

Appendix G

Subsurface Lithology of the Surficial Aquifer at Twin Pines Mine



Twin Pines Minerals, LLC

SUBSURFACE LITHOLOGY OF THE SURFICIAL AQUIFER AT TWIN PINES MINE

Prepared For:

TWIN PINES MINERALS, LLC
PROPOSED HEAVY MINERALS MINE
ST. GEORGE, CHARLTON COUNTY, GEORGIA

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3516 Greensboro Avenue
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Project No. 000180200804.00, Phase 0400

December 11, 2019

TTL

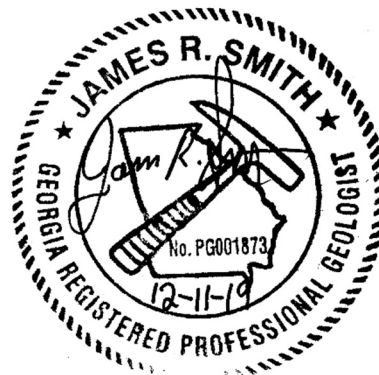


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INTRODUCTION

On July 3, 2019, Twin Pines Minerals (TPM) submitted an individual permit application to the U.S. Army Corps of Engineers for impacts to water of the United States to develop a heavy mineral sand mine along Trail Ridge in Charlton County, Georgia (Figure 1). The proposed mine is located 3.2 miles west of St. George, Georgia, along Georgia State Highway Route 94. Trail Ridge is a 0.6 to 1.2 mile wide and 99 mile long topographic ridge that separates the Okefenokee Basin and Swamp from the coastal plain of Georgia (Force and Rich, 1979). 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 underlain by a shallow aquifer, locally known as the surficial aquifer, which forms a hydrologic divide between the Okefenokee swamplands to the west and the Saint Mary's River to the east. At the proposed mine site, the water table is very shallow with water depths of only a few feet. The surficial aquifer is perched on the clays of the upper Hawthorn Group, which is considered to be the upper confining unit to the Floridian Aquifer in the region (e.g., Williams and Kuniansky, 2016).

The proposed permit area is approximately 2,414-acres, located southeast of the Okefenokee National Wildlife Refuge (ONWR) boundary; however, TPM will only mine an approximate 1,268-acre area located about 2.7 miles from the ONWR boundary (Figure 2). The portion of the proposed permit area extending from the western mining boundary to the edge of the permit boundary will be avoided and will provide a buffer to the ONWR.

The project study area consists of approximately 12,000-acres of land located near St. George, Charlton County, Georgia. This area is comprised of five (5) tracts identified as Loncala, Dallas Police & Fire, Keystone, TIAA, and Adirondack. To evaluate local groundwater, surface water, and precipitation, field activities were performed both within the proposed mining area and on adjacent properties outside of the proposed mining area footprint. Reference to "project study area" in this report refers to activities conducted within the proposed mining area and adjacent tracts.

The purpose of this report is to document the subsurface soil/sediments that comprise the surficial aquifer at the Twin Pines Mine.

SURFICIAL AQUIFER

The surficial aquifer represents the uppermost hydrostratigraphic unit beneath the project study area with thicknesses ranging from 40 to 122 feet below land surface. With water levels ranging in depth from about one to four feet below land surface, the surficial aquifer beneath the study area is generally a subdued replica of the land surface topography. 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.

Water in the surficial aquifer is generally unconfined although semi-confined or confined conditions may exist locally due to the presence of low permeability consolidated sands and clays. Precipitation provides the predominant mode of recharge for the surficial aquifer within the project study area. Rainfall across the project study area varies spatially and groundwater levels respond quickly to rainfall events. These rapid responses reflect the high hydraulic conductivity of the surficial aquifer at Trail Ridge.

SUBSURFACE LITHOLOGY

As documented in the report *Geologic Characterization at Twin Pines Mine* (Holt, et al, 2019a), significant drilling activities were performed to characterize the subsurface soil/sediments that comprise the surficial aquifer beneath the project study area. Subsurface boring data logged by TTL's on-site geologist was used to generate 24 geologic cross sections across the project study area (see Figure 3 and Appendix A). These cross sections were used to evaluate the characteristics of the

subsurface units beneath the site. A list of the subsurface units encountered at the project study area are listed below.

1. Unconsolidated sand unit,
2. Semi-consolidated sand unit,
3. Consolidated black sand unit,
4. Silty-clayey sand unit,
5. Clayey sand unit,
6. Clay unit, and
7. Hawthorn Group (uppermost section)

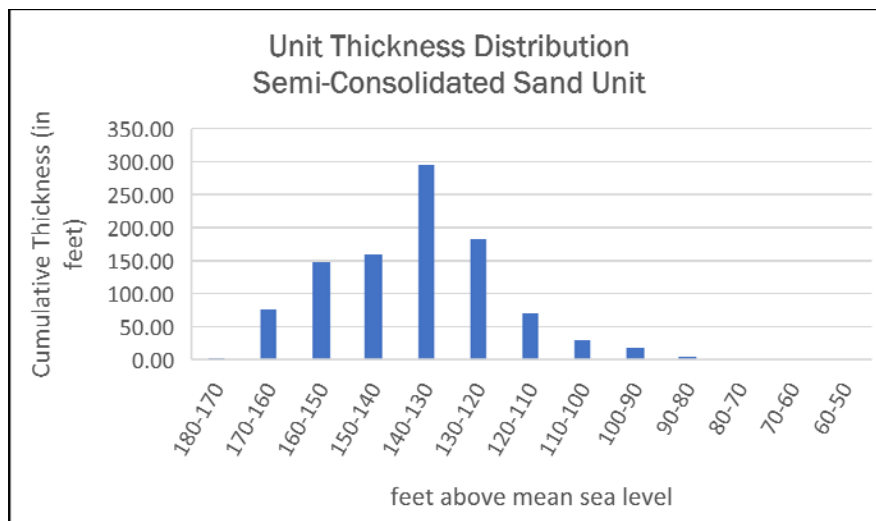
A brief description of each unit is described below:

Unconsolidated Sand Unit

The unconsolidated sand unit comprises the greatest distribution of soil/sediments beneath the project area and 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 and is interlayered with zones of semi-consolidated to consolidated sands, silty-clayey sands, clayey sands and clays.

Semi-Consolidated Sand Unit

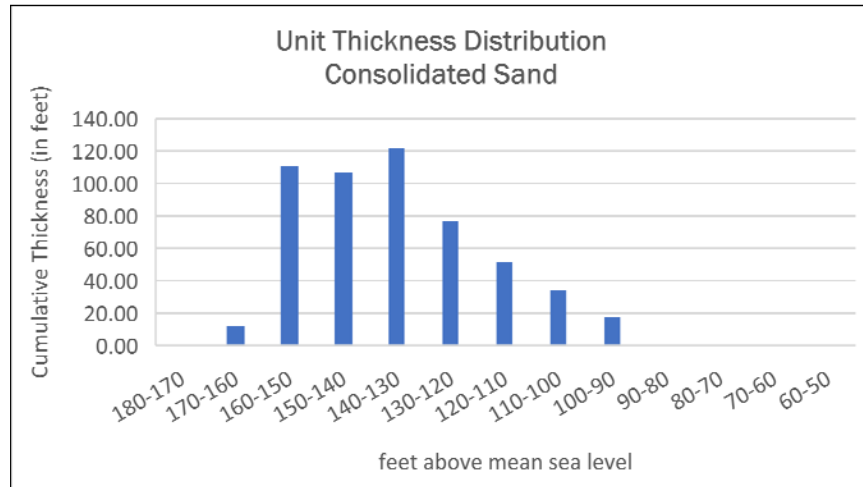
The semi-consolidated sand unit generally consists of fine- to medium-grained silty sands (SM) and well sorted sands (SP) and silty-clayey sand (SC-SM) with a color range from black to brown. The general characteristics of semi-consolidated sand unit includes sands that are moderately cohesive due to the presence of minor amounts of humate. The semi-consolidated sand unit was generally encountered from elevations of 100 to 170 feet above mean sea level (amsl). The cumulative unit thickness was greatest within the interval from 110 to 140 feet elevation.



Consolidated Black Sand Unit

The consolidated black sand unit consists of fine- to medium-grained silty sands (SM) and well sorted sands (SP) and generally described as black in color. In many cases, the presence of significant amounts of humate rendered a greasy appearance to the core samples. The general characteristics

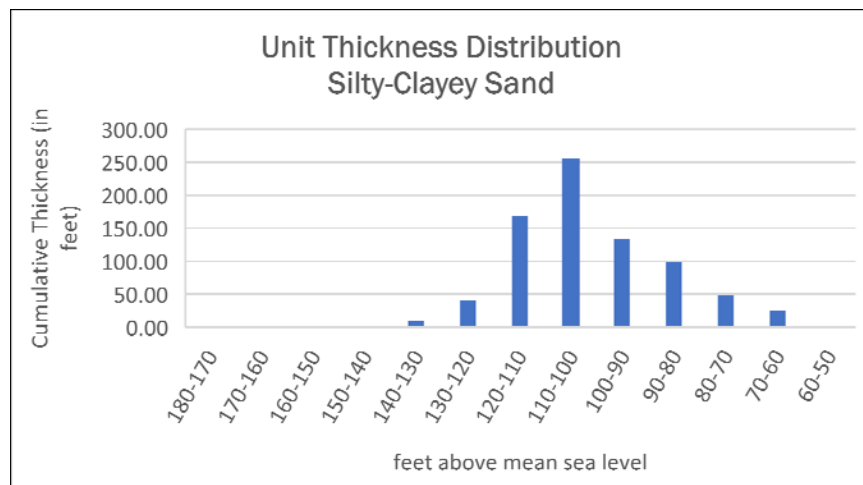
of the consolidated black sand unit includes sands that are cohesive due to significant amounts of humate. The humate appears to serve as a bonding agent for the sand, which can create local areas of lower permeability soil beneath the study area. The consolidated black sand unit was generally encountered from elevations of 90 to 160 feet amsl. The unit thickness was greatest within the interval from 130 to 160 feet elevation



TTL conducted an extensive drilling program to evaluate the lateral continuity of the consolidated black sands, including the drilling and description of 71 closely-spaced soil cores. We found that the consolidated black sands are very discontinuous in the permit area and appear in irregular zones, not continuous layers.

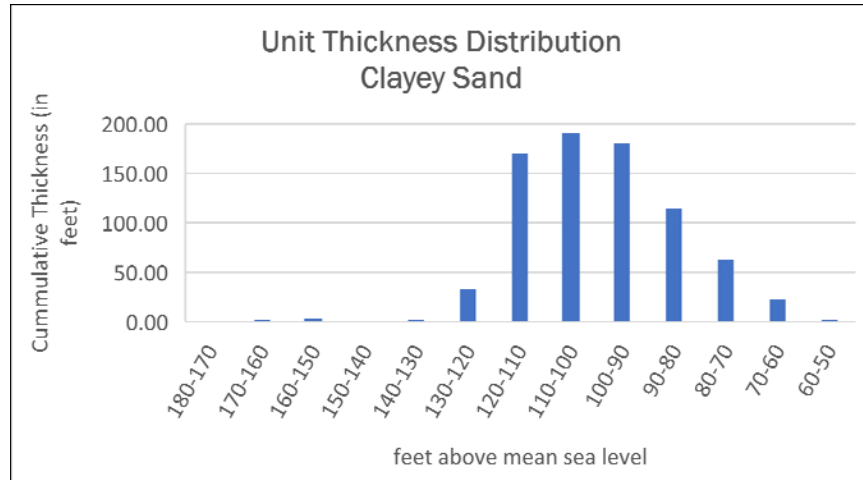
Silty-Clayey Sand Unit

The silty-clayey sand unit generally consists of fine- to medium-grained silty sands, silt, less than five percent clay content, and ranges in color from black to brown to grey. The general characteristics of this unit includes sands that are loosely cohesive due to minor clay content. Within some borings at the site, these soil/sediments were described as black to very dark brown in color and semi-consolidated. The silty-clayey sand unit was generally encountered from elevations ranging from 60 to 130 feet amsl. The unit thickness was greatest within the interval from 80 to 120 feet elevation.



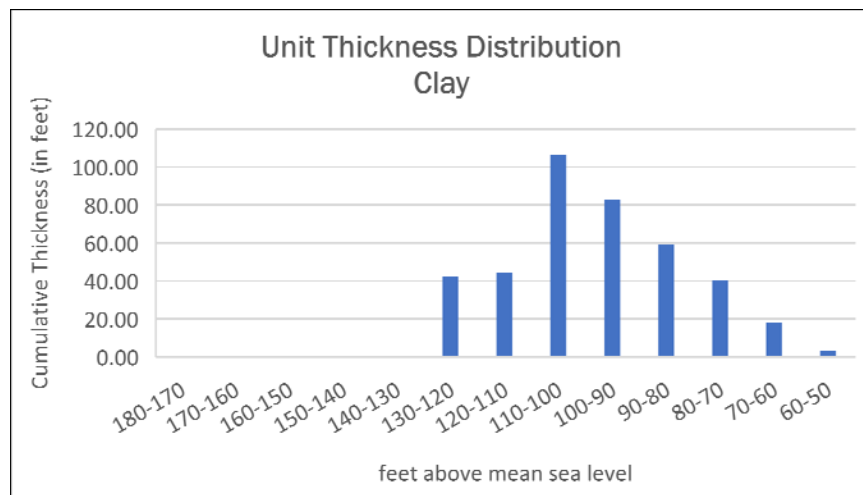
Clayey Sand Unit

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 gray. The general characteristics of the clayey sand unit includes sands that are cohesive due to moderate clay content. The clayey sand unit was generally encountered from elevations ranging from 60 to 130 feet amsl. The unit thickness was greatest within the interval from 80 to 120 feet elevation.



