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Basis of Design Report

Sippo Creek Reservoir Dam Lowering Project
Stark County, Ohio

City of Massillon

Project Reference: ODNR File #0614-012
Project Number: 60439145

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List of Acronyms

AECOM	AECOM/URS Corporation
ASCE	American Society of Civil Engineers
bgs	Below existing ground surface
BOD	Basis of Design Report
BMP	Best Management Practice
cfs	Cubic feet per second
fps	Feet per second
GIS	Geographic Information System
H&H	Hydrologic & Hydraulic
HEC-RAS	Hydraulic Engineering Center River Analysis System
IDF	Inflow Design Flood
LiDAR	Light Detection and Ranging
NAVD 88	North American Vertical Datum of 1988
NEH	National Engineering Handbook
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
pcf	Pounds per cubic foot
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
psf	Pounds per square foot
psi	Pounds per square inch
SCS	Soil Conservation Service
SEI	Structural Engineering Institute
SPT	Standard Penetration Test
SWCD	Stark Soil Water Conservation District
SWPPP	Stormwater Pollution Prevention Plan
TRM	Turf Reinforcement Matting
WSE	Water Surface Elevation

1. Project Description

Sippo Creek Reservoir (Reservoir) is located in the City of Massillon, in west central Stark County, Ohio, east of the Tuscarawas River and State Route 21 and west of Interstate 77. A sit location map is included on **Sheet 01** of the draft design drawings**.** All sheets referenced in this document are provided as **Appendix D** (attached). Sippo Creek Reservoir Dam (Dam) is an earthen dam approximately 19 feet high and 265 feet long, and was built between 1875 and 1896 by the Massillon Water Works Supply Company to supply water to the City. The Massillon Water Works Supply Company is defunct and no longer supplies water to the City; the City now owns the dam and the surrounding park. The Ohio Department of Natural Resources (ODNR), the Dam regulatory agency, has assigned the Dam ODNR File No. 0614-012.

Should a failure occur at the Dam, breach outflow and extents of flooding will likely result in probably loss of human life. Therefore, ODNR has categorized this Dam as Class I. A Class I dam is required by ODNR to safely store and/or pass flows generated from 100% of the Probable Maximum Flood (PMF) without failure.

The City of Massillon has elected to remove the Dam from ODNR regulations and future permitting requirements by reducing the category from Class I to Class IV. By lowering the category of the Dam to Class IV, the inflow design flood (IDF) decreases from 100% of the PMF to the 100-year storm.

On April 7, 2017 correspondence between ODNR and AECOM discussed design criteria and proposed improvements for the Dam. ODNR has requested that the design allow flows generated by the 10-year storm to discharge through the primary spillway without overtopping. Furthermore, ODNR has requested that the design include overtopping protection and downstream erosion control measures to safely pass flows generated by the 100-year storm without failure to the Dam.

AEOCM developed a design to partially lower the Dam and primary spillway, install overtopping protection, and prevent erosion downstream, while satisfying the requested design criteria specified by ODNR. In the post construction condition, the Dam will be twenty-feet or less in height with a total storage volume of fifty acre-feet or less. By definition, the Dam will be categorized as Class IV by ODNR, satisfying the project goals for the City of Massillon.

AECOM has prepared this Basis of Design (BOD) Report to illustrate the proposed improvements and modifications with supporting engineering analysis and calculations for the design.

1.1 Existing Conditions

The Reservoir is located at the lower end of the drainage area of Sippo Creek, a tributary of the Tuscarawas River. The Reservoir is used for recreational purposes, has a surface area of approximately 7.0 acre in size at normal pool (1,001.64 ft.), and impounds 82.2 acre-feet at the crest of the dam (1,004.2 ft.). All elevations in this report reference the North American Vertical Datum of 1988 (NAVD 88) unless otherwise specified. The dam has a 50 foot wide stone block overflow weir that serves as the primary spillway. The weir discharges onto a series of small stone steps and onto a stone pad, providing energy dissipation. A lake drain pipe emerges from the stone steps and lies on the floor of the stone pad. The receiving channel returns to its natural width about 150 feet downstream of the Dam, where a small pedestrian bridge crosses the creek. The Dam is not equipped with an emergency spillway.

AECOM gathered information from site visits, surveys, subsurface investigations, and public records to assist with the design.

1.1.1 Survey and Topography

Ground surveys were performed by AECOM in August 2011 and again in September 2015. The surveys included the primary spillway, topography of the surrounding area, utilities, and other structures downstream of the Dam. Utility locations unable to be surveyed were provided by the City of Massillon and Ohio Edison. The vertical datum for each survey referenced NAVD 88 and the horizontal control is the Ohio State Plane Coordinate System NAD 1983, North Zone, U.S. Foot. Topographical mapping was generated using a Digital Elevation Model created by points developed from Light Detection and Ranging methods, dated 2007 and supplemented with the data from the ground surveys.

Once AECOM gathered all of the survey and available topographical information, an existing basemap was generated for the project. The basemap was utilized throughout the analysis and design process to successfully accomplish project goals.

1.2 Project Goals

The primary goal of this project is to develop construction level drawings and calculations in order to install the proposed improvements and modifications to existing features of the design. Below is a list of the proposed improvements that make up the design:

- Remove top courses of the primary spillway abutment walls down to approximate elevation of 998.6 ft.
- Remove four courses of stone in the primary spillway down to approximate elevation of 995.6 ft.
- Cascade existing core wall and maintain a minimum of 6-inches below final grade.
- Regrade dam crest to include a 5-foot bench out from each abutment that transitions to a 6H:1V slope up to existing grade.
- Install Turf Reinforcement Matting (TRM) on the upstream face of the dam that extends to the downstream toe.
- Construct a grouted riprap outlet channel downstream of the existing stone pad.

Analyses and calculations provided in this BOD include the following:

- Geotechnical Engineering

- ✓ Geotechnical Exploration
- ✓ Slope Stability Analysis

➢ Hydrologic and Hydraulic (H&H) Engineering

- ✓ Hydrologic (HydroCAD) Modeling
- ✓ Hydraulic Engineering Center River Analysis System (HEC-RAS) Modeling
- ✓ Riprap Outlet Channel Design
- ✓ TRM Design

➢ Structural Engineering

- ✓ Structural Analysis

This BOD is intended to support the design of the proposed improvements and accompanies the design drawing set, *Sippo Creek Reservoir Dam Lowering, Draft Design Drawings*, provided as **Appendix D**.

2. Permitting and Project Requirements

Permitting of the proposed modifications is required by ODNR, Division of Soil and Water Resources, Ohio Dam Safety Program. Permits will need to be obtained prior to implementing the proposed improvements. Project permitting and ODNR requirements are presented in the following sections.

2.1 ODNR Dam Improvements Permit

Any improvements to dams that are regulated by the Ohio Department of Natural Resources must obtain a permit for the improvements, prior to any construction per Ohio Revised Code 1521.062 and Ohio Administrative Code 1501:21-21-03. The proposed improvements have been designed to allow for the IDF to be passed and/or stored without failure. This BOD represents the application for the ODNR permit to construct the design discussed herein.

2.2 Stormwater and Erosion and Sediment Control

The Ohio Environmental Protection Agency (OEPA) requires that a Stormwater Pollution Prevention Plan (SWPPP) and a Notice of Intent (NOI) be prepared for a construction project that plans to disturb 1-acre or more of land. The limit of disturbance for this project is less than half an acre, by definition a SWPPP and NOI is not required.

The Stark Soil and Water Conservation District (SWCD) protects the county's resources by following the Stark County Water Management and Sediment Control Regulations, amended in 2008. The SWCD ensures that proper erosion and sediment control and stormwater measures are in place throughout a construction project, also known as Best Management Practices (BMP's). The SWDC has authority to stop work while performing construction site inspections, if BMP's are not installed or maintained correctly. AECOM plans to submit a final copy of the construction drawings as a preconstruction notification to the SWCD for approval of the proposed BMP's.

3. Recommended Design

Selection of the recommended design for the proposed improvements and modifications of existing features to the Dam is a result of the owner electing to remove the Dam from ODNR regulations and future permitting requirements as well as the ODNR requested design criteria, discussed with AECOM in April, 2017.

This section describes the components that make the Sippo Creek Reservoir Dam Lowering Design Project.

3.1 Overview

To meet project goals and the requested design criteria, modifications to the Dam and primary spillway a construction of new improvements are required. Design criteria discussed with ODNR include the following:

- The primary spillway must allow flows generated by the 10-year storm to pass through without overtopping the Dam.
- The Dam must safely store and/or pass flows generated by the 100-year storm without failure.

Lowering the Dam and primary spillway to reduce its ODNR category also reduces its capacity. For the design, it is anticipated that flows generated by storms larger than the 10-year will likely overtop the Dam. Installation of overtopping protection and erosion control measures are required.

The following subsequent sections describe the multiple components that make up the design.

3.2 Primary Spillway and Dam Modifications

Primary spillway and Dam modifications are required to remove the Dam from ODNR regulations and future permitting as well as satisfy the requested design criteria from ODNR. Top courses of the primary spillway abutment walls on each side are to be removed down to an approximate elevation of 998.6 ft. Four courses of stone from the primary spillway are to be removed down to an approximate elevation of 995.6 ft. The estimated 10-year water surface elevation (WSE) in the Reservoir is 998.5 ft., allowing the flows generated by the 10-year storm to pass through the primary spillway without overtopping the Dam.

The existing core wall will be modified to cascade from the abutment walls to existing grade on each side. Sections of the core wall will be removed to maintain a minimum of 6 inches below final grades. Final grading of the Dam crest will include a 5-foot bench out from the abutment walls at an approximate elevation of 998.6 ft. and transition to a 6H:1V slope up to an approximate existing grade elevation of 1,002.0 ft., on both sides.

3.3 Overtopping Protection

Overtopping protection is required to prevent erosion of the Dam during storms larger than the 10-year. TRM will be installed at the upstream face of the Dam and extend to the downstream toe. The TRM specified for the project is PYRAMAT® High Performance, or approved equal. This particular TRM resists velocities up to 25 feet per second (fps) and shear stresses up to 16 pounds per square foot (psf).

Several materials are required to construct the anchor trenches for the TRM. **Sheet 06** of the design set illustrates the proposed TRM plan. The anchor trench along the upstream abutments and the upstream horizontal against the core wall will consist of AquaBlok®. AquaBlok is a composite aggregate sealant consisting of a limestone aggregate core wrapped with powdered sodium bentonite clay. The AquaBlok was chosen for these locations to fill in and plug the voids between the abutment walls and adjacent soil materials, and to reduce seepage through existing pathways.

The anchor trenches located along the downstream face of the core wall and along the downstream abutment walls will consist of 3,000 pounds per square inch (psi) non-shrink grout. Forces along the downstream face of the Dam during overtopping will cause uplift and overturning pressures. The grout anchors proposed at these locations will resist the anticipated pressures and prevent the TRM from displacing.

All other anchors for the TRM are made up of compacted soil, except for at the location of the proposed grouted riprap outlet channel discussed in the next section.

3.4 Grouted Riprap Outlet Channel

As flow increases through the spillway and over the dam, a hydraulic jump occurs, at first, downstream of the existing stone pad. The hydraulic jump starts to move backwards as flow increases, ultimately submerging itself at the location of the existing stone pad. Velocities in the center of the channel are expected to reach nearly 24 fps, while velocities at the banks are expected to reach nearly 19.5 fps at the transition from the stone pad to the natural receiving channel. A grouted riprap outlet channel will be constructed downstream of the existing stone pad and extend on each side onto the existing banks.

The grouted riprap outlet channel will be approximately 90 ft. wide, 20 ft. long and 3 ft. thick. Ohio Department of Transportation (ODOT) Type A will be utilized for the riprap. ODOT Type A ranges in stone size between 18 and 30 inches in diameter, and is recommended to be installed with a thickness of 1.5 times the average stone size (24 inches). The riprap placed on the banks will also serve as the anchor material for the TRM installed at this location.

It is anticipated that a hydraulic jump will occur on the grouted riprap outlet channel and be susceptible to non-uniform flow and high velocities in excess of the ODOT Type A recommended design use. For this reason, AECOM has included in the design that 3,000 psi non-shrink grout be used to hold the riprap in place.

4. Geotechnical Engineering

This section documents the subsurface exploration activities and results of our geotechnical exploration near the spillway structure at the Dam.

4.1 Geotechnical Exploration

A total of four exploratory borings were advanced for the subsurface exploration activities to depths of 20.5 to 40.5 feet below the existing ground surface (bgs). The approximate locations of the borings are provided in **Appendix A**. Prior to drilling, an AECOM representative visited the site to perform reconnaissance and finalize the boring locations. All borings were cleared of any known underground and overhead utilities by notifying the Ohio Utilities Protection Service at least 48 hours prior to the commencement of the exploration drilling activities.

4.1.1 Exploratory Soil Borings

The subsurface exploration was performed on August 24 and 25, 2015, by AECOM's Ohio TestBor Inc., of Hinckley, Ohio. The boring locations were identified in the field relative to existing site features and were later surveyed after drilling and backfilling were completed. A summary of subsurface exploration performed and the corresponding boring locations are presented in Table 4-1 below:

Table 4-1: Summary of Subsurface Exploration Boring Locations

Boring No.	Date Drilled	Boring Depth (feet)	Boring Location Northing (NAD83)	Boring Location Easting (NAD83)	Elevation (NAVD88 feet)
B-1	8/24/2015	40.5	415,890.5	2,243,172.4	1006.6
B-2	8/24/2015	20.5	415,862.3	2,243,217.7	998.3
B-3	8/25/2015	40.5	415,967.9	2,243,257.9	1005.5
B-4	8/25/2015	35.5	415,930.1	2,243,286.2	991.9

Sampling generally occurred as follows:

- After each borehole was drilled to the specified depth, the sampler mounted on the drill rods was lowered to the bottom, seated, and then driven into the soil with a hammer to retrieve a standard penetration test (SPT) sample in general accordance with ASTM D1586.
- The SPT samplers were advanced using a 140-pound safety hammer with a freefall of 30 inches for each blow. The number of hammer blows required to advance the sampler through each of four successive 6-inch increments was recorded in the field. The number of blows required to advance the sampler through the middle 12 inches was recorded as the penetration resistance (blows per foot or "N").
- All borings were sampled at 2.5 foot intervals within the upper 10 feet bgs and at 5-foot intervals thereafter using nominal 2-inch diameter split-spoon samplers.

The presence of groundwater was noted within some of the soil samples collected from the borings and water levels in the open boreholes were measured prior to backfilling. Borings were backfilled with a cement bentonite grout mixture to seal the boreholes.

An AECOM engineering geologist was present to oversee all drilling and sampling operations and to log soil samples. All soils were visually classified during drilling in accordance with the Unified Soil Classification System (ASTM D2487). The SPT samples were placed in glass jars, sealed with a lid, and then transported directly to AECOM's subcontractor Geotechnics Inc. in East Pittsburgh, Pennsylvania for laboratory testing.

Logs of the borings were prepared based on the soil classification made in the field and modified based on the results of laboratory testing results. Graphical boring logs are presented in **Appendix A** of this report.

4.1.2 Geologic Setting

Four significant periods of global cooling during the Pleistocene Epoch (approximately 1.6 million to 10,000 years ago) caused the repeated advancements of continental ice sheets from the Hudson Bay and Labrador areas of Canada southward across the Great Lakes, then into Ohio, Indiana, Illinois and Northern Kentucky. The ice sheets scoured the surface, pulverizing bedrock and soil sediments, incorporating them into the glaciers, transporting and then redepositing the sediments by the glacial-ice itself or by glacial meltwater as the ice sheet melted northward. The Wisconsin period (approximately 85,000 to 11,000 years ago) marked the final glacial advance with glaciers reaching northern Ohio approximately 24,000 years ago. Most of the glacial sediments deposited in the region are Wisconsin-age although earlier deposits may be present beneath.

Till deposits consisting of an unsorted mixture of gravel, sand, silt, and clay were glacial sediments deposited by the glacier itself. Large sheets till deposit formed ground moraine which was flat and compact. Along the edges of the glacier, ridges composed of generally compact till were also deposited by the glacier as terminal or end moraines which marked periods of ice stagnation. As the glacier retreated during warmer periods, the glacial ice melted; enormous quantities of glacial meltwater reworked sediments incorporated into the glacial-ice and redeposited them as glacial fluvial deposits (general term). Sorted to unsorted mixtures of gravel, sand and silt which had formed within or along the edges of the glacial- ice and later collapsed through the weakened melting ice, formed mounds termed kames. Sorted gravel and sand deposits placed by fast-moving water ahead of the glacier formed outwash deposits. Sorted deposits of fine sand, silt and clay were deposited by slower moving meltwater and formed lacustrine deposits which sometimes filled depressions. As the depressions were filled, vegetation would grow along the perimeter and sometimes fill the depression; as the water became stagnant and oxygen-depleted, the dead vegetation did not completely decay and accumulated as peat deposits.

The site was located approximately seven (7) miles north of the irregular-shaped glacial boundary which marked the southern limit of glaciers into Ohio. Kame deposits were mapped directly at the site and ground moraine, end moraine, and outwash deposits were mapped within two miles of the site. The site was also located near the center of a former northeast to southwest trending pre-glacial valley which was subsequently filled by glacial sediment up to approximately 275 feet thick. The depth to bedrock at the site was approximately 275 feet; the elevation of the top of bedrock at the dam location was between 700 and 750 feet. The bedrock beneath the site was identified as the Mississippian-age (359 to 323 million years ago) Cuyahoga Formation.

4.1.3 Site Subsurface Conditions

The subsurface soils at the project site are primarily fill materials overlying Wisconsinan age glacial outwash deposits. The subsurface profile of the site is relatively consistent, and is generally comprised of the following units (from highest to lowest elevation): Topsoil surficial materials; fill material soils; and coarse-grained outwash soils. Bedrock was not encountered in this investigation. Based on the geologic mapping of the local region, bedrock is substantially deep below the outwash deposit.

The following describes the site-specific subsurface conditions in detail and are based on the results of the field exploration performed at the site.

- **Surficial Materials**: Topsoil was encountered at the ground surface in all borings. The thickness of topsoil ranged from 2 to 3.5 inches thick.
- **Fill Materials:** Fill soils were encountered below the topsoil in all borings and are assumed to be the result of grade changes made during the original construction of the embankment. These materials were predominately granular in composition and described as brown, moist, silty sand (SM) or clayey sand (SC) with trace amounts of gravel. In boring B-1, a 4.3 foot thick moist, brown, sandy lean clay layer was encountered at 4.5 feet below the ground surface. Pocket penetrometer test results taken from the clay layer varied from 0.5 to 0.75 tons per square foot (tsf), indicating a medium stiff consistency.

  The fill materials were first encountered within the upper half foot of the ground surface and extended to a maximum depth of 14 feet bgs. Thickness of fill materials varied from 2.5 feet in B-4 to 13.8 feet thick in boring B-1 with borings B-2 and B-3 fill thickness varied from 8.2 feet to 8 feet thick, respectively. SPT N-values within the fill materials ranged from 3 to 14 blows per foot (bpf), with an average value near 8 bpf indicating a loose consistency, on average.
- **Native Granular Soils:** A native granular deposit generally described as brown or brown and gray clayey sand (SC) or silty sand (SM) was encountered beneath the fill materials in all of the borings. The nature of the material indicates these are glacial fluvial and outwash deposits. These soils were first encountered at depths varying from 3 feet to 14 feet bgs. Since all borings were terminated within the native granular soils, thickness of this layer was not determined. SPT N-values within native granular soils ranged from 2 to 47 bpf. The average SPT N-value was about 12 bpf, indicating a medium dense relative density on average.

4.1.4 Results of Laboratory Testing

A number of representative samples collected during the exploration activities were subject to index and characterization testing. These tests were utilized to better evaluate the subsurface conditions and to verify visual classifications of the soils. A summary of the laboratory program is provided in Table 4-2. The table is organized by testing method and soil strata encountered during the exploration activities.

Table 4-2: Summary of Laboratory Testing Program

Test Type	ASTM Standard	Fill Materials			Native Granular Soils		
		No. of Tests	Result Range	Average	No. of Tests	Result Range	Average
Moisture Content	D2216	6	7.2 – 20.7	12.3	5	7.8 – 17.4	13.5
Atterberg Limits*	D4318	4	LL: 23 – 30 PL: 14 – 20 PI: 6 – 11	26 17 9	2	LL: NP & 36 PL: NP & 19 PI: NP & 17	-
Particle Size Analysis	D422	5	% Gravel: 0.1 – 67 % Sand: 26 – 71 % Silt: 21 – 41 % Clay: 8 – 22 % Fines: 7 – 63	19 44 29 17 38	6	% Gravel: 0.2 – 50 % Sand: 31 – 84 % Silt: 10 – 36 % Clay: 5 – 11 % Fines: 9 – 47	29 49 23 8 22

(*) - LL denotes liquid limit, PL denotes plasticity limit, and PI denotes Plasticity Index.

The results of the laboratory testing are summarized on the boring logs at the corresponding sample depths. Boring logs and complete results of the laboratory tests are provided in **Appendix A**.

4.1.5 Groundwater Conditions

Groundwater was monitored during and after the completion of drilling operations. During the subsurface exploration drilling operations, groundwater was encountered in all of the borings. Information regarding groundwater depths and duration the boreholes were left open is summarized in Table 4-3: below:

Table 4-3: Summary of Exploration Groundwater Measurements

Boring No.	Groundwater Depth at the Time of Drilling		Groundwater Depth After Auger Removal	
	Feet bgs	Elevation (feet)	Feet bgs	Elevation (feet)
B-1	10.3	996.3	15	991.6
B-2	13.5	984.8	Dry	NA
B-3	14	991.5	-	-
B-4	23.5	968.4	28.5	963.4

Based on the observations during the exploration activities, the natural static groundwater table is located within the native granular deposits. In boring B-1, a wet layer within a sand layer above a clayey sand layer of the fill materials was encountered.

Due to the short duration of groundwater observations, a complete description of the subsurface groundwater characteristics is beyond the scope of this subsurface exploration. However, the static groundwater table will most likely follow the natural topography and will fluctuate with seasonal variations in climate and water levels within the Reservoir.

4.2 Slope Stability Analysis

A slope stability analysis was performed on the dike embankment by utilizing the computer program Slope/W (GeoStudio 2016, http://www.geo-slope.com/). This software is capable of utilizing a wide variety of methods to evaluate stability based on 2-dimensional limit equilibrium theory. For this evaluation, Slope/W was programmed to utilize Spencer's Method to evaluate slope stability to determine factors of safety for circular failure surface geometries for deep-seated global slip surfaces. A solution by Spencer's Method involves an iterative, trial and error procedure in which values for the factor of safety and side force inclination are assumed repeatedly until all conditions of force and moment equilibrium are satisfied for each slice. Then, the forces for each slice are calculated. This method provides an accurate procedure that is applicable to virtually all slope geometries and soil profiles, and it represents the simplest complete equilibrium procedure for computing factors of safety.

As part of this analysis, two sections, Section A-A' and Section B-B' were selected to evaluate embankment stability. The location of the sections was selected based on the embankment critical slope height, orientation, and/or subsurface conditions encountered. Both sections are shown in **Appendix A**. For evaluation purposes, the analysis was performed in general accordance with the U.S. Corps of Engineers Manual EM-1110-2-1902, "Slope Stability" for the following conditions:

- **Static, Steady-State, Normal Pool Condition**: This case models the conditions under static, long-term conditions, under the normal storage water level within the reservoir. Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on groundwater observations made during the exploration activities and a preliminary seepage analysis further described in the sections below. A target minimum factor of safety of 1.50 is needed for this loading condition. The operating water level of Sippo Creek reservoir prior to modifications is El. 1001.6 feet.
- **Seismic Stability Condition**: This case incorporates a horizontal seismic coefficient k_h selected to be representative of expected loading during the design earthquake event (i.e., a "pseudostatic" analysis). The process of determining the seismic coefficient is explained in the next section. The analysis utilizes peak undrained strength parameters in soils that are not considered to be rapidly draining, and peak drained strengths in soils considered to drain freely. The phreatic surface and pore water pressures corresponding to the Steady State Normal Storage Pool case from the static analyses were utilized. Seismic loading was included in this analysis using a pseudostatic coefficient (k_h), which is further described below. A target minimum Factor of Safety of 1.00 is required for this loading condition.

The analysis conditions were evaluated based on the input parameters of the subsurface material parameters, horizontal seismic coefficient, and pre-modification conditions. These evaluations are further summarized in the subsequent sections below. The results of the slope stability analysis are presented in **Appendix A.**

4.2.1 Seismic Load

Based on the results of the exploration activities, the presence of loose fill materials and medium dense granular native soils indicate the most appropriate classification of the site seismic is Class D.

The seismic coefficient (k_h) is calculated based on the seismic hazard identified at the site. It is a variable in which the inertia forces due to earthquake shaking are represented by a constant horizontal force equal to the weight of the potential sliding mass multiplied by the peak average acceleration of the failure mass. This additional force is used in the limit equilibrium stability analyses to account for seismic impacts in the design for the facility and to minimize impacts to the engineered components. This approach is commonly called a pseudostatic analysis and is one of the simplest means used in earthquake engineering to analyze the seismic response of soil embankments and slopes.

The seismic coefficient is typically the only variable necessary to perform the pseudostatic analysis and is used directly in the limit equilibrium analyses as an additional load applied to the embankment. Determination of the peak ground acceleration (PGA) for high hazard dams is usually associated with a design earthquake with a 2% probability exceedance in 50 years (2,475-year return period). Based on the 2008 USGS seismic hazard map, the design quake around the Reservoir is a Magnitude 6.07 and has a peak ground acceleration of 0.063g at the top of competent deep rock. By using a 1.6 amplification multiplier associated with Site Class D materials (per ASCE/SEI Standard 7-10); the PGA at the ground surface (or base of the embankment) would be near 0.101g. Peak acceleration of the embankment was estimated by using the correlations developed by Harder (1991), which compares the base to crest accelerations (U_{max}) at earthen dams from recorded earthquakes.

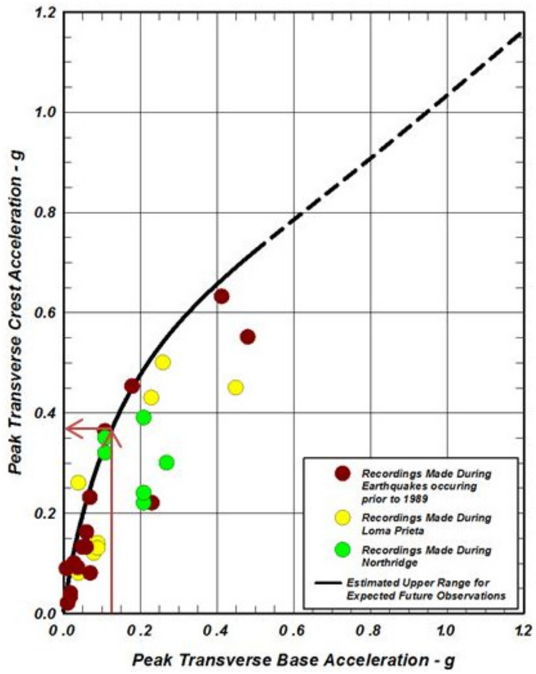


Figure 4-1: Base Crest Acceleration of Earthen Dams (Harder, 1991)

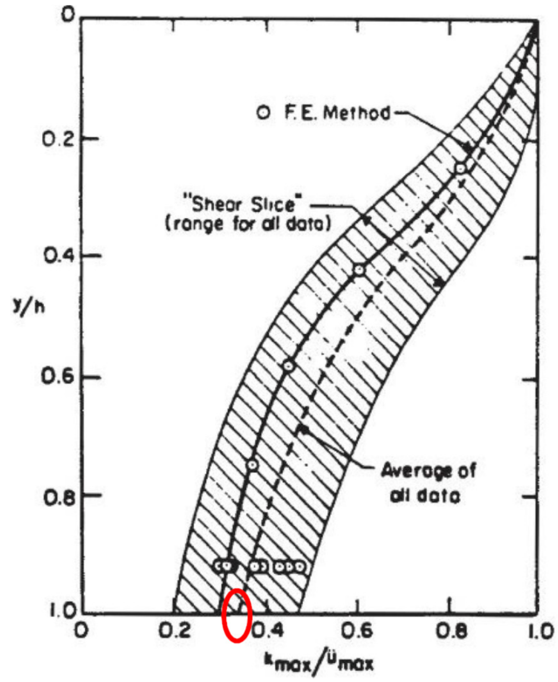


Figure 4-2: Variation of Maximum Acceleration Ratio (Makdisi and Seed, 1978)

Figure 4-1 above includes the Harder curve and the corresponding site crest correlation shown in red. This indicates acceleration at the embankment crest is near 0.34g. In order to determine the coefficient of acceleration at the center of the stability slice (k_{max}), the chart by Makdisi and Seed (1978) was utilized. A value of 1.0 was utilized for the ratio of the height of failure slice to dam height. Based on the correlation shown in Figure 4-2, a k_{max} / U_{max} ratio is equal to 0.34. Therefore, the seismic coefficient of 0.116g (0.34 x 0.34 = 0.1156) was utilized in the stability analysis.

4.2.2 Material Parameters

Material properties for the slope stability analyses were developed by correlating the in-situ testing collected from the exploration activities and the results of the laboratory testing. For material parameters not critical to the analysis, conservative values for the materials were assumed based on engineering judgement. The properties used in the stability analysis are summarized in Table 4-4: below:

Table 4-4: Summary of Material Parameters used in Stability Analysis

Material	Unit Weight	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
	pcf	c' (psf)	Φ' (º)	c' (psf)	Φ' (º)
Granular Fill Materials	115	0	29	-	-
Clay Fill Materials	125	100	29	300	15
Native Granular Soils	117	0	30	-	-

4.2.3 Results

Table 4-5 summarizes the results of the stability analysis for both sections analyzed, and output figures from the SLOPE/W models are provided in **Appendix A.**

Table 4-5. Results of Stability Analysis

Cross Section	Required Factor of Safety	Section A-A'		Section B-B'	
		Downstream	Upstream	Downstream	Upstream
Static, Steady State, Normal Pool	FS ≥ 1.5	1.62	1.61	3.76	1.65
Seismic, Pseudostatic Condition	FS ≥ 1.0	1.22	1.09	2.11	1.06

Both sections pass the static loading condition for steady-state under normal pool conditions and the seismic (earthquake) condition. Based on the analysis performed, the pre-modification conditions of the embankment are stable and do not need additional measures or improvements to the embankment to satisfy global stability requirements.

4.3 Geotechnical Conclusions

Based on the results of the subsurface exploration activities and the subsequent stability analysis, the following geotechnical conclusions as it relates to the proposed improvements are provided:

- Proposed improvements to the spillway structure include removing a two to four layers of the existing stone and lowering the normal pool level within the reservoir to El. 998.6 feet. Lowering the pool level in a controlled manor will result in a lower phreatic surface through the dike embankment and thus a higher factor of safety for global stability.
- The removal of the stone layers on the spillway structure will reduce the bearing pressure applied at the base of the structure. Since the existing structure has remained in place for a long time (over 100 years), the initial bearing stress from the structure has equilibrated within foundation soils. Therefore, bearing calculations were not performed since no new loading will be applied to the foundation soils.

5. Hydrologic and Hydraulic (H&H) Engineering

The basis of this design relied heavily on hydraulic and hydrologic analysis of the entire contributing watershed, the Reservoir, the Dam, and Sippo Creek. Hydraulic and Hydrologic evaluations and computations assisted AECOM in preparing the recommended design solution to successfully accomplish project goals. The following sections represent the multiple components that make up the H&H design.

5.1 Hydrologic Evaluation

In July 2013, URS Corporation (now AECOM) completed an H&H analysis that concentrated on determining the design flood discharge for the Dam and satisfy ODNR regulations for Class I permitting. The intent of the analysis was to determine the design flood to facilitate the design of an economically feasible dam improvement plan that satisfies ODNR, City of Massillon, and the SWCD.

The City of Massillon has elected to remove the Dam from ODNR regulations and future permitting requirements lowering the category of the Dam from Class I to Class IV. The resultant IDF for the Dam is the 100-year storm, down from 100% of the PMF.

5.1.1 HydroCAD Modeling

AECOM utilized the HydroCAD model, updated for the current version of the software (version 10.00-19), developed for the H&H analysis prepared in July 2013 for the City of Massillon to calculate the peak inflow generated from the 10 and 100-year storms. The model was developed by replicating previously constructed hydrologic models updated with topography information gathered from survey data. The drainage area for Sippo Creek includes 9,459 acres, and consists of rural and subdivided areas, residential lots, wooded grassland, and wooded areas. The total drainage area was modeled with several subcatchments, reaches, and ponds representing the complex watershed for the Reservoir. A schematic of the HydroCAD model is illustrated below.

DRAFT

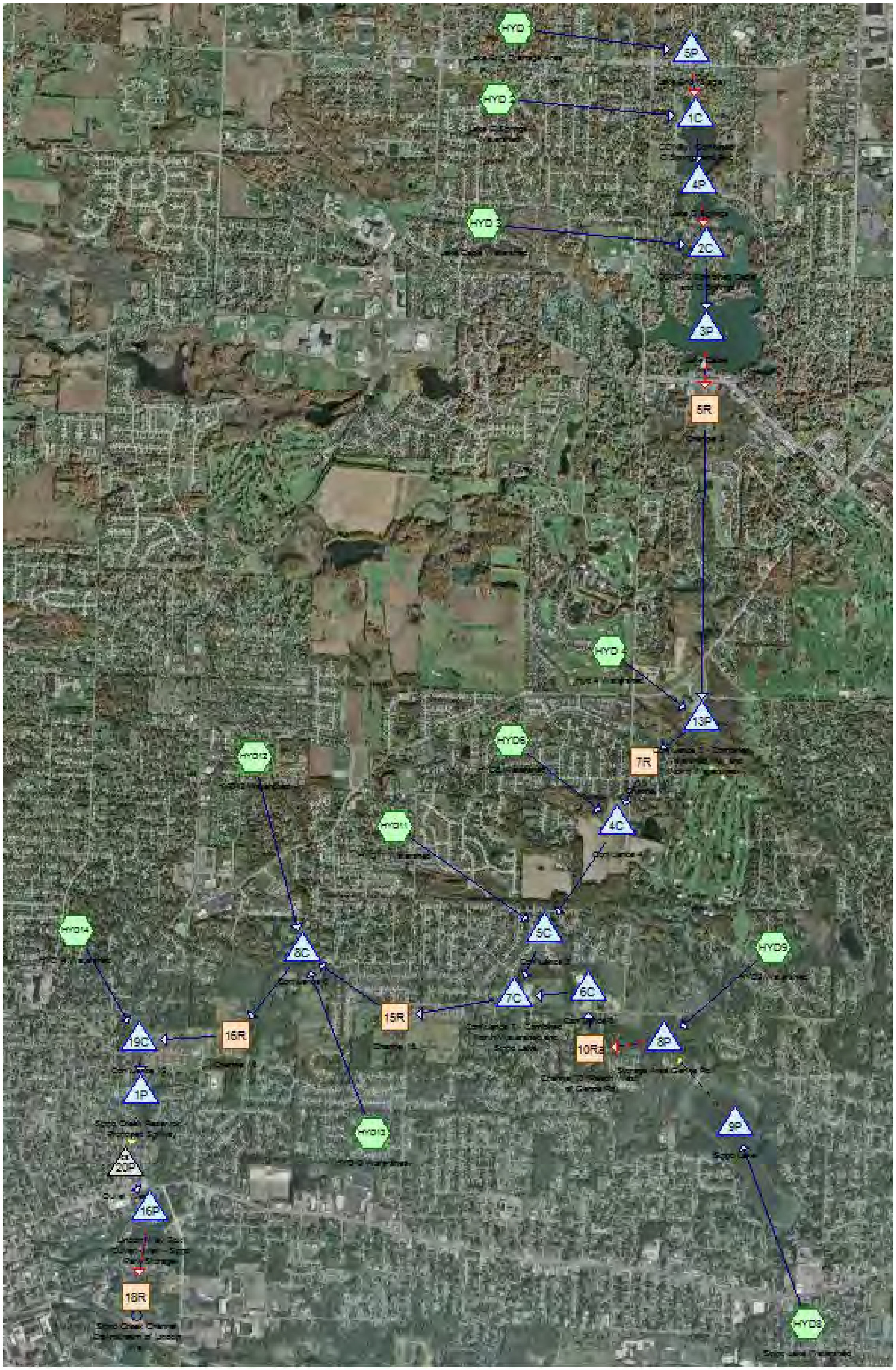


Figure 5-1: HydroCAD Model Routing Diagram

The precipitation frequency amounts for the 10 and 100-year storms were obtained from the National Oceanic and Atmospheric Administration, Massillon Ohio location, for the 24-hour duration, and are tabulated below.

Table 5-1: NOAA Precipitation Frequency for Massillon Ohio (24-hr Duration)

Description	Precipitation (in)
10-year	3.56
100-year	5.74

AECOM selected the Soil Conservation Service (SCS) Type II 24-hour storm type for the distribution, presented below in Figure 5-2.

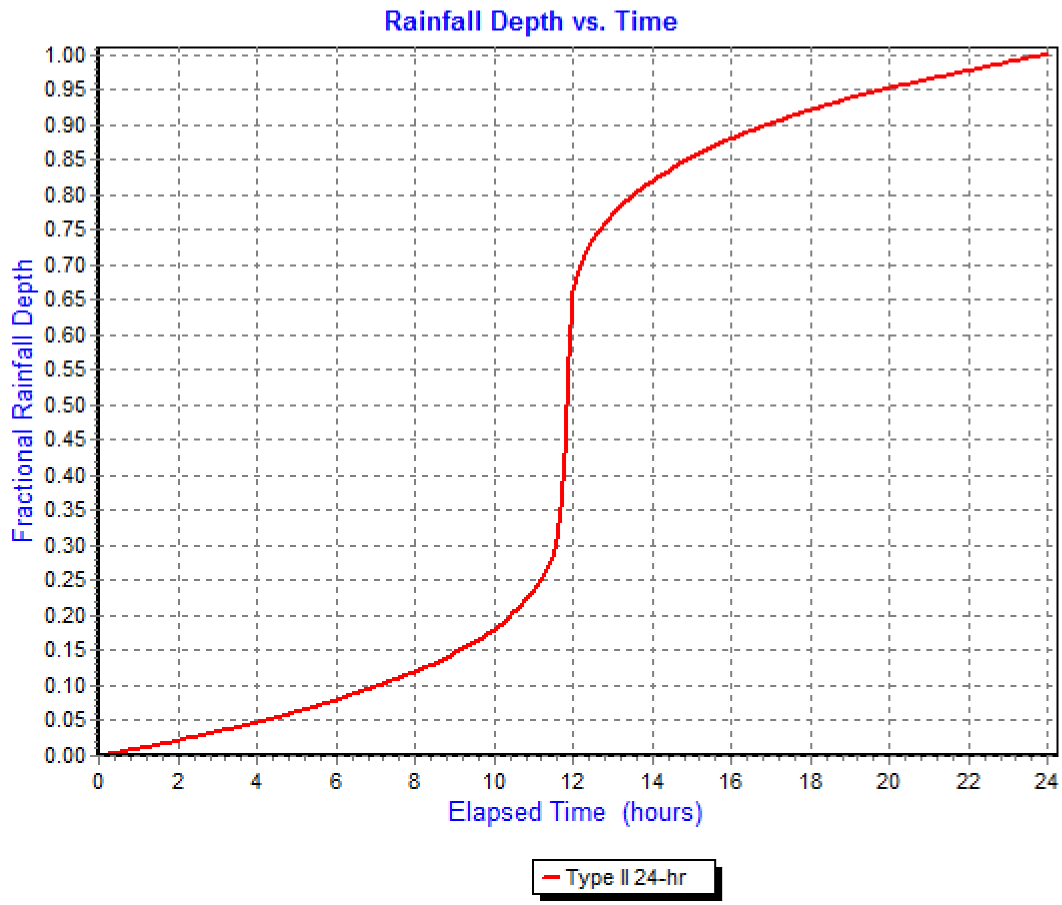


Figure 5-2: Type II 24-hr Distribution

Using HydroCAD, AECOM routed the storm and precipitation frequency depths through the model to obtain Reservoir inflow and outflow hydrographs, peak WSE's, and design storage. The results of the proposed design while routing the 10-year storm into the Reservoir is illustrated in Figure 5-3.

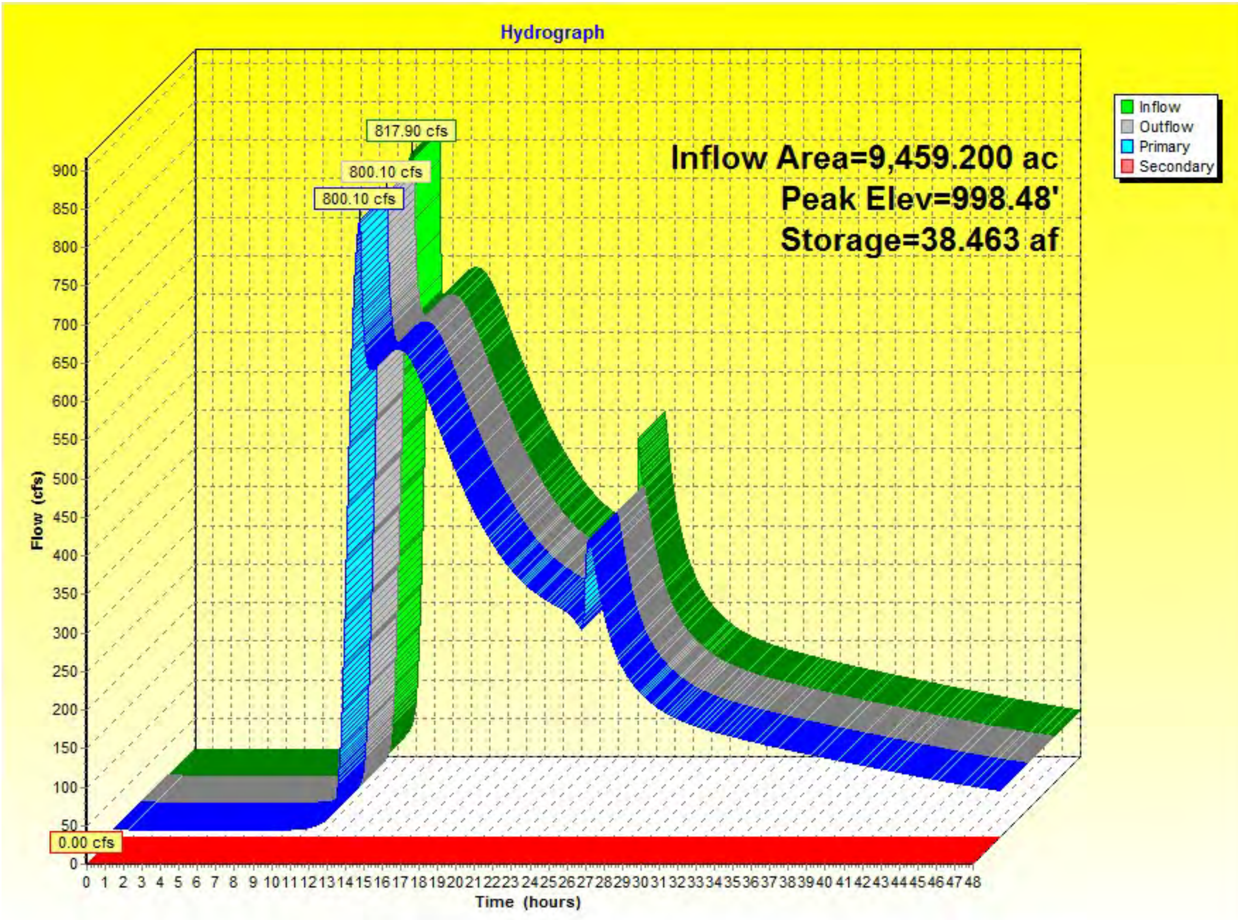


Figure 5-3: HydroCAD 10-yr Storm Design Results

Results of the HydroCAD model indicate a peak inflow of approximately 818 cubic feet per second (cfs) and an outflow of approximately 800 cfs. Note that all the flow is passed through the primary spillway without overtopping the Dam (secondary).

The results of the proposed design while routing the 100-year storm into the Reservoir is illustrated in Figure 5-4.

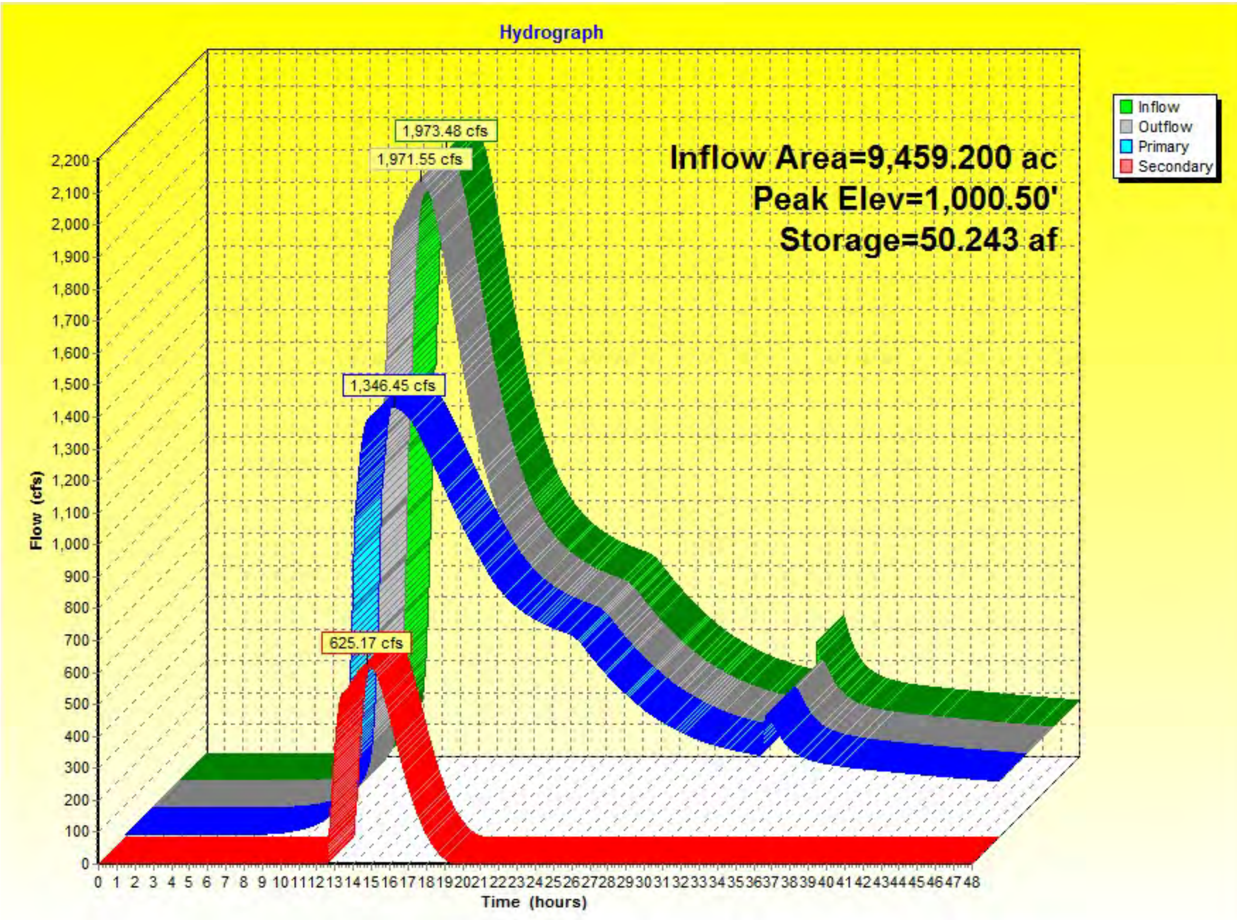


Figure 5-4: HydroCAD 100-yr Storm Design Results

Results of the HydroCAD model indicate a peak inflow of approximately 1,973.5 cfs and an outflow of approximately 1,971.7 cfs. During the 100-year storm, the WSE in the Reservoir is estimated to rise to approximately 1,000.5 ft., approximately 2 ft. above the crest of the Dam. The right and left abutments are anticipated to pass approximately 300 cfs each.

Detailed HydroCAD modeling output and calculations are provided in **Appendix B**.

5.2 Hydraulic Design

AECOM modeled the hydraulic design using the Hydraulic Engineering Center River Analysis System 5.0.3 (HEC-RAS). The model was assembled using Geographic Information System (GIS) software (ArcMap) and Geo-RAS. Geo-RAS is a GIS add-on program that allows the user to create RAS layers such as a reaches, cross sections, bank station and flow paths within GIS to create a geo-referenced model of the existing conditions.

5.2.1 HEC-RAS Modeling

AECOM assembled the HEC-RAS model and inserted the proposed improvements to calculate velocities and shear stresses to assist with the design of the overtopping protection and erosion control measures.. A schematic of a portion of the HEC-RAS model at the location of the Dam is illustrated in Figure 5-5.

Figure 5-5: HEC-RAS Model Schematic

Cross section geometry and roughness coefficients (Manning's n values) were adjusted in the model to account for lowering of the Dam and primary spillway (final grading) as well as the overtopping protection and erosion control measures for the design. The following table illustrates the range of values used for the Manning's roughness coefficients in the model.

Table 5-2: Modeled Manning's Values

Land Use Description	Manning's Value
Buildings	0.1
Trees/Wooded Areas	0.8
Light Brush/Grassy Areas	0.06-0.045
Channel/Lake	0.03
Riprap	0.036

TRM	0.025 (unvegetated)
Stone Pad	0.02
Concrete	0.015

AECOM performed a steady state flow analysis with multiple flow rates (profiles) to determine maximum velocities at critical locations. Figure 5-6 represents a range of profiles from the 10 to the 100-year storm. A hydraulic jump forms downstream of the existing stone pad and as flow increases works its way backwards towards the primary spillway before submerging itself. Maximum velocities occur before the hydraulic jump submerges itself downstream of the existing stone pad and on the stone pad itself.

