2743-B Gunter Park Drive West
Montgomery, AL 36109
334.244.0766
www.TTLUSA.com

March 4, 2020

Transmitted Via: Email (Holly.A.Ross@usace.army.mil)

Ms. Holly Ross, Sr. Project Manager
U.S. Army Corps of Engineers
Savannah District - Regulatory Division
1104 N. Westover Blvd. Unit 9
Albany, Georgia 31707

Subject: *Individual Permit Application*
Twin Pines Minerals, LLC
Saunders Demonstration Mine
Saint George, Charlton County, GA
USACE Project No.: SAS-2018-00554
TTL Project No.: 00180200804.00

Dear Ms. Ross,

TTL, Inc. (TTL) respectfully submits this Individual Permit application package for impacts to waters of the United States associated with the proposed heavy minerals mine operation located near St. George, in Charlton County, Georgia. By signature of the Joint Application and Notification form enclosed, the applicant, Twin Pines Minerals, LLC designates and authorizes TTL to act as Agent on Twin Pine Mineral's behalf in the processing of the permit application.

TTL representatives look forward to working with you on this important permitting project.

Sincerely,

TTL, Inc.

Christopher Terrell	Chris Stanford	Cindy House-Pearson
Project Professional	Project Professional	Vice President

Enclosed: *Joint Application Form*
Individual Permit Application Package

JOINT APPLICATION
FOR
A DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS PERMIT,
STATE OF GEORGIA MARSHLAND PROTECTION PERMIT,
REVOCABLE LICENSE AGREEMENT
AND REQUEST FOR
WATER QUALITY CERTIFICATION
AS APPLICABLE

INSTRUCTIONS FOR SUBMITTING APPLICATION:

Every Applicant is Responsible to Complete The Permit Application and Submit as Follows: One copy each of application, location map, drawings, copy of deed and any other supporting information to addresses 1, 2, and 3 below. If water quality certification is required, send only application, location map and drawing to address No. 4.

1. For Department of the Army Permit, mail to: Commander, Savannah District, US Army Corps of Engineers, ATTN: CESAS-RD, 100 W. Oglethorpe Avenue, .Savannah, Georgia 31401-3640. Phone (912) 652-5347 and/or toll free, Nationwide 1-800-448-2402.

2. For State Permit - State of Georgia (six coastal counties only) mail to: Habitat Management Program, Coastal Resources Division, Georgia Department of Natural Resources, 1 Conservation Way, Brunswick, Georgia 31523. Phone (912) 264-7218.

3. For Revocable License - State of Georgia (six coastal counties plus Effingham, Long, Wayne, Brantley and Charlton counties only) - Request must have State of Georgia's assent or a waiver authorizing the use of State owned lands. All applications for dock permits in the coastal counties or for docks located in tidally influenced waters in the counties listed above need to be submitted to Real Estate Unit. In addition to instructions above, you must send two signed form letters regarding revocable license agreement to: Ecological Services Coastal Resources Division, Georgia Department of Natural Resources, 1 Conservation Way, Brunswick, Georgia 31523. Phone (912) 264-7218.

4. For Water Quality Certification State of Georgia, mail to: Water Protection Branch, Environmental Protection Division, Georgia Department of Natural Resources, 4220 International Parkway, Suite 101, Atlanta, Georgia 30354 (404) 675-1631.

The application must be signed by the person authorized to undertake the proposed activity. The applicant must be the owner of the property or be the lessee or have the authority to perform the activity requested. Evidence of the above may be furnished by copy of the deed or other instrument as may be appropriate. The application may be signed by a duly authorized agent if accompanied by a statement from the applicant designating the agent. See item 6, page 2.

1. Application No. ____________

2. Date 02-28-2020

3. For Official Use Only ____________

4. Name and address of applicant. Twin Pines Minerals, LLC Attn: Mr. Steve Ingle, P.E.2100 Southbridge Parkway Birmingham, Alabama 35209

5. Location where the proposed activity exists or will occur.

Lat. 30.524446 Long. -82.119090

Charlton		
County	Military District	In City or Town
St. George		
Near City or Town	Subdivision	Lot No.
1041.7		
Lot Size	Approximate Elevation of Lo	State
	Boone Creek	
Name of Waterway	Name of Nearest Creek, River, Sound, Bay or Hammock	

6. Name, address and title of applicant's authorized agent for permit application coordination.

Cindy House-Pearson
Senior Natural Resources Manager
TTL, Inc.
2743-B Gunter Park Drive West
Montgomery, Alabama 36109

Statement of Authorization: I hereby designate and authorize the above named person to act in my behalf as my agent in the processing of this permit application and to furnish, upon request, supplemental information in support of this application.

Signature of Applicant ______________________ Date 2-27-20

7. Describe the proposed activity, its purpose and intended use, including a description of the type of structures, if any to be erected on fills, piles, of float-supported platforms, and the type, composition and quantity of materials to be discharged or dumped and means of conveyance. If more space is needed, use remarks section on page 4 or add a supplemental sheet. (See Part III of the Guide for additional information required for certain activities.)

see supplemental application information

8. Proposed use: Private ☑ Public ☐ Commercial ☑ Other ☐ (Explain)

Heavy mineral sand mining demonstration project

9. Names and addresses of adjoining property owners whose property also adjoins the waterway.

see supplemental application information

10. Date activity is proposed to commence. 06-01-2020

Date activity is expected to be completed. 06-01-2026

11. Is any portion of the activity for which authorization is sought now complete ☐Y ☑N

a. If answer is "Yes", give reasons in the remarks in the remarks section. Indicate the existing work on the drawings.

b. If the fill or work is existing, indicate date of commencement and completion.

c. If not completed, indicate percentage completed.

12. List of approvals or certifications required by other Federal, State or local agencies for any structures, construction discharges, deposits or other activities described in this application. Please show zoning approval or status of zoning for this project.

Issuing Agency	Type Approval	Identification No.	Date/Application	Date/Approval
GaEPD	Air Permit	27362	12/20/2019	
GaEPD	NPDES Wastewater Permit		08/30/2019, revised 09/09/2019	
GaEPD	Industrial Stormwater Permit		09/04/2019, revised 01/07/2020	
GaEPD	Surface Mining Permit		07/25/2019	
GaEPD	Groundwater Extraction Permit		07/22/2019, revised 11/22/2019	
GaEPD	Industrial Surfacewater Withdrawal		not yet applied	

13. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein?
☐ Yes ☑ NO (If "yes", explain).

Note: Items 14 and 15 are to be completed if you want to bulkhead, dredge or fill.

14. Description of operation: (If feasible, this information should be shown on the drawing).

a. Purpose of excavation or fill heavy mineral sand mining demonstration project.

1. Access channel length______ depth______ width______

2. Boat basin length______ depth______ width______

3. Fill area length______ depth______ width______

4. Other ________ length______ depth______ width______
(Note: If channel, give reasons for need of dimensions listed above.)

b. If bulkhead, give dimensions ________

-- Type of bulkhead construction (material)________

1. Backfill required: Yes ______ No _____ Cubic yards ________

2. Where obtained The wetlands will be backfilled with the same excavated material following mining.

c. Excavated material

1. Cubic yards 63,410,372 ±

2. Type of material mineral sands

15. Type of construction equipment to be used ________

a. Does the area to be excavated include any wetland? Yes ☑ No ☐

b Does the disposal area contain any wetland? Yes ☑ No ☐

c. Location of disposal area at excavated area

d. Maintenance dredging, estimated amounts, frequency, and disposal sites to be utilized:________

e. Will dredged material be entrapped or encased? no

f. Will wetlands be crossed in transporting equipment to project site? yes

g. Present rate of shoreline erosion (if known) NA

16. Description of Avoidance, Minimization and Compensation: Provide a brief explanation describing how impacts to waters of the United States are being avoided and minimized on the project site. Also, provide a brief description of how impacts to waters of the United States will be compensated for, or a brief statement explaining why compensatory mitigation should not be required for those impacts.

see supplemental application information

17. Water Quality Certification: In some cases, Federal law requires that a Water Quality Certification from the State of Georgia be obtained prior to issuance of a Federal license or permit. Applicability of this requirement to any specific project is determined by the permitting Federal agency. The information requested below is generally sufficient for the Georgia Environmental Protection Division to issue such a certification if required. Any item, which is not applicable to a specific project, should be so marked. Additional information will be requested if needed.

a. Please submit the following:

1. A plan showing the location and size of any facility, existing or proposed, for handling any sanitary or industrial waste waters generally on your property.

2. A plan of the existing or proposed project and your adjacent property for which permits are being requested.

3. A plan showing the location of all points where petro-chemical products (gasoline, oils, cleaners) used and stored. Any aboveground storage areas must be diked, and there should be no storm drain catch basins within the dike areas. All valving arrangements on any petro-chemical transfer lines should be shown.

4. A contingency plan delineating action to be taken by you in the event of spillage of petro-chemical products or other materials from your operation.

5. Plan and profile drawings showing limits of areas to be dredged, areas to be used for placement of spoil, locations of any dikes to be constructed showing locations of any weir(s), and typical cross sections of the dikes.

b. Please provide the following statements:

1. A statement that all activities will be performed in a manner to minimize turbidity in the stream.

2. A statement that there will be no oils or other pollutants released from the proposed activities which will reach the stream.

3. A statement that all work performed during construction will be done in a manner to prevent interference with any legitimate water uses.

18. Application is hereby made for a permit or permits to authorize the activities described herein; Water Quality Certification from the Georgia Environmental Protection Division is also requested if needed. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete and accurate. I further certify that I posses the authority to under take the proposed activities.

Signature of Applicant

19. U.S.C. Section 1001 provides that: Whoever, in any matter within the jurisdiction of any department or agency of the United States, knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious, or fraudulent statements or representations, or makes or uses false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined no more than $10,000 or imprisoned not more than 5 years or both.

PRIVACY ACT NOTICE

The Department of the Army permit program is authorized by Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act and Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972. These laws require permits authorizing structures and work in or affecting navigable waters of the United States, the discharge of dredged or fills material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided will be used in evaluating the application for a permit. Information in the application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

SUPPORTING REMARKS:

U.S. Army Corps of Engineers
Regulatory Branch, Coastal Area Section
100 West Oglethorpe Avenue
Savannah, Georgia 31401-3640

To Whom It May Concern:

This is to certify the work subject to the jurisdiction of the U.S. Army Corps of Engineers as described in my application dated February 28, 2020, is to the best of my knowledge, consistent with the Georgia Management Plan.

Since my project is located in the Coastal Area of Georgia, I understand the U.S. Army Corps of Engineers must provide this statement to the Georgia Department of Natural Resources, Coastal Resources Division, Coastal Management Program (GADNR-CRD) for its review, and a Department of Army permit will not be issued until the GADNR-CRD concurs with my findings. I also understand additional information may be required by the GADNR-CRD to facilitate its review of my project and the additional information certifications may be required for other Federal or State authorizations.

Signature of Application: ______

Date: 2-27-20

Printed Name of Applicant: Mr. Steven R. Ingle

Street Address: 2100 Southbridge Parkway

City, State, Zip Code: Birmingham, Alabama 35209

Phone Number: 205-545-8759

Fax Number: ______

E-Mail Address: single@twinpinesminerals.com

For questions regarding consistency with the Georgia Coastal Management Program, Please contact the Federal Consistency Coordinator, GADNR-CRD, (912) 264-7218.

REVISED JANUARY 2018

INDIVIDUAL PERMIT APPLICATION FOR

Twin Pines Minerals, LLC

SAUNDERS DEMONSTRATION MINE
SAINT GEORGE, CHARLTON COUNTY, GEORGIA
(SAS-2018-00554)

Submitted to:
Ms. Holly Ross, Project Manager
U.S. Army Corps of Engineers
Savannah District - Regulatory Division
1104 N. Westover Blvd. Unit 9
Albany, Georgia 31707

Prepared by:
TTL, Inc.
2743-B Gunter Park Drive West
Montgomery, Alabama 36109

USACE Project No. SAS-2018-00554
TTL Project No. 000180200804

March 4, 2020

TTL

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APPENDICES

1.0 INTRODUCTION

Twin Pines Minerals (TPM) proposes to mine heavy mineral sands (HMS) from a site located along Trail Ridge near Saint George, Charlton County, Georgia (Figure 1). On July 3, 2019, TPM prepared and submitted an Individual Permit Application package (USACE Project No.: SAS-2018-00554) to the U.S. Army Corps of Engineers, Savanah District Regulatory Division for impacts to waters of the US associated with the proposed development of 1,450.4 acres for a heavy minerals mine operation. This proposed mine was located near St. George, Charlton County, Georgia. This application was withdrawn on February 7, 2020.

TPM now wishes to conduct a demonstration mining project for a reduced mining area of approximately 898 acres. This demonstration project has been selected and designed to demonstrate that heavy mineral sand (HMS) mining can be conducted in an environmentally responsible manner. The proposed demonstration project will be used to validate a previously completed groundwater model which predicted that mining will have a negligible impact on local groundwater resources, surface water resources, and the Okefenokee Swamp.

Substantial studies have been conducted to determine site characteristics and evaluate potential impacts. The following summarizes these studies and their results.

Heavy Minerals

Economic heavy mineral assemblages located in the southeastern U.S. are formed as heavy minerals become concentrated through depositional processes which remove less dense, more erodible minerals from the sediment thus increasing the percentage of heavy minerals. Environments conducive to this type of preferential weathering and deposition include fluvial-deltaic, barrier island, and beach ridge sequences deposited on ancient and modern shorelines. Hamilton (1995) defines these heavy mineral deposits as “coastal placers” where eolian, wave, and tidal processes provide the mechanical reworking and deposition of sediment to concentrate zircon, ilmenite, rutile and other heavy minerals. In southeastern Georgia, seven coastlines (paleo and current) have been identified which contain heavy-mineral deposits. Trail Ridge is located on the oldest recognized paleo-shoreline, the Wicomico Shoreline (Figure 2).

HMS deposits contain the primary ores of titanium dioxide (TiO_2) for the pigment industry and zircon ($ZrSiO_2$) used in refractory products. TiO_2 is primarily obtained from mining and processing the minerals ilmenite, rutile, and leucoxene. Zircon is the main ore mineral for the elements zirconium (Zr) and hafnium (Hf) and approximately 97 percent of all zirconium is obtained from of zircon mined from HMS deposits.

Proposed Mining Technique

Twin Pines has developed a novel HMS mining technique using a dragline excavator and conveyor system for materials transport, and land-based permanent processing plants. This mining technique is different from conventional "wet mining", which utilizes a dredge and floating concentrator to mine and process heavy mineral-bearing sands. This technique will utilize an electrically powered dragline for mining which can efficiently move large quantities of material.

After mining and processing, the tailings will be transported back to the open mine pit within five to seven days of excavation and the reclamation area will then be recontoured, covered with topsoil and revegetated. The operation is a continuous process and while the dragline is operating, backfilling of the cut is simultaneously occurring. It is estimated that it will require approximately six years to mine the entire 898-acre mining area (Figure 3).

Geology

Soil cores reveal that the upper part of the Surficial Aquifer is heterogeneous, consisting mainly of unconsolidated sands interspersed with irregular, discontinuous zones of semi-consolidated to consolidated sands cemented by humate. Deeper within the Surficial Aquifer, unconsolidated sands are interbedded with discontinuous lenses of clayey sands, silty-clayey sands, and local clay units, likely derived from the underlying Hawthorn Group. Based on our studies, six subsurface units have been identified within the Surficial Aquifer in the study area.

The Surficial Aquifer is the uppermost geologic unit in the area of the proposed mine. The Surficial Aquifer is underlain by the sediments of the Hawthorn Group. The Hawthorn Group is approximately 350 feet thick under Trail Ridge and consists of low-permeability, calcareous clays that effectively isolate the Surficial Aquifer from the deeper Floridian aquifer.

Slug and Pumping Tests

Slug tests conducted within the Surficial Aquifer are described in Holt et al. (2019a). To estimate the horizontal hydraulic conductivity of the Surficial Aquifer, slug and bail tests were performed in 24 piezometers within the project study area. Both methods produced similar estimates of hydraulic conductivity.

Two pumping tests (wells PWA and PWB) conducted for the Surficial Aquifer are described in Holt et al. (2019a). The purpose of the pumping tests was to obtain transmissivity (T) and storage coefficient (S) data for the Surficial Aquifer beneath the site. For pumping test PWA, estimates of T and S from pumping well PWA data range from 1,490 ft^2/day to 1,967 ft^2/day and from 3.5×10^{-4} to 1.1×10^{-2}, respectively. For pumping test PWB, estimates of T and S from pumping well PWB data range from 530 ft^2/day to 697 ft^2/day and from 2.4×10^{-3} to 0.11, respectively.

Precipitation Monitoring

Details of precipitation monitoring are presented in Holt et al. (2019d, 2019e). Local precipitation data was collected from three rain gauges installed by Twin Pines personnel at the northern, central, and southern portions of the project study area. Rain gauge data collected from the project study area indicates that the greatest rainfall occurred during the months of December 2018 and July 2019 with monthly rainfall gauge totals of about 8 and 14 inches, respectively. An examination of the rain gauge data reveals that rainfall across the project study area varies spatially. Hydrographs show that groundwater levels respond quickly to distant rainfall events, even when the closest rain gauge shows no observed precipitation. These rapid responses reflect the high hydraulic conductivity of the Surficial Aquifer at Trail Ridge. Many observed surface water levels show a significant lag with precipitation data, suggesting that surface water levels in these areas are influenced by groundwater flow.

Potentiometric Surface Maps

Water elevation data collected on January 26, April 26, and July 26, 2019, was used to generate potentiometric surface maps of the Surficial Aquifer. Review of the potentiometric surface maps indicates that groundwater elevations at the site generally mimic land surface topography with groundwater flowing to the west and east of Trail Ridge. This indicates that Trail Ridge represents a hydrologic divide within the underlying Surficial Aquifer. Groundwater flow along the west side of Trail Ridge is to the west. Groundwater flow along the east side of Trail Ridge is to the east. Depths to groundwater in the shallow piezometers beneath the site generally range from just below land surface to about 5 feet below ground surface (bgs). The average groundwater velocity along the west and east sides of the ridge was approximately 0.24 ft/day and 0.32 ft/day, respectively, in July 2019.

Water Quality

Water quality sampling activities at the Twin Pines study area are described in Holt et al. (2019c). Precipitation provides most of the recharge for the Surficial Aquifer beneath the study area. As rainfall infiltrates through the soil zone or sediments it is chemically altered through mineral dissolution, precipitation, cation exchange, oxidation reduction, anion exchange, and dissolution of organic molecules. Surface water on the property is dependent on precipitation for recharge, but appears to be in contact with groundwater (within low-lying areas of the site) during periods of seasonally high precipitation. TTL personnel collected groundwater samples from six piezometers and two surface water locations to evaluate background water quality data at the project site. Results of analyses are summarized in Holt et al. (2019c).

Groundwater Models

Holt et al. (2020) developed two types of groundwater models to evaluate the impact of the proposed Saunders Demonstration Mine on the hydrologic system underlying Trail Ridge: numerical models and analytical models. Two numerical models were developed using the U.S. Geological Survey (USGS) code MODFLOW-2005 to simulate three-dimensional, steady-state groundwater flow in the Surficial Aquifer at the study area. First, a model representing pre-mining conditions was created and calibrated to match observed water levels in piezometers and wells. The second model represents post-mining conditions and is based on the original calibrated model, except the calibrated hydraulic conductivity values of the aquifer within the mined zone were homogenized to represent the mine pit filled with spoil. The pre-mining and post-mining models were compared to evaluate changes in the groundwater discharge to the model boundaries (e.g., the swamps to the west and the groundwater system to the east). The models compare changes in the groundwater discharge to streams along Trail Ridge and changes in the water table position at the mine and near the Okefenokee swamp due to the proposed mining project. This comparison shows that the proposed mining activities will have negligible impact on the hydrologic system of Trail Ridge and the Okefenokee Swamp.

The following conclusions were drawn from these modeling efforts:

- Trail Ridge is a classic example of topographically-driven groundwater flow. It acts as a hydrologic divide that separates the Okefenokee Swamp to the west from the Saint Mary's River to the east. Rainfall on Trail Ridge provides water to the Surficial Aquifer. This groundwater recharge causes the water table to rise within a few feet of the ground surface along Trail Ridge, forming a hydrologic divide that mimics the topography. Because groundwater flow follows the elevation of the water table, Trail Ridge groundwater flows to the west, supplying water to the Okefenokee Swamp, and flows to the east, supplying water to springs and creeks.
- Proposed mining activities will have an insignificant impact on the groundwater and stream flow to the Okefenokee Swamp and the creeks and groundwater system to the east of Trail Ridge. A comparison of groundwater models of the pre-mining conditions and post-mining conditions show that changes to the groundwater discharge and stream discharge are minimal and insignificant.
- Mining activities will cause insignificant changes in the water table across most of the study area. Within the mine pit, the water table position will both increase and decrease due to the placement of homogenized sand spoil in the mine pit. At the Okefenokee Wildlife Refuge, the worst-case scenario models predict that the water table will decrease by no more than 0.0004 ft due to mining.
- Mining activities will not dewater the Okefenokee Swamp. The Okefenokee Swamp is 2.7 miles away from the closest part of the proposed mine footprint. The active mine pit will be small and filled within five to seven days of excavation. Analytical groundwater models of the moving mine pit show that water levels will recover to within four feet of their original position within 10 days following excavation and two feet of their original position within about 30 days. The perturbation of the water table caused by the moving mine pit will not affect the Okefenokee Swamp. The Trail Ridge hydrologic divide separating the Okefenokee Swamp to west from the Saint Mary's River to the east will always be maintained.

Groundwater and Surface Water Quality Monitoring Plan

A Groundwater/Surface Water Monitoring Plan has been designed to document monitoring activities to assess the impact or effect of proposed mining on hydrology along Trail Ridge and surrounding areas (including the Okefenokee Swamp) and verify the results of the groundwater models developed for the site. Groundwater/surface water-level monitoring activities are designed to:

- Monitor changes in groundwater levels due to precipitation, recharge, and runoff
- Characterize the response of surface water levels to precipitation and groundwater levels
- Allow the development of models relating precipitation to groundwater levels and recharge
- Identify changes in levels induced by the moving mine pit
- Quantify changes in post-mining water levels
- Provide water-level data to assist in mine reclamation activities

These data will be used to verify current groundwater models and to support future revisions of the groundwater models. Groundwater/surface-water-quality monitoring activities will be conducted to:

- Establish baseline groundwater and surface water chemistry
- Monitor spatial and temporal changes in water chemistry due to mining activities
- Provide groundwater chemistry data for mine restoration activities

Twin Pines estimates that it will take about six years to mine the entire 898 acres. Post-mining monitoring will be performed for a period equal to the period of mining, and will consist of the monitoring of water levels in the piezometers on a continuous basis. This monitoring will include a manual download of the pressure transducers once every two weeks during the post-mining period. Water-quality samples will be collected semi-annually for analysis of the constituents specified in the monitoring plan.

Waters of the United States

TTL performed a delineation of waters of the U.S. for the various tracts during a time period covering April 2018 to June 2019, identifying 1202.399 acres of wetlands and approximately 11,587 linear feet of stream channel within the project area. The preferred demonstration project proposes to impact 453.111 acres of wetland through mining. An additional 25.124 acres of wetland and 412 linear feet of stream are to be impacted as a result of site development

Threatened & Endangered Species

No federally listed threatened or endangered species will be impacted by the demonstration project. Three active gopher tortoise burrows have been identified within the mining footprint. During burrow camera surveys only one gopher tortoise was observed in this colony.

2.0 PURPOSE AND NEED

The purpose of this demonstration project proposed by TPM is to gather data required to evaluate the groundwater hydrology model completed on the selected site (Section 3.0). This evaluation is necessary to demonstrate that heavy mineral sand (HMS) mining can be accomplished in an environmentally sensitive area with negligible impact to the site and surrounding resources. An additional purpose is to develop a high-quality HMS reserve to produce HMS concentrate products including titanium mineral concentrates and zircon concentrates to meet global demands in a safe, cost effective and environmentally sound manner.

The TPM mining plan and the associated groundwater and surface water monitoring plan will be used to confirm the ability of HMS mining to be conducted within close proximity to sensitive environmental resources. As the economic locations for mining HMS within the United States are becoming scarce, it is vital that new mines be developed in such a manner as to minimize environmental impacts. TPM has completed extensive geologic and hydrogeologic evaluations of the Saunders Tract which culminated with the production of a groundwater hydrology model demonstrating that mining can be safely conducted within the demonstration area with negligible impact to the site, the surrounding area, and the Okefenokee Swamp. Small scale projects, such as the one proposed, that can demonstrate sound environmental practices for extracting heavy mineral resources in environmentally sensitive locations, represents good stewardship of the environment.

HMS deposits contain the primary ores of titanium dioxide (TiO_2) for the pigment industry and zircon ($ZrSiO_2$) used in refractory products. TiO_2 is primarily obtained from mining and processing the minerals ilmenite, rutile, and leucoxene. Leucoxene, not technically a mineral, is a higher quality derivative of ilmenite resulting from the preferential weathering and leaching of iron therefore increasing the TiO_2 percentage to greater than 70 percent (Force, 1991). Zircon is recovered as a co-product from the processing of HMS deposits.

Australia and China are the major global producers of HMS and the United States only accounts for about four percent of the total world production of titanium minerals; therefore, the United States "is heavily dependent on imports of titanium mineral concentrates to meet its domestic needs" (Final List of Critical Minerals, 2018). On December 20, 2017, President Trump issued Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals, directing the Secretary of the Interior to produce a list of critical minerals in order "to reduce the Nation's vulnerability to disruptions in the supply of critical minerals, which constitutes a strategic vulnerability for the security and prosperity of the United States." On May 18, 2018 the Department of the Interior published the "Final List of Critical Minerals" within which included titanium and zirconium (Final List of Critical Minerals, 2018). This project will serve to decrease the United States dependence on foreign imports of critical mineral resources including titanium and zirconium as directed in Executive Order 13817.

Titanium is considered a critical and strategic mineral because of the unique properties of both titanium metal and TiO_2 pigment (Woodruff et. al, 2017). According to the USGS (2020), in 2019 the U.S. imported 93 percent of its titanium mineral concentrates with approximately 90 percent of titanium mineral concentrates consumed in the pigment industry. In powder form, TiO_2 is a white pigment used in paints, paper, and plastics because it provides even whiteness, brightness, very high refractive index, and opacity (USGS 2018, USGS 2020). The remaining 10 percent was utilized for welding-rod coatings and manufacturing of carbides, chemicals, and titanium metal. "Titanium metal, derived from processing rutile, ilmenite, and (or) leucoxene is also used in spacecraft, guided missiles, jewelry, artificial joints, and heart pacemakers to name a few." (van Gosen et. al, 2016). From 2018 to 2019 the domestic consumption of titanium mineral concentrates increased 16 percent (USGS, 2020).

Zircon is the main ore mineral for the elements zirconium (Zr) and hafnium (Hf) and approximately 97 percent of all zirconium is obtained from zircon mined from HMS deposits (Jones, 2017; ZIA, 2019). Zirconium and hafnium are metals that are widely used in the chemical and nuclear-reactor industries due to specific properties of the metals. Zircon mineral is highly refractive with a melting point of 2,550 degrees Celsius (°C) or greater and is commonly used for facings on foundry molds, and milled zircon is used in refractory paints for coating the surfaces of molds (Pirkle et. al, 2007; Jones et. al, 2017).

Micronized zircon (zircon "flour") offers high light reflectivity and thermal stability, and thus is used mostly in refractory products as an opacifier for glazes on ceramics such as tiles, and as foundry sands (Zircon Industry Association, 2019). The ceramic industry represents the most important market for zircon with approximately 85% of the total zircon used by the ceramic industry being used in tile production. Zircon can be used as a whiteness and opacity enhancer in ceramics and with respect to tiles, the whiteness of a tile increases with the zircon content. As a glaze, zircon results in increased resistance to abrasion and chemicals (ZIA, 2019). Other uses for zirconia include medical prosthesis devises, cutting tools, abrasives, high-stress manufacturing components (ball valves, bearings, thermal insulators, etc.), lead zirconate titanate (PZT) which is used in microwaves dielectrics, high voltage capacitors, microphones, sonars, mobile phone cameras, etc. (ZIA, 2019).

At the beginning of 2019, titanium and zirconium mineral concentrates were only being mined from two locales within the U.S. – Starke, Florida by The Chemours Company (Chemours), and Nahunta, Georgia by Southern Ionics (now Chemours) (USGS, 2020). TPM is also recovering and producing zircon concentrates from previously mined tailings in Starke, Florida.

3.0 HYDROGEOLOGY OF TRAIL RIDGE

3.1 Trail Ridge and Okefenokee Swamp Background

Trail Ridge

Trail Ridge is a one mile-wide and 100-mile-long topographic ridge that separates the Okefenokee Basin and Swamp from the coastal plain of Georgia (Force and Rich, 1989) (Figure 1). It represents the crest of a former beach complex and was formed as inland sand dunes near the proposed Twin Pines Mine (e.g., Pirkle et al., 1993). The ridge is composed of fine-grained to medium-grained quartzose sand. In an 18-mile portion of its length in Florida, the sand throughout its thickness averages about four percent heavy minerals, which generally consist of ilmenite, zircon, rutile, staurolite, and aluminosilicates. (Force and Rich, 1989).

The earliest geologic descriptions of Trail Ridge were entirely geomorphic. Cooke (1925, 1939) envisioned the ridge as a large Pleistocene marine sand spit that was attached to a mainland near Jesup, Georgia. (Cooke, 1925, plate Xb). Cooke believed that the sand body possibly was tilted northward after deposition and that the sand was partly eolian in origin. MacNeil (1950) extended this view to include the Okefenokee Swamp as a former lagoon behind a Trail Ridge marine shoreline and bar.

In the 1970's and 1980's, numerous geologic publications about Trail Ridge were prepared by the Pirkle family and their colleagues. These publications primarily focused on the source and quantity of heavy mineral sands found within Trail Ridge and the depositional origin of Trail Ridge. E.C. Pirkle and others (1971) described a core through Trail Ridge, adjacent to the Florida-Georgia line. F.L. Pirkle (1975) compared grain sizes, heavy-mineral suites, and grain shapes among Trail Ridge sands and proposed possible source regions. E.C. Pirkle and others (1977) described the portion of the Trail Ridge deposit northwest of Highway 301 in Florida. F.L. Pirkle and Czel (1983) reported marine fossils of probable Pleistocene age at elevations of 39 to 49 meters (130 to 160 feet) in sands just west of and stratigraphically above a Georgia segment of the ridge. W.A. Pirkle and E.C. Pirkle (1984) and F.L. Pirkle (1984) summarized the evidence for a beach-ridge origin of Trail Ridge, the latter paper concluding that some grain-size characteristics of the deposit are consistent only with an eolian origin. Rich (1985) described the palynology of the peat bed, and Force and Garnar (1985) described eolian crossbedding of the ilmenite ore sand.

The ridge is underlain by a shallow aquifer, locally known as the Surficial Aquifer, and forms a hydrologic divide between the Okefenokee swamplands to the west and the Saint Mary's River to the east. At the Twin Pines project study area, Trail Ridge is a classic example of a topographically-driven hydrologic system as illustrated in the site conceptual model (Figure 4). The water table is shallow and mimics the ground surface. Much of the precipitation that falls on Trail Ridge is returned to the atmosphere by evaporation and transpiration. Precipitation that is not evaporated or transpired to the atmosphere infiltrates to recharge the Surficial Aquifer. Groundwater recharge on Trail Ridge causes the water table to mound close to the land surface. In the absence of recharge, water would flow from the Okefenokee Swamp in the west [where water levels are at an elevation of about 120 feet above mean sea level (amsl)] to the east (where water levels are at an elevation of 80 feet amsl) and the water table would linearly decline to the east.

Groundwater mainly flows from the centerline of Trail Ridge to the west and to the east and small amounts of groundwater discharges to local streams, particularly on the eastern side of the study area. Along the western margin of the study area, groundwater flow provides water to the Okefenokee Swamp and related wetlands. On the eastern side, groundwater provides base flow to streams.

Okefenokee Swamp

The Okefenokee Swamp is a 395,000-acre freshwater wetland. The swamp is one of the largest freshwater wetland complexes in the United States and a National Wildlife Refuge and designated wilderness area (Brook and Sun, 1987). Figure 5 indicates major characteristics such as uplands, stream drainage divides and the watershed of the Okefenokee. Formation of the wetland landscape began at least 650,000 years ago, as plant decay was delayed by continuous flooding, creating anerobic, acidic conditions favorable for peat production (Cohen 1973a). Elevations within the swamp range from 130 feet amsl on the northeast side to about 105 feet amsl on the southwest side.

3.2 Subsurface Geology

The hydrology and geology of Trail Ridge in the study area has been extensively characterized (e.g., Holt et al., 2019a; 2019b; 2019c; 2019d, 2019e, 2019f, and 2019g). 387 exploratory borings were cored and described by TPM. 217 borings were completed and described by TTL including 86 piezometers installed in the Surficial Aquifer (Figure 6). Two deep pumping wells and 22 associated observation wells were drilled in the northern and southern portions of the study area. Soil cores reveal that the upper part of the Surficial Aquifer is heterogeneous, consisting mainly of unconsolidated sands interspersed with irregular, discontinuous zones of semi-consolidated to consolidated sands cemented by humate (Figures 7 and 8). Deeper within the Surficial Aquifer, unconsolidated sands are interbedded with discontinuous lenses of clayey sands, silty-clayey sands, and local clays units, likely derived from the underlying Hawthorn Group. Six subsurface units have been identified within the Surficial Aquifer in the study area; these units are briefly described below:

1) The majority of the sediment underlying Trail Ridge is part of an unconsolidated sand unit that generally consists of silty sands (SM) and well sorted sands (SP). Subsurface boring data collected from the project area indicates that this unit extends from land surface to the top of the Hawthorn Group sediments.
2) Semi-consolidated sands generally consist of fine- to medium-grained silty sands (SM) and well sorted sands (SP) and silty-clayey sand (SC-SM) with a color range from black to brown. The general characteristics of semi-consolidated sand unit includes sands that are moderately cohesive due to the presence of minor amounts of humate.
3) Consolidated black sands consist of fine- to medium-grained silty sands (SM) and well sorted sands (SP) and are generally described as black in color. These sands are cemented by humate.
4) Silty-clayey sands are black to brown to grey and generally consist of fine- to medium-grained sands with silt and less than five percent clay content. These sands are loosely cohesive due to the presence of small amounts of clay.
5) The clayey sand unit generally consists of fine- to medium-grained silty sands with clay content between 10 to 40 percent and ranges in color from yellow to brown to grey. The general characteristics of the clayey sand unit includes sands that are cohesive due to moderate clay content.
6) The clay unit at the site consists of silty clays, sandy clays, and fat clays and ranges in color from brown to grey to greenish grey closer to the Hawthorn Group. The clay layer is generally firmer and more compact than the surrounding sand units.

The Surficial Aquifer is underlain by the sediments of the Hawthorn Group. The Hawthorn Group is approximately 350 feet thick under Trail Ridge (e.g., Williams & Kuniansky, 2016) and consists of low-permeability, calcareous clays that effectively isolate the Surficial Aquifer from the deeper Floridian aquifer.

Holt et al (2019g) generated 24 geologic cross sections depicting subsurface data across the project study area. The cross sections depict the soil/sediment matrix comprising the Surficial Aquifer beneath the project study area as generally being dominated by unconsolidated sand; however, heterogeneity is present within the subsurface due to the presence of irregular zones of lower permeability semi-consolidated to consolidated sands and lenses of silty-clayey sands, clayey sands and clays. Of particular importance is the lateral continuity of the consolidated black sands, which can create local areas of lower permeability soil beneath the study area. Extensive drilling activities performed within and/or immediately adjacent to the proposed permit area indicated that the consolidated black sands are very discontinuous in the permit area and appear in irregular zones, not layers.

Indicator geostatistics were used to examine the spatial continuity of soil types present within the Surficial Aquifer along Trail Ridge. Seven target soil types were identified for this analysis, including clay, consolidated sand, clayey sand, silty-clayey sand, semi-consolidated sand, unconsolidated sand, and unconsolidated humate-stained (black) sand. For each soil type, borehole data were transformed into indicator functions, with a value of 1 assigned where the target soil type is present and a value of 0 assigned where it is absent, e.g.,

$$I(\mathbf{x}) = \begin{cases} 1 & \text{Target soil present} \\ 0 & \text{Target soil absent} \end{cases}$$

where $\mathbf{x}$ is a location (coordinate) vector. Data files containing the transformed data are presented electronically in Appendix A. These data were then used to create experimental indicator variograms using Stanford Geostatistical Modeling Software (SGeMS) (Remy, 2005).

$$\gamma(\mathbf{h}) = \frac{1}{2\,N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \left[I(\mathbf{x}_i + \mathbf{h}) - I(\mathbf{x}_i) \right]^2 \qquad (1)$$

where $N(\mathbf{h})$ is the number of samples in lag interval $\mathbf{h}$ and $I(\mathbf{x})$ is the indicator function. Because the soil data are statistically anisotropic, two horizontal variograms were estimated along the azimuths of the maximum and minimum correlation lengths, and one vertical variogram was calculated. These variograms were then fit using one of the three variogram models described in Table 1 to estimate correlation lengths for each soil type (Tables 2 and 3). In this case, the correlation length nominally represents the maximum distance that the presence or absence of the target soil type can be predicted from an observation of a target soil type in a borehole. Variograms for consolidated sand are shown in Figures 9 and 10, and all variograms are shown in Appendix B.

Indicator variograms were used to indicator krige each of the soil types. Indicator kriging generates a map of the probability that a particular soil type is present (e.g., Journel, 1978). In areas far from borehole data, the probability that a soil type is present is represented by the fraction of that soil type observed in all boreholes. Indicator kriging was performed using a three-dimensional kriging algorithm provided in SGeMS (Remy, 2005). Indicator-kriged maps indicating the probability that consolidated sand is present at various elevations are shown in Figures 11 through 13, and probability maps for all soil types are presented in Appendix C.

The maximum horizontal correlation lengths for all soil types are small (Table 2), ranging from 336 feet for clay and unconsolidated sand to 912 feet for silty-clayey sands, indicating that these units are horizontally very discontinuous. Vertical correlation lengths range from 7.2 feet for semi-consolidated sand to 36 feet for silty-clayey sand (Table 3). Humate-cemented consolidated sand has a maximum horizontal correlation length of 432 feet, a minimum horizontal correlation length of 240 feet, and a vertical correlation length of 18 feet; these short correlation lengths are consistent with a diagenetic origin for the humate cements. The probability maps for the humate-cemented consolidated sand (Figures 11 through 13) illustrate the discontinuity of these sands, particularly in the south-central part of the study area where boreholes are closely spaced.

3.3 Hydraulic Properties and Data

Hydraulic property data obtained from the Surficial Aquifer and subsurface soil/sediments underlying the study area were collected to assist in the creation of groundwater models. A summary of the field and laboratory testing activities performed during the acquisition of hydraulic property data within the study area is listed below:

- Two 24-hour pumping tests along the crest of Trail Ridge and 24 slug and bail tests at piezometers across the project study area.
- Laboratory testing of soil/sediment samples collected across the project study area.
- Installation of 23 staff gauges at surface water locations across the project study area.
- Collection of local precipitation data from three rain gauges installed by Twin Pines personnel at the northern, central, and southern portions of the project study area.
- Deployment of 111 data loggers in select piezometers, observation wells, and staff gauge locations.

Pumping Tests

Pumping tests conducted for the Surficial Aquifer are described in Holt et al. (2019a) and are summarized here.

TTL contracted with Hydro Geo Chem, Inc. (HGC) of Phoenix, Arizona for assistance in design, data collection for the two pumping tests, and analysis of the pumping test data. The purpose of the pumping tests was to obtain transmissivity (T) and storage coefficient (S) data for the Surficial Aquifer beneath the site.

In December 2018, TTL subcontracted Partridge Well Drilling Company, Inc. (Partridge) of Jacksonville, Florida to install two pumping wells (PWA and PWB) within the project study area (Figure 14). The northernmost pumping well on the eastern crest of Trail Ridge was designated PWA and the southernmost well on the western crest of Trail Ridge was designated PWB. Each pumping well was installed to a depth of approximately 115 feet below ground surface (bgs). A TTL geologist was present during the drilling activities to describe soil samples and supervise well installations for PWA and PWB.

During November 2018 through January 2019, Betts Environmental provided drilling services for the installation of 22 observations wells. Eleven observation wells were constructed adjacent to pumping wells PWA and PWB, respectively (Figures 15 and 16). Well construction characteristics of pumping and observation wells are listed on Table 4.

For pumping test PWA, estimates of T and S from pumping well PWA data range from 1,490 ft^2/day to 1,967 ft^2/day and from 3.5×10^{-4} to 1.1×10^{-2}, respectively. Although estimates of T from observation well data range from approximately 1 ft^2/day to 2,288 ft^2/day, the majority of estimates are lower than for the pumping well and average 875 ft^2/day. Estimates of S from observation well data range from approximately 1.6×10^{-5} to 1.7×10^{-2}; estimates of horizontal hydraulic conductivity (Kh) range from <1 to 20 ft/day; estimates of vertical hydraulic conductivity (Kv) range from 0.06 ft/day to 1.8 ft/day; and estimates of aquitard Kv range from 2.4×10^{-6} ft/day to 0.75 ft/day. The lowest T of 1 ft^2/day was derived from one interpretation of data from OWA-3D, where, due to non-uniqueness, T estimates from alternate interpretations ranged from 1 ft^2/day to 1,700 ft^2/day.

For pumping test PWB, estimates of T and S from pumping well PWB data range from 530 ft^2/day to 697 ft^2/day and from 2.4×10^{-3} to 0.11, respectively. T estimates from the shallowest water table well data range from 5,455 ft^2/day to 9,500 ft^2/day. Excluding these estimates, observation well data yield T estimates ranging from approximately 53 ft^2/day to 1,100 ft^2/day; however, the majority of the estimates are lower than for the pumping well and average 432 ft^2/day. Estimates of S from observation well data range from approximately 1×10^{-10} to 5×10^{-3}; estimates of Kh range from <1 to 11 ft/day; estimates of Kv range from 8.6 x 10^{-5} ft/day to 1.5 ft/day; and estimates of aquitard Kv range from 1.1 x 10^{-6} ft/day to 0.3 ft/day.

Slug Tests

Slug tests conducted within the Surficial Aquifer are described in Holt et al. (2019a) and are summarized here.

To estimate the horizontal hydraulic conductivity of the Surficial Aquifer, slug and bail tests were performed in the 24 piezometers within the project study area. Slug and bail tests were conducted by creating an instantaneous change in water level in the piezometer and recording the rate of groundwater recovery relative to the initial measured water level.

The slug and bail tests were interpreted by HGC. Slug test data were analyzed using the Kansas Geological Survey (KGS) method (Hyder et al., 1994) and the Bouwer-Rice method (Bouwer and Rice, 1976). The results from the 24 slug and bail tests performed in the study area are shown in Table 5 and Figures 17 and 18. Both methods produced similar estimates of hydraulic conductivity. Hydraulic conductivities estimated using the KGS method range from 0.2 to 75.1 ft/day and average 12.2 ft/day. The Bouwer-Rice method yields a hydraulic conductivity range of 0.24 to 54.7 ft/day and an average of 13.5 ft/day. Estimates of aquifer specific storage from the KGS method range from 3.8 x 10^{-20} to 2.2 x 10^{-3} 1/ft and average specific storage of 1.6 x 10^{-4} 1/ft.

The averages of the hydraulic conductivity estimated from a slug test and corresponding bail test at each well show a distinct vertical pattern, with lower hydraulic conductivities found below an elevation of 120 feet amsl and much higher hydraulic conductivities found above 120 feet amsl (Figure 19).

Holt et al. (2019) showed that the subsurface lithology is dominated by unconsolidated sands. They also found that humate-cemented sands are more common above 120 feet amsl and that silty-clayey sand, clayey sand, and clay are more common below 120 feet amsl. The vertical distribution of hydraulic conductivity estimated from slug tests reflects the occurrence of clays below 120 feet amsl. The data presented here suggest that there are two distributions of hydraulic conductivity: one for elevations above 120 feet amsl and another for elevations below 120 feet amsl.

The log of the averaged (slug and bail) hydraulic conductivity for both the upper and lower elevations appears to be log normal for both types of estimates (KGS and Bouwer Rice). The geometric means for the upper elevations are 9.4 and 7.9 ft/day for hydraulic conductivities estimated using the KGS and Bouwer-Rice methods, respectively. In the lower elevations, the geometric means are 2.1 and 1.8 ft/day for the KGS and Bouwer-Rice methods, respectively. Figures 20 and 21 depict the normality plots for slug tests conducted above and below 120 feet amsl, respectively. Note: only the results for hydraulic conductivities for the KGS method are shown, as the results for hydraulic conductivities determined using the Bouwer-Rice method are similar.

Laboratory Tests

Laboratory tests of sediments and soils from the Surficial Aquifer are described in Holt et al. (2019f) and are summarized here.

Soil/sediment samples were collected from borings drilled throughout the project study area and submitted for the following laboratory analyses:

- 53 Vertical hydraulic conductivity analysis (undisturbed samples)
- 7 Vertical hydraulic conductivity analysis (remolded or disturbed samples)
- 42 Porosity analysis

- 132 Grain-size distribution analysis
- 3 Soil Moisture Retention Curve Analysis (various analysis)
- Vertical hydraulic conductivity analysis of post-processed sands

Locations of borings utilized for soil/sediment sampling (i.e. UD borings, exploratory borings, and piezometers) are shown on Figures 22 through 24.

Vertical Hydraulic Conductivity

During drilling activities within the project study area, undisturbed and disturbed samples of soil/sediment were collected for vertical hydraulic conductivity (Kv) analysis. A total of 42 soil/sediment samples for Kv analysis were collected from UD borings using mud rotary drilling technique and operation of the Denison Sampler. The remainder of the soil/sediment samples for Kv analysis were collected using either a sonic or hollow-stem auger drill rig and stainless-steel Shelby tubes. The soil/sediment samples collected for Kv testing were transported by TTL courier to Bowser-Morner's laboratory in Dayton, Ohio or TTL's laboratories in Albany, Georgia or Tuscaloosa, Alabama for analyses.

Results of the laboratory analyses indicated Kv values for samples of semi-consolidated to consolidated sands and clayey sands ranging from 1.70×10^{-8} to 6.30×10^{-2} centimeters per second (cm/sec) (Table 6). Results of the laboratory analyses of unconsolidated sands samples indicated Kv values ranging from 2.07×10^{-7} to 3.90×10^{-4} cm/sec. The geometric mean of Kv values for undisturbed unconsolidated sands samples ranged from 1.30×10^{-5} to 4.30×10^{-4} cm/sec. For the modeling efforts, laboratory testing data could not be used to assign the soil-type hydraulic conductivity values because soil samples collected using a mud rotary drilling technique and operation of a Denison Sampler were contaminated by drilling muds, lowering the measured hydraulic conductivity (Holt et al., 2019f). The Kv values of three soil/sediment samples collected from the top of the Hawthorn Group ranged from 1.61×10^{-9} to 1.29×10^{-5} cm/sec.

Two undisturbed samples of the humate-cemented, consolidated sand were collected using Shelby tube samplers. The Kv values of these samples were 2.70×10^{-8} cm/s (PZ59D, 20-22 feet bgs) and 3.47×10^{-7} cm/s (PZ57D, 25-27 feet bgs).

Porosity and Grain-Size Distribution

A total of 42 soil/sediment samples were submitted to Bowser-Morner's off-site laboratory for porosity analysis. Results of the porosity analysis of these 42 soil/sediment samples indicated soil porosity values ranging from 30.1% to 43.7% (Table 7). A total of 125 soil/sediment samples were collected for grain-size distribution and analyzed by either Bowser-Morner's or TTL's off-site laboratory. Results of the grain-size distribution analysis of 125 soil/sediment samples indicated that the majority of the soil samples classified as predominantly sand with very little silts or clays (Table 8).

Soil Moisture Retention Curves

A total of three undisturbed soil samples were collected from the surface at three locations within or adjacent to the proposed permit area for soil moisture retention curve analysis (Figure 25). In addition, a full one-gallon Ziploc bag of loose material was collected from each location for remolded sample testing. The soil samples were submitted to Daniel B. Stephens & Associates, Inc (DB Stephens) in Albuquerque, New Mexico for the following laboratory analyses.

Soil Samples and Analytical Procedures			
Sample ID	Matrix	Number of Samples	Summary of Test Performed
SS-ADK-01	Soil	1	Gravimetric Moisture Content Volume Measurement Method Constant Head Rigid Wall Hanging Column Pressure Plate Dew Point Potentiometer Relative Humidity Box Calculated Unsaturated Hydraulic Conductivity
SS-KEY-01	Soil	1	
SS-TIA-01	Soil	1	

A listing of methods used in performance of the above-referenced tests are listed below:

Tests	Methods
Dry Bulk Density	ASTM D 7263
Moisture Content	ASTM D 7263, ASTM D 2216
Calculated Porosity	ASTM D 7263
Saturated Hydraulic Conductivity:	ASTM D 5856 (modified apparatus)
Hanging Column Method	ASTM D 6836 (modified apparatus)
Pressure Plate Method	ASTM D 6836 (modified apparatus)
Water Potential Method	ASTM D 6836
Relative Humidity Box	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325.
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991.

The porosity in the soil samples ranged from 38.5% to 44.8%, and the saturated hydraulic conductivity varied from 2.0E-03 cm/s to 1.6E-02 cm/s in the undisturbed samples and 3.2E-04 to 1.1E-02 cm/s in the remolded samples. The van Genuchten (1980) parameters α and n are consistent with those of well-sorted to poorly-sorted sands.

Soil Physical Characteristics				
Sample ID	Porosity (-)	Ks (cm/s)	α (cm^{-1})	n (-)
SS-ADK-01 (Undisturbed)	44.8	1.6E-02	0.0305	3.6589
SS-ADK-01 (Remolded)	39.8	1.1E-02	0.0370	2.9456
SS-KEY-01 (Undisturbed)	38.5	2.0E-03	0.0357	1.4480
SS-KEY-01 (Remolded)	39.9	1.9E-03	0.0188	1.6228
SS-T1A-01 (Undisturbed)	42.0	2.4E-03	0.0450	1.3213
SS-T1A-01 (Remolded)	40.1	3.2E-04	0.0236	1.4332

Vertical Hydraulic Conductivity Analysis of Post-Processed Sands

TTL considered that the vertical hydraulic conductivity of sands returned to the mine pit during reclamation/restoration may need to be reduced to ensure that groundwater levels are appropriate for maintaining wetlands. Bench-scale studies were conducted to evaluate methods for decreasing the permeability of sands returned to the mining pit. TTL drilled 14 soil borings (UD borings) across the study area and collected bulk sand samples from ground surface to 50 feet below ground surface (bgs), which represents the proposed maximum mining depth. The bulk sand samples collected from 0 to 50 feet bgs were drummed by individual boring location and transported to Minerals Technologies, Inc. (MT) in Stark, Florida in order to process the material in a similar manner as the proposed mining extraction process (i.e. extraction of the humate, clays (or slime), and heavy minerals).

The post-processed sands, minus humate, clays, and heavy minerals, were drummed and then transported to TTL's office in Tuscaloosa, Alabama for Kv analysis. Once at TTL's office the drums were paired as indicted on Figure 26 and the paired drums were combined to ensure that sufficient material was available for testing. Samples of the post-processed sand were collected from UD 338/25 and placed in a steel chamber that allowed for application of a load equal to approximately 4,500 pounds over 24-hours. Prior to the addition of bentonite, three simulated in-situ samples (UD 338/25 A, B, and C) were collected from the steel chamber using drive tubes for dry bulk density, moisture content, and Kv analysis. This process was repeated for the permeability testing of sand samples mixed with percentages of bentonite equal to 0.35% and 1.42%, respectively. Additionally, individual samples of sand were collected directly from the UD338/25 drum and mixed with the following percentages of bentonite: 5%, 7.5%, 10%, 12.5%, 15%, and 30%. After mixing, each sample was remolded and tested for vertical hydraulic conductivity. Bentonite used for testing was a Wyoming bentonite, high yield, high viscosity bentonite produced by Halliburton, Baroid Industrial Drilling Products. TTL also performed permeability tests on two undisturbed samples of black humate-cemented consolidated sand collected from borehole PZ57D. Permeability test results are provided in Table 9.

Results of the bench-scale study that the Kv value of homogenized post-processed sand is approximately 1.0E-03 cm/sec. The study also indicated that a mixture of approximately 10% to 12.5% bentonite would be required to achieve a relative permeability similar to the results calculated for the black humate-cemented consolidated sand in the two samples from PZ57D (Table 9).

Groundwater, Surface Water, and Precipitation Monitoring

Details of the groundwater, surface water, and precipitation monitoring are presented in Holt et al. (2019d, 2019e) and are summarized here.

Field activities performed to collect local precipitation, surface water, and groundwater data at the site included the following:

- Collection of local precipitation data from three rain gauges installed by Twin Pines personnel at the northern, central, and southern portions of the project study area (Figure 27).
- Installation of 23 staff gauges at surface water locations across the project study area (Figure 28).
- Deployment of 111 data loggers in select piezometers and observation wells (Figure 29).

A summary of rain gauge data is listed in Table 10. Tabulations of surface water and groundwater elevation data at monitored locations are listed in Tables 11 and 12.

The purpose of the above-referenced activities was to obtain water-elevation data that could be used to evaluate: (1) the response of groundwater and surface water to precipitation events, (2) groundwater and surface water interaction, (3) fluctuations of water elevations over time, and (4) groundwater flow direction and velocity.

Between January and July, 2019, TTL installed In-Situ, Inc. Rugged Troll 200 non-vented data loggers equipped with a cable setup for direct-read at land surface in select piezometers, observation wells, and at each staff gauge monitoring location. Each data logger deployed was programmed to record groundwater elevation, water pressure, and temperature data at ten-minute intervals. Additionally, In-Situ, Inc. Rugged BaroTroll 200 data loggers were deployed at land surface across the site to measure and log barometric pressure and temperature.

TTL personnel used a tablet and/or laptop to manually download Rugged Troll and BaroTroll data from each monitoring location. The In-Situ, Inc. BaroTroll 200 data and Win Situ 5/Baro Merge Software were used to automatically correct groundwater elevation data (recorded with the Rugged Troll 200) for barometric pressure changes.

<u>Rain Gauge Data</u>

Rain gauge data collected from the project study area (Figure 30) indicates that the greatest rainfall occurred during the months of December 2018 and July 2019 with monthly rainfall gauge totals of about 8 and 14 inches, respectively. Additionally, during the November 28, 2018 to October 16, 2019 rain gauge monitoring period, monthly rainfall totals varied from about 0.1-inch to over 2-inches in measurements recorded at the three rain gauges. This range of differences in rainfall between the three rain gauges is related to the size of the project study area and indicates variation in local weather patterns. For example, during site field activities, field personnel observed rainfall occurring on the north side of the study area while no rainfall was observed on the southern half of the study area.

<u>Hydrograph Data</u>

Data logger measurements were used to generate hydrographs for comparing daily groundwater and surface water elevations to precipitation data. As reported by Holt et al (2019e), hydrograph data indicates that depths to groundwater beneath the study area generally range from just below ground surface to five feet bgs; however, during periods of increased precipitation, the water levels in some piezometers were observed to temporarily rise above the top of the well casings. Groundwater and surface water elevations generally declined from January through June 2019 followed by a sharp increase during the month of July and a second decline from August to October, which correlates with seasonal rainfall fluctuations at the site. During the January to June and August to October periods of decline of groundwater levels, surface water elevations also decreased and were dry at several staff gauge locations. The hydrograph data indicates that both groundwater and surface elevations showed similar response times to precipitation events at the site (Figure 31), which suggest that the infiltration rate was generally greater than the runoff rate at the monitored locations. Additionally, changes in groundwater elevations and time of response compared to precipitation data were generally the same in shallow and deep piezometer pairs (Figure 32).

An examination of the rain gauge data reveals that rainfall across the project study area varies spatially. Hydrographs show that groundwater levels respond quickly to distant rainfall events, even when the closest rain gauge shows no observed precipitation. These rapid responses reflect the high hydraulic conductivity of the Surficial Aquifer at Trail Ridge. Many observed surface water levels show a significant lag with precipitation data, suggesting that surface water levels in these areas are influenced by groundwater flow (Figures 33 and 34).

Hydrograph data from 8 of 12 shallow and deep piezometer pairs within or adjacent to the proposed permit area indicated generally less than a 0.5-foot separation in groundwater elevations between the deep and shallow piezometers (Figure 35). These eight piezometers are identified as PZ33D/S, PZ31D/S, PZ29D/S, PZ30D/S, PZ55D/S, PZ28D/S, PZ25D/S, and PZ27D/S. Hydrographs from the remaining three shallow and deep piezometer pairs PZ16D/S, PZ48D/S, PZ57D/S, and observation wells OWB1D/S/BS showed separation of groundwater elevations that ranged from 1 to 3 feet above mean sea level (amsl). The small separation between groundwater elevations in these shallow and deep piezometers/wells, as well as, similar response times to rain events indicates that permeability of subsurface soils within the majority of proposed permit area is generally homogenous.

Groundwater elevations in deep piezometers PZ01D, PZ03D, PZ36D exhibited artesian conditions, with groundwater elevations that rose above those of their respective partner shallow piezometer. These three piezometers are located outside the proposed permit area, along the west-northwestern boundary of the project study area. Data collected from shallow and deep piezometer pairs PZ39D/S, PZ45D/S, PZ58D/S, and observation wells OWA1D/1S/1BS, located northeast of the proposed permit area, showed differences of groundwater elevations ranging from about 4 feet to 13 feet (Figure 36). The groundwater elevation differences in these shallow and deep piezometers/wells indicates that the permeability of subsurface soils northeast of the proposed permit area is likely more heterogeneous.

<u>Potentiometric Surface Maps</u>
Water elevation data collected on January 26, April 26, and July 26, 2019, was used to generate potentiometric surface maps of the Surficial Aquifer (Figures 37 through 39, respectively). Review of the potentiometric surface maps indicates that groundwater elevations at the site generally mimic land surface topography with groundwater flowing to the west and east of Trail Ridge. This indicates that Trail Ridge represents a hydrologic divide within the underlying Surficial Aquifer. Groundwater flow along the west side of Trail Ridge is to the west. Groundwater flow along the east side of Trail Ridge is to the east. Review of groundwater data indicates elevations beneath the site range from a high of about 174 feet amsl along the crest of Trail Ridge to 108 feet amsl along the east side of the project study area. Depths to groundwater in the shallow piezometers beneath the site generally range from just below land surface to about five feet bgs.

Assuming steady groundwater flow, the Darcy flux and the groundwater velocity can be estimated by determining the hydraulic gradient along a streamline, averaging the hydraulic conductivity values determined from slug tests, and assuming an effective porosity (0.32 for medium sand; McWorter and Sunada, 1977; Yu et al, 1993). Four streamlines were selected from the July 2019 potentiometric surface map (Figure 39), the horizontal distance between select equipotentials was determined for each streamline, and the hydraulic gradient was determined. The resulting hydraulic gradients were

5.573×10^{-3} for the northwest streamline, 6.456×10^{-3} for the southwest streamline, 8.729×10^{-3} for the northeast streamline, and 6.066×10^{-3} for the southeast streamline. The average hydraulic conductivity from slug tests conducted in the permit area (south streamlines) was 10.3 feet per day (ft/day), and slug tests conducted in the northern part of the study area had an average hydraulic conductivity of 16.0 ft/day. The average groundwater velocity along the west and east sides of the ridge was approximately 0.24 ft/day and 0.32 ft/day, respectively, in July 2019. The average Darcy Flux along the west and east sides of the ridge was approximately 0.08 ft/day and 0.10 ft/day, respectively, in July 2019.

3.4 Water Quality

Water quality sampling activities at the Twin Pines study area are described in Holt et al. (2019c) and are summarized here.

Precipitation provides most of the recharge for the Surficial Aquifer beneath the study area. As rainfall infiltrates through the soil zone or sediments it is chemically altered through mineral dissolution, precipitation, cation exchange, oxidation reduction, anion exchange, and dissolution of organic molecules. Surface water on the property is dependent on precipitation for recharge, but appears to be in contact with groundwater (within low-lying areas of the site) during periods of seasonally high precipitation.

Current land use at the site generally consist of industrial forestry operations and recreational hunting. Historical operations during the late 1800s and early 1900s included industrial forestry operations for the harvesting of resins and distillation of turpentine. An adjacent property owner reported that at least a portion of the study area was used as a cattle ranch in the last 50 years. Based on the historical land use at the site, groundwater and surface water samples were collected to evaluate baseline water quality data within the project study area.

On April 25 and 26, 2019, TTL personnel collected groundwater samples from six piezometers and two surface water locations to evaluate background water quality data at the project site. The groundwater and surface water samples were shipped via FedEx overnight delivery to Xenco Laboratories (Xenco) in Norcross, Georgia for laboratory analysis. The groundwater and surface water samples were analyzed for the following parameters:

Groundwater and Surface Water Sampling Locations and Laboratory Analyses.

Sample ID	Laboratory Analysis	Method
Groundwater Samples PZ08 PZ14 PZ16S PZ28D PZ48S PZ43 Surface Water Samples SW1 (W) SW2 (E)	Alkalinity, Total (as CACO3) Alkalinity, Bicarbonate (as CACO3) Alkalinity, Carbonate (as CACO3)	SM2320B
	Bromide, Chloride, Fluoride, Sulfate, Acetate, Formate	EPA 300
	Isovaleric Acid Valeric Acid Isocaproic Acid Heptanoic Acid Butyric-Isobutyric Acid	Organic & Volatile Acids by HPLC
	Total Dissolved Solids	SM2540C
	Total Organic Carbon	SM5310C
	Phosphorous, Total (as P)	EPA 365.1

Groundwater and Surface Water Sampling Locations and Laboratory Analyses.		
Sample ID	Laboratory Analysis	Method
	Aluminum, Arsenic, Barium, Boron, Calcium, Copper, Iron, Magnesium, Manganese, Potassium, Selenium, Sodium, Titanium, Thorium, Uranium Zinc	SW-846 6020A
	Mercury	SW-846 7470A
	Lithium, Silicon, Scandium 45,	SW-846 6010C
	Nitrogen, Ammonia (as N)	EPA 350.1
	Nitrogen, Total Kjeldahl (TKN)	EPA 351.2
	Nitrogen, Nitrate-Nitrite	EPA 353.2
	Field Measured Parameters: Temperature, pH, specific conductance, dissolved oxygen, oxidation-reduction potential, and turbidity	

Groundwater Sample Data

Field Parameters

A summary of the field parameters measured in groundwater samples collected from the six piezometers are listed below.

Field Measurement	Groundwater Samples			
	# of Measurements	Median	Average	Range
Temperature (degrees °C)	6	20.9	20.8	20.0-21.4
pH (standard units)	6	4.35	4.35	4.11-4.89
Specific Conductance (µS/cm)	6	62.5	59.3	43-70
Oxidation Reduction Potential (mV)	6	279	270	221-310
Dissolved Oxygen (mg/L)	6	0.86	1.50	0.1-3.54

°C = degrees celcius mV = millivolts
µS/cm = microsiemens per centimeter mg/L - milligrams per liter

Laboratory Analytical Data

Concentrations of detected constituents in groundwater samples were compared to groundwater protection standards. The groundwater protection standard consisted of USEPA Regional Screening Levels (RSLs) for tap water, and or the USEPA Maximum Contaminant Levels (MCLs) and Secondary MCLs for drinking water. Based on the results of the laboratory analysis of groundwater samples, the following exceedances of a groundwater protection standard were noted:

- Aluminum exceeded the EPA RSL for tap water of 2.00 mg/L in two of the six groundwater samples.
- Iron exceeded the Secondary MCL value for drinking water of 0.300 mg/L in all six groundwater samples; however, lower pH of the groundwater most likely mobilized iron in the aquifer matrix.
- Manganese exceeded the Secondary MCL value for drinking water of 0.050 mg/L in one of the six groundwater samples.

Surface Water Sample Data

Field Parameters

A summary of the field parameters measured in samples of surface water collected are listed below.

Constituent	Surface Water Samples			
	# of Measurements	Median	Average	Range
Temperature (degrees °C)	2	24.2	24.2	19.7-28.7
pH (standard units)	2	5.14	5.14	4.05-6.22
Specific Conductance (µS/cm)	2	240	240	87-392
Oxidation Reduction Potential (mV)	0	---	---	---
Dissolved Oxygen (mg/L)	2	7.51	7.51	7.09-7.93

°C = degrees celcius mV = millivolts
µS/cm = microsiemens per centimeter mg/L - milligrams per liter

Laboratory Analytical Data

Concentrations of detected constituents in surface water samples were compared to the Georgia Environmental Protection Division instream water quality standards (Rule 391-3-6-.03). Based on a review of the laboratory analytical data, the following constituents were detected in surface water samples; however, there are currently no instream water quality standards listed for these detected constituents.

- Chloride, sulfate, aluminum, barium, boron, calcium, iron, magnesium, manganese, potassium, strontium, total dissolved solids, total organic carbon, total phosphorus, ammonia (as N), and total kjeldahl nitrogen.

3.5 Climate Data

Climate data were collected to support groundwater modeling efforts and are reported in Holt et al. (2019e) and are summarized here.

Historical climate information for temperature, precipitation, and evapotranspiration were obtained from online resource databases from one government and two academic organizations. The table below summarizes source information of historical climate data compiled for this study.

Climate Data Source Information				
Climate Values	Years Compiled	Dataset Title	Data Source	Data Source Affiliation
Temperature	1986 - 2017	Global Summary of the Month (GSOM)	National Centers for Environmental Information (NCEI)	National Oceanic and Atmospheric Administration (NOAA)
Precipitation	1986 - 2017			
Evapotranspiration	2003 - 2017	Evapotranspiration Data from Water Balance Calculator	Automated Environmental Monitoring Network Page (AEMN)	College of Agricultural and Environmental Sciences - University of Georgia (UGA)
		Evapotranspiration Monthly Average	Florida Automated Weather Network (FAWN)	IFAS Extension – University of Florida

As reported by Holt et al (2019d), the estimated average temperature, precipitation, and evapotranspiration values were documented:

- The estimated average temperature at the project study area over a 32-year period is 68.60 degrees Fahrenheit,
- The estimated annual precipitation value at the project study area over the last 32-year period is 51.25 inches per year and,
- The estimated average total annual evapotranspiration value at the project study area over the last 15-year period is 39.50 inches per year.

3.6 Summary of Groundwater Models

Holt et al. (2020) developed two types of groundwater models to evaluate the impact of the proposed Saunders Demonstration Mine on the hydrologic system underlying Trail Ridge: numerical models and analytical models. These groundwater models are summarized here.

Two (2) numerical models were developed using the U.S. Geological Survey (USGS) code MODFLOW-2005 (Harbaugh, 2005) to simulate three-dimensional, steady-state groundwater flow in the Surficial Aquifer at the study area. First, a model representing pre-mining conditions was created and calibrated to match observed water levels in piezometers and wells. The second model represents post-mining conditions and is based on the original calibrated model, except the calibrated hydraulic conductivity values of the aquifer within the mined zone were homogenized to represent the mine pit filled with spoil. The pre-mining and post-mining models were compared to evaluate changes in the groundwater discharge to the model boundaries (e.g., the swamps to the west and the groundwater system to the east). The models compare changes in the groundwater discharge to streams along Trail Ridge and changes in the water table position at the mine and near the Okefenokee swamp due to the proposed mining project. This comparison shows that the proposed mining activities will have negligible impact on the hydrologic system of Trail Ridge and the Okefenokee Swamp.

An analytical model was developed to evaluate drawdown in the Surficial Aquifer caused by the moving mine pit. The model shows that, even in a highly conservative (extreme) modeling scenario, perturbations in the water table due to the moving mine will quickly recover.

For these models, Trail Ridge is conceptualized as a classic example of a topographically-driven hydrologic system as illustrated in the site conceptual model (Figure 4). The water table is shallow and mimics the ground surface (Figures 37 through 39). Much of the precipitation that falls on Trail Ridge is returned to the atmosphere by evaporation and transpiration. Precipitation that is not evaporated or transpired to the atmosphere infiltrates to recharge the Surficial Aquifer. Groundwater recharge on Trail Ridge causes the water table to mound close to the land surface. In the absence of recharge, water would flow from the Okefenokee Swamp in the west (where water levels are ~ 120 ft) to the east (where water levels are < 80 ft) and the water table would linearly decline to the east.

Groundwater mainly flows from the centerline of Trail Ridge to the west and to the east and small amounts of groundwater discharges to local streams, particularly on the eastern side of the study area. Along the western margin of the study area, groundwater flow provides water to the Okefenokee Swamp and related wetlands. On the eastern side, groundwater provides base flow to streams.

Soil cores reveal that the upper part of the Surficial Aquifer is heterogeneous, consisting mainly of unconsolidated sands interspersed with irregular, discontinuous zones of semi-consolidated to consolidated sands cemented by humate (see Section 3.2). Deeper within the Surficial Aquifer, unconsolidated sands are interbedded with discontinuous lenses of clayey sands, silty-clayey sands, and local clay units, likely derived from the underlying Hawthorn Group.

The Surficial Aquifer is underlain by the sediments of the Hawthorn Group. The Hawthorn Group is approximately 350 feet thick under Trail Ridge (e.g., Williams & Kuniansky, 2016) and consists of low-permeability, calcareous clays that effectively isolate the Surficial Aquifer from the deeper Floridian Aquifer. The hydraulic conductivity of three samples of the upper Hawthorn are 3.7×10^{-2} feet per day (ft/d), 2.6×10^{-5} ft/d, and 4.5×10^{-5} ft/d (Holt et al., 2019f).

3.6.1 Three-Dimensional Groundwater Flow Models

Three-dimensional groundwater flow models were developed for a broad region beyond the extent of site characterization activities for Twin Pines Mine (Figure 40). The east and west model boundaries were selected to approximately parallel Trail Ridge and encompass a significant part of the Okefenokee Wildlife Refuge. The northern and southern boundaries were extended beyond the limits of property tracts investigated by Twin Pines. These models numerically approximate solutions to the governing equation for steady-state flow in heterogeneous aquifers:

$$\frac{\partial}{\partial x}\left(K_h\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_h\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_v\frac{\partial h}{\partial z}\right)=0 \qquad (2)$$

where h is the hydraulic head; K_h is the horizontal hydraulic conductivity; K_v is the vertical hydraulic conductivity; and x, y, and z are spatial coordinates. The solution of Equation 1 requires boundary conditions around the entire model domain. The USGS code MODFLOW-2005 (Harbaugh, 2005) was used to simulate steady-state groundwater flow in the model domain. MODFLOW-2005 uses an integrated-finite difference formulation to numerically approximate solutions to Equation 2, given a predetermined set of boundary conditions.

Prior to simulating groundwater flow using MODFLOW-2005, the study area was subdivided into an orthogonal grid of cells and layers. In the horizontal plane, the study area was subdivided into 62 rows in the y-direction and 64 columns in the x-direction (Figure 41). 15 model layers were assigned. Because a deformed model grid was used, model layers vary in thickness from a minimum of 0.1 ft to a maximum of 10.0 ft (Figure 42 and 43). The top of the model is the land surface, and the base of the model is the top of the Hawthorn Group. Since simulations are at a steady state only one stress period, of length one (1) day, was required.

No flow boundaries were assigned to the northern and southern edges of the model domain to approximate the position of streamlines (Figure 41). Along the western and eastern boundaries of the model domain, constant head (constant water table) boundaries were assigned, with the head values set to be at a depth of one (1) ft below the land surface, The base of the Surficial Aquifer is the low permeability Hawthorn Group (Holt et al., 2019b; 2019f, 2019g), and the lower boundary of the model is assigned to be a no-flow boundary. The top boundary of the model receives groundwater recharge, and an initial recharge rate of 4.54 inches per year (in/yr) was applied to the entire upper surface of the model domain. Streams flowing from Trail Ridge are typical gaining streams that derive some or all their flow from aquifer base flow (the aquifer discharges into the stream beds), and drain boundary conditions are assigned to the location of the major streams within the model domain.

The spatial distribution of soil types is highly complex in the Surficial Aquifer, and units identified in adjacent boreholes are difficult to correlate. Because of these complications, it is not possible to identify unique stratigraphic units in the upper part of the Surficial Aquifer. Consequently, a geostatistical approach was used based on indicator kriging (e.g., Journel, 1978) to define the spatial variations in hydraulic conductivity within the Surficial Aquifer (see Section 3.2). Indicator variograms were created for each of the soil types and used in a three-dimensional indicator kriging algorithm (Remy, 2005). The resulting maps (Appendix C) show the probability that each of the soil types that were present in every model grid block. Please note that for the model, the unconsolidated humate-stained (black) sand soil type referenced in Section 3.2 was combined with the unconsolidated sand soil type. For each grid block, the probabilities were normalized so that they summed to 1.0. These probabilities were used to determine the horizontal and vertical hydraulic conductivity for each grid block. The horizontal hydraulic conductivity was determined using an arithmetic mean of each of the soil type hydraulic conductivities, weighted by the probability that each soil type was present in the grid block. Similarly, the vertical hydraulic conductivity was determined using a probability-weighted harmonic mean. Hydraulic conductivity values for each soil type were selected (Table 1) to ensure that the vertical and horizontal hydraulic conductivity in grid blocks far from soil boring locations were consistent with those calculated from pumping tests and slug tests (Holt et al., 2019a), e.g., a horizontal hydraulic conductivity of 6.36×10^{-3} cm/s (18 ft/d) and a vertical hydraulic conductivity of 2.60×10^{-4} cm/s (0.74 ft/d), Example initial hydraulic conductivity values are shown for selected layers in Figures 44 through 46.

Trial and error approaches were used to calibrate the recharge rate and the leakance per unit length for each reach of drains (representing streams). These parameters were systematically varied until the model produced maximum head values that were close to those observed in piezometers and wells. Following the trial and error calibrations, the program PEST (Doherty and Hunt, 2010) was used to automatically calibrate the hydraulic conductivity values. Average groundwater levels measured in piezometers and were used as calibration targets. A number of “soft” calibration targets were added to the calibration target data set to ensure that the water table approximated the land surface. At the location of these soft targets, the water table position was set to 2 feet below the land surface. The objective function (difference between observed and modeled heads) was minimized on the completion of 25 PEST iterations (Figure 47). Overall, the calibration procedure led to a good match between the calibration targets and modeled heads (Figure 48).

The calibrated recharge rate of 2.8 in/yr produced head values near an elevation of 170 feet along the centerline of Trail Ridge. Final leakance per unit length values ranged from 0.001 – 0.1 ft/d for the drain boundaries representing streams. Higher leakance values were required for streams on the eastern side of the model domain. The hydraulic conductivity values for the model were calibrated using PEST; calibrated hydraulic conductivity fields for selected model layers are shown in Figures 49 through 51. Similar hydraulic conductivity patterns are found in all model layers, indicating that the hydraulic heads are not sensitive to vertical variations in hydraulic conductivity. In general, higher hydraulic conductivities were produced on the west and east model boundaries to accommodate the flux of water through a thinner aquifer. Higher hydraulic conductivities along the center of Trail Ridge flatten the water table. North-to-south oriented bands of lower hydraulic conductivity occur along the western and eastern flanks of Trail Ridge, maintaining the water table within a few feet of the land surface. The modeled pre-mining water table (Figure 52) resembles the potentiometric surface of the Surficial Aquifer on July 26, 2019 (Figure 39). The modeled water-table does not reproduce all of the topographic variability shown in the interpreted potentiometric surface map but does retain the overall pattern and shows the influence of the streams on the eastern side of the model domain.

