Subsurface Continuity of Humate-Bearing Sands in the Surficial Aquifer, Trail Ridge, Georgia

Humate-bearing and humate-cemented sands (black sands) are common in the shallow subsurface along Trail Ridge. This summary on the deposition, characteristics, and occurrence of black sands was prepared based on a literature search and review of published information sources on humate and from data compiled and evaluated from the study area located on Trail Ridge in Charlton County, Georgia.

The term "humate" has been used to describe a group of gel-like solid humic substances in sediments that were carried in colloidal suspension or true solution by natural waters and were flocculated or precipitated from these waters on entering a different chemical environment (Swanson and Palacas, 1965). Flocculation or precipitation occurs when humate-laden groundwater or surface water encounters either low-pH or saline to brackish groundwater or surface water. Stable humate dissolves in alkaline waters, with the rate of dissolution increasing at higher pH. Swanson and Palacas (1965) suggest the following model for the accumulation of humate in coastal sands in the Florida – Georgia area:

1. Removal of water-soluble humus by alkaline surface water or groundwater, with more organic material removed by more alkaline water.
2. Transportation of the soluble humic materials in surface and groundwaters, in some cases over large distances (e.g., many miles).
3. Deposition of humate by precipitation or flocculation when these waters encounter acidic or saline to brackish surface water or groundwater.

Swanson and Palacas (1965) observed a variety of types of humate accumulations at several locations along the northwest coast of Florida. They observed humate accumulations in subsurface soil layers, in and beneath marsh deposits, in shore and beach sands of bayous and bays, near the mouths of tea-colored streams, near ground-water seepages, and beneath bodies of brackish or saline water. Humate-containing sands were found to range from poorly or weakly cemented to well cemented with a range of cementation styles observed at a single location. Sand masses well cemented with humate were found in local layers, irregularly shaped and distributed masses (some mimicking tree roots), and as firmly-cemented layers within cross-bedded dune deposits (Figure 1).

Along Trail Ridge, humate-cemented or “black” sands can be subdivided into three groups based on data from continuous core sampling (Figure 2): 1) low permeability, consolidated black sands, 2) semi-consolidated black sands, and 3) unconsolidated black sands. The consolidated black sands are well-cemented with humate, have a greasy feel, and have laboratory determined hydraulic conductivity values of 3.4E-7 cm/s and 2.7E-8 cm/s. The semi-consolidated black sands are poorly-moderately cemented with humate and partially collapse upon removal from the core barrel. The unconsolidated black sands are stained with humate, and fully collapse when removed from the core barrel. Accurate laboratory measurements are unavailable for the semi-consolidated and unconsolidated black sands (see Holt et al. 2019).

In the following, we explore the continuity of humate-bearing sands present in the subsurface along Trail Ridge. Logged borehole data from the study area (Figures 3a and 3b) were used to generate three-dimensional representations of the distribution of humate-cemented, consolidated black sand and all humate-bearing sand, including consolidated black sand, semi-consolidated black sand, and unconsolidated black sand (Figures 4 – 7). Three images are shown in each of the figures: a) a location image with borehole identifiers, b) an image showing the occurrence of consolidated black sand in each borehole, and c) an image displaying where any humate-bearing, black sand is found within the boreholes.

An examination of Figures 4 – 7 reveals that the consolidated black sands occur as small-scale, isolated features within the Surficial Aquifer along Trail Ridge. Consolidated black sand occurs at differing elevations between adjacent boreholes, and in many cases, consolidated black sand is absent in nearby boreholes. Because of this, correlation of consolidated black sand occurrences is not possible over large distances and can only be correlated in a few closely spaced boreholes. This feature is consistent with the short correlation lengths determined from indicator variograms of the consolidated black sand, which revealed that the maximum horizontal correlation length was 432 ft at an azimuth of 90˚ and that the minimum horizontal correlation length was 240 ft at an azimuth of 0˚. Indicator variograms for categorical variables, like soil type, are widely recognized to reveal information about the geometry and size of rock or soil deposits (e.g., Leuangthong et al., 2008). The correlation lengths and directions reveal information about the average scale and orientation of a deposit. It should be noted that average scale of consolidated black sand accumulations is smaller than the grid-block size (495 ft × 503 ft) of the models of Holt et al. (2020 a, b).

Figures 4 – 7 also show that humate containing sands are abundant in the shallow subsurface of Trail Ridge. While it appears that these sands are more correlative, humate still occurs at different elevations or is absent in adjacent boreholes.

The subsurface distribution of humate-bearing sands in the Surficial Aquifer is consistent with the precipitation of humate coatings and cements within a variety of fluid flow systems occurring at different times since the Pleistocene. It is likely that some humate accumulated during the deposition of the barrier island complex that formed Trail Ridge as humus-laden groundwaters moved from lagoonal deposits, through the barrier islands, toward the Atlantic Ocean to the east. Since the deposition of Trail Ridge, wetlands have been present along and to the west of Trail Ridge. Fluids containing soluble humus likely continued the local accumulation of humate. The subsurface distribution of humate has likely been influenced by climatic changes that allowed more alkaline surface waters and groundwaters to locally dissolve and remove humate.

References Cited

Holt, R. M., J.M Tanner, J.R. Smith, A.C. Patton, and Z.B. Lepchitz, 2020a, "Impact of the Proposed Twin Pines Mine on the Trail Ridge Hydrologic System," prepared for Twin Pines Minerals LLC by TTL Incorporated, Tuscaloosa Alabama.

Holt, R. M., J.M Tanner, and J.R. Smith, 2020b, "Assessing the Impact of Soil Amendments During the Reclamation of the Proposed Twin Pines Mine using Groundwater Flow Models," 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, 2019, "Laboratory Testing Data at Twin Pines Mine," prepared for Twin Pines Minerals LLC by TTL Incorporated, Tuscaloosa Alabama.

Leuangthong, O., K.D. Khan, and C.V. Deutsch, 2008, "Solved Problems in Geostatistics," John Wiley and Sons, Inc., Hoboken, New Jersey, 207 p.

Swanson, V.E., and Palacas, J.G., 1965, "Humate in Coastal Sands of Northwest Florida," Geological Survey Bulletin 1214-B, 29 p.

