Stantec

Memo

To:	TVA TDEC Order Team Chattanooga, TN	From:	Stantec TDEC Order Team Lexington, KY
File:	175568209	Date:	March 20, 2019

Reference: CUF TDEC Order – Cone Penetration Testing, Preliminary Findings and Recommendations

INTRODUCTION

This memo presents preliminary findings of the Cone Penetration Testing (CPT) field exploration at Cumberland Fossil Plant (CUF). The program was executed per the approved Exploratory Drilling Sampling and Analysis Plan (SAP) of the Environmental Investigation Plan (EIP). However, certain technical objectives of the CPT program could not be achieved, as described below. This memo presents recommendations for additional geotechnical investigations to achieve these technical objectives.

OBJECTIVE AND ORIGINAL SCOPE

In the SAP, 26 CPT soundings (CPT01 through CPT26) were proposed along the perimeters of the Dry Ash Stack and Stilling Pond (including Retention Pond). These CPTs were proposed to better characterize the uppermost foundation soils in the immediate vicinity of the mapped, pre-construction channels of Wells Creek and in an area of historical grouting. At both stream crossing locations along the perimeter dike system, a series of closely spaced CPT soundings was performed. Pore pressure dissipation tests were performed in select soundings and in select depth intervals. Typically, CPT data, correlated to existing nearby boring logs, can be used to differentiate relatively sandy (i.e., more pervious) foundation soils, if present.

FIELD ACTIVITIES

ConeTec, Stantec's CPT subcontractor, performed the CPT soundings from January 8-23, 2019. Stantec provided a staff geologist to observe field operations, guide the exploration, and document daily activities.

Per the Exploratory Drilling SAP, three groupings of CPTs were conducted initially:

1. CPT01-CPT07: Evaluate the base of the starter dike and the uppermost foundation soil type(s) across the historical Wells Creek alignment (adjacent to Retention Pond).

2. CPT08-CPT19: Better characterize the uppermost foundation soils in the immediate vicinity of an area of historical grouting. Grouting was performed in soil, not in rock.

3. CPT20-CPT26: Evaluate the base of the starter dike and the uppermost foundation soil type(s) across the historical Wells Creek alignment (adjacent to Dry Ash Stack).

The SAP allowed additional CPT soundings to be added while in the field, for further delineation . To obtain the data needed to meet the objective of the CPT field exploration, in the first grouping, three CPTs were added (27, 28, 29) in the field to provide additional data. In the second and third groupings, a total of four offset CPTs were added (17A, 22A, 24A, and 25A) due to pore pressure data acquisition problems in the four original CPTs.

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RESULTS

The attached layout (Figure 4) shows the CPTs performed and their refusal depths. The refusal depths are also shown in Table 1. Although the top of hole elevations have not yet been surveyed, the CPTs were performed from the crest of the raised perimeter dike, which is roughly at elevation 395 feet. Thus, the depths can be directly compared to one another.

Table 1. CPT Refusal Depths

Group 1		Group 2		Group 3	
CPT No.	Refusal Depth (ft, bgs,)*	CPT No.	Refusal Depth (ft, bgs)	CPT No.	Refusal Depth (ft, bgs)
CPT01	34	CPT08	29	CPT20	41
CPT02	20	CPT09	32	CPT21	23
CPT03	23	CPT10	29	CPT22	45
CPT04	21	CPT11	30	CPT22A	42
CPT05	33	CPT12	24	CPT23	42
CPT06	31	CPT13	33	CPT24	20
CPT07	34	CPT14	74	CPT24A	22
CPT27	19	CPT15	43	CPT25	78
CPT28	23	CPT16	43	CPT25A	41
CPT29	19	CPT17	43	CPT26	21
		CPT17A	41		
		CPT18	26		
		CPT19	42		

*ft, bgs = feet, below ground surface

CPT refusals occur for two primary reasons. First, the CPT may encounter a dense zone or a large particle (e.g., gravel, cobble, rip rap) that it cannot penetrate. Second, the CPT alignment may deviate from vertical to such a degree that it poses an unacceptable risk of damage to the CPT probe and is therefore terminated. Alignment deviation is often associated with encountering a large particle and deflecting out of vertical. Based on historical CPT results along the perimeter dike, we anticipated some shallow refusals, although not as many as were experienced. The refusal depths were also more consistent than anticipated.