After the mining is completed, the mined volume will be filled with homogenized sand spoil. The elevation of the base of the proposed mining zone ranges from approximately 136 feet in the northwest part of the mined area to 111 ft in the southeast part of the mined area (Figure 53). For the purpose of this model, it is assumed that the final elevation of the bottom of the mine is 119 ft. Experiments conducted on homogenized sands from the Twin Pines Mine study area reveal that the hydraulic conductivity of the pit filling will be approximately 1.0E-03 cm/s (Holt et al., 2019f). The calibrated hydraulic conductivity values in all grid blocks above 119 ft within the mine footprint were replaced with a horizontal and vertical conductivity of 1.0×10^{-3} cm/s. Example horizontal hydraulic conductivity values for selected layers are shown in Figures 54 through 56. Within the mine footprint some of the horizontal hydraulic conductivity values are reduced; however, nearly all the vertical hydraulic conductivity values were increased.

The changes of hydraulic conductivity within the mine footprint produced only minor variations in the position of the water table (Figure 57). The differences are best revealed by subtracting the post-mining water table from the pre-mining water table (Figure 58). Across much of the model domain, water table changes are very small. In the vicinity of the proposed mine pit, water table elevations both increased and decreased as a result of mining activities. The water table rose over two feet in the western part of the mining area, and locally decreased by over one foot near the central part of the mining area. Within the eastern part of the mining area water level increases and decreases due to mining were less than one foot. These variations result from the groundwater flow system adjusting to a homogeneous block of sand spoil placed within the mine pit. Where the Okefenokee National Wildlife Refuge is closest to the mine footprint, the worst-case scenario models predict that the water table will decrease by no more than 0.0004 ft due to mining.

Table 13 presents a comparison of the water budgets for the pre-mining and post-mining models. Mining leads to a decrease of stream outflow (drains) across the entire model of 35 cubic feet per day (ft^3/d) or 4.1E-04 cubic feet per second (cfs) and an equivalent increase in groundwater discharge at the constant head boundaries. Both models were subdivided into two zones following the topographic divide on Trail Ridge (Figure 59). Separate water budgets were determined for each zone in each model. For the eastern zone (Zone 1), Table 14 presents the water budget. The eastern zone experienced a decrease of 40 ft^3/d of stream discharge and 300 ft^3/d of discharge to the constant head boundaries due to mining. The western zone (Table 15), however, showed an increase of 4 ft^3/d in stream discharge and 340 ft^3/d of groundwater discharge due to mining. Based on these model results, the swamps to the west of the study area, including the Okefenokee Swamp, will receive a fractional increase in both stream and groundwater discharge due to the proposed mine.

3.6.2 Impact of a Moving Mine

At the Twin Pines Mine, heavy mineral sands will be excavated from a moving pit that has a length of 500 feet, a width of 100 feet, and a maximum depth of 50 feet. Here we assume that the pit will advance at a rate of 100 ft/day (e.g., Holt et al., 2020) and the oldest part of the pit will be filled at the same rate, so the pit dimensions will change minimally over time. Some water contained within the excavated sands will be removed from the pit by the drag line. Much of the water within the excavated sands will, however, quickly drain from the excavated sand and infiltrate back into the aquifer. Furthermore, the sand spoil that is returned to the mine pit will also contain a significant amount of water. Some water will be lost to evaporation as the sand is transported on mobile conveyors to and from the processing facility, but the net loss of water from the pit area and the aquifer will be small. Below, we will consider the impact of an extreme case, where all the water in the excavated sands are removed from the aquifer.

The extent of that drawdown in the Surficial Aquifer due to the removal of all water within the excavated sands can be quantified using an analytical solution for a moving, rectangular source of heat (e.g., Ling, 1973 and Tichy 1991). This solution can be adapted to simulate the drawdown effects from a moving mine pit, as the equations for heat flow and groundwater flow are identical.

If we move with the center point of the mine pit, the heads will quickly drawdown, and the pattern of the drawdown will eventually stabilize or reach a steady state. The time required for the moving pit to reach steady state is given by (Hou and Komanduri, 2000)

$$t_{SS} = 20\frac{T}{SV^2} \tag{3}$$

where S is the storage coefficient, V is the velocity of the pit, and T is the aquifer transmissivity. If we assume that

V = 100 ft/d
T = 1,500 ft/d
S = 0.3

the drawdown due to the moving mine pit will reach a steady state in 10 days.

The governing equation and boundary conditions for a moving rectangular sink of groundwater is

$$\nabla^2 h = \frac{S\,V}{T}\frac{\partial h}{\partial x} \tag{4}$$

with boundary conditions

$$z = 0,\ |x| \le L,\ |y| \le W,\ q = -K\frac{\partial h}{\partial z} \tag{5}$$

$$z = 0,\ |x| > L,\ |y| > W,\ -K\frac{\partial h}{\partial z} = 0 \tag{6}$$

$$z \ge 0,\ \sqrt{x^2 + y^2 + z^2} \to \infty,\ h \to 0 \tag{7}$$

where y and z spatial coordinates; x is a Lagrangian spatial coordinate that moves in the x-direction at V; L is the length of the pit; and W is the width of the pit. Figure 60 depicts the half-space geometry of the moving pit. Using the following non-dimensional terms

$$x^* = \frac{x}{L},\ \mathrm{y}^* = \frac{y}{L},\ \mathrm{z}^* = \frac{z}{L},\ \mathrm{h}^* = \frac{hK}{qL}, Pe = \frac{SVL}{T} \tag{8}$$

the solution is (e.g., Ling, 1973)

$$h^* = -\frac{1}{\pi}\int_{-1}^{+1}\int_{-W/L}^{W/L} \frac{\exp\left\{-Pe\left[r^* - (x^* - x^{*'})\right]/2\right\}}{r^*} dy^{*`}dx^{*`} \tag{9}$$

with

$$r^* = \sqrt{(x^* - x^{*'})^2 + (y^* - y^{*'})^2 + (z^*)^2} \tag{10}$$

For our pit, L = 250 feet, W = 50 feet, and K = 13 ft/d. If we assume that a volume of 100 feet × 100 feet × 50 feet of sand is excavated per day, the porosity of the sand is 0.3, and all of the water contained within that pore space is removed with the sand, the volumetric discharge from the pit (Q) will be 150,000 ft^3/d, and the Darcy flux (q) is equal to the volumetric discharge/area of the pit or q = 3 ft/d. Using these parameters in equations 8, 9, and 10, the steady-state drawdown to removing all of the water in the excavated sand is shown in Figure 60. In Figure 60, the origin is fixed at x = 0 and moving to the left at 100 ft/d. In this case, the x-coordinate of the moving origin can be related to time. The pit, and moving origin, moves to the left at a velocity of 100 ft/d; therefore, the drawdown at an x-coordinate of 1,000 feet represents the drawdown 10 days after the moving mine pit has passed that location. In this unrealistic case, the drawdown recovers to about four feet of the original water table position after 10 days and between one foot and two feet after 20 days; this relationship holds true for pit velocities up to 200 ft/d.

It is clear from this unrealistic example (the removal of all water within the excavated sand), that the water table around the moving mine pit will quickly recover to close to its original position and that mining activities will not dewater the Okefenokee Swamp. When superimposed on the existing water table, groundwater divides will continue to separate the moving pit from the Okefenokee to the west and the streams to the east. The Trail Ridge hydrologic divide separating the Okefenokee Swamp to west from the Saint Mary's River to the east will always be maintained.

3.6.3 Summary of Model Results

We draw the following conclusions from these modeling efforts:

- **Trail Ridge is a classic example of topographically-driven groundwater flow.** It acts as a hydrologic divide that separates the Okefenokee Swamp to the west from the Saint Mary's River to the east. Rainfall on Trail Ridge provides water to the Surficial Aquifer. This groundwater recharge causes the water table to rise within a few feet of the ground surface along Trail Ridge, forming a hydrologic divide that mimics the topography. Because groundwater flow follows the elevation of the water table, Trail Ridge groundwater flows to the west, supplying water to the Okefenokee Swamp, and flows to the east, supplying water to springs and creeks.

- **Proposed mining activities will have an insignificant impact on the groundwater and stream flow to the Okefenokee Swamp and the creeks and groundwater system to the east of Trail Ridge.** A comparison of groundwater models of the pre-mining conditions and post-mining conditions show that changes to the groundwater discharge and stream discharge are minimal and insignificant.

- **Mining activities will cause insignificant changes in the water table across most of the study area.** Within the mine pit, the water table position will both increase and decrease due to the placement of homogenized sand spoil in the mine pit. At the Okefenokee Wildlife Refuge, the worst-case scenario models predict that the water table will decrease by no more than 0.0004 ft due to mining.

- **Mining activities will not dewater the Okefenokee Swamp.** The Okefenokee Swamp is 2.7 miles away from the closest part of the proposed mine footprint. The active mine pit will be small and filled within five to seven days. Analytical groundwater models of the moving mine pit show that water levels will recover to within four feet of their original position within 10 days following excavation and two feet of their original position within about 30 days. The perturbation of the water table caused by the moving mine pit will not affect the Okefenokee Swamp. The Trail Ridge hydrologic divide separating the Okefenokee Swamp to west from the Saint Mary's River to the east will always be maintained.

3.7 Groundwater and Surface Water Quality Monitoring Plan

Purpose

This Groundwater/Surface Water Monitoring Plan documents monitoring activities designed to assess the impact or effect of proposed mining on hydrology along Trail Ridge and surrounding areas (including the Okefenokee Swamp) and verify the results of the groundwater models developed for the site. Groundwater/surface water-level monitoring activities are designed to:

- Monitor changes in groundwater levels due to precipitation, recharge, and runoff
- Characterize the response of surface water levels to precipitation and groundwater levels
- Allow the development of models relating precipitation to groundwater levels and recharge
- Identify changes in levels induced by the moving mine pit
- Quantify changes in post-mining water levels
- Provide water-level data to assist in mine reclamation activities

These data will be used to verify current groundwater models and to support future revisions of the groundwater models. Groundwater/surface-water-quality monitoring activities will be conducted to:

- Establish baseline groundwater and surface water chemistry
- Monitor spatial and temporal changes in water chemistry due to mining activities
- Provide groundwater chemistry data for mine restoration activities

In the following, the mining progression is reviewed, the groundwater and surface-water level monitoring plan is described, and the groundwater and surface water-quality monitoring plan is developed.

Progression of Mining

TPM estimates that it will take about six years to mine the entire 898-acre mine area. The Twin Pines Conceptual Mining Plan (CMP) estimates that mining will advance at a rate between 100 and 200 feet per day and average approximately 115 feet per day. The CMP is designed to allow for mining an approximate 100-foot wide by 500-foot long section to a maximum depth of 50 feet below land surface. Once the mined pit reaches a length of approximately 500 feet, processed sands will be returned to the pit as mining continues to advance. The CMP calls for mining to begin in the extreme southwest corner of the mine. The total length of each cut will be, on average, approximately 9,000 linear feet (average distance from the west boundary of the mine to the east boundary of the mine). Once mining reaches either the east or west limit of mining, the dragline will reverse its course and mine the next adjacent cut in the opposite direction. This east-west to west-east alternating mining will continue throughout the entire course of mining.

3.7.1 Groundwater- and Surface-Water-Level Monitoring Plan

Current Groundwater and Surface-Water-Level Monitoring

Currently, there are five piezometers (PZ-15, PZ-16S, PZ-16D, PZ-28S, and PZ-28D,) installed within the proposed mine footprint (Figure 61). There are an additional 19 piezometers located within 2,000 feet of the proposed mine footprint. In addition to the above-referenced monitoring points, 62 piezometers were installed within the larger project study area. Combined, each of these 86 piezometers are equipped with Rugged Troll pressure transducers and have been recording background groundwater-level data for a period of between six months and one year. These piezometers will continue to be monitored throughout the period of mining and during post mining.

An additional 100 shallow 1.5-foot deep piezometers were installed inside the proposed mine footprint to monitor groundwater levels within wetlands. These shallow "wetlands" piezometers are also equipped with Rugged Troll pressure transducers and will be monitored during pre-mining, active mining and post-mining periods (Figure 62).

A total of 23 staff gauges were installed to evaluate surface water elevations across the project study area (Figure 28). Each staff gauge segment measures approximately 3.3 feet in length and is mounted to a metal fence post or pressure-treated wood post so that the base of the gauge was positioned at ground surface. TTL installed In-Situ, Inc. Rugged Troll 200 non-vented data logger/cable combinations at the 23 staff gauge locations across the project study area. The data loggers were installed at each staff gauge with the transducers tip positioned at the approximate ground surface. Each data logger/cable combination has been recording background surface-water-level data for a period of between six months and one year. These staff gauges will continue to be monitored throughout the period of mining and during post mining.

Weather Stations

TPM personnel installed three HOBO rain gauge data loggers at the site in November 2018. The three rain gauge locations (RG01, RG02, and RG03) were installed at the northern, central, and southern portions of the project study area (Figure 27). The data loggers for each rain gauge record the accumulation of precipitation in units of hundredths of an inch. Rain gauge data is manually downloaded in the field by TPM representatives on a monthly or bi-monthly basis. During the proposed course of mining, rain gauge data will continue to be manually downloaded in the field once every two weeks.

Proposed Configuration of Piezometers

As part of this monitoring plan, new piezometers will be installed within the mining footprint for the collection of groundwater data. Prior to the start of mining, a site grid will be established to assist in the placement of these new piezometers. Figure 63 shows the approximate locations of proposed piezometers within the mine footprint. A new piezometer will be installed approximately every 2,000 feet in an east-west direction and every 1,000 feet in the north-south direction. The spacing will provide five rows of piezometers (approximately 23 piezometers), covering an area of roughly 898 acres, or one piezometer every 39 acres. This spacing was developed to provide for monitoring of the predicted steady-state drawdowns due to the moving mine, which has an estimated cone of depression of approximately 1,000 feet wide and 2,000 feet long (Figure 64).

The 23 new piezometers will be identified at MPZ-01 through MPZ-23. In addition to these 23 proposed piezometers, four existing piezometers (PZ30D, PZ14, PZ57D, and PZ44) located within 2,000 feet of the mine footprint will also be included in the monitoring program. Monitoring of these piezometers will be initiated prior to the start of mining.

Piezometer Construction

Each of the 23 new piezometers will be constructed to a depth of approximately 50 feet below land surface (bls) using a sonic drill rig (Figure 65). Fifty feet is the maximum depth of mining. During installation of the new piezometers, soil cores will be continuously collected and described by an on-site geologist. Boring and well construction logs will be prepared for each newly constructed piezometer.

Each piezometer will be constructed with 40 feet of 0.010-inch slotted, 2-inch diameter, threaded-joint, schedule 40 PVC installed from a depth of 10 to 50 feet bls. From the top of the screen to approximate land surface will be cased with solid 2-inch diameter, schedule 40 PVC riser. The natural formation sand will be allowed to settle around the screen to provide a natural pack to a depth of approximately eight feet bls. A two-foot thick bentonite pellet seal will be placed above the top of the natural filter sand. The remaining annular space above the bentonite seal will be grouted to land surface using a cement/bentonite grout. A metal, flush-mount, bolt-down, protective cover will be installed over the piezometer at land surface to include a 2-foot x 2-foot x 4-inch thick concrete pad. Each piezometer will be fitted with a Rugged Troll transducer in order to continuously monitor groundwater levels.

Sequencing of Piezometer Installation Relative to Progression of Mining

Once initiated, mining will advance at an estimated rate of about 115 feet per day and piezometers within the mine footprint will periodically be excavated and reinstalled during the mining progression. The general procedures for the removal and reinstallation piezometers is discussed below:

- Within one or two days of the advancing mine face reaching a piezometer, the transducer will be removed and the piezometer will subsequently be excavated by the advancing drag-line excavator,
- Within approximately five to seven days of mining, the open excavation pit will be backfilled with post-processed soils,
- Within five to ten days of backfilling the excavation, a replacement piezometer will be installed in the approximate location of above-referenced excavated piezometer and,
- The replacement piezometer will be fitted with the Rugged Troll transducer that was removed from the previous piezometer in order to continue monitoring of groundwater levels.

Using this approach for the removal and reinstallation of piezometers, will aid in maintaining the full complement of piezometers within the mine boundary. This same methodology will be applied for the excavation and reinstallation of the shallow “wetlands” piezometers.

Proposed Surface-Water Monitoring Locations

Nine surface water locations are proposed to be monitored in the same general manner as previously installed staff gauges. Six additional staff gauges will be installed and equipped with Rugged Troll pressure transducers. These locations are shown on Figure 66.

Frequency of Water-Level Monitoring

As previously stated, water levels will be recorded using Rugged Troll pressure transducers. The transducers will generally be programmed to record water-level measurements at the following intervals; however, the frequency of measurements may be changed as necessary during the life of the mine.

Shallow “Wetland” Piezometers

- Transducers installed, in the shallow 1.5-foot-deep piezometers for monitoring water levels within existing wetlands, will record water-level measurements at 6-hour intervals.

Remaining Piezometers

- Transducers installed, in the row of 50-foot-deep piezometers located within 1,000 feet of the active excavation and within the mining footprint, will record water-level measurements at 10-minute intervals.
- Transducers installed, in the row of 50-foot-deep piezometers located greater than 1,000 feet from the active excavation but within the mining footprint, will record water-level measurements at one-hour intervals.
- Transducers installed, in the remaining piezometers outside of the mining footprint, will record water-level measurements at 6-hour intervals.

Surface Water Transducers

- Transducers installed at staff gauges will record water-level measurements at 6-hour intervals.

Initially, transducer data will be downloaded twice per week to evaluate water levels within and adjacent to the proposed mine. The frequency of transducer data downloading may be adjusted as needed during the life of the mine.

3.7.2 Groundwater- and Surface-Water Quality Monitoring Plan

Frequency of Groundwater/Surface-Water Quality Monitoring

Water-quality samples will be collected once prior to the start of mining (background) from the 23 new piezometers, four existing piezometers, and nine surface-water locations. The monitoring locations are listed below:

- Newly installed piezometers (MPZ-01 through MPZ-23) (Figures 63),
- Piezometers PZ30D, PZ14, PZ57D, and PZ44 (Figure 61),
- Wetland Monitoring Points WSP-01 through WSP-03 (Figure 66) and,
- Stream monitoring points MSW-01 though MSW-06 (Figure 66).

The following is a schedule for the frequency of water-quality sampling:

- One sampling event performed prior to initiation of mining.
- Four quarterly monitoring events beginning three months after mining is initiated
- Semi-annual sampling thereafter until the end of mining unless a notable change in water quality occurs.
- Semi-annual monitoring of post mining conditions for an estimated period of six years (estimated duration of mining).

Based on the results of water-quality data monitoring and the progression of the mine, the frequency of water-quality data sampling and number of monitoring locations may periodically be adjusted (i.e. increased or decreased) during the life of the mine.

Post-Mining Monitoring

Twin Pines estimates that it will take about six years to mine the entire 898 acres. Post- mining monitoring will be performed for a period equal to the period of mining, and will consist of the monitoring of water levels in the piezometers on a continuous basis. This monitoring will include a manual download of the pressure transducers once every quarter during the post-mining period. Water-quality samples will be collected semi-annually for analysis of the constituents specified in this monitoring plan.

Water-Quality Sample Collection and Analysis of Data

To ensure that water-quality samples are collected properly, a Sampling and Analysis Plan (SAP) has been prepared. The SAP addresses well preparation, sample collection, chain-of-custody, analytical procedures, and field and laboratory quality assurance/quality control (QA/QC).

Groundwater sampling procedures, chain of custody, field parameter measurement, and field QA/QC will be performed in general accordance with the Region 4 US Environmental Protection Agency (EPA), Science and Ecosystem Support Division Operating Procedure, Groundwater Sampling (SESDPROC-301-R4), effective April 26, 2017. Surface water sampling procedures and field QA/QC will be performed in general accordance with the Region 4 US Environmental Protection Agency (EPA), Science and Ecosystem Support Division Operating Procedure, Surface Water Sampling (SESDPROC-

201-R4), effective December 16, 2016. Low-level mercury sampling will be performed in general accordance with EPA Method 1669.

Sample Collection Procedures

Equipment Decontamination
Any reusable sampling equipment that may contact the interior of the piezometer, groundwater, or surface water will be decontaminated in the field immediately prior to use, or in the office/lab and protected using aluminum foil and/or plastic. For sampling events requiring non-dedicated sampling equipment, decontamination procedures will consist of rinsing the equipment once with distilled or deionized water, brushing the equipment with a phosphate free laboratory-quality detergent, and finally rinsing the equipment with distilled or deionized water.

Water Level Measurement – (Piezometers Only)
Prior to purging and sampling, water-level measurements will be made at each piezometer by utilizing a dedicated or portable water-level indicator, tape, or other suitable measuring device capable of achieving an accuracy of 0.01 foot. The depth to water in each piezometer will be measured on the same day and prior to purging. The measuring device will be used in accordance with the manufacturer's recommendations and/or directions. Measurements of the depth to water from the top of the piezometer casing will be to the nearest 0.01 foot, and the value will be recorded. Total depths will be measured at each piezometer and recorded.

Piezometer Purging
Prior to the collection of groundwater samples, each piezometer will be purged to ensure that fresh aquifer water is being sampled. Purging of each piezometer will be completed using either a peristaltic or electric submersible pump. Due to the depths of the proposed piezometers and the high groundwater tables at the site (i.e. excessive purge volumes), low-flow purging procedures may be utilized. During low-flow purging, the pump or tubing intake will be located within the screened interval and at a depth that will remain under water at all times. During low-flow purging:

- The pumping rate will be set at a speed that produces minimal and stable drawdown within the well,
- The pumping rate will be measured using a graduated cylinder or bucket and a stop watch,
- The groundwater level, pumping rate, and field parameters (pH, temperature, specific conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity) will be monitored and recorded every 5 to 10 minutes (or as appropriate),
- The field parameters will be measured using a calibrated multi-parameter instrument and flow-through cell,
- Purging will be considered complete and sampling will begin when the field measured parameters have stabilized. Stabilization is considered complete when three consecutive readings are within the following limits:

    - Turbidity – 10% for values greater than 10 NTU,
    - Dissolved Oxygen – Varies no more than 0.2 mg/L or 10% saturation,
    - Oxidation-Reduction Potential – Varies no more than 20 millivolts,
    - Specific Conductance – Varies no more than 5%,
    - pH – Varies no more 0.1 unit

Sample Collection and Preservation – Piezometers
Groundwater sampling is the process of obtaining, containerizing, and preserving a groundwater sample after the purging process is complete. Appropriate devices to be used to collect groundwater samples from piezometers include: peristaltic or electric submersible pumps. Alternative sampling devices/methods may be utilized if the alternative device/method is approved for use in EPA field sampling guidance literature.

During sample collection, each piezometer will be sampled with equipment and methodologies that minimize the potential for alteration or contamination of the sample and that are capable of obtaining a sample representative of the formation ground water. Care will be taken to avoid placing clean sampling equipment on the ground or on any contaminated surface. Additionally, personnel who contact sampling equipment that may contact the interior of the monitoring well or the ground water will wear new powderless latex or nitrile gloves. Gloves will be changed between sample locations to avoid cross-contamination.

Field personnel responsible for sample collection will record, at a minimum, the following:

- Date, time and technician's name
- Piezometer number and well depth
- Well casing material and inside diameter
- Static water level prior to purging
- Sampling equipment used
- Volume of water purged prior to sampling
- Sample container numbers, types, sizes, and preservatives
- pH, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature of water samples
- Comments about sample color, odor, and unusual characteristics
- Comments about weather conditions
- Comments about accessibility and condition of well

Groundwater collected from each piezometer will be slowly discharged into laboratory provided sample containers of the appropriate size and type, and with the preservatives appropriate for the analytical tests required. The sample container will be labeled with the following information:

- Site name,
- Collected date and time,
- Sampler's name,
- Analysis required, and
- Preservative, if any

The laboratory will specify the preservation methods based on knowledge of methods and procedures approved by the Georgia EPD or EPA.

Sample Collection and Preservation – Surface Water

Surface water samples will be collected directly into the laboratory provided container from the surface water body or by decanting the water sample from a collection device such as an unpreserved laboratory provided plastic container. The field sampler will face upstream if there is a current and collect the sample without disturbing the bottom sediment. Alternative sampling devices/methods may be utilized if the alternative device/method is approved for use in EPA field sampling guidance literature. Water quality samples collected for low-level mercury analysis (EPA Method 1631E) will be collected in general accordance with EPA Method 1669.

Each surface water sample will be sampled with equipment and methodologies that minimize the potential for alteration or contamination of the sample. Care will be taken to avoid placing clean sampling equipment on the ground or on any contaminated surface. Additionally, personnel who contact sampling equipment will wear new powderless latex or nitrile gloves. Gloves will be changed between sample locations to avoid cross-contamination.

Field personnel responsible for sample collection will record, at a minimum, the following:

- Date, time and technician's name
- Sample location identifier
- Sampling equipment used
- Sample container numbers, types, sizes, and preservatives
- pH, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature of water samples
- Comments about sample color, odor, and unusual characteristics
- Comments about weather conditions
- Comments about accessibility and condition of the sample locations

Surface water samples will be collected into laboratory provided sample containers of the appropriate size and type, and with the preservatives appropriate for the analytical tests required. The sample container will be labeled with the following information:

- Site name,
- Collected date and time,
- Sampler's name,
- Analysis required, and
- Preservative, if any

The laboratory will specify the preservation methods based on knowledge of methods and procedures approved by the Georgia EPD or EPA.

Sample Shipment

Upon completion of sampling each piezometer and/or surface water monitoring point, each laboratory provided container will be sealed, labeled and placed in an iced cooler for preservation and transport to a Georgia EPD approved laboratory for analysis. Chain of custody forms will be completed in the field at the time of sampling of each well. Samples will be transported to the laboratory via courier or shipped for overnight delivery using FedEx or UPS delivery.

Laboratory Analysis
Water-quality samples will be analyzed for the constituents listed below and specified in the Table 16. The analytical list may be revised during the life of the mine. Sampling will be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136.

pH	Aluminum, Total	Selenium, Total
BOD5	Antimony, Total	Silver, Total
COD	Arsenic, Total	Tin, Total
Color	Cadmium, Total	Titanium, Total
Fluoride	Chromium, Total	Zinc, Total
Nitrate-Nitrite	Cobalt, Total	Zirconium
Nitrate	Copper, Total	Ammonia, Nitrogen
Nitrite	Iron, Total	Total Kjeldahl Nitrogen
Nitrogen, Total Organic (as N)	Lead, Total	Alkalinity, Total
Oil & Grease	Magnesium, Total	Alkalinity, Bicarbonate
Phosphorus (as P), Total	Manganese, Total	Alkalinity, Carbonate
Sulfate (as SO4)	Mercury, Total	Total Hardness
Sulfide	Molybdenum, Total	Total Cyanide
Sulfite (as SO3)	Nickel, Total	Uranium
Alfa, Total	Radium, Total	Thorium
Beta, Total	Radium 226, Total	

Quality Assurance and Quality Control
A quality-assurance and quality-control program (QA/QC) will be part of the sampling protocol and a requirement of the laboratory chosen to provide analytical services. At a minimum, field QA/QC per sampling event will require the collection of an equipment-rinsate blank if equipment is field cleaned and re-used on-site. Additional QA/QC sampling such as field or trip blanks may also analyzed as deemed necessary.

The laboratory QA/QC program will be a written program and will describe the accuracy and completeness of the laboratory data; the documentation of procedures for calibration and maintenance of laboratory equipment, for analysis of samples, for computing and validating test data, and for chain-of-custody control; and the control and security of all documentation. Laboratory QA/QC standards will be initiated with the receipt of samples and will be maintained throughout the record-keeping period.

Chain-of-Custody Control
The chain-of-custody program will allow tracing the possession of and the handling of individual samples from the time of field collection through the completion of laboratory analysis.

Evaluation of Analytical Data
Results of the field measured and analytical groundwater data will be tabulated for each monitoring event. The data will be analyzed for trends and compared to applicable groundwater protection and in-stream water quality standards. The purpose of the trend analysis will be to evaluate if concentrations are declining, remaining level or constant (no discernable change), or increasing.

3.7.3 Reporting

A report summarizing mining activities and water-level and water-quality data will be prepared and submitted to the applicable regulatory authorities on a quarterly basis for the first year and on an annual basis thereafter. These reports will include groundwater contour maps, results of water-quality analysis for the period of monitoring and trend graphs of concentrations. Water-level and water-chemistry data will be evaluated to determine the success of initial mining operations and methods. Groundwater-level data will be compared with groundwater levels predicted by the groundwater models. Water-chemistry data will be evaluated against current groundwater and surface water quality standards.

4.0 ALTERNATIVE ANALYSIS

Alternatives screening is also pertinent to Clean Water Act (CWA) 40 CFR Part 230 Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (404(b)(1) guidelines), which require the analysis of practicable alternatives to the proposed discharge. The 404(b)(1) guidelines define a practicable alternative as one that is "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes" (40 CFR Part 230.10(a)(2)).

According to USACE's National Environmental Policy Act (NEPA) Implementation Procedures for the Regulatory Program (33 CFR Part 325, Appendix B); the alternatives analysis should be thorough enough to use for both the NEPA review and the 404(b)(1) guidelines analysis.

4.1. Alternatives Development Process

In order to effectively evaluate reasonable alternatives, site screening criteria were established and applied during the initial site selection process. If an option clearly did not meet one of the test-screening criteria, it was eliminated from further consideration, and did not proceed to the subsequent screening tests. These initial criteria include:

1 – that the alternative meets the purpose and need of the demonstration project

- a) The purpose of the demonstration project is to demonstrate that HMS mining can be conducted in an environmentally sensitive area with negligible impacts to the site and surrounding resources and to develop a high-quality HMS reserve to produce HMS concentrate products including titanium mineral concentrates and zircon concentrates to meet global demands in a safe, cost effective and environmentally sound manner.

2 – that the alternative be reasonable and practical from both a technological and economic standpoint

- a) The property must be available for purchase or lease.
- b) For the demonstration project to be economically reasonable the minimum heavy mineral concentration per cut must average greater than 1.5% economic heavy minerals (ilmenite, leucoxene, rutile, zircon)

3 – that the alternative must be located within the Atlantic Coastal Plain physiographic region in southeast Georgia or northeast Florida

- a) HMS are commonly found in beach/shallow offshore and fluvial/alluvial depositional environments. In the U.S., these HMS deposits are primarily located within the Atlantic Coastal Plain (Hou et. al, 2016; Pirkle et. al, 2013, Woodruff et. al, 2018).

4 – the alternative must be accessible to rail

- a) Without adequate rail access, material would require transportation over greater distances or would require the construction of a rail which would ultimately increase onsite impacts. Without the construction of a rail, the cost of handling/transporting of material would increase as a result.

5 – that the alternative minimizes impacts to sensitive features including:

- a) water resources including wetlands, streams, and floodplains,
- b) threatened and endangered species,
- c) cultural resources, and
- d) protected natural areas including the Okefenokee Swamp National Wildlife Refuge.

4.2. Alternatives Screening Process

Pirkle et. al. (2013) identifies several known heavy mineral reserves within southeast Georgia and northeast Florida (Figure 2). These known deposits were evaluated on the established criteria. Alternative mining methodologies were also evaluated to determine the most responsible mining methodology for a demonstration project (Section 4.3). Additional alternative sites were evaluated. Those alternatives are briefly discussed in Section 4.4. The possible alternative sites were narrowed to include: three potential mining locations, two alternate sites within the preferred project location, and a no action alternative (Section 4.5).

The depositional mechanisms for heavy mineral deposits are vital to understanding the locations in which they are found in economic concentrations. Economic heavy mineral assemblages located in the southeastern U.S. are formed as heavy minerals become concentrated through depositional processes which remove less dense, more erodible minerals from the sediment thus increasing the percentage of heavy minerals. Environments conducive to this type of preferential weathering and deposition include fluvial-deltaic, barrier island, and beach ridge sequences deposited on ancient and modern shorelines (Pirkle et. al., 2013). Hamilton (1995) defines these heavy mineral deposits as "coastal placers" where eolian, wave, and tidal processes provide the mechanical reworking and deposition of sediment to concentrate zircon, ilmenite, rutile and other economic heavy minerals (Jones et. al, 2017).

HMS deposits that are being discovered, evaluated, and exploited are smaller and lower grade than those historically mined as many of the more accessible and concentrated HMS deposits are no longer accessible as a result of previous mining, environmental concerns, or regulations associated with mining activities, particularly in southeast Georgia and northeastern Florida (Pirkle et. al., 2007). These prospective areas for HMS deposits in the Atlantic Coastal Plain occur near the modern shores or on barrier islands and much of the modern coastal areas are covered by infrastructure or are otherwise protected lands. As mining moves into more environmentally sensitive areas, it is imperative that mining be conducted in a responsible way manner that is protective of our natural resources.

In southeastern Georgia, seven coastlines (paleo and current) have been identified which contain heavy-mineral deposits (Hails and Hoyt, 1969; Pirkle et. al., 2013). Trail Ridge is located on the oldest recognized paleo-shoreline, the Wicomico Shoreline (Figure 2). These ridges align with heavy mineral deposits noted by Force (1991) within the "Jacksonville district." The Jacksonville district is further refined by Force into deposits, notably the Trail Ridge deposit and the Green Cove Springs deposit. Other heavy mineral deposits located within the Jacksonville district are discussed by Pirkle et. al. (2007) and include the Lulaton, Folkston, Boulogne, Arlington, and Mineral City (Ponte Vedre) ore bodies (Figure 2). Cumberland Island and Amelia Island are noted as modern beaches where heavy mineral accumulation is also currently occurring (Force, 1991).

Older Pleistocene deposits contain more mature heavy mineral suites than younger ridges with relative increases of titanium-bearing minerals and zircon due to leaching of iron from ilmenite and decreasing amounts of monazite and other less stable minerals such as epidote, amphiboles, and staurolite as they tend to weather more rapidly and are generally less abundant. (Kellam et. al., 1991). As a result, the TiO^2 content of ilmenite is higher in Trail Ridge than other ridges (Pirkle, 2005).

4.3 Evaluation of Potential Mining Methodologies

Heavy mineral sands are typically mined by one of two methods in the Southeastern United States. One method is using mobile (truck/shovel) equipment, the other uses a dredge. Due to the sensitive environmental landscape of the Saunders Tract, TPM evaluated whether mining could be conducted in a more environmentally responsible manner than that of traditional HMS mining methods (dredging or truck/shovel) which are common in the Atlantic Coastal Plain. In the Ukraine, HMS reserves are known to have been mined via dragline operation.

TPM evaluated the possibility of utilizing a mobile dragline and conveyor system which would allow for more efficient extraction of mineral resources at depth, minimize the impact to groundwater, and decrease the time between mining activities and beginning reclamation activities.

Truck & Shovel Mining

Truck and shovel operations in these areas typically mine down to a depth of 20 feet below the existing ground surface. The excavation takes place in two approximately 10 feet lifts. Shallow groundwater levels are common in these sands deposits where heavy minerals are found. Groundwater levels in this area range from the ground surface to depths of approximately five feet below the ground surface. With the shallow groundwater levels, dewatering is required for the truck/shovel method. Dewatering is achieved by excavating ‘rim’ ditches around three sides of the mining block to channel the water to a central sump area where the water is pumped from the excavation. The rim ditch is excavated down to the reach of the excavator, approximately 10 feet. This will dewater the pit for the first lift, then the ditch is extended to an elevation just slightly lower than the planned pit bottom elevation. Each pit area is actively dewatered for approximately 30 days before moving to another mining location.

The excavated material is hauled in articulated trucks to a site where the material is screened and passed through a trommel to remove any remaining organics or oversize material. The ore is then mixed with water to produce a slurry and pumped to the Wet Concentration Plant (WCP) where the heavy minerals are separated from the quartz sand and slimes (fine clay/silt size material). The quartz and slimes are then slurried and pumped back to an open pit in preparation for reclamation. The tailings are allowed to build up 10 to 12 feet above the original ground surface. This allows the tailings to dry and the water seeps back into the open pit. As the tailings dry and are able to be worked with a dozer, they are pushed backed into remaining open portion of the pit. Allowing the tailings to dewater by gravity adds time and prolongs the reclamation efforts. Typically, it is 12 to 18 months after the pit is mined before the reclamation process is completed.

Once the tailings are able to support the tracked equipment, the reclamation process starts. The first step in the reclamation process is to slope/grade the tailings to the original topographic contours. Once the site is graded, the stockpiled topsoil is replaced. Then the site is prepped for pine plantation. Due to the nature of a truck shovel operation, there could be more than 300 acres of disturbed/unreclaimed ground at any one time.

Floating Dredge Mining

Another method of moving materials in a sand formation is that of a floating dredge. A dredge is composed of a floating platform with a suction/cutter head. At a dredge operation, the site prep, clearing and grubbing, etc. is the same as that for a truck and shovel HMS mine.

In the southeastern U.S., dredges used to mine minerals sands are typically used to mine deposits down to a depth of 40-50 feet below the ground surface. The dredge(s) is sized to match the capacity of the WCP and the dimensions of the sand deposit. In this area, dredges are usually capable of moving 800-2000 tons of material per hour. Typical dredge pits for mineral sands mine in this area are 600 feet wide. However, sometimes two pits are mined simultaneously for a pit width of 1200 feet. Pit advancement is dependent on width and depth, but is generally approximately five feet per day. On average, 190-220 acres are mined per year.

As the material is mined, it is slurried to the WCP which also floats and is located at the back side of the pit. The WCP in this operation functions the same as that in a truck shovel. After the heavy minerals are separated, the tailings (quartz sand and slimes) are sprayed and discharged from the back of the

WCP and redeposited back in the pit. As the water drains from the tailings, mobile equipment is used to spread and contour the tailings to the approximate original topography. Due to the humate, process water quality can be a problem. In some cases, it can be necessary to use additional settling ponds outside the pit to further clarify the water. This allows the humate and fines to settle out of solution after which, the water is pumped back for use in the wet concentration plant. These humate ponds typically take longer to reclaim because the humate retains that moisture, making it difficult to put heavy equipment on the surface during reclamation.

Reclamation associated with a dredge operation is, on average, completed 18-30 months after mining is completed. Some areas might have up to 600 acres of unreclaimed land at any one time. Reclamation timelines can be tied to the individual property lease requirements, as well as state regulations.

No dewatering is required in a dredge operation, therefore there are typically no significant changes in the groundwater table as a result of pumping. However, if the mineralized zone extends below the depth of the dredge's capability, the water level in the pit is pumped down and lowered. This allows for mining to greater depths with the same equipment. Usually the lowering of the pond level would only extend the mining depth a few feet and is generally done on a temporary basis. Furthermore, large ponds required to float the dredge increase water loss to evaporation and alter groundwater flow directions by mounding groundwater beneath the pond.

Dragline Mining

There are multiple benefits for using the Dragline/Conveyor mining method. In general, a dragline is a more efficient method for moving bulk material where long mining cuts and pits can be utilized. Employing elongated cuts allows for simultaneous mining the mineral sands and tailings placement to occur in the same pit. This process will allow reclamation to occur at a faster rate as backfilling and rough grading may occur up to +/-500 feet behind the dragline dig face. This should allow reclamation to begin within days of mining, where typical methods take several months to greater than a year.

Use of this mining method will also minimize water loss and maximize water recovery/recycling through the use of dewatering screens and cyclones. When compared to dredge mining of mineral sands, this method will allow for more water recovery whereas a dredge loses water to evaporation as process water is sprayed back into the pit from the back side of the wet concentration plant. In TPM's process, the recycled process water quality is improved as they will be separating the humate in the process and burying it in the open pit below the quartz sand tailings. This technique will eliminate the need for separate humate deposition ponds which take extended lengths of time to dry and "set up" to support for equipment to reclamation.

Due to the noted concerns with dredging and dry mining, TPM is proposing to conduct a demonstration project to show the efficiency and minimal environmental effects of the proposed dragline mining methodology. The TPM demonstration project location was selected as the most practical location furthest from the Okefenokee National Wildlife Refuge with the least amount of environmental impacts.

4.4 Alternatives Sites Eliminated from Further Consideration

Green Cove Springs Orebody

The Green Cove Springs orebody is located north of the town of Palatka, Florida and south of the town of Green Cove Springs, Florida. Black Creek limits the northern extension of the deposit and a karst depression and erosion by the St. Johns River restricts the southern extension (Pirkle et. al., 2007). Mining of this orebody began in 1972 and continued until 2006. Following the cessation of mining, Iluka Resources, Inc. began processing tailings of the previously mined material until it was decommissioned in 2009 (NRC, 2018, United States Nuclear Regulatory Commission Iluka Resources, Inc., retrieved February 18, 2020, available at: nrc.gov/info-finder-decommissioning/complex/iluka-resources.html). This orebody is no longer economically viable to mine as the resource has been exhausted; therefore, it is inappropriate for a demonstration project.

Trail Ridge and Highland/Maxville Orebodies

The Trail Ridge orebody represents the largest known heavy mineral orebody in the southeastern U.S. (Pirkle et. al, 1991) and is located along the southern extent of Trail Ridge extending from town of Starke, Florida following Trail Ridge north towards the town of MacClenny, Florida. This deposit has been mined since 1949 and is currently being mined by Chemours (formerly DuPont). As Chemours is actively mining this orebody and owns the majority of the land, it is not economically feasible for TPM to lease or purchase the remainder of this deposit; therefore, it is not practical for a demonstration project.

Mission Deposit

The Mission deposit is located northeast of the town of Folkston, Georgia and is currently being mined by the Chemours Company (previously Southern Ionics Minerals). The Mission deposit is located on the Penholoway Shoreline and generally consists of three major mineralized zones with minimal overburden. The heavy minerals are predominately highly altered ilmenite, with moderate amounts of zircon, rutile, and leucoxene (Pirkle et. al, 2007). As this deposit is being exploited by Chemours, this deposit is not considered a practical demonstration mining alternative.

Buffalo Ridge Deposit

The Buffalo Ridge deposit is located west of the Mission Deposit and east of Trail Ridge approximately 11 miles south of Nahunta, Georgia. The heavy mineral assemblage contains approximately 14% rutile, 12% zircon, and 44% ilmenite plus leucoxene. Pirkle et. al (2007) describe the deposit as five mineralized zones that varies in length from 945 to 2,195 meters, in width from 125 to 300 meters, and in thickness from 0.8 to 4.5 meters. Overburden thickness extends to 2.3 meters. Due to the limited extent of the resource and the thickness of overburden this deposit is not currently economical to mine; therefore, this site is not practical for a demonstration project.

Boulougne Orebody

The Boulogne orebody, located in northeastern Florida, south of the town of Boulogne, has also been developed. Located on the Penholoway Formation, the Boulogne orebody was mined from 1974 to 1979 by the Humphreys Mining Company. The northern portion of the deposit is now developed with houses and the southern unmined portion contains shallow deposits with an average depth of 3.6 meters (~12 feet); therefore, limiting the economic viability of any potential mine (Pirkle et. al, 2007). Due to limited heavy mineral resources remaining in this orebody, it is not currently economical to mine and in not feasible for a demonstration mining project.

Yulee Deposit

The Yulee deposit, located east and north of Yulee, Florida, is part of the Pamlico barrier island complex. The heavy mineral deposits are in narrow north-south trending ridges that are irregular in shape and have been identified as “Crandall Ridge,” “Bells Ridge,” “Haven Road Ridge,”, and “Chester Road Ridge” (Pirkle et. al., 2007). This deposit has been evaluated numerous times including from 1970 to 1971 by Humphreys Mining Company, 1986 by E.I. du Pont de Nemours & Co., and in 2002 by Iluka Resources, Inc. and has an estimated heavy mineral percentage of approximately three percent. However, the reserve contains a high percentage of non-economic heavy minerals with estimates ranging from 22% to 54% non-economic minerals within the heavy mineral suite (Pirkle et. al., 2007). Additionally, Chester Road Ridge and Haven Road Ridge are now developed with residential neighborhoods and therefore unavailable for mining. Based on the reserve area and volume (0.97 km^2 & 3,492 m^3) estimated by Iluka in 2002, the Crandall Ridge reserve is too small for economic mining.

Due to the high percentage of non-economic heavy minerals and the limited size of the available reserve, it is currently not economical to mine and is therefore not practical for a demonstration project.

Lulaton Orebody

The Lulaton Orebody is located just west of the town of Lulaton, Georgia on the Penholoway Formation. This orebody was mined by Iluka Resources, Inc. from 2004 until 2006 (Pirkle et. al, 2007). This orebody is no longer economically viable to mine, as the resources have been exhausted, making it unsuitable as a viable demonstration project.

Altama Deposit

The Altama heavy-mineral deposits are located in eastern Glynn County, Georgia, northwest of Brunswick, in north–south-trending dune ridges of quartz sand that accumulated along a Pamlico shoreline (Figure 2) (Pirkle et. al., 2007). The titanium minerals ilmenite (average 60% $TiO2$), rutile, and leucoxene constitute 63% of the total heavy minerals, and zircon accounts for almost 11%. In 1985, DuPont conducted a detailed evaluation of the main Altama deposit and estimated that approximately 2.34 million metric tons of heavy minerals including approximately 227,000 metric tons of zircon may be within the deposit (Pirkle et. al., 2007). More recently, Iluka Resources, Inc. re-evaluated the Altama deposit and in 2003 purchased acreage that they planned to mine. However, in 2006, Iluka sold a portion of the property to the Glynn County Development Authority after they were denied a mining permit because of community opposition (Starr, 2006). The southern extent of the deposit has since been developed by commercial and residential properties. Due to the sale of the property to the local development authority and development of the southern portion of the deposit, the Altama deposit was not considered a practical alternative, and thus is not a reasonable location for a demonstration mining project.

Folkston Orebody

The Folkston orebody is located approximately 2.5 miles north of the St. Mary's River in Charlton County, near the town of Folkston, Georgia. 80% of the Folkston deposit was mined between 1965 and 1974 and can be considered both economically and geologically depleted (Elsner, 1997). Pirkle et. al. (2007) reiterates this by stating that this orebody has been mined out and is no longer viable. Since this deposit is not economical to mine, it was not considered a practical alternative for the demonstration mining project.

Amelia A/B/C Deposit

The Amelia deposit consists of two separate blocks of heavy mineral concentrated sands, a northern tract (Amelia A & Amelia B) located west/southwest of Jesup, Wayne County, Georgia, and a southern tract (Amelia C) located southeast of Screven, Wayne County, Georgia. According to Pirkle et al.(1993b) the mineable sediments containing heavy-mineral concentrations in the Amelia A and B tract average 5.2 meters in thickness containing an average of approximately 2.5% heavy minerals by weight. Mineable sediments with heavy-mineral concentrations in Amelia C average 6.7 meters in thickness and contain an average of approximately 2.3% heavy minerals. (Pirkle et. al., 2007). Approximately 60% of the heavy mineral is composed of titanium minerals with highly altered ilmenite, and more than 13% zircon Pirkle et. al, 2007). This deposit is being mined by Chemours; it is unavailable for lease or purchase by TPM and therefore not a practical alternative for a demonstration project.

Folkston West

The Folkston West deposit is approximately 9,000 acres located west of the town of Folkston, Georgia and east of the Okefenokee National Wildlife Refuge along Trail Ridge. Titanium minerals compose about 51% of the total heavy minerals and zircon accounts for approximately 13%; the ore-grade sediments contain very small percentages of non-economic heavy minerals (Pirkle et. al., 1993). In 2003, Dupont Company donated approximately 16,000 acres including the entire Folkston West reserve to The Conservation Fund and relinquished mining rights (Seabrook, 2003; Pirkle et. al., 2007). The Folkston West deposit is protected and was not considered for further evaluation as an alternative or demonstration project location.

Toledo Tract

The Toledo Tract is located immediately north of the Saunders Tract and east of the Okefenokee Swamp, along Trail Ridge. The Toledo Tract is approximately 30,637 acres with an average orebody thickness of 9.4 meters, and no overburden (Pirkle et. al, 2007). The deposit is estimated to contain approximately 19.2 million metric tons of heavy minerals (Pirkle et. al, 2007). TPM contacted Toledo Manufacturing Company, owner of the Toledo Tract, regarding potential mineral exploration and subsequent lease or purchase of the property. Toledo Manufacturing Company indicated that the property was not currently available for lease or purchase and thus is not a practical location for a demonstration mining project.

4.5 Alternatives Evaluated Further

4.5.1 Off-Site Alternatives

Alternative 1: Confidential Site 1

Confidential Site 1 (CS 1) is located in Brantley County, Georgia along Trail Ridge and is greater than 1,000 acres in size. CS 1 is located more than three miles from the Okefenokee National Wildlife Refuge. The site is located adjacent to a historically known heavy mineral reserve. TPM evaluated the CS 1 property through exploration drilling and heavy mineral percentages averaged less than 1.5%. As this property did not have the required economic heavy mineral percentage, it was not considered a viable, practical demonstration project location. Since this property was not economical to mine, it was not evaluated for cultural or environmental resources.

Alternative 2: Confidential Site 2

Confidential Site 2 (CS 2) was evaluated by TPM through exploration drilling. The CS 2 property was not economical to mine at this time; therefore, it was not considered a practical alternative for a demonstration project. CS 2 was not evaluated for cultural or environmental resources.

4.5.2 On-Site Alternatives: Saunders Tract

The Saunders Tract is located approximately four miles west of the town of St. George, Georgia. The deposit extends from Highway 94 north along Trail Ridge to the Toledo deposit (Pirkle et. al., 2007). The Saunders Tract is comprised of five individual properties: the Adirondack Tract, the Keystone Tract, the TIAA Tract, the Dallas Police & Fire Tract, and the Loncala Tract (Figure 67). Drilling conducted by Dupont in 1977 and again in 1994 identified an HMS concentration averaging 2.17% with no overburden. At the time, the Saunders deposit was thought to be "lost" due to multiple property owners of the individual tracts (Pirkle et. al., 2007).

Beginning in 2018, TPM began a more extensive mineral exploration of the Saunders Tract. Results of TPM's exploration revealed economic concentrations of heavy minerals along the crest and western flank of Trail Ridge up to a depth of approximately 70 feet below land surface.

Alternative 3: Loncala Tract

Alternative 3 consists of mining an alternative location within the Saunders Tract, the Loncala Tract. The site is an approximately 1,012-acre area depicted on the USGS 7.5-minute Topographic Maps of Moniac, Georgia and Saint George, Georgia (Figure 68). The center of the site is located near latitude

30.576162 and longitude -82.128950 and the site elevation ranges from approximately 120 to 175 feet above mean sea level. The western boundary follows a portion of Swamp Perimeter Road and, Trail Ridge Road is located along the eastern portion of the site. The site has historically been used for silvicultural activities. The primary sources of hydrology for the site are on-site rainfall and surface water flow.

The site is located approximately 0.5 mile east of the eastern boundary of the Okefenokee National Wildlife Refuge. The proposed mining boundary for Alternative 3 is located 0.75 mile from the Okefenokee National Wildlife Refuge property boundary (Figure 69)

TPM began exploratory drilling of Alternative 3 in February 2018 and determined that the Tract is comprised of suitable reserves of heavy mineral sands containing the target minerals suitable for mining. The heavy mineral sands underlying the site average approximately 2% economic heavy mineral concentration.

Aquatic features located within Alternative 3 are summarized below.

Feature	Area (ac)	Length (lf)
Wetland	405.387	---
Intermittent Stream	0.337	3,020
Open Water	0.340	---

Alternative 3 contains two tributaries located within the northwestern portion of the site. Stream S2 flows into Stream S1, which flows offsite westward towards the Okefenokee National Wildlife Refuge. One open water (OW1) totaling 0.34 acre occurs within the site. The observed open water appears to be an excavated feature that is adjacent to Wetland D.

Alternative 3 would result in impacts to approximately 292.209 acres of wetlands and 1,160 linear feet of stream. These estimated impacts do not include impacts associated with processing facilities, attendant features, or road improvements that would be required to operate on the property. In order to efficiently transport HMS concentrate products from the Loncala tract, approximately 3.5 miles of railroad would need to be constructed or significant road improvements would be required to handle the significant increase in heavy truck traffic. Due to the distance of rail access, constructing a rail road to access the property is not currently economically feasible for a demonstration project.

Sensitive species that were identified on the Loncala Tract and would be potentially impacted include the American black bear, gopher tortoise and gopher frog. In a survey completed April 2-4, 2019, TTL and Altamaha Environmental Consulting identified 62 gopher tortoise burrows. During a camera survey of the burrows, also completed April 2-4, 2019, 29 tortoises were identified over four separate colonies. Furthermore, three burrows contained gopher frogs. All of the identified burrows are located within Alternative 3's area and would require relocation.

The Phase I Cultural Resources Survey completed by TerraXplorations, Inc. (TerraX) revealed the presence of one cultural resource site (9CR120) recommended as potentially eligible for the National Register of Historic Places (NRHP) inclusion under Criterion D. Additionally, the NRHP status of another cultural resource is listed as unknown as this site was unable to be fully tested due to the site extending outside of the project limits. However, the investigated portion of the site was determined to lack significant data potential and thus no further archaeological work was recommended within the project area. TerraX recommended that until this site could be fully defined and evaluated, the overall NRHP eligibility status should remain as unknown. For site 9CR120 avoidance or further testing was recommended. If avoidance is not possible, TerraX recommended Phase II testing be conducted prior to any ground disturbing activities in order to better evaluate the NRHP eligibility status of this site.

Locations of sensitive features on Alternative 3 are depicted on Figure 69.

Alternative 4: Keystone Tract Layout 1

Alternative 4 consists of the originally proposed layout submitted in the July 3, 2019 Twin Pines Minerals Individual Permit application. The center of the site is located near latitude 30.524900 and longitude -82.124198. Alternative 4 consists of a combination of dragline and excavator/dozer trap mining at the proposed project site. Mining at the site would be accomplished utilizing dragline mining for the majority of the site and the truck/shovel method would be utilized due to the shallower depth of mineral resource on the TIAA mining block (Figure 70).

The northern boundary of the Alternative 4 site is located approximately 2.7 miles southeast from the nearest boundary of the Okefenokee Swamp National Wildlife Refuge, providing a substantial buffer of protection for this sensitive resource. Alternative 4 contains suitable reserves of heavy mineral sands containing the target minerals suitable for mining. The heavy mineral sands underlying the site are comprised of an average of 1.5% concentration of the economically viable heavy minerals.

The Alternative 4 review area, consists of 2,405.1 acres with a proposed mining area of 1,268.4 acres, an additional 182 acres would be developed to support the mining and mineral processing operations. Alternative 4 is located along a railroad; however, access spurs to the rail would need to be constructed. In Alternative 4, dry processing facilities, office facilities, and storage facilities would be located south of the mining operation between Highway 94 and the railroad.

Alternative 4 contains numerous forested, shrub-scrub, and herbaceous wetlands as well as ephemeral, intermittent, and perennial streams. Stream impacts would occur within partially unstable channels that have been historically impacted by silvicultural activities and stable intermittent streams located in mature forested riparian corridors. The table below summarizes the quantities of aquatic resources for the Alternative 4 project area.

Feature	Area (ac)	Length (lf)
Wetland	1,194.437	---
Stream	1.010	11,587
Open Water	---	---

Alternative 4 provides habitat for the federal candidate, state listed threatened gopher tortoise and federal candidate, state listed rare gopher frog. In a survey completed April 2-4, 2019, TTL and Altamaha Environmental Consulting identified 62 gopher tortoise burrows. During a camera survey of the burrows completed April 2-4, 2019, 29 tortoises were identified over four separate colonies. Furthermore, three burrows contained gopher frogs. Gopher tortoise and gopher frog would be relocated. With the implementation of these mitigation measures, Alternative 4 is not expected to have an effect on these species.

A cultural resource survey identified a total of 16 archaeological locations within the extent of the permit area. These included seven isolated finds and nine archaeological sites. Of these sites, five are the remains of early-to-middle-twentieth century domestic assemblages. None of the sites were recommended as eligible for NRHP inclusion and isolated finds are, by their nature, ineligible for NRHP inclusion. One resource located outside of the permit area boundary is recommended as potentially eligible for NRHP inclusion under Criterion C. This resource is a mid-century ranch home constructed in 1950. Though currently abandoned, the integrity of the structure is intact and its architecture is significant as a representative example of a mid-twentieth century ranch house. The cultural resource survey recommended avoidance of this property. Additionally, the house is currently located near an existing chip mill and railroad tracks and is currently exposed to heavy audible effects. Due to avoidance measures the historic resource will not suffer adverse visual and audible effects as a result of the proposed mining operations.

Locations of sensitive features on the Alternative 4 are depicted on Figure 71.

Alternative 5: Keystone Tract Layout 2 (Preferred)

Alternative 5 consists of the originally proposed layout submitted in the July 3, 2019 Twin Pines Minerals Individual Permit application. The center of the site is located near latitude 30.524900 and longitude -82.119090. Alternative 5 consists solely of dragline mining at the proposed project site.

The northern boundary of the Alternative 5 site is located approximately 2.7 miles southeast from the nearest boundary of the Okefenokee Swamp National Wildlife Refuge, providing a substantial buffer of protection for this sensitive resource (Figure 72). Alternative 5 contains suitable reserves of heavy mineral sands containing the target minerals suitable for mining. The heavy mineral sands underlying the site are comprised of an average of 1.6% concentration of the economically viable heavy minerals.

The Alternative 5 review area is the same review area as Alternative 4 and consists of 2,405.1 acres. However, the proposed mining area has been substantially reduced to 898 acres, an additional 143.7 acres would be utilized to support the mining and mineral processing operations.

In Alternative 5, dry processing facilities, office facilities, and storage facilities would be located at the recently vacant chip mill facility located approximately one mile east of Trail Ridge Road. Heavy truck access would be facilitated by the construction of an internal haul road from the on-site wet processing plant to the dry processing plant at the "chip mill." This road is proposed to be constructed along existing roadways where possible, thus minimizing impacts to aquatic features. The chip mill facility is located along the railroad with existing spurs on the property, no additional construction would be required for rail access.

Two deep water wells will be located east of the mining operation on the Adirondack Tract. These wells will be drilled into the Floridan Aquifer to supply make-up water to the wet-processing plant as needed. These wells will be constructed in uplands and water will be transported to the wet plant via eight-inch high-density polyethylene (HDPE) pipe. The corridor for the piping is proposed as to avoid crossing wetlands or known gopher tortoise burrow locations and to utilize existing roadways where feasible.

Alternative 5 contains numerous forested, shrub-scrub, and herbaceous wetlands as well as portions of intermittent streams. Stream impacts would primarily occur within partially unstable channels that have been historically impacted by agricultural/silvicultural activities. The table below summarizes the quantities of aquatic resources for the project area.

Feature	Area (ac)	Length (lf)
Wetland	1,202.399	---
Stream	1.010	11,587
Open Water	---	---

Alternative 5 provides habitat for one (federal candidate, state listed threatened) gopher tortoise which would be relocated prior to mining. With the implementation of these mitigation measures, Alternative 5 is not expected to have an effect on these species.

A cultural resource survey identified a total of 16 archaeological locations within the extent of the permit area. These included seven isolated finds and nine archaeological sites. Of these sites, five are the remains of early-to-middle-twentieth century domestic assemblages. None of the sites were recommended as eligible for NRHP inclusion and isolated finds are, by their nature, ineligible for NRHP inclusion. One resource located outside of the permit area boundary is recommended as potentially eligible for NRHP inclusion under Criterion C. This resource is a mid-century ranch home constructed in 1950. Though currently abandoned, the integrity of the structure is intact and its architecture is significant as a representative example of a mid-twentieth century ranch house. The cultural resource survey recommended avoidance of this property. Additionally, the house is currently located near the existing chip mill and railroad tracks and is currently exposed to heavy audible effects. Due to avoidance measures the historic resource will not suffer adverse visual and audible effects as a result of the proposed mining operations.

Locations of sensitive features on Alternative 5 are depicted on Figure 73.

Alternative 5: Mining Activities and Progression of Mining
The following is an outline of TPM's Conceptual Mining Plan (CMP). The sequence of mining activities is described in this section. This outline is generalized and may require modification once mining begins and field logistics are established. At the current time, below is the best estimate of the anticipated processes and progression of mining.

The mining concept proposed by TPM is an innovative approach that will utilize a dragline to remove the HMS and an overland conveyor to transport the material to the processing plant. The TPM CMP is designed to allow for mining of an approximate 100-foot wide pit to a maximum depth of 50 feet below the land surface.

Prior to mining, clearing for the Feed conveyor will be completed along a 50-foot corridor along the north section of this initial area. Once clearing for the feed conveyor is completed, clearing for the Tails conveyor and berm to the south will be performed. This tails/berm corridor clearing will extend approximately 150-170 feet north to south. After the clearing for the tailings conveyor corridor is completed, clearing for the mining corridor will be started.

The first step in the mining process will be rough clearing of the mining corridor ahead of the dragline. This corridor will be approximately 450 feet north to south which will allow for mining of three pits before relocating the feed/tailings conveyors. This corridor will be cleared immediately ahead of the dragline. This clearing will extend +/-500 feet ahead of the mining and progress as the dragline advances. The clearing of this 450-foot north to south corridor is required to facilitate the advancement of the apron feeder and mobile conveyors as mining progresses to the east in this initial pit. The initial clearing for all three corridors (feed, tails/berm and mine pit corridor) will extend an approximate distance of 650-670 feet north to south.

Once clearing for the conveyors is completed, both the feed and tailings conveyors will be constructed for the entire length of pit to near the eastern boundary of the mine area, where they will turn to the north towards the wet concentration plant, located near the northeastern portion of the proposed mining area.

Topsoil removal for the active pit will occur in approximately 500-1000 feet sections ahead of the dragline. The topsoil will be pushed up and windrowed just north of the pit being mined. Topsoil removal will advance as needed to stay ahead of the mining.

As stated previously, the mining will advance in 100-foot wide pits. TPM estimates that mining will advance at a rate between 100 and 200 feet per day and average approximately 115 feet per day. Mining will begin in the extreme southwest corner of the permit area and advance to the east. The total length of each cut will be, on average 9,000 feet (average distance from west boundary of the mine to the east boundary). Once mining reaches either the west or east limit of mining, the dragline will reverse its course and mine the next cut in the opposite direction. The east-west to west-east alternation of mining will continue throughout the entire course of mining, overall advancing to the north.

The dragline will excavate the HMS from the mine pits and place material on the apron feeder. The apron feeder plus two shorter conveyors, oriented north-south will move the HMS to the feed conveyor. As the dragline advances east and the HMS are processed at the wet concentration plant, tailings (sand, slimes and humate) are transported back to the mined pit along the tailings conveyor. Once the open pit reaches approximately 500 feet, the tailings will be placed into the open pit and graded to the approximate original topography. After this initial 500 feet of pit is excavated and tailings are being placed back in the pit, the operation should reach a "steady state" where the HMS removal is roughly equal to the tailings placement and only leaving approximately 500 feet of pit open at any one time. TPM refers to this concept as a "moving mine" (Appendix D).

Once an area has been mined, backfilled, and graded, the topsoil will be redistributed back on to the newly graded area. Once the topsoil has been replaced, revegetation will follow as soon as practical for the species to be planted.

Alternative 6: No Action Alternative

The No Action Alternative would be to allow the site to remain in its current land use and condition. This alternative does not meet the projects purpose and need of the project to demonstrate that HMS mining can be conducted in an environmentally sensitive area with negligible impacts to the site and surrounding resources nor a high-quality HMS reserve to produce HMS concentrate products.

The Saunders Tract is currently managed for industrial forest resources. Implementation of the No Action Alternative would entail the continued active industrial logging and unsustainable forestry practices. The industrial logging of the site is, in and of itself, a degradative use of the property. Google Earth and historic aerial images dating back to 1970 (Figure 74) show continuous historic industrial forestry activity on the site.

The prior ownership of the site has not practiced sustainable forestry. None of the tracts (Loncala Tract, Keystone Tract, Adirondack Tract, nor TIAA Tract) have been certified as sustainable forestry by the Sustainable Forestry Initiative (SFI). This on-the-ground evidence indicating that the site has been severely and negatively impacted by industrial forestry activity through intensive mechanical disturbance and herbicide use (site prep and release/mid-rotation) as observed by:

- >18" beds (in most drier areas, in all low-lying areas including wetland ecotones and entire area of shallow wetlands, some beds are >3 feet)
- Windrows/piles
- Lack of stumps and stump holes
- Low plant diversity, vegetation dominated by 'weedy' old field species (e.g. *Andropgon virginicus, Rubus sp., etc.*)

There are many peer-reviewed studies on the effects of mechanical and chemical treatments on vegetation. Many of these studies are inconclusive, funded by forest industry, and focus on species richness (including ruderals and exotics) with no attention to species composition. Miller et. al. (2009) found that preserving biodiversity in managed forests is possible with "judicious, targeted use of forest chemicals". However, the study states that "…there are tradeoffs between intensity of silvicultural practices and potential terrestrial biodiversity. The extreme form of intensive management is the agricultural model, i.e., site preparation and subsequent vegetation control that eliminates most vegetation except for crop trees, resulting in a highly productive stand from a wood production standpoint, but with limited ecological value."

A 2004 study found that "Current site-preparation techniques rely on herbicide combinations ('tank mixes' that affect a broad spectrum of plants), often coupled with mechanical treatments and >1 years post-planting application to enhance the spectrum and duration of vegetation control. This near-total control of associated vegetation at establishment and more rapid pine canopy closure, coupled with shortened and repeated rotations, likely will affect plant diversity…" Short rotations allow less time for herbaceous establishment before canopy closure which results in less seed rain and depletion of the seed bank (Miller and Miller, 2004).

Mechanical site prep is correlated with high mid-story density which suppresses the herbaceous layer. Chemical site prep is correlated with low understory species richness and high mid-story density. Additionally, agricultural history (repeated soil disturbance and herbicide application) has a strong influence on vegetation structure and composition (Hedman et al, 2000). Chemical and physical soil disturbances cause changes in the ectomycorrhizal fungal assemblage that likely have significant and lasting ecological impacts (Jones, et al, 2003).

Additionally, a study looked at the use of herbicides used to establish longleaf pine stand. The rates of application were less than what is typically used by forest industry. Species richness was similar to reference sites, but composition included more ruderal and old-field species less emblematic of high-quality sites (Addlington et al, 2012).

Implementation of Alternative 6 will result in the continuation of these destructive industrial forestry practices on the site.

Table 17 provides a summary of the completed alternatives analysis.

5.0 AVOIDANCE AND MINIMIZATION

In an effort to avoid and minimize impacts to aquatic resources and threatened/endangered species, TPM and TTL developed a site layout by first placing priority on these sensitive features during site layout planning.

Impacts to some aquatic resources were avoided by locating the project's facilities away from the higher quality wetlands. Permanent roadways that required crossing wetlands were located where the crossing was the shortest, avoiding impacts to larger wetlands areas. Culverts are proposed at these wetland crossings in order to minimize the damming effect of the roadway and maintain surface flow out of and into offsite wetlands and streams.

The dry processing, shipping, and office facilities were relocated from south of the Keystone property between Highway 94 and the railroad, to a vacant but developed industrial site (the chip mill site). This not only avoided additional impacts to wetlands but also significantly reduced the number of gopher tortoise that will require relocation (six to one) and eliminated impacts to gopher frogs.

The proposed mining footprint has been reduced to the minimum size necessary to provide an adequate demonstration that dragline mining of HMS can be conducted in an environmentally responsible manner and provide economic viability for the project and long-term success of the site restoration.

The development of dragline mining methodology by TPM for mining HMS also minimizes impacts by reducing the length of time for land disturbance activities in a given area and decreasing the time to begin reclamation activities. Mining via dragline minimizes water loss through evaporation (dredge), and significantly reduces the need to dewater (truck and shovel). Water within the processing plant is able to be recycled due to the humates being removed from the process water early in processing. Using a dragline eliminates the need for separate humate deposition ponds.

In addition to purchasing mitigation credits and in order to minimize the temporal loss of wetland function on-site, TPM is proposing to reconstruct the mined wetlands. A Reclamation Plan will be provided at a later date.

Appendix D provides the general design of the proposed mining activity including plan and profile drawings. Table 18 provides a summary of the on-site alternatives that were evaluated to minimize impacts to sensitive features.

6.0 TYPES OF IMPACTS

The current design for the proposed project would impact waters of the U.S. by dragline mining and subsequent placement of approximately 33,182,677 cubic yards of fill material in wetlands, and streams, as well as the construction of the associated facilities and roads which would involve the placement of fill material in wetlands and streams. The impacts to wetlands from the mining activities are considered permanent for the purposes of mitigation due to the unknown, long-term timeline associated with restoring previously mined areas. However, the mined area will be reclaimed with the excavated material and, once minerals are extracted, restored. Restoring wetlands will minimize the temporal loss of wetland function and provide data to demonstrate the time necessary to complete wetland restoration activities after HMS mining. Mitigation for impacts will be provided through the purchase of wetland and stream credits from an approved commercial mitigation bank, because of this and the proposed reclamation activities there will be no net loss of waters of the U.S. in these areas. Associated infrastructure facilities of the mine that will be constructed will result in permanent impacts to waters of the U.S. Stream SB will be permanently impacted by the placement of a culvert and associated outfall protection in an existing low-water road crossing, detailed drawings for the culverted locations and cross-sections are included in Appendix E.

The waters proposed to be impacted include wetlands and intermittent streams. The streams are generally part of the tributary system of the St. Mary's River. On-site aquatic features and proposed impacts are shown on Figure 75. The review area contains approximately 1,202.399 acres of wetlands and approximately 11,587 linear feet of stream channel. Aquatic resources quantities, proposed impacts, and mining summary are provided in the tables below. All activities will be performed in a manner to minimize turbidity in the stream.

Proposed Mining Summary by Property					
Property	Mining Method	Total Area to be mined (ac)	Mining Depth	Total Wetland to be Mined (ac)	Total Upland to be Mined (ac)
TIAA	Dragline	233.315	25	83.511	149.804
Keystone	Dragline	644.566	50	369.60	294.966
TOTAL		**897.881**		**453.111**	**444.77**

The following table provides a summary of the proposed mining volumes by property area.

Proposed Mining Volume Summary				
Property	Total Volume to be Mined		Total Wetland to Be Mined	
	Cubic feet	Cubic yards	Cubic feet	Cubic yards
TIAA	254,080,050 ±	9,410,372 ±	90,943,484	3,368,277
Keystone	1,447,424,750 ±	53,608,324 ±	804,988,801	29,814,400
TOTAL	**1,701,504,800 ±**	**63,410,372 ±**	**895,932,285**	**33,182,677**

There will be no oils or other pollutants released from the proposed activities which will reach the stream.

All work performed during construction will be done in a manner to prevent interference with any legitimate water uses.

Proposed Mining Wetland Impact Summary by Year											
YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		YEAR 6	
ID	AREA (Acres)	ID	AREA (Acre)	ID	AREA (Acres)	ID	AREA (Acres)	ID	AREA (Acres)	ID	AREA (Acres)
WA[1]	4.947	WH[1]	0.084	WN[1]	3.619	WU[1]	15.485	WAB[1]	27.497	WAH	0.376
WB[1]	9.588	WI[1]	20.476	WO[1]	1.285	WV	11.088	WAC	21.851	WAI	3.992
WC	19.152	WJ	1.419	WP[1]	0.530	WW	6.936	WAD	8.927	WAJ	19.691
WD	25.132	WK	0.081	WQ	0.507	WX	12.960	WAE	1.116		
WE	3.945	WL	21.134	WR	46.530	WY	10.171	WAF	24.490		
WF	15.090	WM	47.133	WS	29.754	WZ	13.915	WAG	1.002		
WG	0.756			WT	1.135	WAA	21.317				
Total Year 1	78.61	Total Year 2	90.327	Total Year 3	83.36	Total Year 4	91.872	Total Year 5	84.883	Total Year 6	24.059
Total Mining Impacts = 453.111 acres											
[1] Wetland area is located on the TIAA property tract.											

Proposed Infrastructure Wetland Impact Summary		
Property	Wetland ID	Permanent Impacted Area (ac)
Adirondack	Area 10 (WA)	0.225
Adirondack	Area 8 (WE)	2.184
Adirondack	Area 17 (WA)	0.645
Adirondack	Area 18 (WA)	0.093
Keystone	Area 4 (WAH)	0.037
Keystone	Area 5 (WAI)	0.060
Keystone	Area 6 (WAJ)	0.618
Keystone	Area 7 (WAA)	4.176
Keystone	Area 9 (WS)	5.027
Keystone	Area 11 (WB)	1.367
Keystone	Area 12 (WF)	0.041
Keystone	Area 13 (WC)	0.920
Keystone	Area 14 (WE)	2.378
Keystone	Area 15 (WD)	3.450
Keystone	Area 16 (WK)	2.438
TIAA	Area 1 (WA)	0.330
TIAA	Area 2 (WN)	0.359
TIAA	Area 3 (WU)	0.776
	TOTAL	25.124

Proposed Stream Impact Summary						
			Total		Permanent Impacts	
Property	Stream ID	Classification	Length (LF)	Area (AC)	Length (LF)	Area (AC)
Keystone	SA	Intermittent	297	0.020	297	0.020
Adirondack	SB	Intermittent	3,257	0.265	115	0.008
	TOTAL		3,554	0.285	412	0.028

7.0 MITIGATION PLAN

Mitigation for permanent impacts will be provided through the purchase of wetland and stream credits from an approved commercial mitigation bank. The Savannah District, US Army Corps of Engineers Regulatory Guidelines to Evaluate Proposed Mitigation Bank Credit Purchases in the State of Georgia was utilized when identifying the appropriate mitigation bank. This analysis is provided below. Using the 2018 Department of the Army Savannah District Corps of Engineers Standard Operating Procedure (SOP), the Qualitative Resource Assessments for Adverse Impact were utilized. SOP worksheets are included in Appendix F. The Qualitative Worksheets for Wetland and Stream Adverse Impacts were utilized to determine the total quantity of wetland and stream credits to be purchased as summarized below. The wetland and stream credits required for the impacts will be purchased prior to the initiation of the associated activities.

Prior to the start of construction, the applicant would purchase the required number of credits for the permanent infrastructure impacts as well as the impacts for the first year of mining (Year 1). The initial purchase would be for 553.36 depressional wetland grandfathered credits and 2,225 stream credits. Upon completion of the first year of mining, the applicant would purchase the required credits for Year 2 prior to commencing further mining. The mitigation for the impacts would continue in a phased manner each year, prior to the start of mining.

Mitigation Credits Required by Year				
Impact Type	Depressional Wetland		Stream	
	Acres of Impact	Grandfathered Credits Required	Acres of Impact	Grandfathered Credits Required
Infrastructure	25.12	119.92	0.028	2,225
Mining Year 1	78.61	433.44	0.000	0
Mining Year 2	90.33	541.92	0.000	0
Mining Year 3	83.36	396.32	0.000	0
Mining Year 4	91.87	489.28	0.000	0
Mining Year 5	84.88	405.44	0.000	0
Mining Year 6	24.06	143.60	0.000	0
TOTAL	**478.23**	**2,529.92**	**0.028**	**2,225**

The project is located in the St. Mary's Primary Service Area (PSA) and in the 03070204 8-digit Hydrologic Unit Code (Figure 76). There are three banks located in the PSA with non-tidal wetland credits. The Musket Bay Mitigation Bank currently has sufficient credits available for purchase for the initial start of construction that includes the permanent infrastructure and mining year 1 impacts. The other banks do not have sufficient credits on their own. Therefore, wetland credits will be purchased from Musket Bay Mitigation Bank or from a combination of banks that have credits available. There is also one bank, the Satilla River Mitigation Bank, that is within the tertiary service area. There are no banks with stream credits that service the 03070204 8-digit Hydrologic Unit Code. The Patriots Pride Mitigation Bank is within the secondary service area. Additional information and analyses are provided in the Table 19.

