PREPARED FOR:
THE TOWN OF WAYLAND CONSERVATION COMMISSION

DESIGN BASIS REPORT
SNAKE BROOK DAM

MA01119

WAYLAND, MASSACHUSETTS

PREPARED BY:

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PARE PROJECT NO. 19167.00

APRIL 2020

SNAKE BROOK DAM

DESIGN BASIS REPORT
WAYLAND, MASSACHUSETTS

April 2020

prepared for: Town of Wayland
Conservation Commission
41 Cochituate Road
Wayland, MA 01778

prepared by: Pare Corporation
10 Lincoln Road Suite 210
Foxboro, MA 02035

Authority

The Town of Wayland has retained Pare Corporation (Pare) to evaluate conditions of the Snake Brook Dam in Wayland, Massachusetts and to complete evaluations and develop a scope of work to address known deficiencies at the dam. This inspection, report, and evaluations were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws.

PREFACE

In accordance with our proposal, Pare Corporation (Pare) has completed preliminary evaluations and developed conceptual design approaches and alternatives for the Snake Brook Dam located in Wayland, Massachusetts and owned by the Town of Wayland (Town).

The intent of the completed evaluations sought to evaluate existing conditions at each of the components of the dam system, identify issues at each which would factor into the management program, and evaluate potential alternatives for the long-term management of each identified component.

The assessment of the condition of the dam is based upon available data, visual inspections, subsurface investigations, hydrologic and hydraulic studies, topographic surveys and stability analyses as well as supplemental information developed by others during previous evaluations of the dam.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team and other information collected as part of the evaluation.

It is critical to note that the condition of the dam is evolutionary in nature and depends on numerous and constantly changing internal and external conditions. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Allen R. Orsi, P.E.
Massachusetts License No.: 46904
Vice President
Pare Corporation

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1.0 BACKGROUND / EXISTING CONDITIONS

1.1 Snake Brook Dam

Location of the Project: Snake Brook Dam is located within Middlesex County in the Town of Wayland, Massachusetts. The dam impounds water along the Snake Brook to form the Old Wayland Reservoirs. The structure and impoundment are shown on the Wayland, Massachusetts USGS quadrangle map near coordinates 42.33425ºN/71.34166ºW. The dam is accessible through an easement at 68 Rice Road. The reservoir area is accessible from the dam as well as from the Hamlen Woods Conservation Area Lot, located west of Rice Road approximately 0.3 miles north of Woodridge Road. The dam is located at the southern end of the impoundment as indicated on Figure 1: Locus Plan.

Owner/Operator: The dam is currently owned by the Town of Wayland, Massachusetts. The Conservation Commission is responsible for operation and maintenance of the dam.

Table 1.1-1: Owner/Operator Information

	Dam Owner	Dam Caretaker
Name	Town of Wayland Conservation Commission	Linda Hansen Conservation Administrator
Mailing Address	41 Cochituate Road Wayland, MA 01778	41 Cochituate Road Wayland, Ma 01778
Daytime Phone	(508) 358-3669	(508) 3558-3669
Emergency Phone	911	911
Email Address	lhansen@wayland.ma.us	lhansen@wayland.ma.us

Purpose of Dam: The dam currently impounds water for recreational purposes. The dam was reportedly constructed as part of the municipal water supply system; however, it has not been used for that purpose in some time.

Description of the Dam: Snake Pond Dam (National ID MA01119/State ID 4-09-315-03) is an approximately 130-foot long, 25-foot high earthen embankment dam with a trapezoidal shaped bedrock channel in the right abutment serving as the spillway as well as several piping systems (18-inch diameter line, a 10-inch diameter water supply line, and an 18-inch waste line) associated with the former water supply system.

The following provides a detailed description of the dam based upon observations made during the inspection, previous Phase I Reports, and a review of the historical documents including the original design drawings from 1878 (included within Appendix G of this report).

- ***Dam Embankment:*** The dam has a maximum structure height of approximately 25 feet and a hydraulic height of approximately 23.5 feet. The crest of the dam is approximately 15 feet wide. The upstream and downstream slopes are each approximately 1.5 horizontal to 1 vertical (1.5H:1V). The upstream slope is protected with riprap/stone lined. The downstream slope is vegetated. Bedrock outcrops are present in areas between the downstream channel of the spillway and the downstream slope/area of the dam embankment. The design top of the dam is reported at El. 226 (converted from the 1978 plan datum to NAVD88).
  - ***Composition:*** Construction records indicate that the dam embankment has a stone masonry core wall, which extends from 0.5 feet above the normal pool elevation (El. 224.5) to the

base of the dam, which is reportedly bedrock for the entire length of the dam. A 4-foot thick clay blanket "PUDDLE" was constructed upstream of the masonry core wall, with the apparent intent of serving as the impermeable core of the dam; subsurface explorations completed as part of this project revealed that the "clay" blanket" is actually silt.. The depth to bedrock varied along the left to right alignment of the dam from outcrops near the dam crest level at the left and right abutments down as deep as El. 204 at its deepest section (in the vicinity of the outlet pipes. The remainder of the embankment (upstream and downstream of the core) is constructed of embankment fill (presumably random granular fill consisting of sands, gravel, and silts).

- ***Former Dam Embankment:*** According to the 1878 design drawing, a former dam embankment "Old Embankment" was in place under the downstream slope of the existing dam embankment and the new (existing) dam section was proposed on top of and upstream of the old section. The former dam embankment appeared to consist of a vertical stone masonry wall that supported the downstream face of an earthen embankment with an apparent crest elevation of El. 220± (6 feet below current design top of dam).

- ***Spillway:*** The spillway consists of a 10-foot-wide open channel, located approximately 50 feet northwest of the right abutment. A stone masonry "waste" weir was reportedly constructed at the upstream end of the spillway. A timber sluiceway and a siphon pipe installed to combat deposition of beaver debris currently act as regulating structures for the reservoir elevation. The upstream most portion of the spillway is in bedrock. The spillway channel downstream of the control is unlined with dry-laid stone masonry walls and passes through a 6-foot wide stone culvert near the right end of the dam. The downstream channel consists of a steep bedrock and boulder lined trapezoidal channel along the right downstream groin of the dam.

- ***Water Supply Components:*** The former water supply system at the dam consists of several components including the following:
  1) An upstream filter gallery collection system along the east (left) side of the reservoir with several intake lines that extend from the center of the impoundment to the left shoreline.
  2) A 10-inch diameter cast iron water supply intake line that extends from the filter well of the filter gallery along the left shore of the impoundment, along the pond bottom, through the dam embankment, and through the right upstream corner of the gatehouse structure.
  3) An 18-inch diameter cast iron conduit that extends from the upstream stone masonry wall at the upstream toe of the upstream slope of the dam, through the embankment, and through the right upstream corner of the gatehouse structure. The 18-inch line is supported on five stone piers along its alignment that all appear to extend down to bedrock.
  4) A stone masonry gatehouse structure that houses the components of the former pumping system of the former water supply system. The pumping system (which reportedly was put into operation during periods of necessary fire protection that required higher pressure within the 10-inch water supply distribution line) includes a series of valves and a former turbine that are situated between the 10-inch and 18-inch intake lines located at the upstream right corner and the sole 10-inch water supply distribution line that leaves the downstream left corner of the gatehouse (See #5 below). The bottom of the gatehouse is vertically irregular and appears to consist of bedrock.
  5) A 10-inch diameter water supply distribution line that extends from the downstream left corner of the gatehouse to the downstream area.
  6) A stone masonry "waste" culvert that extends from the base of the downstream right corner of the gatehouse to the downstream channel. The culvert measures at 1.5-foot wide by 2-

foot high at its upstream end at the gatehouse and 3-foot square at its downstream end at the downstream channel.

The flow through the piping within the gatehouse from the 18-inch and 10-inch intakes is controlled by valves; however, the operability of these valves is unknown at this time, and are presumably inoperable given apparent age and observed condition. The turbine is no longer present, and the system is no longer used for water supply. In the past, the gatehouse piping has reportedly been used as a low-level outlet (LLO) to lower the reservoir level by discharges to the gatehouse, through the stone culvert, and into the brook.

- ***Waste Pipe System:*** According to the 1907 plans, there is "waste" pipe system located along the right (West) shoreline of the impoundment. According to the plan it is controlled at the upstream end via a gate valve within an intake manhole and then flow is conveyed from the manhole to the spillway downstream channel via an 18-inch diameter. This structure has not been located as part of the ongoing evaluations.

Elevations: The following are pertinent elevations of the dam obtained from as-built drawings, previous Phase I Reports, as well as the detailed survey completed by Bay Colony Group, Inc. and several data collection visits completed by Pare as part of this project. Elevations presented below reference the NAVD 88 datum.

DAM	
Top of Dam	El. 226.0
Top of Core Wall	El. 225.0
Normal Pool	El. 224.5
Upstream Water during Inspection	El. 225.2
WATER SUPPLY PIPING	
18-inch Pipe	
Invert In	El. 210.5
Invert (At Gatehouse)	El. 206.1
10-inch Pipe	
Invert In	Various Intake along shoreline
Invert (At Gatehouse)	El. 208.3
Gatehouse Base	El. 207 to El. 200 (Variable Bedrock)
Stone Culvert Invert In / Out	El. 202 ±
WASTE PIPE	
Invert In	El. 221.5 (3 feet below NP)
Invert Out	El. 218.5 ±

Size Classification: Snake Brook Dam has a maximum structural height of approximately 25 feet and a estimated maximum storage capacity of 55 acre-feet (previously reported as 150 acre-feet). Therefore, in accordance with Department of Conservation and Recreation Office of Dam Safety classification, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00, Snake Brook Dam is an **Intermediate** sized structure.

Hazard Potential Classification: Snake Brook Dam is located in a residential area of Wayland, MA. Woodridge Road and Rice Road are located downstream of the dam. There are several residences in the area immediately downstream of the dam. The Loker Elementary School is located approximately 0.4 mile downstream of the dam at an elevation below the normal pool level of the impoundment.

As such, it appears that a failure of the dam at maximum pool may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities. Therefore, in accordance with Department of Conservation and Recreation classification procedures, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00, Snake Brook Dam is classified as a **Class II (Significant)** hazard potential structure.

Inspections/Current Conditions: As part of this project, a visual inspection of the dam was completed in October 2019 and an underwater inspection of the low level outlet was completed on December 6, 2019. In general, Snake Brook Dam was found to be in **Fair** condition, similar to the condition stated in a previous Phase I Reports. The deficiencies observed at the Snake Brook Dam include:

1. Routine beaver activity / accumulated debris issues at the spillway often causing elevated pool levels, limited freeboard during normal operations, and restricted discharge capacity.
2. Inoperable low level outlet system and therefore no means of implementing a drawdown of the impoundment nor means of providing supplemental outlet capacity beyond the beaver/debris plagued primary spillway channel.
3. Steep and irregular downstream slope.
4. Areas of apparent sinkholes/vertical irregularities within the downstream area in the vicinity of the alignment of both the water supply distribution line and the stone culvert. Unknown if related to soil loss/settlement issues along either conduit alignment.
5. Areas of scarping along the water line along the upstream slope.
6. As determined as part of this project, inadequate discharge capacity to accommodate the spillway Design Flood (SDF), which for this dam is the 100-year storm event.
7. Areas of overgrown tree and brush vegetation along the dam embankment.
8. Gatehouse deficiencies including collapsed roof, inoperable door, and no safe access to mechanical equipment.
9. Sediment/leaf accumulation up to 1-foot above the level of the 18-inch conduit within the impoundment.
10. No Emergency Action Plan or Operations and Maintenance Plan

1.2 File Review

As part of this work, Pare completed a review of available files made available by both the Town and MADCR-ODS. The following is a list of the historical information that was made available by the Town and the MADCR that proved to be the highest value in the current project. This is a partial list and does not include all files and correspondence pertaining to the dam:

Table 1.1: Historical Data Available at the Town of Wayland and the MADCR

Historical Information	Date	Description
Reservoir and Land of the Wayland Waterworks	1878	Original design drawings, full details of dam, water supply components, filter gallery, and bathymetry of Upper and Lower Reservoirs
Wayland Water Works Location of Reservoirs, Dams, Proposed Filter, and Waste Pipe	1907	Full Plan view of US system/reservoir with details of filter gallery and waste pipe
Haley & Aldrich Phase I Inspection Report	1999	Phase I Inspection Report
GZA Phase I Inspection Report	2012	Phase I Inspection Report
Haley & Aldrich Phase I Inspection Report	2017	Phase I Inspection Report

2.0 EXISTING CONDITIONS REVIEW

2.1 Data Collection

The following inspections and data collection tasks were performed at the dam in support of this project:

- On October 25, 2019, a visual inspection and a preliminary survey were completed at the Snake Brook Dam to review conditions of the dam in support of the conceptual design alternatives. The preliminary survey collected relative elevations to support the H&H analysis, slope stability, and seepage analysis completed as part of this conceptual design report. The preliminary survey also included limited pond depth survey completed within the impoundment.

- A subsurface exploration program was completed between October 31 and November 1, 2019 along the dam embankment to collect existing subsurface conditions. Information collected during this investigation was utilized in the slope stability and seepage analysis of the embankment and a summary of findings is included within this report.

- A dive inspection was completed on December 6, 2019 to inspect the low-level outlet portion of the gatehouse that has not been accessible during the past inspection.

- A wetland delineation within the vicinity of the dam was completed on November 6, 2019 by Pare.

- An underwater / ROV inspection of the water supply components was completed by Inner Tech Marine Services and Mobile Robotics (with support and coordination from Pare) on December 6, 2019

- Detailed survey of the dam was completed by Bay Colony Group, Inc. (with support and coordination from Pare) on January 17, 2020.

2.2 Pond Depth Survey

Data and bathymetric surveys were completed in the impoundment to verify the depth of the reservoir as depicted within the 1878 original design plans. In general, the pond depth measurements were in agreement with the bathymetric contours provided within the 1878 plans; as such, these bathymetry contours were used to develop the below water portion of the existing conditions surface. Some very loose leaf and organic sediment debris is present in the impoundment bottom which was encountered during the underwater inspection. The depth of sedimentation in the area of the 18-inch intake line was estimated at approximately 4 feet (1 foot above the invert in of the 18-inch pipe, which according to the historical bathymetry contours and sections, is 4 feet above the pond bottom in that area)

2.3 Subsurface Exploration Program

A subsurface investigation was completed at the dam by Soil X Corp. of Leominster, Massachusetts and observed by Pare personnel from October 31 to November 1, 2019. The purpose of this subsurface investigation was to explore, confirm, and characterize the subsurface soil and groundwater conditions and to determine engineering soil properties for use within seepage and slope stability models of the existing embankment.

A total of three (3) test borings (B19-1, B19-2, and B19-3) were completed at the dam with one groundwater observation well installed within B19-2. The boring locations are shown on Sheet 2.0: Existing Conditions Plan. Boring logs are included in Appendix F: Seepage and Slope Stability Analysis.

Table 2.1: Surface Exploration Program Summary

Boring ID	Location	Depth (feet)
B19-1	Dam Crest; Upstream side, right of the gatehouse	26.5
B19-2 (OW)	Dam Crest; Downstream side, right of the gatehouse	14.0
B19-3	Left of the spillway channel culvert	12.5

An observation well was installed in boring B19-2 at a depth of approximately 14 feet below the ground surface. The well consists of 10 feet of screen pipe and approximately 8 feet of riser pipe. Sand was placed around the pipe from 14 feet deep to 4 feet deep, follow by ½ foot of bentonite chips. From a depth of 3.5 feet to the ground surface, the well was backfilled with gravel and 4 feet of standpipe was installed.

Findings: Subsurface profile collected during this investigation identified similar soil subsurface as presented in the historic plan. Approximately 4 inches of TOPSOIL was encountered in all borings.
The following describes the subsurface soil profile in each boring:

- B19-1 consists of approximately 2 feet of medium dense FILL, overlying 14.3 feet of very loose to loose PUDDLED FILL, overlying SANDSTONE bedrock.
- B19-2 consists of 10 feet of loose to medium dense EMBANKMENT FILL, overlying approximately 1.5 feet of SILT, overlying approximately 1 foot of very dense SAND & GRAVEL, overlying presumed SANDSTONE bedrock.
- B19-3 consists of 5 feet of very dense SAND & GRAVEL, overlying SANDSTONE bedrock.

EMBANKMENT FILL was encountered within B19-1 and B19-2. Within B19-1. EMBANKMENT FILL was approximately 2 feet thick and is described as medium dense, black to brown, fine to coarse gravel and fine to coarse sand, trace silt, trace organics. Within B19-2. EMBANKMENT FILL is generally described as medium dense, gray to brown, fine to coarse sand, and fine to coarse gravel, “little” to “and” amount of fine to coarse sand, “trace” silt, and “trace” organics.

PUDDLED FILL was encountered within B19-1. PUDDLE FILL is generally described as very loose to loose, gray to black silt, with “little” to “and” amount of fine to coarse sand, “trace” to “little” amount of fine to coarse gravel, and “trace” organics.

SAND & GRAVEL was encountered within B19-3. SAND & GRAVEL is generally described as white to tan, fine to coarse gravel, “some” medium to coarse sand, “little” fine sand, “trace” silt.

SANDSTONE BEDROCK was encountered within B19-1 and B19-3, as determined by rock coring. Refusal in boring B19-2 was likely due to bedrock being encountered. Based upon a visual inspection of the rock core samples obtained from B19-1 and B19-3, bedrock consists of moderately strong to strong, gray, fine to medium SANDSTONE, interlaminated with Quartz, moderately weathered to fresh. The rock core samples were characterized as “very poor” to “good” using the Rock Quality Designation (RQD) value. As summary of rock core depth, length, and RQD is presented in Table 2.2.

Table 2.2: Rock Core Summary

Boring No.	Approximate Depth (ft)	Length (ft)	Recovery (%)	RQD (%)
B19-1	16.5 – 21.5	5.0	100	67
B19-1	21.5 – 26.5	5.0	100	82
B19-3	5.5 – 7.5	2.0	100	0
B19-3	7.5 – 10.5	3.0	100	39
B19-3	10.5 – 12.5	2.0	100	71

Liquefaction: The liquefaction review completed during the seepage and slope stability analysis considers the soil and groundwater conditions encountered during the subsurface exploration indicated that the in-situ soils do not appear to be susceptible to liquefaction at this time.

2.4 Underwater Inspection

An underwater inspection was completed on December 6, 2019 by Inner Tech Marine Services, LLC of Warwick, RI. The scope of the inspection was to locate and evaluate the current condition of the water supply components with a focus on assessing their potential use for low level outlet capability. The components inspected included the 18-inch intake pipe, the interior of the gatehouse, and the stone discharge culvert from the gatehouse to the downstream channel. The findings of the inspection along with video documentation are included within the underwater inspection report, prepared by Inner Tech Marine Service and Mobile Robotics, both of which are included within appendix C.

The following presents the general findings of the inspections:

- Underwater Dive Inspection:
  - The alignment and details of the water supply systems appear to be in agreement with the 1878 design plans, indicating that most if not all of the system had been installed per plan and little to no modifications have occurred since their original construction.
  - Due to 1-foot of leaf and sediment debris build up within the inlet end of the 18-inch pipe, the visibility within the area resulting from the stirred up sediment did not allow for a video inspection.
  - No trash rack was found at the upstream end of the pipe.
  - The 10-inch water supply intake pipe was found above the 18-inch outlet pipe and extending upstream with an alignment in general agreement with the plans.
  - The vertical stone wall located at the upstream end of the dam and 18-inch outlet pipe was felt by the Inner Tech Diver, although visual confirmation of the wall and condition of the wall was not possible due to the sedimentation.
- Gatehouse Interior Inspection
  - Only access to the base of the structure with all the components was via a 15-foot ladder. No signs of the original gatehouse floor, aside for possible fallen timbers and debris within the lower levels, was apparent.
  - The floor of the gatehouse appeared to be bedrock generally sloping rather steeply from left to right (however, the right half was under several feet of iron oxide stained water and actual bedrock could not be verified).
  - All components, although rusted, appear to be intact and generally along the alignment shown on the original 1878 detail. All components appeared to be plumb and all connections appeared to be sound.

- It was unclear which valves were open and which were closed and therefore it was unclear which pipes had the full head pressure of the reservoir and which ones did not.
- The 18-inch line appeared to have been tapped and plugged in one location with an approximately ½-inch plug located shortly downstream of the first T in the 18-inch line.
- The 10-inch distribution line that extended through the left end of the downstream wall of the gatehouse appeared to be intact and may or may not be under full head pressure from the reservoir.
- The stone culvert appeared to be clear of major debris as the downstream channel daylight could be viewed from the upstream end at the gatehouse.
- The water level within the gatehouse appeared to be about equal to the water level within the downstream channel as the downstream end of the stone culvert, indicating that the source of the source of the water (or at least the main source of the water) within the gatehouse was backwater from the downstream channel through the stone culvert.
- The walls of the gatehouse appeared to be sound with no apparent deficiencies noted. The walls were generally saturated throughout. Iron oxide stained seepage was present at the base of the walls at the interface with the apparent bedrock foundation.

- Stone Culvert Inspection (From DS End)
  - Several still photos were taken with the ROV from the downstream end of the stone culvert looking upstream. The culvert was not traversed with the ROV due to turbidity limiting visibility and sediment/debris preventing suitable subgrade for equipment mobility.
  - It was noted that one of the roof stones of the culvert (approximately 10 feet upstream of the downstream end appeared lower than the rest and may be partially collapsed.

The findings of the inspection were utilized to detail the existing conditions of the low-level outlet included within the drawings, and to aid in the design development of providing low level outlet capability as well as general gatehouse improvements.

2.5 Wetland Delineation

Wetland resource areas in the vicinity of the Snake Pond Dam in Wayland were defined and delineated in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00, referred to as the WPA Regulations), and the methodology specified in the publications entitled Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act (Jackson, 1995) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: North Central and Northeast Region (U.S. Army Corps of Engineers, 2012). Inspection and delineation of wetlands were completed on November 6, 2019.

Wetland resource areas within the vicinity of the site include an earthen dam with an impounded pond upstream of the dam and Snake Brook outlets downstream of the dam.

According to the FEMA Flood Insurance Rate Map for the area (Map Number 25017C0529F, effective date July 7, 2014), the area is not located in a delineated Special Flood Hazard Area (SFHA). The downstream reaches of Snake Brook are located in a delineated SFHA stating at Thompson Street, located approximately 3,000 feet downstream of the dam and approximately 40 feet lower in elevation that the downstream toe of the dam.

According to the most recent available MassGIS data, no certified or potential vernal pools, Areas of Critical Environmental Concern, Outstanding Resource Waters, or mapped rare species habitats are located on or in the vicinity of the site.

A detailed description of the delineation and resource areas are included in Appendix D.

3.0 HYDROLOGIC & HYDRAULIC ANALYSIS

3.1 Background

The Snake Brook Dam is currently classified as an Intermediate size, Significant (Class II) hazard potential structure; as such, the spillway design flood (SDF) for the site is the 100-year flood (100-yr).

3.2 Previous Analysis

Based on the limited H&H analyses completed as part of the 1999 Phase I inspection report prepared by Haley & Aldrich, Inc., the 100-year peak inflow was estimated at 165 cfs and the maximum spillway capacity was estimated as 167 cfs. Therefore, the report concluded that the current spillway appears to have enough capacity to pass the SDF without overtopping the dam. No backup calculations were provided and the level of detail of these calculations is not known.

3.3 Current Analysis

As part of the current evaluation, GIS processing, LiDAR mapping, site specific data collection, and previous reports were utilized to perform an updated, detailed hydrologic and hydraulic analysis (H&H). All elevations reported within this analysis are in NAVD88.

3.3.1 Rainfall

Rainfall: The rainfall depth values and distribution curves for recurrent storm events (1-year through 1,000-year) were obtained from the NOAA Atlas 14 and were imported directly into HydroCAD Version 10.1-3a software. The table below presents the total rainfall depth value for each recurrent storm event.

Table 3.1: 24-hour Mean Precipitation Frequency Estimates

Return Interval	NOAA Atlas 14 (in.)
1-year	2.7
2-year	3.3
5-year	4.3
10-year	5.1
25-year	6.3
50-year	7.1
100-year (SDF)	8.1
200-year	9.3
500-year	11.1
1,000-year	12.7

Note that this rainfall data, although it is believed to be the best available and is consistent with industry standards, does not explicitly take into account any potential future effects of climate change. Currently, there are no specific design guidelines to account for climate change. Additionally, to Pare's knowledge, there is no specific requirement to do within applicable design regulations. As such, Pare recommends that design of repairs consider future rainfall increases and incorporate some degree of conservatism to provide for resilient designs. Such conservative measures may include designing to a higher rainfall recurrence event such as the 500-year event or increasing the amount of freeboard provided by the selected repair approach.

3.3.2 Hydrologic Methodology – General

A rainfall-runoff model was developed in HydroCAD (Version 10.10-3a) using TR-55 Curve Number (CN) methodologies, the Soil Conservation Service (SCS) TR-20 runoff method, and the Natural Resources Conservation Service (NRCS) Unit Hydrograph (UH) and time of concentration methodologies.

The NRCS UH method utilizes a best-approximate hydrograph based on the gamma equation (peak rate factor) that is scaled by the time lag to produce the unit hydrograph for the simulation. The lag is defined as the length of time between the centroid precipitation mass and the peak flow of the resulting hydrograph. The lag is a function of the time of concentration Tc, which was calculated for each watershed utilizing the segmental method (i.e. sheet flow, shallow concentrated flow, channel flow, etc.)

The CN represents the portion of the precipitation depth that will lead to runoff, and is a function of soil type (Hydrologic Soil Groups A through D) and land/ground cover (i.e. impervious surfaces (pavement, water, etc.; forests; grass) within the drainage area. An area with a high CN value (e.g., 98 for pavement/water surface, 90 for developed areas in Soil Group D, etc., 80 for forested wetlands in soil groups B) will have low water retention and a high runoff value while a low CN (e.g., 30 for a wooded area with permeable soils) indicates high infiltration and low runoff volume. The composite curve number (CN) used in the model of each watershed is an average CN value weighted by the percent area of each contributing land cover and soil type in the watershed. To develop the CN, ArcGIS software was used to join GIS based NRCS Soil Survey data layers and MassGIS based Land Cover data layers into a single data layer with discrete areas of unique soil groups and land cover data. A CN Look-Up table specific for Massachusetts and references NRCS TR 55 CN values was used to assign a CN value for each unique soil group and land cover area. The composite CN utilized for each a single watershed or sub-watersheds is an area-weighted average of the CN values contained within the limits of the drainage area. The following table presents a tabulated explanation of the CN and its meaning:

Table 3.2: Curve Number Tabulated Explanation.

Curve Number (CN) - Tabulated Explanation				
COLOR RAMP	**CN Value**	**Perviousness General Category**	**Percent of Rainfall Absorbed (Range)**	**Land Cover (LSG) Type and Subsoil Hydrologic Soil Group (A,B,C,D)**
	30-40	Extremely Pervious	75% - 65%	GOOD LC in A Soils;
	40-50	Very Pervious	65% - 55%	FAIR LC in A Soils; GOOD LC in B Soils
	50-60	Pervious	55% - 45%	FAIR-POOR LC in A Soils; 'GOOD-FAIR LC in B Soils
	60-70	Moderately Pervious	45% - 35%	GOOD-FAIR LC in B Soils; GOOD LC in C Soils
	70-80	Less Pervious	35% - 25%	Poor LC in A Soils; 'GOOD LC in C-D Soils
	80-90	Semi-Impervious	25% - 15%	FAIR-POOR LC in C-D Soils; 'GOOD LC in D Soils
	98	Impervious	8%	IMPERVIOUS LC in All Soils

NOTES:

1. ***CN Definition*** : The runoff curve number (RCN), also refereed to as the curve number (CN) is an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess.

2. Table developed utilizing NRCS TR55 Tables 2-2a through 2-2d

3. Land Cover Types (LC)

GOOD	Forests, Brush, Pasture, Grassed Areas (Golf Course, Lawn); All with good vegetation coverage (>75% ground cover)
FAIR	All of GOOD only with Fair (50-75%) or Poor (<50%) Coverage, Residential Districts with lot sizes larger than 1/2 acre, Cultivated Agricultural Fields,
POOR	Urban districts, Gravel and Dirt Roads
IMPERVIOI	Paved Areas (Roads, Parking Lots, Driveways), Roofs, Surface Water (Ponds, Rivers)

4. Hydrologic Soil Groups (HSG's):

A	Soils with low runoff potential and high infiltration rates (deep well to excessively drained sands or gravels)
B	Soils with moderate infiltration rate (moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures)
C	Soils with low infiltration rates (soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure)
D	Soils with very low infiltration rates (clay soils with a high swelling potential, soils with a permanent high water table (wetlands), soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material)

3.3.3 Hydrologic Parameters – Snake Brook Dam Watershed

To complete the hydrologic analysis, the drainage area for the watershed was delineated utilizing USGS Streamstats with manual adjustments made to the drainage area perimeter utilizing LiDAR data and site reconnaissance.

As shown within the HydroCAD Reports provided as an Appendix to this report, the upstream contributing drainage area to the Snake Brook impoundment was separated into two subbasins as identified within the table below.

Table 3.3: Snake Brook Dam Drainage Areas - Hydrologic Parameters

DA ID	Description	Size		% Impervious	CN	Tc (hrs)	Peak Runoff (cfs)	
		Acres	Sq. mi				10-yr	100-yr
DA 1	Eastern portion of DA leading to a trail crossing off of Rice Road	287	0.44	3	57	5.2	50	125
DA 2	Western portion of the DA leading to the dam that controls the upper reservoir	223	0.35	2	50	4.7	30	80
Totals at Snake Brook Dam		***510***	***0.80***	**-**	**-**	**-**	***65***	***205***

Based upon observed conditions at the site and a review of LiDAR terrain data, the likelihood of a tailwater developing downstream of the dam that would result in limiting the outlet capacity of the dam is unlikely, primarily due to the steep downstream channel. As such, downstream drainage areas and hydraulic structures (i.e. roadways crossings, dams, etc.) were not included in the modelling of Snake Brook Dam and free discharge conditions was assumed at the dam.

These parameters were developed based upon existing land cover and do not take into account the potential for future development within the drainage areas. Should future development occur within either subbasin area, these analyses should be revised accordingly to assess the impact that the development has on the runoff to the Snake Brook impoundment and hydraulic results at the dam. Ideally, development within the drainage areas would be controlled in a manner to force all development to be constructed in such a way that the hydrologic conditions within the drainage area are noe changed (i.e. through stormwater detention ponds to offset the impact of the development).

Alternative to implementing development limitations, hydrologic and hydraulic analyses utilized for design could consider maximum build-out conditions based upon current zoning regulations.

3.3.4 Hydrology Model Results and Calibration Check

No FEMA analyses, detailed H&H analyses, or stream gauge data in the vicinity of the dam was available to use for calibration. As such, the hydrology calibration check was completed utilizing statewide peak flow regression equations that are readily available through the USGS Stream Stats program[1]. The tabulated summary below presents the results of the hydrologic model (peak inflow and outflow into/from the Snake Brook impoundment) compared with the range of peak flows predicted for a drainage area of this

[1] Zarriello, P.J., 2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 54 p., https://doi.org/10.3133/sir20165156

size (and other characteristics) utilizing statewide regression equations.

Table 3.4: Calibration Summary

	10– year (CFS)	50– year (CFS)	100 – year (CFS)	500 – year (CFS)
Model Peak Inflow	65	155	205	345
Model Peak Outflow	60	150	195	345
Regression Range	30 - 140	50 - 240	60 - 300	80 - 430

Based on a comparison between the model results and the predicted range of peak flows estimated through statewide regression equations, the model appears to be within the predicted range of peak flows for most of the storm events evaluated.

3.3.5 Hydraulic Parameters – Existing Conditions

The hydraulic structures that were included within the model included the following from Upstream to Downstream:

1. Stream Crossing Through Trail off of Rice Road (Contributing DA: DA 1): Earthen trail embankment with a 4-foot± wide trapezoidal channel
   a. Storage Characteristics
      i. Pond Bottom El. 223 0 acre-feet
      ii. Normal Pool El. 225.4 2 acre-feet
      iii. Top of Trail El. 226.5 3 acre-feet
   b. Hydraulic Structures
      i. Control Elevation El. 225.4 (Estimated from LiDAR)
      ii. Top of Trail El. 226.5 (LiDAR)

2. Upstream Dam (Contributing DA: DA 2): Earthen dam embankment with a 4-foot± wide trapezoidal channel
   a. Storage Characteristics
      i. Pond Bottom El. 221 0 acre-feet
      ii. Normal Pool El. 225.5 12 acre-feet
      iii. Top of Dam El. 227 20 acre-feet
   b. Hydraulic Structures
      i. Control Elevation El. 225.5 (Estimated from LiDAR)
      ii. Top of Dam El. 227.0 (LiDAR)

3. Snake Brook Dam (Contributing DA: DA 2): Earthen dam embankment with a 4-foot± wide trapezoidal channel
   a. Storage Characteristics
      i. Pond Bottom El. 206.5 0 acre-feet
      ii. Normal Pool El. 224.5 30 acre-feet
      iii. Current Design TOD El. 226 40 acre-feet
      iv. Proposed Design TOD El. 228 58 acre-feet
   b. Hydraulic Structures

i. Spillway Channel El. 224.5 (Survey)
ii. TOD Current (Min) El. 225.5 (Survey)
iii. Proposed Design TOD El. 228 (Survey)

3.3.6 Existing Conditions Model Results

Upon completion of the H&H analyses of the existing conditions, it was determined that the current dam system with a spillway fully cleared of debris and flowing freely (which is not the current condition with the apparent beaver debris and past beaver deceiver devices, all of which are significantly reducing the current hydraulic capacity of the spillway) is predicted to overtop during storm events in excess of the 2-year storm events (3.3 inches of rain / 24 hours). In addition, during the SDF (100-year storm event), the entire dam overtops between 0.5 and 1.2 feet, which would likely cause dam failure.

3.3.7 Conceptual Hydraulic Improvements

Given the findings of completed H&H evaluations, significant hydraulic improvements are necessary to allow the dam to accommodate the SDF. Design constraints considered in developing the conceptual design approach include maintaining similar peak discharges during storm events, limiting the horizontal extent of the required rehabilitation program, a limiting the overall cost of the modifications. Given these constraints, a dam raise was identified as the most practical approach.

The conceptual improvement program includes raise the crest of the dam raise to EL. 228.0 (2 feet above current design top of dam and 2.5 feet above current low point of dam crest). At this elevation, assuming that the spillway remains clear of debris, it is predicted that the dam will be able to accommodate the 100-year storm event with 3 inches of freeboard remaining at the dam with no operation of the low level outlet required. Additional freeboard could be provided if the low level outlet system (once rehabilitated as part of this project) is operated in advance of and/or during the storm event.

3.3.8 Tabulated Summary of H&H Model Results

The following presents the model results at the Snake Brook Dam under a variety of storm events for both existing conditions and with the proposed hydraulic improvements (i.e. dam raise to El. 228):

Table 3.5: H&H Model Results Summary

Storm Event	Existing Conditions			Conceptual Condition (Dam Raise to El. 228)		
	Outflow (cfs)	WSEL (ft)	FB (ft)	Outflow (cfs)	WSEL (ft)	FB (ft)
10-year	60	226.0	- 0.5	60	226.3	1.7
50-year	150	226.6	- 1.1	135	227.3	0.7
100-year	195	226.7	- 1.2	175	227.8	0.2

3.3.9 Implications of Conceptual Conditions

Raising the dam crest to El. 228 will effectively provide a dam capable of accommodating the spillway design flood event, reducing the potential for overtopping and subsequent failure. However, the dam raise will result in higher pool levels within the impoundment as evident from the table (50-year pool is 0.7 feet higher and 100-year pool is 1.1 feet higher).

- Based upon a limited review of the impoundment perimeter, the elevated pool levels do not appear to have a negative impact on any structures or infrastructure.

- This elevated pool level will also result in a slightly larger storage volume being retained by the dam, which could result in an increased inundation footprint and larger dam breach in the event that the dam does fail during a time when the pool level is elevated. This should be taken into account when developing the EAP as part of this project.

4.0 SEEPAGE AND SLOPE STABILITY EVALUATIONS

4.1 Background

The embankment slopes of the Snake Brook Dam are steeper (1.5H:1V) than what is typically recommended for earthen embankment dams. The upstream slope was not visible during inspection due to the reservoir level at the time of the inspection. The downstream slope is covered with dense vegetation and dead tree stumps. However, no indication of immediate seepage or embankment instability were noted during previous reports or the current inspection.

4.2 Previous Analysis

No previous seepage and slope stability analyses were available for the Snake Brook Dam during the review and preparation of this design report.

4.3 Current Analysis

Seepage and slope stability analysis were completed for the embankment of the Snake Brook Dam as part of this project. Historic drawings and site data collection completed as part of this study were used to develop the cross section of the dam embankment that was used for the analyses.

A detailed description of the methodology and results of the calculations performed for existing conditions as well as for recommendation for repairs are included within the seepage and slope stability calculation package included within the Appendices of this report. The following is a brief summary of the methodology, results, and recommendations.

Data collected as part of the subsurface exploration program and data survey were utilized to develop a worst-case cross section for the dam embankment. GeoStudio Seep/W and Slope/W software was utilized to develop finite element models to assess the seepage and slope stability of the embankment.

The dam embankment was analyzed for three loading conditions (Case I: Steady State, Case II: Rapid Drawdown, and Case III: Seismic) as specified within the Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00.

Geotechnical calculations were employed to develop engineering properties for the soil layers in support of the seepage and stability analysis and to assess liquefaction potential of the soil layers. The following table summarizes the soil properties developed based on the subsurface investigation:

Table 4.1 Soil Properties of Existing and Conceptual Embankment Materials

Soil Layer	(N_{ave}) (Blows/ft)	D_r (%)	Angle of Internal Friction (º)	Dry Unit Weight (pcf)	Sat. Unit Weight (pcf	Porosity Saturated Water Content	Saturated Hydraulic Conductivity (ft/sec)	Residual Water Content
Embankment Fill	17	60	34	109	131	0.19	1.64E-5	0.035
Engineered Fill	N/A	85	38	140	150	0.19	1.2E-5	0.035
Puddle Fill (Silt)	5	50	29	87	117	0.47	1.2E-7	0.1
Sand & Gravel	60	90	42	119	137	0.21	1.2E-5	0.035
Riprap	N/A	N/A	43	N/A	150	0.12	8.2E-4	0.01
Rock Core Wall	N/A	N/A	N/A	N/A	160	0.15	0.1	0.035
Rock Upstream Wall	N/A	N/A	N/A	N/A	160	0.1	3.28E-12	0.035
Sandstone	N/A	N/A	N/A	N/A	N/A	0.05	3.28E-12	N/A

4.3.1 Seepage and Slope Stability Analysis (Existing Conditions)

The following elevations were utilized in the model:

- Top of dam: El. 226 ft
- Top of core wall: El. 225.5 ft
- Normal pool: El. 224.5 ft
- Maximum pool: El. 226 ft

The following table presents the results of the models for the existing dam:

Table 4.2: Existing Condition Slope Stability Factor of Safety (FOS)

Design Case	Pool Level	Upstream slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	**1.1**
	Maximum Pool	N/A	N/A	1.4	**1.0**
Rapid Drawdown	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1

Bold values indicate calculated factors of safety lower than the recommended minimum factors of safety.

Based on these results, the downstream slope of the dam embankment did not meet the minimum required factors of safety during both normal and maximum pool steady state conditions. Improvements are necessary to meet the minimum required factor of safety and prevent the dam from failure.

The results of the seepage analysis did not indicate any seepage related concerns.

4.3.2 Seepage and Slope Stability (Conceptual Conditions)

The following elevations were utilized in the model:

- Top of dam: El. 228 ft
- Top of core wall: El. 227.5 ft
- Normal pool: El. 224.5 ft
- Maximum pool: El. 227.5 ft

Raising of the dam crest and flattening of the downstream slope to 2H:1V was assumed to be completed utilizing imported “Engineered Fill”, which consists of a well graded sand and gravel with 10% silt content.

The following table presents the results of the conceptual conditions for the dam:

Table 4.3: Conceptual Condition Factor of Safety (FOS)

Design Case	Pool Level	Upstream slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Drawdown	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.3	N/A	N/A

Seismic	Normal Pool	>1.0	1.0	>1.0	1.3

Bold values indicate calculated factors of safety lower than the recommended minimum factors of safety.

Based on these results, the conceptual embankment improvements (i.e. regrading the downstream slope, raising the top of dam to El. 228, and raising the top of the core wall to El. 227.5) results in all factors of safety for slope stability being met or exceeded.

The results of the seepage analysis did not indicate any seepage related concerns.

5.0 REPAIR APPROACH ALTERNATIVES

5.1 Project Approach Alternatives

As part of this project, Pare developed the following design basis level repair approach alternatives to address the noted deficiencies at the Snake Brook Dam. Two alternatives were developed. Alternative I is a rehabilitation alternative (recommended alternative) that involves implementing repairs at the dam in order to rehabilitee the dam structure to meet all dam safety requirements. Alternative II is to remove the dam and restore the site to a natural stream channel.

The scope of Alternative I: Rehabilitation would generally include the following; detailed descriptions and design approach options are provided in Section 5.2.

a. Embankment Work:
    i. Raise Core Wall to El. 227.5 (2 feet above existing)
    ii. Raise dam crest to El. 228.0 (0.5 to 2.5 feet above existing)
    iii. Regrade downstream slope to 2H:1V (of flatter if desired by the Town)
    iv. Establish maintainable grass vegetation throughout site
b. Spillway Improvements
    i. Remove beaver debris and previous beaver deceiver devices
    ii. Install new control weir
    iii. Install new beaver deceiver/deterrence devices
c. Establish Low Level Outlet Capabilities
    i. Install Upstream Low-Level Outlet Control System
    ii. Slip Lining Existing 18-inch Low-Level Outlet
    iii. Establishing a restored outlet conduit
    iv. Addressing other gatehouse concerns
d. Establish Mid Level Outlet Capabilities
    i. Complete improvements/modifications to the existing 18-inch diameter “waste line” to restore its ability to provide mid-level outlet capabilities as both a beaver deterrent action as well as a simpler means of implementing routine 3-foot drawdowns of the impoundment.

The scope of Alternative II: Removal would generally include the following; detailed descriptions are provided in Section 5.3.

The scope of the removal alternative would generally include:

e. Address Downstream Impacts:
    i. Complete hydraulic modelling to determine the extent of increased inundation expected as the result of loss of attenuation provided by the current dam.
    ii. Coordinate with FEMA as required to evaluate and determine the necessary actions needed to address increased downstream flooding resulting from dam removal
    iii. Implement flood mitigation improvements to downstream infrastructure as needed.
    iv. Implement improvements to the upstream dam and/or remove the upstream dam if determined to be negatively affected by the removal of the tailwater created by the Snake Brook Dam.
f. Sediment Removal:
    i. Remove sediment within the impoundment if needed to prevent downstream migration post dam removal.
g. Remove Dam:

i. Excavate the dam embankment in the area of the low level outlet to restore the site to a natural stream channel.

5.2 Alternative I: Rehabilitation

5.2.1 Embankment Work

The scope of embankment improvements conceptually would include:

i. **Raise the Core Wall to El. 227.5:** The peak predicted pool level during the SDF is approximately EL. 227.8. To limit the potential for concentrated seepage flow over the current top of the core wall (El. 225) it is recommended to raise the top of the core wall to El. 227.5. To complete this, it is anticipated that the crest will be excavated down to expose the top of the existing core wall and the core wall will be extended through mortared stone masonry or reinforced concrete construction.

ii. **Raise the Dam Crest:** Raise the dam crest to El. 228 as shown on the attached drawings. To achieve tie into the abutment, the following work is anticipated:

   a. Left Abutment: Extend the embankment approximately 10-feet into the abutment to match elevated grade at the steep left abutment slope.
   b. Right Abutment: Extend the embankment; given the flatter topography, this extension will be on the order of 170 feet in a non-linear alignment. Two potential alignments were identified including 1) Across the spillway channel culvert, upstream along the right side of the channel, and to the right abutment, and 2) Upstream through the upland between the spillway and dam, through the spillway alignment, and to the right abutment. Conceptually, the second alignment is preferred as it is anticipated to require less imported fill material and reduce impacts to areas not disturbed as part of other anticipated site work.

iii. **Regrade Downstream Slope:** Regrade the downstream slope to a more maintainable slope, 2H:1V, or flatter if desired by the Town. Some minor modifications to the slope, such as low retaining walls, may be needed in the area of the gatehouse.

iv. **Grass Establishment:** Establish a maintainable surface coverage within the limits of the embankment, expected to primarily be maintainable grass.

5.2.2 Spillway Improvements

The scope of spillway improvements conceptually would include:

i. **Remove Debris and Previous Beaver Deceivers:** Remove all current debris and previous beaver deceive devices down to the bedrock channel.

ii. **Install Control Weir:** Remove bedrock and existing stone masonry walls to subgrade for the new control weir. Install the new cast-in-place concrete control weir. Reconstruct the disturbed sections of the training walls.

iii. **Install Beaver Deceiver Device:** Install a new beaver deceiver / deterrent device upstream of the spillway as well as several bypass pipes through the new spillway control weir. Several alternatives are presented within the drawings.

5.2.3 Low Level Outlet Restoration

Based on the result of the dive inspection performed to locate the low-level outlet, the low-level outlet is inaccessible and covered with sediment. The operation of the outlet is unknown. Pare recommends a new low-level outlet system upstream of the gatehouse with the following alternatives:

5.2.3.1 Upstream Control

Install control system at the upstream end of the 18-inch outlet pipe to restore low level outlet capabilities and also to eliminate the charged line through the embankment. Three alternatives were developed during this design basis report and include the following:

Alternative 1: Concrete wall and slide gate control system

- Extend the upstream end of the 18-inch conduit to the location of a new concrete headwall
- Construct a new concrete headwall with an 18-inch slide gate mounted to the upstream face.
- Install a catwalk to provide access to the slide gate operating nut.
- Provide security devices to prevent unauthorized operation of the gate.

Alternative 2: Valve control system with sloping stem along the upstream slope

- Install a valve at the upstream end of the 18-inch pipe.
- Equip the valve with a stem that is installed along and is secured to the riprap along the upstream slope.
- Provide security devices to prevent unauthorized operation of the gate.

Alternative 3: Valve control system with vertical stem and steel frame tie back

- Install a valve at the upstream end of the 18-inch pipe
- Equip the valve with a vertical stem that is supported with a vertical steel frame system
- Install a vertical steel frame support system with tie backs to the upstream slope as needed for support.
- Install a catwalk to provide access to the valve
- Provide security devices to prevent unauthorized operation of the gate.

5.2.3.2 Conduit Improvement Program

The 18-inch outlet line that extends from the upstream toe of the embankment to the gatehouse was not able to be inspected due to debris and sediment within the conduit. As such, its condition is unknown. However, the exterior of the pipe as viewed from the gatehouse interior appears sound and may also be indicative of the interior. At a minimum, the pipe will likely be sound enough to facilitate a lining system. The lining alternatives identified are:

- A cure-in-place pipe (CIPP) epoxy resin type system that is applied to the interior of the existing conduit.
- A smaller new conduit (i.e. 14-inch diameter HDPE pipe) that is installed within the existing conduit and the annulus between the two pipes filled with a non-erodible fill (i.e. cementitious grout)

In addition to slip lining the 18-inch line, it is recommended to abandon the 10-inch water supply intake line through the installation of cementitious fill.

5.2.3.3 Restore Outlet Culvert

Establish a restored outlet conduit from the downstream end of the 18-inch outlet pipe to the downstream channel. Three alternatives were developed during this design basis report and include the following:

Alternative 1: Open Cut Replacement

- Cut the 18-inch pipe at the gatehouse.
- Extend the 18-inch conduit through the downstream wall of the gatehouse and through the downstream area to the downstream channel. To facilitate replacement, an open cut excavation of the area downstream of the gatehouse will be required.
  - The open cut could extend down to the level of the existing store culvert to facilitate the removal of that culvert as part of the work.
  - Alternatively, the existing stone culvert could be abandoned in place through installation of a non-erodible backfill (i.e. cementitious grout)
- Install a new headwall at the downstream end of the conduit at the downstream channel.

Alternative 2: Slip Line Stone Culvert

- Cut the 18-inch pipe at the gatehouse.
- Extend the 18-inch line with two vertical bends along its alignment to the entrance of the existing stone culvert.
- Extend the 18-inch line through the existing stone culvert through sliplining procedures. (Dependent on the stone culvert's ability to accept the 18-inch (or smaller if needed) line.
- Fill voids between the pipe and the culvert with a non-erodible fill (i.e. cementitious grout).
- Install a new headwall at the downstream end of the conduit at the downstream channel.

Alternative 3: Extended 18-inch conduit to existing stone culvert

This would likely represent the most cost effective alternative; however, it is dependent on the existing stone culvert being in suitable enough condition to function through the project design life subject to routine flows from the low level outlet system.

- Cut the 18-inch pipe at the gatehouse.
- Extend the 18-inch line with two vertical bends along its alignment to the entrance of the existing stone culvert
- Provide a concrete bulkhead at this connection to prevent backwater flow into the gatehouse.

