Verification of the Saltwater Interface Location at Selected Monitor Wells in Martin, Palm Beach, Broward, and Miami-Dade Counties During the 2007 Water Shortage

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ACRONYMS AND ABBREVIATIONS

µS/cm	microSiemens per centimeter
bls	below land surface
District	South Florida Water Management District
ft	foot or feet
mg/L	milligrams per liter
mS/m	milliSiemens per meter
SFWMD	South Florida Water Management District
USGS	United States Geological Survey
YSI	Yellow Springs Instruments

How to Convert microSiemens to milliSiemens:

1 µS = 0.001 mS

1 mS = 1000 µ

1 INTRODUCTION

During the water shortage that began in 2007, the South Florida Water Management District (SFWMD or District) performed an investigation to verify the position of the saltwater interface along the east coast of Florida. The investigation included induction logging of 10 monitor wells located in Martin, Palm Beach, Broward, and Miami-Dade counties. This report evaluates data collected during this investigation and compares these data to data collected during previous United States Geological Survey (USGS) studies. The USGS published a series of map reports in the mid to late 1990s showing the location of the saltwater interface along the east coast of Florida (Koszalka 1995, Sonenshein 1997, Hittle 1999). The locations of the monitor wells used during the investigation are shown in **Figure 1**.

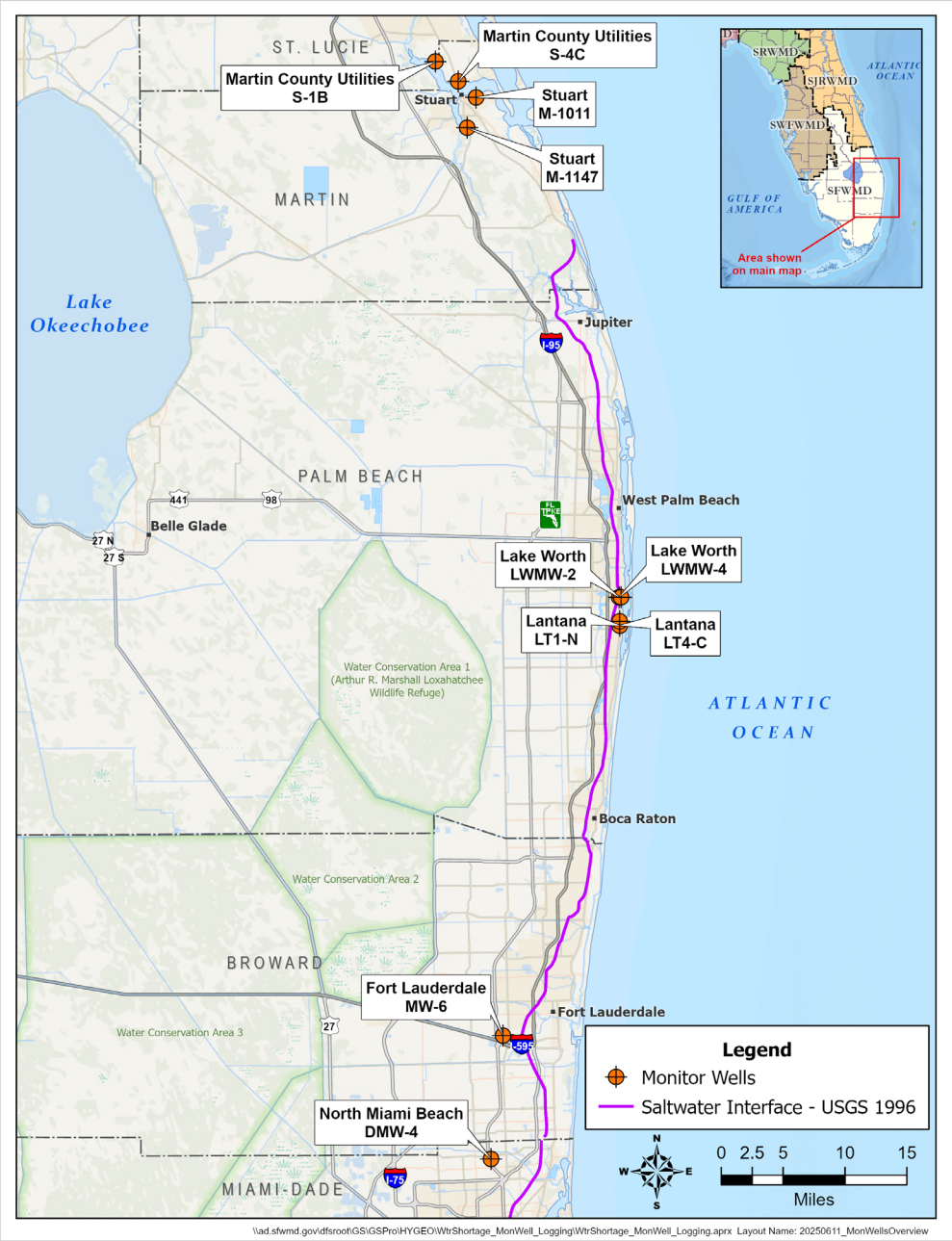

Figure 1. Monitor well locations.

2 INDUCTION LOGGING

The SFWMD contracted with Technos, Inc. to complete induction logs in 10 monitor wells associated with utilities along the east coast of Florida (**Figure 1** and **Table 1)**.

Table 1. Well construction information.

Well	Ground Surface Elevation (feet NAVD88)	Total Depth (feet)	Cased Depth (feet)	County	Associated Utility
DMW-4	11	195	190	Miami-Dade	City of North Miami Beach
MW-6	17	247	-	Broward	City of Fort Lauderdale
LT1-N	11	200	135	Palm Beach	Town of Lantana
LT4-C	8	160	150	Palm Beach	Town of Lantana
LWMW-2	6	170	160	Palm Beach	City of Lake Worth
LWMW-4 (PB-1723)	11	318	310	Palm Beach	City of Lake Worth
M-1011	10	128	-	Martin	City of Stuart
M-1147	8	146	141	Martin	City of Stuart
S-1B (STL-213)	6	173	-	Martin	Martin County Utilities
S-4C	3	188	-	Martin	Martin County Utilities

NAVD88 = North American Vertical Datum of 1988.

The induction logging tool measures the bulk electrical conductivity of the formation surrounding the well. Induction logging provides the most accurate estimates of formation resistivity, which can be calculated by inversion of the induction logging data. Generally, the conductivity of the fluid in the surrounding formation dominates the measurements. The induction logging tool can obtain measurements through polyvinyl chloride well casing. After induction logging was completed at each well, District hydrogeologists collected a groundwater sample for specific conductance and chloride analyses from each of the wells listed in **Table 1**. Technos used these data to correlate induction log readings to chloride concentrations. Their data, as well as the District's water quality data, are provided in a summary report (Technos 2008) included in **Appendix A**.

3 HISTORICAL DATA

This section presents historical data related to the induction logging and conductivity profiling investigations performed by Technos in 2007.

The only monitor well with a historical record of induction logging was LWMW-4 (PB-1723). The USGS has completed induction logs in LWMW-4 (PB-1723) annually since 2000. The USGS provided the SFWMD with the historical induction logs for this monitor well (Scott Prinos, personal communication, February 22, 2007), allowing a comparison with the Technos log. The historical logs from LWMW-4 (PB-1723) are useful for determining if the saltwater interface is present and/or migrating. The series of induction logs collected between September 2000 and June 2007 at LWMW-4 (PB-1723) are shown in **Figure 2**.

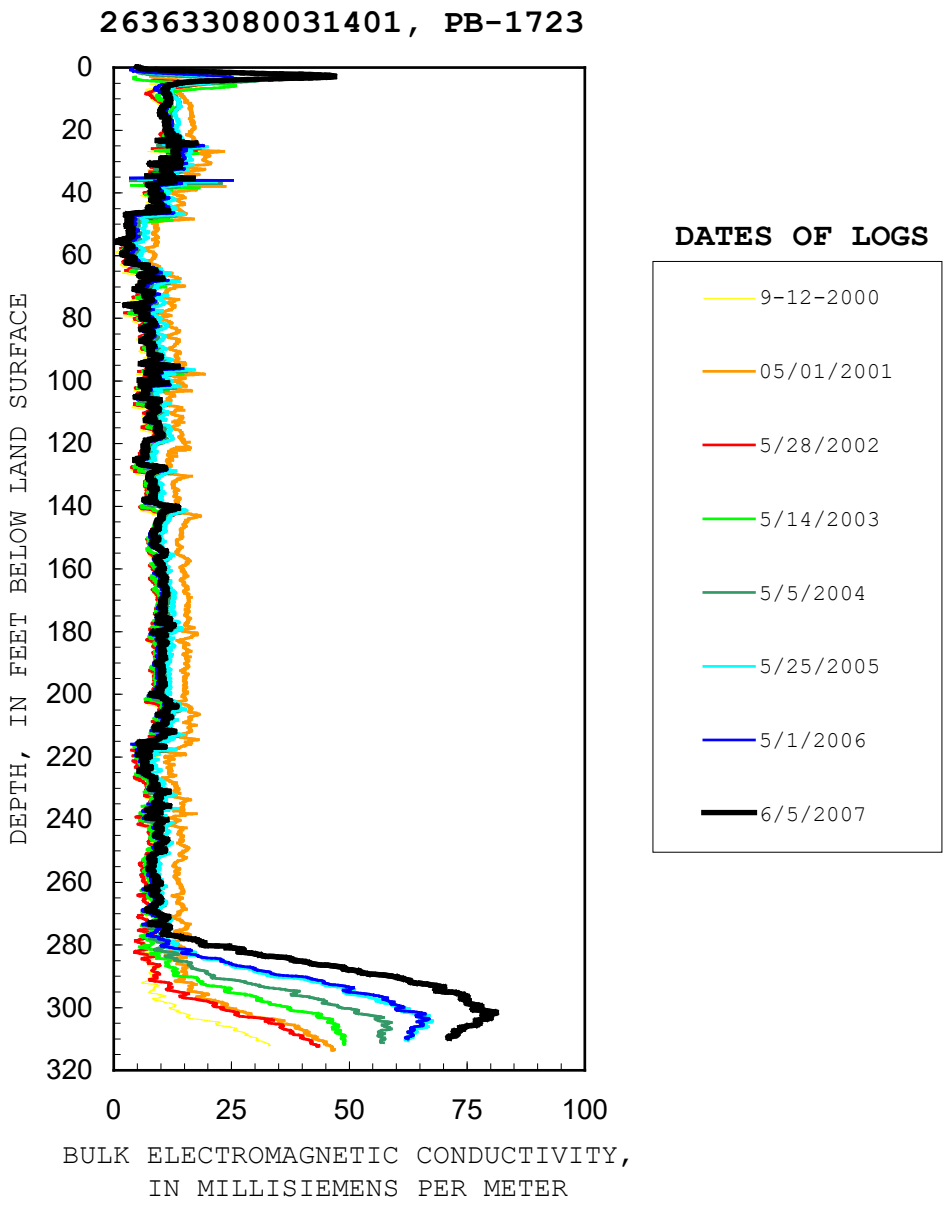

Figure 2. Bulk electrical conductivity profiles collected from LWMW-4 (PB-1723) using dual induction logging methods.

Figure 2 shows that the saltwater interface in LWMW-4 (PB-1723) has thickened by approximately 15 feet between September 2000 (conductivity increased sharply at 295 ft below land surface [ft bls]) and June 2007 (conductivity increased at approximately 280 ft bls) and has migrated inland during that same time period. Inland movement of the saltwater interface is evidenced by the increasing bulk conductivity measurements in this well at depths between 280 and 320 ft bls. Hittle (1999) showed that the saltwater interface in the aquifer around LWMW-4 (PB-1723) is sloped, with the farthest inland extent occurring at the approximate base of the surficial aquifer system (SAS) just inland of LWMW-4 (PB-1723) (**Figure 3**). The saltwater interface will move upwards in a monitor well as the thicker portions of the wedge move inland.

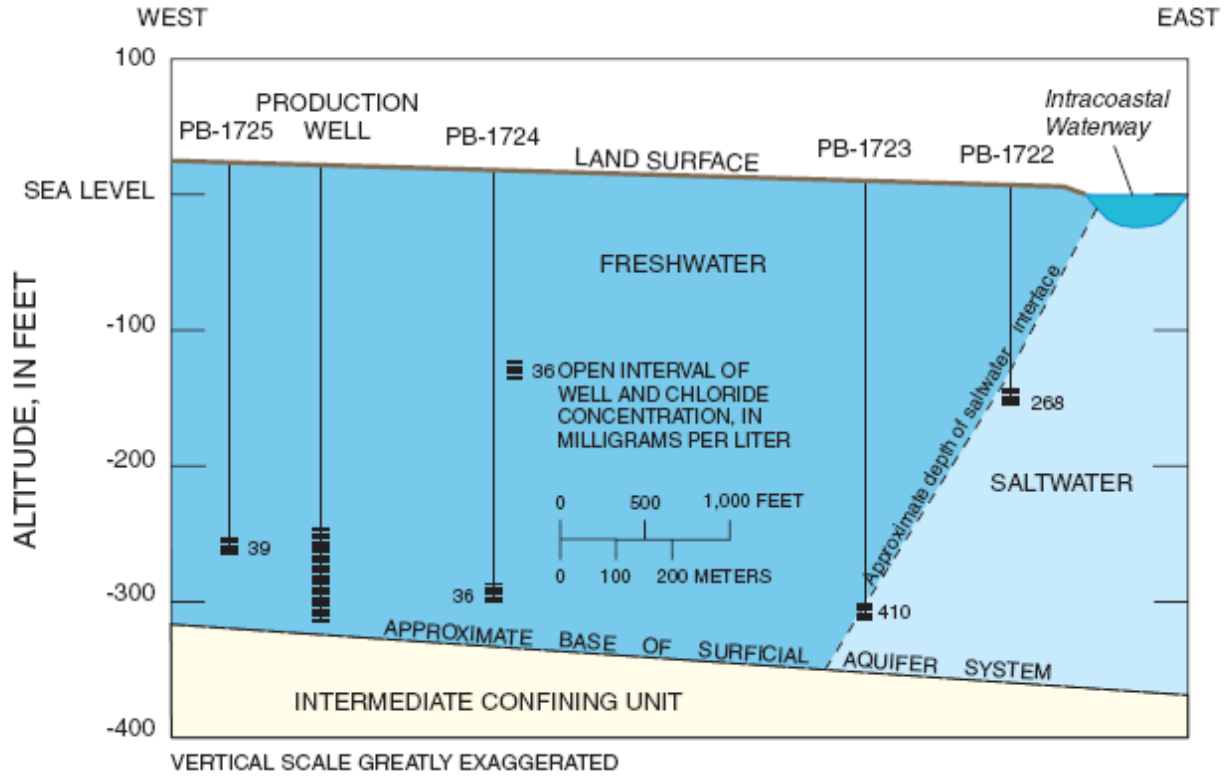

Figure 3. Shape of the saltwater interface near LWMW-4 (PB-1723) (From Hittle 1999).

4 INVESTIGATION RESULTS

This section presents data gathered from the two parts of this investigation conducted in 2007 and 2008 and compares them to historical studies, including the USGS studies mentioned in Section 1.

Technos performed induction logging to collect continuous bulk electrical conductivity measurements in 10 wells (**Table 1)** on July 2 and 3, 2007 (**Appendix A**). The induction logging tool measures the bulk conductivity of the soil, rock, and pore water surrounding a well. In general, large increases in conductivity are due to conductivity changes of the formation's pore water. Each induction log was run both down hole and up hole at a speed of 13 feet per minute. Following completion of induction logging at each well, District hydrogeologists collected water quality samples for laboratory analyses of specific conductance and chloride. These data allowed Technos to correlate the induction logs to known water quality values. Technos concluded that an induction log conductivity value of 47 milliSiemens per meter (mS/m) was equivalent to a chloride concentration of 250 milligrams per liter (mg/L), and a value of 97 mS/m was equivalent to a chloride concentration of 1,000 mg/L.

The well locations where induction logs were collected are shown in **Figure 4** for Miami-Dade, Broward, and Palm Beach counties and in **Figure 5** for Martin County. The induction logs completed in the 10 wells listed in **Table 1** are presented in **Appendix A**. These logs show that the saltwater interface has either remained stable or migrated inland minimally since the USGS investigations. However, this is based on only 10 induction logs from monitor wells separated by large distances.

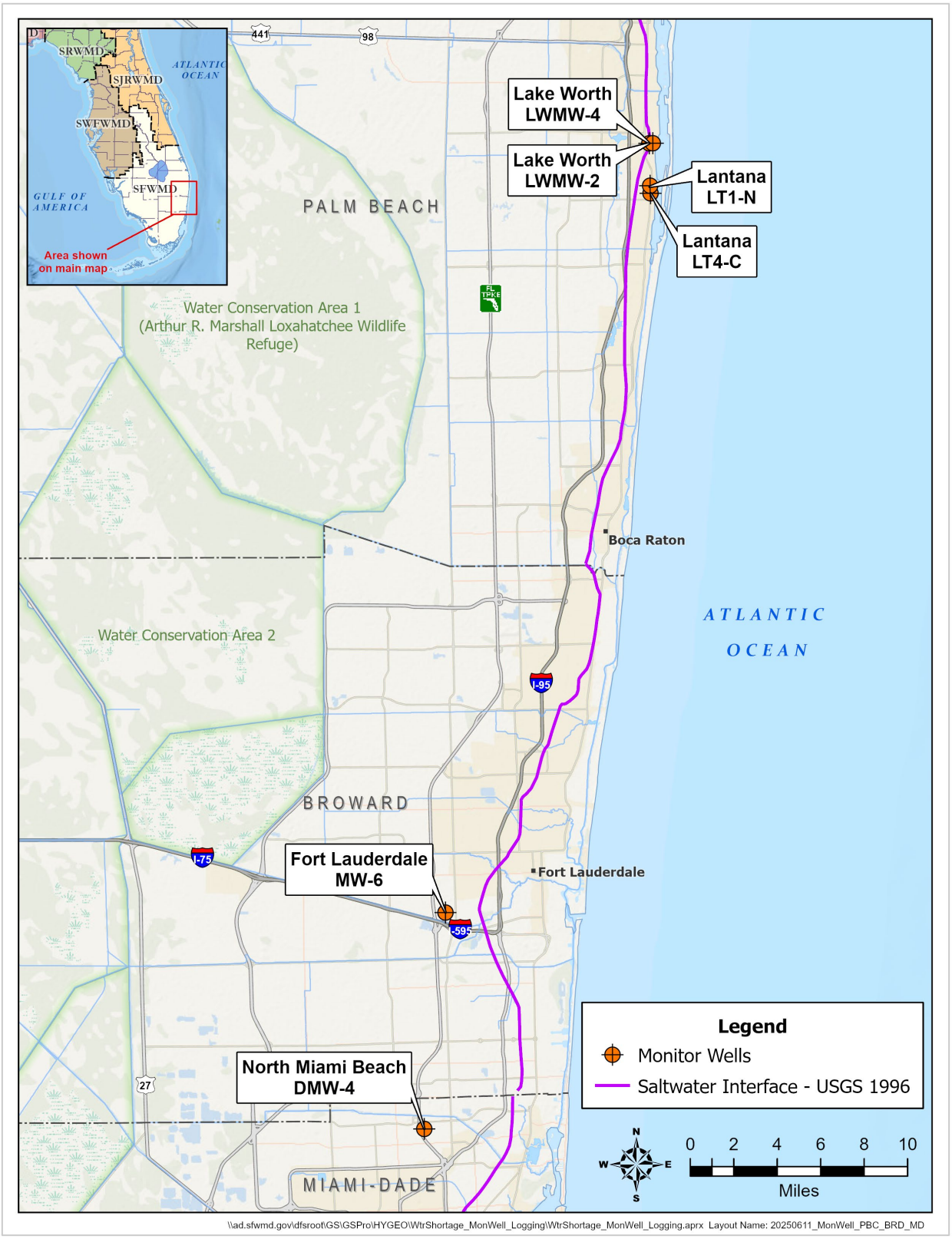

Figure 4. Induction logging locations in Miami-Dade, Broward, and Palm Beach counties.

