VOLUSIA BLUE WETLAND RECHARGE PROJECT
PRELIMINARY DESIGN STUDY

St. Johns River Water Management District | December 2018

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St. Johns River Water Management District

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EXECUTIVE SUMMARY

The B&H Excavation Site, about 0.5-mile northeast of Blue Spring, was identified as a potential recharge site by the West Volusia Water Suppliers (WVWS) and the St. Johns River Water Management District (SJRWMD). The site is an active mine covering about 60 acres that was excavated to approximately 40 to 50 feet below natural grade. The west side of the property borders an existing 10-inch force main owned by Florida Department of Transportation that conveys stormwater discharge from Mill Lake to the St. Johns River.

This report evaluates the feasibility of using the B&H Excavation Site for recharge of between 2 to 5 million gallons per day (MGD) to benefit Blue Spring while not adversely impacting water quality at the spring. The results of this study show that a recharge project on this site project is economically, environmentally, and technically feasible.

Previous investigations by others indicated the presence of a confining clay layer on the site. Jones Edmunds completed geotechnical work and preliminary groundwater modeling to further assess the feasibility of achieving recharge goals at this site. Load testing, groundwater model calibration, and final design will be completed in future phases.

Jones Edmunds coordinated a topographic survey and a geologic assessment of the project site to characterize lithology and soil stratigraphy and to investigate soil characteristics such as clay content and soil permeability in the area.

Jones Edmunds used the geophysical investigation findings (Appendix B), the geotechnical investigation data (Appendix C), and water level data collected at the site to revise the site's aquifer parameters in the SJRWMD's Volusia Steady-State model and used the model to perform a groundwater capacity analysis and to evaluate the potential recharge benefit to Blue Spring.

Mead & Hunt (2018) evaluated the potential quantity and quality of source water that could be delivered to the Volusia Spring Recharge Project (Appendix E). The sources considered were reclaimed water, surface water from the St. Johns River, and stormwater from Mill Lake.

The project's water quality target is assumed to be 0.35 milligrams per liter (mg/L) nitrate at the point of discharge from the treatment system and before recharge. Jones Edmunds developed site layouts and evaluated the following three treatment options:

- Biosorption activated media (BAM) filter.
- Infiltrating wetlands.
- BAM and infiltrating wetlands combination.

The geotechnical data collected and groundwater modeling performed as part of this preliminary engineering report provided valuable information for understanding the site's hydrogeological behavior. Our analysis indicates that the site can be engineered to meet the design goals specified by SJRWMD and WVWS – recharge of between 2 to 5 MGD of reclaimed water to benefit flows from Blue Spring while not adversely impacting water quality at the spring.

Based on the preliminary cost information and assuming a conservative 20-year service life, the anticipated range of annualized nitrogen treatment cost for each option are the following:

- BAM – $30 to $44/lb
- Wetland – $40 to $58/lb
- BAM and Wetland – $25 to $37/lb

We recommend the BAM and infiltrating wetland combined system as the preferred alternative for the following reasons:

- The BAM and wetland combined system strikes a balance in cost and benefits to the environment.
- The BAM and wetland hybrid is expected to have lower operating and maintenance costs relative to full buildout using either BAM or wetlands.
- Achieving the full BAM buildout would require significant site work and may require import of fill material resulting in higher capital costs.
- The WVWS identified an ability to supply 2 MGD of reclaimed water to the site.
- Wetlands are incorporated as a natural system benefit and can serve as an educational park area for the community.

Our groundwater modeling indicates that recharge of 2 MGD of reclaimed water at the project site will result in an additional 1.7 MGD of flow at the spring. The long-term average flow at Blue Springs is about 101.5 MGD. This project could restore almost 2% of the spring flow for a cost less than $10M – a high level of cost-effectiveness that would receive favorable consideration for SJRWMD cost share funding.

1 INTRODUCTION

Paragraph 373.042(2), of the Florida Statutes (FS), mandates the St. Johns River Water Management District (SJRWMD) to adopt minimum flows and levels (MFLs) for all first-magnitude springs (springs with long-term average flows of at least 65 million gallons per day [MGD]).

SJRWMD approved a Minimum Flow Regime (MFR) for Blue Spring and Blue Spring Run in December 2006. Adopting an MFR for Blue Spring protects the spring from a reduction in flows that could threaten its water resource values and functions including its use as a reliable winter warm-water refuge by manatees.

The Volusia MFLs prevention and recovery strategy requires groundwater withdrawals to be maintained at or below sustainable limits or for impacts from groundwater withdrawals to be offset through reclaimed water use, aquifer recharge and water supply projects, and conservation and regulatory measures. Projects and measures proposed in the strategy are designed to ensure MFLs in Blue Spring and the affected lakes (other than Indian Lake) continue to be achieved and to meet future water demands for public water supply utilities and other water users throughout Volusia County.

The B&H Excavation Site, about 0.5-mile northeast of Blue Spring, was identified as a potential recharge site by the West Volusia Water Suppliers (WVWS) and SJRWMD. The site is an active mine covering about 60 acres that has been excavated to approximately 40 to 50 feet below natural grade. The west side of the property borders an existing 10-inch force main owned by Florida Department of Transportation (FDOT) that conveys stormwater discharge from Mill Lake to the St. Johns River.

1.1 PURPOSE

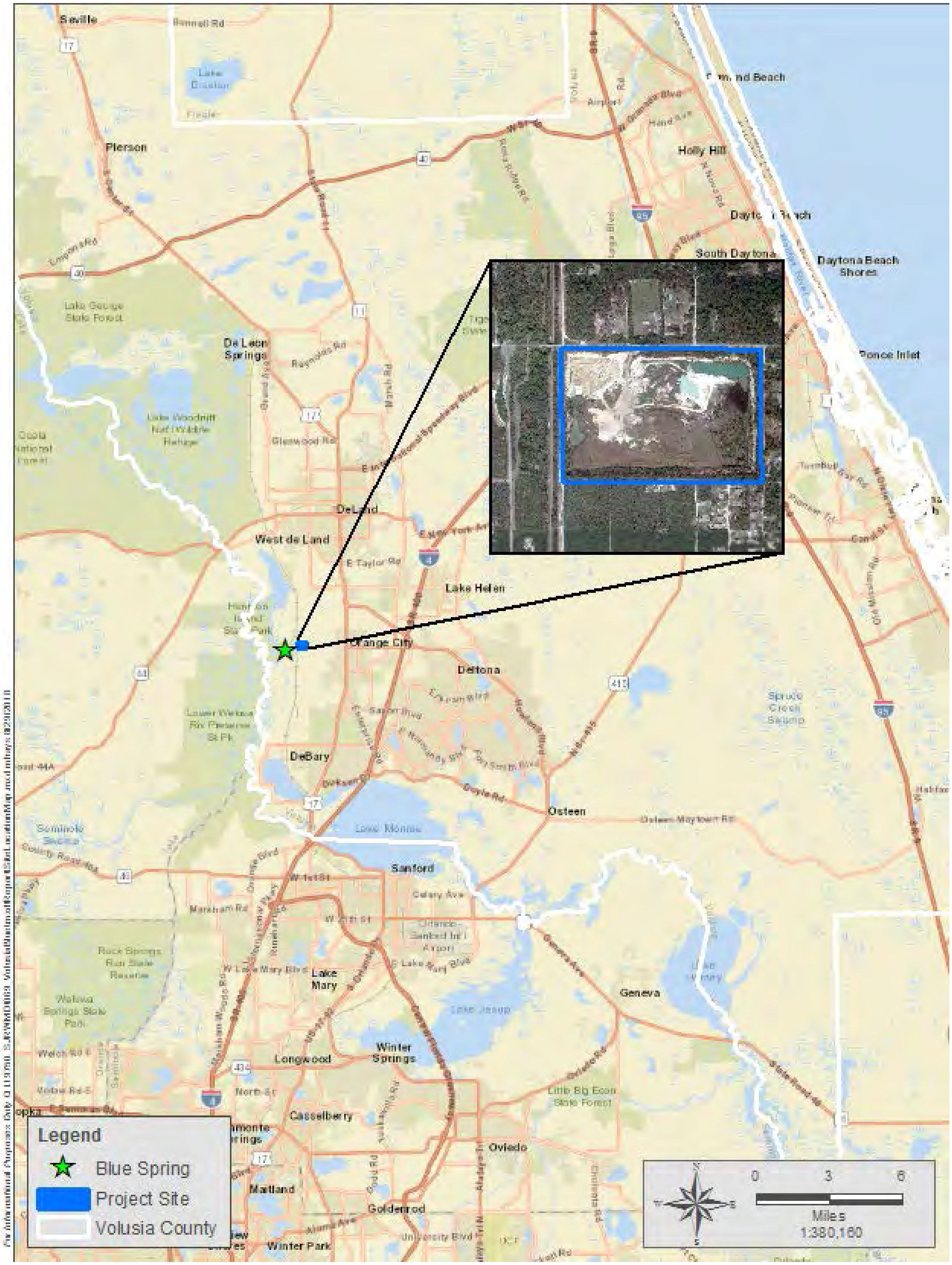
This report evaluates the feasibility of using the B&H Excavation Site for recharge of between 2 to 5 MGD of reclaimed water to benefit flows from Blue Spring while not adversely impacting water quality at the spring.

Previous investigations by others indicated the presence of a confining clay layer on the site. Jones Edmunds completed geotechnical work and preliminary groundwater modeling to further assess the feasibility of achieving recharge goals at this site. Load testing, groundwater model calibration, and final design will be completed in future phases.

2 SITE LOCATION

Figure 1 shows the project area is in west Volusia County in Section 4 of Township 18 South and Range 30 East. The Site is about 0.5 mile northeast of Blue Spring on the south side of West French Avenue, about 1.8 miles west of the intersection of French Avenue and US Highway 17-92 in Orange City, Volusia County, Florida.

Figure 1 Site Location Map



The property is currently an active excavation site. Land use near the project area includes residential and upland forest to the north, residential areas to the east and southeast, and upland forest to the south and west.

3 SURVEY

Appendix A presents the site survey completed by Pickett and Associates, Inc. on July 28, 2018. The survey was completed using Light Detection and Ranging (LiDAR) to capture topography with simultaneous capture of high-resolution digital imagery. The survey coordinates are referenced to the East Zone of the Florida State Plane Coordinate System, North American Datum of 1983 (NAD83), 2011 adjustment. Elevations are referenced to North American Vertical Datum of 1988. The survey contours have an estimated vertical positional accuracy of 0.5 foot. Spot elevations, on hard surfaces, have an estimated vertical accuracy of 0.25 foot.

4 GEOTECHNICAL DATA COLLECTION

Jones Edmunds coordinated a geophysical and a geologic assessment (Appendices B and C) of the project site to characterize lithology and soil stratigraphy and to investigate soil characteristics such as clay content and soil permeability in the area.

4.1 ELECTRICAL RESISTIVITY IMAGING

Geohazards, Inc. conducted a geophysical investigation via multi-electrode electrical resistivity imaging (ERI) at the site in May 2018 (Appendix A). The primary objective of this survey was to determine the approximate depth and thickness of any confining units, the depth to the top of the Upper Floridan Aquifer (UFA), and the presence of subsurface cavities or subsurface disturbance zones related to sinkhole activity. Figure 2 shows that Geohazards conducted the survey along six lines. Appendix B presents the ERI report.

Geohazards used an Advance Geosciences, Inc. SuperSting R8 eight-channel resistivity meter with an incorporated switchbox and a passive electrode cable. The data were processed using EarthImager 2D, a computer program that produces two-dimensional vertical cross-section models of the subsurface.

The resistivity profiles were indicative of more resistive, near-surface sands overlying less resistive, clayey materials and limestone. The limestone surface is variable over the site, ranging from 30 to 130 feet below land surface. Anomalous ERI features were identified along four of the six traverses. The anomalous zone on Traverse 1 consists of lower resistivity materials within the interpreted upper limestone surface. This anomaly likely represents an area of a paleosink with past in-filling of sands. Traverses 4, 5, and 6 cover the east portion of the site. Anomalous zones depicted on these traverses indicate that the upper limestone surface is sloping from west to east on Traverse 4 and from south to north along Traverse 6. The upper limestone surface was not detected on the east half of Traverse 4. The anomalous zones are interpreted to represent an area of a paleosink with previous in-filling of sands in the northeast portion of the site.

Figure 2 ERI and Boring Location Map

4.2 Standard Penetration Test Borings and Piezometer Installations

Fourteen standard penetration test (SPT) borings (B-1 through B-14) were conducted to obtain site-specific soil information. Borings B-1 and B-11 were located to investigate the anomalies identified in the ERI data. The other borings were located to provide representative coverage of the site. Figure 3 shows the boring locations.

The borings generally contained interbedded strata of some or all the following: sand (SP), sand with silt (SP-SM), sand with clay (SP-SC), clayey sand (SC), and very clayey sand (SC/CH). Some of the borings also contained interbedded strata of sandy clay to clay (CH). The upper limestone surface was encountered in the borings from 12 to 57 feet beneath grade, with the except of three borings (B-1, B-11, and B-13), which did not encounter limestone within the depth explored. Appendix C presents the boring logs.

Six piezometers were installed at boring locations to gather groundwater elevation data (Figure 3). Three shallow piezometers – B-1, B-9S, and B-12 – were installed to 20 feet below land surface to monitor the surficial aquifer and to determine if a perched surficial aquifer occurs at the site. Three deep piezometers – B-5, B-9D, and B-2 – were installed to 50 feet below land surface within limestone to monitor the UFA. Following installation, the piezometer locations and top of casing elevations were established using a global positioning system (GPS).

4.3 Laboratory Analysis

Grain-size distribution analyses were conducted on 15 soil samples taken from the SPT borings to better determine clay content and to estimate the confinement of the clay layer. The soil samples were chosen to represent the potentially confining soil types encountered during geotechnical borings. The Shepherd (1989) method was used to calculate hydraulic conductivity of the sands from the mean grain size. Table 1 summarizes the soil sample locations and the grain-size analysis results. Calculated permeability ranged from 6.2 to 86.7 feet per day (ft/day). Appendix C presents the Geotechnical Report and contains the laboratory results.

Figure 3 Piezometer Location and Surface Water GPS Elevations

Table 1 Grain-size Analysis Results

Soil Sample Location	Ground Surface Elevation (ft NAVD88)	Depth (ft)	Soil Description	Mean Grain Size (d50, mm)	Hydraulic Conductivity[1] (ft/day)
B-2	15.5	3.5–5	Very Clayey Sand (SC/CH)	0.16	8.9–30.2
B-3	29.0	18.5–20	Clayey sand with Shell (SC)	0.36	23.1–86.7
B-6	8.0	3.5–5	Clayey sand (SC)	0.18	8.2–27.6
B-7	27.5	6.0–8.0	Clayey sand (SC)	0.11	3.9–12.3
B-7	27.5	8.5–10	Clayey sand (SC)	0.16	6.8–22.8
B-7	27.5	18.5–20	Clayey sand (SC)	0.17	7.5–25.1
B-8[2]	22.0	3.5–5	Sandy clay (CL/CH)	N/A	N/A
B-9	19.0	3.5–5	Clayey sand (SC)	0.15	6.2–20.5
B-10	18.0	18.5–20	Sand with clay (SP-SC)	0.17	7.5–25.1
B-11	20.5	68.5–70	Sand with clay (SP-SC)	0.19	8.9–30.2
B-13	10.6	43.5–45	Sand with clay (SP-SC)	0.20	9.6–32.9

Notes: ft = feet.

[1] From Shepherd (1989), assuming texture ranged from consolidated sediments to channel deposits.

[2] A full-sieve analysis could not be conducted on this sample due to high fines content – only percent fines passing the No. 200 sieve determinations were conducted on the sample.

Additionally, three sample Shelby tubes were collected from clayey materials at the site. Two of the samples were selected for constant head permeability testing to measure the vertical saturated hydraulic conductivity of the confining layer. Grain-size analysis of the sample from B-7 is included in Table 2; however, grain-size analysis could not be conducted on the B-12 sample due to the high clay content. Table 2 shows the results of the permeability tests.

Table 2 Permeability Testing Results

Soil Sample Location	Depth (ft)	Soil Description	Vertical Hydraulic Conductivity[1]	
			(cm/sec)	(ft/day)
B-7	6.0–8.0	Clayey Sand (SC)	1.4 x 10-5	0.40
B-12	10.0–12.0	Clay (CL)	2.0 X 10-8	5.7 x 10-5

[1] From Ardaman & Associates, Inc., Geotechnical Testing Report (2018) (see Appendix C).

4.4 Surface Water and Groundwater Levels

Figure 4 shows the surface water elevations recorded using Real-Time Kinematic Global Positioning Systems (GPS) on July 11, 2018. Additionally, the survey in Appendix A shows the surface water elevations at the time of the survey (July 28, 2018). Surface water elevations range from approximatley 8 to 23 feet NAVD88. The range in elevations indicates that localized perched aquifers occur on site. This observation is consistent with the partial removal of the confining unit separating the surficial aquifer from the UFA by removal of materials during the mining process.

Groundwater levels were monitored in the piezometers installed at the site. Shallow well B-12 was dry following installation and throughout testing at the site. Table 3 shows the piezometer construction details and the manual water elevations collected from the piezometers.

Pressure transducers with data logging capabilities were installed in four of the piezometers to monitor water levels for approximately 4 weeks. Figure 4 shows the water elevations collected and rainfall data from SJRWMD gauge 14833566. The rainfall gauge is about 2.25 miles south of the site. As shown in Figure 4, water levels in shallow well B-1 show increasing trends that correlate with rainfall events, whereas deep piezometers B-5 and B-9D and shallow piezometer B-9S exhibit a dampened response to rainfall events.

Figure 4 Piezometer Water Level Data and Rainfall

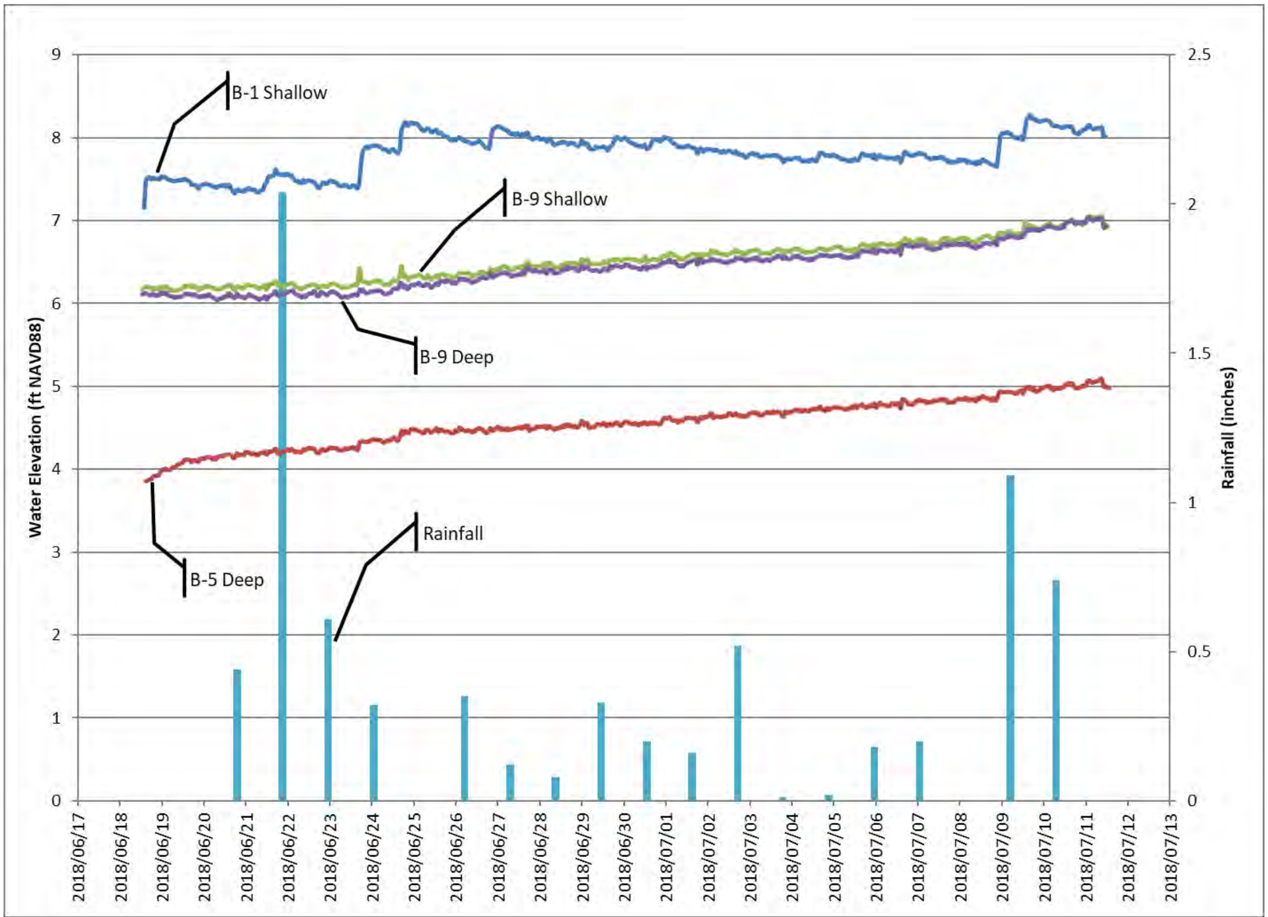


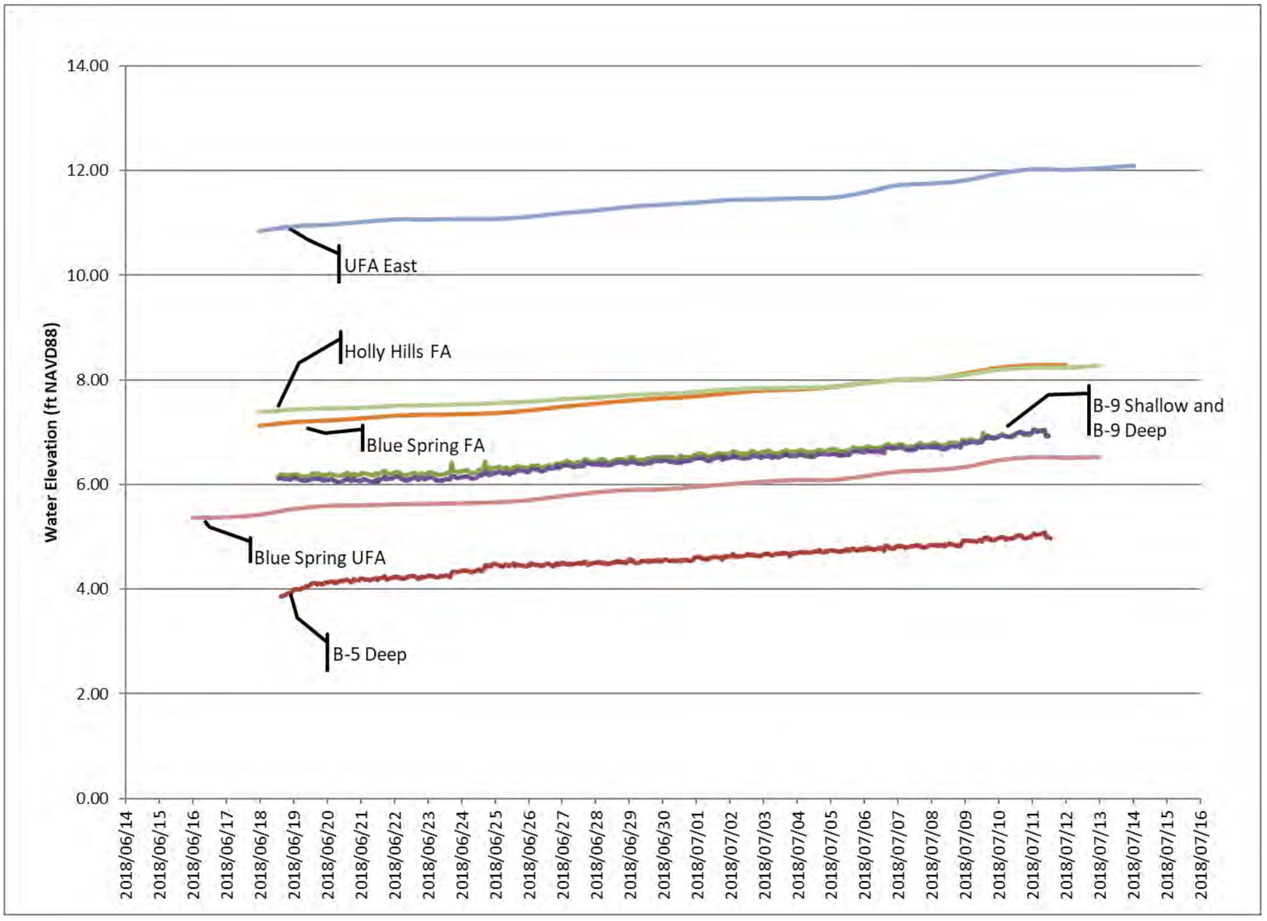
Table 3 Piezometer Construction and Groundwater Elevation Data

Piezometer	B-1	B-2	B-5	B-9S	B-9D	B-12
TOC Elevation	11.03	18.80	12.97	21.64	21.88	30.61
Total Depth	20	50	50	20	50	20
GWE, 6-18-18	7.44	NA	4.15	6.04	5.92	DRY
GWE, 7-11-18	8.02	25.17	4.98	6.94	6.93	DRY

Note: TOC = Top of Casing (feet NAVD).
GWE = Groundwater Elevation (feet NAVD).
NA = Not Accessible.

Piezometer B-1 is near the standing water in the northeast corner of the site. The surface water levels are similar to the water levels measured in B-1. The similarity in water levels and the response to rainfall in B-1 is consistent with an unconfined surficial aquifer in this area of the site. However, water levels in B-5, B-9D, and B-9S all appear to represent confined aquifer conditions. Figure 5 compares the water elevations to elevations from nearby UFA monitor wells maintained by SJRWMD. The water levels observed in the deep piezometers and shallow piezometer B-9S show similar trends to the nearby UFA monitor wells. The UFA elevation at the site is approximately 5 to 7 feet NAVD88. Comparing the water levels in B-1 and the UFA piezometers indicates a downward gradient between the surficial aquifer and the UFA at the site. Surface water measurements in the northwest area of the site range from approximately 14 to 23 feet, indicating a higher degree of confinement.

Figure 5 UFA Water Levels



4.5 Analysis of Water Level Data

As Figure 4 shows, a steady increase in water levels was observed in the UFA piezometers over the period monitored. However, B-1 showed a rapid increase in water level followed by a gradual decline after rain events. Similar increases and decreases were recorded for each rain event.

Jones Edmunds used to the water level data from B-1 to calculate seepage rates (decline in water level over time) for the surficial aquifer. We calculated the slope of the decline using water levels for times when steady declines were observed – one rate was calculated for the rapid decrease immediately following a rainfall event, and one rate was calculated for the long-term decline observed over the monitoring period. Table 4 shows these calculated seepage rates in ft/day. The leakance between the surficial aquifer and the UFA near B-1 was calculated using Darcy's Law. The equation used to calculate leakance is:

$$q = L * \Delta H$$

where: q = Infiltration rate = decline in water level (ft/day).
L = Leakance (day^{-1}).
Δ H = head difference between layers = average head difference between the surficial aquifer and the Floridan aquifer over the period of time.

Table 4 Infiltration Rates and SAS Leakance

Date	Surficial Elevation (from B-1)	UFA Elevation (from B-5)	Time (days)	q (ft/day)	ΔH (ft)	L (day-1)	Average L
06/25/2018 at 1:00	8.17	4.48	0.71	0.22	3.6	0.06	0.036
06/25/2018 at 18:00	8.02	4.45					
06/25/2018 at 1:00	8.17	4.48	13.71	0.036	3.3	0.011	
07/08/2018 at 18:00	7.68	4.83					

Note: L = Leakance.

4.6 Slug Testing

Slug testing was performed at the piezometers to obtain hydraulic conductivity estimates. A solid polyvinyl chloride (PVC) rod was used to impart a sudden increase (slug in) or decrease (slug out) of the water level in the test well. Water level recovery during the slug tests was measured using a pressure transducer pre-programmed to take measurements. The raw test data were analyzed using the Hvorslev Method (1951). Table 5 summarizes the slug testing results. Appendix D provides the field data.

Table 5 Slug Test Results

Well ID	Type	r (inch)	R (inch)	Le (ft)	T37 (min)	T37 (day)	Hydraulic Conductivity (K) (ft/day)
B-1 Shallow	Slug In	1	3	10	211.7	1.47E-01	0.0087
B-1 Shallow (after development)	Slug In	1	3	10	1.13	7.87E-04	1.6274
B-5 Deep	Slug In	1	3	10	29.20	2.03E-02	0.0632
B-9 Shallow	Slug In	1	3	6.4	7.72	5.36E-03	0.3281
B-9 Deep	Slug In	1	3	10	10.73	7.45E-03	0.1719

Notes: Le = Length of the saturated portion of the screen pack.
min = minutes.
T37 = time in minutes for the water level to fall to 37 percent of the initial change.

During testing, extremely slow recovery from the slug in test was noted, and due to time limitations, the slug out tests were omitted. A specialized biodegradable drilling mud was used for the piezometer installations; however, drilling mud was observed on the pressure transducer probes from some of the piezometers. Because the slug tests results were extremely low for the surficial aquifer, a peristaltic pump was used at the second site visit to partially develop B-1. A second slug in test was completed at B-1 after development, which resulted in a significantly higher hydraulic conductivity. However, fines were still present when development of the piezometer was stopped. The post-development results indicate that the slug test results have been impacted by the presence of drilling fluids, and therefore, the slug test results are not believed to be representative of the site aquifer characteristics.

5 PROJECT EVALUATION

5.1 GROUNDWATER FLOW MODEL

Jones Edmunds performed a groundwater capacity analysis using the SJRWMD's Volusia Steady-State model to evaluate the potential recharge benefit to Blue Spring. Jones Edmunds refined the model grid around the site and used the geotechnical data collected to modify the surficial aquifer hydraulic properties and develop an uncalibrated steady-state model of the site. We used the model to assess whether the site can accept recharge in the range of 2 to 5 MGD.

5.1.1 DESCRIPTION OF THE SJRWMD VOLUSIA MODEL

SJRWMD developed the Volusia County groundwater flow model to simulate the surficial aquifer system (SAS) and Floridan aquifer system (FAS) and to facilitate the evaluation of water resources within east-central Florida. The model was constructed using the US Geological Survey (USGS) MODFLOW code (McDonald and Harbaugh, 1988), a three-dimensional finite-difference simulation tool. The model was calibrated to predevelopment hydrologic conditions and to average 1995 conditions. The Volusia model covers almost all of Volusia County, and parts of south Flagler, east Lake, and north Seminole Counties, and small portions of Putnam, Orange, and Brevard Counties. The coordinate system used for the Volusia model is the HARN UTM Zone 17N projection, NAD83.

The Volusia model was developed as a three-layer model with a constant grid spacing of 2,500 feet. Layer 1 corresponds to the SAS. Layer 2 represents the UFA. Layer 3 represents the Lower Floridan Aquifer (LFA) system. The three aquifer layers are simulated explicitly based on elevation data, and confining units representing the intermediate confining unit and the middle semi-confining zone are simulated as non-uniform areal distributions of leakance terms. Springs are modeled as drain cells, and surface water bodies greater than 500 acres in areal extent are modeled as river cells. A steady-state calibration was performed based on the average 1995 conditions.

5.1.2 LOCAL-SCALE MODEL DEVELOPMENT

5.1.2.1 Model Grid and Boundaries

Due to the large grid spacing of 2,500 feet in the Volusia model, the grid spacing in the local-scale model needed to be adjusted to simulate the proposed recharge and mounding accurately. Therefore, the local-scale model was set up by defining a buffer zone of 10,000 feet around the site with a constant grid spacing of 100 feet. The grid spacing was then increased gradually outside the buffer zone by 50 percent until the maximum spacing reached 2,500 feet. As a result, the model area was discretized into 156 columns and 180 rows, and the model space area is 250,000 feet by 250,000 feet. Figure 6 shows the model grid.

Vertically, the hydrogeologic system in the model area was considered to consist of three layers representing the unconfined surficial aquifer system (SAS) shallow zone, the confined UFA, and the confined LFA. The model was developed as a quasi-three-dimensional model in which the semi-confining layer between the SAS and UFA is simulated using a leakance term.

The refinement of the grid near the drain cell for Blue Spring required that the drain cell be adjusted to more accurately locate it spatially in the refined model grid. The drain representing Blue Spring is simulated in Layer 2 with a stage elevation of 1.5 feet, which was imported from the Volusia model.

5.1.2.2 Aquifer Parameters

Initial aquifer properties, SAS hydraulic conductivity, UFA transmissivity, and the leakance across the confining unit were imported from the Volusia model. The aquifer properties were revised using the site-specific survey and geotechnical data to account for changes in site conditions due to previous mining of site soils, which have removed a large portion of the surficial aquifer and potentially the underlying confining unit (Table 6).

Table 6 Model Parameters

Parameter	Layer	Volusia Model	Revised Model
Hydraulic Conductivity	SAS	20 ft/day	15 ft/day
Transmissivity	UFA	6,400 ft^2/day	6,400 ft^2/day
Thickness	SAS	51.6 – 58.2 ft	10.7 – 64.8 ft
	UFA	326 – 340 ft	274 – 332 ft
Leakance	SAS	0.00012 day^{-1}	0.00012 – 0.0347 day^{-1}

Note: ft^2/day = square feet per day.

The survey in Appendix A was used to revise the Layer 1 elevations. The model cells are 100 feet by 100 feet. The average cell top elevation was determined from the survey data and imported into the model. Figure 7 shows the Layer 1 top elevations used in the model. The top-of-limestone elevations from the boring logs were used to estimate the bottom of Layer 1/top of Layer 2. Figure 8 shows the estimated top-of-limestone elevations used in the model.

Figure 6 Model Grid

Figure 7 Model Surficial Aquifer (Layer 1) Top Elevations

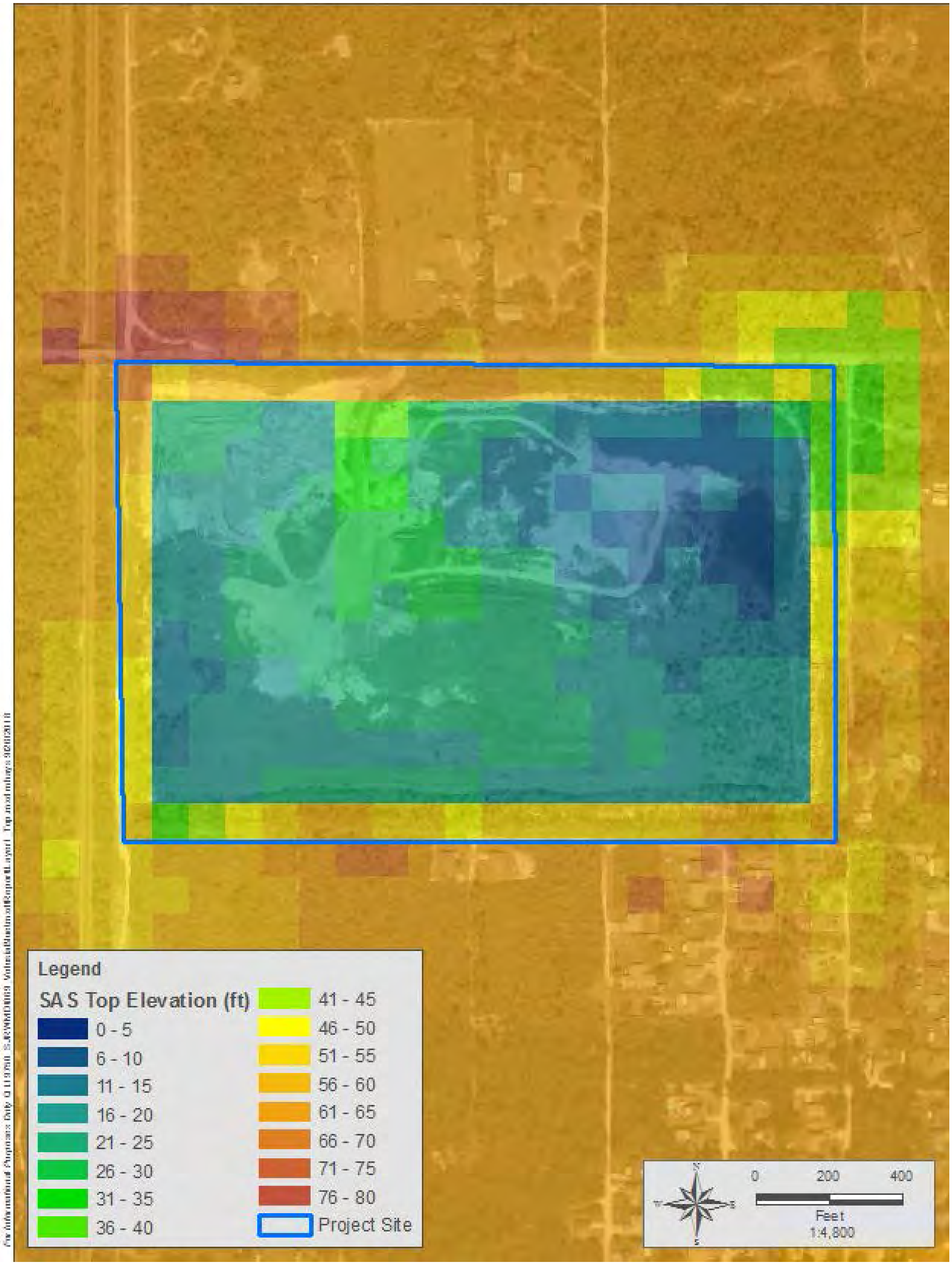
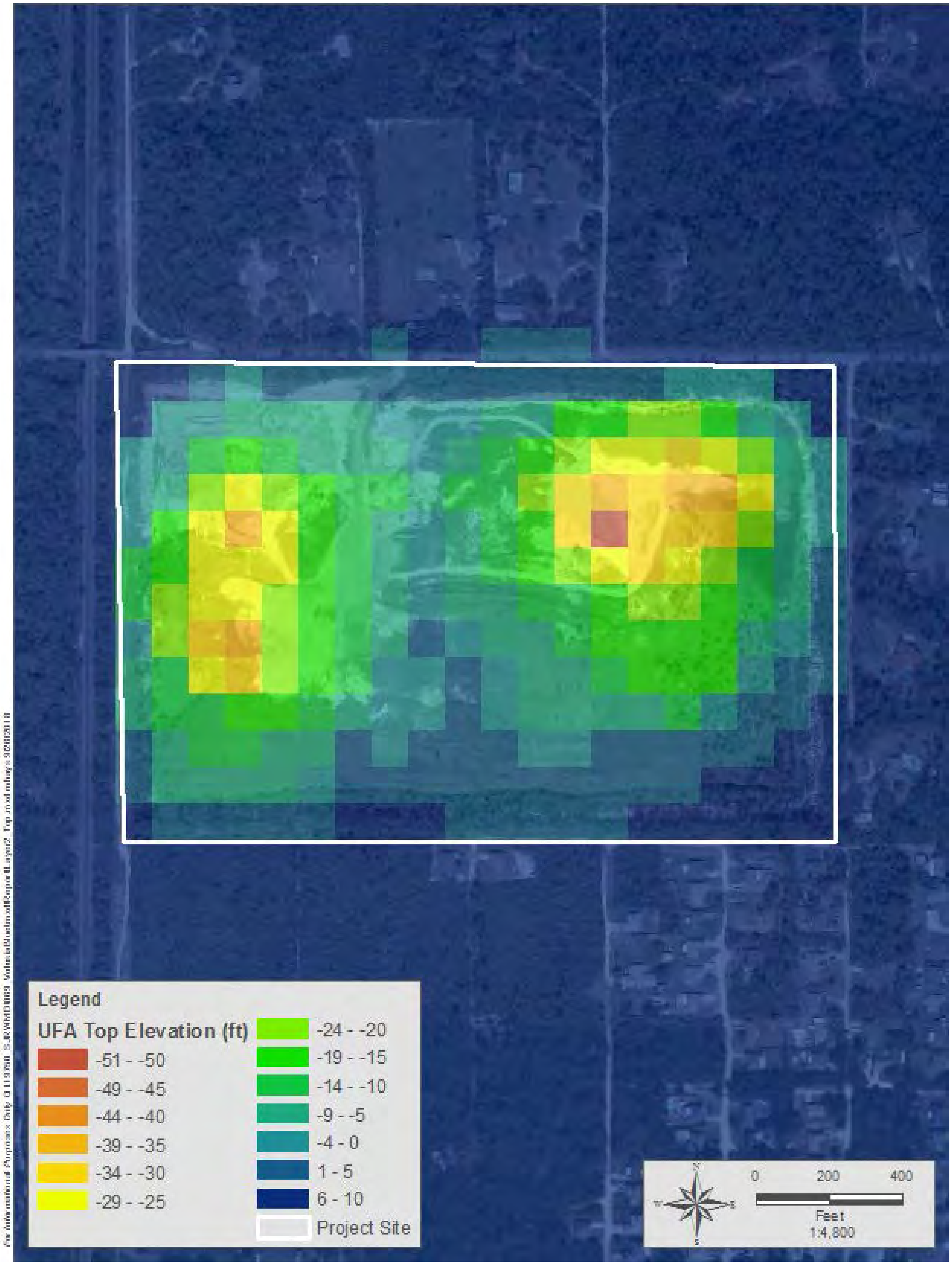


Figure 8 Model UFA (Layer 2) Top Elevations



The Layer 1 hydraulic conductivity and leakance parameters were then modified based on the extents and thicknesses of clayey materials identified in the boring logs and ERI profiles. The leakance parameters and surficial aquifer hydraulic conductivity were adjusted until the steady-state surficial aquifer water levels were approximately equal to the observed elevations in B-1 and the surface waters. Figure 9 shows the adjusted leakance used in the model. Figure 10 compares the modeled heads to the surface water elevations obtained at the site.

Other than refinement of the drain location, the model boundary conditions and the properties of the LFA were not revised. A net recharge of approximately 24.4 inches per year (in/yr) (imported from the Volusia model) was used in the model.

