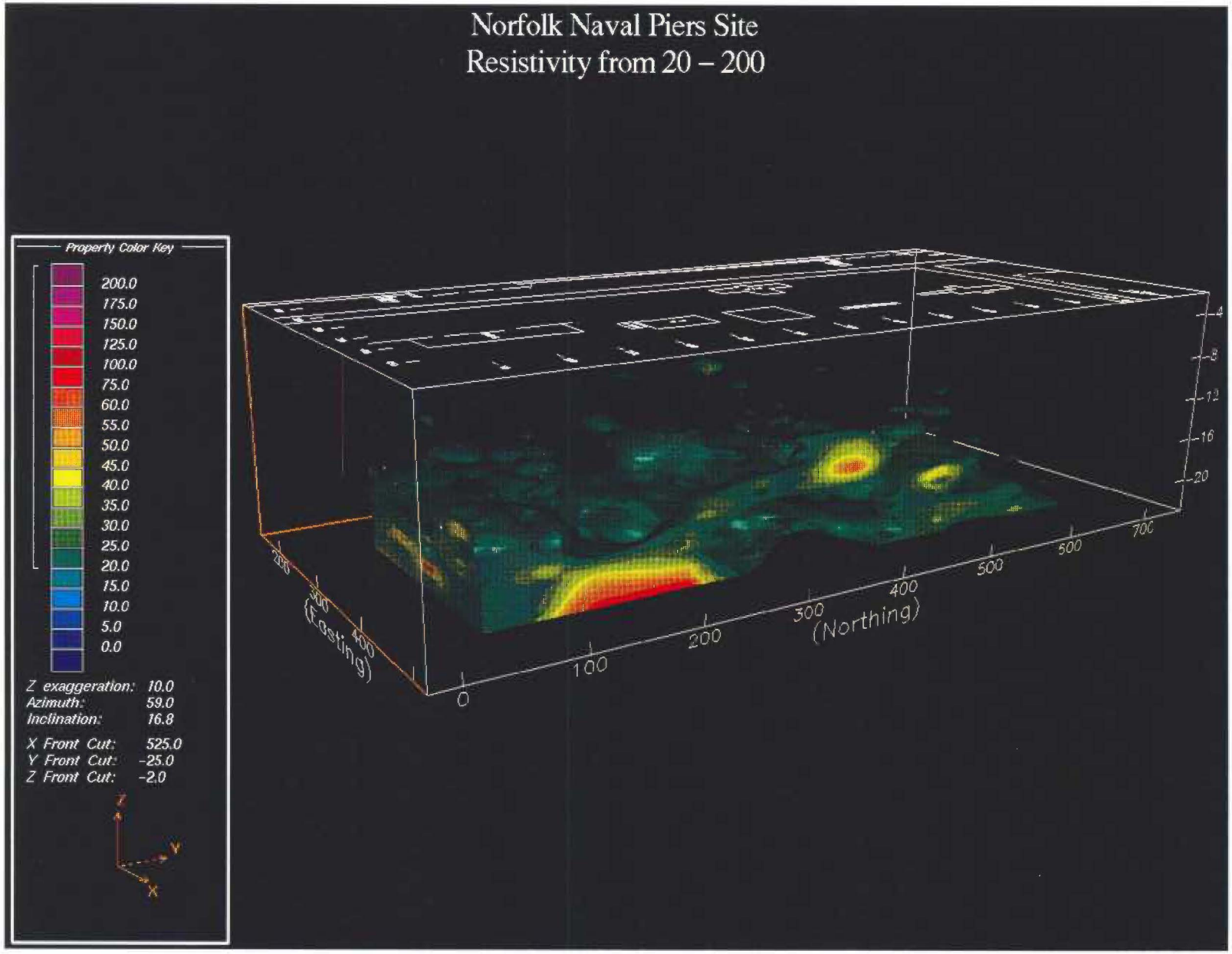
Norfolk Naval Piers Site
Resistivity from 30 – 200

