CONCEPTUAL ENGINEERING REPORT

Robinson Lake Dam

Franklin, Tennessee

City of Franklin

December 8, 2017

CDM Smith

Robinson Lake Dam

Franklin, Tennesee

Conceptual Engineering Report

December 8, 2017

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Executive Summary

CDM Smith was retained by the City of Franklin, Tennessee (the City) to perform a conceptual design study of Robinson Lake Dam. Robinson Lake is located in Franklin, Tennessee between Interstate 65 (I-65) and Carothers Parkway. The lake is impounded by the Robinson Lake Dam on the south side of the lake. It is our understanding that the City is considering acquiring the property on which the dam and lake are located.

The existing dam is an earth embankment dam with a concrete auxiliary spillway in the right abutment area, discharging to the Harpeth River. The dam has a structural height of 22.5 feet and hydraulic height of 19 feet, with a storage capacity of 91 acre-feet at normal pool and 136 acre-feet at maximum pool. The dam site is covered with trees, brush, and tall weeds. The crest is about twelve feet wide with an approximate ground surface at El. 645. The upstream slope is partially covered with riprap and concrete fragments. The upstream and downstream slopes are steep to very steep slopes and are typically 1.5 horizontal to 1 vertical (1.5H:1V) or steeper. In addition, a bare eroded area is present on the crest and downstream slope that may be due to a previous overtopping event. A large seepage flow has been observed through bedrock adjacent to the end of the spillway at the Harpeth River.

The scope of work included a review of available information; a geotechnical investigation including conducting geotechnical test borings, geophysical survey, and geotechnical laboratory testing; simplified inundation mapping; hydrologic/hydraulic (H/H) modeling of the dam; geotechnical analyses including seepage and slope stability analyses; an outline of regulatory requirements; and development of the dam rehabilitation conceptual design and an opinion of probable construction cost (OPCC). This report presents CDM Smith's conclusions and recommendations based upon the data and analyses for this study.

The geotechnical investigation consisted of five geotechnical test borings, installation of one monitoring well, and four geophysical test lines, using Electrical Resistivity Imaging (ERI), along the dam crest and perpendicular to the dam crest for identification of potential karst conditions. Based on the investigation, potential karst conditions were identified. The existing dam embankment fill materials and residual soils appear to be suitable for the proposed rehabilitation of the dam.

The conceptual rehabilitation design includes the following major improvements:

- **Rehabilitation of the Existing Earth Embankment:** The rehabilitation of the existing earth embankment is proposed to include site clearing and grubbing, flattening the upstream and downstream slopes to 3H:1V, armoring the upstream slope from El. 638 to the dam crest with grass-lined articulating concrete block (ACB), and widening the dam crest to 15 feet.

- **Foundation Grouting Program:** To address observed and potential seepage conditions, a foundation grouting program is recommended to address potential seepage paths in the fractured bedrock zone and potential karst conditions noted during the geophysical program. An internal drainage system will be installed in the embankment to control seepage through the dam.

- **Construction of a New Primary Spillway:** The primary spillway construction is proposed to consist of a 4-foot by 12-foot concrete box riser to El. 640 with a 48-inch-diameter prestressed concrete cylinder pipe (PCCP) outlet pipe discharging to a 20-foot-wide impact stilling basin and riprap-lined discharge channel extending to the Harpeth River. The concrete riser drop-inlet will include a low-level outlet gate to lower the lake levels when necessary. The primary spillway is proposed to pass the 25-year design storm without activating the auxiliary or emergency spillways.
- **Replacement of the Existing Auxiliary Spillway:** The auxiliary spillway rehabilitation is proposed to include replacement of the existing cracked and damaged trapezoidal concrete chute spillway along the entire length of the spillway to the Harpeth River. The auxiliary spillway will include an underdrain system that discharges at the Harpeth River. The auxiliary spillway is proposed to pass the 100-year design storm without activating the emergency spillway.
- **Construction of a New Emergency Spillway.** Construction of a new 355-foot-wide, grass-lined emergency spillway to El. 644. The emergency spillway construction is proposed to include armoring with ACB extending from El. 638 on the upstream slope to the first 100 feet of the grass-lined discharge channel. A small embankment (up to 3 feet high) will be constructed on the eastern edge to direct the flow to the Harpeth River. The emergency spillway is proposed to pass the 1/3 Probable Maximum Precipitation (1/3 PMP) design storm.

The conceptual design OPCC is approximately $2.5 million. Engineering design, and permitting costs are estimated to be approximately 25% of the construction cost (i.e., about $625,000). The OPCC breakdown can be found in **Table 8-1**.

Section 1

Introduction

1.1 Background

CDM Smith was previously engaged by the City of Franklin to perform a preliminary assessment of Robinson Lake Dam prior to the City's potentially acquiring the private property on which the dam and lake are located. The purpose of the preliminary assessment was to identify potential dam safety deficiencies and provide recommendations for future actions. The preliminary assessment is summarized in the CDM Smith memorandum titled *Preliminary Assessment of Robinson Lake Dam* dated June 23, 2017.

As a follow-up to that preliminary assessment, the City has requested that CDM Smith perform a conceptual-level design evaluation to identify potential deficiencies, provide a proposed alternative for rehabilitation, and develop an Opinion of Probable Construction Cost (OPCC) for the rehabilitation. Our conceptual design services included field investigations, design analyses, and development of a potential rehabilitation alternative for the dam.

1.2 Purpose and Scope

The purpose of this report is to present the results of our study and provide a recommended alternative and OPCC for the City to aid in proceeding with redevelopment of the dam site property. Specifically, our scope of work included the following:

- Review existing information including available dam records, geologic maps, topographic surveys including field and bathymetric surveys, and LiDAR data of the Robinson Lake drainage basin and surrounding area;
- Conduct five (5) geotechnical test borings (three (3) along the dam crest and two (2) in the downstream area of the existing dam) to investigate subsurface conditions and to obtain soil and rock samples;
- Install one (1) monitoring well along the dam crest to measure groundwater levels;
- Perform geophysical studies consisting of Electrical Resistivity Imaging (ERI) with one (1) ERI survey line along the length of the dam crest and three (3) ERI survey lines perpendicular to the dam crest;
- Perform geotechnical laboratory tests on selected samples to assist with the classification of soils and development of engineering properties;
- Coordinate with the Tennessee Department of Environment and Conservation (TDEC) to determine regulatory requirements;
- Conduct a dam break analysis using DSS WISE (Decision Support System for Water Infrastructure Security) tool to evaluate potential downstream impacts;

- Perform conceptual-level hydrologic/hydraulic (H/H) analyses for the dam drainage area, dam, spillway and downstream areas;
- Perform preliminary seepage and slope stability analyses for the current dam structure and proposed dam rehabilitation alternative;
- Develop the conceptual design drawings for the recommended dam rehabilitation measures;
- Prepare an OPCC for the recommended dam rehabilitation; and
- Prepare this report presenting the data and conclusions of the conceptual design.

1.3 Elevation Datum

Elevations noted herein are in feet and referenced to North American Vertical Datum of 1988 (NAVD 88).

1.4 Report Limitations

This report has been prepared for the Robinson Lake Dam project, located in Franklin, Tennessee and is based upon information available at the time of this report and presented herein. This report has been prepared in accordance with generally accepted engineering practices. No other warranty, express or implied, is made. In the event that changes in the design or location of the structures occur or a variation in the subsurface or hydrologic/hydraulic conditions is encountered, the conclusions and recommendations contained herein should not be considered valid unless verified in writing by CDM Smith.

Section 2
Site Conditions

2.1 Site Description

Robinson Lake is located in the City of Franklin, Tennessee and bordered by Interstate 65 (I-65) to the west, wooded areas and residential structures to the north, Carothers Parkway to the east, and the Harpeth River to the south. The existing dam for Robinson Lake is an earth embankment dam approximately 375 feet long with a crest width of 12 feet at EL. 645. Based upon our observations during the previous site visit, the possible primary spillway drop-inlet is not visible/functioning and the 47-foot-wide trapezoidal concrete auxiliary spillway in the right abutment area is the only means of discharge to the Harpeth River. According to the National Inventory of Dams (NID) database, the dam has a structural height of 22.5 feet, hydraulic height of 19 feet, a storage capacity of 91 acre-feet at normal pool, and a storage capacity of 136 acre-feet at maximum pool. It should be noted that the dam height listed in the NID database is measured from the dam crest to the riverbed of Harpeth River. The appropriate dam height as measured from the dam crest to downstream toe is about 11 feet.

The dam site is covered with trees, brush, and tall weeds. The upstream slope is partially covered with riprap and concrete fragments and is steep, typically ranging from 1.5H:1V to near vertical. The downstream slope is also steep, typically 1.5H:1V with a bare eroded area that may be due to a previous overtopping event.

During the previous site visit, the CDM Smith representatives observed a vertical 36-inch-diameter, 12-foot-long reinforced concrete pipe extending 8 feet below ground surface (ft-bgs) just beyond the downstream slope of the dam. We believe this pipe may be a remnant of the original primary spillway, but the bottom of the pipe had 3 feet of sediment, and no outlet pipes were observed.

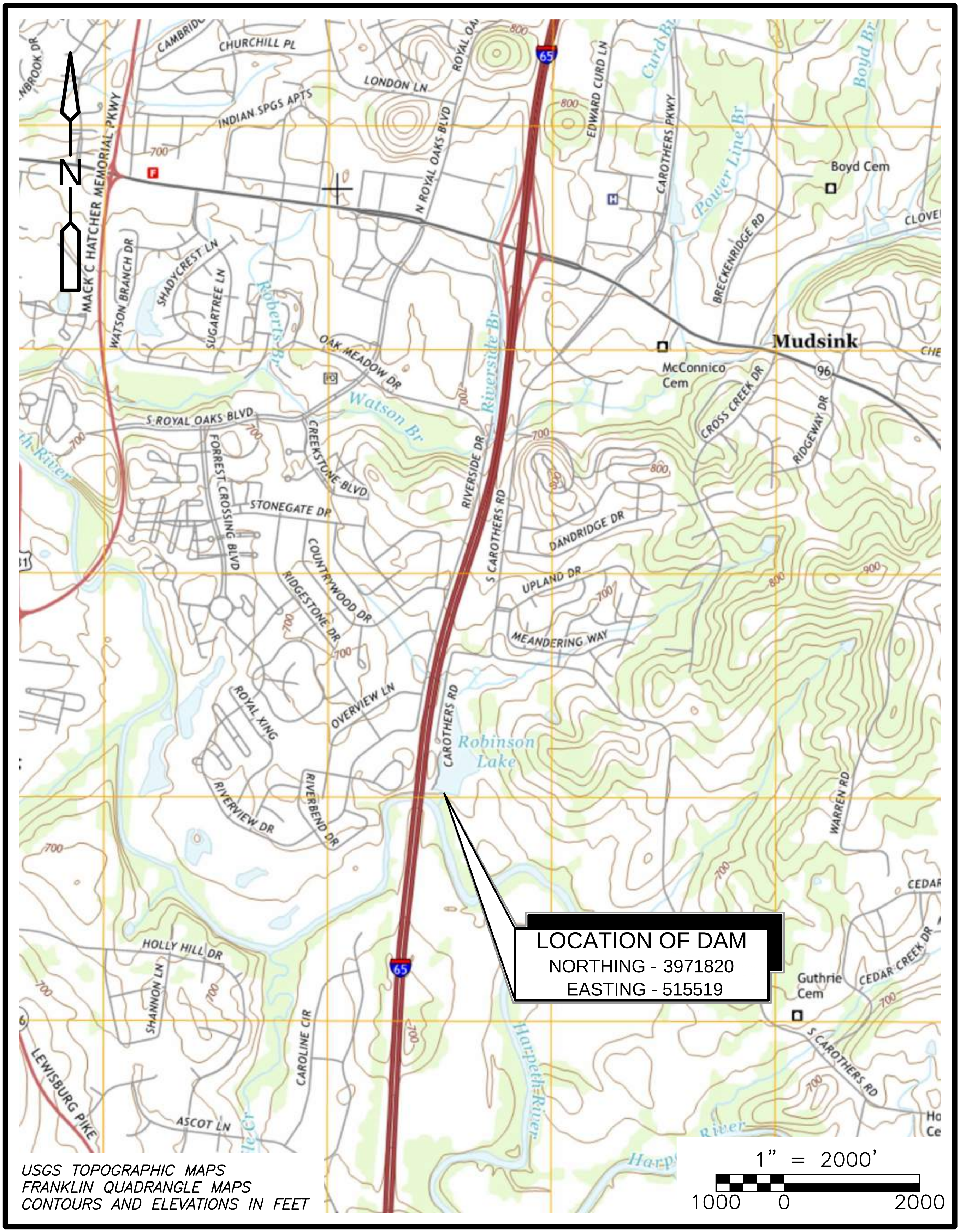
At the end of the auxiliary spillway, it was noted that seepage was flowing through the limestone face at the 15-foot-high drop-off down to the river. In addition, seepage was flowing from the river bank to the left of the limestone face. Total seepage flow was about 100 to 200 gallons per minute. There was erosion in the seepage area, but the seepage flow appeared to be clear.

Note that the terms "right" and "left" used in the report are the directions as viewed looking downstream from the dam crest.

The site locus map is shown on **Figure 2-1**. The State of Tennessee Safe Dams Program information regarding Robinson Lake Dam is included in **Appendix A**.

2.2 Geologic Setting

The site lies within the Carters Limestone formation of the Stones River Group as mapped by the Tennessee Division of Geology on the *West-Central Sheet Geologic Map of Tennessee* dated 1966.



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CITY OF FRANKLIN, TENNESSEE
ROBINSON LAKE DAM
ROBINSON LAKE
FRANKLIN, TENNESSEE

LOCUS MAP
FIGURE 2-1
DECEMBER 2017

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The limestone is typically overlain by a varying thickness of residual soils consisting of clays and silts with low to high plasticity. The Carters Limestone consists of an upper limestone with a typical thickness between 5 and 10 feet and lower limestone with a typical thickness between 60 and 70 feet. The upper limestone is composed of very fine-grained medium light-gray to brownish-gray limestone and yellowish-brown, very fine-grained cryptocrystalline, thin-bedded limestone with thin shale partings. The lower limestone is composed of light-gray to brownish-gray and yellowish brown, cryptocrystalline to very-fine grained limestone with some beds ranging up to coarse-grained, medium- to thick-bedded and thin bands and lenses of Chert locally.

The site is considered susceptible to the typical carbonate hazards of karst topography, including sinkholes based on the results of the geophysical investigation summarized below. Limestone is a carbonate rock and may appear to be very hard and resistant. However, limestone is soluble in slightly acidic water. It is prone to solution and development of karst features that may include a random bedrock surface and irregular weathering, pinnacled bedrock, “floating” boulders, sinkholes, and solution cavities. The occurrence of sinkholes is potentially the most significant of these hazards. Sinkholes occur primarily due to differential weathering of the bedrock and "flushing" or "raveling" of overburden soils into the cavities in the bedrock. The loss of bedrock resulting from solution creates a cavity or "dome" in the overburden. Growth of the dome over time or excavation over the dome can create a condition in which rapid, local subsidence, or collapse of the roof of the dome occurs. Changes in the groundwater flow regime can also accelerate sinkhole development. Solution cavity and sinkhole formation can increase the risk of dam foundation instability and excessive seepage and settlement.

A certain degree of risk with respect to sinkhole formation and subsidence should be considered with any site located within geologic areas underlain by potentially soluble rock units like the Carters Limestone.

Section 3

Conceptual Design Considerations

3.1 General

The conceptual-level rehabilitation design of the existing Robinson Lake Dam in Franklin, Tennessee, must consider the requirements of the Tennessee Dam Regulations, the governing permitting agencies, and general engineering design principles. The following is a discussion of the minimum conceptual design considerations for the existing dam rehabilitation project. The permitting requirements for this project are discussed in **Section 6**.

3.2 Tennessee Dam Regulations

The law pertaining to dam safety in Tennessee is the 1973 Safe Dams Act (TCS, Section 69-12-101 et seq. and 4-5-201 et seq.), amended in March 1996. Regulations are found in the Rules of the Tennessee Department of Environment and Conservation, Division of Water Supply, Chapter 0400-45-07 filed October 16, 2012; effective January 14, 2013. Design criteria presented in this section are in accordance with requirements of these regulations and law. The existing dam was previously designated as a "farm pond" since it was owned by a private citizen and was not regulated by TDEC. When the site is purchased by the City, the dam will be regulated by TDEC and is subject to all dam safety requirements.

3.2.1 Dam Size and Hazard Classification

The existing dam will be classified for size and hazard potential category in accordance with the Tennessee Regulations, Ch. 0400-45-07.05. In accordance with these regulations, dams are classified as small, intermediate, or large as determined by either storage or height, whichever results in the larger size category, as listed below in **Table 3-1**:

Table 3-1. Tennessee Dam Size Classifications

Category	Storage (acre-feet)	Height (feet)
Small	30 to 999	20 to 49
Intermediate	1,000 to 49,999	50 to 99
Large	50,000 or Greater	100 or Greater

Based upon the TDEC Dam Inventory Data, the existing dam has a storage capacity of 136 acre-feet at maximum pool and a structural height of 22.5 feet. Therefore, the existing dam should be classified as a small dam.

The existing dam will be assigned a hazard potential category (HPC) to reflect the potential downstream impacts in the event of a dam failure. The following are the hazard potential categories for Tennessee:

- Category 1 - Dams are located where failure would probably result in any of the following: loss of human life; excessive economic loss due to damage of downstream properties; excessive economic loss, public hazard, or public inconvenience due to loss of impoundment and/or damage to roads or any public or private utilities.
- Category 2 - Dams are located where failure may damage downstream private or public property, but such damage would be relatively minor and within the general financial capabilities of the dam owner. Public hazard or inconvenience due to loss of roads or any public or private utilities would be minor and of short duration. Chances of loss of human life would be possible, but remote.
- Category 3 - Dams are located where failure may damage uninhabitable structures or land but such damage would probably be confined to the dam owner's property. No loss of human life would be expected.

In our discussion with Mr. Lyle Bentley of TDEC, he indicated that TDEC currently classifies the dam as Hazard Potential Category 2. However, Mr. Bentley noted that additional downstream impact analysis may allow for reclassification of the dam. Refer to **Section 6** for additional details regarding these TDEC dam classification discussions.

3.3 Site Constraints

A number of site constraints were identified in this conceptual-level study and taken into consideration during conceptual design. The main site constraints of concern are identified as follows:

- Karst Geology

  The site is underlain by a limestone formation that is characterized by karst features. The existing dam has some degree of risk due to the karst features in the area and those noted during the subsurface investigation program. The quality of the foundation bedrock and severity of karst features were evaluated during the site investigations and studies.

- Borrow Source

  Rehabilitation of the earth embankment dam will require suitable borrow materials to construct the dam modifications. The on-site overburden soils were evaluated during conceptual design with regard to the quantity and suitability for use as borrow material.

3.4 Design Standards

3.4.1 General TDEC Design Criteria

In accordance with the requirements of Tennessee Regulations, Ch. 0400-45-07-.06, the dam needs to meet the following standards for existing dams:

- Stability
  - The dam shall be stable with no excessive cracks, sloughing, seepage, or other signs of instability or deterioration.
- Slope Protection:

- The earth embankment should be protected from surface erosion by appropriate vegetation or some other type of protective surface such as riprap or paving and should be maintained;
- All inappropriate vegetation such as honeysuckle, briers, bushes, and trees should be removed from the dam; and
- The root mass of all trees larger than four inches in diameter as measured two feet above ground level should be grubbed out and the hole backfilled with suitable fill material properly compacted.

- Emergency Spillway:
  - The dam should have an emergency spillway system with capacity to pass a flow resulting from a six-hour design storm.

3.4.2 Stability Criteria

For the rehabilitation of an existing dam, we recommend the use of the USACE Engineer Manual 1110-2-2300 (EM 1110-2-2300) *General Design and Construction Considerations for Earth and Rock-Fill Dams* dated July 30, 2004 and the USBR *Design of Small Dams, Third Edition* dated 1987 as acceptable design references for the rehabilitation of Robinson Lake Dam.

In accordance with these references, the designer is responsible to perform failure mode analyses to determine the most likely modes of failure for the dam, foundation, abutments, and appurtenant structures. The primary cause of failure in the United States is overtopping as a result of inadequate spillway capacity. The next most common cause of embankment dam failure is seepage and piping. These common fatal flaws should be accounted for in design by providing adequate freeboard above the design storm event to reduce the potential for overtopping and provide positive seepage control measures within the dam. Adequate freeboard should be maintained by constructing the crest of the earth dam to a slightly higher elevation than the design to account for the estimated long-term settlement of the dam.

Slope stability should be considered for the existing and proposed conditions. The seepage and slope stability analyses are discussed in detail in **Section 4.2.3**.

3.4.3 Hydrologic/Hydraulic (H/H) Criteria

The existing dam must be able to pass the requirements for existing dams per the Rules and Regulations Applied to the Safe Dams Act of 1973. In accordance with the requirements of the Tennessee Regulations, the emergency spillway shall match the minimum freeboard design storms based on the category and size classification of the dam.

As noted in **Section 3.2**, TDEC has determined that Robinson Lake Dam is a small dam with a Hazard Potential Category 2, therefore requiring safe passage of the 1/3 Probable Maximum Precipitation (PMP), 6-hour duration design storm event. Further documentation of this determination by TDEC is included in **Section 6**. However, based upon our H/H analyses, the current spillway capacity for the dam is not sufficient to pass the required design storm (1/3 PMP for a Category 2 small dam). The current spillway configuration is predicted to pass the 50-year storm for existing land-use conditions, but not future land-use conditions. Thus, the conceptual design will need to account for an increase in spillway capacity.

3.4.4 Other Requirements

3.4.4.1 Dam Crest Width

The proposed dam crest width of the non-overtopping earth dam section should be 15 feet. The crest width for the earth embankment was selected based on the recommended criteria set forth in the USBR *Design of Small Dams, Third Edition* summarized in the equation below, which is more-stringent than the State of Tennessee regulations.

$$W = (z/5) + 10$$

where W is the crest width and z is the height of the dam, in feet, above the streambed.

3.4.4.2 Project Schedule

Design, permitting, and bidding are anticipated to be at least 12 months, and the project schedule will be determined upon notice to proceed with final design. The construction schedule should consider the order of activities and the seasonal rain events to limit exposed areas and reduce the potential for the occurrence of large overtopping events that could impact work-in-place.

3.4.4.3 Construction Limits and Laydown Areas

Construction limits and laydown areas must be identified during design to facilitate land-use permissions or acquisitions negotiated prior to construction activities.

3.4.4.4 State Regulatory Requirements

All submittals to the State for dam alterations should identify the dam, state reasons why alteration is necessary, give details of the proposed work, and provide an evaluation of the effects of the contemplated action. The plans and specifications should accompany the application for existing dams. This information will be submitted after the final design phase.

Section 4

Overview of Design Studies and Analyses

4.1 Studies

An investigation program, including a preliminary dam inspection, topographic survey, geophysical survey, test borings, and geotechnical laboratory testing, was performed to obtain quantitative and qualitative data on the site conditions and to provide a basis for design analyses. The following sections summarize the results of these studies.

4.1.1 Preliminary Dam Inspection

A preliminary dam inspection (i.e., visual inspection only) was performed by Stephen Whiteside and David Mason of CDM Smith on June 12, 2017. The CDM Smith representatives were accompanied by Doug Noonan of the City and Jason Deal of BWSC.

The preliminary dam inspection report is included in **Appendix A**.

4.1.2 Site Surveys

The City of Franklin engaged BWSC to perform a site survey of the Robinson Lake Dam property on September 7, 2017. In addition, the City of Franklin engaged Mainstream Commercial Divers, Inc. to perform a bathymetric survey within Robinson Lake to determine the depth to the top of the sediment within the footprint of the lake. The data collected from the surveys was used to produce a baseline site plan for the project site. Test boring and geophysical test line locations were located in the field by tape measure prior to drilling and line-of-sight from existing site features. The final locations were surveyed by Civil Infrastructure Associates at the completion of the subsurface investigation program.

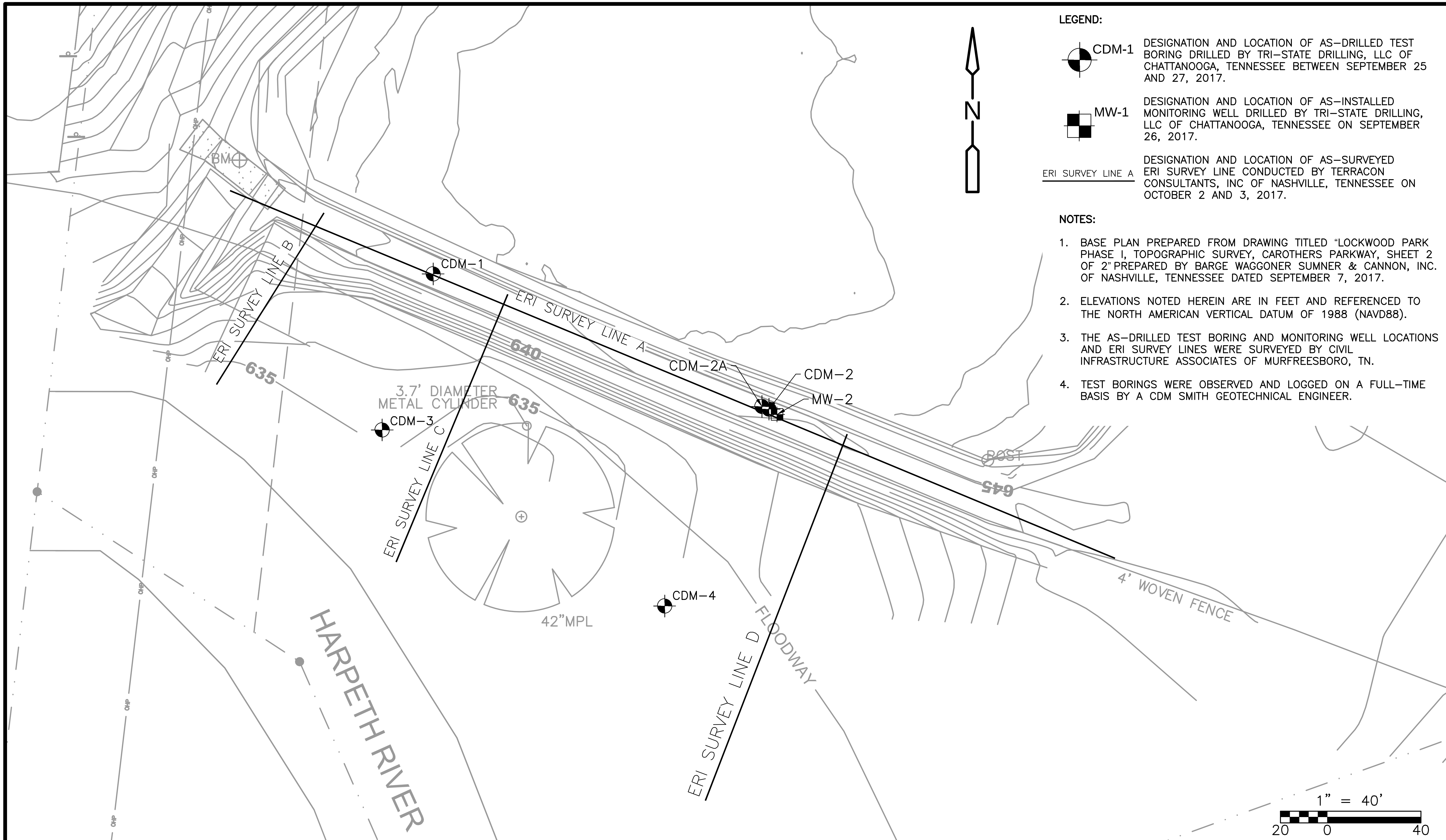
4.1.3 Geotechnical Investigation Program

A geotechnical investigation program, including test borings, geotechnical laboratory testing, and geophysical survey, was performed. The following sections summarize the results of these investigations.

4.1.3.1 Test Borings

CDM Smith conducted a subsurface investigation at the Robinson Lake Dam site between September 25 and 27, 2017.

The test boring program consisted of five (5) geotechnical test borings, CDM-1 through CDM-4 and CDM-2A. The locations of the test borings are shown on **Figure 4-1.** The test borings were drilled by Tri-State Drilling, LCC. using an all-terrain vehicle-mounted CME 550X drill rig. Note that CDM-2 was abandoned at 16 ft-bgs due to loss of drilling equipment in the borehole and offset as test boring CDM-2A. For the purpose of this section, it is assumed that CDM-2 and CDM-2A are a singular continuous test boring denoted as CDM-2/CDM-2A.



LEGEND:

CDM-1 — DESIGNATION AND LOCATION OF AS-DRILLED TEST BORING DRILLED BY TRI-STATE DRILLING, LLC OF CHATTANOOGA, TENNESSEE BETWEEN SEPTEMBER 25 AND 27, 2017.

MW-1 — DESIGNATION AND LOCATION OF AS-INSTALLED MONITORING WELL DRILLED BY TRI-STATE DRILLING, LLC OF CHATTANOOGA, TENNESSEE ON SEPTEMBER 26, 2017.

ERI SURVEY LINE A — DESIGNATION AND LOCATION OF AS-SURVEYED ERI SURVEY LINE CONDUCTED BY TERRACON CONSULTANTS, INC OF NASHVILLE, TENNESSEE ON OCTOBER 2 AND 3, 2017.

NOTES:

1. BASE PLAN PREPARED FROM DRAWING TITLED "LOCKWOOD PARK PHASE I, TOPOGRAPHIC SURVEY, CAROTHERS PARKWAY, SHEET 2 OF 2" PREPARED BY BARGE WAGGONER SUMNER & CANNON, INC. OF NASHVILLE, TENNESSEE DATED SEPTEMBER 7, 2017.
2. ELEVATIONS NOTED HEREIN ARE IN FEET AND REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
3. THE AS-DRILLED TEST BORING AND MONITORING WELL LOCATIONS AND ERI SURVEY LINES WERE SURVEYED BY CIVIL INFRASTRUCTURE ASSOCIATES OF MURFREESBORO, TN.
4. TEST BORINGS WERE OBSERVED AND LOGGED ON A FULL-TIME BASIS BY A CDM SMITH GEOTECHNICAL ENGINEER.

CDM Smith

CITY OF FRANKLIN, TENNESSEE
ROBINSON LAKE DAM
ROBINSON LAKE
FRANKLIN, TENNESSEE

FIGURE 4-1
SUBSURFACE INVESTIGATION PLAN
DECEMBER 2017

Test borings CDM-1 and CDM-2/CDM-2A, located along the existing dam crest, were drilled to depths of 36.3 and 41 ft-bgs, respectively. Test borings CDM-3 and CDM-4, located in the downstream area of the existing dam, were drilled to depths of 23.5 and 21.3 ft-bgs, respectively. The test borings were advanced using 3 ¼" inside diameter (ID) hollow stem auger drilling techniques to auger refusal (i.e., approximate top of bedrock). Auger refusal was encountered between 22 and 22.5 ft-bgs in the crest test borings and between 8.3 and 9.5 ft-bgs in the downstream area test borings.

Split-spoon sampling was conducted continuously in soils from the ground surface until auger refusal was encountered in accordance with ASTM D1586 (using a 2-inch outside-diameter (O.D.) sampler, driven 24 inches by blows from a 140-pound automatic hammer falling freely for 30-inches). The number of blows required to drive the sampler each 6-inch increment was recorded and the Standard Penetration Resistance (SPT) N-value was determined as the sum of the blows over the middle 12 inches of penetration.

Undisturbed (Shelby tube) samples were collected in test borings CDM-1 and CDM-3 in general accordance with ASTM D1587. The Shelby tube samples were trimmed back from both ends of the tube to ensure that only relatively undisturbed material was retained in the tube. Both ends of the tube samples were then sealed with wax, capped with plastic caps, and wrapped in tape. The tubes were labeled and stored upright for transportation. All soil samples were transported to the Terracon Consultants, Inc. (Terracon) Geotechnical Laboratory for storage and geotechnical laboratory testing.

Rock coring was conducted in all test borings in general accordance with ASTM D2113. Rock coring was conducted using an NQ-size rock core barrel, having an outside diameter of approximately 3 inches and an inside diameter of approximately 2 inches. The recovered rock cores were logged in the field by the CDM Smith representative and were stored in cardboard boxes for later review. A Rock Quality Designation (RQD) value was determined for each core run. The RQD is defined as the sum, in inches, of all pieces of sound rock core, four inches in length or longer, divided by the length in inches of the entire core run, expressed as a percentage.

A CDM Smith representative was on-site to observe drilling of the test borings and to visually classify the soil samples recovered in general accordance with the Burmister classification system. Representative soil samples from each split spoon were collected, logged, and stored in bags for later review and geotechnical laboratory testing.

All test borings were backfilled with cement grout to the ground surface upon completion. The test boring logs, prepared by CDM Smith, are included in **Appendix B**.

4.1.3.2 Monitoring Well

A groundwater monitoring well was installed in an offset borehole in the vicinity of test boring CDM-2/CDM-2A. The monitoring well was installed to a depth of 22 ft-bgs to monitor groundwater levels. A 5-foot-long well screen was constructed of 2-inch-diameter, schedule 40 PVC pipe with 0.01-inch machine-slots from 21 to 16 ft-bgs. The well riser was constructed of 2-inch-diameter, threaded, solid PVC.

The annular space around the well screen was backfilled using a sand pack to a level of one foot below and two feet above the screen. The sand pack was allowed to settle while slowly removing the downhole tools. A two-foot-thick bentonite seal was constructed above the sand pack. The remainder of the borehole was backfilled with cement grout around the riser to the ground surface. The monitoring well was completed with an above-grade standpipe embedded in a 6-inch-thick concrete well pad.

The monitoring well installation log is included in **Appendix C**.

4.1.3.3 Geotechnical Laboratory Testing Program

Geotechnical laboratory tests were performed on select split spoon samples obtained from the test borings to assist with soil classification. All geotechnical laboratory tests were performed at the Terracon geotechnical laboratory and consisted of the following:

- Four (4) sieve analysis with hydrometer tests were performed in accordance with ASTM D6913 and ASTM D7928;
- Four (4) sieve analysis with wash of No. 200 sieve tests were performed in accordance with ASTM D6913;
- Eight (8) moisture content tests were performed in accordance with ASTM D2216;
- Eight (8) Atterberg limits tests were performed in accordance with ASTM D4318; and
- One (1) three-point consolidated undrained (CU) triaxial test was performed in accordance with ASTM D4767.

A summary of the geotechnical laboratory index test results is presented in **Table 4-1**. A summary of the triaxial compression test results is presented in **Table 4-2**. The geotechnical laboratory test results are included in **Appendix D**.

4.1.4 Subsurface Conditions

Subsurface conditions encountered during the recent test boring program typically consisted of embankment fill and overburden residual soils overlying bedrock. A summary of soil, bedrock, and groundwater conditions encountered in the test borings is included in **Table 4-3**. Subsurface conditions encountered along the dam crest and perpendicular to the dam crest are described in detail below.

4.1.4.1 Embankment Fill

The embankment fill layer was encountered at test borings CDM-1 and CDM-2/CDM-2A. This layer was overlain by four inches of topsoil and was about 10 feet thick. The embankment fill typically consisted of soft to hard, SILT & CLAY to Silty CLAY, some to trace fine sand and trace to no fine gravel. The SPT-N values for the cohesive layer ranged from 4 to 35 blows per foot (bpf) with an average of about 14 bpf. Pocket penetrometer tests were typically conducted on the split spoon samples, and the measured unconfined compressive strength typically ranged from 3.5 to greater than 4.5 tons per square foot (tsf).

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Table 4-1
Summary of Geotechnical Laboratory Index Test Results

<table>
<tr><th rowspan="2">Test Boring Number</th><th rowspan="2">Sample Number</th><th rowspan="2">Sample Depth (ft)</th><th rowspan="2">Stratum</th><th rowspan="2">USCS Classification [1]</th><th rowspan="2">Moisture Content[2] (%)</th><th colspan="3">Atterberg Limits[3]</th><th colspan="4">Sieve Analysis[4]</th></tr>
<tr><th>LL</th><th>PL</th><th>PI</th><th>% Gravel</th><th>% Sand</th><th>% Silt</th><th>% Clay</th></tr>
<tr><td>CDM-1</td><td>S-3</td><td>4.0-6.0</td><td>Overburden Soils</td><td>CL-ML</td><td>15.6</td><td>23</td><td>16</td><td>7</td><td>1.9</td><td>27.4</td><td colspan="2">70.7</td></tr>
<tr><td>CDM-1</td><td>U-1</td><td>12.0-14.0</td><td>Overburden Soils</td><td>CL</td><td>19.1</td><td>24</td><td>16</td><td>8</td><td>0.0</td><td>23.0</td><td>56.5</td><td>20.6</td></tr>
<tr><td>CDM-1</td><td>S-9</td><td>18.0-20.0</td><td>Overburden Soils</td><td>CL</td><td>23.1</td><td>22</td><td>14</td><td>8</td><td>0.0</td><td>11.0</td><td colspan="2">89.0</td></tr>
<tr><td>CDM-2</td><td>S-2</td><td>2.0 - 4.0</td><td>Overburden Soils</td><td>CL</td><td>11.4</td><td>42</td><td>16</td><td>26</td><td>0.0</td><td>33.9</td><td>47.5</td><td>18.6</td></tr>
<tr><td>CDM-2</td><td>S-5</td><td>8.0-10.0</td><td>Overburden Soils</td><td>CL</td><td>18.1</td><td>31</td><td>17</td><td>14</td><td>0.2</td><td>12.3</td><td>59.2</td><td>28.3</td></tr>
<tr><td>CDM-2A</td><td>S-1</td><td>16.0-18.0</td><td>Overburden Soils</td><td>CL</td><td>19.2</td><td>40</td><td>15</td><td>25</td><td>4.1</td><td>28.6</td><td colspan="2">67.3</td></tr>
<tr><td>CDM-3</td><td>S-2</td><td>2.0-4.0</td><td>Overburden Soils</td><td>CL</td><td>20.6</td><td>33</td><td>17</td><td>16</td><td>0.0</td><td>22.8</td><td>51.0</td><td>26.2</td></tr>
<tr><td>CDM-4</td><td>S-3</td><td>4.0-6.0</td><td>Overburden Soils</td><td>CL</td><td>18.7</td><td>31</td><td>15</td><td>16</td><td>0.6</td><td>20.6</td><td colspan="2">78.7</td></tr>
</table>

Notes:

1. USCS classifications were performed in accordance with ASTM D2487.
2. Moisture content tests were performed in accordance with ASTM D2216.
3. Atterberg Limit tests were performed in accordance with ASTM D4318.
4. Sieve analyses performed in accordance with ASTM D6913 and ASTM D7928.

Abbreviations:

LL	Liquid Limit	CL	Lean Clay
PL	Plastic Limit	CL-ML	Silty Clay
PI	Plasticity Index		

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Table 4-2
Summary of Triaxial Compression Test Results

Test Boring Number	Sample Number	Sample Depth (ft)	Stratum	USCS Classification [1]	Atterberg Limits[3]			Initial Conditions			Effective Confining Stress, σ_c' (psi)	Failure at q_{max} [4&5]	
					LL	PL	PI	Initial Water Content	Initial Void Ratio	Initial Dry Unit Weight (pcf)		p' (psi)	q (psi)
CDM-1	U-1	12.0-14.0	Overburden Soils	CL	24	16	8	19.1	0.64	102.9	7	7.0	23.0
											10	9.7	28.1
											16	14.7	37.6

Notes:
1 USCS classifications were performed in accordance with ASTM D2487.
2 Moisture content tests were performed in accordance with ASTM D2216.
3 Atterberg Limit tests were performed in accordance with ASTM D4318.
4 Failure criterion: maximum deviator stress or maximum deviator stress at strain equal to 15%, whicheve
5 Consolidated Isotropically Undrained (CIU) Triaxial Compression tests were performed in accordance wi

Abbreviations:
CL Lean Clay
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
USCS Unified Soil Classification System

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Table 4-3
Summary of Subsurface Investigation Program

Test Boring Number	Ground Surface Elevation (ft)(1)	Exploration Depth (ft)(2)	Strata Thickness (ft)		Auger Refusal Depth (ft)	Groundwater Depth (ft)(2&3)	Approximate Top of Bedrock Elevation (ft)(1)	Comments
			Overburden Soils	Limestone				
CDM-1	644.4	36.3(4)	22.5	>13.8	621.9	8.0	621.9	Rock coring performed from 22.5 to 36.3 ft-bgs.
CDM-2	646.4	16(4)	>16(5)	NE	NE	5.5	NE	
CDM-2A	646.1	41.0	22(6)	>19	624.1	4.5	624.1	Rock coring performed from 22.0 to 41 ft-bgs
CDM-3	634.3	25.5	9.5	>16	624.8	2.0	624.8	Rock coring perfomred from 9.5 to 25.5 ft-bgs
CDM-4	635.5	21.3	8.3	>13	627.2	NE	627.2	Rock coring performed from 8.3 to 21.3 ft-bgs.

Notes:

1 Elevations are in feet and referenced to the National American Vertical Datum of 1988 (NAVD88).
2 Indicated depths are depths below ground surface at the time of drilling.
3 Groundwater levels were measured at the time of drilling and may not represent the stabilized groundwater level.
4 The top 10 ft of Overburden Soils layer assumed to be embankment fill based on the pocket penetrometer data.
5 Borehole terminated at 16 ft-bgs due to drilling equipment lost in borehole. See CDM-2A for continuation of test boring.
6 Borehole is offset test boring for CDM-2 and was augered directly to 16 ft-bgs prior to commencing sampling.

Abbreviations:

> Indicates strata not fully penetrated
NE Not encountered
ft-bgs Feet below ground surface

The liquid limit of the embankment fill ranged from 23 to 42 with an average of 32; the plastic limit ranged from 16 to 17 with an average of 16; and the plasticity index ranged from 7 to 26 with an average of 16 at the test boring locations. The USCS classification symbols of the soils comprising the majority of the embankment fill were CL (Lean Clay and Sandy Lean Clay) and CL-ML (Silty Clay with Sand).

4.1.4.2 Residual Soils

The residual soils were encountered at all test boring locations. The residual soils layer was encountered below the embankment fill at test borings CDM-1 and CDM-2/CDM-2A and at the ground surface at test borings CDM-3 and CDM-4. This layer was 12.5 and 12 feet thick at the crest borings CDM-1 and CDM-2/CDM-2A, respectively and 9.5 and 8.3 feet thick at the downstream test borings CDM-3 and CDM-4, respectively. The residual soils typically consisted of soft to very stiff, SILT & CLAY to Silty CLAY, some to trace fine sand and trace to no fine gravel. In test boring CDM-3, a loose to medium dense, brown, fine SAND and Silty CLAY layer was encountered from 5 feet to 9.5 ft. The SPT-N values for the cohesive layer ranged from weight of hammer (WOH) to 59 bpf with an average of about 9 bpf. Pocket penetrometer tests were typically conducted on the split spoon samples. In the crest test borings, the pocket penetrometer test results typically ranged from 0.25 to 2 tsf, and in the downstream area test borings, the pocket penetrometer test results typically ranged from 0.5 to 1.5 tsf.

The liquid limit of the residual soils ranged from 22 to 40 with an average of 30; the plastic limit of the ranged from 14 to 17 with an average of 15; and the plasticity index ranged from 16 to 25 with an average of 15 at the test boring locations. The USCS classification symbols of the soils comprising the majority of the residual soils were CL (Lean Clay and Lean Clay with Sand).

4.1.4.3 Limestone

Limestone (bedrock) was encountered below the residual soils at all test boring locations. The bedrock typically consisted of moderately hard, fresh to slightly weathered, fine-grained, gray, LIMESTONE, with extremely thin bedding and horizontal, smooth slickened joints. The bedrock coring depth ranged from 13 to 19 feet in the borings. A 6-inch void was observed in CDM-3 between 11.7 and 12.2 ft-bgs. The rock-core recovery ranged from 65% to 100% with an average of 87%. The RQD ranged from 28% to 73% with an average of 41%.

4.1.4.4 Groundwater Levels

When possible, groundwater levels were observed at the test boring locations at the completion of rock coring and in the installed monitoring well. **Table 4-4** presents the groundwater levels measured in the monitoring well.

The groundwater levels were encountered between 4.5 and 8 feet-bgs (El. 641.6 to El. 636.4) in the crest test borings and between 2 to 4 ft-bgs (El. 632.3 to El. 631.5) in the downstream area test borings. Whereas, the groundwater level readings observed in the monitoring well, MW-2, were between 14 and 14.9 ft-bgs (i.e., El. 632.2 to El. 631.4).

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Table 4-4
Summary of Monitoring Well Readings

Monitoring Well Number	Ground Surface Elevation (ft)[(2)]	Groundwater Elevation (ft)[(2)]			
		9/26/2017	9/27/2017	10/2/2017	10/3/2017
MW-2	646.2	632.2	632.2	631.5	631.4

Notes:
1. See Figure 4-1 for monitoring well location.
2. Elevations are in feet and referenced to the North American Vertical Datum of 1988 (NAVD88).
3. Monitoring well installed in offset boring in the vicinity of CDM-2 and CDM-2A

4.1.4.5 Expected Variation in Subsurface Conditions

The interpretation of general subsurface soil and bedrock conditions presented herein are based on soil, bedrock and groundwater conditions observed during the recent subsurface investigation program. However, subsurface conditions may vary between test boring and ERI survey line locations. If conditions are found to be different than assumed, recommendations contained in this report should be reevaluated by CDM Smith and confirmed in writing.

Water levels measured in the explorations should not necessarily be considered to represent stabilized groundwater levels. In addition, water levels are expected to fluctuate with time due to river level, season, temperature, climate, and construction in the area, as well as other factors.

Therefore, groundwater conditions at the time of construction may be different from those observed at the time of the explorations.

4.1.5 Geophysical Investigation Program

CDM Smith subcontracted Terracon to perform a geophysical survey consisting of ERI to identify potential karst locations and subsurface anomalies. The geophysical investigation program was performed by Terracon on October 2 and 3, 2017. The geophysical survey was performed along the dam crest and downstream area. The geophysical survey consisted of four (4) ERI survey lines. One (1) ERI survey line, Line A, extended along the entire length of the dam crest, and three (3) ERI survey lines, Lines B through D, extended perpendicular to the dam crest from the dam crest to the downstream area in the vicinity of the Harpeth River.

The results of the geophysical survey are summarized in the memorandum included in **Appendix D**.

4.2 Engineering Evaluation

4.2.1 Dam Break Analyses

CDM Smith performed a planning-level dam break analysis to assist in evaluating potential downstream effects if a dam failure were to occur. DSS WISE (Decision Support System for Water Infrastructure Security) can be used to approximate a dam-break and estimate potential downstream effects. In the simulation, the lake's hydraulic height, dam crest length, and lake elevation and volume at normal pool level and maximum (dam-break) pool level were used. The simulation was run assuming a sunny day breach which assumes a non-storm event failure and that the primary outlet structure is blocked and unable to release any water from the lake. The lake level prior to failure was assumed to be at the dam crest.

The model approximates the inundation flood depth downstream of the lake and indicates the potential downstream effects that a dam break would have including inundation of residences and overtopping of roads. Based on the results of the approximate analysis, no residences downstream would be inundated, and no roads downstream would be overtopped. The approximate analysis indicates that the dam may be classified as Hazard Potential Category 3 (low hazard potential). However, TDEC would require a more-robust dam break analysis using HEC-RAS to challenge their current classification of the dam as Hazard Potential Category 2 (significant hazard potential).

A DSS WISE-generated inundation map indicating the approximate flood depth downstream of the lake is contained is **Appendix E**.