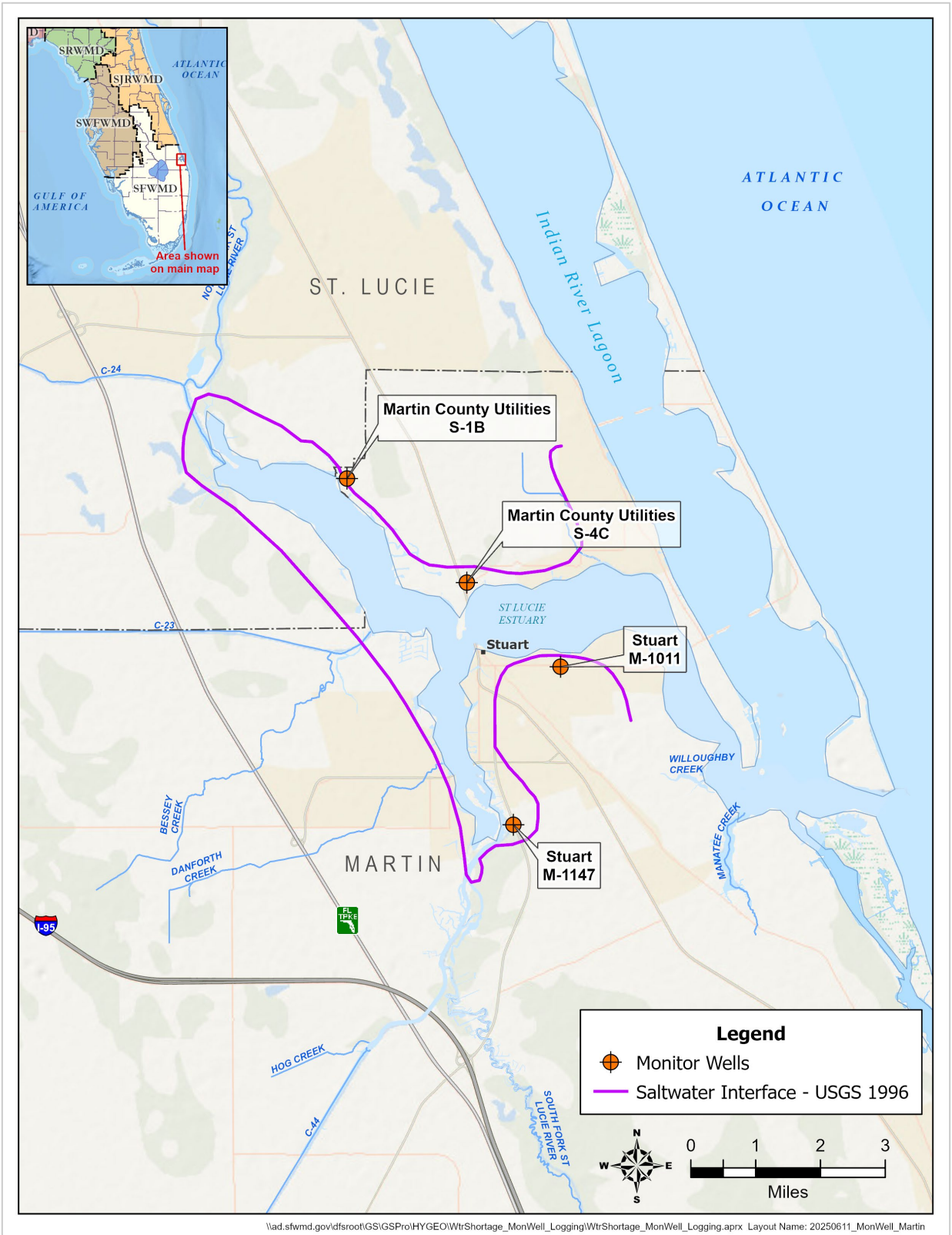

Figure 5. Martin County induction logging locations.

The induction logs for the 10 wells indicate that the saltwater interface may not have migrated very far when compared to the USGS studies (**Appendix B**). However, monitor well DMW-4 in the City of North Miami Beach warranted further investigation. This well showed a spike in conductivity between 65 and 70 ft bls and showed a significant increase in conductivity at depths below 130 ft bls (**Figure 6**). DMW-4 is located in an important area because it is approximately 3.5 miles inland/west of the last plotted position of the saltwater interface (Sonenshein 1997).

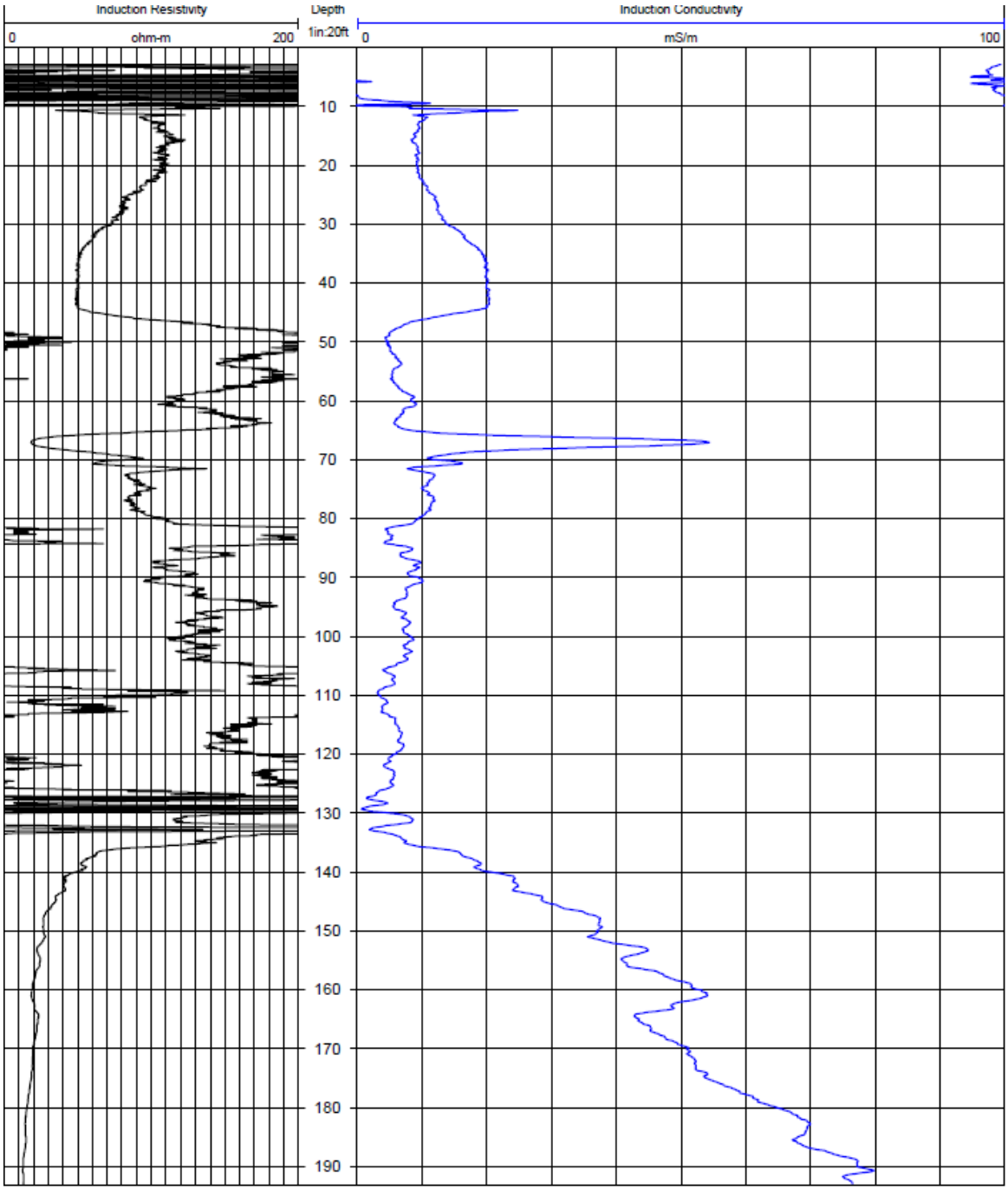

Figure 6. Induction log for City of North Miami Beach monitor well DMW-4.

District hydrogeologists lowered a Yellow Springs Instruments (YSI) Model 600XL water quality probe into DMW-4 and 13 other City of North Miami Beach monitor wells in order to collect vertical profiles of both conductivity and temperature. **Figure 7** shows the locations of the City of North Miami Beach monitor wells, and **Table 2** presents their construction details.

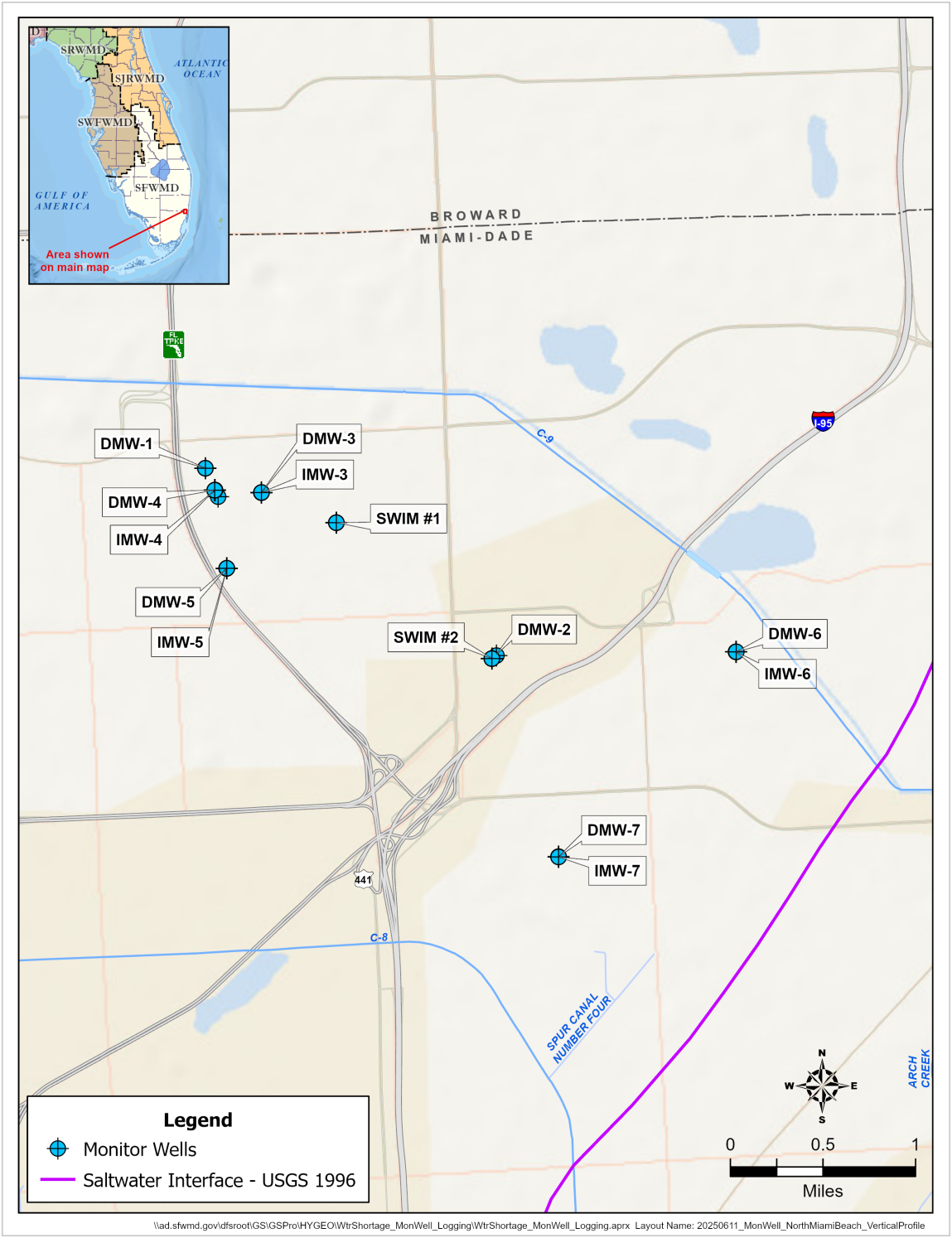

Figure 7. City of North Miami Beach monitor wells selected for vertical water quality profiling.

Table 2. City of North Miami Beach monitor wells selected for vertical water quality profiling.

Well ID	Ground Surface Elevation (feet NAVD88)	Depth (ft bls)	Diameter (inches)
DMW-1	10	146.55	2
DMW-2	7	222.45	2
DMW-3	12	140.65	2
IMW-3	12	59.2	2
DMW-4	11	195.5	2
IMW-4	11	59.2	2
DMW-5	7	27.6	2
IMW-5	7	17.3	-
DMW-6	5	101.4	2
IMW-6	5	73.3	2
DMW-7	9	104.4	2
IMW-7	9	75.8	-
SWIM #1	11	-	2
SWIM #2	7	161.85	2

ft bls = feet below land surface; NAVD88 = North American Vertical Datum of 1988.

Because the probe did not have a pressure sensor (which could be used to calculate depth), readings were collected every second as the probe was lowered to the bottom of each well. An estimated depth was calculated by dividing the time it took for the probe to reach the bottom of the well by the well's total depth and multiplying this result by the time of each measurement. The purpose of the conductivity profiling was to verify the increasing conductivity trend recorded below a depth of 130 ft bls in DMW-4 and to determine the areal extent of this high-conductivity groundwater (i.e., the saltwater interface or wedge) using the data collected from the monitor wells in **Figure 7** and **Table 2**. Unlike the induction log, the YSI probe is only able to measure water quality within the cased well and cannot measure in-situ water quality parameters in the formation outside of the well casing. In addition, water quality within the well is affected by the length of the well screen or open interval of the well. Wells with longer screened intervals are open to a larger portion of the aquifer, resulting in a mixture of water quality from different portions of the aquifer.

The results of the vertical water quality profiling in DMW-4 (**Figure 8**) showed a conductivity spike at approximately 40 ft bls and another slight increase at approximately 190 ft bls. The conductivity spike at 40 ft bls may be a result of a separated well casing at this depth and a mixing of the entire column of water contained in the well. The total conductivity profile recorded by the YSI probe shows less definition than the conductivity recorded by the induction logging tool because the probe cannot measure the groundwater outside of the well casing. Overall, the conductivity of the water in DMW-4 was approximately 35 mS/m at depths below about 40 ft bls.

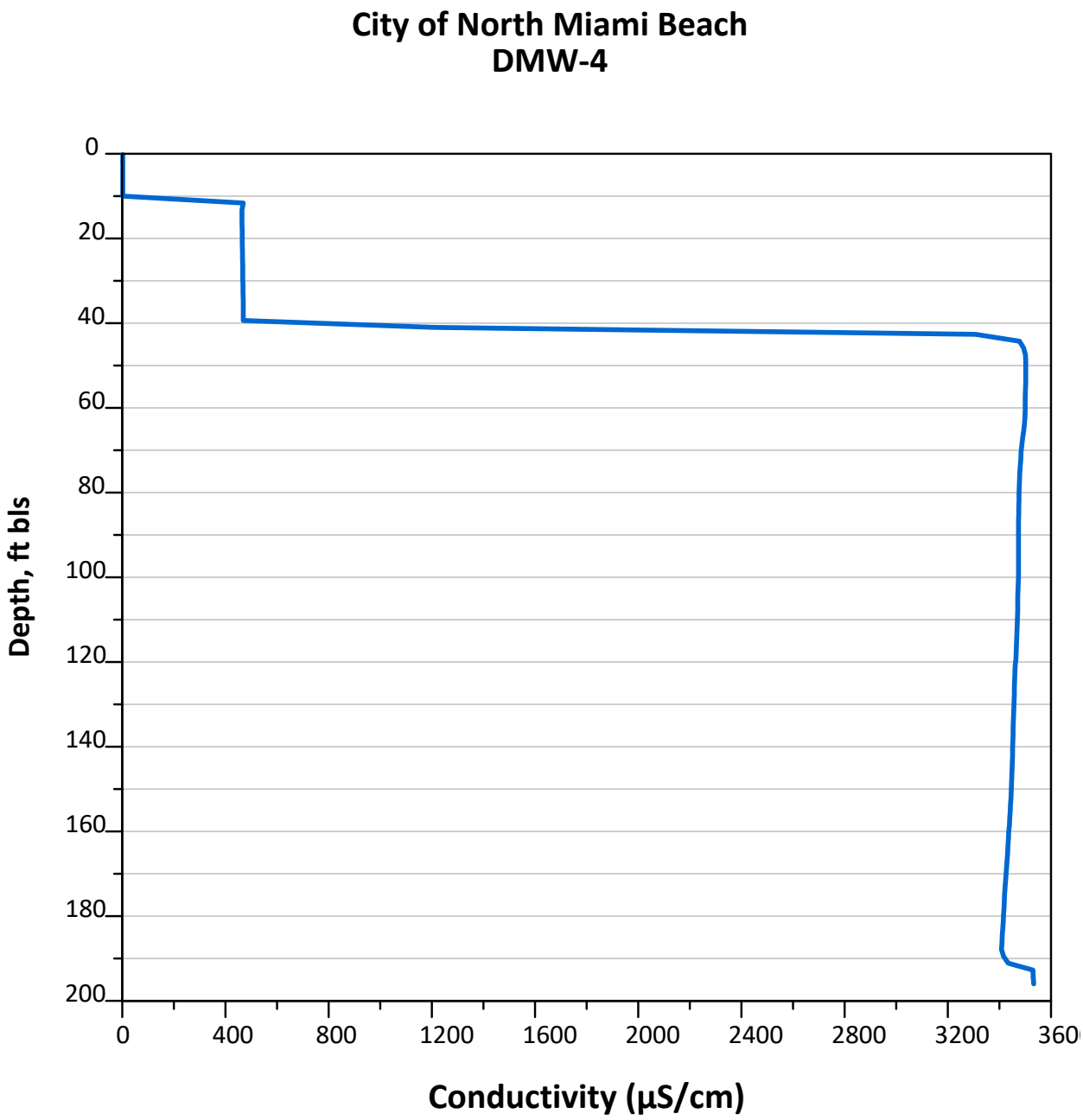

Figure 8. Vertical conductivity profile collected using a YSI water quality probe at DMW-4.

During the DMW-4 vertical water quality profiling, District hydrogeologists noted a raw sewage odor when they removed the YSI probe from the well. This odor could indicate that there is a crack or separation in the well casing. A down-hole camera survey could shed some light on the condition of the well's casing. The only other well with similar conductivity readings was DMW-3, located to the east, which had conductivity values of approximately 31 mS/m. The remaining monitor wells contained fresh water based on the conductivity profiles. A copy of the conductivity profiles for the six deep monitoring wells (wells in **Table 2** that have names starting with "DMW") is included in **Appendix B**.

5 CONCLUSIONS AND RECOMMENDATIONS

Ten induction logs collected by Technos (**Table 1**) indicated minimal inland migration of the saltwater interface along the east coast of Florida between Martin and Miami-Dade counties when compared to previous investigations performed by the USGS. The induction log for the City of North Miami Beach monitor well DMW-4 showed a spike in bulk conductivity between 65 and 70 ft bls and a significant increase in bulk conductivity below a depth of 130 ft bls. DMW-4 is located approximately 3.5 miles west of the saltwater interface as mapped by previous USGS studies (Koszalka 1995, Sonenshein 1997, Hittle 1999). District hydrogeologists collected vertical conductivity profiles in DMW-4 and 13 other City of North Miami Beach monitor wells using a YSI water quality probe. The vertical water quality profile for DMW-4 showed a conductivity spike at approximately 40 ft bls and another slight increase in conductivity at a depth of approximately 190 ft bls, but the majority of the conductivity measurements below 40 ft bls were approximately 35 mS/m. The vertical conductivity profile did not determine the source of conductivity spikes seen on the induction log since the water quality probe is only able to measure the water quality of the water contained within the well casing. District hydrogeologists also noted a raw sewage odor at this well, possibly indicating that a cracked or separated well casing was allowing untreated wastewater to enter the well. A down-hole camera survey should be completed in this well to determine if the well casing is damaged. Further investigation of this well is recommended to determine if the saline water in the well is connate water (ancient seawater) or modern seawater. A water quality sample should also be collected from DMW-4 and analyzed for total anions, total cations, and total dissolved solids analyses in order to determine the origin of the saline water in the well. Additional analyses to determine the origin of the sewage odor is also recommended, and if contamination is present at the site, and the well is damaged, the well should be properly abandoned to prevent further contamination or cross-contamination between aquifers.

