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TECHNICAL LETTER REPORT

December 20, 2005

To: Ing. Antonio Hernández Virella
AHV & Associates
Box 1480, Espinar Ward
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From: Geol. Jaime Feliciano

Re: Results from Geophysical Electrical Resistivity Profiling and Subsurface Sampling and Testing Work, Groundwater Investigation, Proposed Discovery Bay Marina Site, Espinar Ward, Aguada, PR

Introduction

As per the request of Ing. Antonio Hernández Virella of AHV & Associates, JFA Geological & Environmental Scientists, P.S.C. (JFA) has conducted a geophysical resistivity survey and a subsurface sampling and groundwater and testing work at the site of the above-referenced project.

The study was aimed at providing hydrogeologic data to evaluate the proposed development of the site into an inland marina basin and residential complex with a dock-slip capacity of 500 boats. Preliminary designs indicate that the marina will involve the excavation of surficial soils to a depth of 15 ft. below ground surface (bgs), encompassing an area of approximately 60 acres.

The objective of the investigation was to characterize the coastal hydrogeologic conditions and to determine, to the extent possible, the configuration of the saltwater/freshwater interface underlying the proposed project site. The assessment of the hydrogeologic conditions in the coastal area will aid in the determination of any potential effects of the proposed marina excavation on the quality of the surficial water aquifer.

Location and Project Description

The proposed Discovery Bay Marina project site is located within the Río Culebrinas flood valley, just to the northeast of the Espinar Ward of the Municipality of Aguada (Figure 1). The site is limited to the north by the coast line in the Aguadilla Bay, to the west by the Espinar Community and to the east by the Madre Vieja Creek. To the south and southeast, the site is limited by the Culebrinas River and by state road PR-115, respectively.

The project site lies on a coastal plain setting encompassing flood valleys of the meandering Culebrinas River and the Madre Vieja Creek. The land consists of former sugar cane fields, which are generally level and with very low topographic relief. Available topographic data indicates that the elevation in the study area varies from 0 at the coast to about 3.0 meters (~ 10.0 ft) along route PR-115. An area of swamps and mangroves separate the coast from the flood plain fields. Low relief dunes and beach deposits are observed north of the swamp areas.

The proposed Discovery Bay Project will include the development of a resort area and an inland marina basin area as depicted in Figure 2. In essence, the basin area to be excavated will extend from the coastline, near the mouth of the Madre Vieja Creek, approximately 1,200 meters (~3,936 ft.), to where the site is limited by Route PR -115 to the southeast. The eastern limit of the basin will extend, in most areas to the present location of the Madre Vieja Creek.

Based on the site plan provided, the proposed meandering basin will include an area of about 203,296 ^{2} meters with an entrance channel to be approximately 65 meters (~213 ft.) wide. The basin will be excavated 15 ft below sea level.

Geologic and Hydrogeologic Setting

The geology of the study area has been generally described on the Geologic Map of the Aguadilla Quadrangle by W.H. Monroe, U.S.G. S., 1969 (Figure 3). This coastal and flood plain area is primarily underlain by Recent (Quaternary) Age, unconsolidated alluvial sediments (Qa) consisting of clayey sand and sandy clay, containing scattered pebbles and cobbles of volcanic rocks. Coeval swamp deposits consisting of sandy organic muck and peat have been mapped on the northernmost area of the site, overlying the alluvial sediments. Closer to the coastline, the surficial geology is comprised of recent beach deposits, consisting of cross bedded quartz sand and shell fragments.

According to the map, the unconsolidated alluvial sediments would overlie Tertiary Age, Carbonate platform strata of the Cibao Formation at the project site. This formation consists of thick layers of calcarenite, chalky limestone and calcareous clay layers within average thickness of approximately 200-250 meters.

Lithologic descriptions of the above-described alluvial sediments confirming the geologic setting at the site have also been conducted at the site. The studies have been performed by means of subsurface geotechnical borings and the corresponding reports conducted by Advanced Soil Engineering and by Foundation Engineering, Co. on February of 2002 and June 1998, respectively.

Hydrogeologic data from the study area are limited to a regional generalized assessment by the U.S.G.S. on the hydrogeology of northwestern Puerto Rico (T.D. Veve and B.E. Taggart, U.S.G.S. 1996). More recently, in June of 2005, Moffatt and Nichol, Engineers (MNE), have conducted a groundwater flow analysis at the proposed project area. Their evaluation was based on available regional soil characteristics, and field measurements of hydraulic conductivity in the surficial aquifer underlying the site.

According to their reports, two main hydrogeologic units underlie the site. The first aquifer consists of an upper unconfined aquifer composed of stratified unconsolidated alluvial sediments with an assigned thickness of 120 ft bgs. This aquifer is in turn underlain by a limestone formation aquifer of Tertiary Age with an assigned thickness of 600 ft.

MNE has detected groundwater levels in wells varying from 1.89 ft bgs in a well on the northern (coastal) portion of the site, to about 7.10 ft near the southern limit of the proposed project. They have also estimated an average hydraulic conductivity in the surficial aquifer of 45 ft/day, based on hydraulic slug tests performed in the monitoring wells. Based on the above information, MNE has modeled the hydrogeology at the site to simulate the groundwater flow contribution into the proposed marina excavation. Their results indicate that the average rate of total groundwater inflow into the proposed marina basin will average 2.44 million gallons per day (MGD). Approximately 33% of this total inflow will be generated from the base of the surficial aquifer. Groundwater flow directions generated from the analysis suggest a general north-northeast trend across the alluvial valley, towards the mouth of the Madre Vieja Creek.

Field Methodology

The groundwater investigation at the site has been conducted by integrating lithological data, groundwater and surface water conductivity measurements and geophysical electrical resistivity profiling. The goal was to establish a hydrogeologic profile within the area extending near the coastline and through the proposed excavation for the marina. The resulting "best fit" profile would essentially trend roughly north, northwest-southeast, perpendicular to the existing coastline (Figure 4).

The test hole and monitoring well data were obtained in accessible areas along the proposed profile. Drilling and sampling comprised 5 subsoil test holes that were advanced to depths between 40-47.5 ft. and the installation of five, 2-inch and fully-screened monitoring wells with depths varying between 41.8 and 47.8 feet below ground surface. Two additional locations were selected for the collection of additional subsoil samples and of grab groundwater samples at pre-determined depths by means of the Geoprobe Screenpoint 16 Groundwater Sampling System. Drilling and groundwater testing activities were performed during the weeks of November 29, and of December 5, 2005.

Groundwater testing included the collection of water levels and temperature and conductivity readings in units of µs/cm with a Solinst Model 107TCL. Measurements were also obtained from surface water at several locations along the Madre Vieja Creek and adjacent water bodies, including the estuarine zone to the north and sea water from the beach area to the north of the profile.

JFA subcontracted the services of ENSR Geosciences Division from Warrenville, IL for the collection of field geophysical resistivity data at the site. JFA and ENSR performed the data collection activities concurrent with the second half of the drilling and groundwater testing activities from December 2nd through the 6th. Resistivity profile locations and/or lengths were modified as results from the drilling and monitoring activities were obtained and analyzed. The geophysical investigation resulted in the collection of four electrical resistivity profiles totaling 3,788.4 linear ft. of survey (~ 1,155 meters). The geophysical survey layout is shown in Figure 4. The coastal area to the north of profile DB1 and well BW-1 could not be surveyed due to access limitations and the presence of soft soils within a swamp and mangrove area.