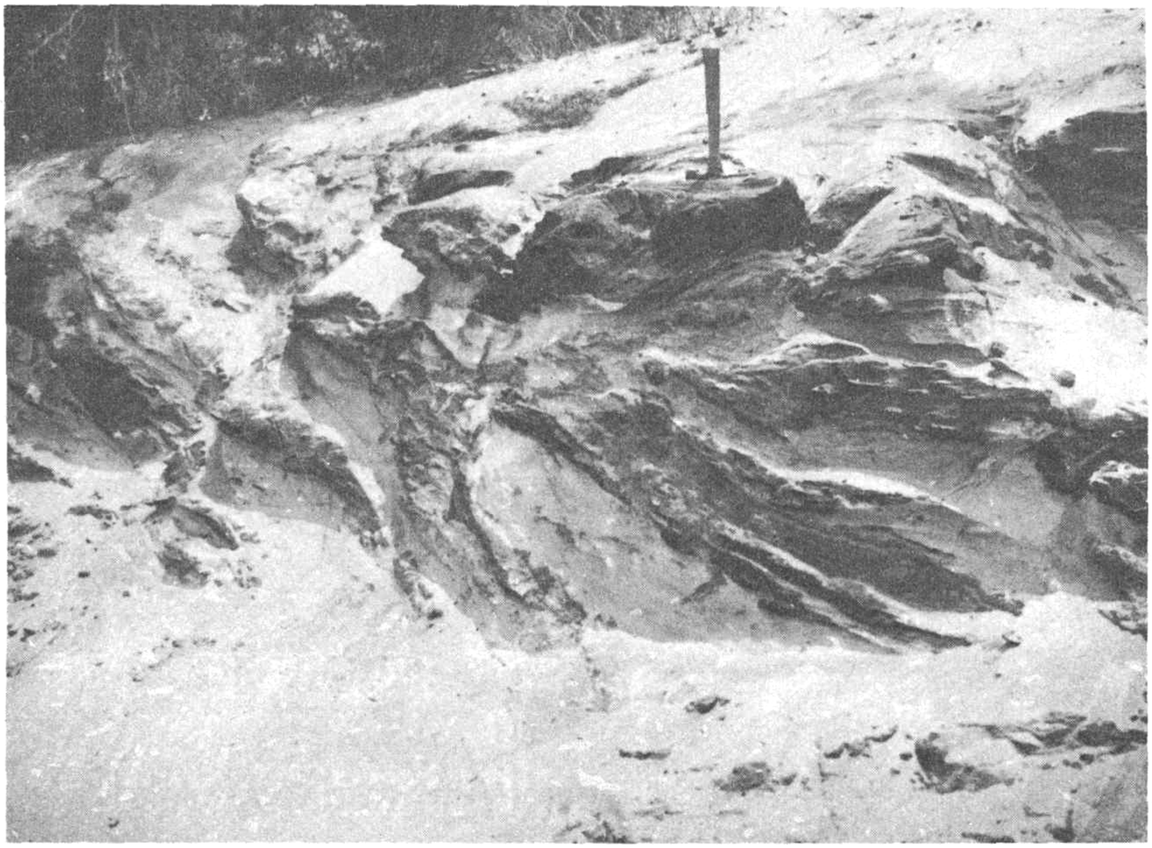

FIGURE 5.—The bluff of an old humate-cemented dune sand on south shore of Choctawhatchee Bay. The white sand is colored with humate and ranges from light tan to very dark brown; the distribution of the humate is apparently controlled by variable permeability of the dune strata.

Figure 1. Figure 5 of Swanson and Palacas (1965) with the original caption. Note that Trail Ridge accumulated in a barrier island – sand dune complex, and it would be expected that consolidated black sands within the dunes may be locally discontinuous in a manner like that displayed in this photograph.

a)

b)

c)

Figure 2. a) Low-permeability, consolidated black sand, b) semi-consolidated black sand, and c) unconsolidated black sand.

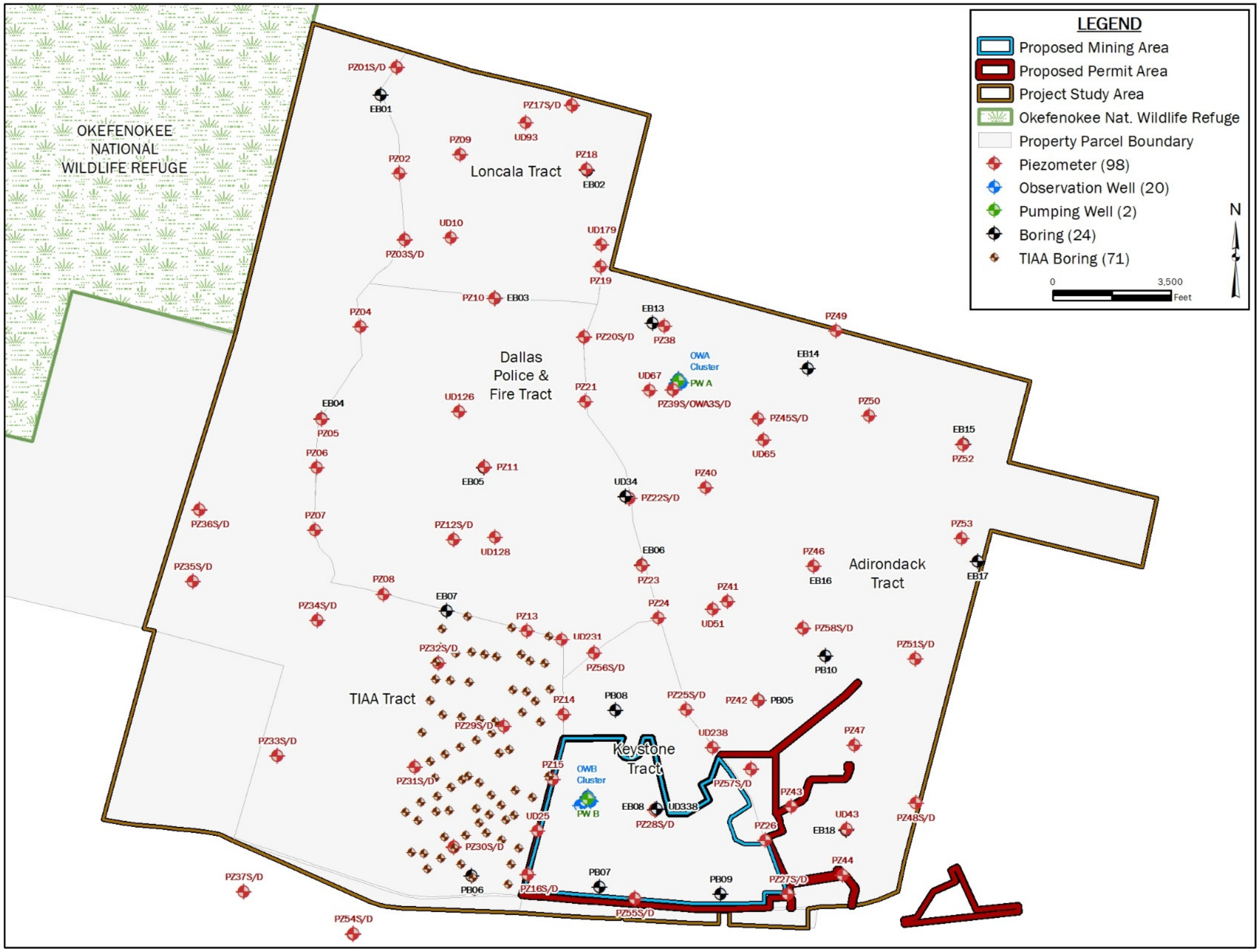

Figure 3a. Borehole locations map.