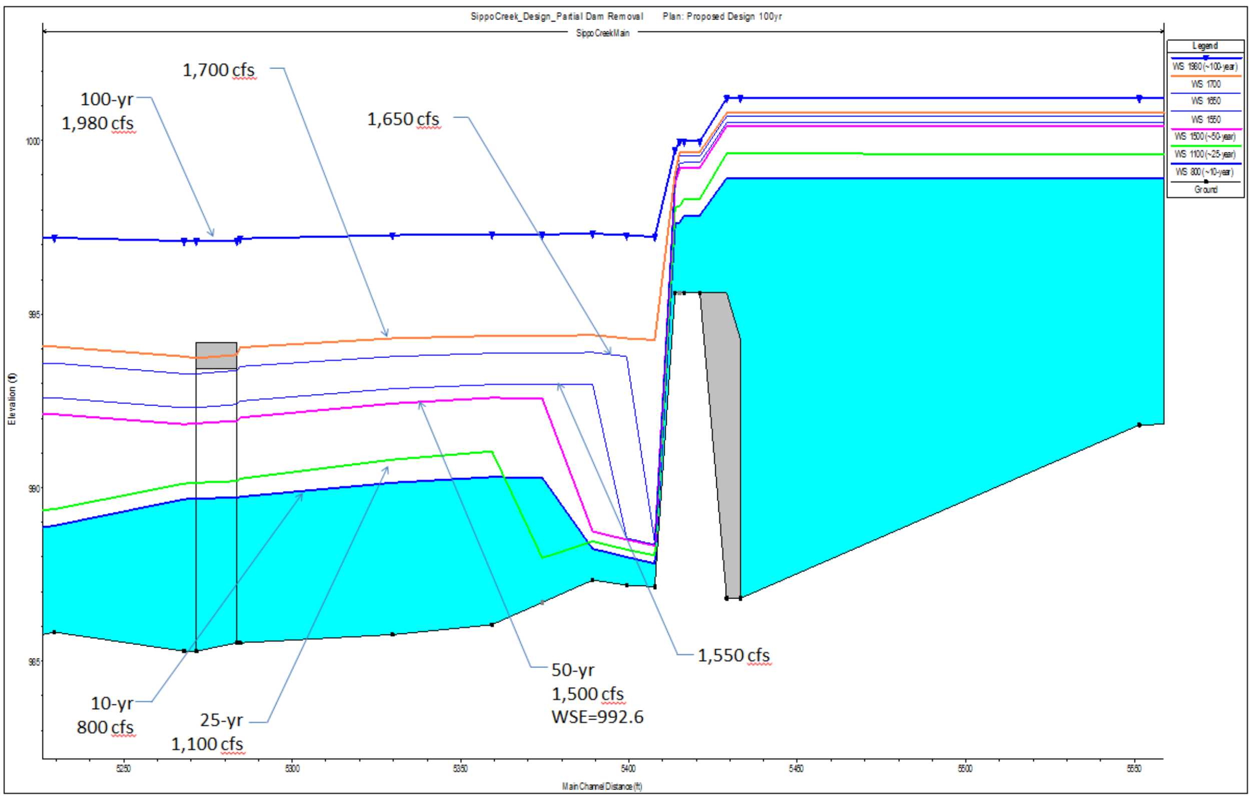


Figure 5-6: HEC-RAS Steady State Flow Analysis Profile Plot

Critical locations for the design of erosion protection of the receiving channel occur at the transition between the existing abutment walls and the banks of the receiving channel (Banks) as well as the receiving channel bed just downstream of the stone pad (Channel). HEC-RAS estimates that a flow rate equal to 1,500 cfs will result in the maximum velocity that occurs at the transition from the stone pad to the riprap outlet channel before the hydraulic jump submerges itself. A table of the estimated maximum velocities at this location is illustrated in Table 5-3.

Table 5-3: HEC-RAS Maximum Velocity Results

Description	Maximum Velocity (fps)
Banks	19.5
Channel	23.8

Design of the erosion protection at the confluence between the existing abutments walls and stone pad with the receiving channel should consider a maximum velocity of 19.5 fps along the channel banks, 23.8 fps at the center of the channel, and should extend up the banks to an elevation of approximately 993.0 ft.

HEC-RAS modeling output for the 10-yr through 100-yr profiles is provided in **Appendix B**.

5.2.2 Grouted Riprap Outlet Channel

AECOM evaluated the maximum velocities that are estimated to occur in the receiving channel. AECOM designed a grouted riprap outlet channel to aid with energy dissipation at the outlet of the existing stone pad. Outlet depths and velocities were evaluated to size the riprap protection and help minimize erosion of underlying material.

The grouted riprap channel is approximately 90-feet wide, extends 20-feet past the stone pad and will be a minimum of 3-feet thick. The grouted riprap placed along the edges of the embankments will also act as the material for the TRM anchor trenches at these locations.

The maximum velocity at the transition from the stone pad to the receiving channel were used to determine an average rock diameter (known as the D_{50} diameter) to be used to specify the size of riprap. This value was calculated using several references, and then an average taken across the analysis. Results of the calculation are tabulated below.

Table 5-4: Riprap Outlet Channel Calculation Results

Description	Max. Velocity (fps)	Average D_{50} (in)	Max. Diameter
Outlet Channel	23.8	44	86 (in)

Results of the calculation indicate that grout will be necessary to reduce the average stone size for the riprap outlet channel. AECOM referenced the following source to assist with the design of the grouted riprap outlet channel:

- Urban Drainage and Flood Control District Criteria Manual, 2008. *Volume 2, Structures, Storage and Recreation, Chapter 9: Hydraulic Structures.*

AECOM calculated a minimum grouted rock size and length of the outlet channel using the reference specified above. A rock sizing parameter was determined to select a minimum grouted rock size. The unit discharge was determined to design the length of the outlet channel. Results of the design are tabulated below.

Table 5-5: Grouted Riprap Outlet Channel Calculation Results

Description	Calculated Value
Rock Sizing Parameter R_p	5.3
Min. Dimensions of Grouted Boulder	24 in
Unit Discharge (q)	25 cfs/ft
Length of Outlet Channel	20 ft.
Grout Height	18 in

Results of the grouted riprap outlet channel design suggest a minimum grouted boulder size of 24 inches, an outlet channel length of 20 feet, and a grout height of 18 inches. AECOM has specified ODOT Type A Riprap (18-30 inches) be used for the rock, placed with a minimum thickness of 3 feet, and grouted in place using a minimum of 3,000 psi non-shrink grout.

5.2.3 TRM

TRMs are permanent solutions that provide erosion control, allow for vegetation establishment, and also provide permanent reinforcement to the vegetation. TRMs are typically used in applications where vegetation alone will not be able to withstand design hydraulic forces. TRM will be used on the upstream and downstream faces of the left and right embankments. The upstream and downstream TRM is designed to provide erosion protection up to and during the design storm.

To construct the embankment overtopping protection, a 3-inch layer of the embankment will be stripped and topsoil will be added to the embankments, and then a seed mixture will be applied to the topsoil. After topsoil and seed has been placed, TRM will be rolled over the seed and anchored with 18-inch pins, at approximately 2.5 per square yard of material, to keep the mat in place. Additionally, 5-foot deep duck bill anchors will be added to the mat in critical locations to ensure that the mat will not be displaced. Vegetation can grow through the TRM and provide a root system into the soil below, reinforcing the matrix. In this manner, the TRM becomes a living blanket over the embankments that requires little maintenance and provides long lasting erosion protection.

The TRM is to be anchored on the upstream side of both embankments in a soil backfilled trench centered at an elevation of approximately 995.0 ft. The upstream embankment along the cutoff wall and the abutment stones will be backfilled with Aquablock™ to help prevent seepage as the WSE in the Reservoir increases. The toe of the mat and the mat adjoining the downstream abutments will be anchored in a grout trench to ensure the mat is not able to be dislodged during anticipated uplift and overturning pressures. Trenches for the TRM are to be on all sides of the overtopping protection and extend roughly 2 feet onto the crest. **Sheets 06**, **08**, and **09** of the draft design set illustrate the details of the anchor trench and anchor pin configurations.

The selected mat must be able to perform under severe hydraulic conditions. The mat must be able to withstand a shear stress of at least 16 psf and velocities of approximately 24 fps. The selected mat is High Performance PYRAMAT, or approved equal, and rated for velocities up to 25 fps and shear stresses up to 16 psf.

Velocities and shear stresses were determined using HEC-RAS, Bentley FlowMaster V8i, and supporting hand calculations. Results indicate that the velocities and shear stress are less than the allowable at all locations where TRM is to be placed.

A detailed calculation for the design of the TRM is provided in **Appendix B**.

6. Structural Engineering

AECOM conducted a site visit at the Dam on May 3, 2017 to assess the current condition of the Dam and to take field measurements. Per emergency order of ODNR, 3 courses of the Dam were partially removed. It was proposed to lower the Dam by 4 complete courses (one additional course and the remaining partial courses), reducing the height of the Dam by approximately 8 feet. Structural analysis of the proposed lowering was conducted according to the Army Corps of Engineers Manuals and Regulations, particularly EM 1110-2-2200 “Gravity Dam Design” and ER 1110-2-1806 “Earthquake Design and Evaluation for Civil Works Projects.” Numerous conservative assumptions were made due to the lack of existing plans and visual constraints.

Per EM 1110-2-2200, three load conditions were investigated: Condition No. 2, Condition No. 3, and Condition No. 6. Note that Condition No. 5 (Unusual – Operating Basis Earthquake) was not considered because Condition No. 3 (Unusual Flood) controlled the unusual load condition. Each load condition was checked for overturning, sliding, and bearing at each course. Additionally, each case was checked with uplift (A) and without uplift (B). For specific load case assumptions, please refer to the structural calculations provided as **Appendix C**. The results for each condition are listed below.

- Load Condition No. 2: Usual Normal Operating Construction
  - ✓ Overturning – All resultants were located within the middle 1/3 of the base
  - ✓ Sliding – Course 5A (bottom course) controlled with FS = 1.87 < 2.0
    Per engineering judgment, the use of numerous conservative assumptions and the existing condition of the Dam, a factor of safety of 1.87 for this load condition is sufficient. All other factors of safety are greater than 2.
  - ✓ Bearing – Course 5B controlled with σ_{max} = 1.25 ksf. < 2.0 ksf.

- Load Condition No. 3: Unusual Flood Discharge (100-yr)
  - ✓ Overturning – All resultants were located within the middle 1/2 of the base
  - ✓ Sliding – Course 5A controlled with FS = 1.87 > 1.7
  - ✓ Bearing – Course 5B controlled with σ_{max} = 1.39 ksf. < 2.0 ksf.

- Load Condition No. 6: Extreme Normal Operating with Earthquake (MCE)
  - ✓ Overturning – All resultants were located within the base
  - ✓ Sliding – Course 5A controlled with FS = 1.23 < 1.3
    Per engineering judgment, the use of numerous conservative assumptions and the existing condition of the Dam, a factor of safety of 1.23 for this load condition is sufficient. All other factors of safety are greater than 1.3.
  - ✓ Bearing – Course 5B controlled with σ_{max} = 1.32 ksf. < 2.0 ksf.

7. Bibliography

To Be Provided In Final Submittal

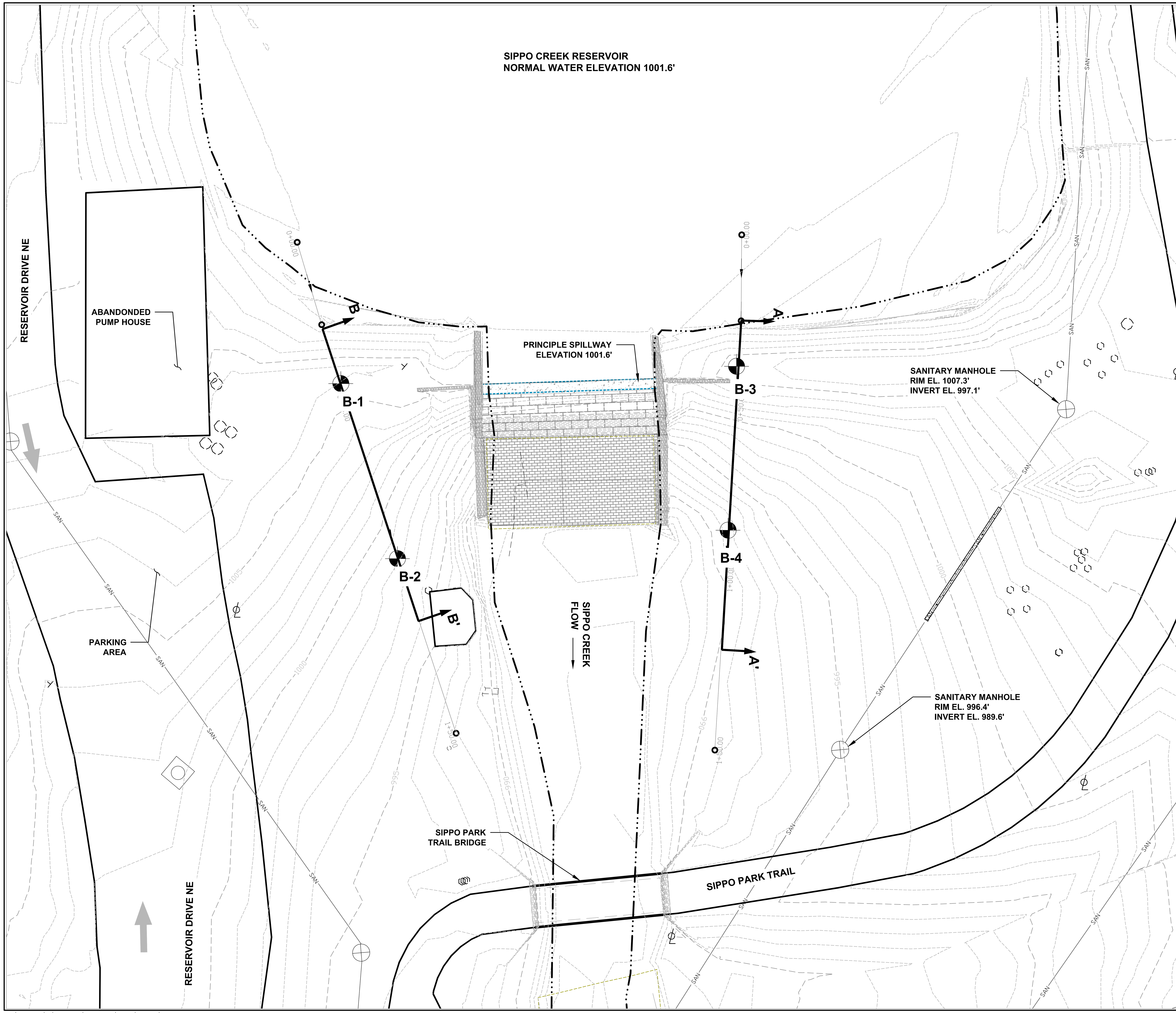
Appendix A Geotechnical Engineering

A.1 Geotechnical Figures

A.2 Geotechnical Boring Logs

A.3 Laboratory Testing Results

A.4 Slope Stability Analysis



GENERAL NOTES:

1. BORING SAMPLES WERE TAKEN BY AECOM ON AUGUST 13, 2015.
2. SEE SHEET C-102 FOR GEOLOGIC CROSS SECTIONS BASED ON THESE BORINGS.

LEGEND

- EXISTING 5-FOOT CONTOUR
- EXISTING 1-FOOT CONTOUR
- SITE ACCESS ROUTE
- SAN — SANITARY SEWER
- STM — STORM SEWER
- EDGE OF PAVEMENT
- B-3 — AECOM BORING LOCATION (2015)
- A / A' — GEOLOGIC CROSS SECTION LOCATION

0 20 40

SCALE IN FEET

BAR IS ONE-INCH ON ORIGINAL DRAWING
0 ½ 1
IF NOT ONE-INCH, THEN ADJUST SCALES ACCORDINGLY

ISSUED FOR BIDDING DATE BY

ADDENDUM REVISIONS

ADDENDUM NO	ADDENDUM DATE	BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE	BY

RECORD DRAWINGS DATE BY

60 PERCENT DESIGN
FOR REVIEW ONLY
NOT FOR CONSTRUCTION

DRAWN NSF	DATE 1/22/16
CHECKED JLM	JOB NO 60439145
SCALE: AS SHOWN	

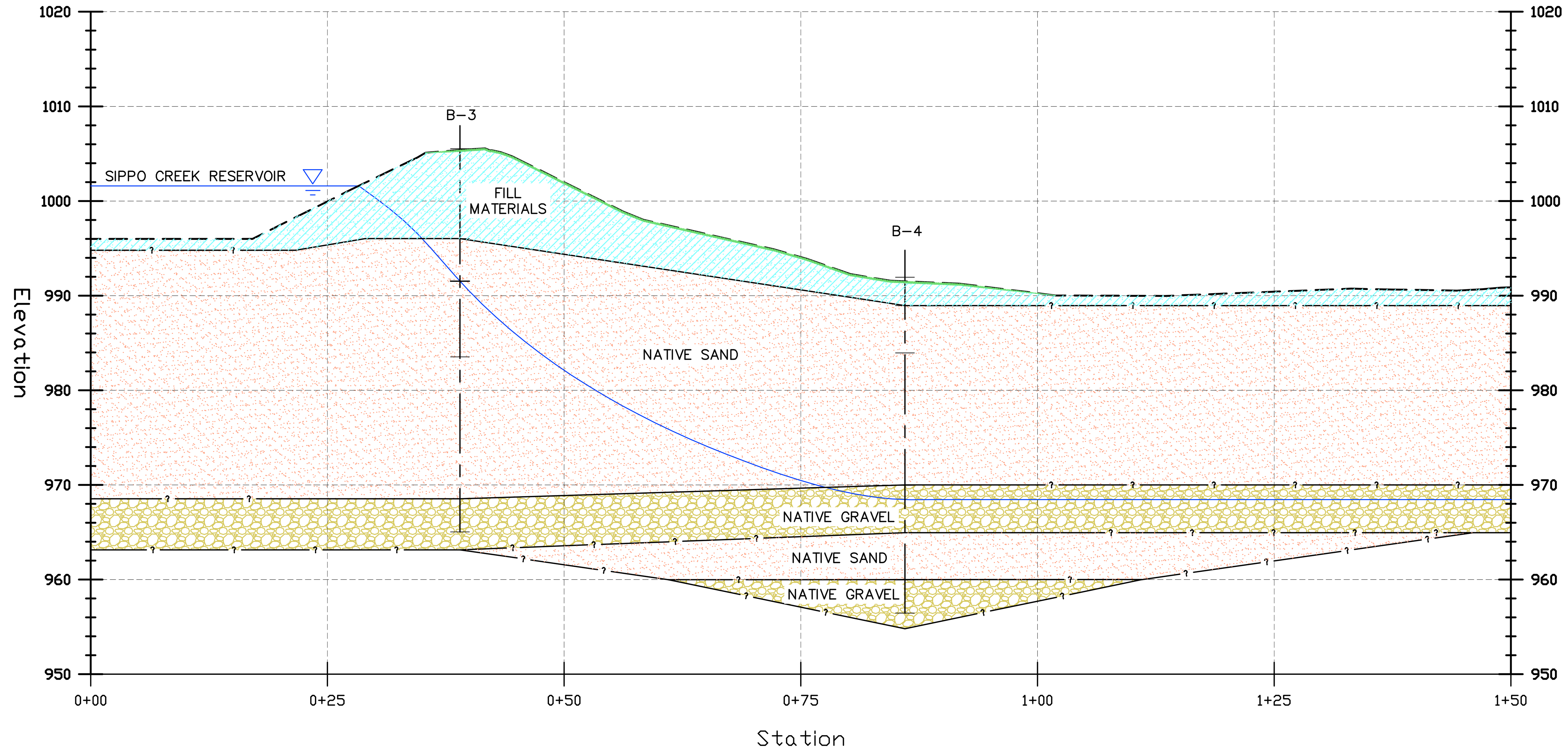
SIPPO CREEK RESERVOIR DAM
REHABILITATION DESIGN
DRAWINGS
MASSILLON, STARK COUNTY, OH
ODNR# 0614-012

BORING LOCATION PLAN

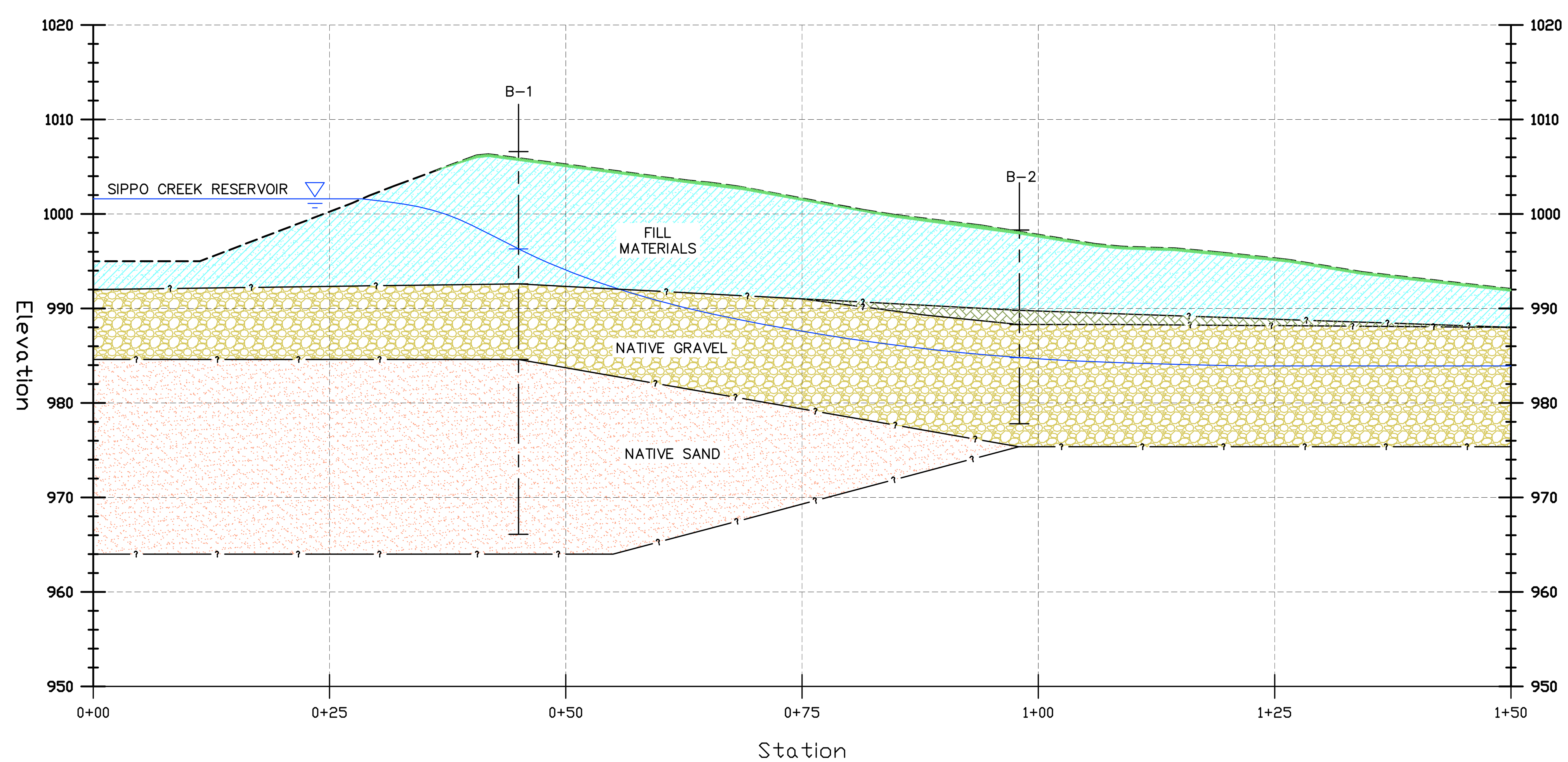
AECOM

C-101

K:\Projects\M\Massillon\13814498\DWGs\Sheets\04_C-101-Boring location map.dwg User:nicholas_fischer Jan 22, 2016 – 9:21am



SECTION A-A'



SECTION B-B'

GENERAL NOTES:

1. SEE SHEET C-101 FOR PLAN LOCATION OF THESE CROSS SECTIONS.
2. BORING SAMPLES WERE COLLECTED BY AECOM FROM AUGUST 24 TO 25, 2015.
3. NATIVE SAND AND NATIVE GRAVEL ARE SHOWN HEREIN AS SEPARATE MATERIALS BASED ON LABORATORY MATERIAL CLASSIFICATIONS. THE NATIVE SAND AND GRAVEL MATERIALS ARE SIMILAR AND ARE SUSPECTED TO CATEGORIZED AS GLACIAL FLUVIAL OUTWASH MATERIALS.

LEGEND

- EXISTING GROUND
- WATER LEVEL AT THE TIME OF EXPLORATION ACTIVITIES
- OBSERVED MATERIAL CHANGE LINE
- UNKNOWN / POSSIBLE MATERIAL CHANGE LINE
- SURFACE MATERIALS (TOPSOIL)
- FILL MATERIALS
- NATIVE SAND DEPOSIT
- NATIVE GRAVEL DEPOSIT
- ORGANIC SOILS

0 10 20

SCALE IN FEET

BAR IS ONE-INCH ON ORIGINAL DRAWING
0 ½ 1
IF NOT ONE-INCH, THEN ADJUST SCALES ACCORDINGLY

ISSUED FOR BIDDING DATE BY

ADDENDUM REVISIONS

ADDENDUM NO	ADDENDUM DATE	BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE	BY

RECORD DRAWINGS DATE BY

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

DRAWN CAD	DATE 1/22/16
CHECKED JLM	JOB NO 60439145
SCALE: AS SHOWN	

SIPPO CREEK RESERVOIR DAM REHABILITATION DESIGN DRAWINGS
MASSILLON, STARK COUNTY, OH
ODNR# 0614-012

GEOLOGIC CROSS SECTIONS

AECOM

C-102

C:\Users\Chet_Dicke\Desktop\Projects\Sippo Creek Reservoir Dam Improvements\dwg\05_C-102-Geologic cross sections.dwg User:Chet_Dicke May 24, 2016 - 7:45pm

Project: Sippo Creek Dam Improvements
Project Location: Massillon, Ohio
Project Number: 60439145

Key to Log of

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance Blows/6"	Recovery, inches	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
1	2	3	4	5	6	7	8	9	10	11

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Sampling Resistance:** Number of blows required to advance driven sampler each 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop.

6 **Recovery:** Percentage of driven sample length actually recovered.

7 **Pocket Penetrometer:** Pocket penetrometer field consistency measurement in tons per square foot (tsf).

8 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

9 **Material Description:** Description of material encountered; may include color, moisture, grain size, and density/consistency.

10 **Water Content:** Water content of soil sample measured in laboratory, expressed as percent of dry weight of sample.

11 **Remarks and Other Details:** Comments and observations regarding drilling or sampling made by driller or field personnel.

- **PL** =Plastic Limit, in percent
- **LL** =Liquid Limit, in percent
- **PI** =Plasticity Index, in percent
- **%G** =Percent gravel
- **%S** =Percent sand
- **%M** =Percent silt
- **%C** =Percent clay

TYPICAL MATERIAL GRAPHIC SYMBOLS

Topsoil
Fill Materials
Silty Sand
Poorly-Graded Sand
Clayey Sand
Silty-Clayey Sand
Silty to Poorly-Graded Sand
Organic Silt
Lean Clay
Clayey Gravel
Silty to Poorly-Grade Gravel
Silty Gravel

OTHER GRAPHIC SYMBOLS

Water level in boring ATD

Water level in boring at time indicated after drilling

Minor change in material properties within a lithologic stratum

---- Inferred or gradational lithologic contact

ATD At Time of Drilling
NR Not Recorded
NA Not Applicable
bgs Below Ground Surface

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

TYPICAL SAMPLER GRAPHIC SYMBOLS

Split spoon

Shelby Tube

Recovered Sample Length
Driven Sample Length

MINOR SOIL TYPE(s)

"trace" When the soil type's percentage is estimated, using visual/manual procedures, to be between 1 and 15 percent of the total sample.

"with" When the soil type's percentage is estimated, using visual/manual procedures, to be greater than 15 percent and less than 30 percent of the total sample.

"y" When the soil type's percentage is estimated, using visual/manual procedures, to be greater than 30 percent of the total sample.

AECOM

Date(s) Drilled	8/24/15	Logged By	T. George	Checked By	C. Dicke
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID, 7" OD	Total Depth of Borehole	40.5´ bgs
Drill Rig Type	Mobile B-57 Rubber Track ATV	Drilling Contractor	Ohio Testbor	Surface Elevation	1006.6 ft above msl
Borehole Backfill	Cement Bentonite grout to 1 ft bgs, auger cuttings to ground surface	Sampling Method(s)	Split Spoon	Hammer Data	140#/30" Auto
Boring Location	N 415,890.5 E 2,243,172.4	Groundwater Level(s)	Encountered @ 10.3' bgs ATD; WL 15' bgs; 45 minutes after drilling		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
1006.6	0.0								
1006.4	0.2						2" Topsoil		
1005		Split Spoon	SS-1	7 7 4	17		Medium dense, moist, brown, coarse to fine silty SAND (SM), trace gravel [FILL]	7.2	*Gravel blocking shoe recovery*
1003.6	3.0						Loose, moist, brown, silty GRAVEL (GM) with clay and sand [FILL]		
	5	Split Spoon	SS-2	2 3 6 1	58	0.5 0.75			
1002.1	4.5						Medium stiff, moist, brown, sandy lean CLAY (CL), trace gravel [POSSIBLE FILL]		
1000		Split Spoon	SS-3	2 2 3	61	0.75 0.75 0.75	becomes with to trace gravel	20.7	*LL=26 PL=16 PI=10 %G=0.30 %S=36.73 %M=40.55 %C=22.42*
997.9	8.8						Loose, moist, brown, coarse to fine SAND (SP-SM), trace gravel [POSSIBLE FILL]		
	10	Split Spoon	SS-4	2 2 3 2	25		▽		
995									
994.4	12.2						Loose, wet, grayish- brown, clayey SAND (SC), trace gravel [POSSIBLE FILL]		
992.6	14.0						Very loose, wet, brown, clayey GRAVEL (GC) with sand, trace dark gray organic stanning		
	15	Split Spoon	SS-5	2 5 1 1	50			13.9	*%G=45.61 %S=30.51 %F=23.88* *Begin to add water inside of augers to prevent heave*
990									
	20	Split Spoon	SS-6	4 5 5 3	42		becomes loose, brown and gray		
985									
984.6	22.0						Medium dense, wet, brown, clayey SAND (SC) with gravel		
	25	Split Spoon	SS-7	10 9 10 8	46				
980									
	30	Split Spoon	SS-8	4	50		becomes loose to medium dense	16.2	*%G=39.46 %S=46.62 %F=13.92*

Project: Sippo Creek Dam Improvements Project Location: Massillon, Ohio Project Number: 60439145	Log of Boring B-1 Sheet 2 of 2

Elevation, feet	Depth, feet	Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
	30		SS-8	6 4 3	50					
975										
			SS-9	12 16 21 10	46			becomes dense, moist to wet, sandy silty GRAVEL (GM)		
	35									
970										
969.6	37.0							Medium dense, wet, brown, poorly-graded SAND (SP-SM), trace gravel		
			SS-10	7 7 8 9	50					
	40									
966.1	40.5							End of Boring at 40.5´ bgs		
965										
960										
955										
950										
945										

Project: Sippo Creek Dam Improvements
Project Location: Massillon, Ohio
Project Number: 60439145

Log of Boring B-2

Date(s) Drilled	8/24/15	Logged By	T. George	Checked By	C. Dicke
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID, 7" OD	Total Depth of Borehole	20.5´ bgs
Drill Rig Type	Mobile B-57 Rubber Track ATV	Drilling Contractor	Ohio Testbor	Surface Elevation	998.3 ft above msl
Borehole Backfill	Cement Bentonite grout to 3 ft bgs, bentonite chips from 1 to 3 ft bgs, auger cuttings to ground surface	Sampling Method(s)	Split Spoon	Hammer Data	140#/30" Auto
Boring Location	N 415,862.3 E 2,243,217.7	Groundwater Level(s)	Encountered @ 13.5' bgs ATD		

Elevation, feet	Depth, feet	Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
998.3	0.0								
998.0	0.3						3.5" Topsoil		
		SS	SS-1	5 6 4	56		Loose, moist, brown, trace red, trace gray, coarse to fine silty SAND (SM) with gravel, trace brick		
995.3	3.0	SS	SS-2	3 2 2 3	25		Very loose, moist, brown, poorly-graded GRAVEL (GP-GM) with silt [FILL]		
		SS	SS-3	8 6 5	44		becomes medium dense, dark brown, trace gray, well- graded GRAVEL with silt and sand	9.2	%G=67.32 %S=25.55 %F=7.13
989.8	8.5	SS	SS-4	3 3 4 3	79	0.75	Medium stiff, moist, brown, ORGANIC SILT (OL) as topsoil with gravel, trace roots		Appears similar to topsoil
988.3	10.0						Loose, moist, brown, trace black, clayey SAND (SC) with gravel, trace coal, trace black organics		
986.1	12.2	SS	SS-5	3 3 6 7	38		Loose, wet, brown, poorly- graded GRAVEL (GP) with silt and sand (groundwater ∇ at 13.5')		
		SS	SS-6	2 2 2 2	29		becomes very loose		%G=49.98 %S=40.96 %F=9.06
977.8	20.5						End of Boring at 20.5´ bgs		No water in auger after drilling

Elevation scale: 995, 990, 985, 980, 975, 970. Depth scale: 0, 5, 10, 15, 20.

AECOM

Project: Sippo Creek Dam Improvements
Project Location: Massillon, Ohio
Project Number: 60439145

Log of Boring B-3

Date(s) Drilled	8/25/15	Logged By	T. George	Checked By	C. Dicke
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID, 7" OD	Total Depth of Borehole	40.5´ bgs
Drill Rig Type	Mobile B-57 Rubber Track ATV	Drilling Contractor	Ohio Testbor	Surface Elevation	1005.5 ft above msl
Borehole Backfill	Cement Bentonite grout to 1 ft bgs, auger cuttings to ground surface	Sampling Method(s)	Split Spoon	Hammer Data	140#/30" Auto
Boring Location	N 415,967.9 E 2,243,257.9	Groundwater Level(s)	Encountered @ 14' bgs ATD		

Elevation, feet	Depth, feet	SAMPLES: Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
1005.5	0.0									
1005.3	0.2							2" Topsoil		
1004.0	1.5							Boulder from 2" to 1.5 ft bgs		
								Medium dense, moist, brown, silty clayey SAND (SC-SM), trace gravel [FILL]		
		Split Spoon	SS-1	3 7 7	61					
		Split Spoon	SS-2	3 4 4 2	83			becomes loose	11.6	LL=23 PL=17 PI=6 %G=0.54 %S=70.93 %M=20.61 %C=7.93
		Split Spoon	SS-3	2 1 2	56			becomes very loose, clayey SAND (SC), trace gravel	16.3	LL=25 PL=14 PI=11 %G=2.71 %S=56.55 %M=25.52 %C=15.23
		Split Spoon	SS-4	1 2 1 2	42			becomes moist to wet		
996.0	9.5							Very loose, moist, grayish-brown, clayey SAND (SC) with gravel		
								becomes moist to wet, clayey gravel with sand		
991.5	14.0							Very loose, wet, grayish-brown, silty SAND (SM) with gravel		
		Split Spoon	SS-5	1 1 1 4	67					Added water inside of augers to prevent heave
		Split Spoon	SS-6	3 3 3 2	50			becomes loose, brown	17.4	%G=38.15 %S=39.62 %F=22.23
983.5	22.0							Loose, wet, brown, coarse to fine poorly-graded SAND (SP) with gravel, trace coal staining		
		Split Spoon	SS-7	3 3 3 3	54					
		Split Spoon	SS-8	3	50			becomes medium dense, fine SAND		

Elevation scale: 1005, 1000, 995, 990, 985, 980; Depth scale: 0, 5, 10, 15, 20, 25, 30

AECOM

Project: Sippo Creek Dam Improvements
Project Location: Massillon, Ohio
Project Number: 60439145

Log of Boring B-3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
975	30		SS-8	4 7 6	50					
			SS-9	8 7 8 9	46			becomes coarse to fine SAND with gravel		
970	35									
968.5	37.0							Medium dense, wet, brown, sandy silty GRAVEL (GM), trace clay		
			SS-10	11 17 11 10	46					*Drill water @ 3.7 ft bgs after drilling*
965.0	40.5							End of Boring at 40.5´ bgs		
965	40									
960										
955										
950										
945										

Project: Sippo Creek Dam Improvements **Project Location: Massillon, Ohio** **Project Number: 60439145**	**Log of Boring B-4** Sheet 1 of 2

Date(s) Drilled	8/25/15	Logged By	T. George	Checked By	C. Dicke
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID, 7" OD	Total Depth of Borehole	35.5´ bgs
Drill Rig Type	Mobile B-57 Rubber Track ATV	Drilling Contractor	Ohio Testbor	Surface Elevation	991.9 ft above msl
Borehole Backfill	Cement Bentonite grout to 1 ft bgs, auger cuttings to ground surface	Sampling Method(s)	Split Spoon	Hammer Data	140#/30" Auto
Boring Location	N 415,930.1 E 2,243,286.2	Groundwater Level(s)	Encountered @ 23.5' bgs ATD; WL 28.5' bgs		

Elevation, feet	Depth, feet	Samples: Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
991.9	0.0								
991.7	0.2						2.5" Topsoil		
991.4	0.5						3" Slag layer		
990		SS	SS-1	4 8 4	39		Medium dense, damp, brown, clayey SAND (SC), trace gravel [FILL]	8.6	LL=30 PL=20 PI=10 %G=21.64 %S=28.53 %M=29.14 %C=20.69
988.9	3.0						Loose, damp, brown, clayey SAND (SC), trace gravel		
	5	SS	SS-2	6 5 5 4	71			12.0	LL=36 PL=19 PI=17 %G=0.50 %S=52.58 %M=35.63 %C=11.28 Boulder at 4.5' bgs based on drilling
985.9	6.0	SS	SS-3	50 2	0		Cobble / Boulder layer from 6 to 7.5 ft bgs		
984.4	7.5						Loose, moist, brown, silty SAND (SM), trace gravel		
	10	SS	SS-4	4 3 2 3	63			7.8	LL=NP PL=NP PI=NP %G=0.26 %S=83.99 %M=10.36 %C=5.4
	15	SS	SS-5	2 2 3 3	46		becomes with gravel, trace dark gray coal staining		
	20	SS	SS-6	4 3 5 6	58		becomes moist to wet, with gray coal staining		
969.9	22.0						Medium dense, moist to wet, brown, sandy silty GRAVEL (GM), trace clay		
	25	SS	SS-7	2 5 8 9	50				
964.9	27.0						Very loose, wet, brown, coarse to fine poorly-graded SAND (SP)		
	30	SS	SS-8	2	88				

Elevation, feet	Depth, feet	Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
	30		SS-8	2 2 4	88			becomes with interbedded lean clay lamina		*Added water to and in drilling*
960								959.9 — 32.0 Loose, wet, brown, sandy GRAVEL (GP-GM)		
	35		SS-9	4 6 3 2	33			956.4 — 35.5		
955								End of Boring at 35.5´ bgs		
950										
945										
940										
935										
930										

MOISTURE CONTENT

ASTM D 2216-10

Client: AECOM
Client Reference: Sippo Crk. Dam Reservoir 60439145
Project No.: 2015-550-001

Lab ID:	001	002	003	004	005
Boring No.:	B1	B1	B1	B1	B2
Depth (ft):	1.0-2.5	6.0-7.5	13.5-15.5	28.5-30.0	6.0-7.5
Sample No.:	SS-1	SS-3	SS-5	SS-8	SS-3
Tare Number	65	10	18	49	17
Wt. of Tare & Wet Sample (g)	71.31	23.17	36.17	66.07	21.94
Wt. of Tare & Dry Sample (g)	66.97	20.38	32.62	57.85	20.69
Weight of Tare (g)	6.99	6.92	7.02	7.10	7.04
Weight of Water (g)	4.34	2.79	3.55	8.22	1.25
Weight of Dry Sample (g)	59.98	13.46	25.60	50.75	13.65
Water Content (%)	**7.2**	**20.7**	**13.9**	**16.2**	**9.2**

Lab ID	007	008	009	010
Boring No.	B3	B3	B3	B4
Depth (ft)	3.5-5.5	6.0-7.5	18.5-20.5	1.0-2.5
Sample No.	SS-2	SS-3	SS-6	SS-1
Tare Number	46	57	45	40
Wt. of Tare & Wet Sample (g)	35.51	36.13	48.72	20.49
Wt. of Tare & Dry Sample (g)	32.54	32.04	42.55	19.44
Weight of Tare (g)	6.92	6.94	7.02	7.24
Weight of Water (g)	2.97	4.09	6.17	1.05
Weight of Dry Sample (g)	25.62	25.10	35.53	12.20
Water Content (%)	**11.6**	**16.3**	**17.4**	**8.6**

Notes :

Tested By *JP* *Date* *10/20/15* *Checked By* *CLK* *Date* *10/22/15*

DCN: CT-S1 DATE: 3/18/13 REVISION: 4

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MOISTURE CONTENT

ASTM D 2216-10

Client: AECOM
Client Reference: Sippo Crk. Dam Reservoir 60439145
Project No.: 2015-550-001

Lab ID:	011	012
Boring No.:	B4	B4
Depth (ft):	3.5-5.5	8.5-10.5
Sample No.:	SS-2	SS-4
Tare Number	11	26
Wt. of Tare & Wet Sample (g)	30.83	33.83
Wt. of Tare & Dry Sample (g)	28.27	31.88
Weight of Tare (g)	6.89	6.96
Weight of Water (g)	2.56	1.95
Weight of Dry Sample (g)	21.38	24.92
Water Content (%)	**12.0**	**7.8**

Notes :

Tested By *JP* *Date* *10/20/15* *Checked By* *CLK* *Date* *10/22/15*

DCN: CT-S1 DATE: 3/18/13 REVISION: 4

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SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

geotechnics
geotechnical & geosynthetic testing

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-002	Soil Color:	Brown

USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.30
#4 To #200	*Sand*	36.73
Finer Than #200	*Silt & Clay*	62.97

USCS Symbol:

CL, TESTED

USCS Classification:

SANDY LEAN CLAY

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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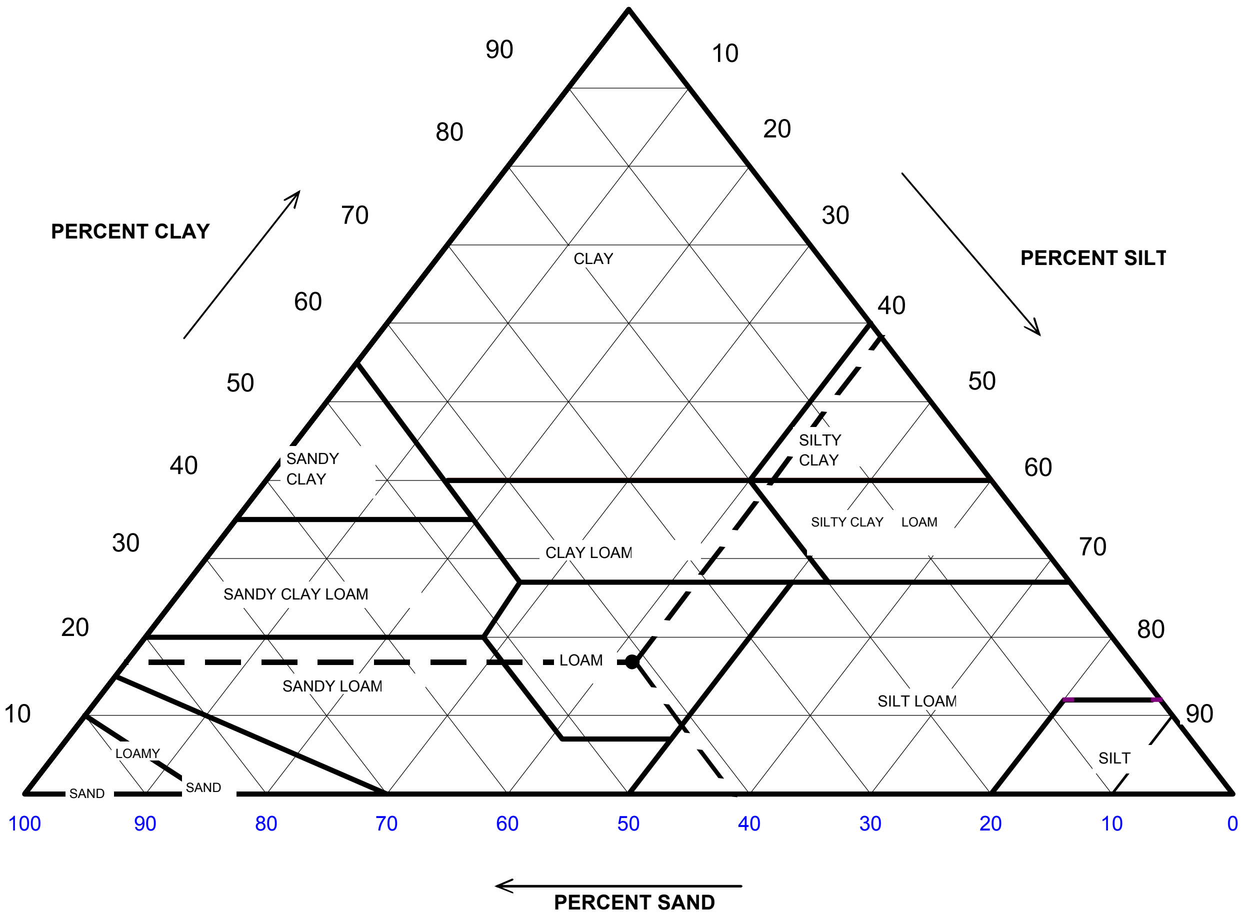
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-002	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	3.31	**0.00**
2	96.69	*Sand*	39.89	**41.26**
0.05	56.79	*Silt*	40.55	**41.94**
0.002	16.24	*Clay*	16.24	**16.80**

USDA Classification: ***LOAM***

 DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-002	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1441	Tare No.	NA
Weight of Tare & Wet Sample (g)	302.73	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	302.73	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	143.89	Weight of Tare (g)	NA
Weight of Water (g)	0.00	Weight of Water (g)	NA
Weight of Dry Sample (g)	158.84	Weight of Dry Sample (g)	NA
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	158.84
Dry Weight of -3/4" Sample (g)	58.82	Weight of - #200 Material (g)	100.03
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	58.82
Dry Weight of +3/4" Sample (g)	0.00		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening	Weight of Soil Retained	Percent Retained	Accumulated Percent Retained		Percent Finer	Accumulated Percent Finer
	(mm)	(g)	(%)	(%)		(%)	(%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	0.00	0.00	0.00		100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00		100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00		100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00		100.00	**100.00**
#4	4.75	0.48	0.30	0.30		99.70	**99.70**
#10	2.00	4.79	3.01	3.31		96.69	**96.69**
#20	0.85	12.03	7.57	10.89		89.11	**89.11**
#40	0.425	8.67	5.46	16.35		83.65	**83.65**
#60	0.250	11.68	7.35	23.70		76.30	**76.30**
#140	0.106	16.20	10.20	33.90		66.10	**66.10**
#200	0.075	4.97	3.13	37.03		62.97	**62.97**
Pan	-	100.03	62.97	100.00		-	**-**

Tested By	JP	Date	10/24/15	Checked By	KC	Date	11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-002	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		33.0	22	6.36	26.6	78.3	0.01313	0.0306	**49.3**
5		28.0	22	6.36	21.6	63.6	0.01313	0.0201	**40.1**
15		24.5	22	6.36	18.1	53.3	0.01313	0.0119	**33.6**
30		21.5	22	6.36	15.1	44.5	0.01313	0.0086	**28.0**
60		19.0	22.1	6.33	12.7	37.3	0.01311	0.0061	**23.5**
250		15.5	22	6.36	9.1	26.9	0.01313	0.0031	**16.9**
1440		14.5	22.7	6.11	8.4	24.7	0.01302	0.0013	**15.5**

Soil Specimen Data		Other Corrections		
Tare No.	644			
Weight of Tare & Dry Material (g)	138.61	a - Factor	0.99	
Weight of Tare (g)	99.94			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	62.97	
Weight of Dry Material (g)	33.7			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 10/27/15 Checked By KC Date 11/2/15

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-002	Soil Description:	BROWN LEAN CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description . (Minus No. 40 sieve material, Airdried)

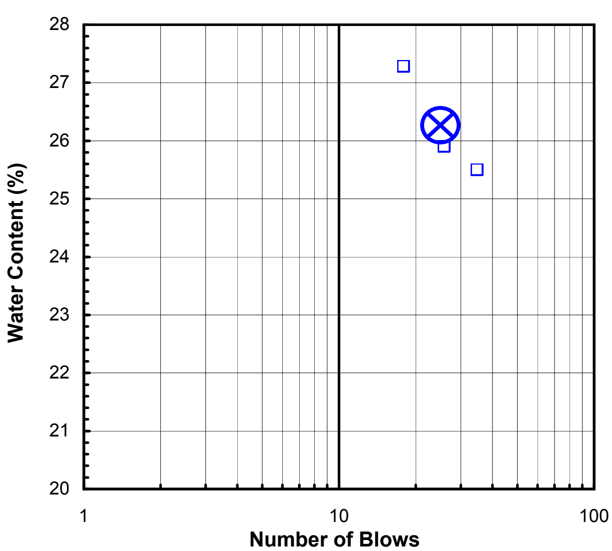
Liquid Limit Test	1	2	3	MULTIPOINT
Tare Number:	1245	293	459	
Wt. of Tare & Wet Sample (g):	31.23	32.79	30.37	
Wt. of Tare & Dry Sample (g):	28.11	29.82	27.16	
Weight of Tare (g):	15.87	18.35	15.39	
Weight of Water (g):	3.1	3.0	3.2	
Weight of Dry Sample (g):	12.2	11.5	11.8	
Moisture Content (%):	**25.5**	**25.9**	**27.3**	
Number of Blows:	**35**	**26**	**18**	

Plastic Limit Test	1	2	Range
Tare Number:	1279	1223	
Wt. of Tare & Wet Sample (g):	20.42	17.34	
Wt. of Tare & Dry Sample (g):	19.51	16.43	
Weight of Tare (g):	14.00	10.79	
Weight of Water (g):	0.9	0.9	
Weight of Dry Sample (g):	5.5	5.6	
Moisture Content (%):	**16.5**	**16.1**	**0.4**

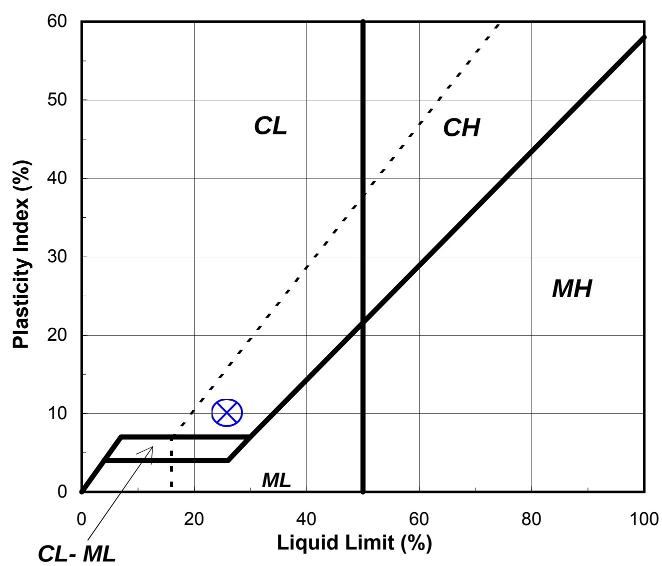
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**26**
Plastic Limit (%):	**16**
Plasticity Index (%):	**10**
USCS Symbol:	**CL**