5.2.3.4 Gatehouse Improvements:

Complete improvements at the gatehouse structure inclusive of:

- Remove and salvage (if desired by the Town) unused components. While all components could be removed, removal could also be limited to sections which interfer with proposed structures.
- Backfill the base of the structure up to the level of the new outlet conduit.

- Provide secondary closure (i.e. valve) along the 18-inch line.
- Plug the 10-inch water supply distribution line at the downstream left corner of the gatehouse.
- Establishing access to the base of the structure, either through a ladder or fabricated stair system.
- Establishing a floor both at the exterior ground level (operating deck) and at the base of the structure.

In addition to these modifications, work within the gatehouse could also include modification of the low level outlet pipe to include a vertical riser to an elevation equal to normal pool elevation. At this level, a control weir could be constructed to provide uncontrolled discharge capacity. While plausible, this approach would require additional modifications within the gatehouse due to potential interference with the gatehouse roof structure.

5.2.4 Establish Mid Level Outlet Capabilities

Complete improvements/modifications to the existing 18-inch diameter "waste line" to restore its ability to provide mid-level outlet capabilities as both a beaver deterrent action as well as a simpler means of implementing routine 3-foot drawdowns of the impoundment.

5.2.5 Incidental Work Items

The scope of work for the rehabilitation program is anticipated to include:

1) **General Requirements:** Complete work plans, submittals, project coordination, QA/QC testing, contract bonds, and other general requirement work items.

2) **Mobilization and Demobilization:** Mobilize equipment and material, establish staging and access areas, maintain site throughout construction, clean and restore site at project completion, demobilize.

3) **Erosion and Sediment Control:** Install and maintain erosion and sediment controls inclusive of straw bales, silt fence, turbidity barrier, and dewatering basins. Remove controls at project completion.

4) **Clearing and Grubbing:** Remove of trees and other unwanted vegetation along the length of the dam. Extent of clearing would include, at a minimum, to at least 20-feet beyond the limits of the existing and conceptual dam embankment alignment, along the downstream slope below the gatehouse, and within 20 feet of the spillway structure.

5) **Control of Water:** Implement a partial drawdown of the impoundment to allow for the work to be completed (primarily for the low level outlet work which is located at the deepest portion of the impoundment and will be occurring at the impoundment bottom). A 6.5-foot drawdown down to El. 218 was considered a feasible drawdown level that would allow the Contractor to utilize a Port-a-dam or similar method for the upstream cofferdam. Without a low-level outlet, the drawdown could be implemented with a combination of pumping and/or siphoning. The drawdown would be maintained through a smaller siphoning system with a contingent siphoning system in place to be used in the event of a large storm event that threated to overtop the cofferdam.

6) **Other Items as Desired by the Town**

5.3 Alternative II: Removal

Prior to fully developing a dam removal design, certain evaluations would need to be completed to identify and address all negative impacts associated with dam removal. Potential negative impacts include scouring and increased differential hydraulic loading on upstream infrastructure (mainly just the upstream dam), and hydraulic changes to the downstream infrastructure along the river channel including increases in flow rate, flow velocity, and flow depths which in turn could result in a greater lateral extent of inundation. As the dam currently does serve to attenuate a portion of the storm events, there are likely some improvements needed to the downstream area to limit the impact to the downstream infrastructure. Also given that the scope of this project would be to remove a flood attenuation structure, although it is not located in a designated SFHA, it is recommended to coordinate with FEMA or the local/state floodplain manager to determine if special permitting/approval processes are needed.

Sediment removal within the impoundment may also be required to prevent the release of sediment downstream post dam removal.

The physical removal of the dam would likely be best located along the alignment of the current water supply components, which is the tallest section of the dam and according to the original design drawings appears to be where the natural channel was located. Removal geometry would likely consist of a trapezoidal channel with a set base width and 2H:1V side slopes. Alternative to the limited trapezoidal channel, given the bedrock at the abutments, it may be worthwhile to remove all the earthen material down to bedrock and have a natural bedrock channel.

5.4 Recommended Approach

It is Pare's understanding the removal is not currently the preferred approach for addressing dam safety deficiencies at the site. However, it has been presented within this report for completeness. Further, given the potential additional work items and studies associated with the dam removal alternative, along with the lower cost associated with the rehabilitation alternative, the recommended alternative at this time is Alternative I: Rehabilitation.

As understood, the intent of the project is to address identified deficiencies at the dam and to provide the Town with reliable discharge capacity and to deter/prevent ongoing issued associated with beaver activity at the dam. With this understanding, Pare recommends the following approach:

- Raise the top of dam elevation by 2-feet; extend the dam to the right abutment via the upland alignment between the existing dam and spillway.
- Regrade the downstream slope above the gatehouse to 2H:1V; provide a retaining wall around the gatehouse structure.
- Rehabilitate the spillway to include a new control weir sized to pass the spillway design flood along with a continuous bypass pipe.
- Restore low level outlet by:
  - Install a new gate with sloped stem to provide for operation from the upstream edge of the crest.
  - Slip lining the intake line from the headwall to the gatehouse
  - Modify piping through the gatehouse to include a continuous pipe section through the gatehouse with a secondary closure valve within the gatehouse.
  - Slip lining the stone culvert with a new outlet pipe; fill stone culvert with grout.
- Complete gatehouse improvement work including:

  - Providing a sub level floor within the lower level of the gatehouse
  - Providing an access ladder from the upper level of the gatehouse
  - Installing a new operating level floor within the gatehouse at the exterior ground level.
- Restore functionality of the 18-inch waste pipe to function as an auxiliary outlet

6.0 OPINIONS OF PROBABLE COSTS

The following conceptual opinions of probable cost have been developed for the recommended alternative noted above. The costs shown herein are based on a limited investigation and are provided for conceptual design information only. This should not be considered an engineer's estimate, as actual construction costs may be somewhat less or considerably more than indicated.

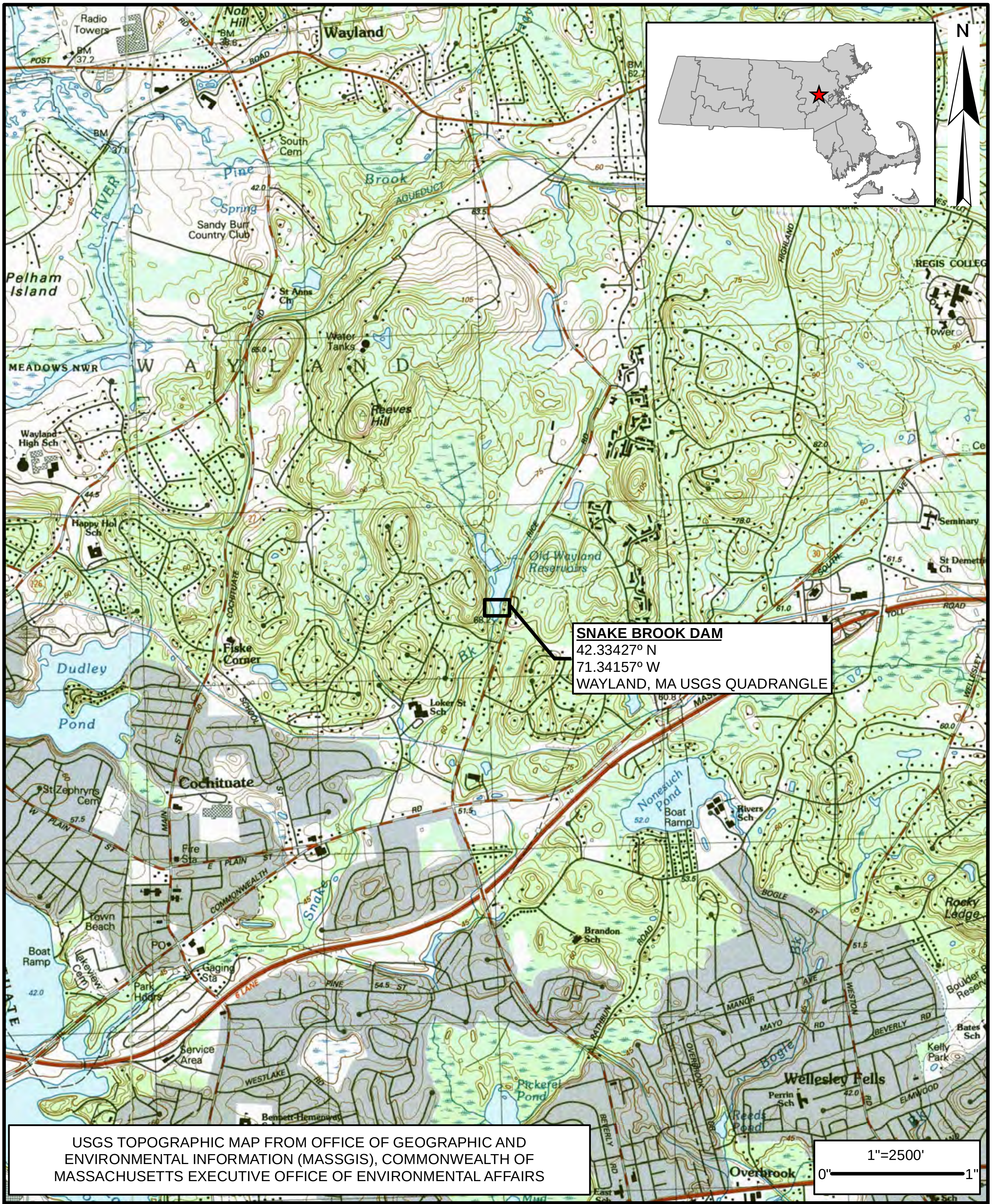
Scope Item	Opinion of Probable Project Cost
Raise Top of Dam	
Core Wall Extension	$ 10,500
Raise Crest to El. 228	$ 23,250
Regrade the Downstream Slope	$ 23,250
New Spillway Control Structure	$ 25,500
Restore Low Level Outlet Capacity	
Upstream Pipe Slip Lining & 10" Abandon	$ 57,500
Upstream Control	$ 56,000
Discharge Culvert	$ 70,500
Gatehouse Work	$ 12,500
Restore Waste Pipe Functionality	$ 51,000
General Requirements & Bonds	$107,500
Control of Water	$ 81,500
Site Restoration	$ 21,000
Design Contingency (15%)	*$ 81,000*
Total Opinion of Probable Construction Cost	**$621,000**
Construction Administration	*$150,000*
Total Opinion of Probable Project Cost	**$771,000**

Additional detail is presented in Appendix B.

FIGURES

Snake Brook Dam

Wayland, Massachusetts



PARE CORPORATION

SNAKE BROOK DAM

MA01119

WAYLAND, MASSACHUSETTS

TOWN OF WAYLAND

LOCUS PLAN

MARCH 2020

FIGURE 1

PARE CORPORATION

SNAKE BROOK DAM

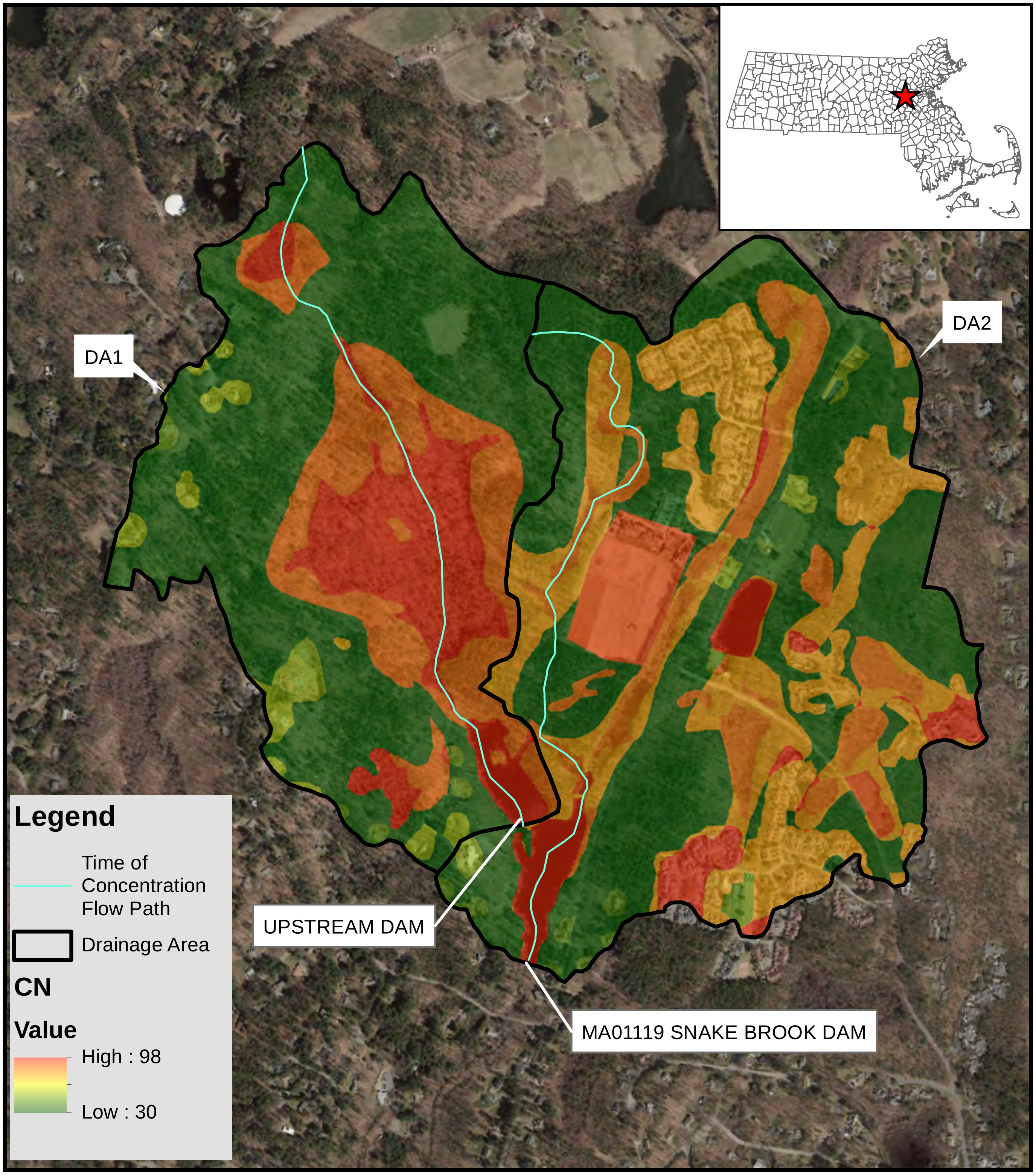
MA01119

WAYLAND, MASSACHUSETTS

TOWN OF WAYLAND

AERIAL PLAN

MARCH 2020 FIGURE 2



MASS GIS

HYDROLOGY MAP

SCALE:1"=1,000'

N
W E
S

8 BLACKSTONE VALLEY PLACE
LINCOLN, RI 02865
(401) 334-4100

10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
(508) 543-1755

PARE PROJECT No. 19167.00 MARCH 2020

FIGURE 3

SNAKE BROOK DAM
WAYLAND, MA

CLIENT: TOWN OF WAYLAND

PHOTOGRAPHS

Snake Brook Dam

Wayland, Massachusetts


Photo No. 1: Overview of the impoundment created by Snake Brook Dam from the dam crest looking upstream.


Photo No. 2: Overview of the downstream side of the dam.

Photo No. 3: Upstream slope from the left abutment looking right. Note limited freeboard at the dam.

Photo No. 4: Overview of the upstream face of the dam from the spillway approach looking downstream and left..

Photo No. 5: Crest of the dam from the stone culvert looking left.

Photo No. 6: Crest of the dam looking right.

Photo No. 7: Downstream slope from the left abutment looking right.

Photo No. 8: Apparent bedrock outcrop in the downstream slope right of the gatehouse.

Photo No. 9: Spillway approach from the dam crest looking upstream and right..

Photo No. 10: Spillway approach from the control section looking upstream.

Photo No. 11: Spillway control section from the approach looking downstream. Note apparent bedrock outcrop n picture foreground.

Photo No. 12: Spillway control section with apparent past beaver deceiving devices.

Photo No. 13: Discharge channel of the spillway.

Photo No. 14: Discharge channel of the spillway.

Photo No. 15: Stone culvert that carries the spillway channel beneath the crest.

Photo No. 16: Discharge channel of the spillway from the stone culvert looking downstream.

Photo No. 17: Approximate location of inlet end of the 18-inch conduit found during the dive inspection completed in December 2019.

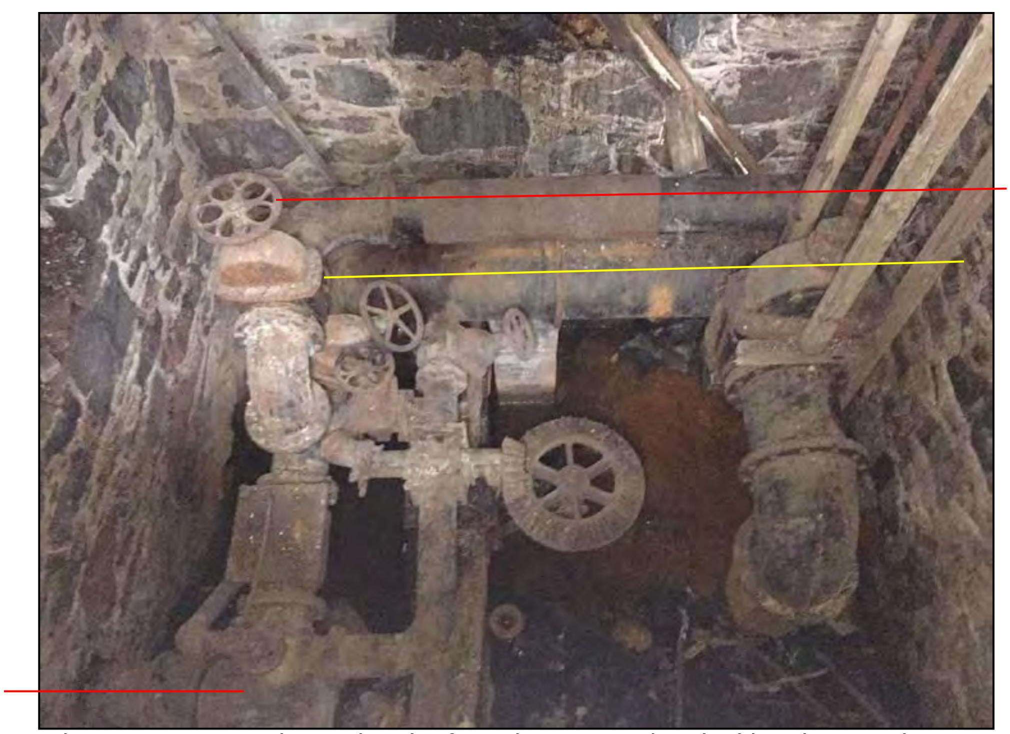


Photo No. 18: Gatehouse interior from the access door looking down and slightly right. 10-inch intake line and 10-inch distribution line both marked with a red line. 18-inch intake line marked with yellow line.

Photo No. 19: Intake lines extending through the upstream wall of the gatehouse.

Photo No. 20: Overview of the water supply piping from the upstream left corner of the gatehouse looking looking downstream and slightly right.

Photo No. 21: Outlet culvert in the base of the downstream wall of the gatehouse.

Photo No. 22: Outlet culvert.

Photo No. 23: Outlet culvert interior from the upstream end at the gatehouse looking downstream. Note daylight at the downstream end of the culvert at the downstream channel.

Photo No. 24: Downstream wall of the gatehouse superstructure.

Photo No. 25: Ground surface along alignment of outlet culvert from the outlet end of the culvert looking upstream.

Photo No. 26: Outlet end of the outlet culvert

Photo No. 27: Downstream channel. Note Woodbridge Road culvert crossing located several hundred feet downstream.

Photo No. 28: Downstream channel from the Woodbridge Road culvert crossing looking upstream.

Photo No. 29: Downstream channel downstream of the Woodbridge Road culvert crossing.

Photo No. 30: Access easement to the left abutment of the dam through 68 Rice Road property.

APPENDIX A
Design Basis Level Drawings
Snake Brook Dam
Wayland, Massachusetts

DESIGN BASIS REPORT SUBMISSION

Prepared for The:

TOWN OF WAYLAND CONSERVATION COMMISSION
SNAKE BROOK DAM REHABILITATION

MA01119

WAYLAND, MASSACHUSETTS

MARCH 2020

LOCUS PLAN
SCALE: 1" = 2000'

Drawing Index

0.0	COVER SHEET
1.0	GENERAL NOTES AND LEGEND
1.1	FULL IMPOUNDMENT PLAN
2.0	EXISTING CONDITIONS PLAN
2.1	EXISTING CONDITIONS SECTIONS & DETAILS
3.0	PROPOSED SITE PLAN
3.1	PROPOSED EMBANKMENT PLAN
3.2	LOW LEVEL OUTLET ALTERNATIVES
3.3	SPILLWAY ALTERNATIVES
4.0	MISCELLANEOUS DETAILS

AERIAL PLAN
SCALE: 1" = 400'

Prepared by:

PARE CORPORATION
Foxboro, Massachusetts

PARE CORPORATION

GENERAL NOTES:

1. FOR THE PURPOSE OF THIS PROJECT

   OWNER – TOWN OF WAYLAND, MASSACHUSETTS
   41 COCHITUATE ROAD, TOWN BUILDING
   WAYLAND, MA 01778–2614
   CONTACT – LINDA HANSEN, CONSERVATION ADMINISTRATOR

   ENGINEER – PARE CORPORATION
   10 LINCOLN ROAD, SUITE 210
   FOXBORO, MA 02035
   CONTACT – ALLEN ORSI, P.E.

2. ALL CONSTRUCTION INDICATED ON THESE PLANS SHALL BE PERFORMED IN ACCORDANCE WITH THE LATEST EDITION OF THE MASSACHUSETTS STATE BUILDING CODE, THE SPECIFICATIONS INCLUDED IN THIS CONTRACT, AND 302 CMR 10.00 DAM SAFETY. THESE PLANS ARE INCOMPLETE UNLESS ACCOMPANIED BY THE SPECIFICATIONS INCLUDED IN THE CONTRACT DOCUMENTS.
3. THE PLANS WERE DEVELOPED FROM A SURVEY PERFORMED BY BAY COLONY GROUP, INC. OF FOXBOROUGH, MA. DATED JANUARY 17, 2020. AS WELL AS AVAILABLE LIDAR DATA THROUGH MASS GIS.
4. ELEVATIONS REFERENCE NAVD 1988. HORIZONTAL DATUM REFERENCES NAD 1983. HORIZONTAL AND VERTICAL CONTROL BASED UPON NOAA'S NATIONAL GEODETIC SURVEY (NGS) NATIONAL SPATIAL REFERENCE SYSTEM (NSRS) OPUS SESSION.
5. BORINGS WERE COMPLETED BY SOIL X, CORP. AND OBSERVED BY PARE PERSONNEL BETWEEN OCTOBER 31 TO NOVEMBER 1, 2019. DEPTHS AND THICKNESS OF THE SUBSURFACE STRATA INDICATED HEREIN ARE GENERALIZED FROM THE SUBSURFACE DATA COLLECTED. INFORMATION SHOWN FOR THE DAM IS INTERPOLATED AND MAY DIFFER. BORING LOGS ARE INCLUDED WITHIN THE SPECIFICATIONS.
6. WETLAND FLAGS WERE FLAGGED BY PARE PERSONNEL ON NOVEMBER 6, 2019 WITH SUPPLEMENTAL DELINEATION IN SUPPORT OF ACCESS, STAGING.
7. ANY DISCREPANCIES ON THESE PLANS WITH REGARD TO DIMENSIONS OR CONDITIONS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH THE AFFECTED PORTION OF WORK.
8. BRUSH AND TREE GROWTH HAS CONTINUED SINCE THE DATE OF THE SURVEY AND SHOULD BE REVIEWED BY THE CONTRACTOR.
9. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING ALL DIMENSIONS. PLANS SHALL NOT BE SCALED FOR DIMENSIONS.
10. CONSTRUCTION SHALL BE MADE FROM APPROVED SHOP DRAWINGS ONLY.
11. NOTES, TYPICAL DETAILS AND SCHEDULES APPLY TO ALL WORK UNLESS OTHERWISE NOTED. FOR CONDITIONS NOT SPECIFICALLY SHOWN, PROVIDE DETAILS OF SIMILAR NATURE. VERIFY APPLICABILITY BY SUBMITTING SHOP DRAWINGS FOR REVIEW.
12. INFORMATION REGARDING THE LOCATION OF SURROUNDING STRUCTURES, UTILITIES, AND THE AS–BUILT CONFIGURATION AND CONDITION OF THE EXISTING DAM AND OUTLET WORKS IS FURNISHED SOLELY FOR THE CONVENIENCE OF THE CONTRACTOR AND SHALL BE FIELD VERIFIED. THE CONTRACTOR SHALL CONDUCT ITS OWN INDEPENDENT EXAMINATION OF SITE CONDITIONS FOR THE PURPOSE OF BIDDING, FABRICATION, AND CONSTRUCTION ASSOCIATED WITH THE PROJECT. ANY RELIANCE UPON INFORMATION MADE AVAILABLE BY THE OWNER OR THE ENGINEER SHALL BE AT THE CONTRACTOR'S RISK.
13. THE CONTRACTOR SHALL PROTECT ALL ADJACENT STRUCTURES AND UTILITIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIR OF ALL DAMAGE TO ADJACENT STRUCTURES AND UTILITIES AT NO ADDITIONAL COST TO THE OWNER.
14. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DISPOSAL OF ALL PROJECT DEMOLITION AND EXCESS MATERIAL IN ACCORDANCE WITH MASSACHUSETTS, LOCAL, AND FEDERAL LAWS.
15. THE CONTRACTOR SHALL FOLLOW ALL OSHA AND OTHER APPLICABLE FEDERAL, STATE, AND LOCAL STANDARDS FOR ALL PROJECT COMPONENTS AND ACTIVITIES. THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR ALL SITE SAFETY PROCEDURES AND PRACTICES REGARDLESS OF THE PRESENCE OF THE OWNER OR ENGINEER.
16. ALL CONSTRUCTION ACTIVITIES SHALL BE CONFINED TO THE LIMITS OF WORK AND TEMPORARY EASEMENTS DEFINED HEREIN.
17. WHERE REFERENCE IS MADE TO ANY STANDARD SPECIFICATION IT SHALL MEAN THE MOST RECENT SPECIFICATION, CODE, STANDARD, OR INTERIM SPECIFICATIONS OF THE ORGANIZATION REFERRED TO AND SHALL BE CONSIDERED A PART OF THESE CONTRACT DOCUMENTS TO THE EXTENT INDICATED. IN CASE OF CONFLICT, THE MORE RIGID REQUIREMENTS AND CODES SHALL GOVERN. THESE CODES INCLUDE, BUT ARE NOT LIMITED TO: AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM).
18. THE CONTRACTOR SHALL STAGE ALL EQUIPMENT IN THE DESIGNATED STAGING AREA. ALL GREASING AND REFUELING ACTIVITIES SHALL OCCUR IN THE STAGING AREA.
19. THE CONTRACTOR SHALL MAINTAIN A SECURE SITE AND PROVIDE APPROPRIATE SAFETY MEASURES TO PREVENT ACCIDENTS. THE SAFETY MEASURES SHALL INCLUDE, BUT NOT BE LIMITED TO SIGNAGE, BARRICADES, FENCES, FLASHING WARNING LIGHTS, AND POLICING IF NECESSARY.
20. NO WORK OR DISCHARGES, OTHER THAN THAT SHOWN, SHALL BE PERFORMED WITHIN WETLANDS WITHOUT FIRST RECEIVING PROPER PERMITS FROM THE REGULATORY AGENCIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REMOVING, RESTORING AND REPAIRING ALL DAMAGE AS A RESULT OF UNAUTHORIZED WORK OR DISCHARGES TO THE WETLAND AREA AT NO ADDITIONAL COST TO THE OWNER.

DIVERSION NOTES:

1. THE CONTRACTOR SHALL MAINTAIN FLOW THROUGHOUT CONSTRUCTION.
2. THE CONTRACTOR SHALL REGULATE DISCHARGES AND PHASE CONSTRUCTION SO THAT CONSTRUCTION EQUIPMENT DOES NOT PASS THROUGH FLOWING WATER.
3. ANY NECESSARY COFFERDAMS AND DIVERSIONS SHALL BE DESIGNED AND BEAR THE STAMP OF A PROFESSIONAL ENGINEER. REVIEW AND APPROVAL BY THE OWNER AND ENGINEER IS REQUIRED PRIOR TO INSTALLATION. DESIGN REQUIREMENTS ARE INCLUDED WITHIN SPECIFICATION SECTION 02400.
4. THE CONTRACTOR SHALL MAINTAIN A STOCKPILE OF MATERIAL ONSITE TO BE UTILIZED TO STABILIZE THE EXCAVATION IN THE EVENT OF HIGH WATER OR OTHER CONDITIONS WHICH MAY COMPROMISE THE COFFERDAM STABILITY. THE STOCKPILE SHALL BE MAINTAINED IN ACCORDANCE WITH A FLOOD EMERGENCY RESPONSE PLAN TO BE DEVELOPED BY THE CONTRACTOR AND SUBJECT TO APPROVAL BY THE ENGINEER, OWNER, AND OFFICE OF DAM SAFETY.

EROSION AND SEDIMENT CONTROL NOTES:

1. THE CONTRACTOR SHALL INSTALL AND MAINTAIN EROSION AND SEDIMENT CONTROLS INCLUDING STRAW BALES, SILT FENCE, TURBIDITY BARRIERS, AND ANY OTHER CONTROLS AS INDICATED IN THE CONTRACT DOCUMENTS.
2. THE CONTRACTOR SHALL PREVENT SEDIMENT FROM ENTERING THE IMPOUNDMENT VIA DISCHARGES THROUGH ANY DRAINAGE STRUCTURES, COFFERDAMS, OR SEDIMENT CONTROL BARRIER.
3. STOCKPILES SHALL BE A MINIMUM OF 1–FOOT FROM THE EDGE OF ANY SLOPE TO LIMIT RUNOFF DOWN THE EMBANKMENT SLOPES.
4. EROSION CONTROLS SHALL BE MODIFIED OR EXPANDED AS FIELD CONDITIONS WARRANT.
5. ALL EROSION CONTROLS SHALL BE INSPECTED IN ACCORDANCE WITH THE CONTRACTOR'S NPDES SWPPP FOR THIS PROJECT.
6. ANY DAMAGED AREAS SHALL BE REPAIRED WITHIN 24 HOURS OF DISCOVERY.
7. DEWATERING BASINS SHALL CONSIST OF STRAW BALE ENCLOSURES, TANKS, PERMEABLE BLADDERS, OR OTHER APPROPRIATE METHOD. DEWATERING WASTE WATERS SHALL BE PUMPED TO THE DEWATERING BASINS AND TREATED PRIOR TO DISCHARGE.
8. DISCHARGE OF TURBID WATER TO THE RIVER, IMPOUNDMENT, OR ANY WETLAND IS PROHIBITED.
9. UPON COMPLETION OF GRADING, ALL EXPOSED SURFACES NOT OTHERWISE TO BE TREATED SHALL BE COVERED WITH A MINIMUM OF 6" OF LOAM AND SEEDED. THE CONTRACTOR SHALL MAINTAIN ALL SEEDED AREAS UNTIL A SATISFACTORY STAND OF HEALTHY GRASS IS ESTABLISHED AS DEFINED IN THE SPECIFICATIONS.

CONSTRUCTION SEQUENCE:

THE FOLLOWING SEQUENCE IS INTENDED TO BE GENERAL IN NATURE AND SHALL NOT BE CONSIDERED DIRECTION BY THE ENGINEER OR THE OWNER. ALTHOUGH IT IS LIKELY THAT SOME OF THE WORK ITEMS WILL OVERLAP, CONSTRUCTION SEQUENCES FOR THE VARIOUS PROJECT COMPONENTS ARE DESCRIBED SEPARATELY AND MAY NOT NECESSARILY PROCEED IN CONSECUTIVE ORDER. ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE PROJECT PLANS AND SPECIFICATIONS.

MOBILIZATION

1. CONTRACTOR MOBILIZATION.
2. INSTALL ALL NECESSARY SIGNAGE.
3. COMPLETE SITE TREE CLEARING.
4. INSTALL PERIMETER EROSION AND SEDIMENT CONTROLS INCLUDING TURBIDITY BARRIER.
5. ESTABLISH ACCESS AND STAGING AREAS.

WATER CONTROL AND DIVERSION

1. IMPLEMENT AND MAINTAIN THE CONSTRUCTION DRAWDOWN.
2. INSTALL COFFERDAMS AND DIVERSION SYSTEMS AS NEEDED TO COMPLETE THE WORK.

TREE AND STUMP REMOVAL

1. CLEAR, GRUB, AND STRIP ALL TREES STUMPS, SHRUBS, BRUSH, WOODY VEGETATION, AND LOAM WITHIN THE LIMITS OF WORK.
2. FILL RESULTING VOIDS WITH APPROVED MATERIAL IN COMPACTED LIFTS.

UPSTREAM LOW LEVEL OUTLET WORK

1. REMOVE SEDIMENT AND DEBRIS TO THE EXTENT NEEDED TO COMPLETE THE WORK.
2. INSTALL NEW UPSTREAM CONTROL STRUCTURE SYSTEM.
3. INSTALL TRASH RACK.

GATEHOUSE WORK

1. CUT AND ABANDON THE 10–INCH WATER SUPPLY LINE.
2. CUT AND EXTEND THE 18–INCH LOW LEVEL OUTLET PIPE.
3. PROVIDE SECONDARY ACCESS TO THE LOW LEVEL OUTLET
4. FILL TO INVERT OF LOW LEVEL OUTLET

SPILLWAY WORK

1. REMOVE AND DISPOSE ACCUMULATED DEBRIS.
2. EXCAVATE TO REMOVE THE COMPONENTS OF THE EXISTING SPILLWAY.
3. REMOVE ALL COMPONENTS OF THE EXISTING SPILLWAY. INCLUSIVE OF THE EXISTING TIMBER SLUICEWAY, SIPHON PIPE, AND ANY OTHER COMPONENTS.
4. INSTALL THE PROPOSED SPILLWAY CONTROL SECTION.
5. INSTALL THE BEAVER DECEIVER SYSTEM.
6. BACKFILL ALL COMPONENTS WITH APPROVED MATERIAL IN COMPACTED LIFTS.

CREST AND DOWNSTREAM SLOPE

1. RAISE THE CREST TO EL. 228.
2. REGRADE THE DOWNSTREAM SLOPE TO 2.5H:1V.

PROJECT COMPLETION

1. PLACEMENT OF LOAM AND SEED ON THE DOWNSTREAM SLOPE, CREST, AND ALL AREAS DISTURBED BY THE CONSTRUCTION ACTIVITIES.
2. NOTIFY ENGINEER OF SUBSTANTIAL PROJECT COMPLETION.
3. DEMOBILIZE AND RETURN DISTURBED AREAS OF THE SITE TO PRE–CONSTRUCTION CONDITIONS.

LEGEND

EXISTING / PROPOSED

- CONTOUR 5'
- CONTOUR 1'
- CART PATH
- CONCRETE WALL
- PROPERTY LINE
- DRAIN LINE
- CLEAN OUT (CO)
- EDGE OF WATER
- EDGE OF WETLAND WETLAND FLAG
- 100 FT. WETLAND BUFFER
- 200 FT RIVERBANK AREA
- FLOODPLAIN
- TURBIDITY BARRIER
- COFFERDAM
- STEEL SHEET PILE
- TREELINE
- TREES
- TREE CLEARING
- SILT FENCE
- STRAW BALE
- FILTER SOCK
- LIMIT OF DISTURBANCE (LOD)
- BORING (B19–1)

PARE
PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

SNAKE BROOK DAM REHABILITATION
MA01119
WAYLAND, MASSACHUSETTS
TOWN OF WAYLAND CONSERVATION COMMISSION

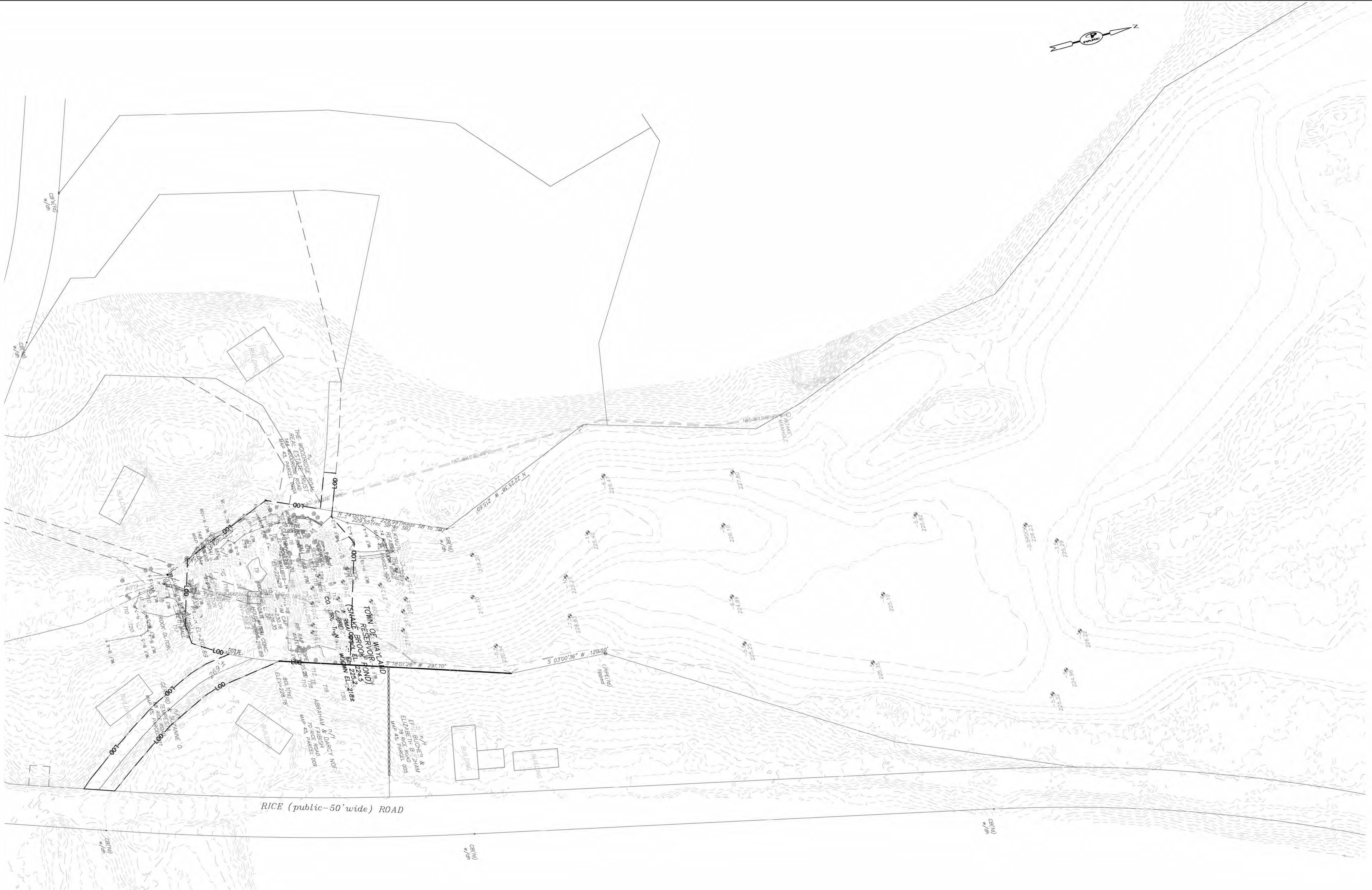
REVISIONS:

PROJECT NO.:	19167.00
DATE:	MARCH 2020
SCALE:	AS NOTED
DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

GENERAL NOTES AND LEGEND

SHEET NO.: 1.0

DESIGN BASIS REPORT SUBMISSION



NOTE:

1. BATHYMETRIC CONTOURS WERE SKETCHED IN BASED ON 1879 HISTORIC PLAN.
2. SEDIMENT/LEAF DEBRIS DEPTH IN THE AREA OF THE LOW LEVEL OUTLET INTAKE WAS APPROXIMATED AT 1 FOOT ABOUT THE PIPE INVERT (WHICH WOULD BE 4+ FEET ABOVE THE BATHYMETRY CONTOURS IN THAT AREA. OTHER AREAS OF SEDIMENT/DEBRIS ACCUMULATION ARE LIKELY. ACTUAL SEDIMENT/DEBRIS DEPTHS MAY VARY.

220± WATER DEPTH MEASUREMENTS TAKEN BY PARE ON OCTOBER 25, 2019 WHILE POOL LEVEL WAS NEAR EL. 225.2±.

+ WLF R-1 WETLAND FLAGS WERE FLAGGED BY PARE PERSONNEL ON NOVEMBER 6, 2019.

FULL IMPOUNDMENT PLAN

SCALE: 1"=60'±

DESIGN BASIS REPORT SUBMISSION

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ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
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SNAKE BROOK DAM REHABILITATION
MA01119
WAYLAND, MASSACHUSETTS
TOWN OF WAYLAND CONSERVATION COMMISSION

REVISIONS:

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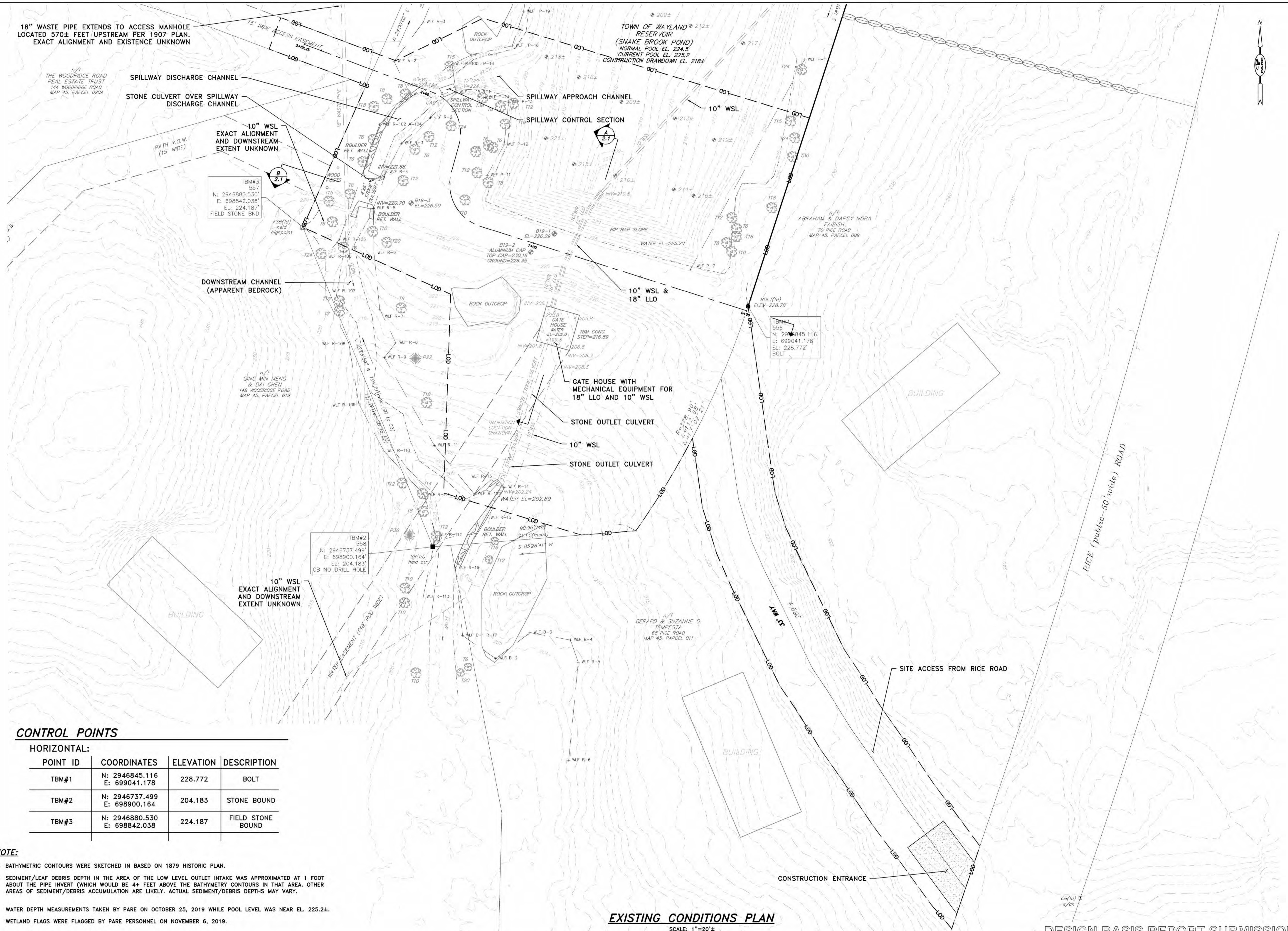
DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

FULL IMPOUNDMENT PLAN

SHEET NO.: 1.1

Y:\JOBS\19 Jobs\19167.00 Wayland-SnakePondDamEngSrvcs-MA\DWG's\1.1 FULL IMPOUNDMENT PLAN.dwg



CONTROL POINTS

HORIZONTAL:

POINT ID	COORDINATES	ELEVATION	DESCRIPTION
TBM#1	N: 2946845.116 E: 699041.178	228.772	BOLT
TBM#2	N: 2946737.499 E: 698900.164	204.183	STONE BOUND
TBM#3	N: 2946880.530 E: 698842.038	224.187	FIELD STONE BOUND

NOTE:

1. BATHYMETRIC CONTOURS WERE SKETCHED IN BASED ON 1879 HISTORIC PLAN.
2. SEDIMENT/LEAF DEBRIS DEPTH IN THE AREA OF THE LOW LEVEL OUTLET INTAKE WAS APPROXIMATED AT 1 FOOT ABOUT THE PIPE INVERT (WHICH WOULD BE 4+ FEET ABOVE THE BATHYMETRY CONTOURS IN THAT AREA. OTHER AREAS OF SEDIMENT/DEBRIS ACCUMULATION ARE LIKELY. ACTUAL SEDIMENT/DEBRIS DEPTHS MAY VARY.

220± WATER DEPTH MEASUREMENTS TAKEN BY PARE ON OCTOBER 25, 2019 WHILE POOL LEVEL WAS NEAR EL. 225.2±.

+ WLF R-1 WETLAND FLAGS WERE FLAGGED BY PARE PERSONNEL ON NOVEMBER 6, 2019.

