

TIERRA

June 22, 2011

City of Tarpon Springs
P.O. Box 5004
324 E. Pine Street
Tarpon Springs, Florida 34688

Attn: Mr. Tom Funcheon – Public Works Director

**RE: Geotechnical Engineering Services Report
Subsidence Investigation – S. Disston Avenue
Tarpon Springs, Florida
Tierra Project No.: 6511-11-209**

Mr. Funcheon:

Tierra, Inc. (Tierra) has completed geotechnical engineering services for the above referenced project. The results of our field exploration program and subsequent geotechnical recommendations are presented in this report.

Tierra appreciates the opportunity to be of service to the City of Tarpon Springs on this project. We look forward to working with you on future projects. If you have any questions or comments regarding this report, please contact Tierra at your earliest convenience.

Respectfully Submitted,

TIERRA, INC.



Kevin H. Scott, P.E.
Senior Geotechnical Engineer
Florida License No. 65514



Henri V. Jean, P.E.
Principal Geotechnical Engineer
Florida License No. 55420

TABLE OF CONTENTS

PROJECT DESCRIPTION	1
Project Information.....	1
Scope of Services.....	1
SITE AND SUBSURFACE CONDITIONS	2
Geophysical Exploration	2
Geotechnical Subsurface Exploration.....	2
Subsurface Conditions.....	2
Groundwater Information	3
EVALUATION AND RECOMMENDATIONS	3
General.....	3
Sinkhole Remediation/Risk Mitigation.....	4
Summary of Pay Items and Cost Estimate - Sinkhole Remediation	5
REPORT LIMITATIONS	6

APPENDIX A

Boring Location Plan & Soil Profiles

APPENDIX B

GPR Survey Results

APPENDIX C

Compaction Grouting Specification

Recommended Grout Point Location Plan

PROJECT DESCRIPTION

Project Information

The project is located along S. Disston Avenue in front of the residence located at 709 S. Disston Avenue in Tarpon Springs, Florida. Based on discussions with City of Tarpon Springs personnel and our site observations, a series of ground subsidences occurred at the above mentioned address and along S. Disston Avenue on June 16, 2011. Tierra mobilized to the site on June 17, 2011. At the time of Tierra's arrival, the depression along the S. Disston Avenue had been backfilled.

Scope of Services

The objective of our study was to obtain information concerning subsurface conditions at the site in order to obtain data from which to base engineering estimates and recommendations in each of the following areas:

1. Estimation of approximate vertical and horizontal extent of the ground subsidence along S. Disston Avenue.
2. Identification of the depth to the competent limestone layer.
3. Formulate recommendations for remediation of the subsurface conditions encountered.

In order to meet the preceding objectives, we provided the following services.

1. Performed a Ground Penetrating Radar (GPR) survey in the area of the observed sinkhole to estimate the approximate vertical and horizontal extent of the depression/raveled soil zones along S. Disston Avenue.
2. Executed a program of subsurface exploration consisting of borings, subsurface sampling and field-testing. We performed four (4) Standard Penetration Test (SPT) borings to depths of 30 to 55 feet below existing grades.
3. Visually classified the samples in the laboratory using the Unified Soil Classification System (USCS). Identified soil conditions at each boring location.
4. Prepared this formal engineering report which summarizes the course of study pursued, the field and laboratory data generated, subsurface conditions encountered and our engineering recommendations in each of the pertinent topic areas.

The scope of our services did not include an environmental assessment for determining the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors, colors, unusual or suspicious items or conditions are strictly for the information of our client.

SITE AND SUBSURFACE CONDITIONS

Geophysical Exploration

A Ground Penetrating Radar (GPR) Survey was performed by GeoView, Inc. to assist in the evaluation of the sinkhole conditions at the project site. The GPR results indicate distinct anomalous areas producing down-warping of the GPR signal and increased depths of penetration. The *Geophysical Exploration* report can be found in **Appendix B** of this report. Tierra used the data obtained from the GPR survey to aid in the placement of the SPT borings.

Geotechnical Subsurface Exploration

As mentioned previously, the subsurface conditions were explored using a total of four (4) SPT borings performed to depths ranging from approximately 30 to 55 feet below the existing ground surface. Two (2) borings (B-1 and B-3) were performed within the ground subsidence along S. Disston Avenue. Borings B-2 and B-4 were performed outside of the apparent affected area. The borings were located in the field by a representative of Tierra based on the features identified by the GPR operator and the observed site conditions. The boring locations were recorded using handheld global positioning system (GPS) units. The approximate boring locations are presented in **Appendix A**.

The SPT borings were performed with the use of a drill rig using Bentonite Mud drilling procedures. The soil sampling was performed in general accordance with American Society for Testing and Materials (ASTM) Test Designation D-1586 titled Penetration Test and Split-Barrel Sampling of Soils. The upper 6 feet of each boring were performed utilizing hand auger methods to confirm utility clearances. SPT resistance N-values were then taken continuously to a depth of 10 feet and at intervals of 5 feet thereafter. As each soil type was encountered samples were collected and visually classified in the field. The samples were transported to our laboratory for verification of the visual classification.

Subsurface Conditions

The borings generally encountered sandy soils from the ground surface to depths ranging from approximately 17 to 31 feet underlain by clayey soils to depths of 22 to 37 feet underlain by limestone to the boring termination depths about 30 to 55 feet below existing grades. Very loose/very soft soil conditions were encountered throughout significant portions of the borings performed. In addition, losses of drilling fluid circulation were observed in each of the borings.

The soil strata encountered in the borings performed at the project site are summarized in the following table:

Stratum Number	Soil Description	Unified Soil Classification Symbol (USCS)
1	Light Brown to Light Gray Fine SAND to SAND With Silt	SP/SP-SM
2	FILL-Brown Fine SAND with Rock	--- ⁽¹⁾
3	Gray to Brown Orange CLAY	CH
4	Weathered Limestone	--- ⁽¹⁾
5	Orange Brown Clayey SAND	SC
⁽¹⁾ USCS nomenclature does not include limestone or FILL classification		

The subsurface soil stratification is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The soil profiles included in **Appendix A** should be reviewed for specific information at individual boring locations. These profiles include soil descriptions, stratifications and penetration resistances. The stratifications shown on the boring profiles represent the conditions only at the actual boring location. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual.