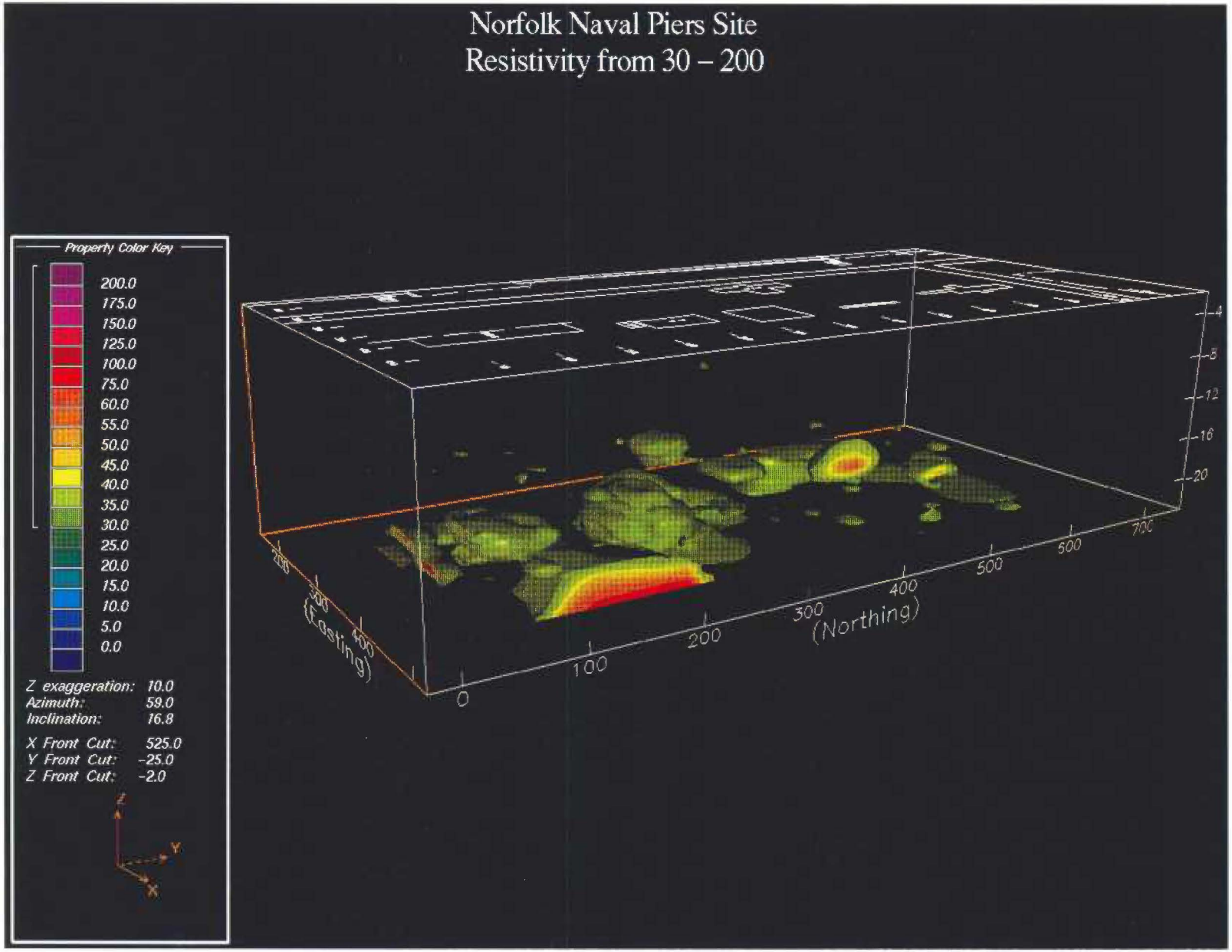


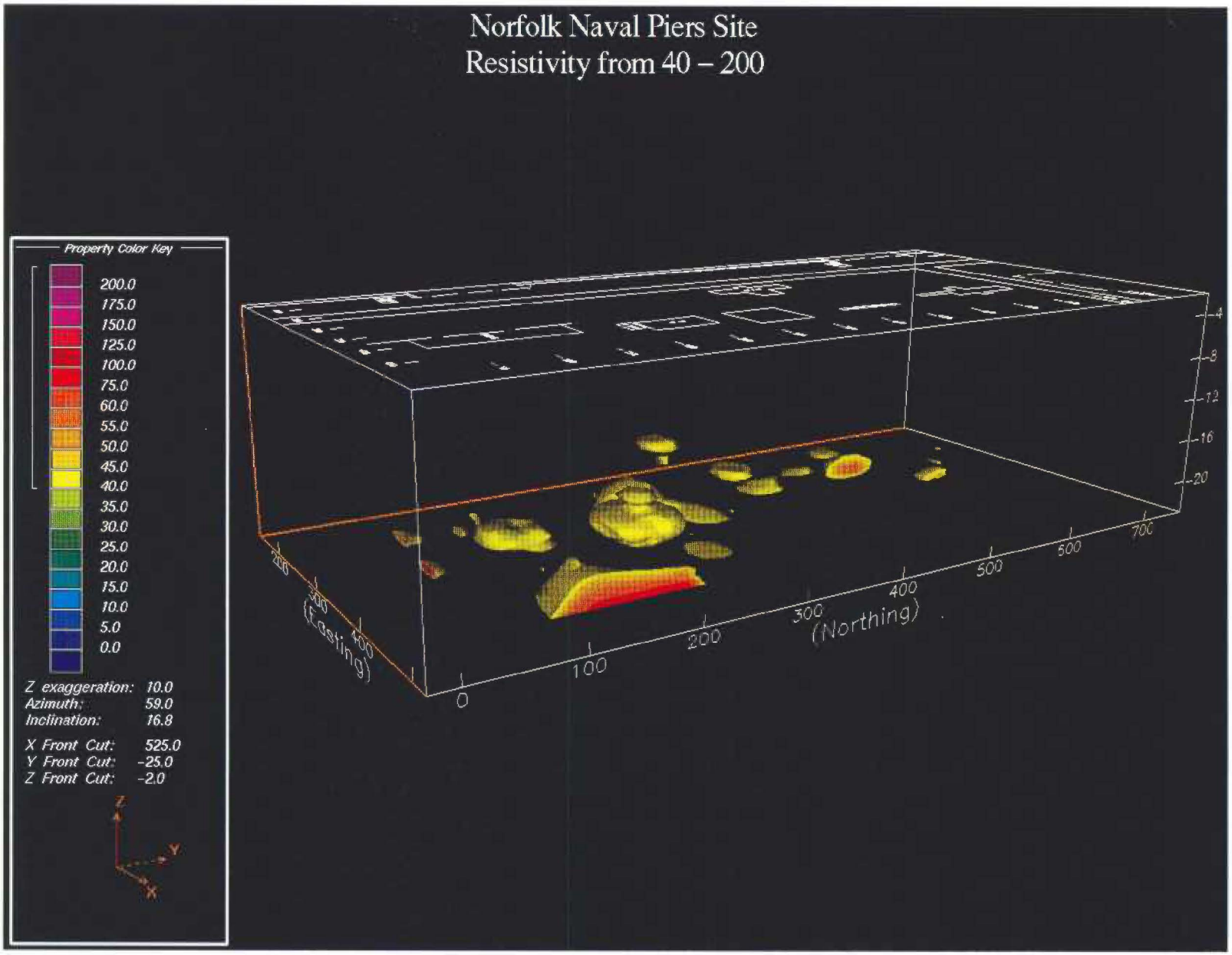
Norfolk Naval Piers Site
Resistivity from 40 – 200