Clay Unit

The clay unit consists of silty clays, sandy clays, and fat clays and ranges in color from brown to grey to greenish gray closer to the Hawthorn Group. The gray to greenish gray clays above the Hawthorn Group are reworked material from the upper Hawthorn. The clay is generally firmer and more compact than the surrounding sands units. The clay unit was generally encountered from elevations ranging from 60 to 130 feet amsl. The unit thickness was greatest within the interval from 80 to 120 feet elevation.



Hawthorn Group

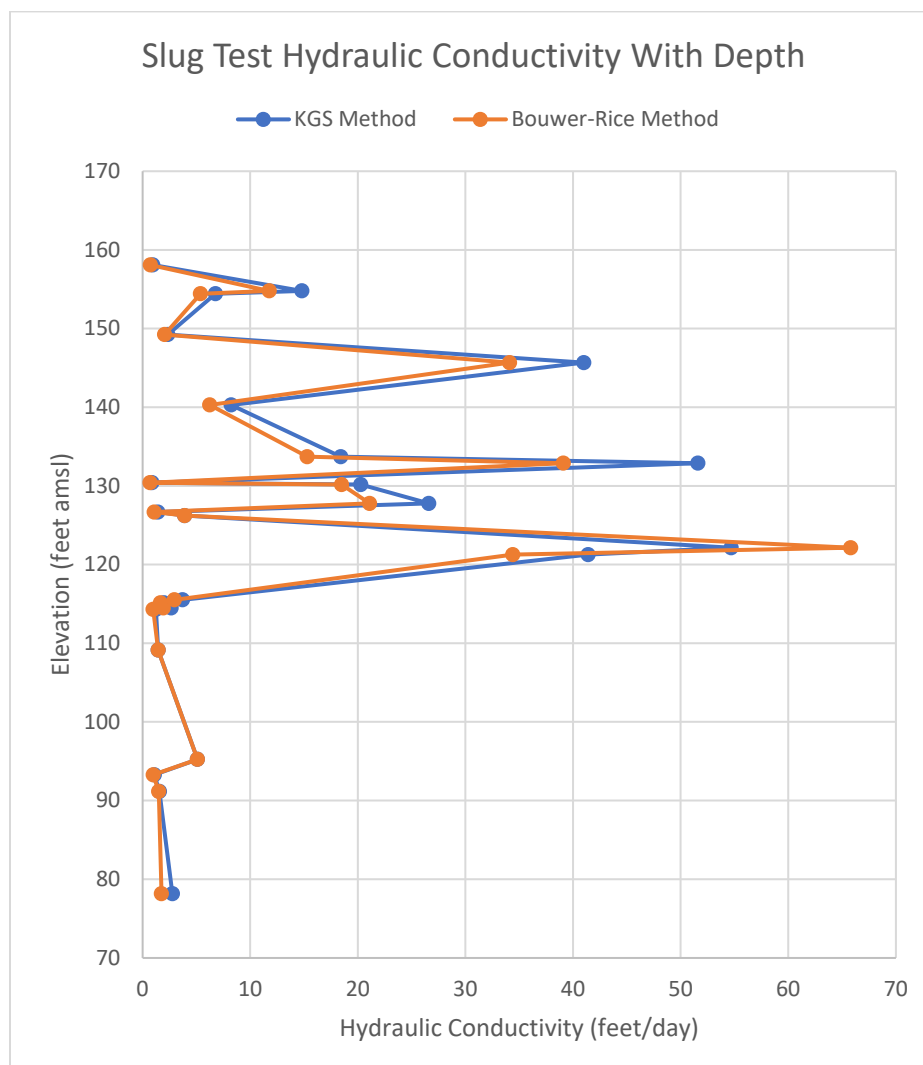
The top of Hawthorn Group within the project area is generally comprised of clayey sands and lean to fat clays that are calcareous and that range in color from greenish gray to grayish green. These sediments represent the base of the surficial aquifer at the site. The Hawthorn Group is reported to be greater than 300 feet thick and unbreached in the general vicinity of the project area (Williams and

Kuniansky, 2016) which is significant since the Hawthorn Group is defined in geologic literature as the upper confining unit for the Floridan aquifer system.

SUMMARY

The geologic 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.

The unconsolidated, semi-consolidated, and consolidated black sands are more common above 120 feet amsl, while silty-clayey sand, clayey sand, and clay are more common below 120 ft amsl. This distribution is supported by our previous evaluation of hydraulic conductivities from slug and bail testing performed in piezometers within the project study area (Holt et al., 2019b). The hydraulic conductivity data showed 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.



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- Force, E.R. and F.R. Rich. 1989. Geologic Evolution of the Trail Ridge Eolian Heavy-Mineral Sand and Underlying Peat, Northern Florida. U.S. Geological Survey Professional Paper, 1499.
- Pirkle, F.L., E.C. Pirkle, J.G. Reynolds, W.A. Pirkle, J.A. Henry, and W.J. Rice, 1993, The Folkston West and Amelia Heavy Mineral Deposits of Trail Ridge, Southeastern Georgia, *Economic Geology*, vol.88, p. 961-971.
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- Holt, R. M., J.M Tanner, J.R. Smith, A.C. Patton, and Z.B. Lepchitz, 2019a, Geologic Characterization at Twin Pines Mine, prepared for Twin Pines Minerals LLC by TTL Incorporated, Tuscaloosa Alabama.
- Holt, R. M., J.M Tanner, J.R. Smith, A.C. Patton, and Z.B. Lepchitz, 2019b, Hydrogeologic Field Characterization at Twin Pines Mine, prepared for Twin Pines Minerals LLC by TTL Incorporated, Tuscaloosa Alabama.

FIGURES

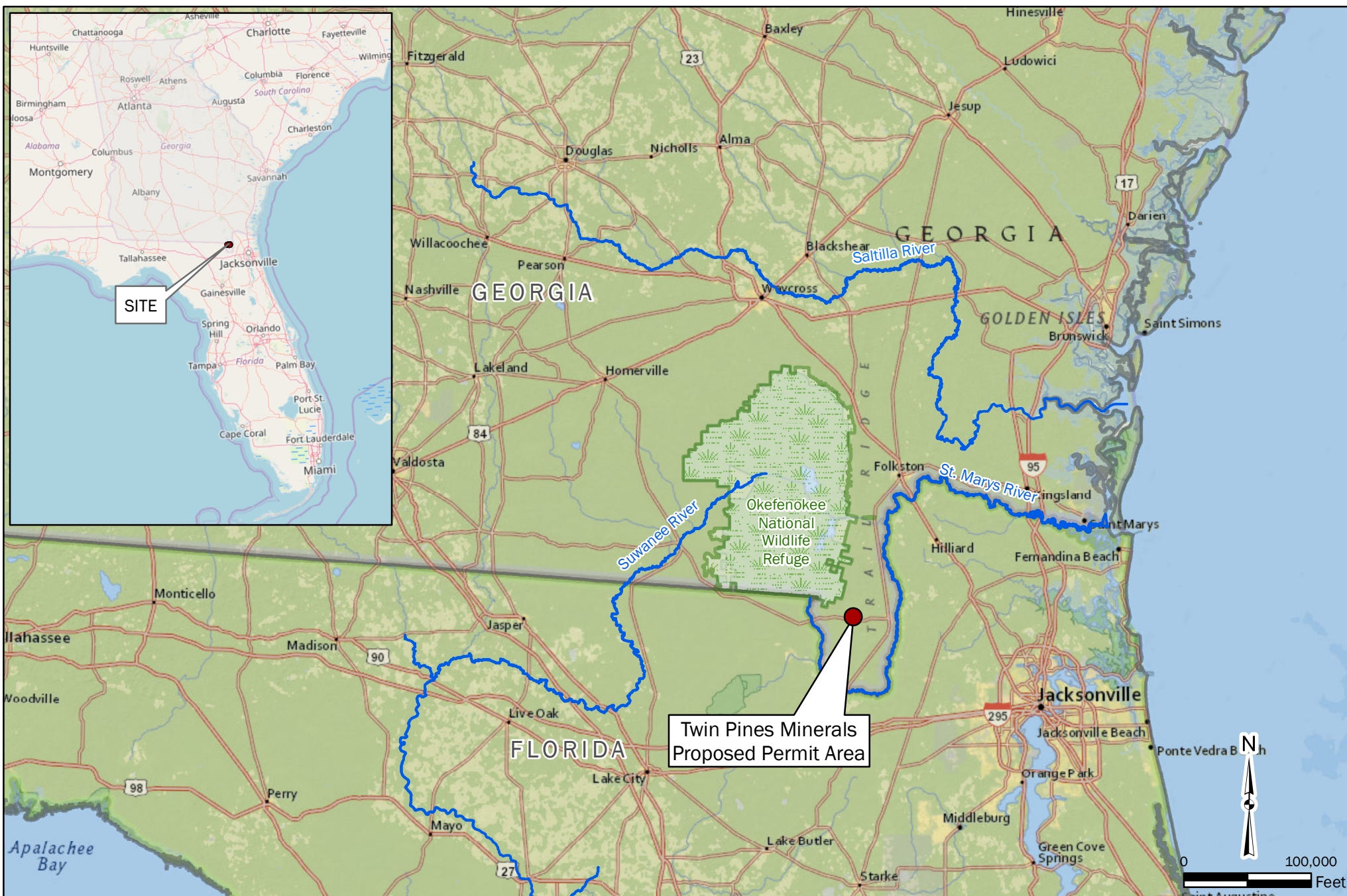


FIGURE 1: LOCATION OF THE PROPOSED TWIN PINES MINE TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

INSET BASEMAP: Open Street Map. BASEMAP: National Geographic World Map.

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CHECKED BY: JMT
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REVISION DATE: N/A
TTL JOB NO.: 000180200804.00
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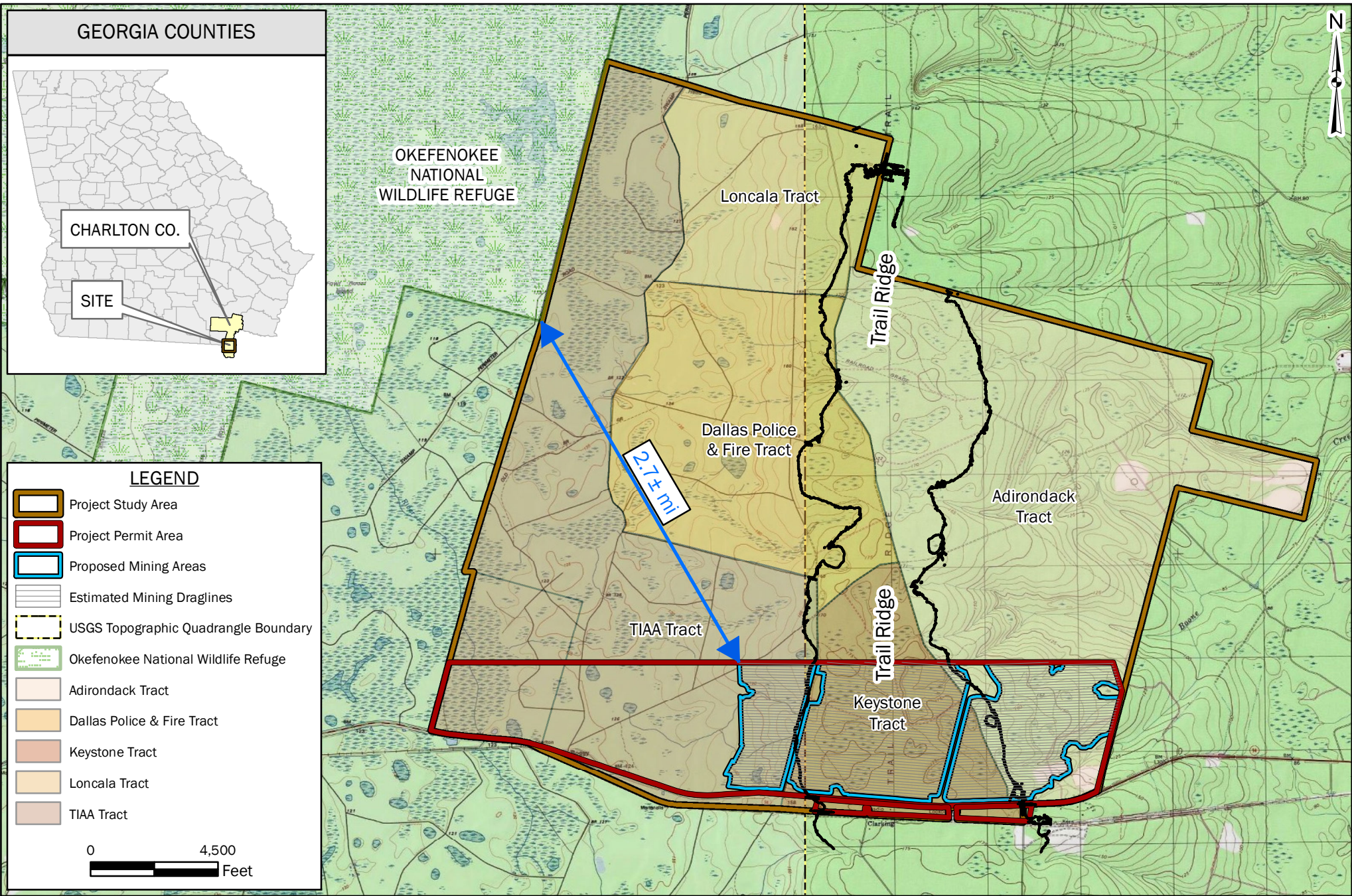


FIGURE 2: PROJECT STUDY & PROPOSED PERMIT AREA TWIN PINES MINERALS

ST. GEORGE, CHARLTON COUNTY, GEORGIA

BASEMAP: USGS 7.5 Minute Quadrangle Map, Florida & Georgia, (West) Moniac 1968 (10-ft Contour Interval), (East) Saint George 1982 (5-ft Contour Interval).