When correlated with the hydrogeologic and groundwater conductivity data, the results from the modeled electrical resistivity survey provided an interpreted vertical extent of the saltwater/freshwater interface at the site.

Subsoil Sampling and Groundwater Monitoring Well Installation

A total of five groundwater monitoring wells were installed in the study area for the collection of subsoil data and groundwater temperature and conductivity measurements. The locations of test holes and monitoring wells (BW-1 through BW-5) are shown in Figure 4. Subsoil samples were collected at borings BW-1, BW-2 and BW-5, for purposes of correlation of the unconsolidated sediments. Available subsoil descriptions from previous geotechnical and hydrogeological studies at the site have indicated generally uniform stratigraphic conditions dominated by sand deposits and a very shallow (2-5 ft.) water table.

The subsoil sampling and groundwater monitoring well installations were performed by means of Geoprobe® 6610-DT direct push soil-probing rig. Samples were collected with the Geoprobe®, large-bore sampler at pre-selected depths or as dictated by geologic conditions.

In general, the subsoil sampling confirms the above-described geologic setting and revealed the presence of the following geologic layered sequence in the area of the borings:

> 0-0.2 ft. - Thin layer of top soil, consisting of soft to medium sandy clay, with little roots and wood fragments, yellowish brown, dark gray.
>
> 0.2-7.0 ft. - Soft clay and/or fine sandy clay, yellowish brown, dark gray.
>
> 7.0-20.0 ft. - Loose, dark gray, fine to medium sand (grades with depth into coarse sand), trace gravel.
>
> 20.0-40.0 ft. - Loose, fine to very fine sand, light olive gray with a trace of organic odor.
>
> 40.0-47.5- Dense to medium dense, very fine sand, some silt to silty, little shell fragments, dark gray.

Subsoil sampling was also performed from 20.0 to 40.0 feet at groundwater sampling location GWS-1 (Boring Log GWS-1b). This target sampling was aimed at determining the composition of a high-resistivity layer identified on the geophysical survey profiling. This boring revealed the presence of dark gray, loose to medium dense, sandy gravel and coarse sand with evidence of partial cementation.

Monitoring wells were installed by means of the DT32 (dual-tube) system. The monitoring wells were fully-screened to the attained depths and were constructed of a 2-inch, schedule 40 PVC material. The wells were placed tightly in the loose sands of the underlying aquifer formation material through the 3.25” drill casing, thus no-filter pack was introduced in the system. Very high hydraulic conductivity values in the surficial aquifer obtained by MNE suggests the presence of highly permeable geologic materials at the site. The wells were surface-finished with a steel protective cover and a cement-bentonite apron. Complete subsoil and well construction logs are presented in Appendix 2.0.

<u>Groundwater Levels</u>

Groundwater was encountered at the borings drilled at depths varying between 1.23 and 3.5 ft. bgs. Additional measurements obtained from the top of the casings of monitoring wells and latter converted into GW elevations above MSL, indicate a general groundwater flow of the surficial aquifer in a north-northeast direction and very low hydraulic gradients (Figure 5). The detected groundwater levels are in general accordance to the observed surface water elevations at the existing Madre Vieja Creek and mangrove areas to the north of the site. The present groundwater flow direction is also in general agreement with the groundwater flow analysis performed by MNE.

Conductivity Measurements

It has been well-established that natural surface waters and groundwater contain many impurities that occur as salts or dissolved minerals. In groundwater, these dissolved constituents are present in the ionic form, as a result of the chemical interaction with the material through which it flows (Freeze and Cherry, 1979). The concentration of the total dissolved solids (TDS) is generally measured in parts per million (ppm) or in mg/l and is directly related to the concentration of dissolved salts in the water.

It is important to note that groundwater with a TDS or mg/l ranging from 2,000-3,000 is too salty for drinking use. Tap water should have 500 mg/l or less and water used for agriculture should generally range below 1,200 mg/l.

Table 1.0 Simple Groundwater Classification Based on Total Dissolved Solids (from Freeze & Cherry, 1979)

Category	Total dissolved solids (mg/l or g/m^3)
Fresh Water	0-1000
Brackish water	1000-10,000
Saline water	More than 100,000

Electrical conductivity measures the ease with which current passes through water. It is the capability of a material to conduct electricity. Another way to measure the total dissolved ionic content in groundwater as well as its salinity is to measure its electrical conductivity. In essence, the higher the electrical conductivity, the greater its salt (or ionic content) concentrations. Electrical conductivity measurements are the most common and rapid methods for collecting indirect measurements of TDS-salinity concentrations in water. Measurements are commonly expressed in µS/cm (micro-siemens per centimeter). Electrical conductivity is the reciprocal of electrical resistivity (e.g., high conductivity equals low resistivity).

As indicated in the literature, the chemical composition of dissolved solids in groundwater can vary between a factor of 0.54-0.96. To convert electrical conductivity measurements to TDS, we use a factor of 0.67 (commonly used as an approximation) by means of the formula TDS (ppm) = (µs/cm) x 0.67.

The formula yields the following ranges:

Category	Electrical Conductivity (µs/cm)
Fresh Water	0-1,492
Brackish Water	1,492-14,925
Saltwater	14,925-149,253

The results of the groundwater conductivity measurements collected on December 7, 2005 are presented in the well logs in Appendix 3.0. It is important to note that wells were not developed to avoid mixing of groundwater with distinct conductivities and/or disturbance of layered aquifers. Given the high hydraulic conductivity properties of the underlying sands, the wells were left to stabilize for a few days following their installation.

Conductivity and temperature measurements were obtained with an electronic water level, temperature and conductivity meter (Model 107 TLC) from Solinst (Figure 6). The instrument was properly calibrated prior to its use with buffer solutions provided by the manufacturer.

Conductivity readings from wells were obtained on December 3 and December 7, 2005. Data from both dates show similar conductivity values at similar depths. This suggests that groundwater entering the monitoring wells appears generally stable. The data collected on December 7, 2005 was measured during the predicted high tide at approximately 14:30 local time. The time of this high tide was obtained from the NOAA web page from tide level data from a station at Magueyes Island in Lajas, PR. Ideally, these measurements provide a good estimate of the saltwater concentrations expected in the area during high tide periods.

In general, monitoring wells BW-1, BW-2, BW-3 and BW-5, indicate a sharp and well-defined increase in the conductivity (salinity) of the groundwater with values well-above 15,000 µs/cm with depths varying between 20-25 ft. bgs. This sharp contrast will correspond to the top of the saltwater layer at the site. At well BW-5, this saltwater layer was encountered at a depth of approximately 14.0 ft. bgs. In wells BW-1, BW-2 and BW-5, the groundwater above the saltwater layer is mainly brackish, with conductivity values ranging from 5,000 µs/cm to 15,000 µs/cm. Based on the drill-hole data, the brackish water gradually increases in salinity with increasing depth until reaching the top of the saltwater layer. The saltwater layer appears to occur within a layer of fine to very fine sand in this area.