This study shows that there has been little migration of the saline water interface when compared to previous USGS studies (Koszalka 1995, Sonenshein 1997, Hittle 1999). However, this study was limited in scope and areal extent, and the District recommends the following:

- Updating the USGS saltwater intrusion studies.
- Completing induction logging of the City of North Miami Beach wells and collecting groundwater samples from each well for chloride and specific conductance laboratory analyses.
- Completing a down-hole camera log in the City of North Miami Beach well DMW-4.

Completion of these recommended tasks will help refine the location of the saltwater interface along the east coast of Florida, particularly near the City of North Miami Beach, and determine if well DMW-4 is damaged and needs to be properly abandoned.

6 LITERATURE CITED

Hittle, C.D. 1999. *Delineation of Saltwater Intrusion in the Surficial Aquifer System in Eastern Palm Beach, Martin, and St. Lucie Counties, Florida 1997-98*. Water-Resources Investigations Report 99-4214, 1 sheet. Prepared in cooperation with the South Florida Water Management District, West Palm Beach, FL. United States Geological Survey, Reston, VA.

Koszalka, E.J. 1995. *Delineation of Saltwater Intrusion in the Biscayne Aquifer, Eastern Broward County, Florida, 1990*. Water-Resources Investigations Report 93-4164, 1 sheet. Prepared in cooperation with the South Florida Water Management District, West Palm Beach, FL. United States Geological Survey, Reston, VA.

Sonenshein, R.S. 1997. *Delineation and Extent of Saltwater Intrusion in the Biscayne Aquifer, Eastern Dade County, Florida, 1995*. Water-Resources Investigations Report 96-4285, 1 sheet. Prepared in cooperation with the Miami-Dade Water and Sewer Department and the Metro-Dade Department of Environmental Resources Management, Miami, FL. United States Geological Survey, Reston, VA.

Technos. 2008. *Revised Report Geophysical Induction Logging of Ten Saltwater Monitoring Wells in Martin, Palm Beach, Broward, and Miami-Dade Counties, Florida*. Technos Project 07-174, January 23, 2008. Prepared for the South Florida Water Management District, West Palm Beach, FL. Technos, Inc., Miami, FL.

APPENDICES

APPENDIX A:
GEOPHYSICAL INDUCTION LOGS COLLECTED FROM 10 SALTWATER MONITORING WELLS IN MARTIN, PALM BEACH, BROWARD, AND MIAMI-DADE COUNTIES, FLORIDA

TECHNOS INC.

Revised Report
Geophysical Induction Logging
Of Ten Saltwater Monitoring Wells
In Martin, Palm Beach, Broward and
Miami-Dade Counties, Florida

for
South Florida Water Management District
West Palm Beach, Florida

January 23, 2008

SFWMD Purchase Order No.: 4100000026
Technos Project No. 07-174

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BACKGROUND AND APPROACH

South Florida Water Management District contracted Technos, Inc. to conduct geophysical induction logging of as many as ten saltwater monitoring wells located in Martin and Palm Beach Counties. The purpose of the logging was to provide data that can be used to aid in the interpretation of saltwater intrusion. Limited interpretation of the logs were included in this effort based upon the results of the water quality sampling completed by the district personnel. The work was carried out in two field efforts. Martin and Palm Beach County wells were logged July 2nd and 3rd, 2007 and included:

- Lantana – LT1-N and LT4-C;
- Lake Worth – LWMW-2 and LWMW-4;
- Stuart – M1011 and M1147; and
- Jensen – S1B and S4C.

Broward and Dade County wells were logged December 4th, 2007 and included:

- Broward County – MW-6 and
- Dade County – DMW-4.

GEOPHYSICAL INDUCTION LOGGING

Electrical conductivity measurements were made using an induction probe that measures conductivities to a radius of about 2.5 feet from the probe. This log provides continuous data through a PVC-cased or open borehole both above and below the water table. Above the water table, the log responds to soil and rock conductivities plus the degree of moisture present and the specific conductance of the moisture. Below the water table, the log responds to soil and rock conductivity plus the saturated pore fluids. The specific conductance of the pore fluid will often have the dominant effect on the measurement. Data acquire within steel casing is not valid and are not used for interpretation.

The induction logs were digitally recorded as the probe moved both down and up the boreholes at approximately 13 feet per minute. The induction log measures conductivity in units of milliSiemens per meter (mS/m). Resistivity (ohm-m) is calculated from this measurement and included in the data file. The data were plotted using WellCAD.

RESULTS

A plot of the geophysical log for each well has been created using WellCAD. Electronic versions of these plots have been provided with this report as PDF files. Digitally logging data has been provided as *.LAS ASCII files showing depth, induction conductivity and induction resistivity values. In addition, maps for each well were developed.

All wells were cased with PVC except one, LT4-C in Lantana which was cased with steel and had an open hole interval from about 140 to 154 feet. Well MW-6 in Fort Lauderdale indicated the present of metal between 195 and 200 feet deep. This could be due to a centralizer.

The geophysical log plots have used consistent scales for each of the log types so the data from one well can easily be compared to data from another well. When measured values for a log exceed the scale, the data wraps itself around the log scale. For example, the induction conductivity log is plotted using a scale of 0 to 100 mS/m. When the measured values exceed 100 mS/m, which occurs in five wells, the data will wrap around and continue plotting.

CORRELATION WITH WATER QUALITY

In 1996, Technos completed a project in Broward County correlating induction conductivity values to chloride values[11] resulting in a linear regression of y = 20.526x - 464.62. This correlation shows that a conductivity value of about 35 mS/m indicates a chloride value of about 250 mg/l and a conductivity values of about 71 mS/m indicates a chloride value of about 1,000 mg/l. While this relationship was based upon data

[1] Technos, Inc. 1996. Broward County Saltwater Intrusion Monitoring Program Final Report: Task 1-100 TDEM Soundings and Task 2-Quantitative Relationship Between Time Domain Electromagnetic Measurements and Water Quality Data.

specifically acquired in Broward County, it should generally be applicable to other areas with similar geologic conditions.

Water quality data was acquired by the district in all ten of these monitoring wells at the time of logging and was used to develop a correlation between the induction logs and chloride values. Table 1 shows a summary of the water quality data from these ten wells.

Table 1
Summary of Water Quality Data

Well ID	Specific Conductance (umhos/cm)	Chloride (mg/L)	Induction Conductivity (mS/m)
PB-1717	5380	1566	116
LT4-C	11340	3596	290
PB-1723	5170	1476	99
LWMW-2	6000	1819	93
STL-317	591	30.3	28
M-1293	18290	5675	435
M-1011	577	34	47
M-1147	1234	198	47
MW-6	1034	152	110
DMW-4	3570	884	75

Figure 1 shows the correlation plot using chloride values and induction conductivity values. The correlation between chloride values and induction conductivity values in these wells resulting in a linear regression of $y = 0.0676x + 29.697$ with an r-squared value of 0.9259 (using Microsoft Excel). This correlation shows that a conductivity value of about 46 mS/m indicates a chloride value of about 250 mg/l and a conductivity values of about 97 mS/m indicates a chloride value of about 1,000 mg/l. However, this relationship is based upon only 10 data points.

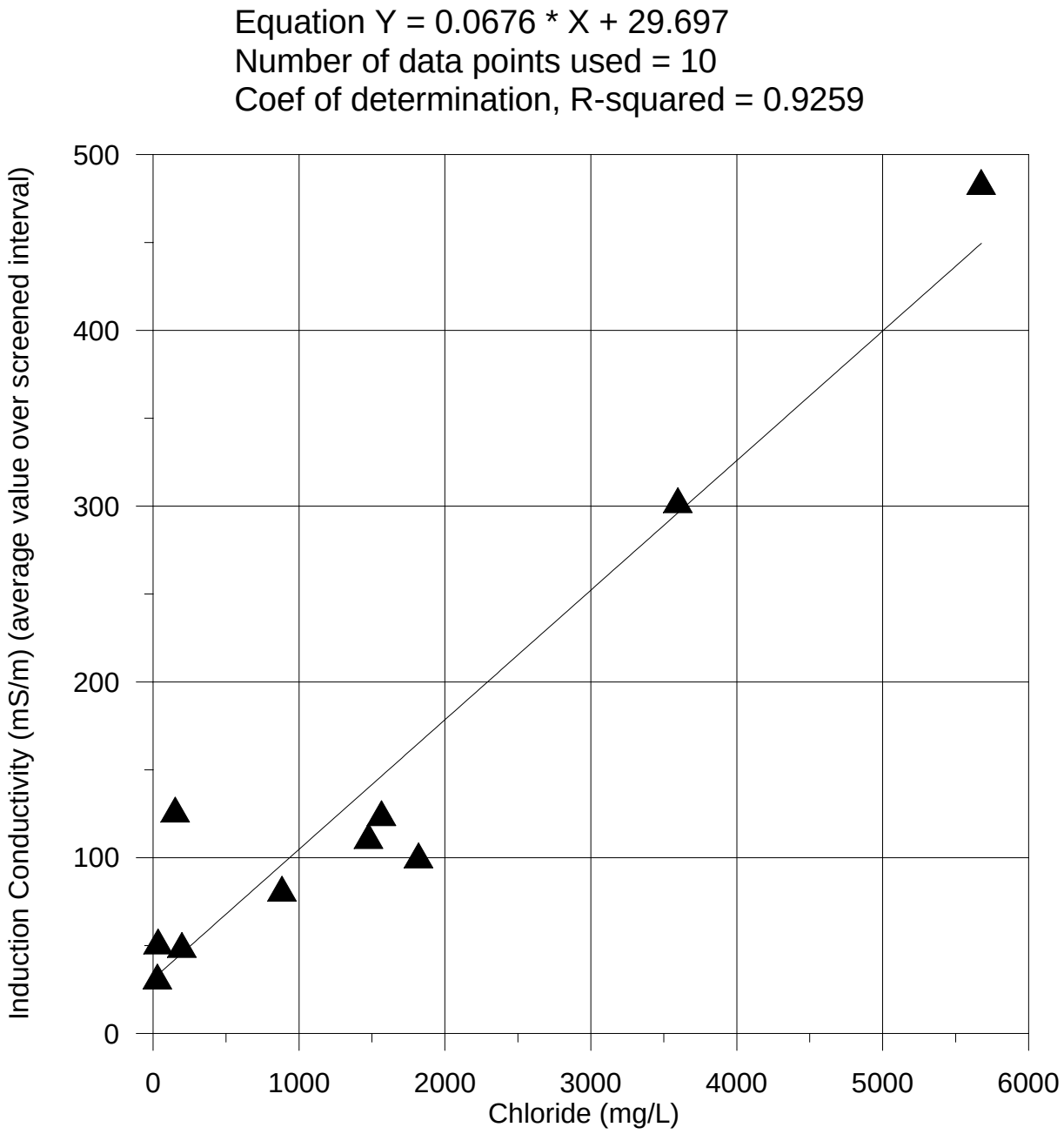
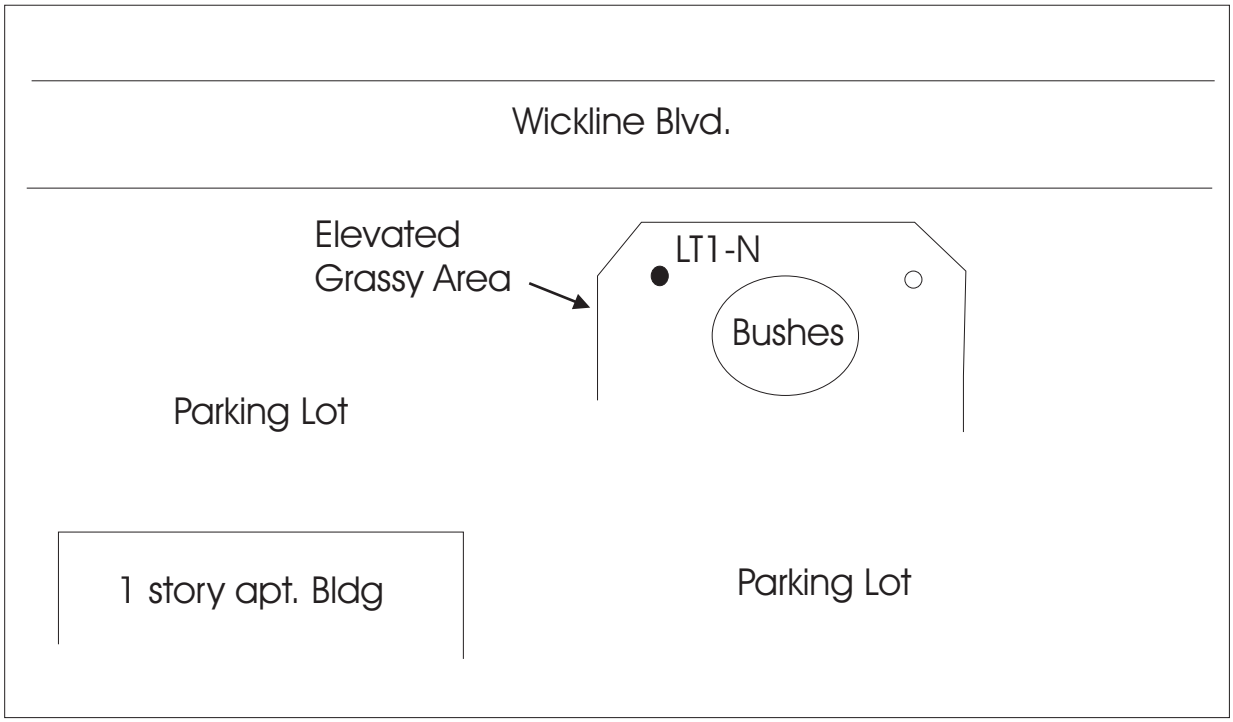


Figure 1. Correlation between induction conductivity logs and chloride values from water quality sampling



Lantana LT1-N

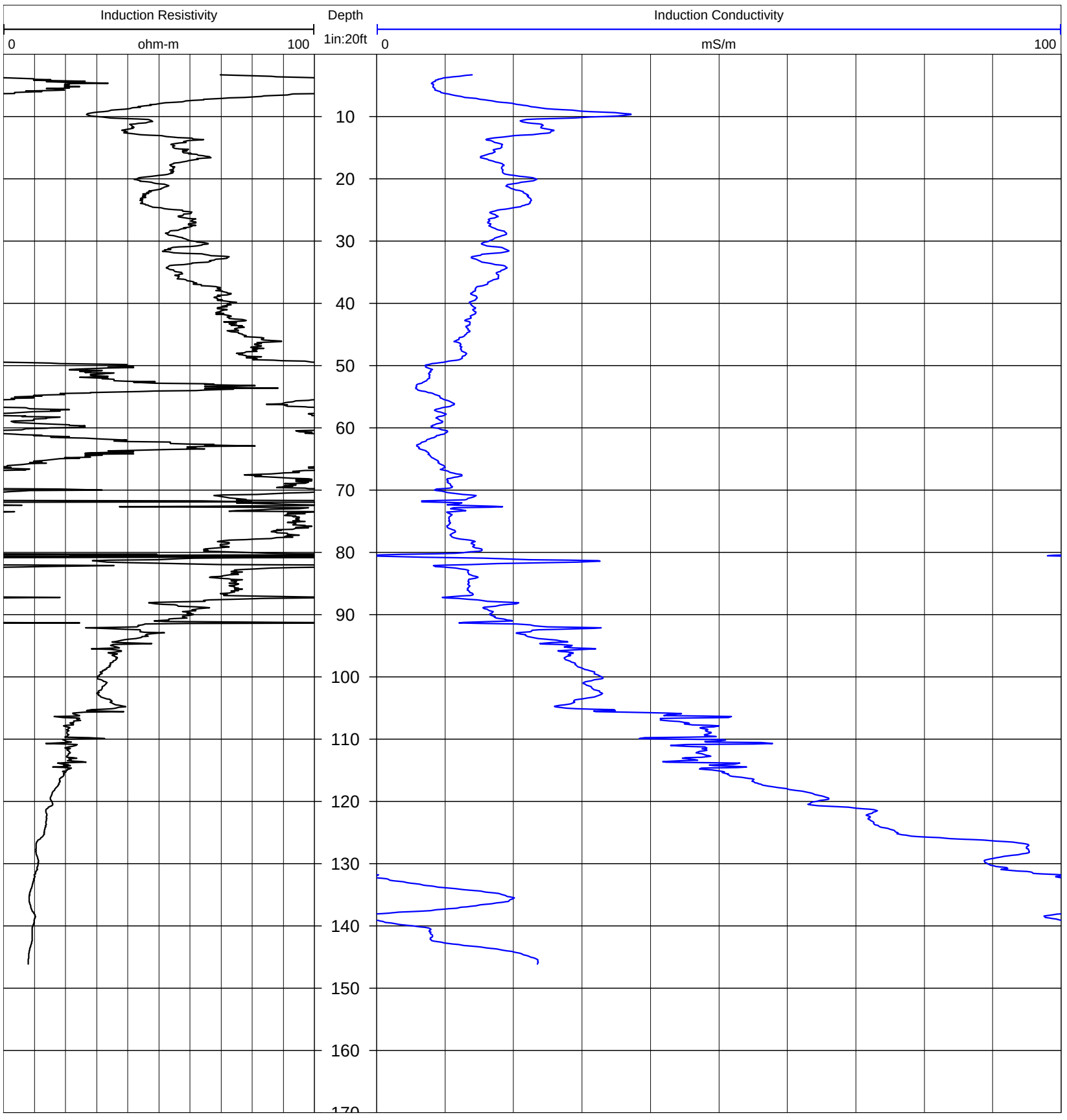
TECHNOS

TECHNOS INC.
10430 NW 31st Terrace
Miami, FL 33172
Phone: (305) 718-9594
FAX: (305) 718-9621
Email: info@technos-inc.com

Project #: 07-174 **Client:** SFWMD **Date:** July 2, 2007
Boring Name: LT1-N **Operator:** L. Yuhr
Site Location: Westernmost well on south side of Wickline Blvd.