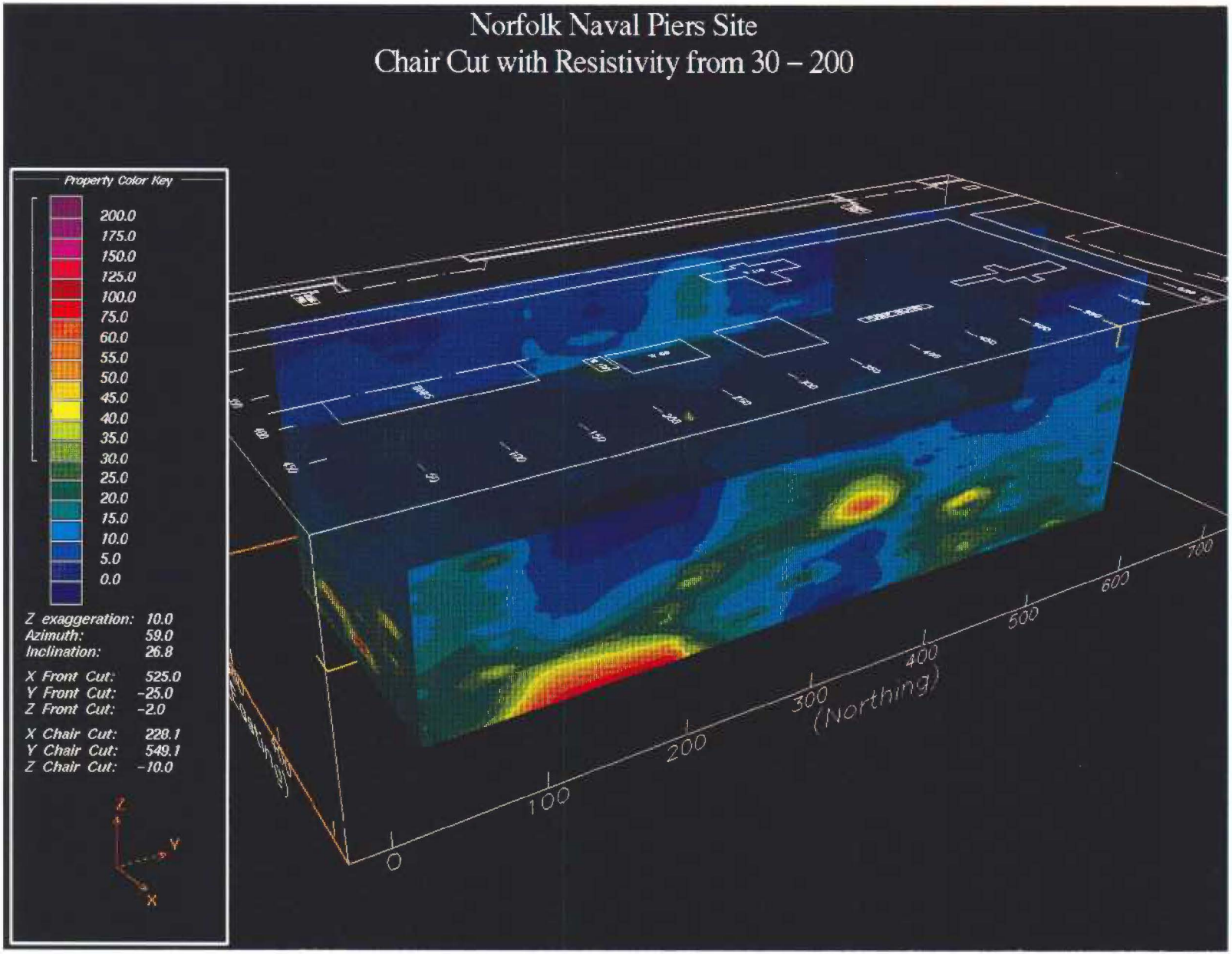


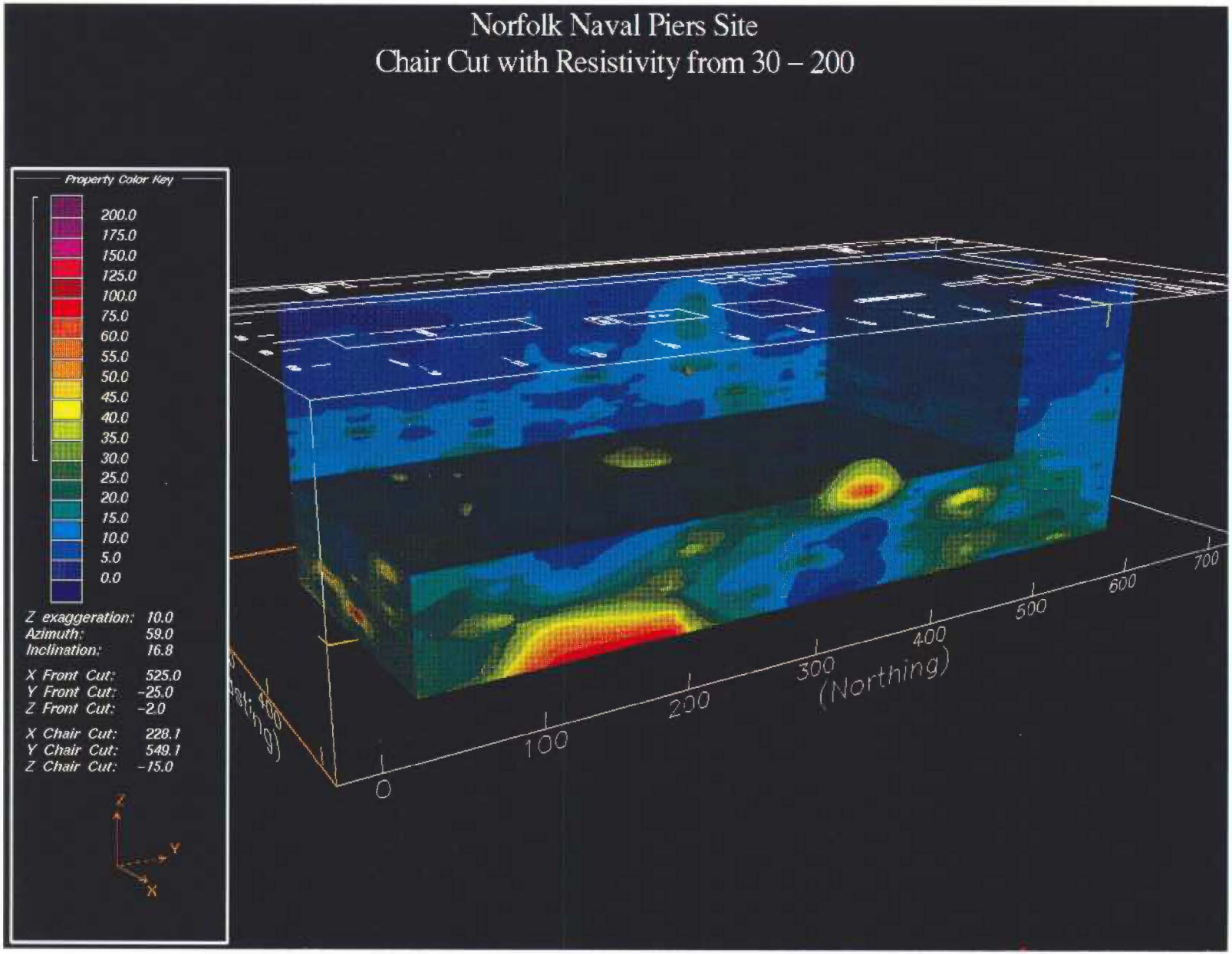

Norfolk Naval Piers Site
Resistivity from 10 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
Z
Y
X
(Easting)
0
100
200
300
400
500
700
(Northing)
4
8
12
16
20


