Special Publication SJ94-SP2

TIME DOMAIN ELECTROMAGNETIC SOUNDINGS AND ANALYSIS
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
NORTHEAST FLORIDA/SOUTHEAST GEORGIA
NOVEMBER 1993

Prepared For:

St. Johns River Water Management District

P.O. Box 1429

Palatka, Florida

(Contract No. 93G168)

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(Project No. 93742)

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November 10, 1993

This is to certify that I, Robert J. Windschauer, have reviewed the figures, tables, and text of the following report.

By:

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SEAL

EXECUTIVE SUMMARY

A time domain electromagnetic (TDEM) survey was performed at 19 sites in the St. Johns River Water Management District and one site in Georgia during the months of April and May, 1993. The TDEM method is a geophysical technique which, through ground surface based measurement, enables description of the vertical distribution (one-dimensional depth layering) of formation electrical resistivity. As such, TDEM soundings provide a gross approximation of an electrical log as performed in a borehole without the significant expense of drilling, completing, and logging such a borehole. In comparing TDEM soundings to electric logs, the minimum thickness of an interval that can be resolved by TDEM is several orders of magnitude larger than what can be resolved by electric logs. The confidence in the conclusions from TDEM findings can be enhanced when water quality information from nearby wells is available. The objective of the TDEM survey was to determine the depths to the 250 mg/L and 5,000 mg/L isochlors.

The determination of the depth to the 5,000 mg/L isochlor was made at 19 of 20 sites. Depths ranged from 413 to 2,427 feet (ft) below land surface (bls). Only one sounding (Site 2--Cumberland Island), failed to detect a low-resistivity basal layer. A forward-modeling sensitivity analysis estimated a minimum depth of 2,200 ft mean sea level (msl) for such a layer. Well data which provided an estimated depth to the 5,000 mg/L isochlor in nearby areas was available at 4 sites. Results from the TDEM soundings reasonably agreed with well data at three of the four sites. The reasons that the results did not agree at the fourth site (Site 8--Union Camp) are not known.

The determination of the depth to the 250 mg/l isochlor was made at 6 of 20 sites. At twelve of the sites (Sites 5, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20) the 250 mg/L isochlor could not be determined because the geoelectric model for the site could not distinguish the Hawthorn Group and surficial sediments from the Floridan aquifer. At one site (Site 2 - Cumberland Island) the depth of investigation was not sufficient to determine the depth to the 250 mg/L isochlor. Accordingly, the assumptions used in the empirical relationships to determine the 250 mg/L isochlor were not valid. At several sites, water quality inferred from TDEM formation resistivities did not agree with water quality results from nearby wells.

This discrepancy is likely due to ground water chemistry in these areas not meeting the assumptions of the empirical relationships for the determination of chloride concentration.

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1.0 INTRODUCTION

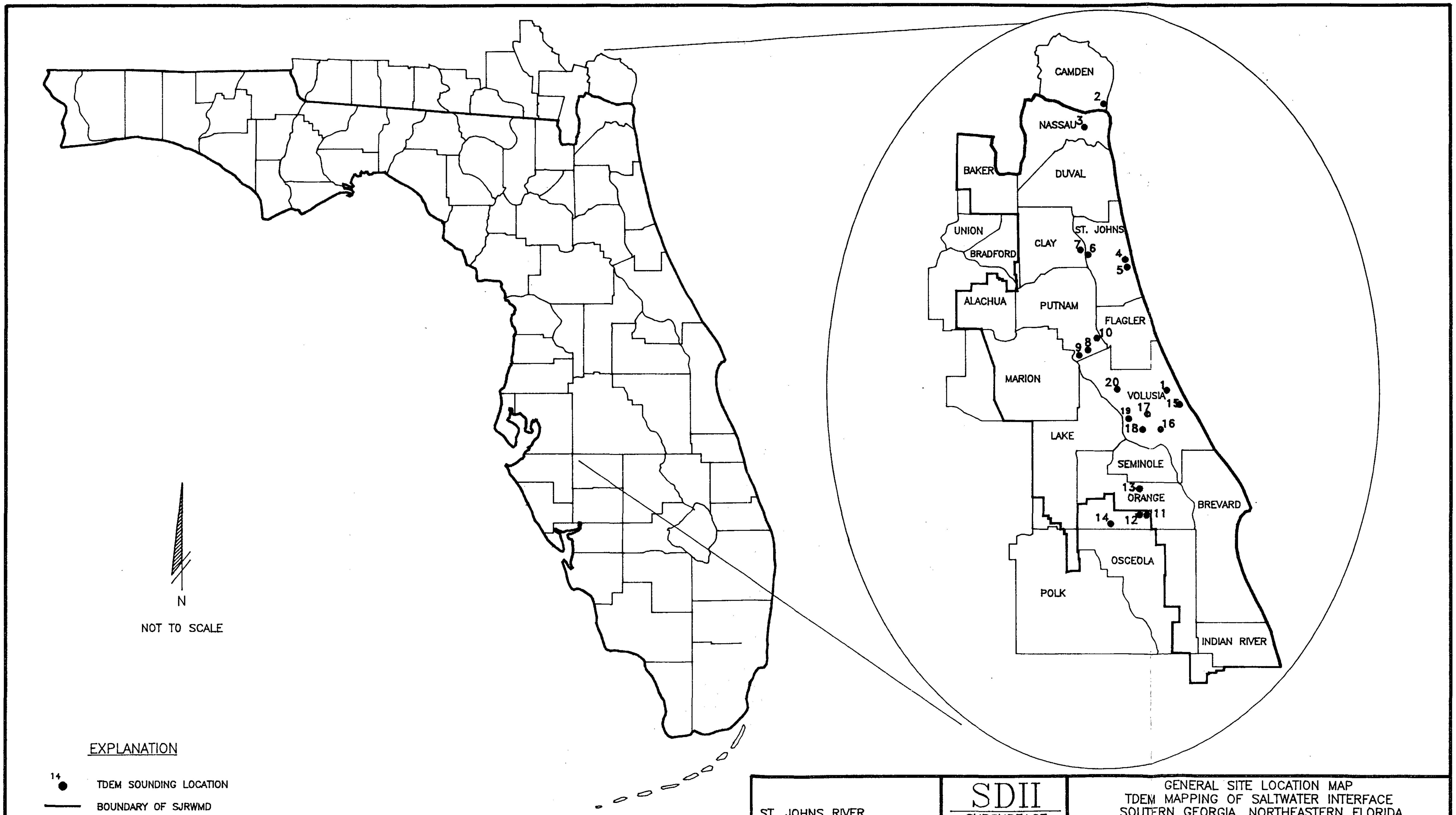
The St. Johns River Water Management District (SJRWMD) has contracted with Subsurface Detection Investigations, Inc. (SDII) to perform a series of Time Domain Electromagnetic (TDEM) survey measurements in northeast Florida and southeast Georgia during the time period April to May 1993. This latest series of TDEM soundings is a continuation of similar TDEM programs funded by SJRWMD in previous years (Blackhawk, 1990 and CEES, 1992). The TDEM method is a geophysical technique which, through ground surface-based measurement, enables description of the vertical distribution (one-dimensional depth layering) of formation electrical resistivity. As such, TDEM soundings provide a gross approximation of an electrical log as performed in a borehole without the significant expense of drilling, completing, and logging such a borehole. In comparing TDEM soundings to electric logs, the minimum thickness of an interval that can be resolved by TDEM is several orders of magnitude larger than what can be resolved by electric logs. As formation resistivity is a direct function of formation lithology, porosity, and pore fluid conductivity, *in situ* determination of formation resistivity offers a means of inferring the water quality within given formations through empirical relationships between assumed porosity, pore-water chloride concentration, and the measured value of resistivity.

Given this background, SJRWMD has set the objectives of this TDEM survey as:

1. determination of the depth to the saltwater interface (water with chloride concentration greater than 5,000 milligrams per liter [mg/L]);
2. determination of the depth within the aquifer (above the saltwater interface) at which chloride concentration of pore waters equals 250 mg/L;
3. estimation of the chloride content of the saltwater layer assuming values of 25, 30, and 35 percent for porosity of that layer.

The principal strength of TDEM is the detection and mapping of depths to the top of a conductive layer within an otherwise resistive medium. As such, the first objective (chlorides greater than 5,000 mg/L) is the easiest to accomplish and is the best resolved. Determination of the second and third objectives relies on empirical relationships derived from studies of wells in Seminole County (in east-central Florida) and, therefore, is a less certain and less well-resolved determination.

This report details the field procedures, data quality control and analyses procedures from a total of 20 sites as selected by SJRWMD personnel. Of these, 19 sites are in northeastern and east central Florida, roughly from Orlando to slightly north of Jacksonville. The remaining site was located just offshore of mainland Georgia (Cumberland Island). Figure 1-1 presents the locations for the 20 TDEM sites.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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GENERAL SITE LOCATION MAP
TDEM MAPPING OF SALTWATER INTERFACE
SOUTERN GEORGIA, NORTHEASTERN FLORIDA

Designed By:	MJW	Proj. No.	93742	Fig. No. 1–1
Checked By:	RJW	DWG	LOC–G	
Drawn By:	SBG	Date:	09/14/93	

2.0 HYDROGEOLOGIC SETTING

Ground water is drawn from three principal aquifers within SJRWMD (Figure 2-1). The three principal aquifers are the surficial aquifer system, the intermediate aquifer system and the Floridan Aquifer System (Scott et al., 1991). The surficial aquifer consists primarily of Upper Miocene to Holocene age consolidated to poorly indurated siliclastic sediments (Scott et al., 1991). Permeable interbeds within these sediments are locally significant sources of potable water near coastal areas and within Seminole, western Clay, and Alachua counties (Fernald and Patton, 1985).

The Miocene-age Hawthorn Group separates the surficial aquifer from the Floridan aquifer and creates confining conditions within the Floridan aquifer. The intermediate aquifer system is comprised of high-transmissivity zones within the Hawthorn Group (Figure 2-1). Typically these high-transmissivity zones occur within sandy phosphatic limestone beds. The intermediate aquifer system is a significant source of potable water in southeastern Flagler and eastern Orange counties (Fernald and Patton, 1985). The Hawthorn Group is thin or absent in the area of TDEM sites 1, 15, 16, 17, 18, 19, and 20.

The primary source of potable water throughout the majority of the SJRWMD is the Floridan aquifer. The Floridan aquifer is composed of (from oldest to youngest) the Cedar Keys Formation, Oldsmar Formation, Avon Park Formation, Ocala Limestone (where present),the Suwannee Limestone and the lower formations of the Hawthorn Group (where present; Figure 2-1; Scott et al., 1991). The ages of these formations range from Paleocene to Miocene.

The Floridan aquifer is subdivided into the Upper and Lower Floridan aquifer by a middle semi-confining unit ranging in thickness from nearly 0 to over 1,000 feet (ft). The middle semi-confining unit is leaky and the hydraulic connection between the Upper and Lower Floridan aquifers is variable (Tibbals, 1990). Depth to the division ranges from approximately 300 to 1,200 ft below mean sea level within SJRWMD (Miller, 1986).

The Ocala Limestone is the most productive aquifer within the Floridan aquifer. Along the east coast and southern portion of SJRWMD, the Cedar Keys or Oldsmar Formations typically contain salt water. In the area of TDEM sites 2 and 3, the Fernandina permeable zone is present within the Lower Floridan aquifer in the Oldsmar and Cedar Keys formations at a depth of greater than 1,900 ft below mean sea level. The Fernandina permeable zone is locally cavernous and fractured and is suspected to affect water quality in the Upper Floridan aquifer along the coast of the northeast portion of SJRWMD (Miller, 1986).

Chloride concentrations within the Upper Floridan aquifer are usually less than 50 mg/L in the northern and west central portions of SJRWMD and exceed 250 mg/L in the east central and southern portions of SJRWMD (Fernald and Patton, 1985). Areas of mineralized water in the Floridan aquifer are present within the central and southern portion of SJRWMD. Sources of mineralized water include lateral seawater intrusion, seawater upwelling, and connate water (Scott et al., 1991).

LITHOSTRATIGRAPHIC UNIT	HYDROSTRATIGRAPHIC UNIT
UNDIFFERENTIATED PLEISTOCENE–HOLOCENE SEDIMENTS ANASTASIA FORMATION CYPRESSHEAD FORMATION NASHUA FORMATION	SURFICIAL AQUIFER SYSTEM
HAWTHORN GROUP STATENVILLE FORMATION COOSAWHATCHIE FM. MARKSHEAD FORMATION PENNEY FARMS FM.	INTERMEDIATE AQUIFER SYSTEM OR CONFINING UNIT
SUWANNEE LIMESTONE	FLORIDAN AQUIFER SYSTEM
OCALA LIMESTONE AVON PARK FORMATION OLDSMAR FORMATION	
CEDAR KEYS FORMATION	
UNDIFFERENTIATED	SUB–FLORIDAN CONFINING UNIT

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LITHOSTRATIGRAPHIC AND HYDROSTRATIGRAPHIC UNITS
SJRWMD

FROM: SCOTT et al. 1991

DESIGNED BY: MJW	PROJECT NO.: 93742	FIGURE
CHECKED BY: RJW	DRAWING NO.: LTH	2–1
DRAWN BY: SBG	DATE: 09/14/93	

3.0 FIELD ACQUISITION PARAMETERS, EQUIPMENT, AND DATA PROCESSING

3.1 FIELD ACQUISITION PARAMETERS

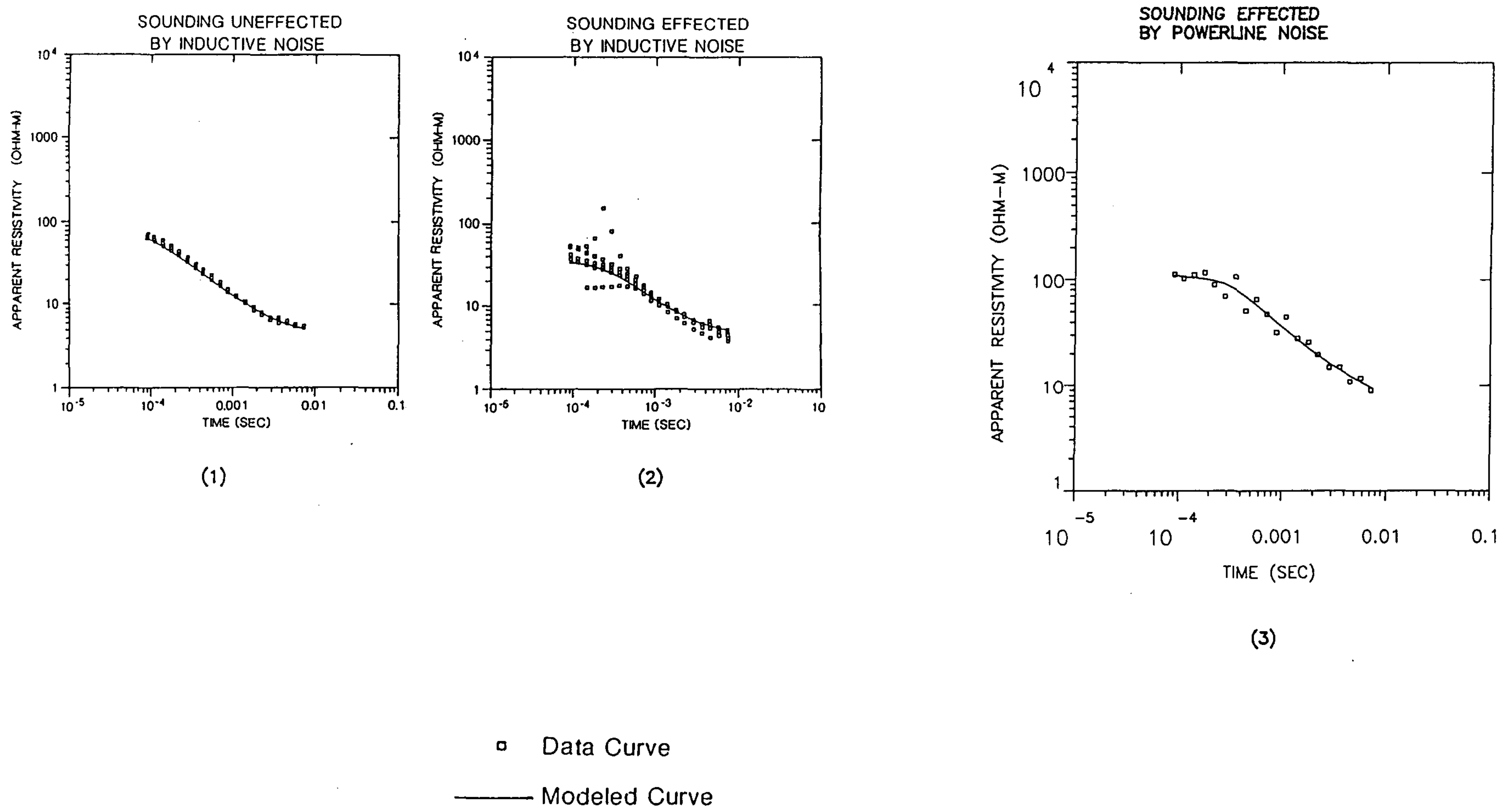
Twenty sites were selected by SJRWMD for TDEM soundings. The TDEM method involves the laying of 12 gauge AWG wire in an approximately square or rectangular loop on the ground over a large area (on the order of 10^6 ft^2 or greater). This is the transmitter, or Tx loop. The Tx loop is energized by a bi-polar electrical current (up to a maximum of 30 amperes). The response of the ground is sensed by a centrally located (midpoint of the Tx loop) search coil (receiver, or Rx coil). The transient response seen by the receiver is recorded digitally by the data-logging module.

To attain the depth of exploration required to determine the depth to the saltwater interface within SJRWMD, Tx loop sizes ranging from 1,000 ft x 1,000 ft up to 1,500 ft x 1,500 ft were employed where possible. Tx loop sizes at individual sites were prescribed by SJRWMD personnel and adjusted in the field to accommodate field logistical constraints such as obvious metal structures, power lines, or limited areas of access. Tx loops were laid out using premarked cables and a compass. Loop dimensions, transmitter currents, and other site-specific information are included in the individual descriptions of the sounding results (Section 5.0).

In addition to the main sounding data set at a given site, SDII also collected quality control (QC) sounding data using an off-center Rx coil location. That is, if there was an obvious, possible source of noise (pipeline or power line, for example) to one side of a Tx loop, then the coupling of the incident pulse from the transmitter with that possible noise source would impart voltage gradients within the loop that would not exist otherwise. In the absence of noise sources, the voltage measured in the loop is very well behaved; it does not vary much with position of the Rx coil. To check for possible interference sources, several soundings are performed 10-15 percent of the Tx loop length away from the initial Rx coil location. It can be shown that the maximum vertical EMF (electromotive force) occurs at the center of the Tx loop and that the EMF remains relatively flat to about 10 percent L (L being the length of one of the sides of the Tx loop) off center (Blackhawk, 1990). If a shallow noise source is affecting the data quality, it would impose a higher EMF gradient in one or more directions off center from the Tx loop. In Figure 3-1 examples of TDEM data that are; 1) unaffected by induction noise, 2) affected by induction noise (as from buried metal pipelines), and 3) affected by powerlines are provided. None of the TDEM sites surveyed during the SDII investigation appeared to have been affected by noise sources.

QC measurements were generally performed at four different locations about the loop center. If the data from the off-center Rx location matches the central-loop data, then the data are not noise-affected. If they diverge significantly, the data are noise-affected and should not be used.

The SDII field crew consisted of one senior project geophysicist, Michael Wightman, P.G., assisted by two geophysical field technicians. During the initial phase of the project, Dr. Thomas L. Dobecki, SDII principal geophysicist, complemented the field crew to ensure survey program objectives were being met by reviewing the field procedures, instrument settings, and resulting data. A representative of SJRWMD, Dr. David Toth, was also present in the field. Table 3-1 summarizes the daily field activities.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	EXAMPLES OF NOISE AFFECTS UPON TDEM DATA	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EXM-1 DATE: 09/16/93
		FIGURE 3-1	

SOURCE: CEES, 1992

Table 3-1. Daily log of field activities

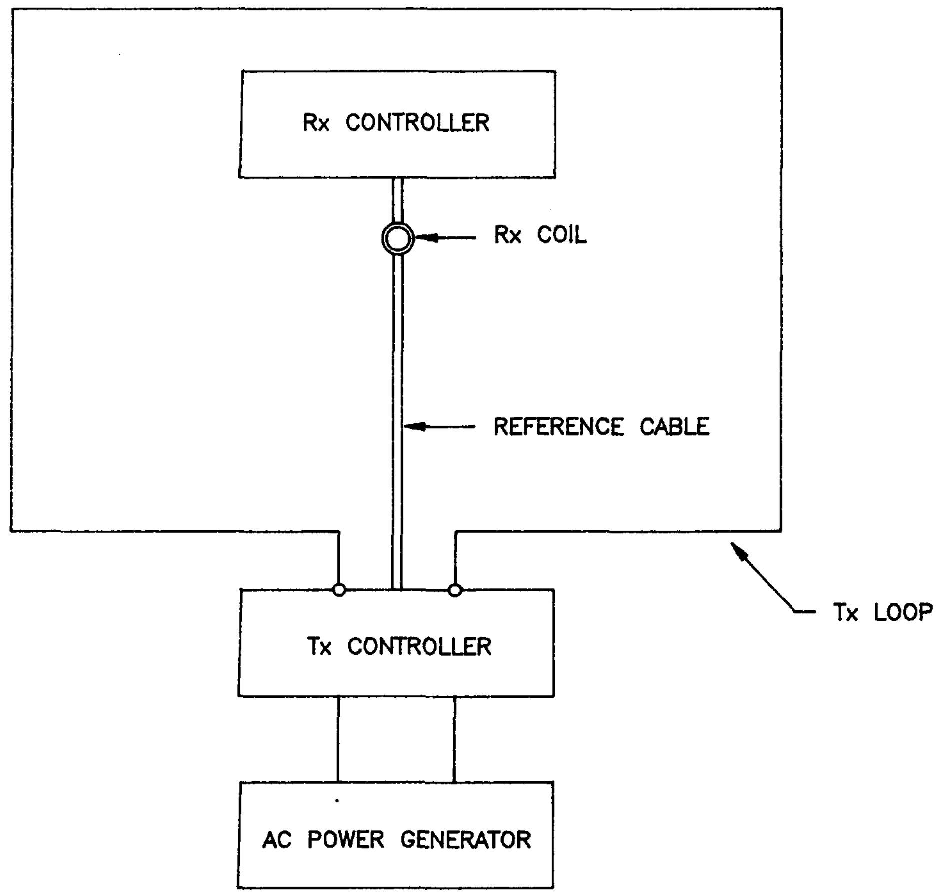
Date (1993)	Activity
April 26	Read Daytona Beach Speedway (Site 1) EM37 TDEM sounding.
April 27	Read Cumberland Island (Site 2) EM37 TDEM sounding.
April 28	Read Nassau County (Site 3) EM37 TDEM sounding.
April 29	Read St. Augustine #1 (Site 4) EM37 TDEM sounding.
April 30	Read St. Augustine #2 (Site 5) EM37 TDEM sounding.
April 30	Read Picolata (Site 6) EM37 TDEM sounding.
May 1	Read Green Cove Springs (Site 7) EM37 TDEM sounding.
May 2	Read Union Camp (Site 8) EM37 TDEM sounding.
May 3	Read Drayton Island (Site 9) EM37 TDEM sounding.
May 4	Read Bear Island (Site 10) EM37 TDEM sounding.
May 5	Read Deseret #1 (Site 11) and Deseret #2 (Site 12) EM37 TDEM sounding.
May 6	Read University of Central Florida (Site 13) EM37 TDEM sounding.
May 7	Read Richland Properties (Site 14) EM37 TDEM sounding.
May 8	Read New Smyrna Beach (Site 15) EM37 TDEM sounding.
May 9	Read Lake Ashby (Site 16) EM37 TDEM sounding.
May 10	Read Lake Helen (Site 17) and Deltona (Site 18) EM37 TDEM sounding.
May 11	Read Blue Springs State Park (Site 19) EM37 TDEM sounding.
May 12	Read Site 17 (re-done) and De Land (Site 20) EM37 TDEM sounding.

3.2 EQUIPMENT

SDII employed the Geonics EM37 TDEM system to accomplish the tasks of this project. The principal components of the EM37 are:

- Transmitter (Tx) loop (variable length 12 gauge AWG wire, insulated)
- Gasoline power generator/EM37 transmitter box (maximum 30 ampere, bi-polar square wave)
- Receiver (Rx) coil (100 square meter effective area)
- EM37 Receiver Module (system control and parameter selection)
- Polycorder digital notebook (data storage)

A block diagram of the field setup of the system is given in Figure 3-2. Once setup is completed, a current waveform as depicted by Figure 3-3 is injected into the Tx loop. The rapid turn-on and turn-off of current in the loop creates a strong EMF which interacts with earth and man-made materials to generate eddy currents within conductive materials. These currents have an associated secondary magnetic field which is detected by the Rx coil as shown on Figure 3-3. Eddy currents close to the Tx coil are induced first and decay below detection limits before deeper currents. Currents in resistive materials also decay faster than currents in conductors. Deeper conductors contribute to responses at later times at the Rx coil than do shallower subsurface features. Thus, by measuring the rate and nature of the decaying magnetic field seen by the Rx coil after Tx shutoff, the distribution of subsurface resistivity can be determined.



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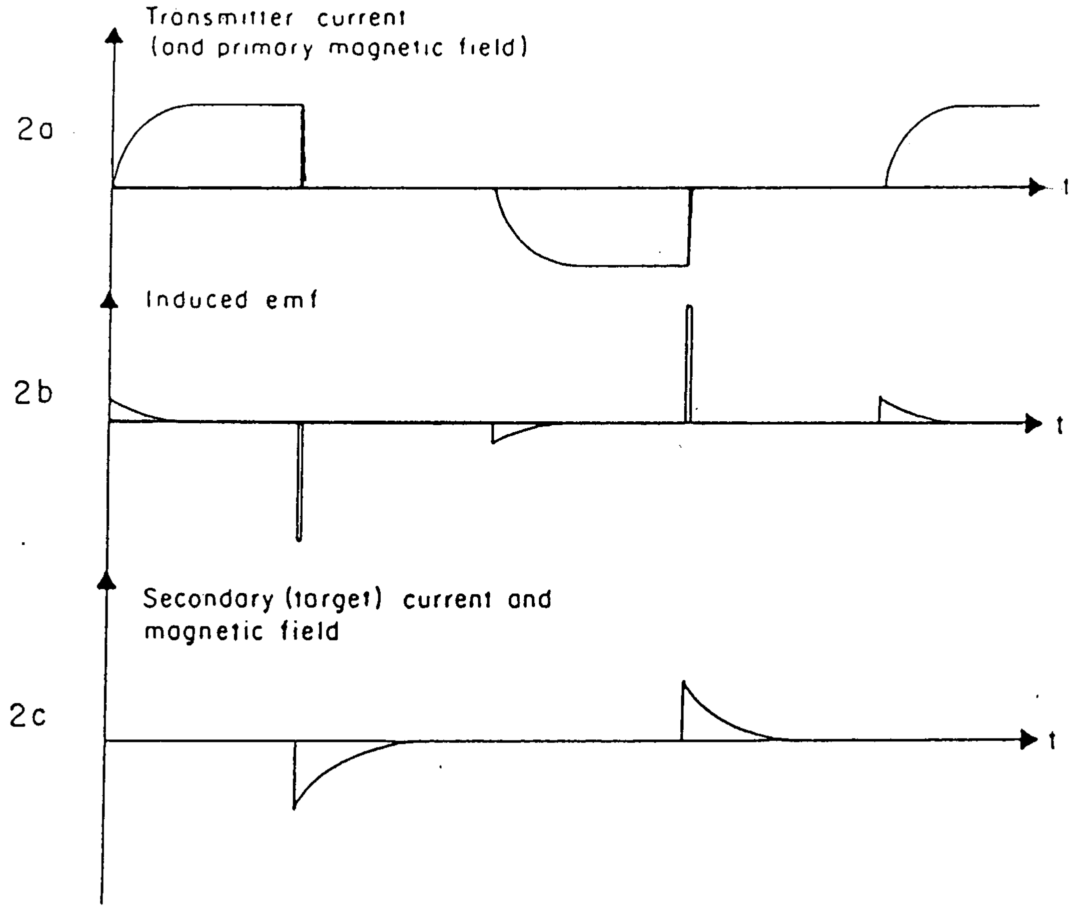
BLOCK DIAGRAM
EM37 FIELD SETUP

DESIGNED BY:	TLD	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LAY	3–2
DRAWN BY:	SBG	DATE:	09/16/93	



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	SYSTEM WAVEFORMS TDEM	
		DESIGNED BY: TLD CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: WVE-1 DATE: 09/16/93
			FIGURE 3-3

The survey variables that can be selected by the TDEM operator are the size of the Tx coil, Tx coil current (which controls the penetration depth), analog stacking (number of repetitions of summed tests in order to increase signal-to-noise ratio), gain at the receiver, and repetition rate (frequency) of the current cycles. For this investigation SDII used three different frequencies (3 Hz, 7.5 Hz, and 30 Hz) to acquire detailed and overlapping segments of the decay curve which enabled resolution of shallow (30 Hz data) and deeper (3, 7.5 Hz data) portions of the subsurface.

3.3 DATA PROCESSING

Data acquired by the EM37 were recorded by the Polycorder digital notebook logger and downloaded to a portable computer for data editing, processing, and interpretation (inversion). The primary software program used to process the data was TEMIXGL (Interpex, Ltd.). This program accepts raw data from the Polycorder and proceeds through the following general processing steps:

Data Edit - Allows for modification of survey description information, for example, loop size, Tx coil amperage, which may have been entered improperly. Decay curves for all frequencies and gain values taken at a site are displayed; suspect data points can be deleted and the individual curves for different frequencies and gains are averaged and converted to a single, apparent resistivity versus time (after Tx turn-off) field curve (see Figure 3-4, for an example of voltage data and apparent resistivity versus time curves).

The field curve is comprised of 30 data points, where each data point represents an apparent voltage collected at a particular time or time gate. Each frequency has 20 time gates and each frequency overlaps the proceeding or preceding frequency by 10 time gates. Combining data collected at the 30 Hz and 3 Hz frequency produces one sounding curve with 30 time gates, with an overlap between time gates 10 through 20. Data collected at 7.5 Hz provides apparent resistivity values for time gates 5 through 25. An advantage of using 30, 7.5, and 3 Hz frequencies for all the soundings is that different gains can be used for each frequency. Lower gains can be used at a frequency of 30 Hz to avoid saturating early channels, and higher gains can be used at 3 Hz to amplify weaker signals in later channels. The combined data is interpreted as one sounding curve.

Initial Model - Review of the apparent resistivity curve shape allows a trained geophysicist to make an initial guess as to the true resistivity versus depth (layered) model which would produce the observed data set. After such a model is created, a field curve is calculated from the model and compared with the observed data. The degree of agreement between model and field data is measured statistically and expressed as the fitting error. The geophysicist may then, in an interactive mode, adjust the model to obtain a better fit or can modify the starting model.

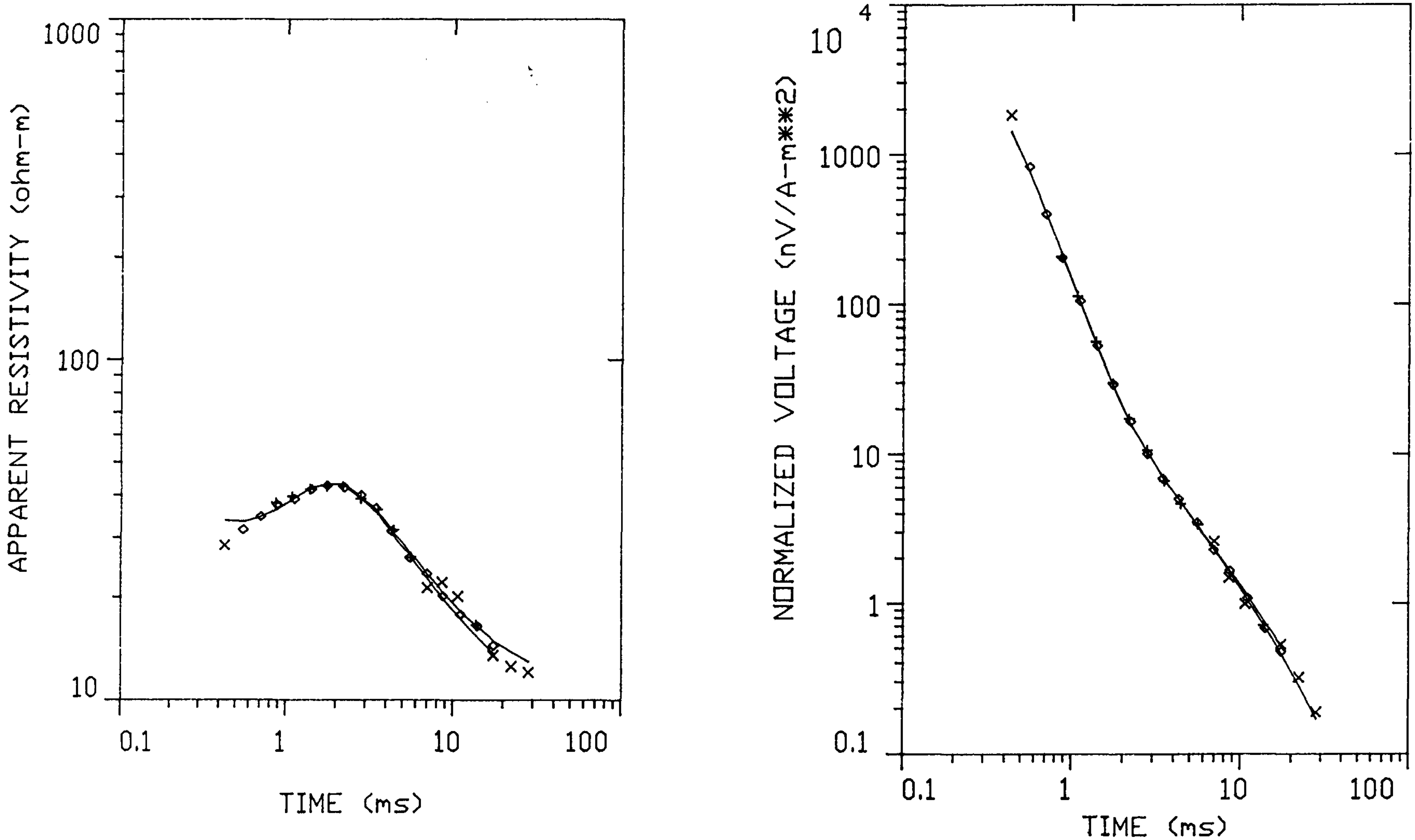
As part of the modeling procedure early and late time data is commonly discarded. Typically, apparent resistivity values collected at early times are discarded because the data collected at these times is often not representative of geological conditions because of the affect of the Tx coil shut off not being truly instantaneous. In the final modeling of this data, in may appear that the model curve passes through several of these early time points, but not all the points. In such a case, all the early time data points are discarded because it is not good modeling practice to delete data points from the middle portion of a curve and utilize data points preceding them. Often, later time data is also not representative of geological conditions because the primary EMF field strength has been too dissipated to provide a representative apparent resistivity value. Suspect late time data is also discarded. Poorly fitting data points are marked with a "x", utilized data points are marked with a square (Figure 3-4).

Modeled curves quite often demonstrate an upward curvature during early times. This upward curvature is usually due the TDEM response not following theoretical behavior or the affect of the Tx coil shut off not being truly instantaneous. This deviation produces a distortion, however, this distortion has little or no affect on the results from the TDEM survey when the target depth is several hundred feet below land surface.

Automatic Inversion - Based upon the initial model, the program will attempt to create a better fit to the observed data using an iterative, Inman Ridge Regression routine to adjust layer thicknesses and resistivities until a minimum error of fit is realized; our goal was to produce models which fit the observed data within a 5% error of fit. This final model is termed the "best fit" model (see Figure 3-5). Only the data points utilized in the determination of the modeled curve are used in calculation of the fitting error.

Equivalence Analysis - Electrical resistivity methods are, as with other geophysical methods, plagued by the so-called "non-uniqueness" problem. That is, while a best-fit model produces an acceptable fit to field data curves, there are several other models having different thicknesses and resistivities which will also provide a "reasonable" fit to the same data. TEMIXGL will produce a suite of models, using the best-fit model as a start, which would produce a reasonably close fit (see Figure 3-6). If the equivalence model segments (layers and resistivities) are tightly constrained then the layering provided by the best-fit model is very good. Those parts of the equivalence models that scatter quite a bit around the best-fit model show less confidence in the absolute values of layer thickness and resistivity. A poorly constrained equivalence model for a given layer means either there are too few data points in the raw data to adequately describe that layer or the data is just not very sensitive to that specific layer.

It is important to note that the interpretations resulting from the TDEM data are, specifically, one-dimensional models of layer thickness and layer resistivity. That is, if the earth subsurface is not, effectively, a one-dimensional horizontal layer, then the produced model may have inherent error. Also, the depths to levels of chloride concentration and not resistivity rely on empirical relationships between resistivity and chloride concentration. This latter point will be detailed further in Section 4.0.

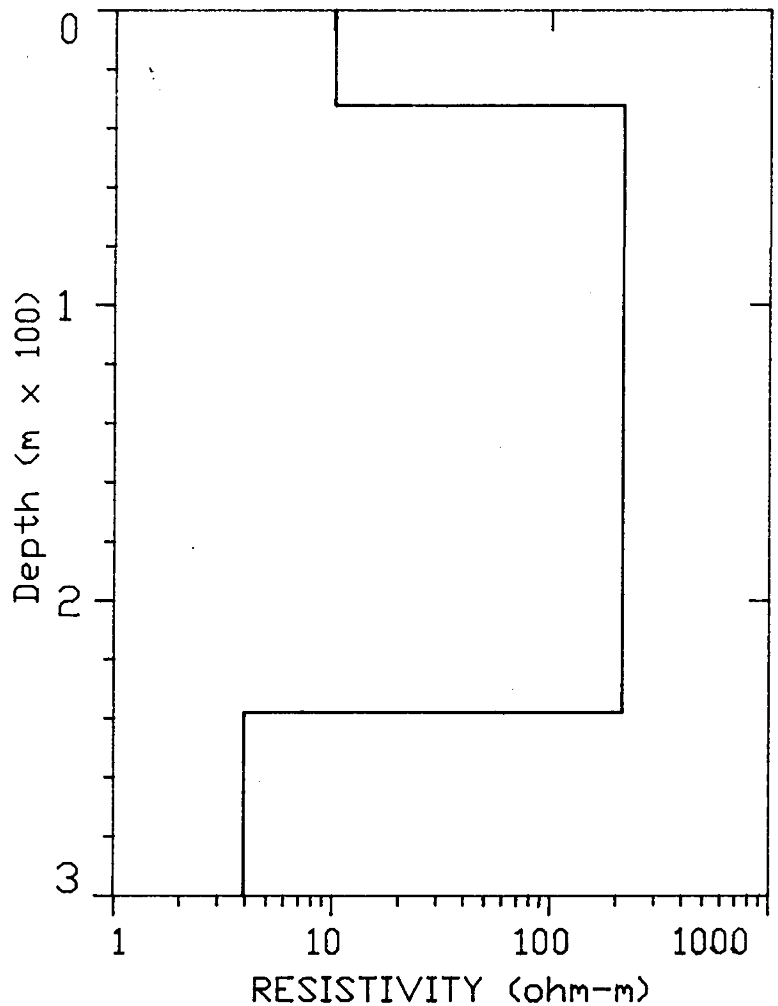


—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	DEMONSTRATION TDEM SURVEY RESULTS SHOWING NORMALIZED VOLTAGE AND APPARENT RESISTIVITY VERSUS TIME	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EXM-2 DATE: 09/16/93	FIGURE 3-4



Fitting Error: 4.091%

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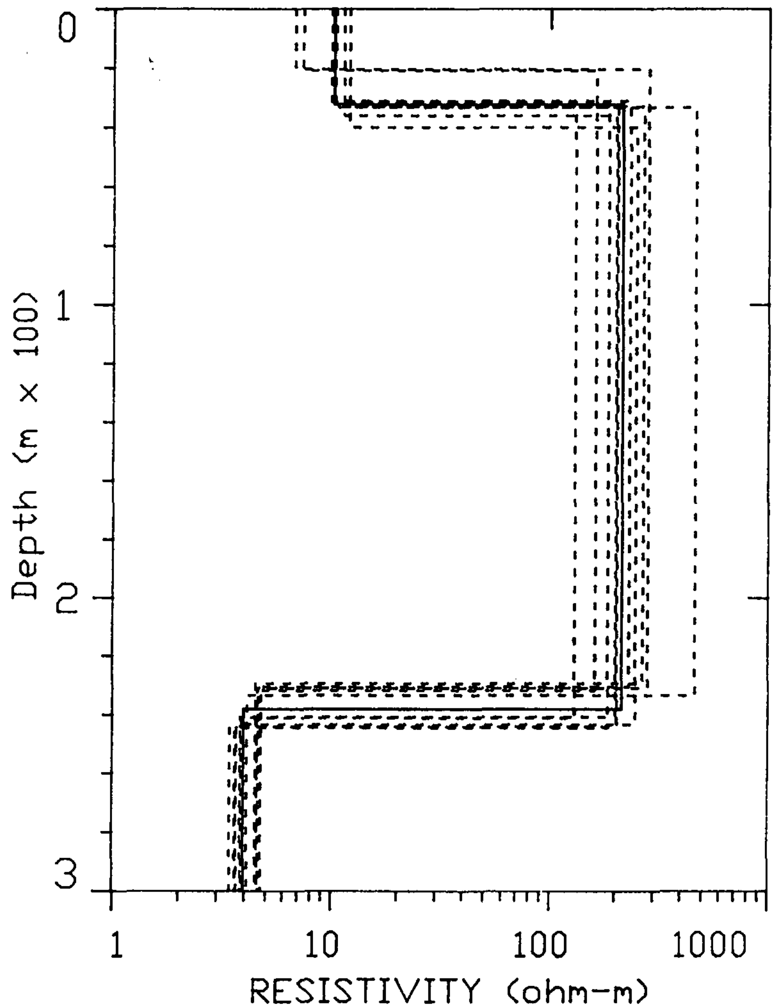
DEMONSTRATION TDEM SURVEY RESULTS
SHOWING BEST-FIT MODEL

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EXM-2	3-5
DRAWN BY:	SBG	DATE:	09/16/93	



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	DEMONSTRATION TDEM SURVEY RESULTS SHOWING RESULTS OF EQUIVALENCE ANALYSIS			
		DESIGNED BY: MJW	PROJECT NO.: 93742	FIGURE	
		CHECKED BY: RJW	DRAWING NO.: EXM-4	3-6	
		DRAWN BY: SBG	DATE: 09/16/93		

4.0 TECHNICAL APPROACH TO SATISFYING SURVEY OBJECTIVES

4.1 GENERAL

As stated previously, the final product of the *geophysical* investigation is a best-fit, one-dimensional model of layer resistivity versus depth. To satisfy the requirements of the survey, these models must be correlated with models of chloride concentration versus depth. Specifically, the resistivity structure must be viewed in terms of determining the depth of occurrence of the 250 mg/L isochlor and the depth to salt water as defined by the 5,000 mg/L isochlor. To ensure that the results from the 1993 TDEM survey are directly comparable to and compatible with the results of TDEM surveys performed in previous years (Blackhawk, 1990 and CEES, 1992), SDII will utilize the identical relationships between resistivity and isochlor depths for the Floridan aquifer. These relationships and assumptions are detailed in the following sections. However, it must be realized that correlations of TDEM-derived layer conductivities with specific chloride values are approximate and based on several simplifying assumptions.

4.2 CORRELATION OF INVERTED GEOELECTRICAL (RESISTIVITY) PROFILES TO CHLORIDE CONCENTRATIONS

In previous studies, it was presumed that the depth to salt water was such that this interface was inferred to occur within the Floridan aquifer system. The only noted exceptions to this were soundings in the area of Jacksonville where the great depth (>2,000 ft) and the very low resistivity (< 2 ohm-m) of the deep, low resistivity layer placed the interface below the Lower Floridan aquifer (CEES, 1992). For such deep sites with very low resistivities, the published relationships between resistivity and chloride concentration cannot be used; it is merely presumed that the chloride concentration at these sites exceeds 5,000 mg/L for the saltwater section.

In cases where the electrical response between the Floridan aquifer and overlying sediments are indistinguishable, the two hydrostratigraphic units must be combined into a single geoelectric layer. Similar to the situation where the interface is below the Floridan aquifer, the published relationships between resistivity and chloride concentration are invalid and the chloride concentration in ground water above the saltwater interface cannot be determined.

For the majority of soundings conducted previously, the saltwater interface positions were "inferred to occur within the Floridan aquifer system" (Blackhawk, 1990 and CEES, 1992) and, therefore, the published relationships are applicable. When the saltwater interface occurred within the Floridan aquifer, the following procedure was used in both this and previous studies (Blackhawk, 1990 and CEES, 1992).

The carbonate rocks of the Floridan aquifer system (as opposed to the highly variable lithologies of overlying formations) are expected to be uniform and, as such, their resistivities are determined principally by, porosity and specific conductance of pore fluids. The governing empirical "law" relating formation resistivity (Ro), fluid resistivity (Rw) and porosity (ϕ) in a clay-free lithology is Archie's Law:

$$F = Ro/Rw = a\phi^{-m} \qquad (1)$$

where F = "formation factor" and "a" and "m" are empirically derived constants which are specific to a given formation in a given area. Previous TDEM reports have used the values of m = 1.6 and a = 1 from Kwader (1982) as being most appropriate for the Floridan aquifer. These values are from studies of wells completed in the Upper Floridan aquifer in Seminole County, Florida.

Kwader (1982) has also established the following relationship from his study of Seminole County wells:

$$Cl = (3500/Rw) - 153 \qquad (2)$$

where Cl is the equivalent chloride concentration in mg/L and Rw is fluid resistivity in ohm-meters. Extrapolating these expressions by Kwader outside of Seminole County presumes that the relative ionic chemistry (especially a chloride/sulfate ratio of 5:1) remains the same or reasonably close to conditions in that area. Significant chemical variation would cause Equation 2 to be, quite likely, invalid.

Because formation resistivity, Ro, is what the geophysical analysis of TDEM data has produced, a combination of equations (1) and (2) allows for determining a functional relationship between chloride concentration, inferred formation resistivity, and porosity:

$$Cl = (3500\phi^{-1.6}/Ro) - 153 \qquad (3)$$

or, for an assumed 25% porosity for the Upper Floridan aquifer as per previous TDEM reports:

$$Cl = (32{,}163/Ro) - 153 \qquad (4)$$

Linking this relationship to the cited survey objectives, we would expect that a Floridan aquifer with 25% porosity, similar water chemistry (5:1 chloride to sulfate ratio) to the Kwader study, and a 250 mg/L chloride concentration would yield a measured formation resistivity of 80 ohm-m. Higher resistivities than this would indicate fresher water. Chloride concentrations of 5,000 mg/L would correspond to formations resistivities of 6.2 omh-m; higher concentrations would yield lower resistivities. These values, then, are what we should expect to see for the fresh and saltwater sections of the Floridan aquifer.

One final consideration, besides porosity and similar chemical species/ratios, is made by previous reports (Blackhawk, 1990 and CEES, 1992) and, again, will be adhered to in this 1993 study. The relationships cited are for a clearly defined, carbonate section within the Floridan aquifer (i.e., beneath the Hawthorn Group). If there is a clearly defined thickness of the Hawthorn Group from the electrical sounding results and if that thickness is in agreement with published Hawthorn Group thickness for the area of a specific site, then there is presumed to be no affect of the measured formation resistivity for the Floridan aquifer due to interfingering of clay stringers of the Hawthorn Group. This means that the inversion resistivity results representing the Floridan aquifer layer are valid.

4.3 DETERMINATION OF DEPTH TO 250 mg/L AND 5,000 mg/L ISOCHLORS

The previous discussion of the relationship of formation conductivity to chloride content is particularly applicable to geoelectrical measurements made on a fine, highly resolved scale, such as a borehole electrical log, where an almost continuous measure of resistivity versus depth is available. As known from geophysical logs and water quality studies, the saltwater interface is not a knife-edge interface in the subsurface but is a gradational interface. Within the freshwater section, we would also expect the chloride concentration to follow a gradually increasing-downwards distribution. Therefore, the TDEM sounding, which presents the subsurface as a sequence of a few layers of presumed, uniform resistivity, is not an actual representation of the true subsurface but a low resolution version of it. The saltwater interface (chlorides greater than 5,000 mg/L), which exhibits a much higher gradient of chloride concentration than the overlying fresher water, comes closest to being a true interface. This is why depth to the saltwater interface from TDEM should be close to the low resistivity layer detected.

Actual reported depth to the 5,000 mg/L isochlor in previous reports (CEES, 1992) is determined by the contrast in resistivity of the layers above and below the geoelectrical interface. If the contrast is large (e.g., greater than 80 ohm-m above and less than 20 ohm-m below), then the depth to the 5,000 mg/L isochlor is assumed to be 50 ft below the interface depth determined from geoelectrical inversion. If the contrast is small (e.g., a 20-80 ohm-m layer above and less than 20 ohm-m layer below), the depth to the 5,000 mg/L isochlor is taken as equal to the depth to interface determined from the geoelectrical inversion. These adjustments are intended to correct for the existence of the transition zone.

The criterion used to define the depth to the 250 mg/L isochlor in previous TDEM surveys for SJRWMD (Blackhawk, 1990 and CEES, 1992) is also a data-based criterion. That is, the final reported position of this isochlor, relative to the boundary between the Floridan aquifer freshwater geoelectrical layer and the saltwater geoelectrical layer depends upon the layer resistivities above and below the interface as determined by the inversion.

Four data classes have been defined based upon a reference value for resistivity of 80 ohm-m for a portion of the Floridan aquifer. We reproduce the following criteria for positioning the 250 mg/L isochlor (CEES, Table 4-2, 1992).

Summarizing Table 4-2 in CEES (1992), if the Floridan freshwater section is in excess of 80 ohm-m while the underlying layer is less than 20 ohm-m (so-called Class A geoelectrical section), then the 250 mg/L isochlor is placed at a position 50 ft higher than the saltwater interface depth defined from geoelectrical inversion.

If the Floridan freshwater section is in excess of 80 ohm-m while the underlying layer is between 20-40 ohm-m (so-called Class B section), then the 250 mg/L isochlor is placed 25 ft above the saltwater interface depth defined from geoelectrical inversion.

If the Floridan freshwater section is in excess of 80 ohm-m and the underlying layer is between 40-80 ohm-m (Class C), then the 250 mg/L isochlor is placed at the interface.

Finally, if there is no contrast (i.e., a uniform layer of > 80 ohm-m; Class D), then we are not seeing an expected saltwater interface within the depth of exploration of the field sounding. Also, there is no detectable/mappable 250 mg/L isochlor.

In the above determinations for the 250 mg/L isochlor, the "depth" to the saltwater interface referred to is the depth to the low resistivity layer taken directly from the TEMIXGL inversion and not the corrected 5,000 mg/L depth as discussed previously.

5.0 RESULTS AND DISCUSSION

5.1 SUMMARY OF RESULTS

A summary of the 1993 TDEM investigation is presented in this section. The summary includes the resulting geoelectrical inversions, 250 mg/L isochlor depth and the 5000 mg/L isochlor depth. More detailed presentation of the individual site results are contained in the following sections 5.2 through 5.21. Each individual site section will present a site description, site map, apparent resistivity versus time (data) curves, the best-fit geoelectrical section with equivalence analysis, and inferred depths to the 5,000 mg/L (salt water) and 250 mg/L isochlors.

Table 5.1-1 lists the 20 sites with summary information describing site number, name, residing county, latitude, longitude and loop size.

Table 5.1-2 summarizes the results of the TEMIXGL geoelectrical inversion section (number of layers, layer thicknesses and resistivities, and range of equivalence models for each layer parameter).

Table 5.1-3 summarizes the estimated chloride content of the saltwater layer assuming porosities of 25, 30, and 35% for the Floridan Aquifer System.

Table 5.1-4 summarizes the interpreted depths to the 250 mg/L and the 5,000 mg/L isochlors at each site based upon the criteria outlined in Section 4.3 and as utilized in TDEM surveys performed for SJRWMD in previous years (Blackhawk, 1990 and CEES, 1992). As in previous years, these calculations are made assuming a 25% porosity for the Floridan Aquifer System and a 5:1 chloride-to-sulfate ratio for the ground water chemistry. The estimated chloride-to-sulfate ratios at each of the sites is provided in Table 5.1-4.

The effect of a CL/SO_4 ratio less than 5:1 would be for waters with equivalent conductivity to have different CL values. SO_4 is less conductive than CL for an equivalent mass volume. If for example the ratio is less than 5:1, it will take a higher conductivity (lower resistivity) to get a 250 mg/L chloride value. That is, for sites where the 5:1 ratio is 1:1, resistivities would have to be less than 80 ohm-m to reach a chloride content of 250 mg/L.

Table 5.1-1
SUMMARY OF TDEM SITE SURVEY INFORMATION

Site Number	Site Name	Residing County	Latitude	Longitude	Loop Size (in feet)
1	Daytona Beach Speedway	Volusia	29°10'37"N	81°04'37"W	1000 x 700
2	Cumberland Island	Camden (GA)	30°48'24"N	81°27'22"W	1750 x 1250
3	Nassau County	Nassau County	30°35'40"N	81°41'03"W	1500 x 1500
4	St. Augustine #1	St. Johns	29°54'49"N	81°24'37"W	1000 x 1000
5	St. Augustine #2	St. Johns	29°53'27"N	81°24'47"W	2000 x 500
6	Picolata	St. Johns	29°55'10"N	81°34'05"W	1000 x 1000
7	Green Cove Springs	Clay	29°57'09"N	81°39'52"W	1000 x 1000
8	Union Camp	Putnam	29°21'29"N	81°34'10"W	1220 x 940
9	Drayton Island	Putnam	29°22'49"N	81°38'32"W	1380 x 600
10	Bear Island	Flagler	29°26'22"N	81°28'59"W	1500 x 115
11	Deseret #1	Orange	28°25'17"N	81°05'17"W	1500 x 1000
12	Deseret #2	Orange	28°25'17"N	81°08'27"W	1575 x 1065
13	UCF	Orange	28°36'11"N	81°11'15"W	1500 x 1500
14	Richland Properties	Orange	28°21'43"N	81°23'30"W	1500 x 1500
15	New Smyrna Beach	Volusia	29°03'00"N	80°56'13"W	1000 x 900
16	Lake Ashby	Volusia	28°54'02"N	81°03'53"W	1350 x 650
17	Lake Helen	Volusia	29°00'39"N	81°14'39"W	1000 x 1000
18	Deltona	Volusia	28°55'15"N	81°10'09"W	900 x 500
19	Blue Springs State Park	Volusia	28°57'17"N	81°20'02"W	750 x 250
20	De Land	Volusia	29°06'11"N	81°20'39"W	1130 x 1000

Table 5.1-2
Summary of Geoelectrical Sections with Range of Equivalence

Site Name	Number of Modeled Layers in Geoelectrical Section	Layer 1						Layer 2						Layer 3						Total Depth To Deepest Conductor which is Interpreted as Salt Water (meters)*		
		Resistivity ρ_1 (ohm-m)			Thickness h_1 (meters)*			Resistivity ρ_2 (ohm-m)			Thickness h_2 (meters)*			Resistivity ρ_3 (ohm-m)			Thickness h_3 (meters)*					
		Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max
1. Daytona Beach Speedway	3	6.7	10.1	11.9	20.5	32.2	40.0	130	215	464	196	206	213	3.4	3.9	4.8	—	—	—	229	238	245
2. Cumberland Island	2	14.4	16.1	17.4	64.8	80.2	95.1	53.3	58	63.6	—	—	—	—	—	—	—	—	—	Not	Seen	
3. Nassau County	3	22.6	23	23.4	132	132	132	943	6010	60,098	559	608	673	2.8	4.7	7.7	—	—	—	691	740	805
4. St. Augustine #1	3	14.1	14.6	15.2	73	73	73	33.8	44	63.7	91	108	126	9.4	10.3	11.3	—	—	—	164	181	199
5. St. Augustine #2	3	8.0	9.5	10.3	34	45	51	118	169	312	118	129	143	17.2	18.4	19.8	—	—	—	153	174	190
6. Picolata	3	22.4	22.3	23.8	90	90	90	88.7	97.8	121.5	341	488	583	14.0	27.4	49.3	—	—	—	431	578	673
7. Green Cove Springs	3	26.6	29.0	31.3	93	93	93	79	108	167	363	383	402	1.0	2.3	4.9	—	—	—	456	476	495
8. Union Camp	3	45	47	49	246	252	258	3.2	3.7	4.2	—	—	—	—	—	—	—	—	—	246	252	258
9. Drayton Island	3	22	23	24	123	127	131	2.2	2.3	2.5	—	—	—	—	—	—	—	—	—	123	127	131
10. Bear Island	3	3.4	5.9	6.9	11	23	28	61	98	180	134	141	150	2.5	2.8	3.1	—	—	—	158	164	169
11. Deseret #1	3	14.7	18.1	20.6	40	56	74	80	101	140	293	329	357	9.3	10.7	12.7	—	—	—	357	385	408
12. Deseret #2	3	7.3	16.5	18.2	19	46	52	538	957	3027	297	314	329	13.5	15.5	20.1	—	—	—	326	360	376
13. UCF	3	14.4	23.6	30.3	22	38	50	399	534	955	382	395	409	4.7	5.5	6.4	—	—	—	424	433	442
14. Richland Properties	3	8.0	16.5	19.5	18	39	47	1007	2551	7112	523	546	590	2.3	2.8	7.0	—	—	—	562	585	628
15. New Smyrna Beach	2	9.1	9.2	9.4	121	126	130	2.1	2.3	2.5	—	—	—							121	126	130
16. Lake Ashby	2	40.4	41.8	43.5	226	234	242	3.8	4.6	5.6	—	—	—	—	—	—				226	234	242
17. Lake Helen	3	32.7	39.8	47.2	50	66	84	321	497	994	242	258	275	1.8	2.0	2.3	—	—	—	324	324	327
18. Deltona	3	65.2	68.4	71.6	296	301	304	1.1	1.4	1.7	—	—	—	—	—	—	—	—	—	296	301	304
19. Blue Springs State Park	3	26.8	27.9	29.2	144	151	156	3.9	4.4	5.0	—	—	—	—	—	—	—	—	—	144	151	156
20. De Land	3	40.9	42.3	43.8	269	277	283	2.8	3.3	4.0	—	—	—	—	—	—	—	—	—	269	277	283

* 1 meter equals 3.28 ft

Table 5.1-3
Estimated Depths to Salt Water and
Estimated Chloride Concentrations at Three Porosities

Site	Formation Resistivity (ohm-m)	Interpreted Depth of Salt water (ft)	Chloride Conc. (mg/L) $\phi = 25\%$	Chloride Conc. (mg/L) $\phi = 30\%$	Chloride Conc. (mg/L) $\phi = 35\%$
1 Daytona Beach Speedway	3.9	780	8,094	6,007	4,661
2 Cumberland Island	Not Present	Beyond System Limit			
3 Nassau County	4.7	2,427	6,690	4,959	3,841
4 St. Augustine #1	10.3	594	2,970	2,180	1,670
5 St. Augustine #2	18.4	571	1,595	1,153	867
6 Picolata	27.4	1,896	1,021	724	532
7 Green Cove Springs	2.3	1,562	13,831	10,293	8,010
8 Union Camp	3.7	826	8,540	6,340	4,921
9 Drayton Island	2.3	416	13,831	10,293	8,010
10 Bear Island	2.8	538	11,334	8,428	6,552
11 Deseret #1	10.7	1,263	2,853	2,092	1,602
12 Deseret #2	15.5	1,181	1,922	1,397	1,058
13 UCF	5.5	1,423	5,695	4,215	3,260
14 Richland Properties	2.8	1,919	11,334	8,427	6,552
15 New Smyrna Beach	2.3	413	13,831	10,293	8,010
16 Lake Ashby	4.6	769	6,839	5,070	3,928
17 Lake Helen	2.0	1,064	15,929	11,860	9,234
18 Deltona	1.4	986	22,821	17,008	13,257
19 Blue Springs State Park	4.4	494	7,157	5,307	4,114
20 De Land	3.3	908	9,594	7,127	5,536

Table 5.1-4
Depth to 5,000 mg/L and 250 mg/L Isochlor
as Determined by Time Domain Electromagnetics

	Site	Estimated Chloride-to-Sulfate ratio [1/]	Interpreted Depth 5,000 mg/L Isochlor (ft bls)	Interpreted Depth 250 mg/L Isochlor
1	Daytona Beach Speedway	5:1	830	730
2	Cumberland Island	1:5	Not Present	Cannot be Determined
3	Nassau County	1:1	2,477	2,377
4	St. Augustine #1	1:2	594	Not Present
5	St. Augustine #2	1:1	621	Cannot be Determined
6	Picolata	1:5	1,946	1,846
7	Green Cove Springs	1:1	1,612	1,512
8	Union Camp	2:1	826	Cannot be Determined
9	Drayton Island	2:1	416	Cannot be Determined
10	Bear Island	2:1	588	488
11	Deseret #1	2:1	1,313	Cannot be Determined
12	Deseret #2	1:1	1,231	Cannot be Determined
13	UCF	1:1	1,473	Cannot be Determined
14	Richland Properties	1:1	1,969	Cannot be Determined
15	New Smyrna Beach	5:1	413	Cannot be Determined
16	Lake Ashby	1:1	769	Cannot be Determined
17	Lake Helen	1:1	1,114	1,014
18	Deltona	10:1	986	Cannot be Determined
19	Blue Springs State Park	10:1	494	Cannot be Determined
20	De Land	10:1	908	Cannot be Determined

1/ Chloride-to-sulfate ratios from all sites except 4, 5, 6, 8, 9, 10, 11, and 12 estimated from Sprinkle, 1981. Chloride-to-sulfate ratios for sites 4, 5, and 6 estimated from Spechler and Hampson, 1984. Chloride-to-sulfate ratios for sites 8, 9, 10, 11 and 12 from SJRWMD.