Groundwater Information

The groundwater level was not apparent to a depth of 10 feet below the existing ground surface where drilling fluid was introduced to the drilling procedure to maintain an open borehole. Therefore, "GNA" (Groundwater Not Apparent) is shown on the SPT boring profiles presented in **Appendix A**. It should be noted that groundwater levels tend to fluctuate during periods of prolonged drought and extended rainfall and may be affected by man-made influences. In addition, a seasonal effect will also occur in which higher groundwater levels are normally recorded in rainy seasons.

EVALUATION AND RECOMMENDATIONS

General

The project area is within a region of Pinellas County and West Central Florida that can be characterized as having a moderate to high potential for sinkhole development. Based on the services performed, the subsurface soils encountered in the borings demonstrate several characteristics that are indicative of potential sinkhole activity including:

- Variable rock depth – Competent Weathered limestone was encountered at depths ranging from approximately 30 to 45 feet below existing grade.
- Circulation loss – Circulation loss of drilling fluid occurred within the borings. Loss of circulation is expected at the soil/rock interface during drilling due to the nature

of the limestone. Loss of circulation above this interface can be indicative of potential raveling zones.

- Very loose/very soft zones – Based on the results of the borings, Weight of Rod (WR) and Weight of Hammer (WH) materials were encountered throughout significant depths before terminating the borings into competent soil/rock. The term “Weight-of Rod” indicates the rod and split spoon were advanced solely by the weight of the drill rod. The term “Weight of Hammer” (WH) indicates the rod and split spoon were advanced solely by the weight of the drill rod and hammer. Very soft/very loose, WR and WH sandy and clayey materials encountered is indicative of potential raveling zones.

Sinkholes in this area are generally caused where a solution cavity develops in the limestone to the extent that overlying soils ravel into the limestone or where the weight of the overburden soils are high enough to fail the surface of the limestone cavity.

Sinkhole Remediation/Risk Mitigation

Tierra recommends that a compaction grouting program be performed to remediate the existing sinkhole depression area along S. Disston Avenue and to mitigate future sinkhole activity in this area. Compaction grouting improves subsurface conditions by displacement. A viscous cement aggregate grout is pumped into the ground in stages to displace and densify the surrounding soil. Essentially, injection pipes are placed in the ground on predetermined grid spacing throughout the anomalous areas indicated by the GPR survey and SPT borings. The depth of the pipes depends on the depth and thickness of the improvement zone in question. Compaction grouting is typically performed from bottom to top by injecting the grout into the ground in bulbs. The goal would be to improve the subgrade from the depth of competent limestone through the soft/loose soil zones. The injection pipe is raised and additional bulbs are formed until the bulbs penetrate the anomalous zone. The process is repeated at each of the points on the predetermined grid.

It is estimated that 10 to 12 grout pipes extending approximately 35 to 55 feet below existing grades will be required.

It should be noted that the estimated amounts of grout pipes as mentioned above should be considered preliminary. Grout injection at each designated pipe location may require secondary and tertiary injection points depending upon the grout take of the primary injection points.

Tierra has developed a site specific compaction grouting program for this project which is detailed in **Appendix C**. It is recommended that Tierra be retained by the City to provide verification testing and oversight during the compaction grouting program to verify that the subsurface conditions encountered during our study are consistent during the field operations and that our recommendations are properly implemented.

Summary of Pay Items and Cost Estimate - Sinkhole Remediation

For the purpose of bidding only, Tierra has provided a summary of Pay Items for prospective specialty contractors to utilize. The quantities provided are for estimating only and in no way guarantee the quantities to be accurate based on the highly variable subsurface conditions encountered and the nature of compaction grouting uncertainties. However, the selected contractor will be expected to honor the provided unit prices for all unit quantities utilized on the project. This includes both under and over estimated quantities for lineal feet of grout pipe and cubic yards of grout.

The Table of quantities is as follows:

Pay Item	Estimated Quantity
Mobilization and Demobilization	1
Grout Pipe – Per Lineal Foot	500 LF
Compaction Grout – Per Cubic Yard	500 LF X .2 Cubic Yard Grout Factor X 1.2 over run factor = 120 cubic yards
Engineering Monitoring/Inspection	Field Technician – 40 hours
	Engineer – 8 hours

Based on the conditions encountered in the SPT borings and our experience with similar projects, the estimated cost to perform the recommended sinkhole remediation is approximately **\$35,000**. This estimate is being provided to the City of Tarpon Springs for budgeting purposes only. Final project costs and quantities may differ from the above estimated cost due to variable subsurface conditions, the Contractor's work schedule, bid unit rates, etc. Therefore, some contingency fund is recommended to accommodate such potential extra costs. The following Table summarizes the estimated cost for performing the recommended remediation program.

Pay Item	Estimated Quantity	Unit Cost	Cost
Mobilization and Demobilization	1	\$3,500.00	\$3,500.00
Grout Pipe – Per Lineal Foot	500 LF	\$17.00	\$8,500.00
Compaction Grout – Per Cubic Yard	120 cy	\$165.00	\$19,800.00
Engineering Monitoring/Inspection	Field Technician 40 hrs	\$50.00	\$2,000.00
	Engineer 8 hrs	\$120.00	\$960.00
Total Estimated Cost			\$34,760.00

REPORT LIMITATIONS

The analyses, conclusions and recommendations contained in this report are professional opinions based on the site conditions and project layout described herein and further assume that the conditions observed in the exploratory borings are representative of the subsurface conditions throughout the site, i.e., the subsurface conditions elsewhere on the site are the same as those disclosed by the borings. If, during the compaction grouting, subsurface conditions different from those encountered in the exploratory borings are observed or appear to be present, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary.

