Water
Wastewater
Infrastructure

February 6, 2013
W-P Project No. 12537B

Mr. Rick Malasky, Public Works Director
Town of Newmarket
4 Young Lane
Newmarket, New Hampshire 03857

Subject: **Macallen Dam - Final Report**
Dam Breach Analysis
Update of May 24, 2010 Report

Dear Mr. Malasky:

The purpose of this letter report is to summarize the results of the dam breach modeling conducted on the Macallen Dam. A dam breach analysis was initially completed by Wright-Pierce, the results of which were presented in a letter report dated May 24, 2010. The New Hampshire Department of Environmental Services (NHDES) Dam Bureau provided review comments on the May 24, 2010 report. This updated dam breach analysis report addresses the NHDES comments.

The breach analysis is part of Wright-Pierce's overall assessment of the dam, which included structural inspection and analysis of the dam. The structural analysis and recommendations were provided under separate cover on March 8, 2010, with a preliminary cost estimate for structural repairs provided on April 1, 2010 and potential cost sharing alternatives provided on October 18, 2010.

Background

The Town of Newmarket initially requested Wright-Pierce to perform preliminary engineering studies to confirm the hazard classification and provide initial inundation mapping of the Macallen Dam (NHDES Dam No. 177.01) for future incorporation into the Emergency Action Plan. In general, the Macallen Dam was classified by the NHDES as a "Significant Hazard" (Class B) dam in March of 2008 and Significant-to-High (Class B to C) in April 2008.

The dam breach analysis was conducted to determine the nature and extent of downstream flooding if the dam were ever to be breached. The location of the Macallen Dam is shown in Figure 1 in Appendix A.

NHDES Dam Bureau Review

As referenced above, the May 24, 2010 breach analysis was submitted to and reviewed by the NHDES Dam Bureau. The review letter, dated September 8, 2010, is provided in Appendix B. The comments provided by the NHDES are listed below with responses to those comments in *italics*. The remaining sections of this report have been updated in accordance with the responses provided.

1. "The 100 year storm inflow estimate used in the analysis was 8,302 cfs. It appears this information is taken from NHDES's February 1999 inspection report. Using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, the 100-year storm event of 8,302 cfs was estimated using the area-ratio technique and based upon the data available at the time. Current information from USGS (Scientific Investigations Report 2008-5206) at the same stream gauge shows a 2008 value of 9,270 cfs for the 100 year storm and when applying the area-ratio technique the resulting 100 year inflow to the dam is approximated as 10,688 cfs. This conversion is rough, but shows the difference for 15% more drainage area. Please update the 100 year inflow estimates in the analysis."

   An updated 100-year flood flow hydrologic analysis for the Lamprey River was conducted using the TR-20/Lag-CN method. The flood flow was also routed through an updated hydraulic analysis model that included a flow diversion near Route 108 in Durham. At this location, flood waters from the Lamprey River overflow Route 108 and exit the Lamprey River watershed through the Oyster River, effectively decreasing the downstream 100-year flood flow. The updated 100-year flood flow at the dam was determined to be approximately 10,260 cfs. The analysis is discussed in greater detailed in this report.

2. "Note; submitted analysis shows a slight over topping during the 100 year storm with gates closed. The storm event of March 16, 2010 (6,710 cfs), classified as a 25-50 year storm event by USGS, had gates completely open and less than 10" of freeboard at the left side concrete abutment."

   Noted.

3. "The submittal uses a restriction at the upstream bridge at NH Route 108 during the 100 year storm event. The upstream bridge per field review on May 16, 2006 by Dam Safety Inspector Grace Levergood noted no restriction by the upstream river bridge. The same determination of no restriction was made also by myself during the high rain event of March 16, 2010, storm classified as a 25-50 year storm event. (6,710 cfs). Review and confirm HEC-RAS results."

   The geometry of the Route 108 Bridge and its position in the river is based on NHDOT record plans of the bridge itself and on best available GIS LiDAR data adjacent to the bridge. The HEC-RAS model predicts a slight restriction at the Route 108 Bridge.

4. "Submitted figure 6, page 6 of 10, shows a breach width estimate of less than 50% of the crest length, and (appears to be 20%). Please use 50% of the crest length as the breach width parameter. Also on figure 6, define the area right of the spillway's right abutment (right of the fish ladder). Per figure 6, flow is shown in this area, unclear why this cross section does not show the mill building."

   The submitted Figure 6 is not a true snapshot of the complete dam breach, it is a snapshot of the very beginning of the dam breach that was included to show the maximum water surface elevation at the dam during the 100-year flood flow, with gates closed. The figure has been updated to show the 100-year flood flow through the dam prior to any breach occurring rather than as the breach is just beginning. The dam breach parameters used for this analysis are discussed in other sections of this report.

   Additionally, the dam cross-section, as shown in the model, is graphically based on the cross-section directly upstream of the dam, where there is no mill building. The mill building sits just below the downstream face of the dam and thus is not depicted in the dam cross-section geometry.

5. "The updated breach analysis will need to also reevaluate habitable living areas in the renovated historic mill building 200 ft. downstream on the left and also consider the historic mill building on the right side that could be renovated in the future and effect the dam's design storm flows."

   The updated breach analysis was evaluated for impacts to downstream habitable living areas. The results show that neither mill building on the right or left side of the dam are impacted by the dam breaches for both the 100-year and Sunny Day flow conditions.

6. "Confirm elevations on HEC-RAS cross section 8914.872. Both mill buildings appear to have the same base elevation, and possibly similar "habitable" elevations. See photos A and B."

   The geometry downstream of the dam including in the vicinity of cross section 8914.872, now cross section 12909.71, has been updated with GIS LiDAR data, and the elevation of the lowest habitable structure has been adjusted to reflect the appropriate vertical datum to be elevation 10.288 feet (NGVD29).

7. "Confirm the downstream limit of dam breach impacts are in line with Env-Wr 502.06(g) 1 & 2. Cross section #16."

   The downstream limit of the dam breach impacts are confirmed to be in line with Env-Wr 502.06(g), which states that:

   "The routing shall continue downstream until:

   (1) The point at which the water surface elevation due to dam failure is no more than 2 feet above the non-failure conditions in areas of potential threat to life and major property damage; or

(2) A point upstream of the point determined pursuant to (1), above, if the owner shows that there is no longer a threat to public safety beyond that point."

The dam breach analysis shows that the impacts at the downstream end of the model extents are less than 2 feet above non-failure conditions for the 100-year and Sunny Day breach analyses during the High Tide downstream boundary conditions as well as for the Sunny Day breach during Low Tide downstream boundary conditions. For the 100-year flood flow breach during Low Tide downstream boundary conditions, the water surface elevation due to dam failure is approximately 2.8 feet above non-failure conditions however, this incremental water level rise is contained entirely within the channel of the Lamprey River and the peak water surface elevation due to the breach wave remains almost 4 feet below high tide conditions without a dam breach. Additionally, an analysis of the potential for further downstream impacts beyond the limits of the model showed that there is no longer a threat to public safety beyond the downstream limit of the model.

8. "Note; the final dam breach analysis submittal to NHDES will need to be stamped by a professional engineer. See Env-Wr 502.06(a) for further details."

   Noted.

   <u>"After the update of your breach analysis per above NHDES comments:</u>

   1. Confirm whether or not any incremental impacts consistent with Env-Wr 101.09 take place to the downstream apartments and historic mill buildings during a dam breach.

      - If no impacts to the apartments or historic mill buildings are confirmed. NHDES recognizes that your dam is only a high hazard classification due to the historic mill building located on the right abutment. This situation would drop your design storm: per Inflow Design Storm (IDF) to a minimum storm event of 100 years.

      - If impacts incremental to the apartments or historic mill buildings are confirmed. NHDES advises that you consider performing an IDF analysis to determine if a storm event below 2.5x100 year storm can be used as the dam's "design storm"."

   The results of the updated dam breach analysis have confirmed that there are no incremental impacts consistent with Env-WR 101.09. Therefore this situation is consistent with the first bulleted item above that indicates the IDF could be dropped to a minimum storm event of 100-years. The results of the analysis are discussed further in this report.

Dam Breach Analysis Model

The breach analysis was completed using the U.S. Army Corps of Engineers Hydraulic Engineering Center's River Analysis System (HEC-RAS) computer program (Version 4.1). HEC-

RAS is computer software designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The system is capable of performing steady and unsteady flow water surface profile calculations in addition to dam breach scenarios.

HEC-RAS Model Input Data Collection

Data for the breach analysis model was collected from the following sources:

Field Data Collection/Site Visit
Wright-Pierce staff visited the Macallen Dam site and surrounding area on April 23, 2010. Field notes recorded pertinent information relative to river widths, natural channel conditions, and dam structure geometry (including height, width, depth, material of construction, headwall/tail-wall geometry, water depth below structure, dimension of supports, channel geometry immediately upstream/downstream, and vegetative cover).

Geographical Information System (GIS)
Publicly available GIS LiDAR topography data was used to produce cross sectional geometry of the river waterway beyond the immediate vicinity of the dam and was used to calculate watershed boundaries and land/water areas tributary to the dam. GIS data was also used to do the following:

- Generate elevation datum
- Generate river channel cross sections
- Determine river channel low points and channel locations
- Calculate slope of river and lowest potential elevation in river channel at each station
- Create channels in the model based on calculated elevations and field observations
- Interpolation between cross sections to provide additional information/boundary conditions for the model.

USGS National Water Information System (NWIS) Web interface
The NWIS Web interface was initially used to verify river peak flow information for the Lamprey River watershed and surrounding area. The closest available river gauge is located upstream of the dam at USGS station 01073500. Because additional runoff is directed to the Lamprey River downstream of the gauge, an area approximation method was used to approximate flow at the dam. The 100-year flood flow data was referenced from the April 7, 2008NHDES Inspection Report as 8,302 cfs. The "Sunny Day" flow of 272 cfs was determined from averaging historical NWIS data collected for the past 70 years for events recorded below the threshold limit of 2,000 cfs.

It should be noted that the NHDES, in comment 1 above from the September 8, 2010 review, suggested that the 100-year flood flow be updated using the entire period of record for the gauge. The NHDES estimated that the 100-year flood flow rate should be closer to 10,688 cfs. The NHDES later requested that the TR-20/Lag-CN method be used to calculate the 100-year flood flow versus using gauging data. As such, the USGS station data has been removed from the analysis and replaced with the TR-20/Lag-CN flood flow calculation method.

Aerial Photographs

Publically available aerial photographs (Orthophotometry, etc) were used as a modeling aid during the construction of the HEC-RAS model. Information such as approximate river width and length of reach were validated. Other information including structures and vegetative cover were obtained using the imagery.

Site Photographs

Photographs were taken of the site and surrounding area (bridges, structures, dam, and the river channel). Photographs collected during the site visit were referenced during the development of the model and included factors such as channel geometry and vegetative cover. In addition, model results for high flow conditions were compared with photographs collected during the spring storms of 2008 and 2010.

NHDOT Information

Upstream bridge geometry was obtained from the original construction drawings for the Route 108 river crossing. The information was obtained directly from the NHDOT archived records.

FEMA Flood Insurance Study (FIS)

The applicable FEMA FIS was reviewed as part of the 100-year flood flow analysis. The FEMA FIS indicated that the FEMA determined 100-year flood flow for the Lamprey River was calculated using regression equations and data from the USGS gaging station in Durham. However, the FIS included an interesting statement about a diversion in the Lamprey River that indicates the following:

> "Newmarket has no existing or proposed flood control structures. During extreme flood events, floodwaters from the Lamprey River overflow State Route 108 upstream in Durham and are diverted into the Oyster River basin. These overflows or diversions reduce peak flood discharges of the Lamprey River before it reaches the Town of Newmarket. During a 100-year flood, diversions to the Oyster River basin reduce flood peaks in Newmarket by approximately 20 percent (FEMA, 1991)."

Additionally, the Town of Newmarket has verified that the section of Route 108, in Durham, indicated by the FEMA FIS, continues to overtop during flood flow conditions. Therefore, in order to calculate the 100-year flood flow rate at the Macallen Dam, this flow split needed to be included in the hydraulic model.

University of New Hampshire Model Data

Based on conversations with Town and NHDES Dam Bureau staff, it was determined that the University of New Hampshire (UNH) had developed a HEC-RAS model of the Lamprey River approximately from the Deerfield/Raymond, NH border to just downstream of the Macallen Dam. Wright-Pierce was able to obtain the UNH HEC-RAS model for use in extending the model further upstream of the dam. In addition, the UNH model was used to configure the flow split that exists along the Lamprey River upstream of the dam. The data used from the UNH HEC-RAS model includes the following:

- Cross-sections of the Lamprey River from just downstream of the Route 152 crossing in Lee, NH downstream to just upstream of the Route 108 crossing in Newmarket,
- Cross-sections of the Piscassic River, tributary to the Lamprey River,
- Cross-sections of LaRoche and Ellison Brooks, tributary to the Lamprey River,
- Roughness Coefficients for the cross-sections, and
- Reach lengths of the Lamprey and Piscassic Rivers, and LaRoche and Ellison Brooks.

HEC-RAS Model Development

The HEC-RAS model for the dam breach analyses was developed using a combination of the aforementioned data. Figure 1 in Appendix A, shows the HEC-RAS model cross section locations. Model input parameters and geometry of specific physical features are summarized below:

<u>The Macallen Dam</u>
Information regarding the dam and spillway location, dimensions and depth/geometry were obtained from field measurements. Construction drawings were not available during generation of the model.

<u>Bridges</u>
The upstream bridge was measured in the field and cross referenced with the original NHDOT drawing set. The following bridge data was used in the HEC-RAS model:

- Low cord elevations: measurement from the bottom of the channel to the underside (lowest section) of the bridge.
- High cord elevations: obtained by adding the thickness of the bridge to the low cord elevation.
- Width of the deck: measured at widest distance.
- Length of the deck: measured at longest distance.
- Abutment shape/design: when applicable, measurements of the abutments were obtained using the smallest potential flow opening as observed from upstream.
- Weir Coefficients: HEC-RAS default condition was utilized.

<u>Model Limits</u>
The upstream limit of the original model was located 750 feet upstream of the dam (500 feet upstream of the Route 108 Bridge). The downstream limit of the original model was located 1,200 feet downstream of the dam (near the boat launch). Based on the need to model the flow split upstream of the dam, the model was extended 16,000 feet, to roughly 16,750 feet upstream of the dam.

<u>Roughness Coefficients (Manning's "n"):</u>
Values for the channel geometry roughness coefficients (channel bottom, banks, and surrounding area outside of banks) within the original limits of the model were obtained from *Open-Channel Hydraulics*; Ven Te Chow, Ph.D., 1959. The selection of roughness coefficients were based on

field observations and compared to literature values. The value of river roughness coefficients are affected by bottom geometry, lining, and slope.

The roughness coefficients used for the model upstream portions of the model were determined as part of the UNH study and model.

River Flow Rate

As discussed earlier, the "Sunny Day" flow and 100-year flood flow rates through the dam were determined to be 272 cfs and 8,302 cfs, respectively, for the initial model runs. Based on comments received from the NHDES, the 100-year flood flow rate has been modified. The following outlines the progression from the original 100-year flood flow rate to the current 100-year flood flow rate:

- March 26, 2008 – NHDES Report referencing 100-year flood flow of **8,300 cfs** via gauging station data through 2006.
- September 8, 2010 – Dam Breach Analysis Response Letter (Appendix B from NHDES suggesting an increase of the 100-year flood flow to approximately **10,688 cfs** using gauging station data and the area-ratio technique.
- June/July 2012 – Discussion with NHDES about use of TR-20 versus USGS gauging data.
- July 2012 – Wright-Pierce conducted TR-20 HydroCAD analysis. TR-20 method resulted in 100-year flood flow of roughly **18,175 cfs**.
- July 2012 – NHDES directed Wright-Pierce to write a letter (Appendix C) explaining why TR-20 method should not be used and justifying the use of the USGS flow rate.
- September 2012 – NHDES letter (Appendix C) denying request to use USGS 100-year flow rate. Suggested using the Area-Depth method to reduce flood flow.
- October 2012 – Wright-Pierce calculated flood flow using Area-Depth method of **15,640 cfs** and submitted analysis to NHDES for review (Appendix D).
- September 2012 – Wright-Pierce discussion with NHDES regarding flow that leaves the Lamprey River watershed at Route 108 in Durham (witnessed by NHDES and cited by FEMA). Potential to decrease flood flow rate by determining amount that would leave watershed (requires additional modeling up to Route 108 crossing). FEMA cites a 20% decrease, which would put flow at **12,512 cfs**.
- January 2013 – Wright-Pierce obtained a HEC-RAS model of the Lamprey River upstream of the Macallen Dam from a previously conducted UNH study. The model contained the river cross sections required to model the upstream flow split near Route 108 in Durham. The UNH model cross sections were used to update the existing Wright-Pierce model. A concurrent update of the TR 20/Lag-CN runoff analysis was conducted based on preliminary e-mailed review comments by the NHDES. These updates to the runoff analysis resulted in a 100-year flood flow rate at the Macallen Dam of approximately **14,500 cfs** before taking the upstream flow split into account. Using these flow rates the updated HEC-RAS model was run to predict the impact of the Route 108 flow split. The results of the model predicted that approximately 4,260 cfs of flow exits the Lamprey River through the flow split, resulting in a 100-year flood flow rate at the Macallen Dam of approximately **10,260 cfs.**

- February 2013 – Wright-Pierce shared the results of the flow split analysis with the NHDES through email correspondence. The NHDES issued a HydroCAD/HEC-RAS Model Review email on February 5, 2013, effectively agreeing with the results of the flow split analysis and establishing the 100-year peak flow conditions for use in the Dam Breach analysis of the Macallen Dam of **10,259 cfs**.

Boundary Conditions

Upstream and downstream boundary conditions were provided for the model. The upstream boundary condition was set as the river flow rates and the downstream boundary condition downstream of the Macallen Dam was set as the low or high tide water surface elevation (-5.90 feet or 4.40 feet, respectively). A downstream boundary condition was also provided for the Route 108 flow split in Durham. This boundary condition was assumed to be equal to the 100-year FEMA FIS base flood elevation, or 33 feet.

Breach Parameters

Timeline and final geometry data related to full breach conditions was obtained from *Chapter II, Appendix II-A, Table 1, Suggested Breach Parameters, Selecting and Accommodating Inflow Design Floods for Dams, 1993,* Federal Energy Regulatory Commission. Excerpts from this document are attached in Appendix E and the entire document can be found at the following website:

http://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide/chap2.pdf

The following breach parameters were used in the model and represent a typical breach scenario for the Macallen Dam.

- Crest Length (W): total length across the dam, from bank to bank, was obtained from the HEC-RAS inline structure editor (varied for each condition).
- Width of Breach (BR): equivalent to one half (0.5) the crest length (varied for each condition).
- Horizontal Component of Side Slope of Breach (Z): Zero (i.e. vertical side slope) for a concrete/stone built structure.
- Time to Failure (TFH): Two tenths of an hour (0.2 hour or 12 minutes) for complete failure.
- Breach Progression: A curve linear S-function was created to produce a maximum breach rate (i.e. steeper slope) at the midway point during the breach.

Submerged Dam Upstream

During the April 2010 field visit, a submerged dam was noted roughly 40 feet upstream of the Macallen Dam. This dam was modeled in HEC-RAS. Because of the potential for this dam to retain water if the Macallen Dam were to breach, sensitivity analyses were run to determine if a breach of the submerged dam would impact the breach wave inundation. As a result of the sensitivity analysis, it was decided to breach the submerged dam shortly after the breach of the Macallen dam to allow the entire stored volume behind the Macallen dam to contribute to the breach wave inundation.

Macallen Dam HEC-RAS Model Breach Analysis Results

Table 1 outlines the dam breach analyses results for the Macallen Dam.

TABLE 1
DAM BREACH ANALYSIS RESULTS

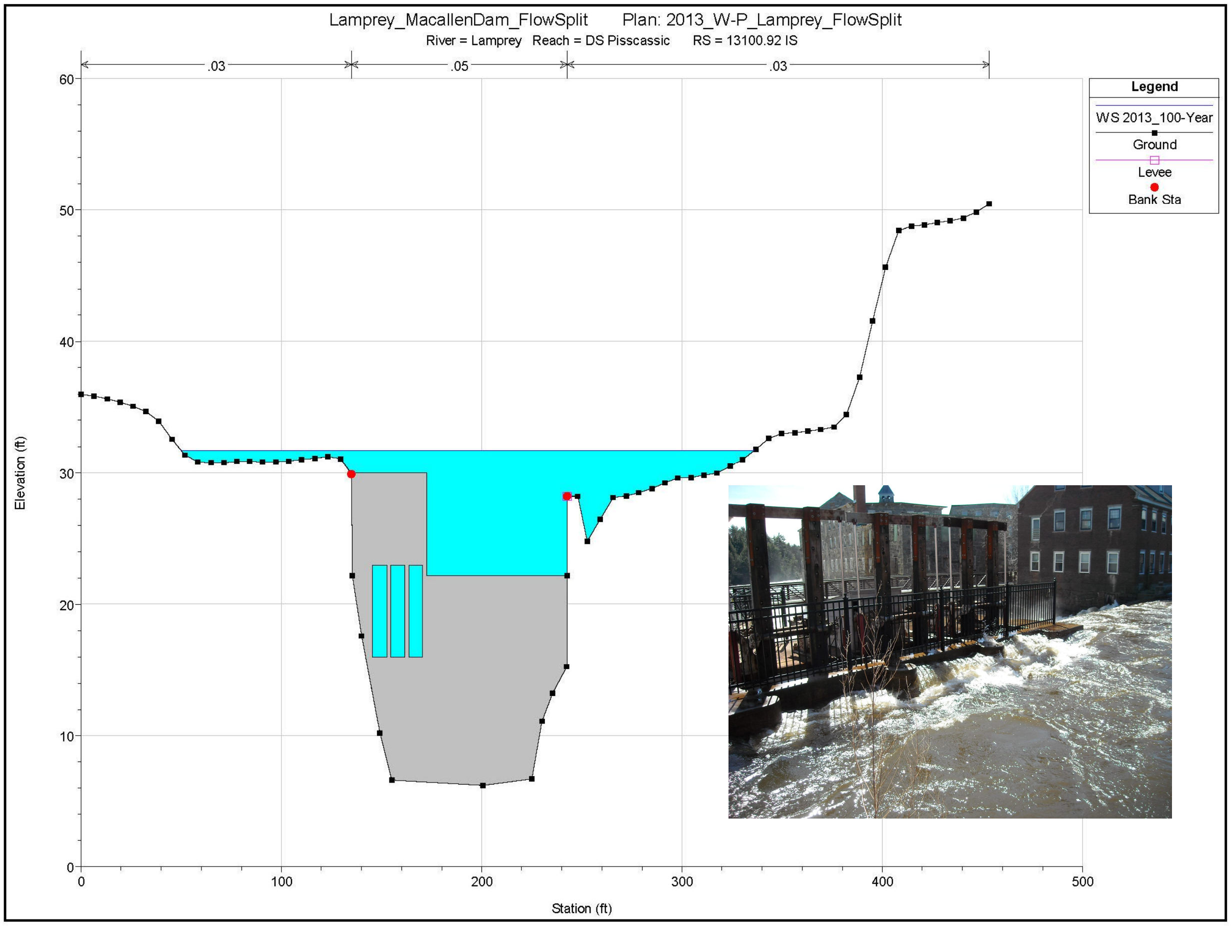
Run No.	Downstream Condition	Flow Rate	Water Surface Elevation (WSE, ft) Upstream of Dam[1]	WSE (ft) Downstream at Lowest Habitable Mill Structure[2] (STA. 12909.71)	Downstream Structure Inundation[3] (Yes/No)	Water Overtopping Bridges (Yes/No)	Breach Surge Timing [4] (min)
1	Low Tide	Sunny Day	23.48	-0.30	NO	No	6
2		100-Year	33.04	4.05	NO	No	4
3	High Tide	Sunny Day	23.48	4.50	NO	No	9
4		100-Year	33.04	5.82	NO	No	8

Notes:
1. Water surface elevations upstream of the dam depict conditions with NO GATE OPERATIONS.
2. Lowest habitable structure in the Mill Building immediately downstream of the dam is at elevation 10.28'
3. Structure inundation downstream of mill buildings was identified by visual inspection of the flood inundation maps.
4. Breach surge timing is time for breach wave to reach boat launch downstream of the dam.

Inundation mapping was developed for each of the four breach analysis model runs. These maps depict the predicted downstream flood water boundaries for each dam breach scenario. The inundation maps were created by exporting the HEC-RAS model data into GIS and are included as Figures 2 through 5 in Appendix A. A HEC-RAS plan view, model cross sections, and tabular output data for the 100-year flood flow with high tide model run are included in Appendix F.

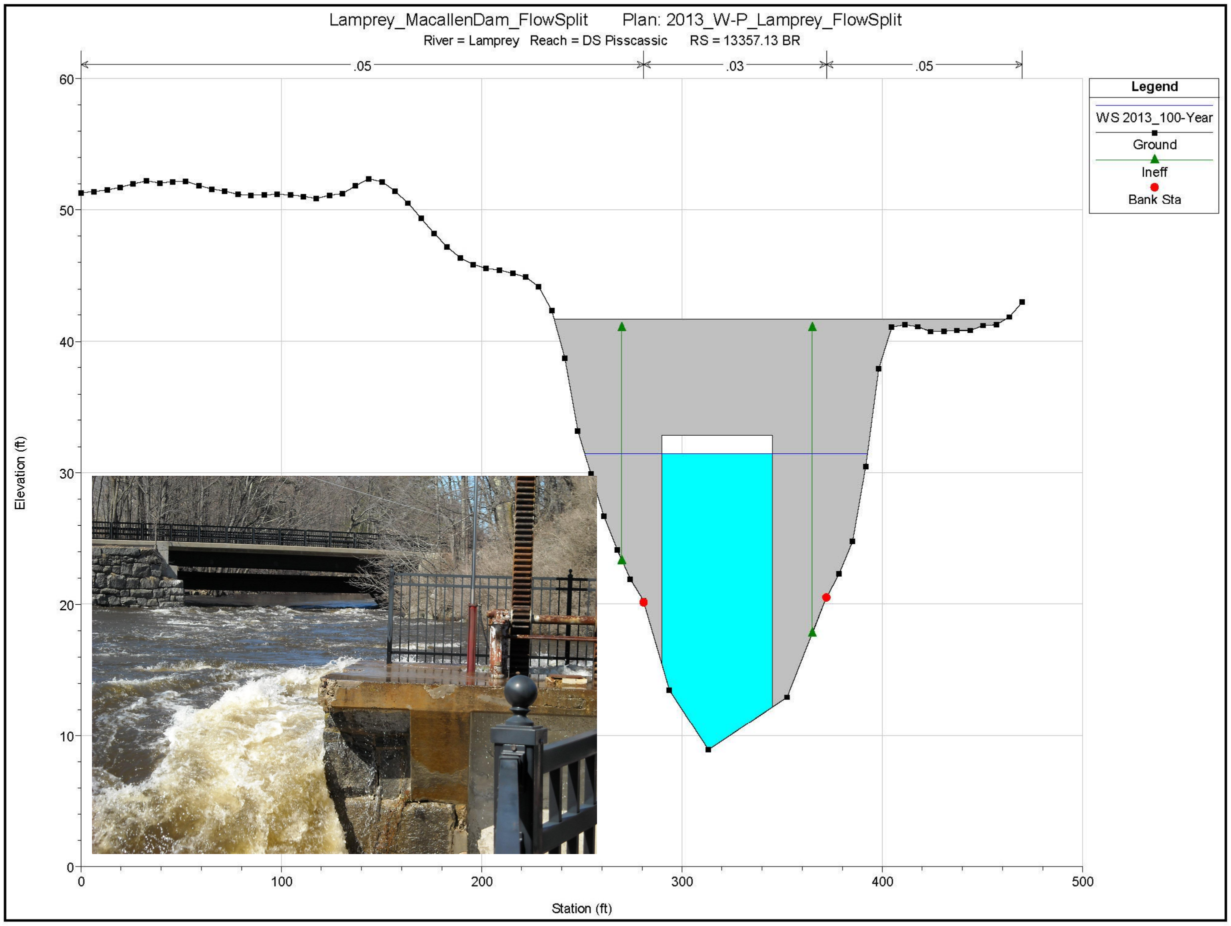
Model results at several locations for the 100-year flood flow runs were compared to photographs collected during a spring storm in 2010. For example, Figures 6 and 7 show the predicted water surface elevations upstream of the dam and at the Route 108 Bridge (without a breach) compared to photos taken upstream of the dam and at the Route 108 Bridge during flood flow conditions that were approximately 35% lower than the 100-year flood flow.

FIGURE 6
MODEL VERSUS OBSERVED WATER SURFACE UPSTREAM OF MACALLEN DAM



As shown in Figure 6, the model is predicting that the left embankment of the dam will be overtopped by approximately 1.7 feet during the 100-year flood flow. The photograph of the lesser flood flow shows that the left embankment is not overtopped. It is assumed that the flood flow experienced that day was at least 35% less than the modeled 100-year flood flow. This accounts for the difference between the model and photographed water surface elevations.

FIGURE 7
MODEL VERSUS OBSERVED WATER SURFACE AT ROUTE 108 BRIDGE



In Figure 7, the model is predicting that the water surface elevation at the Route 108 Bridge is roughly 1.3 feet below the bottom of the bridge. The photograph taken during the lesser flood flow shows the water surface elevation at the bridge to be approximately 3 feet below the bottom of the bridge. This difference in water surface elevation is similar to the difference seen at the dam downstream. Overall, it appears as though the model is accurately predicting water surface elevations throughout the model limits.

It should be noted that boat docking facilities exist downstream of the dam. During sunny day and 100-year flood flow conditions without a dam breach at high tide, the model predicts river velocities between 0.08 and 3.37 feet per second. During breach conditions at high tide, the model predicts that river velocities for sunny day and 100-year flood flow will range from 0.98 to 4.63 feet per second. This minor increase in velocity during a breach should not result in damage to the docking structures or docked boats.

Macallen Dam Breach Analyses Summaries

Classification of Dam
Currently, the Macallen Dam is classified as a High Hazard (Class C) dam. From the NHDES "Classification of Dams in New Hampshire" fact sheet:

> "**High Hazard** means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of:
>
> - Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or commercial or industrial structure, which is occupied under normal conditions.
> - Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial structure, which is occupied under normal conditions when the rise due to dam failure is greater than one foot.
> - Structural damage to an interstate highway, which could render the roadway impassable or otherwise interrupt public safety services.
> - The release of a quantity and concentration of material, which qualify as "hazardous waste" as defined by RSA 471-A:2 VI.
> - Any other circumstance that would more likely than not cause one or more deaths.

Per the NHDES September 8, 2010 letter reviewing the Draft Dam Breach Analysis, the dam will remain classified as a High Hazard dam because "Site visits by the Dam Bureau on November 5, 2009 and during a recent flooding event on March 16, 2010 found the historic mill building located to the right end of the spillway habited. This historic mill building's stone foundation and the right abutment of the dam are integral to one another. This building's location being part of the dam falls under *Env-Wr 101.09(a) Water levels and velocities causing structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions.* Due to this structure, the Macallen Dam will have to remain a high hazard"

Emergency Action Plan Update
The 100-year flood flow with high tide conditions model run results in the highest water surface elevations both upstream and downstream of the dam during a breach. Therefore, it is recommended to use the inundation mapping presented in Figure 5 to update the Emergency Action Plan.

Spillway Capacity and Required Improvements
As shown in Figure 6, the model is predicting that the dam will be overtopped by approximately 1.7 feet during 100-year flood flow conditions with the gates open.

The NHDES requires that High Hazard dams be able to pass 250% of the 100-year flood flow, or at the owner's option, the site specific inflow design flood (IDF) with at least one foot of freeboard without gate operations. As noted in the NHDES September 8, 2010 letter reviewing the Draft Dam Breach Analysis:

> "If no impacts to the apartments or historic mill buildings are confirmed. NHDES recognizes that your dam is only a high hazard classification due to the historic mill building located on the right abutment. This situation would drop your design storm: per Inflow Design Storm (IDF) to a minimum storm event of 100 years"

As indicated in Table 1, the results of the breach analysis confirmed that none of the apartments or historic mill buildings will be impacted by a breach of the Macallen Dam under both Sunny Day and 100-Year Flood flow conditions. As a result, the IDF would be reduced to the minimum storm event of 100-years. <u>Therefore, the dam spillway is required to pass 10,259 cfs with one foot of freeboard without gate operations.</u>

In March of 2010, a structural analysis of the dam structure was completed along with recommendations for improvements. Preliminary cost estimates for the structural repairs were provided in April of 2010. It should be noted that the recommended improvements only address repairs to the current configuration of the dam. They do not include costs to increase the discharge capacity of the dam to pass the design flow. The costs were broken into two phases as follows:

<u>Phase 1</u>
Near term recommendations including:

a. Gate structure improvements
b. Eastern upstream retaining wall repairs

April 2010 Cost Estimate = $215,000 (ENR Index of 8,676)
Cost Estimate updated to February 2013 = **$234,000** (ENR Index of 9,437)

<u>Phase 2</u>
Repairs the may be impacted by spillway capacity improvements including:

a. Dam structure improvements
b. Western upstream retaining wall repairs

April 2010 Cost Estimate = $290,000 (ENR Index of 8,676)
Cost Estimate updated to February 2013 = **$315,500** (ENR Index of 9,437)

Total April 2010 Cost Estimate = $505,000
Total Cost Estimate updated to February 2013 = $549,500

Based on the results of the hydraulic modeling, the statistics in Table 2 were generated to show a select number of dam improvement alternatives that would result in a spillway capable of discharging the 100-year flood flow (10,259 cfs) with one foot of freeboard without gate operations. Calculation sheets used for determining crest lengths and crest elevations are provided for reference in Appendix G.

TABLE 2
DAM SPILLWAY IMPROVEMENT ALTERNATIVES

Alternative	Description	Crest Elevation (feet)	Crest Length (feet)	Freeboard (feet)[1]	Alternative Feasible[2]	Cost[10]
Do Nothing	Existing	22.18	70	-5.84	No	$0
1	Increase spillway crest length	22.18	350	1	No[3]	N/A
2	Lower crest elevation	12.59	70	1	Potential[4]	$1.1M
3	Increase crest length and lower crest elevation	17.30	140	1	Potential[5]	$2.9M
4	Raise west abutment 1.8 feet and increase spillway crest length	22.18	265	1	No[6]	N/A
5	Raise west abutment 1.8 feet and lower crest elevation	14.39	70	1	Potential[7]	$1.3M
6	Raise west abutment 1.8 feet, lower crest elevation, and increase crest length	19.10	140	1	Potential[8]	$3.0M
7	Raise west abutment 1.8 feet, lower crest elevation, increase crest length and add 3' tall crest gate	22.18	140	1	Potential[9]	$4.6M

1. Freeboard is measured against the elevation of the western dam abutment (28.18 feet), the top of which is 6 feet higher than the dam crest elevation (22.18 feet).
2. The feasibility of the option is based on compliance with NHDES Dam Rules and site constraints.
3. This option is not feasible because of site constraints. The existing mill buildings and/or apartments would need to be removed in order to make room for the longer weir crest.
4. This option may not be feasible because of site constraints. The existing dam structure is 16 feet tall on the upstream side. Lowering the crest elevation by 9.6 feet would result in an impoundment that is 6.4 feet deep. This would be considered a partial dam removal alternative.
5. This option may not be feasible because of site constraints. If the site could accommodate a dam crest that is twice as long as the existing crest, the crest elevation would need to be lowered by 4.88 feet, resulting in an impoundment that is 11 feet deep.
6. This option is not feasible because of site constraints. The existing mill buildings and/or apartments would need to be removed in order to make room for the longer weir crest.
7. This option may not be feasible because of site constraints. The existing dam structure is 16 feet tall on the upstream side. Lowering the crest elevation by 8.8 feet would result in an impoundment that is 8.2 feet deep.
8. This option may not be feasible because of site constraints. If the site could accommodate a dam crest that is twice as long as the existing crest, the crest elevation would need to be lowered by 3.1 feet, resulting in an impoundment that is 13 feet deep.
9. This option may not be feasible because of site constraints. The site may not be able to accommodate a dam crest that is twice as long as the existing crest. In addition, recent discussions with NHDES staff have revealed that the use of crest gates may not be an acceptable method for increasing spillway capacity due to the "no operations" clause in the Dam Rules.
10. The costing presented here is conceptual in nature and is based on data collected from across the nation. Alternatives do not include costs to address the required fish ladder improvements. Costs include $234,000 required for structural repairs recommended in April 2010. Backup for the costing can be found in Appendix G.

As shown in Table 2, modifying the existing dam spillway to accommodate the 100-year flood flow without gate operations will be a difficult task. The alternative that shows the most promise involves raising the west abutment, lowering the crest elevation, and doubling the spillway length. It is questionable as to if the site will support a spillway crest that is twice as long (140 feet). In addition, lowering of the dam crest may not be a desirable solution as it will reduce the impoundment depth and length upstream of the dam. The costs associated with each alternative are provided in Table 2.

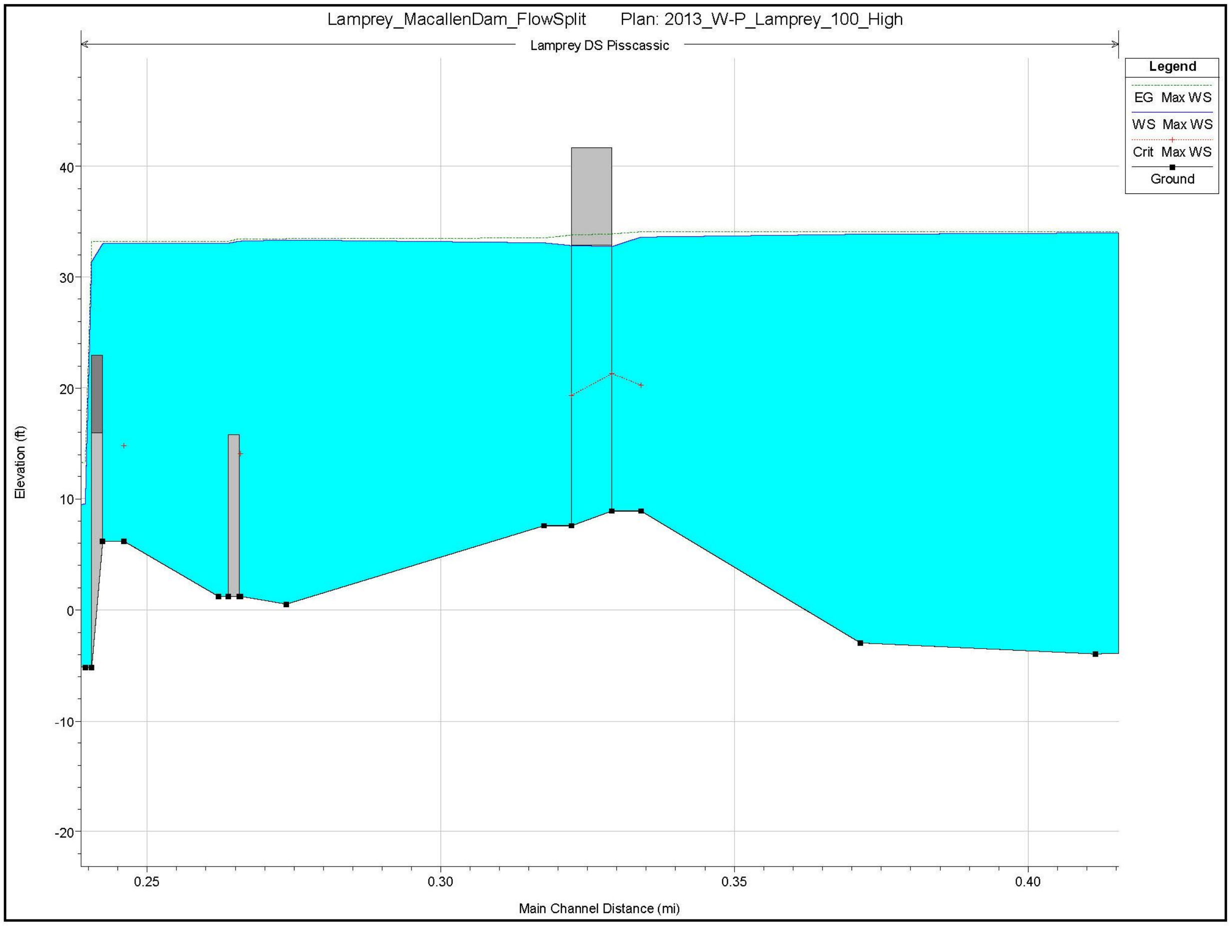
These cost estimates are planning level estimates and are based on conceptual ideas for dam improvements. Additional engineering design and permitting will be required to develop a design acceptable to NHDES and to generate a more exact cost estimate. An allowance of 30% has been added for engineering design and permitting fees.

It should be noted that several dams in the state use crest gates that lower during high flows to increase spillway capacity. Recent discussions with NHDES staff have revealed that the use of crest gates may not be an acceptable method for increasing spillway capacity due to the “no operations” clause in the Dam Rules. With the exception of Alternative 7, the costs above are based on the more traditional methods increasing spillway capacity by increasing the crest length, lowering the crest elevation, and increasing the abutment elevations.

Impact of Route 108 Bridge

Figure 8 shows the modeled 100-year flood flow water surface elevation profile from the Macallen Dam (left) to the Route 108 Bridge (center), based on the model results, the bridge acts as a minor constriction point during the 100-year flood flow. The profile shows between a 0.75 and 1 foot drop in water surface elevation through the bridge structure. If the bridge were not a constriction, zero feet of drop in water surface elevation would occur through the bridge. It should be noted that overtopping of the bridge is not a likely scenario during a 100-year flood flow.

FIGURE 8
IMPACT OF ROUTE 108 BRIDGE



Recommendations

Based on the findings of the breach analyses, Wright-Pierce recommends the following actions:

- The information contained in this letter has been presented to the NHDES. The Town may need to respond to NHDES comments; however, comments are anticipated to be minimal based on the amount of NHDES coordination that has occurred to this point.
- Consider the alternatives presented above relative to site constraints. Some of the conceptual alternatives may be dismissed due to site considerations.
- Use this document as a comparison point to the dam removal options that will be developed.

We appreciate this opportunity to assist the Town of Newmarket with these analyses. We look forward to meeting with you at your convenience to review this draft report and to discuss our recommendations with you. Please feel free to contact us at 430-3728 with any questions or comments you may have.

Very truly yours,
WRIGHT-PIERCE

Ryan T. Wingard, P.E.
Senior Project Manager

Richard N. Davee, P.E.
Vice President

Attachments

cc: Diane Hardy, Newmarket Planner (w/attachments)
Chuck Corliss, NHDES Dam Bureau (w/attachments)

STATE OF NEW HAMPSHIRE
RYAN TODD WINGARD
No. 12361
LICENSED
PROFESSIONAL ENGINEER

Appendix

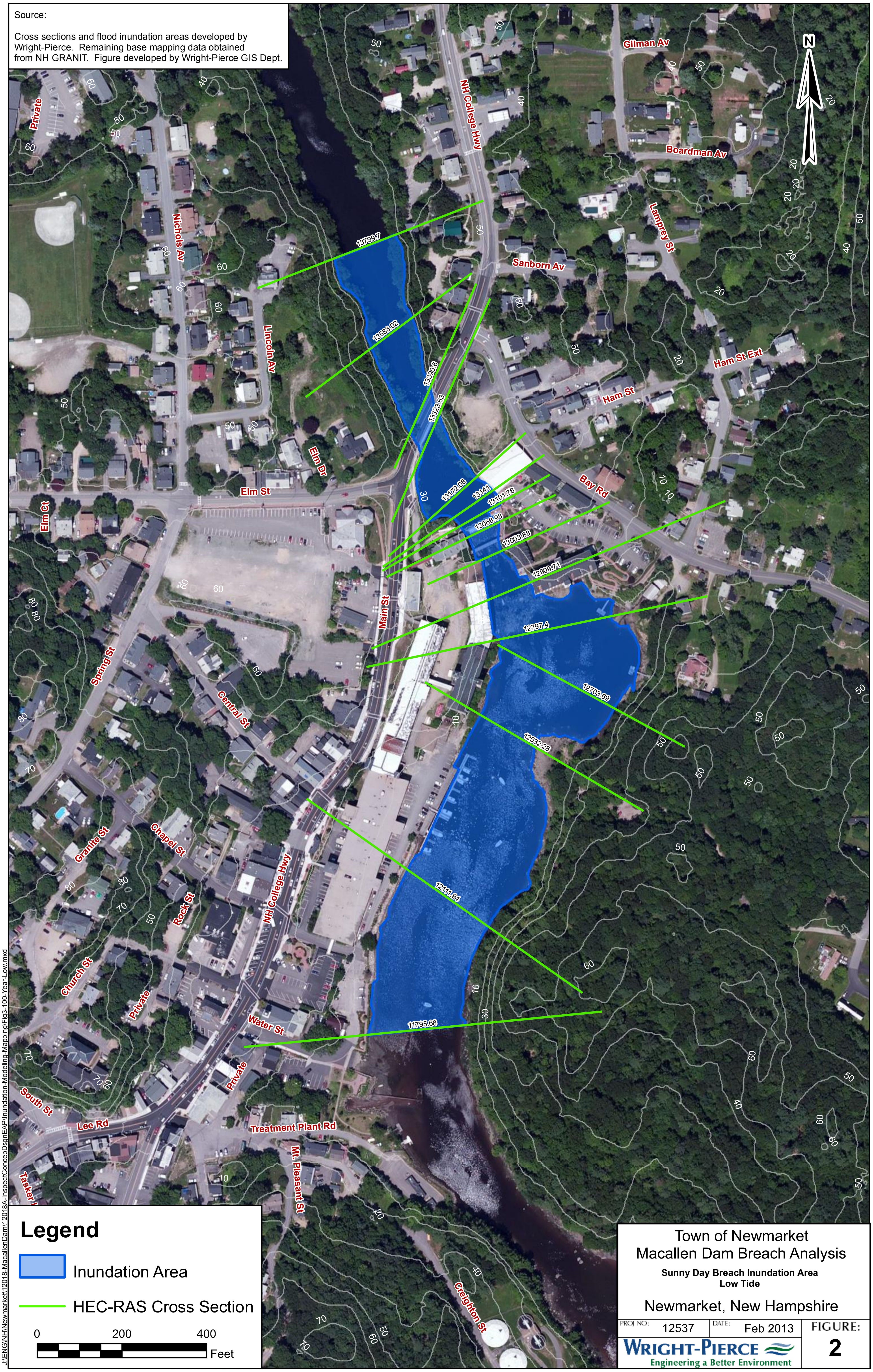
WRIGHT-PIERCE
Engineering a Better Environment

APPENDIX A
Figures

Source:
UNH
NH GRANIT
N
Woodman Brook
La Roche Brook
Lamprey River
Ellison Brook
Folletts Brook
Piscassic River
Lamprey River
Macallen Dam
Legend
Model Cross-Sections (Source: W-P)
Model Cross-Sections (Source: UNH)
River
0 1,000 2,000
Feet
Town of Newmarket, NH
Macallen Dam Breach Analysis
Project Location Map
PROJ NO: 12537
DATE: Feb 2013
FIGURE:
1
WRIGHT-PIERCE
Engineering a Better Environment

Source:

Cross sections and flood inundation areas developed by Wright-Pierce. Remaining base mapping data obtained from NH GRANIT. Figure developed by Wright-Pierce GIS Dept.



Legend

Inundation Area

HEC-RAS Cross Section

0 200 400 Feet

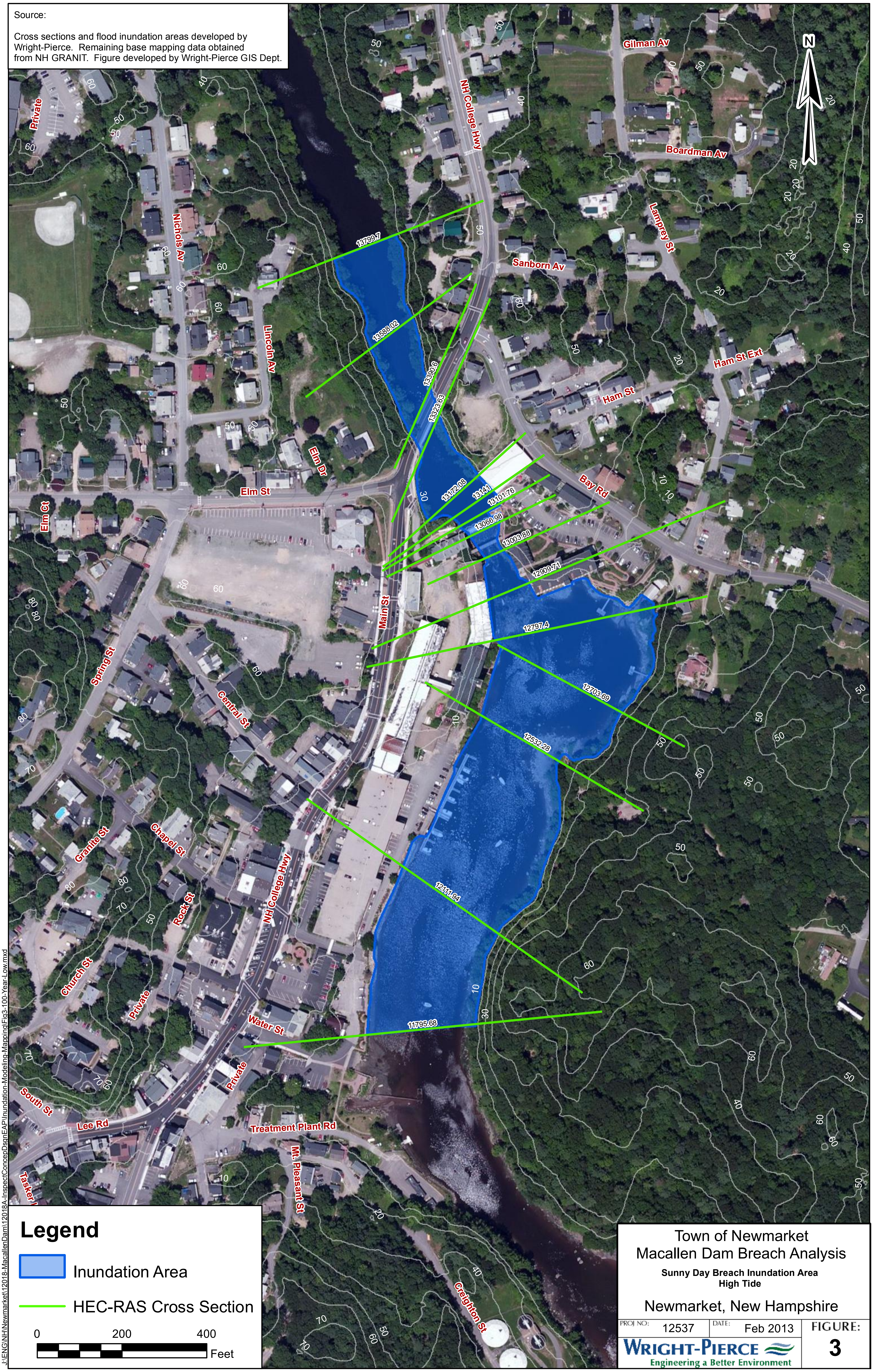
Town of Newmarket
Macallen Dam Breach Analysis

Sunny Day Breach Inundation Area
Low Tide

Newmarket, New Hampshire

PROJ NO: 12537	DATE: Feb 2013	FIGURE: 2

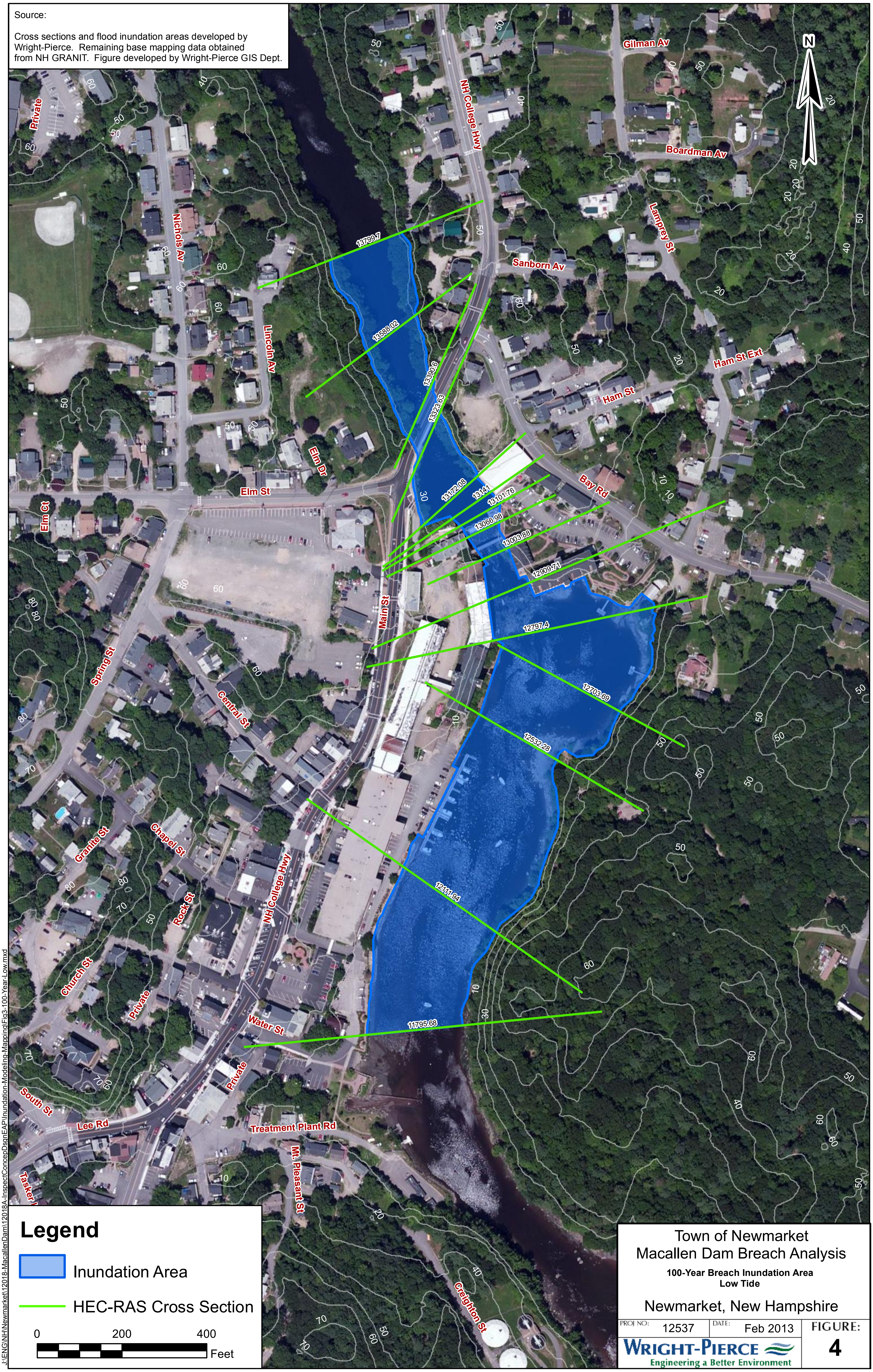
WRIGHT-PIERCE
Engineering a Better Environment



J:\ENG\NH\Newmarket\12018-MacallenDam\12018A-InspectConcepDsgnEAP\Inundation-Modeling-Mapping\Fig3-100-Year-Low.mxd

Source:

Cross sections and flood inundation areas developed by Wright-Pierce. Remaining base mapping data obtained from NH GRANIT. Figure developed by Wright-Pierce GIS Dept.



Legend

Inundation Area

HEC-RAS Cross Section

0 200 400 Feet

Town of Newmarket
Macallen Dam Breach Analysis

100-Year Breach Inundation Area
Low Tide

Newmarket, New Hampshire

PROJ NO:	DATE:	FIGURE:
12537	Feb 2013	4

WRIGHT-PIERCE
Engineering a Better Environment

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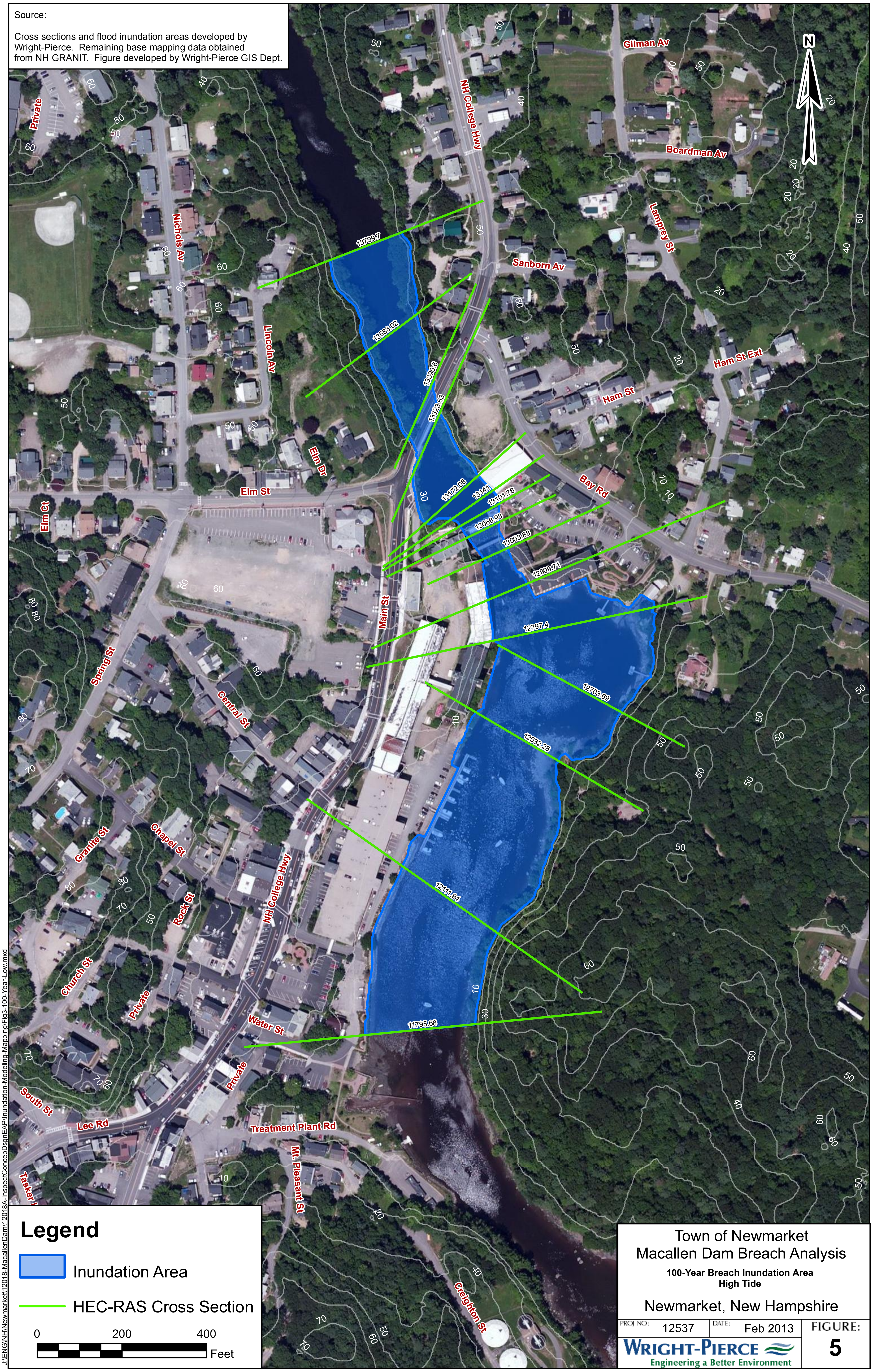
Source:

Cross sections and flood inundation areas developed by Wright-Pierce. Remaining base mapping data obtained from NH GRANIT. Figure developed by Wright-Pierce GIS Dept.



Legend

Inundation Area

HEC-RAS Cross Section

0 200 400 Feet

Town of Newmarket
Macallen Dam Breach Analysis

100-Year Breach Inundation Area
High Tide

Newmarket, New Hampshire

PROJ NO:	DATE:	FIGURE:
12537	Feb 2013	5

WRIGHT-PIERCE
Engineering a Better Environment

J:\ENGINH\Newmarket\12018-MacallenDam\12018A-InspectConcepDsgnEAP\Inundation-Modeling-Mapping\Fig3-100-Year-Low.mxd

APPENDIX B
September 8, 2010 NHDES Letter

The State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES

NHDES

Thomas S. Burack, Commissioner

September 8, 2010

Mr. Edward J. Wojnowski
Town Administrator
Town of Newmarket
186 Main Street
Newmarket NH 03857

RE: Dam Breach Analysis
NH Dam #177.01, Macallen Dam, Newmarket N.H.

Dear Mr. Wojnowski:

The Department of Environmental Services (DES) has reviewed your Dam Breach Analysis as submitted by Ryan Wingard P.E. from Wright-Pierce dated May 24, 2010 and your letter requesting reclassification dated June 7, 2010. DES has the following comments addressing both submittals.

To address the potential reclassification request from the Town of Newmarket to lower the dam from a high to a significant hazard, DES began with a review of its records. The Dam Bureau inspection report dated April 7, 2008 notes the dam classification was raised from significant to high based on flooding anticipated during a dam breach impacting downstream apartments. Past inspectors have also observed the historic building on the right end of the spillway as uninhabitable and did not provide additional justification towards the high hazard classification. Classification was solely based on the flooding above the first floor of the apartments as mentioned above. Site visits by the Dam Bureau on November 5, 2009 and during a recent flooding event on March 16, 2010 found the historic mill building located to the right end of the spillway habited. This historic mill building's stone foundation and the right abutment of the dam are integral to one another. This building's location being part of the dam falls under *Env-Wr 101.09(a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions.* Due to this structure, the Macallen Dam will have to remain a high hazard.

The submitted breach analysis by Wright-Pierce noted no impacts to downstream apartments. This may be the case, but the Dam Bureau has identified some analysis parameters that need to be reviewed and perhaps amended in order to confirm the results of their analysis. Please review and comment on the following items/parameters and update your analysis as necessary to reflect these changes:

1. The 100 year storm inflow estimate used in the analysis was 8,302 cfs. It appears this information is taken from DES's February 1999 inspection report. Using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, the 100-year storm event of 8,302 cfs was estimated using the area-ratio technique and based upon the data available at the time. Current information from USGS (Scientific Investigations Report 2008-5206) at the same stream gauge shows a 2008 value of 9,270 cfs for the 100 year storm and when applying the area-ratio technique the resulting 100 year inflow to the dam is approximated as 10,688 cfs. This conversion is rough, but shows the difference for 15% more drainage area. Please update the 100 year inflow estimates in the analysis.

2. Note; submitted analysis shows a slight over topping during the 100 year storm with gates closed. The storm event of March 16, 2010 (6,710 cfs), classified as a 25-50 year storm event by USGS, had gates completely open and less than 10" of freeboard at the left side concrete abutment.

3. The submittal uses a restriction at the upstream bridge at NH Rte 108 during the 100 year storm event. The upstream bridge per field review on May 16, 2006 by Dam Safety Inspector Grace Levergood noted no restriction by the upstream river bridge. The same determination of no restriction was made also by myself during the high rain event of March 16, 2010, storm classified as a 25-50 year storm event. (6,710 cfs). Review and confirm HEC-RAS results.

4. Submitted figure 6, page 6 of 10, shows a breach width estimate of less than 50% of the crest length, (appears to be 20%). Please use 50% of the crest length as the breach width parameter. Also on figure 6, define the area right of the spillway's right abutment (right of the fish ladder). Per figure 6 flow is shown in this area, unclear why this cross section does not show the mill building.

5. The updated breach analysis will need to also reevaluate habitable living areas in the renovated historic mill building 200 ft downstream on the left and also consider the historic mill building on the right side that could be renovated in the future and effect the dam's design storm flows.

6. Confirm elevations on HEC-RAS cross section 8914.872. Both mill buildings appear to have the same base elevation, and possibly similar "habitable" elevations. See photos A and B.

7. Confirm the downstream limit of dam breach impacts are in line with Env-Wr 502.06(g) 1 & 2. Cross section #16.

8. Note; the final dam breach analysis submittal to DES will need to be stamped by a professional engineer. See Env-Wr 502.06(a) for further details.

<u>After the update of your breach analysis per above DES comments;</u>

1. Confirm whether or not any incremental impacts consistent with Env-Wr 101.09 take place to the downstream apartments and historic mill buildings during a dam breach.

   - If no impacts to the apartments or historic mill buildings are confirmed. DES recognizes that your dam is only a high hazard classification due to the historic mill building located on the right abutment. This situation would drop your design storm per Inflow Design Storm (IDF) to a minimum storm event of 100 years.

   - If impacts incremental to the apartments or historic mill buildings are confirmed. DES advises that you consider performing an IDF analysis to determine if a storm event below 2.5x100 year storm can be used as the dam's "design storm".

If you have any questions or concerns, feel free to call me at 603-271-3406 or email me at: Charles.Corliss@des.nh.gov

Sincerely,

Chuck Corliss

Chuck Corliss
Dam Safety Engineer, Dam Bureau

cc: Ryan Wingard, P.E. Wright-Pierce 230 Commerce Way Suite 302 Portsmouth NH 03801
Attached: Env-Wr 101.09(a), Env-Wr 502.06(g) 1 & 2, Env-Wr 502.06(a), Photo A, Photo B,

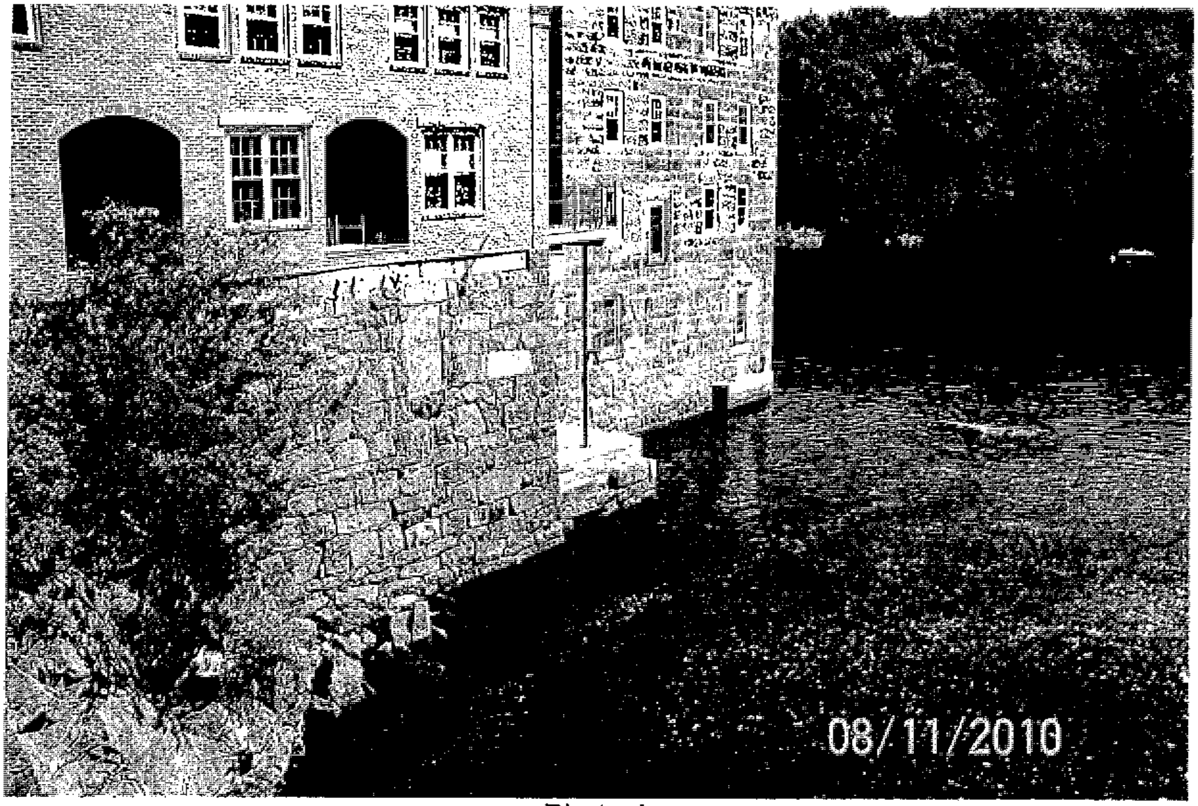


Photo A

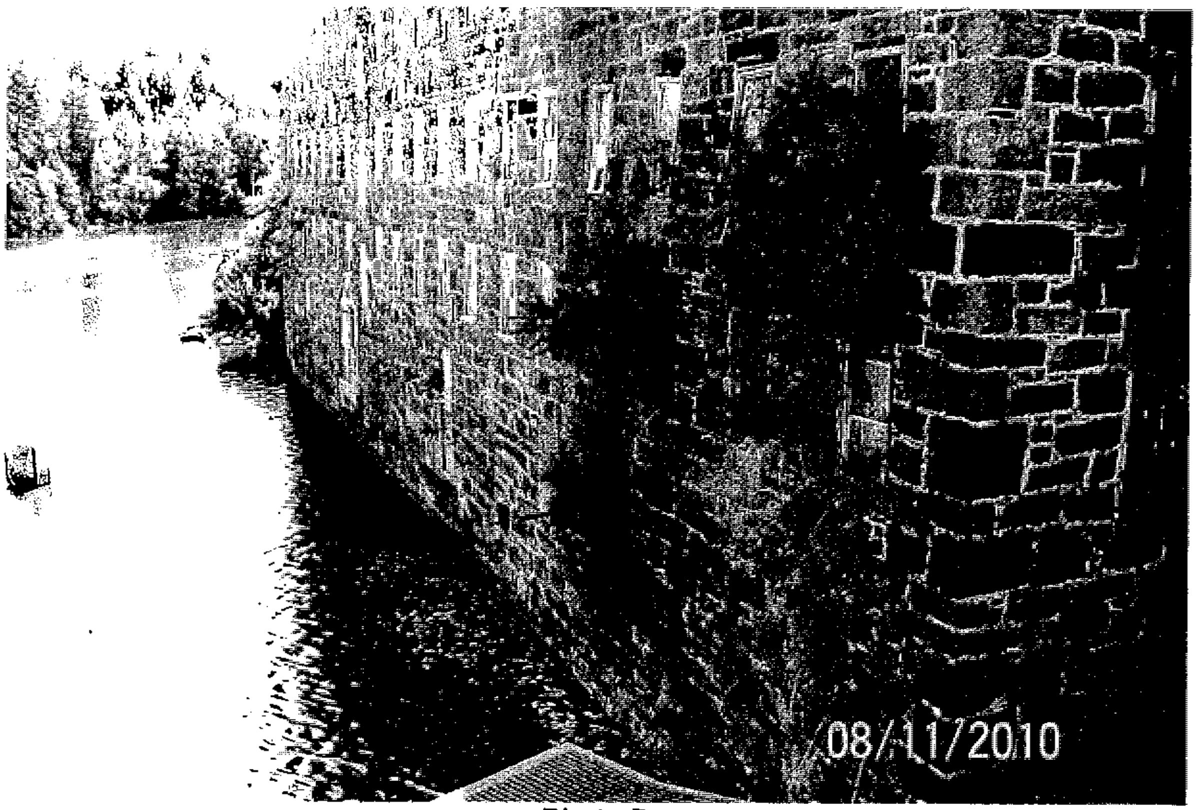


Photo B

APPENDIX C
July 21, 2012 Letter to NHDES
September 10, 2012 NHDES Response Letter

July 31, 2012
W-P Project No. 12537A

Mr. Chuck Corliss, Dam Safety Engineer
NHDES, Dam Bureau
PO Box 95
Concord, NH 03302-0095

Re: 100-Year Flow Analysis
NH Dam #177.01, Macallen Dam, Newmarket, NH

Dear Mr. Corliss:

The purpose of this letter is to present the results of our recent hydrologic analysis for the above referenced project. The hydrologic analysis was completed, partially, in response to comment number 1 in your letter dated September 8, 2010, which states:

1. The 100 year storm inflow estimate used in the analysis was 8,302 cfs. It appears this information is taken from DES's February 1999 inspection report. Using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, the 100-year storm event of 8,302 cfs was estimated using the area-ratio technique and based upon the data available at the time. Current information from USGS (Scientific Investigations Report 2008-5206) at the same stream gauge shows a 2008 value of 9,270 cfs for the 100 year storm and when applying the area-ratio technique the resulting 100 year inflow to the dam is approximated as 10,688 cfs. This conversion is rough, but shows the difference for 15% more drainage area. Please update the 100 year inflow estimates in the analysis.

Based on this directive, a revised dam breach analysis for the subject dam was required using an updated 100-year flood flow rate. As noted, a 100-year flood flow rate of 8,302 cfs was used to conduct the initial Dam Breach Analysis dated May 24, 2010. This flood flow rate was taken from the NHDES February 1999 dam inspection report. This report estimated the 100-year flood flow using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, and applying the area-ratio technique. It should be noted that the period of record for the gauge at the time of the 1999 report was roughly 65 years (1934 to 1999). An updated USGS report (Scientific Investigations Report 2008-5206), at the same stream gauge shows a value of 9,270 cfs for the 100-year storm. This prompted a request to update the 100-year flood flow in the dam breach analysis.

In subsequent correspondence between DES and Wright-Pierce, it was brought to our attention that the 100-year flood flow rate should not be determined using the USGS Regression method set forth in the updated USGS report, (previously used by the DES), but should be determined in accordance with part

Env-Wr 403.05 of the New Code of Administrative Rules, which suggests a hydrologic investigation such as the SCS TR-20 method. It was also suggested that the DES looks for use of the Lag/CN method within HydroCAD (an SCS TR-20 based analysis) to determine the 100-year flow rate.

As a result, a SCS TR-20 HydroCAD analysis was conducted, using the Lag/CN method to determine time of concentration. The analysis was conducted using two separate model setups as follows:

Setup 1: single large subcatchment area (~212 square miles)
Setup 2: delineation of 17 separate subcatchments, including known ponds and reaches within the Lamprey River drainage basin

Both assumptions resulted in calculated 100-year flood flows in excess of 18,000 cfs, or more than twice the original estimate, and well outside the anticipated 100-year flood flow rate presented by NHDES in the September 2010 review letter.

These results have prompted a review of the applicability of the SCS TR-20 method for the purpose of this analysis. A brief reference check revealed that at least two reliable sources indicate the TR-20 method should not generally be used for watersheds greater than 20 square miles. The watershed of the Lamprey River in the area of the Macallen Dam is in excess of 200 square miles. The two references are:

1. Massachusetts DEP (http://www.mass.gov/dep/water/laws/hydrol.pdf)
2. Maine DEP (http://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/appendixb.pdf)

Based on the unreasonably high results of the SCS TR-20 HydroCAD analysis, and the limitations described in the listed references, it is requested that an alternative method to TR-20 be used to determine the appropriate 100-year flood flow rate.

The method proposed for use in determining an updated 100-year flood flow rate at the Macallen Dam is the method listed in the USGS Scientific Investigations Report 2008-5206, identified earlier. Specifically, the procedure listed in the section of the Report titled "Use of Regression Equations at or Near Streamgages". This procedure uses known data from the upstream gauging station on the Lamprey River to determine the 100-year flood flow rate downstream. It should be noted that this gauging station now has over 78 years of flow data. This procedure also applies an area weighted ratio to the flood flow rate to account for the increase or decrease in tributary area from the gauge location to the point of analysis. This procedure is applicable for area changes within 66.7 to 150 percent of the gauged tributary area. The tributary area for the Macallen Dam is approximately 115% of the gauge's tributary area, well within the documented limits.

It should be noted that the data captured by the Lamprey River gauge includes flow rates for some very significant storm events over the period of record. The following flows were recorded for storm events that are considered by many to be in excess of the 100-year flood flow rate:

Date	Total Event Rainfall	Return Period	Measured Flow
April 16, 2007 (Patriot's Day)	4.00 in (24-hours)	10 to 25 year-24 hour	7,590 cfs
May 16, 2006 (Mother's Day Storm)	8.46 in (72-hours)	25 to 50 year-24 hour	8,400 cfs
October 22, 1996	12.2 in (48-hours)*	100 year-24 hour	6,310 cfs

*Note rainfall recorded at Portsmouth for coastal storm actual rainfall may have been less throughout Lamprey River basin.

Using the procedures listed in the USGS Report, the calculations yield a 100-year flood flow rate of approximately 10,350 cfs for the Lamprey River at the Macallen Dam, approximately 25% above the estimate used in the original Breach Analysis and 74% below the flood flow rate calculated using the TR-20 method. This is believed to be a much more reasonable estimate of the 100-year flood flow rate.

In addition, Env-Wr 403.05 was referenced when requesting that the TR-20 method be used. It is our understanding that Section 400 of the Administrative Rules applies to the design of new dams or the reconstruction of a dam. Section 500, which governs the breach analysis procedures, does not reference the TR-20 method, so it is unclear why this method is required.

Based on the findings above, we request the use of the USGS Regression Methods described in the USGS Scientific Investigations Report 2008-5206 to determine the 100-year flood flow rate for use in the Dam Breach Analysis for the Macallen Dam.

We appreciate your time and consideration of this matter, as well as any comments you may have to help. Please do not hesitate to call if you have any questions regarding this letter. We can provide you with additional information if needed to assist you in review of this analysis.

Respectively Submitted,

Ryan T. Wingard, P.E..
Senior Project Manager

Steve L. Guerrette
Project Engineer

The State of New Hampshire
Department of Environmental Services
Thomas S. Burack, Commissioner

Celebrating 25 Years of Protecting New Hampshire's Environment

September 10, 2012

Mr. Ryan T. Wingard, P.E.
Senior Project Manager
Wright-Pierce
75 Washington Ave, Suite 202
Portland, ME 04101

RE: Methodologies for Estimating the 100-Year Flood
Macallen Dam - NH Dam No. 177.01

Mr. Wingard:

The New Hampshire Department of Environmental Services Dam Bureau (DES) is writing in response to your July 31, 2012 letter requesting the use of USGS flood discharge estimates published in their 2008-5206 report in lieu of using a watershed model which estimates a 100-year flood resulting from the 100-year 24-hour rainfall. Provided below, and staying consistent with Administrative Rule Env-Wr 403.05, is the position of the DES regarding the appropriate use of USGS stream gage data for the hydraulic design and analysis of dam projects.

For the hydraulic design of dams, DES requires that the design be based on a watershed model using the 24-hour rainfall event for the appropriate recurrence interval based on the hazard classification of the dam. There are several differences between estimating a flood flow using statistical analysis of stream gage data and a watershed-based model using the 24 hour rainfall event. In general, stream gage analysis estimates a flood flow based on statistical analysis of previously recorded flows regardless of what produced the flow (rainfall, snowmelt, rain/snow event). A watershed based model estimates a flood flow based on rainfall depth, duration and distribution curves, as well as the current runoff potential within the watershed. As summarized from the April 2004 FEMA Guidelines for Dam Safety document, *when engineers first started designing dams they used stream flow records to size dams. Over time they realized new floods exceeded previously recorded maximum floods. Then, with the introduction of the unit hydrograph theory it became possible to estimate flood flows from storm rainfall. The design of dams began to be based on transposition of major storms that has occurred within a region and transposed them to the dam site being evaluated. It was recognized that observed maximum rainfall values could provide a better indication of maximum flood potentials than data on flood discharges from individual watersheds.* Ultimately the industry standard for dams has become estimating flood flows with point rainfall depths and distribution curves such as the NRCC-93 rainfall and SCS Type I, II, & III rainfall distributions for smaller events, and PMP/PMF analysis for the worst case event.

In your letter you question the applicability of the SCS TR-20 methodology for use in watersheds larger than 20 square miles, and you cite information provided on the web pages of the States of Maine and Massachusetts. Both of those states may have incorrectly interpreted TR-20, applying to watersheds the size criteria that used to be specified in TR-20 for subwatersheds. The original TR-20 manual section 2.1, indicates maximum subwatershed should not have an area greater than 25 square miles. This chapter has been replaced with National Engineering Handbook (NEH) 630 chapter 6 with section 630.0603 'Hydrologic Units' discussing large watersheds. Chapter 6 is silent on subwatershed size. Based on DES's review of this information, it would appear that there may have been a limit on the subwatershed size; however, there was never a limit on total watershed size. Although DES typically receives SCS TR-20 models with the Lag/CN methodology, it is up to the project hydrologist to select an appropriate methodology (Clark, Snyder, SCS) for the watershed, and the methodology and model parameters should be vetted through an in-house QA/QC process for applicability and accuracy.

Further, your hydrologist should also be aware of the 'Area-Depth Curves' contained in TP-40 and other engineering references. Those curves allow for reduction of point rainfall for watersheds up to 400 square miles in size. For a 200-square-mile drainage area, when analyzing a 24-hour event, the curves indicate point rainfall amounts can be reduced to approximately 92 percent. It appears that your previous analysis did not use these curves. Again, your hydrologist should look at this methodology and determine if it is appropriate for use with the updated rainfall amounts in the NRCC-93 manual.

Although DES requires that the hydraulic design of dams be based on a watershed model, stream flow data can be very valuable to calibrate a watershed based model. When both stream flow and rainfall data are available for a flood event, the data can be used to calibrate watershed model parameters. However, care must be taken to choose appropriate calibration and confirmation events. Should you decide to calibrate your model, please discuss your approach with DES prior to conducting the calibration. Several years ago, an engineering consultant attempted to calibrate a watershed model in the seacoast area using the SCS methodology and the model failed to reproduce the recorded hydrographs. Ultimately the consultant opted to use the Snyder methodology, and the model more closely matched the recorded hydrographs. Again, although DES is more familiar with the SCS methodology, it is the responsibility of the hydrologist to choose the most appropriate method to analyze the watershed.

If you have any questions, please feel free to contact me directly at tel: (603) 271-1966 or at Steve.Doyon@des.nh.gov. You may also contact Mr. Chuck Corliss at 271-4130 or at Charles.Corliss@des.nh.gov

Sincerely,

Steve N. Doyon., PE
Administrator
Dam Safety & Inspection Section

cc: Chuck Corliss, DES Dam Safety Engineer
Town of Newmarket

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APPENDIX D
100-Year Flood Flow Analysis

WRIGHT-PIERCE
Engineering a Better Environment

Water
Wastewater
Infrastructure

February 5, 2013
W-P Project No. 12537A

Mr. Chuck Corliss, Dam Safety Engineer
NHDES, Dam Bureau
PO Box 95
Concord, NH 03302-0095

Re: Revised 100-Year Flow Determination
NH Dam #177.01, Macallen Dam, Newmarket, NH

Dear Mr. Corliss:

The purpose of this letter is to present the results of our recent hydrologic analysis for the above referenced project. This letter has been updated to include the changes suggested in your Preliminary HydroCAD Model Review sent via email on October 22, 2012 and attached to this document. The hydrologic analysis was completed, partially, in response to comment number 1 in your letter dated September 8, 2010, which states:

1. The 100 year storm inflow estimate used in the analysis was 8,302 cfs. It appears this information is taken from DES's February 1999 inspection report. Using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, the 100-year storm event of 8,302 cfs was estimated using the area-ratio technique and based upon the data available at the time. Current information from USGS (Scientific Investigations Report 2008-5206) at the same stream gauge shows a 2008 value of 9,270 cfs for the 100 year storm and when applying the area-ratio technique the resulting 100 year inflow to the dam is approximated as 10,688 cfs. This conversion is rough, but shows the difference for 15% more drainage area. Please update the 100 year inflow estimates in the analysis.

Based on this directive, a revised dam breach analysis for the subject dam was required using an updated 100-year flood flow rate. As noted, a 100-year flood flow rate of 8,302 cfs was used to conduct the initial Dam Breach Analysis dated May 24, 2010. This flood flow rate was taken from the NHDES February 1999 dam inspection report. This report estimated the 100-year flood flow using the recorded flows at the USGS gauging station #01073500, Lamprey River in Newmarket, and applying the area-ratio technique. An updated USGS report (Scientific Investigations Report 2008-5206), at the same stream gauge shows a value of 9,270 cfs for the 100-year storm. This prompted a request to update the 100-year flood flow in the dam breach analysis.

In subsequent correspondence between DES and Wright-Pierce, it was brought to our attention that the 100-year flood flow rate should not be determined using the USGS Regression method set forth in the updated USGS report, (previously used by the DES), but should be determined in accordance with part Env-Wr 403.05 of the New Code of Administrative Rules, which suggests a hydrologic investigation such as the Lag/Curve Number method within HydroCAD (an SCS TR-20 based runoff analysis) to determine the 100-year flow rate.

A letter dated July 31, 2012 was submitted to DES requesting that the USGS Regression method, described in the USGS Scientific Investigations Report 2008-5206, be allowed for this project due to specific reservations about the initial results of the HydroCAD TR-20 analysis; however, this request was denied in a response letter from DES dated September 10, 2012.

In the September 10, 2012 letter, DES also suggested potential modifications to the HydroCAD TR-20 model that may help obtain more reasonable results. These suggestions included the use of ‘Area-Depth Curves’ described in Technical Paper No. 40. The Area-depth curves take into consideration the average depth of rainfall over large drainage areas rather than just a single rainfall depth determined for one point in the watershed. This allows for a percentage based adjustment to the total depth of rainfall for drainage areas larger than a few square miles. For a 24-hour event and a drainage area of approximately 212 square miles, that adjustment appears to be approximately 92% of the total point rainfall.

The 100-year, 24-hour total point rainfall for Newmarket, NH was initially determined, using the NRCC Publication No. RR 93-5, as 8.02 inches of rainfall. Using the Area-depth curve method, the updated rainfall for use in the HydroCAD TR-20 analysis is 7.38 inches.

The HydroCAD TR-20 analysis was rerun using the new total rainfall number, and also incorporating the NHDES preliminary review comments. The updated model run resulted in a 100-year flow rate routed into the Macallen Dam impoundment of 14,495 cfs. The results of the updated HydroCAD model run and associated watershed map have been attached to this letter as Attachment 1.

Additionally, a review of the FEMA FIS documents for the Lamprey River revealed a potential for a significant reduction in the 100-year flow rate into the Macallen Dam impoundment. The FIS indicates that at flow rates approaching the 100-year flood flow, the Lamprey River overtops a section of Route 108 in Durham, NH, approximately 1 mile upstream of the Newmarket/Durham corporate limits, and is diverted into the Oyster River basin to the north. These overflows reduce peak flood discharges of the Lamprey River before it reaches the Town of Newmarket and the Macallen Dam. The FIS states that “during a 100-year flood, diversions to the Oyster River basin reduce flood peaks in Newmarket by approximately 20 percent”

As a result of this finding, a HEC-RAS hydraulic model of this diversion was conducted to verify this finding. The model was built using a combination of the existing HEC-RAS model developed by Wright-Pierce for use in the draft Dam Breach Analysis of the Macallen Dam, a HEC-RAS model developed by the University of New Hampshire to analyze the Lamprey River Watershed, and GIS LiDAR topographic data. The flow rates determined using the previously described HydroCAD analysis were inserted into the HEC-RAS model for the flow split analysis.

The results of the flow split were obtained using an iterative flow optimization process. Preliminary flow assumptions were inserted into the model at the location of the flow split. The model then conducts an optimization routine to compute the flow rates needed to balance the model. These flows are then used to determine new assumptions at the flow split. The flows are considered optimized when the flow rate downstream of the flow split in the Lamprey River plus the flow rate leaving the Lamprey River through the flow split are equal to the flow rate in the Lamprey River just upstream of the flow split. The results of the HEC-RAS flow split analysis model run have been attached to this letter as Attachment 2 and are summarized for your review as follows:

- Flow rate of the Lamprey River just upstream of the flow split – 12,670 cfs
- Flow rate leaving the Lamprey River through the flow split – 4,261 cfs
- Flow rate of the Lamprey River just downstream of the flow split – 8,409 cfs
- Flow rate from the Piscassic River entering the Lamprey River downstream of the flow split – 1,850 cfs.
- Resulting peak 100-year flood flow rate at the Macallen Dam – 10,259 cfs.

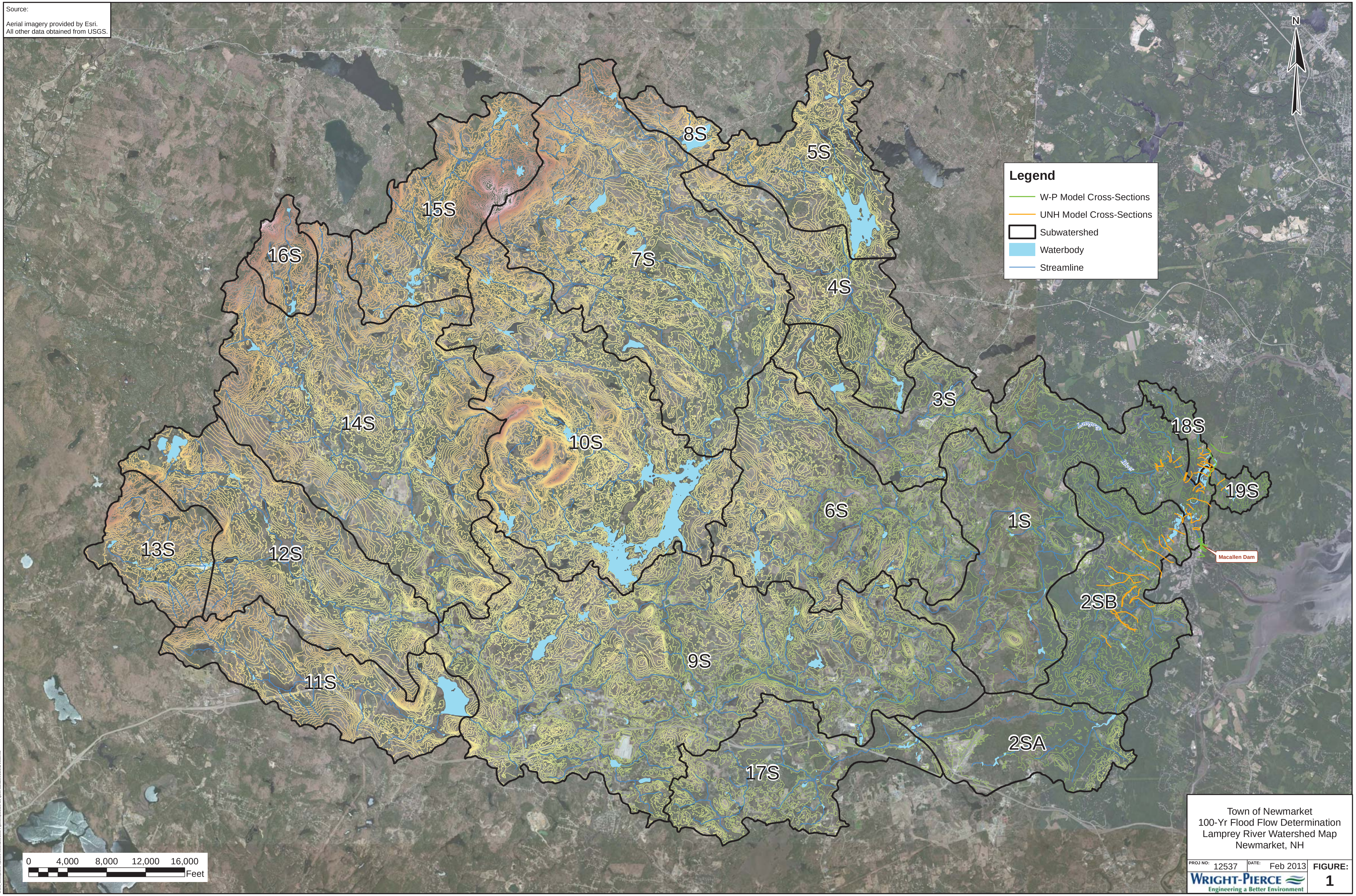
We appreciate your time and consideration of this matter. Please do not hesitate to call if you have any questions regarding this letter. We can provide additional information if needed to assist you in review of this analysis.