Additional conductivity measurements were also obtained through grab water samples collected at depths of 70 and 60 ft. bgs at locations GSW-1 and GWS-2. Conductivity readings indicate the presence of brackish water at 70 ft depth at location GWS-1 (14,900 µs/cm) and of fresh water at 60 ft depth at location GWS-2 (1,805 µs/cm).

Temperature measurements in the above wells indicate a gradual decrease in temperature from approximately 80-82.5 ºF, to about 78.7 ºF, where it becomes generally steady with increasing depth. This steady 78.7 ºF value corresponds with the saltwater layer.

Conductivity and temperature data from well BW-4 located farther inland and to the southeast, indicates conductivity values at depths between 1,100 µs/cm to 2,010 µs/cm and a gradual decrease in temperature from 82.5 ºF to about 79.6 ºF. These values generally correspond to fresh groundwater of the surficial aquifer at the site. Brackish water was minimal to none-detected at depth in well BW-4. Similar values were obtained at well BW-3 to a depth of = 22.0 ft bgs indicating the presence of the freshwater aquifer at that location.

A series of contour maps have been generated depicting the electrical conductivity of the groundwater measured in the wells at different depth intervals (Figure 7). The maps indicate that the freshwater aquifer exists to the south of well BW-3 at the top of the water table and at depths of about 10 ft. At these shallow depths, brackish water dominates the groundwater in the area between the wells and saltwater lies in the extreme north section of the maps. At depths of about 20 ft, saltwater intrudes southward to the area between wells BW-2 and BW-3 and brackish water and fresh water dominate the area between wells BW-3 and BW-4. The conductivity measured at depths below 30-40 ft indicates that the groundwater is dominated by saltwater intrusion to the north and northwest of well BW-4.

Conductivity Measurements of Surface Waters

Conductivity probing was performed at nine locations in accessible areas where surface water bodies are exposed at the site. The data was collected also on December 7, 2005, around the high tide period at approximately 1430 local time. Measurements were obtained by lowering the Solinst 107 TLC meter to about 6-10 inches in the surface water. The conductivity values, presented also as TDS values in Figure 8, indicate that saltwater is present in the surface water to the north and northwest of well BW-1 (Samples SW-6, SW-9), in the area where a creek and mangrove forest trend parallel to the coast. This location is in general agreement with the interpretation obtained from the groundwater conductivity data described in the previous section.

The map also suggests that brackish water extends further inland at locations SW-1, SW-2, SW-7. This influx of brackish water is most likely the result of several factors such as mixing of waters by tidal influence. Other factors to consider are the fact that freshwater discharge at the mouth of the Madre Vieja Creek was hindered due to blockage by large volumes of sand at the time. Also, precipitation and the associated freshwater discharge in the area were minimal during the two weeks of the field study.

As expected, the remaining sampling locations suggest that freshwater dominates the southeastern portion of the Madre Vieja Creek, as indicated at locations SW-3, SW-4, and SW-5.

Electrical Resistivity Profiling

The objective of electrical resistivity profiling is to map the subsurface distribution of the resistivity of materials when applying an electrical current flow into the ground surface. The resistivity of a material to an electrical current is a measure of how difficult it is to make a current flow through it. The resistivity survey consists of generating a 2-D electrical resistivity profile by injecting direct current (DC) into the ground through two current electrodes and measuring the resulting voltage difference through two potential electrodes. In essence, the transmitted, low amperage DC is measured between electrodes (steel stakes) spaced equally apart along a profile with a high sensitivity resistivity meter.

An Advanced GeoSciences, Inc. (AGI) 8-channel, SuperSting with Swift automatic resistivity system was used to collect resistivity readings along profiles. Apparent resistivity values were recorded automatically utilizing an operator-defined data collection sequence and stored digitally in the memory of the instrument. The electrode array consisted of a total of 56 steel electrodes placed at 3-meter or 6-meter intervals (Figure 9). Average depth of penetration along the profile is approximately 25% of the total length of the spread.

JFA subcontracted the services of Mr. John Petruccione, Senior Geophysicist from ENSR Geosciences office in Warrenville, IL. Mr. Petruccione is a field specialist and expert operator on the SuperSting. ENSR services for the project included field operation of the SuperSting unit for data collection and resistivity data interpretation. A summary of field procedures and data collection and interpretation has also been provided by ENSR and has been incorporated into this report.

Since the project objective was to map the saltwater interface at depth at the site, the predicted electrical response consists of elevated resistivity for freshwater saturated zones versus lower resistivities for those areas saturated with brackish and/or saltwater. Whittecar and others (2005) assessed resistivity values lower than 20 ohm-meters (Ω-m) as saturated zones having elevated salinity (brackish water) with respect to freshwater occurrence (>20 Ω-m response) within the subsurface. Similarly, Hild and others (1996) indicated that geophysical surveys performed on the coastal mainland United States and Hawaiian Islands show resistivities of 10 Ω-m or less for saltwater saturated aquifers, and their paper discussed similar results from northern Guam.

Electrical resistivity profile data were collected using both the Schlumberger and Wenner Arrays. Since the lithology at the site is well-established, consisting mostly of of coarser grained (sand) sediments, ENSR designed the resistivity electrode arrangement and spacing to model subsurface resistivity to approximate 100 ft (30 m) bgs for the survey area located within 1,000 ft (330 m) from shoreline. A 20 ft (6 m) electrode spacing was employed for deeper profiling capability in those areas greater than 1,000 ft (330 m) from the shoreline. A total of four resistivity profiles were collected during the field mobilization and consisted of a single profile (DB-1) with 3-m electrode spacing, and three profiles (DB-2 through DB-4) with 6-m electrode spacing.

Lateral location control of the electrode positions along profiles and existing permanent site features such as monitoring wells and culverts were recorded by GPS using a Trimble GeoXT unit for field-grade (<1 m lateral resolution) surveying. GPS locations of the resistivity profile endpoints and every 4th electrode position along profiles were collected during the survey. Spatial information was collected in the Puerto Rico/Virgin Islands coordinate system providing northing and easting position information that was directly overlain on an electronic survey map provided by JFA.

Due to negligible topographic relief at the site, topographic data were not collected and topographic corrections were not performed as part of the data processing sequence.

Prior to the start of data collection for each of the four resistivity profiles, a contact resistance test was performed for the electrode array as a QA/QC means to confirm adequate electrical current ground coupling. Contact resistance was generally low (<300 Ω) and deemed sufficient for transmission of electrical current into the ground. Apparent resistivity data were collected and digitally stored to the SuperSting, and in general, data error was negligible, consistently 0.05% or less.

The geophysical data collected on the SuperSting were downloaded to a laptop computer. These profile data were inverted using AGI's Earth Imager 2-D resistivity software, and the processing sequence included output of both apparent and calculated geo-electrical profiles (pseudosections) and an inverted (modeled) resistivity profile. RMS error for the four inverted resistivity profiles was less than 3%, and this low percentage error provided a relatively high-degree of confidence in data quality. The modeled resistivity profiles were output to Surfer for enhanced visualization purposes (Figures 10-a through 10-d). A final composite modeled electrical resistivity profile was comprised of profiles DB-1, DB-2, and DB-4 that provided a northwest-southeast transect (Figure 11). Monitoring wells and groundwater probe locations were superimposed on the profile.