4.2.2 Hydrologic and Hydraulic (H/H) Analyses

4.2.2.1 Existing Outflow Structures

There is an existing 47-foot-wide auxiliary spillway with a weir crest at El. 643. In addition to the spillway, the dam crest is at El. 645. No other outlet structures were identified for this lake.

4.2.2.2 Initial Analyses

HEC-HMS was utilized to perform the H/H analyses on Robinson Lake Dam. The software was used to determine the appropriate size and outlet configuration for the dam that would be required to pass the 25-year, 6-hour duration design storm through a primary spillway (riser-barrel configuration), the 100-year, 6-hour duration design storm through an auxiliary spillway (weir), and the 1/3 PMP, 6-hour duration storm through an emergency spillway without overtopping the dam. The design precipitation for the 25-year and 100-year, 6-hour storms were identified using NOAA Atlas 14. A hyetograph for the contributing drainage area (~1 mi^2) was created for the 1/3 PMP design storm using HMR 51 and HMR52 references.

4.2.2.3 Potential Improvements to the Robinson Lake Dam Spillway

For the primary spillway, a 4-foot by 12-foot concrete riser drop-inlet at El. 640 feet (existing normal pool) and a 48-inch-diameter outlet pipe is required to successfully pass the 25-year, 6-hour duration storm without activating the auxiliary spillway. The existing auxiliary spillway (47-foot-wide weir at El. 643) in addition to the primary spillway is sufficient to pass a 100-year, 6-hour duration design storm without activating the proposed emergency spillway. In addition to the outlet structures stated above, a proposed 355-foot-wide, grass-lined emergency spillway at El. 644 feet with an increase in dam height to elevation 645.5 feet is required to pass the 1/3 PMP without overtopping the dam. This design storm would safely pass with zero freeboard. It is recommended that articulated concrete block (ACB) be used to armor the first 100-feet of the grass-lined emergency spillway to reduce the potential for erosion. Because the dam is not predicted to overtop under this scenario, overtopping protection is not recommended for the dam.

A detailed description of the H/H analyses and results are contained in **Appendix F**.

4.2.3 Geotechnical Analyses

Seepage and stability analyses were performed as part of the conceptual design studies. These analyses were performed in general accordance with accepted engineering practices and the applicable codes/references as indicated. The soil properties and subsurface profile for the analyses were developed based upon the geotechnical investigation, existing survey data, and the preliminary dam inspection. The complete geotechnical analyses are contained in **Appendix G**.

4.2.3.1 Seepage Analyses

4.2.3.1.1 General

Seepage analyses were performed using the SEEP/W version 2012 software program, a two-dimensional finite element seepage analysis package distributed by GEO-SLOPE International, Ltd.

SEEP/W was run for two-dimensional flow through both the existing and proposed cross-sections. The existing condition model was used to calibrate the dam and foundation materials permeability and the proposed condition model was used to evaluate the following:

- Phreatic surface location in the proposed embankment design; and
- Flow rate captured by the internal drain pipe.

The geometry of existing condition model was based upon the surveyed contours of the existing dam site. Soil and rock permeabilities in the model were adjusted until the model outputs matched the actual water level readings collected at the monitoring well installed on-site. Then, the calibrated soli model was imported into the proposed conditions model.

The proposed conditions model is based on a 15-foot-wide dam crest at EL. 645.5 with 3H:1V upstream and downstream slopes. Seepage analyses were run using two water levels inside the lake including the normal pool level of El. 640 and a higher pool level of El. 643. The higher pool level was based on the elevation of the existing spillway.

4.2.3.1.2 Model Set-Up

The soil profile in the seepage models was developed based upon the results of the field and laboratory investigations and engineering judgment. The model was calibrated based upon monitoring well readings. **Table 1a** in Appendix G summarized the soil properties used in seepage analyses.

4.2.3.1.3 Analyses and Results

The results of the seepage analyses are presented in Appendix G. The seepage results are presented as figures.

Results of the seepage analyses indicate that the phreatic surface within the proposed dam cross-section does not present a concern, and seepage is not expected to daylight in downstream slope. However, the seepage will daylight at the riverbank of the Harpeth River downstream.

4.2.3.2 Slope Stability Analyses

4.2.3.2.1 General

The USACE design references (EM 1110-2-2300, ER 1110-2-1806, and EM 1110-2-1902) were used for preparation of these calculations. In accordance with these references, n four (4) slope stability loading cases were considered and analyzed:

1. End of construction condition,
2. Normal pool conditions under static load,

3. Maximum pool conditions under static load (El. 643 pool was used), and
4. Normal pool under seismic loading.

In the seismic loading condition (case 4), the pseudo-static analysis method is used. A horizontal acceleration equal to the peak ground acceleration (PGA) of the earthquake event happens within 100 years with 10% probability was used in this analysis, based upon ER 1110-2-1806.

4.2.3.2.2 Model Set-Up

Stability analyses were performed using the SLOPE/W 2012 modeling software package from Geo-Slope International. The geometry of the cross-sections, phreatic surface, and the pore water pressure distribution were obtained from the seepage analyses as described in previous sections. The strength properties used in SLOPE/W model were developed from the field and laboratory investigations, and presented in **Table 1b** in Appendix G.

4.2.3.2.3 Analyses and Results

The slope stability analysis results and the minimum slope stability factors of safety required by USACE (EM 1110-2-1902) for each loading condition, are presented in **Table 2** in Appendix G.

Results of the stability analyses indicate that the proposed dam cross-section would have adequate factors of safety under all cases analyzed. Factors of safety selected for all cases are global stability failures and shallow/surficial sloughing type failures were not considered. SLOPE/W run results for all cases performed are included in Appendix G.

4.2.3.3 Karst Potential Evaluation

Terracon noted one anomaly of interest during the geophysical investigation program. This anomaly was found in the ERI Survey Line A cross-section along the dam crest. The anomaly is an area of low resistivity. In general, low resistivity values are indicative of soil overburden or weak, saturated, or fractured bedrock. The anomaly appears to be at and below the contact with bedrock and could indicate a potential karst condition and pathway for potential water seepage. It was noted during the preliminary dam assessment that seepage was observed in the downstream area and at the base of the drop-off, adjacent to the river, and seepage was flowing through the limestone face at the end of the spillway flowing between approximately 100 and 200 gallons per minute.

Refer to **Section 2.2** for the general risks associated with karst topography.

Based on the above information and the proposed modifications to the dam, the risk for sinkhole development at this site is considered to be relatively high and will require grouting of the dam foundation to address seepage issues.

Section 5

Overview of Conceptual Design

5.1 General

Based upon the dam break, H/H, and geotechnical studies and analyses discussed in **Section 4**, the conceptual design summarized in this section provides additional spillway capacity to pass the required design storm. In addition, the following dam deficiencies were noted during the preliminary dam inspection and in the investigation and analyses for the conceptual design:

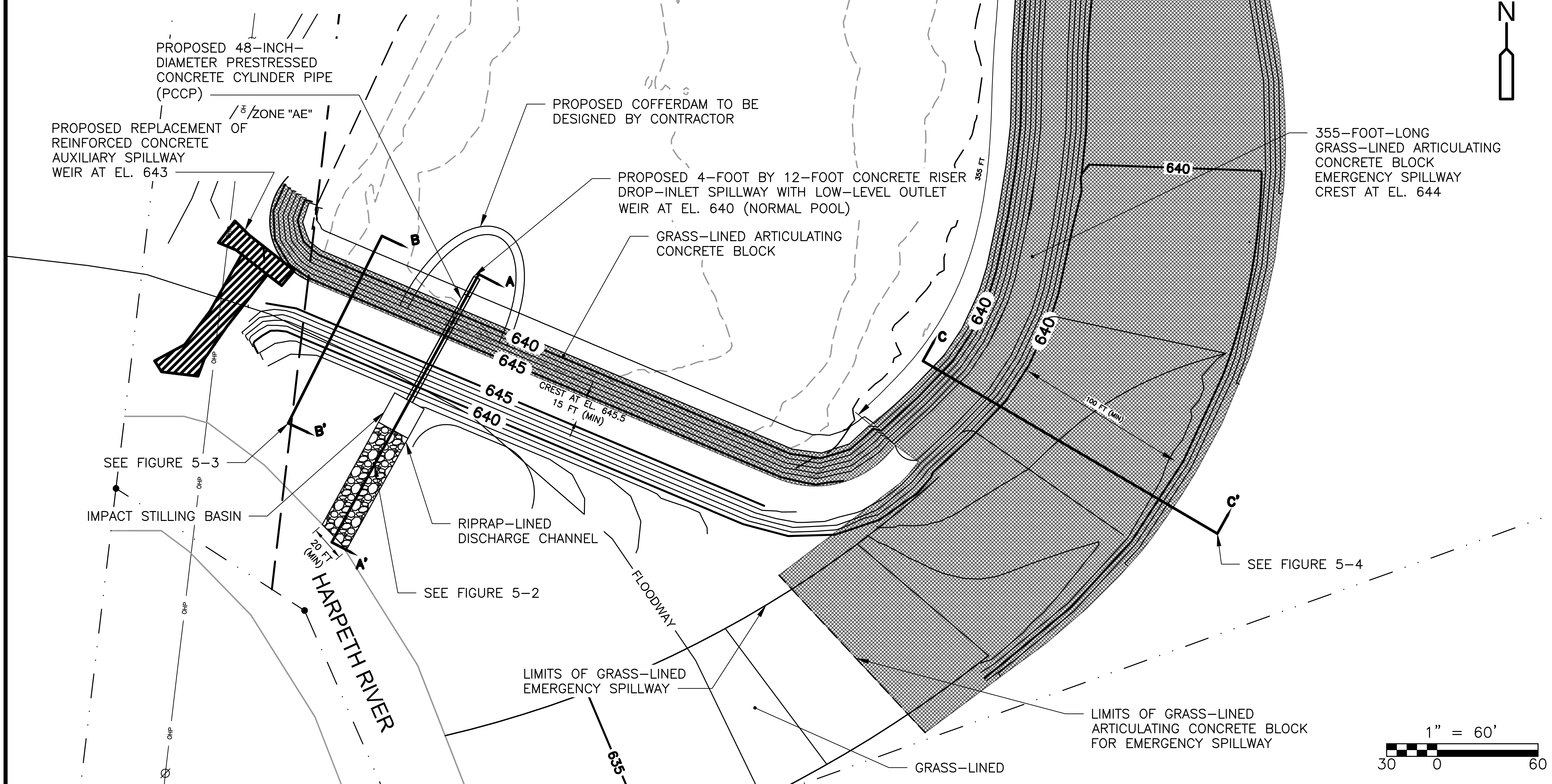
- The upstream and downstream slopes and downstream area are covered with large trees and heavy vegetation;
- The upstream and downstream slopes are steep to very steep ranging from 1.5H:1V to near vertical;
- The bare, eroded area on the crest and downstream slope may indicate previous overtopping of the dam during a flood event. If that is the case, the spillway capacity may be inadequate;
- No outlet works or low-level outlet for draining the pond were observed;
- Seepage was observed in the area downstream of the reinforced concrete riser pipe;
- Seepage was observed through and adjacent to the limestone at the end of the spillway discharge channel;
- There are trees and brush in the approach area to the spillway that will reduce spillway capacity. In addition, the fence along the upstream side of the weir can collect debris and reduce spillway capacity;
- The concrete in the spillway discharge channel is badly cracked and has brush growing in the bottom and sides of the channel;
- The geophysical investigation program noted an approximately 15 ft wide by 20 ft deep anomaly along the dam crest, which may be a potential karst condition; and
- The H/H analyses indicated that the spillway system was too small to pass the required design storm.

5.2 Description of Proposed Improvements

Based on the results of the investigations and analyses, CDM Smith developed a conceptual design for rehabilitation measures to address the identified dam safety deficiencies. This section discusses the proposed improvements for the rehabilitation of Robinson Lake Dam, which are shown on **Figures 5-1** through **5-4**. Refer to **Sections 5.2.1** through **5.2.3** for a detailed description of the proposed improvements.

NOTES:

1. REFER TO SECTION 7.3 OF THE REPORT FOR THE SUGGESTED CONSTRUCTION SEQUENCE.
2. REFER TO FIGURES 5-2 THROUGH 5-4 FOR PROPOSED DAM REHABILITATION CROSS-SECTION THROUGH PRIMARY SPILLWAY, EARTH EMBANKMENT, AND EMERGENCY SPILLWAY, RESPECTIVELY.



CDM Smith

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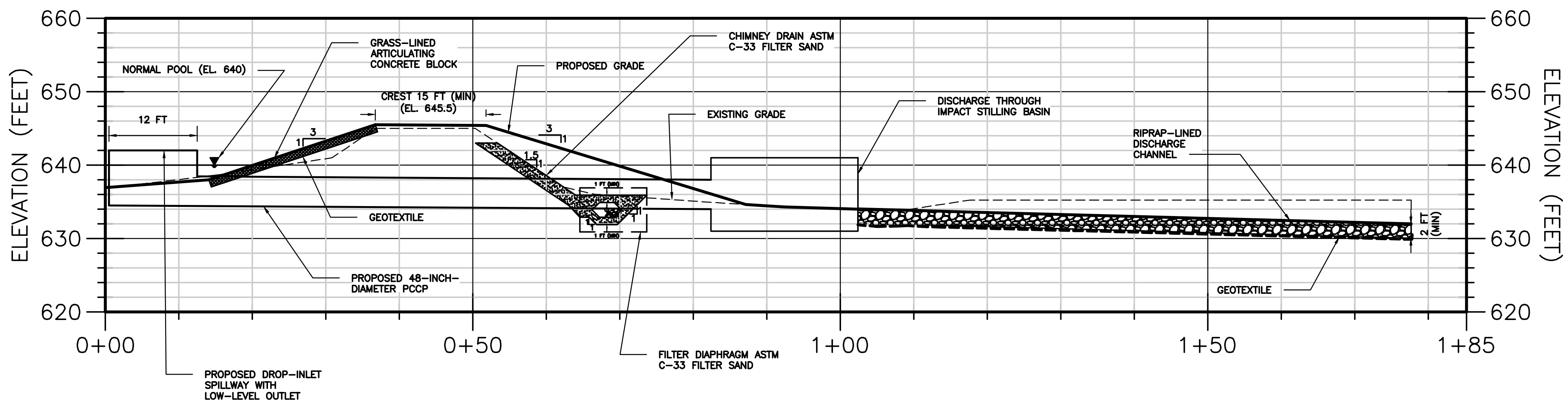
ROBINSON LAKE DAM
ROBINSON LAKE
FRANKLIN, TENNESSEE

FIGURE 5-1
PROPOSED DAM REHABILITATION PLAN
DECEMBER 2017

NOTES:

1. REFER TO FIGURE 5–1 FOR PROPOSED DAM REHABILITATION PLAN.
2. REFER TO SECTION 7.3 OF THE REPORT FOR THE SUGGESTED CONSTRUCTION SEQUENCE.

A CROSS SECTION A–A' A'



1" = 20'

10 0 20

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ROBINSON LAKE
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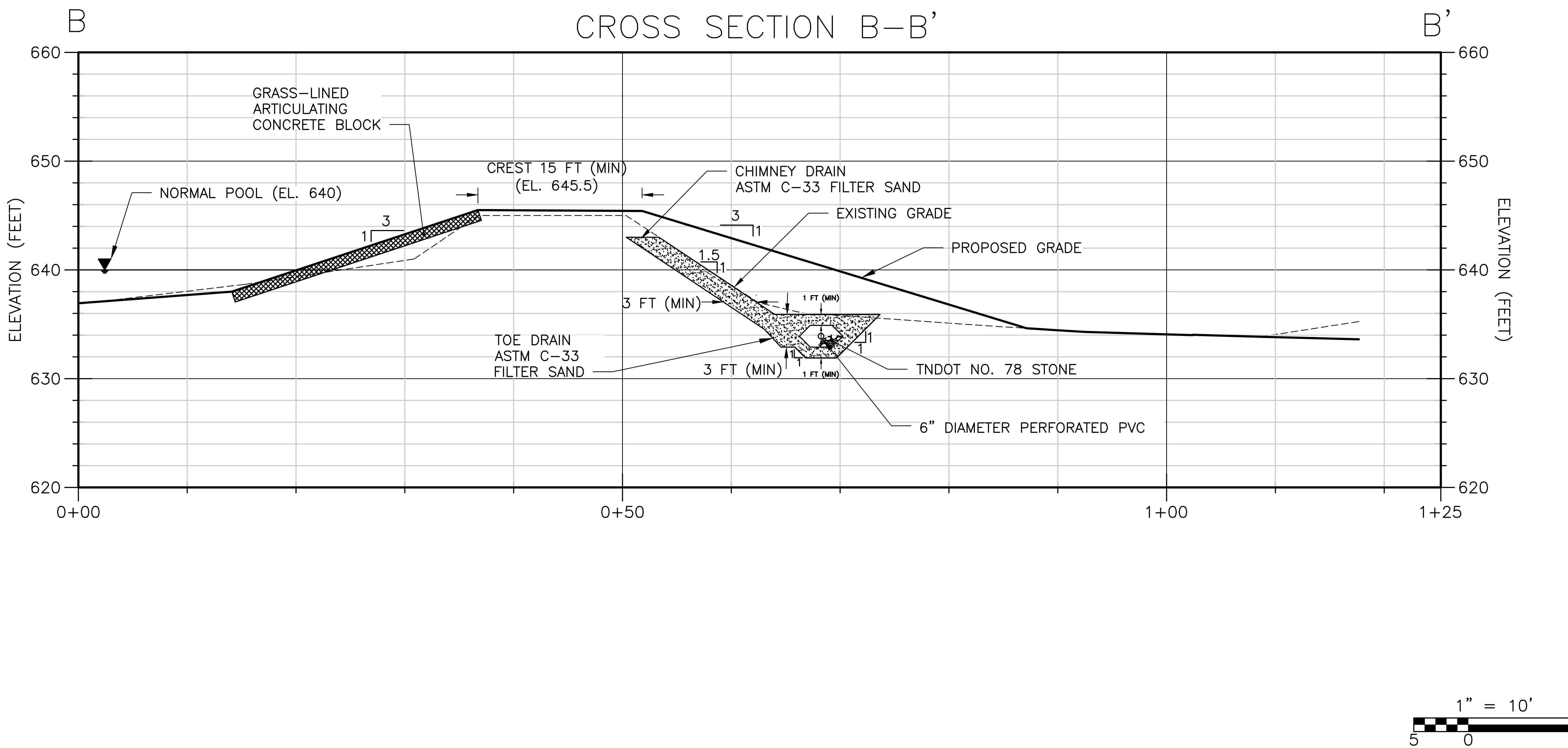
FIGURE 5-2
PROPOSED DAM REHABILITATION PRIMARY SPILLWAY CROSS-SECTION
DECEMBER 2017

NOTES:

1. REFER TO FIGURE 5-1 FOR PROPOSED DAM REHABILITATION PLAN.
2. REFER TO SECTION 7.3 OF THE REPORT FOR THE SUGGESTED CONSTRUCTION SEQUENCE.

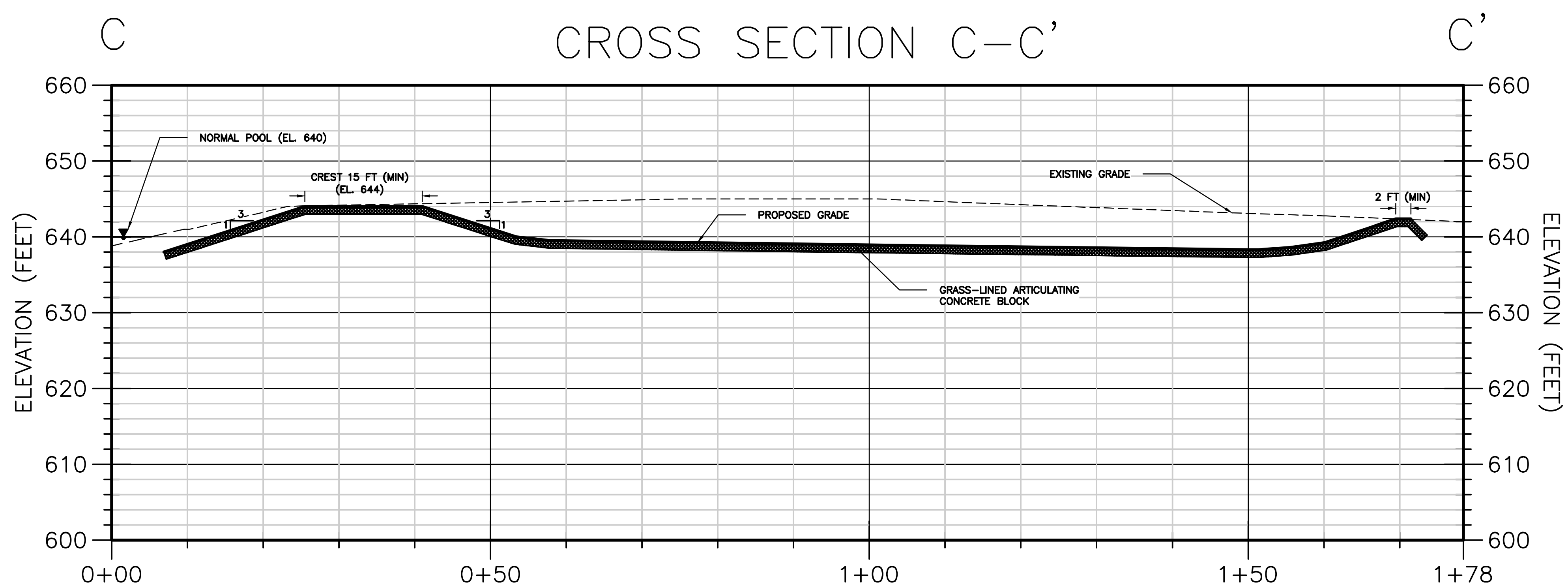


CITY OF FRANKLIN, TENNESSEE
ROBINSON LAKE DAM
ROBINSON LAKE
FRANKLIN, TENNESSEE

FIGURE 5-3
PROPOSED DAM REHABILITATION EMBANKMENT CROSS-SECTION
DECEMBER 2017

NOTES:

1. REFER TO FIGURE 5-1 FOR PROPOSED DAM REHABILITATION PLAN.
2. REFER TO SECTION 7.3 OF THE REPORT FOR THE SUGGESTED CONSTRUCTION SEQUENCE.



CDM Smith

CITY OF FRANKLIN, TENNESSEE
ROBINSON LAKE DAM
ROBINSON LAKE
FRANKLIN, TENNESSEE

FIGURE 5-4
PROPOSED DAM REHABILITATION EMERGENCY SPILLWAY CROSS-SECTION
DECEMBER 2017

5.2.1 Earth Embankment Rehabilitation

The earth embankment rehabilitation will be constructed using borrow materials available from the off-site borrow sources. The earth embankment dam rehabilitation will consist of increasing the dam height to El. 645.5 from El. 645, flattening the upstream and downstream slopes to 3H:1V, widening the dam crest to 15 feet with compacted embankment fill, and placing ACB on the upstream slope from the crest to El. 638. An interior drainage system consisting of a chimney, blanket, and toe drain will be included to control seepage through the embankment.

5.2.2 Foundation Preparation

The earth embankment is founded on approximately 11 feet of residual soils overlying bedrock. Based on the field inspection observations and subsurface data obtained from the test borings and geophysical survey, seepage was observed in the downstream area and at the end of the spillway discharge channel through and adjacent to the limestone. Potential karst conditions were also observed along the dam crest during the geophysical survey. Therefore, a foundation grouting program will be implemented to address potential seepage flow paths in the bedrock underlying the dam.

5.2.3 Spillways

The proposed improvements consider the use of a new primary spillway to pass the 25-year design storm consisting of a 4-foot by 12-foot concrete riser drop-inlet at El. 640 (existing normal pool) and a 48-inch-diameter outlet pipe discharging in the downstream area through an impact stilling basin and flowing via a riprap-lined discharge channel to the Harpeth River. The riser will have a gate to serve as the low-level outlet. A filter diaphragm is recommended around the new spillway pipe through the earthen dam to capture potential seepage around the pipe and discharge it safely to the downstream area. A filter diaphragm consists of a sand filter around the pipe (within the dam) that is hydraulically connected to a filter sand blanket downstream of the diaphragm.

It is proposed to replace the existing trapezoidal weir structure for use as the auxiliary spillway to pass the 100-year design storm without activating the proposed emergency spillway. The auxiliary spillway will be a 47-foot-wide trapezoidal weir at El. 643 (i.e., the current weir elevation). The concrete chute along the entire length of the existing auxiliary is damaged and should be replaced with new reinforced concrete underlain by a drainage layer with an outlet at the Harpeth River.

Also, an emergency spillway is proposed to be constructed along the southeastern edge of Robinson Lake. The proposed emergency spillway will be a 355-foot-wide, grass-lined spillway at El. 644 to pass the 1/3 PMP design storm without overtopping the dam. The first 100 feet of the grass-lined emergency spillway discharge channel will be lined with ACB to reduce the potential for erosion, and a small embankment (up to 3 feet high) will be constructed on the eastern edge of the emergency spillway to direct flow towards the Harpeth River.

Section 6

Permitting

6.1 General

In the State of Tennessee, dams are regulated by the TDEC's Safe Dams Program, which is responsible for conducting certifications, inspections, and approvals of dam and reservoir projects.

To alter a dam in the State of Tennessee several permits need to be acquired. The following permitting bodies will need to issue the following documents:

- TDEC
  1. Aquatic Resource Alteration Permit (ARAP) from the TDEC Division of Water Resources
  2. Alteration Permit from the TDEC Safe Dams Program
  3. National Pollutant Discharge Elimination System (NPDES) Stormwater Construction Permit from the TDEC Division of Water Pollution Control
- The City of Franklin
  1. "No-Impact" Certification for Proposed Developments in Regulatory Floodways
- USACE
  1. Pre-Construction Notification
  2. Section 404 Permit

The Robinson Lake Dam rehabilitation will require submittals to the necessary permitting agencies. A summary of the meetings with the agencies to determine the required permits, and the permit conditions can be found below in **Sections 6.2** and **6.3**.

6.2 Meetings with Agencies

Mr. Lyle Bentley of TDEC Safe Dams Program previously confirmed with Mr. Stephen Whiteside of CDM Smith that the dam is currently classified as a farm pond dam and is not subject to the dam safety regulations. Farm pond dams are defined as any impoundment used only for providing water for agricultural and domestic purposes such as livestock and poultry watering, irrigation of crops, recreation, and conservation, for the owner or occupant of the farm, his family, and invited guests, but does not include any impoundment for which the water, or privileges or products of the water, are available to the general public. However, Mr. Bentley noted that should the City purchase the property and the dam, the dam will be subject to the dam safety regulations.

Mr. Whiteside and Mr. John Briand of CDM Smith spoke with Mr. Lyle Bentley of TDEC Safe Dams Program via conference call on October 23, 2017. Mr. Bentley indicated that Robinson Lake Dam is classified as an existing dam per TDEC regulations, and the current TDEC classification of the dam is a Category 2 (significant hazard) dam. Mr. Bentley stated that the rehabilitation should consider the following requirements:

- The dam should have all trees, brush, vegetation, etc. grubbed and cleared from the footprint of the dam;
- Any steep slopes for the dam should be regraded;
- The dam shall be "stable" based on the geotechnical analyses; and
- Any seepage issues should be dealt with by appropriate measures.

Mr. Bentley suggested that CDM Smith consider rehabilitation assuming the design storm for a Category 1 (high hazard) small dam (i.e., 6-hour, ½ PMP event) in order to not require modifications to the dam based on potential future development downstream, and he suggested modeling the H/H analyses using either the Soil Conservation Service (SCS) Type II rainfall distribution or the Hydrometeorological Report No. 52 (HMR 52). Mr. Bentley also stated that the dam break analyses should consider a dam break during a ½ PMP event in addition to the sunny-day dam break previously analyzed as discussed in **Section 4.2.1** should the Engineer consider reclassifying the dam to a Category 3 (low hazard) dam from a Category 2 (significant hazard) dam, which it is currently classified as discussed prior.

Mr. Briand spoke with Mr. Brandon Yates of TDEC of the Division of Water Resources Permitting/Assessment division via phone on November 1, 2017. Mr. Yates is responsible for the TDEC permitting operations in Williamson County. Mr. Yates confirmed that an ARAP permit is required for the proposed construction, and a NPDES stormwater construction permit is required should the area of disturbance for construction be greater than 1 acre.

Mr. Bernard Graves spoke with Shanna McCoy, Flood Plain Administrator, for the City of Franklin, Tennessee via phone on November 8, 2017, and Ms. McCoy stated that a "No-Impact" Certification for Proposed Developments in Regulatory Floodways is required for the proposed construction. In addition, Mr. Graves spoke with Mr. Casey Ehorn, East Branch Chief for the USACE Nashville District, via phone on November 8, 2017, and Mr. Ehorn stated that a pre-construction notification and USACE Section 404 permit would be required. Mr. Ehorn stated that based on the discussion of the conceptual level rehabilitation improvements that he would anticipate the work would likely require a Nationwide Permit 3 (Maintenance) application.

6.3 Required Permits, Certifications, and Notifications

6.3.1 TDEC ARAP Permit

The ARAP permitting process requires public notice to be issued. If there is sufficient public interest, a public hearing may also be required.

To meet the requests of TDEC, the City of Franklin will submit a new ARAP application. A complete ARAP application contains the following information:

- Scope of the current project;
- USGS topographical map indicating the exact location of the project;

- Photographs of site with location description;
- Description of existing stream or wetland characteristics and dimensions such as depth, length, average width, substrate, and riparian vegetation;
- In the case of wetlands, include a wetland delineation with delineation forms and site map denoting location of data points;
- Description of any proposed channel modifications, such as changes in depth, length, average width, substrate, and riparian vegetation;
- A copy of all hydrologic or jurisdictional determination issued for water resources on the project site;
- A project rationale;
- Detailed plans, specifications, blueprints, or legible sketches of present site conditions and the proposed activity;
- Discussion regarding the sequencing of events and construction methods;
- Depiction and narrative on the location and type of erosion and sediment control measures for the proposed alterations; and
- Description of any other alterations to the properties of waters of the state.

6.3.2 TDEC Alteration Permit

A Safe Dams Alteration Certificate will need to be issued for the rehabilitation of the Robinson Lake Dam. The plans, specifications and engineering report for the rehabilitation will need to be submitted to Mr. Bentley for approval prior to the issuing the project for bid. The submittal will include the modeling input from dam break, H/H and geotechnical seepage and slope stability analyses, and other design criteria. When the plans, specifications, and engineering report are acceptable, Safe Dams will issue a construction permit that extends for one year, contingent on receiving the ARAP permit. Rehabilitation of the dam must be started during this year or another review of the plans, specifications, and engineering report will be required.

6.3.3 TDEC NPDES Stormwater Construction Permit

The NPDES Stormwater Construction permit will be one of the later permits secured once the ARAP is issued. The stormwater runoff permit has a two-step permitting process. The components include:

- A completed and signed Notice of Intent (NOI) for Construction Activity - Storm Water Discharges. The NOI must include a map on 8 ½ inch by 11 inch paper with boundaries 1-2 miles outside the site property with the site and construction area outlined and the receiving water or receiving storm sewer highlighted and identified.
- A site-specific SWPPP (Storm Water Pollution Prevention Plan) must be developed and submitted with the NOI.

6.3.4 FEMA No-Impact Certification

The Federal Emergency Management Agency (FEMA) No-Impact Certification for Proposed Developments in Regulatory Floodways should be submitted to the City of Franklin. The certification requires that following components to confirm there is no change in flood levels from existing conditions:

- Hydraulic models in a currently approved FEMA hydraulic model including an effective model, duplicate effective model, corrected effective model, existing conditions model, and proposed conditions model,
- Project narrative,
- Topographic work map,
- Cross-section plots,
- Property survey, and
- No-rise certification.

6.3.5 USACE Pre-Construction Notification

The USACE pre-construction notification should be submitted to the USACE, and the notification includes the following components:

- Name, address and telephone numbers of the permittee,
- Location of the proposed activity,
- Identification of the specific Nationwide Permits,
- Description of the proposed construction activities including purpose, environmental effects, etc., and
- Delineation of wetlands, other special aquatic sites, and other waters, such as lakes and ponds, and perennial, intermittent, and ephemeral streams, on the project site,

6.3.6 USACE Section 404 Permit

The Robinson Lake Dam rehabilitation will most likely require a Nationwide Permit 3. The Nationwide Permit 3 is reviewed by the USACE, which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines, regulations promulgated by EPA.

Section 8

Conceptual-Level Recommendations

8.1 Recommendations

The conceptual-level design for the rehabilitation of Robinson Lake Dam include the following primary recommendations:

- **Rehabilitation of the Existing Earth Embankment:** The rehabilitation of the existing earth embankment is proposed to include site clearing and grubbing, flattening the upstream and downstream slopes to 3H:1V, armoring the upstream slope from El. 638 with grass-lined articulating concrete block, and widening the dam crest to 15 feet.

- **Foundation Grouting Program:** To address observed and potential seepage conditions, a foundation grouting program is recommended to address potential seepage paths in the fractured bedrock zone and potential karst conditions noted during the geophysical program. An internal drainage system will be installed along the downstream slope of the existing embankment to control seepage through the dam.

- **Construction of a New Primary Spillway:** The primary spillway construction is proposed to consist of a 4-foot by 12-foot concrete box riser to El. 640 with a 48-inch diameter prestressed concrete cylinder pipe (PCCP) barrel discharging to a 20-foot wide impact stilling basin and riprap-lined channel flowing to the Harpeth River. The concrete riser drop-inlet will include a low-level outlet to lower the lake levels when necessary. The primary spillway is proposed to pass the 25-year design storm without activating the auxiliary or emergency spillways.

- **Replacement of the Existing Auxiliary Spillway:** The auxiliary spillway replacement is proposed to include removal and replacement of the existing cracked and damaged trapezoidal concrete chute spillway along the entire length of the spillway to the Harpeth River. The new auxiliary spillway slab will have an underdrain system that discharges at the Harpeth River. The auxiliary spillway is proposed to pass the 100-year design storm without activating the emergency spillway.

- **Construction of a New Emergency Spillway.** Construction of a new 355-foot-wide, grass-lined emergency spillway to El. 644. The emergency spillway construction is proposed to include armoring with ACB extending from El. 638 on the upstream slope to the first 100 feet of the grass-lined discharge channel. A small embankment (up to 3 feet in height) will be constructed on the eastern edge to capture flow from the spillway and direct the flow to the Harpeth River. The emergency spillway is proposed to pass the 1/3 probable maximum precipitation (PMP) design storm.

Section 7

Construction Considerations

7.1 General

The Robinson Lake Dam project involves rehabilitation of approximately 375-foot embankment dam section, a 47-foot-wide trapezoidal concrete weir and discharge channel and construction of a 355-foot-wide emergency spillway. Prior to commencing the work, a supplemental subsurface investigation program should be conducted to further investigate potential seepage paths through the bedrock layer encountered during the recent subsurface investigation program and to investigate the subsurface conditions near the emergency spillway and channel. The supplemental subsurface investigation may include but is not limited to additional geophysical exploration, test borings, and test pits. The test borings should include packer testing to assist in the determination of the bedrock permeability.

The rehabilitation work includes, but is not limited to the following:

- Existing conditions survey and site plan,
- Erosion and siltation control,
- Construction of cofferdam(s) and stream diversion/dewatering,
- Site clearing and grubbing,
- Sediment removal,
- Work and laydown areas,
- Foundation grouting,
- Construction of concrete riser drop-inlet structure and low-level outlet,
- Installation of internal drain system,
- Rehabilitation and grading of the earth embankment dam,
- Replacement of auxiliary spillway,
- Construction of emergency spillway and channel, and
- Site restoration

7.2 Contract Documents

Conceptual figures for the selected alternative are contained in **Section 5**. Contract documents will be developed during final design.

7.3 Suggested Construction Sequence

The opinion of probable construction cost (**Section 8.2**) is based on certain assumptions and sequencing of construction. These assumptions are presented in this Section. The Contractor is not required to perform the work in this sequence, but the work must be coordinated with the City of Franklin and accomplished in a logical order to allow construction to be completed within the time allowed by the final contract documents without exceeding this time limit or causing the need for additional funding. The given sequence outlines a conceptual construction sequence and is provided only as a guide to aid in the bidding process. This sequence outlines only major steps assumed for construction of the project. This sequence is not a detailed procedure, and the Contractor will be held responsible to provide the details, procedures, specifics, and intermediate steps, as required to meet the project requirements and operational restrictions from the owner. The Contractor will determine the actual means and methods employed during construction.

1. **Survey Work:** Prior to beginning any construction, the Contractor will perform a survey to document existing site conditions. As part of the final design, control points established from a land survey will be added to the final contract drawings. The Contractor will be responsible to locate and verify the accuracy of these control points.

2. **Preparation of Site Plan of Existing Conditions:** Results of the survey of existing conditions will be documented on a site plan and included in the project submittals.

3. **Erosion and Siltation Control:** Erosion and siltation control measures will be installed prior to any clearing, earthwork, dewatering and water diversion activities.

4. **Cofferdam Construction and Dewatering:** Prior to any significant construction activities, the lake will be dewatered and a cofferdam such as a Portadam™ will be constructed around the proposed primary spillway structure (i.e., concrete riser drop-inlet with low-level outlet) to protect areas of work and allow construction to be performed in-the-dry. Drawdown of the lake will be in accordance with TDEC guidelines and approved permit(s). Steam diversion will be phased such that flows are initially diverted through the cofferdam via temporary pipes or pumps. Upon completion of this work, the flow will be diverted to the new spillway to allow construction/rehabilitation of the remaining dam components.

5. **Site Clearing and Grubbing**: Clearing and grubbing will be required in the work area and laydown areas. The approximate extents of these areas will be delineated on the contract drawings during final design. All trees, root balls and other vegetation will be removed from the dam embankment, abutments and downstream area prior to commencing excavations.

6. **Sediment Removal:** Sediment will be removed from the lake areas by conventional earth moving equipment and disposed of off-site.

7. **Work and Laydown Areas:** The work and laydown areas will be set-up in the area east of the left abutment as shown on the contract drawings during final design. These areas will be located such that they are accessible and compatible with the stream diversion design.

8. **Foundation Grouting:** Prior to commencing excavation for the primary spillway, primary foundation grouting holes will be drilled to a depth of 20 feet below top of bedrock. Pressure grouting will be conducted in primary grout holes to seal permeable zones in the bedrock (limestone) below the dam foundation. Secondary grout holes will be drilled between primary hole to a depth of 20 feet below top of bedrock and will also be pressure grouted.

Tertiary grout holes will be drilled and grouted as needed and as directed by the Engineer. Note that the foundation grouting plan will be reviewed during final design.

9. **Construction of Primary Spillway and Discharge Channel:** The proposed primary spillway area will be excavated with stable slopes to suitable subgrade. At this time, it is not known whether an abandoned primary spillway is located in the vicinity of the proposed primary spillway. Should an existing abandoned spillway be located at the same location, the Contractor shall remove the existing spillways pipe/structure and construct the new 4-foot by 12-foot concrete riser drop-inlet spillway with low-level outlet in its place. The spillway will consist of a 48-inch-diameter barrel discharging to an impact stilling basin and a riprap-lined channel extending to the Harpeth River. If no existing spillway is present, the Contractor shall construct the primary spillway at the proposed location as shown.

10. **Diversion and Isolation of Proposed Dam Construction Area:** Following completion of proposed primary spillway, flow will be restored to the stream bed through the low-level outlet in the primary spillway.

11. **Rehabilitation of Earth Embankment:** Once the proposed dam area is isolated, excavated and foundation grouting has been completed, construction activities shall commence. The Contractor shall excavate with stable side slopes and install the proposed internal drainage system. The Contractor shall construct the internal drain as shown on the contract drawings during final design. Then, the Contractor shall commence grading for the dam which will include flattening the upstream and downstream slopes to 3H:1V and increasing the dam height to El. 645.5. It is anticipated that the earth dam section will be constructed with on-site borrow materials excavated from the proposed borrow area. Articulating concrete block should be installed to armor the upstream slope to El. 638 and lined with grass (i.e., topsoil and seed or sod).

12. **Replacement of Auxiliary Spillway and Concrete Chute:** The auxiliary spillway replacement will consist of removal of the existing concrete surface along the entire length of the existing spillway and construction of a new 47-foot-wide trapezoidal weir at El. 643. The Contractor should then install a 12-inch-thick reinforced concrete chute over the entire length of the auxiliary spillway to the limestone ledge at the Harpeth River. The spillway and concrete chute will include construction of an underdrain system beneath the slab.

13. **Installation of Emergency Spillway and Discharge Channel:** The proposed emergency spillway will be excavated with stable side slopes for a 15-foot-wide crest at El. 644. The emergency spillway will be grass-lined ACB from El. 638 along the upstream slope and extend along the first approximately 500-feet of the grass-lined emergency spillway discharge channel. The Contractor will re-grade the emergency spillway as shown on the contract drawings including an embankment on the east side of the spillway to contain the 1/3 PMP flood event.

14. **Removal of Stream Diversions:** Following installation of erosion control and overtopping protection measures, all remaining temporary cofferdams and stream diversion measures will be removed to restore the natural flow of the stream.

15. **Site Restoration:** All areas disturbed by construction activities will be restored to pre-construction conditions or better (paved, vegetated, etc.), unless otherwise indicated on the plans.

Section 8

Conceptual-Level Recommendations

8.1 Recommendations

The conceptual-level design for the rehabilitation of Robinson Lake Dam include the following primary recommendations:

- **Rehabilitation of the Existing Earth Embankment:** The rehabilitation of the existing earth embankment is proposed to include site clearing and grubbing, flattening the upstream and downstream slopes to 3H:1V, armoring the upstream slope from El. 638 with grass-lined articulating concrete block, and widening the dam crest to 15 feet.

- **Foundation Grouting Program:** To address observed and potential seepage conditions, a foundation grouting program is recommended to address potential seepage paths in the fractured bedrock zone and potential karst conditions noted during the geophysical program. An internal drainage system will be installed along the downstream slope of the existing embankment to control seepage through the dam.

- **Construction of a New Primary Spillway:** The primary spillway construction is proposed to consist of a 4-foot by 12-foot concrete box riser to El. 640 with a 48-inch diameter prestressed concrete cylinder pipe (PCCP) barrel discharging to a 20-foot wide impact stilling basin and riprap-lined channel flowing to the Harpeth River. The concrete riser drop-inlet will include a low-level outlet to lower the lake levels when necessary. The primary spillway is proposed to pass the 25-year design storm without activating the auxiliary or emergency spillways.

- **Replacement of the Existing Auxiliary Spillway:** The auxiliary spillway replacement is proposed to include removal and replacement of the existing cracked and damaged trapezoidal concrete chute spillway along the entire length of the spillway to the Harpeth River. The new auxiliary spillway slab will have an underdrain system that discharges at the Harpeth River. The auxiliary spillway is proposed to pass the 100-year design storm without activating the emergency spillway.

- **Construction of a New Emergency Spillway.** Construction of a new 355-foot-wide, grass-lined emergency spillway to El. 644. The emergency spillway construction is proposed to include armoring with ACB extending from El. 638 on the upstream slope to the first 100 feet of the grass-lined discharge channel. A small embankment (up to 3 feet in height) will be constructed on the eastern edge to capture flow from the spillway and direct the flow to the Harpeth River. The emergency spillway is proposed to pass the 1/3 probable maximum precipitation (PMP) design storm.

8.2 Opinion of Probable Construction Cost

The following conceptual opinion of probable construction cost (OPCC) has been developed based on the recommendations and rehabilitation measures described above. The costs are based on a limited investigation and are provided for general guidance only. The OPCC should not be considered an engineer's estimate as actual costs may be somewhat more or less than indicated. The actual rehabilitation costs can vary depending on contracting procedures as required by the State of Tennessee as well as other factors. These costs should be considered preliminary and should be confirmed by obtaining estimates from local contractors.

Refer to **Table 8-1** below for the summary of the OPCC.

Table 8-1. Summary of Conceptual-Level Opinion of Probable Construction Cost

Description	OPCC ($)
Erosion and Siltation Control	$16,000
Site Clearing	$38,000
Dewatering and Cofferdam Installation	$205,000
Primary Spillway and Riprap-Lined Discharge Channel	$321,000
Embankment Rehabilitation	$123,000
Emergency Spillway	$1,592,000
Auxiliary Spillway	$122,000
Dam Foundation Grouting	$108,000
Conceptual-Level OPCC Total	$2,500,000

Notes:

1. The conceptual-level OPCC line items have been rounded to the nearest thousand.
2. The conceptual-level OPCC total is considered accurate to two significant figures.
3. Note that the articulating concrete block (i.e., approximately 50% of the total OPCC) may be replaced during final design with lower-cost armoring methods such as turf reinforcement matting after conducting additional H/H analyses.

Finally, it is estimated that the engineering design and permitting costs associated with the project would be approximate 25 percent of the construction cost (i.e., about $625,000).

Appendix A

Preliminary Assessment Memorandum

CDM Smith

Memorandum

To: *Paul Holzen, PE*

From: *Steve Whiteside, PE*
Dave Mason, PE

Date: *June 23, 2017*

Subject: *Preliminary Assessment of Robinson Lake Dam*
Franklin, Tennessee

CDM Smith was engaged by the City of Franklin to perform a preliminary assessment of Robinson Lake Dam in Franklin, Tennessee. We understand that the City is considering acquiring the property on which the dam and lake are located. The purpose of the assessment is to identify potential dam safety deficiencies and provide recommendations for future actions.

Background

The existing dam for Robinson Lake is an earth embankment dam with a concrete spillway in the right abutment area discharging to the Harpeth River. The dam has a structural height of 22.5 feet and hydraulic height of 19 feet, with a storage capacity of 91 acre-feet at normal pool and 136 acre-feet at maximum pool. Currently, the dam is privately owned.

Note that the terms “right” and “left” used in this memorandum are the directions as viewed looking downstream from the dam.

Scope of Work

CDM Smith performed the following scope of work for the assessment.

- Contacted the Tennessee Department of Environment and Conservation, Division of Water Resources, Safe Dams Program to obtain information in their files and confirm the current regulatory status of the dam.
- Performed a site visit to observe the current conditions of the dam and appurtenant structures and identified potential dam safety deficiencies. Our scope did not include any geotechnical or structural investigations.
- Prepared this memorandum summarizing the results of the assessment. The memorandum includes a summary of the field observations and representative photos. It includes our opinion concerning potential dam safety deficiencies that may need to be addressed and

planning--level cost estimates investigating and addressing the potential deficiencies. Our scope did not include geotechnical, structural, or hydrologic analyses.

Safe Dams Program Information

CDM Smith contacted Lyle Bentley who is in charge of the Safe Dams Program. Mr. Bentley provided the information included in Appendix A. Mr. Bentley confirmed that the lake is currently classified as a farm pond and is not subject to the dam safety regulations. Per Mr. Bentley, if the City purchases the property and dam, the dam will be subject to the dam safety regulations.

Site Visit Observations

Steve Whiteside and Dave Mason of CDM Smith performed a preliminary visual inspection of Robinson Lake Dam on June 12, 2017. We were accompanied by Doug Noonan of the City and Jason Deal of Barge Waggoner Sumner & Cannon. At the time of the inspection, the reservoir level appeared to be at normal pool. The dam structural height, according to the National Inventory of Dams (NID) database, is 22.5 feet and there was approximately 5.5 feet of freeboard above normal pool.

A dam inspection checklist and representative photographs are included in Appendix B. An overall view of the lake is shown in Photo 1. The following sections summarize the results of the visual inspection.

Crest

The crest is approximately 12 feet wide. The left portion is covered with tall grass and weeds, and the right portion is mostly bare with tall grass and weeds along both sides of the crest (Photos 2 and 3). There is a bare, slightly eroded area on the may be due to a previous overtopping event (Photo 4).