5.1.3 Assumptions

The following assumptions were included in the development of the hydraulic model:

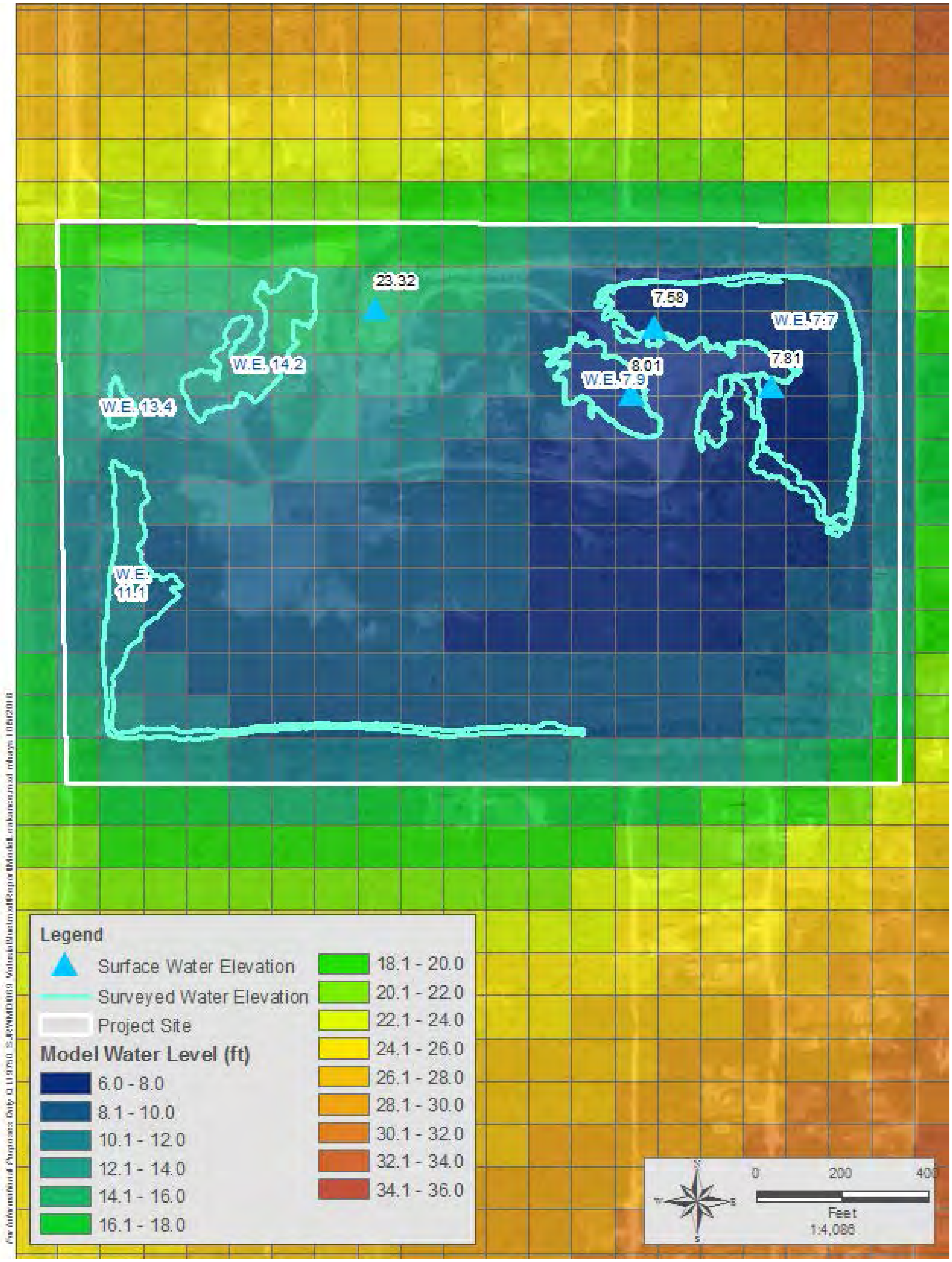
- Each layer is isotropic and homogeneous.
- Net recharge is constant throughout the modeled area.
- The loading rate is constant throughout each application area.
- Leakage occurs from the surficial aquifer through the semi-confining unit.
- The capacity analysis is steady-state.
- Storage in the surface water ponds is ignored.
- Saturated conditions were assumed in which unsaturated vertical infiltration is neglected.

5.1.4 Model Loading Analysis

Once the groundwater model parameters were adjusted, a capacity analysis of the site was initiated. Because the site is an excavated mine, approximately 30 to 40 ft of elevation difference exists between the bottom of the pit and the top of bank. Therefore, it was assumed that water levels in the pit could rise above ground surface. The lowest top-of-bank elevations occur on the northeast side of the site at approximately 45 feet NAVD88. A berm approximately 5 feet high borders the property there, and the east toe of the berm in this area is approximately 40 feet. Model simulations were run up to 38 feet to allow a buffer between the water surface and the lower elevations in the northeast corner of the site.

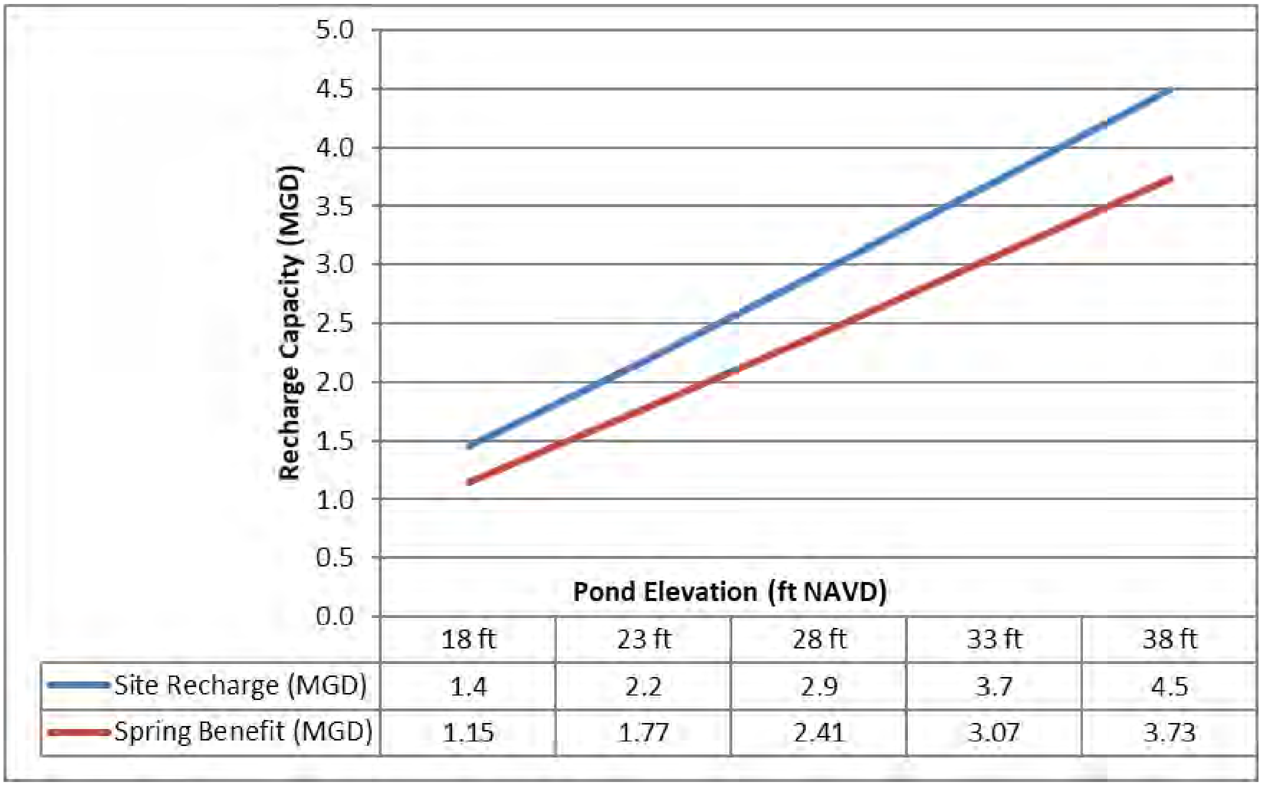
Figure 9 Model Leakance

Figure 10 Model Water Elevations vs. Surface Water Elevations



The model was set to run in steady-state mode and Specified Heads were added to the model cells within the proposed recharge area to simulate potential post-loading water elevations at the site. Multiple Specified Head scenarios were run to simulate water elevations between 18 to 38 feet NAVD88. The cells' Constant Head mass balance was calculated for each simulation to determine the flux of water (i.e., site recharge capacity) needed to maintain the Specified Head elevation. Figure 11 shows the results of the model simulations.

Figure 11 Model Results

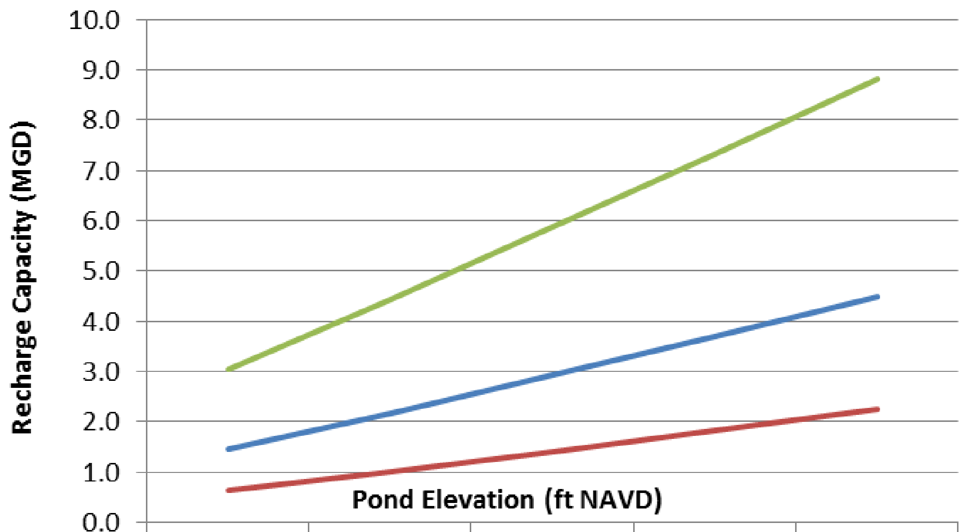


Since the goal of the project is to benefit flows from Blue Spring, we also used the model to estimate the potential benefit to the Spring. Blue Spring is simulated in the model as a drain cell in Layer 2. We used the pre- and post-loading mass balance of this drain cell to calculate the additional groundwater flow to the spring for each Specified Head simulation. The red line in Figure 11 shows the estimated additional spring flow for each scenario.

5.1.5 Sensitivity Analysis

A sensitivity analysis was performed to evaluate the model's response to changes in the leakance parameter. For the analysis, simulations were run where the leakance was reduced by half and where the leakance was doubled. The sensitivity analysis results show that reducing the leakance by half reduces the site capacity by half, whereas, doubling the leakance approximately doubles the site capacity. Figure 12 summarizes the results of sensitivity analysis.

Figure 12 Sensitivity Analysis Results



	18 ft	23 ft	28 ft	33 ft	38 ft
Site Recharge (MGD)	1.4	2.2	2.9	3.7	4.5
Low Leakance (50%)	0.6	1.0	1.4	1.8	2.3
High Leakance (150%)	3.0	4.4	5.9	7.3	8.8

5.2 Water Source and Quality

Mead & Hunt (2018) evaluated the potential quantity and quality of source water that could be delivered to the Volusia Spring Recharge Project (Appendix E). The sources considered were reclaimed water, surface water from the St. Johns River, and stormwater from Mill Lake (Table 7).

Five wastewater treatment plants (WWTPs) are within a 13-mile radius of the Borrow Pit. The five WWTPs and flow rates are described in Table 1 of the Mead & Hunt report. Overall, the system has 7.0 MGD (average daily flow [ADF]) reuse demand and produces 7.11 MGD of effluent.

Volusia County is planning to decommission the Deltona North WWTP and re-route that wastewater for treatment at the Southwest Regional Water Reclamation Facility. By 2024, all WVWS wastewater treatment plants will comply with advanced wastewater treatment (AWT) standards, resulting in effluent that will have less than 3 mg/L total nitrogen (TN).

Based on projected reclaimed water needs, Mead & Hunt (2018) predicted a need to augment the reclaimed system with surface water withdrawals from the Middle St. Johns River. The report presents a predicted 2024 average blended concentration of 2.15 mg/L TN, in the form of nitrate.

Table 7 Sources of Recharge Water

Treatment Plant	Owner	Permitted Effluent Limit	Design Capacity (MGD)	Monthly Average Effluent (MGD)	Public-Access Reuse Permitted Capacity (AADF)	Other
Wiley M. Nash	Deland	AWT TN <3 mg/L	6	3.36	6	4.0 MGD (max) Surface Water St. Johns River
*Deltona North/ Southwest #2	Volusia County	TN <12 mg/L	0.6	0.20	0.77	
Southwest Regional	Volusia County	AWT TN <3 mg/L	1.2	1.33	1.20	
Deltona Lakes	Deltona	TN <12 mg/L	1.4	1.83	1.45	
Deltona East	Deltona	AWT TN <3 mg/L	1	0.39	1.05	
Alexander Avenue	Deltona	N/A	N/A	N/A	N/A	6.0 MGD (max) Stormwater & Surface Water (Lake Monroe)
Mill Lake	Orange City	N/A	Varies	Varies	N/A	Stormwater

* Deltona North is scheduled for decommission.

5.3 Water Quality Target

The project's water quality target is assumed to be 0.35 mg/L nitrate at the point of discharge from the treatment system and before recharge. This target is protective of the Spring water quality and is consistent with Section 62-302.531 of the Florida Administrative Code. Importantly, this preliminary analysis considered a maximum recharge rate of 4.0 MGD, which is a relatively small fraction of the overall discharge from Volusia Blue Spring (~101 MGD).

5.4 Site Layout

Jones Edmunds prepared three conceptual site layouts based on (1) the treatment technology used to reduce the TN concentration, and (2) the expected water level resulting from the recharge rate. The treatment technologies that Jones Edmunds evaluated are biosorption active media (BAM), infiltrating wetlands, and denitrification filters. We evaluated each option for:

- Ability to reduce TN to <0.35 mg/L.
- The amount of land required to treat the maximum target recharge rate of 4 MGD.
- The relative operation cost.

- The maintenance frequency.
- The historical operations to remove TN from reclaimed water.

Denitrification filters require an operator to manage and maintain the delivery of the carbon source. Possible carbon sources include methanol, ethanol, acetic-acid, corn syrup, or glycerin. Jones Edmunds eliminated the denitrification filter from further consideration due to the higher operations and maintenance intensity and costs relative to the other technologies.

5.4.1 Estimated Water Level

The existing site is a sand mine. The operator removed 20 to 55 feet of soil material from most of the site. The land surface in the mined area varies from about 7 to 30 feet NAVD88, and the water surface is about 10 feet NAVD88. Figures 13 and 14 show initial estimates of the inundated area that would result from a 2.0- or 4.5-MGD recharge rate, respectively. The cross-sections shown at the bottom of each figure provide a visual estimate of the water depth. These figures highlight how the site recharge rate will determine the site design and the amount of fill material that will be required to construct a treatment area on the site. A load test on the site will provide greater certainty on the site recharge rate and thus the design requirements.

5.4.2 BAM Filtration Basin

Jones Edmunds evaluated a BAM filter using information from the Deland rapid infiltration basin study (Chang, 2018). The study was conducted at the City of Deland’s Wiley M. Nash WWTP and involved retrofitting one of the rapid infiltration basins (RIBs) with BAM. The BAM-augmented RIB treatment system removed an average of 83 percent of the nitrate load from the reclaimed water and reduced the average nitrate concentration to 0.72 mg/L. When Hurricane Irma passed through the area, the BAM-augmented RIB treatment system was loaded with a blend of excess stormwater and reclaimed water. During this portion of the testing period, the system removed an average of 95 percent of the nitrate and reduced the effluent concentration to 0.014 mg/L. Based on the results of the Deland study, achieving the desired effluent concentration of 0.35 mg/L TN may be possible, particularly if recharging a blend of stormwater and reclaimed water is possible.

Figure 13 Estimated Inundated Area and Water Depth for a 2.0-MGD Recharge Rate

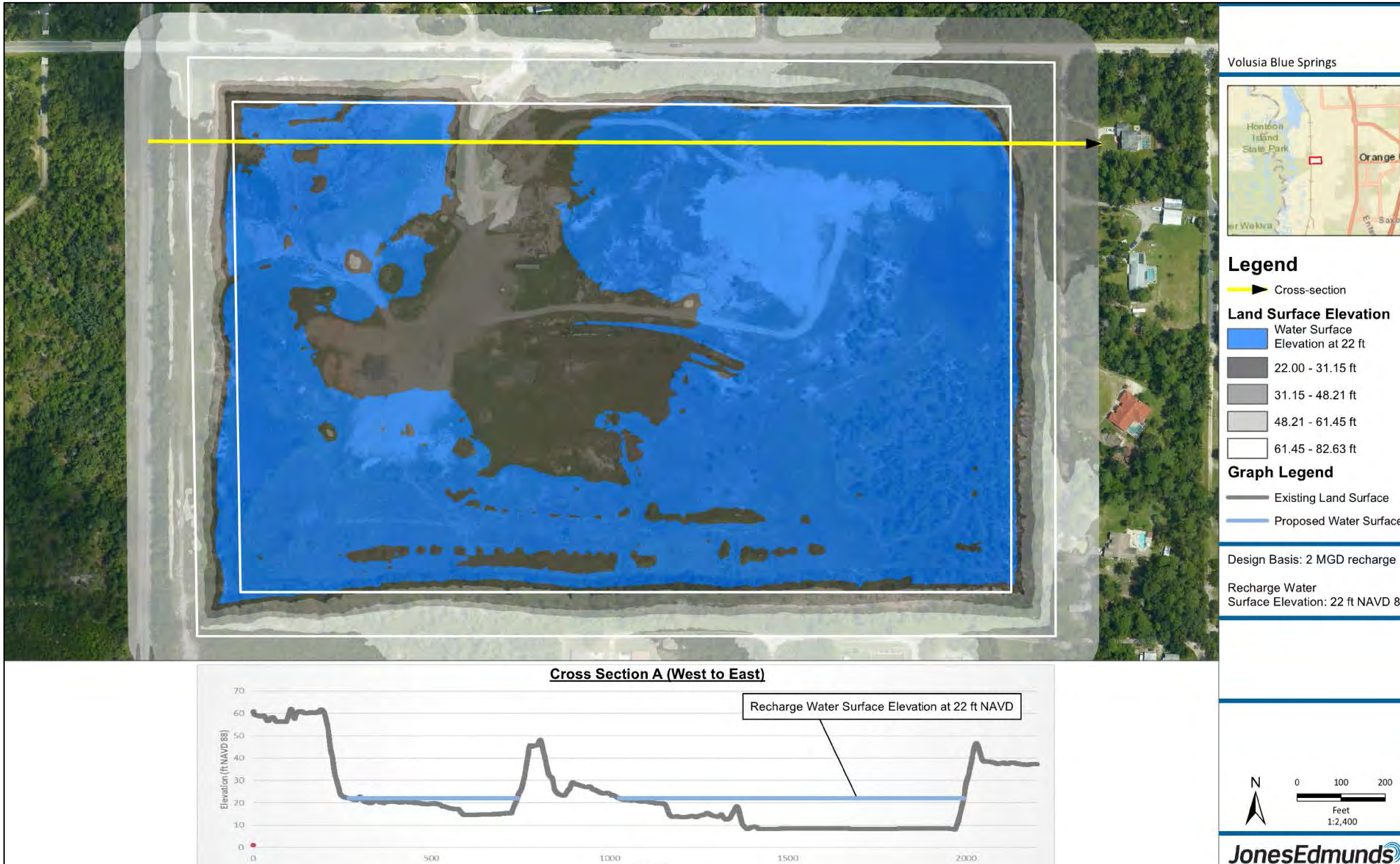


Figure 14 Estimated Inundated Area and Water Depth for a 4.5-MGD Recharge Rate

The main advantages of the BAM system are that a relatively high level of water quality treatment can be achieved with a passive system – once the water is distributed to the cells. The main disadvantage for BAM is that the initial capital cost per acre of material is high relative to other technologies; however, maintenance requirements and costs are lower.

Using the Deland experiment as a basis of design, Jones Edmunds used the following conceptual design criteria (Figure 15):

- Flow rate: 4 MGD – this maximizes the flow rate at the site based on our current understanding of the achievable recharge rate.
- Water source: Reclaimed water with average TN 3 mg/L, assumed to be nitrate.
- Loading rate: 0.02 gallon per minute per square foot (gpm/ft^2).
- Safety Factor: 2.
- Bottom Area: 6.0 to 8.0 acres.
- Cells: Two.
- BAM depth: 24 inches.
- Liner: Ethylene propylene diene monomer (EPDM) to allow collection and control of treated water discharge.
- Total treatment area (includes maintenance access roads): 14 acres.

5.4.2.1 Probable Construction Cost Opinion

All planning-level opinions of costs can be considered Class 4 cost estimates as defined by the American Society for Testing and Materials Standard Classification of Cost Estimating (ASTM E2516-11). Class 4 estimates are for conceptual projects or feasibility studies based on a 1% to 15% complete level of project definition. In the general construction industry, this level of estimate typically has an expected cost accuracy range of -10 to -20 percent on the low side and +20 to +30 percent on the high side. All opinions of costs are presented as ranges (-20 to +30 percent) to give an estimate of the variability that could be associated with the final project costs.

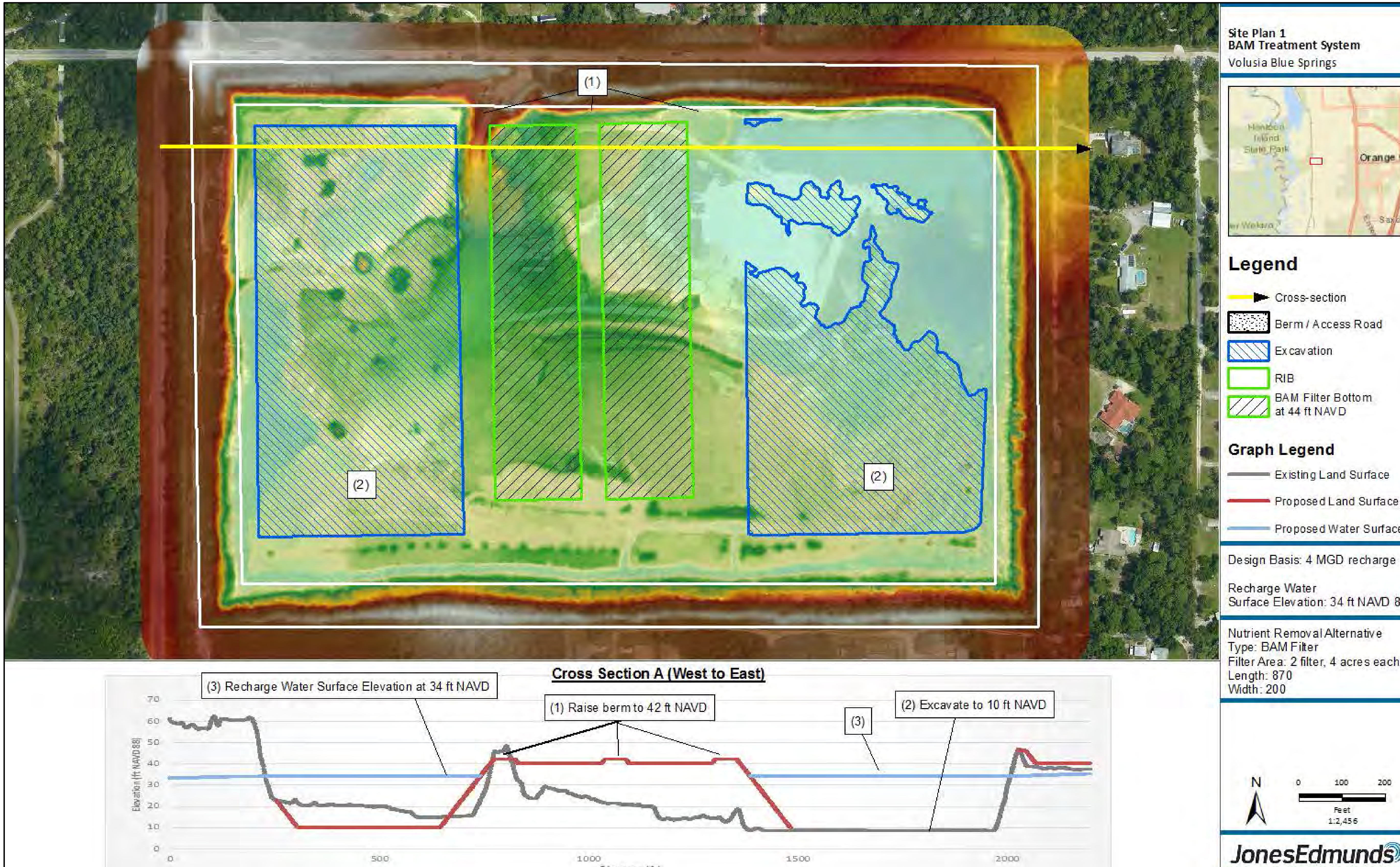
The cost for two 4-acre BAM media filter cells to provide 4 MGD of treatment and recharge is approximately $3.5 to $4.4 million. The largest contributor to this cost is the fill needed to construct the cells above the estimated water elevation.

5.4.2.2 Probable Operation and Maintenance Cost Opinion

The operation and maintenance of the BAM media filters is relatively minor and limited to disking the bottom of the cells every 18 to 24 months. This is like the maintenance done on RIBs and helps to maintain the design infiltration rate and prevent large woody vegetation from taking root in the cells.

The cost for disking the bottom of the cells is approximated at $3,000 per acre per year or $24,000 per year.

Figure 15 BAM Filter Alternative



5.4.3 Infiltrating Wetland

Jones Edmunds evaluated an infiltrating wetland treatment alternative based on design information presented by Wetland Solutions, Inc. (WSI) in 2013. The assumed loading rate for this alternative (3 to 7 inches per week) is based on design information reported by WSI. This loading rate may be conservative since Gainesville Regional Utilities has demonstrated successful nutrient reduction of reclaimed water in an infiltrating wetland receiving both reclaimed water and stormwater, with a loading rate of 20 inches per day. Although achieving the desired nutrient removal may be possible with this loading rate, we used the more typical loading rate reported by WSI.

The main advantages of the infiltrating wetland system are that:

- The treatment is passive – once the water is distributed to the cells, there are no longer pumps, valves, or moving parts to maintain.
- The infiltrating wetland provides valuable wetland habitat. Using the infiltrating wetland to provide passive recreational trails to the public may be possible. Using the wetland creation area to provide offsite wetland mitigation credits may also be possible.

The main disadvantage of the infiltrating wetland system is that the success of the plant community depends on the water level. Since the water level depends on the recharge rate, the success of the wetland design will be highly dependent on data from a load test.

Jones Edmunds used the following conceptual design criteria (Figure 16):

- Flow rate: 0.4 to 0.9 MGD.
- Water source: Reclaimed water with average TN at 3 mg/L, assumed to be nitrate.
- Loading rate: 3 to 7 inches per week.
- Safety Factor: 1.
- Bottom area: 32 acres.
- Cells: Two.
- Total treatment area (includes maintenance access roads): 32 acres.

5.4.3.1 Probable Construction Cost Opinion

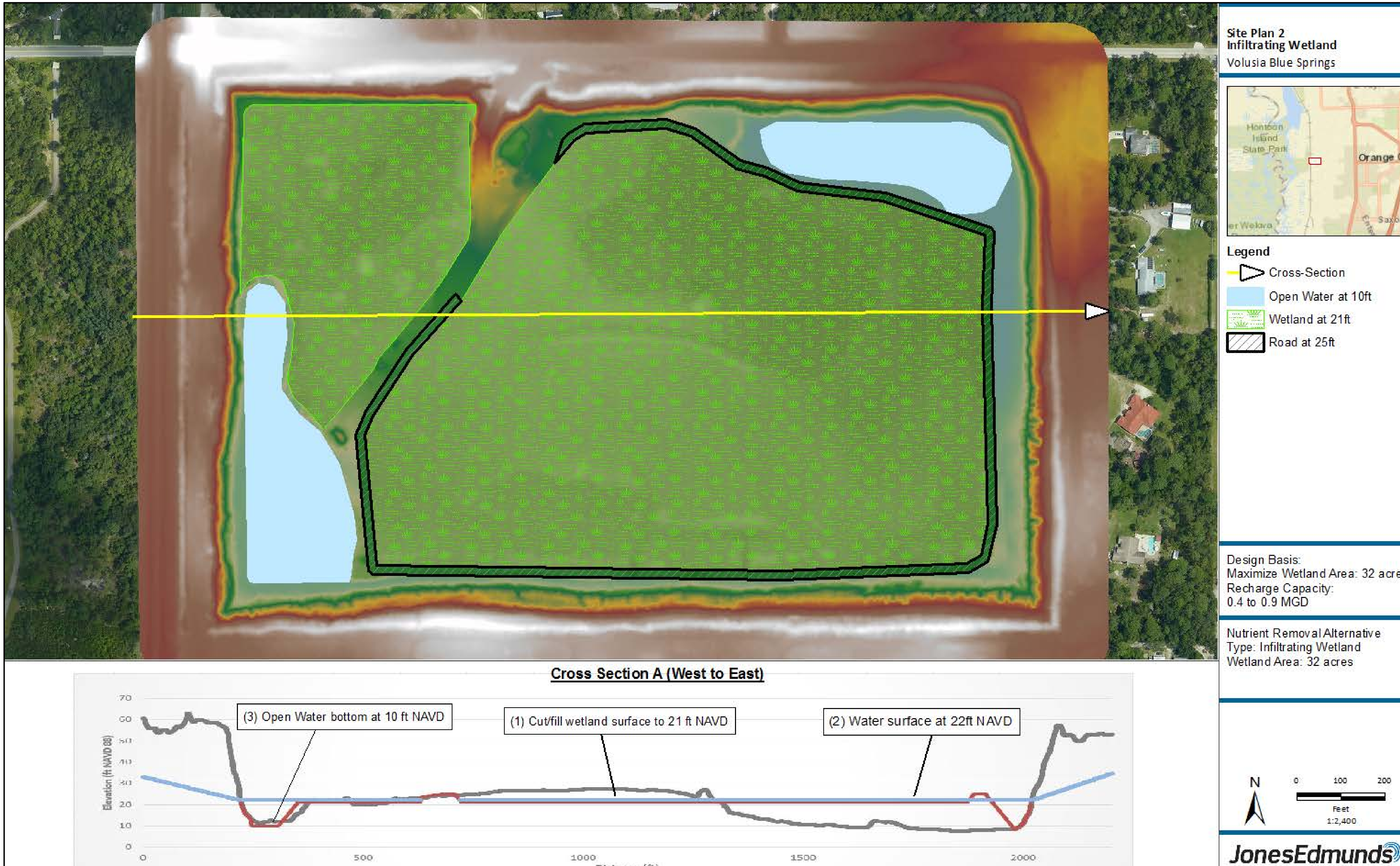
The cost for a 32-acre infiltrating wetland to provide 0.4 to 0.9 MGD of treatment and recharge is approximately $2.5 to $5.4 million. The largest contributor to this cost is the cost to fill the site to construct the wetland above the estimated design water elevation.

5.4.3.2 Probable Operation and Maintenance Cost Opinion

Wetland operation and maintenance costs are highly variable depending on the vegetation management plan and the degree to which it is necessary to control invasive exotic species. The South Florida Water Management District (SFWMD) reports that the annual maintenance cost for the stormwater treatment area wetlands is about $600 per acre per year, which is on the low end and may be driven by economies of scale. Some wastewater utilities spend up to $3,000 per acre per year to manage wetlands in a park setting.

Our opinion of the operation and maintenance cost range for the infiltrating wetland is $20,000 to $96,000 per year, and this largely depends on the diversity of the planting plan and the control of exotic plants.

Figure 16 Infiltrating Wetland Alternative



5.4.4 BAM Filtration Basin and Infiltrating Wetland

Jones Edmunds evaluated combining a BAM filter with an infiltrating wetland at a flow rate of 2.0 MGD. The BAM filter can be designed to provide the required nutrient removal in a compact footprint.

The main advantages of the BAM and infiltrating wetland combined system are that:

- The treatment is passive – once the water is distributed to the cells, there are no longer pumps, valves, or moving parts to maintain.
- The infiltrating wetland provides valuable wetland habitat. Using the infiltrating wetland to provide passive recreational trails to the public may be possible. Using the wetland creation area to provide offsite wetland mitigation credits may also be possible.

The main disadvantage of the BAM and infiltrating wetland combined system is that the success of the plant community depends on the water level. The water level depends on the recharge rate. The success of the wetland design, therefore, also depends on data from a load test.

Jones Edmunds used the following conceptual design criteria (Figure 17):

- BAM filter:
  - Flow rate: 2.0 MGD.
  - Water source: Reclaimed water with average TN at 3 mg/L, assumed to be nitrate.
  - Loading rate: 0.02 gpm/ft^2.
  - BAM filter bottom area: 3.2 acres.
  - Cells: One.
  - BAM depth: 24 inches.
  - Liner: EPDM to allow collection of treated water.
- Infiltrating wetland:
  - Loading rate: 3 to 7 inches per week.
  - Safety Factor: 1.
  - Bottom Area: 15.0 acres.
  - Cells: One.

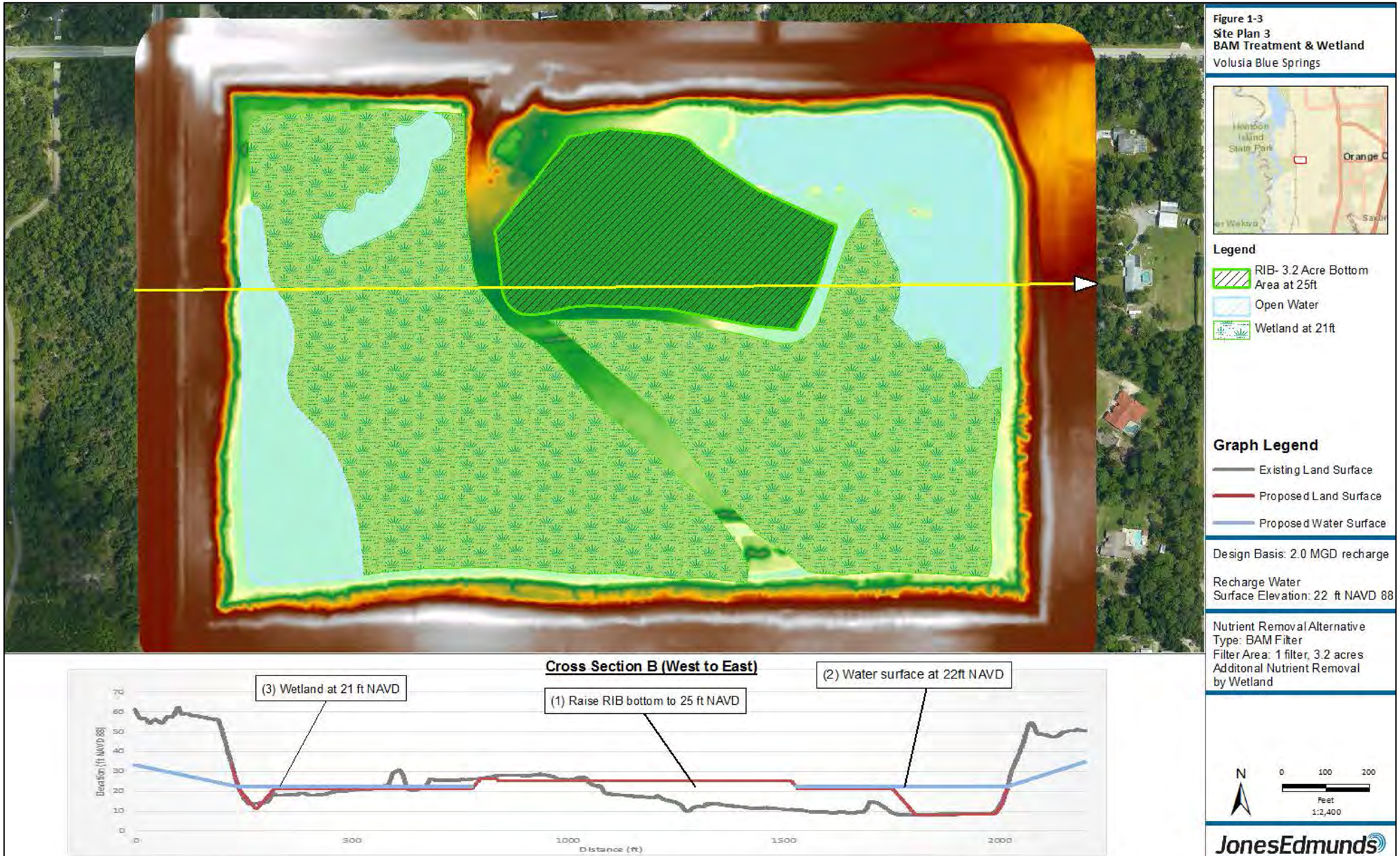
5.4.4.1 Probable Construction Cost Opinion

The cost for a 3.2-acre BAM cell and a 15-acre infiltrating wetland to provide 2 MGD of treatment and recharge is approximately $2.7 to $5.8 million. The largest contributors to this cost are the BAM material and filling the site to construct the wetland above the estimated water elevation.

5.4.4.2 Probable Operation and Maintenance Cost Opinion

The operation and maintenance of the BAM media filters is relatively minor and limited to disking the bottom of the cells every 18 to 24 months. This is similar to the maintenance performed on RIBs and helps to maintain the design infiltration rate and prevent large woody vegetation from taking root in the cells. The cost for disking the bottom of the cell is $3,000 per acre per year or approximately $10,000 per year.

Figure 17 Combined BAM Filter and Infiltrating Alternative



Wetland operation and maintenance costs are highly variable depending on the vegetation management plan and the degree to which it is necessary to control invasive exotic species. SWFWMD reports that the annual maintenance cost for their extensive stormwater treatment area wetlands is about $600 per year, which is on the low end. Some wastewater utilities spend up to $3,000 per acre per year to manage wetlands in a park setting. The operation and maintenance of the infiltrating wetland is $9,000 to $45,000 per year and largely depends on the diversity of the planting plan and the control of exotic plants.

6 PERMITTING AND COMPLIANCE

Table 8 summarizes the permitting needs associated with the proposed project.

Table 8 Summary of Potential Regulatory Agencies and Permitting List

Agency	Jurisdiction	Permit	Comments
US Army Corps of Engineers (USACE)	Federal	Clean Water Act, Section 404	No permits required as the project is isolated from Water of the US.
SJRWMD	Northeast/ North Central Florida	Standard General Environmental Resource Permit (ERP) and Dewatering Permit	ERP and Dewatering Permit applications should be submitted to FDEP for review since SJRWMD is the Owner.
Florida Department of Environmental Protection (FDEP)	State	National Pollutant Discharge Elimination System (NPDES)	Project requires the contractor has an NPDES NGP for Construction Activities, and for Dewatering Discharge.
FDEP	State	Stormwater Pollution Prevention Plan (SWPPP)	Prepared by the contractor before construction.
FDEP	State	Beneficial Reuse	Added to the WWTP reuse plan.
FDEP	State	Mine Reclamation Requirements 62C-39	Vegetation and grading plan.
US Fish and Wildlife Service (FWS)	Federal	None Expected	No known or observed threatened or endangered species. The mining operation already disturbed most of the site.
Florida Fish & Wildlife Conservation Commission (FWC)	State	None Expected	No known or observed threatened or endangered species. The mining operation already disturbed most of the site.
Florida Department of State, Historic Preservation Office (SHPO)	State	None Expected	No known or observed artifacts. The mining operation already disturbed most of the site.

Agency	Jurisdiction	Permit	Comments
Volusia County	County	None	▪ Setbacks. ▪ Perimeter berm or fencing. ▪ Landscaped perimeter. ▪ Additional requirements if the site becomes a public park. ▪ See Appendix E.

6.1 Wetland Mitigation Credits

Two of the site design options include infiltrating wetlands and open-water features. Wetlands created at the site could potentially be permitted as a Regional Offsite Mitigation Area (ROMA). If approved, wetland credits in ROMAs can be used to offset wetland impacts that occur elsewhere due to construction projects where on-site mitigation may not be feasible (e.g. transportation or linear utility projects).

As the site design is refined, the following steps are needed to determine the potential for wetland mitigation credits:

1. **Complete load testing.** The health of the planned vegetative community depends on the water level. Load testing will provide data critical to designing the infiltrating the wetland.
2. **Meet with the permitting agencies.** This system will depend on a supply of pumped water to maintain the vegetative community. In the past, SJRWMD has permitted mitigation areas that depend on a pumped water supply. Jones Edmunds is not aware of a regulatory restriction preventing a mitigation area from using a pumped water supply.
3. **Complete a Uniform Mitigation Assessment Method (UMAM) assessment.** The site is currently a mining site that is very disturbed with some open-water features. Based on our preliminary observation, Jones Edmunds would expect a high lift in the UMAM score and, therefore, the number of wetland credits. In general, we would expect the number of wetland mitigation credits to be equal to the wetland acreage created.
4. **Determine the success criteria and monitoring requirements.** Mitigation sites must be monitored to document the success and health of the vegetative community. In general, the monitoring is more robust following construction of the project to ensure the health of the newly planted vegetative material. After the first year, monitoring is more limited and focused on managing and controlling undesirable plant species such as cattail and invasive exotic plants.

7 SUMMARY OF OPTIONS AND COSTS

Table 9 summarizes the site options we evaluated and associated costs. The BAM infiltration basin and the infiltrating wetland options were sized to maximize treatment volume. The BAM infiltration basin has a significantly higher hydraulic loading rate than the infiltrating wetland; however, maximizing the recharge volume using the BAM infiltrating basin would require significant site work and associate costs. The project stakeholders requested the inclusion of wetlands in the site design – if feasible – to provide additional potential benefits such as wildlife habitat, wetland mitigation credits, public access, and education opportunities. Jones Edmunds sized the BAM and infiltrating wetland combination option to achieve a target recharge rate within the range of available water that the WVWS indicated could be supplied.

Table 9 Summary of Site Options and Associated Costs

Item	Flow and Cost Range
BAM Infiltration Basin	4 MGD
Construction	$11.6 to $18.1 million
Operations	$100 to 150,000 per year
Infiltrating Wetland	0.4 MGD to 0.9 MGD
Construction	$2.6 to $4.0 million
Operations	$50 to 80,000 per year
BAM and Infiltrating Wetland Combination	2.0 MGD
Construction	$2.7 to $5.8 million
Operations	$75 to 115,000 per year
Reclaimed Water Main and Valves	$1,660,500

8 RECOMMENDATIONS AND NEXT STEPS

The geotechnical and groundwater modeling performed as part of this preliminary engineering report provided valuable information for understanding the site's hydrogeological behavior. Our analysis indicates that the site can be engineered to meet the design goals specified by SJRWMD and WVWS – recharge of between 2 to 5 MGD of reclaimed water to benefit flows from Blue Spring while not adversely impacting water quality at the spring.

A load test on the site is needed to more directly determine the site infiltration capacity and better define design parameters. We recommend that SJRWMD and WVWS coordinate a load test design and execution to provide site-specific infiltration performance data. The infiltration data derived from the load test should be used to update the groundwater model and to refine a site design concept. The refined site design will provide a better-defined basis for the project costs and permitting needs.

Based on the preliminary cost information and assuming a conservative 20-year service life, the anticipated range of annualized nitrogen treatment cost for each option are the following:

- BAM – $30 to $44/lb
- Wetland – $40 to $58/lb
- BAM and Wetland – $25 to $37/lb

We recommend the BAM and infiltrating wetland combined system as the preferred alternative for the following reasons:

- The BAM and wetland combined system strikes a balance in cost and benefits to the environment.

- The BAM and wetland hybrid is anticipated to have lower operating and maintenance costs relative to full buildout using either BAM or wetlands.
- Achieving the full BAM buildout would require significant site work and may require import of fill material resulting in higher capital costs.
- The WVWS identified an ability to supply 2 MGD of reclaimed water to the site.
- Wetlands are incorporated as a natural system benefit and can serve as an educational park area for the community.

Our groundwater modeling indicates that recharge of 2 MGD of reclaimed water at the project site will result in an additional 1.7 MGD of flow at the spring. The long-term average flow at Blue Springs is about 101.5 MGD. This project could restore almost 2% of the spring flow for a cost less than $10M – a high level of cost-effectiveness that would receive favorable consideration for SJRWMD cost share funding.

9 REFERENCES

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Appendix A

Survey

SURVEYOR'S REPORT

VOLUSIA BLUE WETLAND DISCHARGE

Prepared for:

JONES EDMUNDS

Prepared by:

PICKETT
SURVEYING • ENGINEERING

PICKETT & ASSOCIATES PROJECT NO.: 18650
TITLE/TYPE OF SURVEY: Topographic Survey
DATE OF SURVEY: This Map is based on aerial imagery & LiDAR data flown 07/28/18

NOTE: THIS REPORT AND ACCOMPANYING MAP TITLED VOLUSIA BLUE WETLAND DISCHARGE, ARE NOT FULL AND COMPLETE WITHOUT THE OTHER AND ARE NOT VALID WITHOUT THE SIGNATURE AND ORIGINAL RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

DATUM:

HORIZONTAL:
Coordinates are referenced to the East Zone of the Florida State Plane Coordinate System, NAD 83, 2011 adjustment.

VERTICAL:
Elevations are to North American Vertical Datum of 1988.