Since the Schlumberger Array provided deeper subsurface electrical imaging capability versus the Wenner Array, the Schlumberger Array data were used for final data presentation and interpretation. Vertical depth resolution for the resistivity profile is placed at one-half the electrode spacing, and based on this assumption resolution ranges from 5 ft (1.5 m) for profile DB-1 and 10 ft (3 m) for profiles DB-2, DB-3, and DB-4.

Based on the literature, the predicted and observed resistivity range appears to be consistent with responses from freshwater transitioning to brackish and saltwater along the areas of profiling. Electrical resistivity data correlation with groundwater conductivity response collected from the drilled monitoring wells on the site indicates the following:

1. In general, higher resistivity values occur within the shallow subsurface and are the interpreted response of fresh-to-brackish groundwater. An observed decrease in resistivity with depth is the interpreted result of an increase of salinity in groundwater.

2. A strong deflection to increasing conductivity (peak response greater than 45,000 microSiemens/cm) and decreasing resistivity (decreasing below 5 Ω-m) is observed at monitoring wells BW-1 and BW-2 at approximately 20 ft (6 m) bgs. This peak conductivity response is interpreted to be saltwater and correlates to the peak decrease in resistivity (on the order of 2 Ω-m or less). Refer also to the well logs BW-1, BW-2 and BW-3 in Appendix 4.0.

3. Areas of elevated resistivity (>20 Ω-m) appear to be dominated by freshwater. Monitoring well BW-4 shows this correlation of relatively low groundwater conductivity and elevated resistivities to a depth of at least 40 ft (12 m) bgs. Based on calibration from monitoring wells where saltwater is apparent at shallow depths (e.g., BW-1 & BW-2), the saltwater interface (resistivity <5 Ω-m) is interpreted to extend to approximately 80-90 ft (24 m) at the BW-4 location.

Based on the correlation of geophysical and groundwater conductivity data collected for this project, an interpreted saltwater interface has been identified (Figure 12). These data findings indicate that the saltwater interface deepens to the southeast away from the shoreline with a somewhat gradual slope over the first 1,000 ft (~300 m) from the shoreline. For instance, this interface is mapped at approximately 20 ft (~6 m) below ground surface (bgs) at approximately 330 ft (~100 m; near DB-1) from shoreline, and at about 1,000 ft (~300 m; near BW-3) from shoreline the interpreted saltwater interface extends to approximately 35 ft (~10 m) bgs. The predicted saltwater interface is interpreted to extend to 80 ft (~24 m) or more bgs at a distance of approximately 1,500 ft (~457 m; near BW-4) from the shoreline. There appears to be either an abrupt deepening of the interpreted saltwater interface at approximately 3,150 ft (~960 m; near GWS-2) from shoreline, a lateral change in geology, or a combination of these factors. Drill-core data at depth (>100 ft (30 m) bgs) are limited towards the southeastern portion of the Site property so only speculation exists as to what factors control a steeping of the interpreted saltwater interface at this location.

Summary of Results and Interpretations

Groundwater conductivity measurements and geophysical electrical resistivity profiling have been performed at the proposed Discovery Bay Resort and Marina site in the coastal plain area, northeast of the Espinar Ward in Aguada, P.R. A successful correlation of test well data and resistivity profiling has been attained and has aided in delineating the saltwater/freshwater interface at the project site. The results indicate that saltwater intrudes the surficial, water table aquifer inland to approximately 275 ft from the coastline as shown in Figure 13. A subsurface contour map showing the top of the saltwater layer in Figure 14 confirms the approximated depth extent and general orientation of the interface.

A generalized hydrogeologic cross-section, trending roughly perpendicular to the coast line has been generated from interpreted groundwater conductivity data and modeled electrical resistivity profiling as shown in Figure 15. Superimposed on the profile is the proposed depth of the excavation for the marina. The interpreted profile suggests that a 60-80 ft. thick freshwater aquifer underlain by brackish water extends from beyond the southern limit of the proposed project in the Culebrinas Valley to about 900 ft. (≈275 m) from the coast line. Brackish water at the site extends from about 900 ft, northward to about 275 ft (≈84 m) from the coastline. To the north of this area, saltwater is present below the mangrove forest and extend into the present day beach zone.

In general, the saltwater/freshwater interface below the freshwater aquifer lies at depths in excess of 80 ft. bgs to the south, southeast of the brackish water limit. The southeast limit of the interpreted profile also indicates that the underlying saltwater layer dips abruptly downward and its inland advancement appear to be hindered by geologic structure. The data also suggests that farther to the south of the study area, the alluvial valley is dominated by a significantly thicker (<100 ft) freshwater aquifer.

Based on the findings of this investigation, the occurrence of low tide variations in the area and the analysis of available hydrogeologic flow data, it is believed that adverse impacts from the proposed marina excavation on the quality of the overlying freshwater surficial aquifer shall be minimal. The effects are likely to be constrained to some inland influx of brackish water within the northern half of the marina basin. This area, as indicated by the conductivity measurements, already shows brackish concentrations within the existing surface water bodies.

Moreover, the groundwater flow in the valley comprises significant freshwater flow to the sea, especially during high precipitation events and the proposed excavation will be limited to approximately 18% of the freshwater aquifer thickness. Saltwater intrusion south of the detected area is unlikely to occur since no pumping and/or extraction of groundwater is proposed. Also, saline intrusion shall be naturally-controlled by the thickness of the freshwater aquifer and by the inherent difference in density between the freshwater and the saltwater layers.

References

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8. USGS 7.5-minute, 1960, Aguadilla Topographic Quadrangle.
9. Whittecar, G.R., Nowroozi, A.A., and Hall, J.R., 2005, Delineation of saltwater intrusion through a coastal borrow pit by resistivity survey: Environmental & Engineering Geoscience, vol. XI, no.3, p. 209-219.

APPENDIX 1.0 Figures

Figure 1. Location map of the proponed study area. (Adapted from the USGS 7.5-Minute Aguadilla Topographic Quadrangle, 1960).