Norfolk Naval Piers Site
Resistivity from 20 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
Z
Y
X
(Easting)
(Northing)
0
100
200
300
400
500
700
4
8
12
16
20

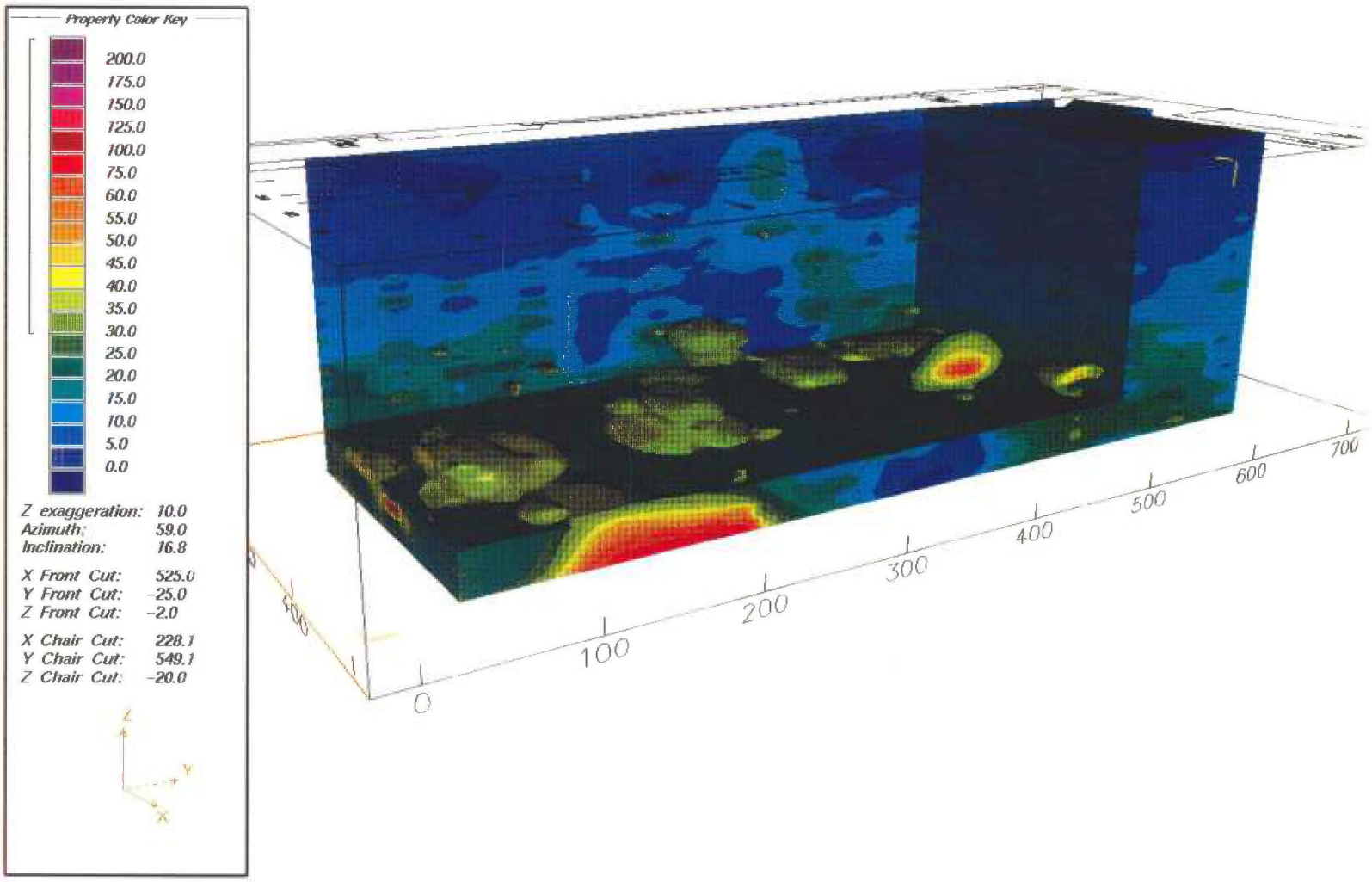

Norfolk Naval Piers Site
Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
Z
Y
X
(Easting)
0
100
200
300
400
(Northing)
500
500
700
4
8
12
16
20