Control Points Used:

Pt#	Northing	Easting	Elevation
102	1679092.36	549546.56	70.40
106	1679114.72	552285.95	48.91
110	1677484.32	549173.46	50.19
114	1677602.91	552611.51	48.99
531	1677438.08	549256.87	50.91

ACCURACY STATEMENT:
The following stated plus or minus tolerances encompass a minimum of 90% of the difference between photogrammetrically measured values and any ground truth of all well-identified features. Mapped features will meet or exceed the Florida Standards of Practice.

VERTICAL:
Contours have an estimated vertical positional accuracy of 0.5'. Spot elevations, on hard surfaces, have an estimated vertical accuracy of 0.25'.

HORIZONTAL:
Well-identified features have an estimated horizontal positional accuracy of 1.66', as per Florida Standards of Practice. All measurements are in U.S. Survey Feet.

Measurement Methods:
The planimetrics shown are limited to those features visible on aerial imagery. Color digital imagery was acquired at an average altitude of 2160' using a metric precision digital camera whose focal length is 70.3mm. Mapping was performed using LiDAR and softcopy photogrammetric techniques. The LiDAR data has an estimated point sample distance of 0.41 foot and a density of 6.02 points per square foot (±64.8 points per square meter). For a vertical accuracy check, the LiDAR data was compared to four (4) points set as targets for aerial imagery and twenty-one (21) ground surveyed points. The Root Mean Square Error of the Elevations (RMSEZ) is 0.093 foot, being the equivalent of 0.182' FGDC/NSSDA Vertical Accuracy. All measurements are in U.S. Survey Feet.

Limitations:

This mapping should be used for preliminary design work only and should not replace an actual field survey where the required accuracy is greater than the accuracy stated in this report. No responsibility is assumed for areas outside the contracted scope.

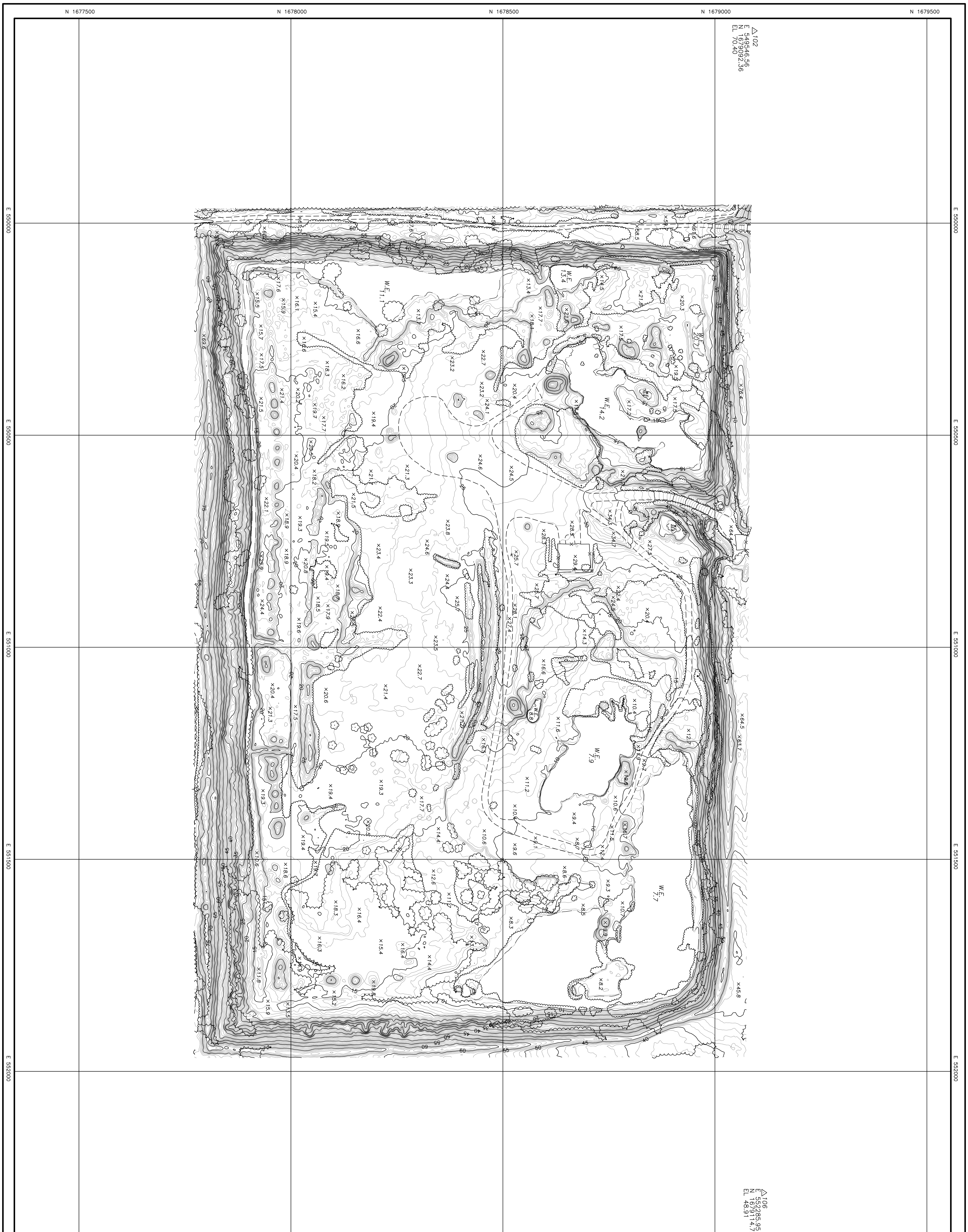
MAP PLOTTING:

This map can be displayed at a scale of 1" = 50' (1:600) or smaller.

T. JEFFREY YOUNG, PSM, CP
FLORIDA REGISTRATION NO. 5440
PICKETT AND ASSOCIATES, INC.
FLORIDA REGISTRATION NO. 364

7/28/18

SURVEY DATE



SURVEYOR's NOTES:

1.) North, the grid, and the coordinates shown hereon are referenced to the East Zone of the Florida State Plane Coordinate System, NAD 83, 2011 adjustment

2.) Elevations are to NAVD88.

3.) This topographic survey was prepared using photogrammetric and LiDAR methods. See the attached report for map accuracy and surveyor's signature and seal. This map is limited to those features visible on aerial imagery.

(THESE FEATURES ARE REPRESENTED BY SYMBOLS NOT TO SCALE)

△ CONTROL
PT# TARGET NUMBER
N NORTHING
E EASTING
EL ELEVATION
UTILITY POLE
LIGHT POLE
TRAFFIC LIGHT
SIGN
POST
FLAG
MAIL BOX
GUYWIRE
CATCH BASIN
VALVE
ELECTRICAL
AIR CONDITIONER
MISCELLANEOUS SYMBOL
CULVERT
MANHOLE
HYDRANT
TREE
PALM
SHRUB

LEGEND:

(THESE FEATURES ARE TO SCALE)

CURB
PAVED ROAD
CONCRETE SURFACE
UNPAVED ROAD
FENCE
GUARDRAIL
WALL
RAILROAD
STRUCTURE
TREE LINE
SHRUB LINE
PIPELINE
RECREATION
EDGE OF GROVE
EDGE OF WATER

(THESE INFORMATIVE LABELS ARE NOT SCALE DEPENDENT)

W.E. WATER ELEVATION
×120.1 SPOT ELEVATION
MISC MISCELLANEOUS

NORTH

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 ft.

TOPOGRAPHIC SURVEY

VOLUSIA BLUE WETLAND RECHARGE

PREPARED FOR: JONES EDMUNDS & ASSOCIATES, INC

PROJECT No.	No.
18650	1
DRAWING No.	OF
LD-6356	1

PICKETT
SURVEYING • ENGINEERING

PICKETT AND ASSOCIATES, INC.
475 SOUTH FIRST AVENUE BARTOW, FLORIDA 33830
PHONE: (863)-533-9095
FAX: (863)-534-1464
LICENSED BUSINESS No. LB364

Horiz. Scale: 1" =100'	Edited by: RP	Compiled by: PL	Flight Date: 7/28/18
Contour Interval: 1'			Drawing Name: 18650.DWG

THIS MAP AND ATTACHED REPORT ARE NOT FULL AND COMPLETE WITHOUT THE OTHER AND ARE NOT VALID WITHOUT THE SIGNATURE AND THE ORIGINAL RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER

No.	DATE	APPROVED	REVISION
O.R.	8/6/18	TJY	ORIGINAL RELEASE

Appendix B

Geophysical Investigation Report

GEOHAZARDS™
ENGINEERING AND GEOLOGY
Expert Solutions. Exceptional Service.

May 31, 2018

Geohazards, Inc., Investigation No. 2018327

GEOPHYSICAL INVESTIGATION OF THE GEOLOGICAL SUBSURFACE AT VOLUSIA BLUE WETLAND RECHARGE, VOLUSIA COUNTY, FLORIDA

INTRODUCTION

Purpose

Geohazards, Inc. was tasked by Jones Edmunds & Associates, Inc., to conduct a geophysical investigation at the above referenced locality. This investigation was conducted via electrical resistivity imaging (ERI). In particular, efforts were designed to determine thickness of the underlying geologic units.

Scope

The investigation conducted and reported herein included the following:

- A review of available geologic maps and other published data to establish the general probable lithology and regional conditions for the site of investigation.
- A reconnaissance of the site of investigation to recognize and identify surface conditions pertinent to the purpose of the investigation.
- An Electrical Resistivity Imaging (ERI) investigation of the site to assist in the recognition of site-specific geological conditions at the subject property and to determine evidence for the presence of subsurface features or conditions.
- A final report summarizing results and conveying professional opinions.

Site Information
The initial reconnaissance and the geophysical field investigation were conducted on May 25, 29, and 30, 2018. The site of investigation consisted partially excavated borrow pit. Areas of ponding and soil mounds were located at multiple locations throughout the property.

REGIONAL CONDITIONS

Geology
Based on map consultations and personal inspection, the surficial geologic material at the study site is a cover of very young unconsolidated sands and sandy clays overlying the Pliocene age Cypresshead Formation. The Cypresshead Formation consists of quartz sands ranging from fine to very coarse, moderately to well sorted with common occurrences of quartz gravel. Clay is commonly present in very minor amounts and is generally kaolinite. Mica often occurs in minor percentages, particularly in the finer grained sediments. Colors range from reddish-orange in exposed sections to olive-gray in the subsurface. The Cypresshead was deposited in a shallow, nearshore, marine setting and unconformably overlies the Hawthorn Group. The late Tertiary, Miocene Hawthorn Group of sediments consists of admixtures of sand, silt, clay and carbonate with varying percentages of phosphate present. These sediments were deposited under marine conditions.

FIELD TEST METHODS: GEOPHYSICAL SURVEYS

Electrical Resistivity Imaging
An electrical resistivity imaging (ERI) survey was completed for the purpose of identifying the electrical properties of the underlying geology. Color prints of the modeled ERI cross sections are included. The ERI survey was conducted in general accordance with ASTM D6431 "Standard Guide for Using Direct Current Resistivity Method for Subsurface Investigation," as applied to a multi-electrode resistivity system.

The ERI data was collected using Dipole/Dipole-Strong Gradient array type sequencing. The depth limits of the modeled ER data are primarily dependent on the type of array (Dipole-Dipole, Schlumberger, Wenner, etc.) and the total spread of the electrode array.

Measurements of ERI were made with Advanced Geosciences, Inc. SuperSting R8 8-channel Resistivity Meter with an incorporated switchbox and a passive electrode cable system. The resulting data were processed utilizing EarthImager 2D, a computer program that produces two-dimensional vertical cross section models of the subsurface. The quality of these models was assessed by root mean square (RMS) and L2 values.

Electrical resistivity measurements involve the passing of an electric current underground and measuring its resistance to flow. Different earth materials (e.g. clay, sand, limestone) and subsurface cavities resist the flow of electrical current differently. Substantially greater contrasts in the degree of resistance (anomalies) are used to identify and locate boundaries among different materials as well as the presence of cavities.

The orientation, configuration and distribution of the ERI traverses were designed to provide representative coverage of the site of investigation (see ERI location map). Six traverses were measured. Maximum depth of penetration was approximately 140 feet.

RESULTS

Electrical Resistivity

1. Calculated resistivity values at the subject property ranged from approximately 4 to 10,000 Ohm-meters for the six traverses. Color print-outs of the modeled two-dimensional ERI cross sections are included. The quality of the resistivity models is considered to be satisfactory to excellent, based on the RMS L2 values.

2. The data collected were interpreted as indicative of more resistive, near-surface sands (reds and yellows), overlying less resistive, clayey materials (blues and greens) and limestone (greens, yellows and reds). The electrically interpreted underlying limestone surface is variable over the site, ranging from 30 to more than 130 feet deep.

3. Anomalous ERI features were detected along four of the six ERI traverses. The following described anomalies are shown in blue on the attached ERI survey map.

4. The ERI cross section for traverse 1 depicts an anomalous zone of lower resistivity materials within the interpreted upper limestone surface. This anomaly represents an area of a paleo-sink with prior in-filling, as evidenced by the concentration of sands.

5. The ERI cross section for traverse 2 depict near horizontal bedding with only minor changes in resistivity laterally. The lateral differences measured within this traverse may be attributable to variations in the amounts of clay/sand content.

6. The ERI cross section for traverse 3 depicts a variable upper limestone surface. The northern portion of the traverse depicts near surface resistive dolomitic limestone underlain by possible in-filling.

7. The ERI cross section for traverse 4 depicts an anomalous zone on the eastern portion of the traverse. The upper limestone surface is interpreted to be sloping from the west to the east at depth. The interpreted upper limestone surface was not detected on the eastern half of traverse 4.

8. The ERI cross section for traverse 5 depicts an anomalous zone of lower resistivity materials within the interpreted upper limestone surface. This anomaly represents an area of a paleo-sink with prior in-filling, as evidenced by the concentration of sands.

9. The ERI cross section for traverse 6 depict near horizontal bedding from the start of the traverse to 570 feet from the start. The upper limestone surface is interpreted to be sloping downward to the north at 570 feet. A thickened layer of sand was detected in the northernmost portion of traverse 6, indicating possible in-filling of a paleo-sink.

CONCLUSIONS

The site of investigation consisted partially excavated borrow pit. Areas of ponding and soil mounds were located at multiple locations throughout the property.

Six ERI traverses were conducted within the project area. Electrical resistivity results are interpreted as indicative near surface sands and clayey materials overlying a variable upper limestone surface. Four anomalous areas were detected within our survey. Each of these anomalies are indicative of paleo-sinks. Three of the anomalies help bound a large paleo-sink located in the northeast portion of the survey area.

Based on the results of this investigation Geohazards, Inc. is of the opinion that a minimum of two paleo-sinks are located in the survey area. The largest of the two paleo-sinks is located in the northeast portion of the survey area and indicates 80 feet of sand overlying clayey materials. The lower limit of the feature was not detected within our survey and is interpreted to be more than 140 feet below the ground surface. Standard penetration test borings are recommended to further investigate these anomalies.

LIMITATIONS

While due care has been exercised in the performance of these measurements and their interpretation, Geohazards, Inc. can make no representations, warranties, or guarantees with respect to latent or concealed conditions which may exist that may be beyond the limits of detection with the methodologies used.

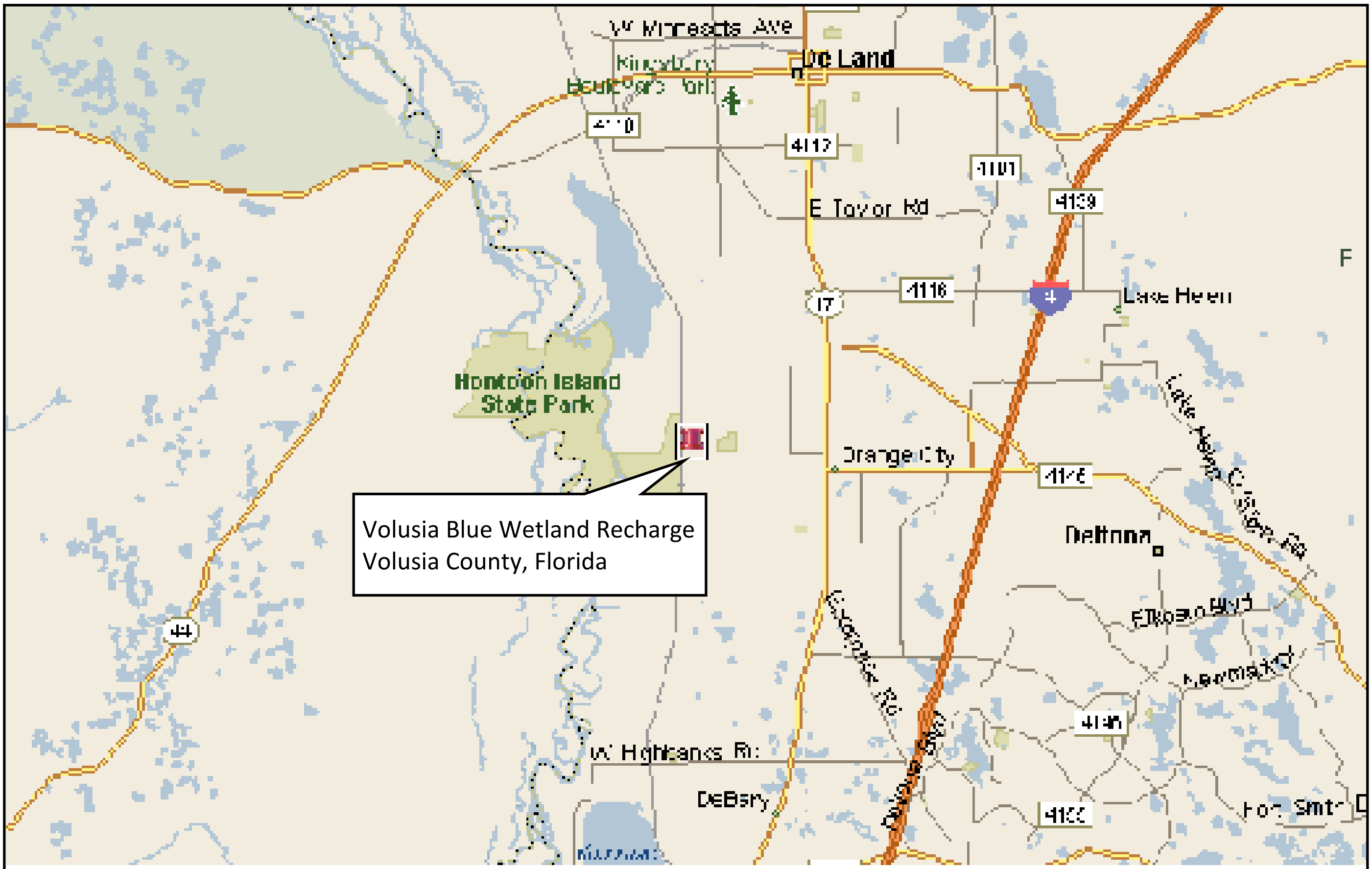
James D. Olson, P.G.
Geologist
Florida License No. 2795

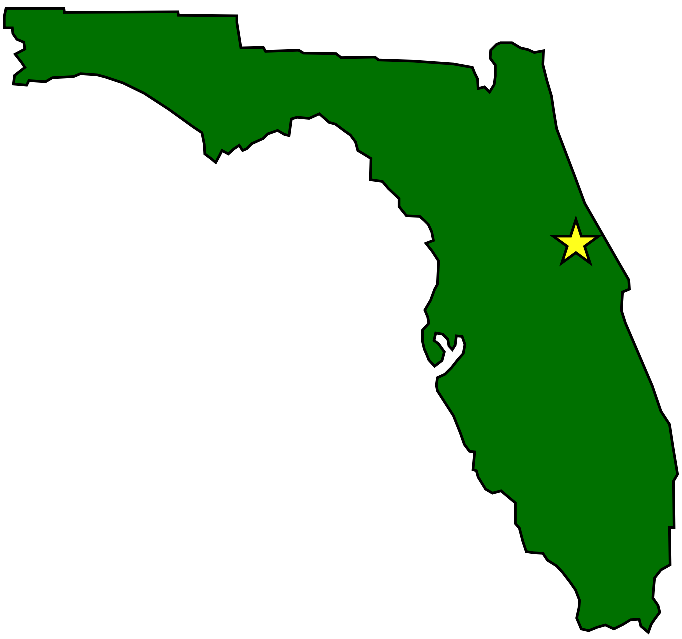
This item has been electronically signed and sealed by James D. Olson, P.G., using a Digital Signature.

Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

Appendix A

Maps and Figures





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SITE LOCATION MAP

Volusia Blue Wetland Recharge
Volusia County, Florida

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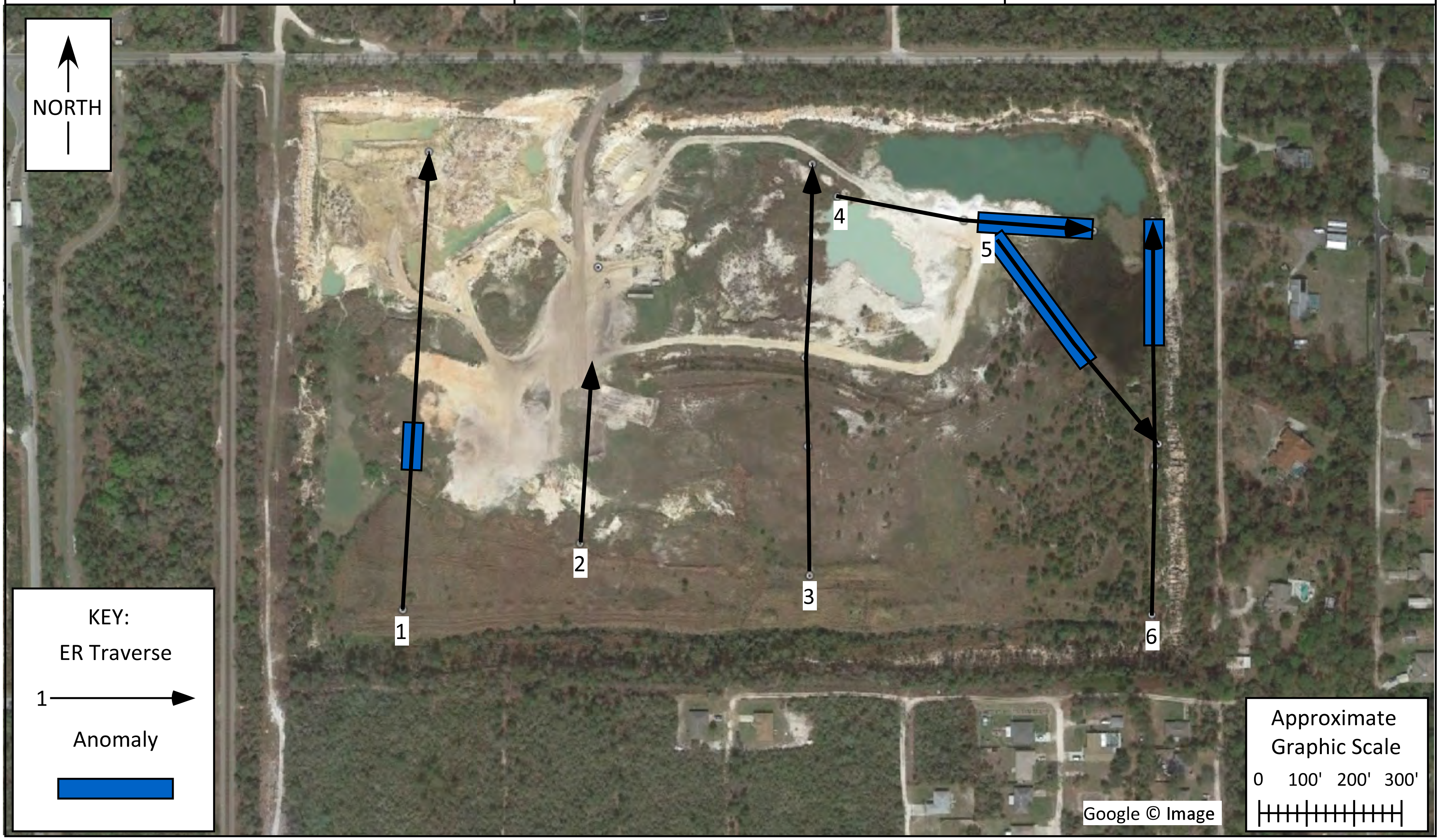
TWO-DIMENSIONAL ELECTRICAL RESISTIVITY IMAGING SURVEY

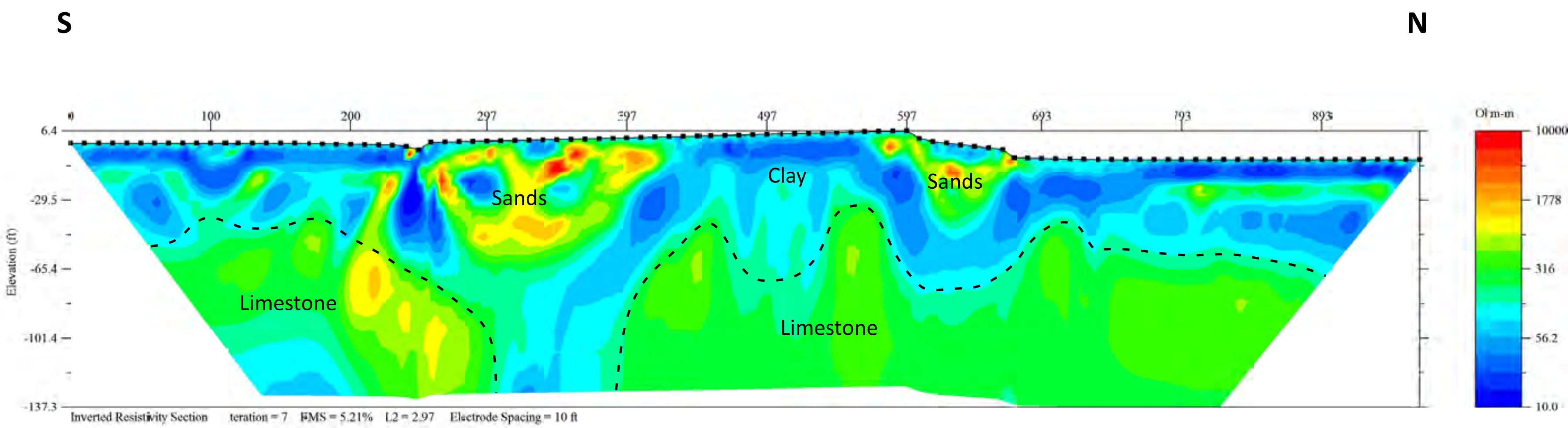
Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327





BEARING: 5°

ARRAY: DIPOLE/DIPOLE

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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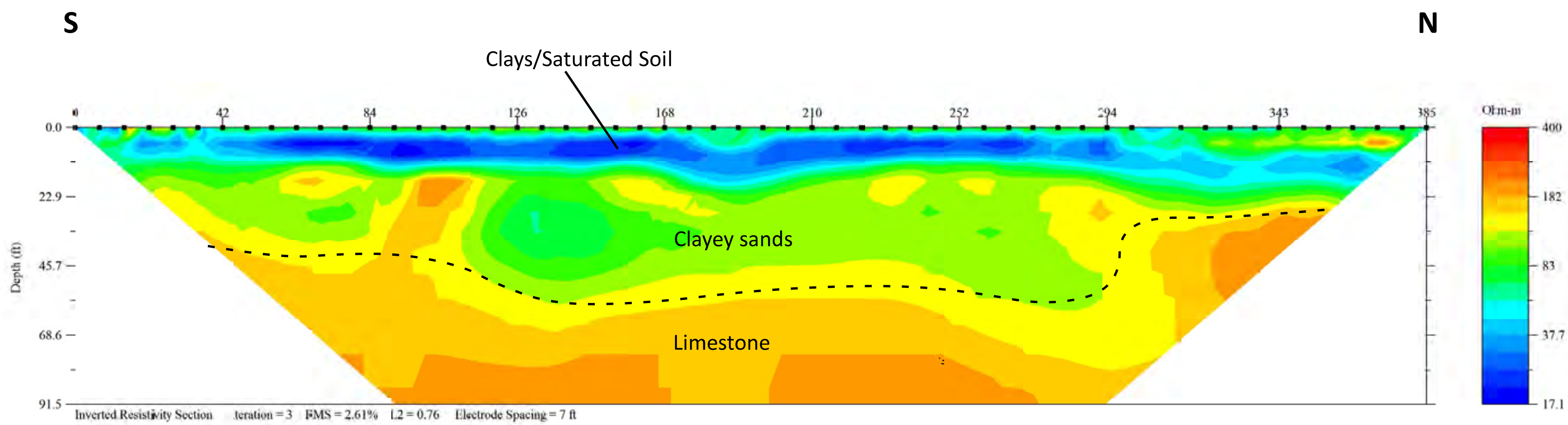
TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 1

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327



BEARING: 5°

ARRAY: DIPOLE/GRADIENT

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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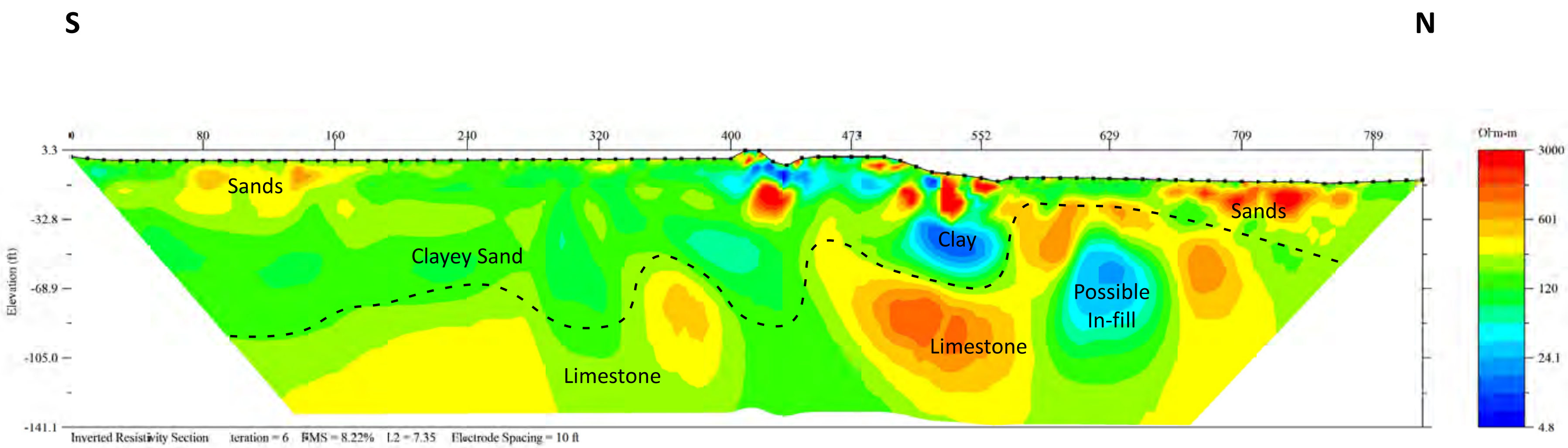
TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 2

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327



BEARING: 0°

ARRAY: DIPOLE/GRADIENT

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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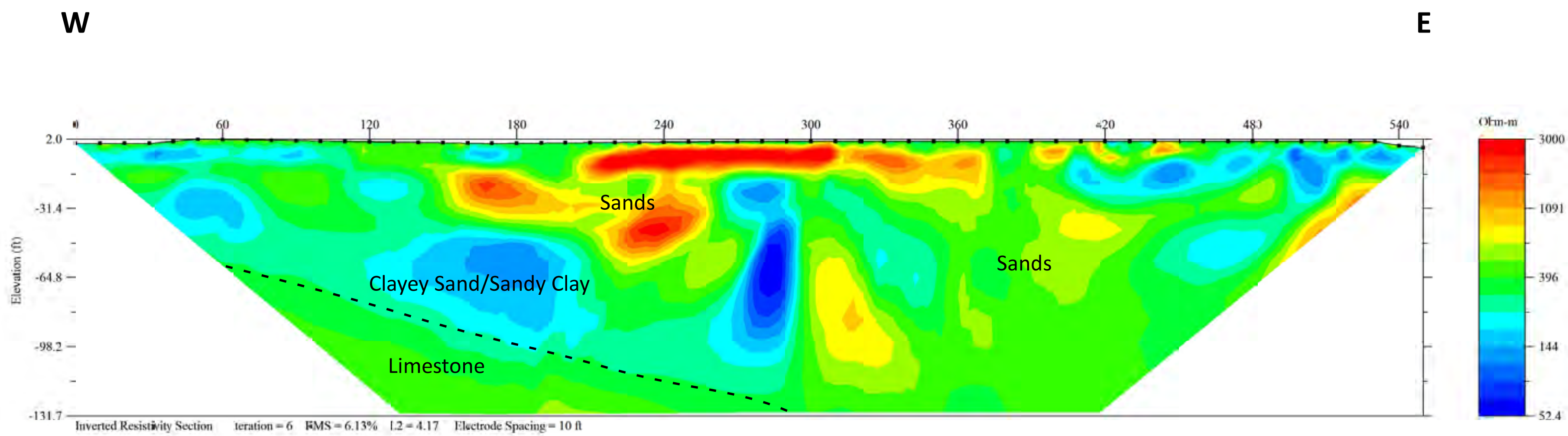
TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 3

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327



BEARING: 95°

ARRAY: DIPOLE/GRADIENT

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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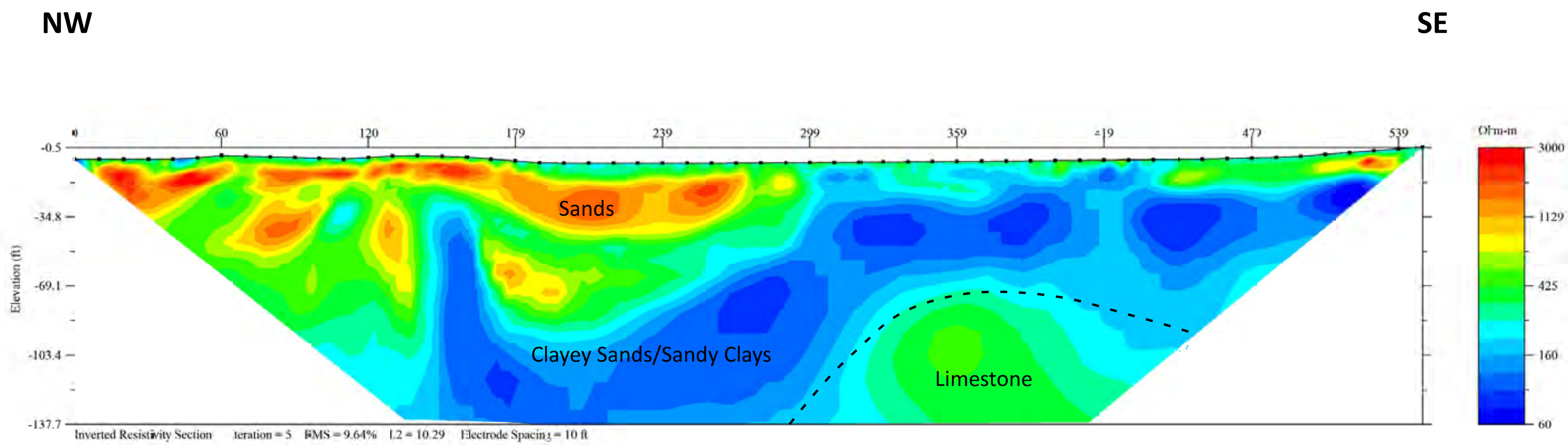
TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 4

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327



BEARING: 140°

ARRAY: DIPOLE/GRADIENT

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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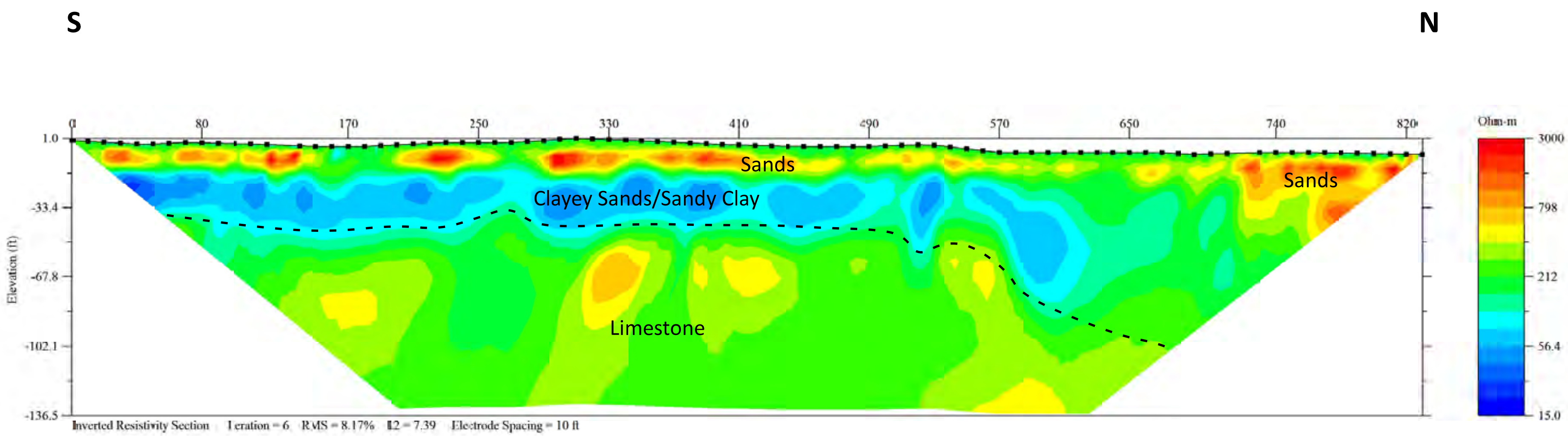
TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 5

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327



BEARING: 0°

ARRAY: DIPOLE/GRADIENT

*The labels are electrical interpretations, verification with borings would be needed to determine actual composition

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TWO-DIMENSIONAL
ELECTRICAL RESISTIVITY PROFILE
TRAVERSE 6

Volusia Blue Wetland Recharge
Volusia County, Florida

FOR: Jones Edmunds & Associates, Inc.

DATE: 5-31-18

BY: J. Olson, P.G.
Investigation #2018327

Appendix C

Geotechnical Site Evaluation Report

SUMMARY REPORT OF A GEOTECHNICAL SITE EXPLORATION

BLUE SPRINGS RECHARGE
VOLUSIA COUNTY, FLORIDA

GSE PROJECT No. 13632

Prepared For:

JONES EDMUNDS & ASSOCIATES, INC.

JULY 2018

Certificate of Authorization No. 27430

GSE Engineering & Consulting, Inc.

July 9, 2018

Michelle R. Hays, MS, PG
Jones Edmunds & Associates, Inc.
730 NE Waldo Road
Gainesville, Florida 32641

Subject: Summary Report of a Geotechnical Site Exploration
Blue Springs Recharge
Volusia County, Florida
GSE Project No. 13632

Dear Michelle:

GSE Engineering & Consulting, Inc. (GSE) is pleased to submit this geotechnical site exploration report for the above referenced project. Presented herein are the findings and conclusions of our exploration.

We appreciate this opportunity to have assisted you on this project. If you have any questions or comments concerning this report, please contact us.

Sincerely,

GSE Engineering & Consulting, Inc.

COREY ALAN DUNLAP
LICENSE
No.77678
STATE OF FLORIDA
PROFESSIONAL ENGINEER

This item has been digitally signed and sealed by

Printed copies of this document are not considered signed and sealed, and the signature must be verified on any electronic copies.

Kenneth L. Hill, P.E.
Principal Engineer
Florida Registration No. 40146

Corey A. Dunlap, P.E.
Senior Engineer
Florida Registration No. 77678

KLH/CAD:slo
Z:Projects\13632 Blue Springs Recharge\13632.doc

Distribution: Addressee (1 - Electronic)
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TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

1.1 General

GSE Engineering & Consulting, Inc. (GSE) has completed this geotechnical exploration for the recharge site for Blue Springs in Volusia County, Florida. This exploration was performed in general accordance with GSE Proposal No. 2018-169 dated March 29, 2018. Mr. Kenneth S. Vogel, P.E. authorized our services on June 1, 2018. The total amount of field work was adjusted in order to maximize the amount of data collected and stay within the lump sum budget in the contract.

1.2 Project Description

This project consists of a potential recharge site for Blue Springs. The project site is at an active mining operation located at the southwest corner of the W. French Avenue and Red Laurel Road intersection in Volusia County, Florida (Figure 1). Michelle Hays with Jones Edmunds, Inc. provided information about the project as well as guidance on boring locations.

GSE was provided with information about the project, including a requested geotechnical scope of services and previous geotechnical report prepared by Yovaish Engineering Sciences, Inc. dated April 15, 2006. Additionally, GSE was furnished a geophysical investigation report authored by Geohazards, Inc. dated May 31, 2018 (Geohazards Investigation No. 2018327).

1.3 Purpose

The purpose of this geotechnical exploration was to determine the general subsurface conditions of the site and perform laboratory testing on the recovered soil samples.

2.0 FIELD AND LABORATORY TESTS

2.1 General Description

The procedures used for field sampling and testing are in general accordance with industry standards of care and established geotechnical engineering practices for this geographic region. This exploration consisted of performing fourteen (14) Standard Penetration Test (SPT) borings to depths ranging from 30 to 70 feet below land surface (bls) across the project area. Additionally, three (3) Shelby Tube samples of the confining soils were collected. Six (6) piezometers were also installed to depths ranging from 20 to 50 feet beneath grade at the boring locations.

The soil borings and piezometers were performed at the approximate locations as shown on Figure 2. The borings were located using a provided layout of the site, Global Positioning System (GPS) coordinates, and other obvious site features as reference. The boring locations should be considered approximate. The soil borings were performed between June 11, 2018 and June 15, 2018.

2.2 Standard Penetration Test Borings

The soil borings were performed with a drill rig employing mud rotary or flight auger drilling techniques and Standard Penetration Testing (SPT) in accordance with ASTM D1586. The SPTs were performed continuously to ten feet and at five-foot intervals thereafter. Soil samples were obtained at the depths where the SPTs were performed. The soil samples were classified in the field, placed in sealed containers, and returned to the laboratory for further evaluation.

After drilling to the sampling depth and flushing the borehole, the standard two-inch O.D. split-barrel sampler was seated by driving it six inches into the undisturbed soil. The sampler was then driven an additional 12 inches by blows of a 140-pound hammer falling 30 inches. The number of blows required to produce the next 12 inches of penetration was recorded as the penetration resistance (N-value). These values and the complete SPT boring logs are provided in Section 4.1.

Upon completion of the sampling, the boreholes were abandoned in accordance with Water Management District guidelines.

2.3 Piezometers

A total of six (6) piezometers were installed at the site. The piezometer locations and depths are illustrated on Figure 2. The 2-inch diameter piezometers were installed by performing a mud rotary boring to depth. A specialized biodegradable drilling mud was used to advance the borehole. The piezometers included 10 feet of screened pipe at the bottom. The void around the pipe was backfilled with coarse 20-30 silica sand until at least 5 feet above the screened section of pipe. The remaining voids were backfilled with bentonite.

2.4 Soil Laboratory Tests

The soil samples recovered from the soil borings were returned to the laboratory and examined to confirm the field descriptions. Representative samples were then selected for laboratory testing. The laboratory tests consisted of ten (10) full grain sieve analysis determinations with natural moisture contents. These tests were performed in order to aid in classifying the soils and to further evaluate their engineering properties. The laboratory tests are provided in Section 4.2.

Two (2) falling head permeability tests are being performed on the Shelby Tube samples collected from the site. The results of these tests will be provided under separate cover.

3.0 FINDINGS

3.1 Surface Conditions

The site is approximately 60 acres and is currently an active aggregate mine. The site contains open mine on the northern portion and grassland on the property outside the mine, mostly on the southern portion.