Flow Curve



Plasticity Chart



Tested By	*TO*	*Date*	*10/21/15*	*Checked By*	*CLK*	*Date*	10/23/15

 DCN: CTS4B, REV. 4, 3/18/13

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SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	13.5-15.5
Project No.:	2015-550-001	Sample No.:	SS-5
Lab ID:	2015-550-001-003	Soil Color:	Brown

USCS Symbol:

gc, ASSUMED

USCS Classification:

CLAYEY GRAVEL WITH SAND

UNABLE TO RUN HYDROMETER

Tested By	HL	Date	10/22/15	Checked By	KC	Date	10/24/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	13.5-15.5
Project No.:	2015-550-001	Sample No.:	SS-5
Lab ID:	2015-550-001-003	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1448	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	330.91	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	304.97	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	138.61	Weight of Tare (g):	NA
Weight of Water (g):	25.94	Weight of Water (g):	NA
Weight of Dry Sample (g):	166.36	Weight of Dry Sample (g):	NA
Moisture Content (%):	**15.6**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	166.36
Dry Weight of - 3/4" Sample (g):	80.7	Weight of - #200 Material (g):	39.73
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	126.63
Dry Weight of + 3/4" Sample (g):	45.95		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	45.95	27.62	27.62	72.38	**72.38**
1/2"	12.50	5.82	3.50	31.12	68.88	**68.88**
3/8"	9.50	8.81	5.30	36.42	63.58	**63.58**
#4	4.75	15.30	9.20	45.61	54.39	**54.39**
#10	2.00	15.13	9.09	54.71	45.29	**45.29**
#20	0.850	13.60	8.18	62.88	37.12	**37.12**
#40	0.425	8.00	4.81	67.69	32.31	**32.31**
#60	0.250	5.34	3.21	70.90	29.10	**29.10**
#140	0.106	5.38	3.23	74.13	25.87	**25.87**
#200	0.075	3.30	1.98	76.12	23.88	**23.88**
Pan	-	39.73	23.88	100.00	-	**-**

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

DCN: CT-S3C DATE 3/20/13 REVISION: 3

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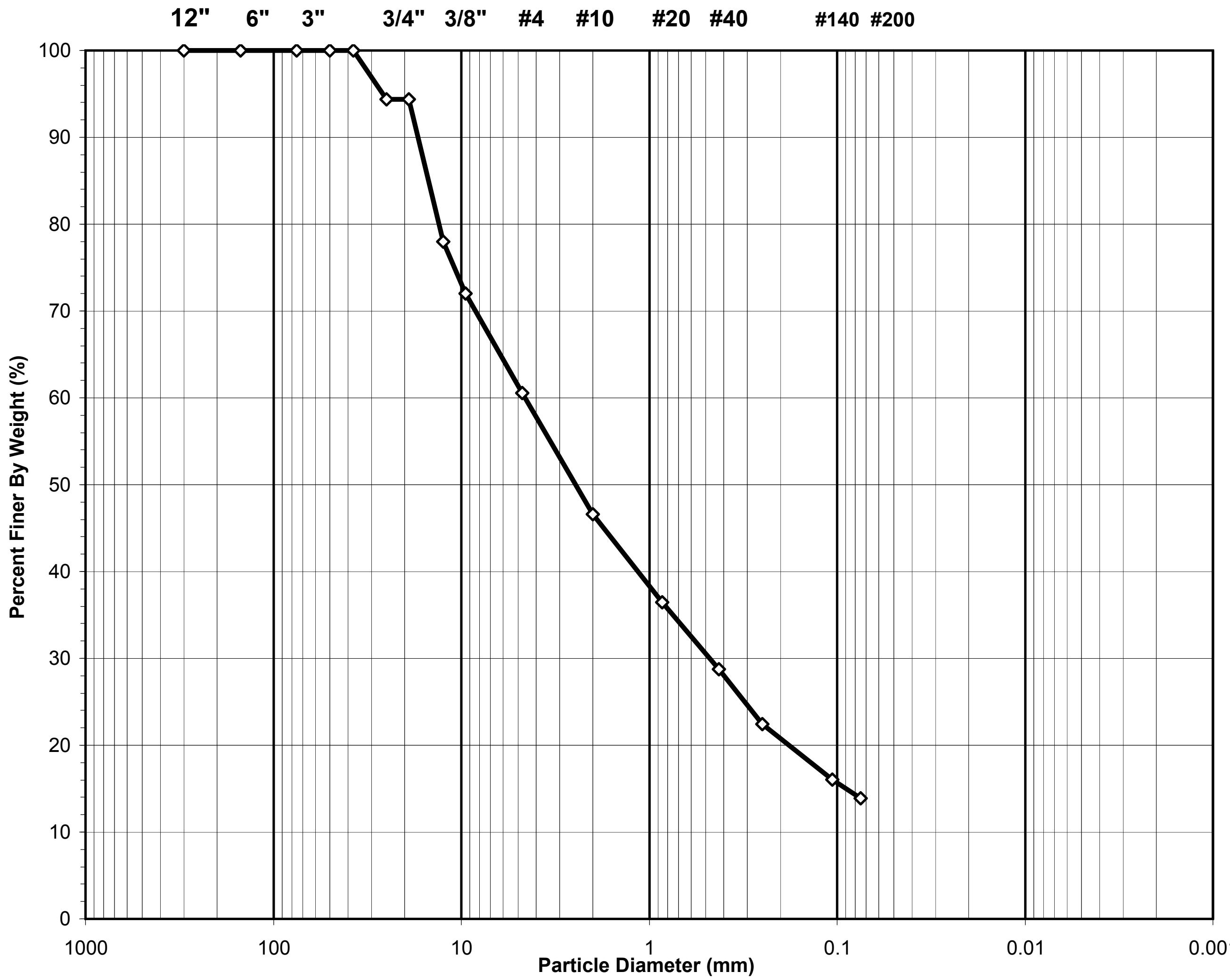
SIEVE ANALYSIS
ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	28.5-30.0
Project No.:	2015-550-001	Sample No.:	SS-8
Lab ID:	2015-550-001-004	Soil Color:	Brown

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol:
sc, ASSUMED

USCS Classification:
CLAYEY SAND WITH GRAVEL

Tested By	HL	Date	10/22/15	Checked By	KC	Date	10/24/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-1
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	28.5-30.0
Project No.:	2015-550-001	Sample No.:	SS-8
Lab ID:	2015-550-001-004	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1447	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	545.90	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	494.70	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	145.30	Weight of Tare (g):	NA
Weight of Water (g):	51.20	Weight of Water (g):	NA
Weight of Dry Sample (g):	349.40	Weight of Dry Sample (g):	NA
Moisture Content (%):	**14.7**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	349.40
Dry Weight of - 3/4" Sample (g):	281.0	Weight of - #200 Material (g):	48.64
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	300.76
Dry Weight of + 3/4" Sample (g):	19.72		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	19.72	5.64	5.64	94.36	**94.36**
3/4"	19.0	0.00	0.00	5.64	94.36	**94.36**
1/2"	12.50	57.24	16.38	22.03	77.97	**77.97**
3/8"	9.50	20.87	5.97	28.00	72.00	**72.00**
#4	4.75	40.04	11.46	39.46	60.54	**60.54**
#10	2.00	48.71	13.94	53.40	46.60	**46.60**
#20	0.850	35.32	10.11	63.51	36.49	**36.49**
#40	0.425	26.95	7.71	71.22	28.78	**28.78**
#60	0.250	22.06	6.31	77.54	22.46	**22.46**
#140	0.106	22.36	6.40	83.94	16.06	**16.06**
#200	0.075	7.49	2.14	86.08	13.92	**13.92**
Pan	-	48.64	13.92	100.00	-	**-**

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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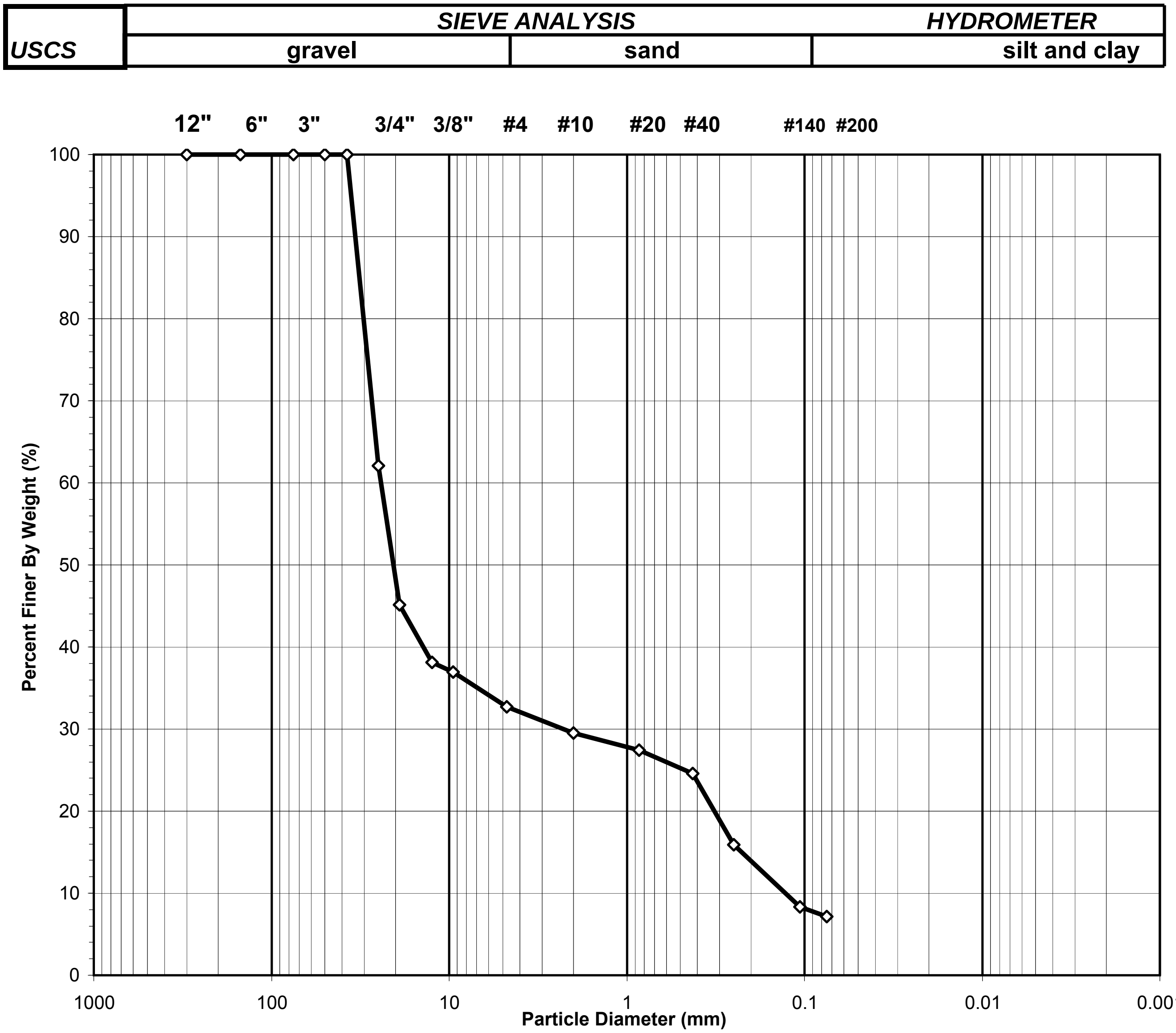
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-005	Soil Color:	Brown



USCS Symbol:

gw-gm, ASSUMED

D60 =	**24.18**	**CC =**	**1.67**
D30 =	**2.27**	**CU =**	**188.72**
D10 =	**0.13**		

USCS Classification:

WELL-GRADED GRAVEL WITH SILT AND SAND

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-005	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1425	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	351.47	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	341.27	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	144.97	Weight of Tare (g):	NA
Weight of Water (g):	10.20	Weight of Water (g):	NA
Weight of Dry Sample (g):	196.30	Weight of Dry Sample (g):	NA
Moisture Content (%):	**5.2**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	196.30
Dry Weight of - 3/4" Sample (g):	74.7	Weight of - #200 Material (g):	13.99
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	182.31
Dry Weight of + 3/4" Sample (g):	107.66		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	74.47	37.94	37.94	62.06	**62.06**
3/4"	19.0	33.19	16.91	54.84	45.16	**45.16**
1/2"	12.50	13.79	7.02	61.87	38.13	**38.13**
3/8"	9.50	2.30	1.17	63.04	36.96	**36.96**
#4	4.75	8.40	4.28	67.32	32.68	**32.68**
#10	2.00	6.17	3.14	70.46	29.54	**29.54**
#20	0.850	4.11	2.09	72.56	27.44	**27.44**
#40	0.425	5.58	2.84	75.40	24.60	**24.60**
#60	0.250	17.12	8.72	84.12	15.88	**15.88**
#140	0.106	14.81	7.54	91.67	8.33	**8.33**
#200	0.075	2.37	1.21	92.87	7.13	**7.13**
Pan	-	13.99	7.13	100.00	-	**-**

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

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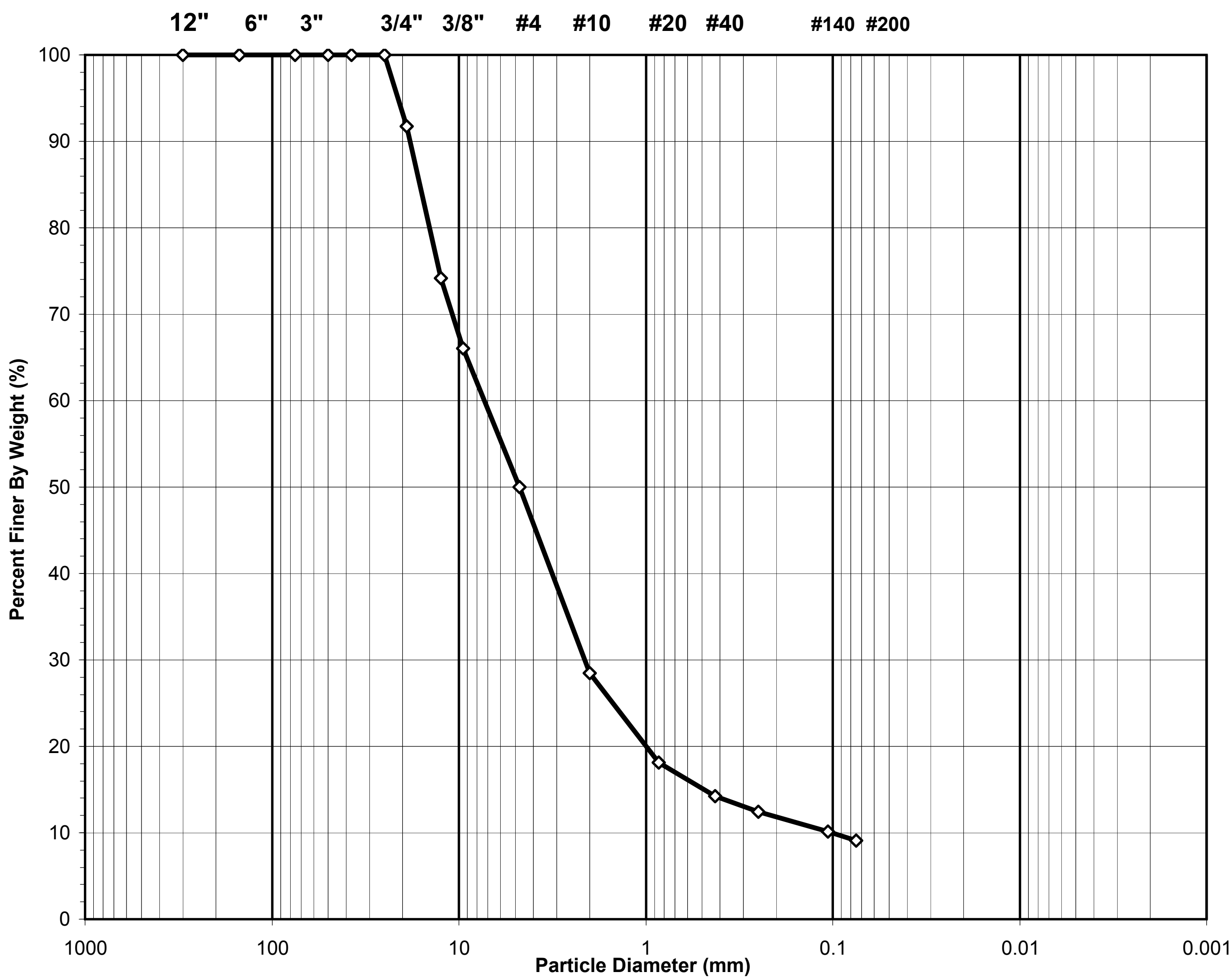
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	18.5-20.5
Project No.:	2015-550-001	Sample No.:	SS-6
Lab ID:	2015-550-001-006	Soil Color:	Brown

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol:

gp-gm, ASSUMED

D60 = 7.31 **CC = 6.09**

USCS Classification:

POORLY GRADED GRAVEL WITH SILT AND SAND

D30 = 2.13 **CU = 72.04**

D10 = 0.10

Tested By	HL	Date	10/22/15	Checked By	KC	Date	10/24/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	18.5-20.5
Project No.:	2015-550-001	Sample No.:	SS-6
Lab ID:	2015-550-001-006	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1429	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	330.08	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	318.73	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	144.84	Weight of Tare (g):	NA
Weight of Water (g):	11.35	Weight of Water (g):	NA
Weight of Dry Sample (g):	173.89	Weight of Dry Sample (g):	NA
Moisture Content (%):	**6.5**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	173.89
Dry Weight of - 3/4" Sample (g):	143.7	Weight of - #200 Material (g):	15.76
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	158.13
Dry Weight of + 3/4" Sample (g):	14.39		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	14.39	8.28	8.28	91.72	**91.72**
1/2"	12.50	30.54	17.56	25.84	74.16	**74.16**
3/8"	9.50	14.12	8.12	33.96	66.04	**66.04**
#4	4.75	27.86	16.02	49.98	50.02	**50.02**
#10	2.00	37.46	21.54	71.52	28.48	**28.48**
#20	0.850	17.95	10.32	81.84	18.16	**18.16**
#40	0.425	6.80	3.91	85.76	14.24	**14.24**
#60	0.250	3.12	1.79	87.55	12.45	**12.45**
#140	0.106	4.03	2.32	89.87	10.13	**10.13**
#200	0.075	1.86	1.07	90.94	9.06	**9.06**
Pan	-	15.76	9.06	100.00	-	**-**

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

DCN: CT-S3C DATE 3/20/13 REVISION: 3

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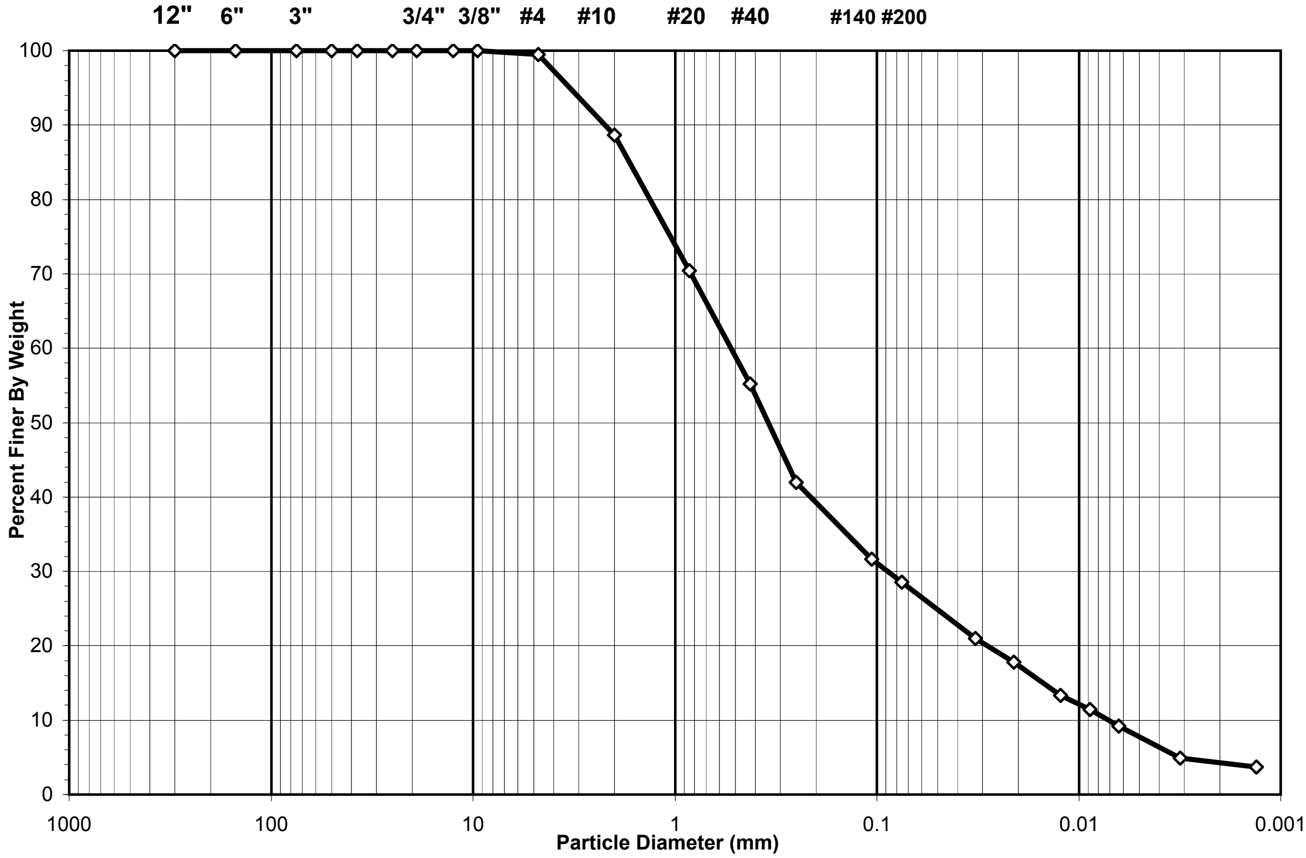
SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM		Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145		Depth (ft):	3.5-5.5
Project No.:	2015-550-001		Sample No.:	SS-2
Lab ID:	2015-550-001-007		Soil Color:	Brown

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.54
#4 To #200	*Sand*	70.93
Finer Than #200	*Silt & Clay*	28.54

USCS Symbol:

SC-SM, TESTED

USCS Classification:

SILTY, CLAYEY SAND

 DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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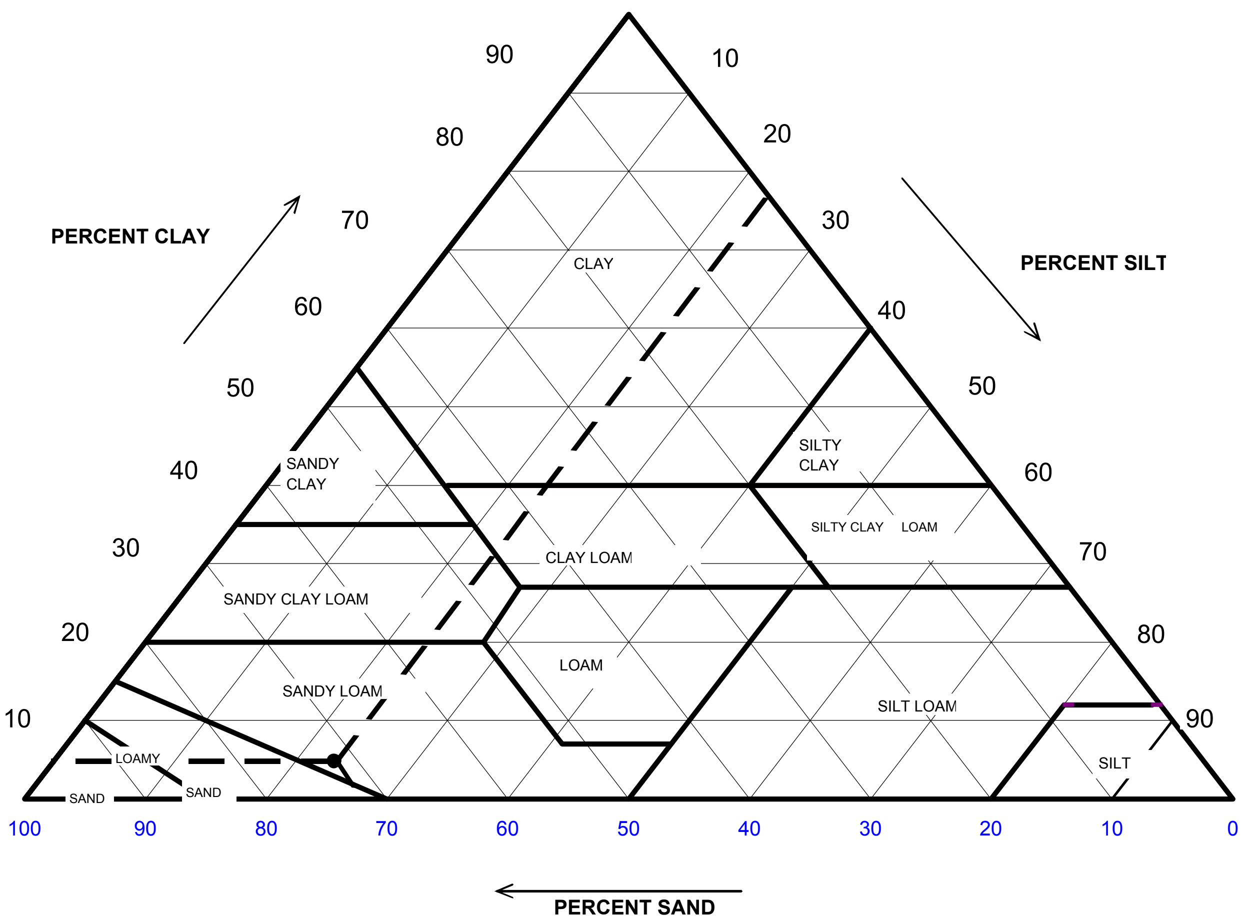
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-007	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	11.33	**0.00**
2	88.67	*Sand*	63.82	**71.98**
0.05	24.85	*Silt*	20.61	**23.24**
0.002	4.24	*Clay*	4.24	**4.78**

USDA Classification: ***SANDY LOAM***

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-007	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1420	Tare No.	NA
Weight of Tare & Wet Sample (g)	338.83	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	338.83	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	144.70	Weight of Tare (g)	NA
Weight of Water (g)	0.00	Weight of Water (g)	NA
Weight of Dry Sample (g)	194.13	Weight of Dry Sample (g)	NA
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	194.13
Dry Weight of -3/4" Sample (g)	138.73	Weight of - #200 Material (g)	55.40
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	138.73
Dry Weight of +3/4" Sample (g)	0.00		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)		Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	0.00	0.00	0.00		100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00		100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00		100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00		100.00	**100.00**
#4	4.75	1.04	0.54	0.54		99.46	**99.46**
#10	2.00	20.96	10.80	11.33		88.67	**88.67**
#20	0.85	35.50	18.29	29.62		70.38	**70.38**
#40	0.425	29.52	15.21	44.83		55.17	**55.17**
#60	0.250	25.57	13.17	58.00		42.00	**42.00**
#140	0.106	20.07	10.34	68.34		31.66	**31.66**
#200	0.075	6.07	3.13	71.46		28.54	**28.54**
Pan	-	55.40	28.54	100.00		-	**-**

Tested By HL Date 10/29/15 Checked By KC Date 11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-007	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		22.5	23.1	5.97	16.5	73.4	0.01296	0.0325	**20.9**
5		20.0	23.1	5.97	14.0	62.3	0.01296	0.0209	**17.8**
15		16.5	23.1	5.97	10.5	46.7	0.01296	0.0123	**13.3**
30		15.0	23.1	5.97	9.0	40.1	0.01296	0.0088	**11.4**
60		13.5	22.4	6.22	7.3	32.3	0.01307	0.0063	**9.2**
250		10.0	22.6	6.15	3.9	17.1	0.01303	0.0032	**4.9**
1440		9.0	22.7	6.11	2.9	12.8	0.01302	0.0013	**3.7**

Soil Specimen Data		Other Corrections		
Tare No.	929			
Weight of Tare & Dry Material (g)	127.54	a - Factor	0.99	
Weight of Tare (g)	100.23			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	28.54	
Weight of Dry Material (g)	22.3			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 10/26/15 Checked By KC Date 11/2/15

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-007	Soil Description:	BROWN SILTY CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description .

(Minus No. 40 sieve material, Airdried)

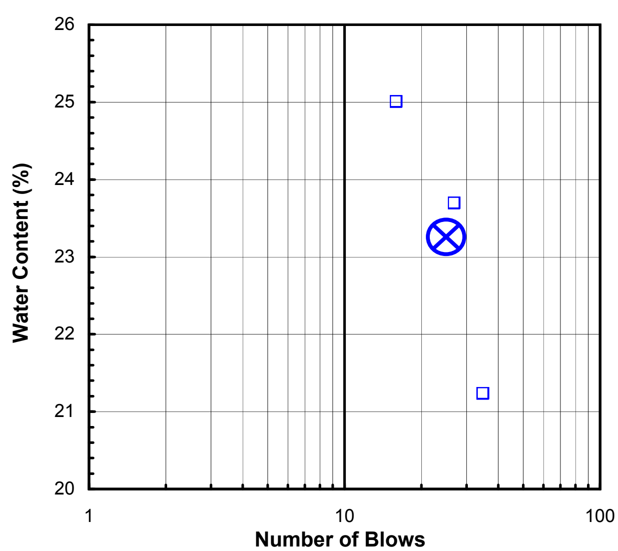
Liquid Limit Test	1	2	3	MULTIPOINT
Tare Number:	206	301	156	
Wt. of Tare & Wet Sample (g):	38.76	39.03	39.13	
Wt. of Tare & Dry Sample (g):	34.69	35.47	35.25	
Weight of Tare (g):	18.41	18.70	18.87	
Weight of Water (g):	4.1	3.6	3.9	
Weight of Dry Sample (g):	16.3	16.8	16.4	
Moisture Content (%):	**25.0**	**21.2**	**23.7**	
Number of Blows:	**16**	**35**	**27**	

Plastic Limit Test	1	2	Range
Tare Number:	231	167	
Wt. of Tare & Wet Sample (g):	26.04	24.85	
Wt. of Tare & Dry Sample (g):	25.10	23.93	
Weight of Tare (g):	19.67	18.42	
Weight of Water (g):	0.9	0.9	
Weight of Dry Sample (g):	5.4	5.5	
Moisture Content (%):	**17.3**	**16.7**	**0.6**

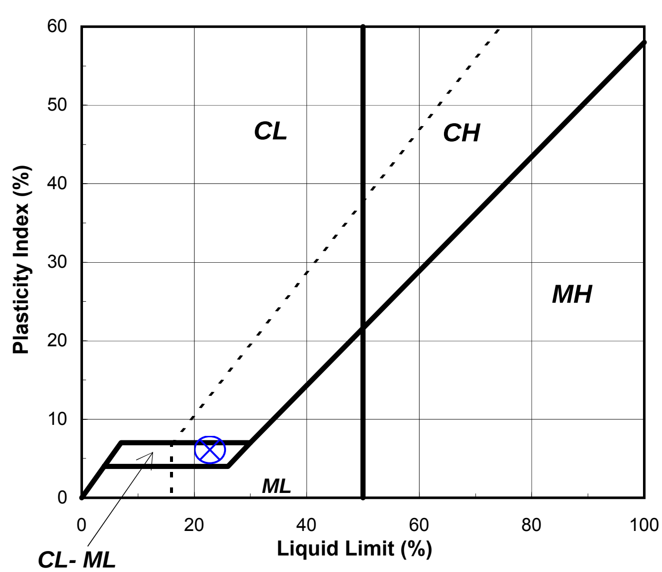
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**23**
Plastic Limit (%):	**17**
Plasticity Index (%):	**6**
USCS Symbol:	**CL-ML**

Flow Curve



Plasticity Chart



Tested By RAL *Date* 10/23/15 *Checked By* CLK *Date* 10/26/15

 DCN: CTS4B, REV. 4, 3/18/13

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SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-008	Soil Color:	Brown

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay

USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	2.71
#4 To #200	*Sand*	56.55
Finer Than #200	*Silt & Clay*	40.75

USCS Symbol:

SC, TESTED

USCS Classification:

CLAYEY SAND

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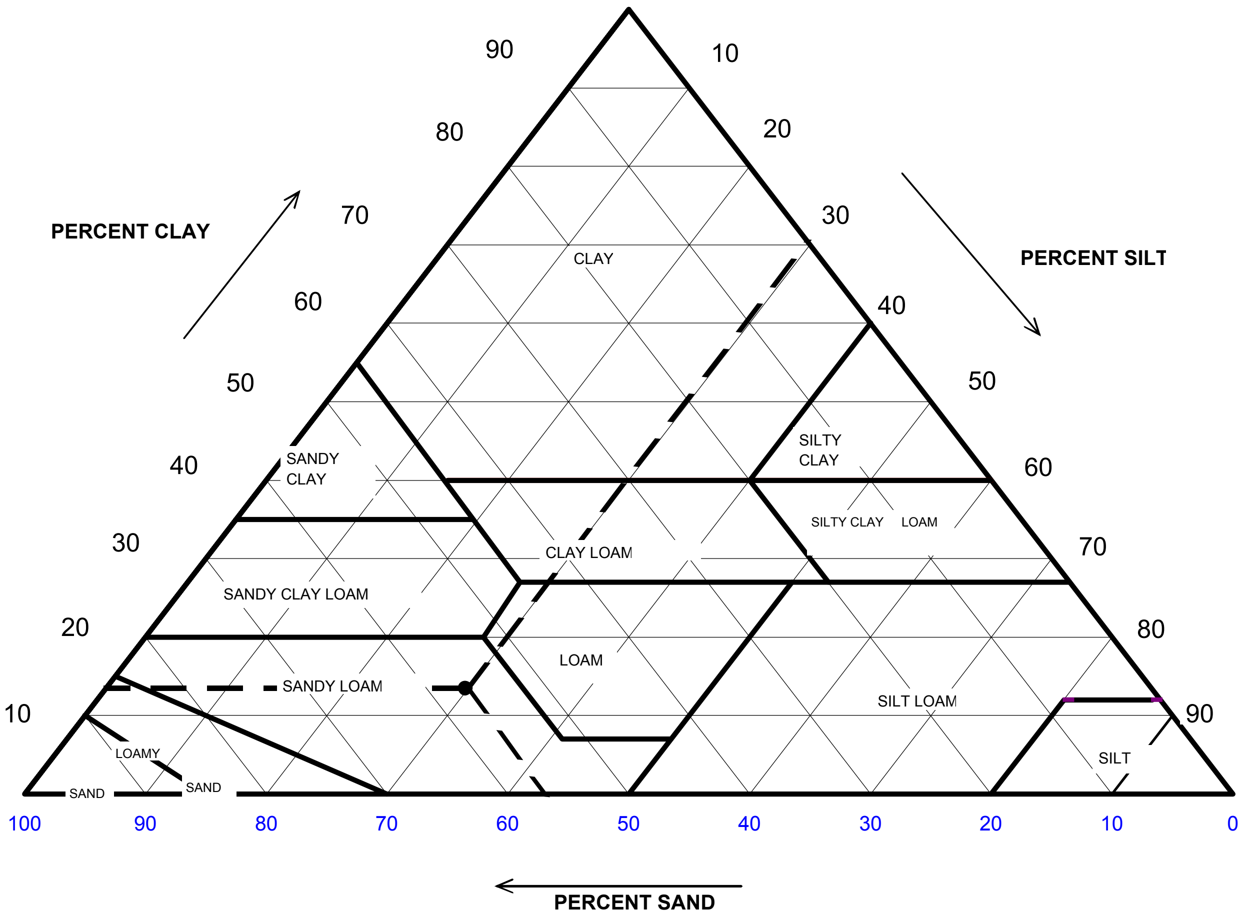
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-008	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	14.36	**0.00**
2	85.64	*Sand*	48.62	**56.78**
0.05	37.02	*Silt*	25.52	**29.80**
0.002	11.50	*Clay*	11.50	**13.43**

USDA Classification: ***SANDY LOAM***

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-008	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1437	Tare No.	NA
Weight of Tare & Wet Sample (g)	347.62	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	347.62	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	144.73	Weight of Tare (g)	NA
Weight of Water (g)	0.00	Weight of Water (g)	NA
Weight of Dry Sample (g)	202.89	Weight of Dry Sample (g)	NA
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	202.89
Dry Weight of -3/4" Sample (g)	120.22	Weight of - #200 Material (g)	82.67
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	120.22
Dry Weight of +3/4" Sample (g)	0.00		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening	Weight of Soil Retained	Percent Retained	Accumulated Percent Retained		Percent Finer	Accumulated Percent Finer
	(mm)	(g)	(%)	(%)		(%)	(%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	0.00	0.00	0.00		100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00		100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00		100.00	**100.00**
3/8"	9.50	1.02	0.50	0.50		99.50	**99.50**
#4	4.75	4.47	2.20	2.71		97.29	**97.29**
#10	2.00	23.65	11.66	14.36		85.64	**85.64**
#20	0.85	30.50	15.03	29.40		70.60	**70.60**
#40	0.425	23.74	11.70	41.10		58.90	**58.90**
#60	0.250	16.84	8.30	49.40		50.60	**50.60**
#140	0.106	14.94	7.36	56.76		43.24	**43.24**
#200	0.075	5.06	2.49	59.25		40.75	**40.75**
Pan	-	82.67	40.75	100.00		-	**-**

Tested By	HL	Date	10/28/15	Checked By	KC	Date	11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-008	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		19.0	22.7	6.11	12.9	81.8	0.01302	0.0334	**33.3**
5		17.5	22.7	6.11	11.4	72.2	0.01302	0.0213	**29.4**
15		15.5	22.7	6.11	9.4	59.6	0.01302	0.0125	**24.3**
30		14.0	22.7	6.11	7.9	50.0	0.01302	0.0089	**20.4**
60		12.5	22.6	6.15	6.4	40.3	0.01303	0.0064	**16.4**
250		11.0	22.7	6.11	4.9	31.0	0.01302	0.0031	**12.6**
1440		10.0	23.1	5.97	4.0	25.6	0.01296	0.0013	**10.4**

Soil Specimen Data		Other Corrections		
Tare No.	927			
Weight of Tare & Dry Material (g)	118.55	a - Factor	0.99	
Weight of Tare (g)	97.94			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	40.75	
Weight of Dry Material (g)	15.6			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By	TO	Date	10/28/15	Checked By	KC	Date	11/2/15

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	6.0-7.5
Project No.:	2015-550-001	Sample No.:	SS-3
Lab ID:	2015-550-001-008	Soil Description:	BROWN LEAN CLAY

Note: The ***USCS*** *symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description .* (Minus No. 40 sieve material, Airdried)

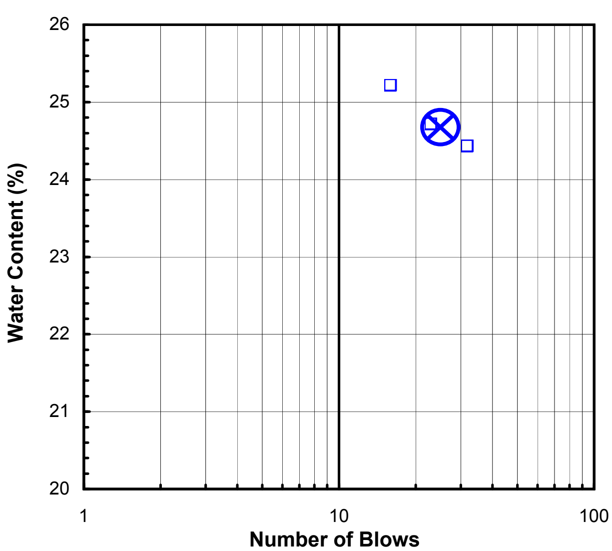
Liquid Limit Test	1	2	3	MULTIPOINT
Tare Number:	235	320	325	
Wt. of Tare & Wet Sample (g):	39.78	40.44	41.25	
Wt. of Tare & Dry Sample (g):	35.65	36.37	36.73	
Weight of Tare (g):	18.74	19.90	18.80	
Weight of Water (g):	4.1	4.1	4.5	
Weight of Dry Sample (g):	16.9	16.5	17.9	
Moisture Content (%):	**24.4**	**24.7**	**25.2**	
Number of Blows:	**32**	**23**	**16**	

Plastic Limit Test	1	2	Range
Tare Number:	169	183	
Wt. of Tare & Wet Sample (g):	25.43	25.27	
Wt. of Tare & Dry Sample (g):	24.65	24.52	
Weight of Tare (g):	19.28	19.28	
Weight of Water (g):	0.8	0.8	
Weight of Dry Sample (g):	5.4	5.2	
Moisture Content (%):	**14.5**	**14.3**	**0.2**

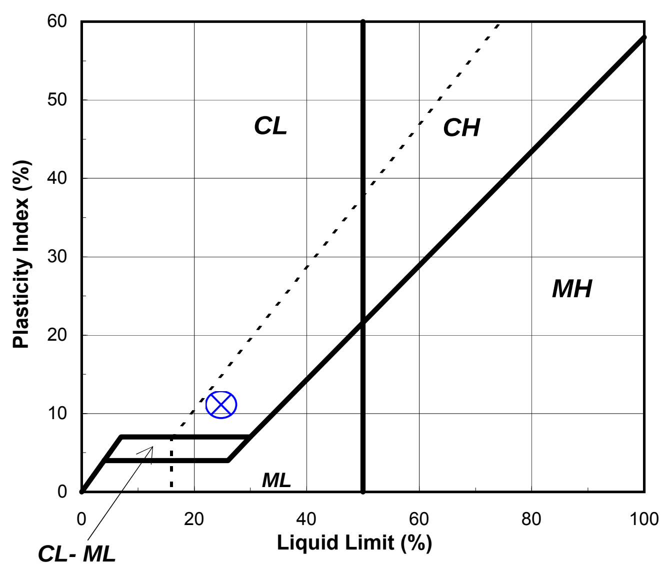
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**25**
Plastic Limit (%):	**14**
Plasticity Index (%):	**11**
USCS Symbol:	**CL**

Flow Curve



Plasticity Chart



Tested By	*JP*	*Date*	*10/24/15*	*Checked By*	*CLK*	*Date*	10/26/15

 DCN: CTS4B, REV. 4, 3/18/13

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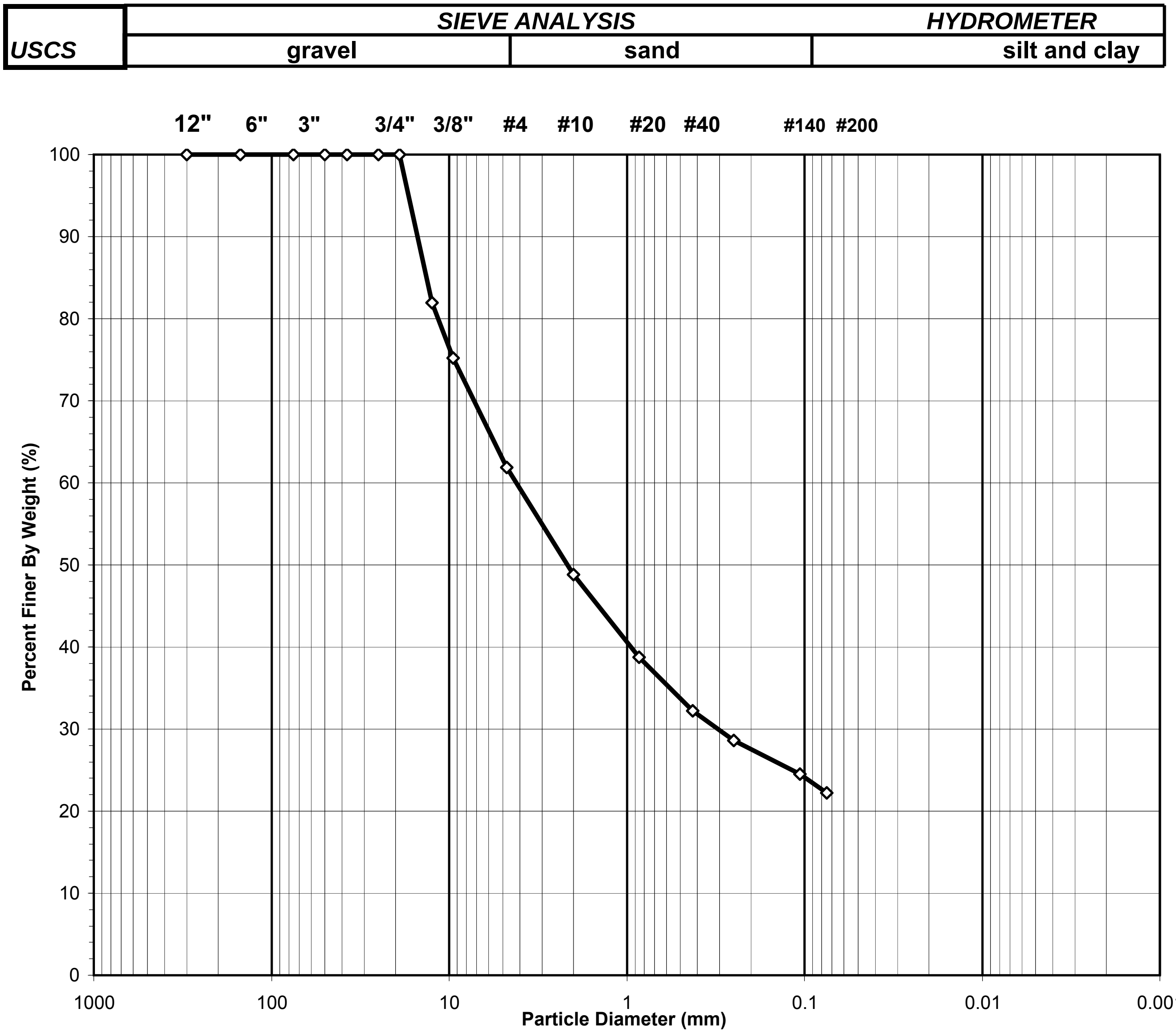
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	18.5-20.5
Project No.:	2015-550-001	Sample No.:	SS-6
Lab ID:	2015-550-001-009	Soil Color:	Brown



USCS Symbol:

sm, ASSUMED

USCS Classification:

SILTY SAND WITH GRAVEL

Tested By	HL	Date	10/22/15	Checked By	KC	Date	10/24/15

DCN: CT-S3C DATE 3/20/13 REVISION: 3

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

geotechnics geotechnical & geosynthetic testing

Client:	AECOM	Boring No.:	B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	18.5-20.5
Project No.:	2015-550-001	Sample No.:	SS-6
Lab ID:	2015-550-001-009	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1456	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	428.40	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	391.89	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	133.07	Weight of Tare (g):	NA
Weight of Water (g):	36.51	Weight of Water (g):	NA
Weight of Dry Sample (g):	258.82	Weight of Dry Sample (g):	NA
Moisture Content (%):	**14.1**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	258.82
Dry Weight of - 3/4" Sample (g):	201.3	Weight of - #200 Material (g):	57.54
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	201.28
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.50	46.76	18.07	18.07	81.93	**81.93**
3/8"	9.50	17.33	6.70	24.76	75.24	**75.24**
#4	4.75	34.64	13.38	38.15	61.85	**61.85**
#10	2.00	33.81	13.06	51.21	48.79	**48.79**
#20	0.850	25.92	10.01	61.22	38.78	**38.78**
#40	0.425	16.94	6.55	67.77	32.23	**32.23**
#60	0.250	9.37	3.62	71.39	28.61	**28.61**
#140	0.106	10.64	4.11	75.50	24.50	**24.50**
#200	0.075	5.87	2.27	77.77	22.23	**22.23**
Pan	-	57.54	22.23	100.00	-	**-**

Tested By HL Date 10/22/15 Checked By KC Date 10/24/15

DCN: CT-S3C DATE 3/20/13 REVISION: 3

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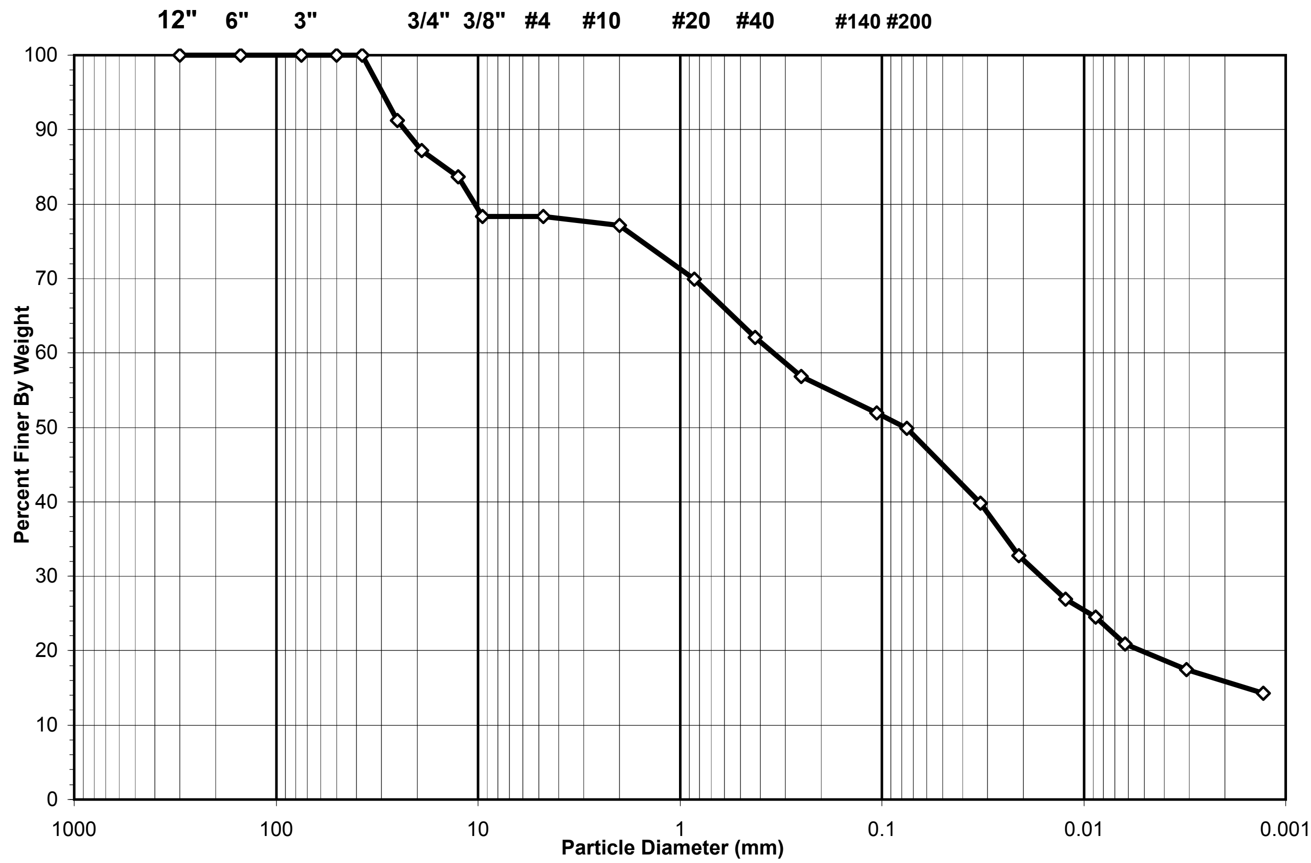
SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	1.0-2.5
Project No.:	2015-550-001	Sample No.:	SS-1
Lab ID:	2015-550-001-010	Soil Color:	Brown