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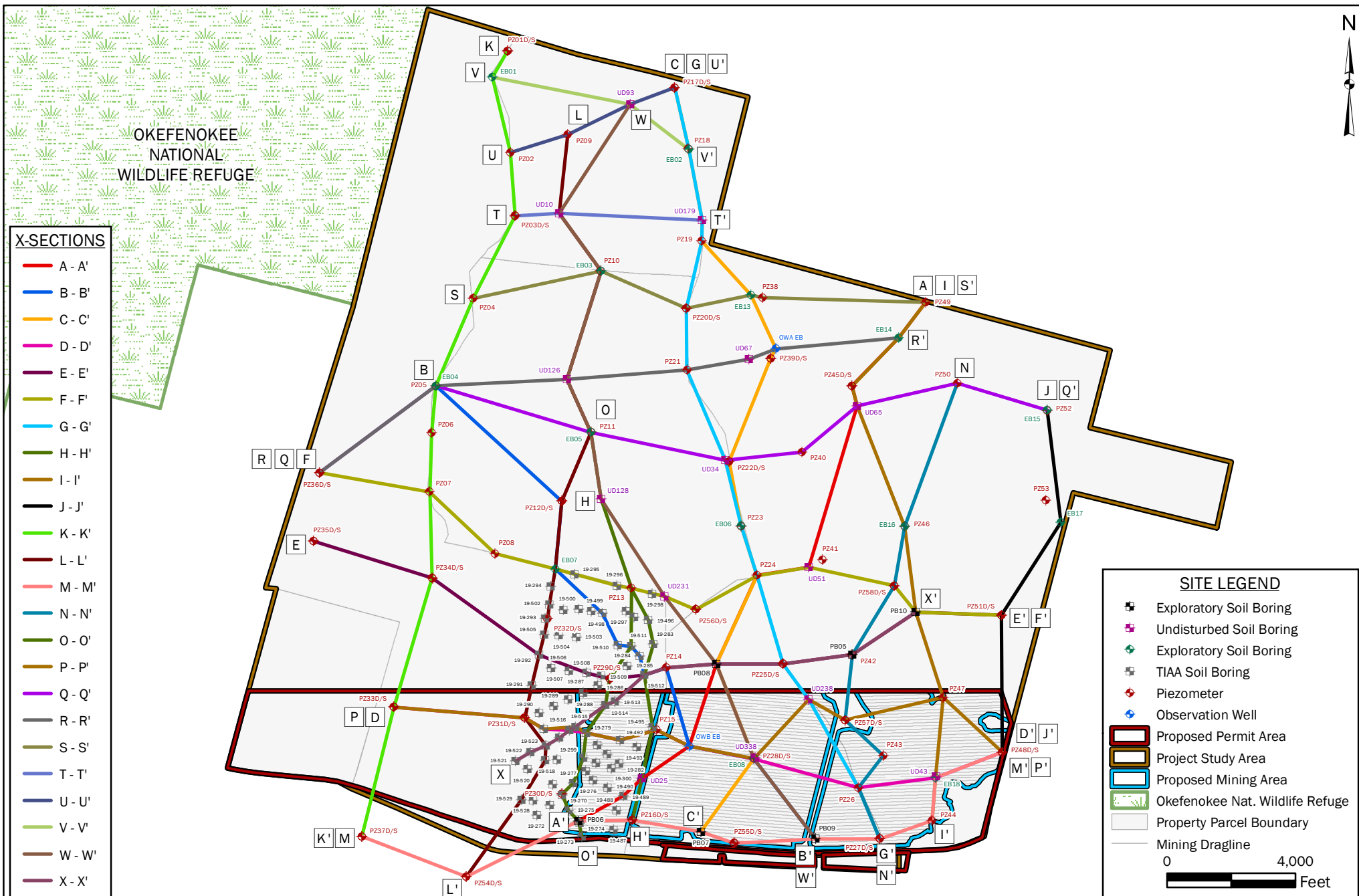


FIGURE 3: SOIL BORING & HYDROGEOLOGIC CROSS-SECTION LOCATION MAP
HYDROGEOLOGY OF THE TWIN PINES PROJECT AREA
TWIN PINES MINERALS
ST. GEORGE, CHARLTON COUNTY, GEORGIA

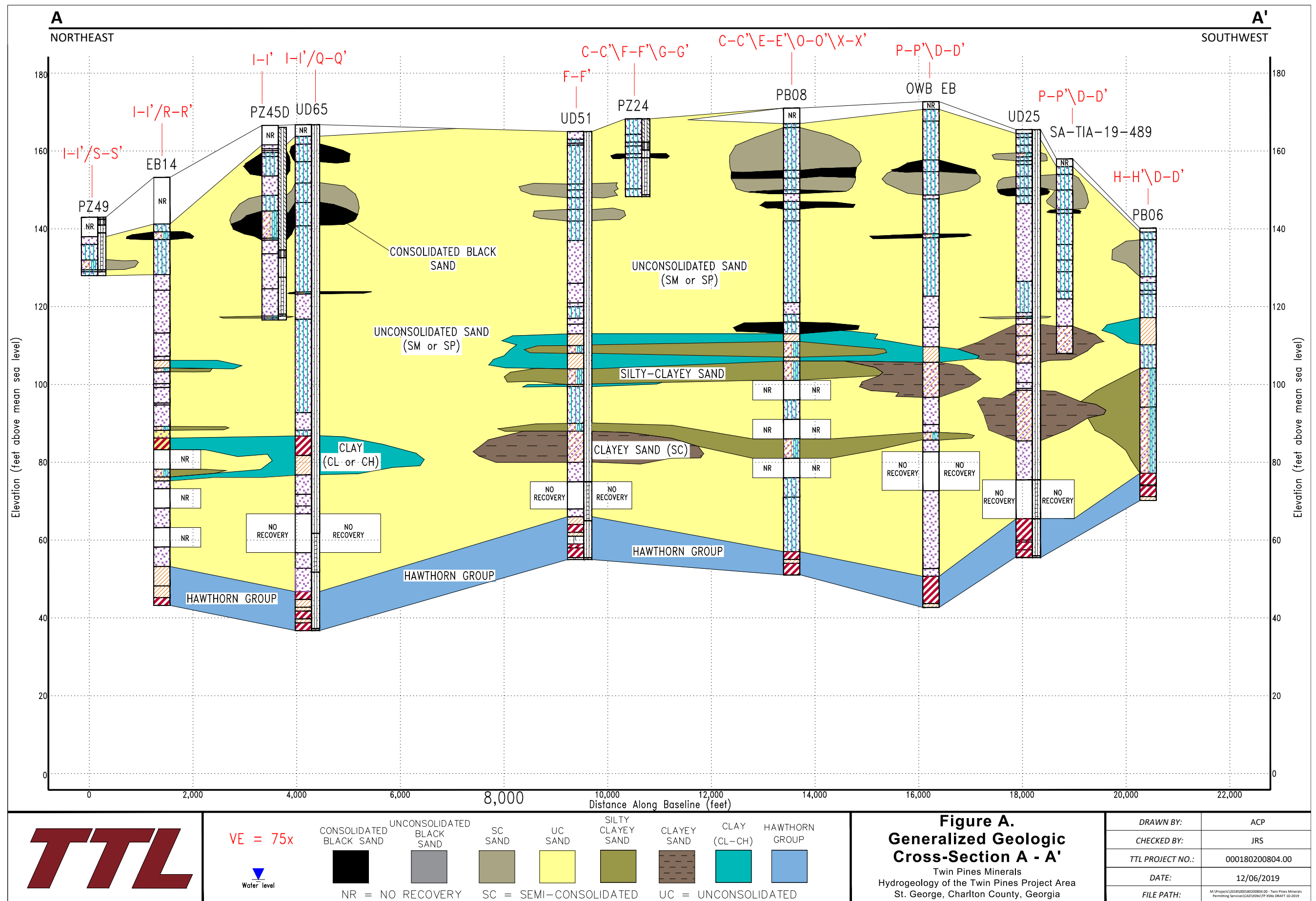


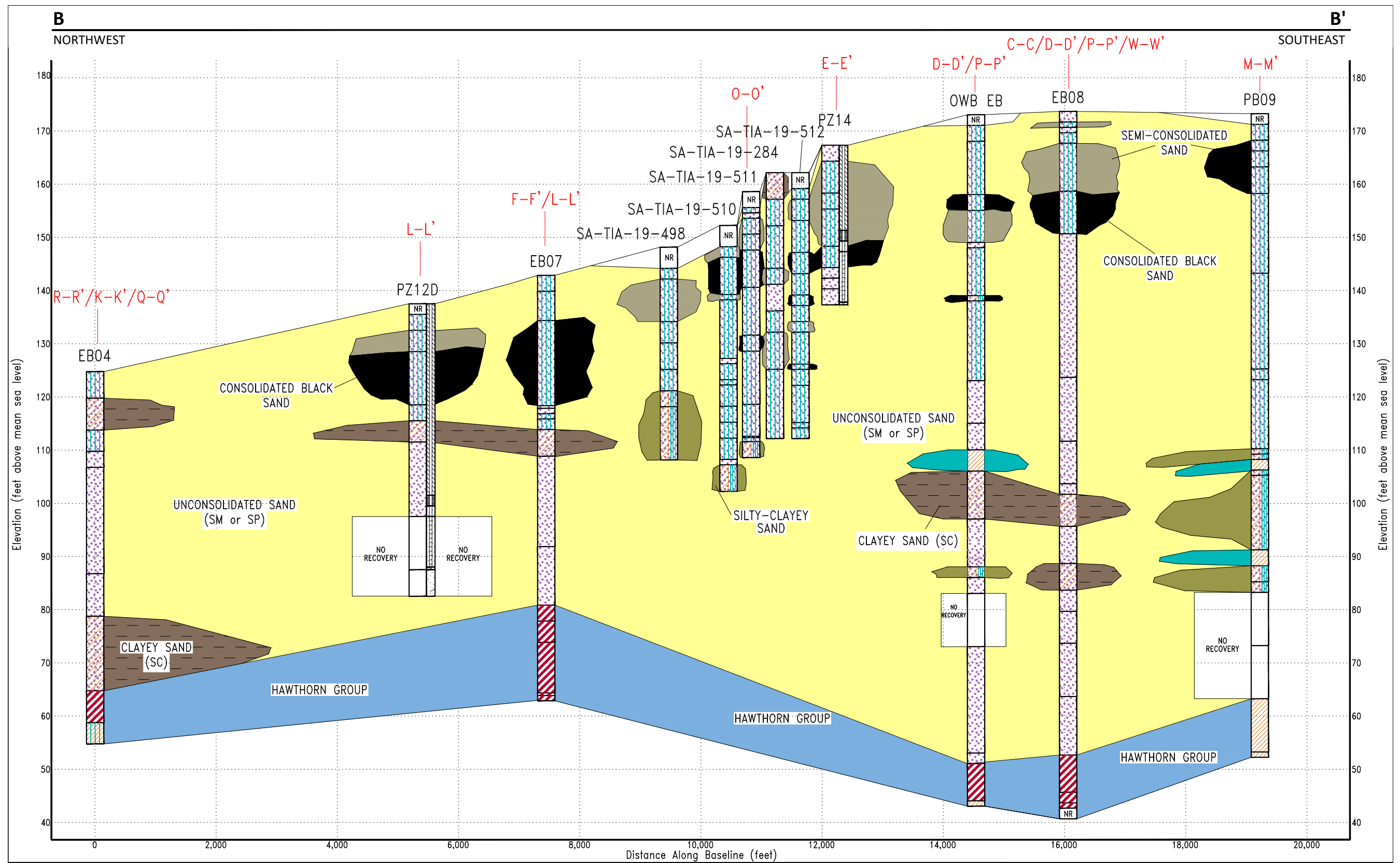
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APPENDIX A

GENERALIZED GEOLOGIC CROSS SECTIONS

Attached Document:
Generalized Geologic Cross Sections A-A' to X-X'





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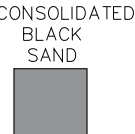