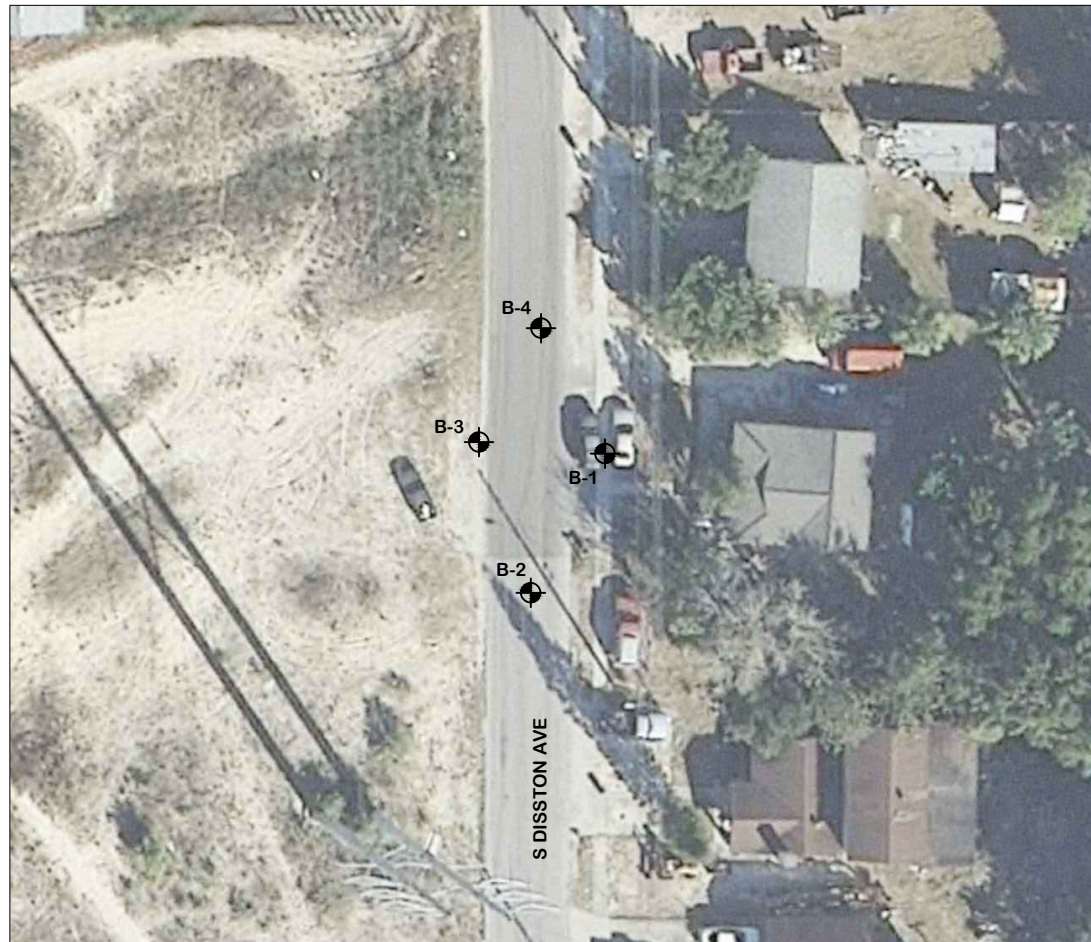
If there is a substantial lapse in time between the submittal of this report and the start of work at the site, or if conditions change due to natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of conclusions and recommendations considering the changed conditions and time lapse.

This report was prepared for the exclusive use of The City of Tarpon Springs for evaluating the the project as it relates to the geotechnical aspects discussed herein. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions included in this report.