5.2 TDEM SITE 1 - DAYTONA BEACH SPEEDWAY SITE

5.2.1 Location Description and Geoelectrical Section

This site is located in Daytona Beach, Florida, in a grassy parking area located adjacent to and serving the Daytona Beach Speedway facility (Figure 5.2-1). Because of curvature of the track oval (fence line and embankment), additional steel fence lines, and local highways, the planned 1,000 ft square Tx loop was altered to a 700 ft by 1,000 ft rectangular loop. The Hawthorn Group is not present in this area (Scott et al., 1991) and the Lower Floridan aquifer begins at approximately 800 ft below msl (Miller, 1986).

A monitor well (DB-1) is located at Daytona Beach International Airport (Figure 5.2-1) and is approximately one mile from the TDEM site. Lithologic logs indicate the Floridan aquifer begins at 96 ft below land surface (bls). Measured chloride concentrations show fresh (<250 mg/L) water down to approximately 770 ft followed by a rapidly increasing chloride concentration gradient below 800 ft depth.

The resistivity sounding data and best-fit model inversion are presented on Figure 5.2-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.2.2 Geological Interpretation of Geoelectrical Model

The model created from the TDEM survey compares well to the nearby well information. The modeled top layer is low resistivity (10 ohm-m) and has a thickness of 105 ft (32.2 m). The top layer is interpreted as the surficial aquifer system and the 105 ft depth is interpreted as the top of the Floridan aquifer. The increased resistivity of the second layer (215 ohm-m) is consistent with freshwater saturation (>80 ohm-m) within the Floridan aquifer; the depth to the interpreted low resistivity (saltwater) layer is 780 ft (238 m). The depth to the saltwater interface occurs at or near top of the the Lower Floridan aquifer. Accordingly, the three-layered geoelectrical model at this site appears to represent the near surface sediments, fresh water within the Floridan aquifer, and saltwater saturation, respectively.

5.2.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 3.9 ohm-m, is interpreted to represent salt water. It occurs at a depth of 780 ft (-758 ft msl) which is near the top of the Lower Floridan aquifer. Because the resistivity of layer 2 (215 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is 50 ft below the depth of the geoelectrical interface, or at 830 ft depth (-808 ft msl). The resistivity of layer 3 (3.9 ohm-m) corresponds to a chloride content of 8,090 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.2.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 215 ohm-m, corresponds to a chloride content of less than 50 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. Using the criteria established in Section 4.3 (this is a Class A type resistivity distribution), the position of the 250 mg/L isochlor is placed 50 ft above the depth to the low resistivity interface, or at a depth of 730 ft (-708 ft msl). The depth to the 250 mg/L isochlor (730 ft bls) correlates well to water quality results from nearby monitor well DB-1 which places the 250 mg/L isochlor at 754 ft bls (Figure 5.2-4).

5.2.5 Accuracy of Measurement and Interpretation

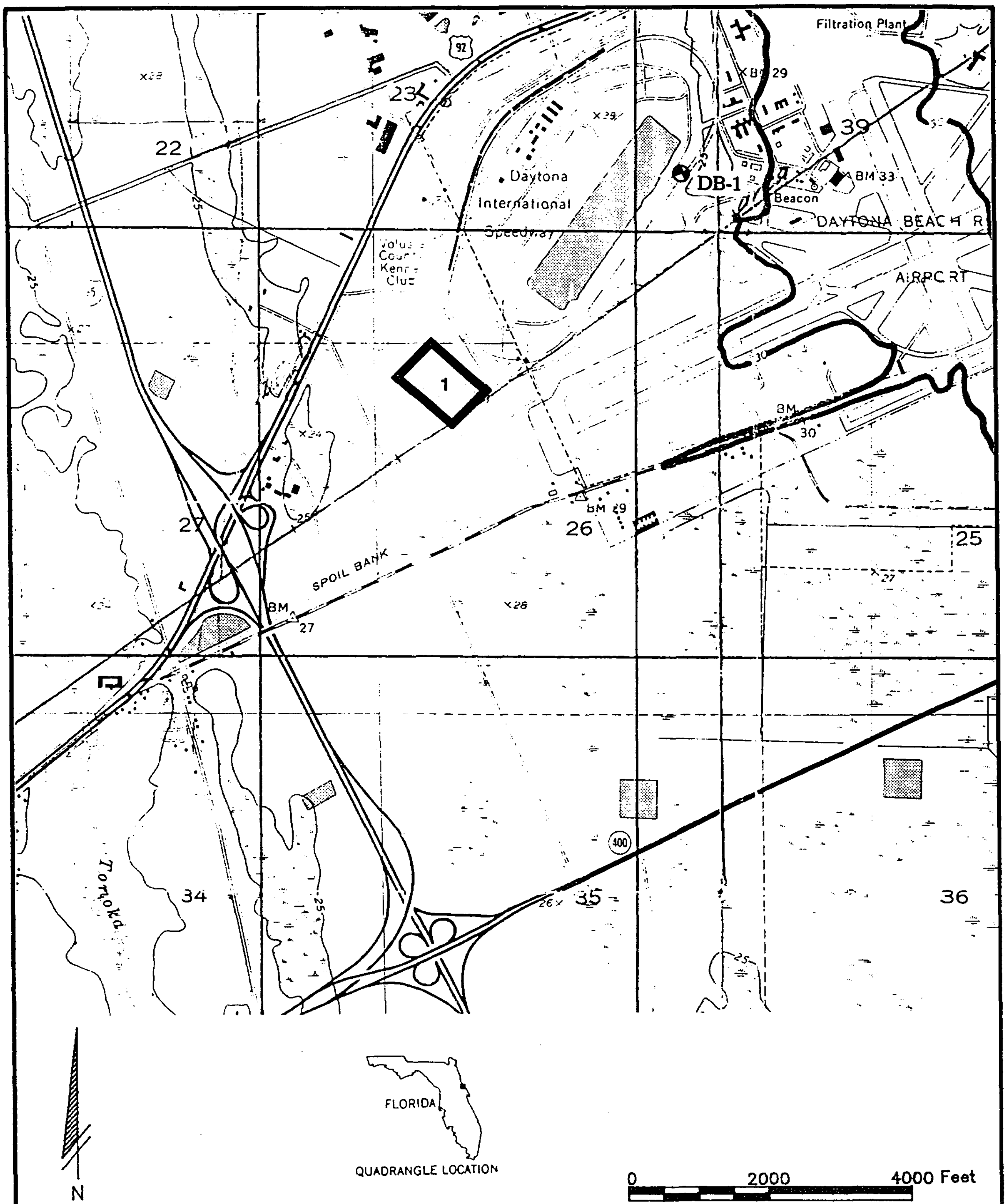
Figure 5.2-3 is the equivalence analysis at this site, and the inversion table (Table 5.2-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 8 m (26 ft), which is 3% of the total depth. The resistivity of this layer has a range of from 3.4 - 4.8 ohm-m. This corresponds to a range in interpreted chloride concentration of from 9,300 mg/L to 6,550 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 130 - 465 ohm-m which corresponds to a range of chloride content of from 200 to less than 50 mg/L. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, the assumptions implicit within equation (4) are valid.

5.2.6 Summary of TDEM Sounding at Daytona Beach Speedway (Site 1)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 830 ft (-808 ft msl) which is the top of the Lower Floridan aquifer. The chloride content below that depth is inferred to be 8,094 mg/L.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 50 mg/L using a porosity value of 25% for the Floridan aquifer. The 250 mg/L isochlor is interpreted to be present within the Floridan aquifer at a depth of 730 ft (-708 ft msl). The estimated depth to 250 mg/L isochlor correlates well to the depth of the 250 mg/L isochlor (754 ft) measured in a nearby well.

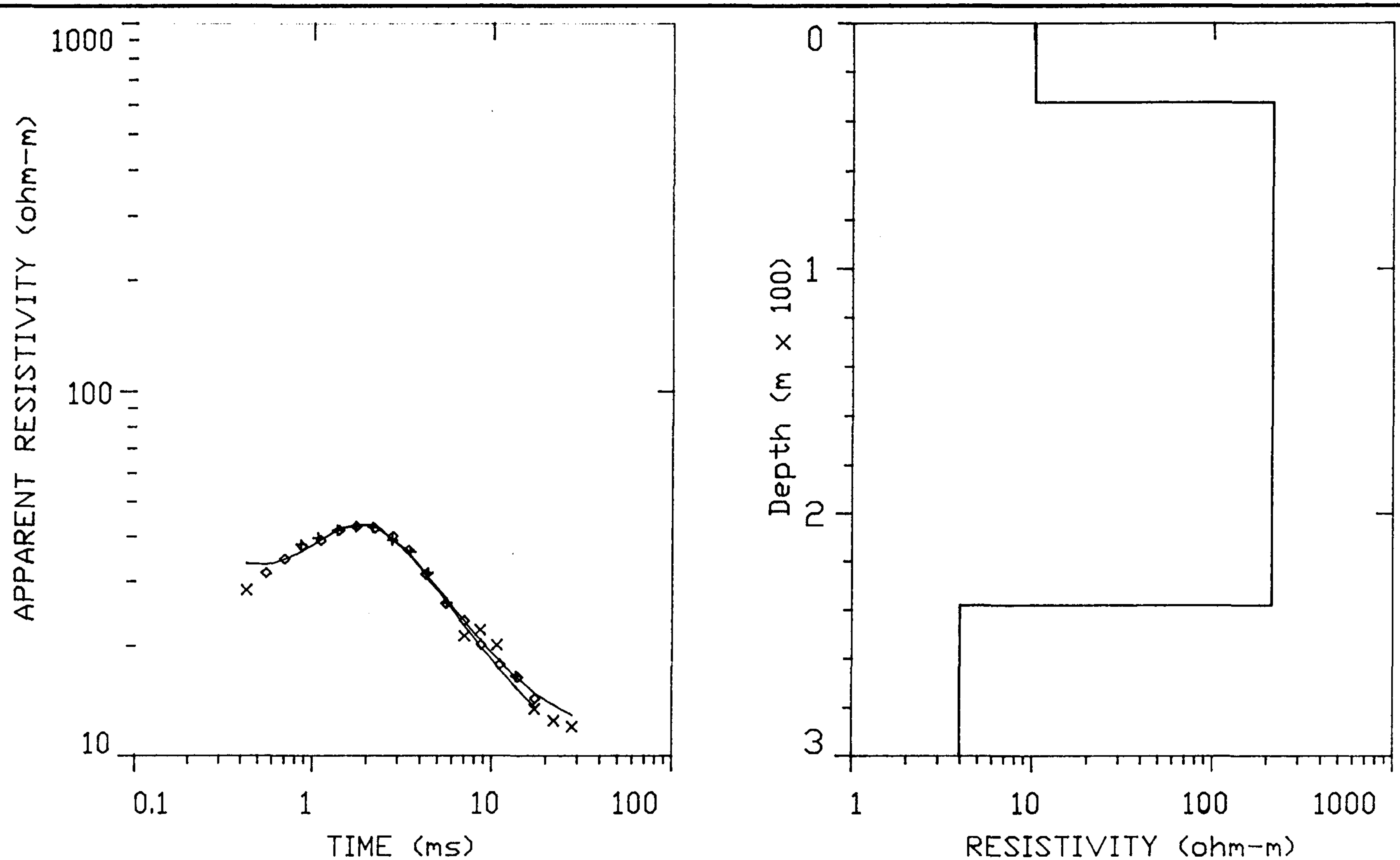


ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 1 – DAYTONA BEACH SPEEDWAY
DAYTONA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-1	5.2-1
DRAWN BY:	SBG	DATE:	08/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

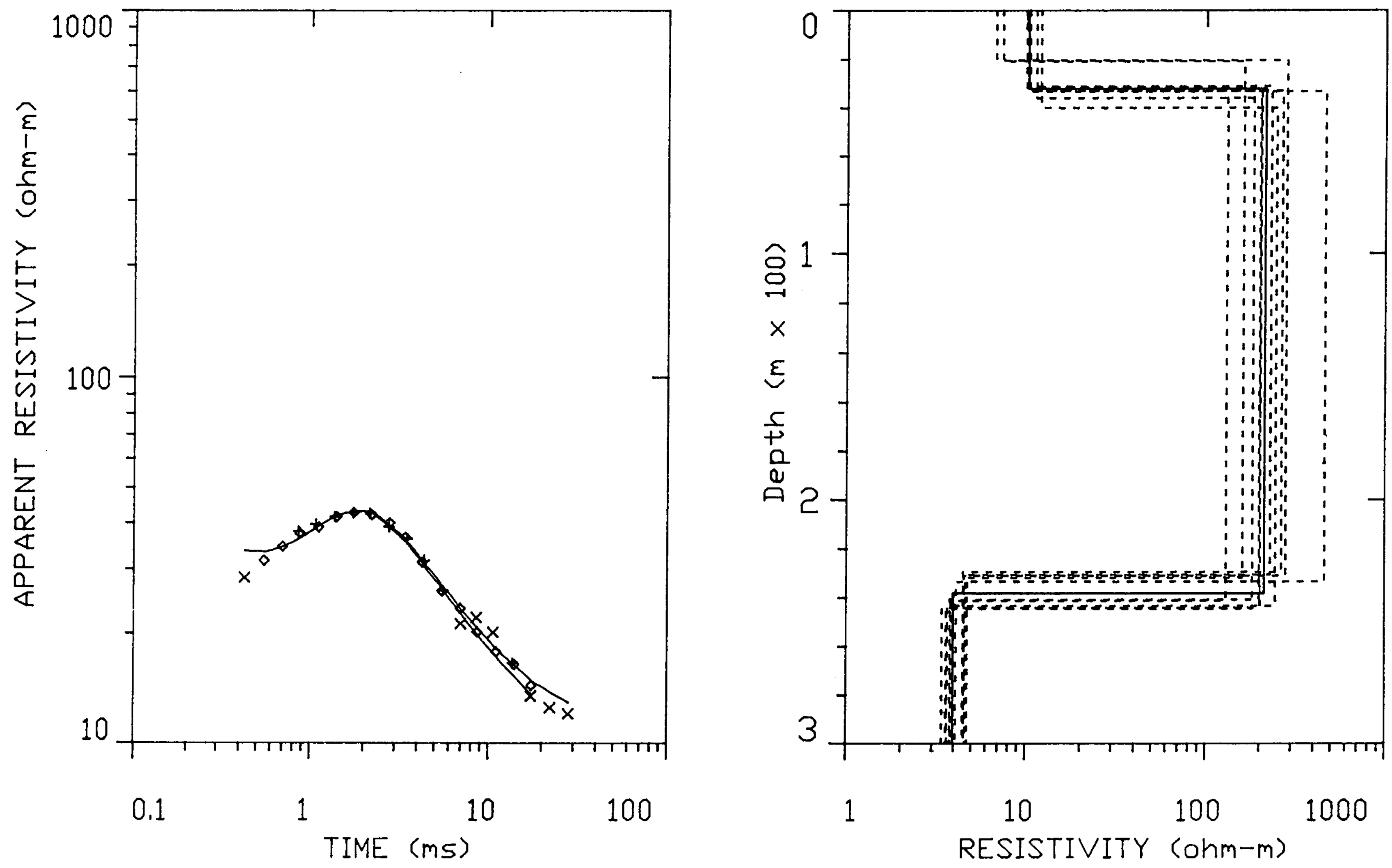
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 1 - DAYTONA BEACH SPEEDWAY
DAYTONA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-1	5.2-2
DRAWN BY:	SBG	DATE:	08/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

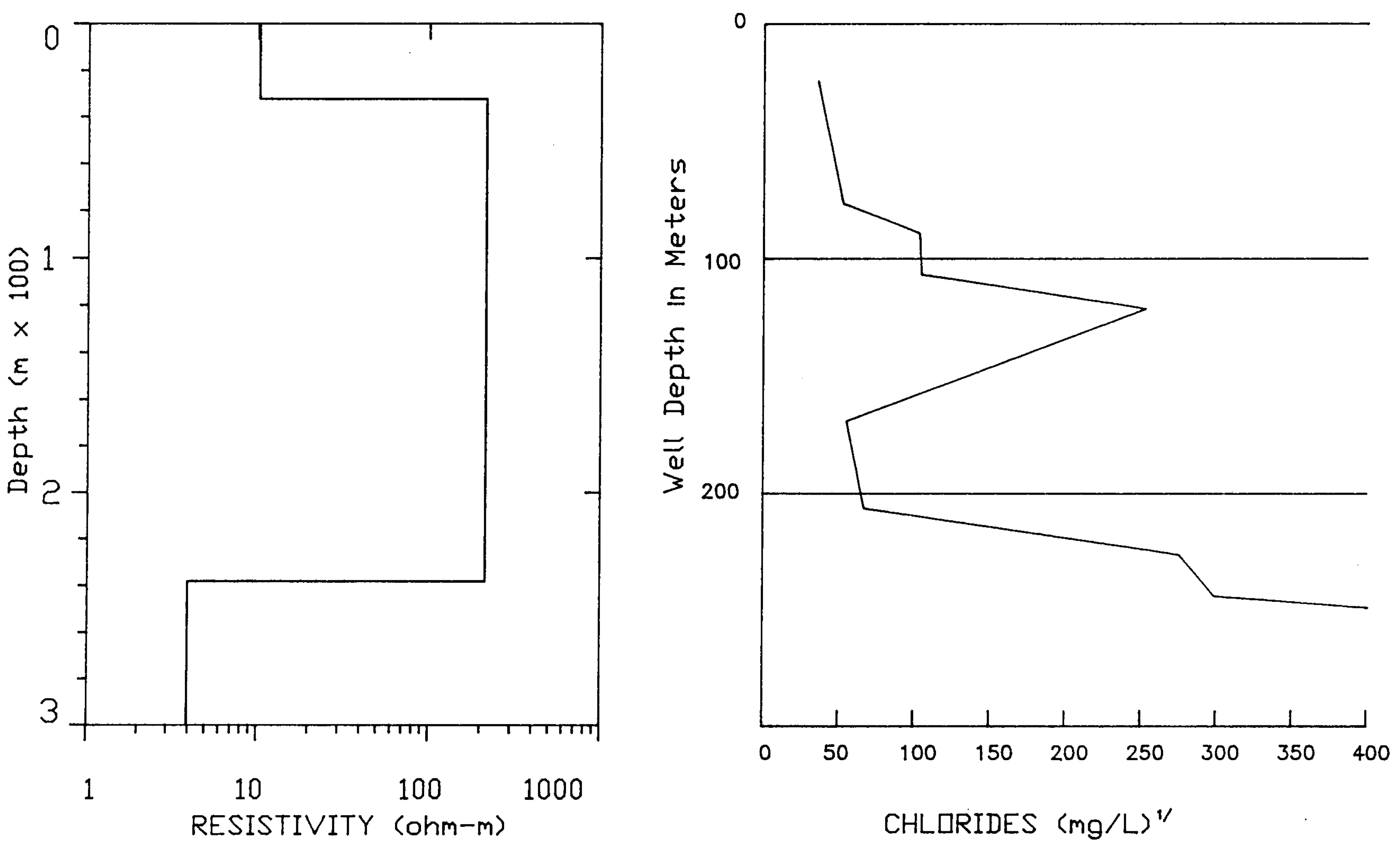
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 1 – DAYTONA BEACH SPEEDWAY
DAYTONA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-1	5.2-3
DRAWN BY:	SBG	DATE:	06/25/93	



1/ ADAPTED FROM TECHNICAL PUBLICATION SJ 87

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	COMPARISON OF TDEM RESULTS TO WATER QUALITY RESULTS FROM MONITOR WELL DB–1 – SOUNDING 1 DAYTONA BEACH SPEEDWAY – DAYTON BEACH, FL

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	CHL–1	5.2–4
DRAWN BY:	SBG	DATE:	08/10/93	

CLIENT: SJWRMD
LOCATION: DAYTONA BEACH SPEEDWAY
COUNTY: VOLUSIA COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 213.000 m by 305.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 04-26-93
SOUNDING: 1
ELEVATION: 7.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.091 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.00	
1	10.13	32.19	-25.19	3.17
2	215.2	205.8	-231.0	0.956
3	3.94			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	6.720	10.133	11.919
	2	130.497	215.256	464.482
	3	3.410	3.949	4.752
THICK	1	20.451	-0.492	39.988
	2	196.383	1.000	212.832
DEPTH	1	20.451	32.197	39.988
	2	229.332	238.025	244.503

CURRENT: 22.00 AMPS EM-37 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 212.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.427	40415.0	31406.3	22.29 MASKED
2	0.550	18264.1	16902.9	7.45
3	0.698	8812.1	8835.6	-0.265

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 1
DAYTONA BEACH SPEEDWAY

PROJECT NO.: 93742
TABLE 5.2-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.869	4506.5	4729.3	-4.94
5	1.10	2324.2	2298.8	1.09
6	1.40	1164.3	1143.9	1.75
7	1.75	645.7	635.5	1.58
8	2.22	363.6	349.8	3.77
9	2.79	221.4	227.5	-2.76
10	3.42	152.0	153.8	-1.16
11	4.26	110.8	110.0	0.706
12	5.49	77.37	72.95	5.71
13	6.96	50.38	50.40	-0.0426
14	8.66	36.48	35.21	3.48
15	11.06	23.89	23.22	2.80
16	14.00	14.92	15.01	-0.618
17	17.47	10.47	9.97	4.69
18	22.23	7.07	6.09	13.77 MASKED
19	28.10	4.17	3.74	10.30 MASKED

CURRENT: 22.00 AMPS EM-37 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 212.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
20	0.857	4590.7	4925.9	-7.30
21	1.06	2492.7	2590.0	-3.90
22	1.37	1237.1	1225.4	0.941
23	1.74	656.5	648.1	1.28
24	2.17	380.1	371.8	2.18
25	2.77	234.3	233.4	0.364
26	3.50	146.2	150.4	-2.91
27	4.37	102.7	108.6	-5.75
28	5.56	74.60	73.99	0.810
29	6.98	57.73	52.53	8.99 MASKED
30	8.56	32.68	38.11	-16.59 MASKED
31	10.64	21.89	26.68	-21.88 MASKED
32	13.70	15.59	17.34	-11.20
33	17.40	11.69	11.47	1.85 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.95				
P 2	0.03	0.05			
P 3	0.02	-0.05	0.88		
T 1	-0.05	-0.04	0.02	0.93	
T 2	0.00	0.03	0.02	0.00	0.99

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PALATKA, FLORIDA

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SUBSURFACE
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INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 1
DAYTONA BEACH SPEEDWAY

PROJECT NO.: 93742
TABLE 5.2-1

5.3 TDEM SITE 2 - CUMBERLAND ISLAND SITE

5.3.1 Location Description and Geoelectrical Section

The Cumberland Island Site is located off the southeast coast of Georgia within Cumberland Island National Seashore Park. The crew and equipment were transported to the island on a service boat operated by the National Park Service. The sounding location (Figure 5.3-1) was in an open area in the central part of the island which also serves as an airstrip. The area was clear with the only apparent potential source of cultural noise being a power line laying on the ground within 200 ft of the western leg of the Tx loop. QC soundings were performed 200 ft east and west of the initial location of Rx coil. Results from the QC soundings indicated that the power line had no affect upon the survey values (Figure 5.3-4) except during very-late times. The apparent resistivity values from these very-late times were not used in the development of the geoelectric model.

The Floridan aquifer begins at a depth of approximately 425 ft below msl and is overlain by the Hawthorn Group (Miller, 1986). The Floridan aquifer in this area is approximately 2,400 ft thick and the Fernandina permeable zone occurs at approximately -2,050 ft msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.3-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.3.2 Geological Interpretation of Geoelectrical Model

The two-layer geoelectrical section, Figure 5.3-2, is the only section observed during this study. The deep low resistivity layer (saltwater interface) was not detected by TDEM measurement. The implication is that, in this area, the depth to the saltwater interface is beyond the depth capacity of the measurement system as defined by loop size and current amperage. There is a relatively thin, upper layer (80 m or 262 ft) of 16 ohm-m resistivity which can be interpreted as the Hawthorn Group and surficial sediments. The depth is smaller than values mapped in this region (Miller, 1986), but fixing the depth at 450 ft produced a poor fit to the observations. As this is a fairly unambiguous data set, the inverted value of 80 m was used instead of fixing the depth.

5.3.3 Depth to Occurrence of Salt Water

The saltwater interface is not apparent in this data set. Similar findings in this general area were cited in the CEES (1992) TDEM survey where depths to salt water were cited as being below the base of the Floridan Aquifer System. To model the sensitivity to the existence of a possible saltwater interface, a forward modeling/sensitivity analysis was performed. To do this, the TDEM data which would have been observed if a third layer of low, 3 ohm-m, resistivity had been present was modeled. To do this, the resistivity and thickness values of the upper two layers were fixed as per the original inversion, a 3 ohm-m base layer was added, and then the thickness of layer 2 (depth to layer 3) was varied. The behavior of fit error was viewed (compared to the real data) as a function of layer 2 thickness (layer 3 depth). This sensitivity analysis is expressed on Figure 5.3-5. What is seen is that if the saltwater interface is greater than 2,200 ft deep, it cannot effectively be seen. If the layer was 2,000 ft or shallower, there would have been significant indications of its existence such that a reasonable (less than 10%) fit to the data would not have been possible to produce with a two-layer model. Accordingly, it appears that the depth to the saltwater interface exceeds 2,200 ft below land surface and, quite possibly, is much deeper in this area.

5.3.4 Depth of Occurrence of the 250 mg/L Isochlor

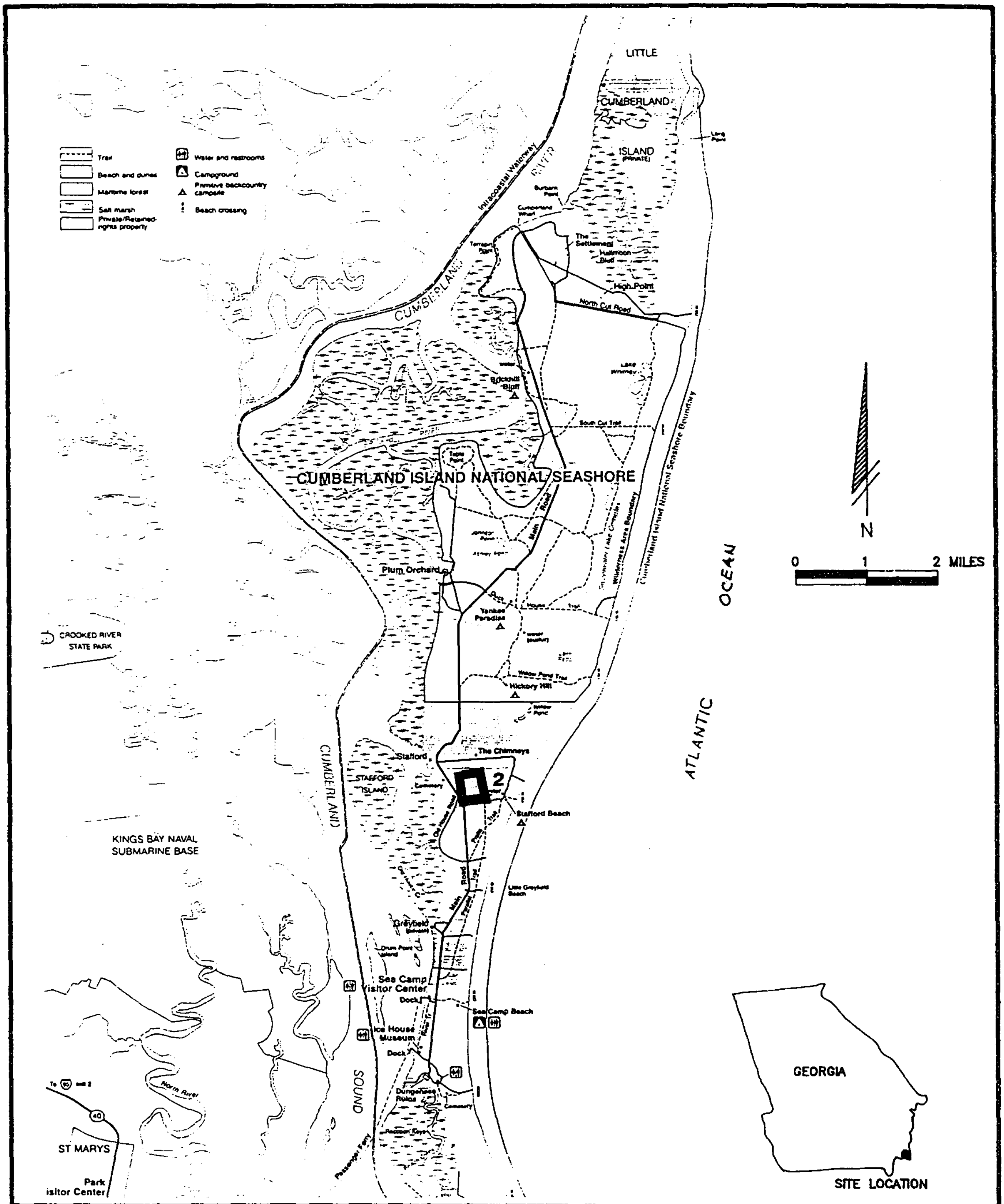
The inversion value of conductivity for layer 2 is 58 ohm-m. It is not possible to determine the chloride concentration in layer 2 because layer 2 contains part of the Hawthorn Group. Accordingly equation (4) may not be valid.

5.3.5 Accuracy of Measurement and Interpretation

Figure 5.3-3 is the equivalence analysis at this site, and the inversion table (Table 5.3-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. A depth to a low resistivity layer could not be determined. The equivalence range of the resistivity of layer 2 is from 53 - 64 ohm-m. A corresponding chloride concentration cannot be determined because layer 2 is in part comprised of part of the Hawthorn Group. Accordingly, equation (4) may not be valid. Results from a study of the island (McLemore, et al., 1981) indicate that the chloride to sulfate ratio is 1:5 (Table 5.1-4), which varies significantly from the 5:1 ratio used in equation (4). Accordingly, the assumptions implicit in equation (4) are not valid. The same study indicates that the chloride concentration in the Upper Floridan aquifer is 37 mg/L.

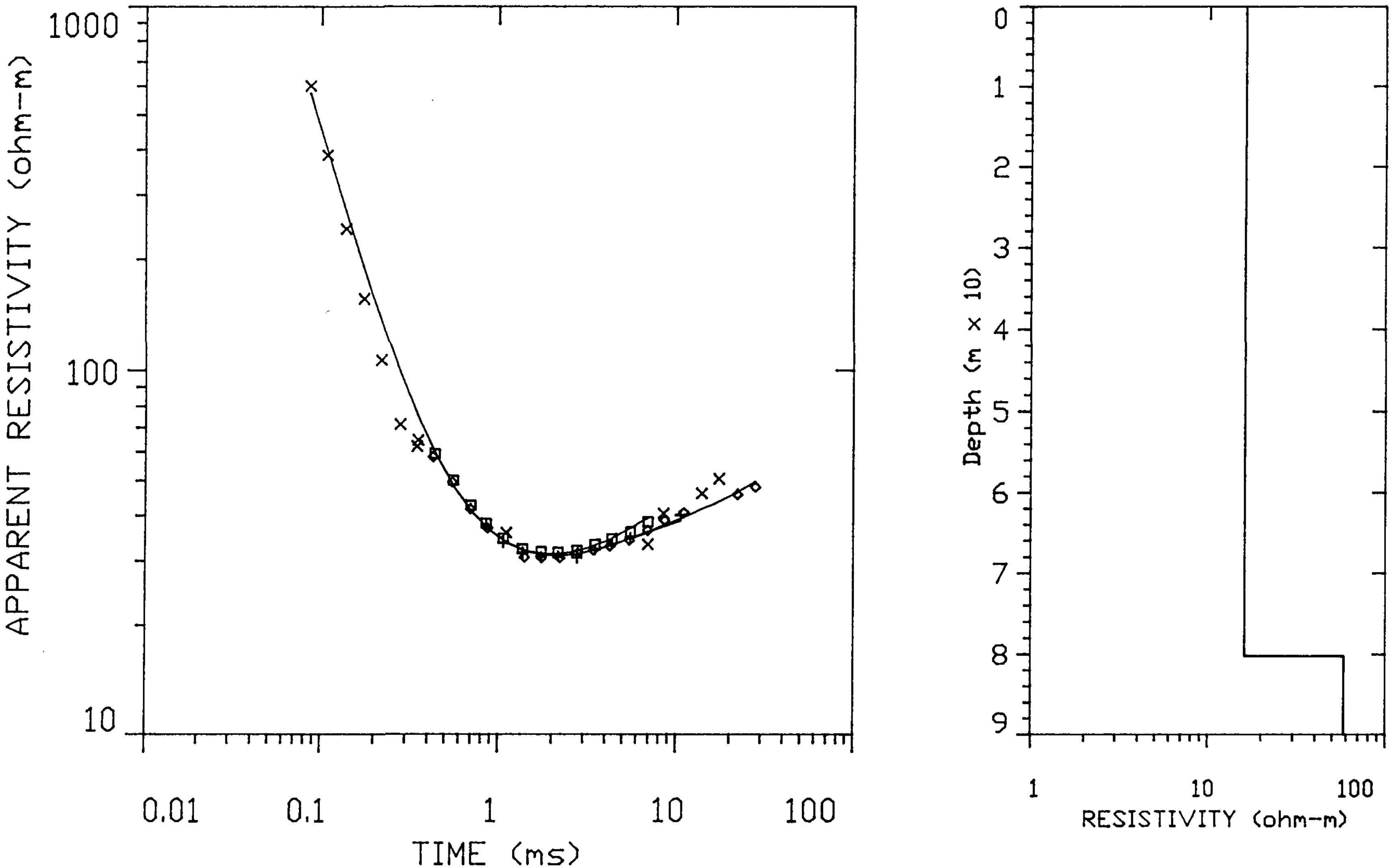
5.3.6 Summary of TDEM Sounding at Cumberland Island (Site 2)

- The depth to occurrence of salt water (5,000 mg/L isochlor) is unknown but it seems probable that it must be deeper than 2,200 ft from the modeling/sensitivity analysis.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow the Hawthorn Group to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 2 – CUMBERLAND ISLAND CUMBERLAND ISLAND, GEORGIA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC –2	5.3-1
DRAWN BY:	SBG	DATE:	06/17/93	



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

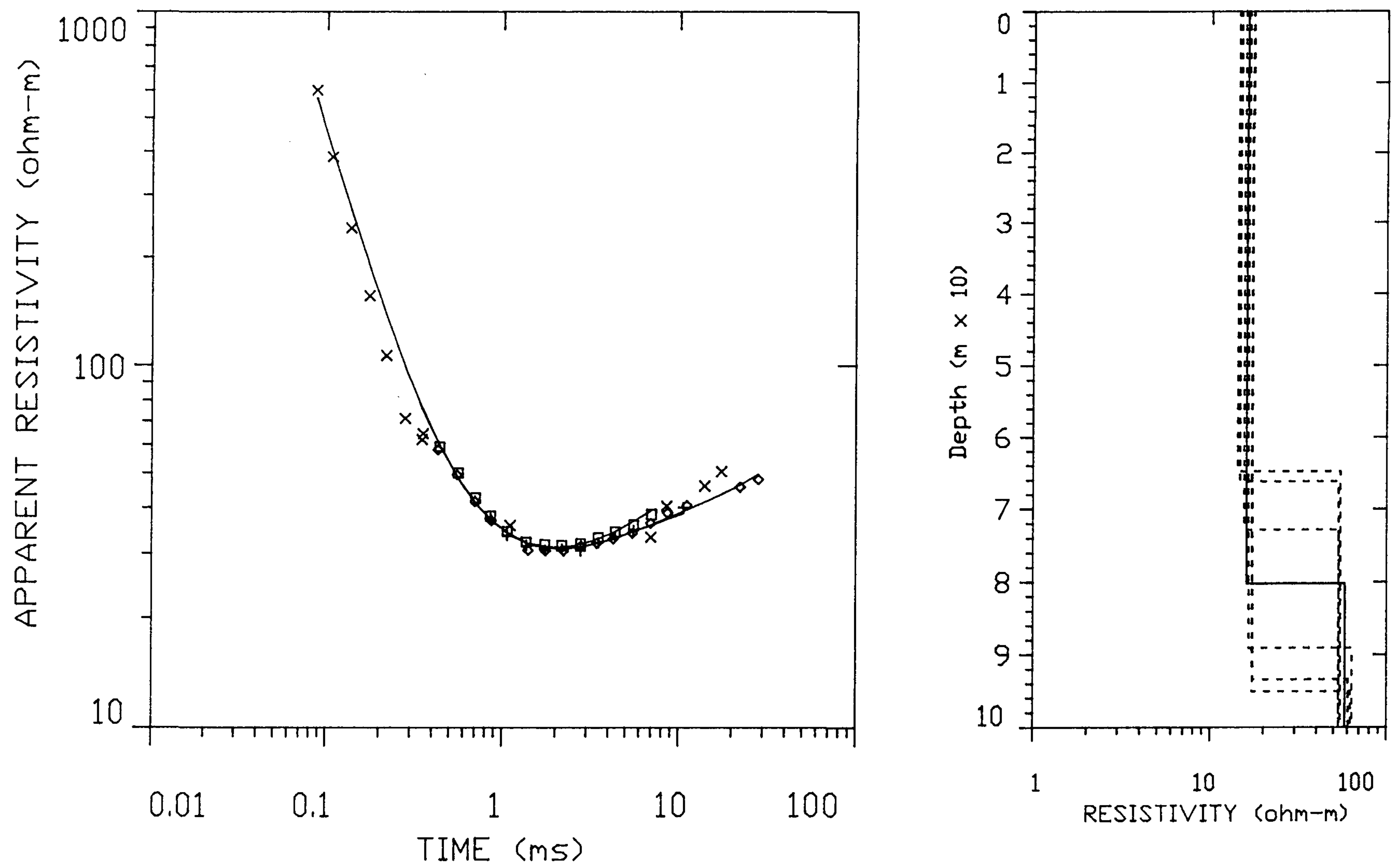
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 2 – CUMBERLAND ISLAND
CUMBERLAND ISLAND, GEORGIA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-2	5.3-2
DRAWN BY:	SBG	DATE:	08/10/93	



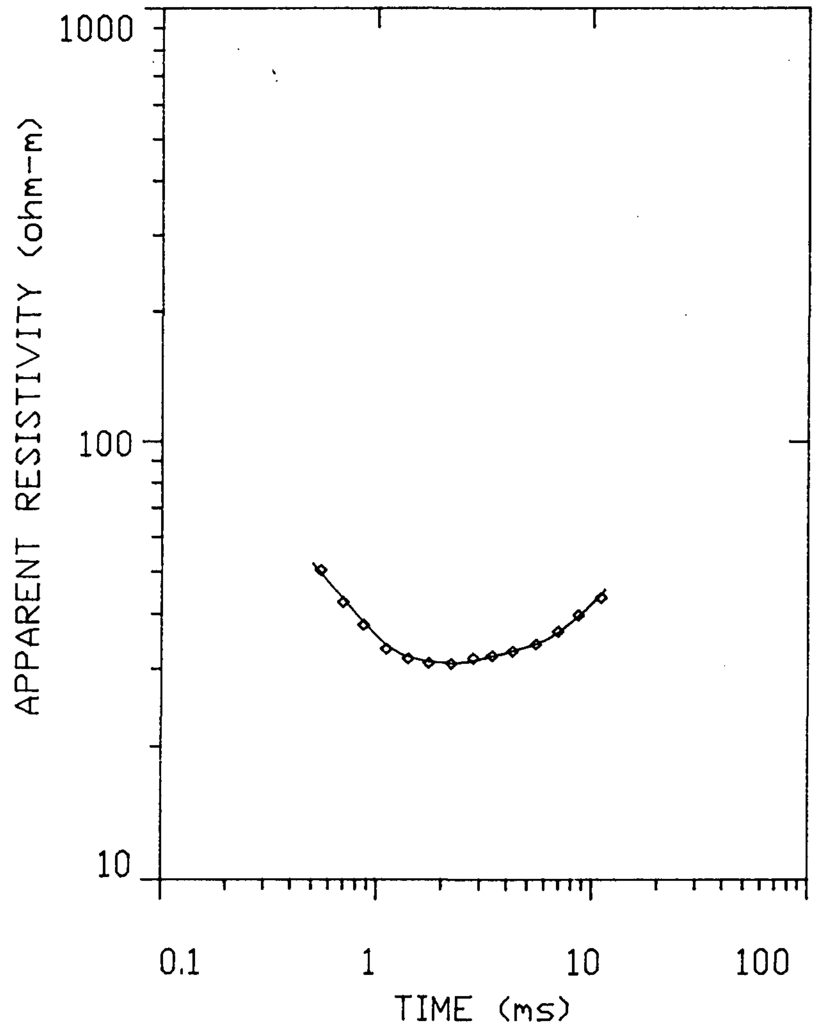
——	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 2 - CUMBERLAND ISLAND
CUMBERLAND ISLAND, GEORGIA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-2	5.3-3
DRAWN BY:	SBG	DATE:	06/25/93	



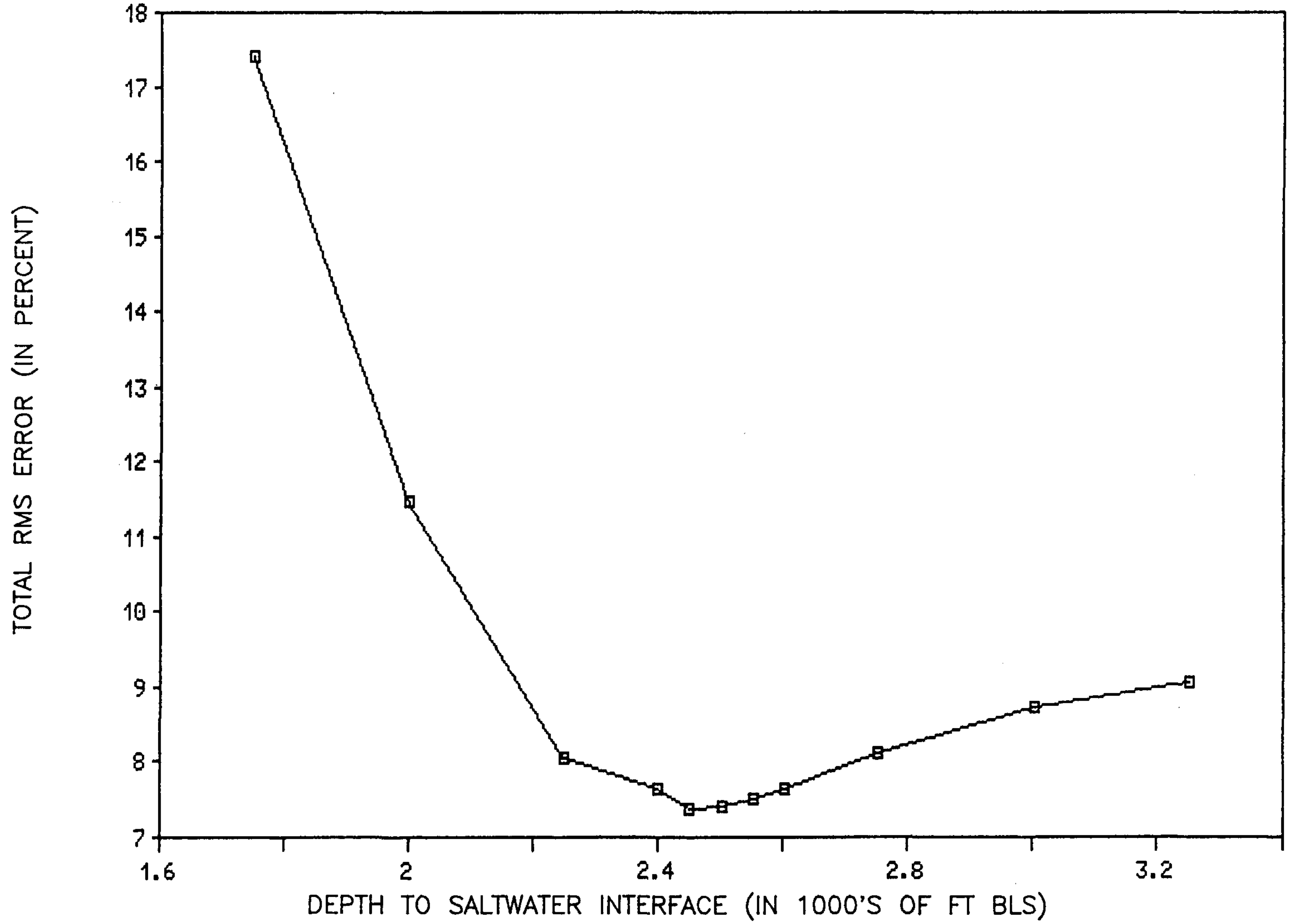
□ APPARENT RESISTIVITY VALUES
— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

QUALITY CONTROL– APPARENT RESISTIVITY VALUES
SOUNDING 2 – CUMBERLAND ISLAND
CUMBERLAND ISLAND, GEORGIA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–2	5.3–4
DRAWN BY:	SBG	DATE:	08/10/93	



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	SENSITIVITY ANALYSIS SHOWING EFFECT ON TOTAL RMS ERROR BY INTRODUCING SALT WATER SATURATED THIRD LAYER – CUMBERLAND ISLAND, GEORGIA	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: TBL–1 DATE: 09/16/93 FIGURE 5.3–5

CLIENT: SJWRMD
LOCATION: CUMBERLAND ISLAND
COUNTY: CAMDEN COUNTY, GEORGIA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 533.000 m by 381.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 27-04-93
SOUNDING: 1
ELEVATION: 2.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 3.044 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			2.00	
1	16.07	80.19	-78.19	4.98
2	57.99			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	14.418	16.079	17.385
	2	53.312	57.990	63.570
THICK	1	64.807	1.000	95.076
DEPTH	1	64.807	80.197	95.076

CURRENT: 19.20 AMPS EM-37 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 3 RAMP TIME: 307.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	60832.5	65593.5	-7.82 MASKED
2	0.108	68162.1	64313.1	5.64 MASKED
3	0.138	74568.1	62213.8	16.56 MASKED
4	0.175	79366.6	59155.7	25.46 MASKED
5	0.218	81405.9	55086.3	32.33 MASKED
6	0.278	80962.0	48967.6	39.51 MASKED
7	0.351	52363.2	41631.7	20.49 MASKED

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 2
CUMBERLAND ISLAND

PROJECT NO.: 93742
TABLE 5.3-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	34285.0	33844.8	1.28
9	0.558	24088.2	25330.4	-5.15
10	0.702	17238.4	18087.6	-4.92
11	0.858	12408.8	12827.6	-3.37
12	1.06	8344.5	8448.2	-1.24
13	1.37	4918.4	4949.1	-0.625
14	1.74	2773.5	2827.2	-1.93
15	2.17	1607.4	1636.0	-1.77
16	2.77	857.7	864.8	-0.827
17	3.50	452.2	456.0	-0.838
18	4.37	245.9	245.6	0.118
19	5.56	125.9	121.6	3.38
20	7.03	63.57	61.00	4.04

CURRENT: 19.20 AMPS EM-37 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 307.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	57629.5	42160.5	26.84 MASKED
22	0.427	37691.9	34799.3	7.67
23	0.550	25410.8	25861.9	-1.77
24	0.698	18102.2	18293.1	-1.05
25	0.869	12558.9	12570.1	-0.0888
26	1.10	7158.2	7843.4	-9.57 MASKED
27	1.40	5007.1	4722.8	5.67
28	1.75	2895.0	2817.3	2.68
29	2.22	1596.7	1569.9	1.67
30	2.79	860.4	870.5	-1.17
31	3.42	504.3	505.4	-0.221
32	4.26	280.0	280.0	-0.0115
33	5.49	140.5	138.4	1.48
34	6.96	70.77	71.91	-1.60
35	8.66	37.18	38.94	-4.72
36	11.06	18.76	19.65	-4.71
37	14.00	8.64	10.05	-16.24 MASKED
38	17.47	4.32	5.37	-24.20 MASKED
39	22.23	2.74	2.69	2.03
40	28.10	1.42	1.35	5.17

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 2
CUMBERLAND ISLAND

PROJECT NO.: 93742
TABLE 5.3-1

CURRENT: 19.20 AMPS EM-37 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 7 RAMP TIME: 307.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
41	0.857	12760.9	12893.7	-1.04	
42	1.06	8658.2	8484.6	2.00	
43	1.37	5081.1	4982.5	1.93	
44	1.74	2920.3	2857.4	2.15	
45	2.17	1662.2	1663.0	-0.0482	
46	2.77	918.2	888.0	3.28	
47	3.50	473.8	475.7	-0.393	
48	4.37	257.5	261.8	-1.66	
49	5.56	132.8	134.3	-1.07	
50	6.98	80.22	71.93	10.32	MASKED
51	8.56	35.83	40.79	-13.83	MASKED
52	10.64	21.14	22.29	-5.44	

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.98		
P 2	-0.01	0.97	
T 1	-0.04	-0.04	0.92

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 2
CUMBERLAND ISLAND

PROJECT NO.: 93742
TABLE 5.3-1

5.4 TDEM SITE 3 - NASSAU COUNTY SITE

5.4.1 Location Description and Geoelectrical Section

The site is located in northern Nassau County, Florida, in a wooded area that had been clear-cut of timber (Figure 5.4-1). The ground surface was rather rough but accessible; no obvious noise sources could be observed near the site. A Tx loop of 1,500 ft was used. This site is 10-15 miles east, northeast from previously performed TDEM soundings (sites 3 and 4, CEES, 1992) and approximately 14 miles southwest of a USGS well N-32 (discussed in Brown, 1980).

The Floridan aquifer occurs at an approximate depth of 430 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The top to the lower Floridan aquifer occurs at approximately 1,200 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.4-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.4.2 Geological Interpretation of Geoelectrical Model

The geoelectrical model for this area is similar to those from previous TDEM investigations and in general agreement with the results from USGS well N-32. A top layer of low resistivity (23 ohm-m) was present. A thickness of 433 ft (132 m) was fixed. The top layer is interpreted as the Hawthorn Group and surficial sediments and the 433 ft depth is interpreted as the top of the Floridan aquifer. The USGS well places this interface at approximately 500 ft. The increased resistivity of the second layer (6,010 ohm-m) is consistent with freshwater saturation (>80 ohm-m) within the Floridan aquifer, and the depth to our interpreted low-resistivity (saltwater) layer at 2,427 ft is deeper than but comparable to indications of salt water (7,800 mg/L at a depth of 2,094 ft) in the USGS well. According to Miller (1986) the base of the Floridan aquifer occurs at a depth of 2,600 ft msl. The depth to salt water therefore occurs near the base of the Floridan aquifer. The TDEM soundings from previous studies (CEES, 1992) determined that the interface was below the bottom of the Floridan aquifer at sites 10-15 miles west, southwest of this site. The base of the Floridan aquifer occurred at approximately 2,350 ft below msl for site 3 and 2,100 ft below msl for site 4 (CEES, 1992).

5.4.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 4.7 ohm-m, is interpreted to represent salt water. It occurs at a depth of 2,427 ft (-2,424 ft msl). Because the resistivity of Layer 2 (6,010 ohm-m) is interpreted to represent fresh water within the Floridian aquifer (i.e., is greater that 80 ohm-m), the interpreted depth of the 5,000 mg/L isochlor is taken as 50 ft greater than the depth of the geoelectric interface, or at a depth of 2,477 ft (-2,474 ft msl). The resistivity of Layer 3 (4.7 ohm-m) corresponds to a chloride concentration of 6,690 mg/L assuming a porosity of 25% and the validity and applicability of Equation (4) in Section 4.2.

5.4.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2 (6,010 ohm-m) corresponds to a chloride content of less than 50 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) in section 4.2. Using the criteria established in Section 4.3 (Class A type resistivity distribution), the position of the 250 mg/L isochlor is placed 50 ft above the depth to the low resistivity interface, or at a depth of 2,377 ft (-2,374 ft msl).

5.4.5 Accuracy of Measurement and Interpretation

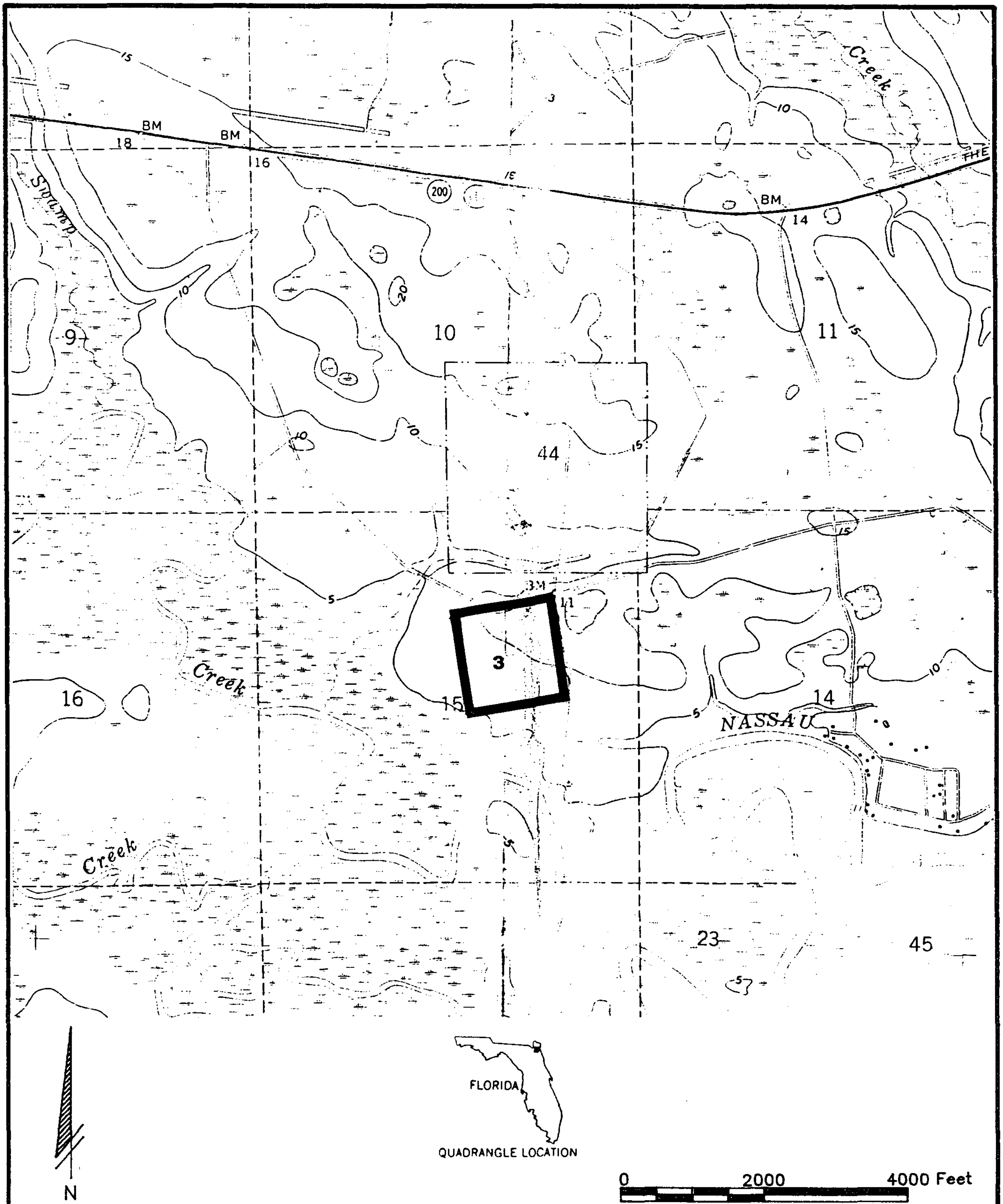
Figure 5.4-3 is the equivalence analysis at this site, and the inversion table (Table 5.4-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 57 m (187 ft) which is 8% of the total depth. The resistivity of this layer has a range of from 2.8 ohm-m to 7.7 ohm-m. This corresponds to a range in interpreted chloride content from 11,334 mg/L to over 4,024 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 943 to over 60,000 ohm-m which corresponds to a chloride concentration of less than 50 mg/L. The chloride-to-sulfate ratio at the site is 1:1 (Table 5.1-4) rather than 5:1. Accordingly, equation (4) may not be valid. A chloride concentration of less than 250 mg/L was mapped in the area of the site by Sprinkle (1981).