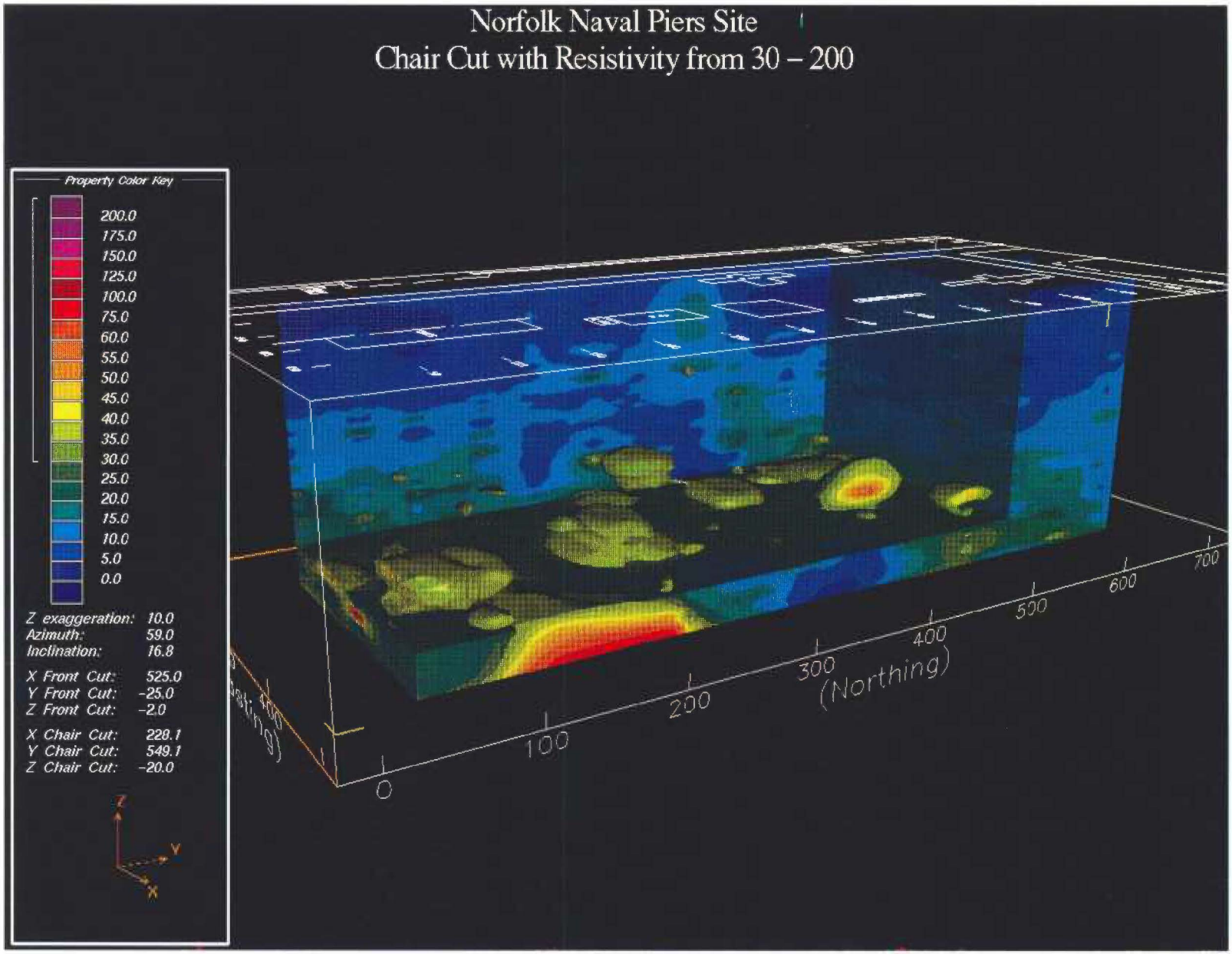

Norfolk Naval Piers Site
Resistivity from 40 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
Z
Y
X
(Easting)
(Northing)
0
100
200
300
400
500
600
700
4
8
12
16
20

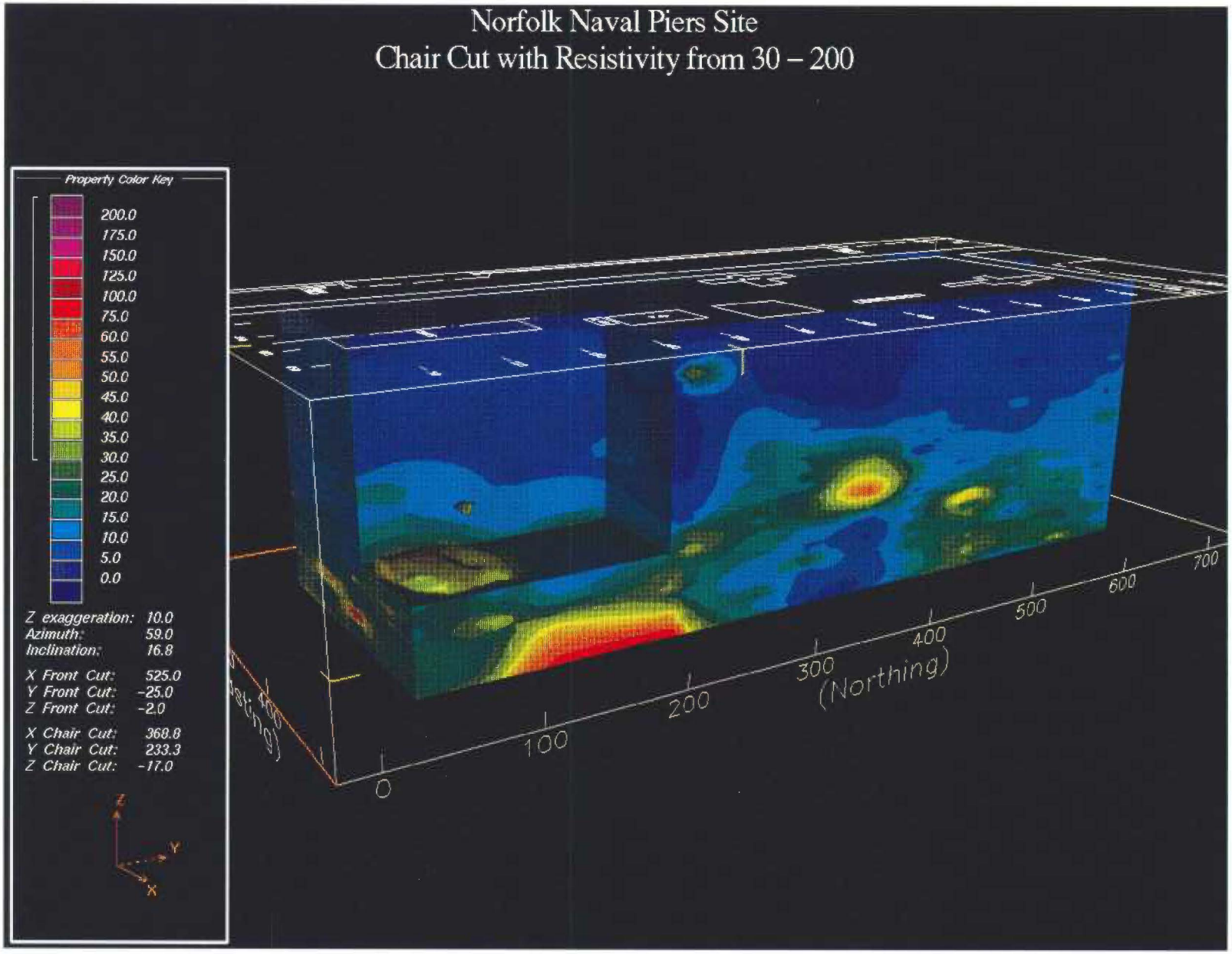

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 26.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 228.1
Y Chair Cut: 549.1
Z Chair Cut: -10.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)