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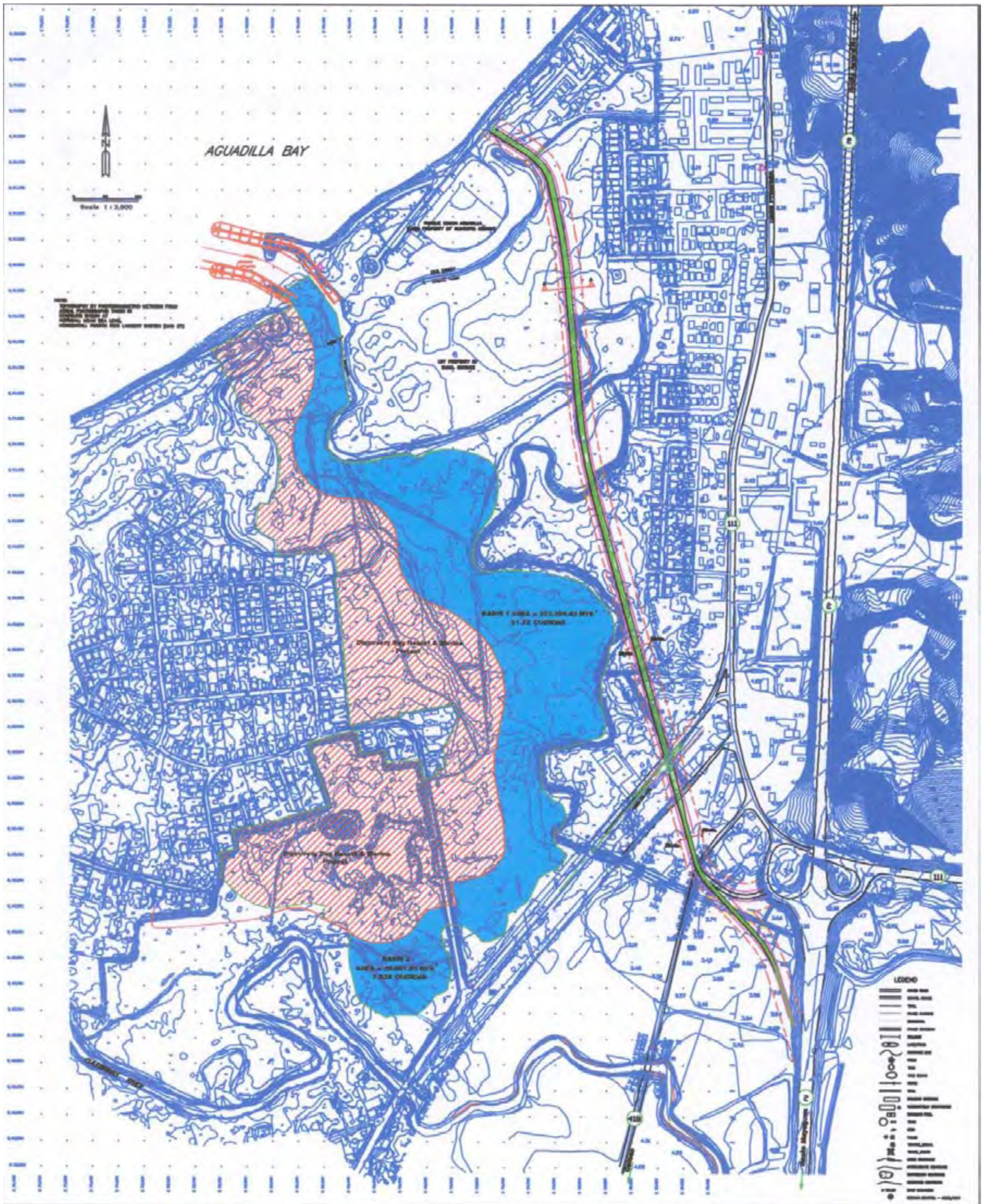

Figure 2. Site plan of the proposed project site. (Provided by CORDECO, Inc.).

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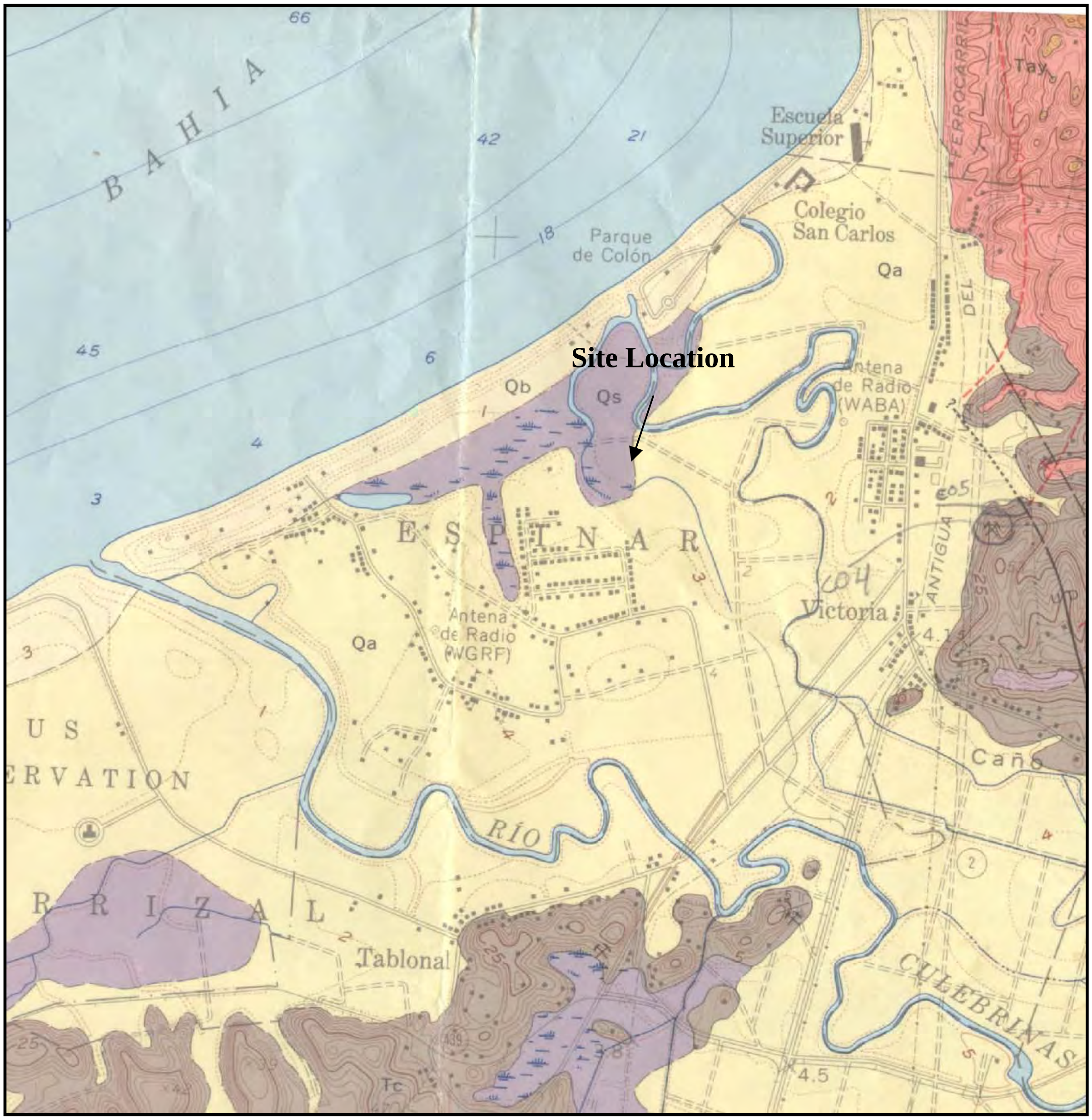

Figure 3. Geologic map of the proposed study area. (Adapted from the USGS Aguadilla Geologic Map, 1969, W.H. Monroe, Map I-569).