In general, reclamation will consist of returning the site to approximate preconstruction contours and elevations, replacement of the stockpiled topsoil and revegetation. The general processes are described below:

- Prior to mining the top 6 inches of topsoil will be removed and stockpiled nearby.
- The mined material will be returned to the mined area and restored to approximate pre-construction contours and elevations.
- The stockpiled topsoil will be replaced.
- The area will be revegetated with the appropriate native vegetation.

The Reclamation Plan detailing the activities that will take place will be submitted at a later date.

8.0 WATERS OF THE U.S. JURISDICTIONAL DETERMINATION

During the TPM due diligence process, TTL performed a delineation of waters of the U.S. for the various tracts during a time period covering April 2018 – June 2019. A report of findings along with a request for a jurisdictional determination for the Keystone and Loncala Tracts was submitted to the USACE and on November 27 and 28, 2018. A site visit was conducted with USACE representatives to review the delineated areas. A verification letter was received December 18, 2018.

On July 3, 2019, waters of the U.S delineation reports were submitted for approximately 551 acres of the Adirondack Tract and 1,143 acres of the TIAA Tract. The USACE reviewed the delineation areas for these tracts from October 21-25, 2019 and provided a verification letter on January 24, 2020.

Following receipt of the verification letter for the Adirondack and TIAA Tracts, TTL contacted the USACE regarding the identification of wetlands crossing historic roads. As these roads were in place prior to Clean Water Act regulation and are actively maintained, they do not meet the criteria for consideration as a wetland. The USACE agreed with this determination and directed TTL to remove wetlands that had been indicated on historic roads. Edits to the wetland features have been included with this application.

TTL completed a desktop review of aquatic features for the proposed haul road east of the Adirondack Tract and the former chip mill areas utilizing available topographic maps, aerial photography, the USFWS National Wetland Inventory (NWI) mapper, the Natural Resources Conservation Service (NRCS) web soil survey and local experience.

Copies of each of the waters of the U.S. delineation reports and the received verification letters are included in Appendix G.

9.0 THREATENED AND ENDANGERED SPECIES

Project site-specific reviews on the USFWS Information for Planning and Consultation (IPaC) website identified three federally-listed species and one federal candidate species (Consultation Codes:04EG1000-2020-SLI-1378 Event Code:04EG1000-2020-E-02535) (Appendix H). Consultations with state agencies in the preliminary planning process resulted in additional species of concern being added to the list of targeted species for review at the proposed site. TTL personnel Christopher Terrell and Christopher Stanford initially performed a habitat characterization site reconnaissance to observe the presence of or the habitat of the targeted species. Where suitable habitat was identified, targeted surveys were conducted. The results of the targeted species surveys are described in detail in the following reports included in Appendix H: "2018-2019 Survey for Protected Amphibians/Reptiles on the Twin Pines Site, Charlton County, Georgia," "2019 Survey for Rare, Threatened, and Endangered Plants" and, "Results of Eastern Indigo Snake Surveys on the Twin Pines Site, Charlton County, Georgia: Year 2."

The federal status species of concern identified by the resource agencies (with IPaC species highlighted in bold) and field findings are summarized in the table below. Results of the review of available data, habitat characterization and focused field surveys for sensitive species are presented in Tables 20 and 21. Table 22 provides a summary of the potential impacts of the project to federal status species.

One federal candidate species, the gopher tortoise, will be impacted by the project due to mining activities. Mitigation measures to reduce this impact include pre-construction surveys to scope burrows and the relocation of the species. Based on the implementation of these conservation measures, the proposed project is not expected to have a significant effect on threatened and endangered species.

9.1 Frosted flatwoods salamander

Potential breeding pond habitats for this species (isolated depressional wetlands forested with pond cypress (*Taxodium ascendens*), black gum (*Nyssa biflora*), slash pine (*Pinus elliottii*), and myrtle-leaved holly (*Ilex myrtifolia*) were visited in December, 2018. Each wetland (25 total) was evaluated as to its potential suitability for the frosted flatwoods salamander based on a ranking system developed by Palis (2002). For each wetland; the hydrology, fire history, presence/absence of graminaceous vegetation within the pond basin (including *Carex*, *Rhynchospora*, *Eriocaulon*, *Xyris*, *Panicum* spp.) as well as the condition of pine uplands (e.g., fire history, integrity of ground cover, soil type and disturbance) surrounding the wetland was considered. Pine uplands on-site, although underlain by hydric-to-mesic flatwoods soils that historically may have supported the specific pine savannah habitats required by flatwoods salamanders (Palis 1996, 1997; USFWS 1999; Jensen and Stevenson 2008); are grossly degraded from commercial forestry operations (e.g., bedding) that date to the 1970s. Today, these uplands no longer support intact ground vegetation (e.g., wiregrass, *Aristida stricta*). Similarly, isolated wetlands on-site are also in poor condition due to bedding, ditching, historic fire suppression and other disturbances.

A total of 12 survey ponds were sampled from February 27 – March 9, 2019. The surveys included 17.25 person-hours dip netting and 175 trap-nights. No frosted flatwoods salamander larvae were found. On these surveys, 2 species of salamanders, 6 species of anurans, 9 species of fishes, and 4 species of snakes were captured. During the same period frosted flatwoods salamander larvae were found on Fort Stewart, Georgia, indicating the species bred at this site during the fall-winter of 2018-2019 (Chris Coppola, U.S. Fish and Wildlife Service, pers. Comm., 2019).

The disappearance of the frosted flatwoods salamander from Chesser Island and Okefenokee National Wildlife refuge lands is most likely attributed to anthropogenic disturbances the region suffered prior to being acquired by the U.S. Fish and Wildlife Service (Jensen 1995). Large-scale declines and extirpations of frosted flatwoods salamanders have been attributed to habitat loss and degradation from commercial forestry practices (Means et al. 1996, Palis 1997). In fact, the impetus, in part, for the federal listing of the species in 1999 was widespread loss of habitat due to silviculture (USFWS 1999). It is probable that the inability to document frosted flatwoods salamanders as well as two easily sampled frog species typical of pine flatwoods habitats on the site (the southern chorus frog (*Pseudacris nigrita*) and ornate chorus frog (*Pseudacris ornata*) is due to their extirpation, historically, from habitat changes caused by forestry operations.

The uplands on the site – although in some areas underlain by hydric-to-mesic flatwoods soils that historically may have supported the specific pine savannah habitats required by frosted flatwoods salamanders− are, as detailed above, grossly degraded from commercial forestry operations that (based on a review of aerial photographs) date at least to the early 1970s. Today, these uplands no longer support intact ground vegetation (e.g., wiregrass, Aristida stricta) as is typical of habitat still occupied by this species. The proposed project is not likely to have an effect on the frosted flatwoods salamander.

9.2 Striped newt

Until recently, the striped newt was considered a candidate for federal listing under the Endangered Species Act. In December 2018, the U.S. Fish and Wildlife Service determined that federal listing is not warranted at this time. This amphibian is known to have declined and disappeared from portions of its historic range on Trail Ridge, near the Okefenokee National Wildlife Refuge, due to commercial forestry operations (Dodd and LaClaire 1993, Farmer et al. 2017).

Sampling for striped newt adults/larvae at the same 10 wetland sites using the same dipnet and minnow trap survey methods as detailed above for the frosted flatwoods salamander was performed during February-March 2019. Dipnet and minnow trap surveys of 12 isolated wetlands on-site did not document the striped newt. Naturally-functioning longleaf pine−wiregrass sandhills, the preferred habitat for transformed examples of this newt, are lacking on-site.

Due to the profound habitat changes and perturbations from commercial forestry practices (see section 8.1 Frosted Flatwoods Salamander above), it is unlikely that the species persists on the site, if in fact it was ever present. The proposed project is not likely to have an effect on the striped newt.

9.3 Gopher frog

Gopher frog tadpoles were sampled at the same 10 wetland sites using the same dipnet and minnow trap survey methods as detailed above for the frosted flatwoods salamander (also during February-March 2019).

In December 2018, this species was documented from a site on the Keystone Tract, finding an adult female gopher frog in a juvenile gopher tortoise burrow. Gopher frog was recorded during gopher tortoise burrow scoping surveys (conducted spring 2019). Single-opening funnel traps made of aluminum screening were placed at active gopher tortoise burrows in an effort to capture gopher frogs that emerge during the night (traps were set at a minimum of six active burrows, for two consecutive nights, at all tortoise colonies on-site that contained eight or more tortoise burrows).

The gopher frog, state-listed as Rare by the Georgia Department of Natural Resources, was documented on the site, including observations for the Adirondack, Keystone, and Loncala tracts. A total of six gopher frogs were observed, including three adults seen in gopher tortoise burrows during indigo snake surveys or gopher tortoise surveys and three adults observed in tortoise burrows while scoping burrows with the burrow camera. Two frogs were captured and voucher photographs were taken of these specimens. Dates and specific location information for these records are provided in the “2018-2019 Survey for Protected Amphibians/Reptiles on the Twin Pines Site, Charlton County, Georgia” report in Appendix H.

Dipnet and minnow trap surveys of 12 isolated wetlands conducted on-site during February-March 2019 did not document egg masses or tadpoles of the gopher frog. An isolated wetland surveyed in March 2019 (A-04; 30.525379°N, 82.09925° W), dry when revisited on 23 April 2019, is a potential breeding pond for the gopher frog. A small cypress pond, converted in part into a borrow pit and located offsite and just south of the Keystone Tract (30.51613°N, 82.11790°W), may be a breeding site used by gopher frogs. Efforts to locate gopher frog choruses, egg masses, and tadpoles in 2019 were unsuccessful, including during site visits conducted in mid-late December 2019, following heavy rains.

Prior to construction, all gopher tortoise burrows will be camera scoped to determine the occupancy status of the burrow. Occupied burrows will be trapped and gopher frog along with gopher tortoise will be captured, then relocated to an area identified in coordination with Georgia DNR. No gopher frogs have been located within the proposed impact area (Alternative 5). A map of known gopher frog locations is provided as Figure 77.

9.4 Red-cockaded woodpecker

Red-cockaded woodpecker are residents of the Okefenokee National Wildlife Refuge and identified by a resource agency as possibly using the proposed project site for foraging. Suitable habitat consists of well-drained, sandy areas dominated by old-growth, longleaf pine communities with sparse mid-story vegetation and dense diverse herbaceous groundcover. Pine trees must be of sufficient size and spatial distribution to be inhabited by red-cockaded woodpeckers. Due to the site’s current use as a commercial forestry operation, this habitat does not exist within the review area. No red-cockaded woodpeckers, cavity trees, or sign were observed during field reconnaissance nor during any of the field work. The proposed project is not likely to have an effect on the red-cockaded woodpecker.

9.5 Florida hartwrightia

This plant flowers from September to November. Targeted surveys were conducted from October 7 to October 14, 2019. The species was not identified on the site.

9.6 Flooplain tickseed

This plant flowers from August to November. Suitable habitat for this species may not occur in the project review area. Targeted surveys were conducted from October 7 to October 14, 2019. The species was not identified on the site.

9.7 Purple honeycomb-head

This plant flowers from August to October. Habitat for this species includes wet savannas and pitcher plant bogs. Targeted surveys were conducted from October 7 to October 14, 2019. The species was not identified on the site.

9.8 Eastern indigo snake

The soil types present at the project site indicate that suitable habitat may be present for the eastern indigo snake and the gopher tortoise. Surveys for indigo snakes overwintering in gopher tortoise burrows were conducted following visual encounter survey methods that are effective for this species in the southern Georgia portion of its range (Stevenson et al. 2003, Bauder et al. 2017). Specifically, all active/inactive tortoise burrows (n=118) were visited on three dates between December 2018 - March 2019 in an effort to locate basking snakes and shed skins; burrows with fresh snake tracks were examined with a tortoise burrow camera (to look for snakes inside burrows). Additionally, all active/inactive tortoise burrows were scoped with a burrow camera (in late March or April/May) in an effort to document burrow commensals, including indigo snakes.

No eastern indigo snakes or eastern indigo snake shed skins were found during visual encounter surveys, and no fresh snake tracks were located at burrows. A single pygmy rattlesnake (*Sistrurus miliarius*), the shed skin of an eastern coachwhip (*Coluber flagellum*) and two observations of gopher frogs (*Rana capito*) were observed during the surveys.

In addition to the above visual encounter surveys, all active/inactive gopher tortoise burrows on-site were visited on 2-4 April 2019. As part of a tortoise survey, most subadult-and-adult-sized burrows were scoped with a tortoise burrow camera at this time (see section 9.9 gopher tortoise below). No indigo snakes or shed skins were found during this effort.

On three dates from November 19 to December 18, 2019, additional surveys for indigo snakes were conducted. No eastern indigo snakes or eastern indigo snake shed skins were found by visual encounter surveys at the site, and no fresh snake tracks were located at burrows. A single pygmy rattlesnake (*Sistrurus miliarius*) and the shed skin of a Florida pinesnake (*Pituophis melanoleucus*) were observed. A map of indigo snake survey areas and gopher tortoise burrow locations is provided in Appendix H.

The indigo snake is an extremely vagile species that often moves between upland and wetland habitats in search of food (Stevenson et al. 2010, Breininger et al. 2011). Individual snakes studied in southern Georgia had large home ranges, for some large males up to 3,500 acres in size (Hyslop et al. 2014). A lack of indigo snake observations during focused surveys doesn't demonstrate that the species is never present or transient on the site (even if the species doesn't winter on-site it is possible that snakes from adjacent tracts, if present that is, may occasionally visit the site to forage. However, there are no recent credible sightings known for the property. The proposed project is not likely to have an effect on the eastern indigo snake.

9.9 Gopher tortoise

Suitable habitat for gopher tortoise is present in the review area. Open canopy pine forests with abundant herbaceous understory are the preferred habitat for gopher tortoises and this habitat was present within the review area. Only one area within the proposed project alternative was identified during surveys to contained gopher tortoise burrows (Figure 77; Appendix H). Other gopher tortoise colonies have been avoided.

From pedestrian surveys, all gopher tortoise burrows were located and each individual burrow classified as "active" or "inactive" (based on presence or absence of fresh tracks, respectively). Also, each burrow was classified as that of an "adult", "subadult", or "juvenile" tortoise (based on burrow width). Gopher tortoise burrow widths were classified as follows: juvenile burrows are 0-7.85 cm in width; subadult burrows 7.86-25.7 cm wide; adult burrows are 25.8+ cm wide (these widths correspond to carapace lengths of 0-12 cm, 12.1-24 cm, and 24+ cm, respectively). Note: 19 burrows that were less than 14 cm in burrow width were not scoped because of their small size; however, they were closely examined using a mirror or flashlight and in doing so we observed tortoises in 5 of these burrows; we scoped all remaining burrows. A total of 118 active/inactive tortoise burrows comprised of 59 adult burrows, 9 subadult burrows, and 26 juvenile burrows were identified during the surveys. In an effort to determine burrow occupancy in Spring 2019, a tortoise burrow camera was used to scope all adult/subadult burrows. (Juvenile burrows were assumed to be occupied by tortoises if fresh tracks were present). These activities assisted in developing a very precise estimate of just how many gopher tortoises are present on-site.

On the site, the sandy, well-drained environments that support gopher tortoises have historically been site-prepped and bedded and are now in planted pine, usually slash pine. Tortoises are not especially common or widespread on the site, occurring only in four to five fairly small and discrete areas of sandy, open-canopied plantation habitat; individual tortoise colonies support ca. 10-15 adult tortoises, or less.

With the burrow camera (or using flashlights/mirrors), we observed gopher tortoises in 23 adult-sized burrows, 11 subadult-sized burrows, and in one juvenile-sized burrow. For another four active adult-sized burrows, 11 active subadult-sized burrows, and two active juvenile burrows, we could not determine conclusively whether or not the burrow was in fact occupied by a tortoise. Tortoise survey data is provided in Appendix H. A map of gopher tortoise locations is provided as Figure 77.

Based on the limits of the proposed demonstration project, approximately three active adult burrows were identified within the preferred project footprint. During the camera survey only one gopher tortoise was observed in the on-site burrows.

Conservation measures include avoidance, translocation and /or habitat management to reduce the adverse impacts and potentially benefit the gopher tortoise population. Gopher tortoise burrows will be avoided to the maximum extent practicable at the site. For the gopher tortoise burrows that cannot be avoided, a translocation project will be conducted for the gopher tortoise in these areas. Prior to construction, all gopher tortoise burrows will be camera scoped to determine the occupancy status of the burrow. Occupied burrows will be trapped and captured gopher tortoise will be relocated to an area identified in coordination with Georgia DNR; should, over the course of the project, the gopher tortoise achieve federal listing status coordination will also occur with the USFWS.

The applicant has successfully trapped and relocated gopher tortoise for its mining operation in Starke, Florida. The applicant, through its consultant, successfully obtained permits to capture by using bucket traps, live traps, hand shovel and backhoe excavation of tortoise burrows. The animals were relocated to a donor site by non-harmful means. The permit was obtained through the Florida Fish and Wildlife Commission, Division of Habitat and Species Conservation. Additionally, the gopher tortoise has successfully recolonized areas that were previously mined for heavy mineral sands. With the implementation of these mitigation measures, the proposed project is not likely to have an effect on the gopher tortoise.

9.10 Other Special Concern Species

As previously stated, consultations with state agencies in the preliminary planning process resulted in additional species of concern being added to the list of targeted species for review at the proposed site. These species do not have federal status but were identified by various resource agencies as being species of special concern. Results of the review of available data, habitat characterization and focused field surveys for other special concern species are presented Table 21.

Bald eagle

Juvenile bald eagles and non-nesting adults can be seen throughout Georgia, but known nesting activity is concentrated mostly along the coast and near major rivers, wetlands, and reservoirs in the southern and central parts of the state. Like other members of the "fish eagle" group, bald eagles almost always nest near open water. Bald eagles have not been observed on the site. Habitat for bald eagle does not occur on site. The proposed project is not likely to have an effect on the bald eagle.

Bachman's sparrow

Habitat for this species consists of open pine or oak woods; old fields; brushy areas, young large grassy pine regeneration areas. The state-listed Bachman's sparrow (*Peucaea aestivalis*) was documented from one location on-site and from a second location just east of the site boundary during the herpetological surveys in April of 2019. This species may utilize the site for foraging. Based on the short-term nature of the majority of the impacts of the project and the poor quality of the existing habitat on site, the proposed project is not likely to have an effect on the Bachman's sparrow.

Red face top minnow

Habitat for this species includes stream margins, backwaters, pools, marshes, and wetlands, often associated with aquatic vegetation. Habitat for this species occurs on the project site. This species was identified on site.

Savannah milkweed

5Habitat for this species consists of pine flatwoods and prairies. Habitat for this species occurs on the project site. Nine individuals were identified during the field survey.

Dwarf pawpaw

Habitat for this species consists of flatwoods and wet savannas. Habitat for this species occurs on the project site. Six populations of this species were identified on site. There were 413 individuals identified during the field survey.

Florida orange-grass

Habitat for this species consists of moist pine barrens. Habitat for this species is present on site. This species was not identified on site.

Green-fly orchid

This species is epiphytic especially on *Magnolia grandiflora*, *Quercus virginiana*, and *Taxodium* spp.in blackwater river swamps and mesic hardwood hammocks. Habitat for this species is present on site. This species was not identified on site.

Southern umbrella-sedge

Habitat for this species consists of pineland depressions, and wet savannas with *Toxicodendron vernix*. Habitat for this species is present on the project site. Populations of this species were identified on the project site. There were 206 individuals identified during the field survey.

Florida milk-pea

Habitat for this species consists of pine flatwoods. This plant is a herbaceous vine that can reach 3 feet in length. It tends to stay prostrate and trailing but will climb if given a support. Habitat for this species is present on the project site. This species was not identified on site.

Chapman's skeleton grass

Habitat for this species consists of calcareous glades and relict prairies with dryish clay loam soils. It also grows in sandy pine barrens and sites inhabited by dwarf palmetto, *Serenoa repens*. Habitat for this species is present on the project site. This species was not identified on the site.

Narrowleaf water-willow

Habitat for this species consists of roadside ditches, often with *Hartwrightia* in shallow sloughs and wet savannas. It is emergent in shallow water wetlands. Habitat for this species is present on the project site. This species was not identified on the site.

Southern bog-button
Habitat for this species consists of flatwoods. Habitat for this species is present on the project site. This species was not identified on the site.

Pond spice
Habitat for this species consists of cypress ponds, and swamp margins. Habitat for this species is present on the project site. This species was not identified on the site.

Odorless bayberry
abitat consists of bayheads, titi swamps, moist to wet pinelands. Habitat for this species is present of the project site. This species was not identified on the site.

Palafoxia
Habitat for this species consists of sandy pine oak scrub. Habitat for this species is present on the project site. This species was not identified on the site.

Arrow arum
Habitat for this species consists of swamps, wet hammocks on pristine sphagnum mats. This species is relatively common in the Piedmont area of Georgia, but lesser known in the coastal plain. Habitat for this species is present on the project site. This species was not identified on the site.

Pennyroyal
Habitat for this species consists of myrtle oak scrub. Habitat for this species is present on the project site. This species was not identified on the site.

Chapman's fringed orchid
Habitat for this species consists of wet savannas, wet pine flatwoods, hillside seeps, and wet roadsides. Habitat for this species is present of the project site. This species was not identified on the site.

Yellow fringeless orchid
Habitat for this species consists of wet savannas and pitcher plant bogs. Habitat for this species is present of the project site. This species was not identified on the site.

Wild coco
Habitat for this species consists of grassy savannas, palmetto barrens and longleaf pine grasslands. Habitat for this species is present on the project site. This species was not identified on the site.

Chapman oak
Habitat for this species consists of sand ridges, dunes, and oak-pine scrub. Habitat for this species is present on the project site. This species was identified on the project site. A total of 4 individuals were identified during the field survey.

Nuttall meadowbeauty
Habitat for this species consists of pine flatwoods and bogs. Habitat for this species is present on the project site. This species was identified on the project site. There were 253 individuals identified during the field survey.

Fernald's beakrush
Habitat for this species consists of sandy, peaty pond margins and depressions. Habitat for this species is present on the project site. This species was not identified on the site.

Hooded pitcherplant

Habitat for this species consists of wet savannas and pitcherplant bogs. Habitat for this species is present on the project site. This species was identified on the proposed project site. A total of 78 individuals were identified during the field survey.

Parrot pitcherplant

Habitat for this species consists of wet savannas and pitcherplant bogs. Habitat for this species is present on the project site. This species was identified on the proposed project site. A total of 8 individuals were identified during the field survey. One plant was identified within the proposed impact area, as shown on Figure 78.

White sunnybell

Habitat for this species consists of wet savannas. Habitat for this species is present on the project site. This species was not identified on the site.

Sandhill skullcap

Habitat for this species consists of sandy scrub. Habitat for this species is present on the project site. This species was not identified on the site.

Florida ladies-tresses

Habitat for this species consists of wet savannas, and mowed grassy openings in the Okefenokee area. Habitat for this species is present on the project site. This species was not identified on the site.

Wireleaf dropseed

Habitat for this species consists of longleaf pine-wiregrass savannas and pitcherplant bogs. Habitat for this species is present on the project site. This species was not identified on the site.

Stokes aster

Habitat for this species consists of coastal plains, bogs, pine savanna, and open woodlands. Habitat for this species is present on the project site. This species was not identified on the site.

Sprawling goats' rue

Habitat for this species consists of dry sandy scrub. Habitat for this species is present on the project site. This species was not identified on site.

Bartram's air-plant

This plant is epiphytic in bay swamps, freshwater tidal swamps; beech-magnolia bluff forests. Habitat for this species is present on the project site. Populations of this plant were identified on the project site. A total of 29 individuals were identified during the field survey.

Diverse-leaf crownbeard

Habitat for this species consists of sandy peat in fire-maintained savannahs or in open stands of slash pine-palmetto flatwoods where wiregrass dominates. Habitat for this species is present on the project site. This species was not identified on site.

Black Bear

Most of the South Georgia bear habitat is slash pine (*Pinus elliottii*) flatwoods, lowland mixed hardwoods, cypress/gum wetlands, and emergent freshwater prairie. The core of the range is a contiguous area of protected public lands totaling 666,107 acres including Dixon Memorial State Forest (and WMA) and Okefenokee NWR in Georgia, and Osceola National Forest and John Bethea State Forest in Florida. Most of the perimeter of the core area is industrial forest land which is managed with intensive pine site preparation and short timber rotations. Most (97%) of the diet of the South Georgia population bears was of plant origin, with the top 3 food items being black gum, saw palmetto, and acorns. Home ranges of adult female bears were in areas with disproportionately high loblolly bay (*Gordonia lasianthus*) and gum-bay-cypress (*Taxodium* spp.) vegetation associations (Dobey et al. 2005). Although Dobey et al.'s (2005) analyses did not rank pine associations highly, 57% of the summer diet of bears was comprised of food items found almost exclusively in pine (i.e., huckleberry, blueberry, bitter gallberry) or bears to have access to all life requisites, they need to be located within the home range of the bear. The mean annual home-range size for females in the South Georgia population was 13,813 acres and they expanded their home ranges during years of poor black gum production (Dobey et al. 2005). The expansion was most apparent between autumn 1998 and 1999 when the average home-range size for females increased from 3,583 acres to 19,373 acres and included a larger proportion of upland areas open to hunting (Dobey et al. 2005). Male home-range size was 84,708 acres (Dobey et al. 2005). Black bear was identified on the Loncala tract (Alternate 3). The proposed project is not likely to have an effect on black bear.

10.0 CULTURAL RESOURCES

A desktop and subsequent Phase I Cultural Resources Survey was conducted for the Keystone review area by TerraX (report dated October 26, 2018). Phase I investigations of this property led to the discovery of six archaeological sites and four isolated finds. Based on the results of the field investigation, none of these resources were considered significant, having been heavily impacted by numerous years of repeated pine cultivation activities. All six archaeological sites were recommended ineligible for NRHP inclusion under Criterion D based on their lack of integrity. As no significant cultural resources will be impacted by the proposed mining operation, TerraX recommended clearance for the project.

An additional Phase I Cultural Resources Survey for the Adirondack tract was conducted by TerraX (report dated May 31, 2019). The Phase I investigation of this property led to the identification of one archaeological site and two isolated finds. The single archaeological site and both isolated finds date to the early-to-middle twentieth century. Neither the single archaeological site nor the isolated finds are recommended as eligible for NRHP inclusion under Criterion D. An architectural survey identified six resources within view of the proposed project area. Of these six, only one, is recommended as potentially eligible for NRHP inclusion under Criterion C. This resource is a mid-century ranch home constructed in 1950. Though currently abandoned, the integrity of the structure is intact and its architecture is significant as a representative example of a mid-twentieth century ranch house. TerraX recommends avoidance of this property, and notes that it may suffer adverse visual and audible effects as a result of the proposed mining operations. However, the house is currently located near an existing chip mill and railroad tracks and is currently exposed to heavy audible effects. The house will not be impacted by the project directly.

An additional Phase I Cultural Resources Survey for the TIAA tract was conducted by TerraX (report dated June 16, 2019. As a summary of findings of this survey, three archaeological sites and one isolated find were discovered. TerraX recommended that the sites be considered ineligible for NRHP inclusion under Criterion D and isolated finds, by their nature, are not eligible for NRHP inclusion. Based on the findings of the survey, no further cultural resources studies were recommended for the proposed project area.

The proposed project is not expected to significantly impact cultural resources. Copies of the Phase I Cultural Resources Survey reports are provided in Appendix I.

11.0 ADJACENT PROPERTY OWNERS

The adjacent property owners are depicted on Figure 79 and summarized in the table below.

Map ID	PIN	OWNER	ADDRESS
1	36001	TIAA TIMBERLANDS, LLC	1500 S FIRST AVE, STE 1150, PORTLAND, OR 97201
2	59001002	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209
3	58001	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209
4	84001	JOHN, VERNON GOWEN	315 AGNES ROAD, FOLKSTON, GA 31537
5	61002	W L OLIVER/CHARLTON, LLC	P.O. BOX 161139, MOBILE, AL 36616
6	60009	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209
7	60003	CHARLTON COUNTY FORREST	FOLKSTON, GA 31537
8	60007	WALTER & DEBRA SCHEIDERER	8024 HWY 94, ST GEORGE, GA, 31562
9	60006	RANDAL DUKES	8208 HWY 94, ST GEORGE, GA 31562
10	60004	FINLEY W WOLFE	8242 HWY 94, ST GEORGE, GA 31562
11	60004001	KIRK W WOLFE	8296 HWY 94, ST GEORGE, GA 31562
12	60005	ERNST HARDEN	SUITE 107, JACKSONVILLE, FL 32211
13	84003001	FRED & MARLENE WINECOFF	8422 HWY 94, ST GEORGE, GA 31562
14	84003	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MACCLENNY, FL 32063
15	84003002	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MACCLENNY, FL 32063
16	84002001	SIDNEY E & RODNEY BELL	P.O. BOX 173, ST GEORGE, GA 31562
17	84002002	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MCCLENNY, FL 32063

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TABLES

Type	Formula
Exponential	$\gamma(\mathbf{h}) = \sigma_n^2 + \sigma^2\left[1 - \exp\left(-3\lvert\mathbf{h}\rvert / a\right)\right]$
Gaussian	$\gamma(\mathbf{h}) = \sigma_n^2 + \sigma^2\left[1 - \exp\left(-3\lvert\mathbf{h}\rvert^2 / a^2\right)\right]$
Spherical	$\gamma(\mathbf{h}) = \begin{cases} \sigma_n^2 + \sigma^2\left[\dfrac{3}{2}\dfrac{\lvert\mathbf{h}\rvert}{a} - \dfrac{1}{2}\left(\dfrac{\lvert\mathbf{h}\rvert}{a}\right)^3\right] & \lvert\mathbf{h}\rvert \le a \\ \sigma_n^2 + \sigma^2 & \lvert\mathbf{h}\rvert > a \end{cases}$

Table 1. Variogram models used to fit experimental indicator variograms of soil data, where **h** is the separation distance, σ^2 is the spatially-correlated variance of the indicator function, σ_n^2 is the uncorrelated component of the variance of the indicator function, and a is the correlation length.

Table 2. Horizontal Correlation Lengths Used in Variogram Models; Twin Pines Mine Project; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00						
Soil Type	Variogram Model	Variance	Nugget Variance	Maximum Horizontal Correlation Length (ft)	Minimum Horizontal Correlation Length (ft)	Azimuth of Maximum Correlation Length
Silty Clayey Sand (SC-SM)	Gaussian	0.095	0	912	384	30
Clayey Sand (SC)	Gaussian	0.080	0	432	380	90
Consolidated Sand	Gaussian	0.052	0	432	240	90
Semi-Consolidated Sand	Spherical	0.120	0	624	144	60
Unconsolidated Black Sand	Exponential	0.013	0	432	96	120
Unconsolidated Sand	Exponential	0.243	0	336	240	45
Clay	Gaussian	0.040	0	336	240	60

Notes:

The azimuth of the minimum horizontal correlation length is 90 degrees from the azimuth of the maximum horizontal correlation length.

Table 3. Vertical Correlation Lengths Used in Variogram Models; Twin Pines Mine Project; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00				
Soil Type	Variogram Model	Variance	Nugget Variance	Vertical Correlation Length (ft)
Silty Clayey Sand (SC-SM)	Spherical and Exponential	0.032 and 0.03	0	36 and 8
Clayey Sand (SC)	Spherical	0.0723	0	33.6
Consolidated Sand	Exponential	0.053	0.01	18
Semi-Consolidated Sand	Exponential	0.084	0	7.2
Unconsolidated Black Sand	Spherical	0.0132	0	9.6
Unconsolidated Sand	Exponential	0.243	0	15.6
Clay	Exponential	0.04	0	20.4

Table 4. Well Construction Summary Table; Hydrologic Field Characteristics at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Well I.D.	Installation Start Date	Screened Interval (feet bgs [1])	Natural Fill Sand Pack (feet bgs)	Bentonite Plug (feet bgs)	Portland Cement Grout (feet bgs)	Construction Depth of Piezometer (feet bgs)	Total Boring Depth (feet bgs)
Pumping & Observation Wells							
OWA1S	11/9/2018	35-25	35-22	22-20	20-0.5	35	35
OWA1D	11/9/2018	90-80	90-76	76-74	74-0	90	90
OWA1BS	12/11/2018	12-2	12-1	1-0.5	--	12	12
OWA2S	11/14/2018	35-25	35-22	22-20	20-0.5	35	35
OWA2D	11/13/2018	90-80	90-76	76-74	74-0	90	90
OWA2BS	12/7/2018	12-2	12-1	1-0.5	--	12	12
OWA3BS	1/30/2019	12-7	12-0	--	--	12	12
OWA4BS	1/30/2019	12-7	12-0	--	--	12	12
OWA5BS	1/30/2019	12-7	12-0	--	--	12	12
PWA	12/20/2018	115-55	115-45	45-40	40-0	115	115
OWB1S	11/27/2018	35-25	35-22	22-20	20-0.5	35	35
OWB1D	11/27/2018	90-80	90-76	76-74	74-0	90	90
OWB1BS	12/7/2018	12-2	12-1	1-0.5	--	12	12
OWB2S	1130/18	35-25	35-22	22-20	20-0.5	35	35
OWB2D	11/28/2018	90-80	90-76	76-74	74-0	90	90
OWB2BS	12/7/2018	12-2	12-1	1-0.5	--	12	12
OWB3S	12/5/2018	35-25	35-22	22-20	20-0.5	35	35
OWB3D	12/5/2018	90-80	90-76	76-74	74-0	90	90
OWB3BS	1/30/2019	12-7	12-0	--	--	12	12
OWB4BS	1/30/2019	12-7	12-0	--	--	12	12
OWB5BS	1/30/2019	12-7	12-0	--	--	12	12
PWB	12/10/2018	115-55	115-45	45-40	40-0	115	115

[1] Below ground surface

[2] Not applicable or missing data

[3] Undisturbed sample borings converted to piezometers for downhole geophysical survey

Table 5. Slug and Bail Test Results Summary Table; Hydrologic Field Characteristics at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Sample Location	Type Test	Easting	Northing	Top of Casing Elevation (ft. amsl)	Well Depth (ft. bgs)	Screen Depth Top (ft. bgs)	Screen Depth Bottom (ft. bgs)	Screen Depth Top (ft. amsl)	Screen Depth Bottom (ft. amsl)	KGS Method		Bouwer-Rice Method
										Kh (ft/d)	Ss (1/ft)	Kh (ft/d)
PZ01S	Bail	664792.9515	213145.725	123.04	14.0	4.0	13.5	119.04	109.54	1.24E+00	3.30E-05	9.82E-01
PZ01S	Slug	664792.9515	213145.725	123.04	14.0	4.0	13.5	119.04	109.54	1.65E+00	2.60E-06	1.14E+00
PZ04	Bail	663720.3298	205447.0841	123.89	14.0	4.0	13.5	119.89	110.39	1.99E+00	4.40E-05	1.66E+00
PZ04	Slug	663720.3298	205447.0841	123.89	14.0	4.0	13.5	119.89	110.39	1.74E+00	1.67E-03	1.38E+00
PZ06	Bail	662436.2138	201256.8347	124.26	14.0	4.0	13.5	120.26	110.76	3.71E+00	2.41E-05	2.95E+00
PZ06	Slug	662436.2138	201256.8347	124.26	14.0	4.0	13.5	120.26	110.76	3.51E+00	1.26E-04	2.22E+00
PZ10	Bail	667689.3258	206292.4778	145.97	25.0	15.0	24.5	130.97	121.47	3.91E+00	1.11E-03	3.91E+00
PZ10	Slug	667689.3258	206292.4778	145.97	25.0	15.0	24.5	130.97	121.47	6.39E+00	5.49E-05	4.22E+00
PZ13	Bail	668652.4560	196413.6877	157.63	30.0	20.0	29.5	137.63	128.13	5.16E+01	1.61E-12	3.91E+01
PZ13	Slug	668652.4560	196413.6877	157.63	30.0	20.0	29.5	137.63	128.13	5.24E+01	1.61E-12	39.8 (middle time) 12.0 (late time)
PZ16S	Bail	668683.7808	189192.1062	160.42	20.0	10.0	19.5	150.42	140.92	4.10E+01	3.34E-05	3.41E+01
PZ16S	Slug	668683.7808	189192.1062	160.42	20.0	10.0	19.5	150.42	140.92	3.99E+01	5.09E-05	2.94E+01
PZ17D	Bail	670005.1448	212015.6518	161.01	45.0	35.0	44.5	126.01	116.51	4.14E+01	8.55E-13	3.44E+01
PZ17D	Slug	670005.1448	212015.6518	161.01	45.0	35.0	44.5	126.01	116.51	4.27E+01	8.55E-13	2.95E+01
PZ20D	Bail	670360.6665	205134.8784	168.46	40.0	30.0	39.5	138.46	128.96	1.84E+01	8.18E-06	1.53E+01
PZ20D	Slug	670360.6665	205134.8784	168.46	40.0	30.0	39.5	138.46	128.96	1.84E+01	2.17E-04	1.53E+01
PZ24	Bail	672562.2118	196807.9532	169.54	20.0	10.0	19.5	159.54	150.04	1.48E+01	2.19E-05	1.18E+01
PZ24	Slug	672562.2118	196807.9532	169.54	20.0	10.0	19.5	159.54	150.04	4.40E+01	3.19E-06	3.05E+01
PZ28D	Bail	672470.6111	191101.7018	173.99	30.0	20.0	29.5	153.99	144.49	2.34E+00	6.99E-05	2.04E+00
PZ29D	Bail	667975.5644	193583.6283	153.88	50.0	40	49.5	113.88	104.38	1.45E+00	1.32E-04	1.45E+00
PZ29D	Slug	667975.5644	193583.6283	153.88	50.0	40	49.5	113.88	104.38	1.25E+00	2.28E-04	1.19E+00
PZ29S	Bail	667981.0292	193588.0244	154.035	19.0	9.0	18.5	145.04	135.54	8.23E+00	7.00E-06	6.24E+00
PZ29S	Slug	667981.0292	193588.0244	154.035	19.0	9.0	18.5	145.04	135.54	5.44E+00	5.13E-04	5.70E+00
PZ30D	Bail	666484.959	189997.8257	138.02	50.0	40.0	49.5	98.02	88.52	1.09E+00	1.14E-05	9.89E-01
PZ30D	Slug	666484.959	189997.8257	138.02	50.0	40.0	49.5	98.02	88.52	1.38E+00	2.23E-05	1.21E+00
PZ30S	Bail	666491.4469	190004.5697	137.65	10.0	5.0	9.5	132.65	128.15	8.68E-01	1.07E-05	6.86E-01
PZ30S	Slug	666491.4469	190004.5697	137.65	10.0	5.0	9.5	132.65	128.15	1.09E+00	1.97E-16	1.43E+00
PZ31D	Bail	665327.2418	192381.7249	135.90	50.0	40.0	49.5	95.90	86.40	1.57E+00	5.94E-05	1.50E+00
PZ31D	Slug	665327.2418	192381.7249	135.90	50.0	40.0	49.5	95.90	86.40	1.98E+00	1.22E-04	1.98E+00
PZ31S	Bail	665331.907	192374.4898	135.92	12.0	7.0	11.5	128.92	124.42	1.42E+00	2.69E-05	1.08E+00
PZ31S	Slug	665331.907	192374.4898	135.92	12.0	7.0	11.5	128.92	124.42	1.36E+00	2.34E-06	1.03E+00
PZ33D	Bail	661249.6461	192704.3174	123.91	50.5	41.0	50.5	82.91	73.41	2.77E+00	8.22E-06	1.75E+00
PZ33D	Slug	661249.6461	192704.3174	123.91	50.5	41.0	50.5	82.91	73.41	2.23E+00	2.55E-05	1.48E+00
PZ33S	Bail	661258.6777	192703.2169	123.73	13.0	7.0	11.5	116.73	112.23	2.66E+00	5.85E-06	1.93E+00
PZ33S	Slug	661258.6777	192703.2169	123.73	13.0	7.0	11.5	116.73	112.23	2.63E+00	7.72E-06	1.99E+00
PZ55D	Bail	663504.9654	187429.6642	174.92	50.0	40.0	49.5	134.92	125.42	2.03E+01	1.16E-05	1.85E+01
PZ55D	Slug	663504.9654	187429.6642	174.92	50.0	40.0	49.5	134.92	125.42	2.20E+01	6.23E-05	2.10E+01
PZ55S	Bail	671858.651	188474.3774	174.83	20.0	14.0	19.5	160.83	155.33	9.46E-01	1.40E-06	7.18E-01
PZ55S	Slug	671858.651	188474.3774	174.83	20.0	14.0	19.5	160.83	155.33	2.40E-01	1.63E-05	1.99E-01
PZ57D	Bail	675314.5224	192314.0733	165.89	50.0	39.0	48.5	126.89	117.39	5.47E+01	3.79E-20	6.58E+01
PZ57D	Slug	675314.5224	192314.0733	165.89	50.0	39.0	48.5	126.89	117.39	3.59E+01	2.03E-04	7.51E+01
PZ57S	Bail	675311.1832	192310.6915	165.68	14.0	9.0	13.5	156.68	152.18	6.77E+00	6.37E-05	5.38E+00
PZ57S	Slug	675311.1832	192310.6915	165.68	14.0	9.0	13.5	156.68	152.18	7.26E+00	5.75E-05	5.78E+00
PZ58D	Bail	676850.4859	196491.6367	139.98	50.0	40.0	49.5	99.98	90.48	5.10E+00	2.24E-04	5.10E+00
PZ58D	Slug	676850.4859	196491.6367	139.98	50.0	40.0	49.5	99.98	90.48	3.55E+00	2.18E-03	5.38E+00
PZ58S	Bail	676849.7667	196495.5787	140.02	15.0	10.0	14.5	130.02	125.52	2.66E+01	7.87E-05	2.11E+01
PZ58S	Slug	676849.7667	196495.5787	140.02	15.0	10.0	14.5	130.02	125.52	2.42E+01	8.67E-05	1.92E+01

Bouwer-Rice = Unconfined Bouwer-Rice solution method in Aqtesolv™

ft/d = feet per day

Kh = hydraulic conductivity

KGS = Unconfined KGS solution method in Aqtesolv™

Ss = specific storage

ft bgs = feet below ground surface

ft amsl = feet above mean sea level

Table 6: Laboratory Results of Soil Samples Analyzed for Vertical Hydraulic Conductivity; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	USCS	Vertical Hydraulic Conductivity (Kv) (cm/sec)	Undisturbed/ Remolded?	Laboratory	Sample Notes
UD10	208093.3130	666408.7486	131.70	13	15	118.70	116.70	SP-SM	1.30E-04	Undisturbed	Bowser-Morner, Inc.	Unconsolidated Sand
UD10	208093.3130	666408.7486	131.70	28	30	103.70	101.70	SP	2.00E-05	Undisturbed		Unconsolidated Sand
UD10	208093.3130	666408.7486	131.70	43	45	88.70	86.70	SP-SM	1.90E-05	Undisturbed		Unconsolidated Sand
UD25	190488.7166	668975.1185	165.49	15	17	150.49	148.49	SP-SM	1.40E-05	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand
UD25	190488.7166	668975.1185	165.49	30	32	135.49	133.49	SP	8.20E-05	Undisturbed		Unconsolidated Sand
UD25	190488.7166	668975.1185	165.49	43	45	122.49	120.49	SP	1.40E-06	Undisturbed		Unconsolidated Sand
UD34	200408.2230	671582.2720	170.29	13	15	157.29	155.29	SP-SM	1.00E-05	Undisturbed	Bowser-Morner, Inc.	Consolidated Sand
UD34	200408.2230	671582.2720	170.29	28	29	142.29	141.29	SP	7.80E-07	Undisturbed		Unconsolidated Sand
UD34	200408.2230	671582.2720	170.29	48	50	122.29	120.29	SP	4.40E-07	Undisturbed		Semi-consolidated Sand
UD43	190542.5306	678135.6130	148.55	13	15	135.55	133.55	SP	7.00E-06	Undisturbed	Bowser-Morner, Inc.	Unconsolidated Sand
UD43	190542.5306	678135.6130	148.55	30	32	118.55	116.55	SP-SM	3.80E-06	Undisturbed		Unconsolidated Sand
UD43	190542.5306	678135.6130	148.55	43	45	105.55	103.55	SC	1.70E-08	Undisturbed		Clayey Sand
UD51	197065.1026	674174.9889	165.00	13	15	152.00	150.00	SP-SM	5.20E-06	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand (Black)
UD51	197065.1026	674174.9889	165.00	28	30	137.00	135.00	SP-SM	7.60E-06	Undisturbed		Unconsolidated Sand
UD51	197065.1026	674174.9889	165.00	43	45	122.00	120.00	SP	6.90E-05	Undisturbed		Unconsolidated Sand
UD65	202093.9328	675684.2974	166.76	17	19	149.76	147.76	SP	2.80E-04	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated
UD65	202093.9328	675684.2974	166.76	28	30	138.76	136.76	SP	1.10E-04	Undisturbed		Unconsolidated Sand
UD65	202093.9328	675684.2974	166.76	43	45	123.76	121.76	SP	6.30E-02	Remolded		Consolidated - Sity-Clay Sand
UD67	203551.9396	672306.1274	172.06	17	19	155.06	153.06	SP-SM	1.40E-04	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand
UD67	203551.9396	672306.1274	172.06	28	30	144.06	142.06	SP	2.90E-04	Undisturbed		Unconsolidated Sand
UD67	203551.9396	672306.1274	172.06	43	45	129.06	127.06	SP	4.10E-06	Undisturbed		Unconsolidated Sand
UD93	211493.3310	668617.5144	150.25	13	15	137.25	135.25	SP	6.50E-07	Undisturbed	Bowser-Morner, Inc.	Consolidated Sand
UD93	211493.3310	668617.5144	150.25	28	30	122.25	120.25	SP-SM	2.40E-05	Undisturbed		Unconsolidated Sand
UD93	211493.3310	668617.5144	150.25	43	45	107.25	105.25	SP	2.80E-05	Undisturbed		Unconsolidated Sand
UD126	202917.1019	666640.3662	140.22	13	15	127.22	125.22	SP-SM	8.30E-05	Undisturbed	Bowser-Morner, Inc.	Consolidated Sand
UD126	202917.1019	666640.3662	140.22	28	30	112.22	110.22	SP	1.00E-05	Undisturbed		Unconsolidated Sand
UD126	202917.1019	666640.3662	140.22	43	45	97.22	95.22	SP-SM	9.30E-07	Undisturbed		Clayey Sand mixed w/ Fat Clay
UD128	199193.1410	667712.6820	150.52	13	15	137.52	135.52	SP	9.50E-05	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand
UD128	199193.1410	667712.6820	150.52	30	32	120.52	118.52	SP-SM	2.20E-06	Undisturbed		Unconsolidated Sand
UD128	199193.1410	667712.6820	150.52	43	45	107.52	105.52	SP	1.70E-04	Undisturbed		Unconsolidated Sand
UD179	207884.9971	670857.1818	166.08	13	15	153.08	151.08	SP	2.10E-06	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand
UD179	207884.9971	670857.1818	166.08	28	30	138.08	136.08	SP	3.90E-04	Undisturbed		Unconsolidated Sand
UD179	207884.9971	670857.1818	166.08	43	45	123.08	121.08	SP	2.00E-07	Undisturbed		Unconsolidated Sand
UD231	196158.7390	669687.5038	167.53	13	15	154.53	152.53	SP-SM	2.70E-06	Undisturbed	Bowser-Morner, Inc.	Unconsolidated Sand
UD231	196158.7390	669687.5038	167.53	30	32	137.53	135.53	SP-SM	6.00E-06	Undisturbed		Unconsolidated Sand
UD231	196158.7390	669687.5038	167.53	43	45	124.53	122.53	SP-SM	1.90E-05	Undisturbed		Semi-consolidated Sand

Table 6: Laboratory Results of Soil Samples Analyzed for Vertical Hydraulic Conductivity; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00												
Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	USCS	Vertical Hydraulic Conductivity (Kv) (cm/sec)	Undisturbed/ Remolded?	Laboratory	Sample Notes
UD238	192952.8585	674171.2238	168.31	13	15	155.31	153.31	SP-SM	1.00E-04	Undisturbed	Bowser-Morner, Inc.	Unconsolidated Sand
UD238	192952.8585	674171.2238	168.31	28	30	140.31	138.31	SP	3.30E-04	Undisturbed		Unconsolidated Sand
UD238	192952.8585	674171.2238	168.31	43	45	125.31	123.31	SP	1.20E-04	Undisturbed		Unconsolidated Sand
UD338	191127.7310	672504.6590	173.56	13	15	160.56	158.56	SP-SM	2.60E-06	Undisturbed	Bowser-Morner, Inc.	Semi-Consolidated Sand
UD338	191127.7310	672504.6590	173.56	28	30	145.56	143.56	SP-SM	2.20E-05	Undisturbed		Unconsolidated Sand
UD338	191127.7310	672504.6590	173.56	43	45	130.56	128.56	SP	9.20E-05	Undisturbed		Unconsolidated Sand
EB03	206290.6294	667706.7987	145.44	92.5	94	52.94	51.44	CH	1.61E-09	Undisturbed	TTL, Inc.	Clay
EB06	198366.9546	672066.9668	171.50	120	122	51.50	49.50	CL	1.29E-05	Undisturbed	TTL, Inc.	Clay
EB08	191112.0239	672464.5741	173.68	130	133	43.68	40.68	CH	9.29E-09	Undisturbed	TTL, Inc.	Clay
EB16	198336.5709	677166.6458	140.28	12	12.5	128.28	127.78	SP	9.60E-02	Remolded	TTL, Inc.	Unconsolidated Sand
EB16	198336.5709	677166.6458	140.28	15.5	17	124.78	123.28	SM	1.80E-04	Disturbed		Consolidated Sand
EB16	198336.5709	677166.6458	140.28	25.5	26	114.78	114.28	SM	2.30E-02	Remolded		Unconsolidated Sand
EB16	198336.5709	677166.6458	140.28	34.5	36	105.78	104.28	SP	1.90E-02	Remolded		Unconsolidated Sand
EB16	198336.5709	677166.6458	140.28	44.5	46	95.78	94.28	SP	2.40E-02	Remolded		Unconsolidated Sand
EB16	198336.5709	677166.6458	140.28	86	90	54.28	50.28	CH	1.30E-08	Disturbed		Clay
PZ57D	192314.0733	675314.5224	165.62	20	22	145.62	143.62	SM	2.70E-08	Undisturbed	TTL, Inc.	Consolidated Sand
PZ57D	192314.0733	675314.5224	165.62	25	27	140.62	138.62	SM	3.40E-07	Undisturbed		Consolidated Sand
UD25R	NS	NS	NS	3	5	NS	NS	SP-SM	3.20E-04	Undisturbed	TTL, Inc.	Unconsolidated Sand
UD25R	NS	NS	NS	10	12	NS	NS	SP	2.30E-04	Undisturbed		Unconsolidated Sand
UD43R	NS	NS	NS	5	7	NS	NS	SP	6.20E-04	Undisturbed	TTL, Inc.	Unconsolidated Sand
UD43R	NS	NS	NS	10	12	NS	NS	SP	4.50E-04	Undisturbed		Unconsolidated Sand
UD238R	NS	NS	NS	6	8	NS	NS	SP	8.50E-04	Undisturbed	TTL, Inc.	Unconsolidated Sand
UD238R	NS	NS	NS	10	12	NS	NS	SP	4.00E-04	Undisturbed		Unconsolidated Sand
UD338R	NS	NS	NS	9	11	NS	NS	SP	3.00E-04	Undisturbed	TTL, Inc.	Unconsolidated Sand

Notes: ft bgs = feet blow ground surface; ft. amsl = feet above mean sea level; USCS = Unified Soil Classification System; cm/sec = centimeters per second; NS = Not surveyed; borings performed within 5-10 feet of original UD boring

Table 7: Laboratory Results of Soil Samples Analzyzed for Porosity; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00										
Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	USCS	Porosity	Sample Notes
UD10	208093.3130	666408.7486	131.70	13	15	118.70	116.70	SP-SM	36.7%	Unconsolidated Sand
UD10	208093.3130	666408.7486	131.70	28	30	103.70	101.70	SP	38.7%	Unconsolidated Sand
UD10	208093.3130	666408.7486	131.70	43	45	88.70	86.70	SP-SM	35.5%	Unconsolidated Sand
UD25	190488.7166	668975.1185	165.49	15	17	150.49	148.49	SP-SM	43.7%	Semi-Consolidated Sand
UD25	190488.7166	668975.1185	165.49	30	32	135.49	133.49	SP	41.6%	Unconsolidated Sand
UD25	190488.7166	668975.1185	165.49	43	45	122.49	120.49	SP	35.0%	Unconsolidated Sand
UD34	200408.2230	671582.2720	170.29	13	15	157.29	155.29	SP-SM	32.9%	Consolidated Sand
UD34	200408.2230	671582.2720	170.29	28	29	142.29	141.29	SP	42.0%	Unconsolidated Sand
UD34	200408.2230	671582.2720	170.29	48	50	122.29	120.29	SP	40.8%	Semi-consolidated Sand
UD43	190542.5306	678135.6130	148.55	13	15	135.55	133.55	SP	39.6%	Unconsolidated Sand
UD43	190542.5306	678135.6130	148.55	30	32	118.55	116.55	SP-SM	36.6%	Unconsolidated Sand
UD43	190542.5306	678135.6130	148.55	43	45	105.55	103.55	SC	35.2%	Clayey Sand
UD51	197065.1026	674174.9889	165.00	13	15	152.00	150.00	SP-SM	33.8%	Semi-Consolidated Sand (Black)
UD51	197065.1026	674174.9889	165.00	28	30	137.00	135.00	SP-SM	39.1%	Unconsolidated Sand
UD51	197065.1026	674174.9889	165.00	43	45	122.00	120.00	SP	32.0%	Unconsolidated Sand
UD65	202093.9328	675684.2974	166.76	17	19	149.76	147.76	SP	40.0%	Semi-Consolidated
UD65	202093.9328	675684.2974	166.76	28	30	138.76	136.76	SP	37.7%	Unconsolidated Sand
UD65	202093.9328	675684.2974	166.76	43	45	123.76	121.76	SP	36.5%	Consolidated - Sity-Clay Sand
UD67	203551.9396	672306.1274	172.06	17	19	155.06	153.06	SP-SM	33.1%	Semi-Consolidated Sand
UD67	203551.9396	672306.1274	172.06	28	30	144.06	142.06	SP	39.8%	Unconsolidated Sand
UD67	203551.9396	672306.1274	172.06	43	45	129.06	127.06	SP	31.7%	Unconsolidated Sand
UD93	211493.3310	668617.5144	150.25	13	15	137.25	135.25	SP	37.7%	Consolidated Sand
UD93	211493.3310	668617.5144	150.25	28	30	122.25	120.25	SP-SM	33.7%	Unconsolidated Sand
UD93	211493.3310	668617.5144	150.25	43	45	107.25	105.25	SP	35.5%	Unconsolidated Sand
UD126	202917.1019	666640.3662	140.22	13	15	127.22	125.22	SP-SM	31.3%	Consolidated Sand
UD126	202917.1019	666640.3662	140.22	28	30	112.22	110.22	SP	31.3%	Unconsolidated Sand
UD126	202917.1019	666640.3662	140.22	43	45	97.22	95.22	SP-SM	33.0%	Clayey Sand mixed w/ Fat Clay
UD128	199193.1410	667712.6820	150.52	13	15	137.52	135.52	SP	37.5%	Semi-Consolidated Sand
UD128	199193.1410	667712.6820	150.52	30	32	120.52	118.52	SP-SM	39.1%	Unconsolidated Sand
UD128	199193.1410	667712.6820	150.52	43	45	107.52	105.52	SP	36.0%	Unconsolidated Sand
UD179	207884.9971	670857.1818	166.08	13	15	153.08	151.08	SP	38.5%	Semi-Consolidated Sand
UD179	207884.9971	670857.1818	166.08	28	30	138.08	136.08	SP	34.6%	Unconsolidated Sand
UD179	207884.9971	670857.1818	166.08	43	45	123.08	121.08	SP	34.4%	Unconsolidated Sand

Table 7: Laboratory Results of Soil Samples Analzyzed for Porosity; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00										
Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	USCS	Porosity	Sample Notes
UD231	196158.7390	669687.5038	167.53	13	15	154.53	152.53	SP-SM	37.1%	Unconsolidated Sand
UD231	196158.7390	669687.5038	167.53	30	32	137.53	135.53	SP-SM	30.1%	Unconsolidated Sand
UD231	196158.7390	669687.5038	167.53	43	45	124.53	122.53	SP-SM	35.4%	Semi-consolidated Sand
UD238	192952.8585	674171.2238	168.31	13	15	155.31	153.31	SP-SM	33.5%	Unconsolidated Sand
UD238	192952.8585	674171.2238	168.31	28	30	140.31	138.31	SP	35.9%	Unconsolidated Sand
UD238	192952.8585	674171.2238	168.31	43	45	125.31	123.31	SP	33.2%	Unconsolidated Sand
UD338	191127.7310	672504.6590	173.56	13	15	160.56	158.56	SP-SM	33.9%	Semi-Consolidated Sand
UD338	191127.7310	672504.6590	173.56	28	30	145.56	143.56	SP-SM	37.0%	Unconsolidated Sand
UD338	191127.7310	672504.6590	173.56	43	45	130.56	128.56	SP	35.3%	Unconsolidated Sand

Notes: ft bgs = feet blow ground surface USCS = Unified Soil Classification System

ft. amsl = feet above mean sea level

Table 8 : Summary of Grain-Size Distribution Analysis of Soil Samples Collected from Borings; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	Gradation Percent Sand	Gradation Percent Silt/Clay
PZ01S	213145.7250	664792.9515	122.98	6	9	116.98	113.98	84.9	15.1
PZ01S	213145.7250	664792.9515	122.98	12.5	20	110.48	102.98	95.0	5.0
PZ02	209988.5659	664881.4667	126.02	4	10	122.02	116.02	90.3	9.7
PZ02	209988.5659	664881.4667	126.02	17.5	20	108.52	106.02	95.8	4.2
PZ03S	208020.1141	665029.0251	123.77	3	7	120.77	116.77	88.9	11.1
PZ03S	208020.1141	665029.0251	123.77	18	20	105.77	103.77	92.5	7.5
PZ03D	208027.2407	665032.2313	123.50	7	12	116.50	111.50	49.5	50.5
PZ03D	208027.2407	665032.2313	123.50	36	50	87.50	73.50	48.9	51.1
PZ04	205447.0841	663720.3298	123.94	6	11	117.94	112.94	92.0	8.0
PZ04	205447.0841	663720.3298	123.94	15	20	108.94	103.94	96.1	3.9
PZ05	202705.7568	662571.7449	124.62	5	11	119.62	113.62	69.2	30.8
PZ05	202705.7568	662571.7449	124.62	15	20	109.62	104.62	90.1	9.9
PZ06	201256.8347	662436.2138	124.39	7.5	8	116.89	116.39	94.8	5.2
PZ06	201256.8347	662436.2138	124.39	14	20	110.39	104.39	78.8	21.2
PZ07	199410.2734	662371.7196	123.08	5	7	118.08	116.08	85.3	14.7
PZ07	199410.2734	662371.7196	123.08	9	20	114.08	103.08	93.2	6.8
PZ08	197508.9048	664403.2655	130.19	5	6.5	125.19	123.69	85.1	14.9
PZ08	197508.9048	664403.2655	130.19	15	20	115.19	110.19	92.5	7.5
PZ09	210549.7044	666674.5353	135.39	7	10	128.39	125.39	91.8	8.2
PZ09	210549.7044	666674.5353	135.39	27	30	108.39	105.39	95.4	4.6
PZ10	206292.4778	667689.3258	145.72	5	8	140.72	137.72	93.2	6.8
PZ10	206292.4778	667689.3258	145.72	28	30	117.72	115.72	92.4	7.6
PZ11	201281.0529	667407.6724	147.48	8	13	139.48	134.48	92.0	8.0
PZ11	201281.0529	667407.6724	147.48	13	19	134.48	128.48	98.3	1.7
PZ12S	199119.7966	666484.6179	138.16	5	9	133.16	129.16	77.6	22.4
PZ12S	199119.7966	666484.6179	138.16	19	20	119.16	118.16	92.0	8.0
PZ12D	199125.8047	666484.2013	137.52	9	19	128.52	118.52	49.2	50.8
PZ12D	199125.8047	666484.2013	137.52	26	40	111.52	97.52	47.3	52.7
PZ13	196413.6877	668652.4560	157.47	5	20	152.47	137.47	90.3	9.7
PZ13	196413.6877	668652.4560	157.47	27	28	130.47	129.47	93.4	6.6
PZ14	193936.6051	669743.4272	167.32	3	9	164.32	158.32	95.8	4.2
PZ14	193936.6051	669743.4272	167.32	27	30	140.32	137.32	97.2	2.8
PZ15	192000.6802	669433.9007	166.95	4	5.5	162.95	161.45	92.9	7.1
PZ15	192000.6802	669433.9007	166.95	6	9	160.95	157.95	84.9	15.1
PZ15	192000.6802	669433.9007	166.95	9	12	157.95	154.95	48.4	51.6
PZ15	192000.6802	669433.9007	166.95	12.5	20	154.45	146.95	95.0	5.0
PZ15	192000.6802	669433.9007	166.95	28	29	138.95	137.95	98.5	1.5
PZ16S	189192.1062	668683.7808	160.60	5	8	155.60	152.60	90.2	9.8
PZ16S	189192.1062	668683.7808	160.60	18	20	142.60	140.60	98.0	2.0
PZ16D	189193.4656	668689.3844	160.43	10	19	150.43	141.43	48.0	52.0
PZ16D	189193.4656	668689.3844	160.43	41	42.5	119.43	117.93	48.0	52.0
PZ17S	212018.9084	669994.2076	161.58	9	10	152.58	151.58	48.7	51.3
PZ17D	212015.6518	670005.1448	160.89	8	10	152.89	150.89	97.4	2.6
PZ17D	212015.6518	670005.1448	160.89	40	45	120.89	115.89	99.2	0.8
PZ18	210112.6384	670419.4050	164.38	13	18	151.38	146.38	97.0	3.0
PZ18	210112.6384	670419.4050	164.38	18	20	146.38	144.38	91.2	8.8
PZ19	207234.6924	670845.9142	169.57	6	13	163.57	156.57	98.2	1.8
PZ19	207234.6924	670845.9142	169.57	13	18	156.57	151.57	95.5	4.5
PZ20D	205134.8784	670360.6665	168.43	7	16	161.43	152.43	97.4	2.6
PZ20D	205134.8784	670360.6665	168.43	33	40	135.43	128.43	98.1	1.9
PZ21	203215.0202	670383.6651	164.61	3	5	161.61	159.61	91.1	8.9
PZ21	203215.0202	670383.6651	164.61	6	17	158.61	147.61	93.0	7.0
PZ22S	200359.9896	671694.6840	170.17	9	10	161.17	160.17	48.2	51.8

Table 8 : Summary of Grain-Size Distribution Analysis of Soil Samples Collected from Borings; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	Gradation Percent Sand	Gradation Percent Silt/Clay
PZ22D	200357.7075	671700.7149	170.54	18	23	152.54	147.54	95.3	4.7
PZ22D	200357.7075	671700.7149	170.54	35	38	135.54	132.54	98.9	1.1
PZ23	198353.0813	672071.4617	169.31	12.5	15	156.81	154.31	46.3	53.7
PZ24	196807.9532	672562.2118	169.44	6	7	163.44	162.44	95.2	4.8
PZ24	196807.9532	672562.2118	169.44	10	18	159.44	151.44	93.2	6.8
PZ25S	194061.9564	673383.9824	169.99	3	5	166.99	164.99	94.9	5.1
PZ25S	194061.9564	673383.9824	169.99	13	19	156.99	150.99	95.8	4.2
PZ25D	194070.0069	673381.4148	169.68	9	11	160.68	158.68	48.9	51.1
PZ25D	194070.0069	673381.4148	169.68	28.5	29	141.18	140.68	47.3	52.7
PZ26	190199.0854	675725.3696	168.99	0	6	168.99	162.99	93.0	7.0
PZ26	190199.0854	675725.3696	168.99	13.5	20	155.49	148.99	92.9	7.1
PZ27S	188607.1176	676385.2376	168.02	9	10	159.02	158.02	47.9	52.1
PZ27D	188607.9571	676394.0349	168.01	8	13	160.01	155.01	96.1	3.9
PZ27D	188607.9571	676394.0349	168.01	24	30	144.01	138.01	97.5	2.5
PZ28D	191101.7018	672470.6111	174.13	9	19	165.13	155.13	89.3	10.7
PZ28D	191101.7018	672470.6111	174.13	27	30	147.13	144.13	74.0	26.0
PZ38	205467.2108	672734.7122	171.69	6	7	165.69	164.69	48.0	52.0
PZ39D	203579.2608	672985.6825	171.84	19	20	152.84	151.84	46.7	53.3
PZ39D	203579.2608	672985.6825	171.84	77	79	94.84	92.84	51.0	49.0
PZ40	200660.5583	673966.9078	169.48	14	15	155.48	154.48	50.4	49.6
PZ43	191206.1308	676493.9937	161.68	5.5	18	156.18	143.68	50.7	49.3
PZ45D	202715.5700	675525.2030	166.58	18	22	148.58	144.58	49.9	50.1
PZ45D	202715.5700	675525.2030	166.58	49	49.5	117.58	117.08	50.9	49.1
PZ45S	202723.2096	675524.3128	166.64	6.5	7	160.14	159.64	50.5	49.5
PZ46	198343.7772	677166.5936	139.98	4	10	135.98	129.98	45.5	54.5
PZ47	193012.6975	678365.3361	138.30	13	15	125.30	123.30	49.8	50.2
PZ49	205324.4574	677820.5368	142.97	13.5	15	129.47	127.97	48.4	51.6
PZ50	202797.9514	678800.9975	127.64	12	13	115.64	114.64	48.9	51.1
PZ53	199168.3109	681563.2307	111.31	5	8	106.31	103.31	48.3	51.7
PZ53	199168.3109	681563.2307	111.31	7	10	104.31	101.31	48.8	51.2
UD10	208093.3130	666408.7486	131.70	13	15	118.70	116.70	93.6	6.4
UD10	208093.3130	666408.7486	131.70	28	30	103.70	101.70	95.6	4.4
UD10	208093.3130	666408.7486	131.70	43	45	88.70	86.70	94.7	5.3
UD25	190488.7166	668975.1185	165.49	15	17	150.49	148.49	93.8	6.2
UD25	190488.7166	668975.1185	165.49	30	32	135.49	133.49	96.1	3.9
UD25	190488.7166	668975.1185	165.49	43	45	122.49	120.49	95.3	4.7
UD34	200408.2230	671582.2720	170.29	13	15	157.29	155.29	92.3	7.7
UD34	200408.2230	671582.2720	170.29	28	29	142.29	141.29	96.7	3.3
UD34	200408.2230	671582.2720	170.29	48	50	122.29	120.29	95.8	4.2
UD43	190542.5306	678135.6130	148.55	13	15	135.55	133.55	96.1	3.9
UD43	190542.5306	678135.6130	148.55	30	32	118.55	116.55	93.9	6.1
UD43	190542.5306	678135.6130	148.55	43	45	105.55	103.55	73.8	26.2
UD51	197065.1026	674174.9889	165.00	13	15	152.00	150.00	92.7	7.3
UD51	197065.1026	674174.9889	165.00	28	30	137.00	135.00	93.4	6.6
UD51	197065.1026	674174.9889	165.00	43	45	122.00	120.00	98.5	1.5
UD65	202093.9328	675684.2974	166.76	17	19	149.76	147.76	97.5	2.5
UD65	202093.9328	675684.2974	166.76	28	30	138.76	136.76	98.3	1.7
UD65	202093.9328	675684.2974	166.76	43	45	123.76	121.76	98.7	1.3
UD67	203551.9396	672306.1274	172.06	17	19	155.06	153.06	92.4	5.4
UD67	203551.9396	672306.1274	172.06	28	30	144.06	142.06	96.3	2.3
UD67	203551.9396	672306.1274	172.06	43	45	129.06	127.06	97.0	2.8
UD93	211493.3310	668617.5144	150.25	13	15	137.25	135.25	95.5	4.5
UD93	211493.3310	668617.5144	150.25	28	30	122.25	120.25	94.3	5.7
UD93	211493.3310	668617.5144	150.25	43	45	107.25	105.25	97.6	2.4

Table 8 : Summary of Grain-Size Distribution Analysis of Soil Samples Collected from Borings; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00									
Sample Identifier	Northing	Easting	Land Surface Elevation (ft. amsl)	Sample Depth Top (ft. bgs)	Sample Depth Bottom (ft. bgs)	Sample Elevation Top (ft. amsl)	Sample Elevation Bottom (ft. amsl)	Gradation Percent Sand	Gradation Percent Silt/Clay
UD126	202917.1019	666640.3662	140.22	13	15	127.22	125.22	92.3	7.7
UD126	202917.1019	666640.3662	140.22	28	30	112.22	110.22	96.8	3.2
UD126	202917.1019	666640.3662	140.22	43	45	97.22	95.22	90.5	9.5
UD128	199193.1410	667712.6820	150.52	13	15	137.52	135.52	96.7	3.3
UD128	199193.1410	667712.6820	150.52	30	32	120.52	118.52	89.5	10.5
UD128	199193.1410	667712.6820	150.52	43	45	107.52	105.52	96.8	3.2
UD179	207884.9971	670857.1818	166.08	13	15	153.08	151.08	98.0	2.0
UD179	207884.9971	670857.1818	166.08	28	30	138.08	136.08	96.0	4.0
UD179	207884.9971	670857.1818	166.08	43	45	123.08	121.08	95.9	4.1
UD231	196158.7390	669687.5038	167.53	13	15	154.53	152.53	94.3	5.7
UD231	196158.7390	669687.5038	167.53	30	32	137.53	135.53	93.6	6.4
UD231	196158.7390	669687.5038	167.53	43	45	124.53	122.53	92.5	7.5
UD238	192952.8585	674171.2238	168.31	13	15	155.31	153.31	94.9	5.1
UD238	192952.8585	674171.2238	168.31	28	30	140.31	138.31	96.4	3.6
UD238	192952.8585	674171.2238	168.31	43	45	125.31	123.31	97.1	2.9
UD338	191127.7310	672504.6590	173.56	13	15	160.56	158.56	94.5	5.5
UD338	191127.7310	672504.6590	173.56	28	30	145.56	143.56	94.5	5.5
UD338	191127.7310	672504.6590	173.56	43	45	130.56	128.56	96.9	3.1
UD25R	NS	NS	NS	3	5	NS	NS	91.4	8.6
UD25R	NS	NS	NS	10	12	NS	NS	96.8	3.2
UD43R	NS	NS	NS	5	7	NS	NS	96.6	3.4
UD43R	NS	NS	NS	10	12	NS	NS	99.0	1.0
UD238R	NS	NS	NS	6	8	NS	NS	98.3	1.7
UD238R	NS	NS	NS	10	12	NS	NS	98.7	1.4
UD338R	NS	NS	NS	9	11	NS	NS	96.2	3.8

Notes: ft bgs = feet below ground surface
ft amsl = feet above mean sea level

NS = Not surveyed; borings performed within 5-10 feet of original UD boring

Table 9. Results of Bench-Scale Study Vertical Hydraulic Conductivity Testing of Post-Processed Soils Compared to Undisturbed Sample PZ57D. Hydrogeology of the Twin Pines Project Area; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Sample Identifier	Bentonite Addition (%)	Hydraulic Conductivity (cm/sec)	Sample Type	ASTM Method
Post-Processed Sand Sample UD338/25				
UD338/25-A	0% bentonite	1.1×10^{-3}	Simulated In Situ	D 5084
UD338/25-B	0% bentonite	1.1×10^{-3}	Simulated In Situ	D 5084
UD338/25-C	0% bentonite	7.2×10^{-4}	Simulated In Situ	D 5084
UD338/25-A	0.35% bentonite to sand	7.0×10^{-4}	Simulated In Situ	D 5084
UD338/25-B	0.35% bentonite to sand	5.6×10^{-4}	Simulated In Situ	D 5084
UD338/25-C	0.35% bentonite to sand	1.2×10^{-3}	Simulated In Situ	D 5084
UD338/25-A	1.42% bentonite to sand	1.7×10^{-3}	Simulated In Situ	D 5084
UD338/25-B	1.42% bentonite to sand	1.6×10^{-3}	Simulated In Situ	D 5084
UD338/25-C	1.42% bentonite to sand	1.5×10^{-3}	Simulated In Situ	D 5084
UD338/25	5% bentonite to sand	5.7×10^{-6}	Remolded	D 5084
UD338/25	7.5% bentonite to sand	2.0×10^{-6}	Remolded	D 5084
UD338/25	10% bentonite to sand	3.0×10^{-7}	Remolded	D 5084
UD338/25	10% bentonite to sand	6.8×10^{-7}	Remolded	D 5084
UD338/25	12.5% bentonite to sand	1.0×10^{-8}	Remolded	D 5084
UD338/25	15% bentonite to sand	5.8×10^{-9}	Remolded	D 5084
UD338/25	15% bentonite to sand	5.0×10^{-9}	Remolded	D 5084
UD338/25	30% bentonite to sand	2.7×10^{-9}	Remolded	D 5084
UD338/25	30% bentonite to sand	2.0×10^{-9}	Remolded	D 5084
Undisturbed Soil Sample PZ57 - Consolidated Black Sand				
PZ57D (20’-22’) Black Sand	0% bentonite	2.7×10^{-8}	Undisturbed	D 5084
PZ57D (25'-27’) Black Sand	0% bentonite	3.4×10^{-7}	Undisturbed	D 5084