Water level



CONSOLIDATED BLACK SAND

NR = NO RECOVERY



UNCONSOLIDATED BLACK SAND



SC SAND

SC = SEMI-CONSOLIDATED



UC SAND

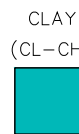


SILTY CLAYEY SAND



CLAYEY SAND

UC = UNCONSOLIDATED



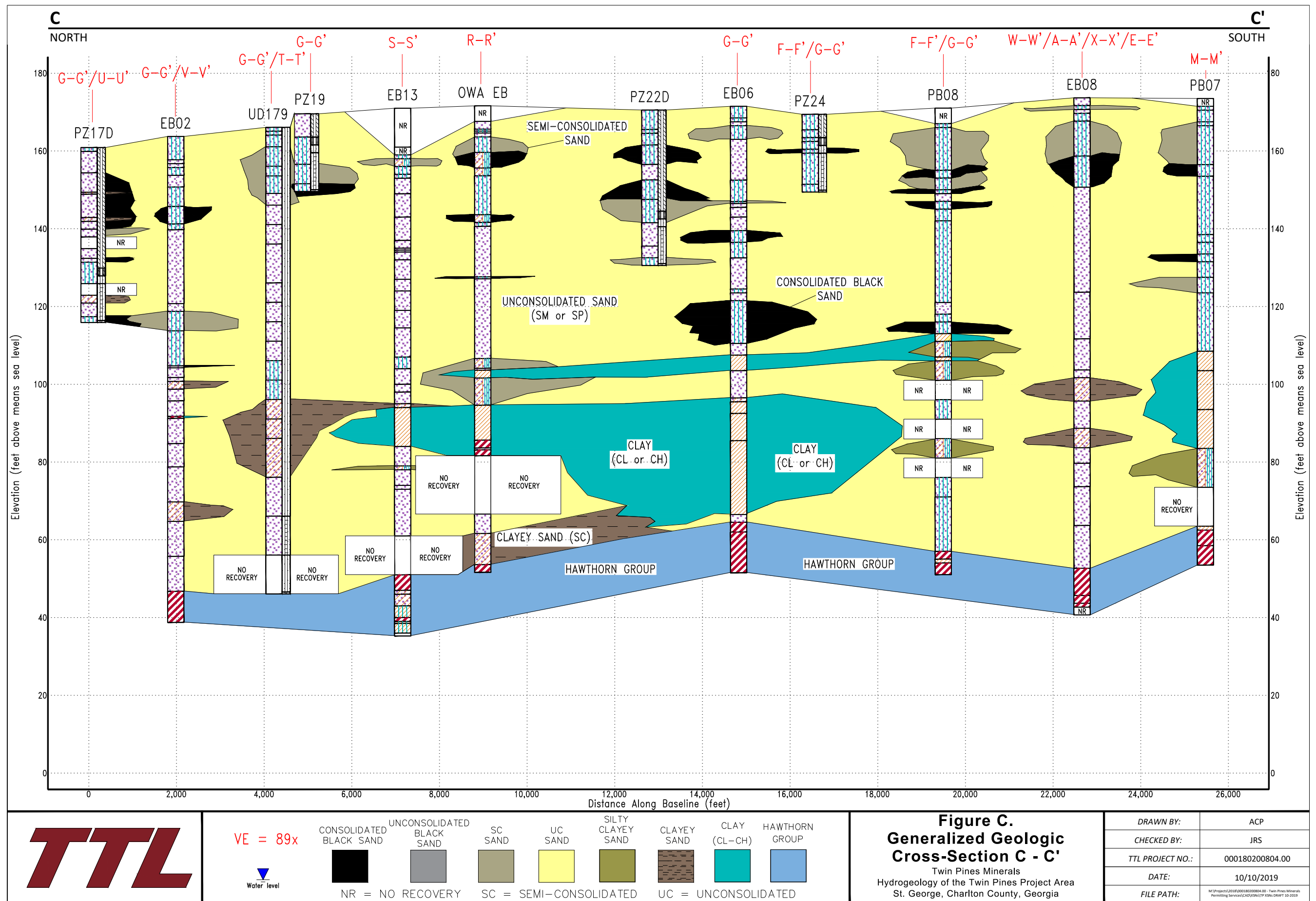
CLAY (CL-CH)

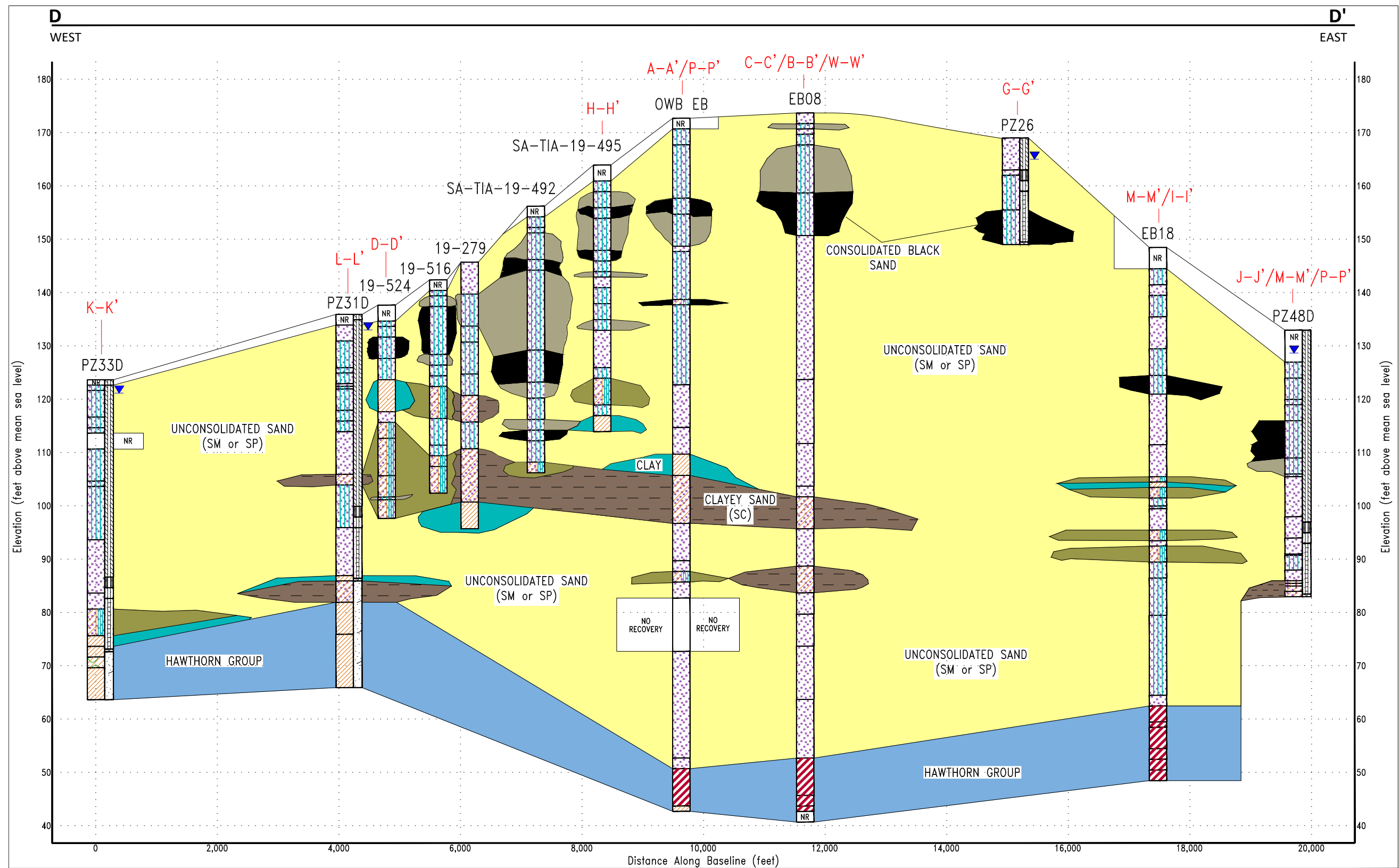


HAWTHORN GROUP

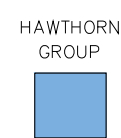
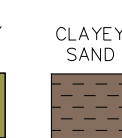
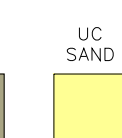
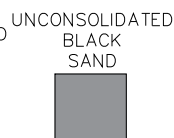
Figure B.
Generalized Geologic Cross-Section B - B'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

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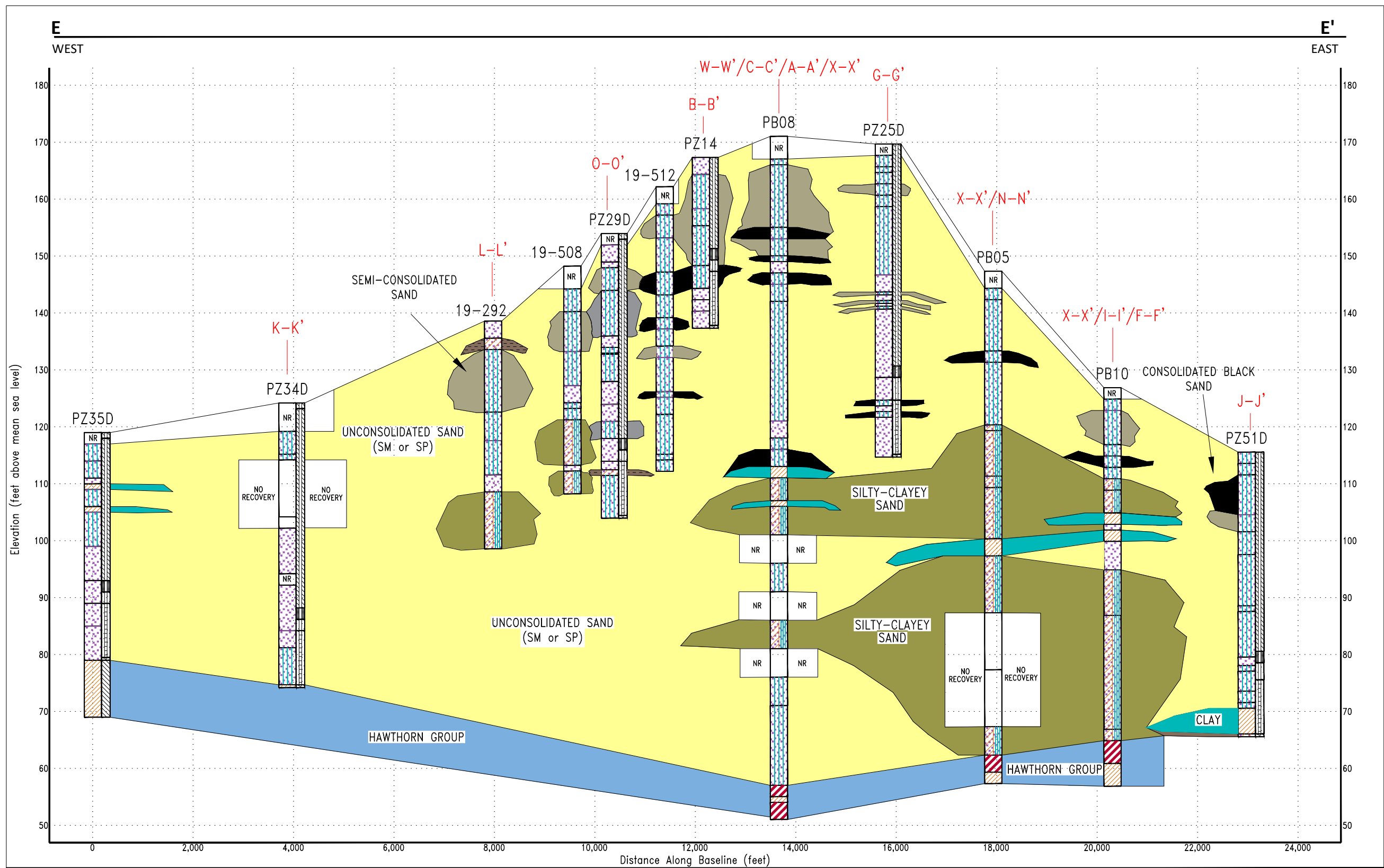
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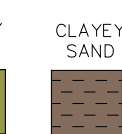
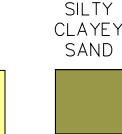
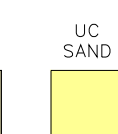
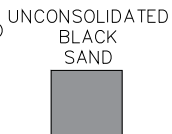
UC = UNCONSOLIDATED

Figure D.
Generalized Geologic
Cross-Section D - D'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