EXISTING CONDITIONS PLAN

SCALE: 1"=20'±

Y:\JOBS\19 Jobs\19167.00 Wayland-SnakePondDamEngSrvcs-MA\DWG's\2.0 EXIST CONDITIONS PLAN.dwg

DESIGN BASIS REPORT SUBMISSION

PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
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SCALE ADJUSTMENT GUIDE
0" 1"
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SNAKE BROOK DAM REHABILITATION

MA01119

WAYLAND, MASSACHUSETTS

TOWN OF WAYLAND CONSERVATION COMMISSION

REVISIONS:

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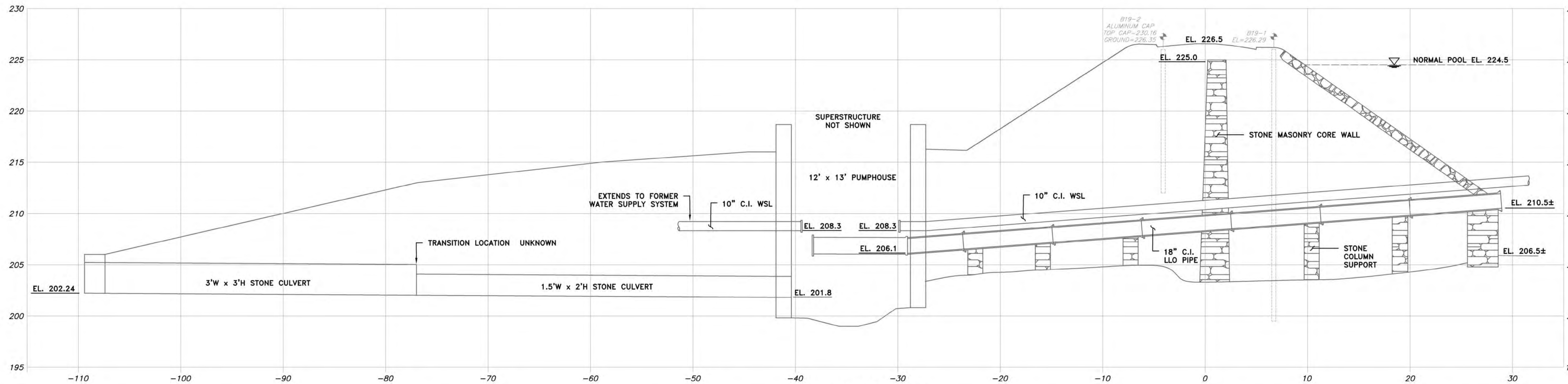
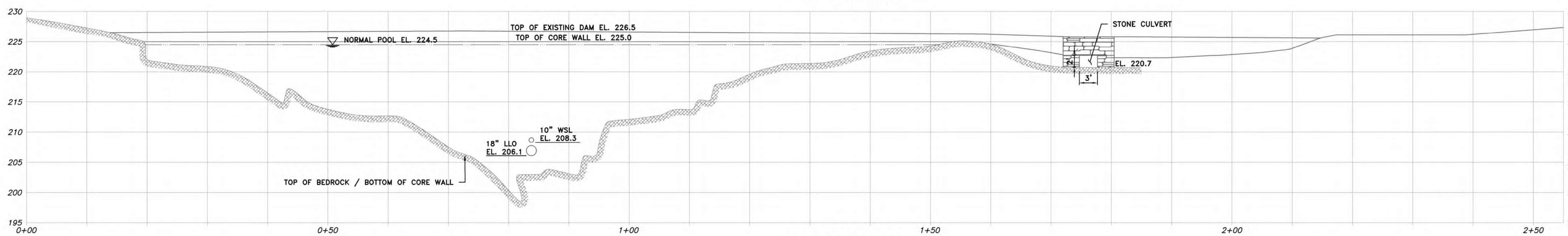
DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

EXISTING CONDITIONS PLAN

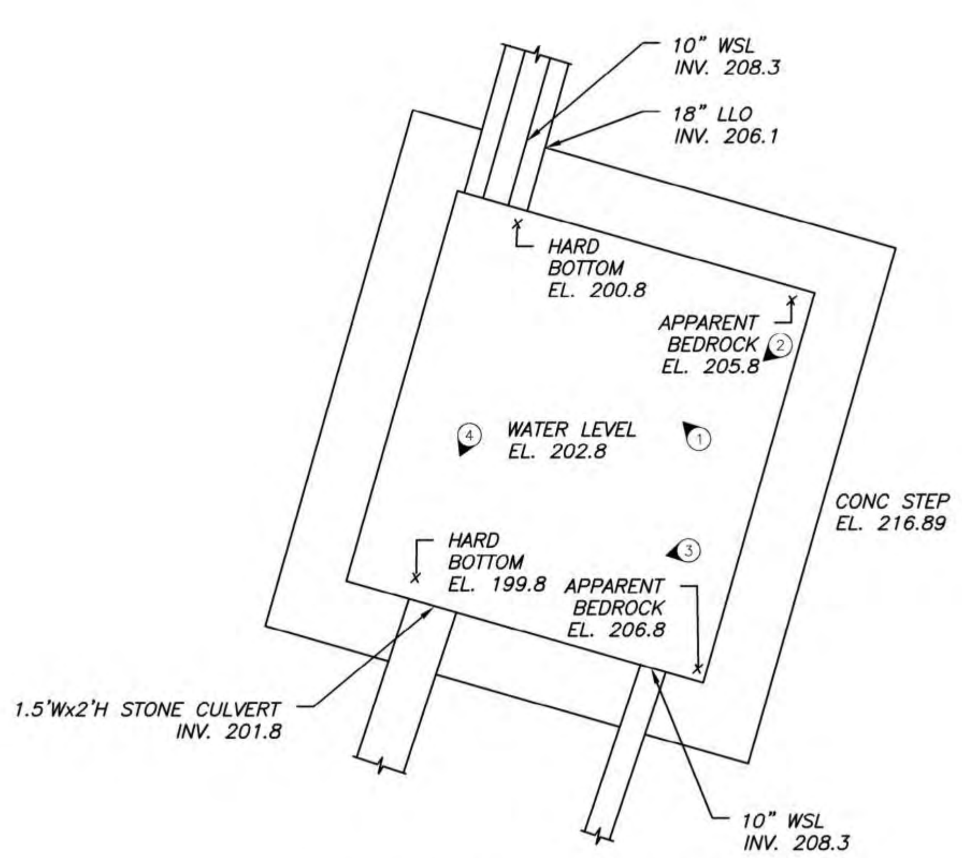
SHEET NO.: 2.0



SECTION A (A / 2.0)
SCALE: 1"=6'



SECTION B (B / 2.0)
SCALE: 1"=10'



GATEHOUSE PLAN
SCALE: 1"=5'±

PHOTO 1

PHOTO 2

PHOTO 3

PHOTO 4

PUMP HOUSE PHOTOS

DESIGN BASIS REPORT SUBMISSION

PARE
PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

SNAKE BROOK DAM REHABILITATION

MA01119
WAYLAND, MASSACHUSETTS
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REVISIONS:

PROJECT NO.:	19167.00
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DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

EXISTING CONDITIONS SECTIONS & DETAILS

SHEET NO.: 2.1

Y:\JOBS\19 Jobs\19167.00 Wayland-SnakePondDamEngSrvcs-MA\DWG's\2.0 EXIST CONDITIONS PLAN.dwg

PROPOSED SITE PLAN

SCALE: 1"=10'±

PARE
PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

SNAKE BROOK DAM REHABILITATION
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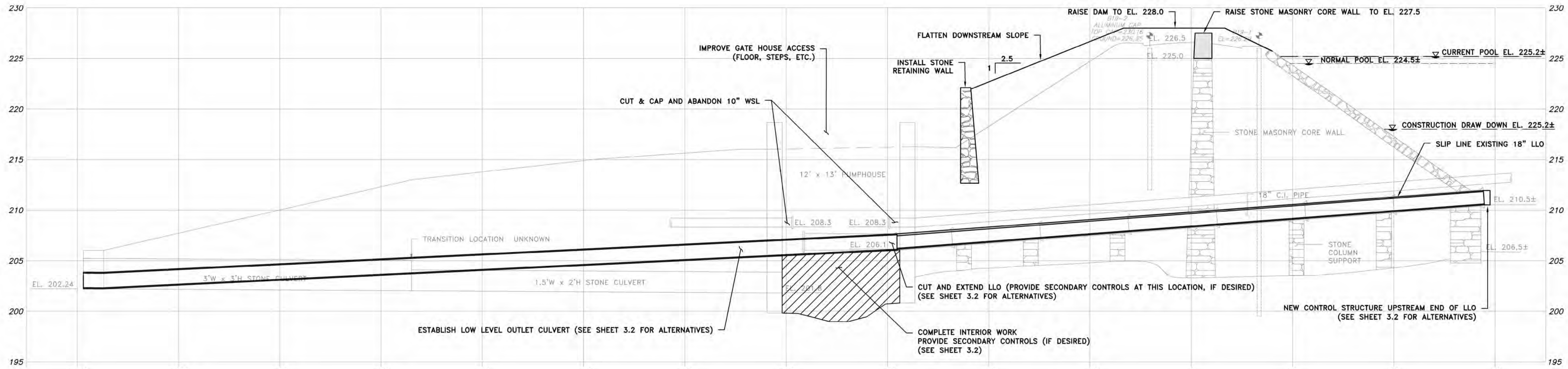
DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

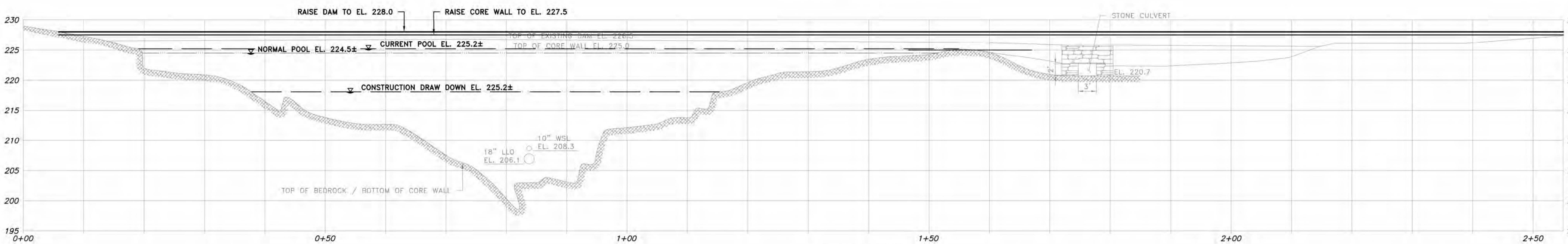
PROPOSED SITE PLAN

SHEET NO.: 3.0

DESIGN BASIS REPORT SUBMISSION



A/3.0 **SECTION A**
SCALE: 1"=6'



B/3.0 **SECTION B**
SCALE: 1"=10'

PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

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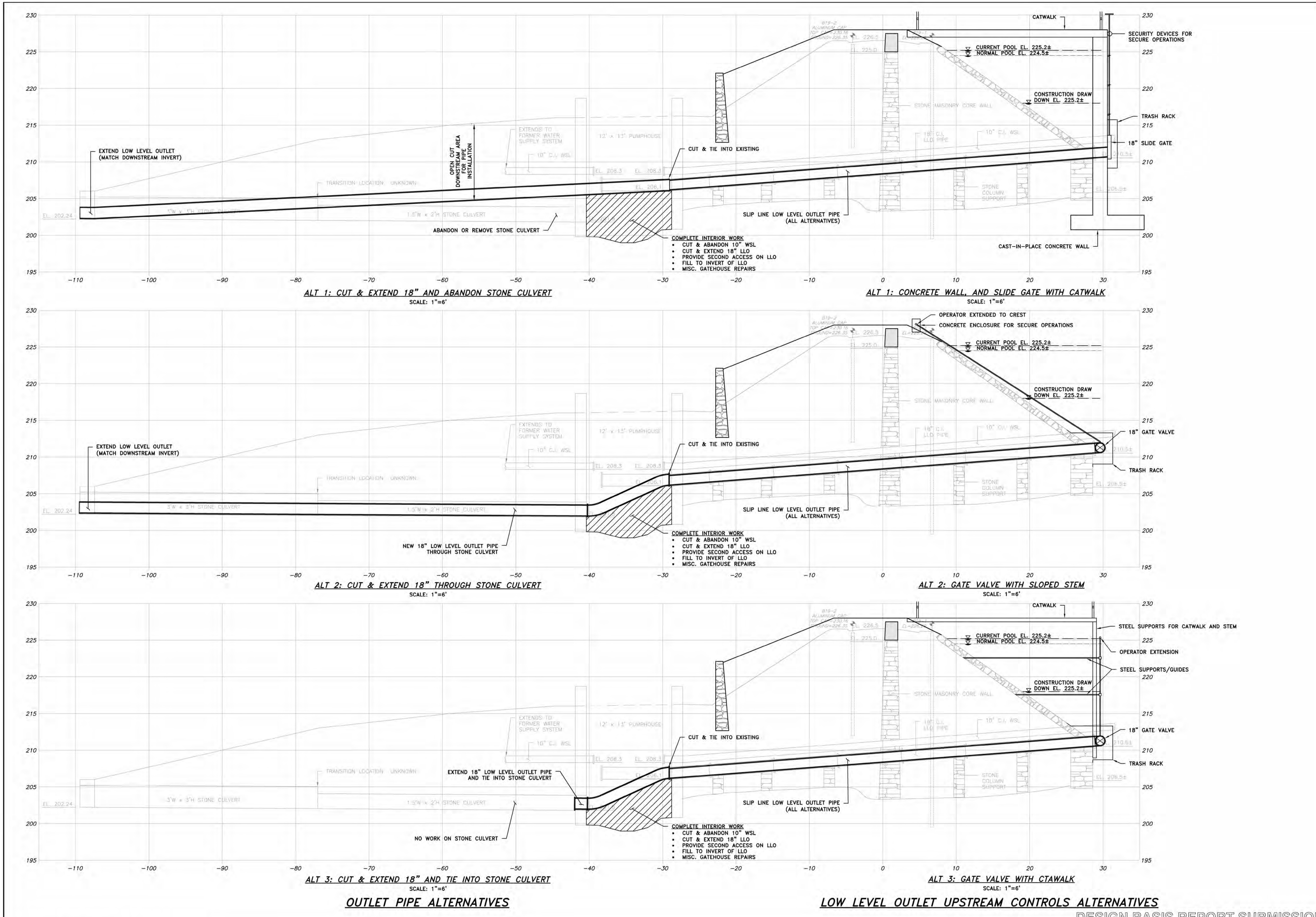
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

PROPOSED EMBANKMENT PLAN

SHEET NO.: 3.1

DESIGN BASIS REPORT SUBMISSION



DESIGN BASIS REPORT SUBMISSION

PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

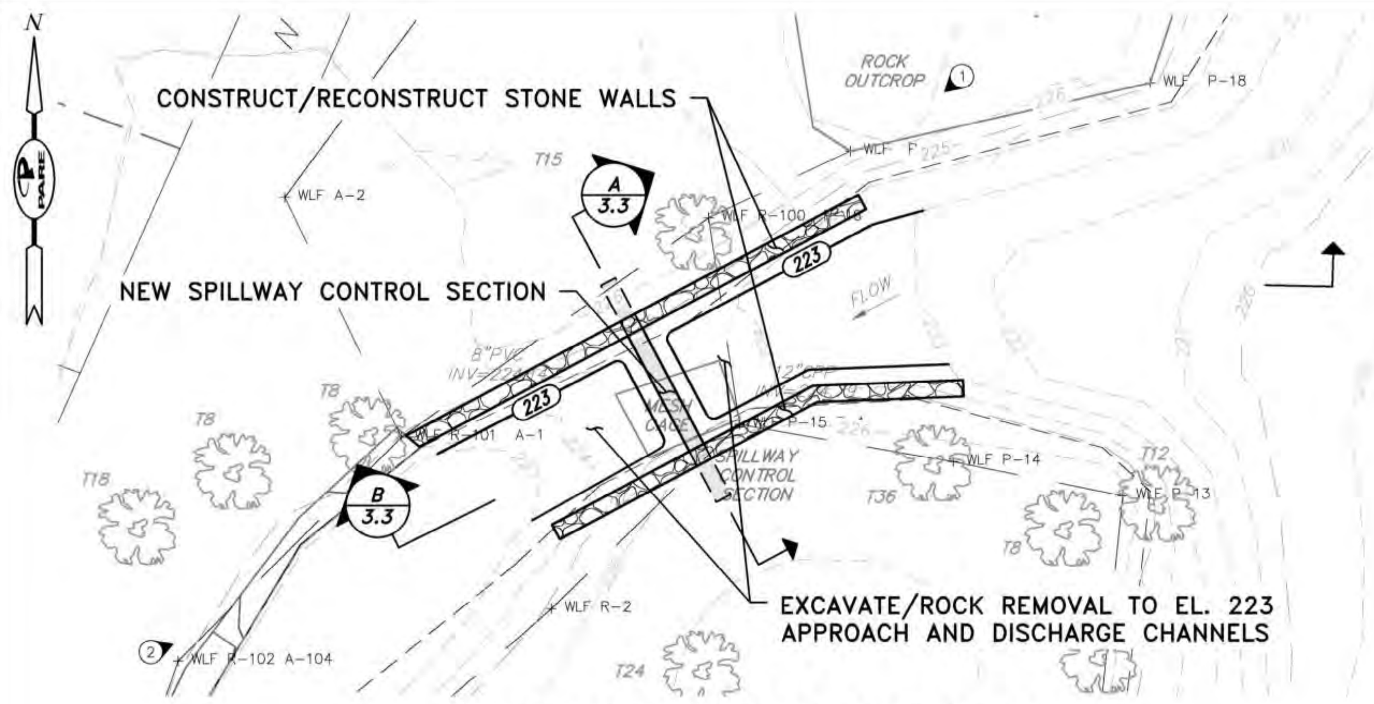
SNAKE BROOK DAM REHABILITATION
MA01119
WAYLAND, MASSACHUSETTS
TOWN OF WAYLAND CONSERVATION COMMISSION

REVISIONS:

PROJECT NO.:	19167.00
DATE:	MARCH 2020
SCALE:	AS NOTED
DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

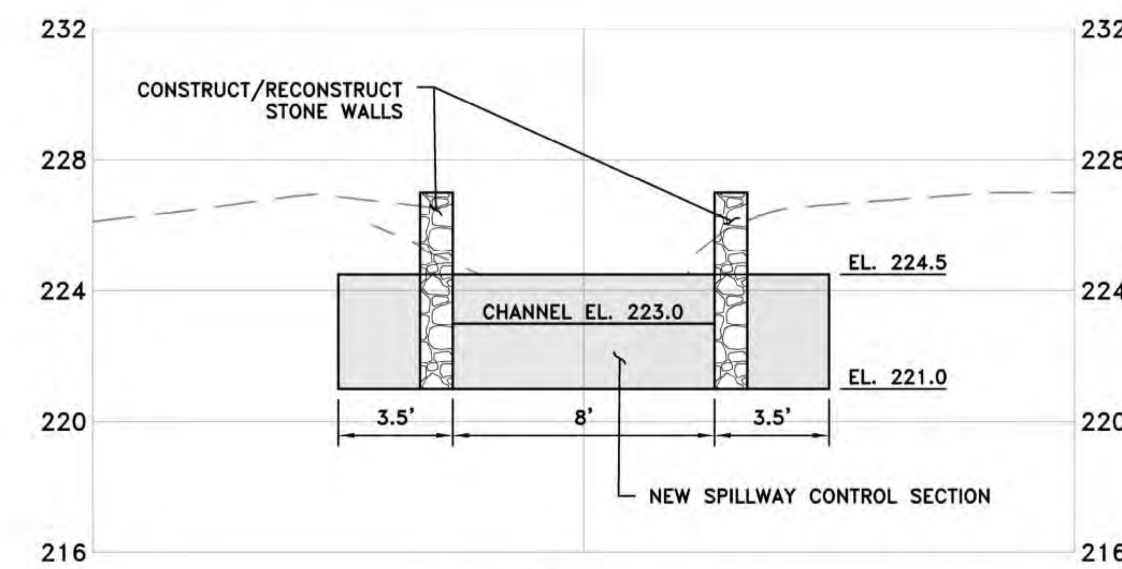
LOW LEVEL OUTLET ALTERNATIVES

SHEET NO.: 3.2



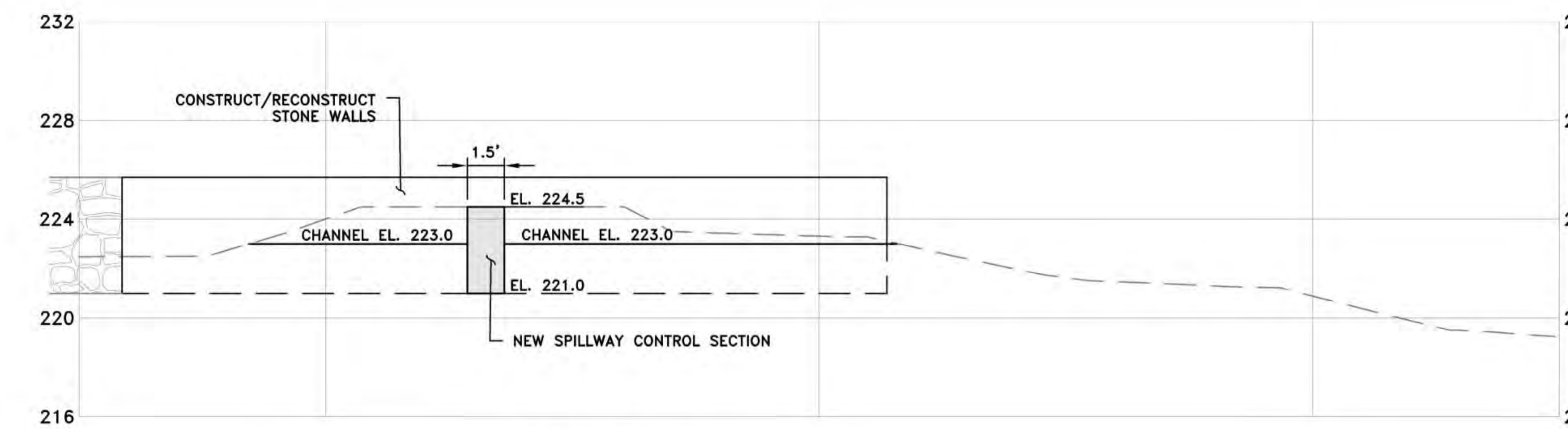
PROPOSED SPILLWAY PLAN

SCALE: 1"=10'±



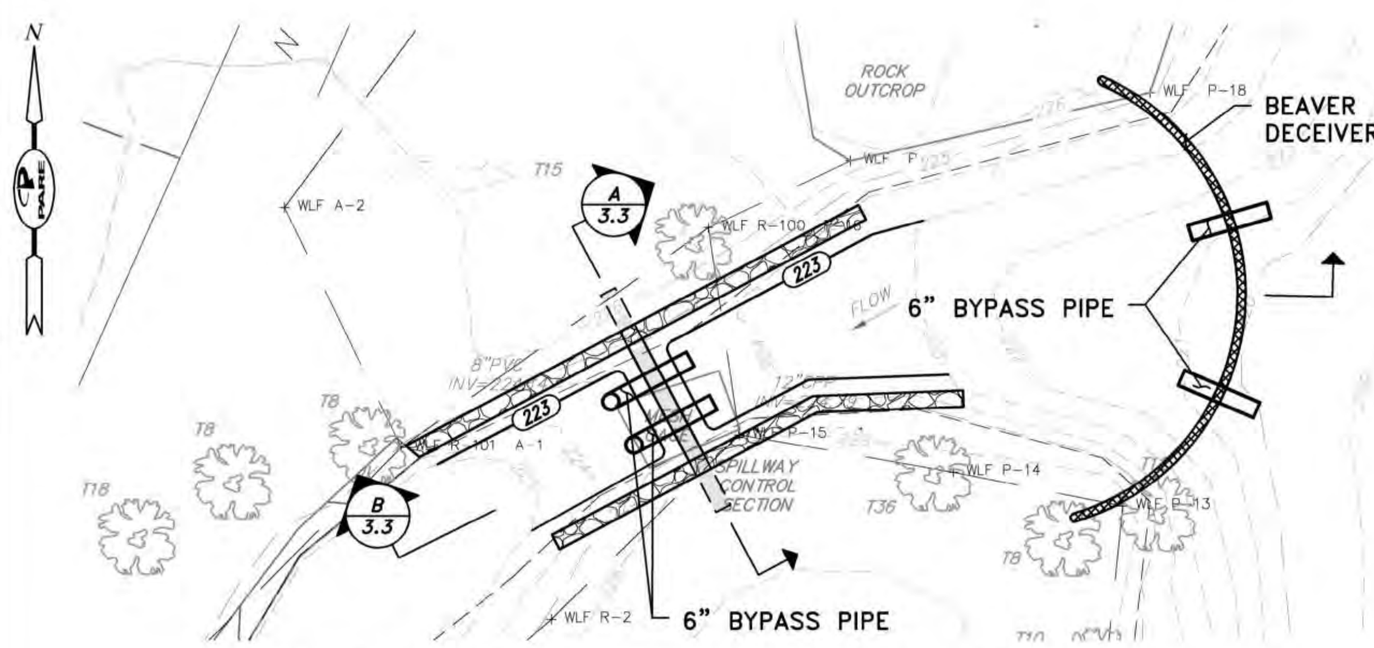
SECTION A

SCALE: 1"=5'



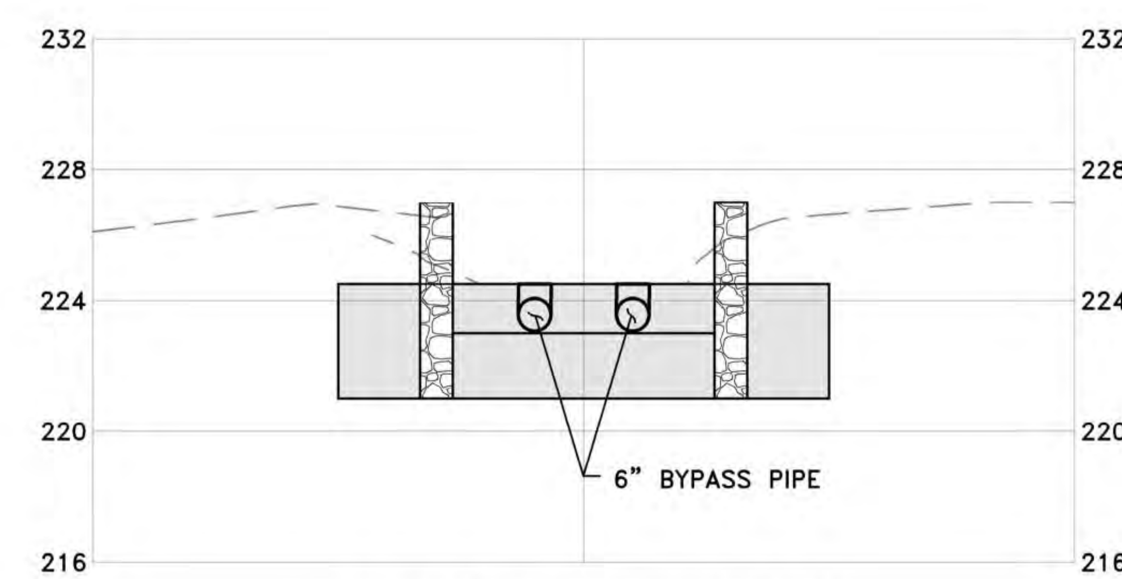
SECTION B

SCALE: 1"=5'



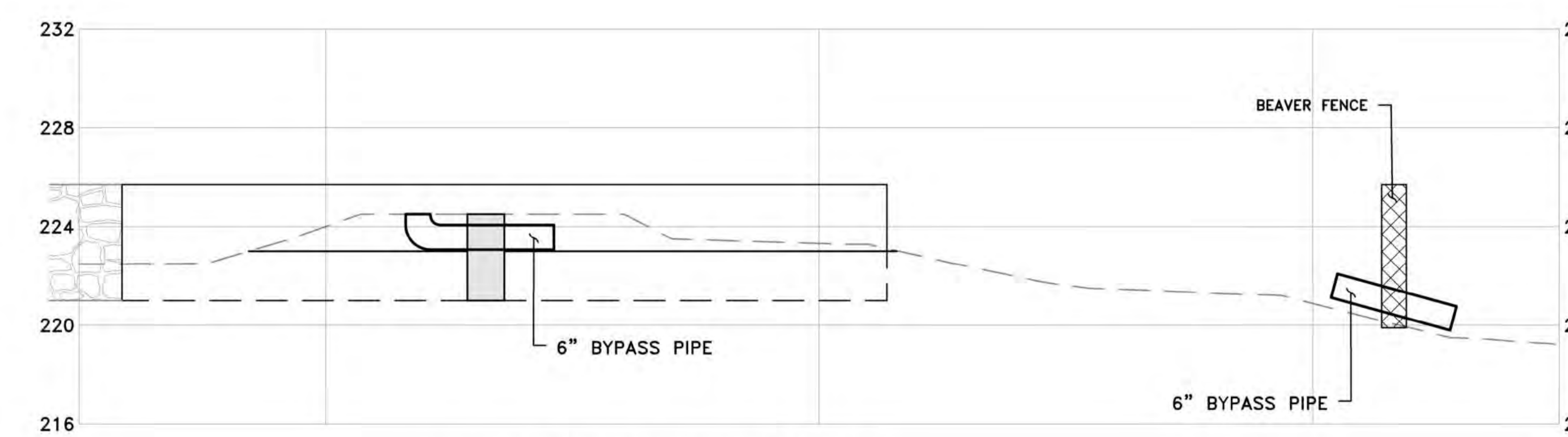
BEAVER DECEIVER ALT 1: SHORT BYPASS PIPES

SCALE: 1"=10'±



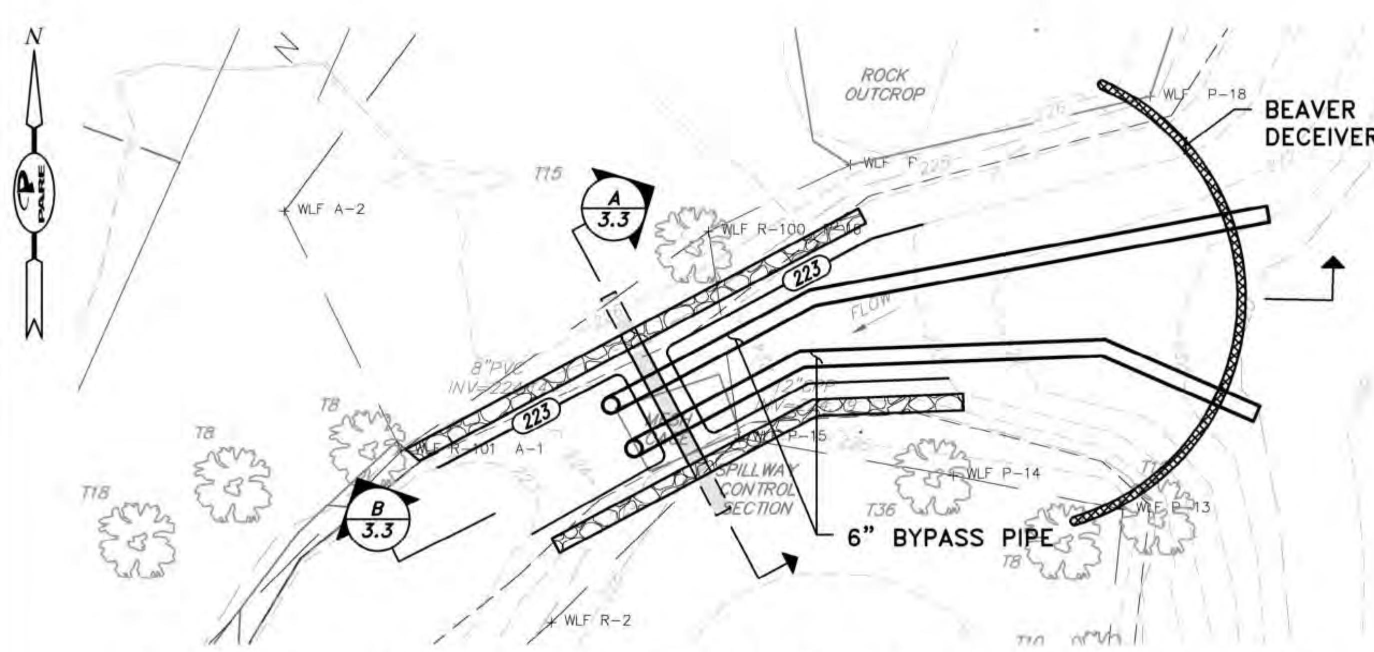
SECTION A – ALT 1

SCALE: 1"=5'



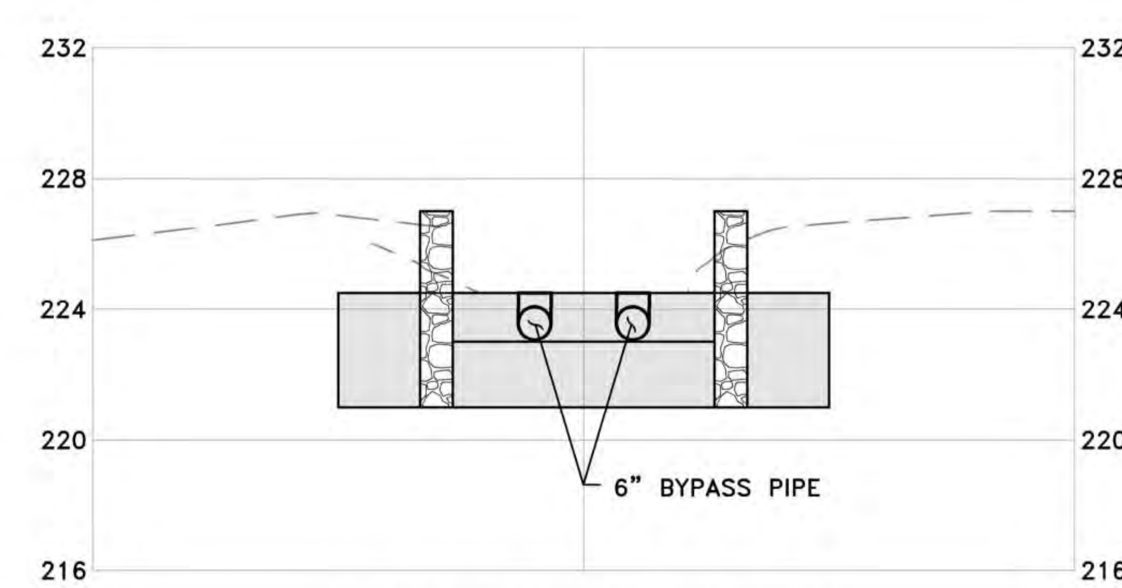
SECTION B – ALT 1

SCALE: 1"=5'



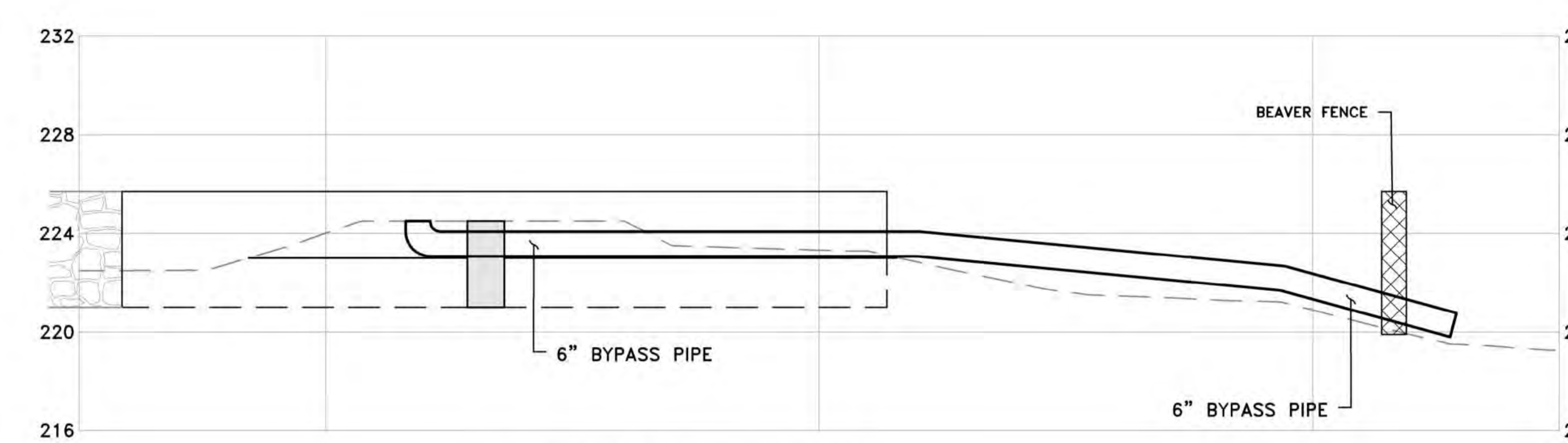
BEAVER DECEIVER ALT 2: CONTINUOUS BYPASS PIPES

SCALE: 1"=10'±



SECTION A – ALT 2

SCALE: 1"=5'



SECTION B – ALT 2

SCALE: 1"=5'

PHOTO 1

PHOTO 2

APPROACH AND DISCHARGE CHANNEL PHOTOS

DESIGN BASIS REPORT SUBMISSION

PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
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SNAKE BROOK DAM REHABILITATION

MA01119
WAYLAND, MASSACHUSETTS
TOWN OF WAYLAND CONSERVATION COMMISSION

REVISIONS:

PROJECT NO.:	19167.00
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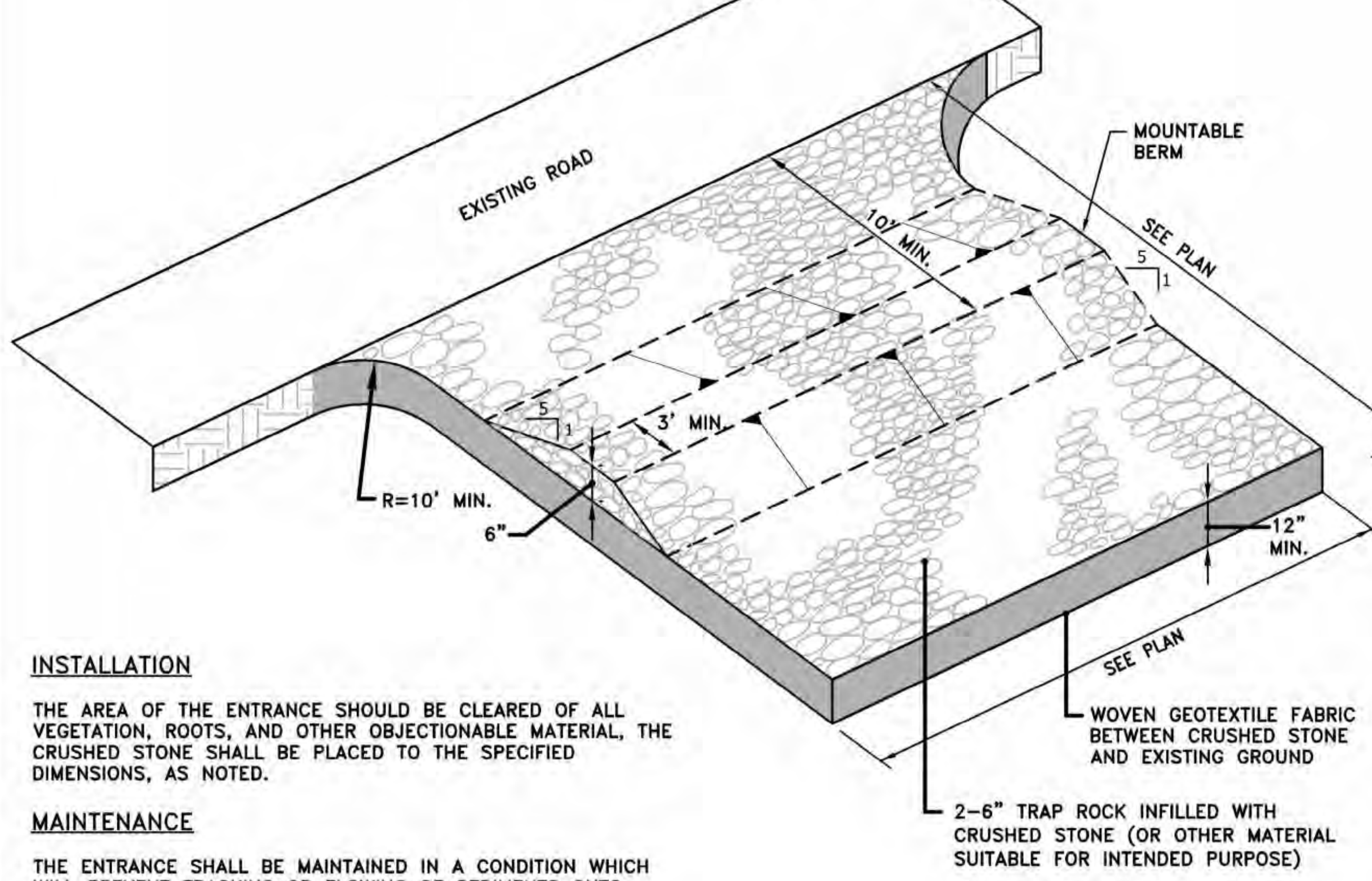
APPROVED BY:	ARO

SPILLWAY ALTERNATIVES

SHEET NO.: 3.3



INSTALLATION

THE AREA OF THE ENTRANCE SHOULD BE CLEARED OF ALL VEGETATION, ROOTS, AND OTHER OBJECTIONABLE MATERIAL, THE CRUSHED STONE SHALL BE PLACED TO THE SPECIFIED DIMENSIONS, AS NOTED.

MAINTENANCE

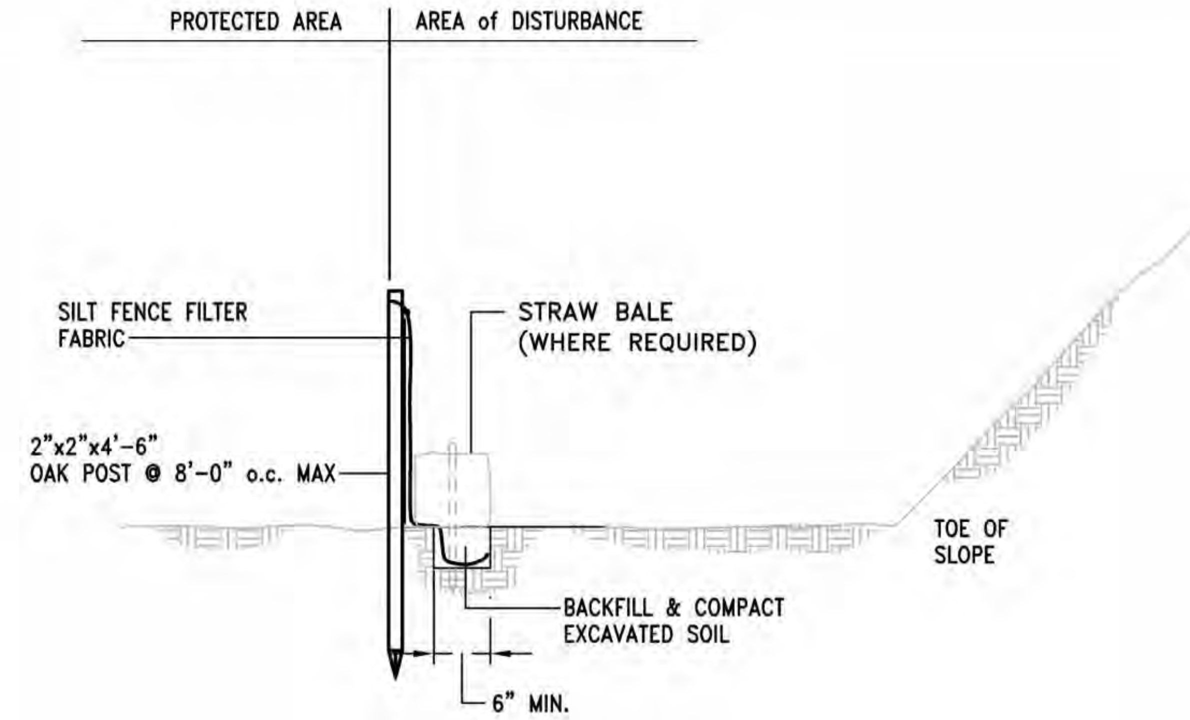
THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENTS ONTO PUBLIC RIGHT- OF-WAYS THIS WILL REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE, OR ADDITIONAL LENGTH, AS CONDITIONS DEMAND, AND REPAIR, AND / OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC RIGHT-OF-WAYS MUST BE REMOVED IMMEDIATELY.

LOCATION

SEE PROJECT PLANS FOR LOCATION OF CONSTRUCTION ENTRANCE.

CONSTRUCTION ENTRANCE PROTECTION STONE STABILIZATION PAD

NOT TO SCALE

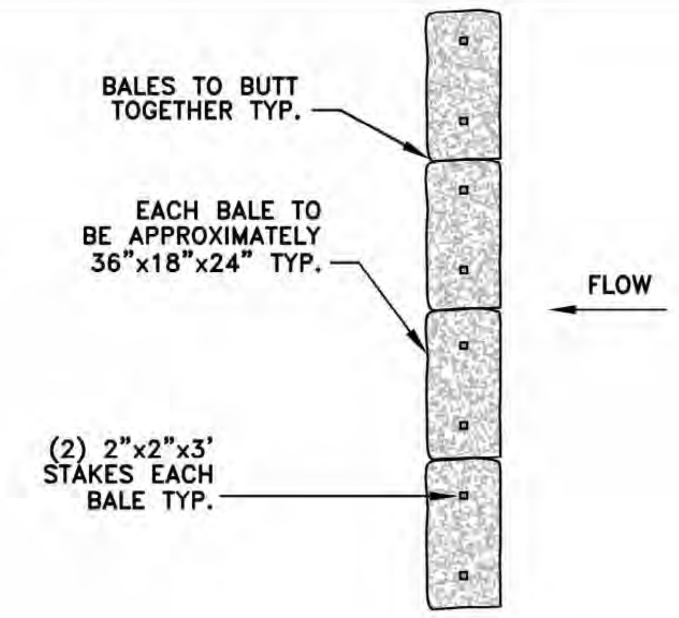


NOTE:

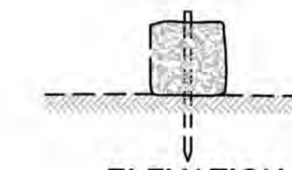
SILT FENCE FABRIC SHALL NOT BE SLIT. STRAW BALE POST SHALL BE DRIVEN THROUGH SILT FENCE FABRIC.

SILT FENCE DETAIL

NOT TO SCALE



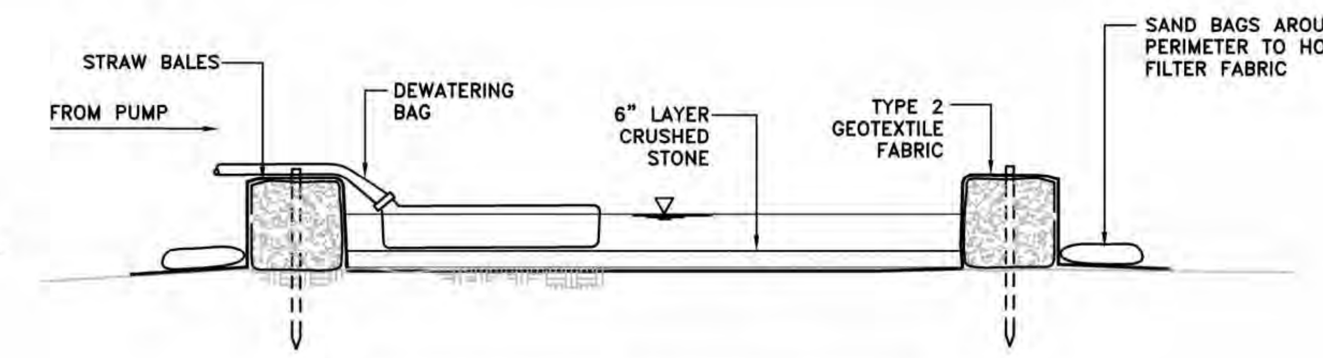
PLAN



ELEVATION

STRAW BALE DETAIL

NOT TO SCALE

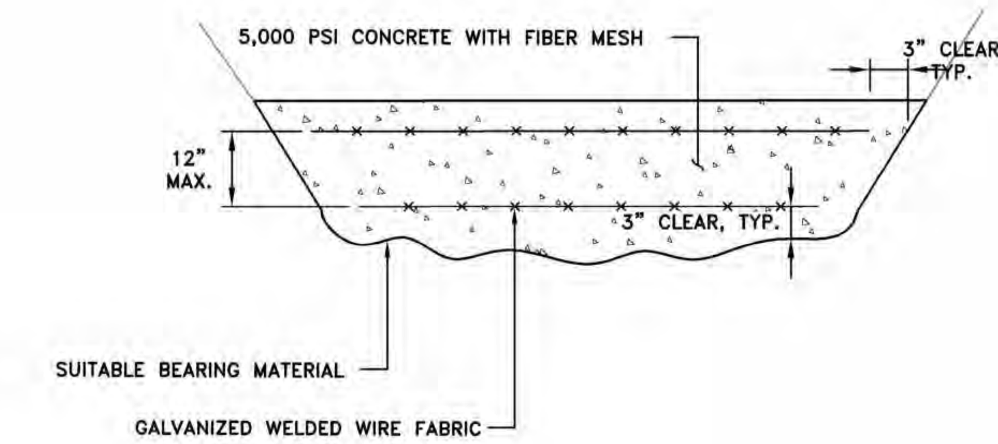


NOTE:

CONTRACTOR TO PERIODICALLY REMOVE SILT AND STONE AT TRENCH DRAIN TO PROMOTE FLOW OF WATER FROM BASIN. ALTERNATIVELY AN OUTFLOW WEIR MAY BE SUBMITTED FOR APPROVAL.