Notes: cm/sec = centimeters per second

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
09/21/18	---[2]	0.20	0.04
09/22/18	---	---	---
09/23/18	---	---	---
09/24/18	0.01	0.09	0.13
09/25/18	---	---	0.01
09/26/18	---	---	---
09/27/18	0.01	---	---
09/28/18	0.33	0.83	1.73
09/29/18	---	---	0.01
09/30/18	---	---	---
Total Monthly	*0.35*	*1.12*	*1.92*
10/01/18	0.42	0.01	---
10/02/18	---	---	---
10/03/18	---	---	---
10/04/18	---	---	---
10/05/18	---	---	---
10/06/18	---	---	---
10/07/18	0.02	0.02	---
10/08/18	0.31	0.08	0.06
10/09/18	0.52	0.55	0.32
10/10/18	0.21	0.24	0.35
10/11/18	---	---	---
10/12/18	---	---	---
10/13/18	---	---	---
10/14/18	---	---	---
10/15/18	---	---	---
10/16/18	---		---
10/17/18	---	0.01	---
10/18/18	---	---	---
10/19/18	---	---	---
10/20/18	0.07	0.04	0.02
10/21/18	---	---	---
10/22/18	---	---	---
10/23/18	0.02	0.01	---
10/24/18	---	---	---
10/25/18	0.01	0.01	0.03
10/26/18	0.10	0.09	0.15
10/27/18	---	---	---
10/28/18	---	---	---
10/29/18	---	---	---
10/30/18	---	---	---
10/31/18	---	---	---
Total Monthly	*1.68*	*1.06*	*0.93*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
11/01/18	0.09	0.12	0.10
11/02/18	0.45	0.30	0.37
11/03/18	---	---	---
11/04/18	0.71	0.52	0.89
11/05/18	0.09	0.07	0.13
11/06/18	---	0.01	---
11/07/18	No Precipitation Data from 11/07/18 to 02/18/19 (RG01 Destroyed)	---	---
11/08/18		---	---
11/09/18		---	---
11/10/18		---	---
11/11/18		---	---
11/12/18		---	---
11/13/18		---	---
11/14/18		---	---
11/15/18		---	---
11/16/18		---	---
11/17/18		---	---
11/18/18		---	---
11/19/18		---	---
11/20/18		---	---
11/21/18		---	---
11/22/18		---	---
11/23/18		---	---
11/24/18		---	---
11/25/18		---	---
11/26/18		---	---
11/27/18		---	---
11/28/18		---	---
11/29/18		---	---
11/30/18		---	---
Total Monthly	*1.34*	*1.02*	*1.49*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00			
Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
12/01/18	No Precipitation Data from 11/07/18 to 02/18/19 (RG01 Destroyed)	0.74	0.74
12/02/18		0.30	0.19
12/03/18		0.66	0.86
12/04/18		---	---
12/05/18		---	---
12/06/18		---	---
12/07/18		---	---
12/08/18		---	---
12/09/18		1.26	1.23
12/10/18		0.01	0.01
12/11/18		---	---
12/12/18		---	---
12/13/18		---	---
12/14/18		1.96	2.23
12/15/18		0.13	0.20
12/16/18		---	---
12/17/18		---	---
12/18/18		---	---
12/19/18		---	---
12/20/18		0.60	0.74
12/21/18		0.04	0.02
12/22/18		---	---
12/23/18		---	---
12/24/18		---	---
12/25/18		---	---
12/26/18		---	---
12/27/18		---	---
12/28/18		0.51	1.24
12/29/18		0.11	0.33
12/30/18		0.01	0.01
12/31/18		---	---
Total Monthly	*No Data*	*6.33*	*7.80*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
01/01/19	No Precipitation Data from 11/07/18 to 02/18/19 (RG01 Destroyed)	---	---
01/02/19		---	---
01/03/19		0.01	0.05
01/04/19		0.48	0.62
01/05/19		---	---
01/06/19		---	---
01/07/19		---	---
01/08/19		---	---
01/09/19		---	---
01/10/19		---	---
01/11/19		---	---
01/12/19		---	---
01/13/19		0.05	0.10
01/14/19		---	---
01/15/19		---	---
01/16/19		---	---
01/17/19		---	---
01/18/19		---	---
01/19/19		---	---
01/20/19		0.53	0.81
01/21/19		---	---
01/22/19		---	---
01/23/19		---	---
01/24/19		1.86	2.20
01/25/19		---	---
01/26/19		---	---
01/27/19		0.58	0.67
01/28/19		0.23	0.27
01/29/19		---	---
01/30/19		---	---
01/31/19		---	---
Total Monthly	*No Data*	*3.74*	*4.72*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
02/01/19	No Precipitation Data from 11/07/18 to 02/18/19 (RG01 Destroyed)	0.01	0.01
02/02/19		0.08	0.09
02/03/19		0.53	0.95
02/04/19		---	---
02/05/19		---	---
02/06/19		---	---
02/07/19		---	---
02/08/19		---	---
02/09/19		---	---
02/10/19		---	---
02/11/19		0.05	0.05
02/12/19		0.07	0.26
02/13/19		0.15	0.13
02/14/19		---	---
02/15/19		---	---
02/16/19		---	---
02/17/19		---	---
02/18/19		---	---
02/19/19	0.05	0.06	0.04
02/20/19	---	---	---
02/21/19	---	---	---
02/22/19	---	---	---
02/23/19	---	---	---
02/24/19	0.26	---	---
02/25/19	---	---	---
02/26/19	---	---	---
02/27/19	0.25	---	---
02/28/19	0.02	---	---
Total Monthly	*0.58*	*0.95*	*1.53*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
03/01/19	0.59	---	---
03/02/19	0.25	---	---
03/03/19	0.32	---	---
03/04/19	---	---	---
03/05/19	0.28	---	---
03/06/19	---	---	---
03/07/19	---	---	---
03/08/19	---	---	---
03/09/19	---	---	---
03/10/19	---	---	---
03/11/19	0.24	---	---
03/12/19	0.01	---	---
03/13/19	---	---	---
03/14/19	---	---	---
03/15/19	---	---	---
03/16/19	---	---	---
03/17/19	0.03	---	---
03/18/19	---	---	---
03/19/19	---	---	---
03/20/19	---	---	---
03/21/19	---	---	---
03/22/19	---	---	---
03/23/19	---	---	---
03/24/19	---	---	---
03/25/19	---	---	---
03/26/19	0.08	0.05	0.02
03/27/19	0.14	0.15	0.16
03/28/19	---	---	---
03/29/19	---	---	---
03/30/19	---	---	---
03/31/19	0.04	0.06	0.10
Total Monthly	*1.98*	*0.26*	*0.28*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
04/01/19	0.42	0.45	0.25
04/02/19	0.31	0.35	0.35
04/03/19	---	---	---
04/04/19	---	---	---
04/05/19	0.57	0.63	0.65
04/06/19	---	---	---
04/07/19	---	---	---
04/08/19	0.03	---	0.10
04/09/19	0.01	0.02	0.11
04/10/19	---	---	---
04/11/19	---	---	---
04/12/19	---	---	0.06
04/13/19	---	---	
04/14/19	0.16	0.10	0.10
04/15/19	---	---	---
04/16/19	---	---	---
04/17/19	---	---	---
04/18/19	---	---	---
04/19/19	0.82	0.58	0.47
04/20/19	---	---	---
04/21/19	---	---	---
04/22/19	---	---	---
04/23/19	---	---	---
04/24/19	---	---	---
04/25/19	---	---	---
04/26/19	0.29	0.31	0.22
04/27/19	---	---	---
04/28/19	---	---	---
04/29/19	---	---	---
04/30/19	---	---	---
Total Monthly	*2.61*	*2.44*	*2.31*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
05/01/19	---	---	---
05/02/19	0.09	---	---
05/03/19	0.07	0.04	0.42
05/04/19	0.29	---	0.01
05/05/19	1.23	0.95	1.07
05/06/19	0.01	0.01	---
05/07/19	---	---	---
05/08/19	---	---	---
05/09/19	---	---	---
05/10/19	---	---	---
05/11/19	---	---	---
05/12/19	0.03	0.01	0.02
05/13/19	---	---	0.39
05/14/19	0.01	---	---
05/15/19	---	---	---
05/16/19	---	---	---
05/17/19	---	---	---
05/18/19	---	---	---
05/19/19	---	---	---
05/20/19	---	---	---
05/21/19	---	---	---
05/22/19	---	---	---
05/23/19	---	---	---
05/24/19	---	---	---
05/25/19	---	---	---
05/26/19	---	---	---
05/27/19	---	---	---
05/28/19	---	---	---
05/29/19	---	---	---
05/30/19	---	---	---
05/31/19	---	---	---
Total Monthly	*1.73*	*1.01*	*1.91*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
06/01/19	---	---	---
06/02/19	---	---	---
06/03/19	---	---	---
06/04/19	---	0.09	---
06/05/19	---	---	0.34
06/06/19	---	---	---
06/07/19	0.01	---	0.01
06/08/19	0.23	0.28	0.14
06/09/19	---	---	0.01
06/10/19	0.39	0.12	---
06/11/19	0.18	0.45	0.53
06/12/19	0.36	0.38	0.30
06/13/19	0.02	0.08	0.01
06/14/19	---	---	---
06/15/19	---	---	---
06/16/19	---	0.31	---
06/17/19	---	---	---
06/18/19	0.22	0.07	0.02
06/19/19	0.45	0.38	0.34
06/20/19	0.67	0.86	0.63
06/21/19	0.01	0.01	---
06/22/19	0.02	---	---
06/23/19	0.01	---	---
06/24/19	---	---	---
06/25/19	---	---	---
06/26/19	---	---	---
06/27/19	---	---	0.01
06/28/19	---	---	---
06/29/19	1.23	1.65	1.21
06/30/19	0.01	---	---
Total Monthly	*3.81*	*4.68*	*3.55*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
07/01/19	---	---	---
07/02/19	0.06	0.03	0.07
07/03/19	---	---	---
07/04/19	0.62	0.44	0.18
07/05/19	0.26	0.54	0.20
07/06/19	1.74	2.18	1.42
07/07/19	0.19	0.37	0.29
07/08/19	0.46	1.59	1.02
07/09/19	---	---	---
07/10/19	1.00	1.01	0.91
07/11/19	0.28	0.86	0.72
07/12/19	2.52	1.82	2.11
07/13/19	0.02	---	0.01
07/14/19	---	---	---
07/15/19	---	---	---
07/16/19	---	---	---
07/17/19	1.68	1.29	0.58
07/18/19	---	---	---
07/19/19	0.18	0.23	0.50
07/20/19	1.22	0.46	0.67
07/21/19	0.27	0.17	0.52
07/22/19	---	---	---
07/23/19	0.12	0.04	0.02
07/24/19	0.78	1.05	0.52
07/25/19	---	0.01	---
07/26/19	---	---	0.01
07/27/19	---	1.44	0.53
07/28/19	---	0.82	1.38
07/29/19	---	---	---
07/30/19	---	---	---
07/31/19	---	---	---
Total Monthly	*11.40*	*14.35*	*11.66*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
08/01/19	---	---	---
08/02/19	---	---	---
08/03/19	0.35	---	0.01
08/04/19	---	---	---
08/05/19	0.15	0.48	0.12
08/06/19	---	---	---
08/07/19	---	---	---
08/08/19	---	---	---
08/09/19	---	---	---
08/10/19	0.16	0.08	0.01
08/11/19	0.04	0.04	0.72
08/12/19	---	---	0.01
08/13/19	---	---	---
08/14/19	0.29	0.52	0.64
08/15/19	0.21	0.62	1.11
08/16/19		---	---
08/17/19	0.33	0.43	0.53
08/18/19	0.03	No Precipitation Data from 08/18/19 to 10/16/19 (transducer data corrupted)	0.19
08/19/19	---		---
08/20/19	---		0.26
08/21/19	---		---
08/22/19	---		---
08/23/19	---		---
08/24/19	---		---
08/25/19	0.18		---
08/26/19	0.07		0.06
08/27/19	0.01		0.45
08/28/19	---		---
08/29/19	---		---
08/30/19	0.11		---
08/31/19	0.69		0.16
Total Monthly	*2.62*	*2.17*	*4.27*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00			
Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
09/01/19	0.01	No Precipitation Data from 08/18/19 to 10/16/19 (transducer data corrupted)	---
09/02/19	0.15		0.02
09/03/19	0.06		---
09/04/19	0.07		0.09
09/05/19	---		---
09/06/19	---		---
09/07/19	---		---
09/08/19	---		---
09/09/19	---		---
09/10/19	---		---
09/11/19	---		---
09/12/19	0.02		0.52
09/13/19	---		---
09/14/19	---		---
09/15/19	0.03		0.04
09/16/19	---		---
09/17/19	---		---
09/18/19	---		---
09/19/19	---		---
09/20/19	---		---
09/21/19	---		---
09/22/19	---		---
09/23/19	---		---
09/24/19	---		---
09/25/19	---		---
09/26/19	---		---
09/27/19	---		---
09/28/19	---		---
09/29/19	---		---
09/30/19	---		---
Total Monthly	*0.34*	*No Data*	*0.67*

Table 10. Local Precipitation Summary Table; Local Groundwater/Surface Water Hydrology At Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

Date	Daily Cumulative Precipitation (in.)[1]		
	RG01	RG02	RG03
10/01/19	0.01	No Precipitation Data from 08/18/19 to 10/16/19 (transducer data corrupted)	---
10/02/19	---		---
10/03/19	---		---
10/04/19	---		---
10/05/19	---		---
10/06/19	0.03		0.01
10/07/19	2.01		2.01
10/08/19	---		0.01
10/09/19	---		---
10/10/19	---		---
10/11/19	---		---
10/12/19	---		---
10/13/19	---		---
10/14/19	---		---
10/15/19	0.10		---
10/16/19	0.12		---
Total Monthly	*2.27*	*No Data*	*2.03*

[1] in. = inches
[2] --- = No Precipitation

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG01	190060.1533	675353.0374	1/26/2019	170.03
			2/26/2019	169.87
			3/26/2019	169.70
			4/26/2019	DRY
			5/26/2019	169.09
			6/26/2019	169.08
			7/26/2019	170.06
			8/26/2019	169.75
			9/26/2019	DRY
SG02	194170.4613	673292.0111	3/26/2019	DRY
			4/26/2019	DRY
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	169.01
			8/26/2019	DRY
			9/26/2019	DRY
SG03	195831.1963	671005.9187	2/26/2019	DRY
			3/26/2019	NO DATA
			4/26/2019	NO DATA
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	170.80
			8/26/2019	DRY
			9/26/2019	DRY
SG04	203312.6721	670258.9505	1/26/2019	163.54
			2/26/2019	163.45
			3/26/2019	163.19
			4/26/2019	163.21
			5/26/2019	163.16
			6/26/2019	163.08
			7/26/2019	163.42
			8/26/2019	162.97
			9/26/2019	DRY

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG05	207341.2463	670317.5041	1/26/2019	162.10
			2/26/2019	DRY
			3/26/2019	DRY
			4/26/2019	DRY
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	161.75
			8/26/2019	DRY
			9/26/2019	DRY
SG06	213217.3710	664858.0050	1/26/2019	122.89
			2/26/2019	122.59
			3/26/2019	122.24
			4/26/2019	121.86
			5/26/2019	120.61
			6/26/2019	119.73
			7/26/2019	122.72
			8/26/2019	121.30
			9/26/2019	119.52
SG07	208304.7741	665040.0182	1/26/2019	121.82
			2/26/2019	121.68
			3/26/2019	121.51
			4/26/2019	121.55
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	121.87
			8/26/2019	121.24
			9/26/2019	DRY
SG08	202479.9185	662783.8356	2/26/2019	Data Lost
			3/26/2019	Data Lost
			4/26/2019	Data Lost
			5/26/2019	Data Lost
			6/26/2019	Data Lost
			7/26/2019	124.75
			8/26/2019	DRY
			9/26/2019	DRY

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG09	203743.3543	665882.4745	1/26/2019	135.27
			2/26/2019	134.85
			3/26/2019	DRY
			4/26/2019	DRY
			5/26/2019	DRY
			6/26/2019	134.71
			7/26/2019	135.32
			8/26/2019	DRY
			9/26/2019	DRY
SG10	200660.2535	666577.4581	2/26/2019	139.86
			3/26/2019	DRY
			4/26/2019	DRY
			5/26/2019	139.91
			6/26/2019	139.89
			7/26/2019	140.33
			8/26/2019	DRY
			9/26/2019	DRY
SG11	198442.8366	662889.7644	2/26/2019	Data Lost
			3/26/2019	Data Lost
			4/26/2019	Data Lost
			5/26/2019	Data Lost
			6/26/2019	Data Lost
			7/26/2019	Test Reset
			8/26/2019	120.67
			9/26/2019	DRY
SG12	191752.2030	670193.4861	3/26/2019	DRY
			4/26/2019	DRY
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	170.38
			8/26/2019	DRY
			9/26/2019	DRY

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG20	200805.0365	673471.1511	1/26/2019	170.32
			2/26/2019	170.19
			3/26/2019	170.01
			4/26/2019	169.53
			5/26/2019	169.62
			6/26/2019	169.60
			7/26/2019	170.50
			8/26/2019	169.75
			9/26/2019	169.43
SG21	198431.5982	677192.9153	1/26/2019	136.01
			2/26/2019	135.96
			3/26/2019	135.97
			4/26/2019	135.95
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	136.15
			8/26/2019	135.88
			9/26/2019	DRY
SG22	189578.3083	677892.6959	1/26/2019	152.13
			2/26/2019	151.83
			3/26/2019	151.33
			4/26/2019	150.98
			5/26/2019	150.57
			6/26/2019	150.54
			7/26/2019	152.06
			8/26/2019	151.68
			9/26/2019	150.39
SG23	202266.8562	681949.5614	1/26/2019	107.34
			2/26/2019	106.87
			3/26/2019	106.77
			4/26/2019	107.01
			5/26/2019	105.47
			6/26/2019	105.76
			7/26/2019	107.36
			8/26/2019	106.77
			9/26/2019	106.08

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG24	197574.4045	681962.1716	5/26/2019	93.71
			6/26/2019	93.69
			7/26/2019	94.58
			8/26/2019	93.72
			9/26/2019	DRY
SG25	196293.4142	681520.1068	5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	97.71
			8/26/2019	DRY
			9/26/2019	DRY
SG26	194274.1234	680987.7320	1/26/2019	99.95
			2/26/2019	99.67
			3/26/2019	99.53
			4/26/2019	99.33
			5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	99.53
			8/26/2019	DRY
			9/26/2019	DRY
SG27	190408.5483	680028.7130	5/26/2019	132.57
			6/26/2019	132.50
			7/26/2019	133.39
			8/26/2019	132.69
			9/26/2019	132.53
SG28	200427.6280	687397.7131	5/26/2019	66.62
			6/26/2019	66.82
			7/26/2019	68.03
			8/26/2019	67.72
			9/26/2019	67.15
SG29	200571.7839	687446.5409	5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	67.77
			8/26/2019	67.41
			9/26/2019	DRY

Table 11. Staff Gauge Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Date of Measurement	Water Level Elevation (ft. AMSL)
SG30	200814.9364	687457.3495	5/26/2019	DRY
			6/26/2019	DRY
			7/26/2019	69.92
			8/26/2019	69.48
			9/26/2019	DRY

ft. AMSL = feet above mean sea level

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ01D	213150.6852	664800.7444	123.10	1/26/2019	-0.50	123.60
				2/26/2019	-0.68	123.78
				3/26/2019	-0.56	123.66
				4/26/2019	-0.48	123.58
				5/26/2019	0.91	122.19
				6/26/2019	1.39	121.71
				7/26/2019	-0.60	123.70
				8/26/2019	0.34	122.76
				9/26/2019	1.90	121.21
PZ01S	213145.7250	664792.9515	123.04	1/26/2019	0.20	122.84
				2/26/2019	0.61	122.43
				3/26/2019	1.38	121.66
				4/26/2019	1.64	121.40
				5/26/2019	3.25	119.79
				6/26/2019	4.00	119.04
				7/26/2019	0.19	122.85
				8/26/2019	2.63	120.41
				9/26/2019	4.36	118.68
PZ02	209988.5659	664881.4667	126.03	1/26/2019	-0.06	126.09
				2/26/2019	0.76	125.27
				3/26/2019	1.42	124.61
				4/26/2019	1.39	124.64
				5/26/2019	2.85	123.18
				6/26/2019	3.21	122.82
				7/26/2019	-0.08	126.11
				8/26/2019	2.37	123.66
				9/26/2019	3.83	122.20
PZ03D	208027.2407	665032.2313	123.56	1/26/2019	-1.32	124.88
				2/26/2019	-0.54	124.10
				3/26/2019	-0.38	123.94
				4/26/2019	-0.17	123.73
				5/26/2019	1.22	122.34
				6/26/2019	1.52	122.04
				7/26/2019	-0.55	124.11
				8/26/2019	0.48	123.08
				9/26/2019	2.04	121.52
PZ03S	208020.1141	665029.0251	123.80	1/26/2019	0.61	123.19
				2/26/2019	1.04	122.76
				3/26/2019	1.77	122.03
				4/26/2019	1.68	122.12
				5/26/2019	3.35	120.45
				6/26/2019	3.33	120.47
				7/26/2019	0.55	123.25
				8/26/2019	2.48	121.32
				9/26/2019	3.94	119.86

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ04	205447.0841	663720.3298	123.89	1/26/2019	1.16	122.73
				2/26/2019	1.84	122.05
				3/26/2019	2.74	121.15
				4/26/2019	3.01	120.88
				5/26/2019	4.57	119.33
				6/26/2019	5.19	118.70
				7/26/2019	1.41	122.48
				8/26/2019	3.51	120.38
				9/26/2019	5.30	118.59
PZ05	202705.7568	662571.7449	124.37	1/26/2019	0.95	123.42
				2/26/2019	1.38	122.99
				3/26/2019	2.44	121.93
				4/26/2019	2.89	121.48
				5/26/2019	4.56	119.82
				6/26/2019	5.45	118.92
				7/26/2019	1.07	123.30
				8/26/2019	3.01	121.36
				9/26/2019	4.95	119.42
PZ06	201256.8347	662436.2138	124.26	1/26/2019	0.20	124.06
				2/26/2019	1.11	123.16
				3/26/2019	1.88	122.38
				4/26/2019	2.14	122.12
				5/26/2019	3.73	120.53
				6/26/2019	4.53	119.74
				7/26/2019	0.53	123.74
				8/26/2019	2.30	121.96
				9/26/2019	4.03	120.23
PZ07	199410.2734	662371.7196	123.41	1/26/2019	-0.20	123.61
				2/26/2019	0.70	122.71
				3/26/2019	1.34	122.07
				4/26/2019	1.97	121.44
				5/26/2019	3.65	119.76
				6/26/2019	4.61	118.80
				7/26/2019	-0.24	123.65
				8/26/2019	1.45	121.96
				9/26/2019	3.45	119.96
PZ08	197508.9048	664403.2655	130.08	1/26/2019	0.59	129.49
				2/26/2019	1.42	128.67
				3/26/2019	2.04	128.04
				4/26/2019	2.70	127.39
				5/26/2019	4.22	125.86
				6/26/2019	4.79	125.29
				7/26/2019	0.56	129.52
				8/26/2019	2.15	127.93
				9/26/2019	4.06	126.02

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ09	210549.7044	666674.5353	135.06	1/26/2019	0.36	134.70
				2/26/2019	0.93	134.13
				3/26/2019	1.43	133.63
				4/26/2019	1.28	133.78
				5/26/2019	2.69	132.37
				6/26/2019	2.87	132.19
				7/26/2019	0.39	134.67
				8/26/2019	2.41	132.65
				9/26/2019	3.53	131.53
PZ10	206292.4778	667689.3258	145.97	1/26/2019	0.77	145.20
				2/26/2019	1.32	144.65
				3/26/2019	2.09	143.88
				4/26/2019	2.11	143.86
				5/26/2019	3.49	142.48
				6/26/2019	3.92	142.05
				7/26/2019	0.74	145.23
				8/26/2019	2.65	143.32
				9/26/2019	3.88	142.09
PZ11	201281.0529	667407.6724	148.10	1/26/2019	1.21	146.89
				2/26/2019	2.07	146.04
				3/26/2019	2.46	145.64
				4/26/2019	2.51	145.59
				5/26/2019	3.73	144.37
				6/26/2019	4.21	143.89
				7/26/2019	1.16	146.94
				8/26/2019	2.53	145.57
				9/26/2019	3.94	144.16
PZ12D	199125.8047	666484.2013	138.18	1/26/2019	-0.09	138.27
				2/26/2019	0.30	137.89
				3/26/2019	1.13	137.05
				4/26/2019	1.22	136.96
				5/26/2019	3.11	135.07
				6/26/2019	2.93	135.25
				7/26/2019	-0.09	138.27
				8/26/2019	1.69	136.50
				9/26/2019	3.22	134.96
PZ12S	199119.7966	666484.6179	138.00	1/26/2019	-0.27	138.27
				2/26/2019	0.18	137.82
				3/26/2019	1.00	137.00
				4/26/2019	1.10	136.90
				5/26/2019	2.93	135.07
				6/26/2019	2.77	135.23
				7/26/2019	-0.29	138.29
				8/26/2019	1.55	136.45
				9/26/2019	3.04	134.96

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ13	196413.6877	668652.4560	157.63	1/26/2019	0.82	156.81
				2/26/2019	1.77	155.86
				3/26/2019	2.13	155.51
				4/26/2019	2.54	155.09
				5/26/2019	3.71	153.92
				6/26/2019	3.96	153.67
				7/26/2019	0.76	156.87
				8/26/2019	2.21	155.42
				9/26/2019	3.68	153.95
PZ14	193936.6051	669743.4272	167.66	1/26/2019	0.17	167.49
				2/26/2019	0.86	166.80
				3/26/2019	1.32	166.35
				4/26/2019	1.97	165.69
				5/26/2019	3.13	164.53
				6/26/2019	3.62	164.04
				7/26/2019	0.68	166.98
				8/26/2019	1.89	165.77
				9/26/2019	3.06	164.60
PZ15	192000.6802	669433.9007	166.84	1/26/2019	1.24	165.60
				2/26/2019	1.83	165.01
				3/26/2019	1.96	164.88
				4/26/2019	2.26	164.58
				5/26/2019	3.37	163.47
				6/26/2019	3.56	163.28
				7/26/2019	1.37	165.47
				8/26/2019	2.16	164.68
				9/26/2019	3.20	163.64
PZ16D	189193.4656	668689.3844	160.41	1/26/2019	3.11	157.30
				2/26/2019	3.71	156.70
				3/26/2019	4.19	156.22
				4/26/2019	4.97	155.44
				5/26/2019	6.04	154.37
				6/26/2019	6.82	153.59
				7/26/2019	4.01	156.40
				8/26/2019	5.01	155.40
				9/26/2019	6.02	154.39
PZ16S	189192.1062	668683.7808	160.42	1/26/2019	0.80	159.62
				2/26/2019	1.63	158.79
				3/26/2019	2.02	158.40
				4/26/2019	2.99	157.43
				5/26/2019	4.02	156.40
				6/26/2019	5.01	155.41
				7/26/2019	2.18	158.24
				8/26/2019	3.09	157.33
				9/26/2019	4.02	156.40

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ17D	212015.6518	670005.1448	161.01	1/26/2019	3.13	157.89
				2/26/2019	3.79	157.22
				3/26/2019	4.19	156.82
				4/26/2019	4.53	156.48
				5/26/2019	5.46	155.55
				6/26/2019	6.13	154.88
				7/26/2019	3.54	157.47
				8/26/2019	5.14	155.87
				9/26/2019	6.23	154.78
PZ17S	212018.9084	669994.2076	161.75	1/26/2019	1.13	160.62
				2/26/2019	2.00	159.75
				3/26/2019	2.34	159.41
				4/26/2019	2.60	159.15
				5/26/2019	3.03	158.72
				6/26/2019	3.74	158.01
				7/26/2019	1.19	160.56
				8/26/2019	3.10	158.65
				9/26/2019	4.06	157.70
PZ18	210112.6384	670419.4050	164.26	1/26/2019	0.66	163.60
				2/26/2019	1.72	162.54
				3/26/2019	2.30	161.96
				4/26/2019	2.80	161.46
				5/26/2019	3.50	160.76
				6/26/2019	4.21	160.05
				7/26/2019	1.30	162.96
				8/26/2019	3.08	161.18
				9/26/2019	4.08	160.18
PZ19	207234.6924	670845.9142	169.87	1/26/2019	1.54	168.33
				2/26/2019	2.39	167.48
				3/26/2019	2.82	167.05
				4/26/2019	3.33	166.54
				5/26/2019	3.96	165.91
				6/26/2019	4.66	165.21
				7/26/2019	1.56	168.31
				8/26/2019	3.13	166.74
				9/26/2019	4.21	165.66
PZ20D	205134.8784	670360.6665	168.46	1/26/2019	2.04	166.42
				2/26/2019	2.84	165.62
				3/26/2019	3.29	165.17
				4/26/2019	3.86	164.60
				5/26/2019	4.77	163.69
				6/26/2019	5.65	162.81
				7/26/2019	2.18	166.28
				8/26/2019	3.52	164.94
				9/26/2019	4.82	163.64

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ20S	205140.4640	670362.1990	168.33	1/26/2019	1.68	166.66
				2/26/2019	2.45	165.88
				3/26/2019	2.90	165.43
				4/26/2019	3.45	164.88
				5/26/2019	4.25	164.08
				6/26/2019	5.20	163.13
				7/26/2019	1.71	166.62
				8/26/2019	3.10	165.23
				9/26/2019	4.35	163.98
PZ21	203215.0202	670383.6651	164.90	1/26/2019	0.07	164.83
				2/26/2019	0.52	164.38
				3/26/2019	1.03	163.87
				4/26/2019	0.92	163.98
				5/26/2019	2.37	162.53
				6/26/2019	2.78	162.12
				7/26/2019	0.12	164.78
				8/26/2019	1.19	163.71
				9/26/2019	2.46	162.44
PZ22D	200357.7075	671700.7149	170.48	1/26/2019	1.18	169.30
				2/26/2019	1.75	168.73
				3/26/2019	2.25	168.23
				4/26/2019	2.49	167.99
				5/26/2019	4.18	166.30
				6/26/2019	4.48	166.00
				7/26/2019	1.24	169.24
				8/26/2019	2.21	168.27
				9/26/2019	3.90	166.58
PZ22S	200359.9896	671694.6840	170.18	1/26/2019	0.50	169.68
				2/26/2019	1.31	168.87
				3/26/2019	1.79	168.39
				4/26/2019	1.91	168.27
				5/26/2019	3.31	166.87
				6/26/2019	3.70	166.48
				7/26/2019	0.39	169.79
				8/26/2019	1.81	168.37
				9/26/2019	3.27	166.91
PZ23	198353.0813	672071.4617	169.44	1/26/2019	0.02	169.42
				2/26/2019	0.87	168.57
				3/26/2019	1.34	168.10
				4/26/2019	1.45	167.99
				5/26/2019	2.86	166.58
				6/26/2019	2.96	166.48
				7/26/2019	-0.10	169.54
				8/26/2019	1.24	168.20
				9/26/2019	2.71	166.73

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ24	196807.9532	672562.2118	169.54	1/26/2019	0.44	169.10
				2/26/2019	0.74	168.80
				3/26/2019	1.27	168.27
				4/26/2019	1.54	168.00
				5/26/2019	3.00	166.54
				6/26/2019	3.26	166.28
				7/26/2019	0.38	169.16
				8/26/2019	1.37	168.17
				9/26/2019	2.59	166.95
PZ25D	194070.0069	673381.4148	169.65	1/26/2019	0.45	169.20
				2/26/2019	0.94	168.71
				3/26/2019	1.42	168.23
				4/26/2019	2.01	167.64
				5/26/2019	3.14	166.51
				6/26/2019	3.65	166.01
				7/26/2019	0.57	169.08
				8/26/2019	1.48	168.17
				9/26/2019	2.79	166.86
PZ25S	194061.9564	673383.9824	169.61	1/26/2019	0.40	169.21
				2/26/2019	1.03	168.58
				3/26/2019	1.45	168.16
				4/26/2019	1.95	167.66
				5/26/2019	3.14	166.47
				6/26/2019	3.64	165.97
				7/26/2019	0.75	168.86
				8/26/2019	1.70	167.91
				9/26/2019	2.92	166.70
PZ26	190199.0854	675725.3696	169.22	1/26/2019	0.24	168.98
				2/26/2019	1.32	167.90
				3/26/2019	1.68	167.54
				4/26/2019	2.25	166.97
				5/26/2019	3.28	165.95
				6/26/2019	3.80	165.42
				7/26/2019	0.80	168.42
				8/26/2019	1.60	167.62
				9/26/2019	3.04	166.18
PZ27D	188607.9571	676394.0349	168.06	1/26/2019	1.03	167.03
				2/26/2019	1.40	166.66
				3/26/2019	1.76	166.30
				4/26/2019	2.18	165.89
				5/26/2019	3.27	164.79
				6/26/2019	3.52	164.54
				7/26/2019	0.97	167.09
				8/26/2019	1.69	166.37
				9/26/2019	3.06	165.00

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ27S	188607.1176	676385.2376	168.17	3/26/2019	2.04	166.13
				4/26/2019	2.34	165.83
				5/26/2019	3.01	165.16
				6/26/2019	3.35	164.82
				7/26/2019	0.71	167.46
				8/26/2019	1.78	166.39
				9/26/2019	2.88	165.29
PZ28D	191101.7018	672470.6111	173.99	1/26/2019	0.69	173.30
				2/26/2019	1.25	172.74
				3/26/2019	1.66	172.33
				4/26/2019	2.21	171.78
				5/26/2019	3.50	170.49
				6/26/2019	3.93	170.06
				7/26/2019	0.87	173.12
				8/26/2019	1.62	172.37
				9/26/2019	2.99	171.00
PZ28S	191103.4804	672457.8838	173.92	1/26/2019	0.46	173.46
				2/26/2019	0.99	172.93
				3/26/2019	1.46	172.46
				4/26/2019	1.84	172.08
				5/26/2019	3.21	170.71
				6/26/2019	3.63	170.29
				7/26/2019	0.62	173.30
				8/26/2019	1.43	172.49
				9/26/2019	2.75	171.17
PZ29D	193584.1783	667976.3949	153.88	7/26/2019	0.97	152.91
				8/26/2019	2.40	151.48
				9/26/2019	3.41	150.47
PZ29S	193588.7986	667981.8218	154.04	7/26/2019	0.75	153.30
				8/26/2019	2.05	151.99
				9/26/2019	2.97	151.07
PZ30D	189999.1411	666485.7096	138.02	7/26/2019	1.19	136.83
				8/26/2019	2.43	135.59
				9/26/2019	3.81	134.21
PZ30S	190003.9590	666490.5901	137.65	7/26/2019	0.53	137.12
				8/26/2019	1.86	135.79
				9/26/2019	3.35	134.30
PZ31D	192380.6325	665328.1184	135.90	7/26/2019	1.57	134.33
				8/26/2019	3.10	132.80
				9/26/2019	4.37	131.53

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ31S	192375.7463	665331.2438	135.92	7/26/2019	1.68	134.24
				8/26/2019	3.20	132.72
				9/26/2019	4.48	131.44
PZ32D	195456.4215	666039.5426	139.68	7/26/2019	0.49	139.19
				8/26/2019	1.87	137.81
				9/26/2019	3.27	136.41
PZ32S	195456.5519	666034.4581	139.94	7/26/2019	0.58	139.36
				8/26/2019	2.04	137.90
				9/26/2019	3.42	136.52
PZ33D	192704.3676	661250.7016	123.91	7/26/2019	1.65	122.26
				8/26/2019	2.91	121.00
				9/26/2019	4.54	119.37
PZ33S	192703.1100	661257.2218	123.73	7/26/2019	1.48	122.25
				8/26/2019	2.41	121.32
				9/26/2019	3.72	120.01
PZ34D	196728.9345	662454.0647	124.48	7/26/2019	1.54	122.94
				8/26/2019	3.08	121.40
				9/26/2019	4.78	119.70
PZ34S	196727.7956	662451.0040	124.39	7/26/2019	1.26	123.13
				8/26/2019	2.54	121.85
				9/26/2019	4.36	120.03
PZ35D	197877.5722	658754.8806	119.17	7/26/2019	1.24	117.93
				8/26/2019	2.52	116.66
				9/26/2019	4.52	114.65
PZ35S	197876.8198	658750.6567	119.17	7/26/2019	1.34	117.83
				8/26/2019	2.38	116.79
				9/26/2019	3.90	115.27
PZ36D	200011.2104	658943.3970	119.18	7/26/2019	0.40	118.78
				8/26/2019	1.50	117.68
				9/26/2019	3.73	115.45
PZ36S	200011.8629	658939.5260	118.83	7/26/2019	0.77	118.06
				8/26/2019	1.82	117.02
				9/26/2019	3.74	115.10

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ38	205467.2108	672734.7122	171.93	3/26/2019	2.48	169.45
				4/26/2019	2.90	169.03
				5/26/2019	3.69	168.24
				6/26/2019	4.50	167.43
				7/26/2019	0.88	171.05
				8/26/2019	2.22	169.71
				9/26/2019	3.60	168.33
PZ39D	203579.2608	672985.6825	171.81	7/26/2019	14.45	157.36
				8/26/2019	14.54	157.27
				9/26/2019	15.69	156.13
PZ39S	203576.2324	672993.8948	171.94	5/26/2019	3.14	168.80
				6/26/2019	3.73	168.21
				7/26/2019	0.08	171.86
				8/26/2019	1.20	170.74
				9/26/2019	2.87	169.07
PZ40	200660.5583	673966.9078	169.70	1/26/2019	0.32	169.38
				2/26/2019	0.94	168.76
				3/26/2019	1.47	168.23
				4/26/2019	1.74	167.96
				5/26/2019	2.97	166.73
				6/26/2019	3.35	166.36
				7/26/2019	-0.01	169.71
				8/26/2019	1.02	168.68
				9/26/2019	2.48	167.22
PZ41	197293.3643	674605.3516	161.19	8/26/2019	0.76	160.43
				9/26/2019	1.92	159.27
PZ42	194351.8655	675527.4483	147.46	1/26/2019	0.33	147.14
				2/26/2019	1.13	146.34
				3/26/2019	1.60	145.86
				4/26/2019	2.44	145.02
				5/26/2019	3.70	143.77
				6/26/2019	3.99	143.48
				7/26/2019	0.34	147.12
				8/26/2019	1.62	145.84
				9/26/2019	3.17	144.29

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ43	191206.1308	676493.9937	161.88	1/26/2019	0.28	161.60
				2/26/2019	0.94	160.94
				3/26/2019	1.34	160.54
				4/26/2019	1.98	159.90
				5/26/2019	2.99	158.89
				6/26/2019	3.55	158.33
				7/26/2019	0.19	161.69
				8/26/2019	0.84	161.04
				9/26/2019	2.35	159.53
PZ44	189175.0361	678021.3317	154.07	1/26/2019	0.56	153.51
				2/26/2019	1.39	152.68
				3/26/2019	1.85	152.22
				4/26/2019	2.26	151.81
				5/26/2019	3.09	150.98
				6/26/2019	3.29	150.78
				7/26/2019	0.60	153.47
				8/26/2019	1.58	152.49
				9/26/2019	3.03	151.04
PZ45D	202715.5700	675525.2030	166.67	2/26/2019	7.03	159.64
				3/26/2019	7.64	159.03
				4/26/2019	8.11	158.56
				5/26/2019	9.02	157.65
				6/26/2019	9.30	157.37
				7/26/2019	6.48	160.19
				8/26/2019	6.99	159.68
				9/26/2019	8.43	158.24
PZ45S	202723.2096	675524.3128	166.72	1/26/2019	0.77	165.95
				2/26/2019	1.52	165.20
				3/26/2019	1.94	164.78
				4/26/2019	2.22	164.50
				5/26/2019	3.03	163.69
				6/26/2019	3.57	163.15
				7/26/2019	0.55	166.17
				8/26/2019	1.61	165.11
				9/26/2019	3.03	163.69
PZ46	198343.7772	677166.5936	139.99	1/26/2019	1.82	138.17
				2/26/2019	2.13	137.86
				3/26/2019	2.56	137.43
				4/26/2019	2.89	137.10
				5/26/2019	3.64	136.35
				6/26/2019	3.44	136.56
				7/26/2019	1.71	138.28
				8/26/2019	2.44	137.55
				9/26/2019	3.39	136.60

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ47	193012.6975	678365.3361	138.47	1/26/2019	0.59	137.88
				2/26/2019	1.63	136.84
				3/26/2019	1.93	136.54
				4/26/2019	2.72	135.75
				5/26/2019	3.54	134.93
				6/26/2019	4.18	134.29
				7/26/2019	2.26	136.21
				8/26/2019	2.26	136.21
				9/26/2019	3.71	134.76
PZ48D	191310.9390	680202.8388	132.78	5/26/2019	4.82	127.96
				6/26/2019	5.04	127.74
				7/26/2019	3.10	129.68
				8/26/2019	3.64	129.14
				9/26/2019	4.84	127.94
PZ48S	191305.7477	680199.1634	133.20	1/26/2019	0.91	132.29
				2/26/2019	1.98	131.22
				3/26/2019	2.32	130.88
				4/26/2019	3.17	130.03
				5/26/2019	4.37	128.83
				6/26/2019	4.88	128.32
				7/26/2019	2.07	131.13
				8/26/2019	2.64	130.56
				9/26/2019	4.39	128.81
PZ49	205324.4574	677820.5368	143.01	3/26/2019	1.32	141.69
				4/26/2019	1.37	141.64
				5/26/2019	2.30	140.71
				6/26/2019	2.40	140.61
				7/26/2019	0.28	142.73
				8/26/2019	1.04	141.97
				9/26/2019	2.44	140.57
PZ50	202797.9514	678800.9975	127.87	1/26/2019	0.75	127.12
				2/26/2019	1.39	126.48
				3/26/2019	2.36	125.51
				4/26/2019	2.66	125.21
				5/26/2019	3.90	123.97
				6/26/2019	3.96	123.91
				7/26/2019	0.45	127.42
				8/26/2019	1.90	125.97
				9/26/2019	3.47	124.40
PZ51D	195571.6636	680184.1086	115.73	1/26/2019	2.00	113.73
				2/26/2019	2.78	112.95
				3/26/2019	3.14	112.59
				4/26/2019	3.62	112.11
				5/26/2019	4.44	111.29
				6/26/2019	4.23	111.50
				7/26/2019	2.05	113.69
				8/26/2019	2.85	112.88
				9/26/2019	4.12	111.61

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ51S	195570.9997	680176.5664	115.84	1/26/2019	0.86	114.98
				2/26/2019	1.65	114.19
				3/26/2019	1.98	113.86
				4/26/2019	2.53	113.31
				5/26/2019	3.22	112.62
				6/26/2019	3.11	112.73
				7/26/2019	0.92	114.92
				8/26/2019	1.69	114.16
				9/26/2019	2.96	112.88
PZ52	201953.0060	681598.5839	111.44	1/26/2019	0.84	110.60
				2/26/2019	1.17	110.27
				3/26/2019	1.92	109.52
				4/26/2019	2.16	109.28
				5/26/2019	3.10	108.34
				6/26/2019	2.92	108.52
				7/26/2019	1.10	110.34
				8/26/2019	1.81	109.63
				9/26/2019	3.20	108.24
PZ53	199168.3109	681563.2307	111.51	1/26/2019	0.91	110.60
				2/26/2019	1.37	110.14
				3/26/2019	1.71	109.80
				4/26/2019	1.92	109.59
				5/26/2019	2.65	108.86
				6/26/2019	2.45	109.06
				7/26/2019	0.73	110.78
				8/26/2019	1.52	109.99
				9/26/2019	2.68	108.83
PZ55D	188479.2448	671856.4725	174.92	7/26/2019	0.81	174.11
				8/26/2019	1.28	173.64
				9/26/2019	3.07	171.86
PZ55S	188475.6036	671858.3517	174.83	7/26/2019	0.82	174.02
				8/26/2019	1.56	173.27
				9/26/2019	2.83	172.00
PZ56D	195754.4210	670661.0392	171.58	7/26/2019	1.18	170.40
				8/26/2019	2.33	169.25
				9/26/2019	3.69	167.89
PZ56S	195749.4737	670660.2256	171.50	7/26/2019	0.78	170.72
				8/26/2019	2.15	169.36
				9/26/2019	3.43	168.07
PZ57D	192314.5030	675315.4839	165.89	7/26/2019	3.64	162.25
				8/26/2019	4.25	161.64
				9/26/2019	5.52	160.37

Table 12. Groundwater Elevation Summary Table; Local Groundwater/Surface Water Hydrology at Twin Pines Mine; Twin Pines Minerals, LLC; St. George, Charlton County, Georgia. TTL Project No. 000180200804.00

WELL ID	Northing	Easting	Top of Casing Elevation (ft. AMSL)	Date of Measurement	Depth to Water (ft bgs)	Water Level Elevation (ft. AMSL)
PZ57S	192311.1446	675312.2756	165.68	7/26/2019	0.43	165.25
				8/26/2019	1.18	164.50
				9/26/2019	2.38	163.31
PZ58D	196490.4671	676850.3236	139.98	7/26/2019	5.14	134.84
				8/26/2019	5.50	134.48
				9/26/2019	6.73	133.25
PZ58S	196494.4807	676849.6803	140.02	7/26/2019	0.59	139.43
				8/26/2019	1.56	138.46
				9/26/2019	2.90	137.12
OWA1BS	203877.7018	673147.0579	172.16	7/26/2019	-0.21	172.37
				8/26/2019	1.18	170.98
				9/26/2019	2.59	169.57
OWA1S	203876.5647	673154.3973	172.12	7/26/2019	0.02	172.10
				8/26/2019	1.38	170.74
				9/26/2019	2.84	169.28
OWA1D	203876.5738	673162.9290	172.23	7/26/2019	8.64	163.59
				8/26/2019	9.11	163.12
				9/26/2019	10.46	161.77
OWB1BS	191480.2903	670459.5027	172.38	7/26/2019	0.87	171.51
				8/26/2019	1.63	170.75
				9/26/2019	2.86	169.52
OWB1S	191476.4642	670468.6448	172.43	7/26/2019	1.95	170.48
				8/26/2019	2.58	169.85
				9/26/2019	3.77	168.66
OWB1D	191475.4850	670475.2055	172.49	7/26/2019	3.87	168.62
				8/26/2019	4.29	168.20
				9/26/2019	5.52	166.97

ft. bgs = feet below ground surface

ft. AMSL = feet above mean sea level

Negative depth to water values indicate artesian conditions

Table 13. Water Budget Comparisons of the Pre-Mining and Post-Mining Models						
Source	Pre-Mining		Post-Mining		Difference	
	In	Out	In	Out	In	Out
Storage*	0.00	0.00	0.00	0.00	0.00	0.00
Constant Head*	0.00	572,079.38	0.00	572,114.56	0.00	-35.19
Drains*	0.00	40,802.34	0.00	40,767.18	0.00	35.17
Recharge**	612,881.69	0.00	612,881.69	0.00	0.00	0.00
Total	**612,881.69**	**612,881.72**	**612,881.69**	**612,881.75**	**0.00**	**-0.02**

* Cumulative Volume (ft^3)

** Rates for time step (ft^3/day)

Table 14. Water Budget Comparison of the Pre-Mining and Post-Mining Models - Zone 1						
Source	Pre-Mining		Post-Mining		Differences	
	In	Out	In	Out	In	Out
Constant Head*	0.00	249,000.00	0.00	248,700.00	0.00	300.00
Drains*	0.00	29,670.00	0.00	29,630.00	0.00	40.00
Recharge**	276,900.00	0.00	276,900.00	0.00	0.00	0.00
Zone 2 to 1	74,254.00	0.00	72,518.00	0.00	1,736.00	0.00
Zone 1 to 2	0.00	72,489.00	0.00	71,092.00	0.00	1,397.00

* Cumulative Volume (ft^3)

** Rates for time step (ft^3/day)

Table 15. Water Budget Comparison of the Pre-Mining and Post-Mining Models - Zone 2						
Source	Pre-Mining		Post-Mining		Differences	
	In	Out	In	Out	In	Out
Constant Head*	0.00	323,080.00	0.00	323,420.00	0.00	-340.00
Drains*	0.00	11,133.00	0.00	11,137.00	0.00	-4.00
Recharge**	335,980.00	0.00	335,980.00	0.00	0.00	0.00
Zone 2 to 1	0.00	74,254.00	0.00	72,518.00	0.00	1,736.00
Zone 1 to 2	72,489.00	0.00	71,092.00	0.00	1,397.00	0.00

* Cumulative Volume (ft^3)

** Rates for time step (ft^3/day)

Table 16. Water-Quality Analytical List; Proposed Twin Pines Mine.	
Analyte	Method
BOD5	5210 B-2011
COD	H8000
Total Organic Carbon	5310C-2011
Total Suspended Solids	SM2540D
Color	2120 F-2011
Bromide	300.0
Fluoride	300.0
Nitrate-Nitrite	300.0
Nitrate	300.0
Nitrite	300.0
Total Kjeldahl Nitrogen	351.2
Ammonia, Nitrogen	350.1
Oil & Grease	1664
Phosphorus (as P), total	200.7
Sulfate (as SO4)	300.0
Sulfide	4500S
Sulfite (as SO3)	4500-SO3
Aluminum, total	200.8
Antimony, total	200.8
Arsenic, total	200.8
Barium, total	200.8
Beryllium, total	200.8
Boron, total	200.8
Cadmium, total	200.8
Chromium, total	200.8
Cobalt, total	200.8
Copper, total	200.8
Iron, total	200.8
Lead, total	200.8
Magnesium, total	200.8
Manganese, total	200.8
Mercury, total	245.1 or 1631E
Molybdenum, total	200.8
Nickel, total	200.8
Selenium, total	200.8
Silver, total	200.8
Thallium, total	200.8
Thorium, total	200.8
Tin, total	200.8
Titanium, total	200.8
Uranium total	200.8
Zinc, total	200.8
Zirconium, total	200.8
Alkalinity, Total	SM2320B
Alkalinity, Bicarbonate	SM2320B
Alkalinity, Carbonate	SM2320B
Total Hardness	SM2340B
Total cyanide	335.4
Alpha, Total	900.0
Beta, Total	900.0
Radium, Total	903.1
Radium 226, Total	904.0
pH	Field Measured
Temperature	Field Measured
Specific Conductance	Field Measured
Oxidation-Reduction Potential	Field Measured
Dissolved Oxygen	Field Measured

Table 17: Summary of Alternatives Analysis

		Off-Site Alternative		On-Site Alternatives: Saunders Tract			
Factor		Alternative 1 (CS 1)	Alternative 2 (CS 2)	Alternative 3 (Loncala Tract)	Alternative 4 (Keystone Tract: Layout 1)	Alternative 5 (Keystone Tract: Layout 2)	Alternative 6 (No Action Alternative)
Distance from Okefenokee Swamp		>3.0 miles	>3.0 miles	0.5 miles	2.7 miles	2.7 miles	NA
Aquatic Resources	Wetland	Not evaluated	Not evaluated	405.11 ac	1,194.437 ac	1,202.399 ac	NA
On-Site	Stream	Not evaluated	Not evaluated	3,020 lf	11,587 lf	11,587 lf	NA
	Open Water	Not evaluated	Not evaluated	0.34 ac	0 ac	0 ac	NA
Cultural Resources		Not evaluated	Not evaluated	Yes – one potentially eligible site; one unknown effect	Yes – one potentially eligible site off-site property	Yes – one potentially eligible site off-site property	No effect
Effect on T&E Species		Not evaluated	Not evaluated	No effect with mitigation measures	No effect with mitigation measures	No effect with mitigation measures	No effect
Economic Feasibility (Mining cuts avg 1.5% HMS)		No	No	Yes	Yes	Yes	No
Available for Lease/Purchase		Yes	Yes	Yes	Yes	Yes	NA
Practicable		No	No	Yes	Yes	Yes	No

<table>
<tr><th colspan="11">Table 18: Avoidance and Minimization Summary Table</th></tr>
<tr><th colspan="2">Factor</th><th colspan="3">Alternative 3 (Loncala Tract)</th><th colspan="3">Alternative 4 (Keystone Tract: Layout 1)</th><th colspan="3">Alternative 5 (Keystone Tract: Layout 2)</th></tr>
<tr><td colspan="2">Distance from Okefenokee Swamp</td><td colspan="3">0.5 miles</td><td colspan="3">2.7 miles</td><td colspan="3">2.7 miles</td></tr>
<tr><td colspan="2">Distance from Rail</td><td colspan="3">3.5 miles</td><td colspan="3">On-site but would need to be constructed</td><td colspan="3">On-site, currently in place</td></tr>
<tr><td rowspan="5">Aquatic Resources</td><td rowspan="2"></td><td rowspan="2">On-site</td><td colspan="2">Impacted</td><td rowspan="2">On-site</td><td colspan="2">Impacted</td><td rowspan="2">On-site</td><td colspan="2">Impacted</td></tr>
<tr><td>Mining</td><td>Infrastructure</td><td>Mining</td><td>Infrastructure</td><td>Mining</td><td>Infrastructure</td></tr>
<tr><td>Wetland (ac)</td><td>405.387</td><td>287.537</td><td>4.672</td><td>1,194.44</td><td>522.134</td><td>65.131</td><td>1,202.40</td><td>453.111</td><td>25.124</td></tr>
<tr><td>Stream (lf/ac)</td><td>3,020 / 0.337</td><td>0</td><td>1,160 / 0.106</td><td>11,587 / 1.010</td><td>0</td><td>8,781 / 0.692</td><td>11,587 / 1.010</td><td>0</td><td>412 / 0.020</td></tr>
<tr><td>Open Water (ac)</td><td>0.34 ac</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">Cultural Resources</td><td colspan="3">One potentially NRHP eligible site within proposed mining area; one undetermined eligible site adjacent to mining area</td><td colspan="3">One potentially NRHP eligible off-site property. Property will be avoided</td><td colspan="3">One potentially NRHP eligible off-site property</td></tr>
<tr><td colspan="2">Threatened & Endangered Species Summary (within proposed impact footprint)</td><td colspan="3">29 gopher tortoise, 3 gopher frogs, not surveyed for listed plants</td><td colspan="3">6 gopher tortoise, 2 gopher frogs, 0 federally listed plants, 3 state listed threatened parrot pitcher plants</td><td colspan="3">1 gopher tortoise, 0 gopher frogs, 0 federally listed plants, 1 state listed threatened parrot pitcher plant</td></tr>
<tr><td colspan="2">LEDPA</td><td colspan="3">NO</td><td colspan="3">NO</td><td colspan="3">YES</td></tr>
</table>

Table 19. Mitigation Bank Analysis for Permanent Impacts and Year 1 of Mining				
RESOURCE ANALYSIS				
IMPACT SITE DATA				
Resource Category	Service Area; HUC	Distance to Impact Site	Credits Needed	
Freshwater Wetland	PSA 3070204	--	553.36	
Stream	PSA; 3070204	--	2,225	
			Sufficient Credits Available	Recommended for Use
MITIGATION BANK DATA				
Hog Creek Mitigation Bank				
Wetland	PSA; 3070204	60 miles	Not by itself	yes
Musket Bay Mitigation Bank				
Wetland	PSA; 3070204	51 miles	yes	yes
Offerman Mitigation Bank				
Wetland	PSA; 3070204	59 miles	Not by itself	yes
Satilla River Mitigation Bank				
Wetland	PSA; 3070203	38 miles	Not by itself	no
Patriots Pride Mitigation Bank				
Stream	PSA; 3070106	122 miles	yes	yes

Table 20: Federal Status Species Potentially Occurring in Project Area			
Group	Name	Federal Status	Supporting Habitat in or near the Site
Amphibians	Frosted flatwoods salamander (Ambystoma cingulatum)	Threatened	Habitat on site is too degraded to support. Species not observed.
	Striped Newt (Notophthalmus perstriatus)	Previous Candidate (listing determined “not warranted” 12/19/2018)	Habitat not observed. Species not observed.
	Gopher frog (Lithobates capito)	Candidate*	Habitat is present on site. A total of 6 individuals observed.
Birds	Red-cockaded woodpecker (Picoides borealis)	Threatened	Habitat not observed. Species not observed. May forage on site.
Flowering Plants	Florida hartwrightia (Hartwrightia floridana)	Under Review	Habitat is present on site. Species not identified on site.
	Floodplain tickseed (Coreopsis integrifolia)	Under Review	Habitat is present on site. Species not identified on site.
	Purple Honeycomb-head (Balduina atropurpurea	Under Review	Habitat is present on site. Species not identified on site.
Reptiles	Eastern indigo snake *(Drymarchon corais couperi)*	Threatened	Habitat observed on site. No individuals observed. May forage on site.
	Gopher tortoise *(Gopherus polyphemus)*	Candidate*	Habitat, burrows and individuals observed.

* Candidate species are not provided protection under the ESA.

Table 21: Other Special Concern Species Potentially Occurring in Project Area			
Group	Name	State Status	Supporting Habitat in or near the Site
Birds	Bald eagle *(Haliaeetus leucocephalus)*	Threatened	Habitat not observed. Species not known to occur on-site.
	Bachman's sparrow (*Peucaea aestivalis*)	Rare	Habitat is present. Observed on site in two locations.
Fish	Red face top minnow (*Fundulus rubifrons*)	None	Habitat is present. Observed on site.
Flowering Plants	Savannah milkweed (*Asclepias pedicellata*)	None	Habitat is present. Observed on site.
	Dwarf pawpaw (*Asimina pygmea*)	None	Habitat is present. Individuals are abundant and widespread on site.
	Florida orange-grass (*Ctenium floridanum*)	None	Habitat is present. Was not identified on site.
	Green-fly orchid (*Epidendrum magnoliae*)	Unusual	Habitat is present. Was not identified on site.
	Southern umbrella-sedge (*Fuirena scirpoidea*)	None	Habitat is present. Individuals are abundant and widespread on site.
	Florida milk-pea (*Galactia floridana*)	None	Habitat is present. Was not identified on site.
	Chapman's skeleton grass (*Gymnopogon chapmanianus*)	None	Habitat is present. Was not identified on site.
	Narrowleaf water-willow (*Justicia angusta*)	None	Habitat is present. Was not identified on site.
	Southern bog-button (*Lachnocaulon beyrichianum*)	None	Habitat is present. Was not identified on site.
	Pond spice (*Litsea aestivalis*)	Rare	Habitat is present. Was not identified on site.
	Odorless bayberry (*Morella inodora*)	Threatened	Habitat is present. Was not identified on site.
	Palafoxia (*Palafoxia integrifolia*)	None	Habitat is present. Was not identified on site.
	Arrow arum (*Peltandra sagittifolia*)	None	Habitat is present. Was not identified on site.
	Pennyroyal (*Piloblephis rigida*)	None	Habitat is present. Was not identified on site.
	Chapman's fringed orchid (*Platanthera chapmanii*)	None	Habitat is present. Was not identified on site.
	Yellow fringeless orchid (*Platanthera integra*)	None	Habitat is present. Was not identified on site.
	Wild coco (*Pteroglossaspis ecristata*)	Threatened	Habitat not present. Was not identified on site.
	Chapman oak (*Quercus chapmanii*)	None	Habitat is present. Individuals observed on site.
	Nuttall meadowbeauty (*Rhexia nutallia*)	None	Habitat is present. Individuals are abundant and widespread on site.
	Fernald's beakrush (*Rhynchospora fernaldii*)	None	Habitat is present. Was not identified on site.

Table 21 (cont'd): Other Special Concern Species Potentially Occurring in Project Area			
Group	Name	State Status	Supporting Habitat in or near the Site
Flowering Plants	Hooded pitcherplant (*Sarracenia minor* var. *minor*)	Unusual	Habitat is present. Individuals observed on site.
	Parrot pitcherplant (*Sarracenia psittacine*)	Threatened	Habitat is present. Individuals observed on site.
	White sunnybell (*Schoenolirion albiflorum*)	None	Habitat is present. Was not identified on site.
	S Sandhill skullcap (*Scutellaria arenicola*)	None	Habitat is present. Was not identified on site.
	Florida ladies-tresses (*Spiranthes floridana*)	None	Habitat is present. Was not identified on site.
	Wireleaf dropseed (*Sporobolus teretifolius*)	None	Habitat is present. Was not identified on site.
	Stokes aster (*Stokesia laevis*)	None	Habitat is present. Was not identified on site.
	Sprawling goats' rue (*Tephrosia chrysophylla*)	None	Habitat is present. Was not identified on site.
	Bartram's air-plant (*Tillandsia bartramii*)	None	Habitat is present. Individuals observed on site.
	Diverse-leaf crownbeard (*Verbesina heterophylla*)	None	Habitat is present. Was not identified on site.
Mammals	Black bear (*Ursus americanus floridanus*)	None	Habitat is present. Individuals not observed on site. Individuals observed on Alternate 3 site.
Reptiles	Spotted Turtle (*Clemmys guttata*)	Unusual	Extremely limited habitat is present on site. Individuals not observed on site.
	Southern hog-nosed snake (*Heterodon simus*)	Threatened	Extremely limited habitat is present on site. Individuals not observed on site.
	Black swampsnake (*Liodytes pygaea*)	None	Habitat is present on site. Individuals observed on site.
	Mimic glass lizard (*Ophisaurus mimicus*)	Rare	Extremely limited habitat is present on site. Individuals not observed on site.
	Florida pine snake (*Pituophis melanoleucus*)	None	Habitat is present on site. Individuals observed on site.

Table 22. Summary of Potential Impacts to Federal Status Species in Project Area					
Group	Name	Federal Status	Supporting Habitat in or near the Site	Effects to Species from Project	Mitigation Measures Proposed to Avoid Adverse Effect
Amphibians	Frosted flatwoods salamander (Ambystoma cingulatum)	T	Habitat on site is too degraded to support. Species not observed.	No effect anticipated.	No mitigation measures proposed.
	Gopher frog (Lithobates capito)	C*	Habitat is present on site. A total of 6 individuals observed.	Occupied habitat is within impact area. One individual identified.	Pre-Construction Surveys to scope burrows and relocate species.
Birds	Red-cockaded woodpecker (Picoides borealis)	T	Habitat not observed. Species not observed. May forage on site.	No effect anticipated.	No mitigation measures proposed.
Flowering Plants	Florida hartwrightia (*Hartwrightia floridana*)	Under Review	Habitat is present on site. Species not observed.	No effect anticipated.	No mitigation measures proposed.
	Flooplain tickseed (*Coreopsis integrifolia*)	Under Review	Habitat is present on site. Species not observed.	No effect anticipated.	No mitigation measures proposed.
	Purple Honeycomb-head (*Balduina atropurpurea*)	Under Review	Habitat is present on site. Species not observed.	No effect anticipated.	No mitigation measures proposed.
Reptiles	Eastern indigo snake *(Drymarchon corais couperi)*	T	Habitat observed on site. No individuals observed. May forage on site.	No effect anticipated.	Pre-Construction Surveys to scope burrows and relocate species.
	Gopher tortoise *(Gopherus polyphemus)*	C*	Habitat, burrows and individuals observed.	Burrows in impact area.	Pre-Construction Surveys to scope burrows and relocate species.

* Candidate species are not provided protection under the ESA.
T = Threatened; C = Candidate

FIGURES

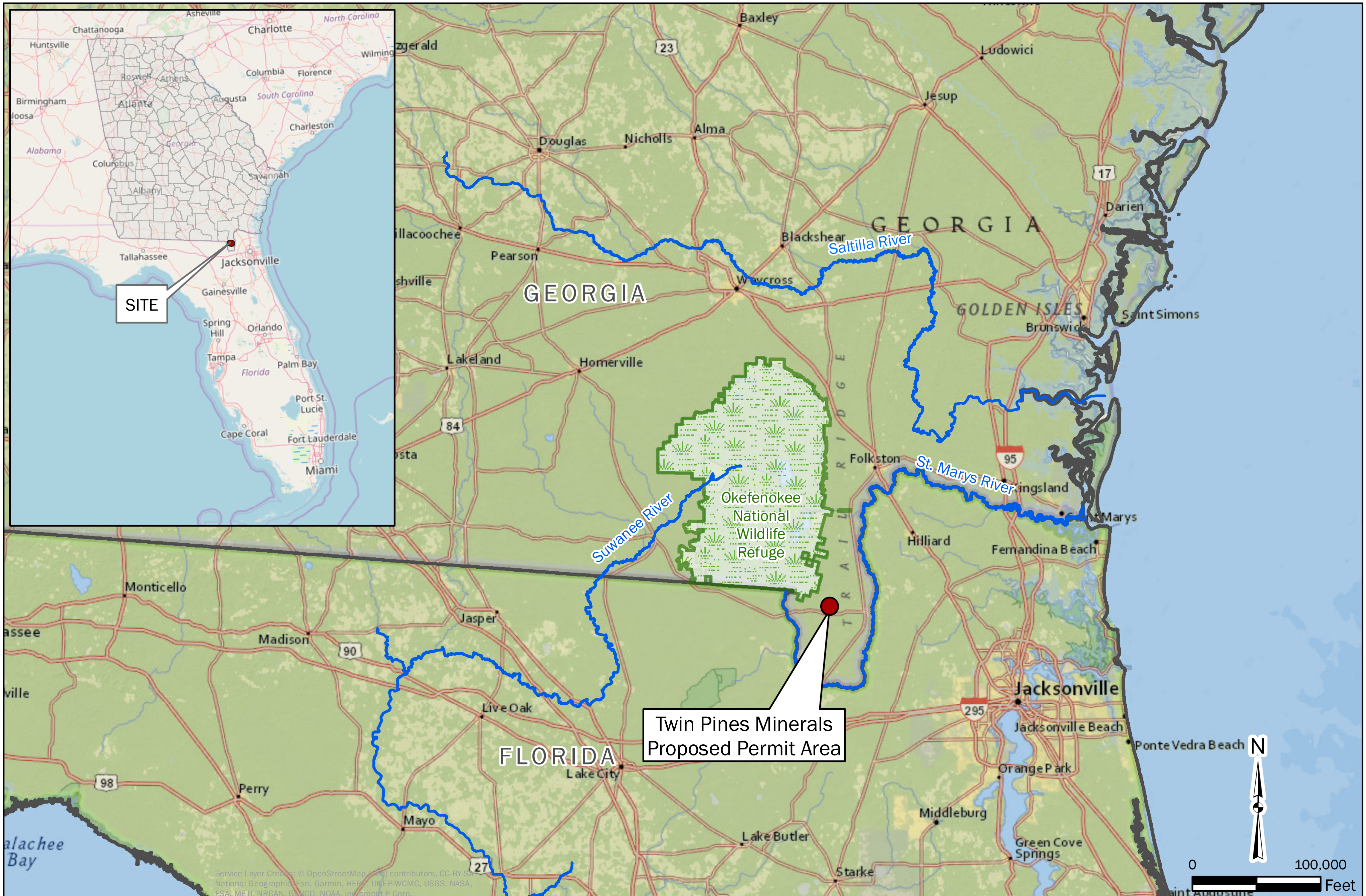

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FIGURE 1: LOCATION OF THE PROPOSED SAUNDERS DEMONSTRATION MINE

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

INSET BASEMAP: Open Street Map; BASEMAP: National Geographic World Map (See Service Layer Credits).

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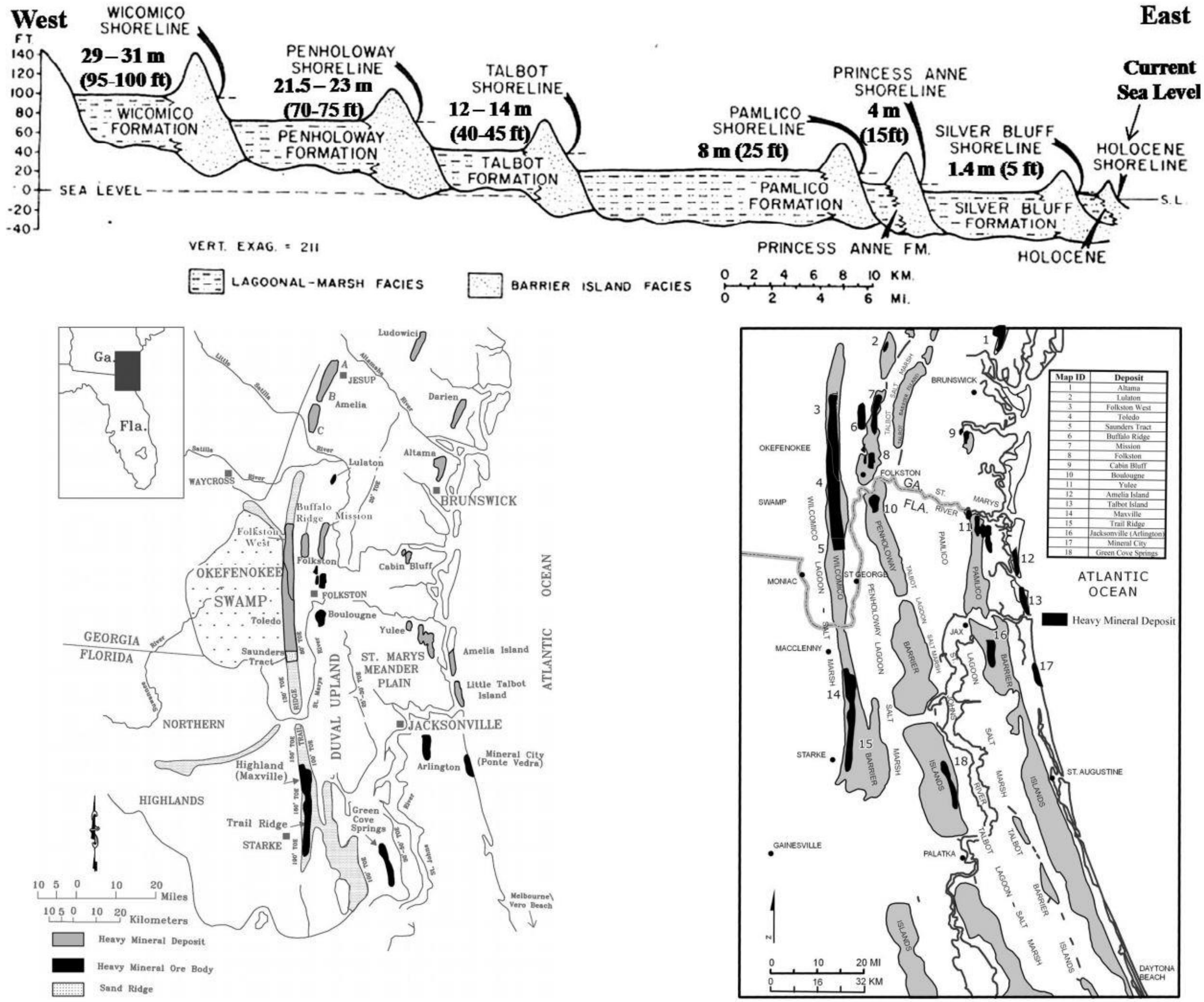

Source: Pirkle, Pirkle & Rich, 2013.