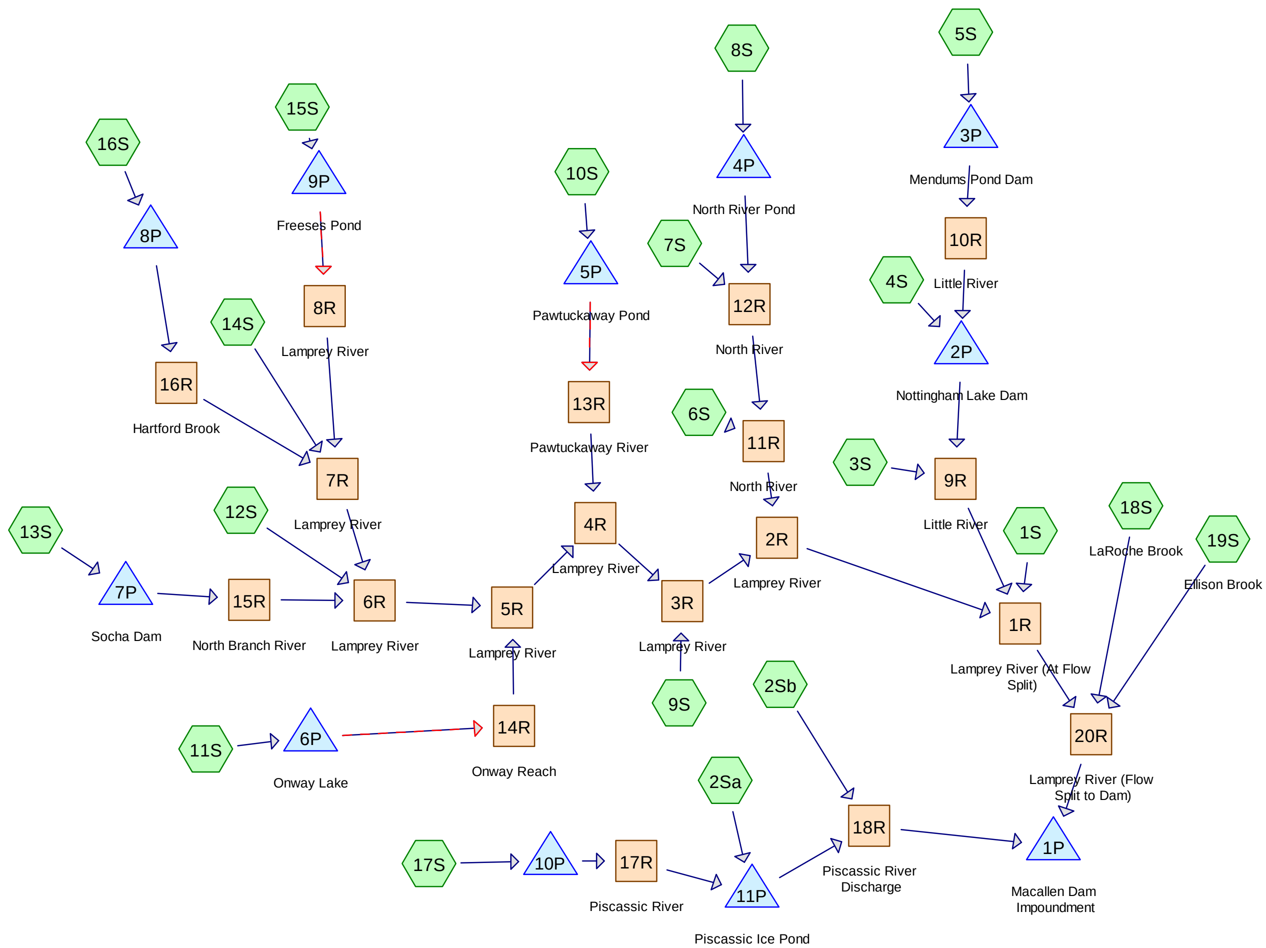
Respectively Submitted,

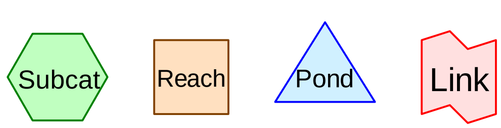
Ryan T. Wingard, P.E..
Senior Project Manager

Steve L. Guerrette
Project Engineer

ATTACHMENT 1
Lamprey River Watershed Map
Lamprey River Watershed HydroCAD Report
NHDES HydroCAD Review E-mail


Source:
Aerial imagery provided by Esri.
All other data obtained from USGS.
Legend
W-P Model Cross-Sections
UNH Model Cross-Sections
Subwatershed
Waterbody
Streamline
N
1S
2SA
2SB
3S
4S
5S
6S
7S
8S
9S
10S
11S
12S
13S
14S
15S
16S
17S
18S
19S
Macallen Dam
0 4,000 8,000 12,000 16,000
Feet
Town of Newmarket
100-Yr Flood Flow Determination
Lamprey River Watershed Map
Newmarket, NH
PROJ NO: 12537
DATE: Feb 2013
FIGURE: 1
WRIGHT-PIERCE
Engineering a Better Environment





Drainage Diagram for MacallenDam-HydrologicAnalysis [updated 02-13]
Prepared by Wright-Pierce, Printed 2/5/2013
HydroCAD® 9.00 s/n 01135 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
10,189.700	30	Woods, Good, HSG A (1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 12S, 14S, 15S, 17S, 18S)
65,135.300	55	Woods, Good, HSG B (1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S)
38,233.700	70	Woods, Good, HSG C (1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S)
15,877.600	77	Woods, Good, HSG D (1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S)
701.100	80	1/2 acre lots, 25% imp, HSG C (1S, 3S, 6S, 14S)
15.100	98	Water Surface, 0% imp, HSG D (18S, 19S)
232.100	98	Water Surface, HSG A (12S)
4,154.100	98	Water Surface, HSG D (2Sa, 2Sb, 4S, 5S, 7S, 8S, 9S, 10S, 11S, 13S, 15S, 16S, 17S)
134,538.700		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Goup	Subcatchment Numbers
10,421.800	HSG A	1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 12S, 14S, 15S, 17S, 18S
65,135.300	HSG B	1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S
38,934.800	HSG C	1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S
20,046.800	HSG D	1S, 2Sa, 2Sb, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S
0.000	Other	
134,538.700		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)
1	11P	80.10	80.00	35.0	0.0029	0.013	144.0	120.0

Time span=5.00-100.00 hrs, dt=0.02 hrs, 4751 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=10,717.600 ac 0.82% Impervious Runoff Depth=2.98"
Flow Length=84,538' Slope=0.0552 '/' Tc=794.5 min CN=61 Runoff=2,226.56 cfs 2,660.939 af

Subcatchment 2Sa: Runoff Area=3,854.900 ac 4.35% Impervious Runoff Depth=3.29"
Flow Length=30,000' Slope=0.0052 '/' Tc=1,046.6 min CN=64 Runoff=738.41 cfs 1,057.962 af

Subcatchment 2Sb: Runoff Area=5,071.800 ac 2.52% Impervious Runoff Depth=2.98"
Flow Length=39,385' Slope=0.0052 '/' Tc=1,405.1 min CN=61 Runoff=663.12 cfs 1,259.207 af

Subcatchment 3S: Runoff Area=4,116.200 ac 0.35% Impervious Runoff Depth=3.19"
Flow Length=45,869' Slope=0.0762 '/' Tc=394.0 min CN=63 Runoff=1,577.28 cfs 1,093.565 af

Subcatchment 4S: Runoff Area=4,692.600 ac 1.43% Impervious Runoff Depth=2.77"
Flow Length=41,187' Slope=0.0834 '/' Tc=382.6 min CN=59 Runoff=1,607.30 cfs 1,084.424 af

Subcatchment 5S: Runoff Area=4,273.900 ac 6.59% Impervious Runoff Depth=1.88"
Flow Length=27,131' Slope=0.0892 '/' Tc=332.5 min CN=50 Runoff=1,036.20 cfs 670.272 af

Subcatchment 6S: Runoff Area=8,684.500 ac 0.13% Impervious Runoff Depth=3.08"
Flow Length=44,026' Slope=0.0876 '/' Tc=364.8 min CN=62 Runoff=3,388.30 cfs 2,231.482 af

Subcatchment 7S: Runoff Area=14,133.000 ac 1.53% Impervious Runoff Depth=3.08"
Flow Length=52,471' Slope=0.0918 '/' Tc=410.1 min CN=62 Runoff=5,173.03 cfs 3,631.474 af

Subcatchment 8S: Runoff Area=813.000 ac 10.60% Impervious Runoff Depth=3.61"
Flow Length=7,430' Slope=0.0868 '/' Tc=77.6 min CN=67 Runoff=1,147.00 cfs 244.750 af

Subcatchment 9S: Runoff Area=20,716.100 ac 5.45% Impervious Runoff Depth=2.88"
Tc=787.8 min CN=60 Runoff=4,170.14 cfs 4,964.773 af

Subcatchment 10S: Runoff Area=13,039.300 ac 11.31% Impervious Runoff Depth=3.29"
Flow Length=59,308' Slope=0.1153 '/' Tc=374.1 min CN=64 Runoff=5,447.66 cfs 3,578.584 af

Subcatchment 11S: Runoff Area=5,433.000 ac 6.31% Impervious Runoff Depth=3.51"
Flow Length=38,791' Slope=0.0815 '/' Tc=308.3 min CN=66 Runoff=2,795.86 cfs 1,587.160 af

Subcatchment 12S: Runoff Area=8,117.700 ac 2.86% Impervious Runoff Depth=3.08"
Flow Length=46,977' Slope=0.0901 '/' Tc=378.9 min CN=62 Runoff=3,143.72 cfs 2,085.843 af

Subcatchment 13S: Runoff Area=2,921.700 ac 2.11% Impervious Runoff Depth=3.19"
Flow Length=17,469' Slope=0.0877 '/' Tc=169.7 min CN=63 Runoff=2,067.78 cfs 776.218 af

Subcatchment 14S: Runoff Area=15,218.900 ac 0.40% Impervious Runoff Depth=3.08"
Flow Length=57,551' Slope=0.0938 '/' Tc=436.8 min CN=62 Runoff=5,290.27 cfs 3,910.496 af

Subcatchment 15S: Runoff Area=5,406.400 ac 0.91% Impervious Runoff Depth=2.77"
Flow Length=31,585' Slope=0.1142 '/' Tc=264.4 min CN=59 Runoff=2,390.84 cfs 1,249.377 af

Subcatchment 16S: Runoff Area=1,302.100 ac 3.62% Impervious Runoff Depth=2.98"
Flow Length=10,715' Slope=0.1136 '/' Tc=106.1 min CN=61 Runoff=1,192.53 cfs 323.282 af

Subcatchment 17S: Runoff Area=4,986.100 ac 2.06% Impervious Runoff Depth=2.88"
Flow Length=35,162' Slope=0.0557 '/' Tc=402.2 min CN=60 Runoff=1,697.04 cfs 1,194.957 af

Subcatchment 18S: LaRoche Brook Runoff Area=585.700 ac 0.00% Impervious Runoff Depth=3.94"
Flow Length=12,650' Slope=0.0565 '/' Tc=135.9 min CN=70 Runoff=615.68 cfs 192.133 af

Subcatchment 19S: Ellison Brook Runoff Area=454.200 ac 0.00% Impervious Runoff Depth=4.49"
Flow Length=10,200' Slope=0.0719 '/' Tc=88.2 min CN=75 Runoff=737.77 cfs 169.793 af

Reach 1R: Lamprey River (At Flow Avg. Depth=12.97' Max Vel=4.38 fps Inflow=12,721.87 cfs 28,087.504 af
L=28,450.0' S=0.0010 '/' Capacity=32,888.73 cfs Outflow=12,669.65 cfs 27,895.945 af

Reach 2R: Lamprey River Avg. Depth=12.00' Max Vel=4.53 fps Inflow=11,926.86 cfs 23,078.962 af
L=30,700.0' S=0.0012 '/' Capacity=35,733.21 cfs Outflow=11,826.55 cfs 22,928.162 af

Reach 3R: Lamprey River Avg. Depth=32.39' Max Vel=2.28 fps Inflow=11,782.95 cfs 17,127.806 af
L=18,850.0' S=0.0003 '/' Capacity=17,060.69 cfs Outflow=10,094.27 cfs 17,044.289 af

Reach 4R: Lamprey River Avg. Depth=24.49' Max Vel=4.04 fps Inflow=10,330.18 cfs 12,258.497 af
L=38,500.0' S=0.0010 '/' Capacity=21,410.58 cfs Outflow=9,161.17 cfs 12,163.033 af

Reach 5R: Lamprey River Avg. Depth=20.59' Max Vel=6.95 fps Inflow=9,484.82 cfs 9,202.983 af
L=38,000.0' S=0.0010 '/' Capacity=15,419.89 cfs Outflow=8,992.78 cfs 9,171.740 af

Reach 6R: Lamprey River Avg. Depth=21.94' Max Vel=5.65 fps Inflow=9,572.64 cfs 8,323.989 af
L=15,000.0' S=0.0011 '/' Capacity=11,099.45 cfs Outflow=9,152.72 cfs 8,321.446 af

Reach 7R: Lamprey River Avg. Depth=18.07' Max Vel=7.02 fps Inflow=7,063.06 cfs 5,466.512 af
L=23,000.0' S=0.0017 '/' Capacity=10,828.53 cfs Outflow=6,722.31 cfs 5,463.736 af

Reach 8R: Lamprey River Avg. Depth=9.24' Max Vel=10.53 fps Inflow=1,563.30 cfs 1,234.721 af
n=0.030 L=21,650.0' S=0.0083 '/' Capacity=13,482.05 cfs Outflow=1,523.16 cfs 1,233.690 af

Reach 9R: Little River Avg. Depth=13.90' Max Vel=5.93 fps Inflow=2,774.74 cfs 2,506.053 af
L=18,480.0' S=0.0049 '/' Capacity=8,256.48 cfs Outflow=2,548.41 cfs 2,498.403 af

Reach 10R: Little River Avg. Depth=5.31' Max Vel=3.06 fps Inflow=165.35 cfs 533.710 af
n=0.050 L=16,350.0' S=0.0031 '/' Capacity=4,910.21 cfs Outflow=164.09 cfs 525.737 af

Reach 11R: North River Avg. Depth=15.45' Max Vel=5.15 fps Inflow=6,817.99 cfs 6,044.391 af
L=40,920.0' S=0.0033 '/' Capacity=9,118.30 cfs Outflow=6,105.85 cfs 6,034.673 af

Reach 12R: North River Avg. Depth=12.44' Max Vel=6.60 fps Inflow=5,219.98 cfs 3,818.534 af
L=33,800.0' S=0.0065 '/' Capacity=12,839.98 cfs Outflow=4,720.38 cfs 3,812.908 af

Reach 13R: Pawtuckaway River Avg. Depth=10.81' Max Vel=5.17 fps Inflow=1,454.87 cfs 3,103.008 af
L=19,800.0' S=0.0040 '/' Capacity=4,923.16 cfs Outflow=1,431.19 cfs 3,086.757 af

Reach 14R: Onway Reach Avg. Depth=6.79' Max Vel=6.65 fps Inflow=545.91 cfs 884.751 af
n=0.030 L=7,920.0' S=0.0040 '/' Capacity=9,359.50 cfs Outflow=545.16 cfs 881.537 af

Reach 15R: North Branch River Avg. Depth=9.95' Max Vel=9.18 fps Inflow=1,987.45 cfs 774.909 af
n=0.030 L=29,000.0' S=0.0063 '/' Capacity=11,746.08 cfs Outflow=1,610.66 cfs 774.410 af

Reach 16R: Hartford Brook Avg. Depth=4.47' Max Vel=8.59 fps Inflow=362.49 cfs 322.591 af
n=0.030 L=29,000.0' S=0.0103 '/' Capacity=15,019.01 cfs Outflow=347.09 cfs 322.326 af

Reach 17R: Piscassic River Avg. Depth=11.78' Max Vel=2.91 fps Inflow=835.86 cfs 1,194.914 af
n=0.040 L=23,600.0' S=0.0010 '/' Capacity=3,464.91 cfs Outflow=802.63 cfs 1,194.473 af

Reach 18R: Piscassic River Discharge Avg. Depth=9.76' Max Vel=4.72 fps Inflow=2,151.73 cfs 3,507.733 af
L=35,000.0' S=0.0017 '/' Capacity=29,822.87 cfs Outflow=1,850.23 cfs 3,504.707 af

Reach 20R: Lamprey River (Flow Split Avg. Depth=17.62' Max Vel=6.28 fps Inflow=12,669.65 cfs 28,257.871 af
L=7,500.0' S=0.0010 '/' Capacity=67,844.37 cfs Outflow=12,666.42 cfs 28,230.753 af

Pond 1P: Macallen Dam Impoundment Inflow=14,493.30 cfs 31,735.460 af
Primary=14,493.30 cfs 31,735.460 af

Pond 2P: Nottingham Lake Dam Peak Elev=150.88' Storage=348.695 af Inflow=1,609.59 cfs 1,610.160 af
Outflow=1,367.16 cfs 1,412.488 af

Pond 3P: Mendums Pond Dam Peak Elev=232.84' Storage=5,660.690 af Inflow=1,036.20 cfs 670.272 af
Outflow=165.35 cfs 533.710 af

Pond 4P: North River Pond Peak Elev=457.11' Storage=530.231 af Inflow=1,147.00 cfs 244.750 af
Outflow=50.29 cfs 187.059 af

Pond 5P: Pawtuckaway Pond Peak Elev=252.95' Storage=17,673.032 af Inflow=5,447.66 cfs 3,578.584 af
Primary=1,404.47 cfs 3,058.522 af Secondary=50.40 cfs 44.487 af Outflow=1,454.87 cfs 3,103.008 af

Pond 6P: Onway Lake Peak Elev=266.44' Storage=2,438.917 af Inflow=2,795.86 cfs 1,587.160 af
Primary=235.53 cfs 660.530 af Secondary=310.38 cfs 224.221 af Outflow=545.91 cfs 884.751 af

Pond 7P: Socha Dam Peak Elev=399.22' Storage=221.092 af Inflow=2,067.78 cfs 776.218 af
Outflow=1,987.45 cfs 774.909 af

Pond 8P: Peak Elev=549.59' Storage=229.102 af Inflow=1,192.53 cfs 323.282 af
Outflow=362.49 cfs 322.591 af

Pond 9P: Freeses Pond Peak Elev=436.87' Storage=983.197 af Inflow=2,390.84 cfs 1,249.377 af
Primary=1,563.30 cfs 1,234.721 af Secondary=0.00 cfs 0.000 af Outflow=1,563.30 cfs 1,234.721 af

Pond 10P: Peak Elev=123.15' Storage=517.198 af Inflow=1,697.04 cfs 1,194.957 af
Outflow=835.86 cfs 1,194.914 af

Pond 11P: Piscassic Ice Pond Peak Elev=93.01' Storage=180.029 af Inflow=1,540.10 cfs 2,252.435 af
Outflow=1,511.21 cfs 2,248.526 af

Total Runoff Area = 134,538.700 ac Runoff Volume = 33,966.693 af Average Runoff Depth = 3.03"
96.61% Pervious = 129,977.225 ac 3.39% Impervious = 4,561.475 ac

Summary for Subcatchment 1S:

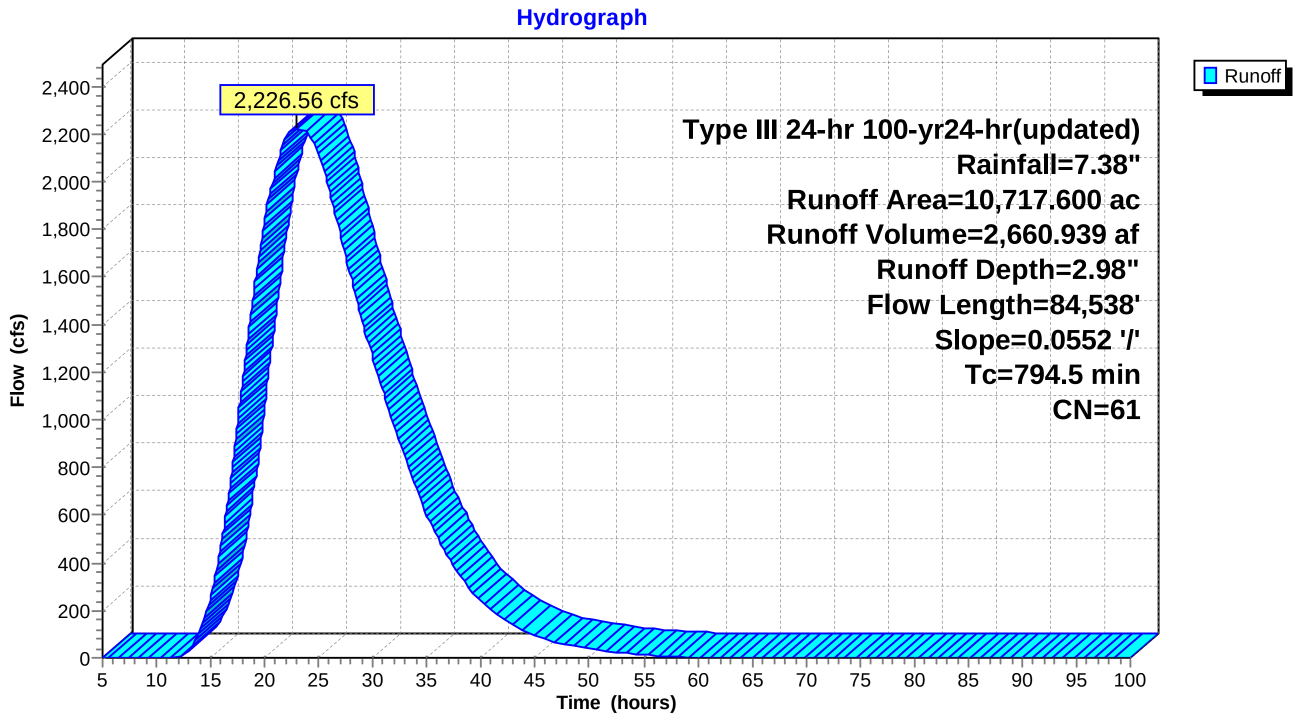
Runoff = 2,226.56 cfs @ 22.96 hrs, Volume= 2,660.939 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
2,055.900	30	Woods, Good, HSG A
2,440.700	55	Woods, Good, HSG B
3,824.100	70	Woods, Good, HSG C
2,043.300	77	Woods, Good, HSG D
353.600	80	1/2 acre lots, 25% imp, HSG C
10,717.600	61	Weighted Average
10,629.200		99.18% Pervious Area
88.400		0.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
794.5	84,538	0.0552	1.77		**Lag/CN Method,**

Subcatchment 1S:



Summary for Subcatchment 2Sa:

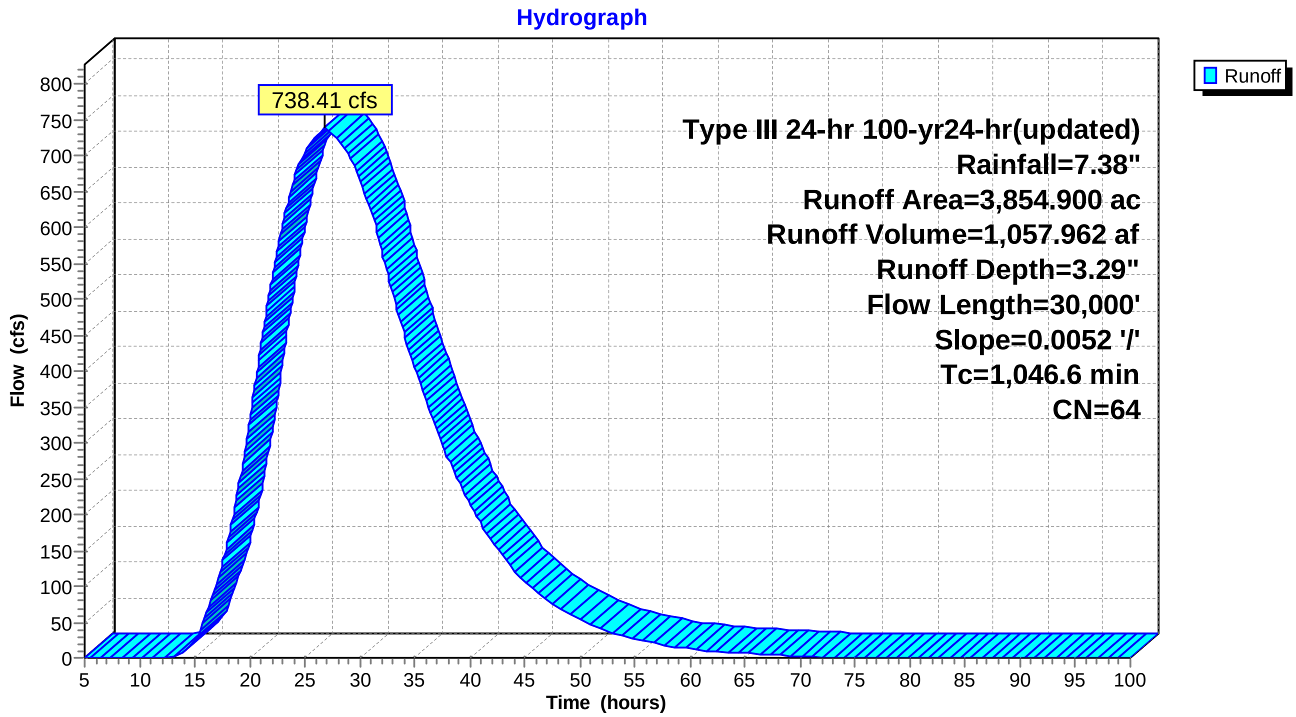
Runoff = 738.41 cfs @ 26.75 hrs, Volume= 1,057.962 af, Depth= 3.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
227.700	30	Woods, Good, HSG A
1,540.200	55	Woods, Good, HSG B
1,502.200	70	Woods, Good, HSG C
417.000	77	Woods, Good, HSG D
167.800	98	Water Surface, HSG D
3,854.900	64	Weighted Average
3,687.100		95.65% Pervious Area
167.800		4.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1,046.6	30,000	0.0052	0.48		**Lag/CN Method,**

Subcatchment 2Sa:



Summary for Subcatchment 2Sb:

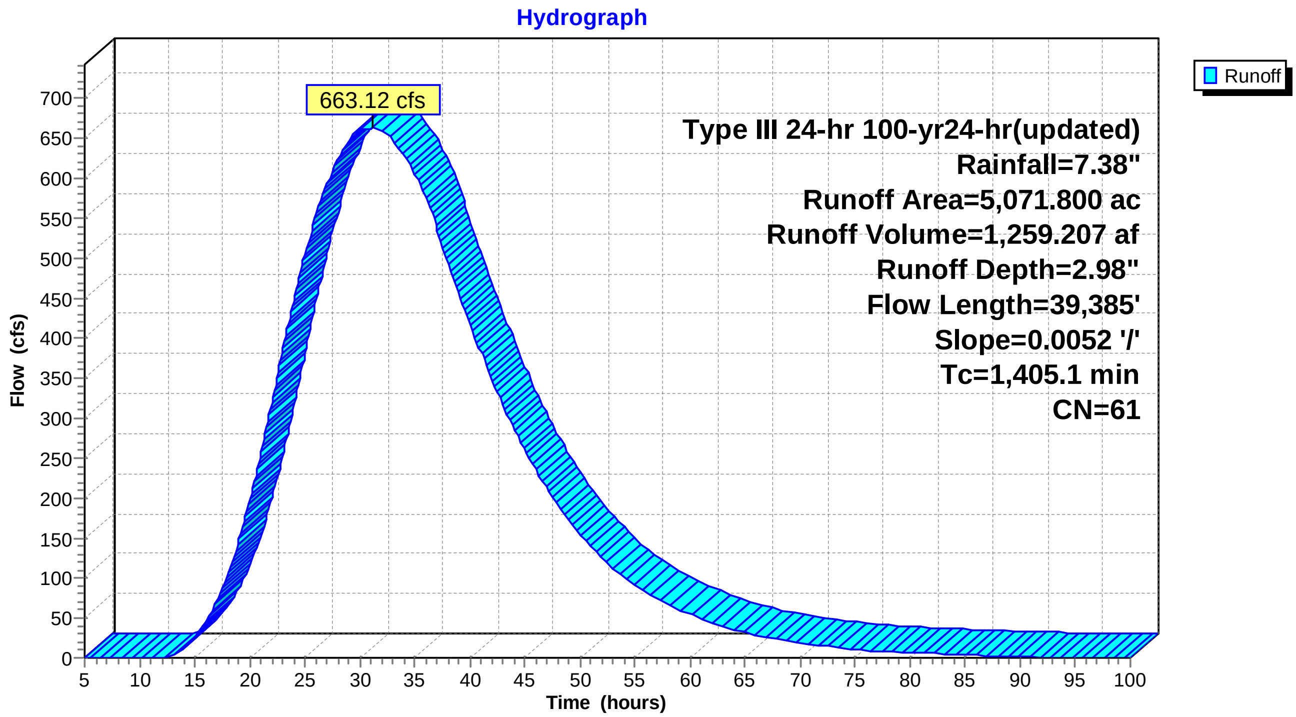
Runoff = 663.12 cfs @ 31.22 hrs, Volume= 1,259.207 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
343.000	30	Woods, Good, HSG A
2,452.300	55	Woods, Good, HSG B
1,957.500	70	Woods, Good, HSG C
191.300	77	Woods, Good, HSG D
127.700	98	Water Surface, HSG D
5,071.800	61	Weighted Average
4,944.100		97.48% Pervious Area
127.700		2.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1,405.1	39,385	0.0052	0.47		**Lag/CN Method,**

Subcatchment 2Sb:



Summary for Subcatchment 3S:

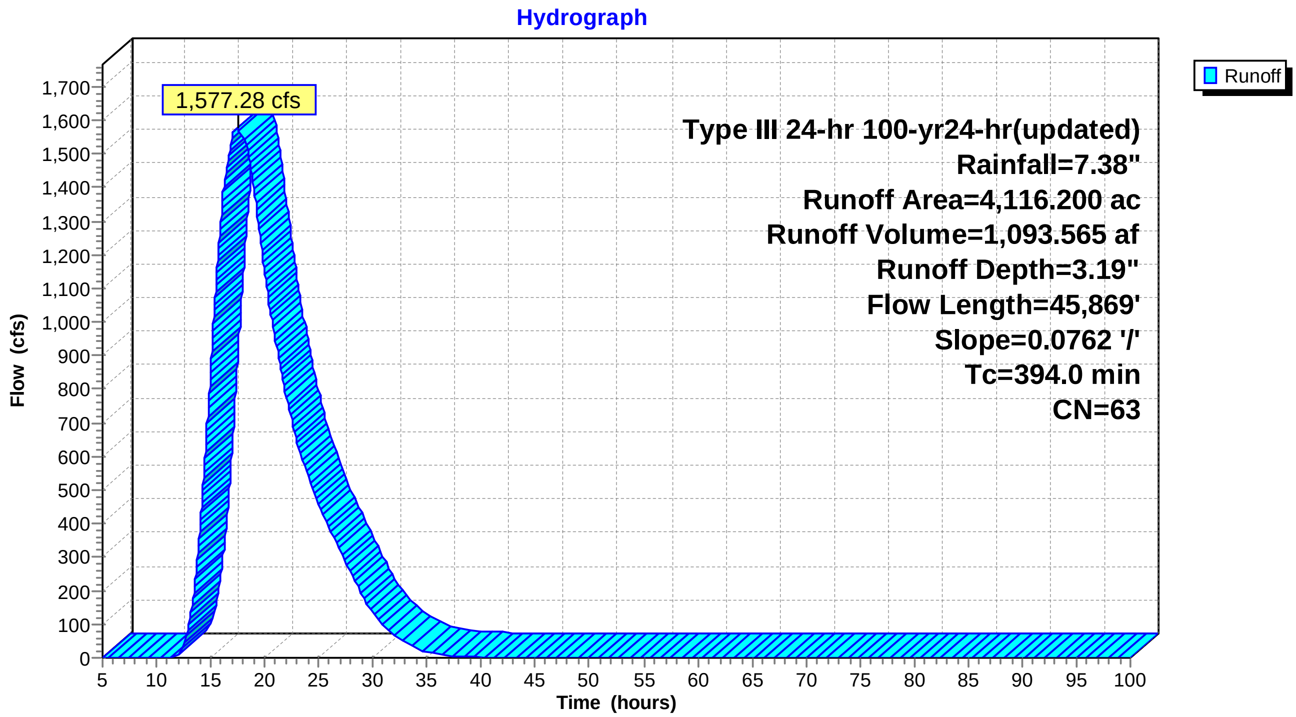
Runoff = 1,577.28 cfs @ 17.51 hrs, Volume= 1,093.565 af, Depth= 3.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
343.100	30	Woods, Good, HSG A
1,426.500	55	Woods, Good, HSG B
1,208.500	70	Woods, Good, HSG C
1,080.100	77	Woods, Good, HSG D
58.000	80	1/2 acre lots, 25% imp, HSG C
4,116.200	63	Weighted Average
4,101.700		99.65% Pervious Area
14.500		0.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
394.0	45,869	0.0762	1.94		**Lag/CN Method,**

Subcatchment 3S:



Summary for Subcatchment 4S:

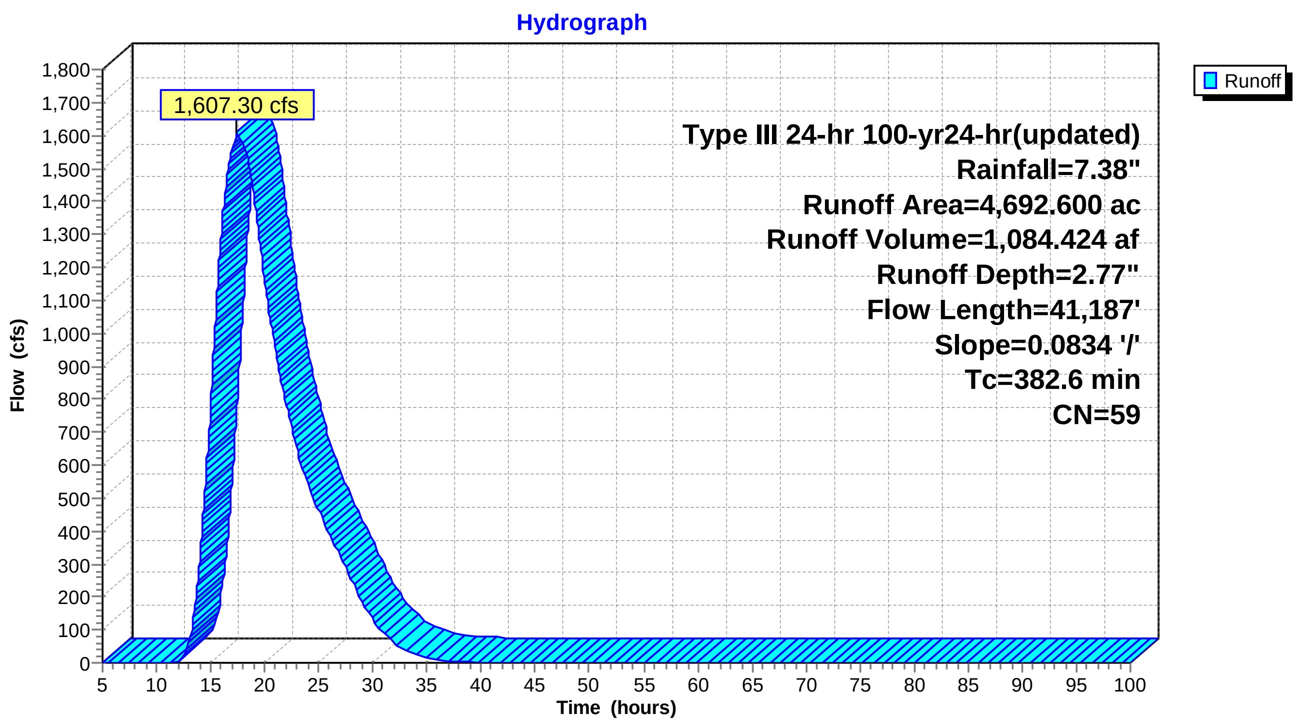
Runoff = 1,607.30 cfs @ 17.44 hrs, Volume= 1,084.424 af, Depth= 2.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
410.100	30	Woods, Good, HSG A
2,548.900	55	Woods, Good, HSG B
1,218.700	70	Woods, Good, HSG C
447.600	77	Woods, Good, HSG D
67.300	98	Water Surface, HSG D
4,692.600	59	Weighted Average
4,625.300		98.57% Pervious Area
67.300		1.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
382.6	41,187	0.0834	1.79		**Lag/CN Method,**

Subcatchment 4S:



Summary for Subcatchment 5S:

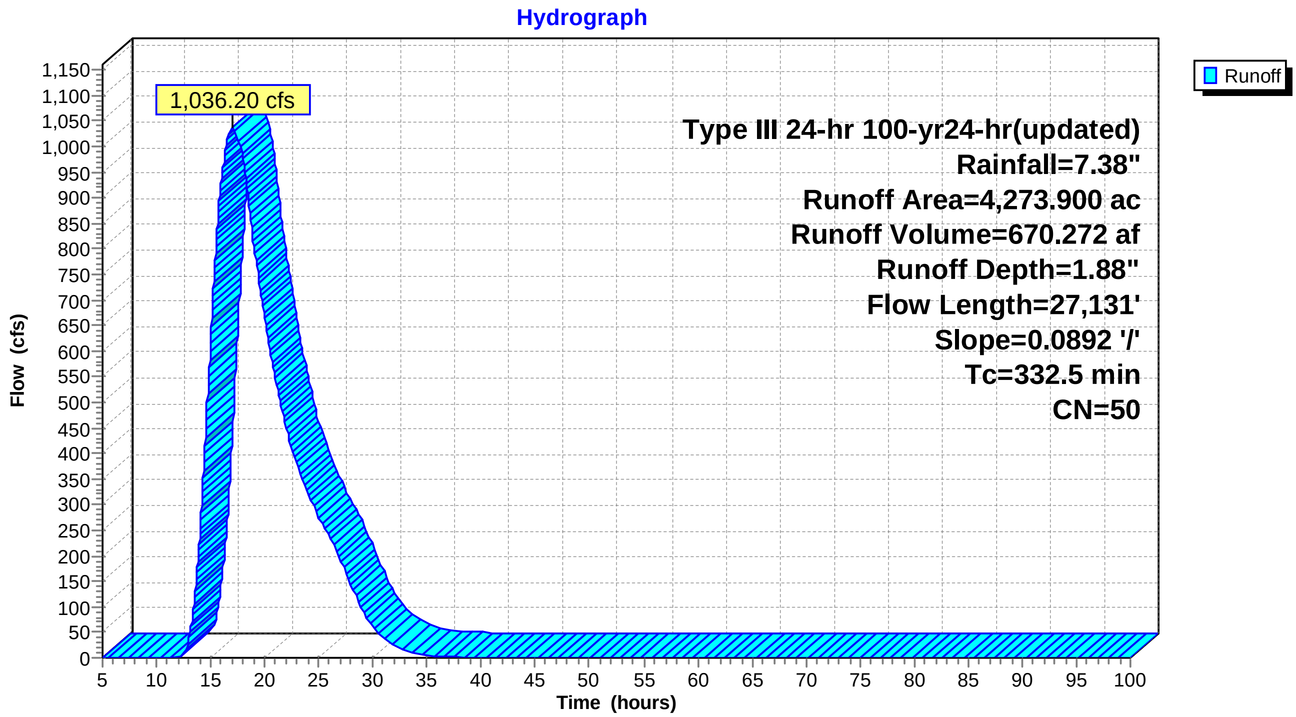
Runoff = 1,036.20 cfs @ 17.00 hrs, Volume= 670.272 af, Depth= 1.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
2,312.500	30	Woods, Good, HSG A
558.200	55	Woods, Good, HSG B
315.500	70	Woods, Good, HSG C
806.200	77	Woods, Good, HSG D
281.500	98	Water Surface, HSG D
4,273.900	50	Weighted Average
3,992.400		93.41% Pervious Area
281.500		6.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
332.5	27,131	0.0892	1.36		**Lag/CN Method,**

Subcatchment 5S:



Summary for Subcatchment 6S:

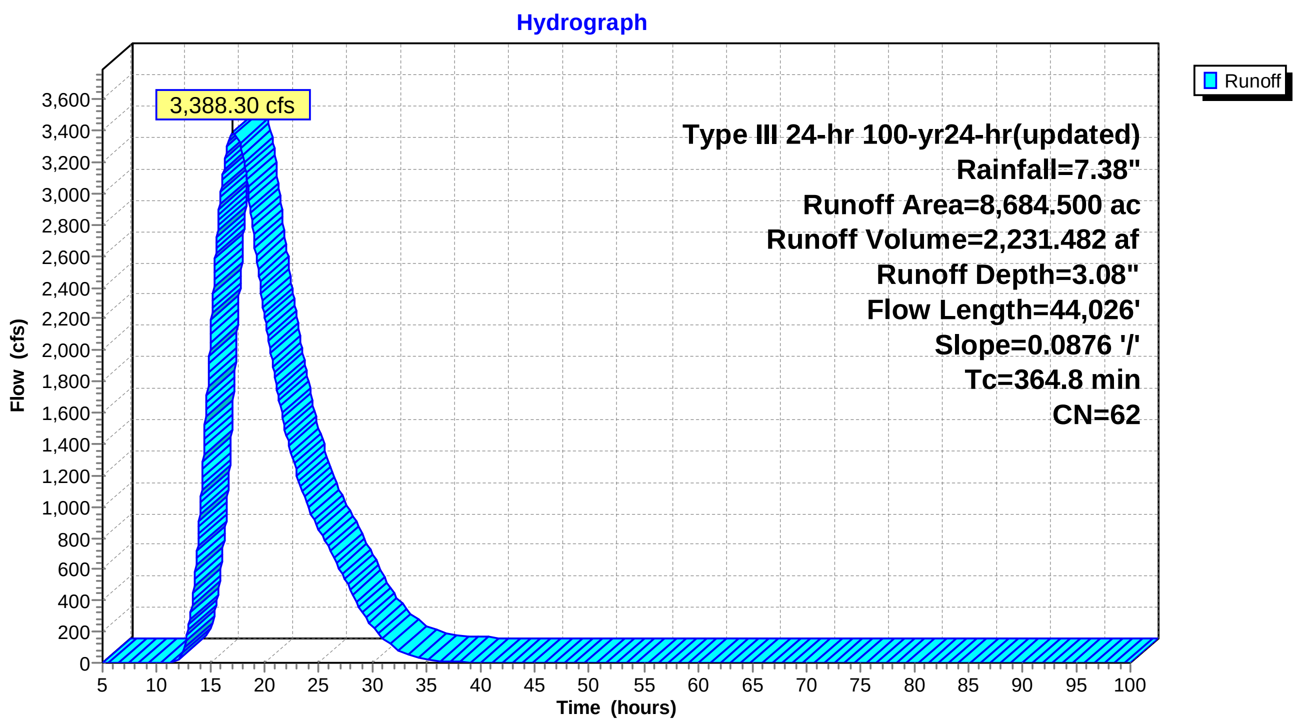
Runoff = 3,388.30 cfs @ 17.04 hrs, Volume= 2,231.482 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
516.400	30	Woods, Good, HSG A
4,089.500	55	Woods, Good, HSG B
2,553.200	70	Woods, Good, HSG C
1,480.600	77	Woods, Good, HSG D
44.800	80	1/2 acre lots, 25% imp, HSG C
8,684.500	62	Weighted Average
8,673.300		99.87% Pervious Area
11.200		0.13% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
364.8	44,026	0.0876	2.01		**Lag/CN Method,**

Subcatchment 6S:



Summary for Subcatchment 7S:

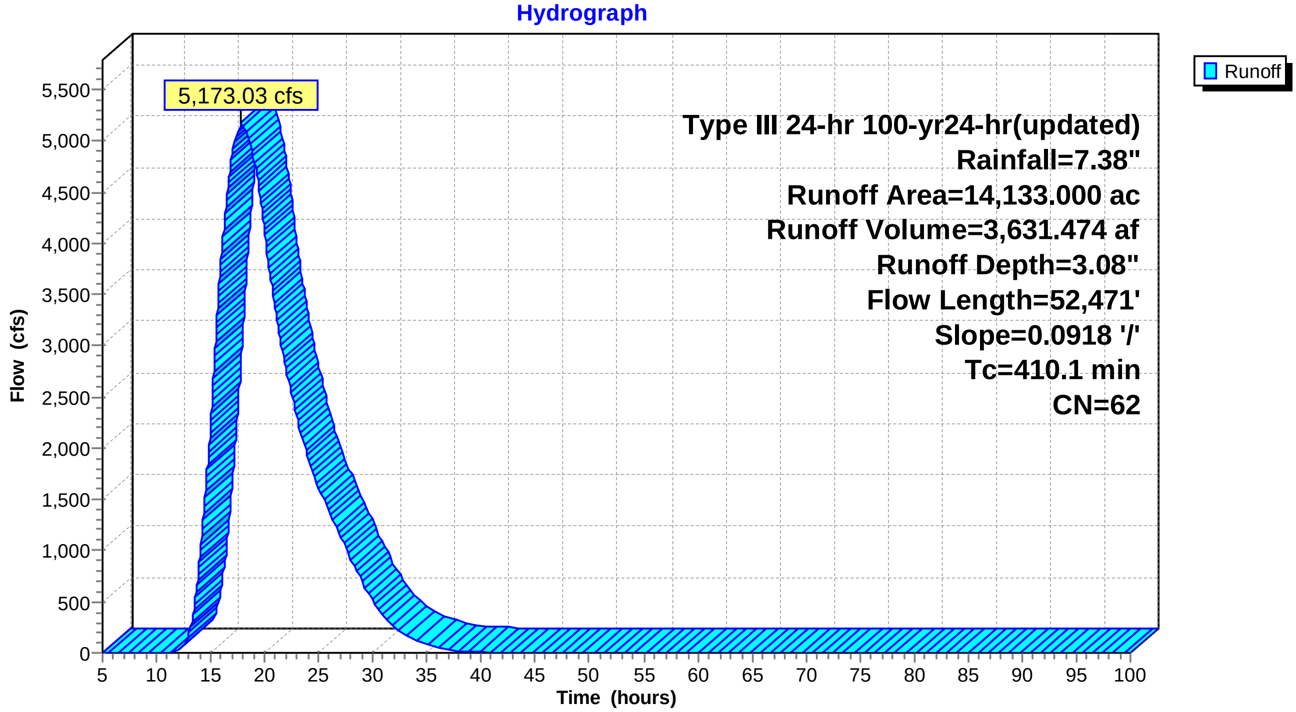
Runoff = 5,173.03 cfs @ 17.78 hrs, Volume= 3,631.474 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
108.600	30	Woods, Good, HSG A
8,157.600	55	Woods, Good, HSG B
3,970.200	70	Woods, Good, HSG C
1,680.100	77	Woods, Good, HSG D
216.500	98	Water Surface, HSG D
14,133.000	62	Weighted Average
13,916.500		98.47% Pervious Area
216.500		1.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
410.1	52,471	0.0918	2.13		**Lag/CN Method,**

Subcatchment 7S:



Summary for Subcatchment 8S:

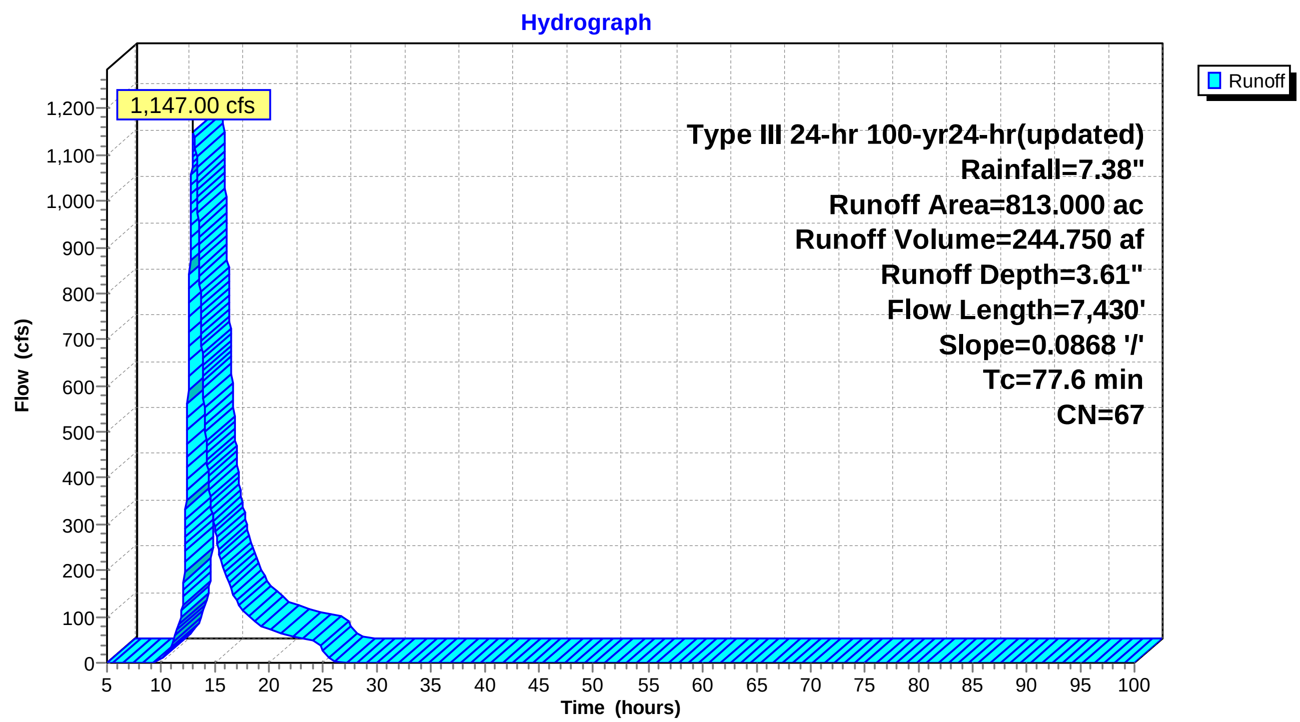
Runoff = 1,147.00 cfs @ 13.03 hrs, Volume= 244.750 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
31.300	30	Woods, Good, HSG A
259.300	55	Woods, Good, HSG B
392.800	70	Woods, Good, HSG C
43.400	77	Woods, Good, HSG D
86.200	98	Water Surface, HSG D
813.000	67	Weighted Average
726.800		89.40% Pervious Area
86.200		10.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
77.6	7,430	0.0868	1.60		**Lag/CN Method,**

Subcatchment 8S:



Summary for Subcatchment 9S:

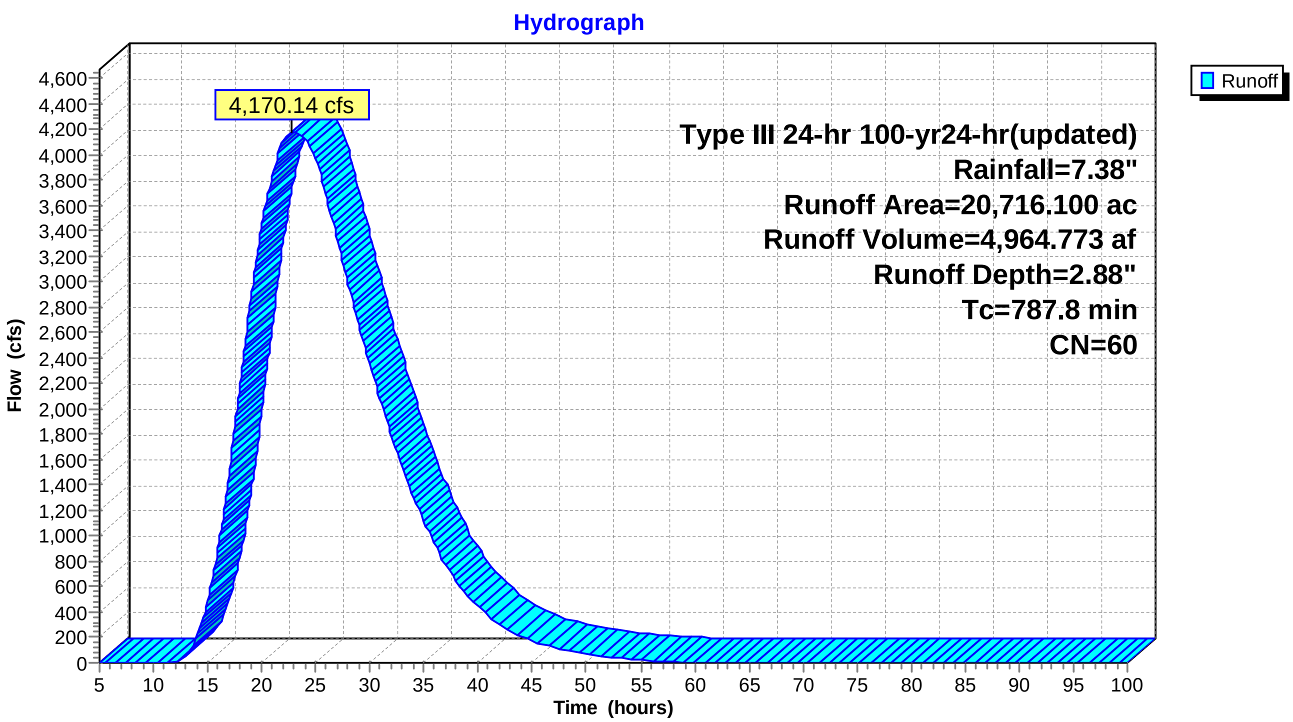
Runoff = 4,170.14 cfs @ 22.78 hrs, Volume= 4,964.773 af, Depth= 2.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
2,165.800	30	Woods, Good, HSG A
10,715.500	55	Woods, Good, HSG B
4,477.600	70	Woods, Good, HSG C
2,228.800	77	Woods, Good, HSG D
1,128.400	98	Water Surface, HSG D
20,716.100	60	Weighted Average
19,587.700		94.55% Pervious Area
1,128.400		5.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
787.8					**Direct Entry, Lag Method - (CN=60, L=108139', Y=8.76%)**

Subcatchment 9S:



Summary for Subcatchment 10S:

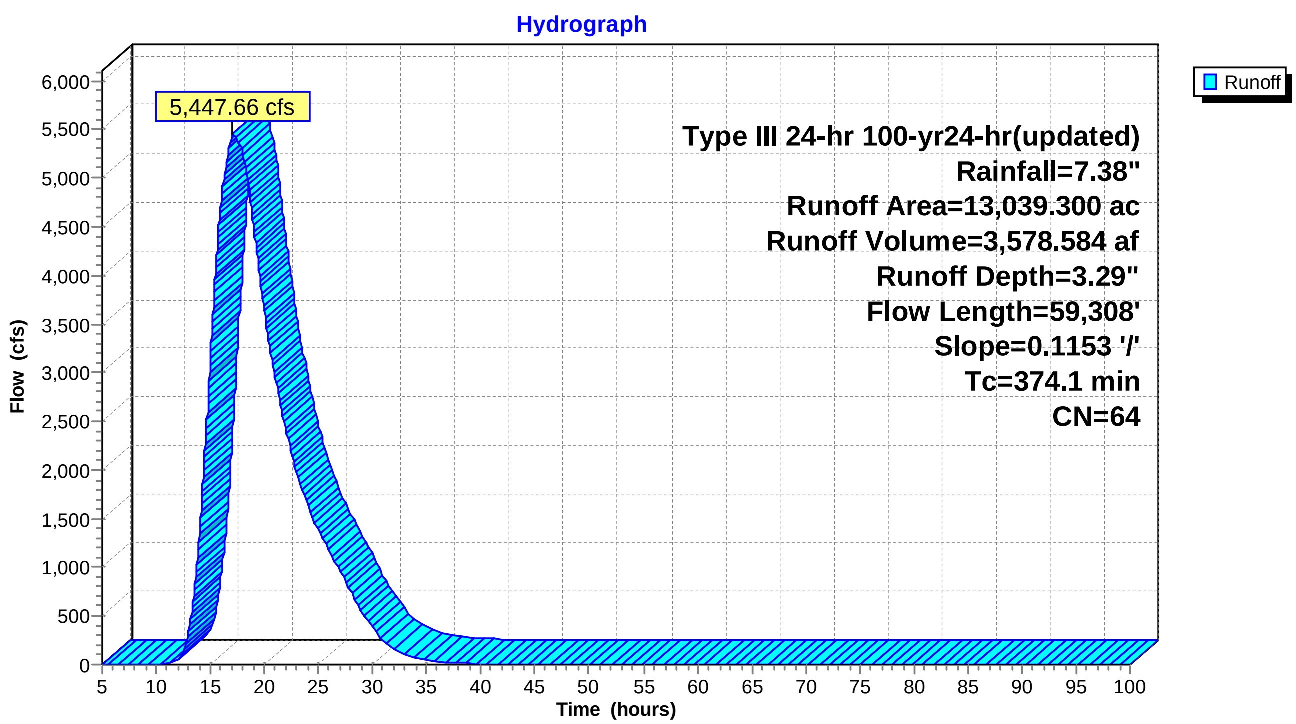
Runoff = 5,447.66 cfs @ 17.05 hrs, Volume= 3,578.584 af, Depth= 3.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
8,427.600	55	Woods, Good, HSG B
1,778.000	70	Woods, Good, HSG C
1,358.500	77	Woods, Good, HSG D
1,475.200	98	Water Surface, HSG D
13,039.300	64	Weighted Average
11,564.100		88.69% Pervious Area
1,475.200		11.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
372.0	57,108	0.1153	2.56		**Lag/CN Method,**
2.1	2,200		17.49		**Lake or Reservoir,** Mean Depth= 9.50'
374.1	59,308	Total			

Subcatchment 10S:



Summary for Subcatchment 11S:

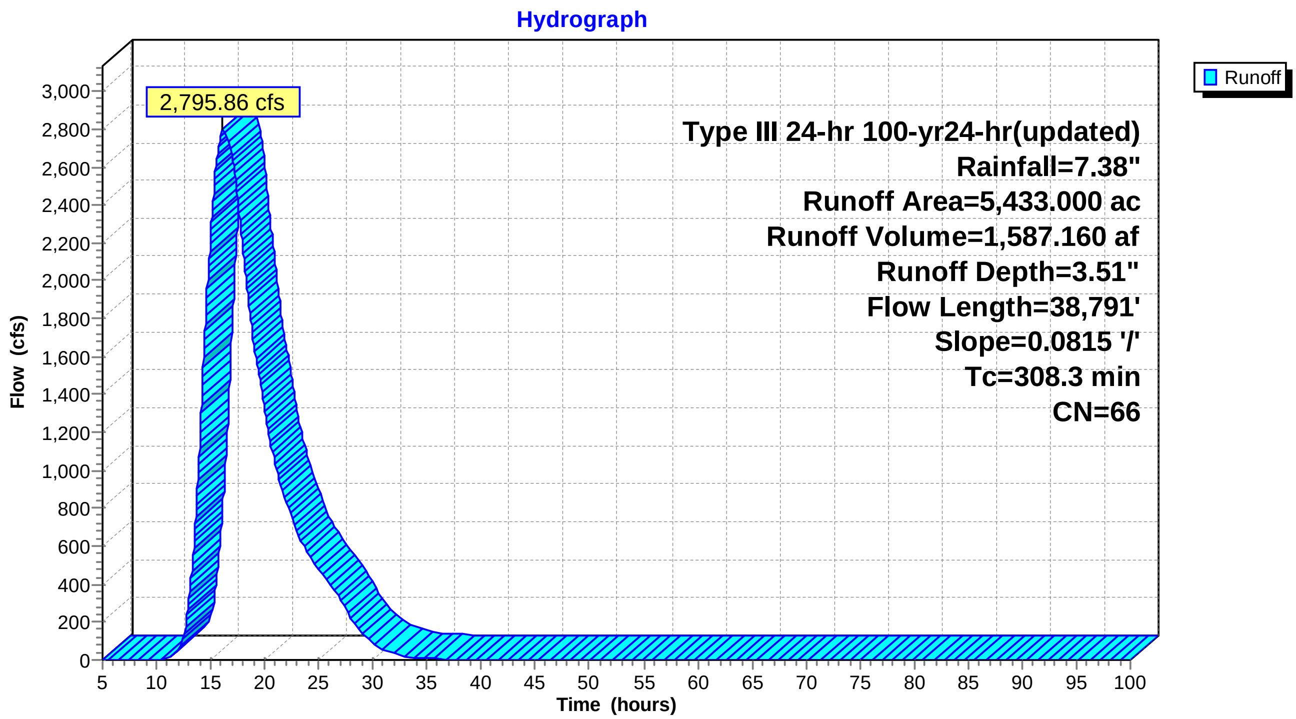
Runoff = 2,795.86 cfs @ 16.11 hrs, Volume= 1,587.160 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
2,272.100	55	Woods, Good, HSG B
2,299.100	70	Woods, Good, HSG C
518.800	77	Woods, Good, HSG D
343.000	98	Water Surface, HSG D
5,433.000	66	Weighted Average
5,090.000		93.69% Pervious Area
343.000		6.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
308.3	38,791	0.0815	2.10		**Lag/CN Method,**

Subcatchment 11S:



Summary for Subcatchment 12S:

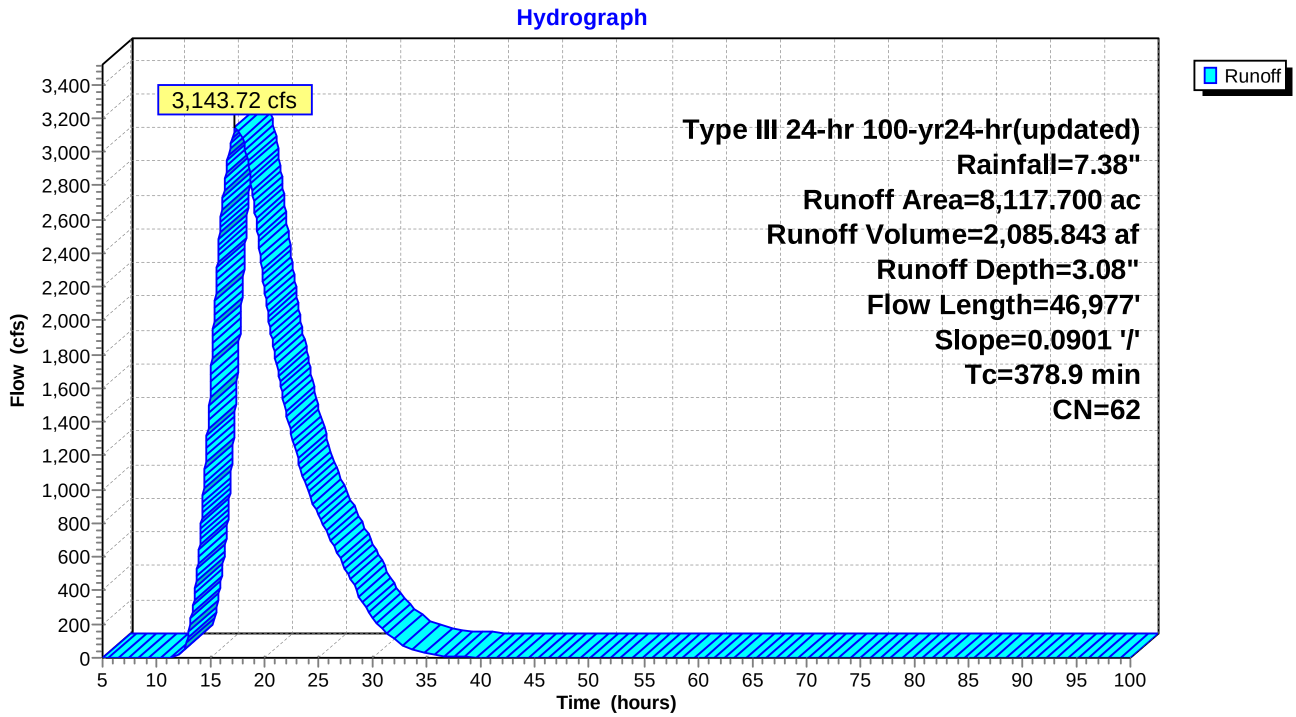
Runoff = 3,143.72 cfs @ 17.27 hrs, Volume= 2,085.843 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
544.400	30	Woods, Good, HSG A
3,708.900	55	Woods, Good, HSG B
3,120.400	70	Woods, Good, HSG C
511.900	77	Woods, Good, HSG D
232.100	98	Water Surface, HSG A
8,117.700	62	Weighted Average
7,885.600		97.14% Pervious Area
232.100		2.86% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
378.9	46,977	0.0901	2.07		**Lag/CN Method,**

Subcatchment 12S:



Summary for Subcatchment 13S:

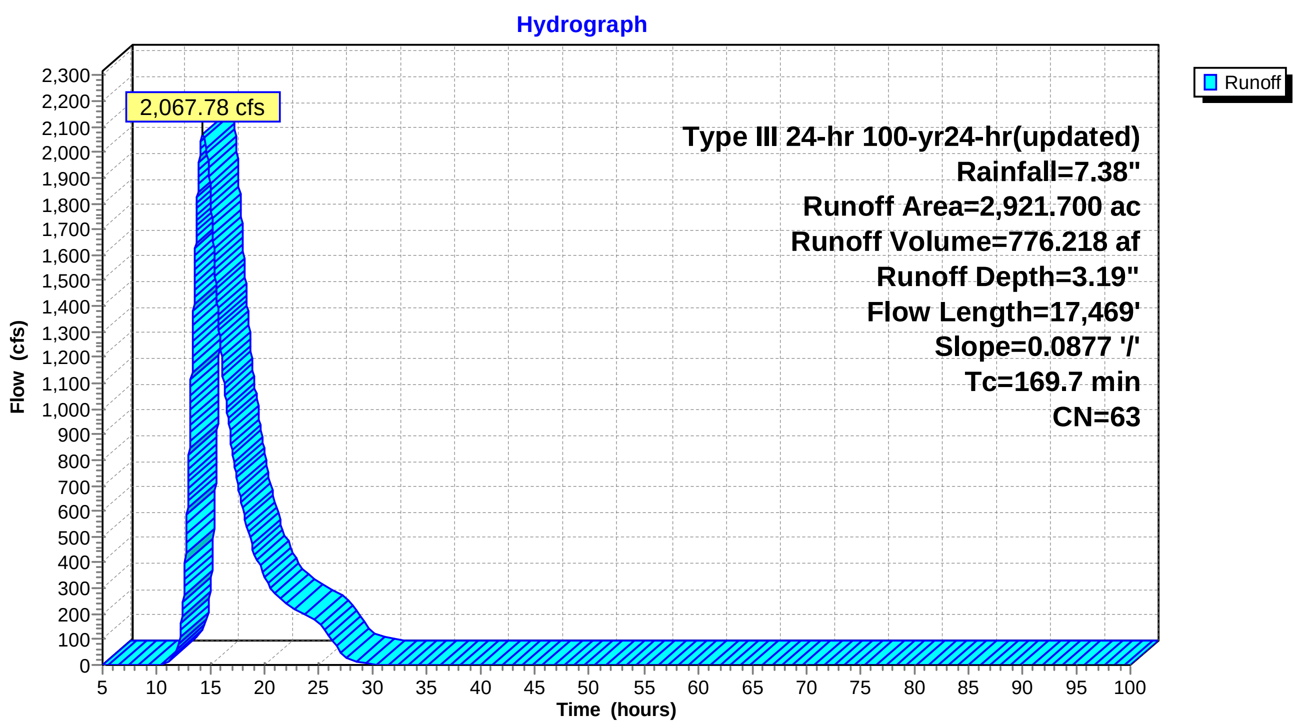
Runoff = 2,067.78 cfs @ 14.33 hrs, Volume= 776.218 af, Depth= 3.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
1,606.400	55	Woods, Good, HSG B
1,080.400	70	Woods, Good, HSG C
173.200	77	Woods, Good, HSG D
61.700	98	Water Surface, HSG D
2,921.700	63	Weighted Average
2,860.000		97.89% Pervious Area
61.700		2.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
169.7	17,469	0.0877	1.72		**Lag/CN Method,**

Subcatchment 13S:



Summary for Subcatchment 14S:

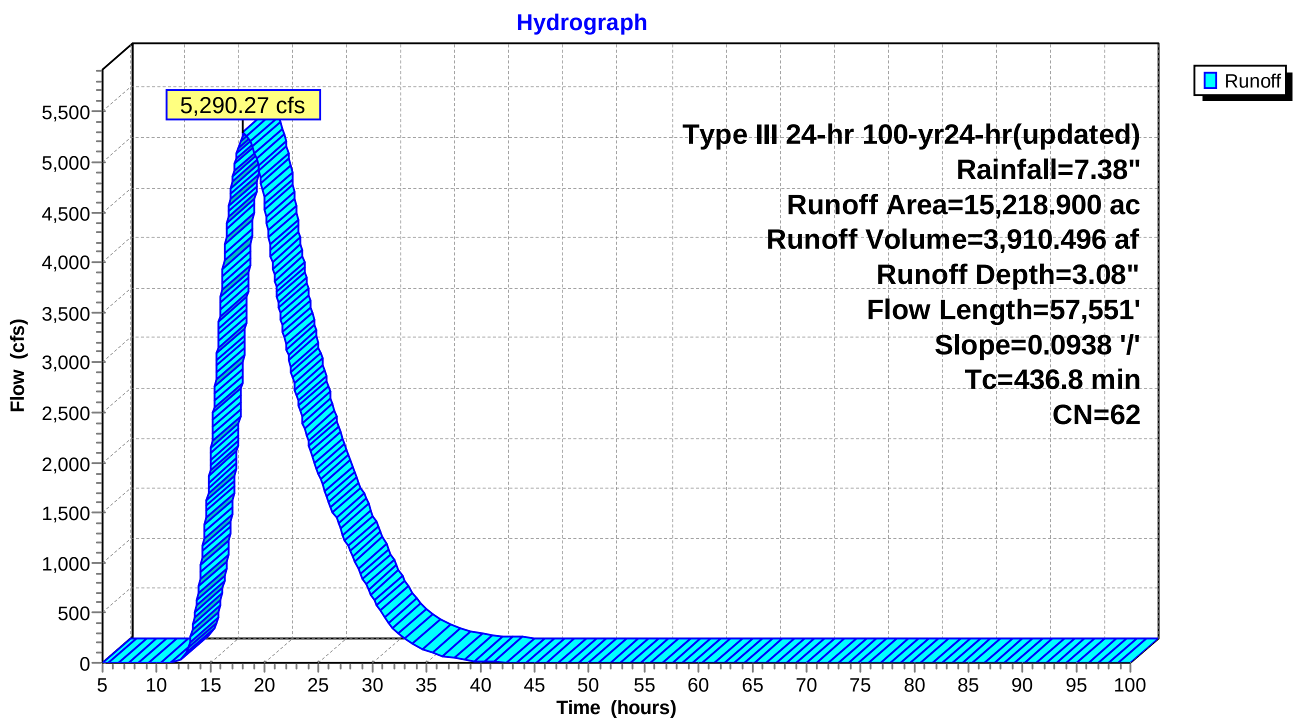
Runoff = 5,290.27 cfs @ 17.97 hrs, Volume= 3,910.496 af, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
639.600	30	Woods, Good, HSG A
7,209.800	55	Woods, Good, HSG B
6,067.800	70	Woods, Good, HSG C
1,057.000	77	Woods, Good, HSG D
244.700	80	1/2 acre lots, 25% imp, HSG C
15,218.900	62	Weighted Average
15,157.725		99.60% Pervious Area
61.175		0.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
436.8	57,551	0.0938	2.20		**Lag/CN Method,**

Subcatchment 14S:



Summary for Subcatchment 15S:

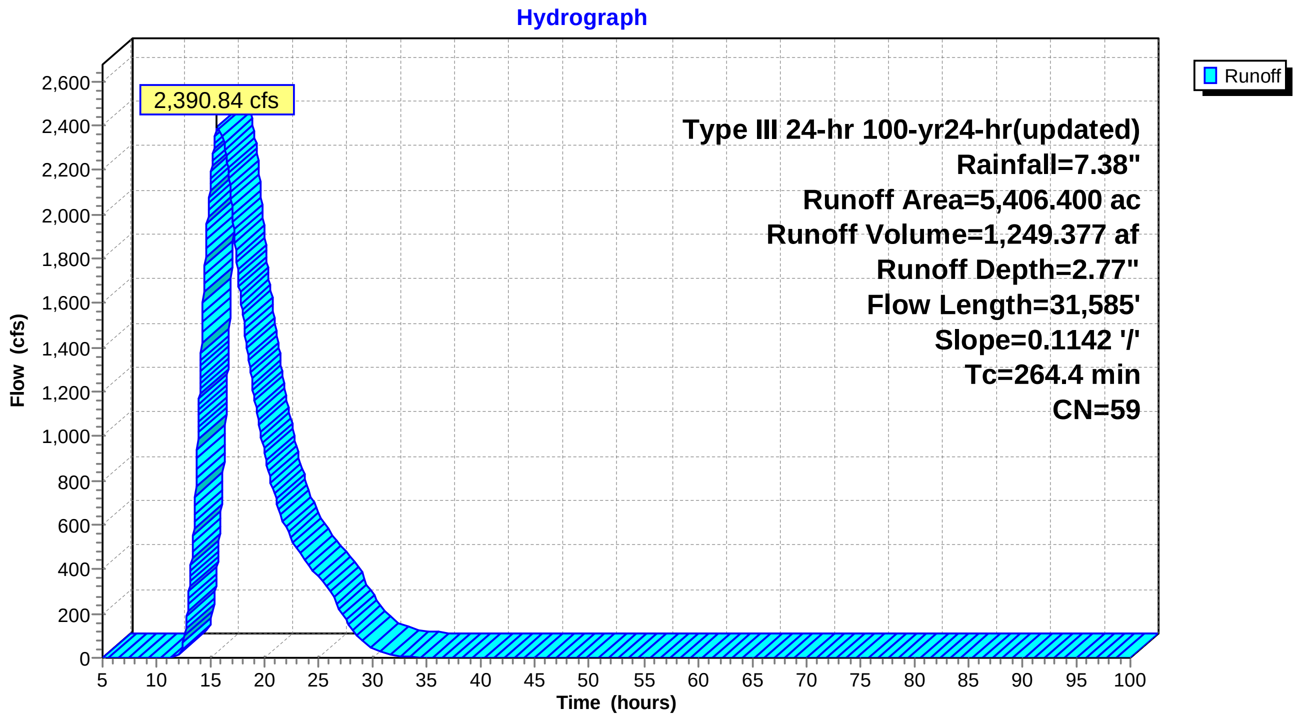
Runoff = 2,390.84 cfs @ 15.59 hrs, Volume= 1,249.377 af, Depth= 2.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
155.100	30	Woods, Good, HSG A
3,866.900	55	Woods, Good, HSG B
890.100	70	Woods, Good, HSG C
445.200	77	Woods, Good, HSG D
49.100	98	Water Surface, HSG D
5,406.400	59	Weighted Average
5,357.300		99.09% Pervious Area
49.100		0.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
264.4	31,585	0.1142	1.99		**Lag/CN Method,**

Subcatchment 15S:



Summary for Subcatchment 16S:

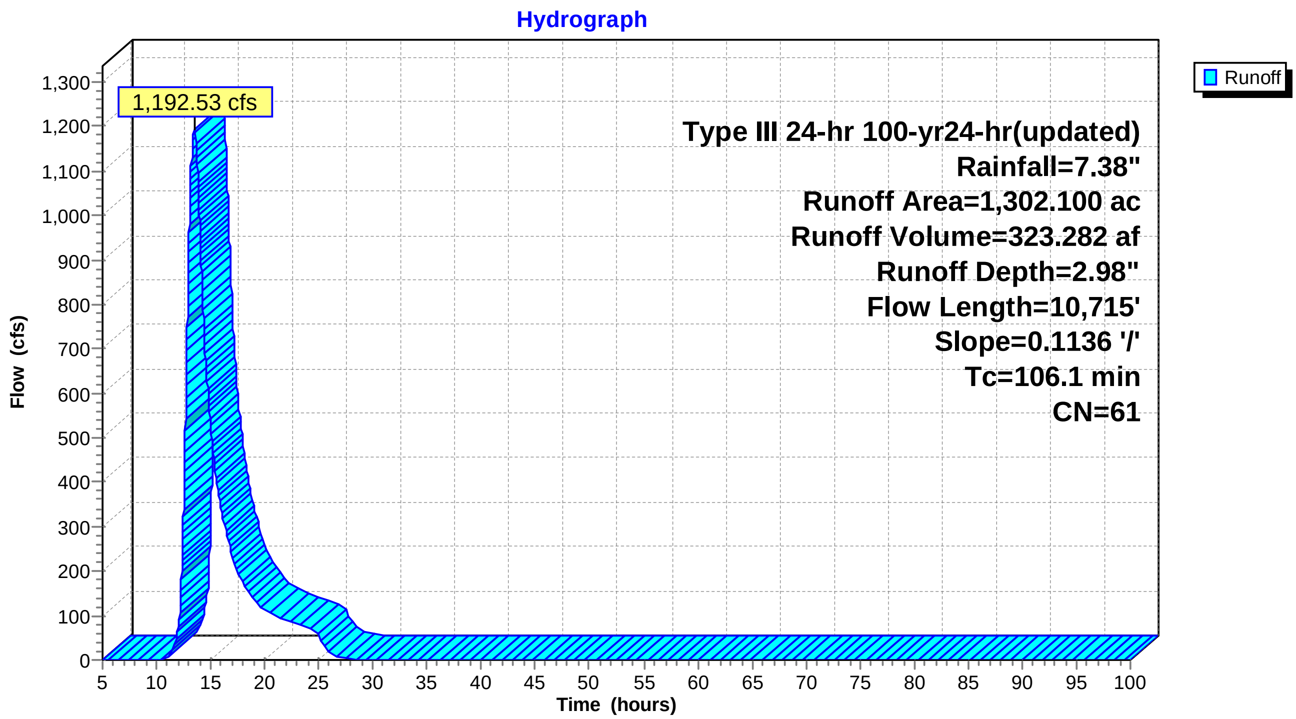
Runoff = 1,192.53 cfs @ 13.45 hrs, Volume= 323.282 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
894.400	55	Woods, Good, HSG B
257.600	70	Woods, Good, HSG C
103.000	77	Woods, Good, HSG D
47.100	98	Water Surface, HSG D
1,302.100	61	Weighted Average
1,255.000		96.38% Pervious Area
47.100		3.62% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
106.1	10,715	0.1136	1.68		**Lag/CN Method,**

Subcatchment 16S:



Summary for Subcatchment 17S:

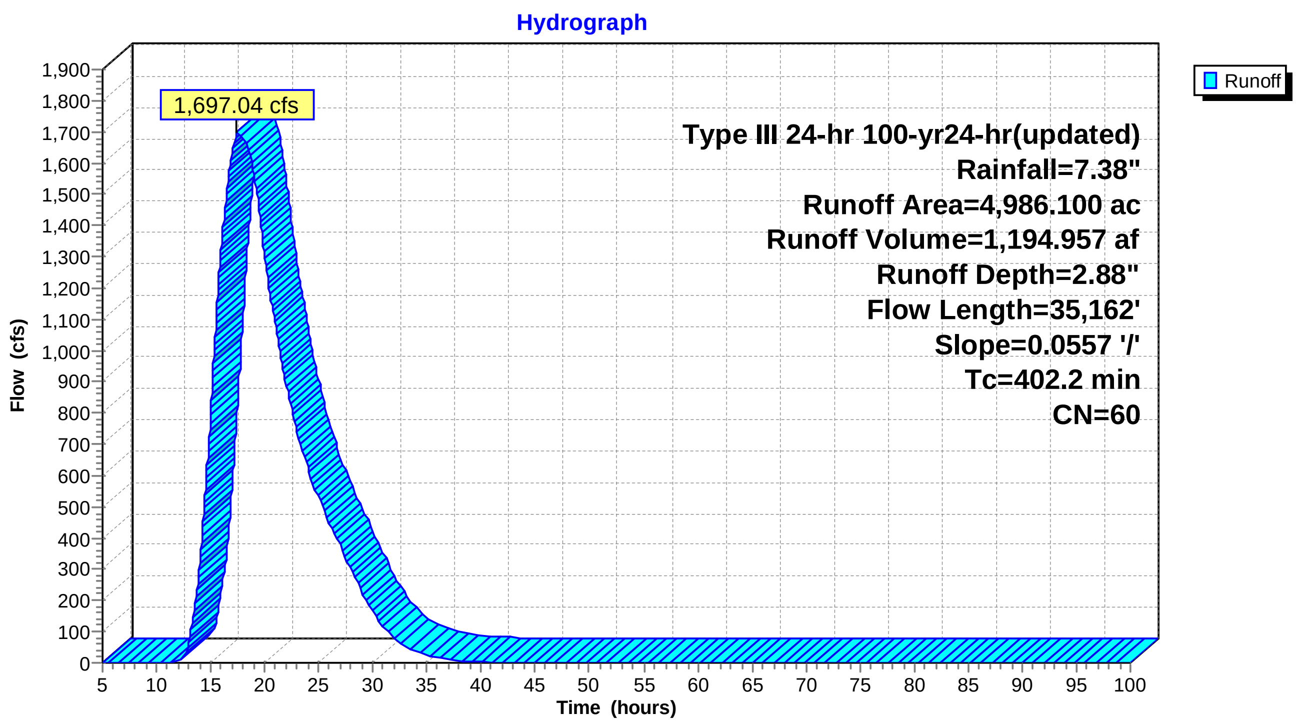
Runoff = 1,697.04 cfs @ 17.44 hrs, Volume= 1,194.957 af, Depth= 2.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
291.800	30	Woods, Good, HSG A
2,904.800	55	Woods, Good, HSG B
1,021.400	70	Woods, Good, HSG C
665.500	77	Woods, Good, HSG D
102.600	98	Water Surface, HSG D
4,986.100	60	Weighted Average
4,883.500		97.94% Pervious Area
102.600		2.06% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
402.2	35,162	0.0557	1.46		**Lag/CN Method,**

Subcatchment 17S:



Summary for Subcatchment 18S: LaRoche Brook

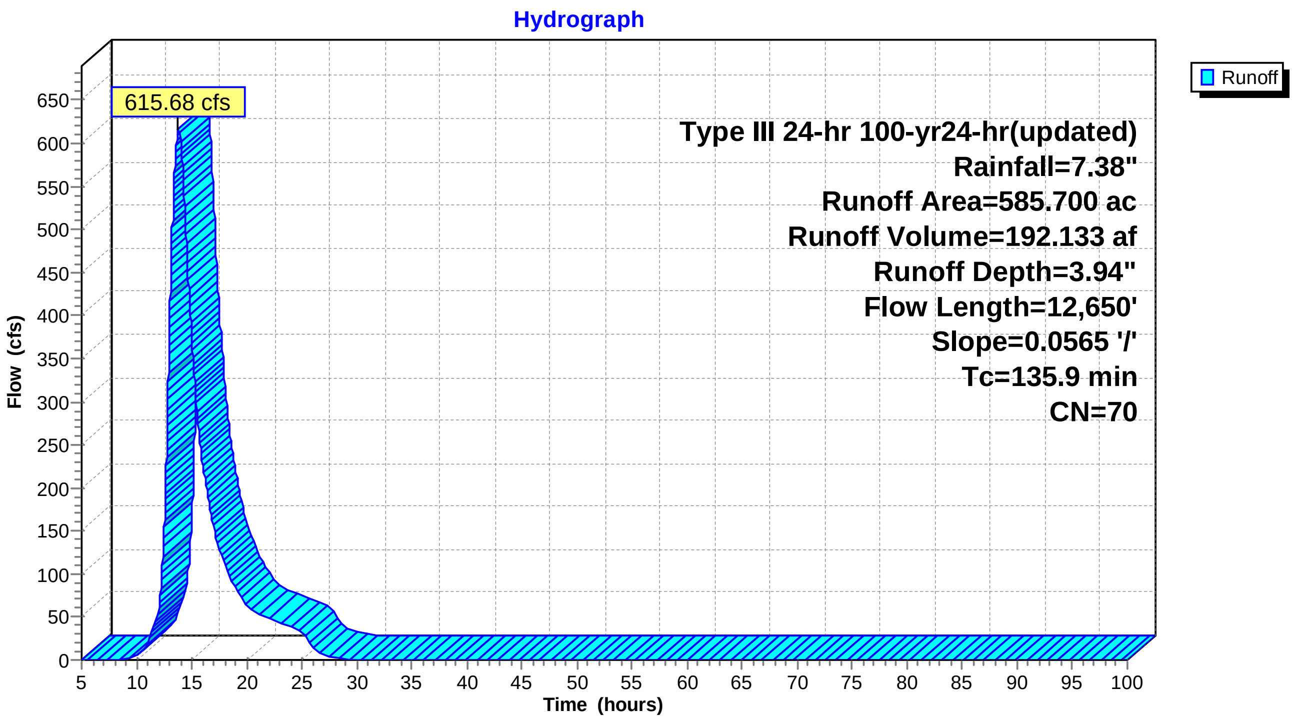
Runoff = 615.68 cfs @ 13.75 hrs, Volume= 192.133 af, Depth= 3.94"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
44.400	30	Woods, Good, HSG A
40.100	55	Woods, Good, HSG B
241.600	70	Woods, Good, HSG C
244.900	77	Woods, Good, HSG D
14.700	98	Water Surface, 0% imp, HSG D
585.700	70	Weighted Average
585.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
135.9	12,650	0.0565	1.55		**Lag/CN Method,**

Subcatchment 18S: LaRoche Brook



Summary for Subcatchment 19S: Ellison Brook

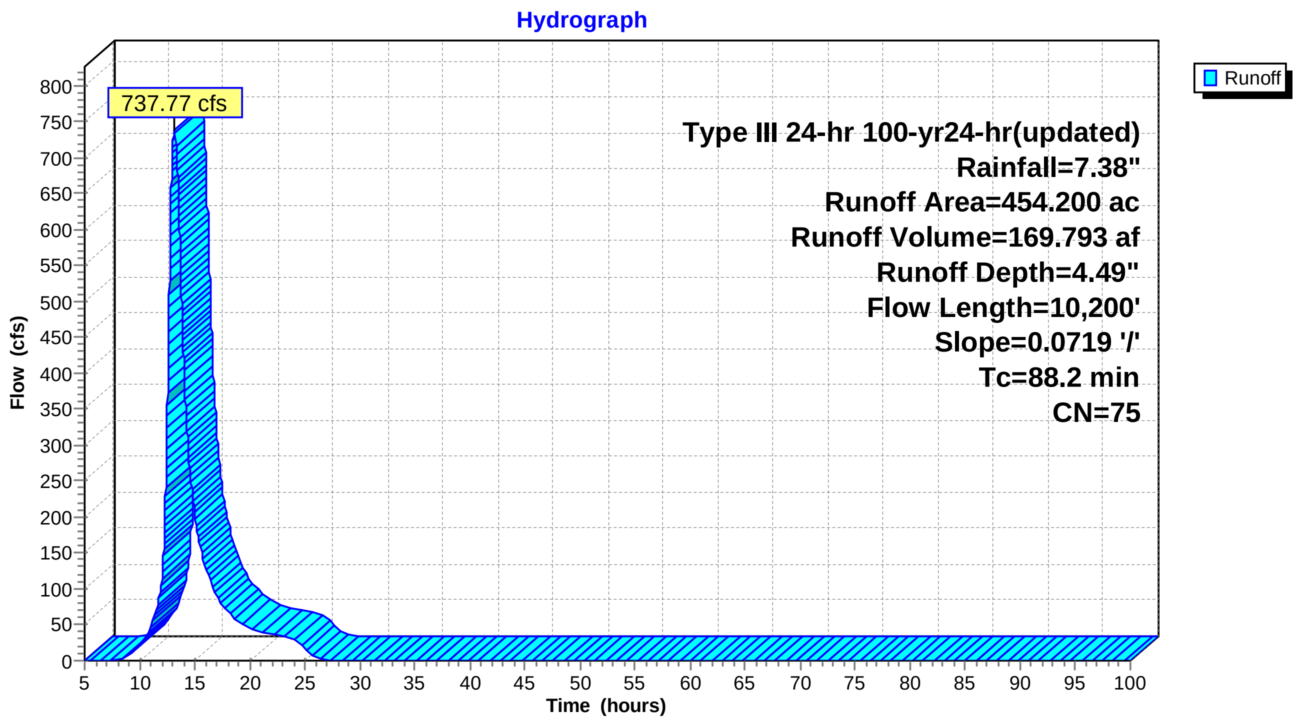
Runoff = 737.77 cfs @ 13.21 hrs, Volume= 169.793 af, Depth= 4.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-yr24-hr(updated) Rainfall=7.38"

Area (ac)	CN	Description
15.600	55	Woods, Good, HSG B
57.000	70	Woods, Good, HSG C
381.200	77	Woods, Good, HSG D
0.400	98	Water Surface, 0% imp, HSG D
454.200	75	Weighted Average
454.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
88.2	10,200	0.0719	1.93		**Lag/CN Method,**

Subcatchment 19S: Ellison Brook



Summary for Reach 1R: Lamprey River (At Flow Split)

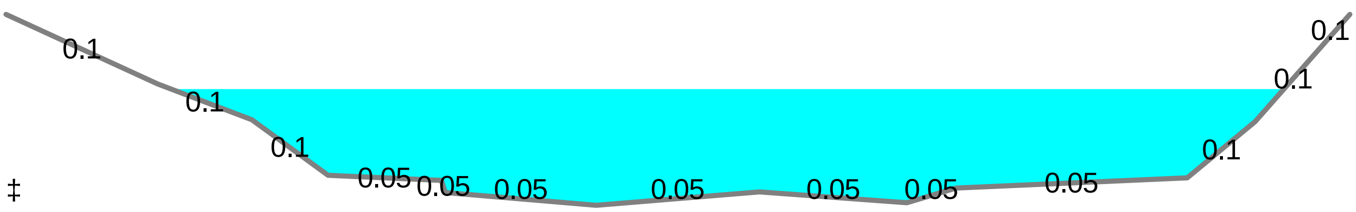
[62] Warning: Exceeded Reach 2R OUTLET depth by 2.14' @ 44.04 hrs
[62] Warning: Exceeded Reach 9R OUTLET depth by 8.23' @ 38.28 hrs

Inflow Area =119,586.000 ac, 3.48% Impervious, Inflow Depth > 2.82" for 100-yr24-hr(updated) event
Inflow = 12,721.87 cfs @ 34.19 hrs, Volume= 28,087.504 af
Outflow = 12,669.65 cfs @ 37.03 hrs, Volume= 27,895.945 af, Atten= 0%, Lag= 170.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.38 fps, Min. Travel Time= 108.2 min
Avg. Velocity = 2.33 fps, Avg. Travel Time= 203.9 min

Peak Storage= 82,237,833 cf @ 35.23 hrs, Average Depth at Peak Storage= 12.97'
Bank-Full Depth= 21.32', Capacity at Bank-Full= 32,888.73 cfs