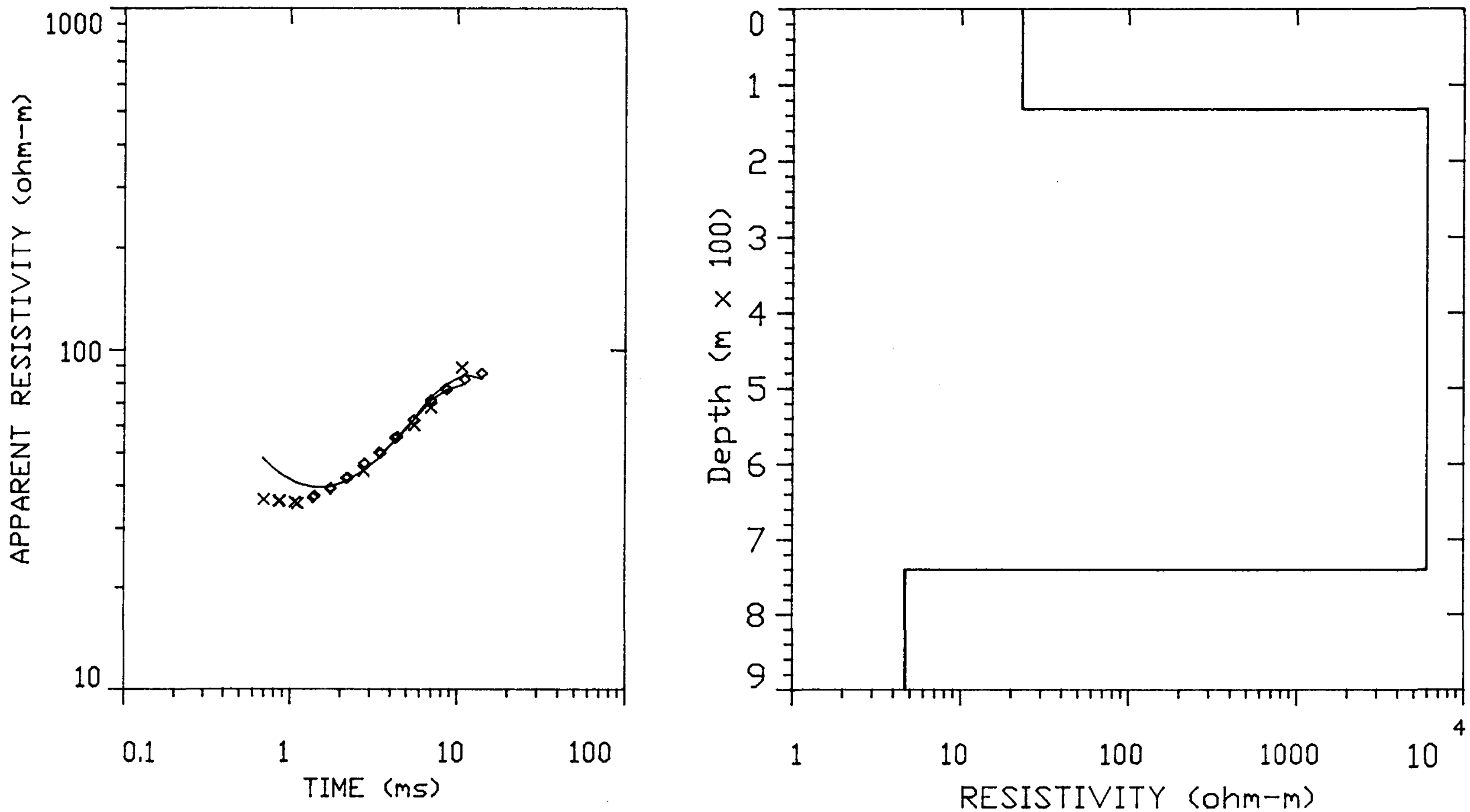
5.4.6 Summary of TDEM Sounding at Nassau County (Site 3)

- The depth to occurrence of salt water (5,000 mg/L isochlor) is interpreted to be near the base of the Floridan aquifer at a depth of 2,477 ft (-2,474 ft msl).
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 50 mg/L owing to the very high and poorly constrained resistivity valve for layer 2. The 250 mg/L isochlor is interpreted to occur above the bottom of the base of the Floridan aquifer at 2,377 ft (-2,374 ft msl).
- The results of the TDEM survey agree with water quality results from other studies 10 to 15 miles from the site.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 3 – NASSAU COUNTY NASSAU COUNTY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE	
CHECKED BY:	RJW	DRAWING NO.:	LOC –3	5.4-1	
DRAWN BY:	SBG	DATE:	08/10/93		



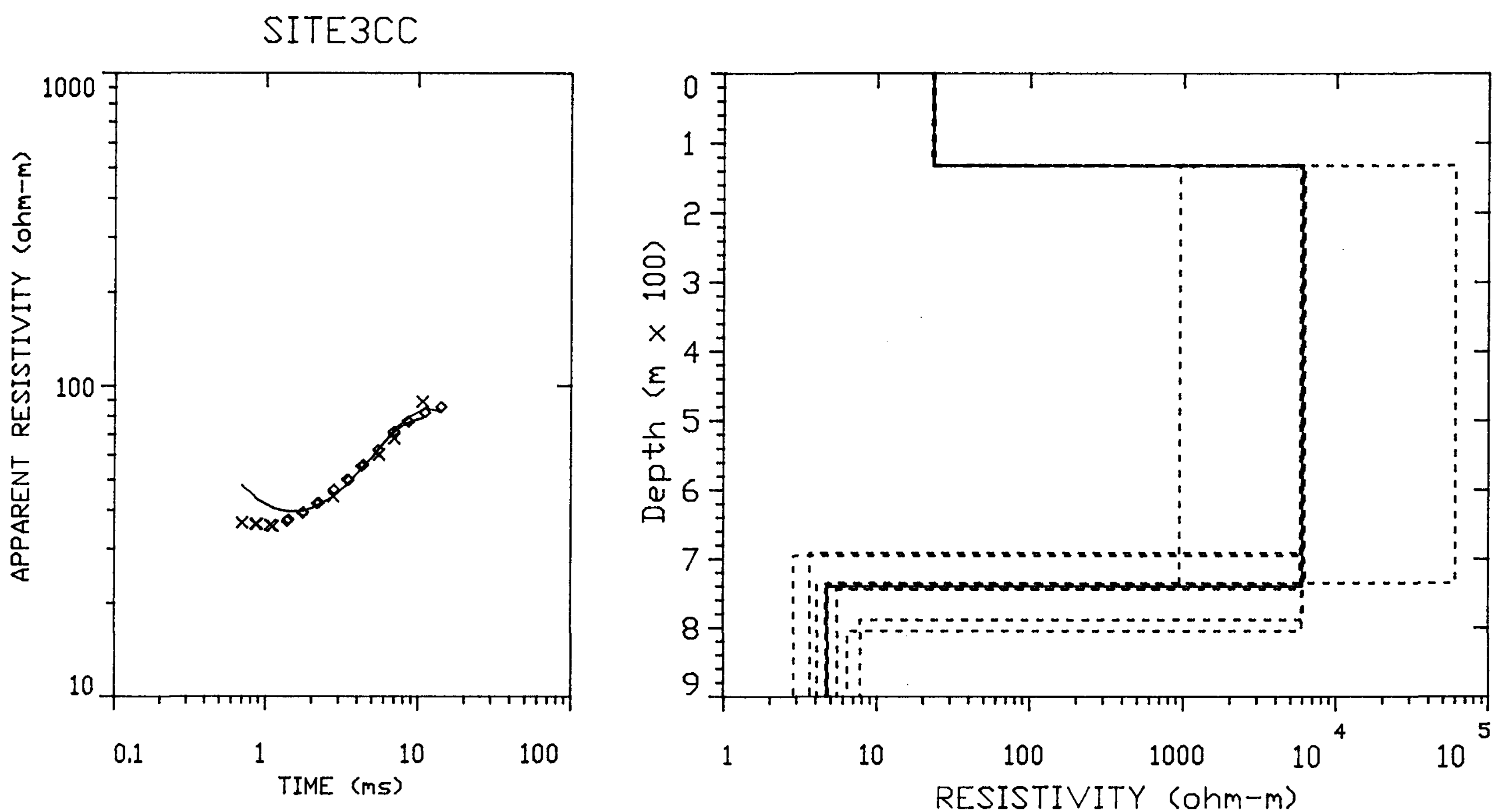
—	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 3 – NASSAU COUNTY
NASSAU COUNTY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–3	5.4–2
DRAWN BY:	SBG	DATE:	11/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 3 - NASSAU COUNTY
NASSAU COUNTY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-3	5.4-3
DRAWN BY:	SBG	DATE:	11/10/93	

DATA SET: SITE3CC

CLIENT: SJWRMD
LOCATION: NASSAU COUNTY,
COUNTY: NASSAU COUNTY, FLORIDA
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 457.000 m by 457.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 04-28-93
SOUNDING: 1
ELEVATION: 1.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.898 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				1.00	
1	22.96	132.0	*	-131.0	5.74
2	6009.8	607.8		-738.8	0.101
3	4.69				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	22.597	22.964	23.379
	2	942.927	6009.815	60098.148
	3	2.839	4.691	7.749
THICK	1	132.000	0.000	132.000
	2	559.064	1.000	672.902
DEPTH	1	132.000	132.000	132.000
	2	691.064	739.884	804.902

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 5 RAMP TIME: 317.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.698	22890.6	15072.7	34.15 MASKED
2	0.869	13413.7	10136.6	24.43 MASKED
3	1.10	7497.1	6118.8	18.38 MASKED

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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TDEM SOUNDING DATA TABLE
SOUNDING 3
NASSAU COUNTY

PROJECT NO.: 93742
TABLE 5.4-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	1.40	3847.7	3537.6	8.05
5	1.75	2040.8	2020.3	1.00
6	2.22	1015.6	1043.6	-2.75
7	2.79	495.8	531.4	-7.18
8	3.42	266.5	281.6	-5.69
9	4.26	132.7	135.9	-2.42
10	5.49	58.78	58.36	0.703
11	6.96	26.59	25.81	2.93
12	8.66	13.79	13.10	5.01
13	11.06	6.74	6.43	4.68
14	14.00	3.52	3.73	-5.90

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 7 RAMP TIME: 317.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
15	0.857	13924.5	10413.3	25.21	
16	1.06	8140.8	6660.4	18.18	
17	1.37	4149.1	3748.2	9.66	
18	1.74	2098.3	2052.2	2.19	
19	2.17	1083.6	1115.3	-2.92	
20	2.77	545.7	544.2	0.27	
21	3.50	253.5	262.1	-3.41	
22	4.37	123.3	125.7	-1.97	
23	5.56	60.16	56.77	5.63	MASKED
24	6.98	28.49	26.36	7.45	MASKED
25	8.56	14.09	14.28	-1.32	
26	10.64	6.59	7.88	-19.49	MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	F 1	T 2
P 1	1.00				
P 2	0.00	0.00			
P 3	-0.01	-0.01	0.19		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.00	-0.12	0.00	0.96

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 3
NASSAU COUNTY

PROJECT NO.: 93742
TABLE 5.4-1

5.5 TDEM SITE 4 - ST. AUGUSTINE #1

5.5.1 Location Description and Geoelectrical Section

The site is located in eastern St. Johns County near St. Augustine, Florida (Figure 5.5-1) and 1.5 miles from Site 5 (Figure 1-1). The site is located within an inactive agricultural field. A possible interference source (a chain link fence) existed 100 ft north of the Tx loop. An underground pipeline is also reported to be present west of the Tx loop. QA soundings were performed 100 ft north, south, east and west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected (Figure 5.5-4) by any interference sources.

The Floridan aquifer occurs at an approximate depth of 200 ft below msl and is overlain by the surficial aquifer system and the Hawthorn Group (Scott et al., 1991). The top of the Lower Floridan aquifer occurs at approximately 900 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.5-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.5.2 Geological Interpretation of Geoelectrical Model

The three-layered geoelectrical section consists of a low resistivity (15 ohm-m), upper layer which is considered to be the Hawthorn Group and surficial sediments above the Floridan aquifer. The thickness of layer 1 was fixed at a 73 m (239 ft) value based on published information (Scott et al., 1991). The second layer has only intermediate resistivity (44 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The thickness of the brackish section is 108 m (354 ft), placing the depth to the low resistivity (saltwater) layer at 181 m (594 ft) below ground surface. The resistivity of the saltwater saturated layer is 10.3 ohm-m. Layer 1 is considered to be the Hawthorn Group and surficial sediments, layer 2 to be the Floridan aquifer (brackish) and layer 3 to be the salt water within the Floridan aquifer.

5.5.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 10.3 ohm-m, is interpreted to represent salt water. It occurs at a depth of 594 ft (-555 ft msl). Because the resistivity of layer 2 (44 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (i.e., is less than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is equal to the depth of the geoelectrical interface, or at 594 ft depth (-555 ft msl). The resistivity of layer 3 (10.3 ohm-m) corresponds to a chloride content of 2,970 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.5.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 44 ohm-m, corresponds to a chloride content above 250 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. As the interpreted chloride content exceeds 250 mg/L, the 250 mg/L isochlor does not occur within the Floridan aquifer at this site.

5.5.5 Accuracy of Measurement and Interpretation

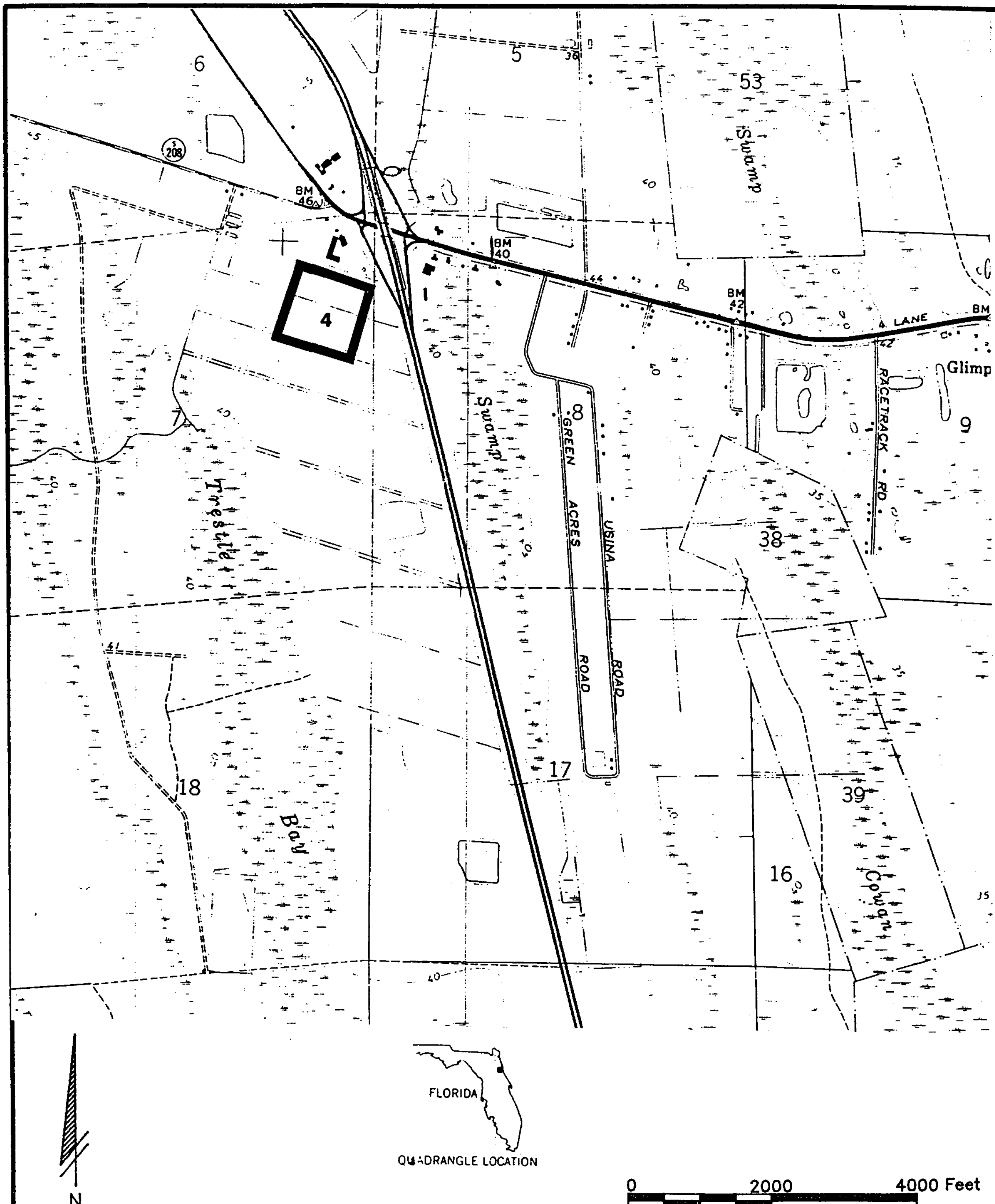
Figure 5.5-3 is the equivalence analysis at this site and the inversion table (Table 5.5-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 18 m (59 ft) which is 10% of the total depth. The resistivity of this layer has a range from 9.4 -11.3 ohm-m. This corresponds to a range in interpreted chloride content of from 3,269 mg/L to 2,693 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 34 - 64 ohm-m which corresponds to chloride content above 250 mg/L. The chloride-to-sulfate ratio at the site is 1:2 (Table 5.1-4), rather than 5:1. Accordingly, equation (4) may not be valid. A chloride concentration above 250 mg/L was mapped in the Upper Floridan aquifer at this site by Spechler and Hampson (1984).

5.5.6 Summary of TDEM Sounding at St. Augustine #1 (Site 4)

- The depth to occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 594 ft (-555 ft msl) and occur within the Upper Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration above 250 mg/L. The 250 mg/L isochlor is not interpreted to be present within the Floridan aquifer.
- Results of the TDEM survey agree with a water quality study in the area of the site which indicates that chloride concentrations in the Floridan aquifer are above 250 mg/L.



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PALATKA, FLORIDA

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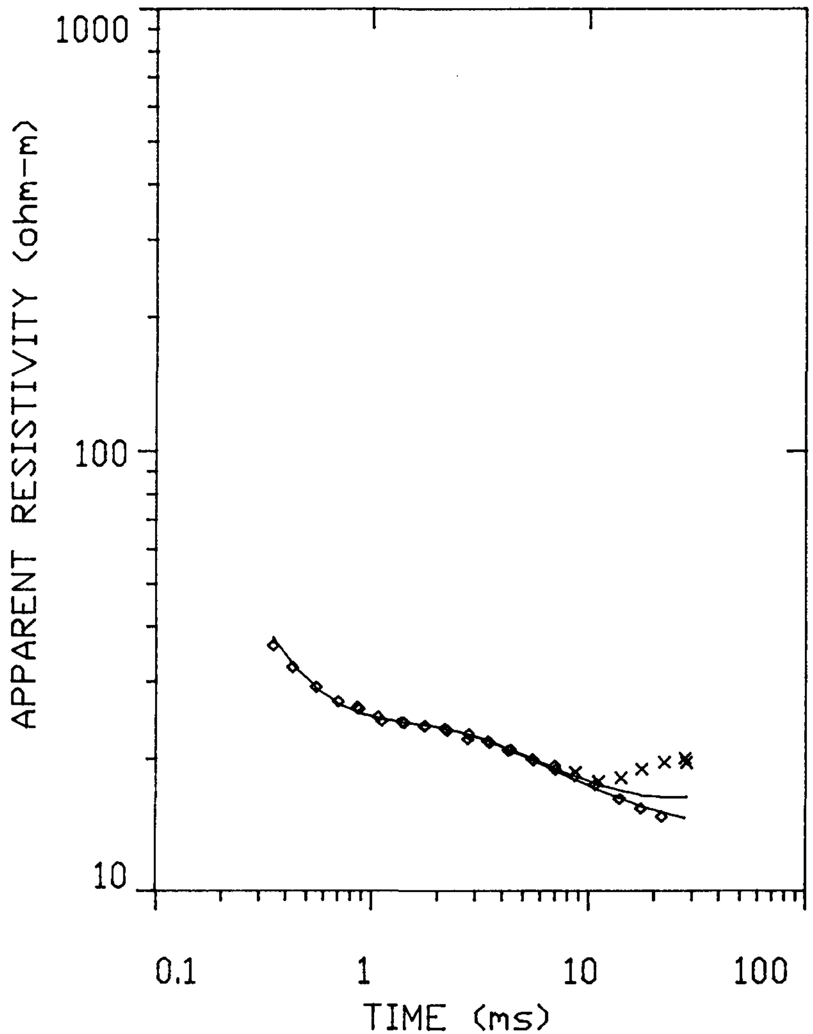
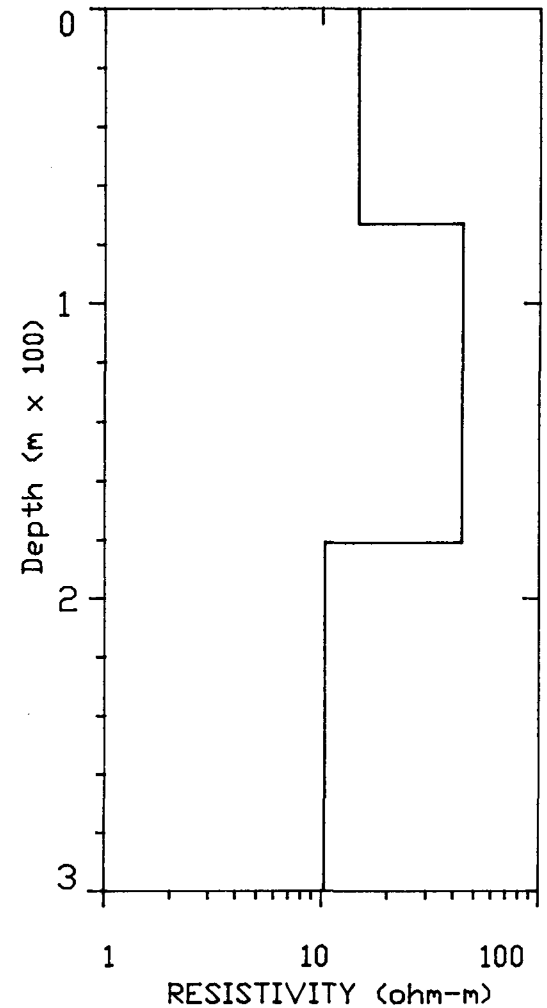
TDEM SURVEY LOCATION MAP
SOUNDING 4 – ST. AUGUSTINE #1
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-4	5.5-1
~~DRAWN BY:~~	SBG	DATE:	06/26/93	





———	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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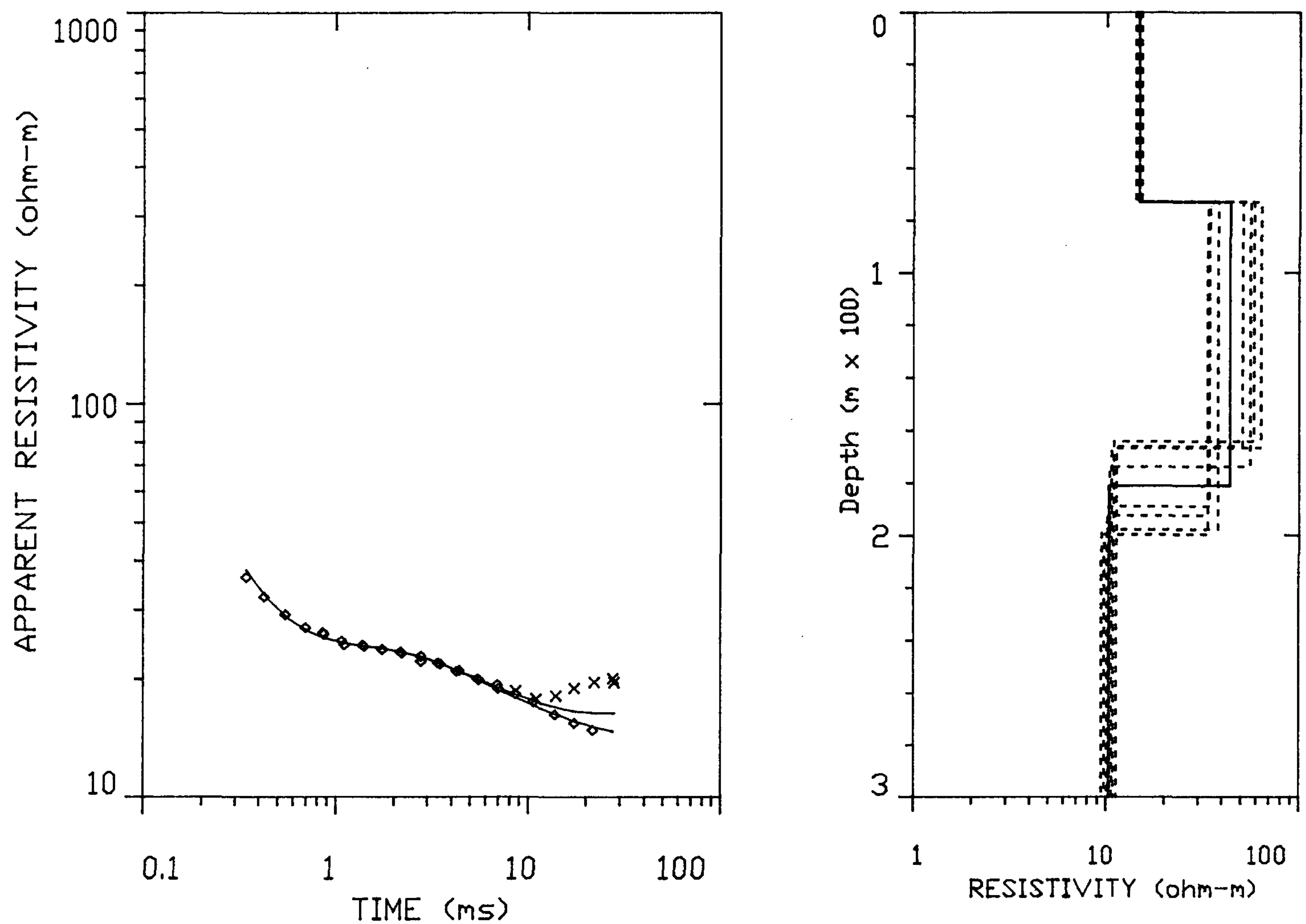
MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 4 – ST. AUGUSTINE #1
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-4	5.5-2
DRAWN BY:	SBG	DATE:	11/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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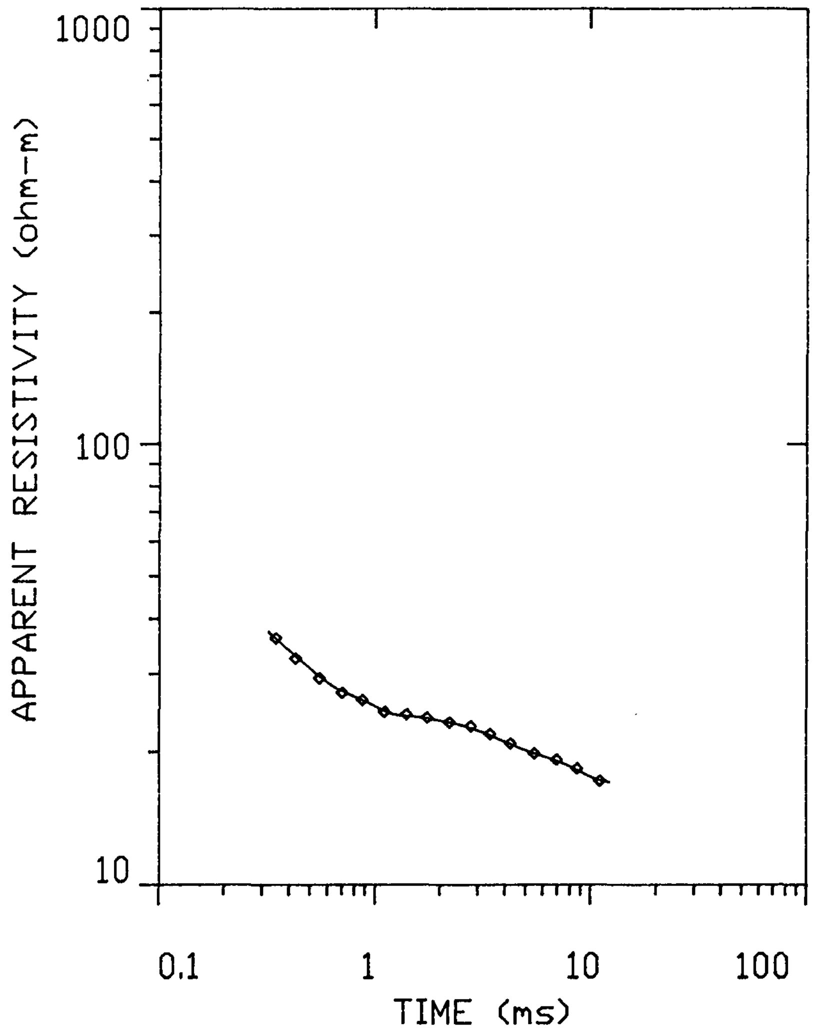
MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 4 - ST. AUGUSTINE #1
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-4	5.5-3
DRAWN BY:	SBG	DATE:	11/10/93	



□ APPARENT RESISTIVITY VALUES

—— DATA CURVE

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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QUALITY CONTROL– APPARENT RESISTIVITY VALUES
SOUNDING 4 – ST. AUGUSTINE #1
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–4	5.5–4
DRAWN BY:	SBG	DATE:	08/10/93	

DATA SET: SITE4C

CLIENT: SJWRMD DATE: 29004-93
LOCATION: ST. AUGUSTINE SITE 1 SOUNDING: 2
COUNTY: ST. JOHNS COUNTY, FLORIDA ELEVATION: 12.00 m
PROJECT: SALT-WATER INTERFACE DETECTION EQUIPMENT: Geonics PROTEM
LOOP SIZE: 305.000 m by 305.000 m AZIMUTH:
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 2.296 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				12.00	
1	14.64	73.00	*	-61.00	4.98
2	44.03	108.0		-169.0	2.45
3	10.31				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	14.118	14.649	15.174
	2	33.753	44.037	63.719
	3	9.449	10.313	11.287
THICK	1	73.000	0.000	73.000
	2	91.238	1.000	126.498
DEPTH	1	73.000	73.000	73.000
	2	164.238	181.011	199.498

CURRENT: 14.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 172.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	42574.3	39953.5	6.15
2	0.427	29824.4	29130.5	2.32
3	0.550	18484.0	18684.3	-1.08

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 4
ST. AUGUSTINE #1

PROJECT NO.: 93742
TABLE 5.5-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
4	0.698	11420.3	11640.9	-1.93	
5	0.869	6984.7	7222.5	-3.40	
6	1.10	4184.7	4114.6	1.67	
7	1.40	2350.8	2347.5	0.141	
8	1.75	1386.6	1375.4	0.809	
9	2.22	793.4	784.1	1.16	
10	2.79	460.5	462.2	-0.364	
11	3.42	293.3	291.1	0.726	
12	4.26	182.0	180.2	0.959	
13	5.49	103.3	102.8	0.518	
14	6.96	60.20	61.63	-2.36	
15	8.66	36.73	37.91	-3.19	MASKED
16	11.06	21.38	21.99	-2.86	MASKED
17	14.00	11.56	12.77	-10.48	MASKED
18	17.47	6.20	7.62	-22.91	MASKED
19	22.23	3.22	4.23	-31.30	MASKED
20	28.10	1.79	2.35	-31.01	MASKED

CURRENT: 14.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 172.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
21	0.857	7157.2	7454.4	-4.15	
22	1.06	4460.3	4507.1	-1.05	
23	1.37	2481.9	2486.9	-0.202	
24	1.74	1414.5	1396.3	1.28	
25	2.17	830.7	828.1	0.306	
26	2.77	490.5	471.5	3.87	
27	3.50	279.9	278.1	0.635	
28	4.37	169.6	171.9	-1.34	
29	5.56	100.9	101.4	-0.440	
30	6.98	61.66	62.47	-1.31	
31	8.56	38.83	40.02	-3.06	
32	10.64	24.21	24.97	-3.13	
33	13.70	14.39	14.28	0.762	
34	17.40	8.54	8.39	1.79	
35	21.70	5.24	5.05	3.61	
36	27.70	1.79	2.87	-59.95	MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.05	0.51			
P 3	0.00	-0.04	0.98		
F 1	0.00	0.00	0.00	0.00	
T 2	-0.01	0.19	0.04	0.00	0.89
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 4
ST. AUGUSTINE #1

PROJECT NO.: 93742
TABLE 5.5-1

5.6 TDEM SITE 5 - ST. AUGUSTINE #2

5.6.1 Location Description and Geoelectrical Section

The site is in eastern St. Johns County near St. Augustine, Florida (Figure 5.6-1) and 1.5 miles from Site 4 (Figure 1-1). The site is located within a tree farm. A 16-inch water line runs parallel to the west side of the Tx loop approximately 75 ft away. QA soundings were performed 50 ft north, south, east, and west of the initial Rx coil position. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources (Figure 5.6-4).

The Floridan aquifer occurs at an approximate depth of 200 ft below msl and is overlain by the surficial aquifer system and the Hawthorn Group (Scott et al., 1991). The top of the Lower Floridan aquifer occurs at approximately 900 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.6-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.6.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above the third saltwater saturated layer. The first layer occurs at a depth of 45 m (148 ft) and not at the hydrostratigraphic contact (239 ft bls) between the Hawthorn Group and the Floridan Aquifer System. The first layer has a low-resistivity value (9.5 ohm-m) and is considered to represent the upper portion of the Hawthorn Group and surficial sediments. The second layer has a high-resistivity value (169 ohm-m) and a thickness of 129 m (423 ft). It is considered to represent a combined but indistinguishable (geoelectricaly) layer consisting of a portion of the Hawthorn Group and the upper portion of the Upper Floridan aquifer. The third layer is considered to represent a saltwater saturated Floridan aquifer at a depth of 571 ft.

5.6.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 18.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 571 ft (-532 ft msl). Because the resistivity of layer 2 (169 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 621 ft (-582 ft msl). The resistivity of layer 3 (18.4 ohm-m) corresponds to a chloride content of 1,595 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.6.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying surficial aquifer system and the Hawthorn Group, the effective chloride concentration of Layer 2 cannot be calculated.

5.6.5 Accuracy of Measurement and Interpretation

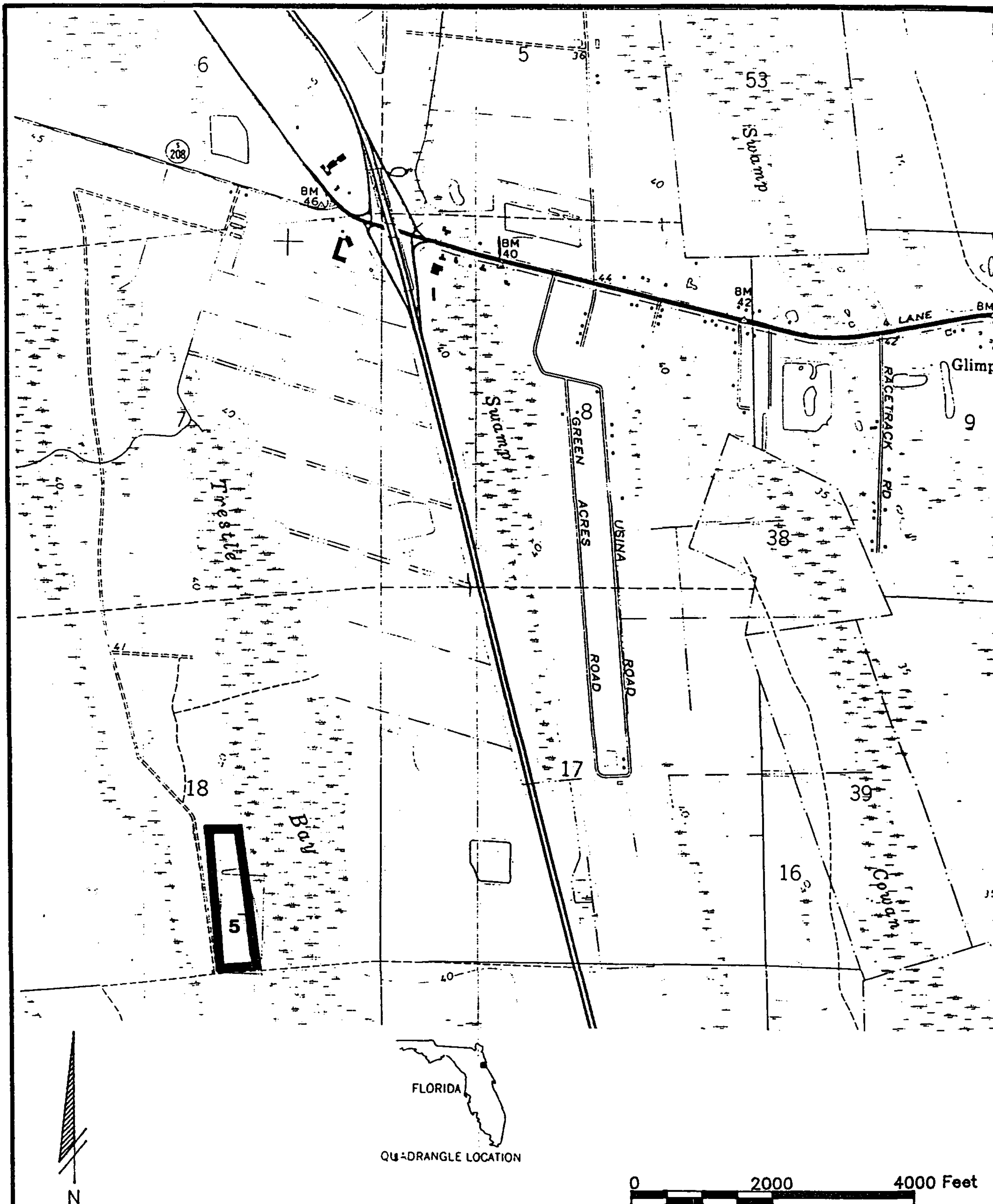
Figure 5.6-3 is the equivalence analysis at this site and the inversion table (Table 5.6-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 19 m (62 ft) which is 11% of the total depth. The resistivity of this layer has a range of from 17.2 - 19.8 ohm-m. This corresponds to a range in interpreted chloride content of from 1,471 mg/L to 1,717 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 118 - 312 ohm-m. A corresponding chloride concentration cannot be determined because Layer 2 is in part comprised of the Hawthorn Group and surficial sediments. A chloride concentration of approximately 250 mg/L was mapped by Spechler and Hampson (1984) in the area of the site.

5.6.6 Summary of TDEM Sounding at St. Augustine #2 (Site 5)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 621 ft (-582 ft msl) and occur within the Upper Floridan aquifer.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow the surficial aquifer system and the Hawthorn Group to be distinguished from the Floridian Aquifer System.



ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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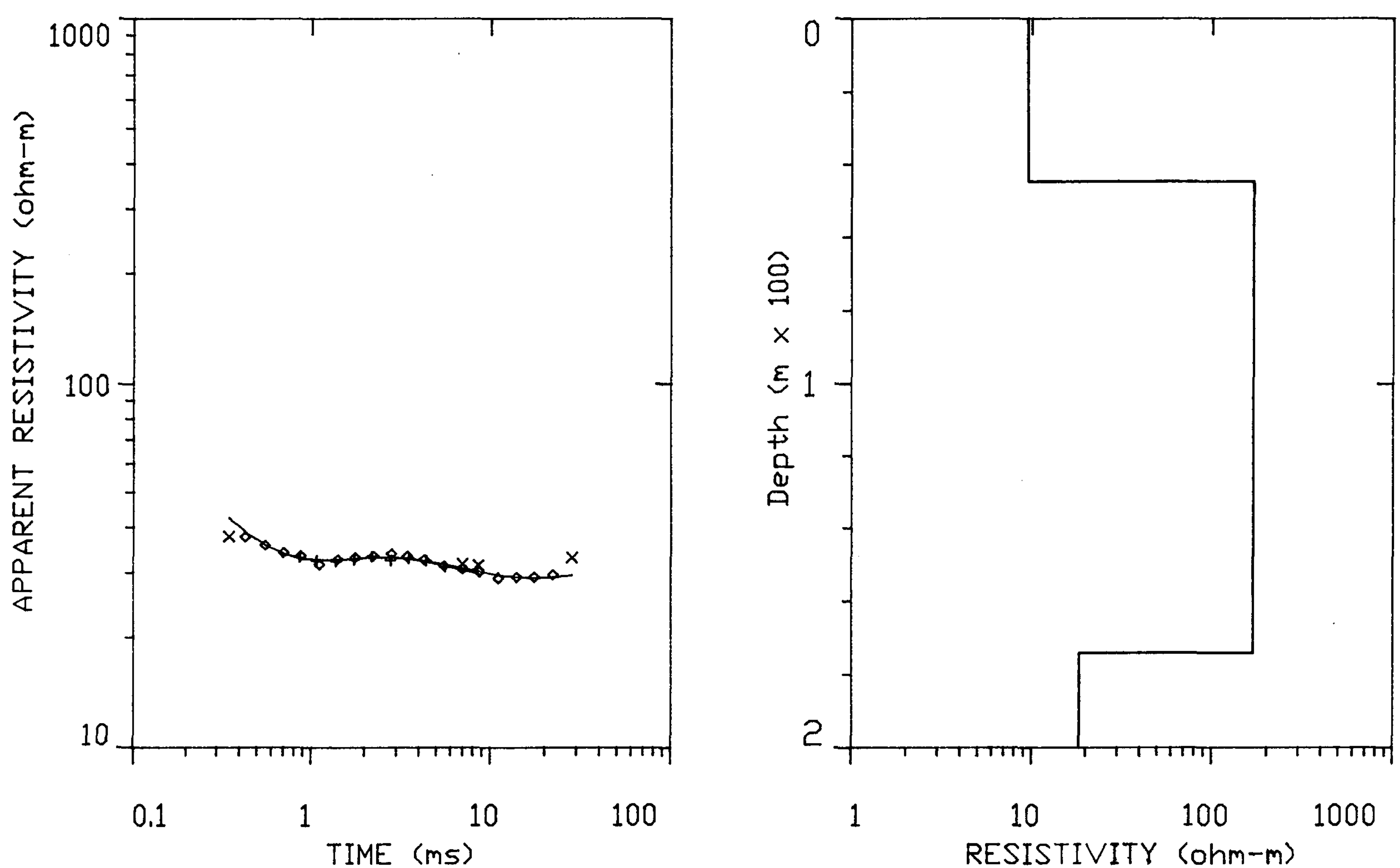
TDEM SURVEY LOCATION MAP
SOUNDING 5 – ST. AUGUSTINE #2
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-5	5.6-1
DRAWN BY:	SBG	DATE:	08/10/93	



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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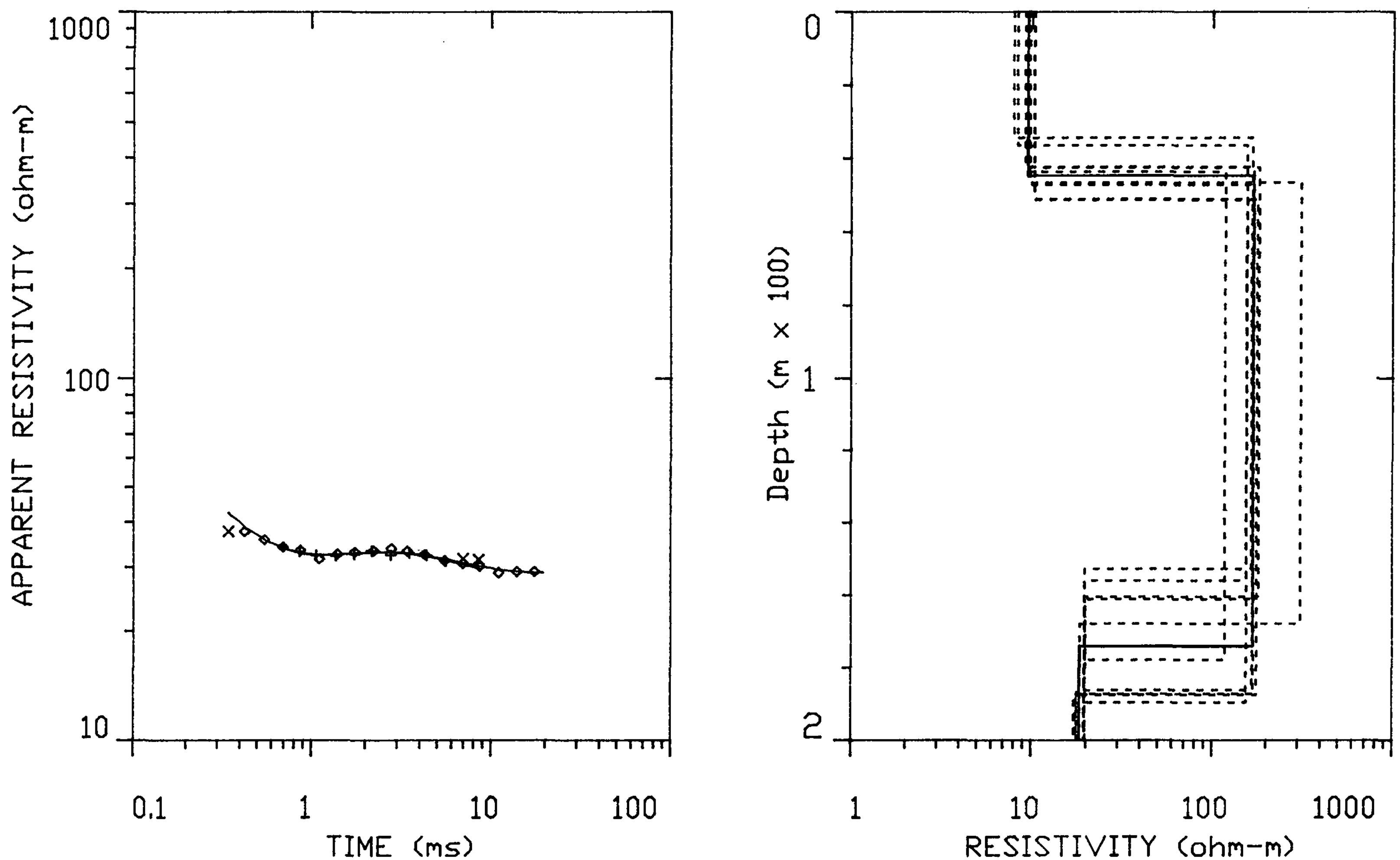
MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SOUNDING 5 – ST. AUGUSTINE #2
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–5	5.6–2
DRAWN BY:	SBG	DATE:	08/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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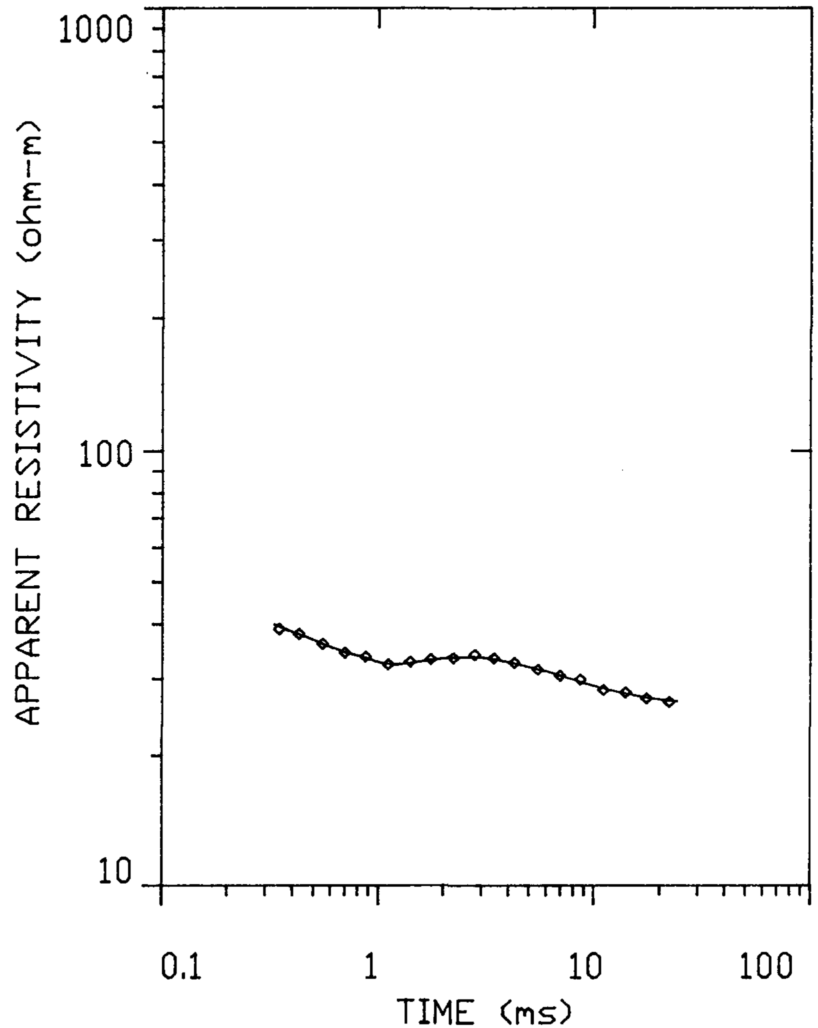
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 5 – ST. AUGUSTINE #2
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-5	5.6-3
DRAWN BY:	SBG	DATE:	06/25/93	



□ APPARENT RESISTIVITY VALUES
—— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

QUALITY CONTROL– APPARENT RESISTIVITY VALUES
SOUNDING 5 – ST. AUGUSTINE #2
ST. AUGUSTINE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–5	5.6–4
DRAWN BY:	SBG	DATE:	08/10/93	

DATA SET: SITE5CC

CLIENT:	SJWRMD	DATE:	30-04-93
LOCATION:	ST. AUGUSTINE-SITE 2	SOUNDING:	1
COUNTY:	ST. JOHNS COUNTY	ELEVATION:	12.00 m
PROJECT:	SALT WATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM

LOOP SIZE: 145.000 m by 609.600 m AZIMUTH:
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 1.951 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			12.00	
1	9.46	44.62	-32.62	4.71
2	169.0	129.3	-161.9	0.765
3	18.40			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	7.953	9.463	10.331
	2	117.906	169.073	312.475
	3	17.158	18.406	19.821
THICK	1	34.273	0.540	51.209
	2	117.992	1.000	142.644
DEPTH	1	34.273	44.630	51.209
	2	152.728	174.000	189.693

CURRENT: 18.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 286.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	62284.0	52025.2	16.47 MASKED
2	0.427	36900.1	35263.4	4.43
3	0.550	21169.2	21175.3	-0.0290

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 5
ST. AUGUSTINE #2

PROJECT NO.: 93742
TABLE 5.6-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.698	12503.7	12662.6	-1.27
5	0.869	7442.8	7648.2	-2.75
6	1.10	4418.1	4236.3	4.11
7	1.40	2335.1	2350.2	-0.647
8	1.75	1319.0	1330.4	-0.864
9	2.22	718.0	727.3	-1.29
10	2.79	396.2	409.5	-3.36
11	3.42	243.8	248.6	-1.99
12	4.26	145.3	146.9	-1.11
13	5.49	81.79	80.61	1.45
14	6.96	46.56	46.28	0.589
15	8.66	27.66	27.65	0.0325
16	11.06	16.00	15.51	3.04
17	14.00	8.77	8.77	-0.0455
18	17.47	5.04	5.10	-1.21
19	22.23	2.69	2.76	-2.51
20	28.10	1.27	1.50	-18.33 MASKED

CURRENT: 18.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 7 RAMP TIME: 286.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	7825.9	7906.3	-1.02
22	1.06	4687.5	4660.2	0.580
23	1.37	2521.6	2497.2	0.969
24	1.74	1364.5	1351.3	0.967
25	2.17	761.7	771.0	-1.22
26	2.77	430.2	418.0	2.83
27	3.50	234.9	236.1	-0.502
28	4.37	137.9	139.1	-0.856
29	5.56	79.84	79.09	0.949
30	6.98	44.04	46.73	-6.09 MASKED
31	8.56	26.69	29.10	-9.05 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.93				
P 2	-0.01	0.02			
P 3	0.03	0.00	0.93		
T 1	-0.10	-0.07	0.05	0.83	
T 2	-0.03	0.10	0.08	-0.06	0.88
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 5
ST. AUGUSTINE #2

PROJECT NO.: 93742
TABLE 5.6-1

5.7 TDEM SITE 6 - PICOLATA SITE

5.7.1 Location Description and Geoelectrical Section

The site is located in western St. Johns County, Florida (Figure 5-7.1). The site was located within a wooded area with no obvious sources of interference.

The Floridan aquifer begins at a depth of approximately 285 ft below msl and is overlain by the Hawthorn Group and surficial aquifer system (Scott et al., 1991). The top of the Lower Floridan aquifer begins at approximately 800 ft below msl. The base of the Floridan aquifer occurs at approximately 2,100 ft below msl in this area (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.7-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.7.2 Geological Interpretation of Geoelectrical Model

The three-layer geoelectrical section consists of a low resistivity (23 ohm-m), upper layer which correlates with the Hawthorn Group and surficial sediments above the Floridan aquifer. The thickness of layer 1 was fixed at 90 m (295 ft) based on the information from Scott et al. (1991). The second layer has high resistivity (98 ohm-m) which means that because it is greater than 80 ohm-m the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 488 m (1,601 ft) placing the depth to the low resistivity (saltwater) layer at 578 m (1,896 ft) below ground surface. The resistivity of the saltwater layer is 27.4 ohm-m. Layer 1 is considered to be the Hawthorn Group and surficial sediments, layer 2 to be the Floridan aquifer containing fresh water and layer 3 to be the salt water within the Lower Floridan aquifer.

5.7.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 27.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,896 ft (-1,886 ft msl). Because the resistivity of layer 2 (98 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at 1,946 ft depth (-1,936 ft msl). The resistivity of layer 3 (27.4 ohm-m) corresponds to a chloride content of 1,021 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/L isochlor that they represent the same effective depth.

5.7.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 98 ohm-m, corresponds to a chloride content of less than 250 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/L isochlor is placed in the Lower Floridan aquifer at a depth 50 ft above the layer 3 interface or at 1,846 ft (-1,836 ft msl).

5.7.5 Accuracy of Measurement and Interpretation

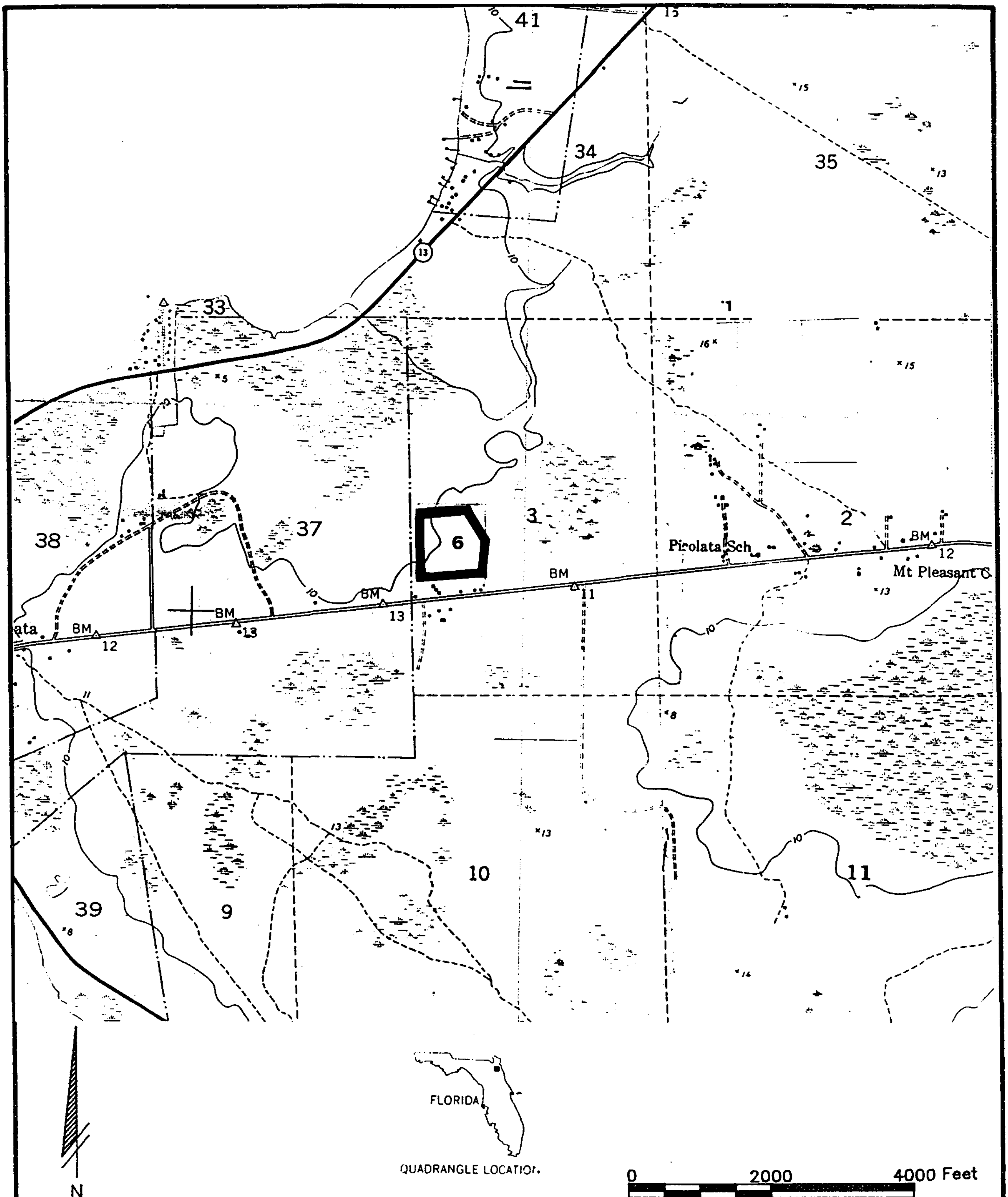
Figure 5.7-3 is the equivalence analysis at this site and the inversion table (Table 5.7-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 121 m (397 ft) which is 21% of the total depth. The resistivity of this layer has a range of from 14.0 - 49.3 ohm-m. This corresponds to a range in interpreted chloride content of from 2,144 mg/L to 499 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 89 - 122 ohm-m which corresponds to a chloride content of less than 250 mg/L. The chloride-to-sulfate ratio at the site is 1:5 (Table 5.1-4), rather than 5:1. Accordingly, equation (4) may not be valid. A chloride concentration of less than 50 mg/L was determined in the area of the site by Spechler and Hampson (1984).