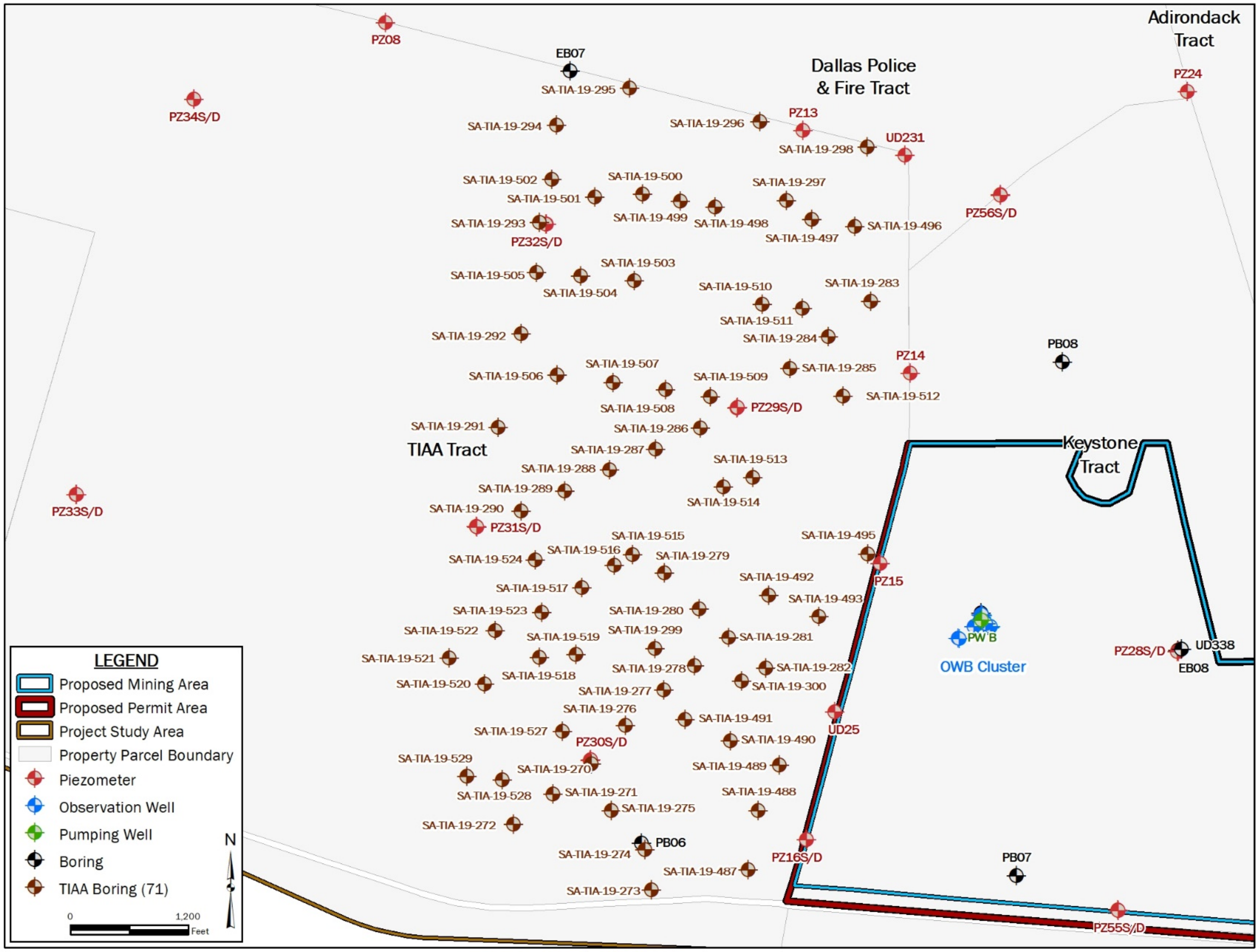

Figure 3b. Borehole locations map (cropped and zoomed version of Figure 3a to depict TIAA boring identifiers).

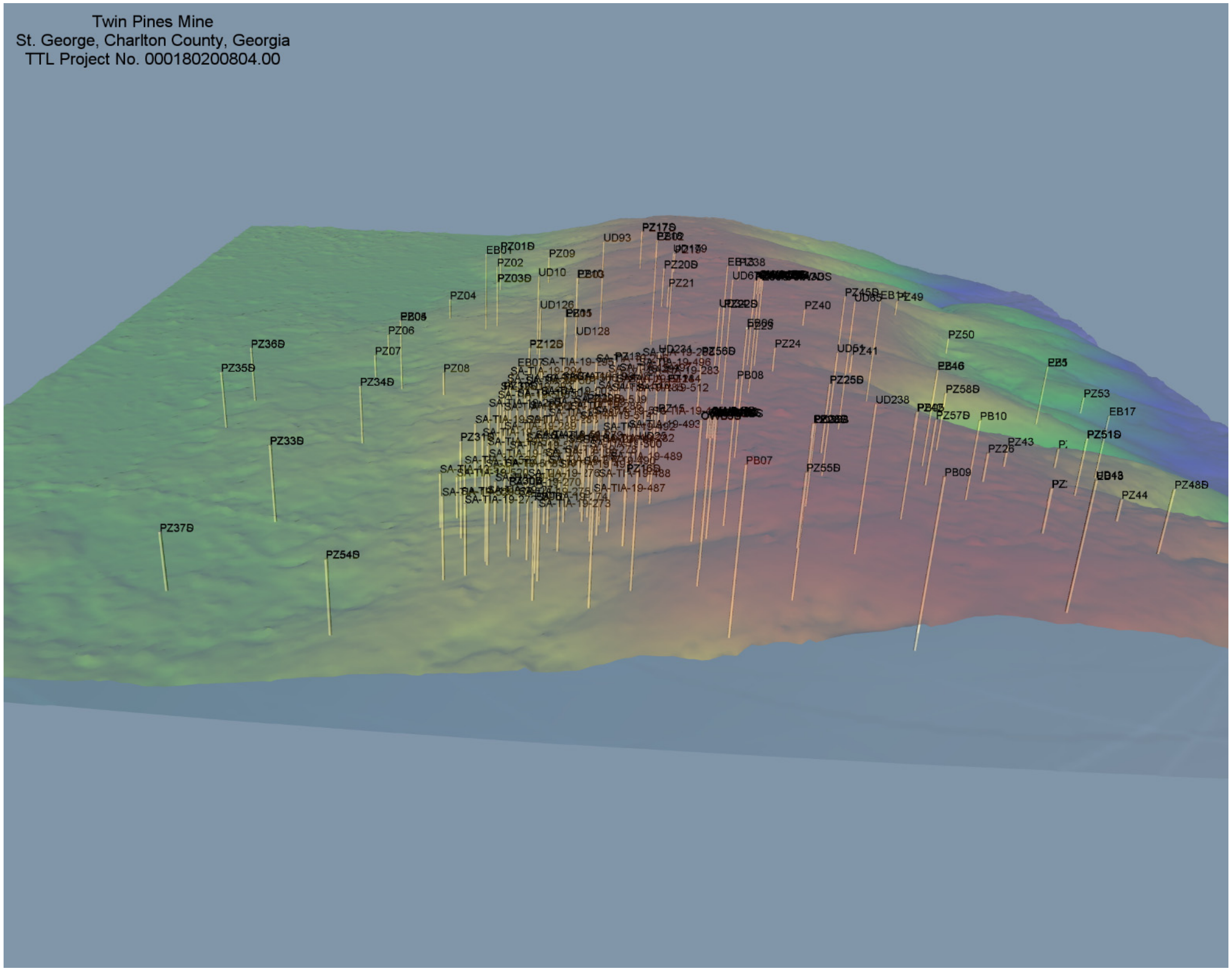

Figure 4a. Borehole locations and borehole identifiers. Note the top surface is the land surface and the bottom surface is the top of the Hawthorn Group. See Figures 3a and 3b for orientation and scale.

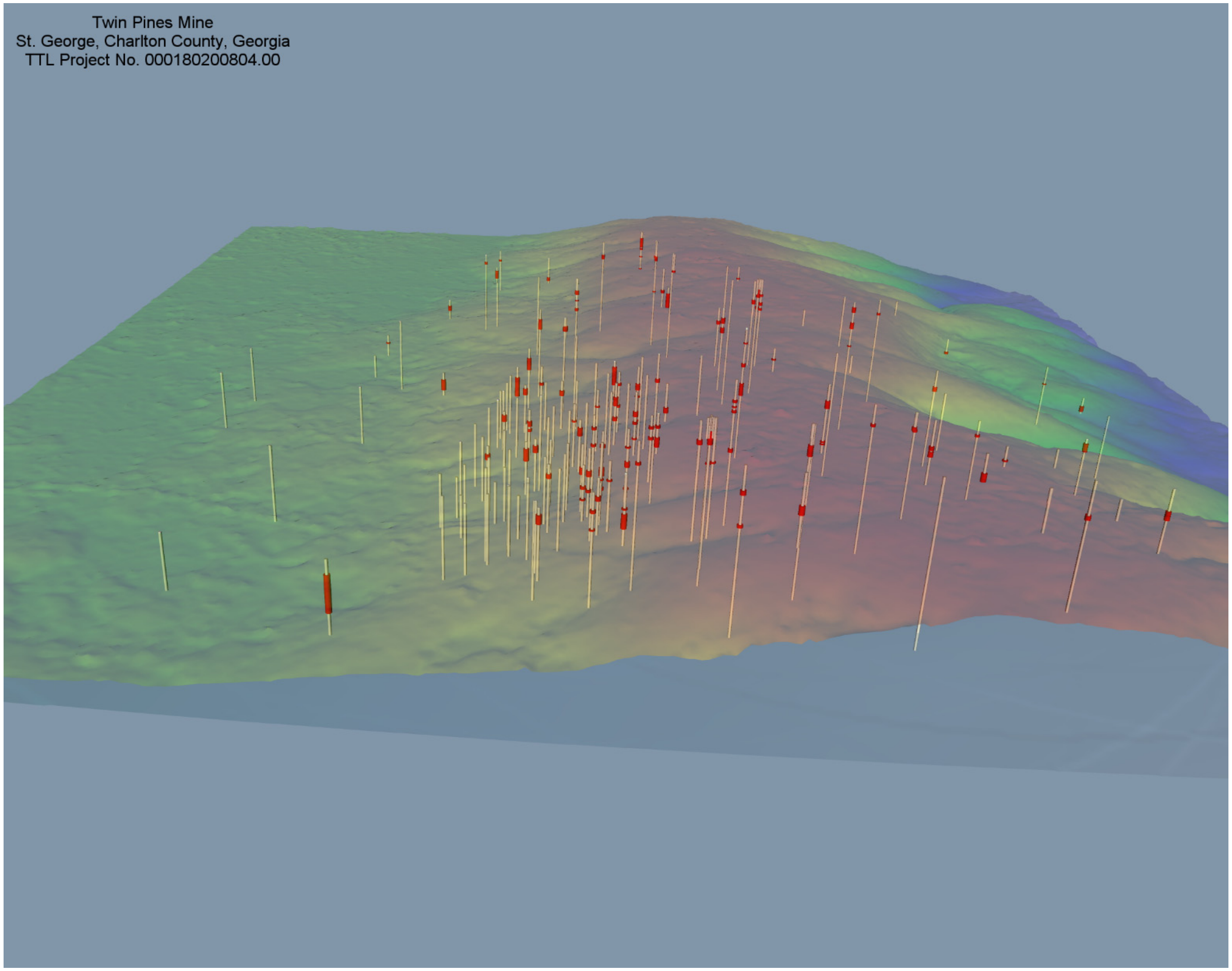

Figure 4b. Location of observed humate-cemented, consolidated black sand in boreholes. Vertical intervals containing consolidated black sand are shown in red. See Figures 3a and 3b for orientation and scale.