Upstream Slope

The upstream slope is covered with trees, brush, and tall weeds (Photos 5 and 6). The left portion of the slope is partially covered with riprap and concrete fragments (Photo 7). The trees are up to 12 inches in diameter (Photo 8). The slope is very steep, ranging from1.5 horizontal to 1 vertical (1.5H:1V) to near vertical.

Downstream Slope and Downstream Area

The downstream slope and downstream area are covered with leaves, vines, brush, and trees up to 12 inches in diameter (Photos 9 through 11). The downstream slope is steep, typically about 1.5H:1V. Photo 12 shows the bare, eroded area that may be due to a previous overtopping event.

There is a vertical 36-inch-diameter RCP pipe located downstream of the dam (Photo 13). The pipe is 12 feet long and extends 8 feet below the ground surface. The bottom of the pipe has three feet of muck or sediment. No outlet pipes were observed.

There is significant seepage downstream of the RCP pipe (Photos 14 and 15). The seepage flows downstream and discharges at a drop-off to the Harpeth River. There appeared to be seepage emerging at the base of the drop-off, adjacent to the river.

Outlet Works

No outlet works or low-level outlet for draining the pond was observed.

Spillway

The spillway is located in the right abutment and consists of a trapezoidal concrete weir and discharge channel. The weir is about 46.5 wide with a 25-foot bottom width (Photo16). There is a partially intact fence along the upstream side of the weir that apparently serves as a trash guard (Photo 17). There are small trees and brush in the approach channel upstream of the fence.

The concrete discharge channel is heavily cracked and has brush growing in the channel bottom and sloped walls (Photos 18 and 19). The channel ends at limestone bedrock (Photo 20) where there is a 15-foot-high drop-off down to the river. Seepage was flowing through the limestone face (Photo 21). In addition, seepage was flowing from the river bank to the left of the limestone face (Photos 22 and 23). Total seepage flow was about 100 to 200 gpm. There was erosion in the seepage area, but the seepage flow appeared to be clear.

Summary of Dam Safety Deficiencies

The following are potential dam safety deficiencies CDM Smith identified during the preliminary visual inspection.

1. The slopes and downstream area are covered with large trees and heavy vegetation.

2. The upstream and downstream slopes are very steep.

3. The bare, eroded area on the crest and downstream slope may indicate previous overtopping of the dam during a flood event. If that is the case, the spillway capacity may be inadequate.

4. No outlet works or low-level outlet for draining the pond were observed.

5. Seepage was observed in the area downstream of the RCP riser pipe.

6. Seepage was observed through and adjacent to the limestone at the end of the spillway discharge channel.

7. There are trees and brush in the approach area to the spillway that will reduce spillway capacity. In addition, the fence along the upstream side of the weir can collect debris and reduce spillway capacity.

8. The concrete in the spillway discharge channel is badly cracked and has brush growing in the bottom and sides of the channel.

Recommendations

CDM Smith has the following recommendations to assess and mitigate the identified dam safety deficiencies. The recommended mitigation measures will require a permit from the Safe Dams Program and will need to be designed by a licensed professional engineer experienced in dam safety engineering.

1. Perform hydrologic/hydraulic analyses to evaluate the required spillway capacity for passing the design storm event without overtopping the dam.

2. Perform a geotechnical and geophysical investigation to evaluate the condition of the dam and foundation.

3. Perform geotechnical analyses, including seepage and stability analyses.

4. Based on the results of the analyses and the identified dam safety deficiencies, develop a rehabilitation design. We anticipate that the design may consist of the following:

    a. Removal of all trees, root balls, and other vegetation.

    b. Flattening the upstream and downstream slopes to 3H:1V. The downstream slope modification would include the installation of an internal drainage system to control seepage.

    c. Repairing or replacing the existing spillway. The spillway modification or replacement would include a drainage system to control seepage.

    d. Grouting bedrock in the spillway area to reduce seepage.

    e. Constructing a low-level outlet combined with a drop inlet spillway to serve as the principal spillway

Planning-Level Estimate of Rehabilitation Costs

CDM Smith has developed a planning-level cost estimate for rehabilitation measures described above. The planning level construction cost is estimated to be $1.5-$2.0 million, which is contingent upon the further exploration and limitations summarized below. On average, the City can also anticipate approximately 25-30% for design and permitting associated with the proposed rehabilitation measures.

Limitations

The conclusions and recommendations provided in this memorandum are based solely on the visual observations of the dam and appurtenant structures by the CDM Smith engineers at the time of the inspection. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team. It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

The planning-level cost estimates provided in this memorandum are based on the visual observations, engineering judgment, and similar projects. No warranty, express or implied, is included.

Appendix A

Tennessee Safe Dams Program Information

94-10 2

TENNESSEE DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES
2611 West End Avenue
Nashville, Tennessee 37203
Telephone (615) 741-2572

Dam # ______

INVENTORY DATA ON IMPOUNDMENT

Quad # 63-NE 8

Name of Dam: Robinson Lake ~~Thomas Robinson~~

Name of Owner: Dexter Lockwood [redacted] ~~William J. Wilson & Tommie Wilson~~

Address: P.O. Box 588 [redacted], Franklin, Tenn. 37064 Tel. 794-3216 (H) 794-8465 (B)

County: Williamson Stream: Trib., Harpeth River (9A)

Dam at Stream, Lat. 35° 53' ~~41~~ 32", Long. 86° 49' ~~35~~ 41"

Type of Dam: Earth Purposes: Recreation

Downstream Hazard Category, (D/S HAZ), ______

Type of Spillway: Concrete, Rock

Length of Crest 354 Ft., ~~Length~~ Width of Spillway 30 Ft.

Hydraulic Cap. of all Spillways ______ cfs ______ cfs-sm

Spillway Lip Elev. ______ Ft. (MSL), Pool Area ~~12~~ 11.5 Ac.

Volume in Dam ______ Cu. Yds., Drainage Area ~~490~~ 521 Ac.

Max. Vol. Pool ~~50 (1)~~ 136 Ac. Ft., ~~Min.~~ Normal Vol. Pool ~~40~~ 91 (1) Ac. Ft.

Structural Ht. Dam 22.5 Ft. Hydraulic Ht. Dam 19 Ft.

Engineered by: None

Construction by: McDowell & Company

Year Completed [redacted] 1950 (2), Plans, ____, At ______

Inspection by ______, Date ______

Certificate # ______, Issued on ______, Expires ______

Comments (1) Estimated by 0.4 factor

(2) Estimated

June 21, 1973

LB 3/23

Lyle Bentley

From: Lyle Bentley
Sent: Monday, March 23, 2015 8:08 AM
To: 'Clay Wallace'
Cc: Ernest Ekwugha; Erin O'Brien
Subject: RE: Robinson/Lockwood Lake #94-7010

Mr. Wallace-
We did discuss what you have said below. If the lake is fenced off and not open to the public, then it would still stay unregulated, assuming it is still privately owned. If Franklin owns it, it will be regulated, fenced or not, because it is publicly owned.
Lyle

Lyle Bentley, P. E.
Natural Resources Unit
Division of Water Resources
Office: (615) 532-0154
Email: Lyle.Bentley@tn.gov

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
Sign-up for the TDEC E-Newsletter.

From: Clay Wallace [mailto:Clay.Wallace@eli-llc.com]
Sent: Monday, March 23, 2015 7:38 AM
To: Lyle.Bentley@state.tn.us
Subject: Robinson/Lockwood Lake

***** This is an EXTERNAL email. Please exercise caution. DO NOT open attachments or click links from unknown senders or unexpected email. - OIR-Security*****

Mr. Bentley,
We spoke earlier this year about the status of Robinson Lake on the Lockwood property (east of I-65 and south of S Carothers Rd). This is part of the property that Khris Pascarella is purchasing for the Lockwood Glen subdivision. It will be separated from all of the houses by Carothers Parkway which is currently under construction. I just wanted to confirm that we discussed that as long as the lake is not open to public access that it will remain unregulated. Per our discussion, it was my understanding that the lake would only fall under regulation at such a time that it became part of a common open space that was accessible and usable by the subdivision or by the general public. Can you please confirm? I did have one question that I don't remember if we covered. If that area was to be converted to usable open space or a park or some sort, and the lake is fenced off, would it still remain unregulated?
Thank you!

Clay Wallace, PE
Senior Project Engineer
Energy Land & Infrastructure, LLC (PLLC in NC)

1420 Donelson Pike, Suite A-12

Nashville, TN 37217
(615) 383-6300 Office
(615) 971-5284 Cell
clay.wallace@eli-llc.com
www.eli-llc.com

Lyle Bentley

From:	Lyle Bentley LB
Sent:	Thursday, December 11, 2014 11:34 AM
To:	Ernest Ekwugha
Cc:	Erin O'Brien
Subject:	Robertson Dam, I. D. No. 94-7010

Ernest-

I contacted Kaye Lockwood, owner of Robertson Dam in Williamson County. The lake is still a farm pond. The construction taking place nearby is due to Franklin extending Carothers Road southward.

Ms. Lockwood is selling the property incrementally to Pearl Street Partners, who will apparently develop it. She thought the lake was eventually going to be given to Franklin to be part of a greenway or something similar. The next property purchase will occur in January, 2015, and the final in January, 2016. She did not know which sale would include the lake.

I also talked to Paul Holzen, the Franklin engineering director, and told him that the dam would become regulated once the property started getting developed. He is now aware that the city would have to bring the dam into compliance if it is not in compliance when transferred to the city.

I left several messages for Kris Pascarella of Pearl Street Partners to call me, but he hasn't, yet. In the last one I told him that the dam would be regulated once the property started getting developed and would have to comply with our regulations.

I am going to flag the dam for follow-up in February, 2015, and February, 2016. Please check on it when it shows up to see if it has been sold and what's going to happen with it. Please print this out for your file.

Kaye Lockwood Cell: (615) 948-7386 Bus: (615) 794-8465

Kris Pascarella
Pearl Street Partners, LLC
205 Powell Place
Brentwood, TN 37027-7525
Bus: (615) 312-8242
Cell: (615) 604-3714

Lyle

Lyle Bentley, P. E.
Natural Resources Unit
Division of Water Resources
Office: (615) 532-0154
Email: Lyle.Bentley@tn.gov

TDEC
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
Sign-up for the TDEC E-Newsletter.

LB 12/11
rec: NFO 12/11

```
1***************************************                                                              ***************************************
 *                                      *                                                             *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                             *  U.S. ARMY CORPS OF ENGINEERS       *
 *             JUN   1998               *                                                             *  HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.1               *                                                             *        609 SECOND STREET            *
 *                                      *                                                             *     DAVIS, CALIFORNIA 95616         *
 * RUN DATE   11DEC14  TIME  11:54:44   *                                                             *        (916) 756-1104               *
 *                                      *                                                             *                                     *
 ***************************************                                                              ***************************************


                                               X     X  XXXXXXX   XXXXX          X
                                               X     X  X        X     X        XX
                                               X     X  X        X               X
                                               XXXXXXX  XXXX     X         XXXXX X
                                               X     X  X        X               X
                                               X     X  X        X     X         X
                                               X     X  XXXXXXX   XXXXX         XXX


              THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

              THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
              THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
              NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
              DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
              KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                                  HEC-1 INPUT                                                  PAGE  1

          LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

            1            ID   ROBERTSON DAM, WILLIAMSON COUNTY, I.D. NO. 94-7010
            2            ID   DATA FROM GIS AND CURRENT FILE DATA.
            3            IT       5 11DEC14       0     109
            4            IO       3       0       0
            5            JR    PREC    0.18    0.33

            6            KK  INFLOW
            7            BA    .814       0
            8            PB    29.4
            9            IN      15 11DEC14       0
           10            PC     0.0    0.02    0.04    0.06    0.08    0.11    0.14    0.18    0.23     0.4
           11            PC    0.58    0.65     0.7    0.74    0.77     0.8    0.83    0.86    0.88     0.9
           12            PC    0.92    0.94    0.96    0.98     1.0
           13            LS       0      85       0
           14            UD     .46

           15            KK  OUTFLOW
           16            RS       1    ELEV     650       0
           17            SV      87     133
           18            SE     650   653.5
           19            SQ       0      90     254     468     589
           20            SE     650     651     652     653   653.5
           21            ST   653.5     354     2.8     1.5
           22            ZZ
1***************************************                                                              ***************************************
 *                                      *                                                             *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                                             *  U.S. ARMY CORPS OF ENGINEERS       *
 *             JUN   1998               *                                                             *  HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.1               *                                                             *        609 SECOND STREET            *
 *                                      *                                                             *     DAVIS, CALIFORNIA 95616         *
 * RUN DATE   11DEC14  TIME  11:54:44   *                                                             *        (916) 756-1104               *
 *                                      *                                                             *                                     *
 ***************************************                                                              ***************************************


                             ROBERTSON DAM, WILLIAMSON COUNTY, I.D. NO. 94-7010
                             DATA FROM GIS AND CURRENT FILE DATA.

    4 IO         OUTPUT CONTROL VARIABLES
                      IPRNT          3  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

      IT         HYDROGRAPH TIME DATA
                       NMIN          5  MINUTES IN COMPUTATION INTERVAL
                      IDATE    11DEC14  STARTING DATE
                      ITIME       0000  STARTING TIME
                         NQ        109  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE    11DEC14  ENDING DATE
                     NDTIME       0900  ENDING TIME
                      ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .08 HOURS
```

```
                         TOTAL TIME BASE    9.00 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT

     JP          MULTI-PLAN OPTION
                       NPLAN             1  NUMBER OF PLANS

     JR          MULTI-RATIO OPTION
                     RATIOS OF PRECIPITATION
                      .18       .33

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
    6 KK    *   INFLOW   *
            *            *
            **************

    9 IN         TIME DATA FOR INPUT TIME SERIES
                       JXMIN          15  TIME INTERVAL IN MINUTES
                       JXDATE    11DEC14  STARTING DATE
                       JXTIME          0  STARTING TIME

               SUBBASIN RUNOFF DATA

    7 BA         SUBBASIN CHARACTERISTICS
                       TAREA         .81  SUBBASIN AREA

                 PRECIPITATION DATA

    8 PB               STORM       29.40  BASIN TOTAL PRECIPITATION

   10 PI           INCREMENTAL PRECIPITATION PATTERN
                        .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                        .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                        .01       .02       .02       .02       .06       .06       .06       .06       .06       .06
                        .02       .02       .02       .02       .02       .02       .01       .01       .01       .01
                        .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                        .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                        .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                        .01       .01

   13 LS         SCS LOSS RATE
                      STRTL          .35  INITIAL ABSTRACTION
                      CRVNBR       85.00  CURVE NUMBER
                      RTIMP          .00  PERCENT IMPERVIOUS AREA

   14 UD         SCS DIMENSIONLESS UNITGRAPH
                      TLAG           .46  LAG

                                                             ***

                                                      UNIT HYDROGRAPH
                                                  30 END-OF-PERIOD ORDINATES
              60.      179.      367.      599.      744.      784.      747.      656.      537.      391.
             293.      222.      174.      133.      101.       77.       58.       44.       34.       26.
              20.       15.       11.        9.        7.        6.        4.        3.        1.        0.

     TOTAL RAINFALL =    29.40, TOTAL LOSS =    2.02, TOTAL EXCESS =   27.38

  PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                       6-HR         24-HR        72-HR       9.00-HR
+   (CFS)        (HR)
                               (CFS)
+    7897.       2.75                  2374.        1598.        1598.        1598.
                            (INCHES)   27.120       27.383       27.383       27.383
                             (AC-FT)    1177.        1189.        1189.        1189.

                            CUMULATIVE AREA =      .81 SQ MI

      ***            ***            ***            ***            ***

                            HYDROGRAPH AT STATION    INFLOW
                              FOR PLAN 1, RATIO =  .18

     TOTAL RAINFALL =     5.29, TOTAL LOSS =    1.65, TOTAL EXCESS =    3.64

  PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                       6-HR         24-HR        72-HR       9.00-HR
+   (CFS)        (HR)
                               (CFS)
+    1068.       2.83                   318.         212.         212.         212.
```

		6-HR	24-HR	72-HR	9.00-HR
	(INCHES)	3.632	3.639	3.639	3.639
	(AC-FT)	158.	158.	158.	158.

CUMULATIVE AREA = .81 SQ MI

*** *** *** *** ***

HYDROGRAPH AT STATION INFLOW
FOR PLAN 1, RATIO = .33

TOTAL RAINFALL = 9.70, TOTAL LOSS = 1.84, TOTAL EXCESS = 7.86

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	9.00-HR
+ 2322.	2.83	(CFS)	686.	459.	459.	459.
		(INCHES)	7.832	7.865	7.865	7.865
		(AC-FT)	340.	341.	341.	341.

CUMULATIVE AREA = .81 SQ MI

*** ***

```
              **************
              *            *
   15 KK      *   OUTFLO   *     W
              *            *
              **************
```

HYDROGRAPH ROUTING DATA

```
 16 RS          STORAGE ROUTING
                     NSTPS            1  NUMBER OF SUBREACHES
                      ITYP         ELEV  TYPE OF INITIAL CONDITION
                    RSVRIC       650.00  INITIAL CONDITION
                         X          .00  WORKING R AND D COEFFICIENT

 17 SV            STORAGE        87.0      133.0

 18 SE          ELEVATION      650.00     653.50

 19 SQ          DISCHARGE          0.        90.       254.       468.       589.

 20 SE          ELEVATION      650.00     651.00     652.00     653.00     653.50

 21 ST          TOP OF DAM
                     TOPEL       653.50  ELEVATION AT TOP OF DAM
                    DAMWID       354.00  DAM WIDTH
                      COQD         2.80  WEIR COEFFICIENT
                      EXPD         1.50  EXPONENT OF HEAD
```

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

(INCLUDING FLOW OVER DAM)

STORAGE	87.00	100.14	113.29	126.43	133.00
OUTFLOW	.00	90.00	254.00	468.00	589.00
ELEVATION	650.00	651.00	652.00	653.00	653.50

*** *** *** *** ***

HYDROGRAPH AT STATION OUTFLO
FOR PLAN 1, RATIO = .18

PEAK OUTFLOW IS 666. AT TIME 3.33 HOURS

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	9.00-HR
+ 666.	3.33	(CFS)	299.	205.	205.	205.
		(INCHES)	3.413	3.505	3.505	3.505
		(AC-FT)	148.	152.	152.	152.

PEAK STORAGE (AC-FT)	TIME (HR)	MAXIMUM AVERAGE STORAGE 6-HR	24-HR	72-HR	9.00-HR
135.	3.33	115.	106.	106.	106.

PEAK STAGE (FEET)	TIME (HR)	MAXIMUM AVERAGE STAGE 6-HR	24-HR	72-HR	9.00-HR
653.63	3.33	652.10	651.46	651.46	651.46

CUMULATIVE AREA = .81 SQ MI

```
      ***              ***              ***              ***              ***

                                HYDROGRAPH AT STATION    OUTFLO
                                  FOR PLAN 1, RATIO =  .33

 PEAK OUTFLOW IS      2229. AT TIME   2.92 HOURS

  PEAK FLOW      TIME                                MAXIMUM AVERAGE FLOW
                                          6-HR         24-HR        72-HR        9.00-HR
+    (CFS)       (HR)
                              (CFS)
+     2229.      2.92                     656.          449.         449.          449.
                            (INCHES)     7.492         7.686        7.686         7.686
                            (AC-FT)       325.          334.         334.          334.

 PEAK STORAGE    TIME                              MAXIMUM AVERAGE STORAGE
                                          6-HR         24-HR        72-HR        9.00-HR
+   (AC-FT)      (HR)
      149.       2.92                     126.          115.         115.          115.

  PEAK STAGE     TIME                                MAXIMUM AVERAGE STAGE
                                          6-HR         24-HR        72-HR        9.00-HR
+    (FEET)      (HR)
    654.72       2.92                   652.97        652.11       652.11        652.11

                             CUMULATIVE AREA =      .81 SQ MI

1

              PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                 FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS


                                                              RATIOS APPLIED TO PRECIPITATION
 OPERATION         STATION      AREA    PLAN             RATIO 1  RATIO 2
                                                             .18      .33

 HYDROGRAPH AT
+                   INFLOW       .81      1    FLOW       1068.    2322.
                                               TIME        2.83     2.83

 ROUTED TO
+                   OUTFLO       .81      1    FLOW        666.    2229.
                                               TIME        3.33     2.92

                                          ** PEAK STAGES IN FEET **
                                          1    STAGE     653.63   654.72
                                               TIME        3.33     2.92
1                                     SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION   OUTFLO
                                (PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED  DURING BREACH FORMATION)


      PLAN  1 ...............                   INITIAL VALUE     SPILLWAY CREST     TOP OF DAM
                                  ELEVATION         650.00            653.50           653.50
                                  STORAGE              87.              133.             133.
                                  OUTFLOW               0.              589.             589.

                      RATIO     MAXIMUM      MAXIMUM    MAXIMUM     MAXIMUM    DURATION     TIME OF      TIME OF
                        OF     RESERVOIR      DEPTH     STORAGE     OUTFLOW    OVER TOP   MAX OUTFLOW    FAILURE
                       PMF      W.S.ELEV    OVER DAM     AC-FT        CFS        HOURS       HOURS        HOURS

                       .18       653.63        .13        135.        666.        .50        3.33          .00
                       .33       654.72       1.22        149.       2229.       2.25        2.92          .00


 *** NORMAL END OF HEC-1 ***
```

~ 1/3 C soils
~ 2/3 B soils
Assume 1/8 ac. lots after devel. is thru
$\frac{2}{3}(85) + \frac{1}{3}(90) = 87$
Not all is developed - use 85
Watershed area: 521 ac.
NPA: 11.5 ac.
Ass. TOD area = 14.5 ac.
NP Vol: 19(11.5)(.4) = 87 ac.
TOD ": 87 + 3.5(13) = 133 ac.
5.4, 5.5, 4.5, 2.6, 4.8, 7.3, 8.4, 10.9 ave: 6.2
$\ell = 6160$

$$L = \frac{(6160)^{.8}\left(\frac{1000}{85} - 9\right)^{.7}}{1900\,(6.2)^{.5}} = .46\text{ hr.}$$

Est. [redacted] NP @ 650, PS: BW = 30, Z = 0

Elev.	H	C	Q
650	0	3	0
651	1	3	90
652	2	3	254
653	3	3	468
653.5	3.5	3	589

Lyle Bentley

LB 7/31
MS 8/01

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

OFFICE CORRESPONDENCE

TRIP REPORT

MEMO TO FILE

DAM NAME: Robinson Lake Dam I.D. No. 94 – 7010

COUNTY: Williamson INSPECTION DATE: July 13, 2012

PURPOSE OF VISIT: FARM POND REVIEW

INSPECTOR'S NAME: Ernest Ekwugha

OTHERS PRESENT:

WEATHER CONDITIONS: Sunny, 90 °

PHOTOS TAKEN: Yes NO X

CHANGE IN HAZARD CATEGORY: NO

FINDINGS: On July 13, 2012, I visited the above referenced dam to determine whether it still qualifies as a farm pond. I noticed that the dam is secured and the public had no access to the lake. There were no changes to the downstream of the dam.

I called Mrs. Dexter Lockwood, the owner of the property to confirm the ownership and usage. A family member answered the phone. She indicated that the farm pond verification will be handled by the owner's daughter.

Based on this trip report, I recommend that the dam remain classified as a significant hazard farm pond. Mrs. Lockwood's address and telephone number had not changed. The next scheduled farm pond review for the above dam will be conducted in July 2017.

Please de-list from upcoming activities report.

Mrs. Dexter Lockwood
4351 South Carothers Road
Franklin, TN 37064

Home Tel. (615) 794 – 3216

Inspector's signature / Date : [signature] July 30, 2012

cc: Central Office

20170715

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

SJS 7/26
EJW - 7/27
LB 10/12
MS 10/12

OFFICE CORRESPONDENCE

TN DEPT OF ENVIRONMENT AND CONSERVATION

2007 OCT 12 P 3:46

TRIP REPORT

DIVISION OF WATER SUPPLY

MEMO TO FILE

DAM NAME:	Robinson Lake Dam	I.D. No.	94 – 7010
COUNTY:	Williamson	INSPECTION DATE:	July 2, 2007
PURPOSE OF VISIT:	FARM POND REVIEW		
INSPECTOR'S NAME:	Ernest Ekwugha		
OTHERS PRESENT:			
WEATHER CONDITIONS:	Sunny, 86 °		
PHOTOS TAKEN:	Yes	NO	X

CHANGE IN HAZARD CATEGORY: NO

FINDINGS: On July 2, 2007, the above referenced dam was visited to determine whether or not it still qualifies as a farm pond. I observed that the impoundment is on private property and there were no developments downstream.

On July 3, 2007, I called Mrs. Dexter Lockwood, the owner of the property to confirm the ownership and usage. She said the impoundment is located on her property, that it is secured and not open to the general public.

Based on this trip report, I recommend that the dam remain classified as a significant hazard farm pond. Mrs. Lockwood's address and telephone number had not changed. The next scheduled farm pond review for the above dam will be conducted in July 2012.

Please de-list from upcoming activities report.

Mrs. Dexter Lockwood
4351 South Carothers Road
Franklin, TN 37064

Home Tel. (615) 794 – 3216

Inspector's signature / Date : Ernest Ekwugha July 26, 2007

cc: Central Office

20120715

LB 5/28
MS 5/29
EE 5/30

DIVISION OF WATER SUPPLY
SAFE DAMS SECTION

TRIP REPORT

DAM NAME Robinson Lake Dam I.D. NO. 94-7010

COUNTY Williamson INSPECTION DATE 5/6/02

PURPOSE OF VISIT Farm Pond Review

INSPECTOR'S NAME Ghufran Barzani

OTHERS PRESENT None.

WEATHER CONDITIONS Cloudy, 65°

PHOTOS TAKEN YES ______ NO X

CHANGE IN HAZARD CATEGORY No

FINDINGS: On May 6, 2002, the above referenced dam was visited for the purpose of evaluating its "farm pond" status. I found nothing changed either on the property or in the downstream area. The property was still fenced and posted with "No-Trespassing" and "No-Fishing" signs. The access road was closed off by a gate.

On the same date, I contacted the owner, Ms. Dexter Lockwood. Her secretary told me that she still owns the property that surrounds Robinson Lake and the lake was used only for livestock purpose and that she did not allow anyone to use it otherwise.

The next scheduled "farm pond" review for the above referenced dam will be conducted in July 2007.

I recommend that the lake be classified as a farm pond and the hazard category remain as high. A "farm pond" letter should be sent to this mailing address:

Ms. Dexter Lockwood
P.O. Box 588
Franklin, TN 37064
(615) 794-3216 (home)
(615) 794-8465 (work)

Ghufran Barzani 5/8/2002

INSPECTOR'S SIGNATURE/DATE

'KB 9/12

LB 9/13
JSM 9/13
EE 9/17

DIVISION OF WATER SUPPLY
SAFE DAMS SECTION

TRIP REPORT

DAM NAME Robinson Lake I.D. NO. 94-7010

COUNTY Williamson INSPECTION DATE 9/6/96

PURPOSE OF VISIT Farm Pond Review

INSPECTOR'S NAME Ghufran Barzani

OTHERS PRESENT Gary Horne

WEATHER CONDITIONS Sunny, 71°

PHOTOS TAKEN YES ____ NO X

CHANGE IN HAZARD CATEGORY No

FINDINGS: On September 6, 1996, Gary Horne and I visited the above referenced dam in order to perform a "farm pond" review.

When we arrived at the property, the entrance access road was unlocked. The property was posted with "No Trespassing and Private Property signs.

I spoke with Mr. Dexter Lockwood's daughter, who stated that her father was deceased, but her Mother still owns the property. According to her, the lake is not open to the general public.

Based upon this inspection, the dam should remain classified as a low hazard "farm pond".

I recommend that the dam be flagged again in September, 2001. A "farm pond" letter should be sent to:

Mrs. Dexter Lockwood
P.O. Box 588
Franklin, TN 37064
(615) 794-3216 home
(615) 8465 work

INSPECTOR'S SIGNATURE/DATE Ghufran Barzani 9/9/96

LB 9/17
SM 9/20
EE 9/23

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER SUPPLY
6th FLOOR, L & C TOWER
401 CHURCH STREET
NASHVILLE, TN 37243-1549

September 13, 1996

Mrs. Dexter Lockwood
P.O. Box 588
Franklin, TN 37064

RE: Robinson Lake Dam; Williamson County
I.D. No. 94-7010

Dear Mrs. Lockwood:

Your dam has been classified as a "farm pond" as defined in the Rules and Regulations. This office does not intend to regulate your dam based on this definition. A "farm pond" means any impoundment used only for providing water for agricultural and domestic purposes such as livestock and poultry watering, irrigation of crops, recreation, and conservation, for the owner or occupant of the farm, his family, and invited guests, but does not include any impoundment for which the water, or privileges or products of the water, are available to the general public.

General public as used above includes patrons, members, and customers of institutions and/or clubs such as but not limited to summer camps, schools, retirement facilities, churches, private clubs, communes, hunting clubs, and health care facilities. The following are examples of impoundments that are not "farm ponds":

State owned recreational lakes, residential subdivision lakes, industrial waste impoundments, industrial water supply impoundments, hunting clubs, public water supply impoundments, commercial land developments, state owned or operated conservation impoundments, and watershed district impoundments.

Farm as used above means a tract of land that is or may be used for cultivation of crops and or raising livestock. A farm pond is not subject to the requirements of the Safe Dams Act; however, at any time in the future that your

PH-2380

TO	DATE
PLB	9/10
cc: NFO	9/19
FILE	

TELEPHONE/MEETING RECORD

DATE: 9-9-91

TO: FILE

FROM: JOHN MCCLURKAN

SUBJECT: ROBINSON LK Dam 94-7010
Williamson County

On 9-6-91, the above site was visited, and it ~~appeared~~ appeared to still be a farmpond.

On 9-9-91, a call was made to Mr. Dexter Lockwood. His secretary told me that he still owns the property that surrounds Robinson Lake.

I recommend that this dam remain as classified.

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT
Bureau of Environment
T.E.R.R.A. BUILDING
150 NINTH AVENUE NORTH
NASHVILLE, TENNESSEE 37219-5404

September 22, 1986

Dexter Lockwood
P.O. Box 588
Franklin, TN 37064

Re: Robinson Lake, Williamson Co.
I.D. No. 94-7010

Dear Mr. Lockwood:

Your dam has been classified as a "farm pond" as defined in the Proposed Rules and Regulations. Although these Rules and Regulations have not yet been promulgated, this office does not intend to regulate your dam based on this definition. A "farm pond" means any impoundment used only for providing water for agricultural and domestic purposes for the owner or occupant of the farm, his family, and invited guest, such as livestock and poultry watering, irrigation of crops, recreation, and conservation, but does not include any impoundment for which the water, or privileges or products of the water, are available to the general public.

General public as used above includes patrons, members, and customers of institutions and/or clubs such as but not limited to summer camps, schools, retirement facilities, churches, private clubs, communes, hunting clubs, and health care facilities. The following are examples of impoundments which are not "farm ponds".

State owned recreational lakes, residential subdivision lakes, industrial waste impoundments, industrial water supply impoundments, hunting clubs, public water supply impoundments, commercial land developments, state owned or operated conservation impoundments, and watershed district impoundments.

Farm as used above means a tract of land which is or may be used for cultivation of crops and/or raising livestock.

A farm pond is not subject to the requirements of the Safe Dams Act; however, at any time in the future that your facility becomes used by the general public or is developed into one of the other regulated types of impoundments, you must comply with the Act. At this time you are required to notify this office.

As the owner of a dam you are legally liable for any damages resulting from the failure of this dam. Enclosed is a manual you should read that will help you evaluate your dam for any potential problems. We recommend that any problems encountered be investigated by a professional engineer.

I.D. NO. 94-7010

JDR 9-19
JCG 9/19
cc NBO

Date 9/18/86 Basin NBO

INSPECTION REPORT

Name of Dam: Robinson Lake County: Williamson

Owner's Name: ~~William + Tommy Wilson~~ Dexter Lockwood Quad: 63-NE

Type Project:

Existing ✓
New Construction ____
Repair/Alteration ____
Removal ____

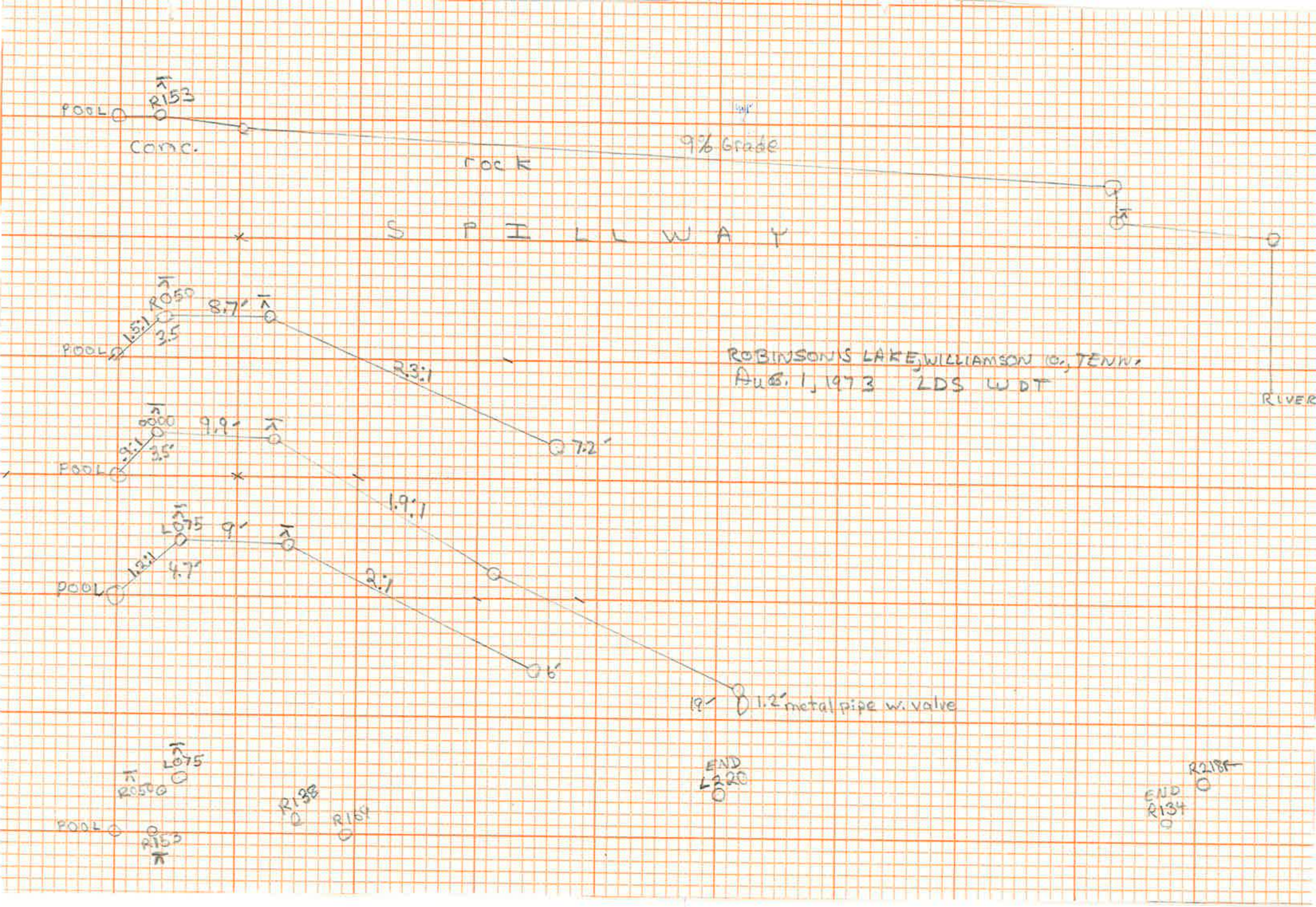
Type Inspection: Cursory

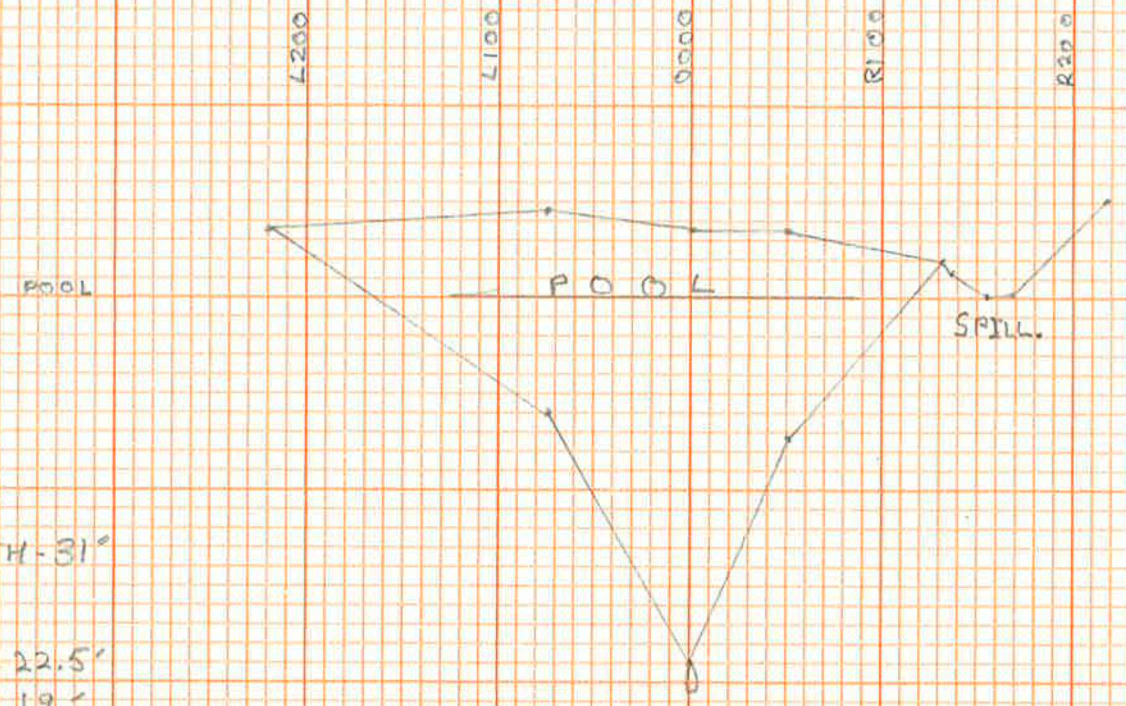
Damage Potential Category: One ___ Two ✓ Three ___ Undetermined ___

Inspection by: L. Bentley

Inspection Results:

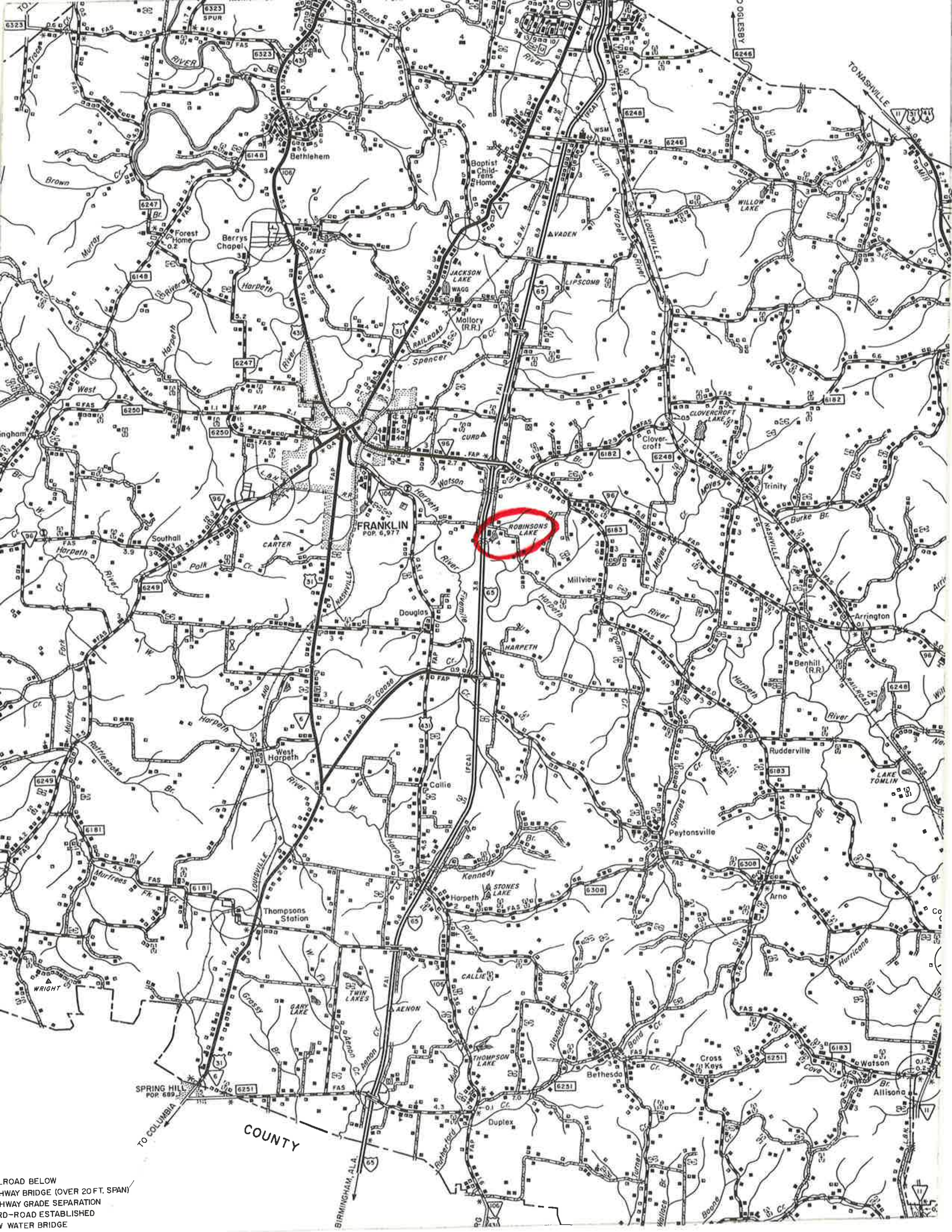
I went to this lake on 9/17/86. It was fenced + posted + was ~~used~~ surrounded by pasture. I recommend that it be classified as a farm pond.