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FIGURE 2: HEAVY MINERALS OF SE GEORGIA & NE FLORIDA

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

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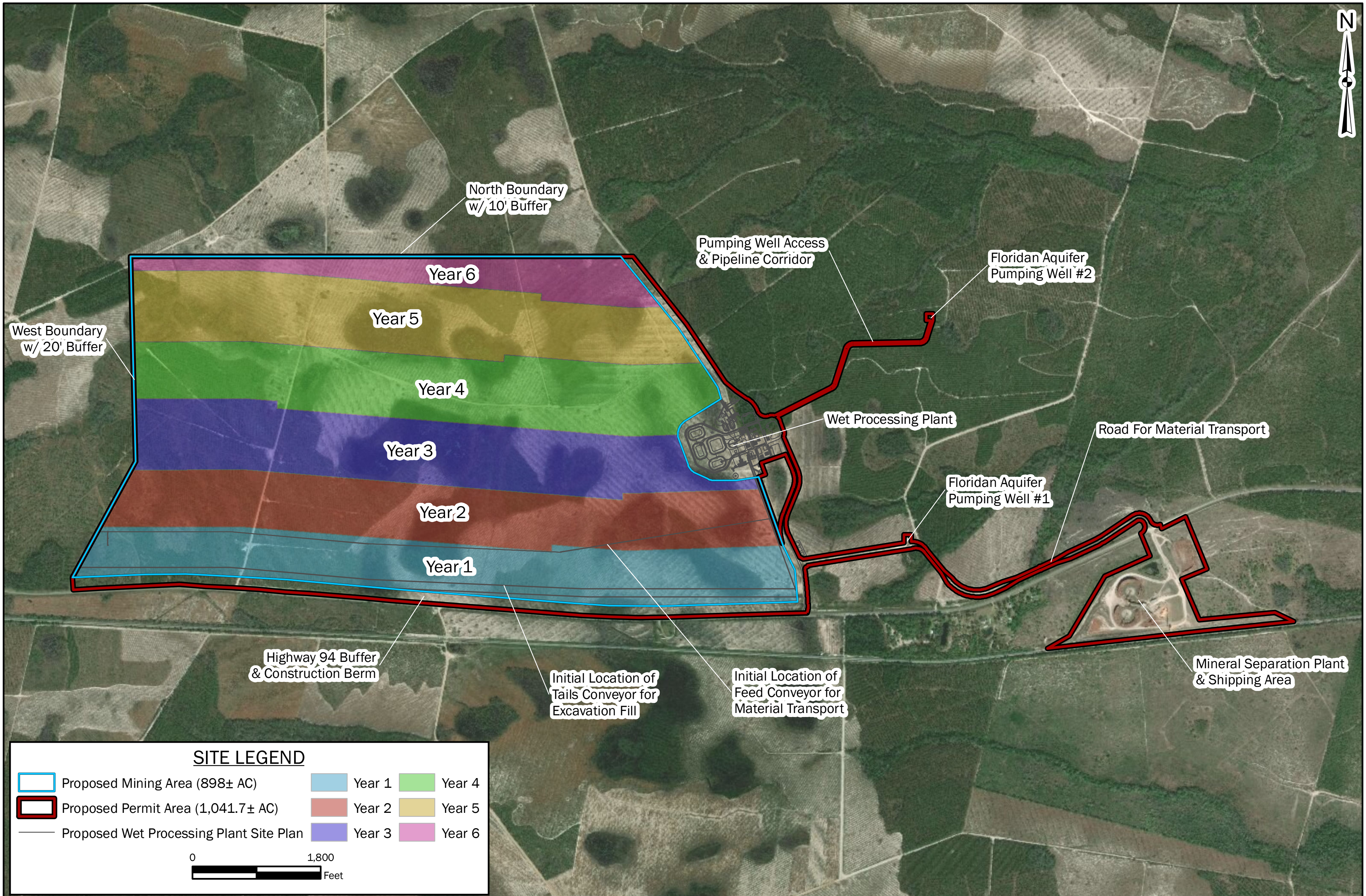

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FIGURE 3: ESTIMATED PROGRESSION OF MINING

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

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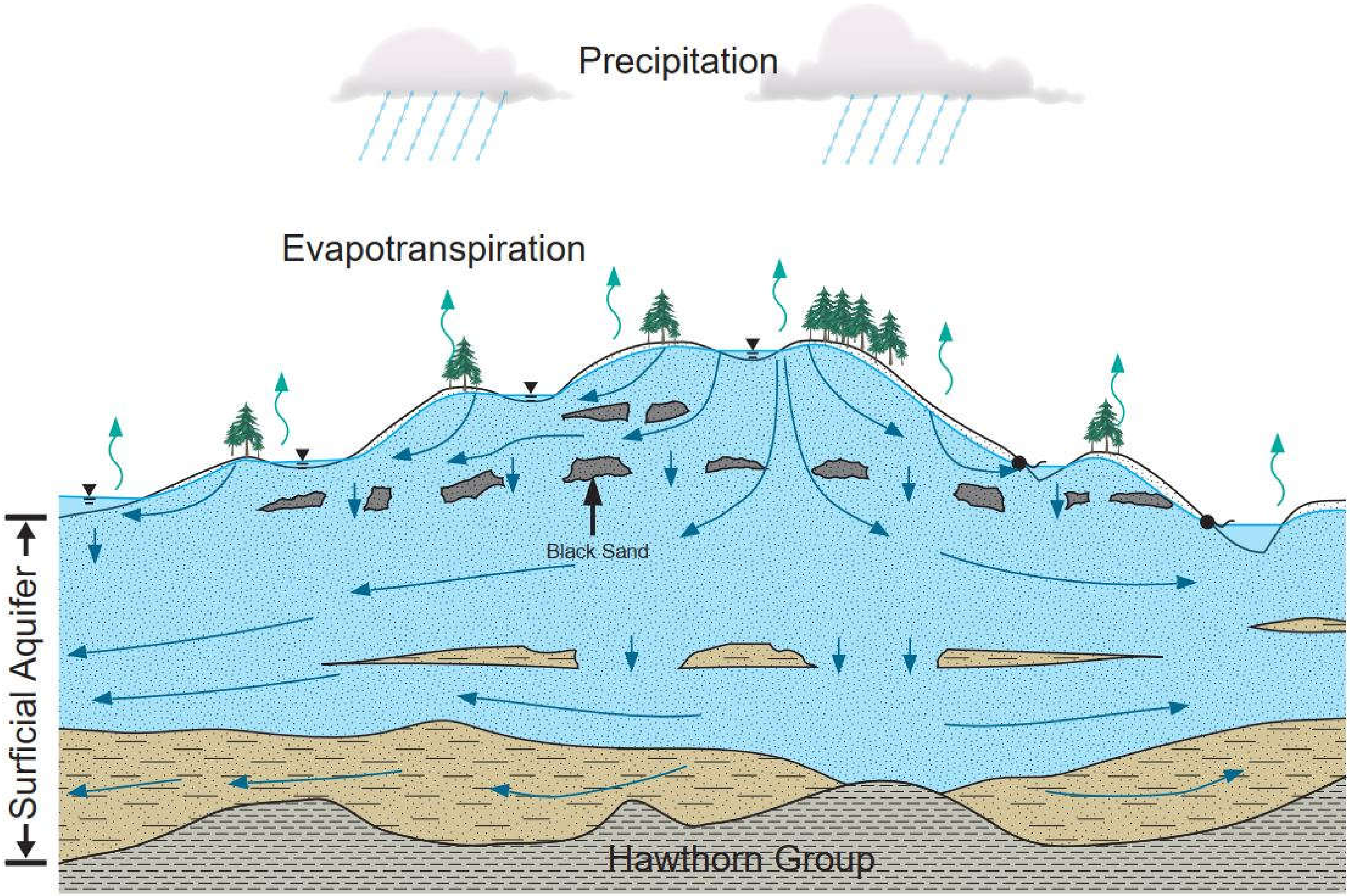

FIGURE 4: CONCEPTUAL HYDROGEOLOGIC MODEL

TWIN PINES MINERALS

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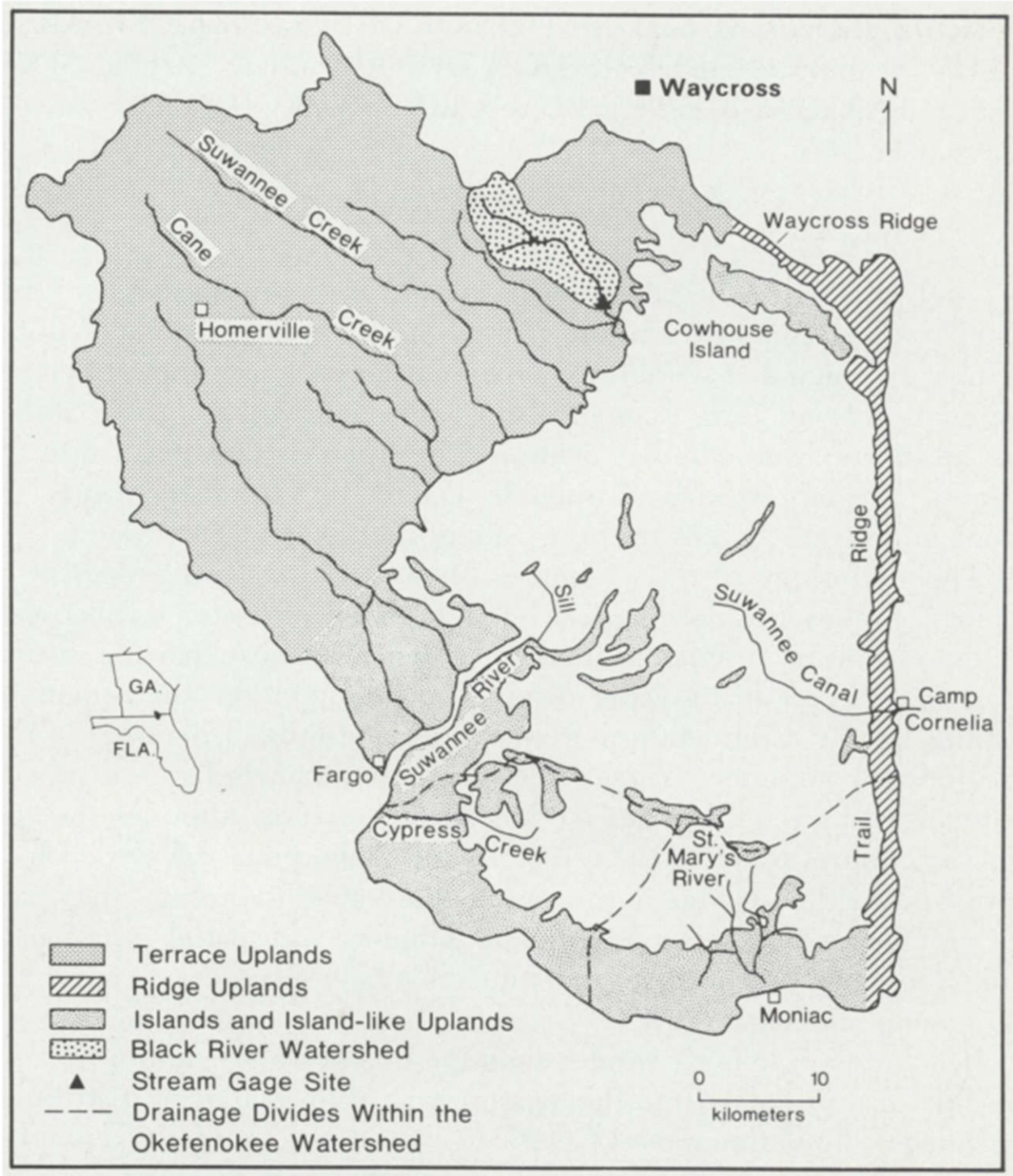

FIGURE 5: OKEFENOKEE SWAMP WATERSHED CHARACTERISTICS

TWIN PINES MINERALS

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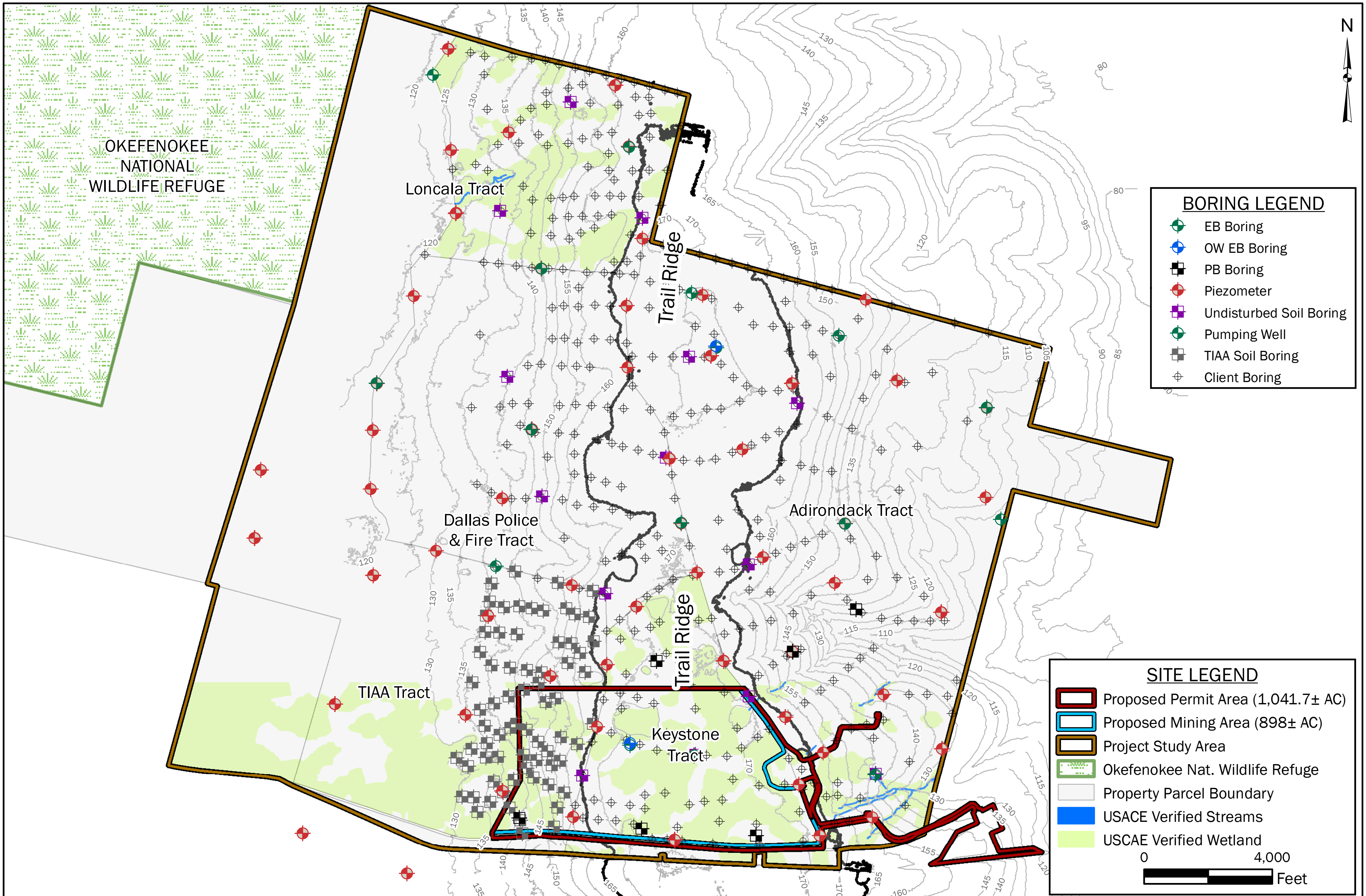

FIGURE 6: SOIL BORING & PIEZOMETER/WELL LOCATION MAP

TWIN PINES MINERALS

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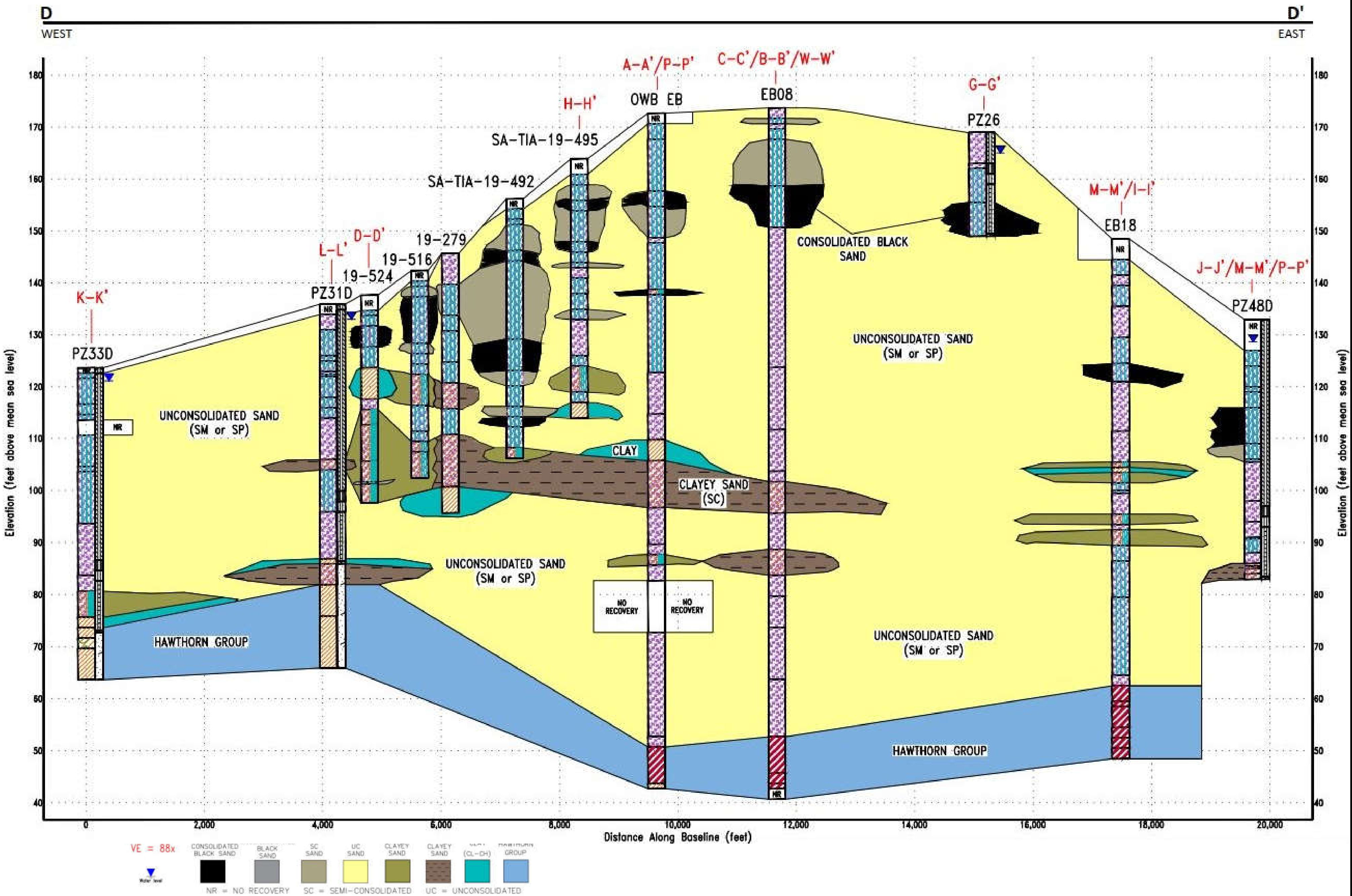

FIGURE 7: EXAMPLE WEST-TO-EAST PROFILE

TWIN PINES MINERALS

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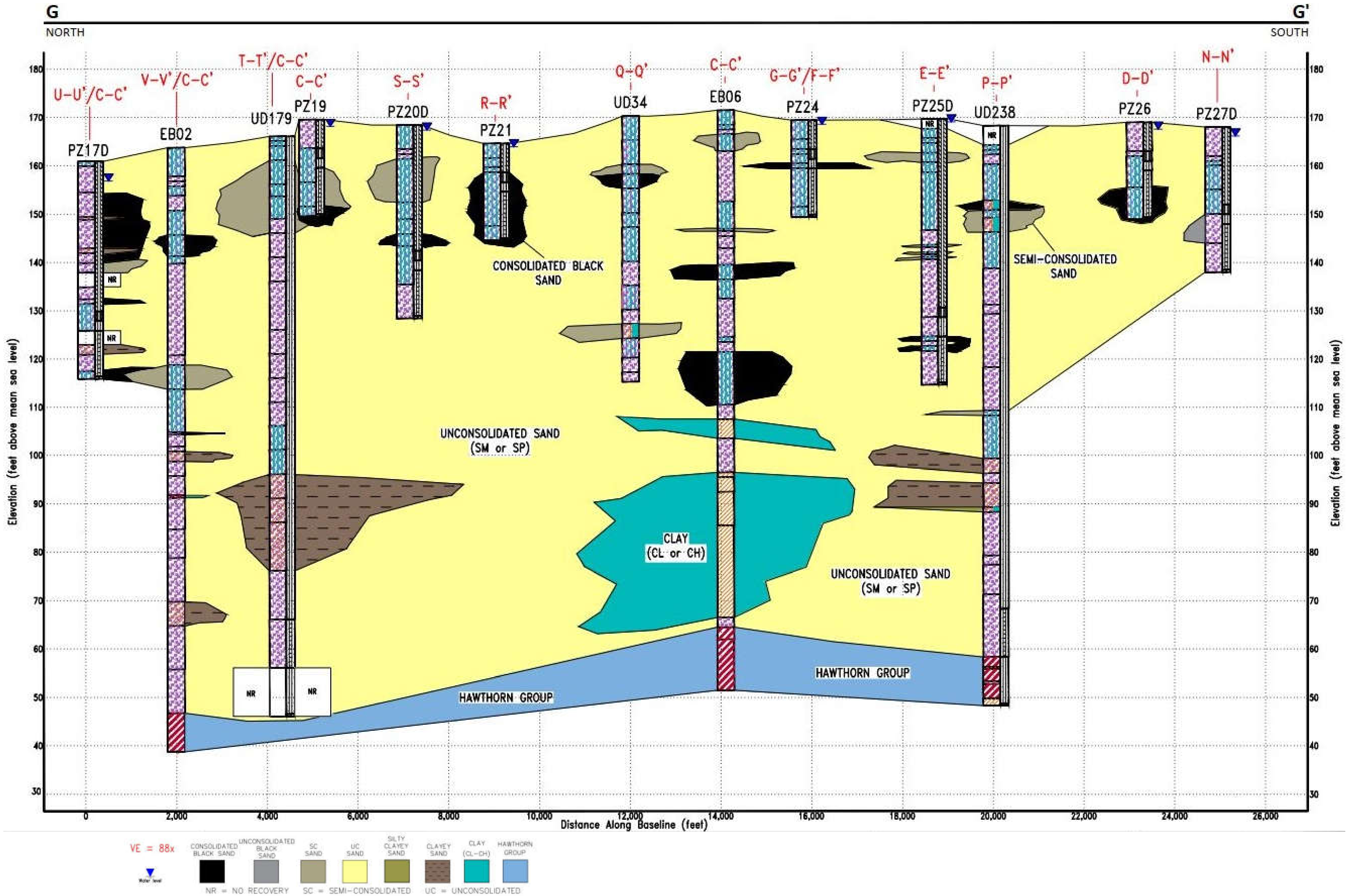

FIGURE 8: EXAMPLE NORTH-TO-SOUTH PROFILE

TWIN PINES MINERALS

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APPROX. SCALE:

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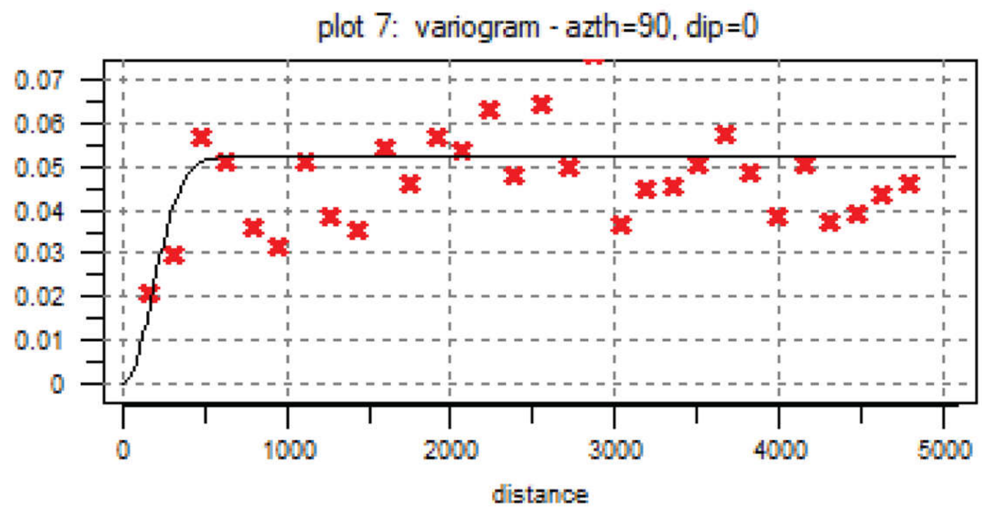
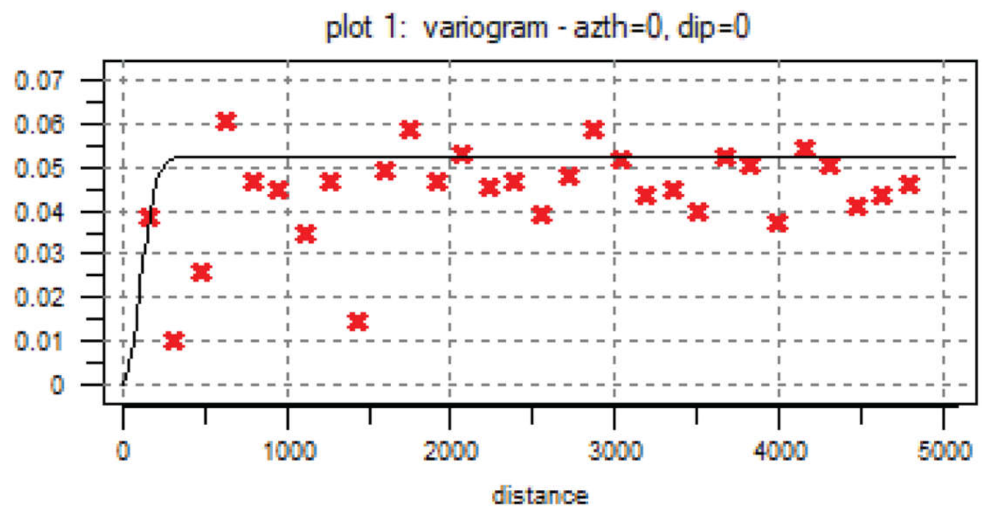


B)



(A) Maximum Correlation Length 432 Feet at Azimuth 90 degrees (B) Minimum Correlation Length 240 Feet at Azimuth 0 degrees. Variance = 0.052, Nugget Variance = 0. Fit with Gaussian Variogram Model.

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FIGURE 9: HORIZONTAL VARIOGRAM FOR CONSOLIDATED SAND

TWIN PINES MINERALS

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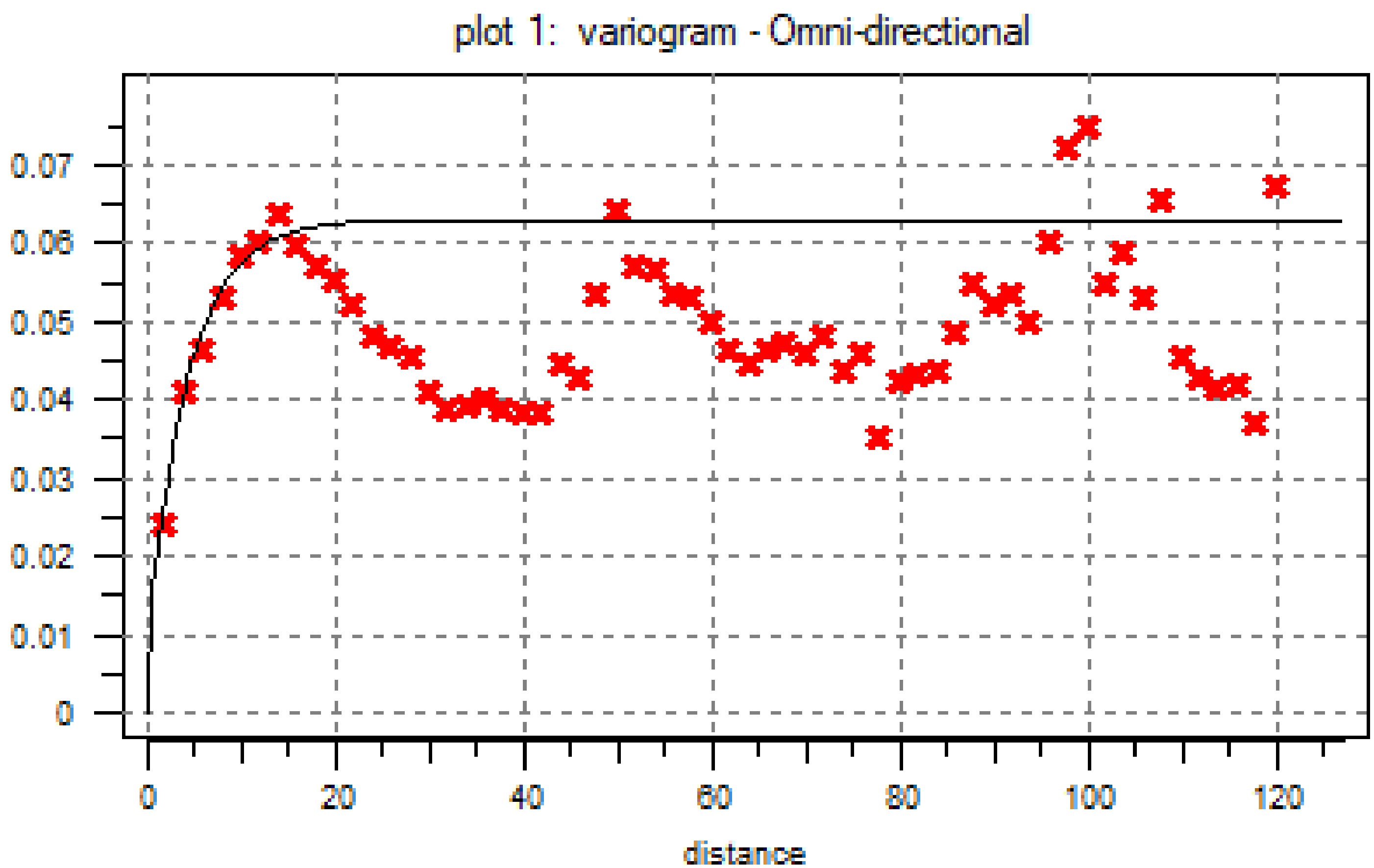

Maximum Correlation Length = 18 Feet, Variance = 0.053, Nugget Variance = 0.01. Fit with Exponential Variogram Model.

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FIGURE 10: VERTICAL VARIOGRAM FOR CONSOLIDATED SAND

TWIN PINES MINERALS

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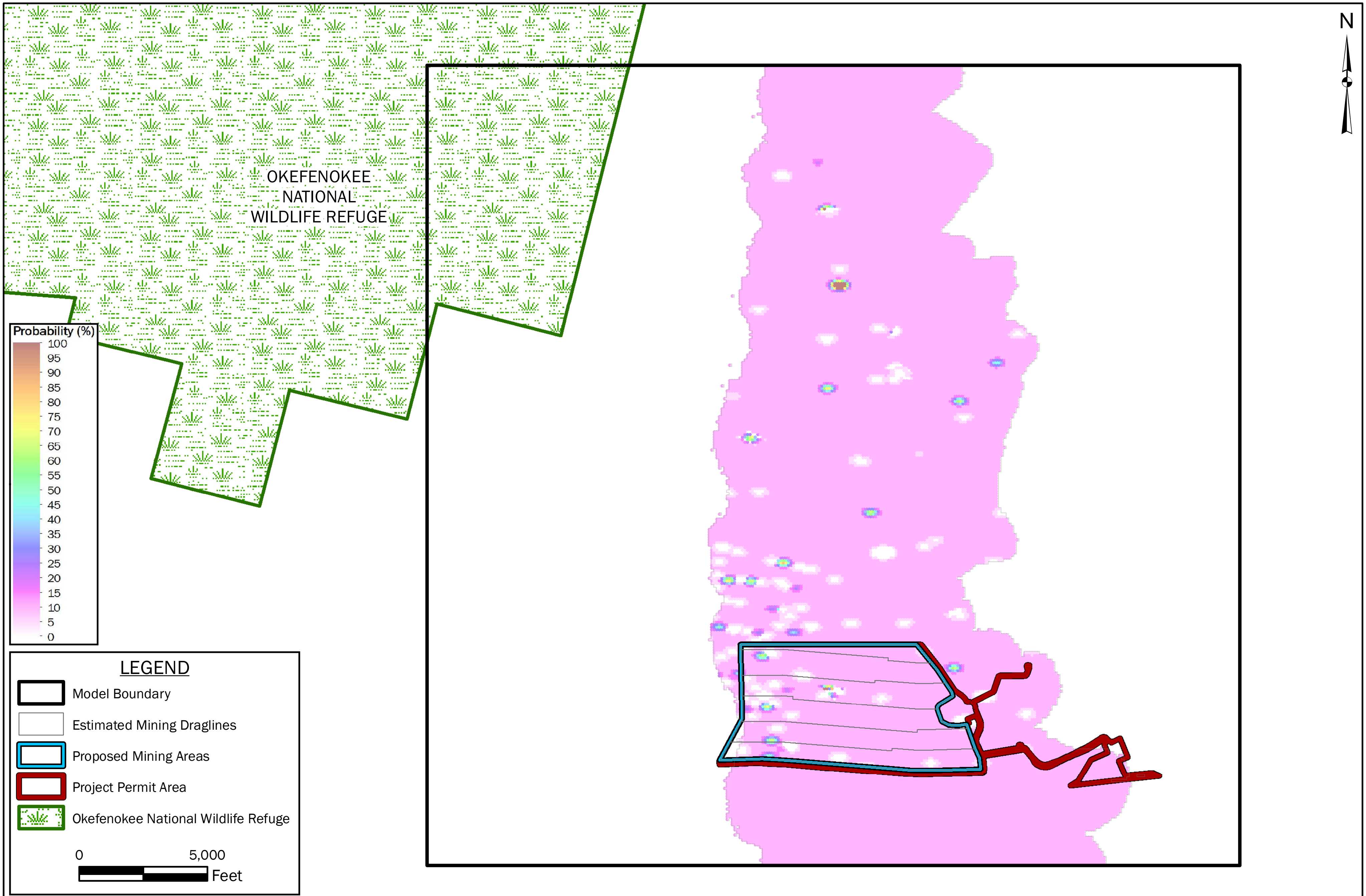

FIGURE 11: PROBABILITY (%) OF CONSOLIDATED SAND PRESENCE
BOTTOM OF 10 FOOT LAYER = 139' (EXPECTED VALUE = 5.54%)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

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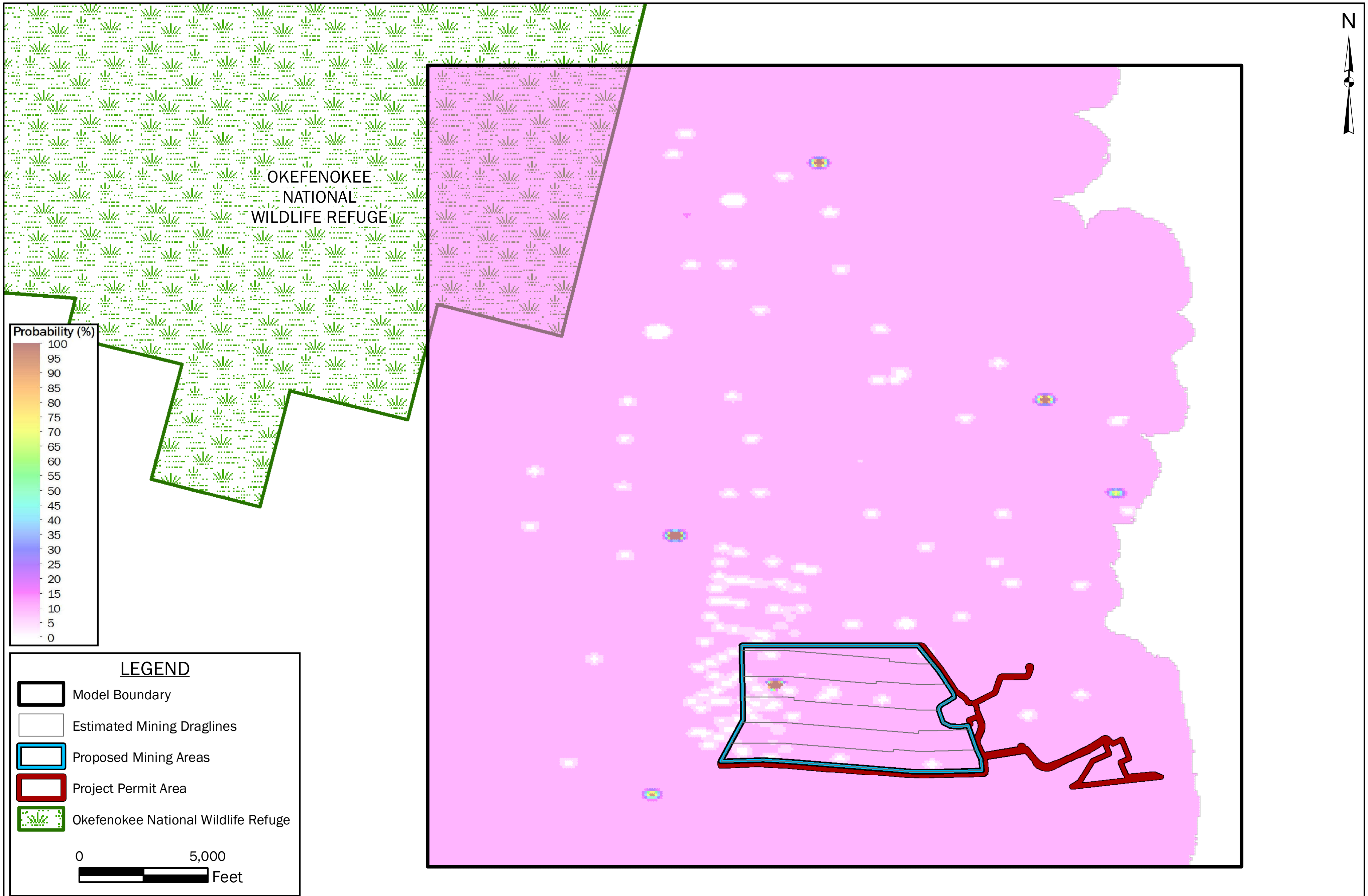

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FIGURE 12: PROBABILITY (%) OF CONSOLIDATED SAND PRESENCE BOTTOM OF 10 FOOT LAYER = 99' (EXPECTED VALUE = 5.54%)

TWIN PINES MINERALS

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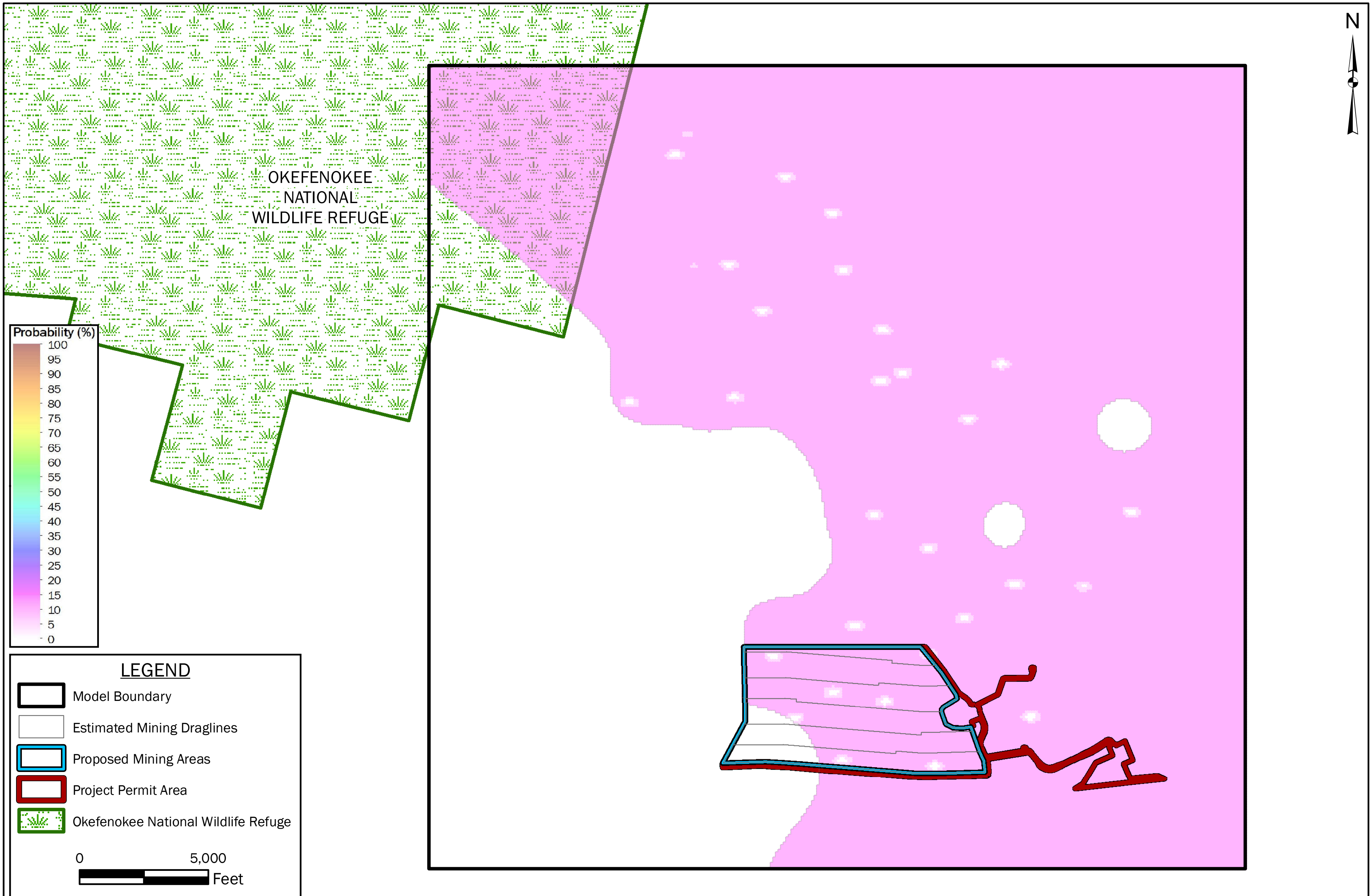

TTL

FIGURE 13: PROBABILITY (%) OF CONSOLIDATED SAND PRESENCE BOTTOM OF 10 FOOT LAYER = 59' (EXPECTED VALUE = 5.54%)

TWIN PINES MINERALS

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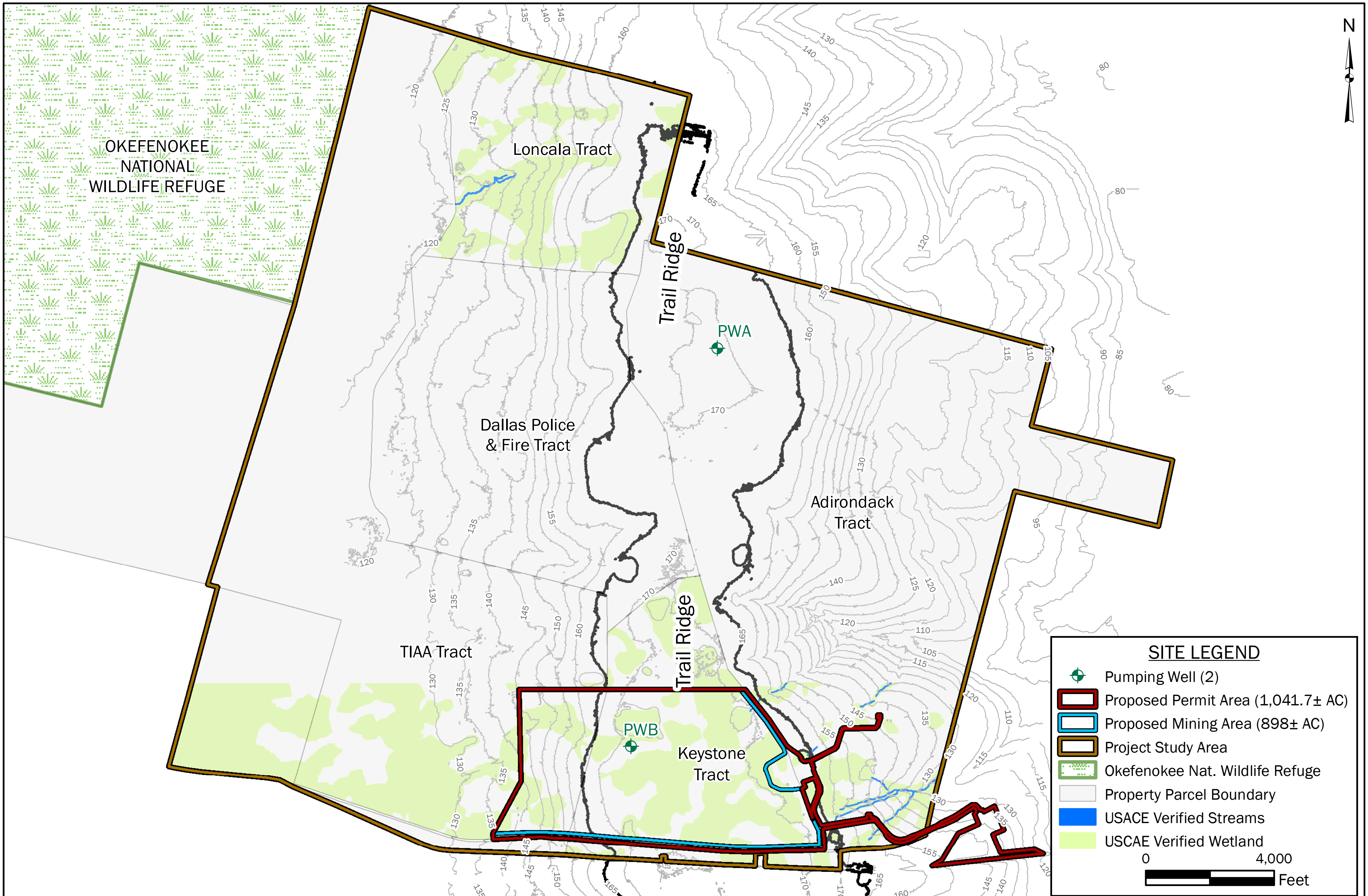

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FIGURE 14: PUMPING WELL LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

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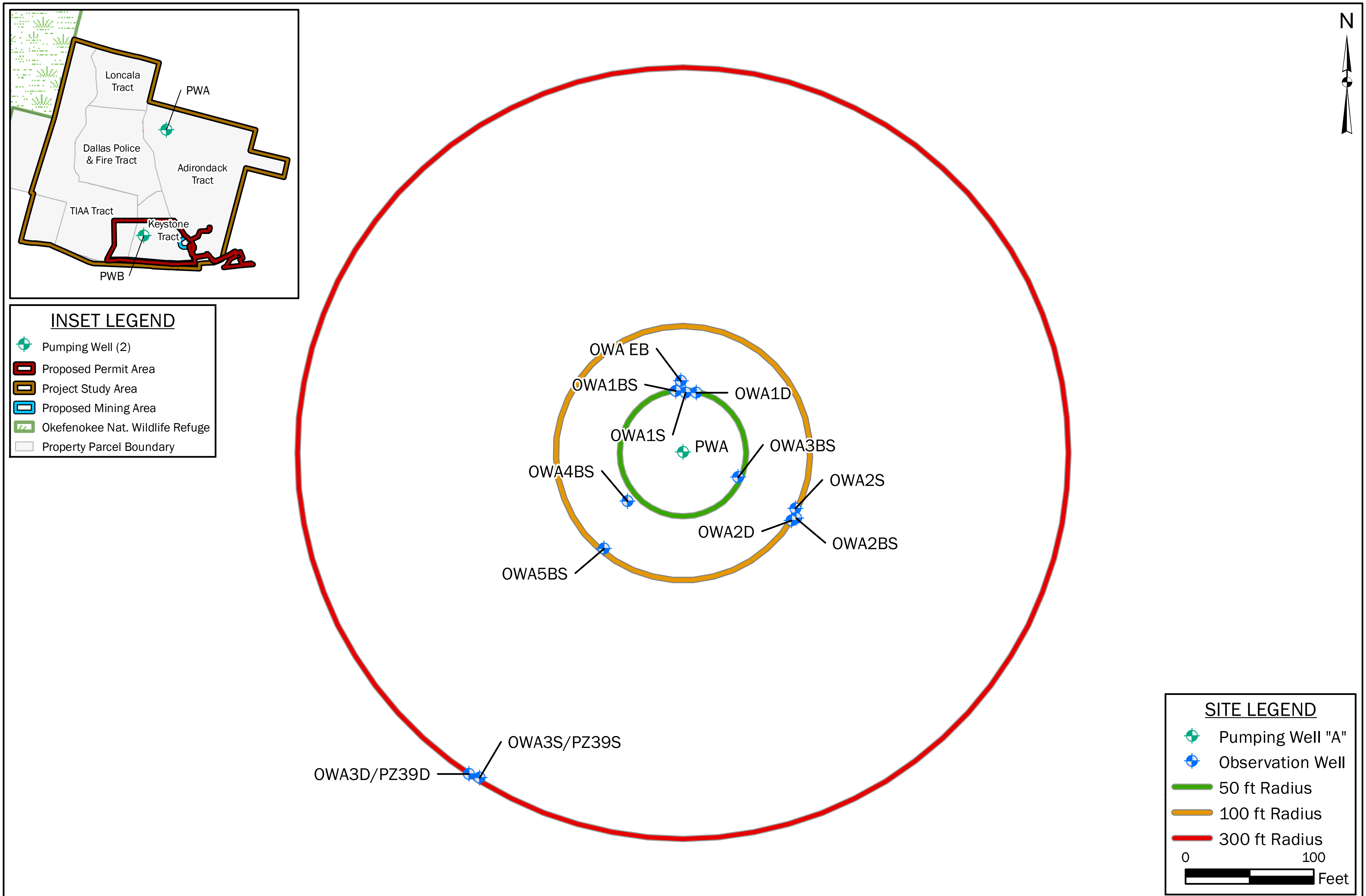

FIGURE 15: PUMPING WELL "A" LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

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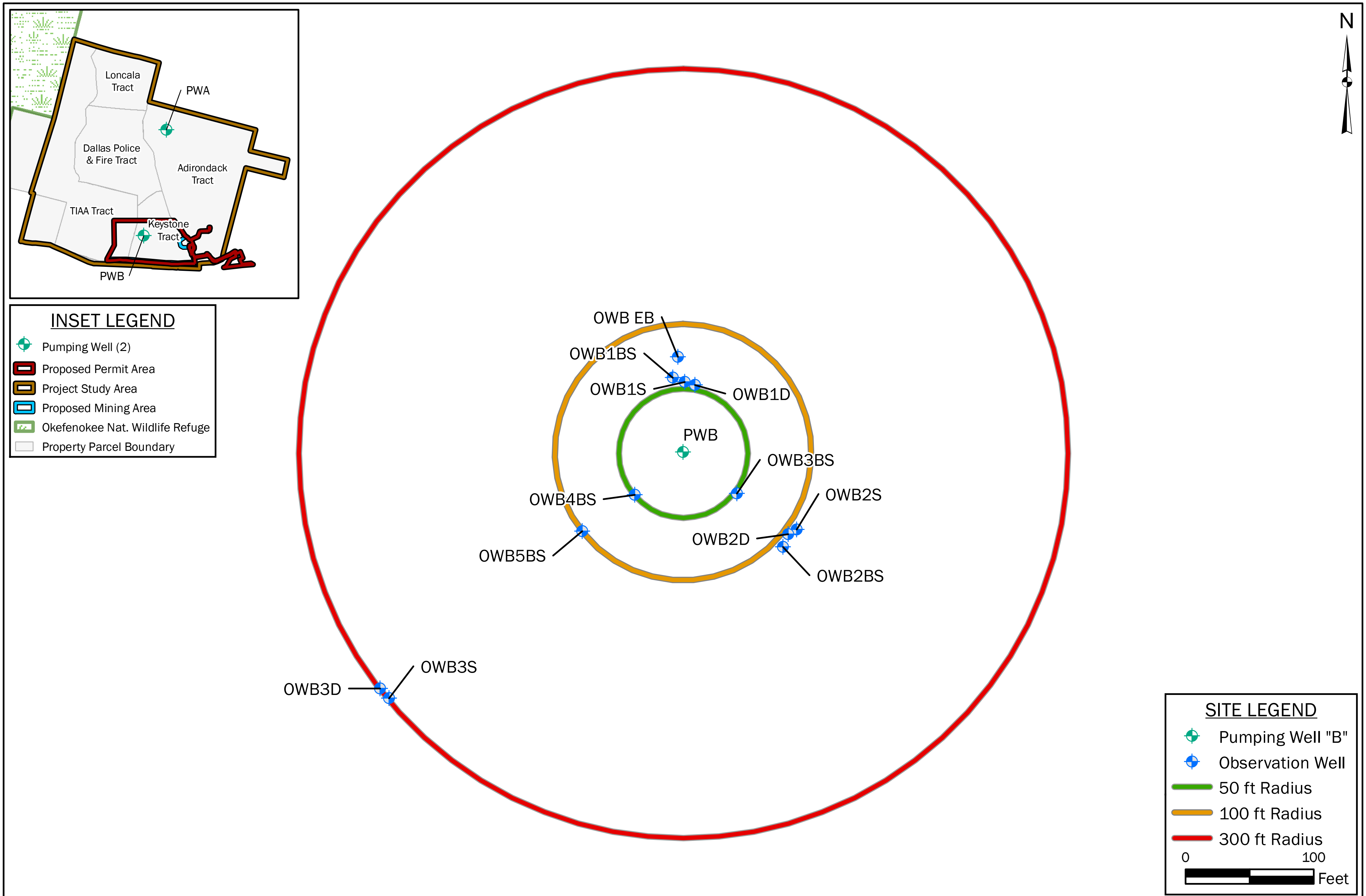

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FIGURE 16: PUMPING WELL "B" LOCATION MAP

TWIN PINES MINERALS

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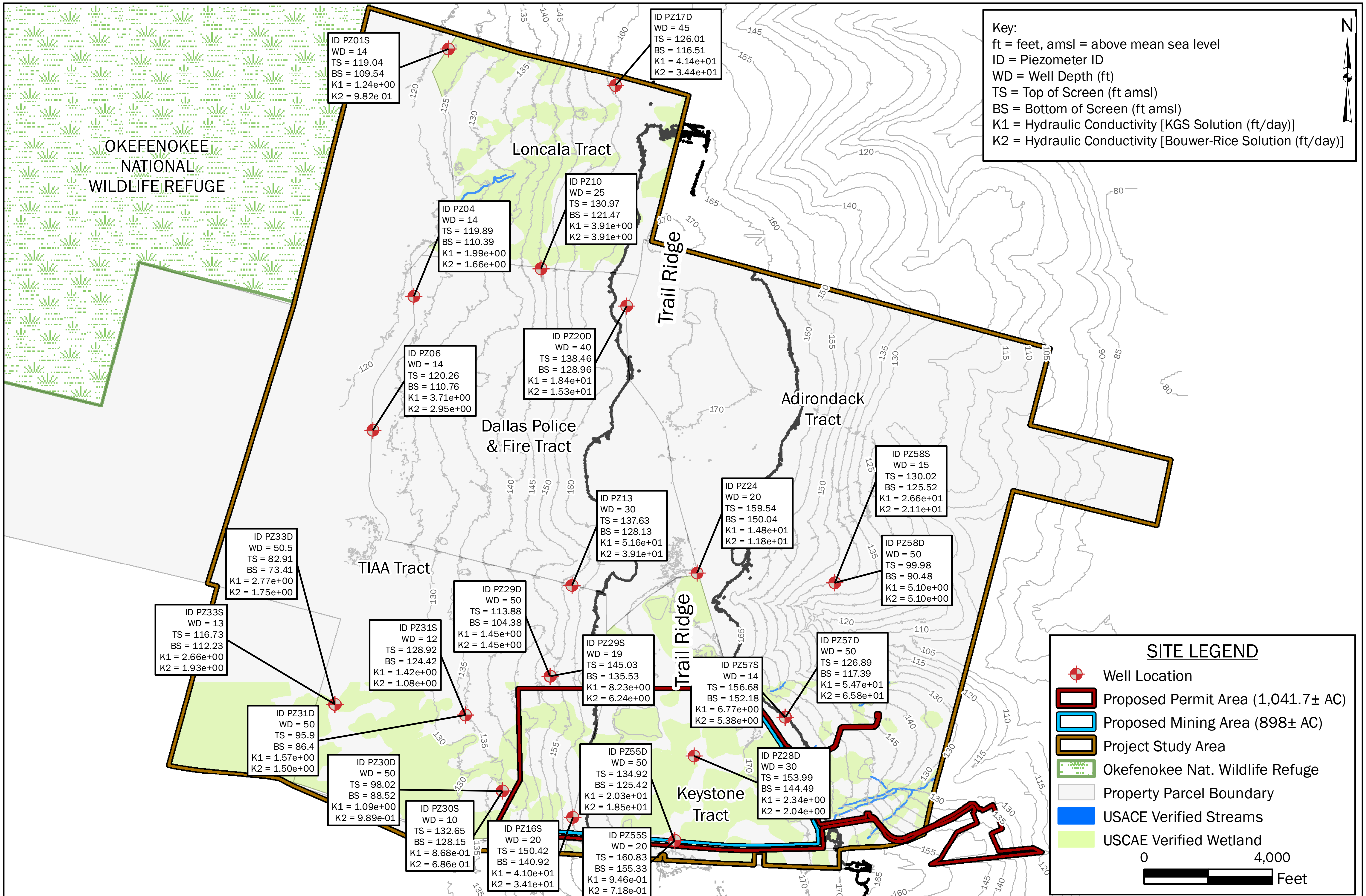

FIGURE 17: HYDRAULIC CONDUCTIVITY (BAIL TESTS)

TWIN PINES MINERALS

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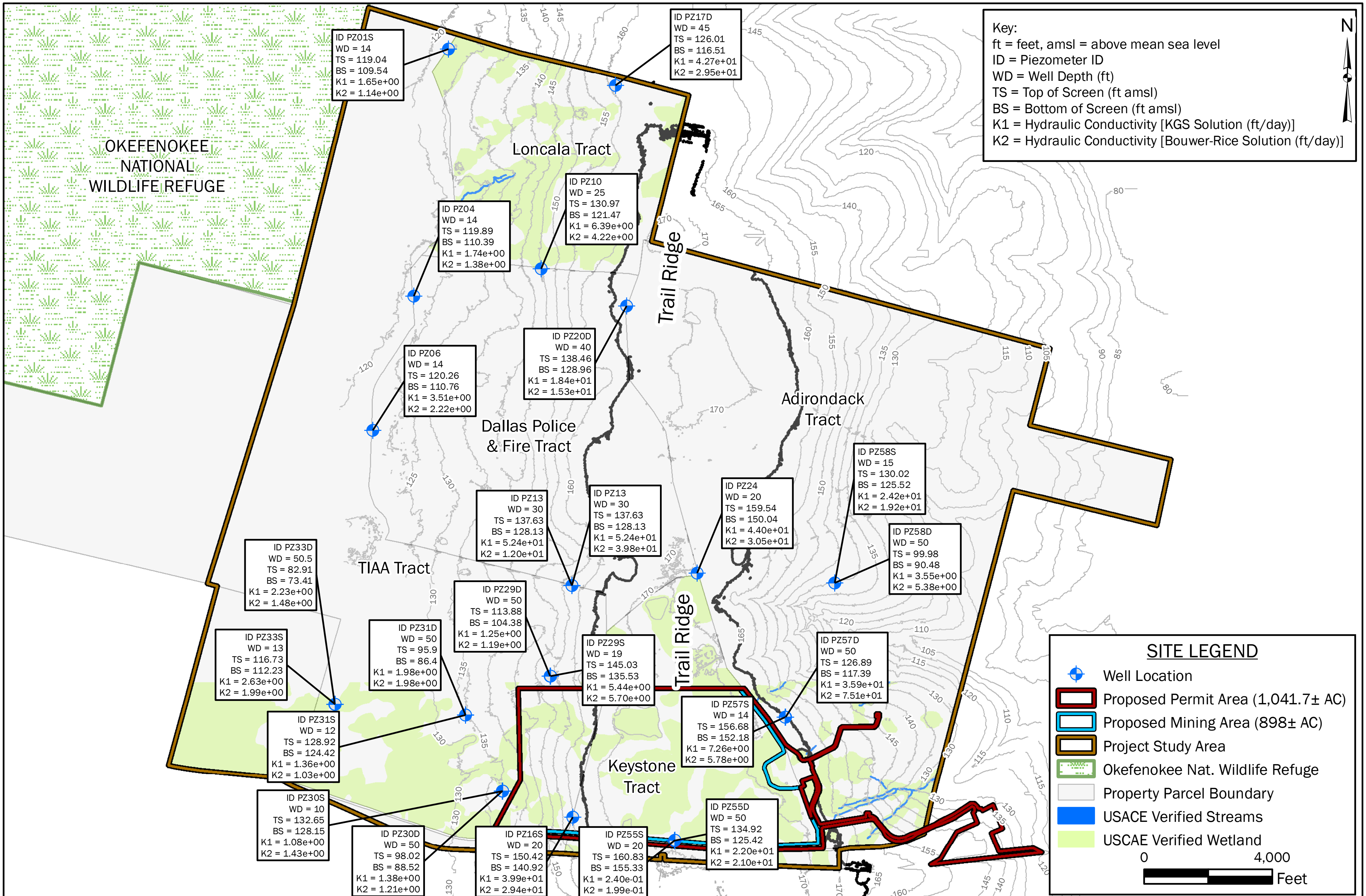

FIGURE 18: HYDRAULIC CONDUCTIVITY (SLUG TESTS)

TWIN PINES MINERALS

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TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

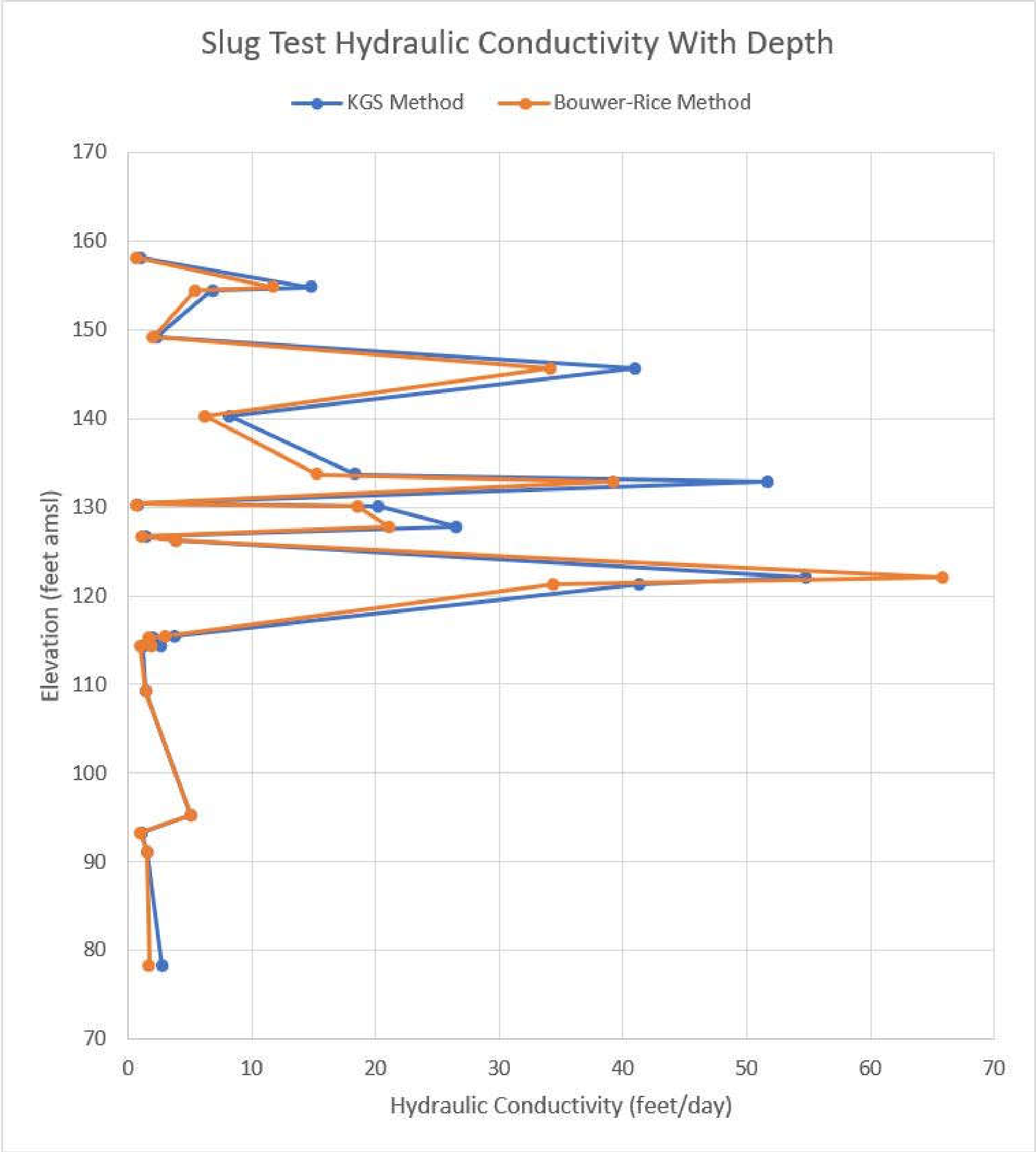


FIGURE 19: SLUG TEST HYDRAULIC CONDUCTIVITY V. ELEVATION

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

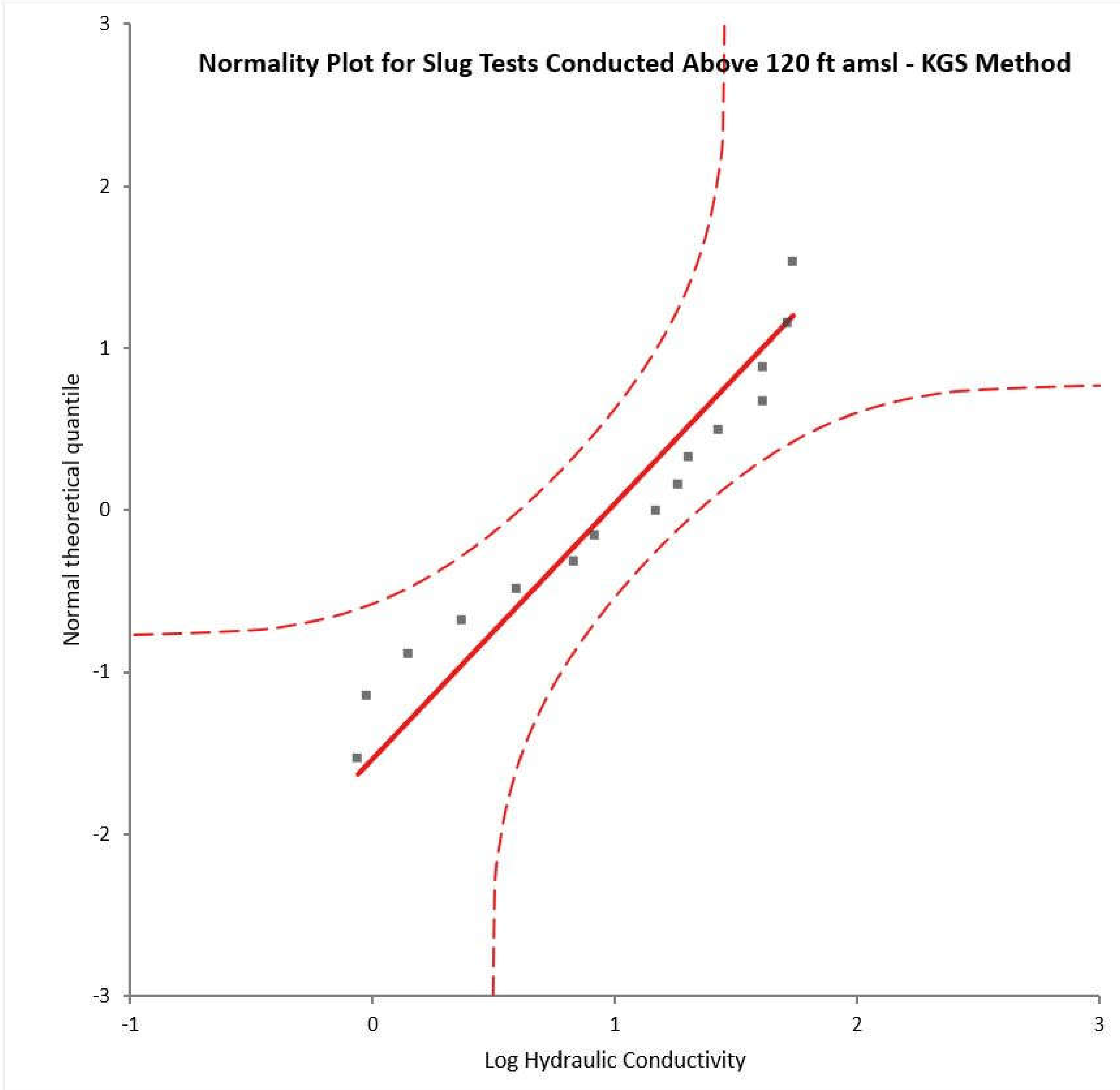


FIGURE 20: SLUG TEST NORMALITY PLOT (ABOVE 120 FT AMSL)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

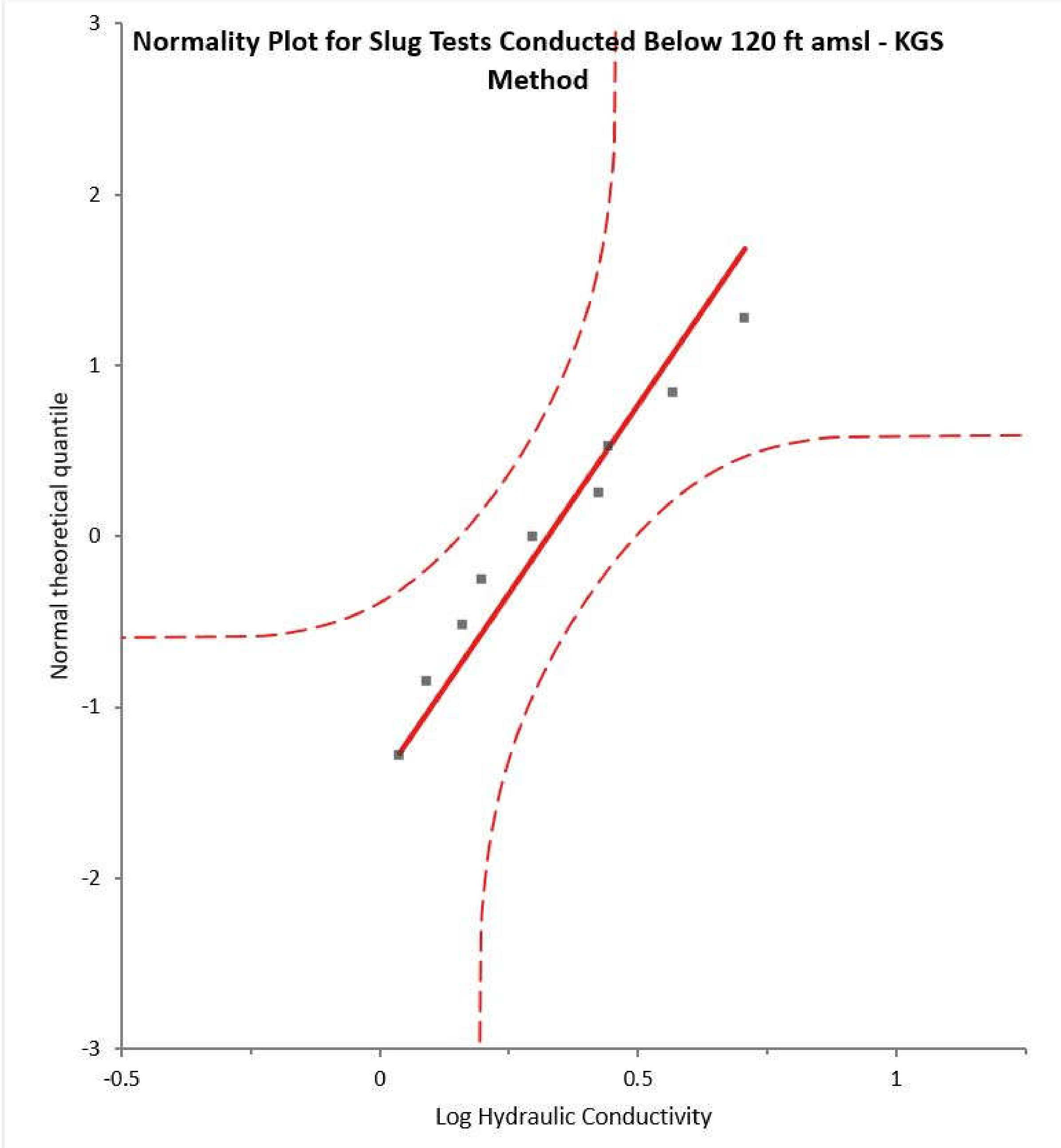


FIGURE 21: SLUG TEST NORMALITY PLOT (BELOW 120 FT AMSL)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

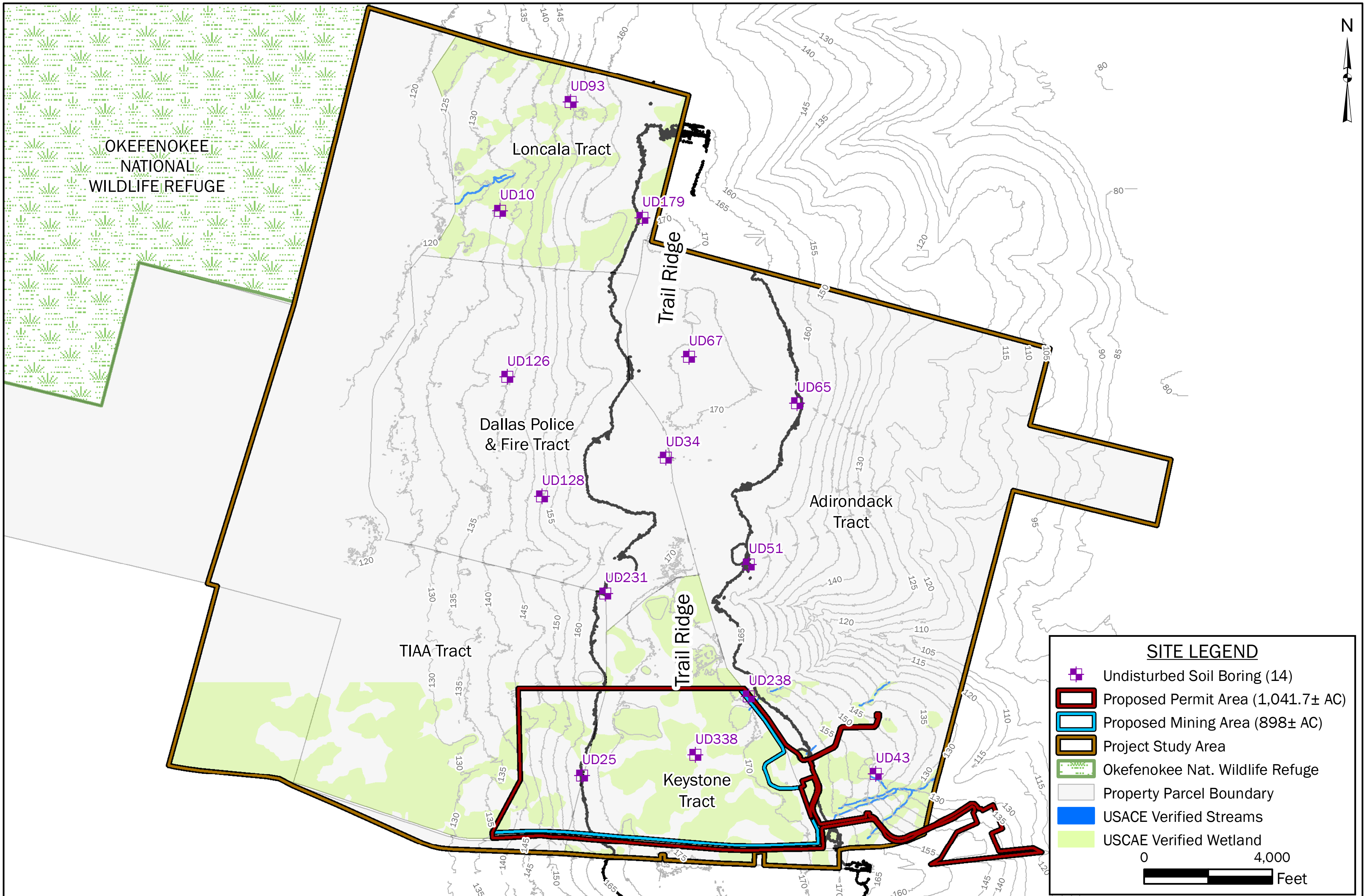


FIGURE 22: UNDISTURBED (UD) SOIL BORING LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK