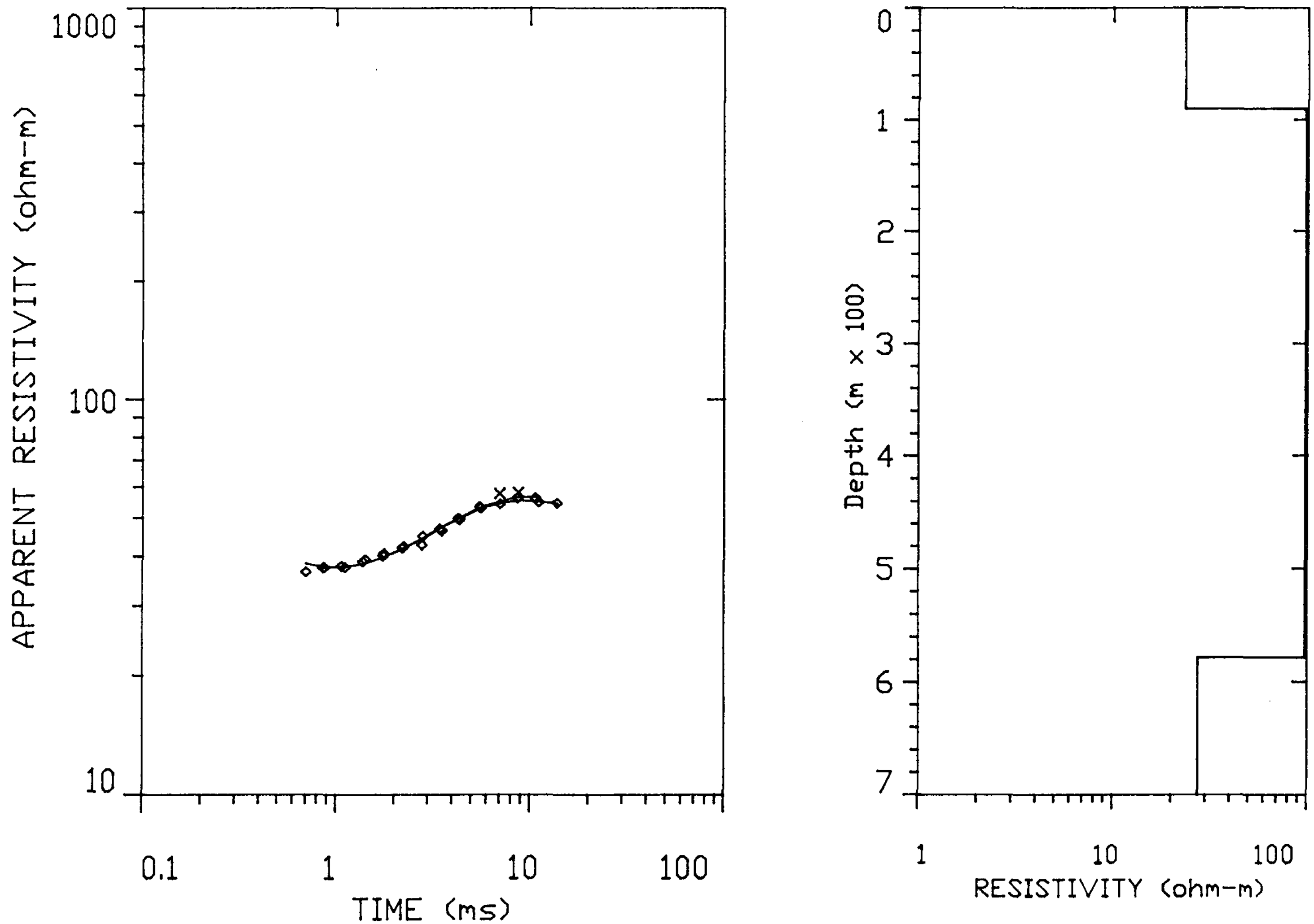
5.7.6 Summary of TDEM Sounding at Picolata (Site 6)

- The depth to occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,946 ft (-1,936 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/L. The 250 mg/L isochlor is interpreted to be present in the Lower Floridan aquifer at a depth of 1,846 ft (-1,836 ft msl).
- Results from the TDEM survey agree with the results from a water quality study in the area of the site.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 6 – PICOLATA PICOLATA, FLORIDA

DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: DRAWING NO.: DATE:	93742 LOC –6 06/17/93	FIGURE 5.7-1	



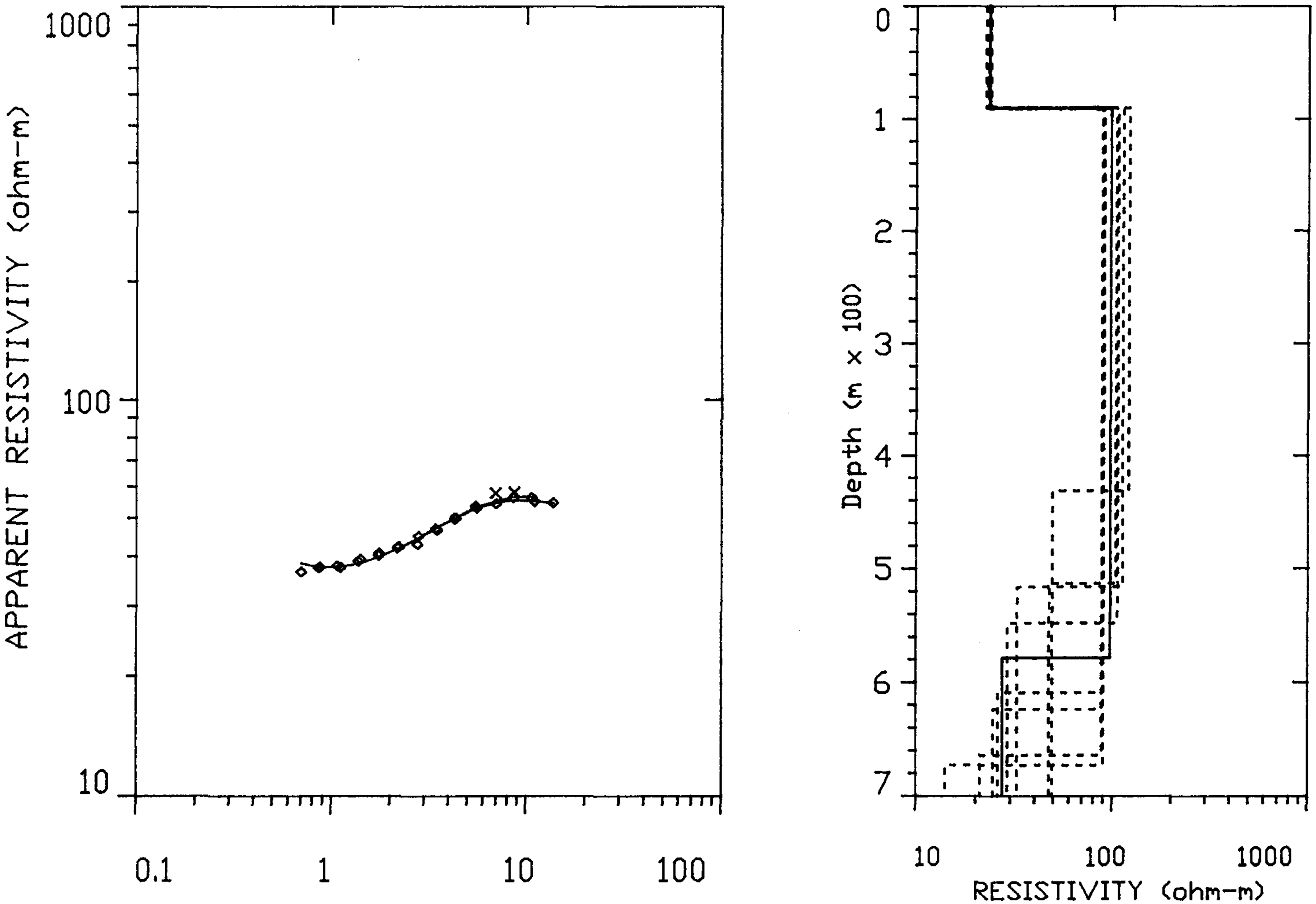
———	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 6 – PICALATA
PICOLATA, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-6	5.7-2
DRAWN BY:	SBG	DATE:	11/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 6 - PICOLATA
PICOLATA, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-6	5.7-3
DRAWN BY:	SBG	DATE:	11/10/93	

DATA SET: SITE6

CLIENT: SJWRMD
LOCATION: PICOLATA
COUNTY: ST. JOHNS COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 305.000 m by 305.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 31-04-93
SOUNDING: 1
ELEVATION: 3.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 2.487 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				3.00	
1	23.26	90.00	*	-87.00	3.86
2	97.79	488.4		-575.4	4.99
3	27.36				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	22.388	23.263	23.814
	2	88.691	97.799	121.519
	3	13.969	27.369	49.336
THICK	1	90.000	0.000	90.000
	2	341.324	1.000	582.781
DEPTH	1	90.000	90.000	90.000
	2	431.324	578.472	672.781

CURRENT: 18.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 4 RAMP TIME: 183.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.698	9362.0	8683.9	7.24
2	0.869	5183.3	5188.0	-0.0910
3	1.10	2829.5	2815.6	0.492

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 6
PICOLATA

PROJECT NO.: 93742
TABLE 5.7-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	1.40	1462.7	1516.1	-3.64
5	1.75	799.7	824.3	-3.07
6	2.22	415.8	421.7	-1.42
7	2.79	214.4	218.1	-1.72
8	3.42	120.7	119.8	0.778
9	4.26	63.67	63.95	-0.436
10	5.49	30.39	30.63	-0.797
11	6.96	14.99	16.09	-7.32 MASKED
12	8.66	8.59	8.95	-4.13 MASKED
13	11.06	5.07	4.85	4.27 MASKED

CURRENT: 18.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 183.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
14	0.857	5407.2	5367.7	0.730
15	1.06	3077.7	3107.8	-0.977
16	1.37	1581.2	1616.3	-2.21
17	1.74	826.9	838.0	-1.33
18	2.17	444.1	450.3	-1.39
19	2.77	234.4	223.1	4.83
20	3.50	115.4	112.3	2.63
21	4.37	59.79	59.67	0.200
22	5.56	29.86	29.87	-0.0288
23	6.98	16.30	16.23	0.441
24	8.56	9.29	9.47	-1.86
25	10.64	5.39	5.55	-2.87
26	13.70	2.99	3.01	-0.490

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.02	0.92			
P 3	0.01	-0.09	0.24		
F 1	0.00	0.00	0.00	0.00	
T 2	-0.01	0.07	0.20	0.00	0.88
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 6
PICOLATA

PROJECT NO.: 93742
TABLE 5.7-1

5.8 TDEM SITE 7 - GREEN COVE SPRINGS SITE

5.8.1 Location Description and Geoelectrical Section

The site is in eastern Clay County, Florida (Figure 5-8.1). The site is a pasture. A flowing well was located near the center of the Tx loop.

The Floridan aquifer begins at a depth of approximately 285 ft below msl and is overlain by the Hawthorn Group and surficial aquifer system (Scott et al., 1991). The top of the Lower Floridan aquifer begins at approximately 700 ft below msl. The base of the Floridan aquifer is approximately 2,000 ft below msl in this area (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.8-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.8.2 Geological Interpretation of Geoelectrical Model

The three-layered geoelectrical section consists of a low resistivity (29 ohm-m), upper layer considered to be the Hawthorn Group and surficial sediments above the Floridan aquifer. The thickness of layer 1 was fixed at 93 m (305 ft) based on published information (Scott et al. 1991). The second layer has high resistivity (108 ohm-m) which, because it is greater than 80 ohm-m, means the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 383 m (1,257 ft) placing the depth to the low resistivity (saltwater) layer at 476 m (1,562 ft) below ground surface. The resistivity of the saltwater layer is 2.3 ohm-m. Layer 1 is considered to be the Hawthorn Group and surficial sediments, layer 2 to be the Floridan aquifer containing fresh water and layer 3 to be the salt water within the Lower Floridan aquifer.

5.8.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 2.3 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,562 ft (-1,542 ft msl). Because the resistivity of layer 2 (108 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at 1,612 ft depth (-1,592 ft msl). The resistivity of layer 3 (2.3 ohm-m) corresponds to a chloride content of 13,831 mg/L, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.8.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 108 ohm-m, corresponds to a chloride content of less than 250 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/L isochlor is placed within the lower Floridan aquifer at a depth 50 ft above the layer 3 interface or at 1,512 ft (-1,492 ft msl).

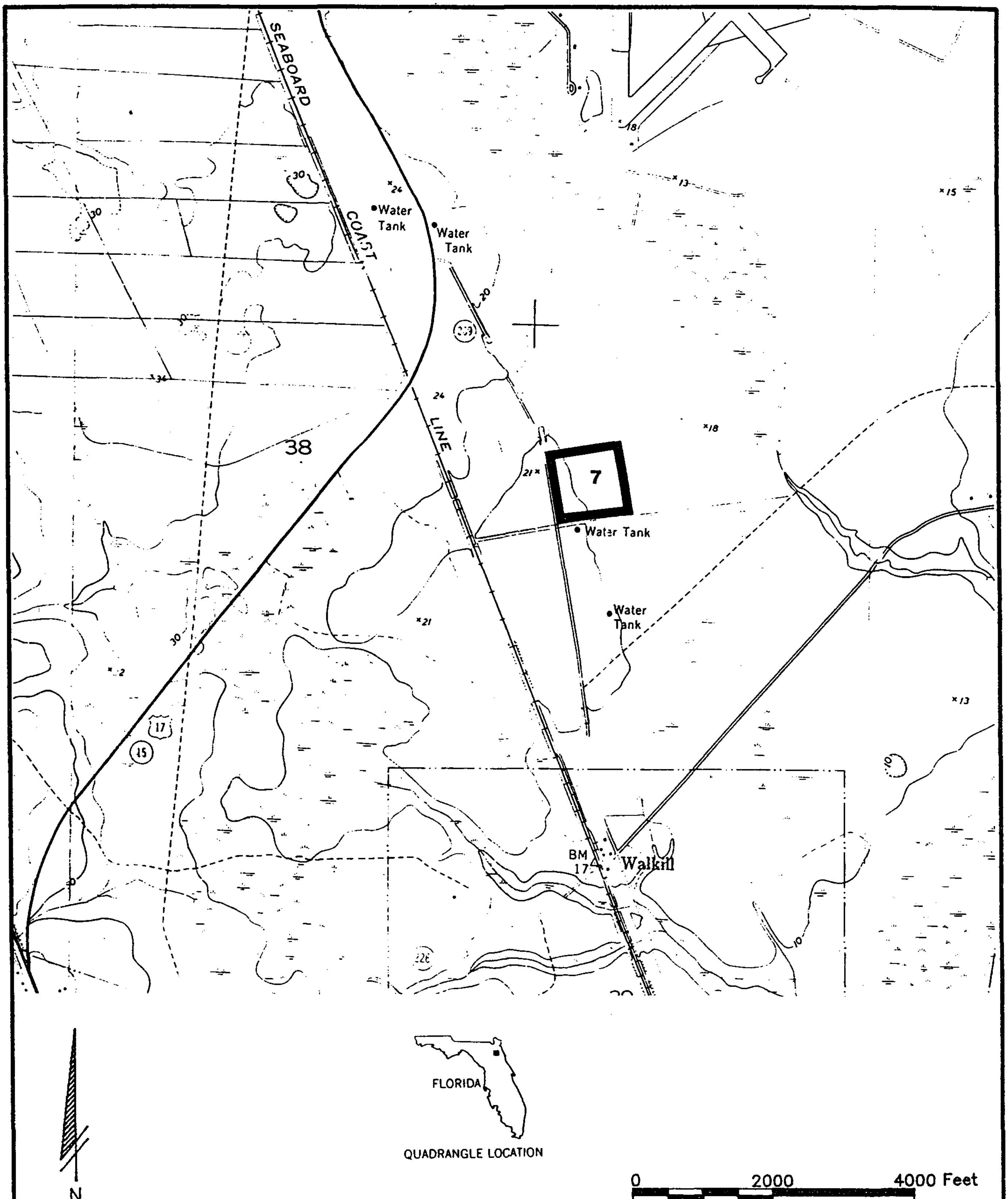
5.8.5 Accuracy of Measurement and Interpretation

Figure 5.8-3 is the equivalence analysis at this site and the inversion table (Table 5.8-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 20 m (66 ft) which is 4% of the total depth. The resistivity of this layer has a range from 1.0 - 4.9 ohm-m. This corresponds to a range in interpreted chloride content of from 32,011 mg/L to 6,411 mg/L. The chloride-to-sulfate ratio at the site is 1:1 (Table 5.1-4), rather than 5:1. Accordingly, equation (4) may not be valid. A chloride concentration of less than 250 mg/L was determined in the area of the site by Sprinkle (1981).

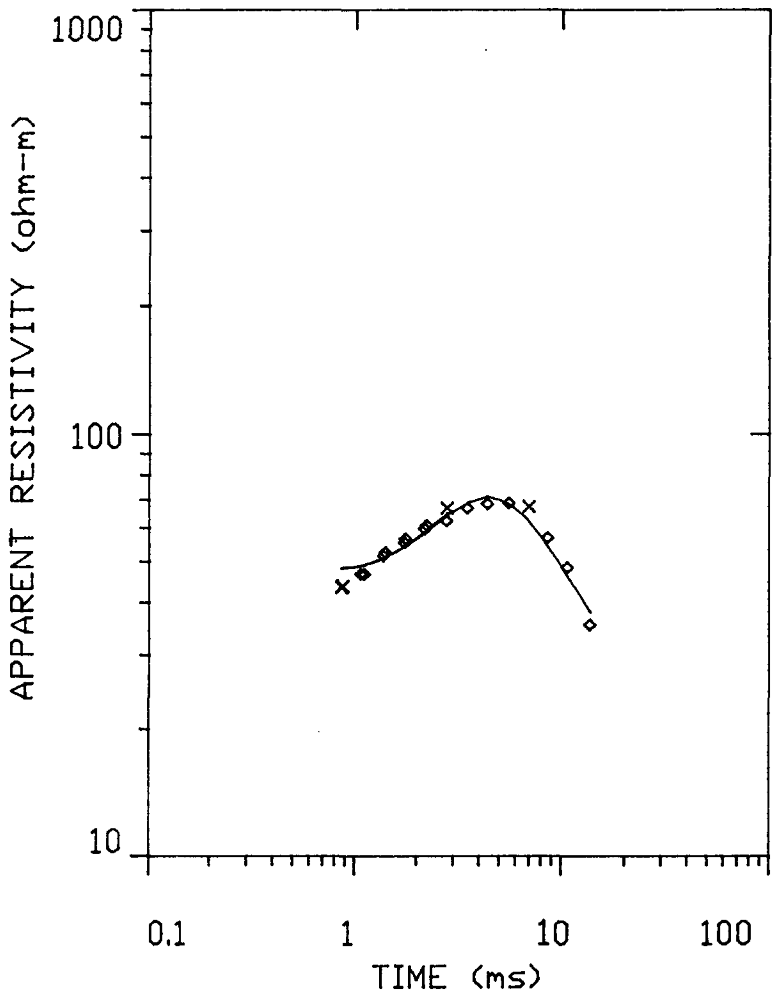
5.8.6 Summary of TDEM Sounding at Green Cove Springs (Site 7)

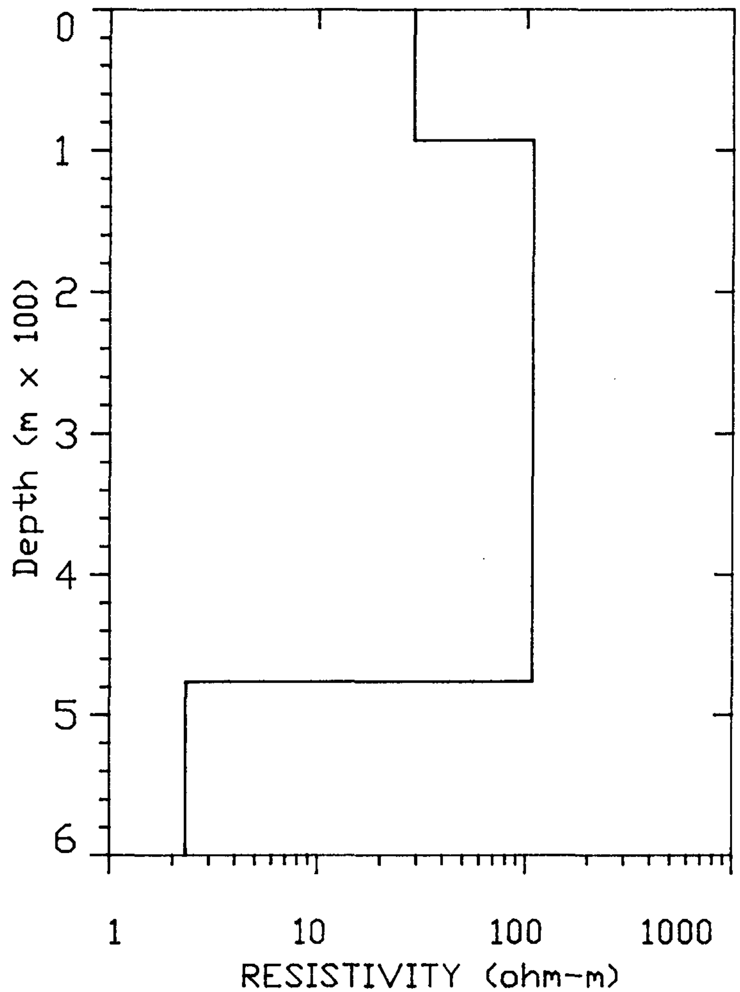
- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,612 ft (-1,592 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/L. The 250 mg/L isochlor is interpreted to be present within the Lower Floridan aquifer at a depth of 1,512 ft (-1,492 ft msl).
- Results of the TDEM survey agree with the results of other water quality studies in the area of the site.



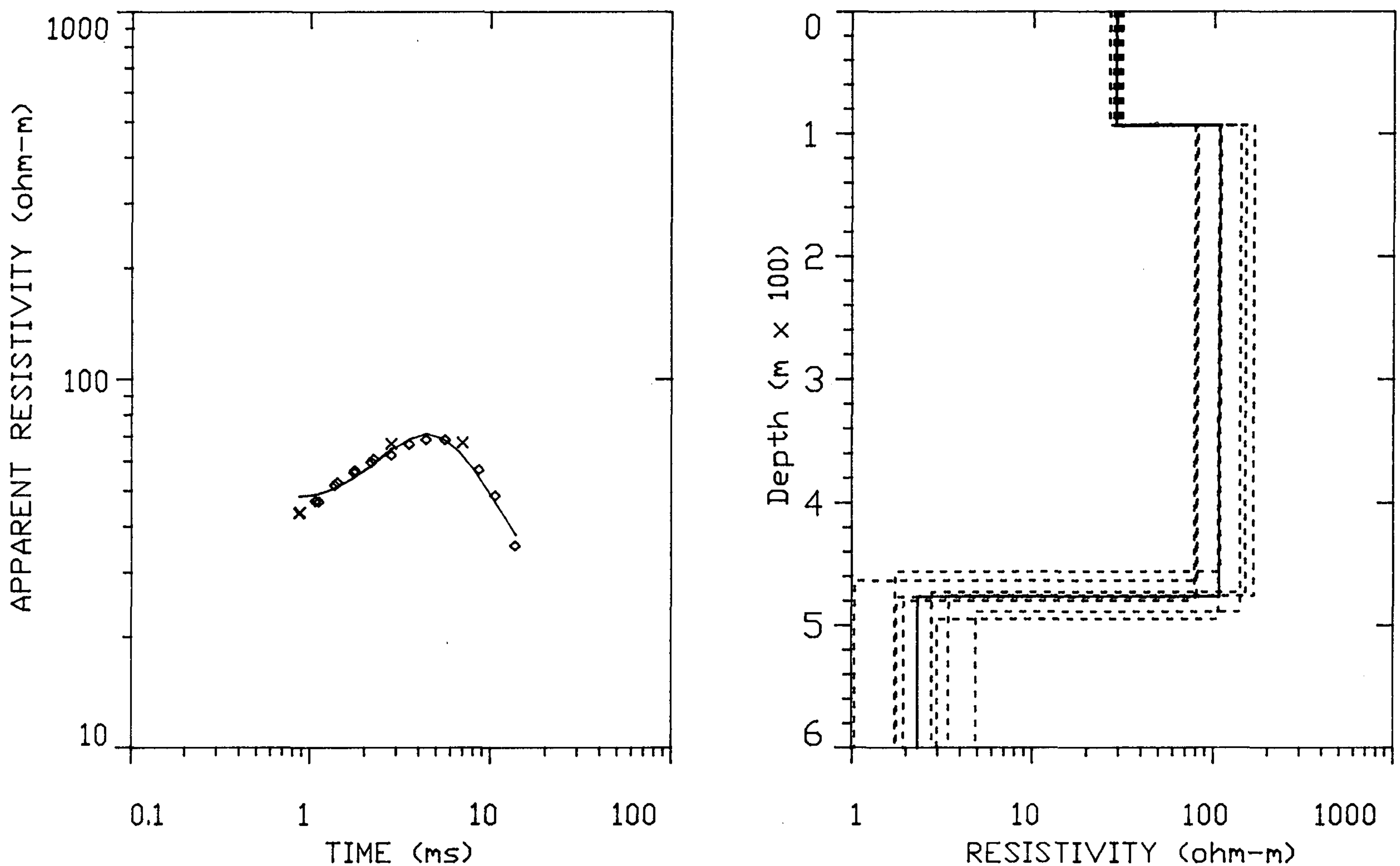
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 7 – GREEN COVE SPRINGS GREEN COVE SPRINGS, FLORIDA

DESIGNED BY: MJW	PROJECT NO.:	93742	FIGURE	
CHECKED BY: RJW	DRAWING NO.:	LOC –7	5.8–1	
DRAWN BY: SBG	DATE:	08/10/93		





—— BEST-FIT MODELED CURVE □ APPARENT RESISTIVITY VALUES USED IN MODEL X APPARENT RESISTIVITY VALUES NOT USED IN MODEL	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION SOUNDING 7 – GREEN COVE SPRINGS GREEN COVE SPRINGS, FLORIDA	
			DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: MDL-7 DATE: 11/10/93 FIGURE 5.8-2



—— BEST-FIT MODELED CURVE □ APPARENT RESISTIVITY VALUES USED IN MODEL X APPARENT RESISTIVITY VALUES NOT USED IN MODEL	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 7 – GREEN COVE SPRINGS GREEN COVE SPRINGS, FLORIDA	
			DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EQU-7 DATE: 11/10/93
			FIGURE	5.8-3

DATA SET: SITE7

CLIENT:	SJWRMD	DATE:	01-05-93
LOCATION:	GREEN COVE SPRINGS	SOUNDING:	1
COUNTY:	CLAY COUNTY, FLORIDA	ELEVATION:	6.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	305.000 m by 305.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 5.711 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				6.00	
1	28.96	93.00	*	-87.00	3.21
2	108.4	383.2		-470.2	3.53
3	2.30				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	26.571	28.969	31.279
	2	79.104	108.451	167.219
	3	1.031	2.305	4.877
THICK	1	93.000	0.000	93.000
	2	362.998	1.000	401.831
DEPTH	1	93.000	93.000	93.000
	2	455.998	476.255	494.831

CURRENT:	16.00 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	7.50 Hz	GAIN: 3	RAMP TIME:	202.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.869	3682.8	3170.3	13.91 MASKED
2	1.10	1815.9	1689.3	6.97
3	1.40	839.7	875.7	-4.29

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 7
GREEN COVE SPRINGS

PROJECT NO.: 93742
TABLE 5.2-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
4	1.75	433.3	459.0	-5.92	
5	2.22	214.4	223.9	-4.45	
6	2.79	104.9	109.7	-4.55	MASKED

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 202.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
7	0.857	3838.7	3284.0	14.45	MASKED
8	1.06	1993.9	1874.9	5.96	
9	1.37	916.2	938.4	-2.42	
10	1.74	452.8	468.1	-3.38	
11	2.17	233.5	241.4	-3.38	
12	2.77	118.7	113.4	4.48	
13	3.50	59.51	57.12	4.01	
14	4.37	32.98	31.06	5.82	
15	5.56	17.99	18.04	-0.267	
16	6.98	10.49	11.86	-12.99	MASKED
17	8.56	8.09	8.67	-7.17	
18	10.64	5.99	6.42	-7.12	
19	13.70	5.09	4.60	9.76	

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	F 1	T 2
P 1	0.99				
P 2	0.05	0.75			
P 3	0.03	-0.24	0.32		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.00	-0.03	0.00	0.99

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 7 GREEN COVE SPRINGS
		PROJECT NO.: 93742
		TABLE 5.2-1

5.9 TDEM SITE 8 - UNION CAMP SITE

5.9.1 Location Description and Geoelectrical Section

The site is located in a wooded area of Putnam County, Florida (Figure 5.9-1). QA soundings were performed 70 ft to the south and 60 ft to the west of the initial Rx coil position. Results from the QA soundings indicate that the apparent resistivity values were not affected by any interference sources (Figure 5.9-4).

The Floridan aquifer begins at an approximate depth of 65 ft below msl and is overlain by the Hawthorn Group and the surficial aquifer system (Scott et al., 1991). The Lower Floridan aquifer begins at an approximate depth of 700 ft below msl (Miller, 1986). An observation well P-0735 is present approximately 1/4 mile from the site (Figure 5.9-1). Based on information provided by SJRWMD the depth to the 250 mg/L isochlor in the observation well occurs at approximately 340 - 360 ft bls and the depth to the 5,000 mg/L isochlor occurs at approximately 450 ft bls.

The resistivity sounding data and best-fit model inversion are presented on Figure 5.9-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.9.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system layer, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (251.9 m = 826 ft) surface layer of intermediate resistivity (47.2 ohm-m) overlying a low resistivity layer (3.7 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group, and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Lower Floridan aquifer at a depth of 826 ft bls.

5.9.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 3.7 ohm-m, is interpreted to represent salt water. It occurs at a depth of 826 ft (-810 ft msl). Because the resistivity of layer 1 (47.2 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken at the depth of the geoelectrical interface, or at 826 ft depth (-810 ft msl). The resistivity of layer 2 (3.7 ohm-m) corresponds to a chloride content of 8,540 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. The depth to the 5,000 mg/L isochlor (826 ft bls) does not correlate well to water quality results from nearby observation well P-0735 which places the 5,000 mg/L isochlor at 450 ft bls (Figure 5.10-5).

5.9.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Hawthorn Group and surficial aquifer system, the effective chloride concentration of layer 1 cannot be calculated.

5.9.5 Accuracy of Measurement and Interpretation

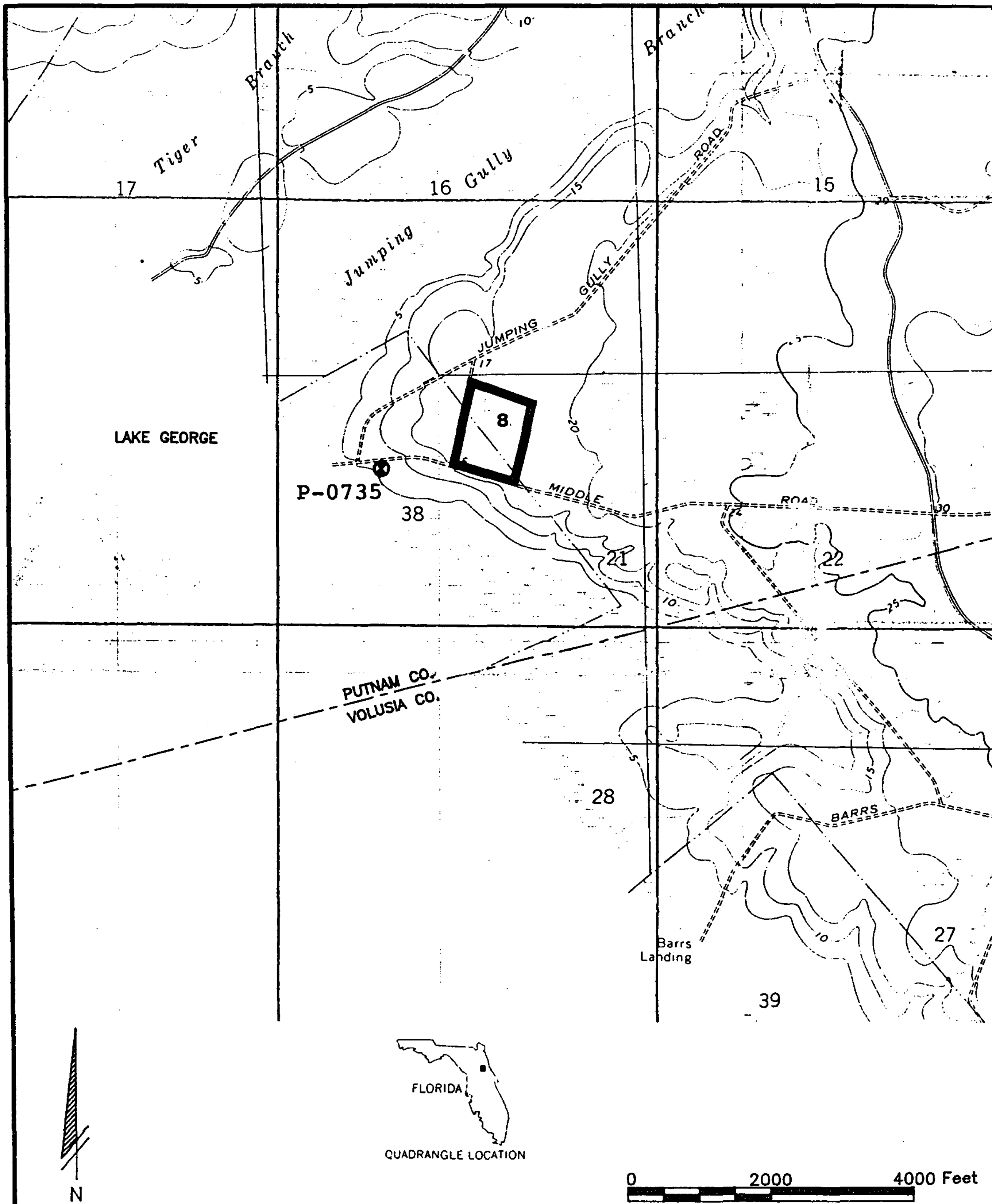
Figure 5.9-3 is the equivalence analysis at this site and the inversion table (Table 5.9-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ± 6 m (20 ft) which is 2% of the total depth. The estimated depth to the 5,000 mg/L isochlor from the TDEM study (826 ft bls) is not in agreement with the data from monitor well, P-0735.

The resistivity of this layer has a range of from 3.2 - 4.2 ohm-m. This corresponds to a range in interpreted chloride content of from 9,898 mg/L to 7,505 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

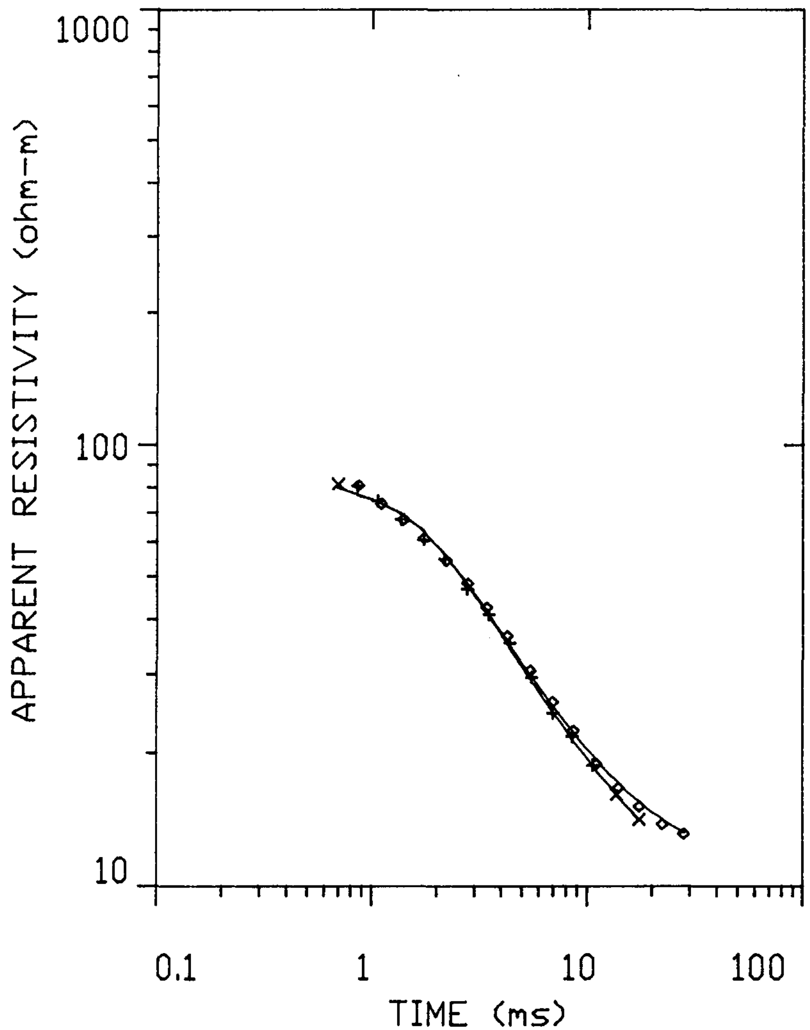
The equivalence range of the resistivity of layer 1 is from 45 - 49 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn Group and surficial sediments. Accordingly, equation (4) may not be valid.

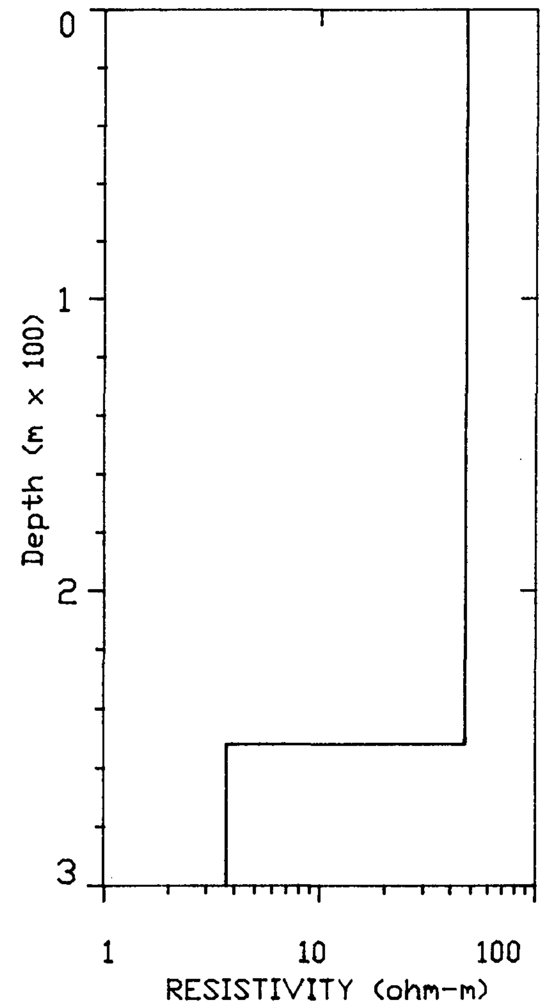
5.9.6 Summary of TDEM Sounding at Union Camp (Site 8)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 826 ft (-810 ft msl) and occur within the Lower Floridan aquifer. The estimated depth to the 5,000 mg/L isochlor from the TDEM study does not agree with the estimated depth from a nearby monitor well. No interference sources appear to be present near the Tx coil that might have affected the quality of survey data. The chloride content below that depth is inferred to be 8,540 mg/L.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Hawthorn Group and surficial aquifer system to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 8 – UNION CAMP WELAKA SE, FLORIDA	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: LOC –8 DATE: 08/10/93
			FIGURE 5.9–1





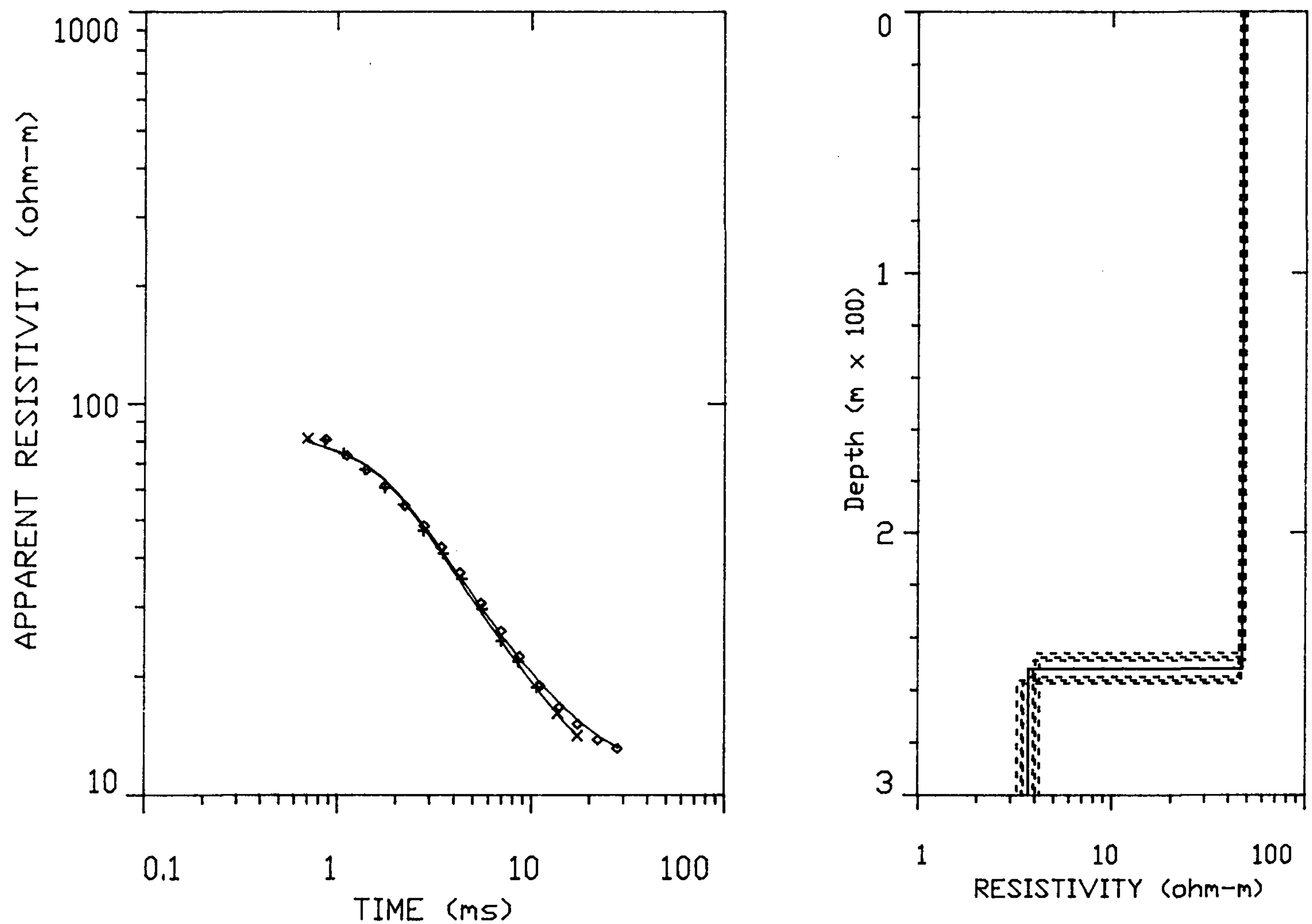
—	BEST–FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SOUNDING 8 – UNION CAMP
WELAKE SE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–8	5–9.2
DRAWN BY:	SBG	DATE:	09/16/93	

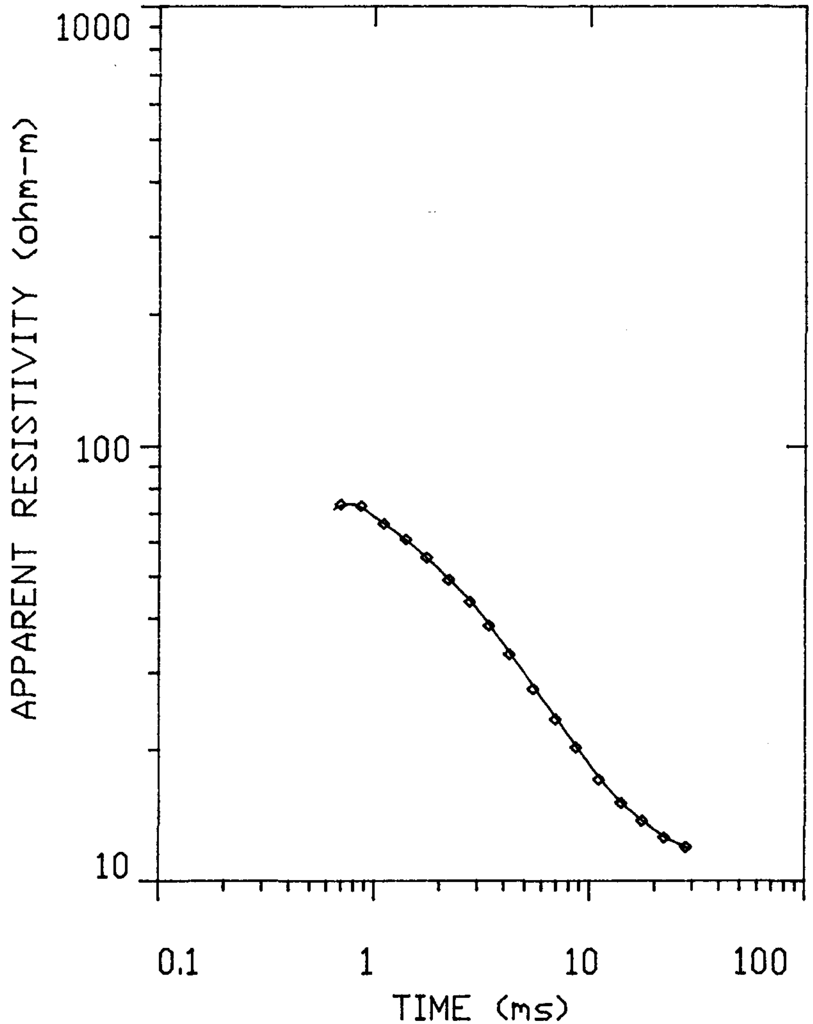


— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

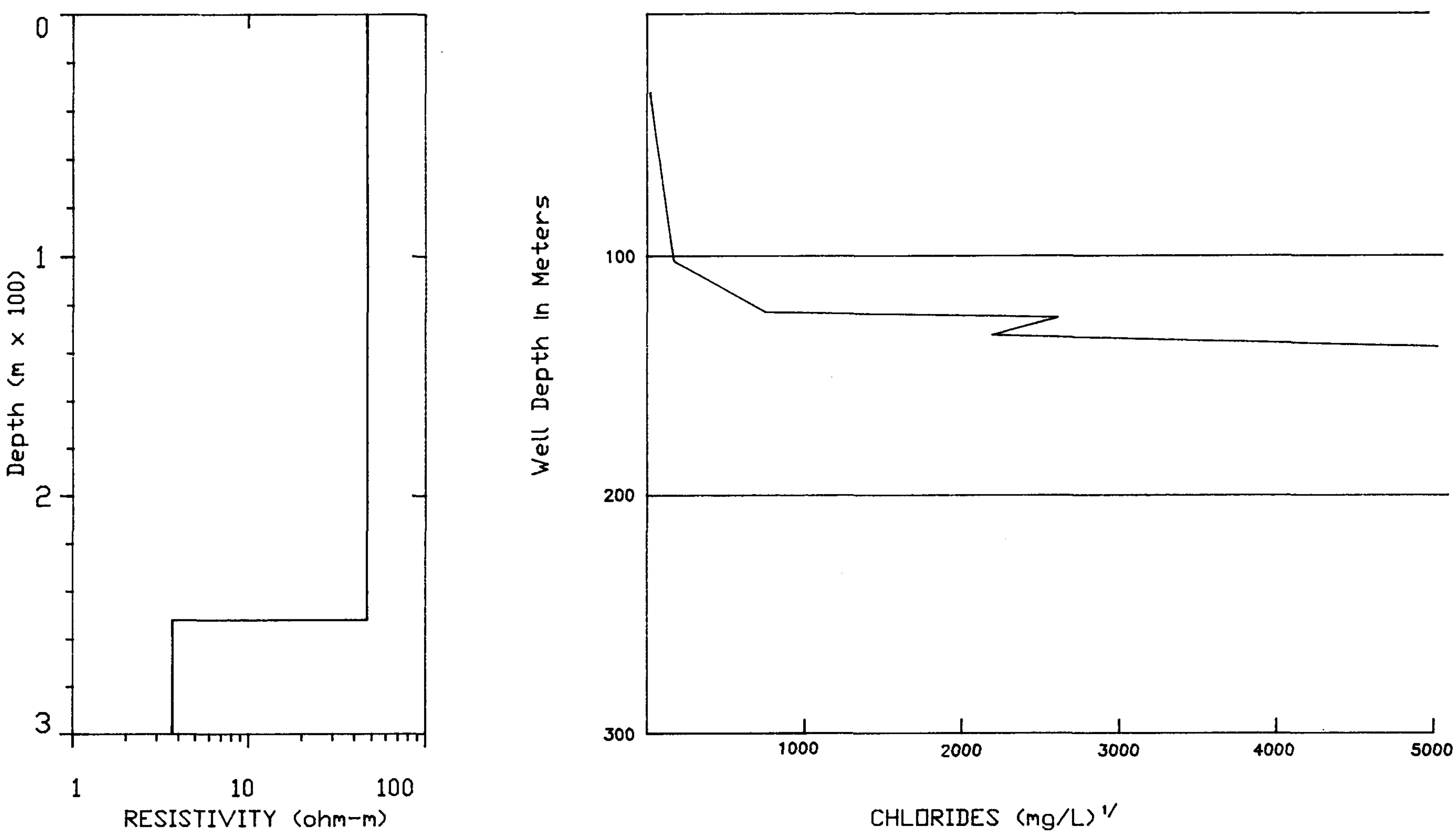
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 8 – UNION CAMP WELAKE SE, FLORIDA		
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EQU-8 DATE: 09/16/93	FIGURE 5.9-3



☐ APPARENT RESISTIVITY VALUES —— DATA CURVE	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	QUALITY CONTROL– APPARENT RESISTIVITY VALUES SOUNDING 8 – UNION CAMP WELAKE SE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE	5.9–4
CHECKED BY:	RJW	DRAWING NO.:	QA–14		
DRAWN BY:	SBG	DATE:	08/10/93		



1/ ADAPTED FROM INFORMATION PROVIDED BY SJWRMD

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	COMPARISON OF TDEM RESULTS TO WATER QUALITY RESULTS FROM MONITOR WELL P-0735 – SOUNDING 8 WELAKE SE, FLORIDA		
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: CHL-8 DATE: 09/16/93	FIGURE 5.9-5

CLIENT:	SJWRMD	DATE:	02-05-93
LOCATION:	UNION CAMP	SOUNDING:	1
COUNTY:	PUTNAM COUNTY, FLORIDA	ELEVATION:	5.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	350.999 m by 350.999 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 0.0000 N: 0.0000		

FITTING ERROR: 3.713 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			5.00	
1	47.17	251.9	-246.9	5.34
2	3.68			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	45.483	47.170	49.010
	2	3.235	3.689	4.212
THICK	1	245.972	1.000	257.518
DEPTH	1	245.972	251.949	257.518

CURRENT:	19.20 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	7.50 Hz	GAIN: 6	RAMP TIME:	252.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.698	3969.7	4092.6	-3.09 MASKED
2	0.869	2322.2	2500.7	-7.68
3	1.10	1462.2	1452.9	0.638
4	1.40	918.7	885.0	3.66
5	1.75	611.0	579.3	5.18
6	2.22	402.8	388.1	3.64
7	2.79	272.1	273.1	-0.373

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 8
UNION CAMP

PROJECT NO.: 93742
TABLE 5.9-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	3.42	197.7	202.8	-2.58
9	4.26	142.8	148.7	-4.13
10	5.49	99.26	102.8	-3.59
11	6.96	69.97	72.27	-3.28
12	8.66	50.58	51.42	-1.66
13	11.06	35.50	34.46	2.91
14	14.00	23.69	22.93	3.18
15	17.47	15.78	15.28	3.14
16	22.23	9.93	9.58	3.50
17	28.10	5.96	5.90	0.905

CURRENT: 19.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 252.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
18	0.857	2418.4	2586.3	-6.94
19	1.06	1575.4	1586.0	-0.669
20	1.37	974.1	934.0	4.11
21	1.74	630.5	590.4	6.36
22	2.17	422.3	407.4	3.52
23	2.77	290.2	280.9	3.22
24	3.50	197.4	200.8	-1.70
25	4.37	141.8	147.8	-4.22
26	5.56	101.4	105.0	-3.60
27	6.98	75.78	75.78	-7.550E-04
28	8.56	54.58	55.91	-2.44
29	10.64	39.58	39.94	-0.897
30	13.70	26.39	26.60	-0.790MASKED
31	17.40	17.69	17.74	-0.288MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99		
P 2	-0.01	0.93	
T 1	0.00	0.01	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 8 UNION CAMP PROJECT NO.: 93742 TABLE 5.9-1

5.10 TDEM SITE 9 - DRAYTON ISLAND SITE

5.10.1 Location Description and Geoelectrical Section

The site is located on Drayton Island which is within the St. Johns River in Putnam County, Florida (Figure 5-10.1). Powerlines were present to the south of the Tx Loop. QA soundings were performed 80 ft to the south and 95 ft to the north of the initial Rx coil position. Results from the QA soundings indicated that the apparent resistivity values were not affected by any interference sources (Figure 5.10-4).

The Floridan aquifer begins at an approximate depth of 50 ft below msl and is overlain by the Hawthorn Group and the surficial aquifer system (Scott et al., 1991). The Lower Floridan aquifer begins at an approximate depth of 700 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.10-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.10.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the upper surficial aquifer system layer, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (126.8 m = 416 ft) surface layer of intermediate to low resistivity (22.7 ohm-m) overlying a low resistivity layer (2.3 ohm-m). It can be interpreted that the upper surficial aquifer system, the Hawthorn Group and part of the Floridan Aquifer System exist as a combined but indistinguishable (geoelectrically) layer, overlying a saltwater saturated Floridan aquifer at a depth of 416 ft bls.

5.10.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 2.3 ohm-m, is interpreted to represent salt water. It occurs at a depth of 416 ft (-406 ft msl). Because the resistivity of layer 1 (22.7 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is equal to the depth of the geoelectrical interface, or at 416 ft depth (-406 ft msl). The resistivity of layer 2 (2.3 ohm-m) corresponds to a chloride content in excess of 13,831 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.10.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying surficial aquifer system and the Hawthorn Group, the effective chloride concentration of layer 1 cannot be determined.