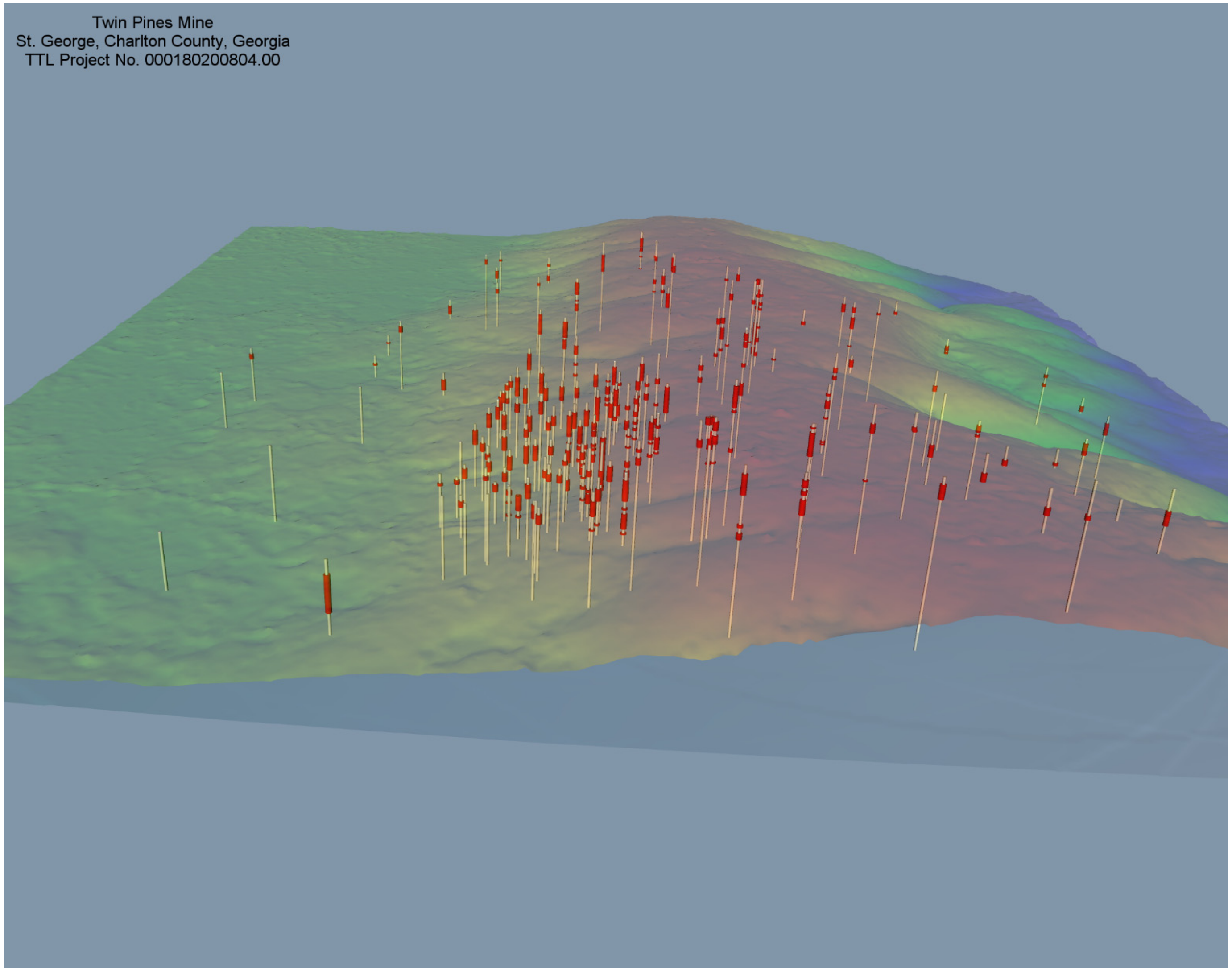

Figure 4c. Location of all humate-stained or cemented black sand in boreholes (including consolidated, semi-consolidated, and unconsolidated black sand). Vertical intervals containing any black sand are shown in red. See Figure 3a and 3b for orientation and scale.

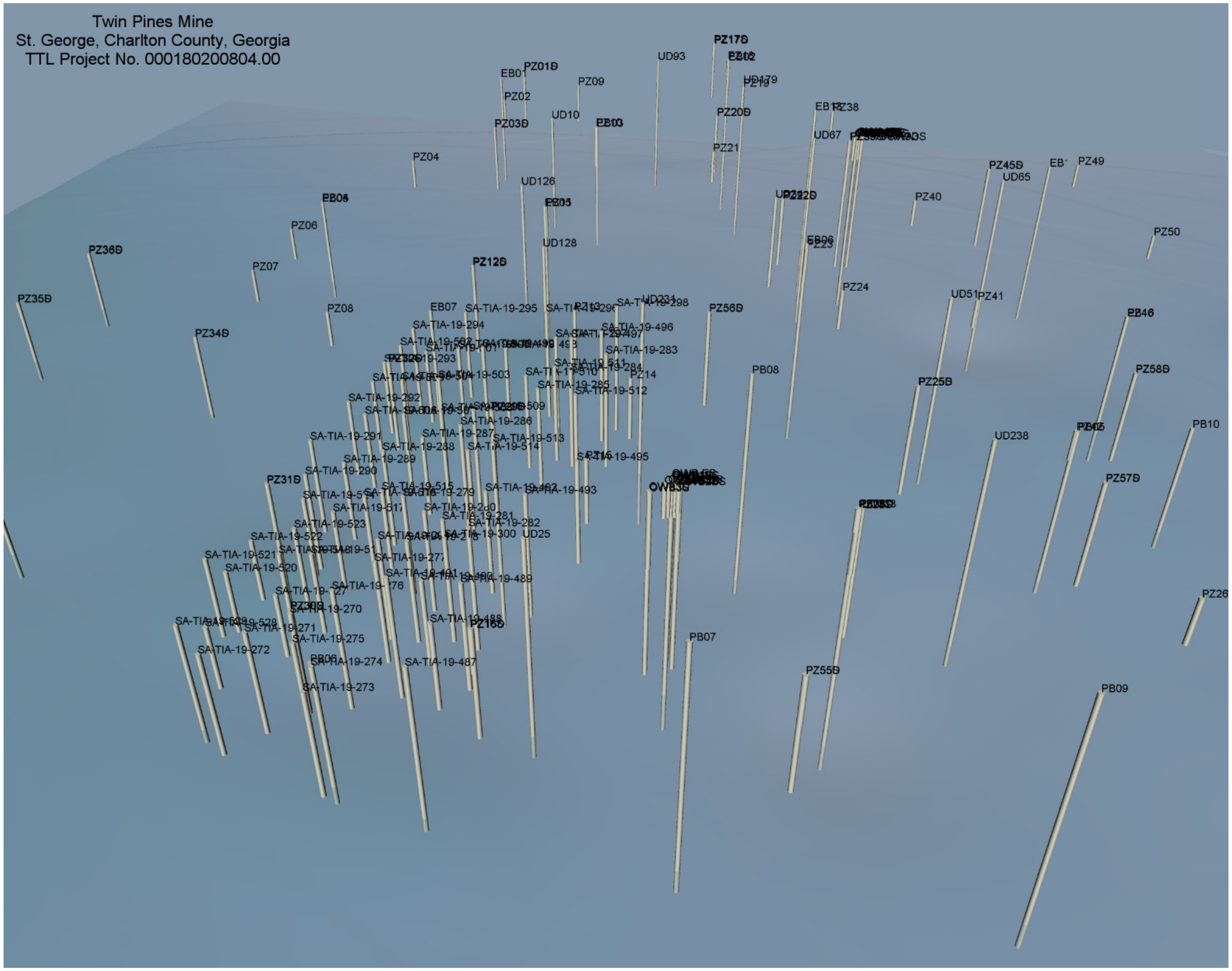

Figure 5a. Borehole locations and borehole identifiers. Note the bottom surface is the top of the Hawthorn Group. See Figures 3a and 3b for orientation and scale.