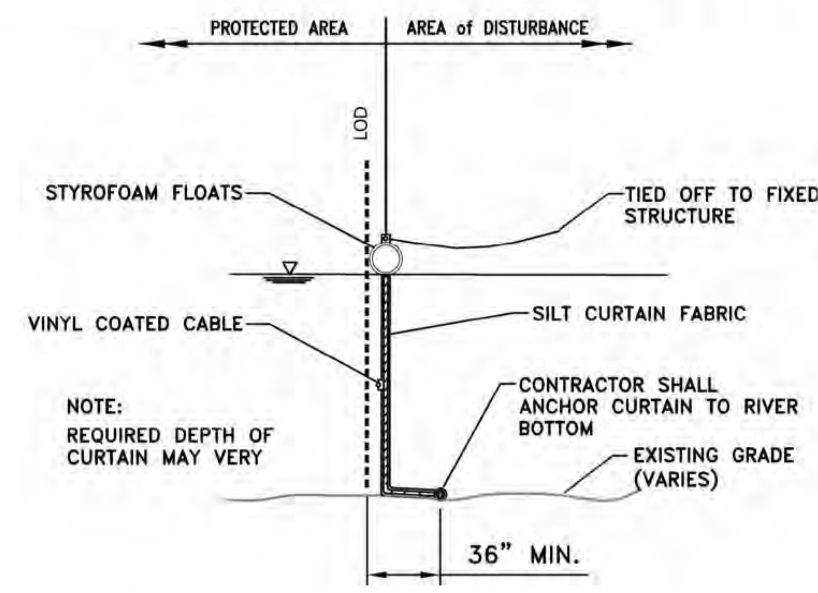
FILTER FABRIC DEWATERING BASIN

NOT TO SCALE



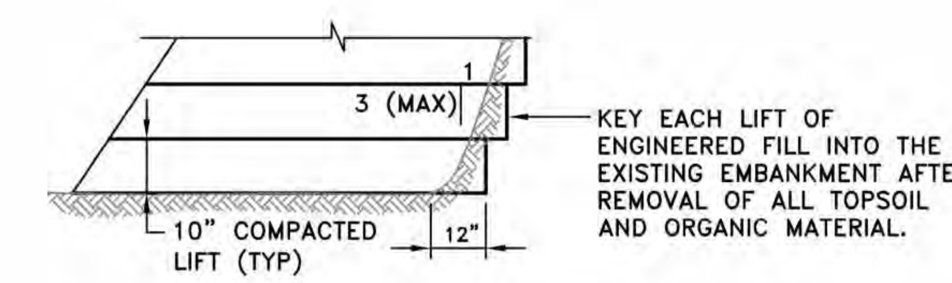
MASS CONCRETE DETAIL

NOT TO SCALE



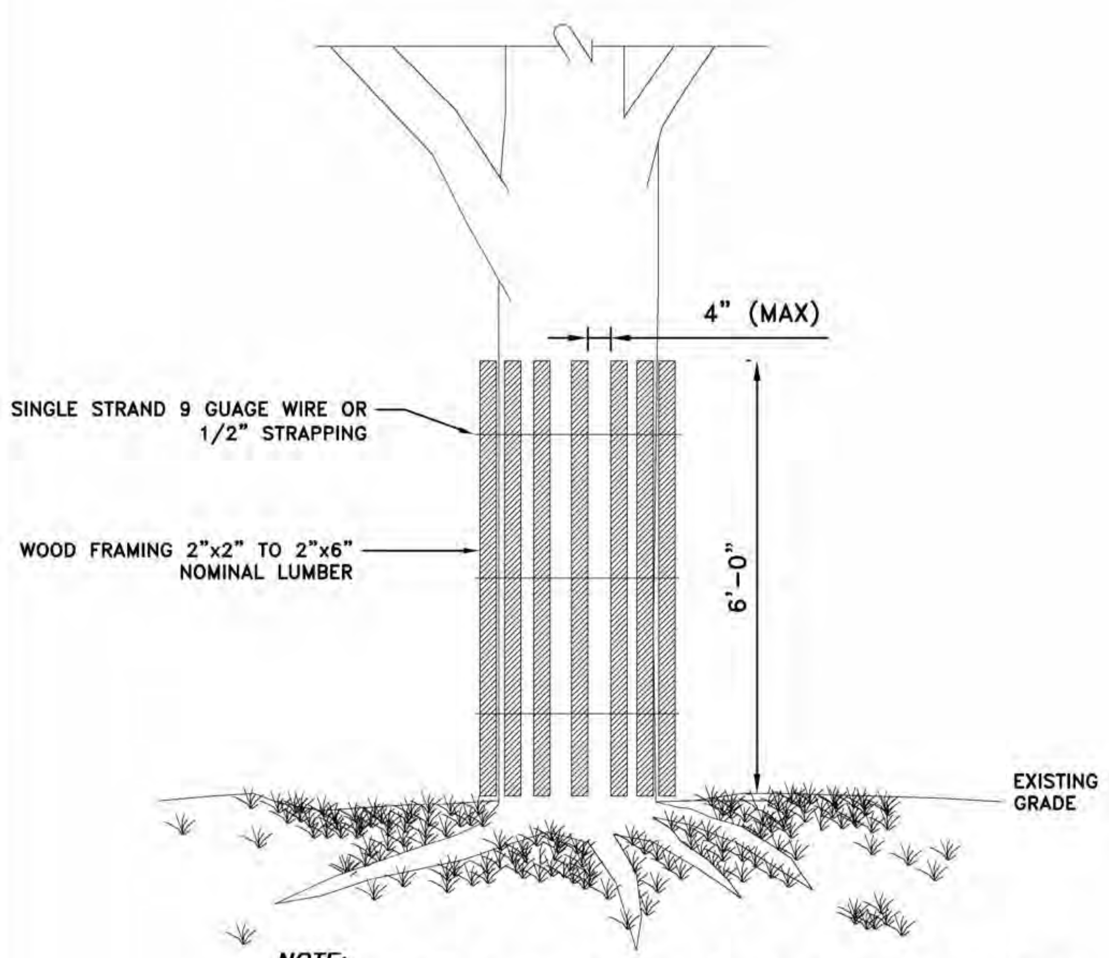
TYPICAL TURBIDITY BARRIER

NOT TO SCALE



PLACEMENT OF FILL MATERIALS

NOT TO SCALE

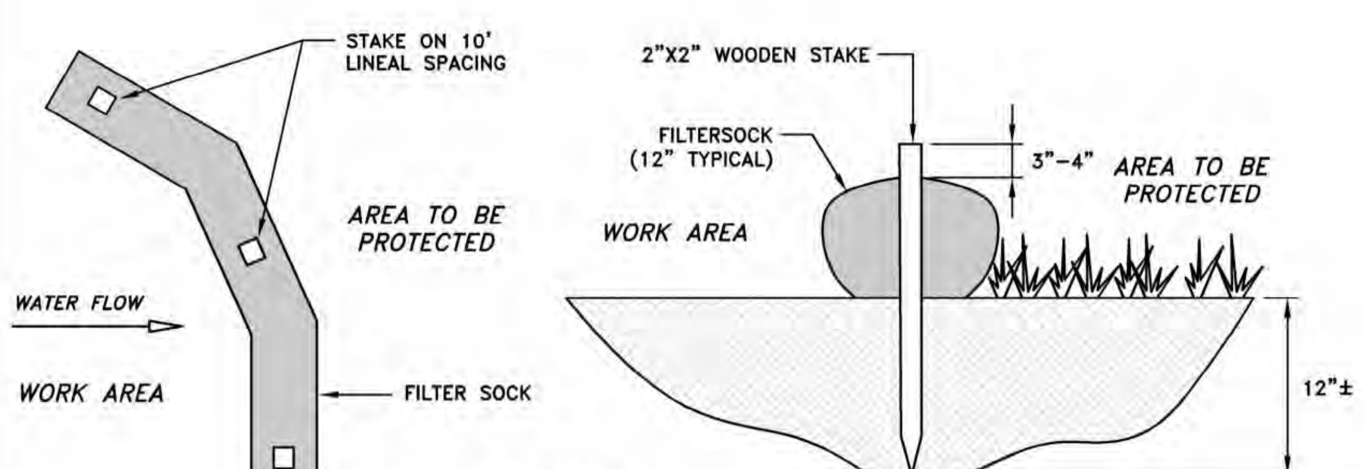


NOTE:

THIS DETAIL SHALL BE USED TO PROTECT THE TREE'S TRUNK IN SITUATIONS WHERE CONSTRUCTION IS IN CLOSE PROXIMITY.

TREE PROTECTION DEVICE

NOT TO SCALE



FILTERSOCK NOTES:

1. COMPOST / SOIL / ROCK / SEED FILL TO MEET APPLICATION REQUIREMENTS.
2. COMPOST MATERIAL TO BE REMOVED OR DISPERSED ON SITE AS DETERMINED BY ENGINEER.

FILTERSOCK DETAIL

NOT TO SCALE

DESIGN BASIS REPORT SUBMISSION

PARE

PARE CORPORATION

ENGINEERS - SCIENTISTS - PLANNERS
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508-543-1755

SCALE ADJUSTMENT GUIDE

0" 1"

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SNAKE BROOK DAM REHABILITATION

MA01119

WAYLAND, MASSACHUSETTS

TOWN OF WAYLAND CONSERVATION COMMISSION

REVISIONS:

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DESIGNED BY:	MED/MLP
CHECKED BY:	ARO/MED
DRAWN BY:	LMC
APPROVED BY:	ARO

MISCELLANEOUS DETAILS

SHEET NO.:

4.0

APPENDIX B
Design Basis Level Opinions of Probable Costs

Snake Brook Dam

Wayland, Massachusetts

PROJECT : Snake Brook Dam	PROJECT NUMBER: 19167.00
SUBJECT: Snake Brook Dam Rehabilitation OPC	
COMPUTATIONS BY: MED	DATE: March 2020
CHECK BY: ARO	DATE: March 2020

DESIGN LEVEL OPINION OF PROBABLE COST

Alternative I: Rehabilitation

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Construction Trailer and Utilities	0	MON	$ 2,700.00	$ -		
Project Superintendent	4	MON	$ 8,200.00	$ 32,800.00		
QC Plans	4	HR	$ 150.00	$ 600.00	Additional for Winter	
Submittals	10	HR	$ 150.00	$ 1,500.00		
Schedules	5	HR	$ 150.00	$ 750.00		
Meetings	12	EA	$ 150.00	$ 1,800.00		Assume 2hrs each @ $150/hr
Project Sign	1	LS	$ 900.00	$ 900.00	Recent project bids	
Proctor Tests	2	TEST	$ 225.00	$ 450.00	Laboratory Quote plus markup	
Sieve Analyses	5	EA	$ 100.00	$ 500.00	Laboratory Quote plus markup	
Concrete Sampling/Testing	1	EA	$ 400.00	$ 400.00	Recent project bids	
Concrete Compression Tests	1	EA	$ 30.00	$ 30.00	Laboratory Quote plus markup	
Field Density Testing	15	DAY	$ 250.00	$ 3,750.00	Recent project bids	
Chemical Soil Tests	1	EA	$ 1,000.00	$ 1,000.00	Recent project bids	
Subtotal				**$ 44,480.00**		
Mobilization & Demolition						
Mobilization	1	LS	$ 10,000.00	$ 10,000.00	Engineers Judgment	
Demobilization	1	LS	$ 7,500.00	$ 7,500.00	Engineers Judgment	
Subtotal				**$ 17,500.00**		
Clear and Grub						
Clear Work Area	3400	SY	$ 3.50	$ 11,900.00	Means 31 11 10.10 0300 Clear Only	
Grub Work Area	3400	SY	$ 2.00	$ 6,800.00	Means 31 11 10.10 0350 Grub	
Clear Trees Larger Than 8 inch	25	EA	$ 250.00	$ 6,250.00		Estimated Value
Engineered Fill Imported	75	TN	$ 20.00	$ 1,500.00	Recent Project Costs	
Engineered Fill Placed	37.5	CY	$ 30.00	$ 1,125.00	Recent Project Costs	Assumed value
Subtotal				**$ 27,575.00**		
Erosion Control						
Hay bales	400	LF	$ 7.00	$ 2,800.00	Recent project bids	
Silt Fence	800	LF	$ 5.00	$ 4,000.00	Recent project bids	
Maintenance and Removal	1	LS	$ 1,500.00	$ 1,500.00	Engineer's Judgment	
Turbidity Barrier	120	LF	$ 30.00	$ 3,600.00	Recent project bids	
Subtotal				**$ 11,900.00**		
Control of Water / Water Diversion						
Implement / Maintain Drawdown	1	LS	$ 15,000.00	$ 15,000.00	Engineer's Judgment	Siphon
US Cofferdam	1	LS	$ 60,000.00	$ 60,000.00	Portadam	
DS Cofferdams	1	LS	$ 2,000.00	$ 2,000.00	Engineer's Judgment	
Dewatering	30	DAY	$ 150.00	$ 4,500.00	Engineer's Judgment	
Subtotal				**$ 81,500.00**		

LLO WORK

Item	Quantity	Unit	Unit Price	Total	Source	Notes
LLO: Sliplining and Abandoning						
Inspect Conduit	1	LS	$ 5,500.00	$ 5,500.00	Engineer's Judgment	
Slipline 18-inch Line	60	LF	$ 750.00	$ 45,000.00	Engineer's Judgment	
Abandon 10-inch line	60	LF	$ 100.00	$ 6,000.00	Engineer's Judgment	
Abandon 10-inch ditribution Line	1	LS	$ 1,000.00	$ 1,000.00	Engineer's Judgment	Cap at Gatehouse
Subtotal				**$ 57,500.00**		

PARE CORPORATION

PROJECT : Snake Brook Dam		PROJECT NUMBER: 19167.00	
SUBJECT: Snake Brook Dam Rehabilitation OPC			
COMPUTATIONS BY: MED		DATE: March 2020	
CHECK BY: ARO		DATE: March 2020	

DESIGN LEVEL OPINION OF PROBABLE COST
Alternative I: Rehabilitation

Item	Quantity	Unit	Unit Price	Total	Source	Notes
US Control - Angled Stemst						
Cast In Place Wall	20	CY	$ 1,500.00	$ 30,000.00	Recent Project Costs	
Earthwork around Footing	1	LS	$ 7,500.00	$ 7,500.00	Recent Project Costs	
Extend Pipe	1	LS	$ 3,500.00	$ 3,500.00	Engineer's Judgment	
Slide Gate	1	LS	$ 15,000.00	$ 15,000.00	Recent Project Costs	
Catwalk	0	:S	$ 15,000.00	$ -	Recent Project Costs	
Security Devices	0	LS	$ 2,000.00	$ -	Recent Project Costs	
Subtotal				**$ 56,000.00**		
US Control (Alt 1) - Highest Cost						
Cast In Place Wall	20	CY	$ 1,500.00	$ 30,000.00	Recent Project Costs	
Earthwork around Footing	1	LS	$ 7,500.00	$ 7,500.00	Recent Project Costs	
Extend Pipe	1	LS	$ 3,500.00	$ 3,500.00	Engineer's Judgment	
Slide Gate	1	LS	$ 12,000.00	$ 12,000.00	Recent Project Costs	
Catwalk	1	:S	$ 15,000.00	$ 15,000.00	Recent Project Costs	
Security Devices	1	LS	$ 2,000.00	$ 2,000.00	Recent Project Costs	
Subtotal (Alt)				**$ 70,000.00**		
Outlet Culvert - Slipline & Fill						
Excavaction	0	CY	$ 15.00	$ -	Recent Project Costs	
Cut and Remove Excess Components	1	LS	$ 7,500.00	$ 7,500.00	Engineer's Judgment	
Install Pipe	70	LF	$ 750.00	$ 52,500.00	Recent Project Costs	
Fill Culvert	16	CY	$ 500.00	$ 8,000.00	Recent Project Costs	
Imported Backfill	0	TN	$ 25.00	$ -	Recent Project Costs	
Install Backfill	0	CY	$ 20.00	$ -	Recent Project Costs	
DS Headwall	1	LS	$ 2,500.00	$ 2,500.00	Recent Project Costs	
Subtotal				**$ 70,500.00**		
Outlet Culvert (Alt 1) - Highest Cost						
Excavaction	940	CY	$ 15.00	$ 14,100.00	Recent Project Costs	
Cut and Remove Excess Components	1	LS	$ 7,500.00	$ 7,500.00	Engineer's Judgment	
Install Pipe	70	LF	$ 150.00	$ 10,500.00	Recent Project Costs	
Install Cradle	10	CY	$ 300.00	$ 3,000.00	Recent Project Costs	
Imported Backfill	1880	TN	$ 25.00	$ 47,000.00	Recent Project Costs	
Install Backfill	940	CY	$ 20.00	$ 18,800.00	Recent Project Costs	
DS Headwall	1	LS	$ 2,500.00	$ 2,500.00	Recent Project Costs	
Subtotal (Alt)				**$ 103,400.00**		
Gatehouse Improvements						
Fill Floor	1	LS	$ 2,500.00	$ 2,500.00	Engineer's Judgment	
Ground Floor	1	LS	$ 3,000.00	$ 3,000.00	Recent Project Costs	
Upper Floor	1	LS	$ 5,000.00	$ 5,000.00	Engineer's Judgment	
Access Ladder	1	LS	$ 2,000.00	$ 2,000.00	Engineer's Judgment	
Subtotal				**$ 12,500.00**		

SPILLWAY

Item	Quantity	Unit	Unit Price	Total	Source	Notes
Preperation of Areas						
Reomve Debris	1	LS	$ 1,000.00	$ 1,000.00	Engineers Judgment	
Subtotal				**$ 1,000.00**		
New Control Weir						
Remove Bedrock	40	CF	$ 75.00	$ 3,000.00	Engineer's Judgement	
Instll Weir	5	CY	$ 1,500.00	$ 7,500.00	Means 31 11 10.10 0350 Grub	
Reomave and recotract T Walls	1	LS	$ 6,500.00	$ 6,500.00	Engineer's Judgement	Estimated Value
Subtotal				**$ 17,000.00**		

PARE CORPORATION

PROJECT : Snake Brook Dam	PROJECT NUMBER: 19167.00
SUBJECT: Snake Brook Dam Rehabilitation OPC	
COMPUTATIONS BY: MED	DATE: March 2020
CHECK BY: ARO	DATE: March 2020

DESIGN LEVEL OPINION OF PROBABLE COST
Alternative I: Rehabilitation

Item	Quantity	Unit	Unit Price	Total	Source	Notes
Beaver Deceiver						
Beaver Deceiver	1	LS	$ 7,500.00	$ 7,500.00	Recent project bids	
Subtotal				**$ 7,500.00**		
DAM EMBANKMENT						
Core Wall						
Excavate down to the core wall	1	LS	$ 3,000.00	$ 3,000.00	Engineer's Judgment	
Raise Core Wall	1	LS	$ 7,500.00	$ 7,500.00	Engineer's Judgment	
Subtotal				**$ 10,500.00**		
Dam Raise						
Prep for Dam Raise	1	LS	$ 1,500.00	$ 1,500.00	Engineer's Judgment	
Imported Backfill	450	TN	$ 25.00	$ 11,250.00	Recent Project Costs	
Install Backfill	300	CY	$ 35.00	$ 10,500.00	Recent Project Costs	
Subtotal				**$ 23,250.00**		
DS Slope						
Prep for DS Slope Work	1	LS	$ 1,500.00	$ 1,500.00	Engineer's Judgment	
Imported Backfill	450	TN	$ 25.00	$ 11,250.00	Recent Project Costs	
Install Backfill	300	CY	$ 35.00	$ 10,500.00	Recent Project Costs	
Subtotal				**$ 23,250.00**		
Loam and Seed						
Loam and Seed	3400	SY	$ 6.00	$ 20,400.00	Recent Project Costs	300 LF x 20' high
Imported loam	850	CY	$ 30.00	$ 25,500.00	Recent Project Costs	300 LF x 20' high
Subtotal				**$ 20,400.00**		
Mid Level Outlet / Waste Pipe						
Inspect Conduit	1	LS	$ 6,000.00	$ 6,000.00	Engineer's Judgment	
Improvements	1	LS	$ 45,000.00	$ 45,000.00	Engineer's Judgment	
Subtotal				**$ 51,000.00**		
SUBTOTAL				$ 533,355.00		
Contract Bonds				$ 6,000.00	Recent Project Costs (1%)	
Design Contingency				**$ 81,000.00**	15%	
OPINION OF PROBABLE CONSTRUCTION COST				**$ 621,000.00**		
Construction Admin				$ 150,000.00		
OPINION OF PROBABLE CONSTRUCTION COST				**$ 771,000.00**		

PARE CORPORATION

PROJECT : Snake Brook Dam	PROJECT NUMBER: 19167.00
SUBJECT: Snake Brook Dam Rehabilitation OPC	
COMPUTATIONS BY: MED	DATE: March 2020
CHECK BY: ARO	DATE: March 2020

DESIGN LEVEL OPINION OF PROBABLE COST
Alternate II: Removal

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Construction Trailer and Utilities	2	MON	$ 2,700.00	$ 5,400.00		
Project Superintendent	2	MON	$ 8,200.00	$ 16,400.00		
QC Plans	6	HR	$ 150.00	$ 900.00	Additional for Winter	
Submittals	6	HR	$ 150.00	$ 900.00		
Schedules	6	HR	$ 150.00	$ 900.00		
Meetings	3	EA	$ 300.00	$ 900.00		Assume 2hrs each @ 150/hr
Project Sign	1	LS	$ 900.00	$ 900.00	Recent project bids	
Proctor Tests	0	TEST	$ 225.00	$ -	Laboratory Quote plus markup	
Sieve Analyses	0	EA	$ 100.00	$ -	Laboratory Quote plus markup	
Concrete Sampling/Testing	0	EA	$ 400.00	$ -	Recent project bids	
Concrete Compression Tests	0	EA	$ 30.00	$ -	Laboratory Quote plus markup	
Field Density Testing	0	DAY	$ 500.00	$ -	Recent project bids	
Chemical Soil Tests	0	EA	$ 1,000.00	$ -	Recent project bids	
Subtotal				**$ 26,300.00**		
Mobilization & Demolition						
Mobilization	1	LS	$ 7,500.00	$ 7,500.00	Engineers Judgment	
Demobilization	1	LS	$ 5,000.00	$ 5,000.00	Engineers Judgment	
Subtotal				**$ 12,500.00**		
Clear and Grub						
Clear Work Area	3400	SY	$ 3.50	$ 11,900.00	Means 31 11 10.10 0300 Clear Only	
Grub Work Area	3400	SY	$ 2.00	$ 6,800.00	Means 31 11 10.10 0350 Grub	
Clear Trees Larger Than 8 inch	5	EA	$ 250.00	$ 1,250.00		Estimated Value
Engineered Fill Imported	15	TN	$ 20.00	$ 300.00	Recent Project Costs	
Engineered Fill Placed	7.5	CY	$ 30.00	$ 225.00	Recent Project Costs	Assumed value
Subtotal				**$ 20,475.00**		
Erosion Control						
Hay bales	400	LF	$ 7.00	$ 2,800.00	Recent project bids	
Silt Fence	800	LF	$ 5.00	$ 4,000.00	Recent project bids	
Maintenance and Removal	1	LS	$ 1,500.00	$ 1,500.00	Engineer's Judgment	
Turbidity Barrier	120	LF	$ 30.00	$ 3,600.00	Recent project bids	
Subtotal				**$ 11,900.00**		
Control of Water / Water Diversion						
Implement / Maintain Drawdown	1	LS	$ 25,000.00	$ 25,000.00	Engineer's Judgment	Siphon
US Cofferdam	1	LS	$ 25,000.00	$ 25,000.00	Bulk bags	
DS Cofferdams	1	LS	$ 2,000.00	$ 2,000.00	Engineer's Judgment	
Dewatering	30	DAY	$ 150.00	$ 4,500.00	Engineer's Judgment	
Subtotal				**$ 56,500.00**		
Remove Dam - Entire Extent						
Excavation	4000	CY	$ 15.00	$ 60,000.00	Engineer's Judgment	
Remove Core Wall	1	LS	$ 5,000.00	$ 5,000.00	Engineer's Judgment	
Install Stream Bank Protection	120	SY	$ 150.00	$ 18,000.00	Recent Project Costs	
Import Riprap for Stream Bank Protection	180	TN	$ 35.00	$ 6,300.00	Recent Project Costs	
Subtotal				**$ 89,300.00**		
Dredging of Impoundment Sediment (Contingency)						
Dredge Impoundment Sediment	5000	CY	$ 20.00	$ 100,000.00	Means 35 20 23.23	
Handling and Disposal	5000	CY	$ 20.00	$ 100,000.00	Engineers Judgment	
Subtotal				**$ 200,000.00**		

PROJECT : Snake Brook Dam	PROJECT NUMBER: 19167.00
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DESIGN LEVEL OPINION OF PROBABLE COST
Alternate II: Removal

Item	Quantity	Unit	Unit Price	Total	Source	Notes
Embankment Work						
Loam Crest and DS Slope	3400	SY	$ 6.00	$ 20,400.00	Recent Project Costs	
Imported Loam	1150	TN	$ 30.00	$ 34,500.00	Recent Project Costs	
Subtotal				**$ 54,900.00**		
SUBTOTAL				$ 471,875.00		
Contract Bonds				$ 5,000.00	Recent Project Costs (1%)	
Design Contingency				**$ 71,550.00**	15%	
OPINION OF PROBABLE CONSTRUCTION COST				**$ 549,000.00**		
Engineering & Design				$ 50,000.00		
Permitting				$ 45,000.00		
Construction Phase Services				$ 75,000.00		
OPINION OF PROBABLE TOTAL PROJECT COST - Removal				**$ 719,000.00**		

DS Impacts

Engineering & Design	$ 85,000.00
Permitting	$ 50,000.00
Public Outreach and General Coordination	$ 75,000.00
Implement Measures	$ 500,000.00
OPINION OF PROBABLE TOTAL PROJECT COST - Floodproofing	**$ 710,000.00**

OPINION OF PROBABLE TOTAL PROJECT COST - Alternative II	**$ 1,429,000.00**

APPENDIX C
Underwater Inspection Reports
Snake Brook Dam
Wayland, Massachusetts

FIELD SUMMARY REPORT
LOCATION, INSPECTION
INSERTION OF A ROBOTIC CAMERA
IN THE
SNAKE BROOK DAM LOW LEVEL OUTLET

DATE OF INSPECTION: 12/06/2019

LOCATION: SNAKE BROOK DAM, TOWN OF WAYLAND, MA

WORK SCOPE: locate the low level outlet, assist in the placing of a remote robotic camera in the low level outlet

DIVE STATION AND EXISTING CONDITIONS: The dive station was trailered to the site and setup in the access road before the dam. Surface air supply and umbilical were used to support diving operations. Cold water support was via water heater, hard wire communications to the diver was maintained at all time. Water temperature was approximately 32F, air temperature was approximately 35F. Water visibility was less than 2ft, water color a light brown. The pond was covered with 4-5 inches of ice. Access to the water was through holes cut into the ice.

BRIEF HISTORY OF THE SITE: The Town of Wayland has used this dam for a supply of water. The piping and mechanism inside the gate house controls the flow through the gate house and provides a low level outlet. There is a water supply line which crosses above the low level out pipe.

SUMMERY OF DIVING OPERATIONS

After setting up and testing the diving equipment, a triangular hole was cut into the ice roughly in line with the edge of the gate house. The diver entered the water and found the dam face was covered with a soft layer of mud, leaves and other organic debris. A search was conducted for the outlet pipe. After searching a reasonable distance from the access hole, the derelict water pipe was located but not the low level outlet. Another access hole was cut into the ice after scaling out approximate distances and known locations from the gate house. The diver located the city water pipe where it crosses over a rock wall located at the toe of the dam. The low level outlet was found by searching through the soft mud below the city water pipe, down the side of the rock wall. The outlet pipe was found to be 75% filled with mud in the rock wall. The diver had to push his hands into the mud to locate the pipe. An attempt was made to place the robotic camera into the outlet pipe. Visibility was 0 due to the mud and the robot could not traverse through the soft mud.

A brief inspection of the area surrounding the outlet pipe revealed that much of the dam slope is covered with mud and organic debris. Much of the wall at the base of the dam is covered with mud, approximately 1 to 2 feet of the wall is uncovered.

Diving operations were suspended and equipment winterized.

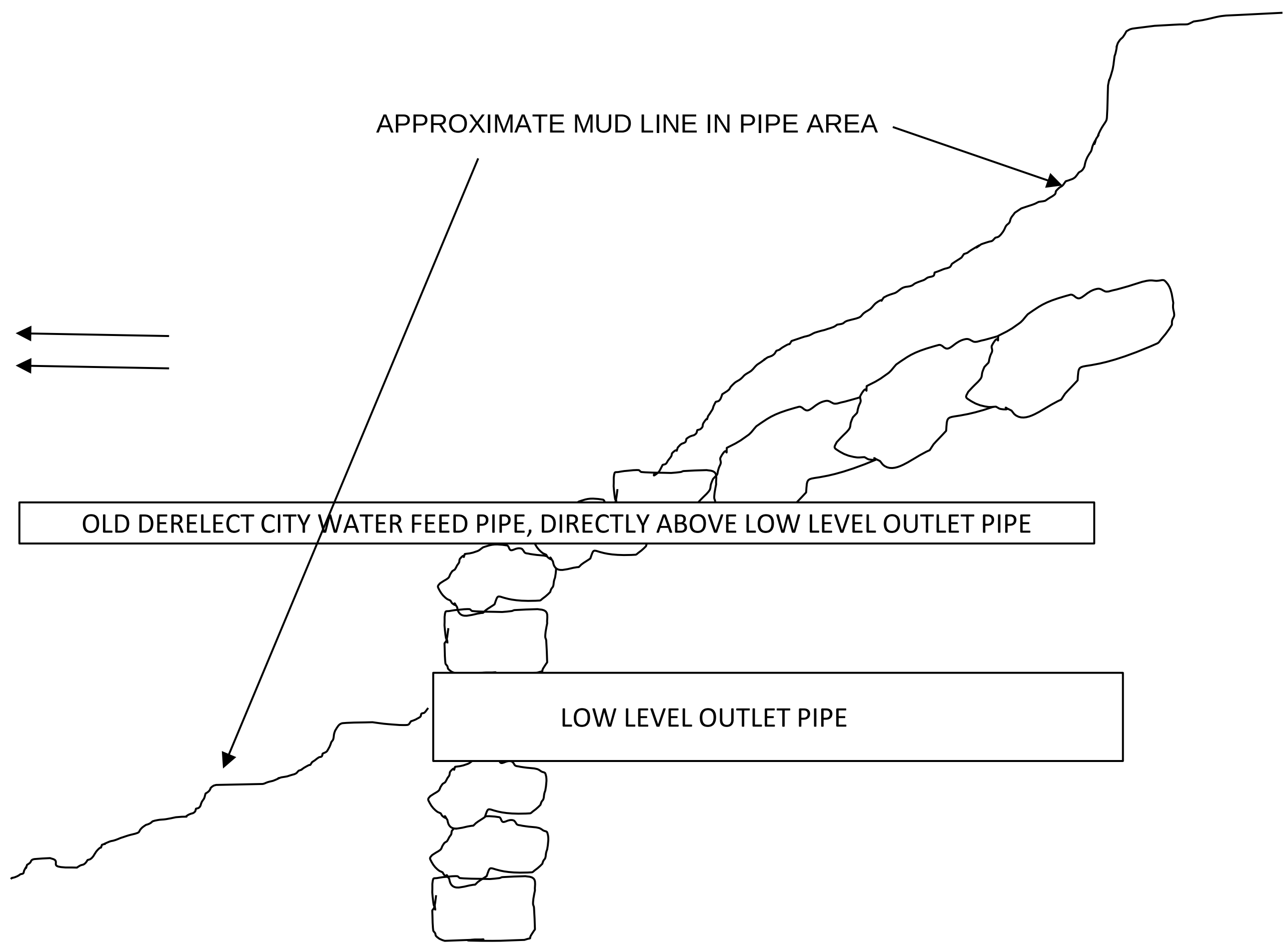
Inner Tech assisted the Pare resident engineer to perform inspections of the inside of the gate house. The piping inside was rusted and a level control mechanism appeared inoperable. A large gate valve was noted which was believed to be the low level outlet gate. The gate appeared non functional. The outlet pipe had a 1inch plugged tap hole in the side, perhaps for water sampling or pressure testing.

REMEDY PROCEDURES: The outlet pipe could not be inspected due to the presence of the soft mud inside the pipe. Possible remedies for eliminating the mud are placing an inflatable plug with a bypass in the outlet pipe and attempt to operate the outlet gate, to flush out the mud. The gate could be repaired to replaced while the plug is in place. Tapping a large hole into the outlet pipe in the gate house and installing a gate valve. Attempt to pump out the mud in the outlet pipe from the outside.

north

SNAKE BROOK DAM
LOW LEVEL OUTLET DETAIL
FIGURE 1

NOT TO SCALE



MOBILE ROBOTICS

Infrastructure Investigations

Video Pipe Inspection Report

Prepared for:

PARE ENGINEERING CORPORATION

Project # 2019184

12/06/2019

Mobile Robotics

110 North Maple Street-Hadley, MA 01035

413-427-5086

www.mrobot.com

charlie@mrobot.com

Snake Brook Dam	Project #2019184	12/06/2019	Inspection #1	

From	To	Direction	ID	System	Length
outlet	gate house	north/against flow	@2X3'	stone culvert	@90'

Snake Brook Dam	Project #2019184	12/06/2019	Inspection #2	

From	To	Direction	ID	System	Length
inlet	gate house	south/with flow	18"	FE/H2O	@70'

	pipe segment is in good condition with no defects
	pipe segment is in fair condition with some defects
	pipe segment is in poor condition with serious defects
ID	approximate inside diameter of pipe
SS	Sanitary Sewer
SD	Storm Drain
TD	Toe Drain
GWI	Groundwater Infiltration
PVC	Poly Vinyl Chloride Pipe
RCP	Re-enforced Concrete Pipe
AC	Asbestos Concrete Pipe
FE	Iron Pipe
HDPE	High Density Poly Ethylene Pipe
CIPP	Cured-in-place Pipe

Snake Brook Dam	Project #2019184	12/06/2019	Inspection #1

From	To	Direction	ID	System	Length
outlet	gate house	north/against flow	@2X3'	stone culvert	@90'

Distance	Clock	Features & Defects	VIDEO
0'-		outlet	
@10'		zoomed view appears to be collapsed	

Conclusion	The culvert appears to be collapsed near the outlet.

Snake Brook Dam	Project #2019184	12/06/2019	Inspection #2

From	To	Direction	ID	System	Length
inlet	gate house	south/with flow	18"	FE/H2O	@70'

Distance	Clock	Features & Defects	VIDEO
25'		offshore-approximate location of inlet	

Conclusion	The inlet pipe is buried in mud. No visibility.

APPENDIX D
Wetland Delineation Supporting Information
Snake Brook Dam
Wayland, Massachusetts

WETLAND FIELD REPORT

PROJECT TITLE: Snake Pond Dam

PARE JOB NO.: 19167.00 **LOCATION:** Wayland, Massachusetts

DELINEATION DATE: 11/6/19 **WEATHER:** Sunny, 50 degrees

REPORT DATE: 11/19/2019 **PERFORMED BY:** Lauren Gluck, P.W.S.

DISCUSSIONS AND COMMENTS

Wetland resource areas in the vicinity of the Snake Pond Dam in Wayland were defined and delineated in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00, referred to as the WPA Regulations), and the methodology specified in the publications entitled Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act (Jackson, 1995) and The Regional Supplement to the Corps of Engineers Wetland Delineation Manual: North Central and Northeast Region (U.S. Army Corps of Engineers, 2012). Inspection and delineation of wetlands were completed on November 6, 2019.

The project site consists of an earthen dam with an impounded pond upstream of the dam and Snake Brook that outlets downstream of the dam. The site is located to the east of Rice Road and north of Woodbridge Road. Land bordering the pond and stream is a combination of undeveloped forest and residential properties. Vegetated wetlands border the eastern and southern sides of the pond.

According to the FEMA Flood Insurance Rate Map for the area (Map Number 25017C0529F, effective date July 7, 2014), the area is not located in a delineated Special Flood Hazard Area (SFHA).

According to the most recent available MassGIS data, no certified or potential vernal pools, Areas of Critical Environmental Concern, Outstanding Resource Waters, or mapped rare species habitats are located on or in the vicinity of the site.

Pink field flags were placed at appropriate intervals along the wetland/upland borders. Primary parameters evaluated in wetland delineation included vegetation, indicators of wetland hydrology, and hydric soil indicators. Observed wetland hydrologic indicators and soils are described in the following sections and within the attached Delineation Data Forms. Wetland resource areas within the vicinity of the site include the following: **Bordering Vegetated Wetlands, Bank,** and **Stream.** Wetland resource areas are discussed in the following sections.

WETLAND DESCRIPTIONS

Pond

The Snake Brook Dam impounds a linear-shaped pond to the west of Rice Street known as the Old Wayland Reservoirs. The edges of the impoundment are defined under section 10.54 of the WPA Regulations as **Bank,** which has an associated **100-foot Buffer Zone**. Flag series P-1 to P-20 defines the Bank in the vicinity of the earthen dam, which were delineated according to first observable break in slope. The series begins at the eastern end of the pond and extends south along a forested slope between flags P-1 to P-6. The series then turns west to follow the upstream edge of the dam embankment between P-6 and P-10, where the Bank consists of a maintained earthen slope. Flags P-10 to P-20 define the wooded western edge of the pond, where the Snake Brook outlets between flags P-15 and P-16. Species of vegetation observed along the Banks included, but were not limited to, the following:

Common Name	Scientific Name	Indicator Status
Red Maple	*Acer rubrum*	FAC
Red Oak	*Quercus rubra*	FACU
White Pine	*Prunus strobus*	FACU
American Beech	*Fagus grandifolia*	FACU
White Oak	*Quercus alba*	FACU
Highbush Blueberry	*Vaccinium corymbosum*	FACW
Sweet Pepperbush	*Clethra alnifolia*	FAC
Glossy Buckthorn	*Frangula alnus*	FAC
Mountain Laurel	*Kalmia latifolia*	FACU
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Japanese Barberry	*Berberis thunbergii*	FACU
Great Laurel	*Rhododendron maximum*	FAC

According to 310 CMR 10.56(2), land below the Mean Low Water (MLW) of the impoundment is defined as **Land Under Waterbodies**. The pond edges appeared shallow and mostly unvegetated near the dam embankment, although communities of emergent vegetation could be observed along the edges further upstream.

Snake Brook

The uncontrolled spillway at the west end of the dam discharges to Snake Brook, which flows south through a wooded area before crossing a culvert beneath Woodridge Road approximately 400 feet to the south. Snake Brook is shown on the USGS Topographic Quadrangle for the area as a perennial river and therefore has an associated **200-foot Riverfront Area** in accordance with section 10.58 (2) of the WPA Regulations.

The edges of the river are defined in section 10.54 of the Regulations as **Bank**. Flag series R-1 to R-18 and R-100 to R-113 define the east and west Banks of the river, respectively. Both series begin at the southwest side of the impoundment and extend south for a short distance along boulder walls flanking the channel before entering a stone culvert under a footpath between flags R-4 and R-103. Downstream of the culvert, the river extends downslope through a wooded area to the south of the dam. A walled outlet channel, which reportedly connects to the nearby gatehouse, is located between flags R-12 and R-16. The Banks are forested and have a variable understory of shrubs, including several invasive species. Vegetation observed along the Bank included, but was not limited to, the following species:

Common Name	Scientific Name	Indicator Status
Red Maple	*Acer rubrum*	FAC
Yellow Birch	*Betula alleghaniensis*	FAC
White Pine	*Prunus strobus*	FACU
American Beech	*Fagus grandifolia*	FACU
White Oak	*Quercus alba*	FACU
Burningbush	*Ailanthus altissima*	NI
Japanese Barberry	*Berberis thunbergii*	FACU
Sweet Pepperbush	*Clethra alnifolia*	FAC
Glossy Buckthorn	*Frangula alnus*	FAC
Mountain Laurel	*Kalmia latifolia*	FACU
Cinnamon Fern	*Osmunda cinnamomea*	FACW

Bordering Vegetated Wetlands

Two vegetated wetland areas were identified and delineated in the vicinity of the dam. Both wetlands border on Snake Brook and are therefore classified as **Bordering Vegetated Wetlands (BVWs)** with associated **100-foot Buffer Zones** under section 10.55 of the WPA Regulations. Each of these areas is described below.

Wetland A

A forested wetland occupies a low-lying area to the west of the dam. The wetland is hydrologically connected with both the impoundment and outlet, although an upland berm separates the area from the pond edge immediately northwest of the dam. Flag series A-1 to A-7 defines the eastern edge of this wetland, beginning at Bank flag R-101 and extending north, ending where the pond connects with the wetland at Bank flag P-20. Flag series A-100 to A-104 defines the west edge of the wetland, beginning along a forested slope to the northwest of the dam and ending along Snake Brook at Bank flag R-102. The wetland is forested, with a dense understory of shrubs and a ground cover of ferns. Most of the wetland appears to have a seasonally flooded hydrology that is primarily driven by groundwater. Water staining and drainage patterns at the north end of the wetland bordering the pond indicate that it likely receives overflow from the impoundment during high water. Species of vegetation observed within the wetland included, but were not limited to, the following:

Common Name	Scientific Name	Indicator Status
Red Maple	*Acer rubrum*	FAC
Yellow Birch	*Betula alleghaniensis*	FAC
White Pine	*Pinus strobus*	FACU
Black Birch	*Betula lenta*	FACU
Glossy Buckthorn	*Frangula alnus*	FAC
Sweet Pepperbush	*Clethra alnifolia*	FAC
Highbush Blueberry	*Vaccinium corymbosum*	FACW
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Royal Fern	*Osmunda regalis*	OBL

Wetland B

A forested wetland is located to the east of Snake Brook within the wooded area downstream of the dam. Flag series B-1 to B-6 defines the north edge of the BVW, beginning at Bank flag R-17 and extending east along the toe of the slope before turning south, terminating along a stone wall bordering the adjacent residential property. The wetland edges are forested with a dense understory dominated by invasive shrubs, although wetter areas in the wetland interior are more sparsely vegetated and dominated by native shrubs. The wetland appears to have a variable hydrology, ranging from seasonally saturated areas along the upper margins to semipermanently flooded areas at the interior. The wetland appears to be fed by a combination of groundwater and overflow from Snake Brook. Species of vegetation observed within the wetland included, but were not limited to, the following:

Common Name	Scientific Name	Indicator Status
Slippery Elm	*Ulmus rubra*	FAC
Red Maple	*Acer rubrum*	FAC
American Beech	*Fagus grandifolia*	FACU
White Pine	*Pinus strobus*	FACU
Burningbush	*Ailanthus altissima*	NI
Japanese Barberry	*Berberis thunbergii*	FACU
Glossy Buckthorn	*Frangula alnus*	FAC
Sweet Pepperbush	*Clethra alnifolia*	FAC
Highbush Blueberry	*Vaccinium corymbosum*	FACW
Elderberry	*Sambucus nigra*	FACW
Jewelweed	*Impantiens capensis*	FACW
Poison Ivy	*Toxicodendron radicans*	FAC
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Royal Fern	*Osmunda regalis*	OBL
Tussock Sedge	*Carex stricta*	OBL

LHG/SWA

Y:\JOBS\19 Jobs\19167.00 Wayland-SnakePondDamEngSrvcs-MA\Wetlands\SnakePondDam Wetland_Field_Report.doc

Photo 1: Bank along upstream slope of embankment, consisting of maintained grass slope.

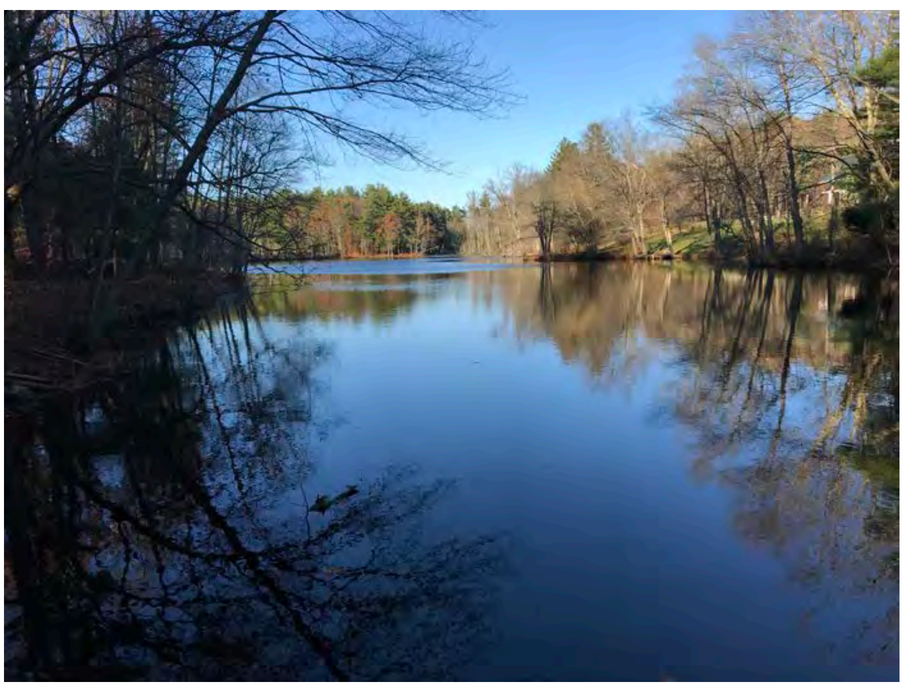


Photo 2: View of impoundment, facing north from dam.

Photo 3: Wooded section of bank at upstream right side of dam, facing southeast toward gatehouse.

Photo 4: A-series BVW to the west of the impoundment and outlet.

Photo 5: Uncontrolled spillway with beaver control device at right abutment.

Photo 6: Outlet channel, facing downstream from spillway toward footbridge.

Photo 7: Walled outlet channel downstream of dam, located between flags R-12 and R-15.

Photo 8: B-series BVW within the wooded area downstream of the dam.