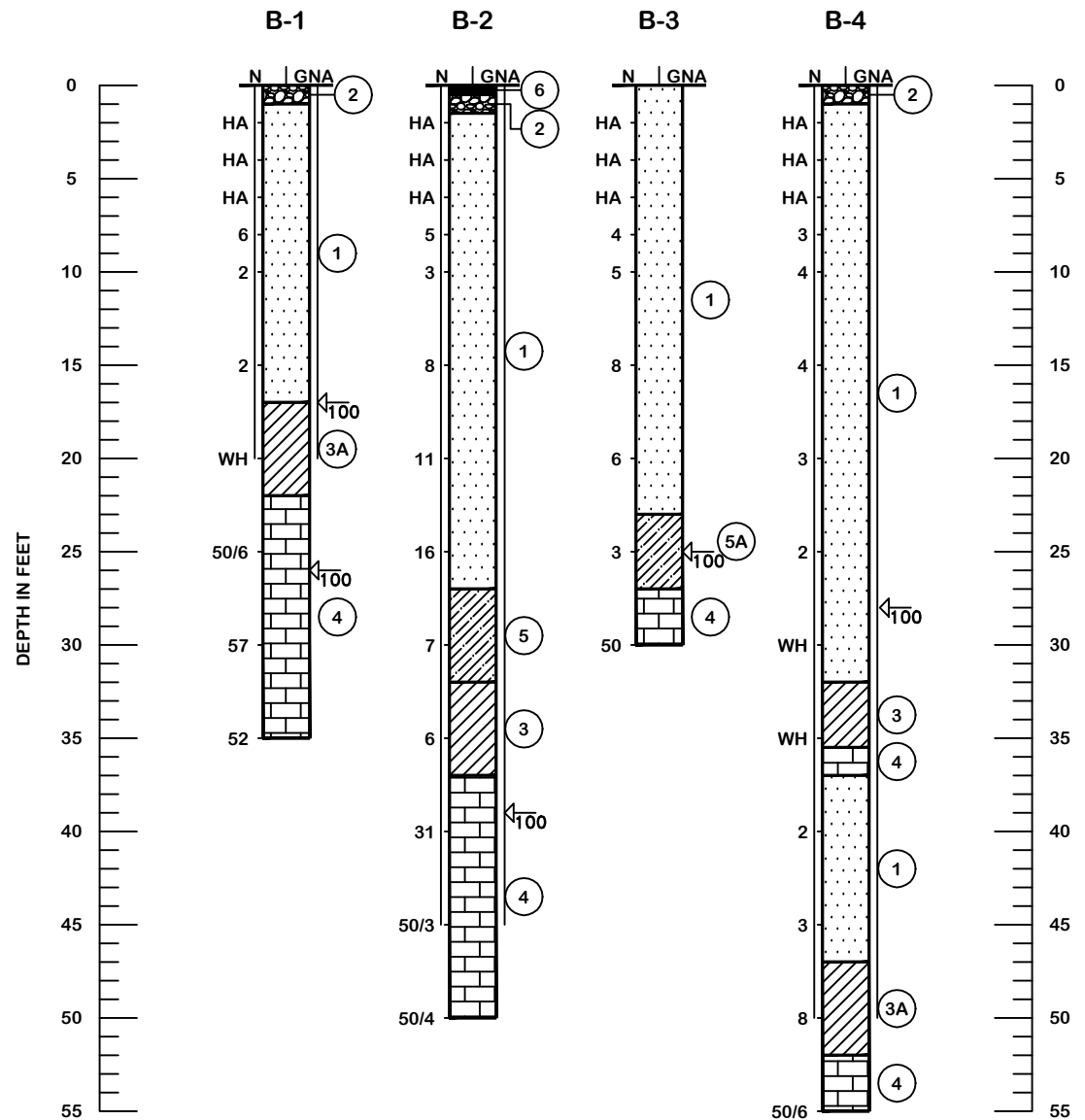
APPENDIX A

Boring Location Plan & Soil Profiles

BORING LOCATION PLAN



SOIL PROFILES



LEGEND

- ① LIGHT BROWN TO LIGHT GRAY FINE SAND TO SAND WITH SILT (SP/SP-SM)
 - ② FILL-BROWN FINE SAND TO SAND WITH ROCK
 - ③ GRAY TO BROWN ORANGE CLAY (CH)
 - ④ WEATHERED LIMESTONE
 - ⑤ ORANGE BROWN CLAYEY SAND (SC)
 - ⑥ ASPHALT PAVEMENT AND LIMEROCK BASE
- A - WITH LIMESTONE FRAGMENTS
- ⊕ APPROXIMATE LOCATION OF SPT BORING
 - CASING
 - N SPT N-VALUE IN BLOWS/FOOT FOR 12 INCHES OF PENETRATION (UNLESS OTHERWISE NOTED)
 - SP UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2488) GROUP SYMBOL AS DETERMINED BY VISUAL REVIEW AND/OR LABORATORY TESTING
 - GNA GROUNDWATER NOT APPARENT DUE TO DRILLING METHOD USED
 - 50/4 NUMBER OF BLOWS FOR 4 INCHES OF PENETRATION
 - HA HAND AUGERED TO VERIFY UTILITY CLEARANCES
 - WH FELL UNDER WEIGHT OF ROD AND HAMMER
 - ←100 LOSS OF CIRCULATION OF DRILLING FLUID (100%)

GRANULAR MATERIALS- RELATIVE DENSITY	SPT N-VALUE (BLOWS/FT.)
VERY LOOSE	LESS THAN 4
LOOSE	4 TO 10
MEDIUM	10 TO 30
DENSE	30 TO 50
VERY DENSE	GREATER THAN 50
SILTS AND CLAYS CONSISTENCY	SPT N-VALUE (BLOWS/FT.)
VERY SOFT	LESS THAN 2
SOFT	2 TO 4
FIRM	4 TO 8
STIFF	8 TO 15
VERY STIFF	16 TO 30
HARD	GREATER THAN 30

DRAWN BY:
SW

CHECKED BY:
KHS

APPROVED BY:
KHS

DATE:
JUNE 2011

ENGINEER OF RECORD:
KEVIN H. SCOTT, P.E.
FLORIDA LICENSE NO.:
65514



TIERRA
7351 Temple Terrace Highway
Tampa, Florida 33637
Phone: 813-989-1354 Fax: 813-989-1355
FL Cert. No.: 6486

SCALE:
NOTED

PROJECT NUMBER:
6511-11-209

GEOTECHNICAL ENGINEERING SERVICES
S. DISSTON AVENUE
PINELLAS COUNTY, FLORIDA

SHEET 1

APPENDIX B

Geophysical Exploration Report by
GeoView, Inc.

FINAL REPORT
GEOPHYSICAL INVESTIGATION
709 SOUTH DISSTON AVENUE SITE
TARPON SPRINGS, FL

Prepared for Tierra, Inc.
Tampa, FL

Prepared by GeoView, Inc.
St. Petersburg, FL



June 22, 2011

Mr. Kevin H. Scott, P..E.
Tierra, Inc.
7351 Temple Terrace Hwy.
Tampa, FL 33637

**Subject: Transmittal of Final Report for Geophysical Investigation
709 South Disston Avenue Site - Tarpon Springs, FL
GeoView Project Number 13416**

Dear Mr. Scott,

GeoView, Inc. (GeoView) is pleased to submit the final report that summarizes and presents the results of the geophysical investigation conducted at the 709 South Disston Avenue Site in Tarpon Springs, FL. Ground penetrating radar was used to evaluate near-surface geological conditions. GeoView appreciates the opportunity to have assisted you on this project. If you have any questions or comments about the report, please contact us.

GEOVIEW, INC.