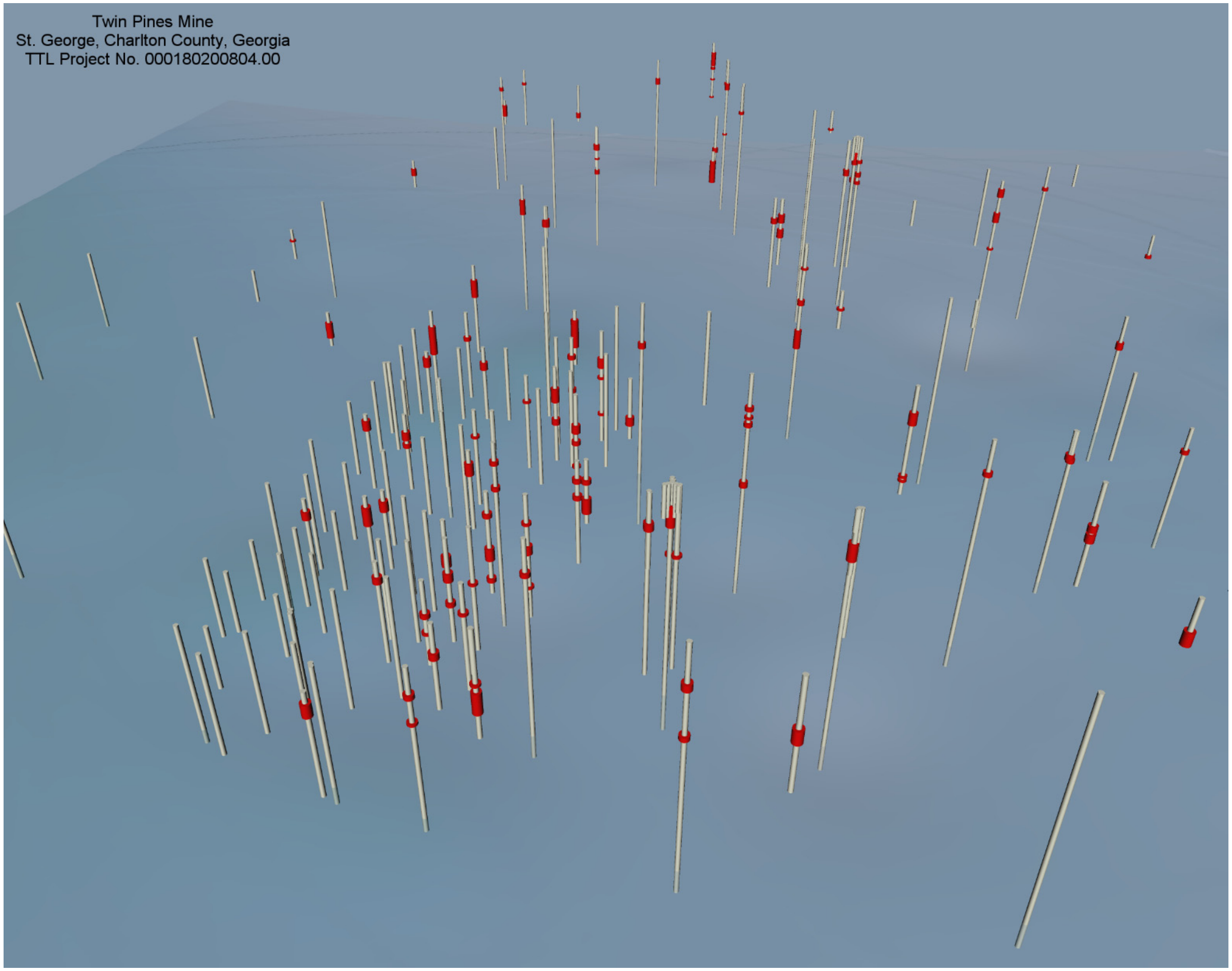

Figure 5b. Location of observed humate-cemented, consolidated black sand in boreholes. Vertical intervals containing consolidated black sand are shown in red. See Figures 3a and 3b for orientation and scale.

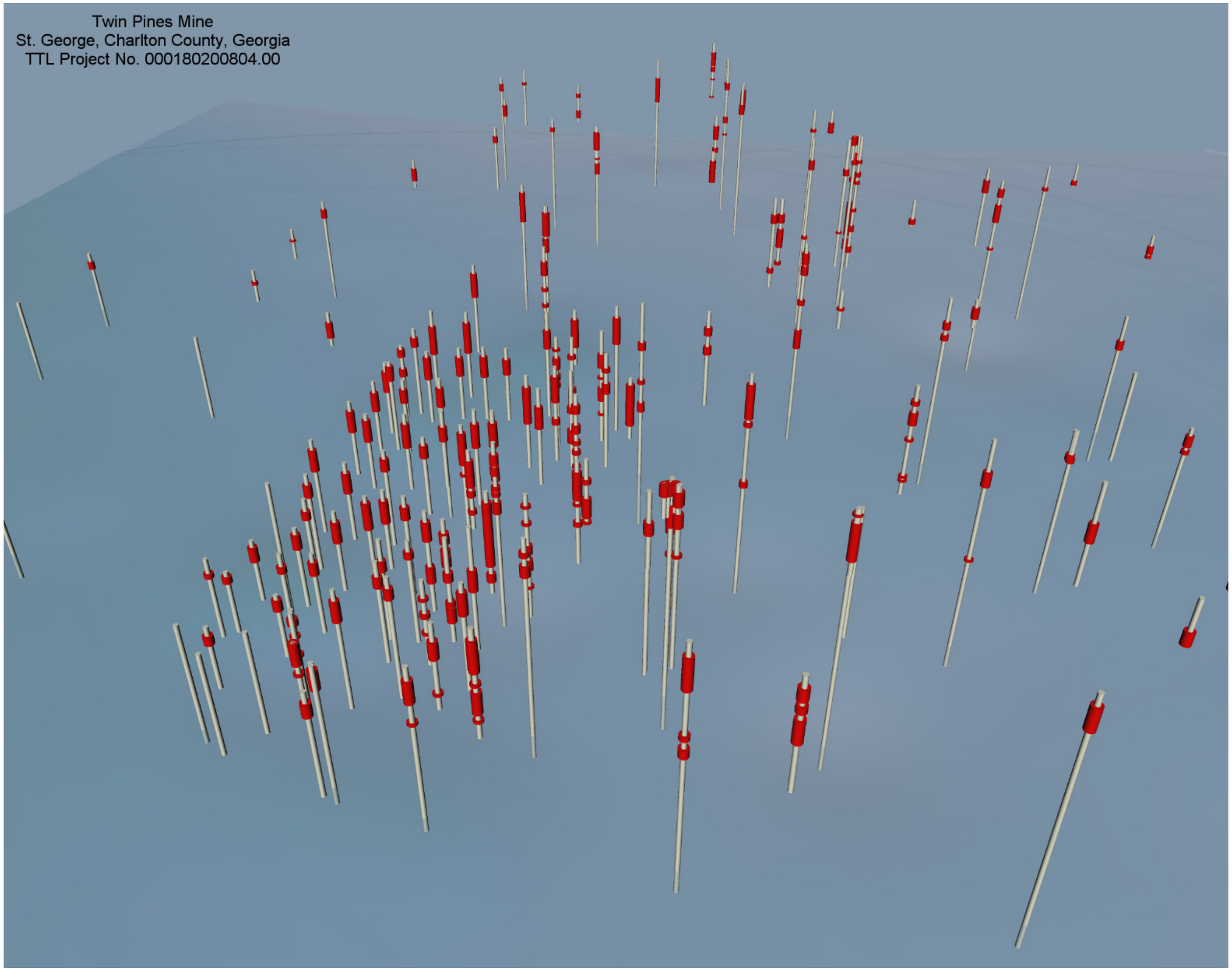

Figure 5c. Location of all humate-stained or cemented black sand in boreholes (including consolidated, semi-consolidated, and unconsolidated black sand). Vertical intervals containing any black sand are shown in red. See Figures 3a and 3b for orientation and scale.