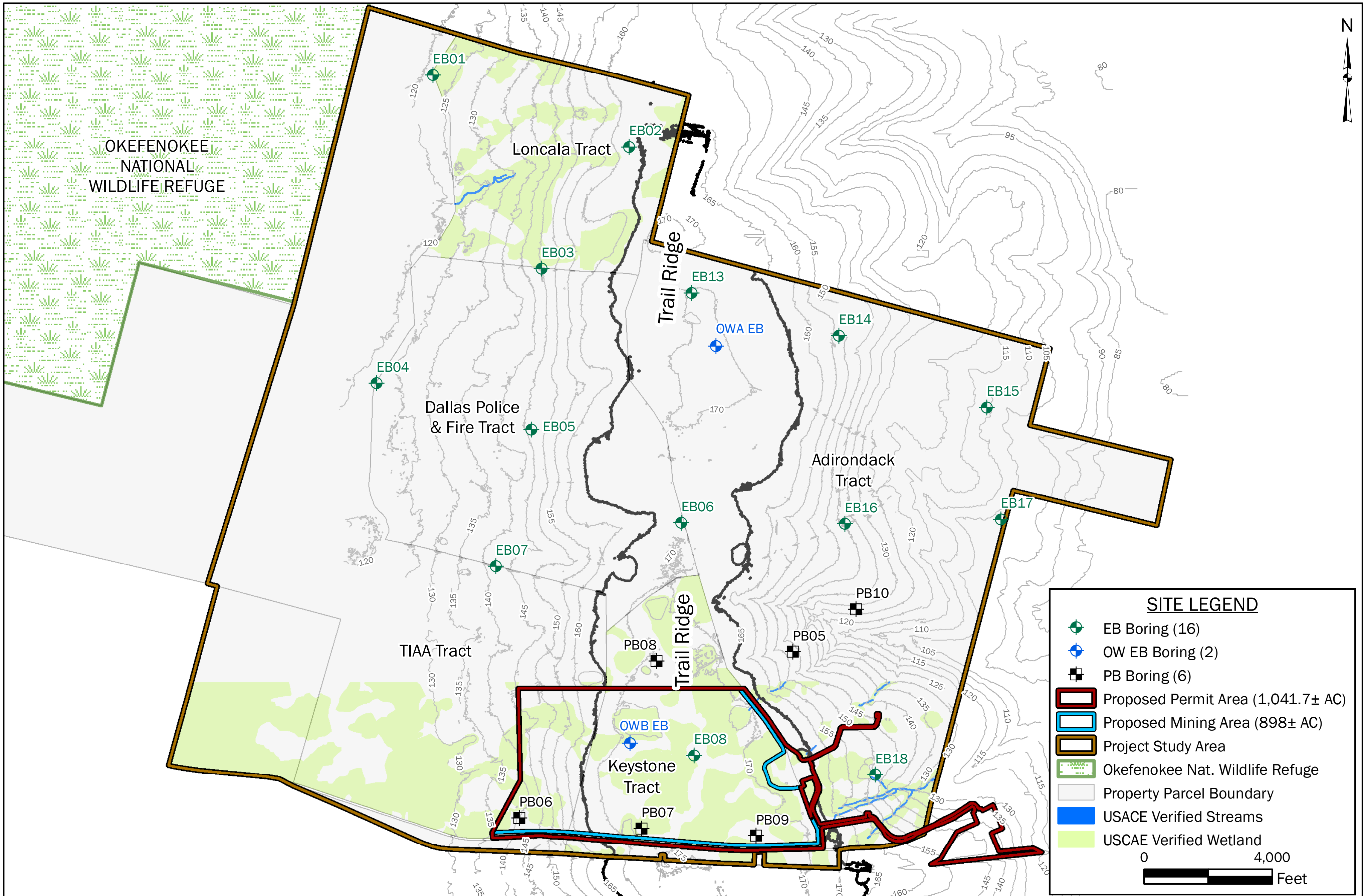
CHECKED BY: JRS

DRAWING DATE: 2/28/2020

REVISION DATE: N/A

TTL JOB NO.: 000180200804.00

APPROX. SCALE: 1 in = 4,000 ft



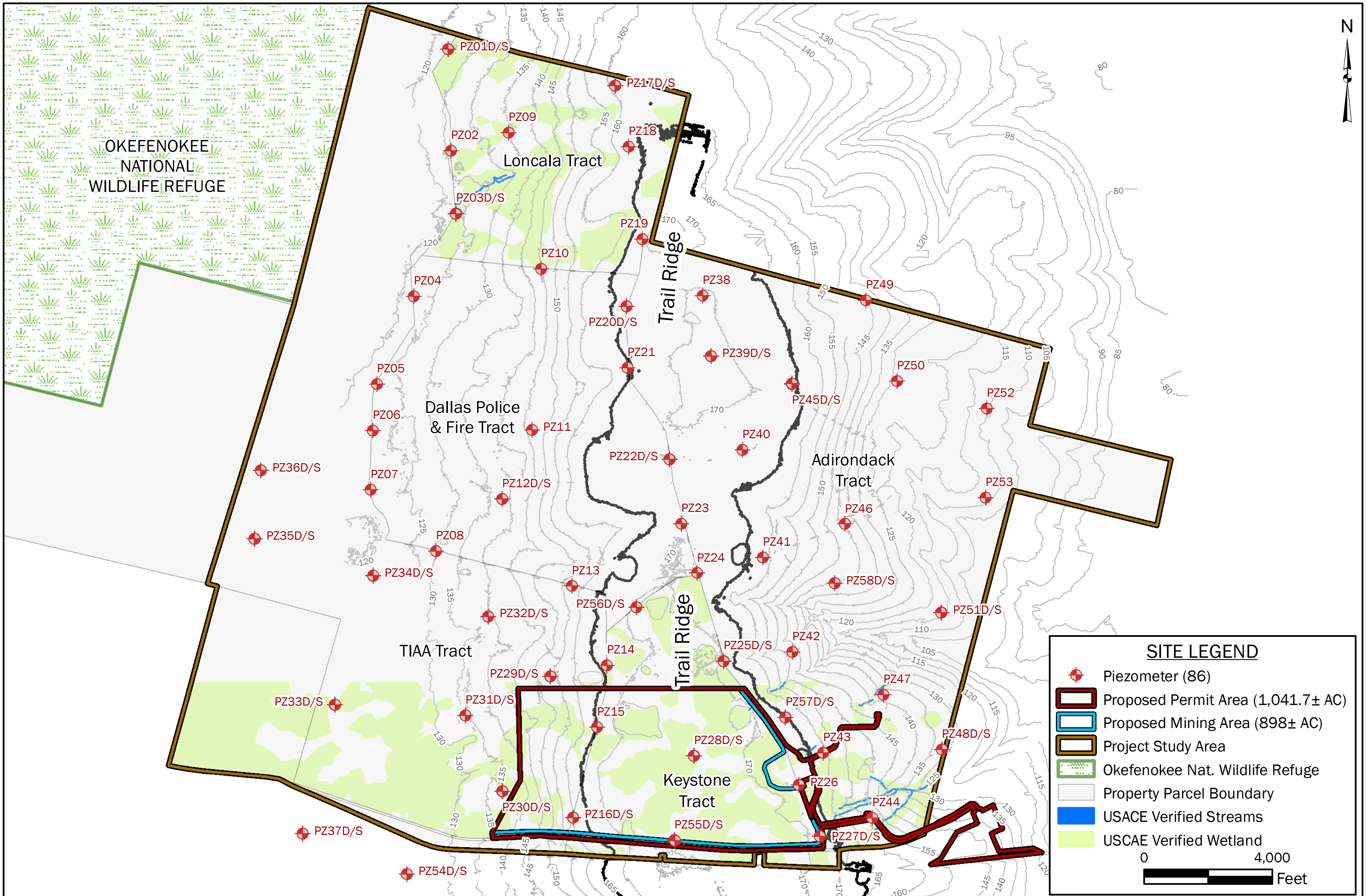
TTL

FIGURE 23: EXPLORATORY BORING LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft



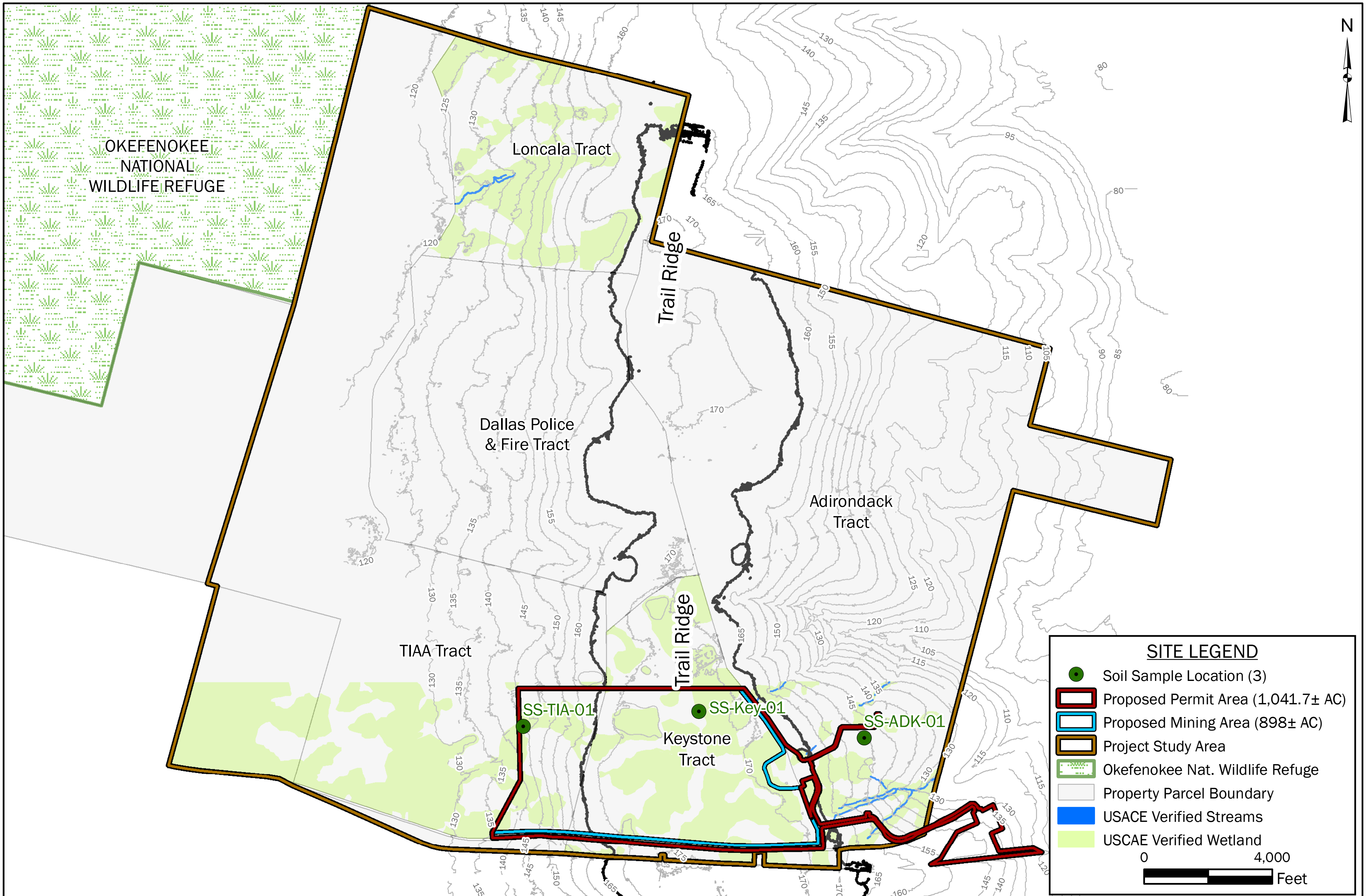
TTL

FIGURE 24: PIEZOMETER LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 4,000 ft



TTL

FIGURE 25: SOIL MOISTURE SAMPLING LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

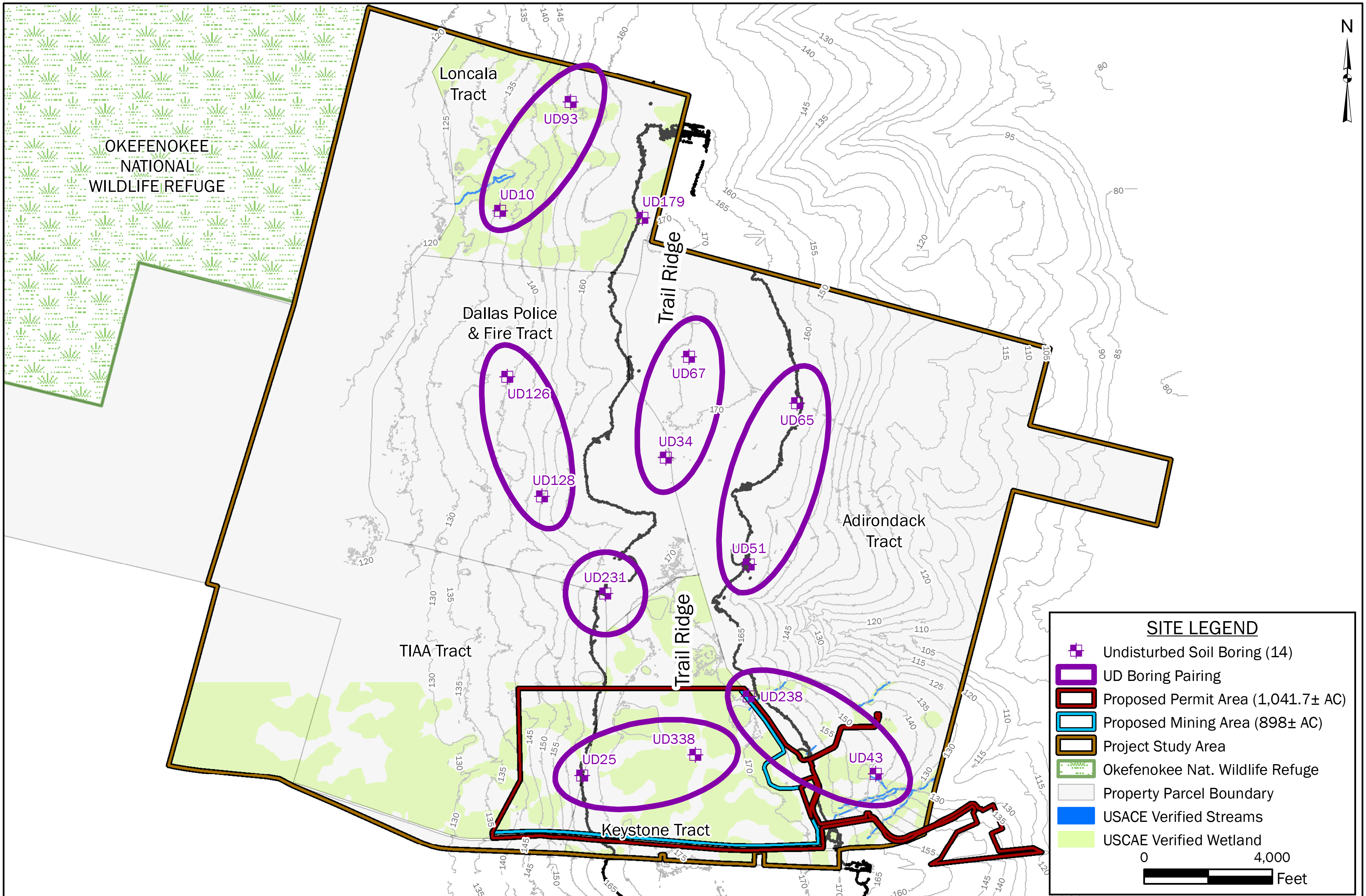
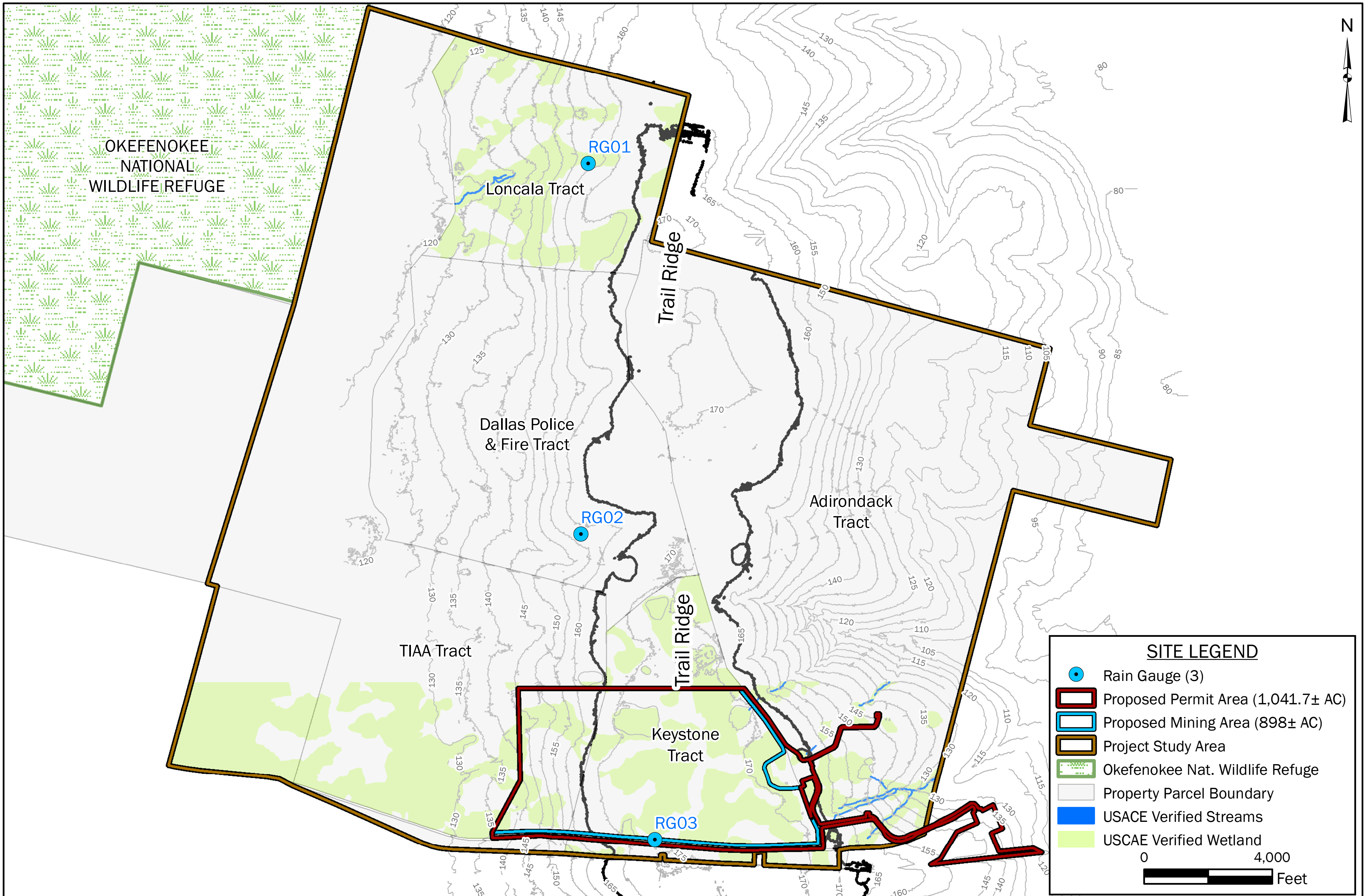


FIGURE 26: UNDISTURBED (UD) SOIL BORING LOCATION & POST-MINERAL PROCESS PAIRING MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft



TTL

FIGURE 27: RAIN GAUGE LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK

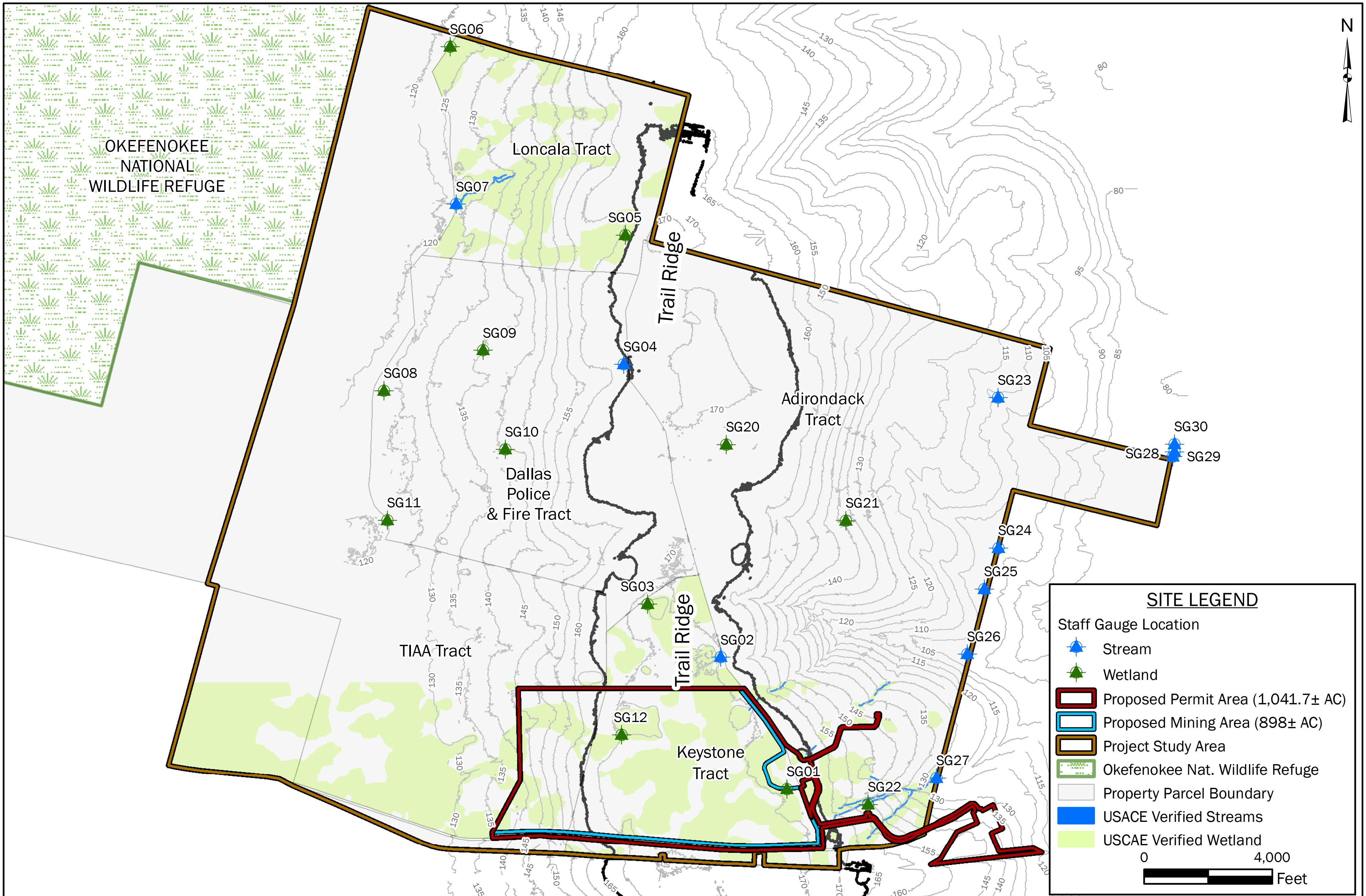
CHECKED BY: JRS

DRAWING DATE: 2/28/2020

REVISION DATE: N/A

TTL JOB NO.: 000180200804.00

APPROX. SCALE: 1 in = 4,000 ft



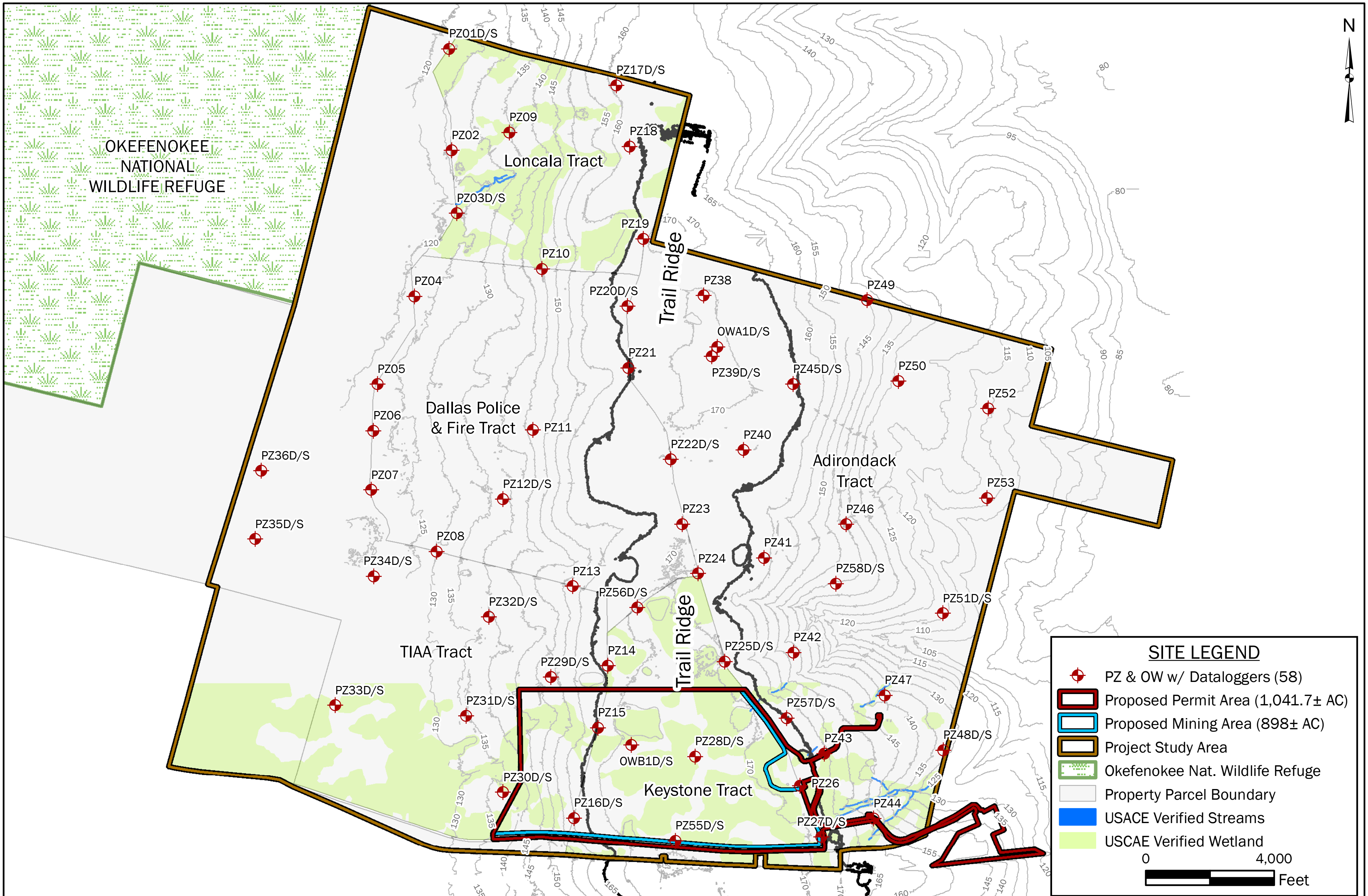
TTL

FIGURE 28: STAFF GAUGE LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 4,000 ft



TTL

FIGURE 29: DATA LOGGER EQUIPPED PIEZOMETERS & OBSERVATION WELLS

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

RG-01, RG-02 & RG-03 HYDROGRAPH

Precipitation

09/21/18 - 10/16/19

Twin Pines Minerals - St. George, Charlton County, Georgia

TTL

LEGEND

- RG-01 Precipitation
- RG-02 Precipitation
- RG-03 Precipitation

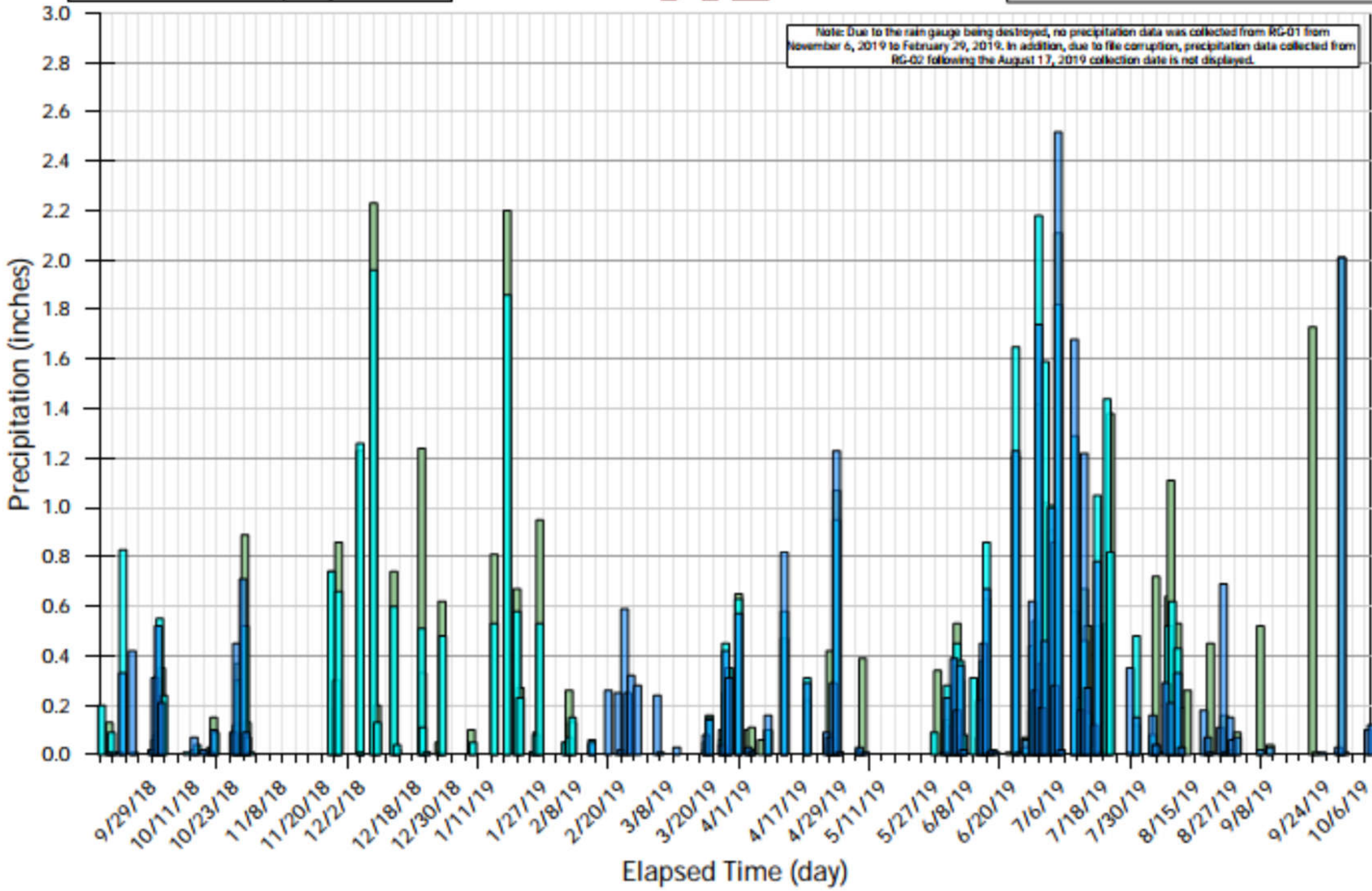


FIGURE 30: Rain Gauge Precipitation Data

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

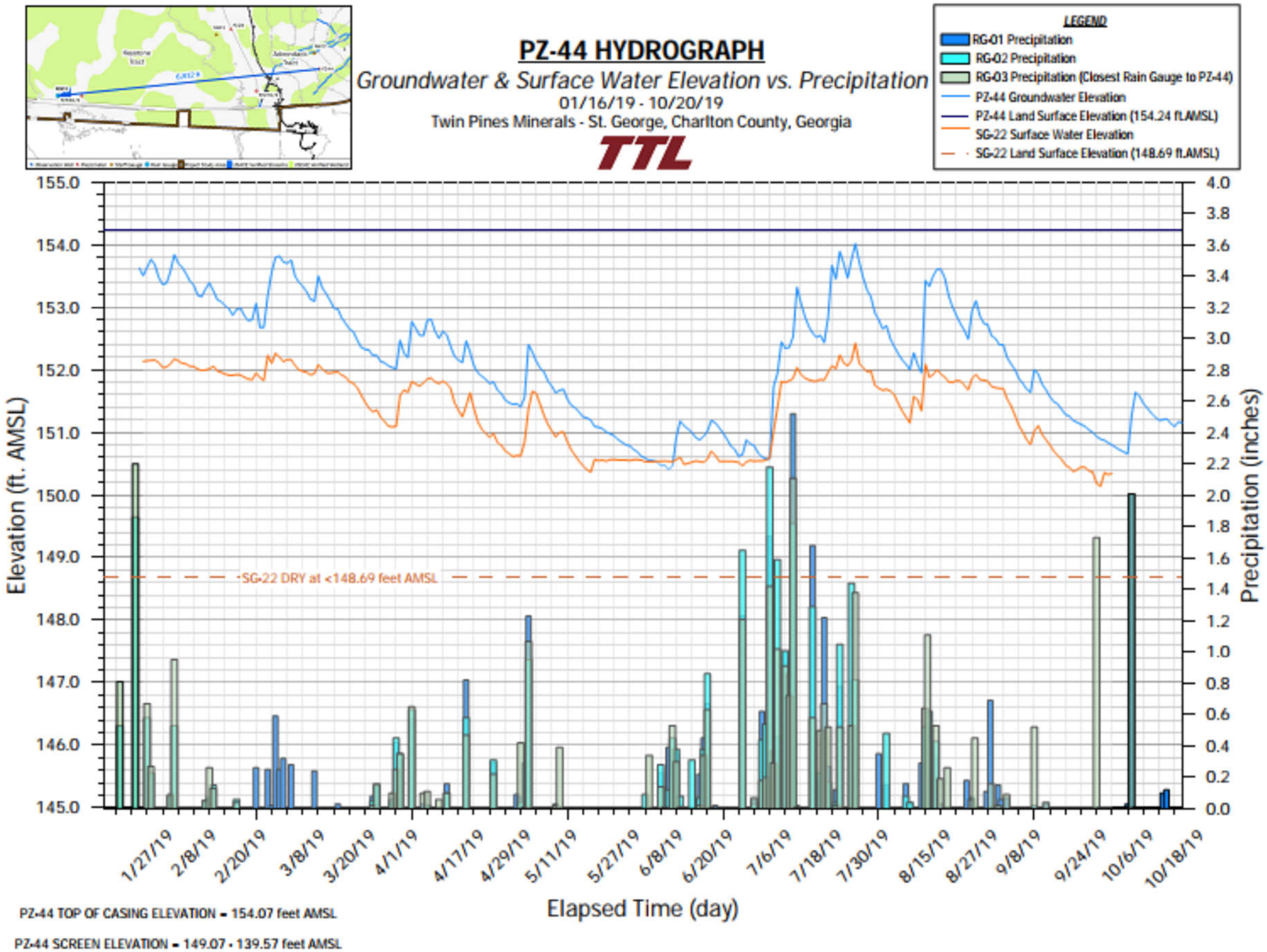


FIGURE 31: PZ-44 & SG-22 HYDROGRAPH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK

CHECKED BY: JRS

DRAWING DATE: 2/28/2020

REVISION DATE: N/A

TTL JOB NO.: 000180200804.00

APPROX. SCALE:

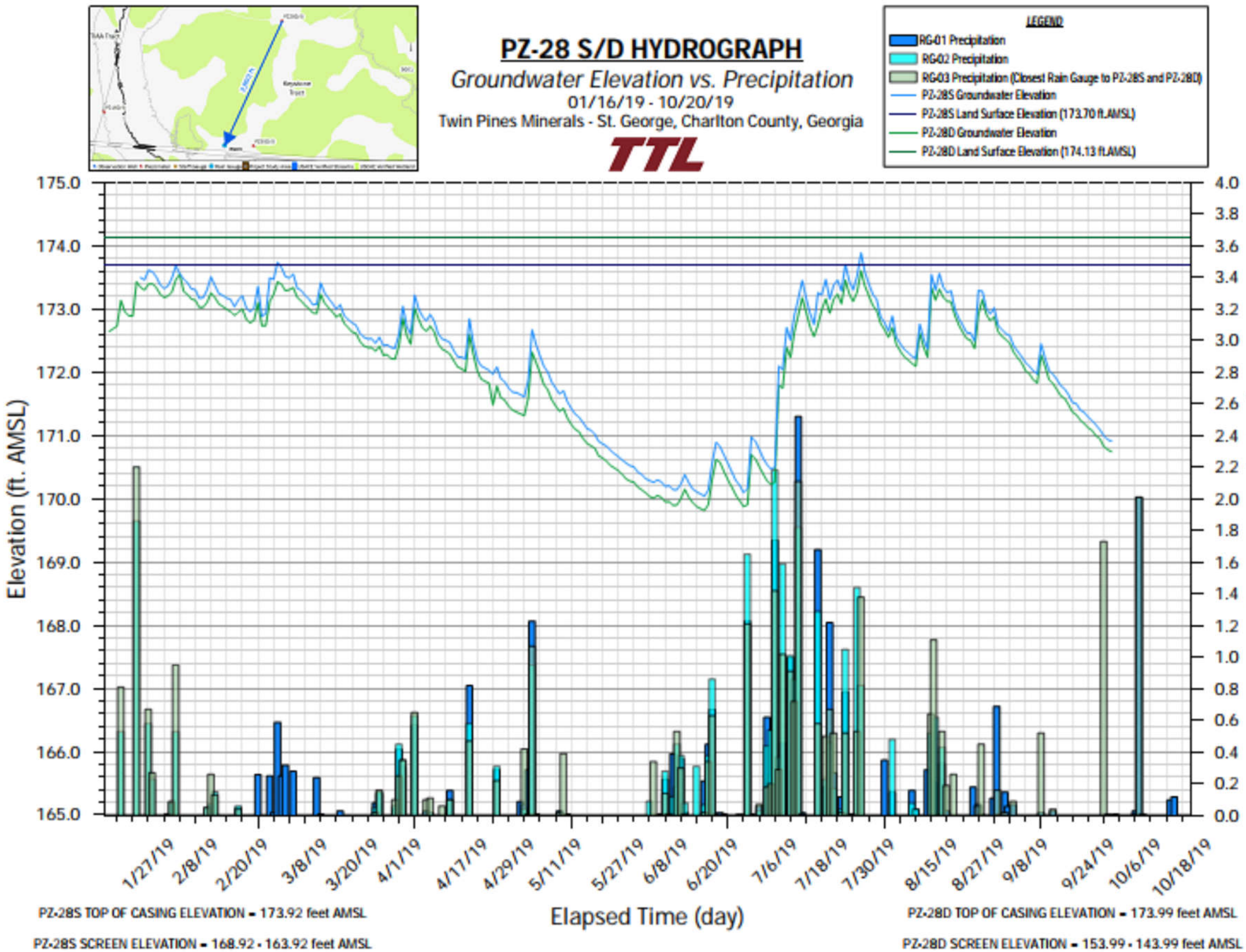


FIGURE 32: PZ-28S/D HYDROGRAPH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

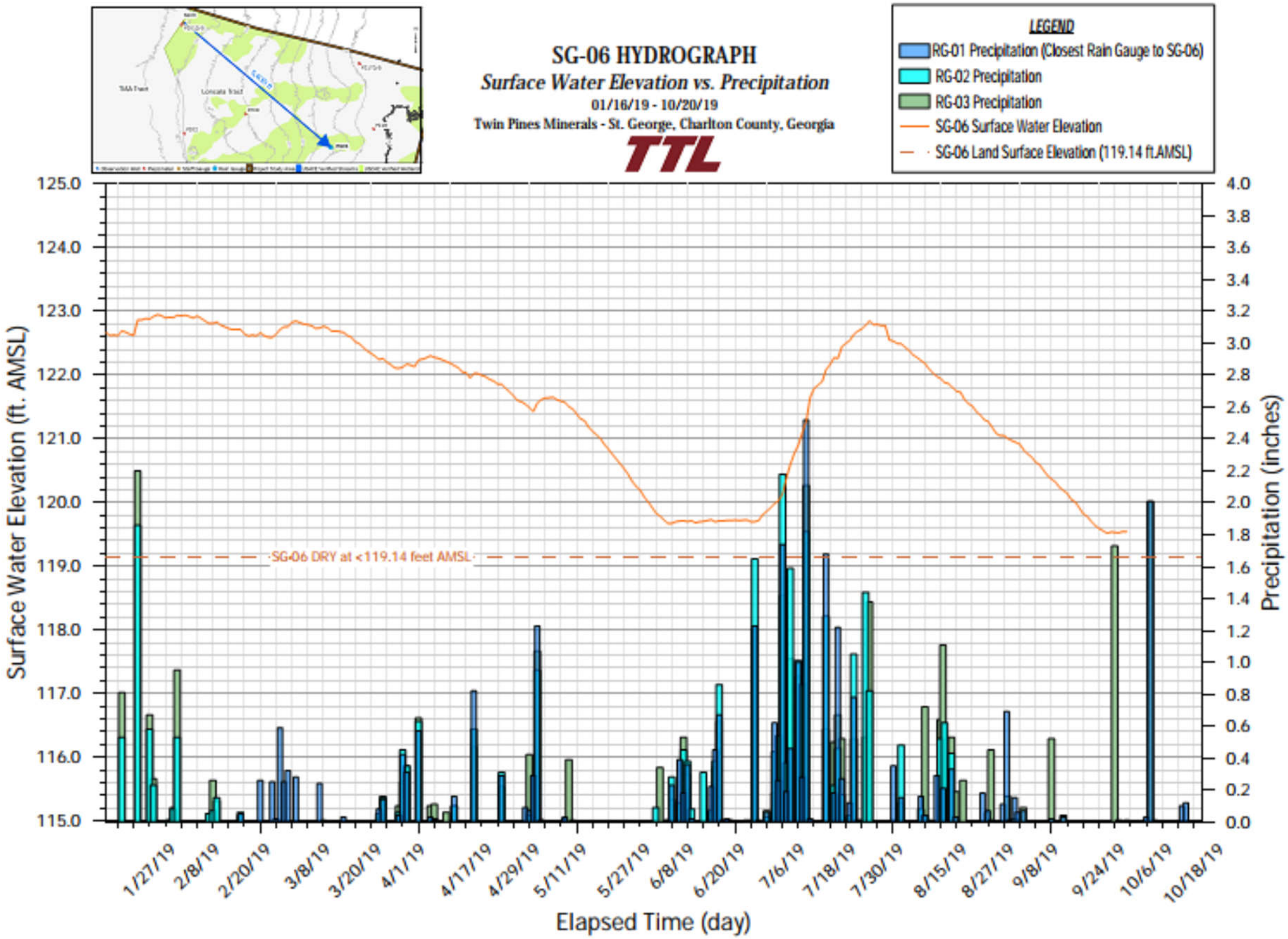


FIGURE 33: SG-06 HYDROGRAPH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

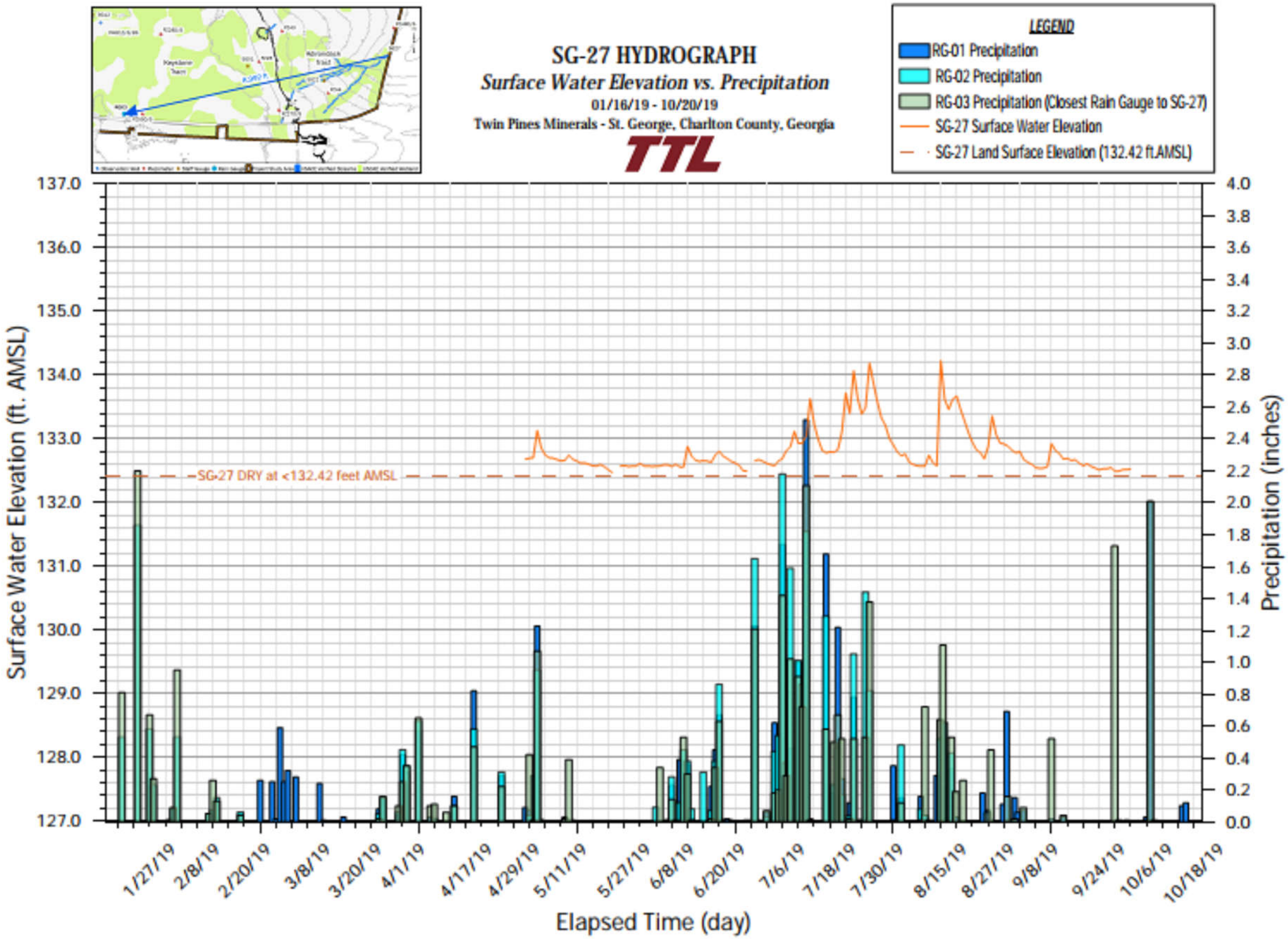


FIGURE 34: SG-27 HYDROGRAPH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:

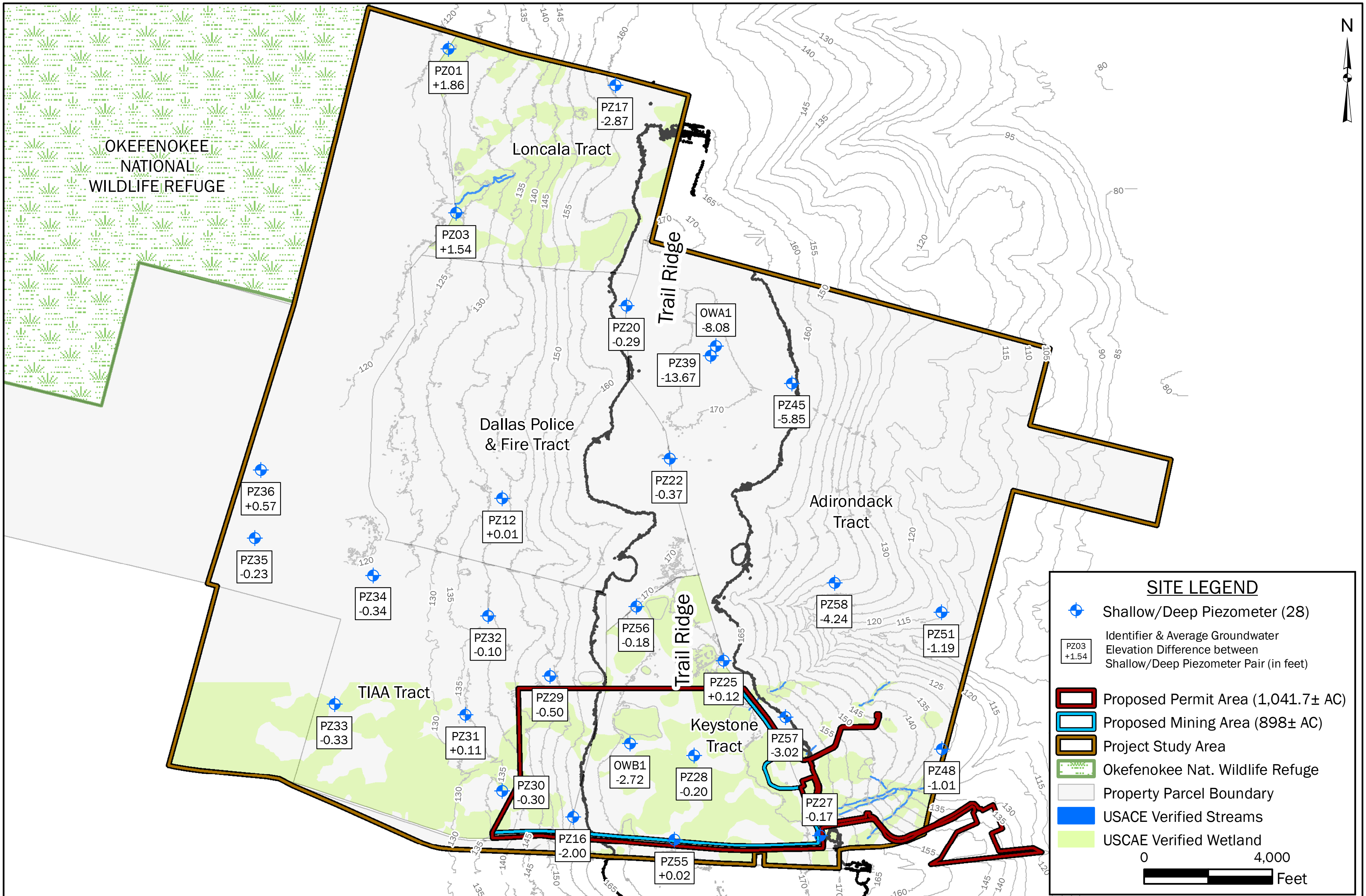


FIGURE 35: AVERAGE GROUNDWATER ELEVATION DIFFERENCES IN SHALLOW & DEEP PIEZOMETER PAIRS

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

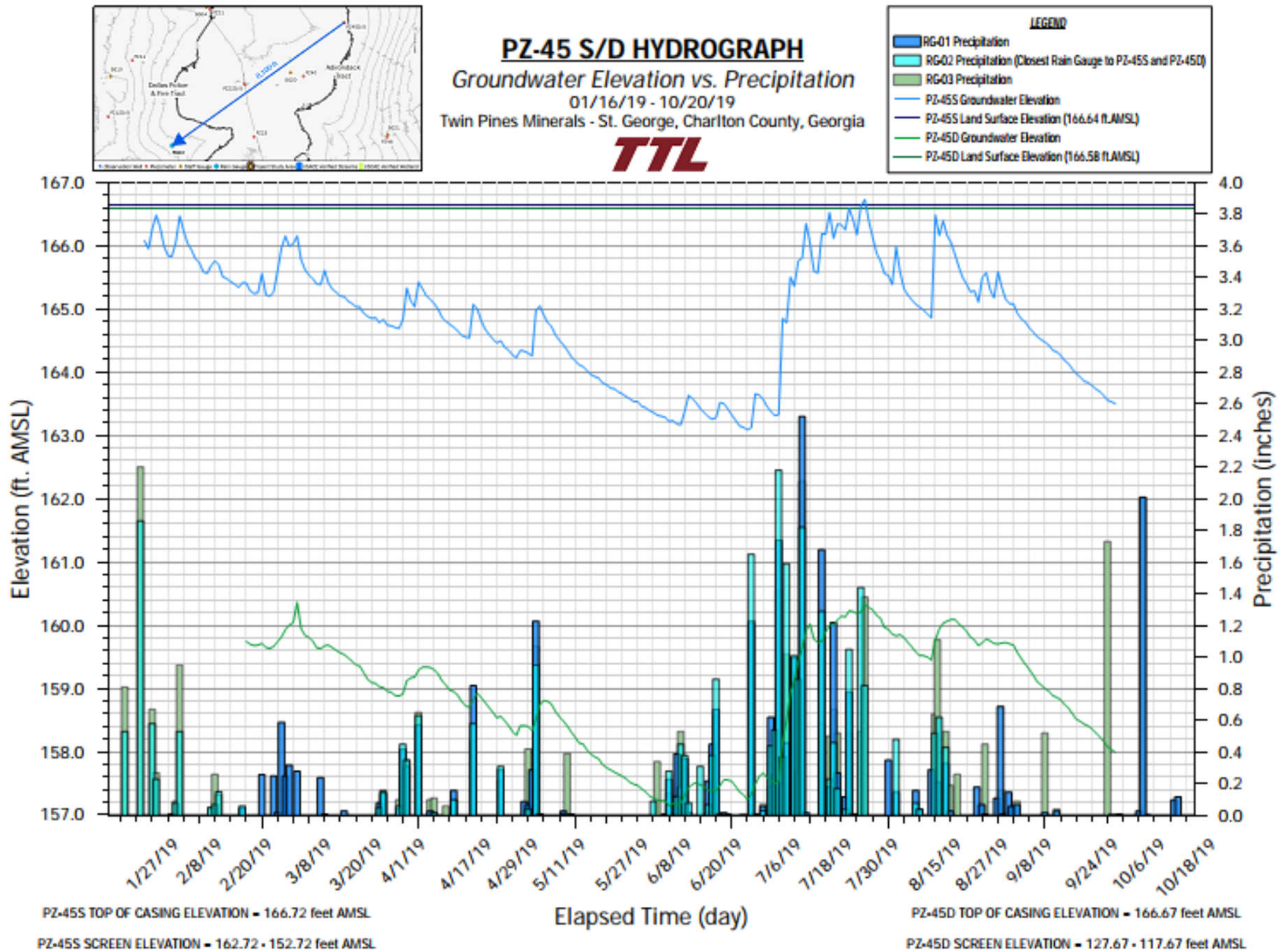


FIGURE 36: PZ-45S/D HYDROGRAPH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK

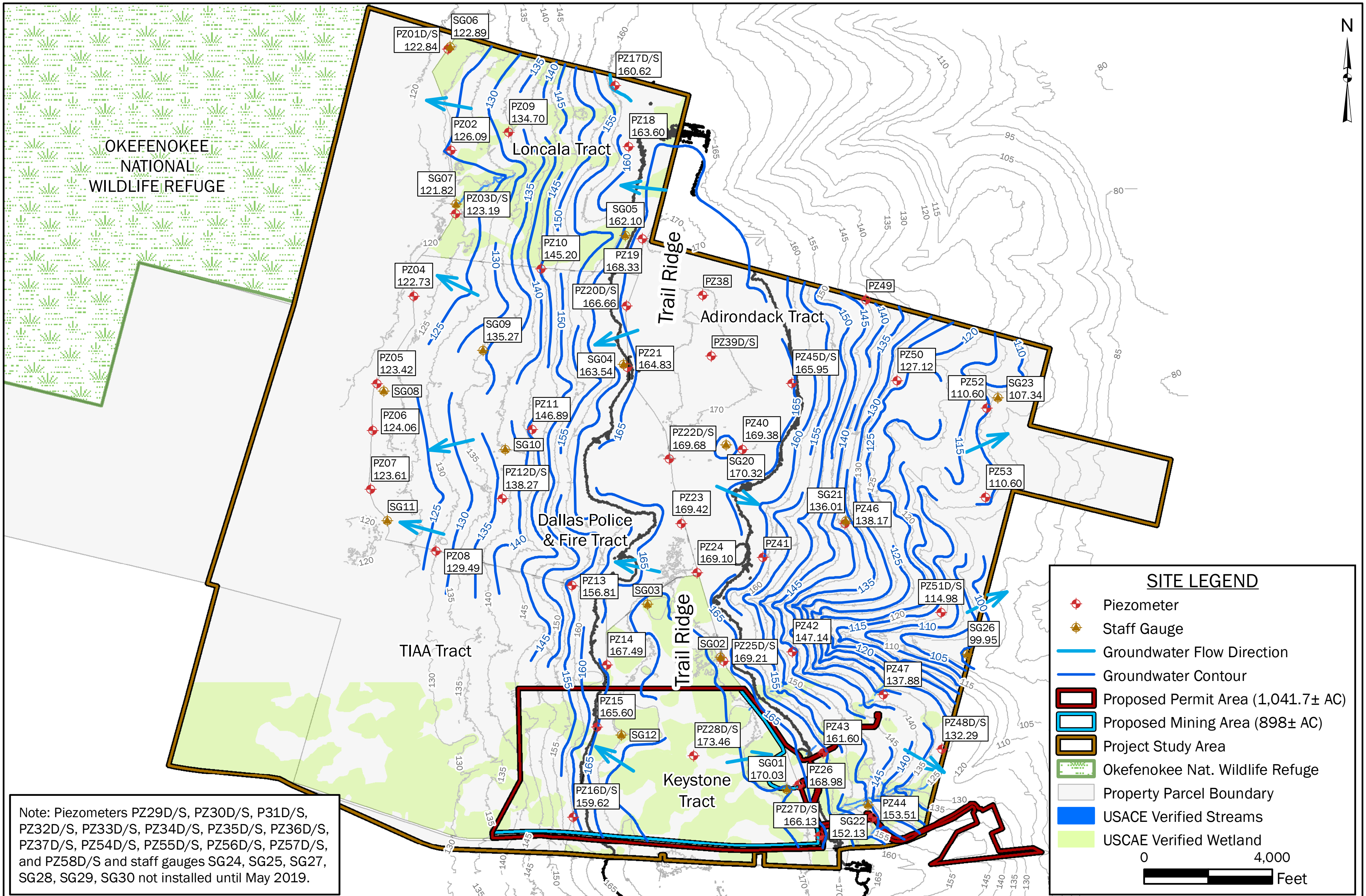
CHECKED BY: JRS

DRAWING DATE: 2/28/2020

REVISION DATE: N/A

TTL JOB NO.: 000180200804.00

APPROX. SCALE:



Note: Piezometers PZ29D/S, PZ30D/S, P31D/S, PZ32D/S, PZ33D/S, PZ34D/S, PZ35D/S, PZ36D/S, PZ37D/S, PZ54D/S, PZ55D/S, PZ56D/S, PZ57D/S, and PZ58D/S and staff gauges SG24, SG25, SG27, SG28, SG29, SG30 not installed until May 2019.

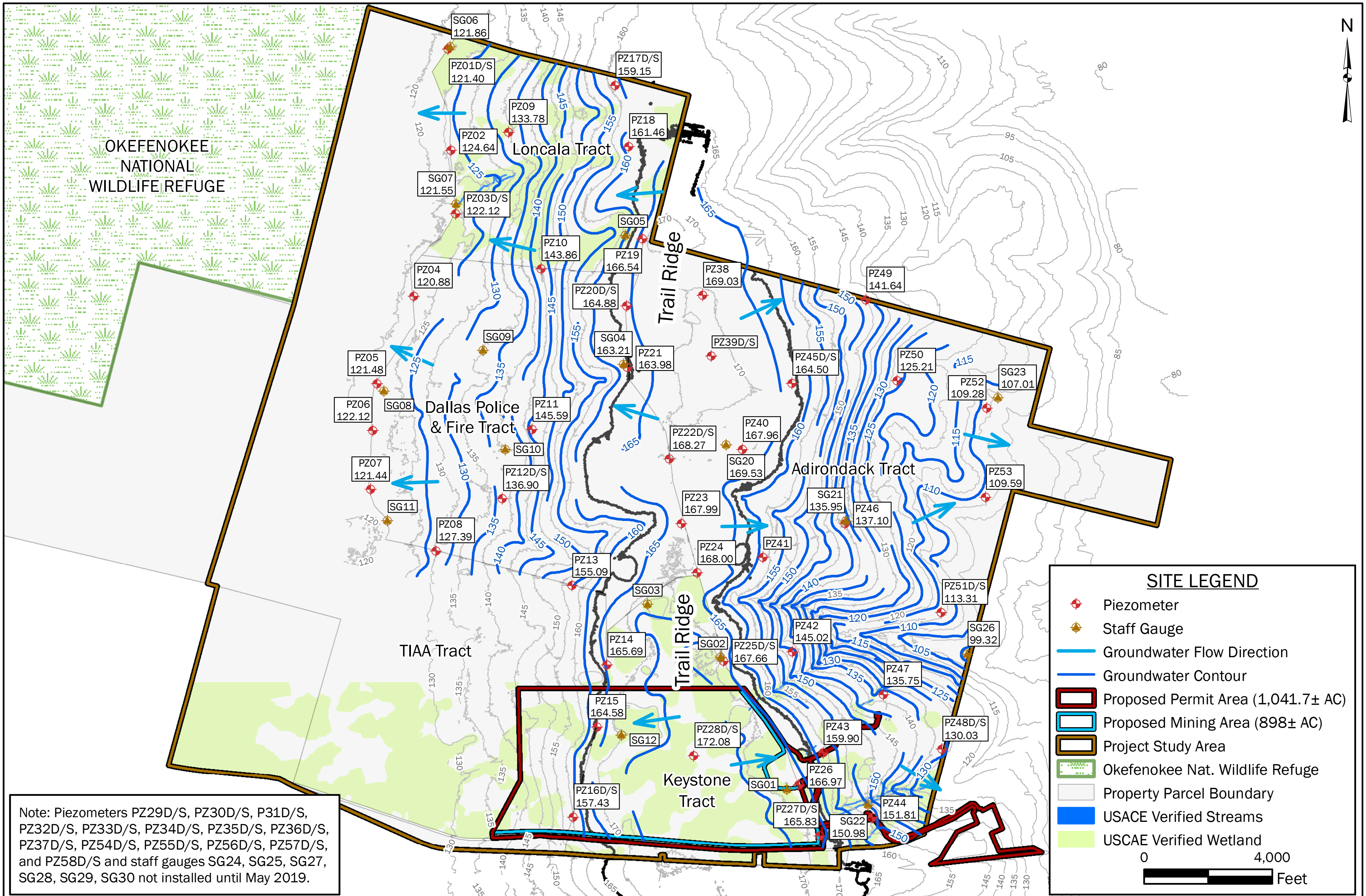
TTL

FIGURE 37: POTENTIOMETRIC SURFACE MAP OF THE SURFICIAL AQUIFER (JANUARY 26, 2019)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JRS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 4,000 ft



TTL

FIGURE 38: POTENTIOMETRIC SURFACE MAP OF THE SURFICIAL AQUIFER (APRIL 26, 2019)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

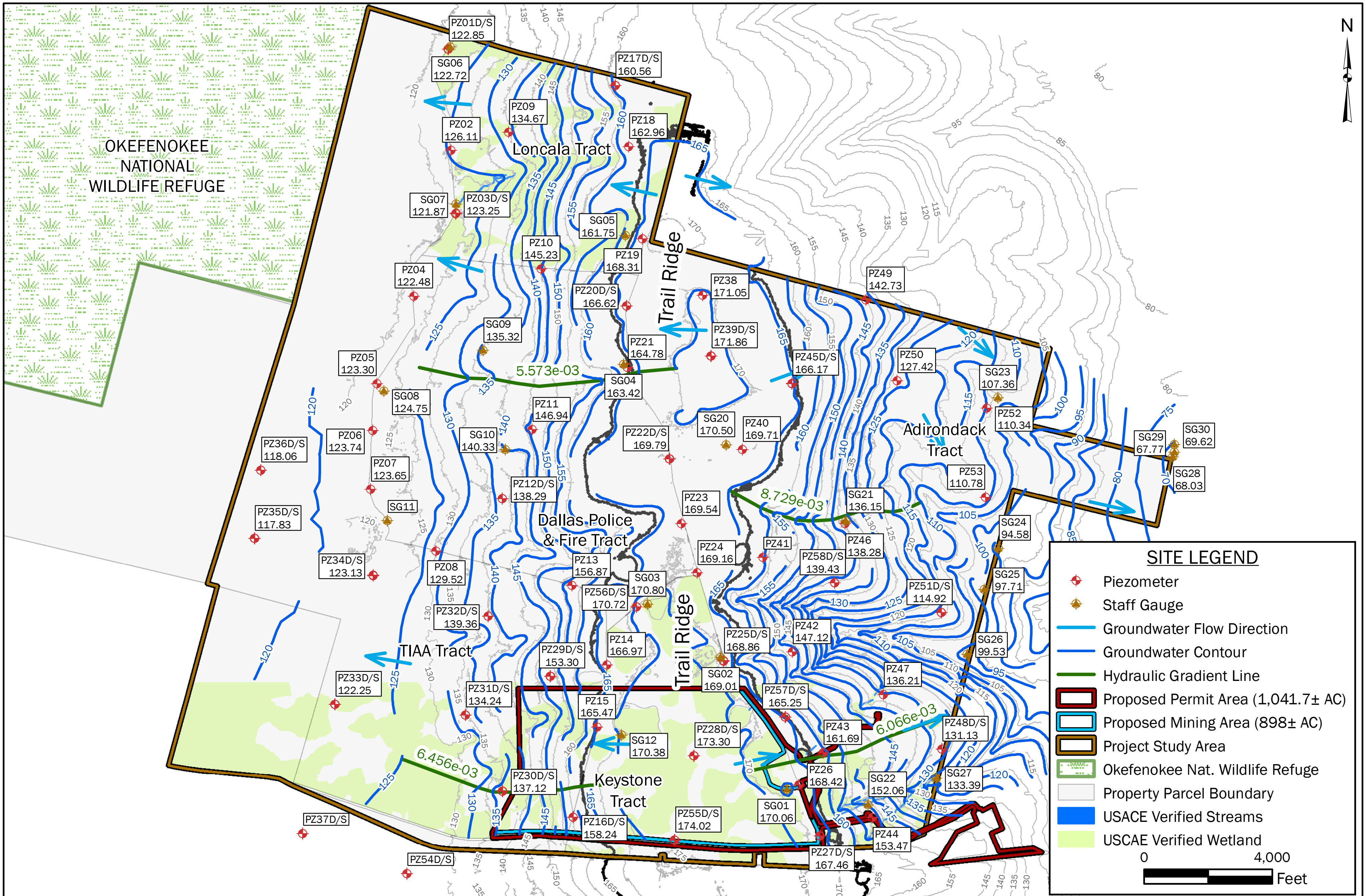
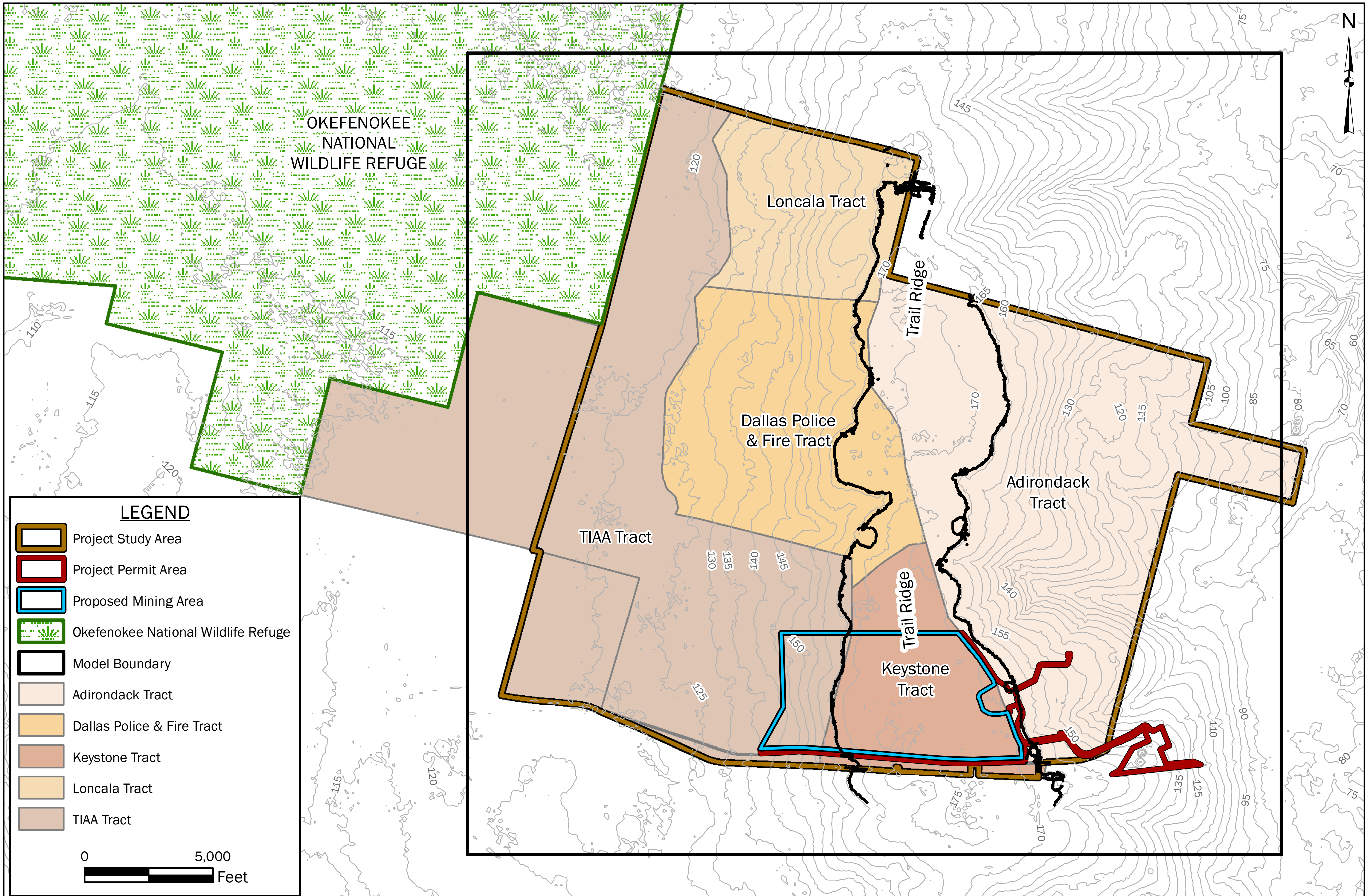


FIGURE 39: POTENTIOMETRIC SURFACE MAP OF THE SURFICIAL AQUIFER (JULY 26, 2019)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: JRS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft



TTL

FIGURE 40: MODEL AREA MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft

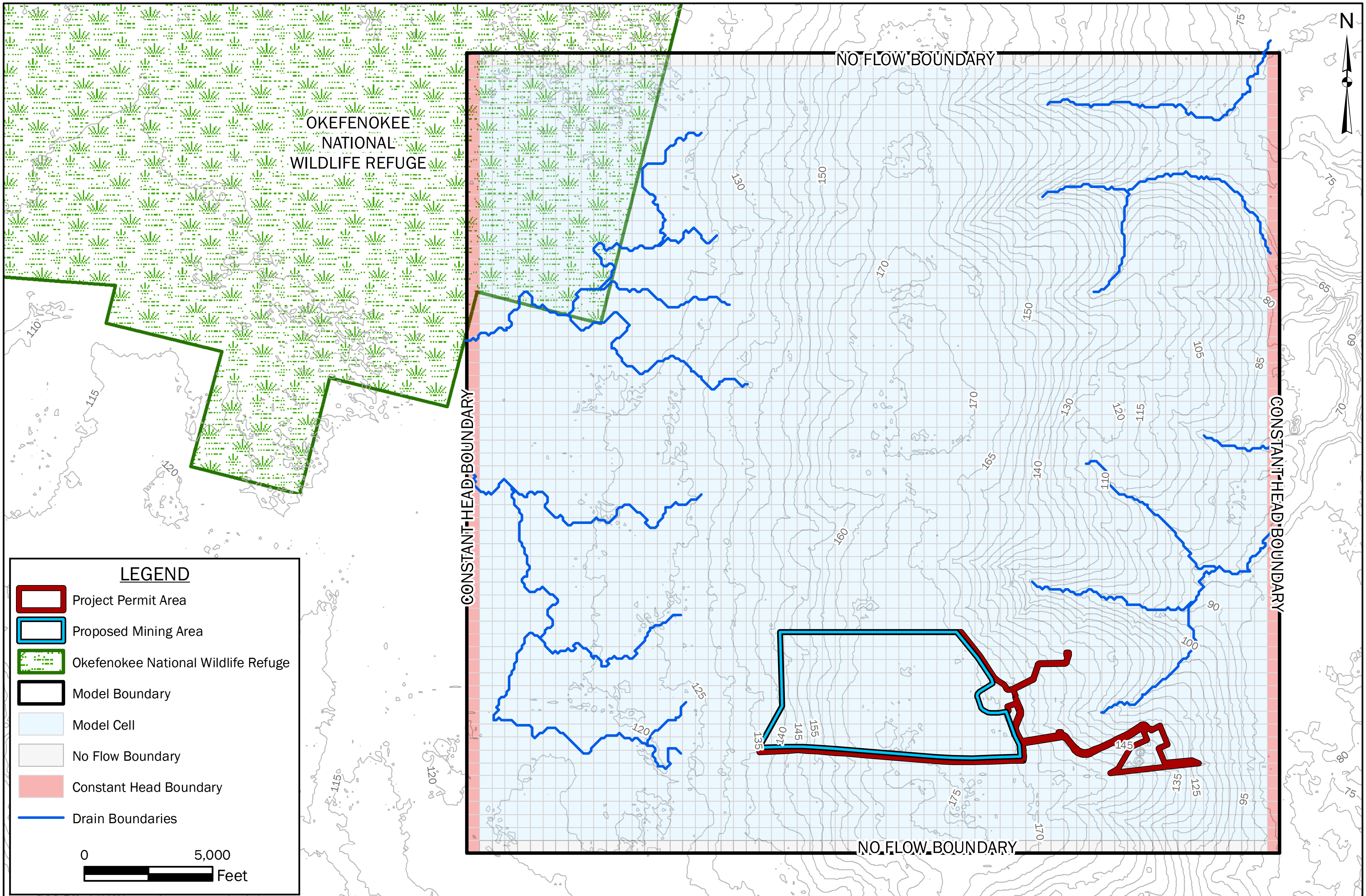
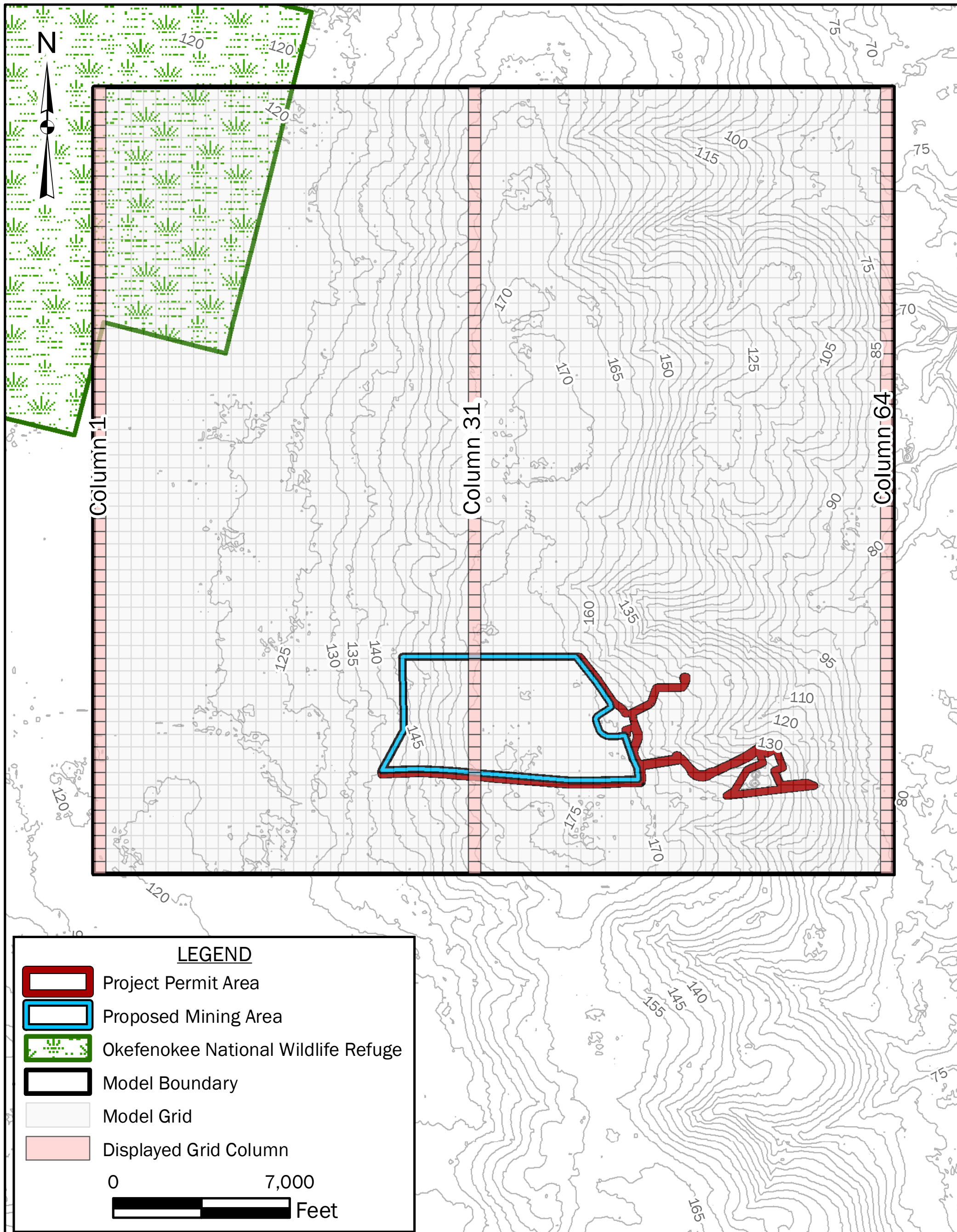


