GEI Consultants

Geotechnical
Environmental
Water Resources
Ecological

Flat Rock Dam Peak Flow Attenuation Study

Flat Rock, Michigan

Submitted to:
Huron-Clinton Metropolitan Authority

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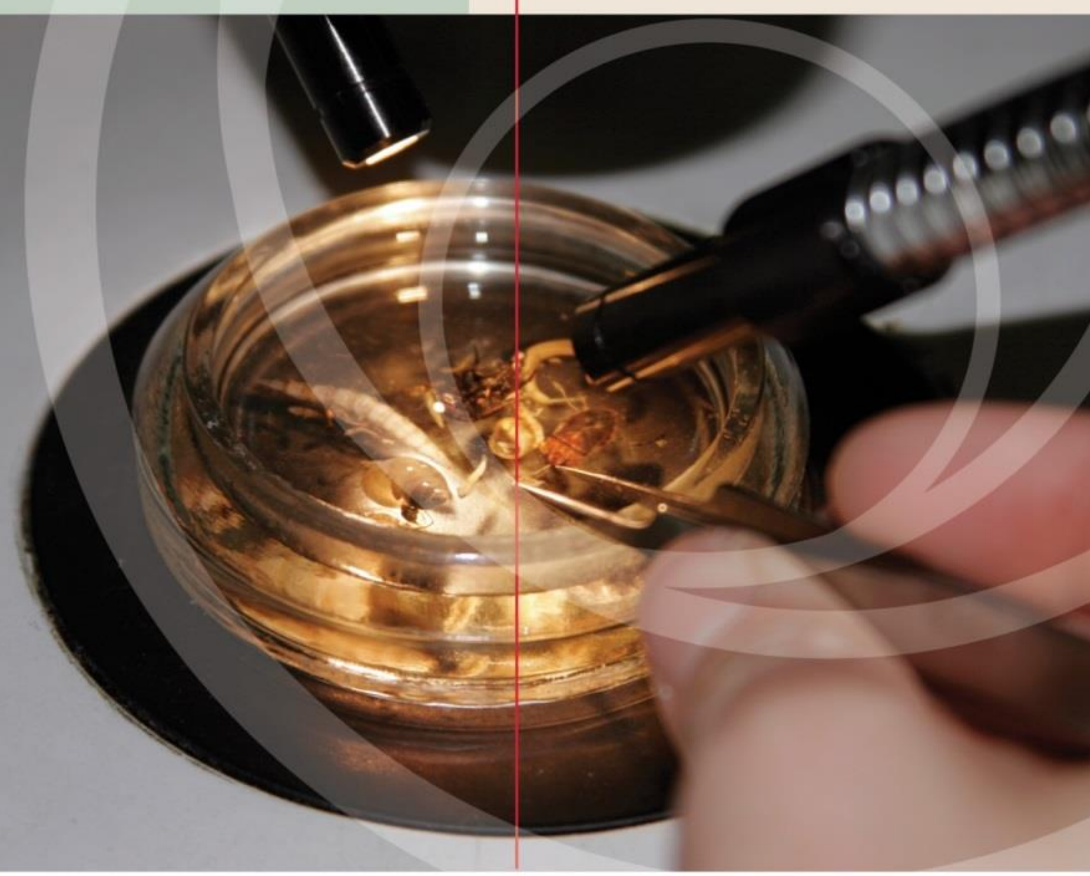

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1 Introduction

The purpose of this study was to evaluate the peak flow attenuation provided by the Flat Rock Dam. This analysis is intended to provide information on potential impacts of dam removal as part of the Flat Rock and Huroc dam removal feasibility study.

Hydraulic modeling showed minimal change in peak flow attenuation between the existing conditions model and the full dam removal scenario. The following sections detail the data collection, modeling methods, and results.

1.1 Site Description

The Flat Rock dam is located approximately 1,000 ft. upstream of the Huroc Dam and approximately 2,000 ft. upstream of Telegraph Road in the city of Flat Rock, MI (**Figure 1**). The Flat Rock dam impounds an area approximately 2.5 miles upstream.