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Based on typical cross sections (Figure 1) and historical borings for the perimeter dike system in the vicinity of Group 1 CPTs, refusal depths of roughly 20-25 feet are likely within the raised dike and refusal depths of roughly 30-35 feet are likely near the base of the raised dike (which also corresponds roughly to the base of the starter dike). It is also possible that the CPTs encountered rip rap on the inboard face (now buried) of the starter dike or a rockfill layer that could be present along the base of the starter dike (Figure 2). It is unlikely that any of these CPTs penetrated significant depths into the foundation soils.

Based on typical cross sections (Figure 2 and Figure 3) and historical borings for the perimeter dike system in the vicinity of Groups 2 and 3 CPTs, refusal depths of roughly 20-30 feet are likely within or near the base of the raised dike and refusal depths of roughly 40-45 feet are likely near the base of the starter dike. It is also possible that the CPTs encountered rip rap on the inboard face (now buried) of the starter dike or a rockfill layer that could be present along the base of the starter dike (Figure 2). Only two CPTs in this vicinity penetrated significant depths into the foundation soils; however, neither of these was within the historical Wells Creek alignment.

Further analysis of these results will be provided in the Environmental Assessment Report (EAR), after field data are available for review.

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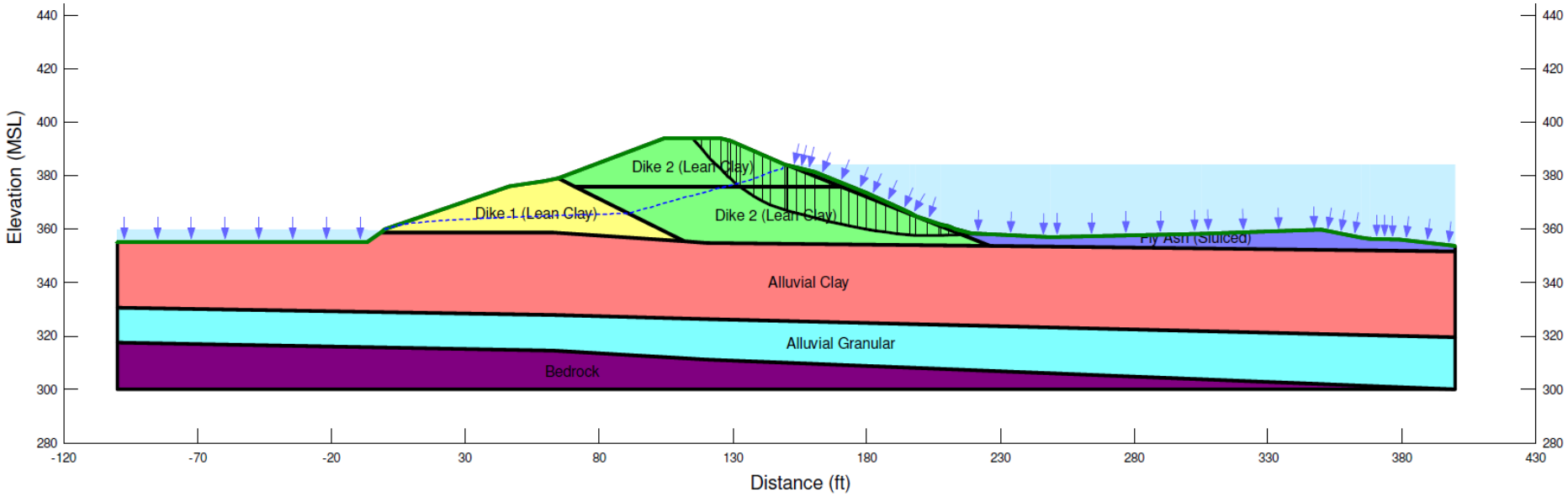

Figure 1. Typical Cross Section along Perimeter Dike Adjacent to Retention Pond (Stantec 2010a)