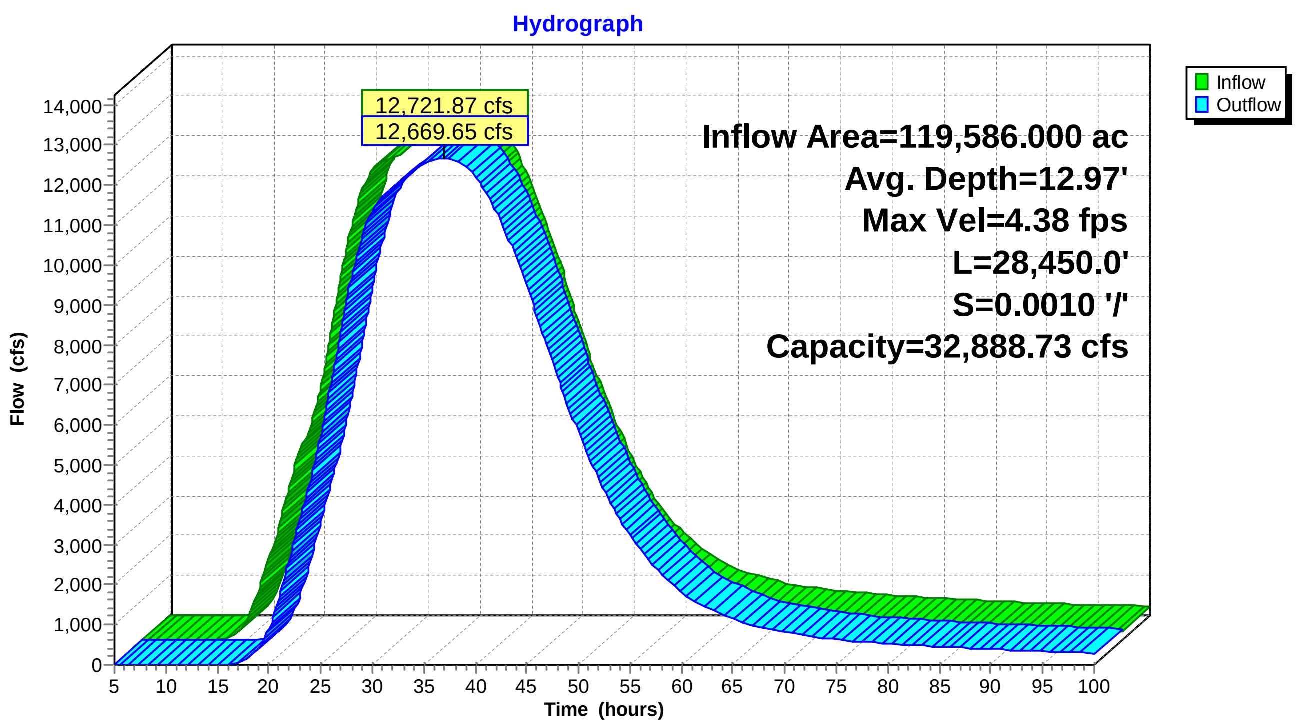
Custom cross-section, Length= 28,450.0' Slope= 0.0010 '/' (111 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 48.84', Outlet Invert= 20.39'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
335.00	49.20	0.00		
375.00	41.45	7.75	0.100	
400.00	37.44	11.76	0.100	
420.00	31.21	17.99	0.100	
450.00	30.68	18.52	0.050	
451.00	29.28	19.92	0.050	
491.00	27.88	21.32	0.050	
534.00	29.38	19.82	0.050	
573.00	28.18	21.02	0.050	
586.00	29.78	19.42	0.050	
647.00	30.95	18.25	0.050	
665.00	37.20	12.00	0.100	
685.00	46.75	2.45	0.100	
690.00	49.20	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	0.0	0	0.00
0.30	2.6	17.2	73,279	0.68
1.40	80.7	125.0	2,295,103	56.63
1.50	93.5	132.0	2,660,177	69.83
1.90	146.9	135.8	4,180,423	145.56
2.80	290.2	183.8	8,255,205	369.71
3.07	343.5	213.2	9,773,093	443.74
3.33	400.7	228.7	11,400,551	548.43
9.32	1,874.2	267.1	53,320,918	6,573.62
9.56	1,937.8	268.5	55,129,423	6,922.59
13.57	3,069.4	303.1	87,324,248	13,841.64
18.87	4,755.5	343.3	135,293,131	26,083.92
21.32	5,603.6	361.7	159,422,562	32,888.73

Reach 1R: Lamprey River (At Flow Split)



Summary for Reach 2R: Lamprey River

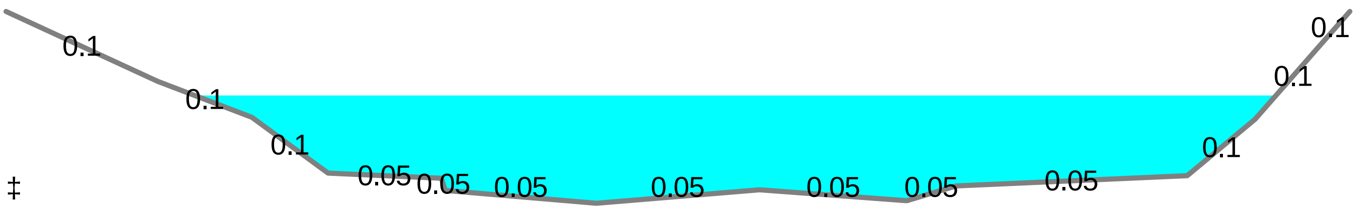
[62] Warning: Exceeded Reach 11R OUTLET depth by 5.48' @ 40.46 hrs

Inflow Area = 95,785.700 ac, 3.87% Impervious, Inflow Depth > 2.89" for 100-yr24-hr(updated) event
Inflow = 11,926.86 cfs @ 32.46 hrs, Volume= 23,078.962 af
Outflow = 11,826.55 cfs @ 35.47 hrs, Volume= 22,928.162 af, Atten= 1%, Lag= 180.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.53 fps, Min. Travel Time= 112.9 min
Avg. Velocity = 2.27 fps, Avg. Travel Time= 225.5 min

Peak Storage= 80,129,790 cf @ 33.58 hrs, Average Depth at Peak Storage= 12.00'
Bank-Full Depth= 21.32', Capacity at Bank-Full= 35,733.21 cfs

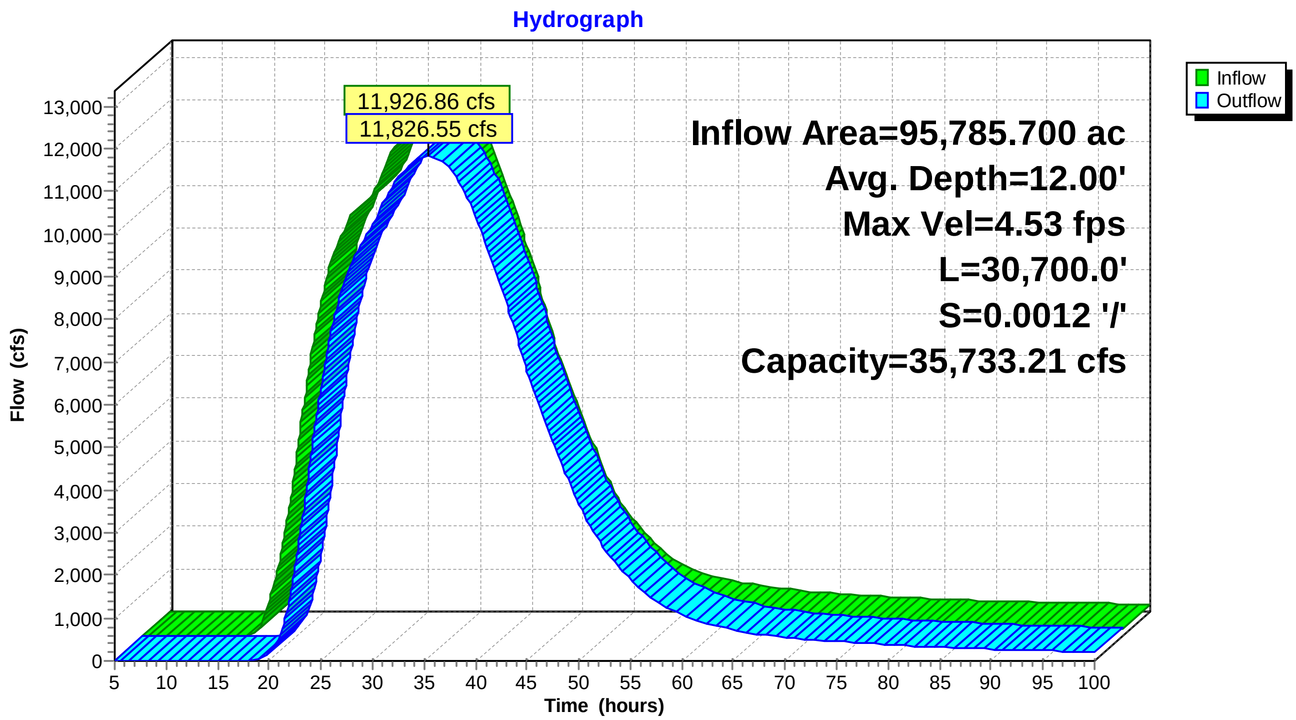
Custom cross-section, Length= 30,700.0' Slope= 0.0012 '/' (111 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 85.08', Outlet Invert= 48.84'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
335.00	49.20	0.00		
375.00	41.45	7.75	0.100	
400.00	37.44	11.76	0.100	
420.00	31.21	17.99	0.100	
450.00	30.68	18.52	0.050	
451.00	29.28	19.92	0.050	
491.00	27.88	21.32	0.050	
534.00	29.38	19.82	0.050	
573.00	28.18	21.02	0.050	
586.00	29.78	19.42	0.050	
647.00	30.95	18.25	0.050	
665.00	37.20	12.00	0.100	
685.00	46.75	2.45	0.100	
690.00	49.20	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	0.0	0	0.00
0.30	2.6	17.2	79,074	0.74
1.40	80.7	125.0	2,476,614	61.53
1.50	93.5	132.0	2,870,560	75.86
1.90	146.9	135.8	4,511,036	158.15
2.80	290.2	183.8	8,908,077	401.69
3.07	343.5	213.2	10,546,009	482.12
3.33	400.7	228.7	12,302,176	595.86
9.32	1,874.2	267.1	57,537,862	7,142.16
9.56	1,937.8	268.5	59,489,395	7,521.31
13.57	3,069.4	303.1	94,230,384	15,038.77
18.87	4,755.5	343.3	145,992,939	28,339.86
21.32	5,603.6	361.7	172,030,674	35,733.21

Reach 2R: Lamprey River



Summary for Reach 3R: Lamprey River

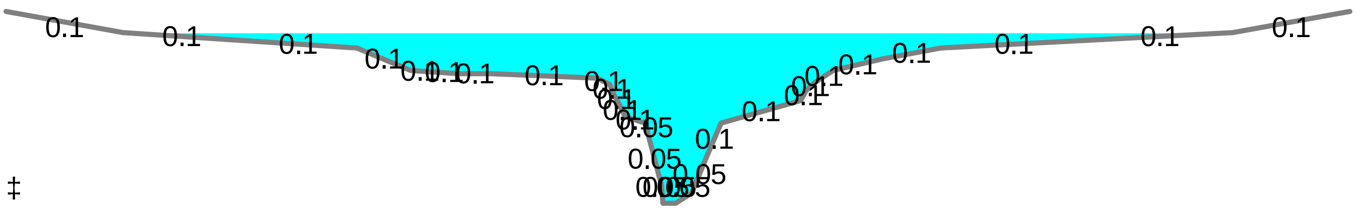
[62] Warning: Exceeded Reach 4R OUTLET depth by 15.54' @ 36.78 hrs

Inflow Area = 72,155.200 ac, 4.71% Impervious, Inflow Depth > 2.85" for 100-yr24-hr(updated) event
Inflow = 11,782.95 cfs @ 28.65 hrs, Volume= 17,127.806 af
Outflow = 10,094.27 cfs @ 34.43 hrs, Volume= 17,044.289 af, Atten= 14%, Lag= 346.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 2.28 fps, Min. Travel Time= 138.1 min
Avg. Velocity = 1.62 fps, Avg. Travel Time= 193.5 min

Peak Storage= 115,829,960 cf @ 32.13 hrs, Average Depth at Peak Storage= 32.39'
Bank-Full Depth= 36.50', Capacity at Bank-Full= 17,060.69 cfs

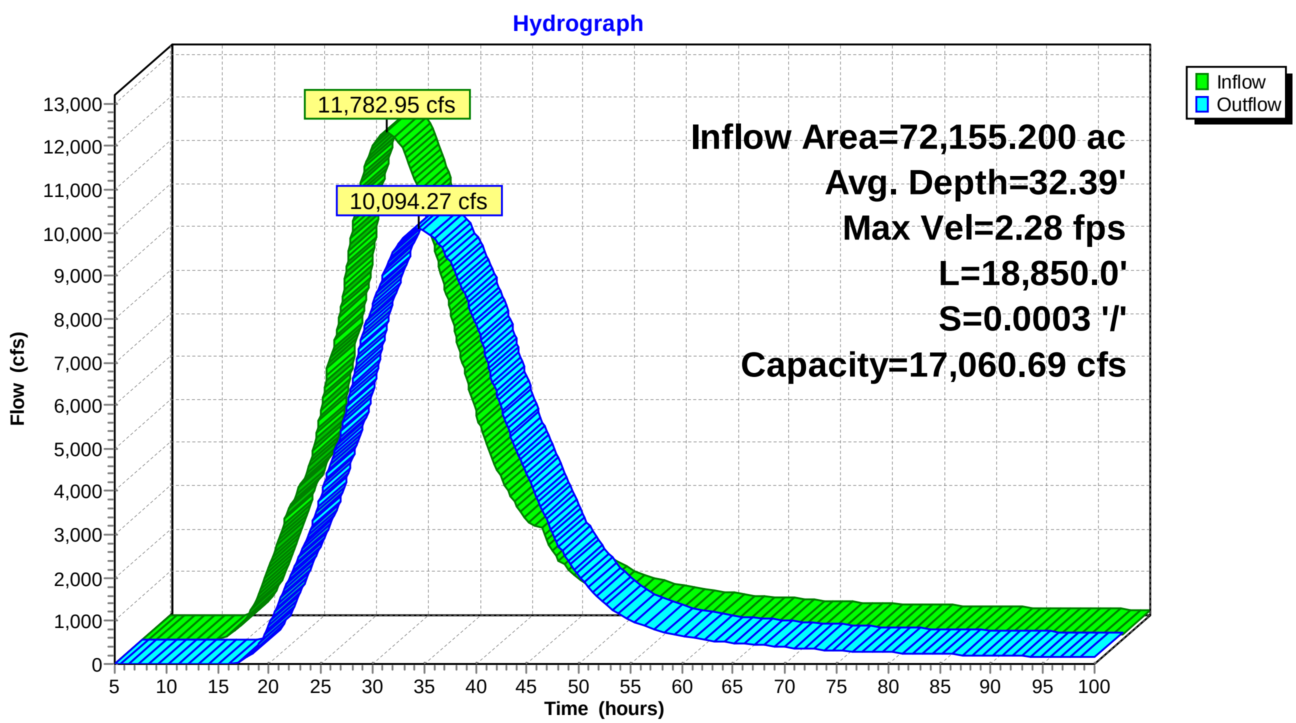
Custom cross-section, Length= 18,850.0' Slope= 0.0003 '/' (119 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 105.56', Outlet Invert= 99.90'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-300.00	58.00	0.00		
-200.00	54.00	4.00	0.100	first n not used
-100.00	52.50	5.50	0.100	first n not used
0.00	51.00	7.00	0.100	first n not used
46.16	46.83	11.17	0.100	first n not used
62.23	46.51	11.49	0.100	
88.00	46.20	11.80	0.100	
115.00	46.10	11.90	0.100	
206.00	45.35	12.65	0.100	
216.45	44.05	13.95	0.100	
220.00	42.30	15.70	0.100	
225.00	40.30	17.70	0.100	
230.00	38.00	20.00	0.100	
247.00	36.70	21.30	0.100	
249.00	35.00	23.00	0.050	
261.00	24.80	33.20	0.050	
262.00	21.50	36.50	0.050	
273.00	21.50	36.50	0.050	
287.00	23.50	34.50	0.050	
300.00	30.50	27.50	0.050	
312.00	36.70	21.30	0.100	
380.00	41.00	17.00	0.100	
385.00	43.00	15.00	0.100	
392.00	44.50	13.50	0.100	
408.00	46.83	11.17	0.100	
450.00	49.00	9.00	0.100	
500.00	51.00	7.00	0.100	
625.00	52.50	5.50	0.100	
750.00	54.00	4.00	0.100	
850.00	58.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	11.0	0	0.00
2.00	36.6	27.2	690,024	22.96
3.30	71.7	31.3	1,351,909	64.15
9.00	283.0	52.2	5,333,829	449.93
13.50	520.1	68.9	9,804,819	1,079.05
15.20	626.2	75.2	11,802,928	1,383.21
16.50	735.1	112.9	13,855,934	1,669.29
18.80	1,018.5	154.8	19,199,185	2,293.26
19.50	1,123.8	167.8	21,182,923	2,513.95
20.80	1,331.8	174.8	25,103,723	2,980.37
21.50	1,447.1	178.3	27,278,721	3,252.38
22.55	1,625.6	185.7	30,642,159	3,681.77
23.00	1,704.9	191.5	32,137,950	3,869.63
23.85	1,862.6	204.2	35,109,905	4,237.67
24.60	2,042.5	300.4	38,501,661	4,519.09
24.70	2,072.7	328.1	39,070,612	4,559.07
25.01	2,174.9	356.1	40,996,765	4,718.01
25.33	2,287.8	374.4	43,124,289	4,894.33
27.50	3,144.6	440.5	59,275,450	6,233.62
29.50	4,072.4	512.8	76,765,628	7,765.10
31.00	4,991.2	737.8	94,084,065	8,741.85
32.50	6,247.4	962.8	117,764,378	10,216.65
36.50	10,447.4	1,163.0	196,934,378	17,060.69

Reach 3R: Lamprey River



Summary for Reach 4R: Lamprey River

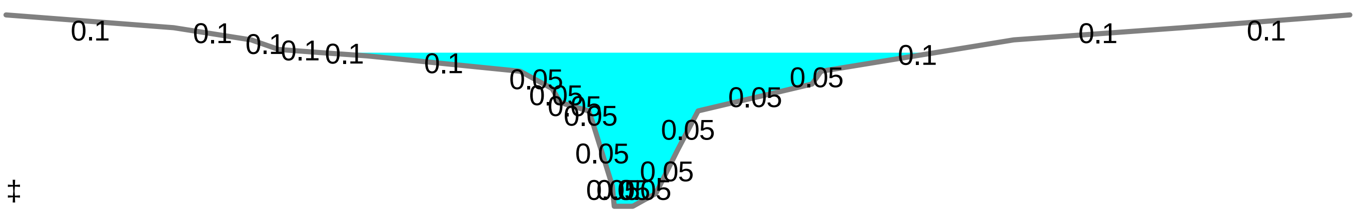
[85] Warning: Oscillations may require Finer Routing>1
[62] Warning: Exceeded Reach 5R OUTLET depth by 11.54' @ 36.46 hrs
[62] Warning: Exceeded Reach 13R OUTLET depth by 13.69' @ 27.08 hrs

Inflow Area = 51,439.100 ac, 4.41% Impervious, Inflow Depth > 2.86" for 100-yr24-hr(updated) event
Inflow = 10,330.18 cfs @ 24.69 hrs, Volume= 12,258.497 af
Outflow = 9,161.17 cfs @ 29.54 hrs, Volume= 12,163.033 af, Atten= 11%, Lag= 290.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.04 fps, Min. Travel Time= 158.7 min
Avg. Velocity = 2.55 fps, Avg. Travel Time= 251.8 min

Peak Storage= 87,230,438 cf @ 26.89 hrs, Average Depth at Peak Storage= 24.49'
Bank-Full Depth= 30.50', Capacity at Bank-Full= 21,410.58 cfs

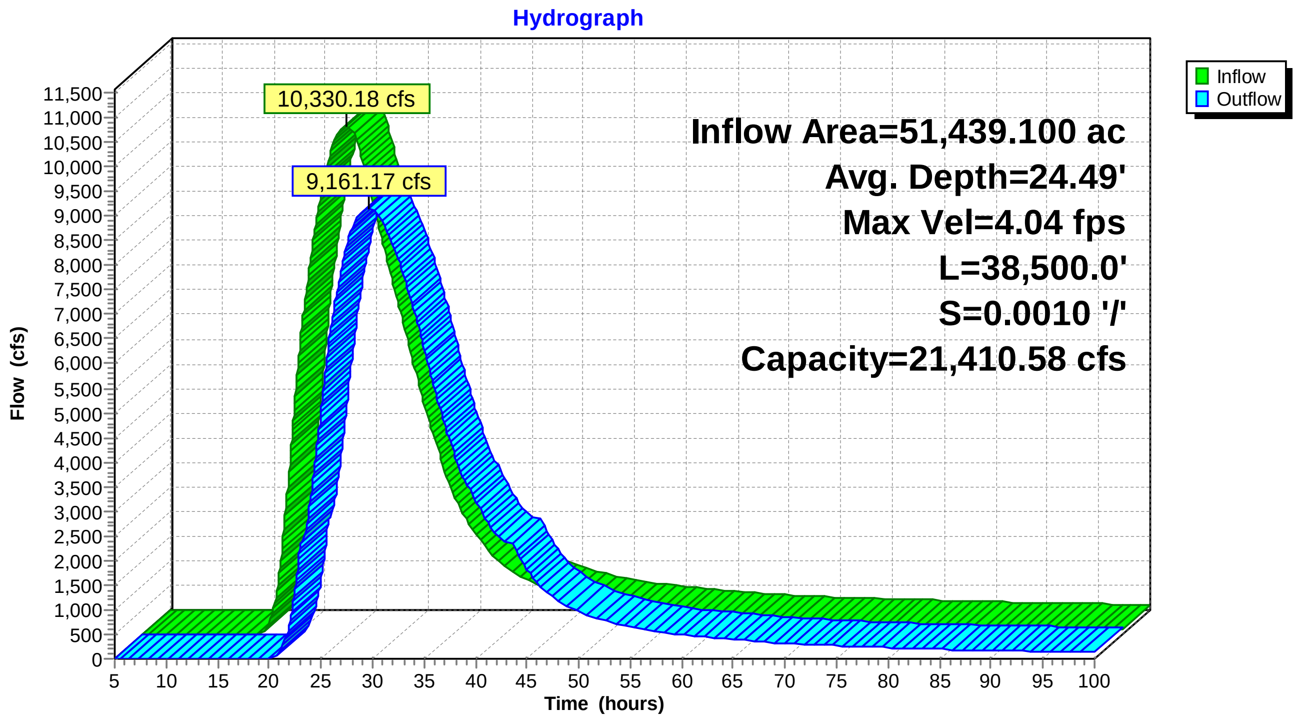
Custom cross-section, Length= 38,500.0' Slope= 0.0010 '/' (113 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 140.21', Outlet Invert= 101.71'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-100.00	52.00	0.00		
0.00	50.00	2.00	0.100	
46.16	48.00	4.00	0.100	
62.23	46.51	5.49	0.100	
88.00	46.00	6.00	0.100	
115.00	45.50	6.50	0.100	
206.00	43.00	9.00	0.100	
225.00	40.30	11.70	0.050	
230.00	38.00	14.00	0.050	
247.00	36.70	15.30	0.050	
249.00	35.00	17.00	0.050	
261.00	24.80	27.20	0.050	
262.00	21.50	30.50	0.050	
273.00	21.50	30.50	0.050	
287.00	23.50	28.50	0.050	
300.00	30.50	21.50	0.050	
312.00	36.70	15.30	0.050	
380.00	41.00	11.00	0.050	
385.00	43.00	9.00	0.050	
500.00	48.00	4.00	0.100	
600.00	50.00	2.00	0.100	
700.00	52.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	11.0	0	0.00
2.00	36.6	27.2	1,409,333	41.90
3.30	71.7	31.3	2,761,193	117.07
9.00	283.0	52.2	10,894,028	821.09
13.50	520.1	68.9	20,025,651	1,881.10
15.20	626.2	75.2	24,106,775	2,416.73
16.50	735.1	112.9	28,299,917	2,408.97
18.80	1,018.5	154.8	39,213,190	3,360.66
19.50	1,124.9	170.9	43,307,652	3,713.01
21.50	1,463.8	190.5	56,356,300	5,356.97
24.00	2,096.9	339.1	80,731,612	8,457.17
24.50	2,270.3	377.6	87,406,550	9,179.86
25.01	2,466.5	415.1	94,961,116	9,962.00
26.50	3,105.2	465.6	119,551,771	12,549.18
28.50	4,159.1	611.8	160,124,611	16,578.54
30.50	5,559.1	811.8	214,024,611	21,410.58

Reach 4R: Lamprey River



Summary for Reach 5R: Lamprey River

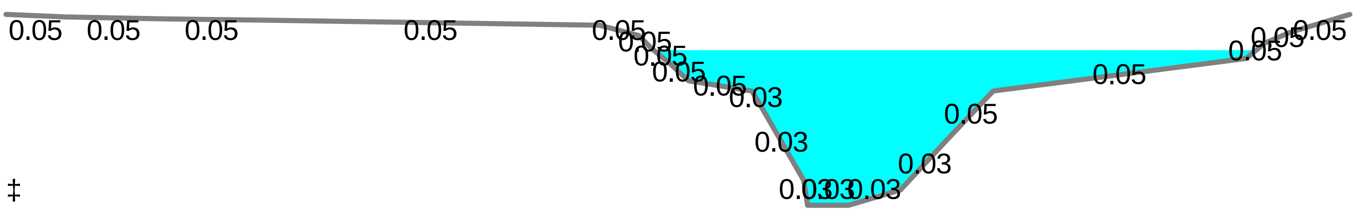
[62] Warning: Exceeded Reach 6R OUTLET depth by 1.77' @ 34.82 hrs
[62] Warning: Exceeded Reach 14R OUTLET depth by 14.90' @ 19.80 hrs

Inflow Area = 38,399.800 ac, 2.07% Impervious, Inflow Depth > 2.88" for 100-yr24-hr(updated) event
Inflow = 9,484.82 cfs @ 21.62 hrs, Volume= 9,202.983 af
Outflow = 8,992.78 cfs @ 24.55 hrs, Volume= 9,171.740 af, Atten= 5%, Lag= 175.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 6.95 fps, Min. Travel Time= 91.2 min
Avg. Velocity = 3.17 fps, Avg. Travel Time= 200.0 min

Peak Storage= 49,339,526 cf @ 23.03 hrs, Average Depth at Peak Storage= 20.59'
Bank-Full Depth= 25.33', Capacity at Bank-Full= 15,419.89 cfs

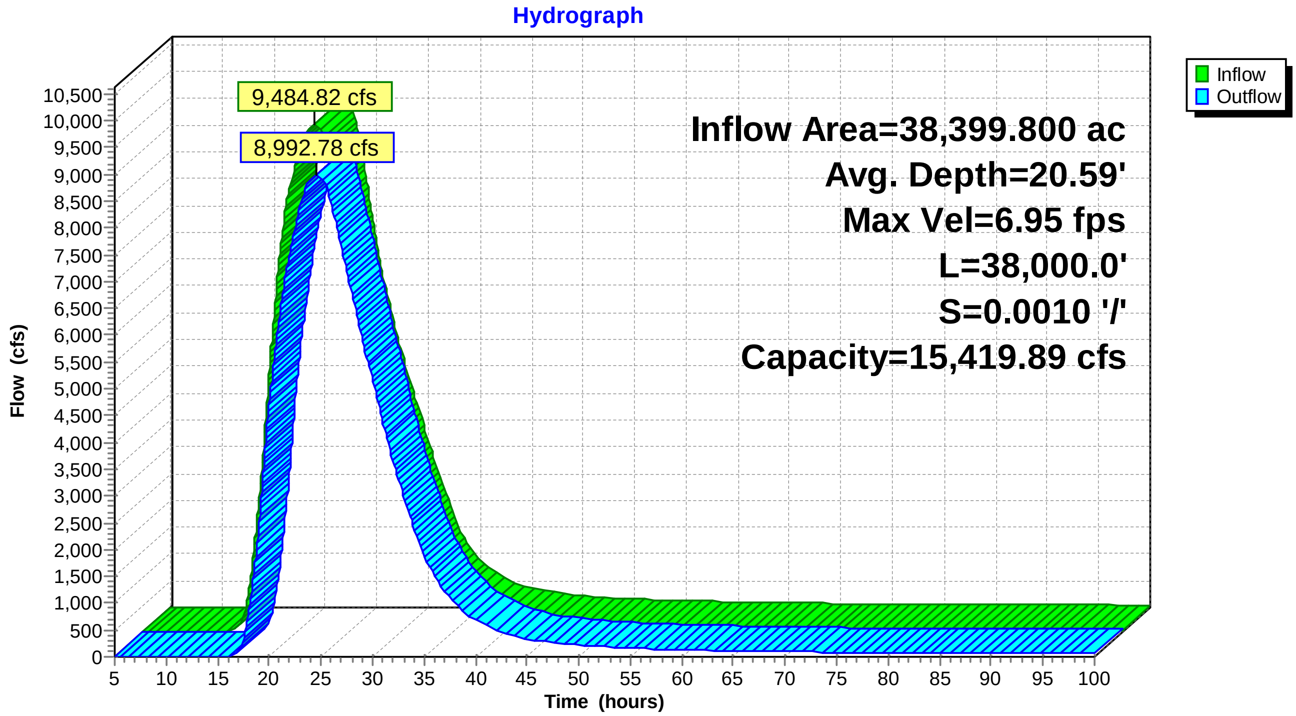
Custom cross-section, Length= 38,000.0' Slope= 0.0010 '/' (114 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 178.21', Outlet Invert= 140.21'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
46.16	46.83	0.00		
62.23	46.51	0.32	0.050	
88.00	46.20	0.63	0.050	
115.00	46.10	0.73	0.050	
206.00	45.35	1.48	0.050	
216.45	44.05	2.78	0.050	
220.00	42.30	4.53	0.050	
225.00	40.30	6.53	0.050	
230.00	38.00	8.83	0.050	
247.00	36.70	10.13	0.050	
249.00	35.00	11.83	0.030	
261.00	24.80	22.03	0.030	
262.00	21.50	25.33	0.030	
273.00	21.50	25.33	0.030	
287.00	23.50	23.33	0.030	
300.00	30.50	16.33	0.030	
312.00	36.70	10.13	0.050	
380.00	41.00	5.83	0.050	
385.00	43.00	3.83	0.050	
392.00	44.50	2.33	0.050	
408.00	46.83	0.00	0.050	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	11.0	0	0.00
2.00	36.6	27.2	1,391,030	69.84
3.30	71.7	31.3	2,725,333	195.12
9.00	283.0	52.2	10,752,547	1,368.48
13.50	520.1	68.9	19,765,577	3,286.82
15.20	626.2	75.2	23,793,974	4,218.64
16.50	735.1	112.9	27,932,386	5,094.66
18.80	1,018.5	154.8	38,703,928	7,045.17
19.50	1,123.8	167.8	42,703,326	7,744.20
20.80	1,331.8	174.8	50,606,975	9,239.45
21.50	1,447.1	178.3	54,991,586	10,116.29
22.55	1,625.6	185.7	61,771,992	11,503.63
23.00	1,704.9	191.5	64,786,870	12,110.08
23.85	1,862.6	204.2	70,778,589	13,300.29
24.60	2,042.5	300.4	77,616,081	14,188.68
24.70	2,072.7	328.1	78,763,037	14,315.84
25.01	2,174.9	356.1	82,645,998	14,837.39
25.33	2,287.8	374.4	86,934,907	15,419.89

Reach 5R: Lamprey River



Summary for Reach 6R: Lamprey River

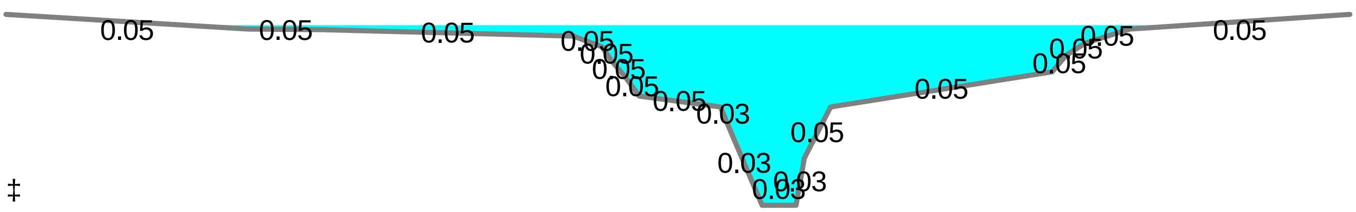
[62] Warning: Exceeded Reach 7R OUTLET depth by 4.70' @ 22.08 hrs
[62] Warning: Exceeded Reach 15R OUTLET depth by 16.60' @ 21.58 hrs

Inflow Area = 32,966.800 ac, 1.37% Impervious, Inflow Depth > 3.03" for 100-yr24-hr(updated) event
Inflow = 9,572.64 cfs @ 19.47 hrs, Volume= 8,323.989 af
Outflow = 9,152.72 cfs @ 21.37 hrs, Volume= 8,321.446 af, Atten= 4%, Lag= 114.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 5.65 fps, Min. Travel Time= 44.3 min
Avg. Velocity = 2.55 fps, Avg. Travel Time= 98.0 min

Peak Storage= 27,933,271 cf @ 20.64 hrs, Average Depth at Peak Storage= 21.94'
Bank-Full Depth= 23.30', Capacity at Bank-Full= 11,099.45 cfs

Custom cross-section, Length= 15,000.0' Slope= 0.0011 '/' (112 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 194.71', Outlet Invert= 178.21'



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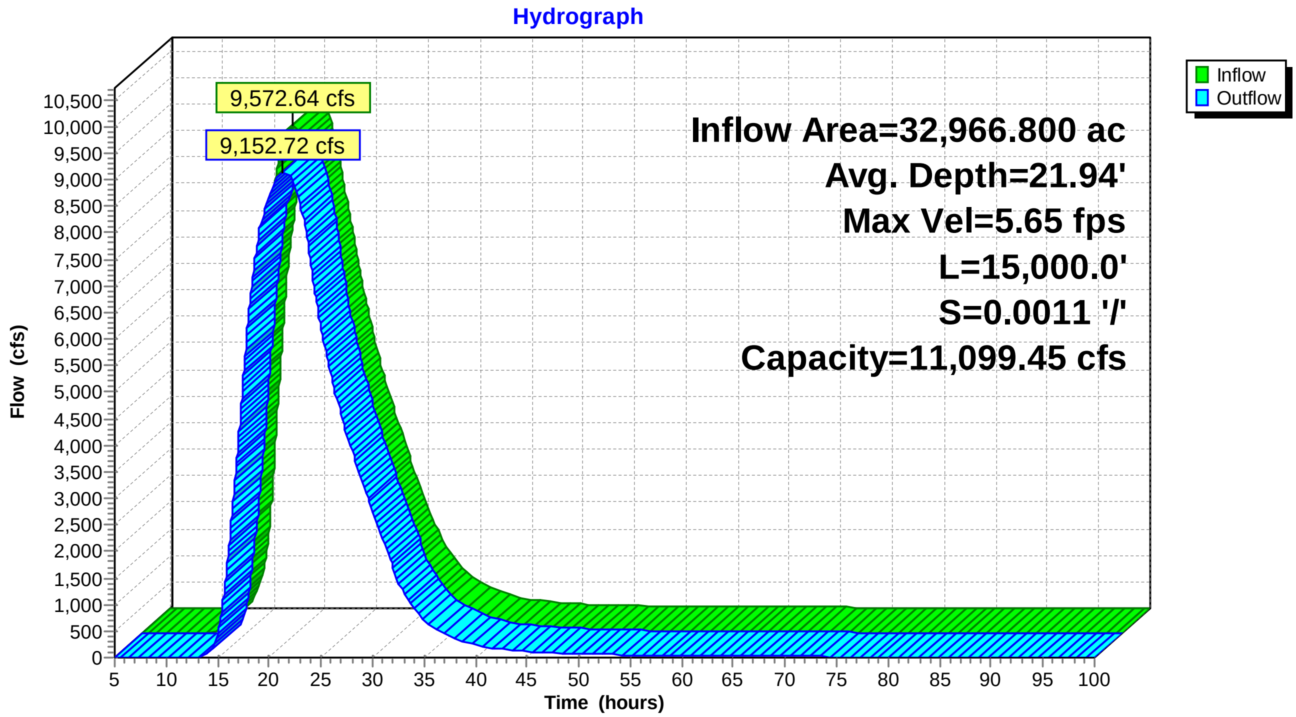
Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
0.00	48.00	0.00		
88.00	46.20	1.80	0.050	first n not used
115.00	46.10	1.90	0.050	
206.00	45.35	2.65	0.050	
216.45	44.05	3.95	0.050	
220.00	42.30	5.70	0.050	
225.00	40.30	7.70	0.050	
230.00	38.00	10.00	0.050	
259.50	36.70	11.30	0.050	
261.50	35.00	13.00	0.030	
274.50	24.70	23.30	0.030	
287.00	24.70	23.30	0.030	
290.00	30.50	17.50	0.030	
299.50	36.70	11.30	0.050	
380.00	41.00	7.00	0.050	
385.00	43.00	5.00	0.050	
392.00	44.50	3.50	0.050	
408.00	46.20	1.80	0.050	
488.00	48.00	0.00	0.050	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	12.5	0	0.00
5.80	102.4	28.4	1,536,437	396.03
10.30	233.4	43.8	3,501,212	1,220.79
12.00	297.5	49.6	4,462,500	1,667.72
13.30	384.5	103.5	5,767,413	2,122.11
15.60	655.6	152.1	9,833,799	3,355.27
16.30	760.1	167.1	11,401,687	3,842.26
17.60	968.1	174.1	14,521,687	4,960.65
18.30	1,083.5	177.6	16,252,455	5,638.77
19.35	1,261.9	185.0	18,928,931	6,732.30
19.80	1,341.3	190.8	20,119,124	7,207.86
20.65	1,499.9	205.7	22,497,956	8,128.79
21.40	1,682.1	303.8	25,232,037	8,638.57
21.50	1,712.7	331.7	25,691,081	8,710.47
23.30	2,439.9	499.8	36,599,081	11,099.45

Reach 6R: Lamprey River



Summary for Reach 7R: Lamprey River

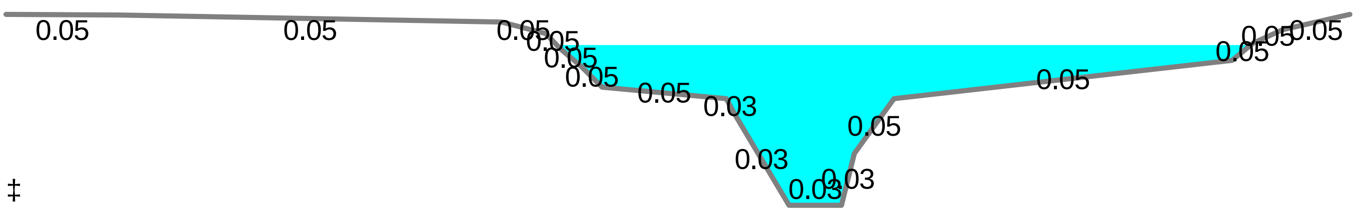
[62] Warning: Exceeded Reach 8R OUTLET depth by 9.19' @ 21.70 hrs
[62] Warning: Exceeded Reach 16R OUTLET depth by 14.06' @ 19.94 hrs

Inflow Area = 21,927.400 ac, 0.72% Impervious, Inflow Depth > 2.99" for 100-yr24-hr(updated) event
Inflow = 7,063.06 cfs @ 18.45 hrs, Volume= 5,466.512 af
Outflow = 6,722.31 cfs @ 20.41 hrs, Volume= 5,463.736 af, Atten= 5%, Lag= 117.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 7.02 fps, Min. Travel Time= 54.6 min
Avg. Velocity = 2.84 fps, Avg. Travel Time= 134.9 min

Peak Storage= 24,031,177 cf @ 19.50 hrs, Average Depth at Peak Storage= 18.07'
Bank-Full Depth= 21.50', Capacity at Bank-Full= 10,828.53 cfs

Custom cross-section, Length= 23,000.0' Slope= 0.0017 '/' (110 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 233.81', Outlet Invert= 194.71'



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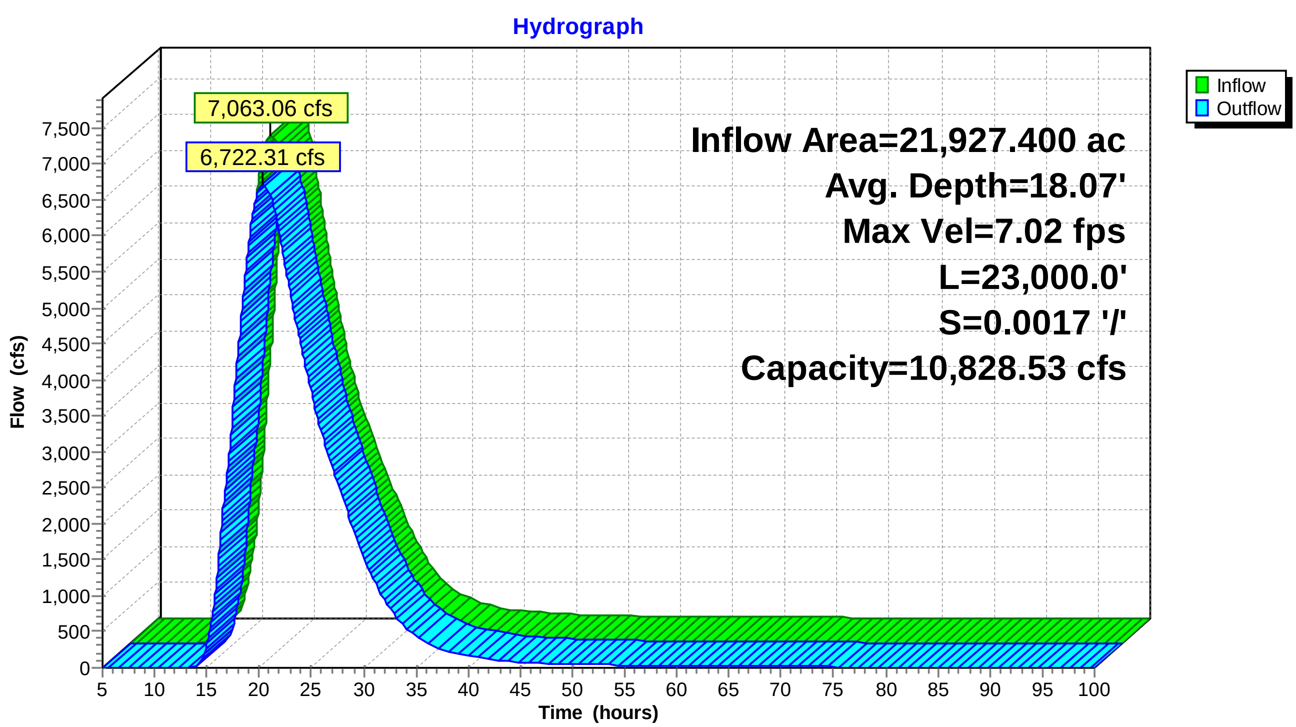
Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
88.00	46.20	0.00		
115.00	46.10	0.10	0.050	
206.00	45.35	0.85	0.050	
216.45	44.05	2.15	0.050	
220.00	42.30	3.90	0.050	
225.00	40.30	5.90	0.050	
230.00	38.00	8.20	0.050	
259.50	36.70	9.50	0.050	
261.50	35.00	11.20	0.030	
274.50	24.70	21.50	0.030	
287.00	24.70	21.50	0.030	
290.00	30.50	15.70	0.030	
299.50	36.70	9.50	0.050	
380.00	41.00	5.20	0.050	
385.00	43.00	3.20	0.050	
392.00	44.50	1.70	0.050	
408.00	46.20	0.00	0.050	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	12.5	0	0.00
5.80	102.4	28.4	2,355,892	492.41
10.30	233.4	43.8	5,368,525	1,517.64
12.00	297.5	49.6	6,842,500	2,073.25
13.30	384.5	103.5	8,843,366	2,638.13
15.60	655.6	152.1	15,078,492	4,171.14
16.30	760.1	167.1	17,482,587	4,776.56
17.60	968.1	174.1	22,266,587	6,166.90
18.30	1,083.5	177.6	24,920,431	7,009.91
19.35	1,261.9	185.0	29,024,361	8,369.34
19.80	1,341.3	190.8	30,849,156	8,960.78
20.65	1,499.9	205.7	34,496,866	10,105.41
21.40	1,682.1	303.8	38,689,124	10,739.16
21.50	1,712.7	331.7	39,392,991	10,828.53

Reach 7R: Lamprey River



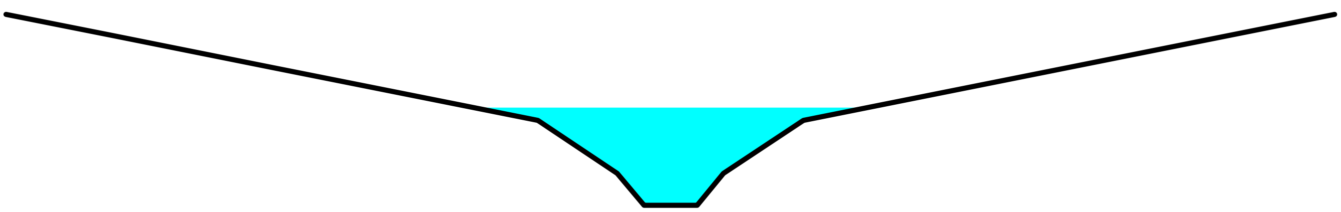
Summary for Reach 8R: Lamprey River

Inflow Area = 5,406.400 ac, 0.91% Impervious, Inflow Depth > 2.74" for 100-yr24-hr(updated) event
Inflow = 1,563.30 cfs @ 17.92 hrs, Volume= 1,234.721 af
Outflow = 1,523.16 cfs @ 19.19 hrs, Volume= 1,233.690 af, Atten= 3%, Lag= 75.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 10.53 fps, Min. Travel Time= 34.3 min
Avg. Velocity = 4.51 fps, Avg. Travel Time= 80.1 min

Peak Storage= 3,219,167 cf @ 18.62 hrs, Average Depth at Peak Storage= 9.24'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 13,482.05 cfs

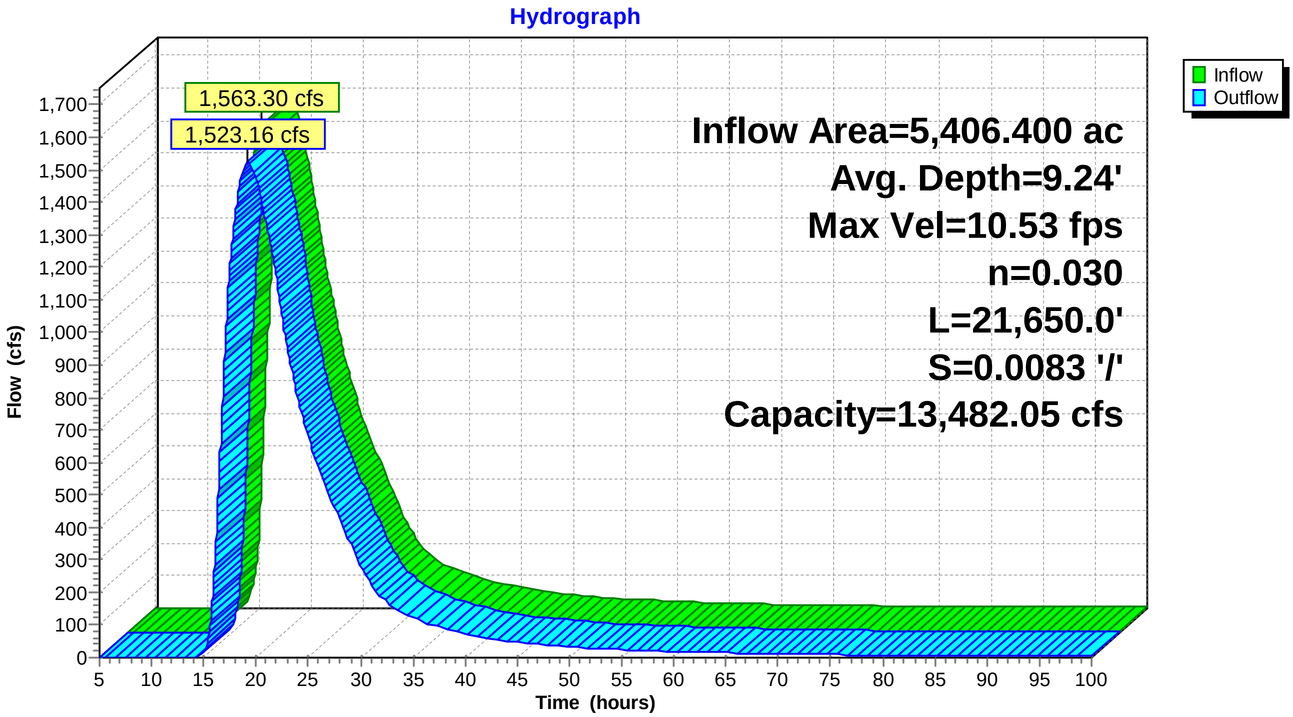
Custom cross-section, Length= 21,650.0' Slope= 0.0083 '/' (104 Elevation Intervals)
Constant n= 0.030 Earth, grassed & winding
Inlet Invert= 413.50', Outlet Invert= 233.81'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	487,125	147.81
8.00	110.0	30.8	2,381,500	1,158.85
13.00	360.0	81.8	7,794,000	4,361.80
16.00	630.0	112.4	13,639,500	8,969.39
18.00	860.0	132.8	18,619,000	13,482.05

Reach 8R: Lamprey River



Summary for Reach 9R: Little River

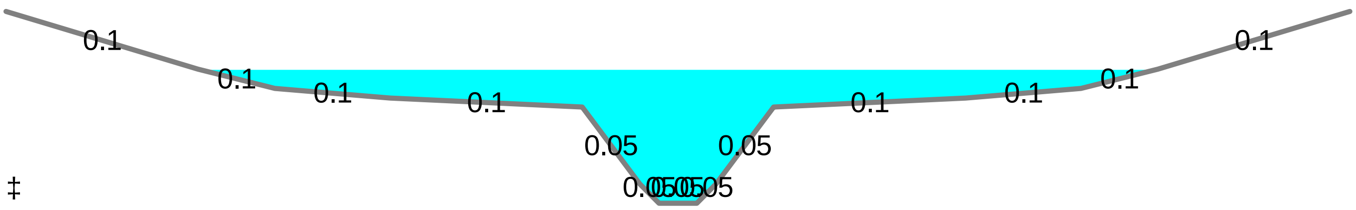
[81] Warning: Exceeded Pond 2P by 4.26' @ 15.30 hrs

Inflow Area = 13,082.700 ac, 2.78% Impervious, Inflow Depth > 2.30" for 100-yr24-hr(updated) event
Inflow = 2,774.74 cfs @ 18.72 hrs, Volume= 2,506.053 af
Outflow = 2,548.41 cfs @ 20.63 hrs, Volume= 2,498.403 af, Atten= 8%, Lag= 114.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 5.93 fps, Min. Travel Time= 52.0 min
Avg. Velocity = 3.40 fps, Avg. Travel Time= 90.5 min

Peak Storage= 9,473,066 cf @ 19.76 hrs, Average Depth at Peak Storage= 13.90'
Bank-Full Depth= 20.00', Capacity at Bank-Full= 8,256.48 cfs

Custom cross-section, Length= 18,480.0' Slope= 0.0049 '/'
Flow calculated by Manning's Subdivision method
Inlet Invert= 140.00', Outlet Invert= 48.84'

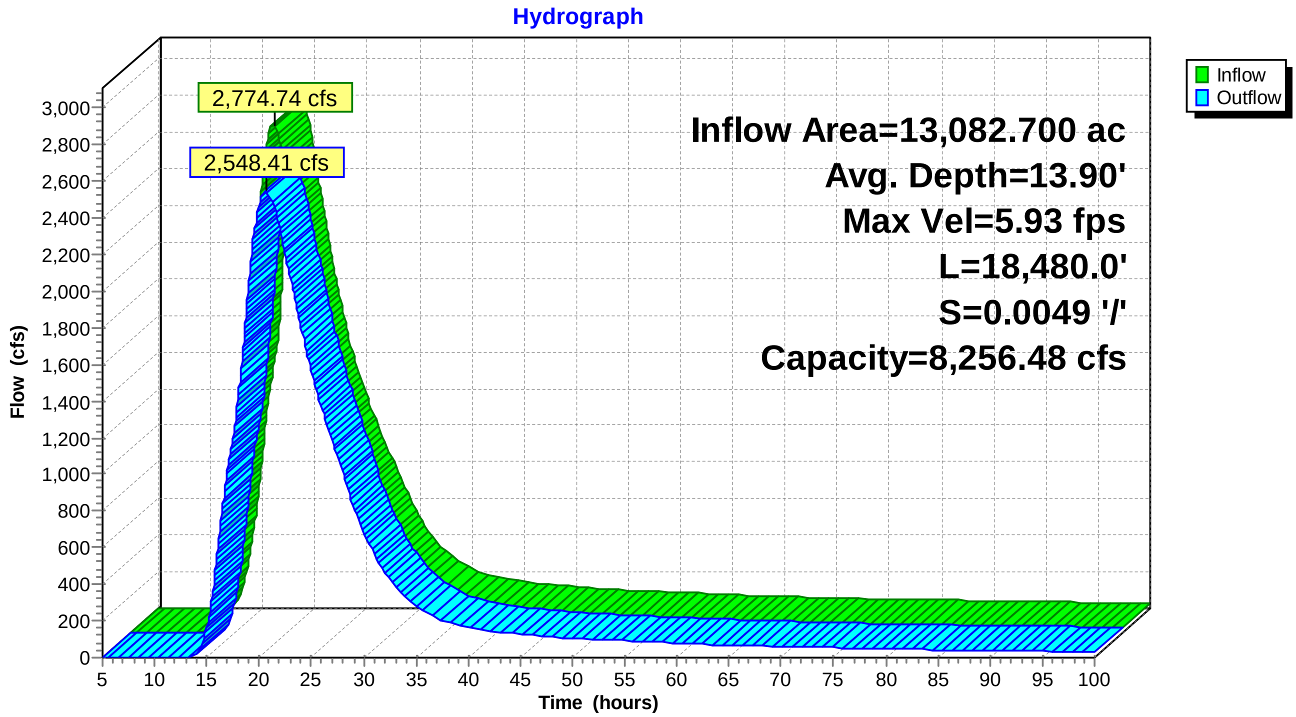


‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-25.00	200.00	0.00		
0.00	194.00	6.00	0.100	
10.00	192.00	8.00	0.100	
25.00	191.00	9.00	0.100	
50.00	190.00	10.00	0.100	
57.50	182.00	18.00	0.050	
60.00	180.00	20.00	0.050	
65.00	180.00	20.00	0.050	
67.50	182.00	18.00	0.050	
75.00	190.00	10.00	0.050	
100.00	191.00	9.00	0.100	
115.00	192.00	8.00	0.100	
125.00	194.00	6.00	0.100	
150.00	200.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
2.00	15.0	11.4	277,200	37.59
10.00	155.0	33.3	2,864,400	901.34
11.00	205.0	83.4	3,788,400	1,172.87
12.00	295.0	113.4	5,451,600	1,537.86
14.00	525.0	133.8	9,702,000	2,611.07
20.00	1,425.0	185.3	26,334,000	8,256.48

Reach 9R: Little River



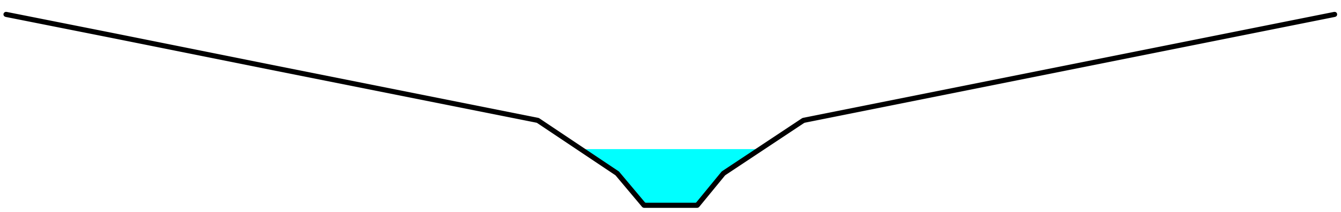
Summary for Reach 10R: Little River

Inflow Area = 4,273.900 ac, 6.59% Impervious, Inflow Depth > 1.50" for 100-yr24-hr(updated) event
Inflow = 165.35 cfs @ 27.50 hrs, Volume= 533.710 af
Outflow = 164.09 cfs @ 30.14 hrs, Volume= 525.737 af, Atten= 1%, Lag= 158.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 3.06 fps, Min. Travel Time= 89.1 min
Avg. Velocity = 2.39 fps, Avg. Travel Time= 113.9 min

Peak Storage= 877,380 cf @ 28.65 hrs, Average Depth at Peak Storage= 5.31'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 4,910.21 cfs

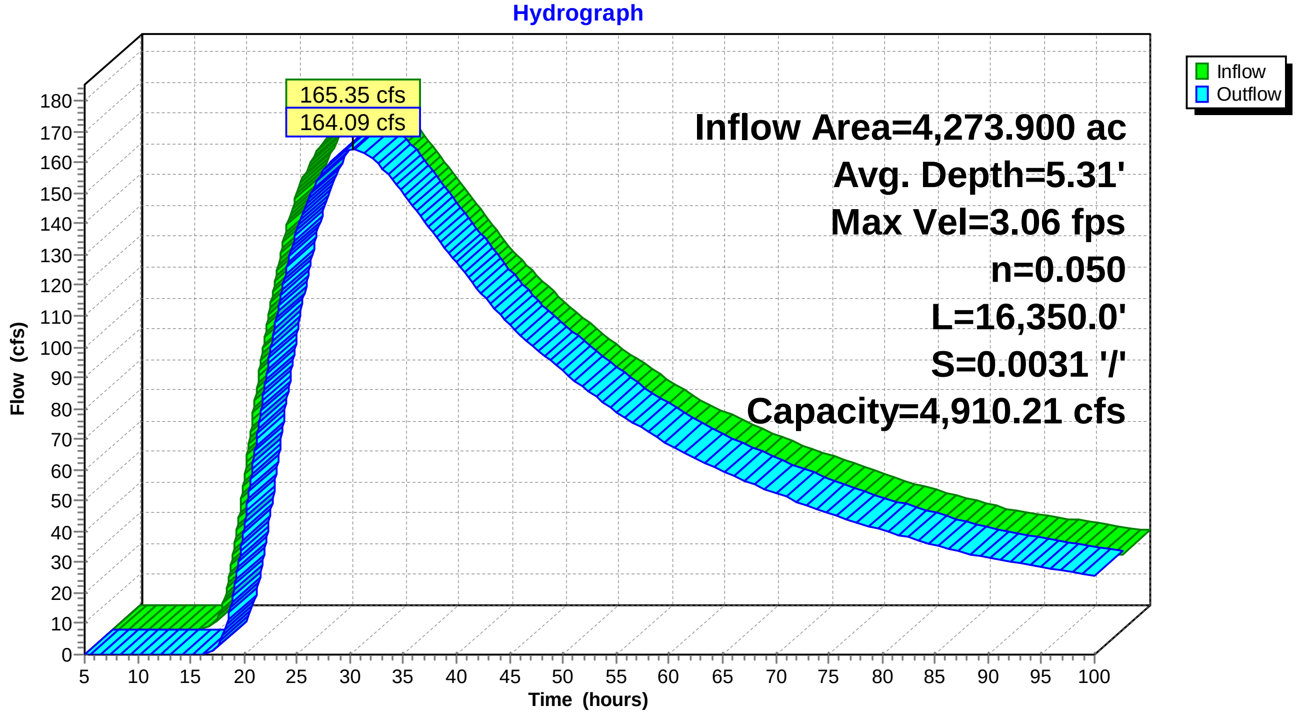
Custom cross-section, Length= 16,350.0' Slope= 0.0031 '/' (104 Elevation Intervals)
Constant n= 0.050 Mountain streams w/large boulders
Inlet Invert= 200.00', Outlet Invert= 150.00'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	367,875	53.83
8.00	110.0	30.8	1,798,500	422.06
13.00	360.0	81.8	5,886,000	1,588.58
16.00	630.0	112.4	10,300,500	3,266.69
18.00	860.0	132.8	14,061,000	4,910.21

Reach 10R: Little River



Summary for Reach 11R: North River

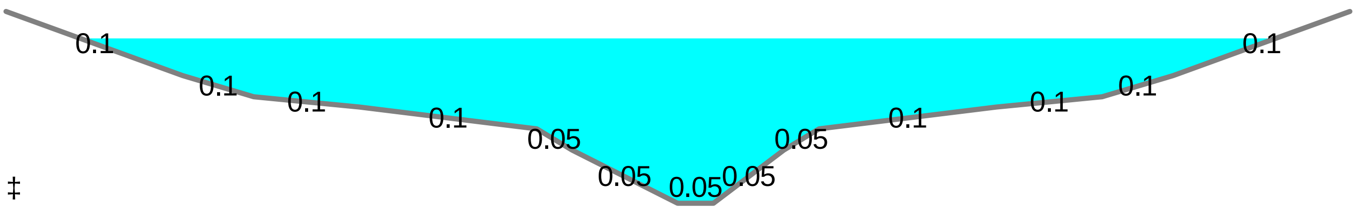
[62] Warning: Exceeded Reach 12R OUTLET depth by 4.52' @ 23.90 hrs

Inflow Area = 23,630.500 ac, 1.33% Impervious, Inflow Depth > 3.07" for 100-yr24-hr(updated) event
Inflow = 6,817.99 cfs @ 19.76 hrs, Volume= 6,044.391 af
Outflow = 6,105.85 cfs @ 23.80 hrs, Volume= 6,034.673 af, Atten= 10%, Lag= 242.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 5.15 fps, Min. Travel Time= 132.4 min
Avg. Velocity = 2.54 fps, Avg. Travel Time= 268.2 min

Peak Storage= 48,503,354 cf @ 21.59 hrs, Average Depth at Peak Storage= 15.45'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 9,118.30 cfs

Custom cross-section, Length= 40,920.0' Slope= 0.0033 '/' (104 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 220.00', Outlet Invert= 85.68'

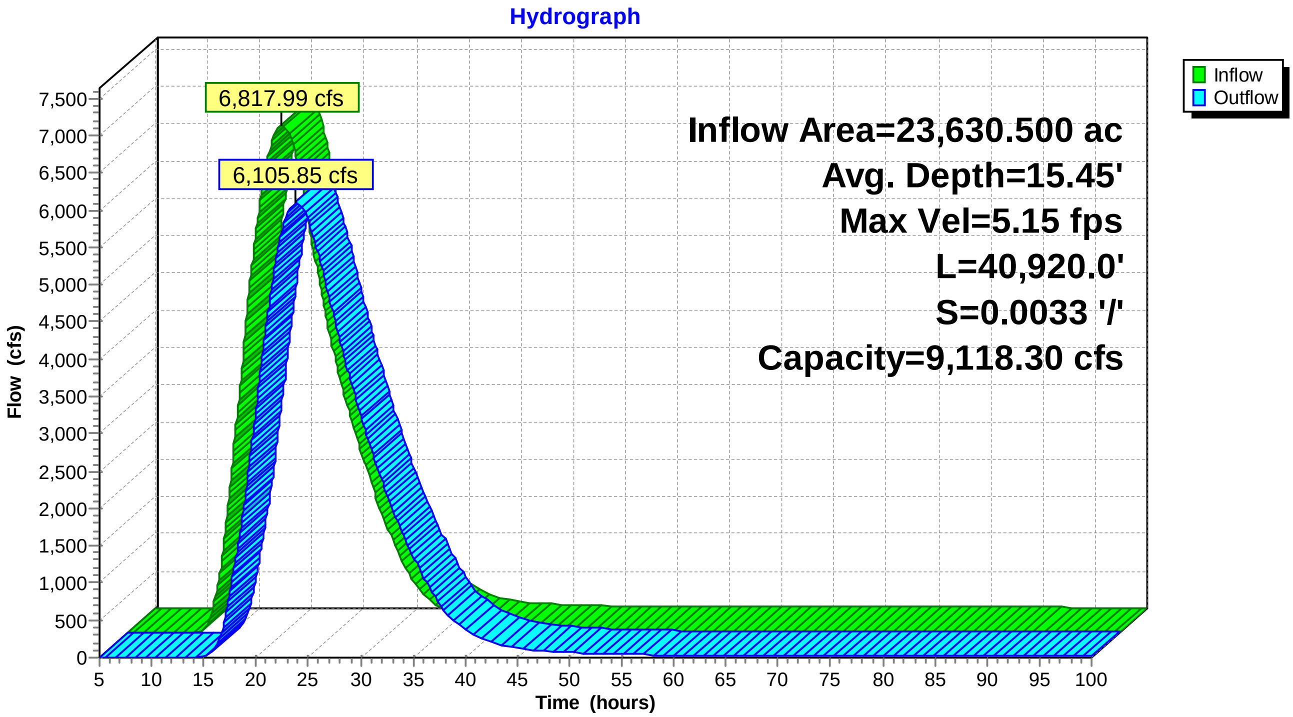


‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-25.00	200.00	0.00		
0.00	194.00	6.00	0.100	first n not used
10.00	192.00	8.00	0.100	
25.00	191.00	9.00	0.100	
50.00	189.00	11.00	0.100	
55.00	187.00	13.00	0.050	
70.00	182.00	18.00	0.050	
75.00	182.00	18.00	0.050	
85.00	187.00	13.00	0.050	
90.00	189.00	11.00	0.050	
115.00	191.00	9.00	0.100	
130.00	192.00	8.00	0.100	
140.00	194.00	6.00	0.100	
165.00	200.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
5.00	87.5	32.0	3,580,500	291.39
7.00	157.5	42.8	6,444,900	639.61
9.00	287.5	92.9	11,764,500	1,310.77
10.00	392.5	123.0	16,061,100	1,768.40
12.00	652.5	143.4	26,700,300	3,021.96
18.00	1,642.5	194.8	67,211,100	9,118.30

Reach 11R: North River



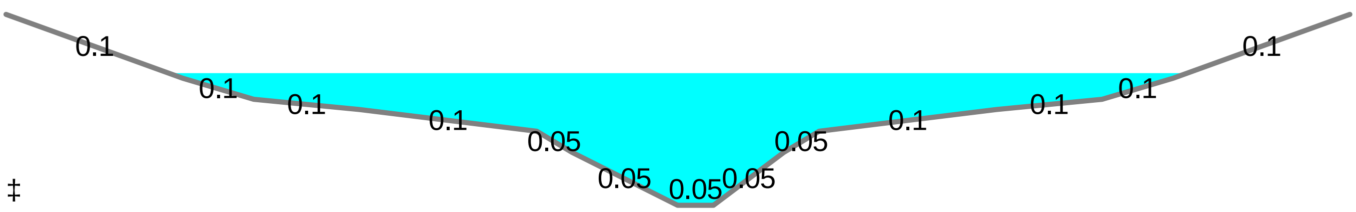
Summary for Reach 12R: North River

Inflow Area = 14,946.000 ac, 2.03% Impervious, Inflow Depth > 3.07" for 100-yr24-hr(updated) event
Inflow = 5,219.98 cfs @ 17.78 hrs, Volume= 3,818.534 af
Outflow = 4,720.38 cfs @ 20.67 hrs, Volume= 3,812.908 af, Atten= 10%, Lag= 173.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 6.60 fps, Min. Travel Time= 85.3 min
Avg. Velocity = 3.04 fps, Avg. Travel Time= 185.4 min

Peak Storage= 24,164,408 cf @ 19.25 hrs, Average Depth at Peak Storage= 12.44'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 12,839.98 cfs

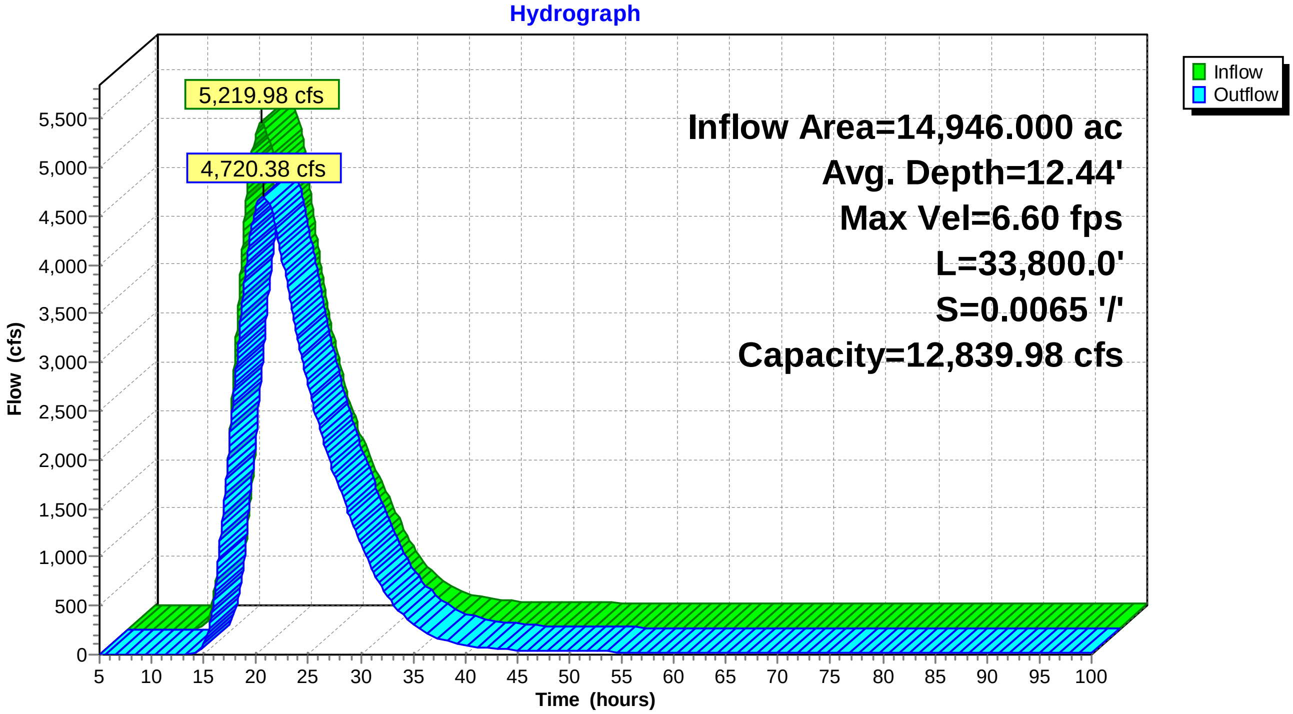
Custom cross-section, Length= 33,800.0' Slope= 0.0065 '/' (104 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 440.00', Outlet Invert= 220.00'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-25.00	200.00	0.00		
0.00	194.00	6.00	0.100	first n not used
10.00	192.00	8.00	0.100	
25.00	191.00	9.00	0.100	
50.00	189.00	11.00	0.100	
55.00	187.00	13.00	0.050	
70.00	182.00	18.00	0.050	
75.00	182.00	18.00	0.050	
85.00	187.00	13.00	0.050	
90.00	189.00	11.00	0.050	
115.00	191.00	9.00	0.100	
130.00	192.00	8.00	0.100	
140.00	194.00	6.00	0.100	
165.00	200.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
5.00	87.5	32.0	2,957,500	410.32
7.00	157.5	42.8	5,323,500	900.67
9.00	287.5	92.9	9,717,500	1,845.76
10.00	392.5	123.0	13,266,500	2,490.19
12.00	652.5	143.4	22,054,500	4,255.39
18.00	1,642.5	194.8	55,516,500	12,839.98

Reach 12R: North River



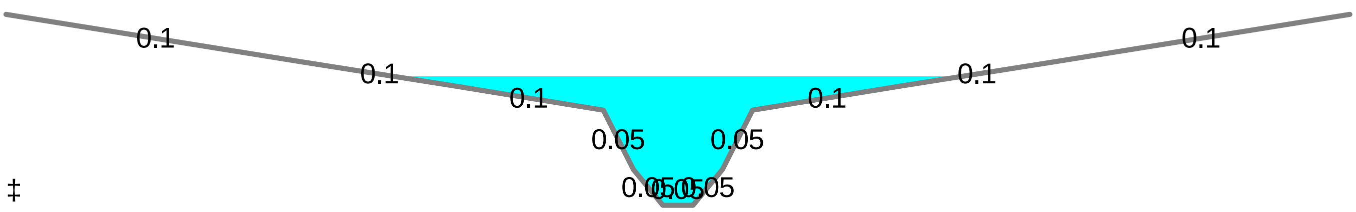
Summary for Reach 13R: Pawtuckaway River

Inflow Area = 13,039.300 ac, 11.31% Impervious, Inflow Depth > 2.86" for 100-yr24-hr(updated) event
Inflow = 1,454.87 cfs @ 24.70 hrs, Volume= 3,103.008 af
Outflow = 1,431.19 cfs @ 27.36 hrs, Volume= 3,086.757 af, Atten= 2%, Lag= 159.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 5.17 fps, Min. Travel Time= 63.8 min
Avg. Velocity = 3.82 fps, Avg. Travel Time= 86.4 min

Peak Storage= 5,913,026 cf @ 26.29 hrs, Average Depth at Peak Storage= 10.81'
Bank-Full Depth= 16.00', Capacity at Bank-Full= 4,923.16 cfs

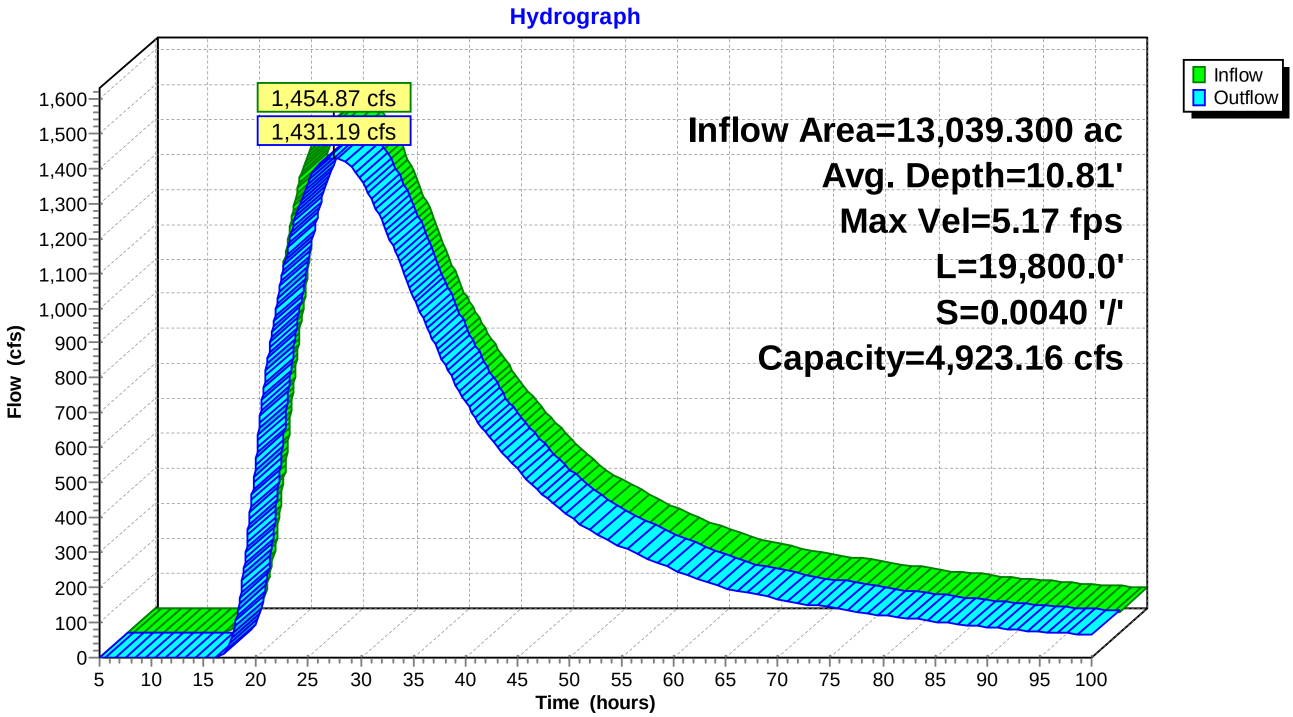
Custom cross-section, Length= 19,800.0' Slope= 0.0040 '/' (102 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 220.00', Outlet Invert= 140.21'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
-50.00	198.00	0.00		
0.00	194.00	4.00	0.100	
25.00	192.00	6.00	0.100	
50.00	190.00	8.00	0.100	
55.00	185.00	13.00	0.050	
60.00	182.00	16.00	0.050	
65.00	182.00	16.00	0.050	
70.00	185.00	13.00	0.050	
75.00	190.00	8.00	0.050	
100.00	192.00	6.00	0.100	
125.00	194.00	4.00	0.100	
175.00	198.00	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	30.0	16.7	594,000	83.77
8.00	130.0	30.8	2,574,000	640.51
10.00	230.0	81.0	4,554,000	1,148.79
12.00	430.0	131.1	8,514,000	1,956.52
16.00	1,130.0	231.4	22,374,000	4,923.16

Reach 13R: Pawtuckaway River



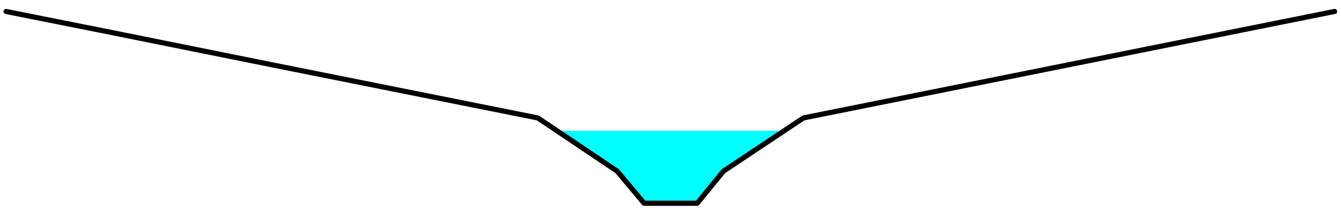
Summary for Reach 14R: Onway Reach

Inflow Area = 5,433.000 ac, 6.31% Impervious, Inflow Depth > 1.95" for 100-yr24-hr(updated) event
Inflow = 545.91 cfs @ 24.21 hrs, Volume= 884.751 af
Outflow = 545.16 cfs @ 24.81 hrs, Volume= 881.537 af, Atten= 0%, Lag= 36.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 6.65 fps, Min. Travel Time= 19.8 min
Avg. Velocity = 4.33 fps, Avg. Travel Time= 30.5 min

Peak Storage= 648,904 cf @ 24.47 hrs, Average Depth at Peak Storage= 6.79'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 9,359.50 cfs

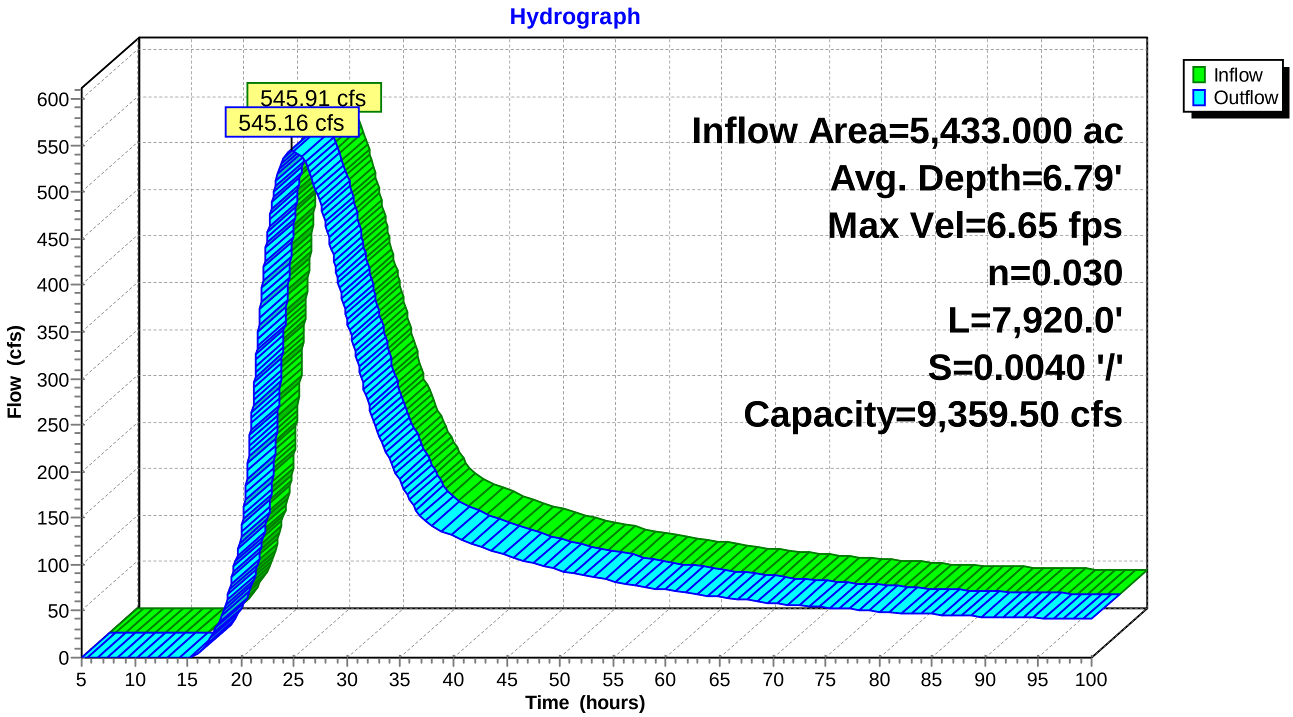
Custom cross-section, Length= 7,920.0' Slope= 0.0040 '/' (104 Elevation Intervals)
Constant n= 0.030 Earth, grassed & winding
Inlet Invert= 209.89', Outlet Invert= 178.21'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	178,200	102.61
8.00	110.0	30.8	871,200	804.50
13.00	360.0	81.8	2,851,200	3,028.05
16.00	630.0	112.4	4,989,600	6,226.73
18.00	860.0	132.8	6,811,200	9,359.50

Reach 14R: Onway Reach



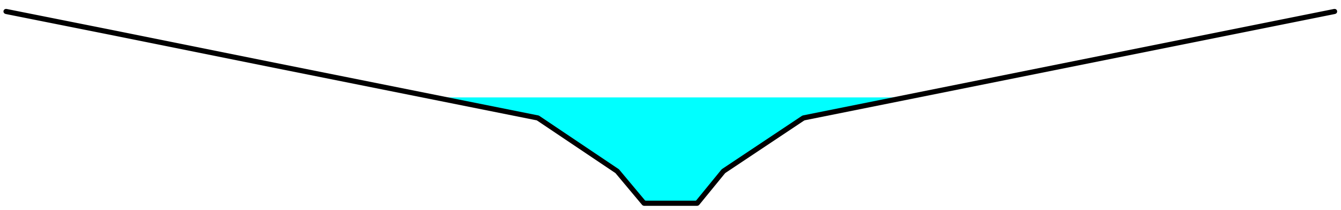
Summary for Reach 15R: North Branch River

Inflow Area = 2,921.700 ac, 2.11% Impervious, Inflow Depth > 3.18" for 100-yr24-hr(updated) event
Inflow = 1,987.45 cfs @ 14.70 hrs, Volume= 774.909 af
Outflow = 1,610.66 cfs @ 16.43 hrs, Volume= 774.410 af, Atten= 19%, Lag= 104.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 9.18 fps, Min. Travel Time= 52.7 min
Avg. Velocity = 2.88 fps, Avg. Travel Time= 167.8 min

Peak Storage= 5,149,593 cf @ 15.55 hrs, Average Depth at Peak Storage= 9.95'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 11,746.08 cfs

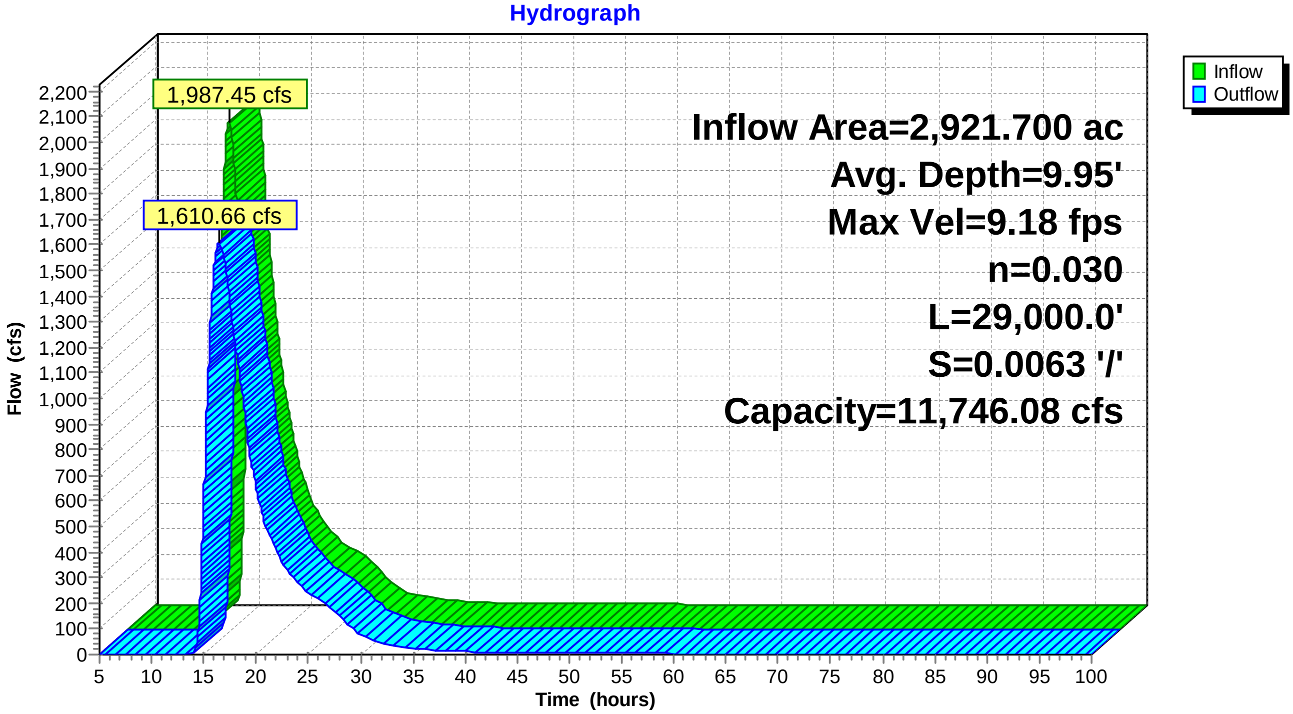
Custom cross-section, Length= 29,000.0' Slope= 0.0063 '/' (104 Elevation Intervals)
Constant n= 0.030 Earth, grassed & winding
Inlet Invert= 377.41', Outlet Invert= 194.71'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	652,500	128.78
8.00	110.0	30.8	3,190,000	1,009.64
13.00	360.0	81.8	10,440,000	3,800.17
16.00	630.0	112.4	18,270,000	7,814.49
18.00	860.0	132.8	24,940,000	11,746.08

Reach 15R: North Branch River



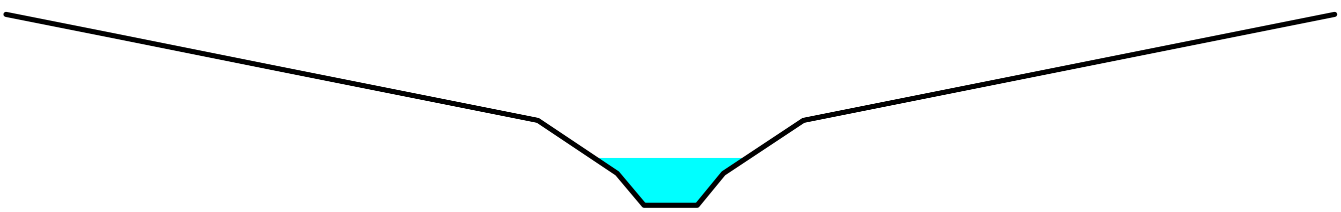
Summary for Reach 16R: Hartford Brook

Inflow Area = 1,302.100 ac, 3.62% Impervious, Inflow Depth > 2.97" for 100-yr24-hr(updated) event
Inflow = 362.49 cfs @ 15.79 hrs, Volume= 322.591 af
Outflow = 347.09 cfs @ 17.79 hrs, Volume= 322.326 af, Atten= 4%, Lag= 120.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 8.59 fps, Min. Travel Time= 56.3 min
Avg. Velocity = 3.30 fps, Avg. Travel Time= 146.3 min

Peak Storage= 1,172,064 cf @ 16.85 hrs, Average Depth at Peak Storage= 4.47'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 15,019.01 cfs

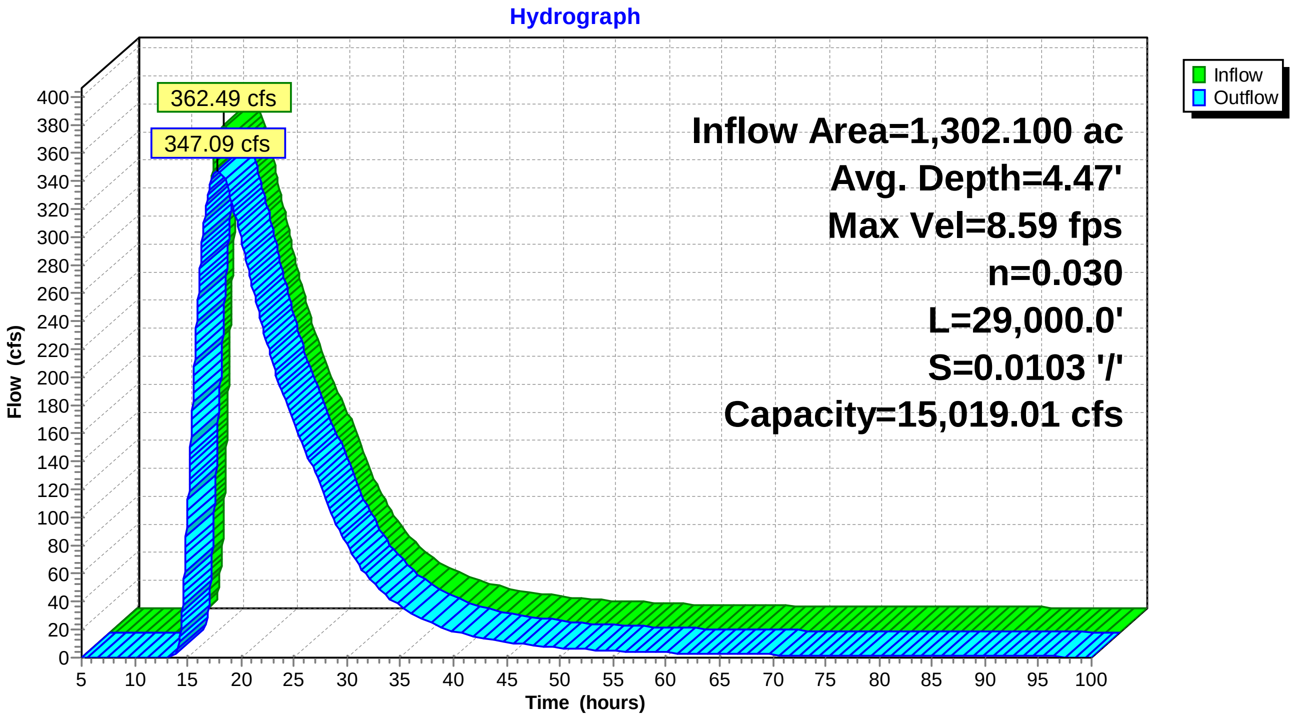
Custom cross-section, Length= 29,000.0' Slope= 0.0103 '/' (104 Elevation Intervals)
Constant n= 0.030 Earth, grassed & winding
Inlet Invert= 532.51', Outlet Invert= 233.81'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	652,500	164.66
8.00	110.0	30.8	3,190,000	1,290.96
13.00	360.0	81.8	10,440,000	4,859.05
16.00	630.0	112.4	18,270,000	9,991.91
18.00	860.0	132.8	24,940,000	15,019.01

Reach 16R: Hartford Brook



Summary for Reach 17R: Piscassic River

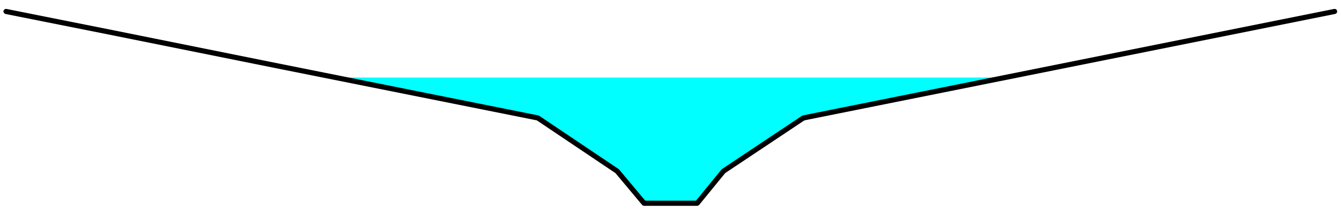
[81] Warning: Exceeded Pond 10P by 5.39' @ 35.80 hrs