The topography for this area varies across the site. The property outside the mine slopes gently with little elevation change. The Orange City USGS Topographic Map indicates the ground surface elevations around the perimeter of the unexcavated portions of the site are near 45 to 75 feet[1] NAVD88. We estimate that most of the property has been excavated 20 to 30+ feet below adjacent grade by the mining activities.

3.2 Subsurface Conditions

The locations of the SPT borings are provided on Figure 2. Complete logs for the borings are provided in Section 4.1. Descriptions for the soils encountered are accompanied by the Unified Soil Classification System symbol (SM, SP-SM, etc.) and are based on visual examination of the recovered soil samples and the laboratory tests performed. Stratification boundaries between the soil types should be considered approximate, as the actual transition between soil types may be gradual.

The SPT borings indicate that the subsurface conditions across the site vary. The borings generally contained interbedded strata of some or all of the following: sand (SP), sand with silt (SP-SM), sand with clay (SP-SC), clayey sand (SC), and very clayey sand (SC/CH). Some of the borings also contained interbedded strata of sandy clay to clay (CH).

The SPT borings encountered limestone anywhere from 12 to 57 feet beneath grade. Three borings (B-5, B-7, and B-8) encountered a layer of limestone on top of a layer of soil. Boring B-5 contained a layer of limestone from 22 to 27 feet bls on top of a layer of sand with clay and limestone (SP-SC) from 27 to 37 feet bls. Limestone was encountered again at 37 feet bls to the bottom of the borehole at 50 feet bls. Boring B-7 contained a layer of limestone from 23 to 27 feet bls on top of a layer of poorly graded sand with limestone (SP) from 27 feet bls to the bottom of the borehole at 49.7 feet bls. Boring B-8 encountered a layer of limestone from 17 to 22 feet bls on top of a layer of poorly graded sand with limestone (SP) before encountering limestone again at 32 feet bls to the bottom of the borehole at 45 feet bls.

Boring B-9 contained a layer of flint rock from 17 to 27 feet bls on top of a layer of limestone that extended from 27 feet bls to the bottom of the borehole at 49.4 feet bls. Boring B-12 contained a layer of sand with clay and sandstone (SP-SC) from 17 to 39 feet bls on top of a layer of limestone that extended from 39 feet bls to the bottom of the borehole at 50 feet bls.

[1] United States Department of the Interior, United States Geological Survey, Orange City Quadrangle, 2015.

Three borings (B-1, B-11, and B-13) did not encounter the limestone formation within the explored depth. Boring B-1 encountered poorly graded sand through the first 37 feet bls and sand with silt and organics (SP-SM/PT) from 37 feet bls to the bottom of the borehole at 60 feet bls. Boring B-11 encountered poorly graded sand (SP) through the first 42 feet bls. A layer of clayey sand (SC) was found from 42 to 52 feet bls, followed by a layer of clay with sand (CH) from 52 feet to 57 feet bls and sand with clay (SP-SC) from 57 feet bls to the bottom of the borehole at 70 feet bls. Boring B-13 contained alternating layers of poorly graded sand (SP) and sand with clay (SP-SC) or clayey sand (SC) until the bottom of the borehole was reached at 70 feet bls.

The SPTs performed in the borings indicate a mostly consistent soil strength profile. The strengths generally range from very loose to medium dense for the sands and soft to stiff for the clays as depths increase and approach the limestone. The N-values for the soils generally range from 2 to 30 blows per foot and 3 to 10 blows per foot for the sands and clays respectively. The strength profile for the limestone ranges from soft to very hard with N-values ranging from 13 blows per foot to 50 blows for less than 1 inch of penetration. Weight-of-rod and weight-of-hammer events were encountered in SPT boring B-4.

Due to the mud rotary method of advancing the boreholes, the groundwater table was not apparent.

3.3 Review of Published Soil Information

The Soil Conservation Service (SCS) Soil Survey for Volusia County[2] maps three soil series in the areas where the borings were conducted consisting of Apopka fine sand, Astatula fine sand, and Pits. The following soil description is from the Soil Survey.

Apopka fine sand, 0 to 5 percent slopes – This nearly level to gently sloping, well-drained soil is on intermediate to high sand hills. The acreage is moderate in extent. Individual areas are irregularly shaped and range from about 5 to 300 acres.

Typically, the surface layer is very dark grayish brown fine sand about 6 inches thick. The subsurface layer is fine sand to a depth of 62 inches. In sequence downward, 16 inches is grayish brown mottled with very pale brown, 28 inches is light yellowish brown mottled with brownish yellow, and 12 inches is white. The subsoil is brownish yellow sandy clay loam mottled with pale brown to more than 80 inches.

Included with this soil in mapping are small areas of Astatula, Electra, Orsino, and Tavares soils. Also included are soils in shallow depressions that are not so well drained as this Apopka soil. The included soils generally make up no more than 15 percent of any one mapped area.

The water table is below 72 inches. Permeability is rapid in the sandy layers and moderate in the sandy clay loam subsoil. Runoff is slow. The available water capacity is very low. Natural fertility and the organic matter content are low.

Astatula fine sand, 0 to 8 percent slopes – This excessively drained, nearly level to sloping soil is on sandhills. Individual areas vary widely in shape and range from 5 to 600 acres.

---

[2] United States Department of Agriculture, Natural Resources Conservation Service, Volusia County Soil Survey.

Typically, the surface layer is gray fine sand about 2 inches thick. The underlying layers are fine sand about 93 inches thick. In sequence downward, 8 inches is brown, 16 inches is pale brown, and 69 inches is very pale brown.

Included with this soil in mapping are small areas of Apopka, Deland, Orsino, Paola, St. Lucie, and Tavares soils. Also included are small areas where slopes are more than 8 percent. In some areas, the surface layer is darker colored than is described for the series. The included areas make up about 15 percent of any one mapped area.

The water table is always below 80 inches and is usually below 120 inches. The available water capacity is very low. Permeability is very rapid. Natural fertility and the organic matter content are very low. The response to fertilizer is moderate, but fertilizer is rapidly leached.

Pits – Pits are excavations from which soil and geologic material have been removed for use in road construction or for foundations. Most are abandoned, but excavation is continuing in a few places. Vegetation has become established in the older abandoned pits. It is mostly an assortment of weedy forbs, grasses, and shrubs. Pits, locally called borrow pits, occur in small to large mapped areas. Those that have been excavated below the normal water table and contain water for 9 months or more each year are mapped as water.

3.4 Review of Published Regional Geology

The site is located near the western portion of Volusia County. This area of Volusia County maps as the Holocene Sediments and the Cypresshead Formation[3]. The following descriptions are from the Geological Survey.

Holocene Sediment – The Holocene sediments in Florida occur near the present coastline at elevations generally less than 5 feet (1.5 meters). The sediments include quartz sands, carbonate sands and muds, and organics.

Cypresshead Formation – The Cypresshead Formation, named by Huddlestun (1988), is composed of siliciclastics and occurs only in the peninsula and eastern Georgia. It is at or near the surface from northern Nassau County southward to Highlands County forming the peninsular highlands. It appears that the Cypresshead Formation occurs in the subsurface southward from the outcrop region and similar sediments, the Long Key Formation, underlie the Florida Keys. The Cypresshead Formation is a shallow marine, near shore deposit equivalent to the Citronelle Formation deltaic sediments and the Miccosukee Formation prodeltaic sediments.

The Cypresshead Formation consists of reddish brown to reddish orange, unconsolidated to poorly consolidated, fine to very coarse grained, clean to clayey sands. Cross bedded sands are common within the formation. Discoid quartzite pebbles and mica are often present. Clay beds are scattered and not generally extensive. In general, the Cypresshead Formation in exposure occurs above 100 feet (30 meters) above mean sea level (msl).

Original fossil material is not present in the sediments although poorly preserved molds and casts of mollusks and burrow structures are occasionally present. The presence of these fossil “ghosts” and trace fossils documents marine influence on deposition of the Cypresshead sediments.

[3] Open-File Report 80, Thomas M. Scott, P.G. No. 99, Text to Accompany the Geological Map of Florida, Florida Geological Survey, 2001.

The permeable sands of the Cypresshead Formation form part of the surficial aquifer system.

3.5 Laboratory Soil Analysis

Selected soil samples recovered from the soil borings were analyzed for grain size distribution and natural moisture content. Selected soil samples were collected from depths ranging from 3.5 to 70 feet bls. These tests were performed to confirm visual soil classification and evaluate their engineering properties. The complete laboratory report is provided in Section 4.2. Falling head permeability tests are also being performed which will be summarized under separate cover.

The laboratory tests indicate the tested soils consist of sand with clay (SP-SC), clayey sand (SC), very clayey sand (SC/CH), and sandy clay (CL/CH). The tested sand with clay (SP-SC) contains approximately 5.7 to 11 percent soil fines passing the No. 200 sieve with natural moisture contents of about 25 to 32 percent. The tested clayey sand (SC) contains approximately 18 to 27 percent soil fines passing the No. 200 sieve with natural moisture contents of about 25 to 34 percent. The tested very clayey sand (SC/CH) contains approximately 32 percent soil fines passing the No. 200 sieve with a natural moisture content of 32 percent. The tested sandy clay (CL/CH) contains approximately 51 percent soil fines passing the No. 200 sieve with a natural moisture content of 49 percent.

The complete grain size distributions are provided in Section 4.2.

4.0 FIELD DATA

4.1 Standard Penetration Test Soil Boring Logs

GSE Engineering & Consulting, Inc.
5590 SW 64th Street, Suite B
Gainesville, Florida 32608
Telephone: (352) 377-3233
Fax: (352) 377-0335

BORING NUMBER B-1

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/12/18 **COMPLETED** 3/12/18
GROUND ELEVATION ____ **HOLE SIZE** ____
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0		(SP) Medium dense pale gray SAND									
5				SPT 1	6-7-6 (13)						
10				SPT 2	4-5-6 (11)						
		(SP) Loose brown SAND	12								
15				SPT 3	2-5-2 (7)						
		(SP) Medium dense pale gray SAND	17								
20				SPT 4	2-6-14 (20)						
25				SPT 5	10-10-10 (20)						
30				SPT 6	8-9-11 (20)						
35				SPT 7	5-6-7 (13)						

(Continued Next Page)

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BORING NUMBER B-1

CLIENT Jones Edmunds & Associates, Inc.

PROJECT NAME Blue Springs Recharge

PROJECT NUMBER 13632

PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
35	(SP) Medium dense pale gray SAND *(continued)*	37							
	(SP-SM/PT) Medium dense dark brown SAND with silt and organics								
40			SPT 8	5-6-10 (16)					
45			SPT 9	9-6-12 (18)					
50			SPT 10	10-11-10 (21)					
55			SPT 11	11-9-13 (22)					
60		60	SPT 12	9-11-11 (22)					
	Bottom of borehole at 60.0 feet.								

▲ SPT N VALUE ▲ (20 40 60 80)

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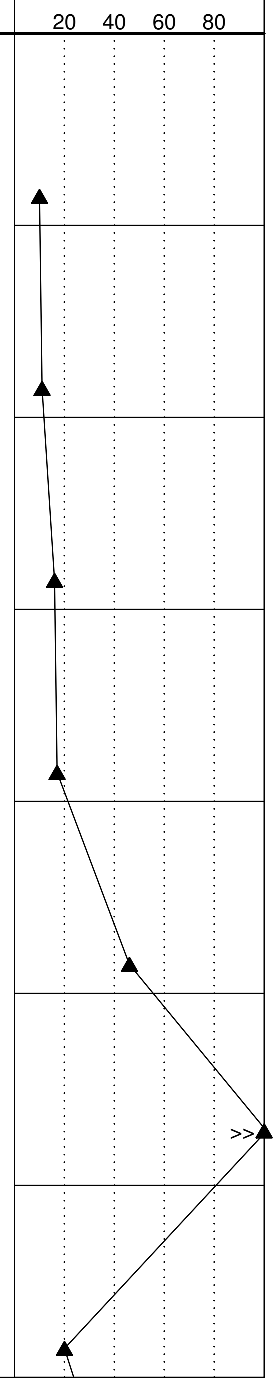
BORING NUMBER B-2

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/13/18 **COMPLETED** 6/13/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0	(SC/CH) Loose orange very clayey SAND								
5			SPT 1	3-5-5 (10)				32	32
	(SC) Medium dense pale brown clayey SAND	7							
10			SPT 2	6-7-4 (11)					
	Soft pale brown LIMESTONE	12							
15			SPT 3	9-7-9 (16)					
	Soft to very hard pale gray LIMESTONE	17							
20	*100% Loss of Circulation at approximately 19 ft.*		SPT 4	6-9-8 (17)					
25			SPT 5	17-23-23 (46)					
30			SPT 6	50/2"					
35			SPT 7	26-11-9 (20)					

▲ SPT N VALUE ▲



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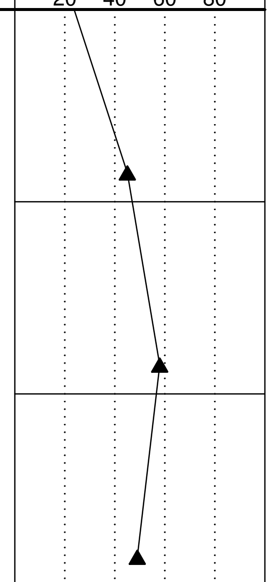
BORING NUMBER B-2

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ 20 40 60 80
35		Soft to very hard pale gray LIMESTONE *(continued)*									
40				SPT 8	12-13-32 (45)						
45				SPT 9	10-24-34 (58)						
50			50	SPT 10	20-19-30 (49)						
		Bottom of borehole at 50.0 feet.									



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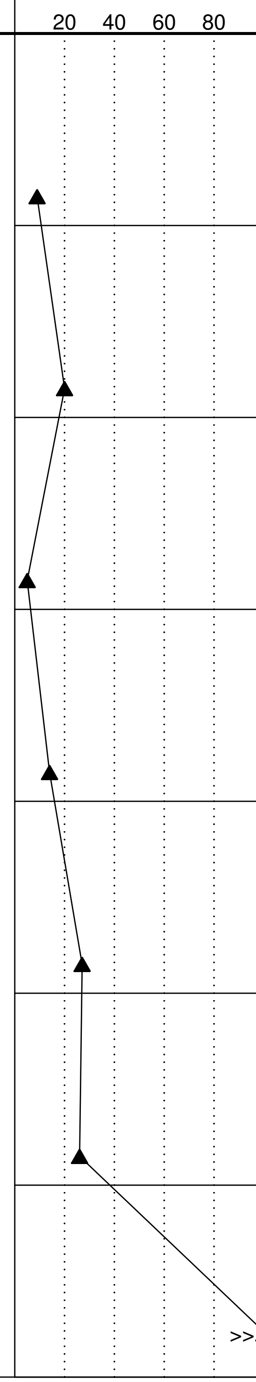
BORING NUMBER B-3

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/13/18 **COMPLETED** 6/13/18
GROUND ELEVATION ______ **HOLE SIZE** ______
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
▼ **AT TIME OF DRILLING** NA
LOGGED BY WDI **CHECKED BY** CAD
▽ **ESTIMATED SEASONAL HIGH** NA
NOTES ______

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0	(SC) Loose to medium dense orange clayey SAND								
5			SPT 1	2-4-5 (9)					
10			SPT 2	5-9-11 (20)					
15			SPT 3	3-2-3 (5)					
17	(SC) Medium dense brown clayey SAND with shell *100% Loss of Circulation at 18 ft.*	17							
20			SPT 4	7-5-9 (14)				18	33
22	(SP) Medium dense brown SAND with limestone	22							
25			SPT 5	13-16-11 (27)					
27	(SP-SC) Medium dense gray SAND with clay and rock	27							
30			SPT 6	10-10-16 (26)					
32	Very hard LIMESTONE	32							
35			SPT 7	40-50/3" 50/3"					

▲ SPT N VALUE ▲



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BORING NUMBER B-3

CLIENT Jones Edmunds & Associates, Inc. **PROJECT NAME** Blue Springs Recharge

PROJECT NUMBER 13632 **PROJECT LOCATION** Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ 20 40 60 80
35		Very hard LIMESTONE *(continued)*	39.6	SPT 8	28-42-50/1" 92/7"						>>▲
		Bottom of borehole at 39.6 feet.									

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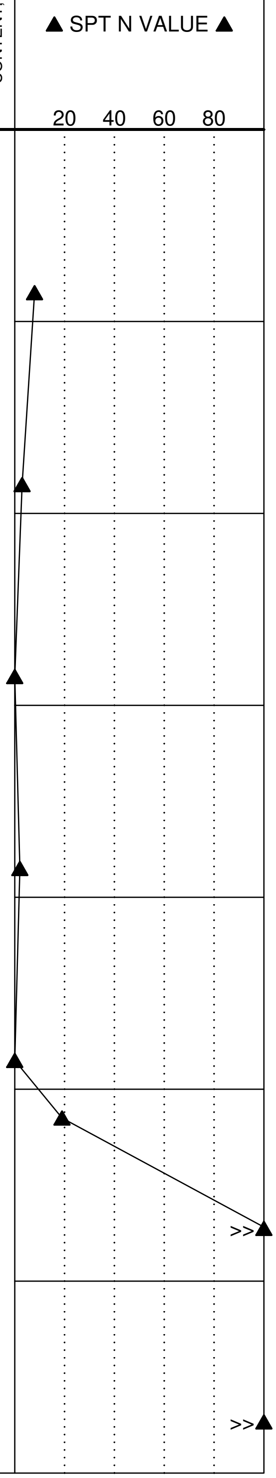
BORING NUMBER B-4

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/13/18 **COMPLETED** 6/13/18
GROUND ELEVATION ______ **HOLE SIZE** ______
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES ______

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0		(SP) Loose gray and orange SAND								
		Shelby Tube from 1 to 3 ft.								
5				SPT 1	3-4-4 (8)					
			7							
		(SC) Very loose orange clayey SAND								
10				SPT 2	2-2-1 (3)					
		Weight-of-Hammer from 13.5 to 15 ft.		SPT 3	0-0-0 (0)					
15			17							
		(SP) Very loose brown SAND								
20				SPT 4	1-1-1 (2)					
			22							
		Very soft to very hard LIMESTONE								
25		*Weight-of-Rod from approximately 23.5 to 25 ft.*		SPT 5	0-0-0 (0)					
				SPT	17-10-9 (19)					
				SPT 6	50/3"					
30										
			33.8	SPT 7	50/4"					
		Bottom of borehole at 33.8 feet.								



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BORING NUMBER B-5

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/11/18 **COMPLETED** 6/11/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0	(SP-SC) Loose gray SAND with clay									
5			SPT 1	3-4-5 (9)						
		7								
10	(SP-SC) Loose orange SAND with clay		SPT 2	3-3-2 (5)						
		12								
15	(SP) Loose orange SAND		SPT 3	2-2-4 (6)						
		17								
20	(SP-SC) Loose brown and orange SAND with clay		SPT 4	2-2-3 (5)						
		22								
25	Very hard gray LIMESTONE		SPT 5	16-18-50/3" 68/9"						>>
		27								
30	(SP-SC) Very dense gray SAND with clay and limestone		SPT 6	18-50/5" 50/5"						>>
35			SPT 7	22-45-18 (63)						

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BORING NUMBER B-5

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		(SP-SC) Very dense gray SAND with clay and limestone *(continued)*	37								
		Hard gray weathered LIMESTONE									
40				SPT 8	33-21-18 (39)						
45				SPT 9	24-30-16 (46)						
50			50	SPT 10	11-10-23 (33)						
		Bottom of borehole at 50.0 feet.									

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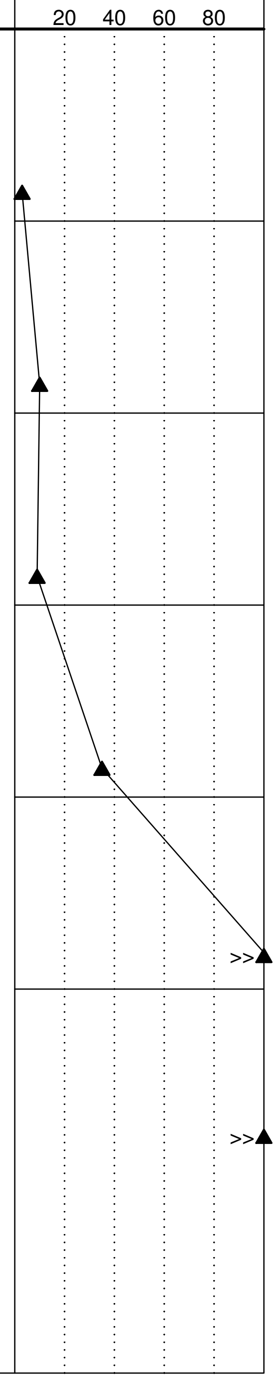
BORING NUMBER B-6

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/13/18 **COMPLETED** 6/13/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0		(SC) Very loose gray and orange clayey SAND								
5				SPT 1	2-1-2 (3)				19	31
			7							
		(SP) Loose orange SAND with rock								
10				SPT 2	4-4-6 (10)					
15			14.5	SPT 3	1-4-5 (9)					
		Soft to very hard white LIMESTONE								
20				SPT 4	17-14-21 (35)					
25				SPT 5	16-31-50/3" 81/9"					
			29.2	SPT 6	27-50/2" 50/2"					
		Bottom of borehole at 29.2 feet.								

▲ SPT N VALUE ▲



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BORING NUMBER B-7

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/13/18 **COMPLETED** 6/13/18
GROUND ELEVATION ______ **HOLE SIZE** ______
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
▼ **AT TIME OF DRILLING** NA
LOGGED BY WDI **CHECKED BY** CAD
▽ **ESTIMATED SEASONAL HIGH** NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0	(SC/CH) Very loose orange and gray very clayey SAND									
5			SPT 1	2-2-1 (3)						3
	Shelby Tube from 6 to 8 ft.	7								
	(SC) Very loose dark gray clayey SAND									
10			SPT 2	2-2-2 (4)				27	27	4
		12								
	(SP-SC) Medium dense brown SAND with clay and limestone									
15			SPT 3	3-4-7 (11)						11
		17								
	(SC) Medium dense brown clayey SAND									
20			SPT 4	5-8-6 (14)				21	25	14
		23								
	Soft white LIMESTONE									
25			SPT 5	10-8-9 (17)						17
		27								
	(SP) Medium dense to very dense brown SAND with limestone									
30			SPT 6	9-7-8 (15)						15
35			SPT 7	26-50/2" 50/2"						>>

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BORING NUMBER B-7

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		(SP) Medium dense to very dense brown SAND with limestone *(continued)*									
40				SPT 8	50/3"						>>
45				SPT 9	22-30-44 (74)						
			49.7	SPT 10	32-46-50/2" 96/8"						>>
		Bottom of borehole at 49.7 feet.									

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BORING NUMBER B-8

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/14/18 **COMPLETED** 6/14/18
GROUND ELEVATION ____ **HOLE SIZE** ____
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	SPT N VALUE
0	(CL/CH) Soft gray and orange sandy CLAY									
5			SPT 1	2-1-2 (3)				51	49	3
7	(SC) Medium dense orange clayey SAND	7								
10			SPT 2	3-5-7 (12)						12
15			SPT 3	4-5-6 (11)						11
17	Moderately hard pale gray LIMESTONE	17								
20			SPT 4	15-14-12 (26)						26
22	(SP) Medium dense gray SAND with limestone	22								
25			SPT 5	10-11-9 (20)						20
30			SPT 6	10-7-8 (15)						15
32	Soft to hard white LIMESTONE	32								
35			SPT 7	35-8-7 (15)						15

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BORING NUMBER B-8

CLIENT Jones Edmunds & Associates, Inc.

PROJECT NAME Blue Springs Recharge

PROJECT NUMBER 13632

PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		Soft to hard white LIMESTONE *(continued)*									
40				SPT 8	12-17-10 (27)						
45			45	SPT 9	13-22-19 (41)						
		Bottom of borehole at 45.0 feet.									

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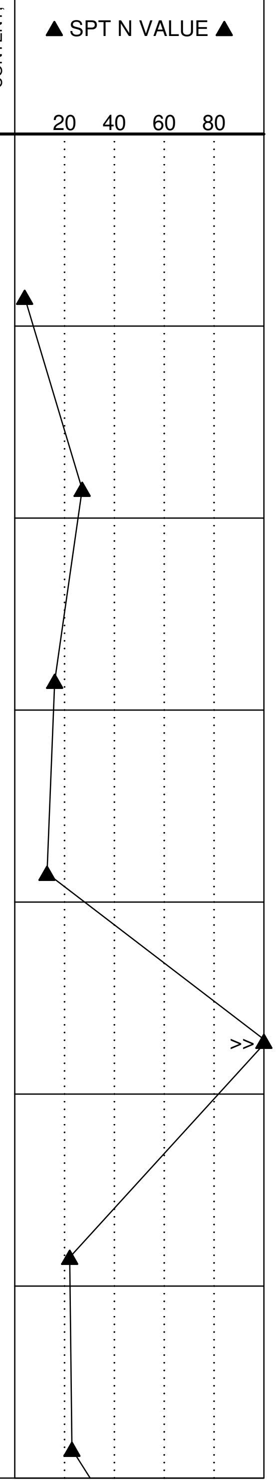
BORING NUMBER B-9

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/12/18 **COMPLETED** 6/12/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0	(SC) Very loose orange clayey SAND								
5			SPT 1	2-2-2 (4)				26	34
	(SP-SC) Medium dense brown SAND with clay and sandstone	7							
10			SPT 2	15-16-11 (27)					
	(SP-SC) Medium dense gray SAND with clay and limestone	12							
15			SPT 3	4-7-9 (16)					
	Soft to very hard Flint Rock	17							
20			SPT 4	12-8-5 (13)					
25			SPT 5	50/3"					
	Moderately hard to very hard pale gray LIMESTONE	27							
30			SPT 6	9-10-12 (22)					
35			SPT 7	17-12-11 (23)					



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BORING NUMBER B-9

CLIENT Jones Edmunds & Associates, Inc.

PROJECT NAME Blue Springs Recharge

PROJECT NUMBER 13632

PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		Moderately hard to very hard pale gray LIMESTONE *(continued)*									
40				SPT 8	27-34-37 (71)						
45				SPT 9	50/4"						>>
			49.4	SPT 10	24-50/5" 50/5"						>>
		Bottom of borehole at 49.4 feet.									

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BORING NUMBER B-10

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/14/18 **COMPLETED** 6/14/18
GROUND ELEVATION ______ **HOLE SIZE** ______
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
▼ **AT TIME OF DRILLING** NA
LOGGED BY WDI **CHECKED BY** CAD
▽ **ESTIMATED SEASONAL HIGH** NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0	(CL/CH) Soft brown and orange CLAY									
5			SPT 1	1-1-2 (3)						
	(SC) Loose brown and orange clayey SAND	7								
10			SPT 2	3-2-3 (5)						
	(SP-SC) Very loose brown and orange SAND with clay	12								
15			SPT 3	1-1-1 (2)						
	(SP-SC) Medium dense brown SAND with clay	17								
20			SPT 4	5-6-7 (13)				11	32	
	(SP) Medium dense brown SAND with limestone	22								
25	◀ *75% Loss of Circulation at approximately 24 ft.*		SPT 5	8-6-5 (11)						
	50% Regain Circulation at approximately 27 ft.									
	Very hard gray LIMESTONE	27								
30			SPT 6	50/0"						>>
	No Recovery (Presumed to be gray limestone)	32								
35			SPT 7	50/0"						>>

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BORING NUMBER B-10

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		*No Recovery* (Presumed to be gray limestone) *(continued)*	37								
		Very hard gray LIMESTONE	39.9	SPT 8	15-40-50/5" 90/11"						>>▲
		Bottom of borehole at 39.9 feet.									

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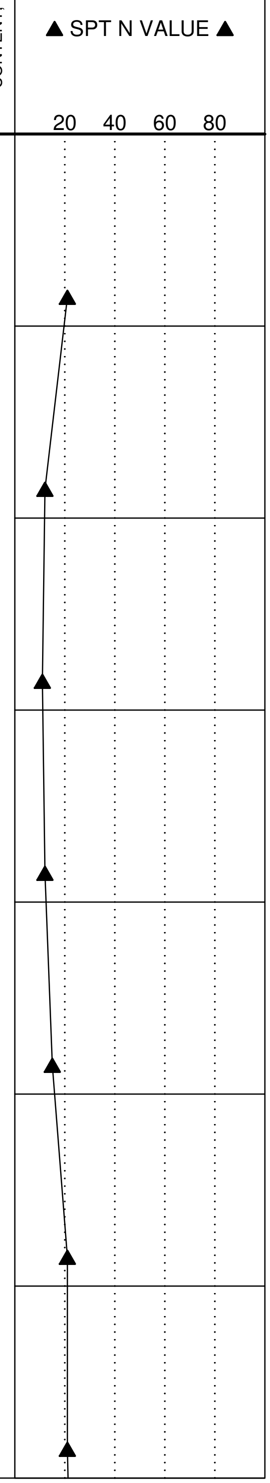
BORING NUMBER B-11

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/14/18 **COMPLETED** 6/14/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0	(SP) Medium dense gray SAND								
5			SPT 1	9-9-12 (21)					
10			SPT 2	4-5-7 (12)					
15			SPT 3	4-5-6 (11)					
20			SPT 4	4-5-7 (12)					
22	(SP) Medium dense dark gray SAND	22							
25			SPT 5	5-7-8 (15)					
30			SPT 6	8-9-12 (21)					
32	(SP) Medium dense gray SAND	32							
35			SPT 7	8-9-12 (21)					



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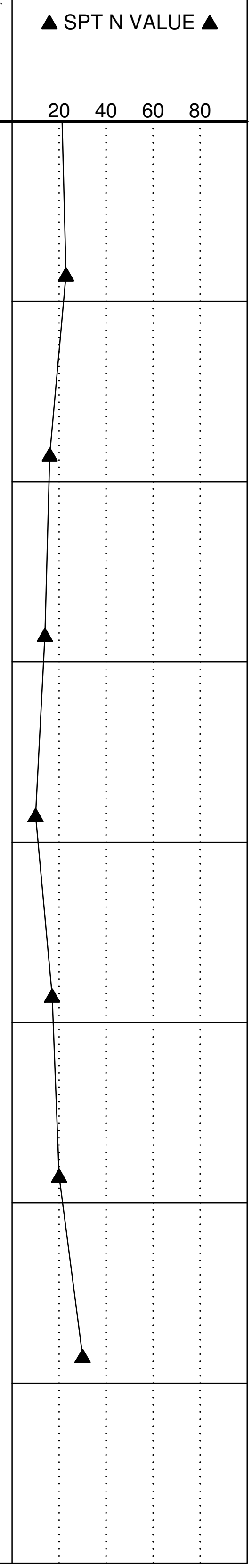
BORING NUMBER B-11

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
35	(SP) Medium dense gray SAND *(continued)*	37							
	(SP) Medium dense gray and orange SAND	42	SPT 8	11-11-12 (23)					
40									
	(SC) Medium dense gray clayey SAND	52	SPT 9	7-8-8 (16)					
45									
50			SPT 10	5-6-8 (14)					
	(CL/CH) Stiff gray CLAY with sand	57	SPT 11	4-5-5 (10)					
55									
	(SP-SC) Medium dense gray and orange SAND with clay	62	SPT 12	5-5-12 (17)					
60									
	(SP-SC) Medium dense gray SAND with clay	70	SPT 13	12-9-11 (20)					
65									
70			SPT 14	18-17-13 (30)				9.3	25
	Bottom of borehole at 70.0 feet.								



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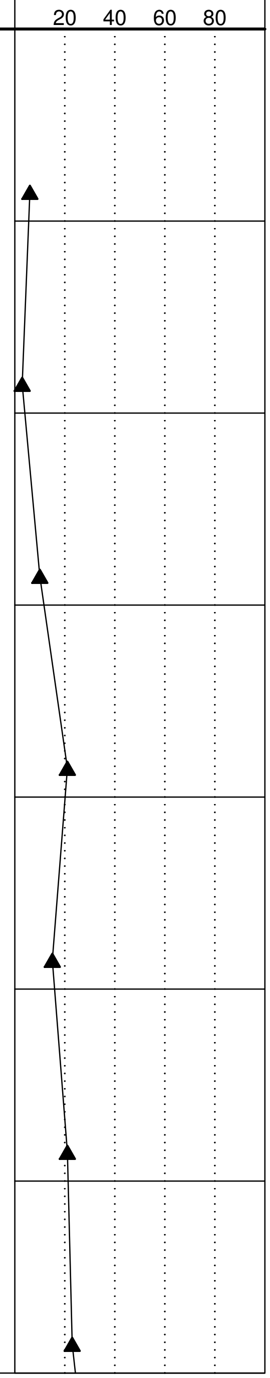
BORING NUMBER B-12

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/11/18 **COMPLETED** 6/11/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING NA
LOGGED BY WDI **CHECKED BY** CAD
ESTIMATED SEASONAL HIGH NA
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %
0	(SP) Loose orange SAND								
5			SPT 1	2-3-3 (6)					
	(CL/CH) Soft dark gray CLAY	7							
10	*Shelby Tube from 10 to 12 ft.*		SPT 2	1-1-2 (3)					
	(SC) Loose orange clayey SAND	12							
15			SPT 3	2-4-6 (10)					
	(SP-SC) Medium dense brown SAND with clay and sandstone	17							
20			SPT 4	10-10-11 (21)					
	(SP-SC) Medium dense gray SAND with clay and sandstone	22							
25			SPT 5	10-9-6 (15)					
30			SPT 6	11-11-10 (21)					
35			SPT 7	30-13-10 (23)					

▲ SPT N VALUE ▲



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BORING NUMBER B-12

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		(SP-SC) Medium dense gray SAND with clay and sandstone *(continued)*									
40		Moderately hard to very hard gray LIMESTONE	39	SPT 8	13-14-17 (31)						
45				SPT 9	23-23-27 (50)						
50			50	SPT 10	24-26-26 (52)						
		Bottom of borehole at 50.0 feet.									

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BORING NUMBER B-13

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/15/18 **COMPLETED** 6/15/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
▼ **AT TIME OF DRILLING** NA
LOGGED BY WDI **CHECKED BY** CAD
▽ **ESTIMATED SEASONAL HIGH** NA
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0		(SP) Loose white SAND									
5				SPT 1	5-4-3 (7)						
10				SPT 2	5-5-5 (10)						
		(SC) Loose to medium dense gray clayey SAND	12								
15				SPT 3	4-4-4 (8)						
20				SPT 4	5-6-6 (12)						
		(SP) Medium dense white SAND	22								
25				SPT 5	6-5-6 (11)						
30				SPT 6	7-6-7 (13)						
		(SP-SC) Medium dense gray SAND with clay	32								
35				SPT 7	8-7-6 (13)						

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BORING NUMBER B-13

CLIENT Jones Edmunds & Associates, Inc.

PROJECT NAME Blue Springs Recharge

PROJECT NUMBER 13632

PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		(SP-SC) Medium dense gray SAND with clay *(continued)*									
40				SPT 8	8-8-7 (15)						
45				SPT 9	6-7-4 (11)				5.7	25	
		(SP) Loose to medium dense gray SAND	47								
50				SPT 10	7-4-5 (9)						
55				SPT 11	6-8-9 (17)						
		(SC) Medium dense gray clayey SAND	57								
60				SPT 12	7-8-8 (16)						
		(SP-SC) Medium dense gray SAND with clay	62								
65				SPT 13	6-7-9 (16)						
		(SP) Loose gray and orange SAND	67								
70			70	SPT 14	4-4-5 (9)						
		Bottom of borehole at 70.0 feet.									

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BORING NUMBER B-14

CLIENT Jones Edmunds & Associates, Inc.
PROJECT NAME Blue Springs Recharge
PROJECT NUMBER 13632
PROJECT LOCATION Orange City, Volusia County, Florida
DATE STARTED 6/14/18 **COMPLETED** 6/14/18
GROUND ELEVATION **HOLE SIZE**
DRILLING CONTRACTOR Whitaker Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
▼ **AT TIME OF DRILLING** NA
LOGGED BY WDI **CHECKED BY** CAD
▽ **ESTIMATED SEASONAL HIGH** NA
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
0		(SP) Loose to medium dense brown SAND									
5				SPT 1	9-9-8 (17)						17
10				SPT 2	2-3-4 (7)						7
15				SPT 3	4-4-4 (8)						8
20				SPT 4	5-7-6 (13)						13
		(CL/CH) Firm gray CLAY with sand	22								
25				SPT 5	5-4-4 (8)						8
		(SC) Loose gray and orange clayey SAND	27								
30				SPT 6	3-3-4 (7)						7
		(SP-SC) Very loose to medium dense brown orange SAND with clay	32								
35				SPT 7	4-5-7 (12)						12

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BORING NUMBER B-14

CLIENT Jones Edmunds & Associates, Inc.

PROJECT NAME Blue Springs Recharge

PROJECT NUMBER 13632

PROJECT LOCATION Orange City, Volusia County, Florida

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	CONTACT DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX	PERCENT PASS NO. 200 SIEVE	MOISTURE CONTENT, %	▲ SPT N VALUE ▲ (20 40 60 80)
35		(SP-SC) Very loose to medium dense brown orange SAND with clay *(continued)*									
40				SPT 8	5-4-4 (8)						
45				SPT 9	4-5-7 (12)						
50		◀ *100% Loss of Circulation at 50 ft.*		SPT 10	1-1-1 (2)						
		(SP) Loose brown and orange SAND	52								
55				SPT 11	3-4-6 (10)						
		Soft gray LIMESTONE	57								
60			60	SPT 12	7-8-8 (16)						

Bottom of borehole at 60.0 feet.

Boring terminated at 60 ft due to borehole collapse.

4.2 Laboratory Results

GSE Engineering & Consulting, Inc.