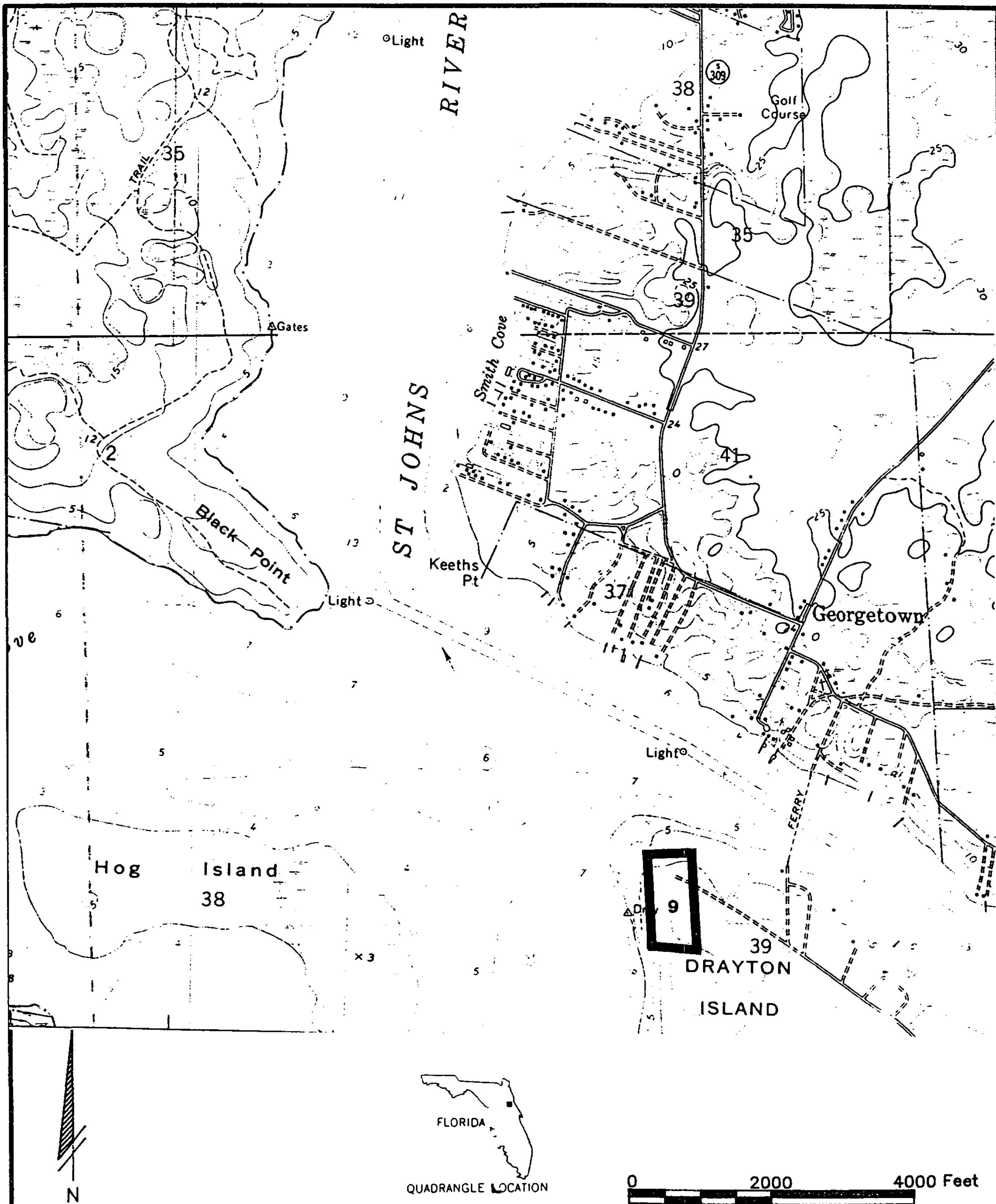
5.10.5 Accuracy of Measurement and Interpretation

Figure 5.10-3 is the equivalence analysis at this site and the inversion table (Table 5.10-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ± 4 m (13 ft) which is 3% of the total depth. The resistivity of this layer has a range of from 2.2 - 2.5 ohm-m. This corresponds to a range in interpreted chloride content of from 14,467 mg/L to 12,712 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

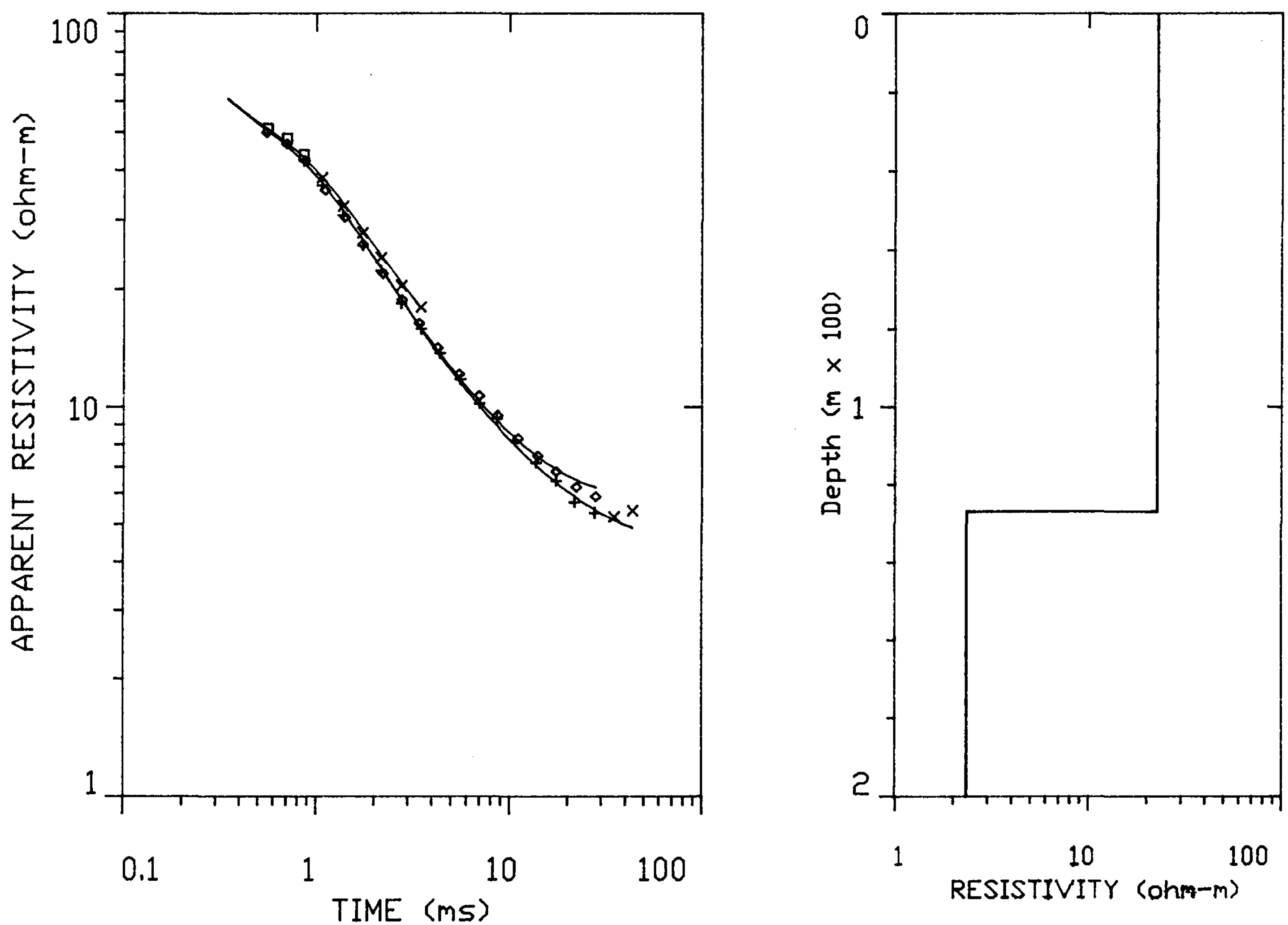
The equivalence range of the resistivity of layer 1 is from 21.8 - 23.6 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn group and surficial sediments. Accordingly, equation (4) may not be valid. Chloride concentrations of less than 250 mg/L have been mapped in the area of the site by SJRWMD.

5.10.6 Summary of TDEM Sounding at Drayton Island (Site 9)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 416 ft (-406 ft msl) and occur within the Floridan aquifer. The chloride content below that depth is inferred to be in excess of 10,000 mg/L.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow the surficial aquifer system and the Hawthorn Group to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 9 – DRAYTON ISLAND WELAKA, FLORIDA
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG
		PROJECT NO.: 93742 DRAWING NO.: LOC –9 DATE: 06/17/93
		FIGURE 5.10-1



BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

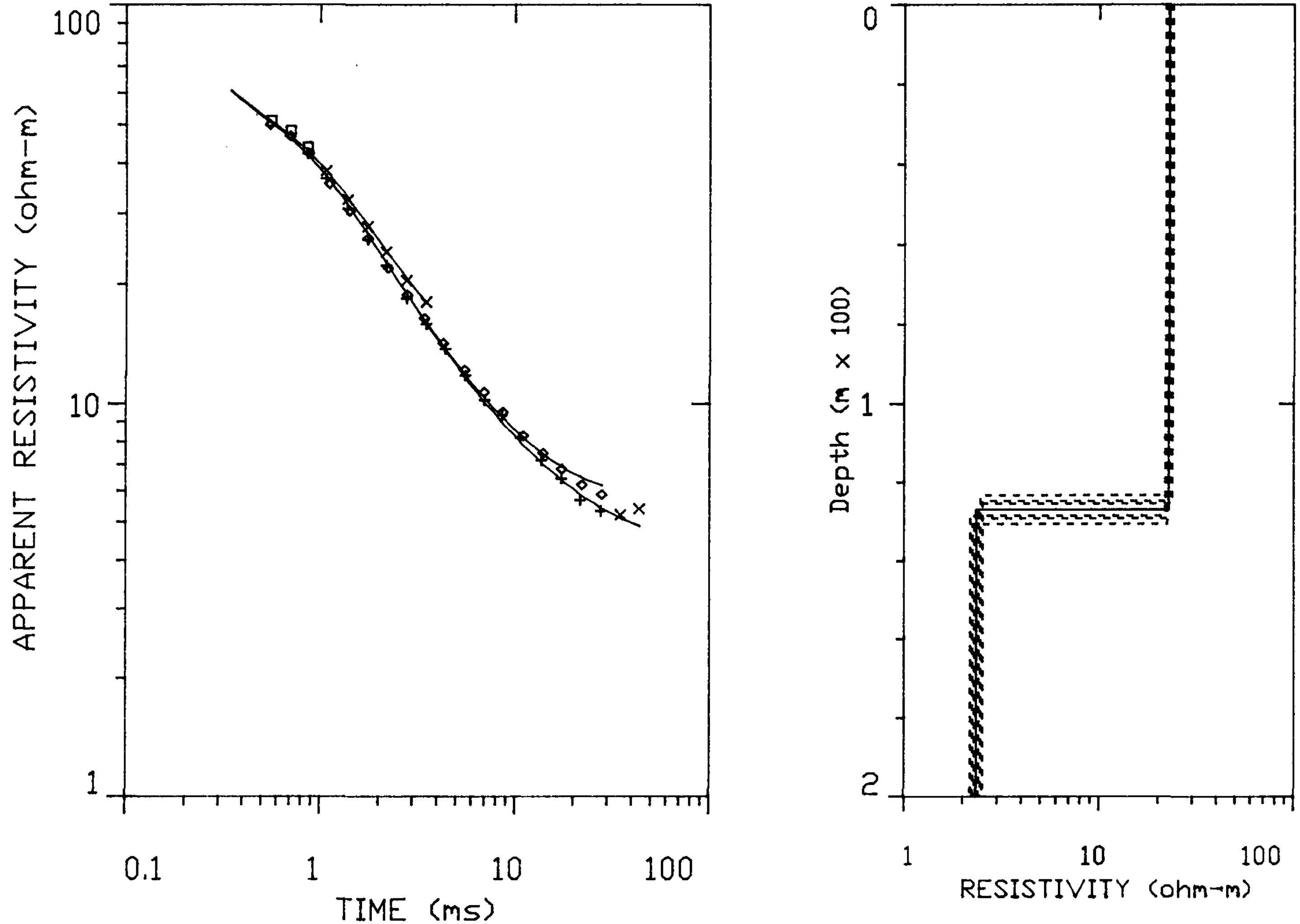
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SOUNDING 9 – DRAYTON ISLAND
WELAKA, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–9	5–10.2
DRAWN BY:	SBG	DATE:	09/16/93	



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

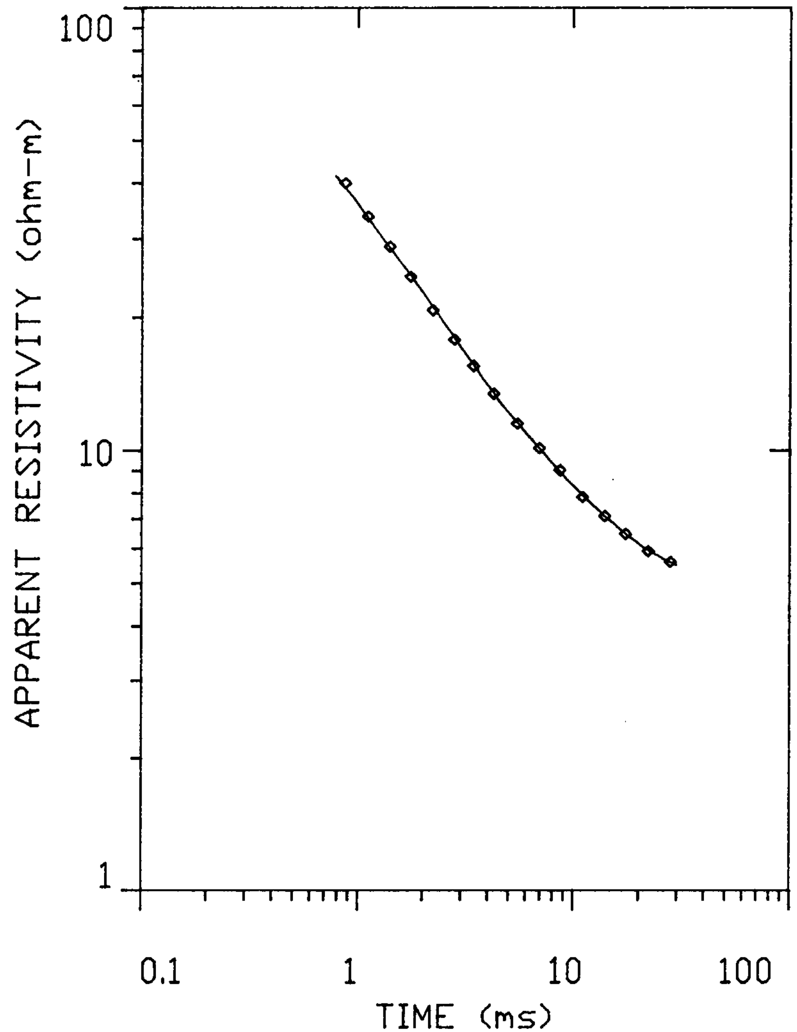
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 9 - DRAYTON ISLAND
WELAKA, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-9	5.10-3
DRAWN BY:	SBG	DATE:	09/16/93	



□ APPARENT RESISTIVITY VALUES ——— DATA CURVE	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	QUALITY CONTROL– APPARENT RESISTIVITY VALUES SOUNDING 9 – DRAYTON ISLAND WELAKA, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–9	5.10–4
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT: SJWRMD DATE: 03-05-93
LOCATION: DRAYTON ISLAND SOUNDING: 1
COUNTY: PUTNAM COUNTY, FLORIDA ELEVATION: 3.00 m
PROJECT: SALTWATER INTERFACE DETECTION EQUIPMENT: Geonics PROTEM
LOOP SIZE: 452.000 m by 182.800 m AZIMUTH:
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 3.407 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			3.00	
1	22.66	126.8	-123.8	5.59
2	2.34			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	21.767	22.663	23.637
	2	2.177	2.341	2.523
THICK	1	123.209	1.000	130.573
DEPTH	1	123.209	126.884	130.573

CURRENT: 16.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 3 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.351	31561.9	21426.1	32.11 MASKED
2	0.438	15864.9	14053.4	11.41 MASKED
3	0.558	8685.2	8732.9	-0.549
4	0.702	5332.2	5583.5	-4.71
5	0.858	3733.2	3841.5	-2.90
6	1.06	2651.1	2644.8	0.238MASKED
7	1.37	1813.8	1770.5	2.38 MASKED

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 9
DRAYTON ISLAND

PROJECT NO.: 93742
TABLE 5.10-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	1.74	1259.5	1232.3	2.16 MASKED
9	2.17	902.1	889.4	1.40 MASKED
10	2.77	626.7	613.1	2.17 MASKED
11	3.50	420.4	425.0	-1.09 MASKED

CURRENT: 16.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 3 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
12	0.346	34273.0	22140.5	35.39 MASKED
13	0.427	17752.8	14897.2	16.08 MASKED
14	0.550	9319.5	9116.4	2.17
15	0.698	5674.1	5772.6	-1.73
16	0.869	3807.2	3878.3	-1.86
17	1.10	2688.2	2600.1	3.27
18	1.40	1883.0	1818.2	3.44
19	1.75	1371.6	1327.1	3.24
20	2.22	979.5	956.6	2.33
21	2.79	696.1	694.3	0.257
22	3.42	514.0	520.4	-1.25
23	4.26	368.2	376.7	-2.29
24	5.49	246.8	254.8	-3.26
25	6.96	165.2	173.8	-5.22
26	8.66	113.9	119.8	-5.14
27	11.06	75.91	77.46	-2.04
28	14.00	49.14	49.62	-0.962
29	17.47	32.46	31.95	1.57
30	22.23	20.43	19.25	5.76
31	28.10	12.37	11.44	7.49

CURRENT: 16.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
32	0.857	3949.2	3983.1	-0.859
33	1.06	2842.9	2773.4	2.44

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 9
DRAYTON ISLAND

PROJECT NO.: 93742
TABLE 5.10-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	emf (nV/m sqrd) SYNTHETIC	DIFFERENCE (percent)
34	1.37	1969.4	1892.5	3.90
35	1.74	1407.2	1346.9	4.29
36	2.17	1013.6	996.1	1.72
37	2.77	731.3	710.1	2.90
38	3.50	510.3	511.8	-0.284
39	4.37	363.1	370.3	-1.97
40	5.56	250.9	257.2	-2.49
41	6.98	176.0	179.8	-2.18
42	8.56	121.0	128.5	-6.19
43	10.64	85.12	88.76	-4.28
44	13.70	55.18	56.54	-2.47
45	17.40	35.73	36.25	-1.44
46	21.70	24.81	23.61	4.83
47	27.70	14.84	14.42	2.80
48	35.00	8.54	8.81	-3.07 MASKED
49	43.70	4.64	5.41	-16.45 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	0.00	0.98	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 9
DRAYTON ISLAND

PROJECT NO.: 93742
TABLE 5.10-1

5.11 TDEM SITE 10 - BEAR ISLAND SITE

5.11.1 Location Description and Geoelectrical Section

The site is located on an island within Crescent Lake, east of the St. Johns River in Flagler County, Florida (Figure 5.11-1). No apparent sources of interference were visible.

The Floridan aquifer begins at an approximate depth of 75 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The Lower Floridan aquifer begins at an approximate depth of 800 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.11-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.11.2 Geological Interpretation of Geoelectrical Model

The best-fit model shows a three-layer subsurface with the uppermost layer (presumed Hawthorn Group and surficial sediments; 6 ohm-m) overlying a second layer (Floridan aquifer; 98 ohm-m). Layer 1 is interpreted to represent the Hawthorn Group and surficial sediments. Layer 1 is 22.6 m (74 ft) thick which corresponds well to published thickness of the Hawthorn Group and surficial sediments (78 ft) in this area (Scott et al., 1991). Layer 2 is presumed to represent the freshwater saturated Floridan aquifer. These two layers are underlain by a low resistivity layer (2.8 ohm-m) at a depth of 164 m (538 ft) which is presumed to represent the saltwater saturated Floridan aquifer.

5.11.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 2.8 ohm-m, is interpreted to represent salt water. It occurs at a depth of 538 ft (-535 ft msl). Because the resistivity of layer 2 (98 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at 588 ft depth (-585 ft msl). The resistivity of layer 3 (2.8 ohm-m) corresponds to a chloride content of 11,334 mg/L, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.11.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 98 ohm-m, corresponds to a chloride content less than 250 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/L isochlor is placed in the Floridan aquifer at a depth 50 ft above the layer 3 interface or at 488 ft bls (-485 ft msl).

5.11.5 Accuracy of Measurement and Interpretation

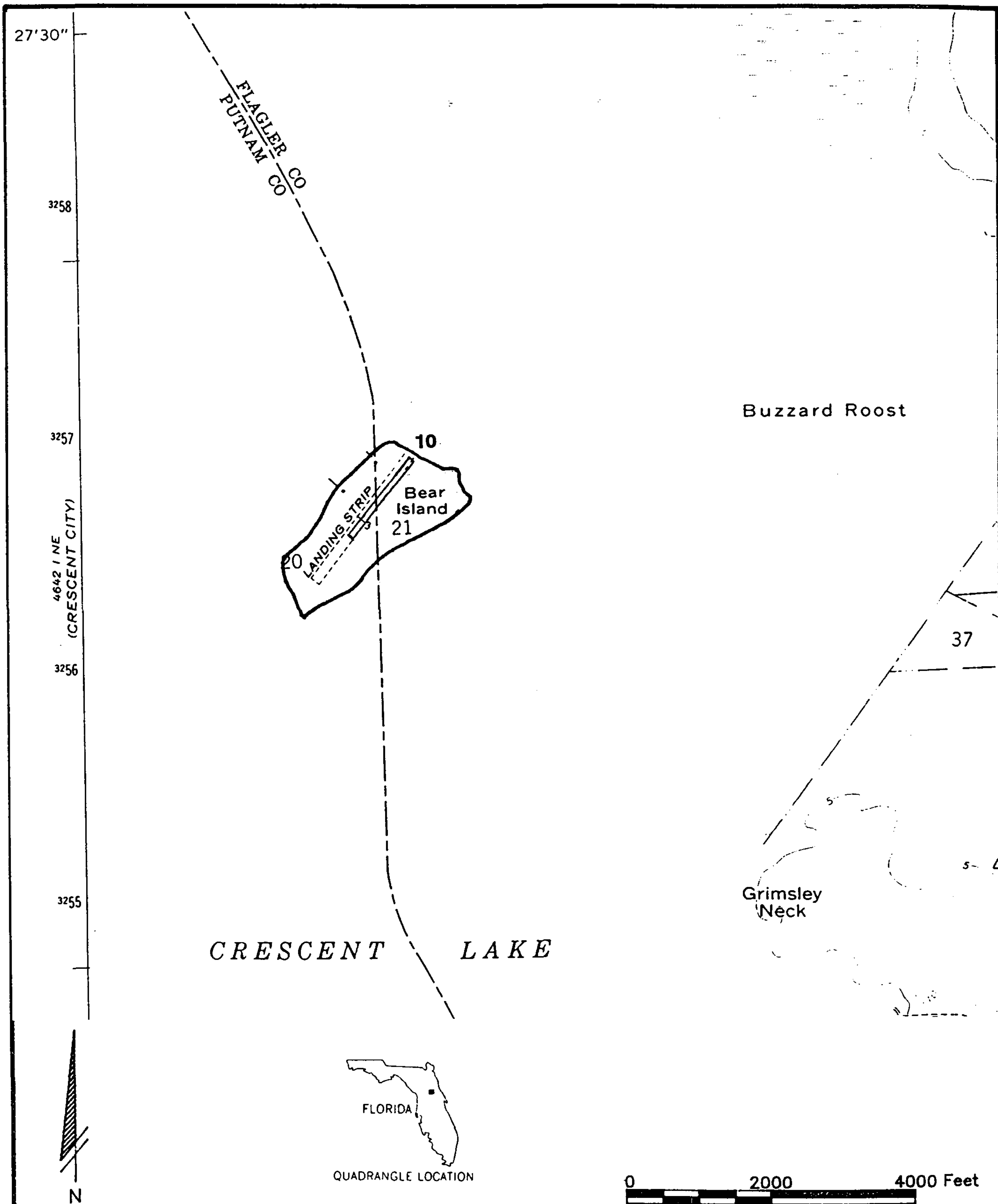
Figure 5.11-3 is the equivalence analysis at this site and the inversion table (Table 5.11-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 6 m (20 ft) which is 4% of the total depth. The resistivity of this layer has a range of from 2.5 - 3.1 ohm-m. This corresponds to a range in interpreted chloride content of from 12,712 mg/L to 10,222 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 61 - 180 ohm-m which corresponds to a chloride content ranging from less than 250 mg/L to greater than 250 mg/L. The chloride-to-sulfate ratio at the site is 2:1 (Table 5.1-4), rather than 5:1. Accordingly, equation (4) may not be valid. Chloride concentrations are not known on the island. Chloride concentrations have been mapped above 250 mg/L east of the island and less than 250 mg/L west of the island (SJRWMD, personnel communication).

5.11.6 Summary of TDEM Sounding at Bear Island (Site 10)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 588 ft (-535 ft msl) and occur within the Floridan aquifer. The chloride content below that depth is inferred to be in excess of 10,000 mg/L.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration below 250 mg/L. The 250 mg/L isochlor is interpreted to be present within the Floridan aquifer at a depth of 488 ft bls. Water quality on the island is unknown.



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PALATKA, FLORIDA

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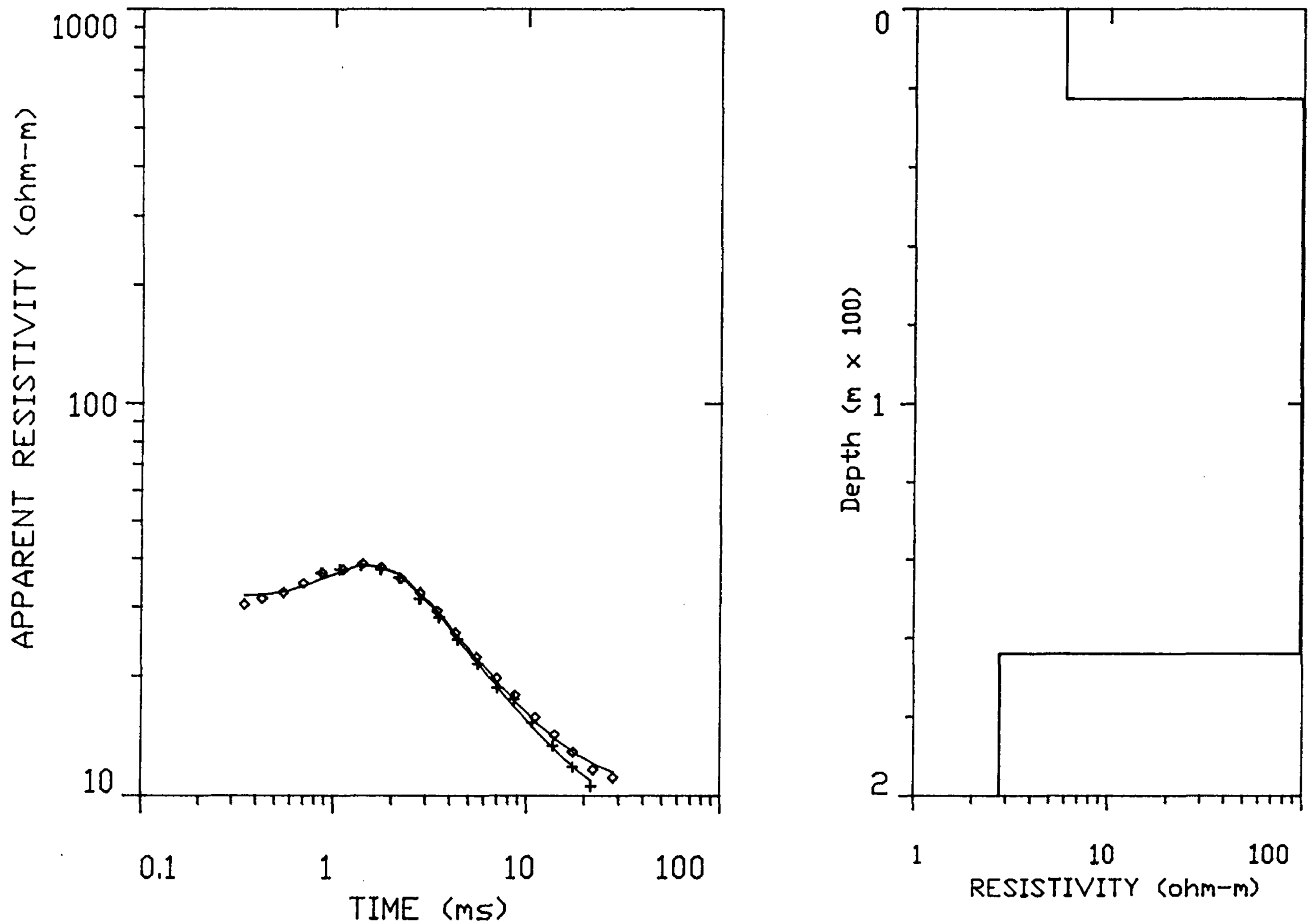
TDEM SURVEY LOCATION MAP
SOUNDING 10 – BEAR ISLAND
ST. JOHNS PARK, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-10	5.11-1
DRAWN BY:	SBG	DATE:	06/17/93	



—	BEST–FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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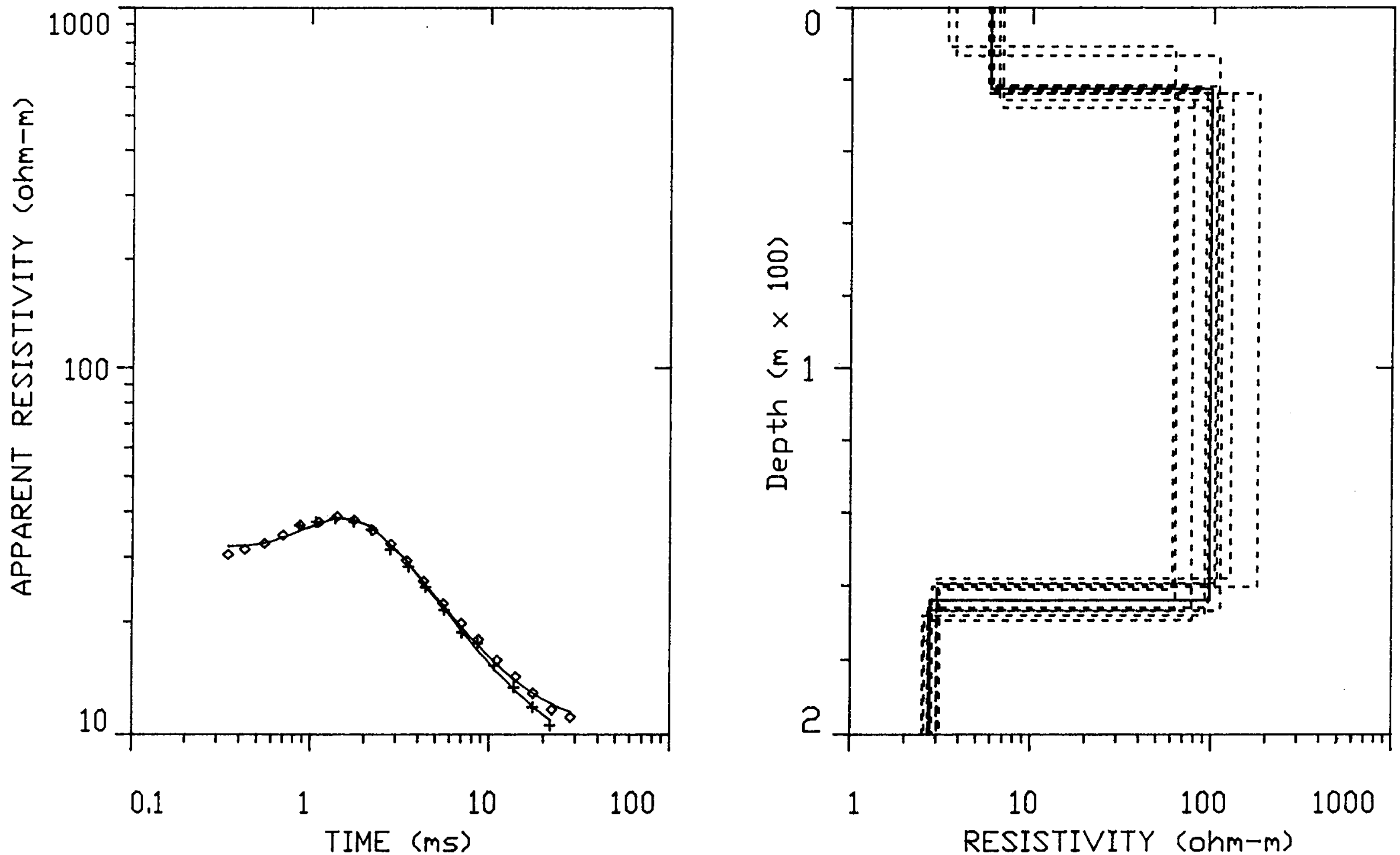
MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SOUNDING 10 – BEAR ISLAND
ST. JOHNS PARK, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–10	5–11.2
DRAWN BY:	SBG	DATE:	08/10/93	



— BEST-FIT MODELED CURVE □ APPARENT RESISTIVITY VALUES USED IN MODEL X APPARENT RESISTIVITY VALUES NOT USED IN MODEL	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 10 - BEAR ISLAND ST. JOHNS PARK, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-10	5.11-3
DRAWN BY:	SBG	DATE:	06/25/93	

CLIENT: SJWRMD
LOCATION: BEAR ISLAND
COUNTY: PUTNAM/FLAGLER COUNTY, FL.
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 457.200 m by 39.600 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 05-04-93
SOUNDING: 1
ELEVATION: 1.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 3.387 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			1.00	
1	5.88	22.62	-21.62	3.84
2	98.44	141.3	-162.9	1.43
3	2.76			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	3.396	5.885	6.886
	2	61.457	98.441	180.317
	3	2.513	2.770	3.123
THICK	1	10.774	-1.040	27.960
	2	134.149	1.000	150.312
DEPTH	1	10.774	22.623	27.960
	2	158.029	163.933	169.473

CURRENT: 18.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 4 RAMP TIME: 182.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	26244.6	24219.6	7.71
2	0.427	14731.2	14247.7	3.28
3	0.550	7400.6	7374.5	0.351

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 10
BEAR ISLAND

PROJECT NO.: 93742
TABLE 5.11-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.698	3763.7	3856.9	-2.47
5	0.869	1980.3	2081.2	-5.09
6	1.10	1049.4	1061.6	-1.16
7	1.40	550.8	554.9	-0.749
8	1.75	327.3	327.7	-0.110
9	2.22	199.6	193.1	3.25
10	2.79	127.9	128.8	-0.679
11	3.42	90.27	89.53	0.816
12	4.26	63.17	63.53	-0.563
13	5.49	41.38	41.79	-0.997
14	6.96	27.49	28.44	-3.45
15	8.66	18.49	19.52	-5.58
16	11.06	12.14	12.63	-4.01
17	14.00	7.84	8.12	-3.56
18	17.47	5.24	5.26	-0.264
19	22.23	3.34	3.18	4.92
20	28.10	1.99	1.90	4.54

CURRENT: 18.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 182.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	2057.8	2163.9	-5.15
22	1.06	1154.6	1187.7	-2.86
23	1.37	597.3	590.8	1.07
24	1.74	339.6	333.6	1.76
25	2.17	209.9	204.0	2.81
26	2.77	137.6	131.8	4.19
27	3.50	90.28	87.47	3.11
28	4.37	62.91	62.36	0.873
29	5.56	42.61	42.20	0.948
30	6.98	29.74	29.46	0.937
31	8.56	19.76	20.98	-6.16
32	10.64	14.04	14.51	-3.32
33	13.70	9.14	9.29	-1.56
34	17.40	6.04	5.99	0.856
35	21.70	4.12	3.92	4.79

PARAMETER RESOLUTION MATRIX:

"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.92				
P 2	0.02	0.11			
P 3	0.02	-0.04	0.93		
T 1	-0.09	-0.08	0.02	0.88	
T 2	0.01	0.05	0.02	0.01	0.99

ST. JOHNS RIVER WATER
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PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 10
BEAR ISLAND

PROJECT NO.: 93742
TABLE 5.11-1

5.12 TDEM SITE 11 - DESERET #1 SITE

5.12.1 Location Description and Geoelectrical Section

The site is located in central Orange County, Florida (Figure 5.12-1) and is 3.3 miles east of TDEM site 12. The site is within a pasture with no obvious signs of interference. The site is approximately 1,200 ft from public supply wells Cocoa 1 and Cocoa 7 (Figure 5.12-1) with depths of 374 ft and 379 ft, respectively. This site is approximately 3.5 miles east of Cocoa C (a nested set of monitor wells) with a maximum depth of 1,357 ft. Water quality results from Cocoa C show a measured chloride concentration of less than 250 mg/L to a depth of at least 1,224 ft and a value of 2,700 mg/L at a depth of 1,357 ft (Figure 5.12-4).

The Floridan aquifer begins at a depth of approximately 170 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The top of the Lower Floridan begins at an approximate depth of 1100 ft below msl. The base of the Floridan aquifer is approximately 2,600 ft below msl in this area (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.12-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.12.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above the third saltwater saturated layer. The first layer occurs at a depth of 56 m (184 ft) and not at the hydrostratigraphic contact (239 ft bls) between the Hawthorn Group and the Floridan aquifer System. The first layer has a low-resistivity value (18 ohm-m) and is considered to represent the upper portion of the Hawthorn Group and surficial sediments. The second layer has a high-resistivity value (101 ohm-m) and a thickness of 329 m (1,079 ft). It is considered to represent a combined but indistinguishable (geoelectrical) layer consisting of a portion of the Hawthorn Group and part of the Floridan aquifer. The third layer is considered to represent a saltwater saturated Floridan aquifer at a depth of 1,263 ft. The depth to the interpreted low resistivity (saltwater) layer at 1,263 ft is in good agreement with the position of the higher chloride value seen in the Cocoa C well.

5.12.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 10.7 ohm-m, is interpreted to represent moderately salty water. It occurs at a depth of 1,263 ft (-1,194 ft msl). This is in good agreement with the water quality results from the Cocoa C well, 3.5 miles west of the site. Because the resistivity of layer 2 (101 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater tha 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is 50 ft below the depth of the geoelectrical interface, or at 1,313 ft depth (-1,244 ft msl). The resistivity of layer 3 (10.7 ohm-m) corresponds to a chloride concentration of 2,853 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of expected high chlorinity gradients, this value is sufficiently close to 5,000 mg/L that they represent the same effective depth.

5.12.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from part of the overlying Hawthorn Group, the effective chloride concentration of Layer 2 cannot be calculated. Water quality results from Cocoa C well places the 250 mg/L isochlor at approximatly 1,250 ft bls (Figure 5.12-4)

5.12.5 Accuracy of Measurement and Interpretation

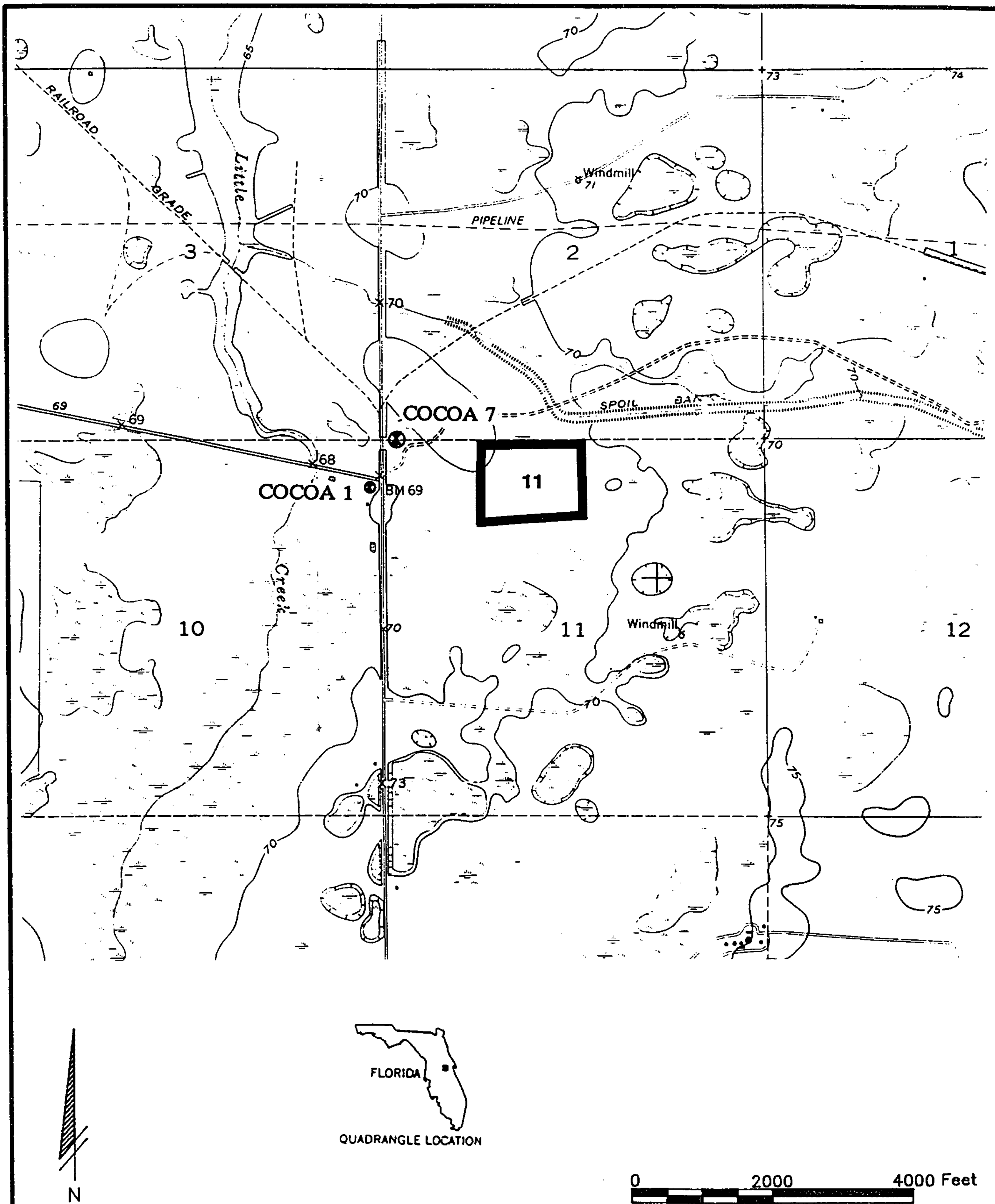
Figure 5.12-3 is the equivalence analysis at this site, and the inversion table (Table 5.12-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. Both the estimated depth to the 5,000 mg/L and 250 mg/L isochlor and chloride concentration from the TDEM study are in agreement with the results from nearby wells.

The range of equivalence in determining the depth to the low resistivity layer is about ± 26 m (85 ft) which is 7% of the total depth. The resistivity of this layer has a range of from 9.3 - 12.7 ohm-m. This corresponds to a range in interpreted chloride content of from 3,305 mg/L to 2,380 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence of the resisitivity of Layer 2 is from 80 - 140 ohm-m. A corresponding chloride concentration cannot be determined because Layer 2 is in part comprised of the Hawthorn Group.

5.12.6 Summary of TDEM Sounding at Deseret #1 (Site 11)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,313 ft (-1,244 ft msl) in the Lower Floridan aquifer. The estimated depth agrees with water quality results from a nearby well. The measured layer resistivity at this level yields a chloride concentration of 2,853 mg/L. It is assumed that this is sufficiently close to 5,000 mg/L that the derived depth is applicable to the saltwater interface depth.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow part of the Hawthorn Group to be distinguished from the Floridian Aquifer System.



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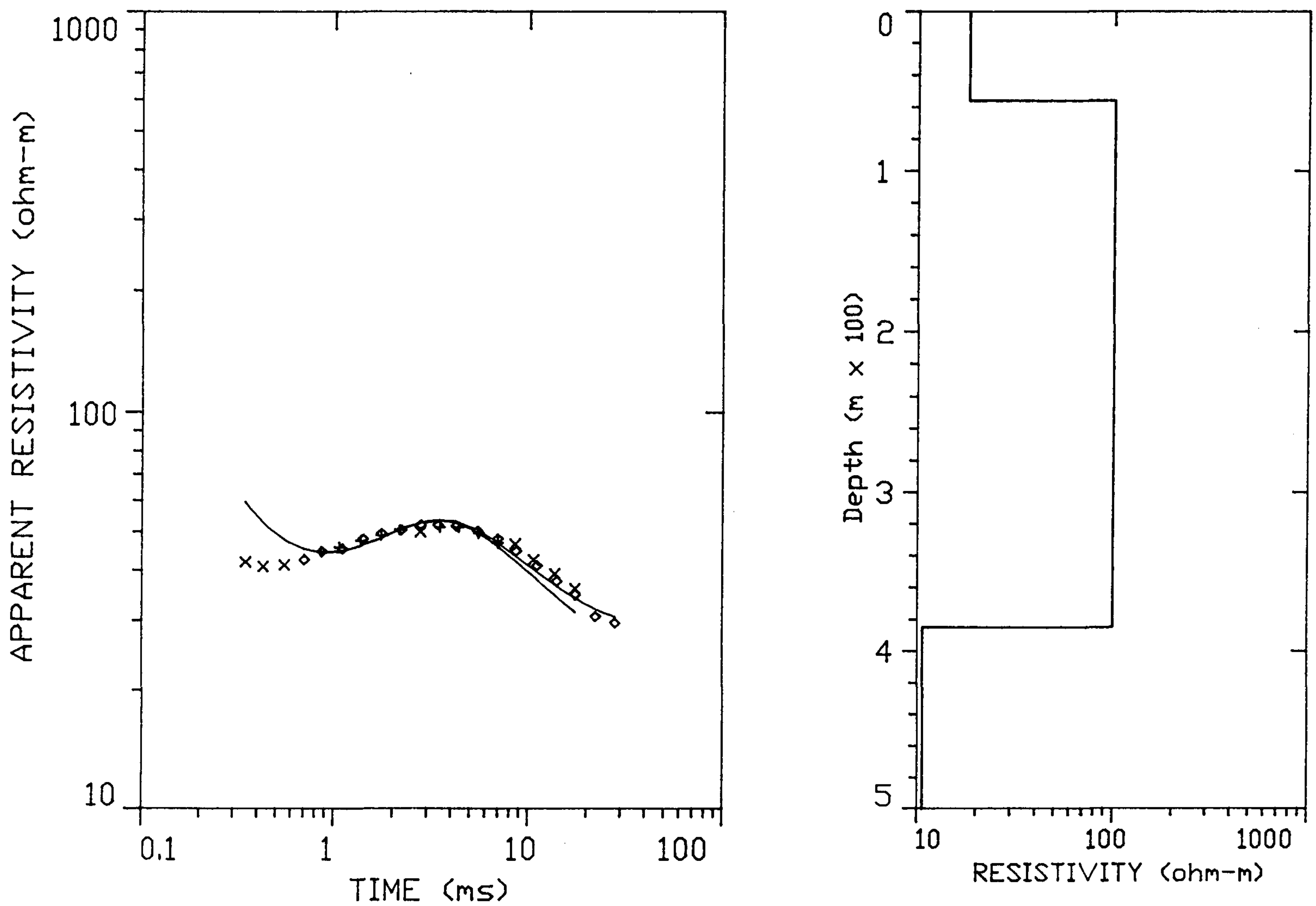
TDEM SURVEY LOCATION MAP
SOUNDING 11 – DESERET #1
NARCOOSSEE NE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC –11	5.12-1
DRAWN BY:	SBG	DATE:	06/17/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

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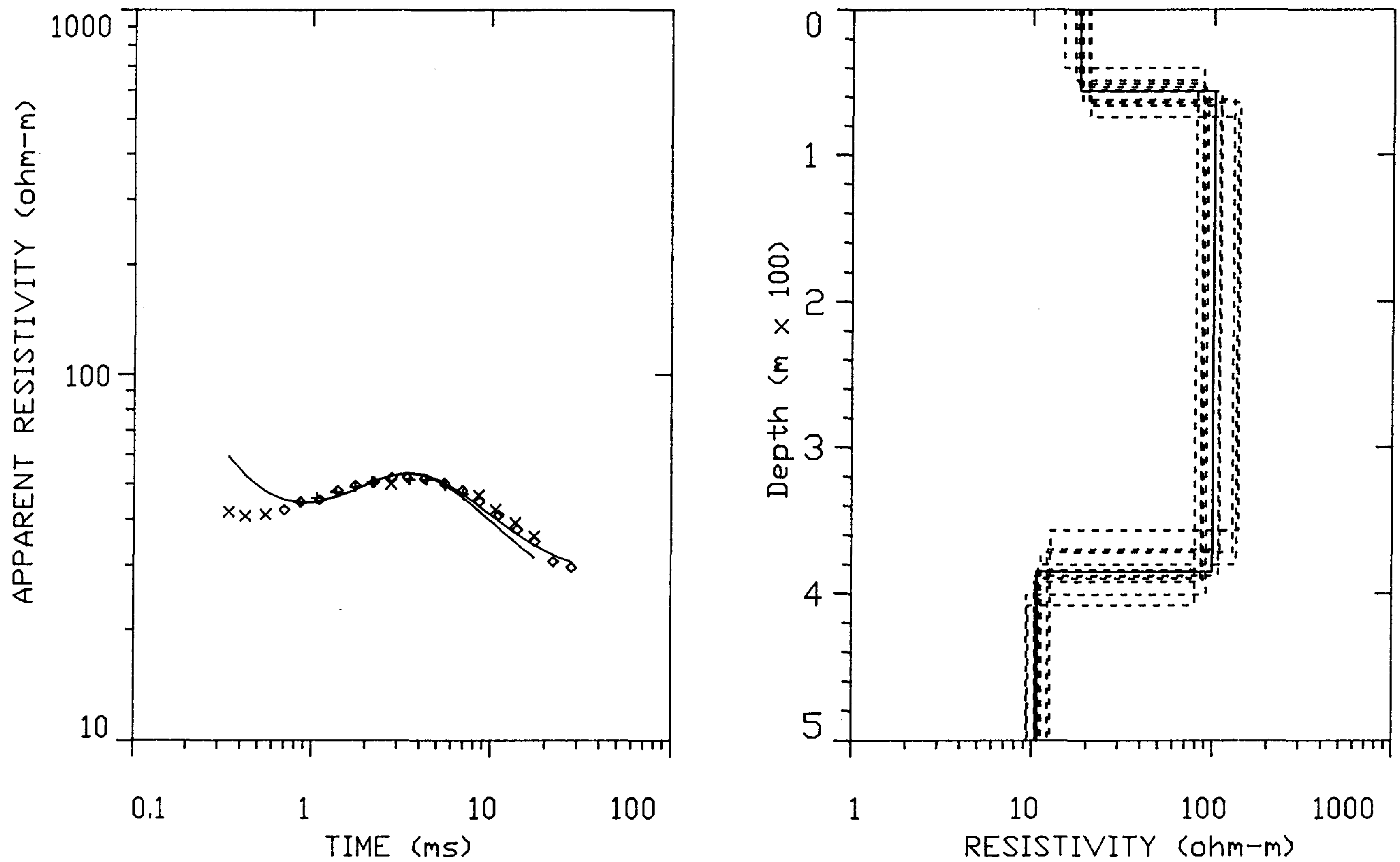
MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 11 – DESERET #1
NARCOOSSEE NE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-11	5-12.2
DRAWN BY:	SBG	DATE:	08/10/93	

5-101



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

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PALATKA, FLORIDA

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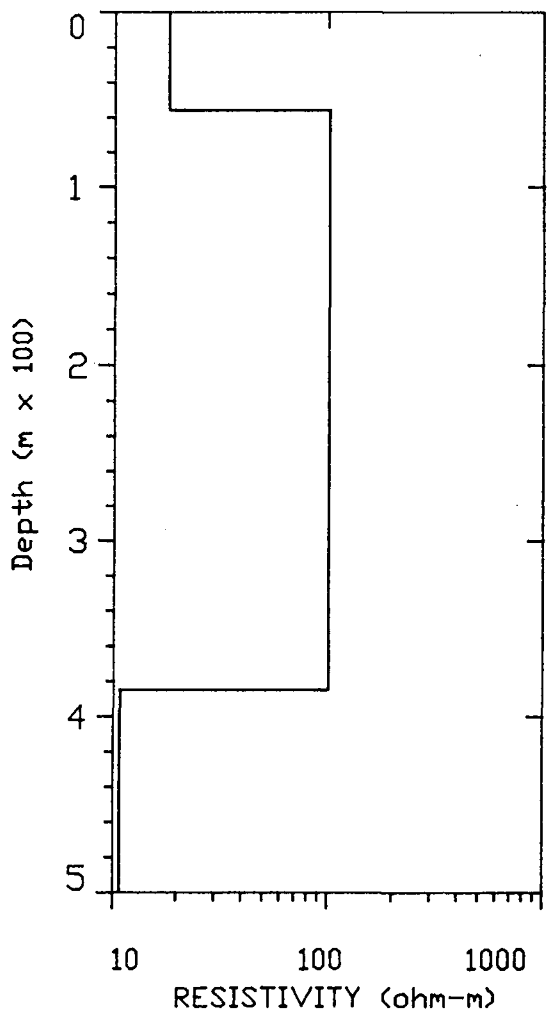
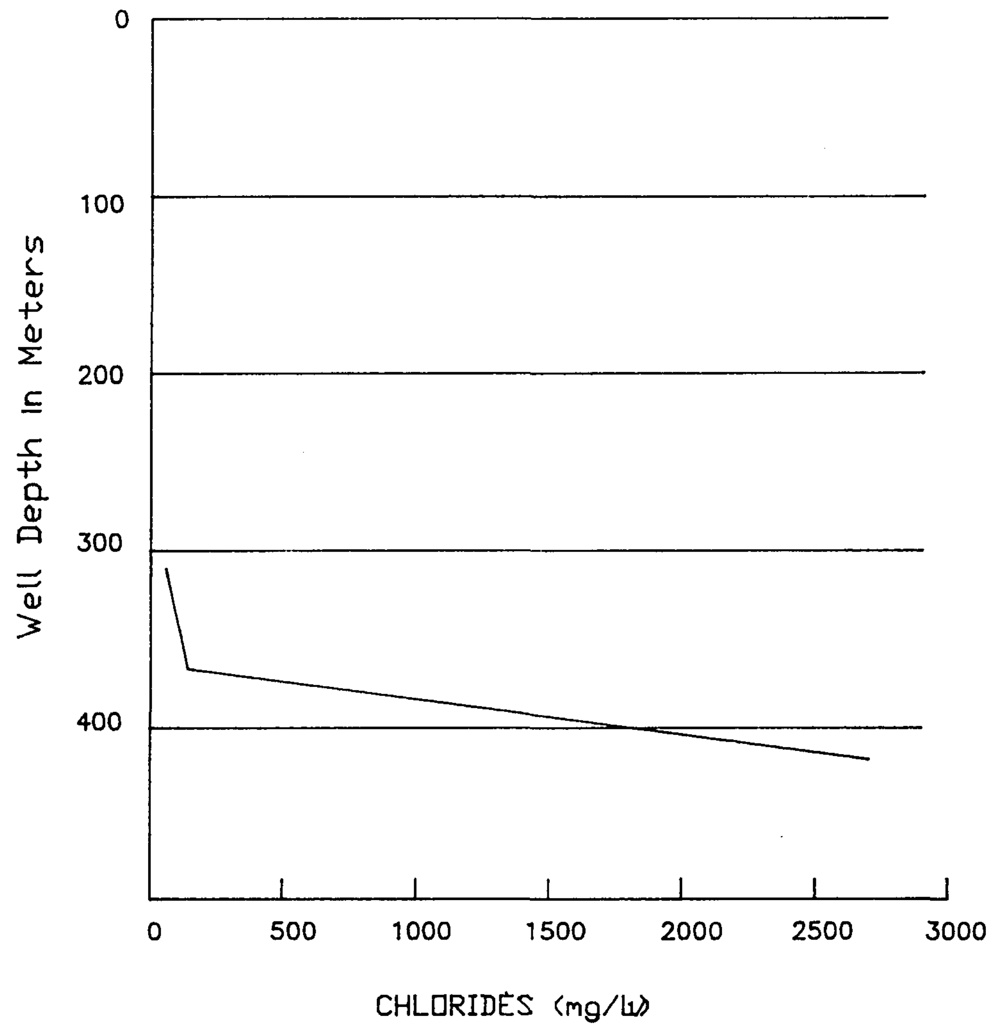
MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 11 - DESERET #1
NARCOOSSEE NE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-11	5.12-3
DRAWN BY:	SBG	DATE:	06/25/93	





1/ ADAPTED FROM INFORMATION PROVIDED BY SJRWMD PERSONNEL

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COMPARISON OF TDEM RESULTS TO WATER QUALITY
RESULTS FROM MONITOR WELL COCOA C – SOUNDING 11
DESERET #1 – NARCOOSSEE NE, FL

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	CHL–11	5.12–4
DRAWN BY:	SBG	DATE:	08/10/93	

CLIENT: SJWRMD
LOCATION: DESERET #1
COUNTY: ORANGE COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 305.000 m by 457.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 05-05-93
SOUNDING: 1
ELEVATION: 21.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.192 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			21.00	
1	18.11	55.83	-34.83	3.08
2	101.1	328.9	-363.8	3.25
3	10.69			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	14.708	18.115	20.610
	2	80.136	101.110	140.288
	3	9.336	10.691	12.683
THICK	1	39.917	-1.146	73.873
	2	292.928	1.000	357.231
DEPTH	1	39.917	55.840	73.873
	2	356.714	384.818	408.038

CURRENT: 17.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 3 RAMP TIME: 242.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	64179.4	38094.6	40.64 MASKED
2	0.427	39473.3	26920.8	31.80 MASKED
3	0.550	20695.3	16616.4	19.70 MASKED

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 11
DESERET #1

PROJECT NO.: 93742
TABLE 5.12-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.698	10900.0	9911.9	9.06
5	0.869	5854.1	5907.2	-0.908
6	1.10	3119.7	3174.0	-1.73
7	1.40	1585.9	1672.4	-5.45
8	1.75	869.5	905.2	-4.10
9	2.22	464.6	459.1	1.18
10	2.79	251.1	246.5	1.85
11	3.42	151.3	144.0	4.79
12	4.26	88.32	84.52	4.30
13	5.49	48.73	48.48	0.507
14	6.96	28.86	29.72	-2.96
15	8.66	18.59	19.48	-4.80
16	11.06	11.45	12.07	-5.44
17	14.00	7.27	7.60	-4.57
18	17.47	4.68	4.84	-3.31
19	22.23	3.09	2.91	5.90
20	28.10	1.82	1.73	5.02

CURRENT: 17.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 7 RAMP TIME: 242.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	6062.5	6112.8	-0.829
22	1.06	3390.4	3517.9	-3.76
23	1.37	1706.4	1786.4	-4.68
24	1.74	895.2	921.3	-2.91
25	2.17	491.8	491.1	0.132
26	2.77	272.3	252.6	7.24 MASKED
27	3.50	145.6	137.0	5.92
28	4.37	83.59	80.95	3.16
29	5.56	48.17	48.31	-0.295
30	6.98	29.80	30.60	-2.69
31	8.56	17.99	20.90	-16.16 MASKED
32	10.64	11.99	13.87	-15.63 MASKED
33	13.70	7.19	8.68	-20.68 MASKED
34	17.40	4.49	5.50	-22.42 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.95				
P 2	-0.04	0.53			
P 3	0.01	-0.10	0.84		
T 1	-0.08	-0.19	-0.01	0.82	
T 2	0.01	0.11	0.06	0.05	0.96
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 11
DESERET #1

PROJECT NO.: 93742
TABLE 5.12-1

5.13 TDEM SITE 12 - DESERET #2 SITE

5.13.1 Location Description and Geoelectrical Section

The site is located in central Orange County, Florida (Figure 5.13-1) and is 3.3 miles west of TDEM site 11. The site was within an abandoned orchard; no obvious signs of interference sources were present. The site is approximately 1,000 ft away from public supply wells Cocoa 14 and Cocoa 15 and 1,200 ft away from Cocoa C (Figure 5.13-1). The maximum depth of each of the wells is 761, 702 and 1,351 ft, respectively. Water quality results from the Cocoa C well show a measured chloride concentration of less than 250 mg/L to a depth of at least 1,224 ft and a value of 2,700 mg/L at a depth of 1,357 ft.

The Floridan aquifer begins at a depth of approximately 170 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The top of the Lower Floridan begins at an approximate depth of 1,100 ft below msl. The base of the Floridan aquifer occurs at approximately 2,600 ft below msl in this area (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.13-2. The interpreted geoelectrical section consists of a three-layer subsurface, similar to Site 11.

5.13.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above the third saltwater saturated layer. The first layer occurs at a depth of 46.2 m (152 ft) and not at the hydrostratigraphic contact (239 ft bls) between the Hawthorn Group and the Floridan aquifer System. The first layer has a low-resistivity value (16.5 ohm-m) and is considered to represent the upper portion of the Hawthorn Group and surficial sediments. The second layer has a high-resistivity value (957 ohm-m) and a thickness of 314 m (1,030 ft) and is considered to represent a combined but indistinguishable (geoelectrical) layer consisting of a portion of the Hawthorn Group and part of the Floridan aquifer. The third layer is considered to represent a saltwater saturated Floridan aquifer at a depth of 1,181 ft. The depth to the interpreted low resistivity (saltwater) layer at 1,181 ft is in agreement with the position of a higher chloride value in the Cocoa C well and with the 1,263 ft depth at nearby Site 11.

5.13.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 15.5 ohm-m, is interpreted to represent moderately salty water. It occurs at a depth of 1,181 ft (-1,112 ft msl). This is in agreement with water quality results from the Cocoa C well, 1,200 ft away. Because the resistivity of layer 2 (957 ohm-m) is interpreted to represent freshwater within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is 50 ft below the depth of the geoelectrical interface, or at 1,231 ft depth (-1,162 ft msl). The resistivity of layer 3 (15.5 ohm-m) corresponds to a chloride concentration of 1,922 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of expected high chlorinity gradients, this value is sufficiently close to 5,000 mg/L that they represent the same effective depth.

5.13.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from part of the overlying Hawthorn Group, the effective chloride concentration of Layer 2 cannot be calculated. Water quality results from the Cocoa C well places the 250 mg/L isochlor at approximately 1,250 ft bls (Figure 5.13-4).