Inflow Area = 4,986.100 ac, 2.06% Impervious, Inflow Depth = 2.88" for 100-yr24-hr(updated) event
Inflow = 835.86 cfs @ 22.35 hrs, Volume= 1,194.914 af
Outflow = 802.63 cfs @ 27.12 hrs, Volume= 1,194.473 af, Atten= 4%, Lag= 286.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 2.91 fps, Min. Travel Time= 135.1 min
Avg. Velocity = 1.41 fps, Avg. Travel Time= 279.8 min

Peak Storage= 6,507,347 cf @ 24.87 hrs, Average Depth at Peak Storage= 11.78'
Bank-Full Depth= 18.00', Capacity at Bank-Full= 3,464.91 cfs

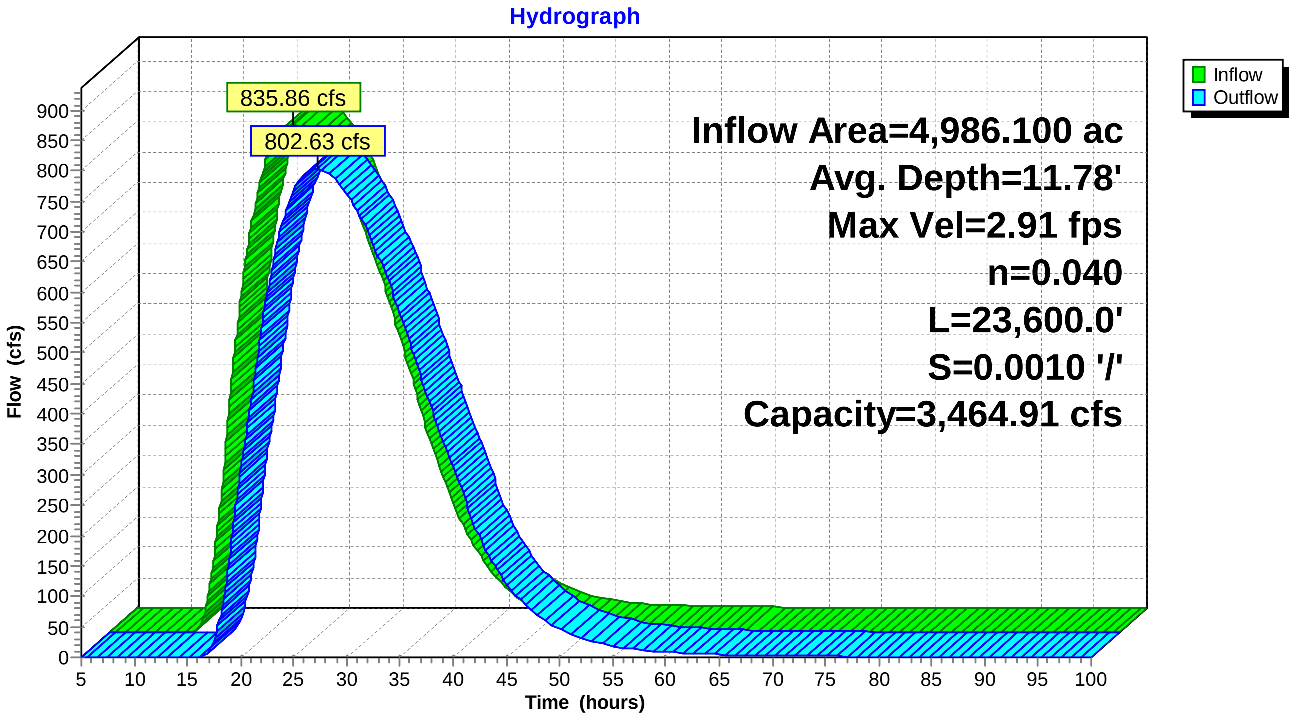
Custom cross-section, Length= 23,600.0' Slope= 0.0010 '/' (104 Elevation Intervals)
Constant n= 0.040 Winding stream, pools & shoals
Inlet Invert= 115.00', Outlet Invert= 92.00'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	200.00	0.00
10.00	198.00	2.00
25.00	195.00	5.00
50.00	190.00	10.00
57.50	185.00	15.00
60.00	182.00	18.00
65.00	182.00	18.00
67.50	185.00	15.00
75.00	190.00	10.00
100.00	195.00	5.00
125.00	200.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	5.0	0	0.00
3.00	22.5	12.8	531,000	37.99
8.00	110.0	30.8	2,596,000	297.83
13.00	360.0	81.8	8,496,000	1,120.99
16.00	630.0	112.4	14,868,000	2,305.15
18.00	860.0	132.8	20,296,000	3,464.91

Reach 17R: Piscassic River



Summary for Reach 18R: Piscassic River Discharge

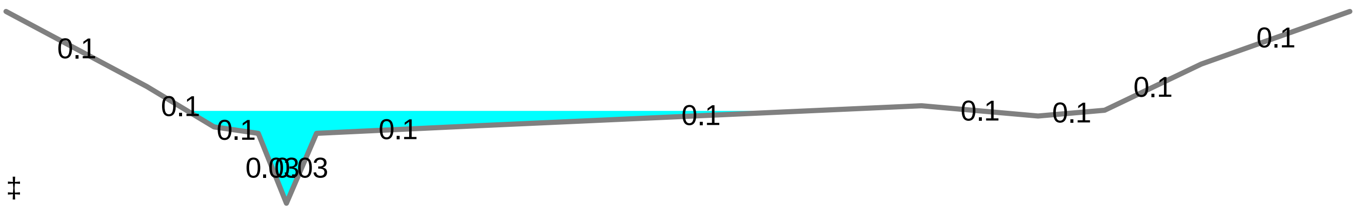
[81] Warning: Exceeded Pond 11P by 0.41' @ 45.64 hrs

Inflow Area = 13,912.800 ac, 2.86% Impervious, Inflow Depth > 3.03" for 100-yr24-hr(updated) event
Inflow = 2,151.73 cfs @ 29.16 hrs, Volume= 3,507.733 af
Outflow = 1,850.23 cfs @ 35.80 hrs, Volume= 3,504.707 af, Atten= 14%, Lag= 398.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.72 fps, Min. Travel Time= 123.5 min
Avg. Velocity = 2.62 fps, Avg. Travel Time= 222.8 min

Peak Storage= 25,142,202 cf @ 33.75 hrs, Average Depth at Peak Storage= 9.76'
Bank-Full Depth= 20.30', Capacity at Bank-Full= 29,822.87 cfs

Custom cross-section, Length= 35,000.0' Slope= 0.0017 '/' (107 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 80.00', Outlet Invert= 20.50'

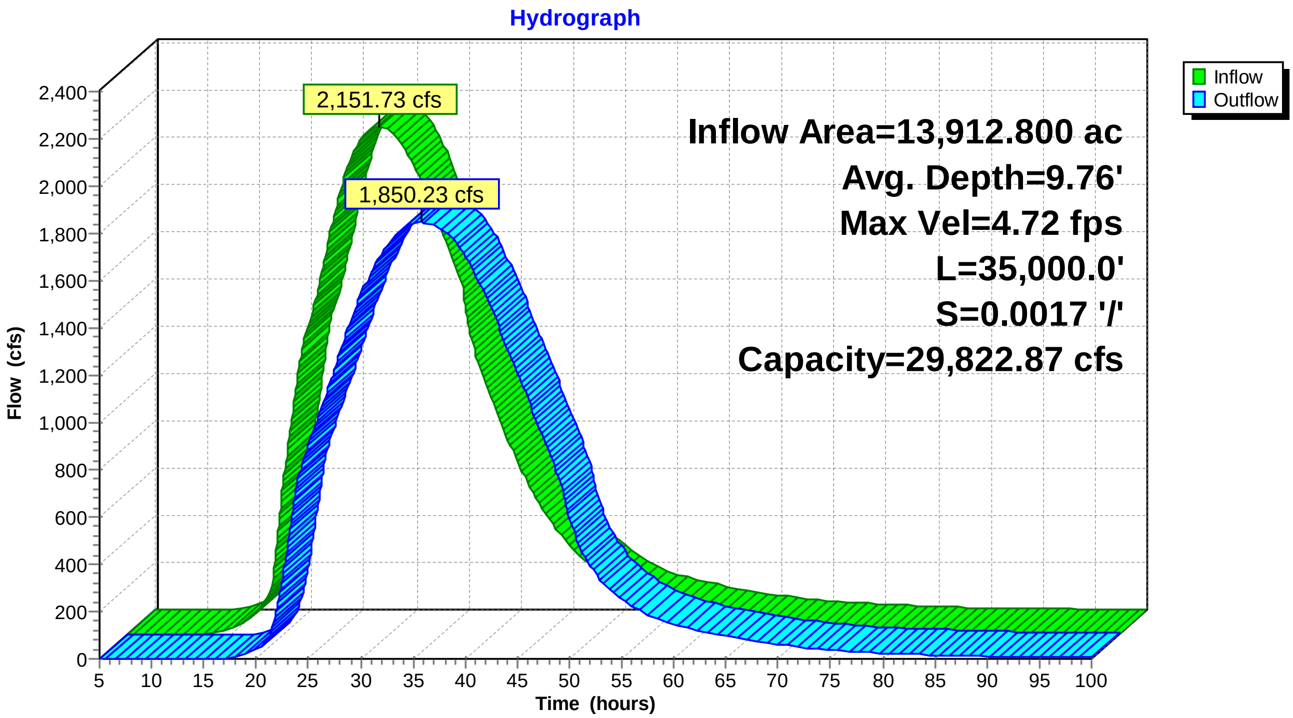


‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
445.00	79.20	0.00		
540.00	71.27	7.93	0.100	
585.00	67.00	12.20	0.100	
615.08	66.27	12.93	0.100	
634.00	58.90	20.30	0.030	
654.00	66.27	12.93	0.030	
764.00	67.10	12.10	0.100	
1,061.61	69.25	9.95	0.100	
1,140.00	68.10	11.10	0.100	
1,185.00	68.75	10.45	0.100	
1,250.00	73.65	5.55	0.100	
1,350.00	79.20	0.00	0.100	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	0.0	0	0.00
7.37	143.4	41.6	5,019,707	668.25
8.10	218.1	168.5	7,634,328	917.64
8.20	235.4	182.8	8,239,479	958.13
9.20	489.9	331.8	17,148,198	1,472.53
9.85	764.3	518.0	26,750,565	1,923.06
10.35	1,050.7	633.2	36,776,016	2,389.96
12.37	2,372.5	681.5	83,038,760	5,484.81
14.75	4,058.7	741.7	142,054,334	10,851.41
20.30	8,619.4	908.6	301,680,435	29,822.87

Reach 18R: Piscassic River Discharge



Summary for Reach 20R: Lamprey River (Flow Split to Dam)

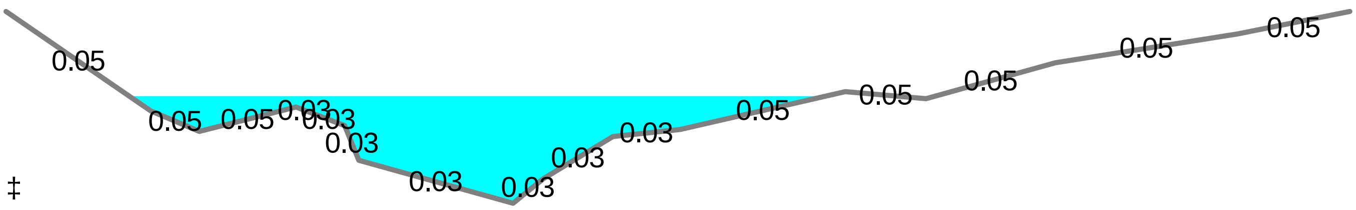
[62] Warning: Exceeded Reach 1R OUTLET depth by 6.66' @ 13.76 hrs

Inflow Area =120,625.900 ac, 3.45% Impervious, Inflow Depth > 2.81" for 100-yr24-hr(updated) event
Inflow = 12,669.65 cfs @ 37.03 hrs, Volume= 28,257.871 af
Outflow = 12,666.42 cfs @ 37.63 hrs, Volume= 28,230.753 af, Atten= 0%, Lag= 36.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Max. Velocity= 6.28 fps, Min. Travel Time= 19.9 min
Avg. Velocity = 4.07 fps, Avg. Travel Time= 30.7 min

Peak Storage= 15,120,631 cf @ 37.30 hrs, Average Depth at Peak Storage= 17.62'
Bank-Full Depth= 31.56', Capacity at Bank-Full= 67,844.37 cfs

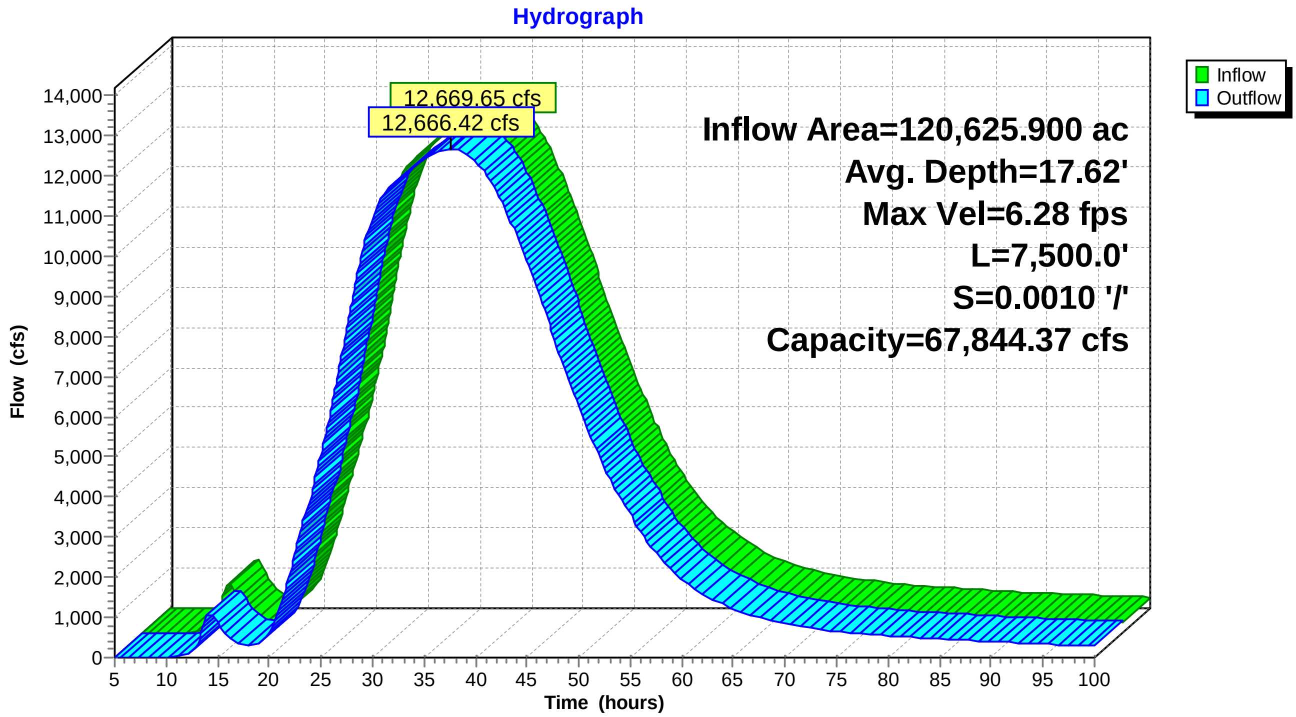
Custom cross-section, Length= 7,500.0' Slope= 0.0010 '/' (112 Elevation Intervals)
Flow calculated by Manning's Subdivision method
Inlet Invert= 20.39', Outlet Invert= 12.89'



Offset (feet)	Elevation (feet)	Chan.Depth (feet)	n	Description
235.25	42.04	0.00		
293.39	25.70	16.34	0.050	
312.87	22.33	19.71	0.050	
351.83	26.26	15.78	0.050	
358.32	25.22	16.82	0.030	
371.30	23.26	18.78	0.030	
377.00	17.58	24.46	0.030	
439.00	10.48	31.56	0.030	
451.00	14.48	27.56	0.030	
479.00	21.48	20.56	0.030	
506.00	22.58	19.46	0.030	
572.31	28.89	13.15	0.050	
604.74	27.71	14.33	0.050	
656.61	33.64	8.40	0.050	
730.00	38.34	3.70	0.050	
775.00	42.04	0.00	0.050	

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	0.0	0	0.00
4.00	93.9	47.8	703,944	230.51
7.10	300.5	87.8	2,253,900	1,068.82
11.00	675.5	109.4	5,066,488	3,560.57
11.85	774.8	131.5	5,810,910	3,958.47
12.10	808.0	142.0	6,059,883	4,106.86
12.78	908.1	160.9	6,810,558	4,892.23
14.74	1,277.7	225.7	9,583,123	7,317.61
15.22	1,387.5	241.4	10,405,956	8,022.00
15.78	1,524.6	258.5	11,434,170	8,902.71
17.23	1,906.6	279.2	14,299,440	11,842.68
18.41	2,264.5	338.9	16,984,059	14,499.33
23.16	3,985.2	398.2	29,889,101	29,049.59
27.86	6,036.9	489.1	45,276,722	48,392.09
31.56	7,926.4	548.0	59,447,743	67,844.37

Reach 20R: Lamprey River (Flow Split to Dam)



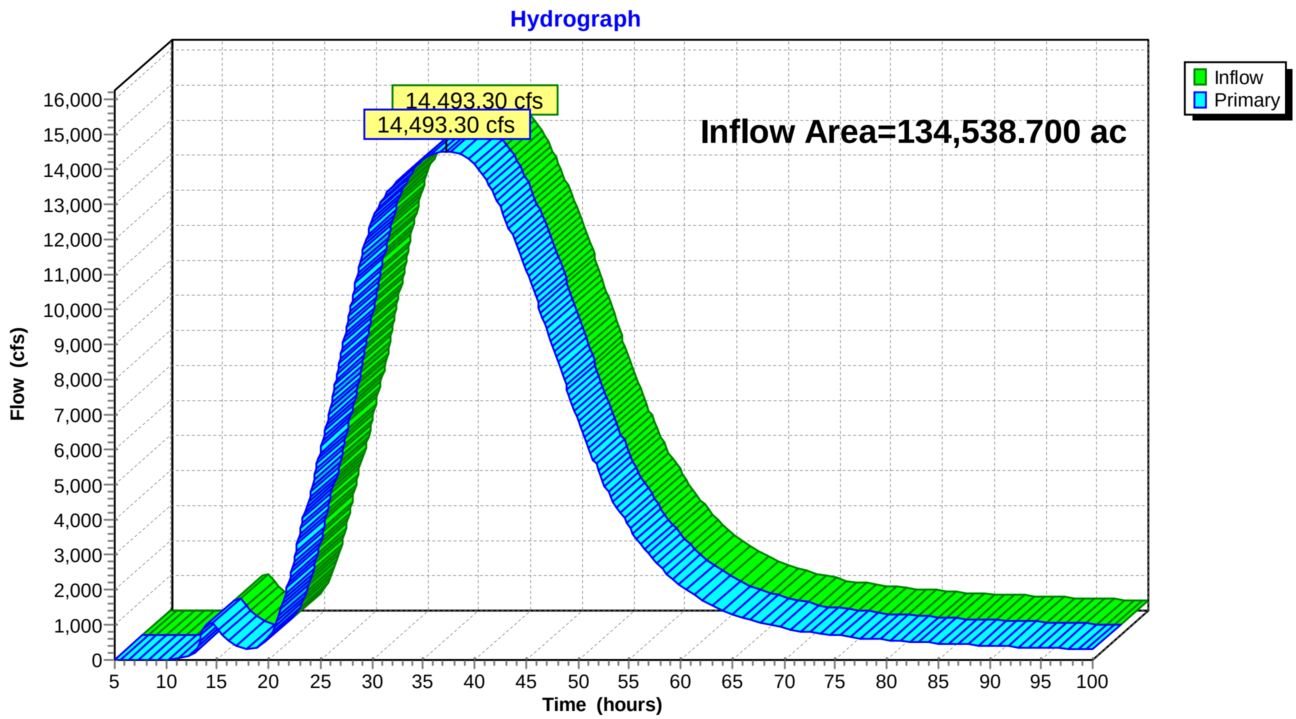
Summary for Pond 1P: Macallen Dam Impoundment

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =134,538.700 ac, 3.39% Impervious, Inflow Depth > 2.83" for 100-yr24-hr(updated) event
Inflow = 14,493.30 cfs @ 37.33 hrs, Volume= 31,735.460 af
Primary = 14,493.30 cfs @ 37.33 hrs, Volume= 31,735.460 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs

Pond 1P: Macallen Dam Impoundment



Summary for Pond 2P: Nottingham Lake Dam

[61] Hint: Exceeded Reach 10R outlet invert by 0.88' @ 19.30 hrs

Inflow Area = 8,966.500 ac, 3.89% Impervious, Inflow Depth > 2.15" for 100-yr24-hr(updated) event
Inflow = 1,609.59 cfs @ 17.44 hrs, Volume= 1,610.160 af
Outflow = 1,367.16 cfs @ 19.30 hrs, Volume= 1,412.488 af, Atten= 15%, Lag= 111.8 min
Primary = 1,367.16 cfs @ 19.30 hrs, Volume= 1,412.488 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Peak Elev= 150.88' @ 19.30 hrs Surf.Area= 0.000 ac Storage= 348.695 af

Plug-Flow detention time= 566.9 min calculated for 1,412.488 af (88% of inflow)
Center-of-Mass det. time= 220.5 min (1,977.9 - 1,757.5)

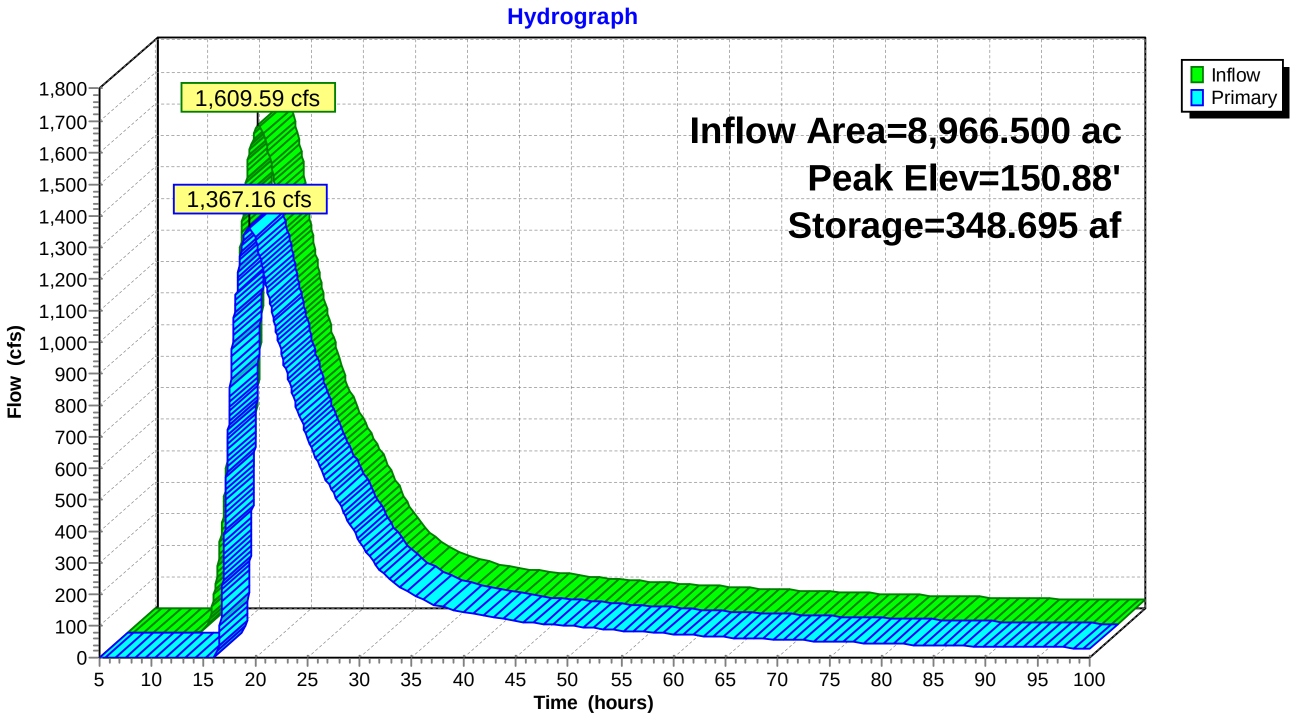
Volume	Invert	Avail.Storage	Storage Description
#1	140.00'	987.000 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
140.00	0.000
142.00	27.000
148.00	172.300
150.00	287.000
160.00	987.000

Device	Routing	Invert	Outlet Devices
#1	Primary	148.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 5.00 5.01 7.00 7.01 10.00 Width (feet) 5.00 5.00 30.00 30.00 215.00 215.00
#2	Primary	148.00'	**32.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	148.50'	**65.0' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Primary OutFlow Max=1,366.17 cfs @ 19.30 hrs HW=150.88' (Free Discharge)
├─**1=Custom Weir/Orifice** (Weir Controls 80.09 cfs @ 5.56 fps)
├─**2=Broad-Crested Rectangular Weir** (Weir Controls 496.01 cfs @ 5.38 fps)
└─**3=Broad-Crested Rectangular Weir** (Weir Controls 790.07 cfs @ 5.10 fps)

Pond 2P: Nottingham Lake Dam



Summary for Pond 3P: Mendums Pond Dam

Inflow Area = 4,273.900 ac, 6.59% Impervious, Inflow Depth = 1.88" for 100-yr24-hr(updated) event
Inflow = 1,036.20 cfs @ 17.00 hrs, Volume= 670.272 af
Outflow = 165.35 cfs @ 27.50 hrs, Volume= 533.710 af, Atten= 84%, Lag= 630.0 min
Primary = 165.35 cfs @ 27.50 hrs, Volume= 533.710 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 231.00' Surf.Area= 275.000 ac Storage= 5,137.500 af
Peak Elev= 232.84' @ 27.50 hrs Surf.Area= 294.398 ac Storage= 5,660.690 af (523.190 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 1,572.6 min (2,753.4 - 1,180.8)

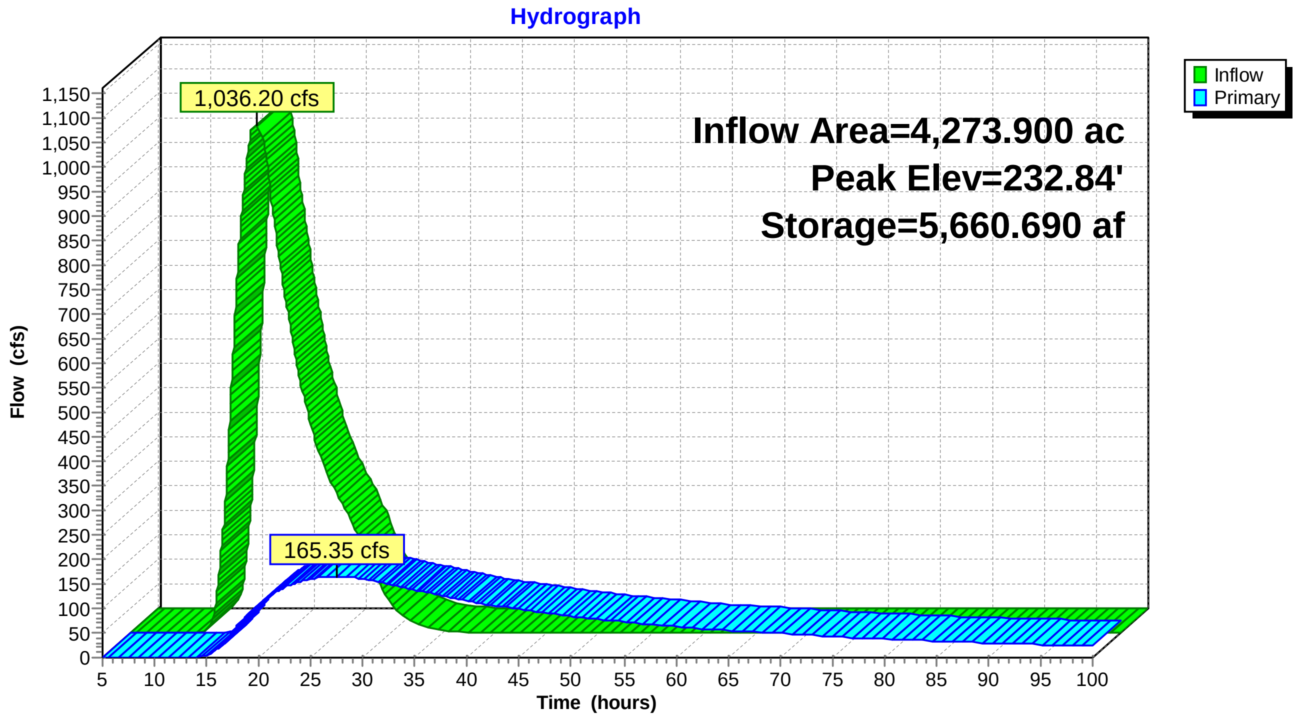
Volume	Invert	Avail.Storage	Storage Description
#1	200.00'	8,040.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
200.00	5.000	0.000	0.000
205.00	100.000	262.500	262.500
231.00	275.000	4,875.000	5,137.500
240.00	370.000	2,902.500	8,040.000

Device	Routing	Invert	Outlet Devices
#1	Primary	231.00'	**25.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=165.04 cfs @ 27.50 hrs HW=232.84' (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 165.04 cfs @ 3.59 fps)

Pond 3P: Mendums Pond Dam



Summary for Pond 4P: North River Pond

Inflow Area = 813.000 ac, 10.60% Impervious, Inflow Depth = 3.61" for 100-yr24-hr(updated) event
Inflow = 1,147.00 cfs @ 13.03 hrs, Volume= 244.750 af
Outflow = 50.29 cfs @ 23.59 hrs, Volume= 187.059 af, Atten= 96%, Lag= 634.0 min
Primary = 50.29 cfs @ 23.59 hrs, Volume= 187.059 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 455.00' Surf.Area= 80.000 ac Storage= 330.000 af
Peak Elev= 457.11' @ 23.59 hrs Surf.Area= 109.574 ac Storage= 530.231 af (200.231 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 1,766.8 min (2,668.1 - 901.3)

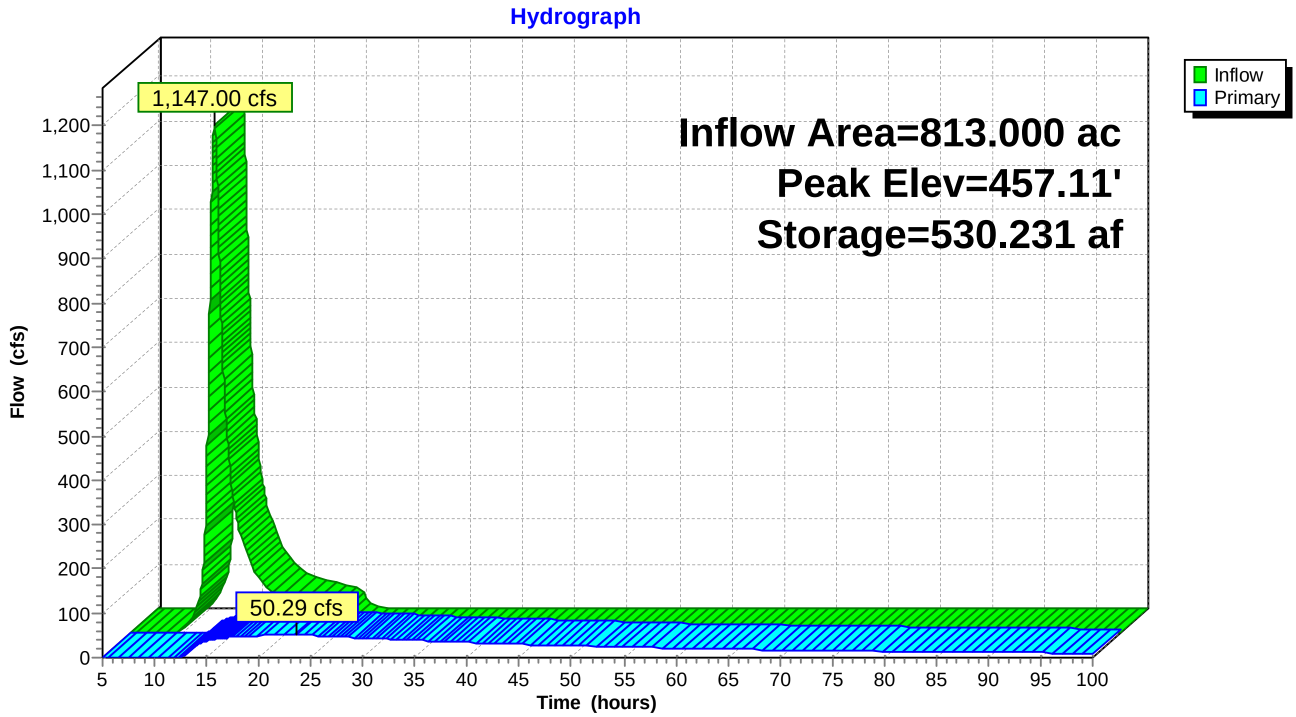
Volume	Invert	Avail.Storage	Storage Description
#1	447.00'	905.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
447.00	2.500	0.000	0.000
455.00	80.000	330.000	330.000
460.00	150.000	575.000	905.000

Device	Routing	Invert	Outlet Devices
#1	Primary	455.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 3.00 3.01 5.00 Width (feet) 5.00 5.00 140.00 140.00

Primary OutFlow Max=50.28 cfs @ 23.59 hrs HW=457.11' (Free Discharge)
↑—**1=Custom Weir/Orifice** (Weir Controls 50.28 cfs @ 4.76 fps)

Pond 4P: North River Pond



Summary for Pond 5P: Pawtuckaway Pond

Inflow Area = 13,039.300 ac, 11.31% Impervious, Inflow Depth = 3.29" for 100-yr24-hr(updated) event
Inflow = 5,447.66 cfs @ 17.05 hrs, Volume= 3,578.584 af
Outflow = 1,454.87 cfs @ 24.70 hrs, Volume= 3,103.008 af, Atten= 73%, Lag= 459.0 min
Primary = 1,404.47 cfs @ 24.70 hrs, Volume= 3,058.522 af
Secondary = 50.40 cfs @ 24.70 hrs, Volume= 44.487 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 250.00' Surf.Area= 783.500 ac Storage= 15,271.250 af
Peak Elev= 252.95' @ 24.70 hrs Surf.Area= 847.272 ac Storage= 17,673.032 af (2,401.782 af above start)
Flood Elev= 253.00' Surf.Area= 848.450 ac Storage= 17,719.175 af (2,447.925 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 1,110.5 min (2,293.5 - 1,183.0)

Volume	Invert	Avail.Storage	Storage Description
#1	220.00'	24,188.750 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

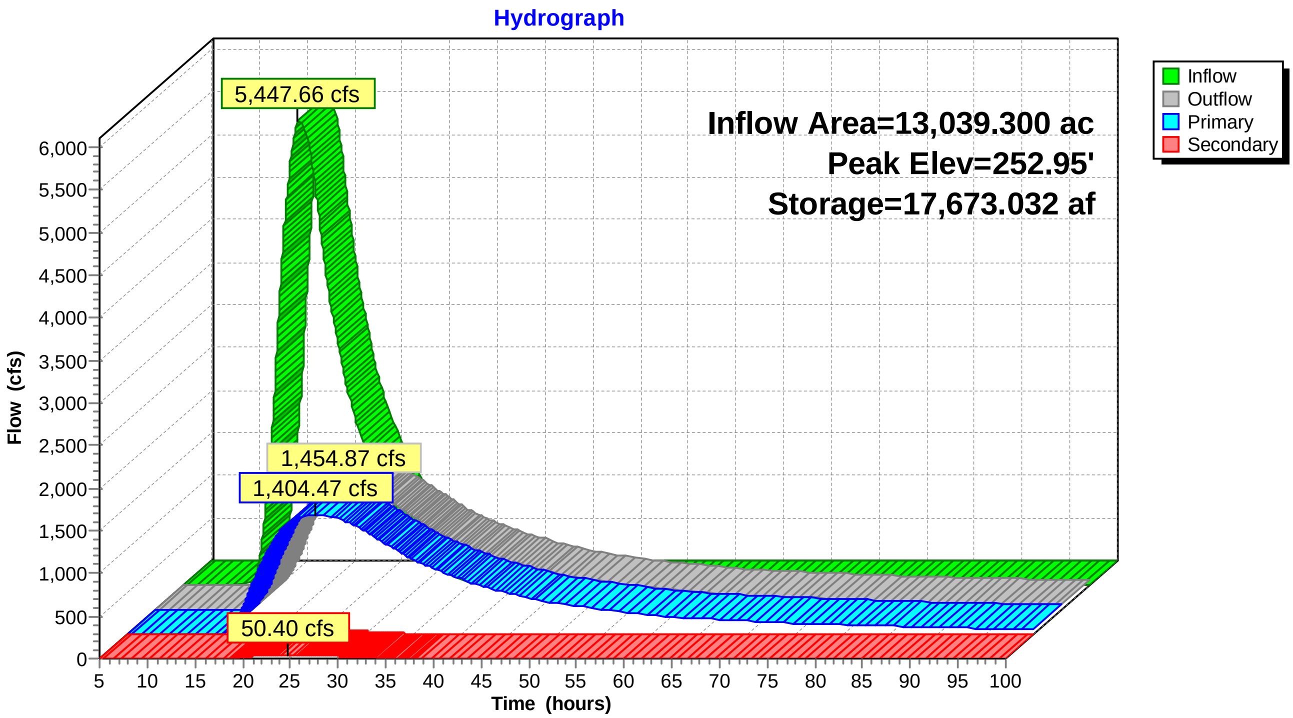
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
220.00	225.000	0.000	0.000
245.00	700.000	11,562.500	11,562.500
250.00	783.500	3,708.750	15,271.250
260.00	1,000.000	8,917.500	24,188.750

Device	Routing	Invert	Outlet Devices
#1	Primary	250.40'	**4.5' long x 12.10' rise Sharp-Crested Rectangular Weir X 3.00** 2 End Contraction(s) 7.3' Crest Height
#2	Primary	250.14'	**41.0' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#3	Secondary	252.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#4	Primary	250.40'	**4.6' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 9.1' Crest Height
#5	Primary	250.30'	**20.2' long x 2.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=1,401.18 cfs @ 24.70 hrs HW=252.95' (Free Discharge)
1=Sharp-Crested Rectangular Weir (Weir Controls 165.79 cfs @ 5.44 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 638.92 cfs @ 5.55 fps)
4=Sharp-Crested Rectangular Weir (Weir Controls 56.19 cfs @ 5.40 fps)
5=Broad-Crested Rectangular Weir (Weir Controls 540.28 cfs @ 5.05 fps)

Secondary OutFlow Max=49.33 cfs @ 24.70 hrs HW=252.95' (Free Discharge)
3=Broad-Crested Rectangular Weir (Weir Controls 49.33 cfs @ 2.61 fps)

Pond 5P: Pawtuckaway Pond



Summary for Pond 6P: Onway Lake

Inflow Area = 5,433.000 ac, 6.31% Impervious, Inflow Depth = 3.51" for 100-yr24-hr(updated) event
Inflow = 2,795.86 cfs @ 16.11 hrs, Volume= 1,587.160 af
Outflow = 545.91 cfs @ 24.21 hrs, Volume= 884.751 af, Atten= 80%, Lag= 485.9 min
Primary = 235.53 cfs @ 24.21 hrs, Volume= 660.530 af
Secondary = 310.38 cfs @ 24.21 hrs, Volume= 224.221 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 260.00' Surf.Area= 178.000 ac Storage= 1,190.000 af
Peak Elev= 266.44' @ 24.21 hrs Surf.Area= 209.607 ac Storage= 2,438.917 af (1,248.917 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 1,336.7 min (2,453.7 - 1,117.1)

Volume	Invert	Avail.Storage	Storage Description
#1	250.00'	5,865.700 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

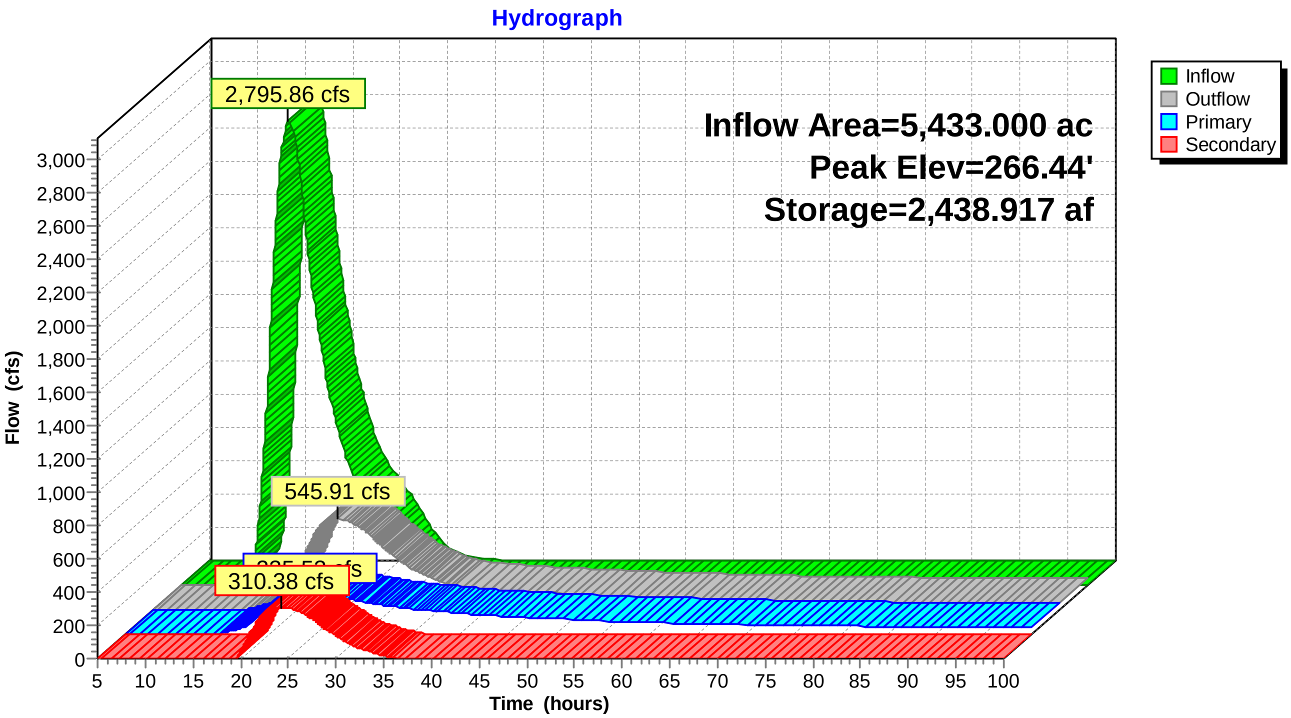
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
250.00	22.000	0.000	0.000
255.00	138.000	400.000	400.000
260.00	178.000	790.000	1,190.000
275.00	251.570	3,221.775	4,411.775
280.00	330.000	1,453.925	5,865.700

Device	Routing	Invert	Outlet Devices
#1	Primary	260.33'	**24.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600
#2	Primary	264.00'	**6.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	264.00'	**5.2' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#4	Primary	265.20'	**0.7' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#5	Secondary	265.53'	**60.0' long x 1.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Primary OutFlow Max=235.41 cfs @ 24.21 hrs HW=266.44' (Free Discharge)
1=Orifice/Grate (Orifice Controls 96.81 cfs @ 8.07 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 69.83 cfs @ 4.76 fps)
3=Broad-Crested Rectangular Weir (Weir Controls 65.75 cfs @ 5.17 fps)
4=Broad-Crested Rectangular Weir (Weir Controls 3.02 cfs @ 3.47 fps)

Secondary OutFlow Max=306.75 cfs @ 24.21 hrs HW=266.44' (Free Discharge)
5=Broad-Crested Rectangular Weir (Weir Controls 306.75 cfs @ 2.80 fps)

Pond 6P: Onway Lake



Summary for Pond 7P: Socha Dam

Inflow Area = 2,921.700 ac, 2.11% Impervious, Inflow Depth = 3.19" for 100-yr24-hr(updated) event
Inflow = 2,067.78 cfs @ 14.33 hrs, Volume= 776.218 af
Outflow = 1,987.45 cfs @ 14.70 hrs, Volume= 774.909 af, Atten= 4%, Lag= 22.2 min
Primary = 1,987.45 cfs @ 14.70 hrs, Volume= 774.909 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 396.00' Surf.Area= 30.000 ac Storage= 105.000 af
Peak Elev= 399.22' @ 14.70 hrs Surf.Area= 42.080 ac Storage= 221.092 af (116.092 af above start)

Plug-Flow detention time= 221.7 min calculated for 669.768 af (86% of inflow)
Center-of-Mass det. time= 115.9 min (1,110.9 - 995.0)

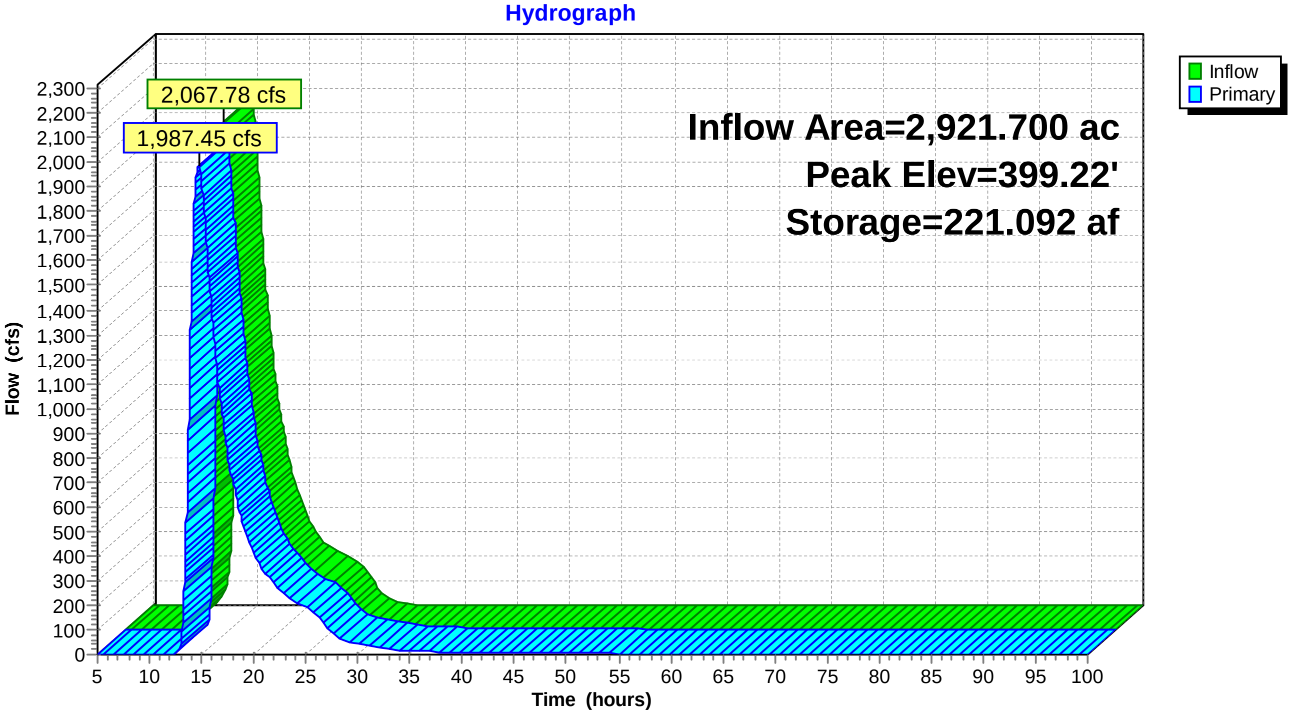
Volume	Invert	Avail.Storage	Storage Description
#1	390.00'	1,485.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
390.00	5.000	0.000	0.000
396.00	30.000	105.000	105.000
400.00	45.000	150.000	255.000
420.00	78.000	1,230.000	1,485.000

Device	Routing	Invert	Outlet Devices
#1	Primary	396.00'	**Primary Spillway, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 0.50 2.00 3.00 4.00 Width (feet) 8.00 8.00 30.00 30.00 70.00 100.00
#2	Primary	397.00'	**80.0' long x 1.5' breadth Secondary Spillway** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32
#3	Primary	398.00'	**140.0' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Primary OutFlow Max=1,977.00 cfs @ 14.70 hrs HW=399.22' (Free Discharge)
├─**1=Primary Spillway** (Weir Controls 560.95 cfs @ 4.87 fps)
├─**2=Secondary Spillway** (Weir Controls 831.73 cfs @ 4.68 fps)
└─**3=Broad-Crested Rectangular Weir** (Weir Controls 584.32 cfs @ 3.42 fps)

Pond 7P: Socha Dam



Summary for Pond 8P:

Inflow Area = 1,302.100 ac, 3.62% Impervious, Inflow Depth = 2.98" for 100-yr24-hr(updated) event
Inflow = 1,192.53 cfs @ 13.45 hrs, Volume= 323.282 af
Outflow = 362.49 cfs @ 15.79 hrs, Volume= 322.591 af, Atten= 70%, Lag= 140.2 min
Primary = 362.49 cfs @ 15.79 hrs, Volume= 322.591 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 545.00' Surf.Area= 25.000 ac Storage= 75.750 af
Peak Elev= 549.59' @ 15.79 hrs Surf.Area= 41.828 ac Storage= 229.102 af (153.352 af above start)

Plug-Flow detention time= 611.4 min calculated for 246.841 af (76% of inflow)
Center-of-Mass det. time= 387.5 min (1,328.5 - 940.9)

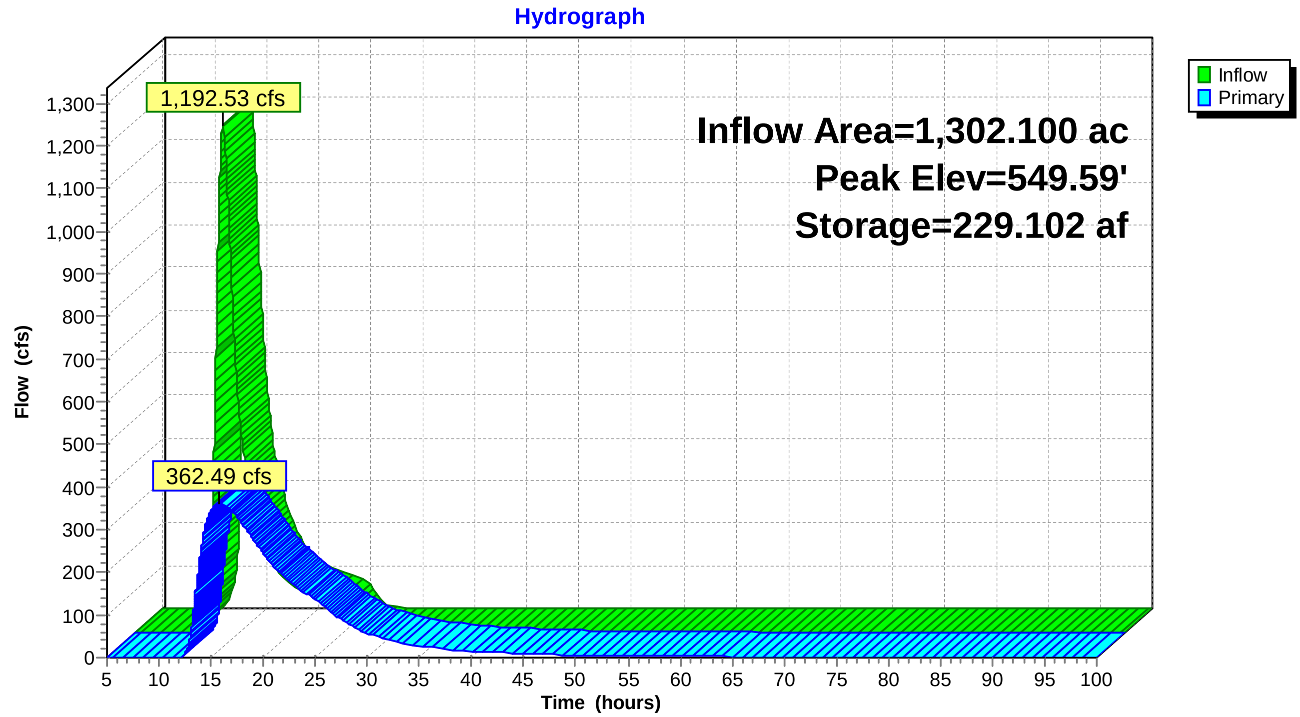
Volume	Invert	Avail.Storage	Storage Description
#1	540.00'	863.250 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
540.00	0.500	0.000	0.000
543.00	20.000	30.750	30.750
545.00	25.000	45.000	75.750
560.00	80.000	787.500	863.250

Device	Routing	Invert	Outlet Devices
#1	Primary	545.00'	**45.0 deg x 10.0' long x 10.00' rise Sharp-Crested Vee/Trap Weir** C= 2.56

Primary OutFlow Max=362.47 cfs @ 15.79 hrs HW=549.59' (Free Discharge)
└─**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 362.47 cfs @ 6.64 fps)

Pond 8P:


Hydrograph
1,192.53 cfs
362.49 cfs
Inflow Area=1,302.100 ac
Peak Elev=549.59'
Storage=229.102 af
Inflow
Primary
Flow (cfs)
Time (hours)
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

Summary for Pond 9P: Freeses Pond

Inflow Area = 5,406.400 ac, 0.91% Impervious, Inflow Depth = 2.77" for 100-yr24-hr(updated) event
Inflow = 2,390.84 cfs @ 15.59 hrs, Volume= 1,249.377 af
Outflow = 1,563.30 cfs @ 17.92 hrs, Volume= 1,234.721 af, Atten= 35%, Lag= 140.2 min
Primary = 1,563.30 cfs @ 17.92 hrs, Volume= 1,234.721 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 432.50' Surf.Area= 82.000 ac Storage= 543.750 af
Peak Elev= 436.87' @ 17.92 hrs Surf.Area= 126.232 ac Storage= 983.197 af (439.447 af above start)

Plug-Flow detention time= 791.2 min calculated for 690.971 af (55% of inflow)
Center-of-Mass det. time= 344.7 min (1,437.3 - 1,092.5)

Volume	Invert	Avail.Storage	Storage Description
#1	420.00'	1,446.250 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

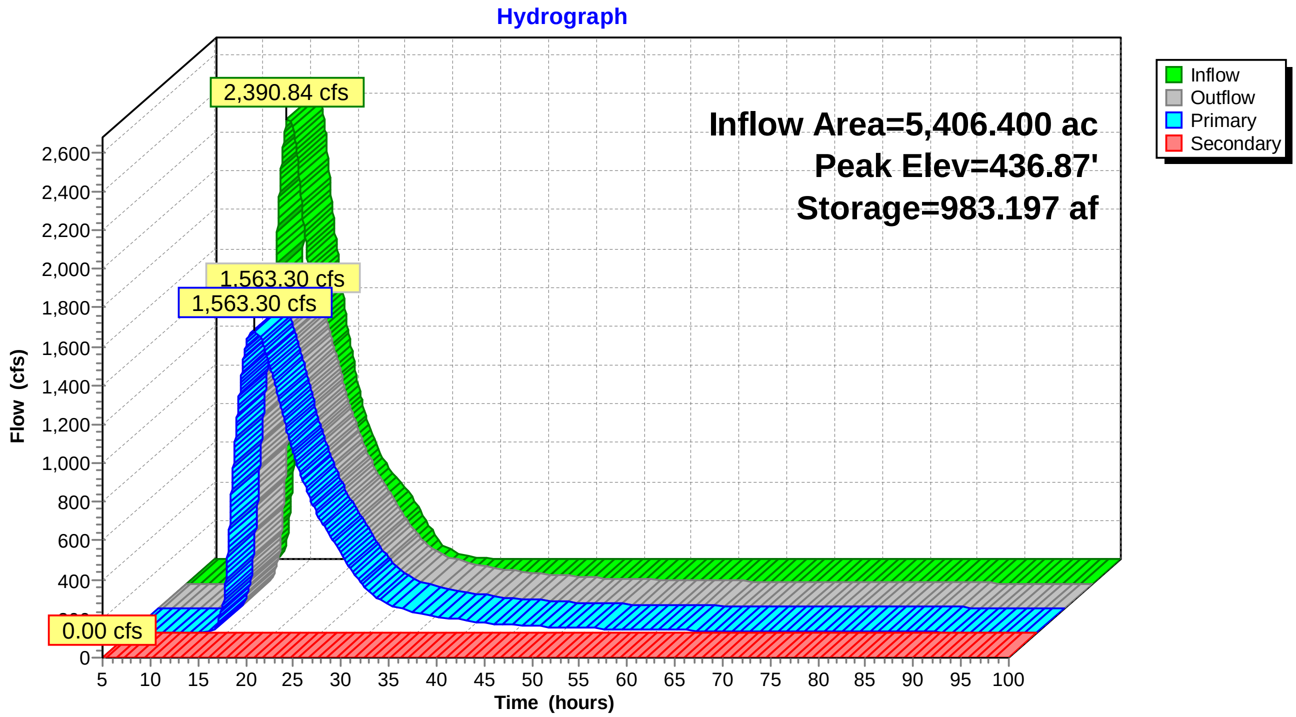
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
420.00	5.000	0.000	0.000
432.50	82.000	543.750	543.750
435.00	100.000	227.500	771.250
440.00	170.000	675.000	1,446.250

Device	Routing	Invert	Outlet Devices
#1	Primary	432.50'	**17.0' long x 1.7' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.59 2.63 2.63 2.65 2.71 2.80 2.86 3.00 2.99 2.96 3.20 3.27 3.32
#2	Primary	432.70'	**3.8' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Primary	434.25'	**84.0' long x 17.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Secondary	437.40'	**100.0' long x 106.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=1,562.70 cfs @ 17.92 hrs HW=436.87' (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 516.25 cfs @ 6.94 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 107.57 cfs @ 6.78 fps)
3=Broad-Crested Rectangular Weir (Weir Controls 938.88 cfs @ 4.26 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=432.50' (Free Discharge)
4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 9P: Freeses Pond



Summary for Pond 10P:

Inflow Area = 4,986.100 ac, 2.06% Impervious, Inflow Depth = 2.88" for 100-yr24-hr(updated) event
Inflow = 1,697.04 cfs @ 17.44 hrs, Volume= 1,194.957 af
Outflow = 835.86 cfs @ 22.35 hrs, Volume= 1,194.914 af, Atten= 51%, Lag= 294.6 min
Primary = 835.86 cfs @ 22.35 hrs, Volume= 1,194.914 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 115.00' Surf.Area= 10.131 ac Storage= 29.077 af
Peak Elev= 123.15' @ 22.35 hrs Surf.Area= 148.715 ac Storage= 517.198 af (488.121 af above start)

Plug-Flow detention time= 403.1 min calculated for 1,165.591 af (98% of inflow)
Center-of-Mass det. time= 368.1 min (1,586.3 - 1,218.2)

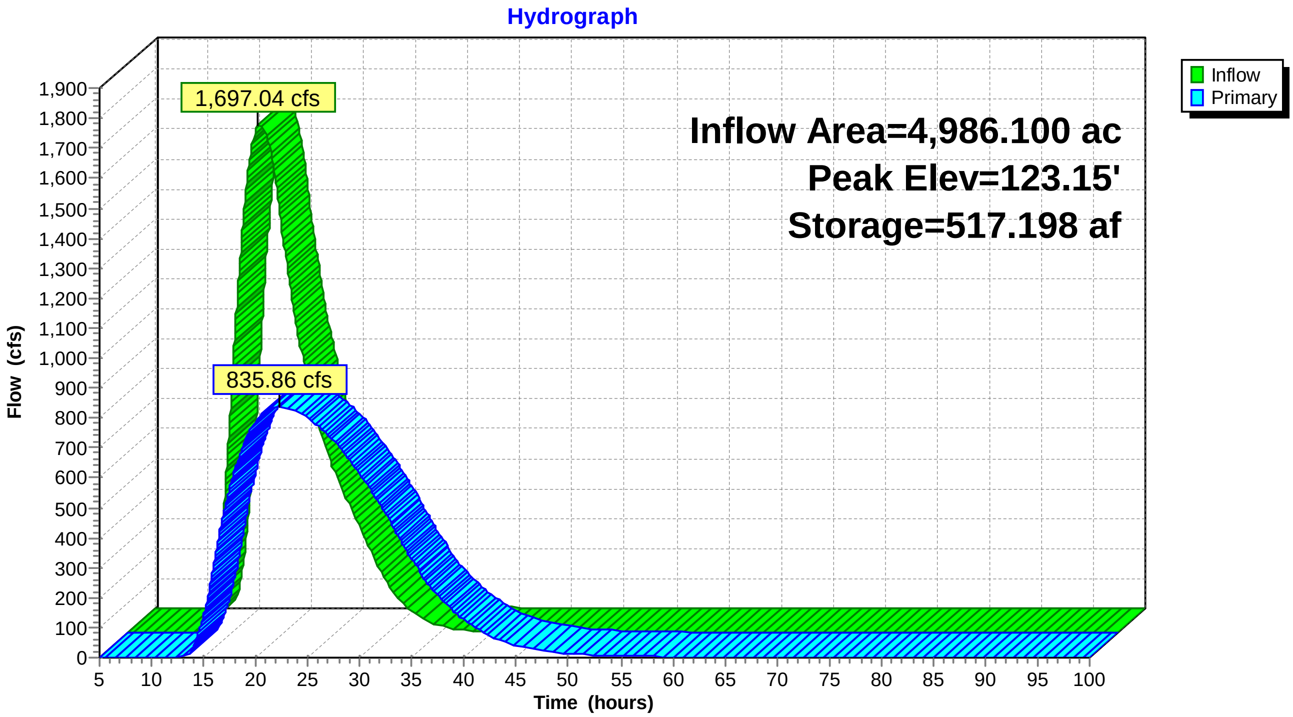
Volume	Invert	Avail.Storage	Storage Description
#1	110.00'	2,224.405 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
110.00	1.500	0.000	0.000
115.00	10.131	29.077	29.077
120.00	56.000	165.328	194.405
130.00	350.000	2,030.000	2,224.405

Device	Routing	Invert	Outlet Devices
#1	Primary	115.00'	**10.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=835.83 cfs @ 22.35 hrs HW=123.15' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 835.83 cfs @ 10.25 fps)

Pond 10P:


Hydrograph
1,697.04 cfs
835.86 cfs
Inflow Area=4,986.100 ac
Peak Elev=123.15'
Storage=517.198 af
Inflow
Primary
Flow (cfs)
Time (hours)
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
1,600
1,700
1,800
1,900
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

Summary for Pond 11P: Piscassic Ice Pond

[58] Hint: Peaked 1.01' above defined flood level
[61] Hint: Exceeded Reach 17R outlet invert by 1.01' @ 28.30 hrs

Inflow Area = 8,841.000 ac, 3.06% Impervious, Inflow Depth > 3.06" for 100-yr24-hr(updated) event
Inflow = 1,540.10 cfs @ 26.76 hrs, Volume= 2,252.435 af
Outflow = 1,511.21 cfs @ 28.30 hrs, Volume= 2,248.526 af, Atten= 2%, Lag= 92.6 min
Primary = 1,511.21 cfs @ 28.30 hrs, Volume= 2,248.526 af

Routing by Stor-Ind method, Time Span= 5.00-100.00 hrs, dt= 0.02 hrs
Starting Elev= 84.00' Surf.Area= 0.000 ac Storage= 27.000 af
Peak Elev= 93.01' @ 28.30 hrs Surf.Area= 0.000 ac Storage= 180.029 af (153.029 af above start)
Flood Elev= 92.00' Surf.Area= 0.000 ac Storage= 109.000 af (82.000 af above start)

Plug-Flow detention time= 129.5 min calculated for 2,221.526 af (99% of inflow)
Center-of-Mass det. time= 94.8 min (1,941.2 - 1,846.5)

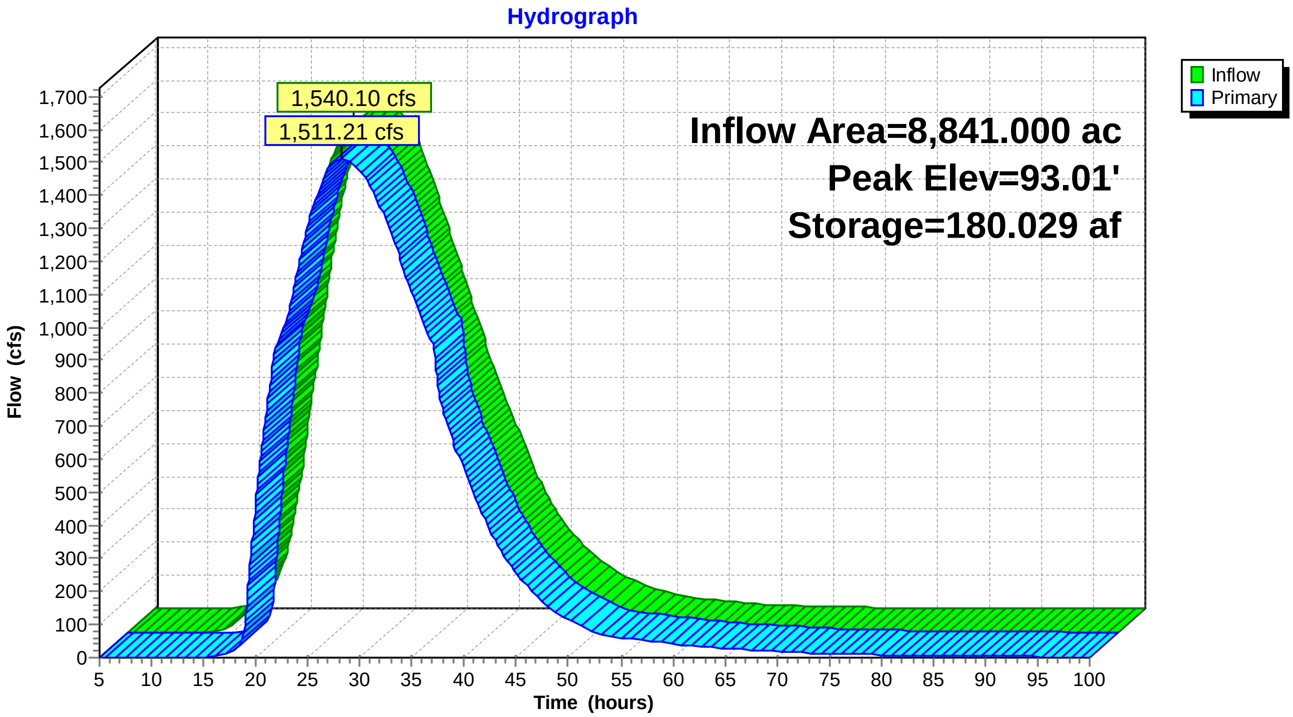
Volume	Invert	Avail.Storage	Storage Description
#1	80.00'	250.000 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
80.00	0.000
84.00	27.000
86.00	67.000
92.00	109.000
94.00	250.000

Device	Routing	Invert	Outlet Devices
#1	Primary	80.10'	**144.0" W x 120.0" H Box Culvert** L= 35.0' RCP, square edge headwall, Ke= 0.500 Outlet Invert= 80.00' S= 0.0029 '/' Cc= 0.900 n= 0.013
#2	Device 1	84.00'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 4.0' Crest Height
#3	Device 1	84.00'	**3.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 4.0' Crest Height
#4	Device 1	86.00'	**12.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 6.0' Crest Height
#5	Primary	92.00'	**135.0' long x 24.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=1,510.85 cfs @ 28.30 hrs HW=93.01' (Free Discharge)
└─**1=Culvert** (Passes 1,151.75 cfs of 1,374.58 cfs potential flow)
  ├─**2=Sharp-Crested Rectangular Weir** (Weir Controls 247.88 cfs @ 12.52 fps)
  ├─**3=Sharp-Crested Rectangular Weir** (Weir Controls 169.13 cfs @ 12.52 fps)
  └─**4=Sharp-Crested Rectangular Weir** (Weir Controls 734.74 cfs @ 9.89 fps)
└─**5=Broad-Crested Rectangular Weir** (Weir Controls 359.11 cfs @ 2.64 fps)

Pond 11P: Piscassic Ice Pond



Steve Guerrette

From: Corliss, Charles A <Charles.Corliss@des.nh.gov>
Sent: Monday, October 22, 2012 3:57 PM
To: Steve Guerrette
Subject: 177.01 Newmarket, Preliminary HydroCAD Model Review
Attachments: 3781_001.pdf

Steve,
Per your letter and HydroCAD submittal dated October 3, 2012, please find below comments per my review.

Lag/Curve number method:

- Watershed size, subcatchment 9S noted at 20,884 acres, 32.6 square miles.
- Review and comment.

Soils:

- Overall drainage area soil summary by group, submitted page 3.
- Some of the totals vary from DES totals.
- See attached sheet noting soil group totals as run by DES. (Attachment A).

Water bodies:

- No water bodies accounted for and appear to be noted as CN =80 in subcatchments, CN factor of 98 commonly used to account for water bodies. Review each subcatchments water area.
- Guidance suggests large water bodies should be modeled as storage. I.e. Pawtuckaway Lake (sub 10S). Reference National Engineering Handbook Part 630 Chapter 15, 630.1503(d).
- Some subcatchments noted individually below.
- Review and comment.

Dam #037.03 Socha Dam

- DES outflow at this dam approx 2,500 cfs compared with submitted 960 cfs.
- See attached sheet with outlet dimensions. (Attachment B).

Dam #061.02 Freeze's Pond Dam

- DES outflow at this dam approx 2,590 cfs compared with submitted 1,600 cfs.
- See attached sheet with outlet dimensions. (Attachment C).
- Review and comment.

Dam #061.07 Beaver Pond Dam

- Located in Sub 12S
- See attached sheet with outlet dimensions. (Attachment D).
- Review and comment.

Dam #171.01 Piscassic Ice Pond Dam

- Submittal doesn't include this dam as a subcatchment.
- 4.24 sq mile drainage area
- See attached sheet with outlet dimensions. (Attachment E).
- Review and comment.

Dam #184.01 Mendums Pond Dam

- DES outflow at this dam approx 185 cfs compared with submitted 325 cfs
- See attached sheet with outlet dimensions. (Attachment F)
- Review and comment.

Dam #184.04 Pawtuckaway Lake Dam

- DES outflow at this dam approx 1,200 cfs compared with submitted 300 cfs.
- See attached sheet with outlet dimensions. (Attachment G, pages 1 through 3).
- Review and comment.

Dam #184.08 Nottingham Lake Dam (Noted on submitted model as Marston Pond Dam)

- See attached sheet with outlet dimensions. (Attachment H)
- Review and comment.

Dam #201.01 Onway Dam

- DES outflow at this dam approx 945 cfs compared with submitted 415 cfs.
- See attached sheet with outlet dimensions. (Attachment I)
- Review and comment.

Subcatchment #5S:

- Does not account for Mendums Pond surface area of 265 acres.
- Review and comment.

Subcatchment #12S:

- Area has over 200 acres +/- of wetlands and ponds.
- Review and comment.

Subcatchment #11S:

- Does not account for Onway Lake surface area of 192 +/- acres.
- Review and comment.

Bridge #051/053 Epping, rte 27 over Lamprey River

- Evaluate opening for potential flow restriction and possible storage upstream.

Bridge #112/098 Newmarket, Packers Falls Road over Piscassic River (Adjacent dam #177.02 Newmarket).

- 18.6 sq mile DA.
- Evaluate opening for potential flow restriction and possible storage upstream.

Identify and include any other roadway crossings that have an influence on the 100 year flood flow.

Review the attached active dam listing for the Lamprey River water shed. Identify and include additional dams that could possibly influence the 100 year flood flow.

Please note the included attachments referencing dam outlets are the latest DES has on file and should be used as guide information, field verification may be necessary.

I will be interested in how the overflow at route 108 reduces the flow. Keep me posted.

Call with any questions or for clarification.

Chuck Corliss
Dam Safety Engineer, Water Division
NH Dept. Environmental Services
29 Hazen Drive PO Box 95, Concord NH 03302-0095
Ph 603-271-3406, 603-271-4130, Fax 603-271-6120
Charles.Corliss@des.nh.gov
Dam Bureau web site:
http://des.nh.gov/organization/divisions/water/dam

AllDASoil2, 10/10/2012, Page 1

OID	HydrolGrp	Count_HydrolGrp	Sum_Acres
0		240	5063.167
1	A	535	10258.9228
2	A/D	34	447.7778
3	B	1990	65253.3578
4	C	2092	38384.1621
5	C/D	283	3790.7979
6	D	935	12224.6251

Newmarket 177.01 10-10-2012

ATTACHMENT "A"

Summary for Pond 50P: SOCHA DAM

Inflow Area = 2,798.380 ac, 4.39% Impervious, Inflow Depth > 2.93" for JUNK event
Inflow = 2,636.89 cfs @ 13.18 hrs, Volume= 683.508 af
Outflow = 2,534.63 cfs @ 13.39 hrs, Volume= 633.443 af, Atten= 4%, Lag= 12.5 min
Primary = 1,711.47 cfs @ 13.39 hrs, Volume= 507.393 af
Secondary = 823.17 cfs @ 13.39 hrs, Volume= 126.050 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 388.49' @ 13.39 hrs Surf.Area= 28.388 ac Storage= 93.174 af

Plug-Flow detention time= 46.6 min calculated for 633.443 af (93% of inflow)
Center-of-Mass det. time= 25.1 min (906.2 - 881.0)

Volume	Invert	Avail.Storage	Storage Description
#1	385.00'	483.900 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
385.00	25.020	0.000	0.000
400.00	39.500	483.900	483.900

Device	Routing	Invert	Outlet Devices
#1	Primary	385.00'	**PRIMARY SPILLWAY, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 0.50 2.00 2.00 3.00 4.00 Width (feet) 8.00 8.00 30.00 30.00 30.00 70.00 100.00
#2	Primary	386.00'	**80.0' long x 1.5' breadth SECONDARY SPILLWAY** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32
#3	Secondary	387.00'	**140.0' long x 1.0' breadth TOP OF DAM** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Primary OutFlow Max=1,710.68 cfs @ 13.39 hrs HW=388.49' (Free Discharge)
└─**1=PRIMARY SPILLWAY** (Weir Controls 682.40 cfs @ 4.99 fps)
└─**2=SECONDARY SPILLWAY** (Weir Controls 1,028.27 cfs @ 5.17 fps)

Secondary OutFlow Max=822.58 cfs @ 13.39 hrs HW=388.49' (Free Discharge)
└─**3=TOP OF DAM** (Weir Controls 822.58 cfs @ 3.95 fps)

03703

Attachment "B"

Summary for Pond 4P: Freezes Pond Dam, 61.02

[93] Warning: Storage range exceeded by 0.48'
[58] Hint: Peaked 0.48' above defined flood level
[78] Warning: Submerged Pond 3P Primary device # 1 by 103.98'
[81] Warning: Exceeded Pond 3P by 95.85' @ 13.40 hrs

Inflow Area = 4,947.100 ac, 0.00% Impervious, Inflow Depth > 2.69"
Inflow = 4,279.72 cfs @ 15.30 hrs, Volume= 1,109.305 af
Outflow = 2,593.74 cfs @ 15.80 hrs, Volume= 1,054.298 af, Atten= 39%, Lag= 30.0 min
Primary = 2,472.66 cfs @ 15.80 hrs, Volume= 1,051.166 af
Secondary = 121.08 cfs @ 15.80 hrs, Volume= 3.132 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.10 hrs
Starting Elev= 100.00' Surf.Area= 0.000 ac Storage= 66.300 af
Peak Elev= 105.48' @ 15.80 hrs Surf.Area= 0.000 ac Storage= 192.000 af (125.700 af above start)
Flood Elev= 105.00' Surf.Area= 0.000 ac Storage= 192.000 af (125.700 af above start)

Plug-Flow detention time= 124.2 min calculated for 987.998 af (89% of inflow)
Center-of-Mass det. time= 39.8 min (1,185.8 - 1,146.0)

Volume	Invert	Avail.Storage	Storage Description
#1	87.00'	192.000 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
87.00	0.000
100.00	66.300
105.00	192.000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**17.0' long x 1.7' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.59 2.63 2.63 2.65 2.71 2.80 2.86 3.00 2.99 2.96 3.20 3.27 3.32
#2	Primary	100.20'	**3.8' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Primary	101.75'	**84.0' long x 17.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Secondary	104.90'	**100.0' long x 106.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

061.02

ATTACHMENT "C"

Primary OutFlow Max=2,472.29 cfs @ 15.80 hrs HW=105.48' (Free Discharge)
├—**1=Broad-Crested Rectangular Weir** (Weir Controls 724.87 cfs @ 7.77 fps)
├—**2=Broad-Crested Rectangular Weir** (Weir Controls 153.25 cfs @ 7.63 fps)
└—**3=Broad-Crested Rectangular Weir** (Weir Controls 1,594.17 cfs @ 5.08 fps)

Secondary OutFlow Max=120.57 cfs @ 15.80 hrs HW=105.48' (Free Discharge)
└—**4=Broad-Crested Rectangular Weir** (Weir Controls 120.57 cfs @ 2.06 fps)

Approved	By	Date

INSPECTION REPORT

To: Steve Doyon, P.E.
Water Resources Administrator

Subject: Scheduled Inspection of Beaver Pond Dam, Deerfield
Dam# 61.07

From: Grace Levergood, P.E.
Dam Safety Engineer

Classification: AA

Date: April 8, 2004

PERTINENT DATA:

Date Inspected:	June 16, 2003
Town:	Deerfield
Waterbody:	Beaver Pond
Maximum Height:	4 ft.
Overall Length:	75 ft.
Pond Area:	50 ac
Drainage Area:	4.0 sq. mi.
Storage:	16.5 ac-ft.perm, 66.5 ac-ft max
25 Year Storm:	***cfs inflow, *** cfs routed
Discharge Capacity:	*** cfs w/ 1' freeboard, 30 cfs w/ no freeboard, no ops
Type of Construction:	Earthen embankment with timber outlet
Construction Date:	1993 reconstructed outlet
Outlet Works:	1 – 5.5' wide timber stoplog bay, 4' high

OWNER/OPERATOR:
DRED
PO Box 1856
Concord, NH 03301
Contact: Mr. John White Tel: 603-271-2606

HYDROLOGY/HYDRAULICS:

The inflow from a 25 year storm event was analyzed using the SCS curve number method (TR-20) with the software, HydroCAD, version 6.0. The 4.0 square mile drainage area was divided into ***. The model predicted that there would be an inflow of *** cfs that, when routed through the pond would produce an outflow of **** cfs. This flow would pass through the drop inlet with *** foot of freeboard.

The dam can pass *** cfs with 1 foot of freeboard and *** cfs with no freeboard and no operations.

CLASSIFICATION AND JUSTIFICATION: AA

Downstream from the dam the discharge develops into the North Branch ***. There are no houses or road crossings between the dam and ***.

Since there are no downstream residences or road crossings that might sustain damage in the event of a dam breach, the hazard classification of "AA", non-menace dam, is justified for this structure.

EAP STATUS: (If applicable, if not, indicate by N/A)

None required.

061.07

ATTACHMENT "D"

~~Approved~~	~~By~~	~~Date~~
Chief Engr.	____	____
Bureau Admin	____	____

INSPECTION REPORT

To: Steve Doyon, P.E.
Dam Safety Engineer

Subject: Scheduled Inspection of Piscassic Ice Pond Dam in Newfields
Dam# 171.01

From: Dale F. Guinn
Dam Safety Engineer

Classification: Recommend change from AA to A

Date: February 11, 2000

PERTINENT DATA:

Date Inspected:	February 8, 2000
Town:	Newfields
Waterbody:	Piscassic River
Maximum Height:	12 ft., Crest of road
Overall Length:	35 ft. spillway and lower embankments, ± 100 ft crest of road
Pond Area:	13.69 acres
Drainage Area:	4.24 square miles
Storage:	27 ac-ft.- normal storage, 109 ac-ft – max storage
Discharge Capacity:	540 cfs.- over spillway and through attached culvert
Type of Construction:	Concrete spillway with two stop-log bays and a concrete box culvert with associated earth embankments
Construction Date:	1939
Outlet Works:	1- 4' stop-log section w/invert @ approximately 2' below crest of spillway 1- 3' stop-log section w/invert @ appr. 2' below crest of spillway 1- 12' concrete spillway w/ 6' of freeboard to the crest of the road 1- 10' x 12' foot box culvert along the existing road

OWNER/OPERATOR:

171.01

ATTACHMENT "E"

Dam Inspection Form

Dam number: 184.01
Hazard Classification: Significant changed to High is April 9, 2009 Memo
Dam name(s): Mendums Pond
Town: Nottingham
Date of inspection: May 22, 2009
Inspector: James R. Weber, P.E.
Water level: 0 on gage
Report date: NA

Pertinent Data:

Maximum Height: 31 ft
Storage: 1,960 ac-ft. perm, 3,330 ac-ft max
Overall Length: 440 ft
Drainage Area: 6.97 sq. mi.
Pond Area: 265 acres
Design event: 2.5 x 100 year storm
100 Year Storm: 1,558 cfs inflow routed to 330 cfs outflow 4.8 ft remaining fbd
2.5 x 100 Year: Verify at next inspection
Discharge Capacity: 1,235 cfs w/1'fbd-no ops
1,600 cfs no fbd-no ops
1,890 cfs no fbd-full ops
Type of Construction: Stone, Earth, Concrete
Construction Date: 1840 original; 1977 last reconstruction
Outlet Works: 1 – 25 ft broad crest overflow spillway, perm. crest elev = *Verify* ft
1 – 4 ft w x 2 ft h gate, sill elev = *Verify* ft
2 – 1.5 ft w x 2 ft h midlevel gates, sill elev = *Verify* ft

Dam Inspection Observations:

Feature	**Observation**	**Type M/S/ NA***
Dam Crest	• Generally good condition • Crest elevation appears uneven • A small sinkholes (12-inch dia & 3 inch deep) between gate house and downstream face over gate shaft • Barren area on left abutment	NA M M M
Upstream Face	• Concrete face appeared in good condition where not submerged • Stone face above concrete had numerous voids • Minor vegetation in several locations in stonework • Upstream tie rod anchors rusted and may not be able to support load	NA M M M/S
Downstream Face	• Downstream tie rod anchors rusted and may not be able to support load • Sloughing of crest over deteriorating/failed top of downstream wall near left of the outlet • Brush and trees in stonework, on stone buttresses to the right of the	M/S M/S M

184.01

ATTACHMENT "F"

Summary for Pond 1P: Pawtuckaway

[58] Hint: Peaked 0.65' above defined flood level
[79] Warning: Submerged Pond 6P Primary device # 1 by 3.65'

Inflow Area = 11,373.801 ac, 12.64% Impervious, Inflow Depth > 3.15" for JUNK event
Inflow = 4,153.09 cfs @ 17.04 hrs, Volume= 2,986.188 af
Outflow = 1,196.57 cfs @ 24.93 hrs, Volume= 2,137.180 af, Atten= 71%, Lag= 473.8 min
Primary = 1,167.56 cfs @ 24.93 hrs, Volume= 2,112.854 af
Secondary = 29.00 cfs @ 24.93 hrs, Volume= 24.327 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Starting Elev= 250.40' Surf.Area= 791.643 ac Storage= 4,463.836 af
Peak Elev= 252.65' @ 24.93 hrs Surf.Area= 886.265 ac Storage= 6,350.896 af (1,887.059 af above start)
Flood Elev= 252.00' Surf.Area= 858.591 ac Storage= 5,784.189 af (1,320.352 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 598.9 min (1,797.9 - 1,199.0)

Volume	Invert	Avail.Storage	Storage Description
#1	241.41'	14,094.166 af	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
241.41	278.287	0.000	0.000	278.287
242.41	325.272	301.474	301.474	325.273
243.41	356.573	340.803	642.277	356.575
244.41	387.464	371.912	1,014.189	387.468
245.41	451.674	419.159	1,433.347	451.679
246.41	514.280	482.639	1,915.986	514.286
247.41	577.512	545.591	2,461.577	577.520
248.41	635.992	606.517	3,068.094	636.001
249.41	690.093	662.858	3,730.952	690.104
250.41	792.704	740.806	4,471.758	792.716
260.00	1,230.000	9,622.408	14,094.166	1,230.042

184.04

ATTACHMENT "G" 1 OF 3

Device	Routing	Invert	Outlet Devices
#1	Primary	227.21'	**48.0" W x 36.0" H Vert. Dollof-Gate X 0.00** C= 0.600
#2	Primary	243.08'	**4.5' long x 1.0' breadth Dollof-Perm Stoplog Crest (3) X 0.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#3	Primary	250.40'	**4.5' long x 12.10' rise Dollof-Stoplog Bays (3) X 3.00** 2 End Contraction(s) 7.3' Crest Height
#4	Primary	250.14'	**41.0' long x 1.0' breadth Dollof-Secondary Spillway** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#5	Secondary	254.10'	**40.0' long x 30.0' breadth Dollof-Crest 4** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#6	Secondary	253.80'	**40.0' long x 30.0' breadth Dollof-Crest 3** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#7	Secondary	254.60'	**155.0' long x 30.0' breadth Dollof-Crest 2** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#8	Secondary	255.20'	**101.0' long x 30.0' breadth Dollof-Crest 1** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#9	Secondary	252.00'	**20.0' long x 10.0' breadth Dollof-Crest-Left Abutment** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#10	Secondary	255.10'	**175.0' long x 26.0' breadth Drowns-Crest** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#11	Secondary	253.00'	**25.0' long x 10.0' breadth Drowns-Left end ASW** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#12	Primary	241.30'	**4.6' long x 2.0' breadth Drowns-Perm Stoplog X 0.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#13	Primary	250.40'	**4.6' long Drowns-Stoplogs** 2 End Contraction(s) 9.1' Crest Height
#14	Primary	250.30'	**20.2' long x 2.0' breadth Drowns-Spillway (2) X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#15	Secondary	253.60'	**110.0' long x 25.0' breadth GoveDike-Crest-Right** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#16	Secondary	255.60'	**270.0' long x 25.0' breadth GoveDike-Crest-Left** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

#17	Secondary	254.00'	**50.0' long x 1.0' breadth DrownsDike-2-Crest** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#18	Secondary	254.00'	**280.0' long x 15.0' breadth DrownsDike-1-Crest** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=1,162.92 cfs @ 24.93 hrs HW=252.65' (Free Discharge)
- **1=Dollof-Gate** (Controls 0.00 cfs)
- **2=Dollof-Perm Stoplog Crest (3)** (Controls 0.00 cfs)
- **3=Dollof-Stoplog Bays (3)** (Weir Controls 139.11 cfs @ 5.09 fps)
- **4=Dollof-Secondary Spillway** (Weir Controls 539.57 cfs @ 5.24 fps)
- **12=Drowns-Perm Stoplog** (Controls 0.00 cfs)
- **13=Drowns-Stoplogs** (Weir Controls 47.17 cfs @ 5.05 fps)
- **14=Drowns-Spillway (2)** (Weir Controls 437.07 cfs @ 4.60 fps)

Secondary OutFlow Max=28.25 cfs @ 24.93 hrs HW=252.65' (Free Discharge)
- **5=Dollof-Crest 4** (Controls 0.00 cfs)
- **6=Dollof-Crest 3** (Controls 0.00 cfs)
- **7=Dollof-Crest 2** (Controls 0.00 cfs)
- **8=Dollof-Crest 1** (Controls 0.00 cfs)
- **9=Dollof-Crest-Left Abutment** (Weir Controls 28.25 cfs @ 2.17 fps)
- **10=Drowns-Crest** (Controls 0.00 cfs)
- **11=Drowns-Left end ASW** (Controls 0.00 cfs)
- **15=GoveDike-Crest-Right** (Controls 0.00 cfs)
- **16=GoveDike-Crest-Left** (Controls 0.00 cfs)
- **17=DrownsDike-2-Crest** (Controls 0.00 cfs)
- **18=DrownsDike-1-Crest** (Controls 0.00 cfs)

Operation, Maintenance and Response Information

Completed on: *May 8, 2008*

For information or questions, please contact the dam owner using the information below or the NH Dept. of Environmental Services at (603) 271-3406.

1. Dam and Owner/Operator Information

Dam Name: *Nottingham Lake Dam*

NH Dam # & Hazard Classification: *#184.08 Class A Low*

City/Town: *Nottingham, NH*

Downstream Watercourse: *Little River*

Dam Owner
Name: *Mill Pond View, LLC*
Address: c/o *Larry Costa*
224 Mill Pond Road
Nottingham, NH 03290
Tel: *603-734-2378* Cell:
E-mail: *larry.costa@wwlr.com*

Emergency Contact (Dam incidents or flooding)
Name: *Ian Rollins*
Address: *21 Little River Road*
Nottingham, NH 03290
Tel: *(603)679-1865* Office: *(603)679-3777*
Cell: (603)235-6744

2. Dam Information

Height (ft): *14* Length (ft): *150* Pond Size (ac): *31.6 @ El. 143.9'*
Normal Storage Capacity (ac-ft): *172.3 @ El. 143.9'* Drainage Area (sq mi): *14.6*

Outlet Works – Describe the dam's discharge features, and then include specific information on each below (sizes, dimensions, inverts, etc…): *The outlet works include two spillways and one low-level slide gate. Top of Dam Elev: 147.8 ft.*

Spillway No. 1:	*Weir with removable stoplogs; Length: 32 ft.; Crest Elev: 143.9 ft; Invert Elev. (w/ stoplogs removed): 141.7 ft*
Spillway No. 2:	*Concrete Weir; Length: 65 ft; Crest Elev: 144.4 ft*
Low-level gate:	*30" x 30" slide gate with seat; Elev. 133.6 ft*

Description of the Area Downstream of the Dam: (Include information on such things as roadways, dams, bridges or property that may be in danger of flooding due to high water events, dam failure or dam operations and, if known, the flow rates at which areas begin to be impacted. Also include information on any minimum flow needs downstream.):

The Little River downstream of the dam flows for approximately 3 miles through mostly wooded flood plain before entering the Lamprey River. There are five bridge crossings over these three miles. The first one, the Mill Pond Road bridge, is located immediately downstream of the dam.

3. Operations and Maintenance Information

Normal Reservoir Management Procedures (How is the impoundment level managed throughout the course of a calendar year? How do you achieve this?)

Summer:
Fall:
Winter:
Spring:

There are no seasonal operations. The lake level is maintained at the top of the stoplogs of Spillway No. 1 year-round. There may be infrequent reductions in the lake level below the stoplogs due to hydropower operations.