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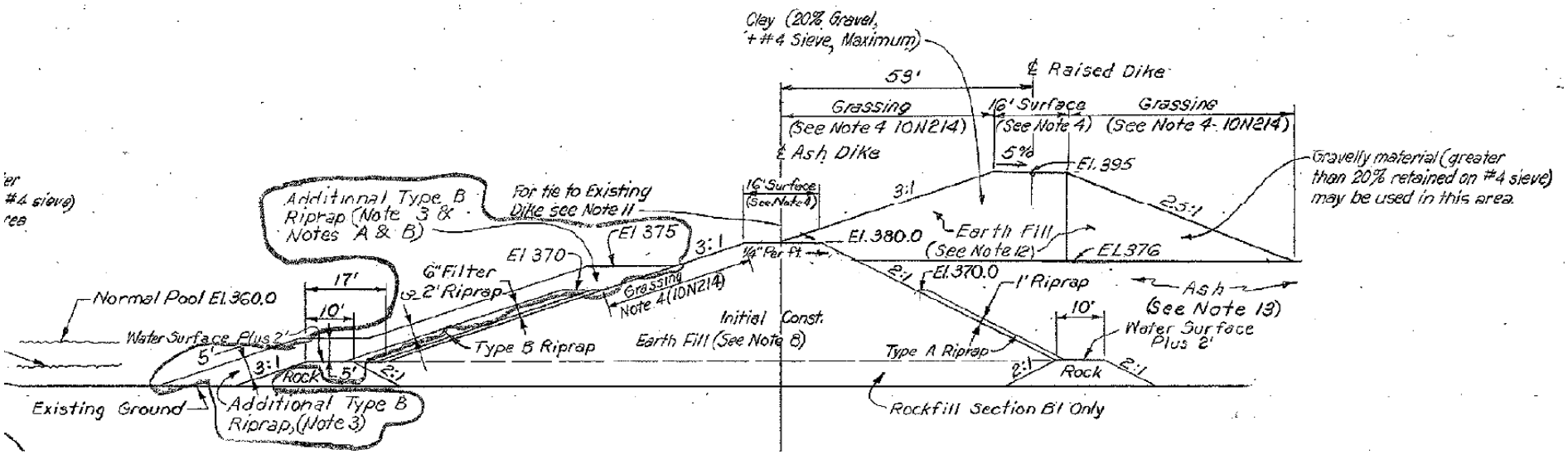

Figure 2. Typical Design Cross Section along Perimeter Dike Adjacent to Dry Ash Stack (TVA Historical Drawing 10N213-R6, 1991)

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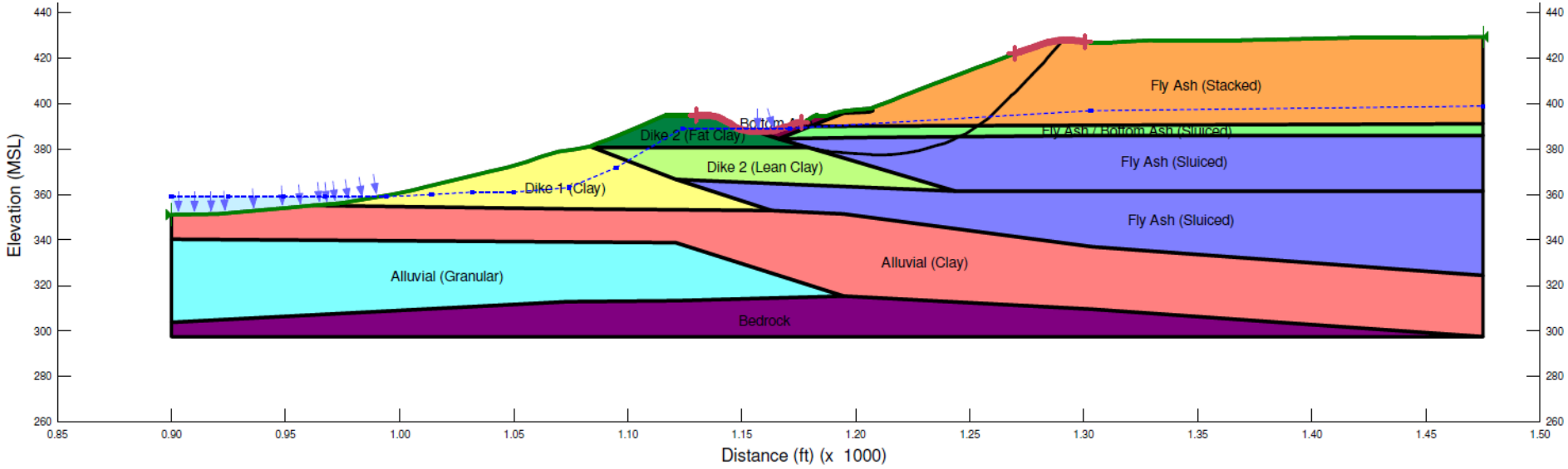

Figure 3. Typical Cross Section along Perimeter Dike Adjacent to Dry Ash Stack (Stantec 2010b)