SUMMARY REPORT OF LABORATORY TEST RESULTS

Project Number: 13632

Project Name: Blue Springs Recharge

Boring Number	Depth (ft)	Soil Description	Natural Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Percent Passing No. 200 Sieve	Organic Content (%)	Hydraulic Conductivity (ft/day)	Unified Soil Classification
B-2	3.5-5	Orange very clayey SAND	32				32			SC/CH
B-3	18.5-20	Brown clayey SAND with shell	33				18			SC
B-6	3.5-5	Gray and orange clayey SAND	31				19			SC
B-7	8.5-10	Dark gray clayey SAND	27				27			SC
B-7	18.5-20	Brown clayey SAND	25				21			SC
B-8	3.5-5	Gray and orange sandy CLAY	49				51			CL/CH
B-9	3.5-5	Orange clayey SAND	34				26			SC
B-10	18.5-20	Brown SAND with clay	32				11			SP-SC
B-11	68.5-70	Gray SAND with clay	25				9.3			SP-SC
B-13	43.5-45	Gray SAND with clay	25				5.7			SP-SC

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-2 ; S1
Material Description:	Orange very clayey SAND
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	32
% Passing No. 200 Sieve (%)	32

Atterberg Limits

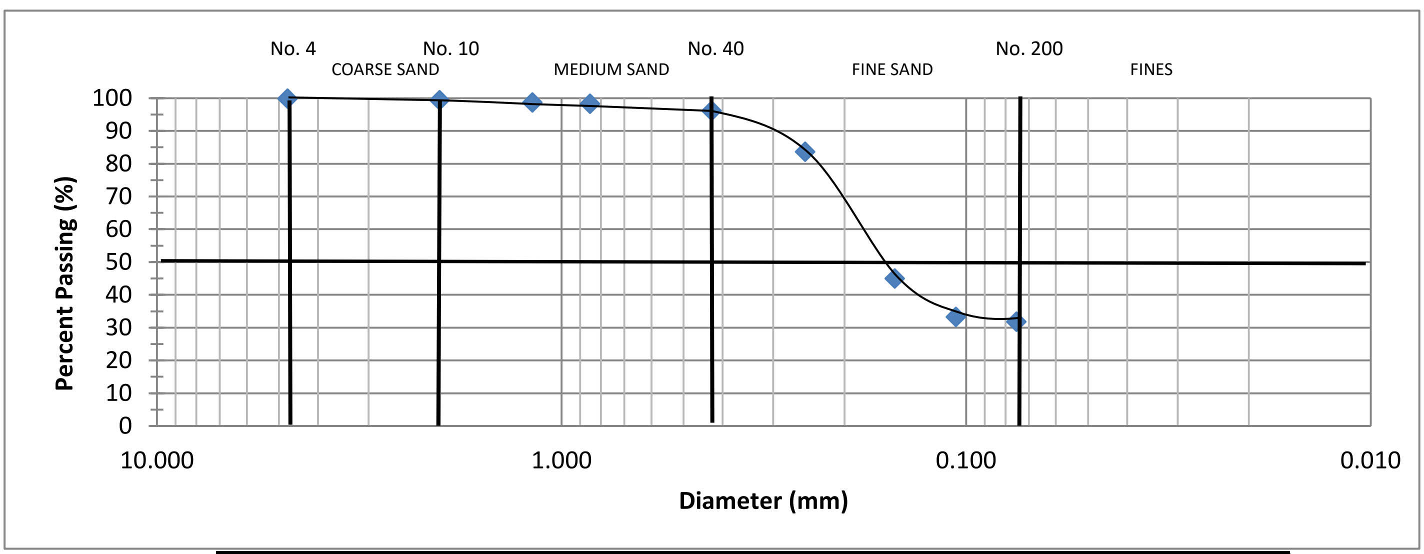
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.19
D_{50} =	0.16
D_{30} =	N/A
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.2	0.1	99.9
No. 10	2.00	0.9	0.6	99.3
No. 16	1.18	1.1	0.7	98.6
No. 20	0.850	0.5	0.3	98.3
No. 40	0.425	3.5	2.2	96.1
No. 60	0.250	19.8	12.5	83.6
No. 100	0.150	61.5	38.7	44.9
No. 140	0.106	18.6	11.7	33.2
No. 200	0.075	2.1	1.3	31.8
pan	NA	0.4	0.3	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.7	3.2	64.2	31.8

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-3 ; S4
Material Description:	Brown clayey SAND with shell
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	33
% Passing No. 200 Sieve (%)	18

Atterberg Limits

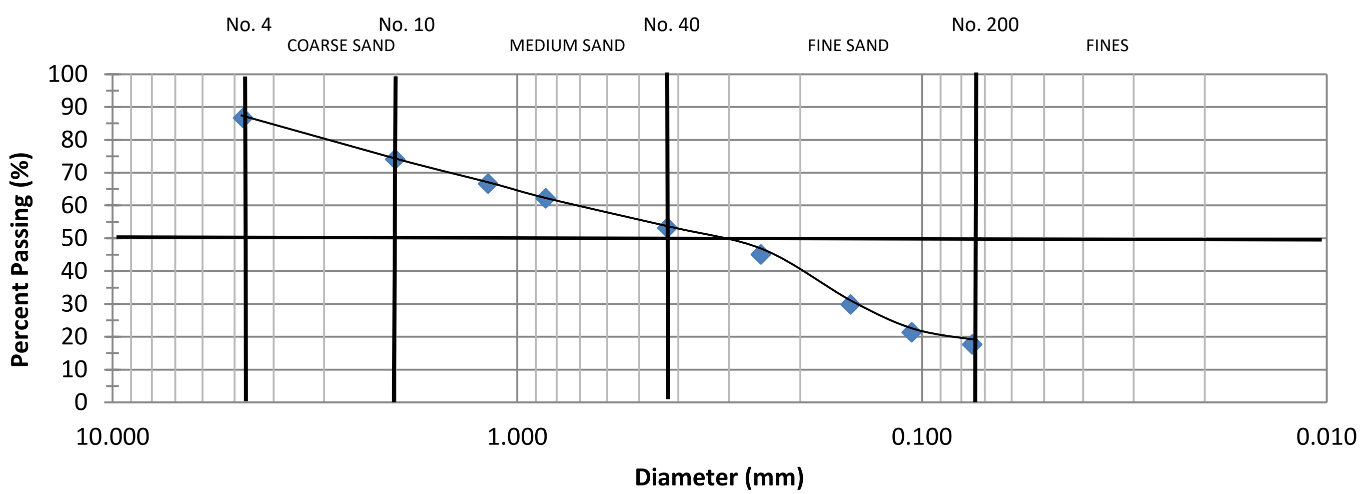
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.75
D_{50} =	0.36
D_{30} =	0.15
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	29.8	13.4	86.6
No. 10	2.00	27.9	12.5	74.1
No. 16	1.18	16.6	7.5	66.6
No. 20	0.850	10.0	4.5	62.1
No. 40	0.425	19.9	8.9	53.1
No. 60	0.250	17.9	8.0	45.1
No. 100	0.150	33.9	15.2	29.9
No. 140	0.106	18.9	8.5	21.4
No. 200	0.075	9.1	4.1	17.7
pan	NA	3.8	1.7	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
25.9	20.9	35.9	17.7

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-6 ; S1
Material Description:	Gray and orange clayey SAND
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	31
% Passing No. 200 Sieve (%)	19

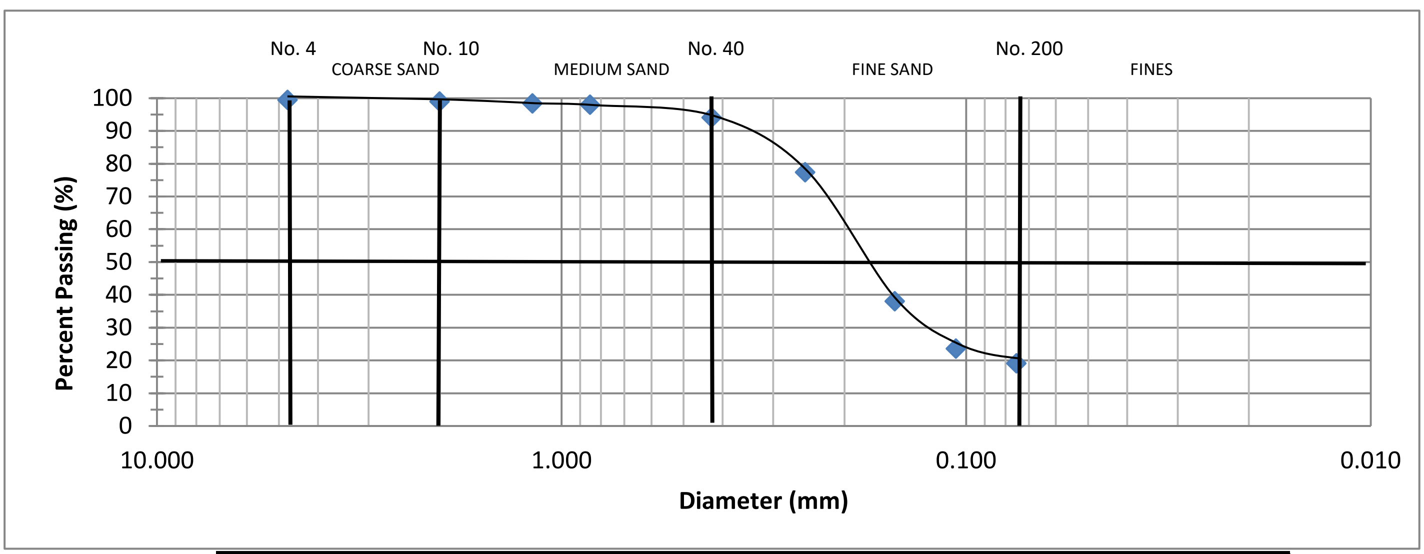
Atterberg Limits

Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT
Organic Content	NT

Coefficients

D_{60} =	0.21
D_{50} =	0.18
D_{30} =	0.13
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.9	0.5	99.5
No. 10	2.00	0.9	0.5	98.9
No. 16	1.18	1.0	0.6	98.4
No. 20	0.850	0.7	0.4	97.9
No. 40	0.425	6.6	3.9	94.1
No. 60	0.250	28.5	16.7	77.3
No. 100	0.150	67.0	39.3	38.0
No. 140	0.106	24.7	14.5	23.5
No. 200	0.075	8.8	5.2	19.1
pan	NA	2.0	1.2	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
1.1	4.9	75.7	19.1

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-7 , S2
Material Description:	Dark gray clayey SAND
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	27
% Passing No. 200 Sieve (%)	27

Atterberg Limits

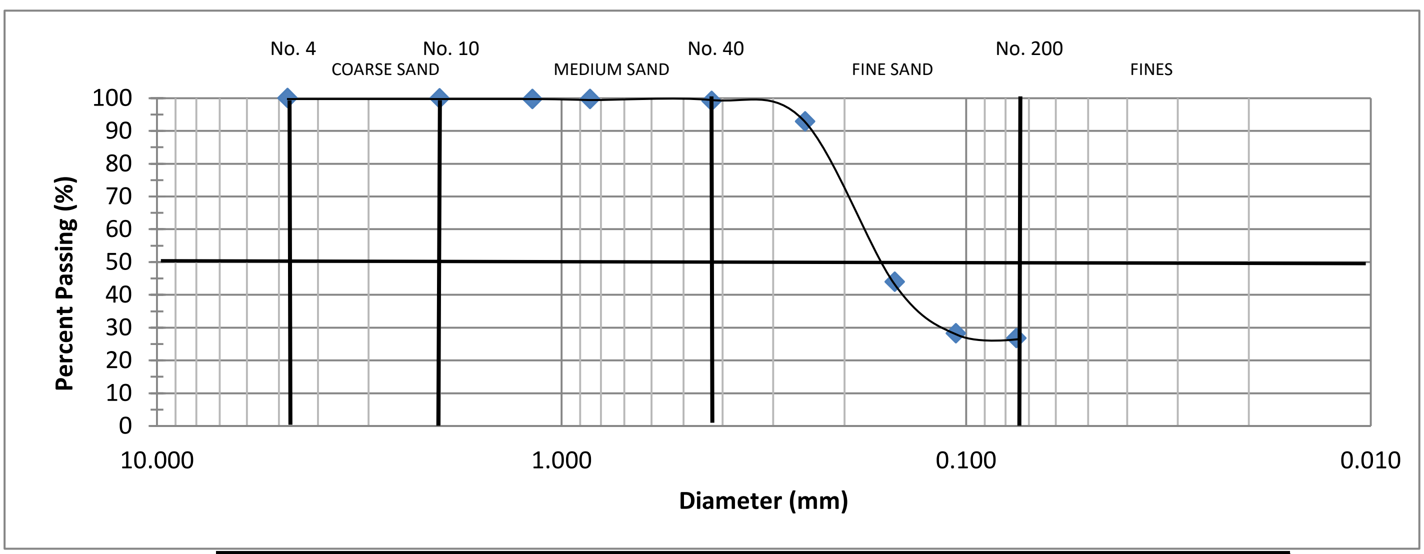
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.18
D_{50} =	0.16
D_{30} =	0.11
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.2	0.1	99.9
No. 16	1.18	0.2	0.1	99.8
No. 20	0.850	0.1	0.1	99.7
No. 40	0.425	0.9	0.5	99.2
No. 60	0.250	10.6	6.3	92.9
No. 100	0.150	82.7	48.9	44.0
No. 140	0.106	26.6	15.7	28.2
No. 200	0.075	3.3	2.0	26.8
pan	NA	1.2	0.7	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.1	0.7	72.9	26.8

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-7 ; S4
Material Description:	Brown clayey SAND
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	25
% Passing No. 200 Sieve (%)	21

Atterberg Limits

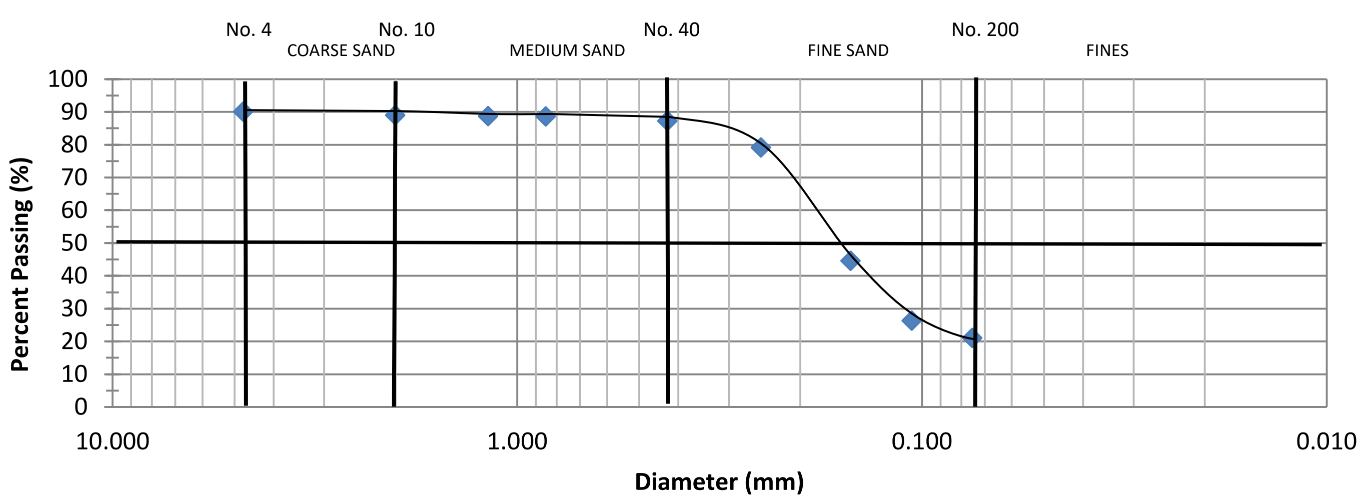
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.19
D_{50} =	0.17
D_{30} =	0.11
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	19.2	9.9	90.1
No. 10	2.00	2.1	1.1	89.0
No. 16	1.18	0.5	0.3	88.7
No. 20	0.850	0.3	0.2	88.6
No. 40	0.425	2.5	1.3	87.3
No. 60	0.250	15.7	8.1	79.2
No. 100	0.150	66.8	34.6	44.6
No. 140	0.106	35.3	18.3	26.3
No. 200	0.075	10.6	5.5	21.0
pan	NA	3.3	1.7	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
11.0	1.7	66.4	21.0

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-8 ; S1
Material Description:	Gray and orange sandy CLAY
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-6
USCS	CL/CH

Material Properties

Moisture Content (%)	49
% Passing No. 200 Sieve (%)	51

Atterberg Limits

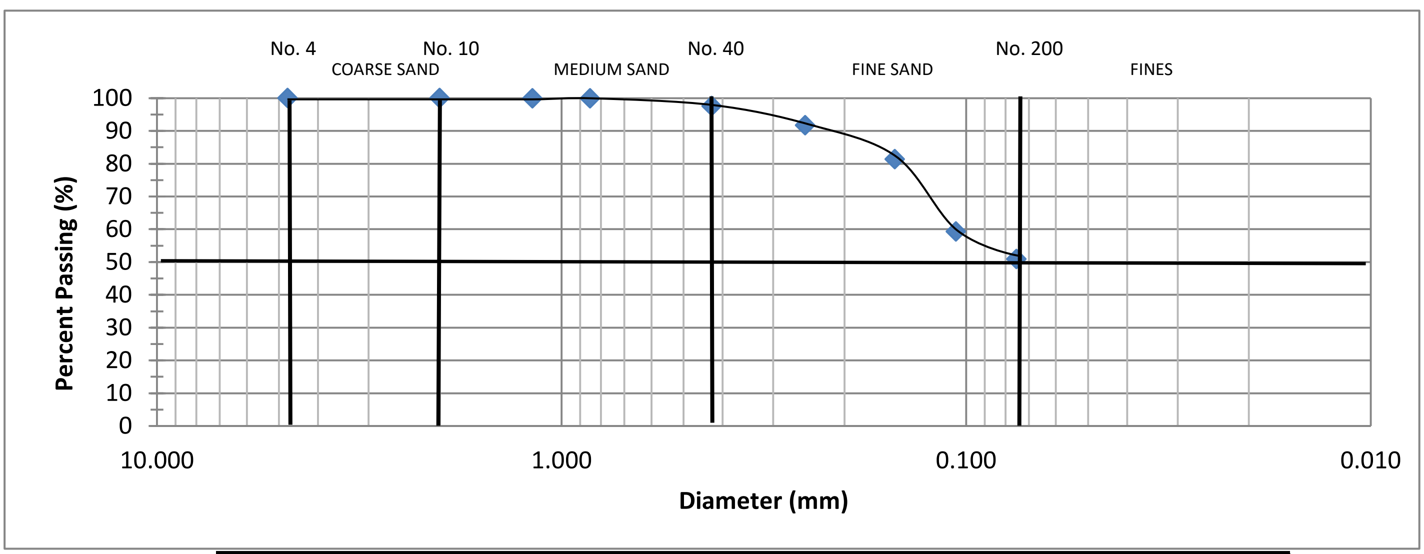
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.11
D_{50} =	N/A
D_{30} =	N/A
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.0	0.0	100.0
No. 16	1.18	0.1	0.1	99.9
No. 20	0.850	0.0	0.0	99.9
No. 40	0.425	2.6	2.3	97.6
No. 60	0.250	6.6	5.9	91.7
No. 100	0.150	11.6	10.4	81.3
No. 140	0.106	24.7	22.1	59.3
No. 200	0.075	9.5	8.5	50.9
pan	NA	2.7	2.4	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.0	2.4	46.8	50.9

GSE Engineering & Consulting, Inc.
5590 SW 64th St, Ste B
Gainesville, FL 32608
(352) 377-3233

Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-9 ; S1
Material Description:	Orange clayey SAND
Performed By:	MBS
Date:	6/28/2018

AASHTO	A-2
USCS	SC

Material Properties

Moisture Content (%)	34
% Passing No. 200 Sieve (%)	26

Atterberg Limits

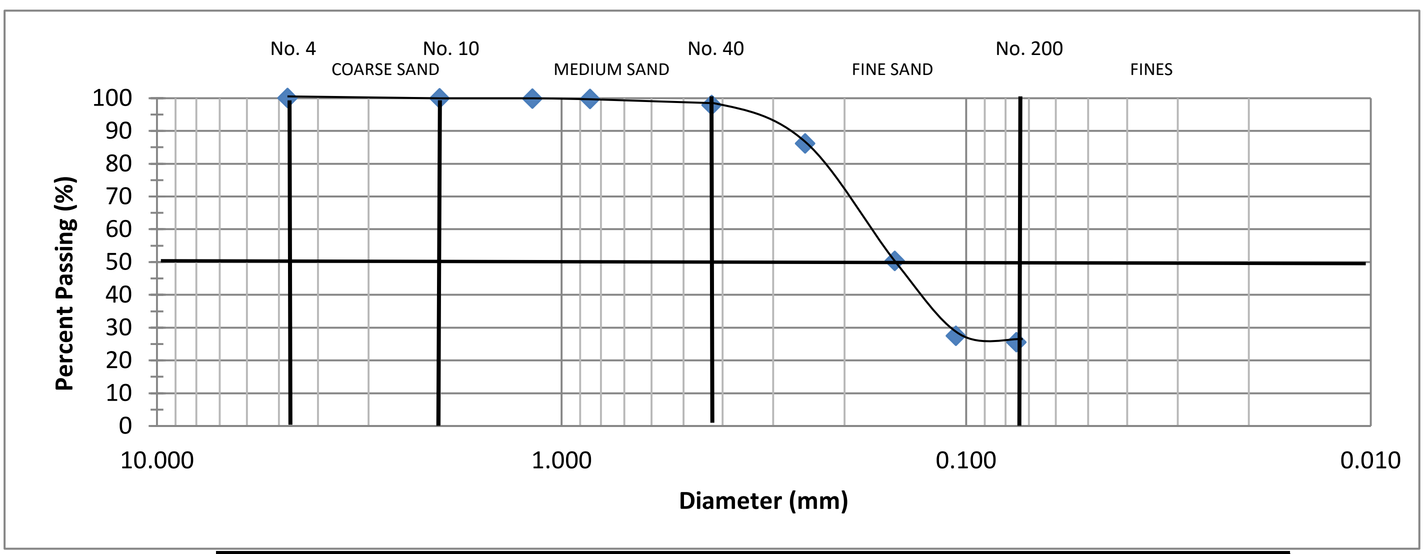
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.18
D_{50} =	0.15
D_{30} =	0.11
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.1	0.1	99.9
No. 16	1.18	0.1	0.1	99.9
No. 20	0.850	0.2	0.1	99.7
No. 40	0.425	2.6	1.8	97.9
No. 60	0.250	16.9	11.7	86.2
No. 100	0.150	51.6	35.9	50.3
No. 140	0.106	32.8	22.8	27.5
No. 200	0.075	3.7	2.6	25.5
pan	NA	0.7	0.5	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.1	2.0	73.0	25.5

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Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-10 ; S4
Material Description:	Brown SAND with clay
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SP-SC

Material Properties

Moisture Content (%)	32
% Passing No. 200 Sieve (%)	11

Atterberg Limits

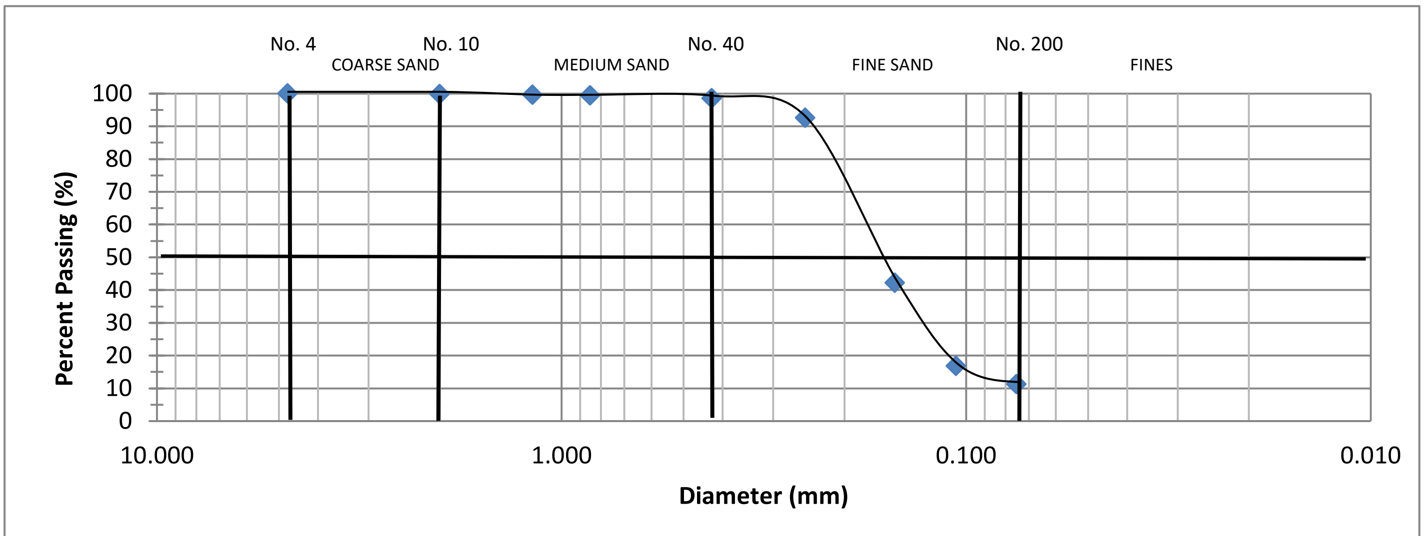
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.19
D_{50} =	0.17
D_{30} =	0.13
D_{10} =	N/A
C_U =	N/A
C_C =	N/A

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.3	0.1	99.9
No. 16	1.18	0.5	0.2	99.6
No. 20	0.850	0.3	0.1	99.5
No. 40	0.425	1.9	0.9	98.5
No. 60	0.250	12.2	5.9	92.6
No. 100	0.150	103.4	50.3	42.3
No. 140	0.106	52.2	25.4	16.8
No. 200	0.075	12.6	6.1	11.2
pan	NA	3.4	1.7	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.1	1.3	87.8	11.2

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(352) 377-3233

Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-11 ; S14
Material Description:	Gray SAND with clay
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SP-SC

Material Properties

Moisture Content (%)	25
% Passing No. 200 Sieve (%)	9.3

Atterberg Limits

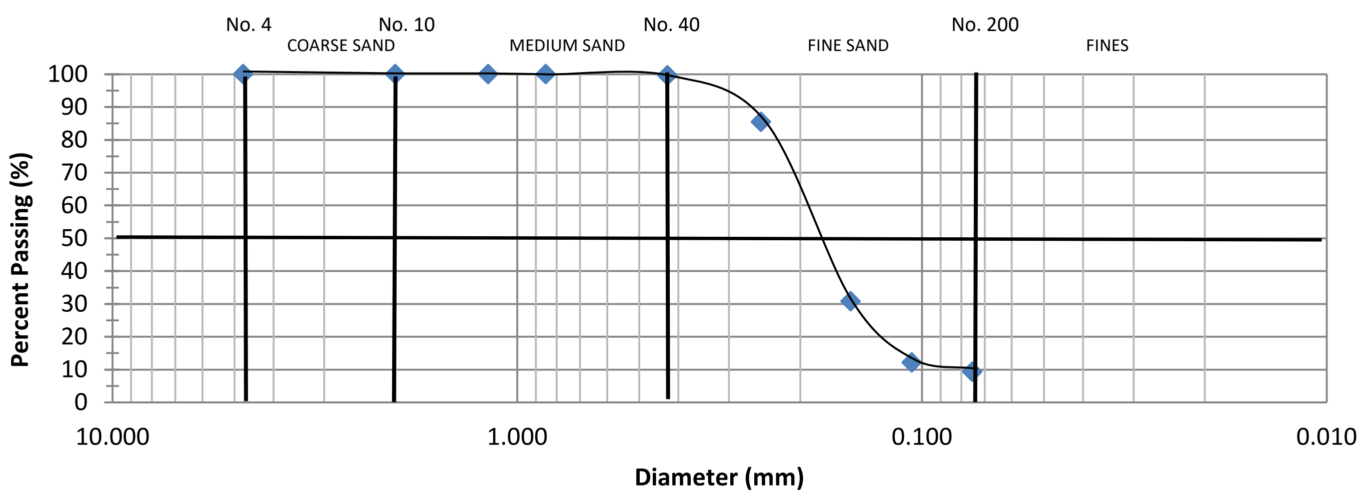
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.20
D_{50} =	0.19
D_{30} =	0.15
D_{10} =	0.08
C_U =	2.46
C_C =	1.31

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.0	0.0	100.0
No. 16	1.18	0.0	0.0	100.0
No. 20	0.850	0.0	0.0	100.0
No. 40	0.425	0.6	0.3	99.7
No. 60	0.250	25.8	14.2	85.5
No. 100	0.150	99.6	54.7	30.8
No. 140	0.106	33.8	18.6	12.2
No. 200	0.075	5.2	2.9	9.3
pan	NA	0.4	0.2	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.0	0.3	90.3	9.3

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Gainesville, FL 32608
(352) 377-3233

Particle Size Distribution (AASHTO T88)

Project	Blue Springs Recharge
Project No.	13632
Sample No./Dept	B-13 ; S9
Material Description:	Gray SAND with clay
Performed By:	MBS
Date:	6/28/2018

Classification	
AASHTO	A-2
USCS	SP-SC

Material Properties

Moisture Content (%)	25
% Passing No. 200 Sieve (%)	5.7

Atterberg Limits

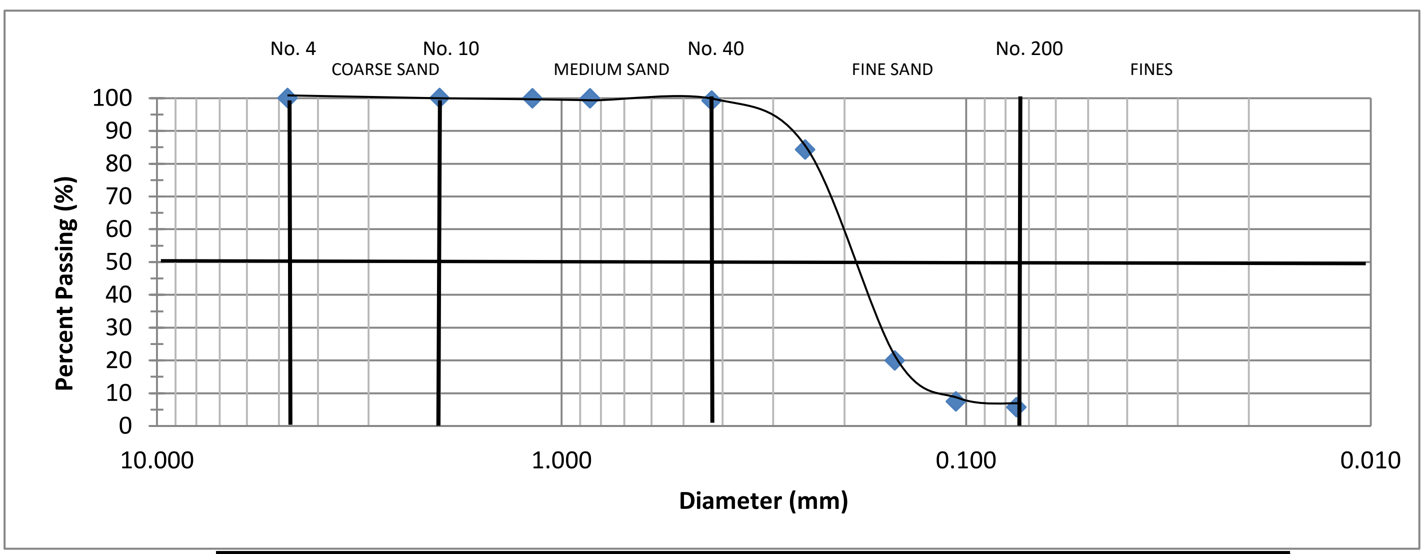
Liquid Limit	NT
Plastic Limit	NT
Plasticity Index	NT

Organic Content	NT

Coefficients

D_{60} =	0.21
D_{50} =	0.20
D_{30} =	0.17
D_{10} =	0.11
C_U =	1.85
C_C =	1.12

Sieve No.	Diameter (mm)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)
No. 4	4.75	0.0	0.0	100.0
No. 10	2.00	0.0	0.0	100.0
No. 16	1.18	0.1	0.0	100.0
No. 20	0.850	0.0	0.0	100.0
No. 40	0.425	1.4	0.7	99.3
No. 60	0.250	31.3	15.0	84.3
No. 100	0.150	134.6	64.3	20.0
No. 140	0.106	26.2	12.5	7.5
No. 200	0.075	3.9	1.9	5.7
pan	NA	0.5	0.2	N/A



Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Fines (%)
0.0	0.7	93.7	5.7

4.3 Key to Soil Classification

KEY TO SOIL CLASSIFICATION CHART

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests				SYMBOLS		GROUP NAME
				GRAPHIC	LETTER	
COARSE-GRAINED SOILS	Gravels	Clean Gravels	$Cu \geq 4$ and $1 \leq Cc \leq 3$		**GW**	Well graded GRAVEL
More than 50% retained on No. 200 sieve	More than 50% of coarse fraction retained on No. 4 sieve	Less than 5% fines	$Cu < 4$ and/or $1 > Cc > 3$		**GP**	Poorly graded GRAVEL
		Gravels with fines	Fines classify as ML or MH		**GM**	Silty GRAVEL
		More than 12% fines	Fines classify as CL or CH		**GC**	Clayey GRAVEL
	Sands	Clean Sands	$Cu \geq 6$ and $1 \leq Cc \leq 3$		**SW**	Well graded SAND
	50% or more of coarse fraction passes No. 4 sieve	Less than 5% fines	$Cu < 6$ and/or $1 > Cc > 3$		**SP**	Poorly graded SAND
		Sand with fines	Fines classify as ML or MH		**SP-SM**	SAND with silt
		$5\% \leq$ fines $< 12\%$	Fines classify as CL or CH		**SP-SC**	SAND with clay
		Sand with fines	Fines classify as ML or MH		**SM**	Silty SAND
		$12\% \leq$ fines $< 30\%$	Fines classify as CL or CH		**SC**	Clayey SAND
		Sand with fines	Fines classify as ML or MH		**SM**	Very silty SAND
		30% fines or more	Fines classify as CL or CH		**SC**	Very clayey SAND
FINE-GRAINED SOILS	Clays	inorganic	$50\% \leq$ fines $< 70\%$		**CL/CH**	Sandy CLAY
50% or more passes the No. 200 sieve			$70\% \leq$ fines $< 85\%$		**CL/CH**	CLAY with sand
			fines $\geq 85\%$		**CL/CH**	CLAY
	Silts and Clays	inorganic	PI > 7 and plots on/above "A" line		**CL**	Lean CLAY
	Liquid Limit less than 50		PI < 4 or plots below "A" line		**ML**	SILT
		organic	$\frac{\text{Liquid Limit - oven dried}}{\text{Liquid Limit - not dried}} < 0.75$		**OL**	Organic clay Organic silt
	Silts and Clays	inorganic	PI plots on or above "A" line		**CH**	Fat CLAY
	Liquid Limit 50 or more		PI plots below "A" line		**MH**	Elastic SILT
		organic	$\frac{\text{Liquid Limit - oven dried}}{\text{Liquid Limit - not dried}} < 0.75$		**OH**	Organic clay Organic silt
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor				**PT**	PEAT

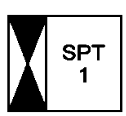
CORRELATION OF PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY

	No. OF BLOWS, N	RELATIVE DENSITY
SANDS:	0 - 4	Very Loose
	5 - 10	Loose
	11 - 30	Medium dense
	31 - 50	Dense
	OVER 50	Very Dense

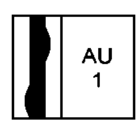
	No. OF BLOWS, N	CONSISTENCY
SILTS & CLAYS:	0 - 2	Very Soft
	3 - 4	Soft
	5 - 8	Firm
	9 - 15	Stiff
	16 - 30	Very Stiff
	31 - 50	Hard
	OVER 50	Very Hard

	No. OF BLOWS, N	RELATIVE DENSITY
LIMESTONE:	0 - 8	Very Soft
	9 - 18	Soft
	19 - 32	Moderately Hard
	33 - 50	Hard
	OVER 50	Very Hard

SAMPLE GRAPHIC TYPE LEGEND



Location of SPT Sample



Location of Auger Sample

PARTICLE SIZE IDENTIFICATION

BOULDERS:		Greater than 300 mm
COBBLES:		75 mm to 300 mm
GRAVEL:	Coarse -	19.0 mm to 75 mm
	Fine -	4.75 mm to 19.0 mm
SANDS:	Coarse -	2.00 mm to 4.75 mm
	Medium -	0.425 mm to 2.00 mm
	Fine -	0.075 mm to 0.425 mm
SILTS & CLAYS:		Less than 0.075 mm

LABORATORY TEST LEGEND

LL	=	Liquid Limit, %
PL	=	Plastic Limit, %
PI	=	Plasticity Index, %
% PASS - 200	=	Percent Passing the No. 200 Sieve
MC	=	Moisture Content, %
ORG	=	Organic Content, %
k_h	=	Horizontal Hydraulic Conductivity, ft/day

5.0 LIMITATIONS

5.1 Warranty

This report has been prepared for our client for his exclusive use, in accordance with generally accepted soil and foundation engineering practices, and makes no other warranty, either expressed or implied, as to the professional advice provided in the report.

5.2 Standard Penetration Test Borings

The determination of soil type and conditions was performed from the ground surface to the maximum depth of the borings, only. Any changes in subsurface conditions that occur between or below the borings would not have been detected or reflected in this report.

Soil classifications that were made in the field are based upon identifiable textural changes, color changes, changes in composition or changes in resistance to penetration in the intervals from which the samples were collected. Abrupt changes in soil type, as reflected in boring logs and/or cross sections may not actually occur, but instead, be transitional.

Depth to the water table is based upon observations made during the performance of the SPT and auger borings. This depth is an estimate and does not reflect the annual variations that would be expected in this area due to fluctuations in rainfall and rates of evapotranspiration.

5.3 Site Figures

The measurements used for the preparation of the figures in this report were made with a fiberglass tape and by estimating distances from existing structures and site features. Figures in this report were not prepared by a licensed land surveyor and should not be interpreted as such.

5.4 Unanticipated Soil Conditions

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations indicated on the Site Plan. This report does not reflect any variations that may occur between these borings.

The nature and extent of variations between borings may not become known until excavation begins. If variations appear, we may have to re-evaluate our recommendations after performing on-site observations and noting the characteristics of any variations.

5.5 Misinterpretation of Soil Engineering Report

GSE Engineering & Consulting, Inc. is responsible for the conclusions and opinions contained within this report based upon the data relating only to the specific project and location discussed herein. If others make the conclusions or recommendations based upon the data presented, those conclusions or recommendations are not the responsibility of GSE.

FIGURES

PROJECT SITE LOCATION MAP

BLUE SPRINGS RECHARGE
ORANGE CITY, VOLUSIA COUNTY, FLORIDA
GSE PROJECT NO. 13632

DESIGNED BY : CAD
CHECKED BY : KLH
DRAWN BY : DCJ

GSE Engineering & Consulting, Inc.

FIGURE 1

REFERENCE: AERIAL PHOTOGRAPH (2018) GOOGLE EARTH

LEGEND:

- SPT BORING
- 50' DEEP PIEZOMETER
- 20' DEEP PIEZOMETER

NORTH

0 300'

SCALE: 1" = 300' APPROX.

BLUE SPRINGS RECHARGE ORANGE CITY, VOLUSIA COUNTY, FLORIDA GSE PROJECT NO. 13632	AERIAL PHOTOGRAPH SHOWING APPROXIMATE LOCATIONS OF FIELD TESTS		
	DESIGNED BY : CAD CHECKED BY : KLH DRAWN BY : DCJ	GSE Engineering & Consulting, Inc.	FIGURE 2

GSE Engineering & Consulting, Inc.

August 16, 2018

Michelle R. Hays, PG
Jones Edmunds & Associates, Inc.
730 NE Waldo Road
Gainesville, Florida 32641

Subject: Transmittal of Laboratory Testing
Blue Springs Recharge
Volusian County, Florida
GSE Project No. 13632

Dear Michelle:

GSE Engineering & Consulting, Inc. (GSE) performed a geotechnical site exploration for the subject project as summarized in a draft report entitled *Summary of a Geotechnical Site Exploration* dated July 9, 2018 (GSE Project No. 13632). Please refer to the draft report for additional background information.

The geotechnical scope of services for this project included two (2) constant head permeability tests. Due to the amount of time required to perform these tests, GSE recommended the test results be provided under separate cover. The constant head permeability test results are attached below.

We appreciate this opportunity to have assisted you on this project. If you have any questions or comments concerning our services, please contact us.

Sincerely,

GSE Engineering & Consulting, Inc.

COREY ALAN DUNLAP LICENSE No.77678 ★ STATE OF FLORIDA PROFESSIONAL ENGINEER

This item has been digitally signed and sealed by

Printed copies of this document are not considered signed and sealed, and the signature must be verified on any electronic copies.

Kenneth L. Hill, P.E.
Principal Engineer
Florida Registration Number 40146

Corey A. Dunlap, P.E.
Senior Engineer
Florida Registration Number 77678

KLH/CAD:ldj
Z:/Projectcs\13632 Blue Springs Recharge/13632 Transmittal of Laboratory Testing.doc

Distribution: Addressee – 1, Electronic
File – 1

Attachment: Laboratory Test Results from Ardaman & Associates, Inc.

GSE Engineering & Consulting, Inc.
5590 SW 64th Street, Suite B
Gainesville, Florida 32608
352-377-3233 Phone ♦ 352-377-0335 Fax
www.gseengineering.com
Certificate of Authorization No. 27430

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

July 31, 2018
File Number 18-13-0066

GSE Engineering & Consulting, Inc.
5590 SW 64th Street
Gainesville, Florida 32608

Attention: Corey A Dunlop, P.E.
Senior Geotechnical Engineer

Subject: Laboratory Test Results, Blue Springs Recharge

Gentlemen:

As requested, permeability tests have been completed on the following undisturbed tube samples provided for testing by your firm.

Boring	Depth (feet)
B-4	1.0 – 3.0
B-7	6.0 – 8.0
B-12	10.0 – 12.0

Each sample was horizontally extruded from the Shelby tube and photographed. Water contents were measured at selected locations along the sample, portions were selected for the requested tests, and the average total unit weight and dry density of the sample was calculated from the measured mass, volume and water contents. The results are presented on the attached Undisturbed Tube Sample Extrusion Test Reports. Photographs of the extruded samples are attached. As directed, a permeability test was not performed on the sample from boring B-4. The tests were performed in general accordance with the following ASTM Standards.

- Density was determined on each tube sample in general accordance with ASTM Standard D7263 "Laboratory Determination of Density (Unit Weight) of Soil Specimens" Method B – Direct Measurement.

- Water content was determined in accordance with ASTM Standard D2216 "Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass" using Method B and an oven temperature of 107°C.

- Particle-size distribution was determined in accordance with ASTM Standard D6913 "Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis".

- Fines content was determined in accordance with ASTM Standard D1140 "Determining the Amount of material Finer than 75-µm (No. 200 Sieve) in Soils by Washing" Method B.

- Hydraulic conductivity was determined in accordance with ASTM Standard D5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a

Flexible Wall Permeameter" Method A – Constant Head. Photographs of the permeability test specimens are attached.

The test samples were reported to be from the client-specified designations herein. The test results are indicative of only the specimens that were actually tested. The test results presented are based upon accepted industry practice as well as the test methods listed. Ardaman & Associates, Inc. neither accepts responsibility for, nor makes claims to the final use and purpose of the test results.

Please contact us if you have any questions or require additional information.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.
Certificate of Authorization No. 5950

Thomas S. Ingra, P.E.
Laboratory Director
Florida License No. 31987
Encls.

ARDAMAN & ASSOCIATES, INC. GEOTECHNICAL TESTING LABORATORY
UNDISTURBED TUBE SAMPLE EXTRUSION TEST REPORT

CLIENT: GSE Engineering & Consulting, Inc.
PROJECT: Blue Springs Recharge
FILE NO.: 18-13-0066

DATE SAMPLE RECEIVED: ---
DATE SAMPLE EXTRUDED: 07/03/18
DATE REPORTED: 07/31/18

ASTM STANDARD D7263 TEST METHOD: ☒ Method B

BORING: **B-4**
SAMPLE: ----
DEPTH: 1.0 – 3.0 ☒ feet; ☐ meters
DATE SAMPLED: ------
TUBE TYPE: ☒ Steel ☐ SS ☐ Brass ☐ Plastic
SEAL TYPE: ☐ Wax ☐ Plugs ☒ Caps ☐ Other
TUBE CONDITION: Good
TUBE INSIDE DIAMETER (cm): 7.30
PHOTOGRAPHY OF EXTRUDED SAMPLE: ☒ Yes ☐ No

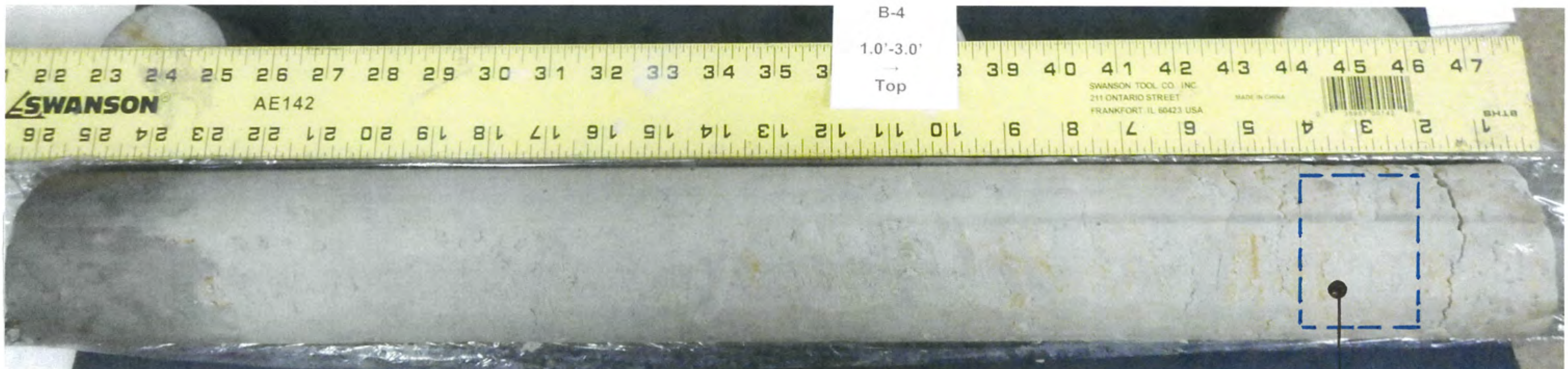
Tube Length (cm)	Length of Void		Sample Length		Change in Length (%)	Total WWS (grams)	Disturbed Soil Removed from Sample: ☐ Yes ☒ No		
	Top (cm)	Bottom (cm)	Inside Tube (cm)	Extruded (cm)			WWS (grams)	Length (cm)	Percentage of Total WWS (%)
76.0	12.0	0.0	64.0	63.5	-0.8	4,801	----	----	----

Length (cm)	Description	w_c (%)	-200 (%)	Atterberg Limits			OC (%)	$CaCO_3$ (%)	G_s	Tube Average		
				LL	PL	PI				w_c (%)	γ_t (lb/ft^3)	γ_d (lb/ft^3)
54.0	Light brown clayey sand (SC)	28.1 28.4 30.1 30.6 30.5	23.5	---	---	---	---	---	---	29.5	111.7	82.7
9.5	Dark brown clay	65.1	---	---	---	---	---	---	---	65.1		

Where: WWS = Mass of wet solids; w_c = Water content (ASTM D2216); LL = Liquid limit; PL = Plastic limit; PI = Plasticity index (ASTM D4318 wet preparation with LL by Method A); -200 = Fines content (ASTM D6913 or D1140); OC = Organic content (ASTM D2974-Method C); $CaCO_3$ = Carbonate content (ASTM D4373); G_s = Specific gravity (ASTM D854); γ_t = Total unit weight; and γ_d = Dry density.

The test data and all associated project information presented hereon shall be held in confidence and disclosed to other parties only with the authorization of the Client. Physical and electronic records of each project are kept for a minimum of 7 years. Test samples are kept in storage for at least 10 working days after mailing of the test report, prior to being discarded, unless a longer storage period is requested in writing and accepted by Ardaman & Associates, Inc.

Checked By: TM
Date: 07/31/18
Form SR-9 Rev.2



FINES CONTENT SPECIMEN

BORING B-4 : 1.0'-3.0'

ARDAMAN & ASSOCIATES, INC. GEOTECHNICAL TESTING LABORATORY
UNDISTURBED TUBE SAMPLE EXTRUSION TEST REPORT

CLIENT: GSE Engineering & Consulting, Inc.
PROJECT: Blue Springs Recharge
FILE NO.: 18-13-0066

DATE SAMPLE RECEIVED: -----
DATE SAMPLE EXTRUDED: 07/03/18
DATE REPORTED: 07/31/18

ASTM STANDARD D7263 TEST METHOD: ☒ Method B

BORING: **B-7**
SAMPLE: -----
DEPTH: 6.0 – 8.0 ☒ feet; ☐ meters
DATE SAMPLED: ------
TUBE TYPE: ☒ Steel ☐ SS ☐ Brass ☐ Plastic
SEAL TYPE: ☐ Wax ☐ Plugs ☒ Caps ☐ Other
TUBE CONDITION: Good
TUBE INSIDE DIAMETER (cm): 7.30
PHOTOGRAPHY OF EXTRUDED SAMPLE: ☒ Yes ☐ No

Tube Length (cm)	Length of Void		Sample Length		Change in Length (%)	Total WWS (grams)	Disturbed Soil Removed from Sample: ☐ Yes ☒ No		
	Top (cm)	Bottom (cm)	Inside Tube (cm)	Extruded (cm)			WWS (grams)	Length (cm)	Percentage of Total WWS (%)
76.0	23.0	1.3	51.7	51.5	-0.4	3,955	----	----	----

Length (cm)	Description	w_c (%)	-200 (%)	Atterberg Limits			OC (%)	$CaCO_3$ (%)	G_s	Tube Average		
				LL	PL	PI				w_c (%)	γ_t (lb/ft^3)	γ_d (lb/ft^3)
51.5	Light brown to brown clayey sand (SC)	35.9 38.5 35.4 37.0 34.2 33.1	29.4	---	---	---	---	---	---	35.6	114.0	84.1

Where: WWS = Mass of wet solids; w_c = Water content (ASTM D2216); LL = Liquid limit; PL = Plastic limit; PI = Plasticity index (ASTM D4318 wet preparation with LL by Method A); -200 = Fines content (ASTM D6913 or D1140); OC = Organic content (ASTM D2974-Method C); $CaCO_3$ = Carbonate content (ASTM D4373); G_s = Specific gravity (ASTM D854); γ_t = Total unit weight; and γ_d = Dry density.