#184.08

ATTACHMENT "H"

Summary for Pond 2P: Onway Lake #201.01

[58] Hint: Peaked 1.22' above defined flood level
[62] Hint: Exceeded Reach 2R OUTLET depth by 1.08' @ 34.45 hrs

Inflow Area = 3,787.000 ac, 0.00% Impervious, Inflow Depth = 3.72"
Inflow = 2,371.67 cfs @ 14.91 hrs, Volume= 1,172.755 af
Outflow = 942.53 cfs @ 18.73 hrs, Volume= 1,034.288 af, Atten= 60%, Lag= 229.0 min
Primary = 440.59 cfs @ 18.73 hrs, Volume= 723.721 af
Secondary = 501.94 cfs @ 18.73 hrs, Volume= 310.567 af

Routing by Stor-Ind method, Time Span= 0.00-50.00 hrs, dt= 0.05 hrs
Starting Elev= 264.00' Surf.Area= 180.340 ac Storage= 551.124 af
Peak Elev= 266.75' @ 18.73 hrs Surf.Area= 198.154 ac Storage= 1,145.218 af (594.094 af above start)
Flood Elev= 265.53' Surf.Area= 190.247 ac Storage= 881.535 af (330.411 af above start)

Plug-Flow detention time= 1,072.7 min calculated for 483.164 af (41% of inflow)
Center-of-Mass det. time= 439.8 min (1,481.8 - 1,042.0)

Volume	Invert	Avail.Storage	Storage Description
#1	260.33'	2,926.629 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
260.33	120.000	0.000	0.000
264.00	180.340	551.124	551.124
275.00	251.570	2,375.505	2,926.629

Device	Routing	Invert	Outlet Devices
#1	Primary	264.00'	**6.0' long x 2.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	264.00'	**5.2' long x 1.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#3	Primary	265.20'	**0.7' long x 1.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#4	Secondary	265.53'	**60.0' long x 1.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32
#5	Primary	260.33'	**24.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

ATTACHMENT "I" # 201.01

Primary OutFlow Max=440.49 cfs @ 18.73 hrs HW=266.75' (Free Discharge)
├─**1=Broad-Crested Rectangular Weir** (Weir Controls 171.67 cfs @ 5.20 fps)
├─**2=Broad-Crested Rectangular Weir** (Weir Controls 157.31 cfs @ 5.50 fps)
├─**3=Broad-Crested Rectangular Weir** (Weir Controls 8.82 cfs @ 4.06 fps)
└─**5=Orifice/Grate** (Orifice Controls 102.70 cfs @ 8.56 fps)

Secondary OutFlow Max=500.68 cfs @ 18.73 hrs HW=266.75' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Weir Controls 500.68 cfs @ 3.42 fps)

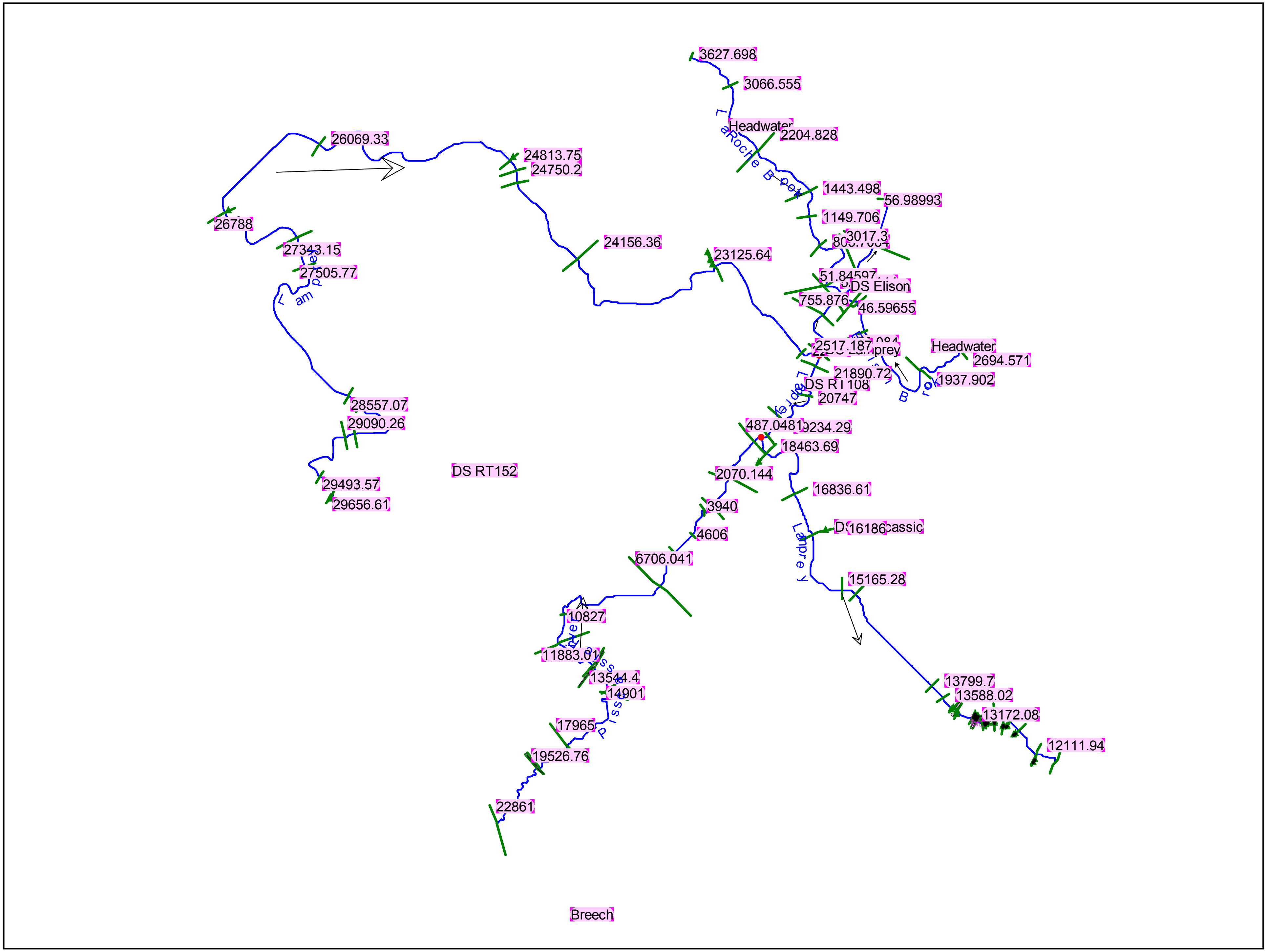
DAM	HAZCL	TOWN	NAME	RIVER	HEIGHT	IMPND	lattrunc	lontrunc	DASM
037.03	L	CANDIA	SOCHA DAM	TR NORTH BRANCH RIVE	6	30	43.0777	-71.314	4.35
037.11	NM	CANDIA	LACOMBE DAM	UNNAMED STREAM	6	0.1	43.0702	-71.246	
061.02	L	DEERFIELD	FREESES POND DAM	LAMPREY RIVER	12.5	55.3	43.1502	-71.234	8.58
061.07	NM	DEERFIELD	BEAVER POND DAM	NORTH BRANCH RIVER	4	62	43.1066	-71.329	4
061.14	NM	DEERFIELD	RECREATION POND DAM	TR BACK CREEK	11	0.2	43.1444	-71.212	
071.04	S	DURHAM	WISWALL DAM	LAMPREY RIVER	18	30	43.1038	-70.963	182
071.18	NM	DURHAM	WILDLIFE POND	NATURAL SWALE	8	0.66	43.1075	-70.964	45
071.21	NM	DURHAM	FARM POND	NATURAL SWALE	10	0.73	43.0977	-70.956	0.1
071.22	NM	DURHAM	FARM POND	NATURAL SWALE	6	0.5	43.1011	-70.953	25
071.34	NM	DURHAM	RECREATION POND DAM	UNNAMED STREAM	10	0.5	43.088	-70.95	0.1
078.02	L	EPPING	BUNKER POND DAM	LAMPREY RIVER	15	29	43.0405	-71.13	76.8
078.03	NM	EPPING	FARM POND	NATURAL SWALE	6	0.22	43.0636	-71.057	0.03
078.04	NM	EPPING	FARM POND	NATURAL SWALE	8	1	43.0777	-71.061	
078.05	L	EPPING	MELLING GLEN WOODLANDS DET PON	TR LAMPREY RIVER	19	0.7	43.0455	-71.046	0.05
078.10	NM	EPPING	GCF REALTY TRUST POND	UNNAMED STREAM	10.5	4	43.0508	-71.112	0.33
078.11	NM	EPPING	GCF REALTY TRUST DET POND	RUNOFF	10.5	0.5	43.0483	-71.106	0.33
135.07	NM	LEE	RECREATION POND	NATURAL SWALE	7.5	1.4	43.0844	-71.007	0.16
171.01	L	NEWFIELDS	PISCASSIC ICE POND DAM	PISCASSIC RIVER	12	13.7	43.0338	-70.968	4.24
177.01	H	NEWMARKET	MACALLEN DAM	LAMPREY RIVER	27	120	43.0811	-70.935	211
177.02	NM	NEWMARKET	PISCASSIC RIVER DAM	PISCASSIC RIVER	9	4	43.0822	-70.949	18.6
177.08	NM	NEWMARKET	CONSERVATION POND DAM	TRIB TO PISCASSIC	13	1.5	43.08	-70.969	0.26
177.09	NM	NEWMARKET	WILDLIFE POND DAM	UNNAMED STREAM	16	4	43.0536	-70.966	0.2
183.08	L	NORTHWOOD	LUCAS POND DAM	NORTH RIVER	4	40	43.1819	-71.163	1.16
183.13	L	NORTHWOOD	SAULS POND	UNNAMED STREAM	11	7.6	43.1805	-71.178	0.39
183.15	NM	NORTHWOOD	TUDOR WILDLIFE POND DAM	TR NORTH RIVER	11	7	43.1947	-71.178	0.29
183.17	L	NORTHWOOD	WOODMAN MARSH DAM	WOODMAN MARSH	7	10	43.1711	-71.181	1.1
183.18	L	NORTHWOOD	DOLE MARSH DAM	UNNAMED BROOK	8	25	43.1741	-71.189	0.52
183.24	NM	NORTHWOOD	NEWMAN RECREATION POND DAM	UNNAMED STREAM	8	0.5	43.1883	-71.197	0.0015
184.01	H	NOTTINGHAM	MENDUMS POND DAM	LITTLE RIVER	31	265	43.1627	-71.069	6.97
184.02	H	NOTTINGHAM	PAWTUCKAWAY LAKE/DOLLOF DAM	PAWTUCKAWAY RIVER	28	900	43.0722	-71.152	21
184.03	S	NOTTINGHAM	PAWTUCKAWAY LAKE/GOVE DIKE	TR PAWTUCKAWAY RIVE	9	900	43.0805	-71.134	21
184.04	S	NOTTINGHAM	PAWTUCKAWAY LAKE /DROWNS DAM	TR BEAN RIVER	18	900	43.1072	-71.125	21
184.05	L	NOTTINGHAM	NORTH RIVER POND DAM	NORTH RIVER	8	80	43.1925	-71.132	1.24
184.08	L	NOTTINGHAM	NOTTINGHAM LAKE DAM	LITTLE RIVER	14	35	43.1197	-71.051	14.58
184.11	L	NOTTINGHAM	DEER POND DAM	TR MOUNTAIN BROOK	12	38	43.0863	-71.200	0.61
184.13	NM	NOTTINGHAM	BURNHAMS DIKE	PAWTUCKAWAY POND			43.1002	-71.151	
184.15	NM	NOTTINGHAM	MOUNTAIN BROOK DAM	MOUNTAIN BROOK	9	5	43.0833	-71.172	0.607813
184.16	NM	NOTTINGHAM	OUTLET BURNHAMS MARSH DAM	BURNHAMS MARSH	7	1.65	43.0855	-71.157	
184.17	NM	NOTTINGHAM	FARM POND DAM	SPRINGS	7	0.05	43.1297	-71.138	
184.19	L	NOTTINGHAM	PAWTUCKAWAY LAKE/ DROWNS DIKE	PAWTUCKAWAY LAKE	12	900	43.1072	-71.123	21
201.01	L	RAYMOND	ONWAY LAKE DAM	TR LAMPREY RIVER	8.5	192	43.0344	-71.216	8.45
201.08	NM	RAYMOND	FIRE POND DAM	NATURAL SWALE	7	2.6	43.0552	-71.194	0.03

Lamprey River DA Active Dams

DAM	HAZCL	TOWN	NAME	RIVER	HEIGHT	IMPND	lattrunc	lontrunc	DASM
201.13	NM	RAYMOND	FIRE POND DAM	UNNAMED STREAM	7	0.2	43.0547	-71.149	

ATTACHEMNT 2

HEC-RAS Flow Split Model Output



3627.698
3066.555
Headwater
2204.828
26069.33
24813.75
24750.2
1443.498
56.98993
26788
1149.706
3017.3
27343.15
24156.36
23125.64
27505.77
DS Elison
755.876
46.59655
2517.187
Headwater
2694.571
21890.72
DS RT108
1937.902
20747
28557.07
29090.26
487.0481
18463.69
DS RT152
2070.144
29493.57
16836.61
29656.61
3940
16186
4606
Lamprey
6706.041
15165.28
10827
11883.01
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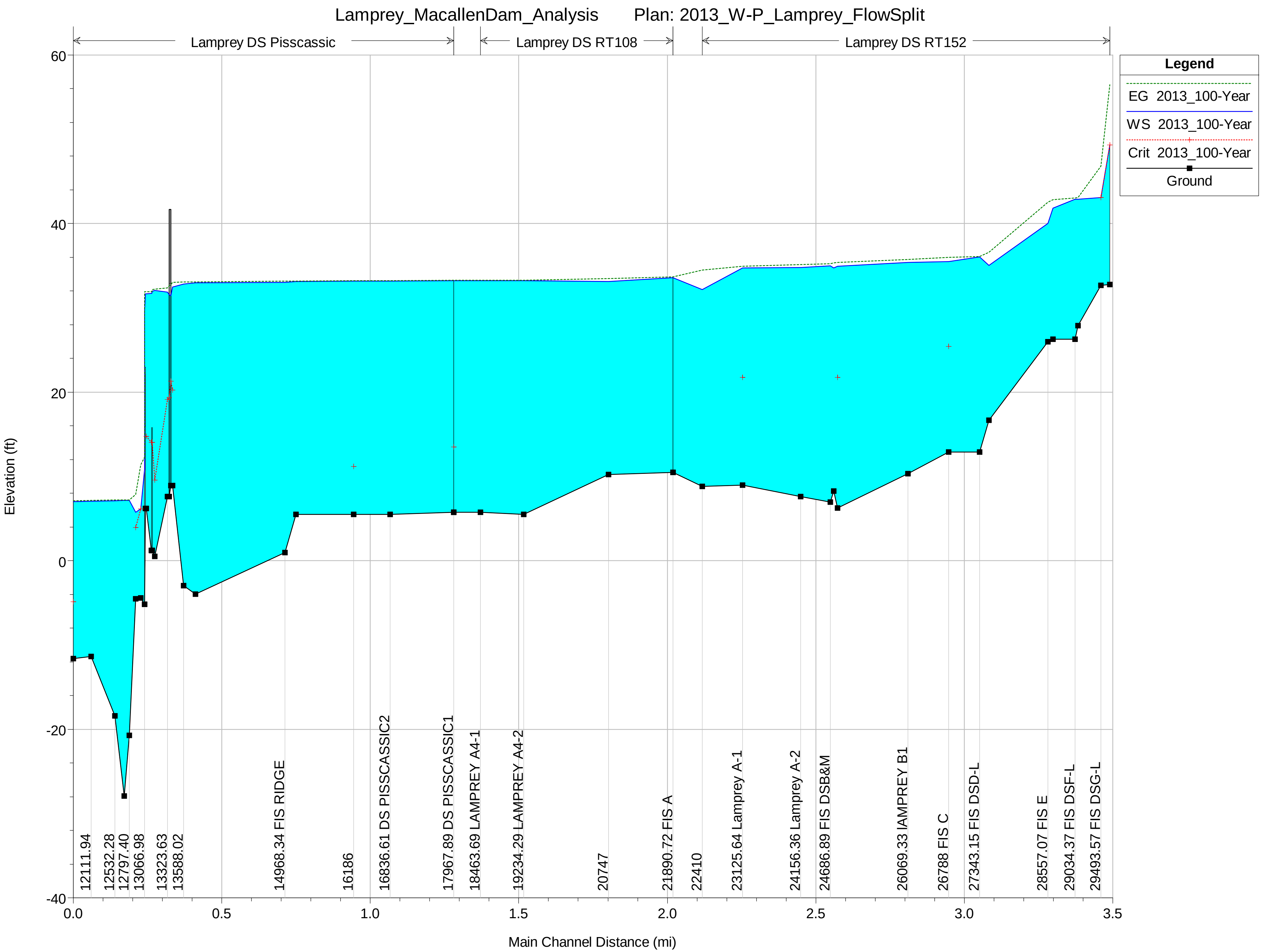
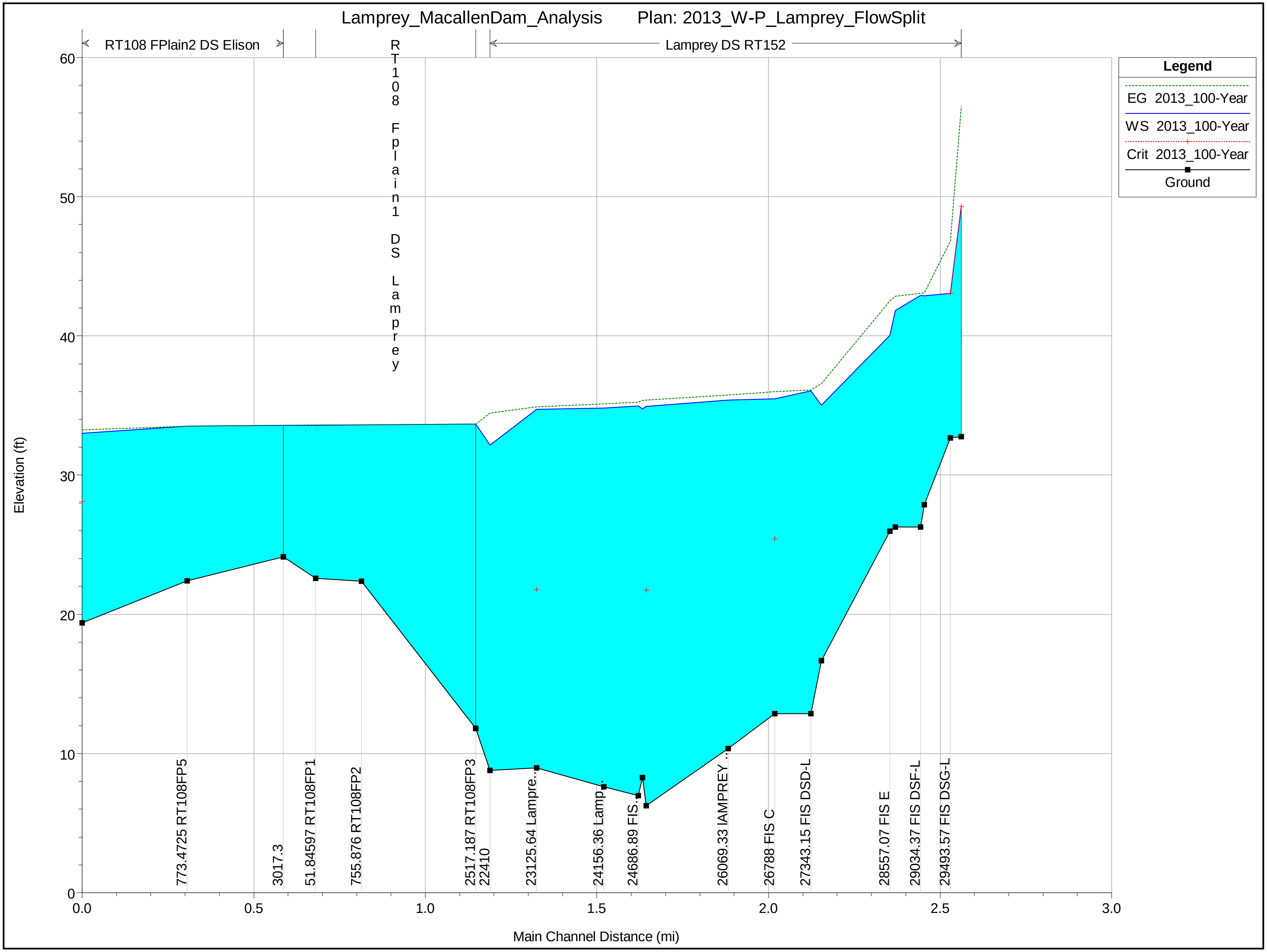
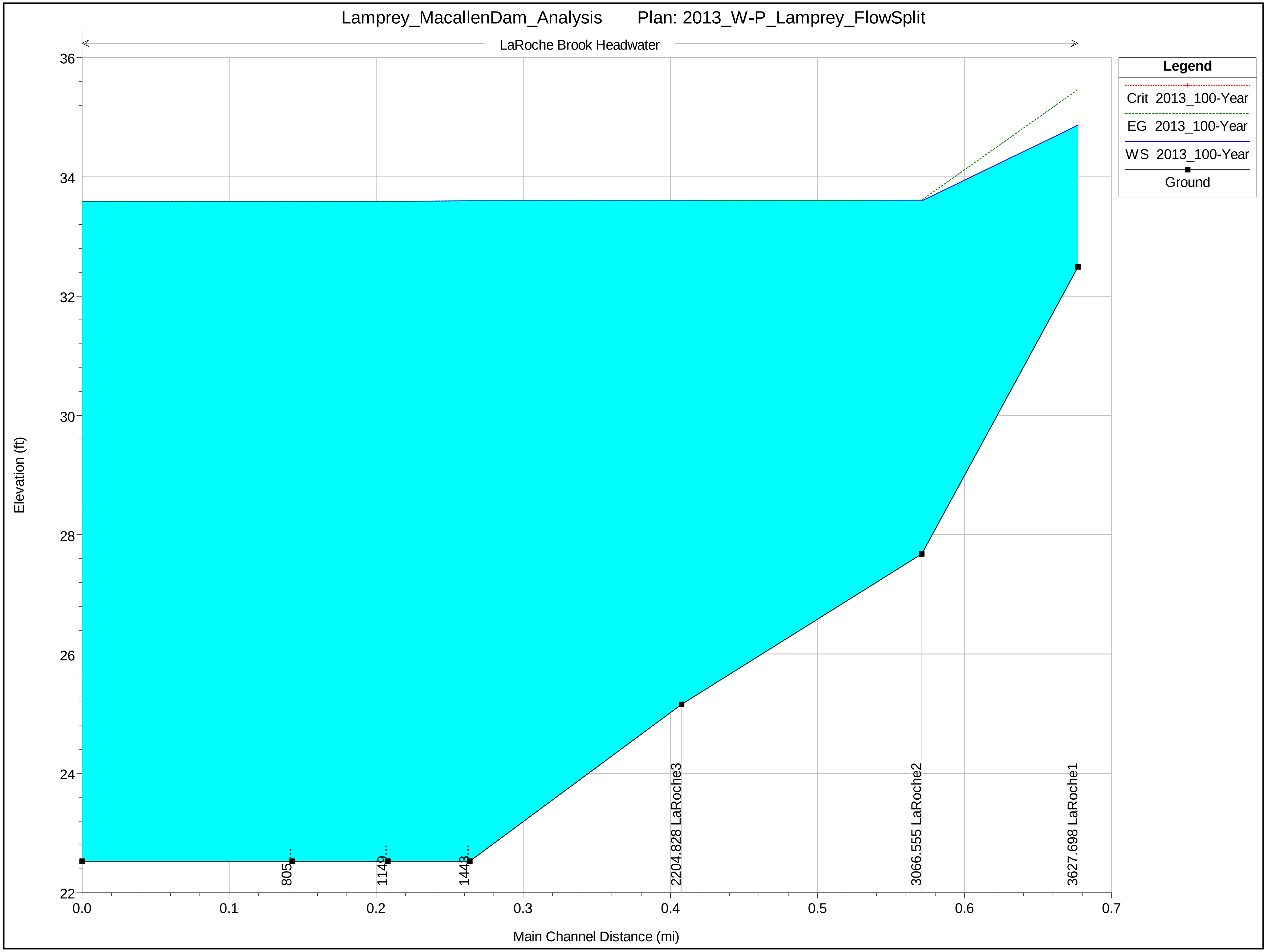
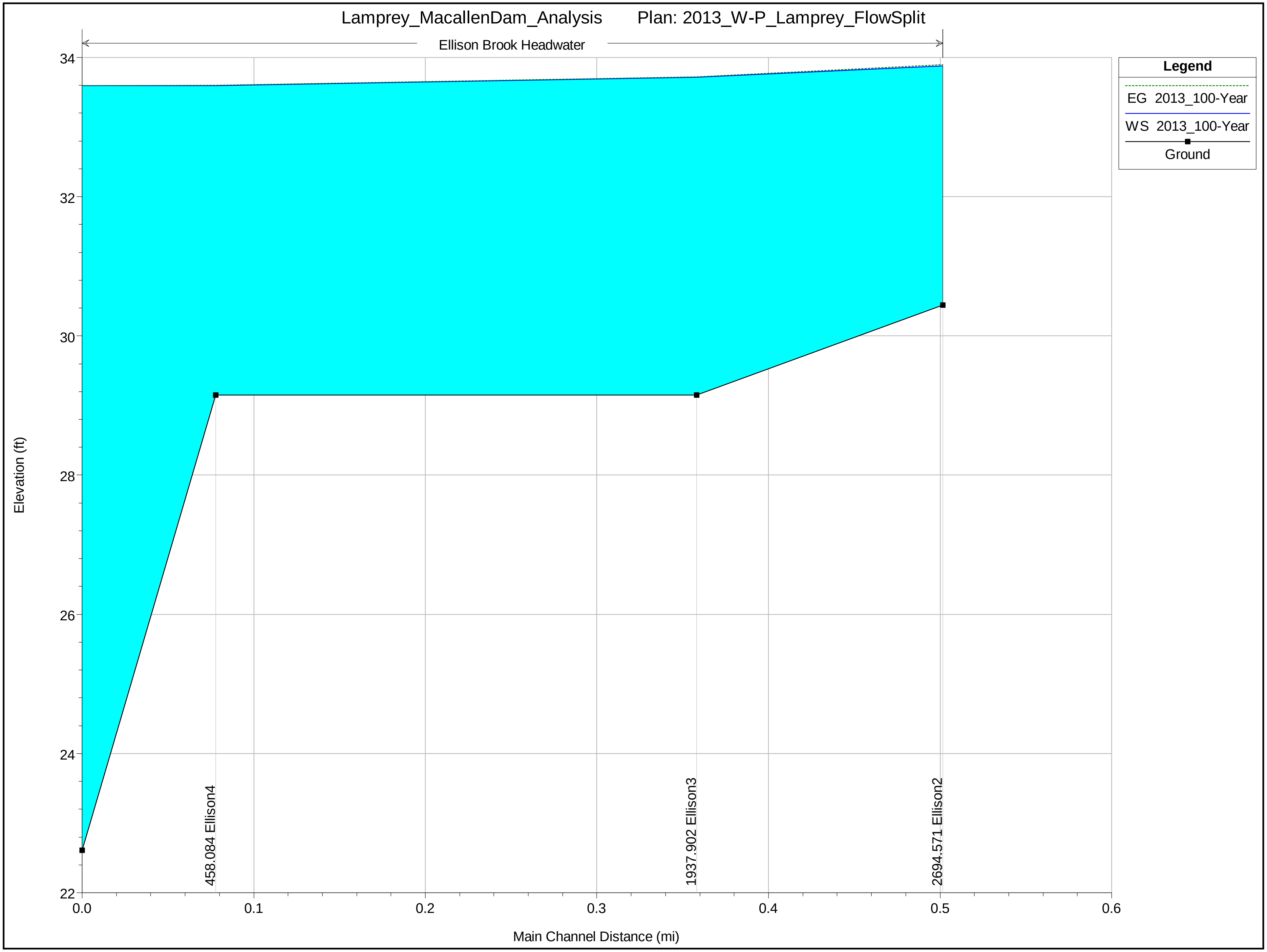
14901
13799.7
13588.02
13172.08
17965
12111.94
19526.76
22861
Breech

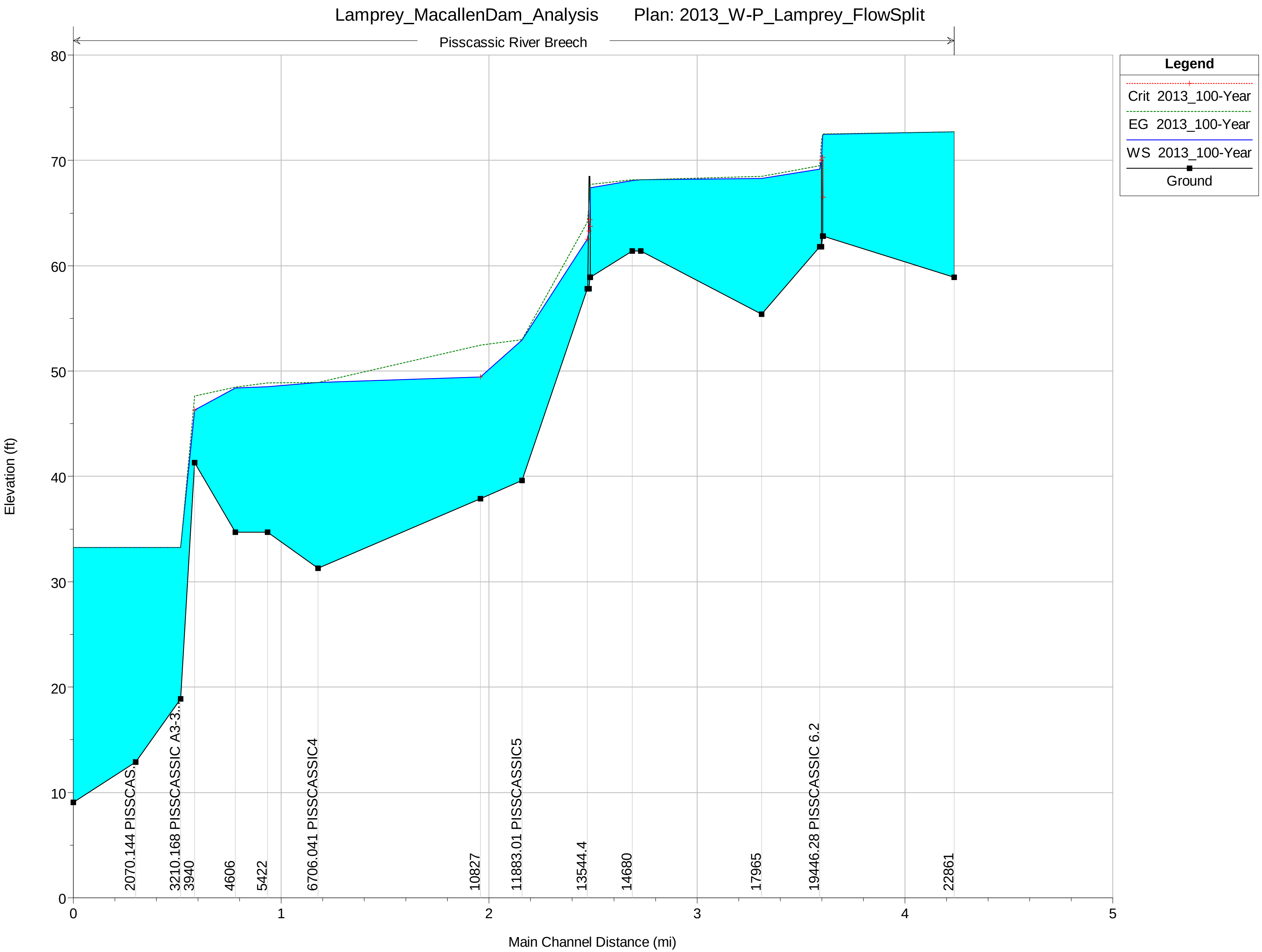


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
Lamprey DS Pisscassic
Lamprey DS RT108
Lamprey DS RT152
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Elevation (ft)
Main Channel Distance (mi)
12111.94
12532.28
12797.40
13066.98
13323.63
13588.02
14968.34 FIS RIDGE
16186
16836.61 DS PISSCASSIC2
17967.89 DS PISSCASSIC1
18463.69 LAMPREY A4-1
19234.29 LAMPREY A4-2
20747
21890.72 FIS A
22410
23125.64 Lamprey A-1
24156.36 Lamprey A-2
24686.89 FIS DSB&M
26069.33 lAMPREY B1
26788 FIS C
27343.15 FIS DSD-L
28557.07 FIS E
29034.37 FIS DSF-L
29493.57 FIS DSG-L
60
40
20
0
-20
-40
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
RT108 FPlain2 DS Elison
RT108 FPlain1 DS Lamprey
Lamprey DS RT152
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Elevation (ft)
Main Channel Distance (mi)
773.4725 RT108FP5
3017.3
51.84597 RT108FP1
755.876 RT108FP2
2517.187 RT108FP3
22410
23125.64 Lampre...
24156.36 Lamp...
24686.89 FIS...
26069.33 lAMPREY ...
26788 FIS C
27343.15 FIS DSD-L
28557.07 FIS E
29034.37 FIS DSF-L
29493.57 FIS DSG-L
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
LaRoche Brook Headwater
Legend
Crit 2013_100-Year
EG 2013_100-Year
WS 2013_100-Year
Ground
Elevation (ft)
Main Channel Distance (mi)
36
34
32
30
28
26
24
22
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
805...
1149...
1443...
2204.828 LaRoche3
3066.555 LaRoche2
3627.698 LaRoche1

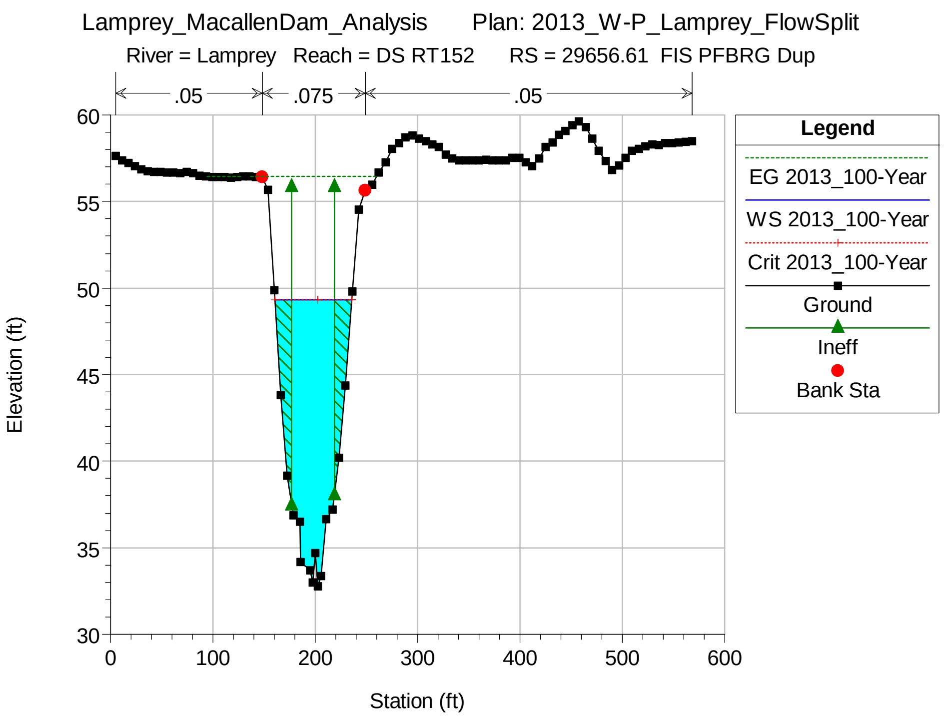

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
Ellison Brook Headwater
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Elevation (ft)
34
32
30
28
26
24
22
458.084 Ellison4
1937.902 Ellison3
2694.571 Ellison2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Main Channel Distance (mi)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
Pisscassic River Breech
Legend
Crit 2013_100-Year
EG 2013_100-Year
WS 2013_100-Year
Ground
Elevation (ft)
Main Channel Distance (mi)
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5
2070.144 PISSCAS...
3210.168 PISSCASSIC A3-3...
3940
4606
5422
6706.041 PISSCASSIC4
10827
11883.01 PISSCASSIC5
13544.4
14680
17965
19446.28 PISSCASSIC 6.2
22861

HEC-RAS Plan: 2013LampreySplit Profile: 2013_100-Year

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
RT108 FPlain2	DS Elison	3017.3	2013_100-Year	5615.09	24.12	33.58		33.58	0.000039	0.66	13718.29	3076.20	0.04
RT108 FPlain2	DS Elison	773.4725 RT108FP5	2013_100-Year	5615.09	22.42	33.52		33.53	0.000056	0.84	10364.68	1778.71	0.05
RT108 FPlain2	DS Elison	56.98993 RT108FP6	2013_100-Year	5615.09	19.38	33.00	28.11	33.25	0.002365	5.53	1469.59	215.61	0.29
RT108 Fplain1	DS Lamprey	2517.187 RT108FP3	2013_100-Year	4260.09	11.80	33.67		33.68	0.000060	1.21	4704.41	460.56	0.05
RT108 Fplain1	DS Lamprey	755.876 RT108FP2	2013_100-Year	4260.09	22.39	33.61		33.61	0.000028	0.63	8902.94	1156.08	0.03
RT108 Fplain1	DS Lamprey	51.84597 RT108FP1	2013_100-Year	4260.09	22.60	33.59		33.59	0.000014	0.46	11590.63	1514.07	0.02
Pisscassic River	Breech	22861	2013_100-Year	1850.00	58.90	72.71		72.73	0.000074	1.91	3483.96	708.91	0.11
Pisscassic River	Breech	19526.76 PISSCASSIC 6.1	2013_100-Year	1850.00	62.80	72.46	66.51	72.49	0.000069	1.64	2000.57	327.06	0.10
Pisscassic River	Breech	19484.18 Ash Swamp Road,		Bridge									
Pisscassic River	Breech	19446.28 PISSCASSIC 6.2	2013_100-Year	1850.00	61.80	69.16		69.50	0.001081	5.04	622.83	194.68	0.38
Pisscassic River	Breech	17965	2013_100-Year	1850.00	55.40	68.30		68.50	0.000437	4.00	920.30	213.73	0.25
Pisscassic River	Breech	14901	2013_100-Year	1850.00	61.40	68.16		68.17	0.000036	0.96	2232.08	485.69	0.07
Pisscassic River	Breech	14680	2013_100-Year	1850.00	61.40	68.09		68.15	0.000198	2.03	948.89	204.11	0.16
Pisscassic River	Breech	13620.5	2013_100-Year	1850.00	58.89	67.41	63.73	67.73	0.000947	4.55	406.53	76.28	0.35
Pisscassic River	Breech	13578.1		Bridge									
Pisscassic River	Breech	13544.4	2013_100-Year	1850.00	57.80	62.51	62.51	64.15	0.009295	10.27	180.17	55.87	1.01
Pisscassic River	Breech	11883.01 PISSCASSIC5	2013_100-Year	1850.00	39.60	52.94		52.97	0.000058	1.34	1670.17	316.36	0.09
Pisscassic River	Breech	10827	2013_100-Year	1850.00	37.90	49.45	49.45	52.45	0.012662	13.93	136.28	27.03	0.98
Pisscassic River	Breech	6706.041 PISSCASSIC4	2013_100-Year	1850.00	31.30	48.92		48.92	0.000003	0.35	7417.70	1288.21	0.02
Pisscassic River	Breech	5422	2013_100-Year	1850.00	34.70	48.53		48.88	0.000800	4.87	506.75	187.16	0.32
Pisscassic River	Breech	4606	2013_100-Year	1850.00	34.70	48.38		48.48	0.000236	2.56	825.27	162.29	0.18
Pisscassic River	Breech	3940	2013_100-Year	1850.00	41.29	46.29	46.29	47.63	0.008463	10.53	338.43	141.84	0.98
Pisscassic River	Breech	3210.168 PISSCASSIC A3-3	2013_100-Year	1850.00	18.90	33.26		33.27	0.000005	0.56	3809.99	449.88	0.03
Pisscassic River	Breech	2070.144 PISSCASSIC A3-2	2013_100-Year	1850.00	12.90	33.26		33.26	0.000004	0.53	5853.46	974.39	0.03
Pisscassic River	Breech	487.0481 PISSCASSIC A3-1	2013_100-Year	1850.00	9.05	33.26		33.26	0.000001	0.21	11058.11	1208.26	0.01
LaRoche Brook	Headwater	3627.698 LaRoche1	2013_100-Year	615.00	32.49	34.87	34.87	35.47	0.036969	7.32	111.44	88.20	0.93
LaRoche Brook	Headwater	3066.555 LaRoche2	2013_100-Year	615.00	27.68	33.60		33.61	0.000242	1.22	737.69	197.29	0.09
LaRoche Brook	Headwater	2204.828 LaRoche3	2013_100-Year	615.00	25.16	33.60		33.60	0.000004	0.20	5409.24	1388.08	0.01
LaRoche Brook	Headwater	1443.498 LaRoche4	2013_100-Year	615.00	22.53	33.59		33.60	0.000004	0.26	4679.26	985.35	0.01
LaRoche Brook	Headwater	1149.706 LaRoche5	2013_100-Year	615.00	22.53	33.59		33.59	0.000014	0.46	2380.05	435.13	0.02
LaRoche Brook	Headwater	805.7084 LaRoche7	2013_100-Year	615.00	22.53	33.59		33.59	0.000007	0.31	3449.16	604.38	0.02
LaRoche Brook	Headwater	52.38144 LaRoche8	2013_100-Year	615.00	22.53	33.59		33.59	0.000000	0.07	12232.18	1586.62	0.00
Lamprey	DS RT152	29656.61 FIS PFBRG Dup	2013_100-Year	12670.00	32.78	49.32	49.32	56.45	0.038730	21.44	591.02	74.70	1.00
Lamprey	DS RT152	29493.57 FIS DSG-L	2013_100-Year	12670.00	32.68	43.07	43.07	46.80	0.041785	15.55	832.40	120.02	0.98
Lamprey	DS RT152	29090.26 FIS F	2013_100-Year	12670.00	27.88	42.87		43.10	0.000559	3.97	3528.46	309.44	0.19
Lamprey	DS RT152	29034.37 FIS DSF-L	2013_100-Year	12670.00	26.28	42.91		43.06	0.000137	3.14	4038.05	349.81	0.16
Lamprey	DS RT152	28641.67 FIS USE-L	2013_100-Year	12670.00	26.28	41.83		42.86	0.001071	8.14	1555.95	146.83	0.44
Lamprey	DS RT152	28557.07 FIS E	2013_100-Year	12670.00	25.98	40.04		42.52	0.009013	12.91	1121.05	137.44	0.67
Lamprey	DS RT152	27505.77 FIS D	2013_100-Year	12670.00	16.68	35.02		36.58	0.003549	12.96	1636.32	187.47	0.57
Lamprey	DS RT152	27343.15 FIS DSD-L	2013_100-Year	12670.00	12.88	36.04		36.10	0.000046	2.01	7157.66	624.64	0.09
Lamprey	DS RT152	26788 FIS C	2013_100-Year	12670.00	12.88	35.48	25.42	36.00	0.000343	5.86	2556.07	263.68	0.25
Lamprey	DS RT152	26069.33 lAMPREY B1	2013_100-Year	12670.00	10.35	35.38		35.75	0.000241	5.04	3481.27	399.22	0.21
Lamprey	DS RT152	24813.75 FIS B	2013_100-Year	12670.00	6.26	34.95	21.74	35.40	0.000316	5.48	2826.38	376.65	0.24
Lamprey	DS RT152	24750.2 FIS B&M	2013_100-Year	12670.00	8.28	34.76		35.36	0.000484	6.23	2034.23	132.66	0.28
Lamprey	DS RT152	24686.89 FIS DSB&M	2013_100-Year	12670.00	6.98	34.97		35.24	0.000218	4.36	3285.87	404.98	0.20
Lamprey	DS RT152	24156.36 Lamprey A-2	2013_100-Year	12670.00	7.62	34.80		35.13	0.000205	4.66	3819.42	557.59	0.20
Lamprey	DS RT152	23125.64 Lamprey A-1	2013_100-Year	12670.00	8.98	34.74	21.77	34.92	0.000130	3.55	4783.33	457.17	0.15
Lamprey	DS RT152	22410	2013_100-Year	12670.00	8.80	32.17		34.46	0.002483	13.93	1892.76	214.49	0.59
Lamprey	DS RT108	21890.72 FIS A	2013_100-Year	8409.91	10.48	33.60		33.68	0.000068	2.42	3980.19	384.31	0.11
Lamprey	DS RT108	20747	2013_100-Year	8409.91	10.25	33.14		33.50	0.000335	5.59	2044.05	255.42	0.24
Lamprey	DS RT108	19234.29 LAMPREY A4-2	2013_100-Year	8409.91	5.50	33.22		33.30	0.000035	2.38	5222.90	411.46	0.09
Lamprey	DS RT108	18463.69 LAMPREY A4-1	2013_100-Year	8409.91	5.77	33.24		33.26	0.000016	1.33	6499.32	445.84	0.06
Lamprey	DS Pisscassic	17967.89 DS PISSCASSIC1	2013_100-Year	10259.91	5.77	33.21	13.50	33.25	0.000024	1.57	7241.81	1026.84	0.07
Lamprey	DS Pisscassic	16836.61 DS PISSCASSIC2	2013_100-Year	10259.91	5.50	33.18		33.22	0.000024	1.72	6358.63	462.21	0.07
Lamprey	DS Pisscassic	16186	2013_100-Year	10259.91	5.50	33.19	11.19	33.21	0.000010	1.11	9935.19	947.83	0.04
Lamprey	DS Pisscassic	15165.28 SRY A2	2013_100-Year	10259.91	5.50	33.10		33.18	0.000037	2.29	4620.17	249.14	0.09
Lamprey	DS Pisscassic	14968.34 FIS RIDGE	2013_100-Year	10259.91	0.98	33.03		33.17	0.000076	2.95	3712.92	282.23	0.13
Lamprey	DS Pisscassic	13799.7	2013_100-Year	10259.91	-3.96	32.99		33.09	0.000029	2.48	4433.34	177.36	0.08
Lamprey	DS Pisscassic	13588.02	2013_100-Year	10259.91	-2.96	32.84		33.06	0.000093	3.87	2939.33	141.46	0.13
Lamprey	DS Pisscassic	13390.60	2013_100-Year	10259.91	8.91	32.46	20.26	33.00	0.000282	5.96	1792.94	143.85	0.24
Lamprey	DS Pisscassic	13357.13		Bridge									
Lamprey	DS Pisscassic	13323.63	2013_100-Year	10259.91	7.59	31.85	19.12	32.35	0.000298	5.75	1874.16	145.85	0.23
Lamprey	DS Pisscassic	13172.08	2013_100-Year	10259.91	0.52	32.09	9.56	32.21	0.000048	2.73	3829.36	172.18	0.10
Lamprey	DS Pisscassic	13141	2013_100-Year	10259.91	1.23	31.97	14.05	32.19	0.000314	3.84	2829.37	194.17	0.14
Lamprey	DS Pisscassic	13140.84		Inl Struct									
Lamprey	DS Pisscassic	13121	2013_100-Year	10259.91	1.23	31.70	14.05	31.93	0.000118	3.89	2777.78	192.36	0.14
Lamprey	DS Pisscassic	13101.76	2013_100-Year	10259.91	6.19	31.69	14.77	31.92	0.000389	3.94	2797.51	285.99	0.14
Lamprey	DS Pisscassic	13100.92		Inl Struct									
Lamprey	DS Pisscassic	13066.98	2013_100-Year	10259.91	-5.15	10.83		12.30	0.004421	9.74	1058.52	90.04	0.49
Lamprey	DS Pisscassic	13003.88	2013_100-Year	10259.91	-4.42	6.13	6.13	11.37	0.025392	18.38	558.31	53.27	1.00
Lamprey	DS Pisscassic	12909.71	2013_100-Year	10259.91	-4.52	5.73	3.96	7.86	0.012066	11.72	875.84	102.40	0.71
Lamprey	DS Pisscassic	12797.40	2013_100-Year	10259.91	-20.71	7.17		7.21	0.000066	1.66	6291.80	410.70	0.07
Lamprey	DS Pisscassic	12703.69	2013_100-Year	10259.91	-27.92	7.18		7.20	0.000024	1.23	8322.76	341.77	0.04
Lamprey	DS Pisscassic	12532.28	2013_100-Year	10259.91	-18.43	7.09		7.19	0.000064	2.55	4033.24	242.35	0.11
Lamprey	DS Pisscassic	12111.94	2013_100-Year	10259.91	-11.36	7.04		7.16	0.000085	2.72	3773.36	276.02	0.12
Lamprey	DS Pisscassic	11795.68	2013_100-Year	10259.91	-11.61	7.00	-4.89	7.13	0.000095	2.86	3650.89	302.74	0.13
Ellison Brook	Headwater	2694.571 Ellison2	2013_100-Year	740.00	30.44	33.88		33.90	0.000563	1.10	660.46	246.59	0.11
Ellison Brook	Headwater	1937.902 Ellison3	2013_100-Year	740.00	29.15	33.71		33.72	0.000125	0.65	1245.90	366.56	0.05
Ellison Brook	Headwater	458.084 Ellison4	2013_100-Year	740.00	29.15	33.60		33.60	0.000055	0.43	2100.98	790.63	0.04
Ellison Brook	Headwater	46.59655 Ellison5	2013_100-Year	740.00	22.61	33.60		33.60	0.000004	0.21	4082.77	584.03	0.01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River = Lamprey Reach = DS RT152 RS = 29656.61 FIS PFBRG Dup
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Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
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Station (ft)
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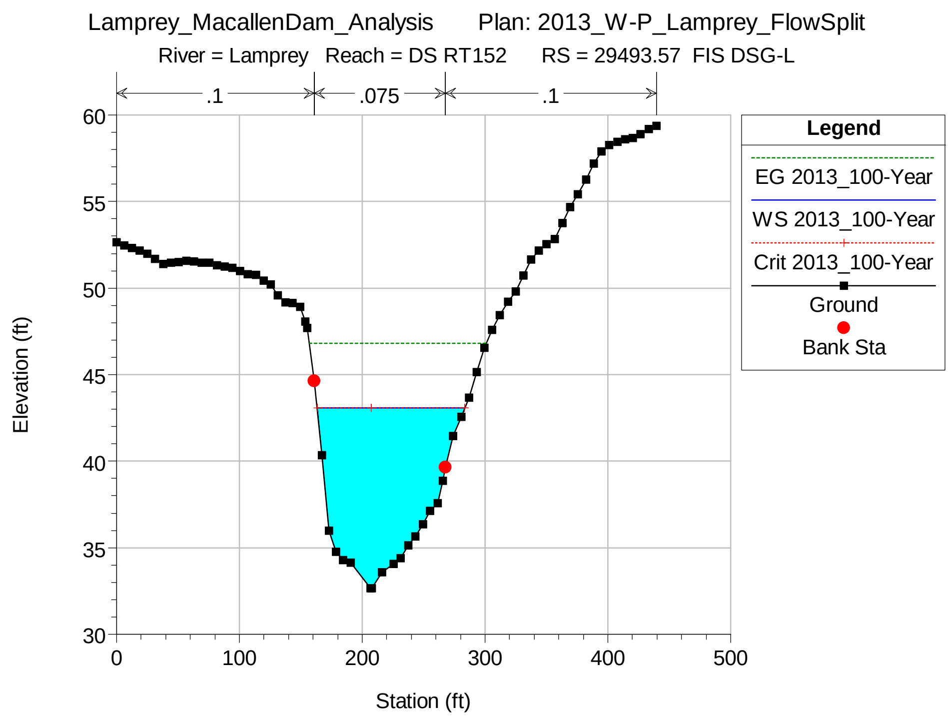
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Crit 2013_100-Year
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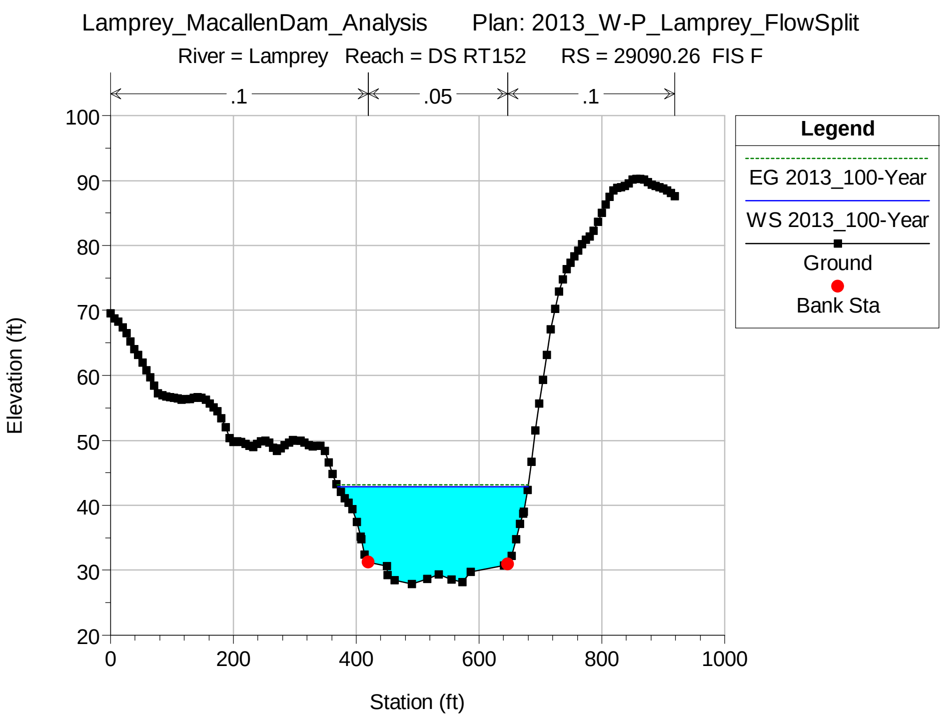
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River = Lamprey Reach = DS RT152 RS = 29090.26 FIS F
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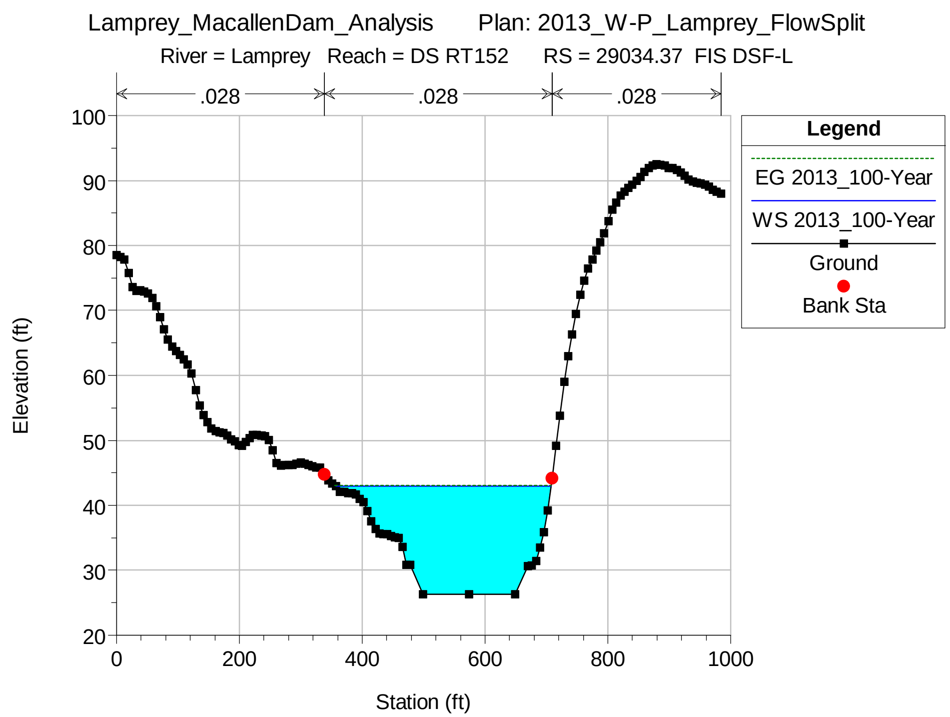
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River = Lamprey Reach = DS RT152 RS = 29034.37 FIS DSF-L
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Legend
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WS 2013_100-Year
Ground
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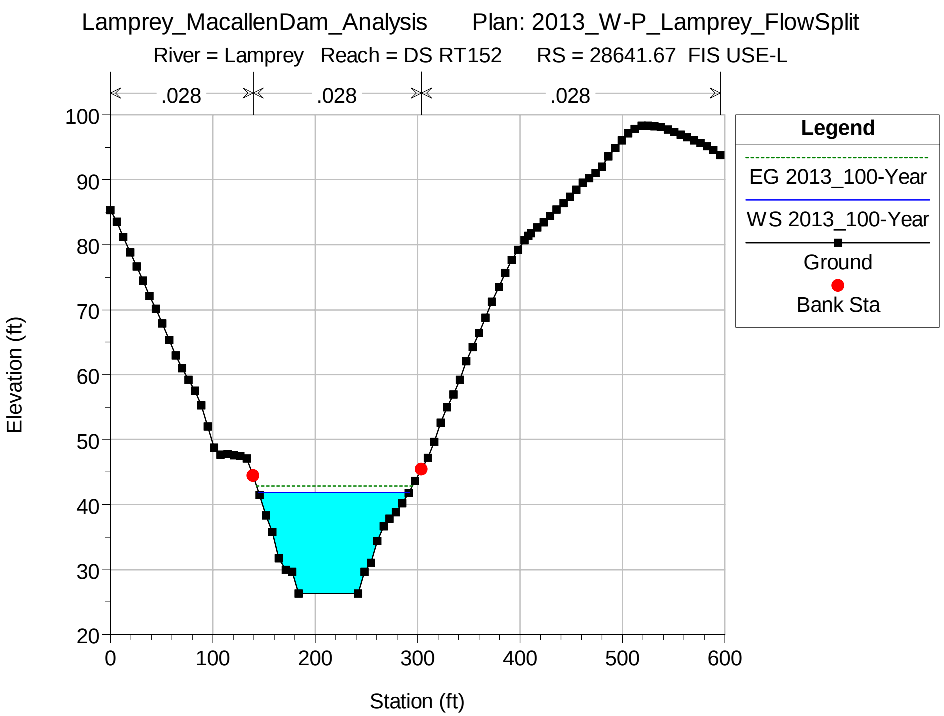
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River = Lamprey Reach = DS RT152 RS = 28641.67 FIS USE-L
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.028
.028
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
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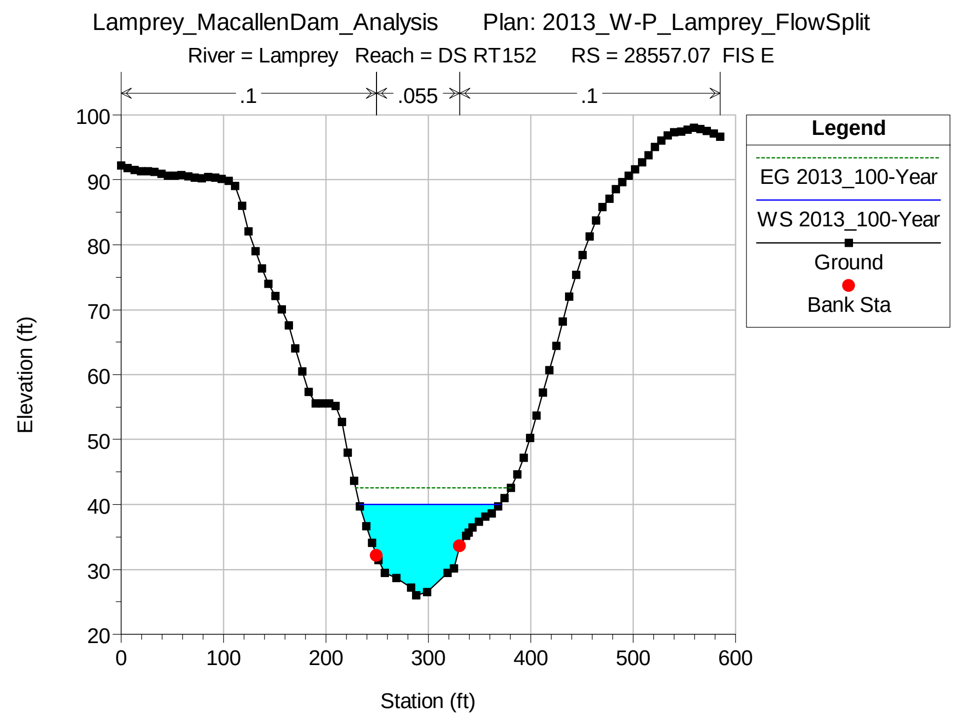
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River = Lamprey Reach = DS RT152 RS = 28557.07 FIS E
.1
.055
.1
Legend
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WS 2013_100-Year
Ground
Bank Sta
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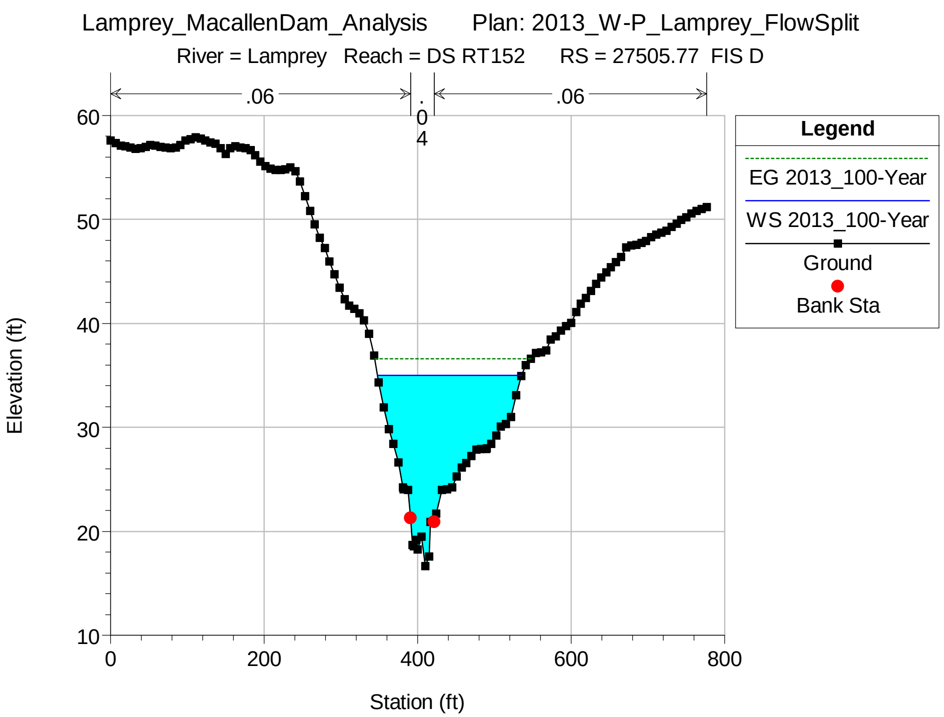
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River = Lamprey Reach = DS RT152 RS = 27505.77 FIS D
.06
.
0
4
.06
Legend
EG 2013_100-Year
WS 2013_100-Year
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Bank Sta
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600
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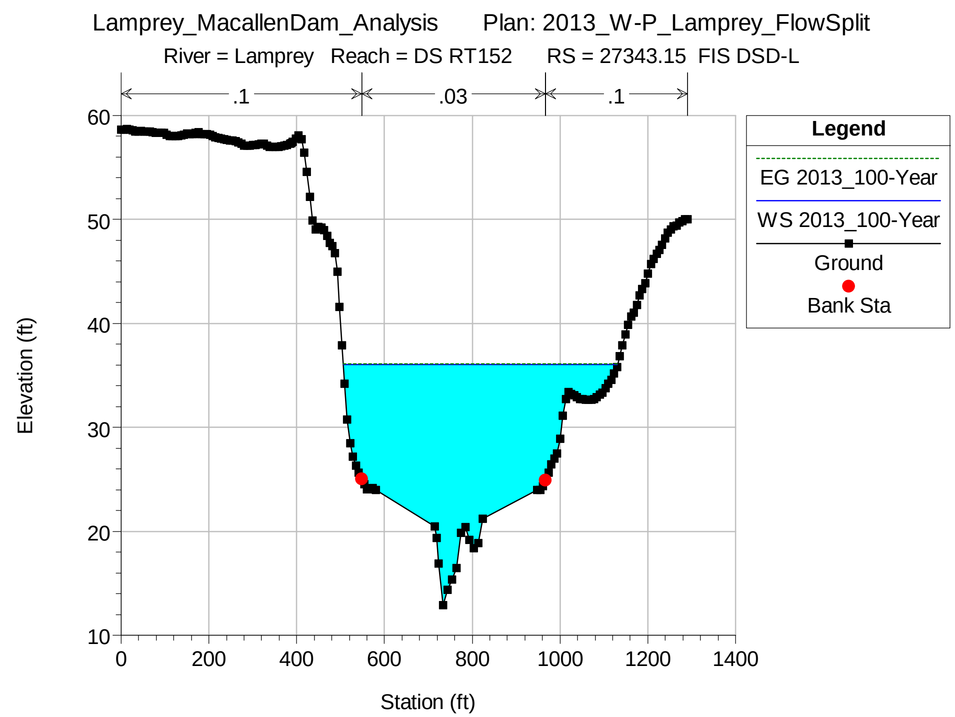
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 27343.15 FIS DSD-L
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.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
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200
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600
800
1000
1200
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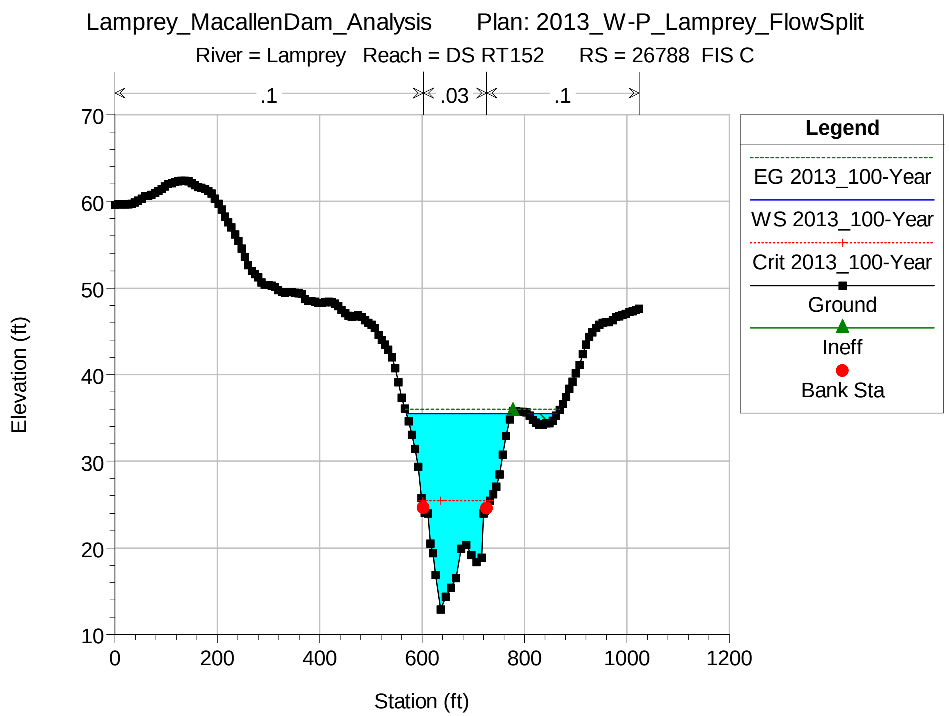
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 26788 FIS C
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta
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10
0
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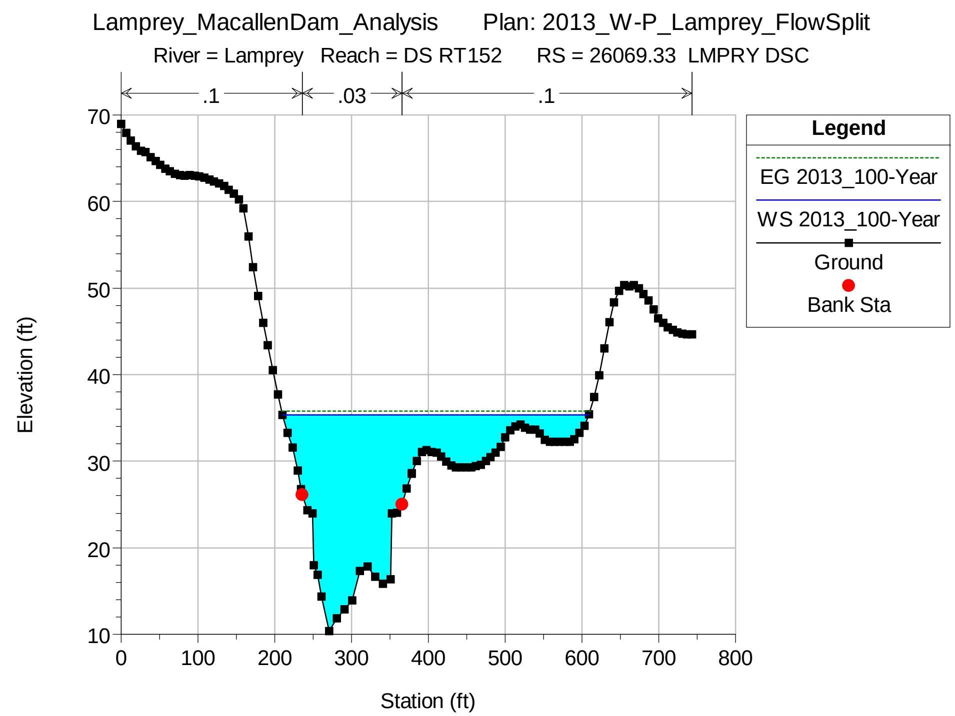
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 26069.33 LMPRY DSC
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.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
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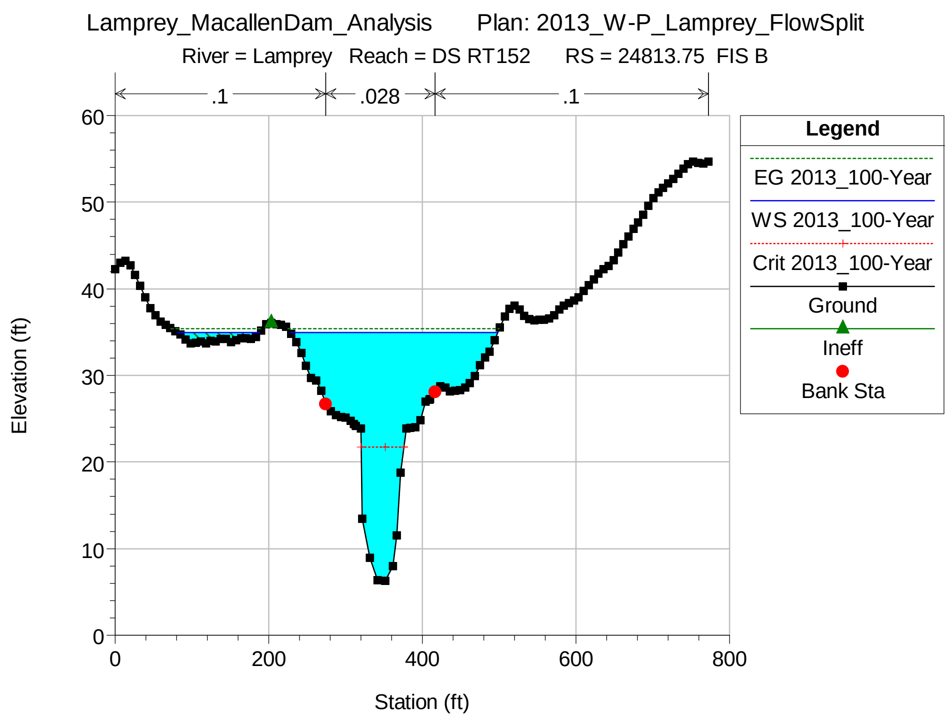
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 24813.75 FIS B
.1
.028
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta
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Station (ft)
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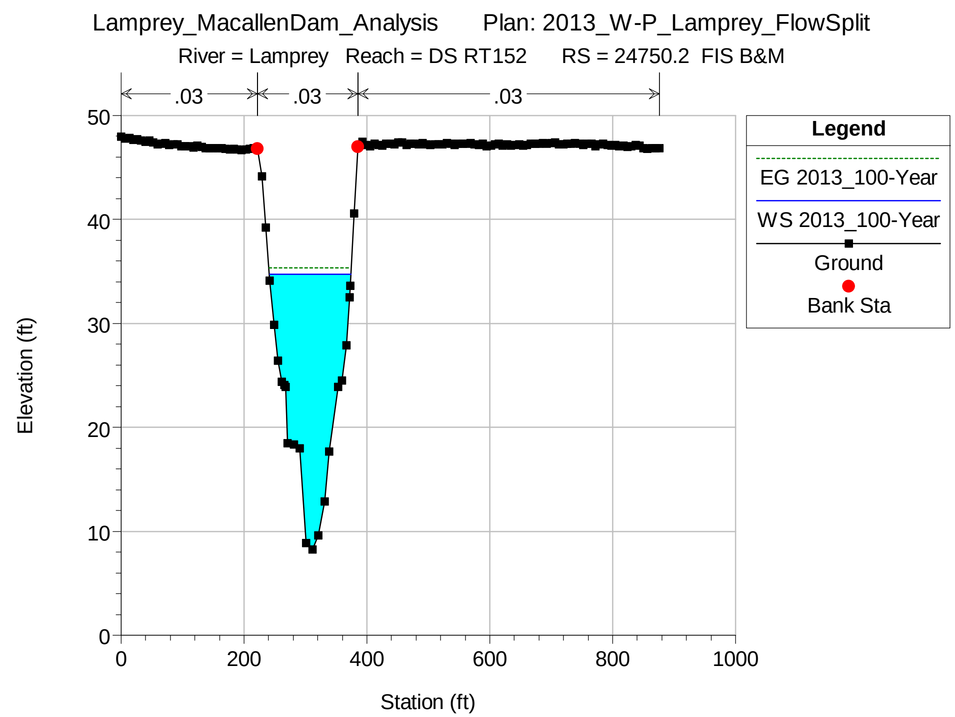
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 24750.2 FIS B&M
.03
.03
.03
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
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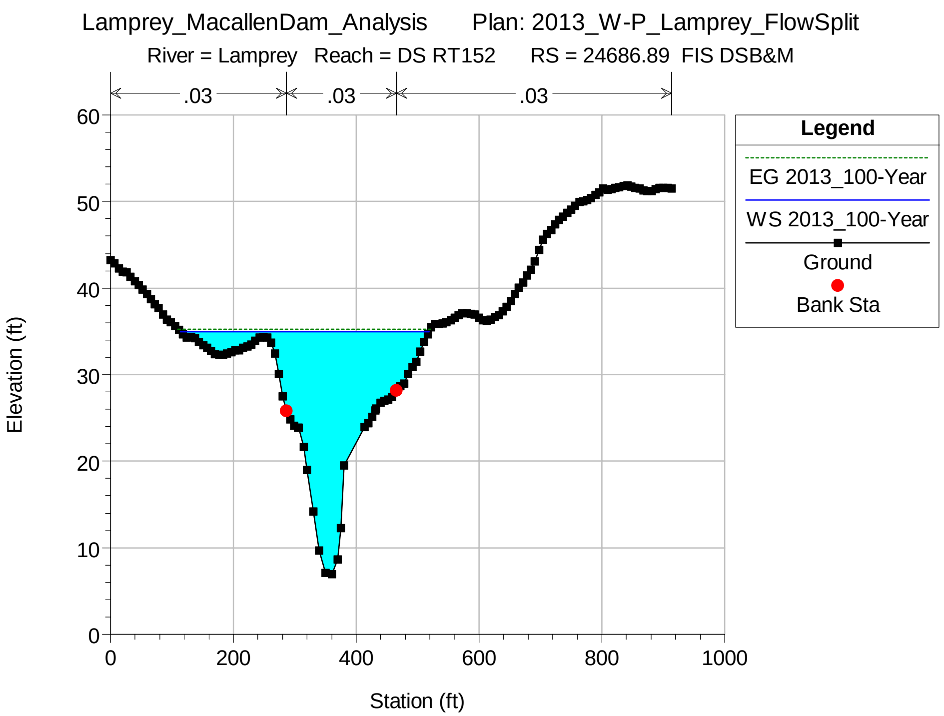
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 24686.89 FIS DSB&M
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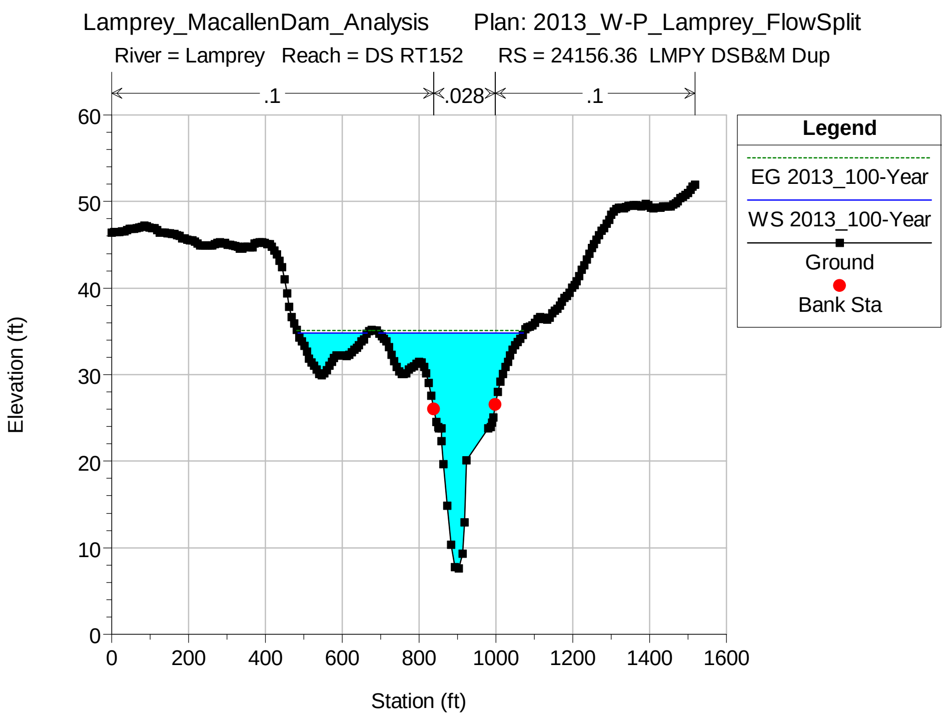
.03
.03
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 24156.36 LMPY DSB&M Dup
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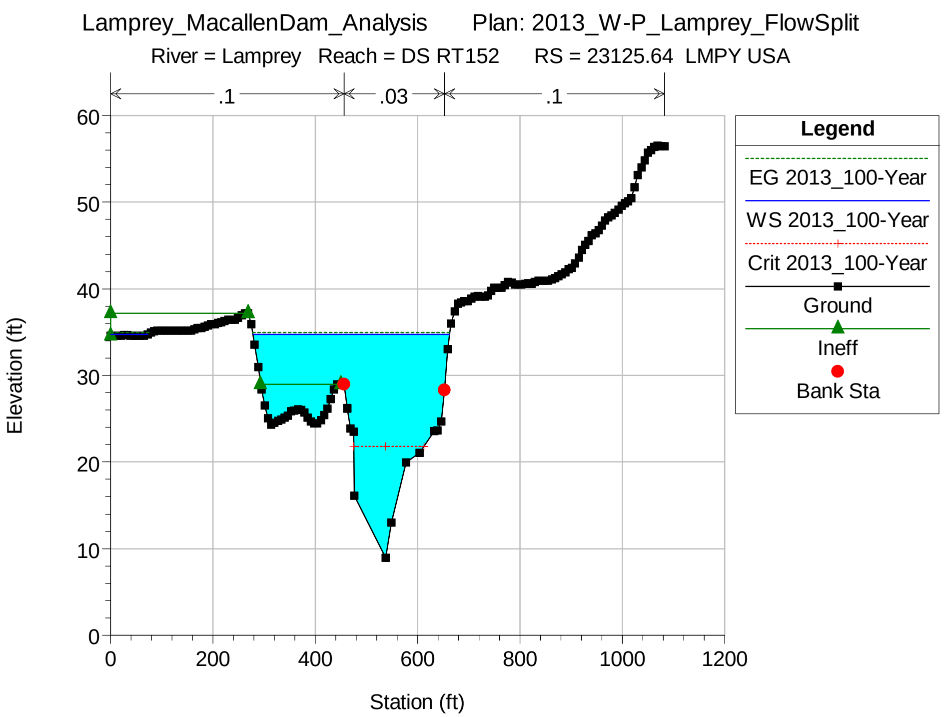
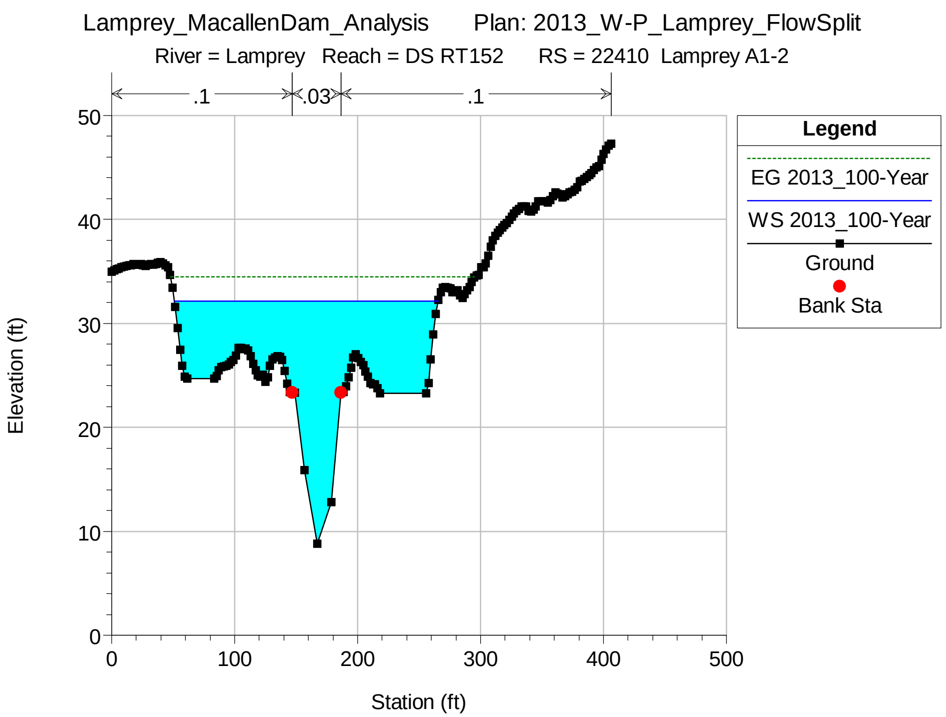
.028
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 23125.64 LMPY USA
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT152 RS = 22410 Lamprey A1-2
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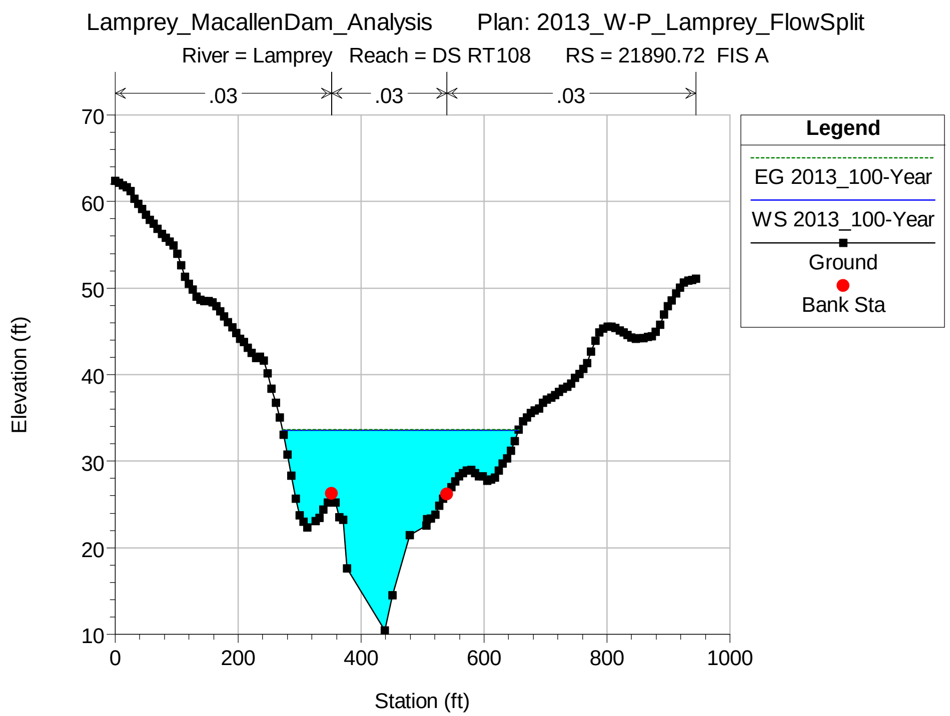
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT108 RS = 21890.72 FIS A
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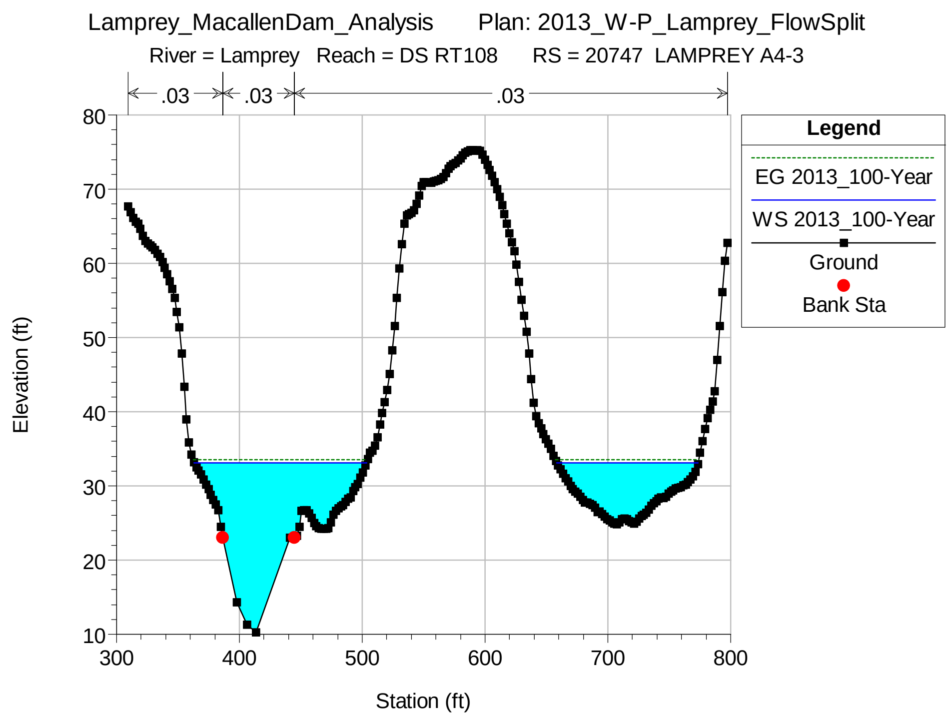
.03
.03
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT108 RS = 20747 LAMPREY A4-3
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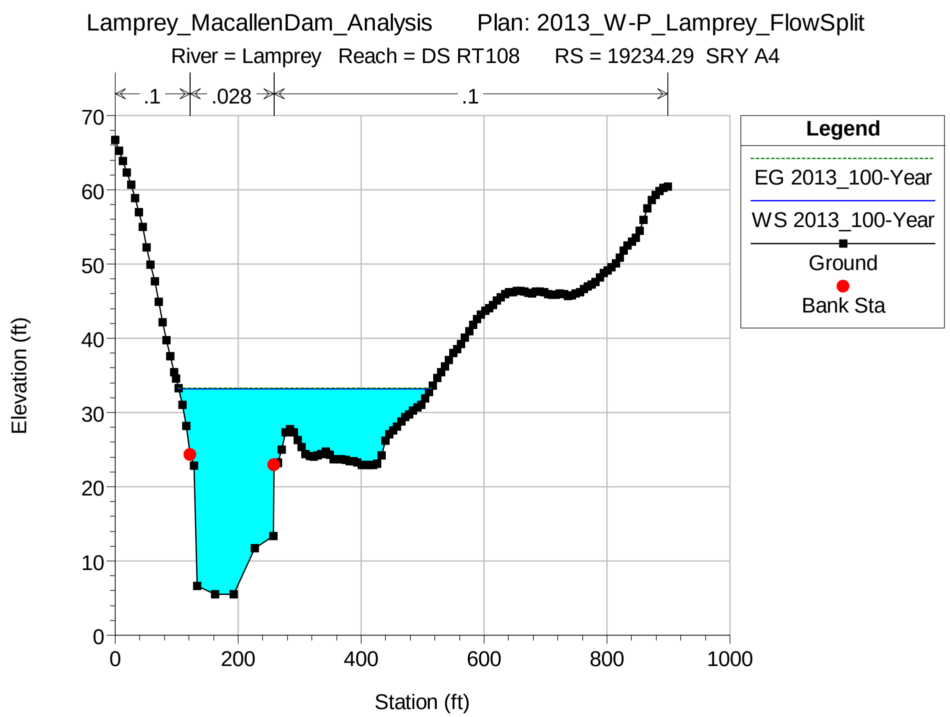
.03
.03
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT108 RS = 19234.29 SRY A4
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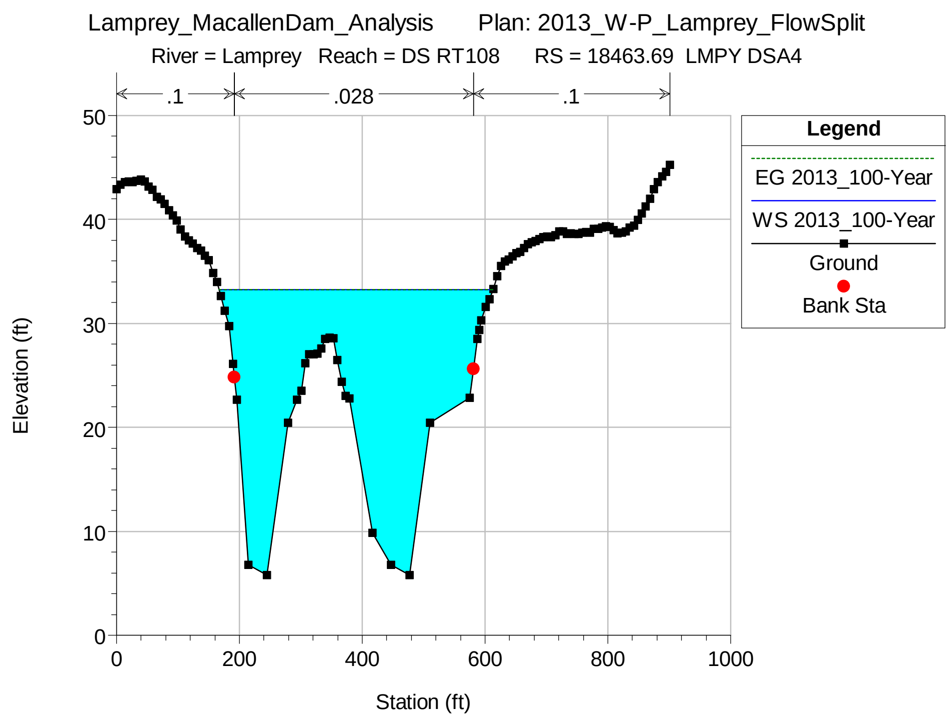
.028
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS RT108 RS = 18463.69 LMPY DSA4
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.028
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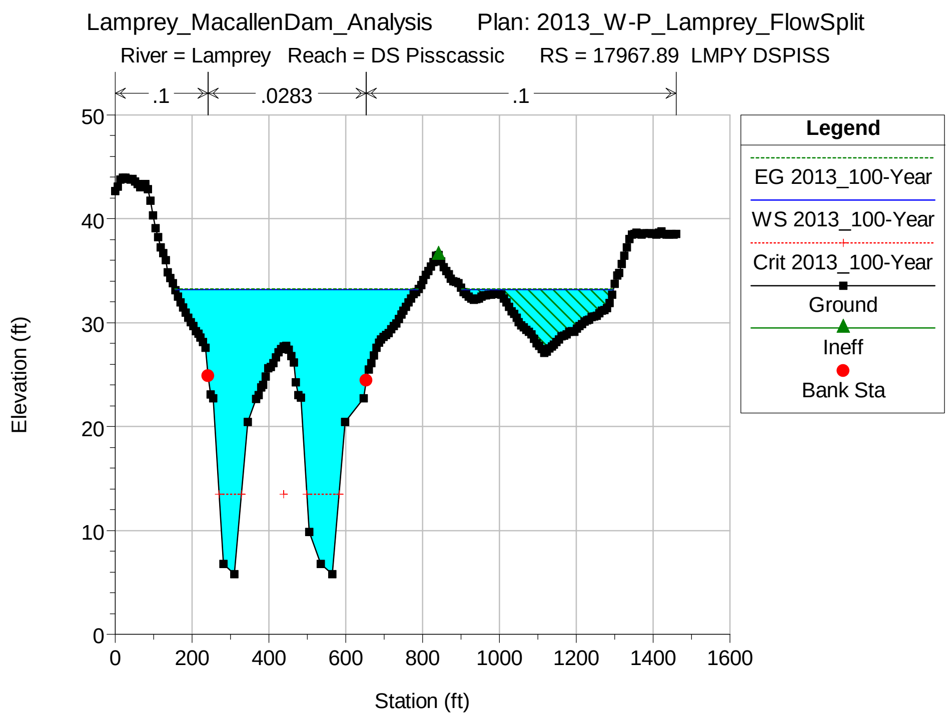
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 17967.89 LMPY DSPISS
.1
.0283
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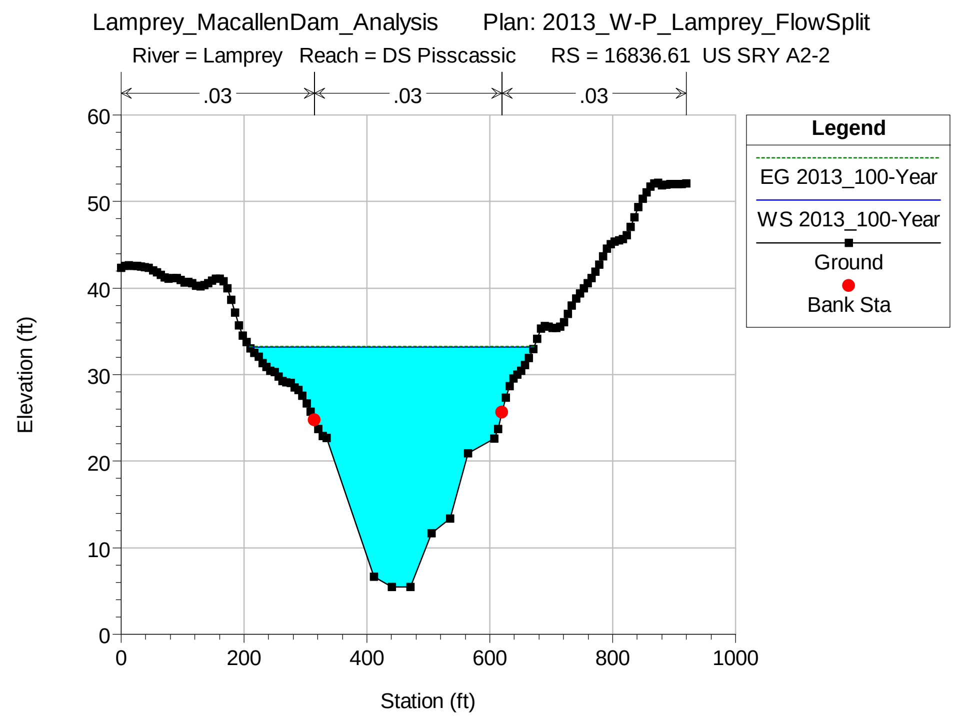
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 16836.61 US SRY A2-2
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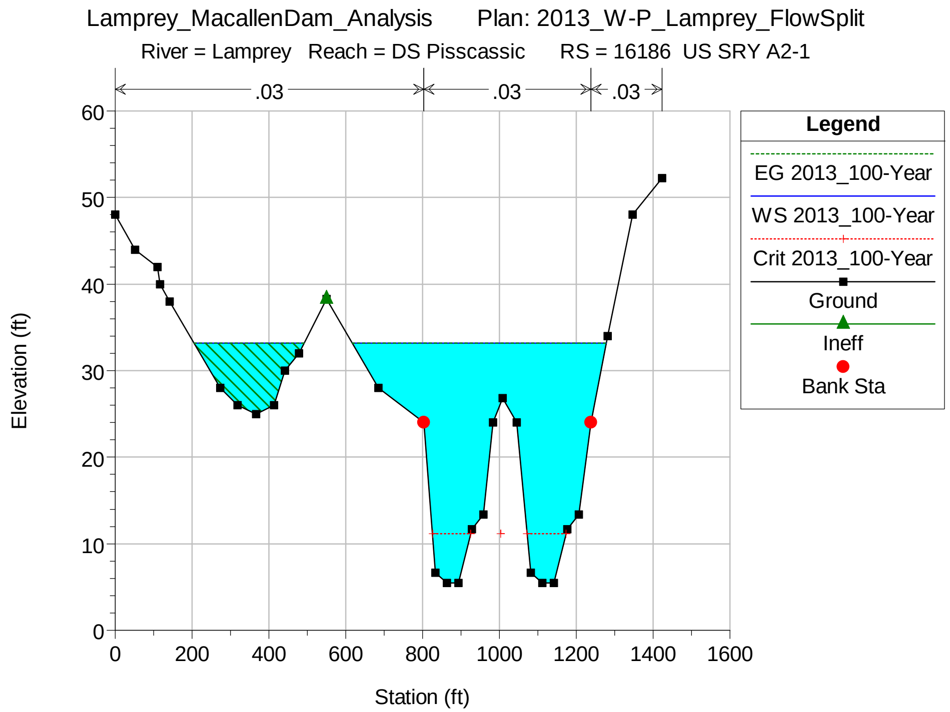
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)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River = Lamprey Reach = DS Pisscassic RS = 16186 US SRY A2-1
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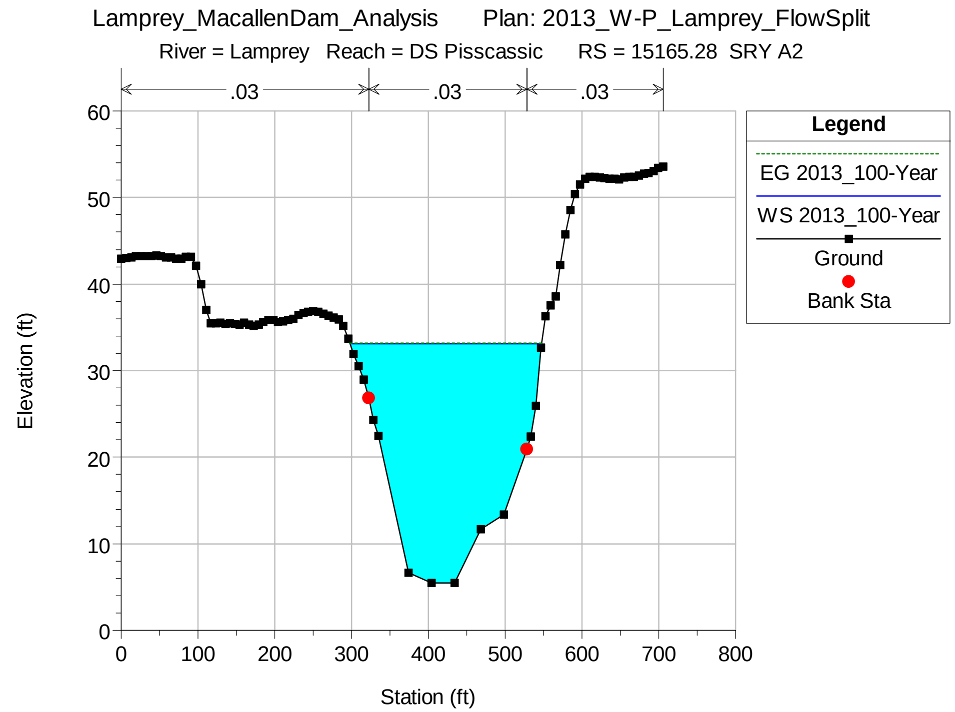
Crit 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 15165.28 SRY A2
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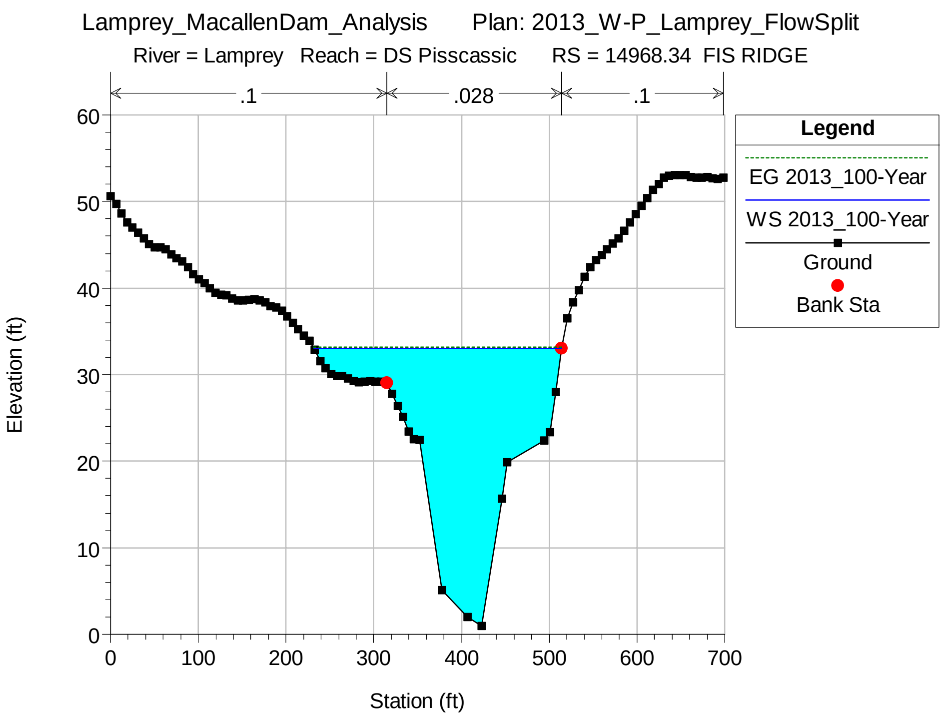
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 14968.34 FIS RIDGE
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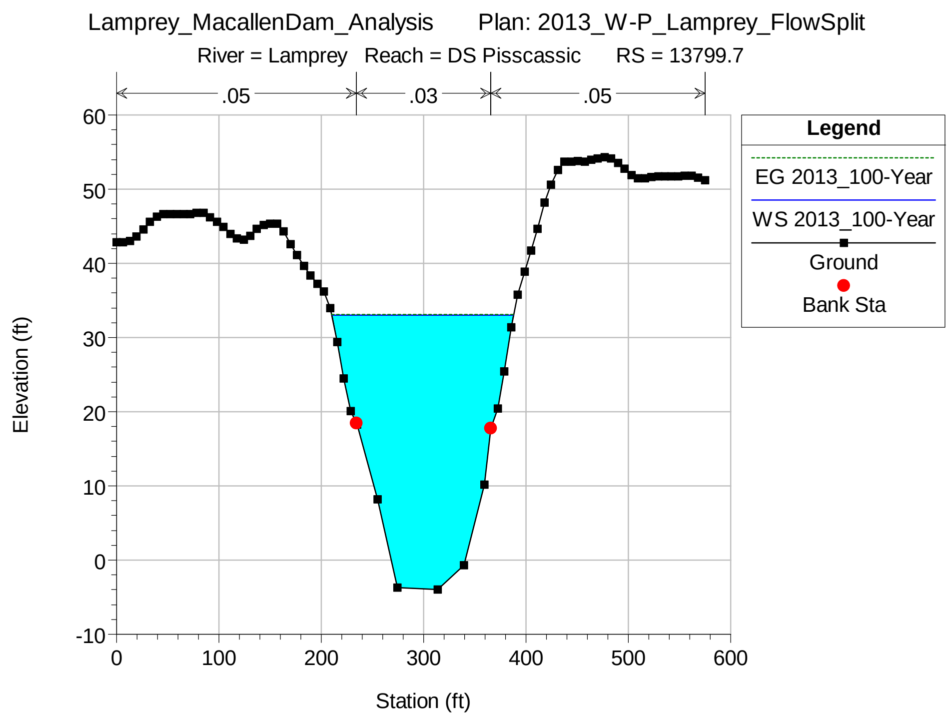
.028
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13799.7
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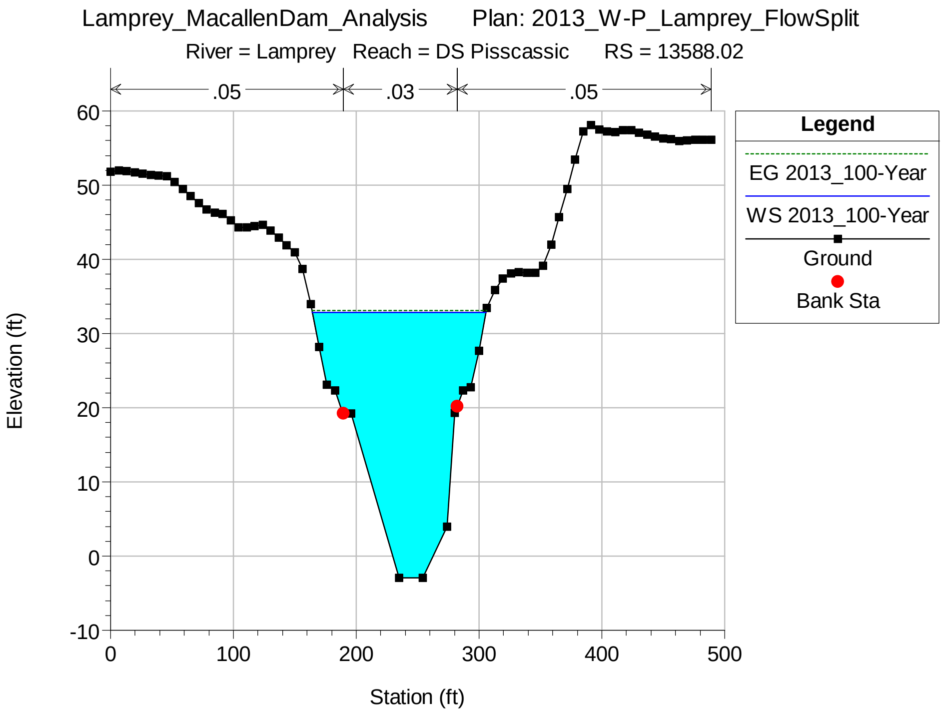
.03
.05
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13588.02
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Legend
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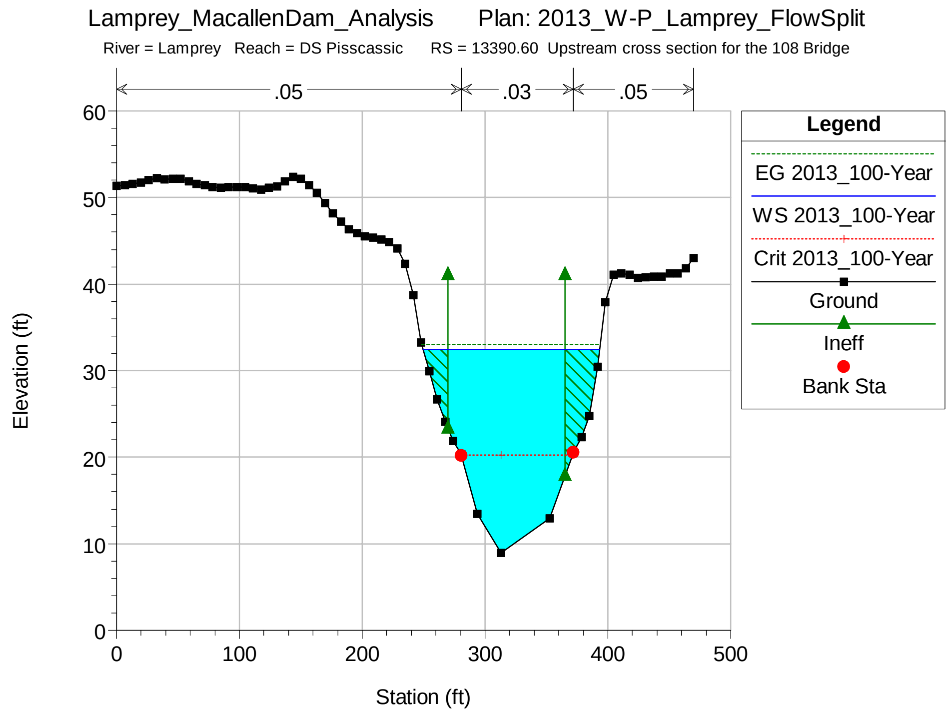
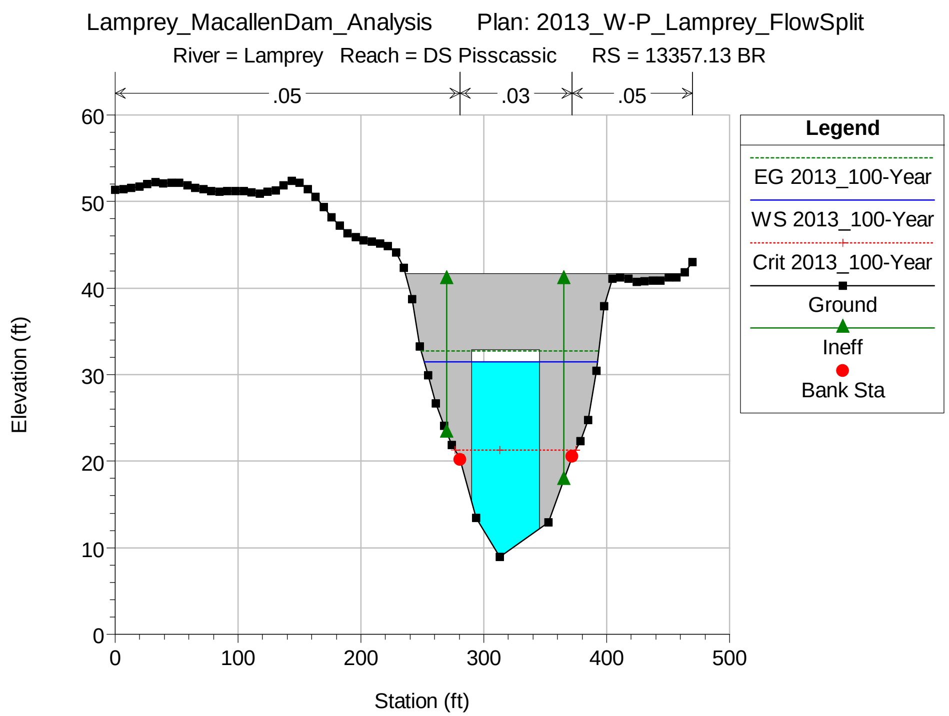
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13390.60 Upstream cross section for the 108 Bridge
.05
.03
.05
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13357.13 BR
.05
.03
.05
Elevation (ft)
Station (ft)
0
10
20
30
40
50
60
0
100
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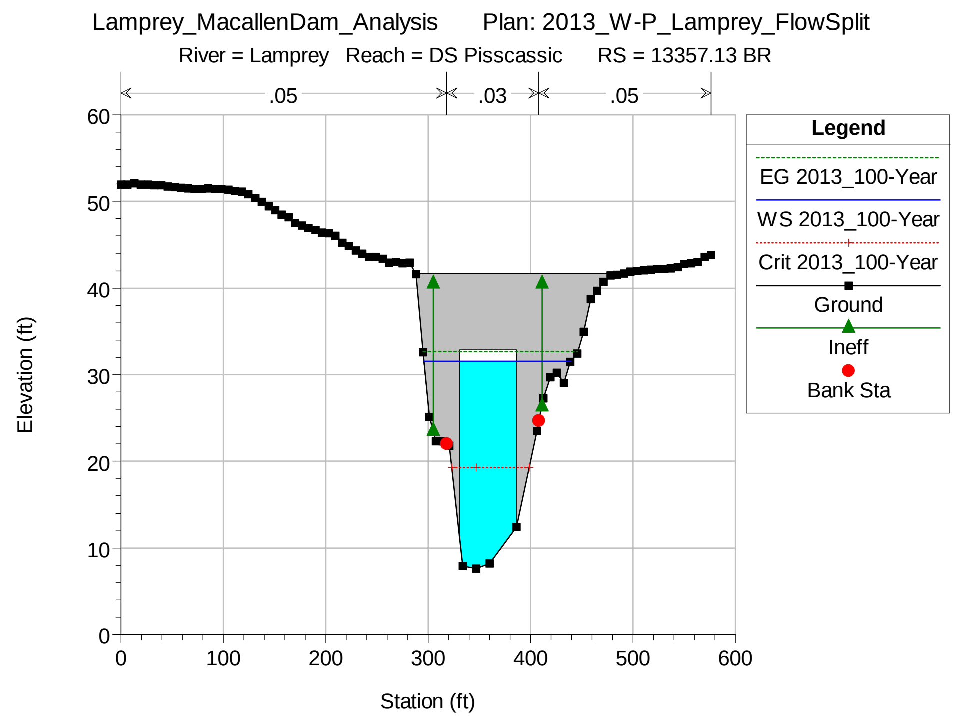
500
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13357.13 BR
.05
.03
.05
Elevation (ft)
Station (ft)
0
10
20
30
40
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60
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500
600
Legend
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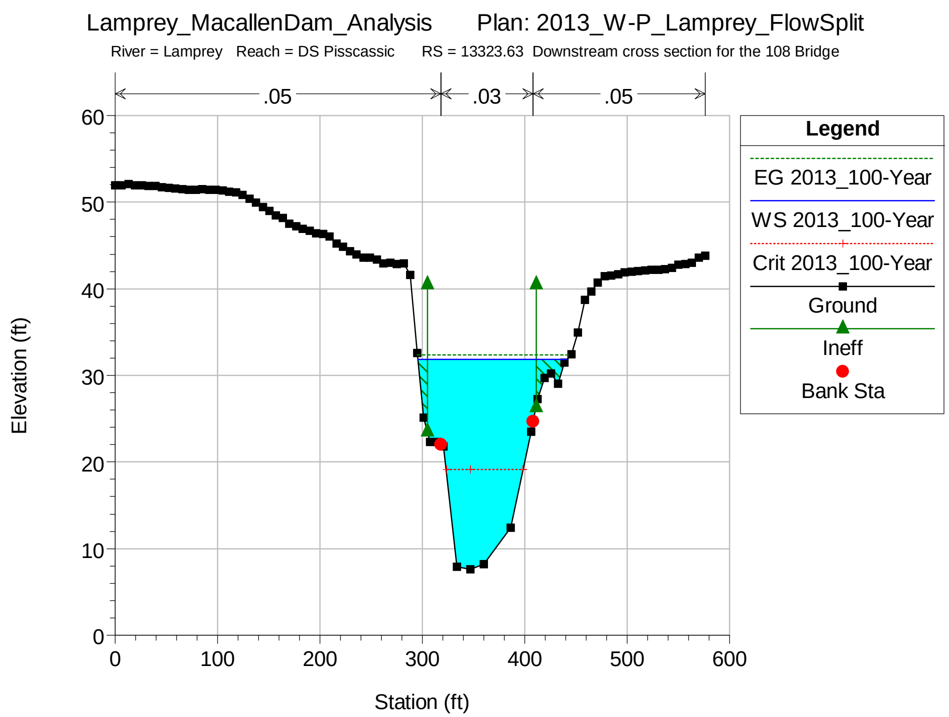
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13323.63 Downstream cross section for the 108 Bridge
.05
.03
.05
Elevation (ft)
Station (ft)
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10
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30
40
50
60
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Legend
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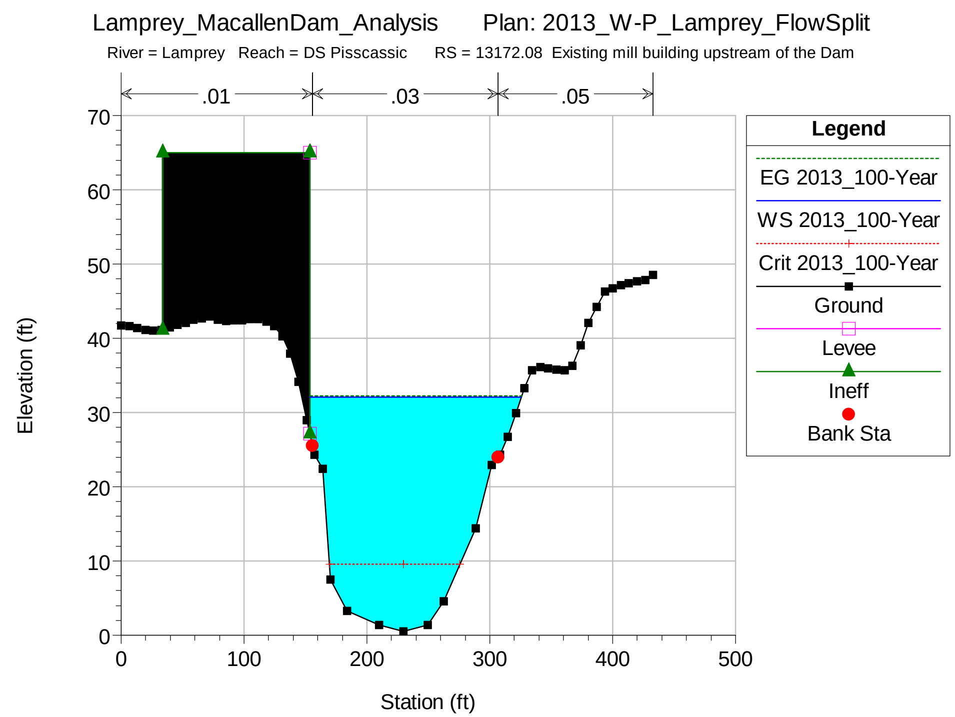
WS 2013_100-Year
Crit 2013_100-Year
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13172.08 Existing mill building upstream of the Dam
.01
.03
.05
Elevation (ft)
Station (ft)
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20
30
40
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60
70
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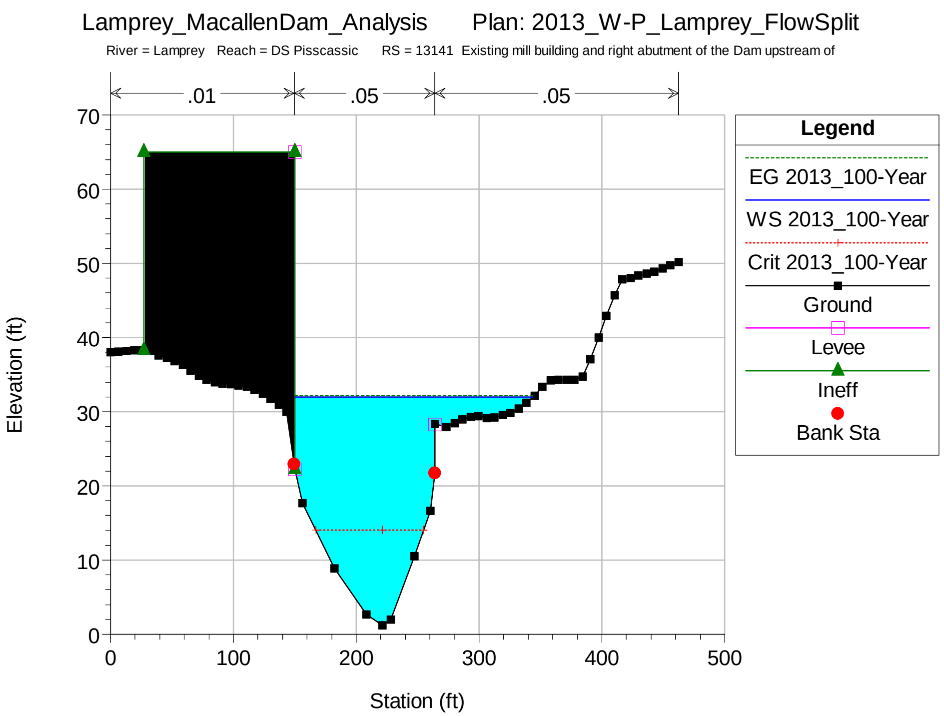
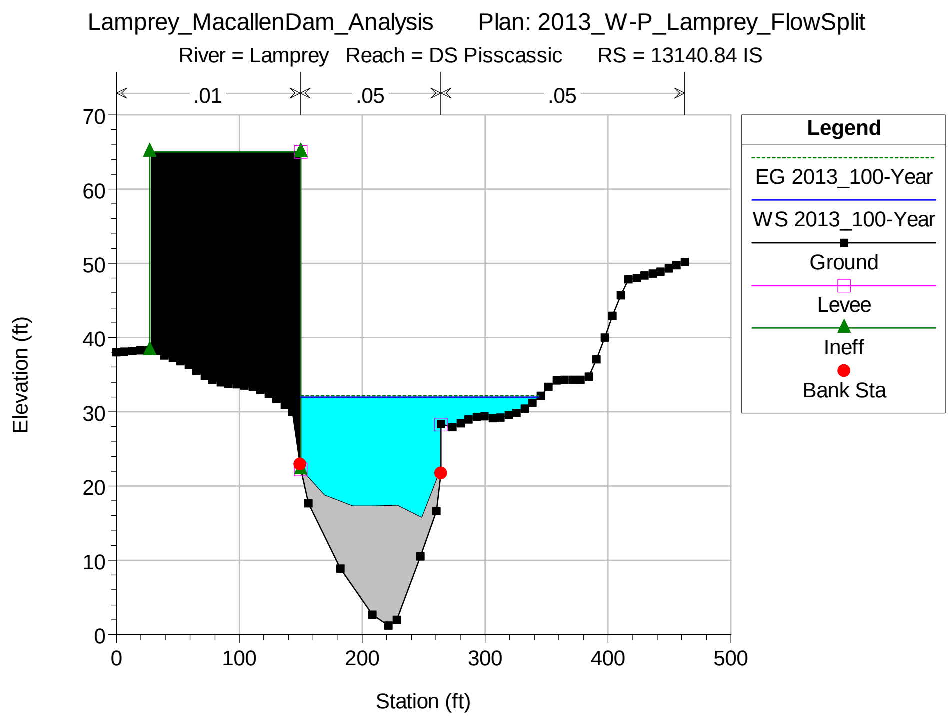
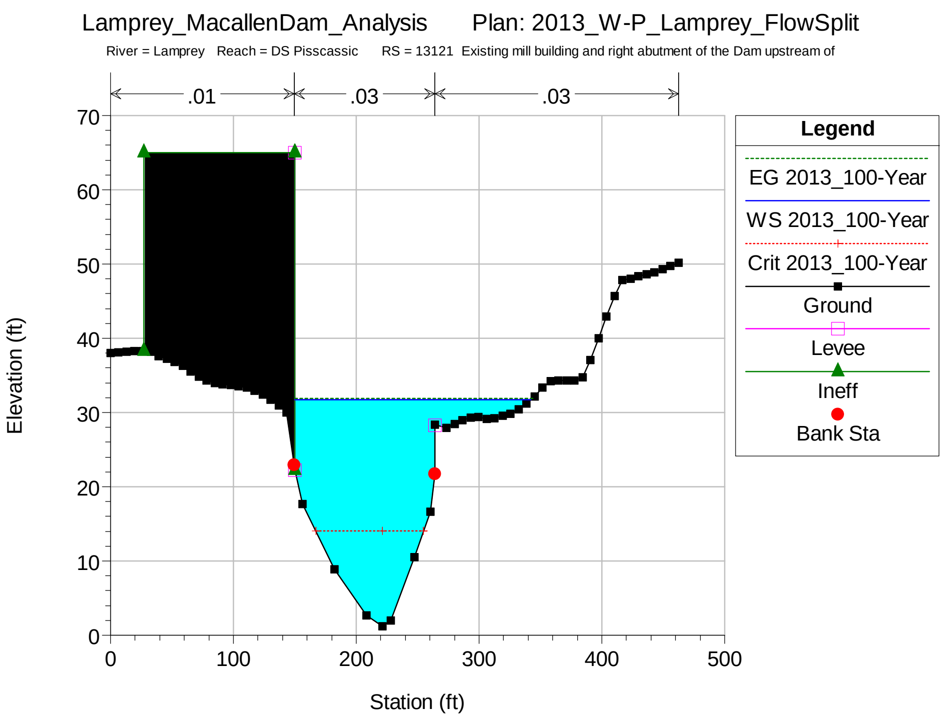
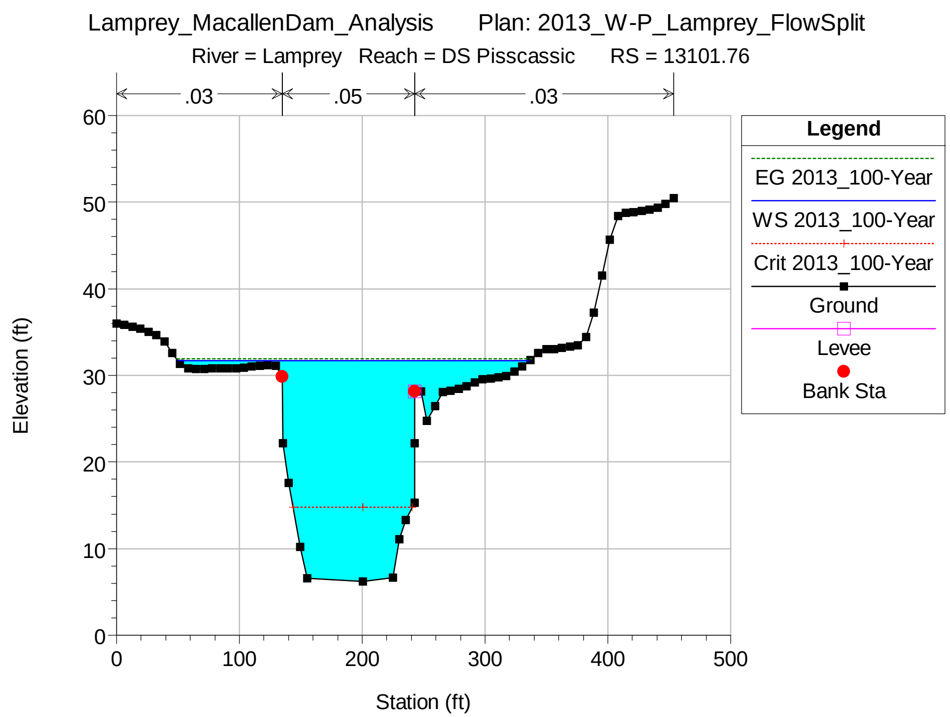
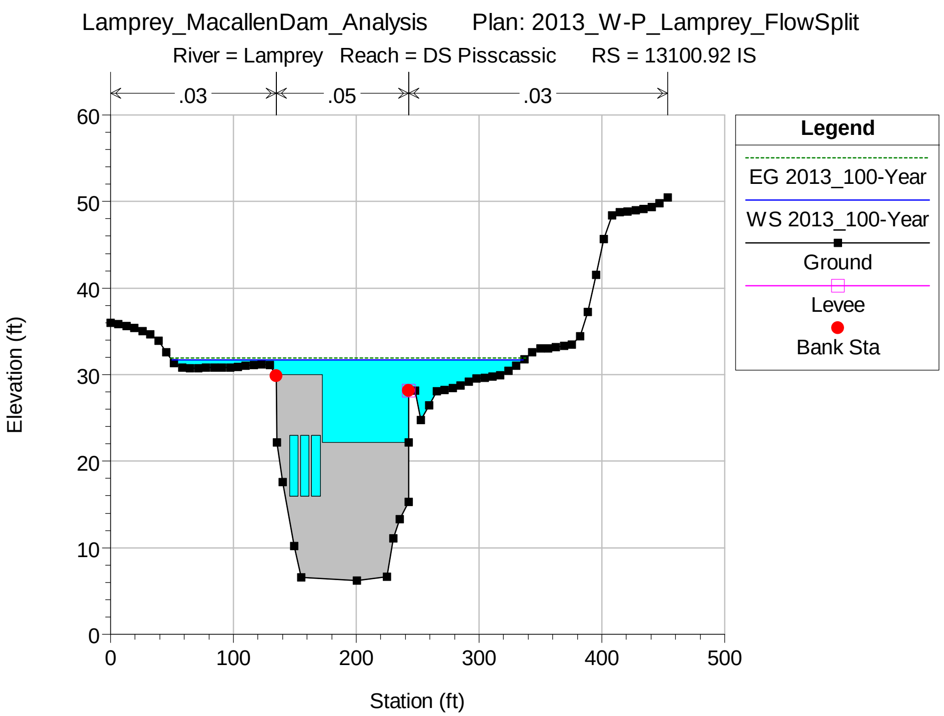
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Ineff
Bank Sta