Michael J. Wightman, P.G.
President
Florida Professional Geologist
Number 1423

Chris Taylor, P.G.
Vice President
Florida Professional Geologist
Number 2256

A Geophysical Services Company

*4610 Central Avenue
St. Petersburg, FL 33711*

*Tel.: (727) 209-2334
Fax: (727) 328-2477*

1.0 Introduction

The site was located west of the residence located at 709 South Disston Avenue in Tarpon Springs, Florida. Prior to the geophysical investigation, a series of major sinkhole collapses occurred within the boundaries of the residence. One of the collapses continued on to Disston Avenue to the west. At the time of the GeoView investigation the collapse feature had been filled with sand.

The purpose of the geophysical investigation was to help characterize near-surface geological conditions in the area of the collapse and to identify subsurface features that may be associated with sinkhole activity in the surrounding public right-of-way areas to the north, south and west. The survey area was 150 ft by 90 feet (ft) in size (Figure 1). The investigation was conducted on June 17, 2011. A discussion of the field methods used to generate the report figures is provided in Appendix A2.1.

2.0 Description of Geophysical Investigation

2.1 Ground Penetrating Radar Survey

The GPR survey was conducted along a series of perpendicular transects spaced approximately 10 ft apart. The GPR data was collected with a Mala radar system. The GPR settings used for the survey are presented in Table 1.

Table 1
GPR Equipment Settings Used for Exterior and Interior GPR Surveys

Location	Antenna Frequency	Time Range (nano-seconds)	Estimated Depth of GPR Signal Penetration
	250 MHz ^{1/}	128	12 to 14 ft bls

^{1/} MHz means mega-Hertz and is the mid-range operating frequency of the GPR antenna.

A description of the GPR technique and the methods employed for geological characterization studies is provided in Appendix A2.2.

3.0 Identification of Possible Sinkhole Features Using GPR

The features observed on GPR data that are most commonly associated with sinkhole activity are:

- A downwarping of GPR reflector sets, that are associated with suspected lithological contacts, toward a common center. Such features typically have with a bowl or funnel shaped configuration and can be associated with a deflection of overlying sediment horizons

caused by the migration of sediments into voids in the underlying limestone. If the GPR reflector sets are sharply downwarping and intersect, they can create “bow-tie” shaped GPR reflection feature, which often designates the apparent center of the GPR anomaly.

- A localized significant increase in the depth of the penetration and/or amplitude of the GPR signal response. The increase in GPR signal penetration depth or amplitude is often associated with either a localized increase in sand content at depth or decrease in soil density.
- An apparent discontinuity in GPR reflector sets, that are associated with suspected lithological contacts. The apparent discontinuities and/or disruption of the GPR reflector sets may be associated with the downward migration sediments.

The greater the severity of these features or a combination of these features the greater the likelihood that the identified feature is a sinkhole. It is not possible based on the GPR data alone to determine if an identified feature is a sinkhole or, more importantly, whether that feature is an active sinkhole.