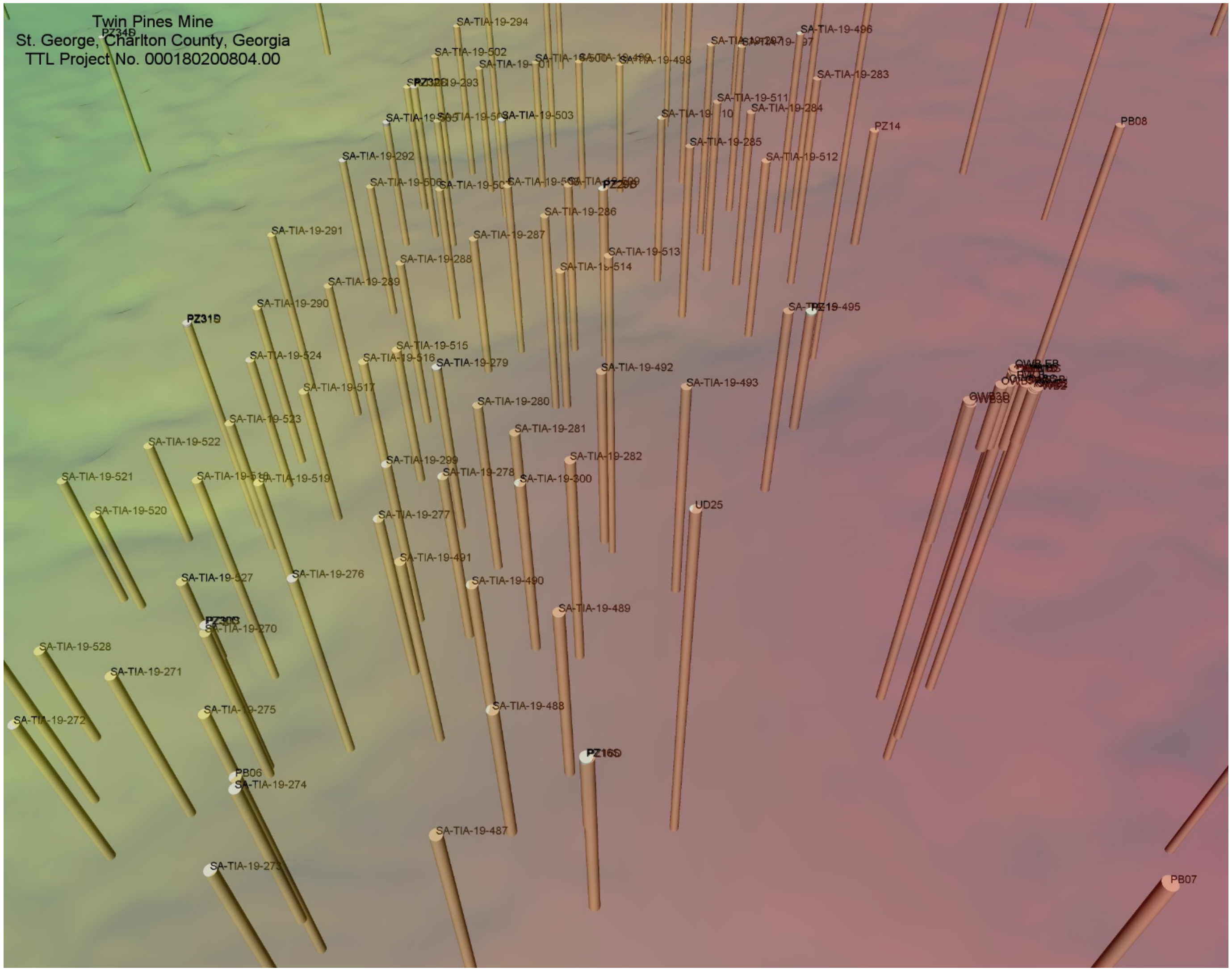

Figure 6a. Borehole locations and borehole identifiers. Note the top surface is the land surface, red colors indicate higher elevation and yellow-green colors indicate lower elevation. See Figures 3a and 3b for orientation and scale.

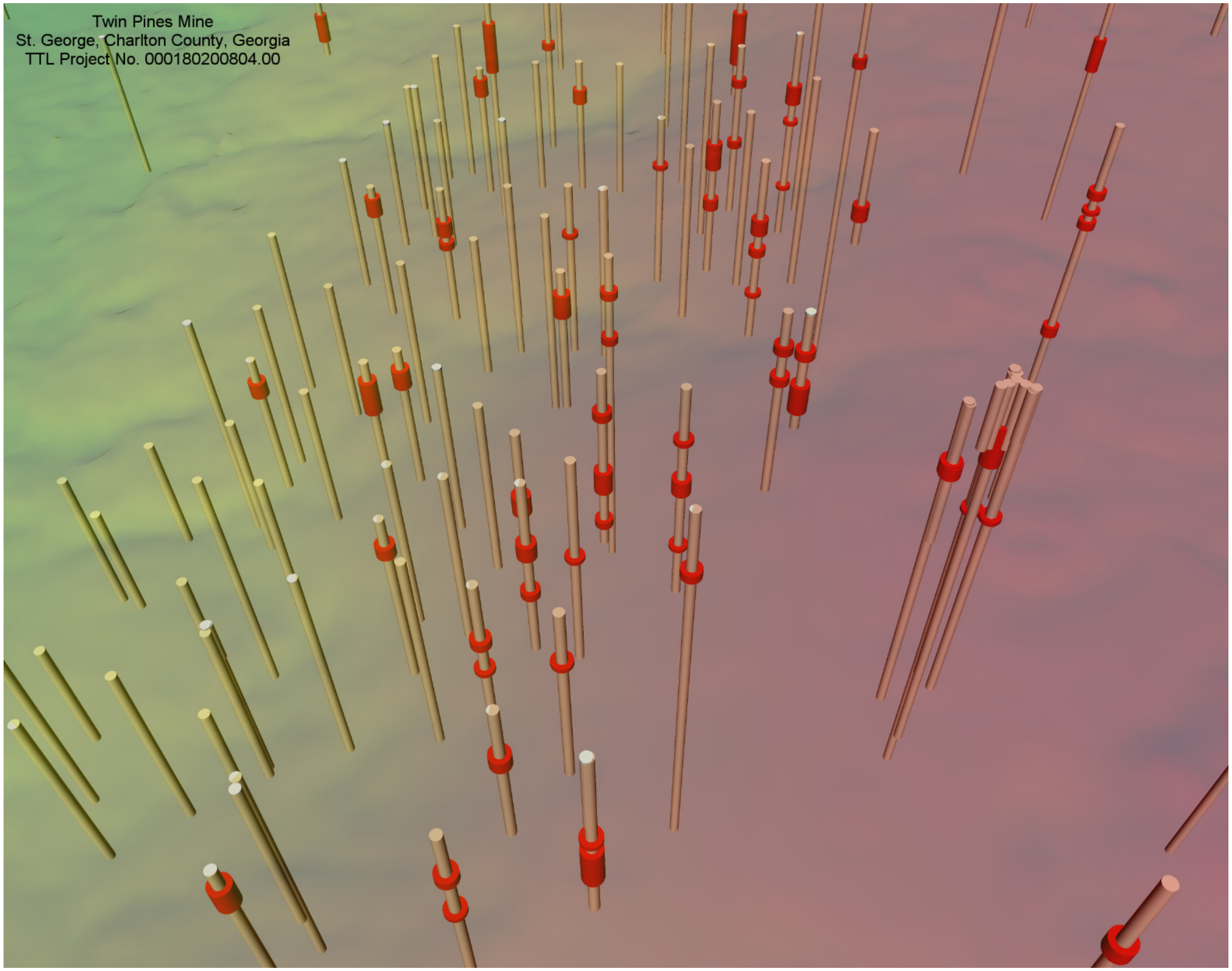

Figure 6b. Location of observed humate-cemented, consolidated black sand in boreholes. Vertical intervals containing consolidated black sand are shown in red. See Figures 3a and 3b for orientation and scale.