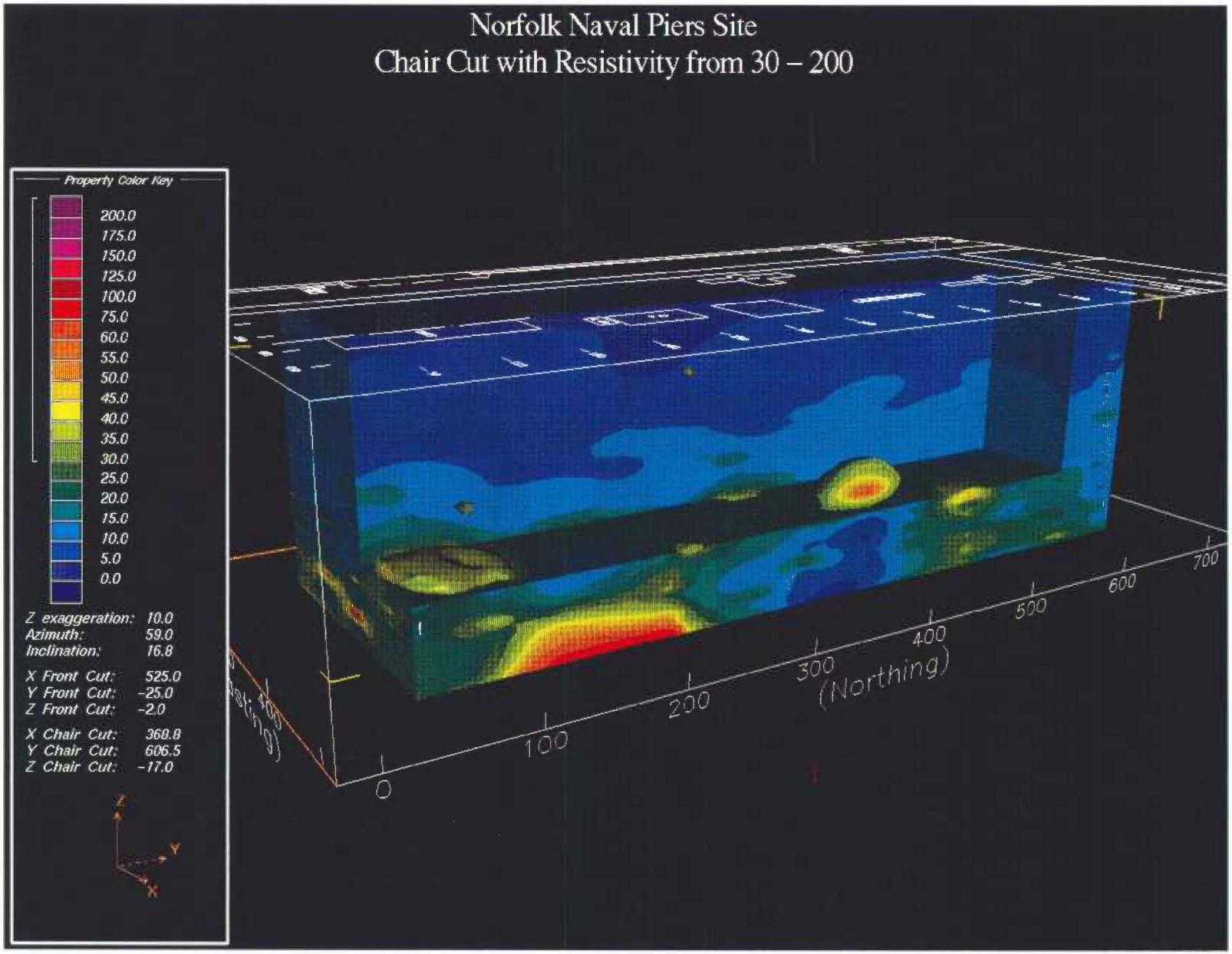

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 228.1
Y Chair Cut: 549.1
Z Chair Cut: -15.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200