4.0 Survey Results

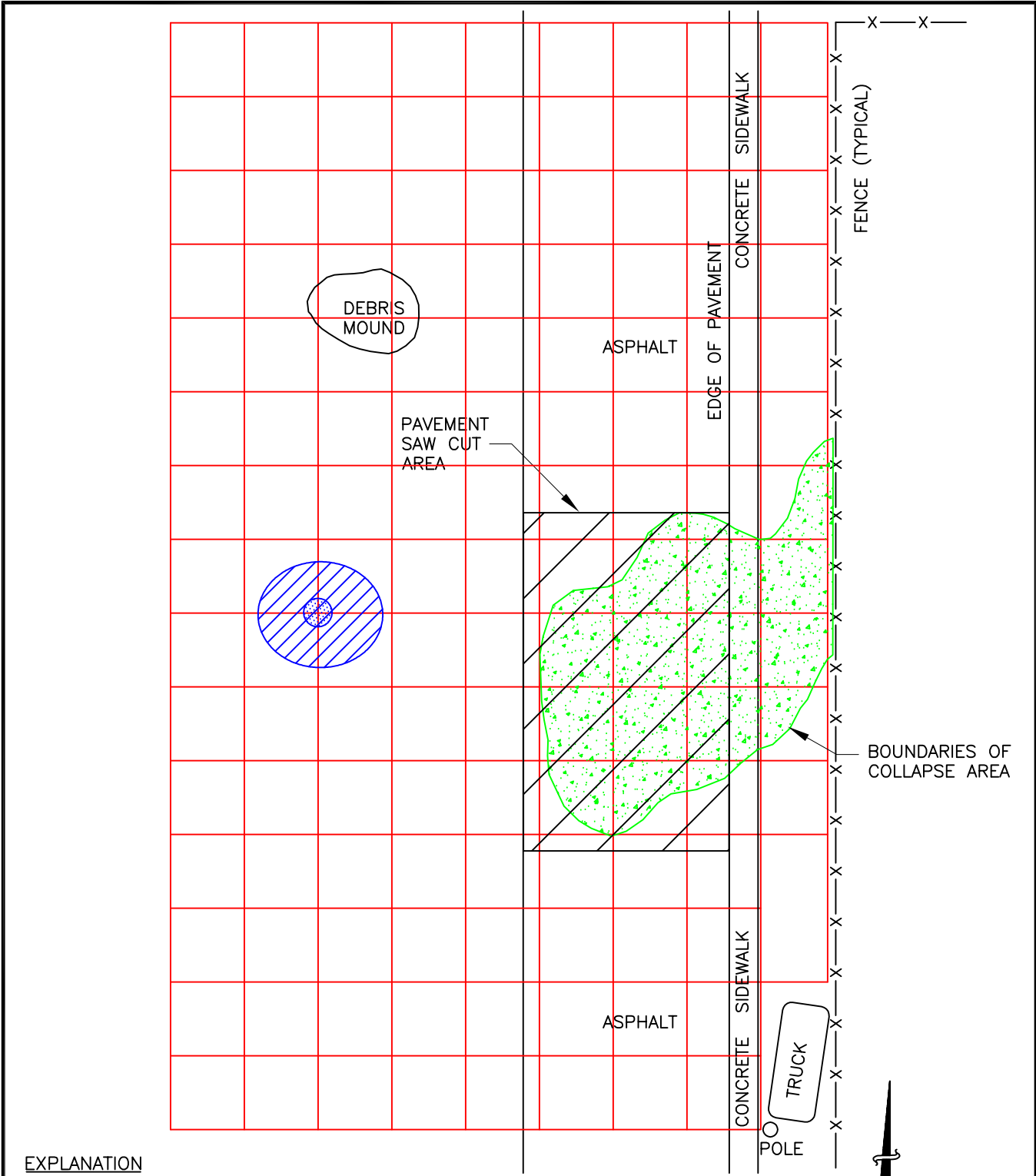
4.1 Discussion of GPR Survey Results

Results of the GPR survey indicated the presence of one well-defined, relatively continuous sets of GPR reflectors at depth ranges of 8 to 12 ft bls. The GPR reflector set is most likely associated with some change in soil conditions within that depth range.


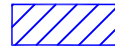
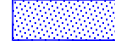
The boundaries of the filled collapse feature were identified on the GPR data and are shown on Figure 1. One very minor GPR anomaly area was identified in the western portion of the site. The anomaly is circular in shape with a total area of approximately 190 square ft. The anomaly was characterized by a downwarping of 1 to 2 ft the GPR reflector. It is noted that no downwarping to the sediments within the anomaly area was observed. This suggests that the GPR anomaly is likely associated with relic depositional or erosion activity, rather than possible karst activity. The location of the anomaly area is shown on Figure 1.

The apparent center of the GPR anomaly was indicated on the ground surface at the site to facilitate the geotechnical testing of the feature. An example of the GPR data collected across the anomaly area is provided in Appendix 1. A discussion of the limitations of the GPR technique in geological characterization studies is provided in Appendix 2.

APPENDIX 1
FIGURE AND EXAMPLE OF
GPR ANOMALY



EXPLANATION

-  PATH OF GPR TRANSECT LINES
-  LOCATION OF GPR ANOMALY
-  APPARENT CENTER OF GPR ANOMALY



SCALE: 1"=20' APPROXIMATE

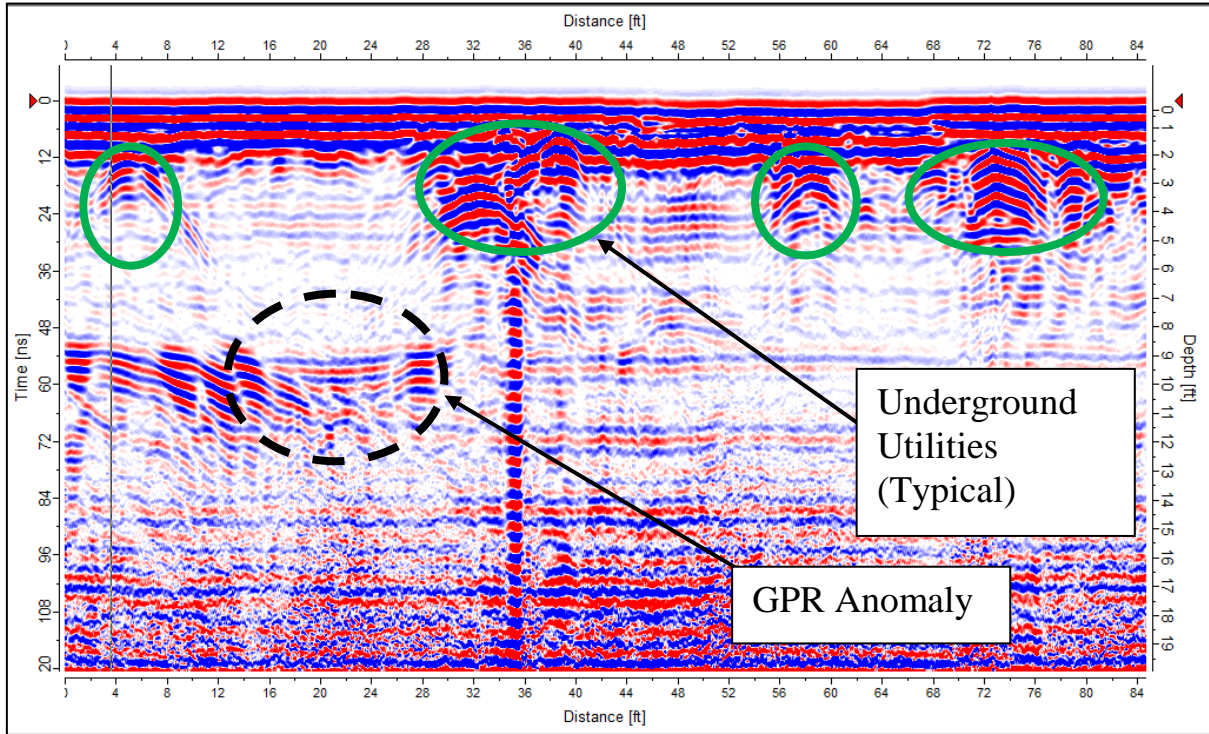


FIGURE 1
SITE MAP
SHOWING RESULTS
OF GEOPHYSICAL
INVESTIGATION

709 DISSTON AVENUE SITE
TARPON SPRINGS, FLORIDA

TIERRA, INC.
TAMPA, FLORIDA

PROJECT:
13416
DATE:
06/22/11



GPR Transect Showing Example of the GPR Anomaly

APPENDIX 2

DESCRIPTION OF GEOPHYSICAL METHODS, SURVEY METHODOLOGIES AND LIMITATIONS

A2.1 On Site Measurements

The measurements that were collected and used to create the site map were made using a fiberglass measuring tape. The degree of accuracy of such an approach is typically +/- 5% for lengths and +/- 2.5 degrees for angles.