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 8.3 ft **Hole Depth:** 146 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



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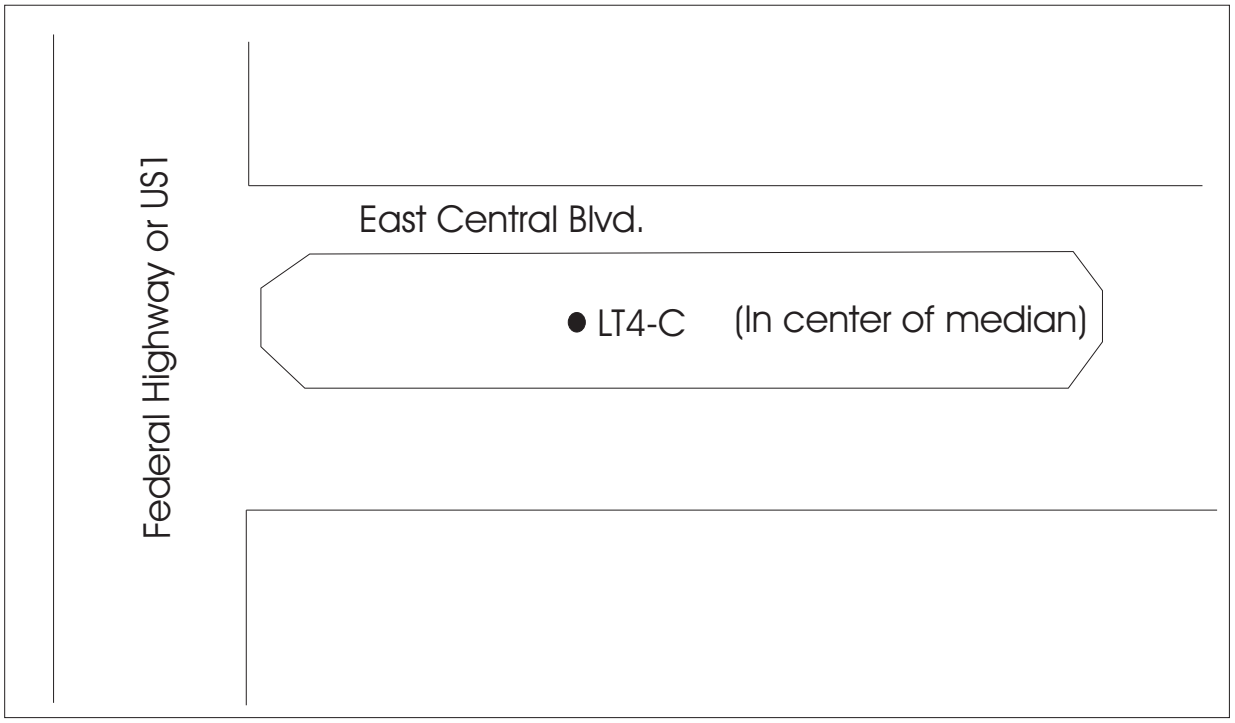

Lantana LT4-C

TECHNOS

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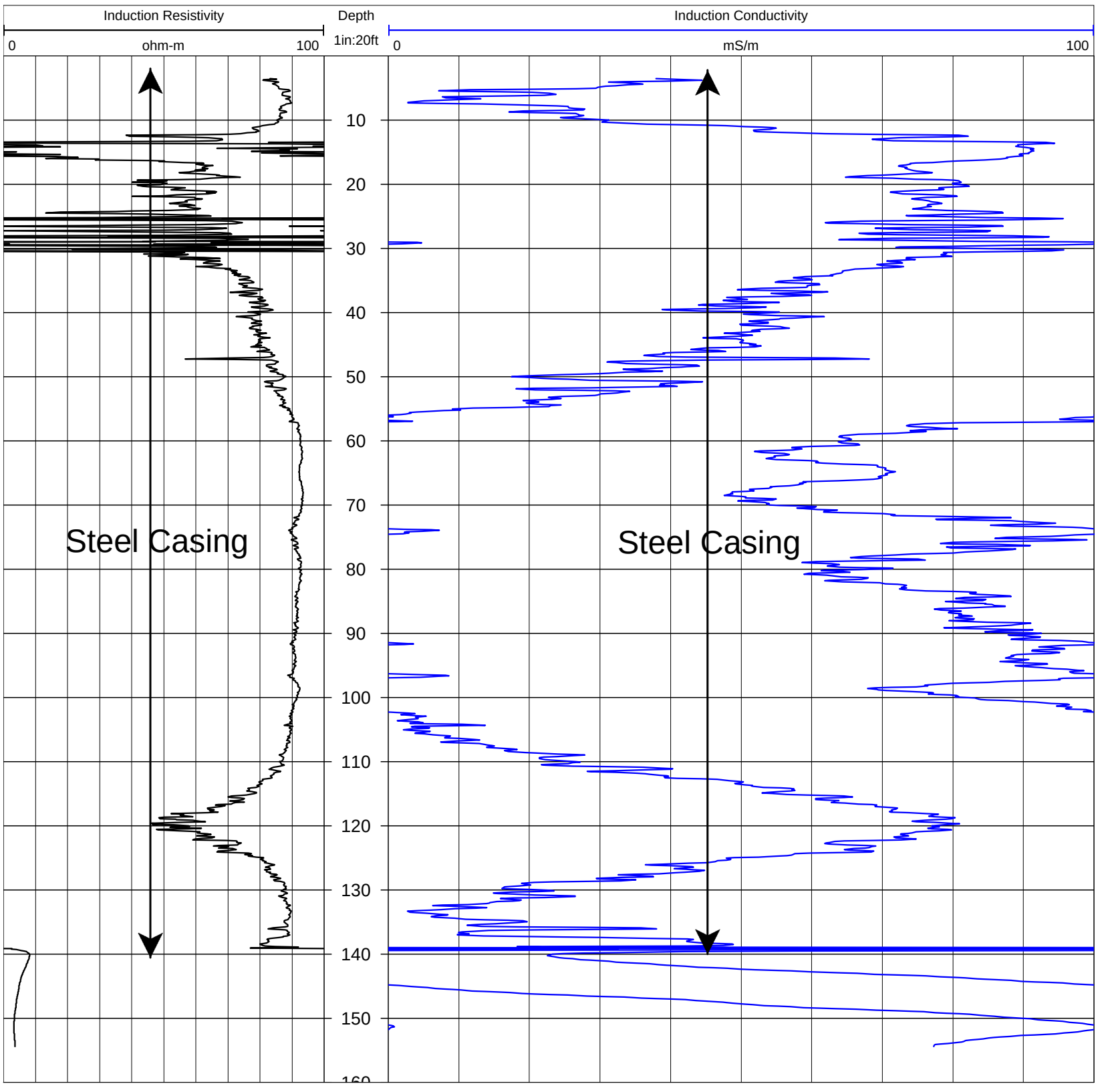
FAX: (305) 718-9621
Email: info@technos-inc.com

Project #: 07-174 **Client:** SFWMD **Date:** July 2, 2007
Boring Name: LT4-C **Operator:** L. Yuhr
Site Location: East of US1 in median of Central Blvd.

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 5.0 ft **Hole Depth:** 154 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



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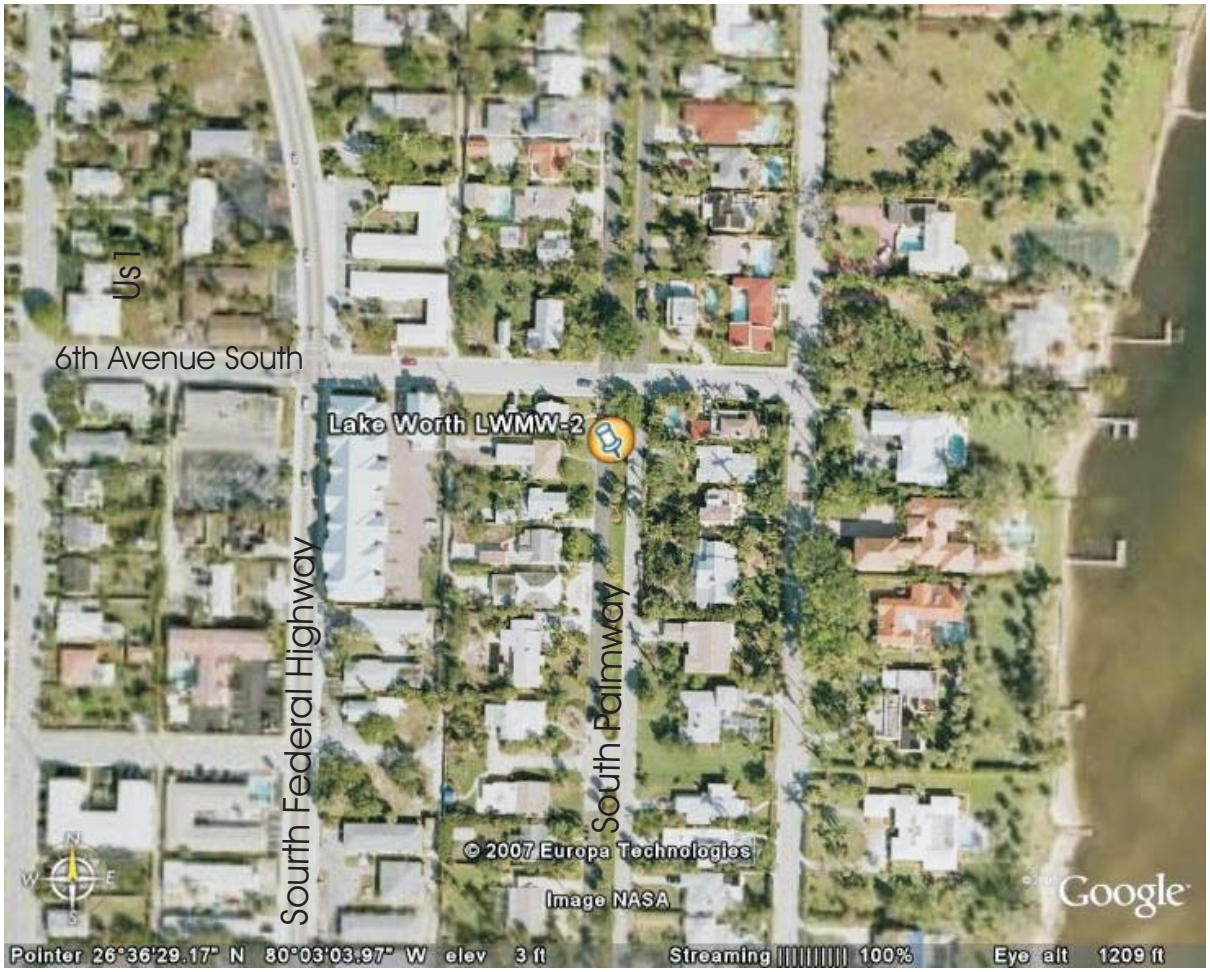

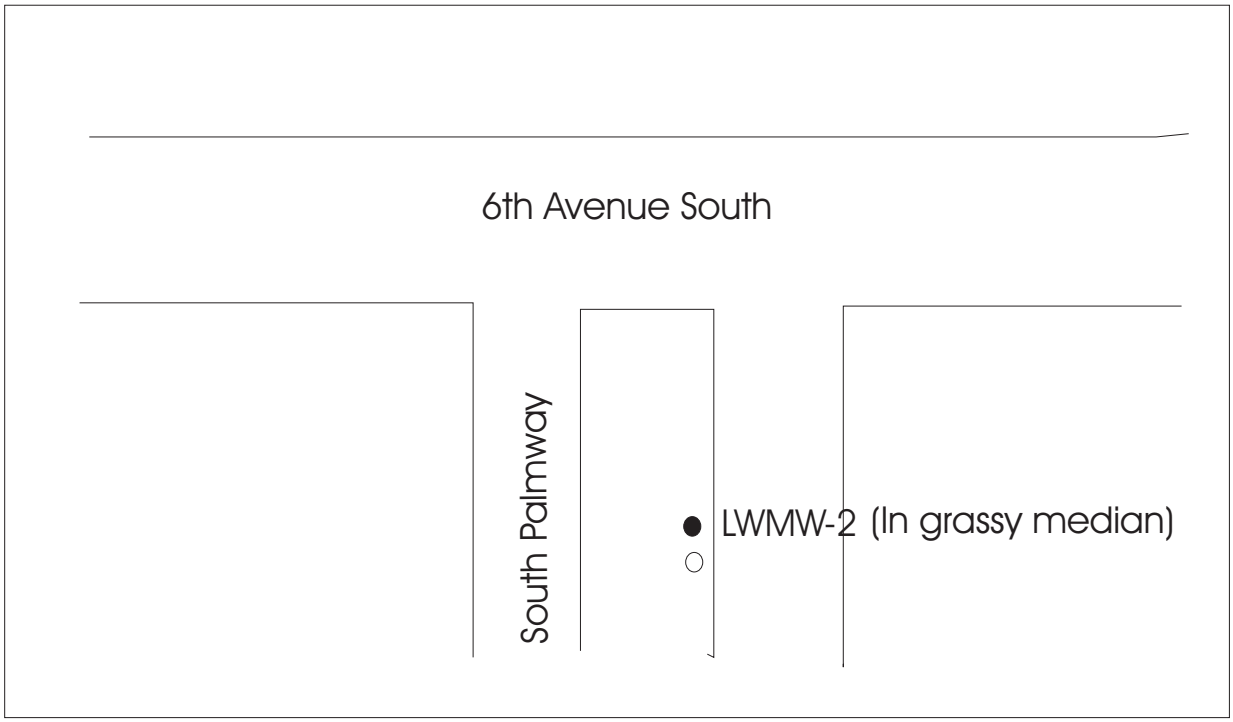

Lake Worth LWMW-2

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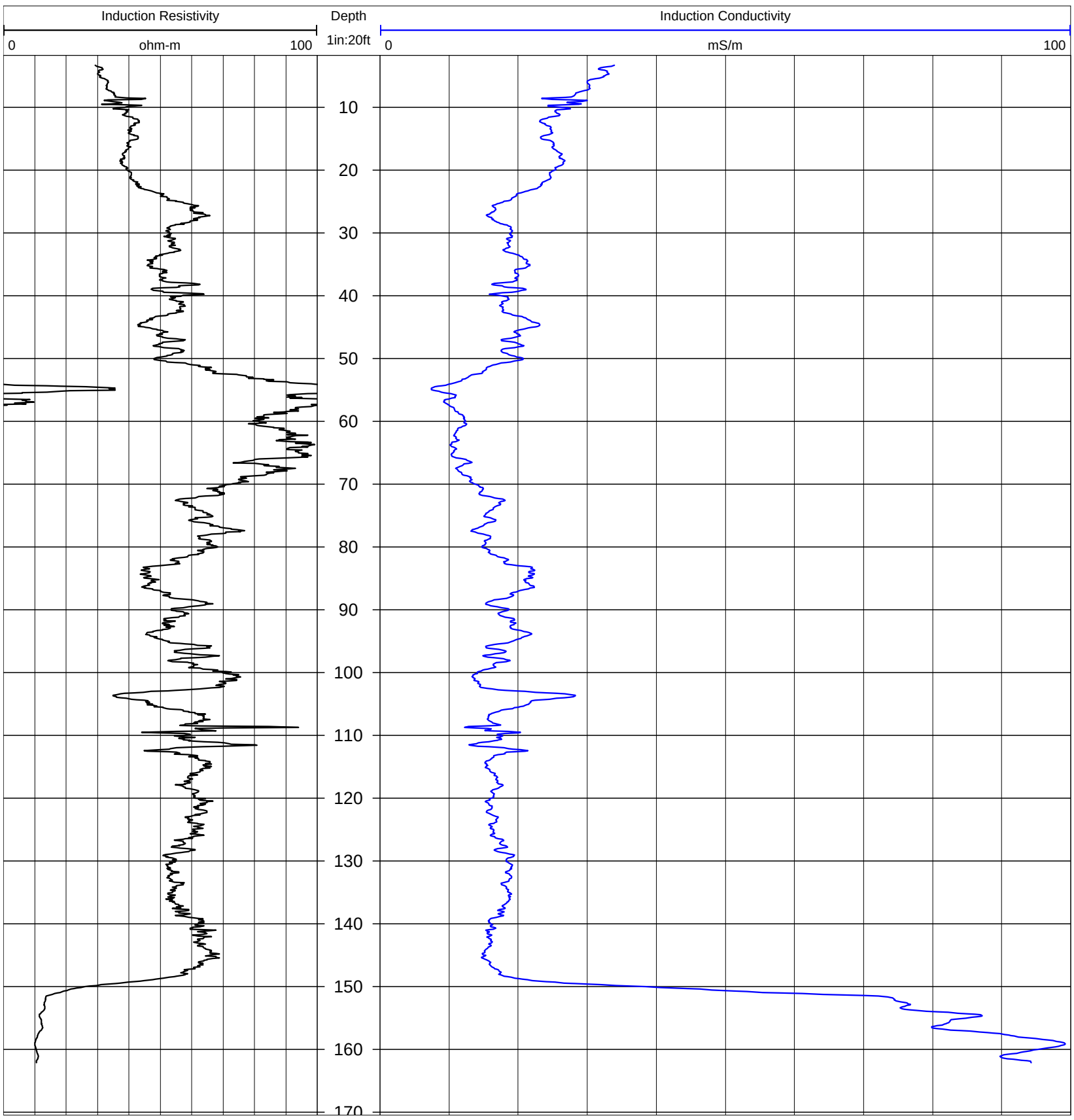
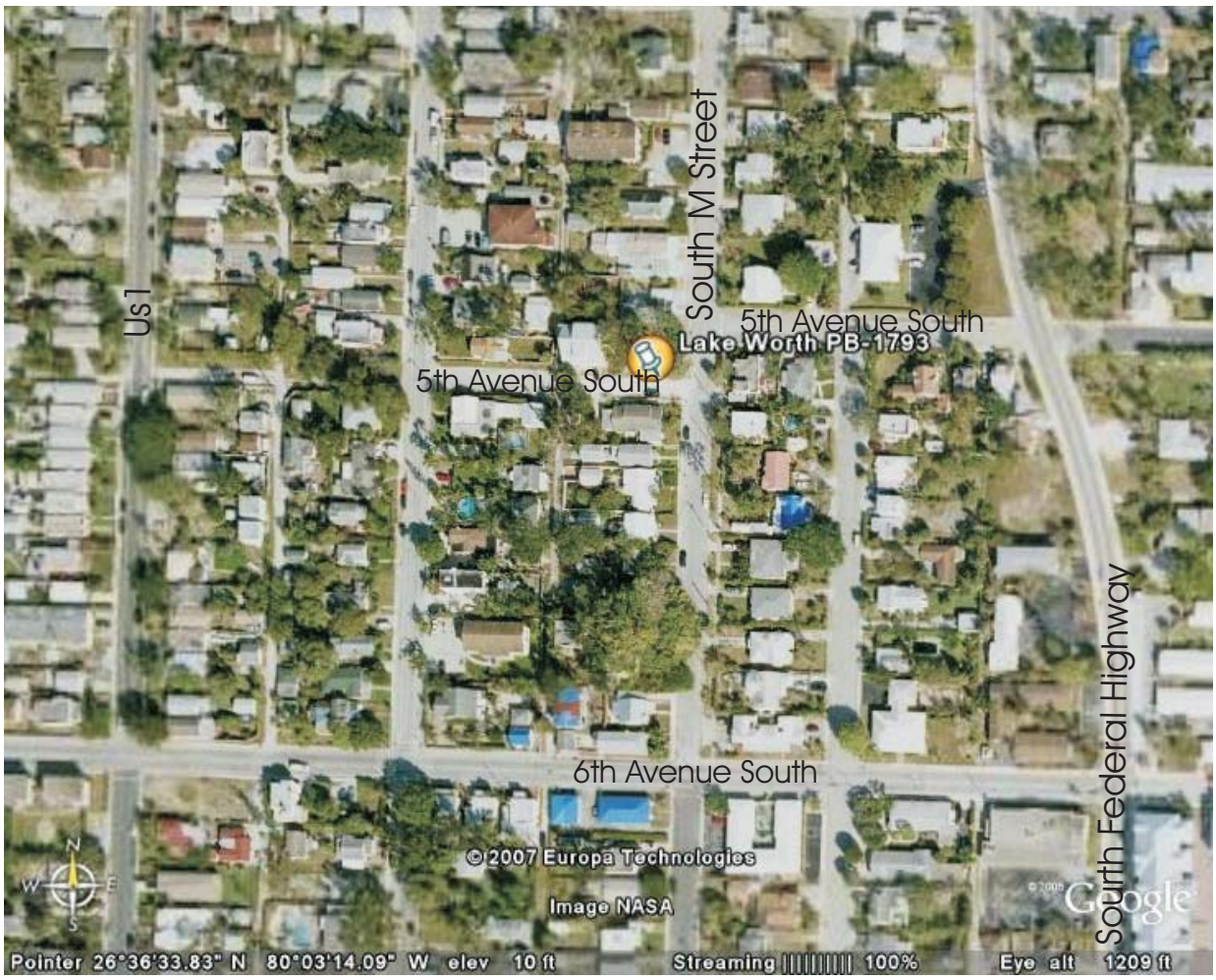
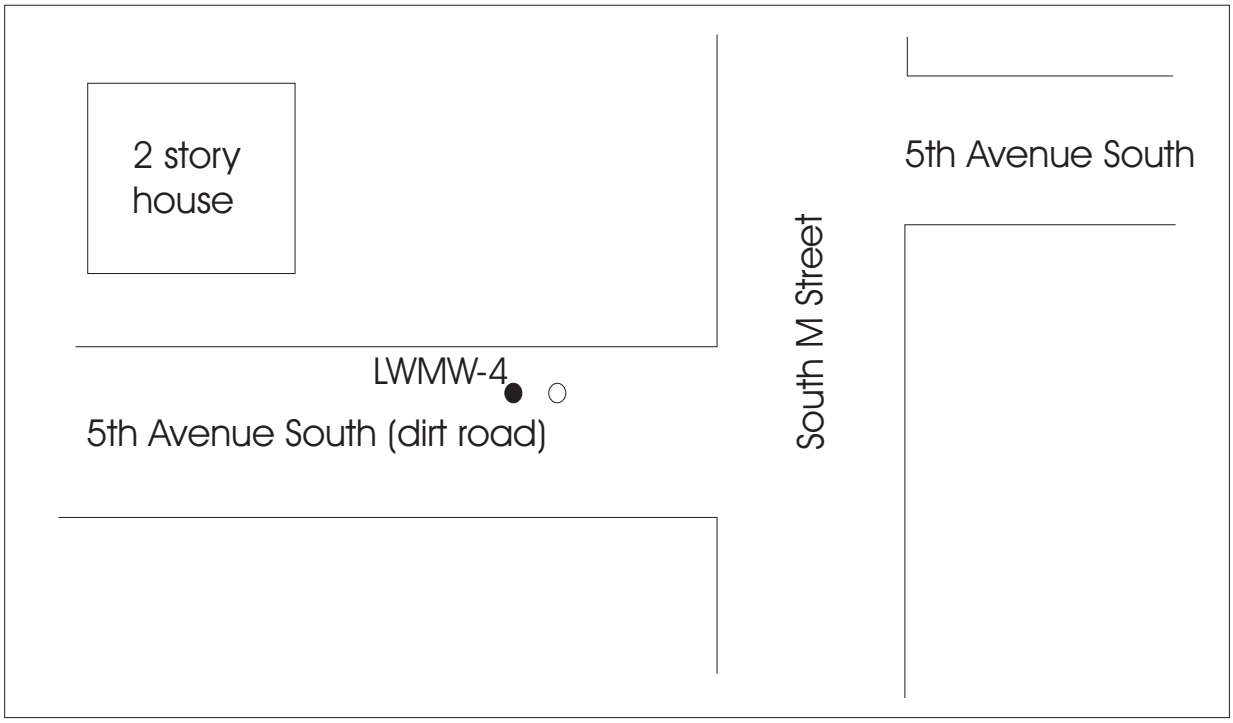
Project #: 07-174 **Client:** SFWMD **Date:** July 3, 2007
Boring Name: LWMW-2 **Operator:** L. Yuhr
Site Location: Northernmost well in median of So. Palmway, south of 6th Ave.