POOL
R153
Conc.
rock
9% Grade
SPILLWAY
RIVER
R050
1.5:1
3.5
8.7'
2.3:1
7.2'
ROBINSON'S LAKE, WILLIAMSON Co., TENN.
Aug. 1, 1973 LDS WDT
0000
9:1
3.5'
9.9'
1.9:1
L075
1.2:1
4.7'
9'
2:1
6'
19'
1.2' metal pipe w. valve
R138
R164
END
L220
END
R134
R218

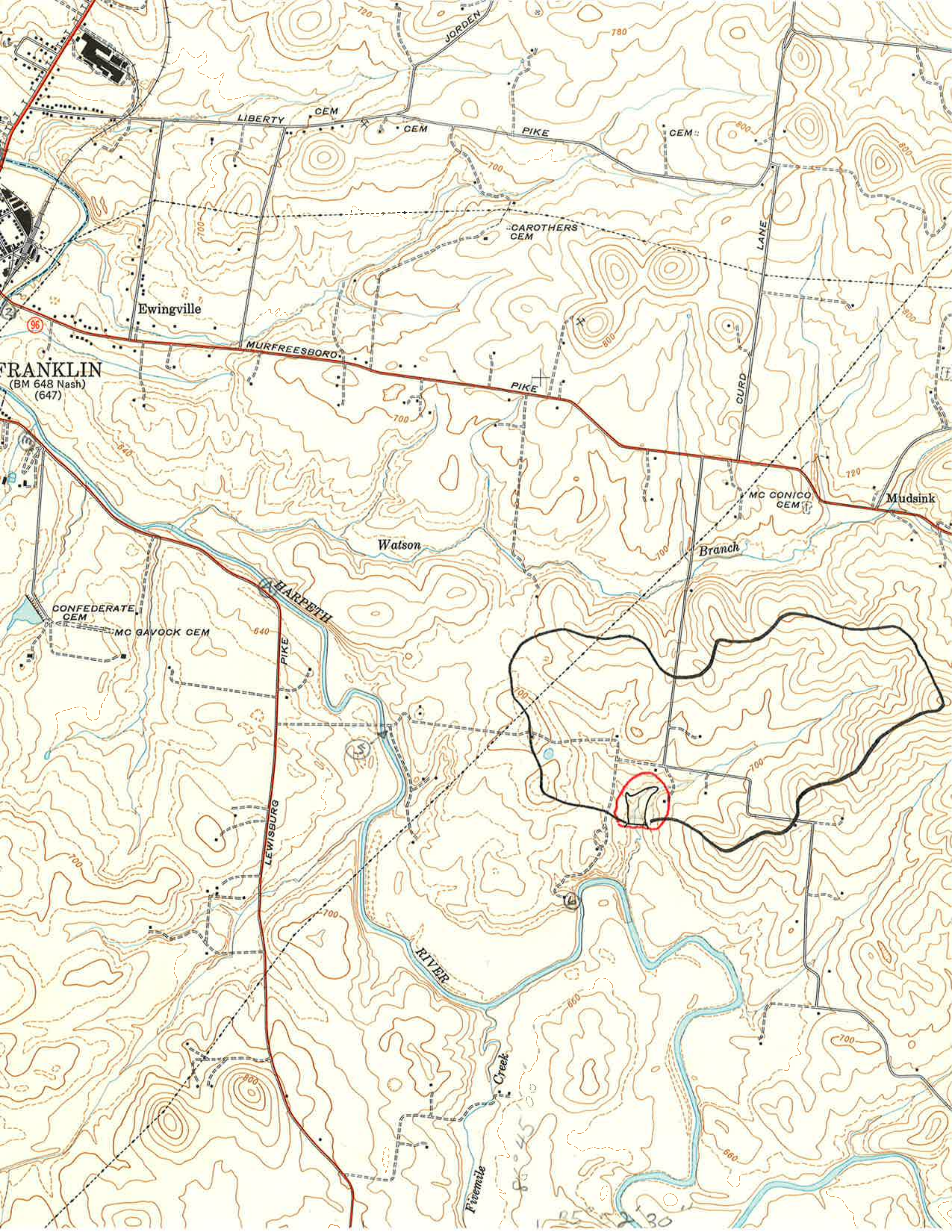


CREST: LENGTH - 354'
WIDTH - 9'
SPILLWAY: WIDTH - 31'
Conc., rock
HEIGHT: STRUCTURAL - 22.5'
HYDRAULIC - 19'

ROBINSON'S LAKE, WILLIAMSON CO., TENN.
Aug. 1, 1973   LDS, WDT



SPUR
RIVER
Bethlehem
Brown
Murray
Forest Home
Berrys Chapel
Harpeth
SIMS
Baptist Childrens Home
JACKSON LAKE
WAGG
Mallory (R.R.)
RAILROAD
Spencer
VADEN
LIPSCOMB
Little Harpeth River
LOUISVILLE
WILLOW LAKE
Owl Cr.
TO NASHVILLE
OGLESBY
WSM
West
CURD
Watson
FRANKLIN
POP. 6,977
CARTER
Southall
Polk Cr.
ROBINSONS LAKE
Millview
Clover-croft
CLOVERCROFT LAKE
Trinity
Burke Br.
Mayes Cr.
NASHVILLE
Arrington
Douglas
Fivemile
HARPETH
Tom Cr.
Benhill (R.R.)
Goose
Rattlesnake
Murfrees
West Harpeth
Callie
Rudderville
LAKE TOMLIN
Peytonsville
Stones Cr.
McClorys Br.
Kennedy
STONES LAKE
Harpeth
Arno
Thompsons Station
WRIGHT
CALLIE
TWIN LAKES
GARY LAKE
AENON
Aenon Cr.
Grassy Br.
THOMPSON LAKE
Alexander Br.
Bethesda
Bond Cr.
Cross Keys
Watson
Cove
Allisona
Hurricane
SPRING HILL
POP. 689
TO COLUMBIA
COUNTY
Duplex
Rutherford
BIRMINGHAM, ALA.
Turner
Wallace Br.
Boone
LROAD BELOW
HWAY BRIDGE (OVER 20 FT. SPAN)
HWAY GRADE SEPARATION
RD-ROAD ESTABLISHED
WATER BRIDGE


JORDEN
720
780
LIBERTY
CEM
CEM
PIKE
CEM
800
700
CAROTHERS
CEM
LANE
Ewingville
MURFREESBORO
PIKE
96
FRANKLIN
(BM 648 Nash)
(647)
CURD
640
MC CONICO
CEM
Mudsink
Watson
Branch
HARPETH
CONFEDERATE
CEM
MC GAVOCK CEM
PIKE
LEWISBURG
RIVER
Creek
Fivemile Creek
660

Substation
Water
Royal Oaks
Carothers Cem
BM W 222 767
PRIVATE
Curd 882
Water
BM Y 222 636
MURFREESBORO
BM X 222 708
ROAD
INTERCHANGE 65
Royal Heights Ch
CURD
LANE
Boyd
Mudsink
McConnico Cem
Pumping Station
Watson
Branch
RIVER
FRANKLIN RESERVOIR
CORP BDY
BOUNDARY
BM Z 222 673
ROBINSON
Robinson Lake
LEWISBURG
Creek
Donelson Cem
Redwing Farms
CAROTHERS
Guthrie Cem
Creek
BM X 223 656
PIKE
ROAD
Estates
Ellington Park
Fivemile
LANG LAKE

Appendix B

Field Checklist and Photographs

DAM INSPECTION CHECKLIST

NAME OF DAM: Robinson Lake Dam **DAM NO.:** 94-7010

LOCATION: **Municipality:** Franklin, TN **County:** Williamson

CLASSIFICATION DATA: **Size:** Small **Hazard:** Significant

PHYSICAL DATA:
Type of Dam: Embankment **Height of Dam:** 22.5 ft **Normal Pool Storage Capacity:** 91 ac-ft

ELEVATIONS:
Normal Pool: **Pool at Inspection:** Normal **Tailwater at Inspection:**

DAM OWNER: Kaye Lockwood **OPERATOR:** ____________________________

ADDRESS: P. O. Box 588 Franklin, TN 37064

PHONE: (615) 948-7386 **FAX NO.:** (___)-___-____ **E-MAIL ADDRESS:** ____________________________

PERSONS PRESENT AT INSPECTION:

Name	Title/Position	Representing
Steve Whiteside	Vice President	CDM Smith
David Mason	Associate	CDM Smith
Doug Noonan	Water Quality Specialist	City of Franklin
Jason Deal	Technical Manager	Barge Waggoner Sumner & Cannon

DATE OF INSPECTION: 6/12/17

WEATHER: Sunny

TEMPERATURE: 85-90 degrees

____ ____________

NAME OF DAM: Robinson Lake Dam	DAM NO.: 94-7010	DATE: 6/12/17

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
EMBANKMENT: CREST					
1	Surface Cracking	None observed.	☐	☐	☐
2	Sinkhole, Animal Burrow	None observed.	☐	☐	☐
3	Low Area(s)	Low area near middle of crest. Possible overtopping location.	☐	☒	☐
4	Horizontal Alignment	Satisfactory.	☐	☐	☐
5	Ruts and/or Puddles	None observed	☐	☐	☐
6	Vegetation Condition	Tall grass and weeds on both sides of crest.	☐	☐	☐
7	Warning Signs	Possible overtopping location observed.	☐	☒	☐
8			☐	☐	☐
9			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Crest length = 375 feet
Crest width = 12 feet
Freeboard = 5.5 feet

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
EMBANKMENT: UPSTREAM SLOPE					
10	Slide, Slough, Scarp	View obscured by heavy vegetation.	☐	☐	☐
11	Slope Protection	Riprap on portions of the slope.	☐	☐	☐
12	Sinkhole, Animal Burrow	View obscured by heavy vegetation.	☐	☐	☐
13	Emb.-Abut. Contact	Satisfactory.	☐	☐	☐
14	Erosion	Eroded areas around tree roots.	☐	☐	☒
15	Vegetation Condition	Trees up to 12-inch diameter. Tall weeds, brush, and grass.	☐	☐	☒
16			☐	☐	☐
17			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Slope ranges from 1.5H:1V to near vertical.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
EMBANKMENT: DOWNSTREAM SLOPE					
18	Wet Area(s) (No Flow)	None observed.	☐	☐	☐
19	Seepage	None observed.	☐	☐	☐
20	Slide, Slough, Scarp	None observed.	☐	☐	☐
21	Emb. - Abut. Contact	Satisfactory.	☐	☐	☐
22	Sinkhole, Animal Burrow	None observed.	☐	☐	☐
23	Erosion	Some bare areas. Possible overtopping area.	☐	☒	☐
24	Unusual Movement	None observed.	☐	☐	☐
25	Vegetation Control	Trees up to 12-inch diameter, mostly 2-6 inch diameter.	☐	☐	☐
26		Leaves, vines, and brush.	☐	☐	☐
27			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Slope is typically 1.5H:1V.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
EMBANKMENT: INSTRUMENTATION					
28	Piezometers/Observ. Wells		☐	☐	☐
29	Staff Gauge and Recorder		☐	☐	☐
30	Weirs		☐	☐	☐
31	Survey Monuments		☐	☐	☐
32	Drains		☐	☐	☐
33	Low Flow Release		☐	☐	☐
34	Frequency of Readings		☐	☐	☐
35	Location of Records		☐	☐	☐
36			☐	☐	☐
37			☐	☐	☐

Additional Comments (Refer to item number if applicable):

No instrumentation observed.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
DOWNSTREAM AREA					
38	Abutment Leakage	Seepage to left of spillway at Harpeth River.	☐	☒	☐
39	Foundation Seepage	Seepage downstream of RCP standpipe.	☐	☒	☐
40	Slide, Slough, Scarp	Erosion at river in seepage areas.	☐	☒	☐
41	Drainage System	None observed.	☐	☐	☐
42	Boils	None observed.	☐	☐	☐
43	Wet Areas	Wet areas adjacent to seepage areas.	☐	☒	☐
44	Reservoir Slopes	Covered with vegetation.	☐	☐	☐
45	Access Roads	Unpaved access road.	☐	☐	☐
46	Security Devices	Locked gate.	☐	☐	☐
47			☐	☐	☐
48			☐	☐	☐
49			☐	☐	☐

Additional Comments (Refer to item number if applicable):

SPILLWAYS: ERODIBLE CHANNEL

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
50	Slide, Slough, Scarp		☐	☐	☐
51	Erosion		☐	☐	☐
52	Vegetation Condition		☐	☐	☐
53	Debris		☐	☐	☐
54			☐	☐	☐
55			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Not Applicable.

NAME OF DAM: Robinson Lake Dam	DAM NO.: 94-7010	DATE: 6/12/17

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
SPILLWAYS: NON-ERODIBLE CHANNEL					
56	Sidewalls	Sloped concrete side walls are cracked and have brush on them.	☐	☒	☐
57	Channel Floor	Concrete floor is heavily cracked.	☐	☒	☐
58	Unusual Movement	Cracked concrete floor and walls have displaced in some areas.	☐	☒	☐
59	Approach Area	Small trees and heavy brush. 2-foot-high fence at weir.	☐	☐	☒
60	Weir or Control	Trapezoidal concrete weir with 2-foot-high fence trash guard.	☒	☐	☐
61	Discharge Channel	Concrete channel is heavily cracked.	☐	☒	☐
62	Boils	None observed.	☐	☐	☐
63			☐	☐	☐
64			☐	☐	☐

Additional Comments (Refer to item number if applicable):

60. Trapezoidal weir is 46.5 feet wide with 25-foot bottom width.
61. Spillway channel is about 80 feet long. Spillway downstream channel ends at limestone bedrock. There is a 15-foot-high drop-off down to the river. Water was flowing through the limestone face and to the left of it. Portions of the rock have broken off.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
SPILLWAYS: DROP INLET					
65	Intake Structure		☐	☐	☐
66	Trash rack		☐	☐	☐
67	Stilling Basin		☐	☐	☐
68			☐	☐	☐
69			☐	☐	☐

Additional Comments (Refer to item number if applicable):

None observed.

NAME OF DAM: Robinson Lake Dam	DAM NO.: 94-7010	DATE: 6/12/17

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
OUTLET WORKS					
70	Intake Structure	None observed.	☐	☒	☐
71	Trash rack	None observed.	☐	☐	☐
72	Stilling Basin	None observed.	☐	☐	☐
73	Primary Closure	None observed.	☐	☐	☐
74	Secondary Closure	None observed.	☐	☐	☐
75	Control Mechanism	None observed.	☐	☐	☐
76	Outlet Pipe	None observed.	☐	☐	☐
77	Outlet Tower	None observed.	☐	☐	☐
78	Outlet Structure	Vertical 36-inch-diameter RCP pipe downstream of dam.	☐	☒	☐
79	Seepage	Seepage flowing downstream of RCP pipe.	☐	☒	☐
80	Unusual Movement	None observed.	☐	☐	☐
81			☐	☐	☐
82			☐	☐	☐

Additional Comments (Refer to item number if applicable):

78. RCP pipe is 12 feet long and extends 8 feet below ground surface. The bottom has about 3 feet of muck. No outlet pipes were observed.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
CONCRETE/MASONRY DAMS: UPSTREAM FACE					
83	Surface Conditions		☐	☐	☐
84	Condition of Joints		☐	☐	☐
85	Unusual Movement		☐	☐	☐
86	Abutment-Dam Contacts		☐	☐	☐
87			☐	☐	☐
88			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Not Applicable.

NAME OF DAM: Robinson Lake Dam	DAM NO.: 94-7010	DATE: 6/12/17

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
CONCRETE/MASONRY DAMS: DOWNSTREAM FACE					
89	Surface Conditions		☐	☐	☐
90	Condition of Joints		☐	☐	☐
91	Unusual Movement		☐	☐	☐
92	Abutment-Dam Contacts		☐	☐	☐
93	Drains		☐	☐	☐
94	Leakage		☐	☐	☐
95			☐	☐	☐
96			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Not Applicable.

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
CONCRETE/MASONRY DAMS: CREST					
97	Surface Conditions		☐	☐	☐
98	Horizontal Alignment		☐	☐	☐
99	Vertical Alignment		☐	☐	☐
100	Condition of Joints		☐	☐	☐
101	Unusual Movements		☐	☐	☐
102			☐	☐	☐
103			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Not Applicable.

NAME OF DAM: Robinson Lake Dam	DAM NO.: 94-7010	DATE: 6/12/17

ITEM	CONDITION	COMMENTS	MONITOR	INVESTIGATE	REPAIR
RESERVOIR AREA					
104	Sedimentation		☐	☐	☐
105	Slope Stability		☐	☐	☐
106	Sinkholes		☐	☐	☐
107	Fractures		☐	☐	☐
108	Unwanted Growth		☐	☐	☐
109	Storage Gage		☐	☐	☐
110			☐	☐	☐
111			☐	☐	☐

Additional Comments (Refer to item number if applicable):

Did not inspect the reservoir area.

Final Comments:

Robinson Lake Dam Inspection – June 12, 2017

Photo No. 1: Robinson Lake viewed from dam crest.

Photo No. 2: Crest viewed from left abutment.

Photo No. 3: Crest viewed from right abutment.

Photo No. 4: Erosion on crest due to possible overtopping.

Photo No. 5: Upstream slope viewed from left abutment.

Photo No. 6: Upstream slope viewed from right abutment.

Photo No. 7: Riprap present on portions of upstream slope.

Photo No. 8: Trees on upstream slope.

Photo No. 9: Downstream slope viewed from right abutment.

Photo No. 10: Downstream slope and downstream area viewed from left abutment.

Photo No. 11: Downstream slope and downstream area viewed from right abutment.

Photo No. 12: Erosion on downstream slope due to possible overtopping.

Photo No. 13: 36-inch-diameter RCP pipe downstream of dam.

Photo No. 14: Seepage downstream of RCP pipe.

Photo No. 15: Seepage downstream of RCP pipe.

Photo No. 16: Spillway weir viewed from right abutment.

Photo No. 17: Fence (trash guard) on upstream side of spillway weir.

Photo No. 18: Spillway discharge channel viewed looking downstream.

Photo No. 19: Spillway discharge channel viewed looking upstream.

Photo No. 20: Bedrock drop-off at downstream end of spillway discharge channel.

Photo No. 21: Seepage through bedrock at downstream end of spillway discharge channel.

Photo No. 22: Seepage to left of spillway.

Photo No. 23: Seepage to left of spillway.

Appendix B

Test Boring Logs

CDM Smith

BOREHOLE LOG
CDM-1

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Drilling Contractor: Tri-State Drilling
Surface Elevation (ft.): 644.4
Drilling Method/Rig: 3 1/4" HSA/CME-550
Total Depth (ft.): 36.3
Drillers: Kurt Roberts
Depth to Initial Water Level (ft-bgs): 8, after coring
Drilling Date: Start: 9-26-17 **End:** 9-26-17
Abandonment Method: Grout
Borehole Coordinates:
Field Screening Instrument: Pocket Penetrometer
N: 568538 E: 1723319
Logged By: BJG

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			644.4 / 0				Topsoil	4" Topsoil.
SS	S-1	24/4		7	2, 4, 3, 3		CL	Dry, medium stiff, brown, CLAY & SILT, little course gravel, trace fine sand, contains IOS. (PP=4.5+ TSF) **EMBANKMENT FILL**
SS	S-2	24/19		24	7, 12, 12, 13		CL	Dry, very stiff, brown, CLAY & SILT, little course gravel, trace fine sand, contains IOS. (PP=4.5+ TSF)
SS	S-3	24/22	639.4 / 5	35	9, 18, 17, 13		CL-ML	Dry, hard, dark brown, SILT & CLAY, some fine to medium sand, trace fine gravel.
SS	S-4	24/24		10	4, 4, 6, 6		CL	Moist, stiff, olive gray, CLAY & SILT, trace fine gravel, trace fine sand, contains IOS. 1" seam of brown, silty clay at 10.3 ft-bgs. (PP=4.5+ TSF)
SS	S-5	24/24		10	2, 4, 6, 5		CL	Moist, stiff, olice gray, CLAY & SILT, trace fine gravel, trace fine sand contains IOS. (PP=3.5 TSF)
			634.4 / 10					
SS	S-6	24/16		5	2, 2, 3, 6		CL	Moist, medium stiff, olive gray, CLAY & SILT, trace fine gravel, trace fine sand, contains IOS. (PP=1.0 TSF) **RESIDUAL SOILS**
ST	U-1	24/18		TUBE	PUSH		CL	Moist, olive gray, SILT & CLAY, some fine sand.
			629.4		WOH, WOH		CL	Moist, very soft, olive gray, CLAY & SILT, trace fine gravel, trace fine sand, contains IOS.

EXPLANATION OF ABBREVIATIONS

DRILLING METHODS:
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
HA - Hand Auger
AR - Air Rotary
DTR - Dual Tube Rotary
FR - Foam Rotary
MR - Mud Rotary
RC - Reverse Circulation
CT - Cable Tool
JET - Jetting
D - Driving
DTC - Drill Through Casing

SAMPLING TYPES:
AS - Auger/Grab Sample
CS - California Sampler
BX - 1.5" Rock Core
NX - 2.1" Rock Core
GP - Geoprobe
HP - Hydro Punch
SS - Split Spoon
ST - Shelby Tube
WS - Wash Sample
OTHER:
AGS - Above Ground Surface

REMARKS

Hammer Weight: 140 lb
Hammer Drop Height: 30 inches
Spoon Size: 2 inch O.D., 24 inches long
ft-bgs = feet below ground surface
TSF = tons per square foot, PP= pocket penetrometer
+ = greater than
RQD= rock quality designation, REC= recovery
WOH= weight of hammer, IOS=irone oxide staining

Reviewed by: J. Briand **Date:** 10-26-17

CDM Smith

BOREHOLE LOG
CDM-1

Client: City of Franklin **Project Name:** Robinson Lake Dam
Project Location: Franklin, Tennessee **Project Number:** 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
SS	S-7	24/22	629.4 / 15	WOH	WOH 2		CL	(PP=0.5 TSF)
SS	S-8	24/24		4	WOH 2 2 3			Moist, soft to medium stiff, gray, CLAY & SILT, trace fine sand. (PP=1.0 to 1.25 TSF)
SS	S-9	24/24		5	2 2 3 3			Moist, medium stiff, olive gray, SILT & CLAY, little fine sand, minor IOS. (PP=1.25 TSF)
SS	S-10	24/18	624.4 / 20	2	WOH WOH 2 3			Moist, very soft to soft, olive gray, CLAY & SILT, trace fine sand, trace fine gravel. (PP=0.25 to 1.0 TSF) Auger refusal encountered at 22.5 ft-bgs.
NX	R-1	46/39	619.4 / 25				LS	Moderately hard, fresh to slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=85% RQD=39% **LIMESTONE**
NX	R-2	60/60	614.4 / 30					Moderately hard, fresh to slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=100% RQD=40%
NX	R-3	60/59	609.4 / 35					Moderately hard, fresh to slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=98% RQD=73%
								Test boring terminated at 36.3 ft-bgs

CDM Smith

BOREHOLE LOG
CDM-2

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Drilling Contractor: Tri-State Drilling
Surface Elevation (ft.): 646.4
Drilling Method/Rig: 3 1/4" HSA/CME-550
Total Depth (ft.): 16
Drillers: Kurt Roberts
Depth to Initial Water Level (ft-bgs): 5.5, after drilling
Drilling Date: Start: 9-25-17 **End:** 9-25-17
Abandonment Method: Grout
Borehole Coordinates:
Field Screening Instrument: Pocket Penetrometer
N: 568481 E: 1723462
Logged By: BJG

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. / Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			646.4 / 0				TOPSOIL	4" Topsoil
SS	S-1	24/2		4	2, 2, 2, 2			Dry, soft to medium stiff, brown, Silty CLAY, trace fine to course sand, trace fine gravel, contains IOS. (PP=3.5 TSF) **EMBANKMENT FILL**
SS	S-2	24/22		18	2, 7, 11, 8			Dry, very stiff, brown, Silty CLAY, some fine to medium sand, contains IOS. (PP=3.5 TSF)
SS	S-3	24/24	641.4 / 5	15	2, 6, 9, 8		CL	Dry, stiff to very stiff, olive brown, CLAY & SILT, trace fine sand. (PP=4.5+)
SS	S-4	24/23		11	3, 4, 7, 6			Moist, stiff, olive, Silty CLAY, trace fine to medium sand, contains IOS. (PP=4.5+ TSF)
SS	S-5	24/24	636.4	10	3, 4, 6, 6			Moist, stiff, olive, CLAY & SILT, little fine to medium sand, trace fine gravel, contains IOS. (PP=3.5 TSF)
SS	S-6	24/16	10	10	2, 4, 6, 7			Moist, stiff, olive, CLAY & SILT, trace fine to medium sand, trace fine gravel. (PP=2 TSF) **RESIDUAL SOILS**
SS	S-7	24/23		3	1, 1, 2, 2		CL	Moist, soft, gray, CLAY & SILT, little fine to course, sand, trace fine gravel. (PP=0.25 TSF)
			631.4		5, 7			Moist, stiff, gray, CLAY & SILT, little fine to course sand, trace fine gravel.

EXPLANATION OF ABBREVIATIONS

DRILLING METHODS:
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
HA - Hand Auger
AR - Air Rotary
DTR - Dual Tube Rotary
FR - Foam Rotary
MR - Mud Rotary
RC - Reverse Circulation
CT - Cable Tool
JET - Jetting
D - Driving
DTC - Drill Through Casing

SAMPLING TYPES:
AS - Auger/Grab Sample
CS - California Sampler
BX - 1.5" Rock Core
NX - 2.1" Rock Core
GP - Geoprobe
HP - Hydro Punch
SS - Split Spoon
ST - Shelby Tube
WS - Wash Sample
OTHER:
AGS - Above Ground Surface

REMARKS

Hammer Weight: 140 lb
Hammer Drop Height: 30 inches
Spoon Size: 2 inch O.D., 24 inches long
ft-bgs = feet below ground surface
+= greater than, IOS=irone oxide staining
TSF= tons per square foot, PP=pocket penetrometer
Borehole collapsed at 12 ft-bgs.
Shelby tube lost in hole at 14 ft-bgs. Borehole abandoned.

Reviewed by: J. Briand **Date:** 10-26-17

BOREHOLE LOG
CDM-2

Client: City of Franklin **Project Name:** Robinson Lake Dam
Project Location: Franklin, Tennessee **Project Number:** 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			631.4					
SS	S-8	24/24	15	13	6 6		CL	(PP=0.5 TSF) Shelby tube was attempted from 14'-16', tube was lost in borehole and borehole was abandoned following SS sample.
								Test boring terminated at 16 ft-bgs. See offset boring CDM-2A for continuation of test boring.
			626.4 20					
			621.4 25					
			616.4 30					
			611.4 35					

CDM Smith

BOREHOLE LOG
CDM-2A

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Drilling Contractor: Tri-State Drilling
Surface Elevation (ft.): 646.1
Drilling Method/Rig: 3 1/4" HSA/CME-550
Total Depth (ft.): 41
Drillers: Kurt Roberts
Depth to Initial Water Level (ft-bgs): 4.5, after coring
Drilling Date: Start: 9-25-17 **End:** 9-25-17
Abandonment Method: Monitoring Well
Borehole Coordinates:
N: 568482 E: 1723460
Field Screening Instrument: Pocket Penetrometer
Logged By: BJG

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			646.1 / 0					Offset test boring CDM-2A augered directly to 16 ft-bgs.
			641.1 / 5					
AS	AS-1	192/192					Auger	
			636.1 / 10					
			631.1					

EXPLANATION OF ABBREVIATIONS

DRILLING METHODS:
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
HA - Hand Auger
AR - Air Rotary
DTR - Dual Tube Rotary
FR - Foam Rotary
MR - Mud Rotary
RC - Reverse Circulation
CT - Cable Tool
JET - Jetting
D - Driving
DTC - Drill Through Casing

SAMPLING TYPES:
AS - Auger/Grab Sample
CS - California Sampler
BX - 1.5" Rock Core
NX - 2.1" Rock Core
GP - Geoprobe
HP - Hydro Punch
SS - Split Spoon
ST - Shelby Tube
WS - Wash Sample
OTHER:
AGS - Above Ground Surface

REMARKS

Hammer Weight: 140 lb
Hammer Drop Height: 30 inches
Spoon Size: 2 inch O.D., 24 inches long
ft-bgs = feet below ground surface
WOH = weight of hammer
PP = pocket penetrometer; TSF=tons per square foot
RQD = rock quality designation; REC = recovery

Reviewed by: J. Briand **Date:** 10-26-17

CDM Smith

BOREHOLE LOG
CDM-2A

Client: City of Franklin **Project Name:** Robinson Lake Dam
Project Location: Franklin, Tennessee **Project Number:** 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. / Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			631.1 / 15				Auger	
SS	S-1	24/24		10	3 4 6 6		CL	Moist, stiff, olive gray, Silty CLAY, some fine to course sand, trace fine gravel. (PP=1.75 to 2.0 TSF) **RESIDUAL SOILS**
SS	S-2	24/23	626.1 / 20	10	3 4 6 7		CL	Moist, stiff, olive gray and olive brown, Silty CLAY, trace fine sand, trace fine gravel. (PP=2.0 to 2.5 TSF)
SS	S-3	24/23		6	1 2 4 4		CL	Moist, medium stiff, olive brown, Silty CLAY, little fine to course sand, little fine gravel. (PP=3.0 to 3.75 TSF) Auger refusal encountered at 22 ft-bgs.
BX	R-1	48/31	621.1 / 25				LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=65% RQD=54% **LIMESTONE**
BX	R-2	60/58	616.1 / 30				LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=97% RQD=32%
NX	R-3	60/60	611.1 / 35				LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=100% RQD=53%
BX	R-4	60/58					LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=97% RQD=28%

BOREHOLE LOG
CDM-2A

Client: City of Franklin | **Project Name:** Robinson Lake Dam

Project Location: Franklin, Tennessee | **Project Number:** 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			606.1 / 40				LS	
								Test boring terminated at 41 ft-bgs.
			601.1 / 45					
			596.1 / 50					
			591.1 / 55					
			586.1 / 60					

CDM Smith

BOREHOLE LOG
CDM-3

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Drilling Contractor: Tri-State Drilling
Surface Elevation (ft.): 634.3
Drilling Method/Rig: 3 1/4" HSA/CME-550
Total Depth (ft.): 23.5
Drillers: Kurt Roberts
Depth to Initial Water Level (ft-bgs): 2, after coring
Drilling Date: Start: 9-27-17 **End:** 9-27-17
Abandonment Method: Grout
Borehole Coordinates:
Field Screening Instrument: Pocket Penetrometer
N: 568472 E: 1723298
Logged By: BJG

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			634.3 0					
SS	S-1	24/20		4	2 2 2 3		CL	Moist, soft to medium stiff, brown, CLAY & SILT, trace fine sand, trace fine gravel, trace roots. (PP=0.5 to 1.5 TSF) **RESIDUAL SOILS**
SS	S-2	24/12		5	1 2 3 3		CL	Moist, medium stiff, dark brown, CLAY & SILT, some fine sand, trace roots. (PP=1.5 TSF)
ST	U-1	24/24	629.3 5	TUBE	PUSH		CL / SC	Moist, brown, fine SAND and CLAY & SILT.
SS	S-3	24/24		9	3 4 5 6		SC	Moist, loose, brown, fine SAND and CLAY & SILT.
SS	S-4	18/18		11	3 5 6 50/3"		SC	Wet, medium dense, brown, fine SAND and CLAY & SILT. Auger refusal encountered at 9.5 ft-bgs.
NX	R-1	12/9	624.3 10				LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=75% RQD=42% **LIMESTONE**
NX	R-2	60/52					VOID / LS	Moderately hard, slightly weathered, fine grained, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=87% RQD=43% 6" void at 11.7 ft-bgs, staining in the joints at 14 ft-bgs
			619.3					

EXPLANATION OF ABBREVIATIONS

DRILLING METHODS:
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
HA - Hand Auger
AR - Air Rotary
DTR - Dual Tube Rotary
FR - Foam Rotary
MR - Mud Rotary
RC - Reverse Circulation
CT - Cable Tool
JET - Jetting
D - Driving
DTC - Drill Through Casing

SAMPLING TYPES:
AS - Auger/Grab Sample
CS - California Sampler
BX - 1.5" Rock Core
NX - 2.1" Rock Core
GP - Geoprobe
HP - Hydro Punch
SS - Split Spoon
ST - Shelby Tube
WS - Wash Sample
OTHER:
AGS - Above Ground Surface

REMARKS

Hammer Weight: 140 lb
Hammer Drop Height: 30 inches
Spoon Size: 2 inch O.D., 24 inches long
ft-bgs = feet below ground surface
WOH = weight of hammer
PP = pocket penetrometer
RQD = rock quality designation; REC = recovery
TSF=Tons per square feet

Reviewed by: J. Briand **Date:** 10-26-17

BOREHOLE LOG
CDM-3

Client: City of Franklin
Project Location: Franklin, Tennessee
Project Name: Robinson Lake Dam
Project Number: 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. / Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			619.3 / 15					
NX	R-3	60/60					LS	Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=100% RQD=32%
			614.3 / 20					
NX	R-4	60/50						Moderately hard, slightly weathered, fine-grained, gray, LIMESTONE, extremely thin bedding, horizontal, smooth slickened undulating. REC=83% RQD=32%
			609.3 / 25					Test boring terminated at 25.5 ft-bgs.
			604.3 / 30					
			599.3 / 35					

CDM Smith

BOREHOLE LOG
CDM-4

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Drilling Contractor: Tri-State Drilling
Surface Elevation (ft.): 635.5
Drilling Method/Rig: 3 1/4" HSA/CME-550
Total Depth (ft.): 21.3
Drillers: Kurt Roberts
Depth to Initial Water Level (ft-bgs): 4, after coring
Drilling Date: Start: 9-27-17 **End:** 9-27-17
Abandonment Method: Grout
Borehole Coordinates:
Field Screening Instrument: Pocket Penetrometer
N: 568397 E: 1723418
Logged By: BJG

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. / Depth (ft.)	N-Value	Blows per 6-in	USCS Designation	Material Description
			635.5 / 0				
SS	S-1	24/24		5	3 3 2 3	CL	Moist, medium stiff to stiff, brown, CLAY & SILT, trace fine sand. (PP=1.0 TSF) **RESIDUAL SOILS**
SS	S-2	24/20		5	1 2 3 3	CL	Moist, medium stiff, brown, CLAY & SILT, trace fine sand, trace fine gravel. (PP=1.0 TSF)
SS	S-3	24/22	630.5 / 5	7	1 3 4 7	CL	Moist, medium stiff, grayish brown, CLAY & SILT, some fine to course sand, trace fine gravel, contains IOS. (PP=1.0 TSF)
SS	S-4	15/15		59+	5 9 50/3"	CL	Moist, hard, grayish brown, CLAY & SILT, trace fine sand, trace fine to course gravel, contains IOS. (PP=4.5+ TSF) Auger refusal encountered at 8.3 ft-bgs.
NX	R-1	36/24	625.5 / 10			LS	Moderately hard, slightly to moderately weathered, fine-grained, gray, LIMESTONE, very thin bedding, horizontal, smooth slickened undulating. Slight joint staining at 9.1 ft-bgs. REC=67% RQD=28% **LIMESTONE**
NX	R-2	60/50	620.5			LS	Moderately hard, slightly to moderately weathered, fine-grained, gray, LIMESTONE, very thin bedding, horizontal, smooth slickened undulating. Slight join staining at 12 ft-bgs. REC=83% RQD=38%

EXPLANATION OF ABBREVIATIONS

DRILLING METHODS:
- HSA - Hollow Stem Auger
- SSA - Solid Stem Auger
- HA - Hand Auger
- AR - Air Rotary
- DTR - Dual Tube Rotary
- FR - Foam Rotary
- MR - Mud Rotary
- RC - Reverse Circulation
- CT - Cable Tool
- JET - Jetting
- D - Driving
- DTC - Drill Through Casing

SAMPLING TYPES:
- AS - Auger/Grab Sample
- CS - California Sampler
- BX - 1.5" Rock Core
- NX - 2.1" Rock Core
- GP - Geoprobe
- HP - Hydro Punch
- SS - Split Spoon
- ST - Shelby Tube
- WS - Wash Sample

OTHER:
- AGS - Above Ground Surface

REMARKS

Hammer Weight: 140 lb
Hammer Drop Height: 30 inches
Spoon Size: 2 inch O.D., 24 inches long
ft-bgs = feet below ground surface
NR = not recorded; TSF=tons per square feet
+=greater than
PP = pocket penetrometer
RQD = rock quality designation; REC = recovery

Reviewed by: J. Briand **Date:** 10-26-17

CDM Smith

BOREHOLE LOG
CDM-4

Client: City of Franklin
Project Name: Robinson Lake Dam
Project Location: Franklin, Tennessee
Project Number: 14915-222189

Sample Type	Sample Number	Sample Adv/Rec (inches)	Elev. Depth (ft.)	N-Value	Blows per 6-in	Graphic Log	USCS Designation	Material Description
			620.5 / 15					
NX	R-3	60/51	615.5 / 20				LS	Moderately hard, slightly to moderately weathered, fine-grained, gray, LIMESTONE, very thin bedding, horizontal, smooth slickened undulating. REC=85% RQD=43%
			610.5 / 25 605.5 / 30 600.5 / 35					Test boring terminated at 21.3 ft-bgs.

Appendix C

Monitoring Well Installation Log

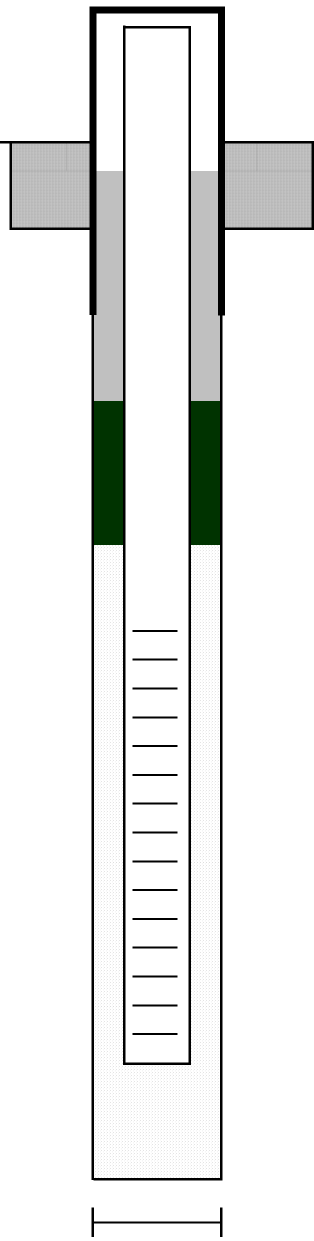
5400 Gleenwood Ave
Suite 400
Raleigh, NC 27612
(919)-787-5620

Monitoring Well Installation Log

Client:	City of Franklin	Contractor:	Tri-State Drilling, LLC	Boring/Well No.:	MW-2
Project Name:	Robinson Lake Dam	Driller:	Kurt Roberts	Date Installed:	9/26/2017
Project Location:	Franklin, TN	Ground EL:	646.2	Logged By:	BJG
Project Number:	14915-222189	Riser EL:	650.1	Page:	1 of 1

GROUND SURFACE

LOCKED PROTECTIVE CASING



SURFACE SEAL: (Thickness & Type) 6-inch thick concrete well pad

BACKFILL MATERIAL: (Type) Cement Grout

TOP OF SEAL: 12 feet

SEAL CONSTRUCTION: (Thickness & Type) 2 feet of bentonite chips

TOP OF SANDPACK: 14 feet

RISER CONSTRUCTION: (Type, Diameter & Material) SCH 40, 2-inch-diameter PVC

TOP OF SCREEN: 16 feet

SANDPACK TYPE: Well sand pack

SCREEN MATERIAL: (Type, Slot, Diameter & Material) SCH 40, 2-inch-diameter slotted PVC

BOTTOM OF SCREEN: 21 feet

BOTTOM OF BOREHOLE: 22 feet

BOREHOLE DIAMETER: 12 Inches

NOTE: All depths are in feet below ground surface, unless noted otherwise.

Remarks:

Appendix D

Report of Site Characterization and Geophysical Services

November 3, 2017

CDM Smith
5400 Glenwood Avenue, Suite 400
Raleigh, NC 27612

Attn: Mr. John Briand, P.E.
E: briandjp@cdmsmith.com
P: 919-325-3562

Re: Report of Site Characterization and Geophysical Services
Robinson Lake Dam
Franklin, Williamson County, TN
Terracon Project No. 18175159

Dear Mr. Briand:

Terracon has completed our site characterization and geophysical services for the above-referenced project. The purpose of this study was to characterize the site subsurface conditions using geotechnical drilling and sampling and conduct a geophysical survey at locations prescribed by CDM Smith. Our efforts have been completed in general accordance with our proposal dated September 5, 2017.

1.0 PROJECT INFORMATION

Site Location

Item	Description
Location	Earthen Dam at South end of Robinson Lake Franklin, Williamson County, TN Latitude/Longitude: 35.8921152 / -86.8281411
Existing improvements	None
Current ground cover	Grasses and forested areas.
Existing topography	The dam crest is approximately 15-feet wide and descends on both sides. Based on the survey data provided by CMD Smith, the top of the dam is at approximate elevation 645 feet and the base is at approximate elevation 636 feet.

2.0 GEOPHYSICAL EXPLORATION

Terracon Consultants, Inc. (Terracon) performed geophysical exploration services consisting of Electrical Resistivity Imaging (ERI) on October 2 & 3, 2017. The purpose of the geophysical exploration was to locate geologic features below the dam which may be causing seepage. Terracon utilized an Electrical Resistivity system consisting of an Advanced Geosciences Inc. (AGI) SuperSting R8 control unit.

This method utilizes potential and current electrodes that function independently of one another to measure the potential field. A transmitting current dipole is followed by a series of potential dipoles which measure the resulting voltage gradient at each station. As the transmitting dipole is advanced along the electrodes, the resulting gradient measurements were collected as a 2D section below the survey array. After field collection, the resistivity data was processed using EarthImager 2D (engineered by AGI), an inversion and modeling software package. Changes in the earth resistivity can indicate changes in lithology, saturation, and amount of fracturing. The method can accurately image the interface from soil overburden to bedrock.

Survey Design

Four (4) ERI survey lines were conducted at the southern end of Robinson Lake (Exhibit 1).

- Line A was conducted across the crest of the dam in an approximate west to east orientation. The line consisted of an approximate 400-foot linear array with 81 electrode stakes that were inserted into the ground, spaced approximately 5 feet apart.
- Line B was conducted in an approximate north to south orientation, from the crest of the dam near the water's edge. The line consisted of an approximate 90-foot linear array with 19 electrode stakes that were inserted into the ground, spaced approximately 5 feet apart. The line was not extended over the upstream side of the dam due to ground cover and accessibility.
- Line C was conducted in an approximate north to south orientation, from the crest of the dam near the water's edge. The line consisted of an approximate 130-foot linear array with 27 electrode stakes that were inserted into the ground, spaced approximately 5 feet apart. The line was not extended over the upstream side of the dam due to ground cover and accessibility.
- Line D was conducted in an approximate north to south orientation, from the crest of the dam near the water's edge. The line consisted of an approximate 170-foot linear array with 35 electrode stakes that were inserted into the ground, spaced approximately 5 feet apart. The line was not extended over the upstream side of the dam due to ground cover and accessibility.

2.1 GEOPHYSICAL FINDINGS

The cross-sectional images generated from the ERI testing are displayed on Exhibit 2. Each image is a representation of the electrical resistivity of the subsurface. In general, high resistivity values (red, orange, and yellow) are indicative of quality bedrock with minimal fractures and voids. Lower resistivity values (green, blue, and purple) are indicative of soil overburden or weak, saturated, or fractured bedrock.

Line A – The cross sectional image shows that the dam is made up of materials which have a moderately low resistivity value. The values are mostly consistent across the length of the dam. Below this layer are resistivity values that indicate bedrock, with the highest values being found next to the spillway, where the bedrock is exposed at the surface. One anomaly is found in the material that makes up the dam. An area of low resistivity is seen from station 110 to station 125 centered at an elevation of 623. The anomaly is at and below the contact with bedrock and could indicate a pathway for potential water seepage.

Line B – The cross sectional image shows the dam is made of materials consistent with Line A, and no major anomalies are seen.

Line C – This line crosses Line A on the eastern edge of the located anomaly. An area of low resistivity is seen, consistent with Line A in elevation, which extends to station 70.

Line D – The cross sectional image shows the dam is made of materials consistent with Line A, and no major anomalies are seen.

2.2 LIMITATIONS

All geophysical testing methods rely on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, standing water, high subsurface moisture content, and other buried objects. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and geophysical scientist evaluating the results. The provided depth measurements are estimations based on an estimation of the electrical properties of the subsurface material.

This report has been prepared for the application discussed and in accordance with generally accepted geophysical practices. No warranties, expressed or implied, are intended or made. The findings presented in this report are based upon the data obtained from the geophysical surveys and from other information discussed in this report. This report does not reflect variations that may occur in areas not tested or inaccessible to the geophysical equipment, across the site, or due to the modifying effects of construction or weather.

2.3 CONCLUSION AND RECOMMENDATIONS

The results of the geophysical testing show the Robinson Lake dam consists of moderately low resistivity materials and are placed on top of competent bedrock. One anomaly was found in the cross section of the dam. This anomaly is an area of low resistivity that is found near the base of the dam and extends into the bedrock below. This may be an area for potential water seepage.

3.0 GEOTECHNICAL DRILLING AND SAMPLING

Terracon's trusted subcontract driller completed four soil test borings and installed two piezometers as proposed and directed by CDM Smith's field engineer on September 25, 26, and 27, 2017. The Borehole location plan and logs are attached. Paths to the bore locations and the geophysical test locations were cleared with a skid steer and a mulching attachment.

4.0 LABORATORY

As requested, we completed Natural moisture content testing on eight samples, sieve analysis with a No. 200 sieve wash on four samples, sieve analysis with hydrometer testing on four samples, Atterberg limits testing on eight samples, and one 3-point CIU Triaxial test on one sample. The results of these tests are attached.

5.0 CLOSING

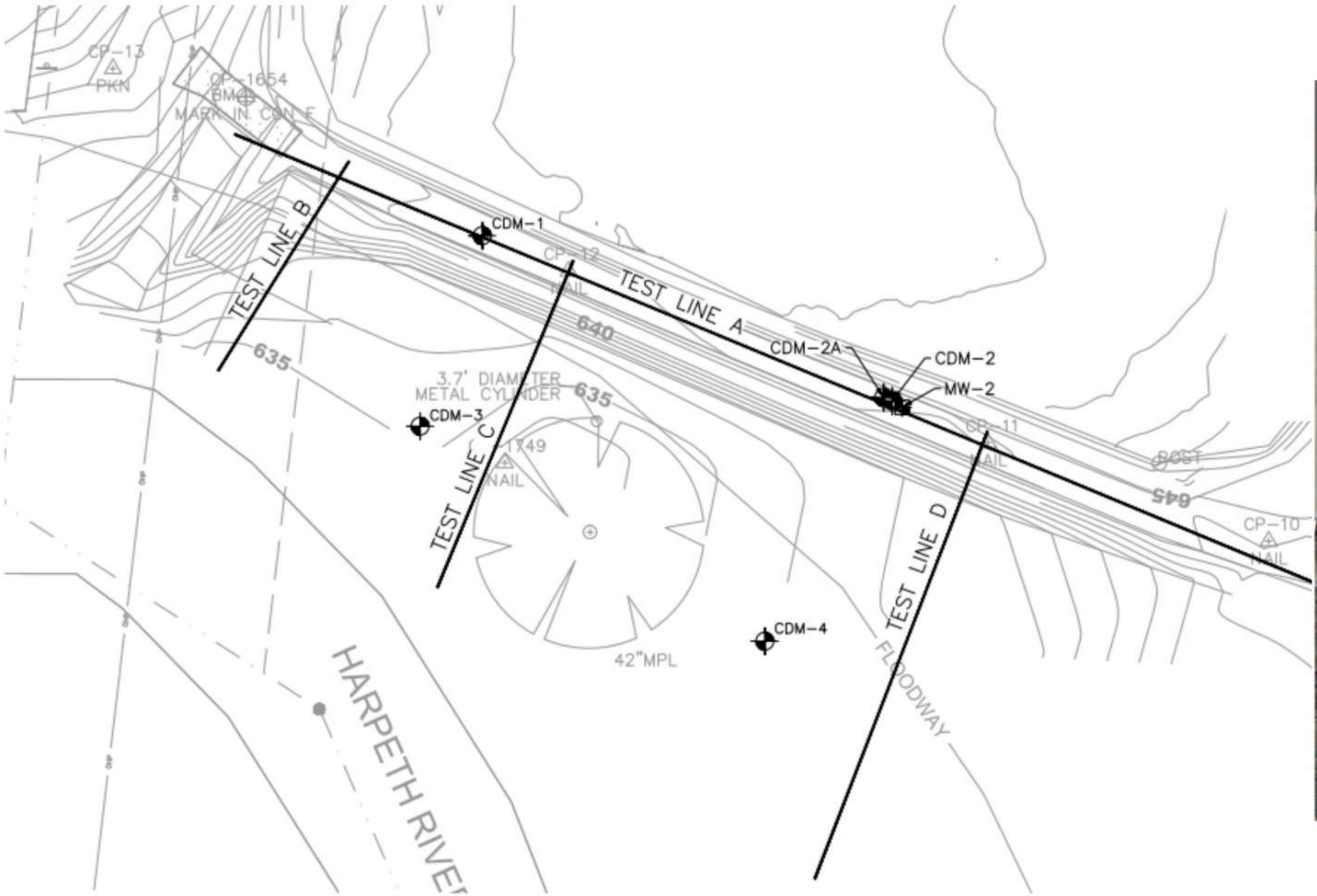
We appreciate the opportunity to work with you on this project. If you have any questions or comments regarding this data or require additional services, please give us a call.

Sincerely,
Terracon Consultants, Inc.