Checked By: TM
Date: 07/31/18
Form SR-9 Rev.2

PERMEABILITY TEST SPECIMEN

BORING B-7: 6.0'-8.0'

ARDAMAN & ASSOCIATES, INC. GEOTECHNICAL TESTING LABORATORY
UNDISTURBED TUBE SAMPLE EXTRUSION TEST REPORT

CLIENT: GSE Engineering & Consulting, Inc.
PROJECT: Blue Springs Recharge
FILE NO.: 18-13-0066

DATE SAMPLE RECEIVED: ----
DATE SAMPLE EXTRUDED: 07/03/18
DATE REPORTED: 07/31/18

ASTM STANDARD D7263 TEST METHOD: ☒ Method B

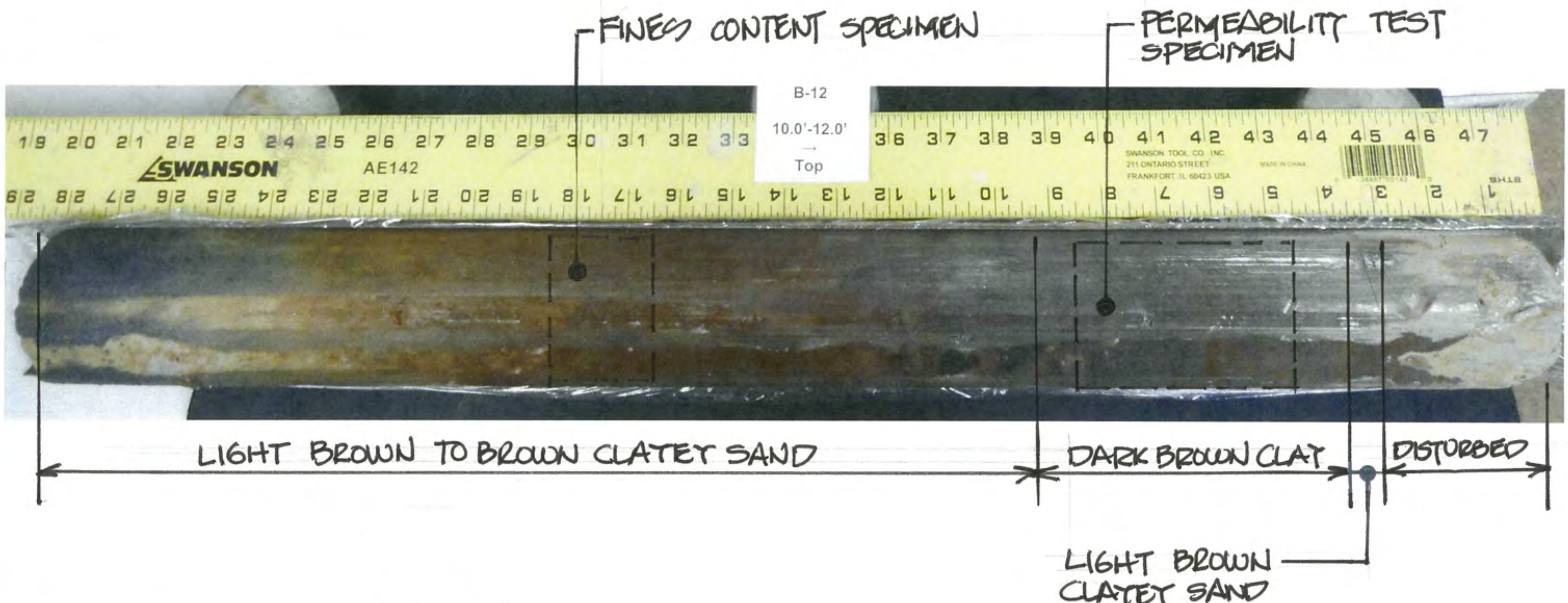
BORING: **B-12**
SAMPLE: ---
DEPTH: 10.0 – 12.0 ☒ feet; ☐ meters
DATE SAMPLED: ------
TUBE TYPE: ☒ Steel ☐ SS ☐ Brass ☐ Plastic
SEAL TYPE: ☐ Wax ☐ Plugs ☒ Caps ☐ Other
TUBE CONDITION: Good
TUBE INSIDE DIAMETER (cm): 7.30
PHOTOGRAPHY OF EXTRUDED SAMPLE: ☒ Yes ☐ No

Tube Length (cm)	Length of Void		Sample Length		Change in Length (%)	Total WWS (grams)	Disturbed Soil Removed from Sample: ☒ Yes ☐ No		
	Top (cm)	Bottom (cm)	Inside Tube (cm)	Extruded (cm)			WWS (grams)	Length (cm)	Percentage of Total WWS (%)
76.1	5.5	0.0	70.6	69.2	-2.0	5,374	444.34	7.5	8.3

Length (cm)	Description	w_c (%)	-200 (%)	Atterberg Limits			OC (%)	$CaCO_3$ (%)	G_s	Tube Average		
				LL	PL	PI				w_c (%)	γ_t (lb/ft^3)	γ_d (lb/ft^3)
1.0	Light brown clayey sand (SC)	---	---	---	---	---	---	---	---	---	119.0	87.6
15.0	Dark brown clay	69.5 73.9 40.4	85.4	---	---	---	---	---	---	61.3		
45.7	Light brown to brown clayey sand	28.1 27.6 27.3	27.5	---	---	---	---	---	---	27.7		

Where: WWS = Mass of wet solids; w_c = Water content (ASTM D2216); LL = Liquid limit; PL = Plastic limit; PI = Plasticity index (ASTM D4318 wet preparation with LL by Method A); -200 = Fines content (ASTM D6913 or D1140); OC = Organic content (ASTM D2974-Method C); $CaCO_3$ = Carbonate content (ASTM D4373); G_s = Specific gravity (ASTM D854); γ_t = Total unit weight; and γ_d = Dry density.

Checked By: TM
Date: 07/31/18
Form SR-9 Rev.2



BORING B-12: 10.0' - 12.0'

ARDAMAN & ASSOCIATES, INC. GEOTECHNICAL TESTING LABORATORY
HYDRAULIC CONDUCTIVITY TEST REPORT

CLIENT: GSE Engineering & Consulting, Inc.
PROJECT: Blue Springs Recharge
FILE NO.: 18-13-0066
DATE SAMPLE RECEIVED: --- SET UP: 07/03/18
DATE REPORTED: 07/31/18

INCOMING LABORATORY SAMPLE NO.: **BORING B-7: 6.0' – 8.0'**
LABORATORY IDENTIFICATION NO.: 180066/B7
SAMPLE DESCRIPTION: Light brown to brown clayey sand (SC)

ASTM STANDARD D5084 TEST METHOD:

- ☒ A - Constant Head
- ☐ B - Falling Head; Constant Tailwater
- ☐ C - Falling Head; Rising Tailwater
- ☐ D – Constant Rate of Flow
- ☐ F - Constant Volume; Falling Head - Rising Tailwater

PERMEANT: ☒ Deaired Tap Water ☐ Other

SPECIFIC GRAVITY, G_s: 2.70 ☒ Assumed ☐ Measured

B-factor: ---- % ☐ Beginning of Test; ☐ End of Test

$\Delta\sigma_c$ (lb/in²): ----

SPECIMEN PREPARATION			
Type	Diameter (inch)	Diameter Trimmed	
☒ Undisturbed Sample	3.0	☐ Yes	☒ No
☐ Drive Cylinder		☐ Yes	☐ No
☐ Rock Core		☐ Yes	☐ No
Compacted	☐ Tamped Uniform Lifts:	No. of Lifts:	
	☐ Kneading:	No. of Lifts ____ Spring ____ lb. Blows per Lift ____	
☐ Other			

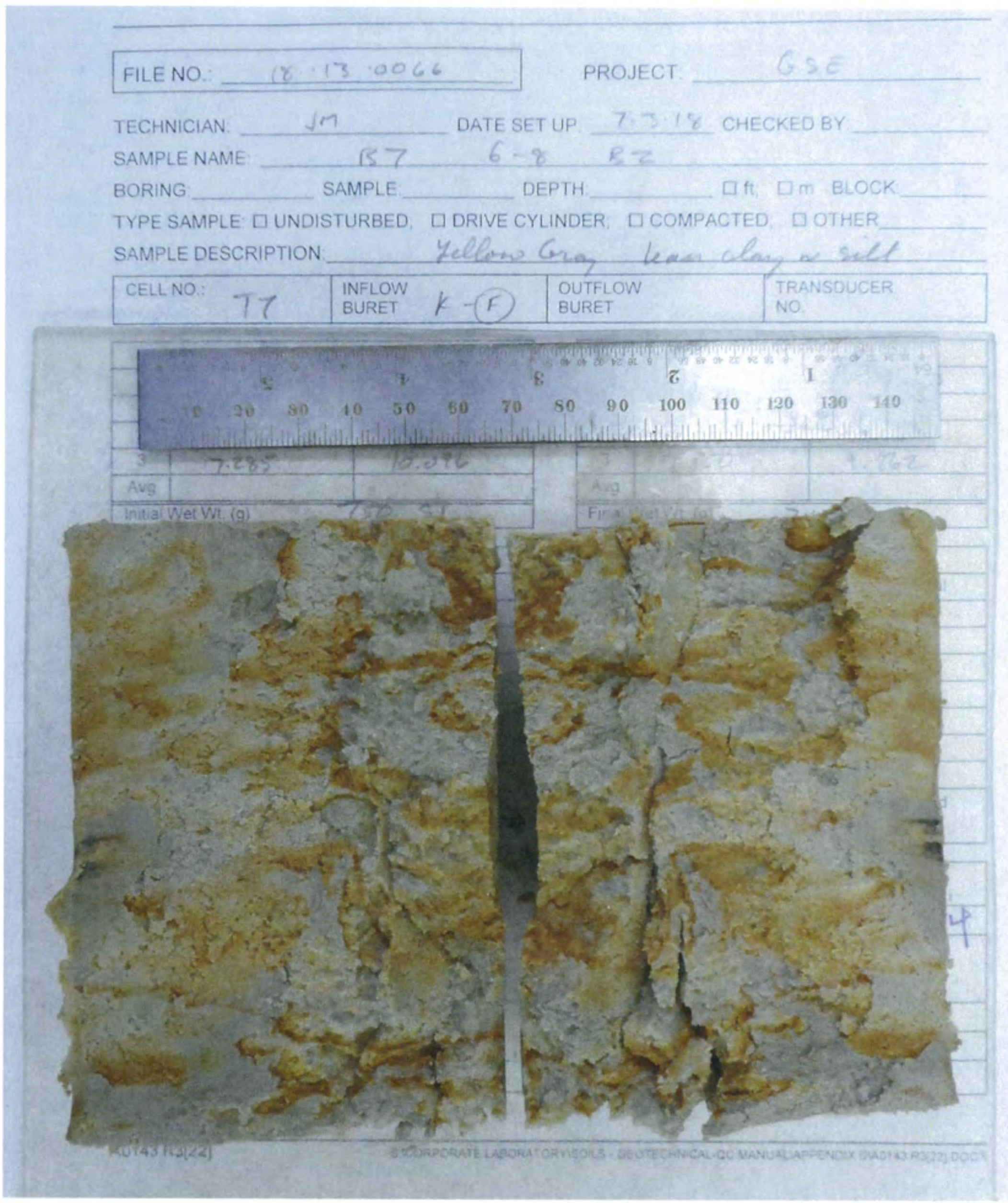
Initial Conditions							Test Conditions						Final Conditions						Hydraulic Conductivity
H (cm)	D (cm)	V_o (cm³)	WDS (grams)	w_c (%)	γ_d (lb/ft³)	S (%)	σ'_c (lb/in²)	u_b (lb/in²)	i_{avg}	Q_{avg} (cm³)	Flow Ratio $[Q_o/Q_i]$	Σt (days)	H (cm)	V_f (cm³)	$\Delta V/V_o$ (%)	w_c (%)	γ_d (lb/ft³)	S (%)	k_{20} (cm/sec)
10.088	7.249	416.39	547.79	37.0	82.1	95	5	185	14.5	3.00	1.05	1	9.860	400.99	-3.7	35.5	85.2	98	**1.4E-05**

Particle-Size Analysis		U.S. Standard Sieve Size	Gravel				Coarse Sand	Medium Sand		Fine Sand			
☒ ASTM D6913 ☐ ASTM D1140-Method B			1"	3/4"	3/8"	No. 4	No. 10	No. 20	No. 40	No. 60	No. 100	No. 140	No. 200
Dry Mass (grams)	263.49	Soil Passing (%, dry mass basis)	100	100	100	100	100	100	100	99.6	97.7	44.0	29.4

The test data and all associated project information presented hereon shall be held in confidence and disclosed to other parties only with the authorization of the Client. Physical and electronic records of each project are kept for a minimum of 7 years. Test samples are kept in storage for at least 10 working days after mailing of the test report, prior to being discarded, unless a longer storage period is requested in writing and accepted by Ardaman & Associates, Inc.

Where: H = Specimen height; D = Specimen diameter; V_o = Initial volume; WDS = Dry mass; w_c = Water content (ASTM D2216); γ_d = Dry density; S = Saturation; σ'_c = Isotropic effective consolidation stress; u_b = Back-pressure; i_{avg} = Average hydraulic gradient; Q_{avg} = Flow volume $[(Q_o+Q_i)/2]$; Q_o= Outflow volume; Q_i= Inflow volume; Σt = Test duration; V_f = Final volume; $\Delta V/V_o$ = Volume change ("-" denotes consolidation, "+" denotes swelling); and k_{20} = Saturated hydraulic conductivity at 20°C.

Checked By: TM
Date: 07/31/18


FILE NO.: 18·13·0066
PROJECT: GSE
TECHNICIAN: JM
DATE SET UP: 7·3·18
CHECKED BY:
SAMPLE NAME: B7 6-8 B2
BORING: SAMPLE: DEPTH: ☐ ft; ☐ m BLOCK:
TYPE SAMPLE: ☐ UNDISTURBED; ☐ DRIVE CYLINDER; ☐ COMPACTED; ☐ OTHER
SAMPLE DESCRIPTION: Yellow Gray lean clay w silt
CELL NO.: T7
INFLOW BURET K-(F)
OUTFLOW BURET
TRANSDUCER NO.
Avg
Initial Wet Wt. (g)

ARDAMAN & ASSOCIATES, INC. GEOTECHNICAL TESTING LABORATORY
HYDRAULIC CONDUCTIVITY TEST REPORT

CLIENT: GSE Engineering & Consulting, Inc.
PROJECT: Blue Springs Recharge
FILE NO.: 18-13-0066
DATE SAMPLE RECEIVED: --- SET UP: 07/03/18
DATE REPORTED: 07/31/18

INCOMING LABORATORY SAMPLE NO.: **BORING B-12: 10.0' – 12.0'**
LABORATORY IDENTIFICATION NO.: 180066/B12
SAMPLE DESCRIPTION: Dark brown clay

ASTM STANDARD D5084 TEST METHOD:
- ☒ A - Constant Head
- ☐ B - Falling Head; Constant Tailwater
- ☐ C - Falling Head; Rising Tailwater
- ☐ D – Constant Rate of Flow
- ☐ F - Constant Volume; Falling Head - Rising Tailwater

PERMEANT: ☒ Deaired Tap Water ☐ Other ______

SPECIFIC GRAVITY, G_s: 2.70 ☒ Assumed ☐ Measured

B-factor: 100 % ☐ Beginning of Test; ☒ End of Test

$\Delta\sigma_c$ (lb/in^2): 8.4; 13.3; 16.7

SPECIMEN PREPARATION		
Type	Diameter (inch)	Diameter Trimmed
☒ Undisturbed Sample	3.0	☐ Yes ☒ No
☐ Drive Cylinder		☐ Yes ☐ No
☐ Rock Core		☐ Yes ☐ No
Compacted	☐ Tamped Uniform Lifts: No. of Lifts: ______	
	☐ Kneading: No. of Lifts ______ Spring ______ lb. Blows per Lift ______	
☐ Other		

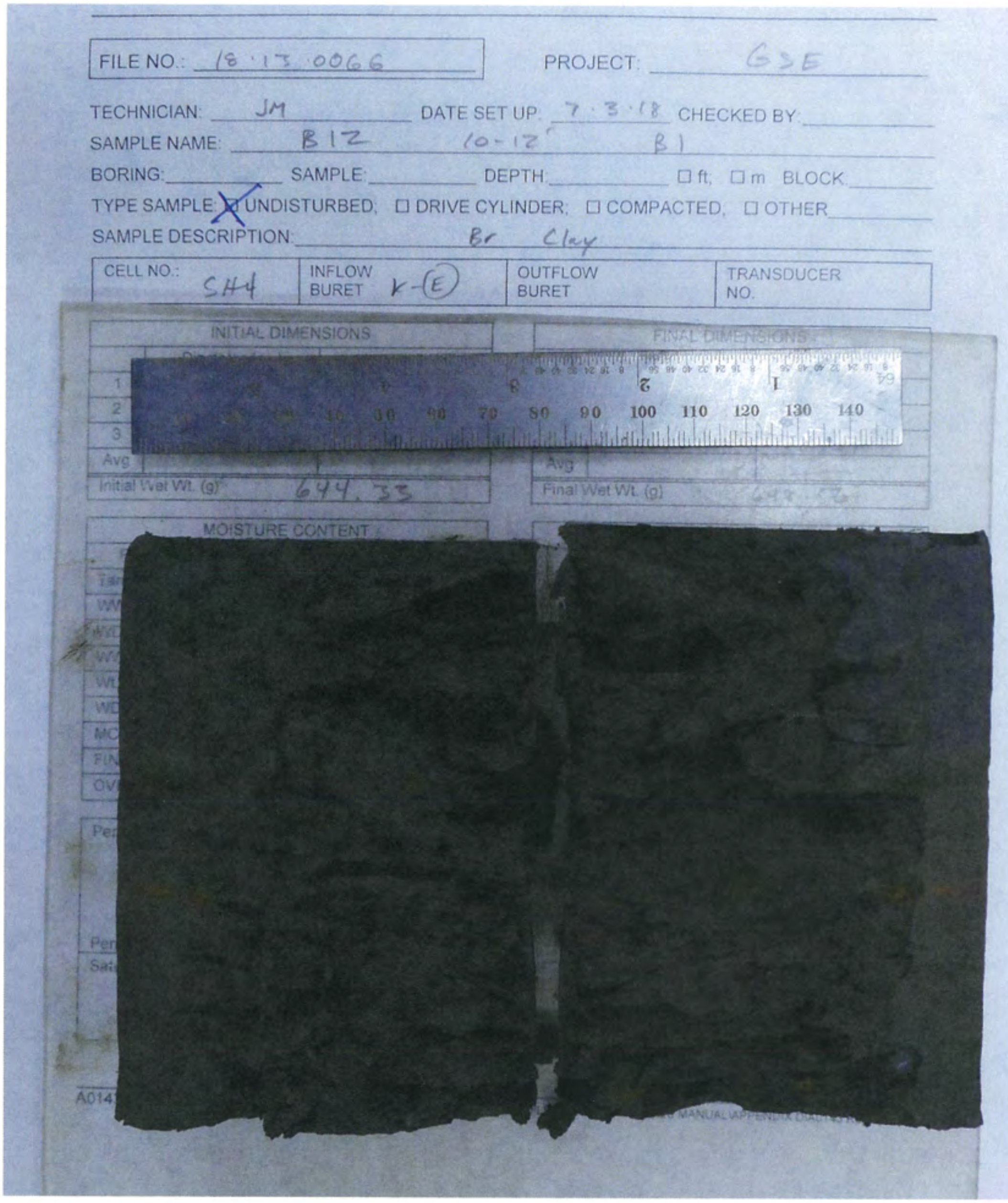
Initial Conditions							Test Conditions						Final Conditions						Hydraulic Conductivity
H (cm)	D (cm)	V_o (cm^3)	WDS (grams)	w_c (%)	γ_d (lb/ft^3)	S (%)	σ'_c (lb/in^2)	u_b (lb/in^2)	i_{avg}	Q_{avg} (cm^3)	Flow Ratio [Q_o/Q_i]	Σt (days)	H (cm)	V_f (cm^3)	$\Delta V/V_o$ (%)	w_c (%)	γ_d (lb/ft^3)	S (%)	k_{20} (cm/sec)
10.174	7.246	419.52	370.46	73.9	55.1	97	5	185	15.6	2.81	1.17	8	10.049	416.99	-0.6	75.1	55.4	99	**2.0E-08**

Particle-Size Analysis		U.S. Standard Sieve Size	Gravel				Coarse Sand	Medium Sand		Fine Sand			
☐ ASTM D6913 ☒ ASTM D1140-Method B			1"	3/4"	3/8"	No. 4	No. 10	No. 20	No. 40	No. 60	No. 100	No. 140	No. 200
Dry Mass (grams)	369.82	Soil Passing (%, dry mass basis)	---	---	---	---	---	---	---	---	---	---	85.4

The test data and all associated project information presented hereon shall be held in confidence and disclosed to other parties only with the authorization of the Client. Physical and electronic records of each project are kept for a minimum of 7 years. Test samples are kept in storage for at least 10 working days after mailing of the test report, prior to being discarded, unless a longer storage period is requested in writing and accepted by Ardaman & Associates, Inc.

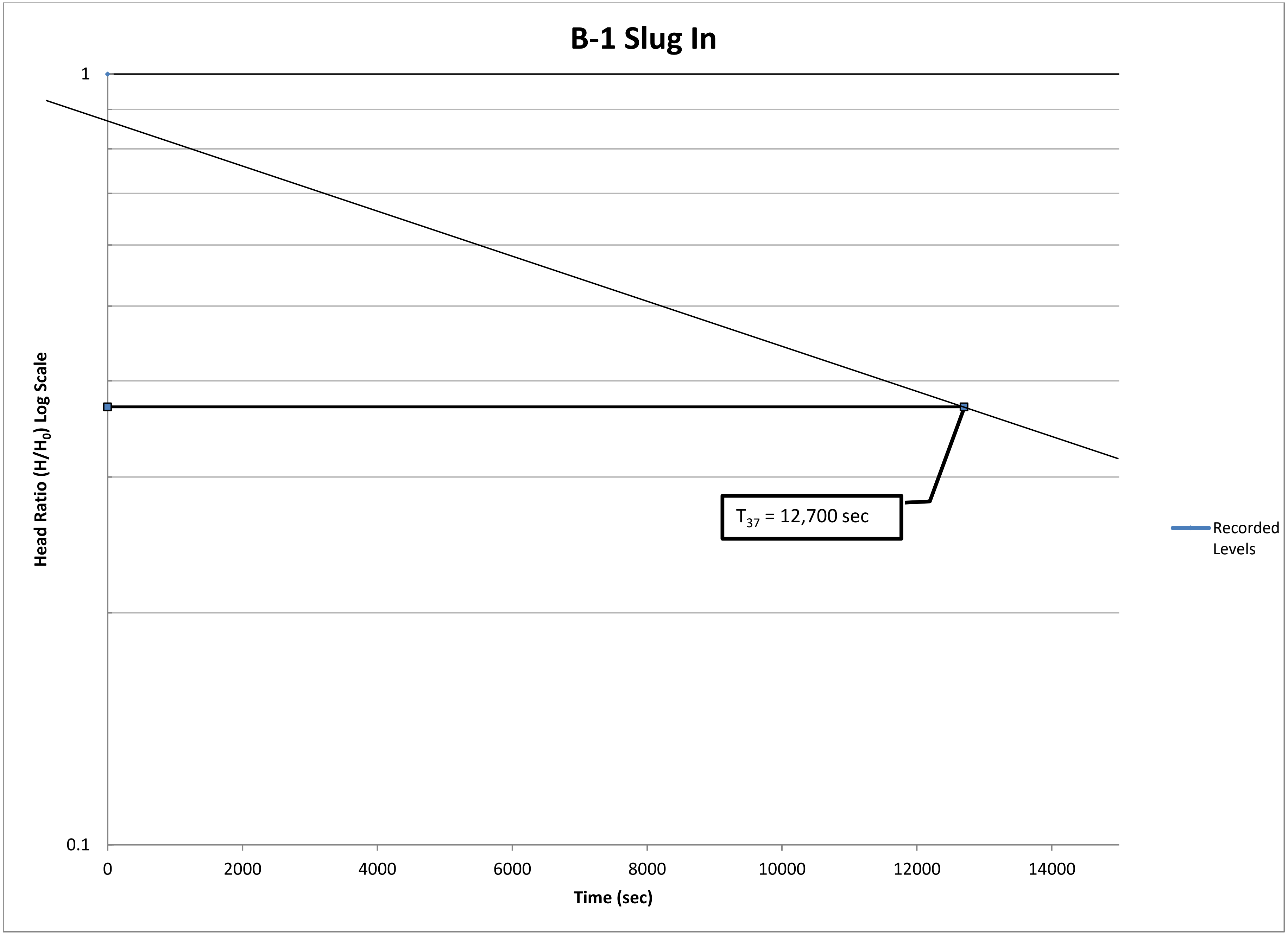
Where: H = Specimen height; D = Specimen diameter; V_o = Initial volume; WDS = Dry mass; w_c = Water content (ASTM D2216); γ_d = Dry density; S = Saturation; σ'_c = Isotropic effective consolidation stress; u_b = Back-pressure; i_{avg} = Average hydraulic gradient; Q_{avg} = Flow volume [$(Q_o+Q_i)/2$]; Q_o= Outflow volume; Q_i= Inflow volume; Σt = Test duration; V_f = Final volume; $\Delta V/V_o$ = Volume change ("-" denotes consolidation, "+" denotes swelling); and k_{20} = Saturated hydraulic conductivity at 20°C.

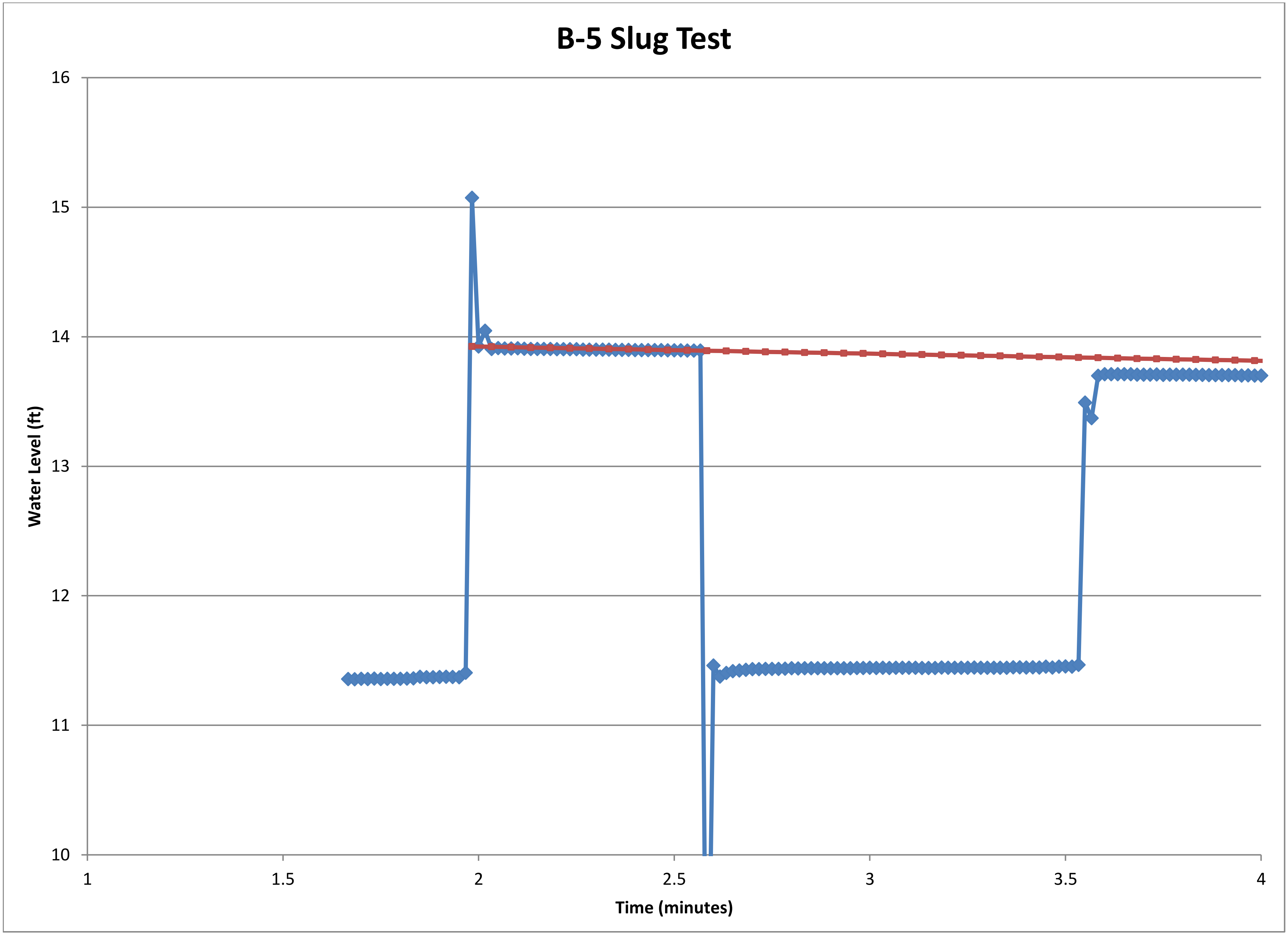
Checked By: TM
Date: 07/31/18


FILE NO.: 18.13.0066
PROJECT: G3E
TECHNICIAN: JM
DATE SET UP: 7.3.18
CHECKED BY:
SAMPLE NAME: B12 10-12' B1
BORING:
SAMPLE:
DEPTH:
ft, m
BLOCK:
TYPE SAMPLE: UNDISTURBED; DRIVE CYLINDER; COMPACTED; OTHER
SAMPLE DESCRIPTION: Br Clay
CELL NO.: SH4
INFLOW BURET K-(E)
OUTFLOW BURET
TRANSDUCER NO.
INITIAL DIMENSIONS
FINAL DIMENSIONS
Avg
Initial Wet Wt. (g) 644.33
Final Wet Wt. (g)
MOISTURE CONTENT

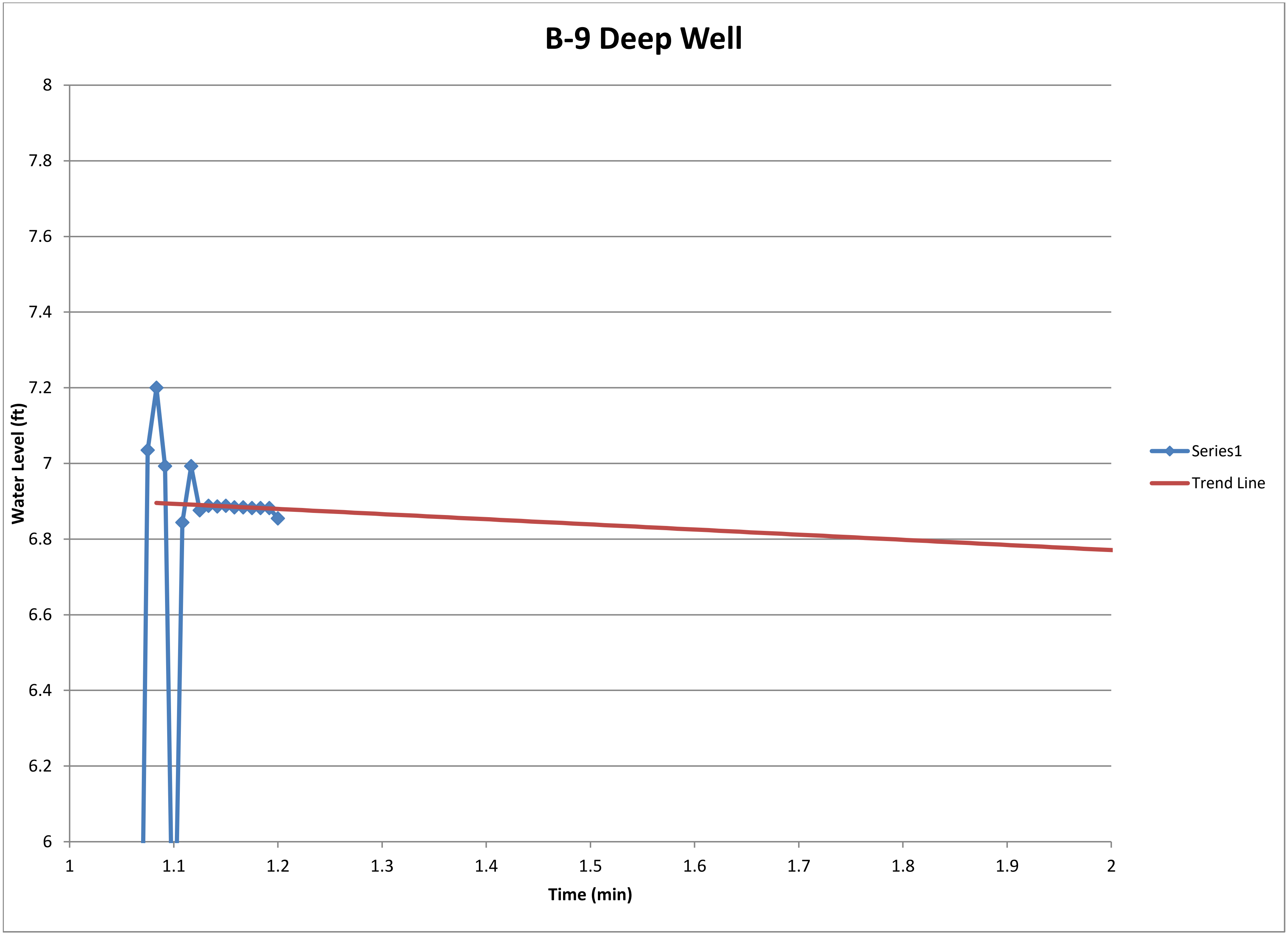
Appendix D

Slug Test Data

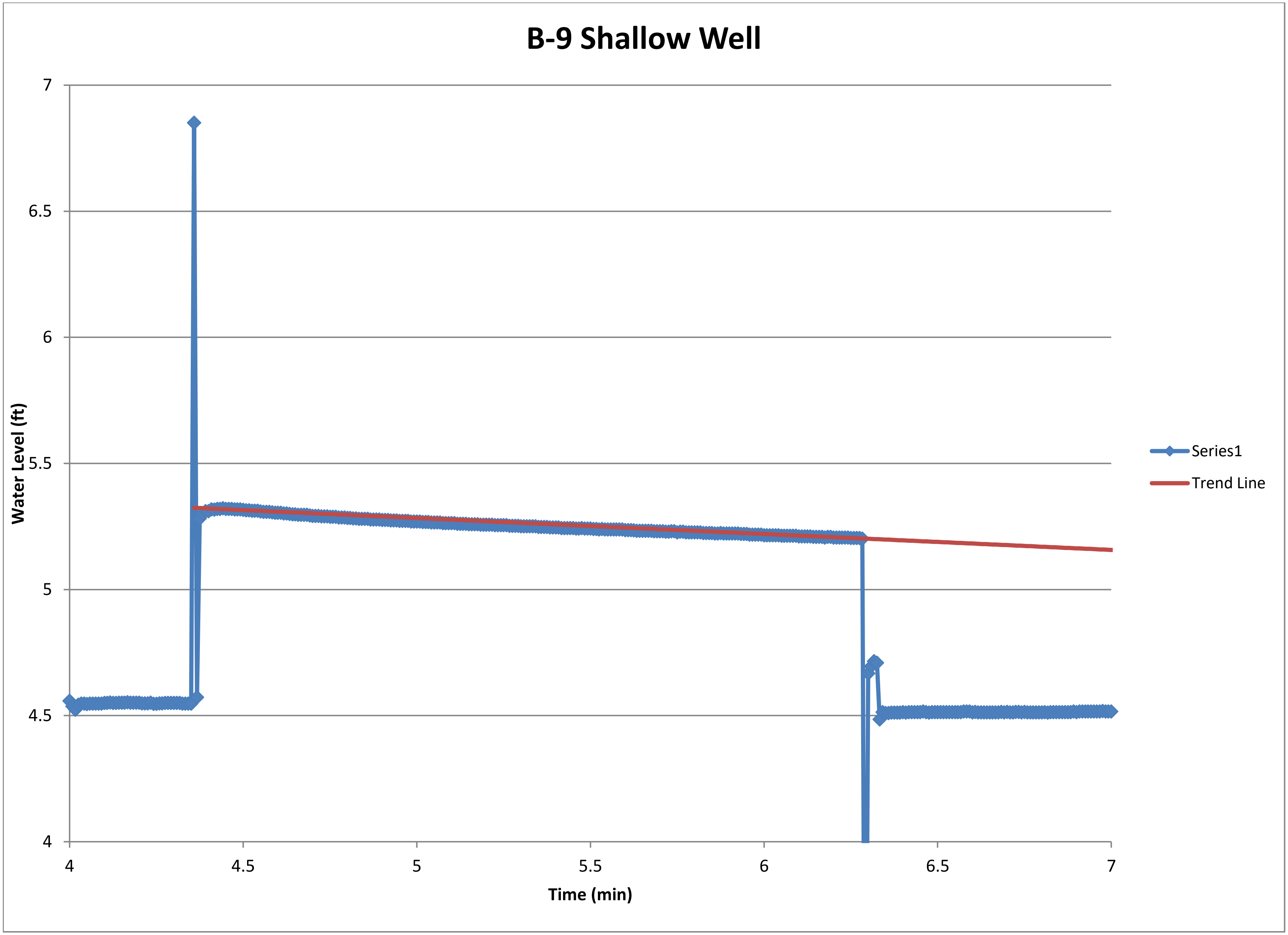

B-1 Slug In
1
0.1
Head Ratio (H/H0) Log Scale
T37 = 12,700 sec
Recorded Levels
0
2000
4000
6000
8000
10000
12000
14000
Time (sec)



B-5 Slug Test
Water Level (ft)
16
15
14
13
12
11
10
1
1.5
2
2.5
3
3.5
4
Time (minutes)



B-9 Deep Well
Water Level (ft)
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
Time (min)
Series1
Trend Line


B-9 Shallow Well
Water Level (ft)
7
6.5
6
5.5
5
4.5
4
4
4.5
5
5.5
6
6.5
7
Time (min)
Series1
Trend Line

Appendix E

Source Water Quantity and Quality Evaluation

Volusia Blue Recharge Preliminary Design Report

Report prepared by:

Mead & Hunt
4401 Eastport Parkway
Port Orange, FL. 32127
(386) 761-6810

December 18, 2018

Table of Contents

List of Tables

1. Introduction

The West Volusia Water Supply (WVWS) utility providers and SJRWMD have proposed to jointly participate in development of an aquifer recharge site in Orange City to receive a combination of reclaimed water, surface water, and stormwater. This project is intended to provide additional water quantity to the Spring for Blue Spring Minimum Flow Regime (MFR) compliance. This report also analyzes water quality for potential impacts to the Blue Spring Total Maximum Daily Load (TMDL). This project has two (2) elements: 1) enhance recharge within Blue Spring and 2) treat reclaimed water and stormwater to reduce nitrate (NO_3). The subject site is a 60+ acre borrow pit located approximately one (1) mile from Blue Spring.

This report evaluates water quality characteristics of the proposed source water being directed to the Borrow Pit. Water sources under consideration include effluent from five (5) wastewater facilities, and surface water from the St. Johns River and Lake Monroe. This report also identifies potential routes for reclaimed water transmission piping from the existing, interconnected reclaimed water distribution system, to the project location. It includes hydraulic modeling to determine if there is sufficient capacity within the existing distribution system to properly load the Borrow Pit site.

2. Existing Conditions

The WVWS member utilities include: DeLand, Deltona, Orange City, and Volusia County. Three utilities operate wastewater treatment plants, Orange City sends sewage to Volusia County for treatment. The WVWS group has five (5) wastewater treatment plants (WWTP) within a 13-mile radius of the Borrow Pit. Recently constructed projects have interconnected the reclaimed water system of each of the five (5) systems to one another, herein after called “the system”. The five (5) WWTP’s are listed below and ***Figure 1*** illustrates the location of each WWTP and the Borrow Pit.

- Wiley M. Nash (DeLand), AWT*
- Deltona North/Southwest #2 (Volusia County), will be decommissioned/converted to a regional lift station and convey flow to the Southwest Regional Plant
- Southwest Regional (Volusia County), AWT*
- Deltona Lakes (Deltona)
- Deltona East (Deltona), AWT*

*AWT refers to advanced wastewater treatment

The reclaimed water system includes five (5) WWTPs, all plants produce public access reclaimed water. Three (3) of the five (5) produce AWT quality effluent with total nitrogen concentrations of or below 3 mg/L. AWT facilities are identified in the list above. In addition to influent flow, Deland’s Wiley M. Nash facility can receive and treat up to 4.0 MGD of surface water from the St. Johns River (SJR). Additionally, Deltona is constructing new surface water treatment facilities at the Alexander Avenue site, that can provide up to 6.0 MGD of alternative water from stormwater sources and surface water from Lake Monroe. The overall distribution system is comprised of piping varying in size from 4-inch to 24-inch. ***Figure 2*** depicts the configuration of the current system and includes proposed projects in the north end of the system. It is pressurized to 70± psi and supplied by variable speed high service pump stations at each WWTP.

The reclaimed water distribution network depicted on Figure #2 currently operates as three (3) separate pressurized distribution systems. Each is owned and controlled by their respective utilities. The systems are interconnected with two (2) control valves sites, A.K.A. interconnect vaults #1 and #2. Flow from Sanford’s reuse system is also available via an interconnect from the south.

In order to supply the proposed system, the utilities will need to implement an operational protocol that provides for unrestricted movement of water and accounting for same.