5.13.5 Accuracy of Measurement and Interpretation

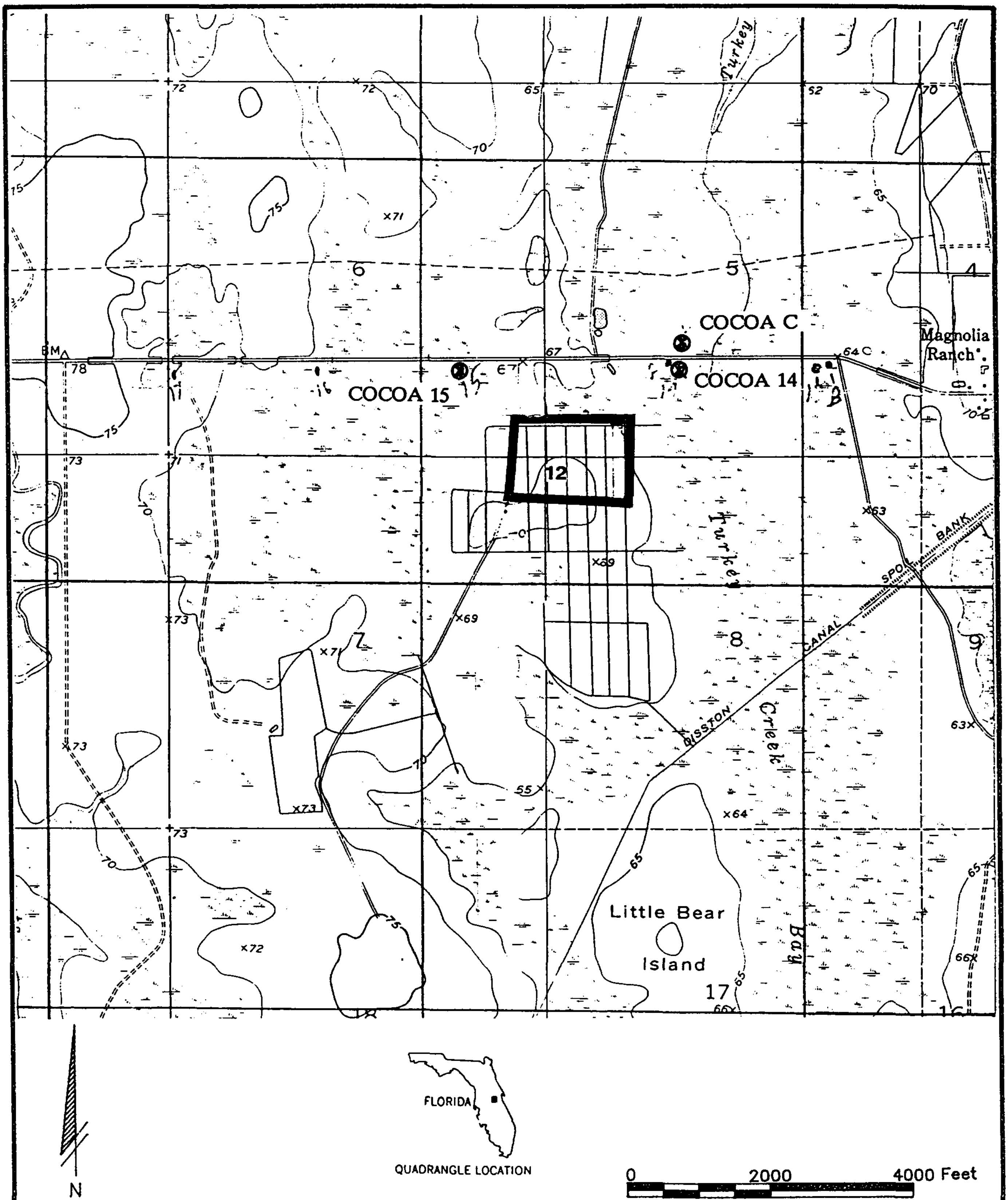
Figure 5.13-3 is the equivalence analysis at this site, and the inversion table (Table 5.13-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 25 m (82 ft) which is 7% of the total depth. The resistivity of this layer has a range of from 13.5 - 20.1 ohm-m. This corresponds to a range in interpreted chloride content of from 2,229 mg/L to 1,447 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 538 - 3,027 ohm-m. A corresponding chloride concentration cannot be determined because Layer 2 is in part comprised of the Hawthorn Group.

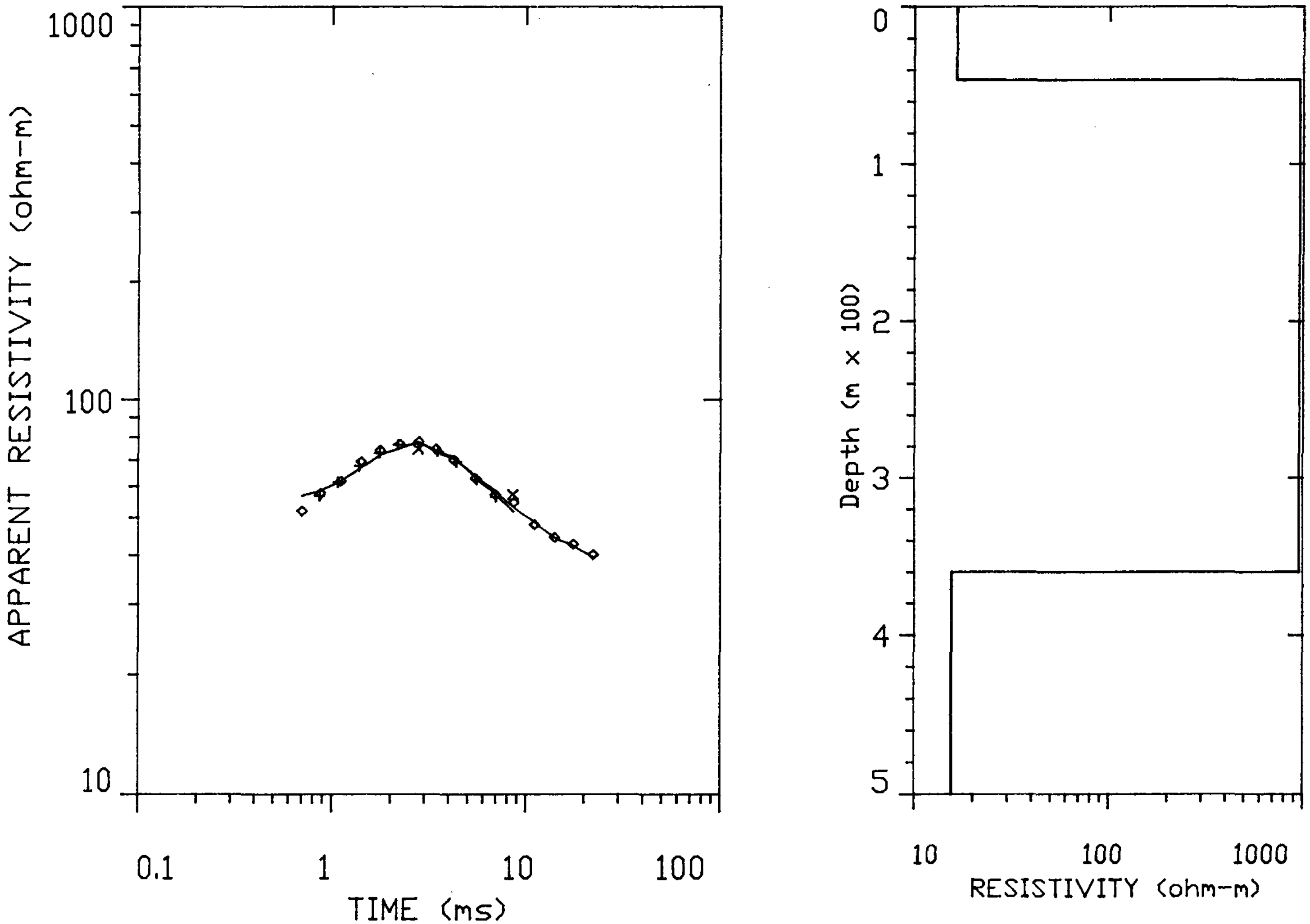
5.13.6 <u>Summary of TDEM Sounding at Deseret #2 (Site 12)</u>

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,231 ft (-1,162 ft msl) and occur in the Lower Floridan aquifer. The estimated depth correlates well to the estimated depth based on water quality in a nearby well. The measured layer resistivity at this level yields a chloride concentration of only 1,922 mg/L, but we assume that this is sufficiently close to 5,000 mg/L that the derived depth is applicable to the saltwater interface depth.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow part of the overlying Hawthorn Group to be distinguished from the Floridian Aquifer System.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 12 – DESERET #2 NARCOOSSEE NW, FLORIDA

DESIGNED BY: MJW	PROJECT NO.: 93742	FIGURE
CHECKED BY: RJW	DRAWING NO.: LOC – 12	5.13-1
DRAWN BY: SBG	DATE: 06/17/93	



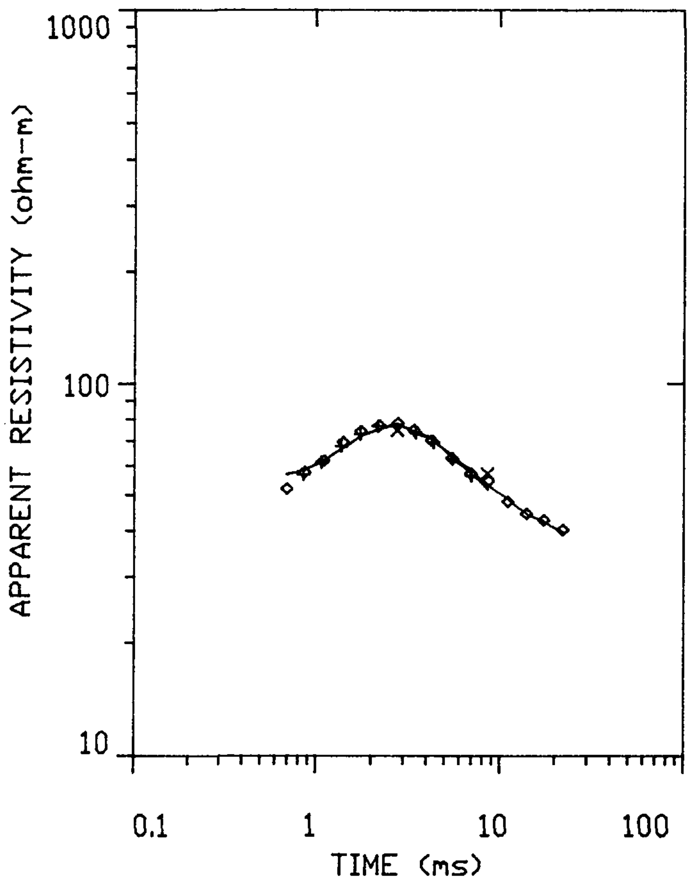
—	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

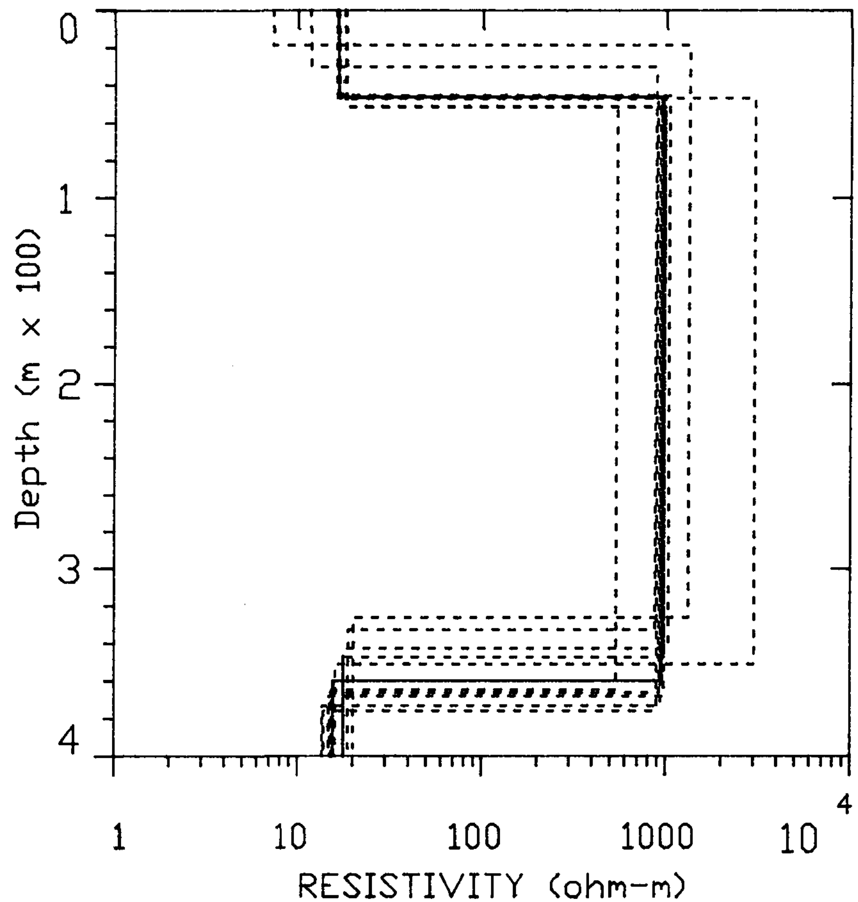
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 12 - DESERET #2
NARCOOSSEE NW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-12	5-13.2
DRAWN BY:	SBG	DATE:	09/16/93	





BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

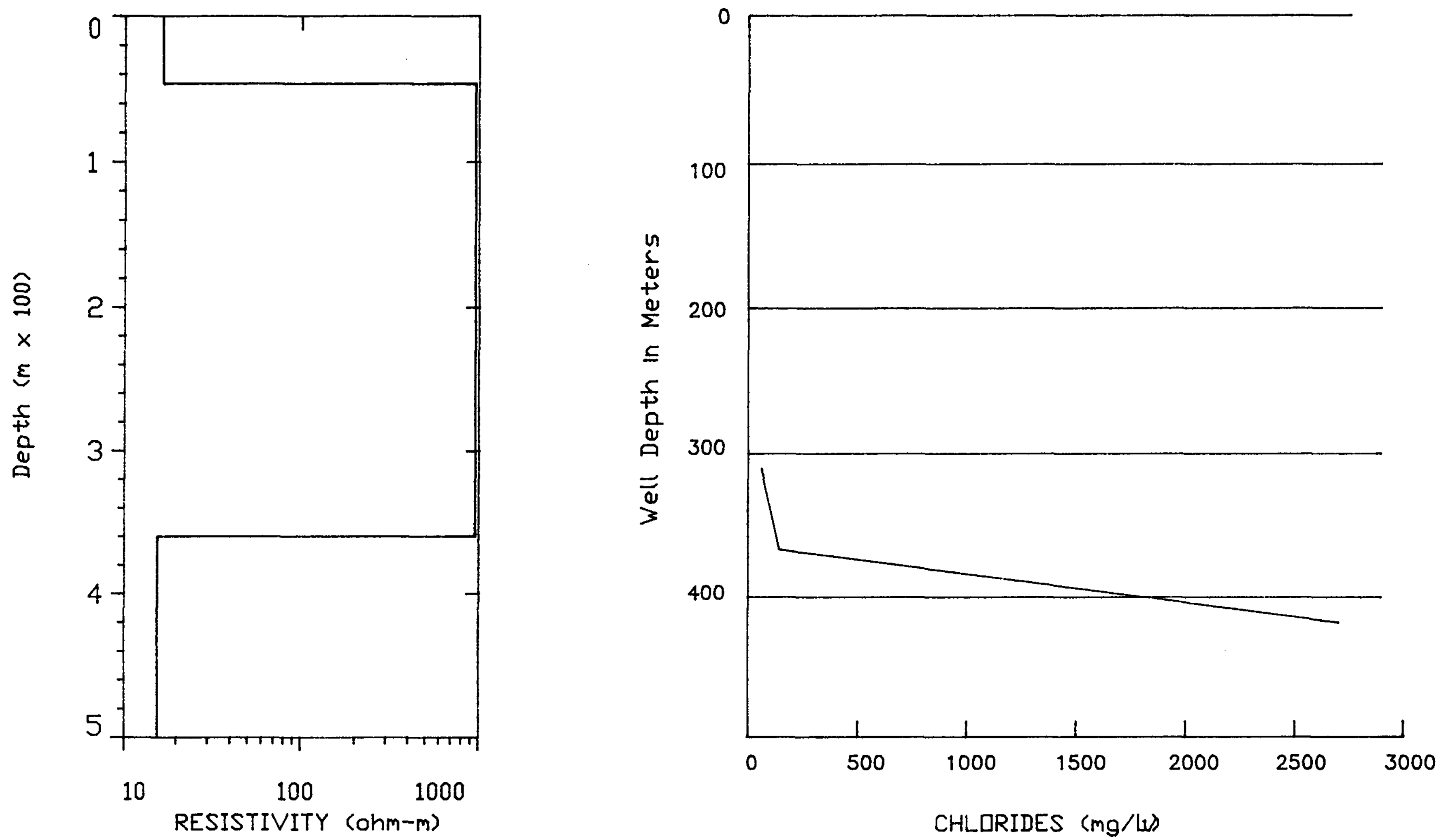
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 12 - DESERET #2
NARCOOSSEE NW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-12	5.13-3
DRAWN BY:	SBG	DATE:	09/16/93	



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

COMPARISON OF TDEM RESULTS TO WATER QUALITY RESULTS FROM MONITOR WELL COCOA C – SOUNDING 12
DESERET #2 – NARCOOSSEE NW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	CHL–12	5.13–4
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT:	SJWRMD	DATE:	05-05-93
LOCATION:	DESERET #2	SOUNDING:	1
COUNTY:	ORANGE COUNTY, FLORIDA	ELEVATION:	21.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	480.000 m by 325.000 m	AZIMUTH:	

COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 3.854 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			21.00	
1	16.47	46.21	-25.21	2.80
2	957.2	313.7	-338.9	0.327
3	15.51			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	7.308	16.471	18.232
	2	538.329	957.299	3027.245
	3	13.544	15.514	20.061
THICK	1	18.633	0.269	51.768
	2	297.173	1.000	329.000
DEPTH	1	18.633	46.212	51.768
	2	326.210	359.969	375.805

CURRENT:	16.75 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	7.50 Hz	GAIN: 3	RAMP TIME:	252.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.698	8775.1	7665.3	12.64
2	0.869	4340.6	4240.3	2.30
3	1.10	2123.8	2123.0	0.0375

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 12 DESERET #2
		PROJECT NO.: 93742
		TABLE 5.13-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	1.40	990.6	1044.3	-5.42
5	1.75	515.8	539.0	-4.50
6	2.22	269.9	278.4	-3.15
7	2.79	148.9	149.4	-0.347
8	3.42	95.56	96.93	-1.42
9	4.26	60.78	59.02	2.88
10	5.49	37.98	37.10	2.32
11	6.96	24.19	23.39	3.29
12	8.66	14.99	15.69	-4.64
13	11.06	9.89	9.66	2.36
14	14.00	6.14	6.18	-0.538
15	17.47	3.74	3.79	-1.22
16	22.23	2.24	2.30	-2.65

CURRENT: 16.75 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 252.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
17	0.857	4599.7	4410.3	4.11
18	1.06	2369.9	2372.7	-0.118
19	1.37	1093.8	1125.5	-2.89
20	1.74	537.5	548.9	-2.12
21	2.17	287.6	297.6	-3.45
22	2.77	162.5	153.1	5.76 MASKED
23	3.50	92.47	93.14	-0.730
24	4.37	58.10	56.95	1.98
25	5.56	37.11	37.07	0.103
26	6.98	24.49	24.04	1.80
27	8.56	14.39	16.73	-16.24 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.96				
P 2	0.02	0.01			
P 3	0.01	-0.03	0.84		
T 1	-0.05	-0.01	0.03	0.94	
T 2	0.00	0.03	0.05	0.00	0.98
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 12
DESERET #2

PROJECT NO.: 93742
TABLE 5.13-1

5.14 TDEM SITE 13 - UNIVERSITY OF CENTRAL FLORIDA (UCF) SITE

5.14.1 Location Description and Geoelectrical Section

The site is located in Orange County, Florida (Figure 5.14-1) on the University of Central Florida campus. The site is located in a wooded area with no obvious sources of interference and approximately 4 miles from a previous TDEM sounding (Site 10; CEES, 1992).

The Floridan aquifer begins at an approximate depth of 115 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The top of the Lower Floridan aquifer begins at a depth of approximately 1,000 ft below msl. The base of the Floridan aquifer approximately occurs at 2,400 ft below msl in this area (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.14-2. The interpreted geoelectrical section consists of a three-layer subsurface similar to nearby Sites 11 and 12.

5.14.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above the third saltwater saturated layer. The first layer occurs at a depth of 38 m (125 ft) and not at the hydrostratigraphic contact (181 ft bls) between the Hawthorn Group and the Floridan aquifer System. The first layer has a low-resistivity value (24 ohm-m) and a thickness of 38 m (125 ft). It is considered to represent the upper portion of the Hawthorn Group and surficial sediments. The interpreted thickness and resistivity compares well with that obtained at the site 10 (CEES, 1992) sounding (26 ohm-m and 124 ft). The second layer has a high-resistivity value (534 ohm-m) and a thickness of 396 m (1,299 ft). It is considered to represent a combined but indistinguishable (geoelectrical) layer consisting of a portion of the Hawthorn Group and part of the Floridan aquifer. The third layer is considered to represent a saltwater saturated Floridan aquifer at a depth of 1,423 ft. The depth to the interpreted low resistivity (saltwater) layer at 1,423 ft is in agreement with the position of this same layer from the 1992 sounding (1,556 ft).

5.14.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 5.5 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,423 ft (-1,357 ft msl). Because the resistivity of layer 2 (534 ohm-m) is interpreted to represent freshwater within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is 50 ft below the depth of the geoelectrical interface, or at 1,473 ft depth (-1,407 ft msl). The resistivity of layer 3 (5.5 ohm-m) corresponds to a chloride content of 5,695 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.14.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from part of the overlying Hawthorn Group, the effective chloride concentration of Layer 2 cannot be calculated. A chloride concentration of less than 250 mg/L was mapped in the area of the site by Sprinkle (1981).

5.14.5 Accuracy of Measurement and Interpretation

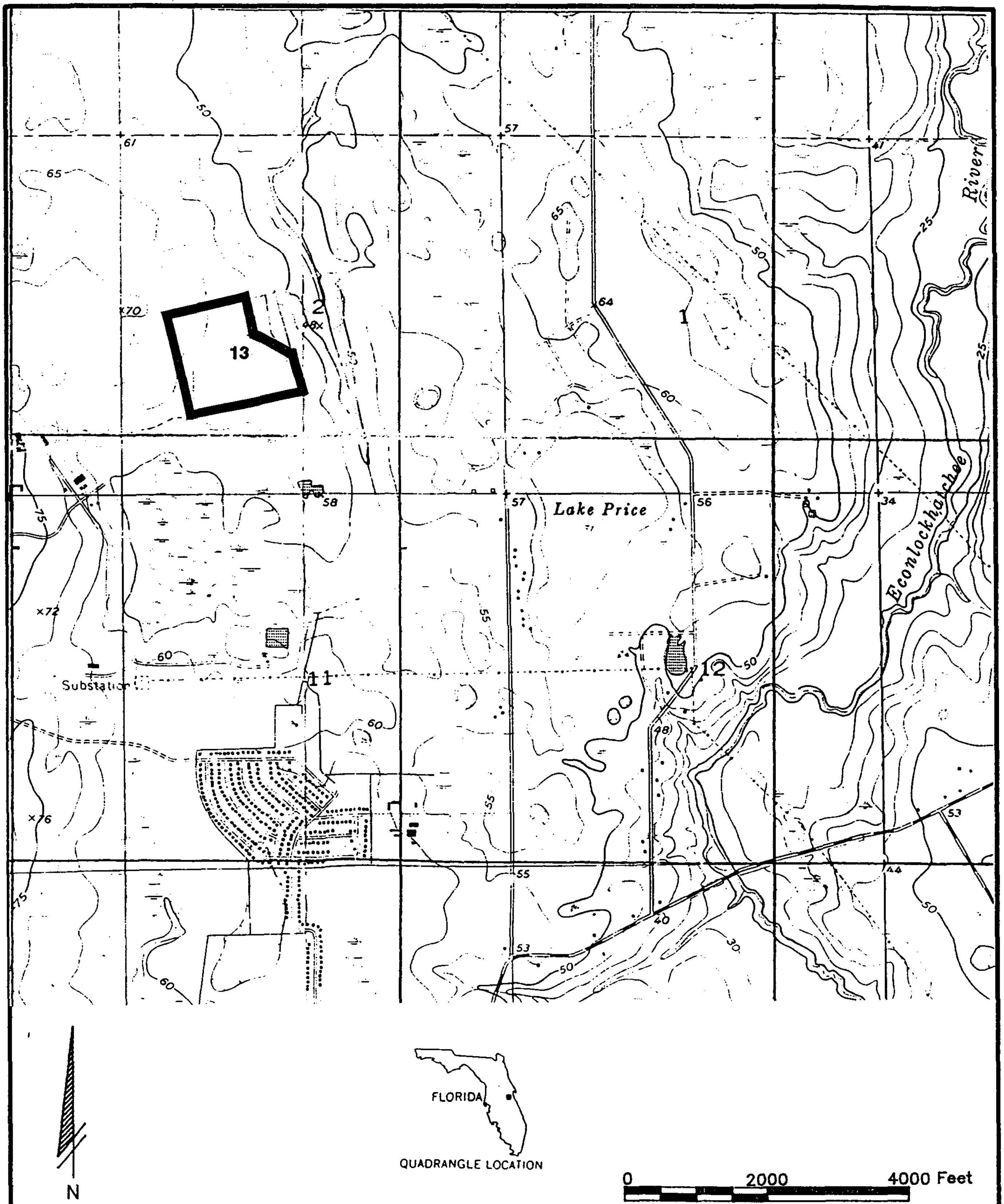
Figure 5.14-3 is the equivalence analysis at this site, and the inversion table (Table 5.14-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about 10 m (33 ft) which is 2% of the total depth. The resistivity of this layer has a well-constrained range of from 4.7 - 6.4 ohm-m. This corresponds to a range in interpreted chloride content of from 6,690 mg/L to 4,872 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 399 - 955 ohm-m. A corresponding chloride concentration cannot be determined because Layer 2 is in part comprised of the Hawthorn Group.

5.14.6 Summary of TDEM Sounding at UCF (Site 13)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,473 ft (-1,407 ft msl) and occur within the Lower Floridan aquifer. The measured layer resistivity at this level yields a chloride concentration of 5,695 mg/L. The results of the TDEM survey are in agreement with other water quality studies conducted in the area of the site.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow part of the overlying Hawthorn Group to be distinguished from the Floridian Aquifer System.

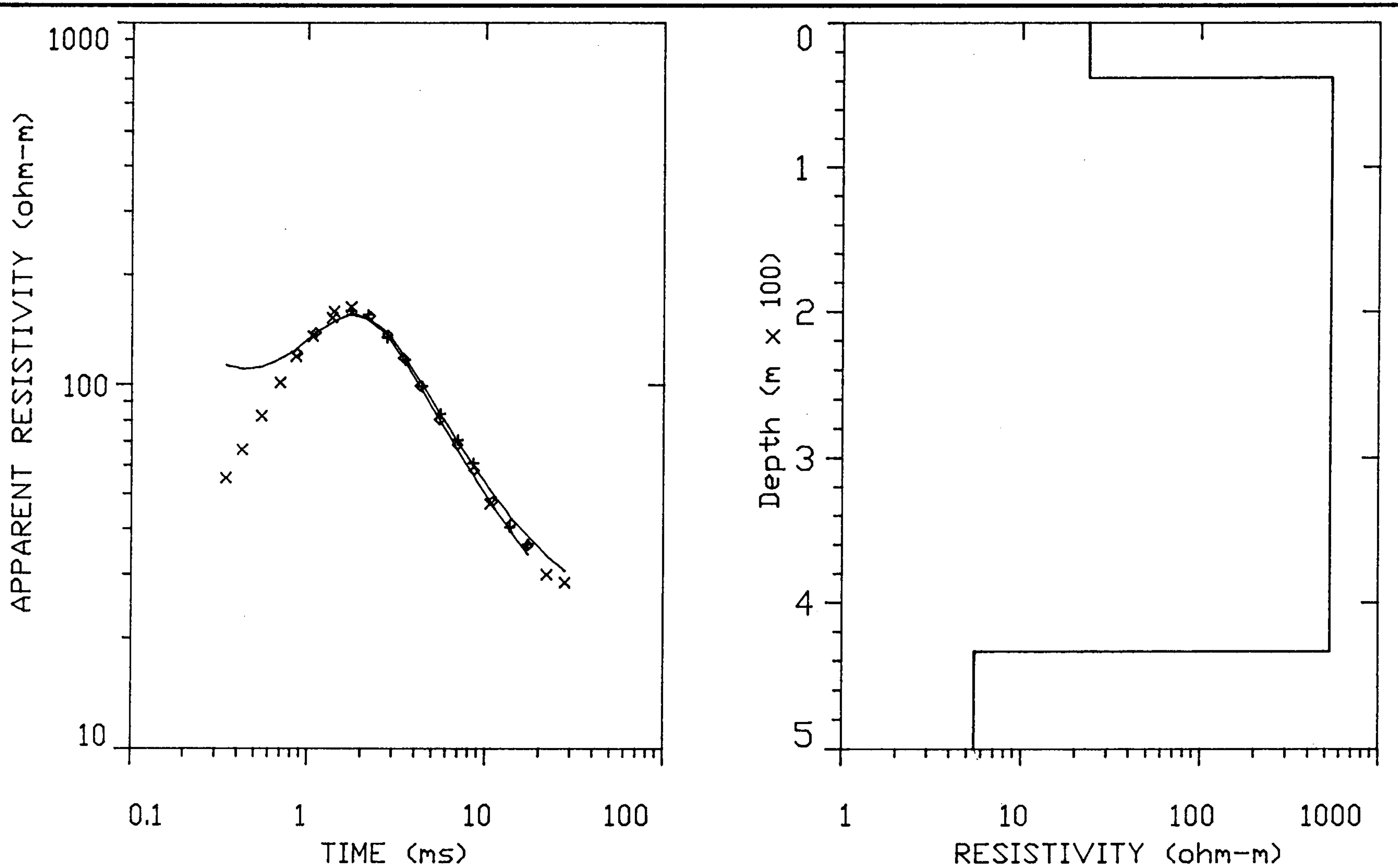


ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 13 – UNIVERSITY OF CENTRAL FLORIDA
OVIEDO SW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-13	5.14-1
DRAWN BY:	SBG	DATE:	06/17/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

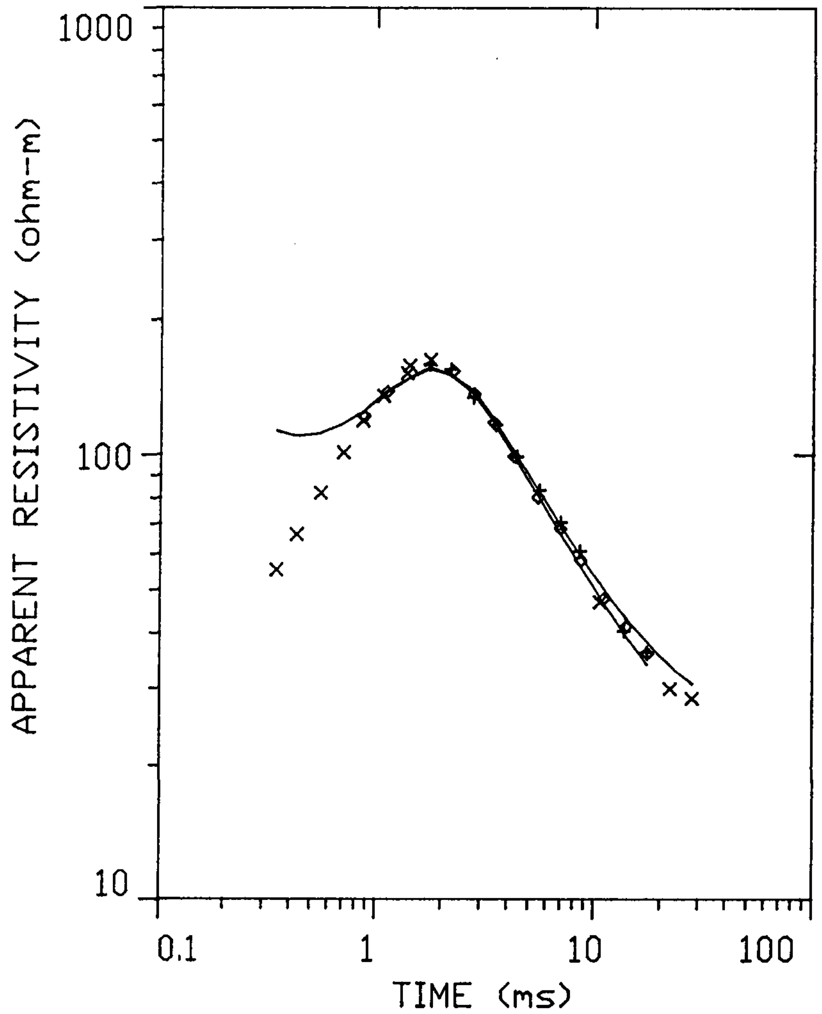
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

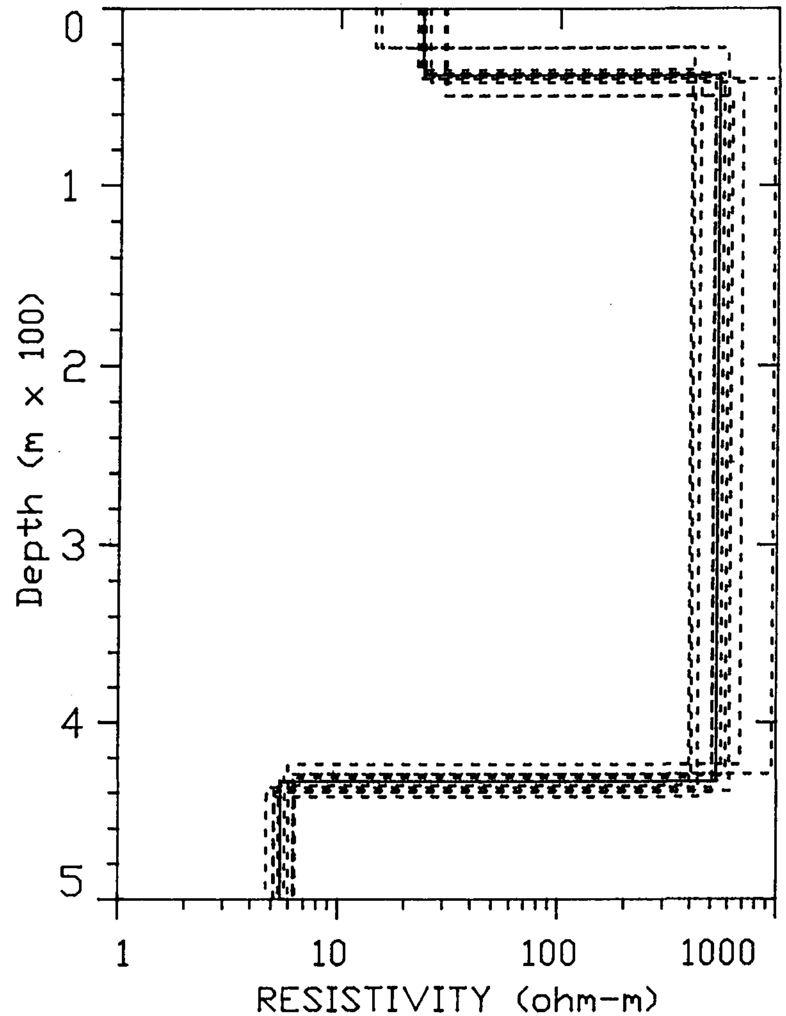
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 13 – UNIVERSITY OF CENTRAL FLORIDA
OVIEDO SW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-13	5-14.2
DRAWN BY:	SBG	DATE:	08/10/93	





——— BEST-FIT MODELED CURVE □ APPARENT RESISTIVITY VALUES USED IN MODEL X APPARENT RESISTIVITY VALUES NOT USED IN MODEL	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 13 - UNIVERSITY OF CENTRAL FLORIDA OVIEDO SW, FLORIDA		
			DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EQU-13 DATE: 06/25/93	FIGURE 5.14-3

CLIENT: SJWRMD
LOCATION: UNIVERSITY OF CENTRAL FLORIDA
COUNTY: ORANGE COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 381.000 m by 457.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 06-05-93
SOUNDING: 1
ELEVATION: 20.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 5.673 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			20.00	
1	23.60	37.80	-17.80	1.60
2	534.0	395.6	-413.4	0.740
3	5.49			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	14.370	23.605	30.255
	2	399.364	534.065	955.093
	3	4.728	5.494	6.384
THICK	1	21.939	-2.938	49.622
	2	381.717	1.000	409.431
DEPTH	1	21.939	37.803	49.622
	2	423.732	433.496	441.995

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 3 RAMP TIME: 272.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	48482.4	16647.8	65.66 MASKED
2	0.427	21861.0	10219.7	53.25 MASKED
3	0.550	8422.0	5312.2	36.92 MASKED

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 13
UNIVERSITY OF CENTRAL FLORIDA

PROJECT NO.: 93742
TABLE 5.14-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.698	3393.4	2717.0	19.93 MASKED
5	0.869	1489.0	1423.6	4.39
6	1.10	667.5	664.1	0.504
7	1.40	302.9	332.8	-9.87 MASKED
8	1.75	166.8	176.1	-5.60 MASKED
9	2.22	100.3	103.3	-2.89
10	2.79	67.62	66.31	1.94
11	3.42	50.74	48.99	3.44
12	4.26	38.05	36.46	4.17
13	5.49	27.65	25.88	6.39
14	6.96	19.46	18.87	3.04
15	8.66	14.36	13.89	3.29
16	11.06	10.45	9.71	7.00
17	14.00	7.19	6.80	5.47
18	17.47	5.09	4.68	7.96
19	22.23	3.68	3.08	16.31 MASKED
20	28.10	2.21	1.97	10.74 MASKED

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 272.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	1587.9	1487.5	6.32 MASKED
22	1.06	761.7	751.2	1.37 MASKED
23	1.37	341.1	357.6	-4.82 MASKED
24	1.74	175.4	180.8	-3.09
25	2.17	104.7	109.6	-4.66
26	2.77	70.72	68.91	2.56
27	3.50	48.73	49.18	-0.925
28	4.37	35.80	36.79	-2.78
29	5.56	25.36	26.99	-6.40
30	6.98	18.43	20.20	-9.59
31	8.56	13.79	15.40	-11.69
32	10.64	11.84	11.53	2.60 MASKED
33	13.70	7.87	8.07	-2.51
34	17.40	5.09	5.61	-10.10

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.88				
P 2	0.02	0.14			
P 3	0.03	-0.07	0.79		
T 1	-0.13	-0.08	0.04	0.84	
T 2	0.01	0.02	0.01	0.01	1.00
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 13 UNIVERSITY OF CENTRAL FLORIDA PROJECT NO.: 93742 TABLE 5.14–1

5.15 TDEM SITE 14 - RICHLAND PROPERTIES SITE

5.15.1 Location Description and Geoelectrical Section

The site is located within a pasture in Orange County, Florida (Figure 5.15-1). Power lines were present approximately three-quarters of a mile to the east and west of the site. Quality control soundings made during the survey indicate that the power lines did not have a significant affect on survey results (Figure 5.15-4). Noticeable scatter was evident in late-time data, however, data from these late-times were not used in the modeling of the geoelectric section.

The Floridan aquifer begins at an approximate depth of 135 ft below msl and is overlain by the Hawthorn Group and surficial sediments (Scott et al., 1991). The top of the Lower Floridan aquifer begins at approximately 1,050 ft below msl. The base of the Floridan aquifer occurs at approximately 2,400 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.15-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.15.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above the third saltwater saturated layer. The first layer occurs at a depth of 39 m (128 ft) and not at the hydrostratigraphic contact (220 ft bls) between the Hawthorn Group and the Floridan aquifer System. The first layer has a low-resistivity value (16.5 ohm-m) and is considered to represent the upper portion of the Hawthorn Group and surficial sediments. The second layer has a high-resistivity value (2,551 ohm-m) and a thickness of 546 m (1,791 ft). It is considered to represent a combined but indistinguishable (geoelectrical) layer consisting of a portion of the Hawthorn Group and part of the Floridan aquifer. The third layer is considered to represent a saltwater saturated Floridan aquifer at a depth of 1,919 ft.

5.15.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 2.8 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,919 ft (-1,834 ft msl). Because the resistivity of layer 2 (2,551 ohm-m) is interpreted to represent fresh water within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is 50 ft below the depth of the geoelectrical interface, or at 1,969 ft depth (-1,884 ft msl). The resistivity of layer 3 (2.8 ohm-m) corresponds to a chloride content of 11,334 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.15.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from part of the overlying Hawthorn Group, the effective chloride concentration of Layer 2 cannot be calculated. A chloride concentration of less then 250 mg/L was mapped in the area of the site by Sprinkle (1981).

5.15.5 Accuracy of Measurement and Interpretation

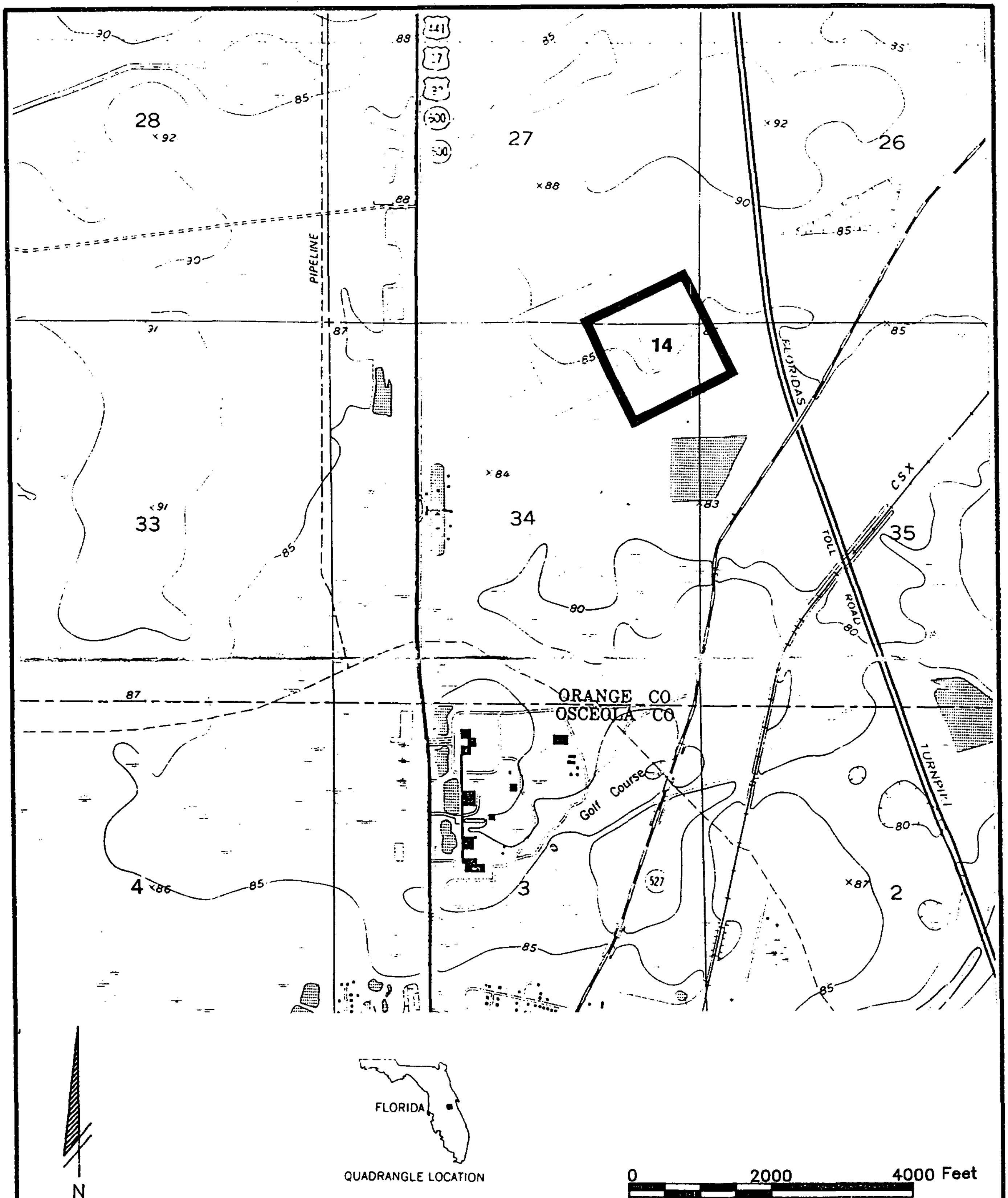
Figure 5.15-3 is the equivalence analysis at this site, and the inversion table (Table 5.15-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 33 m (108 ft), which is 6% of the total depth. The resistivity of this layer has a poorly-constrained range of from 2.3 - 7.0 ohm-m. This corresponds to a range in interpreted chloride content of from 13,831 mg/L to 4,442 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is from 1,007 - 7,112 ohm-m. A corresponding chloride concentration cannot be determined because Layer 2 is in part comprised of the Hawthorn Group.

5.15.6 <u>Summary of TDEM Sounding at Richland Properties (Site 14)</u>

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,969 ft (-1,884 ft msl) and occurs within the Lower Floridan aquifer. The measured layer resistivity at this level suggests a chloride concentration of 11,334 mg/L.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow part of the overlying Hawthorn Group to be distinguished from the Floridian Aquifer System.

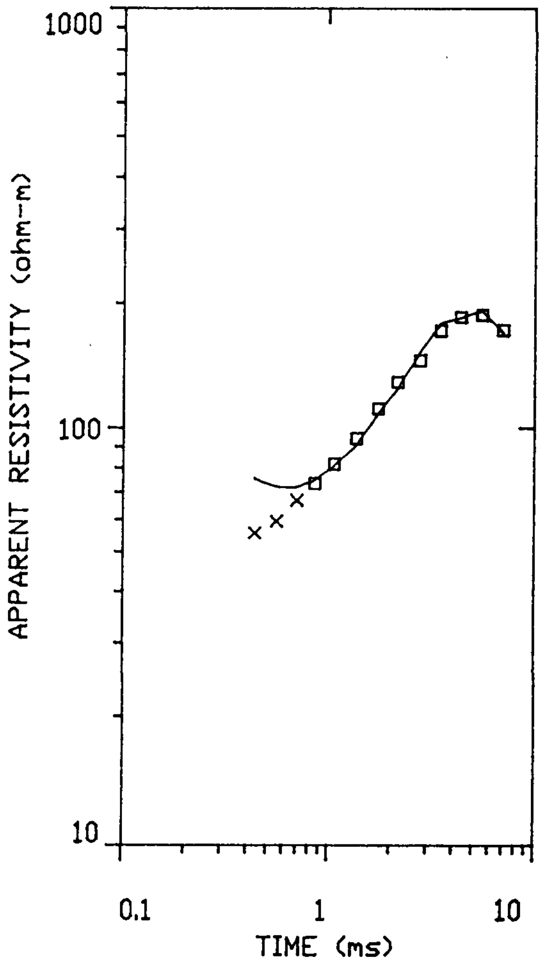


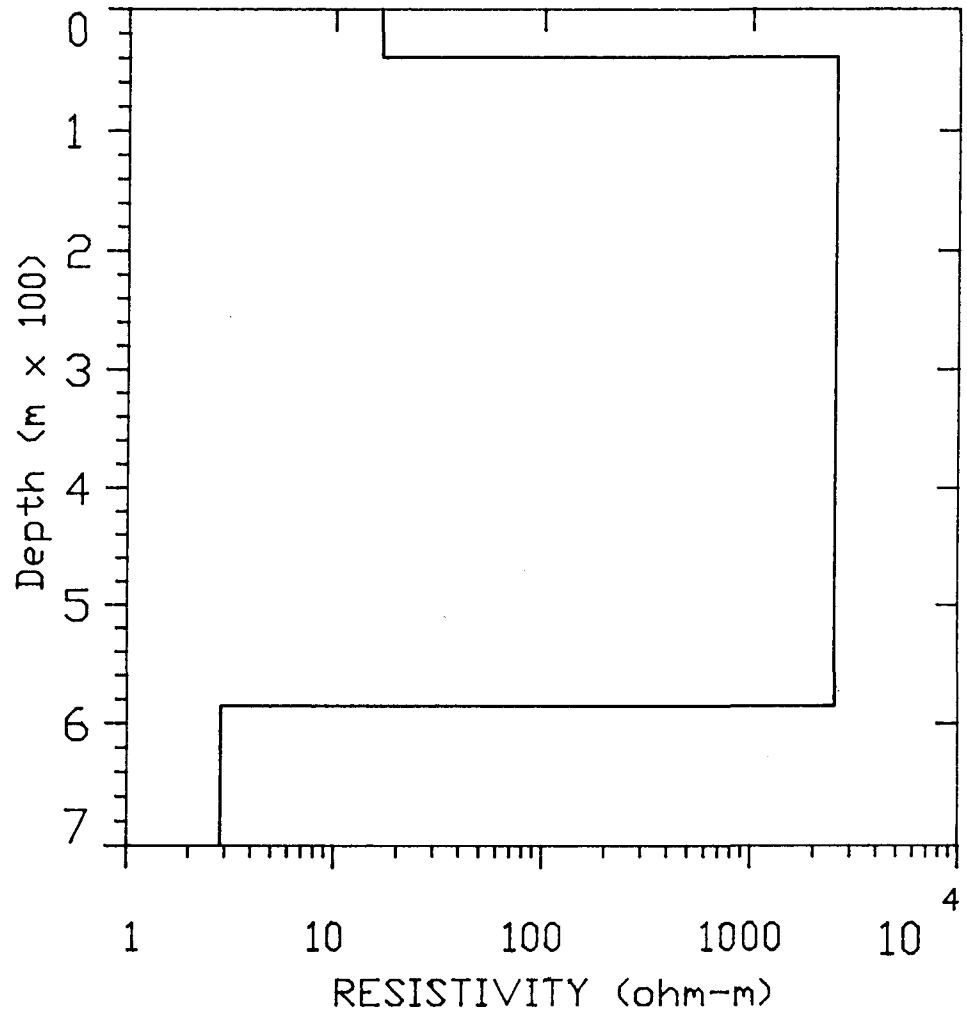
ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 14 – RICHLAND PROPERTIES
KISSIMMEE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC –14	5.15-1
DRAWN BY:	SBG	DATE:	06/17/93	





——	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

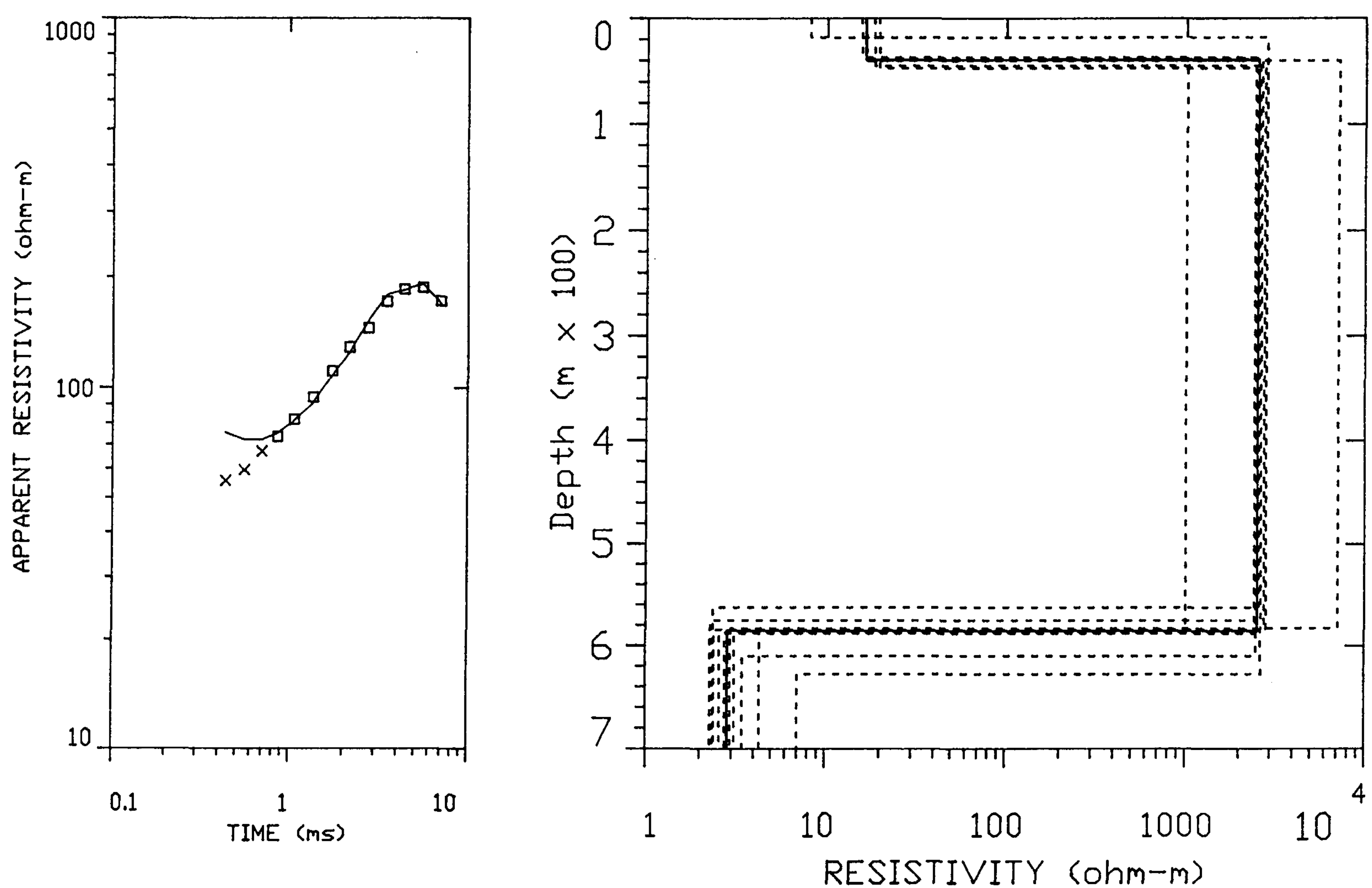
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII

SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

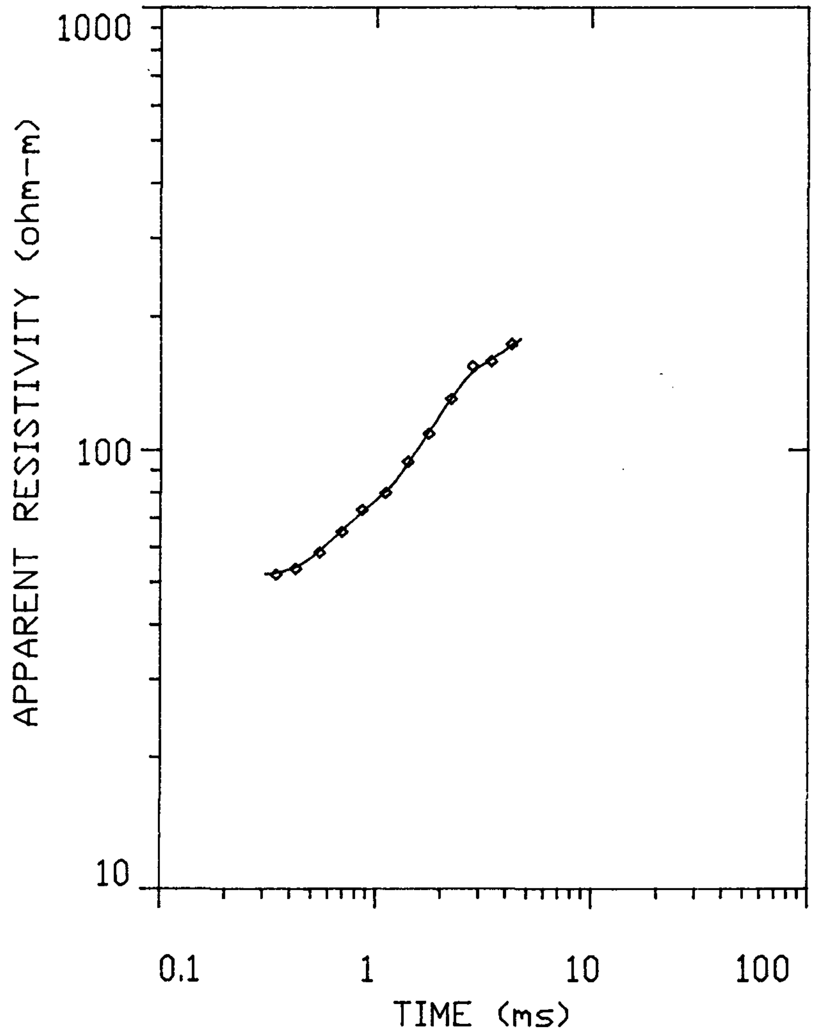
MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 14 – RICHLAND PROPERTIES
KISSIMMEE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-14	5-15.2
DRAWN BY:	SBG	DATE:	08/10/93	



BEST-FIT MODELED CURVE □ APPARENT RESISTIVITY VALUES USED IN MODEL X APPARENT RESISTIVITY VALUES NOT USED IN MODEL	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 14 – RICHLAND PROPERTIES KISSIMMEE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-14	5.15-3
DRAWN BY:	SBG	DATE:	06/25/93	



□ APPARENT RESISTIVITY VALUES
—— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

QUALITY CONTROL– APPARENT RESISTIVITY VALUES
SOUNDING 14 – RICHLAND PROPERTIES
KISSIMMEE, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–14	5.15–4
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT: SJWRMD
LOCATION: RICHLAND PROPERTIES
COUNTY: ORANGE COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 457.000 m by 457.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 07-05-93
SOUNDING: 1
ELEVATION: 26.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.431 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			26.00	
1	16.46	39.37	-13.37	2.39
2	2551.4	545.8	-559.2	0.213
3	2.84			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	8.037	16.466	19.484
	2	1007.085	2551.418	7112.259
	3	2.269	2.840	6.975
THICK	1	18.155	-0.151	47.217
	2	522.762	1.000	589.838
DEPTH	1	18.155	39.375	47.217
	2	562.394	585.271	627.732

CURRENT: 15.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 2 RAMP TIME: 262.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.438	29918.4	18902.3	36.82 MASKED
2	0.558	14757.2	11088.9	24.85 MASKED
3	0.702	6967.7	6248.7	10.31 MASKED

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 14
RICHLAND PROPERTIES

PROJECT NO.: 93742
TABLE 5.15-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.858	3670.4	3566.9	2.82
5	1.06	1812.2	1841.5	-1.61
6	1.37	783.7	828.5	-5.71
7	1.74	336.2	350.9	-4.35
8	2.17	154.7	163.0	-5.35
9	2.77	70.07	65.64	6.33
10	3.50	30.49	28.63	6.10
11	4.37	15.59	15.72	-0.862
12	5.56	8.39	8.11	3.39
13	7.03	5.29	5.42	-2.45

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.98				
P 2	0.00	0.01			
P 3	0.01	-0.03	0.24		
T 1	-0.02	-0.02	0.03	0.98	
T 2	0.00	0.01	-0.07	0.00	0.98

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 14
RICHLAND PROPERTIES

PROJECT NO.: 93742
TABLE 5.15-1

5.16 TDEM SITE 15 - NEW SMYRNA BEACH SITE

5.16.1 Location Description and Geoelectrical Section

The site is situated in eastern Volusia County, Florida (Figure 5.16-1). The site was located in a grassy area within the New Smyrna Beach Municipal Airport. A buried steel pipe was present approximately 100 ft east of the Tx loop. QA soundings were performed 100 ft north, south, east and 80 ft west of the initial Rx coil location. Results from the QA soundings indicated that apparent resistivity values were not affected by any interference sources (Figure 5.16-4).