WETLAND DELINEATION SKETCH:

Snake Pond Dam – Wayland, MA

Flagged by Lauren Gluck, PWS of Pare Corporation November 6, 2019

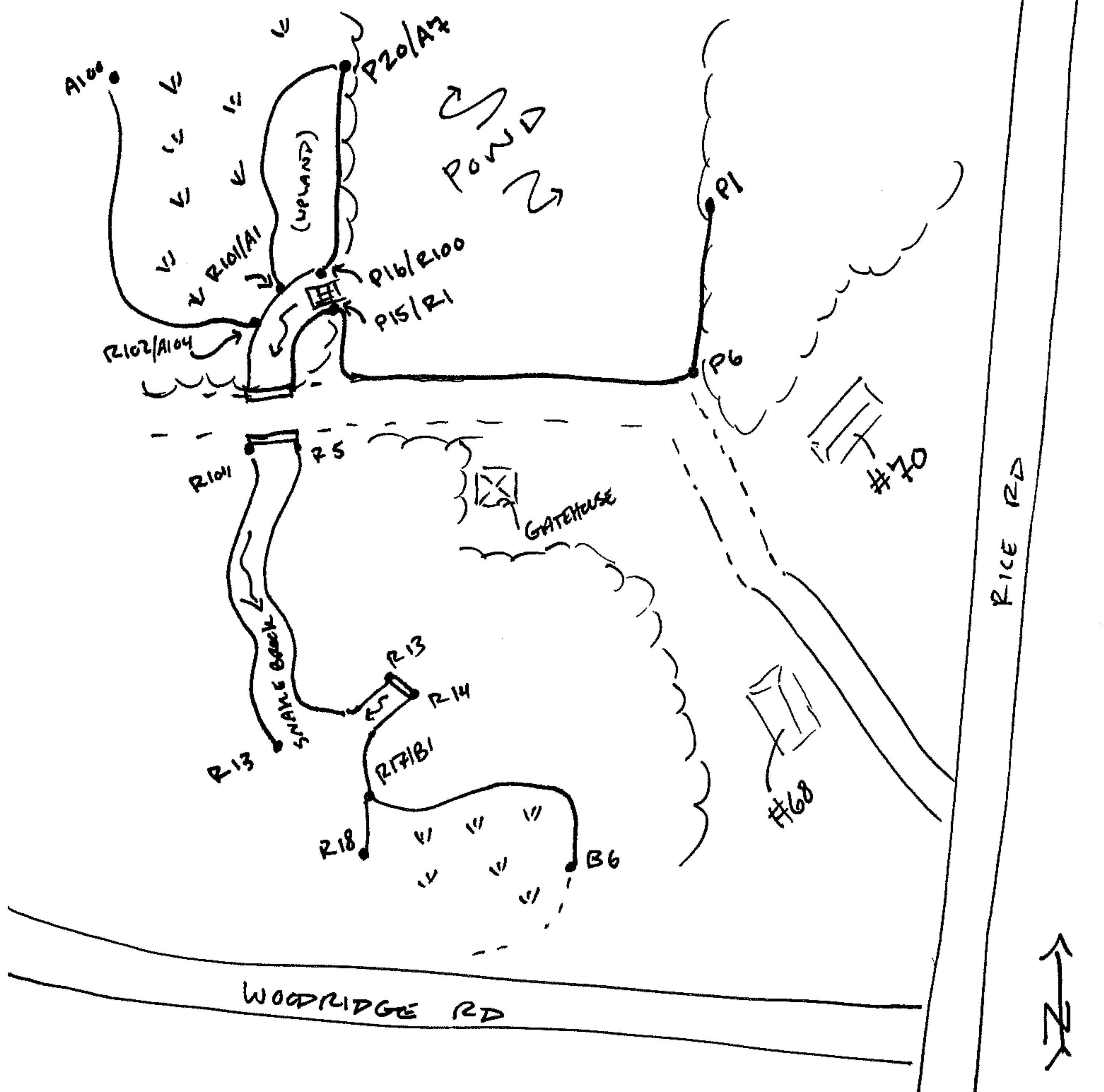
508-543-1755 (o) 617-504-3089 (m)

FLAG SERIES TO LOCATE

Pond Bank: P-1 to P-20

River Banks: R-1 to R-18 & R-100 to R-113

Bordering Vegetated Wetlands: A-1 to A-7, A-100 to A-104, B-1 to B-6



Soil Map—Middlesex County, Massachusetts
(Snake Pond Dam)

Map Scale: 1:4,140 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 19, Sep 12, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 28, 2019—Aug 15, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	10.4	11.4%
51A	Swansea muck, 0 to 1 percent slopes	2.7	2.9%
52A	Freetown muck, 0 to 1 percent slopes	1.5	1.7%
53A	Freetown muck, ponded, 0 to 1 percent slopes	2.3	2.5%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	10.2	11.2%
106C	Narragansett-Hollis-Rock outcrop complex, 3 to 15 percent slopes	20.2	22.1%
106D	Narragansett-Hollis-Rock outcrop complex, 15 to 25 percent slopes	22.9	25.0%
251B	Haven silt loam, 3 to 8 percent slopes	6.2	6.8%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	4.0	4.4%
416B	Narragansett silt loam, 3 to 8 percent slopes, very stony	2.7	3.0%
416C	Narragansett silt loam, 8 to 15 percent slopes, very stony	8.0	8.7%
656	Udorthents-Urban land complex	0.4	0.4%
Totals for Area of Interest		**91.7**	**100.0%**

APPENDIX E
Hydrologic and Hydraulics Analyses

Snake Brook Dam

Wayland, Massachusetts

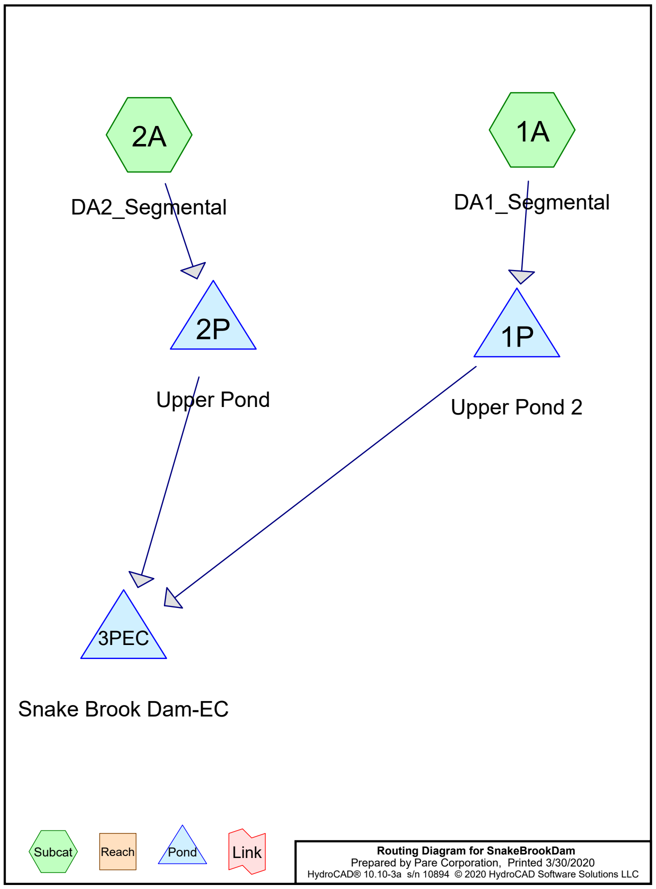
Events for Pond 2P: Upper Pond

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	28.68	18.31	226.66	17.455
50-yr	62.04	57.76	227.11	20.476
100-yr	**80.30**	**78.26**	**227.15**	**20.788**

Events for Pond 3PEC: Snake Brook Dam-EC

Event	Inflow (cfs)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)	Tertiary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	65.64	58.19	45.21	**0.00**	12.97	226.02	40.842
50-yr	156.18	148.14	78.33	0.00	69.81	226.56	44.941
100-yr	**203.72**	**196.42**	**87.91**	0.00	**108.51**	**226.70**	**46.513**

TABLE OF CONTENTS



Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-yr	MA-Snake 24-hr S1	1-yr	Default	24.00	1	2.66	2
2	2-yr	MA-Snake 24-hr S1	2-yr	Default	24.00	1	3.28	2
3	5-yr	MA-Snake 24-hr S1	5-yr	Default	24.00	1	4.29	2
4	10-yr	MA-Snake 24-hr S1	10-yr	Default	24.00	1	5.13	2
5	25-yr	MA-Snake 24-hr S1	25-yr	Default	24.00	1	6.29	2
6	50-yr	MA-Snake 24-hr S1	50-yr	Default	24.00	1	7.14	2
7	100-yr	MA-Snake 24-hr S1	100-yr	Default	24.00	1	8.08	2
8	200-yr	MA-Snake 24-hr S1	200-yr	Default	24.00	1	9.25	2
9	500-yr	MA-Snake 24-hr S1	500-yr	Default	24.00	1	11.10	2
10	1000-yr	MA-Snake 24-hr S1	1000-yr	Default	24.00	1	12.70	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
223.000	51	"2% imp" (2A)
287.000	58	"3% imp" (1A)
510.000	**55**	**TOTAL AREA**

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	3PEC	210.50	207.50	60.0	0.0500	0.013	18.0	0.0	0.0

Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=1.49"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=51.24 cfs 35.651 af

Subcatchment2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=1.05"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=28.08 cfs 19.429 af

Pond 1P: Upper Pond 2 Peak Elev=226.65' Storage=2.737 af Inflow=52.14 cfs 40.115 af
Outflow=52.10 cfs 39.837 af

Pond 2P: Upper Pond Peak Elev=226.66' Storage=17.455 af Inflow=28.68 cfs 22.404 af
Outflow=18.31 cfs 21.278 af

Pond 3PEC: Snake Brook Dam-EC Peak Elev=226.02' Storage=40.842 af Inflow=65.64 cfs 61.115 af
Primary=45.21 cfs 53.280 af Secondary=0.00 cfs 0.000 af Tertiary=12.97 cfs 6.479 af Outflow=58.19 cfs 59.759 af

Total Runoff Area = 510.000 ac Runoff Volume = 55.080 af Average Runoff Depth = 1.30"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

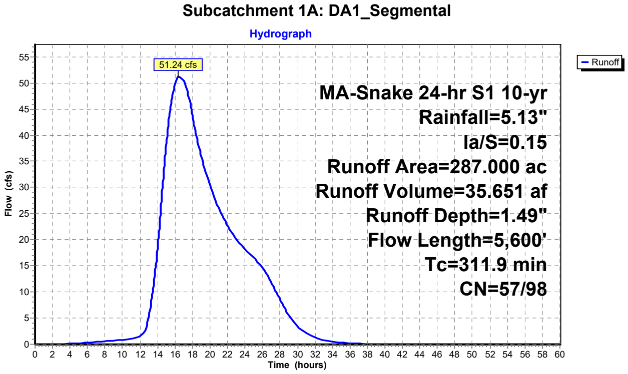
Runoff = 51.24 cfs @ 16.30 hrs, Volume= 35.651 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

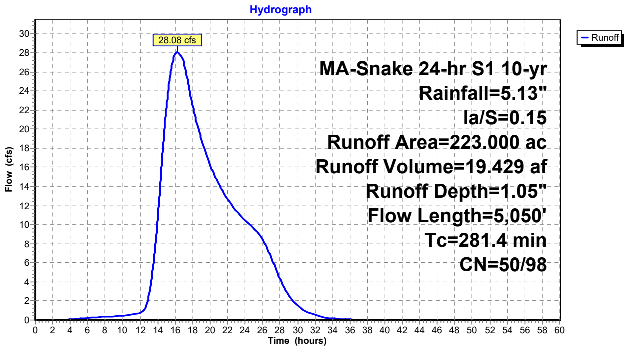
Runoff = 28.08 cfs @ 16.26 hrs, Volume= 19.429 af, Depth= 1.05"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 1.68" for 10-yr event
Inflow = 52.14 cfs @ 16.30 hrs, Volume= 40.115 af, Incl. 0.90 cfs Base Flow
Outflow = 52.10 cfs @ 16.39 hrs, Volume= 39.837 af, Atten= 0%, Lag= 5.3 min
Primary = 52.10 cfs @ 16.39 hrs, Volume= 39.837 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.65' @ 16.67 hrs Storage= 2.737 af (1.087 af above start)

Plug-Flow detention time= 133.7 min calculated for 38.180 af (95% of inflow)
Center-of-Mass det. time= 26.3 min (1,269.0 - 1,242.7)

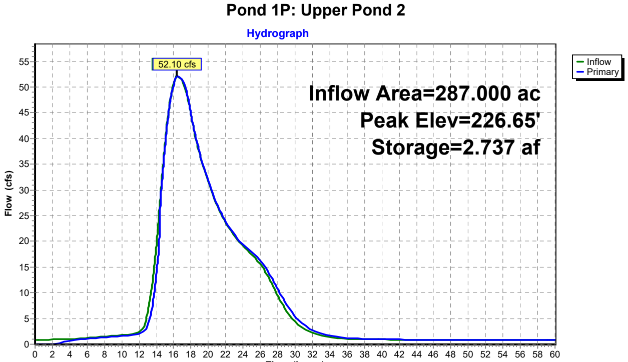
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=52.10 cfs @ 16.39 hrs HW=226.65' TW=225.67' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 52.10 cfs @ 1.50 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 1.21" for 10-yr event
Inflow = 28.68 cfs @ 16.26 hrs, Volume= 22.404 af, Incl. 0.60 cfs Base Flow
Outflow = 18.31 cfs @ 19.71 hrs, Volume= 21.278 af, Atten= 36%, Lag= 207.0 min
Primary = 18.31 cfs @ 19.71 hrs, Volume= 21.278 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 226.66' @ 19.45 hrs Storage= 17.455 af (6.535 af above start)

Plug-Flow detention time= 909.7 min calculated for 10.358 af (46% of inflow)
Center-of-Mass det. time= 233.9 min (1,486.0 - 1,252.1)

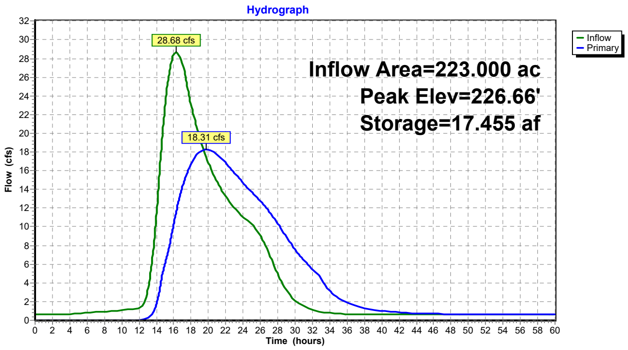
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=18.31 cfs @ 19.71 hrs HW=226.66' TW=225.98' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 18.31 cfs @ 2.23 fps)

Pond 2P: Upper Pond



Summary for Pond 3PEC: Snake Brook Dam-EC

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 1.44" for 10-yr event
Inflow = 65.64 cfs @ 17.00 hrs, Volume= 61.115 af
Outflow = 58.19 cfs @ 18.49 hrs, Volume= 59.759 af, Atten= 11%, Lag= 89.3 min
Primary = 45.21 cfs @ 18.49 hrs, Volume= 53.280 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 12.97 cfs @ 18.49 hrs, Volume= 6.479 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 226.02' @ 18.49 hrs Storage= 40.842 af (10.555 af above start)

Plug-Flow detention time= 854.2 min calculated for 29.472 af (48% of inflow)
Center-of-Mass det. time= 162.6 min (1,507.1 - 1,344.5)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

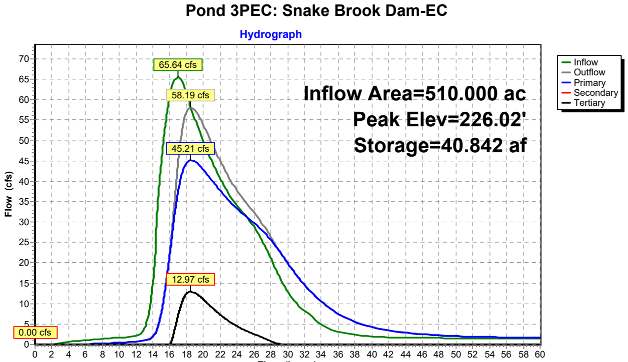
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=45.21 cfs @ 18.49 hrs HW=226.02' (Free Discharge)
└**1=Spillway Channel (Cleared)** (Weir Controls 45.21 cfs @ 2.67 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=12.97 cfs @ 18.49 hrs HW=226.02' (Free Discharge)
├**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└**3=Dam Crest RT of Spwy** (Weir Controls 12.97 cfs @ 1.61 fps)

Pond 3PEC: Snake Brook Dam-EC



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=2.79"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=99.94 cfs 66.758 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.13"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=61.44 cfs 39.609 af

Pond 1P: Upper Pond 2 Peak Elev=226.80' Storage=2.847 af Inflow=100.84 cfs 71.221 af
Outflow=100.62 cfs 70.943 af

Pond 2P: Upper Pond Peak Elev=227.11' Storage=20.476 af Inflow=62.04 cfs 42.584 af
Outflow=57.76 cfs 41.457 af

Pond 3PEC: Snake Brook Dam-EC Peak Elev=226.56' Storage=44.941 af Inflow=156.18 cfs 112.400 af
Primary=78.33 cfs 81.523 af Secondary=0.00 cfs 0.000 af Tertiary=69.81 cfs 29.502 af Outflow=148.14 cfs 111.025 af

Total Runoff Area = 510.000 ac Runoff Volume = 106.366 af Average Runoff Depth = 2.50"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

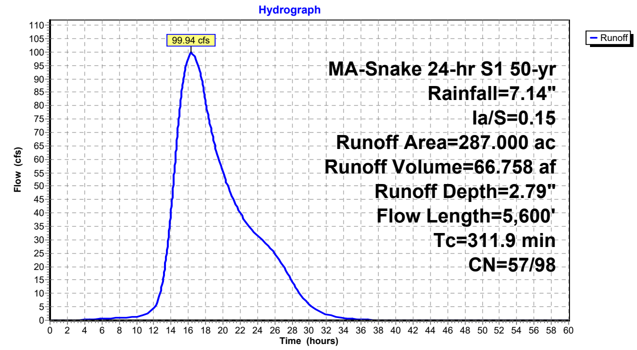
Runoff = 99.94 cfs @ 16.29 hrs, Volume= 66.758 af, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

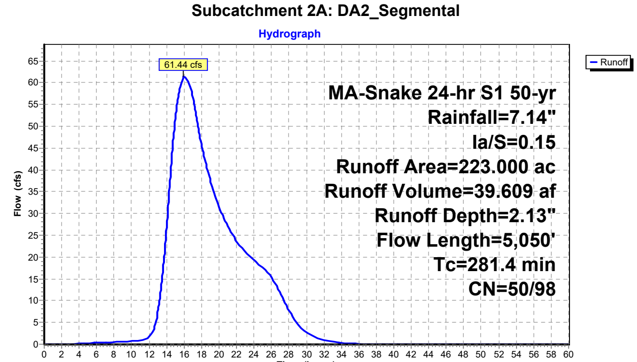
Runoff = 61.44 cfs @ 15.95 hrs, Volume= 39.609 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 2.98" for 50-yr event
Inflow = 100.84 cfs @ 16.29 hrs, Volume= 71.221 af, Incl. 0.90 cfs Base Flow
Outflow = 100.62 cfs @ 16.31 hrs, Volume= 70.943 af, Atten= 0%, Lag= 1.3 min
Primary = 100.62 cfs @ 16.31 hrs, Volume= 70.943 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.80' @ 16.95 hrs Storage= 2.847 af (1.197 af above start)

Plug-Flow detention time= 77.2 min calculated for 69.293 af (97% of inflow)
Center-of-Mass det. time= 16.8 min (1,212.8 - 1,196.0)

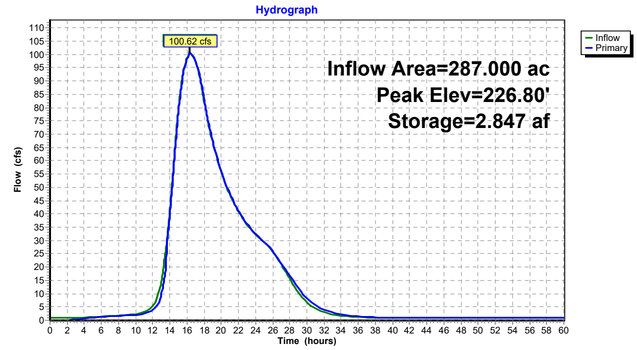
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=100.61 cfs @ 16.31 hrs HW=226.79' TW=226.39' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 100.61 cfs @ 1.65 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.29" for 50-yr event
Inflow = 62.04 cfs @ 15.95 hrs, Volume= 42.584 af, Incl. 0.60 cfs Base Flow
Outflow = 57.76 cfs @ 16.92 hrs, Volume= 41.457 af, Atten= 7%, Lag= 58.2 min
Primary = 57.76 cfs @ 16.92 hrs, Volume= 41.457 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.11' @ 16.96 hrs Storage= 20.476 af (9.556 af above start)

Plug-Flow detention time= 507.3 min calculated for 30.537 af (72% of inflow)
Center-of-Mass det. time= 188.4 min (1,381.7 - 1,193.3)

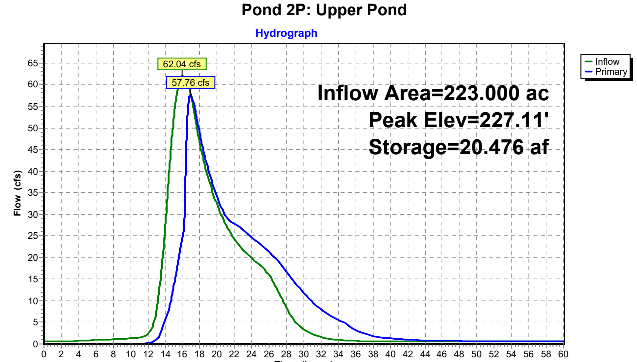
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=57.76 cfs @ 16.92 hrs HW=227.11' TW=226.54' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 57.76 cfs @ 1.35 fps)

Pond 2P: Upper Pond



Summary for Pond 3PEC: Snake Brook Dam-EC

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 2.64" for 50-yr event
Inflow = 156.18 cfs @ 16.81 hrs, Volume= 112.400 af
Outflow = 148.14 cfs @ 17.39 hrs, Volume= 111.025 af, Atten= 5%, Lag= 34.8 min
Primary = 78.33 cfs @ 17.39 hrs, Volume= 81.523 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 69.81 cfs @ 17.39 hrs, Volume= 29.502 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 226.56' @ 17.39 hrs Storage= 44.941 af (14.654 af above start)

Plug-Flow detention time= 455.9 min calculated for 80.738 af (72% of inflow)
Center-of-Mass det. time= 115.9 min (1,391.0 - 1,275.1)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

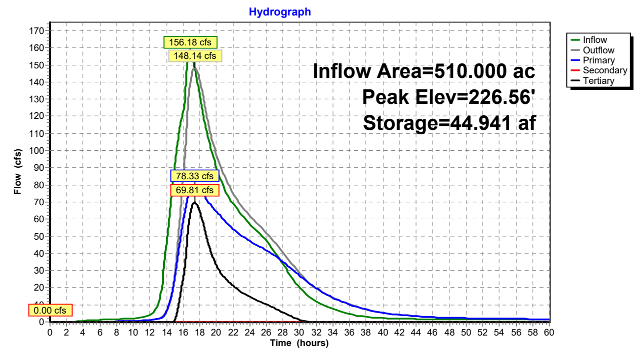
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=78.33 cfs @ 17.39 hrs HW=226.56' (Free Discharge)
└**1=Spillway Channel (Cleared)** (Weir Controls 78.33 cfs @ 2.97 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=69.81 cfs @ 17.39 hrs HW=226.56' (Free Discharge)
├**2=Dam Crest LT of Spwy** (Weir Controls 22.43 cfs @ 1.25 fps)
└**3=Dam Crest RT of Spwy** (Weir Controls 47.37 cfs @ 1.98 fps)

Pond 3PEC: Snake Brook Dam-EC



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=3.47"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=125.28 cfs 82.920 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.72"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=79.70 cfs 50.475 af

Pond 1P: Upper Pond 2 Peak Elev=226.89' Storage=2.914 af Inflow=126.18 cfs 87.383 af
Outflow=125.60 cfs 87.105 af

Pond 2P: Upper Pond Peak Elev=227.15' Storage=20.788 af Inflow=80.30 cfs 53.451 af
Outflow=78.26 cfs 52.323 af

Pond 3PEC: Snake Brook Dam-EC Peak Elev=226.70' Storage=46.513 af Inflow=203.72 cfs 139.429 af
Primary=87.91 cfs 92.221 af Secondary=0.00 cfs 0.000 af Tertiary=108.51 cfs 45.826 af Outflow=196.42 cfs 138.047 af

Total Runoff Area = 510.000 ac Runoff Volume = 133.395 af Average Runoff Depth = 3.14"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

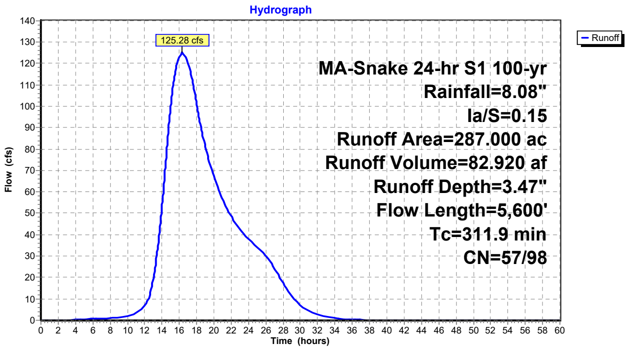
Runoff = 125.28 cfs @ 16.29 hrs, Volume= 82.920 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

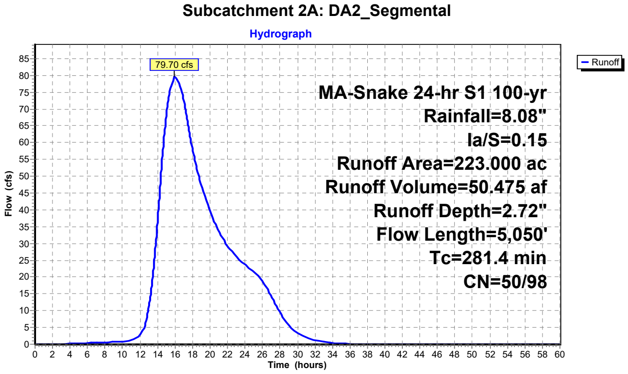
Runoff = 79.70 cfs @ 15.95 hrs, Volume= 50.475 af, Depth= 2.72"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 3.65" for 100-yr event
Inflow = 126.18 cfs @ 16.29 hrs, Volume= 87.383 af, Incl. 0.90 cfs Base Flow
Outflow = 125.60 cfs @ 16.31 hrs, Volume= 87.105 af, Atten= 0%, Lag= 1.1 min
Primary = 125.60 cfs @ 16.31 hrs, Volume= 87.105 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.89' @ 16.77 hrs Storage= 2.914 af (1.264 af above start)

Plug-Flow detention time= 63.8 min calculated for 85.455 af (98% of inflow)
Center-of-Mass det. time= 14.4 min (1,196.8 - 1,182.4)

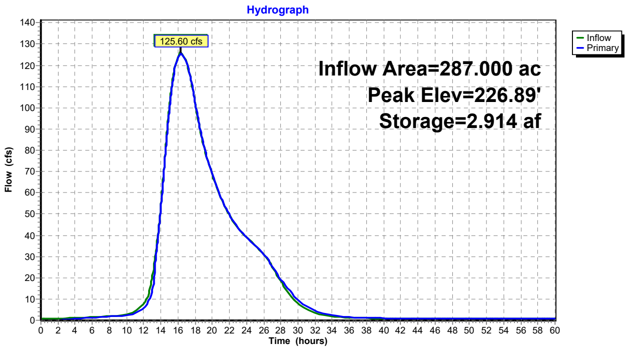
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=125.60 cfs @ 16.31 hrs HW=226.87' TW=226.65' (Dynamic Tailwater)
1=Upper Dam 1 (Weir Controls 125.60 cfs @ 1.65 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.88" for 100-yr event
Inflow = 80.30 cfs @ 15.95 hrs, Volume= 53.451 af, Incl. 0.60 cfs Base Flow
Outflow = 78.26 cfs @ 16.41 hrs, Volume= 52.323 af, Atten= 3%, Lag= 27.5 min
Primary = 78.26 cfs @ 16.41 hrs, Volume= 52.323 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.15' @ 16.52 hrs Storage= 20.788 af (9.868 af above start)

Plug-Flow detention time= 412.0 min calculated for 41.396 af (77% of inflow)
Center-of-Mass det. time= 163.5 min (1,340.6 - 1,177.1)

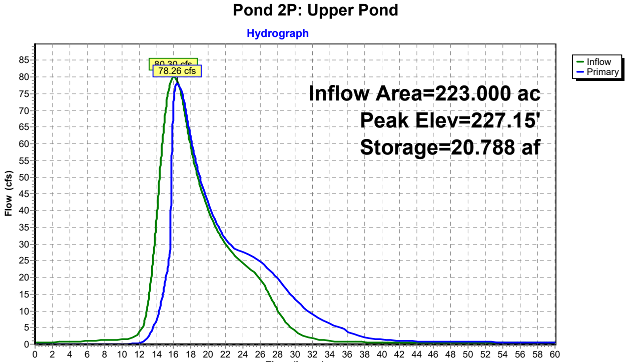
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=78.26 cfs @ 16.41 hrs HW=227.15' TW=226.66' (Dynamic Tailwater)
└─**1=Upper Dam** (Weir Controls 78.26 cfs @ 1.40 fps)

Pond 2P: Upper Pond



Summary for Pond 3PEC: Snake Brook Dam-EC

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 3.28" for 100-yr event
Inflow = 203.72 cfs @ 16.33 hrs, Volume= 139.429 af
Outflow = 196.42 cfs @ 17.00 hrs, Volume= 138.047 af, Atten= 4%, Lag= 40.1 min
Primary = 87.91 cfs @ 17.00 hrs, Volume= 92.221 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 108.51 cfs @ 17.00 hrs, Volume= 45.826 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 226.70' @ 17.00 hrs Storage= 46.513 af (16.226 af above start)

Plug-Flow detention time= 372.0 min calculated for 107.742 af (77% of inflow)
Center-of-Mass det. time= 101.9 min (1,352.6 - 1,250.8)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

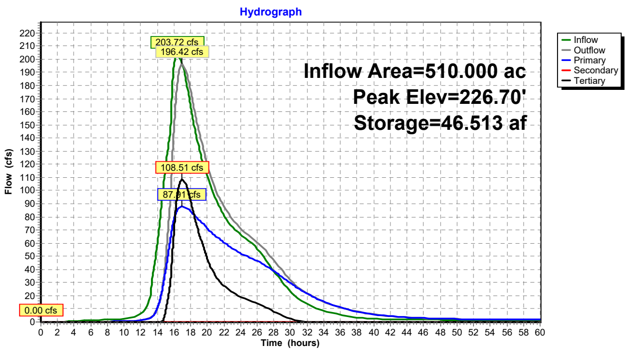
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=87.91 cfs @ 17.00 hrs HW=226.70' (Free Discharge)
└─**1=Spillway Channel (Cleared)** (Weir Controls 87.91 cfs @ 3.12 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└─**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=108.51 cfs @ 17.00 hrs HW=226.70' (Free Discharge)
├─**2=Dam Crest LT of Spwy** (Weir Controls 49.09 cfs @ 1.49 fps)
└─**3=Dam Crest RT of Spwy** (Weir Controls 59.41 cfs @ 2.05 fps)

Pond 3PEC: Snake Brook Dam-EC



Events for Subcatchment 1A: DA1_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	51.24	35.651	1.49
50-yr	7.14	99.94	66.758	2.79
100-yr	**8.08**	**125.28**	**82.920**	**3.47**

Events for Subcatchment 2A: DA2_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	28.08	19.429	1.05
50-yr	7.14	61.44	39.609	2.13
100-yr	**8.08**	**79.70**	**50.475**	**2.72**

Events for Pond 1P: Upper Pond 2

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	52.14	52.10	226.65	2.737
50-yr	100.84	100.62	226.80	2.847
100-yr	**126.18**	**125.60**	**226.89**	**2.914**

Events for Pond 2P: Upper Pond

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	28.68	18.80	226.63	17.262
50-yr	62.04	57.82	227.09	20.375
100-yr	**80.30**	**78.79**	**227.14**	**20.681**

Events for Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)

Event	Inflow (cfs)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)	Tertiary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	66.35	51.73	0.00	51.73	**0.00**	219.90	7.675
50-yr	156.18	71.11	11.93	59.18	0.00	225.19	35.087
100-yr	**204.76**	**114.47**	**53.99**	**60.48**	0.00	**226.18**	**41.958**

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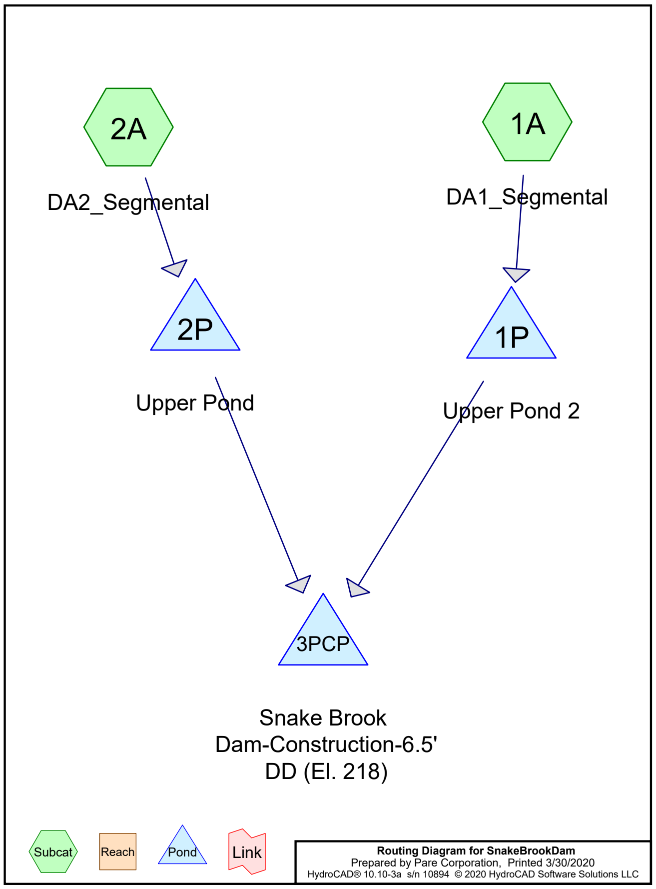


Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-yr	MA-Snake 24-hr S1	1-yr	Default	24.00	1	2.66	2
2	2-yr	MA-Snake 24-hr S1	2-yr	Default	24.00	1	3.28	2
3	5-yr	MA-Snake 24-hr S1	5-yr	Default	24.00	1	4.29	2
4	10-yr	MA-Snake 24-hr S1	10-yr	Default	24.00	1	5.13	2
5	25-yr	MA-Snake 24-hr S1	25-yr	Default	24.00	1	6.29	2
6	50-yr	MA-Snake 24-hr S1	50-yr	Default	24.00	1	7.14	2
7	100-yr	MA-Snake 24-hr S1	100-yr	Default	24.00	1	8.08	2
8	200-yr	MA-Snake 24-hr S1	200-yr	Default	24.00	1	9.25	2
9	500-yr	MA-Snake 24-hr S1	500-yr	Default	24.00	1	11.10	2
10	1000-yr	MA-Snake 24-hr S1	1000-yr	Default	24.00	1	12.70	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
223.000	51	"2% imp" (2A)
287.000	58	"3% imp" (1A)
510.000	**55**	**TOTAL AREA**

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	3PCP	210.50	207.50	60.0	0.0500	0.013	18.0	0.0	0.0

Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=1.49"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=51.24 cfs 35.651 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=1.05"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=28.08 cfs 19.429 af

Pond 1P: Upper Pond 2 Peak Elev=226.65' Storage=2.736 af Inflow=52.14 cfs 40.115 af
Outflow=52.13 cfs 39.837 af

Pond 2P: Upper Pond Peak Elev=226.63' Storage=17.262 af Inflow=28.68 cfs 22.404 af
Outflow=18.80 cfs 21.278 af

Pond 3PCP: Snake Brook Peak Elev=219.90' Storage=7.675 af Inflow=66.35 cfs 61.115 af
Primary=0.00 cfs 0.000 af Secondary=51.73 cfs 61.278 af Tertiary=0.00 cfs 0.000 af Outflow=51.73 cfs 61.278 af

Total Runoff Area = 510.000 ac Runoff Volume = 55.080 af Average Runoff Depth = 1.30"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

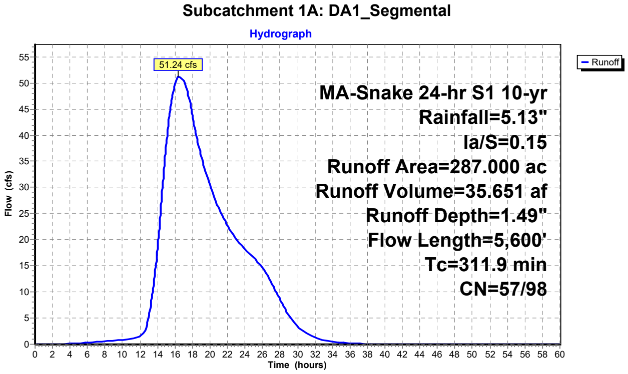
Runoff = 51.24 cfs @ 16.30 hrs, Volume= 35.651 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

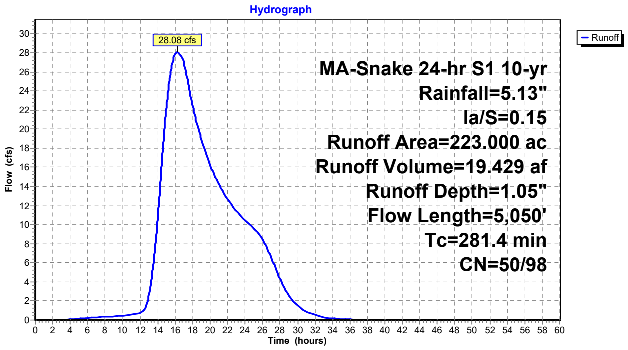
Runoff = 28.08 cfs @ 16.26 hrs, Volume= 19.429 af, Depth= 1.05"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 1.68" for 10-yr event
Inflow = 52.14 cfs @ 16.30 hrs, Volume= 40.115 af, Incl. 0.90 cfs Base Flow
Outflow = 52.13 cfs @ 16.40 hrs, Volume= 39.837 af, Atten= 0%, Lag= 5.8 min
Primary = 52.13 cfs @ 16.40 hrs, Volume= 39.837 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.65' @ 16.40 hrs Storage= 2.736 af (1.086 af above start)

Plug-Flow detention time= 133.8 min calculated for 38.187 af (95% of inflow)
Center-of-Mass det. time= 26.1 min (1,268.8 - 1,242.7)

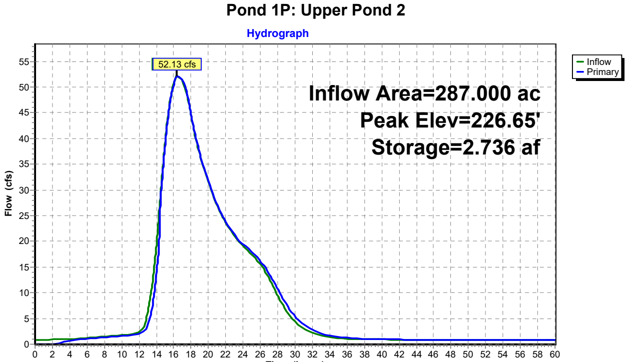
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=52.13 cfs @ 16.40 hrs HW=226.65' TW=218.77' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 52.13 cfs @ 1.51 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 1.21" for 10-yr event
Inflow = 28.68 cfs @ 16.26 hrs, Volume= 22.404 af, Incl. 0.60 cfs Base Flow
Outflow = 18.80 cfs @ 19.27 hrs, Volume= 21.278 af, Atten= 34%, Lag= 180.3 min
Primary = 18.80 cfs @ 19.27 hrs, Volume= 21.278 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 226.63' @ 19.27 hrs Storage= 17.262 af (6.342 af above start)

Plug-Flow detention time= 903.7 min calculated for 10.358 af (46% of inflow)
Center-of-Mass det. time= 227.9 min (1,480.0 - 1,252.1)

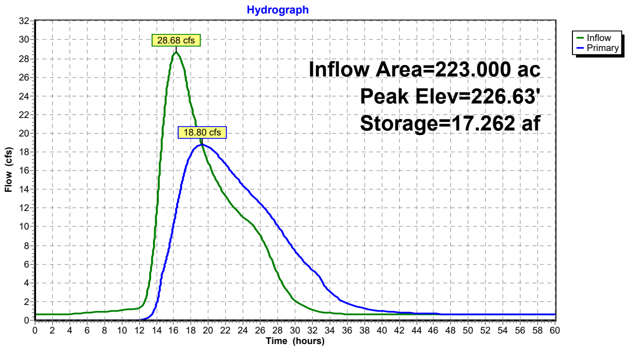
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=18.80 cfs @ 19.27 hrs HW=226.63' TW=219.88' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 18.80 cfs @ 2.37 fps)

Pond 2P: Upper Pond



Summary for Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 1.44" for 10-yr event
Inflow = 66.35 cfs @ 17.03 hrs, Volume= 61.115 af
Outflow = 51.73 cfs @ 19.71 hrs, Volume= 61.278 af, Atten= 22%, Lag= 160.6 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Secondary = 51.73 cfs @ 19.71 hrs, Volume= 61.278 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 218.00' Storage= 3.898 af
Peak Elev= 219.90' @ 19.71 hrs Storage= 7.675 af (3.777 af above start)

Plug-Flow detention time= 165.9 min calculated for 57.381 af (94% of inflow)
Center-of-Mass det. time= 30.9 min (1,373.3 - 1,342.4)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices (Turned on 1257 times)
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

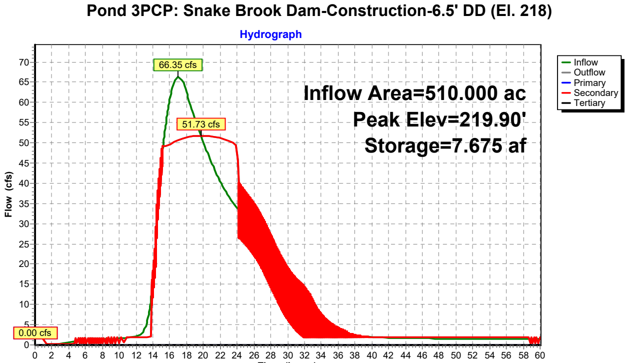
Device	Routing	Invert	Outlet Devices
			L= 60.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 Cast iron, coated, Flow Area= 1.77 sf
#5	Secondary	206.00'	**Construction Diversion System X 2.00** 18.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@218.20' Breaks@218.19'
#6	Secondary	206.00'	**Construction Diversion System** 6.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@217.90' Breaks@217.89'

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=218.00' (Free Discharge)
└─**1=Spillway Channel (Cleared)** (Controls 0.00 cfs)

Secondary OutFlow Max=51.73 cfs @ 19.71 hrs HW=219.90' (Free Discharge)
├─**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)
├─**5=Construction Diversion System** (Tube Controls 49.96 cfs @ 14.14 fps)
└─**6=Construction Diversion System** (Tube Controls 1.76 cfs @ 8.98 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=218.00' (Free Discharge)
├─**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└─**3=Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=2.79"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=99.94 cfs 66.758 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.13"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=61.44 cfs 39.609 af

Pond 1P: Upper Pond 2 Peak Elev=226.78' Storage=2.832 af Inflow=100.84 cfs 71.221 af
Outflow=100.77 cfs 70.943 af

Pond 2P: Upper Pond Peak Elev=227.09' Storage=20.375 af Inflow=62.04 cfs 42.584 af
Outflow=57.82 cfs 41.457 af

Pond 3PCP: Snake Brook Peak Elev=225.19' Storage=35.087 af Inflow=156.18 cfs 112.400 af
Primary=11.93 cfs 4.634 af Secondary=59.18 cfs 107.916 af Tertiary=0.00 cfs 0.000 af Outflow=71.11 cfs 112.550 af

Total Runoff Area = 510.000 ac Runoff Volume = 106.366 af Average Runoff Depth = 2.50"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

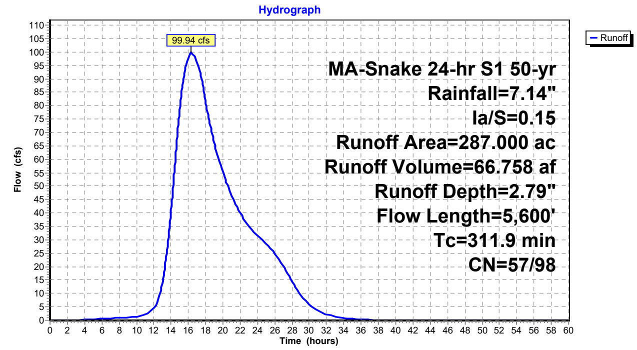
Runoff = 99.94 cfs @ 16.29 hrs, Volume= 66.758 af, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

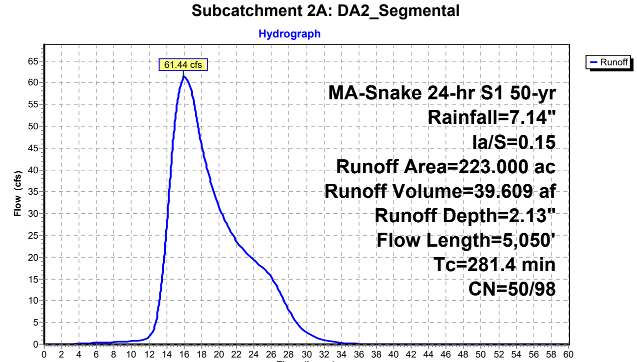
Runoff = 61.44 cfs @ 15.95 hrs, Volume= 39.609 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 2.98" for 50-yr event
Inflow = 100.84 cfs @ 16.29 hrs, Volume= 71.221 af, Incl. 0.90 cfs Base Flow
Outflow = 100.77 cfs @ 16.32 hrs, Volume= 70.943 af, Atten= 0%, Lag= 1.4 min
Primary = 100.77 cfs @ 16.32 hrs, Volume= 70.943 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.78' @ 16.32 hrs Storage= 2.832 af (1.182 af above start)

Plug-Flow detention time= 77.0 min calculated for 69.293 af (97% of inflow)
Center-of-Mass det. time= 16.7 min (1,212.6 - 1,196.0)

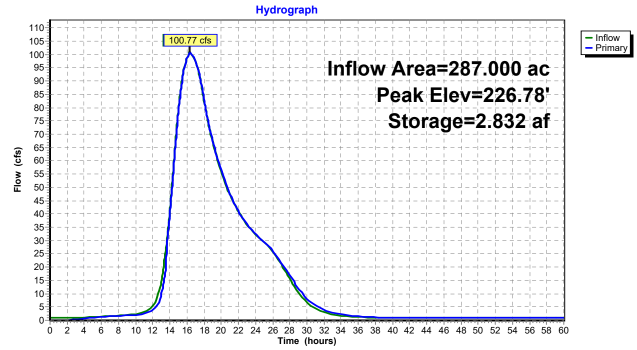
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=100.77 cfs @ 16.32 hrs HW=226.78' TW=221.24' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 100.77 cfs @ 1.74 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.29" for 50-yr event
Inflow = 62.04 cfs @ 15.95 hrs, Volume= 42.584 af, Incl. 0.60 cfs Base Flow
Outflow = 57.82 cfs @ 16.95 hrs, Volume= 41.457 af, Atten= 7%, Lag= 59.8 min
Primary = 57.82 cfs @ 16.95 hrs, Volume= 41.457 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.09' @ 16.95 hrs Storage= 20.375 af (9.455 af above start)

Plug-Flow detention time= 500.7 min calculated for 30.532 af (72% of inflow)
Center-of-Mass det. time= 183.3 min (1,376.6 - 1,193.3)

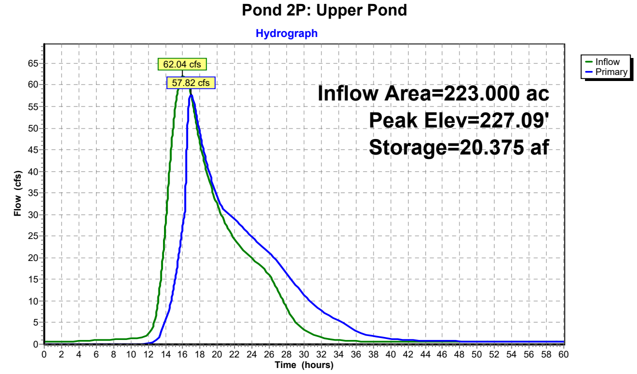
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=57.82 cfs @ 16.95 hrs HW=227.09' TW=222.32' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 57.82 cfs @ 1.50 fps)

Pond 2P: Upper Pond



Summary for Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 2.64" for 50-yr event
Inflow = 156.18 cfs @ 16.84 hrs, Volume= 112.400 af
Outflow = 71.11 cfs @ 21.86 hrs, Volume= 112.550 af, Atten= 54%, Lag= 301.2 min
Primary = 11.93 cfs @ 21.86 hrs, Volume= 4.634 af
Secondary = 59.18 cfs @ 21.86 hrs, Volume= 107.916 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 218.00' Storage= 3.898 af
Peak Elev= 225.19' @ 21.86 hrs Storage= 35.087 af (31.189 af above start)

Plug-Flow detention time= 310.3 min calculated for 108.653 af (97% of inflow)
Center-of-Mass det. time= 229.6 min (1,502.8 - 1,273.1)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

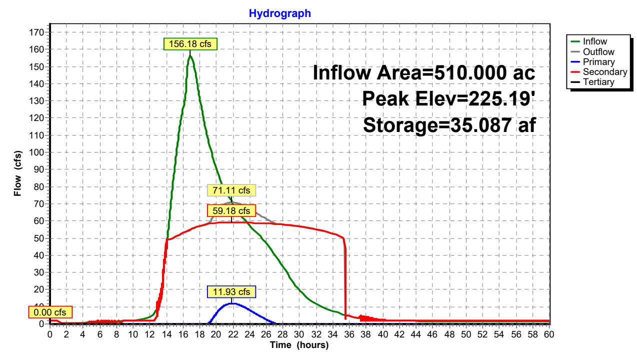
Device	Routing	Invert	Outlet Devices (Turned on 448 times)
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00** L= 60.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900 n= 0.013 Cast iron, coated, Flow Area= 1.77 sf
#5	Secondary	206.00'	**Construction Diversion System X 2.00** 18.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@218.20' Breaks@218.19'
#6	Secondary	206.00'	**Construction Diversion System** 6.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@217.90' Breaks@217.89'

Primary OutFlow Max=11.93 cfs @ 21.86 hrs HW=225.19' (Free Discharge)
└─**1=Spillway Channel (Cleared)** (Weir Controls 11.93 cfs @ 2.07 fps)

Secondary OutFlow Max=59.18 cfs @ 21.86 hrs HW=225.19' (Free Discharge)
├─**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)
├─**5=Construction Diversion System** (Tube Controls 57.16 cfs @ 16.17 fps)
└─**6=Construction Diversion System** (Tube Controls 2.02 cfs @ 10.30 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=218.00' (Free Discharge)
├─**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└─**3=Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=3.47"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=125.28 cfs 82.920 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.72"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=79.70 cfs 50.475 af

Pond 1P: Upper Pond 2 Peak Elev=226.83' Storage=2.874 af Inflow=126.18 cfs 87.383 af
Outflow=126.11 cfs 87.105 af

Pond 2P: Upper Pond Peak Elev=227.14' Storage=20.681 af Inflow=80.30 cfs 53.451 af
Outflow=78.79 cfs 52.323 af

Pond 3PCP: Snake Brook Peak Elev=226.18' Storage=41.958 af Inflow=204.76 cfs 139.429 af
Primary=53.99 cfs 24.546 af Secondary=60.48 cfs 115.015 af Tertiary=0.00 cfs 0.000 af Outflow=114.47 cfs 139.561 af

Total Runoff Area = 510.000 ac Runoff Volume = 133.395 af Average Runoff Depth = 3.14"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

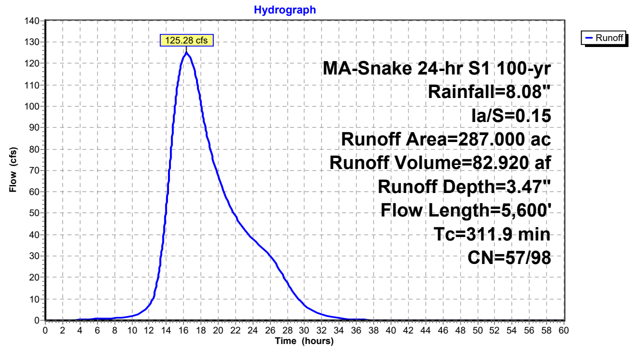
Runoff = 125.28 cfs @ 16.29 hrs, Volume= 82.920 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