A2.2 Ground Penetrating Radar

Ground Penetrating Radar (GPR) consists of a set of integrated electronic components that transmits high frequency (200 to 1500 megahertz [MHz]) electromagnetic waves into the ground and records the energy reflected back to the ground surface. The GPR system consists of an antenna, which serves as both a transmitter and receiver, and a profiling recorder that both processes the incoming signal and provides a graphic display of the data. The GPR data can be reviewed as both printed hard copy output or recorded on the profiling recorder's hard drive for later review. GeoView uses a Mala GPR system. Geological characterization studies are typically conducted using a 250 MHz antenna.

A GPR survey provides a graphic cross-sectional view of subsurface conditions. This cross-sectional view is created from the reflections of repetitive short-duration electromagnetic (EM) waves that are generated as the antenna is pulled across the ground surface. The reflections occur at the subsurface contacts between materials with differing electrical properties. The electrical property contrast that causes the reflections is the dielectric permittivity that is directly related to conductivity of a material. The GPR method is commonly used to identify such targets as underground utilities, underground storage tanks or drums, buried debris, voids or geological features.

The greater the electrical contrast between the surrounding earth materials and target of interest, the greater the amplitude of the reflected return signal. Unless the buried object is metal, only part of the signal energy will be reflected back to the antenna with the remaining portion of the signal continuing to propagate downward to be reflected by deeper features. If there is little or no electrical contrast between the target interest and surrounding earth materials it will be very difficult if not impossible to identify the object using GPR.

The depth of penetration of the GPR signal is very site specific and is controlled by two primary factors: subsurface soil conditions and selected antenna

frequency. The GPR signal is attenuated (absorbed) as it passes through earth materials. As the energy of the GPR signal is diminished due to attenuation, the energy of the reflected waves is reduced, eventually to the level that the reflections can no longer be detected. As the conductivity of the earth materials increases, the attenuation of the GPR signal increases thereby reducing the signal penetration depth. In Florida, the typical soil conditions that severely limit GPR signal penetration are near-surface clays and/or organic materials.

The depth of penetration of the GPR signal is also reduced as the antenna frequency is increased. However, as antenna frequency is increased the resolution of the GPR data is improved. Therefore, when designing a GPR survey a tradeoff is made between the required depth of penetration and desired resolution of the data. As a rule, the highest frequency antenna that will still provide the desired maximum depth of penetration should be used.

A GPR survey is conducted along survey lines (transects) that are measured paths along which the GPR antenna is moved. Electronic marks are placed in the data by the operator at designated points along the GPR transects. These marks allow for a correlation between the GPR data and the position of the GPR antenna on the ground.

For geological characterization surveys, the GPR survey is conducted along a set of perpendicularly orientated transects. The survey is conducted in two directions because subsurface features such as sinkholes are often asymmetric. Spacing between the transects typically ranges from 10 to 50 feet. Closely spaced grids are used when the objective of the GPR survey is to identify all sinkhole features within a project site. Coarser grids are used when the objective is to provide a general overview of site conditions. After completion of a survey using a given grid spacing, additional more-closely spaced GPR transects are often performed to better characterize sinkhole features identified by the initial survey. This information can be used to provide recommended locations for geotechnical borings.

Depth estimates to the top of lithological contacts or sinkhole features are determined by dividing the time of travel of the GPR signal from the ground surface to the top of the feature by the velocity of the GPR signal. The velocity of the GPR signal is usually obtained from published tables of velocities for the type and condition (saturated vs. unsaturated) of soils underlying the site. The accuracy of GPR-derived depths typically ranges from 20 to 40 percent of the total depth.

Interpretation and Limitations of GPR data

The analysis and collection of GPR data is both a technical and interpretative skill. The technical aspects of the work are learned from both training and experience. Having the opportunity to compare GPR data collected in numerous settings to the results from geotechnical studies performed at the same locations develops interpretative skills for geological characterization studies.

The ability of GPR to collect interpretable information at a project site is limited by the attenuation (absorption) of the GPR signal by underlying soils. Once the GPR signal has been attenuated at a particular depth, information regarding deeper geological conditions will not be obtained. GPR data can only resolve subsurface features that have a sufficient electrical contrast between the feature in question and surrounding earth materials. If an insufficient contrast is present, the subsurface feature will not be identified. GeoView can make no warranties or representations of geological conditions that may be present beyond the depth of investigation or resolving capability of the GPR equipment or in areas that were not accessible to the geophysical investigation.

APPENDIX C

Compaction Grouting Specification

COMPACTION GROUTING SPECIFICATION

1.0 DESCRIPTION

The work identified in this Specification is to treat and stabilize the sinkhole conditions found to exist along S, Disston Avenue in the vicinity of 709 S. Disston Avenue in Tarpon Springs, Florida. The grout should plug and seal potential avenues for further migration of the overlying soils which may contribute to continuing sinkhole activity and strengthen the relatively weak soils disturbed during the formation of the existing depression(s).

2.0 SCOPE OF WORK

A qualified contractor specializing in compaction grouting shall be responsible for project control, supervision, labor, materials, and the equipment necessary to accomplish the following scope of work:

1. Install the grout injection points to competent limestone at locations indicated on the attached Grout Point Location Plan. Anticipated depths are between 35 to 45 feet below existing ground surface. The Engineer may adjust actual tip elevations of the grout pipe based on encountered subsurface conditions.
2. Provide necessary equipment to install, clean and extract 3 to 4 inch inside diameter flush joint grout pipe.
3. Provide equipment and material necessary to inject 3 to 5 inch slump Portland cement grout into the desired zones. The maximum quantity of grout to be placed (per injection point) is indicated in Section 6.0 Grouting Procedures.
4. Provide detailed documentation of the borehole drilling and grouting procedures including, but not limited to, quantity of pipe installed and quantity of grout pumped.
5. Provide equipment, materials, and manpower to monitor the relative elevations of ground surface, pavement surface and nearby buildings during grouting.