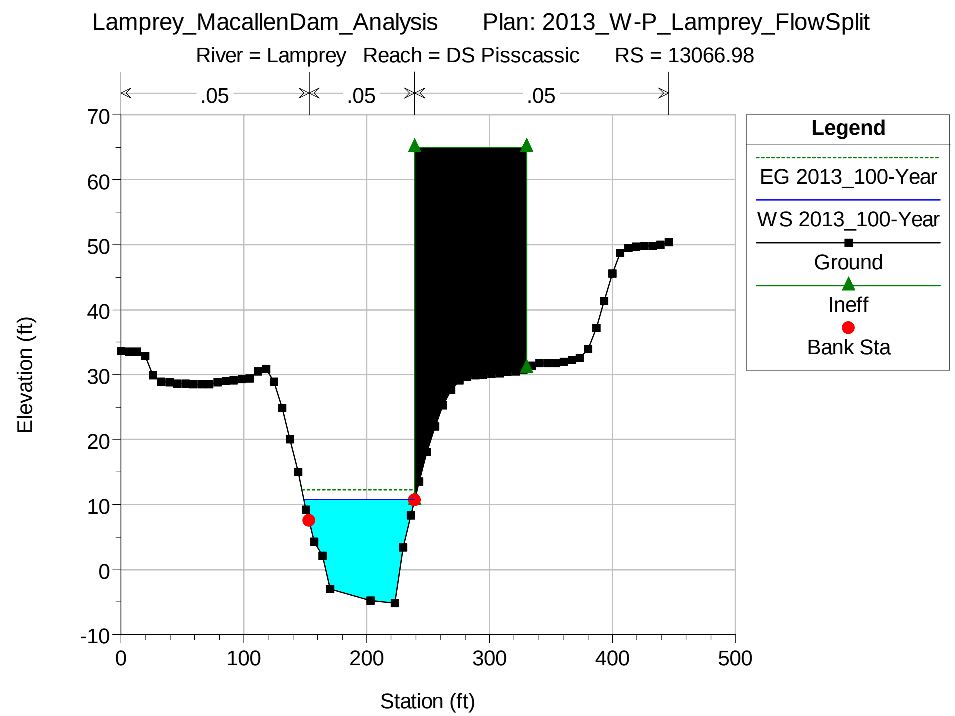

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13141 Existing mill building and right abutment of the Dam upstream of
.01
.05
.05
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Ineff
Bank Sta

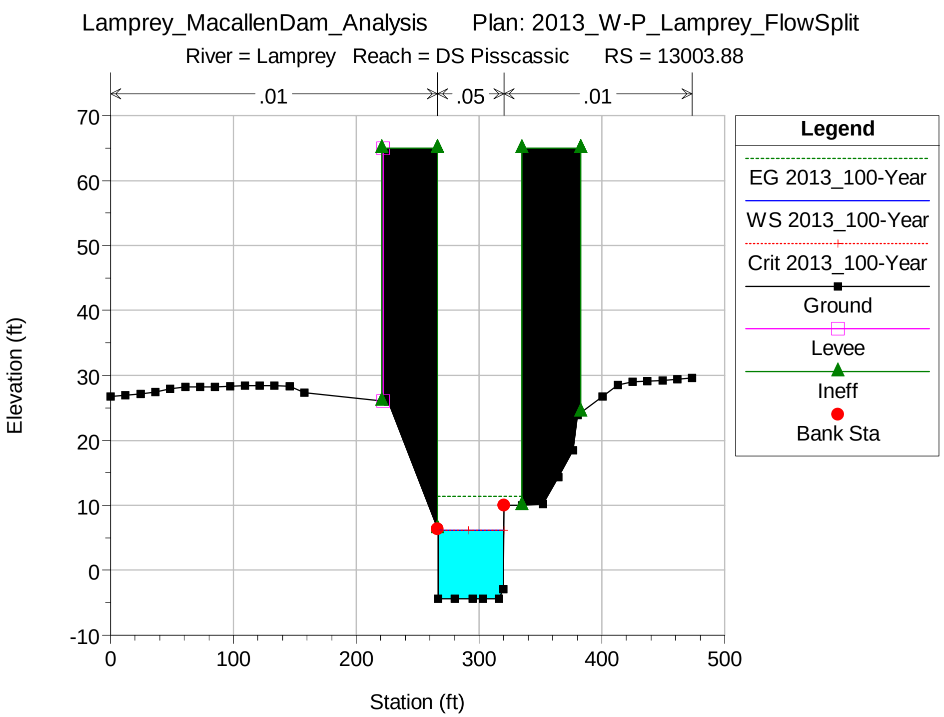

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13140.84 IS
.01
.05
.05
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Levee
Ineff
Bank Sta

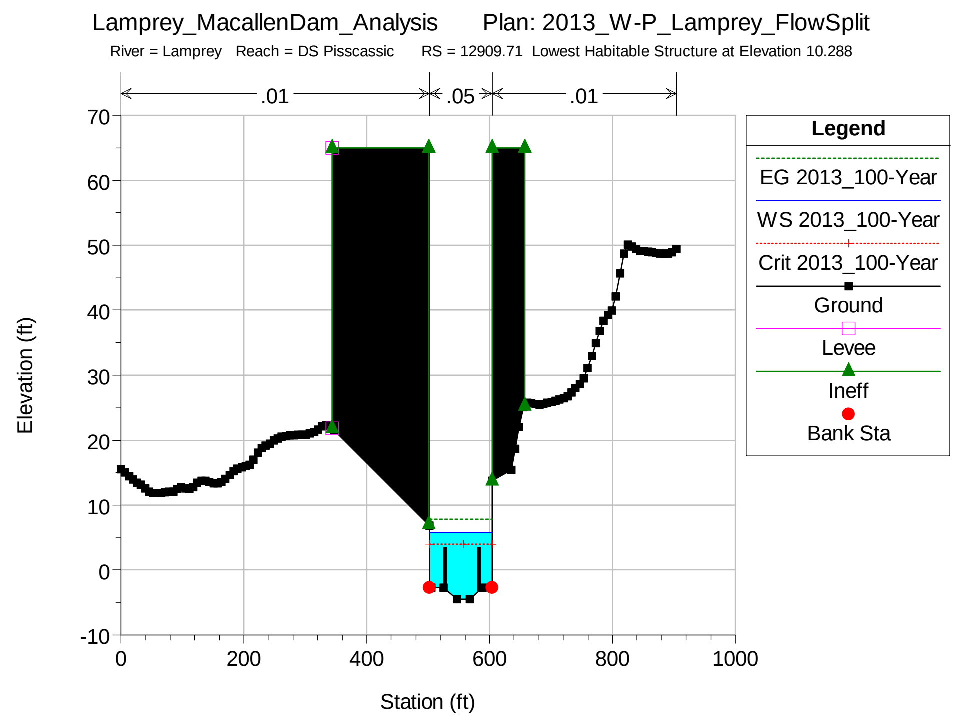

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13121 Existing mill building and right abutment of the Dam upstream of
.01
.03
.03
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Ineff
Bank Sta

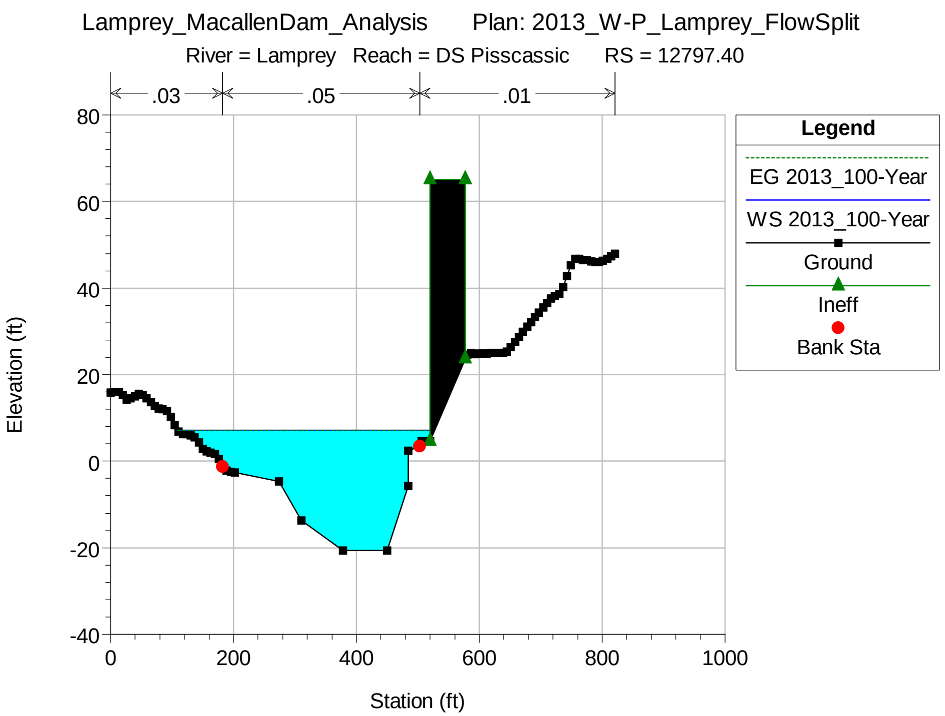

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13101.76
.03
.05
.03
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Bank Sta

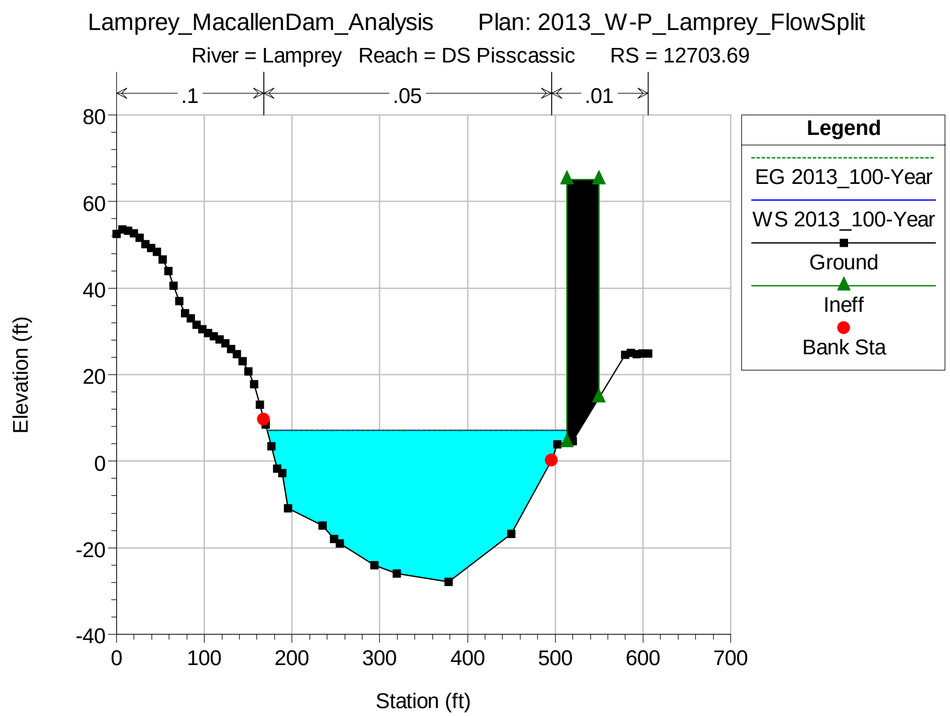

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13100.92 IS
.03
.05
.03
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

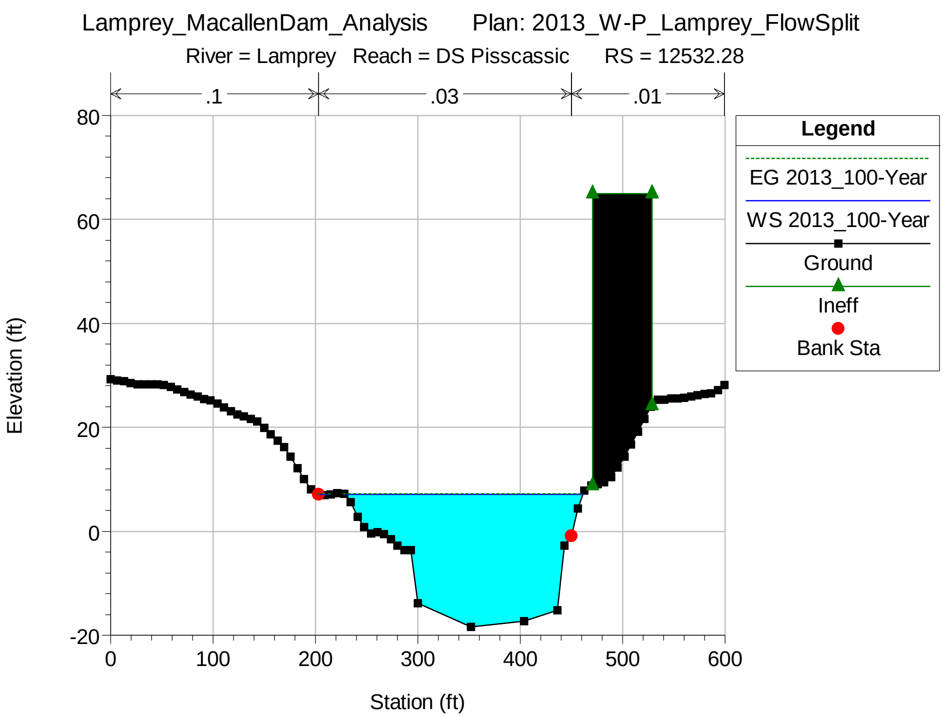

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13066.98
.05
.05
.05
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

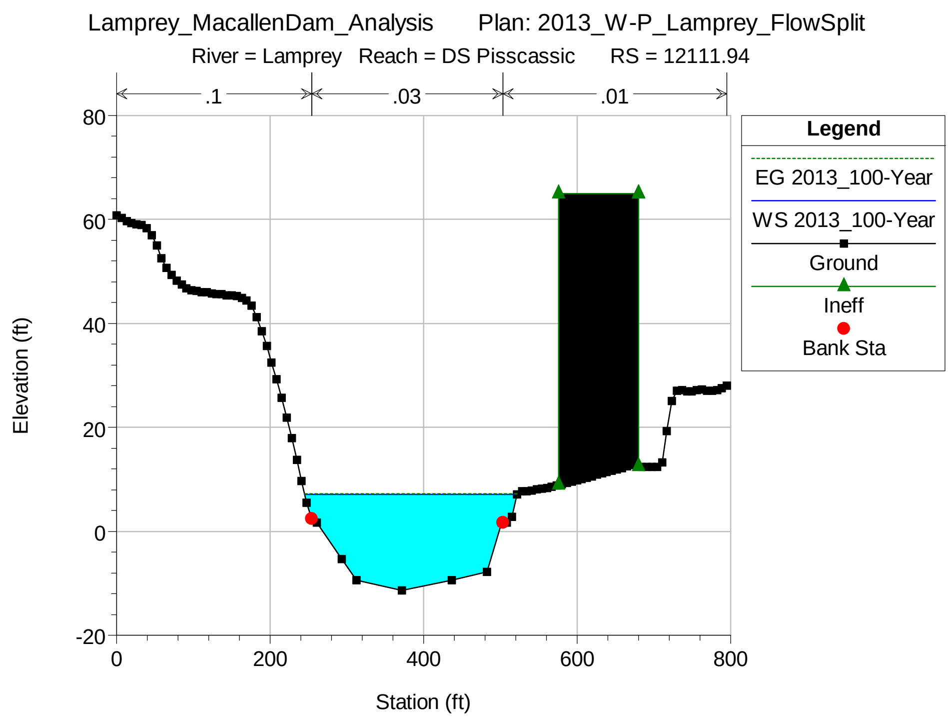

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 13003.88
.01
.05
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

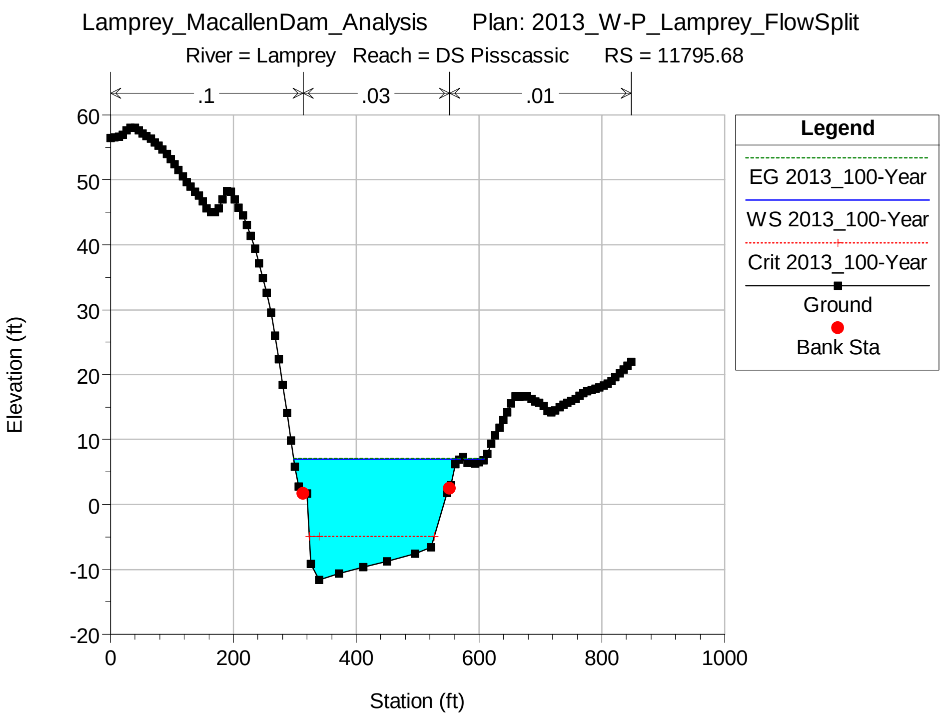

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 12909.71 Lowest Habitable Structure at Elevation 10.288
.01
.05
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

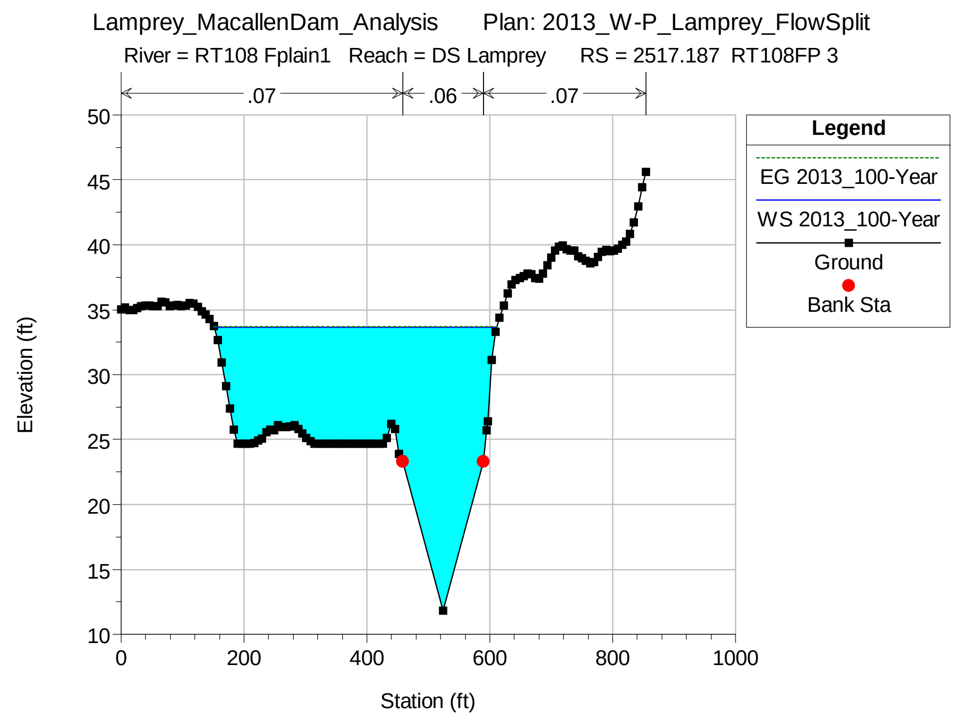

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 12797.40
.03
.05
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

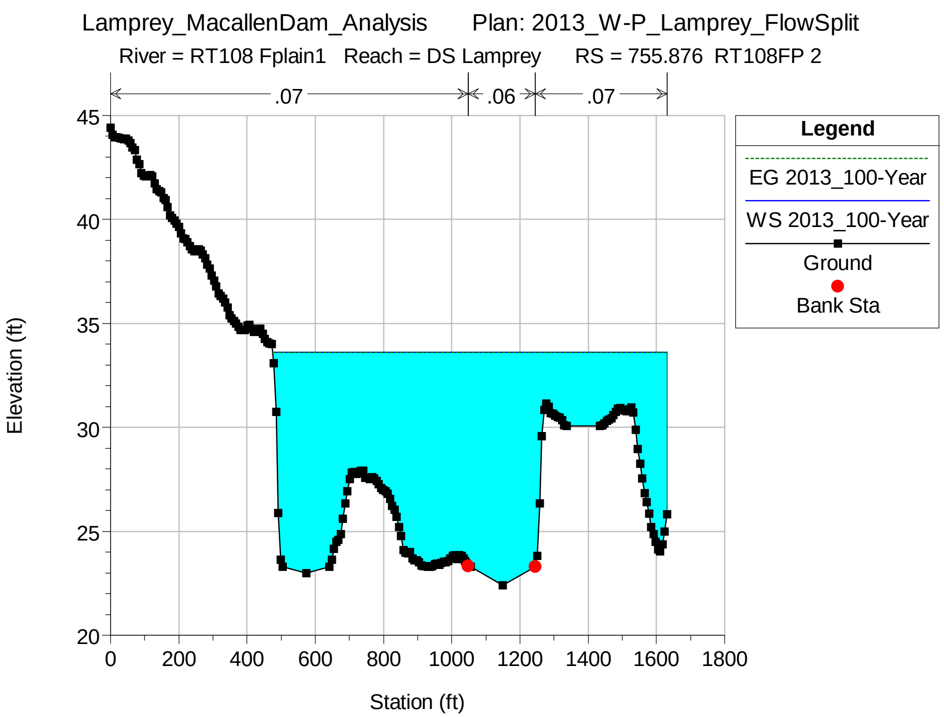

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 12703.69
.1
.05
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

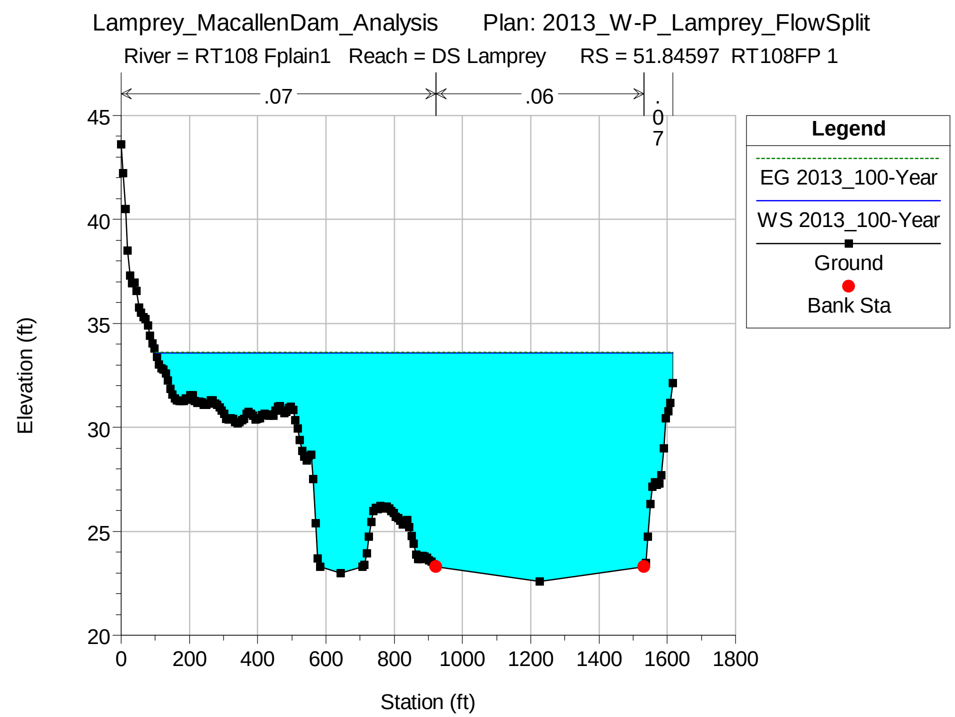

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 12532.28
.1
.03
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

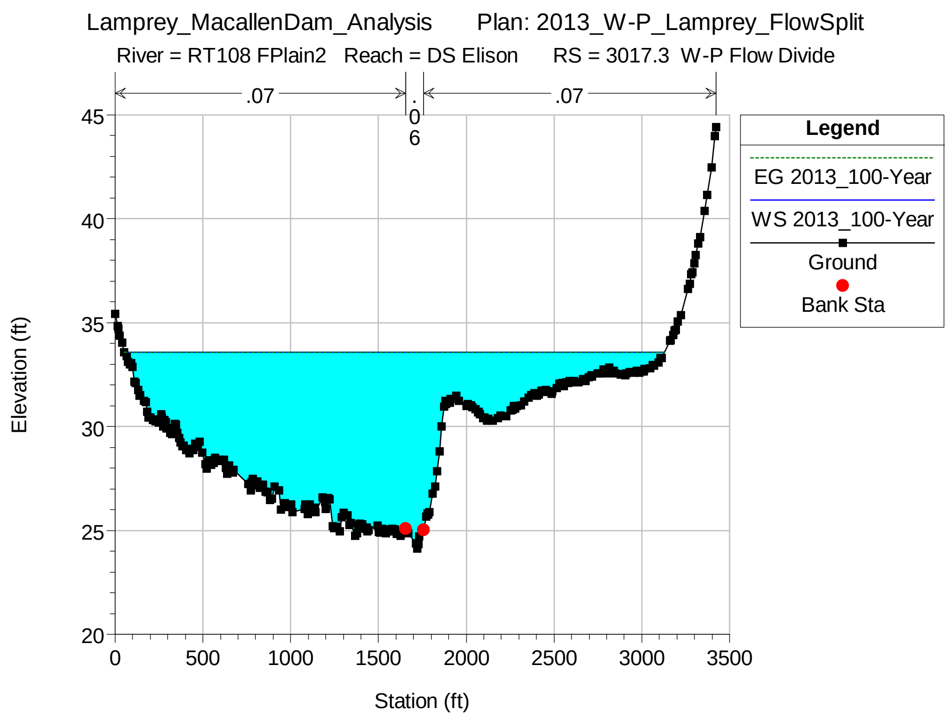

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 12111.94
.1
.03
.01
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Lamprey Reach = DS Pisscassic RS = 11795.68
.1
.03
.01
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta

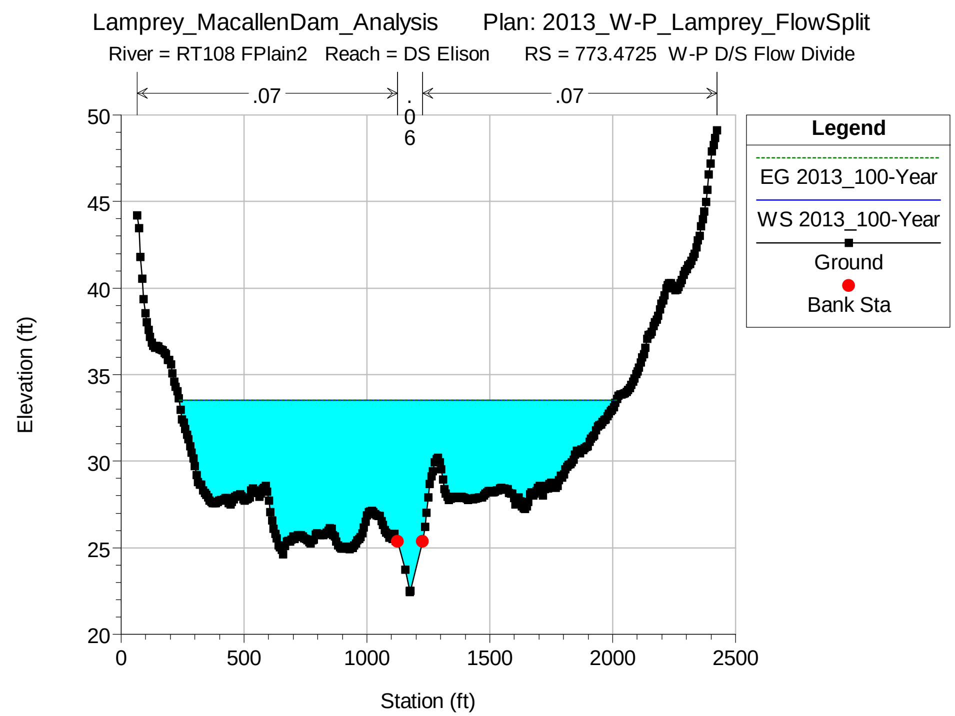

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 Fplain1 Reach = DS Lamprey RS = 2517.187 RT108FP 3
.07
.06
.07
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 Fplain1 Reach = DS Lamprey RS = 755.876 RT108FP 2
.07
.06
.07
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta

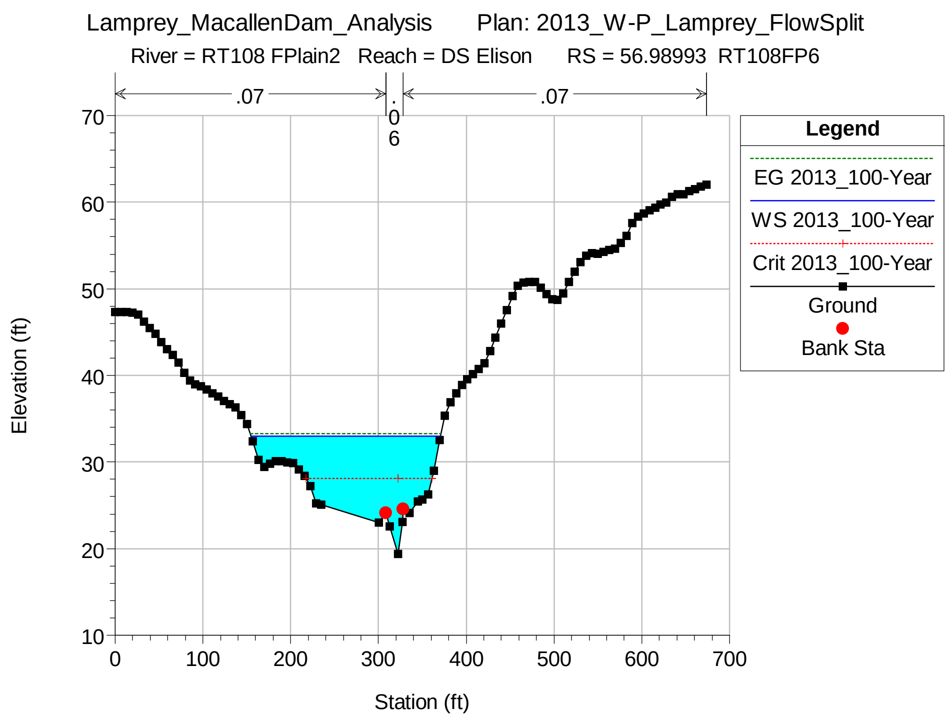

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 Fplain1 Reach = DS Lamprey RS = 51.84597 RT108FP 1
.07
.06
.07
Elevation (ft)
Station (ft)
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta



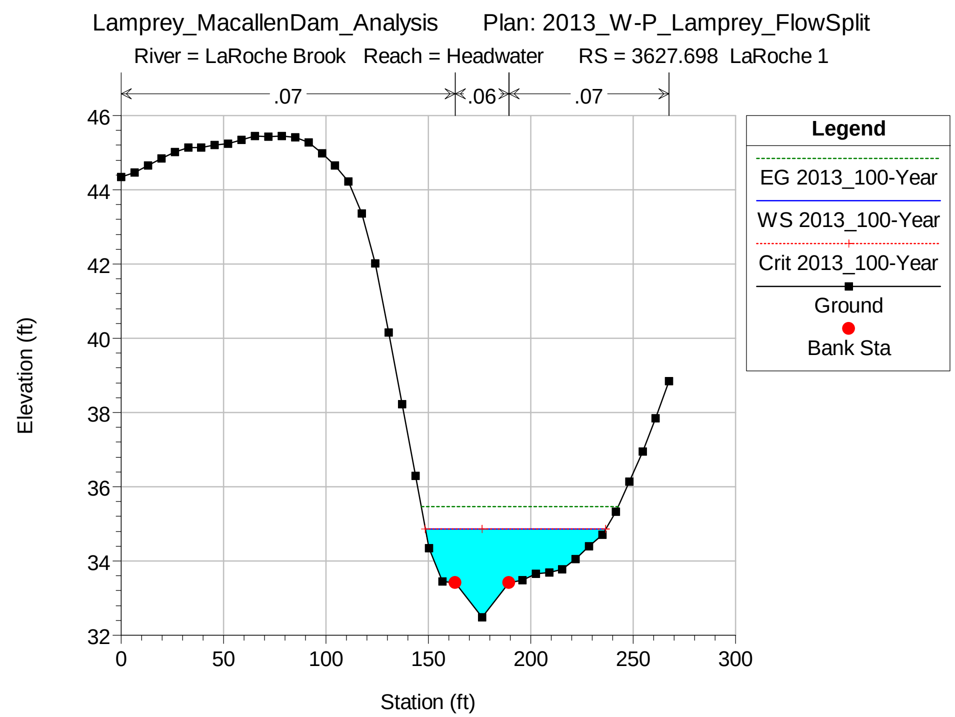
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 FPlain2 Reach = DS Elison RS = 3017.3 W-P Flow Divide
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



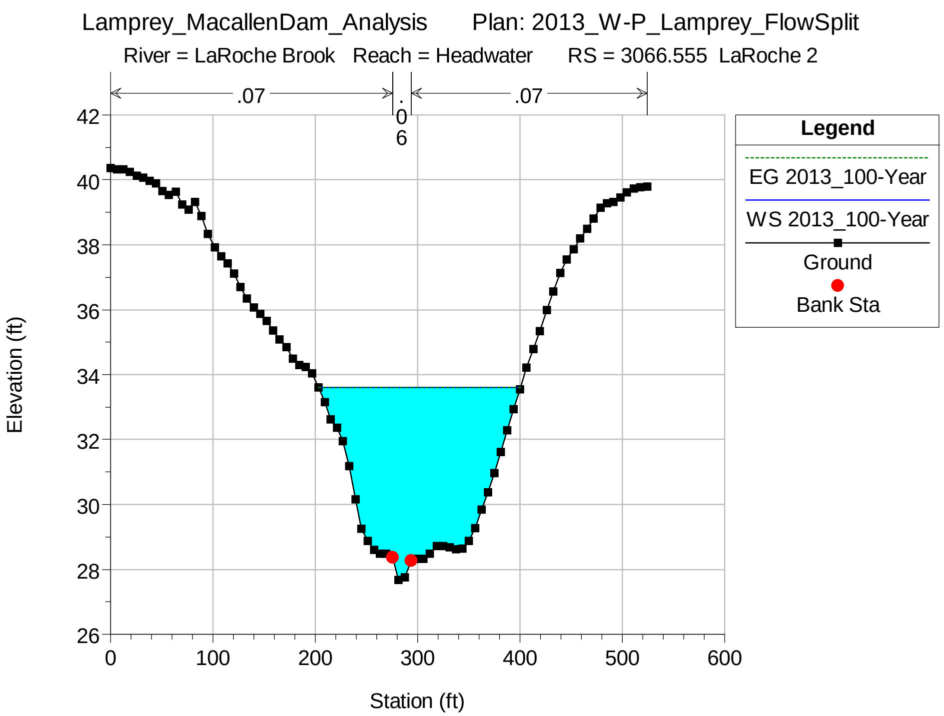
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 FPlain2 Reach = DS Elison RS = 773.4725 W-P D/S Flow Divide
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

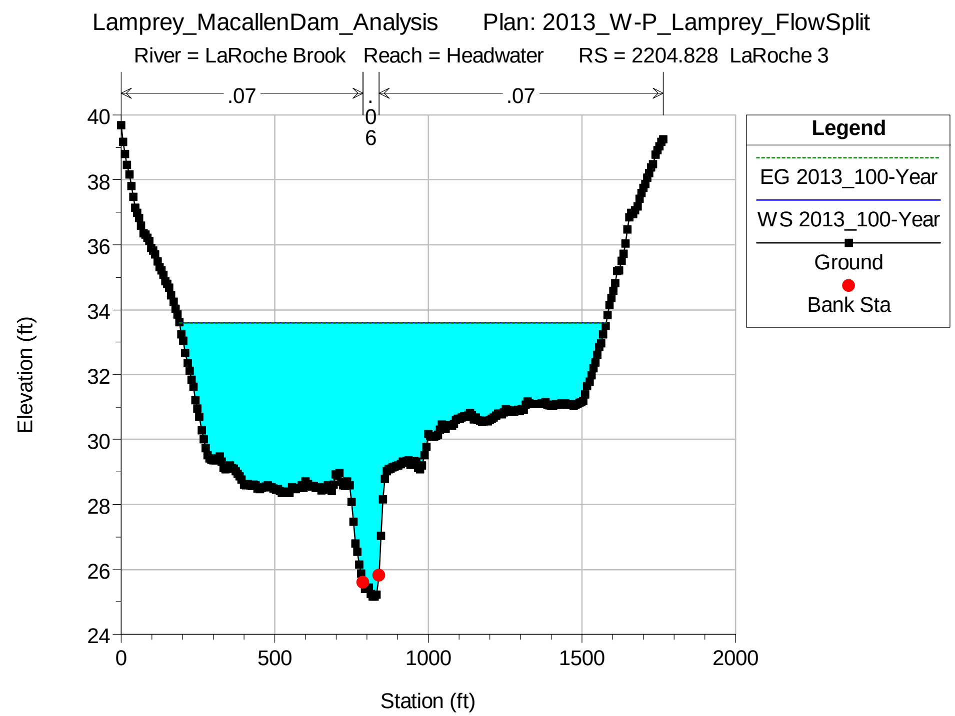


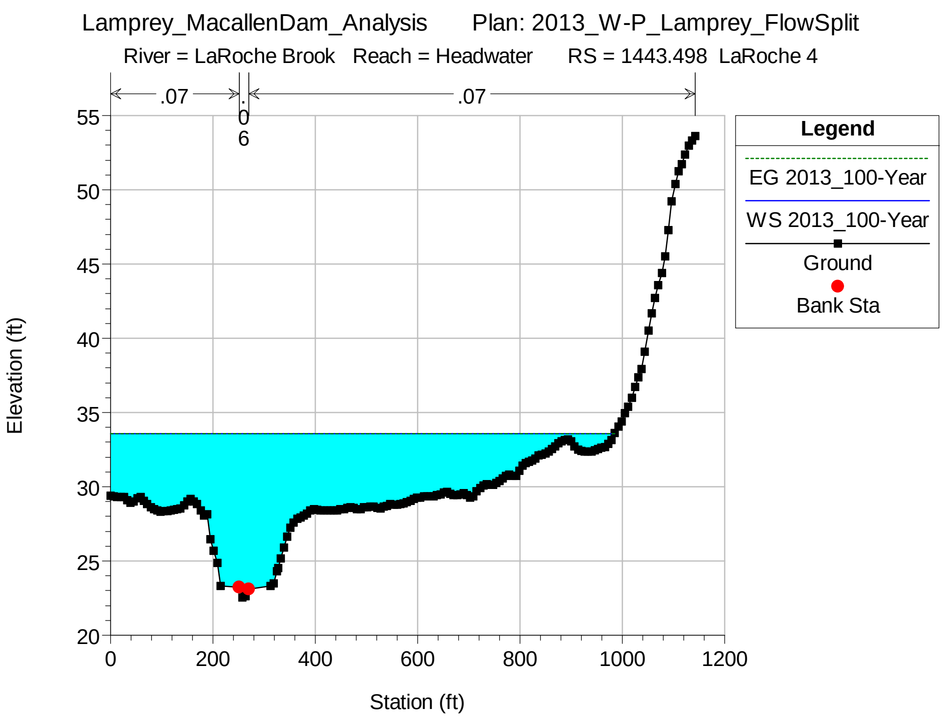
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = RT108 FPlain2 Reach = DS Elison RS = 56.98993 RT108FP6
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

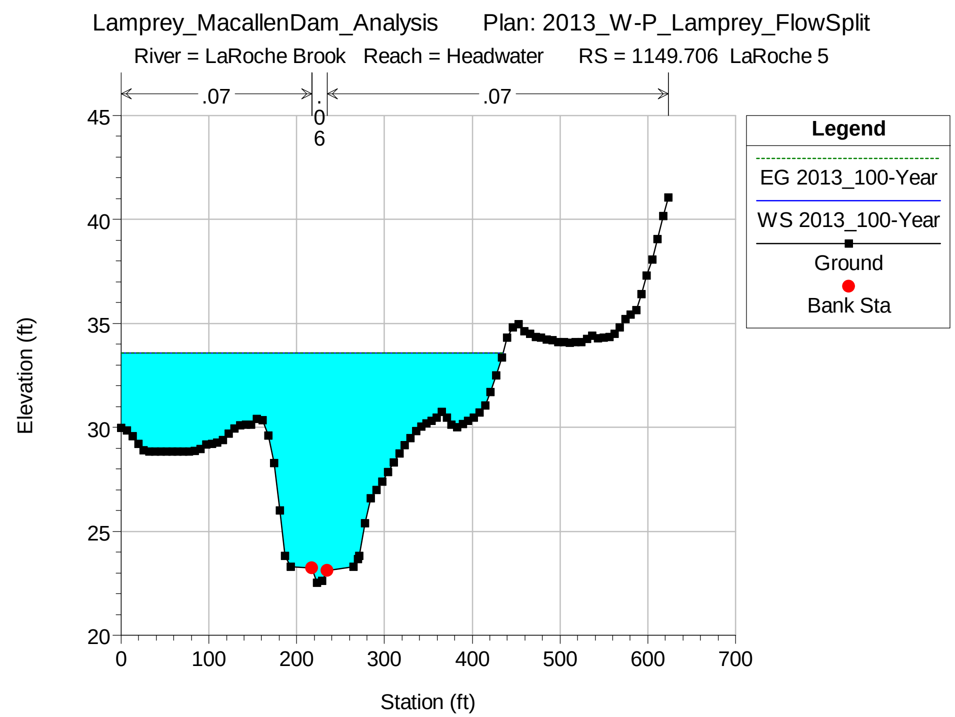


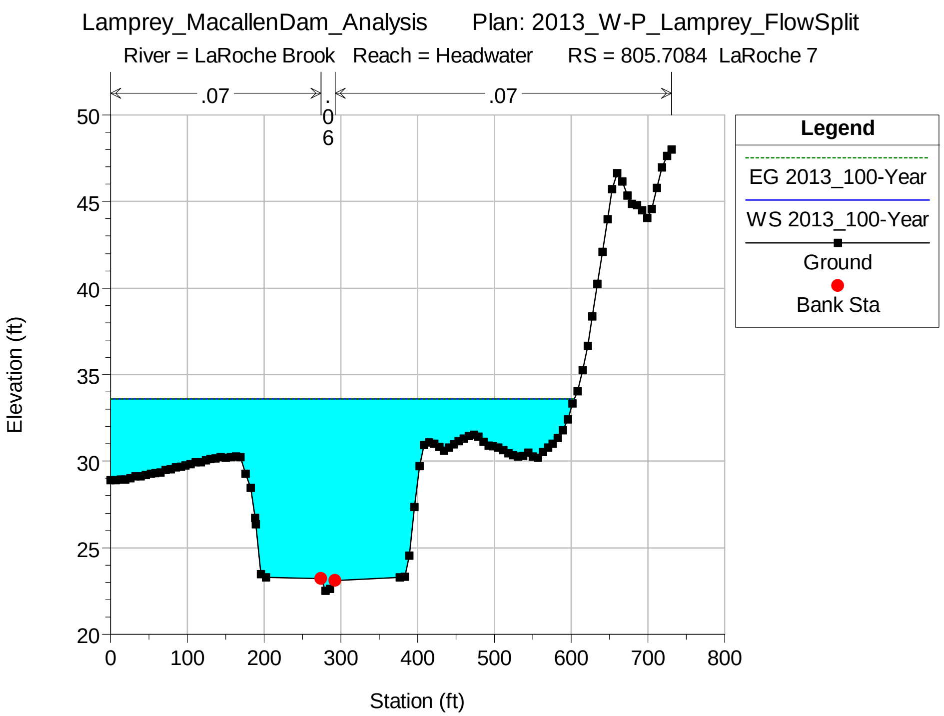
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 3627.698 LaRoche 1
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

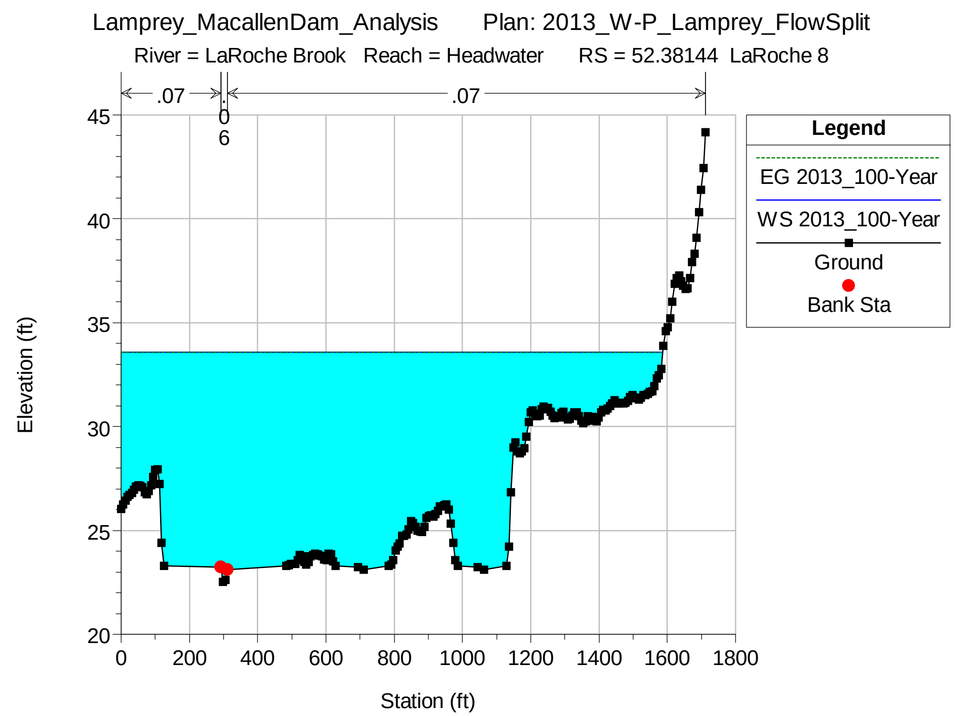

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 3066.555 LaRoche 2
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 2204.828 LaRoche 3
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 1443.498 LaRoche 4
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 1149.706 LaRoche 5
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 805.7084 LaRoche 7
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
20
25
30
35
40
45
50
0
100
200
300
400
500
600
700
800


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = LaRoche Brook Reach = Headwater RS = 52.38144 LaRoche 8
.07
.06
.07
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
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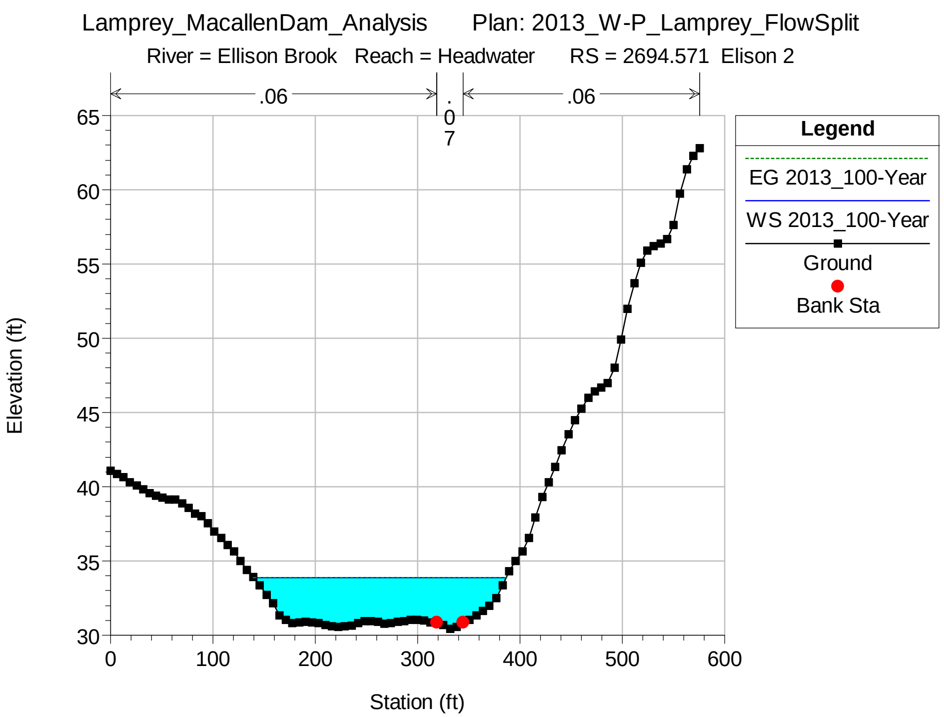
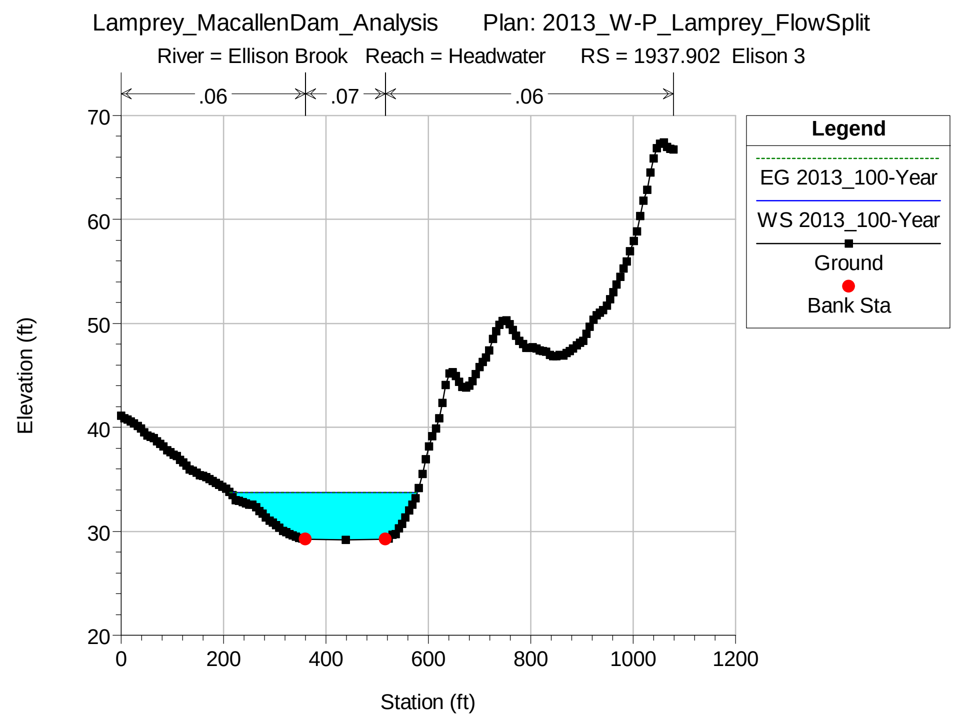
25
30
35
40
45
0
200
400
600
800
1000
1200
1400
1600
1800


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Ellison Brook Reach = Headwater RS = 2694.571 Elison 2
.06
.07
.06
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
35
40
45
50
55
60
65
0
100
200
300
400
500
600