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 3.73 ft **Hole Depth:** 162 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m







Lake Worth LWMW-4

TECHNOS

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10430 NW 31st Terrace
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Phone: (305) 718-9594
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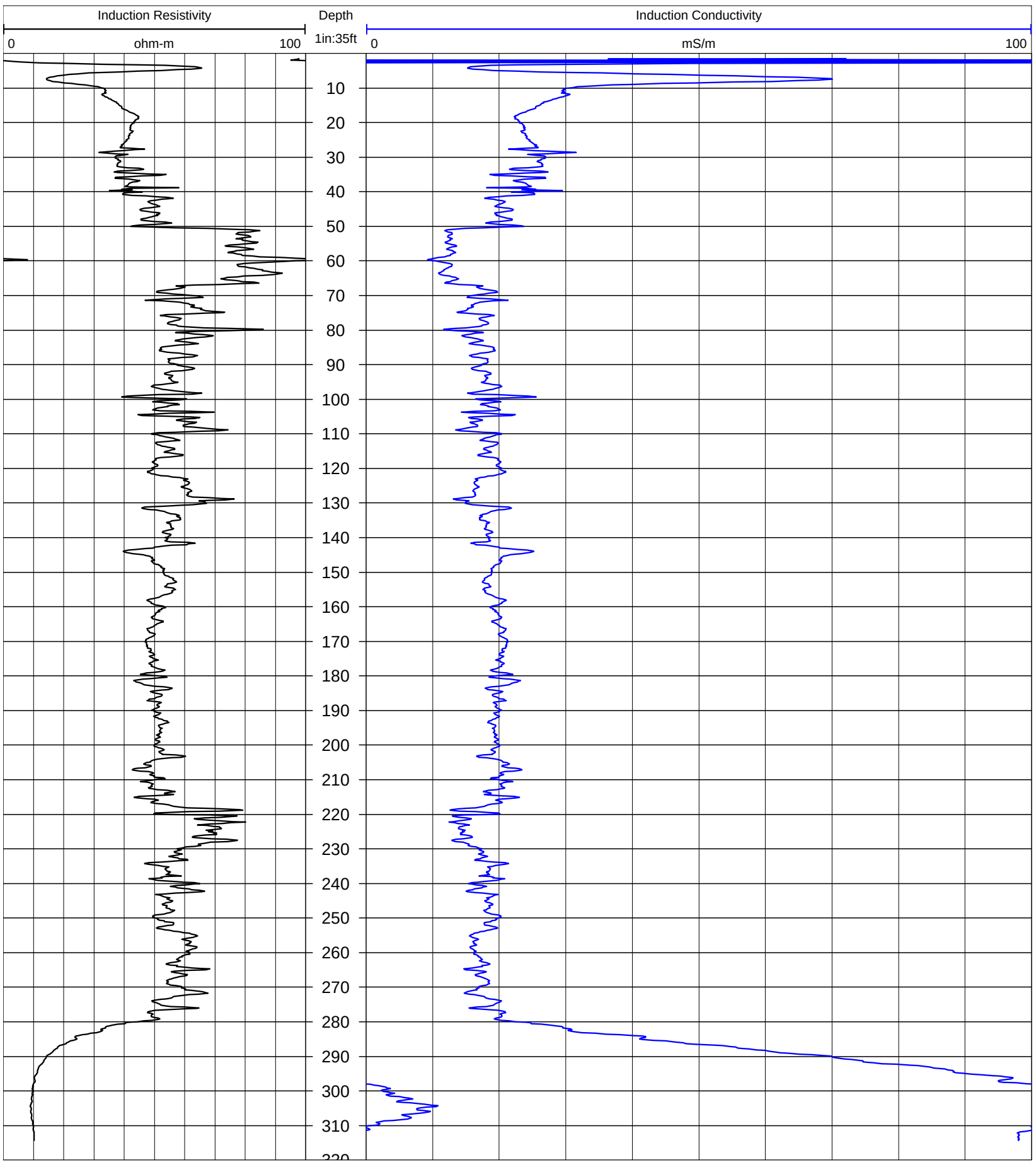
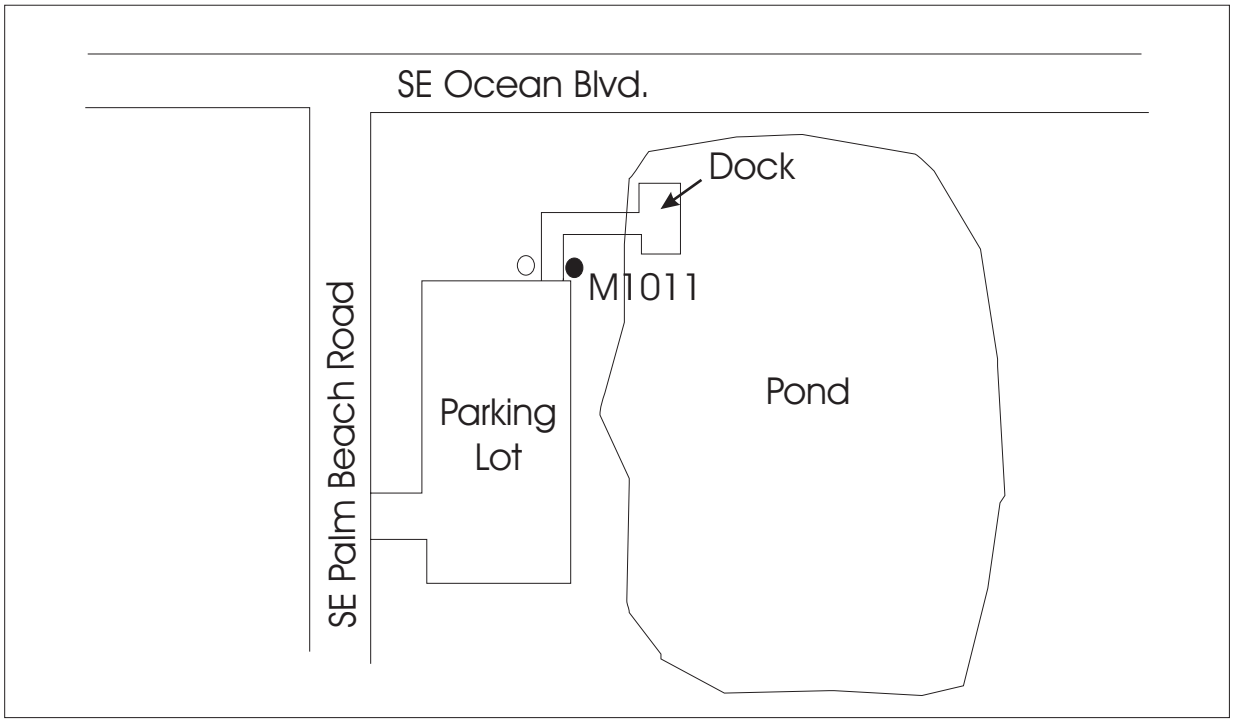
Project #: 07-174 **Client:** SFWMD **Date:** July 3, 2007
Boring Name: LWMW-4 (PB-1723) **Operator:** L. Yuhr
Site Location: Westernmost well, north of 5th Ave. & west of M St.

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 5.9 ft **Hole Depth:** 316 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



TECHNOS



Stuart M1011

TECHNOS

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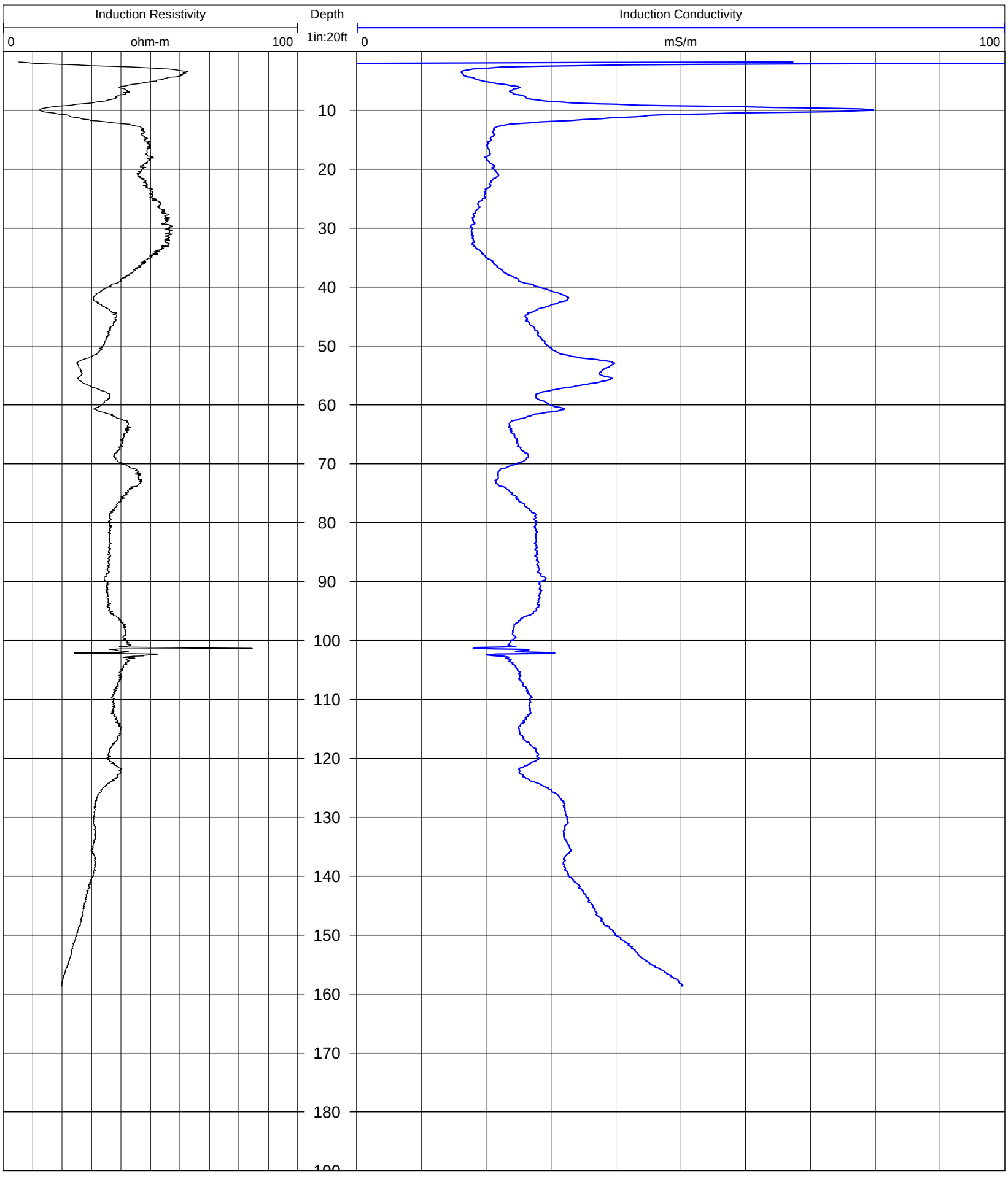
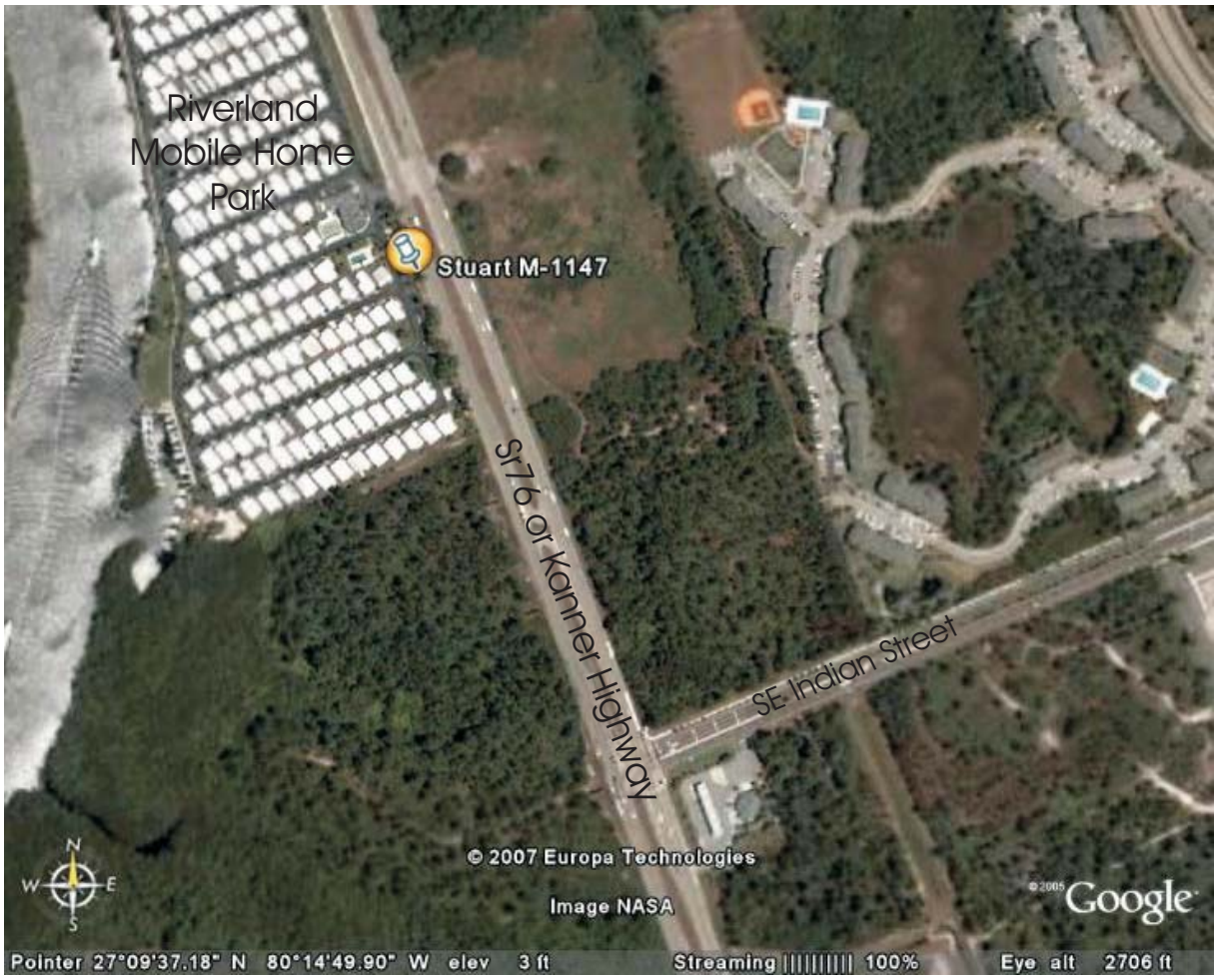
Project #: 07-174 **Client:** SFWMD **Date:** July 3, 2007
Boring Name: M1011 **Operator:** L. Yuhr
Site Location: East of path to dock at park (SE Ocean Blvd & Palm Beach Road)

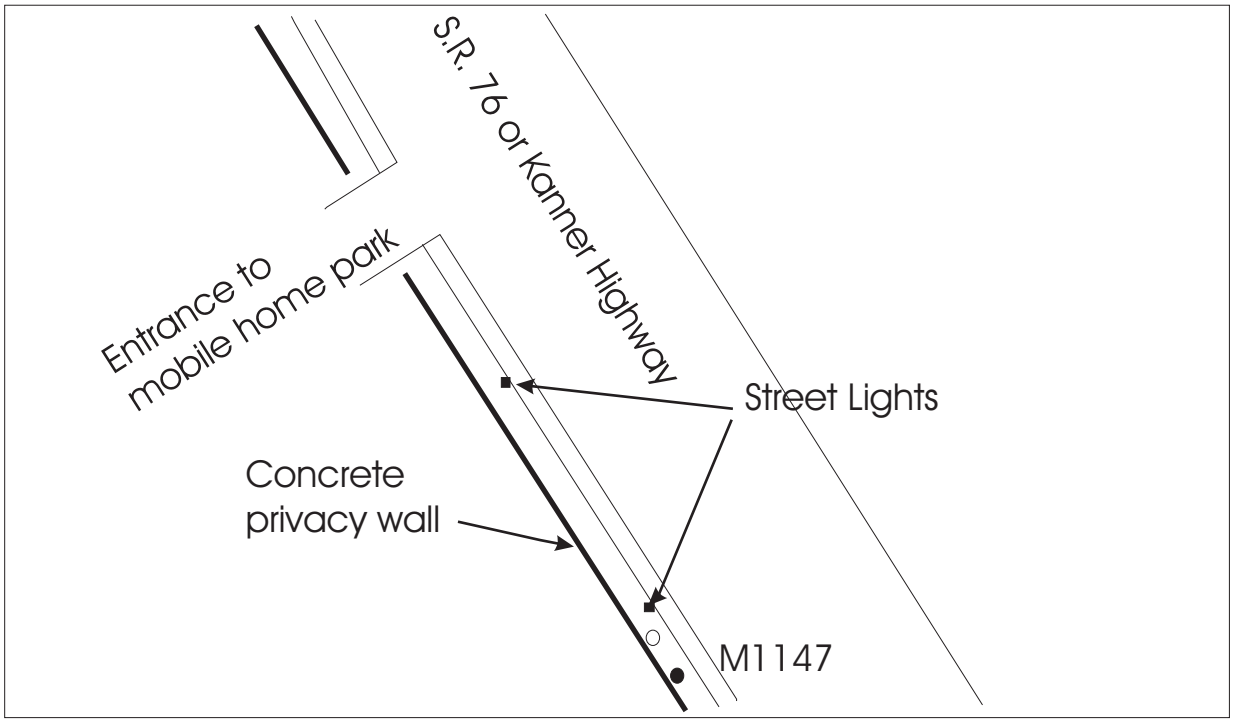
Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 4.75 ft **Hole Depth:**