3.0 CONTRACTOR QUALIFICATIONS

The contractor should have: 1) a minimum of 5 years experience in the compaction grouting process; and 2) should have satisfactorily completed at least three (3) projects of similar scope and purpose. As part of the qualification process, the proposed contractor must submit to the Engineer:

1. Project experience list.
2. A list of key personnel to be used on the project with a brief experience resume for each.
3. The proposed grouting procedure and schedule.
4. Grout mix data.
5. A list of equipment to be used on the project (i.e., type of drilling apparatus, grout pump data, pipe extraction equipment, etc.).

4.0 MATERIALS: COMPACTION GROUT

The grout mix should be proportioned to provide an average 7-day compressive strength of 150 psi. The maximum slump shall be 3 to 5 inches. Grout with excessive slump shall be rejected. The temperature of the grout mix should not exceed 100°F and the grout mix should not be more than three (3) hours old at the time of pumping.

The proposed grout mix shall be submitted by the contractor to the Engineer for review prior to commencing the grouting program. Detailed documentation shall be presented by the Contractor to the Engineer which shows that slump and strength requirements have been met on past projects using the proposed mix design.

5.0 EQUIPMENT

The contractor shall provide all equipment and tools necessary to drill grout holes into hard limestone, place grout pipes, clean grout pipes, inject grout and extract the pipe. Equipment required for this project may include, but is not limited to:

1. Suitable drilling equipment capable of installing 3 to 4 inch diameter casing to and into limestone, subject to the approval of the Geotechnical Engineer.
2. Drilling equipment should be free of any leaks of oil, fuel or any other hazardous materials. The drilling equipment should be steam cleaned and inspected by the Geotechnical Engineer prior to commencing the drilling operation.
3. A crane, hydraulic ram or other suitable lifting apparatus capable of extracting the grout pipe.

4. A grout pump capable of pumping 3 to 5 inch slump cement grout. The pump should be fitted with a stroke counter or other acceptable device for use in grout volume calibration. The pump shall also have a pressure gauge at the point of discharge.
5. A sufficient supply of durable 3 to 4 inch inside diameter grout casing, 3 to 4 inch diameter grout hose, and any necessary fittings/couplings.
6. An accurate, self-leveling survey level, level rod, and other equipment necessary to permit accurate elevation surveys during grout pumping.
7. All other incidental equipment and tools necessary to complete the project.

6.0 GROUTING PROCEDURES

The injection points shall be installed at the locations proposed by the contractor and approved by the Engineer. Secondary and tertiary injection points may be installed depending upon the grout take of the primary injection points and at the discretion of the Engineer. The contractor shall provide at least 72 hours notice to the Engineer prior to commencement of drilling or grouting operations.

The contractor shall keep a drilling record for each borehole. The record should include the grout point number, the time rate of advancement (sec/ft.) for each foot of penetration, the drill being used, start date/time, and the date/time of completion. This data shall be reviewed by the Engineer prior to commencement of grouting.

Compaction grout with 3 to 5 inch slump shall be injected into each grout point through a 3 to 4 inch I.D. pipe. Unless otherwise directed by the Engineer, grouting shall be continued until one of the following criteria has been satisfied.

1. **Maximum grout pressures at the ground surface of 150 psi or as directed by the engineer.**
2. Maximum grout quantity of 5 cubic yards (c.y.) per 5 foot interval. We recommend the maximum volume of grout per day per grout point not exceed 10 c.y.

3. Maximum observed ground heave of ¼ inch is observed.
4. or at the direction of the Engineer.

The grout pipe shall then be lifted up in two to four foot increments. The grouting procedure shall repeat until the bottom of grout pipe reaches 10 feet below existing grade.

The contractor shall provide a detailed grouting record for each grout point. The record shall include the grout point number, date, the maximum grouting depth, the volume of grout placed versus depth, the total quantity of grout placed, and the injection pressure versus depth. This data shall be submitted to the Engineer for review and approval during the monitoring operation. Copies of the grout delivery tickets shall be provided to the Engineer.

7.0 TESTING AND QUALITY CONTROL

For off-site batching and mixing of the grout, a minimum of one (1) set of two (2) 3-inch diameter by 6-inch long grout cylinders shall be made every day. Unconfined compression tests shall be performed on the samples at 7 days. Slump tests shall be performed on each load of grout brought to the site or at the direction of the Engineer. The above testing shall be performed by the Engineer.

The Contractor shall supply the daily drilling and grouting documents outlined above to the Engineer within 24 hours after completion of each days work. The Engineer shall review reports and provide on-site personnel to verify the procedures performed, the quantities used, and alter grouting procedures as necessary.

8.0 UTILITY LOCATION AND SITE UTILITY CONTROL

Utility location prior to the commencement of any work at the site associated with this specification is the responsibility of the contractor. The Contractor shall limit the vertical and horizontal utility displacement to less than ¼ inch during the pressure grouting operation.

9.0 SITE CONTROL MEASUREMENTS

The contractor shall be prepared to place and monitor up to 9 points for heave control. A minimum of 2 control points will be required in the vicinity of the hot oil transmission line, located west S. Disston Avenue and up to seven (7) additional points in the project vicinity.

10.0 MEASUREMENT AND PAYMENT

For the purpose of bidding only, Tierra has provided a summary of Pay Items to be utilized by the prospective contractors. The quantities provided are for estimating only and in no way guarantee the quantities to be accurate based on the highly variable subsurface conditions encountered and the nature of compaction grouting uncertainties. However, the selected contractor will be expected to honor the provided unit prices for all unit quantities utilized on the project. This includes both under and overestimated quantities for lineal foot of grout pipe and cubic yard of grout.

The Table of quantities is as follows:

Pay Item	Estimated Quantity
Mobilization and Demobilization	1
Grout Pipe – Per Lineal Foot	500 LF
Compaction Grout – Per Cubic Yard	500 LF X .2 Cubic Yard Grout Factor X 1.2 over run factor ~ 120 cubic yards