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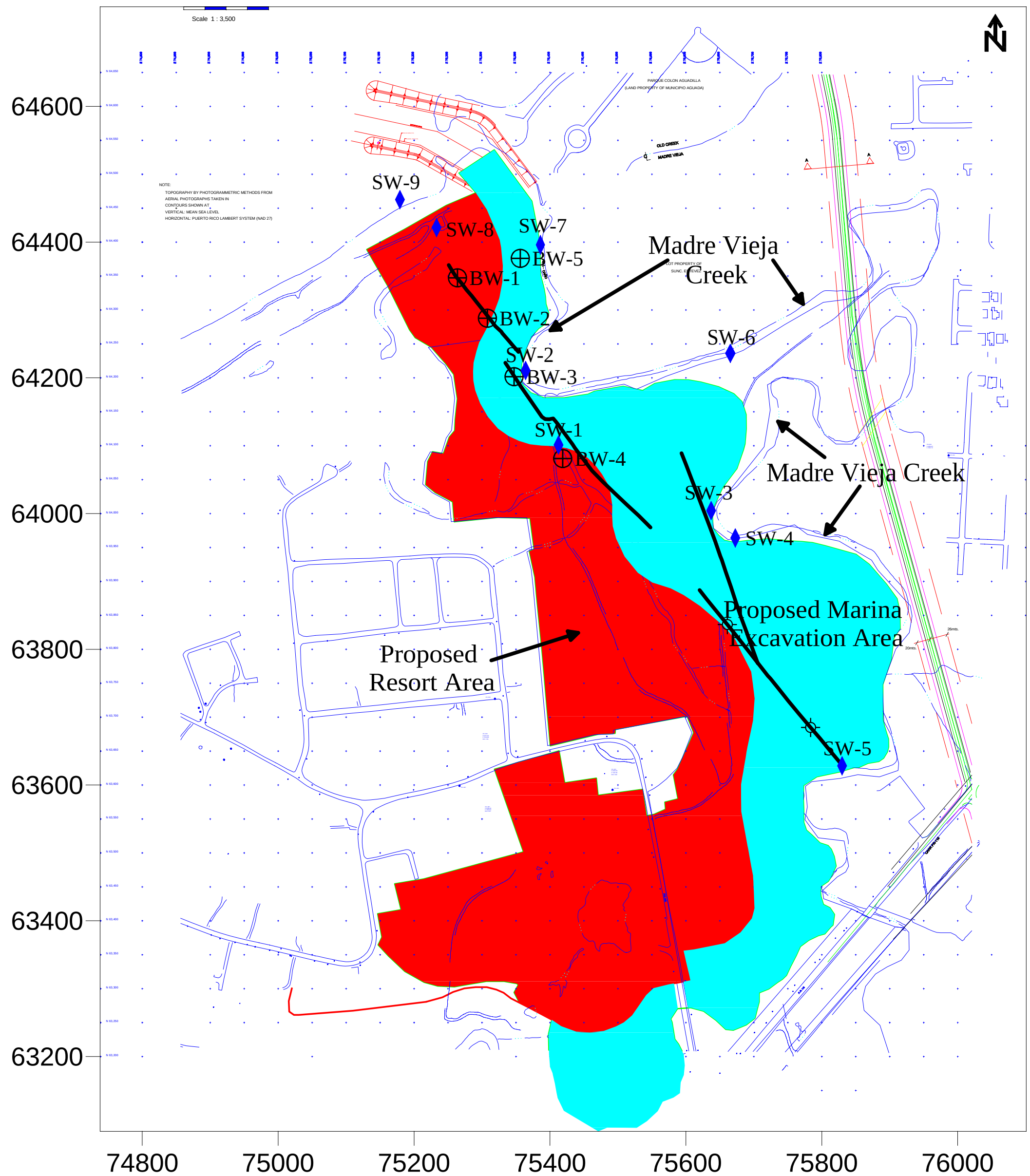

Figure 4. Layout Plan of Electrical Resistivity Profiles, Monitoring Wells and Surface Water Conductivity Sampling Locations.

LEGEND

- Monitoring Well
- Groundwater Sampling Point
- Electrical Resistivity Profile Line
- Surface Water Sampling Location

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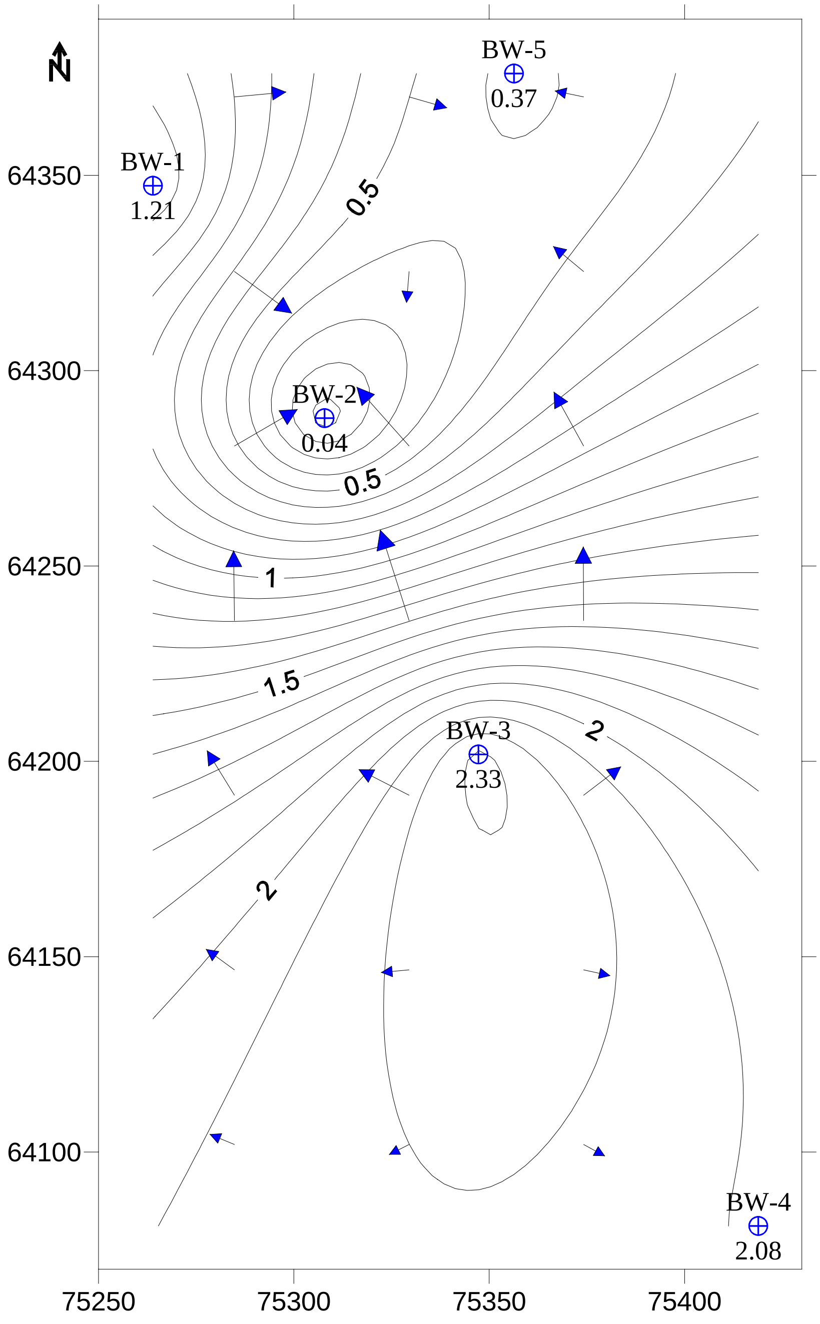

Figure 5. General Groundwater Flow Map in the Area of the Monitoring Wells.
Measurements obtained during high tide period at 14:30 on 12/7/05.