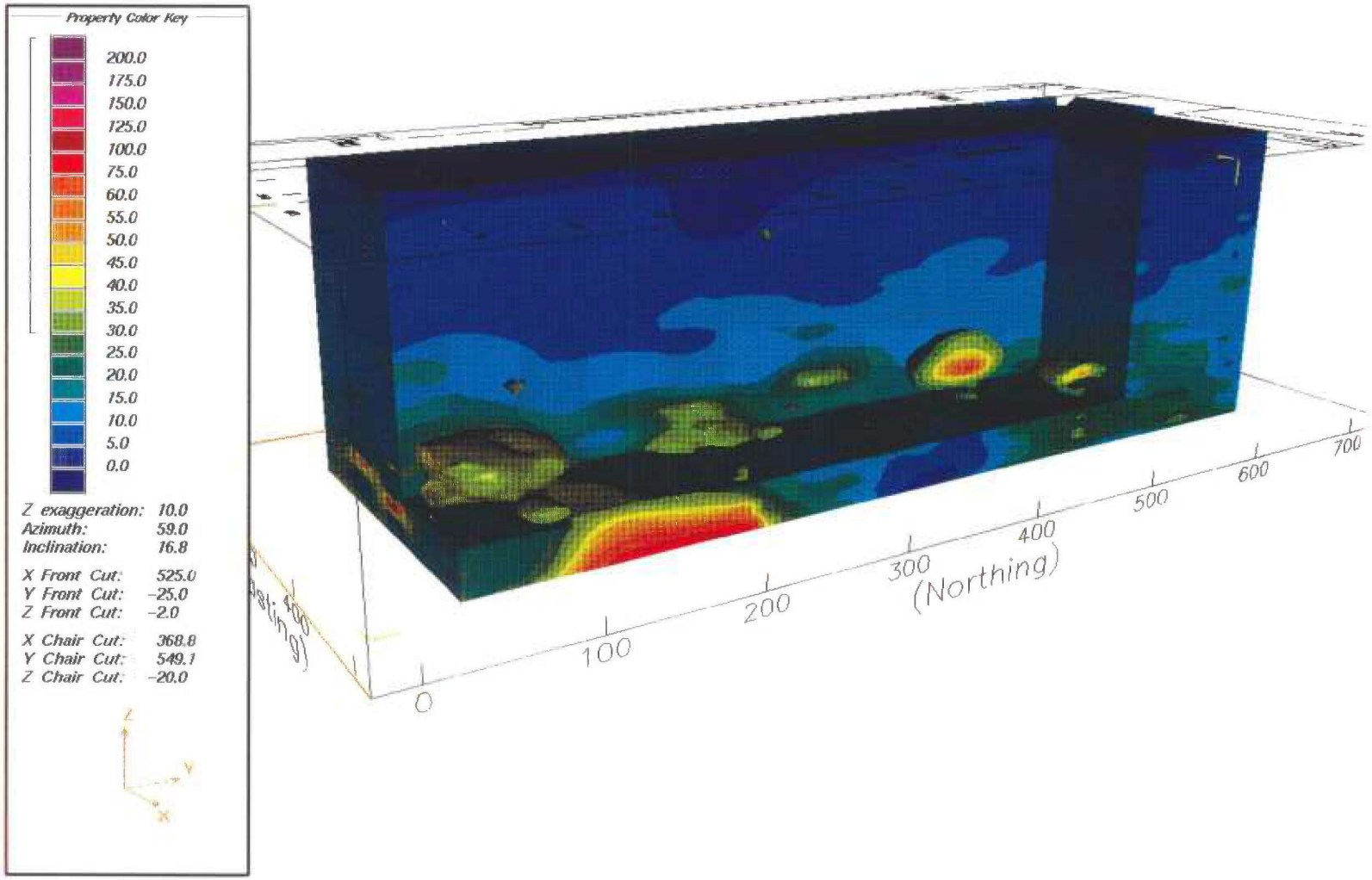


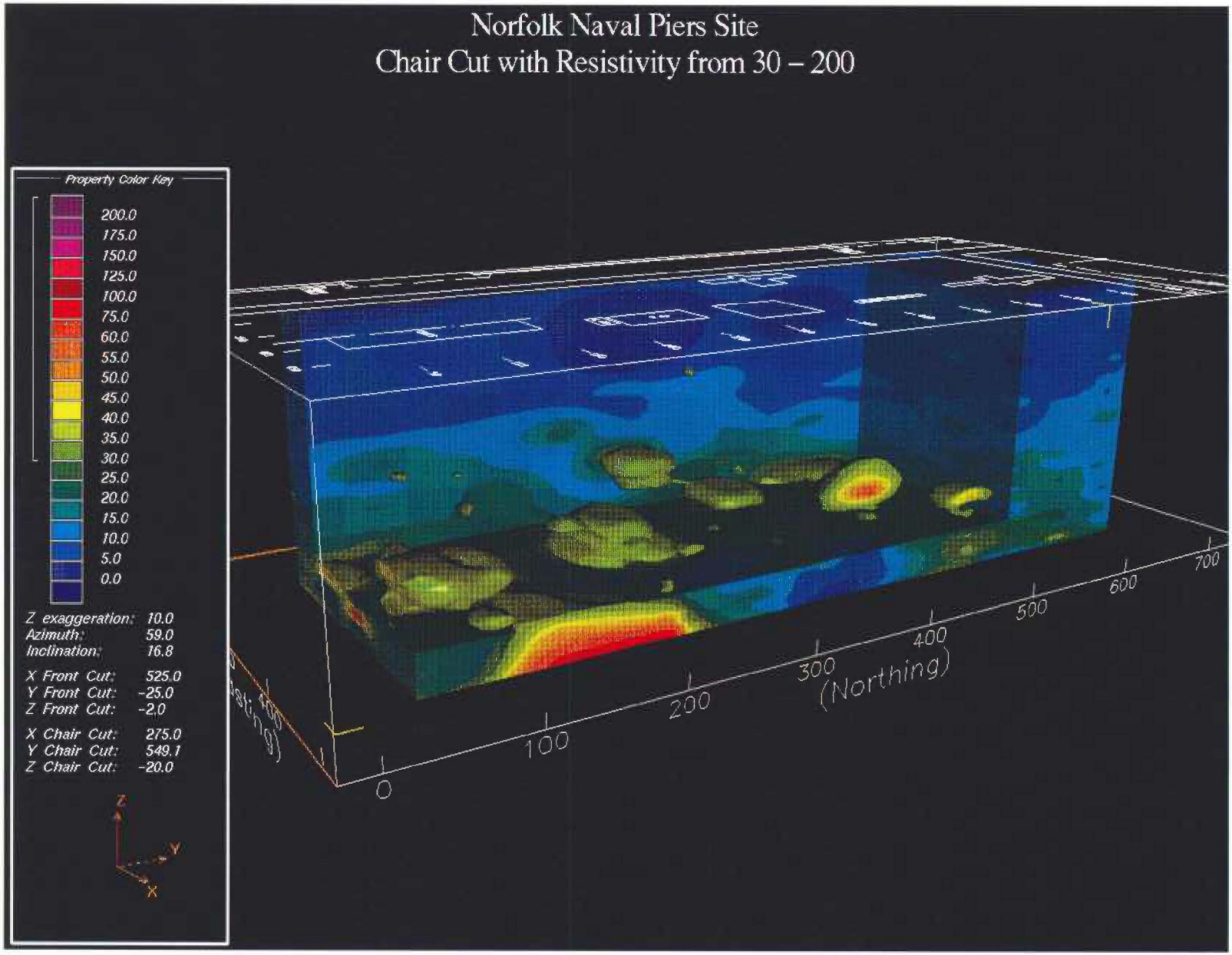

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 228.1
Y Chair Cut: 549.1
Z Chair Cut: -20.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)