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Ellison Brook Reach = Headwater RS = 1937.902 Elison 3
.06
.07
.06
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
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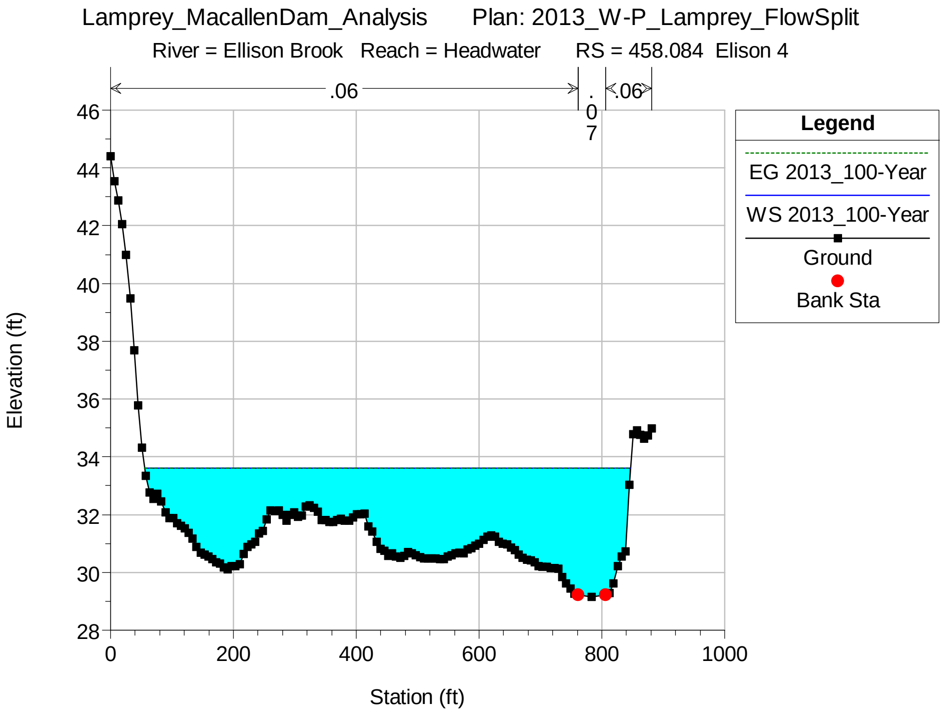
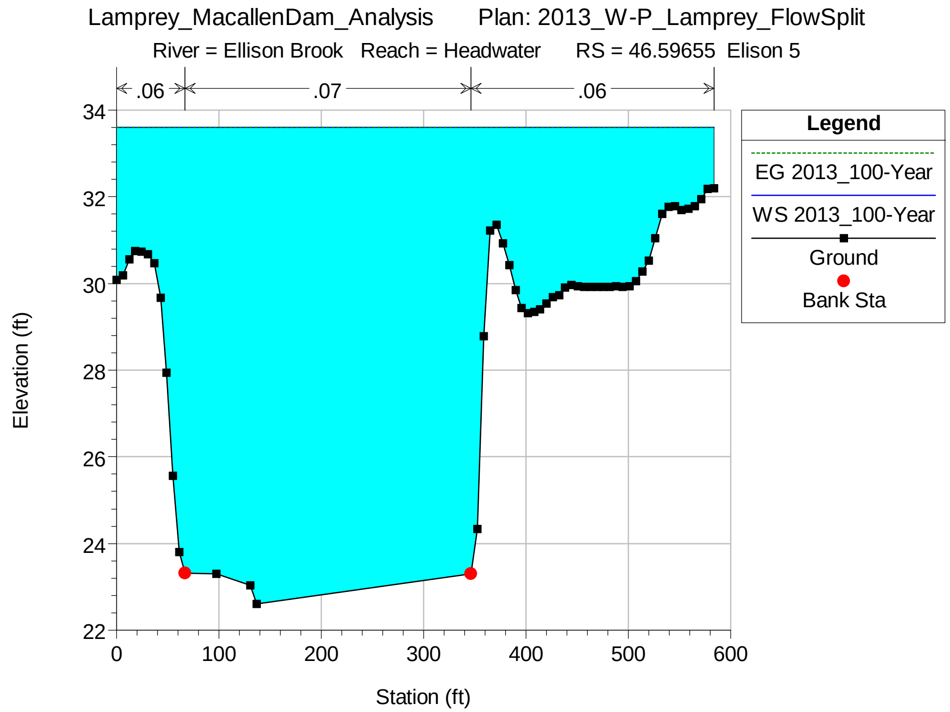
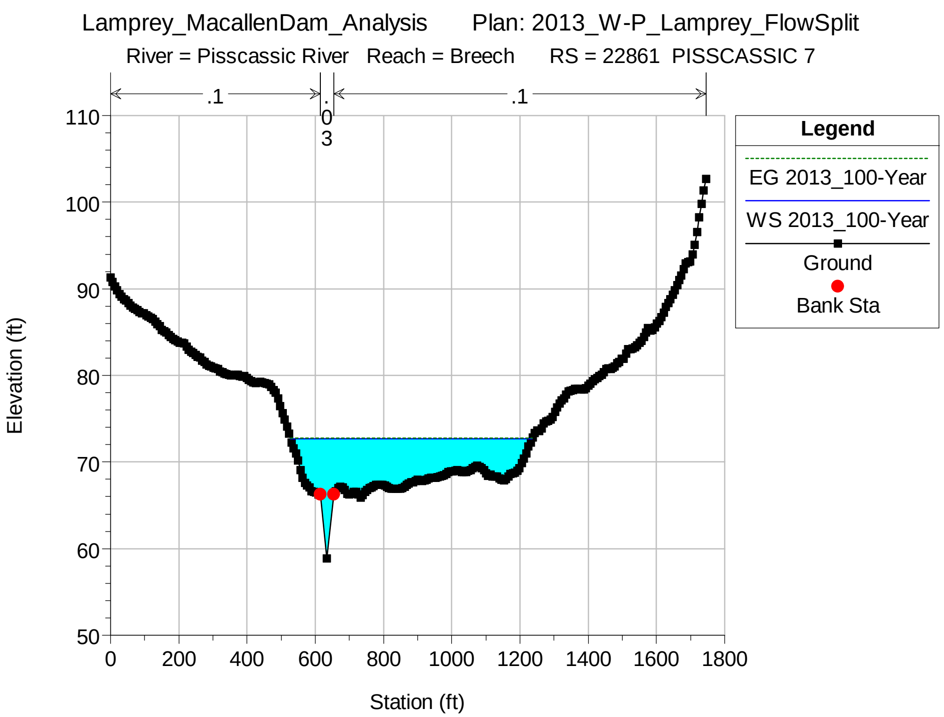
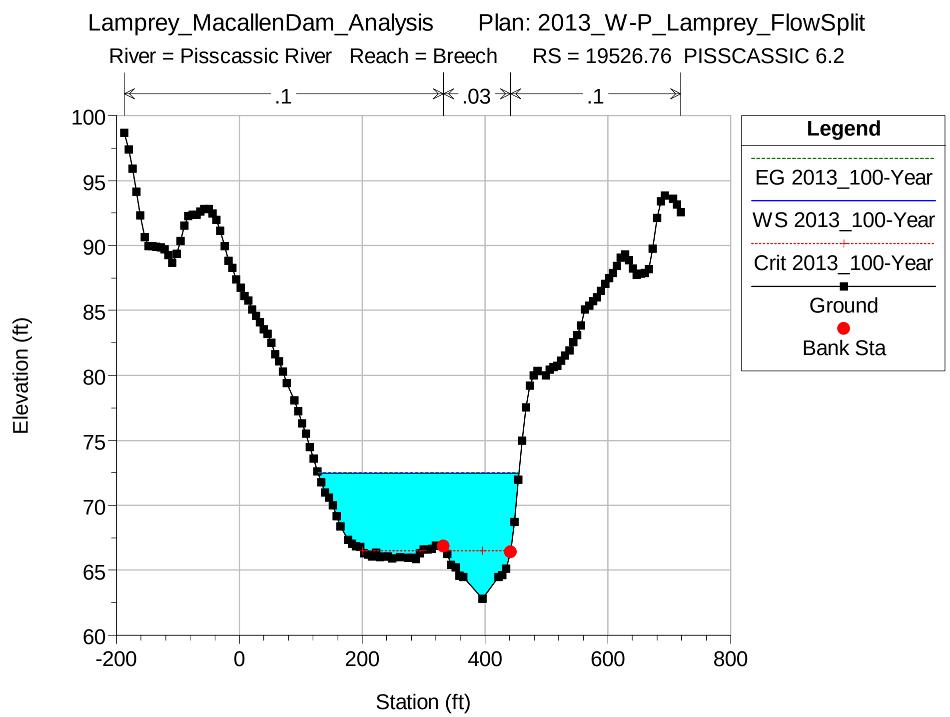
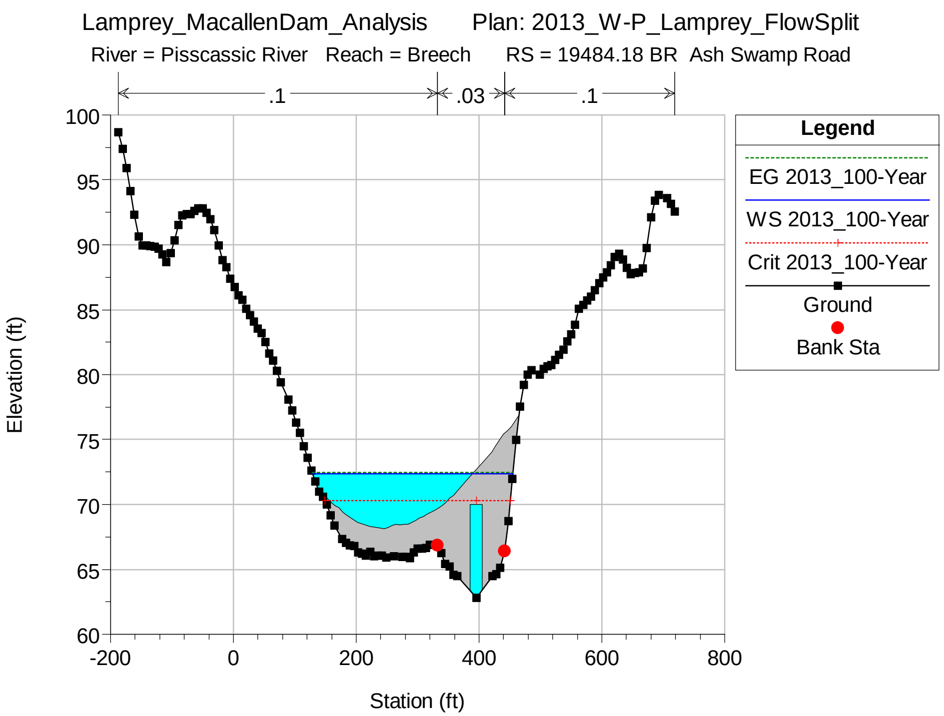
30
40
50
60
70
0
200
400
600
800
1000
1200

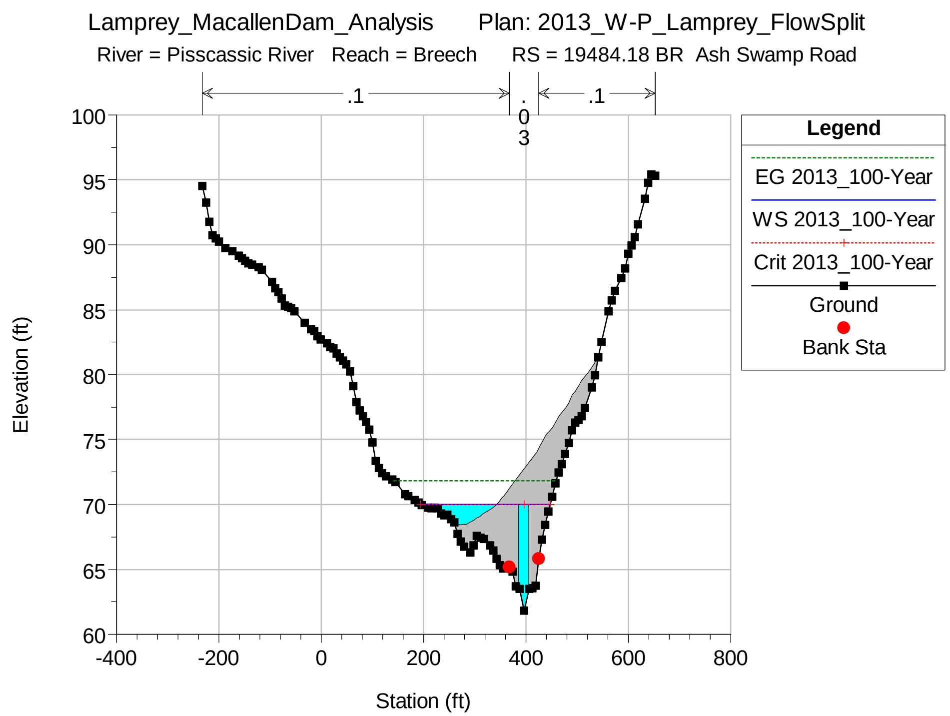

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Ellison Brook Reach = Headwater RS = 458.084 Elison 4
.06
.07
.06
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
46
44
42
40
38
36
34
32
30
28
0
200
400
600
800
1000

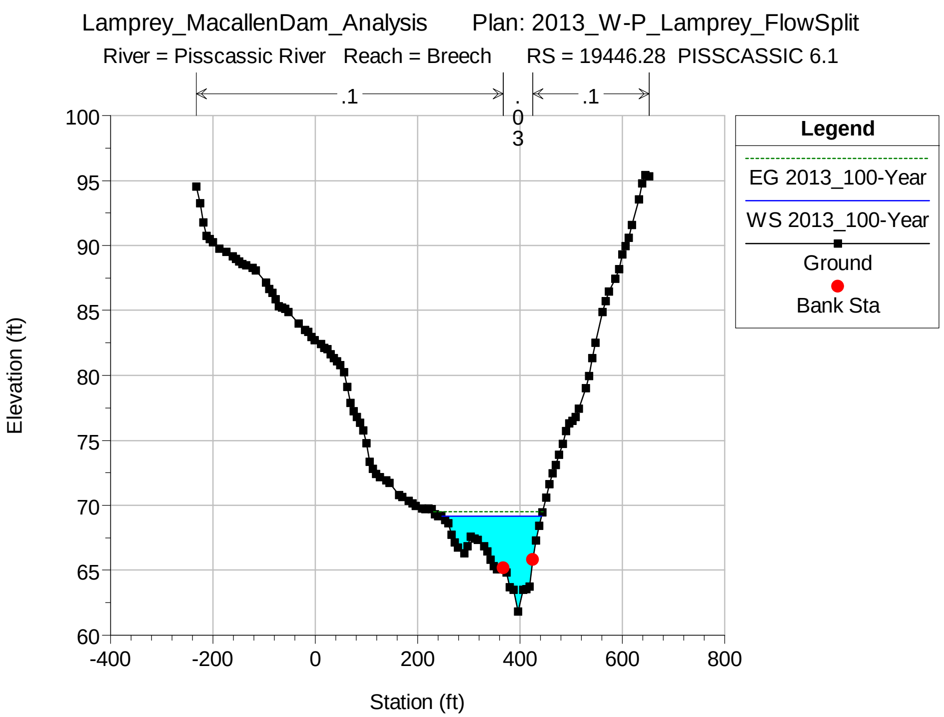

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Ellison Brook Reach = Headwater RS = 46.59655 Elison 5
.06
.07
.06
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
34
32
30
28
26
24
22
0
100
200
300
400
500
600

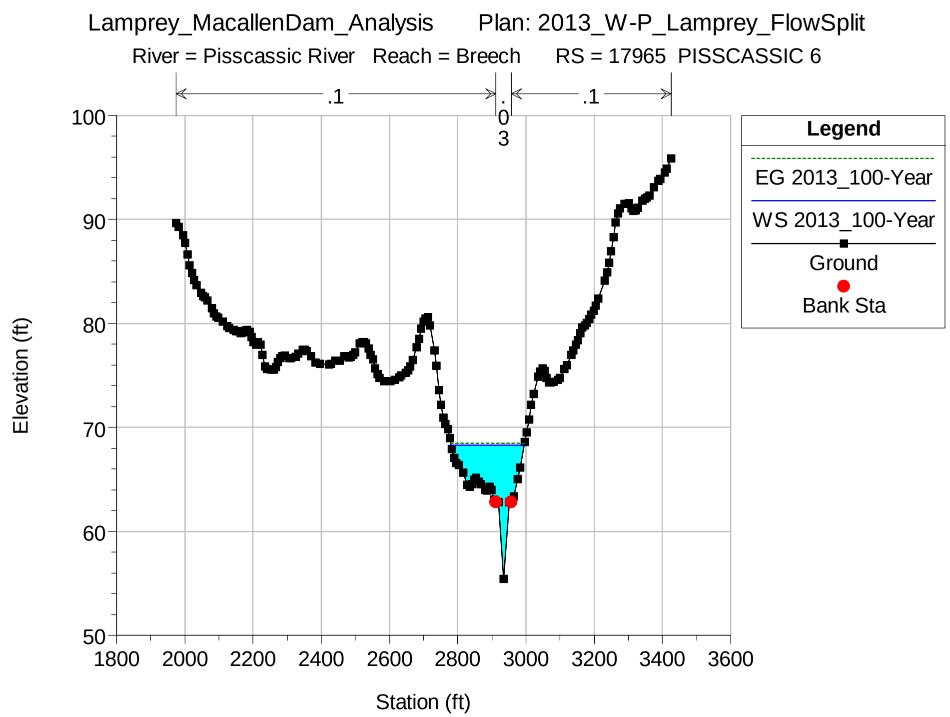

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 22861 PISSCASSIC 7
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
110
100
90
80
70
60
50
0
200
400
600
800
1000
1200
1400
1600
1800

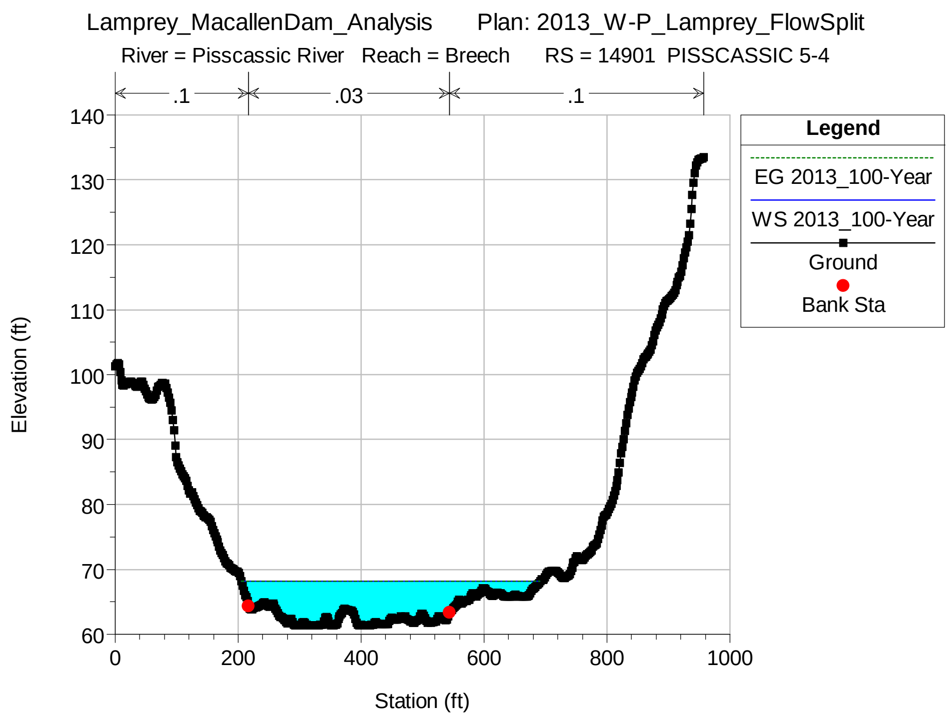

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 19526.76 PISSCASSIC 6.2
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
100
95
90
85
80
75
70
65
60
-200
0
200
400
600
800


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 19484.18 BR Ash Swamp Road
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 19484.18 BR Ash Swamp Road
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 19446.28 PISSCASSIC 6.1
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
River = Pisscassic River Reach = Breech RS = 17965 PISSCASSIC 6
.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_FlowSplit
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WS 2013_100-Year
Ground
Bank Sta
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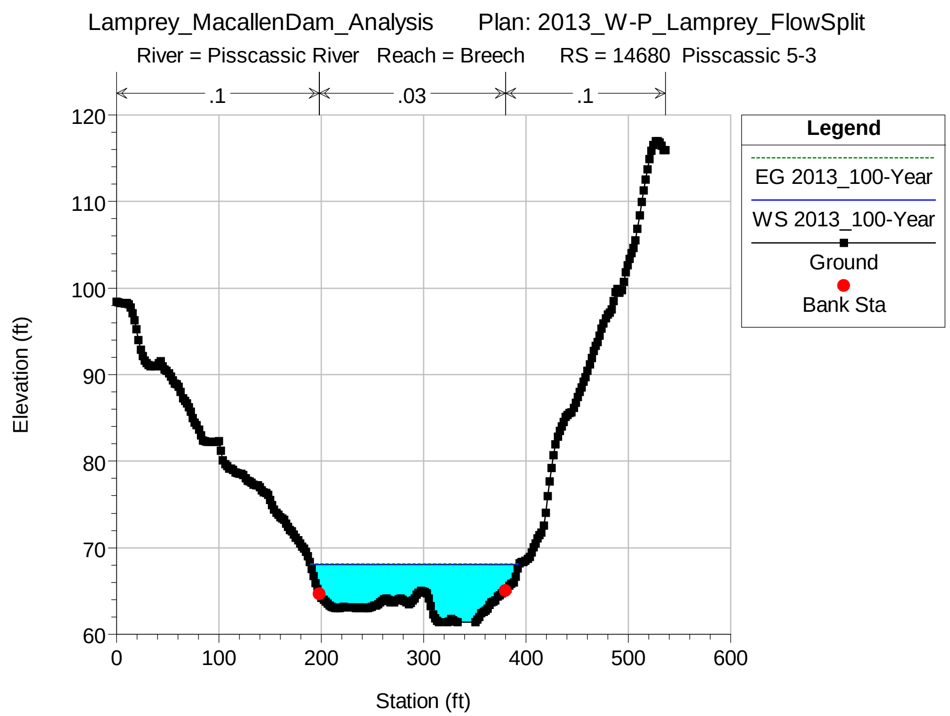
Station (ft)



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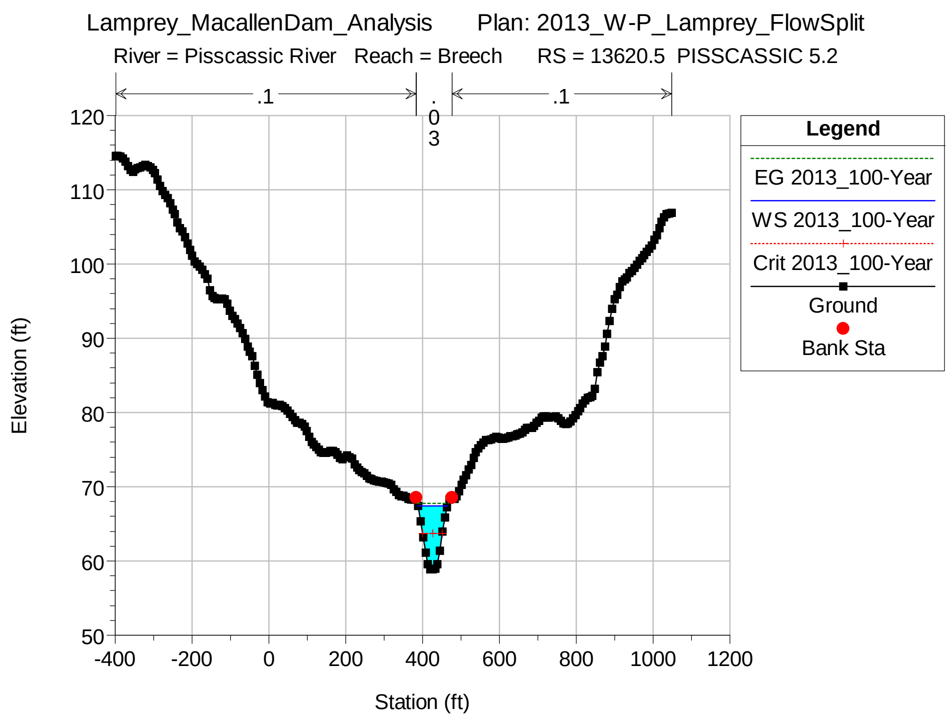

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Crit 2013_100-Year
Ground
Bank Sta
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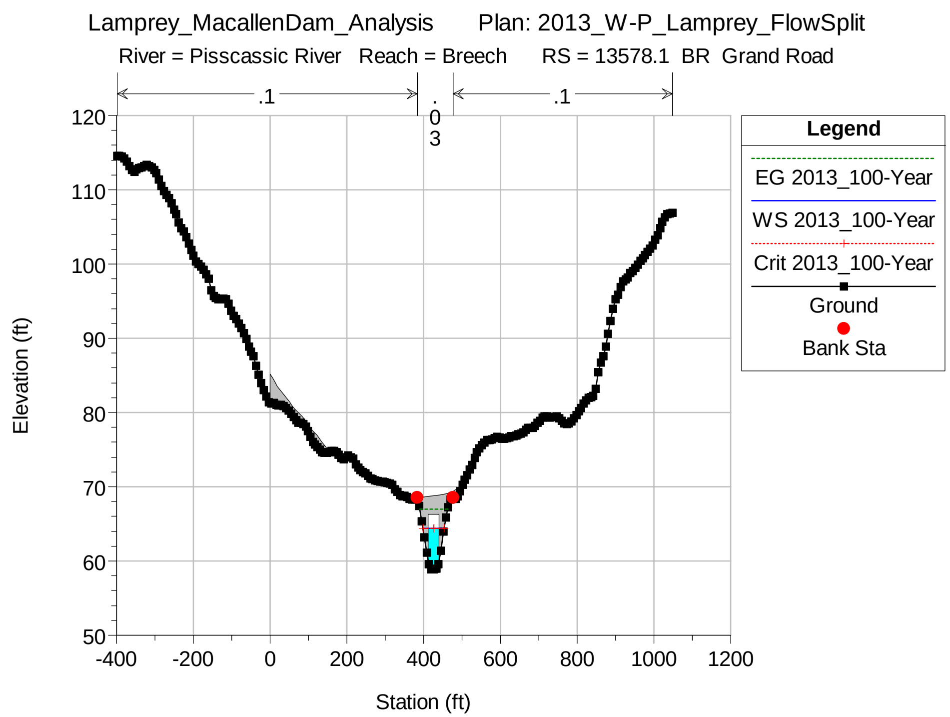
Station (ft)



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WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
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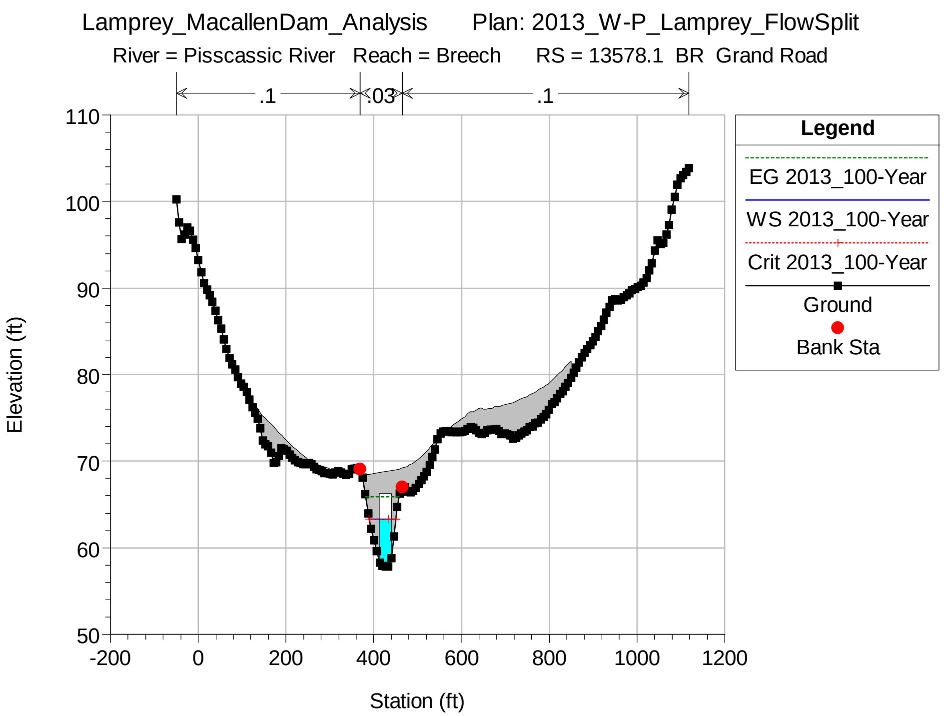
Station (ft)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Crit 2013_100-Year
Ground
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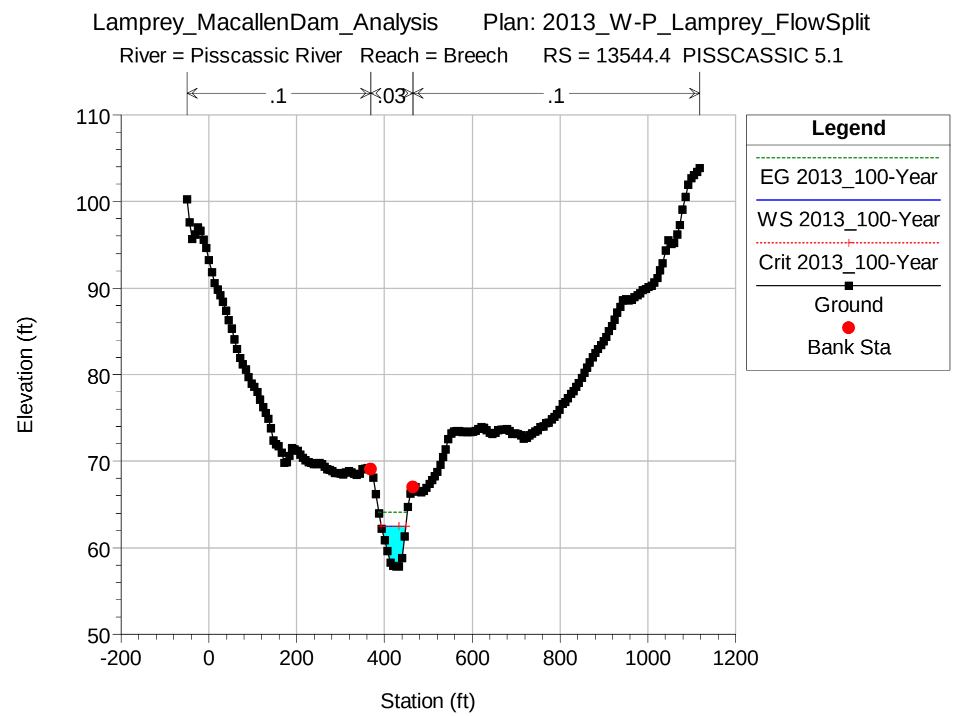
Station (ft)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Crit 2013_100-Year
Ground
Bank Sta
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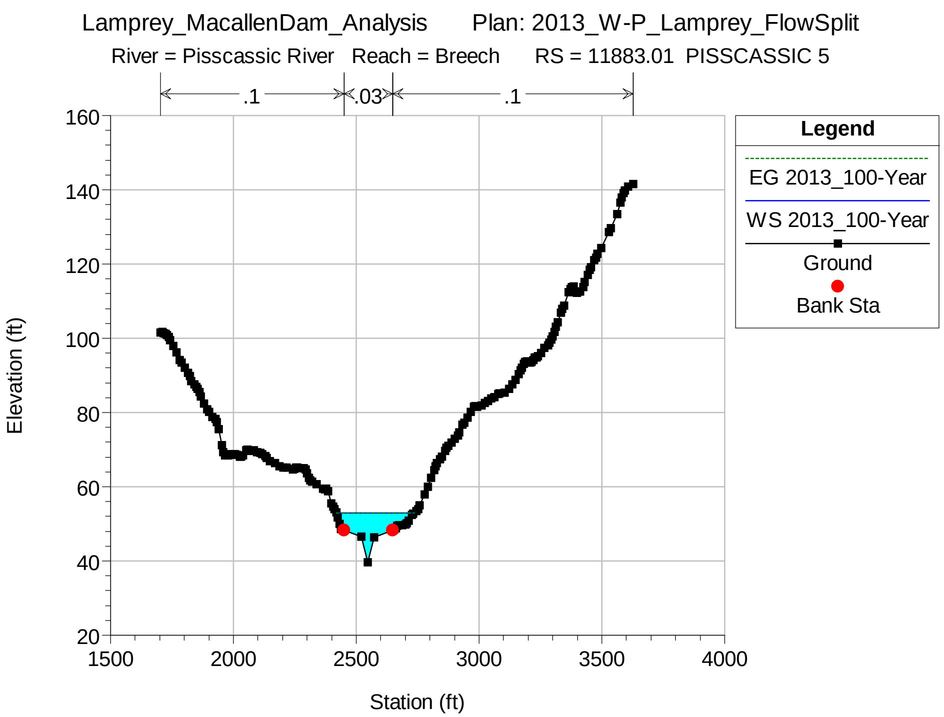
Station (ft)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Bank Sta
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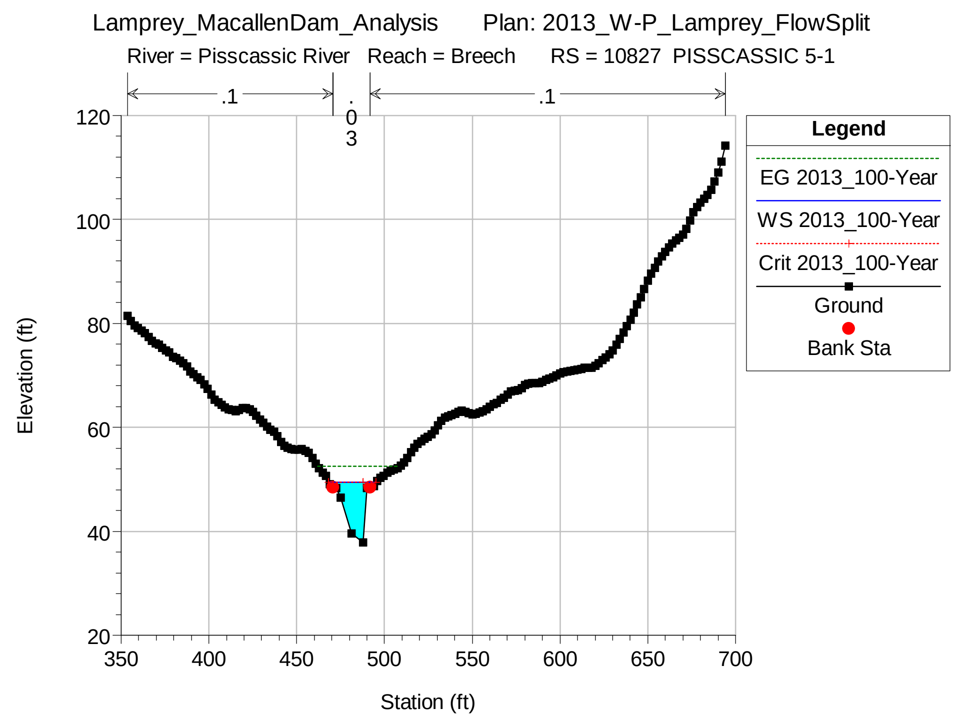
Station (ft)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Crit 2013_100-Year
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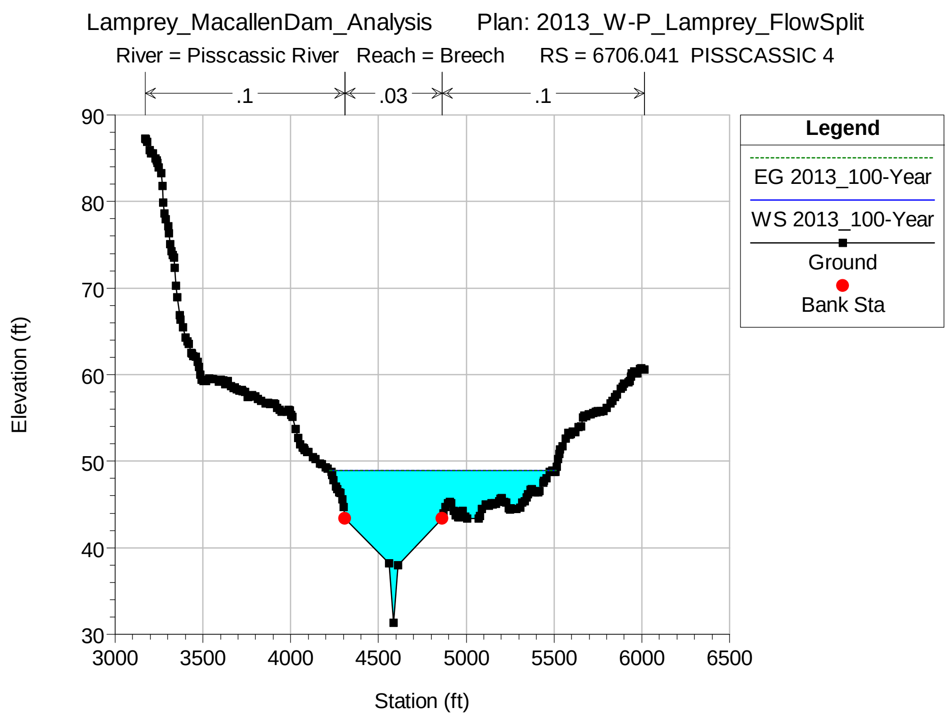
Station (ft)



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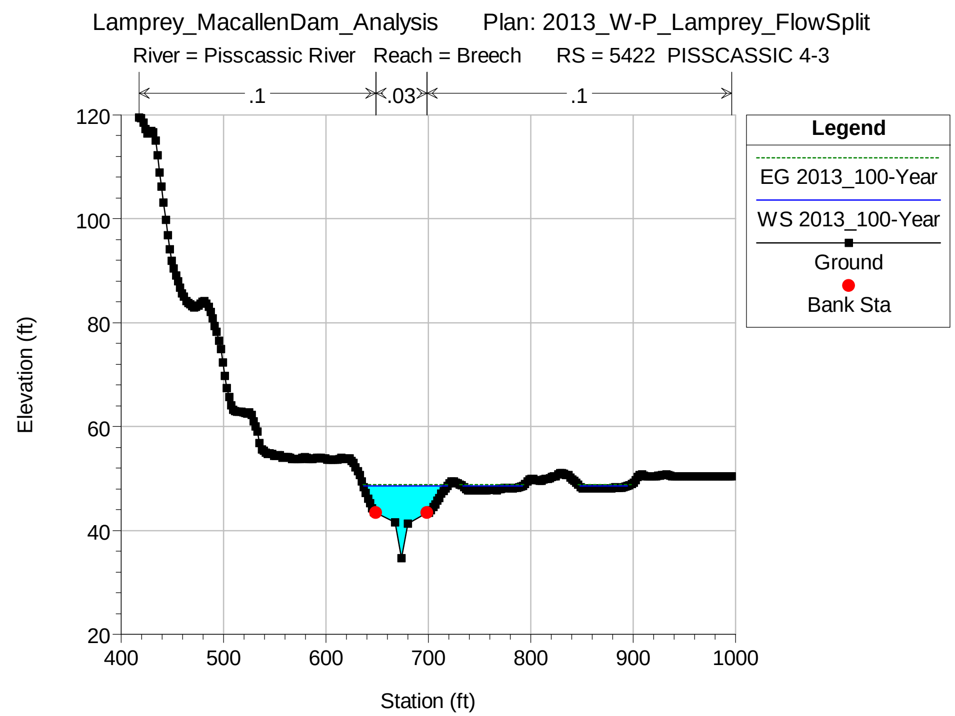
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



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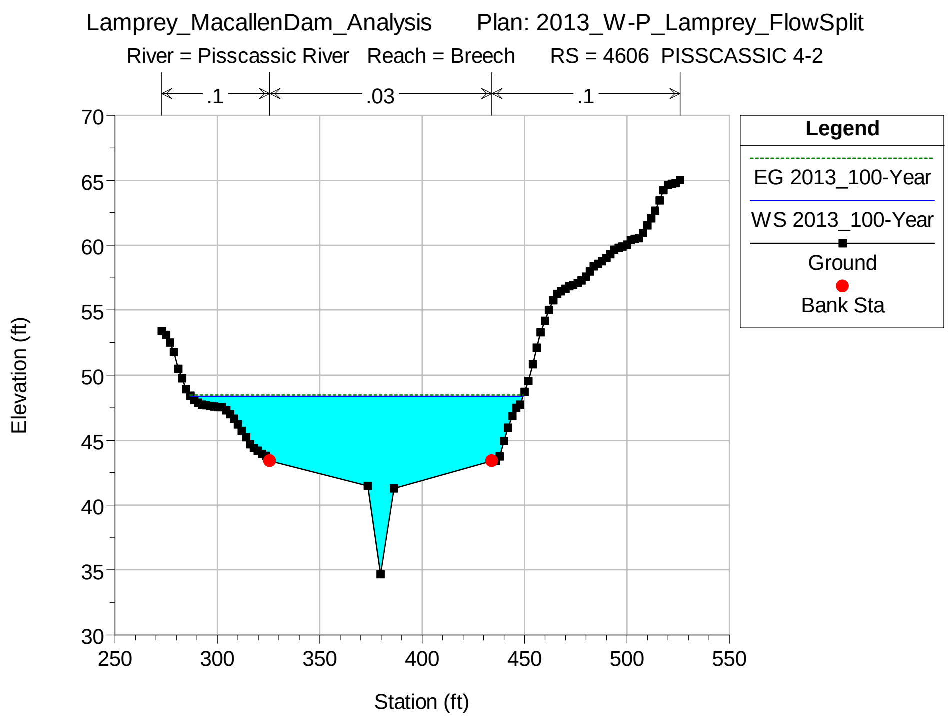
Station (ft)



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Ground
Bank Sta
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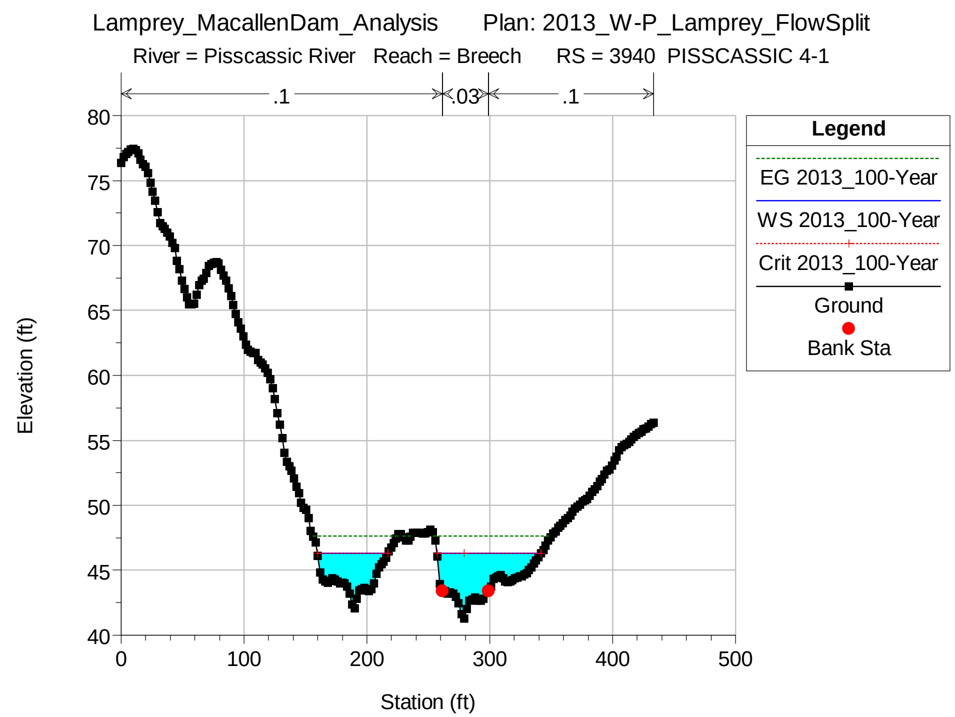
Station (ft)



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Legend
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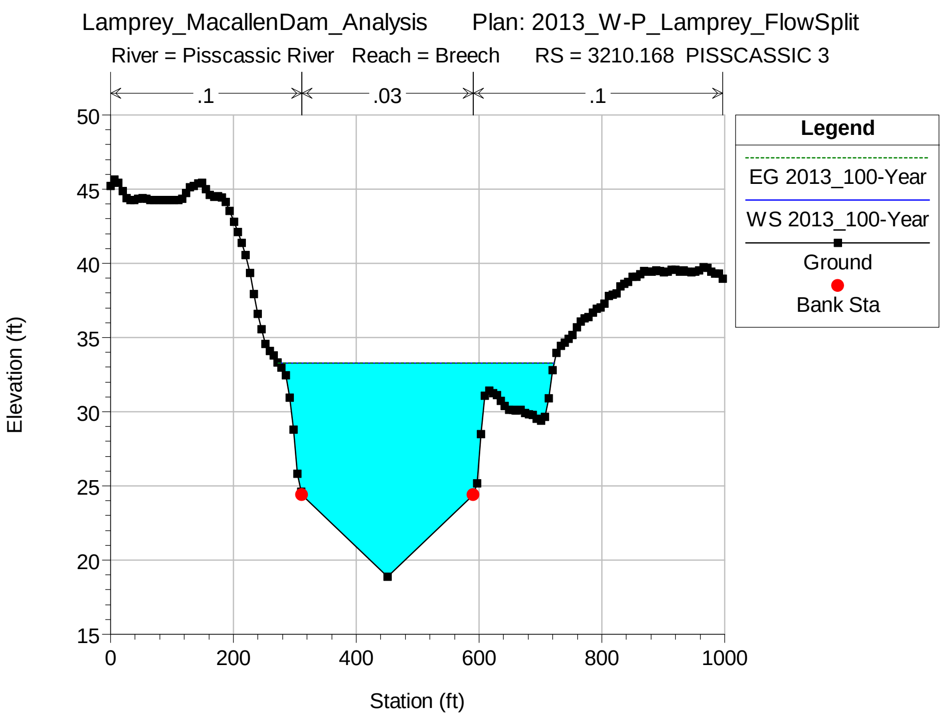
WS 2013_100-Year
Crit 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)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.03
.1
Legend
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WS 2013_100-Year
Ground
Bank Sta
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Station (ft)
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40
35
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20
15
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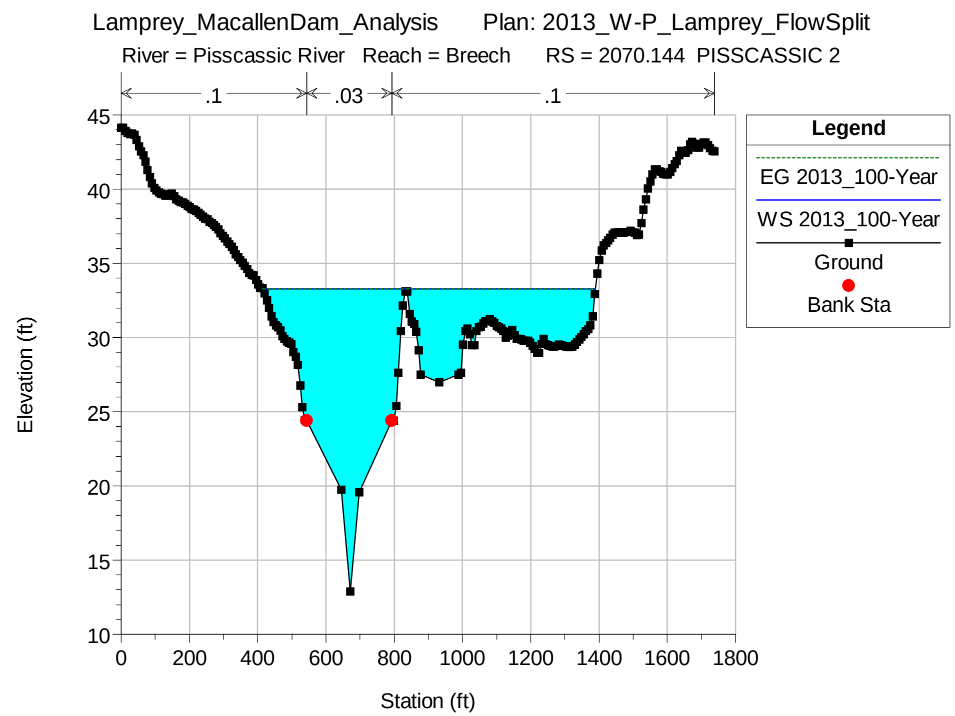
200
400
600
800
1000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.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
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30
25
20
15
10
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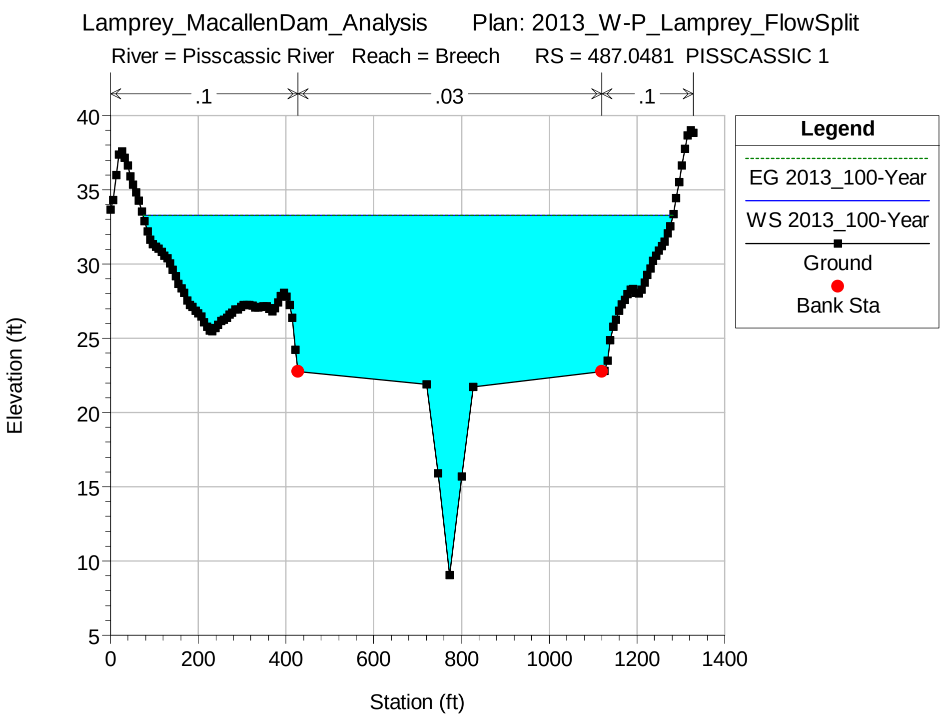
1000
1200
1400
1600
1800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.1
.03
.1
Legend
EG 2013_100-Year
WS 2013_100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
40
35
30
25
20
15
10
5
0
200
400
600
800
1000
1200
1400

APPENDIX E
NHDES Dambreak Studies

Appendix II-A

DAMBREAK STUDIES

October 1993

APPENDIX II-A

Dambreak Studies

The evaluation of the downstream consequences in the event of a dam failure is a main element in determining hazard potential and formulating emergency action plans for hydroelectric projects. The solution requires knowledge of the lateral and longitudinal geometry of the stream, its frictional resistance, a discharge-elevation relationship at one boundary, and the time-varying flow or elevation at the opposite boundary.

The current state-of-the-art is to use transient flow or hydraulic methods to predict dambreak wave formation and downstream progression. The transient flow methods solve and therefore account for the essential momentum forces involved in the rapidly changing flow caused by a dambreak. Another technique, referred to as storage routing or the hydrologic method, solves one-dimensional equations of steady flow ignoring the pressure and acceleration contributions to the total momentum force. For the same outflow hydrograph, the storage routing procedures will always yield lower water surface elevations than hydraulic or transient flow routing.

When routing a dambreak flood through the downstream reaches appropriate local inflows should be included in the routing which are consistent with the assumed storm centering.

The mode and degree of dam failure involves considerable uncertainty and cannot be predicted with acceptable engineering accuracy; therefore, conservative failure postulations are necessary. Uncertainties can be circumvented in situations where it can be shown that the complete and sudden removal of a dam (or dams) will not endanger human life or cause significant property damage.

The following provides references on dambreak analyses and criteria which may prove useful as indicators of reasonableness of the breach parameters, peak discharge, depth of flow, and travel time determined by the licensee. In addition, **Section 6-2 and Appendix VI-C of Chapter VI of these Guidelines provides additional criteria on analytical requirements for dambreak analyses.**

I. REFERENCES

Suggested acceptable references regarding dam failure studies include the following:

A. Fread, D. L. "DAMBRK - The NWS Dam-Break Flood Forecasting Model," National Weather Service, Silver Spring, Maryland, 1988 Version. This (or

the most recent version) is the preferred method for performing dambreak studies.

B. Fread, D. L. "NWS FLDWAV Model: The Replacement of DAMBRK for Dam-Break Flood Prediction", Proceedings, Association of State Dam Safety Officials, 10th Annual Conference, Kansas City, Missouri, September 26-29, 1993. ***Since this model combines the NWS DAMBRK model and the NWS DWOPER model, it is also considered the preferred method.***

C. Westmore, Jonathan N. and Fread, Danny L., "The NWS Simplified Dam-Break Flood Forecasting Model," National Weather Service, Silver Spring, Maryland, 1981. (Copy previously furnished to each Regional Office with a detailed example).

D. Fread, D. L., 1977: The development and testing of a dam-break flood forecasting model, "Proceedings, Dam-Break Flood Modeling Workshop," U.S. Water Resources Council, Washington, D.C., 1977, pp. 164-197.

E. Hydrologic Engineering Center, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations," September, 1990.

F. Gandlach, D. L. and Thomas, W. A., "Guidelines for Calculating and Routing a Dam-Break Flood," Research Note No. 5, U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1977.

G. Cecilio, C. B. and Strassburger, A. G., "Downstream Hydrograph from Dam Failure," Engineering Foundation Conference on Evaluation of Dam Safety, 1976.

H. Soil Conservation Service, "Simplified Dam-Breach Routing Procedure," March 1979. (To be used only for flood routing technique, not dambreak discharge).

I. Chow, V. T., <u>Open Channel Hydraulics</u>, McGraw-Hill Book Company, Inc., New York, 1959, Chapter 20.

J. Henderson, F. M., <u>Open Channel Flow</u>, McMillan Company, New York, 1966, Chapters 8 and 9.

K. Hydrologic Engineering Center, "Flood Emergency Plans, Guidelines for Corps Dam," June 1980. (Forwarded to all Regional Engineers by memorandum dated February 11, 1981).

L. Hydrologic Engineering Center, "UNET, One-Dimensional Unsteady Flow Through a Full Network of Open Channels", September 1992.

II. CRITERIA

The following criteria may prove useful as an indicator of the reasonableness of a dambreak study:

A. If the dambreak analysis has been performed by an acceptable method (**References A and B are the preferred methods**), then generally only the breach parameters, peak discharge, and flood wave travel time should be <u>verified</u> as an indicator of the licensee's correct application of the method selected. Downstream routing parameters (i.e., Manning's "n") should be reviewed for acceptability and inundation maps should be reviewed for clarity and completeness of information (i.e., travel times). The following criteria are considered to be adequate and appropriate for verifying the selected breach parameters and peak discharge:

1. Breach Parameters - Most serious dam failures result in a situation resembling weir conditions. Breach width selection is judgmental and should be made based on the channel or valley width with failure occurring at the deepest section. The bottom of the breach should generally be assumed to be at the foundation elevation of the dam. Pages 2-A-8 through 2-A-11 of this appendix contain suggested breach parameters and should be used when verifying the selected breach parameters. For worst case scenarios, the breach width should be in the upper range while the time of failure should be in the lower range. However a sensitivity analysis is recommended to determine the reasonableness of the assumptions.

2. Peak Discharge - The peak discharge may be verified by use of equations (11) and (13) of Reference No. 1. Although the equations assume a rectangular-shaped breach, a trapezoidal breach may be analyzed by specifying a rectangular breach width that is equal to the average width of the trapezoidal breach.

<u>Equation 11</u>:

$$C = \frac{23.4 A_s}{\overline{BR}}$$

Where: C = constant
A_s = reservoir surface area, in acres
$\overline{BR}$ = average breach width, in feet

Equation 13:

$$Q_{bmax} = 3.1\overline{BR}\left(\frac{C}{(t_f + \frac{C}{\sqrt{H}})}\right)^3$$

Where: Q_{bmax} = maximum breach outflow, in cfs
t_f = time of failure, in hours
H = maximum head over the weir, in feet

This equation for Q_{bmax} has been found to give results within +5% of the Q_{peak} from the full DAMBRK model.

In a rare case where a dam impounding a small storage volume has a large time of failure, the equations above will predict a much higher flow than actually occurs.

At a National Weather Service Dam-Break Model Symposium held in Tulsa, Oklahoma, June 27-30, 1983, Dr. Danny Fread presented an update to his simplified method. Equation 13 has been modified as follows to include additional outflow not attributed to breach outflow:

$$Q_{bmax} = Q_o + 3.1\overline{BR}\left(\frac{C}{(t_f + \frac{C}{\sqrt{H}})}\right)^3$$

Where: Q_o = Additional (non-breach) outflow (cfs) at time t_f (i.e., spillway flow and/or crest overflow) (optional data value, may be set to 0).

This equation has also been modified to address instantaneous failure, because in some situations where a dam fails very rapidly, the negative wave that forms in the reservoir may significantly affect the outflow from the dam.

3. Flood Wave Travel Time - Reasonableness of the flood wave travel time may be determined by use of the following "rule-of-thumb" approximation for average wave speed:

(a) Assume an equivalent rectangular channel section for the selected irregular channel section.

(b) Assume a constant average channel slope.

(c) Compute depth of flow from the following adjusted Manning's equation.

$$d = \left(\frac{Qn}{1.46B(S)^{0.5}}\right)^{0.6}$$

Where: d = depth of flow for assumed rectangular section, ft.
Q = peak discharge, cfs
B = average width (rectangular), ft.
S = average slope, ft./ft.
n = Manning's roughness coefficient

(d) Compute average velocity from Manning's Equation:

$$V = \frac{1.49(S)^{0.5}(d)^{0.67}}{n}$$

Where: V = average velocity, fps

(e) Compute wave speed, C (Kinematic velocity):

$$C = \frac{5}{3}V(0.68)$$

Where: C = wave speed (mph)

Note: *1 fps = 0.68 mph*

(f) Determination travel time, TT

$$TT = \frac{X}{C}$$

Where: TT = travel time, hr.
X = distance from dam, mi.

Note: *If the slope is flat, the following "rule-of-thumb" provides a very rough estimate of the wave speed:*

$$C = 2(S)^{0.5}$$

Where: C = wave speed, mph
S = average slope, ft./mi.

In addition, as a "rule-of-thumb", the dynamic routing (NWS) method should be used whenever severe backwater conditions at downstream areas occur and/or the slope is less than 20 ft/mi. When these restrictions are not present normal hydrologic routing (HEC-1) may provide reasonable results. It is recommended that HEC-2 be used to determine the resulting water surface elevations when HEC-1 is used for the dambreak study.

<u>The HEC-I Manual (Reference E) states that when "a higher order of accuracy is needed, then an unsteady flow model, such as the National Weather Service's DAMBRK should be used."</u> Experience demonstrates that the higher order of accuracy is usually required. Therefore, the NWS DAMBRK model and the more recent NWS FLOODWAV model are the preferred methods and recommended for all situations requiring dambreak studies.

B. If a dambreak analysis has been performed by a method other than one of the suggested acceptable methods, the selected breach parameters, peak discharge, depth of flow and travel time of the flood wave shall be <u>verified</u> by one of the two methods:

1. **Unsteady Flow - Dynamic Routing Method (Recommended)**

The NWS "DAMBRK" Model (Reference A) and the NWS "FLOODWAV" Model (Reference B) are the recommended methods. Each FERC Regional Office has received the software using the NWS DAMBRK program and should use this program, as necessary, to verify dambreak studies. As the flood wave travels downstream, the peak discharge and wave velocity generally, but not always, decrease. This attenuation in the flood wave is primarily due to energy dissipation when it is near the dam and to valley storage as it progresses in an unsteady flow downstream. It is important that the NWS model be calibrated to historical floods, if at all possible.

2. **Steady Flow Method (Provides a rough estimate)**

If this method is selected, the breach parameters and peak discharge shall be verified as in part "A" above. The method described below should be utilized only for preliminary assessments and the obtained values may be far from the actually expected results. Sound judgement and extensive numerical experience is necessary when evaluating the results.

For a rough estimate of the travel time and flood wave, it is recommended that one of the following two steady state methods be used for verification of the licensee's values:

a. When steam gage data are available, the depth of flow and travel time can be estimated as follows (This method will indirectly take valley storage into consideration):

(1) Identify existing stream gages located downstream of the dam.

(2) Obtain the stage-discharge curve for each gage.

(3) Assuming Q_{peak} remains constant, extrapolate the curves to the Q_{peak} value of the flood wave and determine the corresponding water surface elevation.

(4) Using the continuity equation to determine the velocity, estimate the travel time between each cross-section.

b. When stream gage data is not available, the depth of flow and travel time can be estimated based on the following steady-state method:

(1) Assume the area downstream of the dam is a channel. This will neglect valley storage.

(2) Identify on topographic maps all abrupt changes in channel width and/or slope. Using this as a basis, select and plot channel cross-sections.

(3) Assume Q_{bmax} remains constant throughout the entire stream length under consideration.

(4) Selecting a fairly rough Manning's n value, determine the depth of flow by applying Manning's equation to each cross-section. Assume the energy slope is equal to the slope of the channel.

(5) Using the continuity equation to determine the velocity, estimate the travel time between each cross-section.

C. The above criteria for breach parameters, peak discharge, depth of flow, and travel time should provide the necessary "ballpark figures" needed for comparison with licensee's estimates. When large discrepancies in compared values exist, or questions arise about assumptions to be made, or it appears that an extensive review will be necessary, the Regional Director should contact the Washington Office, D2SI for guidance. The methodology used by the licensee should be a part of the study and should be requested if not included.

TABLE 1

SUGGESTED BREACH PARAMETERS

(Definition Sketch Shown in Figure 1)

Parameter	Value	Type of Dam
Average width of Breach (BR) (See Comment No. 1)*	$\overline{BR}$ = Crest Length	Arch
	$\overline{BR}$ = Multiple Slabs	Buttress
	$\overline{BR}$ = Width of 1 or more Monoliths, Usually $\overline{BR} \leq 0.5$ W	Masonry, Gravity
	HD $\leq \overline{BR} \leq$ 5HD (usually between 2HD & 4HD)	Earthen, Rockfill, Timber Crib
	$\overline{BR} \geq$ 0.8 x Crest Length	Slag, Refuse
Horizontal Component of Side Slope of Breach (Z) (See Comment No. 2)*	$0 \leq Z \leq$ slope of valley walls	Arch
	Z = O	Masonry, Gravity Timber Crib, Buttress
	$¼ \leq Z \leq 1$	Earthen (Engineered, Compacted)
	$1 \leq Z \leq 2$	Slag, Refuse (Non-Engineered)
Time to Failure (TFH) (in hours) (See Comment No. 3)*	TFH $\leq$ 0.1	Arch
	0.1 $\leq$ TFH $\leq$ 0.3	Masonry, Gravity, Buttress
	0.1 $\leq$ TFH $\leq$ 1.0	Earthen (Engineered, Compacted) Timber Crib
	0.1 $\leq$ TFH $\leq$ 0.5	Earthen (Non Engineered Poor Construction)
	0.1 $\leq$ TFH $\leq$ 0.3	Slag, Refuse

Definition:

HD - Height of Dam
Z - Horizontal Component of Side Slope of Breach
BR - Average Width of Breach
TFH - Time to Fully Form the Breach
W - Crest Length

Note: See Page 2-A-12 for definition Sketch

**Comments: See Page 2-A-10 - 2-A-11*

Comments:

1. $\overline{BR}$ is the average breach width, which is not necessarily the bottom width. $\overline{BR}$ is the bottom width for a rectangle, but $\overline{BR}$ is not the bottom width for a trapezoid.

2. Whether the shape is rectangular, trapezoidal, or triangular is not generally critical if the average breach width for each shape is the same. What is critical is the assumed average width of the breach.

3. Time to failure is a function of height of dam and location of breach. Therefore, the longer the time to failure, the wider the breach should be. Also, the greater the height of the dam and the storage volume, the greater the time to failure and average breach width will probably be. Time to failure is the time from the start of the breach formation until the complete breach is formed. It does not include the time leading up to the start of the breach formation. For example, the time to erode away the downstream slope of an earth dam is not included. In this situation, the time to failure commences after sufficient erosion of the downstream slope has occurred and actual formation of the breach (the lowering of the crest) has begun.

4. The bottom of the breach should be at the foundation elevation.

5. Breach width assumptions should be based on the type of dam, the height of dam, the volume of the reservoir, and the type of failure (e.g. piping, sustained overtopping, etc.). Slab and buttress dams require sensitivity analyses that vary the number of slabs assumed to fail.

6. For a worst-case scenario, the average breach width should be in the upper portion of the recommended range, the time to failure should be in the lower portion of the range, and the Manning's "n" value should be in the upper portion of the recommended range. In order to fully evaluate the impacts of a failure on downstream areas, a sensitivity analysis is required to estimate the confidence and relative differences resulting from varying assumptions.

    a. To compare relative differences in peak elevation based on variations in breach widths, the sensitivity analysis should be based on the following assumptions:

        1. Assume a probable (reasonable) maximum breach width, a probable minimum time to failure, and a probable maximum Manning's "n" value. Manning's "n" values for sections immediately below the dam and up to several thousand feet or more downstream of the dam should be assumed to be larger than the maximum value suggested by field investigations in

order to account for uncertainties of high energy losses, velocities, turbulence, etc., resulting from the initial failure.

2. Assume a probable minimum breach width, a probable maximum time to failure, and a probable minimum Manning's "n" value.

Plot the resulting water surface elevation at selected locations downstream from the dam for each run on the same graph. Compare the differences in elevation with respect to distance downstream from the dam for the two cases.

b. To compare differences in travel time of the flood wave, the sensitivity analysis should be based on the following assumptions:

1. Use criteria in a. 1.

2. Assume a probable maximum breach width, a probable minimum time to failure, and a probable minimum Manning's "n" value.

Plot the results (elevation-distance downstream) of both runs on the same graph to compare the changes in travel time with respect to distance downstream from the dam.

c. To compare differences in elevation between natural flood conditions and natural flood conditions plus dambreak, the sensitivity analysis should be based on the following assumptions:

1. Route natural flood without dambreak assuming maximum probable Manning's "n" value.

2. Use criteria in a. 1.

Plot the results (elevation-distance downstream) of both runs on the same graph to compare the changes in elevation with respect to distance downstream from the dam.

7. When dams are assumed to fail from overtopping, wider breach widths than those suggested in Table 1 should be considered if overtopping is sustained for a long period of time.

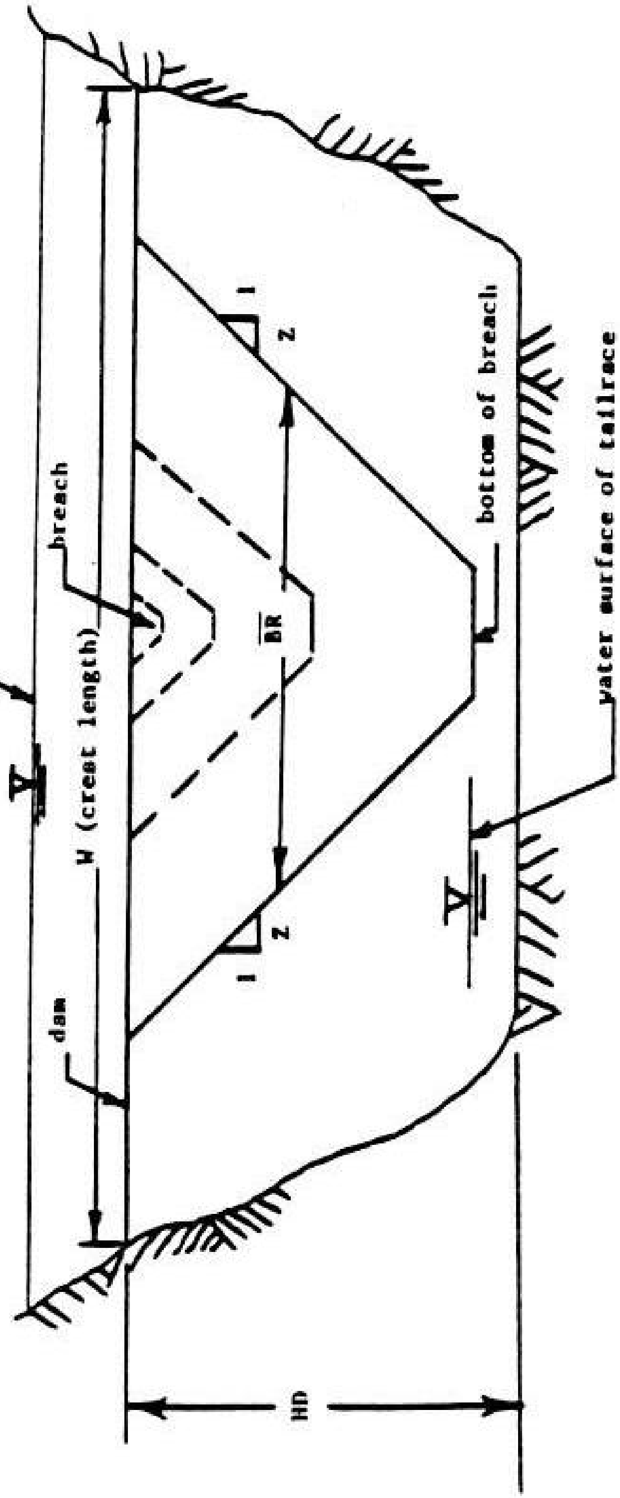
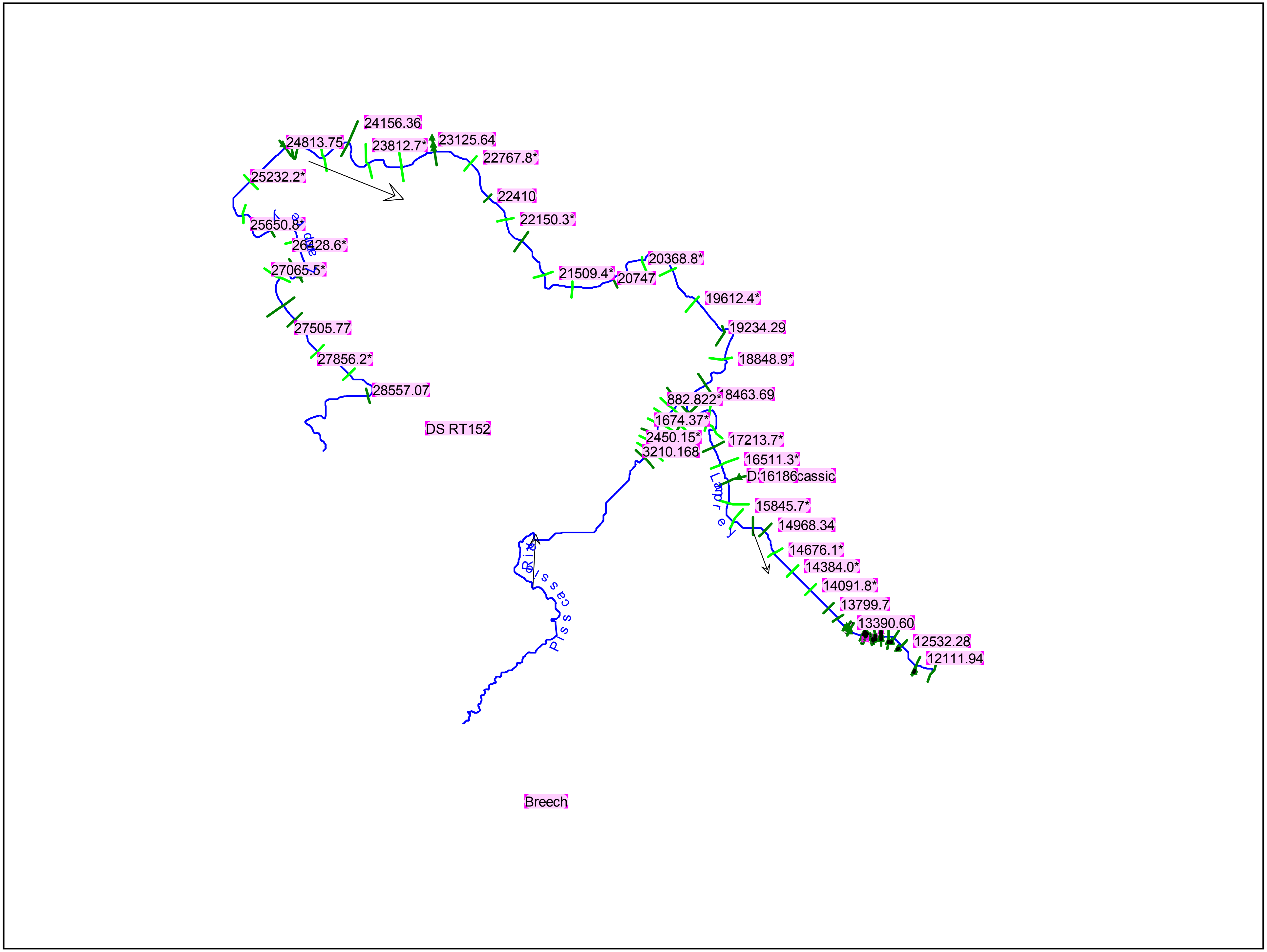


FIGURE 1. DEFINITION SKETCH OF BREACH PARAMETERS

APPENDIX F
HEC-RAS Model Outputs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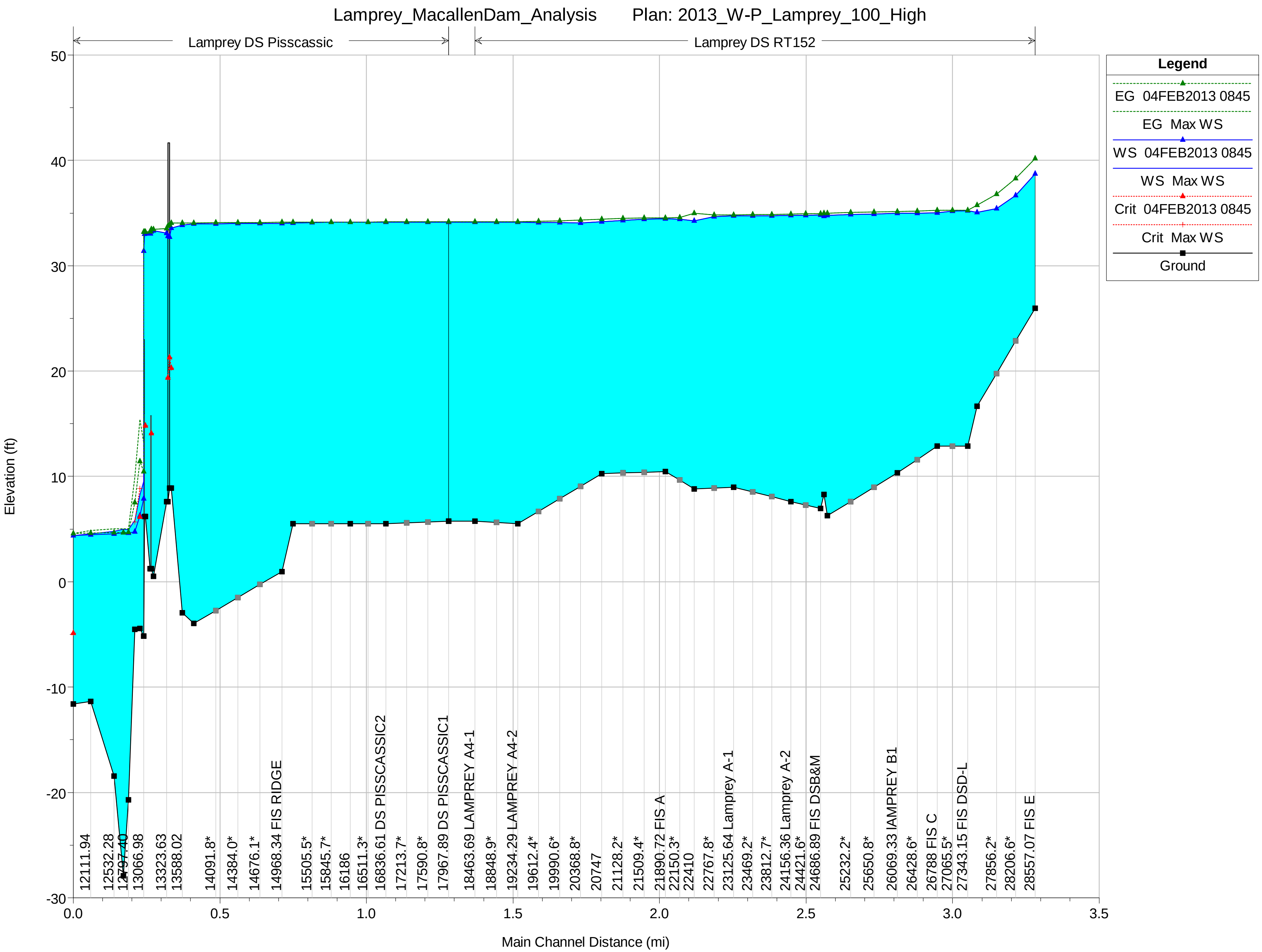
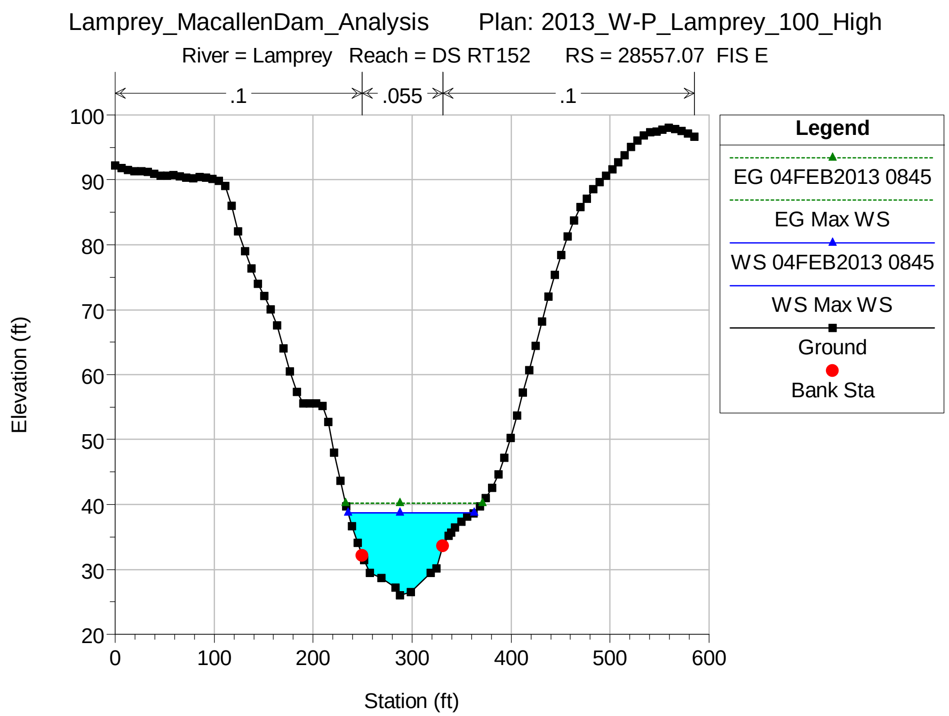
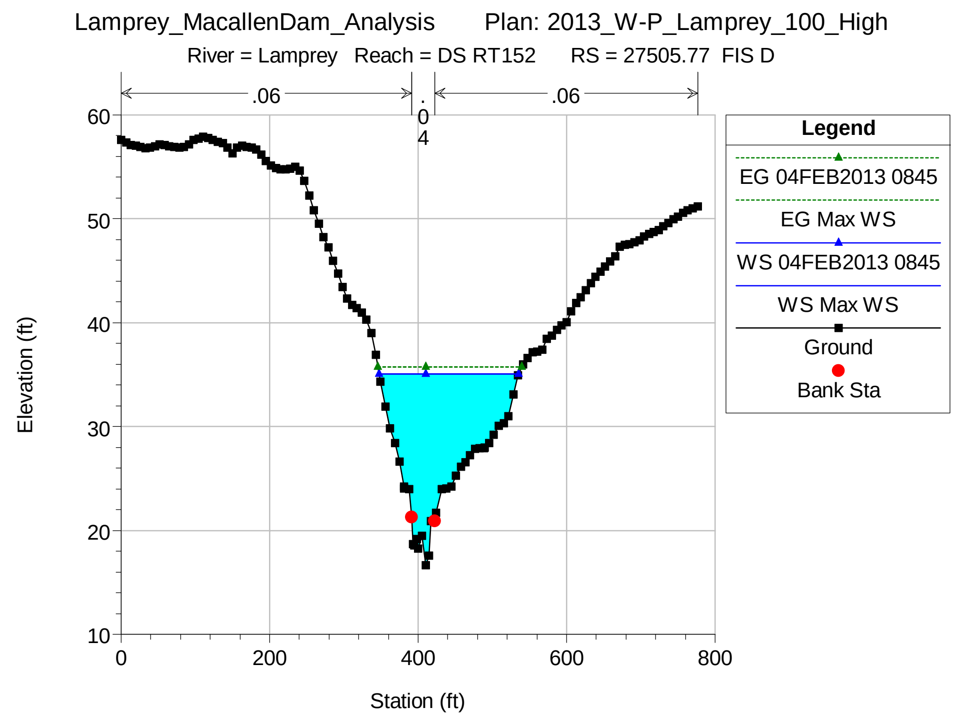
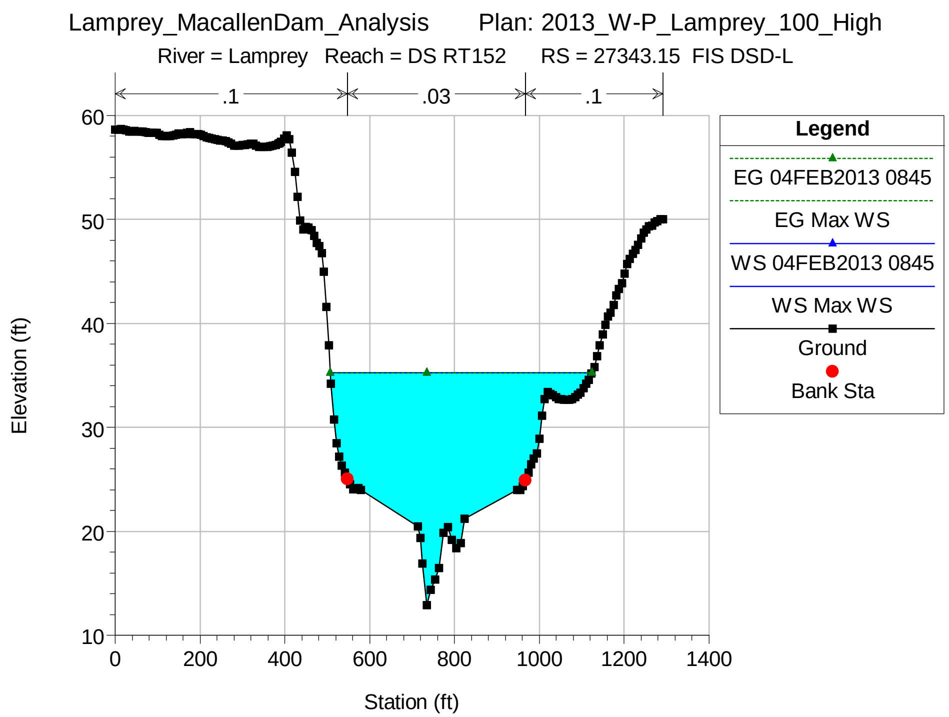
23812.7*
23125.64
22767.8*
25232.2*
22410
22150.3*
25650.8*
26428.6*
27065.5*
20368.8*
21509.4*
20747
19612.4*
27505.77
19234.29
27856.2*
18848.9*
28557.07
882.822*
18463.69
1674.37*
DS RT152
2450.15*
17213.7*
3210.168
16511.3*
16186
15845.7*
14968.34
14676.1*
14384.0*
14091.8*
13799.7
13390.60
12532.28
12111.94
Breech

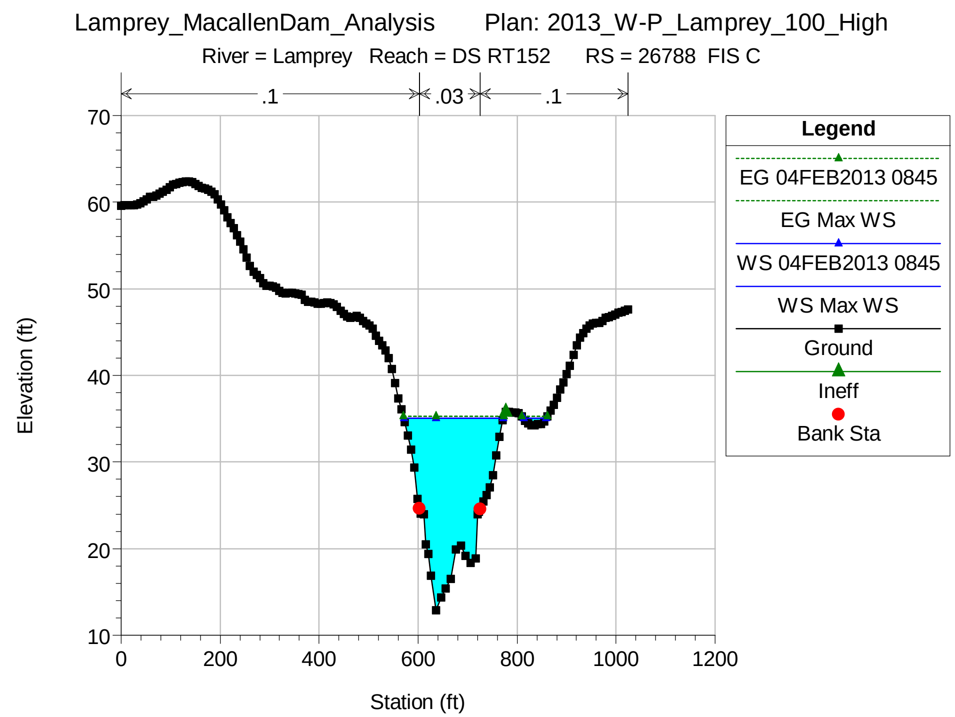


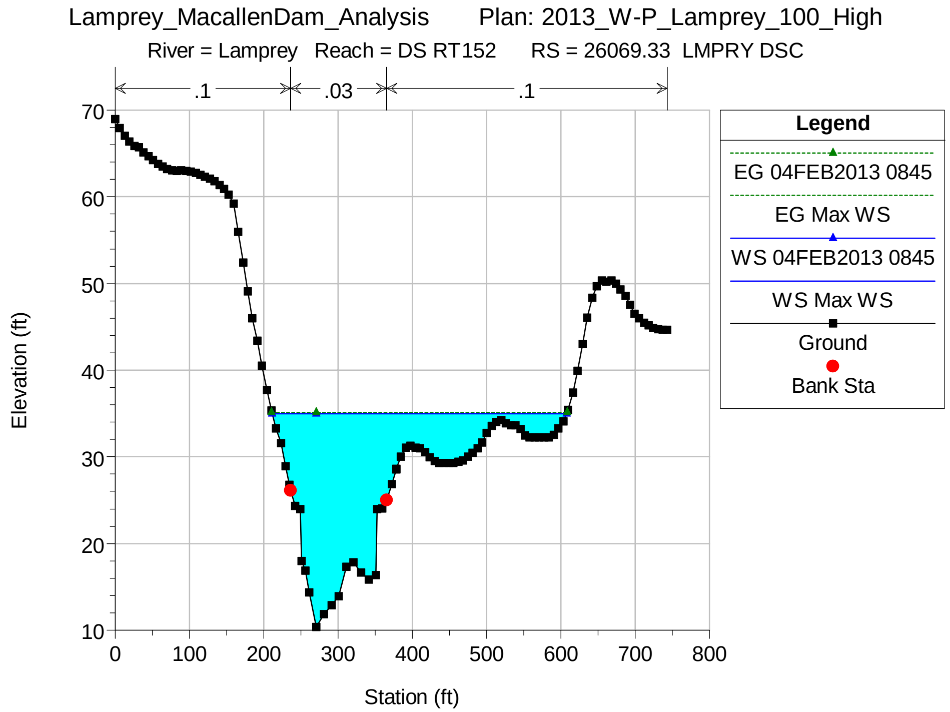
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
Lamprey DS Pisscassic
Lamprey DS RT152
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit 04FEB2013 0845
Crit Max WS
Ground
Elevation (ft)
Main Channel Distance (mi)
12111.94
12532.28
13066.98
13323.63
13588.02
14091.8*
14384.0*
14676.1*
14968.34 FIS RIDGE
15505.5*
15845.7*
16186
16511.3*
16836.61 DS PISSCASSIC2
17213.7*
17590.8*
17967.89 DS PISSCASSIC1
18463.69 LAMPREY A4-1
18848.9*
19234.29 LAMPREY A4-2
19612.4*
19990.6*
20368.8*
20747
21128.2*
21509.4*
21890.72 FIS A
22150.3*
22410
22767.8*
23125.64 Lamprey A-1
23469.2*
23812.7*
24156.36 Lamprey A-2
24421.6*
24686.89 FIS DSB&M
25232.2*
25650.8*
26069.33 IAMPREY B1
26428.6*
26788 FIS C
27065.5*
27343.15 FIS DSD-L
27856.2*
28206.6*
28557.07 FIS E


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 28557.07 FIS E
.1
.055
.1
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

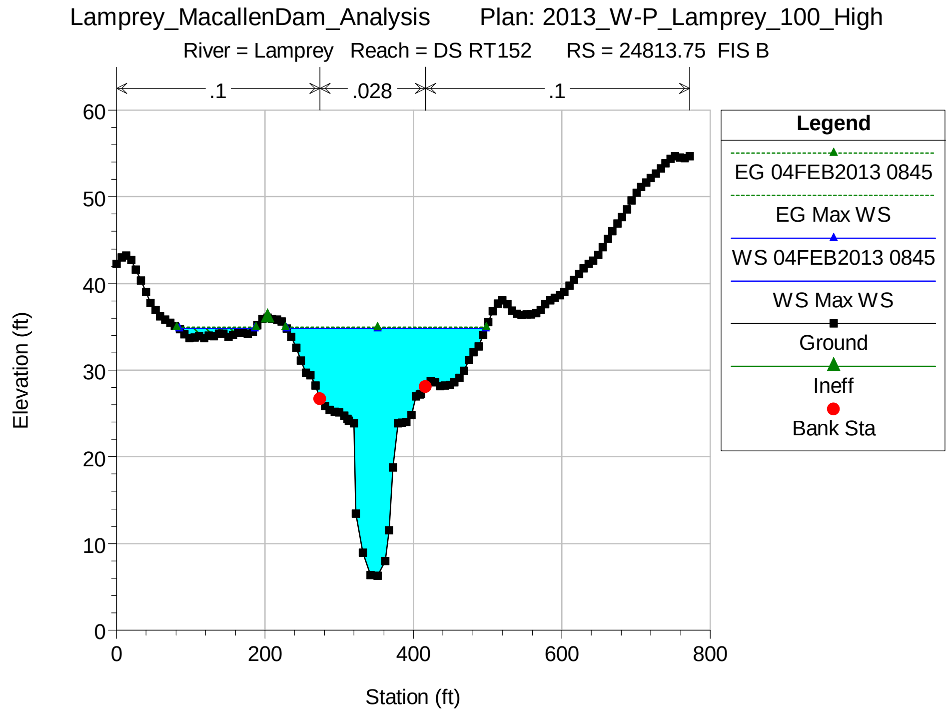

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 27505.77 FIS D
.06
.04
.06
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 27343.15 FIS DSD-L
.1
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

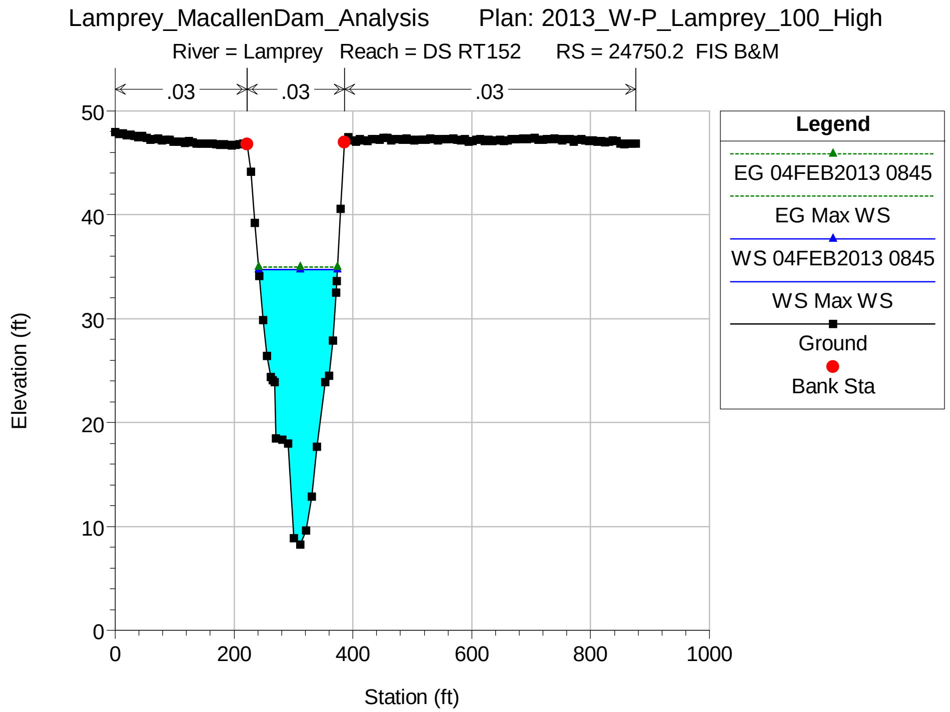

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 26788 FIS C
.1
.03
.1
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta



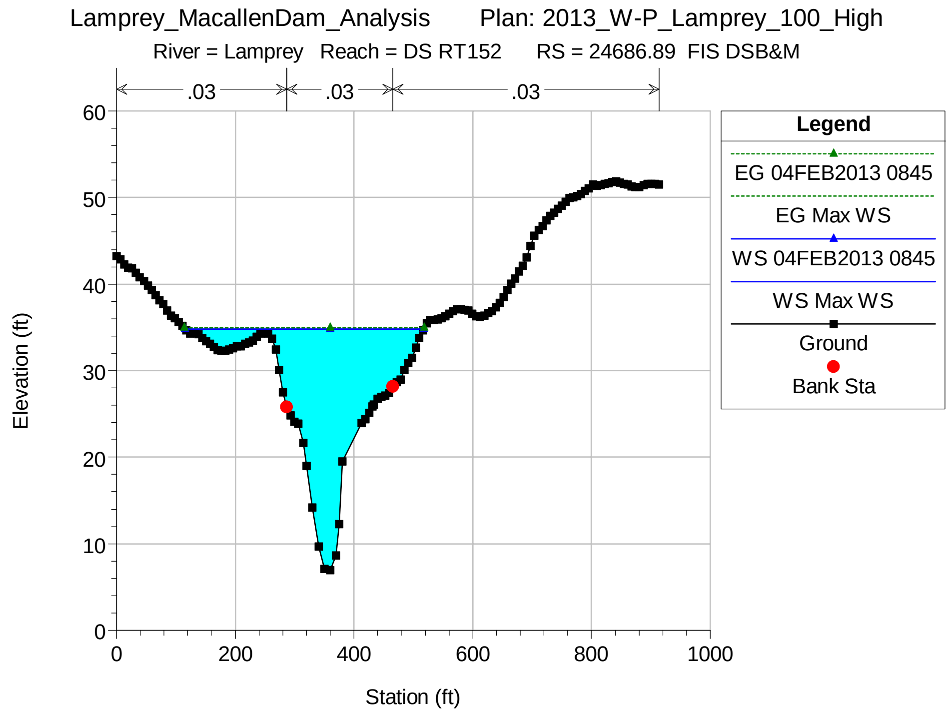
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 26069.33 LMPRY DSC
.1 .03 .1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)