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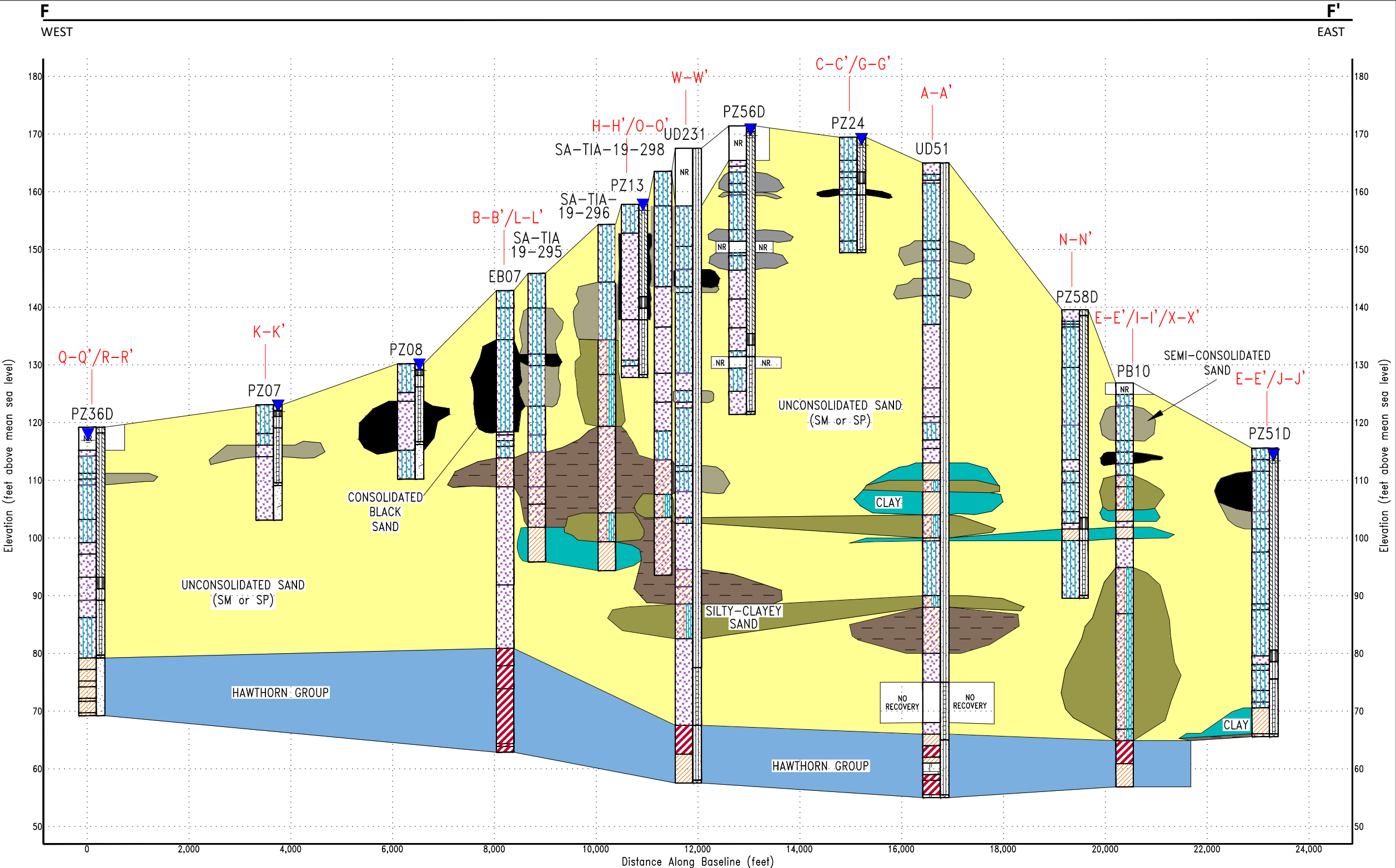
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SC = SEMI-CONSOLIDATED

UC = UNCONSOLIDATED

Figure E.
Generalized Hydrogeologic
Cross-Section E - E'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

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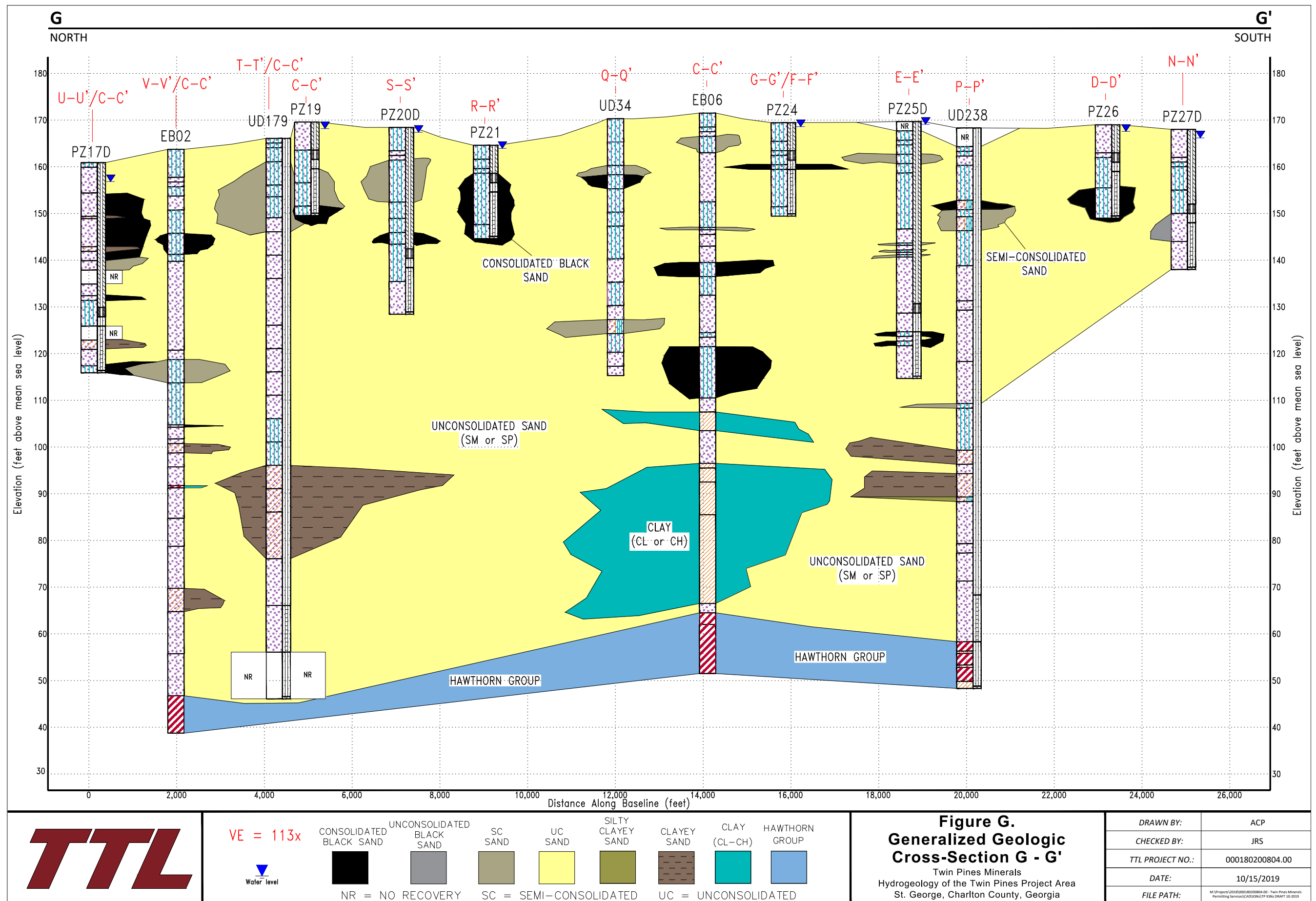
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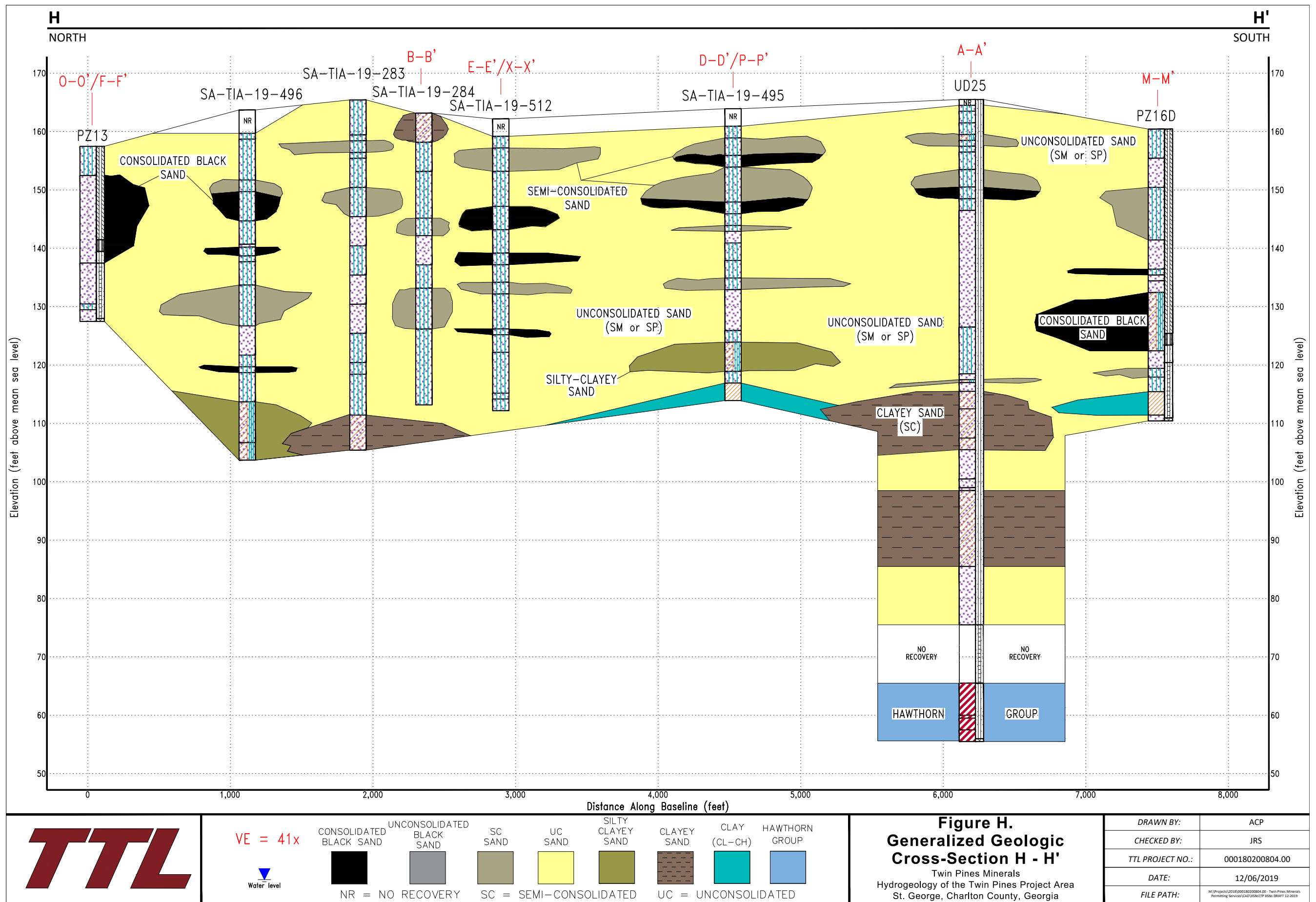
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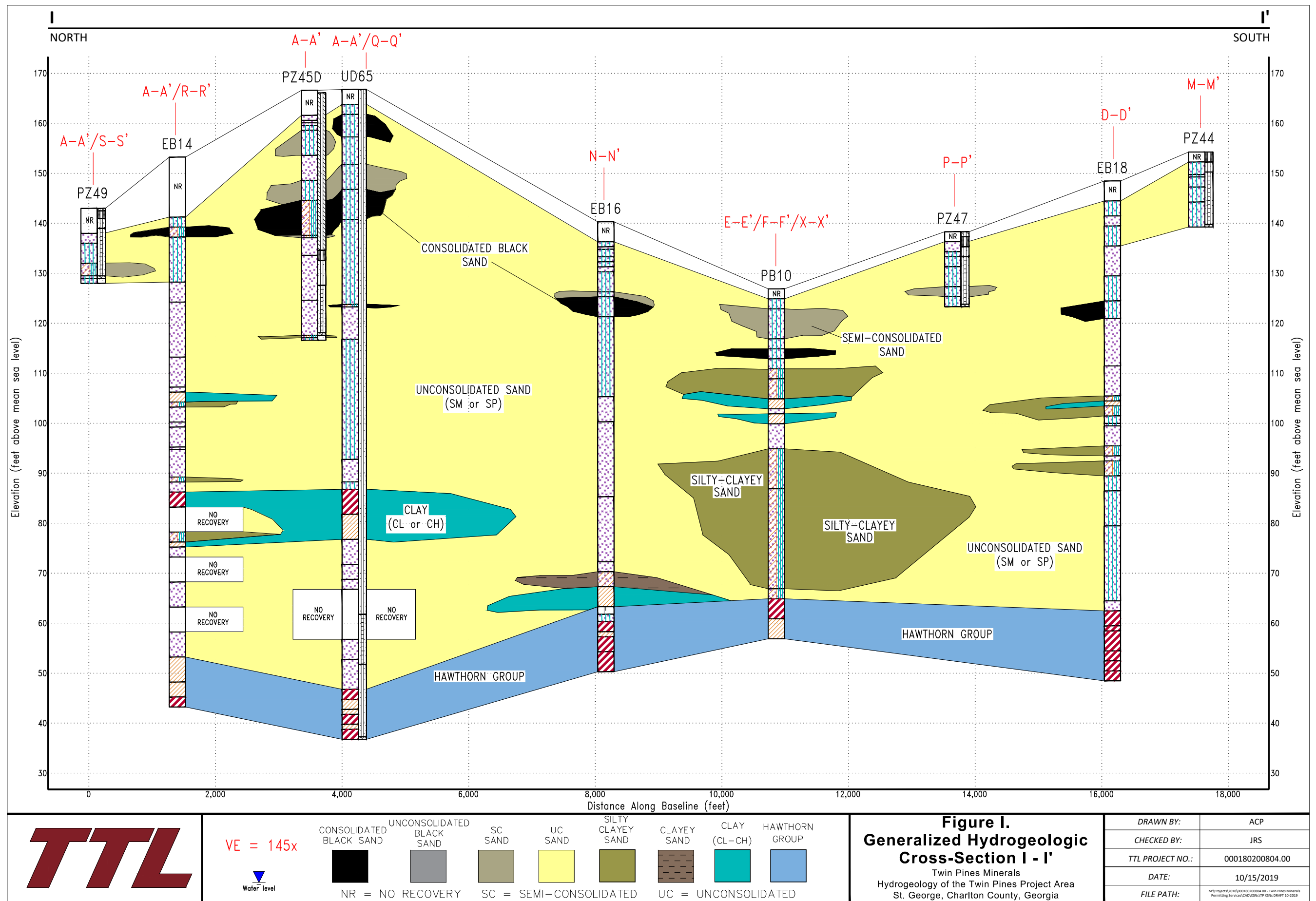
CONSOLIDATED BLACK SAND	UNCONSOLIDATED BLACK SAND	SC SAND	UC SAND	SILTY CLAYEY SAND	CLAYEY SAND	CLAY (CL-CH)	HAWTHORN GROUP
NR = NO RECOVERY		SC = SEMI-CONSOLIDATED	UC = UNCONSOLIDATED				