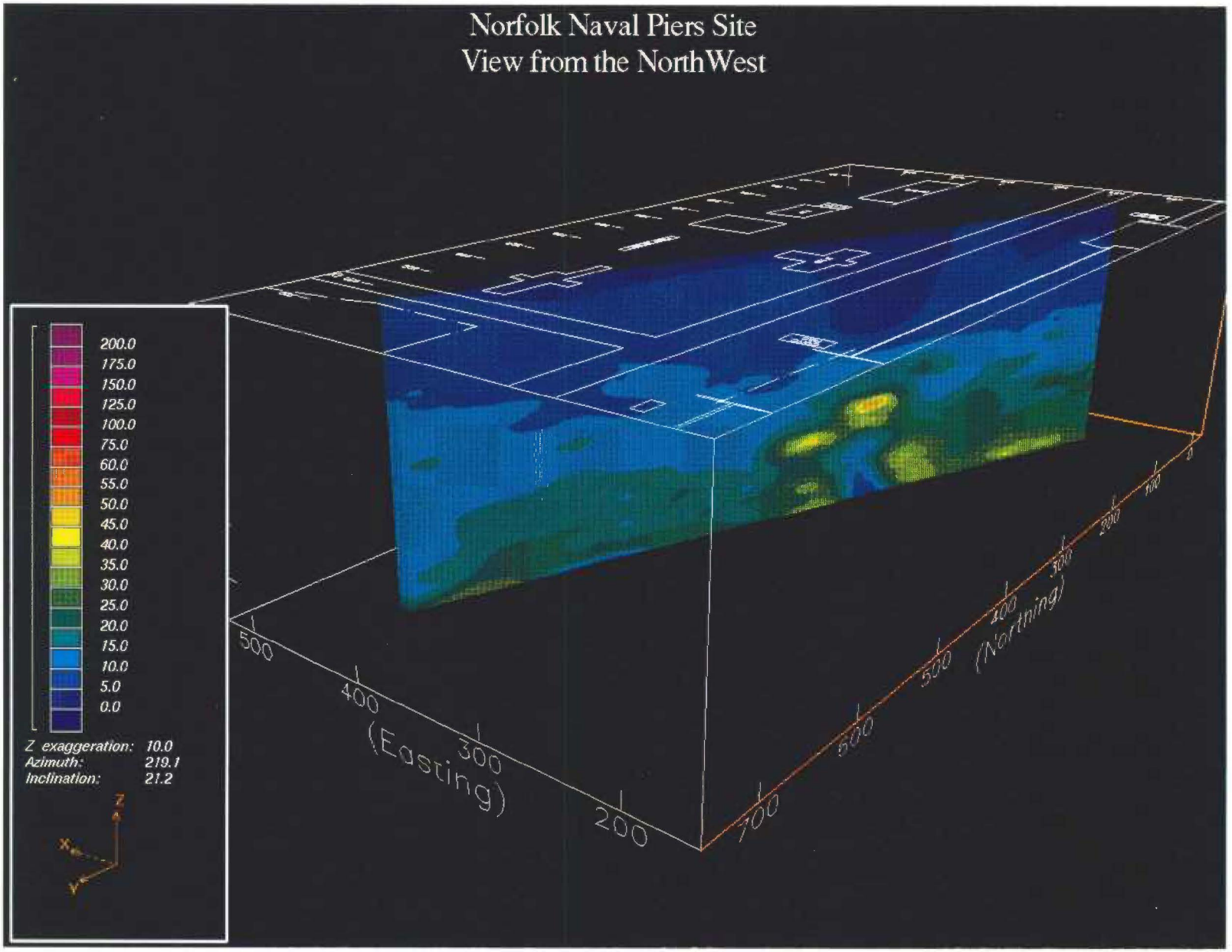

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 368.8
Y Chair Cut: 233.3
Z Chair Cut: -17.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)

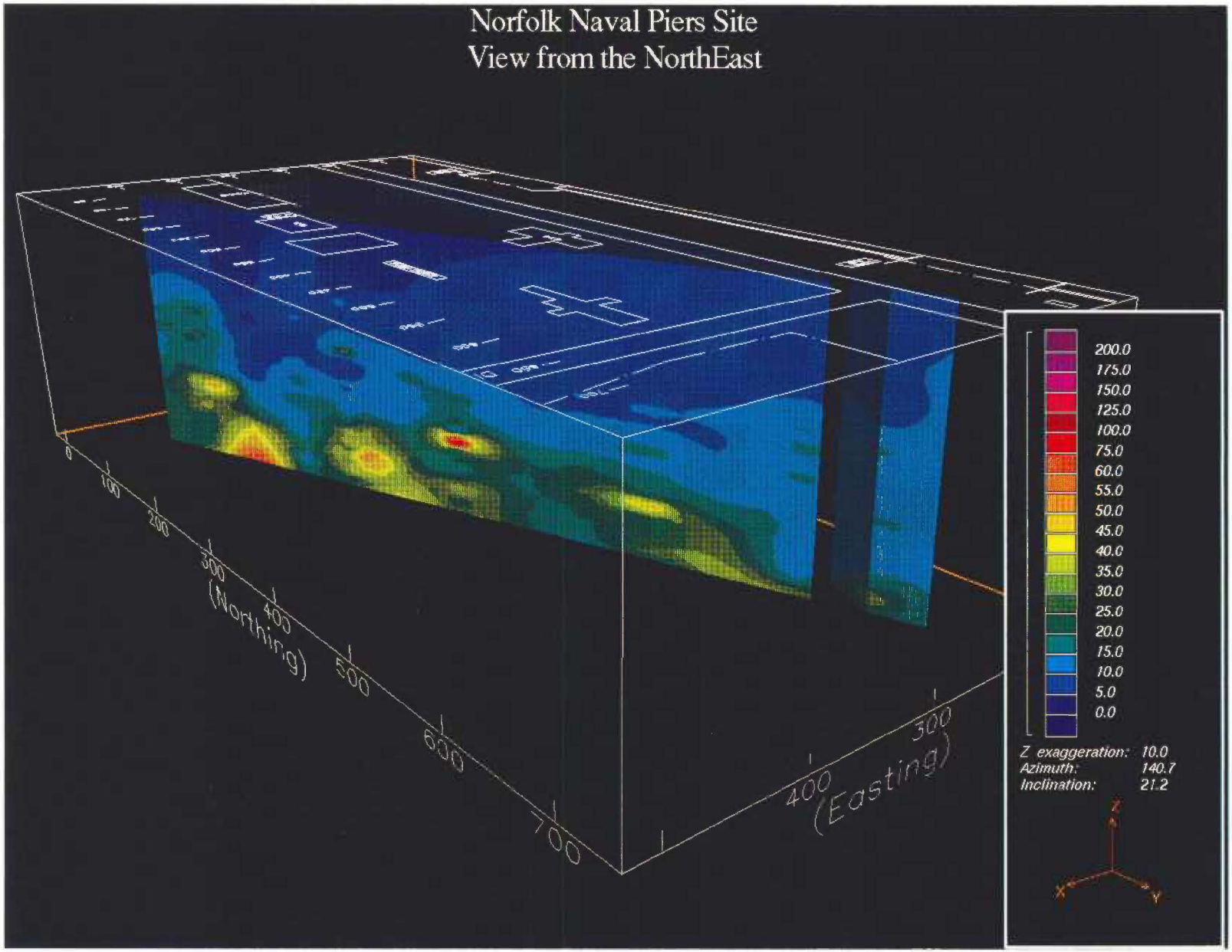

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 368.8
Y Chair Cut: 606.5
Z Chair Cut: -17.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)

Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200




Norfolk Naval Piers Site
Chair Cut with Resistivity from 30 – 200
Property Color Key
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 59.0
Inclination: 16.8
X Front Cut: 525.0
Y Front Cut: -25.0
Z Front Cut: -2.0
X Chair Cut: 275.0
Y Chair Cut: 549.1
Z Chair Cut: -20.0
Z
Y
X
0
100
200
300
400
500
600
700
(Northing)


Norfolk Naval Piers Site
View from the NorthWest
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 219.1
Inclination: 21.2
Z
X
Y
500
400
300
200
(Easting)
700
600
500
400
300
200
100
0
(Northing)


Norfolk Naval Piers Site
View from the NorthEast
200.0
175.0
150.0
125.0
100.0
75.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z exaggeration: 10.0
Azimuth: 140.7
Inclination: 21.2
0
100
200
300
400
500
600
700
(Northing)
300
400
(Easting)
Z
X
Y