Daniel A. Bean for
John E. Agee, P.E.
Regional Manager

Kyle J. Shalek
Kyle J. Shalek, Ph.D.
Geophysics Manager

Attachments Exhibits 1-2
Laboratory Results



N

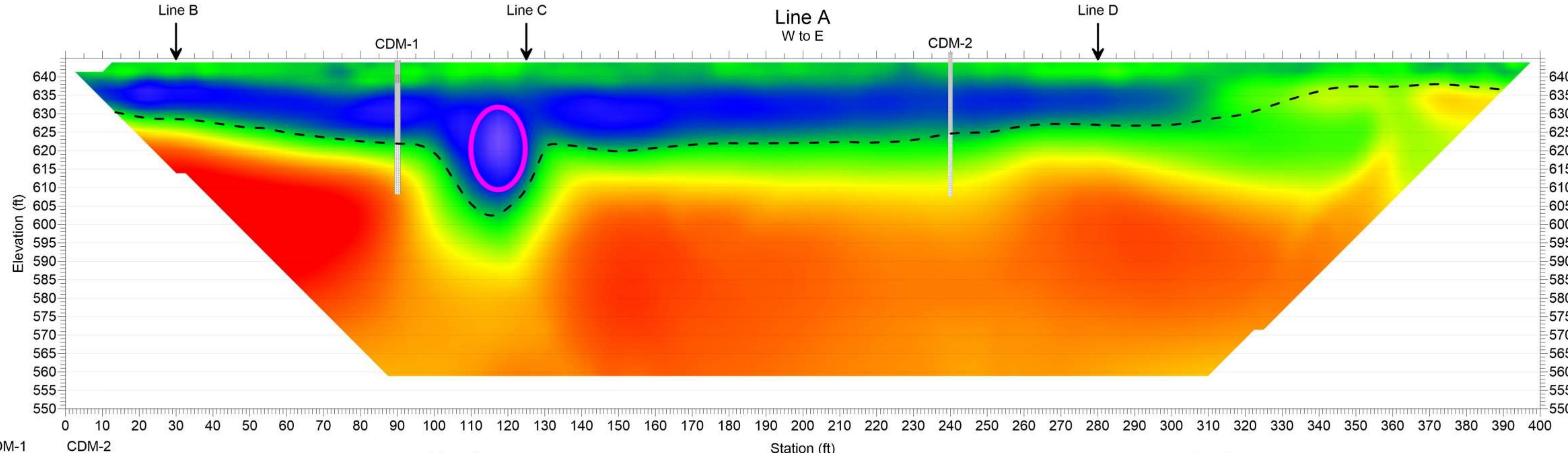
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

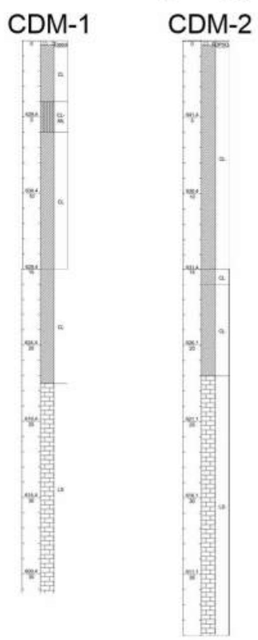
Terracon
Consulting Engineers and Scientists
5217 LINBAR DRIVE NASHVILLE, TN 37211

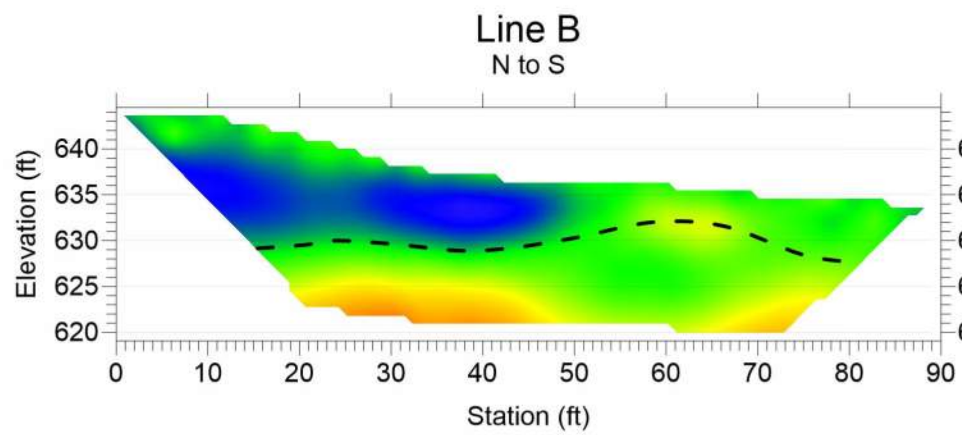
SURVEY LOCATION PLAN
ROBINSON LAKE DAM
CDM SMITH
FRANKLIN, WILLIAMS COUNTY, TENNESSEE

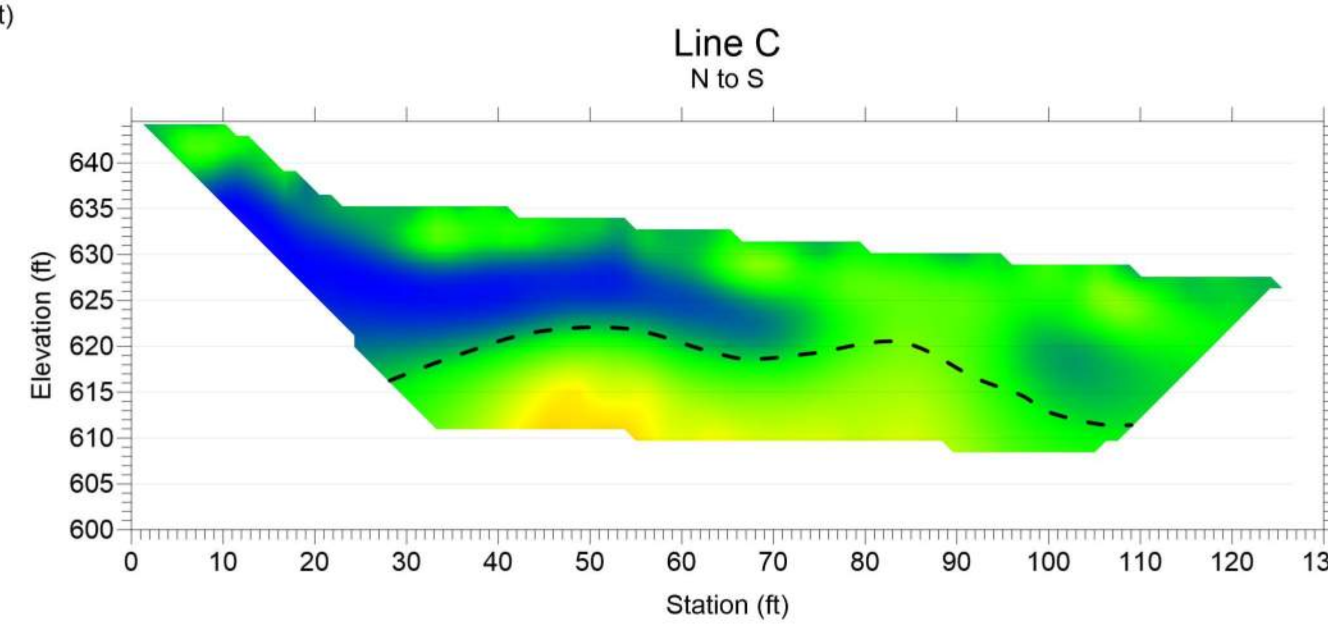
EXHIBIT 1

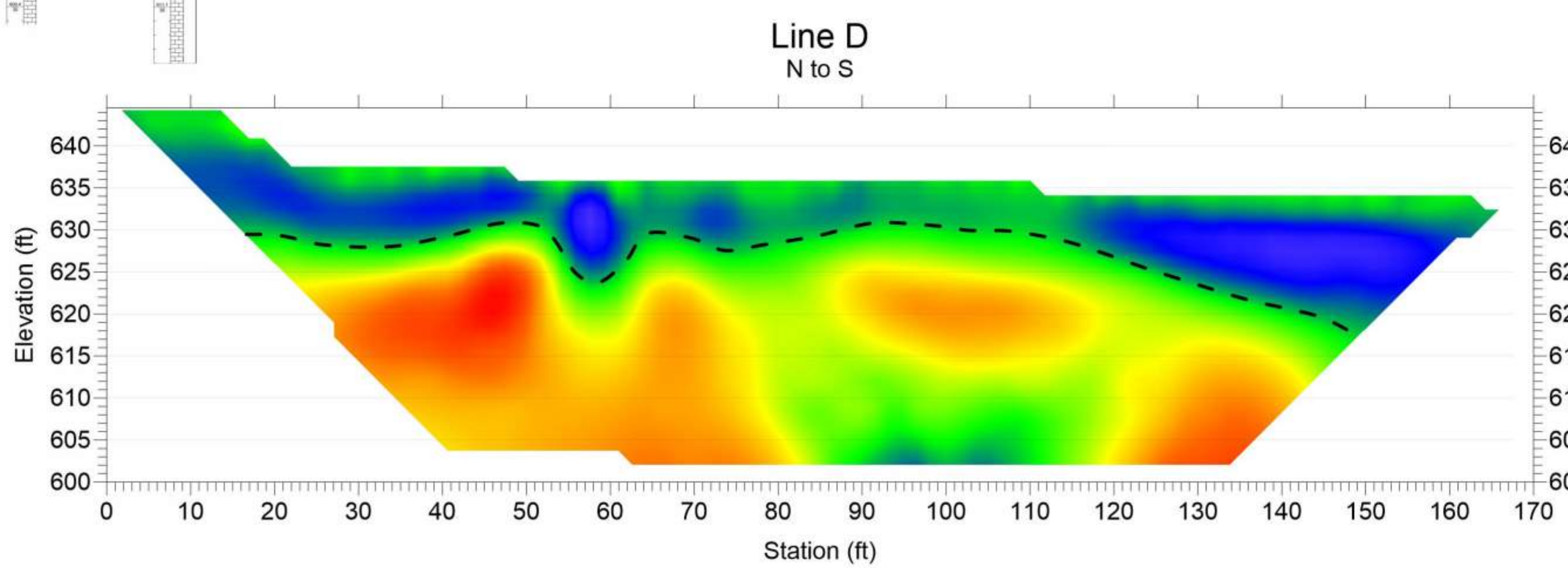
DESIGNED BY:	KJS
DRAWN BY:	KJS
APPVD. BY:	JEA
SCALE:	As Shown
DATE:	11/03/2017
JOB NO.	18175159











Anomaly

Terracon
Consulting Engineers and Scientists
5217 LINBAR DRIVE NASHVILLE, TN 37211

ERI CROSS-SECTIONS
ROBINSON LAKE DAM
CDM SMITH
FRANKLIN, WILLIAMS COUNTY, TENNESSEE

EXHIBIT 2	
DESIGNED BY:	KJS
DRAWN BY:	KJS
APPVD. BY:	JEA
SCALE:	As Shown
DATE:	11/03/2017
JOB NO.	18175159

Summary of Laboratory Results

BORING ID	Depth	USCS Classification and Soil Description	Specific Gravity	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Dry Density (pcf)
CDM-1	4 - 6	SILTY CLAY with SAND(CL-ML)		23	16	7	70.7	1.9	27.4			15.6	
CDM-1	12 - 14	LEAN CLAY with SAND(CL)		24	16	8	77.0	0.0	23.0	56.5	20.6	19.1	
CDM-1	18 - 20	LEAN CLAY(CL)		22	14	8	89.0	0.0	11.0			23.1	
CDM-2	1.5 - 3	SANDY LEAN CLAY(CL)		42	16	26	66.1	0.0	33.9	47.5	18.6	11.4	
CDM-2	8 - 10	LEAN CLAY(CL)		31	17	14	87.5	0.2	12.3	59.2	28.3	18.1	
CDM-2A	16 - 18	SANDY LEAN CLAY(CL)		40	15	25	67.3	4.1	28.6			19.2	
CDM-3	2 - 4	LEAN CLAY with SAND(CL)		33	17	16	77.2	0.0	22.8	51.0	26.2	20.6	
CDM-4	4 - 6	LEAN CLAY with SAND(CL)		31	15	16	78.7	0.6	20.6			18.7	

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

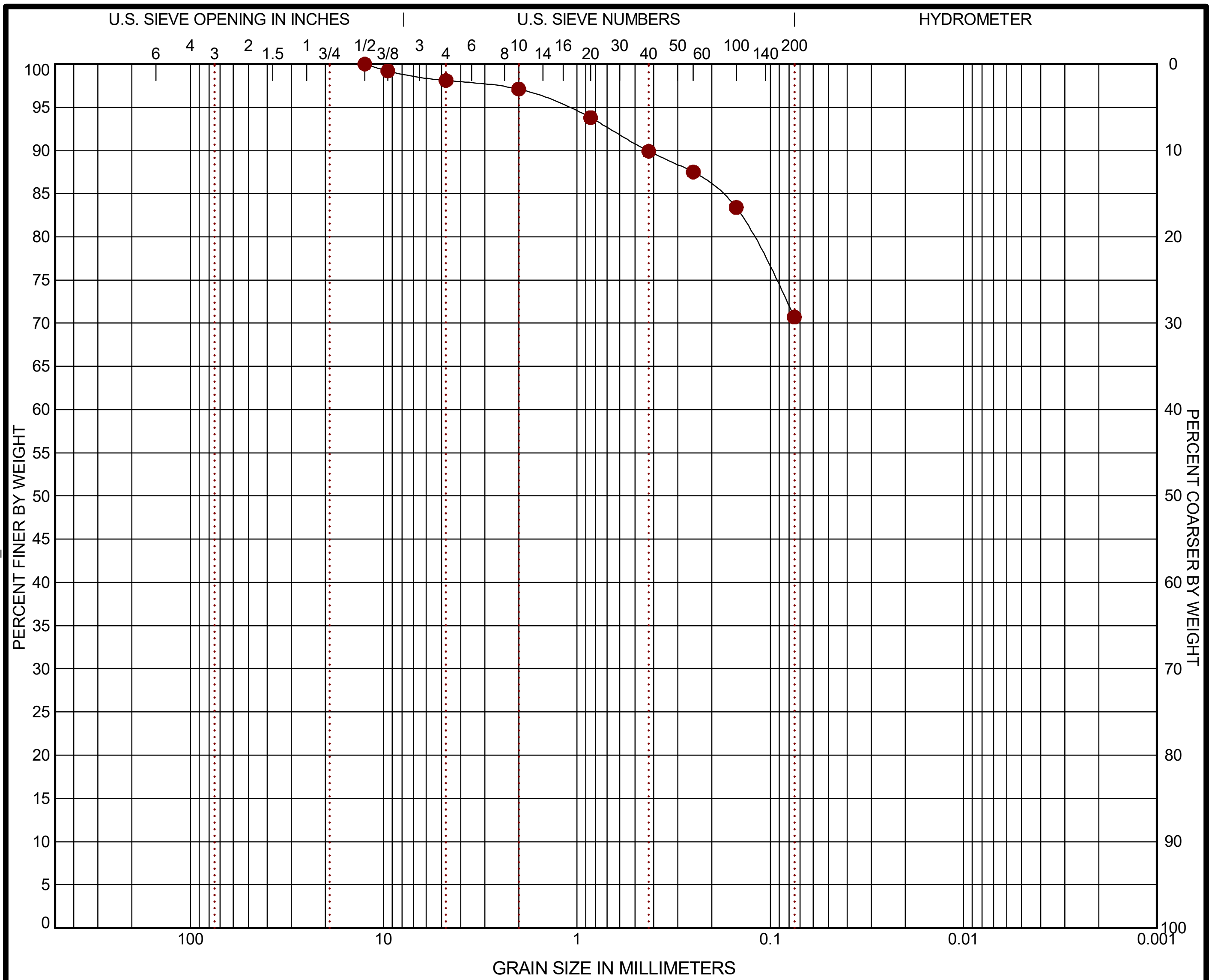
Terracon

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-1**	**4 - 6**	**0.0**	**1.9**	**27.4**		**70.7**		**CL-ML**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"	**100.0**		
3/8"	**99.2**		
#4	**98.1**		
#10	**97.1**		
#20	**93.8**		
#40	**89.9**		
#60	**87.5**		
#100	**83.4**		
#200	**70.7**		

SOIL DESCRIPTION

● SILTY CLAY with SAND (CL-ML)

REMARKS

●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

Terracon

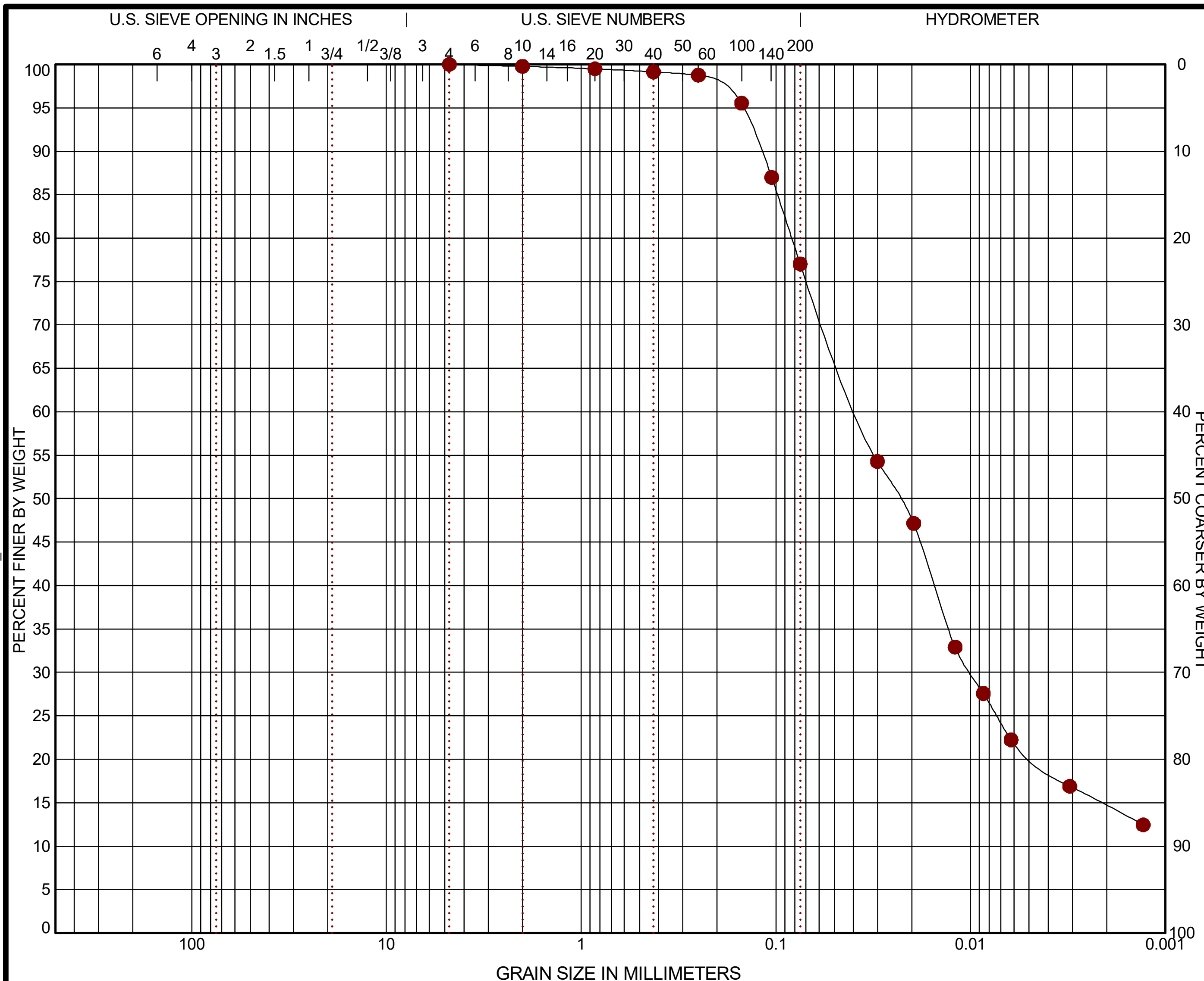
PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 CORRECTED 18175159-ROBINSON LAKE DAM.GPJ TERRACON_DATATEMPLATE.GDT 10/26/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	CDM-1	12 - 14	0.0	0.0	23.0	56.5		20.6	CL

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4	100.0		
#10	99.77		
#20	99.49		
#40	99.14		
#60	98.76		
#100	95.53		
#200	77.03		

SOIL DESCRIPTION
● LEAN CLAY with SAND (CL)

REMARKS
●

PROJECT: Robinson Lake Dam

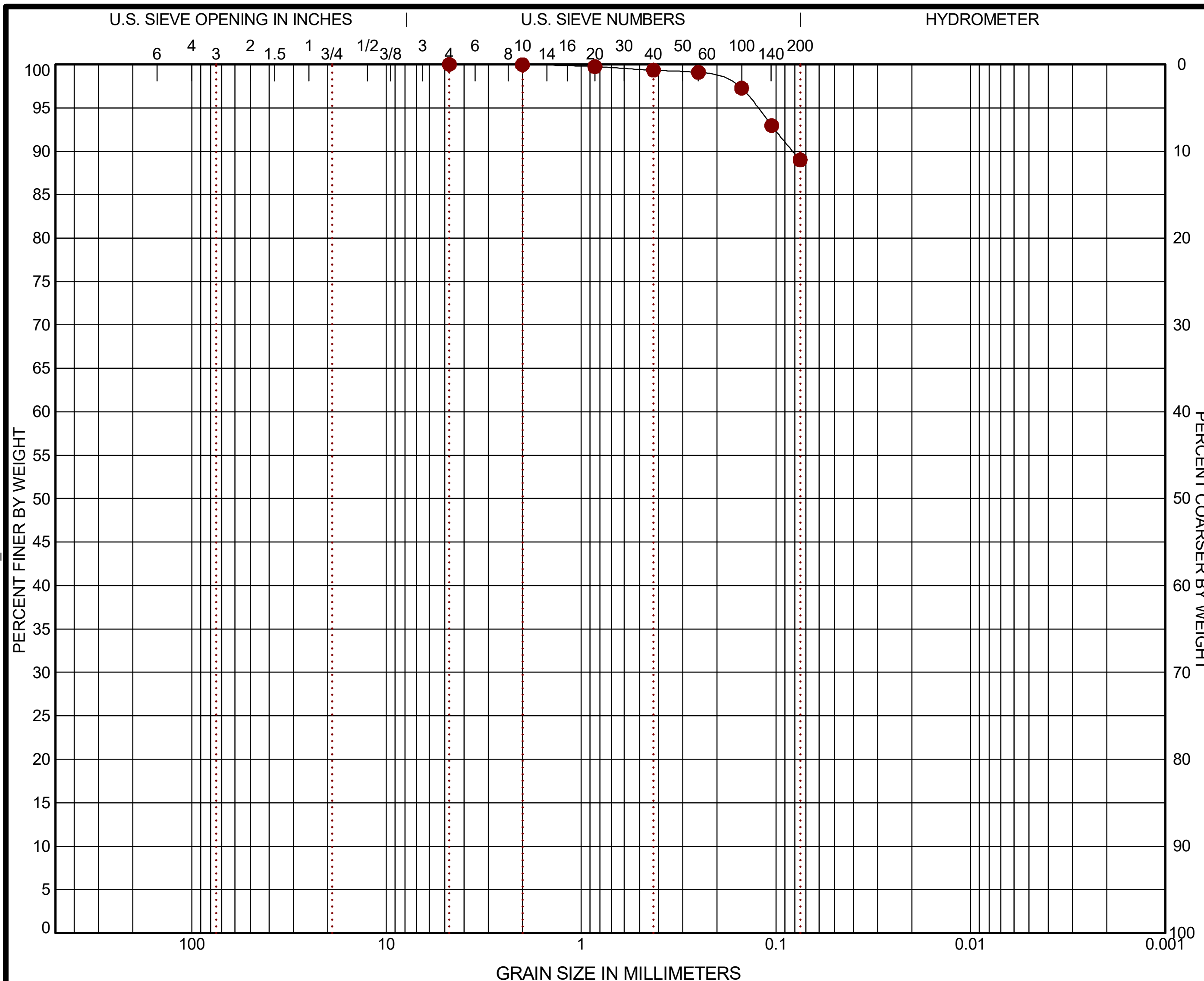
SITE: Franklin, TN

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-1**	**18 - 20**	**0.0**	**0.0**	**11.0**		**89.0**		**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4	**100.0**		
#10	**99.96**		
#20	**99.74**		
#40	**99.34**		
#60	**99.09**		
#100	**97.27**		
#200	**89.01**		

SOIL DESCRIPTION
● LEAN CLAY (CL)

REMARKS
●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

Terracon

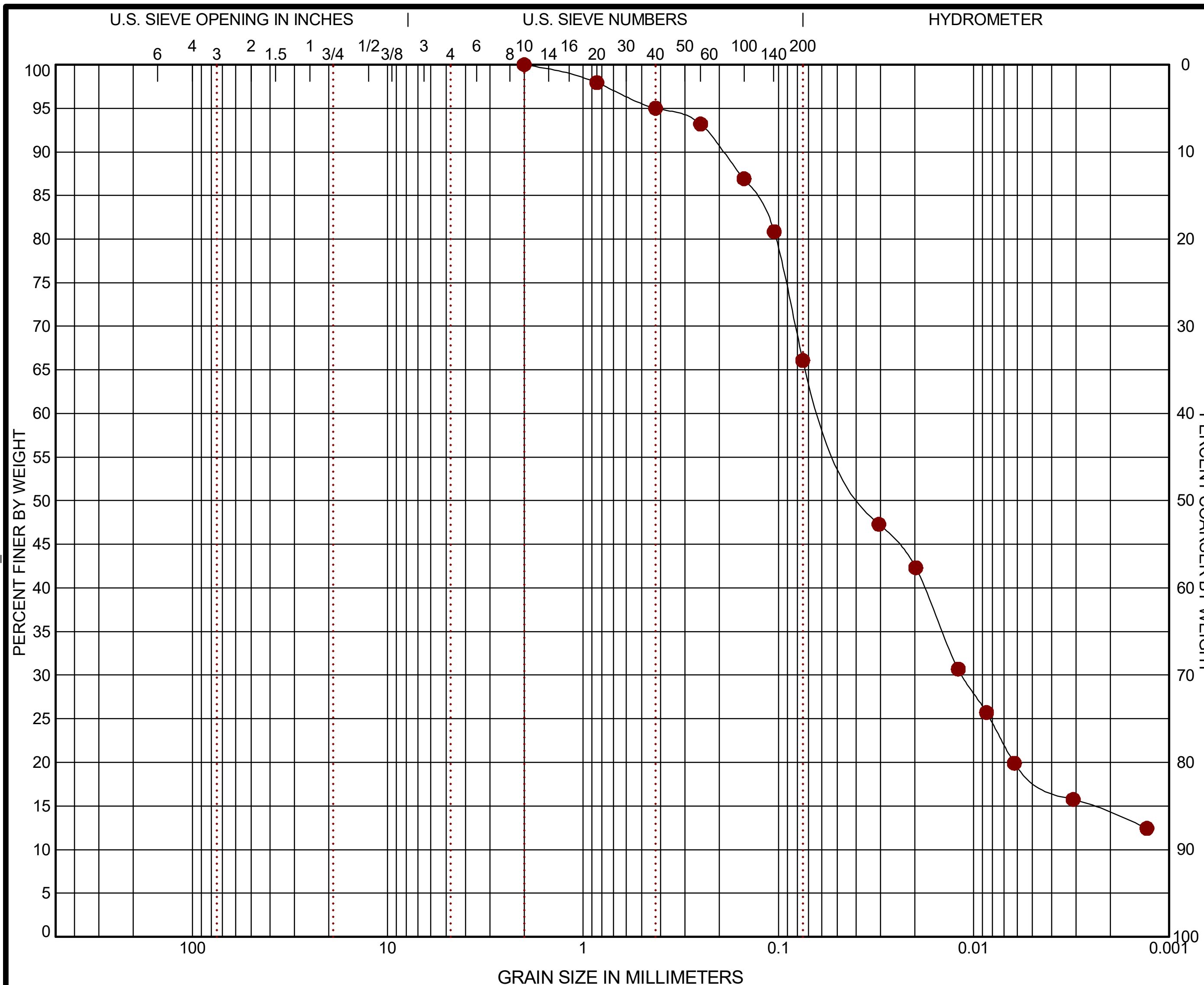
PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 CORRECTED 18175159-ROBINSON LAKE DAM.GPJ TERRACON_DATATEMPLATE.GDT 10/26/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-2**	**1.5 - 3**	**0.0**	**0.0**	**33.9**	**47.5**		**18.6**	**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4			
#10	**100.0**		
#20	**97.94**		
#40	**95.0**		
#60	**93.19**		
#100	**86.92**		
#200	**66.08**		

SOIL DESCRIPTION

● SANDY LEAN CLAY (CL)

REMARKS

●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

Terracon

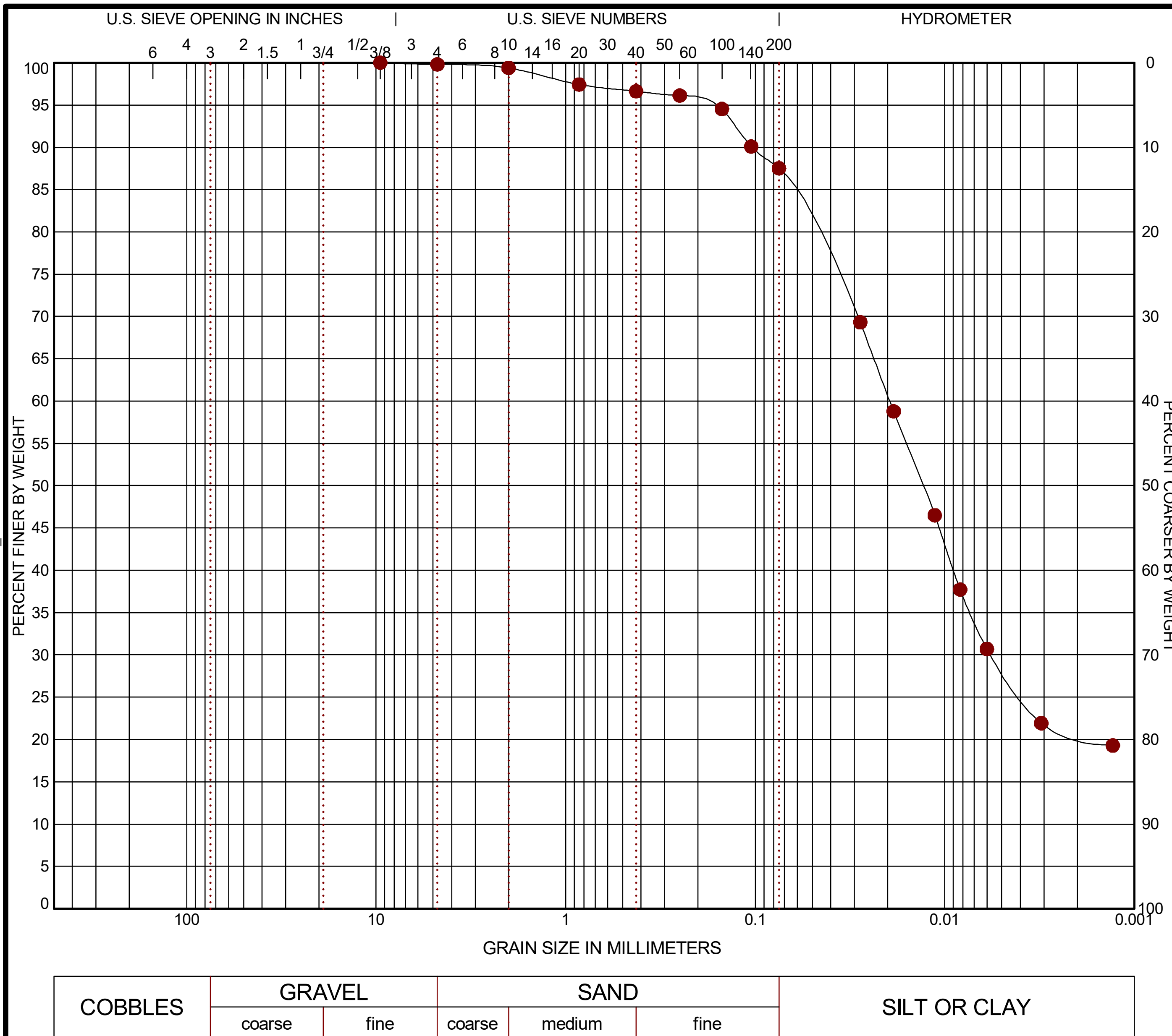
PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 CORRECTED 18175159-ROBINSON LAKE DAM.GPJ TERRACON_DATATEMPLATE.GDT 10/26/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-2**	**8 - 10**	**0.0**	**0.2**	**12.3**	**59.2**		**28.3**	**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"	**100.0**		
#4	**99.8**		
#10	**99.39**		
#20	**97.42**		
#40	**96.63**		
#60	**96.12**		
#100	**94.53**		
#200	**87.52**		

SOIL DESCRIPTION
● LEAN CLAY (CL)

REMARKS
●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

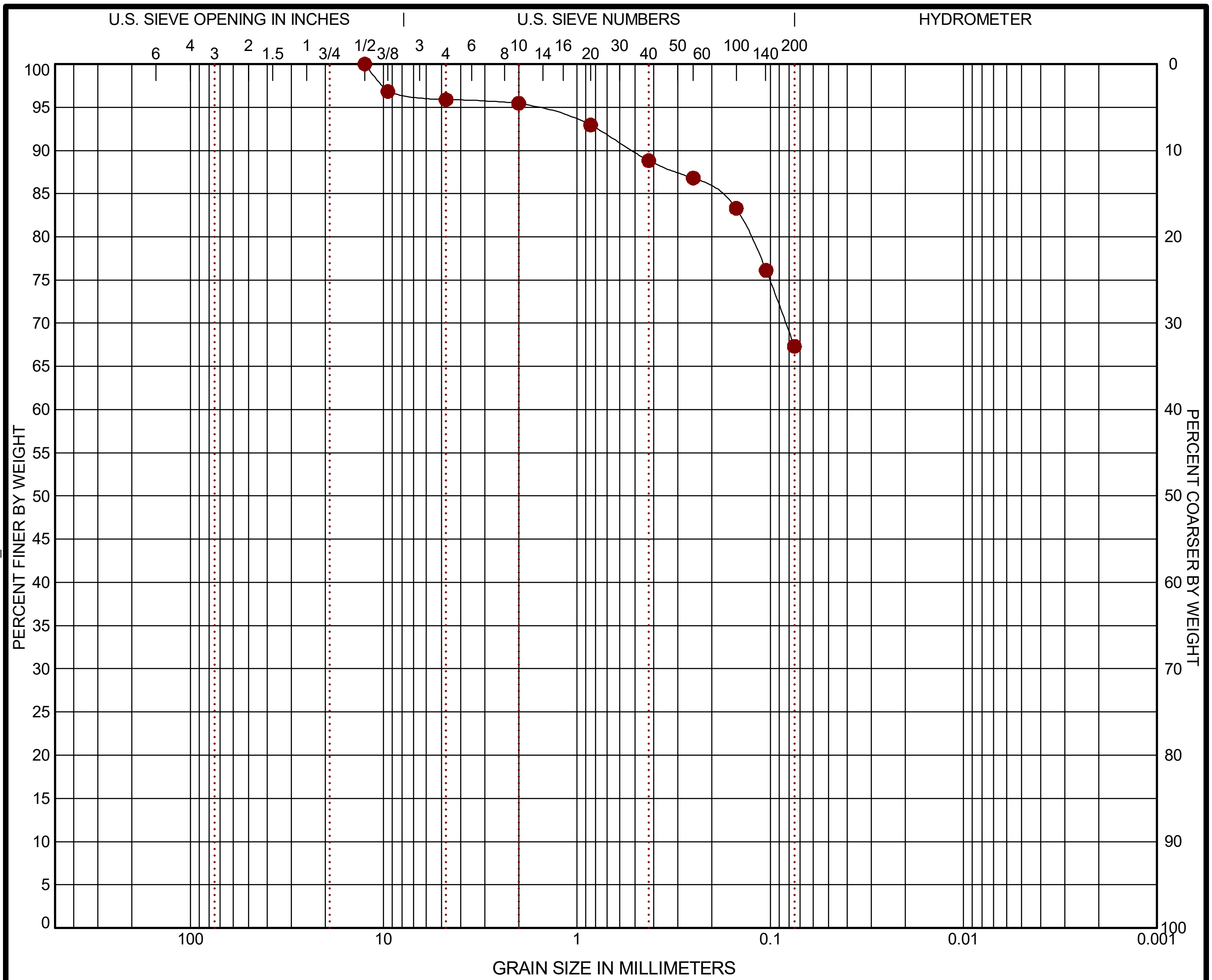
PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 CORRECTED 18175159-ROBINSON LAKE DAM.GPJ TERRACON_DATATEMPLATE.GDT 10/26/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-2A**	**16 - 18**	**0.0**	**4.1**	**28.6**		**67.3**		**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"	**100.0**		
3/8"	**96.83**		
#4	**95.87**		
#10	**95.45**		
#20	**92.94**		
#40	**88.82**		
#60	**86.8**		
#100	**83.3**		
#200	**67.32**		

SOIL DESCRIPTION

● SANDY LEAN CLAY (CL)

REMARKS

●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

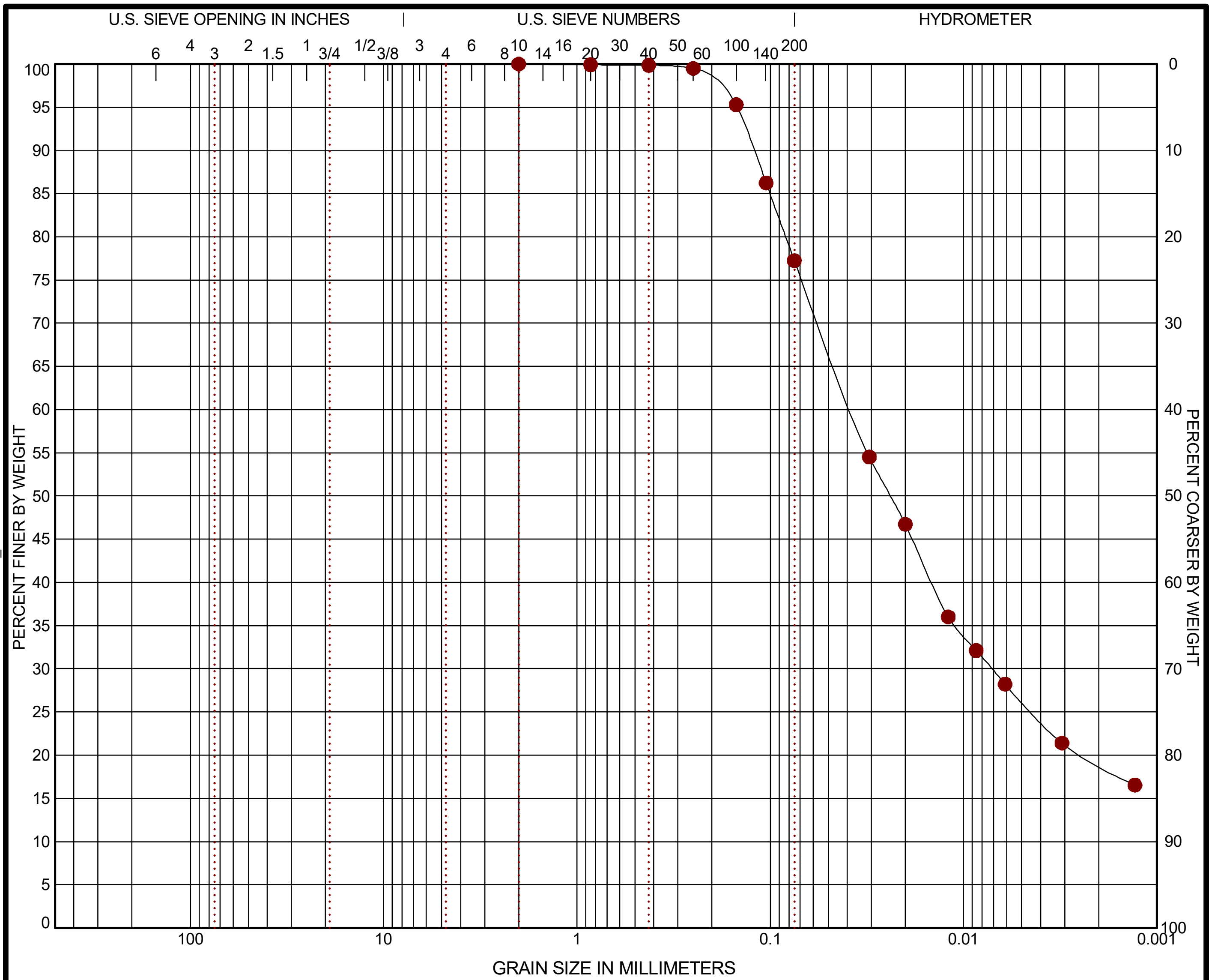
Terracon

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-3**	**2 - 4**	**0.0**	**0.0**	**22.8**	**51.0**		**26.2**	**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4			
#10	**100.0**		
#20	**99.92**		
#40	**99.85**		
#60	**99.49**		
#100	**95.28**		
#200	**77.24**		

SOIL DESCRIPTION

● LEAN CLAY with SAND (CL)

REMARKS

●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

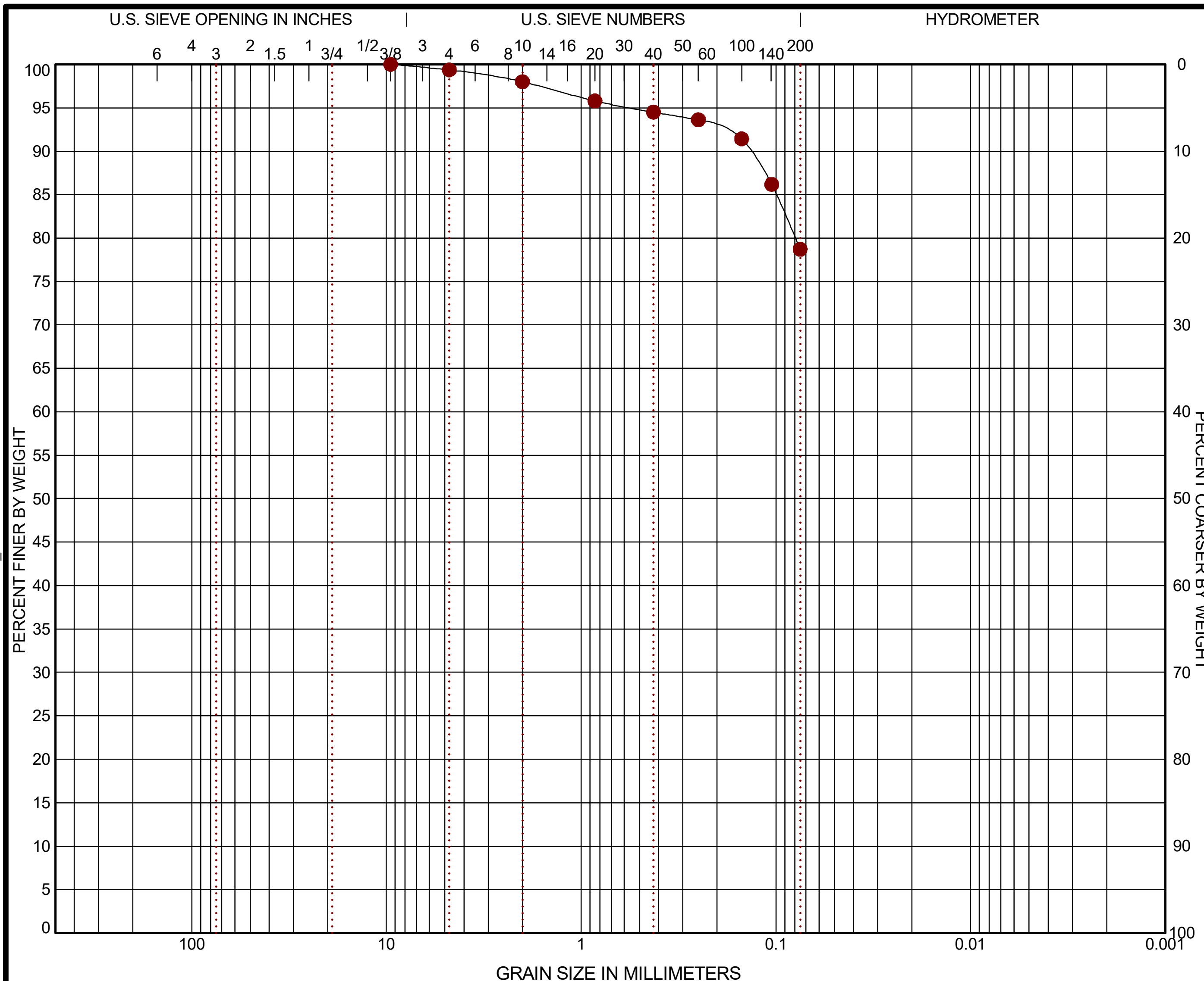
Terracon

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**CDM-4**	**4 - 6**	**0.0**	**0.6**	**20.6**		**78.7**		**CL**

	GRAIN SIZE		
	●		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"	**100.0**		
#4	**99.37**		
#10	**98.0**		
#20	**95.79**		
#40	**94.5**		
#60	**93.62**		
#100	**91.43**		
#200	**78.72**		

SOIL DESCRIPTION

● LEAN CLAY with SAND (CL)

REMARKS

●

PROJECT: Robinson Lake Dam

SITE: Franklin, TN

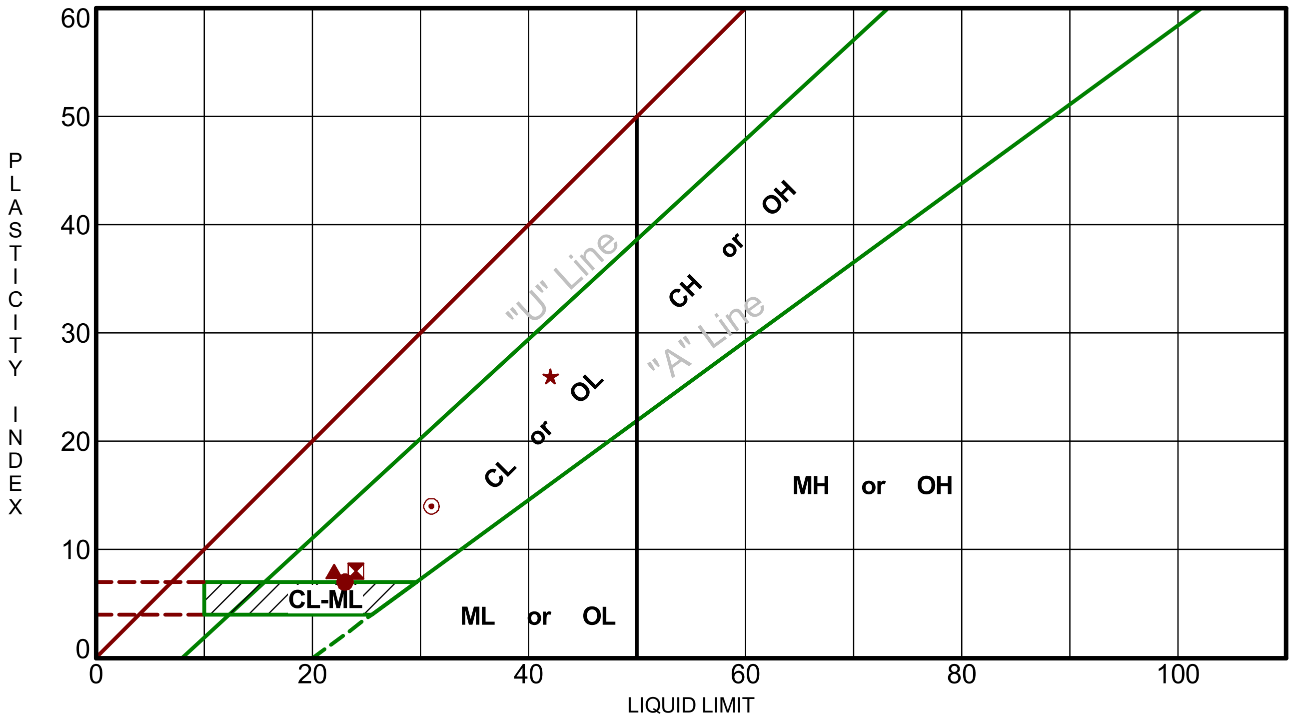
Terracon

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**CDM-1**	**4 - 6**	**23**	**16**	**7**	**71**	**CL-ML**	**SILTY CLAY with SAND**
⊠	**CDM-1**	**12 - 14**	**24**	**16**	**8**	**77**	**CL**	**LEAN CLAY with SAND**
▲	**CDM-1**	**18 - 20**	**22**	**14**	**8**	**89**	**CL**	**LEAN CLAY**
★	**CDM-2**	**1.5 - 3**	**42**	**16**	**26**	**66**	**CL**	**SANDY LEAN CLAY**
⊙	**CDM-2**	**8 - 10**	**31**	**17**	**14**	**88**	**CL**	**LEAN CLAY**

PROJECT: Robinson Lake Dam	PROJECT NUMBER: 18175159
SITE: Franklin, TN	CLIENT: City of Franklin Franklin, TN