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



TECHNOS





Stuart M1147

TECHNOS

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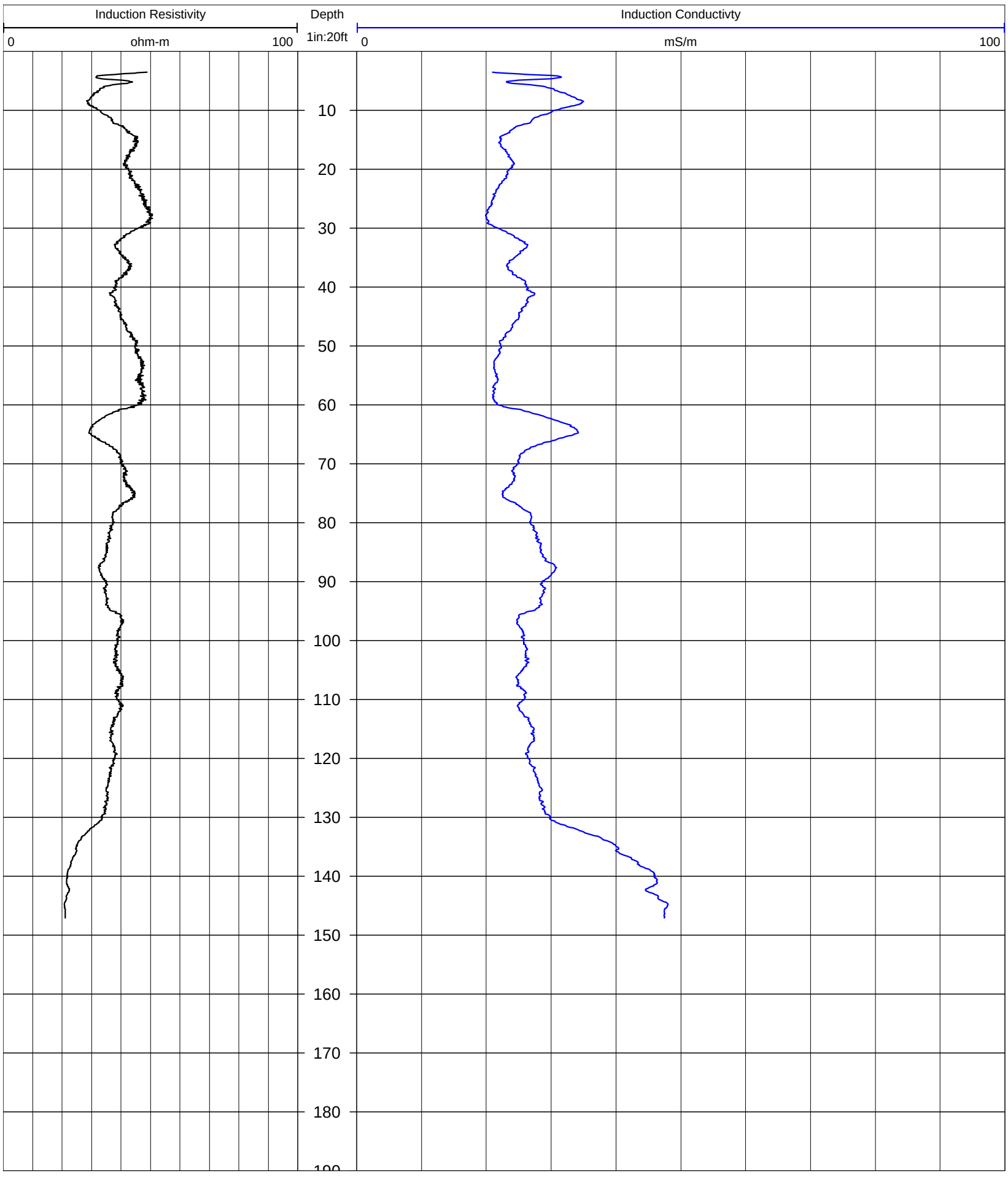
Phone: (305) 718-9594
FAX: (305) 718-9621
Email: info@technos-inc.com

Project #: 07-174 **Client:** SFWMD **Date:** July 3, 2007
Boring Name: M1147 **Operator:** L. Yuhr
Site Location: West side of SR76, south of Riverland Mobile Home Park entrance

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: **Hole Depth:** 147 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



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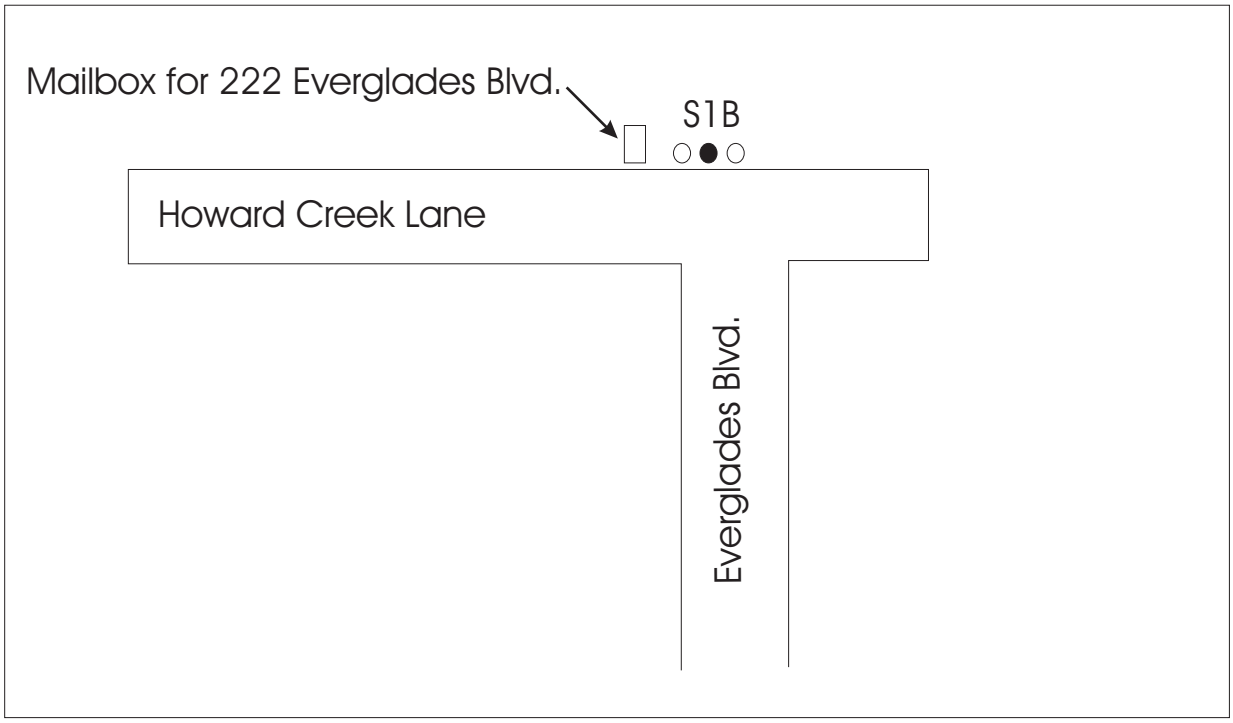

Jensen - S1B

TECHNOS

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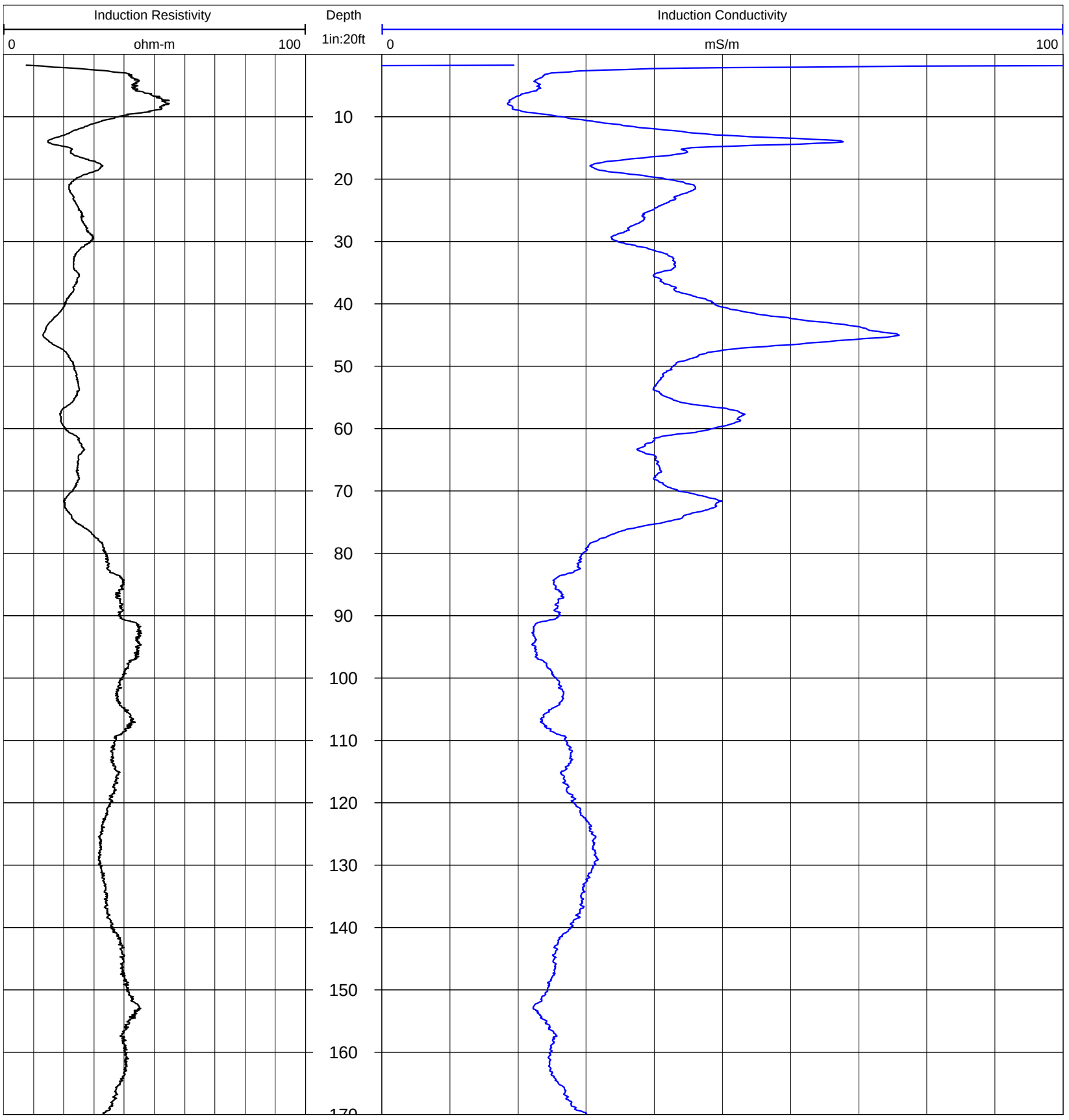
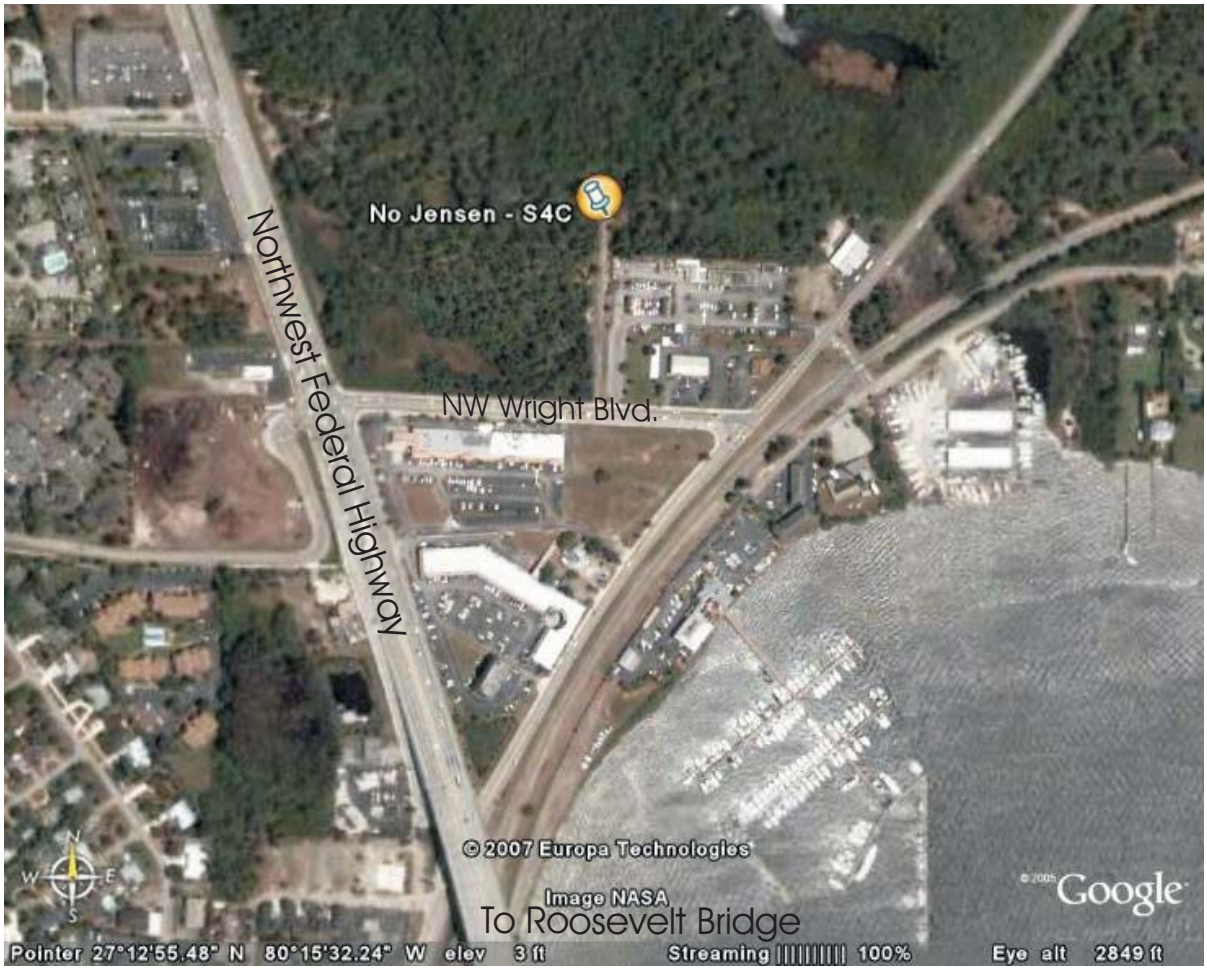
Project #: 07-174 **Client:** SFWMD **Date:** July 2, 2007
Boring Name: S1B (STL-317) **Operator:** L. Yuhr
Site Location: 222 Everglades Blvd.

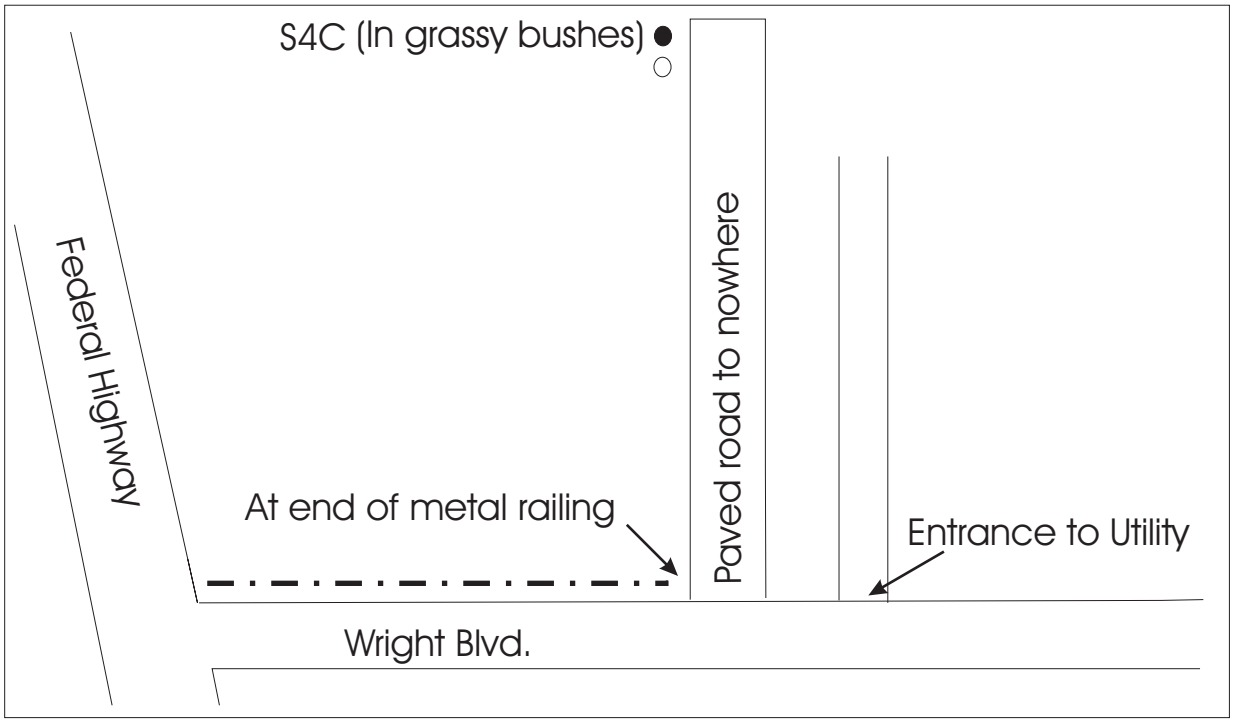
Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 3.41 ft **Hole Depth:** 170 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



TECHNOS





Jensen - S4C

TECHNOS

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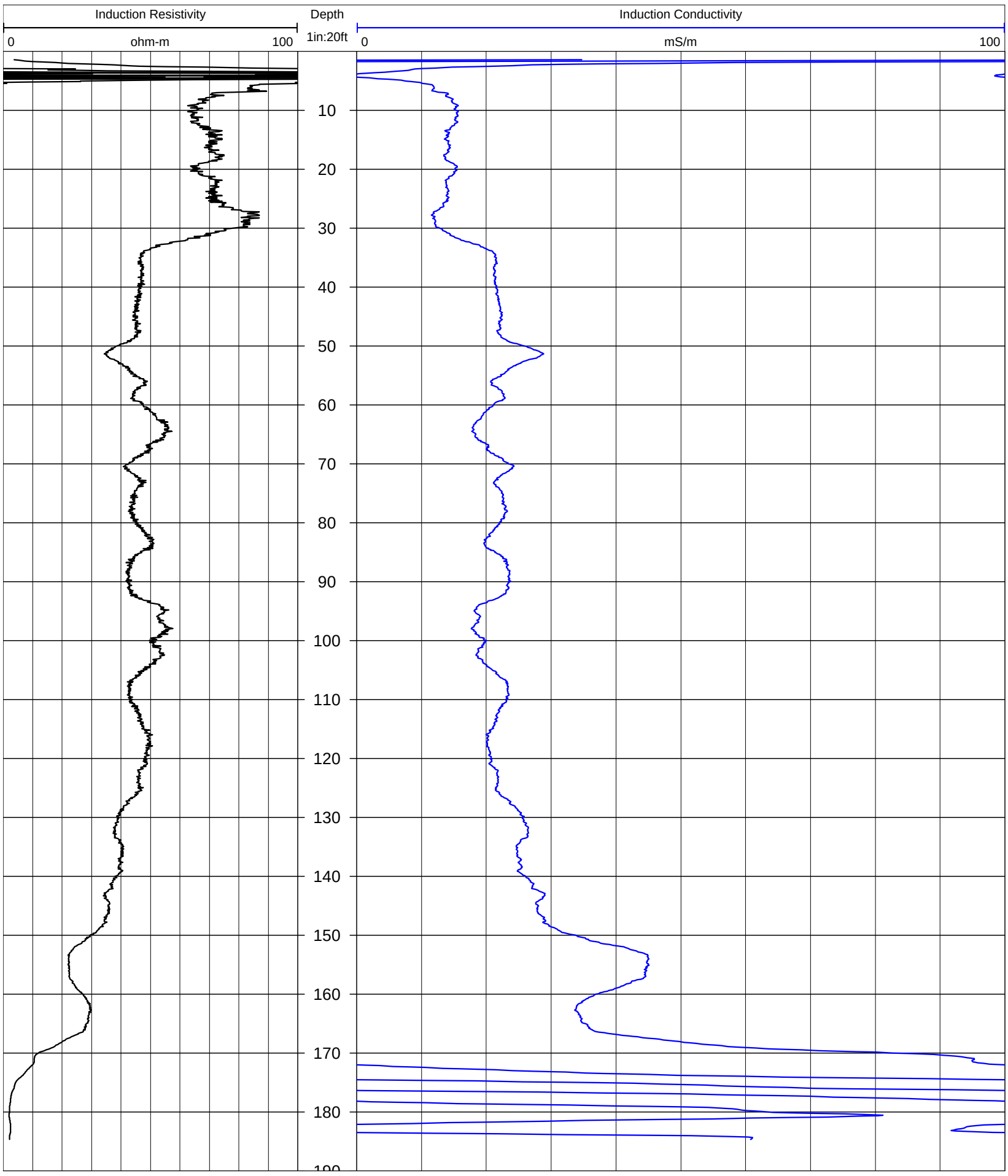
Email: info@technos-inc.com