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	21.64
#4 To #200	*Sand*	28.53
Finer Than #200	*Silt & Clay*	49.83

USCS Symbol:

SC, TESTED

USCS Classification:

CLAYEY SAND WITH GRAVEL

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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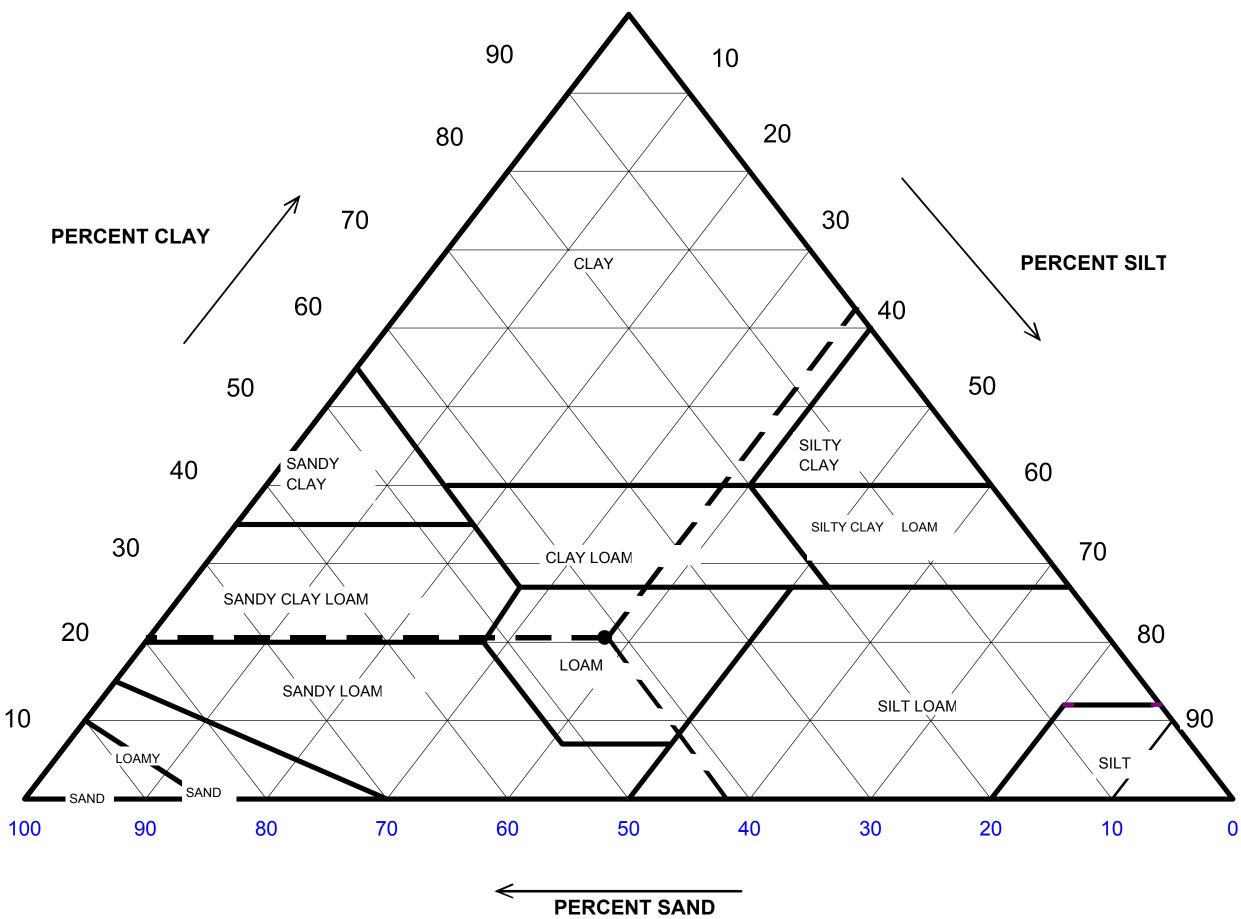
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	1.0-2.5
Project No.:	2015-550-001	Sample No.:	SS-1
Lab ID:	2015-550-001-010	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	22.83	**0.00**
2	77.17	*Sand*	32.19	**41.72**
0.05	44.98	*Silt*	29.14	**37.76**
0.002	15.84	*Clay*	15.84	**20.52**

USDA Classification: ***LOAM***

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	1.0-2.5
Project No.:	2015-550-001	Sample No.:	SS-1
Lab ID:	2015-550-001-010	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1439	Tare No.	NA
Weight of Tare & Wet Sample (g)	344.69	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	344.69	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	145.05	Weight of Tare (g)	NA
Weight of Water (g)	0.00	Weight of Water (g)	NA
Weight of Dry Sample (g)	199.64	Weight of Dry Sample (g)	NA
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	199.64
Dry Weight of -3/4" Sample (g)	74.61	Weight of - #200 Material (g)	99.48
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	100.16
Dry Weight of +3/4" Sample (g)	25.55		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening	Weight of Soil Retained	Percent Retained	Accumulated Percent Retained		Percent Finer	Accumulated Percent Finer
	(mm)	(g)	(%)	(%)		(%)	(%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	17.44	8.74	8.74		91.26	**91.26**
3/4"	19.0	8.11	4.06	12.80		87.20	**87.20**
1/2"	12.5	7.13	3.57	16.37		83.63	**83.63**
3/8"	9.50	10.53	5.27	21.64		78.36	**78.36**
#4	4.75	0.00	0.00	21.64		78.36	**78.36**
#10	2.00	2.37	1.19	22.83		77.17	**77.17**
#20	0.85	14.49	7.26	30.09		69.91	**69.91**
#40	0.425	15.56	7.79	37.88		62.12	**62.12**
#60	0.250	10.49	5.25	43.14		56.86	**56.86**
#140	0.106	9.80	4.91	48.05		51.95	**51.95**
#200	0.075	4.24	2.12	50.17		49.83	**49.83**
Pan	-	99.48	49.83	100.00		-	**-**

Tested By HL Date 10/28/15 Checked By KC Date 11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	1.0-2.5
Project No.:	2015-550-001	Sample No.:	SS-1
Lab ID:	2015-550-001-010	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		23.0	22.7	6.11	16.9	80.0	0.01302	0.0326	**39.8**
5		20.0	22.7	6.11	13.9	65.8	0.01302	0.0210	**32.8**
15		17.5	22.7	6.11	11.4	53.9	0.01302	0.0123	**26.9**
30		16.5	22.7	6.11	10.4	49.2	0.01302	0.0088	**24.5**
60		15.0	22.6	6.15	8.9	41.9	0.01303	0.0063	**20.9**
250		13.5	22.7	6.11	7.4	35.0	0.01302	0.0031	**17.4**
1440		12.0	23.1	5.97	6.0	28.6	0.01296	0.0013	**14.2**

Soil Specimen Data		Other Corrections		
Tare No.	633			
Weight of Tare & Dry Material (g)	121.94	a - Factor	0.99	
Weight of Tare (g)	96.03			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	49.83	
Weight of Dry Material (g)	20.9			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 10/28/15 Checked By KC Date 11/2/15

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	1.0-2.5
Project No.:	2015-550-001	Sample No.:	SS-1
Lab ID:	2015-550-001-010	Soil Description:	BROWN LEAN CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description . (Minus No. 40 sieve material, Airdried)

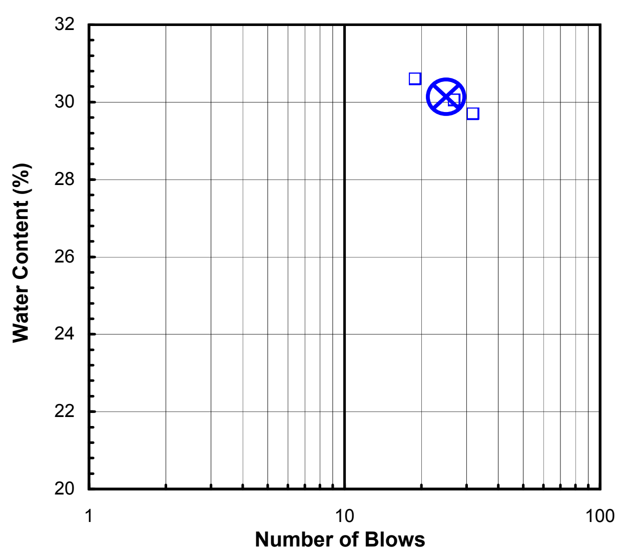
Liquid Limit Test	1	2	3	MULTIPOINT
Tare Number:	215	217	227	
Wt. of Tare & Wet Sample (g):	32.21	32.99	30.64	
Wt. of Tare & Dry Sample (g):	29.04	29.68	27.60	
Weight of Tare (g):	18.36	18.66	17.66	
Weight of Water (g):	3.2	3.3	3.0	
Weight of Dry Sample (g):	10.7	11.0	9.9	
Moisture Content (%):	**29.7**	**30.0**	**30.6**	
Number of Blows:	**32**	**27**	**19**	

Plastic Limit Test	1	2	Range
Tare Number:	175	184	
Wt. of Tare & Wet Sample (g):	25.81	25.83	
Wt. of Tare & Dry Sample (g):	24.79	24.83	
Weight of Tare (g):	19.67	19.63	
Weight of Water (g):	1.0	1.0	
Weight of Dry Sample (g):	5.1	5.2	
Moisture Content (%):	**19.9**	**19.2**	**0.7**

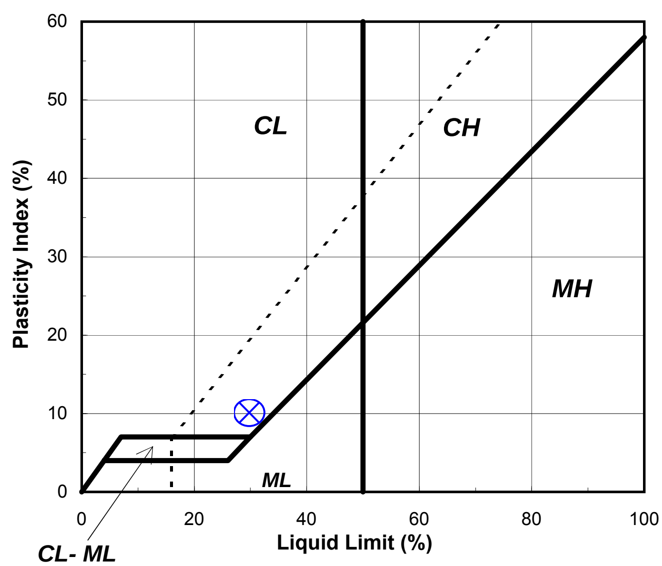
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**30**
Plastic Limit (%):	**20**
Plasticity Index (%):	**10**
USCS Symbol:	**CL**

Flow Curve



Plasticity Chart



Tested By	*JP*	*Date*	*10/24/15*	*Checked By*	*CLK*	*Date*	10/26/15

 DCN: CTS4B, REV. 4, 3/18/13

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SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

geotechnics
geotechnical & geosynthetic testing

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-011	Soil Color:	Brown

USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.50
#4 To #200	*Sand*	52.58
Finer Than #200	*Silt & Clay*	46.91

USCS Symbol:

SC, TESTED

USCS Classification:

CLAYEY SAND

 DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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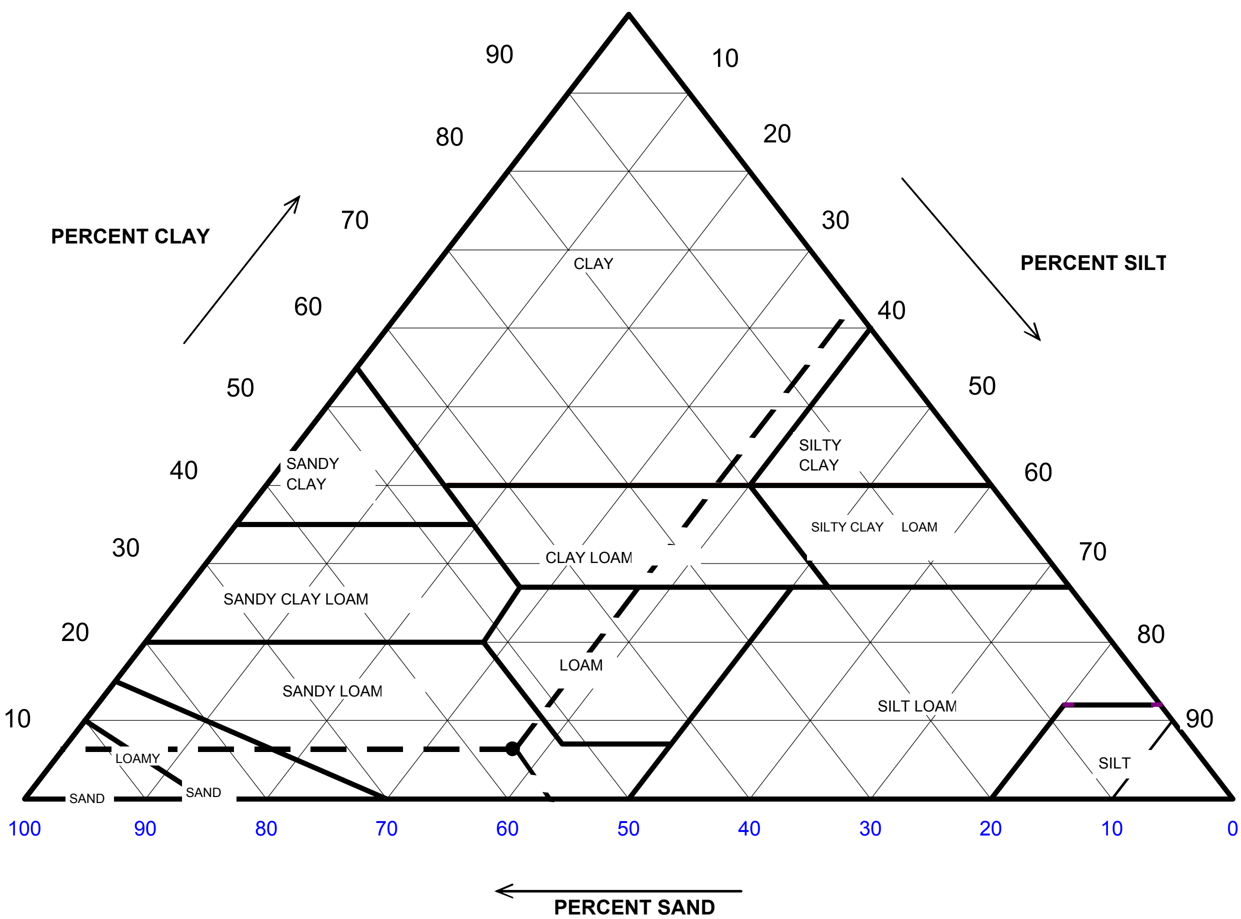
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-011	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	4.36	**0.00**
2	95.64	*Sand*	53.93	**56.39**
0.05	41.71	*Silt*	35.63	**37.26**
0.002	6.08	*Clay*	6.08	**6.36**

USDA Classification: ***SANDY LOAM***

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-011	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1454	Tare No.	NA
Weight of Tare & Wet Sample (g)	323.32	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	323.32	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	138.28	Weight of Tare (g)	NA
Weight of Water (g)	0.00	Weight of Water (g)	NA
Weight of Dry Sample (g)	185.04	Weight of Dry Sample (g)	NA
Moisture Content (%)	**0.0**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	185.04
Dry Weight of -3/4" Sample (g)	98.23	Weight of - #200 Material (g)	86.81
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	98.23
Dry Weight of +3/4" Sample (g)	0.00		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening	Weight of Soil Retained	Percent Retained	Accumulated Percent Retained		Percent Finer	Accumulated Percent Finer
	(mm)	(g)	(%)	(%)		(%)	(%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	0.00	0.00	0.00		100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00		100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00		100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00		100.00	**100.00**
#4	4.75	0.93	0.50	0.50		99.50	**99.50**
#10	2.00	7.14	3.86	4.36		95.64	**95.64**
#20	0.85	11.07	5.98	10.34		89.66	**89.66**
#40	0.425	23.80	12.86	23.21		76.79	**76.79**
#60	0.250	29.03	15.69	38.89		61.11	**61.11**
#140	0.106	20.42	11.04	49.93		50.07	**50.07**
#200	0.075	5.84	3.16	53.09		46.91	**46.91**
Pan	-	86.81	46.91	100.00		-	**-**

Tested By HL Date 10/29/15 Checked By KC Date 11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-011	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		27.0	23.1	5.97	21.0	76.3	0.01296	0.0316	**35.8**
5		23.0	23.1	5.97	17.0	61.8	0.01296	0.0205	**29.0**
15		18.5	23.1	5.97	12.5	45.5	0.01296	0.0122	**21.3**
30		16.5	23.1	5.97	10.5	38.2	0.01296	0.0087	**17.9**
60		14.5	22.4	6.22	8.3	30.1	0.01307	0.0063	**14.1**
250		10.5	22.6	6.15	4.4	15.8	0.01303	0.0031	**7.4**
1440		9.0	22.6	6.15	2.9	10.4	0.01303	0.0013	**4.9**

Soil Specimen Data		Other Corrections		
Tare No.	506			
Weight of Tare & Dry Material (g)	131.37	a - Factor	0.99	
Weight of Tare (g)	99.09			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	46.91	
Weight of Dry Material (g)	27.3			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 10/29/15 Checked By KC Date 11/2/15

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	3.5-5.5
Project No.:	2015-550-001	Sample No.:	SS-2
Lab ID:	2015-550-001-011	Soil Description:	BROWN LEAN CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description .

(Minus No. 40 sieve material, Airdried)

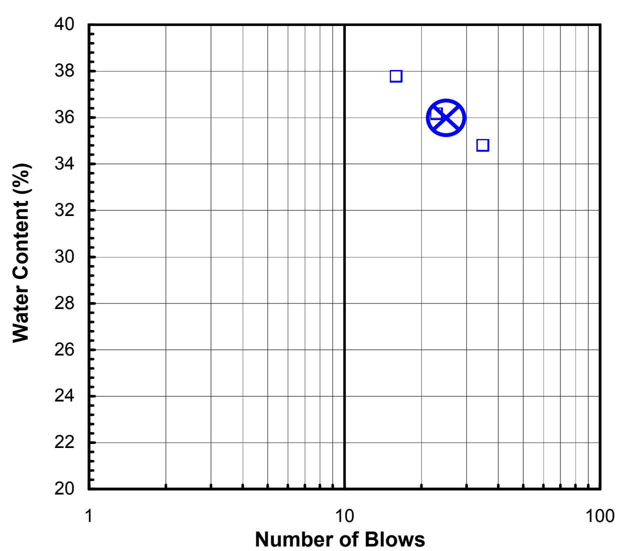
Liquid Limit Test	1	2	3	MULTIPOINT
Tare Number:	5	1101	242	
Wt. of Tare & Wet Sample (g):	37.94	38.58	39.37	
Wt. of Tare & Dry Sample (g):	32.24	33.17	34.15	
Weight of Tare (g):	17.14	18.20	19.14	
Weight of Water (g):	5.7	5.4	5.2	
Weight of Dry Sample (g):	15.1	15.0	15.0	
Moisture Content (%):	**37.7**	**36.1**	**34.8**	
Number of Blows:	**16**	**23**	**35**	

Plastic Limit Test	1	2	Range
Tare Number:	185	118	
Wt. of Tare & Wet Sample (g):	25.88	25.60	
Wt. of Tare & Dry Sample (g):	24.85	24.59	
Weight of Tare (g):	19.38	19.33	
Weight of Water (g):	1.0	1.0	
Weight of Dry Sample (g):	5.5	5.3	
Moisture Content (%):	**18.8**	**19.2**	**-0.4**

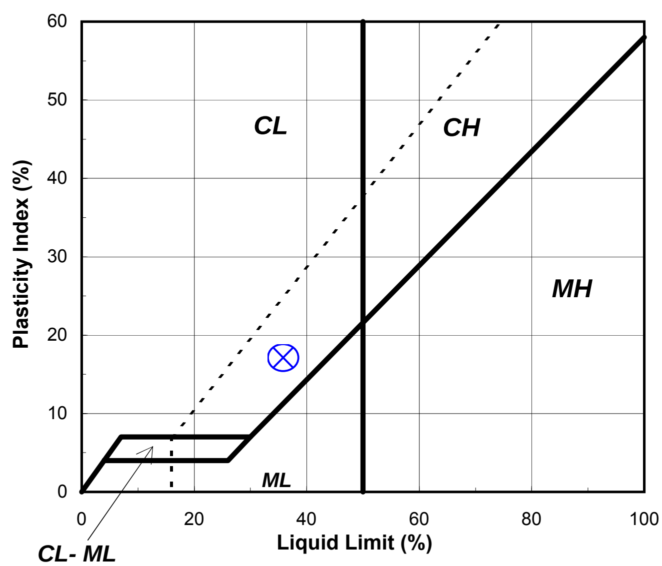
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**36**
Plastic Limit (%):	**19**
Plasticity Index (%):	**17**
USCS Symbol:	**CL**

Flow Curve



Plasticity Chart



Tested By	*RAL*	*Date*	*10/23/15*	*Checked By*	*CLK*	*Date*	10/26/15

 DCN: CTS4B, REV. 4, 3/18/13

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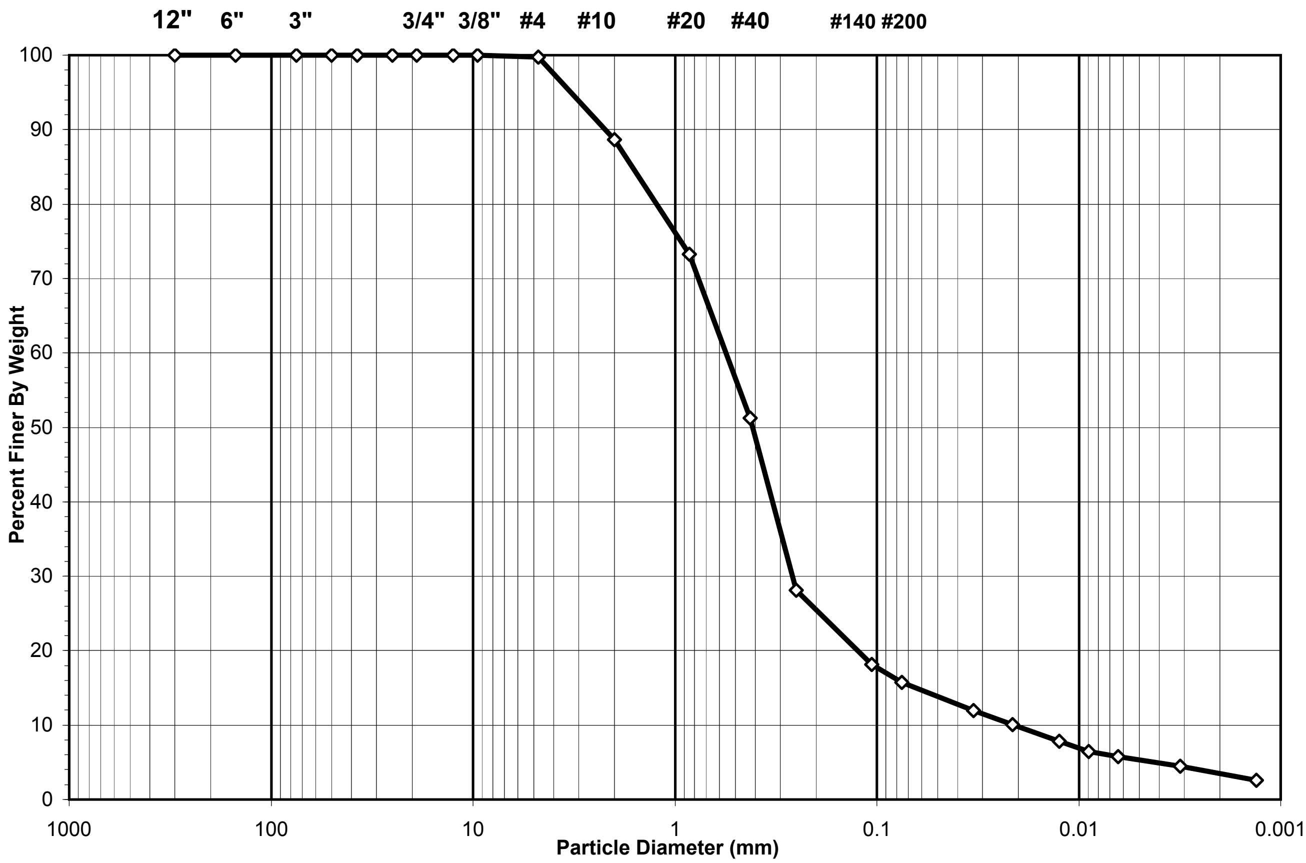
SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	8.5-10.5
Project No.:	2015-550-001	Sample No.:	SS-4
Lab ID:	2015-550-001-012	Soil Color:	Brown

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



Sieve Sizes (mm)	USCS Summary	Percentage
Greater Than #4	*Gravel*	0.26
#4 To #200	*Sand*	83.99
Finer Than #200	*Silt & Clay*	15.76

USCS Symbol:

SM, TESTED

USCS Classification:

SILTY SAND

(NON-PLASTIC FINES)

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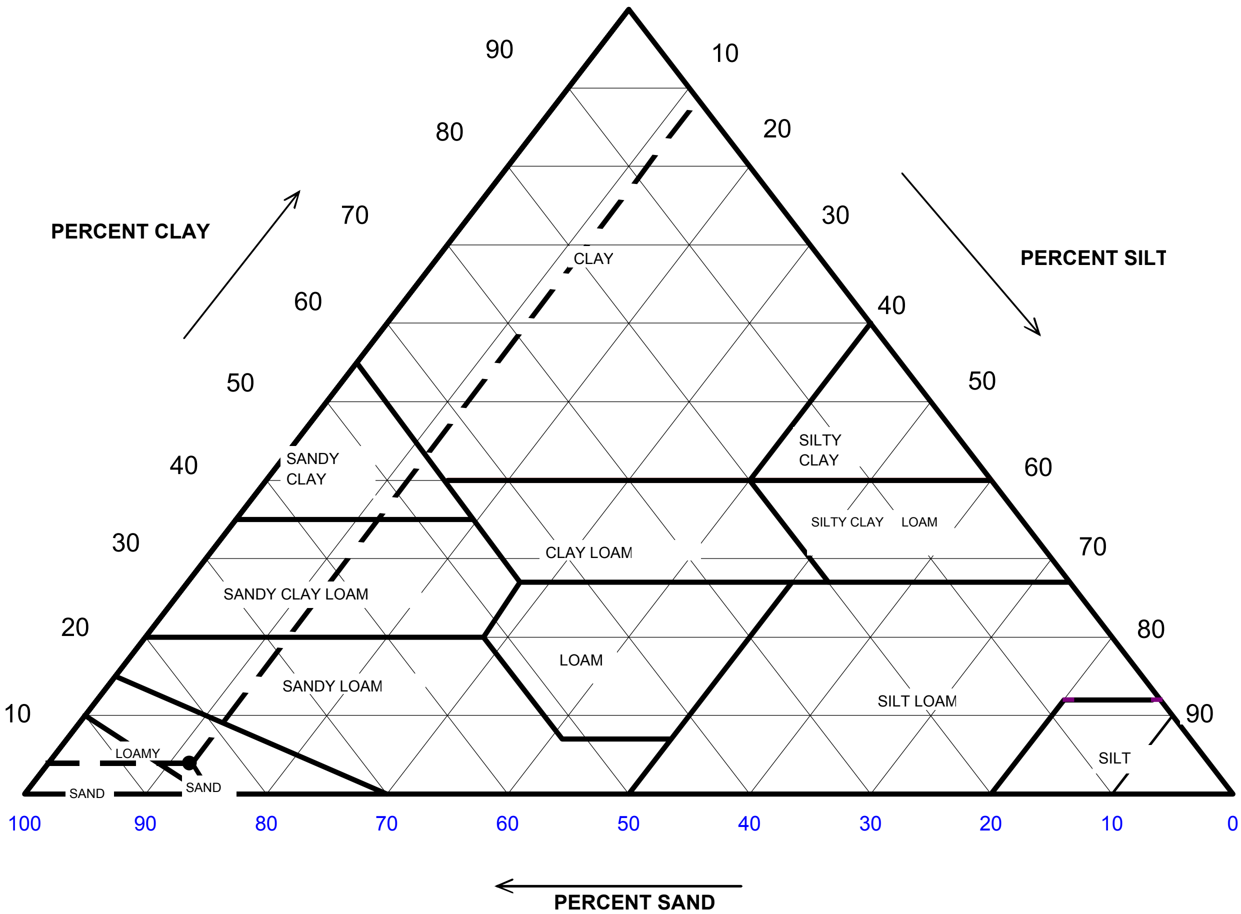
USDA CLASSIFICATION CHART

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	8.5-10.5
Project No.:	2015-550-001	Sample No.:	SS-4
Lab ID:	2015-550-001-012	Soil Color:	Brown



Particle Size	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
(mm)	(%)		(%)	(%)
		Gravel	11.33	**0.00**
2	88.67	*Sand*	74.82	**84.38**
0.05	13.85	*Silt*	10.36	**11.68**
0.002	3.49	*Clay*	3.49	**3.94**

USDA Classification: ***LOAMY SAND***

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	8.5-10.5
Project No.:	2015-550-001	Sample No.:	SS-4
Lab ID:	2015-550-001-012	Soil Color:	Brown

Moisture Content of Passing 3/4" Materia		Water Content of Retained 3/4" Material	
Tare No.	1434	Tare No.	NA
Weight of Tare & Wet Sample (g)	383.04	Weight of Tare & Wet Sample (g)	NA
Weight of Tare & Dry Sample (g)	359.56	Weight of Tare & Dry Sample (g)	NA
Weight of Tare (g)	145.00	Weight of Tare (g)	NA
Weight of Water (g)	23.48	Weight of Water (g)	NA
Weight of Dry Sample (g)	214.56	Weight of Dry Sample (g)	NA
Moisture Content (%)	**10.9**	**Moisture Content (%)**	**NA**

Wet Weight of -3/4" Sample (g)	NA	Weight of the Dry Sample (g)	214.56
Dry Weight of -3/4" Sample (g)	180.75	Weight of - #200 Material (g)	33.81
Wet Weight of +3/4" Sample (g)	NA	Weight of + #200 Material (g)	180.75
Dry Weight of +3/4" Sample (g)	0.00		
Total Dry Weight of Sample (g)	NA		

Sieve Size	Sieve Opening	Weight of Soil Retained	Percent Retained	Accumulated Percent Retained		Percent Finer	Accumulated Percent Finer
	(mm)	(g)	(%)	(%)		(%)	(%)
12"	300	0.00	0.00	0.00		100.00	**100.00**
6"	150	0.00	0.00	0.00		100.00	**100.00**
3"	75	0.00	0.00	0.00		100.00	**100.00**
2"	50	0.00	0.00	0.00		100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00		100.00	**100.00**
1"	25.0	0.00	0.00	0.00		100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00		100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00		100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00		100.00	**100.00**
#4	4.75	0.55	0.26	0.26		99.74	**99.74**
#10	2.00	23.76	11.07	11.33		88.67	**88.67**
#20	0.85	33.12	15.44	26.77		73.23	**73.23**
#40	0.425	47.20	22.00	48.76		51.24	**51.24**
#60	0.250	49.59	23.11	71.88		28.12	**28.12**
#140	0.106	21.40	9.97	81.85		18.15	**18.15**
#200	0.075	5.13	2.39	84.24		15.76	**15.76**
Pan	-	33.81	15.76	100.00		-	**-**

Tested By	HL	Date	10/29/15	Checked By	KC	Date	11/2/15

DCN: CT-S3A DATE: 3/18/13 REVISION: 11

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	8.5-10.5
Project No.:	2015-550-001	Sample No.:	SS-4
Lab ID:	2015-550-001-012	Soil Color:	Brown

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		19.0	23.1	5.97	13.0	75.7	0.01296	0.0333	**11.9**
5		17.0	23.1	5.97	11.0	64.1	0.01296	0.0213	**10.1**
15		14.5	23.1	5.97	8.5	49.6	0.01296	0.0125	**7.8**
30		13.0	23.1	5.97	7.0	40.9	0.01296	0.0089	**6.4**
60		12.5	22.4	6.22	6.3	36.5	0.01307	0.0064	**5.8**
250		11.0	22.6	6.15	4.9	28.2	0.01303	0.0031	**4.4**
1440		9.0	22.6	6.15	2.9	16.6	0.01303	0.0013	**2.6**

Soil Specimen Data		Other Corrections		
Tare No.	947			
Weight of Tare & Dry Material (g)	122.25	a - Factor	0.99	
Weight of Tare (g)	100.21			
Weight of Deflocculant (g)	5.0	Percent Finer than # 200	15.76	
Weight of Dry Material (g)	17.0			
		Specific Gravity	2.7	Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By	TO	Date	10/29/15	Checked By	KC	Date	11/2/15

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ATTERBERG LIMIT

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-4
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	8.5-10.5
Project No.:	2015-550-001	Sample No.:	SS-4
Lab ID:	2015-550-001-012	Visual:	BROWN SILT
			(MInus No. 40 sieve material, Airdried)

NON - PLASTIC MATERIAL

Tested By	*RAL*	*Date*	*10/23/15*	*Checked By*	*CLK*	*Date*	*10/26/15*

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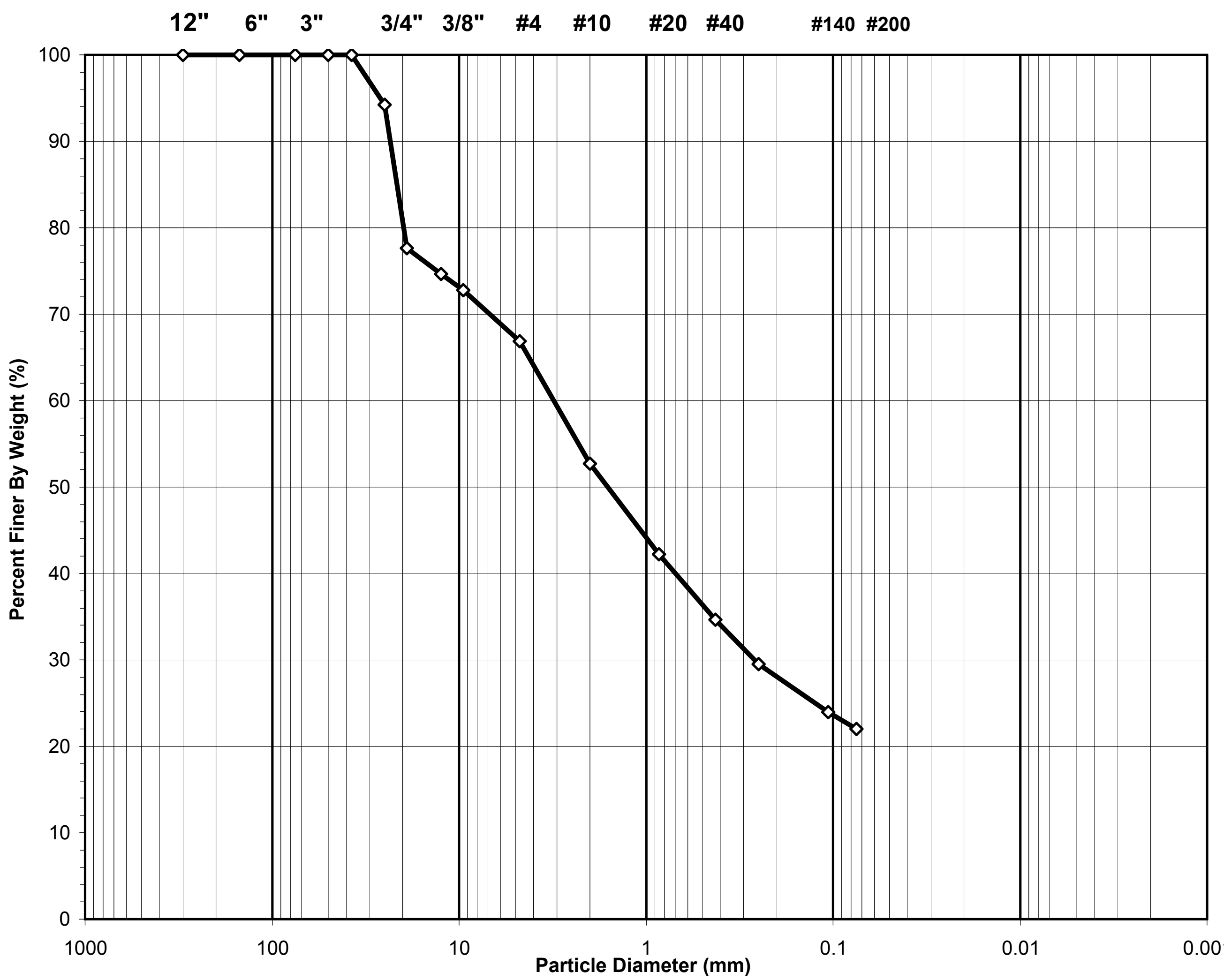
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2, B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	Composite
Project No.:	2015-550-001	Sample No.:	SS-1&2, SS-1
Lab ID:	2015-550-001-013	Soil Color:	Brown

USCS	*SIEVE ANALYSIS*		*HYDROMETER*
	gravel	sand	silt and clay



USCS Symbol:

SC, TESTED

USCS Classification:

CLAYEY SAND WITH GRAVEL

Tested By	HL	Date	10/27/15	Checked By	KC	Date	10/27/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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WASH SIEVE ANALYSIS
ASTM D 422-63 (2007)

Client:	AECOM	Boring No.:	B-2, B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	Composite
Project No.:	2015-550-001	Sample No.:	SS-1&2, SS-1
Lab ID:	2015-550-001-013	Soil Color:	Brown

Moisture Content of Passing 3/4" Sample		Water Content of Retained 3/4" Sample	
Tare No.:	1422	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	755.01	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	755.01	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	144.85	Weight of Tare (g):	NA
Weight of Water (g):	0.00	Weight of Water (g):	NA
Weight of Dry Sample (g):	610.16	Weight of Dry Sample (g):	NA
Moisture Content (%):	**0.0**	**Moisture Content (%):**	**NA**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	610.16
Dry Weight of - 3/4" Sample (g):	339.5	Weight of - #200 Material (g):	134.16
Wet Weight of +3/4" Sample (g):	NA	Weight of + #200 Material (g):	476.00
Dry Weight of + 3/4" Sample (g):	136.53		
Total Dry Weight of Sample (g):	NA		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	35.35	5.79	5.79	94.21	**94.21**
3/4"	19.0	101.18	16.58	22.38	77.62	**77.62**
1/2"	12.50	17.99	2.95	25.32	74.68	**74.68**
3/8"	9.50	11.38	1.87	27.19	72.81	**72.81**
#4	4.75	36.22	5.94	33.13	66.87	**66.87**
#10	2.00	86.57	14.19	47.31	52.69	**52.69**
#20	0.850	64.02	10.49	57.81	42.19	**42.19**
#40	0.425	46.10	7.56	65.36	34.64	**34.64**
#60	0.250	31.34	5.14	70.50	29.50	**29.50**
#140	0.106	33.83	5.54	76.04	23.96	**23.96**
#200	0.075	12.02	1.97	78.01	21.99	**21.99**
Pan	-	134.16	21.99	100.00	-	**-**

Tested By HL Date 10/27/15 Checked By KC Date 10/27/15

 DCN: CT-S3C DATE 3/20/13 REVISION: 3

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ATTERBERG LIMITS

ASTM D 4318-10

Client:	AECOM	Boring No.:	B-2, B-3
Client Reference:	Sippo Crk. Dam Reservoir 60439145	Depth (ft):	Composite
Project No.:	2015-550-001	Sample No.:	SS-1&2, SS-1
Lab ID:	2015-550-001-013	Soil Description:	BROWN LEAN CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description . (Minus No. 40 sieve material, Airdried)

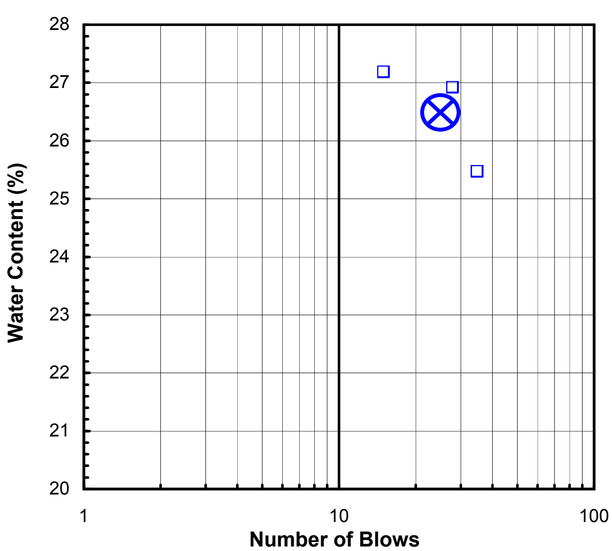
Liquid Limit Test	**1**	**2**	**3**	**MULTIPOINT**
Tare Number:	245	1253	157	
Wt. of Tare & Wet Sample (g):	37.75	41.73	37.69	
Wt. of Tare & Dry Sample (g):	33.38	37.33	33.59	
Weight of Tare (g):	17.30	20.98	17.49	
Weight of Water (g):	4.4	4.4	4.1	
Weight of Dry Sample (g):	16.1	16.4	16.1	
Moisture Content (%):	**27.2**	**26.9**	**25.5**	
Number of Blows:	**15**	**28**	**35**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number:	335	1274	
Wt. of Tare & Wet Sample (g):	25.94	29.63	
Wt. of Tare & Dry Sample (g):	25.12	28.77	
Weight of Tare (g):	19.71	23.28	
Weight of Water (g):	0.8	0.9	
Weight of Dry Sample (g):	5.4	5.5	
Moisture Content (%):	**15.2**	**15.7**	**-0.5**

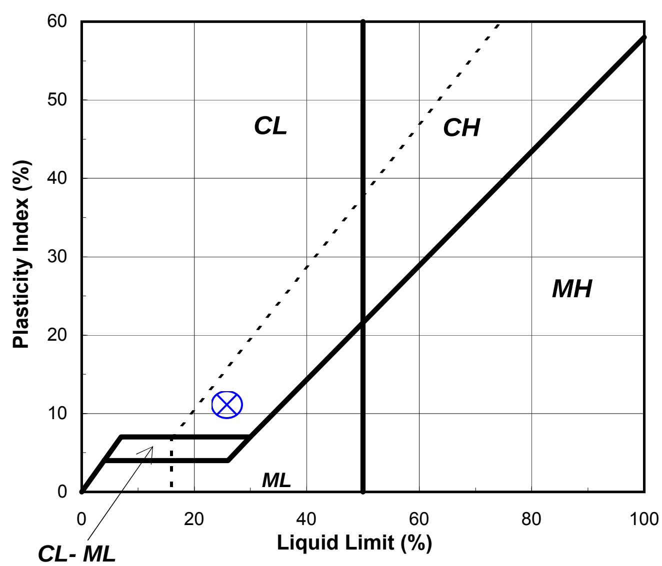
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%):	**26**
Plastic Limit (%):	**15**
Plasticity Index (%):	**11**
USCS Symbol:	**CL**

Flow Curve



Plasticity Chart



Tested By	*RAL*	*Date*	*10/23/15*	*Checked By*	*CLK*	*Date*	10/26/15

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544 Braddock Avenue • East Pittsburgh, PA 15112 • Phone (412) 823-7600 • Fax (412) 823-8999 • www.geotechnics.net

USGS Design Maps Detailed Report

ASCE 7-10 Standard (40.80403°N, 81.5076°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1]	S_S = 0.128 g
From Figure 22-2 [2]	S_1 = 0.055 g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_S$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.128 g, F_a = 1.600

Table 11.4–2: Site Coefficient F_V

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.055 g, F_V = 2.400

Equation (11.4–1): $S_{MS} = F_a S_S = 1.600 \times 0.128 = 0.204$ g

---

Equation (11.4–2): $S_{M1} = F_v S_1 = 2.400 \times 0.055 = 0.132$ g

---

Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4–3): $S_{DS} = ⅔ S_{MS} = ⅔ \times 0.204 = 0.136$ g

---

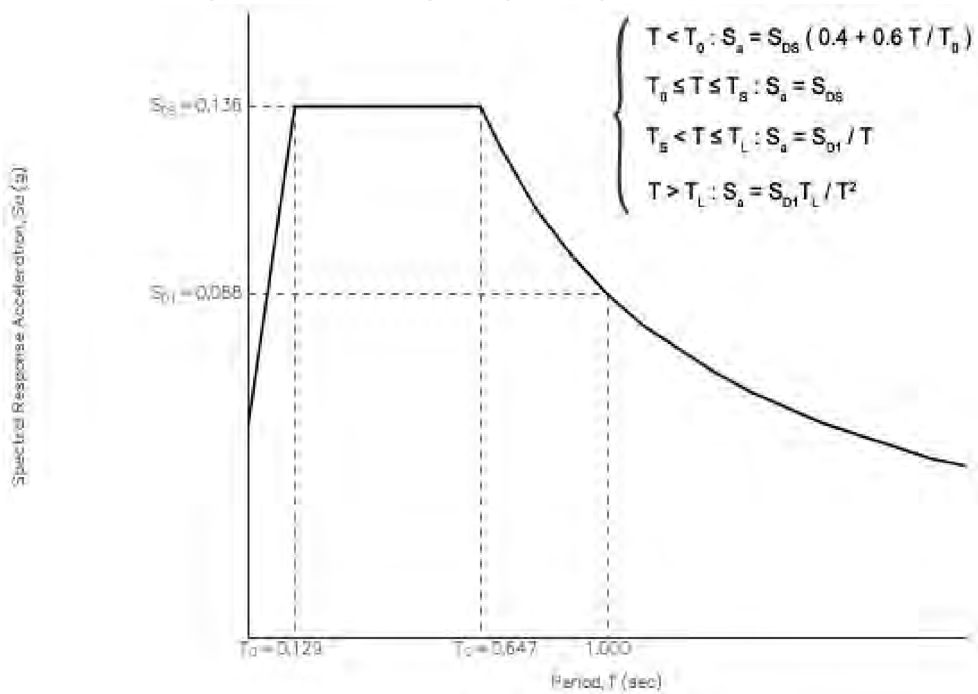
Equation (11.4–4): $S_{D1} = ⅔ S_{M1} = ⅔ \times 0.132 = 0.088$ g

---

Section 11.4.5 — Design Response Spectrum

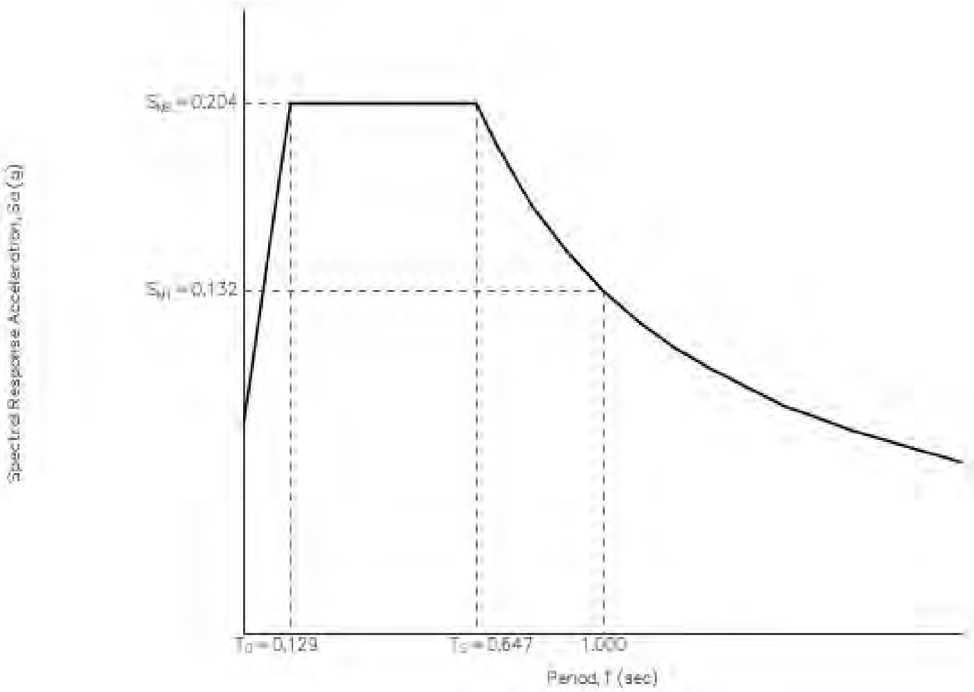
From Figure 22-12 [3] $T_L = 12$ seconds

Figure 11.4–1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.063

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.600 \times 0.063 = 0.101$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.063 g, F_{PGA} = 1.600

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] C_{RS} = 0.898

From Figure 22-18 [6] C_{R1} = 0.919

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.136 g, Seismic Design Category = A

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.088 g, Seismic Design Category = B