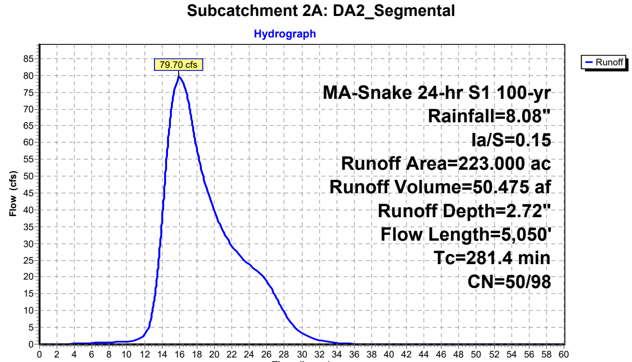
Runoff = 79.70 cfs @ 15.95 hrs, Volume= 50.475 af, Depth= 2.72"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 3.65" for 100-yr event
Inflow = 126.18 cfs @ 16.29 hrs, Volume= 87.383 af, Incl. 0.90 cfs Base Flow
Outflow = 126.11 cfs @ 16.31 hrs, Volume= 87.105 af, Atten= 0%, Lag= 1.1 min
Primary = 126.11 cfs @ 16.31 hrs, Volume= 87.105 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.83' @ 16.31 hrs Storage= 2.874 af (1.224 af above start)

Plug-Flow detention time= 63.3 min calculated for 85.441 af (98% of inflow)
Center-of-Mass det. time= 14.2 min (1,196.6 - 1,182.4)

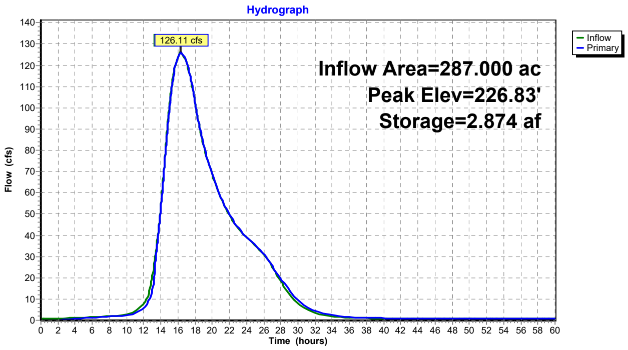
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=126.10 cfs @ 16.31 hrs HW=226.83' TW=222.62' (Dynamic Tailwater)
└1=**Upper Dam 1** (Weir Controls 126.10 cfs @ 1.84 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.88" for 100-yr event
Inflow = 80.30 cfs @ 15.95 hrs, Volume= 53.451 af, Incl. 0.60 cfs Base Flow
Outflow = 78.79 cfs @ 16.40 hrs, Volume= 52.323 af, Atten= 2%, Lag= 26.9 min
Primary = 78.79 cfs @ 16.40 hrs, Volume= 52.323 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.14' @ 16.40 hrs Storage= 20.681 af (9.761 af above start)

Plug-Flow detention time= 407.5 min calculated for 41.396 af (77% of inflow)
Center-of-Mass det. time= 159.7 min (1,336.9 - 1,177.1)

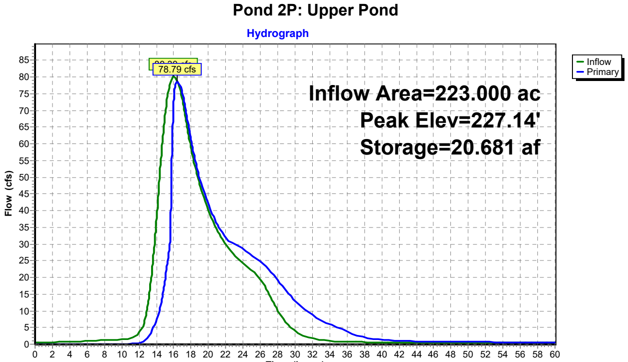
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=78.78 cfs @ 16.40 hrs HW=227.14' TW=222.82' (Dynamic Tailwater)
└─**1=Upper Dam** (Weir Controls 78.78 cfs @ 1.53 fps)

Pond 2P: Upper Pond



Summary for Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 3.28" for 100-yr event
Inflow = 204.76 cfs @ 16.33 hrs, Volume= 139.429 af
Outflow = 114.47 cfs @ 19.79 hrs, Volume= 139.561 af, Atten= 44%, Lag= 207.6 min
Primary = 53.99 cfs @ 19.79 hrs, Volume= 24.546 af
Secondary = 60.48 cfs @ 19.79 hrs, Volume= 115.015 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 218.00' Storage= 3.898 af
Peak Elev= 226.18' @ 19.79 hrs Storage= 41.958 af (38.060 af above start)

Plug-Flow detention time= 294.9 min calculated for 135.641 af (97% of inflow)
Center-of-Mass det. time= 229.7 min (1,479.0 - 1,249.3)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices (Turned on 427 times)
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

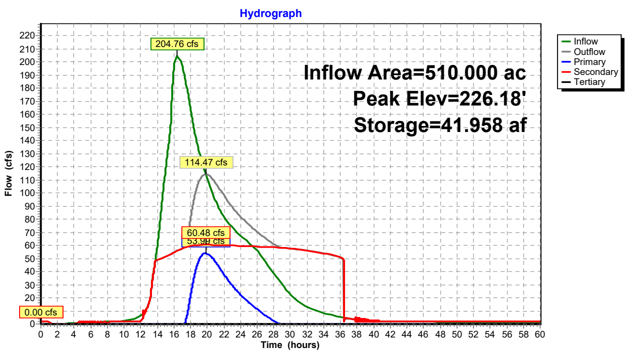
#5	Secondary	206.00'	**Construction Diversion System X 2.00** 18.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@218.20' Breaks@218.19'
#6	Secondary	206.00'	**Construction Diversion System** 6.000" Diameter, C= 0.600, 2.000" Trickle Diameter 300.0' Long Tube, Hazen-Williams C= 130 Inlet / Outlet Elev. = 206.00' / 202.00' Starts@217.90' Breaks@217.89'

Primary OutFlow Max=53.99 cfs @ 19.79 hrs HW=226.18' (Free Discharge)
└─**1=Spillway Channel (Cleared)** (Weir Controls 53.99 cfs @ 2.75 fps)

Secondary OutFlow Max=60.48 cfs @ 19.79 hrs HW=226.18' (Free Discharge)
├─**4=LLO Existing (Assuming cut at Gatehouse)** (Controls 0.00 cfs)
├─**5=Construction Diversion System** (Tube Controls 58.41 cfs @ 16.53 fps)
└─**6=Construction Diversion System** (Tube Controls 2.07 cfs @ 10.53 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=218.00' (Free Discharge)
├─**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└─**3=Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PCP: Snake Brook Dam-Construction-6.5' DD (El. 218)



Events for Subcatchment 1A: DA1_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	51.24	35.651	1.49
50-yr	7.14	99.94	66.758	2.79
100-yr	**8.08**	**125.28**	**82.920**	**3.47**

Events for Subcatchment 2A: DA2_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	28.08	19.429	1.05
50-yr	7.14	61.44	39.609	2.13
100-yr	**8.08**	**79.70**	**50.475**	**2.72**

Events for Pond 1P: Upper Pond 2

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	52.14	52.13	226.65	2.736
50-yr	100.84	100.77	226.78	2.832
100-yr	**126.18**	**126.11**	**226.83**	**2.874**

Events for Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly

Event	Inflow (cfs)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)	Tertiary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	65.48	53.60	53.60	**0.00**	**0.00**	226.17	41.910
50-yr	153.20	115.73	115.73	0.00	0.00	227.06	50.498
100-yr	196.86	142.84	142.84	0.00	0.00	227.38	53.076
200-yr	**235.58**	**180.22**	**180.22**	0.00	0.00	**227.79**	**56.355**

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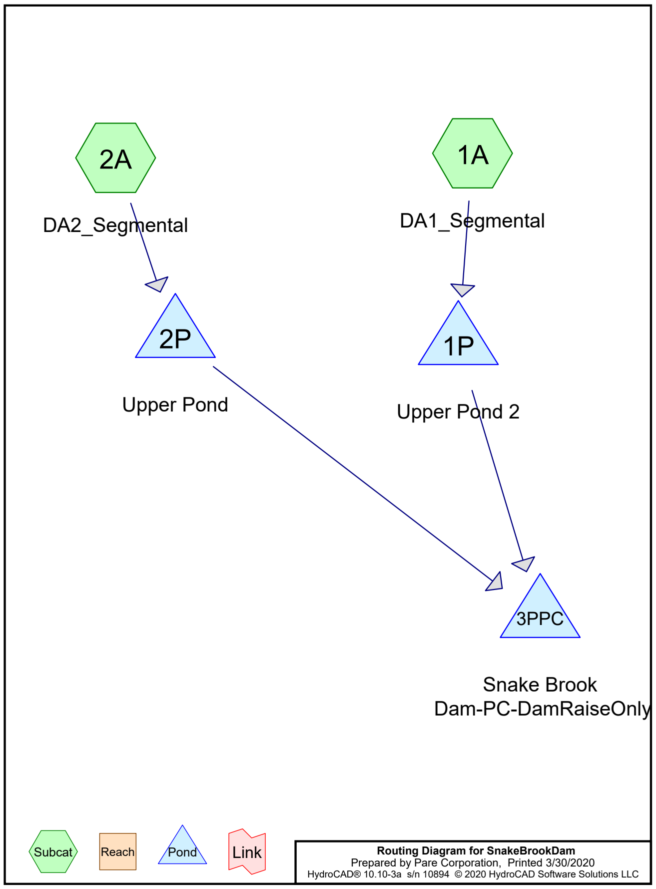


Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-yr	MA-Snake 24-hr S1	1-yr	Default	24.00	1	2.66	2
2	2-yr	MA-Snake 24-hr S1	2-yr	Default	24.00	1	3.28	2
3	5-yr	MA-Snake 24-hr S1	5-yr	Default	24.00	1	4.29	2
4	10-yr	MA-Snake 24-hr S1	10-yr	Default	24.00	1	5.13	2
5	25-yr	MA-Snake 24-hr S1	25-yr	Default	24.00	1	6.29	2
6	50-yr	MA-Snake 24-hr S1	50-yr	Default	24.00	1	7.14	2
7	100-yr	MA-Snake 24-hr S1	100-yr	Default	24.00	1	8.08	2
8	200-yr	MA-Snake 24-hr S1	200-yr	Default	24.00	1	9.25	2
9	500-yr	MA-Snake 24-hr S1	500-yr	Default	24.00	1	11.10	2
10	1000-yr	MA-Snake 24-hr S1	1000-yr	Default	24.00	1	12.70	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
223.000	51	"2% imp" (2A)
287.000	58	"3% imp" (1A)
510.000	**55**	**TOTAL AREA**

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	3PPC	210.50	207.50	60.0	0.0500	0.013	18.0	0.0	0.0

Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=1.49"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=51.24 cfs 35.651 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=1.05"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=28.08 cfs 19.429 af

Pond 1P: Upper Pond 2 Peak Elev=226.65' Storage=2.737 af Inflow=52.14 cfs 40.115 af
Outflow=52.10 cfs 39.837 af

Pond 2P: Upper Pond Peak Elev=226.68' Storage=17.600 af Inflow=28.68 cfs 22.404 af
Outflow=17.65 cfs 21.278 af

Pond 3PPC: Snake Brook Peak Elev=226.17' Storage=41.910 af Inflow=65.48 cfs 61.115 af
Primary=53.60 cfs 59.758 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=53.60 cfs 59.758 af

Total Runoff Area = 510.000 ac Runoff Volume = 55.080 af Average Runoff Depth = 1.30"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

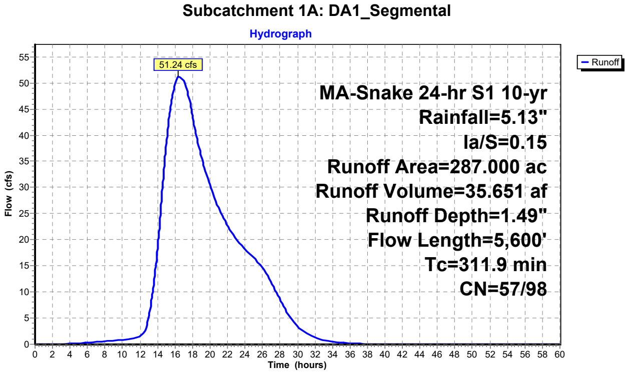
Runoff = 51.24 cfs @ 16.30 hrs, Volume= 35.651 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

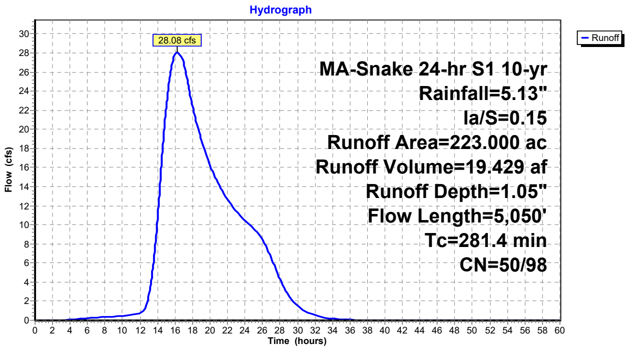
Runoff = 28.08 cfs @ 16.26 hrs, Volume= 19.429 af, Depth= 1.05"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 10-yr Rainfall=5.13", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 1.68" for 10-yr event
Inflow = 52.14 cfs @ 16.30 hrs, Volume= 40.115 af, Incl. 0.90 cfs Base Flow
Outflow = 52.10 cfs @ 16.39 hrs, Volume= 39.837 af, Atten= 0%, Lag= 5.1 min
Primary = 52.10 cfs @ 16.39 hrs, Volume= 39.837 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 226.65' @ 16.68 hrs Storage= 2.737 af (1.087 af above start)

Plug-Flow detention time= 134.1 min calculated for 38.187 af (95% of inflow)
Center-of-Mass det. time= 26.4 min (1,269.1 - 1,242.7)

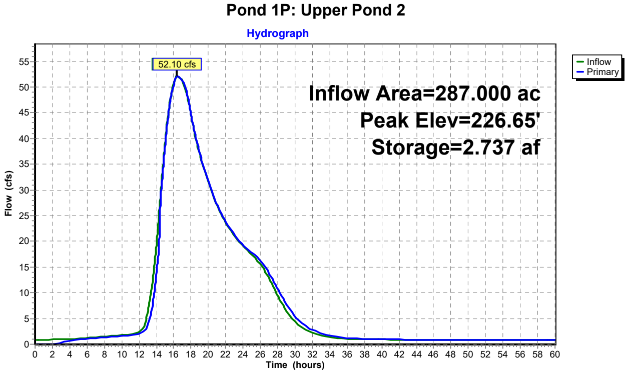
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=52.10 cfs @ 16.39 hrs HW=226.65' TW=225.67' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 52.10 cfs @ 1.50 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 1.21" for 10-yr event
Inflow = 28.68 cfs @ 16.26 hrs, Volume= 22.404 af, Incl. 0.60 cfs Base Flow
Outflow = 17.65 cfs @ 20.13 hrs, Volume= 21.278 af, Atten= 38%, Lag= 232.1 min
Primary = 17.65 cfs @ 20.13 hrs, Volume= 21.278 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 226.68' @ 19.71 hrs Storage= 17.600 af (6.680 af above start)

Plug-Flow detention time= 916.5 min calculated for 10.358 af (46% of inflow)
Center-of-Mass det. time= 239.8 min (1,491.9 - 1,252.1)

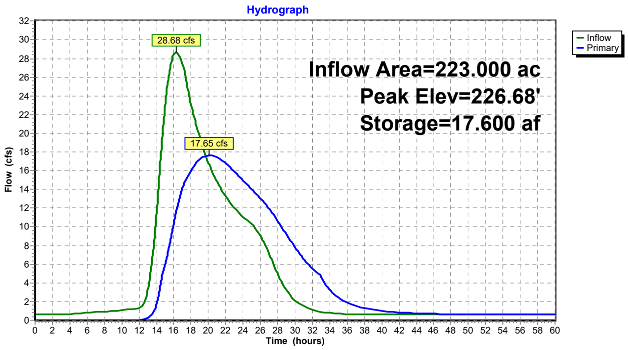
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=17.65 cfs @ 20.13 hrs HW=226.68' TW=226.15' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 17.65 cfs @ 2.10 fps)

Pond 2P: Upper Pond



Summary for Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 1.44" for 10-yr event
Inflow = 65.48 cfs @ 17.00 hrs, Volume= 61.115 af
Outflow = 53.60 cfs @ 19.13 hrs, Volume= 59.758 af, Atten= 18%, Lag= 127.6 min
Primary = 53.60 cfs @ 19.13 hrs, Volume= 59.758 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 226.17' @ 19.13 hrs Storage= 41.910 af (11.623 af above start)

Plug-Flow detention time= 866.2 min calculated for 29.471 af (48% of inflow)
Center-of-Mass det. time= 174.2 min (1,520.9 - 1,346.7)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

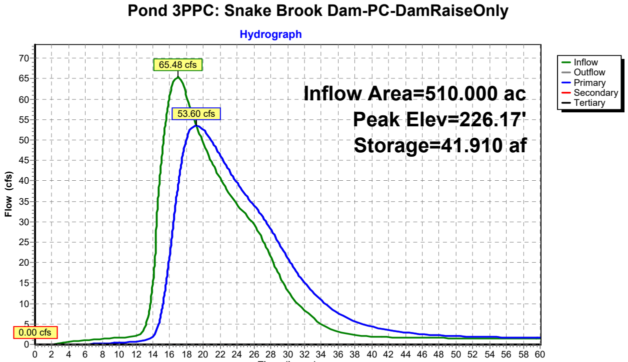
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=53.60 cfs @ 19.13 hrs HW=226.17' (Free Discharge)
└**1=Spillway Channel (Cleared)** (Weir Controls 53.60 cfs @ 2.75 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└**4=LLO Existing (Assuming cut at Gatehouse)** (Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
├**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└**3=Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=2.79"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=99.94 cfs 66.758 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.13"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=61.44 cfs 39.609 af

Pond 1P: Upper Pond 2 Peak Elev=227.08' Storage=3.760 af Inflow=100.84 cfs 71.221 af
Outflow=100.33 cfs 70.943 af

Pond 2P: Upper Pond Peak Elev=227.12' Storage=20.583 af Inflow=62.04 cfs 42.584 af
Outflow=56.47 cfs 41.457 af

Pond 3PPC: Snake Brook Peak Elev=227.06' Storage=50.498 af Inflow=153.20 cfs 112.400 af
Primary=115.73 cfs 111.021 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=115.73 cfs 111.021 af

Total Runoff Area = 510.000 ac Runoff Volume = 106.366 af Average Runoff Depth = 2.50"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

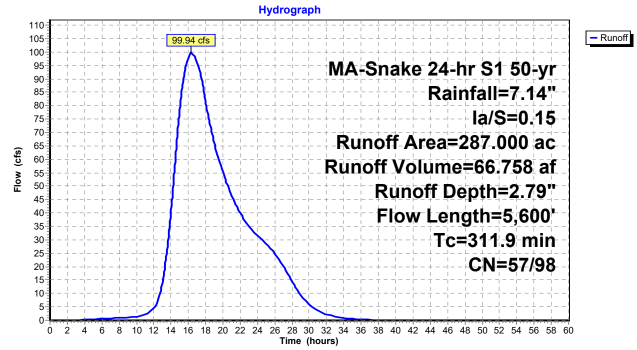
Runoff = 99.94 cfs @ 16.29 hrs, Volume= 66.758 af, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

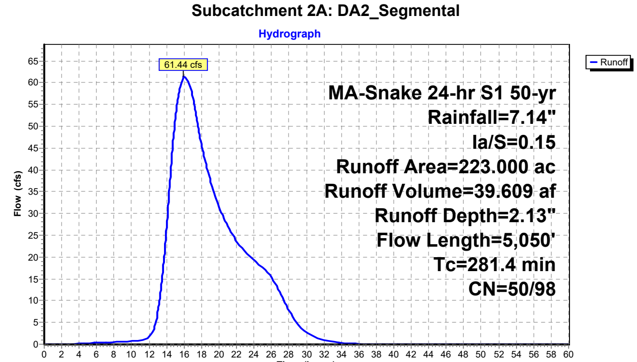
Runoff = 61.44 cfs @ 15.95 hrs, Volume= 39.609 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 50-yr Rainfall=7.14", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 2.98" for 50-yr event
Inflow = 100.84 cfs @ 16.29 hrs, Volume= 71.221 af, Incl. 0.90 cfs Base Flow
Outflow = 100.33 cfs @ 16.30 hrs, Volume= 70.943 af, Atten= 0%, Lag= 0.5 min
Primary = 100.33 cfs @ 16.30 hrs, Volume= 70.943 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 227.08' @ 18.52 hrs Storage= 3.760 af (2.110 af above start)

Plug-Flow detention time= 79.4 min calculated for 69.293 af (97% of inflow)
Center-of-Mass det. time= 19.0 min (1,215.0 - 1,196.0)

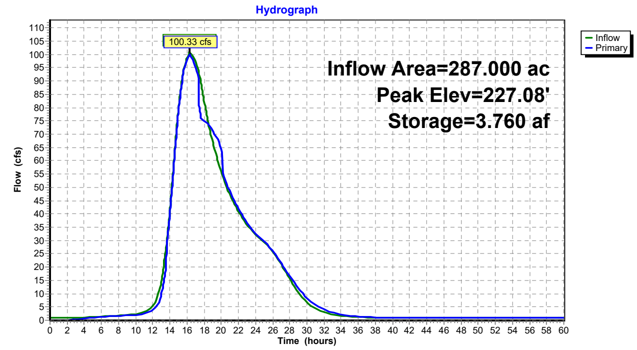
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=100.33 cfs @ 16.30 hrs HW=226.80' TW=226.54' (Dynamic Tailwater)
↑—**1=Upper Dam 1** (Weir Controls 100.33 cfs @ 1.61 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.29" for 50-yr event
Inflow = 62.04 cfs @ 15.95 hrs, Volume= 42.584 af, Incl. 0.60 cfs Base Flow
Outflow = 56.47 cfs @ 16.87 hrs, Volume= 41.457 af, Atten= 9%, Lag= 55.0 min
Primary = 56.47 cfs @ 16.87 hrs, Volume= 41.457 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.12' @ 18.32 hrs Storage= 20.583 af (9.663 af above start)

Plug-Flow detention time= 519.7 min calculated for 30.537 af (72% of inflow)
Center-of-Mass det. time= 197.8 min (1,391.1 - 1,193.3)

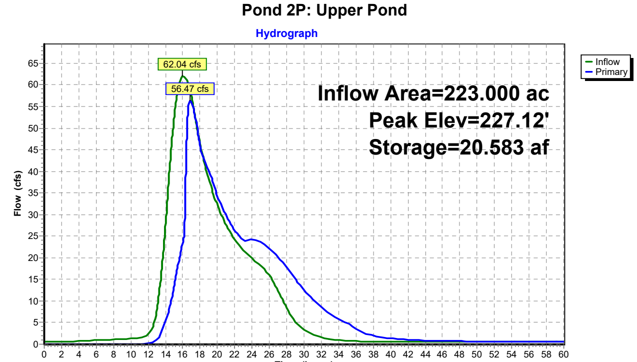
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=56.47 cfs @ 16.87 hrs HW=227.12' TW=226.80' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 56.47 cfs @ 1.24 fps)

Pond 2P: Upper Pond



Summary for Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 2.64" for 50-yr event
Inflow = 153.20 cfs @ 16.73 hrs, Volume= 112.400 af
Outflow = 115.73 cfs @ 18.55 hrs, Volume= 111.021 af, Atten= 24%, Lag= 109.3 min
Primary = 115.73 cfs @ 18.55 hrs, Volume= 111.021 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 227.06' @ 18.55 hrs Storage= 50.498 af (20.211 af above start)

Plug-Flow detention time= 488.6 min calculated for 80.734 af (72% of inflow)
Center-of-Mass det. time= 143.5 min (1,423.5 - 1,279.9)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

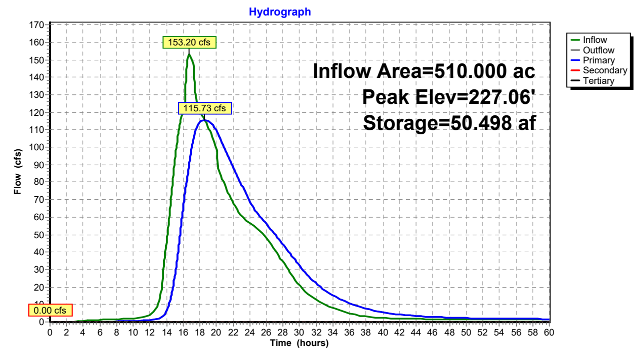
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=115.73 cfs @ 18.55 hrs HW=227.06' (Free Discharge)
└1=**Spillway Channel (Cleared)** (Weir Controls 115.73 cfs @ 3.53 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└4=**LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
├2=**Dam Crest LT of Spwy** (Controls 0.00 cfs)
└3=**Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=3.47"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=125.28 cfs 82.920 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=2.72"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=79.70 cfs 50.475 af

Pond 1P: Upper Pond 2 Peak Elev=227.40' Storage=6.587 af Inflow=126.18 cfs 87.383 af
Outflow=121.38 cfs 87.105 af

Pond 2P: Upper Pond Peak Elev=227.39' Storage=22.408 af Inflow=80.30 cfs 53.451 af
Outflow=75.96 cfs 52.323 af

Pond 3PPC: Snake Brook Peak Elev=227.38' Storage=53.076 af Inflow=196.86 cfs 139.428 af
Primary=142.84 cfs 138.042 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=142.84 cfs 138.042 af

Total Runoff Area = 510.000 ac Runoff Volume = 133.395 af Average Runoff Depth = 3.14"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

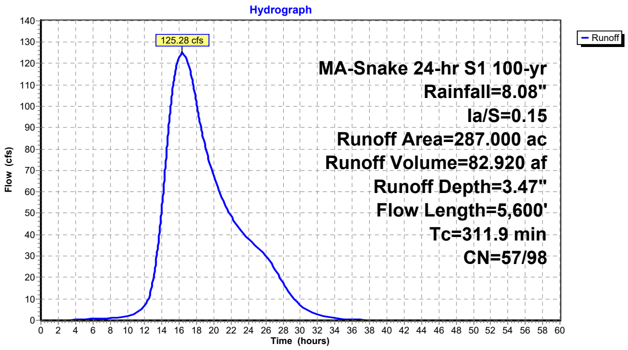
Runoff = 125.28 cfs @ 16.29 hrs, Volume= 82.920 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

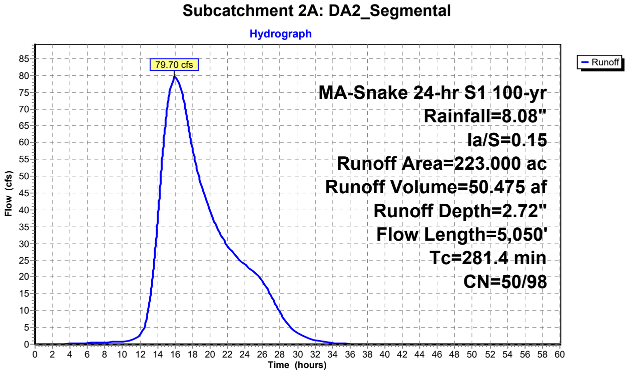
Runoff = 79.70 cfs @ 15.95 hrs, Volume= 50.475 af, Depth= 2.72"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 100-yr Rainfall=8.08", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 3.65" for 100-yr event
Inflow = 126.18 cfs @ 16.29 hrs, Volume= 87.383 af, Incl. 0.90 cfs Base Flow
Outflow = 121.38 cfs @ 16.22 hrs, Volume= 87.105 af, Atten= 4%, Lag= 0.0 min
Primary = 121.38 cfs @ 16.22 hrs, Volume= 87.105 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 227.40' @ 18.53 hrs Storage= 6.587 af (4.937 af above start)

Plug-Flow detention time= 74.7 min calculated for 85.441 af (98% of inflow)
Center-of-Mass det. time= 25.4 min (1,207.8 - 1,182.4)

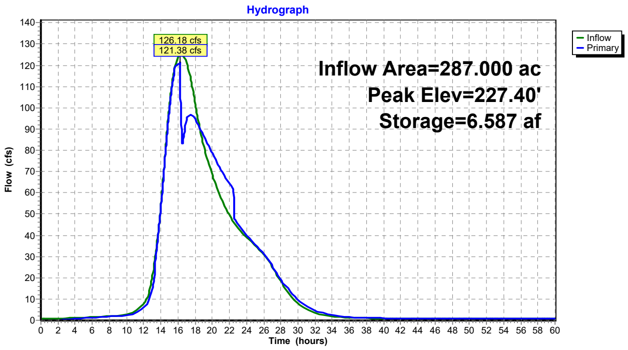
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=121.44 cfs @ 16.22 hrs HW=227.00' TW=226.90' (Dynamic Tailwater)
↑**1=Upper Dam 1** (Weir Controls 121.44 cfs @ 1.21 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 2.88" for 100-yr event
Inflow = 80.30 cfs @ 15.95 hrs, Volume= 53.451 af, Incl. 0.60 cfs Base Flow
Outflow = 75.96 cfs @ 16.40 hrs, Volume= 52.323 af, Atten= 5%, Lag= 27.2 min
Primary = 75.96 cfs @ 16.40 hrs, Volume= 52.323 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.39' @ 18.54 hrs Storage= 22.408 af (11.488 af above start)

Plug-Flow detention time= 431.0 min calculated for 41.403 af (77% of inflow)
Center-of-Mass det. time= 178.6 min (1,355.7 - 1,177.1)

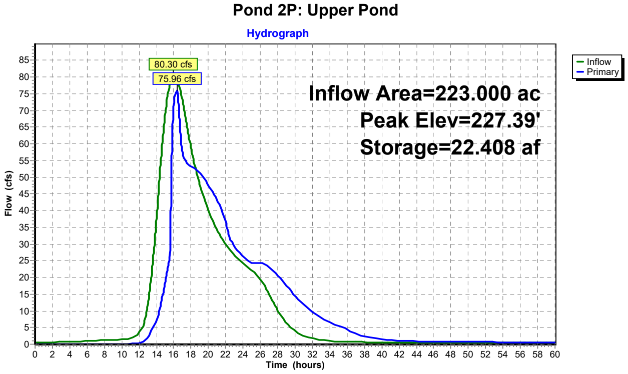
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=75.96 cfs @ 16.40 hrs HW=227.17' TW=227.00' (Dynamic Tailwater)
↑—**1=Upper Dam** (Weir Controls 75.96 cfs @ 1.26 fps)

Pond 2P: Upper Pond



Summary for Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 3.28" for 100-yr event
Inflow = 196.86 cfs @ 16.22 hrs, Volume= 139.428 af
Outflow = 142.84 cfs @ 18.55 hrs, Volume= 138.042 af, Atten= 27%, Lag= 139.7 min
Primary = 142.84 cfs @ 18.55 hrs, Volume= 138.042 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 227.38' @ 18.55 hrs Storage= 53.076 af (22.789 af above start)

Plug-Flow detention time= 409.4 min calculated for 107.737 af (77% of inflow)
Center-of-Mass det. time= 134.4 min (1,397.7 - 1,263.3)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

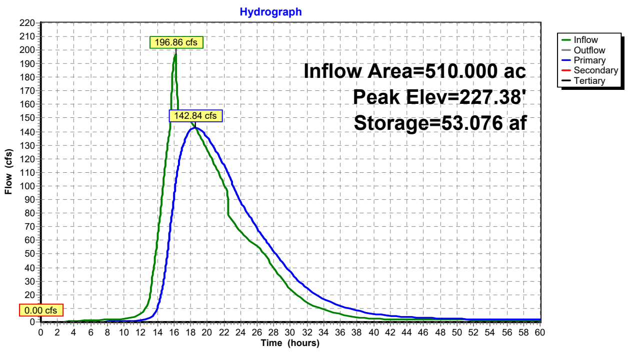
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=142.84 cfs @ 18.55 hrs HW=227.38' (Free Discharge)
↑**1=Spillway Channel (Cleared)** (Weir Controls 142.84 cfs @ 3.87 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
↑**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
2=Dam Crest LT of Spwy (Controls 0.00 cfs)
3=Dam Crest RT of Spwy (Controls 0.00 cfs)

Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly



Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1A: DA1_Segmental Runoff Area=287.000 ac 3.00% Impervious Runoff Depth=4.35"
Flow Length=5,600' Tc=311.9 min CN=57/98 Runoff=157.57 cfs 104.097 af

Subcatchment 2A: DA2_Segmental Runoff Area=223.000 ac 2.00% Impervious Runoff Depth=3.50"
Flow Length=5,050' Tc=281.4 min CN=50/98 Runoff=103.48 cfs 64.977 af

Pond 1P: Upper Pond 2 Peak Elev=227.80' Storage=10.239 af Inflow=158.47 cfs 108.560 af
Outflow=143.23 cfs 108.282 af

Pond 2P: Upper Pond Peak Elev=227.80' Storage=25.138 af Inflow=104.08 cfs 67.953 af
Outflow=96.63 cfs 66.825 af

Pond 3PPC: Snake Brook Peak Elev=227.79' Storage=56.355 af Inflow=235.58 cfs 175.107 af
Primary=180.22 cfs 173.712 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=180.22 cfs 173.712 af

Total Runoff Area = 510.000 ac Runoff Volume = 169.074 af Average Runoff Depth = 3.98"
97.44% Pervious = 496.930 ac 2.56% Impervious = 13.070 ac

Summary for Subcatchment 1A: DA1_Segmental

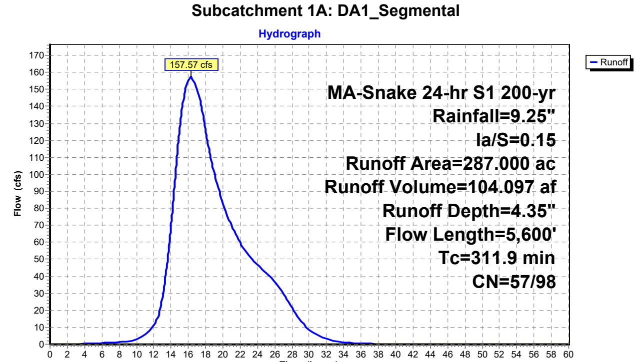
Runoff = 157.57 cfs @ 16.29 hrs, Volume= 104.097 af, Depth= 4.35"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 200-yr Rainfall=9.25", Ia/S=0.15

	Area (ac)	CN	Description
*	287.000	58	"3% imp"
	278.390	57	97.00% Pervious Area
	8.610	98	3.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
70.1	100	0.0010	0.02		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.30"
6.0	400	0.0500	1.12		**Shallow Concentrated Flow, 270 to 253** Woodland Kv= 5.0 fps
21.5	500	0.0060	0.39		**Shallow Concentrated Flow, 253 to 250** Woodland Kv= 5.0 fps
11.8	500	0.0200	0.71		**Shallow Concentrated Flow, 250 to 238** Woodland Kv= 5.0 fps
105.4	1,000	0.0010	0.16		**Shallow Concentrated Flow, 238 to 237** Woodland Kv= 5.0 fps
95.8	1,700	0.0035	0.30		**Shallow Concentrated Flow, 237 to 231** Woodland Kv= 5.0 fps
1.3	1,400		17.94		**Lake or Reservoir,** Mean Depth= 10.00'
311.9	5,600	Total			

Subcatchment 1A: DA1_Segmental



Summary for Subcatchment 2A: DA2_Segmental

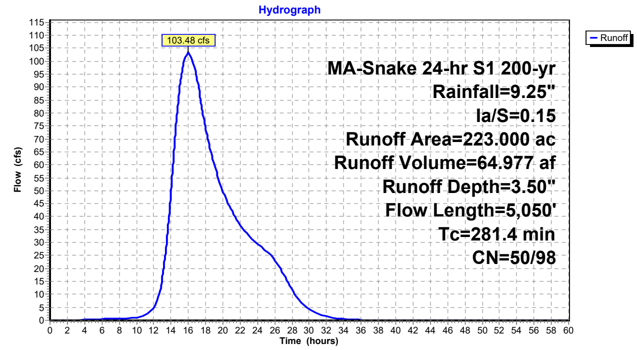
Runoff = 103.48 cfs @ 15.95 hrs, Volume= 64.977 af, Depth= 3.50"

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv., Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
MA-Snake 24-hr S1 200-yr Rainfall=9.25", Ia/S=0.15

	Area (ac)	CN	Description
*	223.000	51	"2% imp"
	218.540	50	98.00% Pervious Area
	4.460	98	2.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	100	0.0300	0.09		**Sheet Flow, 392 to 389** Woods: Light underbrush n= 0.400 P2= 3.30"
15.8	150	0.0010	0.16		**Shallow Concentrated Flow, 389 to 389** Woodland Kv= 5.0 fps
1.3	200	0.2500	2.50		**Shallow Concentrated Flow, 389 to 339** Woodland Kv= 5.0 fps
52.7	500	0.0010	0.16		**Shallow Concentrated Flow, 338 to 338** Woodland Kv= 5.0 fps
20.8	1,600	0.0660	1.28		**Shallow Concentrated Flow, 338 to 233** Woodland Kv= 5.0 fps
172.1	2,000	0.0015	0.19		**Shallow Concentrated Flow, 233 to 230** Woodland Kv= 5.0 fps
0.7	500		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
281.4	5,050	Total			

Subcatchment 2A: DA2_Segmental



Summary for Pond 1P: Upper Pond 2

Inflow Area = 287.000 ac, 3.00% Impervious, Inflow Depth > 4.54" for 200-yr event
Inflow = 158.47 cfs @ 16.29 hrs, Volume= 108.560 af, Incl. 0.90 cfs Base Flow
Outflow = 143.23 cfs @ 15.56 hrs, Volume= 108.282 af, Atten= 10%, Lag= 0.0 min
Primary = 143.23 cfs @ 15.56 hrs, Volume= 108.282 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 1.650 af
Peak Elev= 227.80' @ 18.49 hrs Storage= 10.239 af (8.589 af above start)

Plug-Flow detention time= 75.0 min calculated for 106.614 af (98% of inflow)
Center-of-Mass det. time= 35.0 min (1,205.0 - 1,170.0)

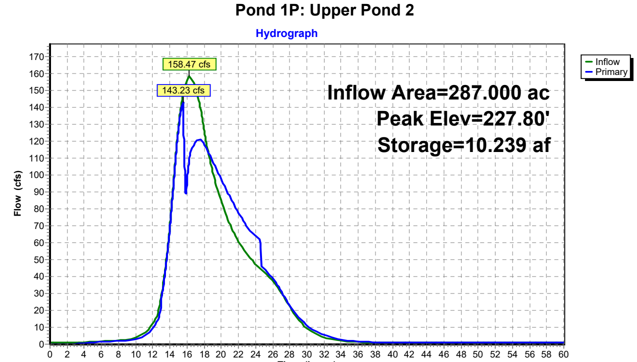
Volume	Invert	Avail.Storage	Storage Description
#1	223.00'	30.000 af	**Ras Terrain with Bathy** Listed below

Elevation (feet)	Cum.Store (acre-feet)
223.00	0.000
227.00	3.000
230.00	30.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.40'	**Upper Dam 1, C= 3.00** Offset (feet) 50.00 100.00 200.00 202.00 206.00 208.00 270.00 350.00 Elev. (feet) 231.00 226.50 226.50 225.40 225.40 226.50 226.50 231.00

Primary OutFlow Max=143.29 cfs @ 15.56 hrs HW=227.00' TW=226.87' (Dynamic Tailwater)
└─**1=Upper Dam 1** (Weir Controls 143.29 cfs @ 1.42 fps)

Pond 1P: Upper Pond 2



Summary for Pond 2P: Upper Pond

Inflow Area = 223.000 ac, 2.00% Impervious, Inflow Depth > 3.66" for 200-yr event
Inflow = 104.08 cfs @ 15.95 hrs, Volume= 67.953 af, Incl. 0.60 cfs Base Flow
Outflow = 96.63 cfs @ 15.74 hrs, Volume= 66.825 af, Atten= 7%, Lag= 0.0 min
Primary = 96.63 cfs @ 15.74 hrs, Volume= 66.825 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 225.20' Storage= 10.920 af
Peak Elev= 227.80' @ 18.50 hrs Storage= 25.138 af (14.218 af above start)

Plug-Flow detention time= 362.2 min calculated for 55.905 af (82% of inflow)
Center-of-Mass det. time= 164.5 min (1,327.3 - 1,162.8)

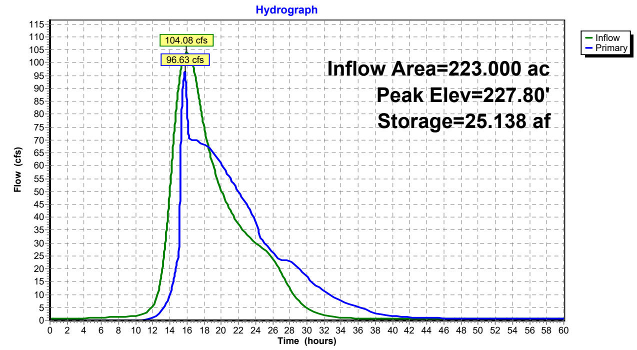
Volume	Invert	Avail.Storage	Storage Description
#1	221.00'	40.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
221.00	0.000
226.00	13.000
230.00	40.000

Device	Routing	Invert	Outlet Devices
#1	Primary	225.50'	**Upper Dam, C= 3.00** Offset (feet) 0.00 25.00 100.00 102.00 106.00 108.00 310.00 340.00 Elev. (feet) 231.00 227.00 227.00 225.50 225.50 227.00 227.00 231.00

Primary OutFlow Max=96.65 cfs @ 15.74 hrs HW=227.20' TW=227.01' (Dynamic Tailwater)
└─**1=Upper Dam** (Weir Controls 96.65 cfs @ 1.37 fps)

Pond 2P: Upper Pond



Summary for Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly

Inflow Area = 510.000 ac, 2.56% Impervious, Inflow Depth > 4.12" for 200-yr event
Inflow = 235.58 cfs @ 15.56 hrs, Volume= 175.107 af
Outflow = 180.22 cfs @ 18.51 hrs, Volume= 173.712 af, Atten= 23%, Lag= 177.2 min
Primary = 180.22 cfs @ 18.51 hrs, Volume= 173.712 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 2
Starting Elev= 224.50' Storage= 30.287 af
Peak Elev= 227.79' @ 18.51 hrs Storage= 56.355 af (26.068 af above start)

Plug-Flow detention time= 343.1 min calculated for 143.401 af (82% of inflow)
Center-of-Mass det. time= 124.9 min (1,376.6 - 1,251.7)

Volume	Invert	Avail.Storage	Storage Description
#1	206.50'	100.000 af	**Ras Terrain with Bathy**Listed below

Elevation (feet)	Cum.Store (acre-feet)
206.50	0.000
210.80	0.065
213.30	0.439
215.20	1.190
217.30	2.884
219.20	5.635
220.50	9.420
222.00	15.900
224.20	28.200
226.50	44.200
227.00	50.000
228.00	58.000
229.00	65.000
230.00	75.000
231.00	85.000
232.00	100.000

Device	Routing	Invert	Outlet Devices
#1	Primary	224.50'	**Spillway Channel (Cleared), C= 3.00** Offset (feet) 2.20 2.20 7.00 13.00 15.00 15.00 Elev. (feet) 233.00 226.50 224.50 224.50 226.50 233.00
#2	Tertiary	226.30'	**Dam Crest LT of Spwy X 0.00, C= 3.00** Offset (feet) 10.00 50.00 75.00 100.00 105.00 150.00 180.00 200.00 200.00 Elev. (feet) 233.00 227.30 226.50 226.50 226.30 226.30 227.00 227.00 233.00
#3	Tertiary	225.50'	**Dam Crest RT of Spwy X 0.00, C= 3.00** Offset (feet) 233.00 233.00 242.00 280.00 290.00 310.00 Elev. (feet) 233.00 225.50 225.50 228.50 229.00 233.00
#4	Secondary	210.50'	**18.0" Round LLO Existing (Assuming cut at Gatehouse) X 0.00**

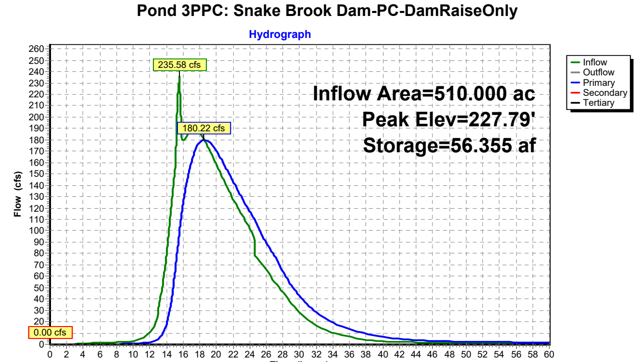
L= 60.0' RCP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 210.50' / 207.50' S= 0.0500 '/' Cc= 0.900
n= 0.013 Cast iron, coated, Flow Area= 1.77 sf

Primary OutFlow Max=180.22 cfs @ 18.51 hrs HW=227.79' (Free Discharge)
└─**1=Spillway Channel (Cleared)** (Weir Controls 180.22 cfs @ 4.27 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
└─**4=LLO Existing (Assuming cut at Gatehouse)**(Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=224.50' (Free Discharge)
├─**2=Dam Crest LT of Spwy** (Controls 0.00 cfs)
└─**3=Dam Crest RT of Spwy** (Controls 0.00 cfs)

Pond 3PPC: Snake Brook Dam-PC-DamRaiseOnly



Events for Subcatchment 1A: DA1_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	51.24	35.651	1.49
50-yr	7.14	99.94	66.758	2.79
100-yr	8.08	125.28	82.920	3.47
200-yr	**9.25**	**157.57**	**104.097**	**4.35**

Events for Subcatchment 2A: DA2_Segmental

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
10-yr	5.13	28.08	19.429	1.05
50-yr	7.14	61.44	39.609	2.13
100-yr	8.08	79.70	50.475	2.72
200-yr	**9.25**	**103.48**	**64.977**	**3.50**

Events for Pond 1P: Upper Pond 2

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	52.14	52.10	226.65	2.737
50-yr	100.84	100.33	227.08	3.760
100-yr	126.18	121.38	227.40	6.587
200-yr	**158.47**	**143.23**	**227.80**	**10.239**

Events for Pond 2P: Upper Pond

Event	Inflow (cfs)	Primary (cfs)	Elevation (feet)	Storage (acre-feet)
10-yr	28.68	17.65	226.68	17.600
50-yr	62.04	56.47	227.12	20.583
100-yr	80.30	75.96	227.39	22.408
200-yr	**104.08**	**96.63**	**227.80**	**25.138**

APPENDIX F
Seepage and Slope Stability Analyses
Snake Brook Dam
Wayland, Massachusetts

Calculation Cover Sheet

Project #: 19167.00 **Calculation #:** 2

Project: Snake Brook Dam **Date:** 2/20/2020

Subject/Task: Existing/ Proposed Embankment: Seepage and Stability Analysis

Status: Draft

Revision Summary:

Revision #	Description	Date
0	Original Calculation	1/8/2020
1	Revised Calculation	2/20/2020

Design Basis: Perform seepage and slope stability analyses to determine the factors of safety for the existing embankment of the Snake Brook Dam in Wayland, MA. If the embankment does not meet the minimum required factor of safety (FOS), provide improvement to the dam embankment to meet the required FOS.

Provided

1. Boring logs for B19-1, B19-2, and B19-3 completed by Pare Corporation between October 31 and November 1, 2019.
2. Soil Parameters developed by Pare Corporation based on Boring information.
3. GeoStudio 2016 V. 8.12, SEEP/W, SLOPE/W, GEOSLOPE International, Ltd.
4. Plan of Reservoir and Land of the Wayland Water Works, 1878.
5. Commonwealth of Massachusetts Regulations 302 CMR 10.00 Dam Safety.

Assumptions:

1. Soil properties are uniform through layers and soil borings are representative of the embankment.
2. Section geometry drawn based on provided information from the Plan of Reservoir and Land of the Wayland Water Works plan.
3. All material was modeled using unsaturated/saturated conditions. The hydraulic conductivity functions were estimated within the Seep/W software using the Van Genuchten method.
4. Maximum Pool was modeled at the top of the dam elevation of 226 feet and normal pool was modeled at an elevation of 224 feet for existing condition.
5. The entry and exit method was used to generate the potential slip surfaces. The Morgenstern-Price method was sued to compute the factors of safety foe each potential slip surface. The minimum slip surface depth was set to 4 feet.

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Soil Parameters:

Soil parameters provided in Table 1 were determined by corelating the boring logs information collected by Pare during the subsurface exploration program and the information collected base on historical drawings of the dam.

In general, the exploration program and historical drawings indicated that the embankment consists of embankment fill at the crest, and upstream. A stone masonry core wall with puddle fill on the upstream face of the wall was modeled at the center of the crest. Upstream slope is approximately 1.5H:1V and is covered with riprap. A rock core wall is also present at the toe of the upstream slope. Downstream slope is approximately 1.5H:1V slope. Sand and Gravel was modeled at the toe of the slope. The dam is approximately 28 feet high and is seated on Sandstone bedrock

Riprap properties were referenced from the 1989 FHWA publication by Brown S. A. and Clyde S. C. titled "Design of Riprap Revetment – HEC 11". The relative density determined from the Standard Penetration Test (SPT) blow counts was used to determine the void ratio, angle of internal friction and dry unit weight by referencing Figure 7 (Correlations of Strength Characteristics for Granular Soil) of the NAVFEC Manual and PE Civil Reference Manual Edition 16. The saturated unit weight and saturated water content were calculated using equations provided in the 6th edition of the textbook by Das, M. B. titled "Principals of Geotechnical Engineering". The hydraulic conductivity was referenced from the 3rd edition of the text book titled "Soil Mechanics in Engineering Practice" by Terzaghi, K., Peck, R. B. and Mesri, G published in 1996 and from a 1983 publication titled " Basic Ground-Water Hydrology" by Heath, R. C.