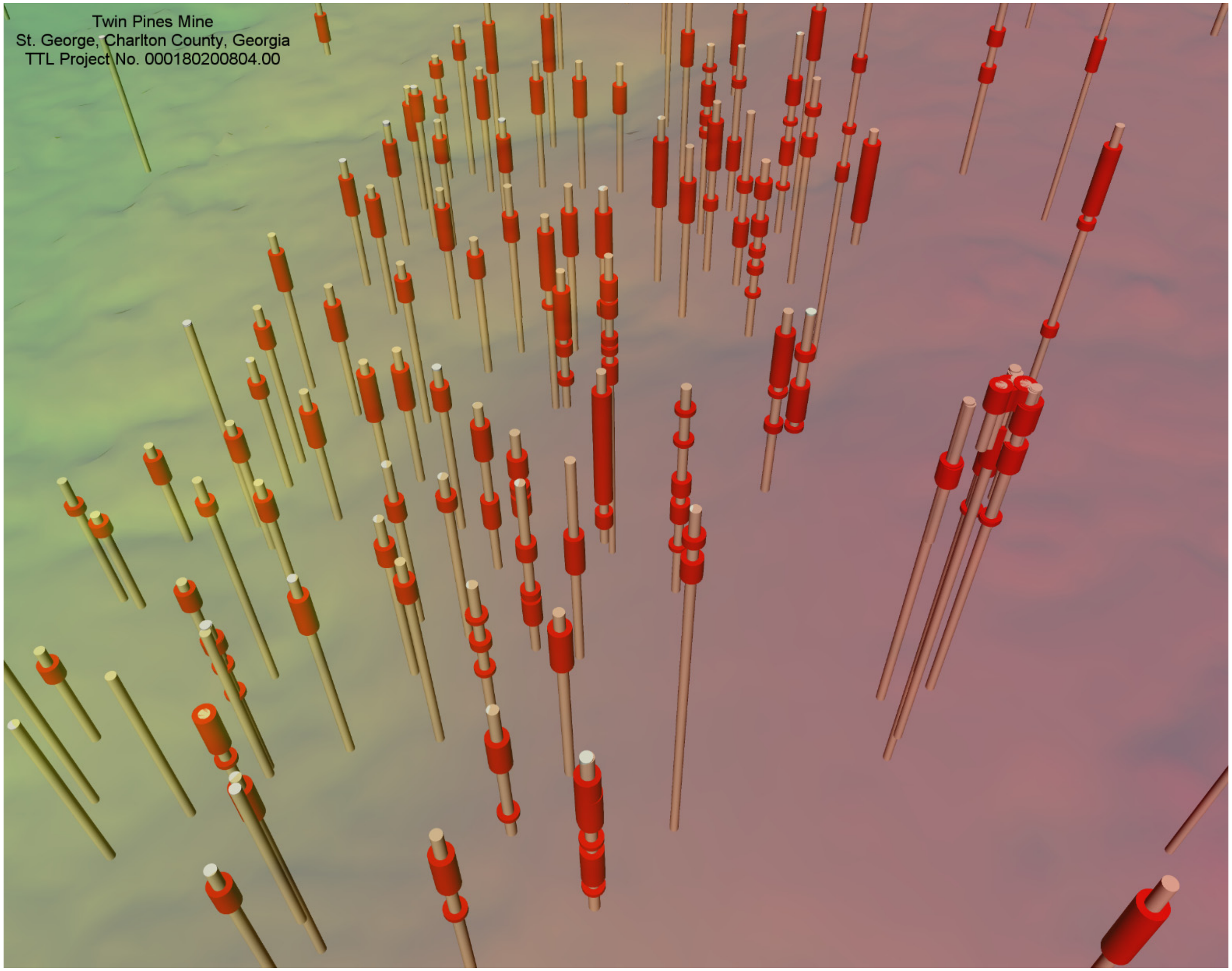

Figure 6c. Location of all humate-stained or cemented black sand in boreholes (including consolidated, semi-consolidated, and unconsolidated black sand). Vertical intervals containing any black sand are shown in red. See Figures 3a and 3b for orientation and scale.

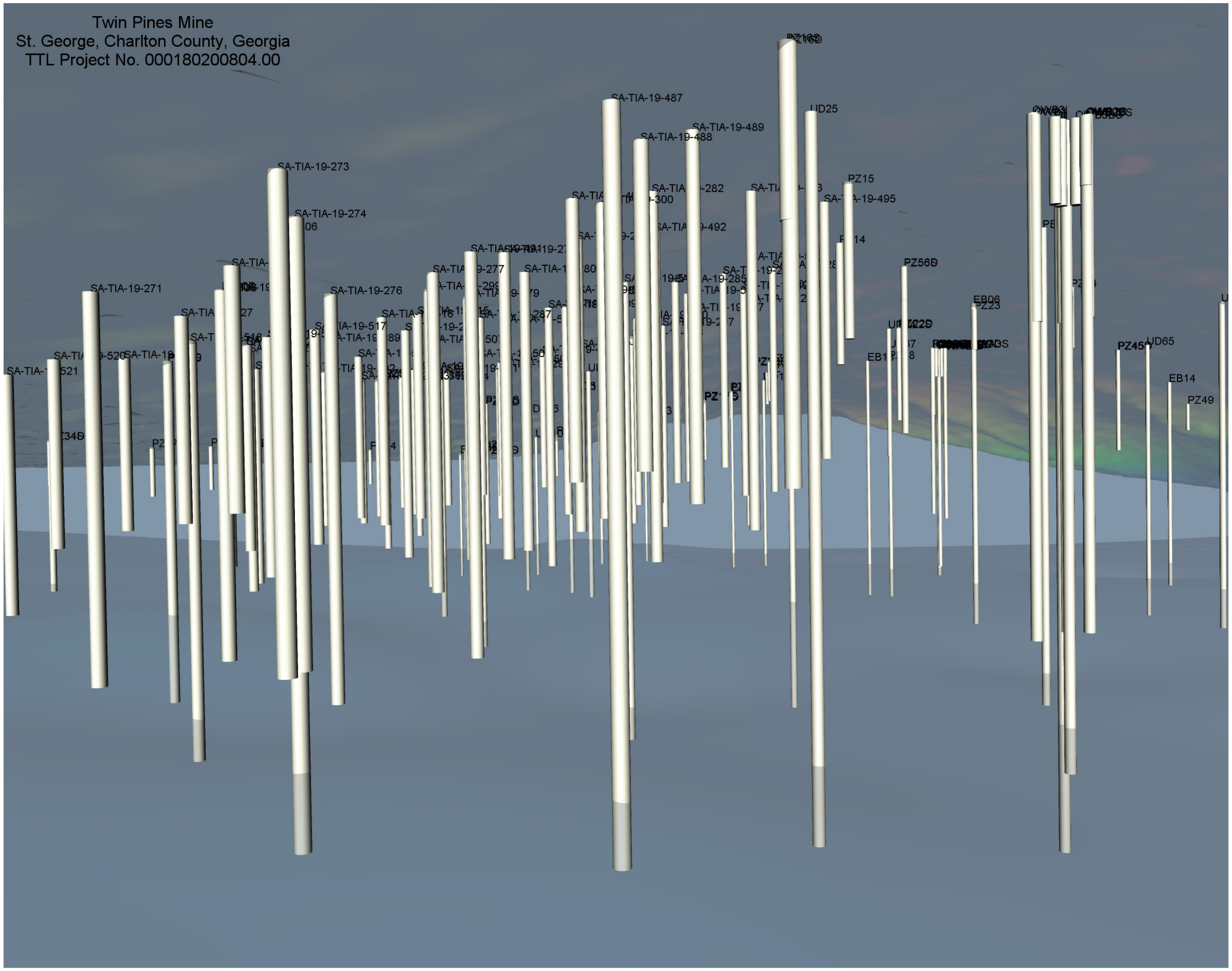

Figure 7a. Borehole locations and borehole identifiers. Note the top surface is the land surface, the bottom surface is the top of the Hawthorn Group, and boreholes turn gray when the penetrate the top of the Hawthorn Group. See Figures 3a and 3b for orientation and scale.