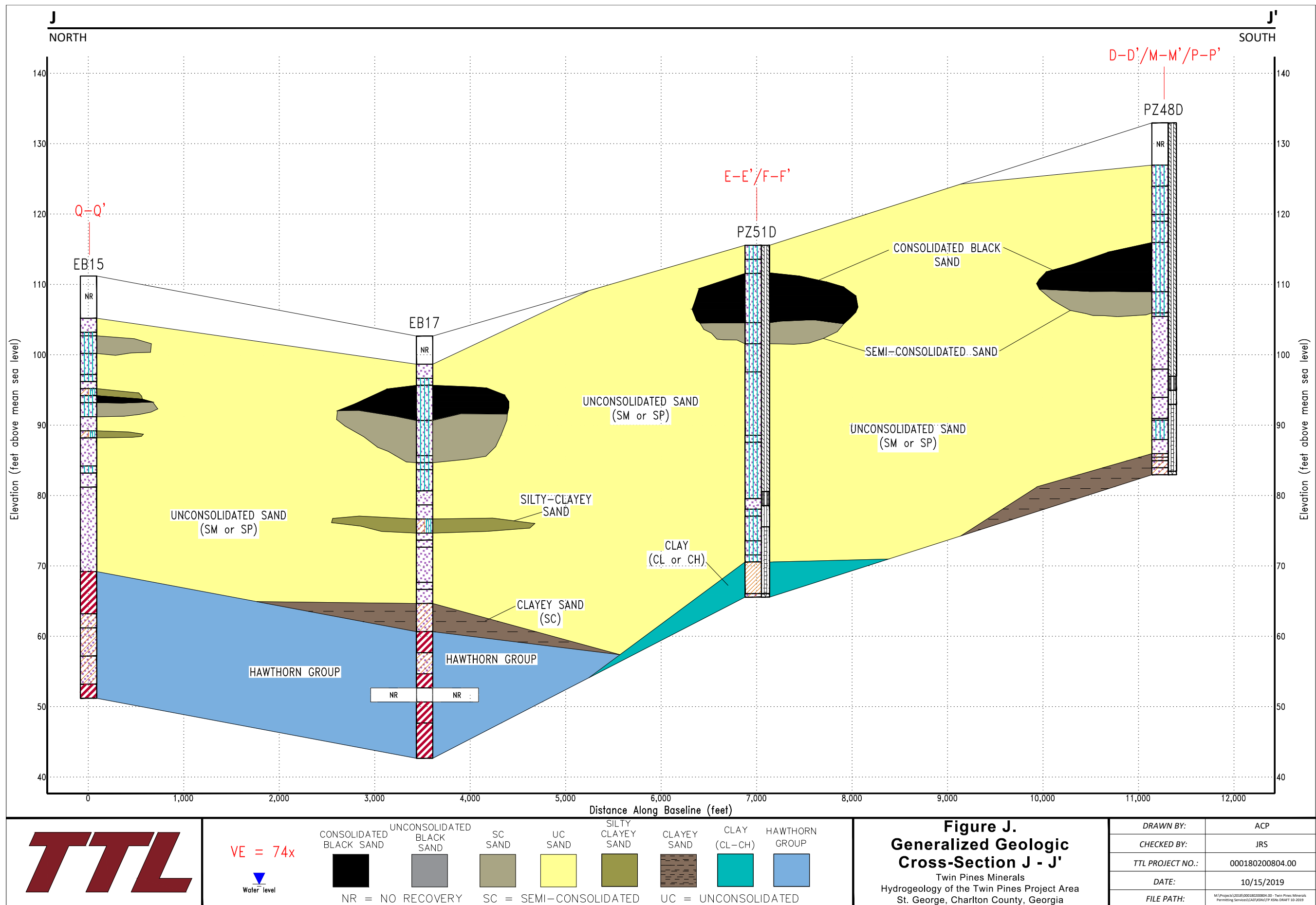
Figure F.
Generalized Geologic Cross-Section F - F'
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Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

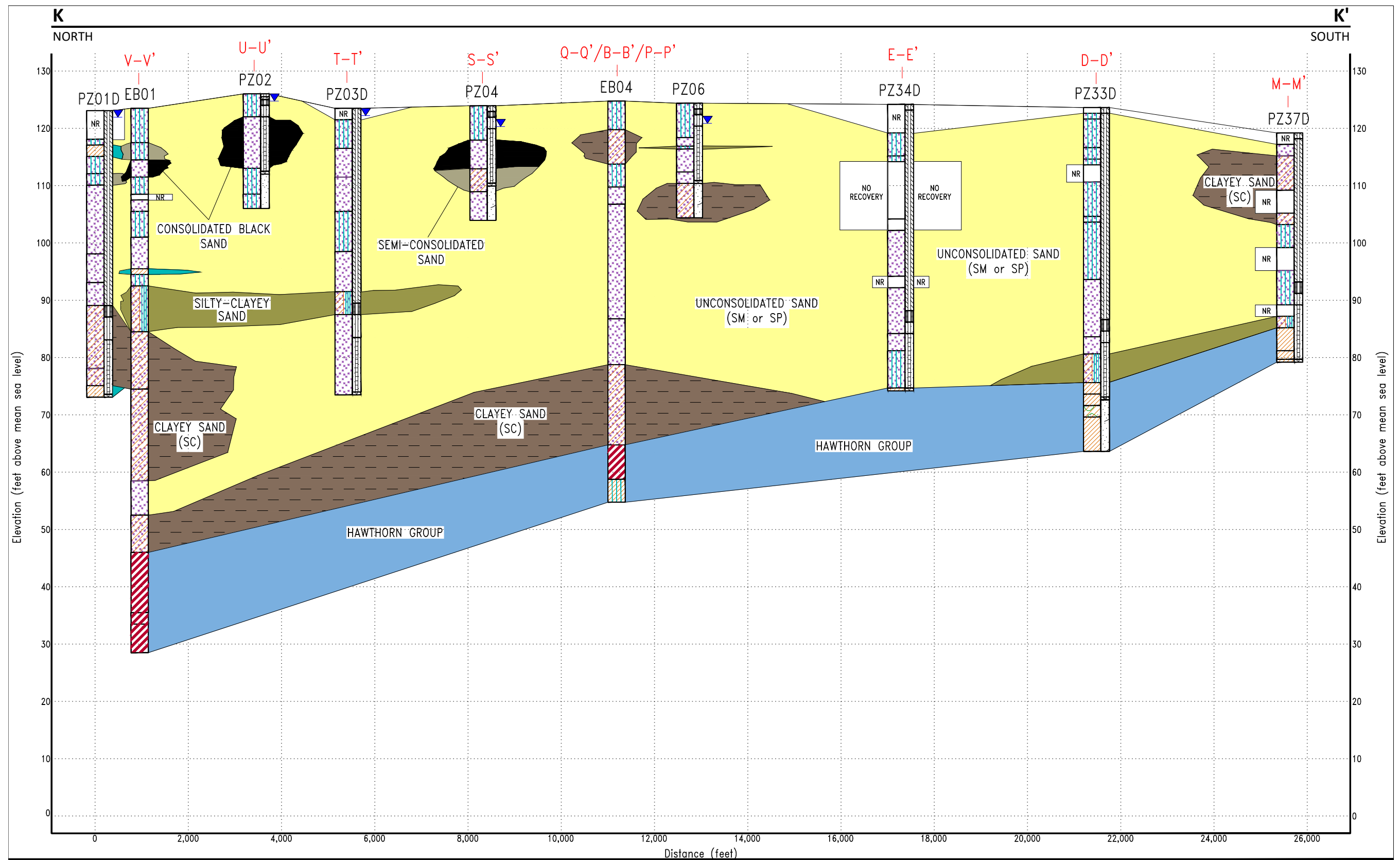
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VE = 123x