For existing condition:
- Top of dam: El. 226 ft
- Top of core wall: El. 225.5 ft
- Normal pool: El. 224 ft
- Maximum pool: El. 226 ft

For proposed condition:
- Top of dam: El. 228 ft
- Top of core wall: El. 227.5 ft
- Normal pool: El. 224 ft
- Maximum pool: El. 228 ft
- Engineered fill was imported to raise the downstream slope to a more maintainable 2H:1V slope. Riprap was added along the upstream slope.

The soil parameters used in the Slope/W and Seep/W analyses are presented in Table 1below:

Table 1: Soil Properties of the existing and proposed embankment

Soil Layer	(N_{ave}) (Blows/ft)	D_r (%)	Angle of Internal Friction (º)	Dry Unit Weight (pcf)	Sat. Unit Weight (pcf	Porosity Saturated Water Content	Saturated Hydraulic Conductivity (ft/sec)	Residual Water Content
Embankment Fill	17	60	34	109	131	0.19	1.64E-5	0.035
Engineered Fill	N/A	85	38	140	150	0.19	1.2E-5	0.035
Puddle Fill (Silt)	5	50	29	87	117	0.47	1.2E-7	0.1
Sand & Gravel	60	90	42	119	137	0.21	1.2E-5	0.035
Riprap	N/A	N/A	43	N/A	150	0.12	8.2E-4	0.01
Rock Core Wall	N/A	N/A	N/A	N/A	160	0.15	0.1	0.035
Rock Upstream Wall	N/A	N/A	N/A	N/A	160	0.1	3.28E-12	0.035
Sandstone	N/A	N/A	N/A	N/A	N/A	0.05	3.28E-12	N/A

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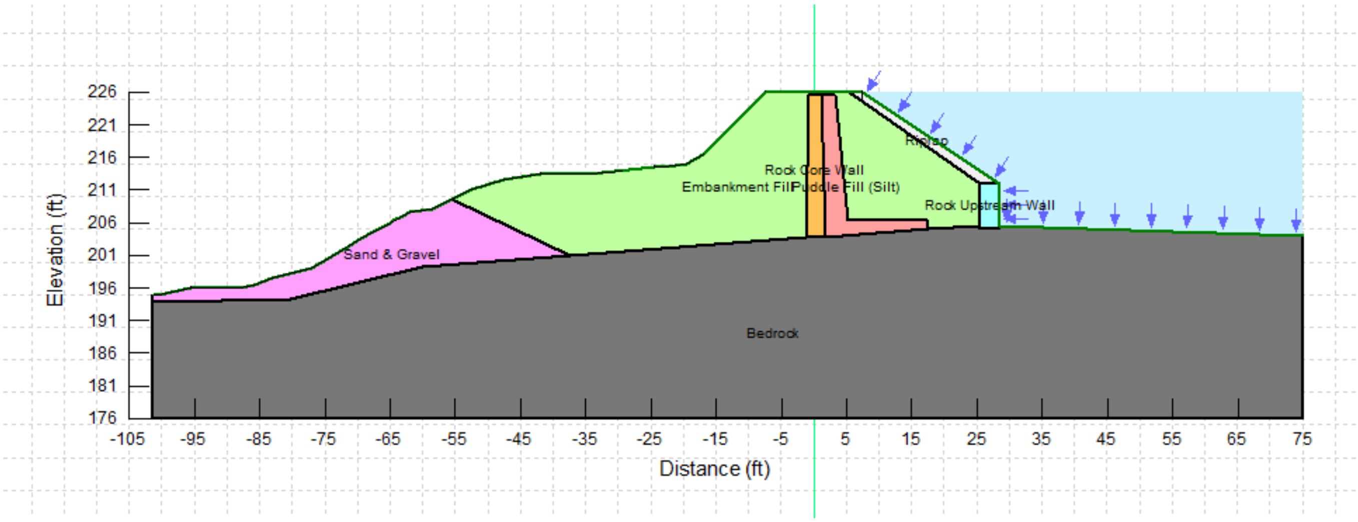
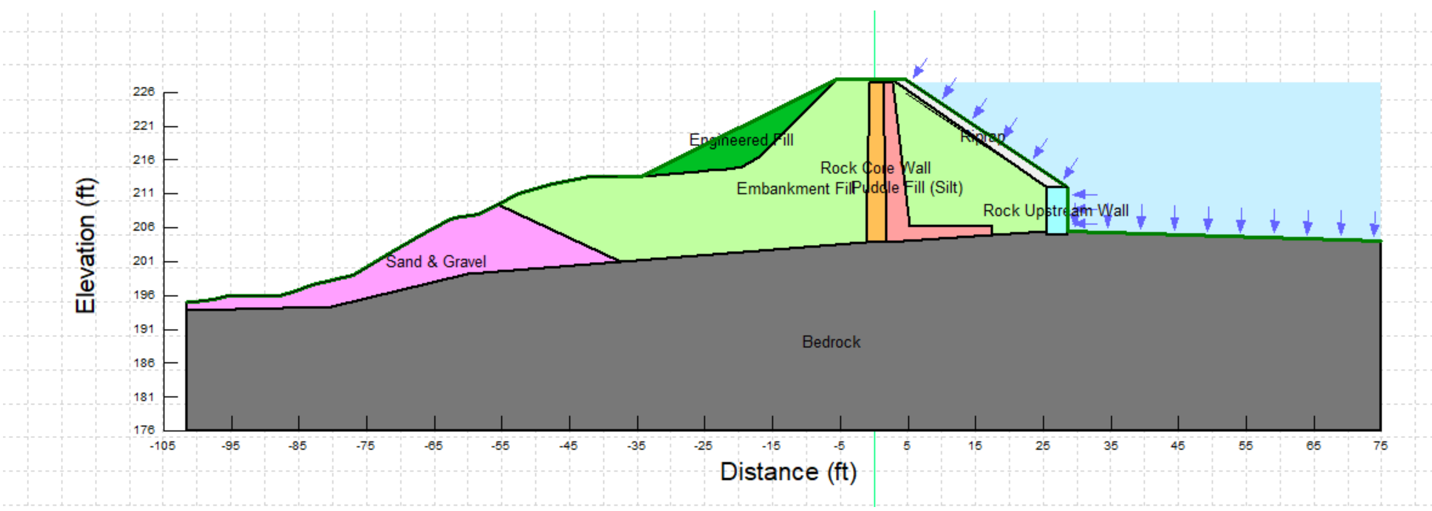
Embankment Geometry:

Existing:



Proposed:



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Results

Existing Condition:

Seepage: For normal and maximum pool conditions, the results indicate a seepage breakout along the crest of the embankment during normal pool and maximum pool. Improvement needs to be made to make the dam more stable.

Slope Stability: The following table summarizes the results of the slope stability analysis over various design conditions for the existing embankment. Bold numbers in the "Calculated Factor of Safety" column indicate that the condition does not meet required factors of safety.

Table 2: Existing Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	**1.1**
	Maximum Pool	N/A	N/A	1.4	**1.0**
Rapid Drawdown	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1

Proposed Condition:

Seepage: For normal and maximum pool conditions, the results did not indicate a seepage breakout along the crest of the embankment during normal pool and maximum pool.

Slope Stability: The following table summarizes the results of the slope stability analysis over various design conditions for the existing embankment. Bold numbers in the "Calculated Factor of Safety" column indicate that the condition does not meet required factors of safety.

Table 3: Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Drawdown	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.3	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3

	Name	Position	Signature	Date
Calculation by:	Heather Shank My Linh Pham	Engineer II/Engineer I		2/20/2020
Checked by:	Matthew Dunn, P.E.,CFM	Project Engineer		4/10/2020

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References:

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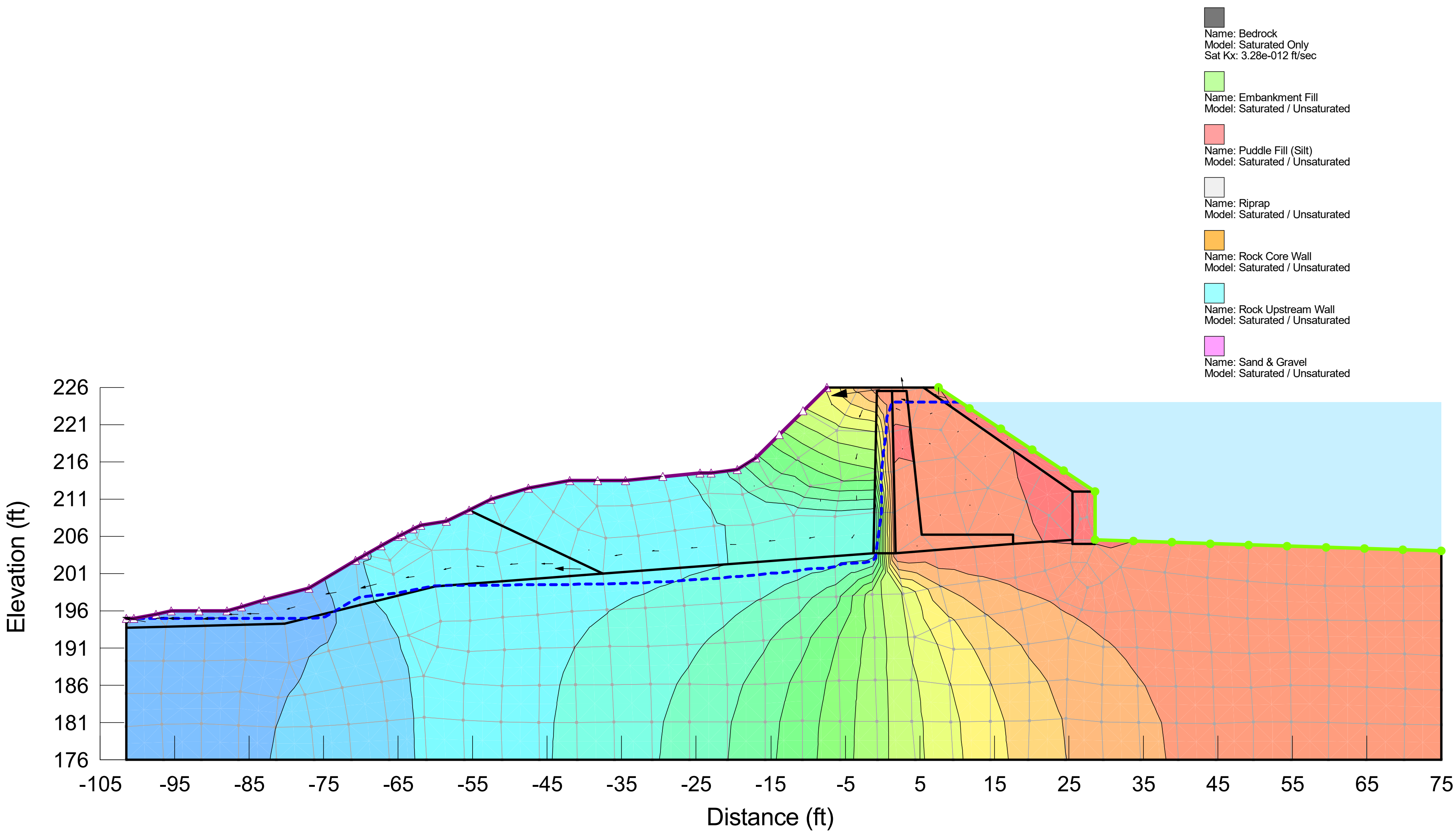
EXITING CONDITION RESULTS

Seepage Stability at Normal Pool

Snake Brook Dam, Wayland, MA

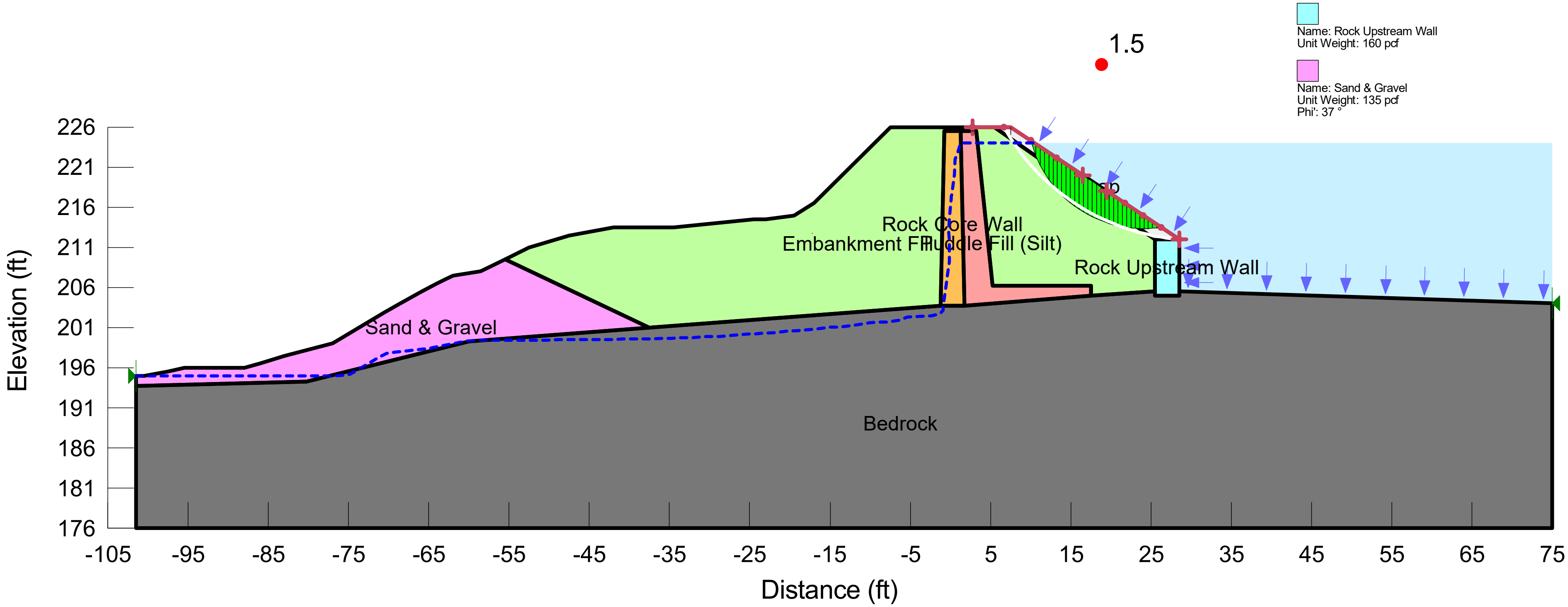


Upstream Slope Stability at Normal Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1

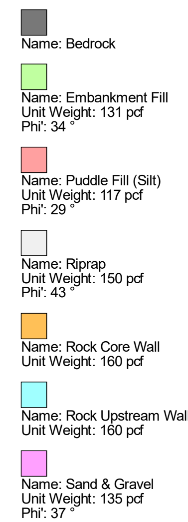


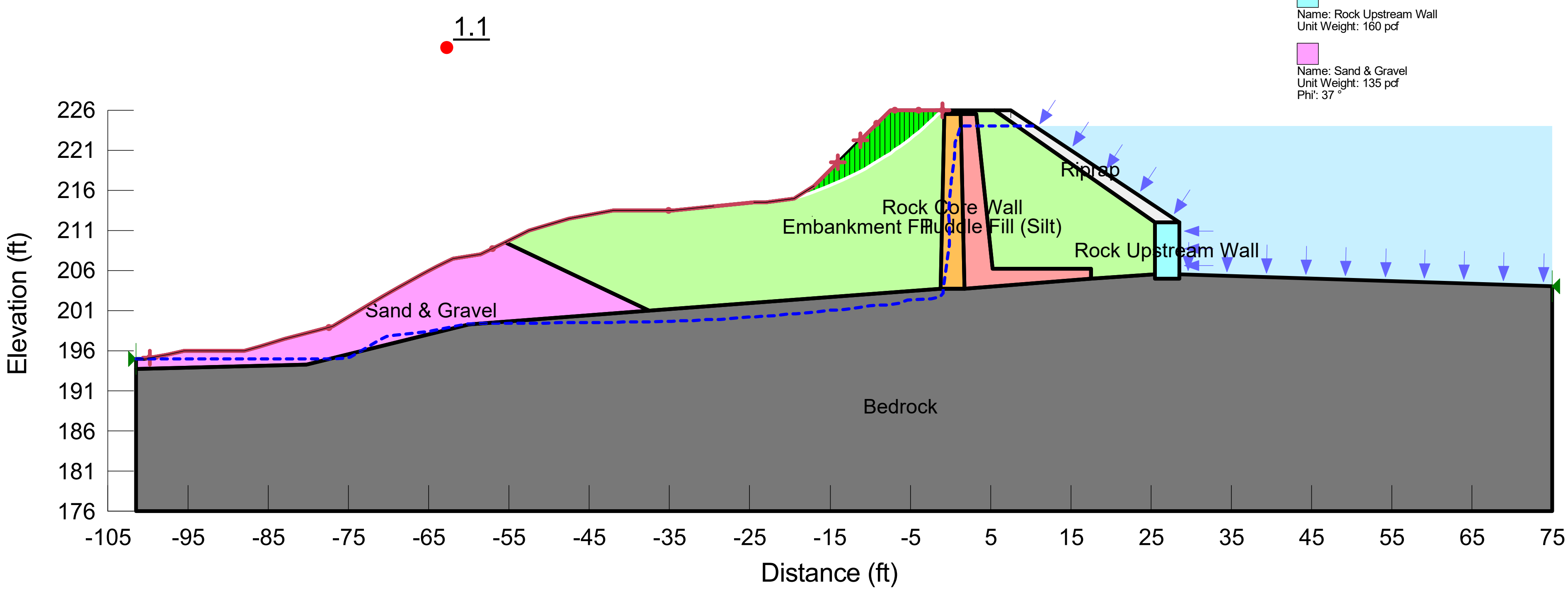
Downstream Slope Stability at Normal Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

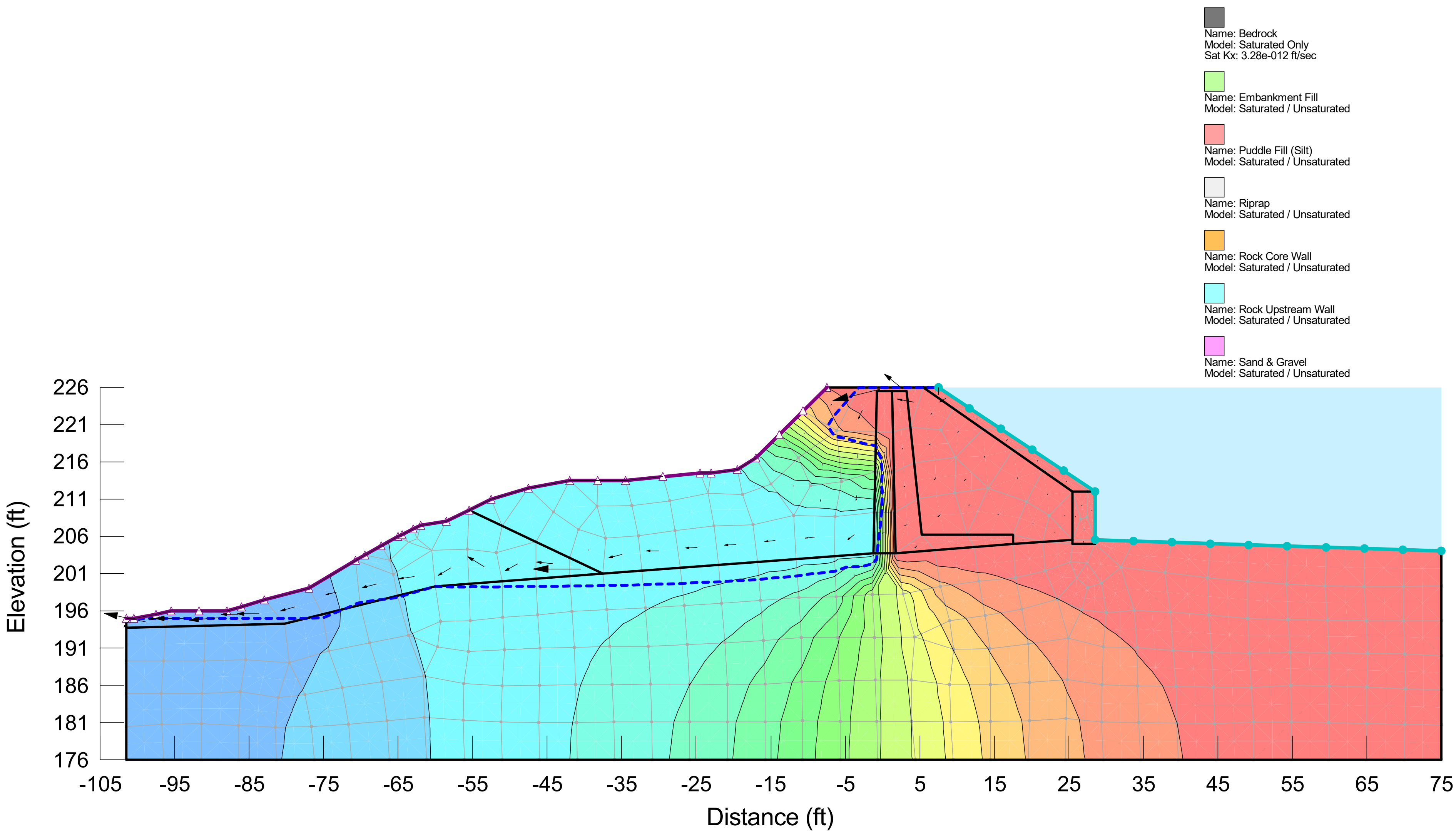
Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1





Seepage Stability at Maximum Pool

Snake Brook Dam, Wayland, MA

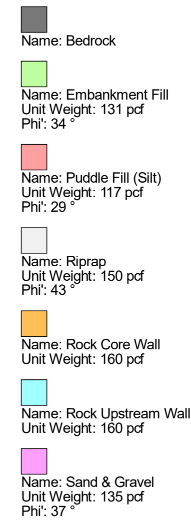


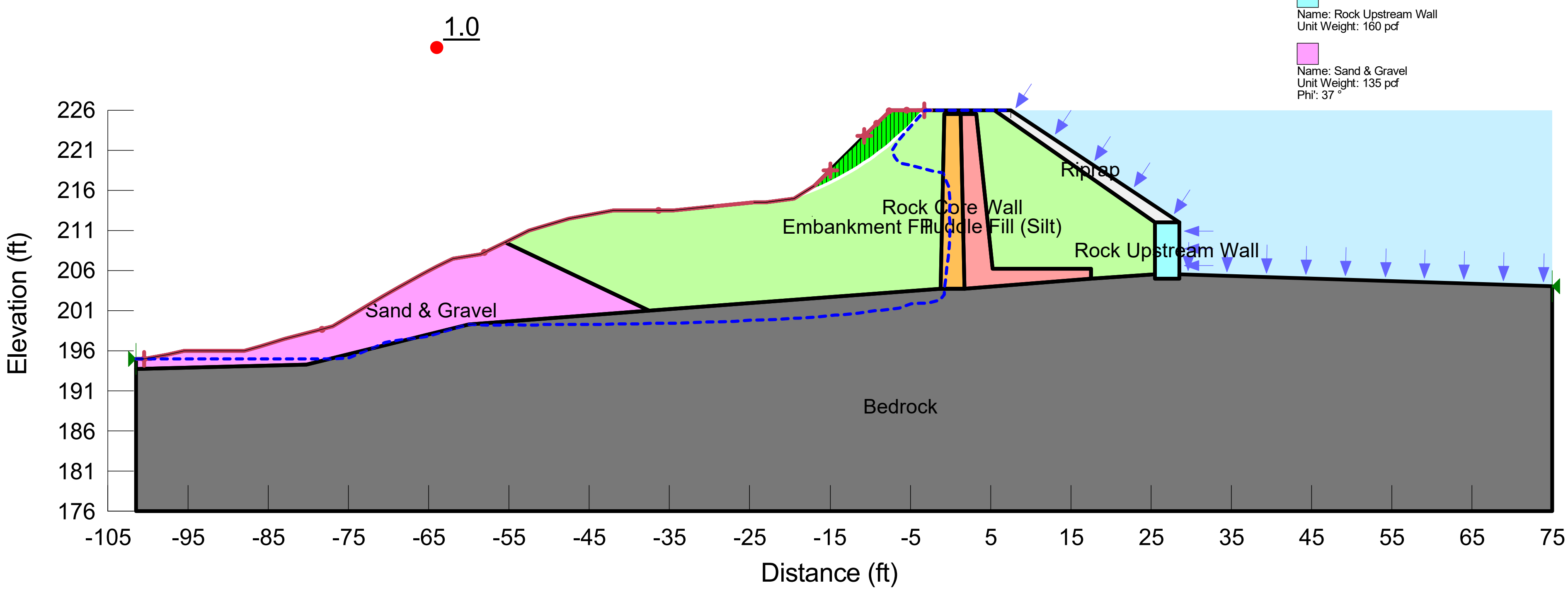
Downstream Slope Stability at Maximum Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

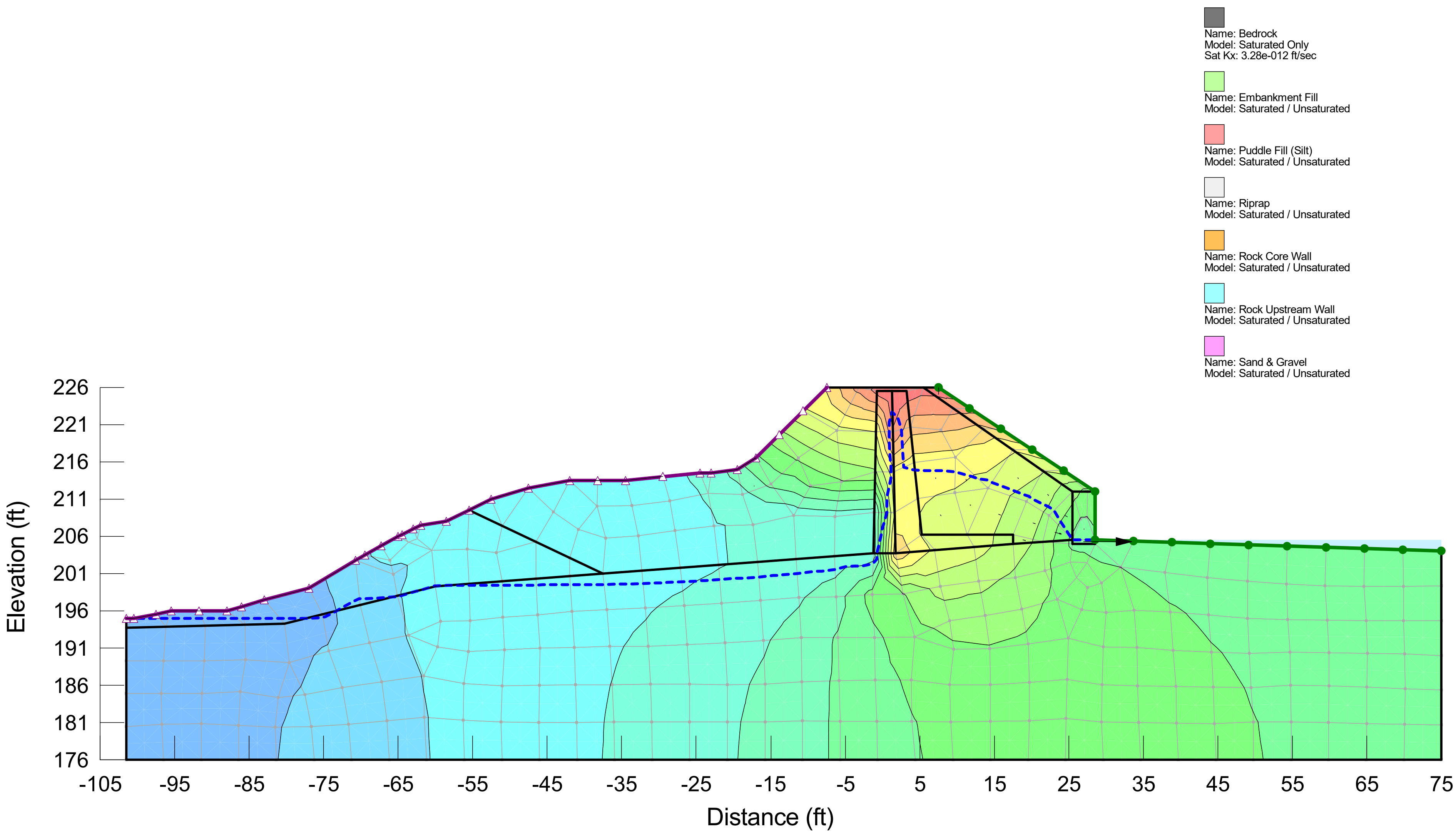
Design Case	**Pool Level**	**Upstream Slope**		**Downstream Slope**	
		Required FOS	**Calculated FOS**	**Required FOS**	**Calculated FOS**
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1





Rapid Drawdown from Normal Pool

Snake Brook Dam, Wayland, MA

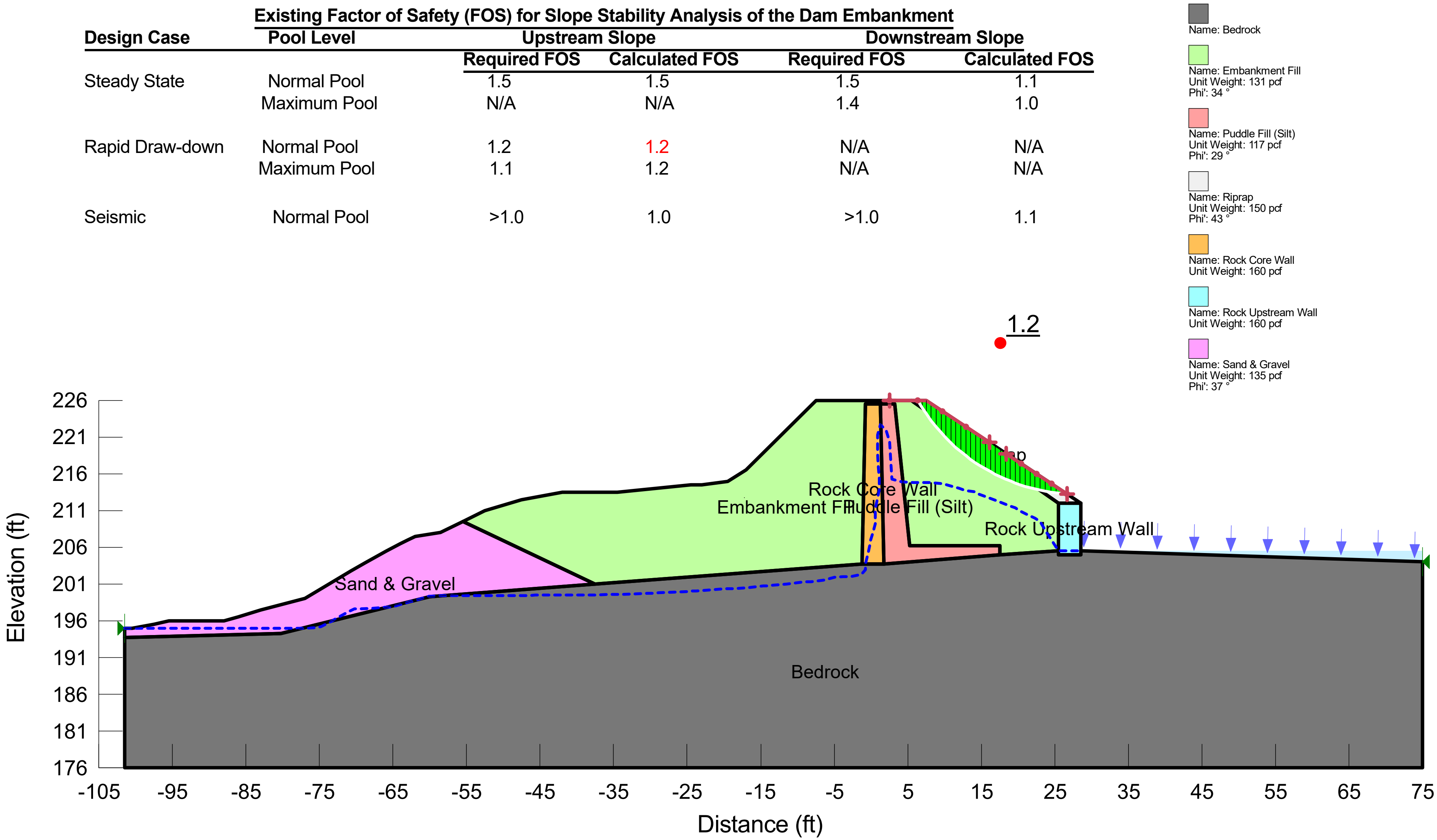


Upstream Slope Stability at Rapid Drawdown from Normal Pool

Snake Brook Dam, Wayland, MA

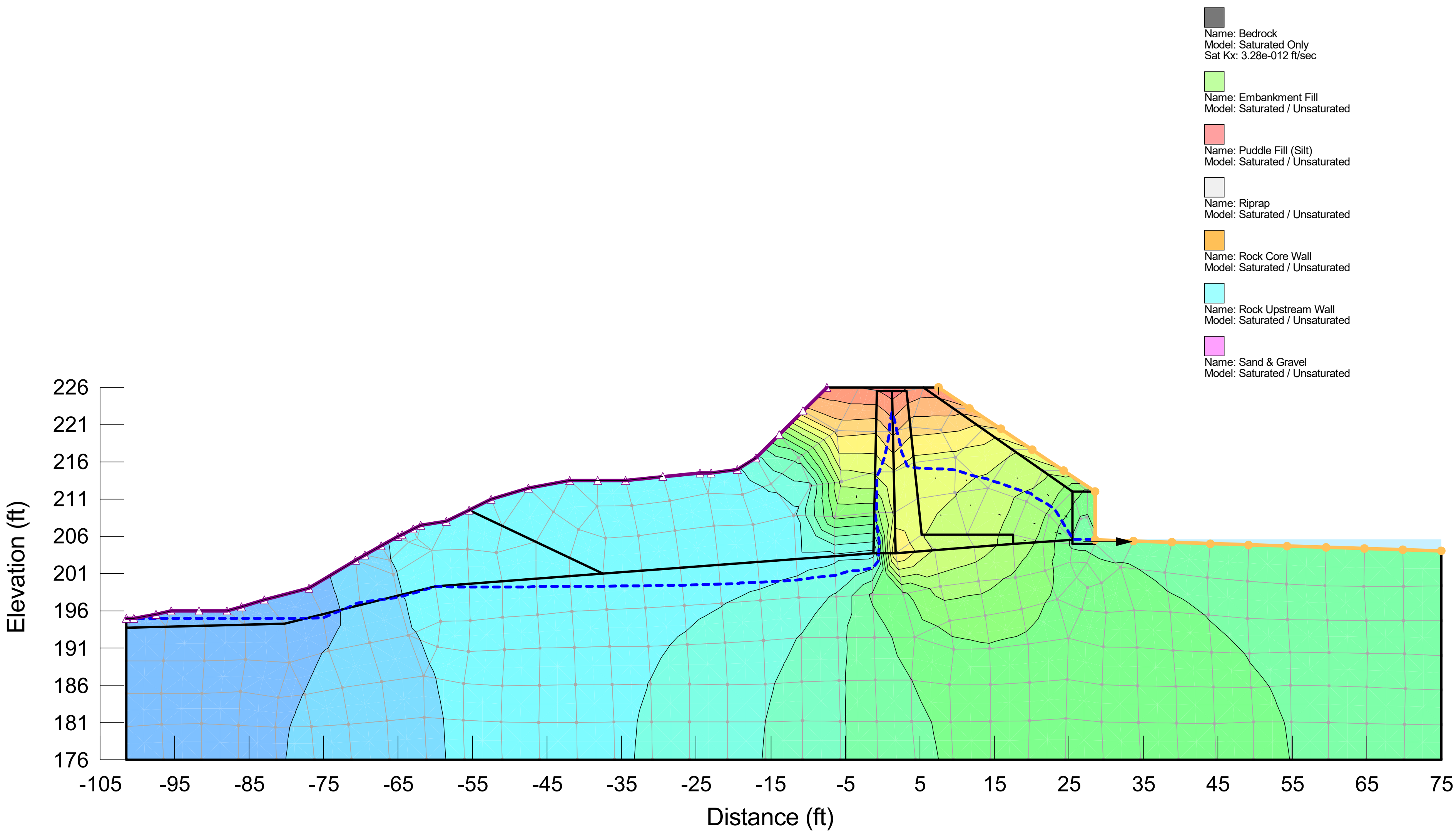
Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1



Rapid Drawdown from Maximum Pool

Snake Brook Dam, Wayland, MA

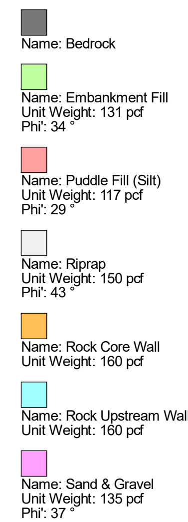


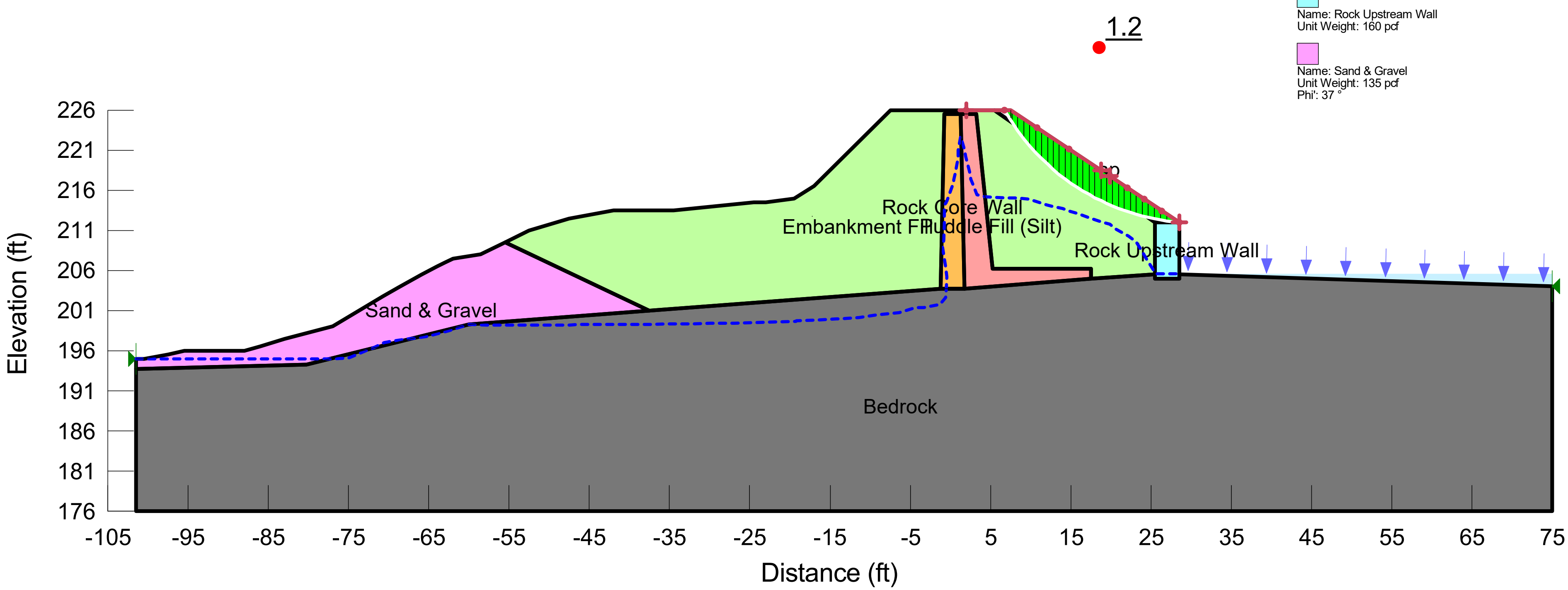
Upstream Slope Stability at Rapid Drawdown from Maximum Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	**Calculated FOS**	**Required FOS**	**Calculated FOS**
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1



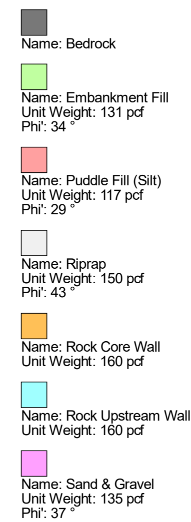


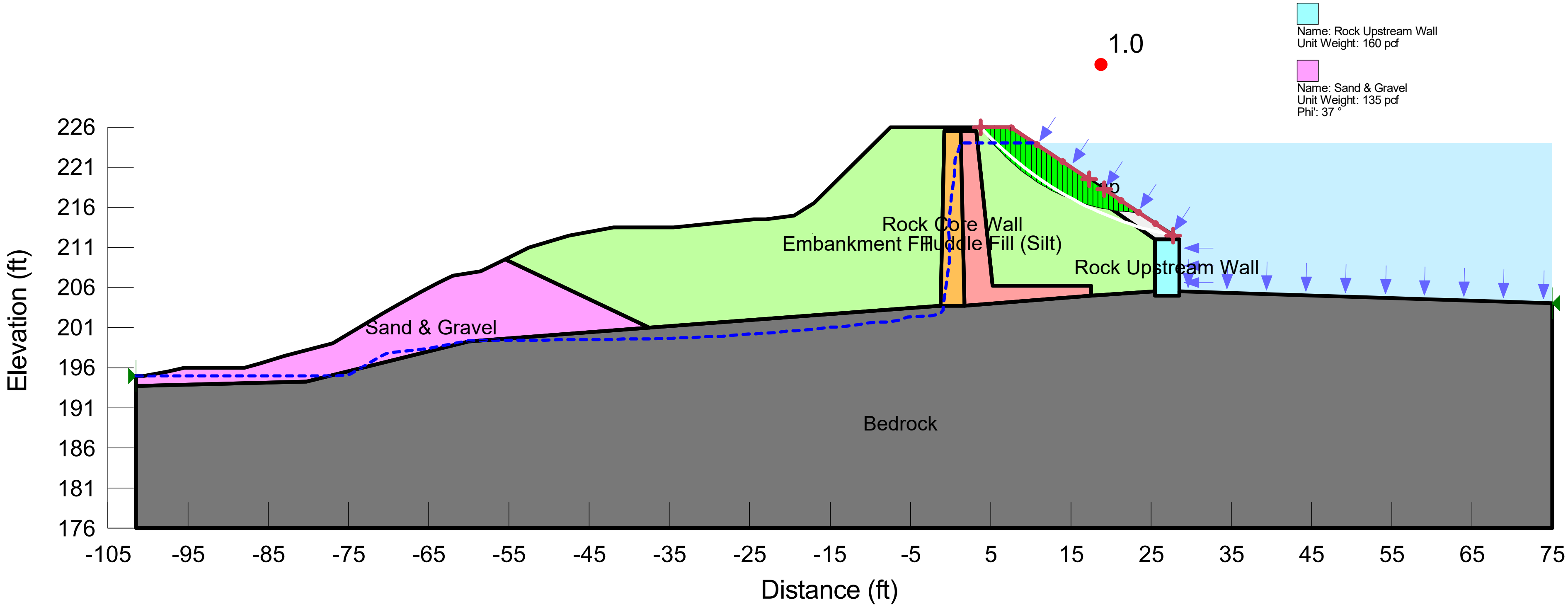
Upstream Slope Seismic Stability at Normal Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1



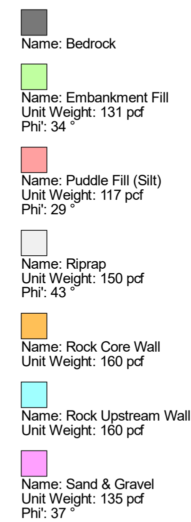


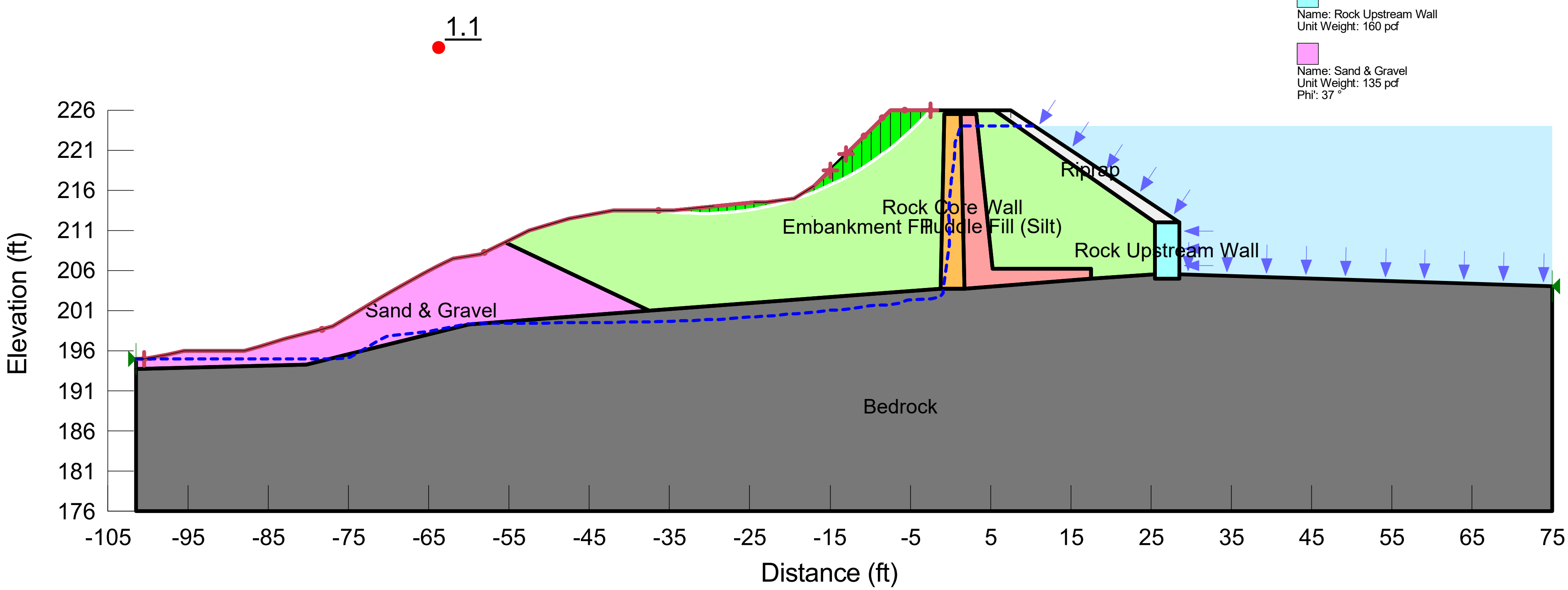
Downstream Slope Seismic Stability at Normal Pool

Snake Brook Dam, Wayland, MA

Existing Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.1
	Maximum Pool	N/A	N/A	1.4	1.0
Rapid Draw-down	Normal Pool	1.2	1.2	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.1