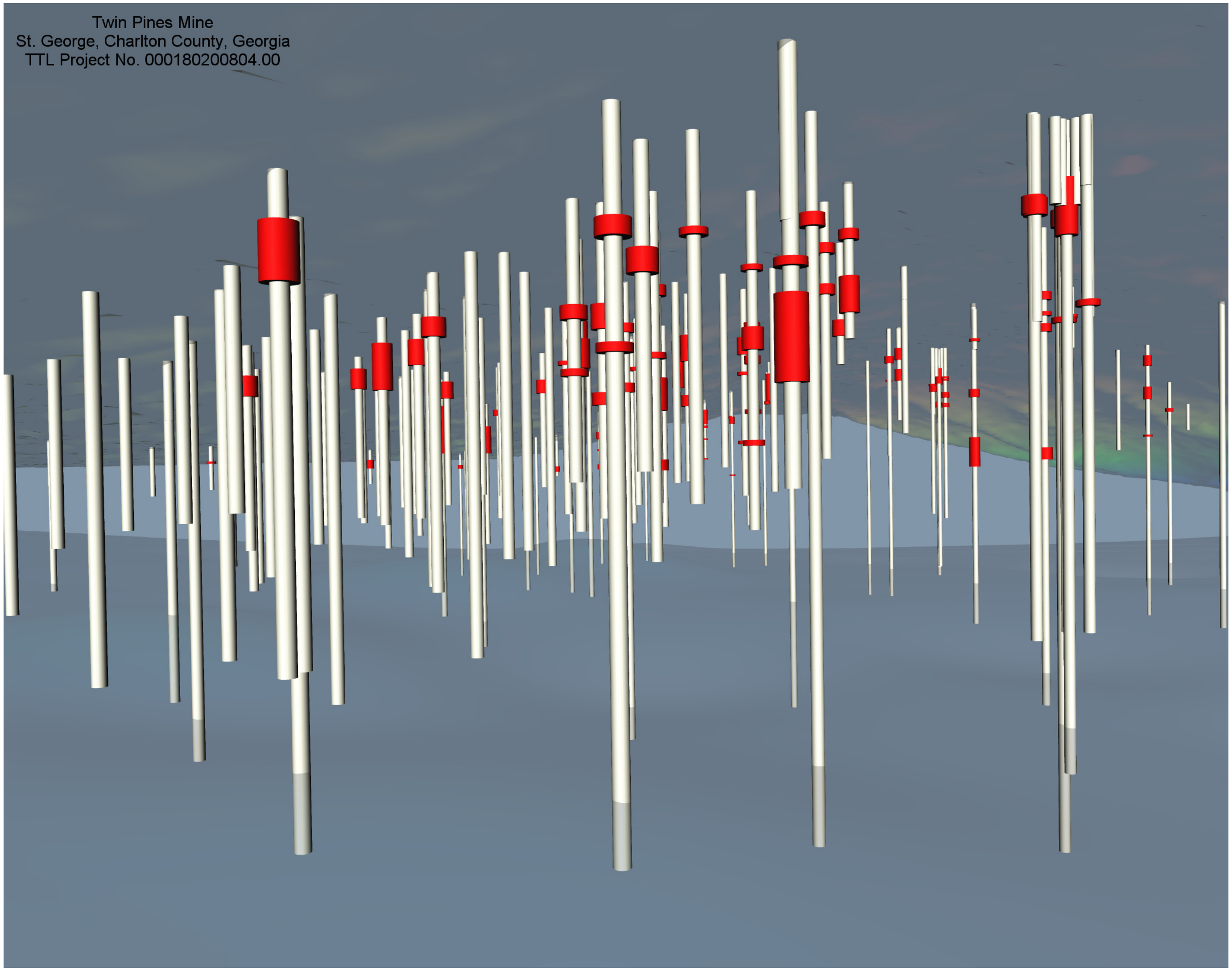

Figure 7b. Location of observed humate-cemented, consolidated black sand in boreholes. Vertical intervals containing consolidated black sand are shown in red. See Figures 3a and 3b for orientation and scale.

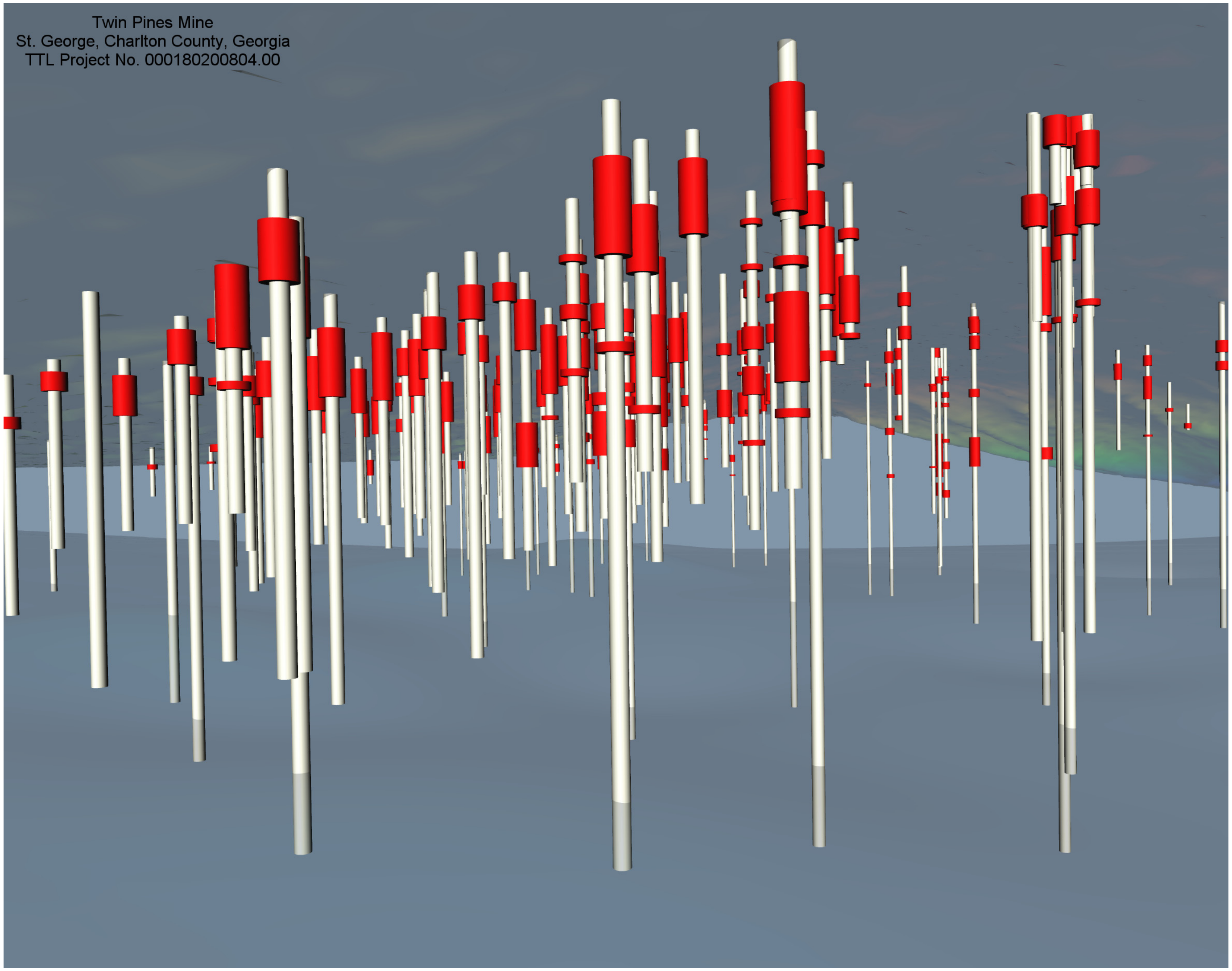

Figure 7c. Location of all humate-stained or cemented black sand in boreholes (including consolidated, semi-consolidated, and unconsolidated black sand). Vertical intervals containing any black sand are shown in red. See Figures 3a and 3b for orientation and scale.