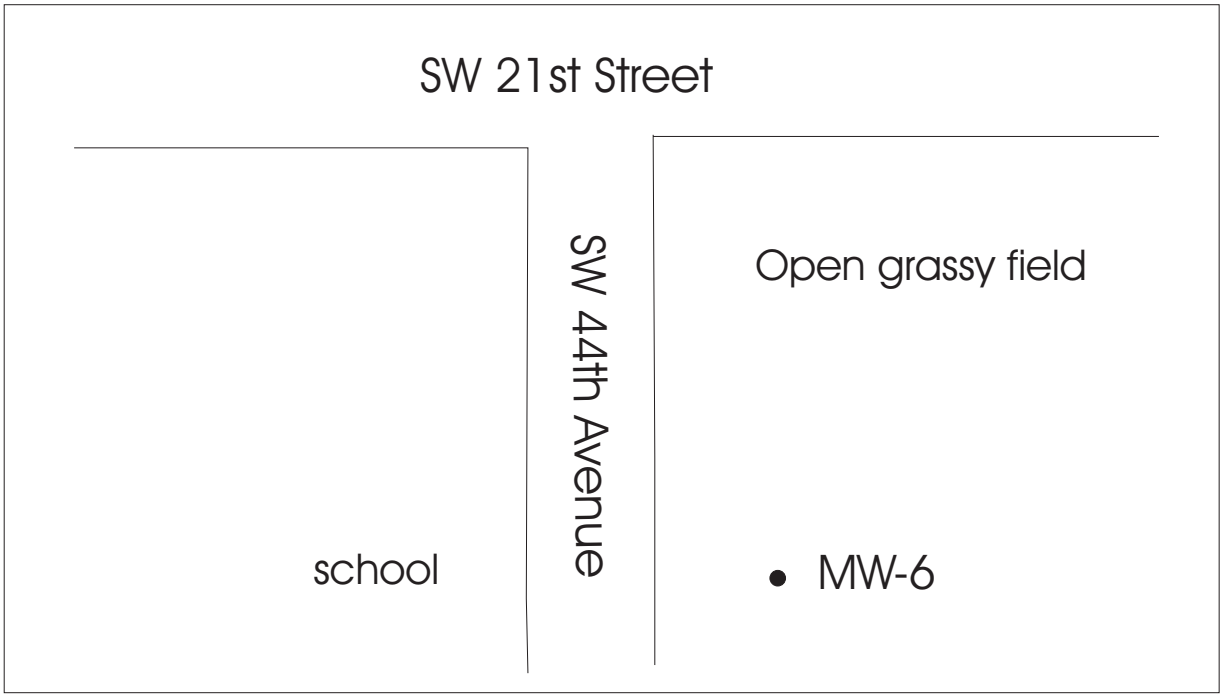
Project #: 07-174 **Client:** SFWMD **Date:** July 2, 2007
Boring Name: S4C (M1293) **Operator:** L. Yuhr
Site Location: West of utilities at end of paved road, north of Wright Blvd. in Jensen

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:**
Water Level: 3.71 ft **Hole Depth:** 185 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 13ft/min
Logs: Induction
Measurement Units: mS/m



TECHNOS



Ft. Lauderdale MW-6

TECHNOS

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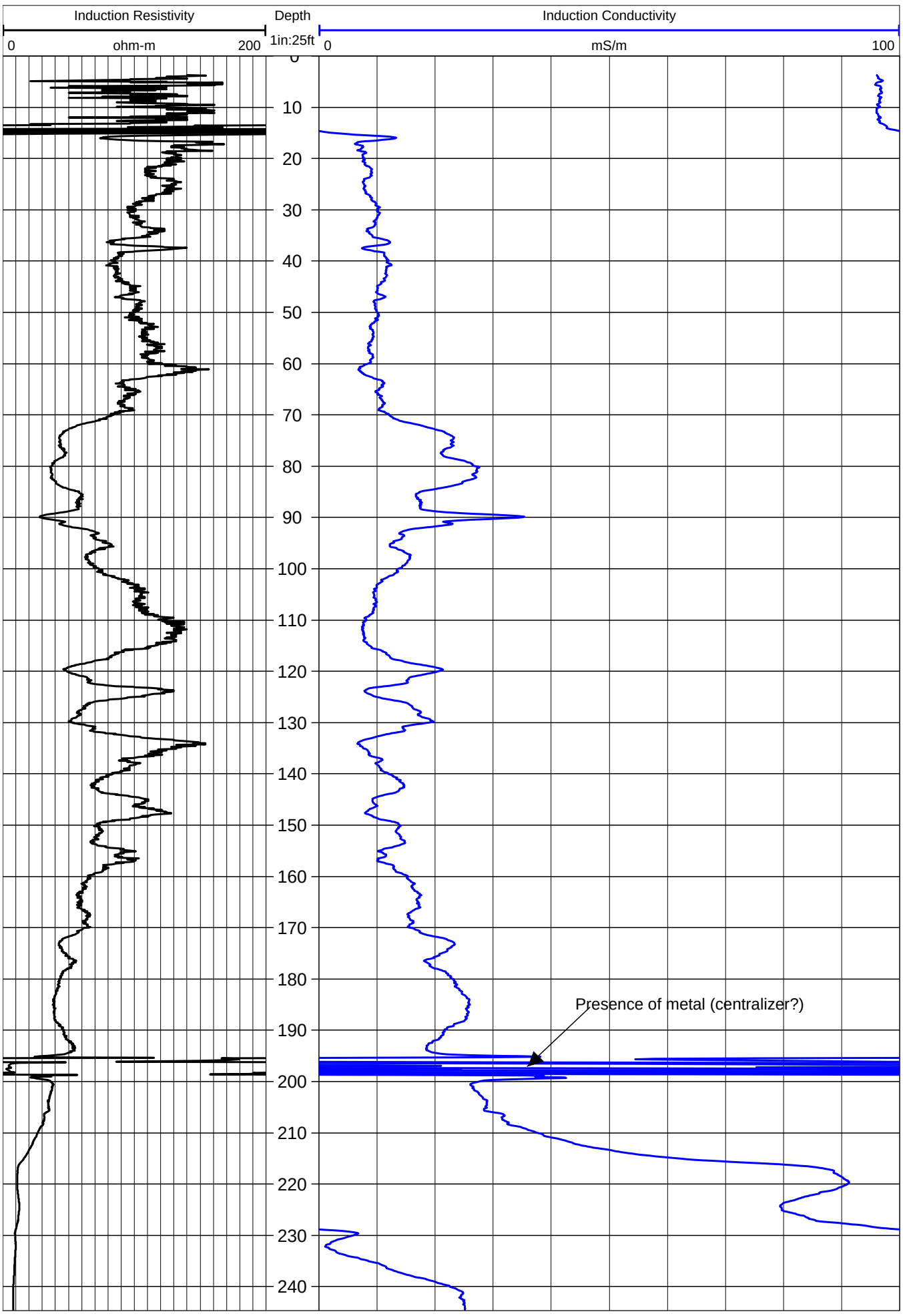
Miami, FL 33172
Phone: (305) 718-9594
FAX: (305) 718-9621
Email: info@technos-inc.com

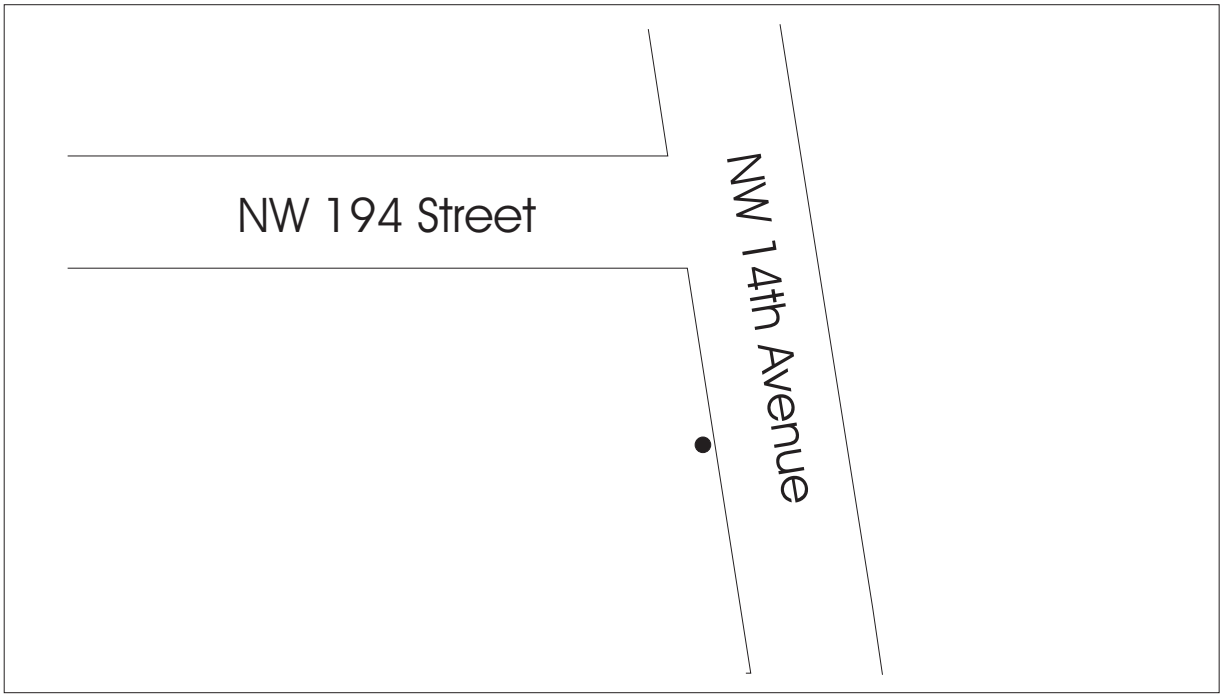
Project #: 07-174 **Client:** SFWMD **Date:** Dec 4, 2007
Boring Name: Fort Lauderdale MW-6 **Operator:** L. Yuhr
Site Location: 100 yards south of SW 44 Ave/Way and SW 21st Street

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:** 247 ft
Water Level: 17.04 ft **Hole Depth:** 247 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 15ft/min
Logs: Induction
Measurement Units: mS/m



TECHNOS



Dade DMW-4

TECHNOS

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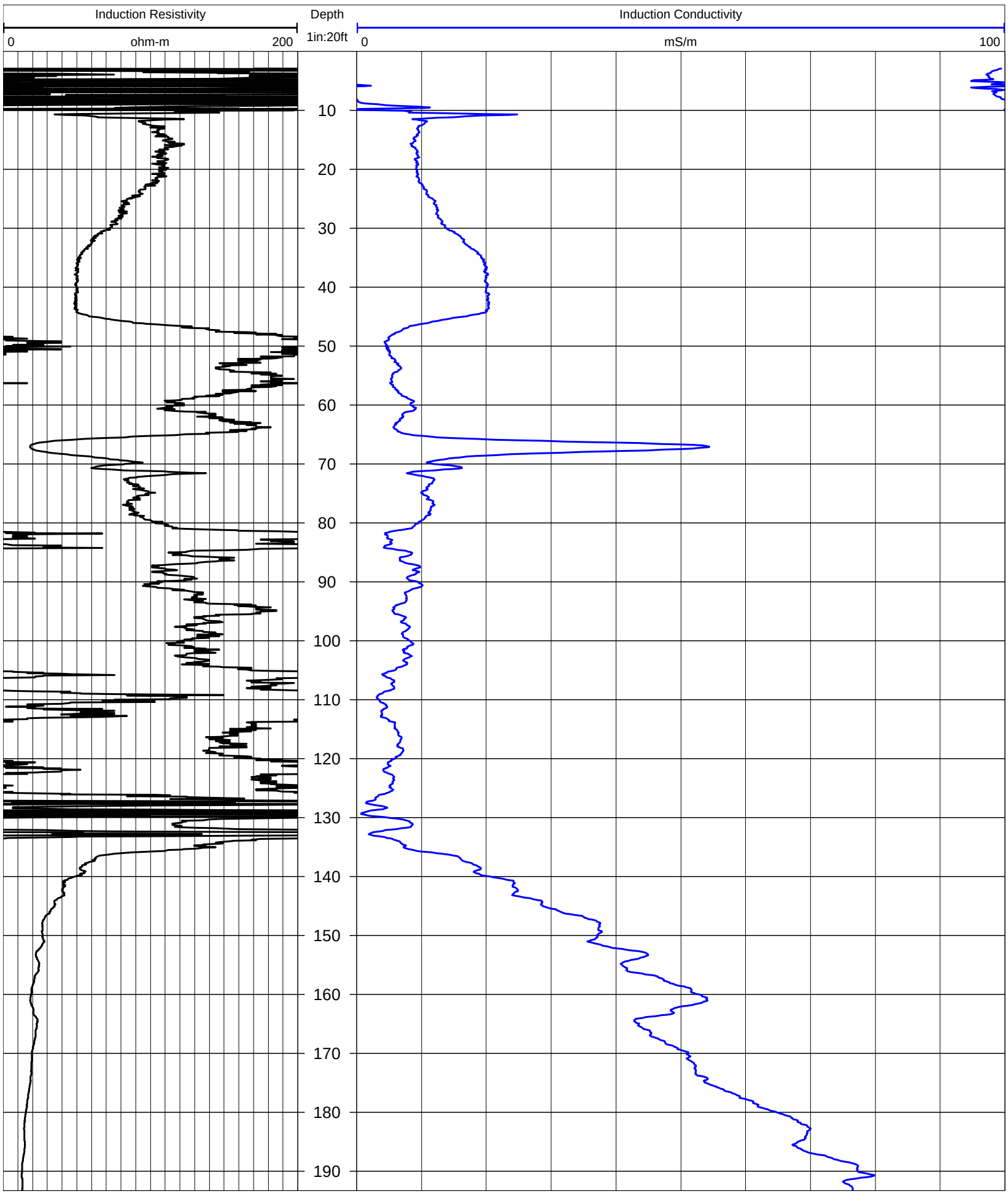
FAX: (305) 718-9621
Email: info@technos-inc.com

Project #: 07-174 **Client:** SFWMD **Date:** Dec 4, 2007
Boring Name: Dade County DMW-4 **Operator:** L. Yuhr
Site Location: west side of NW 14 Ave, 100 south of NW 194 St

Depth Units: feet **Depth Ref.:** ground surface **Ref. Elev.:** unknown
Casing Material/Dia.: 2-in PVC **Casing Stickup:** flush mount **Casing Depth:** 196 ft
Water Level: na **Hole Depth:** 196 ft

Logging System: Mount Sopris MGXII **Log UP/DOWN:** Up **Logging Speed:** 15ft/min
Logs: Induction
Measurement Units: mS/m