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = B

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

USGS Design Maps Summary Report

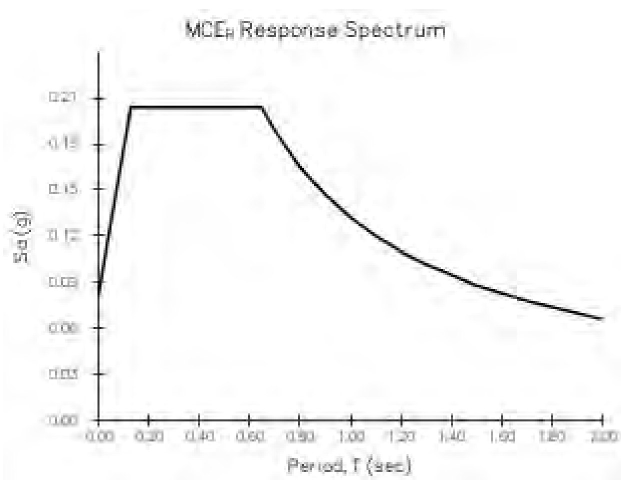
User–Specified Input

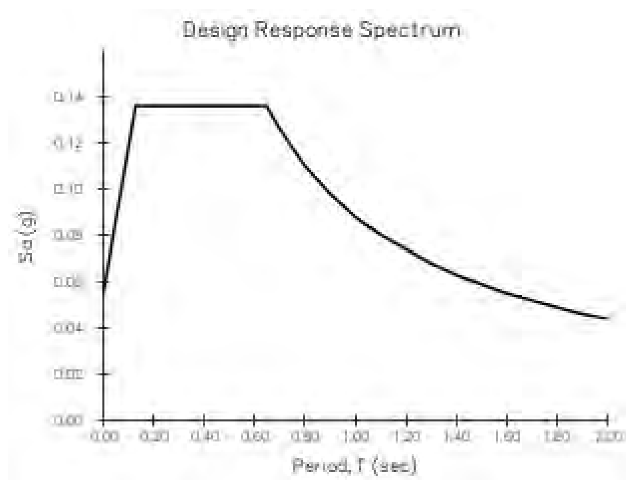
Report Title	Sippo Creek Thu June 1, 2017 16:35:20 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	40.80403°N, 81.5076°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S =	0.128 g	S_{MS} =	0.204 g	S_{DS} =	0.136 g
S_1 =	0.055 g	S_{M1} =	0.132 g	S_{D1} =	0.088 g

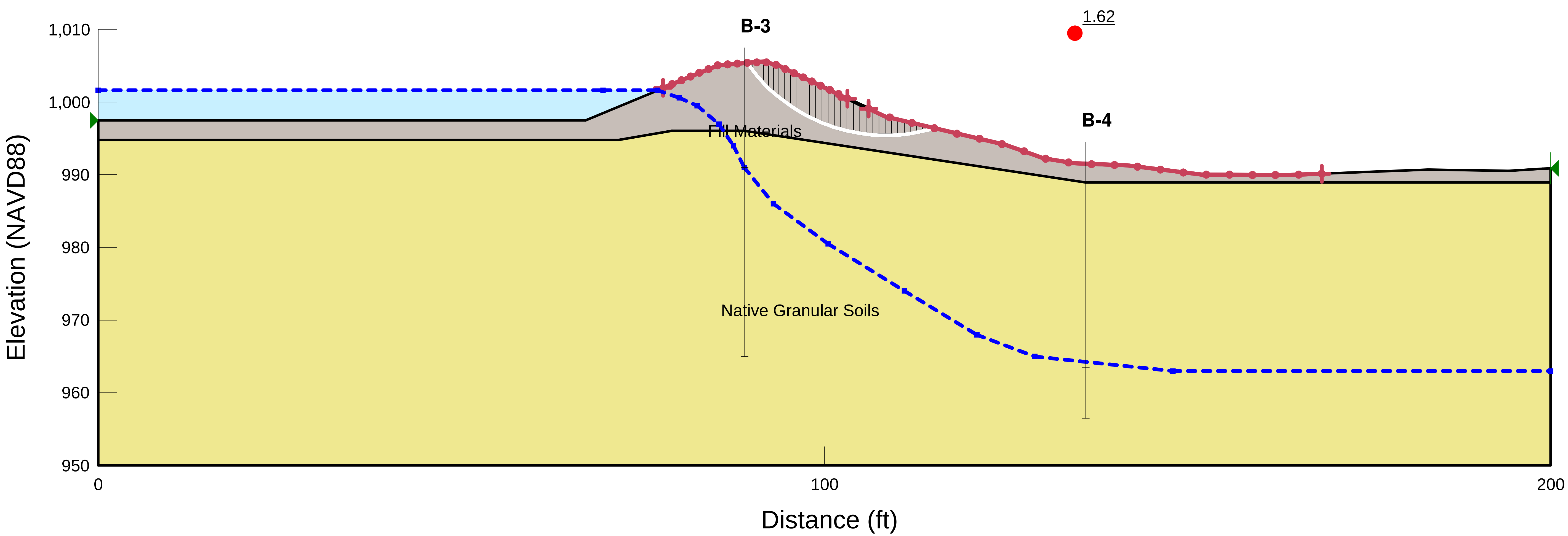
For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: A-A' (EXISTING CONDITIONS)
ANALYSIS: 1_Static, Steady State, Downstream

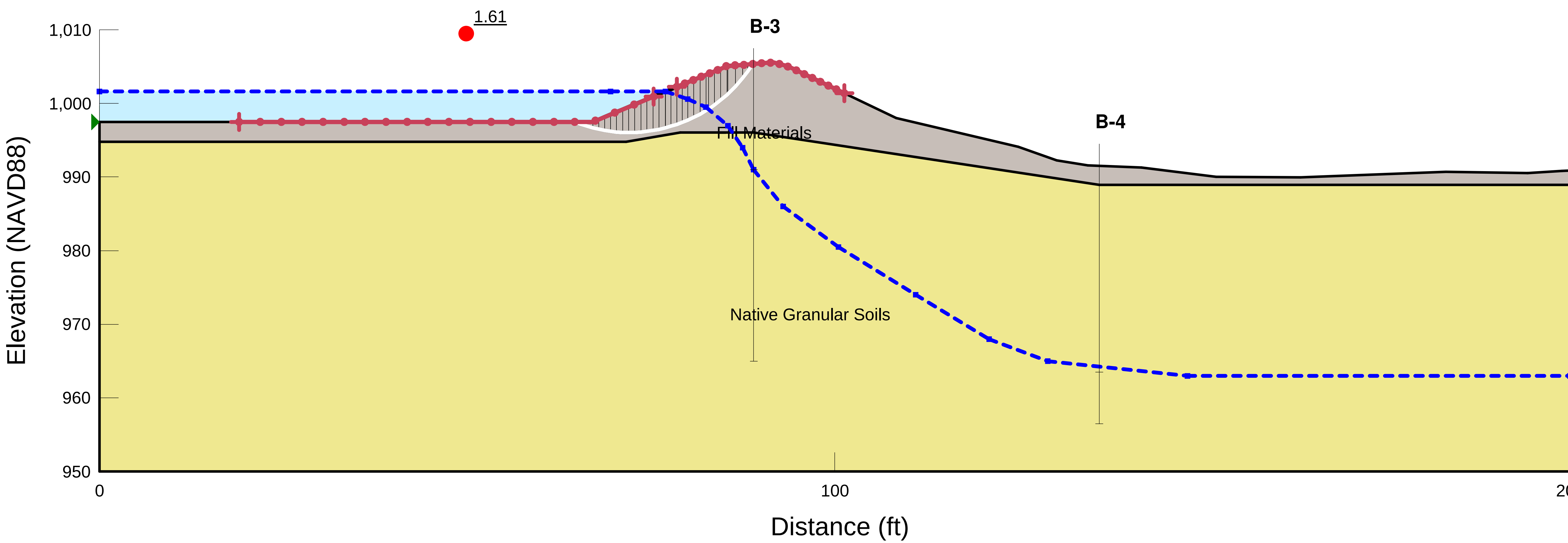


Material Properties

Name: Fill Materials
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 29 °

Name: Native Granular Soils
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 30 °

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: A-A' (EXISTING CONDITIONS)
ANALYSIS: 2_Static, Steady State, Upstream

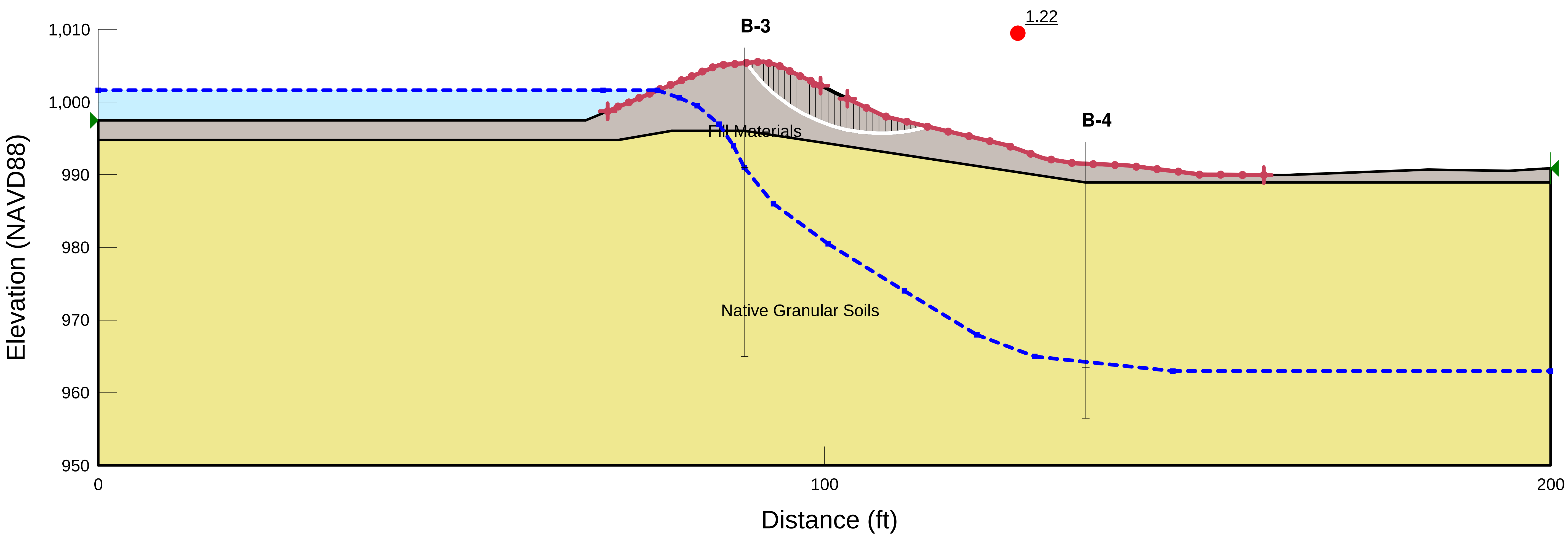


Material Properties

Name: Fill Materials
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 29 °

Name: Native Granular Soils
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 30 °

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: A-A' (EXISTING CONDITIONS)
ANALYSIS: 3_Seismic (Pseudostatic) Condition, Downstream

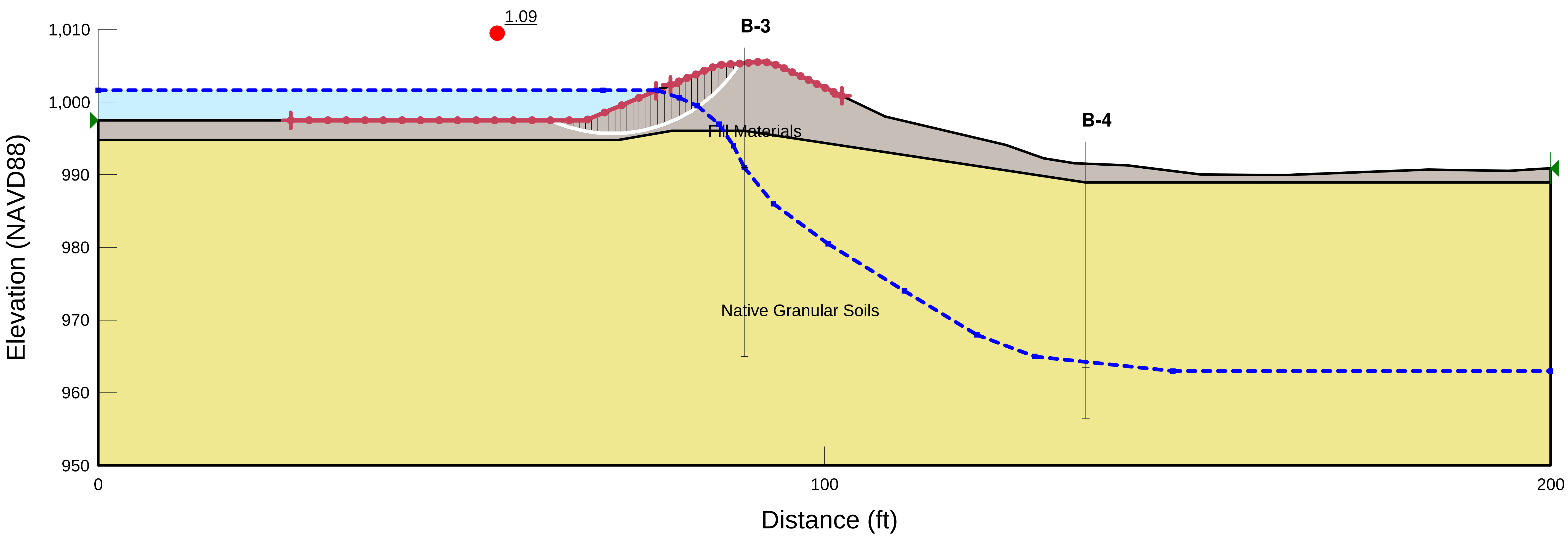


Material Properties

Name: Fill Materials
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 29 °

Name: Native Granular Soils
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 30 °

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: A-A' (EXISTING CONDITIONS)
ANALYSIS: 4_Seismic (Pseudostatic) Condition, Upstream

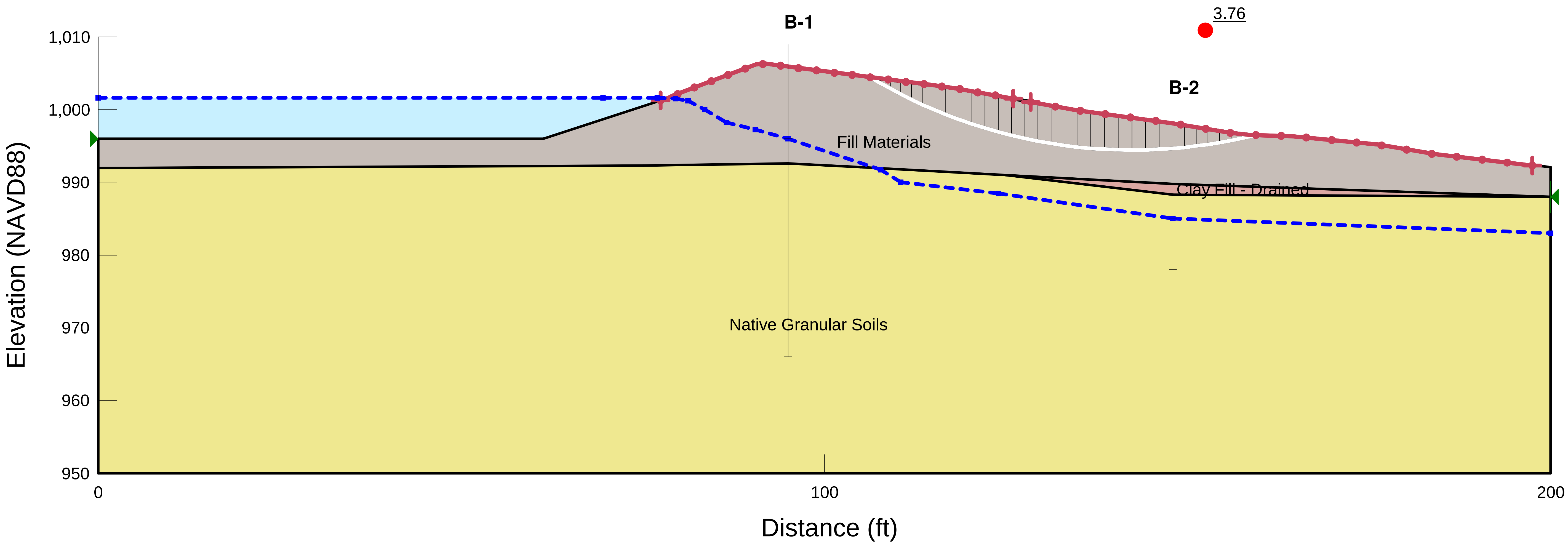


Material Properties

Name: Fill Materials
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 29 °

Name: Native Granular Soils
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 30 °

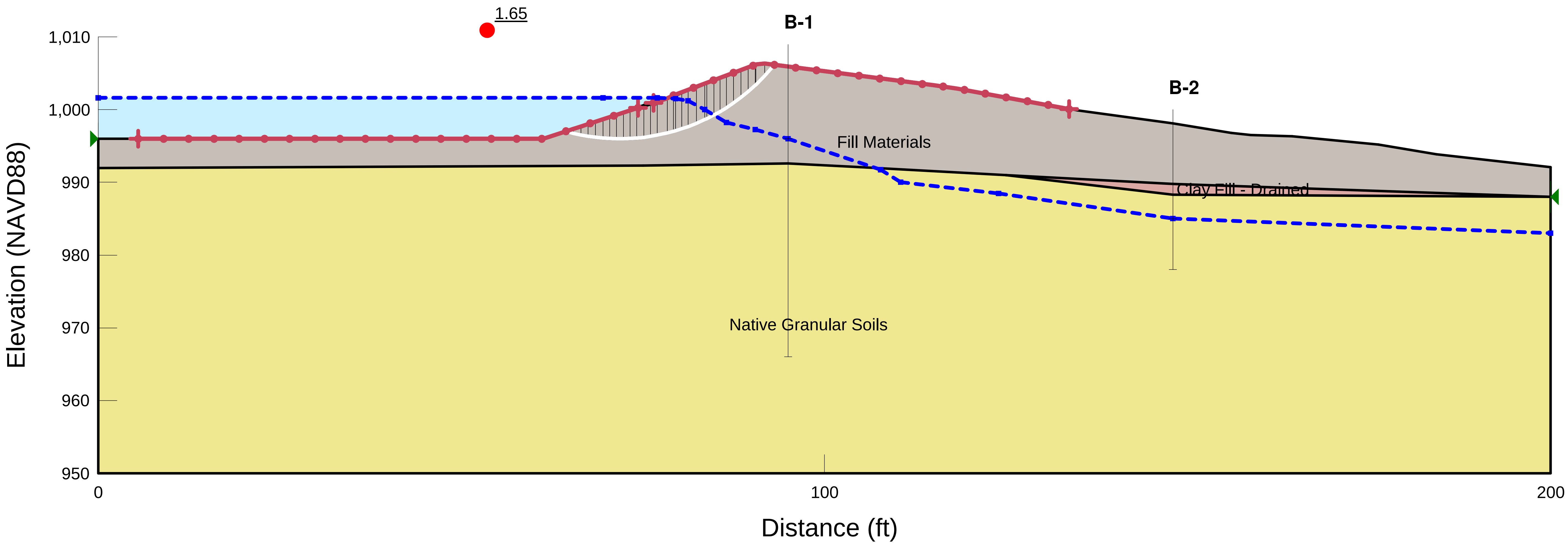
PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: B-B' (EXISTING CONDITIONS)
ANALYSIS: 1_Static, Steady State, Downstream



Material Properties

Name: Fill Materials **Model: Mohr-Coulomb** **Unit Weight: 115 pcf** **Cohesion': 0 psf** **Phi': 29 °**	**Name: Native Granular Soils** **Model: Mohr-Coulomb** **Unit Weight: 117 pcf** **Cohesion': 0 psf** **Phi': 30 °**	**Name: Clay Fill - Drained** **Model: Mohr-Coulomb** **Unit Weight: 125 pcf** **Cohesion': 100 psf** **Phi': 29 °**

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: B-B' (EXISTING CONDITIONS)
ANALYSIS: 2_Static, Steady State, Upstream



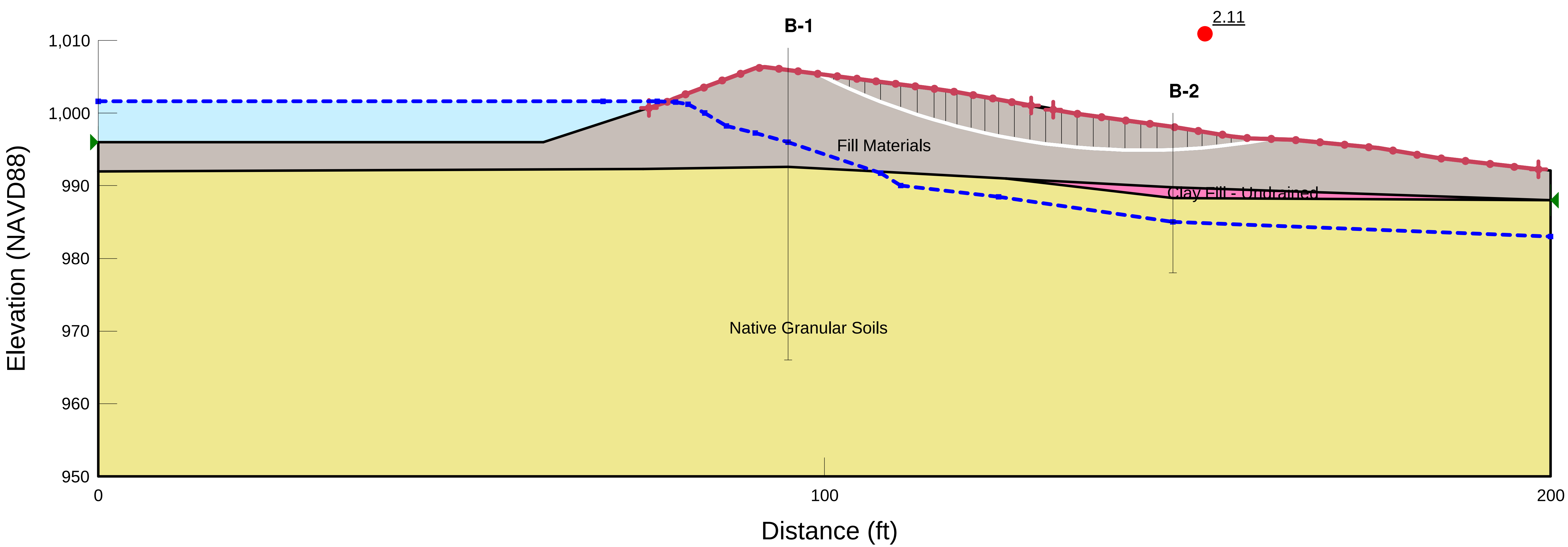
Material Properties

Name: Fill Materials
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 29 °

Name: Native Granular Soils
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Clay Fill - Drained
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 29 °

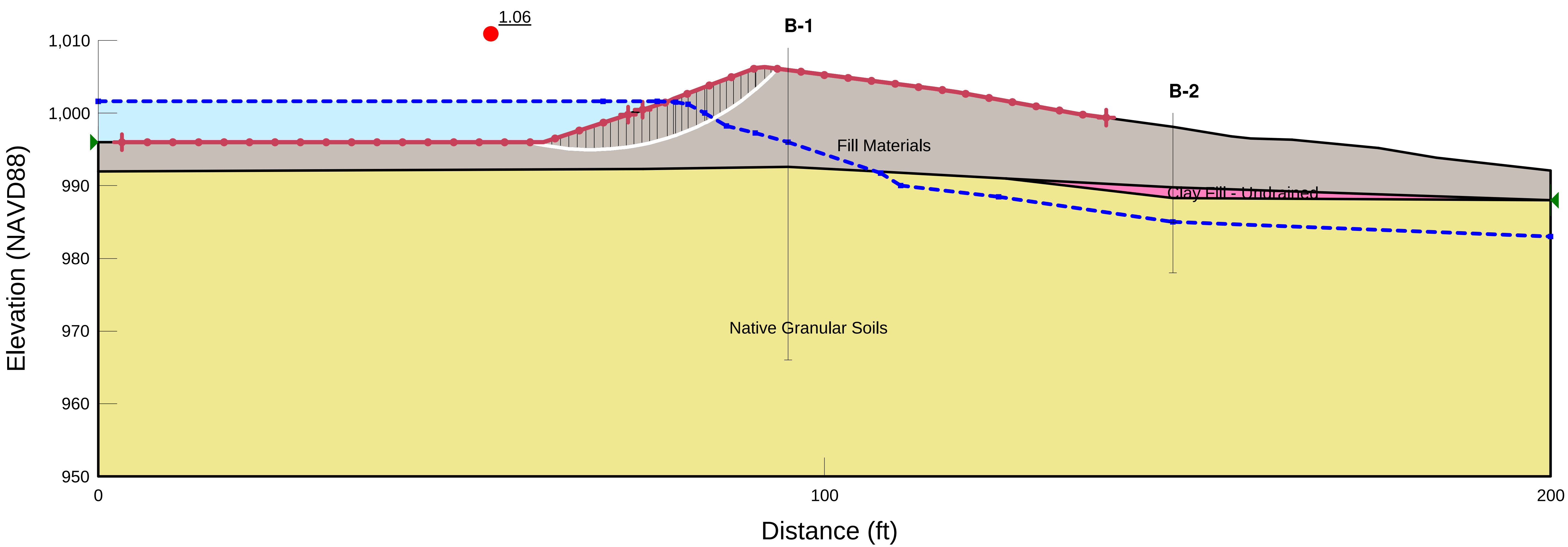
PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: B-B' (EXISTING CONDITIONS)
ANALYSIS: 3_Seismic (Pseudostatic) Condition, Downstream



Material Properties

Name: Fill Materials	Name: Native Granular Soils	Name: Clay Fill - Undrained
Model: Mohr-Coulomb	Model: Mohr-Coulomb	Model: Mohr-Coulomb
Unit Weight: 115 pcf	Unit Weight: 117 pcf	Unit Weight: 125 pcf
Cohesion': 0 psf	Cohesion': 0 psf	Cohesion': 300 psf
Phi': 29 °	Phi': 30 °	Phi': 15 °

PROJECT: SIPPO CREEK RESERVIOR
CLIENT: CITY OF MASSILLON
PROJECT LOCATION: MASSILLON, OHIO
AECOM PROJECT NO. : 60439145
CROSS SECTION: B-B' (EXISTING CONDITIONS)
ANALYSIS: 4_Seismic (Pseudostatic) Condition, Upstream



Material Properties

Name: Fill Materials	**Name: Native Granular Soils**	**Name: Clay Fill - Undrained**
Model: Mohr-Coulomb	**Model: Mohr-Coulomb**	**Model: Mohr-Coulomb**
Unit Weight: 115 pcf	**Unit Weight: 117 pcf**	**Unit Weight: 125 pcf**
Cohesion': 0 psf	**Cohesion': 0 psf**	**Cohesion': 300 psf**
Phi': 29 °	**Phi': 30 °**	**Phi': 15 °**

Appendix B Hydrologic and Hydraulic (H&H) Engineering

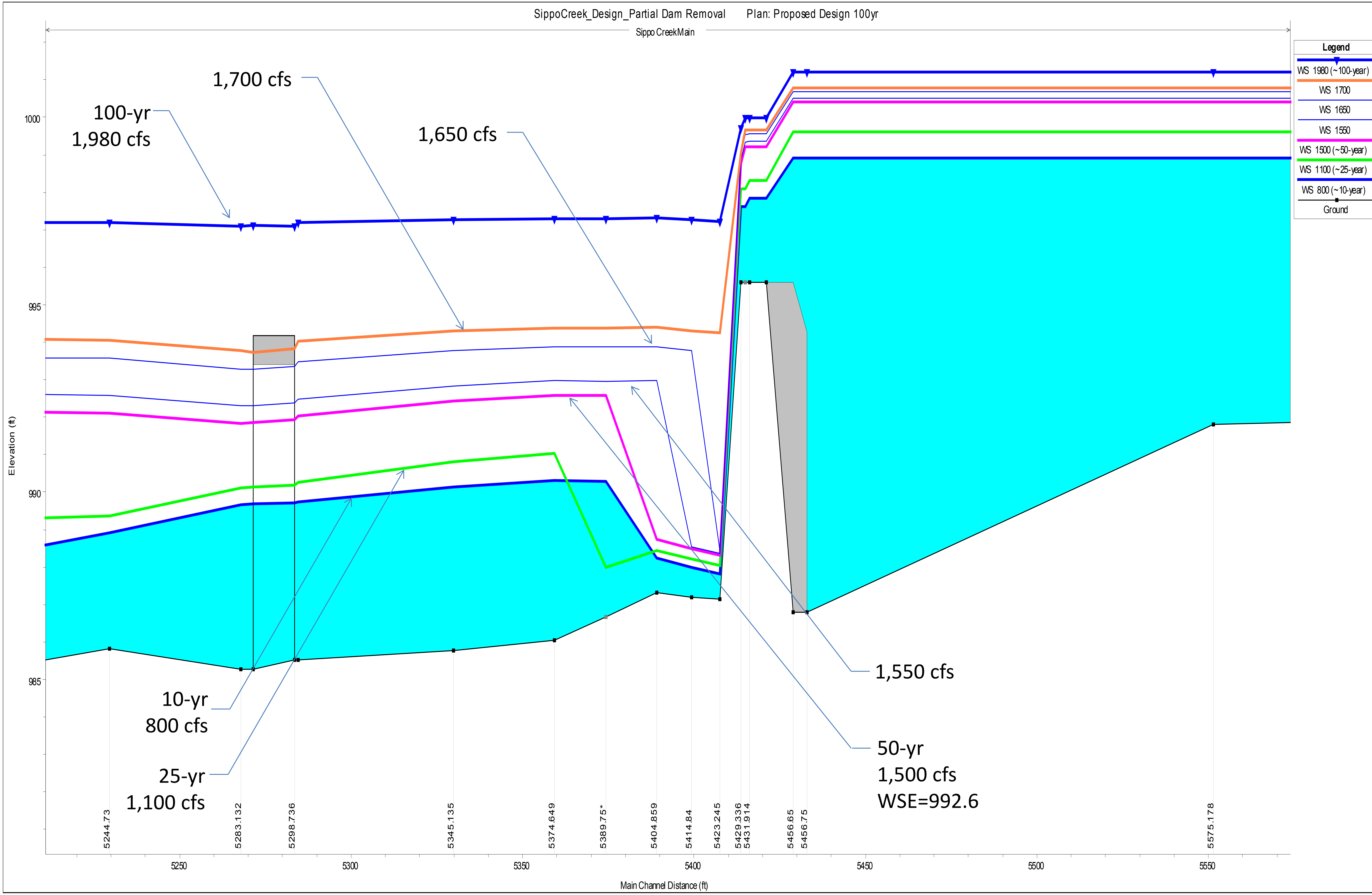
B.1 HydroCAD Modeling

B.2 HEC-RAS Modeling

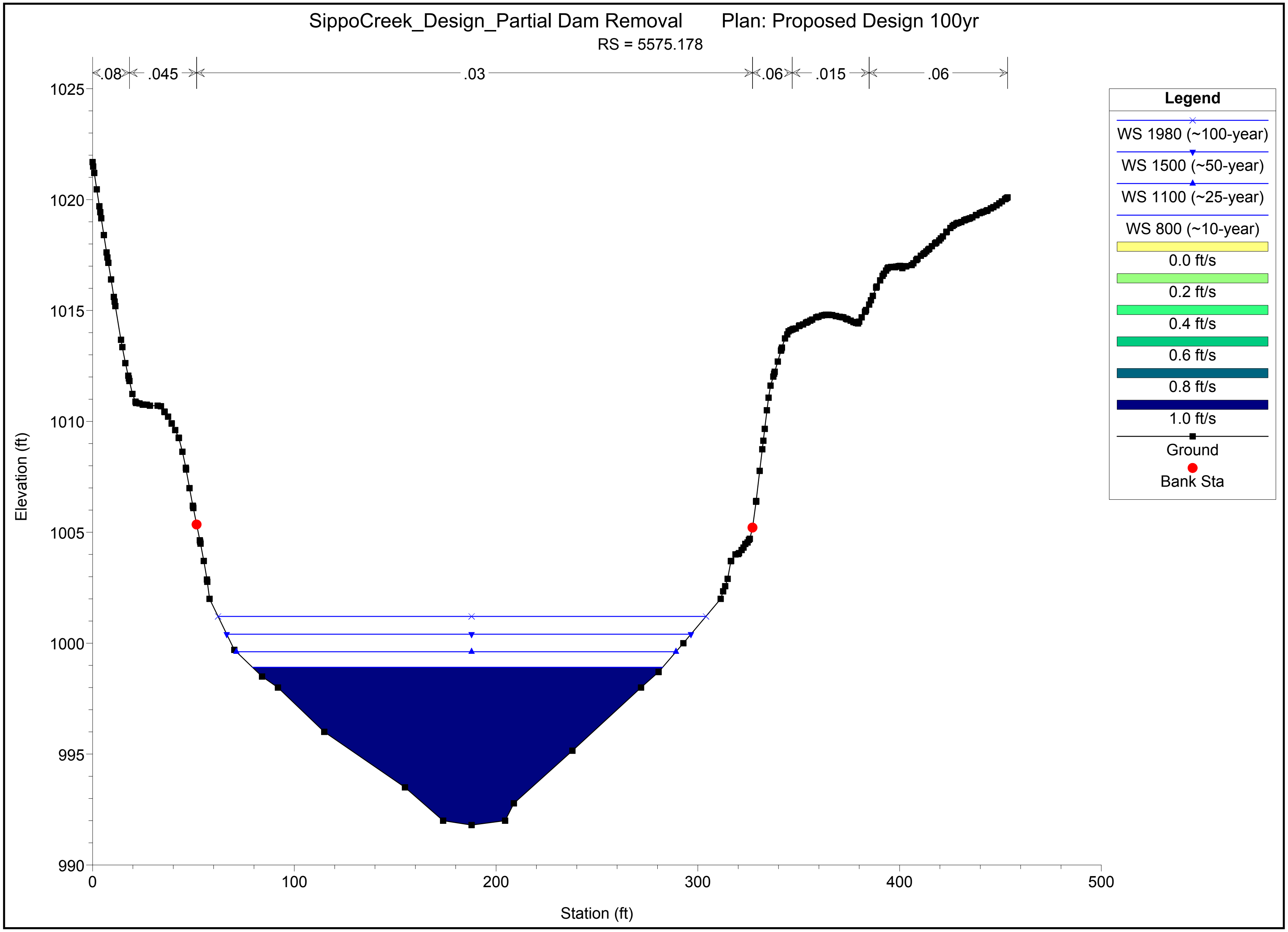
B.3 Grouted Riprap Outlet Channel Design

B.4 TRM Design

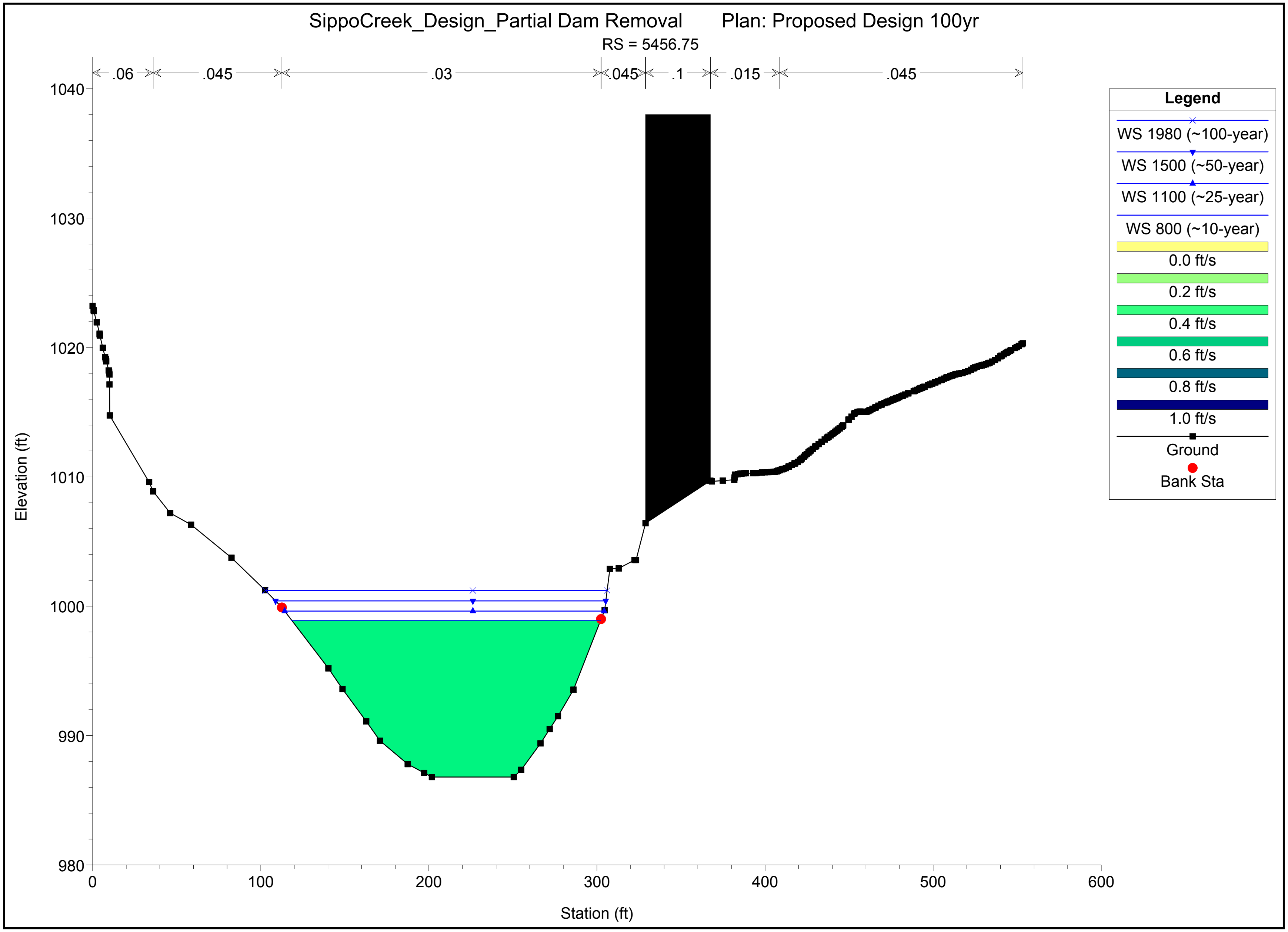

5575.178
5456.75
5431.914
5430.63*
5429.336
5299.836
5244.73
5141.343
4981.155
4930.635

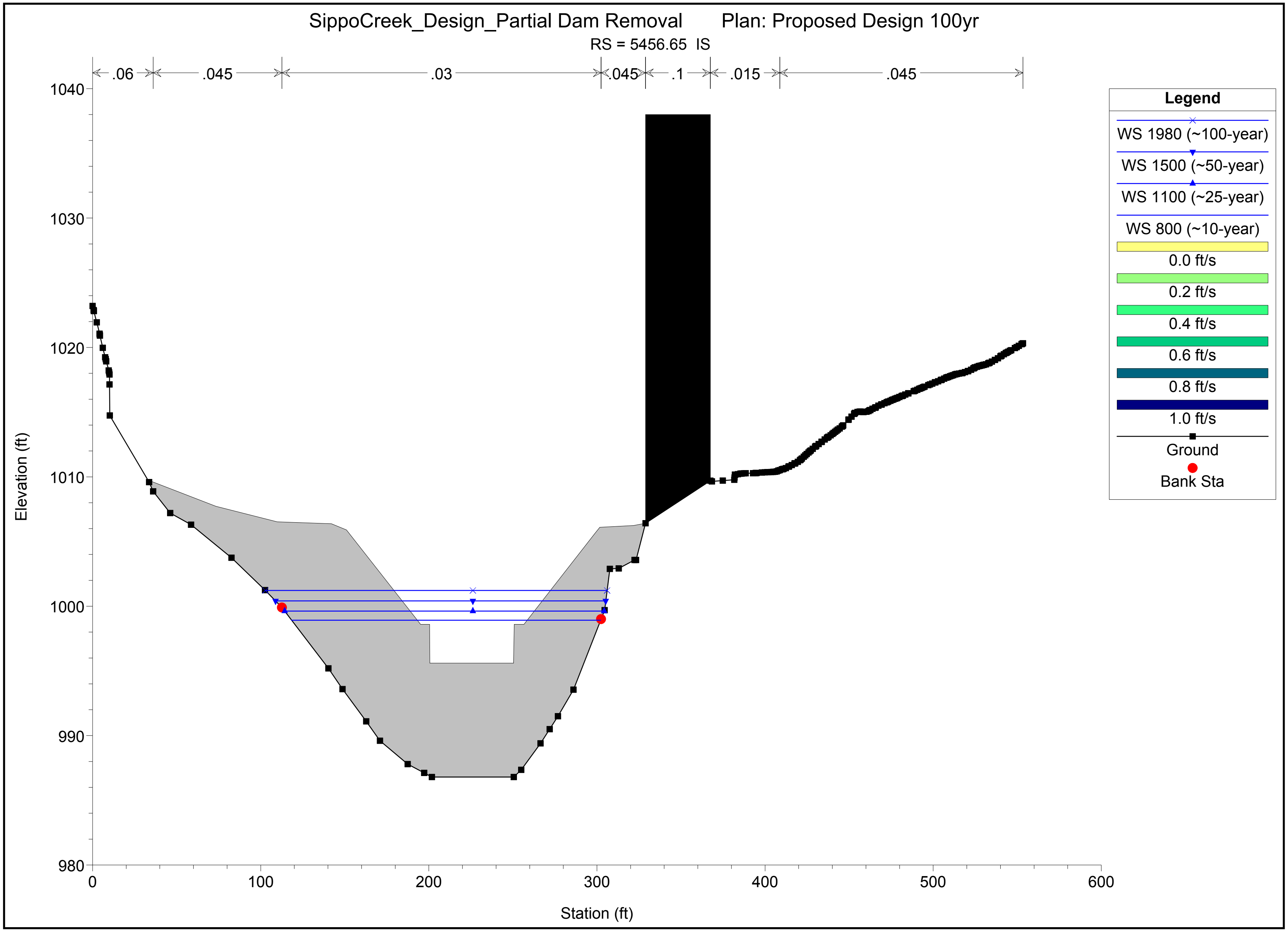


SippoCreek_Design_Partial Dam Removal   Plan: Proposed Design 100yr
Sippo CreekMain
Legend
WS 1980 (~100-year)
WS 1700
WS 1650
WS 1550
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
Ground
100-yr
1,980 cfs
1,700 cfs
1,650 cfs
1,550 cfs
50-yr
1,500 cfs
WSE=992.6
10-yr
800 cfs
25-yr
1,100 cfs
Elevation (ft)
1000
995
990
985
5244.73
5283.132
5298.736
5345.135
5374.649
5389.75*
5404.859
5414.84
5423.245
5429.336
5431.914
5456.65
5456.75
5575.178
5250
5300
5350
5400
5450
5500
5550
Main Channel Distance (ft)

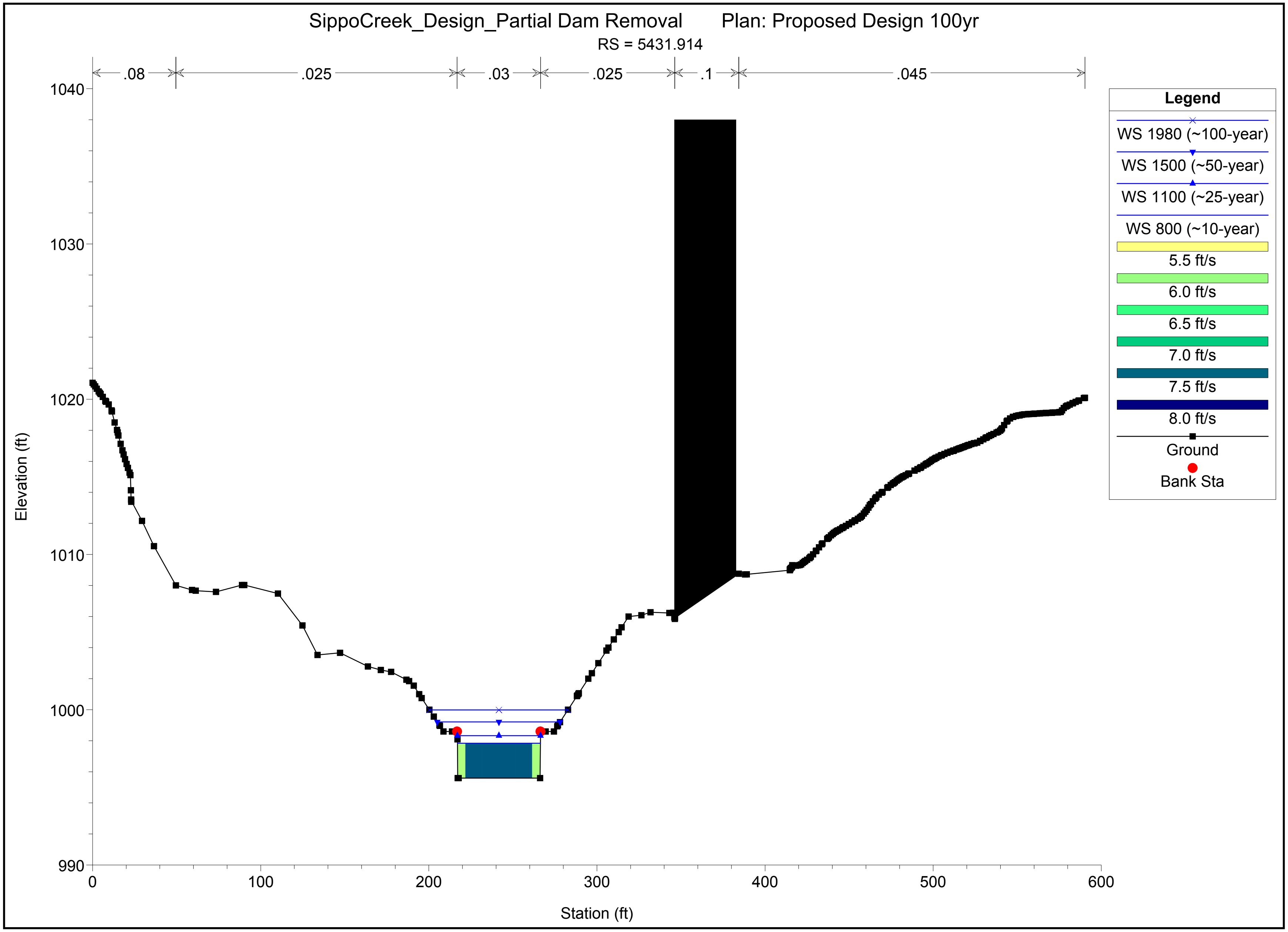


SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5575.178
.08
.045
.03
.06
.015
.06
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
0
100
200
300
400
500
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta

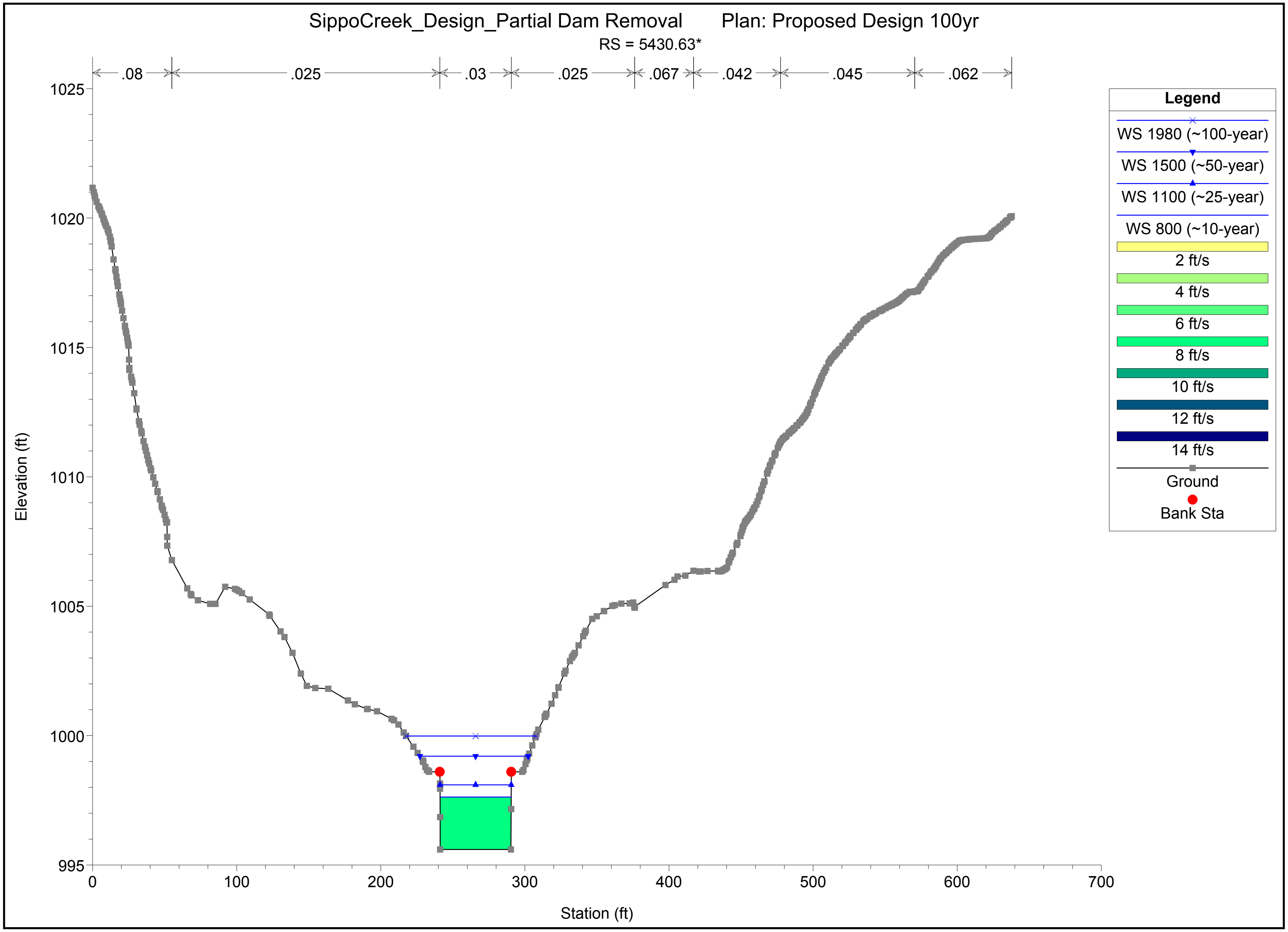

SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5456.75
.06
.045
.03
.045
.1
.015
.045
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta
Elevation (ft)
1040
1030
1020
1010
1000
990
980
0
100
200
300
400
500
600
Station (ft)