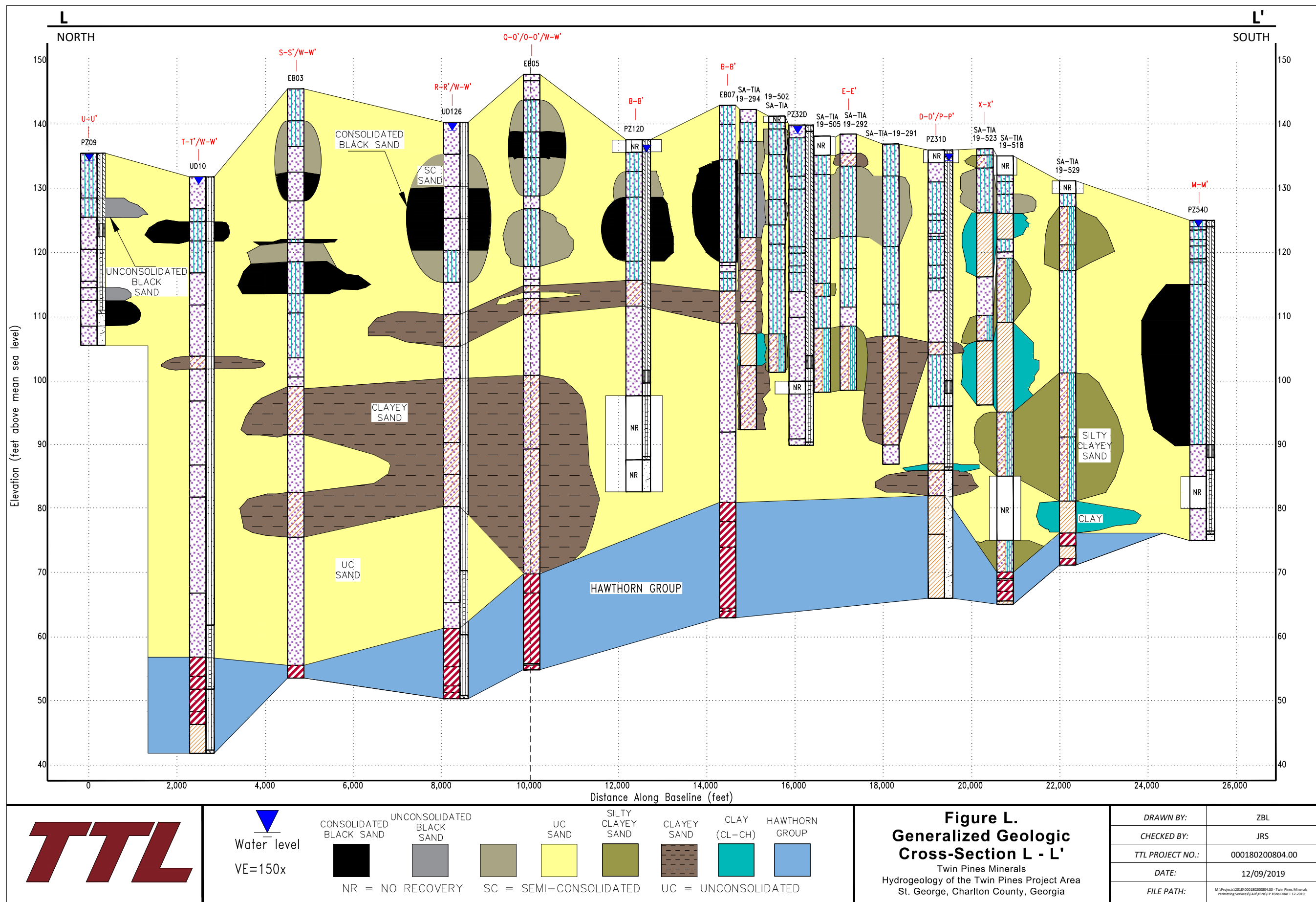


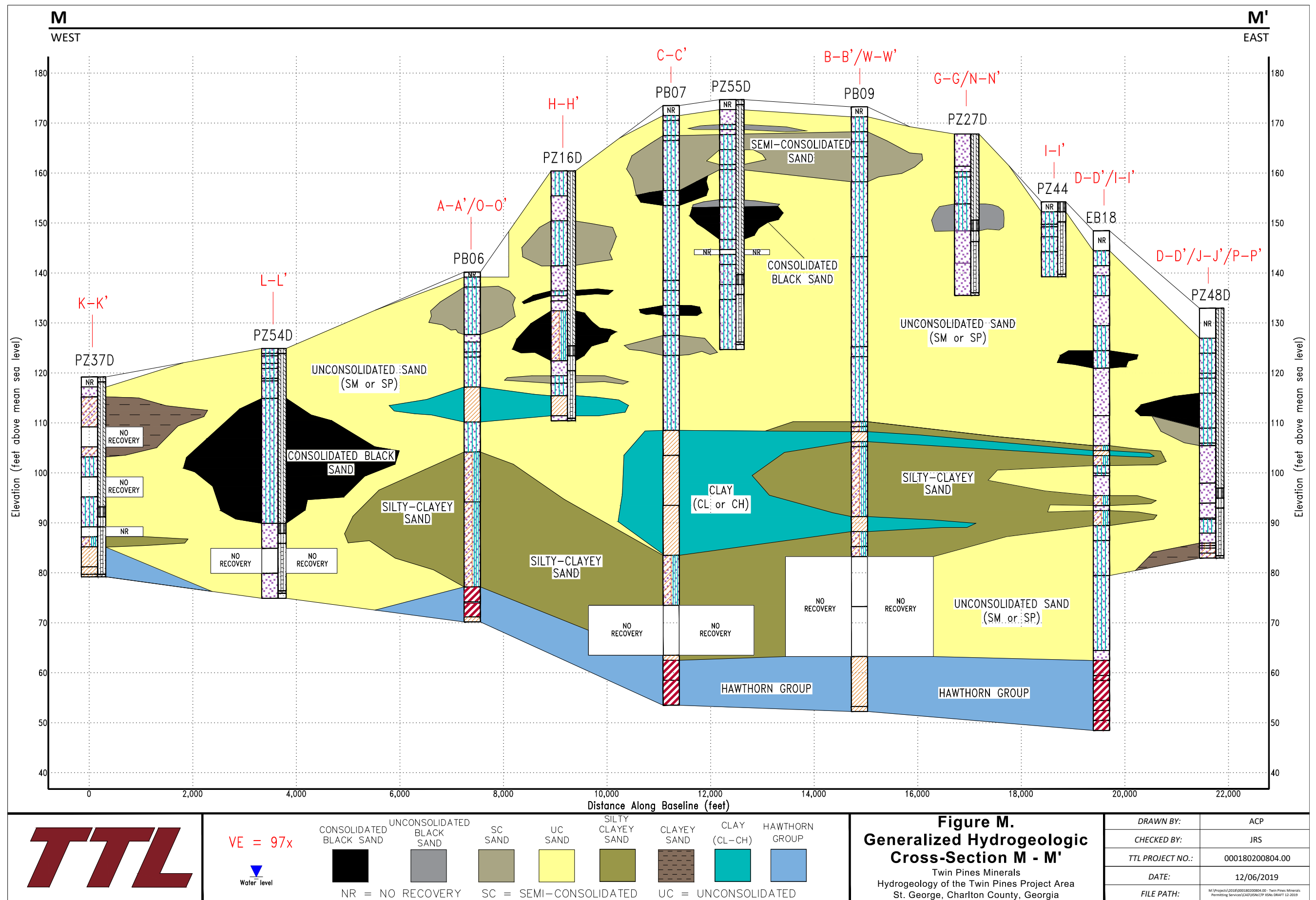
CONSOLIDATED BLACK SAND	UNCONSOLIDATED BLACK SAND	SC SAND	UC SAND	SILTY CLAYEY SAND	CLAYEY SAND	CLAY (CL-CH)	HAWTHORN GROUP
							
NR = NO RECOVERY		SC = SEMI-CONSOLIDATED		UC = UNCONSOLIDATED			

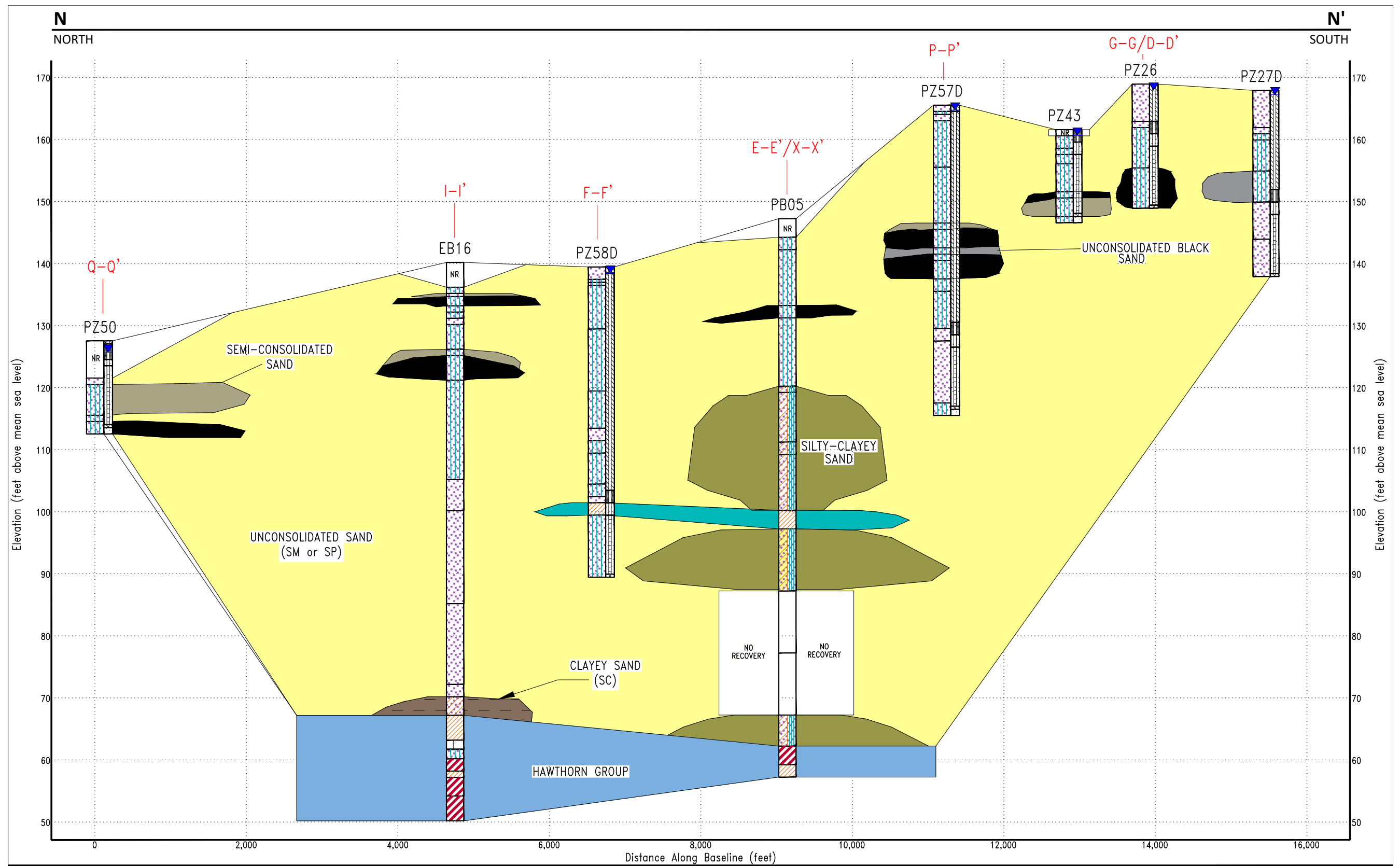
Figure K.
Generalized Geologic
Cross-Section K - K'

Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

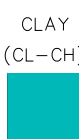
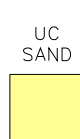
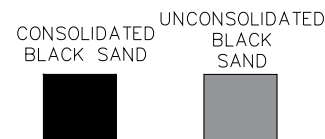
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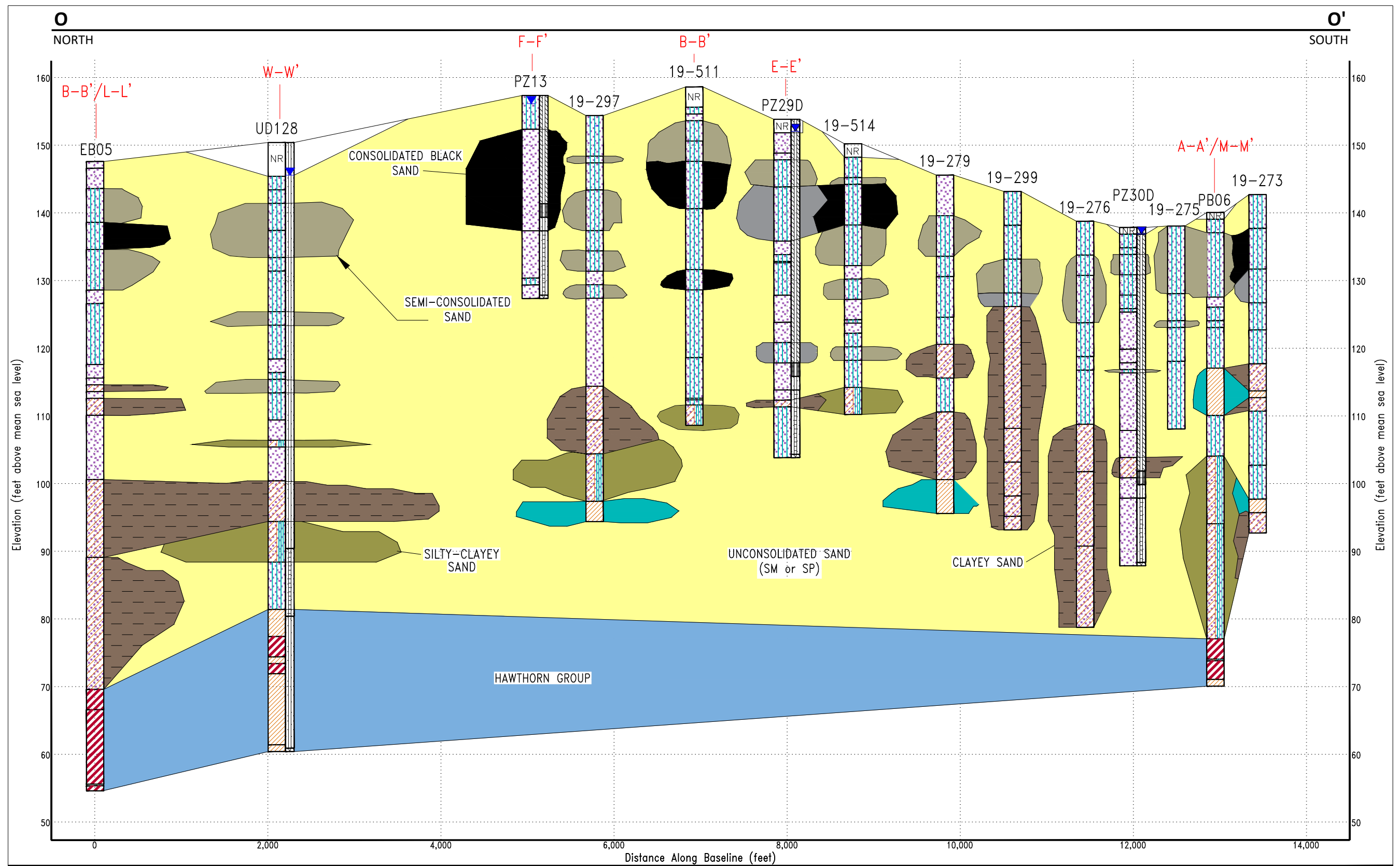
NR = NO RECOVERY

SC = SEMI-CONSOLIDATED

UC = UNCONSOLIDATED

Figure N.
Generalized Hydrogeologic
Cross-Section N - N'
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 Hydrogeology of the Twin Pines Project Area
 St. George, Charlton County, Georgia