Terracon

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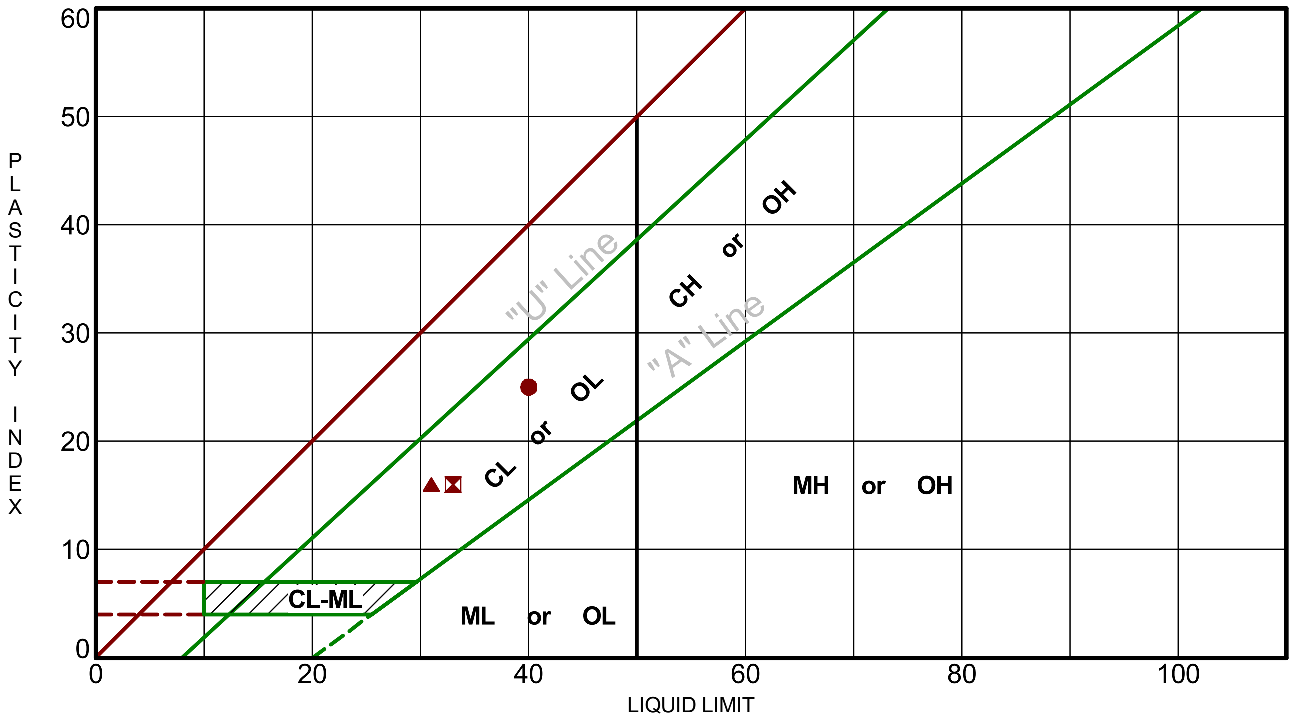
ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**CDM-2A**	**16 - 18**	**40**	**15**	**25**	**67**	**CL**	**SANDY LEAN CLAY**
⊠	**CDM-3**	**2 - 4**	**33**	**17**	**16**	**77**	**CL**	**LEAN CLAY with SAND**
▲	**CDM-4**	**4 - 6**	**31**	**15**	**16**	**79**	**CL**	**LEAN CLAY with SAND**

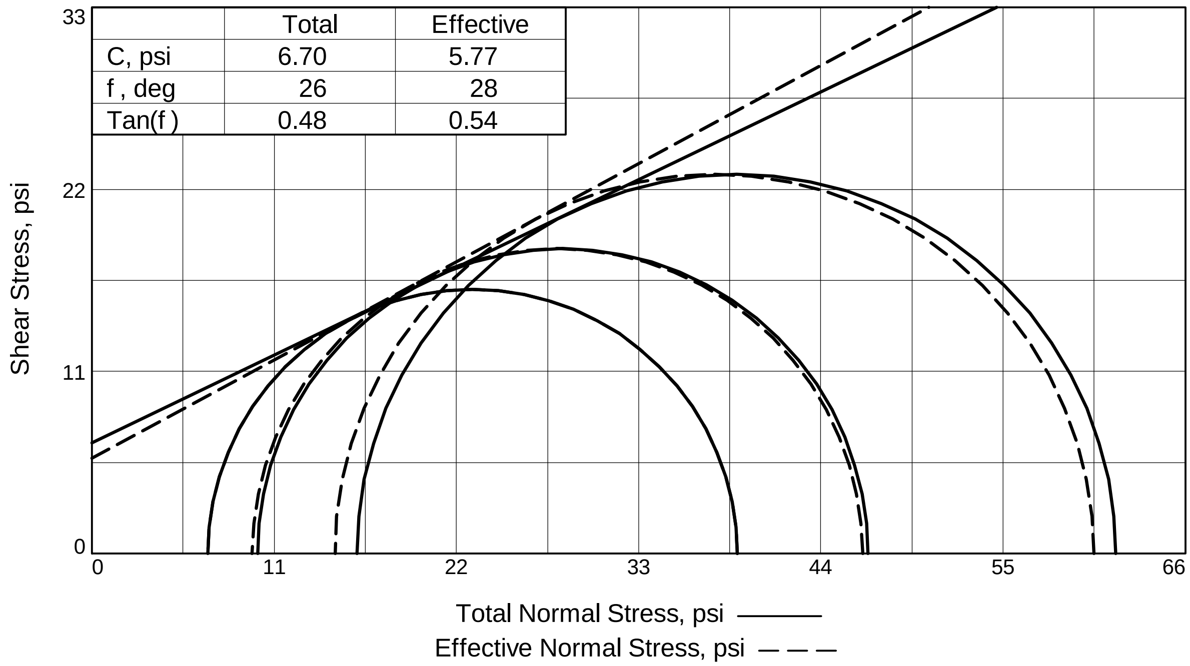
PROJECT: Robinson Lake Dam

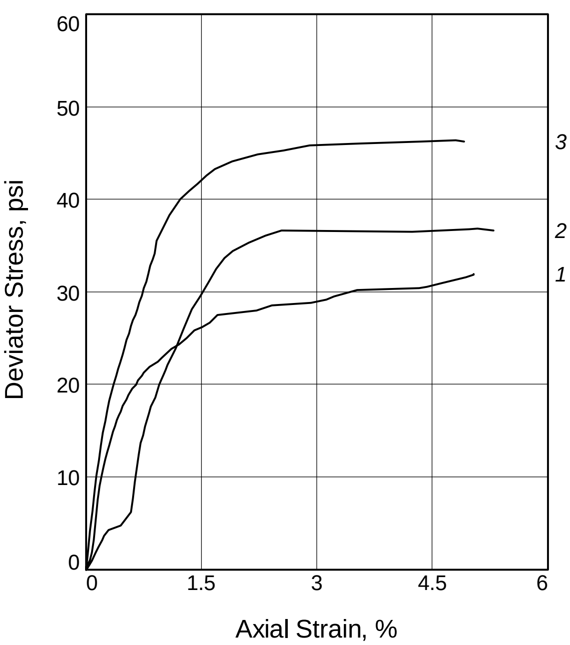
SITE: Franklin, TN

Terracon

PROJECT NUMBER: 18175159

CLIENT: City of Franklin
Franklin, TN





	Sample No.	1	2	3
Initial	Water Content, %	19.1	19.1	19.1
	Dry Density, pcf	102.9	102.9	102.9
	Saturation, %	80.8	80.8	80.8
	Void Ratio	0.6375	0.6375	0.6375
	Diameter, in.	1.380	1.380	1.380
	Height, in.	2.790	2.790	2.790
At Test	Water Content, %	22.8	22.5	21.9
	Dry Density, pcf	103.9	104.4	105.5
	Saturation, %	99.0	99.0	98.9
	Void Ratio	0.6216	0.6144	0.5977
	Diameter, in.	1.376	1.408	1.438
	Height, in.	2.781	2.644	2.507
	Strain rate, in./min.	.0003	.0003	.0003
	Eff. Cell Pressure, psi	7.0	10.0	16.0
	Fail. Stress, psi	31.9	36.8	45.8
	Excess Pore Pr., psi	0.0	0.3	1.3
	Strain, %	5.0	5.1	2.9
	$\bar{s}_1$ Failure, psi	38.9	46.5	60.5
	$\bar{s}_3$ Failure, psi	7.0	9.7	14.7

Type of Test:
CU with Pore Pressures

Sample Type: Tube

Description: Lean Clay with Sand

LL= 24 **PL=** 16 **PI=** 8

Assumed Specific Gravity= 2.7

Remarks: Multistage CU

Client: City of Franklin

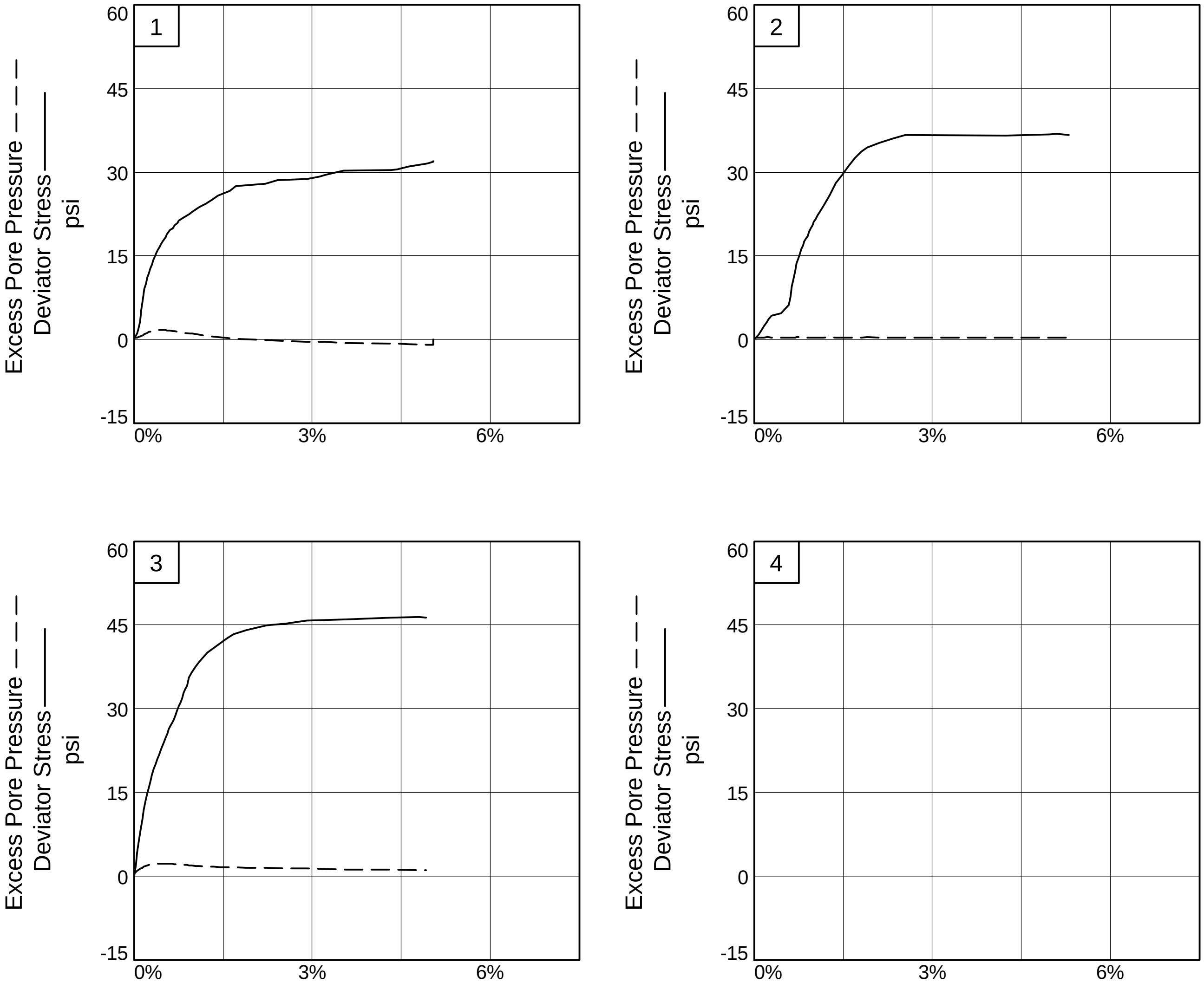
Project: Robinson Lake Dam

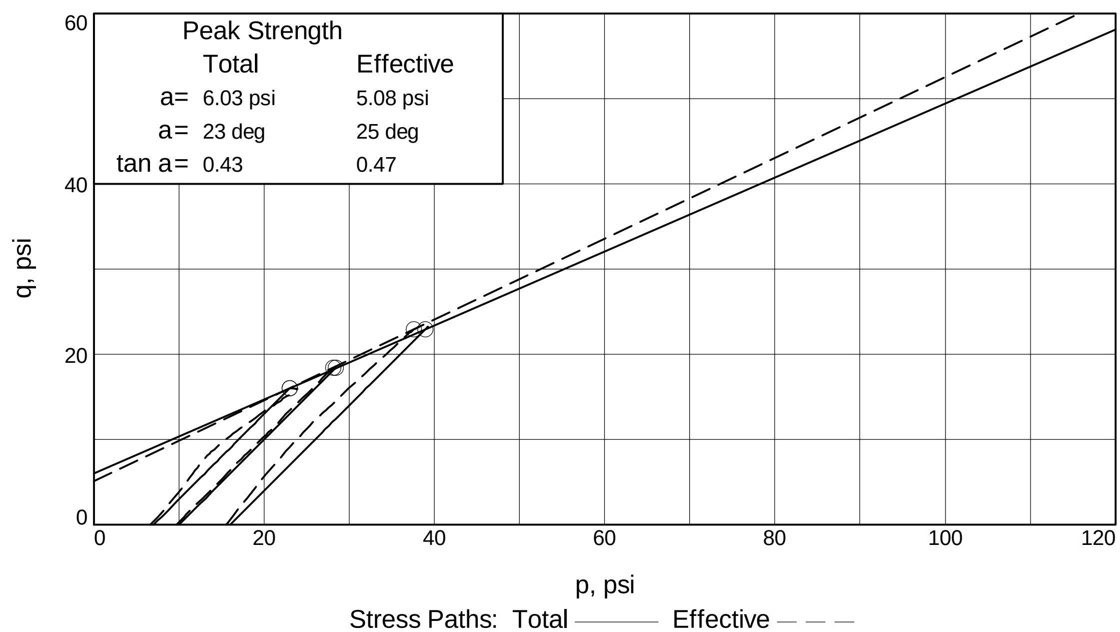
Source of Sample: CDM-1 **Depth:** 12.0-14.0 ft

Sample Number: 6U

Proj. No.: 18175159 **Date Sampled:** 9/26/17

TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN





Client: City of Franklin

Project: Robinson Lake Dam

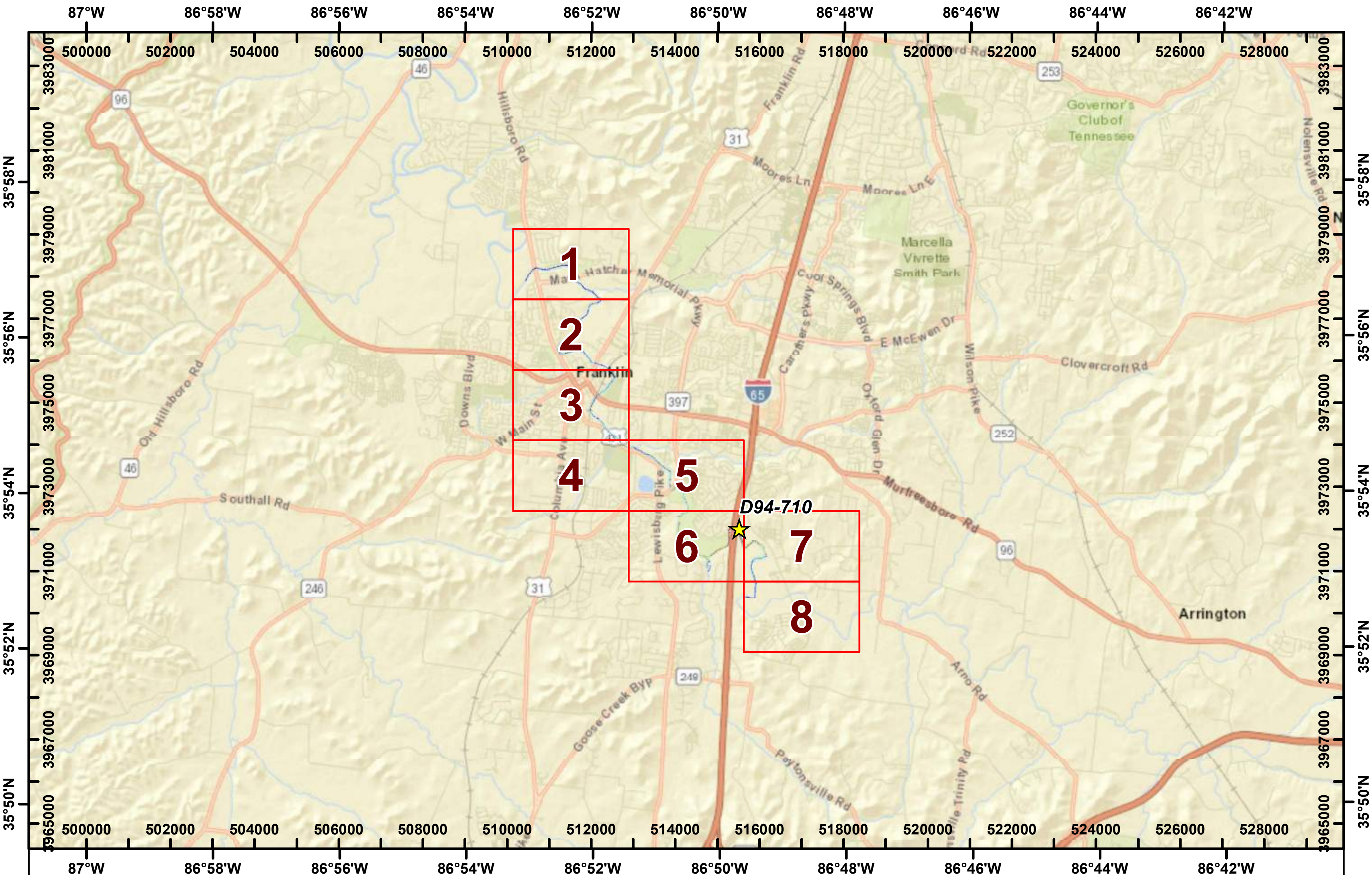
Source of Sample: CDM-1 **Depth:** 12.0-14.0 ft **Sample Number:** 6U

Project No.: 18175159

Terracon Consultants, Inc.

Appendix E

Dam Break Analyses



N

1 in = 2 miles

0 0.5 1 1.5 2 Miles

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
Basemap: Esri World Street Map

Inundation maps assist the dam owner and emergency management authorities with identifying critical infrastructure and population-at-risk sites that may require protective measures and warning and evacuation planning. The inundation boundary was derived from DSS-WISE™ Lite, which has inherent limitations. More advanced, precision methods exist. The information presented herein should be used for general reference only. CDM Smith makes no warranty, representation or guarantee as to the content, sequence, accuracy, timeliness or completeness of any of the information provided herein. CDM Smith, its contractors, suppliers, and consultants assume no liability for any damages due to errors, omissions, or positional accuracy in this product.

Author: BEERSJB

N

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6

1.7 - 3.3

3.4 - 5.4

5.5 - 8

8.1 - 11.3

11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
Basemap: Esri World Imagery

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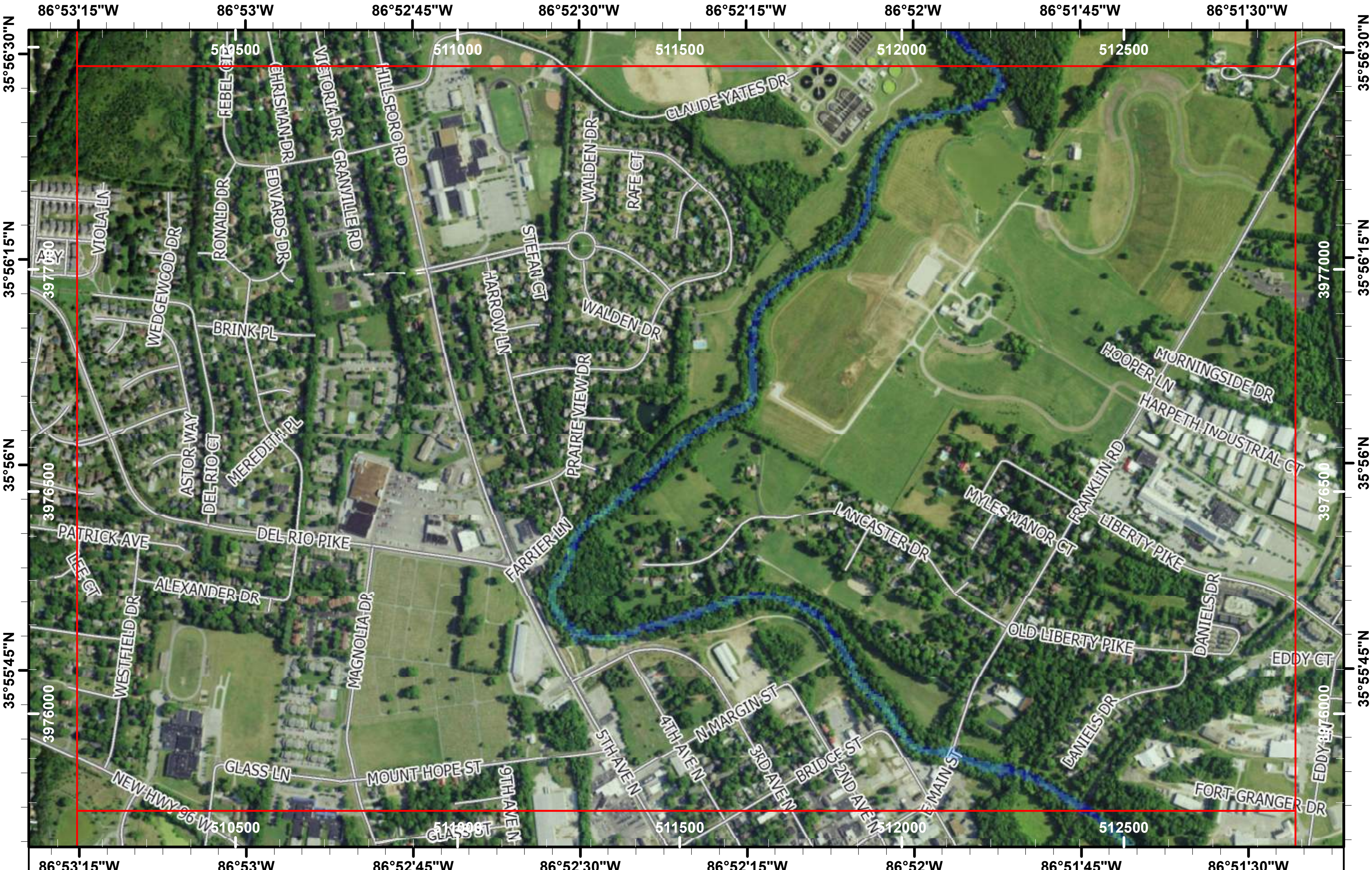

N

1 in = 1,000 feet

0 500 1,000 *Feet*

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
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Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
Basemap: Esri World Imagery

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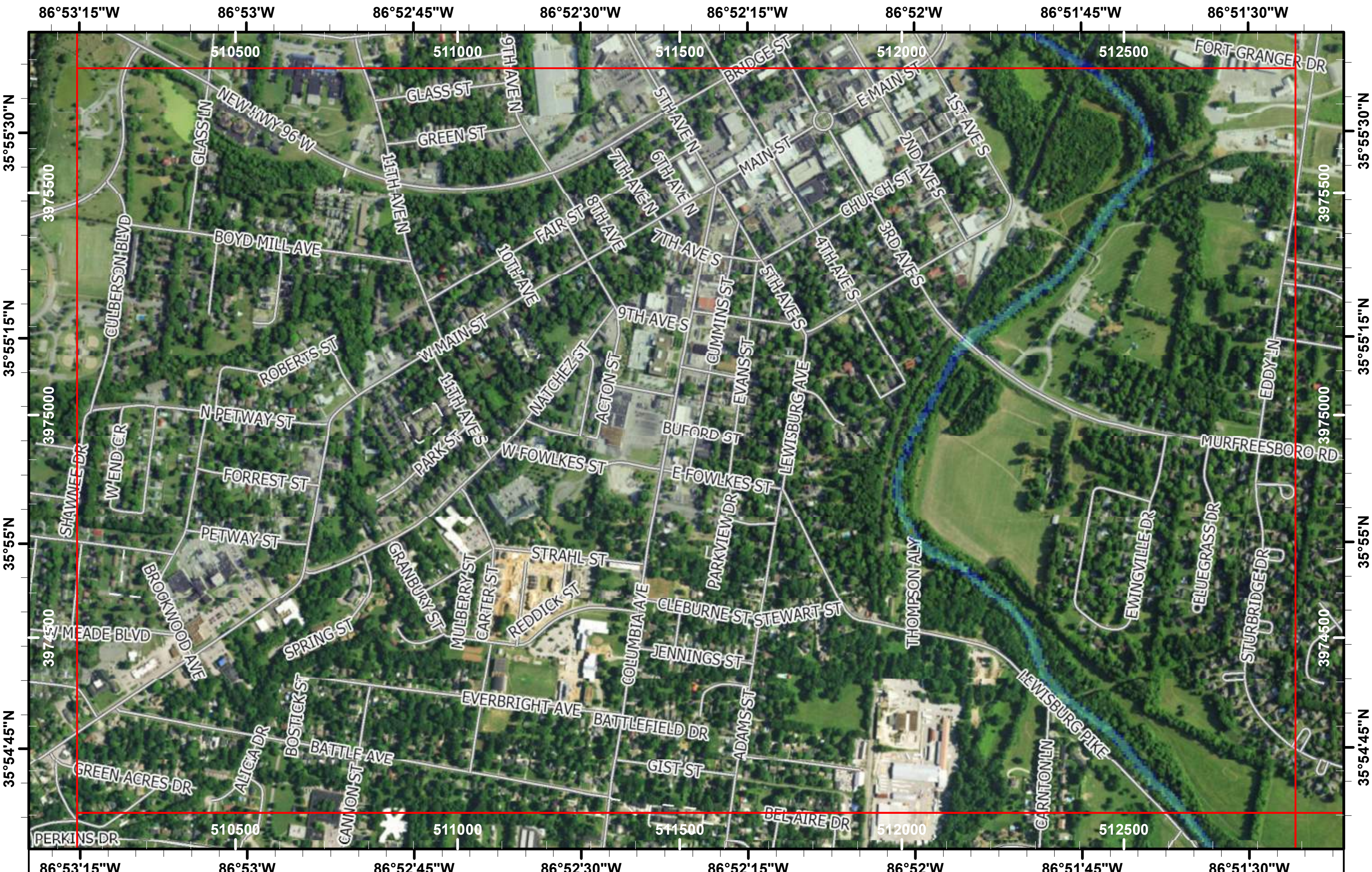

N

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6

1.7 - 3.3

3.4 - 5.4

5.5 - 8

8.1 - 11.3

11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources

Elev. Model: National Elev Dataset

Inundation Model: DSS-WISE™ Lite

At-Risk Structure Identification: Google Earth

Basemap: Esri World Imagery

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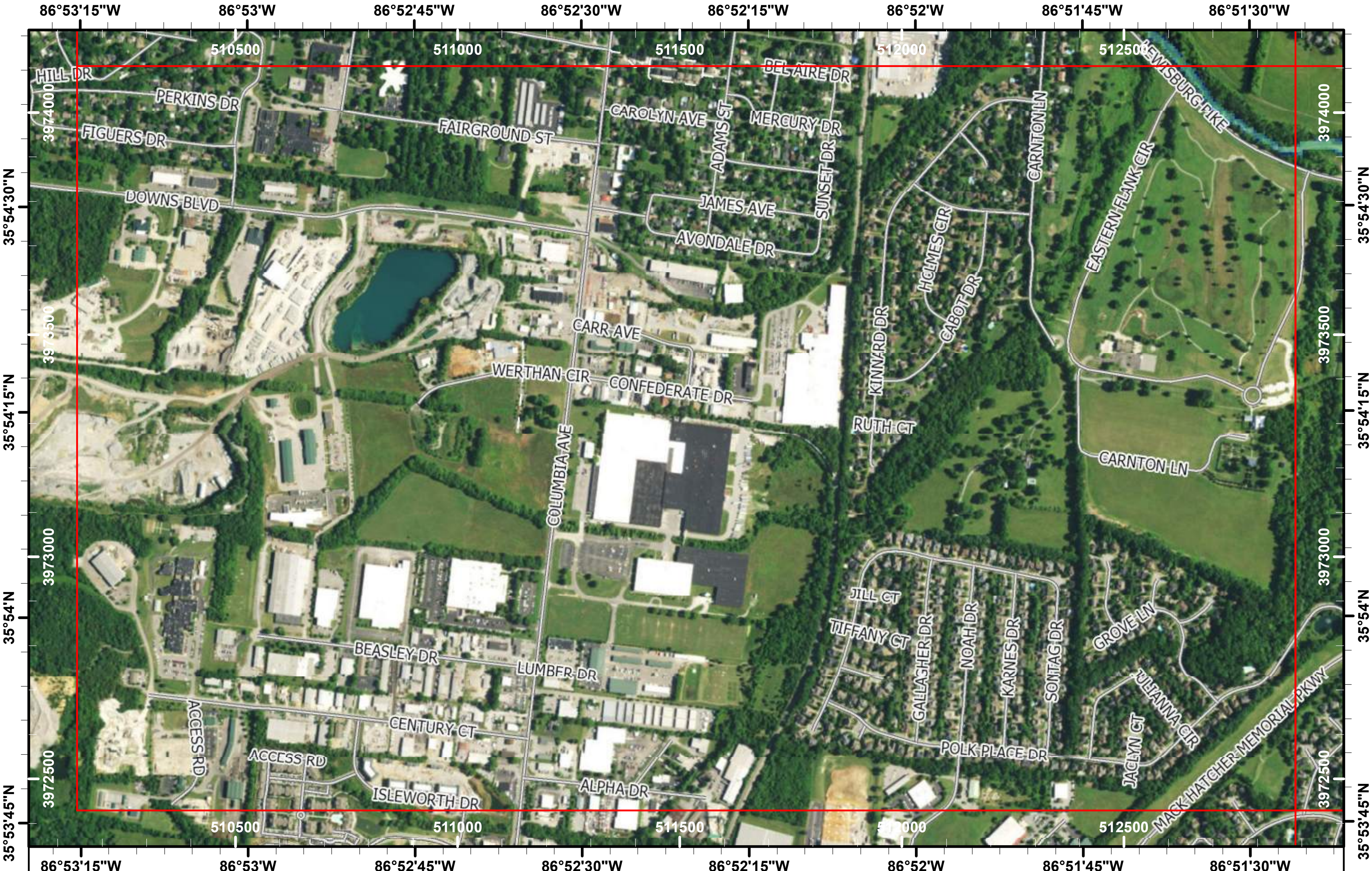

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
Basemap: Esri World Imagery

Inundation maps assist the dam owner and emergency management authorities with identifying critical infrastructure and population-at-risk sites that may require protective measures and warning and evacuation planning. The inundation boundary was derived from DSS-WISE™ Lite, which has inherent limitations. More advanced, precision methods exist. The information presented herein should be used for general reference only. CDM Smith makes no warranty, representation or guarantee as to the content, sequence, accuracy, timeliness or completeness of any of the information provided herein. CDM Smith, its contractors, suppliers, and consultants assume no liability for any damages due to errors, omissions, or positional accuracy in this product.

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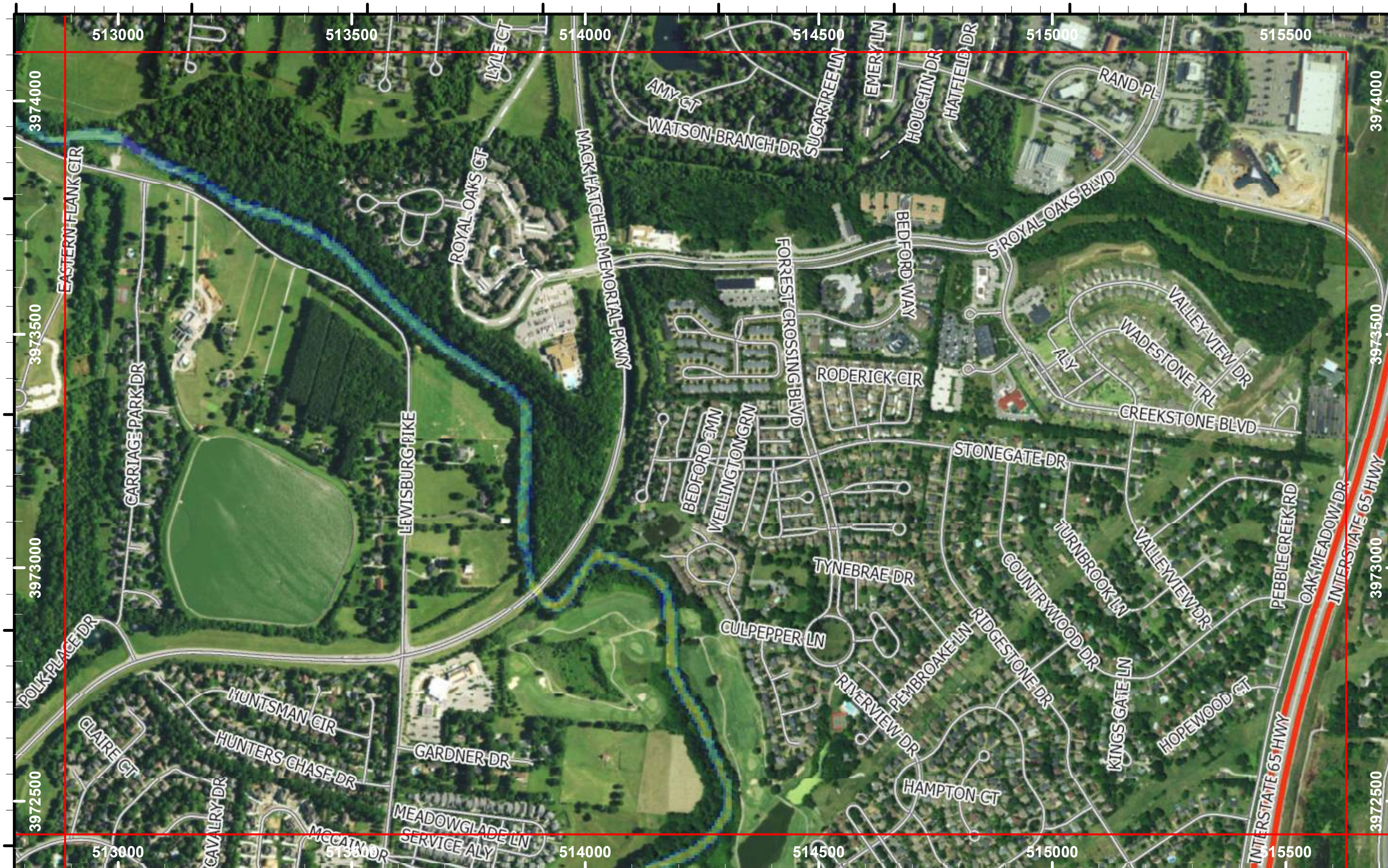

N

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure	
Dam	
Map Grid	

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
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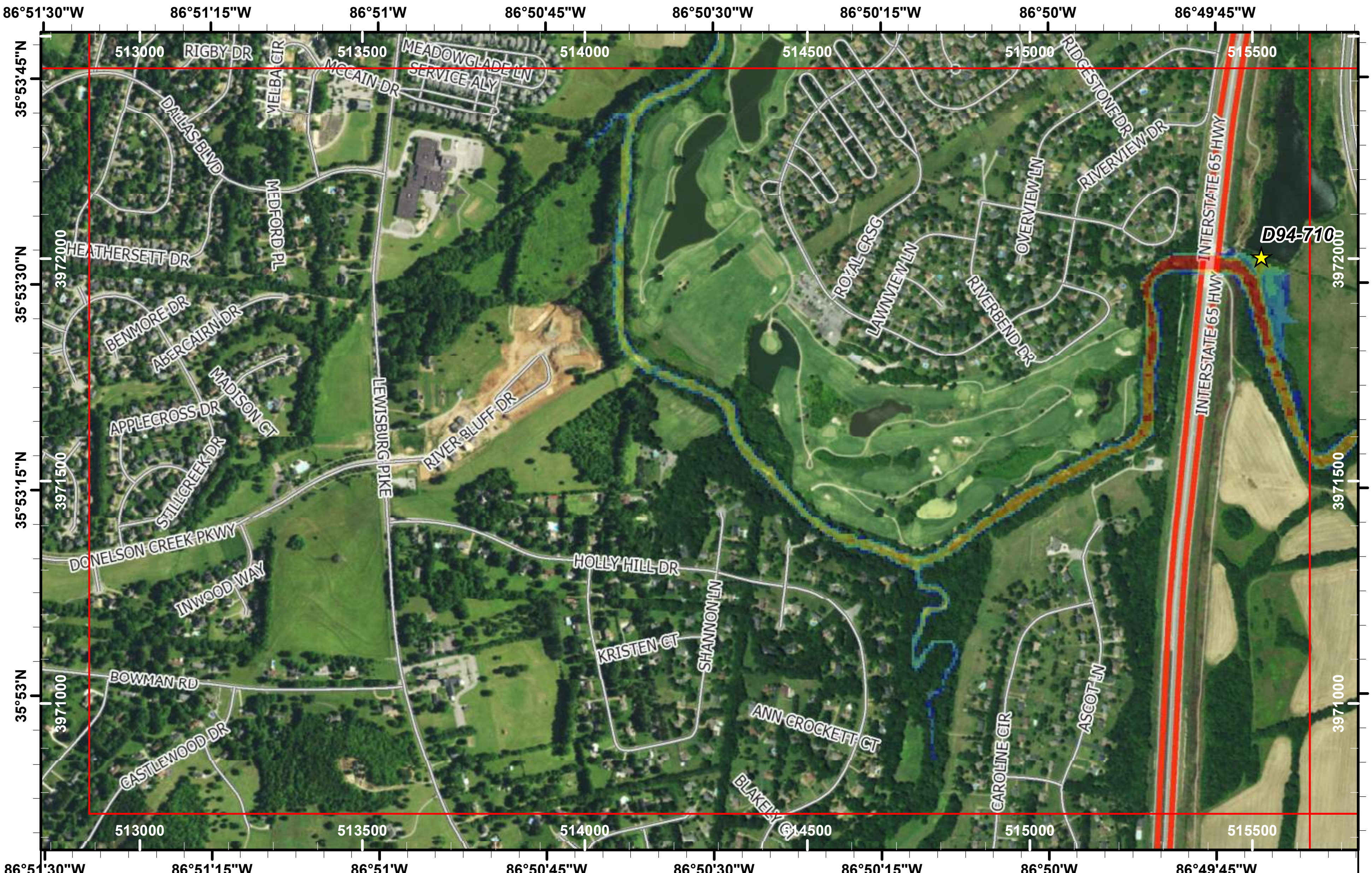

N

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
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N

1 in = 1,000 feet

0 500 1,000 Feet

NAD 1983, UTM Zone 16N

Identified At-Risk Structure

Dam

Map Grid

Flood Depth (Feet)

0 - 1.6	5.5 - 8
1.7 - 3.3	8.1 - 11.3
3.4 - 5.4	11.4 - 15.8

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
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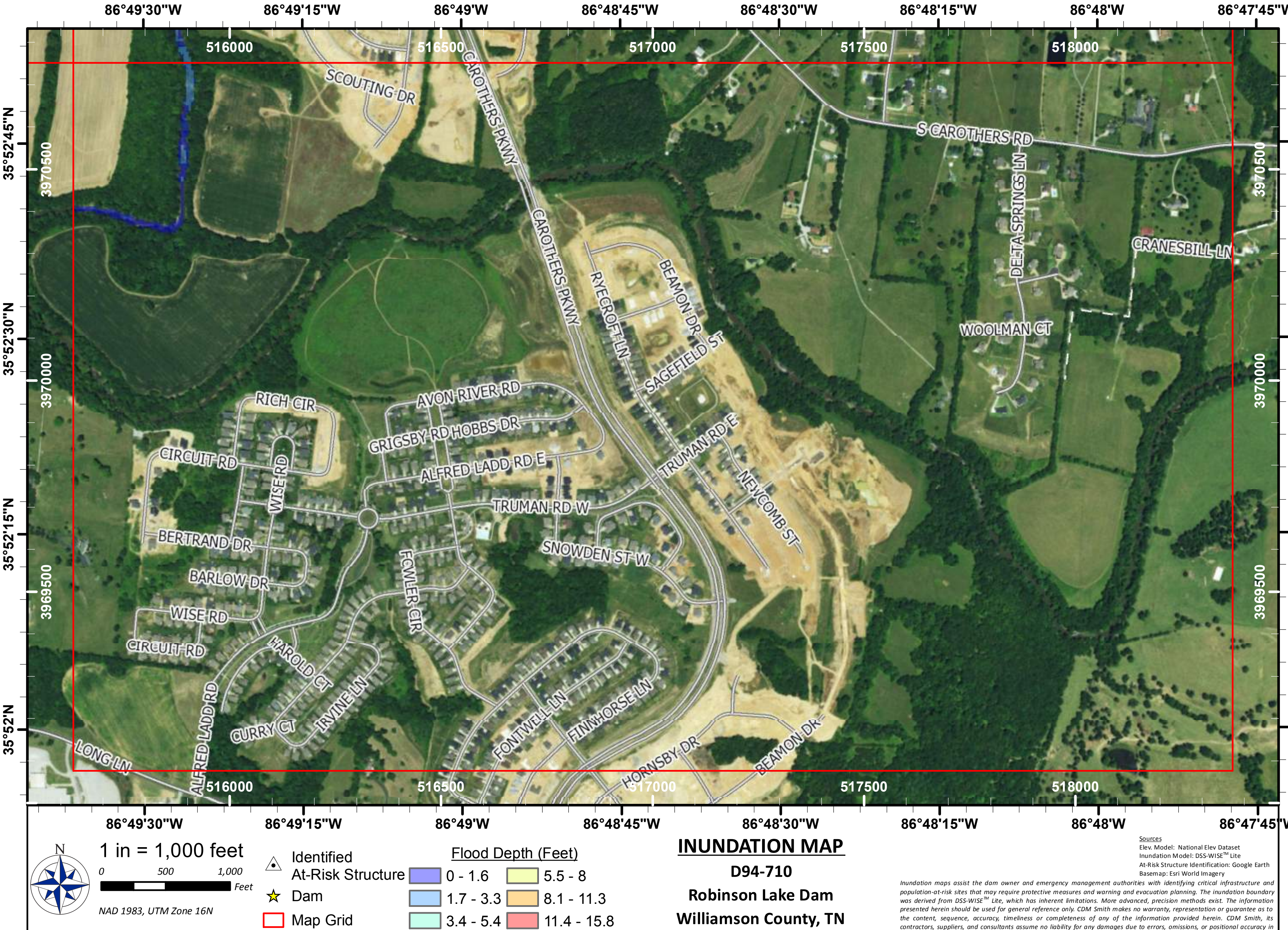

INUNDATION MAP

D94-710

Robinson Lake Dam

Williamson County, TN

Sources
Elev. Model: National Elev Dataset
Inundation Model: DSS-WISE™ Lite
At-Risk Structure Identification: Google Earth
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Author: BEERSJB

Appendix F

Hydrologic and Hydraulic (H/H) Analyses

1/3 PMP Model Run

Project: Robinson Lake Simulation Run: Run1

Reservoir: Reservoir-1

Start of Run:	01Jan2000, 00:00	Basin Model:	RobinsonLake
End of Run:	02Jan2000, 06:00	Meteorologic Model:	g. 1/3 PMP
Compute Time:	21Nov2017, 16:47:54	Control Specifications:	Control 1

Volume Units: (●) IN ( ) AC-FT

Computed Results

Peak Inflow:	3353.4 (CFS)	Date/Time of Peak Inflow:	01Jan2000, 03:30
Peak Discharge:	3286.0 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 03:35
Inflow Volume:	8.69 (IN)	Peak Storage:	65.1 (AC-FT)
Discharge Volume:	8.69 (IN)	Peak Elevation:	645.5 (FT)

One-Third PMP Design Storm

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
1-Jan-00	0:00	0	0	640	0
1-Jan-00	0:05	0	0	640	0
1-Jan-00	0:10	0	0	640	0
1-Jan-00	0:15	0	0	640	0
1-Jan-00	0:20	0	0	640	0
1-Jan-00	0:25	0	0	640	0
1-Jan-00	0:30	0	0	640	0
1-Jan-00	0:35	0	0	640	0
1-Jan-00	0:40	0	0	640	0
1-Jan-00	0:45	0	0	640	0
1-Jan-00	0:50	0	0	640	0
1-Jan-00	0:55	0	0	640	0
1-Jan-00	1:00	0	0	640	0
1-Jan-00	1:05	0.1	0	640	0
1-Jan-00	1:10	0.7	0	640	0
1-Jan-00	1:15	2.6	0	640	0
1-Jan-00	1:20	6.7	0	640	0
1-Jan-00	1:25	13.4	0.1	640	0.1
1-Jan-00	1:30	22.6	0.2	640	0.3
1-Jan-00	1:35	33.9	0.4	640	0.7
1-Jan-00	1:40	47.3	0.7	640.1	1.4
1-Jan-00	1:45	62.7	1.1	640.1	2.6
1-Jan-00	1:50	80.8	1.5	640.1	4.5
1-Jan-00	1:55	102.2	2.1	640.2	7.3
1-Jan-00	2:00	126.6	2.9	640.3	11.3
1-Jan-00	2:05	153.2	3.7	640.3	16.8
1-Jan-00	2:10	181.3	4.7	640.4	24.1
1-Jan-00	2:15	209.4	5.9	640.5	33.4
1-Jan-00	2:20	235.7	7.1	640.7	44.7
1-Jan-00	2:25	261.5	8.5	640.8	58
1-Jan-00	2:30	290.2	9.9	640.9	73.4
1-Jan-00	2:35	327.7	11.5	641	91.2
1-Jan-00	2:40	387.7	13.3	641.2	112.5
1-Jan-00	2:45	494.8	15.4	641.4	140.6
1-Jan-00	2:50	671.3	18.3	641.7	181.4
1-Jan-00	2:55	929.9	22.4	642	243.7
1-Jan-00	3:00	1273.4	28	642.5	337.1
1-Jan-00	3:05	1683.9	35.4	643.1	480.8
1-Jan-00	3:10	2124	44.2	643.9	756.7
1-Jan-00	3:15	2552.5	52.8	644.6	1482.2
1-Jan-00	3:20	2930.7	58.4	645	2269.8
1-Jan-00	3:25	3209.3	61.9	645.3	2784.8
1-Jan-00	3:30	3353.4	64.1	645.4	3119.5

Outlet Structures	Elevation
Riser and Barrel	640'
Auxiliary Spillway	643'
Emergency Spillway	644'
Dam Crest	645.5'

1-Jan-00	3:35	3347.7	65.1	645.5	3286
1-Jan-00	3:40	3192.5	65	645.5	3274.5
1-Jan-00	3:45	2913.6	64	645.4	3115
1-Jan-00	3:50	2559.4	62.3	645.3	2847.4
1-Jan-00	3:55	2183.1	60.3	645.1	2534.9
1-Jan-00	4:00	1827	57.9	645	2195.7
1-Jan-00	4:05	1516.4	55.7	644.8	1859.7
1-Jan-00	4:10	1264.3	53.5	644.6	1574.3
1-Jan-00	4:15	1071.8	51.6	644.5	1342
1-Jan-00	4:20	931.5	50	644.4	1160.7
1-Jan-00	4:25	832.3	48.6	644.2	1024
1-Jan-00	4:30	760.7	47.4	644.1	922.9
1-Jan-00	4:35	705.5	46.3	644.1	847.9
1-Jan-00	4:40	659.2	45.4	644	798
1-Jan-00	4:45	616.8	44.4	643.9	762.2
1-Jan-00	4:50	578.3	43.4	643.8	726.3
1-Jan-00	4:55	545.6	42.4	643.7	691.2
1-Jan-00	5:00	518.3	41.4	643.7	658.2
1-Jan-00	5:05	495	40.4	643.6	627.6
1-Jan-00	5:10	475.2	39.6	643.5	599.6
1-Jan-00	5:15	458.4	38.7	643.4	574.3
1-Jan-00	5:20	443.3	38	643.4	551.4
1-Jan-00	5:25	430	37.2	643.3	530.8
1-Jan-00	5:30	418.1	36.6	643.2	512.3
1-Jan-00	5:35	406.7	35.9	643.2	495.5
1-Jan-00	5:40	395.6	35.3	643.1	480.2
1-Jan-00	5:45	383.9	34.8	643.1	466.2
1-Jan-00	5:50	372.3	34.2	643.1	453.3
1-Jan-00	5:55	360.7	33.6	643	441.5
1-Jan-00	6:00	346.1	33.1	643	430.6
1-Jan-00	6:05	321.3	32.5	642.9	418.7
1-Jan-00	6:10	283.4	31.7	642.8	404.6
1-Jan-00	6:15	236.1	30.8	642.8	387.2
1-Jan-00	6:20	186.4	29.6	642.7	366.4
1-Jan-00	6:25	140.2	28.3	642.5	342.8
1-Jan-00	6:30	101.1	26.9	642.4	317.6
1-Jan-00	6:35	70.4	25.4	642.3	292
1-Jan-00	6:40	47.5	23.8	642.1	266.9
1-Jan-00	6:45	31.2	22.4	642	243.1
1-Jan-00	6:50	20	20.9	641.9	220.6
1-Jan-00	6:55	12.6	19.6	641.8	200.1
1-Jan-00	7:00	7.7	18.4	641.7	181.6
1-Jan-00	7:05	4.7	17.2	641.6	165
1-Jan-00	7:10	2.8	16.1	641.5	150.2
1-Jan-00	7:15	1.6	15.2	641.4	137.1
1-Jan-00	7:20	0.9	14.3	641.3	125.3
1-Jan-00	7:25	0.5	13.5	641.2	114.8