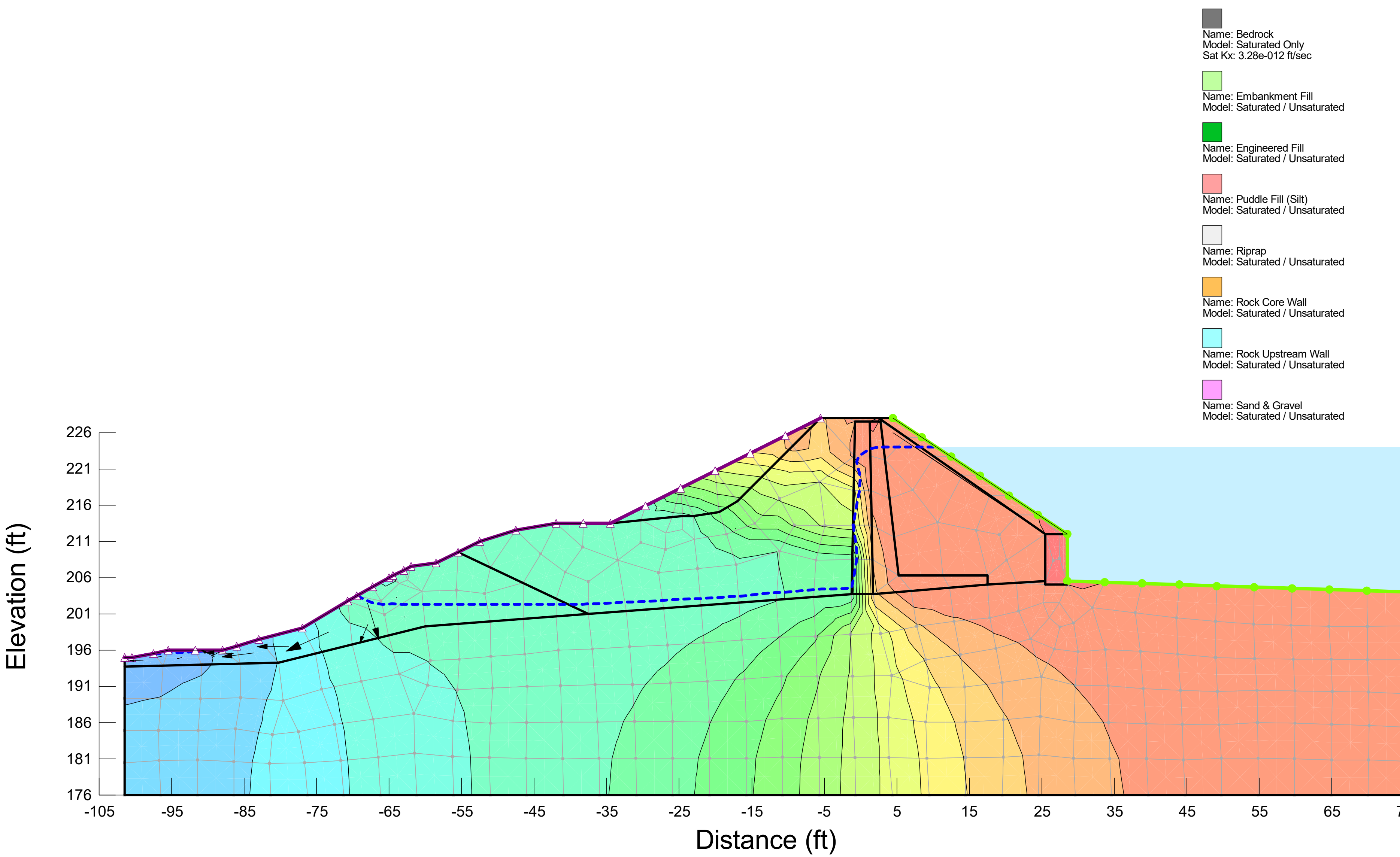




PROPOSED CONDITION RESULTS

Seepage Stability at Normal Pool

Snake Brook Dam, Wayland MA

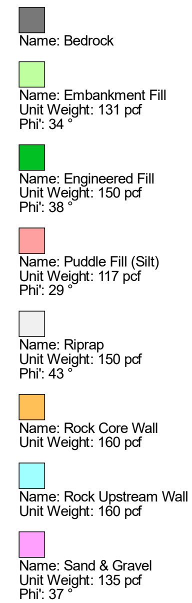


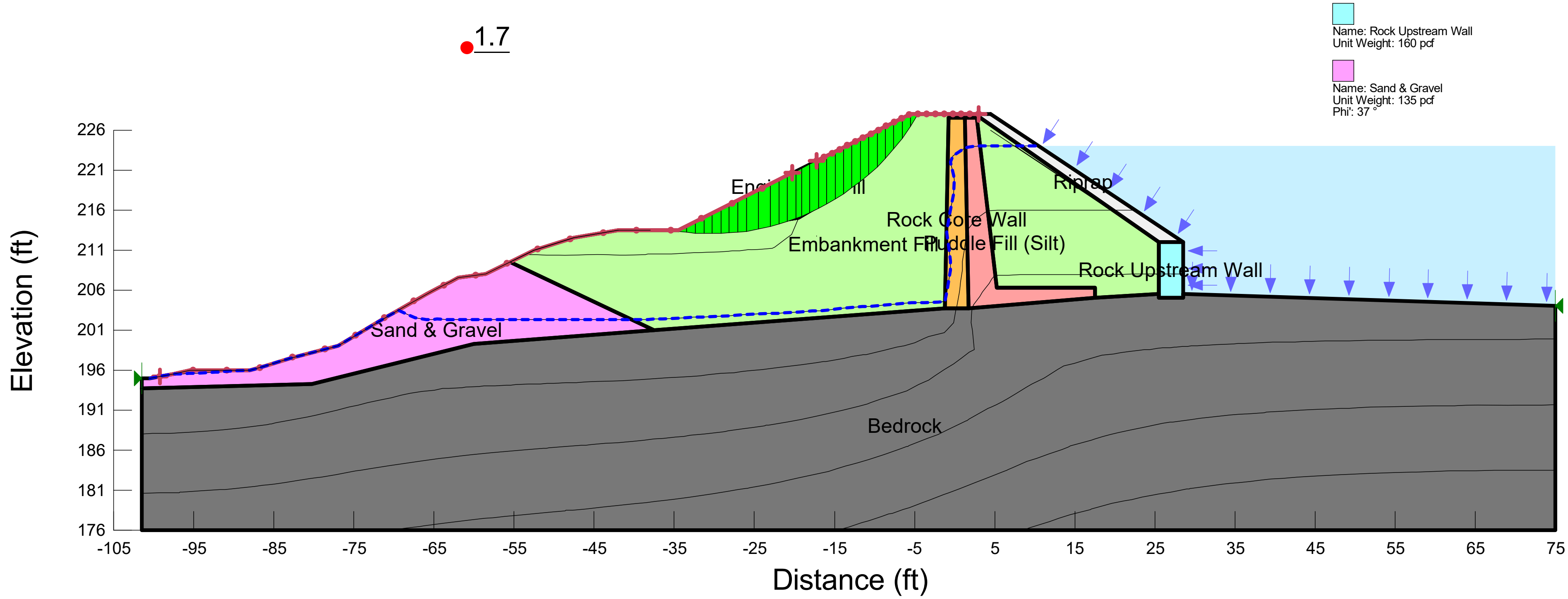
Downstream Slope Stability at Normal Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3



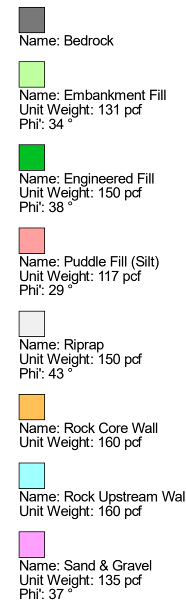


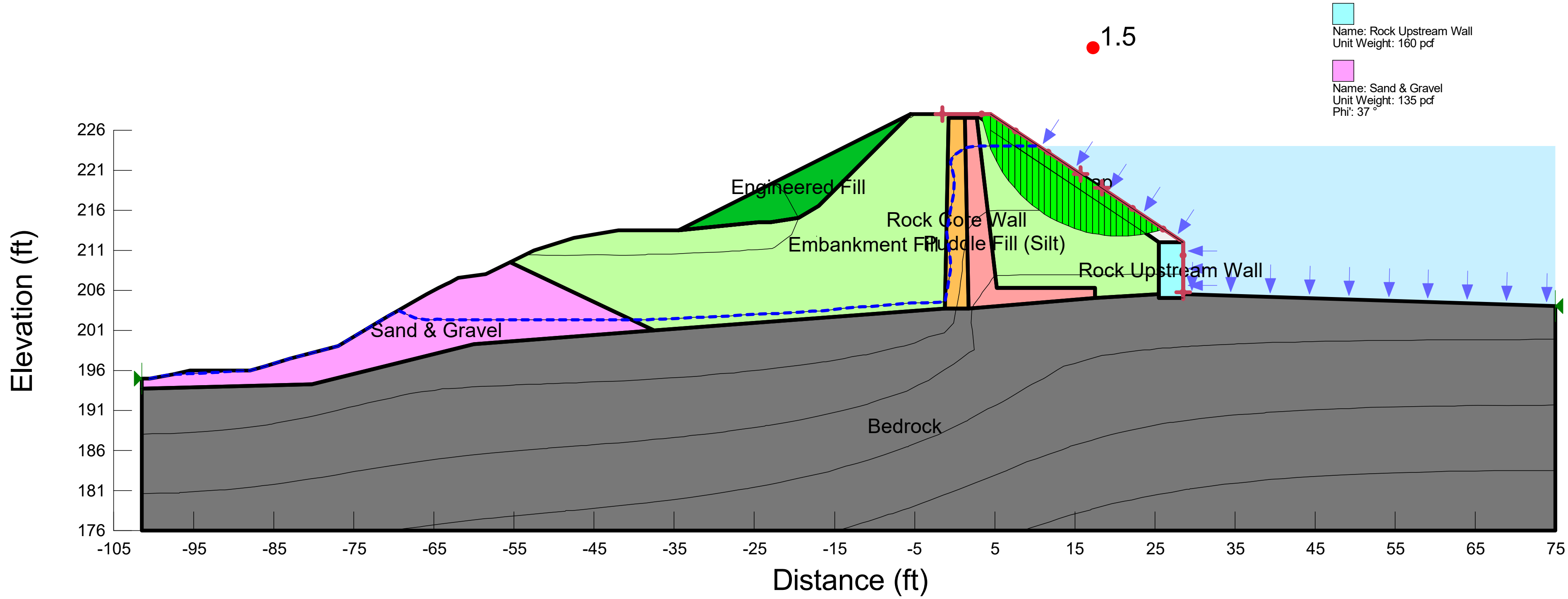
Upstream Slope Stability at Normal Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

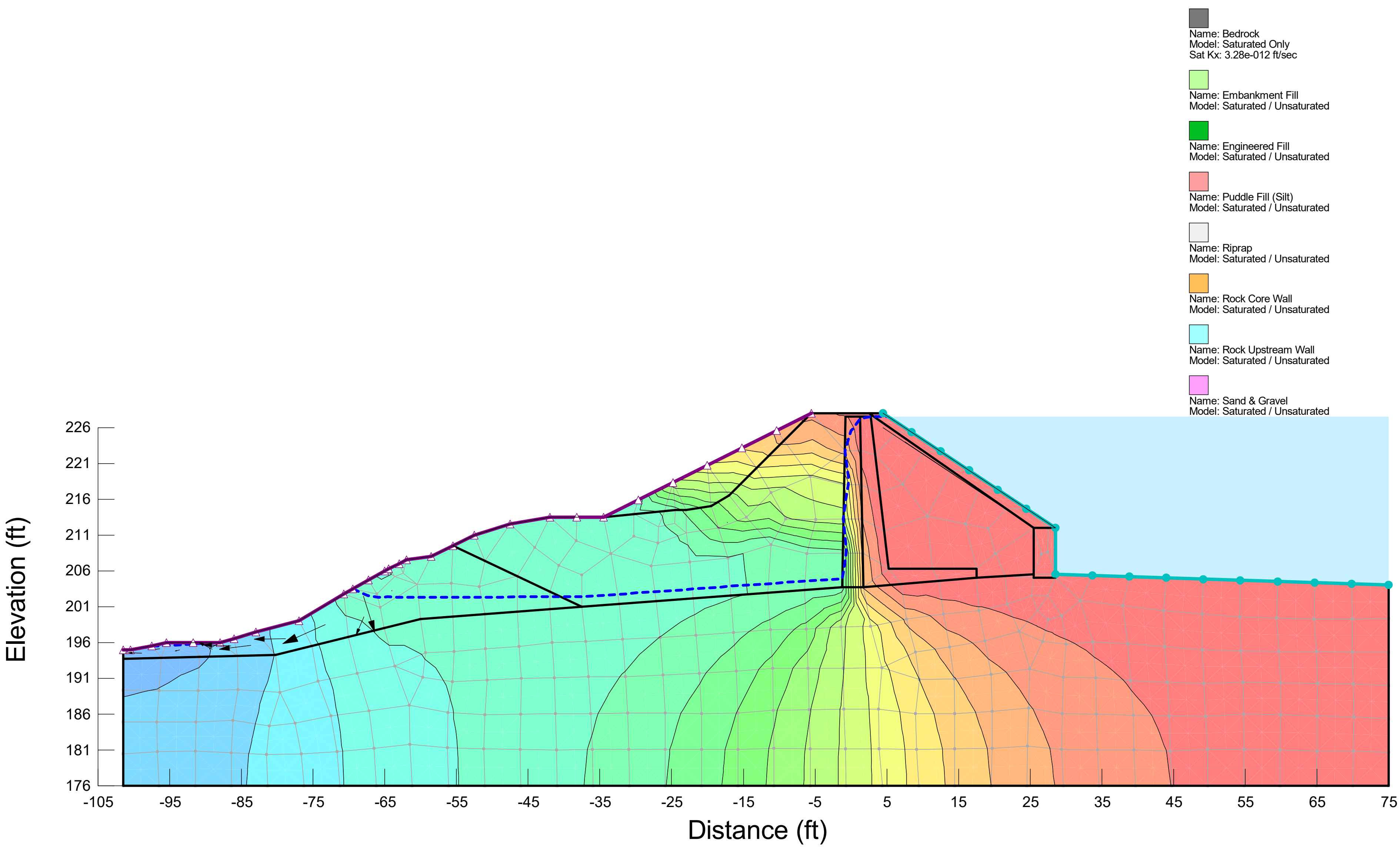
Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3





Seepage Stability at Maximum Pool

Snake Brook Dam, Wayland MA

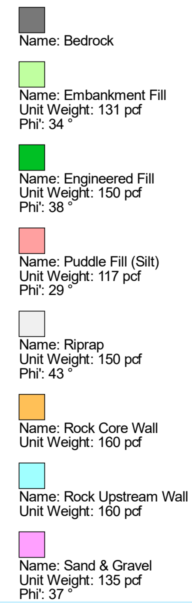


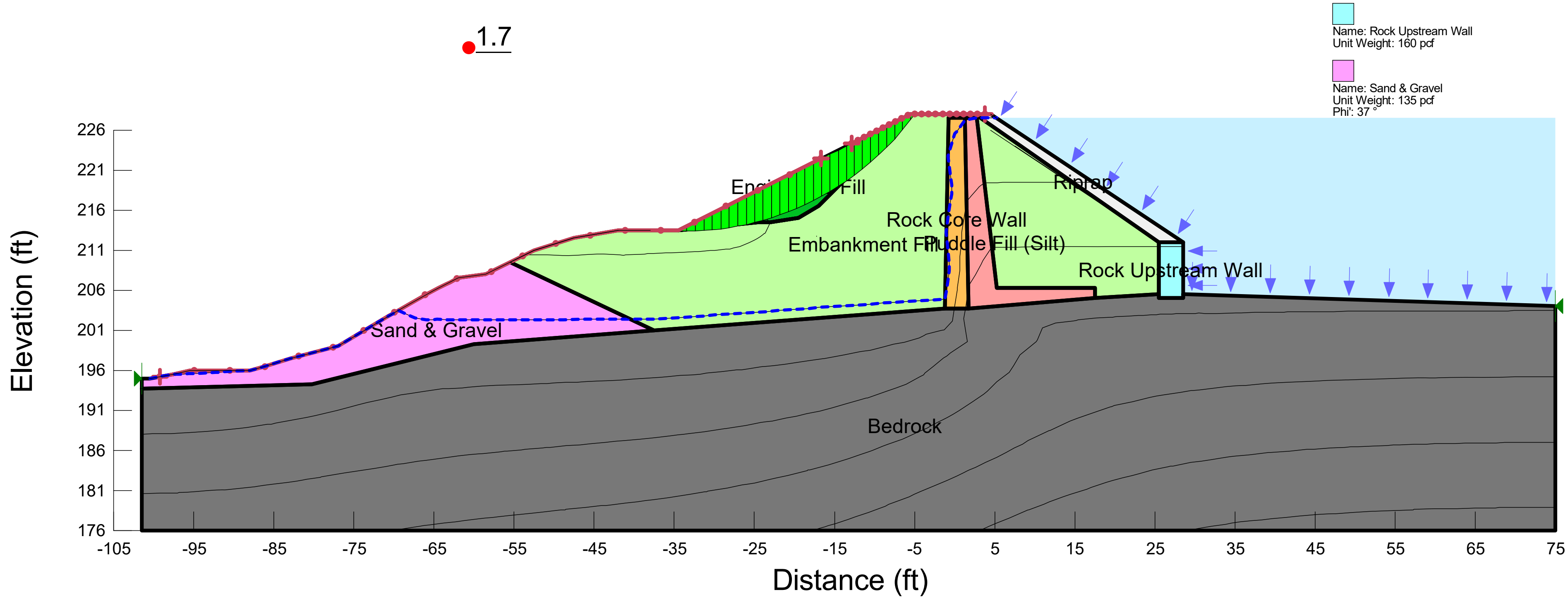
Downstream Slope Stability at Maximum Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

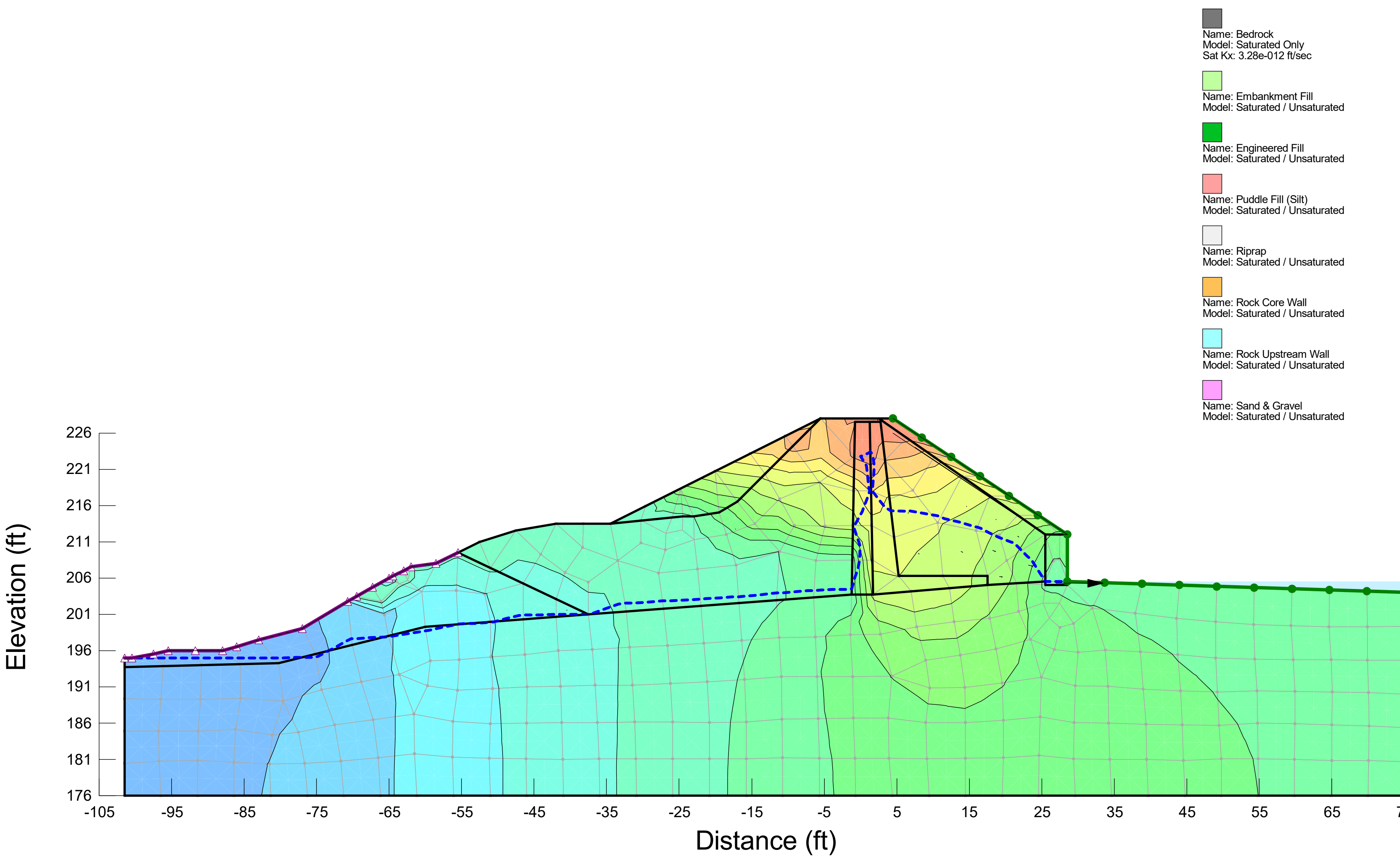
Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3





Rapid Drawdown from Normal Pool

Snake Brook Dam, Wayland MA

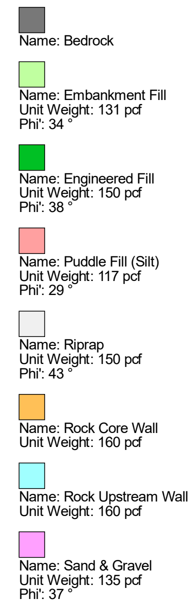


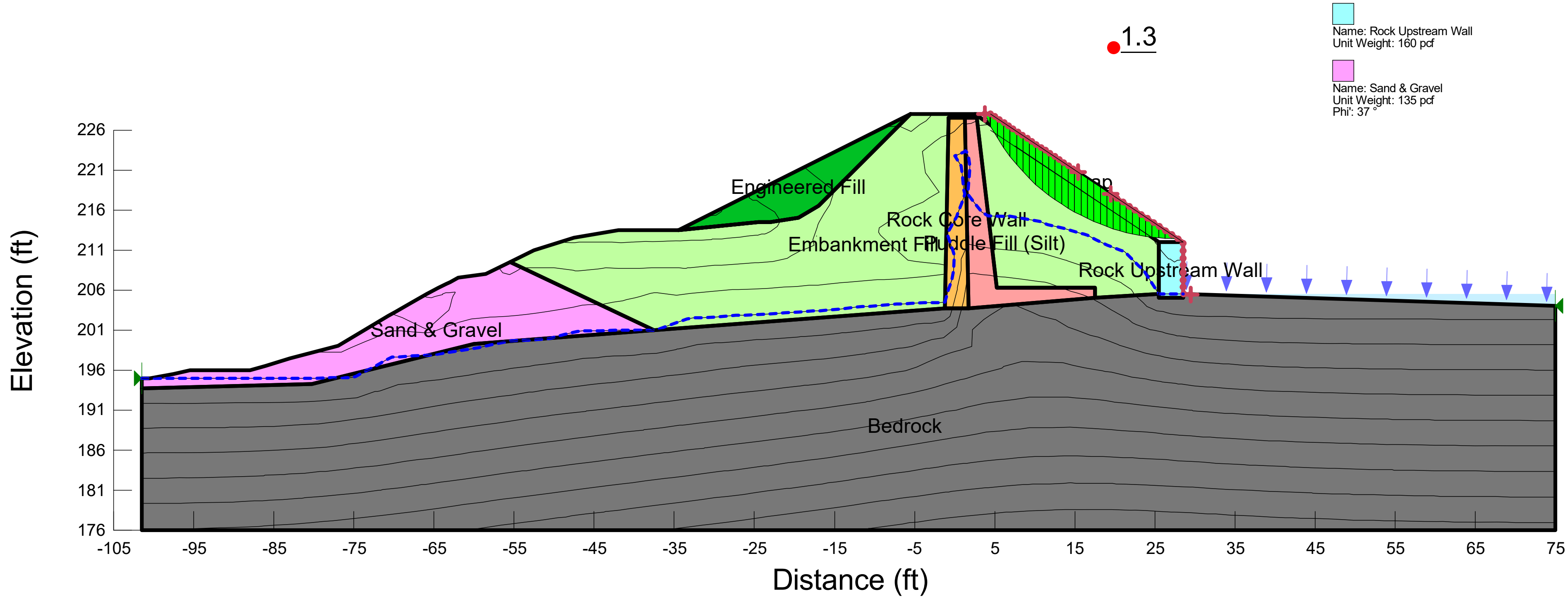
Upstream Slope Stability at Rapid Drawdown from Normal Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

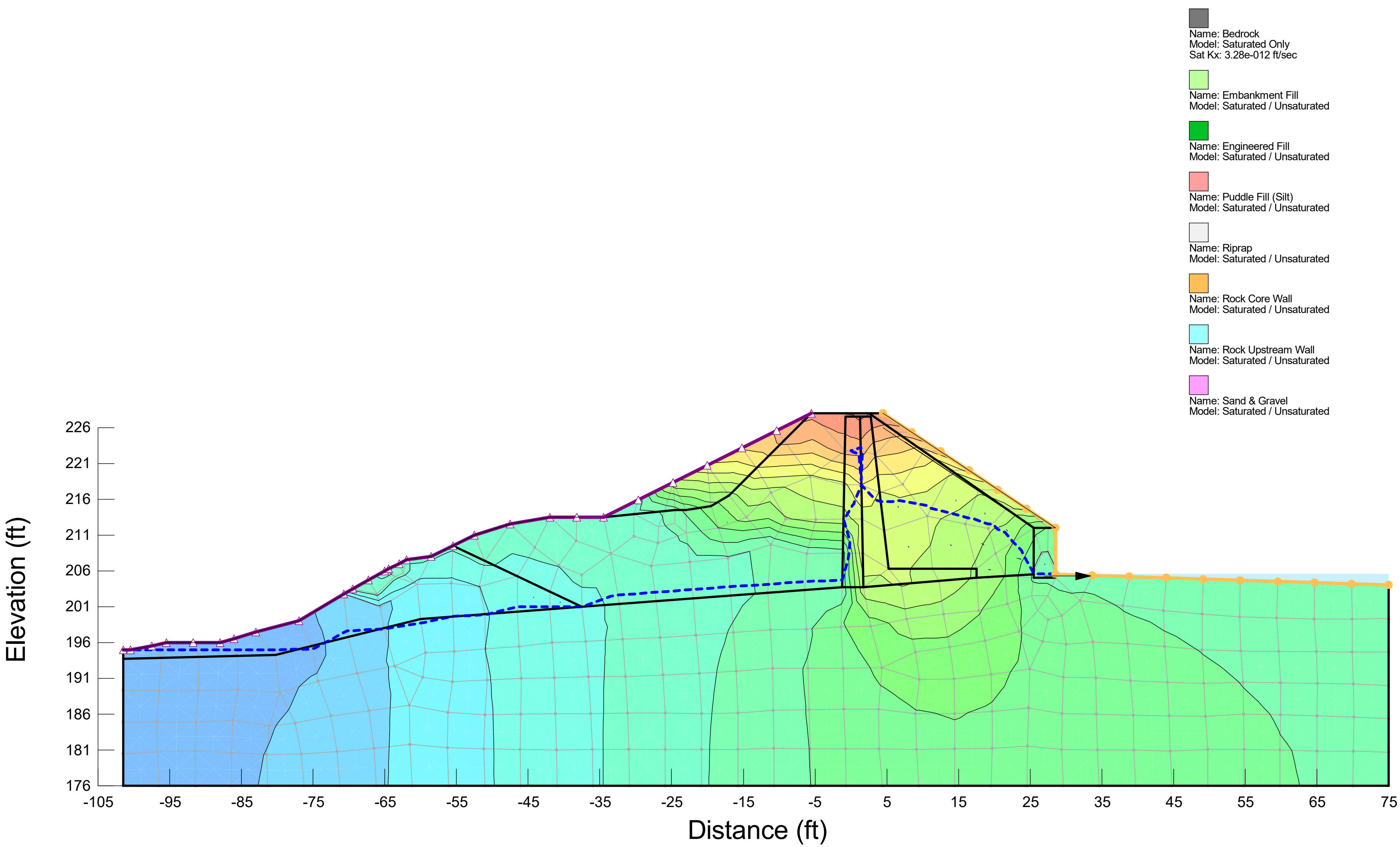
Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3





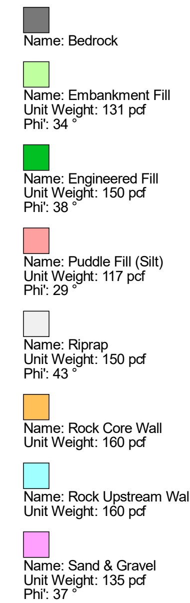
Rapid Drawdown from Maximum Pool

Snake Brook Dam, Wayland MA



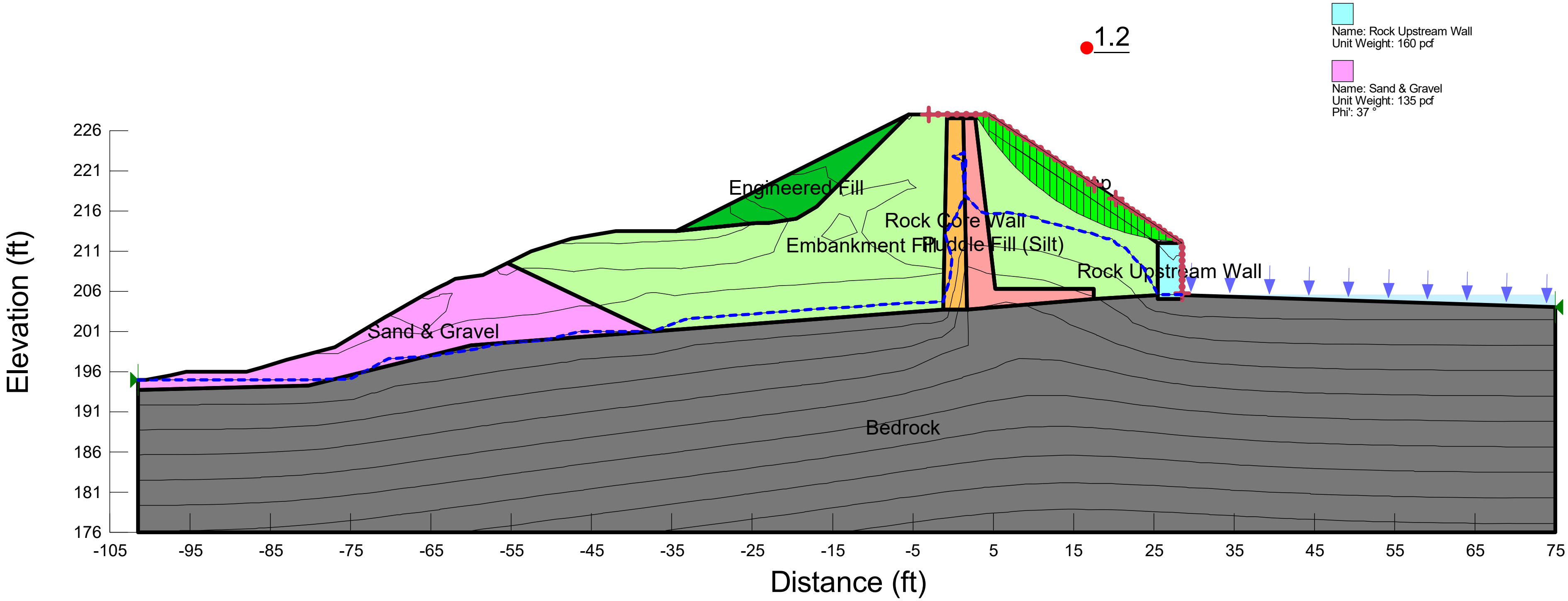
Upstream Slope Stability at Rapid Drawdown from Maximum Pool

Snake Brook Dam, Wayland MA



Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3

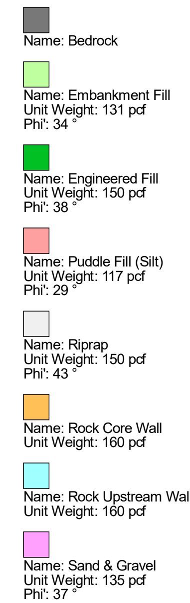


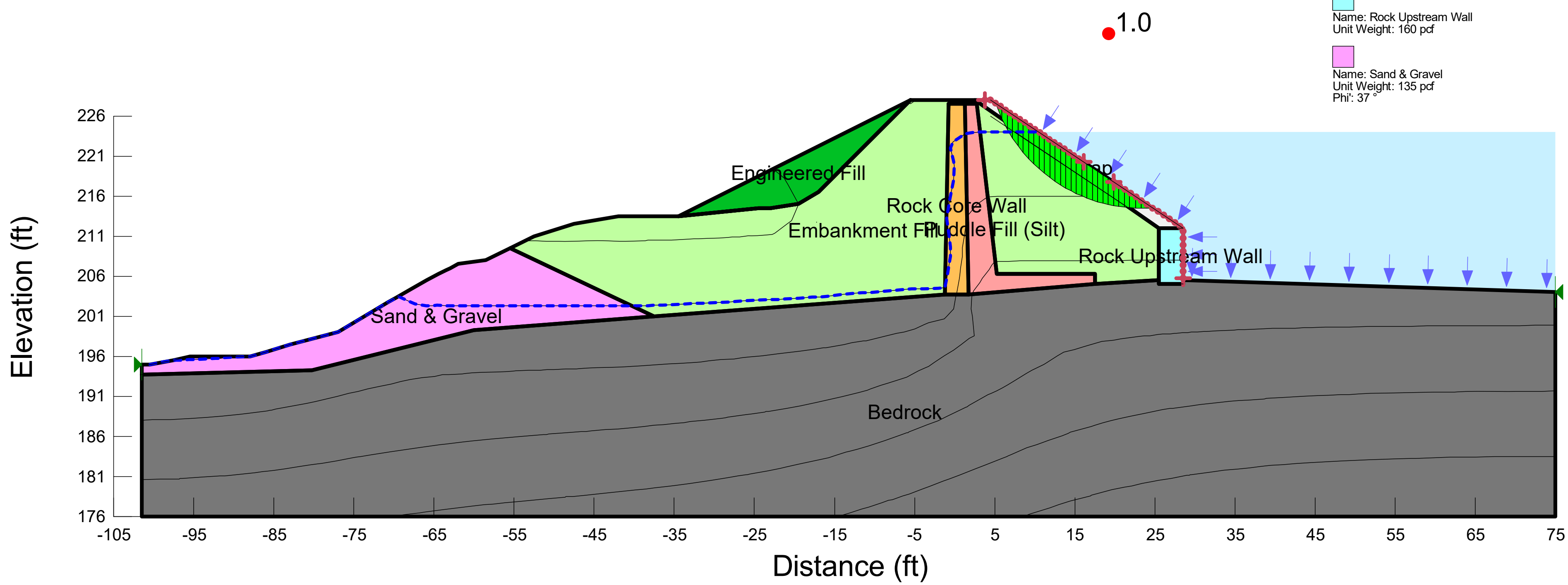
Upstream Slope Seismic Stability at Normal Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3



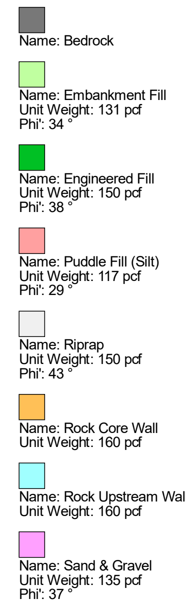


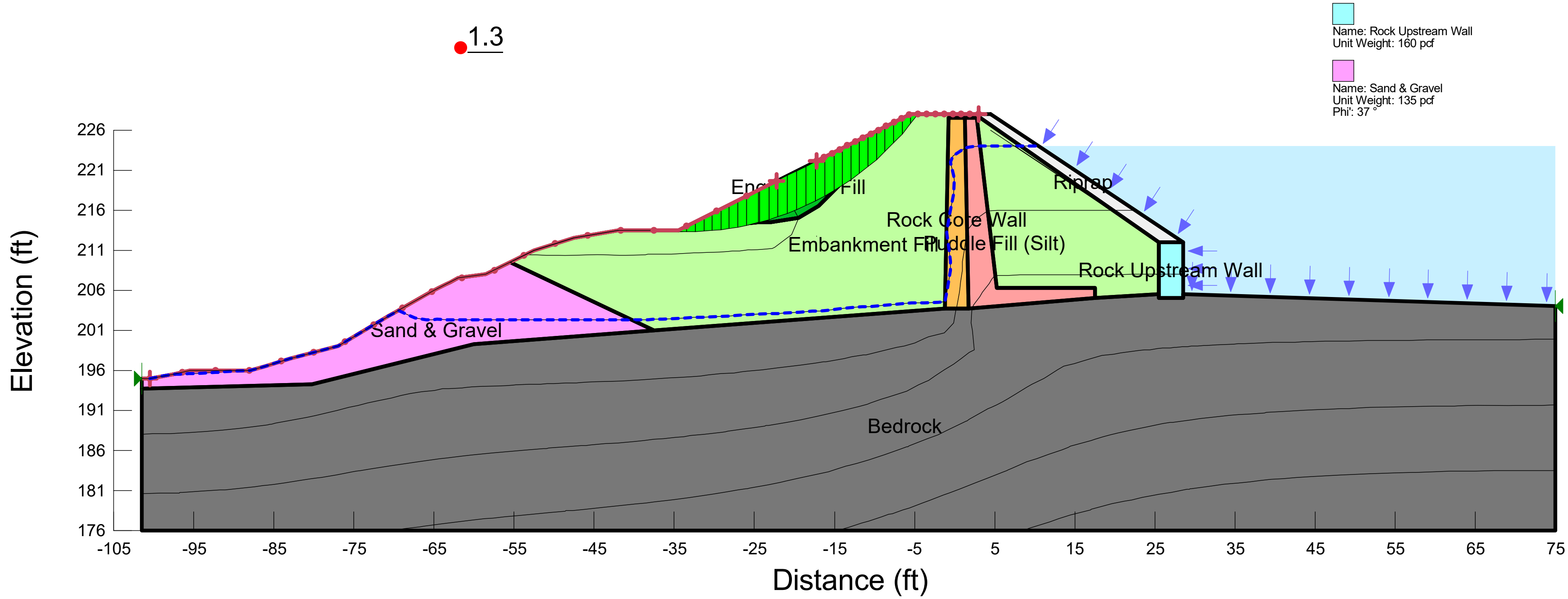
Downstream Slope Seismic Stability at Normal Pool

Snake Brook Dam, Wayland MA

Proposed Condition Factor of Safety (FOS) for Slope Stability Analysis of the Dam Embankment

Design Case	Pool Level	Upstream Slope		Downstream Slope	
		Required FOS	Calculated FOS	Required FOS	Calculated FOS
Steady State	Normal Pool	1.5	1.5	1.5	1.7
	Maximum Pool	N/A	N/A	1.4	1.7
Rapid Draw-down	Normal Pool	1.2	1.3	N/A	N/A
	Maximum Pool	1.1	1.2	N/A	N/A
Seismic	Normal Pool	>1.0	1.0	>1.0	1.3

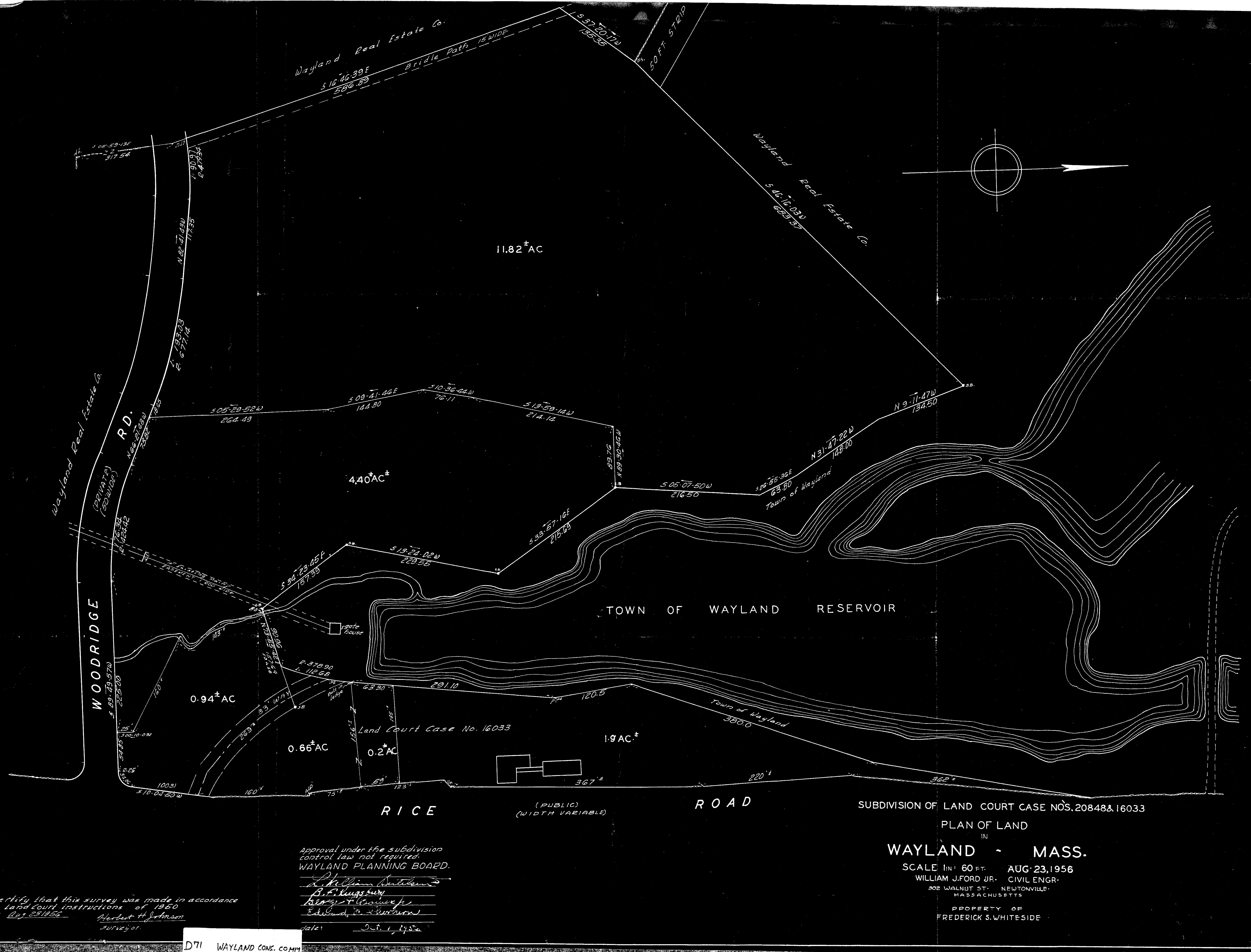




APPENDIX G
Historical Information
Snake Brook Dam
Wayland, Massachusetts


TRANSVERSE SECTION THROUGH DAM.
DRIVEWAY.
HIGH WATER.
OLD EMBANKMENT
PUDDLE
EMBANKMENT
PUMP ROOM 11' x 15'.
LEDGE
HEIRS OF CYRUS LEE.
GEO. A. RICE
DAM
FILTER GALLERY
G. A. RICE
HEIRS OF CYRUS LEE.
RIGHT OF WAY
GEO. A. RICE.
HEIRS OF CYRUS LEE.
HIGHWAY
RIGHT OF WAY.
HEIRS OF CYRUS LEE.
PLAN OF
RESERVOIR AND LAND
OF THE
WAYLAND WATER WORKS.
SCALE 30 FEET TO AN INCH.
H. W. BLAISDELL,
HYD. ENGR.
1878.
LONGITUDINAL SECTION
THROUGH CENTRE WALL OF DAM.
FILTER WELL.


WAYLAND WATER WORKS
LOCATION OF RESERVOIRS DAMS PROPOSED FILTER AND WASTE PIPE
WAYLAND MASS.
J. J. VAN VALKENBURGH, C.E.
SCALE 1 INCH = 80 FEET.
JUNE 1907
PUMPING STATION
DAM
OVERFLOW
RIGHT OF WAY
RESIDENCE
HIGHWAY
WALL
LOWER RESERVOIR
UPPER RESERVOIR
ELEVATION WATER 101.0'
AREA 4.5 ACRES
GRAVEL BANK
DYKE
RIGHT OF WAY
ELM TREE
SPRING
SWAMP
AREA 32.4 ACRES
PLAN
DETAILS OF
INTAKE MANHOLE
SCALE 1 INCH = 4 FEET
18 INCH
AKRON PIPE
SECTION A-B
SECTION C-D
SURFACE WATER 101.0'
ELEVATION 80.0'
ANGLE
PROFILE OF WASTE PIPE
SCALES HORIZONTAL 1 INCH = 80 FEET
VERTICAL 1 INCH = 4 FEET
COPPER SCREEN
12 INCH IRON PIPE
MANHOLE
PLAN
DETAILS OF
PROPOSED FILTER
SCALE 1 INCH = 4 FEET
SAND
SECTION A-B
GATE BOX
12 INCH IRON PIPE
SECTION C-D


Wayland Real Estate Co.
Bridle Path 15' WIDE
S 16°46'39" E
586.89
S 37°20'17" W
135.36
50 FT. STRIP
Wayland Real Estate Co.
S 46°16'03" W
683.57
11.82± AC
Wayland Real Estate Co.
WOODRIDGE
RD.
(PRIVATE)
(50' WIDE)
S 05-29-52 W
264.49
S 09-41-46 E
144.80
S 10-36-44 W
76.11
S 13-59-14 W
214.14
N 89-30-46 W
89.76
4.40± AC
S 05-07-50 W
216.50
63.80
N 31-47-22 W
148.00
Town of Wayland
N 9-11-47 W
134.50
S 33-57-16 E
215.69
S 13-24-02 W
229.56
S 34-23-45 E
157.38
gate house
TOWN OF WAYLAND RESERVOIR
0.94± AC
S 89-49-57 W
225.00
291.10
120.5
Town of Wayland
380.0
Land Court Case No. 16033
0.66± AC
0.2± AC
1.9 AC±
S 10-04-50 W
160±
367±
220±
368±
RICE
(PUBLIC)
(WIDTH VARIABLE)
ROAD
SUBDIVISION OF LAND COURT CASE NOS. 20848 & 16033
PLAN OF LAND
IN
WAYLAND - MASS.
SCALE 1 IN: 60 FT. AUG 23, 1956
WILLIAM J. FORD JR. CIVIL ENGR.
302 WALNUT ST. NEWTONVILLE
MASSACHUSETTS
PROPERTY OF
FREDERICK S. WHITESIDE
Approval under the subdivision control law not required.
WAYLAND PLANNING BOARD.
date:
I certify that this survey was made in accordance with Land Court instructions of 1960
Date Aug 23 1956
Herbert H. Johnson
surveyor.
D71 WAYLAND CONS. COMM.

APPENDIX H
Visual Inspection & Report Limitations

Snake Brook Dam

Wayland, Massachusetts

VISUAL INSPECTION & REPORT LIMITATIONS

Visual Inspection

1. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

2. In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team.

3. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

4. It is critical to note that the condition of the dam is evolutionary in nature and depends on numerous and constantly changing internal and external conditions. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Use of Report

1. The applicability of other environmental permits (ie., NOI, PGP, Water Quality Certificate, etc.) needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of MADEP, the local conservation commission or other regulatory agency.

2. This report has been prepared for the exclusive use of the Town of Wayland for specific application to the Snake Brook Dam site in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

3. This report has been prepared for this project by Pare. This report is for preliminary evaluation purposes only and is not necessarily sufficient to support design or repairs or recommendations or to prepare an accurate bid.

APPENDIX I
Common Dam Safety Definitions

Snake Brook Dam
Wayland, Massachusetts

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to 302 CMR10.00 Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA. Please note should discrepancies between definitions exits, those definitions included within 302 CMR 10.00 govern for dams located within the Commonwealth of Massachusetts.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom. including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Size Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

Large – structure with a height greater than 40 feet or a storage capacity greater than 1,000 acre-feet.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 50 to 1,000 acre-feet.

Small – structure with a height between 6 and 15 feet and a storage capacity of 15 to 50 acre-feet.

Non-Jurisdictional – structure less than 6 feet in height or having a storage capacity of less than 15 acre-feet.

Hazard Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others .Loss of life is not expected.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

Unsafe - Major structural, operational, and maintenance deficiencies exist under normal operating conditions.

Poor - Significant structural, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

Satisfactory - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF

APPENDIX J
Previous Reports and References
Snake Brook Dam
Wayland, Massachusetts

PREVIOUS REPORTS AND REFERENCES

The following documents were identified within the dam safety database or reference as part of this work:

1. "Snake Brook Dam – Phase I Inspection/Evaluation Report", prepared by Haley & Aldrich, Inc., date of Inspection: August 16, 2017.

2. "Snake Brook Dam – Phase I Inspection/Evaluation Report", prepared by GZA GeoEnvironmental, Inc., date of Inspection: August 14, 2012.

3. "Snake Brook Dam –Inspection/Evaluation Report", Haley & Aldrich, Inc., date of Inspection: April 30, 1999.

4. Drawings: "Wayland Water Works – Location of Reservoirs Dams Proposed Filter and Waste Pipe, Wayland Mass." Prepared by J.J. Van Valkenburgh, Original Scale: 1" = 80', dated June 1907.

5. Hiram W. Blaisdell. "Report of the Construction Committee of the Wayland Water Works". March 1, 1879.

6. Drawing: "Plan of Reservoir and Land of Wayland Water Works." Prepared by H.W. Blaisdell, Original Scale: As Noted, dated 1878.

During the development of the report Pare also reviewed available information included within the following databases:

1. MADCR – Dams Viewer Database http://maps.massgis.state.ma.us/dams/viewer.htm

The following references were utilized during the preparation of this report and the development of the recommendations presented herein:

1. "Design of Small Dams", United States Department of the Interior Bureau of Reclamation, 1987.

2. "ER 110-2-106 - Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979.

3. "Guidelines for Reporting the Performance of Dams" National Performance of Dams Program, October 1994.

4. 302 CMR: Department of Conservation and Recreation Section 10.00 Dam Safety

5. Massachusetts State Building Code Sec. 1612.4.9

6. Massachusetts Wetlands Protection Act Regulations 310 CMR 10.