Together, Sites 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is either thin or absent. The top of the Floridan aquifer begins at approximately 80 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 750 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.16-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.16.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system layer, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (126 m = 413 ft) surface layer of intermediate to low (9.2 ohm-m) resistivity overlying a very low resistivity layer (2.3 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group and part of the Floridan aquifer exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 413 ft.

5.16.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 2.3 ohm-m, is interpreted to represent salt water. It occurs at a depth of 413 ft (-407 ft msl). Because the resistivity of layer 1 (9.2 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken at the depth of the geoelectrical interface, or at 413 ft depth (-407 ft msl). The resistivity of layer 2 (2.3 ohm-m) corresponds to a chloride content of 13,831 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.16.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Hawthorn Group and surficial aquifer system, the effective chloride concentration of layer 1 cannot be calculated.

5.16.5 Accuracy of Measurement and Interpretation

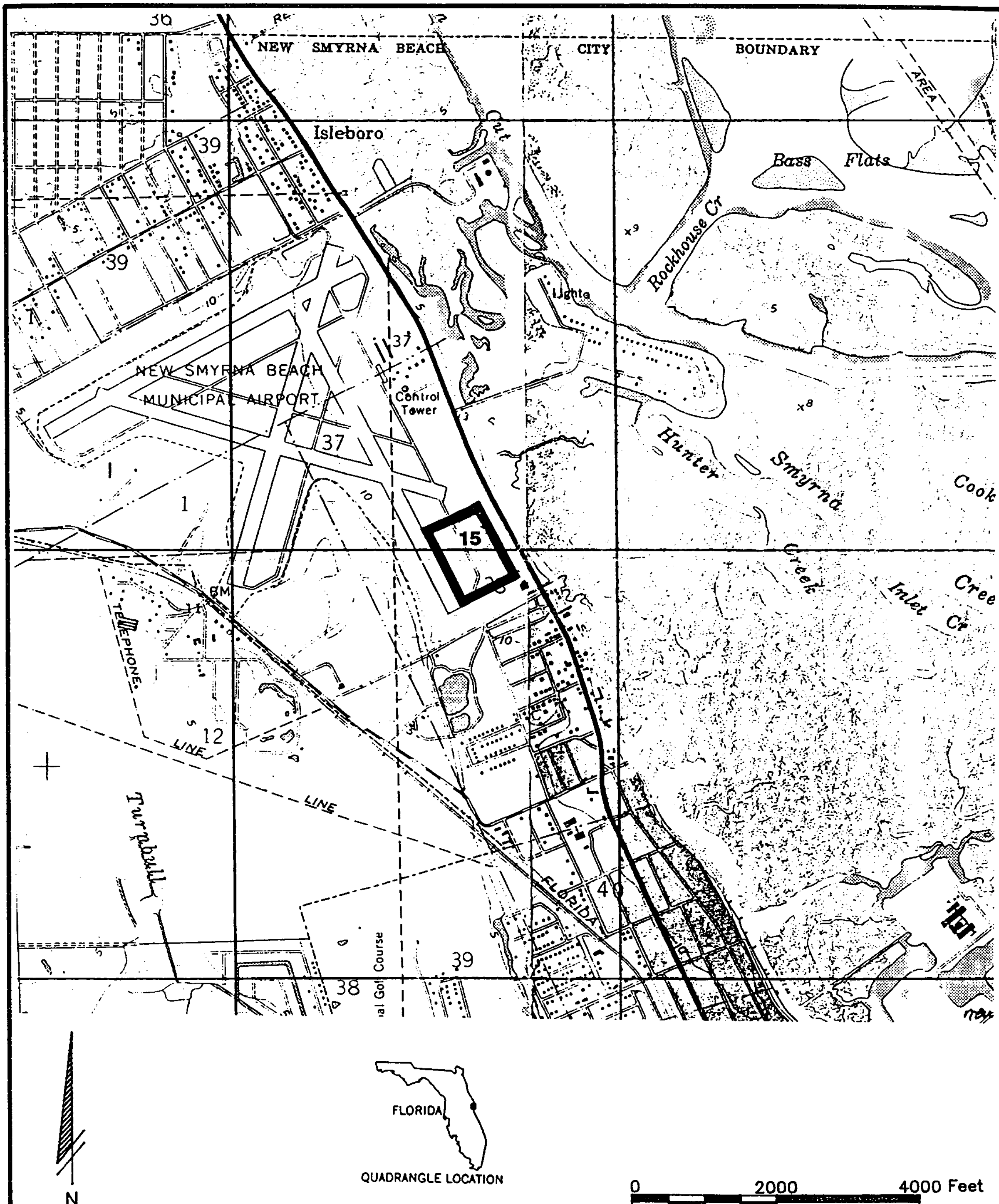
Figure 5.16-3 is the equivalence analysis for this site, and the inversion table (Table 5.16-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 5 m (15 ft), which is 4% of the total depth. The resistivity of this layer has an equivalence range of from 2.1 - 2.5 ohm-m. This corresponds to a range in interpreted chloride content of from 15,163 mg/L to 12,712 mg/L, again subject to the same assumptions of porosity and validity of equation (4). The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid.

The equivalence range of the resistivity of layer 1 is from 9.1 - 9.4 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn Group and surficial sediments. Accordingly, equation (4) may not be valid. Rutledge (1985) mapped a chloride concentration of greater than 250 mg/L in the area of the site.

5.16.6 <u>Summary of TDEM Sounding at New Smyrna Beach (Site 15)</u>

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 413 ft (-407 ft msl) and occur within the Upper Floridan aquifer. The measured layer resistivity at this level yields a chloride concentration of 13,831 mg/L.
- The groundwater within the Floridan aquifer at this site cannot be determined because analysis of the TDEM data does not allow for the surficial aquifer system and the Hawthorn Group to be distinguished from the Floridan Aquifer System.



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PALATKA, FLORIDA

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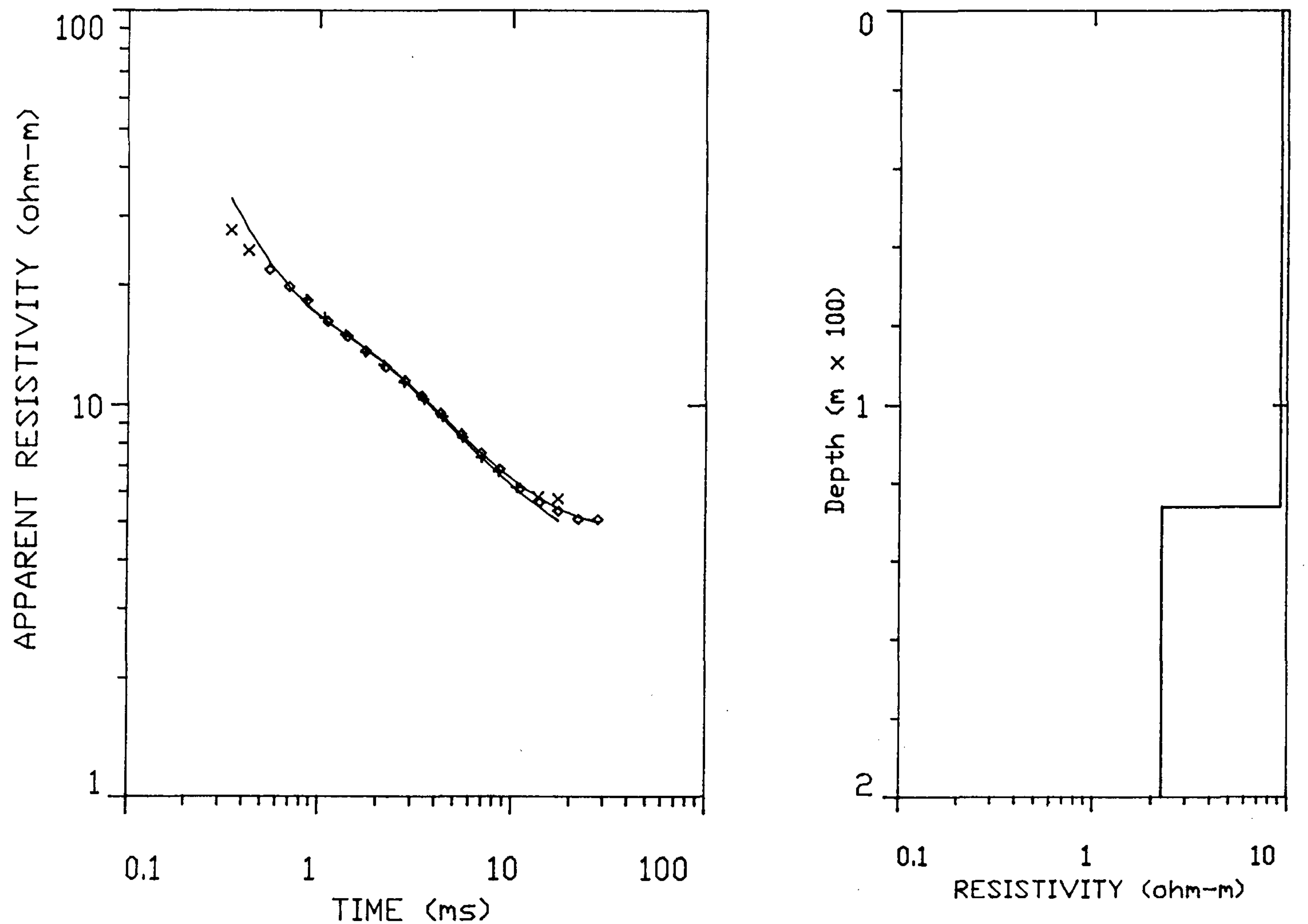
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 15 – NEW SMYRNA
NEW SMYRNA BEACH, FLORIDA

DESIGNED BY: MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY: RJW	DRAWING NO.:	LOC–15	5.16-1
DRAWN BY: SBG	DATE:	06/17/93	



——	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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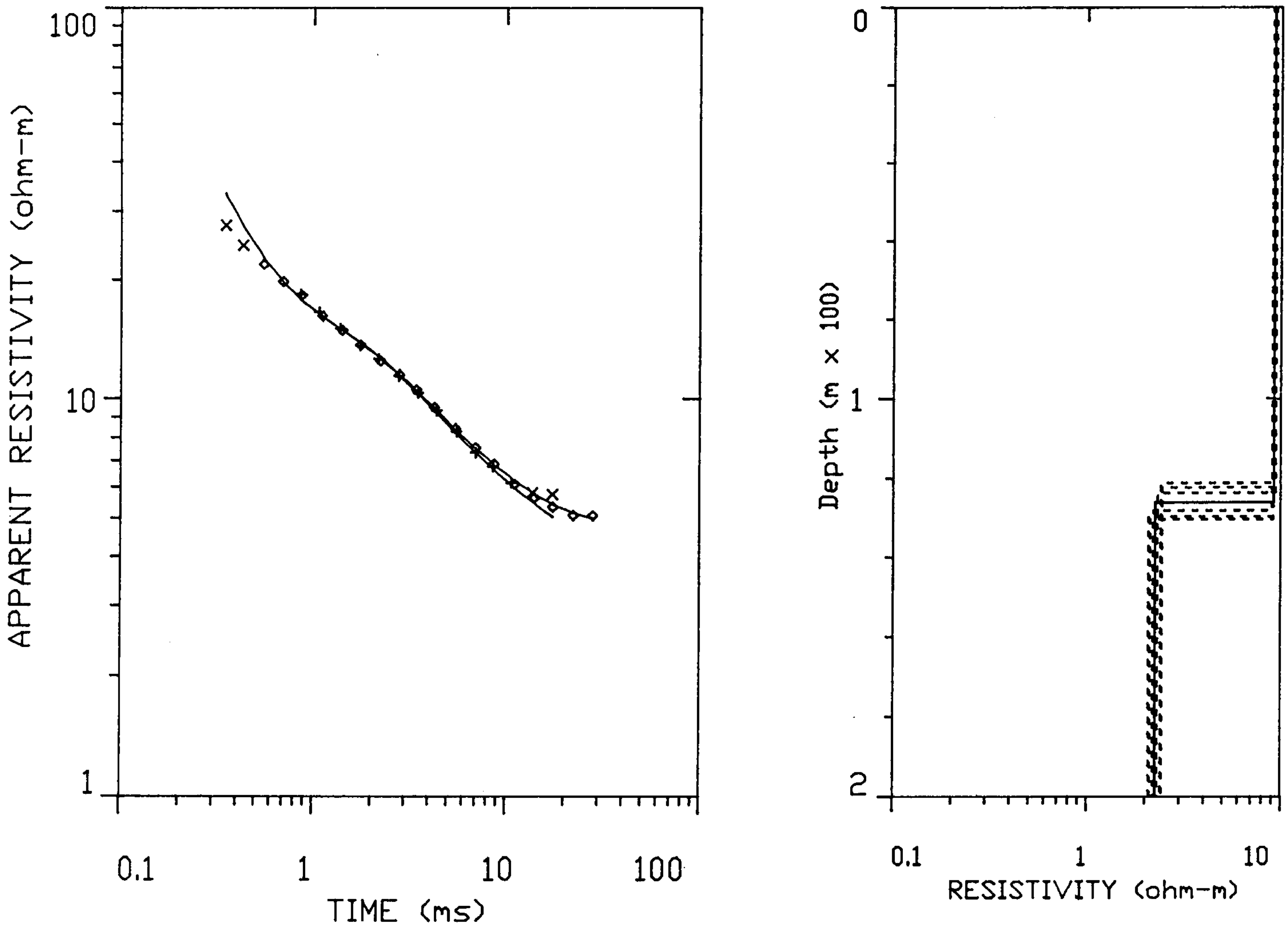
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 15 – NEW SMYRNA
NEW SMYRNA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-15	5-16.2
DRAWN BY:	SBG	DATE:	08/10/93	



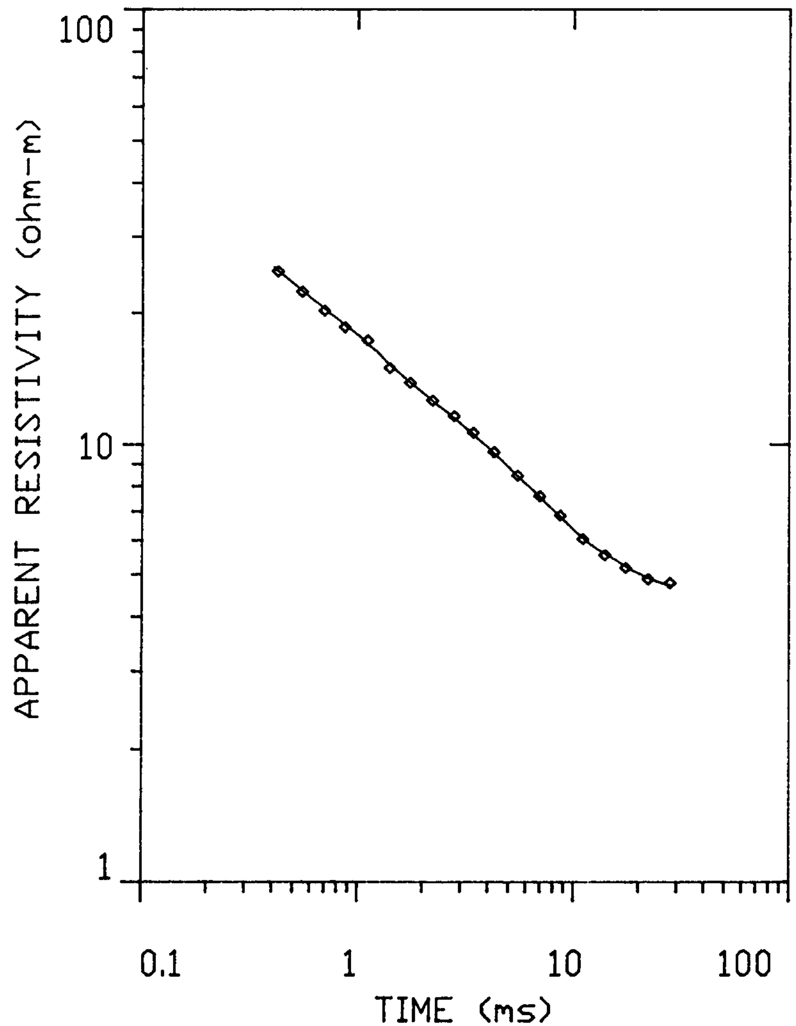
——	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 15 – NEW SMYRNA
NEW SMYRNA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-15	5.16-3
DRAWN BY:	SBG	DATE:	06/25/93	



□ APPARENT RESISTIVITY VALUES
—— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

QUALITY CONTROL– APPARENT RESISTIVITY VALUES
SOUNDING 15 – NEW SMYRNA
NEW SMYRNA BEACH, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	QA–15	5.16–4
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT: SJWRMD
LOCATION: NEW SMYRNA BEACH
COUNTY: VOLUSIA COUNTY, FLORIDA
PROJECT: SALT WATER INTERFACE DETECTION
LOOP SIZE: 304.000 m by 274.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 08-05-93
SOUNDING: 1
ELEVATION: 2.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 2.256 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			2.00	
1	9.24	126.0	-124.0	13.63
2	2.25			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	9.068	9.244	9.448
	2	2.094	2.259	2.451
THICK	1	121.161	1.000	130.360
DEPTH	1	121.161	126.059	130.360

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 2 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	65738.9	49556.9	24.61 MASKED
2	0.427	46489.1	38962.7	16.18 MASKED
3	0.550	29202.6	27569.0	5.59
4	0.698	18714.0	18859.5	-0.777
5	0.869	12204.0	12763.9	-4.58
6	1.10	7981.4	7999.3	-0.224
7	1.40	5017.3	4998.2	0.380

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MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 15
NEW SMYRNA BEACH

PROJECT NO.: 93742
TABLE 5.16-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	1.75	3278.9	3214.6	1.96
9	2.22	2079.3	2020.0	2.85
10	2.79	1321.5	1318.9	0.198
11	3.42	905.3	911.0	-0.636
12	4.26	609.0	615.0	-0.995
13	5.49	388.6	392.3	-0.943
14	6.96	252.7	254.9	-0.900
15	8.66	168.7	170.1	-0.805
16	11.06	109.2	106.2	2.73
17	14.00	68.37	66.27	3.07
18	17.47	42.58	41.75	1.94
19	22.23	25.09	24.59	1.98
20	28.10	13.99	14.37	-2.73

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	12544.9	13109.4	-4.49
22	1.06	8496.2	8642.2	-1.71
23	1.37	5252.0	5253.3	-0.0250
24	1.74	3348.4	3262.6	2.56
25	2.17	2161.5	2120.9	1.87
26	2.77	1362.0	1347.0	1.10
27	3.50	881.2	883.9	-0.310
28	4.37	588.3	597.4	-1.55
29	5.56	386.4	392.5	-1.57
30	6.98	261.7	261.9	-0.0467
31	8.56	177.6	181.4	-2.09
32	10.64	119.1	121.4	-1.93
33	13.70	68.97	75.05	-8.80 MASKED
34	17.40	38.53	46.95	-21.84 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	0.00	0.96	
T 1	0.00	0.01	0.99
	P 1	P 2	T 1

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 15 NEW SMYRNA BEACH PROJECT NO.: 93742 TABLE 5.16-1

5.17 TDEM SITE 16 - LAKE ASHBY SITE

5.17.1 Location Description and Geoelectrical Section

The site is located in south-central Volusia County, Florida (Figure 5.17-1) within an operating sod farm. No obvious signs of interference sources were present. Together, Sites 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is either thin or absent. The top of the Floridan aquifer begins at approximately 85 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 700 ft below msl (Miller, 1986). Results from QC soundings performed 100 ft north, south, east and west of the initial Rx coil position indicated that no sources of interference were present (Figure 5.17-4).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.17-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.17.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (234.4 m = 769 ft) surface layer of intermediate resistivity (41.8 ohm-m) overlying a low resistivity layer (4.6 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 769 ft bls.

5.17.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 4.6 ohm-m, is interpreted to represent salt water. It occurs at a depth of 769 ft (-743 ft msl). Because the resistivity of layer 1 (41.8 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is equal to the depth of the geoelectrical interface, or at 769 ft depth (-743 ft msl). The resistivity of layer 2 (4.6 ohm-m) corresponds to a chloride content of 6,839 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.17.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridian aquifer from the overlying surficial aquifer system and the Hawthorn Group, the effective chloride concentration of layer 1 cannot be calculated. Rutledge (1985) mapped a chloride concentration of less than 250 mg/L in the area of the site.

5.17.5 Accuracy of Measurement and Interpretation

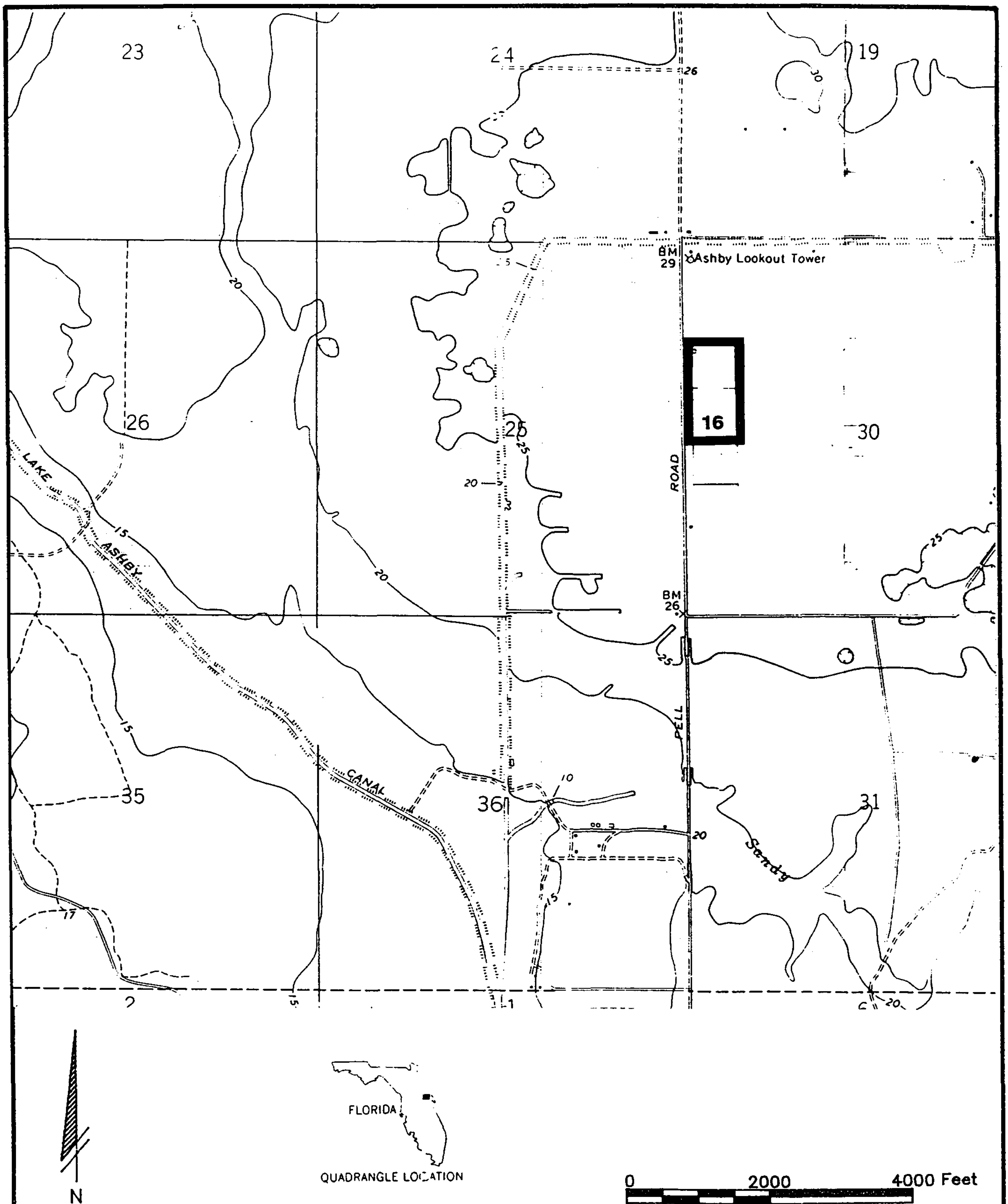
Figure 5.17-3 is the equivalence analysis at this site, and the inversion table (Table 5.17-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 8 m (26 ft), which is 3% of the total depth. The resistivity of this layer has an equivalence range of from 3.8 - 5.6 ohm-m. This corresponds to a range in interpreted chloride content of from 8,311 mg/L to 5,590 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is constrained from 40.4 - 43.5 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn Group and surficial sediments. Accordingly, equation (4) may not be valid.

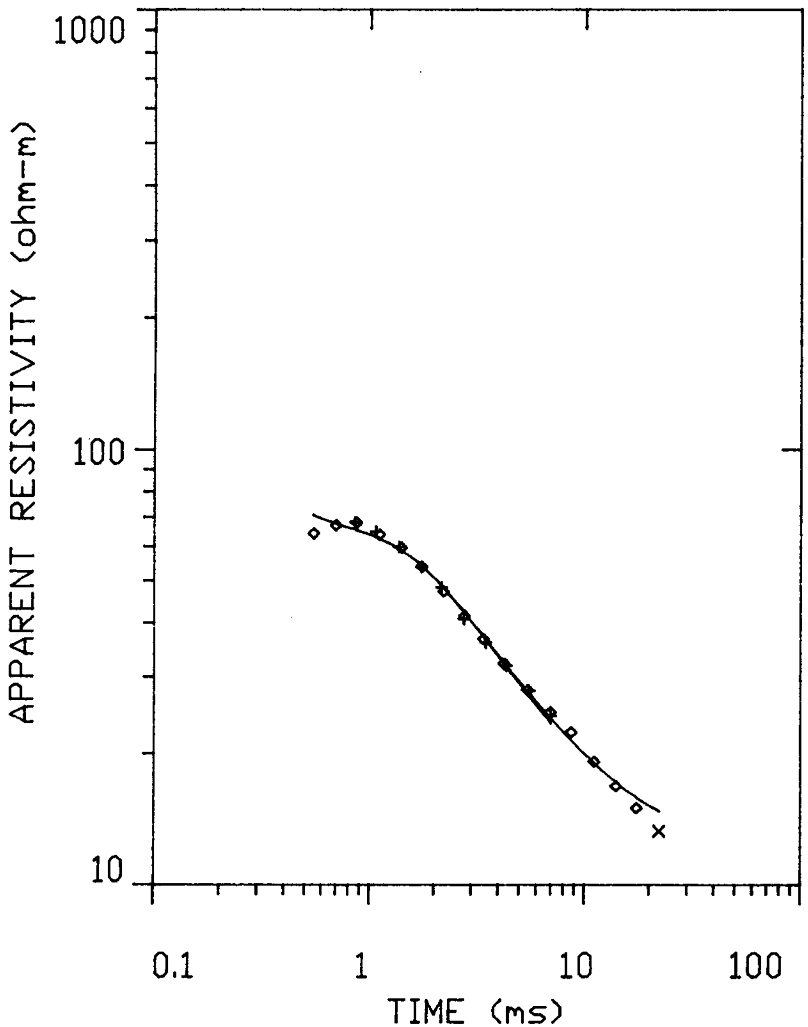
5.17.6 Summary of TDEM Sounding at Lake Ashby (Site 16)

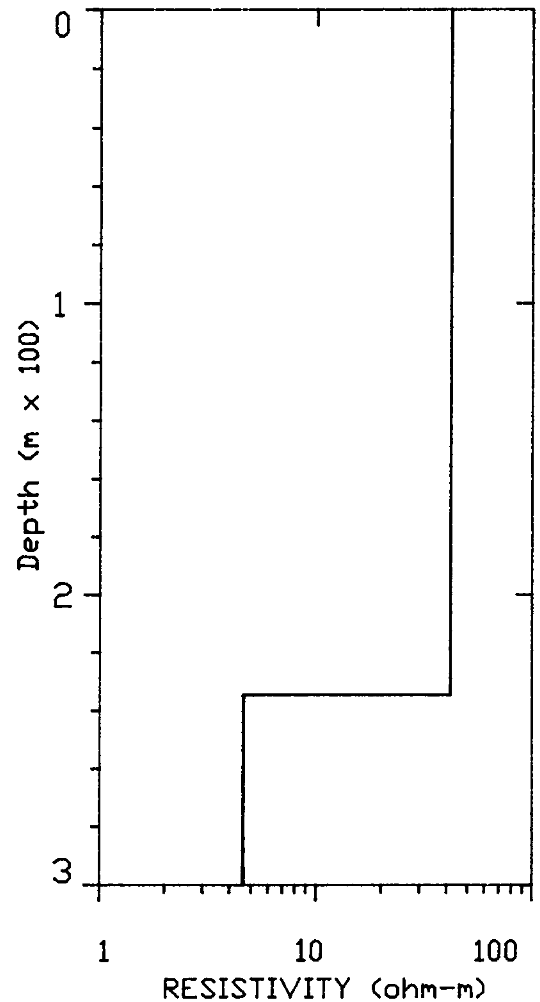
- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 769 ft (-743 ft msl) and occur in the Lower Floridan aquifer. The measured layer resistivity at this level yields a chloride concentration of 6,839 mg/L.
- The ground water within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow the surficial aquifer system and the Hawthorn Group to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 16 – LAKE ASHBY LAKE ASHBY, FLORIDA

DESIGNED BY: MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY: RJW	DRAWING NO.:	LOC–16	5.17-1
DRAWN BY: SBG	DATE:	06/17/93	





BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

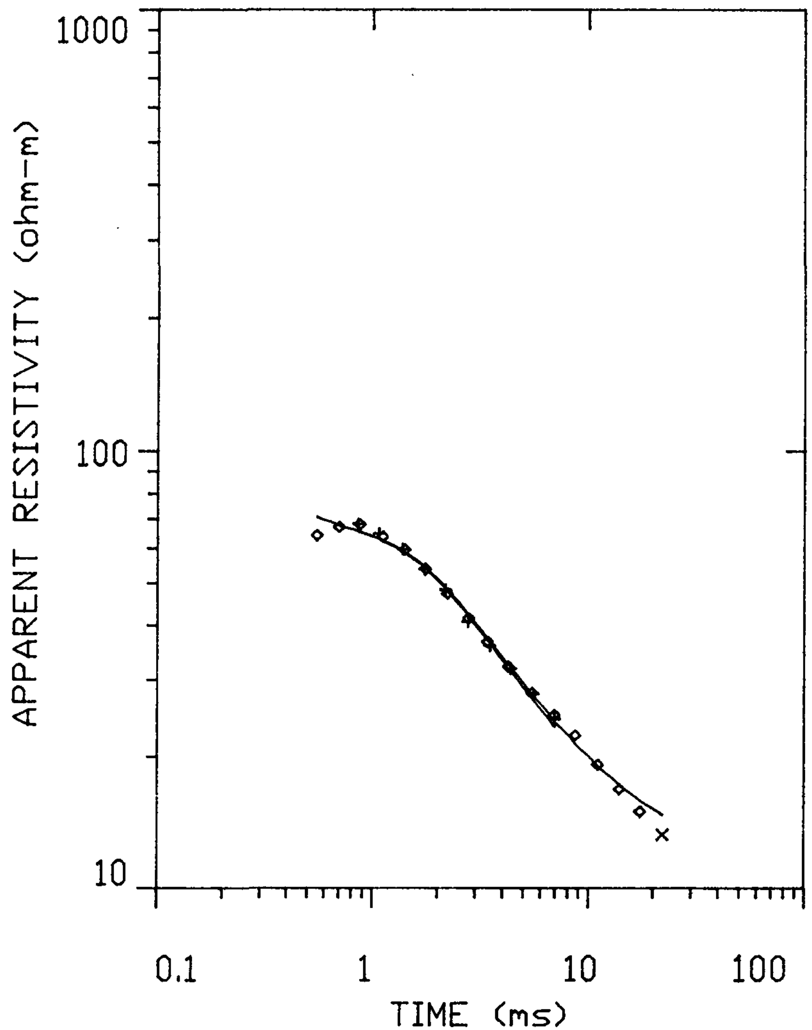
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

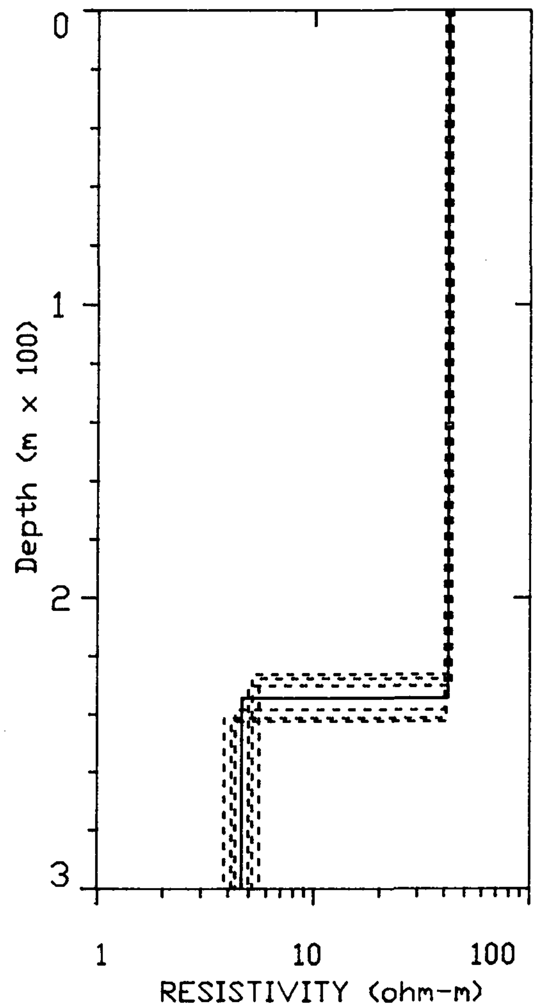
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 16 – LAKDE ASHBY
LAKE ASHBY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-16	5-17.2
DRAWN BY:	SBG	DATE:	09/16/93	



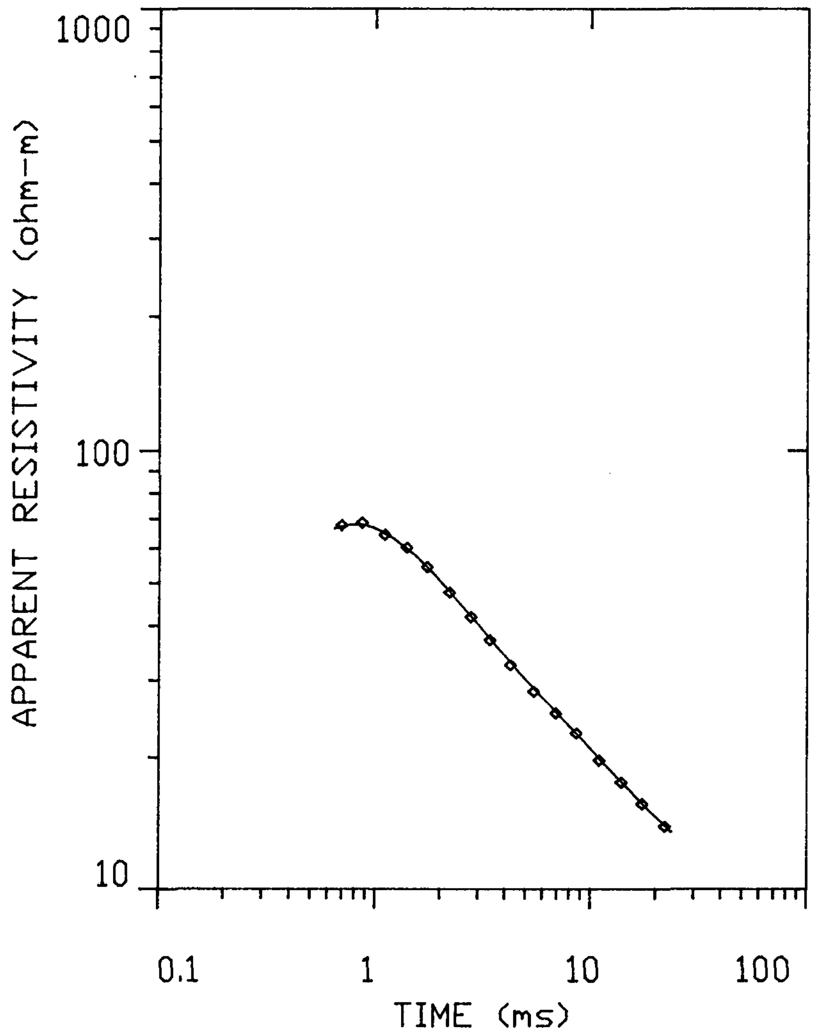


BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SOUNDING 16 – LAKE ASHBY LAKE ASHBY, FLORIDA	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: EQU-16 DATE: 09/16/93	FIGURE 5.17-3



□ APPARENT RESISTIVITY VALUES
—— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	QUALITY CONTROL– APPARENT RESISTIVITY VALUES SOUNDING 16 – LAKDE ASHBY LAKE ASHBY, FLORIDA		
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: QA–16 DATE: 09/16/93	FIGURE 5.17–4

CLIENT:	SJWRMD	DATE:	09-05-93
LOCATION:	LAKE ASHBY	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY, FLORIDA	ELEVATION:	8.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	411.000 m by 198.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 0.0000 N: 0.0000		

FITTING ERROR: 4.803 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			8.00	
1	41.84	234.4	-226.4	5.60
2	4.61			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	40.366	41.843	43.497
	2	3.829	4.613	5.563
THICK	1	226.224	1.000	242.476
DEPTH	1	226.224	234.476	242.476

CURRENT:	16.10 AMPS	EM-57		COIL AREA:	100.00 sq m.
FREQUENCY:	7.50 Hz	GAIN: 4		RAMP TIME:	192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.550	6083.0	5263.9	13.46
2	0.698	3141.9	3109.6	1.02
3	0.869	1779.4	1885.6	-5.97
4	1.10	1066.6	1096.5	-2.80
5	1.40	654.7	665.8	-1.69
6	1.75	438.8	432.9	1.33
7	2.22	295.4	285.2	3.42

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 16 LAKE ASHBY PROJECT NO.: 93742 TABLE 5.17-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	2.79	201.9	196.2	2.82
9	3.42	146.1	142.3	2.61
10	4.26	102.7	101.4	1.25
11	5.49	67.17	67.88	-1.04
12	6.96	44.18	46.27	-4.72
13	8.66	29.99	32.00	-6.70
14	11.06	20.56	20.80	-1.16
15	14.00	13.87	13.45	3.01
16	17.47	9.49	8.73	7.98
17	22.23	6.24	5.33	14.62 MASKED

CURRENT: 16.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
18	0.857	1838.4	1949.0	-6.01
19	1.06	1147.6	1196.2	-4.23
20	1.37	692.2	701.6	-1.35
21	1.74	446.6	440.2	1.41
22	2.17	302.6	298.9	1.21
23	2.77	211.1	201.0	4.81
24	3.50	142.0	139.7	1.62
25	4.37	98.03	99.78	-1.78
26	5.56	65.54	68.65	-4.74
27	6.98	45.29	48.01	-6.00

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	-0.01	0.93	
T 1	0.00	0.01	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 16
LAKE ASHBY

PROJECT NO.: 93742
TABLE 5.17-1

5.18 TDEM SITE 17 - LAKE HELEN SITE

5.18.1 Location Description and Geoelectrical Section

The site is situated in south-central Volusia County, Florida (Figure 5.18-1) and was located within an abandoned orange grove. No obvious signs of interference sources were present. Together, Site 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is thin to absent. The top of the Floridan aquifer begins at approximately 55 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 425 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.18-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.18.2 Geological Interpretation of Geoelectrical Model

There is sufficient electrical resistivity contrast to distinguish two geoelectric layers above the third, saltwater saturated layer. The depth to the contact between the first and second layers occurs at 66 m (217 ft) and not at the hydrostratigraphic contact (130 ft bls) between the Hawthorn Group and the Floridan Aquifer System. The upper layer has an intermediate value of resistivity (40 ohm-m) and a modeled thickness of 66 m (217 ft). This overlies a 258 m (846 ft) thick layer of high resistivity (497 ohm-m). The base layer in the geoelectrical model is a very low resistivity layer (2 ohm-m) situated at a depth of 324 m (1,063 ft). It can be interpreted that these layers represent the combined Hawthorn Group and surficial aquifer system and upper portion of the Upper Floridan aquifer (layer 1), overlying the Floridan aquifer (layer 2) at a depth of 217 ft. Layer 3 is the salt water portion of the Floridan aquifer; this interface occurs at a depth of 1,064 ft.

5.18.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 2 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,064 ft (-989 ft msl). Because the resistivity of layer 2 (497 ohm-m) is interpreted to represent freshwater within the Floridan aquifer (i.e., is greater than 80 ohm-m), the interpreted depth to the 5,000 mg/L isochlor is taken at 50 ft below the depth of the geoelectrical interface, or at 1,114 ft depth (-1,039 ft msl). The resistivity of layer 3 (2 ohm-m) corresponds to a chloride content of greater than 10,000 mg/L (15,929 mg/L) assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.18.4 Depth of Occurrence of the 250 mg/L Isochlor

The resistivity of layer 2, 497 ohm-m, corresponds to a chloride content of less than 50 mg/L, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. Using the criteria established in Section 4.3 (this is a Class A type resistivity distribution), the position of the 250 mg/L isochlor is placed 50 ft above the depth to the low resistivity interface, or at a depth of 1,014 ft (-939 ft msl).

5.18.5 Accuracy of Measurement and Interpretation

Figure 5.18-3 is the equivalence analysis at this site, and the inversion table (Table 5.18-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

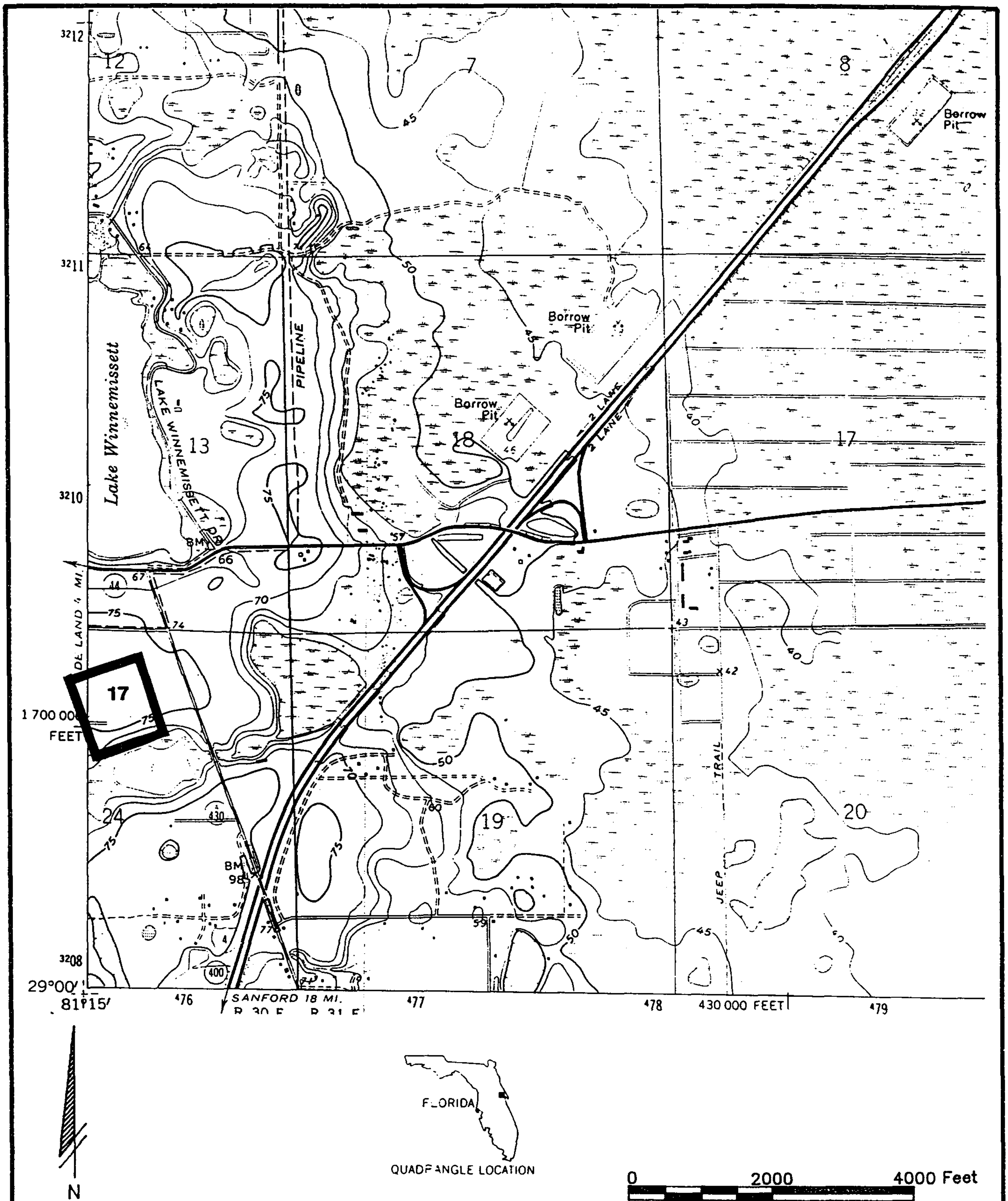
The range of equivalence in determining the depth to the low resistivity layer is about ± 1.5 m (5 ft), which is less than 1% of the total depth. The resistivity of this layer has an equivalence range of from 1.8 - 2.3 ohm-m. This corresponds to a range in interpreted chloride content of from 17,716 mg/L to 13,831 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 2 is poorly constrained from 321 - 994 ohm-m which corresponds to chloride concentrations which are all less than 50 mg/L (assuming 25% porosity). The chloride-to-sulfate ratio at the site (Table 5.1-4) is 1:1. Accordingly, equation (4) may not be valid. Rutledge (1985) mapped a chloride concentration of less than 250 mg/L in the area of the site.

The estimated depth to the 250 mg/L isochlor from the TDEM study (1,014 ft) does not agree with the estimated depth to the freshwater/saltwater interface of approximately 1,400 ft bls determined by Ghyben-Herzberg analysis (Rutledge, 1982). Rutledge (1982) defines the depth to the freshwater/seawater interface as forty times the groundwater table elevation above msl. The freshwater/saltwater interface is assumed to occur at the transition to unmixed seawater with a chloride concentration of 19,000 mg/L. The difference between the estimated depth of the 250 mg/L isochlor (1,014 ft bls -- from TDEM) and the estimated depth to the 19,000 mg/L isochlor (1,400 ft -- from Ghyben-Herzberg analysis) may indicate the presence of a thick transition zone from freshwater to saltwater in the area of the site.

5.18.6 Summary of TDEM Sounding at Lake Helen (Site 17)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 1,114 ft (-1,039 ft msl) and occurred within the Lower Floridan aquifer. The measured layer resistivity at this level yields a chloride concentration of greater than 10,000 mg/L.
- The 250 mg/L isochlor is interpreted to occur within the Lower Floridan aquifer at this site at a depth of 1,014 ft (-939 ft msl). The average chloride concentration within the fresh Floridan aquifer section is less than 50 mg/L. The water quality results from the TDEM survey are in agreement with other water quality studies in the area of the site.
- The estimated depth to the 250 mg/L isochlor is not in agreement with the estimated depth from Rutledge (1982) who estimated a depth of approximately 1,400 ft bls to the freshwater/saltwater interface.

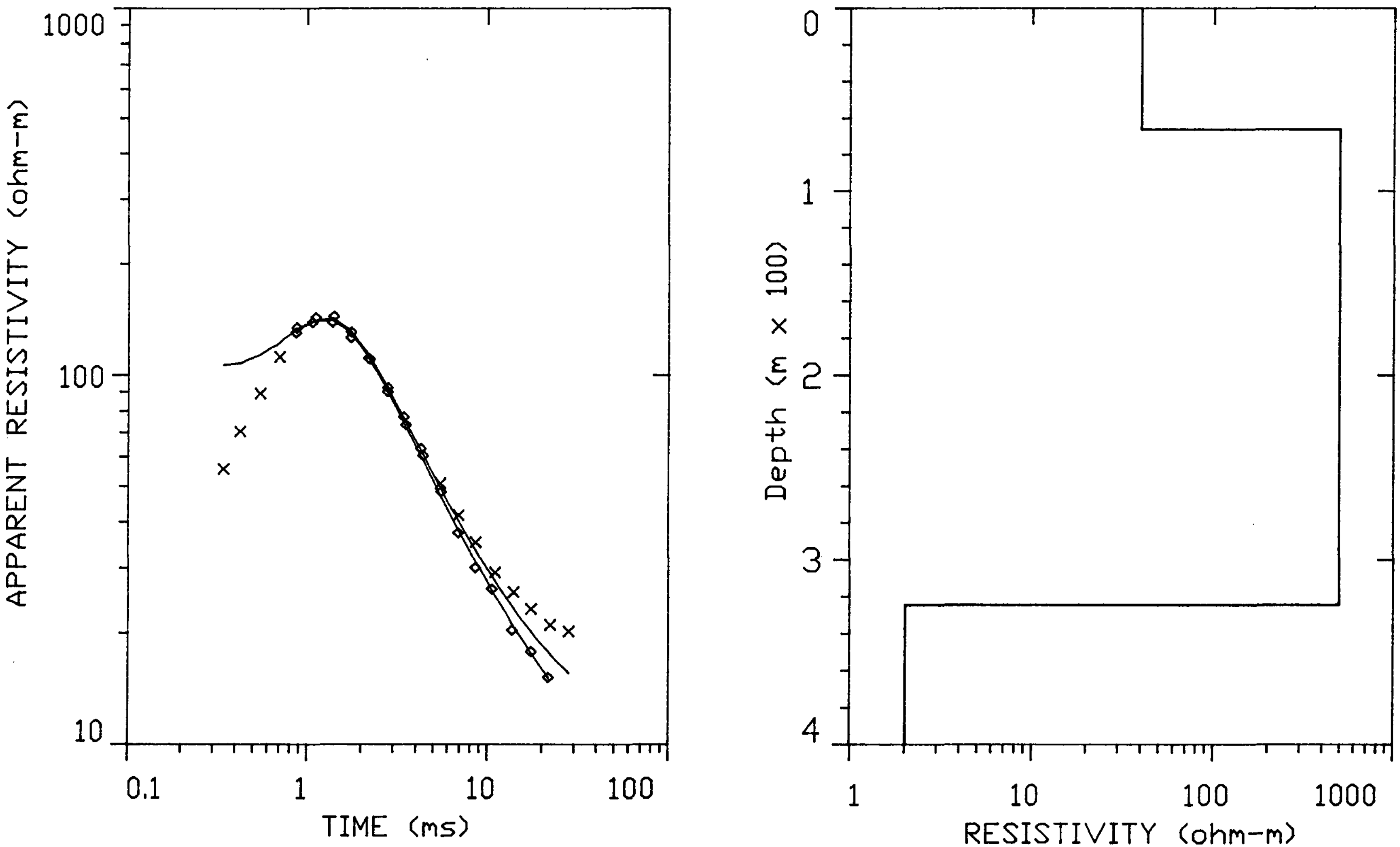


ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 17 – LAKE HELEN
DAYTONA BEACH SW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC–17	5.18-1
DRAWN BY:	SBG	DATE:	06/17/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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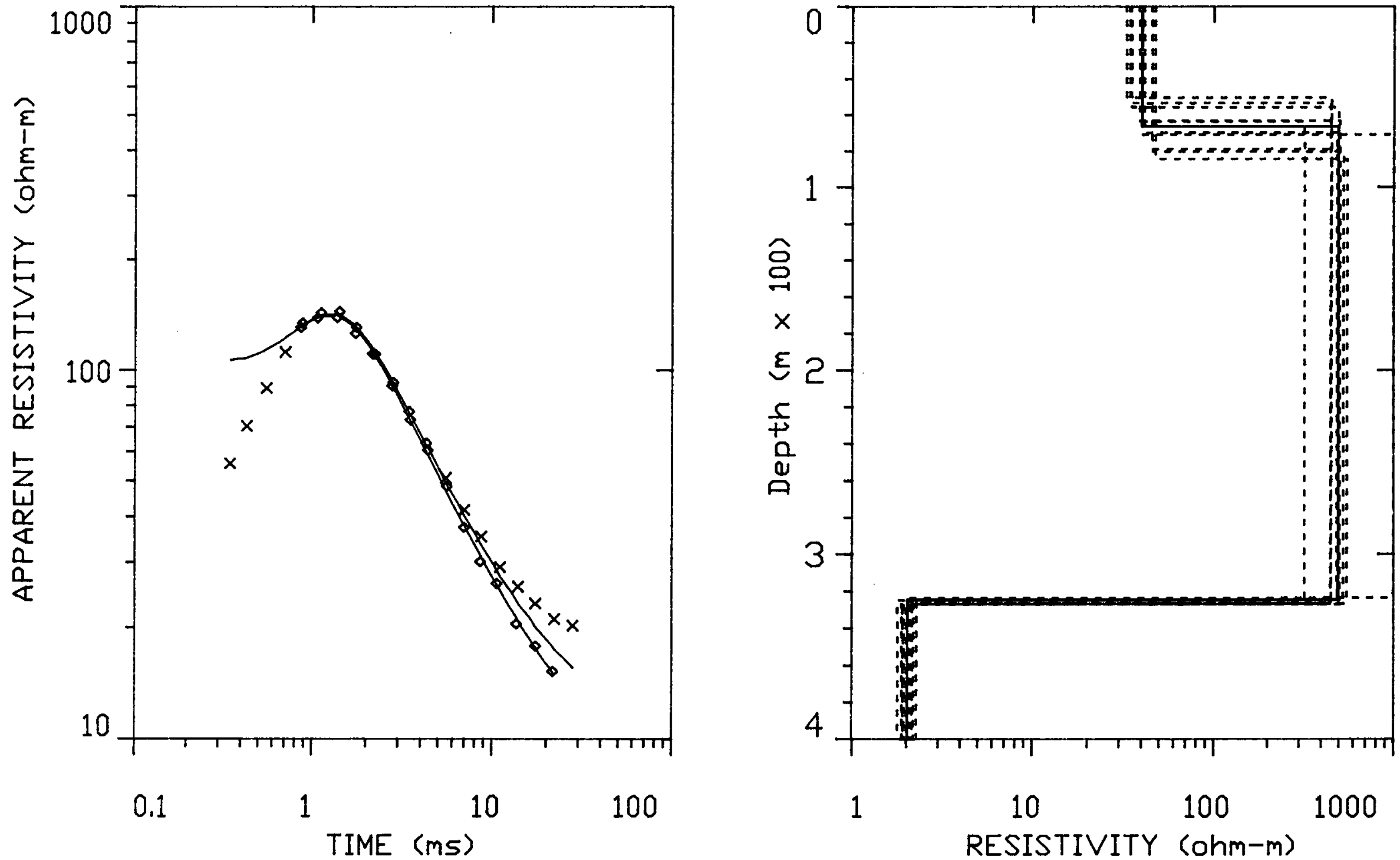
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 17 – LAKE HELEN
DAYTONA BEACH SW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL–17	5.18–2
DRAWN BY:	SBG	DATE:	11/10/93	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 17 – LAKE HELEN
DAYTONA BEACH SW, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-17	5.18-3
DRAWN BY:	SBG	DATE:	11/10/93	

CLIENT:	SJWRMD	DATE:	11-05-93
LOCATION:	LAKE HELEN	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY, FLORIDA	ELEVATION:	23.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	305.000 m by 305.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 2.838 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			23.00	
1	39.82	66.35	-43.35	1.66
2	496.9	258.0	-301.4	0.519
3	2.00			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	32.748	39.827	47.230
	2	320.892	496.934	993.659
	3	1.773	2.010	2.265
THICK	1	50.494	-3.785	84.265
	2	242.284	1.000	275.388
DEPTH	1	50.494	66.352	84.265
	2	323.501	324.427	326.917

CURRENT:	16.50 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	7.50 Hz	GAIN: 6	RAMP TIME:	212.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.346	26391.5	9986.1	62.16 MASKED
2	0.427	10965.4	5784.4	47.24 MASKED
3	0.550	4083.6	2837.7	30.51 MASKED

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SOUNDING 17 LAKE HELEN PROJECT NO.: 93742 TABLE 5.18-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)	
4	0.698	1601.4	1406.1	12.19	MASKED
5	0.869	704.7	715.8	-1.56	
6	1.10	348.8	356.6	-2.22	
7	1.40	191.1	195.3	-2.15	
8	1.75	127.4	126.3	0.892	
9	2.22	90.47	88.18	2.52	
10	2.79	66.72	66.47	0.375	
11	3.42	52.68	53.23	-1.04	
12	4.26	40.88	41.54	-1.60	
13	5.49	30.09	31.41	-4.40	MASKED
14	6.96	22.39	23.66	-5.69	MASKED
15	8.66	16.69	18.06	-8.21	MASKED
16	11.06	12.04	13.06	-8.47	MASKED
17	14.00	8.02	9.35	-16.55	MASKED
18	17.47	5.39	6.68	-23.82	MASKED
19	22.23	3.42	4.51	-31.82	MASKED
20	28.10	2.02	2.99	-47.74	MASKED

CURRENT: 16.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 212.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.857	759.5	749.9	1.25
22	1.06	398.1	398.6	-0.134
23	1.37	213.6	209.8	1.78
24	1.74	136.2	130.3	4.27
25	2.17	94.96	93.95	1.06
26	2.77	70.16	69.78	0.543
27	3.50	53.54	54.55	-1.88
28	4.37	41.04	42.96	-4.66
29	5.56	31.42	33.38	-6.22
30	6.98	26.24	25.86	1.42
31	8.56	21.74	20.46	5.86
32	10.64	15.52	15.71	-1.24
33	13.70	11.99	11.37	5.17
34	17.40	8.09	8.21	-1.47
35	21.70	5.92	5.97	-0.840

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.85				
P 2	0.00	0.02			
P 3	0.05	-0.03	0.80		
T 1	-0.20	-0.09	0.08	0.72	
T 2	0.05	0.03	-0.02	0.07	0.98

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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TDEM SOUNDING DATA TABLE
SOUNDING 17
LAKE HELEN

PROJECT NO.: 93742
TABLE 5.18-1

5.19 TDEM SITE 18 - DELTONA SITE

5.19.1 Location Description and Geoelectrical Section

The site is situated in southwestern Volusia County, Florida (Figure 5.19-1) and is located within a wooded area. A buried pipeline was present approximately 100 ft north of the Tx loop. QA soundings were collected 100 ft to the south and north of the initial Rx coil position. Results of the QA soundings indicated that the data was unaffected by the pipeline (Figure 5.19-4). Together, Sites 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is thin to absent. The top of the Floridan aquifer begins at approximately 85 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 700 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.19-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.19.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (300.5 m = 986 ft) surface layer of intermediate (68.4 ohm-m) resistivity overlying a very low resistivity layer (1.4 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group and part of the Floridan aquifer exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 986 ft.