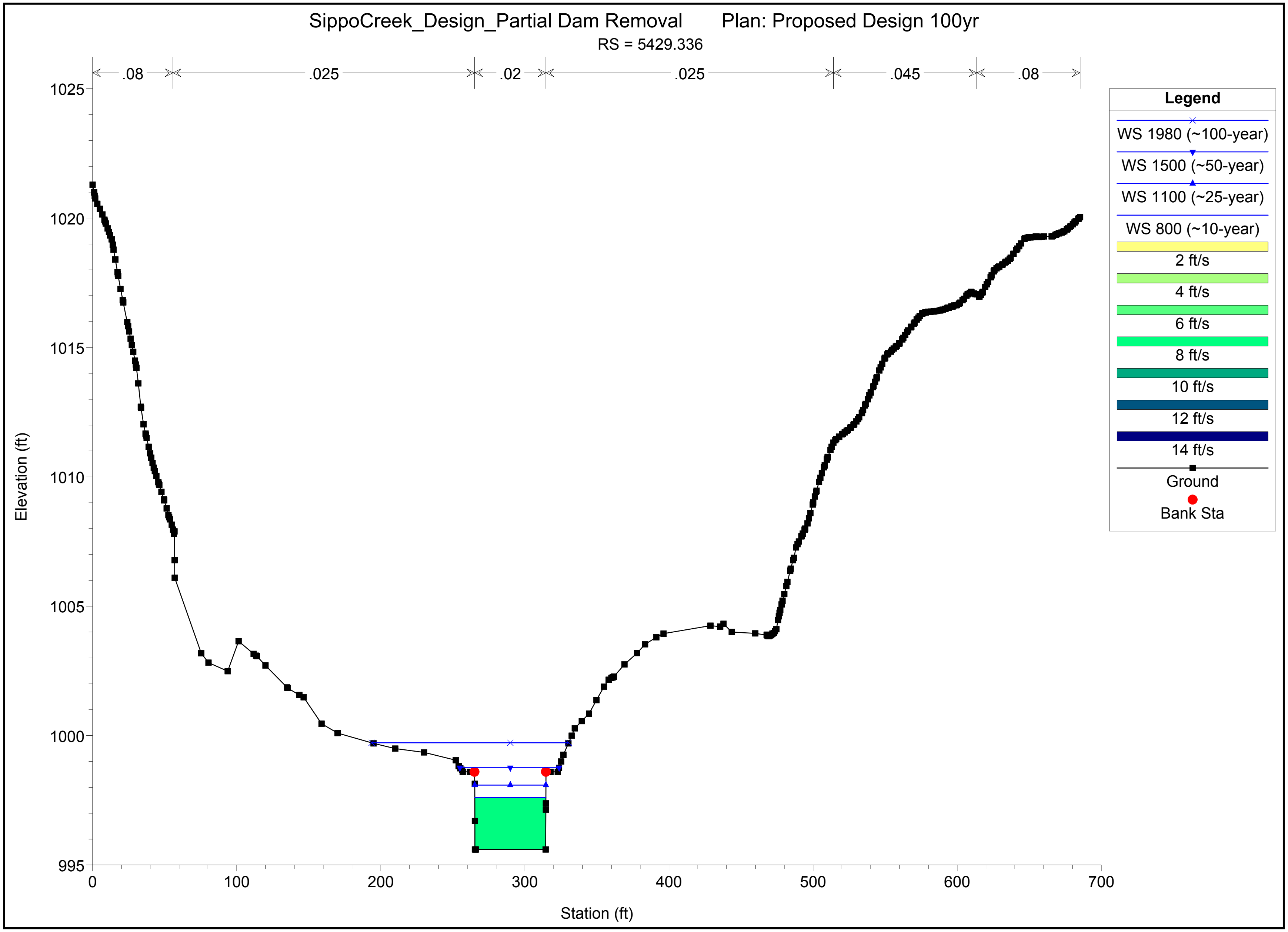


SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5456.65 IS
.06
.045
.03
.045
.1
.015
.045
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta
Elevation (ft)
1040
1030
1020
1010
1000
990
980
0
100
200
300
400
500
600
Station (ft)

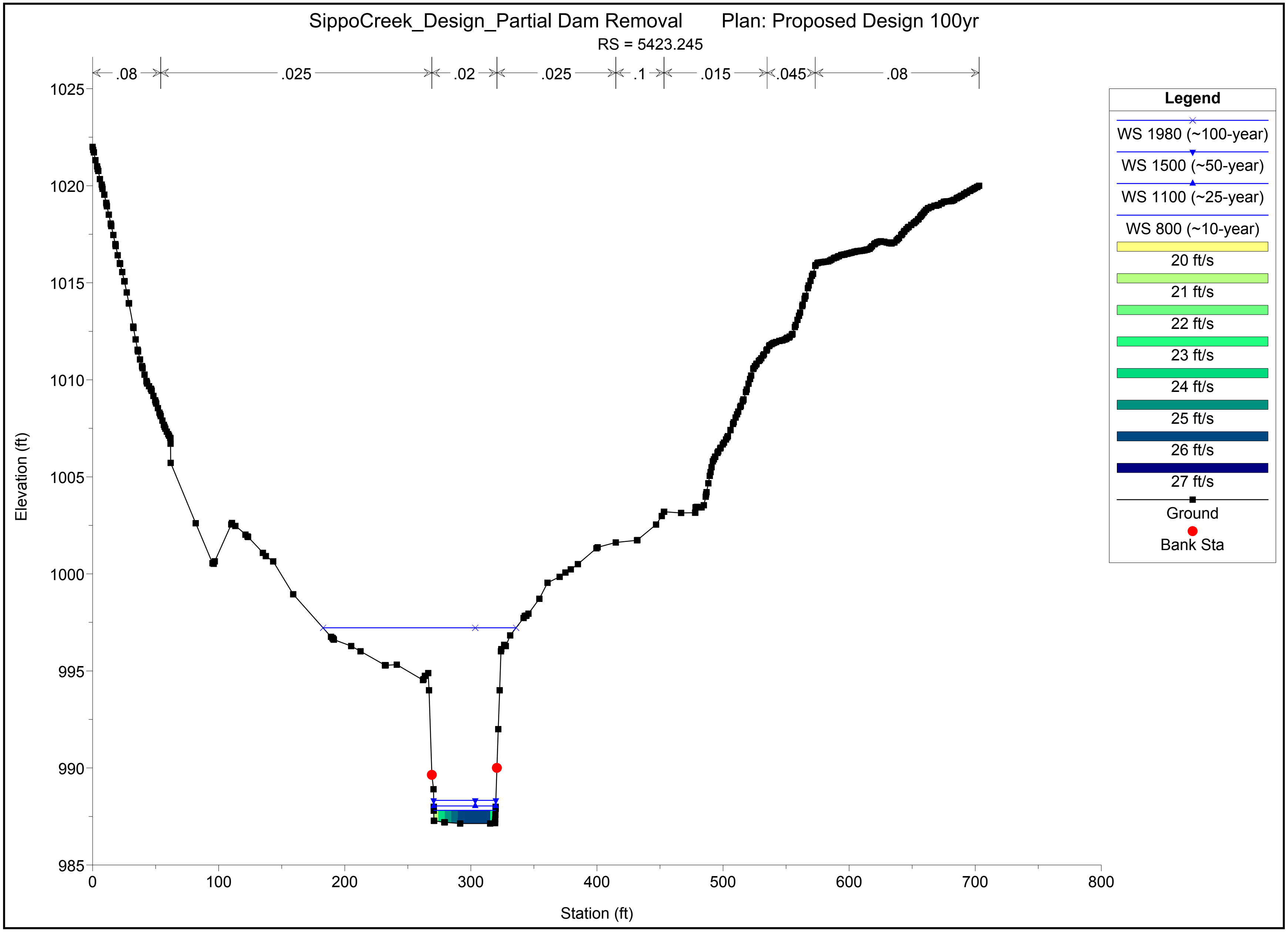


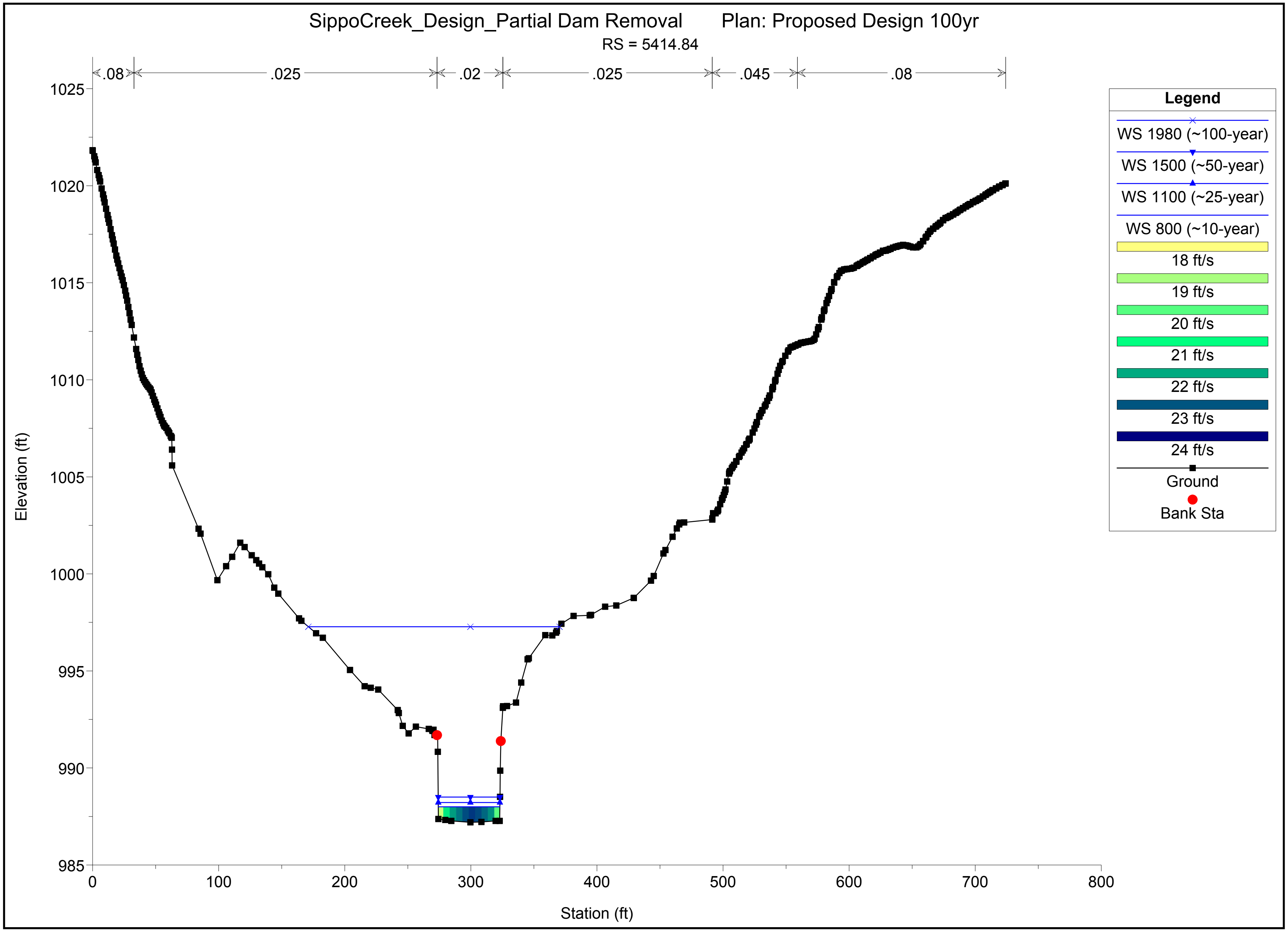
SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5431.914
.08
.025
.03
.025
.1
.045
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
5.5 ft/s
6.0 ft/s
6.5 ft/s
7.0 ft/s
7.5 ft/s
8.0 ft/s
Ground
Bank Sta
Elevation (ft)
1040
1030
1020
1010
1000
990
0
100
200
300
400
500
600
Station (ft)


SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5430.63*
.08
.025
.03
.025
.067
.042
.045
.062
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
0
100
200
300
400
500
600
700
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta

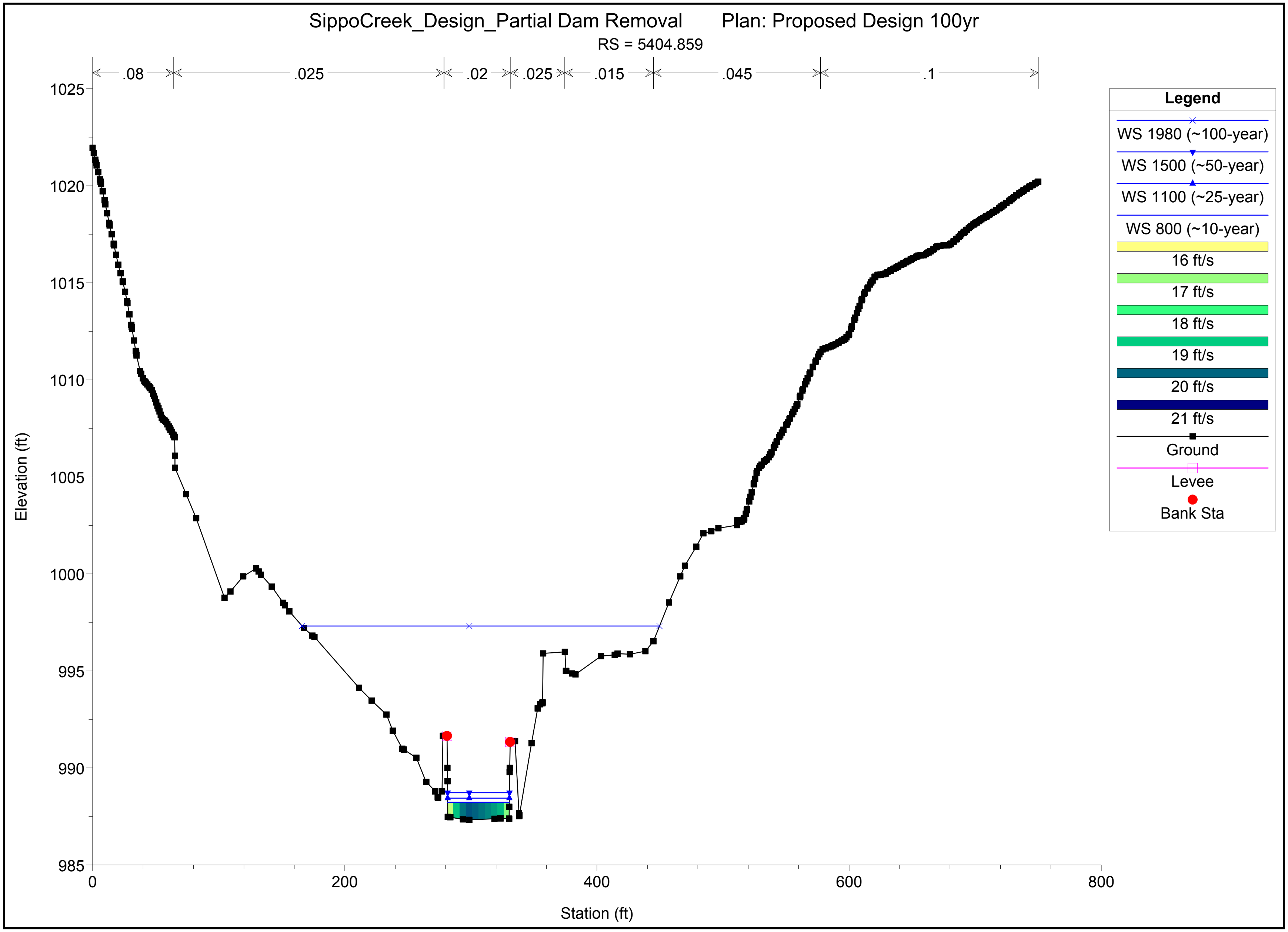


SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5429.336
.08
.025
.02
.025
.045
.08
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta
Elevation (ft)
1025
1020
1015
1010
1005
1000
995
0
100
200
300
400
500
600
700
Station (ft)

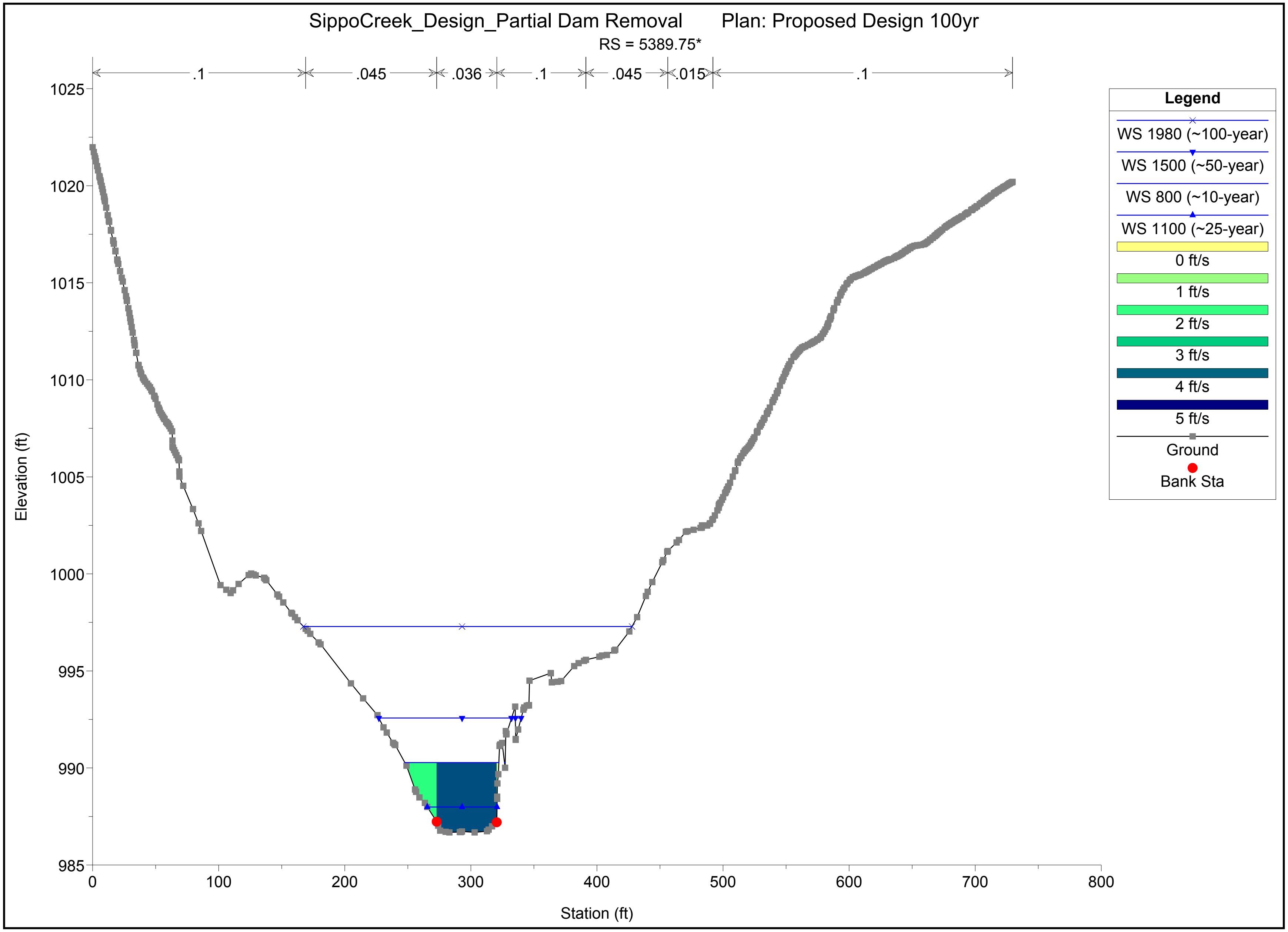

SippoCreek_Design_Partial Dam Removal   Plan: Proposed Design 100yr
RS = 5423.245
.08
.025
.02
.025
.1
.015
.045
.08
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
20 ft/s
21 ft/s
22 ft/s
23 ft/s
24 ft/s
25 ft/s
26 ft/s
27 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
800



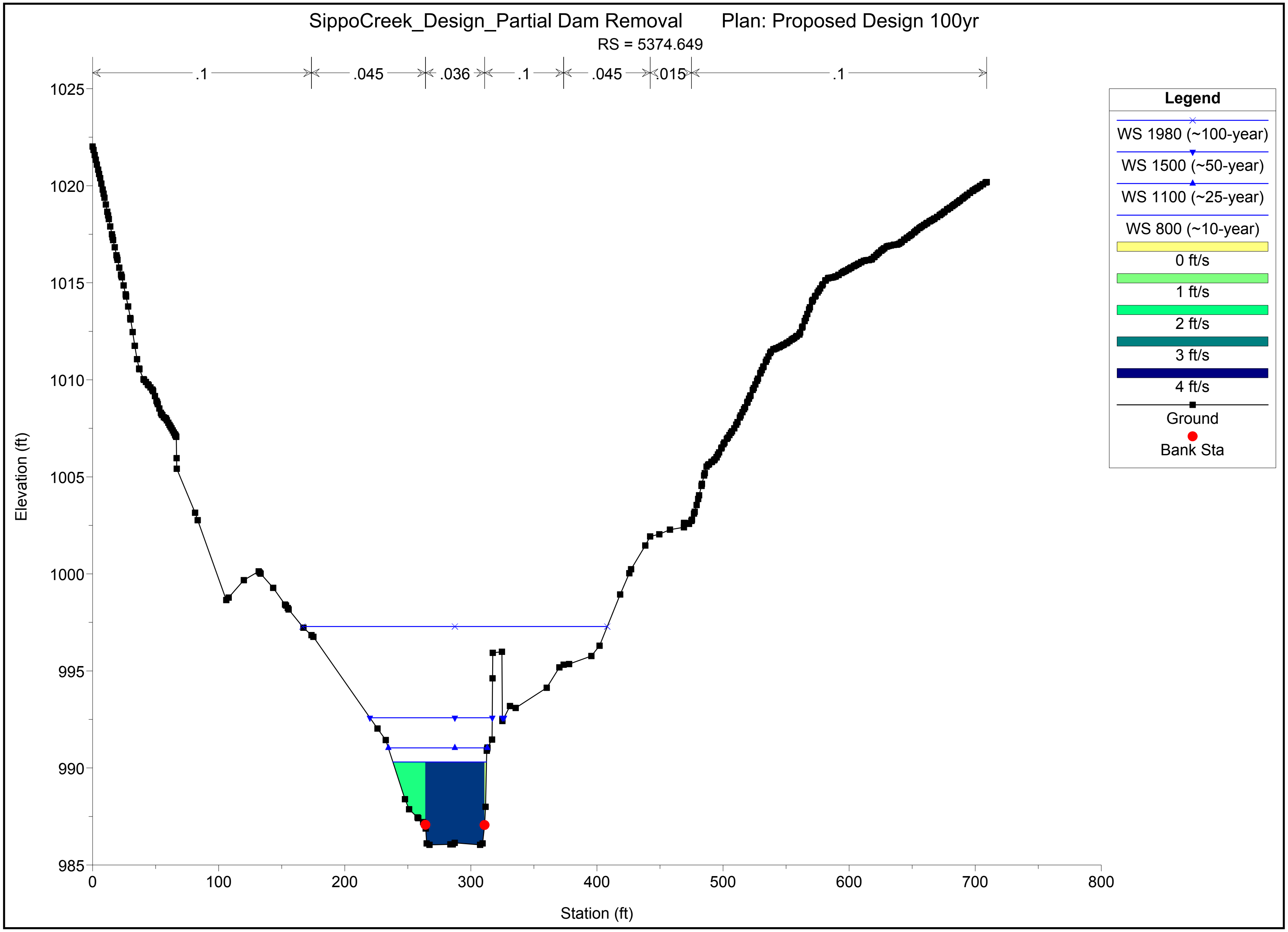
SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5414.84
.08
.025
.02
.025
.045
.08
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
18 ft/s
19 ft/s
20 ft/s
21 ft/s
22 ft/s
23 ft/s
24 ft/s
Ground
Bank Sta
Elevation (ft)
985
990
995
1000
1005
1010
1015
1020
1025
0
100
200
300
400
500
600
700
800
Station (ft)

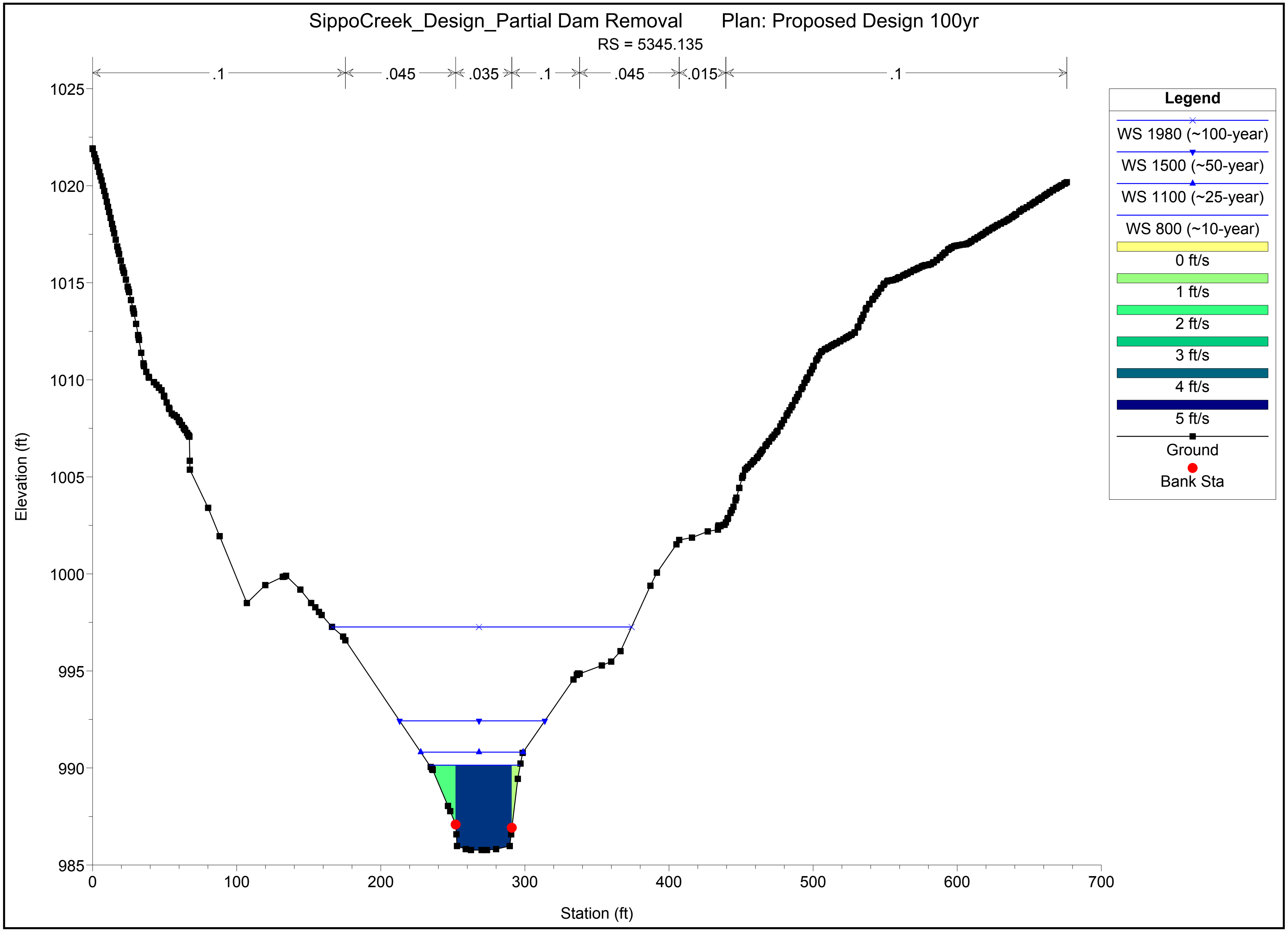


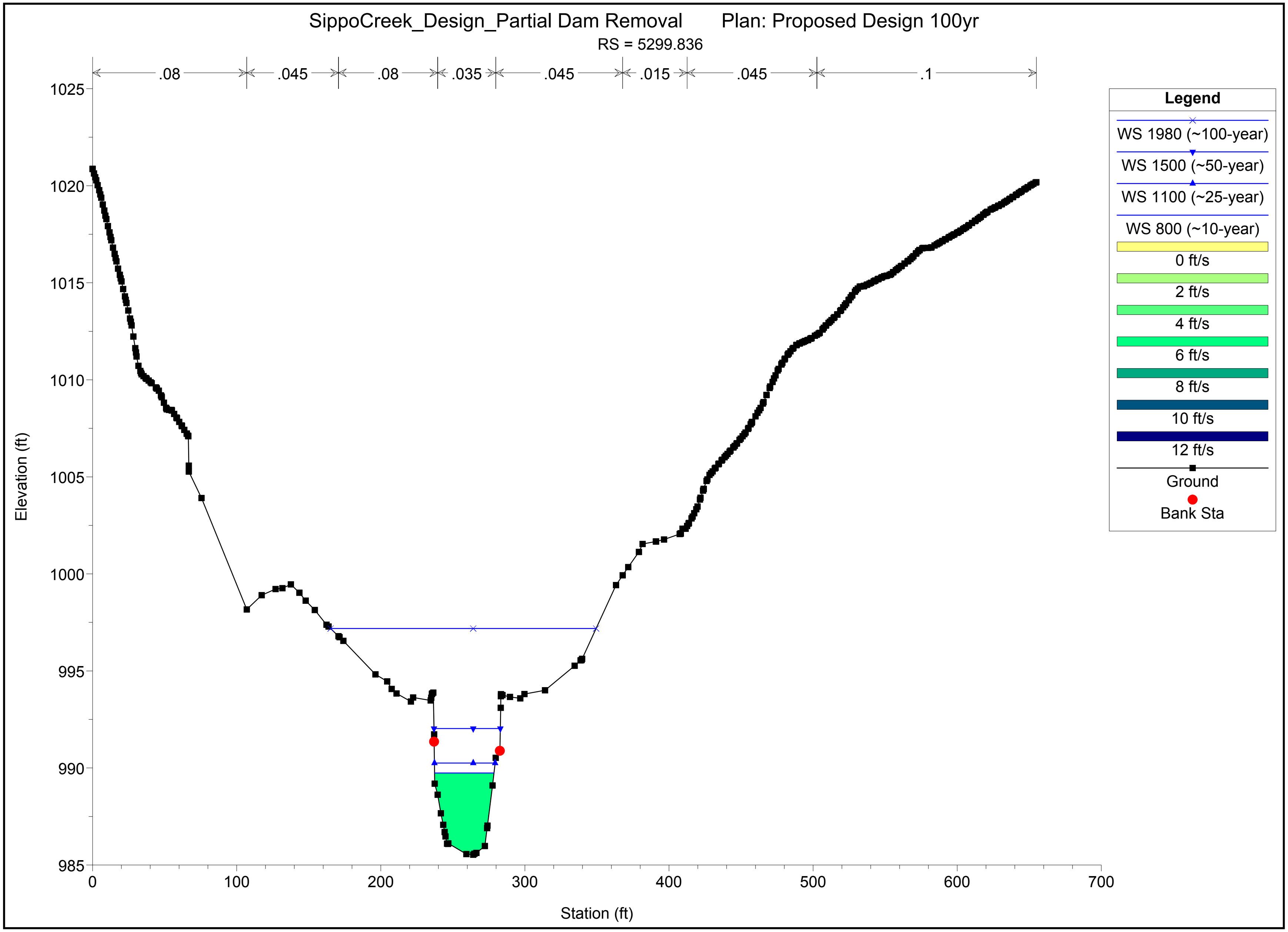
SippoCreek_Design_Partial Dam Removal   Plan: Proposed Design 100yr
RS = 5404.859
.08
.025
.02
.025
.015
.045
.1
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
16 ft/s
17 ft/s
18 ft/s
19 ft/s
20 ft/s
21 ft/s
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
200
400
600
800



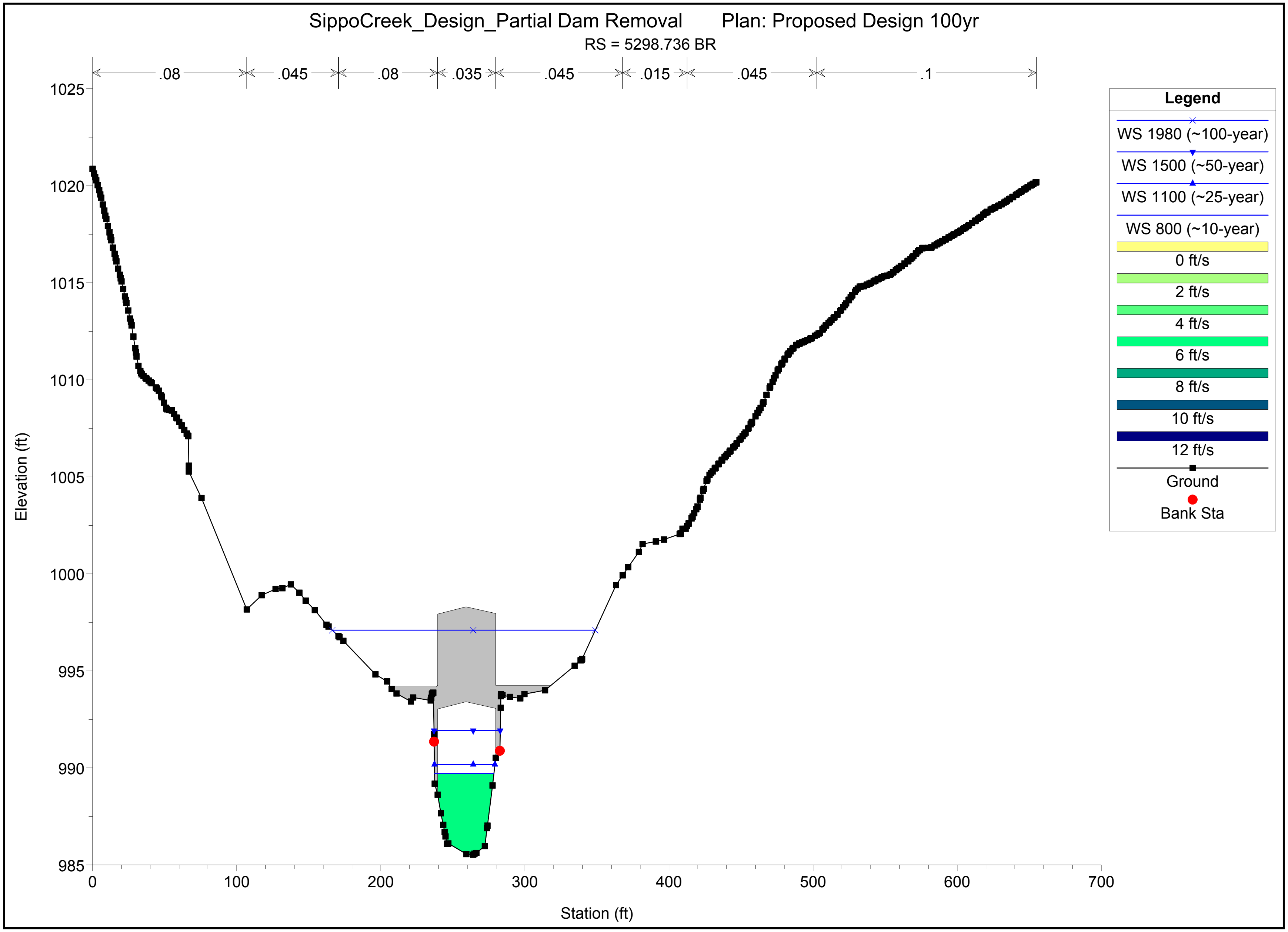
SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5389.75*
.1
.045
.036
.1
.045
.015
.1
Elevation (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
800
Station (ft)
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 800 (~10-year)
WS 1100 (~25-year)
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Bank Sta


SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5374.649
.1
.045
.036
.1
.045
.015
.1
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
800

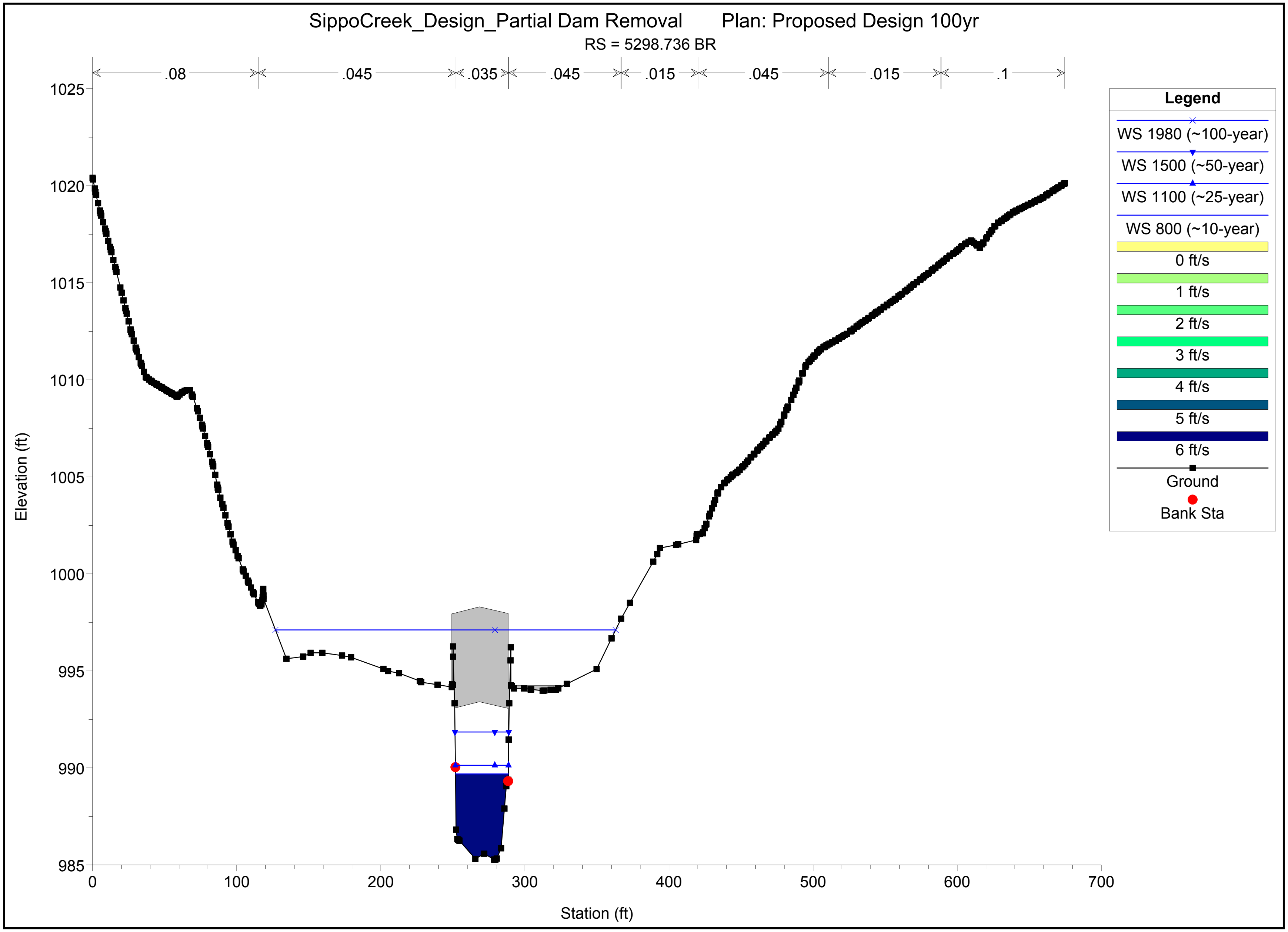

SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5345.135
.1
.045
.035
.1
.045
.015
.1
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Bank Sta
Elevation (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
Station (ft)



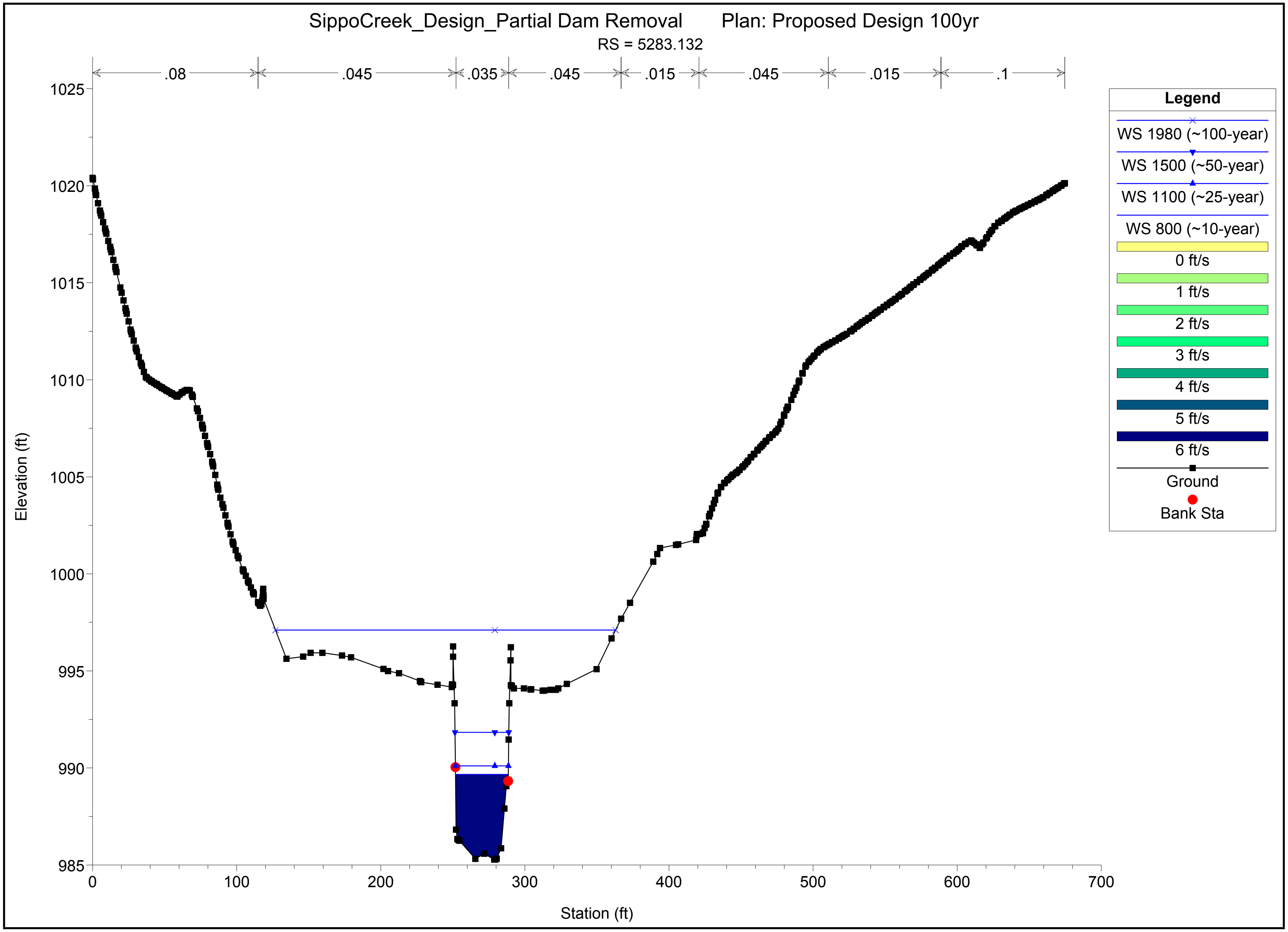
SippoCreek_Design_Partial Dam Removal   Plan: Proposed Design 100yr
RS = 5299.836
.08
.045
.08
.035
.045
.015
.045
.1
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta



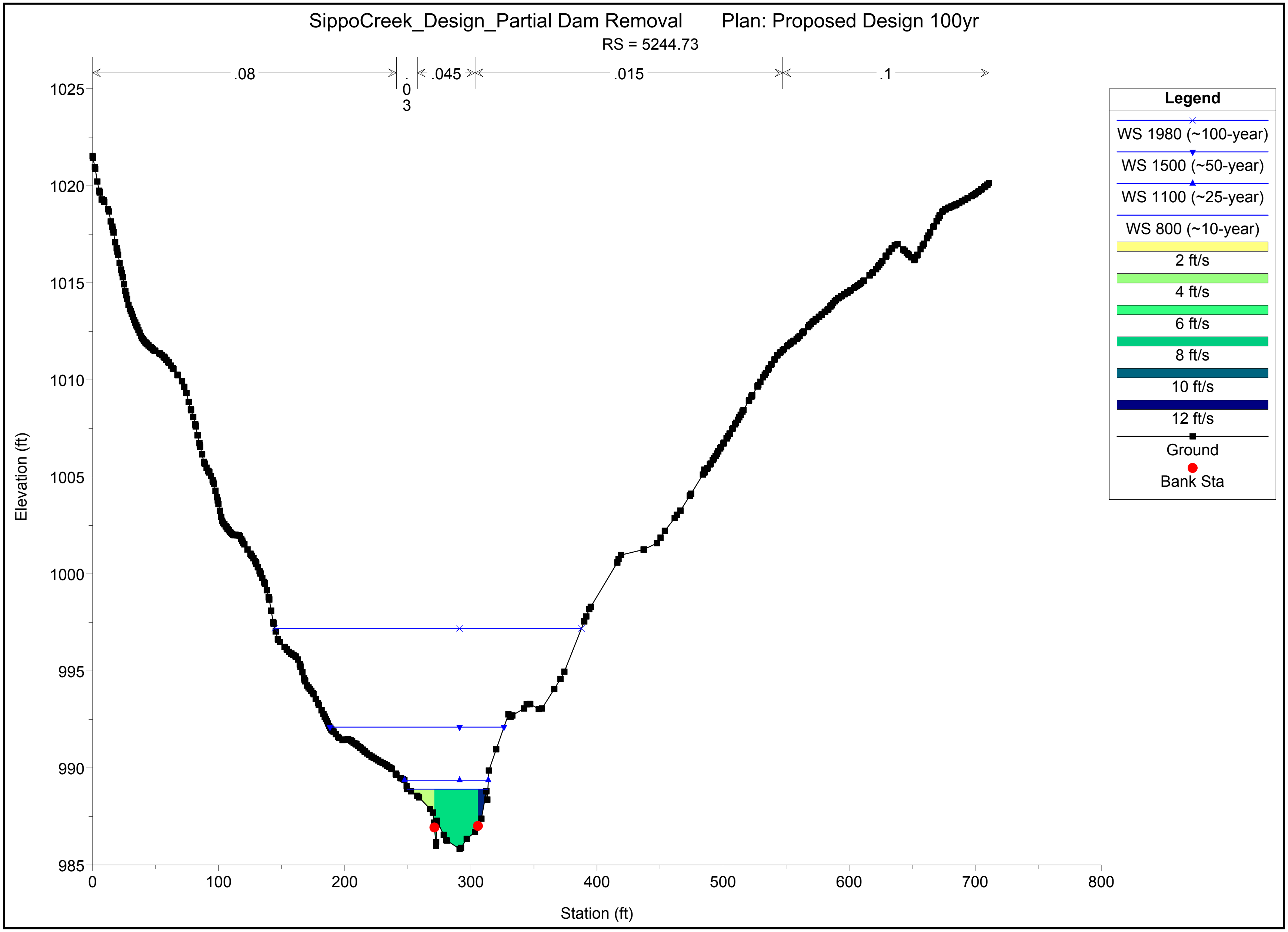
SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5298.736 BR
.08
.045
.08
.035
.045
.015
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta



SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5298.736 BR
.08
.045
.035
.045
.015
.045
.015
.1
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700



SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5283.132
.08
.045
.035
.045
.015
.045
.015
.1
Elevation (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta



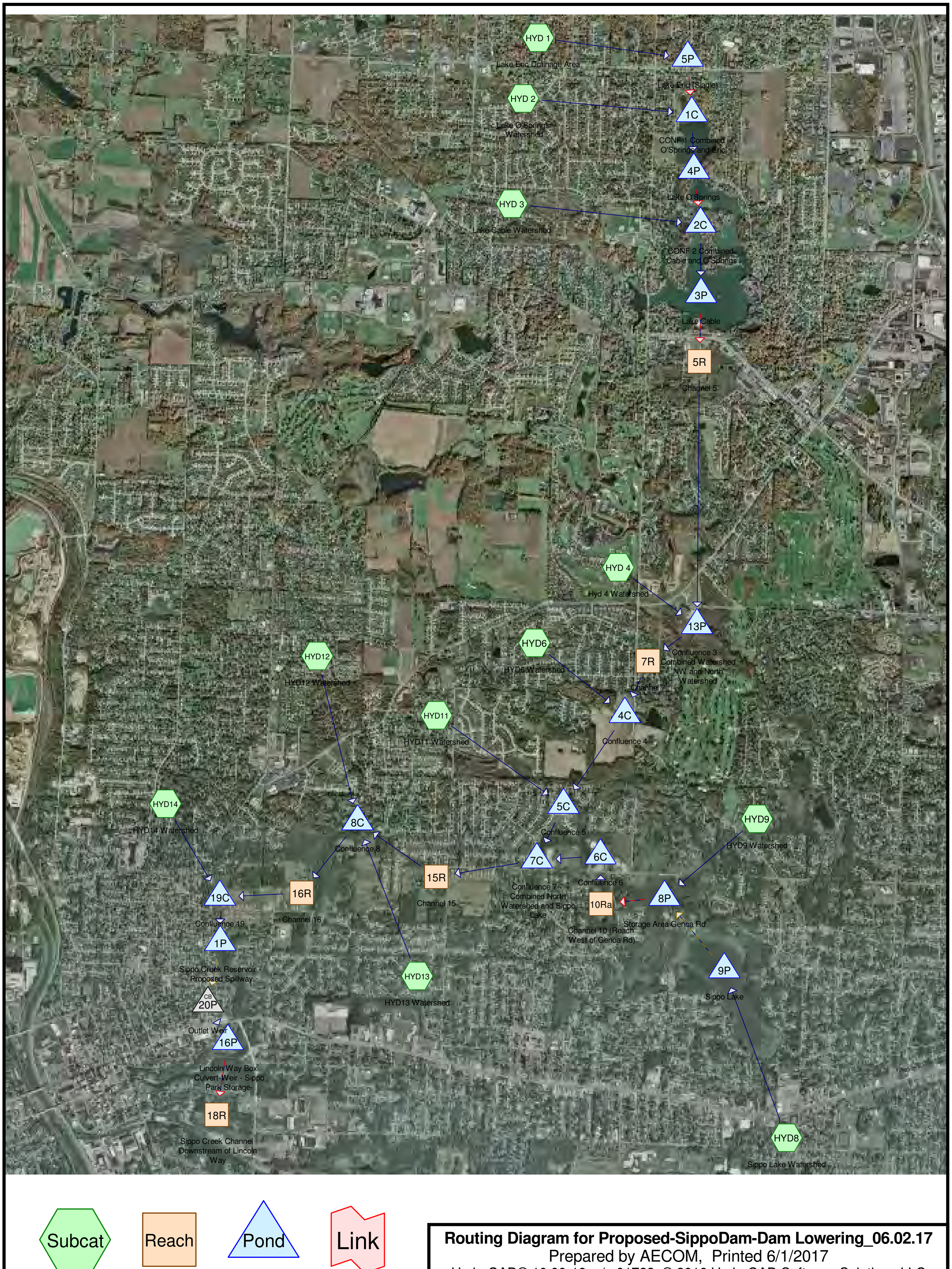
SippoCreek_Design_Partial Dam Removal Plan: Proposed Design 100yr
RS = 5244.73
.08
.03
.045
.015
.1
Legend
WS 1980 (~100-year)
WS 1500 (~50-year)
WS 1100 (~25-year)
WS 800 (~10-year)
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
1025
1020
1015
1010
1005
1000
995
990
985
0
100
200
300
400
500
600
700
800