RECOMMENDATIONS

While it is possible to use an auger rig to predrill past the depth of refusal and resume the CPT, we believe there is better value in sampling the refusal materials and continuing down to sample the foundation soils. Given the site conditions that have been encountered to date, geotechnical borings provide a more certain way to meet the original technical objectives. Further, because a large number of borings cannot be performed as efficiently as CPTs, TDEC suggested (during a February 11, 2019 meeting) the use of surface geophysics to profile the subsurface in the areas where CPTs were performed. As such, we recommend a surface geophysics program (multiple techniques) followed by up to three targeted geotechnical soil borings. The exact number and locations of the soil borings will be determined based on the results of the surface geophysics. The attached layout (Figure 4) shows the surface geophysics transects and three hypothetical boring locations. Stantec's subconsultant, ARM Geophysics (ARM), will perform the surface geophysical surveys as described below.

SURFACE GEOPHYSICAL SURVEYS

The technical objectives of the proposed surface geophysical surveys are as follows:

- Image foundation soils down to top of rock, recognizing that foundation soils could be beneath gravelly fill materials or rockfill layers.
- Image to depths of up to about 80 feet below crest of raised dike and up to about 65 feet below remnant crest of starter dike.
- If electrical resistivity imaging (ERI) is performed, the resolution in the foundation soils must be better than the ERI performed in 2016 (see Step 1 below).
- Differentiate lateral changes in foundation soil type, which may range from clayey soils to sandy/gravelly soils. This is important, assuming that more sandy stream channel deposits may be incised into more clayey soils on either side.

Step 1 - Reprocess Previously Collected Data

In 2016, TVA completed a subsurface investigation in support of an ongoing hydrogeologic characterization study (AECOM 2016). This investigation included a surface geophysical survey, using ERI methods. Eight ERI transects were performed along the western and southern perimeter of the CCR units. The purpose of the survey was to evaluate subsurface conditions, including bedrock conditions that could potentially influence groundwater flow. The results were intended to aid in planning subsequent intrusive investigations.

For the portions of the previous ERI transects that coincide with the groups of CPTs described herein, ARM will review the 2016 ERI data for the area of investigation and reprocess selected ERI profiles that relate to the goals of this project. ARM will utilize high-resolution methods in the ERI data reprocessing. Reprocessed ERI data will be correlated with nearby boring logs to determine if the presence of buried stream channels can be detected and resolved with these existing data. Results from this effort will be considered to determine if additional geophysical data (per Step 2 below) will be necessary to meet the objectives of this project.

Step 2 – Collect New Geophysical Data

ARM will mobilize a field crew to the site to complete the geophysical surveys. Two transects will be performed along the crest of the raised dike (i.e., perimeter road) and two transects will be performed along the remnant crest of the starter dike, as listed below and shown on Figure 4. Transect locations and lengths are approximate and may vary for each geophysical technique.

- Transect 1: 650 feet long, along the raised dike crest (i.e., perimeter road); associated with CPT01-CPT07 and CPT27-CPT29.
- Transect 2: 650 feet long, along the remnant starter dike crest; parallel to Transect 1.
- Transect 3: 1,000 feet long, along the raised dike crest (i.e., perimeter road); associated with CPT08-CPT26.
- Transect 4: 1,000 feet long, along the remnant starter dike crest; parallel to Transect 3.

The length of the transects will be sufficient to provide data coinciding with the groups of CPTs (see Figure 4). Surveys will focus on characterization of the subsurface soils and the top of rock, as was the objective of the CPTs, and will not target characterization of the bedrock. A description of the proposed geophysical techniques is presented below. Upon acceptance of the proposed plan, detailed plans for execution of the surface geophysics will be added to the appropriate Sampling and Analysis Plan(s) (SAPs). Where applicable, recently accepted SAP revisions to perform surface geophysics at TVA Bull Run Fossil Plant will be leveraged for CUF.

a. **Multichannel analysis of surface waves (MASW):** ARM will collect P-wave and S-wave surface wave data (Raleigh Wave and Love Wave) along each transect. Measurable P- and S-wave velocity variations can be used to differentiate various soil types in the perimeter dikes and foundation soils. In addition, S-wave data tends to be higher resolution for relatively shallow targets as expected at this site.

b. **3D ERI:** ARM will use 3D ERI arrays to collect high resolution data along each transect.

c. **Induced Polarization (IP):** ARM will utilize the ERI arrays to collect IP data along each transect. IP has been shown to distinguish between coarse- and fine-grained soils.