5.19.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 1.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 986 ft (-940 ft msl). Because the resistivity of layer 1 (68.4 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken at the depth of the geoelectrical interface, or at 986 ft depth (-940 ft msl). The resistivity of layer 2 (1.4 ohm-m) corresponds to a chloride content of 22,821 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.19.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying surficial aquifer system and Hawthorn Group, the effective chloride concentration of layer 1 cannot be calculated. Rutledge (1985) mapped a chloride concentration of less than 250 mg/L in the area of the site.

5.19.5 Accuracy of Measurement and Interpretation

Figure 5.19-3 is the equivalence analysis at this site, and the inversion table (Table 5.19-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

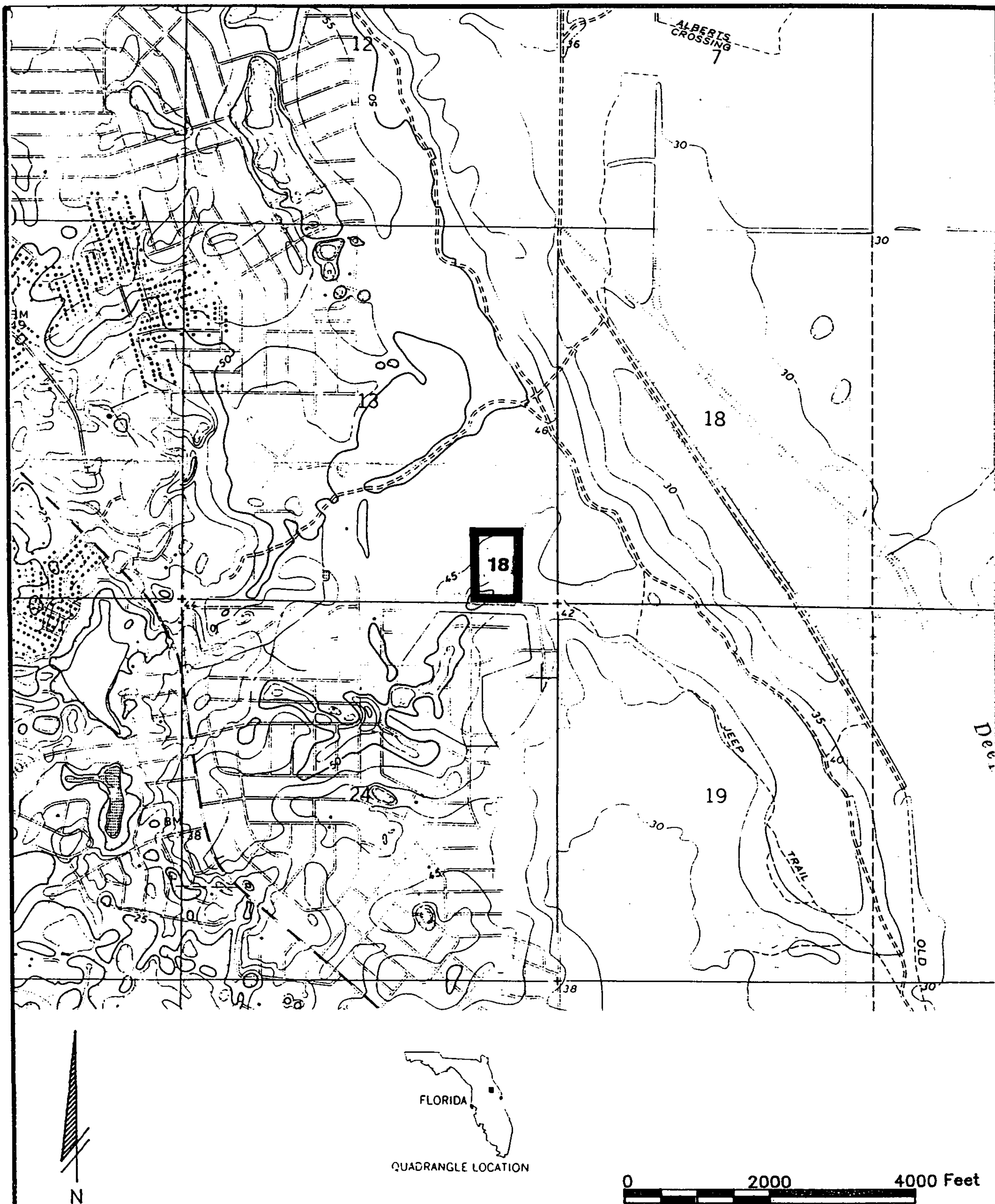
The range of equivalence in determining the depth to the low resistivity layer is about ± 4 m (13 ft), which is 1% of the total depth. The resistivity of this layer has an equivalence range of from 1.1 - 1.7 ohm-m. This corresponds to a range in interpreted chloride content of from 29,087 mg/L to 18,767 mg/L, again subject to the same assumptions of porosity and validity of equation (4). The estimated depth of the saltwater layer (986 ft bls) is in good agreement with the estimated depth of the freshwater/saltwater interface (approximately 1000 ft bls) based on Ghyben-Herzberg analysis (Rutledge, 1982). Rutledge (1982) defines the depth to the freshwater/saltwater interface as forty times the groundwater elevation above msl. The freshwater/saltwater interface is assumed to occur at the transition to unmixed seawater with a chloride concentration of 19,000 mg/L. The difference between the estimated depth to the 5,000 mg/L isochlor (986 ft bls -- from TDEM) and the estimated depth to the 19,000 mg/L isochlor

(1,000 ft bls -- from Ghyben-Herzberg analysis) may indicate the presence of a thin transition zone from fresh to salt water in the area of the site.

The equivalence range of the resistivity of layer 1 is from 65.2 - 71.6 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn group and surficial sediments. Accordingly, equation (4) may not be valid.

5.19.6 Summary of TDEM Sounding at Deltona (Site 18)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 986 ft (-940 ft msl) and occur within the Lower Floridan aquifer. The results from the TDEM studies are in agreement with the results from another study in the area (Rutledge, 1982). The measured layer resistivity at this level yields a chloride concentration of greater than 10,000 mg/L.
- The quality of groundwater within the Floridan aquifer at this site cannot be interpreted because analysis of the TDEM data does not allow the surficial aquifer system and the Hawthorn Group to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER
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PALATKA, FLORIDA

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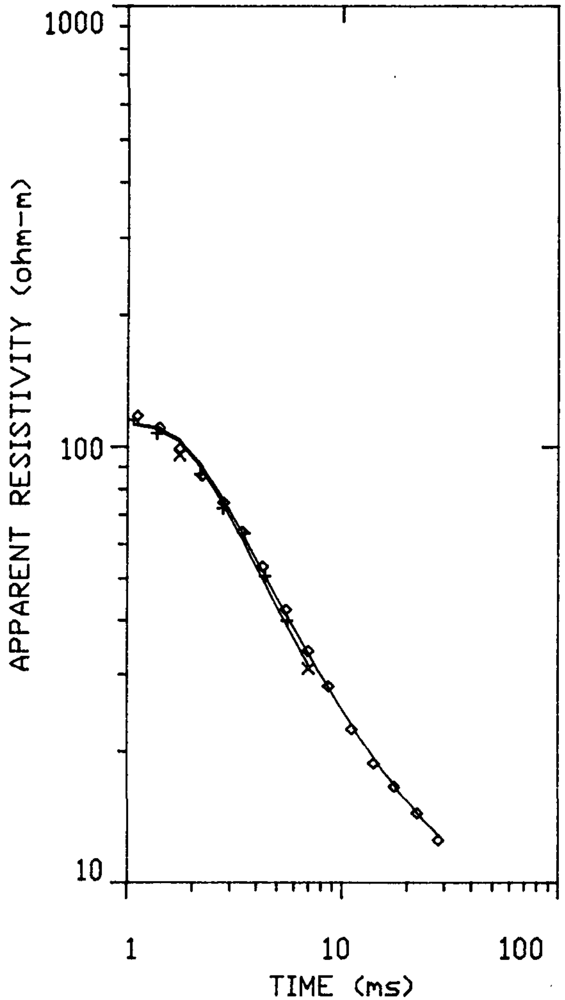
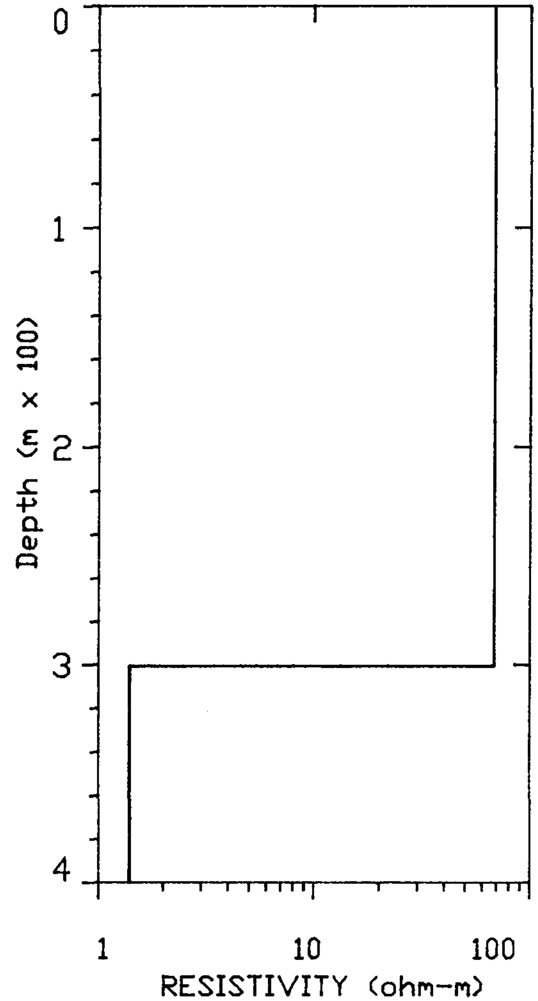
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 18 – DELTONA
LAKE HELEN, FLORIDA

DESIGNED BY: MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY: RJW	DRAWING NO.:	LOC –18	5.19-1
DRAWN BY: SBG	DATE:	06/17/93	





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

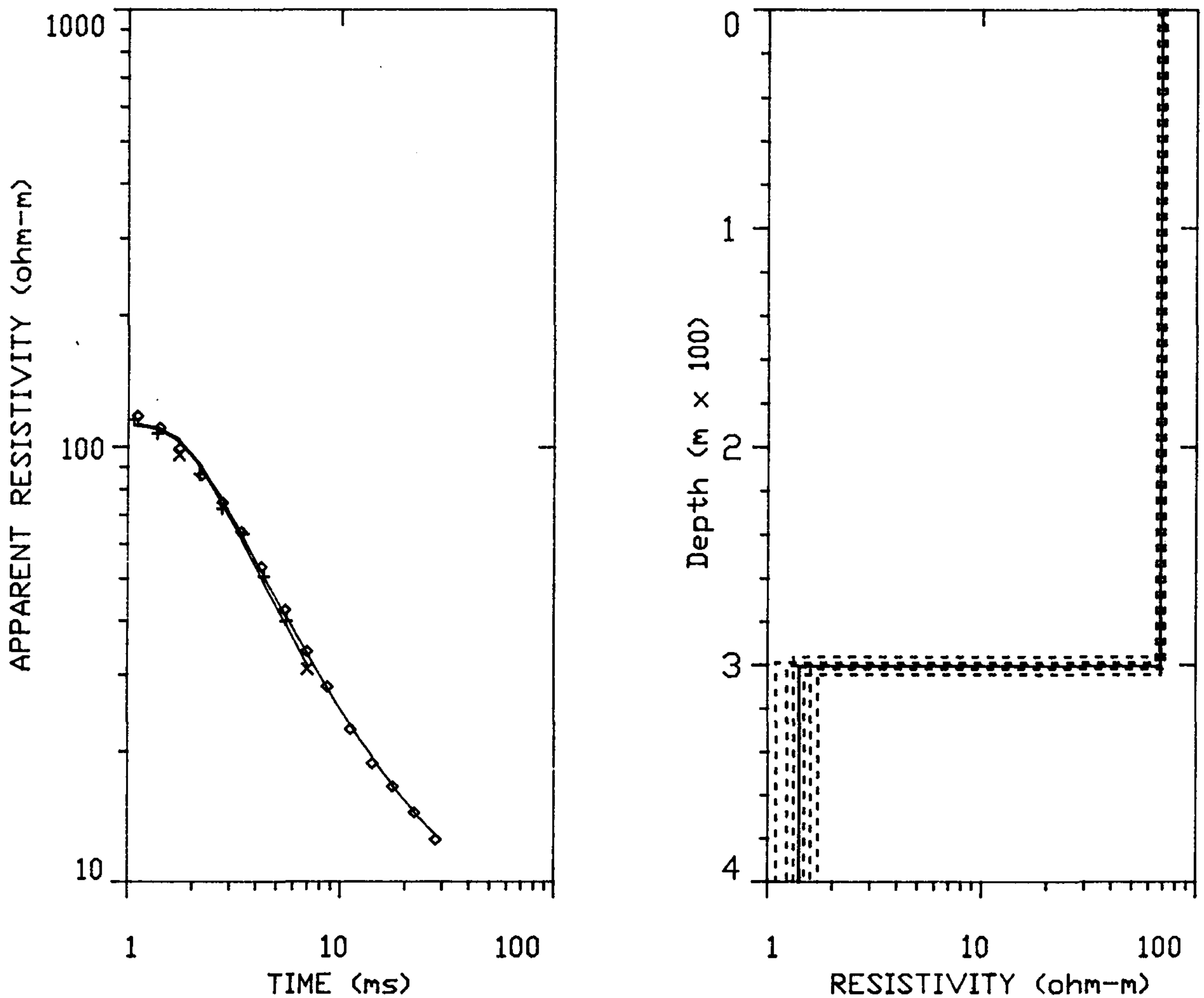
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 18 – DELTONA
LAKE HELEN, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-18	5-19.2
DRAWN BY:	SBG	DATE:	09/16/93	



BEST-FIT MODELED CURVE

☐ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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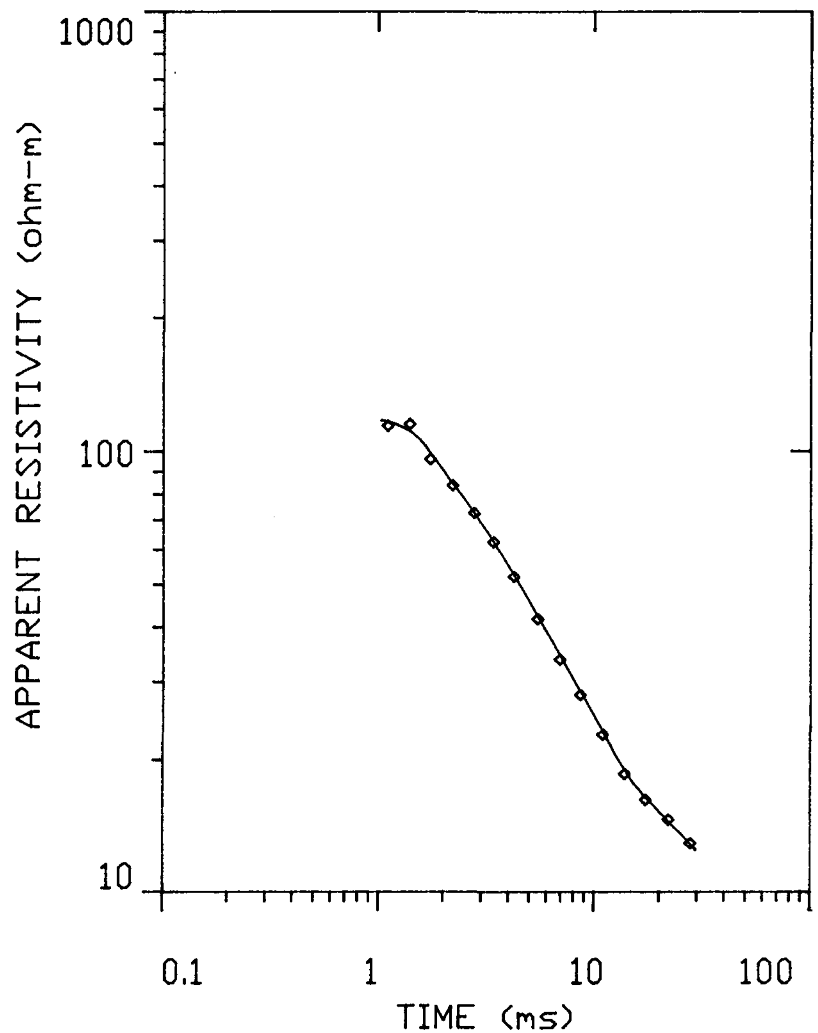
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 18 – DELTONA
LAKE HELEN, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-18	5.19-3
DRAWN BY:	SBG	DATE:	09/16/93	



□ APPARENT RESISTIVITY VALUES

—— DATA CURVE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	QUALITY CONTROL– APPARENT RESISTIVITY VALUES SOUNDING 18 – DELTONA LAKE HELEN, FLORIDA	
		DESIGNED BY: MJW CHECKED BY: RJW DRAWN BY: SBG	PROJECT NO.: 93742 DRAWING NO.: QA–18 DATE: 09/16/93	FIGURE 5.19–4

CLIENT: SJWRMD
LOCATION: DELTONA
COUNTY: VOLUSIA COUNTY, FLORIDA
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 274.000 m by 152.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 10-05-93
SOUNDING: 1
ELEVATION: 14.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.364 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			14.00	
1	68.36	300.5	-286.5	4.39
2	1.39			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	65.162	68.368	71.573
	2	1.087	1.395	1.709
THICK	1	296.325	1.000	304.465
DEPTH	1	296.325	300.552	304.465

CURRENT: 21.30 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 5 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	1.10	281.6	299.8	-6.45
2	1.40	171.3	171.4	-0.0876
3	1.75	116.2	108.6	6.52
4	2.22	79.34	73.90	6.85
5	2.79	55.48	54.34	2.05
6	3.42	42.03	42.43	-0.954
7	4.26	31.93	33.16	-3.84

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 18
DELTONA

PROJECT NO.: 93742
TABLE 5.19-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	5.49	23.89	24.69	-3.36
9	6.96	18.34	18.68	-1.88
10	8.66	14.09	14.24	-1.09
11	11.06	10.72	10.34	3.54
12	14.00	7.79	7.44	4.57
13	17.47	5.39	5.34	0.991
14	22.23	3.63	3.63	0.00114
15	28.10	2.51	2.42	3.35

CURRENT: 21.30 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
16	1.06	320.1	332.8	-3.96
17	1.37	190.4	183.5	3.62
18	1.74	124.2	112.1	9.69 MASKED
19	2.17	83.22	78.75	5.36
20	2.77	59.23	57.12	3.55
21	3.50	40.29	43.53	-8.02
22	4.37	32.36	34.34	-6.11
23	5.56	25.30	26.35	-4.13
24	6.98	20.99	20.51	2.27 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.98		
P 2	-0.04	0.74	
T 1	0.00	-0.01	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 18
DELTONA

PROJECT NO.: 93742
TABLE 5.19-1

5.20 TDEM SITE 19 - BLUE SPRINGS STATE PARK SITE

5.20.1 Location Description and Geoelectrical Section

The site is situated in southwestern Volusia County, Florida (Figure 5.20-1) and is located at Blue Springs State Park within an area of known karst activity. Together, Sites 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is thin to absent. The top of the Floridan aquifer begins at approximately 125 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 600 ft below msl (Miller, 1986). Water quality data supplied by SJRWMD from surface water collected from Blue Springs on February 3, 1993 showed that chloride concentrations equalled 443 mg/L and sulfate concentrations equaled 67 mg/L.

The resistivity sounding data and best-fit model inversion are presented on Figure 5.20-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.20.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system, the Hawthorn Group, and the upper part of the Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (150.5 m = 494 ft) surface layer of intermediate (27.9 ohm-m) resistivity overlying a low resistivity layer (4.4 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group and part of the Floridan aquifer exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 494 ft.

5.20.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 4.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 494 ft (-448 ft msl). Because the resistivity of layer 1 (27.8 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken at the depth of the geoelectrical interface, or at 494 ft depth (-448 ft msl). The resistivity of layer 2 (4.4 ohm-m) corresponds to a chloride content of 7,157 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.20.4 Depth of Occurrence of the 250 mg/L Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying surficial aquifer system and the Hawthorn Group, the effective chloride concentration of layer 1 cannot be calculated. Water quality results supplied by SJRWMD indicated that chloride concentrations in water discharging from Blue Springs exceed 250 mg/L. Rutledge (1985) mapped a chloride concentration of above 250 mg/L in the area near the site.

5.20.5 Accuracy of Measurement and Interpretation

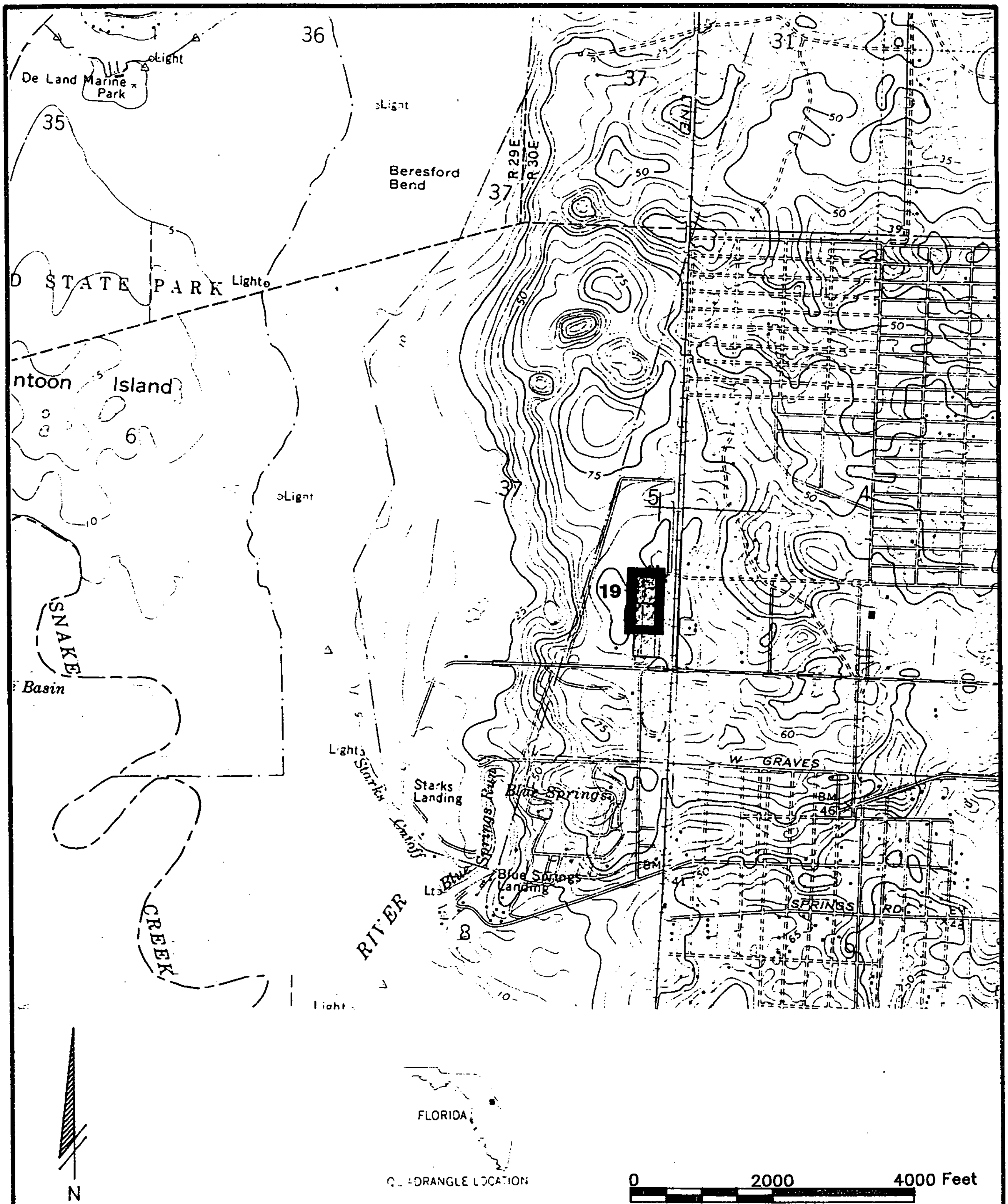
Figure 5.20-3 is the equivalence analysis at this site, and the inversion table (Table 5.20-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about 6 m (20 ft), which is 4% of the total depth. The resistivity of this layer has an equivalence range of from 3.9 - 5.0 ohm-m. This corresponds to a range in interpreted chloride content of from 8,094 mg/L to 6,280 mg/L, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of layer 1 is constrained from 26.8 - 29.2 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn group and surficial sediments. Accordingly, equation (4) may not be valid.

5.20.6 Summary of TDEM Sounding at Blue Springs State Park (Site 19)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 494 ft (-448 ft msl). The measured layer resistivity at this level yields a chloride concentration of 7,157 mg/L.
- The quality of groundwater within the Floridan aquifer at the site cannot be interpreted because analysis of the TDEM data does not allow for the surficial aquifer and the Hawthorn Group to be distinguished from the Floridan Aquifer System.

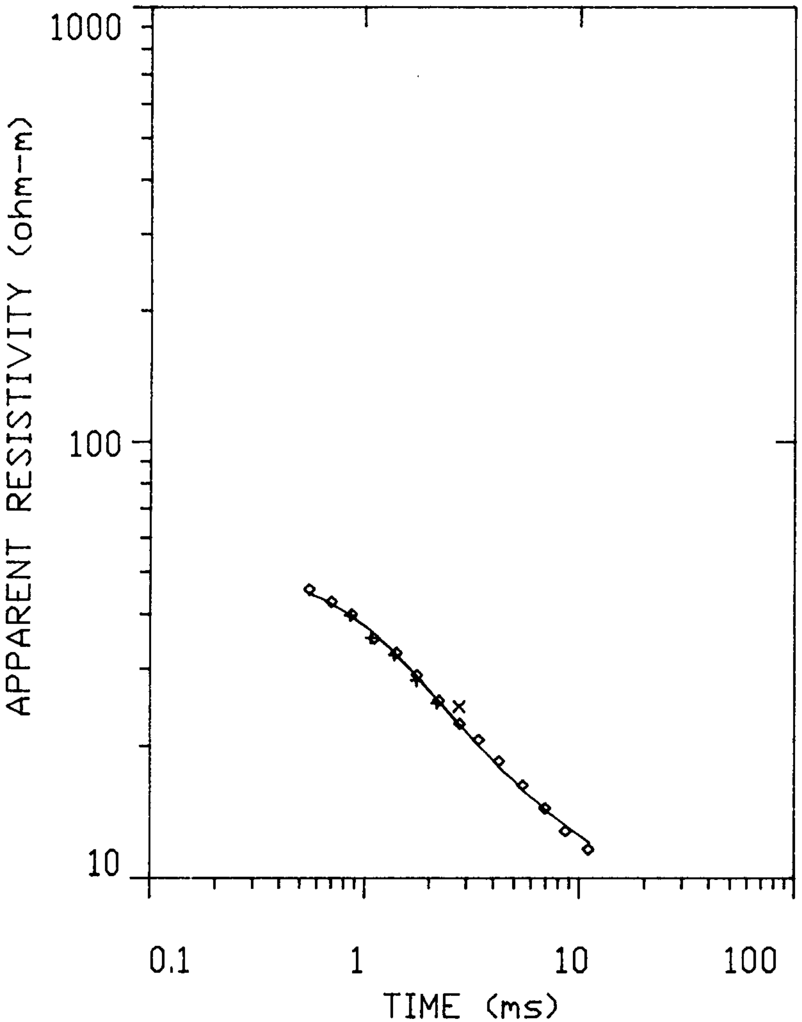


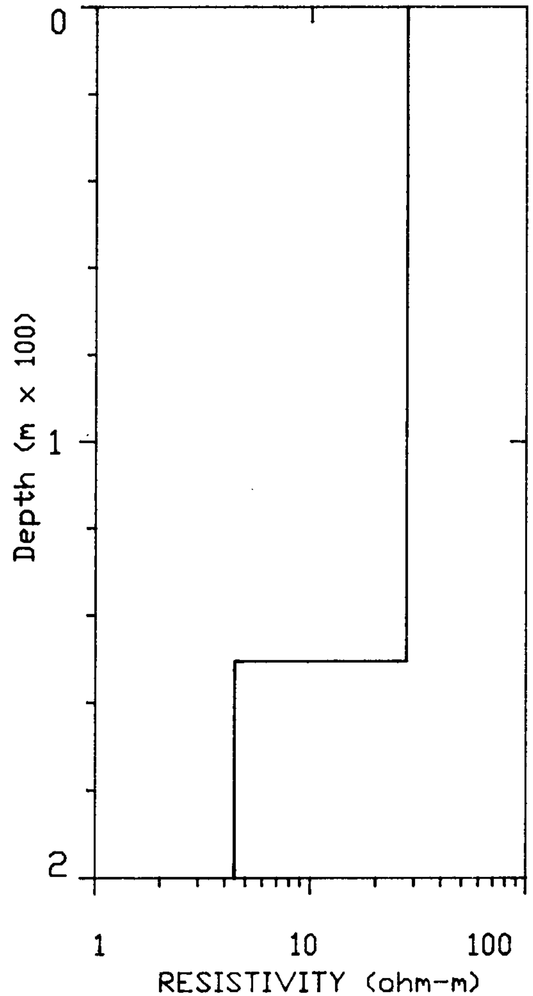
ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 19 – BLUE SPRINGS STATE PARK
ORANGE CITY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	LOC-19	5.20-1
DRAWN BY:	SBG	DATE:	06/17/93	





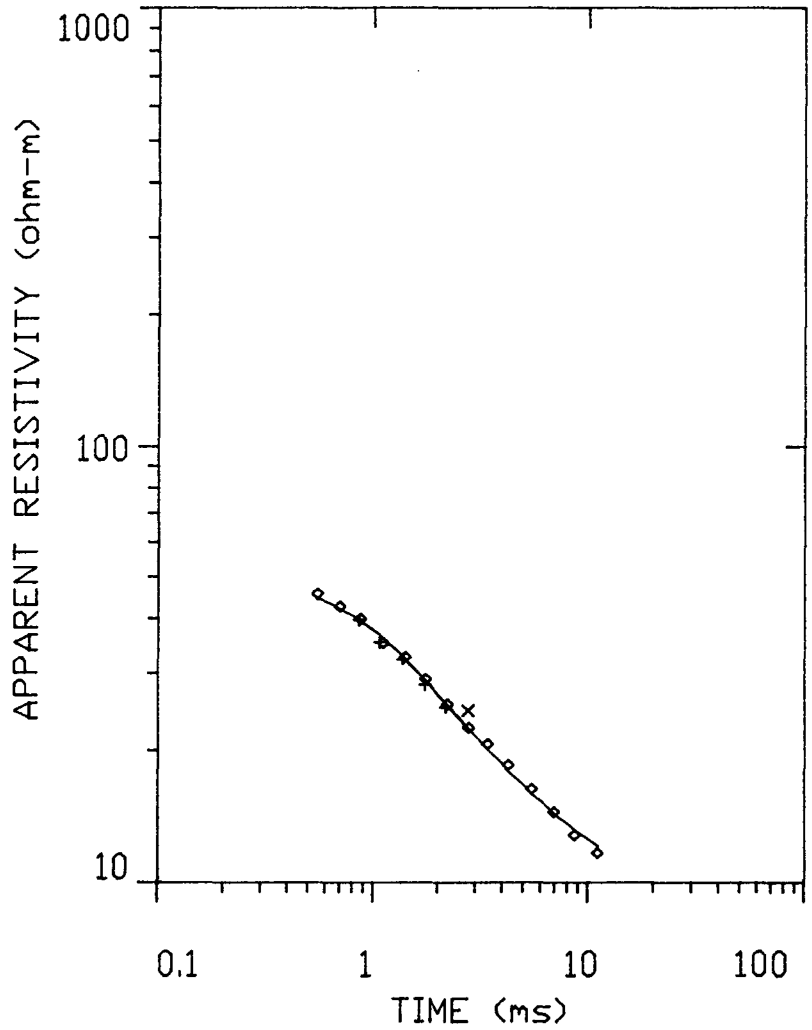
——	BEST-FIT MODELED CURVE
□	APPARENT RESISTIVITY VALUES USED IN MODEL
X	APPARENT RESISTIVITY VALUES NOT USED IN MODEL

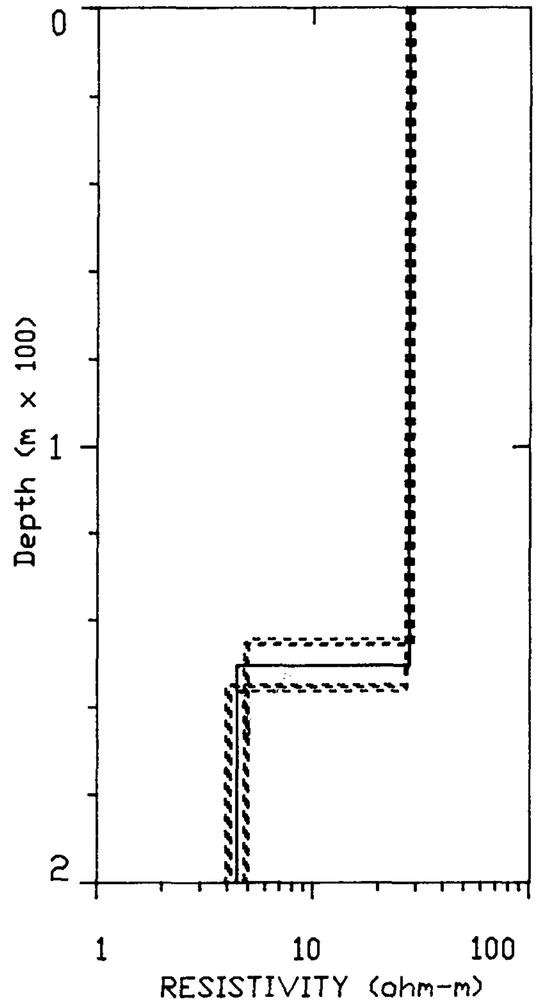
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 19 - BLUE SPRINGS STATE PARK
ORANGE CITY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-19	5.20-2
DRAWN BY:	SBG	DATE:	09/16/93	





— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 19 – BLUE SPRINGS STATE PARK
ORANGE CITY, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-19	5.20-3
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT: SJWRMD
LOCATION: BLUE SPRINGS STATE PARK
COUNTY: VOLUSIA COUNTY, FLORIDA
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 229.000 m by 76.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 11-05-93
SOUNDING: 1
ELEVATION: 14.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 3.306 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			14.00	
1	27.85	150.5	-136.5	5.40
2	4.42			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	26.797	27.858	29.164
	2	3.928	4.426	4.992
THICK	1	144.390	1.000	156.402
DEPTH	1	144.390	150.512	156.402

CURRENT: 24.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 4 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.550	3508.2	3615.1	-3.04
2	0.698	2133.2	2172.8	-1.85
3	0.869	1360.3	1381.0	-1.52
4	1.10	898.5	863.9	3.85
5	1.40	556.9	565.3	-1.51
6	1.75	381.7	386.3	-1.18
7	2.22	256.8	258.9	-0.793

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 19
BLUE SPRINGS STATE PARK

PROJECT NO.: 93742
TABLE 5.20-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	2.79	174.3	176.8	-1.43
9	3.42	119.1	124.9	-4.84
10	4.26	81.37	85.52	-5.10
11	5.49	52.18	54.35	-4.16
12	6.96	34.58	35.07	-1.41
13	8.66	23.99	23.09	3.72
14	11.06	14.99	14.21	5.20

CURRENT: 24.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
15	0.857	1423.0	1421.4	0.109
16	1.06	984.4	930.4	5.48
17	1.37	601.3	590.6	1.76
18	1.74	405.6	391.5	3.48
19	2.17	278.1	270.2	2.82
20	2.77	155.2	180.3	-16.21 MASKED

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.99		
P 2	-0.01	0.94	
T 1	0.00	0.02	0.99

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 19
BLUE SPRINGS STATE PARK

PROJECT NO.: 93742
TABLE 5.20-1

5.21 TDEM SITE 20 - DE LAND SITE

5.21.1 Location Description and Geoelectrical Section

The site is situated in southwestern Volusia County, Florida (Figure 5.21-1) and is located within a woodland with no obvious sources of interference. Together, Sites 1, 15, 16, 17, 18, 19 and 20 each lie within the area where the Hawthorn Group is thin to absent. The top of the Floridan aquifer begins at approximately 65 ft below msl (Scott et al., 1991). The top of the Lower Floridan aquifer is approximately 750 ft below msl (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.21-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.21.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the surficial aquifer system, the Hawthorn Group and the underlying Floridan aquifer to distinguish the three. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (276.7 m = 908 ft) surface layer of intermediate resistivity (42.3 ohm-m) overlying a low resistivity layer (3.3 ohm-m). It can be interpreted that the surficial aquifer system, the Hawthorn Group, and part of the Floridan aquifer exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Florida aquifer at a depth of 908 ft.

5.21.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 3.3 ohm-m, is interpreted to represent salt water. It occurs at a depth of 908 ft (-869 ft msl). Because the resistivity of layer 1 (42.3 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/L isochlor is taken at the depth of the geoelectrical interface, or at 908 ft depth (-869 ft msl). The resistivity of layer 2 (3.3 ohm-m) corresponds to a chloride content of 9,594 mg/L assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2.

5.21.4 <u>Depth of Occurrence of the 250 mg/L Isochlor</u>

Because of the inability to segregate the Floridan aquifer from the overlying surficial aquifer system and the Hawthorn Group, the effective chloride concentration of layer 1 cannot be calculated. According to Rutledge (1982), the chloride concentration in the Upper Floridan aquifer in the area of this site is less than 250 mg/L.

5.21.5 <u>Accuracy of Measurement and Interpretation</u>

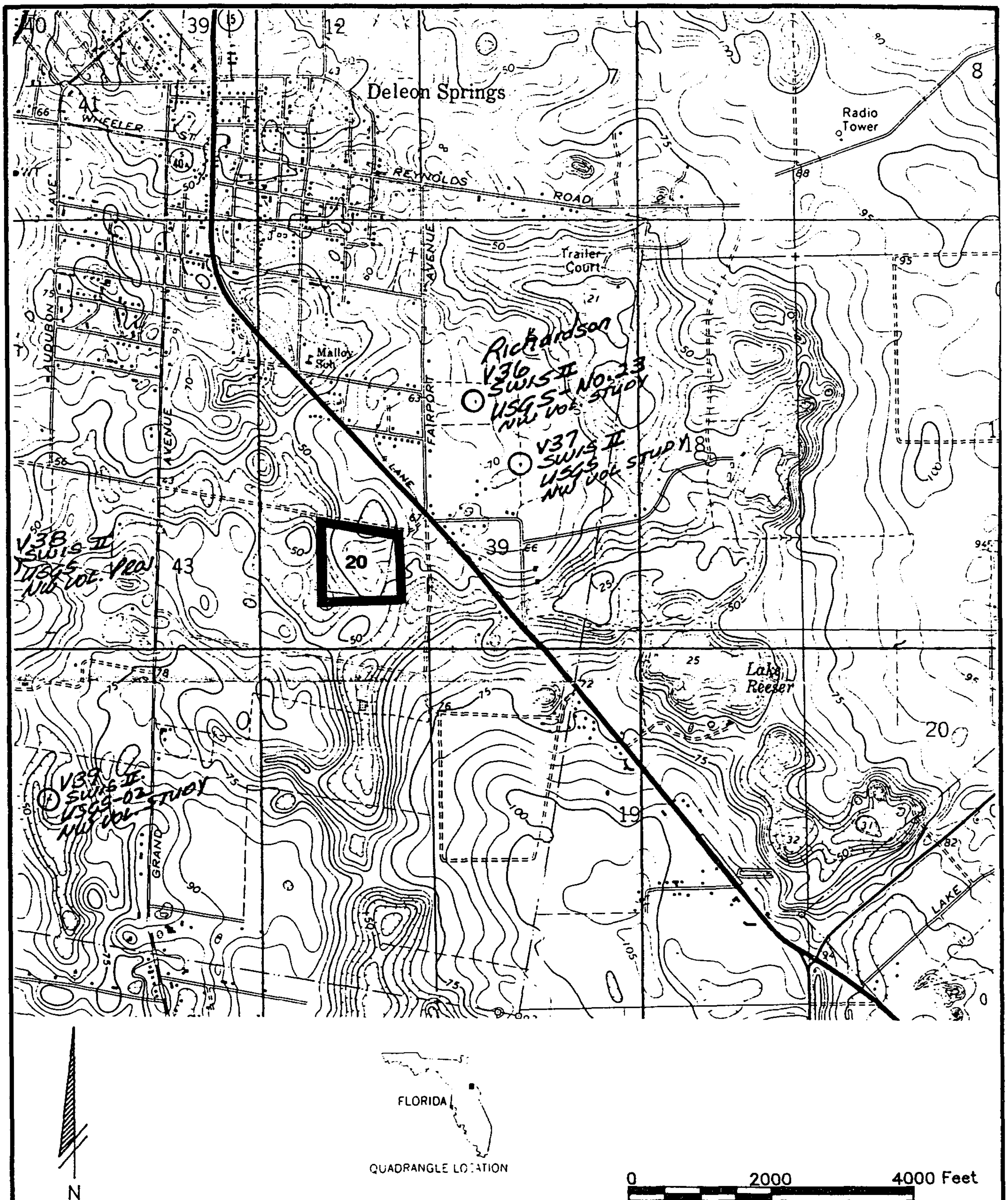
Figure 5.21-3 is the equivalence analysis at this site, and the inversion table (Table 5.21-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ± 7 m (23 ft), which is 3% of the total depth. The resistivity of this layer has an equivalence range of from 2.8 - 4.0 ohm-m. This corresponds to a range in interpreted chloride content of from 11,334 mg/L to 7,888 mg/L, again subject to the same assumptions of porosity and validity of equation (4). The estimated depth of the saltwater layer (908 ft bls) does not concur with the estimated depth of the freshwater/saltwater interface (approximately 600 ft bls) based on Ghyben-Herzberg analysis (Rutledge, 1982). Rutledge (1982) defines the depth to the freshwater/saltwater interface as forty times the groundwater table elevation above msl. The freshwater /saltwater interface is assumed to occur at the transition to unmixed seawater with a chloride concentration of 19,000 mg/L.

The equivalence range of the resistivity of layer 1 is from 41 - 44 ohm-m. A corresponding chloride concentration cannot be determined because layer 1 is in part comprised of the Hawthorn Group and surficial sediments. Accordingly, equation (4) may not be valid.

5.21.6 Summary of TDEM Sounding at De Land (Site 20)

- The depth of occurrence of salt water (5,000 mg/L isochlor) is interpreted to be 908 ft (-869 ft msl) and occur within the Lower Floridan aquifer. The measured layer resistivity at this level yields a chloride concentration of 9,594 mg/L. The results of the TDEM study do not agree with the results from other studies in the area. Rutledge (1982) estimated a depth of approximately 600 ft bls to the freshwater/saltwater interface.
- The quality of groundwater within the Floridan aquifer at the site cannot be interpreted because analysis of the TDEM data does not allow for the surficial aquifer and the Hawthorn Group to be distinguished from the Floridan Aquifer System.



ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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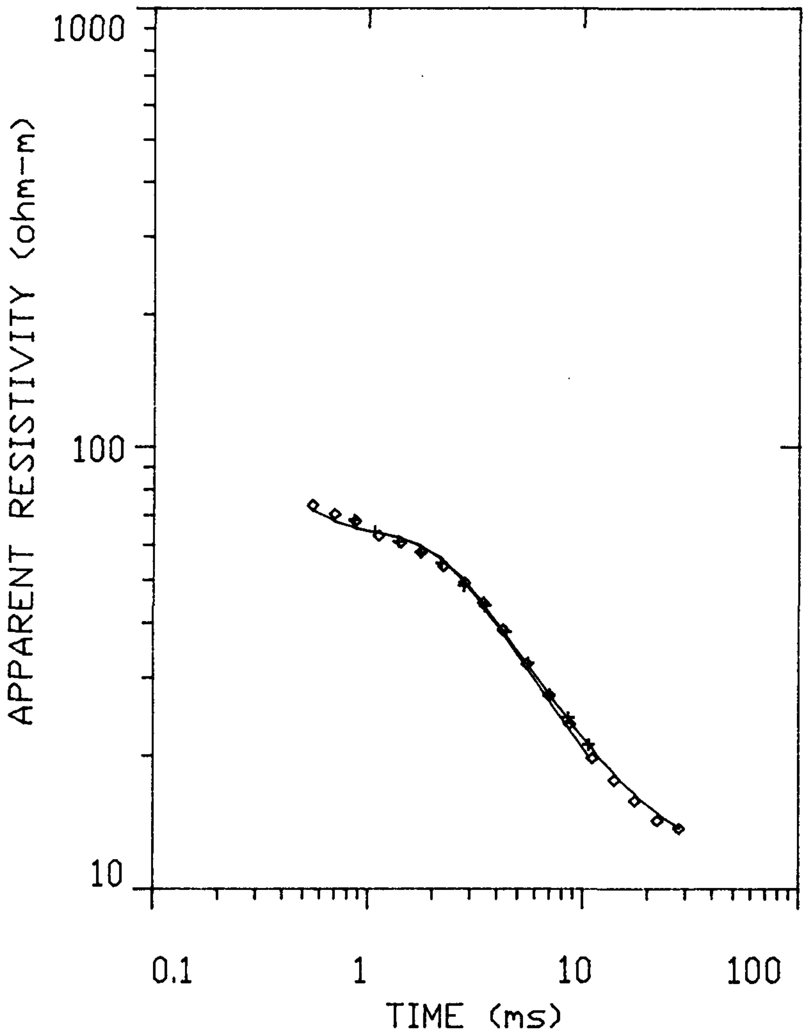
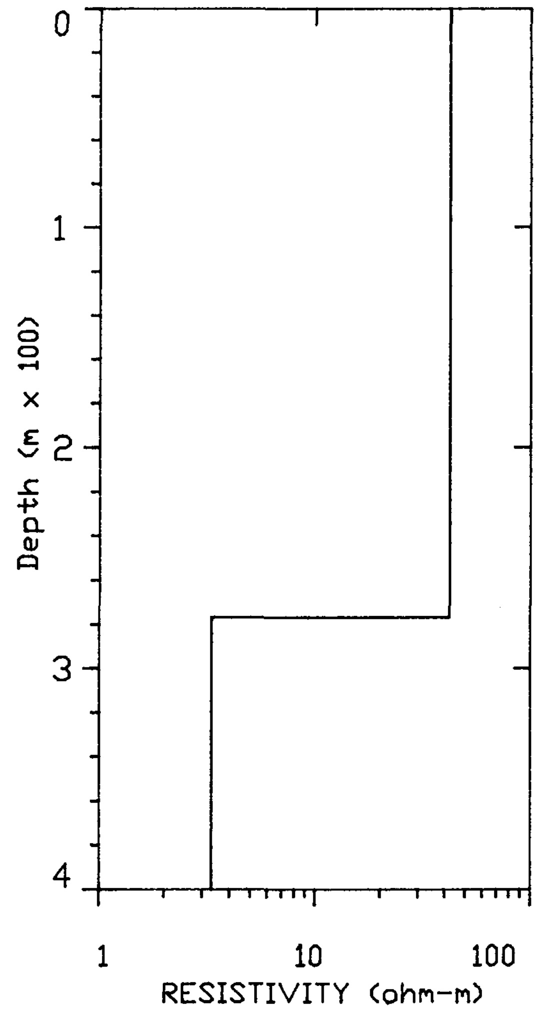
INVESTIGATIONS
INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 20 – DE LAND
DE LAND, FLORIDA

DESIGNED BY: MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY: RJW	DRAWING NO.:	LOC –20	5.21–1
DRAWN BY: SBG	DATE:	08/10/93	





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

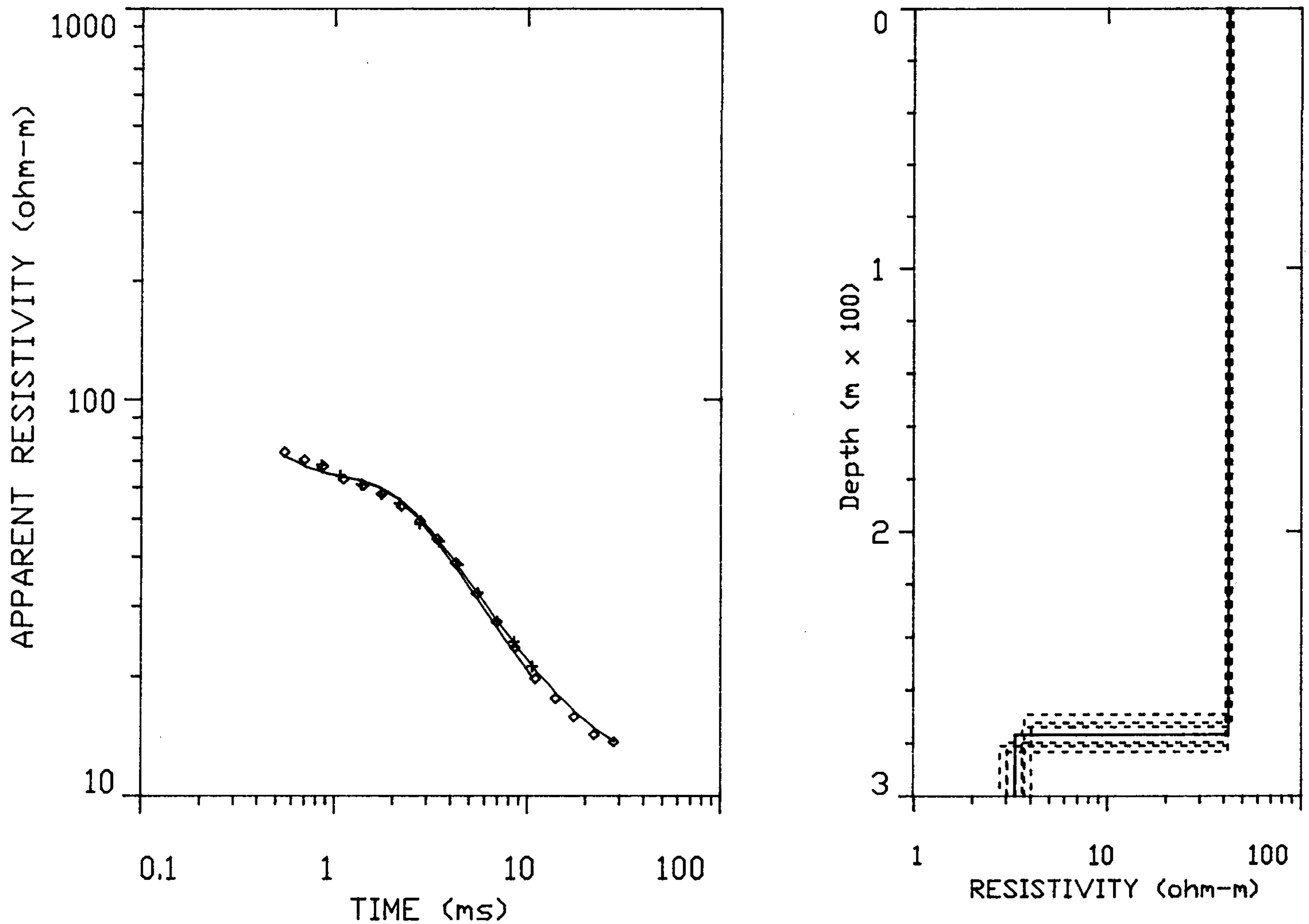
X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SOUNDING 20 -DELAND
DELAND, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	MDL-20	5-21.2
DRAWN BY:	SBG	DATE:	09/16/93	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SOUNDING 20 – DE LAND
DE LAND, FLORIDA

DESIGNED BY:	MJW	PROJECT NO.:	93742	FIGURE
CHECKED BY:	RJW	DRAWING NO.:	EQU-20	5.21-3
DRAWN BY:	SBG	DATE:	09/16/93	

CLIENT: SJWRMD
LOCATION: DELAND
COUNTY: VOLUSIA COUNTY, FLORIDA
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 305.000 m by 345.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 12-05-93
SOUNDING: 1
ELEVATION: 12.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.656 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			12.00	
1	42.33	276.7	-264.7	6.53
2	3.30			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	40.901	42.336	43.843
	2	2.759	3.309	4.023
THICK	1	269.115	1.000	283.295
DEPTH	1	269.115	276.743	283.295

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 4 RAMP TIME: 257.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.550	7275.6	7531.1	-3.51
2	0.698	4295.6	4548.8	-5.89
3	0.869	2622.1	2772.2	-5.72
4	1.10	1600.7	1567.5	2.07
5	1.40	935.7	901.3	3.67
6	1.75	579.8	551.3	4.90
7	2.22	356.6	339.0	4.93

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
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SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SOUNDING 20
DELAND

PROJECT NO.: 93742
TABLE 5.21-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	2.79	229.0	224.5	1.95
9	3.42	161.3	161.4	-0.0922
10	4.26	115.0	115.2	-0.124
11	5.49	79.77	79.33	0.548
12	6.96	56.38	55.71	1.18
13	8.66	40.78	39.83	2.32
14	11.06	28.96	26.99	6.81
15	14.00	19.06	18.11	4.97
16	17.47	12.87	12.24	4.84
17	22.23	8.22	7.75	5.67
18	28.10	4.87	4.85	0.386

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 257.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
19	0.857	2695.3	2867.1	-6.37
20	1.06	1708.4	1722.4	-0.819
21	1.37	985.4	956.3	2.95
22	1.74	590.0	562.4	4.67
23	2.17	368.1	358.5	2.61
24	2.77	239.1	231.3	3.26
25	3.50	155.8	159.6	-2.38
26	4.37	109.5	114.5	-4.56
27	5.56	76.78	81.35	-5.94
28	6.98	55.85	58.70	-5.09
29	8.56	39.96	43.55	-8.98
30	10.64	28.71	31.46	-9.58

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	-0.01	0.89	
T 1	0.00	0.01	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
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TDEM SOUNDING DATA TABLE
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TABLE 5.21-1

6.0 SUMMARY AND CONCLUSIONS

A time domain electromagnetic (TDEM) survey was performed at 19 sites in the St. Johns River Water Management District and one site in Georgia during the months of April-May, 1993. The principal findings of this survey can be summarized as follows:

TDEM is a geoelectrical method which can be used to estimate the vertical variation or resistivity of subsurface formations and/or hydrostratigraphic units. Translating the geophysical measurement of electrical resistivity into a model of geology and water quality depends upon comparison to other available subsurface data, consistency of data sets from nearby soundings from this and prior years, and application of empirical relationships to produce interpreted water-quality results. As outlined in Section 4, the conversions to water quality values (chloride concentrations) are based upon the relationships established using Kwader's (1982) data for Seminole County, as used for SJRWMD in previous studies (Blackhawk, 1990 and CEES, 1992). The formulae employed use assumptions of a 25% porosity, similar water chemistry (specifically, a 5:1 chloride-to-sulfate ratio) as Kwader's data, and that the saltwater interface occurs within the Floridan Aquifer System. With regards the latter point, chloride concentration values are presented only for those portions of the geoelectrical section which correspond to the Floridan aquifer and not for the Hawthorn Group and surficial sediments or for surficial sediments where the Hawthorn Group is missing.

Under circumstances where there is little contrast in resistivity between the surficial sediments and/or Hawthorn Group and the Upper Floridan aquifer, the chloride concentration of the ground water above the freshwater/saltwater interface cannot be determined. This is because of the assumptions implicit in equation (4) are not valid.

Finally, because the freshwater/saltwater boundary is not an abrupt interface but a transition zone, criteria relating to the relative resistivities above and below the geoelectrical interface were used to establish an empirical definition of depths to the 250 and 5,000 mg/L isochlors. Again, these were the same criteria as used in past years' TDEM surveys (Blackhawk, 1990 and CEES, 1992) in order to maintain consistency from year to year.

6.1 DETERMINING THE DEPTH OF THE INTERFACE BETWEEN FRESH WATER AND GROUND WATER OF HIGH CHLORIDE CONCENTRATION (GREATER THAN 1,450 mg/L)

As stated in previous years' reports (Blackhawk, 1990 and CEES, 1992), "ground water with a chloride content greater than 1,450 mg/L is characterized in the Floridan aquifer by resistivities less than 20 ohm-m when the aquifer has a porosity of about 25%." In accordance with this statement, a deep layer with a resistivity of less than 20 ohm-m was detected at 18 of the 20 sites surveyed. At the Picolata sounding, Site 6, the basal resistivity layer had a resistivity of 27.4 ohm-m. The resistivity value was sufficiently close to 20.0 ohm-m that the results of this sounding were considered similar to the other 18 sites. Only the Cumberland Island sounding, Site 2, failed to detect the basal, low resistivity layer. A forward-modeling/sensitivity analysis indicates that if such a layer were present, it must be at least 2,200 ft deep. The remaining 19 sites show variation in depth to this interface to range from approximately 413 - 2,427 ft. All the interpreted depths place the saltwater interface within the Floridan aquifer System.

6.2 WATER QUALITY IN THE FLORIDAN AQUIFER AND DEPTH OF OCCURRENCE OF THE 250 mg/L ISOCHLOR

Based on the assumptions that: (a) The Floridan aquifer has a porosity of 25%, (b) ground water within the study area have a chemistry similar to those analyzed by Kwader (1982), and (c) equation (4) in Section 4.2 is valid, ground water having chloride concentrations of less than 250 mg/L correspond to geoelectrical layers having resistivities in excess of 80 ohm-m. The distribution of resistivities of the Upper Floridan aquifer show, for the most part, high resistivities and, therefore, fresh waters of less than 250 mg/L are present in the Floridan aquifer over much of the survey area. There was one site, St. Augustine #1 (Site 4), where the resistivity of the Upper Floridan aquifer was less than 80 ohm-m and brackish water is interpreted to be present. When a layer with a chloride concentration of less than 250 mg/L is interpreted, the position of the 250 mg/L isochlor is fixed by the relative resistivities of the deep, conductive layer and the fresh (resistive) layer above - generally placing it 50 ft above the geoelectrical interface. When the resistivity of the Upper Floridan aquifer is such that the interpreted chloride concentration exceeds 250 mg/L, a depth to the 250 mg/L isochlor was not determined as the entire system is considered to be brackish.

7.0 REFERENCES

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