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VE = 78x



CONSOLIDATED
BLACK SAND

NR = NO RECOVERY

UNCONSOLIDATED
BLACK SAND


SC SAND

SC = SEMI-CONSOLIDATED

UC SAND

UC = UNCONSOLIDATED

SILTY
CLAYEY
SAND

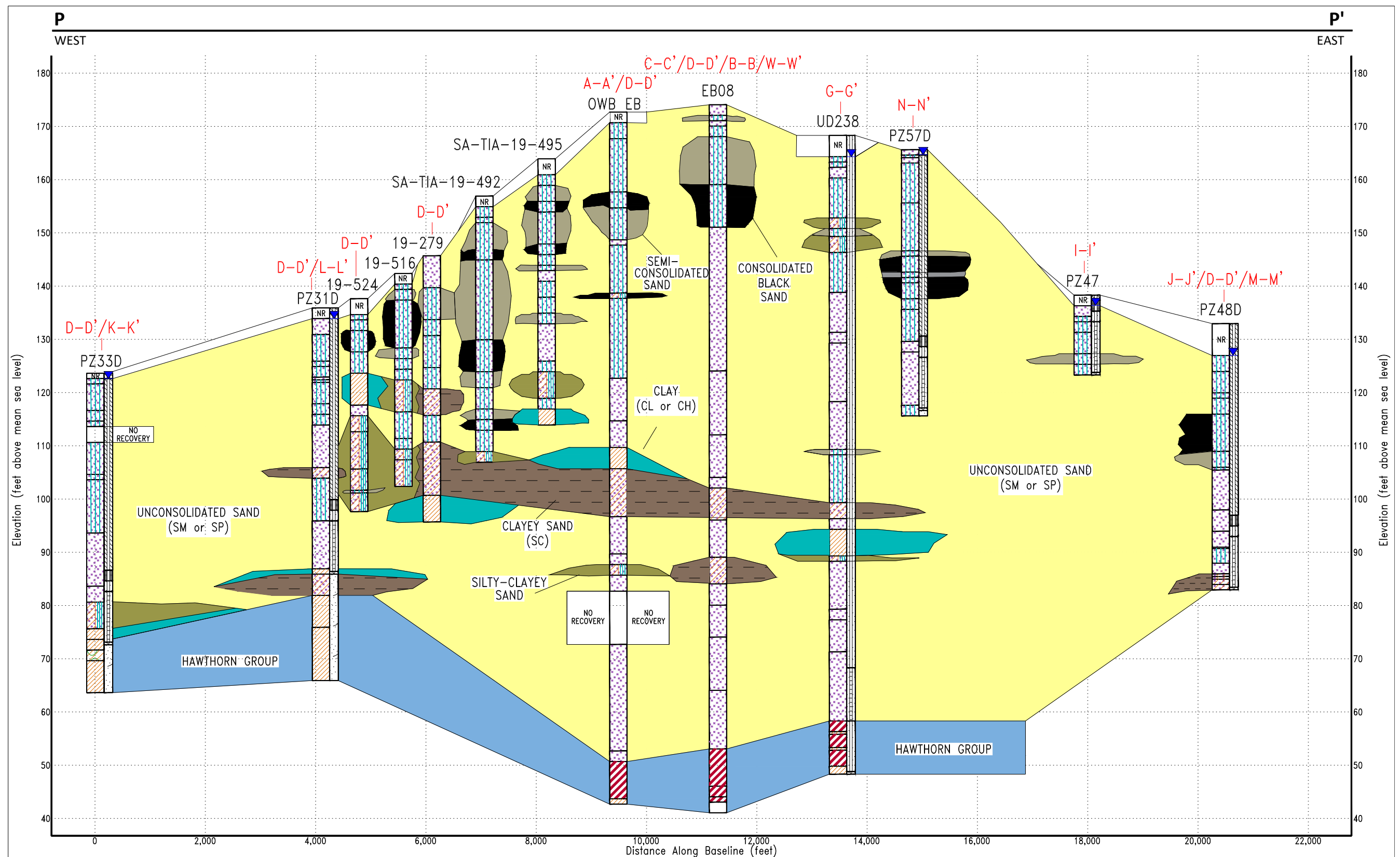

CLAYEY
SAND


CLAY
(CL-CH)

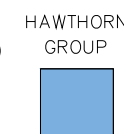
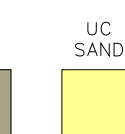
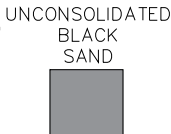

HAWTHORN
GROUP


Figure O.
Generalized Geologic
Cross-Section O - O'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

DRAWN BY:	ZBL
CHECKED BY:	JRS
TTL PROJECT NO.:	000180200804.00
DATE:	12/06/2019
FILE PATH:	M:\Projects\2018\000180200804.00 - Twin Pines Minerals Permitting Services\CAD\XGEN\TP XGEN DRAFT 10-2019



VE = 69x



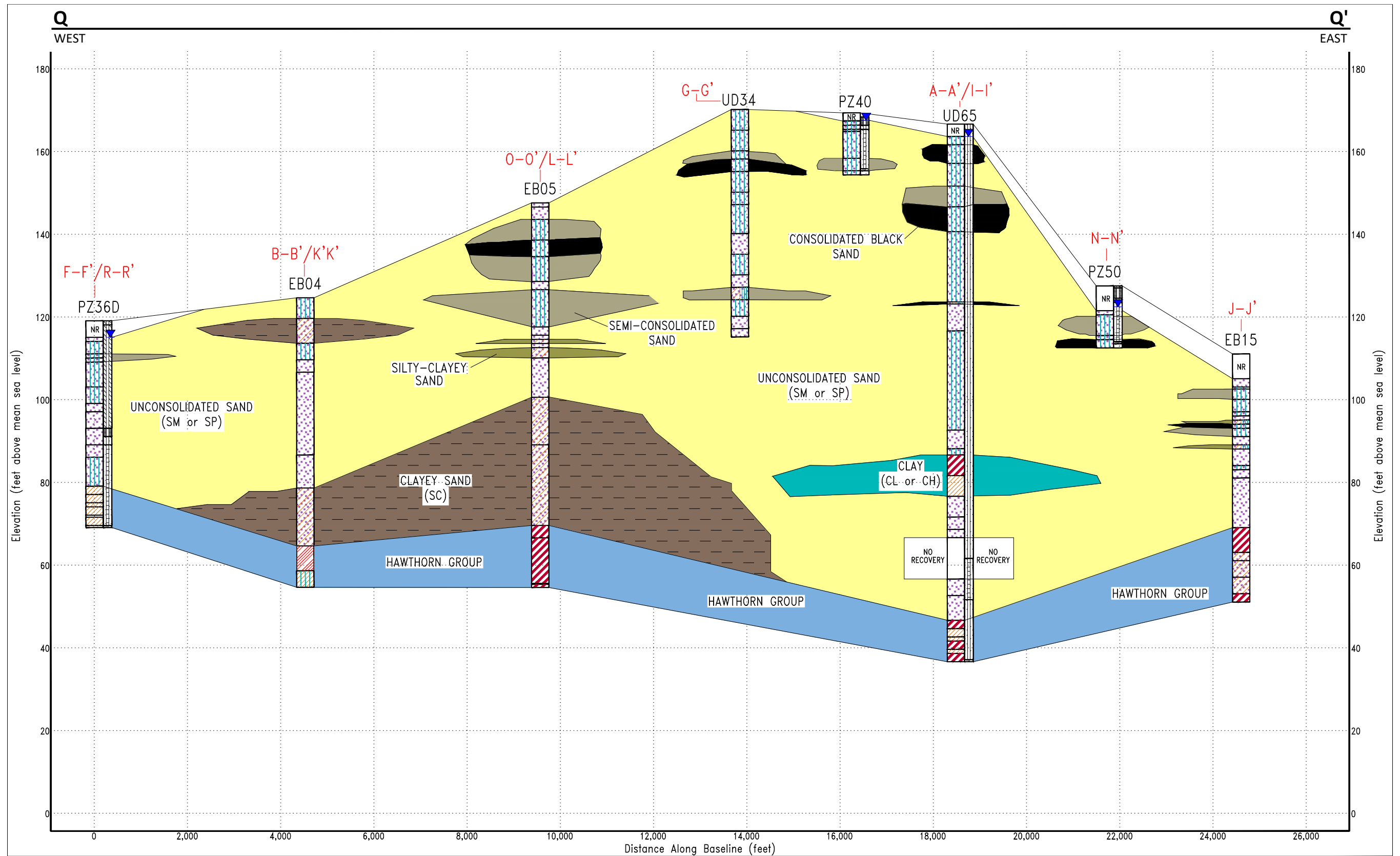
NR = NO RECOVERY

SC = SEMI-CONSOLIDATED

UC = UNCONSOLIDATED

Figure P.
Generalized Geologic
Cross-Section P - P'
 Twin Pines Minerals
 Hydrogeology of the Twin Pines Project Area
 St. George, Charlton County, Georgia

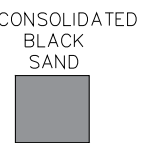
DRAWN BY:	ZBL
CHECKED BY:	JRS
TTL PROJECT NO.:	000180200804.00
DATE:	12/06/2019
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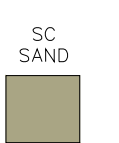
VE = 88x



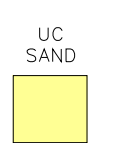
CONSOLIDATED
BLACK SAND



UNCONSOLIDATED
BLACK SAND



SC
SAND



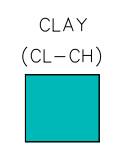
UC
SAND



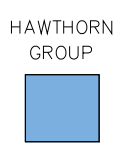
SILTY
CLAYEY
SAND



CLAYEY
SAND



CLAY
(CL-CH)



HAWTHORN
GROUP

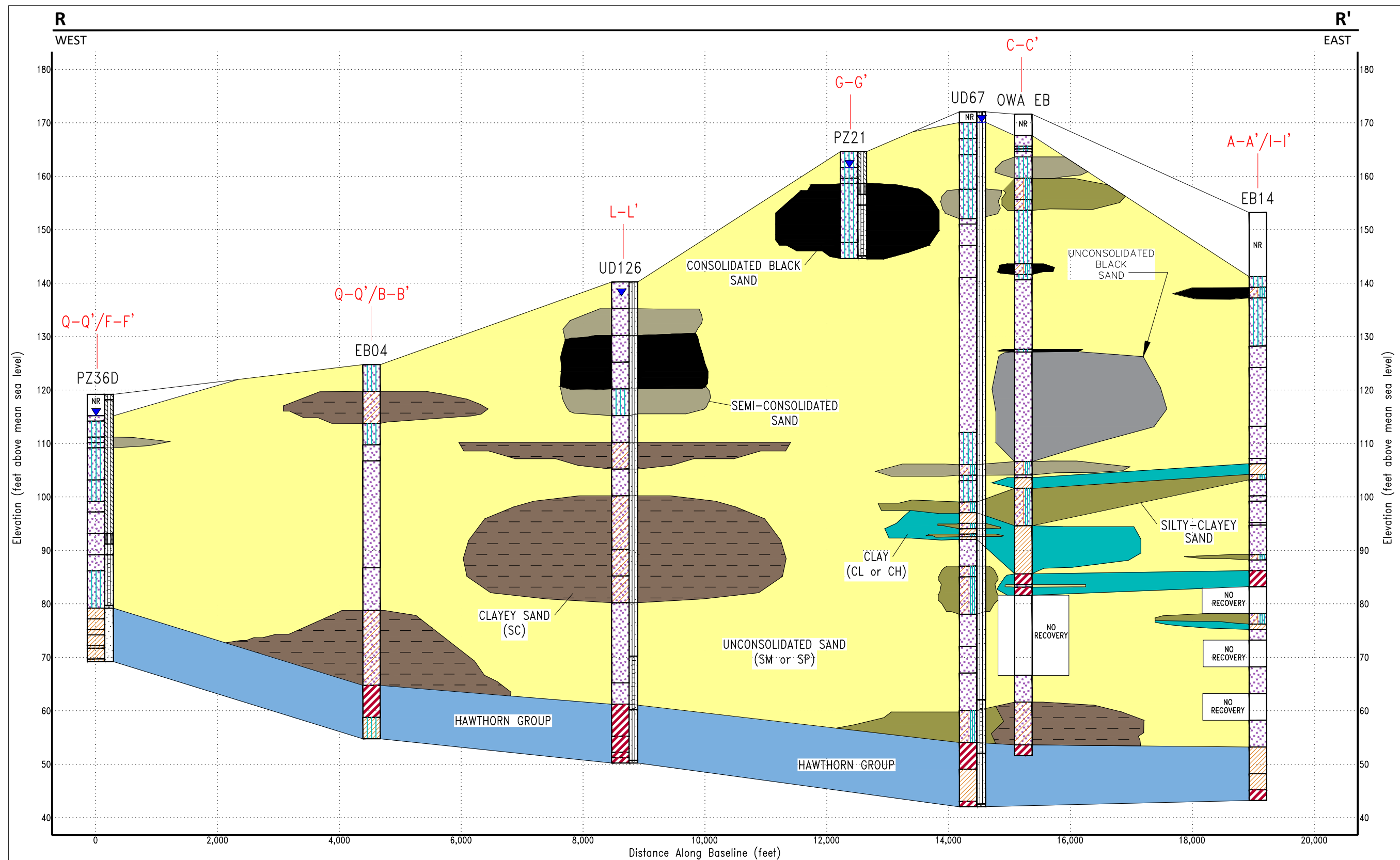
NR = NO RECOVERY

SC = SEMI-CONSOLIDATED

UC = UNCONSOLIDATED

Figure Q.
Generalized Geologic
Cross-Section Q - Q'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

DRAWN BY:	ZBL
CHECKED BY:	JRS
TTL PROJECT NO.:	000180200804.00
DATE:	10/15/2019
FILE PATH:	M:\Projects\2018\000180200804.00 - Twin Pines Minerals Permitting Services\CADD\X50\TP X50\ DRAFT 10-2019



VE = 88x



CONSOLIDATED BLACK SAND
UNCONSOLIDATED BLACK SAND
SC SAND
UC SAND
SILTY CLAYEY SAND
CLAYEY SAND
CLAY (CL-CH)
HAWTHORN GROUP

NR = NO RECOVERY
SC = SEMI-CONSOLIDATED
UC = UNCONSOLIDATED

CLAY (CL-CH)
HAWTHORN GROUP

Figure R.
Generalized Geologic Cross-Section R - R'
Twin Pines Minerals
Hydrogeology of the Twin Pines Project Area
St. George, Charlton County, Georgia

DRAWN BY:	ZBL
CHECKED BY:	JRS
TTL PROJECT NO.:	000180200804.00
DATE:	10/15/2019
FILE PATH:	M:\Projects\2019\000180200804.00 - Twin Pines Minerals\Permitting Services\CADD\NAT\TP XS\NAT DRAFT 10-2019