Step 3 – Data Processing and Reporting

ARM staff will process the field data from these surveys and present the results in a letter report following the data collection. The interpreted geophysical data will be used to create the following:

a. Geophysical profiles and depth slices

b. Interpreted areas of subsurface conditions and potential buried stream channel development on maps and profiles

c. A final report including a summary of ARM activities and the final work products described above.

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SUPPLEMENTAL GEOTECHNICAL BORINGS

Upon receipt of the final report from ARM for the surface geophysical surveys, Stantec will review the results and consider whether targeted geotechnical borings are recommended to correlate to buried stream channels or other geophysical anomalies identified in the soil. A maximum of three borings is proposed to supplement the CPT data, with locations to be determined, but for planning purposes are assumed as follows:

- To supplement Group 1 (CPT01-CPT07): 1 boring (B20) in the stream alignment. The purpose is to confirm the foundation soil type(s) within the stream alignment.
- To supplement Group 2 (CPT08-CPT19): 1 boring (B21) to evaluate the area of historical grouting. The purpose is to confirm the foundation soil type(s) in the area of historical grouting.
- To supplement Group 3 (CPT20-CPT26): 1 boring (B22) in the stream alignment. The purpose is to confirm the foundation soil type(s) within the stream alignment.

The assumed supplemental geotechnical boring locations are shown on Figure 4. If conducted, the borings will be drilled using the hollow stem augering method; the drilling and sampling methodologies are provided in the Exploratory Drilling SAP.

Sampling will be targeted for the materials that caused CPT refusal as well as the shallow foundation soils, where stream deposits may be present. Within the context of an overall phased approach defined for the EI, this supplemental scope is a reasonable level of effort to follow the CPT work and accomplish the original technical objectives.

REFERENCES

AECOM. 2016. “Hydrogeologic Characterization Plan, Geophysical Survey Report, TVA Cumberland Fossil Plant, Stewart County, Tennessee.” Prepared for Tennessee Valley Authority. January.

Stantec Consulting Services Inc. (Stantec). 2010a. “Report of Geotechnical Exploration and Slope Stability Evaluation, Ash Pond, Cumberland Fossil Plant, Stewart County, Tennessee.” Prepared for Tennessee Valley Authority. March.

Stantec Consulting Services Inc. (Stantec). 2010b. “Report of Geotechnical Exploration, Dry Ash Stack and Gypsum Disposal Complex, Cumberland Fossil Plant, Stewart County, Tennessee.” Prepared for Tennessee Valley Authority. June.

Stantec Consulting Services Inc.

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Figure No.

4

Title

Cone Penetration Testing Refusal Depths, Proposed Surface Geophysical Surveys, and Proposed Borings

Client/Project

Tennessee Valley Authority
Cumberland Fossil Plant

Project Location

Stewart County, Tennessee

175566329

Prepared by LMB on 2019-03-11
Technical Review by JD on 2019-03-11

0 300 600 900 1,200 Feet

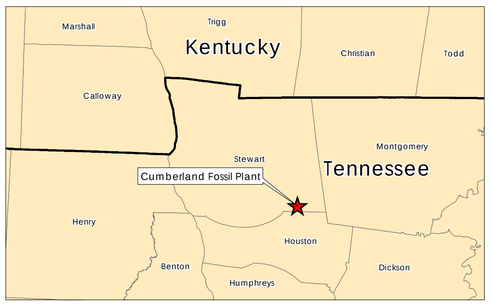
1:3,600 (At original document size of 22x34)

Legend

- Proposed Boring (Geotechncial Data)
- Proposed Surface Geophysical Survey
- Existing Boring
- Existing CPT [ID, Refusal Depth]
- Historical Wells Creek Alignment (Approximate)
- 1990's Perimeter Dike and Foundation Soil Grouting Alignment (Approximate)
- 1980's Interior Bottom Ash Dike (Approximate)
- CCR Unit Area (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by Tuck Mapping (c. 2017)
3. Historical TVA Drawing 10N212R11 (1991) is shown
4. Based on historical mapping, Wells Creek is approximately 40 feet wide. Within 60 feet of the historical Wells Creek centerline, CPT borings were advanced on 20-foot spacing. Outside of this window, CPT borings were advanced on 40-foot spacing.
5. Locations of performed CPTs and Proposed Borings are approximate.
6. CPT Refusal Depths are relative to crest of raised perimeter dike (approximate elevation 395 feet)
7. Proposed surface geophysical survey transects run along the raised dike crest (i.e., perimeter road) and the remnant starter dike crest. Transect locations and lengths are approximate and may vary for each geophysical technique.



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