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Figure 6. View of conductivity measurements with the Solinst TLC meter at well BW-4.

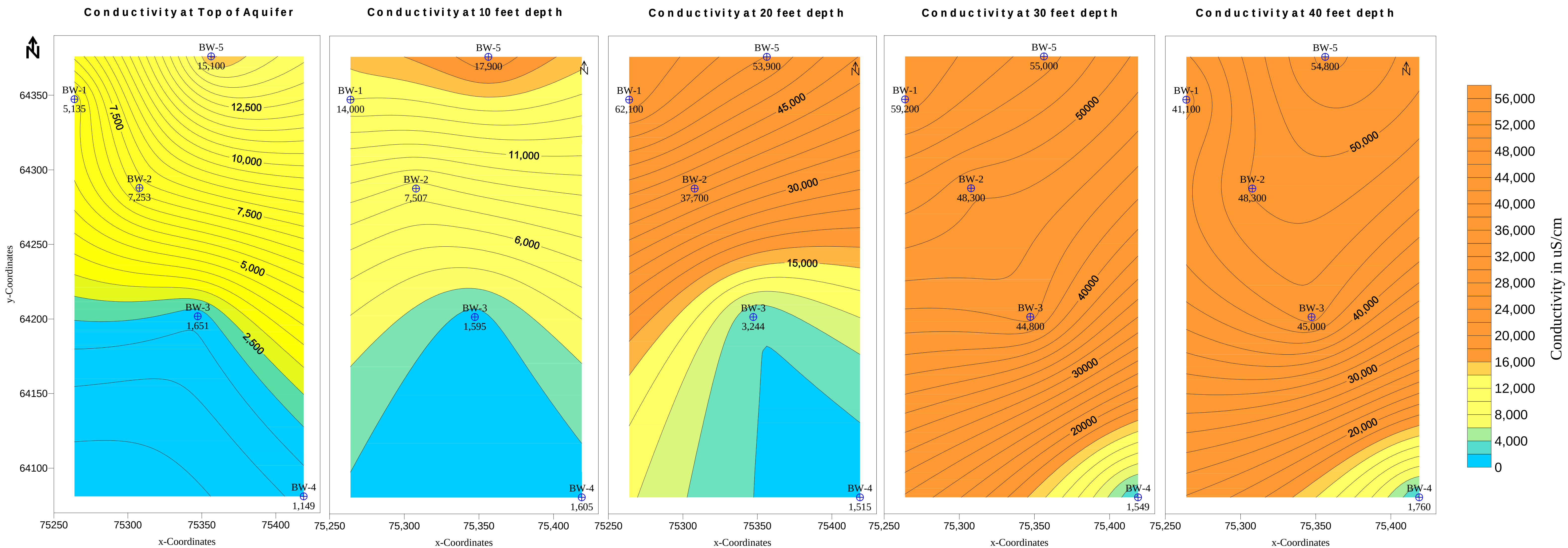

Figure 7. Contour maps generated from monitoring well conductivity measurements at 10 ft. depth intervals from the top of surficial aquifer

FW- Fresh Water Aquifer (0-2000 uS/cm)

BW- Brackish Water (2000-15,000 uS/cm)

SW- Salt Water (>15,000 uS/cm)

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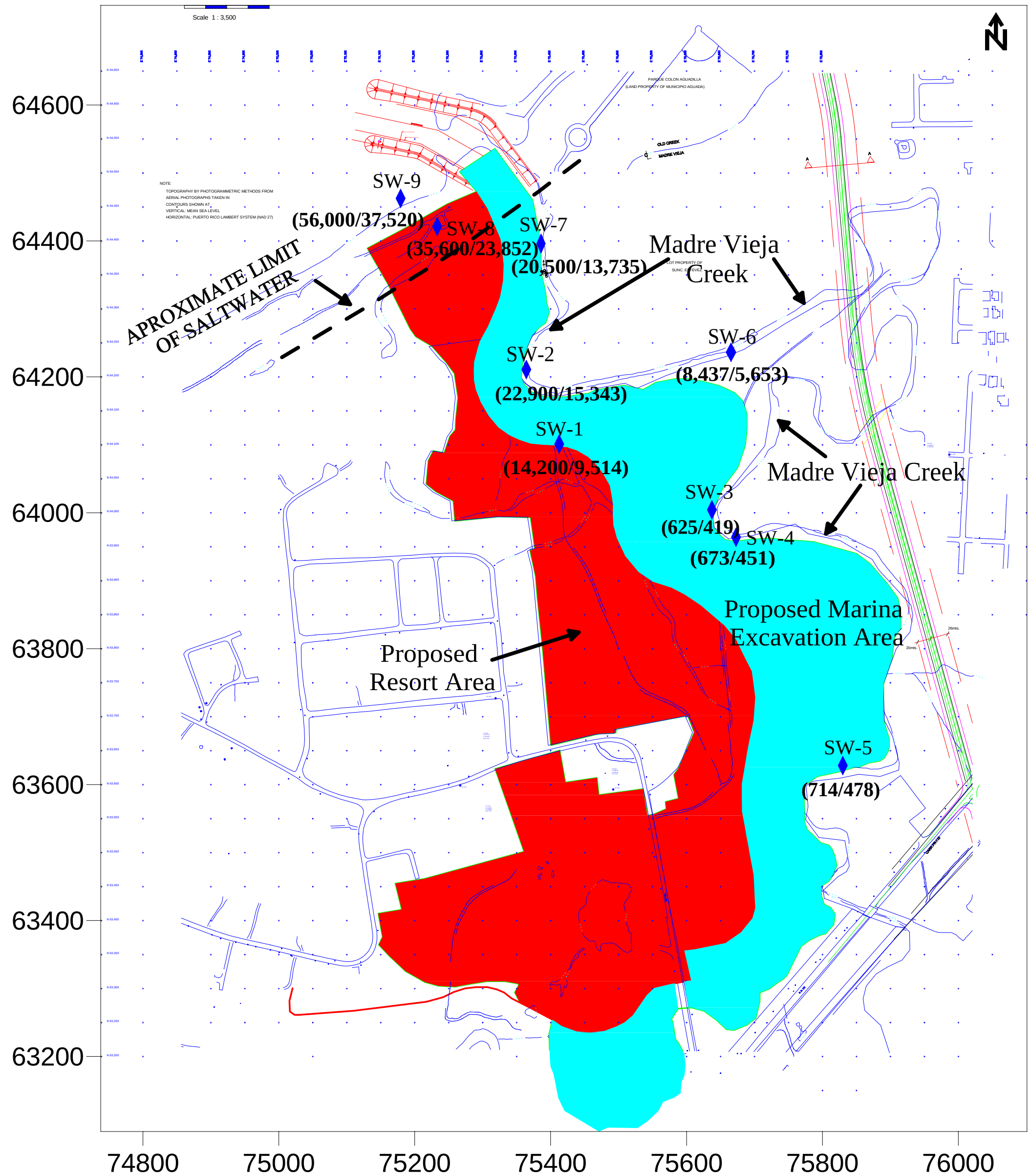

Figure 8. Surface Water Conductivity Measurements at the Proposed Project Site. Measurements obtained during high tide period at 14:30 on 12/7/05.