HEC-RAS Plan: Prop 100yr Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sippo Creek	Main	5575.178	800 (~10-year)	800.00	991.80	998.92		998.93	0.000064	0.99	806.04	203.38	0.09
Sippo Creek	Main	5575.178	1100 (~25-year)	1100.00	991.80	999.61		999.63	0.000076	1.15	952.92	217.95	0.10
Sippo Creek	Main	5575.178	1500 (~50-year)	1500.00	991.80	1000.40		1000.43	0.000086	1.33	1129.82	230.07	0.11
Sippo Creek	Main	5575.178	1980 (~100-year)	1980.00	991.80	1001.21		1001.24	0.000096	1.50	1320.04	241.84	0.11
Sippo Creek	Main	5456.75	800 (~10-year)	800.00	986.80	998.92	988.56	998.93	0.000007	0.52	1531.74	183.85	0.03
Sippo Creek	Main	5456.75	1100 (~25-year)	1100.00	986.80	999.62	988.92	999.63	0.000010	0.66	1662.30	190.05	0.04
Sippo Creek	Main	5456.75	1500 (~50-year)	1500.00	986.80	1000.41	989.35	1000.42	0.000014	0.83	1814.93	196.45	0.05
Sippo Creek	Main	5456.75	1980 (~100-year)	1980.00	986.80	1001.22	989.79	1001.23	0.000019	1.01	1976.21	203.27	0.06
Sippo Creek	Main	5456.65		Inl Struct									
Sippo Creek	Main	5431.914	800 (~10-year)	800.00	995.60	997.84	997.61	998.66	0.008154	7.25	110.40	49.36	0.85
Sippo Creek	Main	5431.914	1100 (~25-year)	1100.00	995.60	998.33	998.09	999.37	0.008223	8.19	134.27	49.49	0.88
Sippo Creek	Main	5431.914	1500 (~50-year)	1500.00	995.60	999.22		1000.24	0.005742	8.21	190.48	73.07	0.76
Sippo Creek	Main	5431.914	1980 (~100-year)	1980.00	995.60	999.99		1001.05	0.004740	8.49	250.34	82.33	0.72
Sippo Creek	Main	5430.63*	800 (~10-year)	800.00	995.60	997.62	997.61	998.63	0.011374	8.03	99.60	49.35	1.00
Sippo Creek	Main	5430.63*	1100 (~25-year)	1100.00	995.60	998.10	998.09	999.34	0.010893	8.94	123.01	49.42	1.00
Sippo Creek	Main	5430.63*	1500 (~50-year)	1500.00	995.60	999.20	998.82	1000.24	0.005809	8.24	190.20	75.17	0.77
Sippo Creek	Main	5430.63*	1980 (~100-year)	1980.00	995.60	999.98	999.52	1001.03	0.004697	8.45	254.76	90.03	0.71
Sippo Creek	Main	5429.336	800 (~10-year)	800.00	995.60	997.61	997.61	998.63	0.005151	8.08	99.04	49.35	1.01
Sippo Creek	Main	5429.336	1100 (~25-year)	1100.00	995.60	998.09	998.09	999.34	0.004912	8.98	122.48	49.40	1.01
Sippo Creek	Main	5429.336	1500 (~50-year)	1500.00	995.60	998.76	998.76	1000.19	0.004199	9.61	158.68	68.84	0.95
Sippo Creek	Main	5429.336	1980 (~100-year)	1980.00	995.60	999.72	999.72	1000.99	0.002733	9.26	249.41	136.69	0.81
Sippo Creek	Main	5423.245	800 (~10-year)	800.00	987.14	987.82	989.19	997.66	0.208964	25.16	31.79	48.99	5.51
Sippo Creek	Main	5423.245	1100 (~25-year)	1100.00	987.14	988.04	989.67	998.35	0.149572	25.75	42.71	49.14	4.87
Sippo Creek	Main	5423.245	1500 (~50-year)	1500.00	987.14	988.33	990.23	999.18	0.109515	26.42	56.77	49.34	4.34
Sippo Creek	Main	5423.245	1980 (~100-year)	1980.00	987.14	997.22	990.83	997.41	0.000118	3.58	676.13	153.10	0.20
Sippo Creek	Main	5414.84	800 (~10-year)	800.00	987.20	988.00	989.28	995.59	0.136048	22.10	36.19	48.80	4.52
Sippo Creek	Main	5414.84	1100 (~25-year)	1100.00	987.20	988.22	989.76	996.75	0.109404	23.43	46.94	48.86	4.22
Sippo Creek	Main	5414.84	1500 (~50-year)	1500.00	987.20	988.50	990.33	997.94	0.086853	24.64	60.87	48.95	3.90
Sippo Creek	Main	5414.84	1980 (~100-year)	1980.00	987.20	997.27		997.39	0.000091	3.00	914.95	199.16	0.17
Sippo Creek	Main	5404.859	800 (~10-year)	800.00	987.33	988.23	989.41	993.97	0.086019	19.22	41.63	48.90	3.67
Sippo Creek	Main	5404.859	1100 (~25-year)	1100.00	987.33	988.45	989.89	995.35	0.077462	21.08	52.18	48.96	3.60
Sippo Creek	Main	5404.859	1500 (~50-year)	1500.00	987.33	988.73	990.46	996.76	0.066894	22.73	65.98	49.05	3.46
Sippo Creek	Main	5404.859	1980 (~100-year)	1980.00	987.33	997.31	991.10	997.37	0.000052	2.26	1290.10	283.42	0.13
Sippo Creek	Main	5389.75*	800 (~10-year)	800.00	986.68	990.28	988.82	990.53	0.001974	4.23	212.58	75.18	0.40
Sippo Creek	Main	5389.75*	1100 (~25-year)	1100.00	986.68	987.98	989.25	993.29	0.156805	18.62	60.92	55.31	2.98
Sippo Creek	Main	5389.75*	1500 (~50-year)	1500.00	986.68	992.57	989.77	992.83	0.001100	4.42	421.47	109.82	0.32

HEC-RAS Plan: Prop 100yr Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sippo Creek	Main	5389.75*	1980 (~100-year)	1980.00	986.68	997.29		997.36	0.000169	2.57	1270.89	260.62	0.14
Sippo Creek	Main	5374.649	800 (~10-year)	800.00	986.04	990.31		990.49	0.001120	3.57	253.61	74.26	0.31
Sippo Creek	Main	5374.649	1100 (~25-year)	1100.00	986.04	991.03	988.66	991.27	0.001192	4.09	308.70	78.52	0.32
Sippo Creek	Main	5374.649	1500 (~50-year)	1500.00	986.04	992.59		992.81	0.000828	4.09	445.91	98.35	0.28
Sippo Creek	Main	5374.649	1980 (~100-year)	1980.00	986.04	997.29		997.36	0.000153	2.53	1253.73	241.73	0.13
Sippo Creek	Main	5345.135	800 (~10-year)	800.00	985.77	990.15		990.44	0.001656	4.49	201.93	62.95	0.38
Sippo Creek	Main	5345.135	1100 (~25-year)	1100.00	985.77	990.82		991.21	0.001848	5.23	246.80	71.10	0.41
Sippo Creek	Main	5345.135	1500 (~50-year)	1500.00	985.77	992.43		992.77	0.001185	5.05	384.98	100.68	0.35
Sippo Creek	Main	5345.135	1980 (~100-year)	1980.00	985.77	997.26		997.36	0.000189	2.92	1125.14	207.74	0.15
Sippo Creek	Main	5299.836	800 (~10-year)	800.00	985.53	989.74	988.64	990.30	0.005277	5.97	134.05	41.20	0.58
Sippo Creek	Main	5299.836	1100 (~25-year)	1100.00	985.53	990.25	989.27	991.03	0.006550	7.08	155.38	42.08	0.65
Sippo Creek	Main	5299.836	1500 (~50-year)	1500.00	985.53	992.03	989.93	992.66	0.003766	6.39	235.06	46.05	0.50
Sippo Creek	Main	5299.836	1980 (~100-year)	1980.00	985.53	997.18	990.72	997.34	0.000440	3.47	817.58	184.18	0.19
Sippo Creek	Main	5298.736		Bridge									
Sippo Creek	Main	5283.132	800 (~10-year)	800.00	985.28	989.67		990.21	0.004099	5.93	134.91	36.71	0.54
Sippo Creek	Main	5283.132	1100 (~25-year)	1100.00	985.28	990.11		990.93	0.005414	7.29	151.08	36.82	0.63
Sippo Creek	Main	5283.132	1500 (~50-year)	1500.00	985.28	991.84		992.60	0.003125	6.99	215.31	37.38	0.51
Sippo Creek	Main	5283.132	1980 (~100-year)	1980.00	985.28	997.11		997.28	0.000392	3.80	825.32	236.00	0.20
Sippo Creek	Main	5244.73	800 (~10-year)	800.00	985.83	988.91	988.91	989.90	0.013479	7.64	108.13	64.19	0.85
Sippo Creek	Main	5244.73	1100 (~25-year)	1100.00	985.83	989.37	989.37	990.59	0.012406	8.23	137.83	66.49	0.84
Sippo Creek	Main	5244.73	1500 (~50-year)	1500.00	985.83	992.10		992.38	0.001274	4.13	414.58	137.97	0.30
Sippo Creek	Main	5244.73	1980 (~100-year)	1980.00	985.83	997.19		997.24	0.000078	1.57	1423.50	243.29	0.08



Routing Diagram for Proposed-SippoDam-Dam Lowering_06.02.17
Prepared by AECOM, Printed 6/1/2017
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Summary for Pond 1P: Sippo Creek Reservoir - Proposed Spillway

Inflow Area = 9,459.200 ac, 19.70% Impervious, Inflow Depth > 0.96" for 10 year - NOAA event
Inflow = 817.90 cfs @ 13.24 hrs, Volume= 757.900 af, Incl. 10.00 cfs Base Flow
Outflow = 800.10 cfs @ 13.32 hrs, Volume= 756.591 af, Atten= 2%, Lag= 5.2 min
Primary = 800.10 cfs @ 13.32 hrs, Volume= 756.591 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 995.76' Surf.Area= 3.584 ac Storage= 26.623 af
Peak Elev= 998.48' @ 13.32 hrs Surf.Area= 5.175 ac Storage= 38.463 af (11.840 af above start)
Flood Elev= 1,005.00' Surf.Area= 12.657 ac Storage= 88.432 af (61.809 af above start)

Plug-Flow detention time= 90.1 min calculated for 729.811 af (96% of inflow)
Center-of-Mass det. time= 9.8 min (1,371.3 - 1,361.5)

Volume	Invert	Avail.Storage	Storage Description
#1	985.00'	1,289.545 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

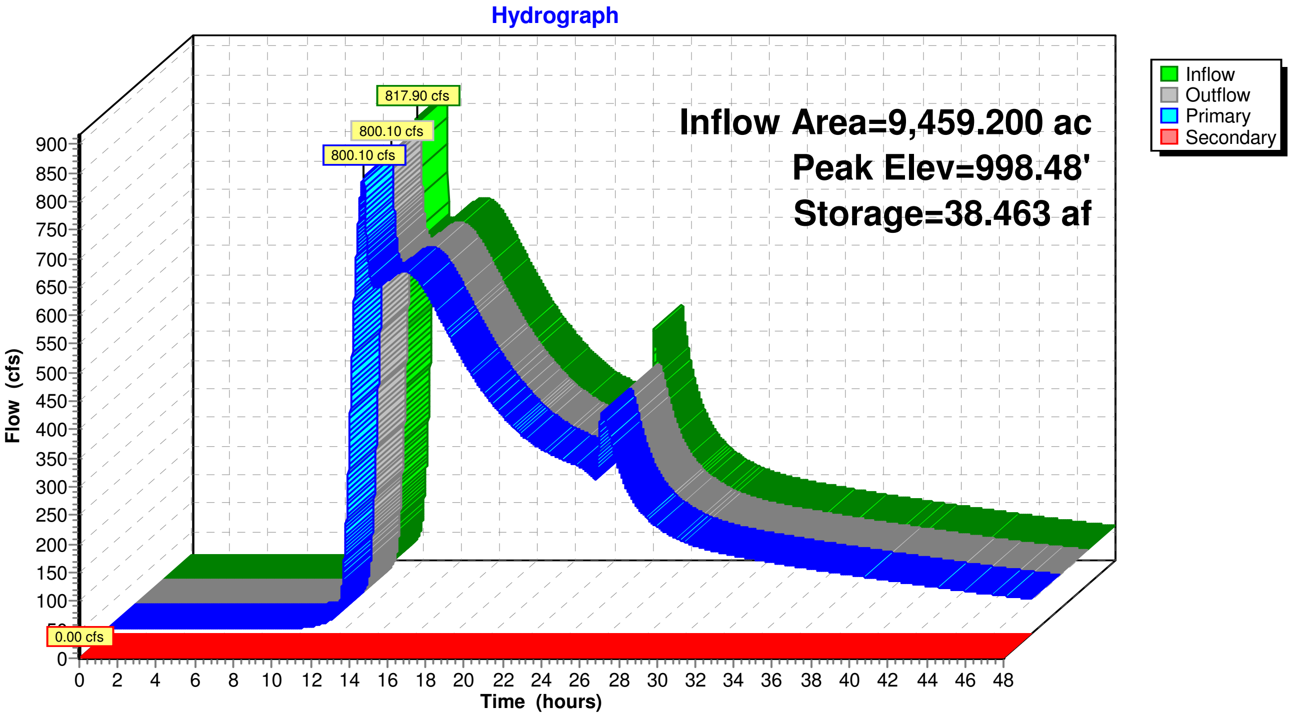
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
985.00	0.500	500.0	0.000	0.000	0.500
990.00	3.000	1,000.0	7.875	7.875	1.873
995.60	3.500	1,750.0	18.182	26.057	5.645
998.00	4.870	2,500.0	9.999	36.055	11.469
1,000.00	6.204	3,251.0	11.047	47.103	19.360
1,002.00	7.243	5,147.0	13.434	60.536	48.449
1,004.00	9.610	10,274.0	16.797	77.333	192.887
1,006.00	16.124	11,202.9	25.455	102.788	229.335
1,008.00	21.577	15,736.9	37.569	140.357	452.476
1,010.00	29.674	20,301.4	51.036	191.393	752.988
1,012.00	39.539	22,845.5	68.977	260.371	953.524
1,014.00	68.669	34,370.5	106.876	367.247	2,158.174
1,025.00	100.000	50,000.0	922.298	1,289.545	4,567.204

Device	Routing	Invert	Outlet Devices
#1	Primary	995.60'	**Primary Spillway, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.99 3.00 Width (feet) 50.00 50.00 54.00
#2	Secondary	998.60'	**Dam, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 Width (feet) 64.00 88.00

Primary OutFlow Max=800.02 cfs @ 13.32 hrs HW=998.48' TW=991.03' (Dynamic Tailwater)
└─**1=Primary Spillway** (Weir Controls 800.02 cfs @ 5.56 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=995.76' TW=987.88' (Dynamic Tailwater)
└─**2=Dam** (Controls 0.00 cfs)

Pond 1P: Sippo Creek Reservoir - Proposed Spillway



Summary for Pond 1P: Sippo Creek Reservoir - Proposed Spillway

Inflow Area = 9,459.200 ac, 19.70% Impervious, Inflow Depth > 2.27" for 100 year-NOAA event
Inflow = 1,973.48 cfs @ 14.67 hrs, Volume= 1,791.834 af, Incl. 10.00 cfs Base Flow
Outflow = 1,971.55 cfs @ 14.75 hrs, Volume= 1,788.430 af, Atten= 0%, Lag= 5.2 min
Primary = 1,346.45 cfs @ 14.72 hrs, Volume= 1,594.197 af
Secondary = 625.17 cfs @ 14.77 hrs, Volume= 194.233 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 995.76' Surf.Area= 3.584 ac Storage= 26.623 af
Peak Elev= 1,000.50' @ 14.77 hrs Surf.Area= 6.454 ac Storage= 50.243 af (23.620 af above start)
Flood Elev= 1,005.00' Surf.Area= 12.657 ac Storage= 88.432 af (61.809 af above start)

Plug-Flow detention time= 44.8 min calculated for 1,761.803 af (98% of inflow)
Center-of-Mass det. time= 7.7 min (1,346.9 - 1,339.1)

Volume	Invert	Avail.Storage	Storage Description
#1	985.00'	1,289.545 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

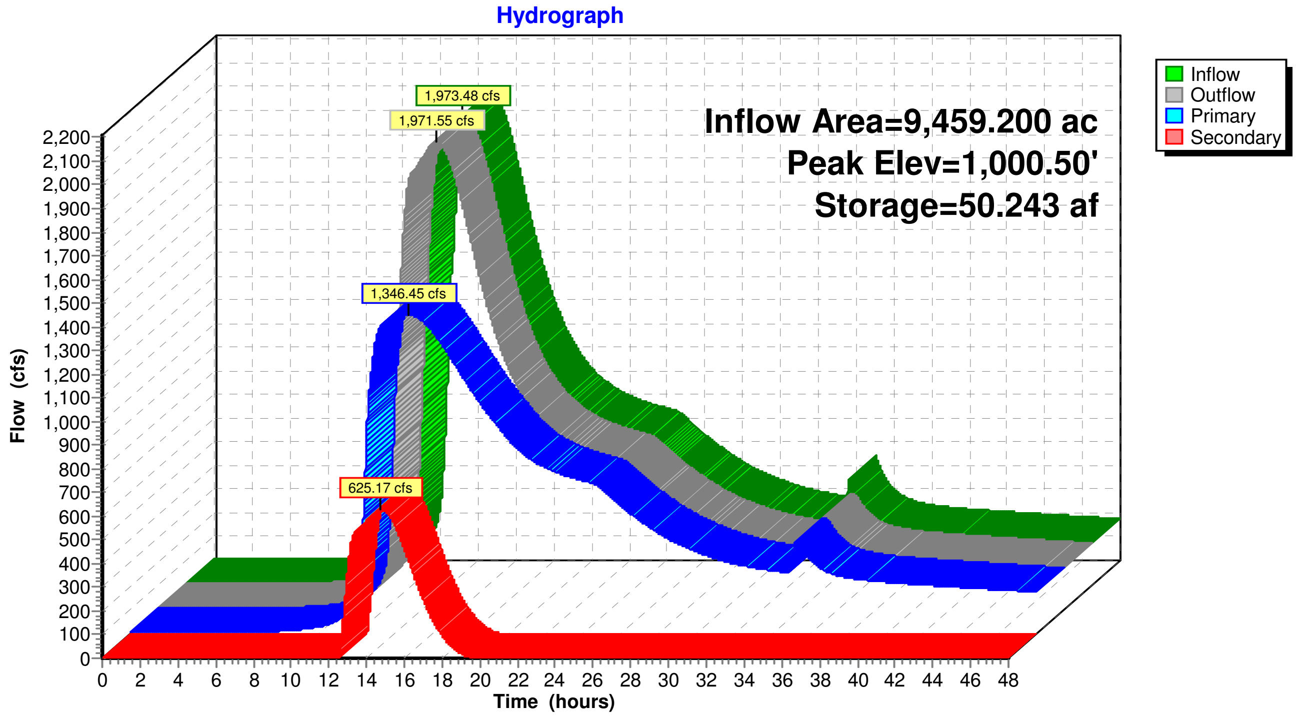
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
985.00	0.500	500.0	0.000	0.000	0.500
990.00	3.000	1,000.0	7.875	7.875	1.873
995.60	3.500	1,750.0	18.182	26.057	5.645
998.00	4.870	2,500.0	9.999	36.055	11.469
1,000.00	6.204	3,251.0	11.047	47.103	19.360
1,002.00	7.243	5,147.0	13.434	60.536	48.449
1,004.00	9.610	10,274.0	16.797	77.333	192.887
1,006.00	16.124	11,202.9	25.455	102.788	229.335
1,008.00	21.577	15,736.9	37.569	140.357	452.476
1,010.00	29.674	20,301.4	51.036	191.393	752.988
1,012.00	39.539	22,845.5	68.977	260.371	953.524
1,014.00	68.669	34,370.5	106.876	367.247	2,158.174
1,025.00	100.000	50,000.0	922.298	1,289.545	4,567.204

Device	Routing	Invert	Outlet Devices
#1	Primary	995.60'	**Primary Spillway, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.99 3.00 Width (feet) 50.00 50.00 54.00
#2	Secondary	998.60'	**Dam, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 Width (feet) 64.00 88.00

Primary OutFlow Max=1,346.41 cfs @ 14.72 hrs HW=1,000.50' TW=995.68' (Dynamic Tailwater)
└─**1=Primary Spillway** (Orifice Controls 1,346.41 cfs @ 8.97 fps)

Secondary OutFlow Max=625.17 cfs @ 14.77 hrs HW=1,000.50' TW=995.71' (Dynamic Tailwater)
└─**2=Dam** (Weir Controls 625.17 cfs @ 4.37 fps)

Pond 1P: Sippo Creek Reservoir - Proposed Spillway



Project Number: 60439145
Calculated By: CDM Date 5/30/2017
Checked By: MMS Date 6/1/2017

Grouted Riprap Outlet Channel Design

Reference: *Urban Drainage and Flood Control District Criteria Manual, 2008. Volume 2, Structures, Storage and Recreation, Chapter 9: Hydraulic Structures.*

Given

Basin Outlet Velocity, V		
Maximum (HEC-RAS)	23.8	ft/s
Channel Slope	0.001	ft/ft
Specific Gravity of rock	2.65	lbs/ft^3

Calculate Rp

Rp	5.284909

Table HS-5 Grouted Boulders

Dr	24	in

Determine Unit Discharge

Q	1500	cfs
Channel Width*	60	ft
q	25	cfs/ft

* 50 ft plus 5 ft on each side

Results

Min. Grouted Rock size	24	in
Length of Downstream Apron	20	ft
Use ODOT Type A Riprap	24	in
Thickness	3	ft
Grout Height	18	in

$$R_p = \frac{V_c S^{0.17}}{(S_s - 1)^{0.66}}$$

in which: S = longitudinal slope along direction of flow in ft/ft

S_s = Specific gravity of the rock. Assume 2.55 unless the quarry certifies higher specific gravity.

Table HS-5—Boulder Sizes for Various Rock Sizing Parameters

Rock Sizing Parameter, R_p	Ungrouted Boulders: Minimum Dimensions of Boulder, D_r	Ungrouted Boulders: Boulder Classification	Grouted Boulders *: Minimum Dimensions of Boulder, D_r	Grouted Boulders *: Boulder Classification
Less than 4.50	18 inches	B18	18 inches	B18
4.50 to 4.99	24 inches	B24	18 inches	B18
5.00 to 5.59	30 inches	B30	24 inches	B24
5.60 to 6.39	36 inches	B36	30 inches	B30
6.40 to 6.99	42 inches	B42	36 inches	B36
7.00 to 7.49	48 inches	B48	42 inches	B42
7.50 to 8.00	n/a	n/a	48 inches	B48

* Grouted to no less than ½ the height (+1"/- 0"), no more than ⅓ (+0"/- 1") of boulder height.

MAXIMUM UNIT DISCHARGE q (cfs/ft	ALLOWABLE CHUTE SLOPE - So FOR EACH RIPRAP CLASSIFICATION: M	H	VH	LENGTH OF DOWNSTREAM APRON L_B (Ft)
15	0 to 7:1	7:1 to 4:1	N/A	15
20	0 to 8:1	8:1 to 5:1	5:1 to 4:1	20
25	0 to 10:1	10:1 to 6:1	6:1 to 4:1	20
30	0 to 12:1	12:1 to 7:1	7:1 to 4.5:1	25
35	0 to 13:1	13:1 to 8:1	8:1 to 6:1	25
DR*	1.75'	2.6'	3.5'	
DR**	2.0'	3.0'	4.0'	
DRW	1.5 x DR	1.25 x DR	1.0 x DR	

AECOM

Velocity Calculation
Sippo Creek Reservoir Dam Overtopping Protection

Project: Sippo Creek Reservoir Dam
Project #: 13814498 Date: 05/31/17
Designed by: MMS Checked by: SW

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:
- Q = Flow Rate, (ft^3/s)
- v = Velocity, (ft/s)
- A = Flow Area, (ft^2)
- n = Manning's Roughness Coefficient
- R = Hydraulic Radius, (ft)
- S = Channel Slope, (ft/ft)

Results from HEC-RAS Qt=2400 cfs

Cross Section	Q L (cfs)	Q R (cfs)	Area L (ft2)	Area R (ft2)	Wetted Perimeter L (ft)	Wetted Perimeter R (ft)	Hydraulic Radius L (ft)	Hydraulic Radius R (ft)
5456.75	384.05	201.71	77.1325	39.215	158.76	82.44	0.485843411	0.475679282
5456.65 IS								

Assume n = 0.025 Articulated Concrete Block
S = 0.4 ft/ft Proposed

Velocity	XS 5456.75
Left (fps)	23.29559463
Right (fps)	22.96954608

Conclusion:

Use Pyramat 75 with 18-inch anchors

Worksheet for Trapezoidal Channel - Partial Removal-Crest

Project Description

Friction Method	Manning Formula
Solve For	Channel Slope

Input Data

Roughness Coefficient	0.028	
Normal Depth	1.35	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Results

Channel Slope	0.01077	ft/ft
Flow Area	49.07	ft²
Wetted Perimeter	39.37	ft
Hydraulic Radius	1.25	ft
Top Width	37.70	ft
Critical Depth	1.34	ft
Critical Slope	0.01111	ft/ft
Velocity	6.38	ft/s
Velocity Head	0.63	ft
Specific Energy	1.98	ft
Froude Number	0.99	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.35	ft
Critical Depth	1.34	ft
Channel Slope	0.01077	ft/ft

Worksheet for Trapezoidal Channel - Partial Removal-Crest

GVF Output Data

Critical Slope	0.01111	ft/ft

Rating Table for Trapezoidal Channel - Partial Removal-Crest

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.028	
Channel Slope	0.01080	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Channel Slope (ft/ft)	Normal Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.01000	1.38	6.23	50.23	39.47	37.76
0.02000	1.12	7.74	40.45	38.62	37.24
0.03000	0.99	8.78	35.65	38.21	36.98
0.04000	0.91	9.60	32.61	37.94	36.82
0.05000	0.85	10.28	30.44	37.75	36.70
0.06000	0.80	10.88	28.78	37.60	36.61
0.07000	0.77	11.41	27.43	37.48	36.53
0.08000	0.74	11.89	26.33	37.38	36.47
0.09000	0.71	12.33	25.39	37.30	36.42
0.10000	0.69	12.73	24.58	37.23	36.38
0.11000	0.67	13.10	23.89	37.17	36.34
0.12000	0.65	13.46	23.25	37.11	36.30
0.13000	0.64	13.79	22.70	37.06	36.27
0.14000	0.62	14.11	22.19	37.02	36.25
0.15000	0.61	14.42	21.71	36.97	36.22
0.16000	0.60	14.70	21.29	36.94	36.20
0.17000	0.59	14.97	20.91	36.90	36.17
0.18000	0.58	15.24	20.54	36.87	36.15
0.19000	0.57	15.49	20.20	36.84	36.14
0.20000	0.56	15.75	19.88	36.81	36.12
0.21000	0.55	15.98	19.59	36.78	36.10
0.22000	0.54	16.21	19.31	36.76	36.09
0.23000	0.54	16.42	19.06	36.74	36.07

Rating Table for Trapezoidal Channel - Partial Removal-Crest

Input Data

Channel Slope (ft/ft)	Normal Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.24000	0.53	16.64	18.81	36.71	36.06
0.25000	0.52	16.85	18.58	36.69	36.05
0.26000	0.52	17.05	18.36	36.67	36.03
0.27000	0.51	17.25	18.15	36.65	36.02
0.28000	0.51	17.45	17.94	36.63	36.01
0.29000	0.50	17.63	17.75	36.62	36.00
0.30000	0.49	17.82	17.56	36.60	35.99
0.31000	0.49	17.99	17.40	36.59	35.98
0.32000	0.49	18.17	17.23	36.57	35.97
0.33000	0.48	18.34	17.07	36.56	35.96
0.34000	0.48	18.51	16.91	36.54	35.95
0.35000	0.47	18.67	16.76	36.53	35.95
0.36000	0.47	18.83	16.62	36.52	35.94
0.37000	0.46	18.99	16.48	36.50	35.93
0.38000	0.46	19.14	16.35	36.49	35.92
0.39000	0.46	19.31	16.21	36.48	35.91
0.40000	0.45	19.46	16.09	36.47	35.91
0.41000	0.45	19.60	15.97	36.46	35.90
0.42000	0.45	19.75	15.85	36.45	35.89
0.43000	0.44	19.89	15.73	36.44	35.89
0.44000	0.44	20.02	15.64	36.43	35.88
0.45000	0.44	20.16	15.53	36.42	35.88
0.46000	0.44	20.29	15.42	36.41	35.87
0.47000	0.43	20.43	15.32	36.40	35.86
0.48000	0.43	20.56	15.22	36.39	35.86
0.49000	0.43	20.69	15.13	36.38	35.85
0.50000	0.42	20.82	15.03	36.37	35.85

Cross Section for Trapezoidal Channel - Partial Removal-Crest

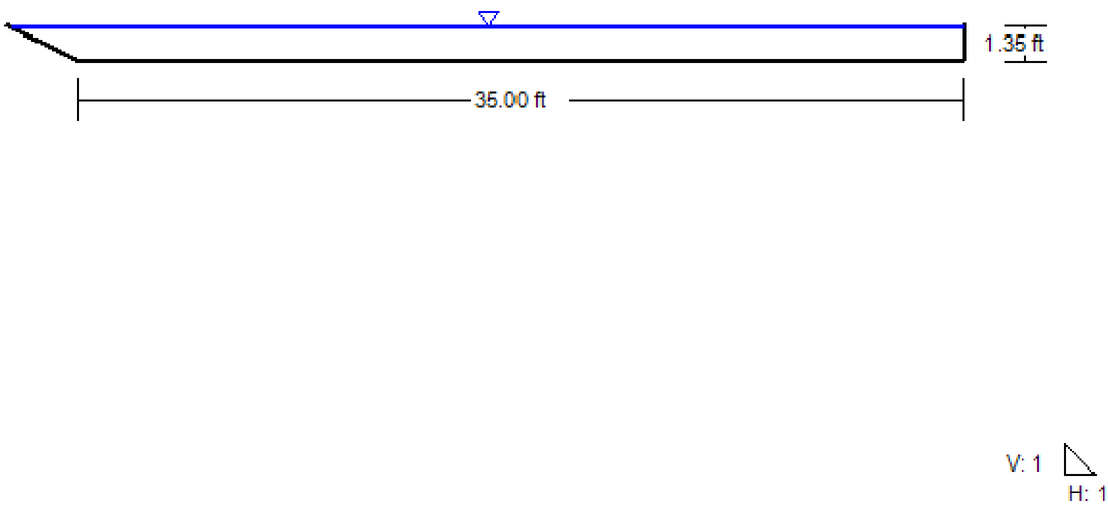
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.028	
Channel Slope	0.01080	ft/ft
Normal Depth	1.35	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Cross Section Image



Worksheet for Trapezoidal Channel - Partial Removal-Toe

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.028	
Channel Slope	0.50000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Results

Normal Depth	0.42	ft
Flow Area	15.03	ft²
Wetted Perimeter	36.37	ft
Hydraulic Radius	0.41	ft
Top Width	35.85	ft
Critical Depth	1.34	ft
Critical Slope	0.01111	ft/ft
Velocity	20.82	ft/s
Velocity Head	6.74	ft
Specific Energy	7.16	ft
Froude Number	5.67	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.42	ft
Critical Depth	1.34	ft
Channel Slope	0.50000	ft/ft

Worksheet for Trapezoidal Channel - Partial Removal-Toe

GVF Output Data

Critical Slope	0.01111	ft/ft

Rating Table for Trapezoidal Channel - Partial Removal-Toe

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.028	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Channel Slope (ft/ft)	Normal Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.01000	1.38	6.23	50.23	39.47	37.76
0.02000	1.12	7.74	40.45	38.62	37.24
0.03000	0.99	8.78	35.65	38.21	36.98
0.04000	0.91	9.60	32.61	37.94	36.82
0.05000	0.85	10.28	30.44	37.75	36.70
0.06000	0.80	10.88	28.78	37.60	36.61
0.07000	0.77	11.41	27.43	37.48	36.53
0.08000	0.74	11.89	26.33	37.38	36.47
0.09000	0.71	12.33	25.39	37.30	36.42
0.10000	0.69	12.73	24.58	37.23	36.38
0.11000	0.67	13.10	23.89	37.17	36.34
0.12000	0.65	13.46	23.25	37.11	36.30
0.13000	0.64	13.79	22.70	37.06	36.27
0.14000	0.62	14.11	22.19	37.02	36.25
0.15000	0.61	14.42	21.71	36.97	36.22
0.16000	0.60	14.70	21.29	36.94	36.20
0.17000	0.59	14.97	20.91	36.90	36.17
0.18000	0.58	15.24	20.54	36.87	36.15
0.19000	0.57	15.49	20.20	36.84	36.14
0.20000	0.56	15.75	19.88	36.81	36.12
0.21000	0.55	15.98	19.59	36.78	36.10
0.22000	0.54	16.21	19.31	36.76	36.09
0.23000	0.54	16.42	19.06	36.74	36.07

Rating Table for Trapezoidal Channel - Partial Removal-Toe

Input Data

Channel Slope (ft/ft)	Normal Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.24000	0.53	16.64	18.81	36.71	36.06
0.25000	0.52	16.85	18.58	36.69	36.05
0.26000	0.52	17.05	18.36	36.67	36.03
0.27000	0.51	17.25	18.15	36.65	36.02
0.28000	0.51	17.45	17.94	36.63	36.01
0.29000	0.50	17.63	17.75	36.62	36.00
0.30000	0.49	17.82	17.56	36.60	35.99
0.31000	0.49	17.99	17.40	36.59	35.98
0.32000	0.49	18.17	17.23	36.57	35.97
0.33000	0.48	18.34	17.07	36.56	35.96
0.34000	0.48	18.51	16.91	36.54	35.95
0.35000	0.47	18.67	16.76	36.53	35.95
0.36000	0.47	18.83	16.62	36.52	35.94
0.37000	0.46	18.99	16.48	36.50	35.93
0.38000	0.46	19.14	16.35	36.49	35.92
0.39000	0.46	19.31	16.21	36.48	35.91
0.40000	0.45	19.46	16.09	36.47	35.91
0.41000	0.45	19.60	15.97	36.46	35.90
0.42000	0.45	19.75	15.85	36.45	35.89
0.43000	0.44	19.89	15.73	36.44	35.89
0.44000	0.44	20.02	15.64	36.43	35.88
0.45000	0.44	20.16	15.53	36.42	35.88
0.46000	0.44	20.29	15.42	36.41	35.87
0.47000	0.43	20.43	15.32	36.40	35.86
0.48000	0.43	20.56	15.22	36.39	35.86
0.49000	0.43	20.69	15.13	36.38	35.85
0.50000	0.42	20.82	15.03	36.37	35.85

Cross Section for Trapezoidal Channel - Partial Removal-Toe

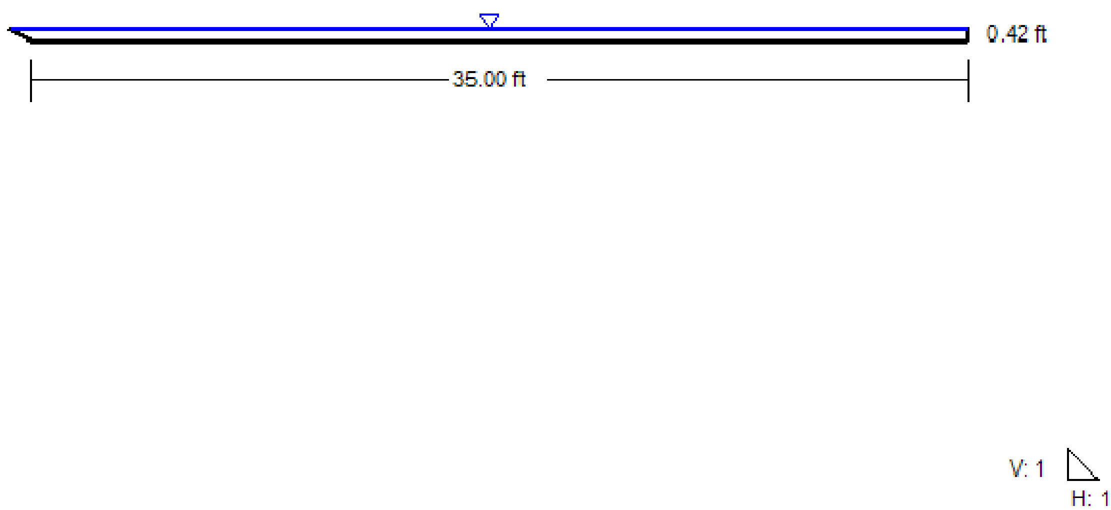
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.028	
Channel Slope	0.50000	ft/ft
Normal Depth	0.42	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	313.00	ft³/s

Cross Section Image



Appendix C Structural Engineering

C.1 Structural Analysis

AECOM
564 White Pond Drive
Akron, OH 44320-1100

330.836.9111 tel
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May 31, 2017

Subject: Sippo Dam
Massillon, OH
Job No. 60439145
Structural Analysis Memorandum

Dear Mr. Walker:

We have conducted a site visit to Sippo Dam in Massillon, OH on May 3, 2017 to assess the current condition of the dam and to take field measurements. Per emergency order of ODNR, 3 courses of the dam were partially removed. It was proposed to lower the dam by 4 complete courses (one additional course and the remaining partial courses), reducing the height of the dam to 5 courses (8'-0"). Structural analysis of the proposed dam lowering was then conducted according to the Army Corps of Engineers Manuals and Regulations, particularly EM 1110-2-2200 "Gravity Dam Design" and ER 1110-2-1806 "Earthquake Design and Evaluation for Civil Works Projects." Numerous conservative assumptions were made due to the lack of existing plans and visual constraints.

Per EM 1110-2-2200, three load conditions were investigated: Condition No. 2, Condition No. 3, and Condition No. 6. Please note that Condition No. 5 (Unusual – Operating Basis Earthquake) was not considered because Condition No. 3 (Unusual Flood) controlled the Unusual load condition. Each load condition was checked for overturning, sliding, and bearing at each course. Additionally, each case was checked with uplift (A) and without uplift (B). For specific load case assumptions, please refer to the structural calculations. The results for each condition are listed below.

1) Load Condition No. 2: Usual Normal Operating Construction

    - Overturning – All resultants were located within the middle 1/3 of the base
    - Sliding – Course 5A (bottom course) controlled with FS = 1.87 < 2.0
      Per engineering judgment, the use of numerous conservative assumptions, and the existing condition of the dam, we feel that a factor of safety of 1.87 for this load condition is sufficient. All other factors of safety are greater than 2.
    - Bearing – Course 5B controlled with σ_{max} = 1.25 ksf. < 2.0 ksf.

2) Load Condition No. 3: Unusual Flood Discharge (100-YR)

    - Overturning – All resultants were located within the middle 1/2 of the base
    - Sliding – Course 5A controlled with FS = 1.87 > 1.7
    - Bearing – Course 5B controlled with σ_{max} = 1.39 ksf. < 2.0 ksf.

3) Load Condition No. 6: Extreme Normal Operating with Earthquake (MCE)

    - Overturning – All resultants were located within the base
    - Sliding – Course 5A controlled with FS = 1.24 < 1.3
      Per engineering judgment, the use of numerous conservative assumptions, and the existing condition of the dam, we feel that a factor of safety of 1.24 for this load condition is sufficient. All other factors of safety are greater than 1.3.
    - Bearing – Course 5B controlled with σ_{max} = 1.32 ksf. < 2.0 ksf.

AECOM

Job: Sippo Dam	Project No.	Page ___ of ___	
		Sheet 1 of 13	
Description: Conclusion	Computed by: CRG	Date: 5/15/17	
	Checked by: MRW	Date: 5/31/17	
		Reference	

Calculations:

- See Excel for Calculations of each Check for each Condition along each course

Results:

Condition 2:

Overturning - all resultants in middle 1/3 B
Sliding - Course 5 (A) Controls FS = 1.87 *
BRG - Course 5 (B) Controls σ_{max} = 1.25 ksf

Condition 3:

Over - all resultants within middle 1/3 B
Sliding - Course 5 (A) Controls FS = 1.87
BRG - Course 5 (B) Controls σ_{max} = 1.39 ksf

Condition 6:

Over - all resultants within Base
Sliding - Course 5 (A) Controls FS = 1.23 *

BRG - Course 5 (B) Controls σ_{max} = 1.32 ksf

* Numerous conservative assumptions were made throughout the analysis, therefore we feel that 1.87 ≈ 2.00
1.23 ≈ 1.30
are acceptable factors of safety for the existing structure

AECOM

Job: Sippo Dam | Project No. 60439145 | Page ___ of ___ | Sheet 2 of 13

Description: Dam Structural Eval. | Computed by: CRG | Date: 5/8/17

Checked by: MRW | Date: 5/31/17

Reference

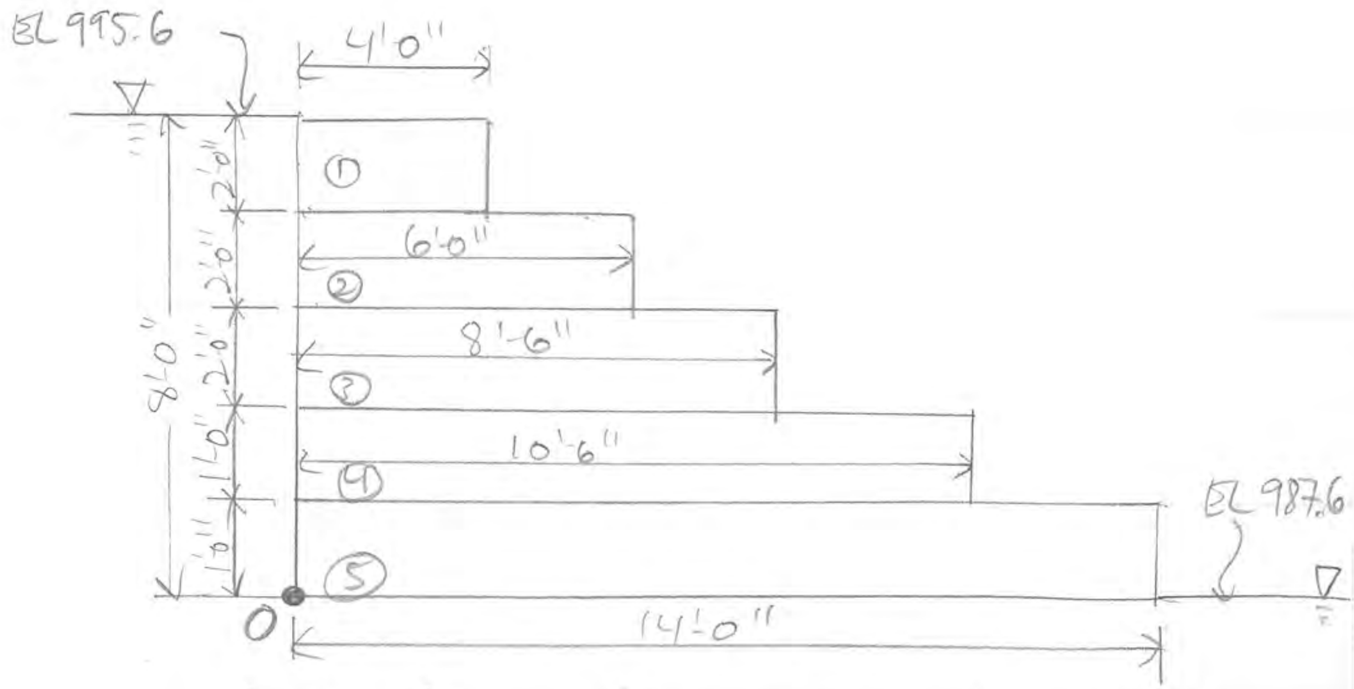
- ODNR / City of Massillon have decided to remove 4 courses from existing Sippo Reservoir Dam to lower headwater
- Conduct following checks for each Condition
  - → Overturning
  - → Sliding
  - → Bearing
- Check following Conditions for each Course
  - → Usual Loading
  - → Unusual (100-YR Flood)
  - → Extreme (Earthquake - MCE)

References:

1) Army Corps of Engineers Gravity Dam Design Manual, June 30 1995 (COE) (EM-1110-2-2200)
2) AASHTO LRFD 2014 7th Edition w/ 2016 Interims
3) Site visit Field Measurements
4) Army COE Earthquake Eval Manual (5/31/16) ER-1110-2-1806

Note: each check for each condition must be completed for each course of the Dam

Dam Dimensions: Taken from field measurements on both sides of existing dam and averaged. Assume existing Dam has a vertical back to reservoir (conservative assumption, usually would be symmetrical but w/ no plans and existing silt backfill, it is not possible to confirm symmetry)



Ave. Dam Crosssection (Figure 1)

Materials:

Stone Blocks	γ = 150 pcf
Silt / Backfill (Sat)	γ_{SAT} = 135 pcf
Water	γ = 62.4 pcf

Assumptions:
- Silt Backfill will Remain (no dredging)
- Dam cutoff walls do not prevent drainage
- Foundation rests on soil
- No mortar / Continuity between blocks

AECOM

Job: Sippo Dam | Project No. | Page ___ of ___
Description: Loads | Computed by: CRG | Sheet 4 of 13
| Checked by: MEW | Date: 5/8/17
| | Date: 5/31/17
Reference

Loads Consitered for Evaluation: *Note: each course consitered independently*

See Ecel for actual calculations
All loads considered on a per ft basis

Dead Load: $DL = \gamma h w$; Note: no earth DL consitered

Saturated Earth load:

- Assume no dredging behind the dam
- Assume $\gamma_{sat\ soil} = 135$ pcf (conservative)
- Assume $k_a = 0.33$

$$F_{eh} = k_a \gamma_{sat} \frac{h^2}{2}$$

$$M_{eh} = k_a \gamma_{sat} \frac{h^3}{6}$$

Uplift:

- Assume uplift acts btw normal headwater elev (h_1) and tailwater (h_2)

$$F_{up} = (h_1 - h_2)\gamma_{water} w/2$$

$$M_{up} = (h_1 - h_2)\gamma_{water} \frac{w^2}{6}$$

- Assume Uplift pressure only acts on bottom 2 courses

- During flood, assume dam is fully submerged so $F_{up} = h w \gamma_{water}$; $M_{up} = \frac{h w^2}{2} \gamma_{water}$

Flood: 100-YR Flood Elev = 1000.13

- Assume an additional column of water load acting on horizontal sat. earth load
- Assume no "wave" action because of silt buildup

Let $F_{eh+Flood} = k_a \gamma_{sat} \frac{h_2^2}{2} + h_1 \gamma_{water} h_2$

$M_{eh+Flood} = k_a \gamma_{sat} \frac{h_2^3}{2} + h_1 \gamma_{water} \frac{h_2^2}{2}$

Note: Add $h_1 \gamma_{water}$ DL acting over dam for flood condition

Earthquake: Ref: EM-1110-2-1806 & AASHTO

Soil Site Class D per boring logs.
Zone 1 Low based on Seismic Maps (1806-Ap. C)

- Design using Response Spectrum (1806-App E)
  - See RS Attached

1) Dam:
- Assume rigid structure (fail in slipping)
- Design for MCE (Extreme)

$PGA = 0.080 = \alpha \quad \therefore \quad P_{EQ} = \alpha W$

2) Water: There is no reservoire behind the dam, just saturated earth. ∴ disregard water force on dam (active earth enough)

Load Conditions:

Per COE Considered Load Conditions: (Figure 4-1)

No. 2 - Normal operating
No. 3 - Unusual Flood (100-Yr)
No. 6 - Extreme EQ (MCE)

- Did not consider No. 5 bc. Flood controls Unusual
- Did not need to consider No. 7 Max. Prob. Flood bc $h_{Dam} < 10'$

- Considered 2-A with Uplift
  2-B without Uplift
  typ. all Conditions

Checks: (See COE Table 4-1)

Overturning Stability:

Resultant location $(e) = \frac{\Sigma \text{Moments}}{\Sigma \text{Vert. Forces}}$
See table 4-1 for acceptable locations

Sliding: $FS = \frac{T_F}{T} = \frac{N \tan\phi_f - cL^{\,0}}{\Sigma \text{ Horiz. Forces}} \geq$ See table 4-1

for stone/stone $\phi_f = 29°$
stone/soil $\phi_f = 25°$
$N = W_{Dam} - \text{Uplift}$
assume $c = 0$ for cohesionless soil.
assume no grout/mortar btw courses

Bearing: $q_{max} = \frac{P(1 + 6e)}{B}$

See table 4-1 for acceptable range.
note: e calculated from center, not edge

7/13
CHK: MRW 5/31/17

Table 4-1
Stability and stress criteria

Load Condition	Resultant Location at Base	Minimum Sliding FS	Foundation Bearing Pressure	Concrete Stress	
				Compressive	Tensile
Usual	Middle 1/3	2.0	≤ allowable	$0.3\ f'_c$	0
Unusual	Middle 1/2	1.7	≤ allowable	$0.5\ f'_c$	$0.6\ f_c'^{2/3}$
Extreme	Within base	1.3	≤ 1.33 × allowable	$0.9\ f'_c$	$1.5\ f_c'^{2/3}$

Note: f'_c is 1-year unconfined compressive strength of concrete. The sliding factors of safety (*FS*) are based on a comprehensive field investigation and testing program. Concrete allowable stresses are for static loading conditions.

$$Resultant\ location = \frac{\Sigma M}{\Sigma V} \qquad (4\text{-}1)$$

The methods for determining the lateral, vertical, and uplift forces are described in Chapter 3.

b. Criteria. When the resultant of all forces acting above any horizontal plane through a dam intersects that plane outside the middle third, a noncompression zone will result. The relationship between the base area in compression and the location of the resultant is shown in Figure 4-2. For usual loading conditions, it is generally required that the resultant along the plane of study remain within the middle third to maintain compressive stresses in the concrete. For unusual loading conditions, the resultant must remain within the middle half of the base. For the extreme load conditions, the resultant must remain sufficiently within the base to assure that base pressures are within prescribed limits.