1-Jan-00	7:30	0.3	12.7	641.2	105.5
1-Jan-00	7:35	0.1	12	641.1	97.1
1-Jan-00	7:40	0.1	11.4	641	89.6
1-Jan-00	7:45	0	10.8	641	82.8
1-Jan-00	7:50	0	10.2	640.9	76.5
1-Jan-00	7:55	0	9.7	640.9	70.9
1-Jan-00	8:00	0	9.2	640.8	65.8
1-Jan-00	8:05	0	8.8	640.8	61.2
1-Jan-00	8:10	0	8.4	640.8	57
1-Jan-00	8:15	0	8	640.7	53.2
1-Jan-00	8:20	0	7.7	640.7	49.7
1-Jan-00	8:25	0	7.3	640.7	46.5
1-Jan-00	8:30	0	7	640.6	43.6
1-Jan-00	8:35	0	6.7	640.6	40.9
1-Jan-00	8:40	0	6.5	640.6	38.5
1-Jan-00	8:45	0	6.2	640.6	36.2
1-Jan-00	8:50	0	6	640.5	34.1
1-Jan-00	8:55	0	5.7	640.5	32.2
1-Jan-00	9:00	0	5.5	640.5	30.4
1-Jan-00	9:05	0	5.3	640.5	28.7
1-Jan-00	9:10	0	5.1	640.5	27.2
1-Jan-00	9:15	0	4.9	640.5	25.7
1-Jan-00	9:20	0	4.8	640.4	24.4
1-Jan-00	9:25	0	4.6	640.4	23.1
1-Jan-00	9:30	0	4.5	640.4	22
1-Jan-00	9:35	0	4.3	640.4	20.9
1-Jan-00	9:40	0	4.2	640.4	19.9
1-Jan-00	9:45	0	4	640.4	18.9
1-Jan-00	9:50	0	3.9	640.4	18
1-Jan-00	9:55	0	3.8	640.3	17.2
1-Jan-00	10:00	0	3.7	640.3	16.4
1-Jan-00	10:05	0	3.6	640.3	15.7
1-Jan-00	10:10	0	3.4	640.3	15
1-Jan-00	10:15	0	3.3	640.3	14.3
1-Jan-00	10:20	0	3.3	640.3	13.7
1-Jan-00	10:25	0	3.2	640.3	13.1
1-Jan-00	10:30	0	3.1	640.3	12.6
1-Jan-00	10:35	0	3	640.3	12.1
1-Jan-00	10:40	0	2.9	640.3	11.6
1-Jan-00	10:45	0	2.8	640.3	11.1
1-Jan-00	10:50	0	2.8	640.3	10.7
1-Jan-00	10:55	0	2.7	640.2	10.3
1-Jan-00	11:00	0	2.6	640.2	9.9
1-Jan-00	11:05	0	2.5	640.2	9.5
1-Jan-00	11:10	0	2.5	640.2	9.1
1-Jan-00	11:15	0	2.4	640.2	8.8
1-Jan-00	11:20	0	2.4	640.2	8.5

1-Jan-00	11:25	0	2.3	640.2	8.2
1-Jan-00	11:30	0	2.2	640.2	7.9
1-Jan-00	11:35	0	2.2	640.2	7.6
1-Jan-00	11:40	0	2.1	640.2	7.3
1-Jan-00	11:45	0	2.1	640.2	7.1
1-Jan-00	11:50	0	2	640.2	6.8
1-Jan-00	11:55	0	2	640.2	6.6
1-Jan-00	12:00	0	2	640.2	6.4
1-Jan-00	12:05	0	1.9	640.2	6.2
1-Jan-00	12:10	0	1.9	640.2	6
1-Jan-00	12:15	0	1.8	640.2	5.8
1-Jan-00	12:20	0	1.8	640.2	5.6
1-Jan-00	12:25	0	1.7	640.2	5.4
1-Jan-00	12:30	0	1.7	640.2	5.2
1-Jan-00	12:35	0	1.7	640.2	5.1
1-Jan-00	12:40	0	1.6	640.2	4.9
1-Jan-00	12:45	0	1.6	640.1	4.8
1-Jan-00	12:50	0	1.6	640.1	4.6
1-Jan-00	12:55	0	1.5	640.1	4.5
1-Jan-00	13:00	0	1.5	640.1	4.4
1-Jan-00	13:05	0	1.5	640.1	4.2
1-Jan-00	13:10	0	1.5	640.1	4.1
1-Jan-00	13:15	0	1.4	640.1	4
1-Jan-00	13:20	0	1.4	640.1	3.9
1-Jan-00	13:25	0	1.4	640.1	3.8
1-Jan-00	13:30	0	1.3	640.1	3.7
1-Jan-00	13:35	0	1.3	640.1	3.6
1-Jan-00	13:40	0	1.3	640.1	3.5
1-Jan-00	13:45	0	1.3	640.1	3.4
1-Jan-00	13:50	0	1.3	640.1	3.3
1-Jan-00	13:55	0	1.2	640.1	3.2
1-Jan-00	14:00	0	1.2	640.1	3.1
1-Jan-00	14:05	0	1.2	640.1	3
1-Jan-00	14:10	0	1.2	640.1	3
1-Jan-00	14:15	0	1.1	640.1	2.9
1-Jan-00	14:20	0	1.1	640.1	2.8
1-Jan-00	14:25	0	1.1	640.1	2.7
1-Jan-00	14:30	0	1.1	640.1	2.7
1-Jan-00	14:35	0	1.1	640.1	2.6
1-Jan-00	14:40	0	1.1	640.1	2.5
1-Jan-00	14:45	0	1	640.1	2.5
1-Jan-00	14:50	0	1	640.1	2.4
1-Jan-00	14:55	0	1	640.1	2.4
1-Jan-00	15:00	0	1	640.1	2.3
1-Jan-00	15:05	0	1	640.1	2.2
1-Jan-00	15:10	0	1	640.1	2.2
1-Jan-00	15:15	0	0.9	640.1	2.1

1-Jan-00	15:20	0	0.9	640.1	2.1
1-Jan-00	15:25	0	0.9	640.1	2
1-Jan-00	15:30	0	0.9	640.1	2
1-Jan-00	15:35	0	0.9	640.1	2
1-Jan-00	15:40	0	0.9	640.1	1.9
1-Jan-00	15:45	0	0.9	640.1	1.9
1-Jan-00	15:50	0	0.8	640.1	1.8
1-Jan-00	15:55	0	0.8	640.1	1.8
1-Jan-00	16:00	0	0.8	640.1	1.7
1-Jan-00	16:05	0	0.8	640.1	1.7
1-Jan-00	16:10	0	0.8	640.1	1.7
1-Jan-00	16:15	0	0.8	640.1	1.6
1-Jan-00	16:20	0	0.8	640.1	1.6
1-Jan-00	16:25	0	0.8	640.1	1.6
1-Jan-00	16:30	0	0.8	640.1	1.5
1-Jan-00	16:35	0	0.7	640.1	1.5
1-Jan-00	16:40	0	0.7	640.1	1.5
1-Jan-00	16:45	0	0.7	640.1	1.4
1-Jan-00	16:50	0	0.7	640.1	1.4
1-Jan-00	16:55	0	0.7	640.1	1.4
1-Jan-00	17:00	0	0.7	640.1	1.4
1-Jan-00	17:05	0	0.7	640.1	1.3
1-Jan-00	17:10	0	0.7	640.1	1.3
1-Jan-00	17:15	0	0.7	640.1	1.3
1-Jan-00	17:20	0	0.7	640.1	1.3
1-Jan-00	17:25	0	0.7	640.1	1.2
1-Jan-00	17:30	0	0.6	640.1	1.2
1-Jan-00	17:35	0	0.6	640.1	1.2
1-Jan-00	17:40	0	0.6	640.1	1.2
1-Jan-00	17:45	0	0.6	640.1	1.1
1-Jan-00	17:50	0	0.6	640.1	1.1
1-Jan-00	17:55	0	0.6	640.1	1.1
1-Jan-00	18:00	0	0.6	640.1	1.1
1-Jan-00	18:05	0	0.6	640.1	1.1
1-Jan-00	18:10	0	0.6	640.1	1
1-Jan-00	18:15	0	0.6	640.1	1
1-Jan-00	18:20	0	0.6	640.1	1
1-Jan-00	18:25	0	0.6	640.1	1
1-Jan-00	18:30	0	0.6	640.1	1
1-Jan-00	18:35	0	0.5	640	0.9
1-Jan-00	18:40	0	0.5	640	0.9
1-Jan-00	18:45	0	0.5	640	0.9
1-Jan-00	18:50	0	0.5	640	0.9
1-Jan-00	18:55	0	0.5	640	0.9
1-Jan-00	19:00	0	0.5	640	0.9
1-Jan-00	19:05	0	0.5	640	0.9
1-Jan-00	19:10	0	0.5	640	0.8

1-Jan-00	19:15	0	0.5	640	0.8
1-Jan-00	19:20	0	0.5	640	0.8
1-Jan-00	19:25	0	0.5	640	0.8
1-Jan-00	19:30	0	0.5	640	0.8
1-Jan-00	19:35	0	0.5	640	0.8
1-Jan-00	19:40	0	0.5	640	0.8
1-Jan-00	19:45	0	0.5	640	0.7
1-Jan-00	19:50	0	0.5	640	0.7
1-Jan-00	19:55	0	0.5	640	0.7
1-Jan-00	20:00	0	0.5	640	0.7
1-Jan-00	20:05	0	0.4	640	0.7
1-Jan-00	20:10	0	0.4	640	0.7
1-Jan-00	20:15	0	0.4	640	0.7
1-Jan-00	20:20	0	0.4	640	0.7
1-Jan-00	20:25	0	0.4	640	0.7
1-Jan-00	20:30	0	0.4	640	0.6
1-Jan-00	20:35	0	0.4	640	0.6
1-Jan-00	20:40	0	0.4	640	0.6
1-Jan-00	20:45	0	0.4	640	0.6
1-Jan-00	20:50	0	0.4	640	0.6
1-Jan-00	20:55	0	0.4	640	0.6
1-Jan-00	21:00	0	0.4	640	0.6
1-Jan-00	21:05	0	0.4	640	0.6
1-Jan-00	21:10	0	0.4	640	0.6
1-Jan-00	21:15	0	0.4	640	0.6
1-Jan-00	21:20	0	0.4	640	0.6
1-Jan-00	21:25	0	0.4	640	0.5
1-Jan-00	21:30	0	0.4	640	0.5
1-Jan-00	21:35	0	0.4	640	0.5
1-Jan-00	21:40	0	0.4	640	0.5
1-Jan-00	21:45	0	0.4	640	0.5
1-Jan-00	21:50	0	0.4	640	0.5
1-Jan-00	21:55	0	0.4	640	0.5
1-Jan-00	22:00	0	0.4	640	0.5
1-Jan-00	22:05	0	0.3	640	0.5
1-Jan-00	22:10	0	0.3	640	0.5
1-Jan-00	22:15	0	0.3	640	0.5
1-Jan-00	22:20	0	0.3	640	0.5
1-Jan-00	22:25	0	0.3	640	0.5
1-Jan-00	22:30	0	0.3	640	0.5
1-Jan-00	22:35	0	0.3	640	0.4
1-Jan-00	22:40	0	0.3	640	0.4
1-Jan-00	22:45	0	0.3	640	0.4
1-Jan-00	22:50	0	0.3	640	0.4
1-Jan-00	22:55	0	0.3	640	0.4
1-Jan-00	23:00	0	0.3	640	0.4
1-Jan-00	23:05	0	0.3	640	0.4

1-Jan-00	23:10	0	0.3	640	0.4
1-Jan-00	23:15	0	0.3	640	0.4
1-Jan-00	23:20	0	0.3	640	0.4
1-Jan-00	23:25	0	0.3	640	0.4
1-Jan-00	23:30	0	0.3	640	0.4
1-Jan-00	23:35	0	0.3	640	0.4
1-Jan-00	23:40	0	0.3	640	0.4
1-Jan-00	23:45	0	0.3	640	0.4
1-Jan-00	23:50	0	0.3	640	0.4
1-Jan-00	23:55	0	0.3	640	0.4
2-Jan-00	0:00	0	0.3	640	0.4
2-Jan-00	0:05	0	0.3	640	0.3
2-Jan-00	0:10	0	0.3	640	0.3
2-Jan-00	0:15	0	0.3	640	0.3
2-Jan-00	0:20	0	0.3	640	0.3
2-Jan-00	0:25	0	0.3	640	0.3
2-Jan-00	0:30	0	0.3	640	0.3
2-Jan-00	0:35	0	0.3	640	0.3
2-Jan-00	0:40	0	0.3	640	0.3
2-Jan-00	0:45	0	0.3	640	0.3
2-Jan-00	0:50	0	0.3	640	0.3
2-Jan-00	0:55	0	0.3	640	0.3
2-Jan-00	1:00	0	0.3	640	0.3
2-Jan-00	1:05	0	0.3	640	0.3
2-Jan-00	1:10	0	0.3	640	0.3
2-Jan-00	1:15	0	0.3	640	0.3
2-Jan-00	1:20	0	0.2	640	0.3
2-Jan-00	1:25	0	0.2	640	0.3
2-Jan-00	1:30	0	0.2	640	0.3
2-Jan-00	1:35	0	0.2	640	0.3
2-Jan-00	1:40	0	0.2	640	0.3
2-Jan-00	1:45	0	0.2	640	0.3
2-Jan-00	1:50	0	0.2	640	0.3
2-Jan-00	1:55	0	0.2	640	0.3
2-Jan-00	2:00	0	0.2	640	0.3
2-Jan-00	2:05	0	0.2	640	0.3
2-Jan-00	2:10	0	0.2	640	0.3
2-Jan-00	2:15	0	0.2	640	0.3
2-Jan-00	2:20	0	0.2	640	0.3
2-Jan-00	2:25	0	0.2	640	0.2
2-Jan-00	2:30	0	0.2	640	0.2
2-Jan-00	2:35	0	0.2	640	0.2
2-Jan-00	2:40	0	0.2	640	0.2
2-Jan-00	2:45	0	0.2	640	0.2
2-Jan-00	2:50	0	0.2	640	0.2
2-Jan-00	2:55	0	0.2	640	0.2
2-Jan-00	3:00	0	0.2	640	0.2

2-Jan-00	3:05	0	0.2	640	0.2
2-Jan-00	3:10	0	0.2	640	0.2
2-Jan-00	3:15	0	0.2	640	0.2
2-Jan-00	3:20	0	0.2	640	0.2
2-Jan-00	3:25	0	0.2	640	0.2
2-Jan-00	3:30	0	0.2	640	0.2
2-Jan-00	3:35	0	0.2	640	0.2
2-Jan-00	3:40	0	0.2	640	0.2
2-Jan-00	3:45	0	0.2	640	0.2
2-Jan-00	3:50	0	0.2	640	0.2
2-Jan-00	3:55	0	0.2	640	0.2
2-Jan-00	4:00	0	0.2	640	0.2
2-Jan-00	4:05	0	0.2	640	0.2
2-Jan-00	4:10	0	0.2	640	0.2
2-Jan-00	4:15	0	0.2	640	0.2
2-Jan-00	4:20	0	0.2	640	0.2
2-Jan-00	4:25	0	0.2	640	0.2
2-Jan-00	4:30	0	0.2	640	0.2
2-Jan-00	4:35	0	0.2	640	0.2
2-Jan-00	4:40	0	0.2	640	0.2
2-Jan-00	4:45	0	0.2	640	0.2
2-Jan-00	4:50	0	0.2	640	0.2
2-Jan-00	4:55	0	0.2	640	0.2
2-Jan-00	5:00	0	0.2	640	0.2
2-Jan-00	5:05	0	0.2	640	0.2
2-Jan-00	5:10	0	0.2	640	0.2
2-Jan-00	5:15	0	0.2	640	0.2
2-Jan-00	5:20	0	0.2	640	0.2
2-Jan-00	5:25	0	0.2	640	0.2
2-Jan-00	5:30	0	0.2	640	0.2
2-Jan-00	5:35	0	0.2	640	0.2
2-Jan-00	5:40	0	0.2	640	0.2
2-Jan-00	5:45	0	0.2	640	0.2
2-Jan-00	5:50	0	0.2	640	0.2
2-Jan-00	5:55	0	0.2	640	0.2
2-Jan-00	6:00	0	0.2	640	0.2

100-year 6 hour Model Run

Project: Robinson Lake   Simulation Run: Run1

Reservoir: Reservoir-1

Start of Run:	01Jan2000, 00:00	Basin Model:	RobinsonLake
End of Run:	02Jan2000, 06:00	Meteorologic Model:	c. 100 yr 6 hr
Compute Time:	21Nov2017, 16:49:11	Control Specifications:	Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow:	1272.0 (CFS)	Date/Time of Peak Inflow:	01Jan2000, 03:30
Peak Discharge:	767.5 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 03:55
Inflow Volume:	2.66 (IN)	Peak Storage:	44.5 (AC-FT)
Discharge Volume:	2.66 (IN)	Peak Elevation:	643.9 (FT)

100-Year 6 Hour Storm

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
1-Jan-00	0:00	0	0	640	0
1-Jan-00	0:05	0	0	640	0
1-Jan-00	0:10	0	0	640	0
1-Jan-00	0:15	0	0	640	0
1-Jan-00	0:20	0	0	640	0
1-Jan-00	0:25	0	0	640	0
1-Jan-00	0:30	0	0	640	0
1-Jan-00	0:35	0	0	640	0
1-Jan-00	0:40	0	0	640	0
1-Jan-00	0:45	0	0	640	0
1-Jan-00	0:50	0	0	640	0
1-Jan-00	0:55	0	0	640	0
1-Jan-00	1:00	0	0	640	0
1-Jan-00	1:05	0	0	640	0
1-Jan-00	1:10	0	0	640	0
1-Jan-00	1:15	0	0	640	0
1-Jan-00	1:20	0	0	640	0
1-Jan-00	1:25	0	0	640	0
1-Jan-00	1:30	0	0	640	0
1-Jan-00	1:35	0	0	640	0
1-Jan-00	1:40	0	0	640	0
1-Jan-00	1:45	0	0	640	0
1-Jan-00	1:50	0	0	640	0
1-Jan-00	1:55	0	0	640	0
1-Jan-00	2:00	0	0	640	0
1-Jan-00	2:05	0	0	640	0
1-Jan-00	2:10	0	0	640	0
1-Jan-00	2:15	0.3	0	640	0
1-Jan-00	2:20	1	0	640	0
1-Jan-00	2:25	2.6	0	640	0
1-Jan-00	2:30	5.5	0	640	0
1-Jan-00	2:35	10.2	0.1	640	0.1
1-Jan-00	2:40	19.4	0.2	640	0.2
1-Jan-00	2:45	36.3	0.4	640	0.6
1-Jan-00	2:50	64.5	0.7	640.1	1.5
1-Jan-00	2:55	111.8	1.3	640.1	3.5
1-Jan-00	3:00	189.7	2.3	640.2	8.3
1-Jan-00	3:05	321.8	4	640.4	18.6
1-Jan-00	3:10	541	6.8	640.6	41.1
1-Jan-00	3:15	809.4	11	641	85.1
1-Jan-00	3:20	1051.9	16.6	641.5	155.9
1-Jan-00	3:25	1211.8	22.9	642.1	252.5
1-Jan-00	3:30	1272	29.4	642.6	362.1

Outlet Structures	Elevation
Riser and Barrel	640'
Auxiliary Spillway	643'
Emergency Spillway	644'
Dam Crest	645.5'

1-Jan-00	3:35	1246.3	35.2	643.1	476.3
1-Jan-00	3:40	1156.1	39.7	643.5	605
1-Jan-00	3:45	1024.9	42.7	643.8	703.8
1-Jan-00	3:50	876.9	44.2	643.9	757.1
1-Jan-00	3:55	731.8	44.5	643.9	767.5
1-Jan-00	4:00	602.3	43.9	643.9	745.4
1-Jan-00	4:05	494	42.7	643.8	702.9
1-Jan-00	4:10	406.9	41.2	643.6	650.6
1-Jan-00	4:15	338.5	39.4	643.5	595.7
1-Jan-00	4:20	285.5	37.7	643.3	543
1-Jan-00	4:25	244.7	35.9	643.2	495.1
1-Jan-00	4:30	213.6	34.2	643.1	454.1
1-Jan-00	4:35	190	32.6	642.9	421.9
1-Jan-00	4:40	173.4	31.1	642.8	392.8
1-Jan-00	4:45	163.4	29.6	642.7	366.2
1-Jan-00	4:50	158.3	28.3	642.5	342.4
1-Jan-00	4:55	155.7	27.1	642.4	321.3
1-Jan-00	5:00	154.8	26	642.3	302.8
1-Jan-00	5:05	154	25	642.3	286.6
1-Jan-00	5:10	152.8	24.2	642.2	272.2
1-Jan-00	5:15	150.9	23.4	642.1	259.5
1-Jan-00	5:20	148.5	22.7	642	248
1-Jan-00	5:25	145.7	22	642	237.6
1-Jan-00	5:30	142.6	21.4	641.9	227.9
1-Jan-00	5:35	139.3	20.8	641.9	219
1-Jan-00	5:40	136.1	20.3	641.8	210.7
1-Jan-00	5:45	132.8	19.8	641.8	203.1
1-Jan-00	5:50	129.7	19.3	641.7	196
1-Jan-00	5:55	126.7	18.9	641.7	189.4
1-Jan-00	6:00	123.8	18.5	641.7	183.2
1-Jan-00	6:05	120.5	18.1	641.6	177.3
1-Jan-00	6:10	114	17.7	641.6	171.6
1-Jan-00	6:15	102.4	17.3	641.6	165.7
1-Jan-00	6:20	86.6	16.8	641.5	159.1
1-Jan-00	6:25	69.2	16.3	641.5	151.7
1-Jan-00	6:30	52.6	15.7	641.4	143.5
1-Jan-00	6:35	38.3	15	641.4	134.9
1-Jan-00	6:40	26.8	14.3	641.3	126.1
1-Jan-00	6:45	18.2	13.7	641.2	117.3
1-Jan-00	6:50	12	13	641.2	108.9
1-Jan-00	6:55	7.7	12.3	641.1	100.9
1-Jan-00	7:00	4.9	11.7	641.1	93.5
1-Jan-00	7:05	3	11.1	641	86.6
1-Jan-00	7:10	1.8	10.6	641	80.2
1-Jan-00	7:15	1.1	10	640.9	74.3
1-Jan-00	7:20	0.6	9.5	640.9	69
1-Jan-00	7:25	0.4	9.1	640.8	64.1

1-Jan-00	7:30	0.2	8.7	640.8	59.7
1-Jan-00	7:35	0.1	8.3	640.8	55.6
1-Jan-00	7:40	0.1	7.9	640.7	51.9
1-Jan-00	7:45	0	7.6	640.7	48.6
1-Jan-00	7:50	0	7.2	640.7	45.5
1-Jan-00	7:55	0	6.9	640.6	42.6
1-Jan-00	8:00	0	6.6	640.6	40
1-Jan-00	8:05	0	6.4	640.6	37.7
1-Jan-00	8:10	0	6.1	640.6	35.4
1-Jan-00	8:15	0	5.9	640.5	33.4
1-Jan-00	8:20	0	5.7	640.5	31.5
1-Jan-00	8:25	0	5.4	640.5	29.8
1-Jan-00	8:30	0	5.3	640.5	28.2
1-Jan-00	8:35	0	5.1	640.5	26.7
1-Jan-00	8:40	0	4.9	640.4	25.3
1-Jan-00	8:45	0	4.7	640.4	23.9
1-Jan-00	8:50	0	4.6	640.4	22.7
1-Jan-00	8:55	0	4.4	640.4	21.6
1-Jan-00	9:00	0	4.3	640.4	20.5
1-Jan-00	9:05	0	4.1	640.4	19.5
1-Jan-00	9:10	0	4	640.4	18.6
1-Jan-00	9:15	0	3.9	640.4	17.8
1-Jan-00	9:20	0	3.7	640.3	16.9
1-Jan-00	9:25	0	3.6	640.3	16.2
1-Jan-00	9:30	0	3.5	640.3	15.4
1-Jan-00	9:35	0	3.4	640.3	14.8
1-Jan-00	9:40	0	3.3	640.3	14.1
1-Jan-00	9:45	0	3.2	640.3	13.5
1-Jan-00	9:50	0	3.1	640.3	12.9
1-Jan-00	9:55	0	3	640.3	12.4
1-Jan-00	10:00	0	3	640.3	11.9
1-Jan-00	10:05	0	2.9	640.3	11.4
1-Jan-00	10:10	0	2.8	640.3	11
1-Jan-00	10:15	0	2.7	640.2	10.5
1-Jan-00	10:20	0	2.7	640.2	10.1
1-Jan-00	10:25	0	2.6	640.2	9.7
1-Jan-00	10:30	0	2.5	640.2	9.4
1-Jan-00	10:35	0	2.5	640.2	9
1-Jan-00	10:40	0	2.4	640.2	8.7
1-Jan-00	10:45	0	2.3	640.2	8.4
1-Jan-00	10:50	0	2.3	640.2	8.1
1-Jan-00	10:55	0	2.2	640.2	7.8
1-Jan-00	11:00	0	2.2	640.2	7.5
1-Jan-00	11:05	0	2.1	640.2	7.2
1-Jan-00	11:10	0	2.1	640.2	7
1-Jan-00	11:15	0	2	640.2	6.8
1-Jan-00	11:20	0	2	640.2	6.5

1-Jan-00	11:25	0	1.9	640.2	6.3
1-Jan-00	11:30	0	1.9	640.2	6.1
1-Jan-00	11:35	0	1.9	640.2	5.9
1-Jan-00	11:40	0	1.8	640.2	5.7
1-Jan-00	11:45	0	1.8	640.2	5.5
1-Jan-00	11:50	0	1.7	640.2	5.4
1-Jan-00	11:55	0	1.7	640.2	5.2
1-Jan-00	12:00	0	1.7	640.2	5
1-Jan-00	12:05	0	1.6	640.1	4.9
1-Jan-00	12:10	0	1.6	640.1	4.7
1-Jan-00	12:15	0	1.6	640.1	4.6
1-Jan-00	12:20	0	1.5	640.1	4.4
1-Jan-00	12:25	0	1.5	640.1	4.3
1-Jan-00	12:30	0	1.5	640.1	4.2
1-Jan-00	12:35	0	1.4	640.1	4.1
1-Jan-00	12:40	0	1.4	640.1	4
1-Jan-00	12:45	0	1.4	640.1	3.8
1-Jan-00	12:50	0	1.4	640.1	3.7
1-Jan-00	12:55	0	1.3	640.1	3.6
1-Jan-00	13:00	0	1.3	640.1	3.5
1-Jan-00	13:05	0	1.3	640.1	3.4
1-Jan-00	13:10	0	1.3	640.1	3.3
1-Jan-00	13:15	0	1.2	640.1	3.3
1-Jan-00	13:20	0	1.2	640.1	3.2
1-Jan-00	13:25	0	1.2	640.1	3.1
1-Jan-00	13:30	0	1.2	640.1	3
1-Jan-00	13:35	0	1.2	640.1	2.9
1-Jan-00	13:40	0	1.1	640.1	2.9
1-Jan-00	13:45	0	1.1	640.1	2.8
1-Jan-00	13:50	0	1.1	640.1	2.7
1-Jan-00	13:55	0	1.1	640.1	2.6
1-Jan-00	14:00	0	1.1	640.1	2.6
1-Jan-00	14:05	0	1	640.1	2.5
1-Jan-00	14:10	0	1	640.1	2.5
1-Jan-00	14:15	0	1	640.1	2.4
1-Jan-00	14:20	0	1	640.1	2.3
1-Jan-00	14:25	0	1	640.1	2.3
1-Jan-00	14:30	0	1	640.1	2.2
1-Jan-00	14:35	0	1	640.1	2.2
1-Jan-00	14:40	0	0.9	640.1	2.1
1-Jan-00	14:45	0	0.9	640.1	2.1
1-Jan-00	14:50	0	0.9	640.1	2
1-Jan-00	14:55	0	0.9	640.1	2
1-Jan-00	15:00	0	0.9	640.1	1.9
1-Jan-00	15:05	0	0.9	640.1	1.9
1-Jan-00	15:10	0	0.9	640.1	1.9
1-Jan-00	15:15	0	0.8	640.1	1.8

1-Jan-00	15:20	0	0.8	640.1	1.8
1-Jan-00	15:25	0	0.8	640.1	1.7
1-Jan-00	15:30	0	0.8	640.1	1.7
1-Jan-00	15:35	0	0.8	640.1	1.7
1-Jan-00	15:40	0	0.8	640.1	1.6
1-Jan-00	15:45	0	0.8	640.1	1.6
1-Jan-00	15:50	0	0.8	640.1	1.6
1-Jan-00	15:55	0	0.8	640.1	1.5
1-Jan-00	16:00	0	0.7	640.1	1.5
1-Jan-00	16:05	0	0.7	640.1	1.5
1-Jan-00	16:10	0	0.7	640.1	1.4
1-Jan-00	16:15	0	0.7	640.1	1.4
1-Jan-00	16:20	0	0.7	640.1	1.4
1-Jan-00	16:25	0	0.7	640.1	1.3
1-Jan-00	16:30	0	0.7	640.1	1.3
1-Jan-00	16:35	0	0.7	640.1	1.3
1-Jan-00	16:40	0	0.7	640.1	1.3
1-Jan-00	16:45	0	0.7	640.1	1.2
1-Jan-00	16:50	0	0.6	640.1	1.2
1-Jan-00	16:55	0	0.6	640.1	1.2
1-Jan-00	17:00	0	0.6	640.1	1.2
1-Jan-00	17:05	0	0.6	640.1	1.2
1-Jan-00	17:10	0	0.6	640.1	1.1
1-Jan-00	17:15	0	0.6	640.1	1.1
1-Jan-00	17:20	0	0.6	640.1	1.1
1-Jan-00	17:25	0	0.6	640.1	1.1
1-Jan-00	17:30	0	0.6	640.1	1
1-Jan-00	17:35	0	0.6	640.1	1
1-Jan-00	17:40	0	0.6	640.1	1
1-Jan-00	17:45	0	0.6	640.1	1
1-Jan-00	17:50	0	0.6	640.1	1
1-Jan-00	17:55	0	0.6	640.1	1
1-Jan-00	18:00	0	0.5	640	0.9
1-Jan-00	18:05	0	0.5	640	0.9
1-Jan-00	18:10	0	0.5	640	0.9
1-Jan-00	18:15	0	0.5	640	0.9
1-Jan-00	18:20	0	0.5	640	0.9
1-Jan-00	18:25	0	0.5	640	0.9
1-Jan-00	18:30	0	0.5	640	0.8
1-Jan-00	18:35	0	0.5	640	0.8
1-Jan-00	18:40	0	0.5	640	0.8
1-Jan-00	18:45	0	0.5	640	0.8
1-Jan-00	18:50	0	0.5	640	0.8
1-Jan-00	18:55	0	0.5	640	0.8
1-Jan-00	19:00	0	0.5	640	0.8
1-Jan-00	19:05	0	0.5	640	0.8
1-Jan-00	19:10	0	0.5	640	0.7

1-Jan-00	19:15	0	0.5	640	0.7
1-Jan-00	19:20	0	0.5	640	0.7
1-Jan-00	19:25	0	0.4	640	0.7
1-Jan-00	19:30	0	0.4	640	0.7
1-Jan-00	19:35	0	0.4	640	0.7
1-Jan-00	19:40	0	0.4	640	0.7
1-Jan-00	19:45	0	0.4	640	0.7
1-Jan-00	19:50	0	0.4	640	0.7
1-Jan-00	19:55	0	0.4	640	0.6
1-Jan-00	20:00	0	0.4	640	0.6
1-Jan-00	20:05	0	0.4	640	0.6
1-Jan-00	20:10	0	0.4	640	0.6
1-Jan-00	20:15	0	0.4	640	0.6
1-Jan-00	20:20	0	0.4	640	0.6
1-Jan-00	20:25	0	0.4	640	0.6
1-Jan-00	20:30	0	0.4	640	0.6
1-Jan-00	20:35	0	0.4	640	0.6
1-Jan-00	20:40	0	0.4	640	0.6
1-Jan-00	20:45	0	0.4	640	0.5
1-Jan-00	20:50	0	0.4	640	0.5
1-Jan-00	20:55	0	0.4	640	0.5
1-Jan-00	21:00	0	0.4	640	0.5
1-Jan-00	21:05	0	0.4	640	0.5
1-Jan-00	21:10	0	0.4	640	0.5
1-Jan-00	21:15	0	0.4	640	0.5
1-Jan-00	21:20	0	0.4	640	0.5
1-Jan-00	21:25	0	0.4	640	0.5
1-Jan-00	21:30	0	0.3	640	0.5
1-Jan-00	21:35	0	0.3	640	0.5
1-Jan-00	21:40	0	0.3	640	0.5
1-Jan-00	21:45	0	0.3	640	0.5
1-Jan-00	21:50	0	0.3	640	0.5
1-Jan-00	21:55	0	0.3	640	0.4
1-Jan-00	22:00	0	0.3	640	0.4
1-Jan-00	22:05	0	0.3	640	0.4
1-Jan-00	22:10	0	0.3	640	0.4
1-Jan-00	22:15	0	0.3	640	0.4
1-Jan-00	22:20	0	0.3	640	0.4
1-Jan-00	22:25	0	0.3	640	0.4
1-Jan-00	22:30	0	0.3	640	0.4
1-Jan-00	22:35	0	0.3	640	0.4
1-Jan-00	22:40	0	0.3	640	0.4
1-Jan-00	22:45	0	0.3	640	0.4
1-Jan-00	22:50	0	0.3	640	0.4
1-Jan-00	22:55	0	0.3	640	0.4
1-Jan-00	23:00	0	0.3	640	0.4
1-Jan-00	23:05	0	0.3	640	0.4

1-Jan-00	23:10	0	0.3	640	0.4
1-Jan-00	23:15	0	0.3	640	0.4
1-Jan-00	23:20	0	0.3	640	0.4
1-Jan-00	23:25	0	0.3	640	0.4
1-Jan-00	23:30	0	0.3	640	0.3
1-Jan-00	23:35	0	0.3	640	0.3
1-Jan-00	23:40	0	0.3	640	0.3
1-Jan-00	23:45	0	0.3	640	0.3
1-Jan-00	23:50	0	0.3	640	0.3
1-Jan-00	23:55	0	0.3	640	0.3
2-Jan-00	0:00	0	0.3	640	0.3
2-Jan-00	0:05	0	0.3	640	0.3
2-Jan-00	0:10	0	0.3	640	0.3
2-Jan-00	0:15	0	0.3	640	0.3
2-Jan-00	0:20	0	0.3	640	0.3
2-Jan-00	0:25	0	0.3	640	0.3
2-Jan-00	0:30	0	0.3	640	0.3
2-Jan-00	0:35	0	0.3	640	0.3
2-Jan-00	0:40	0	0.2	640	0.3
2-Jan-00	0:45	0	0.2	640	0.3
2-Jan-00	0:50	0	0.2	640	0.3
2-Jan-00	0:55	0	0.2	640	0.3
2-Jan-00	1:00	0	0.2	640	0.3
2-Jan-00	1:05	0	0.2	640	0.3
2-Jan-00	1:10	0	0.2	640	0.3
2-Jan-00	1:15	0	0.2	640	0.3
2-Jan-00	1:20	0	0.2	640	0.3
2-Jan-00	1:25	0	0.2	640	0.3
2-Jan-00	1:30	0	0.2	640	0.3
2-Jan-00	1:35	0	0.2	640	0.3
2-Jan-00	1:40	0	0.2	640	0.3
2-Jan-00	1:45	0	0.2	640	0.3
2-Jan-00	1:50	0	0.2	640	0.2
2-Jan-00	1:55	0	0.2	640	0.2
2-Jan-00	2:00	0	0.2	640	0.2
2-Jan-00	2:05	0	0.2	640	0.2
2-Jan-00	2:10	0	0.2	640	0.2
2-Jan-00	2:15	0	0.2	640	0.2
2-Jan-00	2:20	0	0.2	640	0.2
2-Jan-00	2:25	0	0.2	640	0.2
2-Jan-00	2:30	0	0.2	640	0.2
2-Jan-00	2:35	0	0.2	640	0.2
2-Jan-00	2:40	0	0.2	640	0.2
2-Jan-00	2:45	0	0.2	640	0.2
2-Jan-00	2:50	0	0.2	640	0.2
2-Jan-00	2:55	0	0.2	640	0.2
2-Jan-00	3:00	0	0.2	640	0.2

2-Jan-00	3:05	0	0.2	640	0.2
2-Jan-00	3:10	0	0.2	640	0.2
2-Jan-00	3:15	0	0.2	640	0.2
2-Jan-00	3:20	0	0.2	640	0.2
2-Jan-00	3:25	0	0.2	640	0.2
2-Jan-00	3:30	0	0.2	640	0.2
2-Jan-00	3:35	0	0.2	640	0.2
2-Jan-00	3:40	0	0.2	640	0.2
2-Jan-00	3:45	0	0.2	640	0.2
2-Jan-00	3:50	0	0.2	640	0.2
2-Jan-00	3:55	0	0.2	640	0.2
2-Jan-00	4:00	0	0.2	640	0.2
2-Jan-00	4:05	0	0.2	640	0.2
2-Jan-00	4:10	0	0.2	640	0.2
2-Jan-00	4:15	0	0.2	640	0.2
2-Jan-00	4:20	0	0.2	640	0.2
2-Jan-00	4:25	0	0.2	640	0.2
2-Jan-00	4:30	0	0.2	640	0.2
2-Jan-00	4:35	0	0.2	640	0.2
2-Jan-00	4:40	0	0.2	640	0.2
2-Jan-00	4:45	0	0.2	640	0.2
2-Jan-00	4:50	0	0.2	640	0.2
2-Jan-00	4:55	0	0.2	640	0.2
2-Jan-00	5:00	0	0.2	640	0.2
2-Jan-00	5:05	0	0.2	640	0.2
2-Jan-00	5:10	0	0.2	640	0.2
2-Jan-00	5:15	0	0.2	640	0.2
2-Jan-00	5:20	0	0.2	640	0.2
2-Jan-00	5:25	0	0.2	640	0.2
2-Jan-00	5:30	0	0.2	640	0.2
2-Jan-00	5:35	0	0.2	640	0.2
2-Jan-00	5:40	0	0.2	640	0.2
2-Jan-00	5:45	0	0.2	640	0.2
2-Jan-00	5:50	0	0.2	640	0.2
2-Jan-00	5:55	0	0.2	640	0.1
2-Jan-00	6:00	0	0.2	640	0.1

25-year 6 hour Model Run

Project: Robinson Lake   Simulation Run: Run1

Reservoir: Reservoir-1

Start of Run:	01Jan2000, 00:00	Basin Model:	RobinsonLake
End of Run:	02Jan2000, 06:00	Meteorologic Model:	a. 25yr 6 hr
Compute Time:	21Nov2017, 16:49:50	Control Specifications:	Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow:	871.5 (CFS)	Date/Time of Peak Inflow:	01Jan2000, 03:30
Peak Discharge:	428.1 (CFS)	Date/Time of Peak Discharge:	01Jan2000, 04:00
Inflow Volume:	1.80 (IN)	Peak Storage:	32.9 (AC-FT)
Discharge Volume:	1.79 (IN)	Peak Elevation:	642.9 (FT)

25-Year 6 Hour Storm

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
1-Jan-00	0:00	0	0	640	0
1-Jan-00	0:05	0	0	640	0
1-Jan-00	0:10	0	0	640	0
1-Jan-00	0:15	0	0	640	0
1-Jan-00	0:20	0	0	640	0
1-Jan-00	0:25	0	0	640	0
1-Jan-00	0:30	0	0	640	0
1-Jan-00	0:35	0	0	640	0
1-Jan-00	0:40	0	0	640	0
1-Jan-00	0:45	0	0	640	0
1-Jan-00	0:50	0	0	640	0
1-Jan-00	0:55	0	0	640	0
1-Jan-00	1:00	0	0	640	0
1-Jan-00	1:05	0	0	640	0
1-Jan-00	1:10	0	0	640	0
1-Jan-00	1:15	0	0	640	0
1-Jan-00	1:20	0	0	640	0
1-Jan-00	1:25	0	0	640	0
1-Jan-00	1:30	0	0	640	0
1-Jan-00	1:35	0	0	640	0
1-Jan-00	1:40	0	0	640	0
1-Jan-00	1:45	0	0	640	0
1-Jan-00	1:50	0	0	640	0
1-Jan-00	1:55	0	0	640	0
1-Jan-00	2:00	0	0	640	0
1-Jan-00	2:05	0	0	640	0
1-Jan-00	2:10	0	0	640	0
1-Jan-00	2:15	0	0	640	0
1-Jan-00	2:20	0	0	640	0
1-Jan-00	2:25	0	0	640	0
1-Jan-00	2:30	0	0	640	0
1-Jan-00	2:35	0.4	0	640	0
1-Jan-00	2:40	2.2	0	640	0
1-Jan-00	2:45	7.3	0	640	0
1-Jan-00	2:50	18.2	0.1	640	0.1
1-Jan-00	2:55	40	0.3	640	0.4
1-Jan-00	3:00	81.3	0.7	640.1	1.5
1-Jan-00	3:05	163	1.6	640.1	4.6
1-Jan-00	3:10	314.3	3.1	640.3	13.1
1-Jan-00	3:15	511	5.8	640.5	33
1-Jan-00	3:20	694.9	9.6	640.9	70
1-Jan-00	3:25	820.1	14.2	641.3	124.1
1-Jan-00	3:30	871.5	18.9	641.7	190

Outlet Structures	Elevation
Riser and Barrel	640'
Auxiliary Spillway	643'
Emergency Spillway	644'
Dam Crest	645.5'

1-Jan-00	3:35	858.8	23.3	642.1	258.8
1-Jan-00	3:40	798.5	27.1	642.4	320.8
1-Jan-00	3:45	708.5	29.9	642.7	370.6
1-Jan-00	3:50	606.6	31.7	642.8	404.9
1-Jan-00	3:55	506.7	32.7	642.9	423.4
1-Jan-00	4:00	417.7	32.9	642.9	428.1
1-Jan-00	4:05	343.3	32.6	642.9	422.3
1-Jan-00	4:10	283.7	31.9	642.9	409
1-Jan-00	4:15	236.9	31	642.8	391.1
1-Jan-00	4:20	200.8	29.9	642.7	370.7
1-Jan-00	4:25	173.1	28.7	642.6	349.3
1-Jan-00	4:30	151.9	27.5	642.5	327.9
1-Jan-00	4:35	135.9	26.3	642.4	307.3
1-Jan-00	4:40	124.6	25.1	642.3	287.9
1-Jan-00	4:45	117.7	24	642.2	269.9
1-Jan-00	4:50	114.1	23	642.1	253.7
1-Jan-00	4:55	112.3	22.1	642	239.1
1-Jan-00	5:00	111.5	21.3	641.9	225.9
1-Jan-00	5:05	110.8	20.5	641.9	214.2
1-Jan-00	5:10	109.9	19.8	641.8	203.8
1-Jan-00	5:15	108.5	19.2	641.7	194.5
1-Jan-00	5:20	106.7	18.7	641.7	186
1-Jan-00	5:25	104.7	18.1	641.6	178.3
1-Jan-00	5:30	102.4	17.6	641.6	171.2
1-Jan-00	5:35	100.1	17.2	641.6	164.7
1-Jan-00	5:40	97.8	16.8	641.5	158.6
1-Jan-00	5:45	95.5	16.3	641.5	152.9
1-Jan-00	5:50	93.2	16	641.4	147.6
1-Jan-00	5:55	91.1	15.6	641.4	142.7
1-Jan-00	6:00	89	15.2	641.4	138
1-Jan-00	6:05	86.7	14.9	641.4	133.6
1-Jan-00	6:10	82	14.6	641.3	129.4
1-Jan-00	6:15	73.7	14.3	641.3	124.9
1-Jan-00	6:20	62.3	13.9	641.3	120.1
1-Jan-00	6:25	49.8	13.5	641.2	114.8
1-Jan-00	6:30	37.9	13	641.2	108.9
1-Jan-00	6:35	27.6	12.5	641.1	102.8
1-Jan-00	6:40	19.3	12	641.1	96.5
1-Jan-00	6:45	13.1	11.4	641	90.3
1-Jan-00	6:50	8.6	10.9	641	84.2
1-Jan-00	6:55	5.6	10.4	640.9	78.4
1-Jan-00	7:00	3.5	9.9	640.9	72.9
1-Jan-00	7:05	2.2	9.4	640.9	67.8
1-Jan-00	7:10	1.3	9	640.8	63.2
1-Jan-00	7:15	0.8	8.6	640.8	58.9
1-Jan-00	7:20	0.5	8.2	640.7	54.9
1-Jan-00	7:25	0.3	7.8	640.7	51.3

1-Jan-00	7:30	0.2	7.5	640.7	48
1-Jan-00	7:35	0.1	7.2	640.7	45
1-Jan-00	7:40	0	6.9	640.6	42.2
1-Jan-00	7:45	0	6.6	640.6	39.6
1-Jan-00	7:50	0	6.3	640.6	37.3
1-Jan-00	7:55	0	6.1	640.6	35.1
1-Jan-00	8:00	0	5.8	640.5	33.1
1-Jan-00	8:05	0	5.6	640.5	31.2
1-Jan-00	8:10	0	5.4	640.5	29.5
1-Jan-00	8:15	0	5.2	640.5	27.9
1-Jan-00	8:20	0	5	640.5	26.4
1-Jan-00	8:25	0	4.9	640.4	25
1-Jan-00	8:30	0	4.7	640.4	23.7
1-Jan-00	8:35	0	4.5	640.4	22.5
1-Jan-00	8:40	0	4.4	640.4	21.4
1-Jan-00	8:45	0	4.2	640.4	20.4
1-Jan-00	8:50	0	4.1	640.4	19.4
1-Jan-00	8:55	0	4	640.4	18.5
1-Jan-00	9:00	0	3.8	640.4	17.6
1-Jan-00	9:05	0	3.7	640.3	16.8
1-Jan-00	9:10	0	3.6	640.3	16
1-Jan-00	9:15	0	3.5	640.3	15.3
1-Jan-00	9:20	0	3.4	640.3	14.7
1-Jan-00	9:25	0	3.3	640.3	14
1-Jan-00	9:30	0	3.2	640.3	13.4
1-Jan-00	9:35	0	3.1	640.3	12.9
1-Jan-00	9:40	0	3	640.3	12.3
1-Jan-00	9:45	0	2.9	640.3	11.8
1-Jan-00	9:50	0	2.9	640.3	11.3
1-Jan-00	9:55	0	2.8	640.3	10.9
1-Jan-00	10:00	0	2.7	640.2	10.5
1-Jan-00	10:05	0	2.6	640.2	10.1
1-Jan-00	10:10	0	2.6	640.2	9.7
1-Jan-00	10:15	0	2.5	640.2	9.3
1-Jan-00	10:20	0	2.4	640.2	9
1-Jan-00	10:25	0	2.4	640.2	8.6
1-Jan-00	10:30	0	2.3	640.2	8.3
1-Jan-00	10:35	0	2.3	640.2	8
1-Jan-00	10:40	0	2.2	640.2	7.7
1-Jan-00	10:45	0	2.2	640.2	7.5
1-Jan-00	10:50	0	2.1	640.2	7.2
1-Jan-00	10:55	0	2.1	640.2	6.9
1-Jan-00	11:00	0	2	640.2	6.7
1-Jan-00	11:05	0	2	640.2	6.5
1-Jan-00	11:10	0	1.9	640.2	6.3
1-Jan-00	11:15	0	1.9	640.2	6.1
1-Jan-00	11:20	0	1.8	640.2	5.9