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♦ Surface Water Sampling Location and Measurements Conductivity (uS/cm)/TDS (mg/l)

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Figure 9. View of the SuperSting Electrical Resistivity Equipment.

Figure 10-a. Profile DB1 - Schlumberger Array 3 m Electrode Spacing

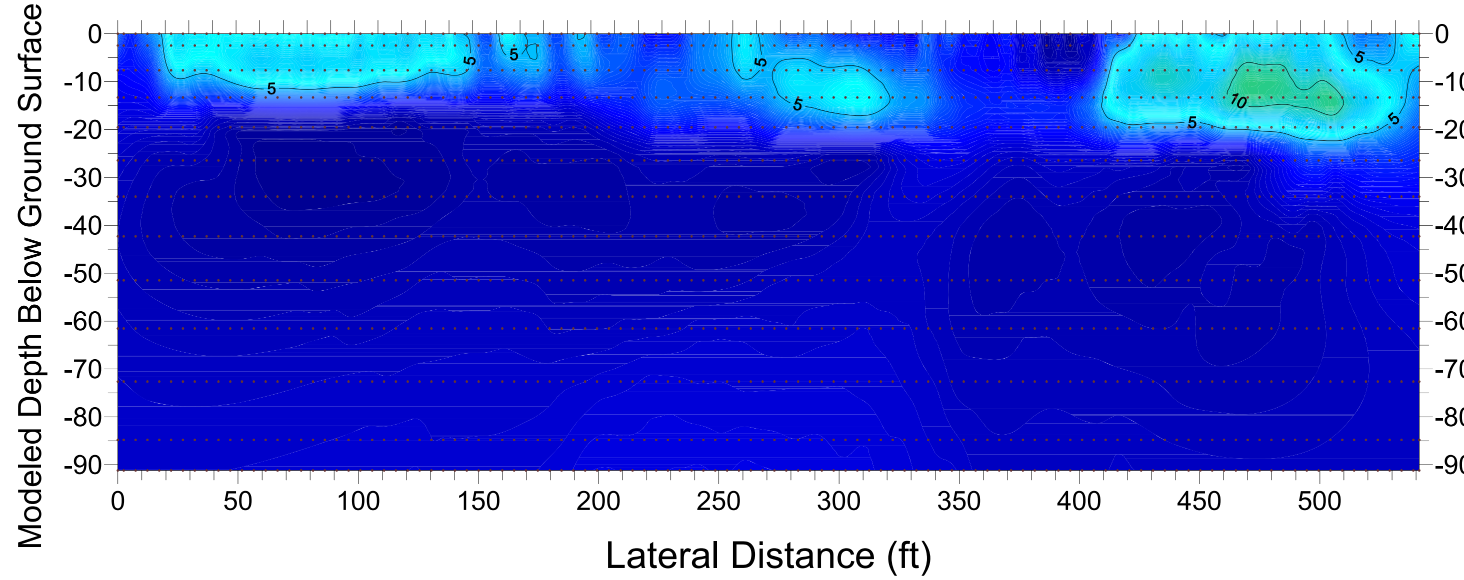
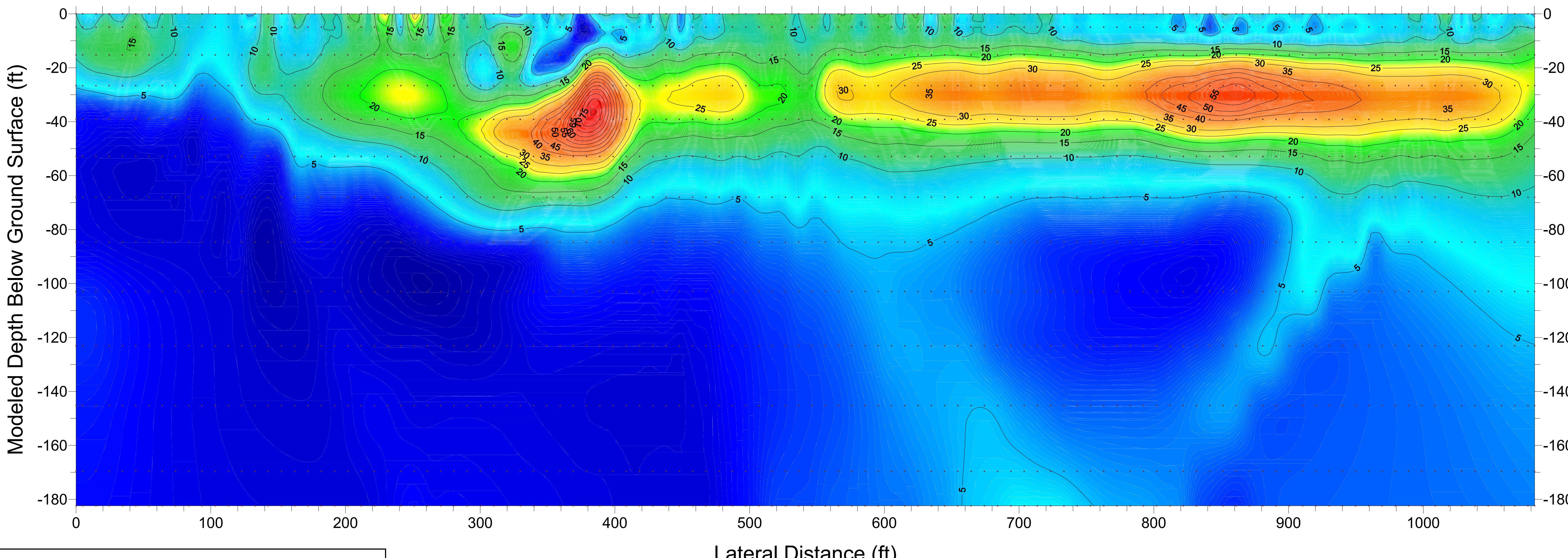
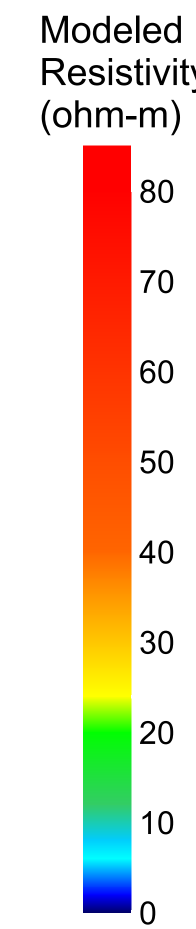


Figure 10-b. Profile DB2 - Schlumberger Array 6 m Electrode Spacing





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