Mead & Hunt

West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 1

WWTP's & Borrow Pit Locations

Path: \\corp.meadhunt.com\sharedfolders\entp\4565700\181420.01\TECH\CAD\GIS\Figures\Figure 2 - Existing Reclaimed Water Distribution System.mxd

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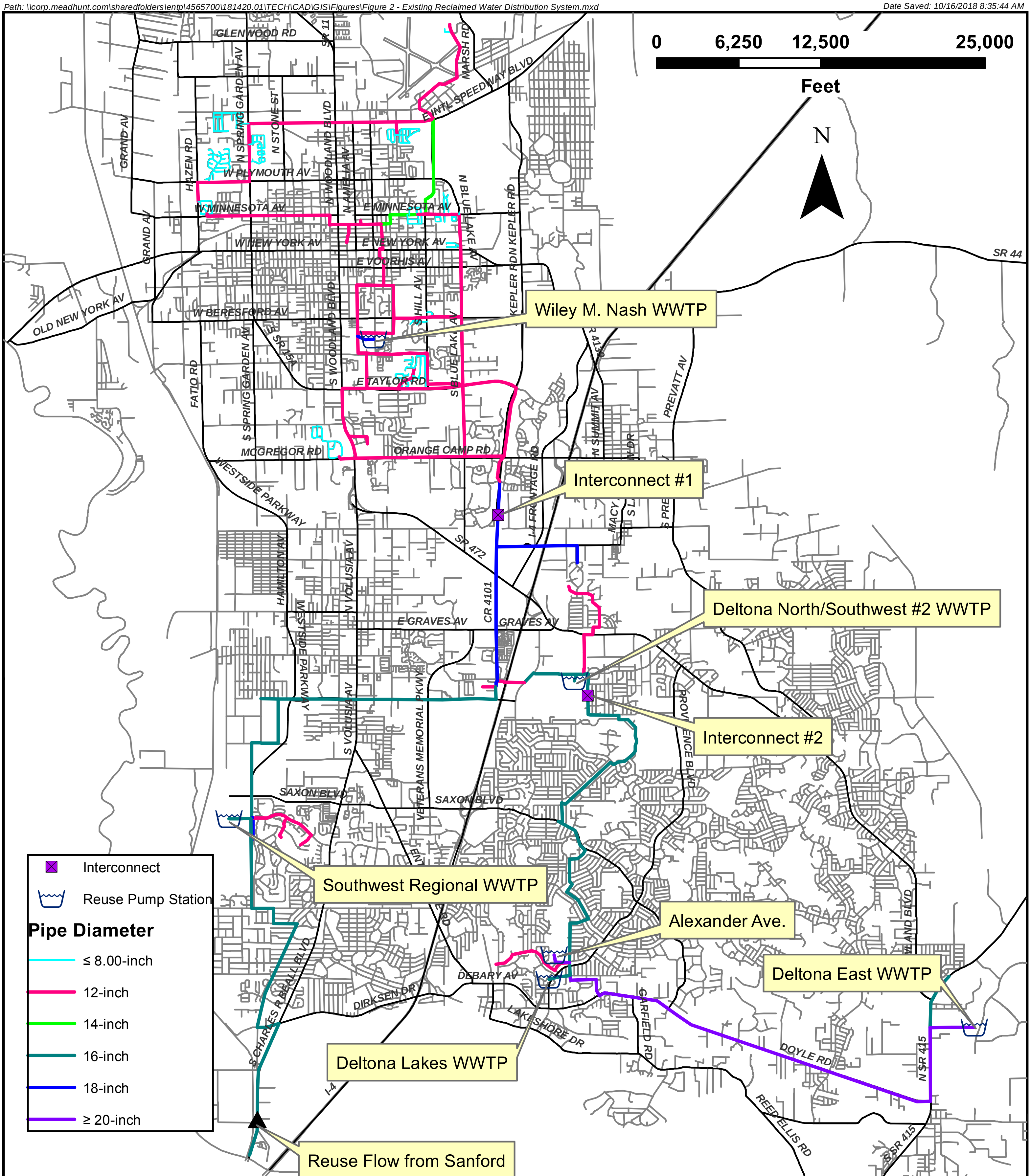


West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 2 Proposed Reclaimed Water Distribution System

A. Hydraulic Model

The modeling software used for this study is Innovyze InfoWater 12.3, Update #7. This software can perform hydraulic modeling tracking flow rates, pressures, velocities, and many other parameters based upon system demand and head conditions.

The demand within the model was based on the design capacity and major users listed in the operating permits of each WWTP. Within the model, a node with the corresponding demand, in gallons per minutes (GPM) was placed at each major users' location. The WWTP's that list on-site irrigation as a major user had the appropriate demand loaded into the model at the node closest to the WWTP location. The residential irrigation demand listed in the WWTP permits was distributed evenly throughout the corresponding service area, based upon neighborhoods served.

Examining the most recent, July 2018, discharge monitoring reports (DMR) for each facility, the combined effluent reclaimed water flows are approximately 7.0 MGD. ***Table 1*** shows the annual average effluent flows for each WWTP. For the purposes of this report 7.0 MGD is considered the existing average daily reclaimed water demand.

Under various demand scenarios, reclaimed water demands nodes preferentially pull water from certain WWTP's at rates higher than the given WWTP's production capacity. This is due to the proximity of demand in relation to points of supply. Flow control valves (FCV's) were placed in the model at each WWTP and set to the corresponding capacity at each WWTP (***Table 2***). This better represents a steady state condition where each WWTP is supplying its production capacity to the overall system. In practice, a protocol would need to be established to manage demands and that could entail re-pumping at Southwest Regional. Additional system improvements will also be necessary as the system grows and demand increases. These are further detailed in Section 4.

Table 1: Annual Average Effluent Flows

	Wiley M. Nash WWTP	Deltona North/Southwest #2 WWTP	Southwest Regional WWTP	Deltona Lakes WWTP	Deltona East WWTP
Flow to Public Access Reuse (mgd)	2.8	0.119	0.884	0.191	0.062
Flow to On-Site RIB (mgd)		0.07	0.234	0.124	0.323
Flow to Terra Alta RIB (mgd)			0.064		
Flow to Four Towns RIB (mgd)			0.126		
Flow to Del. North RIB (mgd)			0.043		
Flow to Alexander Ave. RIB (mgd)				-	
Flow to Deltona Hills Golf Course (mgd)				0.262	
Flow to On-site Irrigation (mgd)				0.262	
Total	**2.8**	**0.19**	**1.35**	**0.84**	**0.39**

Table 2: Wastewater Treatment Plant Capacities

Plant Name	Design Capacity (MGD)	Design Effluent Total Nitrogen (mg/L)
Wiley M. Nash WWTP	6.0	3.0
Deltona North/Southwest #2 WWTP	0.6	12.0
Southwest Regional WWTP	1.2	3.0
Deltona Lakes WWTP	1.4	12.0
Deltona East WWTP	1.0	3.0
Total	**10.2**	**4.73***

* Composite Average

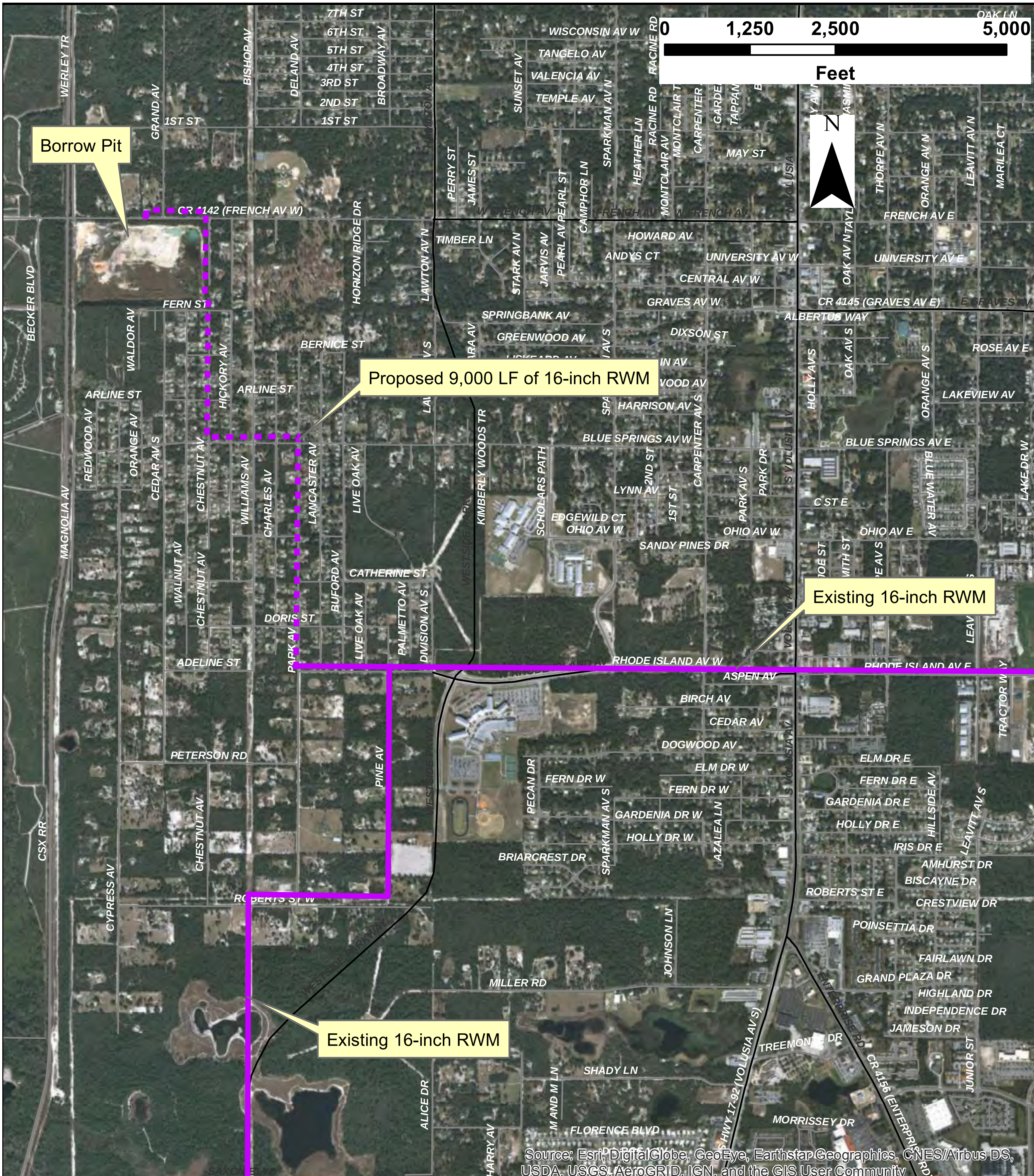
3. Proposed Conditions

The proposed project is a Borrow Pit site located on W. French Ave in Orange City. The objective of this project is to load the site with augmented, public access, reclaimed water. The loading rate will be limited by existing groundwater and soil conditions that will constrain the site's ability to absorb supplemental water without negatively affecting adjacent property owners or groundwater conditions in the surrounding area. The loading rate will also be constrained by the site's ability to absorb and reduce nitrate (NO_3) that recharges to groundwater. For the purpose of hydraulic modeling, a 2.5 MGD loading rate is proposed, that is the rate determined to achieve 2.0 MGD of recharge. To model the additional flow, a node with a 2.5 MGD demand was placed at the Borrow Pit site. Placement of the demand node was determined based on the elevations of the site. Elevations vary from 10-16 feet above sea level (NGVD '88) within the property boundary. A demand node with elevation 60, located on the northern side of the site, was chosen to have the 2.5 MGD demand.

The nearest reclaimed water main (RWM), one neighborhood south of the Borrow Pit, is a 16-inch RWM on Adeline Street, it is fed from two (2) directions. The shortest and most efficient route to the north side of the Borrow Pit is north on Park Avenue to W. Blue Springs Ave., west on W. Blue Springs Ave to Chestnut Ave. and north on Chestnut Ave. From Chestnut Ave. around the property line of the Borrow Pit to the Northern side of the site. ***Figure 3*** shows the proposed piping configuration, 9,000 LF of 16-inch diameter PVC or HDPE equivalent.

Path: X:\4565700\181420.01\TECH\CAD\GIS\Figures\Figure 3 - Proposed RWM Route.mxd

Date Saved: 10/12/2018 8:26:33 AM



Mead & Hunt	**West Volusia Water Suppliers** **Volusia Blue Recharge PDR**	***FIGURE 3*** ***Proposed RWM Route***

4. Model Results

As previously stated, 7.0 MGD was assumed to be the average day flow (ADF) under existing conditions. It is known, throughout the system, that the retail reclaimed customers mainly consume reclaimed water during the night. To model this situation, two (2) demand scenarios were conducted within the model, a nighttime demand set, and a daytime demand set.

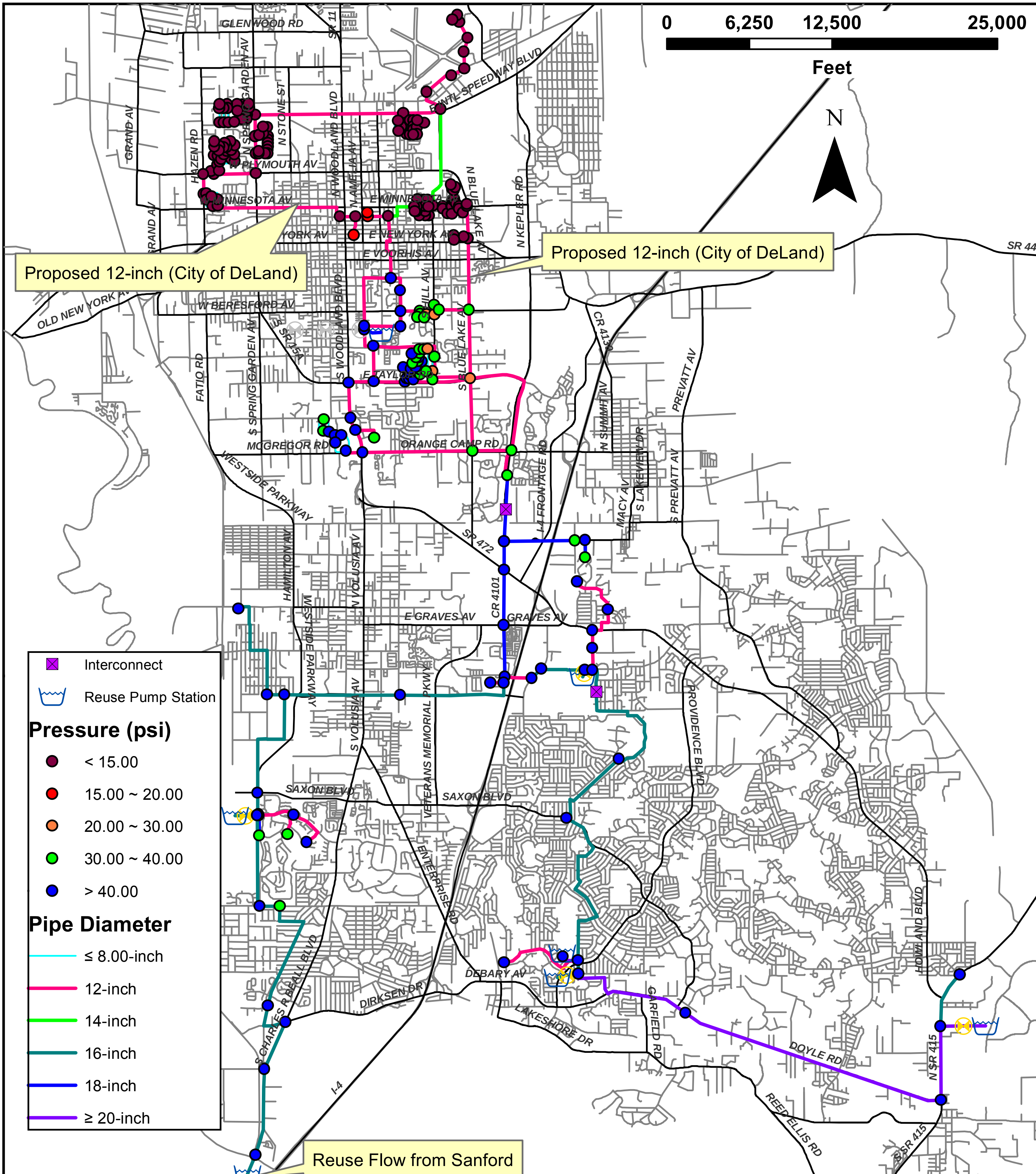
During different model scenarios, the north side of DeLand's system, north of S.R. 44 experiences low pressures. The City of DeLand is aware of these limitations and is researching options to satisfy demand while maintaining pressure. One option could be to construct two (2) 12-inch segments creating a loop. The first segment along Minnesota Ave from Forest Trace to E. Michigan Ave. and the second segment from Pup Fish Ln. along S. Blue Lake Ave. to E. Beresford Ave. For purposes of this report, this loop is shown as "Proposed 12-inch (City of DeLand)." This solution works for current flows but if future buildout is anticipated, additional storage and pumping will be required.

A. Scenario 1 – Nighttime Scenario

During the nighttime demand scenario, the RIB's within the system were turned off as the WWTPs do not currently fill unless there is excess flow. The retail reclaimed customers, residential and commercial, typically consume reclaimed water over an eight (8) hr. period during the night. To model these demands a peaking factor (P.F) of 3.0 is applied to the retail residential demands. During the night it is assumed that the Borrow Pit will be filling at 700 gpm, this is offset by a Borrow Pit demand of 2,100 gpm from 6:00 AM to 10:00 PM. This filling strategy will provide approximately 2.5 MGD to the Borrow Pit. The total demand applied to the system in the model for the nighttime scenario is 12,500 gpm.

With these demands placed in the model, the system has no issues with the exception of extremely low pressures in the north portion of DeLand. The majority of pressures throughout the system excluding north DeLand, range between approximately 30 and 92 psi. ***Figures 4 and 5*** depict the system pipe diameters, pressure, and velocity results of Scenario 1.

While the current system is capable of supporting the Borrow Pit. It involves purchasing water and utilizing the Sanford interconnect to sustain pressures in the system above 30 psi (excluding north DeLand). An alternative to using the Sanford interconnect to aide with boosting pressures is the construction of an additional 16-inch pipe connecting the Deltona Lakes and Southwest Regional WWTP's creating a loop. This loop provides approximately the same pressures throughout the system as the Sanford interconnect does. This 16-inch would be constructed along Highbanks Rd., Enterprise Rd., and Debary Ave. Including this pipeline in the model and turning off the flow from Sanford, pressures (excluding North DeLand) range from 30 to 92 psi. Results including the 16-inch future pipe are shown on ***Figures 6 and 7.***



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Volusia Blue Recharge PDR

FIGURE 4
Nighttime Existing Conditions Pressure & Diameter

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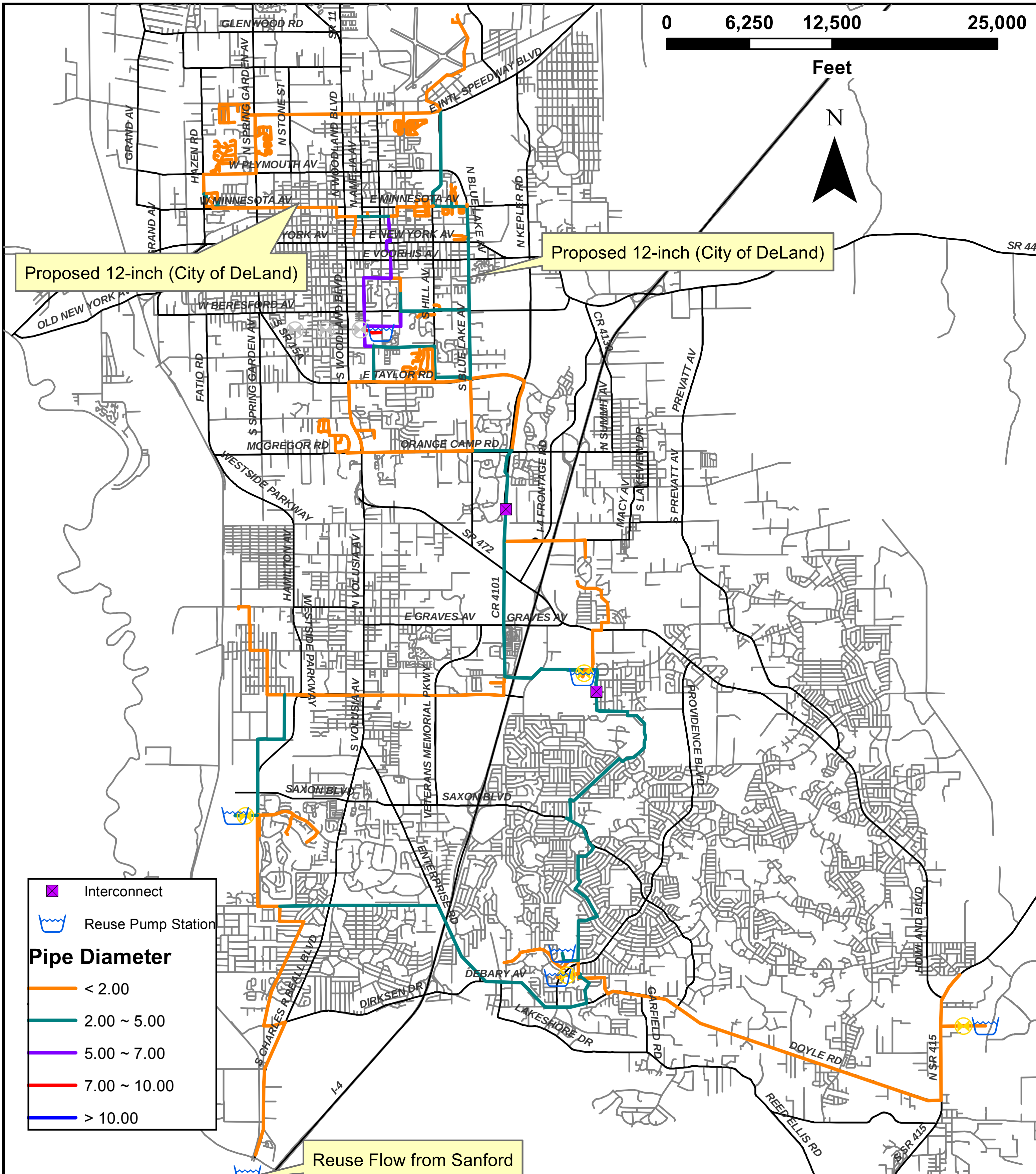

Mead & Hunt

West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 5
Nighttime Existing Conditions Velocity

Path: X:\4565700\181420.01\TECH\CAD\GIS\Figures\Figure 6 - Nighttime Future Existing Pressure & Diameter.mxd

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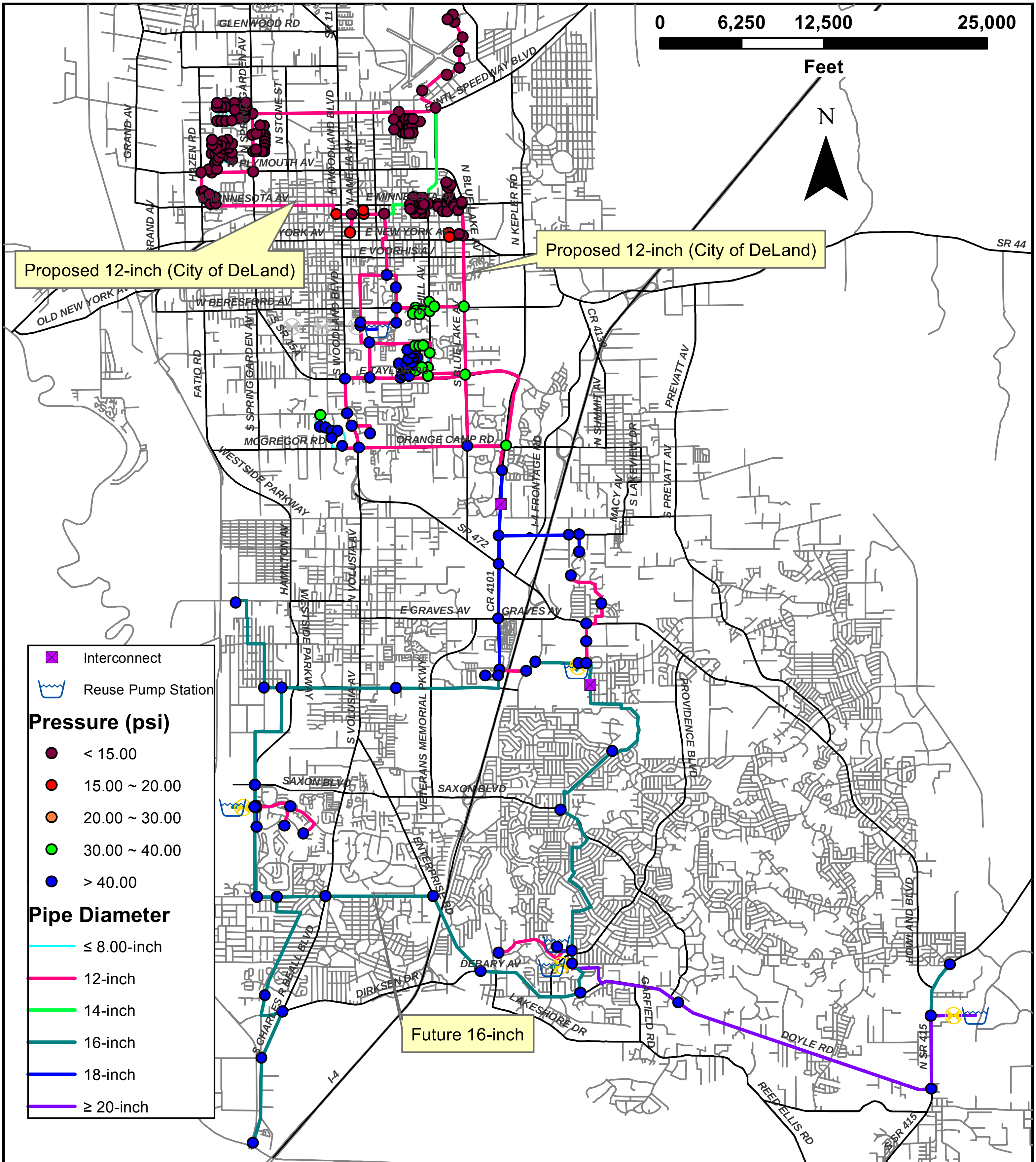

Mead & Hunt	**West Volusia Water Suppliers** **Volusia Blue Recharge PDR**	***FIGURE 6*** ***Nighttime Future 16-inch Pressure & Diameter***

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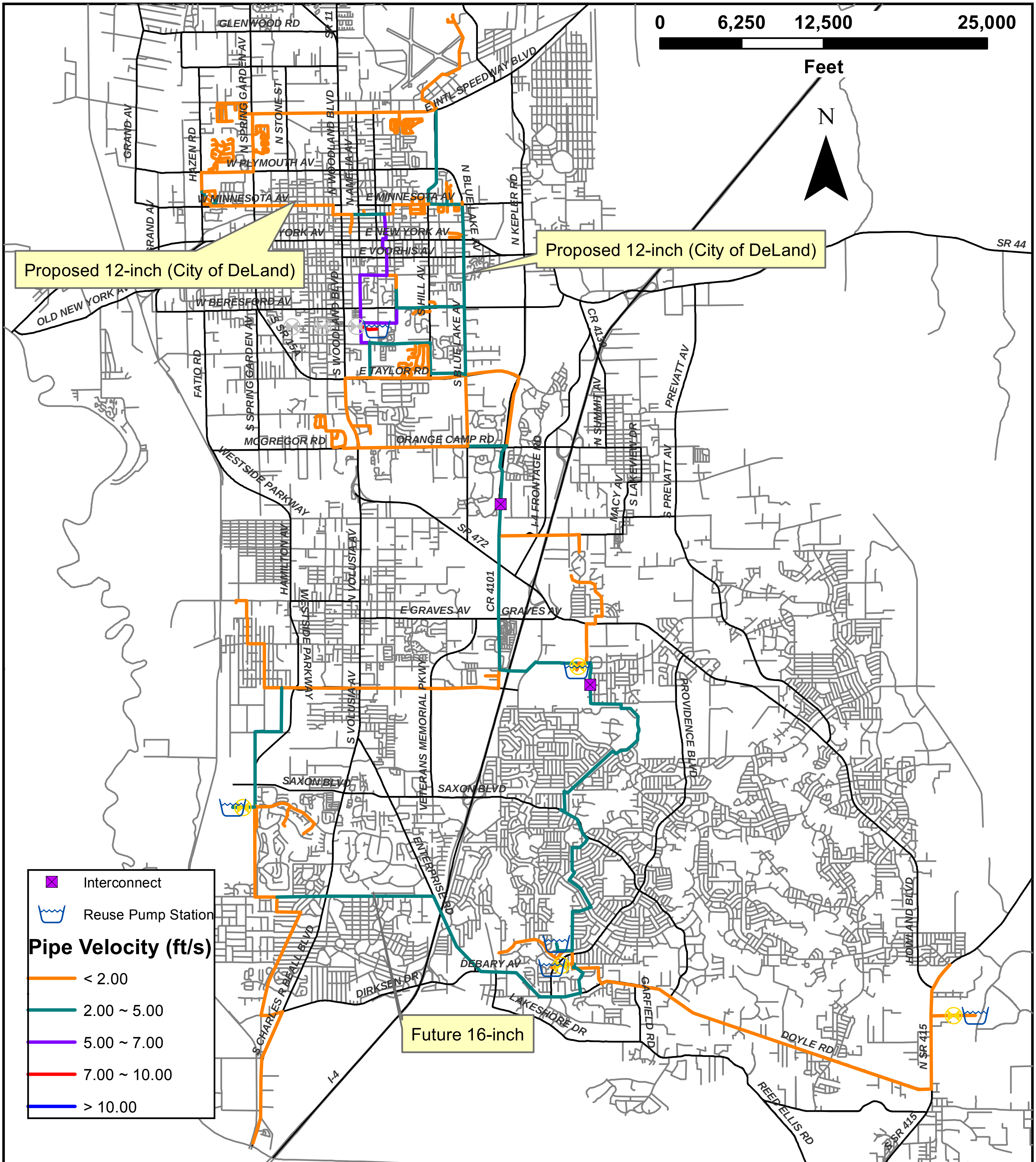


Mead & Hunt

West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 7
Nighttime Future 16-inch Velocity

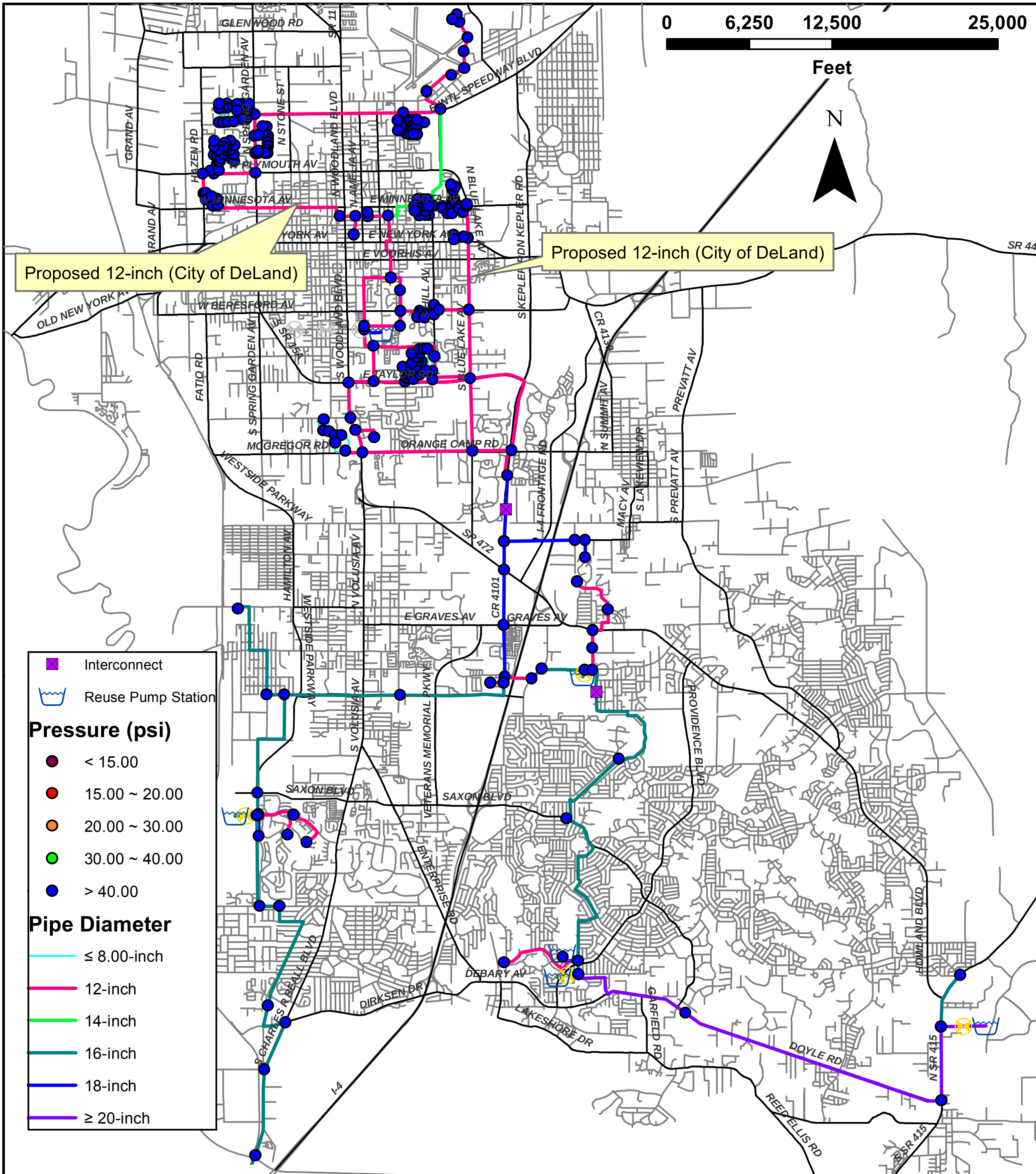
B. Scenario 2 – Daytime Scenario

During the daytime hours, it is assumed that the ponds and RIB's are filling, while the retail residential users are consuming much less. To model these parameters, the golf course pond's demands have a peak factor of 2.0 applied to them to represent filling over a 12-hour period and the RIB's were left filling at P.F = 1.0 during the day. The retail residential customers are assumed to be consuming 20% of their demand thus, each retail residential demand had a P.F of 0.2 applied to obtain the reduced flow. During the day, the Borrow Pit was assumed to be filling at 2,100 gpm for sixteen (16) hours. The total demand applied in the model for this scenario was 4,400 gpm.

With these demands placed in the model, including the 12-inch loop in north DeLand, the system has no issues. Pressures throughout the system are acceptable. In this scenario pressure range from 45 to 93 psi. No flow from the Sanford interconnect is needed to obtain these pressures for the daytime scenario. ***Figures 8 and 9*** depict the system pipe diameters, pressure, and velocity results of Scenario 2.

As stated previously, the model limits flow from the Southwest Regional, Deltona North (Southwest #2), Deltona Lakes, and Deltona East WWTP's via flow control valves. However, flow is not limited at either Wiley M. Nash WWTP or Alexander Ave site. This is required to create demand from DeLand's Wiley M. Nash WWTP and Deltona's Alexander Ave site, where the primary source of water is available. In order to create hydraulic conditions that will properly distribute flows, and operating protocol will need to be developed that satisfies the needs of each utility. This operating protocol will also need to address operation of the interconnect vaults and control valves.

Similar to Scenario 1, the construction of a 16-inch pipe along Highbanks Rd. Enterprise Rd., and Debary Ave. will slightly improve the pressure in the surrounding areas during the daytime fill cycles. The addition of the 16-inch provides pressures in the range of 51 and 97 psi. ***Figures 10 and 11*** depict pipe diameter, pressure, and velocity results of the 16-inch addition.

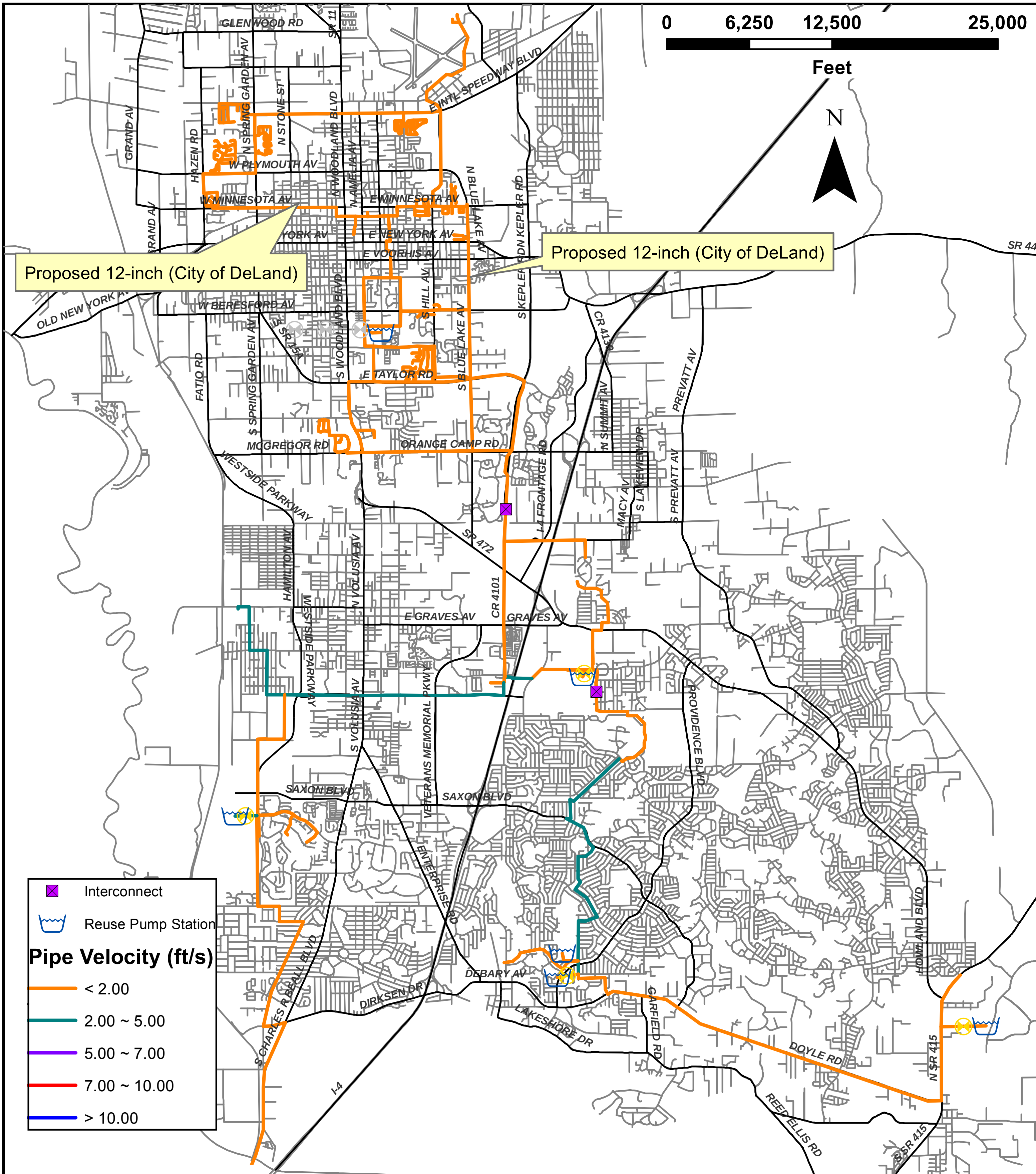


Mead & Hunt

West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 8
Daytime Existing Conditions Pressure & Diameter



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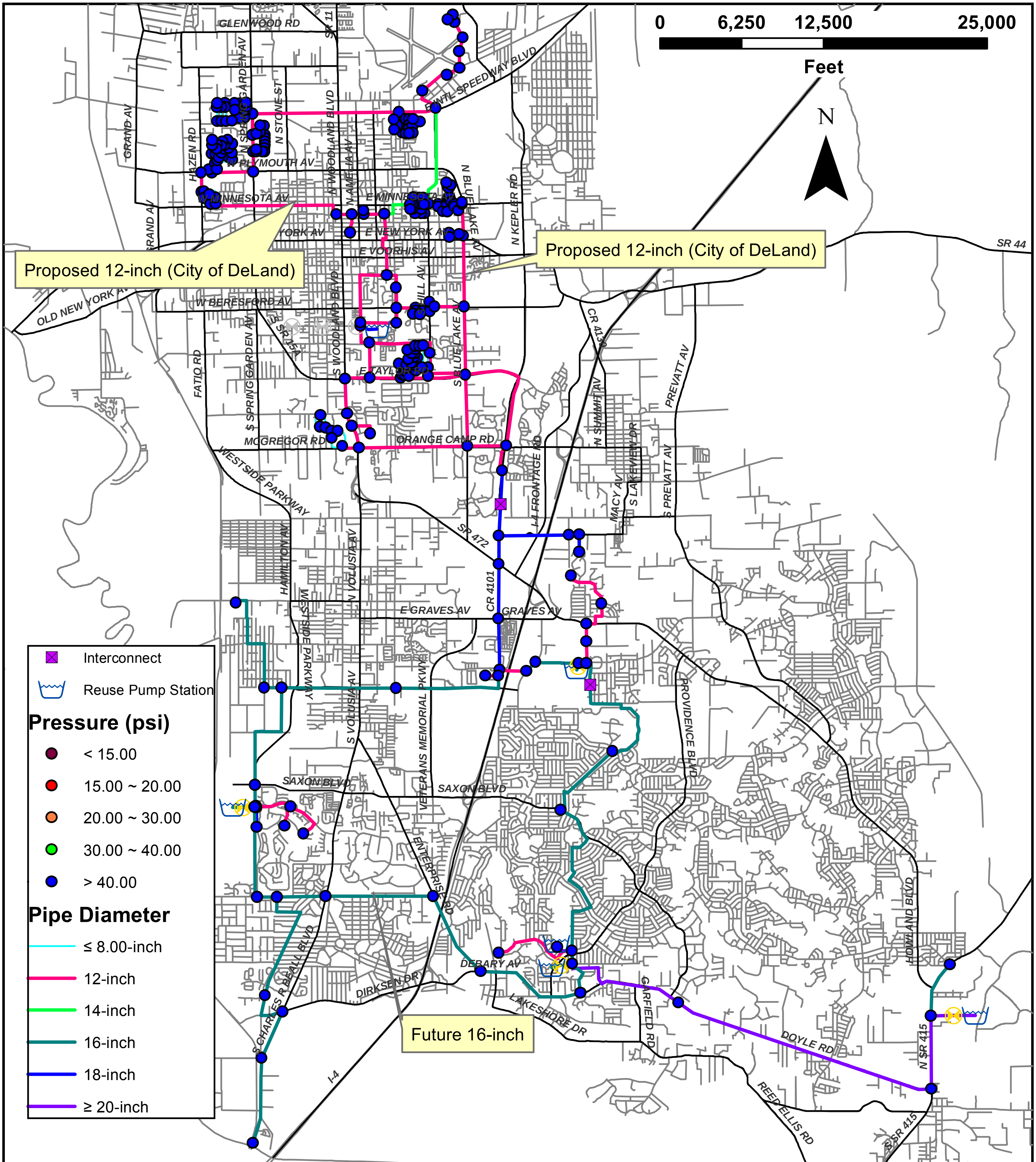
West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 9
Daytime Existing Conditions Velocity



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West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 10
Daytime Future 16-inch Pressure & Diameter

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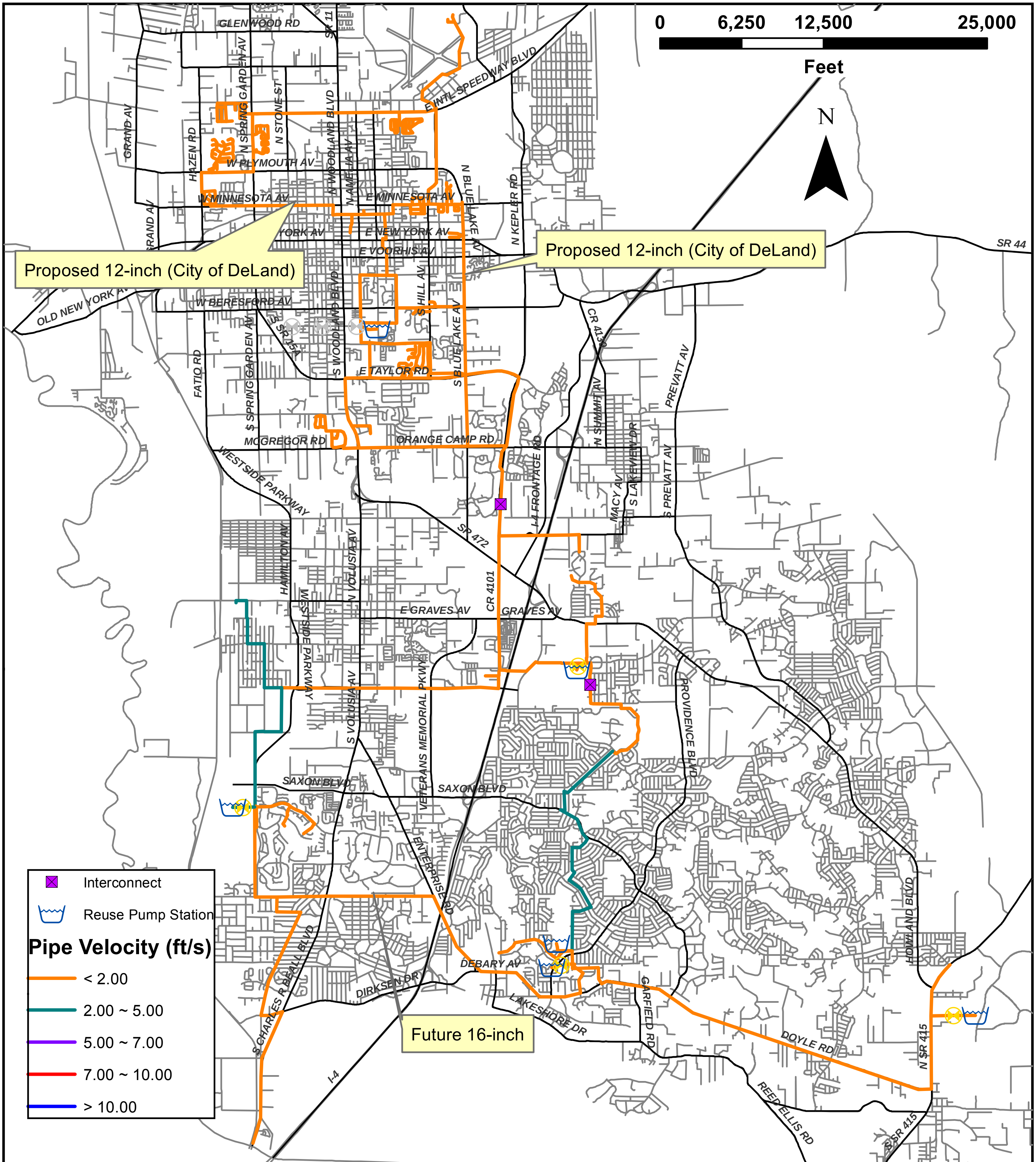

Mead & Hunt

West Volusia Water Suppliers

Volusia Blue Recharge PDR

FIGURE 11
Daytime Future 16-inch Velocity

5. Water Quality

As previously stated, the proposed borrow pit is approximately one (1) mile from Blue Spring. Due to this proximity, as well as the interconnection of all the WVWS reclaimed systems, it is important to analyze/review WWTP effluent nutrient concentrations from each contributor. Mead & Hunt gathered discharge monitoring report (DMR) data from each WWTP for the period from January 2016 to July 2018 as well as two months' worth of data for Mill Lake stormwater.