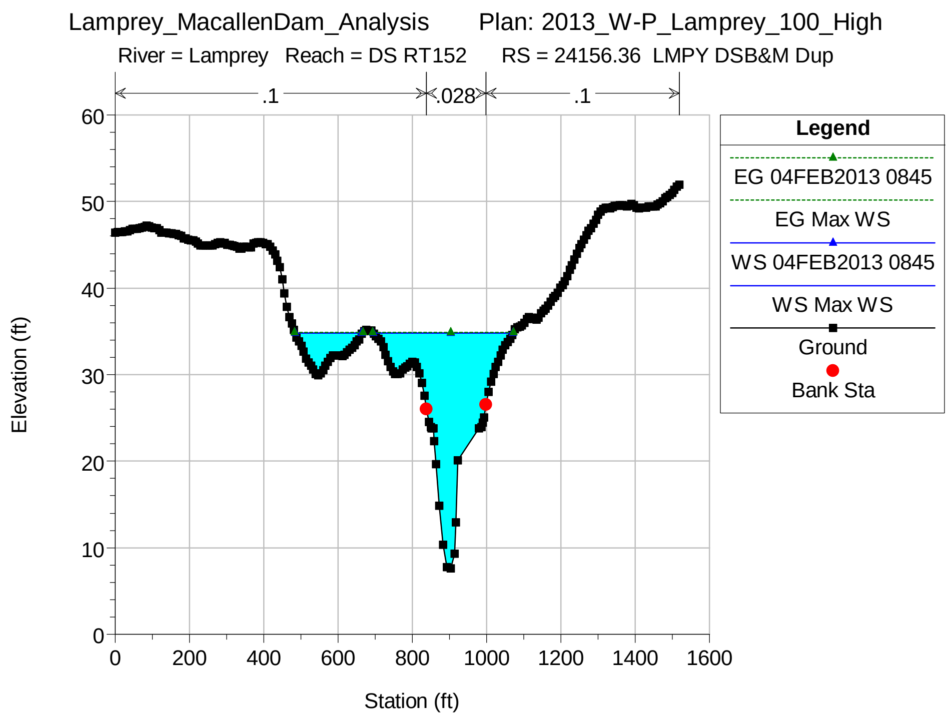
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 24813.75 FIS B
.1 .028 .1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

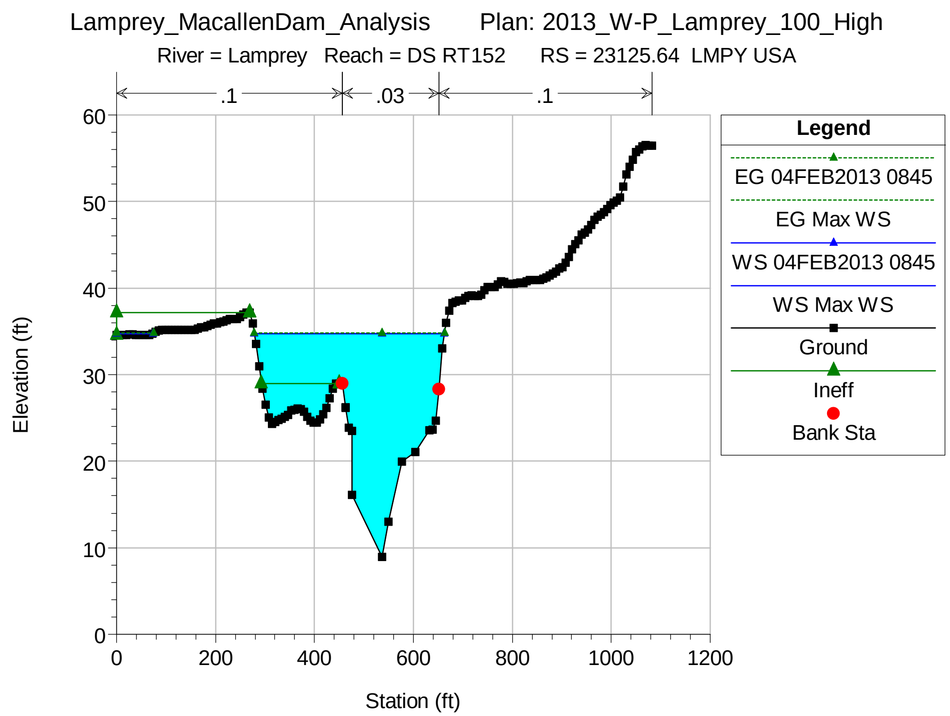


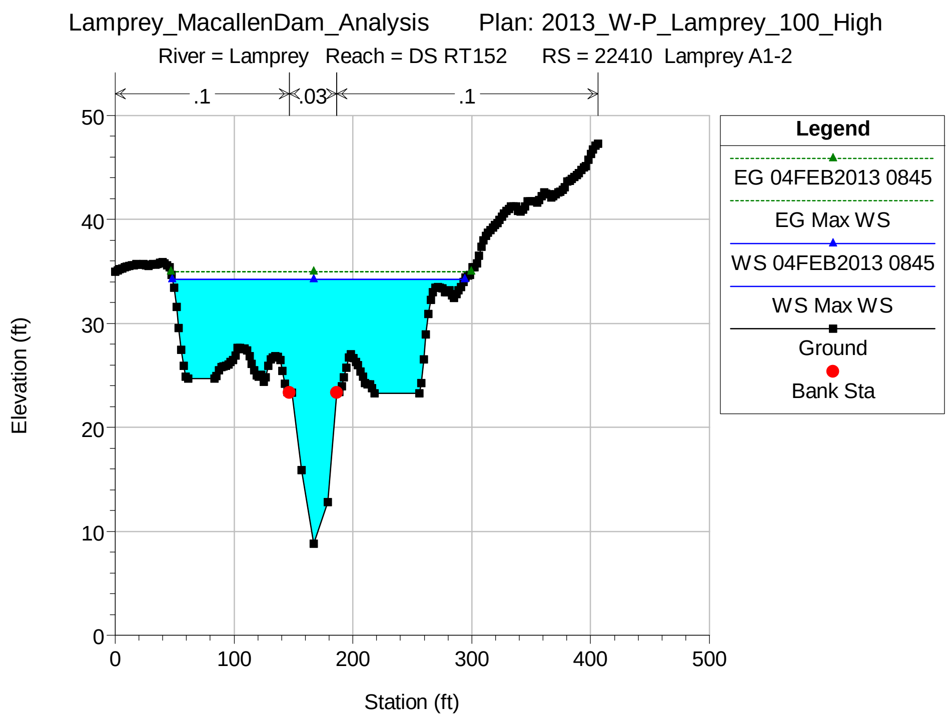
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 24750.2 FIS B&M
.03 .03 .03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

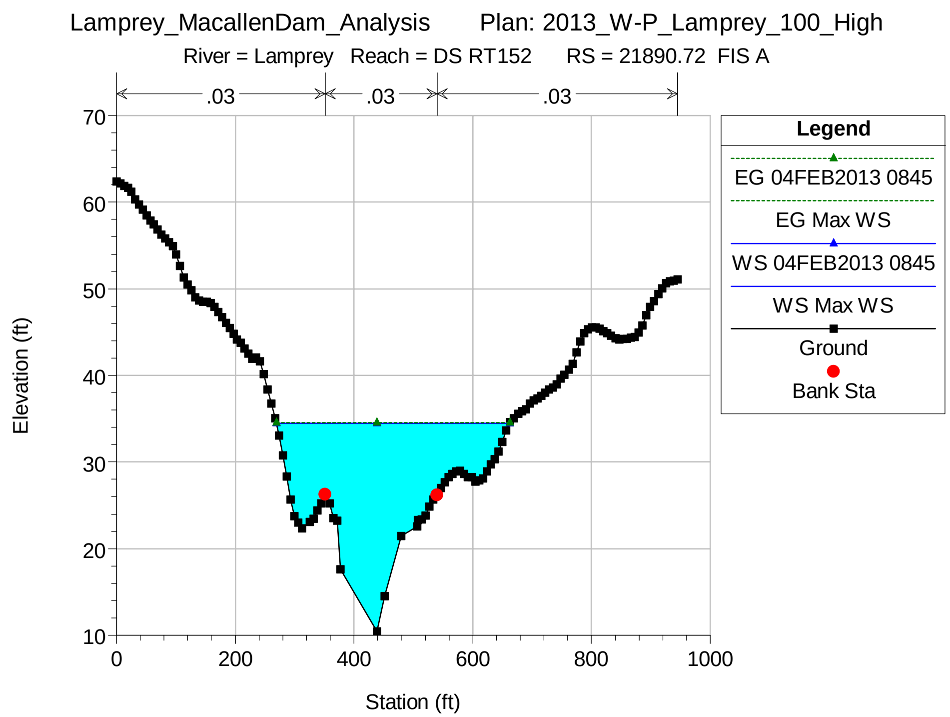


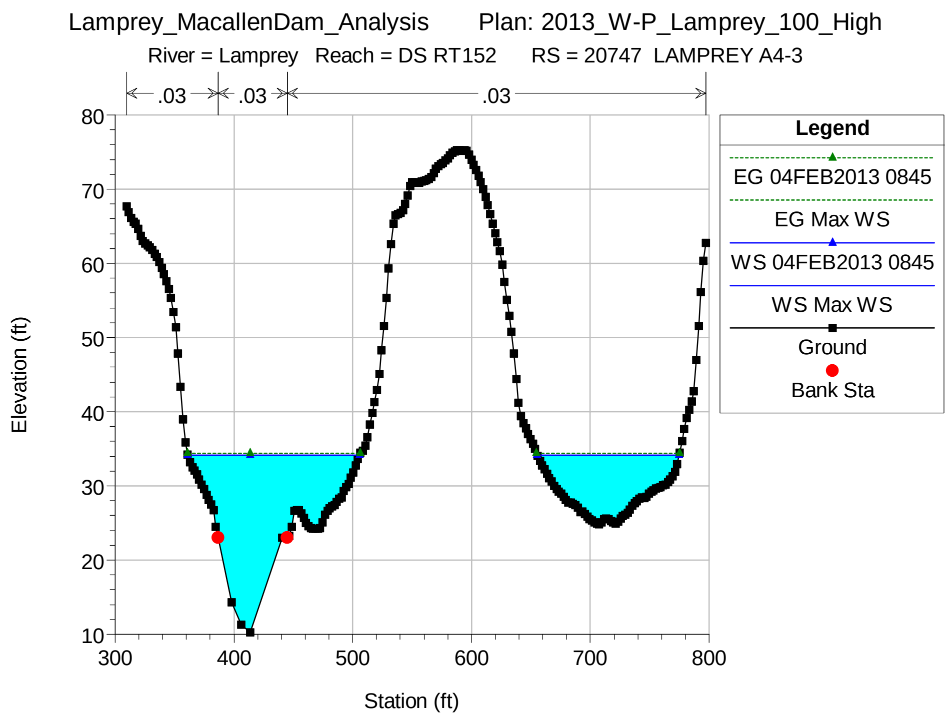
Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 24686.89 FIS DSB&M
.03 .03 .03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

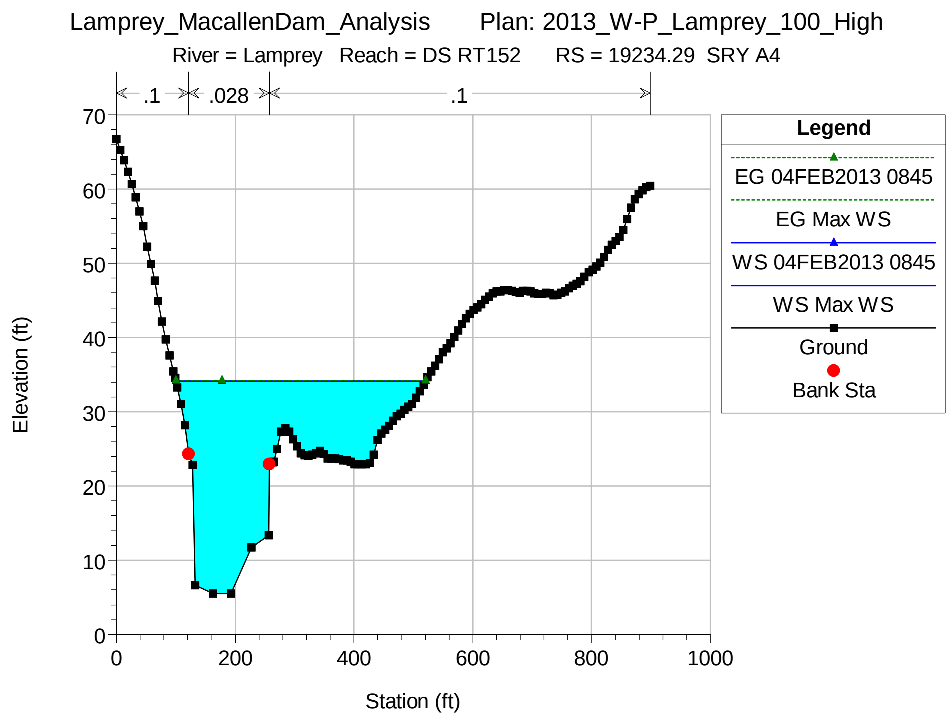

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 24156.36 LMPY DSB&M Dup
.1
.028
.1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

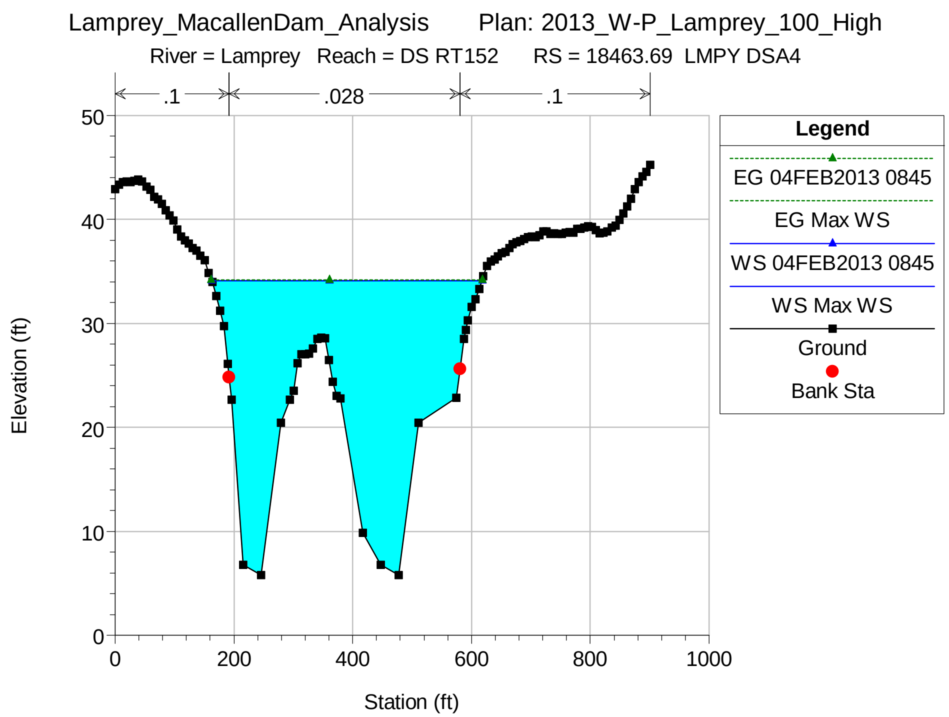

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 23125.64 LMPY USA
.1
.03
.1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

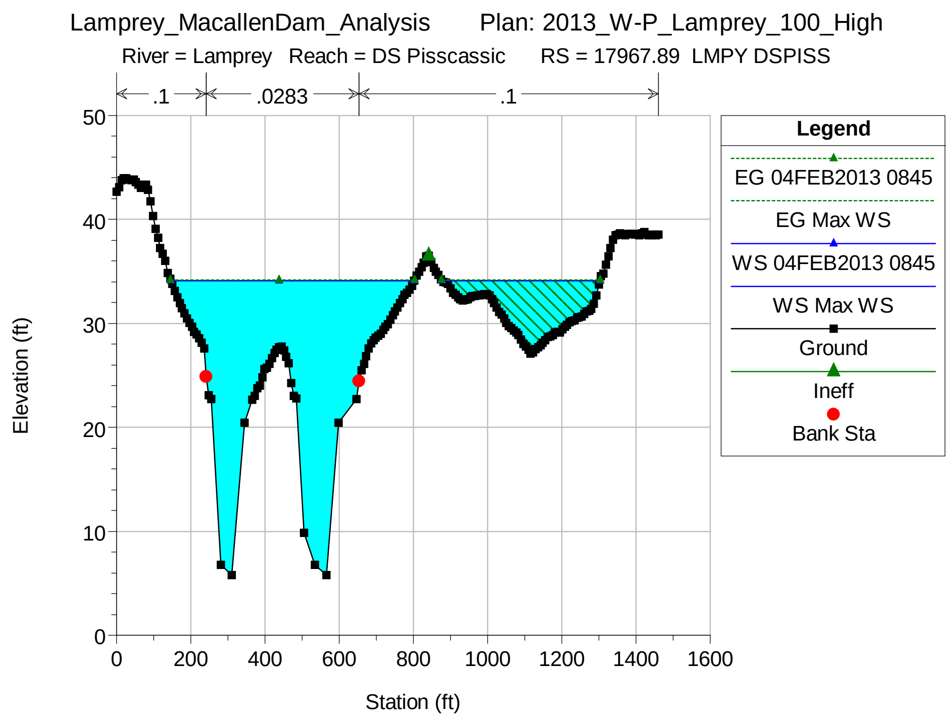

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 22410 Lamprey A1-2
.1
.03
.1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

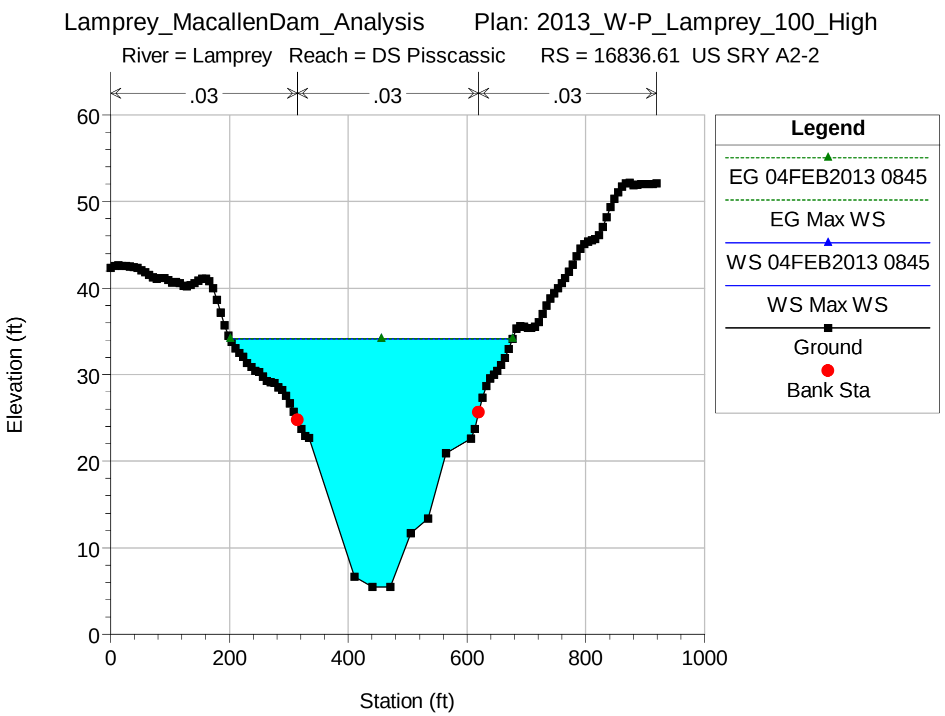

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 21890.72 FIS A
.03
.03
.03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

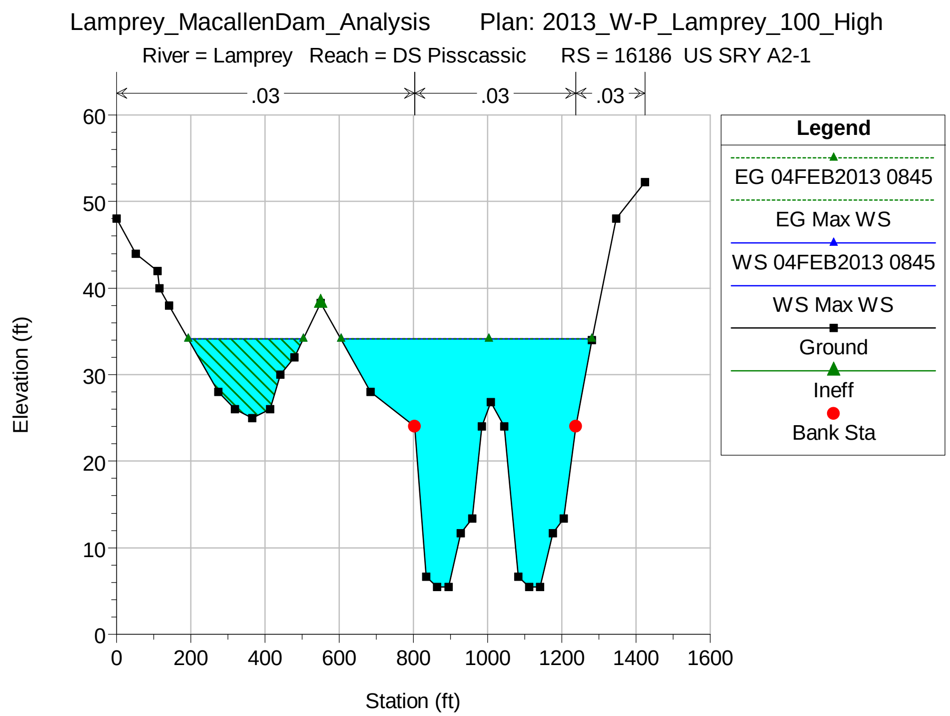

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 20747 LAMPREY A4-3
.03
.03
.03
Elevation (ft)
Station (ft)
10
20
30
40
50
60
70
80
300
400
500
600
700
800
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

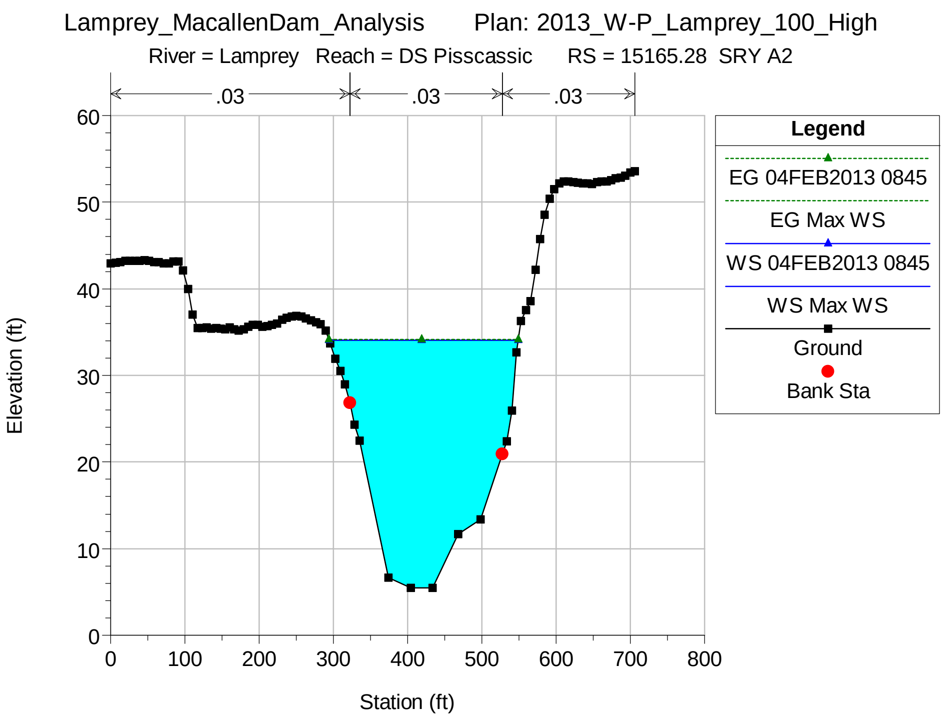

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 19234.29 SRY A4
.1
.028
.1
Elevation (ft)
Station (ft)
0
10
20
30
40
50
60
70
0
200
400
600
800
1000
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

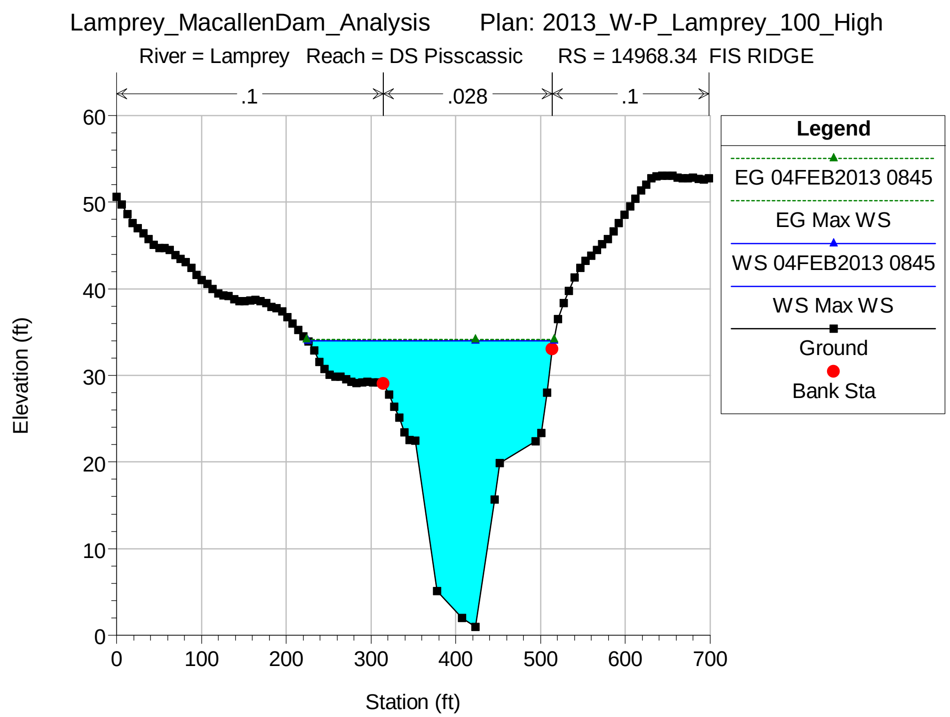

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS RT152 RS = 18463.69 LMPY DSA4
.1
.028
.1
Elevation (ft)
Station (ft)
0
10
20
30
40
50
0
200
400
600
800
1000
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

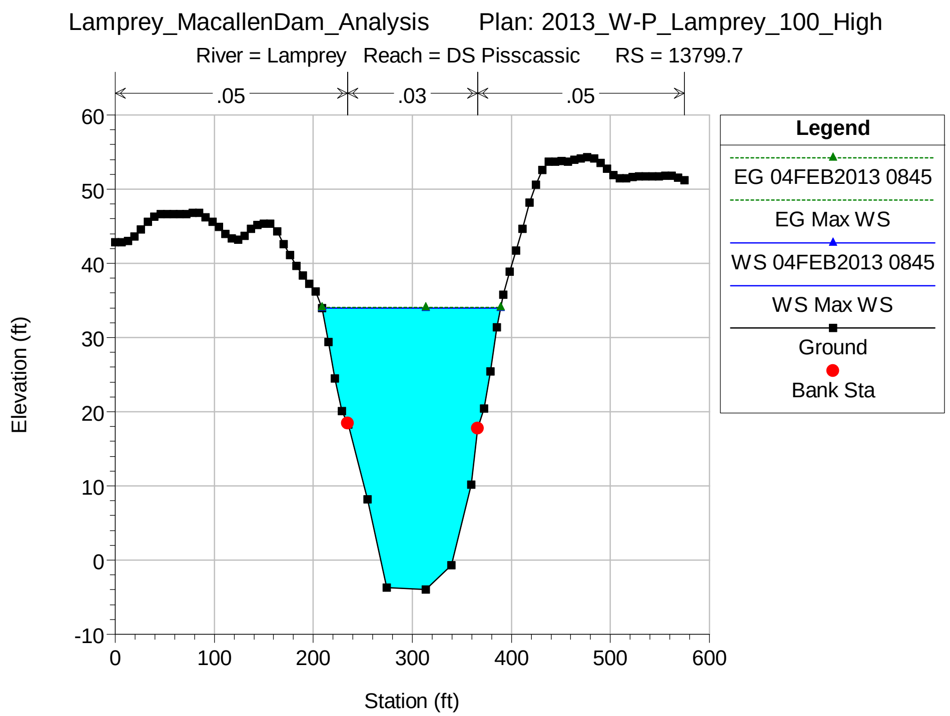

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 17967.89 LMPY DSPISS
.1
.0283
.1
Elevation (ft)
Station (ft)
0
10
20
30
40
50
0
200
400
600
800
1000
1200
1400
1600
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta

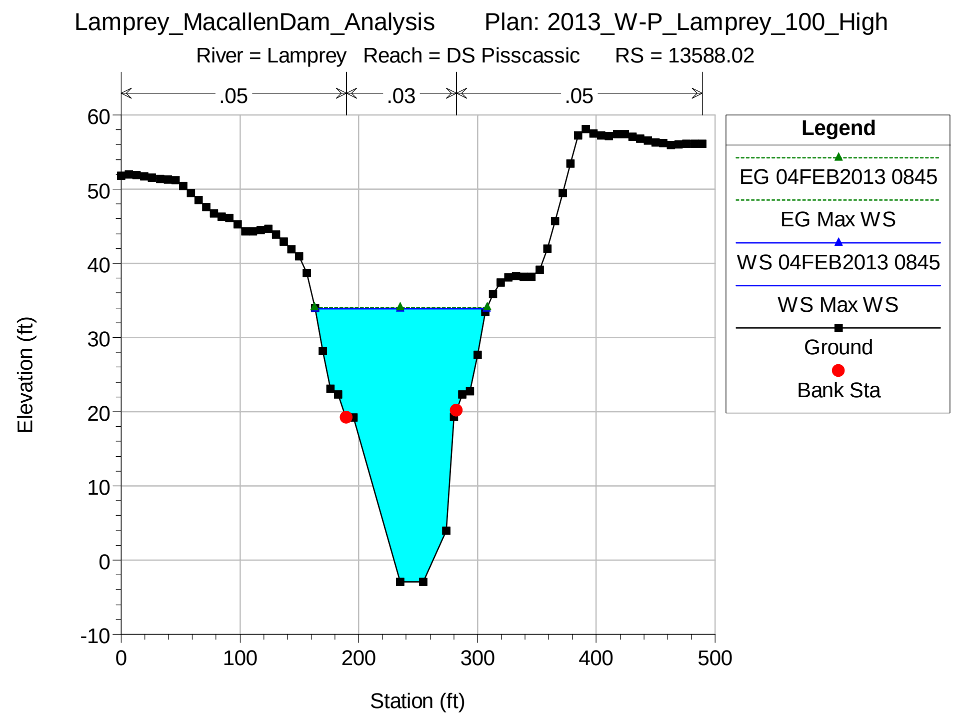

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 16836.61 US SRY A2-2
.03
.03
.03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

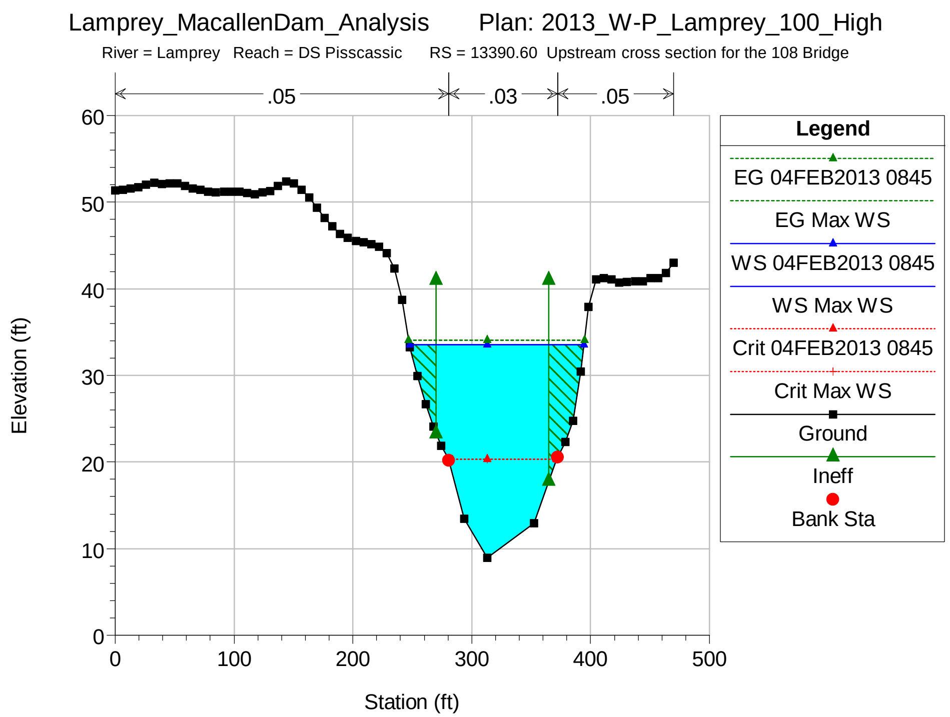

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 16186 US SRY A2-1
.03
.03
.03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

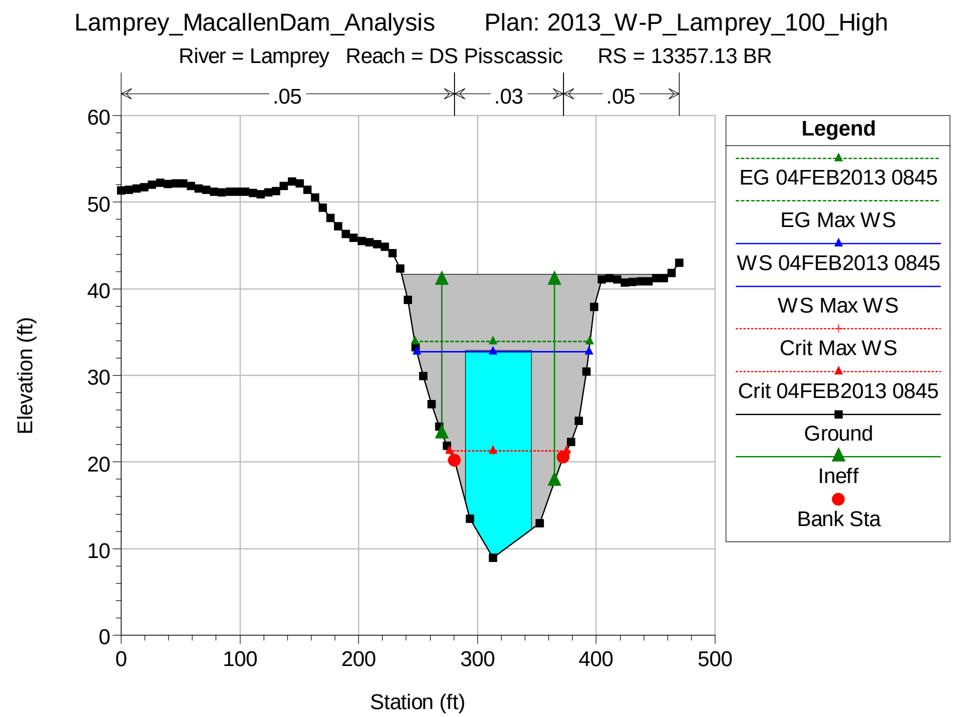

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 15165.28 SRY A2
.03
.03
.03
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

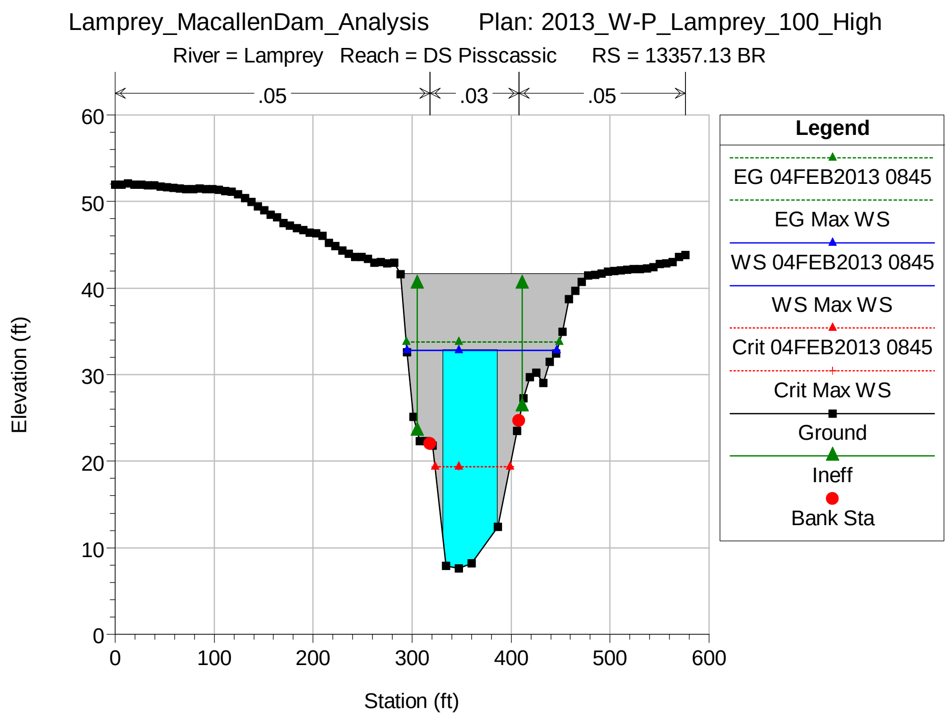

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 14968.34 FIS RIDGE
.1
.028
.1
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

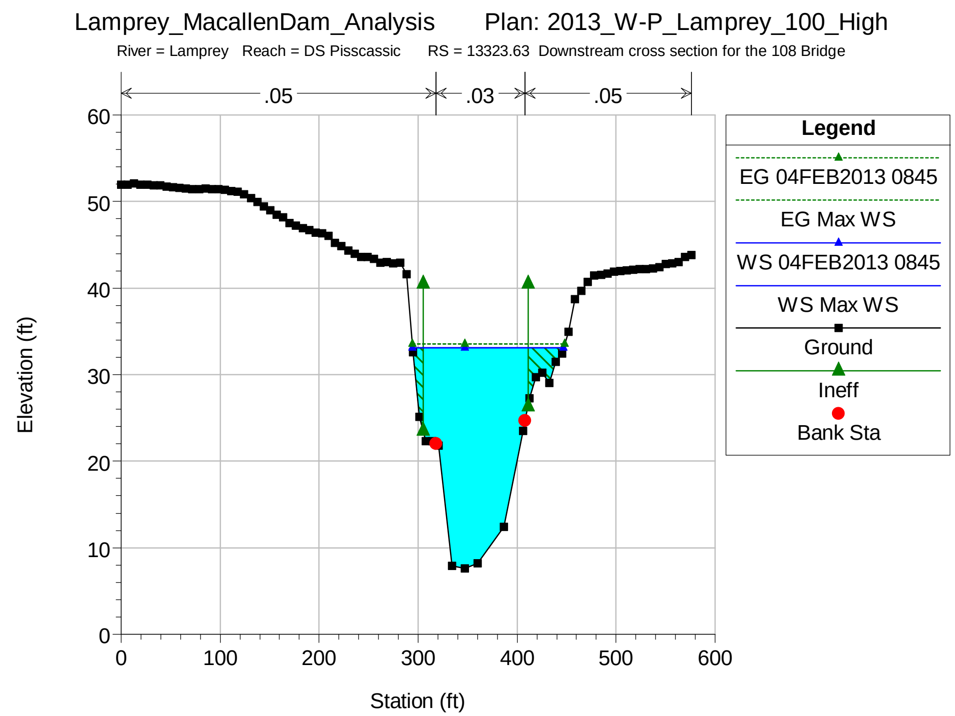

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13799.7
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

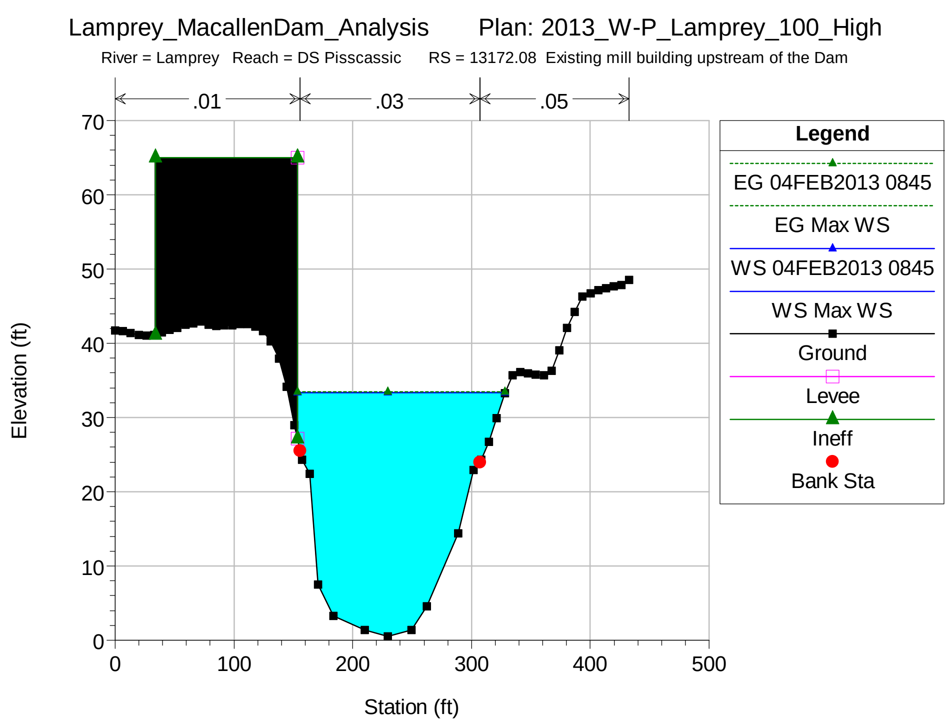

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13588.02
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Bank Sta

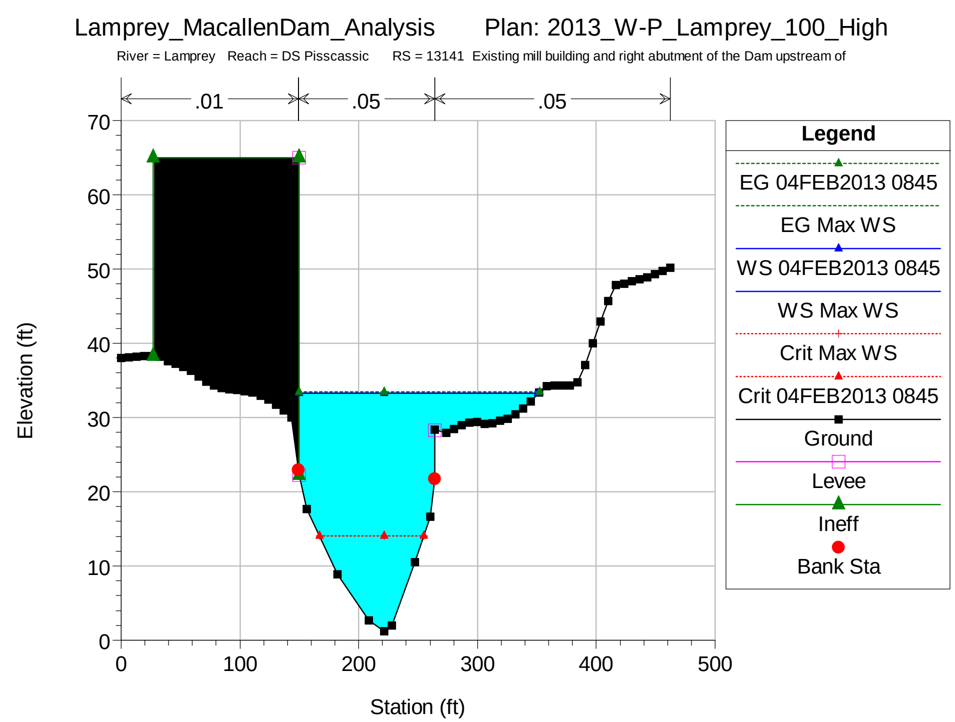

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13390.60 Upstream cross section for the 108 Bridge
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit 04FEB2013 0845
Crit Max WS
Ground
Ineff
Bank Sta

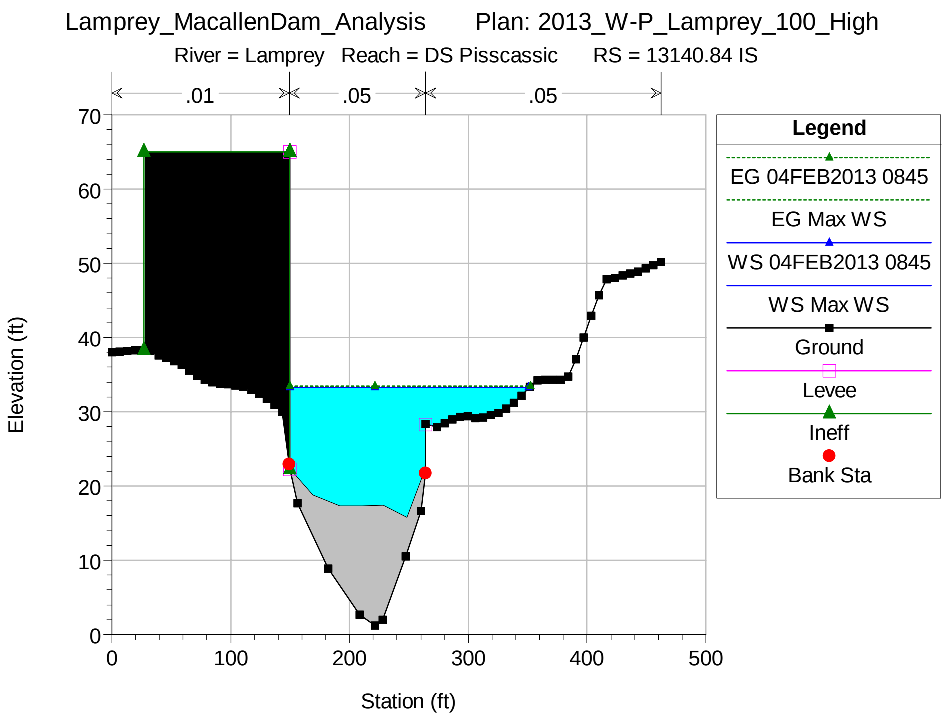

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13357.13 BR
.05
.03
.05
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit Max WS
Crit 04FEB2013 0845
Ground
Ineff
Bank Sta

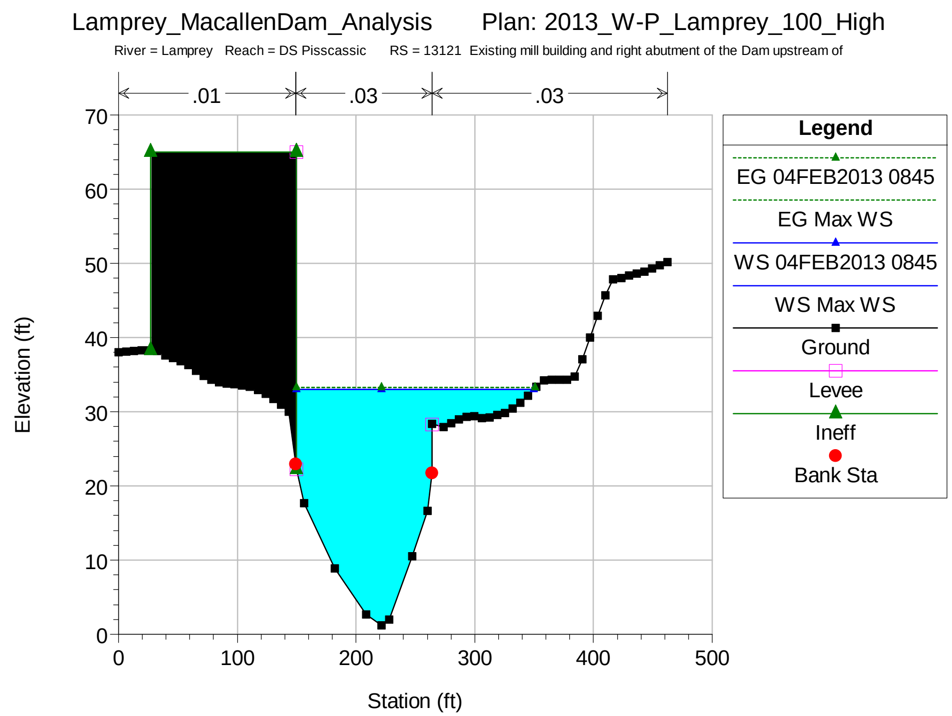

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13357.13 BR
.05
.03
.05
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit 04FEB2013 0845
Crit Max WS
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

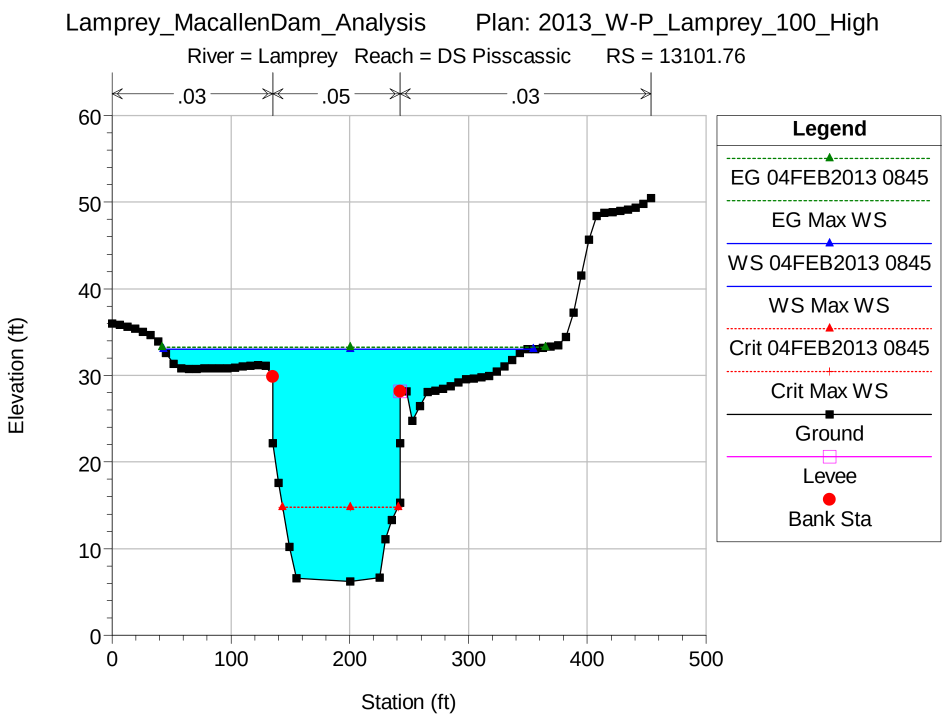

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13323.63 Downstream cross section for the 108 Bridge
.05
.03
.05
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

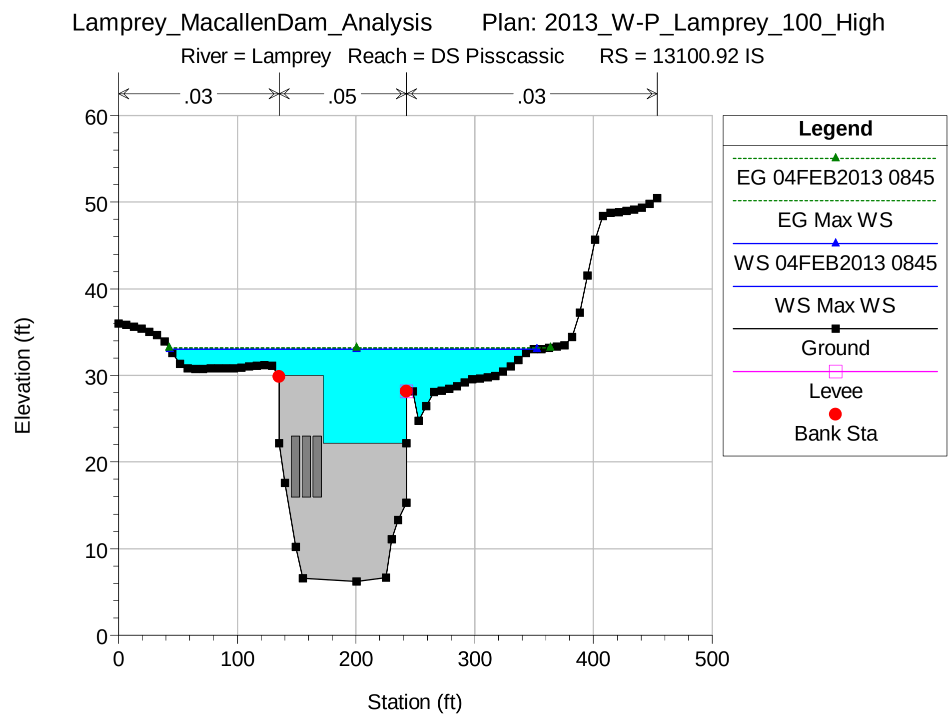

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13172.08 Existing mill building upstream of the Dam
.01
.03
.05
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

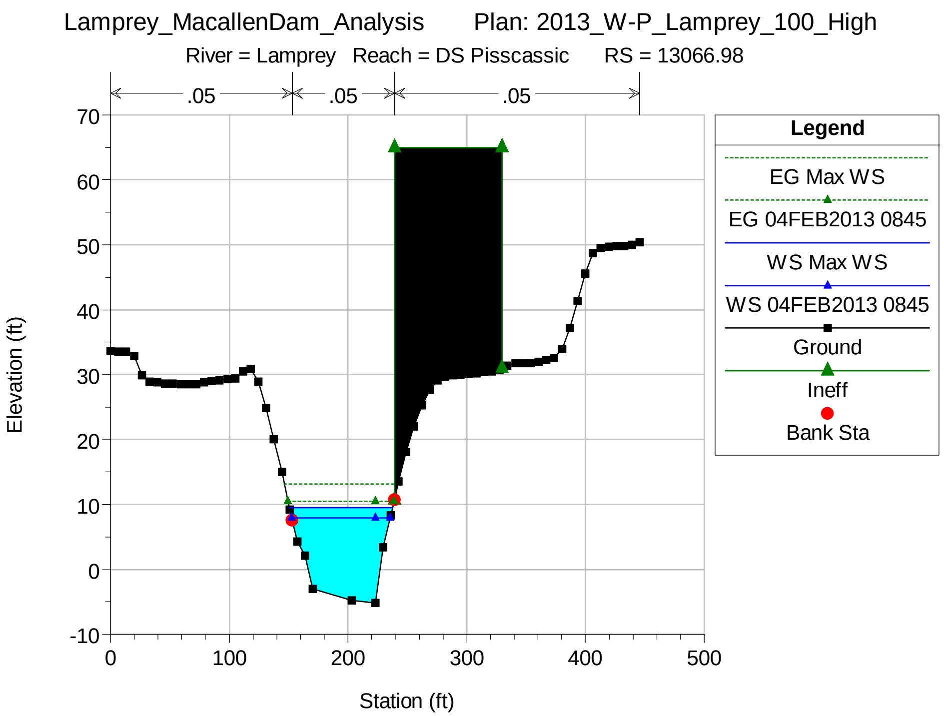

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13141 Existing mill building and right abutment of the Dam upstream of
.01
.05
.05
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit Max WS
Crit 04FEB2013 0845
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

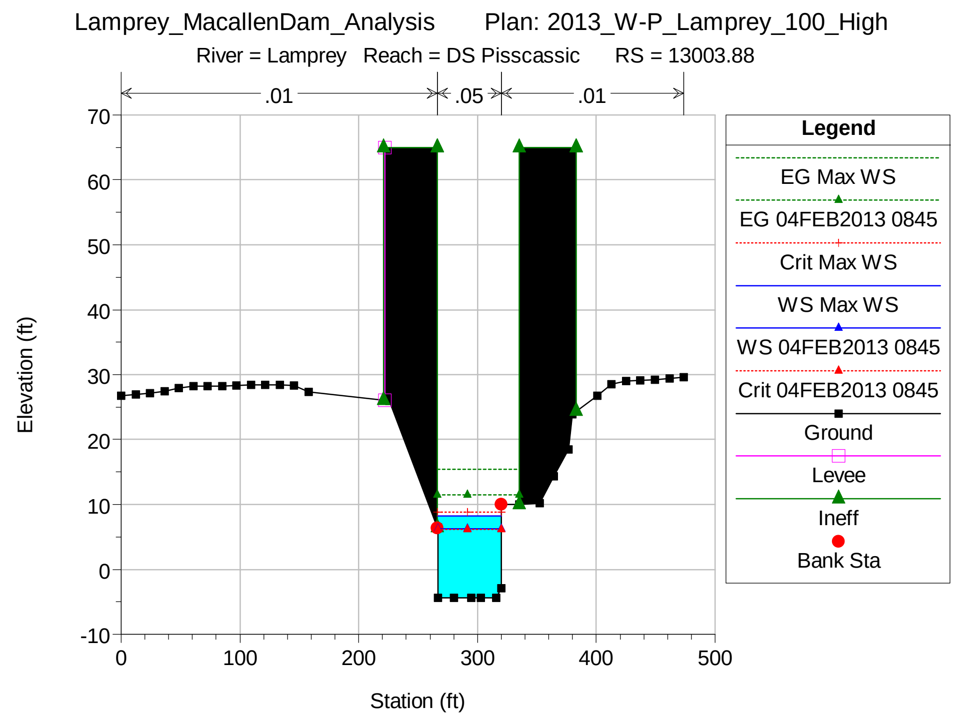

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13140.84 IS
.01
.05
.05
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Levee
Ineff
Bank Sta

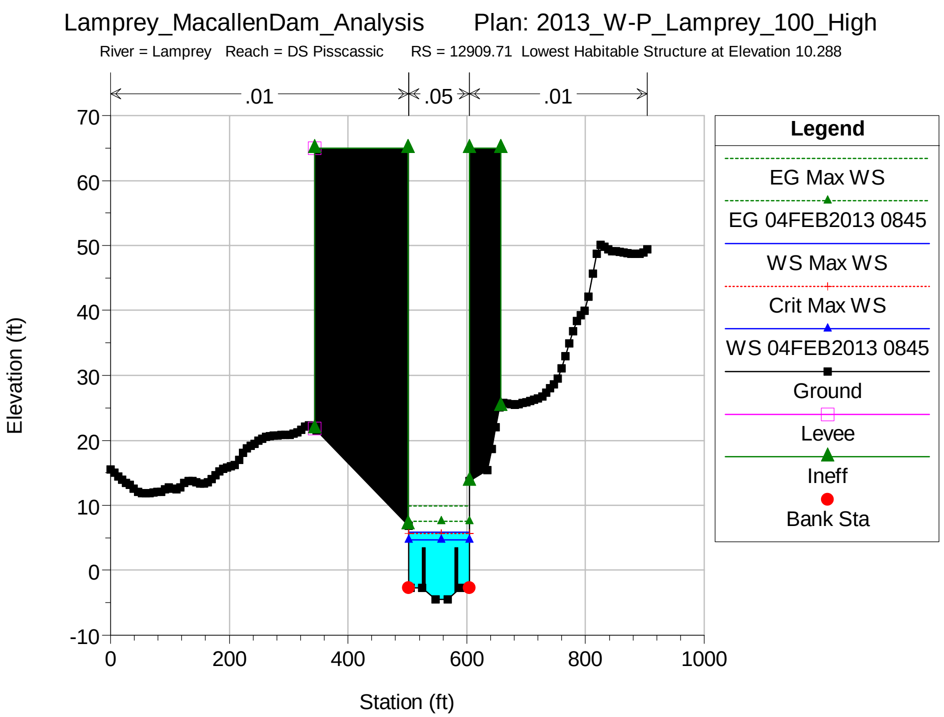

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13121 Existing mill building and right abutment of the Dam upstream of
.01
.03
.03
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Levee
Ineff
Bank Sta

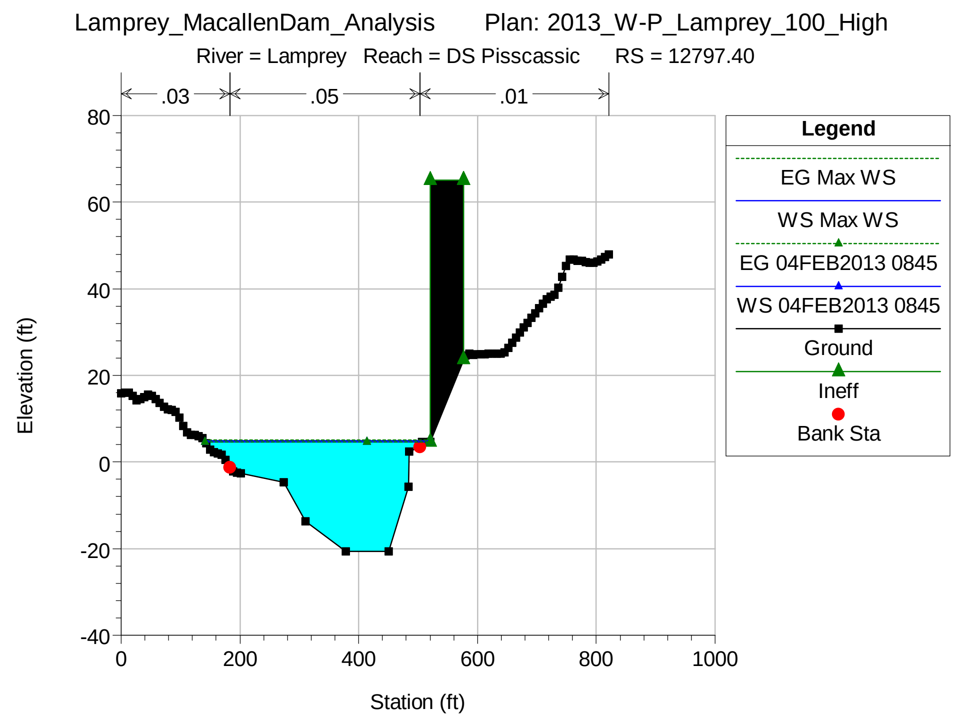

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13101.76
.03
.05
.03
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit 04FEB2013 0845
Crit Max WS
Ground
Levee
Bank Sta

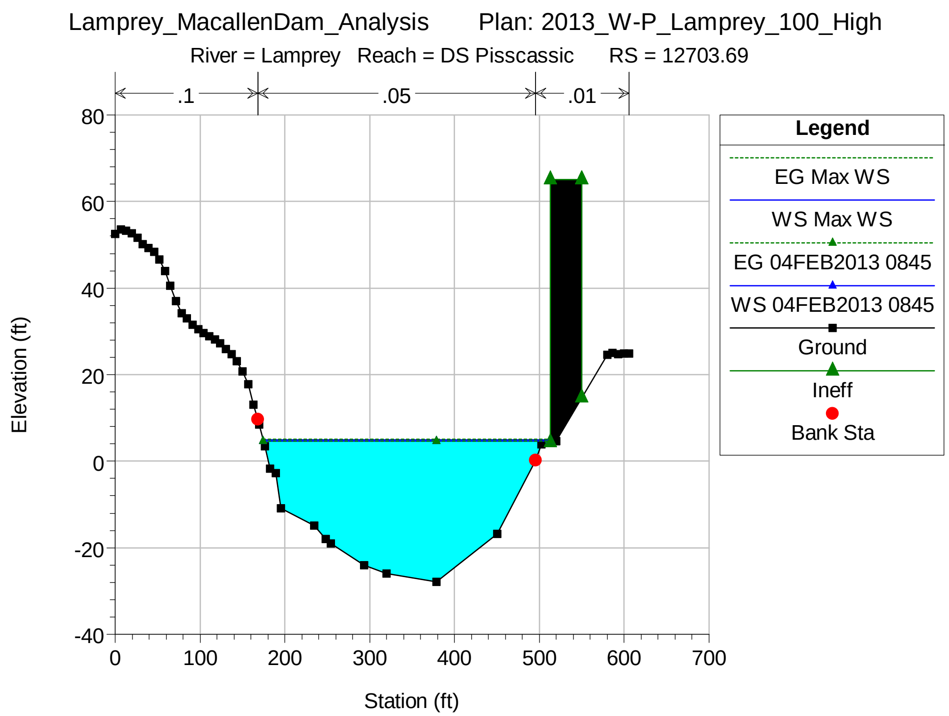

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13100.92 IS
.03
.05
.03
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Ground
Levee
Bank Sta

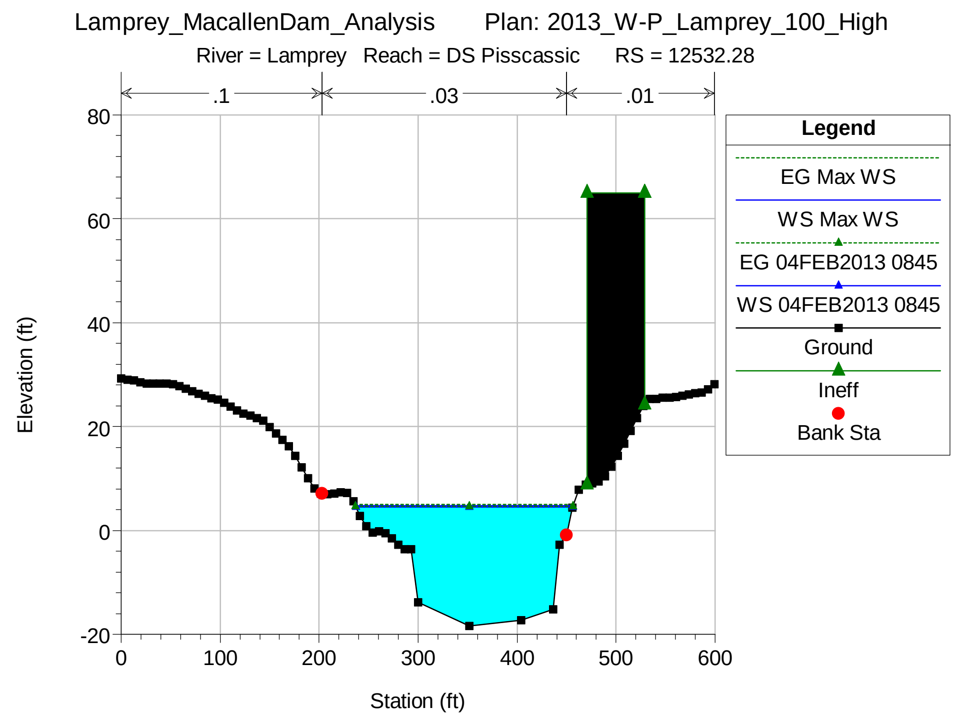

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13066.98
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
EG Max WS
EG 04FEB2013 0845
WS Max WS
WS 04FEB2013 0845
Ground
Ineff
Bank Sta

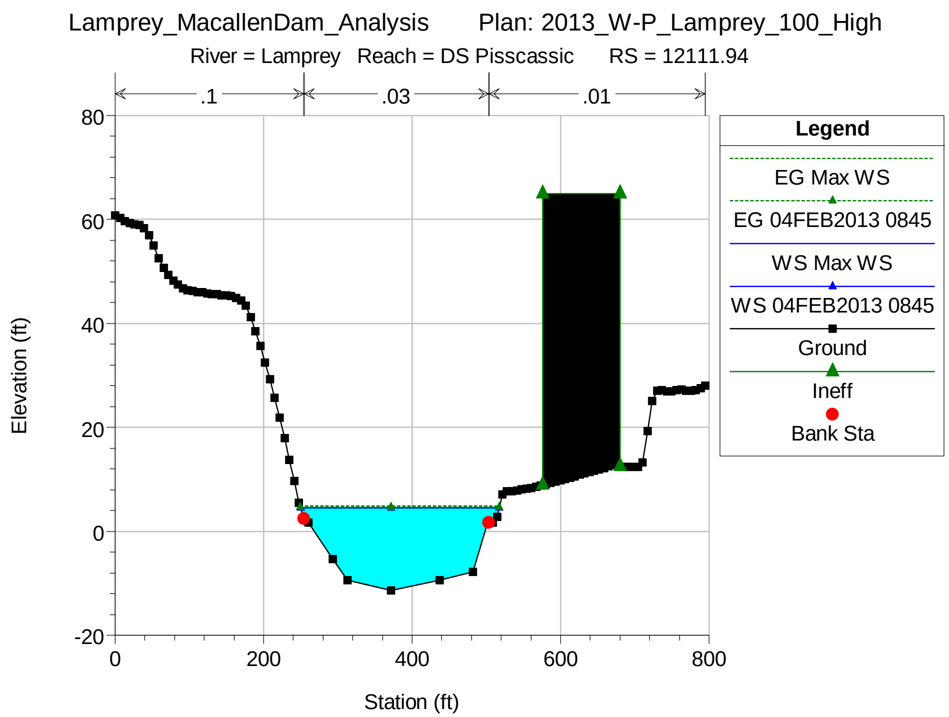

Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 13003.88
.01
.05
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
EG 04FEB2013 0845
Crit Max WS
WS Max WS
WS 04FEB2013 0845
Crit 04FEB2013 0845
Ground
Levee
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 12909.71 Lowest Habitable Structure at Elevation 10.288
.01
.05
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
EG 04FEB2013 0845
WS Max WS
Crit Max WS
WS 04FEB2013 0845
Ground
Levee
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 12797.40
.03
.05
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
WS Max WS
EG 04FEB2013 0845
WS 04FEB2013 0845
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 12703.69
.1
.05
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
WS Max WS
EG 04FEB2013 0845
WS 04FEB2013 0845
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 12532.28
.1
.03
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
WS Max WS
EG 04FEB2013 0845
WS 04FEB2013 0845
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 12111.94
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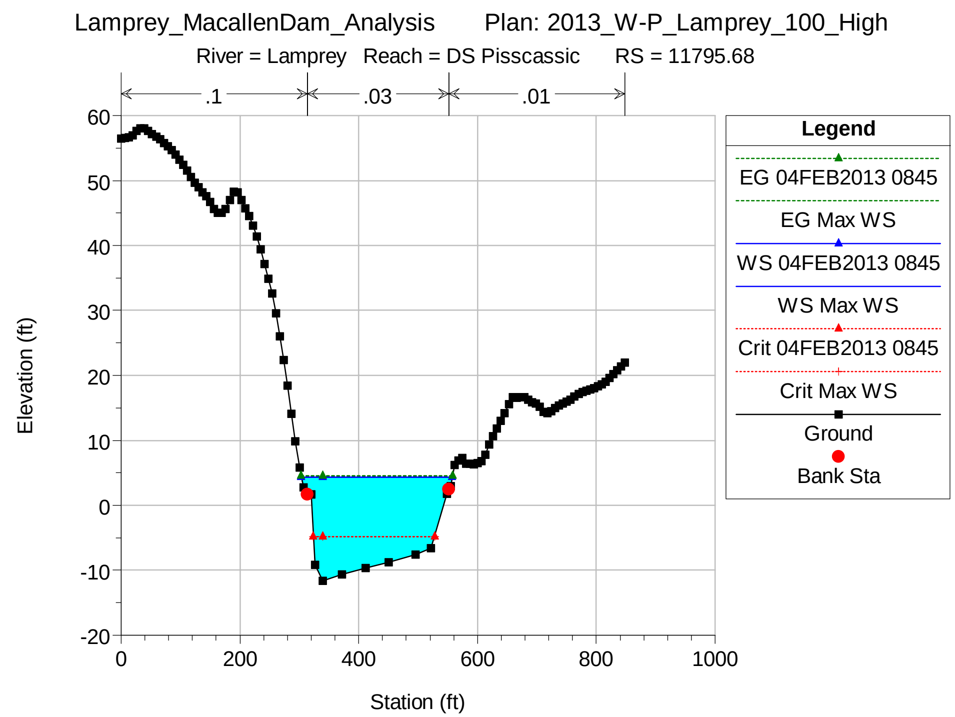
.03
.01
Elevation (ft)
Station (ft)
Legend
EG Max WS
EG 04FEB2013 0845
WS Max WS
WS 04FEB2013 0845
Ground
Ineff
Bank Sta


Lamprey_MacallenDam_Analysis Plan: 2013_W-P_Lamprey_100_High
River = Lamprey Reach = DS Pisscassic RS = 11795.68
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.03
.01
Elevation (ft)
Station (ft)
Legend
EG 04FEB2013 0845
EG Max WS
WS 04FEB2013 0845
WS Max WS
Crit 04FEB2013 0845
Crit Max WS
Ground
Bank Sta

HEC-RAS Plan: 100-Year_High

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DS RT152	28557.07	Max WS	8409.91	25.98	38.73		40.19	0.006095	9.80	948.35	127.67	0.54
DS RT152	28557.07	04FEB2013 0845	8409.91	25.98	38.73		40.19	0.006095	9.80	948.35	127.67	0.54
DS RT152	27505.77	Max WS	8410.56	16.68	35.05		35.73	0.001547	8.57	1643.13	187.77	0.38
DS RT152	27505.77	04FEB2013 0845	8410.58	16.68	35.05		35.73	0.001547	8.57	1643.16	187.77	0.38
DS RT152	27343.15	Max WS	8410.94	12.88	35.22		35.25	0.000025	1.42	6649.88	616.17	0.07
DS RT152	27343.15	04FEB2013 0845	8410.96	12.88	35.22		35.25	0.000025	1.42	6649.99	616.18	0.07
DS RT152	26788	Max WS	8412.38	12.88	35.02		35.26	0.000167	4.01	2461.27	246.32	0.17
DS RT152	26788	04FEB2013 0845	8412.40	12.88	35.02		35.26	0.000167	4.01	2461.31	246.32	0.17
DS RT152	26069.33	Max WS	8413.77	10.35	34.97		35.15	0.000116	3.44	3319.19	396.06	0.14
DS RT152	26069.33	04FEB2013 0845	8413.79	10.35	34.97		35.15	0.000116	3.44	3319.26	396.06	0.14
DS RT152	24813.75	Max WS	8416.39	6.26	34.78		34.99	0.000145	3.69	2781.01	370.27	0.16
DS RT152	24813.75	04FEB2013 0845	8416.43	6.26	34.78		34.99	0.000145	3.69	2781.06	370.27	0.16
DS RT152	24750.2	Max WS	8416.49	8.28	34.71		34.98	0.000216	4.15	2027.46	132.54	0.19
DS RT152	24750.2	04FEB2013 0845	8416.53	8.28	34.71		34.98	0.000216	4.15	2027.49	132.54	0.19
DS RT152	24686.89	Max WS	8416.60	6.98	34.83		34.96	0.000100	2.93	3231.70	402.18	0.13
DS RT152	24686.89	04FEB2013 0845	8416.64	6.98	34.83		34.96	0.000100	2.93	3231.77	402.19	0.13
DS RT152	24156.36	Max WS	8418.13	7.62	34.77		34.91	0.000091	3.11	3798.33	555.33	0.14
DS RT152	24156.36	04FEB2013 0845	8418.19	7.62	34.77		34.91	0.000091	3.11	3798.44	555.35	0.14
DS RT152	23125.64	Max WS	8421.30	8.98	34.74		34.82	0.000057	2.36	4783.96	457.22	0.10
DS RT152	23125.64	04FEB2013 0845	8421.37	8.98	34.74		34.82	0.000057	2.36	4784.03	457.22	0.10
DS RT152	22410	Max WS	8423.13	8.80	34.26		34.97	0.000682	7.89	2375.71	245.84	0.32
DS RT152	22410	04FEB2013 0845	8423.23	8.80	34.26		34.97	0.000682	7.89	2375.75	245.84	0.32
DS RT152	21890.72	Max WS	8424.23	10.48	34.48		34.54	0.000054	2.24	4322.39	393.20	0.10
DS RT152	21890.72	04FEB2013 0845	8424.33	10.48	34.48		34.55	0.000054	2.24	4322.46	393.20	0.10
DS RT152	20747	Max WS	8426.49	10.25	34.16		34.44	0.000246	4.97	2308.28	264.23	0.21
DS RT152	20747	04FEB2013 0845	8426.60	10.25	34.16		34.44	0.000246	4.97	2308.34	264.23	0.21
DS RT152	19234.29	Max WS	8429.35	5.50	34.12		34.19	0.000031	2.28	5598.99	420.36	0.08
DS RT152	19234.29	04FEB2013 0845	8429.49	5.50	34.12		34.19	0.000031	2.28	5599.08	420.36	0.08
DS RT152	18463.69	Max WS	8431.66	5.77	34.14		34.17	0.000013	1.26	6907.78	455.80	0.05
DS RT152	18463.69	04FEB2013 0845	8431.81	5.77	34.14		34.17	0.000013	1.26	6907.87	455.80	0.05
DS Pisscassic	17967.89	Max WS	10299.19	5.77	34.14		34.18	0.000020	1.48	7839.68	1083.05	0.06
DS Pisscassic	17967.89	04FEB2013 0845	10299.46	5.77	34.14		34.18	0.000020	1.48	7839.81	1083.06	0.06
DS Pisscassic	16836.61	Max WS	10304.12	5.50	34.12		34.16	0.000020	1.63	6797.91	475.15	0.06
DS Pisscassic	16836.61	04FEB2013 0845	10304.42	5.50	34.12		34.16	0.000020	1.63	6798.00	475.16	0.06
DS Pisscassic	16186	Max WS	10306.91	5.50	34.13		34.15	0.000008	1.06	10565.28	987.40	0.04
DS Pisscassic	16186	04FEB2013 0845	10307.23	5.50	34.13		34.15	0.000008	1.06	10565.42	987.41	0.04
DS Pisscassic	15165.28	Max WS	10311.62	5.50	34.06		34.14	0.000032	2.19	4861.71	254.71	0.08
DS Pisscassic	15165.28	04FEB2013 0845	10311.96	5.50	34.06		34.14	0.000032	2.19	4861.76	254.71	0.08
DS Pisscassic	14968.34	Max WS	10311.96	0.98	34.01		34.13	0.000064	2.80	3991.99	290.36	0.12
DS Pisscassic	14968.34	04FEB2013 0845	10312.31	0.98	34.01		34.13	0.000064	2.80	3992.05	290.36	0.12
DS Pisscassic	13799.7	Max WS	10314.34	-3.96	33.98		34.07	0.000026	2.41	4609.78	180.21	0.08
DS Pisscassic	13799.7	04FEB2013 0845	10314.68	-3.96	33.98		34.07	0.000026	2.41	4609.82	180.21	0.08
DS Pisscassic	13588.02	Max WS	10314.56	-2.96	33.86		34.07	0.000082	3.74	3085.67	144.42	0.12
DS Pisscassic	13588.02	04FEB2013 0845	10314.89	-2.96	33.86		34.07	0.000082	3.74	3085.70	144.42	0.12
DS Pisscassic	13390.60	Max WS	10314.75	8.91	33.58	20.29	34.07	0.000237	5.66	1899.27	146.75	0.22
DS Pisscassic	13390.60	04FEB2013 0845	10315.05	8.91	33.58	20.29	34.07	0.000237	5.66	1899.29	146.75	0.22
DS Pisscassic	13357.13		Bridge									
DS Pisscassic	13323.63	Max WS	10314.75	7.59	33.08		33.52	0.000244	5.41	2004.50	152.56	0.21
DS Pisscassic	13323.63	04FEB2013 0845	10315.05	7.59	33.08		33.52	0.000244	5.41	2004.52	152.56	0.21
DS Pisscassic	13172.08	Max WS	10314.90	0.52	33.33		33.44	0.000041	2.61	4043.91	174.63	0.09
DS Pisscassic	13172.08	04FEB2013 0845	10315.23	0.52	33.33		33.44	0.000041	2.61	4043.94	174.63	0.09
DS Pisscassic	13141	Max WS	10314.93	1.23	33.24	14.09	33.44	0.000261	3.60	3081.01	201.16	0.13
DS Pisscassic	13141	04FEB2013 0845	10315.28	1.23	33.24	14.09	33.44	0.000261	3.60	3081.03	201.16	0.13

HEC-RAS Plan: 100-Year_High (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DS Pisscassic	13140.84		Inl Struct									
DS Pisscassic	13121	Max WS	10314.93	1.23	33.03		33.23	0.000097	3.64	3039.52	200.06	0.13
DS Pisscassic	13121	04FEB2013 0845	10315.28	1.23	33.03		33.23	0.000097	3.64	3039.54	200.06	0.13
DS Pisscassic	13101.76	Max WS	10315.02	6.19	33.04	14.80	33.22	0.000295	3.56	3196.81	311.45	0.13
DS Pisscassic	13101.76	04FEB2013 0845	10315.39	6.19	33.04	14.80	33.22	0.000295	3.56	3196.85	311.47	0.13
DS Pisscassic	13100.92		Inl Struct									
DS Pisscassic	13066.98	Max WS	14454.71	-5.15	9.54		13.20	0.012380	15.35	943.77	87.11	0.81
DS Pisscassic	13066.98	04FEB2013 0845	10315.39	-5.15	7.89		10.45	0.010276	12.83	803.89	82.90	0.72
DS Pisscassic	13003.88	Max WS	14436.88	-4.42	8.25	8.84	15.40	0.028616	21.46	672.98	54.24	1.07
DS Pisscassic	13003.88	04FEB2013 0845	10317.07	-4.42	6.26	6.17	11.43	0.024728	18.24	565.52	53.27	0.99
DS Pisscassic	12909.71	Max WS	14413.20	-4.52	5.82	5.69	9.94	0.023059	16.30	884.33	102.40	0.98
DS Pisscassic	12909.71	04FEB2013 0845	10340.20	-4.52	4.73		7.51	0.018587	13.38	772.97	102.40	0.86
DS Pisscassic	12797.40	Max WS	14383.16	-20.71	4.94		5.05	0.000205	2.69	5411.22	379.92	0.12
DS Pisscassic	12797.40	04FEB2013 0845	10334.91	-20.71	4.63		4.69	0.000113	1.97	5295.09	378.30	0.09
DS Pisscassic	12703.69	Max WS	14360.97	-27.92	4.97		5.03	0.000064	1.90	7571.97	338.90	0.07
DS Pisscassic	12703.69	04FEB2013 0845	10329.40	-27.92	4.65		4.68	0.000034	1.39	7463.17	338.48	0.05
DS Pisscassic	12532.28	Max WS	14334.51	-18.43	4.77		5.03	0.000180	4.09	3508.15	220.27	0.18
DS Pisscassic	12532.28	04FEB2013 0845	10323.42	-18.43	4.55		4.68	0.000097	2.99	3459.40	219.35	0.13
DS Pisscassic	12111.94	Max WS	14303.79	-11.36	4.55		4.89	0.000314	4.63	3097.03	267.89	0.23
DS Pisscassic	12111.94	04FEB2013 0845	10317.53	-11.36	4.45		4.63	0.000168	3.37	3069.70	267.52	0.17
DS Pisscassic	11795.68	Max WS	10314.12	-11.61	4.38	-4.87	4.57	0.000186	3.51	2953.01	254.25	0.18
DS Pisscassic	11795.68	04FEB2013 0845	10316.64	-11.61	4.38	-4.87	4.57	0.000186	3.52	2953.01	254.25	0.18

APPENDIX G
Macallen Dam Spillway Calculations

BY SLG DATE 2-5-13 **WRIGHT-PIERCE** Engineering a Better Environment SHEET NO. 1 OF 3

CHCKD. BY RTW DATE 2/5/13 PROJECT NO. 12537A

PROJECT Newmarket, NH - Macallen Dam - Spillway Capacity BOOK NO.

1) Calculate the required spillway crest length to pass the 100-year flood flow.

- 100-year flood flow = 10,259 cfs

$Q = CLH^{3/2}$

$C = 2.63$

$L =$ crest length

$H_{max} = 5$ ft.

$$L = \frac{10{,}259}{2.63(5^{3/2})} = \boxed{348.9 \text{ ft.}}$$

2) Calculate the required crest elevation to pass the 100-year flood flow without changing crest length or abutment heights.

- existing crest elevation = 22.178 ft.
- Lowest Abutment elevation = 28.18 ft.

$Q = CLH^{3/2}$

$$H = \left(\frac{Q}{CL}\right)^{2/3}$$

$H = 14.59$ ft. + 1 ft. freeboard

$H = 15.59$ ft.

$$28.18 - 15.59 = \boxed{12.59 \text{ ft.}}$$

- Lowers existing crest by 9.6 ft.
- Current Assumed elevation of upstream base of dam = 6.19 ft.

BY SLG DATE 2-5-13 **WRIGHT-PIERCE** Engineering a Better Environment SHEET NO. 2 OF 3

CHCKD. BY RTW DATE 2/5/13 PROJECT NO. 12537A

PROJECT Spillway Capacity (cont.) BOOK NO.

3) Calculate crest elevation required to pass the 100-year flood flow if crest length is increased to 140 ft.

$$Q = CLH^{3/2}$$

$$H = \left(\frac{Q}{CL}\right)^{2/3} = \left(\frac{10,259}{2.63(140)}\right)^{2/3}$$

$$H = 9.88 + 1^{ft} = 10.88 \text{ ft}$$

$$28.18 - 10.88 = \boxed{17.3 \text{ ft}}$$

- Lowers existing Crest by 4.88 ft.

4) Calculate spillway crest length required to pass 100-year flood flow if west abutment is raised 1.8 ft.

$$Q = CLH^{3/2}$$

$$H_{max} = 6.8 \text{ ft.}$$

$$L = \frac{10,259}{2.63(6^{3/2})}$$

$$\boxed{L = 265.4 \text{ ft.}}$$

5) Calculate spillway crest elevation required to pass the 100-year flood flow if the west abutment is raised 1.8 ft.

- Required H to pass 100-year flood with 1-ft of freeboard
  H = 15.59 ft.
- New abutment elevation = 29.98 ft.

$$29.98 - 15.59 = \boxed{14.39 \text{ ft.}}$$

6) Calculate spillway crest elevation required to pass the 100-year flood flow if the crest length is increased to 140 ft. and the west abutment is raised 1.8 ft.

H required for 140 ft. length = 10.88 ft.

29.98 ft − 10.88 ft. = $\boxed{19.1 \text{ ft.}}$

Newmarket, NH
Macallen Dam Alternative Analysis
Conceptual Cost Estimates

Alternative	Modify Crest Length		Modify Crest Elevation		Raise West Abutment		Construction Cost	Contingency (30%)	Total Construction Cost	Engineering and Permitting (30%)	Total Project Cost
	Additional Length	Cost	Feet Lowered	Cost	Feet Raised	Cost					
Do Nothing	0	$0	0	$0	0	$0	$0	$0	$0	$0	$0
1	280	$5,071,360	0	$0	0	$0	$5,071,360	$1,521,408	$6,592,768	$1,977,830	$8,571,000
2	0	$0	9.59	$469,910	0	$0	$469,910	$140,973	$610,883	$183,265	$795,000
3	70	$1,267,840	4.88	$239,120	0	$0	$1,506,960	$452,088	$1,959,048	$587,714	$2,547,000
4	195	$3,531,840	0	$0	1.8	$199,800	$3,731,640	$1,119,492	$4,851,132	$1,455,340	$6,307,000
5	0	$0	7.79	$381,710	1.8	$199,800	$581,510	$174,453	$755,963	$226,789	$983,000
6	70	$1,267,840	3.08	$150,920	1.8	$199,800	$1,618,560	$485,568	$2,104,128	$631,238	$2,736,000

Cost of Additional 70 feet of Crest Length =	$1,267,840
Cost of Lowering Crest Elevation by 1 foot =	$49,000
Cost of Raising West Abutment 1 foot =	$111,000

Newmarket, NH
Macallen Dam Alternative Analysis
Dam Rehab Costs

Location	Name	Type	Rehab Activitiy	Dam Length (ft)	Dam Height (ft)	Crest Removal (Vertical ft)	Raise Abutment (Vertical ft)	Dam Extension (ft)	Total Construction Cost*	Cost per Vertical Foot Removed per foot of Crest Length	Cost per Vertical Foot of Abutment Raised	Cost per Foot of Extension per Vertical Foot of Dam Height	Source
Exeter, NH	Great Dam	Concrete Gravity	Removal*	136	16	16	-	-	$764,000	$351	-	-	*Exeter River Great Dam Removal Feasibility and Impact Analysis* , VHB, October 31, 2012
Exeter, NH	Great Dam	Concrete Gravity	Remove 3 vertical feet of crest*	136	16	3	-	-	$225,477	$553	-	-	*Exeter River Study Phase I Final Report* , W-P, March 2007 (includes 19.3% inflation)
Exeter, NH	Great Dam	Concrete Gravity	Increase abutment height by 1.3 feet**	136	16	-	1.3	-	$158,669	-	$122,053	-	*Exeter River Study Phase I Final Report* , W-P, March 2007 (includes 19.3% inflation)
Exeter, NH	Great Dam	Concrete Gravity	Remove 4 vertical feet of crest*	136	16	4	-	-	$333,500	$613	-	-	*Exeter River Great Dam Removal Feasibility and Impact Analysis* , VHB, October 31, 2012
Exeter, NH	Great Dam	Concrete Gravity	Increase abutment height by 1.4 feet**	136	16	-	1.4	-	$69,000	-	$49,286	-	*Exeter River Great Dam Removal Feasibility and Impact Analysis* , VHB, October 31, 2012
Exeter, NH	Great Dam	Concrete Gravity	Remove 5 vertical feet of crest*	136	16	5	-	-	$368,000	$541	-	-	*Exeter River Great Dam Removal Feasibility and Impact Analysis* , VHB, October 31, 2012
Waterville Valley, NH	Corcoran's Pond Dam	Concrete Butress Spillway	Expand/extend existing spillway *	43.5	14	-	-	16.5	$520,000	-	-	$2,251	*Corcoran's Pond Dam Preliminary Engineering Report, W-P, June 2010*
Croghan, NY	Croghan Dam	Concrete Gravity	Remove 3 vertical feet of crest*	222	14	3	-	-	$369,050	$554	-	-	*Feasibility Study for Dam Rehab...at Groghan Dam* , G&S, March2006 (includes 21% inflation)
Jackson County, OR	Gold Ray Dam	Concrete Gravity	Extend Dam*	360	14	-	-	100	$443,606	-	-	$317	*Gold Ray Dam Project Rehabilitation Technical Memo* , HDR, June 2010 (includes 6% inflation)
Guilford, VT	Sweet Pond Dam	Earth Filled Stone	Construct New Dam*	77	8	-	-	77	$511,000	-	-	$830	*Alternatives Evaluation - Sweet Pond Dam* , D&K, January 2012
Guilford, VT	Sweet Pond Dam	Earth Filled Stone	Remove 4 vertical feet of crest*	77	8	4	-	-	$270,000	$877	-	-	*Alternatives Evaluation - Sweet Pond Dam* , D&K, January 2012
Guilford, VT	Sweet Pond Dam	Earth Filled Stone	Dam Removal*	77	8	8	-	-	$161,000	$261	-	-	*Alternatives Evaluation - Sweet Pond Dam* , D&K, January 2012
Windham, NH	Moeckel Dam	Stone with Concrete	Lower Spillway 3 feet*	70	13	3	-	70	$115,000	$548	-	-	Moeckel Dam Evaluation Report, W-P, January 2011 (includes 6% inflation)
									Average	$537	$85,669	$1,132	
									Min	$261	$49,286	$317	
									Max	$877	$122,053	$2,251	
									Std. Dev.	$170	$36,384	$818	

* Includes mob/demob, water control and contractor OH&P.
** Includes contractor OH&P