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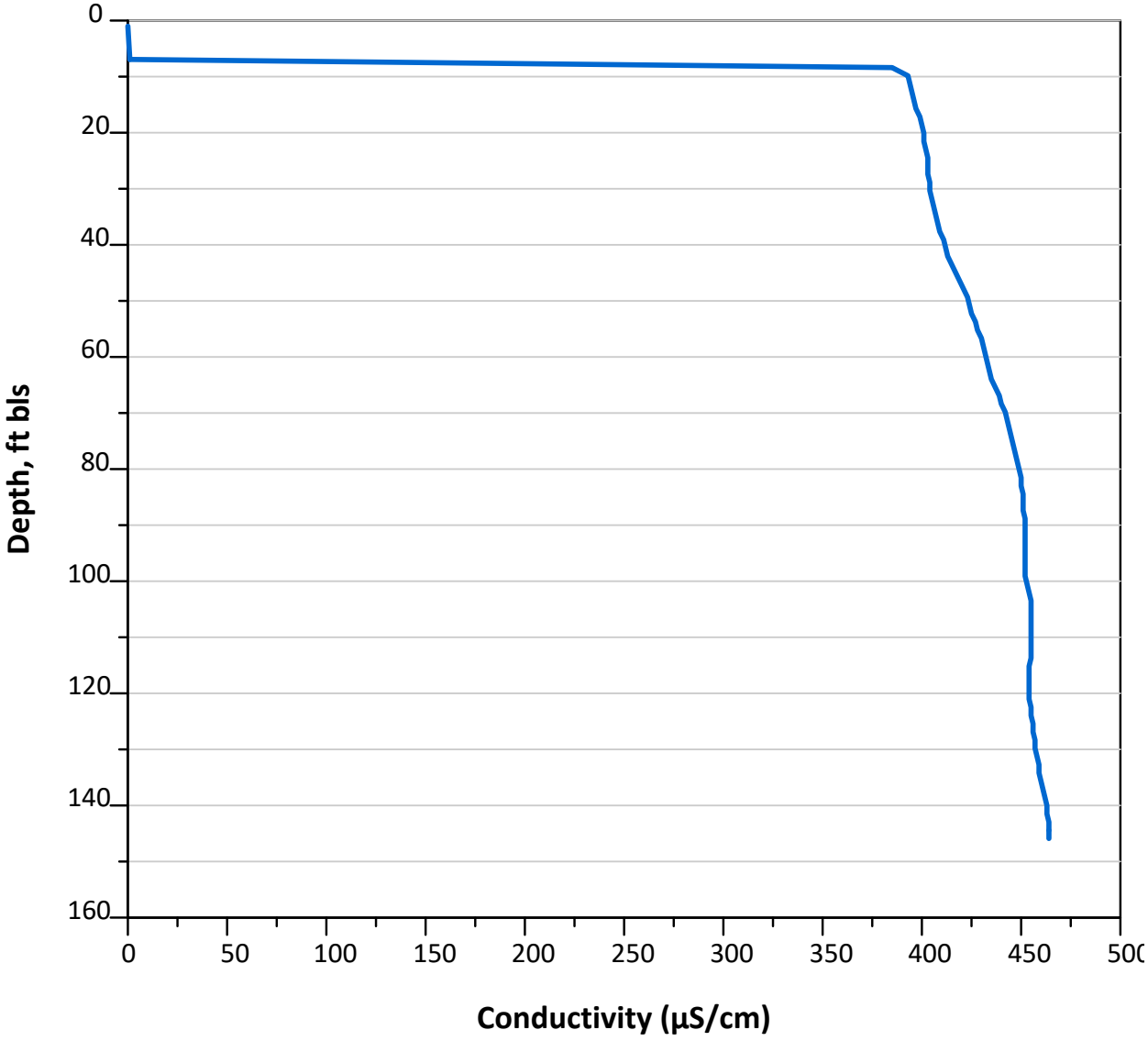
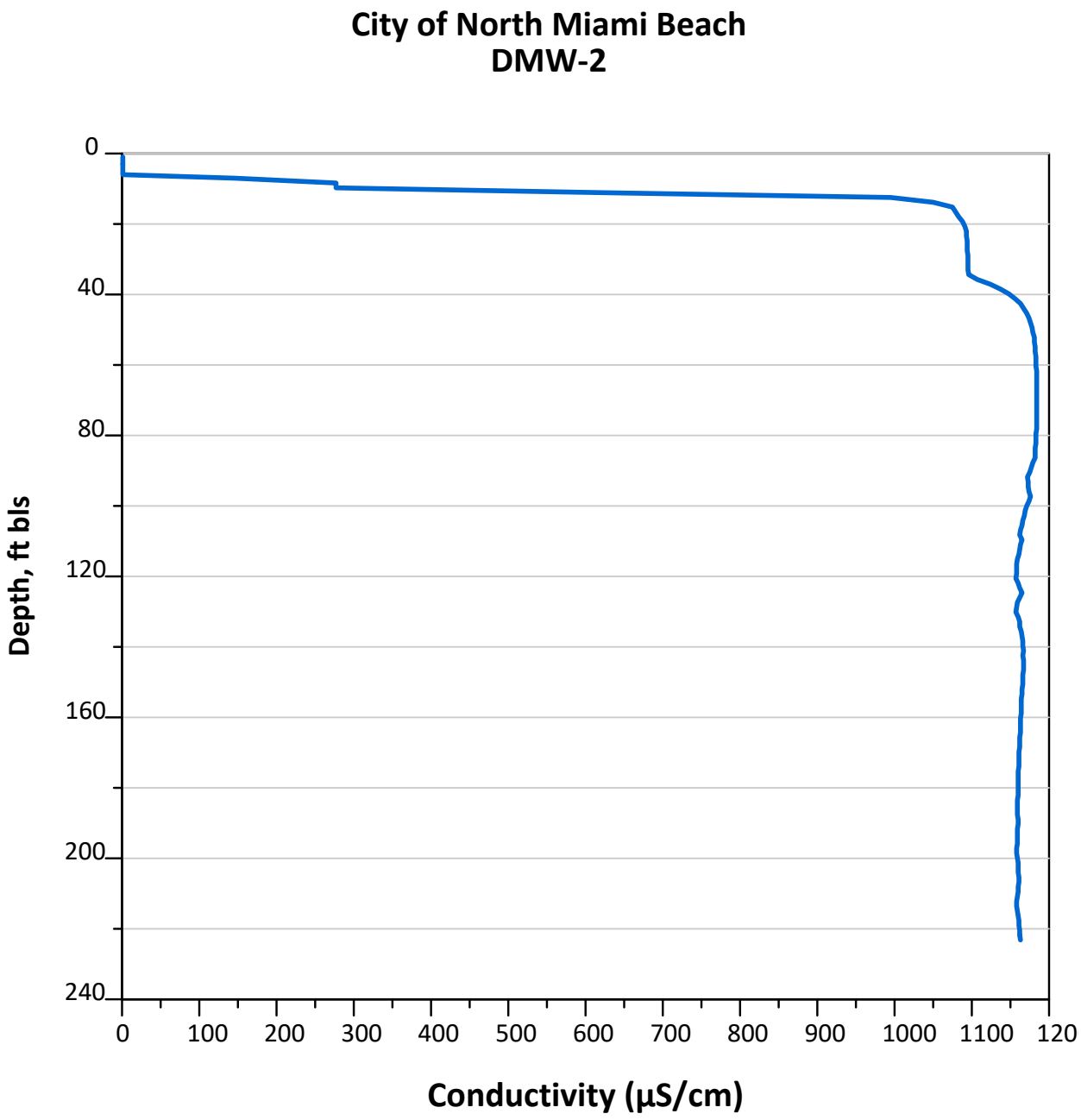
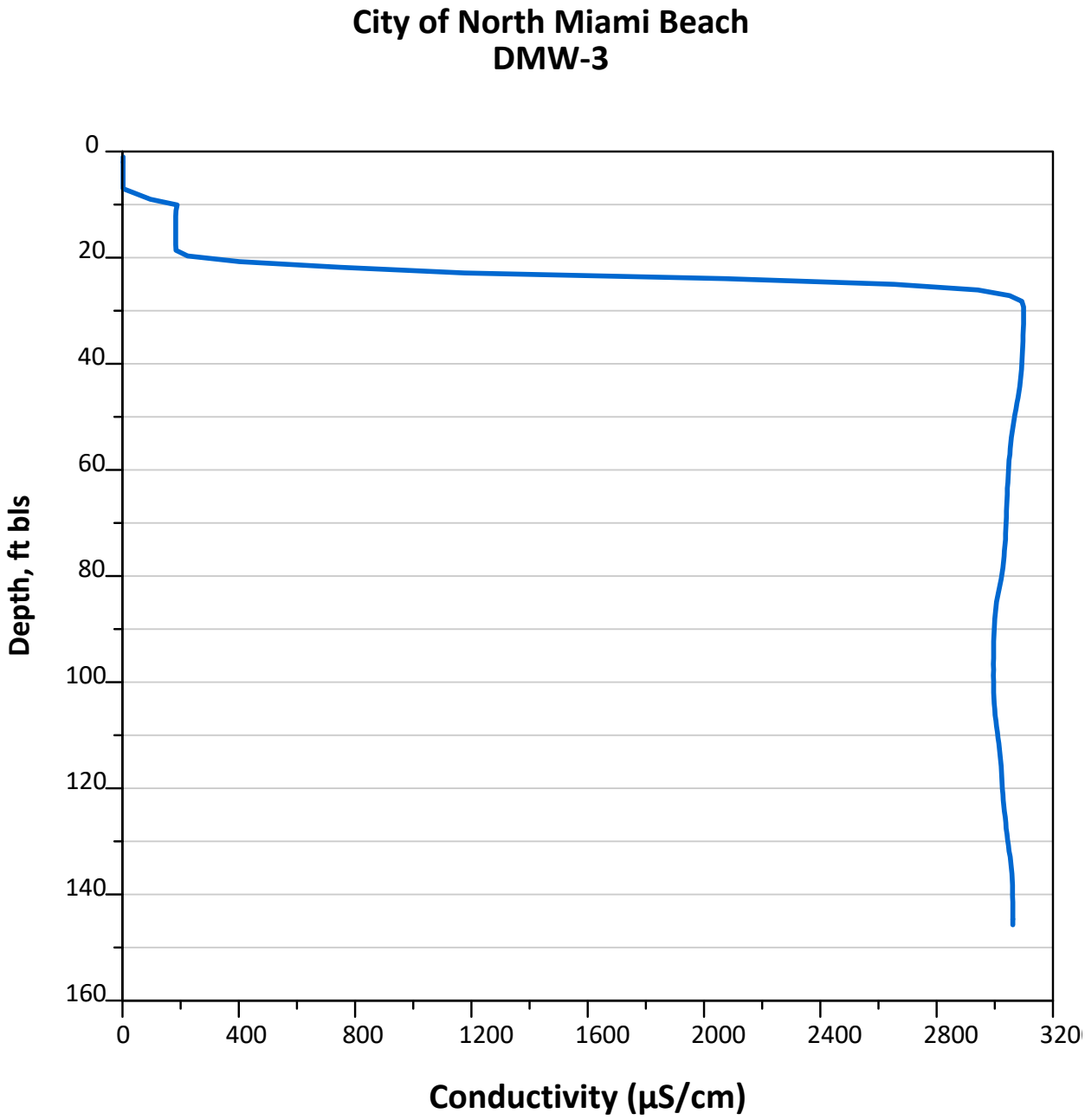
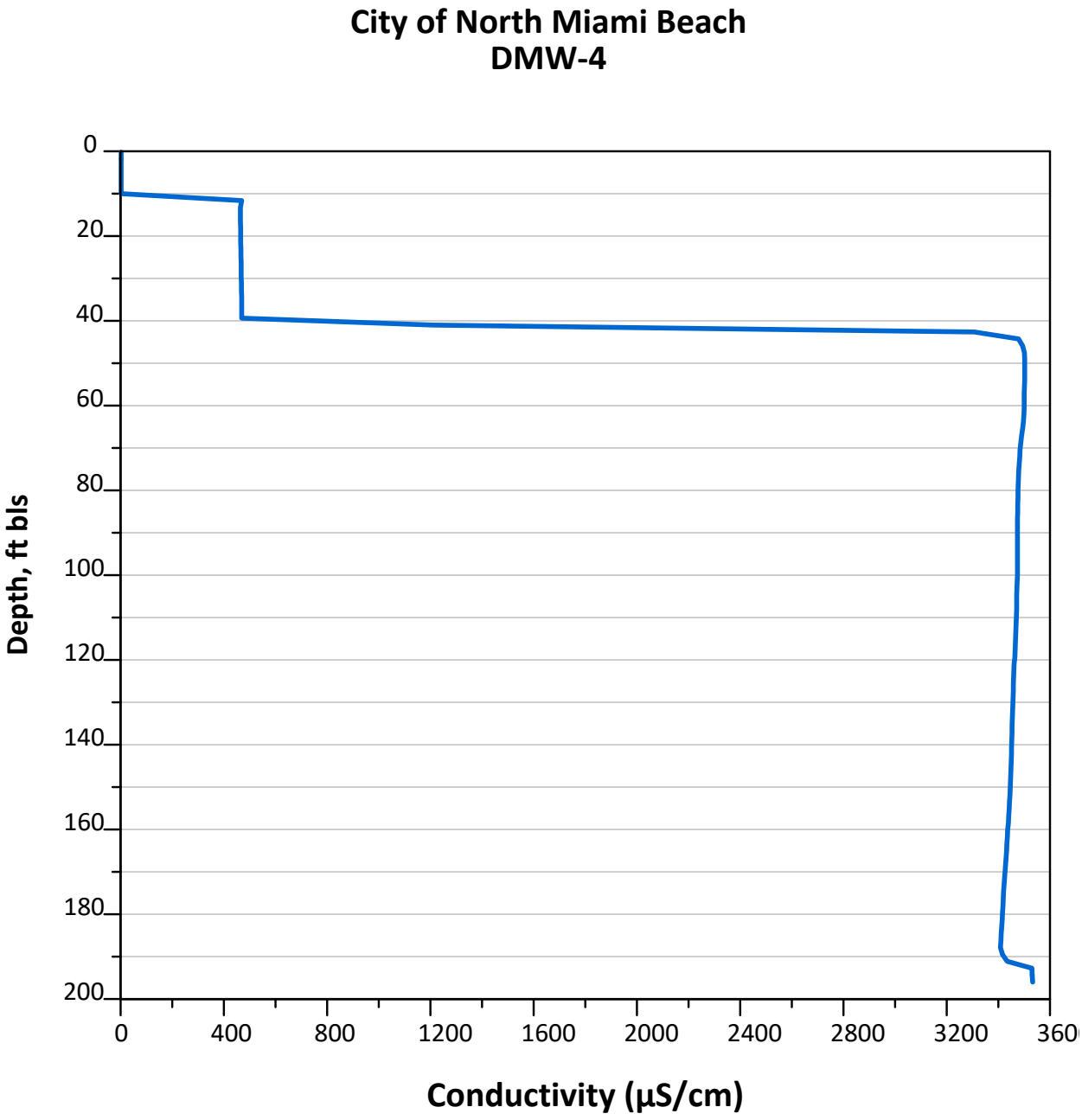
APPENDIX B:
VERTICAL CONDUCTIVITY PROFILES FROM SIX CITY OF NORTH MIAMI BEACH MONITOR WELLS

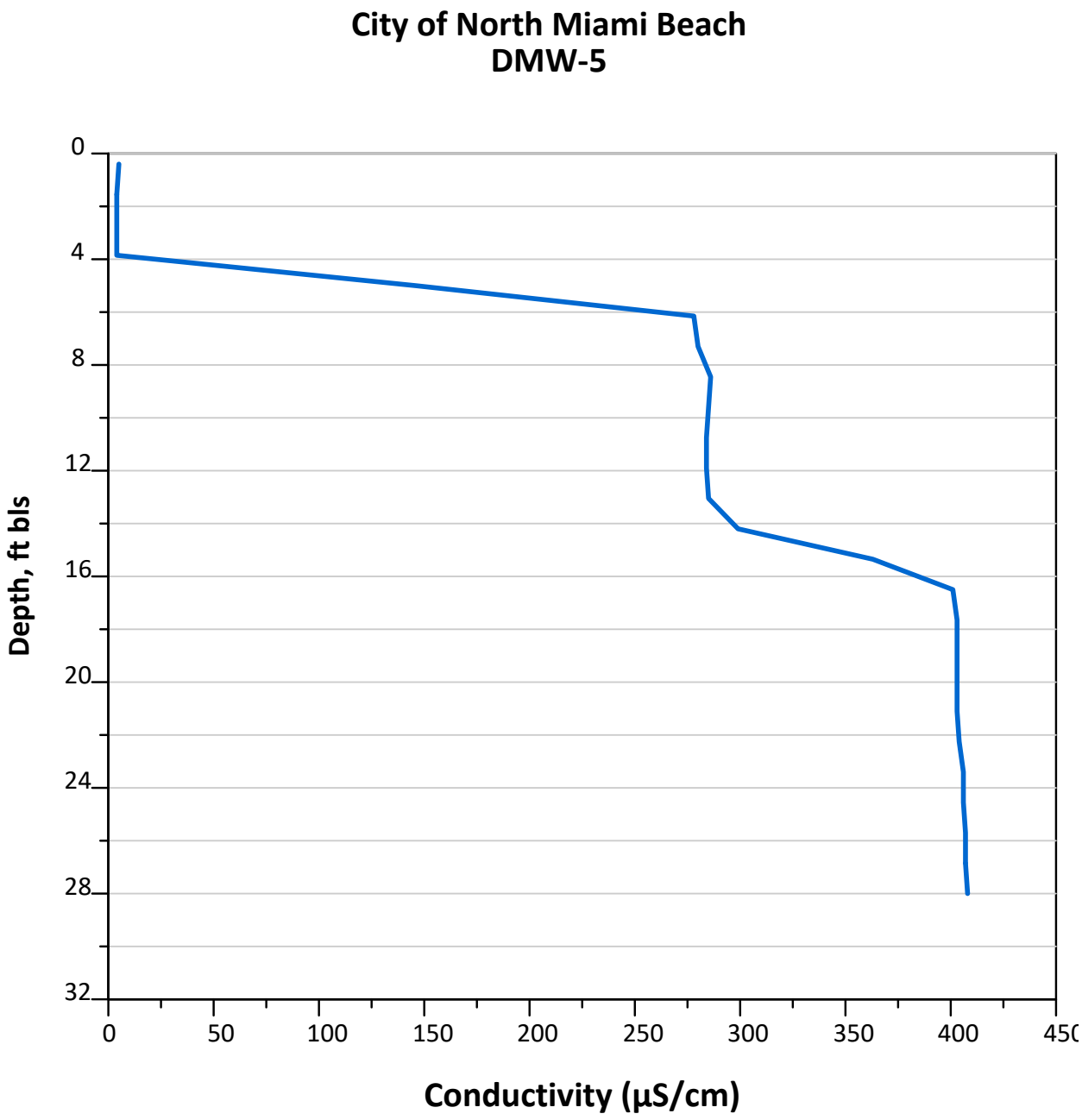
City of North Miami Beach
DMW-1

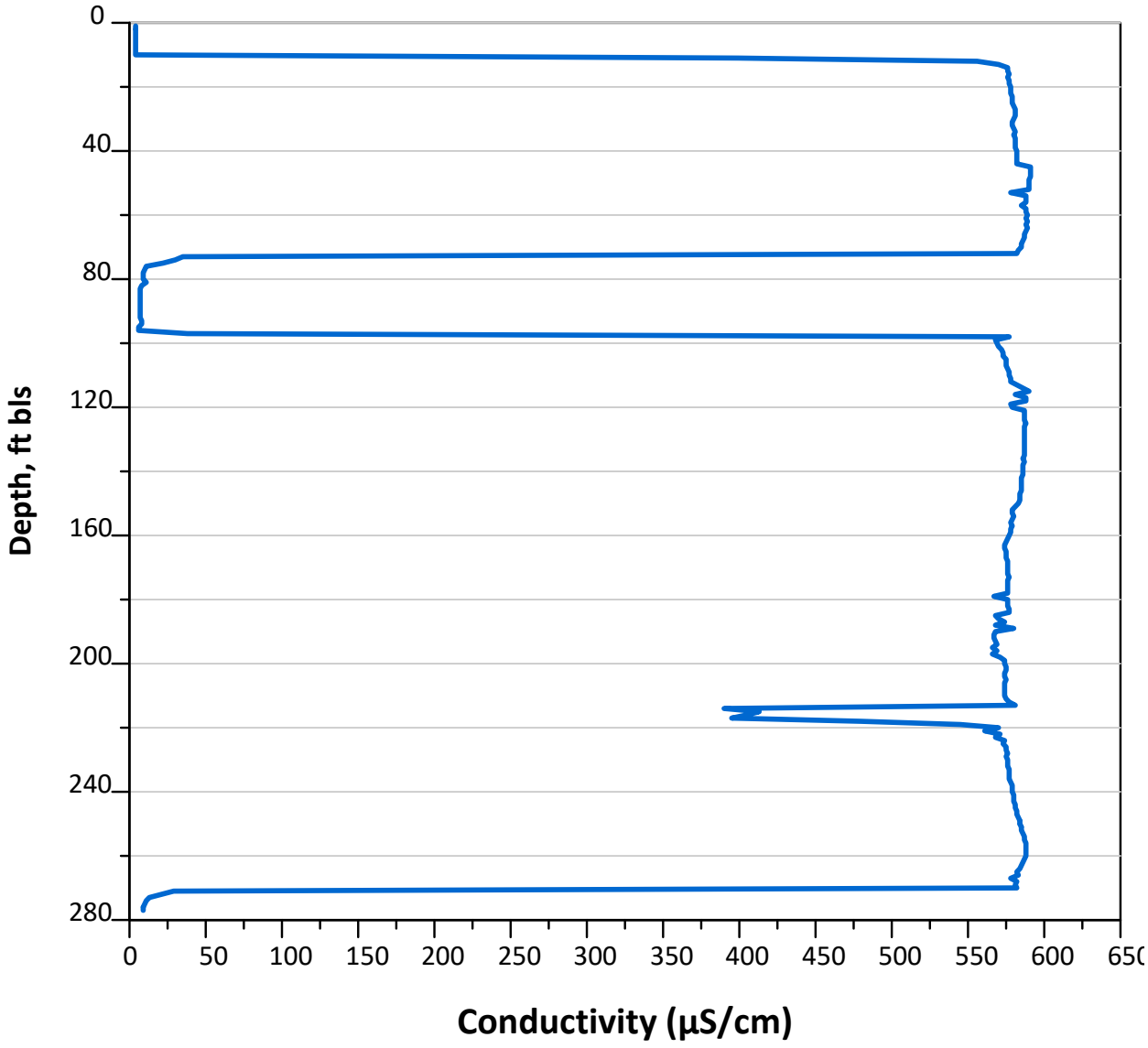



City of North Miami Beach
DMW-2
Depth, ft bls
0
40
80
120
160
200
240
0
100
200
300
400
500
600
700
800
900
1000
1100
120
Conductivity (µS/cm)


City of North Miami Beach
DMW-3
Depth, ft bls
0
20
40
60
80
100
120
140
160
0
400
800
1200
1600
2000
2400
2800
320
Conductivity (µS/cm)


City of North Miami Beach
DMW-4
Depth, ft bls
0
20
40
60
80
100
120
140
160
180
200
0
400
800
1200
1600
2000
2400
2800
3200
Conductivity (µS/cm)


City of North Miami Beach
DMW-5
Depth, ft bls
0
4
8
12
16
20
24
28
32
0
50
100
150
200
250
300
350
400
450
Conductivity (µS/cm)


City of North Miami Beach
DMW-6
Depth, ft bls
0
40
80
120
160
200
240
280
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Conductivity (µS/cm)