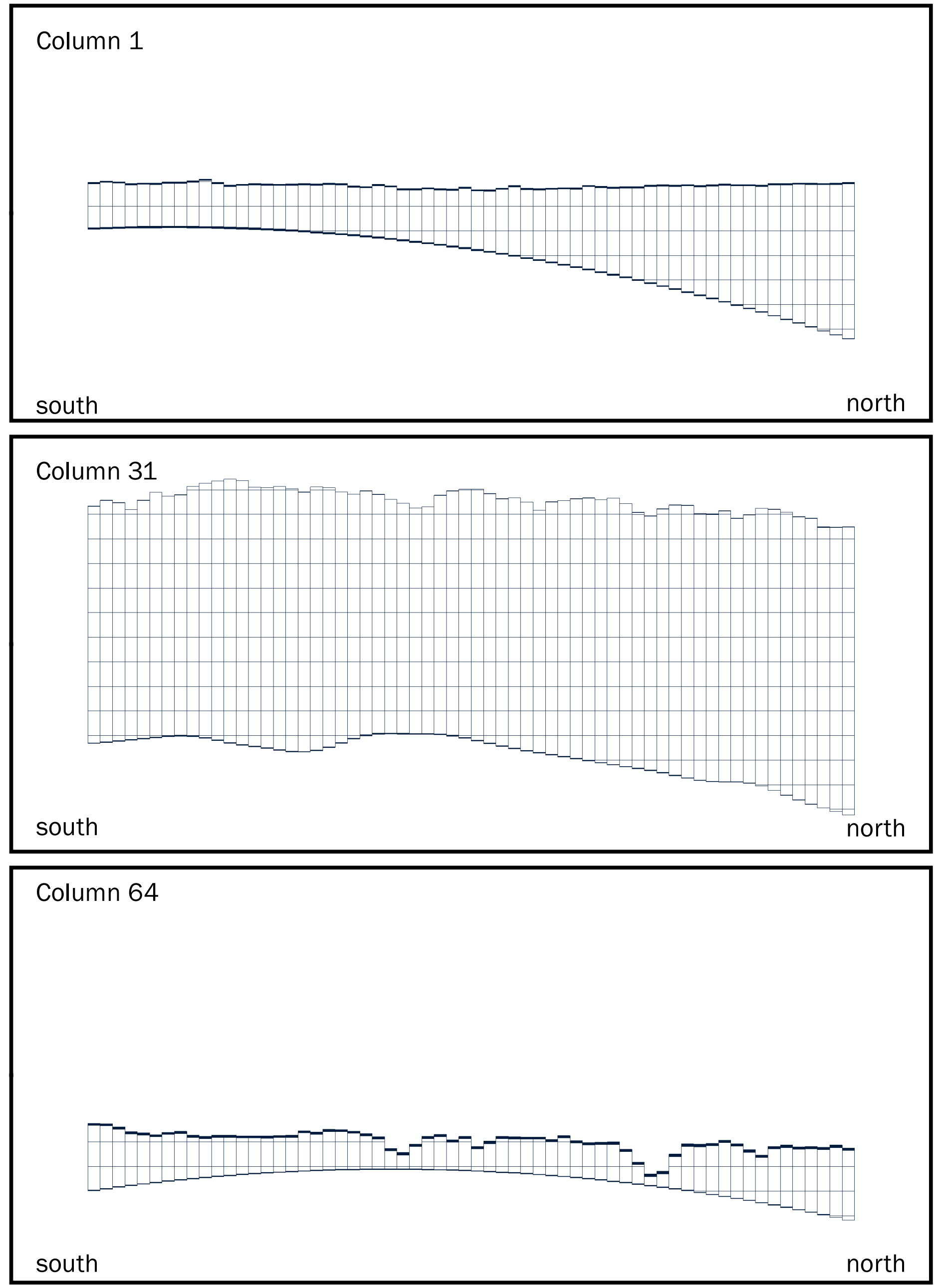
FIGURE 41: MODEL GRID & BOUNDARY CONDITIONS

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft





TTL

FIGURE 42: VERTICAL MODEL GRID - NORTH TO SOUTH

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 7,000 ft

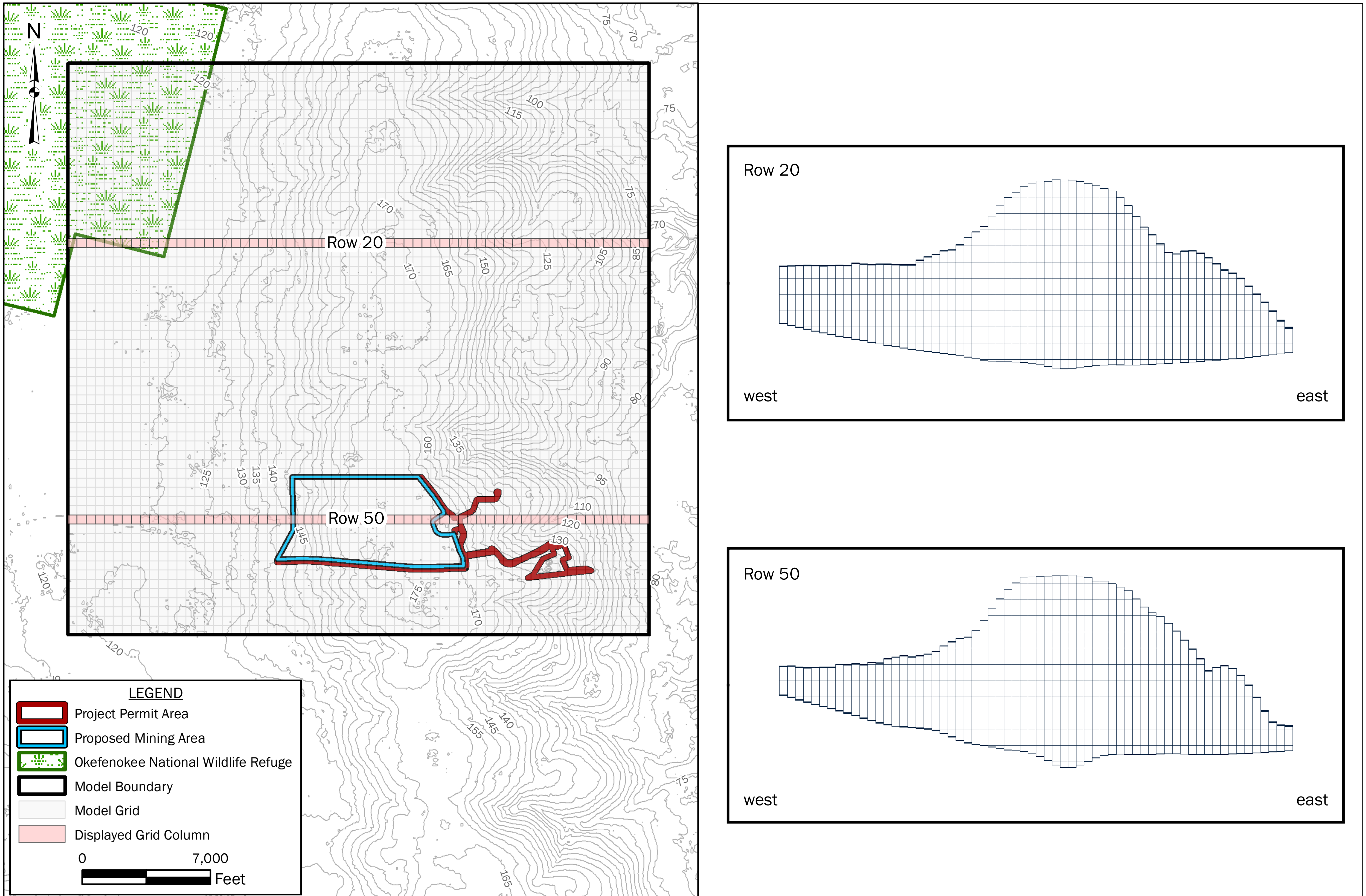


FIGURE 43: VERTICAL MODEL GRID - WEST TO EAST

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 7,000 ft

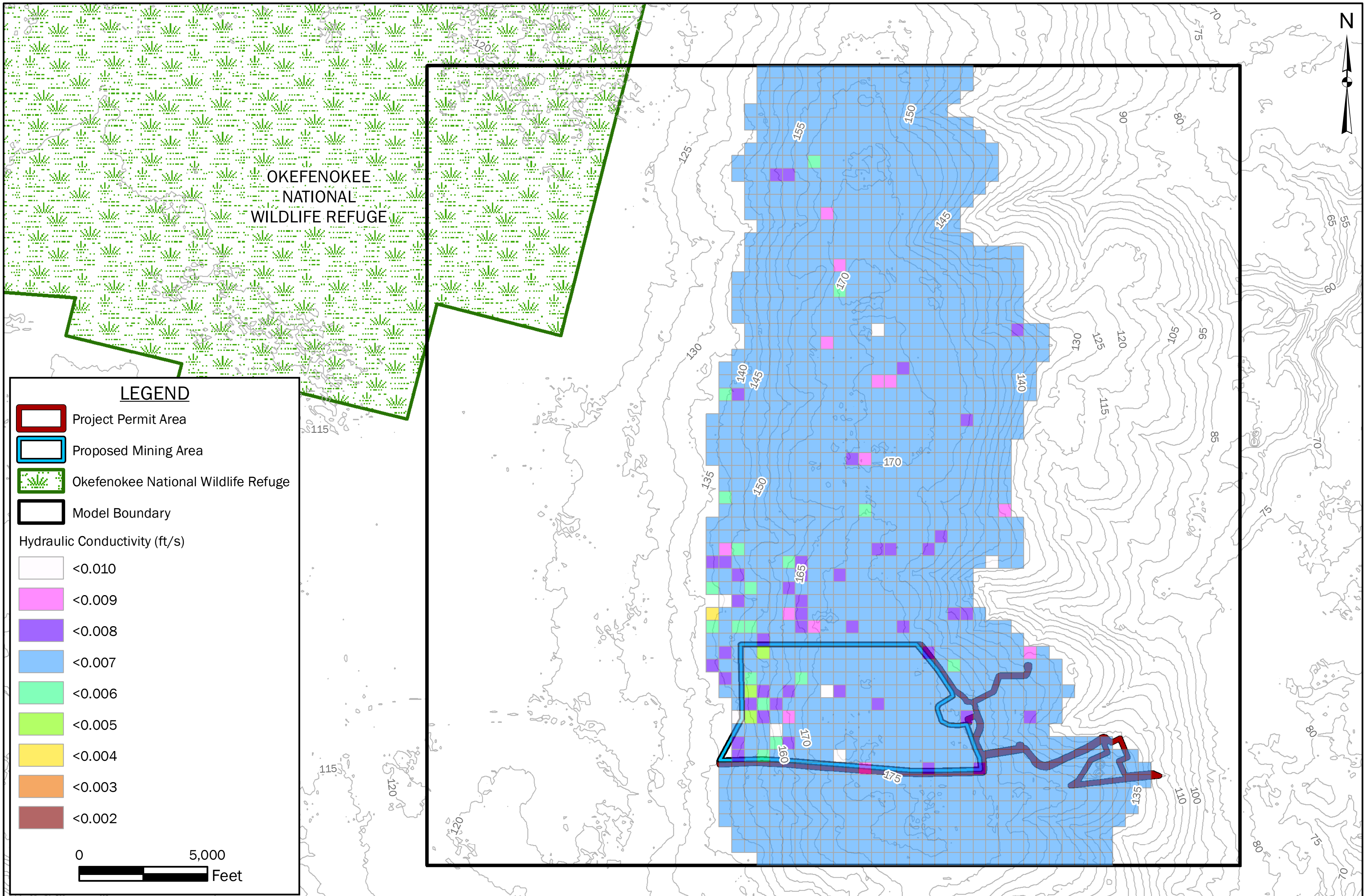


FIGURE 44: INITIAL MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 4

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

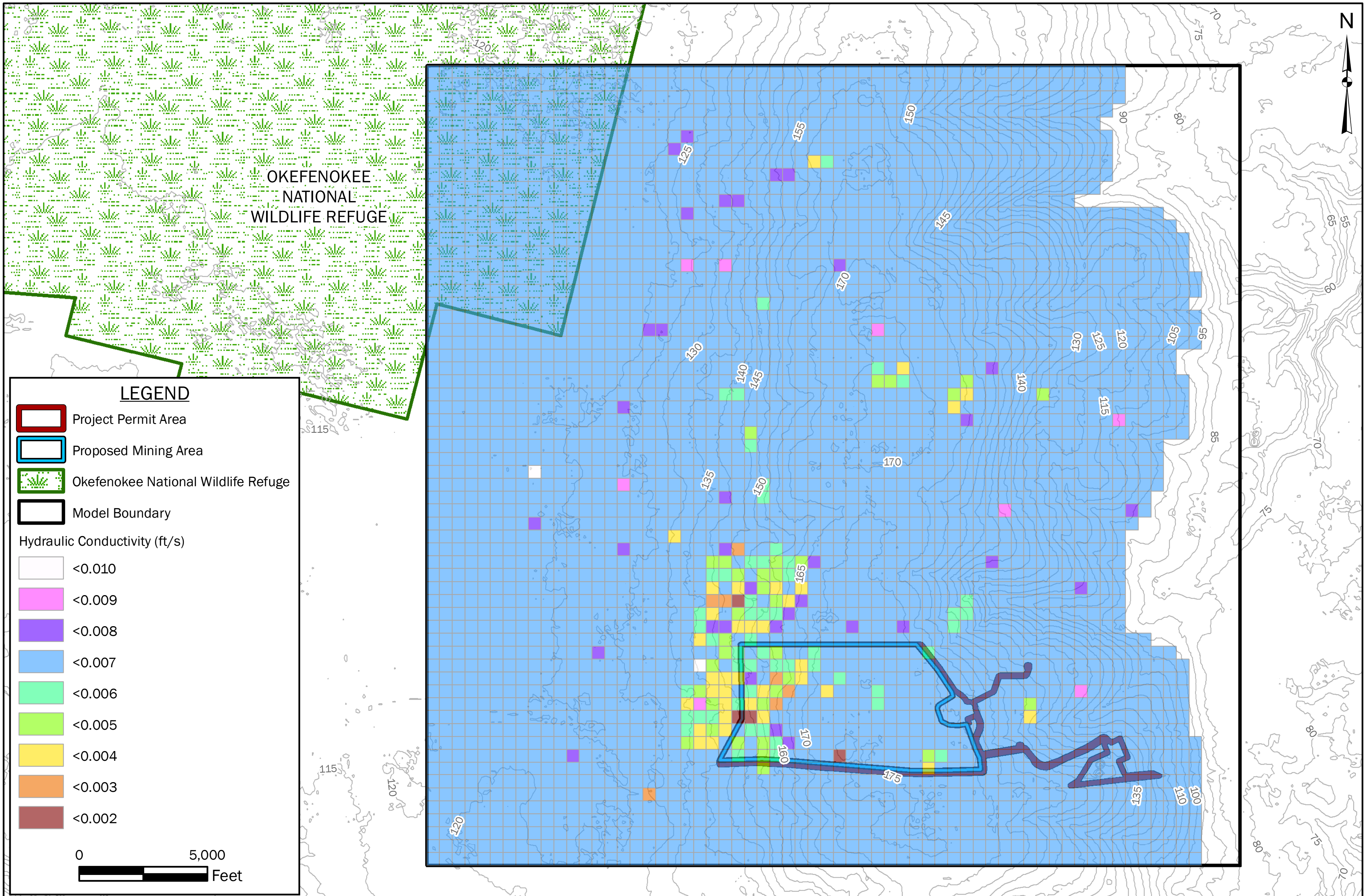


FIGURE 45: INITIAL MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 8

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

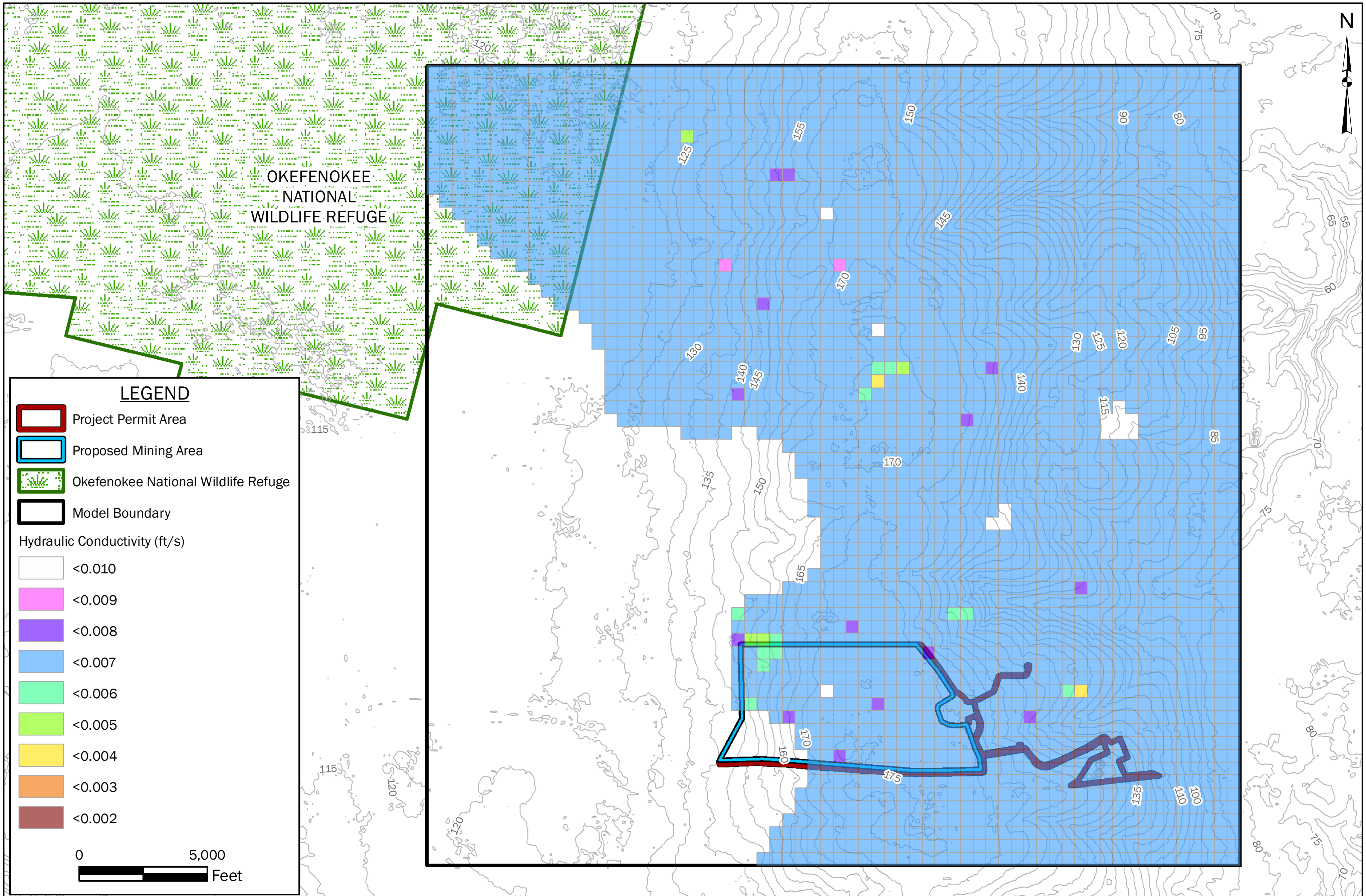


FIGURE 46: INITIAL MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 12

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

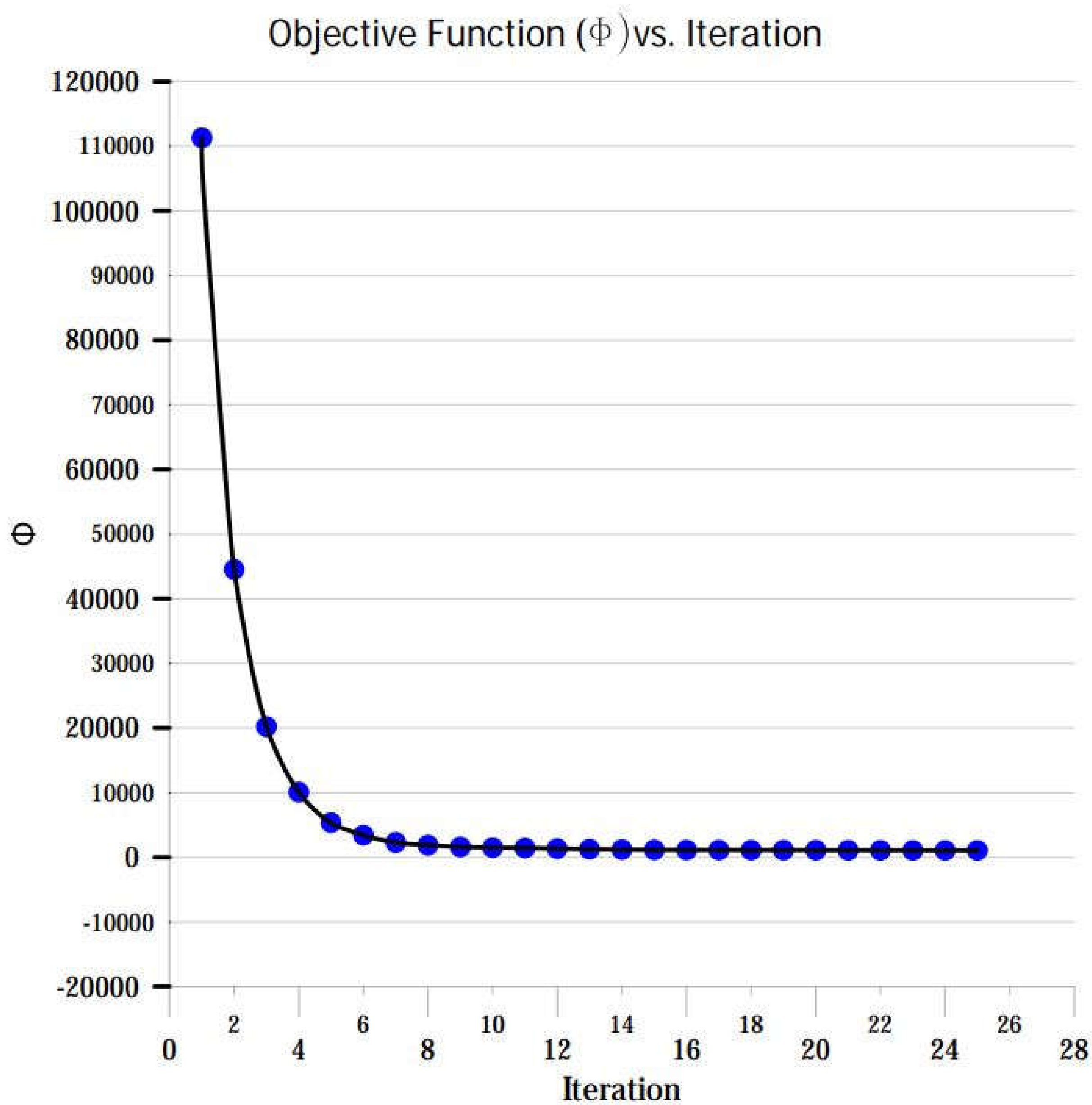
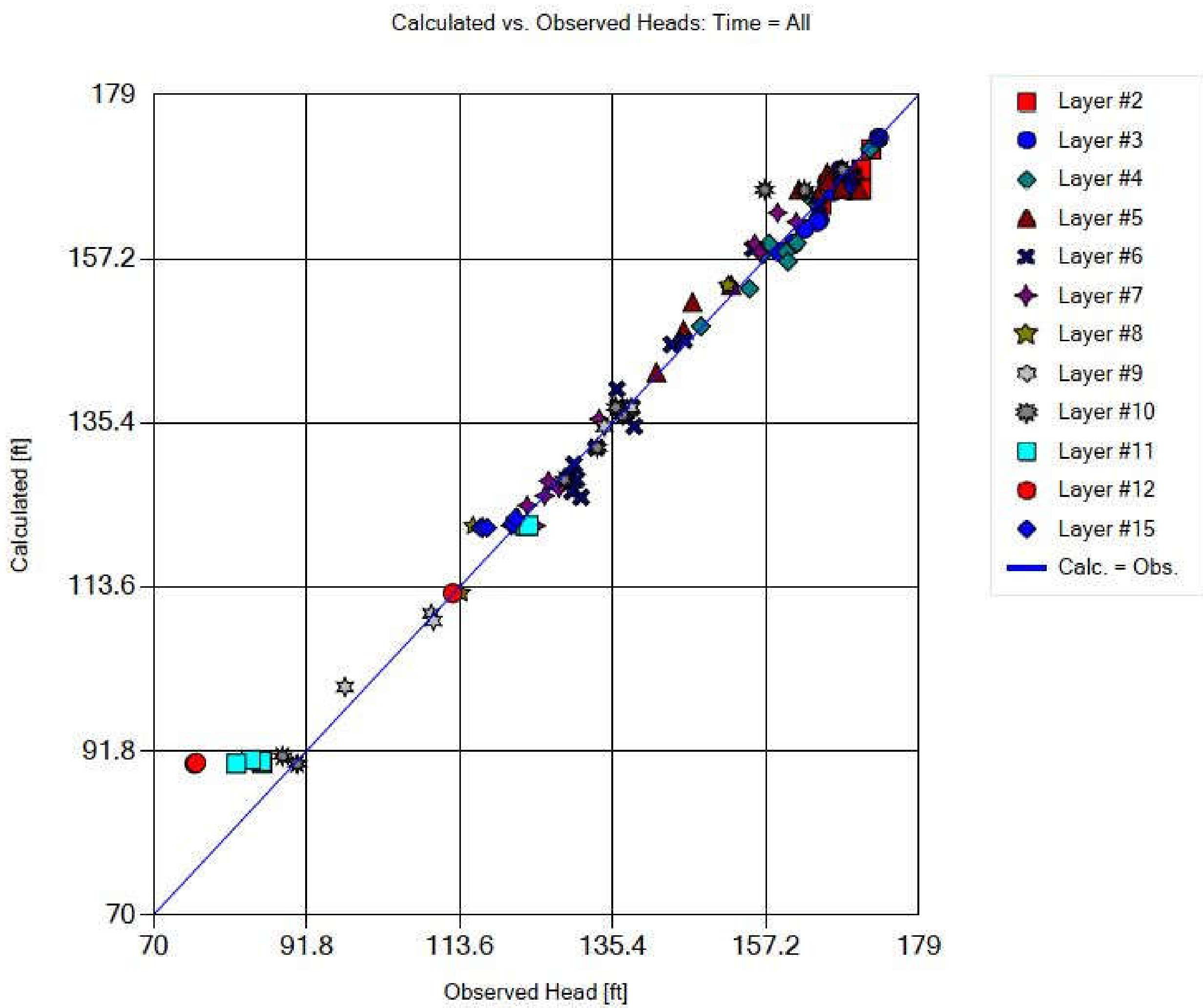


FIGURE 47: OBJECTIVE FUNCTION VS. ITERATION

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:



Min.Residual: -0.0051 (ft) at PZ06/PZ06 Time=0
Max.Residual: 14.27 (ft) at L7/L7 Time=0
Residual Mean: 0.76 (ft)
Abs.Residual Mean: 2.16 (ft)

Standard Error of the Estimate: 0.3 (ft)
Root Mean Squared: 3.23 (ft)
Normalized RMS: 3.31 (%)
Correlation Coefficient: 0.99

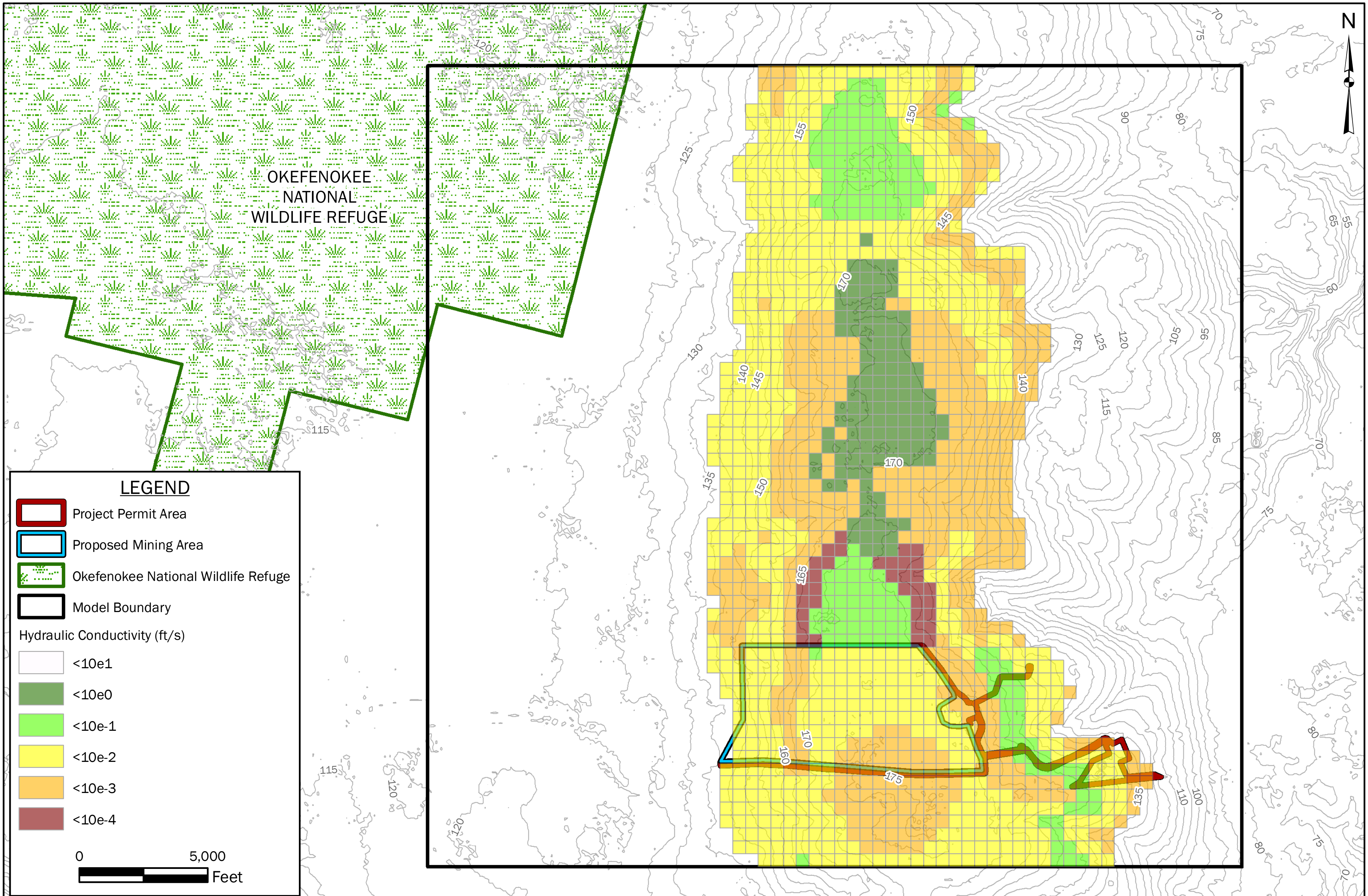
TTL

FIGURE 48: CALCULATED VS. OBSERVED HEADS - CALIBRATED

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:



TTL

FIGURE 49: CALIBRATED MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 4

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK

CHECKED BY: RMH

DRAWING DATE: 2/28/2020

REVISION DATE: N/A

TTL JOB NO.: 000180200804.00

APPROX. SCALE: 1 in = 5,000 ft

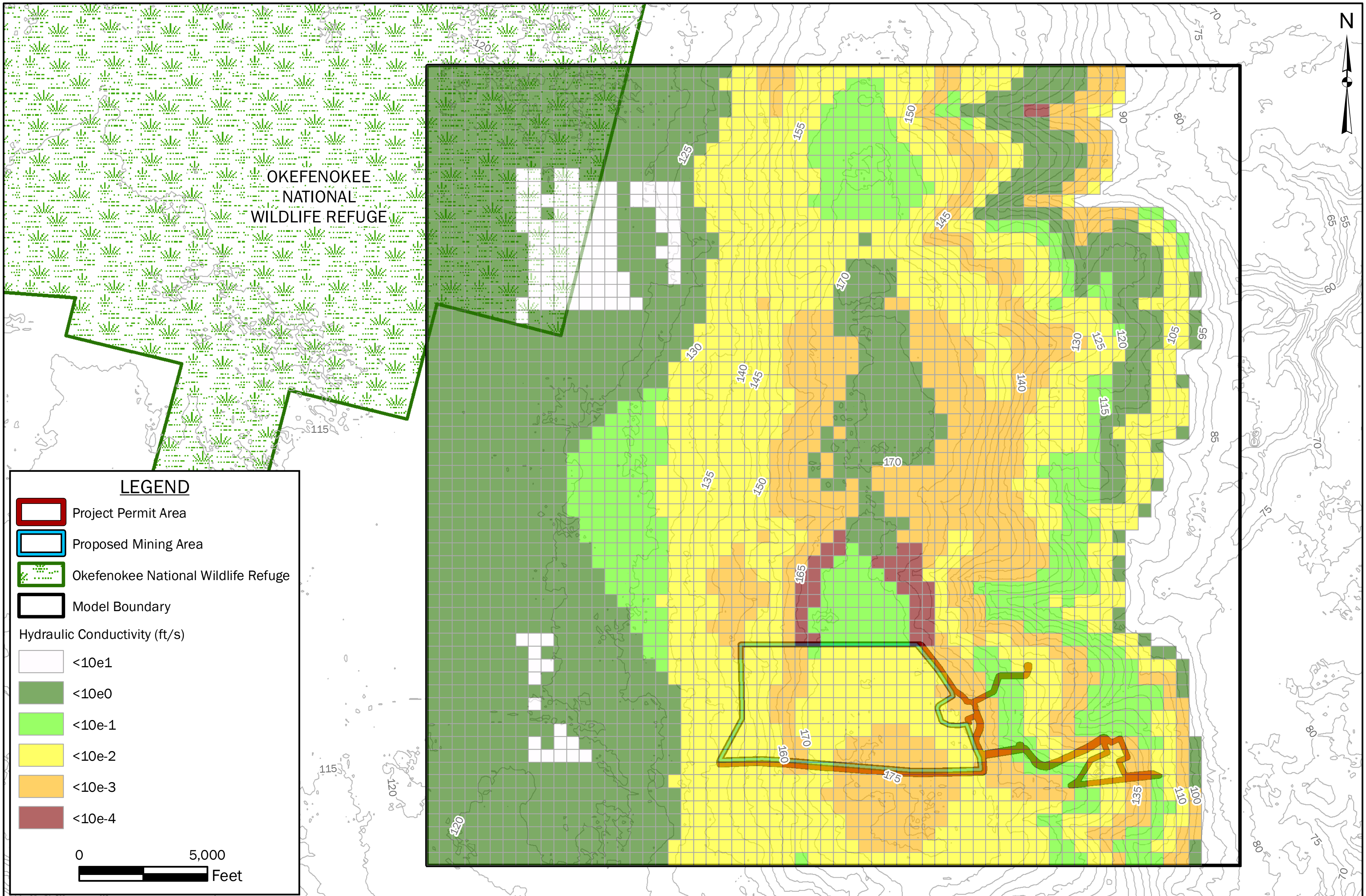
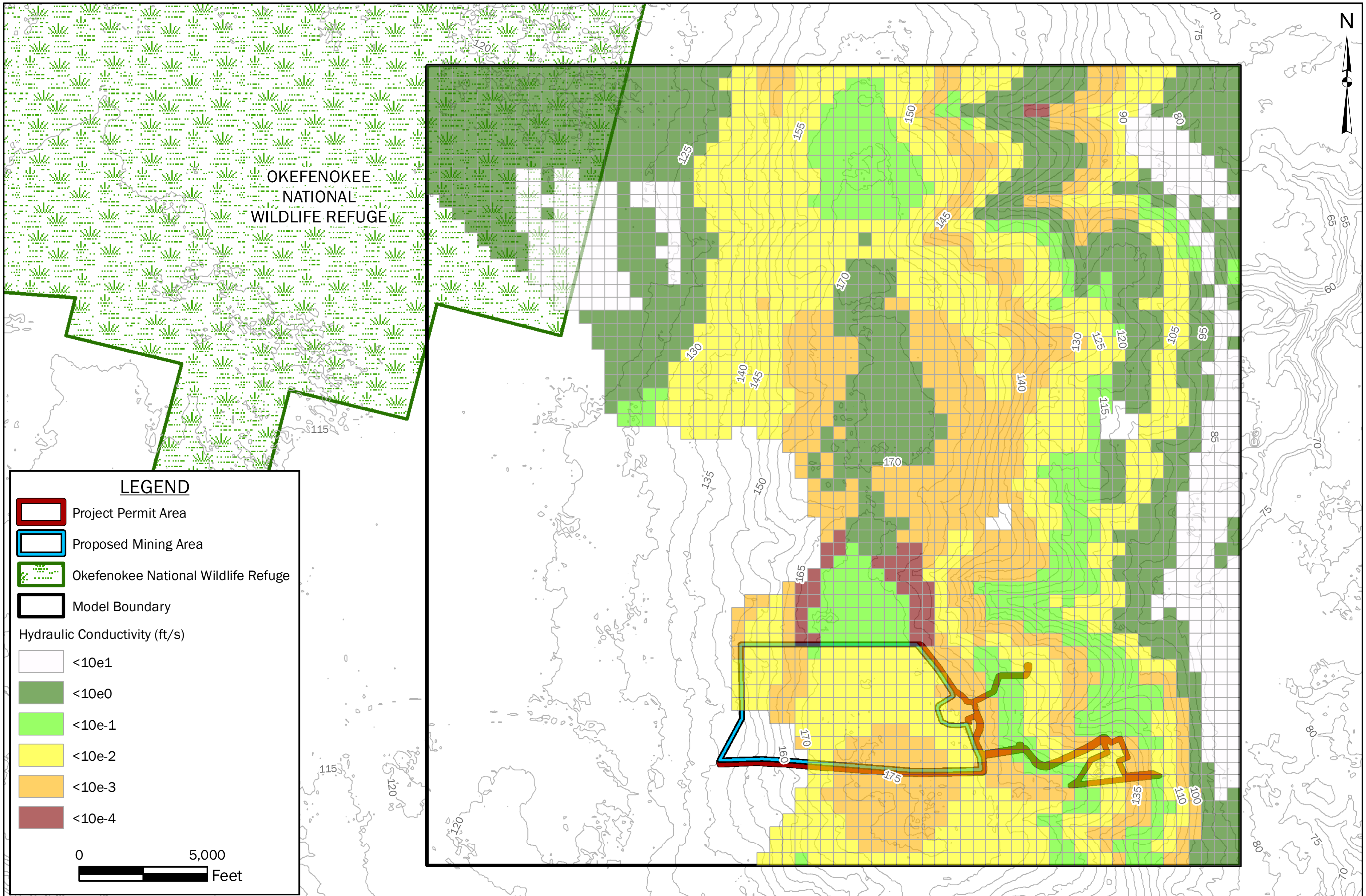


FIGURE 50: CALIBRATED MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 8

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft



TTL

FIGURE 51: CALIBRATED MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 12

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft

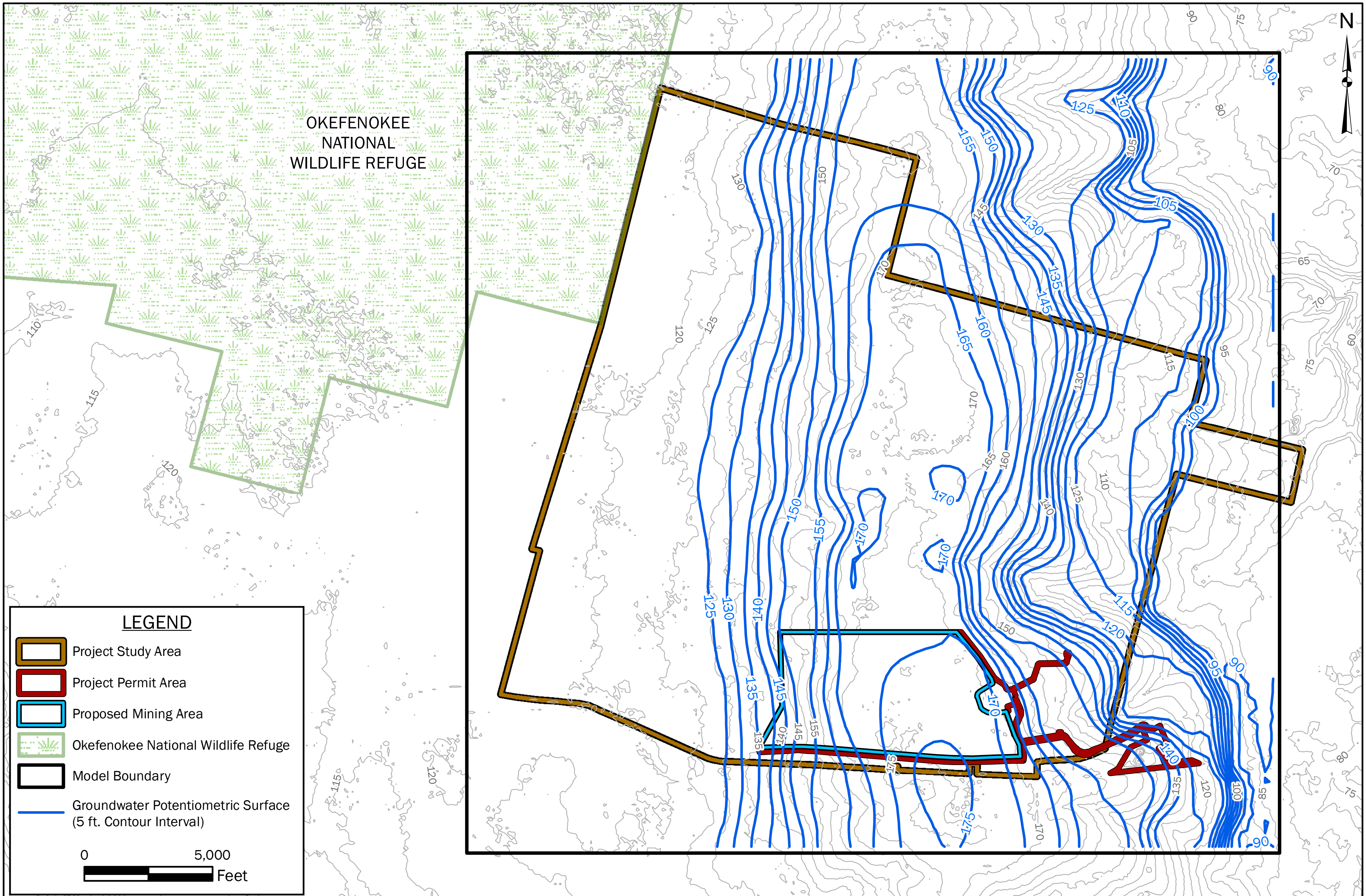
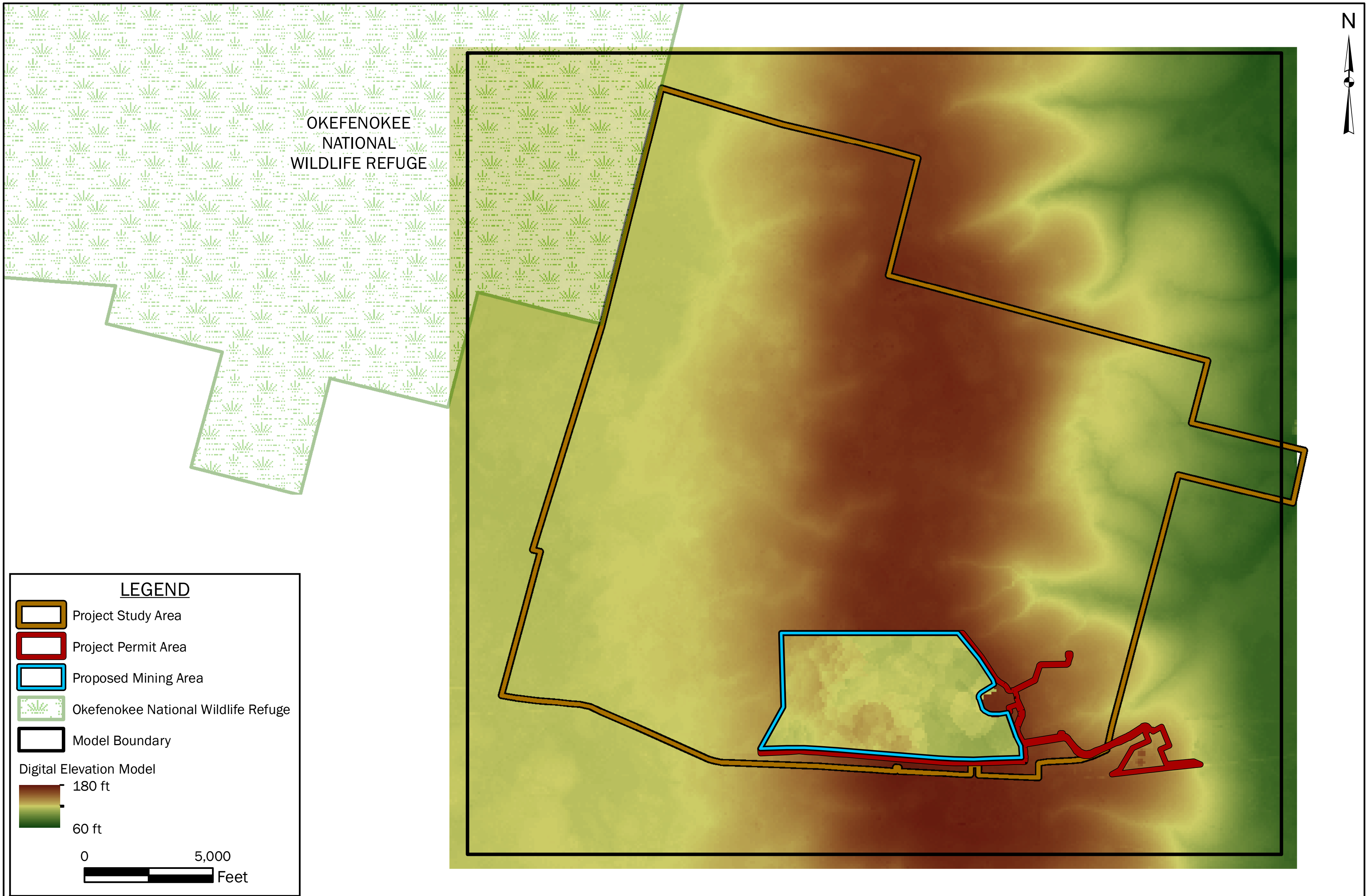


FIGURE 52: PRE-MINING MODEL POTENTIOMETRIC SURFACE MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft



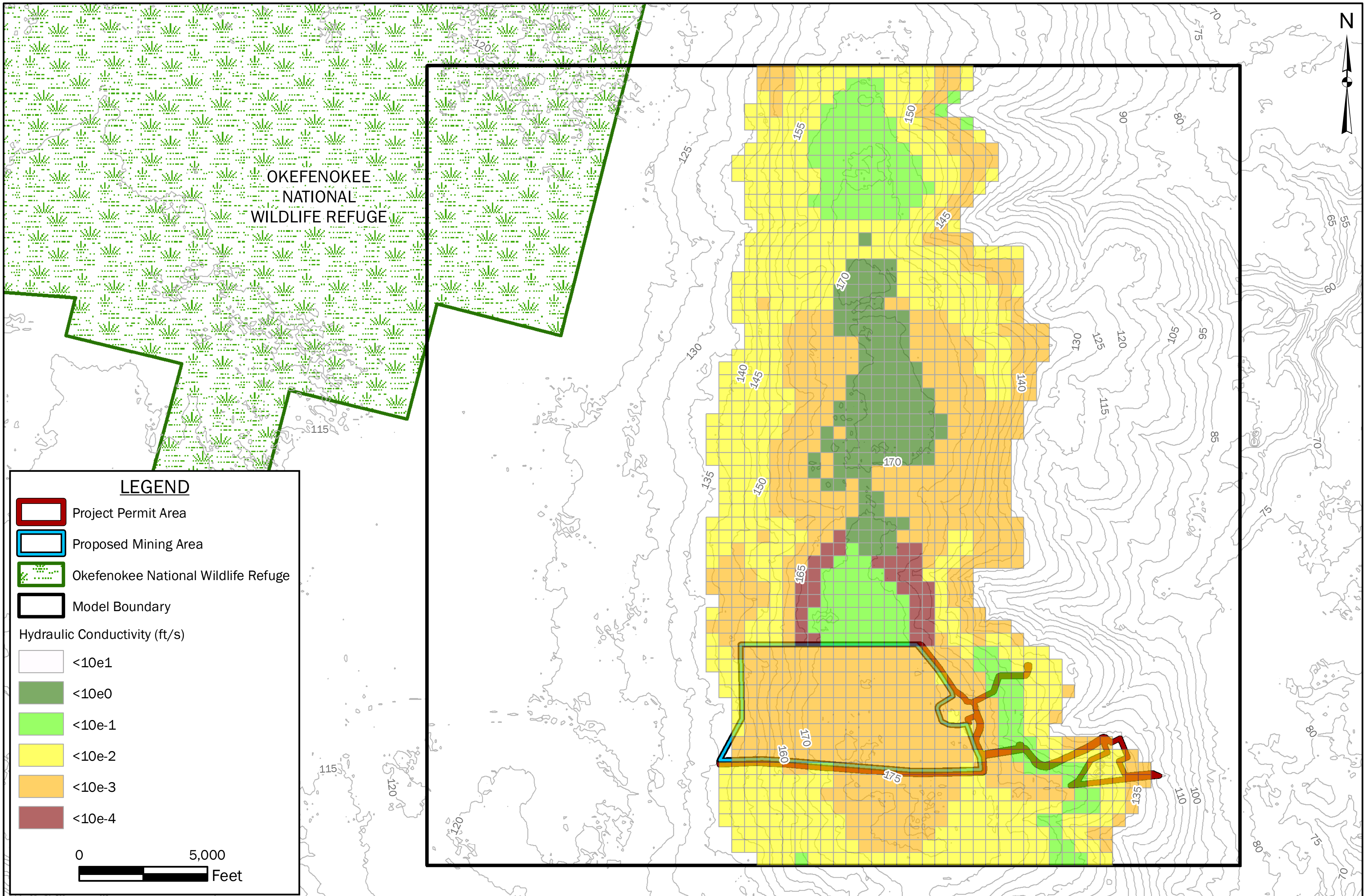
TTL

FIGURE 53: SURFACE & MINING BASE DIGITAL ELEVATION MODEL

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft



TTL

FIGURE 54: POST-MINING MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 4

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

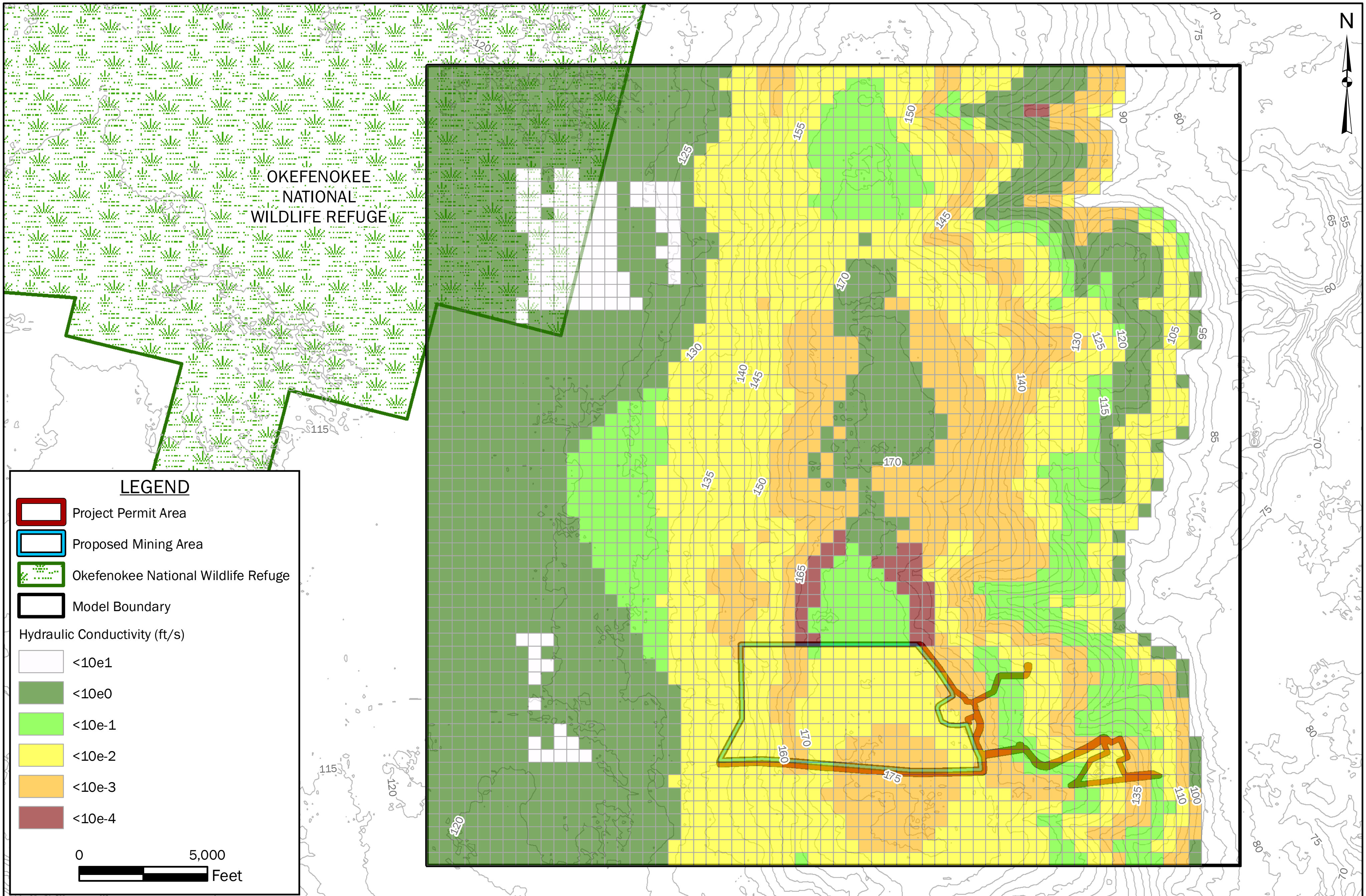


FIGURE 55: POST-MINING MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 8

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

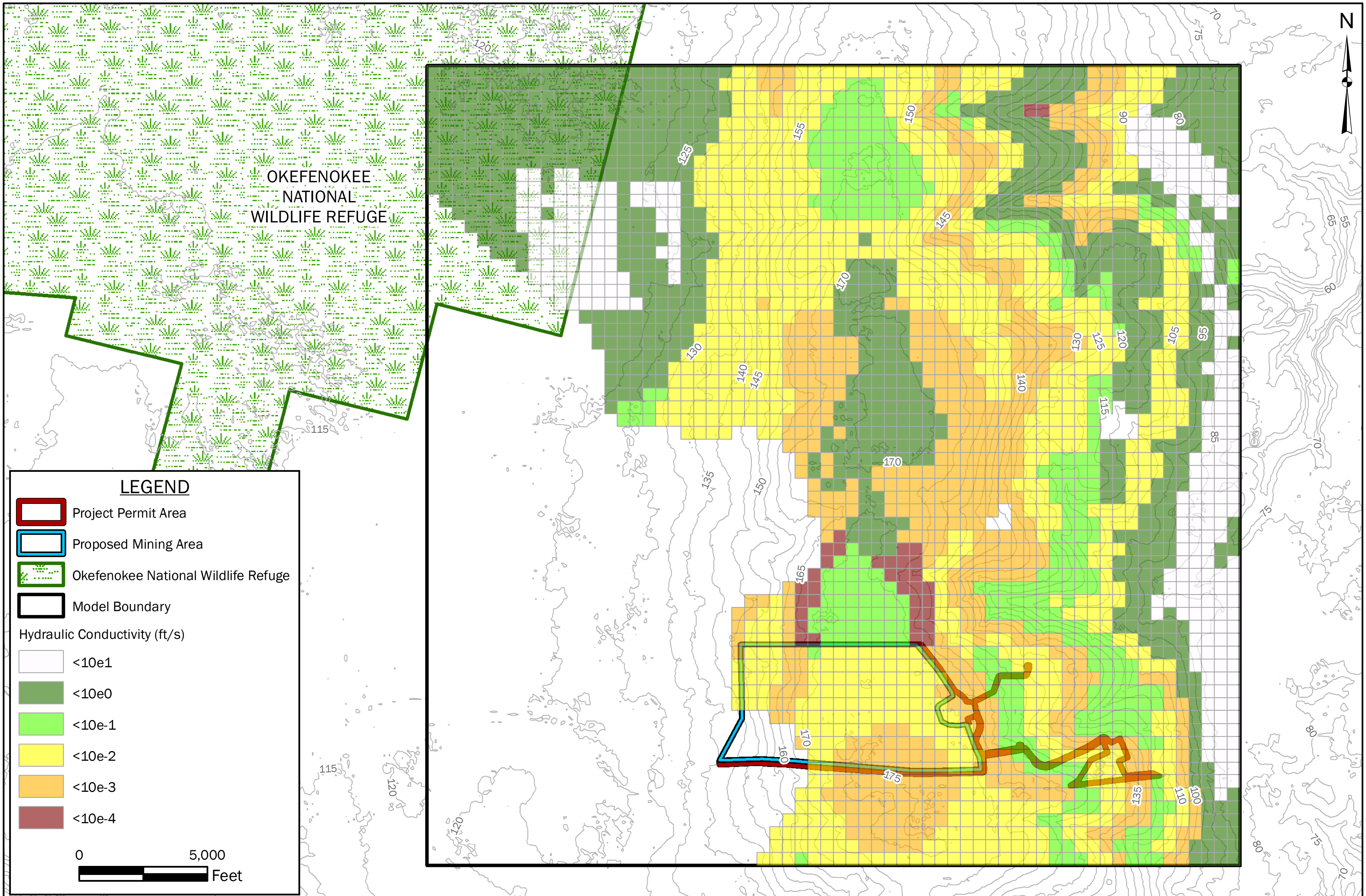


FIGURE 56: POST-MINING MODEL HORIZONTAL HYDRAULIC CONDUCTIVITY LAYER 12

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 5,000 ft

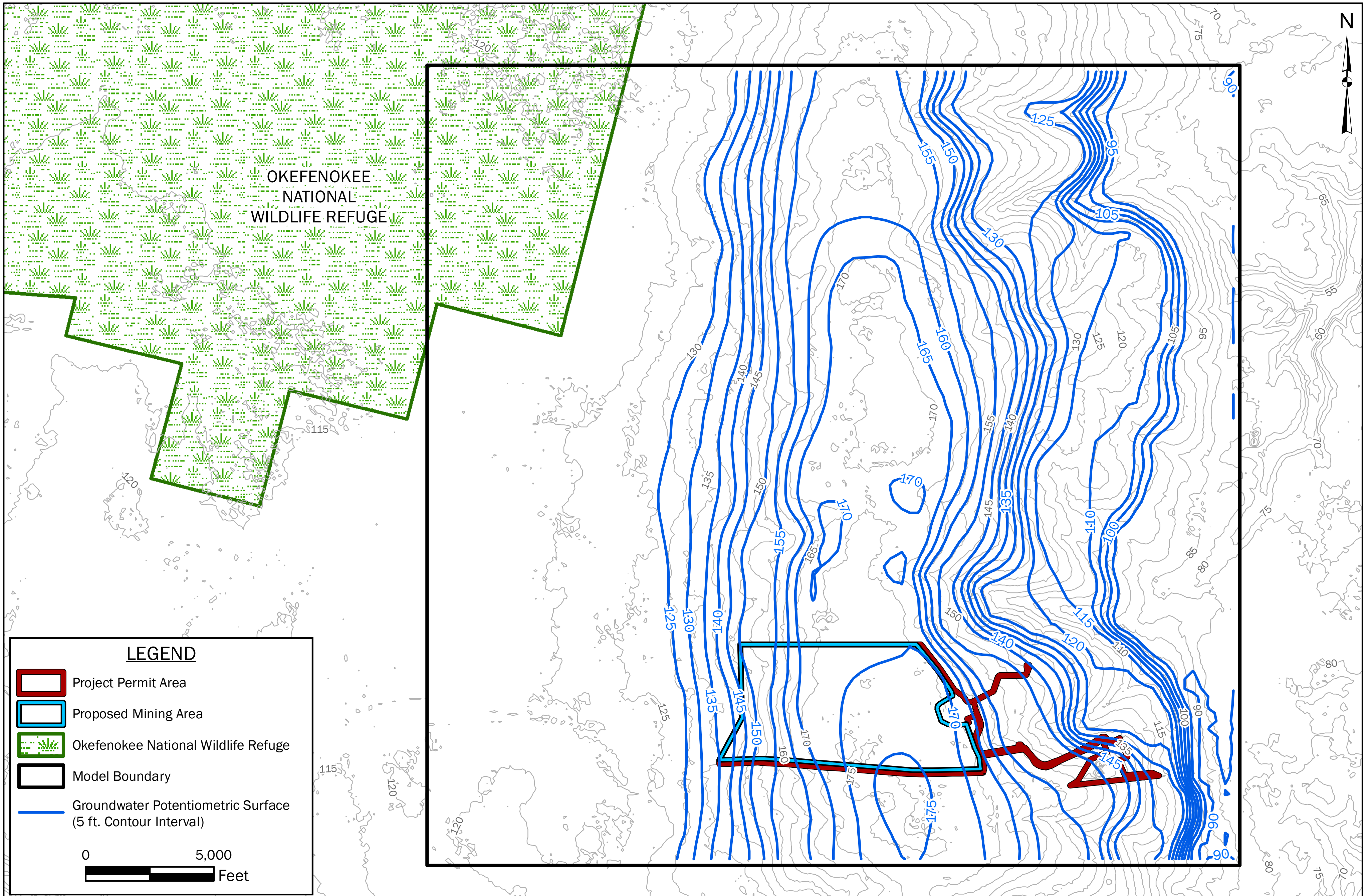


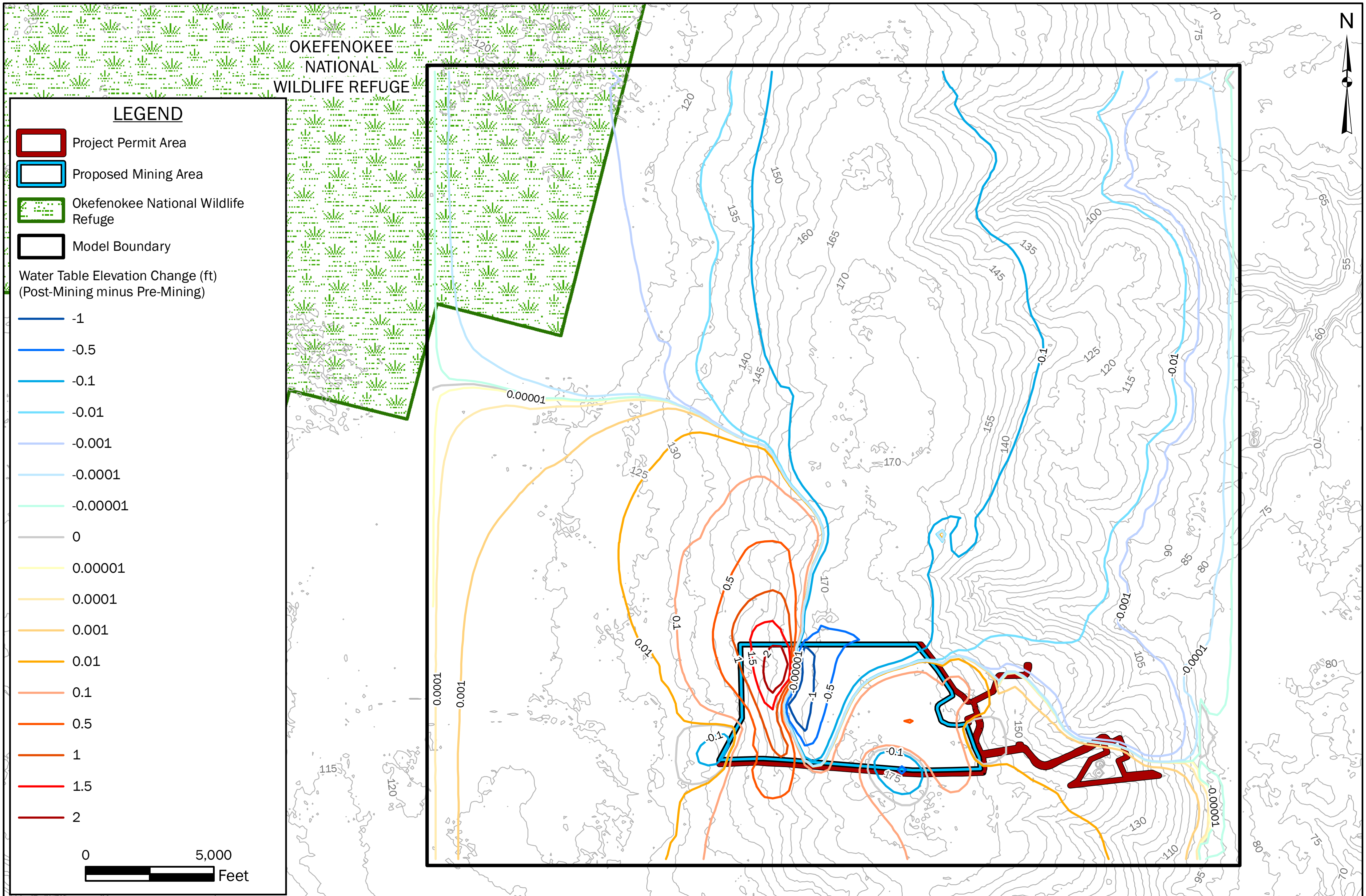
FIGURE 57: POST-MINING MODEL POTENTIOMETRIC SURFACE MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

TTL

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft



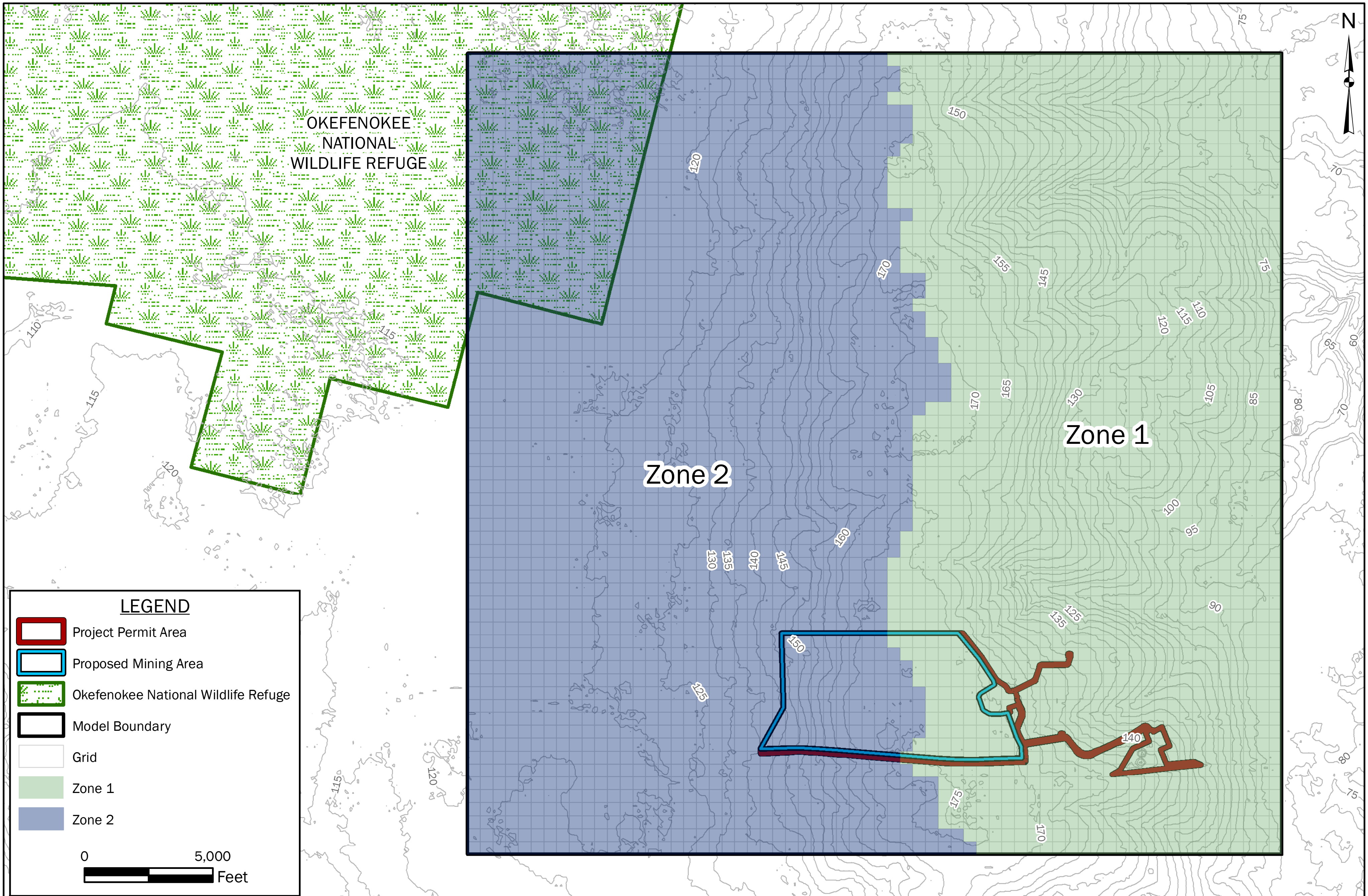
TTL

FIGURE 58: POST-MINING WATER TABLE ELEVATION CHANGE MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft



TTL

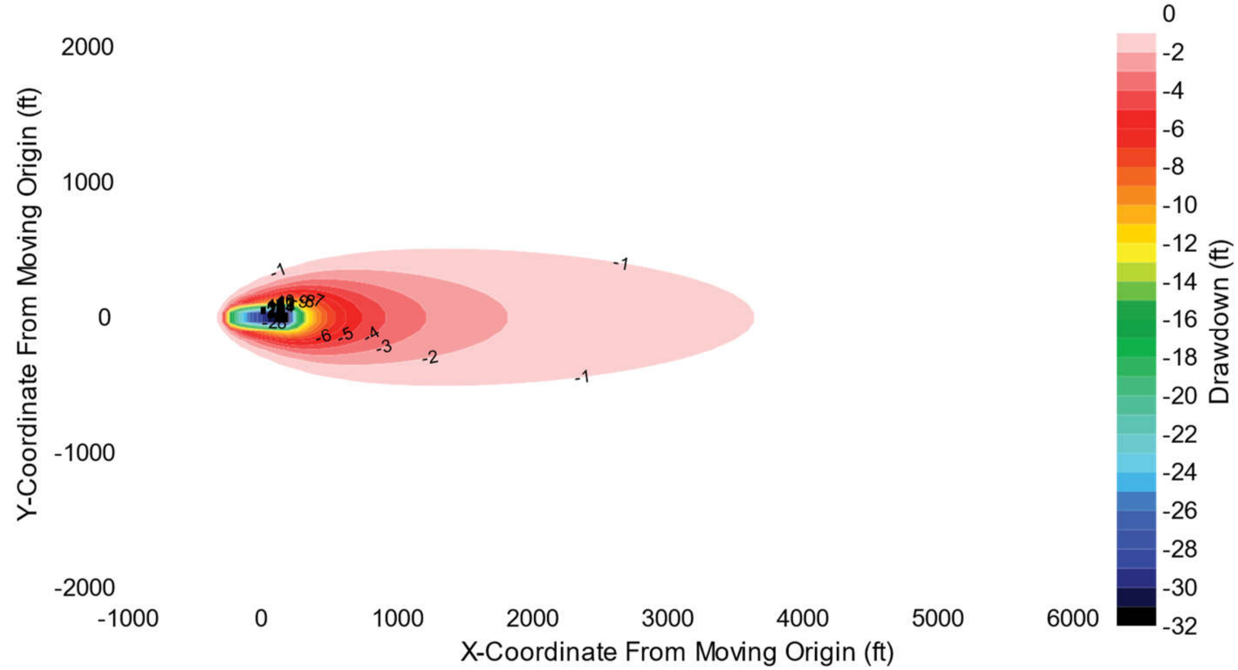
FIGURE 59: MODEL WATER BUDGET ZONE MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

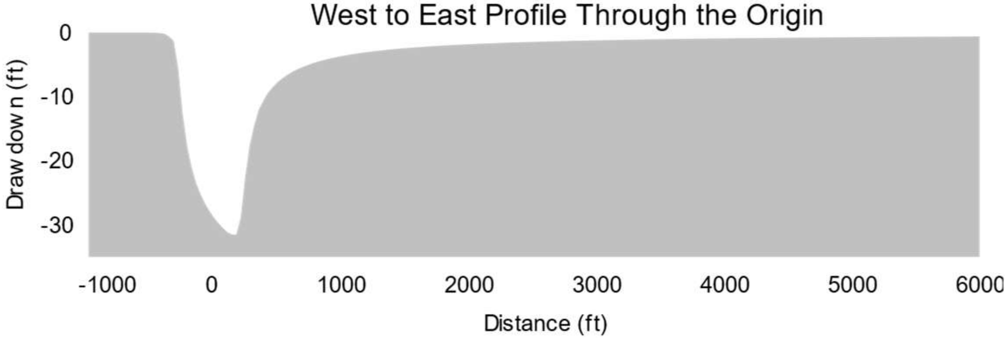
DRAWN BY: DEK	
CHECKED BY: RMH	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft

Drawdown Due to a Moving Rectangular Pit

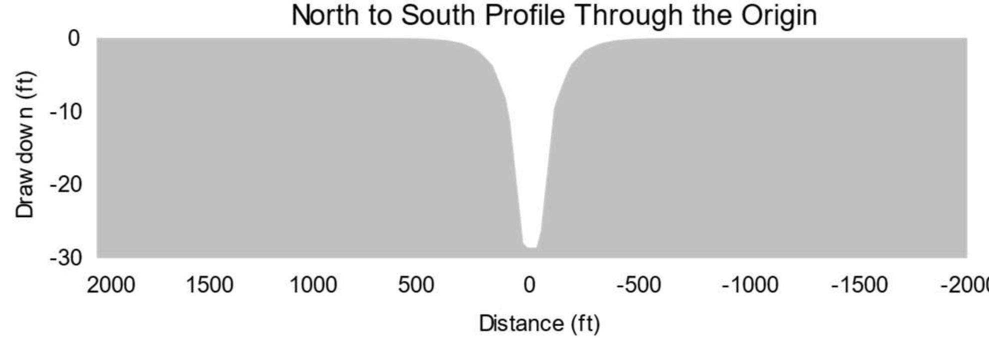


Drawdown Profiles through the Origin

West to East Profile Through the Origin



North to South Profile Through the Origin



- *The zone of drawdown moves 100 ft/d in the x-direction*
- *Recovery is fast behind the pit, with drawdown decreasing to > -2 ft in less than 20 days*
- *When superimposed on the existing water table, groundwater divides will separate the moving pit from the Okefenokee to the west and the streams to the east*