1-Jan-00	11:25	0	1.8	640.2	5.7
1-Jan-00	11:30	0	1.8	640.2	5.5
1-Jan-00	11:35	0	1.7	640.2	5.3
1-Jan-00	11:40	0	1.7	640.2	5.2
1-Jan-00	11:45	0	1.7	640.2	5
1-Jan-00	11:50	0	1.6	640.1	4.8
1-Jan-00	11:55	0	1.6	640.1	4.7
1-Jan-00	12:00	0	1.6	640.1	4.6
1-Jan-00	12:05	0	1.5	640.1	4.4
1-Jan-00	12:10	0	1.5	640.1	4.3
1-Jan-00	12:15	0	1.5	640.1	4.2
1-Jan-00	12:20	0	1.4	640.1	4.1
1-Jan-00	12:25	0	1.4	640.1	3.9
1-Jan-00	12:30	0	1.4	640.1	3.8
1-Jan-00	12:35	0	1.4	640.1	3.7
1-Jan-00	12:40	0	1.3	640.1	3.6
1-Jan-00	12:45	0	1.3	640.1	3.5
1-Jan-00	12:50	0	1.3	640.1	3.4
1-Jan-00	12:55	0	1.3	640.1	3.3
1-Jan-00	13:00	0	1.2	640.1	3.2
1-Jan-00	13:05	0	1.2	640.1	3.2
1-Jan-00	13:10	0	1.2	640.1	3.1
1-Jan-00	13:15	0	1.2	640.1	3
1-Jan-00	13:20	0	1.2	640.1	2.9
1-Jan-00	13:25	0	1.1	640.1	2.8
1-Jan-00	13:30	0	1.1	640.1	2.8
1-Jan-00	13:35	0	1.1	640.1	2.7
1-Jan-00	13:40	0	1.1	640.1	2.6
1-Jan-00	13:45	0	1.1	640.1	2.6
1-Jan-00	13:50	0	1	640.1	2.5
1-Jan-00	13:55	0	1	640.1	2.4
1-Jan-00	14:00	0	1	640.1	2.4
1-Jan-00	14:05	0	1	640.1	2.3
1-Jan-00	14:10	0	1	640.1	2.3
1-Jan-00	14:15	0	1	640.1	2.2
1-Jan-00	14:20	0	0.9	640.1	2.2
1-Jan-00	14:25	0	0.9	640.1	2.1
1-Jan-00	14:30	0	0.9	640.1	2.1
1-Jan-00	14:35	0	0.9	640.1	2
1-Jan-00	14:40	0	0.9	640.1	2
1-Jan-00	14:45	0	0.9	640.1	1.9
1-Jan-00	14:50	0	0.9	640.1	1.9
1-Jan-00	14:55	0	0.9	640.1	1.8
1-Jan-00	15:00	0	0.8	640.1	1.8
1-Jan-00	15:05	0	0.8	640.1	1.8
1-Jan-00	15:10	0	0.8	640.1	1.7
1-Jan-00	15:15	0	0.8	640.1	1.7

1-Jan-00	15:20	0	0.8	640.1	1.7
1-Jan-00	15:25	0	0.8	640.1	1.6
1-Jan-00	15:30	0	0.8	640.1	1.6
1-Jan-00	15:35	0	0.8	640.1	1.6
1-Jan-00	15:40	0	0.7	640.1	1.5
1-Jan-00	15:45	0	0.7	640.1	1.5
1-Jan-00	15:50	0	0.7	640.1	1.5
1-Jan-00	15:55	0	0.7	640.1	1.4
1-Jan-00	16:00	0	0.7	640.1	1.4
1-Jan-00	16:05	0	0.7	640.1	1.4
1-Jan-00	16:10	0	0.7	640.1	1.3
1-Jan-00	16:15	0	0.7	640.1	1.3
1-Jan-00	16:20	0	0.7	640.1	1.3
1-Jan-00	16:25	0	0.7	640.1	1.3
1-Jan-00	16:30	0	0.7	640.1	1.2
1-Jan-00	16:35	0	0.6	640.1	1.2
1-Jan-00	16:40	0	0.6	640.1	1.2
1-Jan-00	16:45	0	0.6	640.1	1.2
1-Jan-00	16:50	0	0.6	640.1	1.1
1-Jan-00	16:55	0	0.6	640.1	1.1
1-Jan-00	17:00	0	0.6	640.1	1.1
1-Jan-00	17:05	0	0.6	640.1	1.1
1-Jan-00	17:10	0	0.6	640.1	1.1
1-Jan-00	17:15	0	0.6	640.1	1
1-Jan-00	17:20	0	0.6	640.1	1
1-Jan-00	17:25	0	0.6	640.1	1
1-Jan-00	17:30	0	0.6	640.1	1
1-Jan-00	17:35	0	0.6	640.1	1
1-Jan-00	17:40	0	0.5	640.1	1
1-Jan-00	17:45	0	0.5	640	0.9
1-Jan-00	17:50	0	0.5	640	0.9
1-Jan-00	17:55	0	0.5	640	0.9
1-Jan-00	18:00	0	0.5	640	0.9
1-Jan-00	18:05	0	0.5	640	0.9
1-Jan-00	18:10	0	0.5	640	0.9
1-Jan-00	18:15	0	0.5	640	0.8
1-Jan-00	18:20	0	0.5	640	0.8
1-Jan-00	18:25	0	0.5	640	0.8
1-Jan-00	18:30	0	0.5	640	0.8
1-Jan-00	18:35	0	0.5	640	0.8
1-Jan-00	18:40	0	0.5	640	0.8
1-Jan-00	18:45	0	0.5	640	0.8
1-Jan-00	18:50	0	0.5	640	0.7
1-Jan-00	18:55	0	0.5	640	0.7
1-Jan-00	19:00	0	0.5	640	0.7
1-Jan-00	19:05	0	0.5	640	0.7
1-Jan-00	19:10	0	0.4	640	0.7

1-Jan-00	19:15	0	0.4	640	0.7
1-Jan-00	19:20	0	0.4	640	0.7
1-Jan-00	19:25	0	0.4	640	0.7
1-Jan-00	19:30	0	0.4	640	0.7
1-Jan-00	19:35	0	0.4	640	0.6
1-Jan-00	19:40	0	0.4	640	0.6
1-Jan-00	19:45	0	0.4	640	0.6
1-Jan-00	19:50	0	0.4	640	0.6
1-Jan-00	19:55	0	0.4	640	0.6
1-Jan-00	20:00	0	0.4	640	0.6
1-Jan-00	20:05	0	0.4	640	0.6
1-Jan-00	20:10	0	0.4	640	0.6
1-Jan-00	20:15	0	0.4	640	0.6
1-Jan-00	20:20	0	0.4	640	0.6
1-Jan-00	20:25	0	0.4	640	0.6
1-Jan-00	20:30	0	0.4	640	0.5
1-Jan-00	20:35	0	0.4	640	0.5
1-Jan-00	20:40	0	0.4	640	0.5
1-Jan-00	20:45	0	0.4	640	0.5
1-Jan-00	20:50	0	0.4	640	0.5
1-Jan-00	20:55	0	0.4	640	0.5
1-Jan-00	21:00	0	0.4	640	0.5
1-Jan-00	21:05	0	0.4	640	0.5
1-Jan-00	21:10	0	0.4	640	0.5
1-Jan-00	21:15	0	0.3	640	0.5
1-Jan-00	21:20	0	0.3	640	0.5
1-Jan-00	21:25	0	0.3	640	0.5
1-Jan-00	21:30	0	0.3	640	0.5
1-Jan-00	21:35	0	0.3	640	0.5
1-Jan-00	21:40	0	0.3	640	0.4
1-Jan-00	21:45	0	0.3	640	0.4
1-Jan-00	21:50	0	0.3	640	0.4
1-Jan-00	21:55	0	0.3	640	0.4
1-Jan-00	22:00	0	0.3	640	0.4
1-Jan-00	22:05	0	0.3	640	0.4
1-Jan-00	22:10	0	0.3	640	0.4
1-Jan-00	22:15	0	0.3	640	0.4
1-Jan-00	22:20	0	0.3	640	0.4
1-Jan-00	22:25	0	0.3	640	0.4
1-Jan-00	22:30	0	0.3	640	0.4
1-Jan-00	22:35	0	0.3	640	0.4
1-Jan-00	22:40	0	0.3	640	0.4
1-Jan-00	22:45	0	0.3	640	0.4
1-Jan-00	22:50	0	0.3	640	0.4
1-Jan-00	22:55	0	0.3	640	0.4
1-Jan-00	23:00	0	0.3	640	0.4
1-Jan-00	23:05	0	0.3	640	0.4

1-Jan-00	23:10	0	0.3	640	0.4
1-Jan-00	23:15	0	0.3	640	0.3
1-Jan-00	23:20	0	0.3	640	0.3
1-Jan-00	23:25	0	0.3	640	0.3
1-Jan-00	23:30	0	0.3	640	0.3
1-Jan-00	23:35	0	0.3	640	0.3
1-Jan-00	23:40	0	0.3	640	0.3
1-Jan-00	23:45	0	0.3	640	0.3
1-Jan-00	23:50	0	0.3	640	0.3
1-Jan-00	23:55	0	0.3	640	0.3
2-Jan-00	0:00	0	0.3	640	0.3
2-Jan-00	0:05	0	0.3	640	0.3
2-Jan-00	0:10	0	0.3	640	0.3
2-Jan-00	0:15	0	0.3	640	0.3
2-Jan-00	0:20	0	0.3	640	0.3
2-Jan-00	0:25	0	0.2	640	0.3
2-Jan-00	0:30	0	0.2	640	0.3
2-Jan-00	0:35	0	0.2	640	0.3
2-Jan-00	0:40	0	0.2	640	0.3
2-Jan-00	0:45	0	0.2	640	0.3
2-Jan-00	0:50	0	0.2	640	0.3
2-Jan-00	0:55	0	0.2	640	0.3
2-Jan-00	1:00	0	0.2	640	0.3
2-Jan-00	1:05	0	0.2	640	0.3
2-Jan-00	1:10	0	0.2	640	0.3
2-Jan-00	1:15	0	0.2	640	0.3
2-Jan-00	1:20	0	0.2	640	0.3
2-Jan-00	1:25	0	0.2	640	0.3
2-Jan-00	1:30	0	0.2	640	0.3
2-Jan-00	1:35	0	0.2	640	0.2
2-Jan-00	1:40	0	0.2	640	0.2
2-Jan-00	1:45	0	0.2	640	0.2
2-Jan-00	1:50	0	0.2	640	0.2
2-Jan-00	1:55	0	0.2	640	0.2
2-Jan-00	2:00	0	0.2	640	0.2
2-Jan-00	2:05	0	0.2	640	0.2
2-Jan-00	2:10	0	0.2	640	0.2
2-Jan-00	2:15	0	0.2	640	0.2
2-Jan-00	2:20	0	0.2	640	0.2
2-Jan-00	2:25	0	0.2	640	0.2
2-Jan-00	2:30	0	0.2	640	0.2
2-Jan-00	2:35	0	0.2	640	0.2
2-Jan-00	2:40	0	0.2	640	0.2
2-Jan-00	2:45	0	0.2	640	0.2
2-Jan-00	2:50	0	0.2	640	0.2
2-Jan-00	2:55	0	0.2	640	0.2
2-Jan-00	3:00	0	0.2	640	0.2

2-Jan-00	3:05	0	0.2	640	0.2
2-Jan-00	3:10	0	0.2	640	0.2
2-Jan-00	3:15	0	0.2	640	0.2
2-Jan-00	3:20	0	0.2	640	0.2
2-Jan-00	3:25	0	0.2	640	0.2
2-Jan-00	3:30	0	0.2	640	0.2
2-Jan-00	3:35	0	0.2	640	0.2
2-Jan-00	3:40	0	0.2	640	0.2
2-Jan-00	3:45	0	0.2	640	0.2
2-Jan-00	3:50	0	0.2	640	0.2
2-Jan-00	3:55	0	0.2	640	0.2
2-Jan-00	4:00	0	0.2	640	0.2
2-Jan-00	4:05	0	0.2	640	0.2
2-Jan-00	4:10	0	0.2	640	0.2
2-Jan-00	4:15	0	0.2	640	0.2
2-Jan-00	4:20	0	0.2	640	0.2
2-Jan-00	4:25	0	0.2	640	0.2
2-Jan-00	4:30	0	0.2	640	0.2
2-Jan-00	4:35	0	0.2	640	0.2
2-Jan-00	4:40	0	0.2	640	0.2
2-Jan-00	4:45	0	0.2	640	0.2
2-Jan-00	4:50	0	0.2	640	0.2
2-Jan-00	4:55	0	0.2	640	0.2
2-Jan-00	5:00	0	0.2	640	0.2
2-Jan-00	5:05	0	0.2	640	0.2
2-Jan-00	5:10	0	0.2	640	0.2
2-Jan-00	5:15	0	0.2	640	0.2
2-Jan-00	5:20	0	0.2	640	0.2
2-Jan-00	5:25	0	0.2	640	0.2
2-Jan-00	5:30	0	0.2	640	0.2
2-Jan-00	5:35	0	0.2	640	0.1
2-Jan-00	5:40	0	0.2	640	0.1
2-Jan-00	5:45	0	0.2	640	0.1
2-Jan-00	5:50	0	0.2	640	0.1
2-Jan-00	5:55	0	0.2	640	0.1
2-Jan-00	6:00	0	0.2	640	0.1

Appendix G

Geotechnical Analyses

CDM Smith Calculation Form

Client:	**City of Franklin,TN**	**Job No. 222189**	**Calculations By: J.W.**
Project:	**Robinson Lake Dam**	**Checked By/Date B.B.11/22/2017**	**Date: 11/1/2017**
Detail:	**Seepage&Slope Stability**	**Reviewed By/Date S.W., 11/26/2017**	**Calc #: 1**
			Revision No./Date: Rev 1, 11/30/2017

Calculation Brief Title: Robinson Lake Dam Rehabilitation – Preliminary Seepage and Slope Stability Analyses

1.0 Purpose/Objective:

This calculation package contains seepage and slope stability analyses for the existing and proposed conditions of the Robinson Lake Dam Project at the City of Franklin, Tennessee. The analyses were performed in support of proposed changes to the exisiting dam cross-section. The objective is to confirm that the calculated factors of safety for the proposed design meet the minimum design requirements.

2.0 Procedure:

The calculations contained herein were performed in general accordance with the requirements outlined in Reference B and Reference C (listed below in Section 3.0).

A. Based on the soil borings performed by CDM Smith at project site, a generalized design subsurface soil profile was assumed. The dam cross-section was checked for both existing and proposed geometries. Subsurface conditions observed in test borings, field and laboratory testing data, topographic information collected by the survey, and also the information collected during field inspection were used as the basis for the stability analyses.

B. Prior to beginning the stability analyses, steady-state seepage analyses were performed using the SEEP/W model developed by GEO-SLOPE International. For the seepage analyses, hydraulic conductivity values of the various subsurface layers were assumed based upon experience with similar geologic units. The seepage model was run under steady-state seepage conditions for each of the design cases to provide pore pressure input for SLOPE/W.

C. For the slope stability analyses, soil strength values of the various subsurface layers were assumed based upon field SPT N-values, pocket penetrometer test results, laboratory test results, and experience with similar geologic units.

D. The slope stability modeling was performed using the SLOPE/W model developed by GEO-SLOPE International, and Spencer Method was selected. The stability requirements are based on criteria listed in Reference B.

E. The seismic acceleration coefficient used in seismic condition is assumed equal to PGA (peak ground acceleration) of 0.088g for the return period of 950 years, based on Reference D.

3.0 References/Data Sources:

A. Subsurface investigations performed by CDM Smith at the Project site.

B. “Slope Stability”, USACE EM 1110-2-1902.

C. USACE (2004), General Design and Construction Considerations for Earth and Rock-Fill Dams, EM 1110-2-2300, July 30, 2004.
D. USACE (2016), Earthquake Design and Evaluation for Civil Works Projects, ER 1110-2-1806, May 31, 2016.

4.0 Assumptions and Limitations:

A. Slope stability cross-sections assume a subsurface profile similar to conditions encountered in the test borings performed by CDM Smith in this area. Refer to modeling results for assumed subsurface layers.
B. Design soil parameters and the basis for selection are summarized in Tables 1a and 1b.
C. Only deep-seated slope failures with depths greater than 5 feet are considered in this analyses.
D. A crest width of 15 feet and upstream/downstream side slopes of 3H:1V were assumed for proposed dam cross-section.
E. The proposed fill used on the dam to constructed the new cross-section will be compacted clay.
F. The proposed dam section also includes an ACB (Articulating Concrete Block) layer at the upstream slope from EL 638 to crest, and an internal drain system which includes chimney, blanket, and toe drains.
G. For short-term loading cases including end of construction and seismic loading, undrained strengths were assumed for the cohesive soil materials.
H. Model boundary conditions used in the seepage models are listed as follows:
   1. Water level at upstream lake assumed as: maximum pool level =643 (assumed as the existing spillway's elevation); normal pool level=EL 640 (approximate water level observed during field inspection).
   2. Water level at the Harpeth River assumed as EL 621.
   3. Downstream area ground surface was assumed as free seepage face;
   4. All other boundaries were assumed as non-flow boundaries.

5.0 Calculations: Modeling results for each case are attached and Factors of Safety are summarized in Table 2.

6.0 Conclusions/Results:

A. Under existing condition at normal pool, the seepage analyses show the phreatic surface depth at the dam crest is at about 13 feet, which is close to the field-recorded water depths of 14.7 to 14.85 feet measured during the field exploration on 10/2/2017 and 10/3/2017. This serves as a reasonable calibration for the seepage model.
B. Calculated Factors of Safety under existing and proposed conditions are listed in Tables 2. For existing condition, the downstream slope doesn't meet the required factor of safety under normal pool water level. For proposed dam cross-section, all cases analyzed produced an acceptable factor of safety.

Robinson Lake Dam Rehabilitation Project
City of Franklin, TN

Table 1a: Seepage Parameters used in SEEP/W Model

Layer	Material	K_h		k_h / k_v	Basis of Parameter Selection
		ft/day	cm/sec		
1	Embankment Fill	0.0142	5.0E-06	10	From Peck[(1)]; typical value for clay.
2a	Medium Stiff to Stiff Clay	0.0142	5.0E-06	10	From Peck[(1)]; typical value for clay.
2b	Soft/M. Stiff Clay	0.0142	5.0E-06	10	From Peck[(1)]; typical value for clay.
3	Clayey Sand (SC)	0.28	1.0E-04	4	From Peck[(1)]; typical value for mixture of sand and clay.
4	Fractured Limestone	0.028	1.0E-05	4	From Domenico[(2)]; typcial value for limestone
5	Filter Sand	28.35	1.0E-02	1	From Peck[(1)]; typical value for clean sand.
6	ACB Layer	2835	1.0E-01	1	Assumed.

References:

1. Ralph B. Peck, 'Foundation Engineering', 2nd edition; page 43.

2. Patrick A. Domenico, 'Physical and Chemical Hydrogeology', 2nd edition.

Robinson Lake Dam Rehabilitation Project
City of Franklin, TN

Table 1b: Strength Parameters used in SLOPE/W Model

Layer	Material	Unit Weight, pcf	Effective Friction Angle, degrees	Undrained Shear Strength, psf	Basis of Parameter Selection [1]
1	Embankment Fill	120	30	1000[2]	Selected based on N-value and pocket penetrometer readings[1]
2	Filter Sand	120	32	-	Based upon experience in similar projects
3	ACB Layer	125	35	-	Assumed
4a	Medium Stiff to Stiff Clay	110	28	600[2]	Selected based on N-value and pocket penetrometer readings[1] from borings
4b	Soft/M. Stiff Clay	110	26	200[2]	Selected based on N-values and pocket penetrometer readings[1] from borings
5	Clayey Sand (SC)	120	28	-	Selected based on N-value
6	Fractured Limestone	130	40	-	Based upon experience in similar geologic conditions

Notes:

1. Pocket penetrometer readings were performed on split spoon samples and Shelby tube sample during drilling.
2. Undrained shear strength used for end-of-construction and seismic conditions.

Robinson Lake Dam Rehabilitation Project

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Table 2 - Results of Slope Stability Analyses

Cross-Section	Run #	Modeling Scenario[2]	Required Factor of Safety	Calculated Factor of Safety[1]	
				Upstream	Downstream
Existing Dam Section	1a	Normal Pool	1.5	2.1	1.4
	1b	Maximum Pool	1.4	2.4	1.4
	1c	Seismic Condition[3]	1.0	1.8	1.4
Proposed Dam Section	2a	End of Construction	1.3	1.6	1.8
	2b	Normal Pool	1.5	2.0	1.9
	2c	Maximum Pool	1.4	2.4	1.9
	2d	Seismic Condition[3]	1.0	1.3	1.2

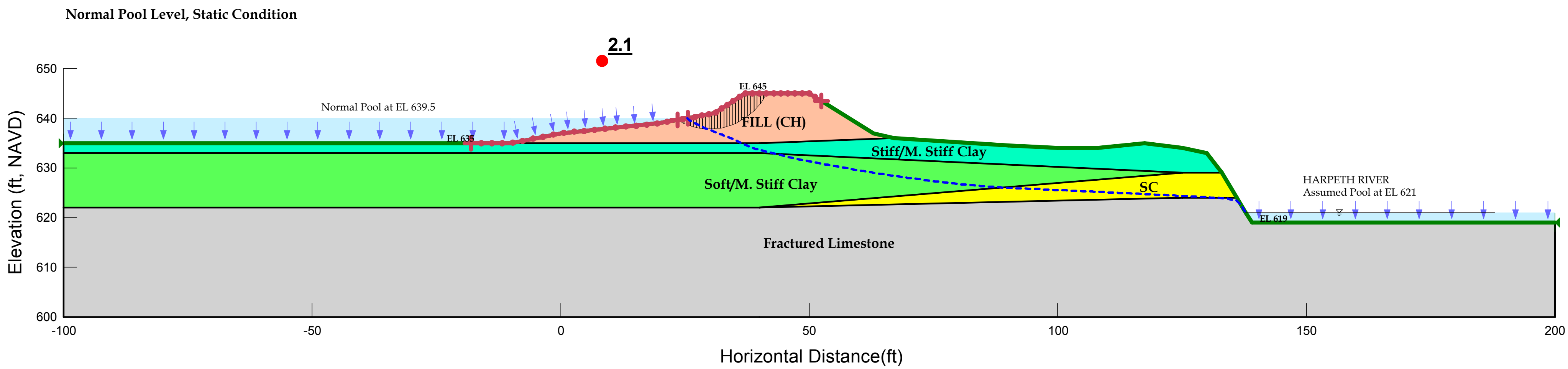
Notes:

1. Factor of Safety was calculated by using Spencer Method. Failure surfaces less than 5 feet deep were not considered deep-seated, and results are not listed here.

2. For run 1c, 2a and 2d, undrained strength was used for clay layers.

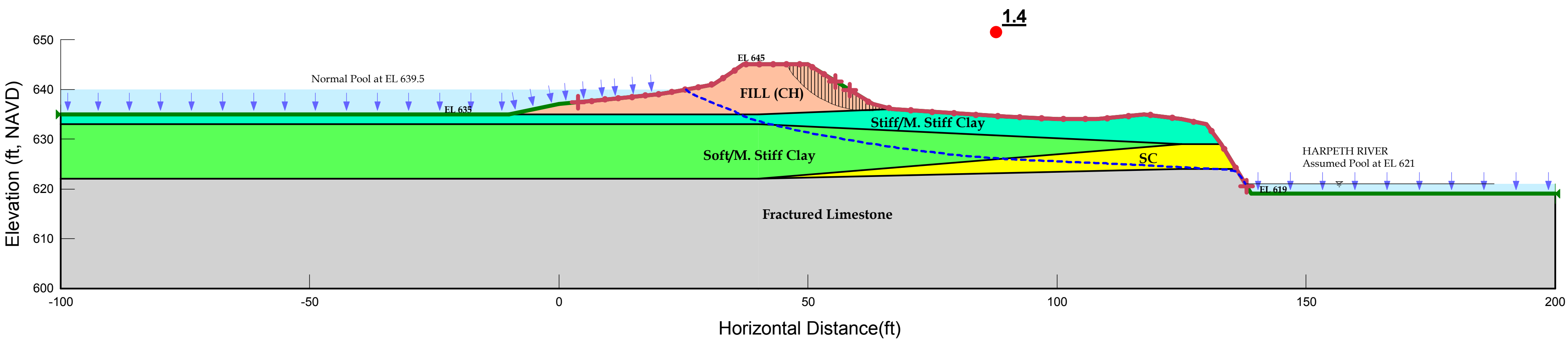
3. For seismic condition, a 950-year return period PGA=0.088g was used as peak ground acceleration.

Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Existing Condition



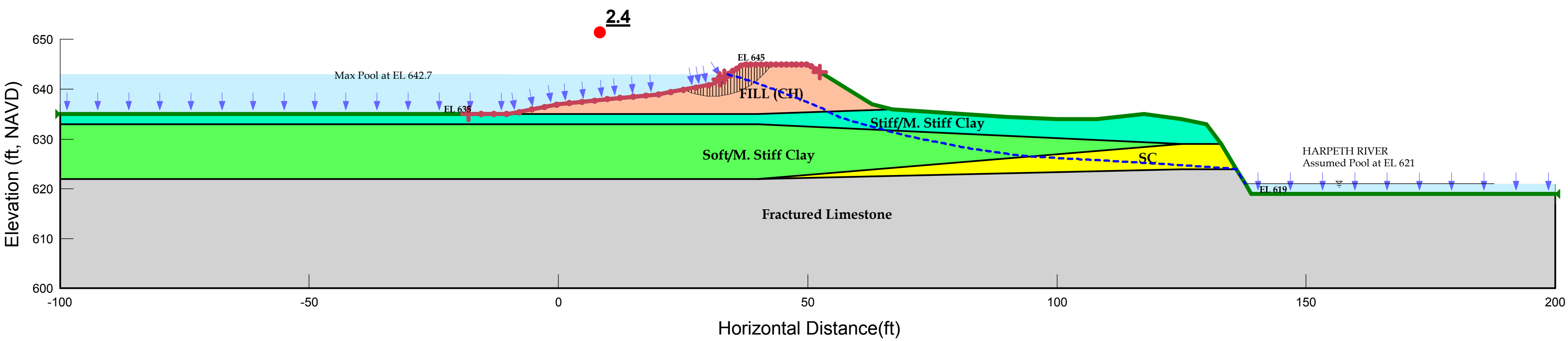
Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Existing Condition

Normal Pool Level, Static Condition



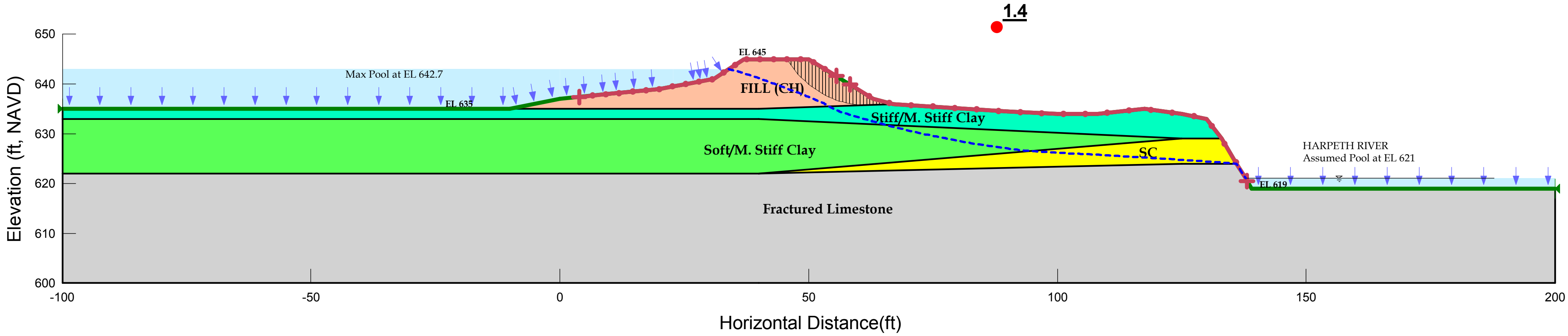
Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Existing Condition

Max Pool Level, Static Condition



Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Existing Condition

Max Pool Level, Static Condition



Robinson Lake Dam Rehabilitation
City of Franklin, TN
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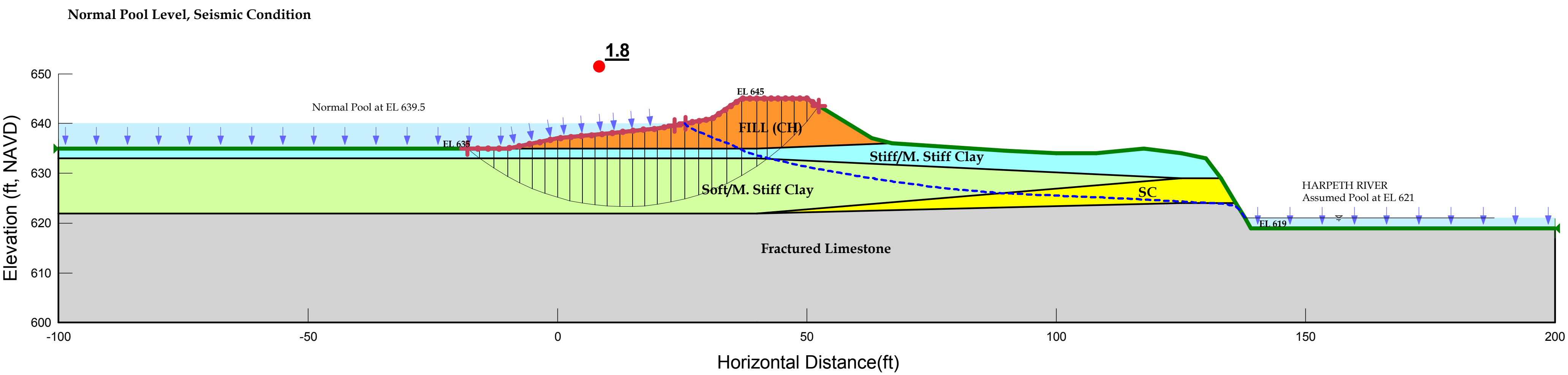
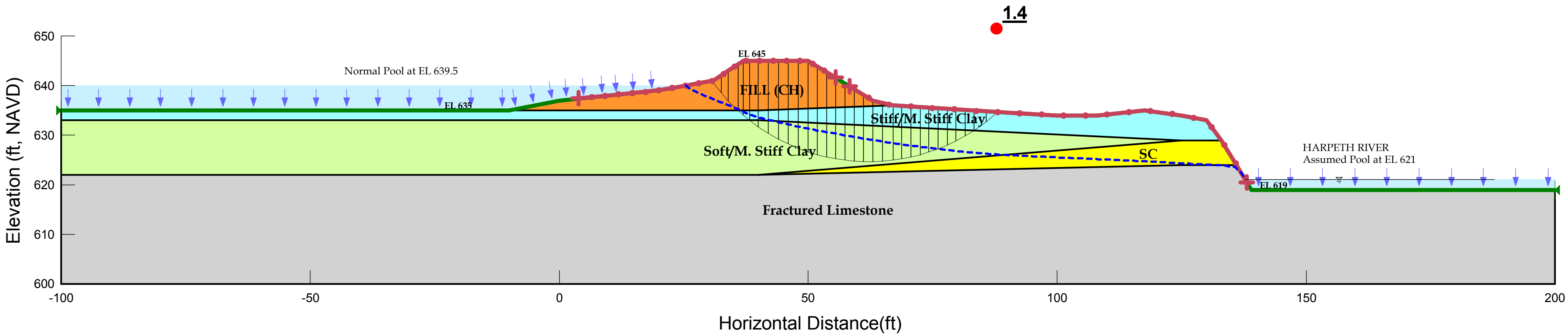
Existing Condition



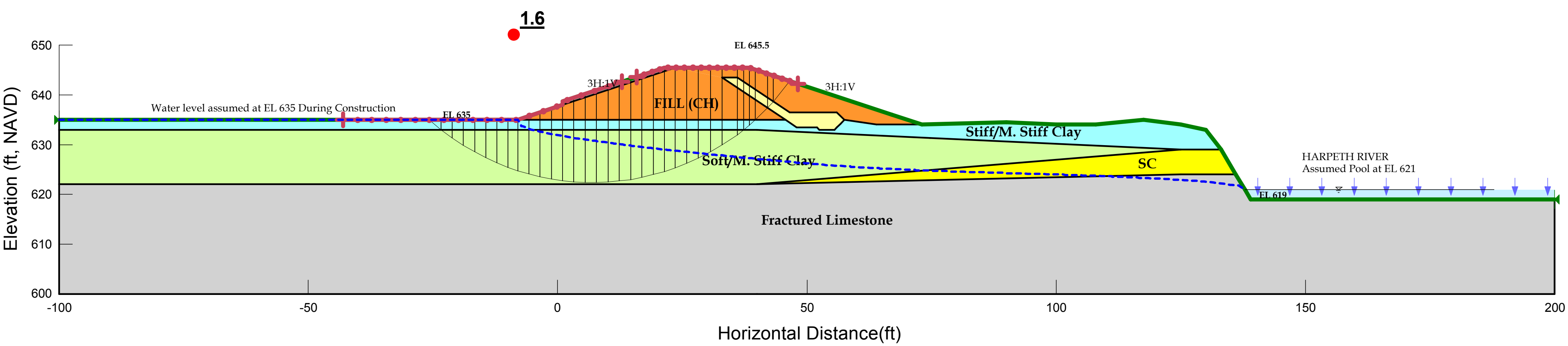
Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Existing Condition

Normal Pool Level, Seismic Condition



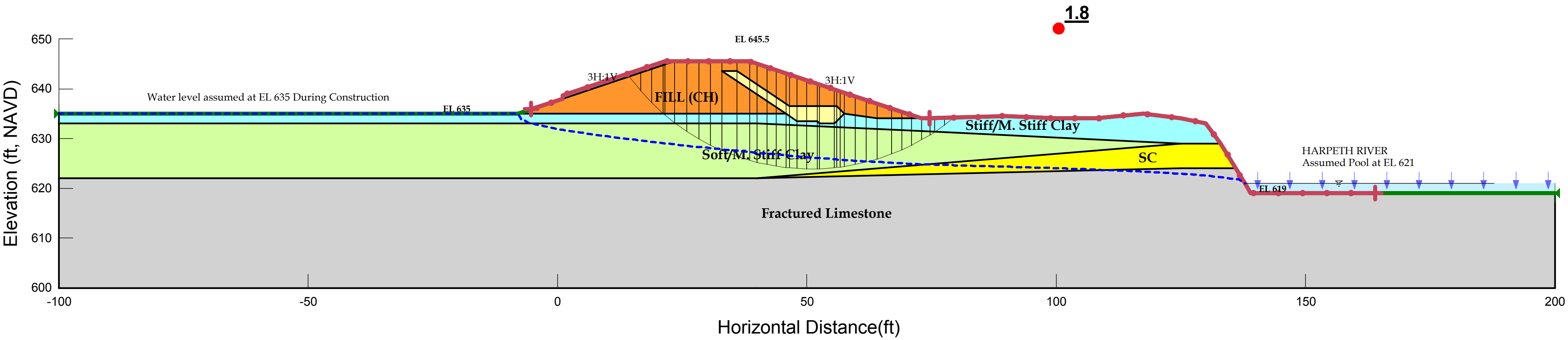
Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Proposed Condition

End of Construction



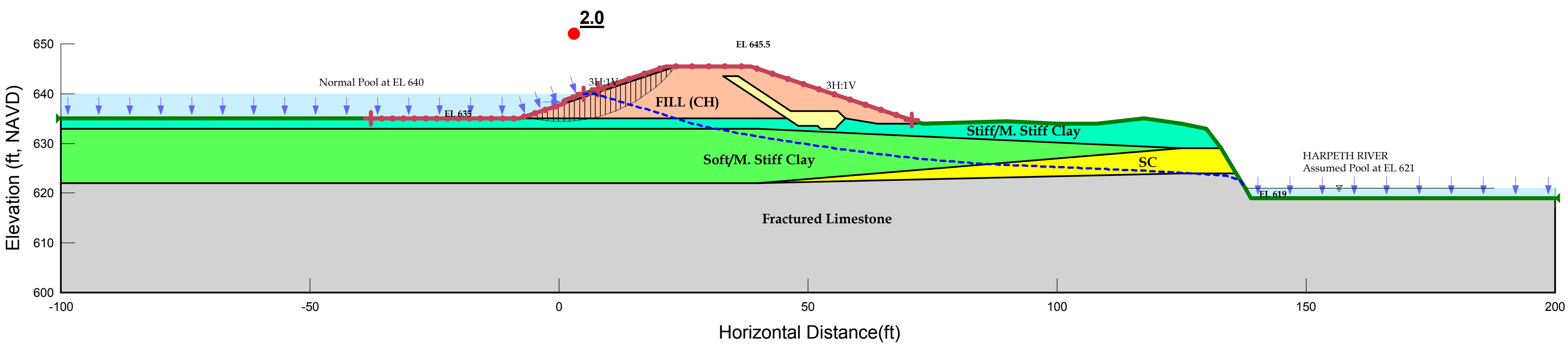
Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Proposed Condition

End of Construction



Robinson Lake Dam Rehabilitation
City of Franklin, TN
Seepage and Slope Stability Analyses
Proposed Condition

Normal Pool Level, Static Condition



Robinson Lake Dam Rehabilitation
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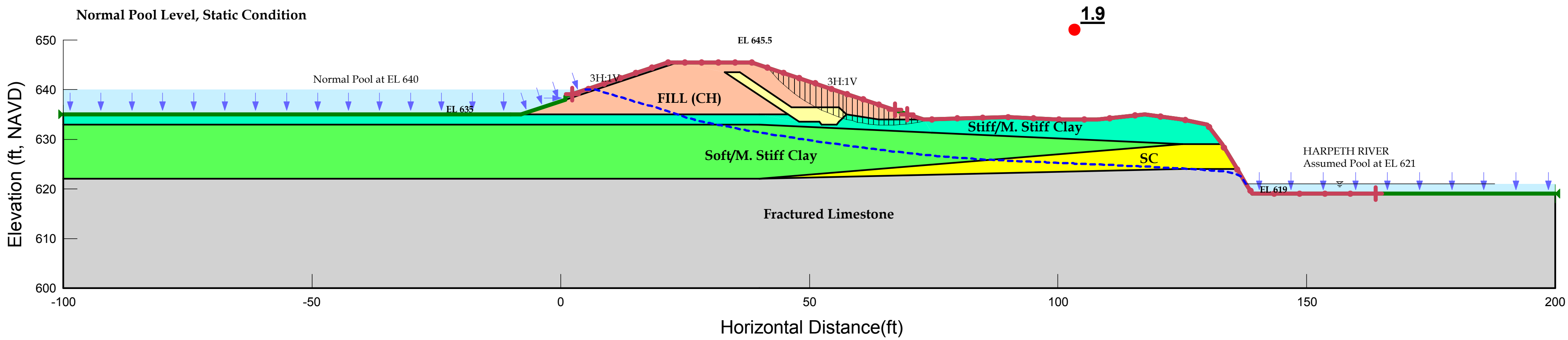
Seepage and Slope Stability Analyses
Proposed Condition



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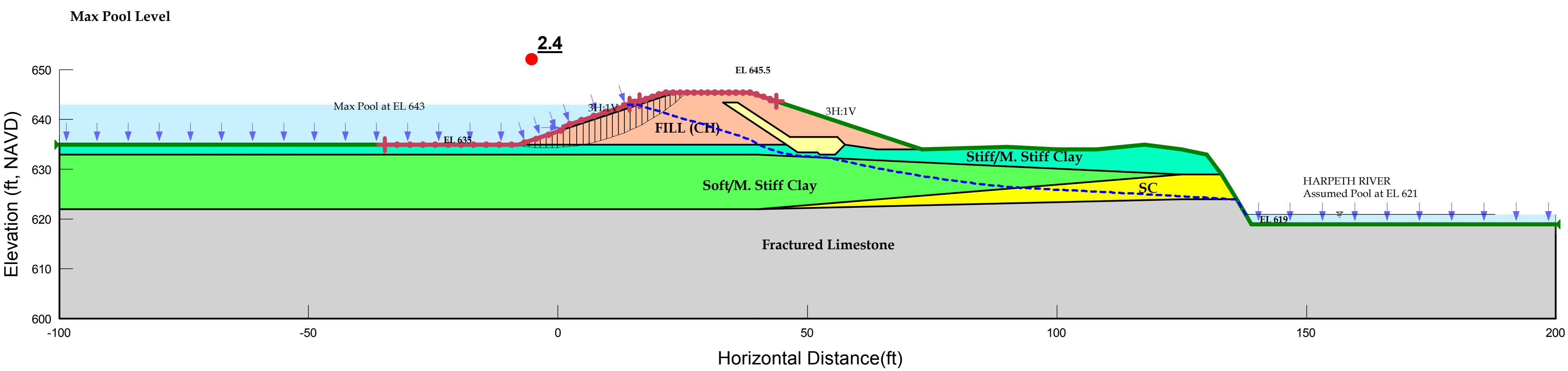
Seepage and Slope Stability Analyses
Proposed Condition



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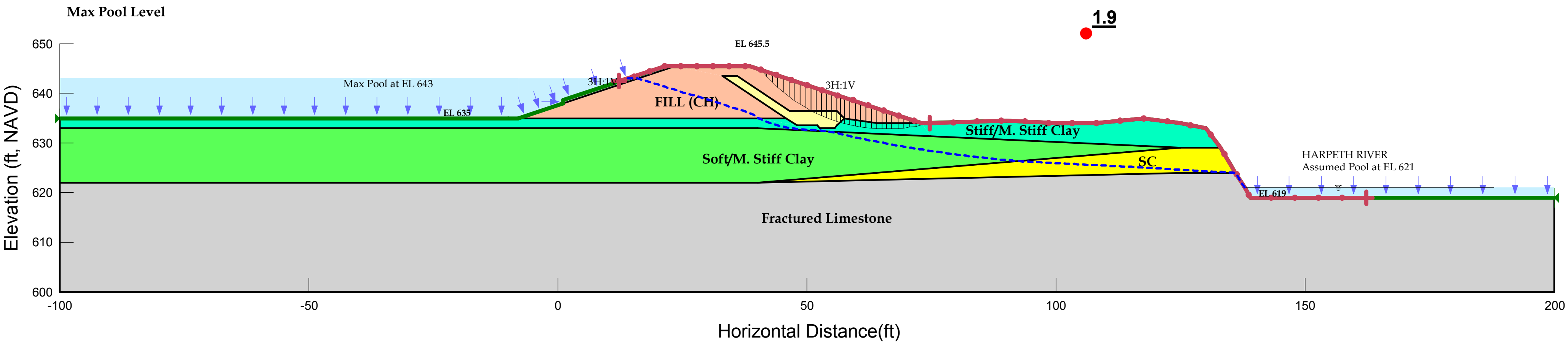
Proposed Condition



Robinson Lake Dam Rehabilitation
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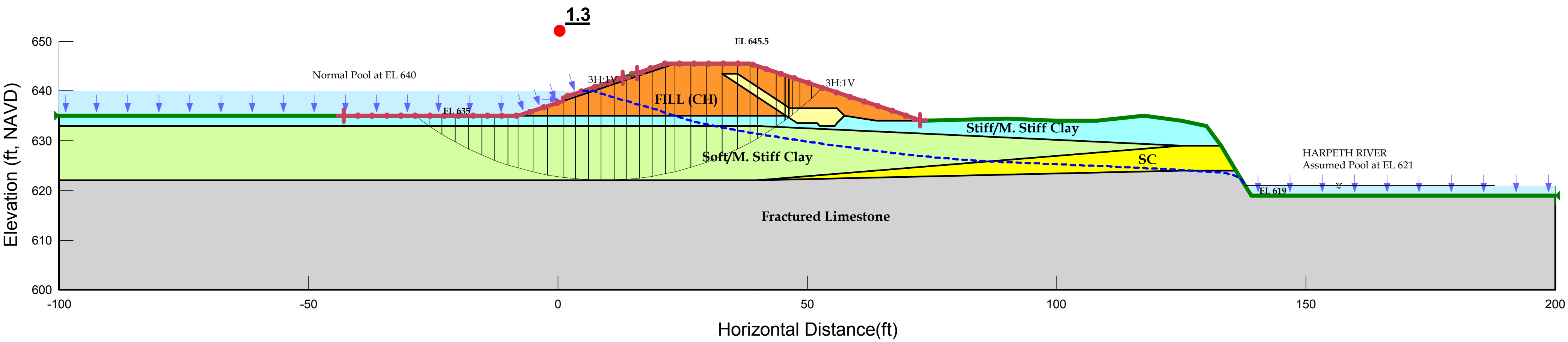
Seepage and Slope Stability Analyses
Proposed Condition

Normal Pool Level, Seismic Condition



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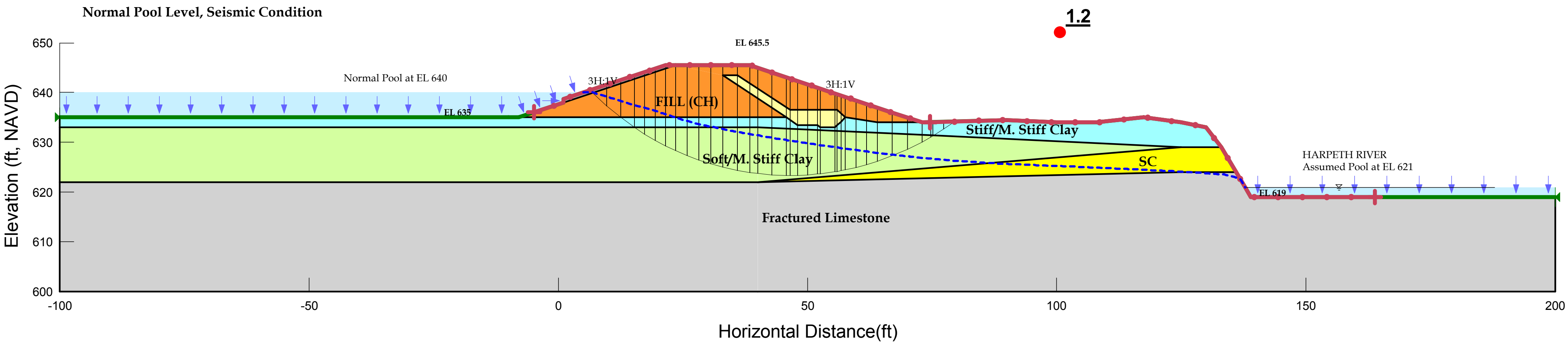

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