4-6. Sliding Stability

a. General. The sliding stability is based on a factor of safety (*FS*) as a measure of determining the resistance of the structure against sliding. The multiple-wedge analysis is used for analyzing sliding along the base and within the foundation. For sliding of any surface within the structure and single planes of the base, the analysis will follow the single plane failure surface of analysis covered in paragraph 4-6*e*.

b. Definition of sliding factor of safety.

(1) The sliding *FS* is conceptually related to failure, the ratio of the shear strength (τ_F), and the applied shear stress (τ) along the failure planes of a test specimen according to Equation 4-2:

$$FS = \frac{\tau_F}{\tau} = \frac{(\sigma \tan \phi + c)}{\tau} \qquad (4\text{-}2)$$

where $\tau_F = \sigma \tan \phi + c$, according to the Mohr-Coulomb Failure Criterion (Figure 4-3). The sliding *FS* is applied to the material strength parameters in a manner that places the forces acting on the structure and rock wedges in sliding equilibrium.

(2) The sliding *FS* is defined as the ratio of the maximum resisting shear (T_F) and the applied shear (T) along the slip plane at service conditions:

$$FS = \frac{T_F}{T} = \frac{(N \tan \phi + cL)}{T} \qquad (4\text{-}3)$$

where

N = resultant of forces normal to the assumed sliding plane

ϕ = angle of internal friction

c = cohesion intercept

L = length of base in compression for a unit strip of dam

c. Basic concepts, assumptions, and simplifications.

(1) Limit equilibrium. Sliding stability is based on a limit equilibrium method. By this method, the shear force necessary to develop sliding equilibrium is determined for an assumed failure surface. A sliding mode of failure will occur along the presumed failure surface when the applied shear (T) exceeds the resisting shear (T_F).

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Calculated: CRG Date: 5/15/2017

Project: Sippo Dam

Checked: MRW Date: 5/30/2017

Title: Condition 2 - Usual Loading

Inputs:

headwater elev. =	995.6	tailwater elev. =	987.6
γ_{stone} =	0.15 kcf	$\phi_{f,\ rock\text{-}rock}$ =	29 deg
$\gamma_{sat\ soil}$ =	0.135 kcf	$\phi_{f,\ rock\text{-}soil}$ =	25 deg
γ_{water} =	0.0624 kcf	σ_{BRG} =	2 ksf
ka =	0.33		

Notes & Assumptions:

Moments taken about heel of dam.
Uplift assumes that headwater elevation = top of dam elevation & tailwater elevation = bottom of dam elevation.

Calculations:

	Input		Force and Moment Calculations								
	Block Width (ft)	Block Height (ft)	Dam Height (ft)	Block Weight (k/ft)	Dam Weight (k/ft)	DL Block Moment (k-ft/ft)	DL Dam Moment (k-ft/ft)	Sat Soil Horiz. Force (k/ft)	Sat Soil Mom (k-ft/ft)	Uplift (k/ft)	Uplift Moment (k-ft/ft)
Course 1	4	2	2	1.2	1.2	2.4	2.4	0.09	0.06	0.00	0.00
Course 2	6	2	4	1.8	3	5.4	7.8	0.36	0.48	0.00	0.00
Course 3	8.5	2	6	2.55	5.55	10.84	18.64	0.80	1.60	0.00	0.00
Course 4	10.5	1	7	1.58	7.13	8.27	26.91	1.09	2.55	2.29	8.03
Course 5	14	1	8	2.10	9.23	14.70	41.61	1.43	3.80	3.49	16.31

	Overturning Condition 2-A: Usual Condition with Uplift from Seepage							Sliding Condition 2-A			Bearing Condition 2-A		
	Sum Vertical with Uplift (k/ft)	Sum Moment with Uplift (k-ft/ft)	1/3 Base (ft)		Resultant (ft)		2/3 Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σ_u (ksf)		σ_{all} (ksf)
Course 4	4.83	21.43	3.50	<	4.43	<	7.00	1.09	2.68	2.45	0.67	<	2
Course 5	5.73	29.10	4.67	<	5.08	<	9.33	1.43	2.67	1.87	0.75	<	2

	Overturning Condition 2-B: Usual Condition without Uplift							Sliding Condition 2-B			Bearing Condition 2-B		
	Sum Vertical, No Uplift (k/ft)	Sum Moment, No Uplift (k-ft/ft)	1/3 Base (ft)		Resultant (ft)		2/3 Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σ_u (ksf)		σ_{all} (ksf)
Course 1	1.20	2.46	1.33	<	2.05	<	2.67	0.09	0.67	7.47	0.32	<	2
Course 2	3.00	8.28	2.00	<	2.76	<	4.00	0.36	1.66	4.67	0.62	<	2
Course 3	5.55	20.24	2.83	<	3.65	<	5.67	0.80	3.08	3.84	0.93	<	2
Course 4	7.13	29.45	3.50	<	4.13	<	7.00	1.09	3.95	3.62	1.11	<	2
Course 5	9.23	45.41	4.67	<	4.92	<	9.33	1.43	4.30	3.02	1.25	<	2

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Calculated: CRG Date: 5/15/2017

Project: Sippo Dam

Checked: MRW Date: 5/30/2017

Title: Condition 3 - Unusual Loading (100-yr Flood)

Inputs:

100 YR Flood Elev. =	1000.13	Normal Water Elev. =	995.6
headwater elev. =	1000.13	tailwater elev. =	997
γ_{stone} =	0.15 kcf	$\phi_{f, rock\text{-}rock}$ =	29 deg
$\gamma_{sat\ soil}$ =	0.135 kcf	$\phi_{f, rock\text{-}soil}$ =	25 deg
γ_{water} =	0.0624 kcf	σ_{BRG} =	2 ksf
ka =	0.33		

Notes & Assumptions:

Moments taken about heel of dam.
For vertical loading, uplift assumes full dam submersion. Assume dead load of water on dam equals 100 year flood - normal headwater.
For horizontal loading, flood water acts as a column of water (with no additional wave pressure) above usual conditions because of the silt build up.

Calculations:

	Input		Force and Moment Calculations										
	Block Width (ft)	Block Height (ft)	Dam Height (ft)	Block Weight (k/ft)	Dam Weight (k/ft)	DL Block Moment (k-ft/ft)	DL Dam Moment (k-ft/ft)	Flood & Soil Horiz. Force (k/ft)	Flood &Sat Soil Mom (k-ft/ft)	DL Flood Water (k/ft)	Mom. Flood Water (k/ft)	Uplift (k/ft)	Uplift Moment k-ft/ft
Course 1	4	2	2	1.2	1.2	2.4	2.4	0.44	0.42	1.13	2.26	0.50	1.00
Course 2	6	2	4	1.8	3	5.4	7.8	0.97	1.82	1.70	5.09	1.25	3.24
Course 3	8.5	2	6	2.55	5.55	10.84	18.64	1.60	4.38	2.40	10.21	2.31	7.75
Course 4	10.5	1	7	1.58	7.13	8.27	26.91	1.95	6.15	2.97	15.58	2.96	11.19
Course 5	14	1	8	2.10	9.23	14.70	41.61	2.33	8.29	3.96	27.70	3.84	17.31

	Overturning Condition 3-A: Unusual Condition with Uplift from Seepage							Sliding Condition 3-A			Bearing Condition 3-A		
	Sum Vertical with Uplift (k/ft)	Sum Moment with Uplift (k-ft/ft)	1/4 Base (ft)		Resultant (ft)		3/4 Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σu (ksf)		σ_{all} (ksf)
Course 1	1.83	4.09	1.00	<	2.23	<	3.00	0.44	1.02	2.31	0.62	<	2
Course 2	3.45	11.46	1.50	<	3.32	<	4.50	0.97	1.91	1.96	0.76	<	2
Course 3	5.64	25.47	2.13	<	4.51	<	6.38	1.60	3.13	1.95	0.79	<	2
Course 4	7.13	37.45	2.63	<	5.25	<	7.88	1.95	3.95	2.02	0.68	<	2
Course 5	9.34	60.29	3.50	<	6.45	<	10.50	2.33	4.36	1.87	0.82	<	2

	Overturning Condition 3-B: Unusual Condition without Uplift							Sliding Condition 3-B			Bearing Condition 3-B		
	Sum Vertical, No Uplift (k/ft)	Sum Moment, No Uplift (k-ft/ft)	1/4 Base (ft)		Resultant (ft)		3/4 Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σu (ksf)		σ_{all} (ksf)
Course 1	2.33	5.08	1.00	<	2.18	<	3.00	0.44	1.29	2.95	0.74	<	2
Course 2	4.70	14.71	1.50	<	3.13	<	4.50	0.97	2.60	2.68	0.89	<	2
Course 3	7.95	33.23	2.13	<	4.18	<	6.38	1.60	4.41	2.75	0.98	<	2
Course 4	10.09	48.64	2.63	<	4.82	<	7.88	1.95	5.59	2.86	1.20	<	2
Course 5	13.18	77.60	3.50	<	5.89	<	10.50	2.33	6.15	2.64	1.39	<	2

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AECOM

Calculated: CRG   Date: 5/15/2017

Project: Sippo Dam

Checked: MRW   Date: 5/30/2017

Title: Condition 6 - Extreme Condition (Earthquake)

Inputs:

headwater elev. =	995.6	tailwater elev. =	987.6
γ_{stone} =	0.15 kcf	$\phi_{f, rock-rock}$ =	29 deg
$\gamma_{sat\ soil}$ =	0.135 kcf	$\phi_{f, rock-soil}$ =	25 deg
γ_{water} =	0.0624 kcf	σ_{BRG} =	2 ksf
ka =	0.33	α =	0.08

Notes & Assumptions:

Moments taken about heel of dam.
Uplift assumes that headwater elevation = top of dam elevation & tailwater elevation = bottom of dam elevation.
Assume no saturated earth additional load due to earthquake, just EQ on dam.
Assumed rigid structure for response spectrum coefficient (T = 0).

Calculations:

	Input		Force and Moment Calculations											
	Block Width (ft)	Block Height (ft)	Dam Height (ft)	Block Weight (k/ft)	Dam Weight (k/ft)	DL Block Moment (k-ft/ft)	DL Dam Moment (k-ft/ft)	Sat Soil Horiz. Force (k/ft)	Sat Soil Mom (k-ft/ft)	Uplift (k/ft)	Uplift Moment (k-ft/ft)	Pex Dam (k/ft)	Mex Dam (k-ft/ft)
Course 1	4	2	2	1.2	1.2	2.4	2.4	0.09	0.06	0.00	0.00	0.10	0.10
Course 2	6	2	4	1.8	3	5.4	7.8	0.36	0.48	0.00	0.00	0.24	0.43
Course 3	8.5	2	6	2.55	5.55	10.84	18.64	0.80	1.60	0.00	0.00	0.44	1.12
Course 4	10.5	1	7	1.58	7.13	8.27	26.91	1.09	2.55	2.29	8.03	0.57	1.62
Course 5	14	1	8	2.10	9.23	14.7	41.61	1.43	3.80	3.49	16.31	0.74	2.28

	Overturning Condition 6-A: Extreme Condition with Possible Uplift from Seepage							Sliding Condition 6-A			Bearing Condition 6-A		
	Sum Vertical with Uplift (k/ft)	Sum Moment with Uplift (k-ft/ft)	Within Base (ft)		Resultant (ft)		Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σu (ksf)		$1.33\sigma_{all}$ (ksf)
Course 4	4.83	23.05	0.00	<	4.77	<	10.50	1.66	2.68	1.61	0.59	<	2.66
Course 5	5.73	31.38	0.00	<	5.48	<	14.00	2.16	2.67	1.24	0.68	<	2.66

	Overturning Condition 6-B: Extreme Condition without Uplift							Sliding Condition 6-B			Bearing Condition 6-B		
	Sum Vertical, No Uplift (k/ft)	Sum Moment, No Uplift (k-ft/ft)	Within Base (ft)		Resultant (ft)		Base (ft)	Ru (k/ft)	Rr (k/ft)	FS	σu (ksf)		$1.33\sigma_{all}$ (ksf)
Course 1	1.20	2.56	0.00	<	2.13	<	4.00	0.19	0.67	3.59	0.36	<	2.66
Course 2	3.00	8.71	0.00	<	2.90	<	6.00	0.60	1.66	2.79	0.55	<	2.66
Course 3	5.55	21.36	0.00	<	3.85	<	8.50	1.25	3.08	2.47	0.84	<	2.66
Course 4	7.13	31.08	0.00	<	4.36	<	10.50	1.66	3.95	2.38	1.02	<	2.66
Course 5	9.23	47.68	0.00	<	5.17	<	14.00	2.16	4.30	1.99	1.18	<	2.66

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CHK: MRW 5/31/17

APPENDIX B

Table B-1
HAZARD POTENTIAL CLASSIFICATION
FOR CIVIL WORKS PROJECTS

	Category[1]			
Hazard Potential Classification	Direct Loss of Life[2]	Lifeline Losses[3]	Property Losses[4]	Environmental Losses[5]
Low	None Expected	No disruption of services – repairs are cosmetic or rapidly repairable damage	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	None Expected	Disruption of essential facilities and access	Major or extensive public and private facilities	Major or extensive mitigation required or impossible to mitigate
High	Probable (one or more)	Disruption of critical facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

[1] Categories are based upon project performance and are not applicable to individual structures within a project.

[2] Loss of life potential based upon inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.

[3] Indirect threats to life caused by the interruption of lifeline services due to project failure or operation (*i.e.*, direct loss of (or access to) critical medical facilities).

[4] Direct economic impact of property damages to project facilities and downstream property and indirect economic impact due to loss of project services (*i.e.*, impact on navigation industry of the loss of a dam and navigation pool or impact upon a community of the loss of water or power supply).

[5] Environmental impact downstream caused by the incremental flood wave produced by the project failure beyond which would normally be expected for the magnitude flood event under which the failure occurred.

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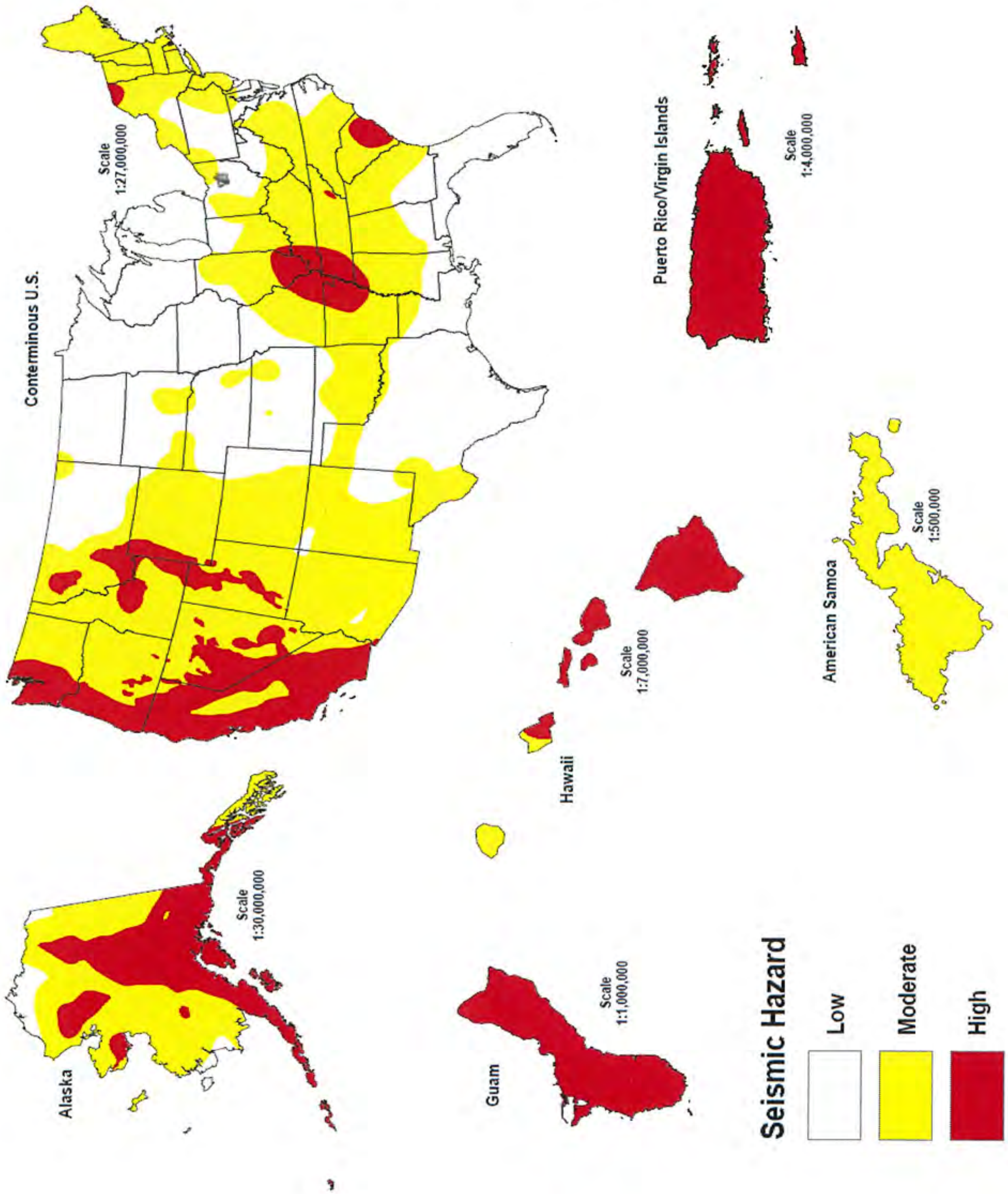
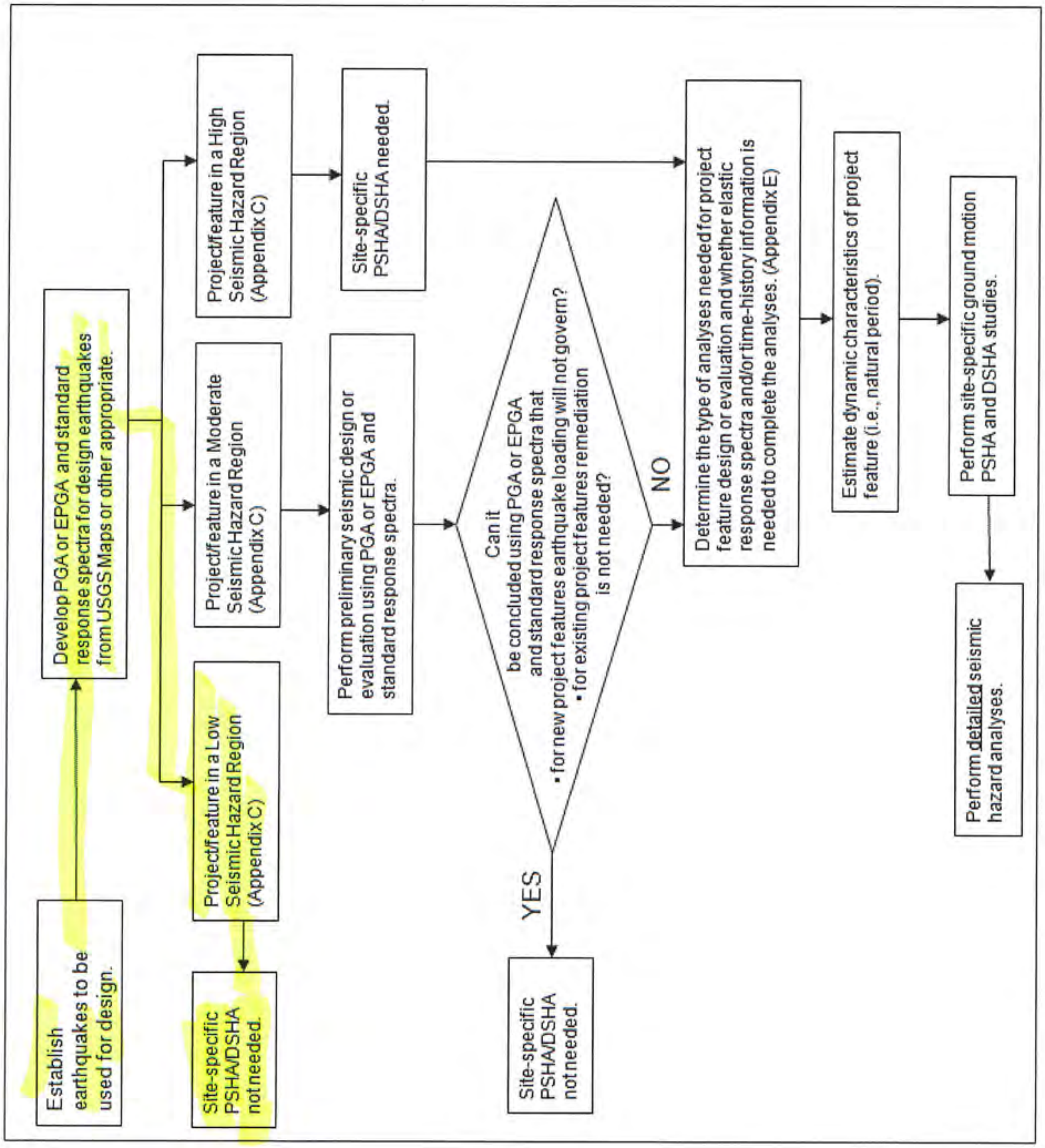
CHK: MEW 5/31/17

APPENDIX C
Seismic Hazard in USA
(Based on USGS maps of 2013)



APPENDIX D
Seismic Study- Flow Chart



Earthquake Appendix

CHK: MRW 5/31/17

APPENDIX E
PROGRESSIVE SEISMIC ANALYSIS REQUIREMENTS FOR CONCRETE AND STEEL HYDRAULIC STRUCTURES

Table E-1 shows the progression of seismic analyses required for each phase of project design. Additional guidance concerning these methods of analysis is provided in paragraphs 9e and 9g and in the references in Appendix A. The types of project seismic studies are described in paragraphs 6h and 11.

Table E-1
Seismic Analysis Progression

Seismic Hazard Region	Project Stage				
	Reconnaissance		Feasibility		PED[1]
Low	E	→	SCM	→	RS[2]
Moderate	E SCM[2]	→ →	SCM RS[2]	→ →	RS TH[3]
High	SCM RS[2]	→ →	RS TH[3]	→ →	RS[4] or TH TH[3]

Note:
- E = Experience of the structural design engineer
- SCM = Seismic coefficient method of analysis
- RS = Response spectrum analysis
- TH = Time-history analysis

[1] If the project proceeds directly from feasibility to plans and specifications stage, seismic design documentation must be required for all projects in high seismic hazard region and projects for which a TH analysis is required.
[2] Seismic loading condition controls design of an unprecedented structure or unusual configuration or adverse foundation conditions.
[3] Seismic loading controls the design requiring linear or nonlinear time-history analysis.
[4] RS should be used in high seismic hazard region for the feasibility and PED phases of project development only if it can be demonstrated that phenomena sensitive to frequency content (*i.e.*, soil structure interaction and structure-reservoir interaction) can be adequately modeled in an RS.

USGS Design Maps Summary Report

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User–Specified Input

Report Title Sippo Dam

Wed May 31, 2017 16:12:09 UTC

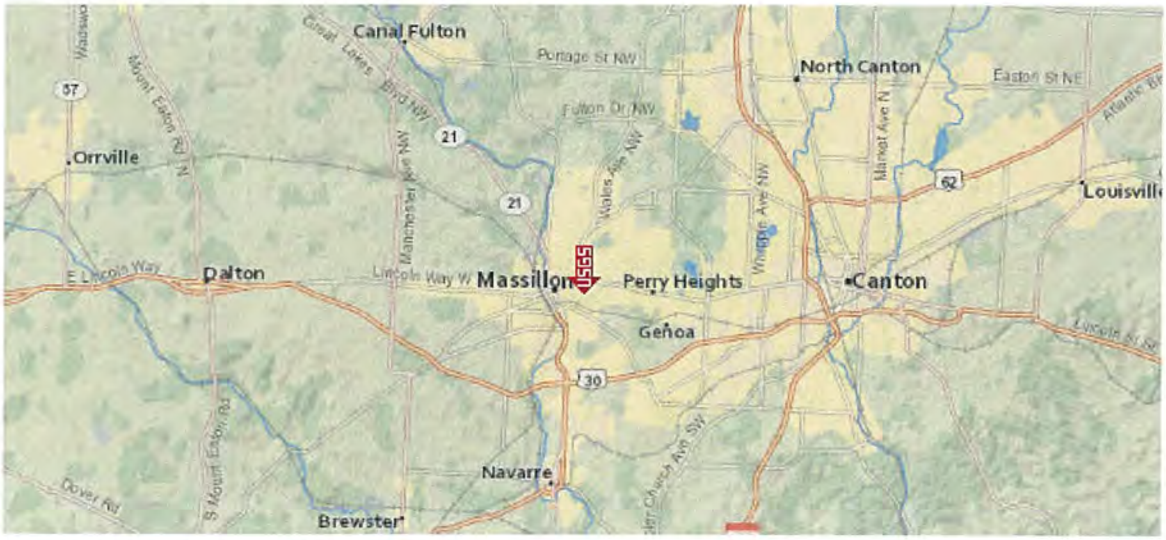
Building Code Reference Document 2009 NEHRP Recommended Seismic Provisions

(which utilizes USGS hazard data available in 2008)

Site Coordinates 40.80405°N, 81.50761°W

Site Soil Classification Site Class D – "Stiff Soil"

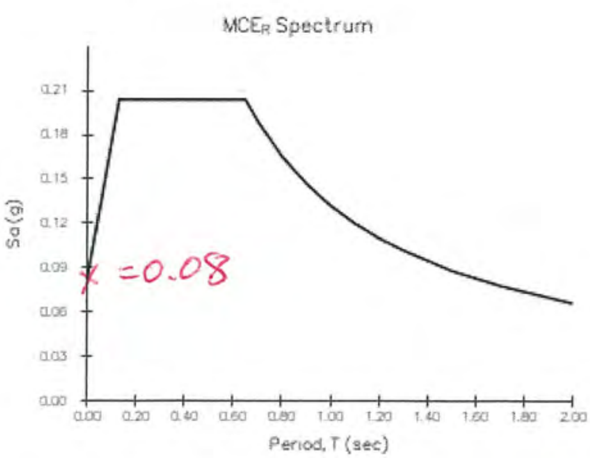
Risk Category I/II/III

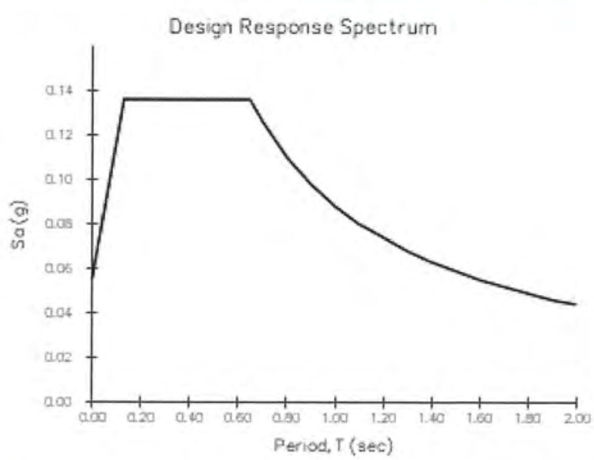


USGS–Provided Output

S_S =	0.128 g	S_{MS} =	0.204 g	S_{DS} =	0.136 g
S_1 =	0.055 g	S_{M1} =	0.132 g	S_{D1} =	0.088 g

For information on how the S_S and S_1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please view the detailed report.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Detailed Report

CHK: MRW 5/31/

2009 NEHRP Recommended Seismic Provisions (40.80405°N, 81.50761°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters and Risk Coefficients

Note: Ground motion values contoured on Figures 22-1, 2, 5, & 6 below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_{SUH} and S_{SD}) and 1.3 (to obtain S_{1UH} and S_{1D}). Maps in the Proposed 2015 NEHRP Provisions are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

Figure 22-1: Uniform-Hazard (2% in 50-Year) Ground Motions of 0.2-Second Spectral Response Acceleration (5% of Critical Damping), Site Class B

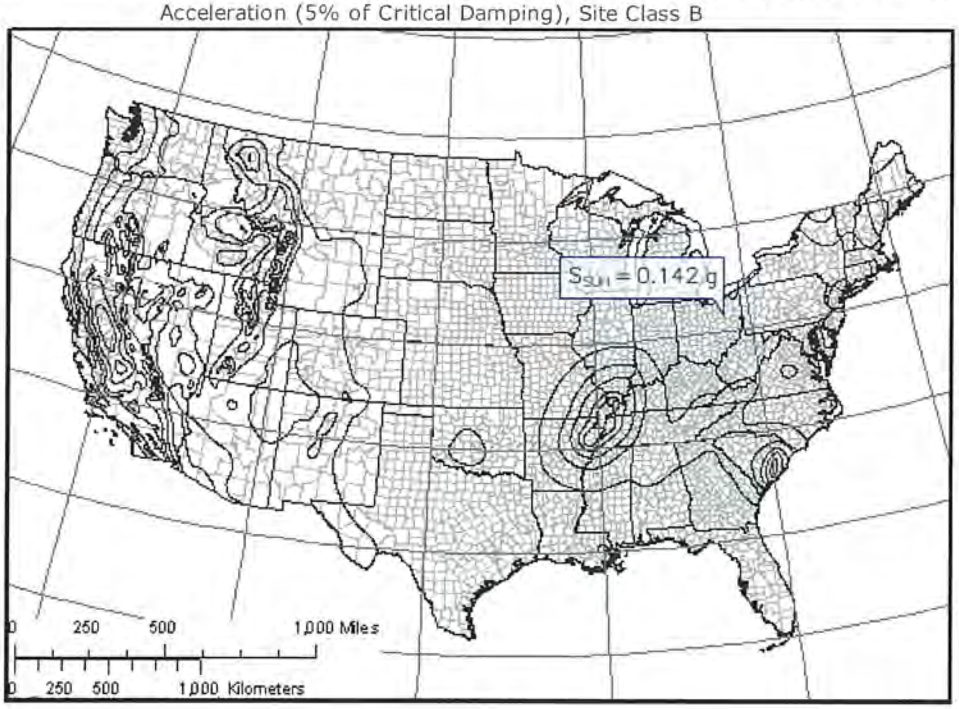
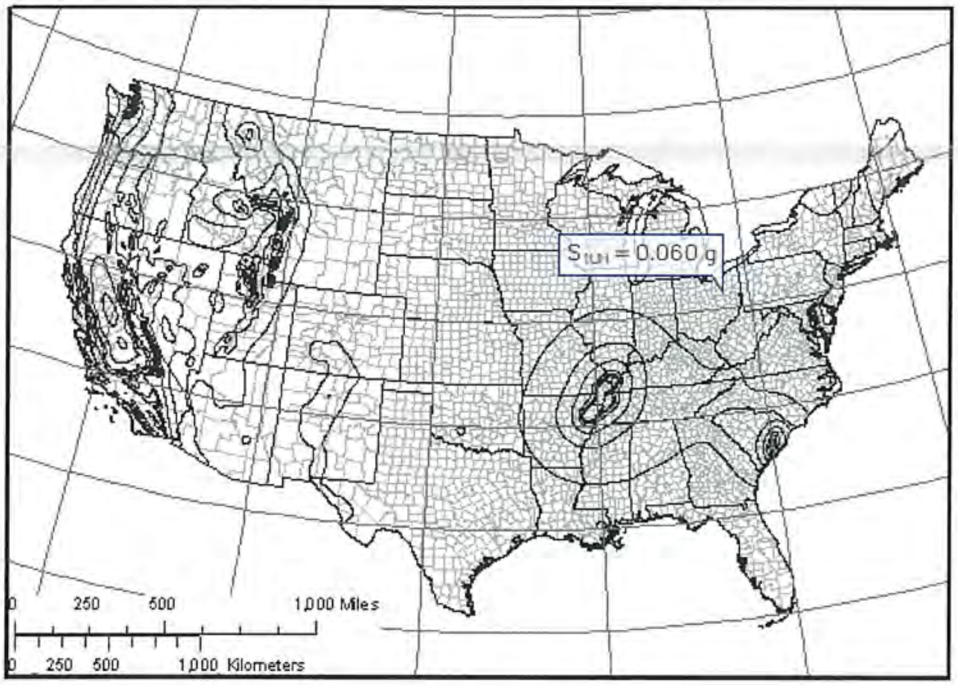


Figure 22-2: Uniform-Hazard (2% in 50-Year) Ground Motions of 1.0-Second Spectral Response Acceleration (5% of Critical Damping), Site Class B

CHK: MEW 5/31/17



CHK: MRW 5/31/17

Figure 22-3: Risk Coefficient at 0.2-Second Spectral Response Period

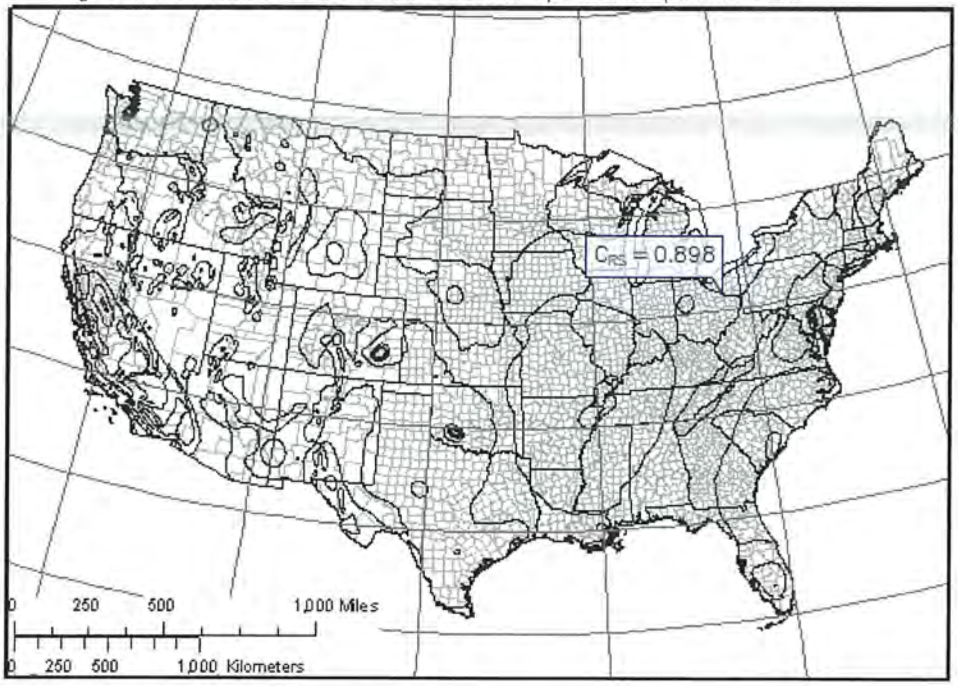
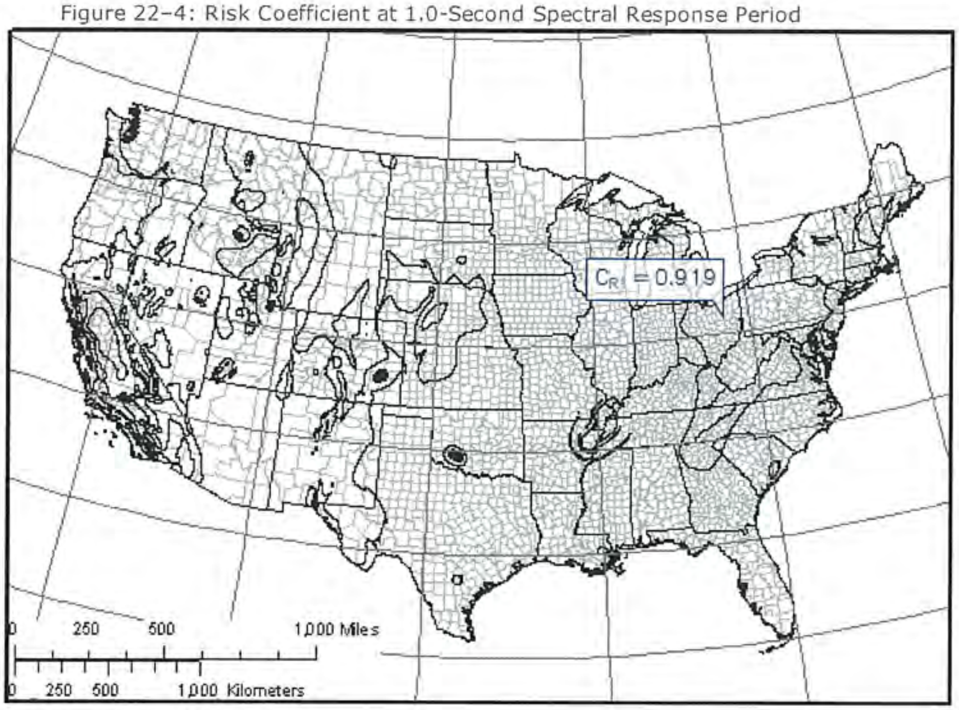


Figure 22-4: Risk Coefficient at 1.0-Second Spectral Response Period



CHK: MRW 5/31/17

Figure 22-5: Deterministic Ground Motions of 0.2-Second Spectral Response Acceleration (5% of Critical Damping), Site Class B

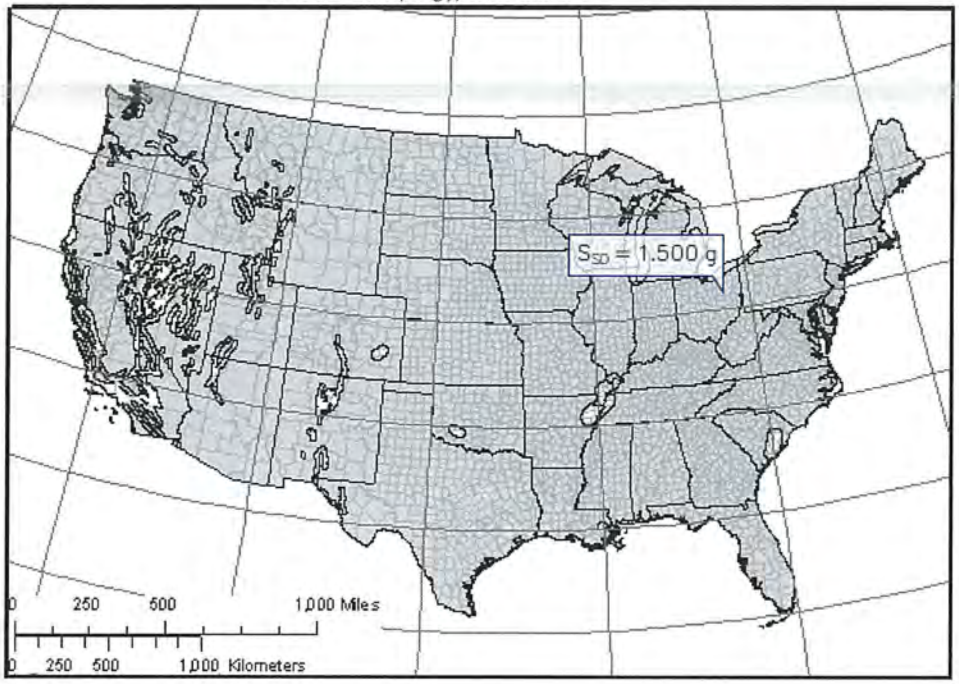
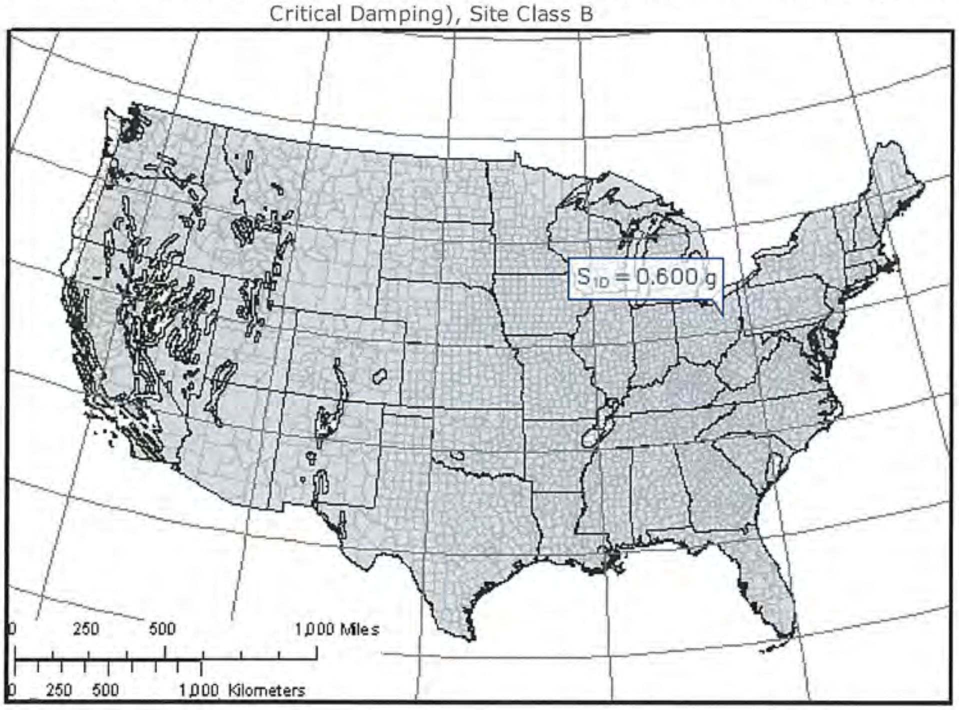


Figure 22-6: Deterministic Ground Motions of 1.0-Second Spectral Response Acceleration (5% of Critical Damping), Site Class B



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Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\overline{v}_S$	$\overline{N}$ or $\overline{N}_{ch}$	$\overline{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index $PI > 20$, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\overline{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients, Risk Coefficients, and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Equation (11.4–1): $C_{RS}S_{SUH} = 0.898 \times 0.142 = 0.128$ g

Equation (11.4–2): $S_{SD} = 1.500$ g

$S_S \equiv$ "Lesser of values from Equations (11.4–1) and (11.4–2)" = 0.128 g

Equation (11.4–3): $C_{R1}S_{1UH} = 0.919 \times 0.060 = 0.055$ g

Equation (11.4–4): $S_{1D} = 0.600$ g

$S_1 \equiv$ "Lesser of values from Equations (11.4–3) and (11.4–4)" = 0.055 g

CHK: MRW 5/31/17

Table 11.4-1: Site Coefficient F_a

Site Class	Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.128 g, F_a = 1.600

Table 11.4-2: Site Coefficient F_v

Site Class	Spectral Response Acceleration Parameter at 1-Second Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.055 g, F_v = 2.400

CHK: MRW 5/31/1

Equation (11.4-5): $S_{MS} = F_a S_S = 1.600 \times 0.128 = 0.204$ g

Equation (11.4-6): $S_{M1} = F_v S_1 = 2.400 \times 0.055 = 0.132$ g

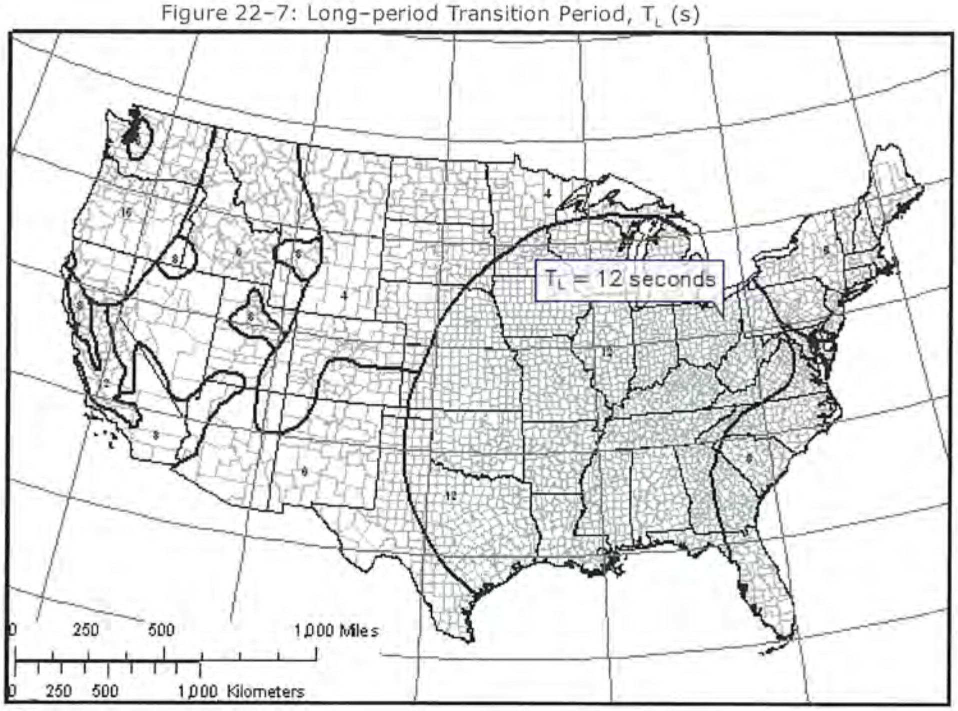
Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4-7): $S_{DS} = ⅔\, S_{MS} = ⅔ \times 0.204 = 0.136$ g

Equation (11.4-8): $S_{D1} = ⅔\, S_{M1} = ⅔ \times 0.132 = 0.088$ g

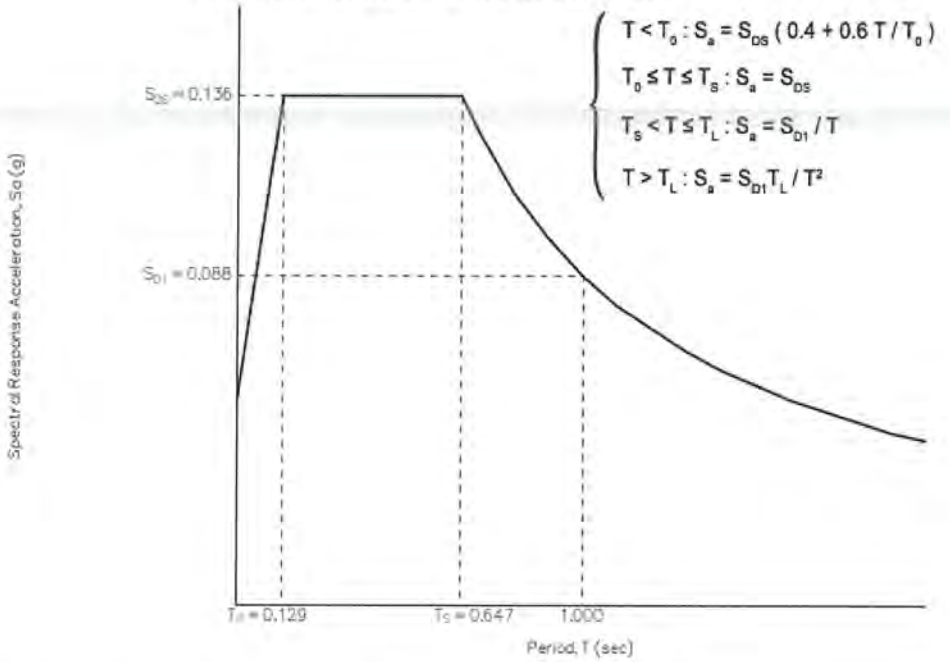
Section 11.4.5 — Design Response Spectrum

Figure 22-7: Long-period Transition Period, T_L (s)



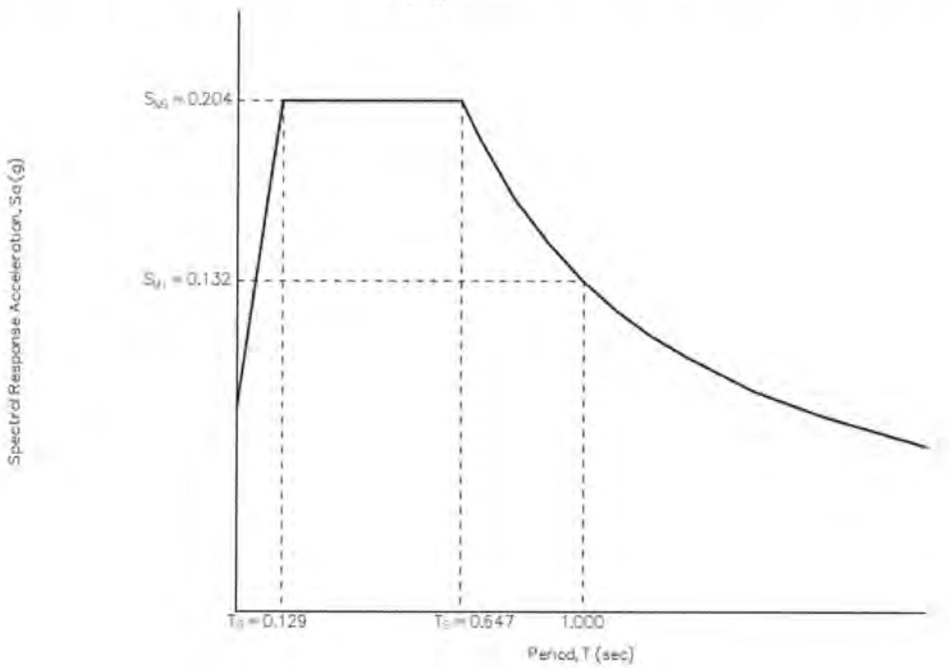
CHK: MEW 5/31/17

Figure 11.4-1: Design Response Spectrum



Section 11.4.6 — MCE_R Response Spectrum

The MCE_R response spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

CHK: MRW 5/31/1

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.063 g, F_{PGA} = 1.600

Mapped PGA PGA = 0.063 g

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.600 \times 0.063 = 0.101$ g

Appendix D Design Drawings (Attached)