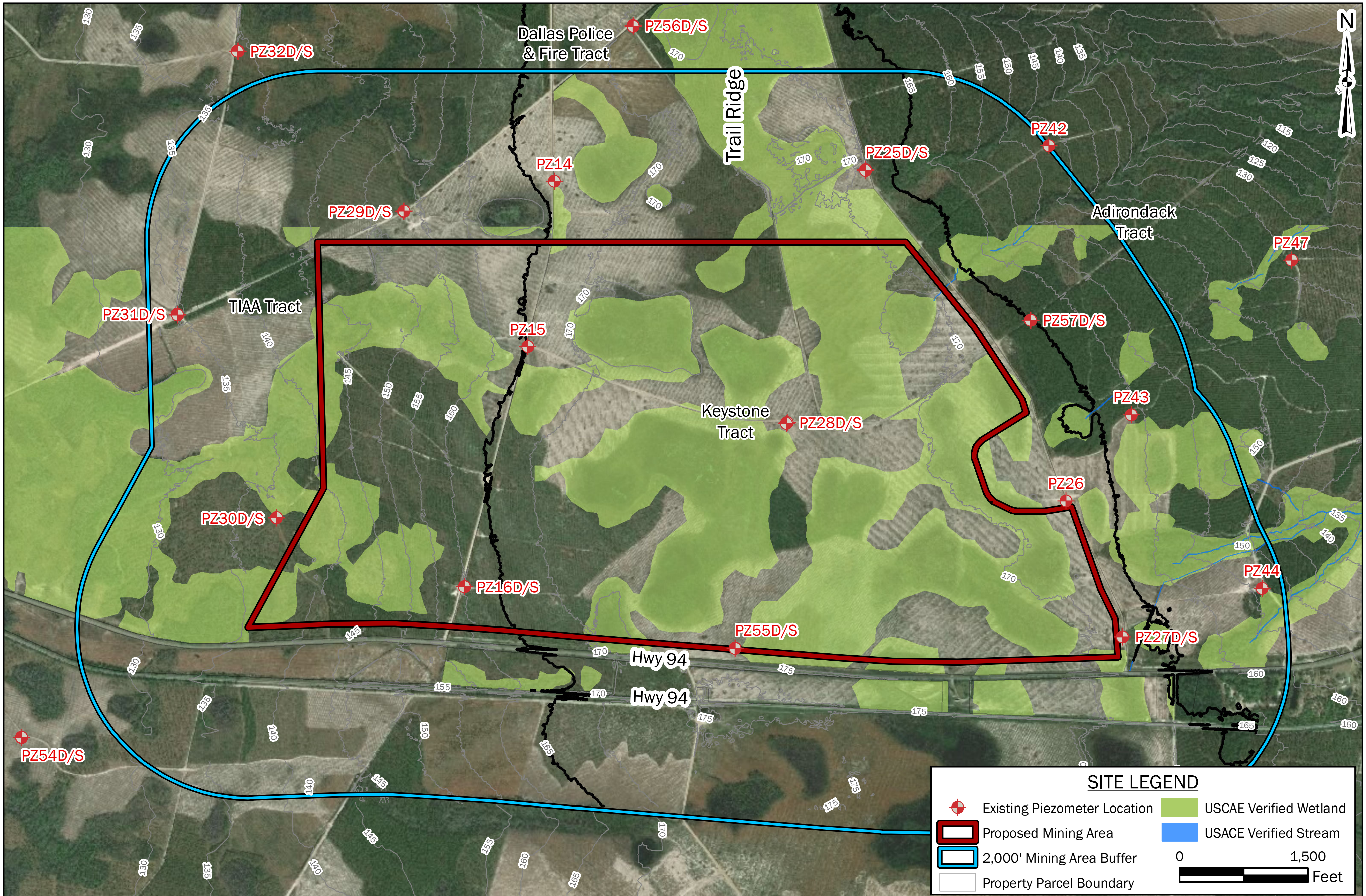
TTL

FIGURE 60: DRAWDOWN DUE TO THE MOVING MINE

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: RMH
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:



TTL

FIGURE 61: EXISTING PIEZOMETER LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK	
CHECKED BY: JMT	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 1,500 ft

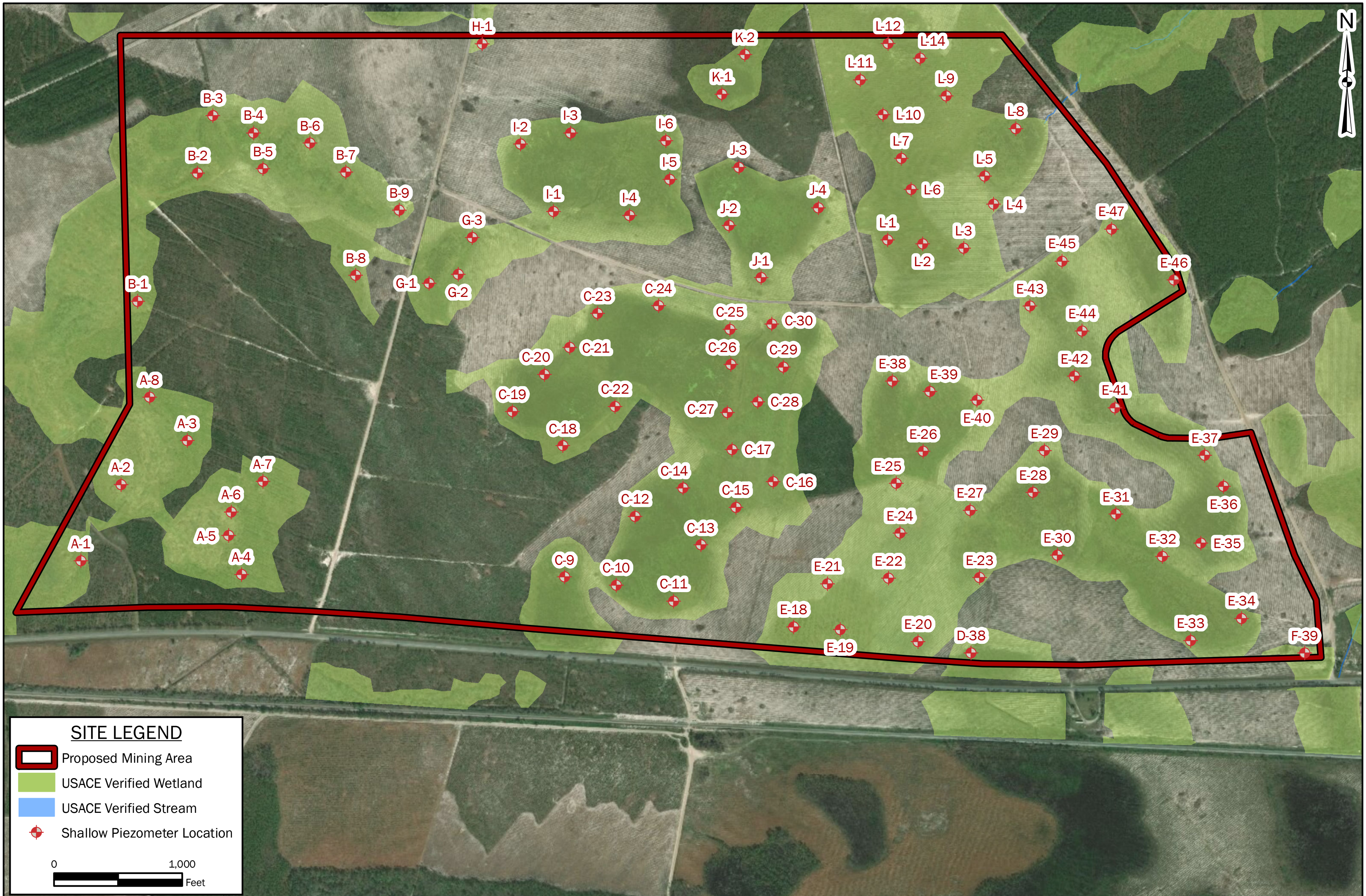


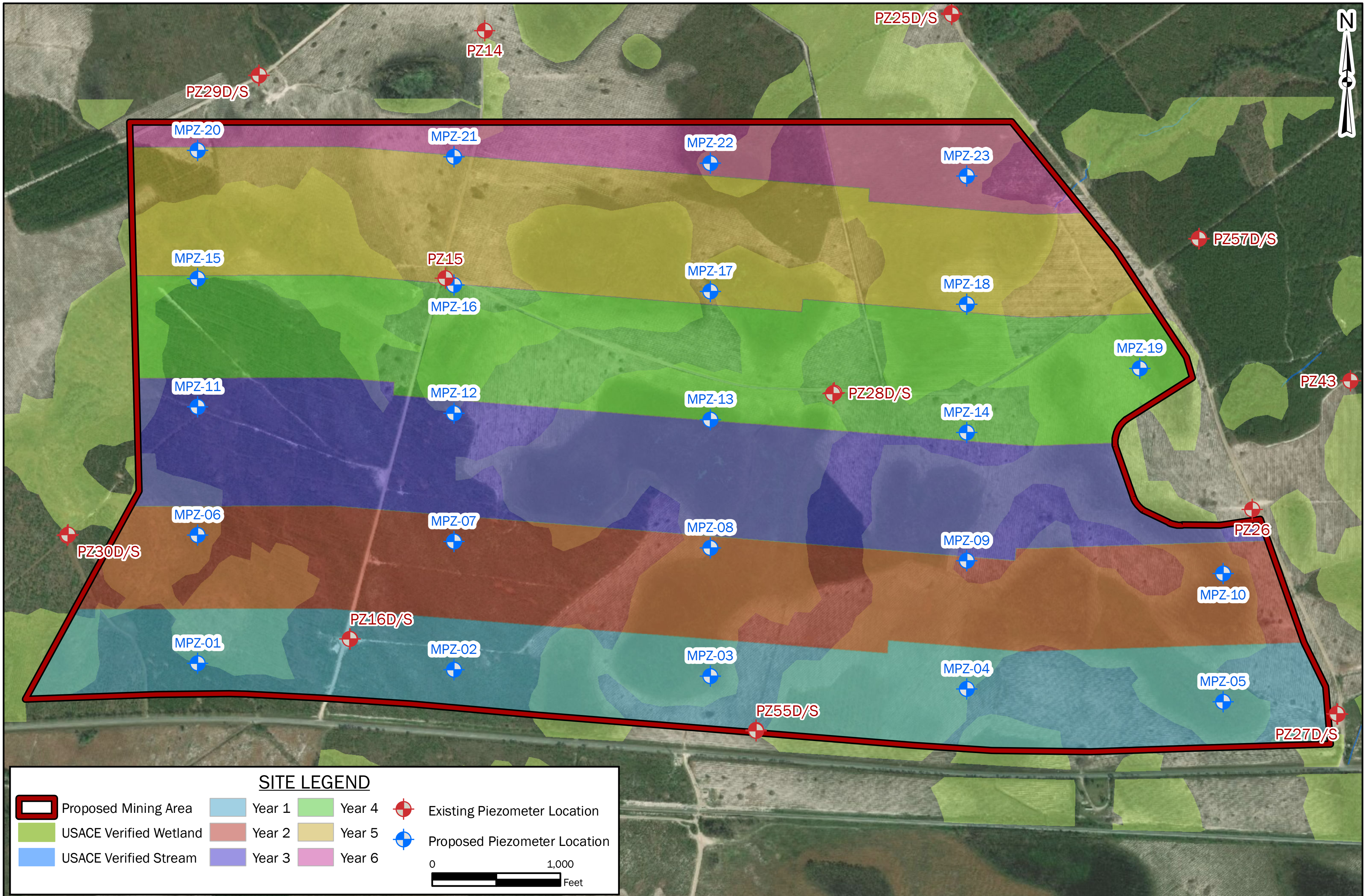
FIGURE 62: EXISTING SHALLOW "WETLANDS" PIEZOMETER LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK	
CHECKED BY: JMT	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 1,000 ft



TTL

FIGURE 63: PROPOSED PIEZOMETER LOCATION & MINING TIMELINE MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK	
CHECKED BY: JMT	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 1,000 ft

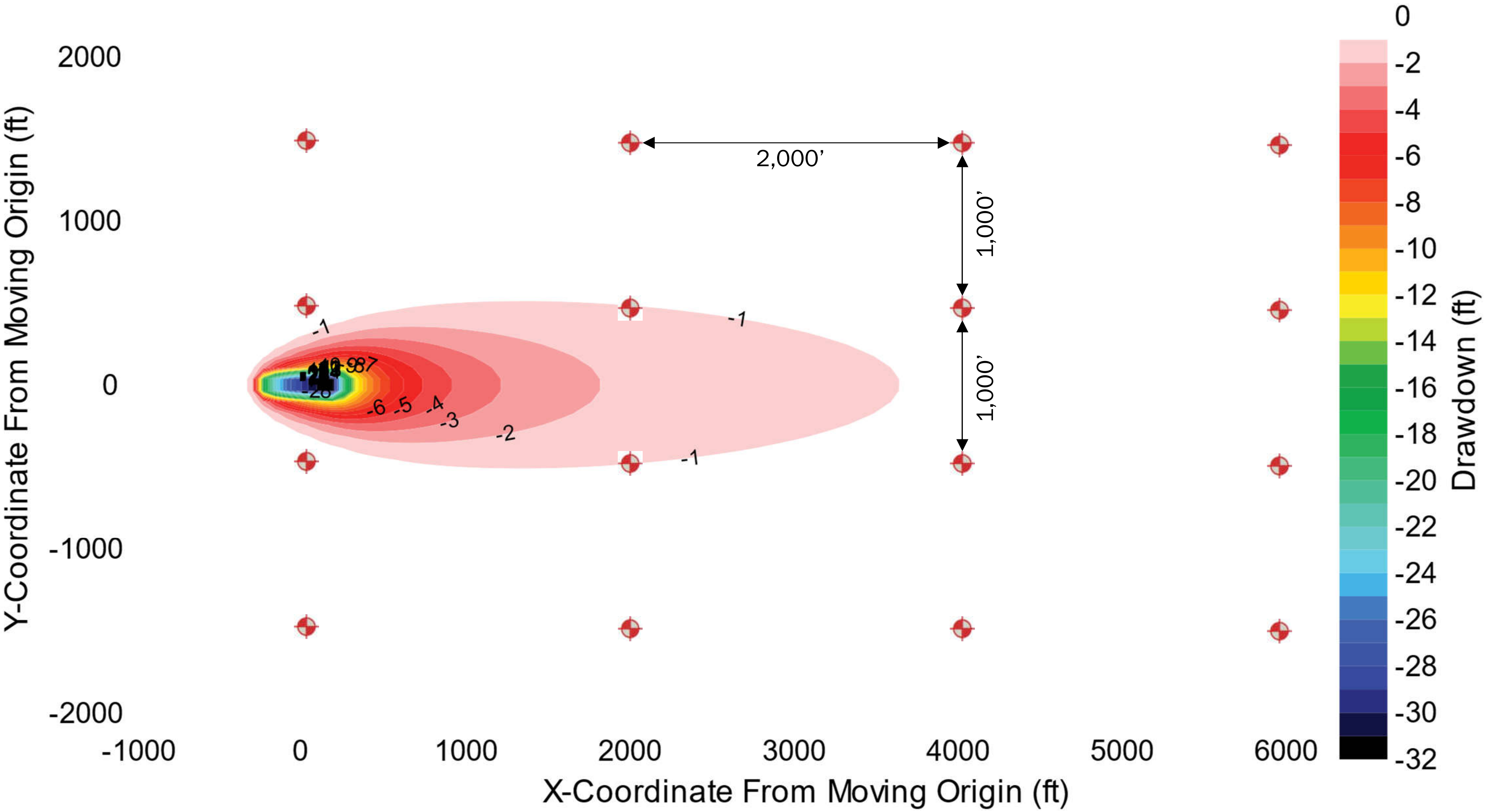
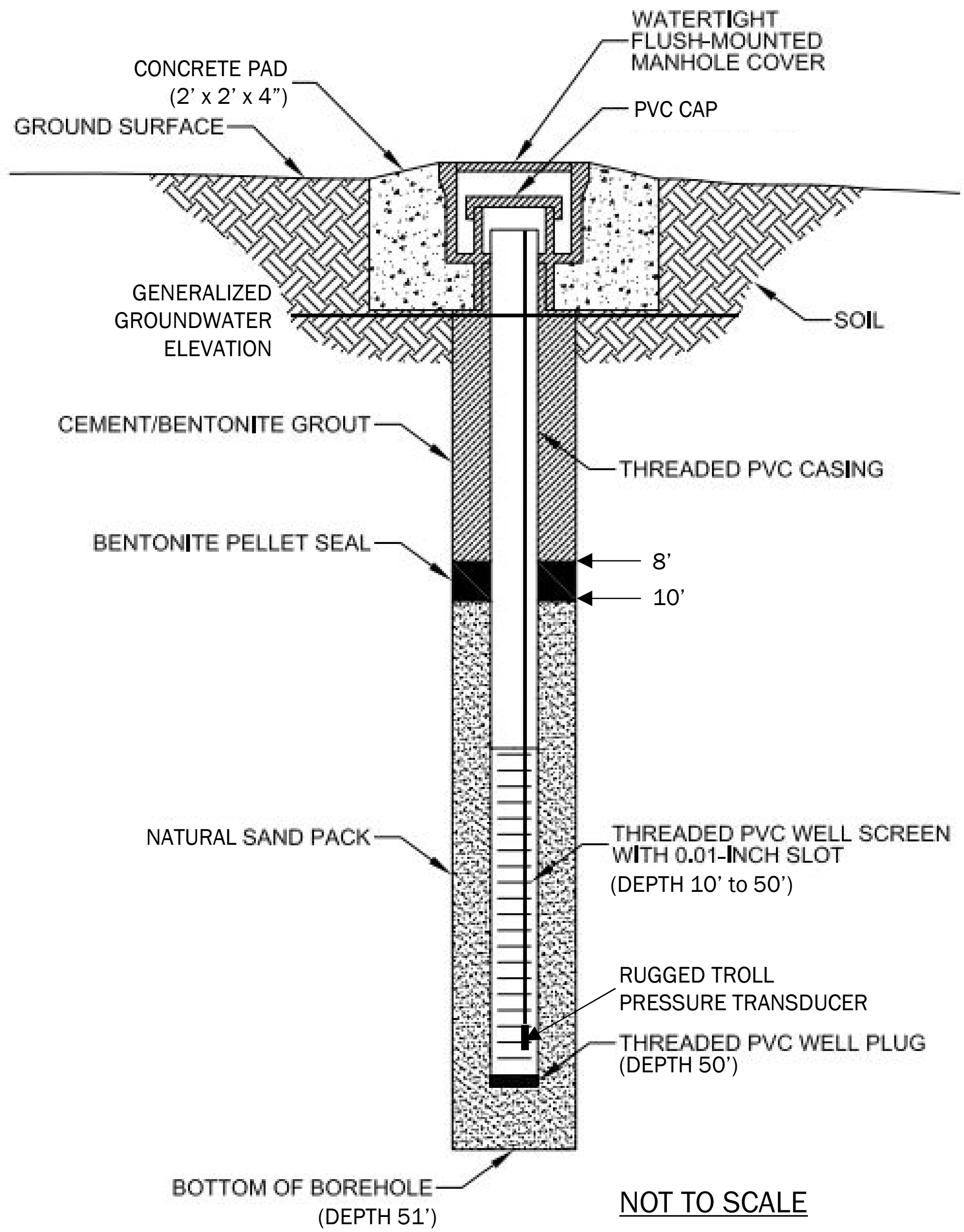


FIGURE 64: PREDICTIVE DRAWDOWN DUE TO THE MOVING MINE

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JMT
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:



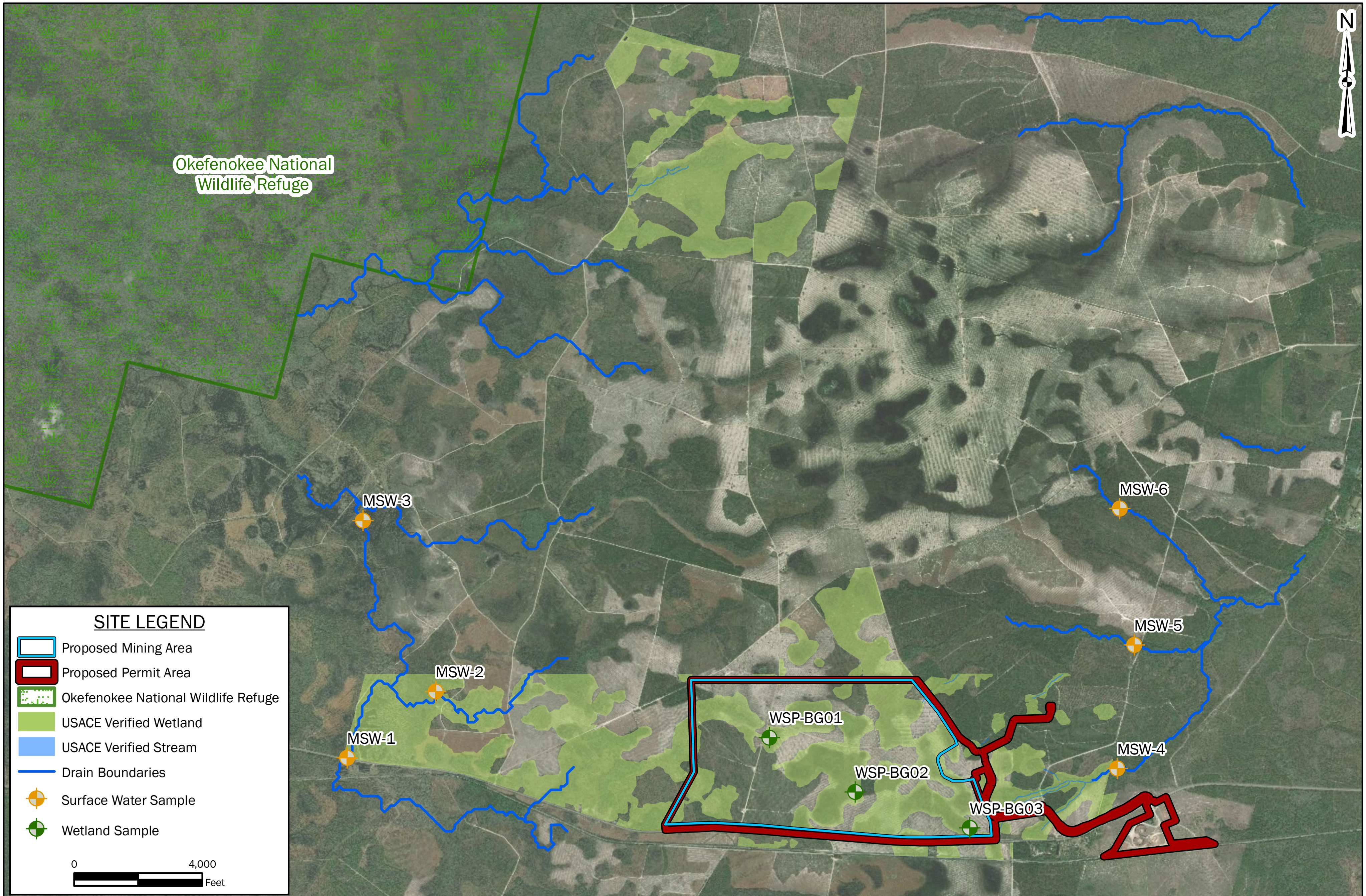
TTL

FIGURE 65: TYPICAL PIEZOMETER CONSTRUCTION DETAIL

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

DRAWN BY: DEK
CHECKED BY: JMT
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE:



TTL

FIGURE 66: PROPOSED SURFACE WATER MONITORING LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: JMT
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 4,000 ft

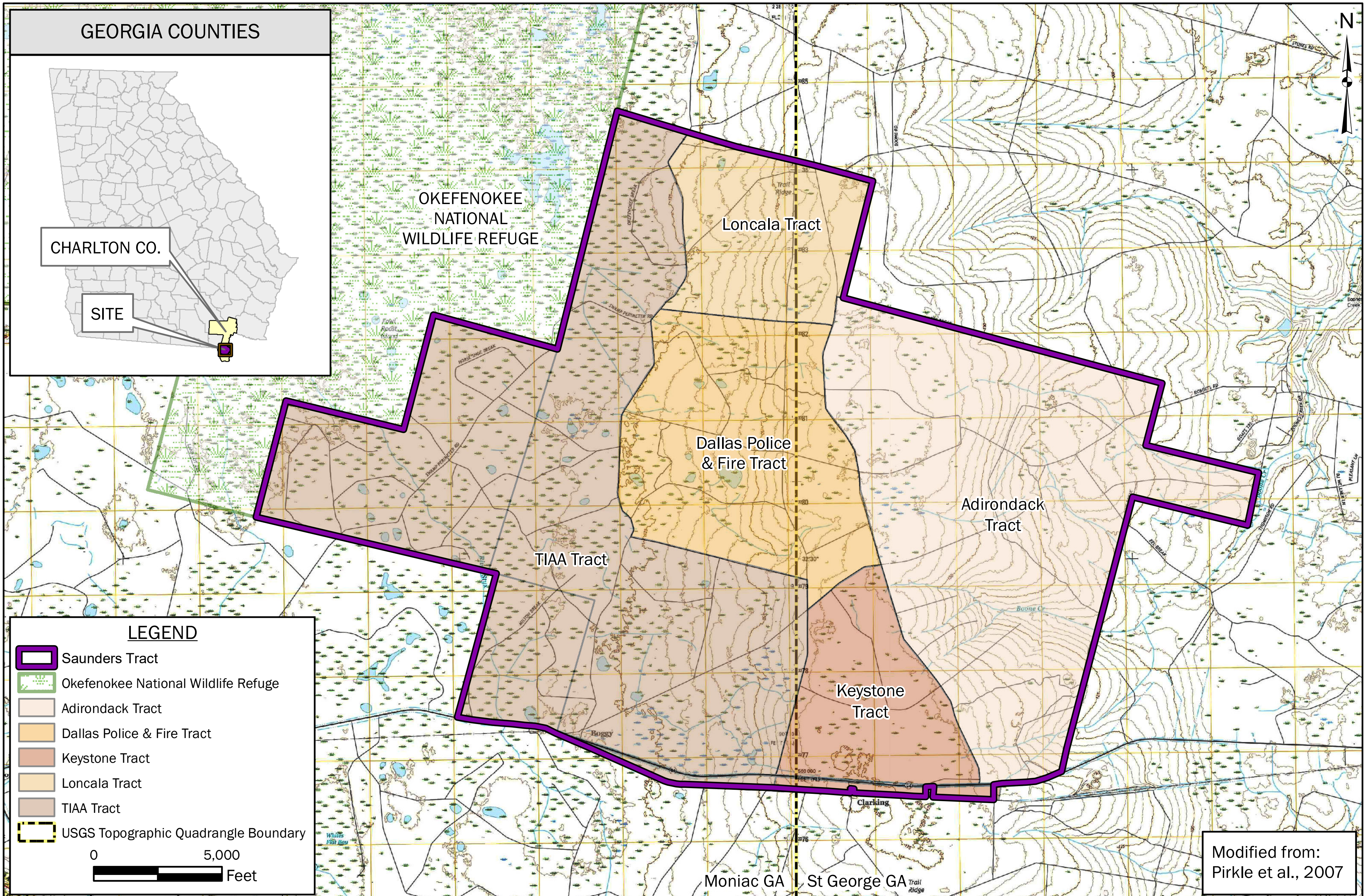


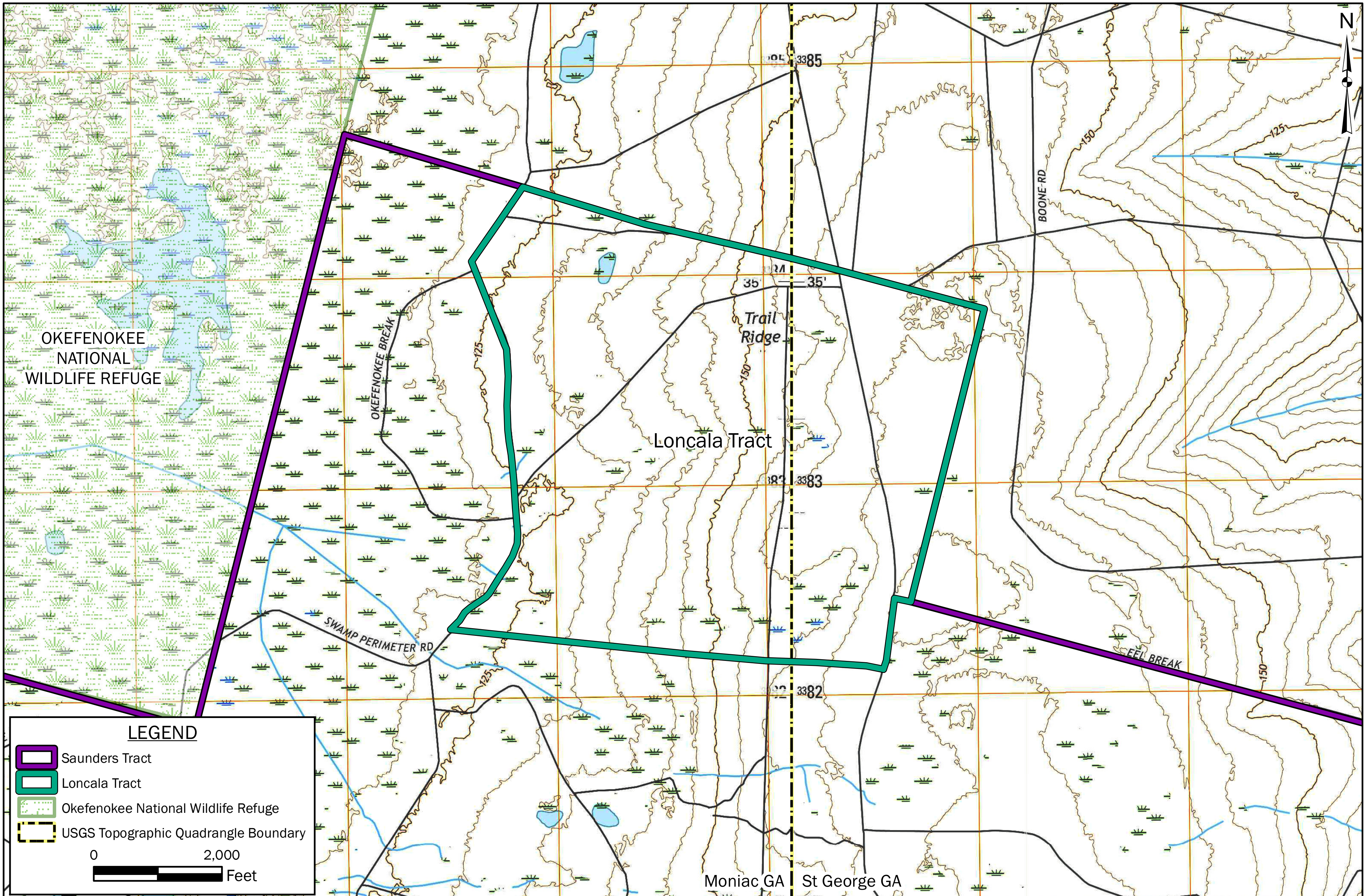
FIGURE 67: OVERALL SAUNDERS TRACT MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS 7.5 Minute Quadrangle Map, Florida & Georgia, (West) Moniac 2017 (10-ft Contour Interval), (East) Saint George 2017 (5-ft Contour Interval).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 5,000 ft



TTL

FIGURE 68: LONCALA TRACT RELATIVE TO THE OKEFENOKEE SWAMP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS 7.5 Minute Quadrangle Map, Florida & Georgia, (West) Moniac 2017 (10-ft Contour Interval), (East) Saint George 2017 (5-ft Contour Interval).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 2,000 ft

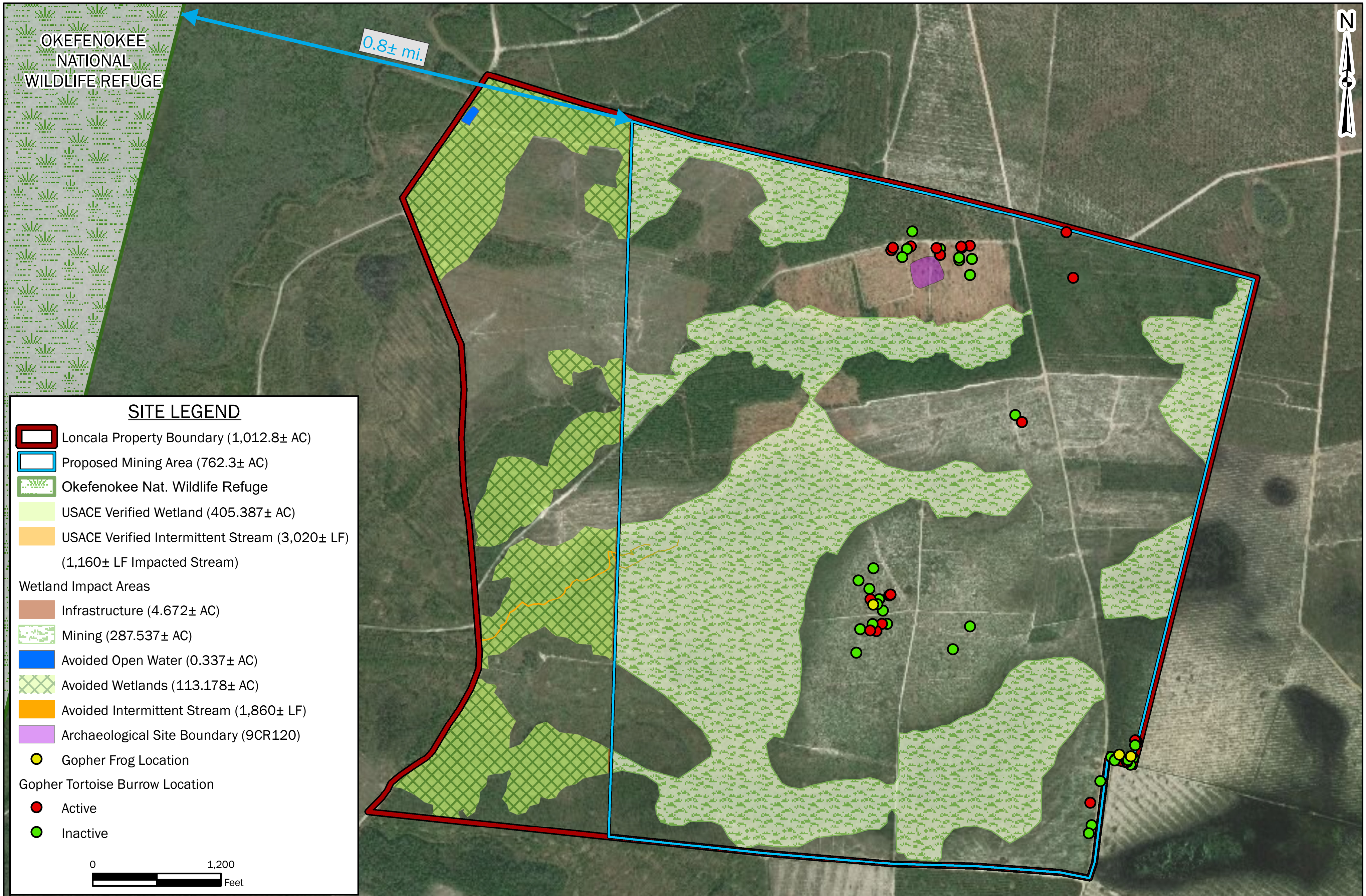


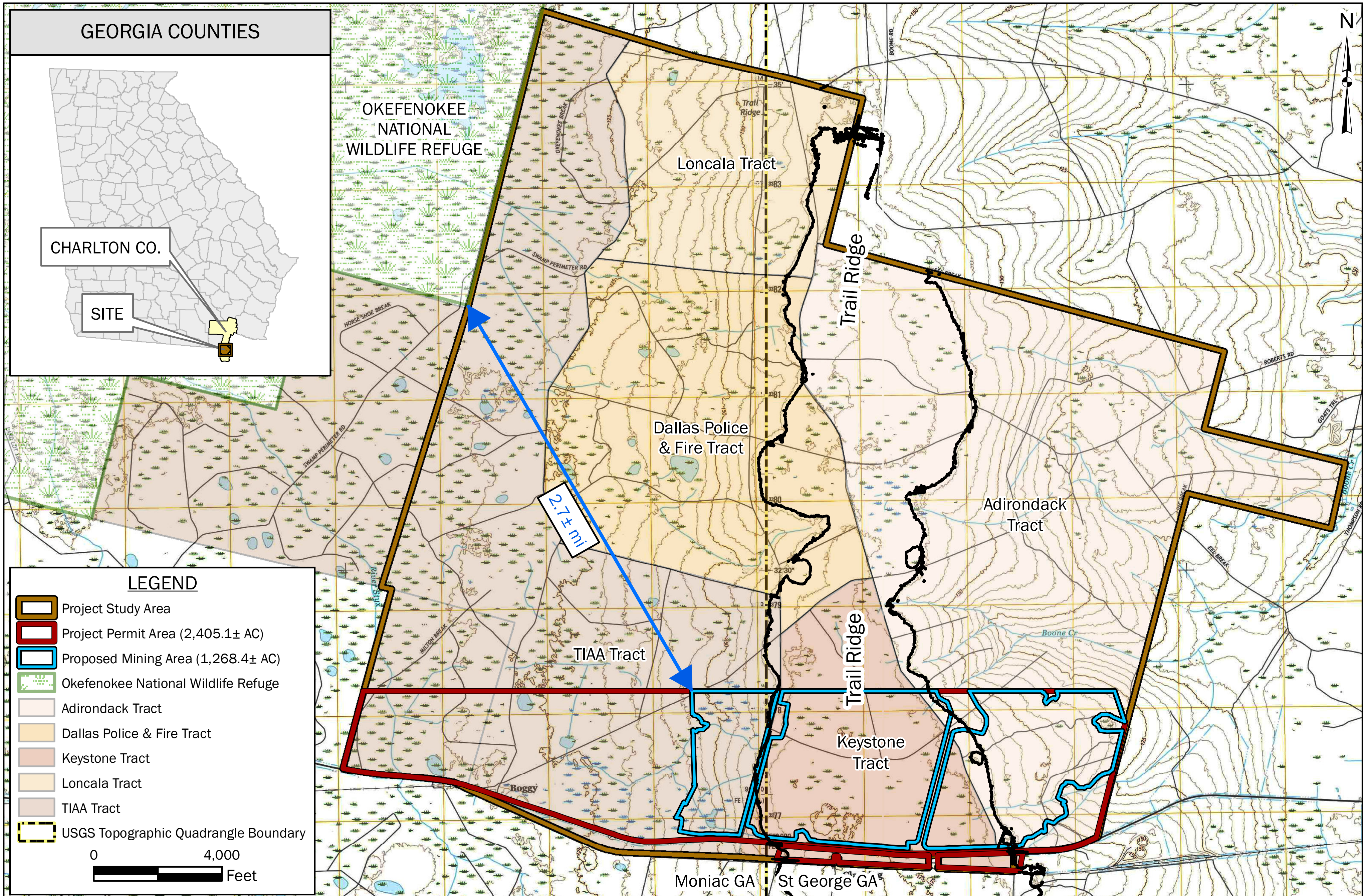
FIGURE 69: SENSITIVE FEATURES MAP: ALTERNATIVE 3

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: CMS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 1,200 ft



TTL

FIGURE 70: ALTERNATIVE 4 RELATIVE TO THE OKEFENOKEE SWAMP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS 7.5 Minute Quadrangle Map, Florida & Georgia, (West) Moniac 2017 (10-ft Contour Interval), (East) Saint George 2017 (5-ft Contour Interval).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

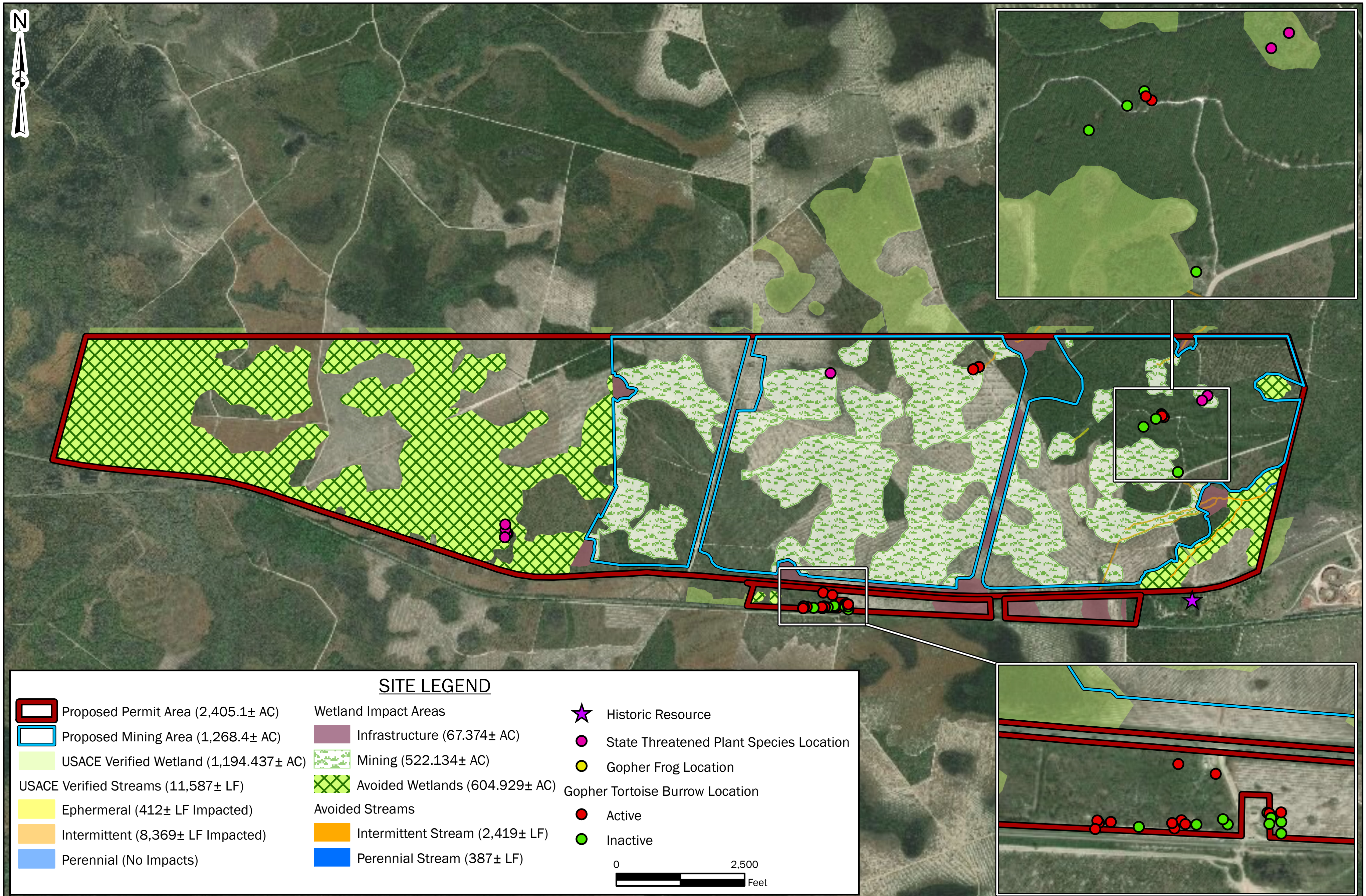


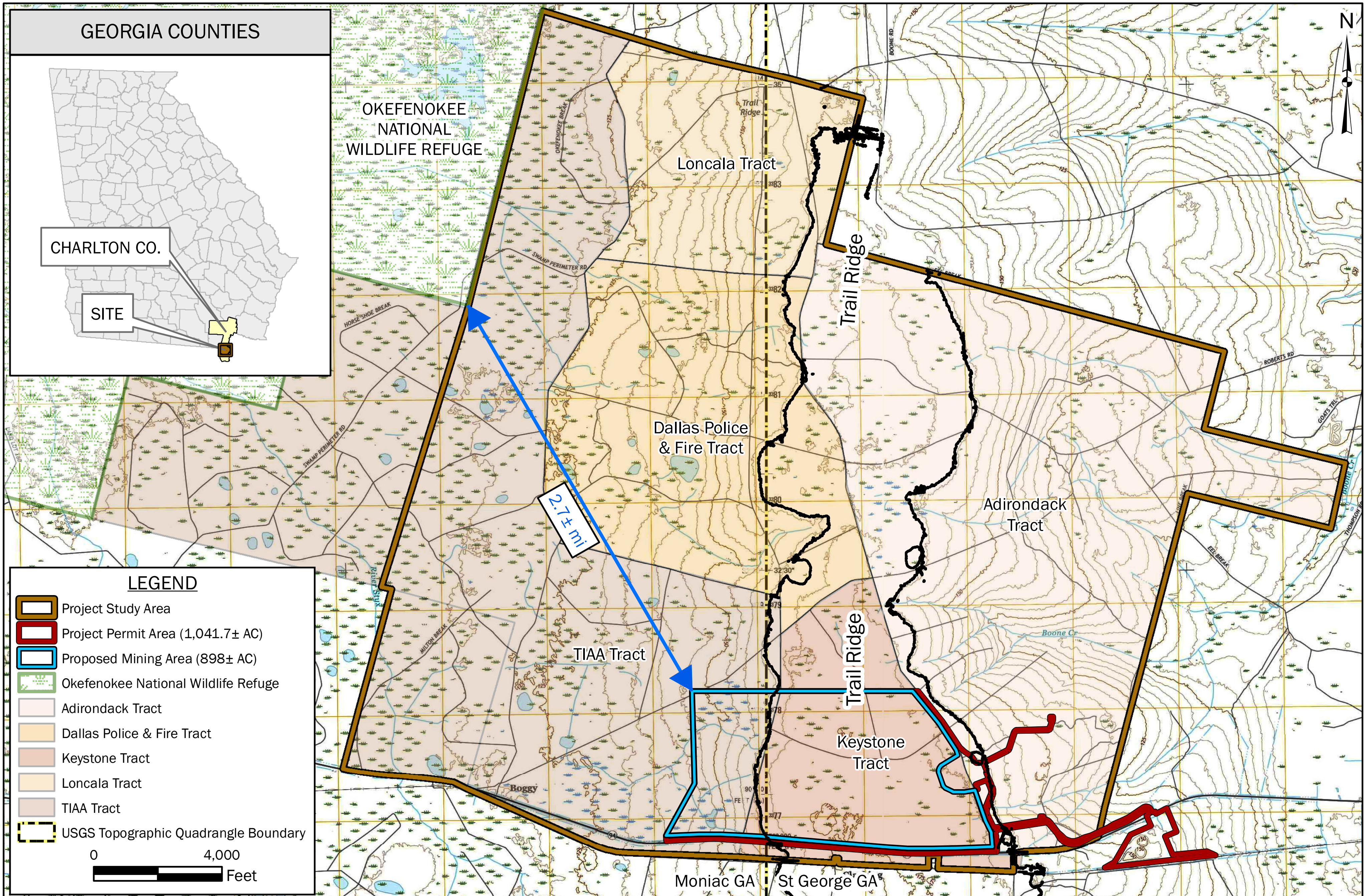
FIGURE 71: SENSITIVE FEATURES MAP: ALTERNATIVE 4

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 2,500 ft



TTL

FIGURE 72: ALTERNATIVE 5 RELATIVE TO THE OKEFENOKEE SWAMP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS 7.5 Minute Quadrangle Map, Florida & Georgia, (West) Moniac 2017 (10-ft Contour Interval), (East) Saint George 2017 (5-ft Contour Interval).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 4,000 ft

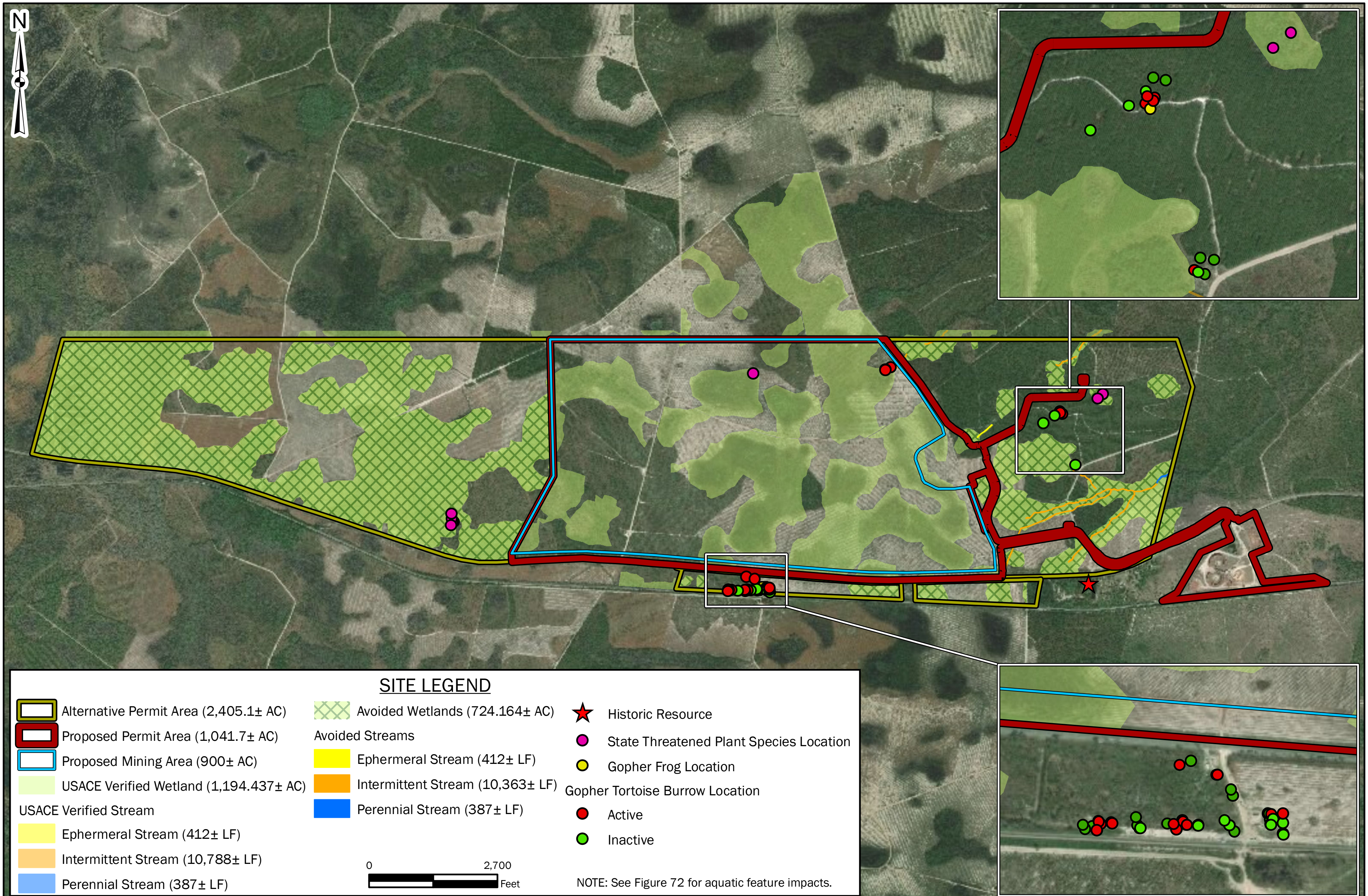


FIGURE 73: SENSITIVE FEATURES MAP: ALTERNATIVE 5

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: CMS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 2,700 ft

TTL

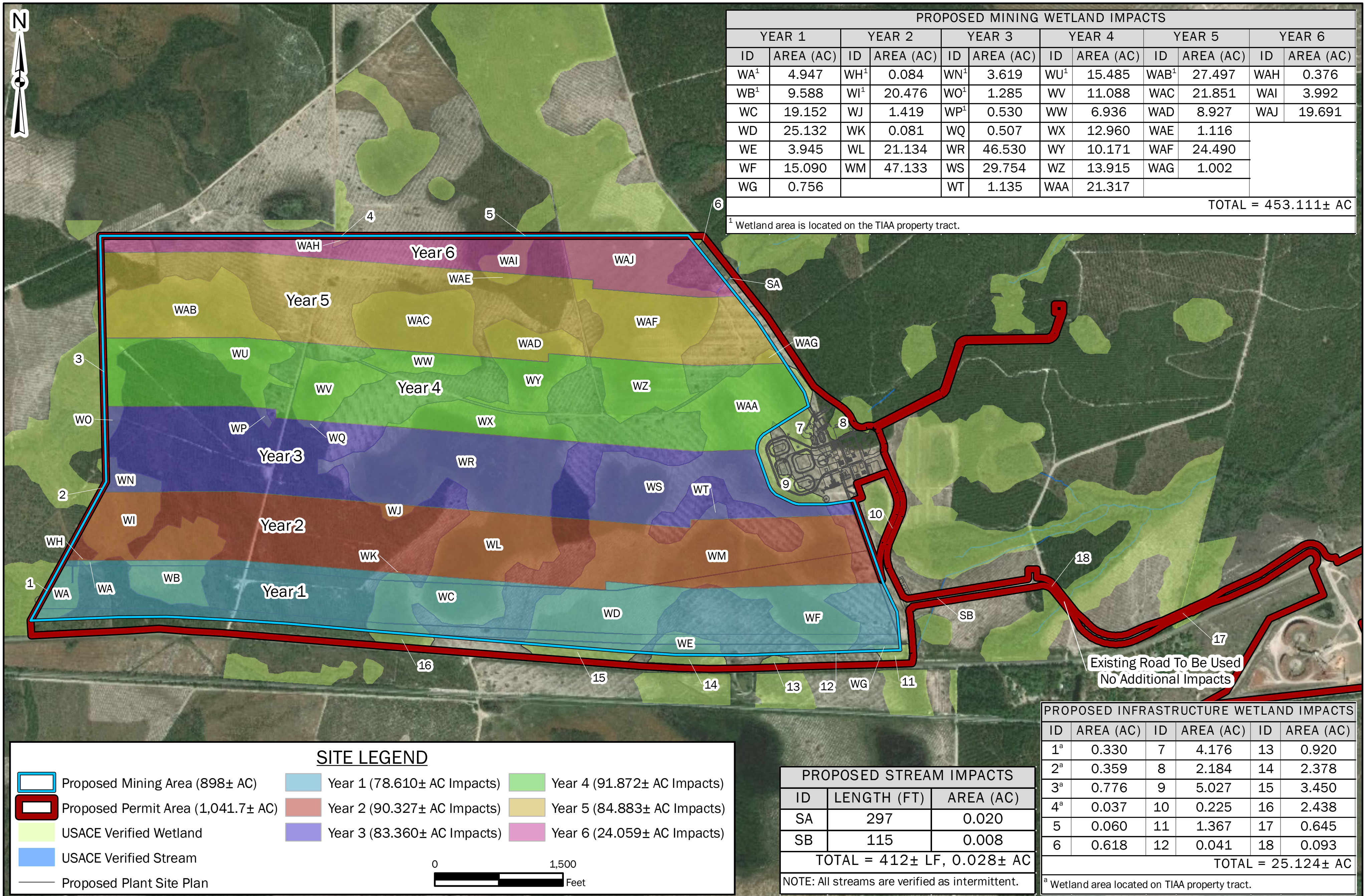
FIGURE 74: HISTORICAL AERIAL PHOTOGRAPH (1970)

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS Single Frame Photo SWDG00030130, SWDG00010127, SWDG00010128, SWDG00010124, SWDG00030131, SWDG00010050, and SWDG00010126. Image dates January 8, 1970 & January 23, 1970.

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 1,700 ft



PROPOSED MINING WETLAND IMPACTS											
YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		YEAR 6	
ID	AREA (AC)	ID	AREA (AC)	ID	AREA (AC)	ID	AREA (AC)	ID	AREA (AC)	ID	AREA (AC)
WA[1]	4.947	WH[1]	0.084	WN[1]	3.619	WU[1]	15.485	WAB[1]	27.497	WAH	0.376
WB[1]	9.588	WI[1]	20.476	WO[1]	1.285	WV	11.088	WAC	21.851	WAI	3.992
WC	19.152	WJ	1.419	WP[1]	0.530	WW	6.936	WAD	8.927	WAJ	19.691
WD	25.132	WK	0.081	WQ	0.507	WX	12.960	WAE	1.116		
WE	3.945	WL	21.134	WR	46.530	WY	10.171	WAF	24.490		
WF	15.090	WM	47.133	WS	29.754	WZ	13.915	WAG	1.002		
WG	0.756			WT	1.135	WAA	21.317				
TOTAL = 453.111± AC											

[1] Wetland area is located on the TIAA property tract.

SITE LEGEND

- Proposed Mining Area (898± AC)
- Proposed Permit Area (1,041.7± AC)
- USACE Verified Wetland
- USACE Verified Stream
- Proposed Plant Site Plan
- Year 1 (78.610± AC Impacts)
- Year 2 (90.327± AC Impacts)
- Year 3 (83.360± AC Impacts)
- Year 4 (91.872± AC Impacts)
- Year 5 (84.883± AC Impacts)
- Year 6 (24.059± AC Impacts)

0 1,500 Feet

PROPOSED STREAM IMPACTS		
ID	LENGTH (FT)	AREA (AC)
SA	297	0.020
SB	115	0.008
TOTAL = 412± LF, 0.028± AC		

NOTE: All streams are verified as intermittent.

PROPOSED INFRASTRUCTURE WETLAND IMPACTS					
ID	AREA (AC)	ID	AREA (AC)	ID	AREA (AC)
1[a]	0.330	7	4.176	13	0.920
2[a]	0.359	8	2.184	14	2.378
3[a]	0.776	9	5.027	15	3.450
4[a]	0.037	10	0.225	16	2.438
5	0.060	11	1.367	17	0.645
6	0.618	12	0.041	18	0.093
TOTAL = 25.124± AC					

[a] Wetland area located on TIAA property tract.

TTL

FIGURE 75: PROPOSED PROJECT AQUATIC FEATURE IMPACT AREAS MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: CMS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: 1 in = 1,500 ft

	LEVEL	HUC	NAME
REGION	1	03	South Atlantic-Gulf Region
SUBREGION	2	0307	Altamaha-St. Marys
BASIN	3	030702	St. Marys-Satilla
SUBBASIN	4	03070204	St. Marys
WATERSHED (W)	5	0307020403	North Prong St. Marys River
WATERSHED (E)	5	0307020406	Middle St. Marys River
SUBWATERSHED (W)	6	030702040301	Soldiers Camp Island
SUBWATERSHED (E)	6	030702040602	Boone Creek

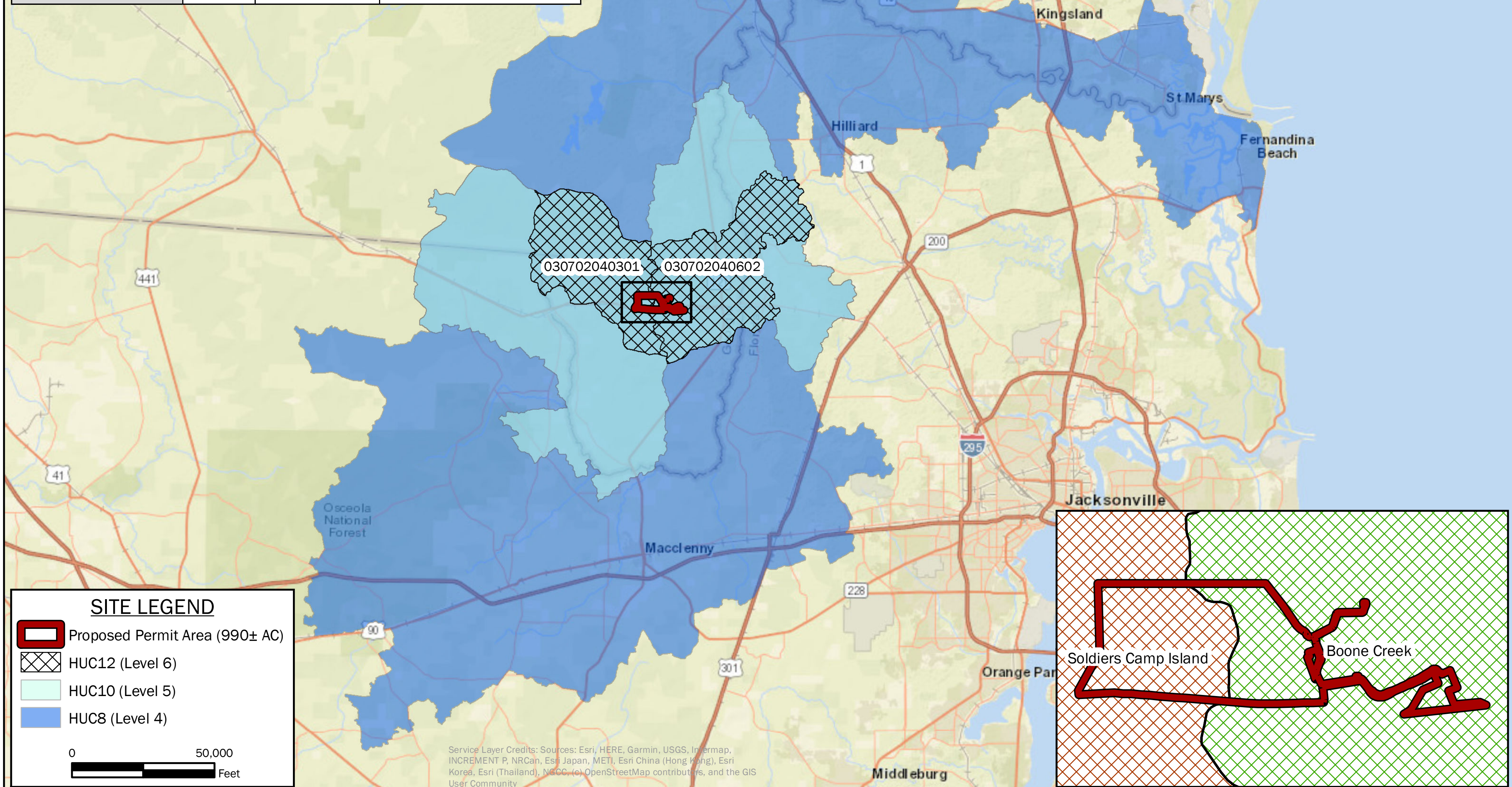


FIGURE 76: HYDROLOGIC UNIT CODE (HUC) MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: ESRI World Street Map (See Service Layer Credits).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 50,000 ft

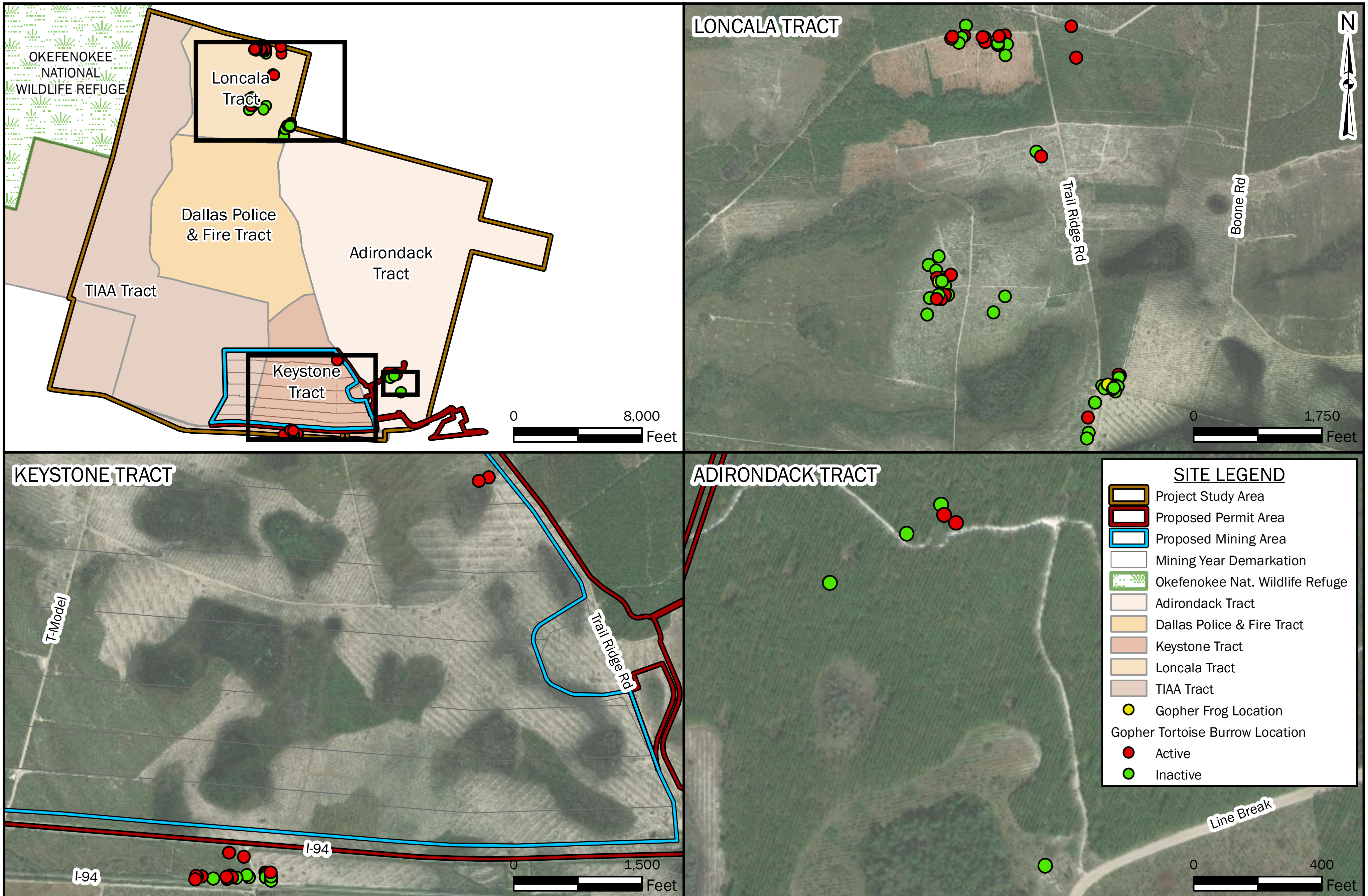


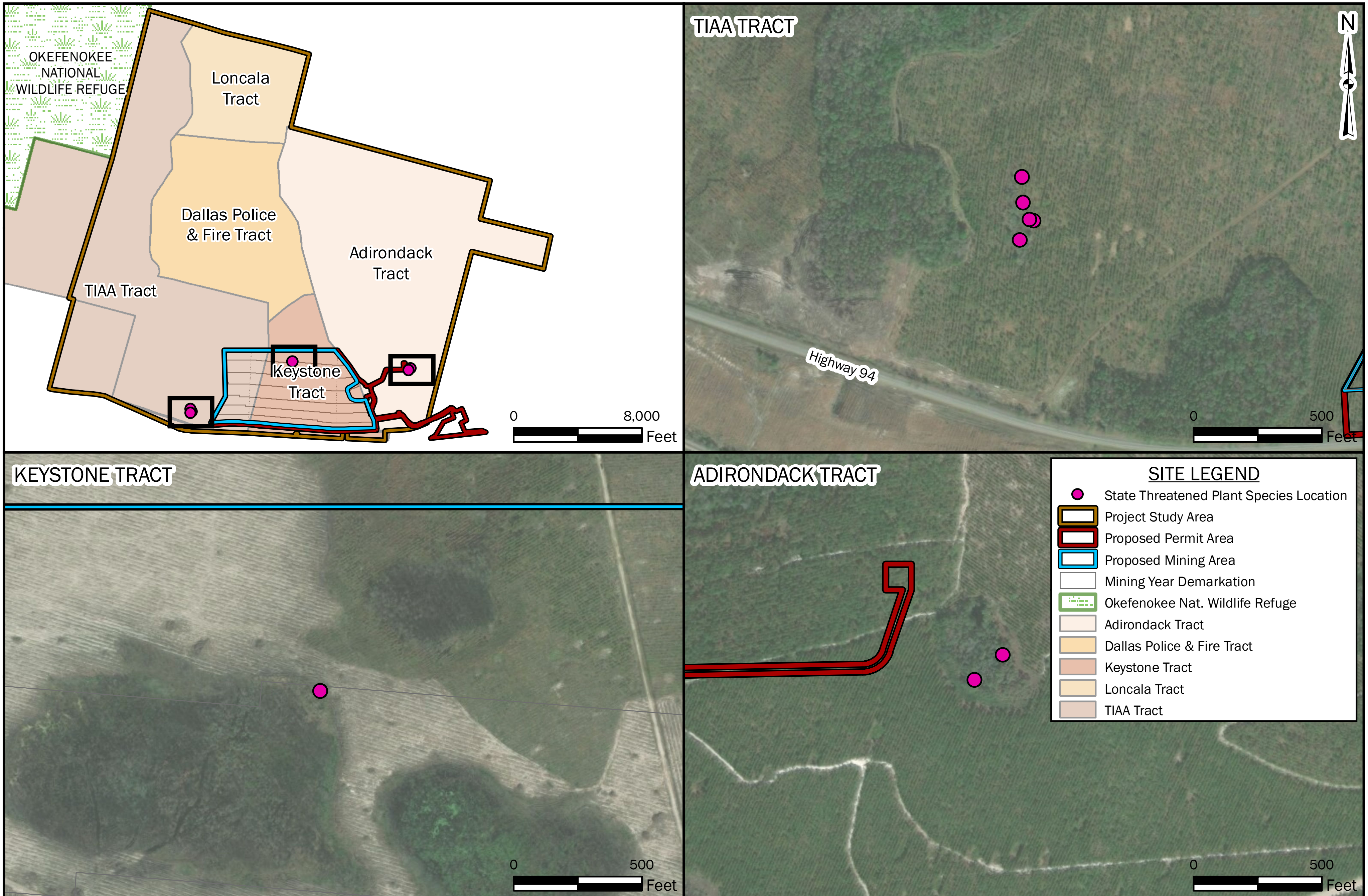
FIGURE 77: THREATENED & ENDANGERED SPECIES LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: CMS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: See Panels



TTL

FIGURE 78: PARROT PITCHERPLANT LOCATION MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK
CHECKED BY: CMS
DRAWING DATE: 2/28/2020
REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
APPROX. SCALE: See Panels

LABEL	PIN	OWNER	ADDRESS	LABEL	PIN	OWNER	ADDRESS
1	0036001	TIAA TIMBERLANDS, LLC	1500 S FIRST AVE, STE 1150, PORTLAND, OR 97201	10	0060004	FINLEY W WOLFE	8242 HWY 94, ST GEORGE, GA 31562
2	0059001002	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209	11	0060004001	KIRK W WOLFE	8296 HWY 94, ST GEORGE, GA 31562
3	0058001	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209	12	0060005	ERNST HARDEN	SUITE 107, JACKSONVILLE, FL 32211
4	0084001	JOHN, VERNON GOWEN	315 AGNES ROAD, FOLKSTON, GA 31537	13	0084003001	FRED & MARLENE WINECOFF	8422 HWY 94, ST GEORGE, GA 31562
5	0061002	W L OLIVER/CHARLTON, LLC	P.O. BPX 161139, MOBILE, AL 36616	14	0084003	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MACCLENNY, FL 32063
6	0060009	TRAIL RIDGE LAND, LLC	2100 SOUTHBRIDGE PKWY, BIRMINGHAM, AL 35209	15	0084003002	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MACCLENNY, FL 32063
7	0060003	CHARLTON COUNTY FORREST	FOLKSTON, GA 31537	16	0084002001	SIDNEY E & RODNEY BELL	P.O. BOX 173, ST GEORGE, GA 31562
8	0060007	WALTER & DEBRA SCHEIDERER	8024 HWY 94, ST GEORGE, GA, 31562	17	0084002002	SHARON BELL & ELI L. PADGETT	10624 HILLSIDE DR, MCCLENNY, FL 32063
9	0060006	RANDAL DUKES	8208 HWY 94, ST GEORGE, GA 31562				

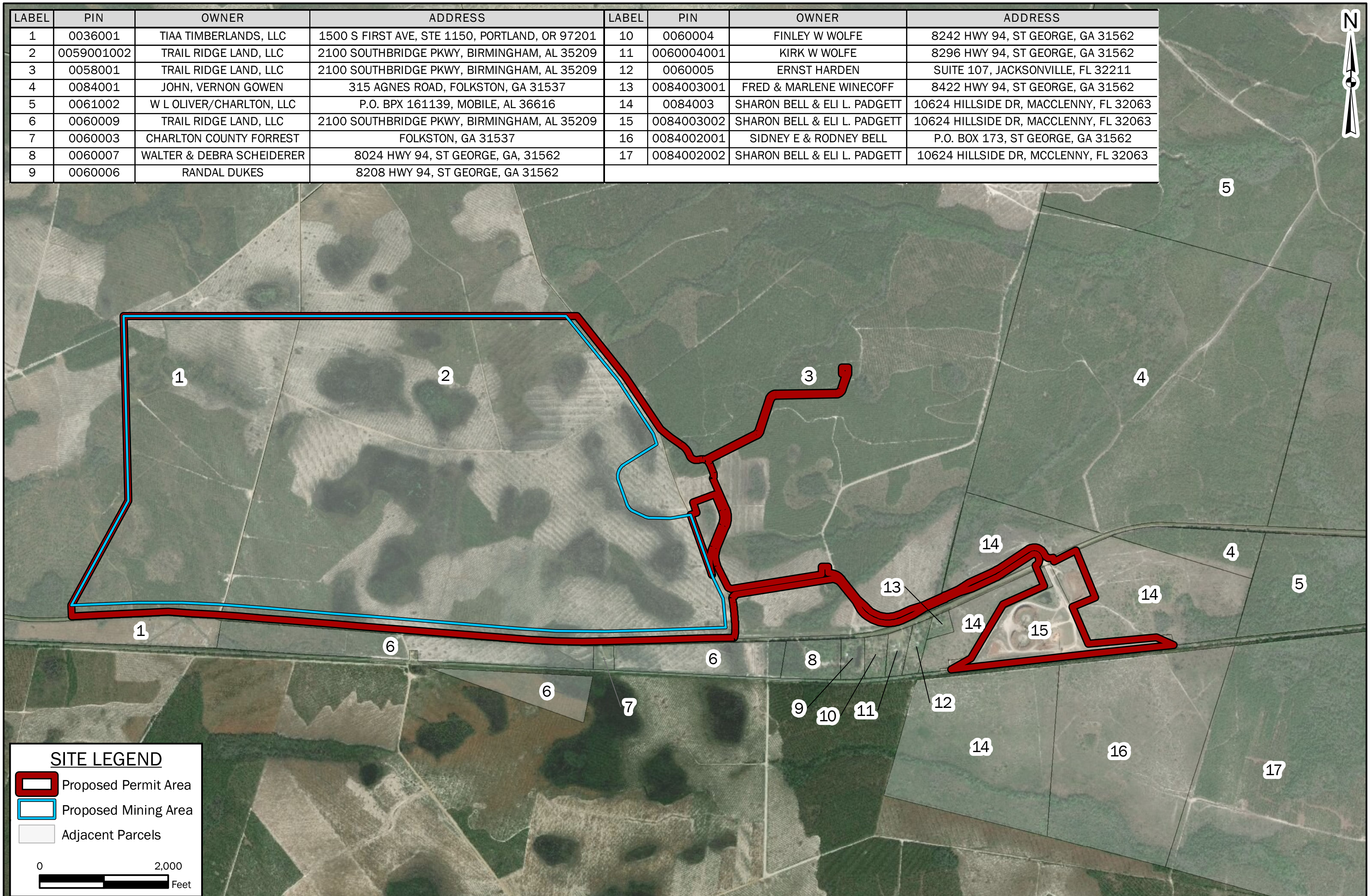


FIGURE 79: SITE LOCATION & REAL ESTATE PARCEL MAP

TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: DigitalGlobe, 3/24/2018 (0.46 m Resolution).

DRAWN BY: DEK	
CHECKED BY: CMS	
DRAWING DATE: 2/28/2020	
REVISION DATE: N/A	
TTL JOB NO.: 000180200804.00	
APPROX. SCALE:	1 in = 2,000 ft