This site is intended to recharge the aquifer. With this being said, background groundwater quality was also examined. Mead & Hunt gathered groundwater quality data from the St. Johns River Water Management District (SJRWMD) for six (6) active groundwater monitoring sites.

It is estimated that in the future, the WVWS will need to augment supply to the borrow pit with surface water, this concept is discussed in further detail later in this section. Due to this, surface water, water quality was collected and analyzed from two (2) SJRWMD surface monitoring sites, one (1) in the St. Johns River and one (1) in Lake Monroe, and sample data from the City of DeLand's St. Johns River intake. The location of each site is shown on ***Figure 12.***

Table 3 contains a compilation of the past years (2017/2018) water quality data obtained for this report. Water quality parameters evaluated include, total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). ***Tables 4 and 5*** compile source data from the SJRWMD monitoring stations and recent samples at the City of DeLand's St. Johns River intake. ***Figures 12-21*** are graphical representations of the data shown in **Tables 4** of the various water qualities within the WVWS system.

Document Path: \\corp.meadhunt.com\sharedfolders\entp\4565700\181420.01\TECH\CAD\GIS\Figures\FIGURE 11 - PROJECT VICINITY\Figure11_ProjectVicinity (10-9-18).mxd

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- Stormwater Contributer
- Wastewater Treatment Plant
- Borrow Pit
- Ground Water Data Location
- Surface Water Data Location

N

0 1 2 4 6 8 Miles

West Volusia Water Supply
Figure 12 - Project Vicinity Map
October 2018

Mead & Hunt

Table 3: 2018 Borrow Pit Contributors Water Quality

	Deland/Wiley M Nash			Volusia Southwest			Del. North/SW #2*			Deltona Lakes			Deltona East			Composite Average		
	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Solids, Total Suspended (mg/L) (Meter)	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Solids, Total Suspended (mg/L) (Meter)	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Solids, Total Suspended	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Solids, Total Suspended (mg/L) (Meter)	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Solids, Total Suspended	Nitrogen, Total (mg/L)	Phosphorus, Total (as P) (mg/L)	Total Suspended Solids (mg/L)
	EFA-1	EFA-1	EFB-1	EFA-1	EFA-1	EFB-1	EFA-1	EFA-1	EFB-1	EFA-1	EFA-1	EFB-1	EFA-1	EFA-1	EFB-1	Calc	Calc	Calc
	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Monthly Avg	Composite Average	Composite Average	Composite Average
Aug-2017	1.67	2.85	0.50	6.2	0.12	1.42	8.90	1.40	1.31	8.4	2.4	1.6	3.5	3.7	0.5	4.16	2.13	0.92
Sep-2017	2.45	1.14	0.50	6.2	0.2	1.81	9.70	2.80	0.89	4.7	1.7	2	3.1	1	0.5	3.99	1.04	1.06
Oct-2017	2.15	0.39	0.35	4.5	0.7	3.46	12.50	1.80	0.83	4	1.5		2.9	2	0.6	3.40	0.79	1.09
Nov-2017	2.13	2.65	0.79	8.6	6	2.56	11.40	2.10	0.98	11.7	2.5	1.5	2.8	5.2	0.6	5.51	3.60	1.32
Dec-2017	1.61	3.15	0.54	7	6	0.88	10.70	1.70	1.64	19	4.2	1.4	2.4	2.2	0.5	5.90	3.89	0.79
Jan-2018	2.40	3.59	0.82	0.7	0.2	1.33	22.10	0.50	2.12	14.9	3.9	1.3	3.3	1.7	1	4.60	2.58	1.07
Feb-2018	2.74	4.15	0.58	2	0.3	1.4	28.90	1.50	1.78	11	4	1.3	3.0	1.8	0.5	4.71	2.94	0.92
Mar-2018	4.06	3.21	1.77	13	1.9	2.13	20.30	0.80	1.53	15.2	4	1.1	3.5	2.6	0.6	8.42	2.89	1.67
Apr-2018	1.89	3.66	0.50	2.9	0.1	1.25	37.70	3.20	2.89	11.9	3	0.8	3.1	0.9	0.5	4.94	2.49	0.81
May-2018	2.20	3.10	2.05	2.2	0.5	0.83	29.10	3.60	1.81	10.5	2.8	1	3.6	7.9	0.5	4.46	2.77	1.48
Jun-2018	2.42	4.13	0.30	1.8	0.1	0.9	18.00	2.40	1.5	9	1.7	0.7	2.6	4.8	0.4	3.80	2.77	0.55
Jul-2018	2.70	4.20	0.56	0.023	1.7	0.99	12.80	1.50	1.1	6.1	1.6	1.3	1.7	2.3	0.4	2.84	2.98	0.78
Average	2.37	3.02	0.77	4.59	1.49	1.58	18.51	1.94	1.53	10.53	2.78	1.27	2.96	3.01	0.55	**4.73**	**2.57**	**1.04**

	Mill Lake Stormwater*		
	Nitrate-Nitrite (mg/L)	Total Kjedahl Nitrogent (mg/L)	Total Phosphorus (mg/L)
	Outlet	Outlet	Outlet
	Monthly Avg	Monthly Avg	Monthly Avg
Apr-2018	0.22	1.3	0.184
May-2018	0.42	0.9	0.046
Average	0.32	1.10	0.12

*not Included in the calculation for the composite average above

Table 4: Ground Water Quality (SJRWMD)

	SJRWMD Station V-0196						SJRWMD Station V-0780						SJRWMD Station V-0197						SJRWMD Station V-0115					
	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)
Mar-2018	0.0086 T	0.0376	0.0662I	0.0806	0.1218	168	0.007T	1.0541	1.0057	0.011T	0.0151I	3460	0.705	0.004T	0.078I	0.0102T	0.0362I	59	0.0032T	0.1072	0.163	0.086	0.12	866

	SJRWMD Station V-1151						SJRWMD Station V-1152					
	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)	Nox-T (mg/L)	NH4-D (mg/L)	TKN-T (mg/L)	PO4-T (mg/L)	TP-T (mg/L)	TDS (mg/L)
Mar-2018	0.591	0.033	0.154	0.147	0.2	174	0.0083T	0.009I	0.02T	0.085	0.1058	177

Table 5: Surface Water Quality (SJRWMD & City of DeLand)

	SJRWMD Station SJ16 (St. Johns River)						SJRWMD LMAC Station (Lake Monroe)								DeLand Influent (St. Johns River)		
	Nox-D (mg/L)	NH4-D (mg/L)	TKN-T(mg/L)	PO4-D (mg/L)	TP-T (mg/L)	TSS (mg/L)	Nox-D (mg/L)	NH4-D (mg/L)	TKN-D (mg/L)	TKN-T(mg/L)	PO4-D (mg/L)	TP-D (mg/L)	TP-T (mg/L)	TSS (mg/L)	Total Nitrogen, (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Jun-2017							0.004T	0.0112I	0.819	1.596	0.002T	0.014I	0.11	20			
Jul-2017	0.06	0.0852	1.3263	0.028I	0.0859	7.2I	0.0041T	0.0108I	1.126	1.481	0.004T	0.022	0.08	7.4I	1.99	<0.15	17.5
Aug-2017							0.1023	0.1948	1.589	1.831	0.103	0.13JV	0.15JV	0.8T			
Sep-2017								0.141V	1.37	1.71	0.1V	0.126V	0.18	3.2T			
Oct-2017							0.0915	0.0981	1.169	1.276	0.167	0.154	0.17	-0.4T			
Nov-2017	0.2	0.042	1.2721	0.1	0.1567	0.6T	0.1262	0.0396	1.208	1.304	0.096	0.137	0.16	0.6T			
Dec-2017							0.0928	0.0077I	1.17	1.49	0.083	0.107	0.14	1.2T			
Jan-2018							0.1864	0.0118I	1.08	1.235	0.04IQ	0.054	0.09	2.8I			
Feb-2018	0.17	0.0536	1.1346	0.034I	0.0874	3I	0.0034T	0.0101I	0.982	1.458	0.023I	0.033I	0.11	16			
Mar-2018							0.0194I	0.0153I	1.048	2.017	0.01T	0.029I	0.15	31.5	0.597	<0.119	3.2
Apr-2018							0.0062T	0.0115I	0.983	2.177	0.005T	0.018I	0.15	21.2			
May-2018	0.06	0.0282	1.3647	0.05	0.128	10.6	0.0087T	0.011I	0.949	1.51	0.029I	0.047	0.12	10.4			
Jun-2018							0.0568	0.1424	1.193	1.328	0.075	0.103	0.14	1T	1.44	0.119	14.5

T Value reported is less than the laboratory method detection limit. The value is reported for informational purposes, only and shall not be used in statistical analysis.

I The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.

V Indicates that the analyte was detected in both the sample and the associated method blank. Note: the value in the blank shall not be subtracted from associated samples.

Q Sample held beyond the accepted holding time. This code shall be used if the value is derived from a sample that was prepared or analyzed after the approved holding time restrictions for sample preparation or analysis.

J Estimated value; value not accurate. This code shall be used in the following instances:

1. surrogate recovery limits have been exceeded;
2. no known quality control criteria exists for the component;
3. the reported value failed to meet the established quality control criteria for either precision or accuracy;
4. the sample matrix interfered with the ability to make any accurate determination; or
5. if the data is questionable because of improper laboratory or field protocols (e.g. composite sample was collected instead of a grab sample).

Note: a "J" value shall be accompanied by justification for its use. A "J" value shall not be used if another code applies (e.g., K, L, M, T, V, Y, PQL)

Y The laboratory analysis was from an unpreserved or improperly preserved sample. The data may not be accurate.

Figure 13: DeLand/Wiley M. Nash Monthly Averages

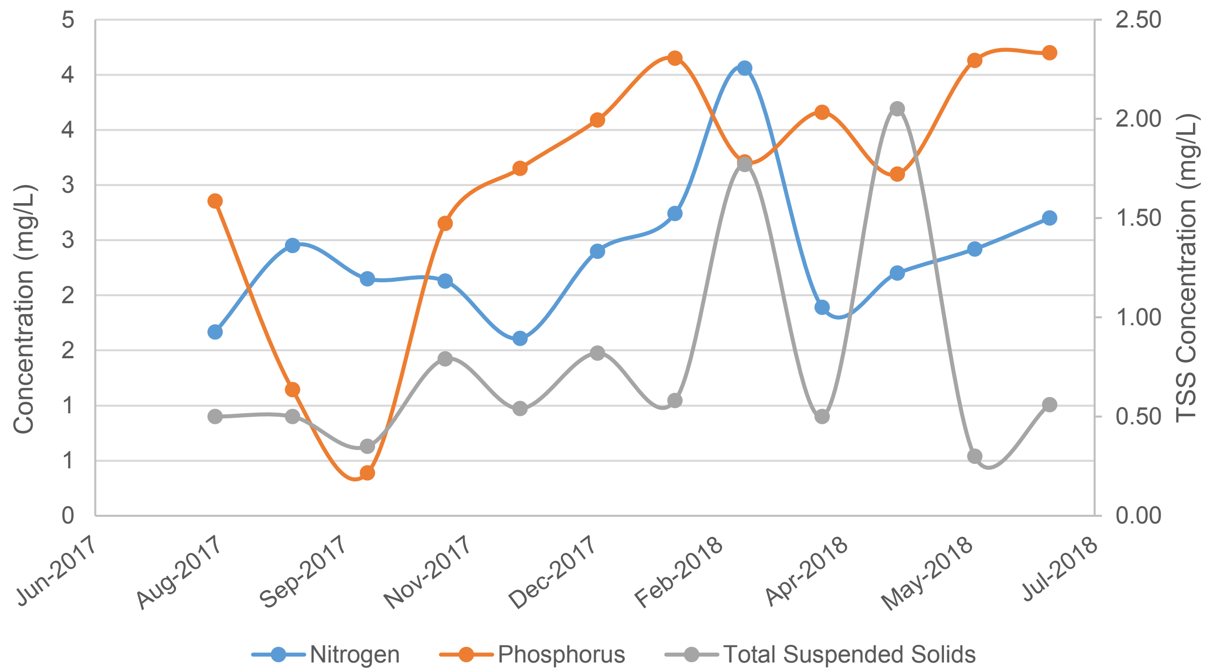


Figure 14: Volusia Southwest Monthly Averages

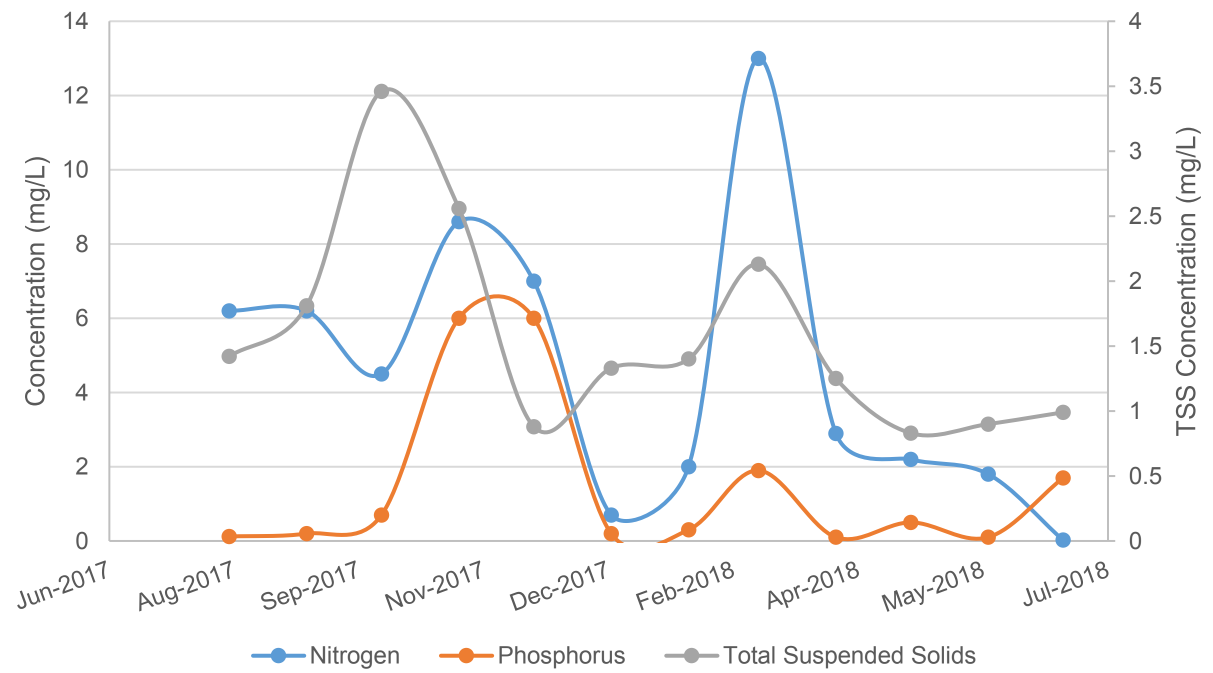


Figure 15: Volusia SW#2/Deltona North Monthly Averages

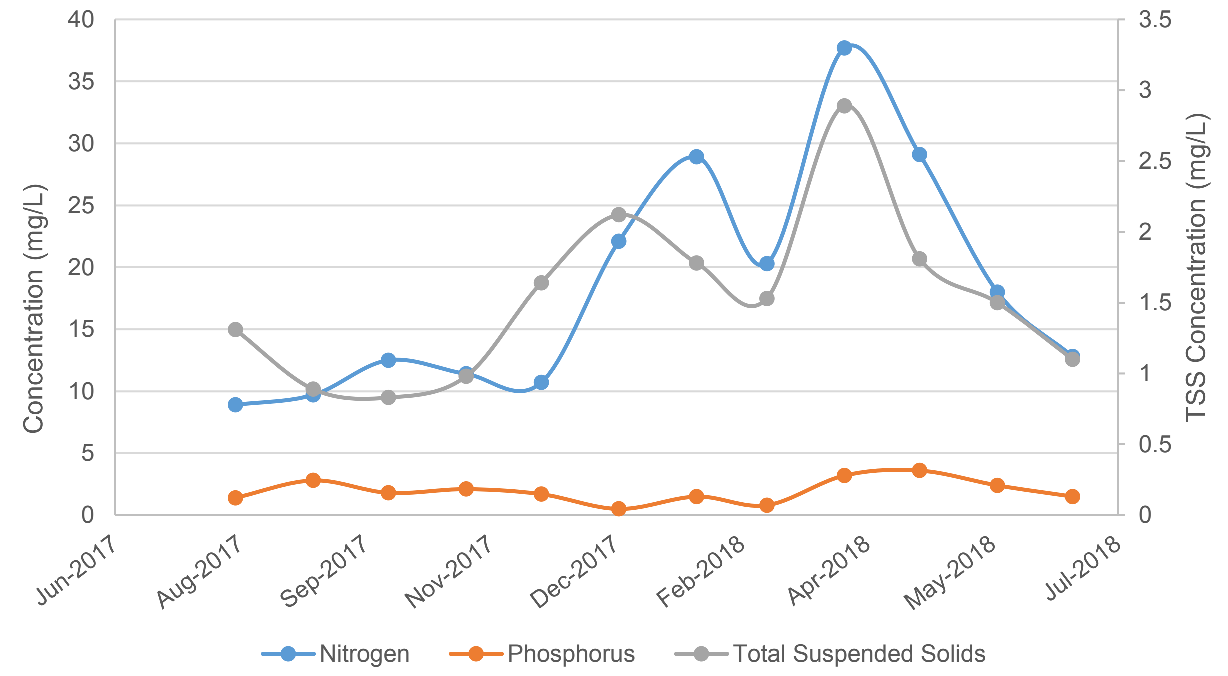
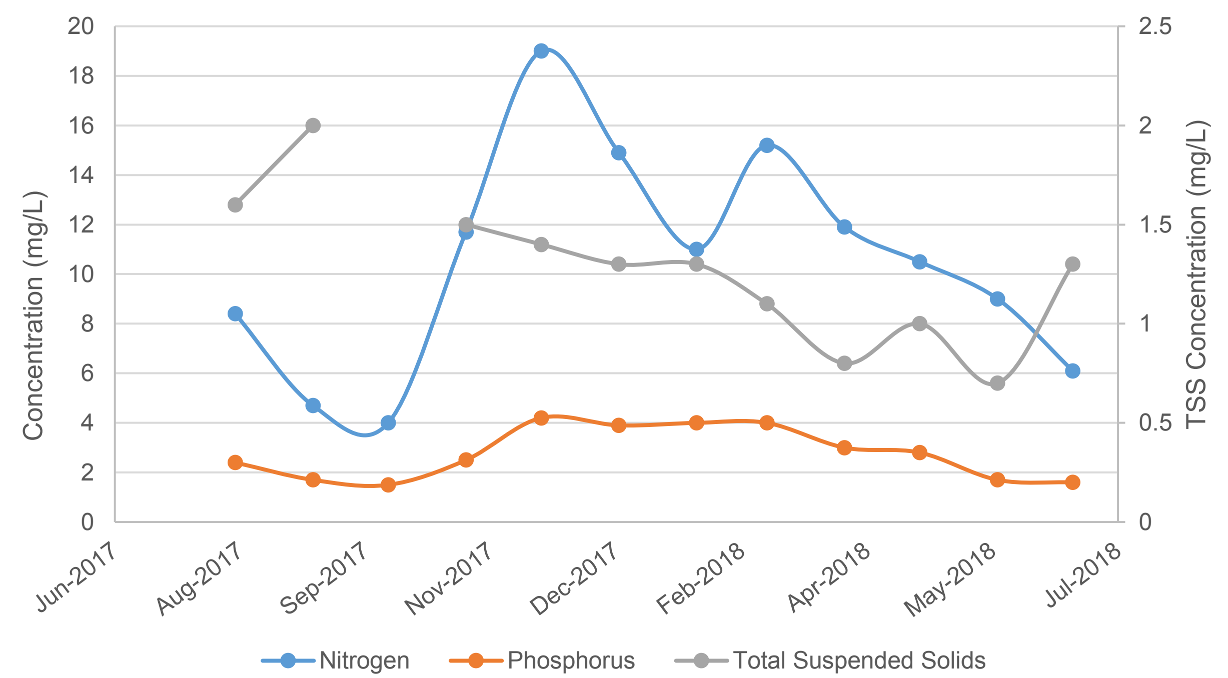


Figure 16: Deltona Lakes Monthly Averages



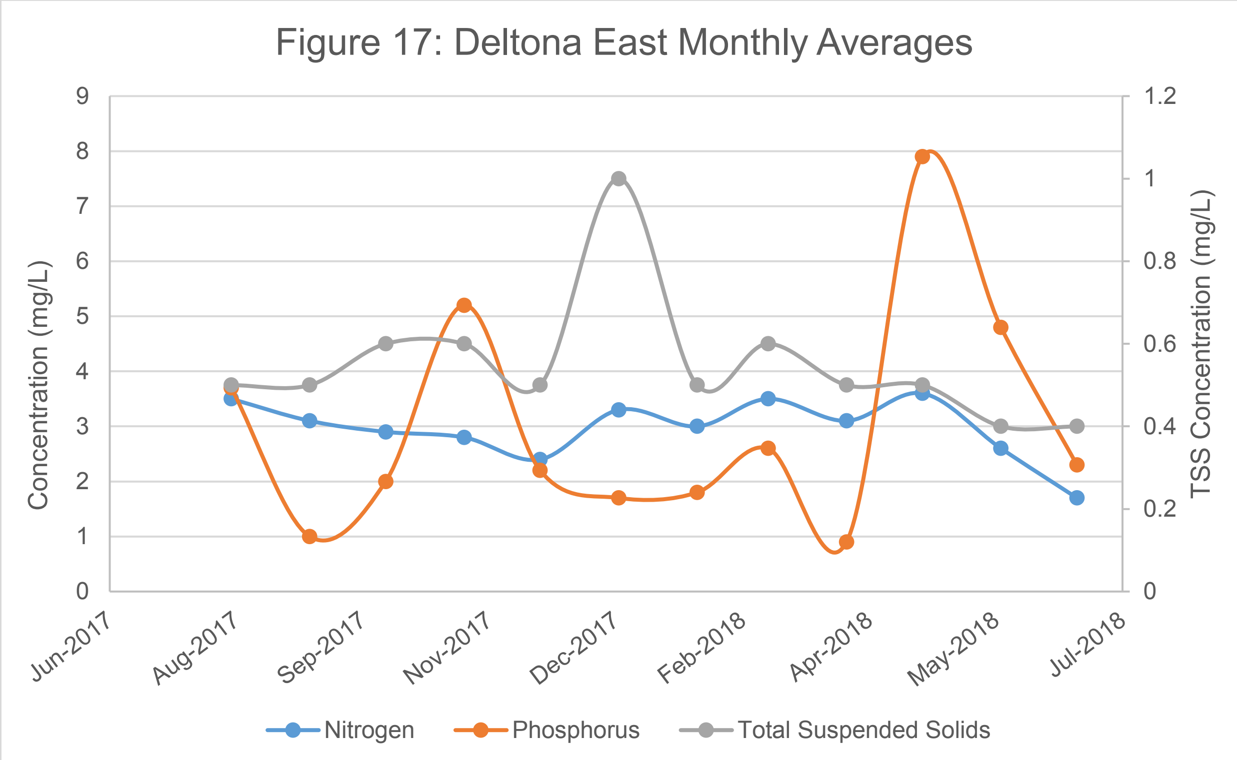


Figure 17: Deltona East Monthly Averages
Concentration (mg/L)
TSS Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
0
0.2
0.4
0.6
0.8
1
1.2
Jun-2017
Aug-2017
Sep-2017
Nov-2017
Dec-2017
Feb-2018
Apr-2018
May-2018
Jul-2018
Nitrogen
Phosphorus
Total Suspended Solids

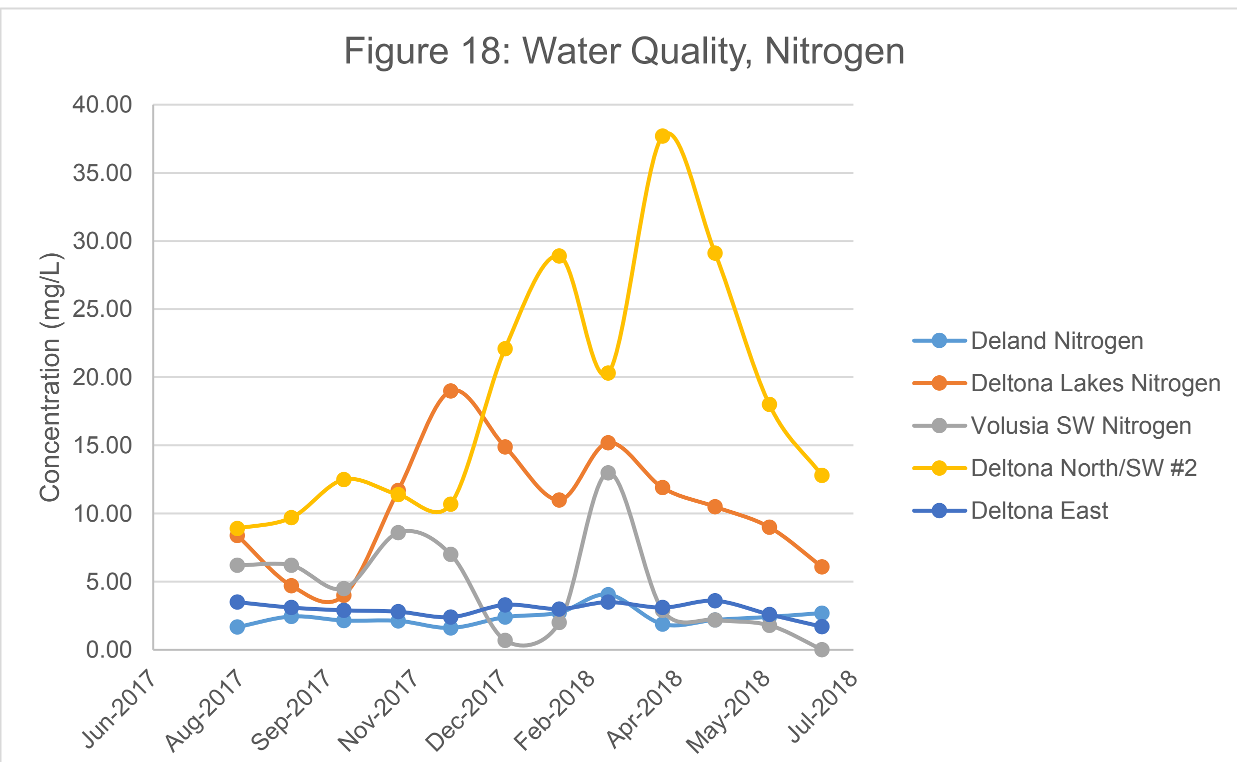


Figure 18: Water Quality, Nitrogen
Concentration (mg/L)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
Jun-2017
Aug-2017
Sep-2017
Nov-2017
Dec-2017
Feb-2018
Apr-2018
May-2018
Jul-2018
Deland Nitrogen
Deltona Lakes Nitrogen
Volusia SW Nitrogen
Deltona North/SW #2
Deltona East

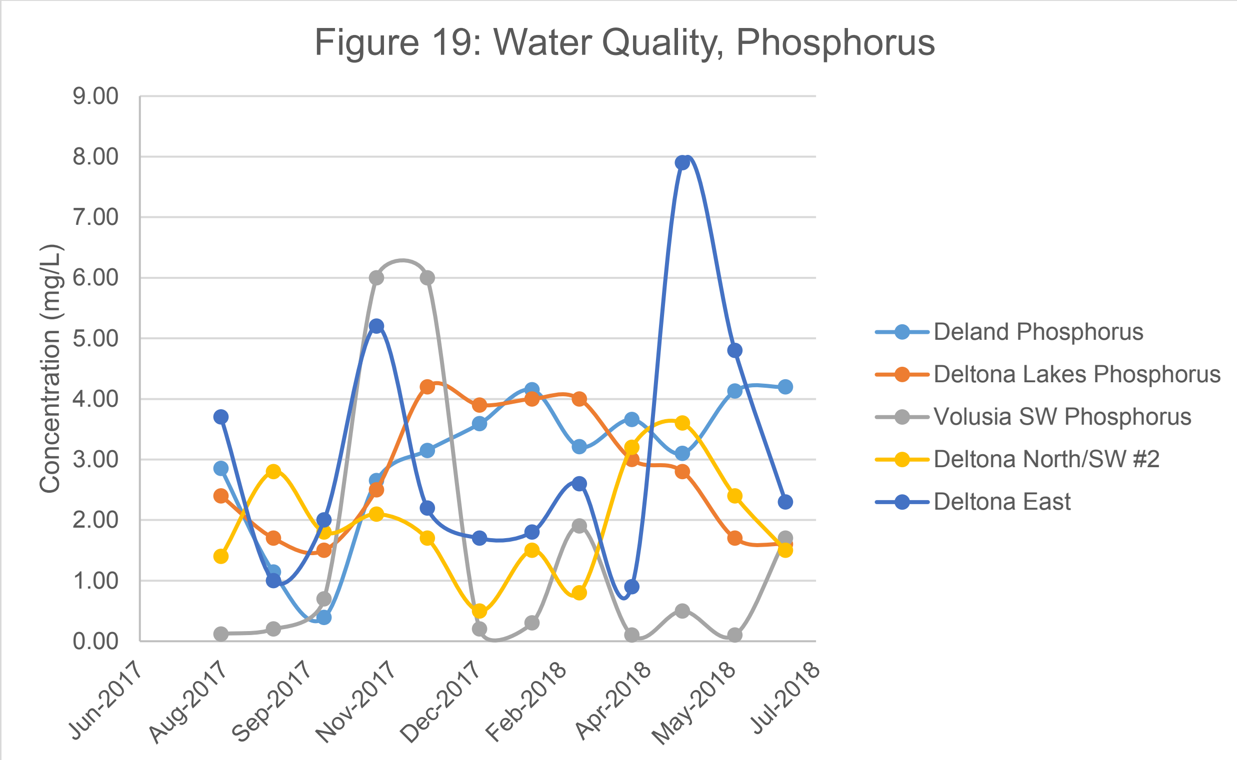


Figure 19: Water Quality, Phosphorus
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Concentration (mg/L)
Jun-2017
Aug-2017
Sep-2017
Nov-2017
Dec-2017
Feb-2018
Apr-2018
May-2018
Jul-2018
Deland Phosphorus
Deltona Lakes Phosphorus
Volusia SW Phosphorus
Deltona North/SW #2
Deltona East

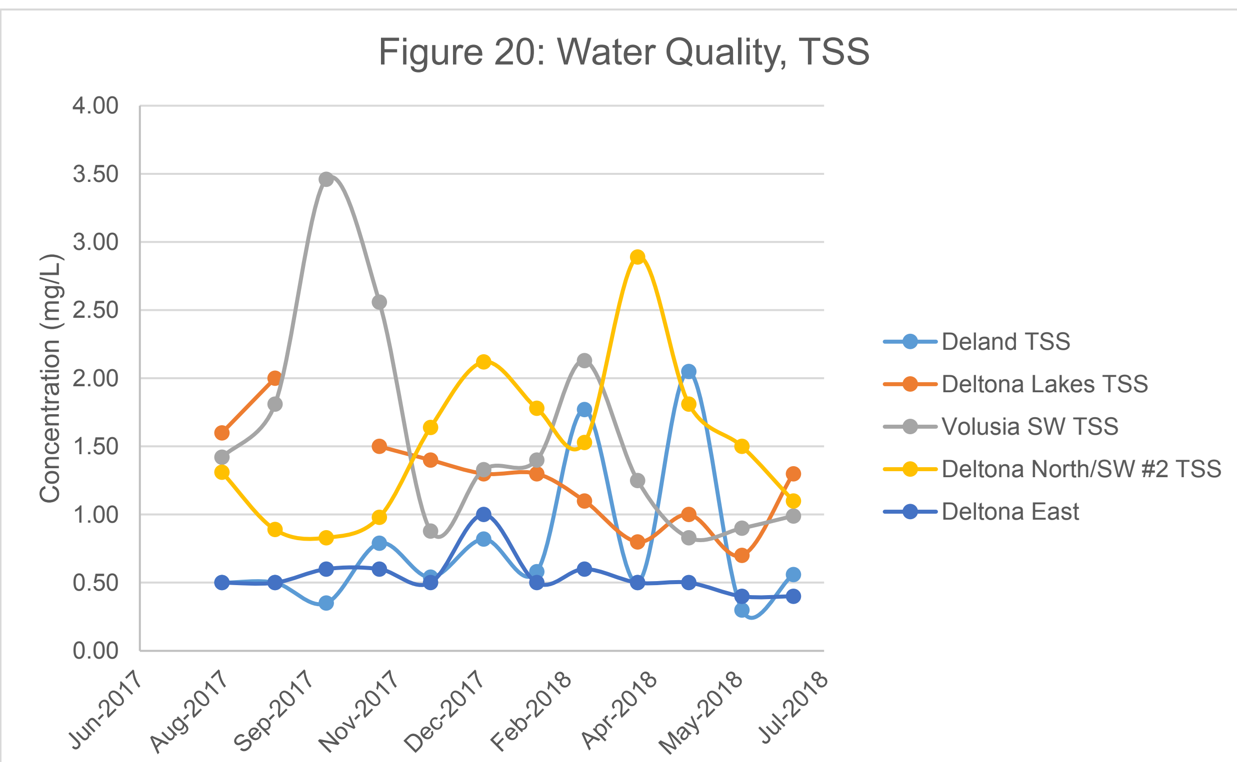
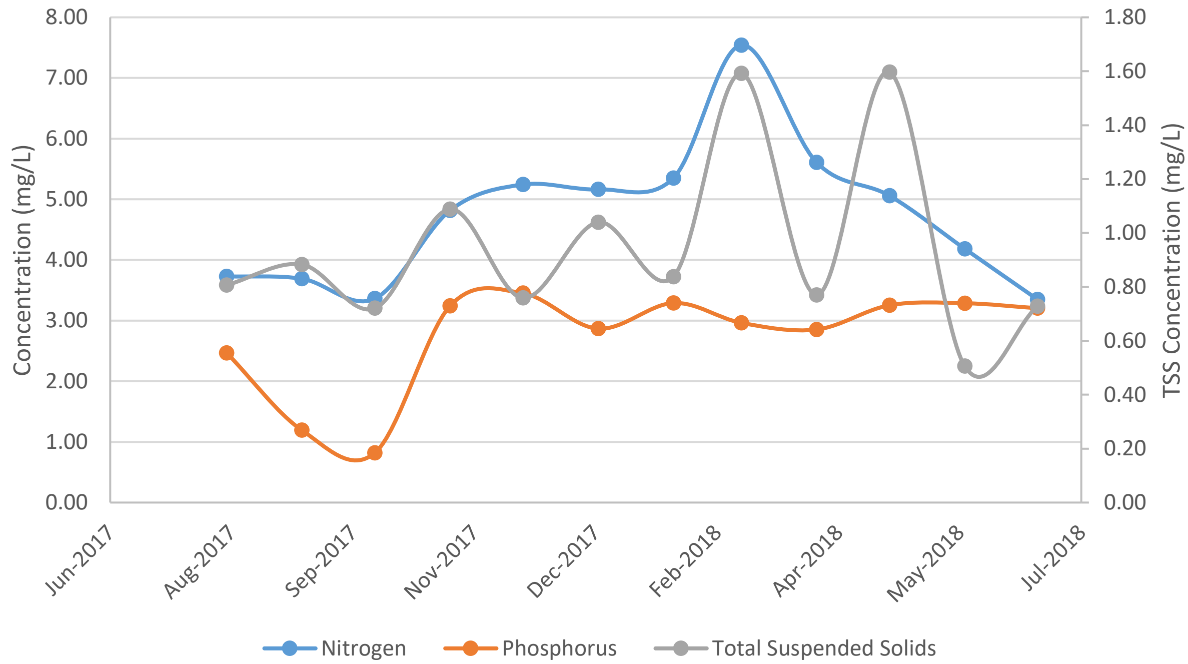


Figure 20: Water Quality, TSS
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Concentration (mg/L)
Jun-2017
Aug-2017
Sep-2017
Nov-2017
Dec-2017
Feb-2018
Apr-2018
May-2018
Jul-2018
Deland TSS
Deltona Lakes TSS
Volusia SW TSS
Deltona North/SW #2 TSS
Deltona East

Figure 21: Water Quality, Composite Averages



Future Water Quality

In the near future, by 2024, all the WVWS wastewater treatment plants will be complying with advanced wastewater treatment (AWT) standards. This means the effluent from each wastewater treatment plant must meet comply with the following:

- < 5 ppm Total Suspended Solids (TSS)
- < 3 ppm Total Nitrogen (TN)
- < 1 ppm Total Phosphorus (TP)

Along with becoming AWT facilities, the Deltona North/Southwest #2 site will be converted into a regional lift station. All flow received to this site will be transferred to the Southwest #1 WWTP. This conversion is expected to be complete in 2019.

For purposes of this report, it was assumed that each contributor would be producing an effluent of 2.9 mg/L TN, and .9 mg/L TP. It is assumed that the current effluent TSS concentrations for each WWTP will continue moving forward, future water will be of similar quality.

A. Blended Water Quality

Understanding the future water quality of the borrow pit contributors, i.e. the WWTP's, allows for the calculation of what a blended water would look like.

The Borrow Pit is anticipated to need 2.5 MGD of water. It is probably that the WVWS group will be unable to supply the fully 2.5 MGD as reclaimed water. St. Johns River and/or Lake Monroe will be used to augment the available reclaimed water supply. As previously stated, nutrient loading is important due to the proximity of the spring. As a result, an acceptable blend ratio between reclaimed and surface water must be deduced.

Table 6 shows the composite average for Total Nitrogen (TN), Total Phosphorus (TP) and Total Suspended Solids (TSS) for the WVWS contributors currently, in 2024, and the average TN, TP, and TSS concentrations of the surface water (average of St. Johns River and Lake Monroe).

Table 6: Nutrient Averages (WWTP's & St. Johns River)

2018 Composite Average of WWTP			2024 Composite Average of WWTP			2017-2018 Surface Water Averages		
Total Nitrogen, (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Nitrogen, (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Nitrogen, (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
4.73	2.57	1.04	2.90	1.01	1.01	1.45	0.13	8.67

Based on annual average, the WVWS has flowed 5.56 MGD to reuse customers over the last year. With the addition of the 2.5 MGD for the borrow pit a required 8.06 MGD of water is needed. In 2024, it is projected that the WWTP's reuse flows will be 12.19 MGD. Assuming the WWTP's increase their production by 20% per year, in the year 2024 the WWTP's will be producing 8.80 MGD. This includes the transition of flow from Deltona North/Southwest #2 to Southwest #1, and the reduction of Deltona Lakes to 1.0 MGD. With the addition of the 2.5 MGD for the Borrow Pit, it is projected the group will need 14.69 MGD of reclaimed water; therefore, the group will need to augment 5.89 MGD from surface waters. ***Table 7*** below depicts the above in tabular format.

Table 7: Augmentation Requirements

	2018	2024	
	Flow to Application Areas (MGD)	Projected Flow to Application Areas (MGD)	WWTP Flow (MGD)
DeLand	2.8	6	3.36
Volusia SW	1.35	3.19	1.84
Del North/SW #2	0.19	-	-
Deltona Lakes	0.84	1.45	1.00
Deltona East	0.39	1.55	2.60
Subtotal (MGD)	5.56	12.19	8.80
Borrow Pit Flow (MGD)	2.5	2.5	-
Total Needed (MGD)	8.06	14.69	**-**
Surface Water Augmentation (MGD)	**2.50**	**5.89**	

Knowing the required amount of augmentation water, a blended water quality can be obtained. Using the values from ***Table 6*** and flows shown in ***Table 7*** a blended water quality can be obtained and is shown in ***Table 8.*** It is can be assumed that the total nitrogen (TN) value is comprised of 90% Nitrate with the remaining 10% being comprised of other species of nitrogen.

Table 8: Blended Water Quality

	TN (mg/L)	TP (mg/L)	TSS (mg/L)
2018 Blended Water Quality	3.71	1.81	3.40
2024 Blended Water Quality	2.32	0.65	4.08

6. Cost Estimate

The Borrow Pit location off of French Ave will required the installation of approximately 9,000 LF of 16-inch PVC or HDPE reclaimed water main (RWM). The new RWM will tie into an existing RWM on Adeline Street and follow to the north side of the Borrow Pit utilizing Park Avenue, W. Blue Springs Ave, and Chestnut Ave. The proposed routing was previously shown on ***Figure 3.*** The cost to construct this pipeline is approximately 1.6 M. A preliminary cost estimate is included on ***Table 9.***

Table 9: Reclaimed Water Main Preliminary Cost Estimate

Item No.	Description	QTY	Unit	Unit Cost	Total
1	**Directional Drill PVC/HDPE Reclaimed Water Main**				
	16-inch	9,000	LF	$120.00	$1,080,000.00
2	**Valves**				
	16-inch Butterfly Valves	5	EA	$15,000.00	$75,000.00
3	Telemetry & Instrumentation	1	LS	$75,000.00	$75,000.00
	Construction Estimate				$1,230,000.00
	Contingency @ 20 %				$246,000.00
	Planning, Design, CA, and Inspection @ 15 %				$184,500.00
	Total Cost Estimate*				**$1,660,500.00**

*This cost estimate is solely for the cost of the transmission piping shown on ***Figure 3.***