2 Peak Flow Attenuation Modeling

The hydraulics at the site were evaluated by modeling the site with HEC-RAS version 6.3.1 software (USACE, 2022). The initial model was set up using 1-dimensional, steady flow. Then, peak flow attenuation was evaluated by running 1-dimensional, unsteady flows through the model. The following sections provide additional information on data collection and model creation.

2.1 Flow Events & EGLE Discharge Request

GEI requested discharge estimates for the site from Michigan Department of Environmental Great Lakes, and Energy. EGLE provided the following flow estimates (**Table 1**).

Table 1. Huron River flows by return period provided by EGLE

Return period	Flow (CFS)
50%	3,700
20%	5,300
10%	6,500
4%	7,900
2%	8,800
1%	10,400
0.5%	11,700
0.2%	12,100

EGLE also provided low flows at the site, including the harmonic mean, which is 270 cfs.

2.2 FEMA Flood Insurance Study

The Flat Rock and Huroc dams are within the FEMA 100-year floodplain (Zone AE) (**Figure 2**) (FEMA, 2012). The effective FEMA model was not used for this analysis, but the model results were compared to the FEMA modeled 100-year water surface profiles (**Figure 11**).

2.3 Topographic and Bathymetric Survey

Topographic and bathymetric survey data was collected in June and July 2023 by Metro Consulting Associates and LimnoTech, respectively. The survey data was combined with Wayne County and Monroe County 1-meter LiDAR data from USGS from 2016 for design and modeling. Survey data included bathymetric cross sections from Telegraph Road to the Huroc Dam, between the Huroc Dam and Flat Rock Dam, and from the Flat Rock Dam to approximately the upstream end of the impoundment. The survey also included the Flat Rock and Huroc Dam structures and associated bridges. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified.

2.4 Existing Conditions Hydraulic Model

2.4.1 Channel Geometry

The Existing Conditions model extends from just upstream of Telegraph Road to approximately the upstream end of the Flat Rock Dam impoundment (**Figure 3**). 1-D cross sections were spaced approximately 200 ft apart, with closer spaced cross sections near the dam structures. Survey and LiDAR data were used to define the model geometry. Upstream of the Flat Rock Dam, the upper portion of the impoundment consists of several braided channels. Ineffective flow stations were used to represent the side channels and impoundment backwater areas in the model. The side channel downstream of the Flat Rock dam was also modeled as ineffective flow since it only conveys a small portion of the overall flow.

2.4.2 Manning's n

Manning's *n* is the model coefficient that represents the relative roughness or resistance to flow for the streambed, banks, and floodplain. The larger the Manning's *n* coefficient, the higher the drag forces from the bed and banks, slowing water velocities and raising water surface elevations. Manning's *n* values were selected based on field observations of substrate type, bank conditions, and ground cover and subsequently appropriate adjustments to the base values to represent existing conditions. The base channel value was set as $n = 0.035$ and represents a clean, straight natural channel with sand to gravel substrate. The floodplain value varied between $n = 0.08$ and $n = 0.15$ (Chow, 1959) for the overbank areas and the islands within the impoundment based on the density of tree cover (**Figures 4 and 5**). Areas of the floodplain with a low density of tree cover and little undergrowth were represented with a value of $n = 0.08$, and the floodplain areas containing very dense tree cover were represented with a value of $n = 0.15$. The changes in Manning's *n* values were represented as horizontal variation across each cross section based on aerial imagery and site photos (**Figure 6**).

2.4.3 Flat Rock Dam

The Flat Rock Dam spillway and the railroad bridge immediately downstream were modeled as a single inline structure spillway with gates. The spillway was represented as the base of the gate, the bridge piers were represented as the space between the gate openings, and the bridge deck was represented as the top of weir. The gates were modeled as fully open for all model runs. See **Figures 7 and 8**. Spillways and bridges in 1 Dimensional HEC-RAS models each require four cross sections (two upstream of the structure and two downstream), which are placed so that the outermost cross sections are outside of the hydraulic influence of the structure. In this case, the spillway and railroad bridge are so close together that flows in between them are influenced by both structures at the same time. This representation of the spillway and bridge as a single hydraulic structure was checked against surveyed water surfaces upstream and downstream of Flat Rock Dam to verify the model set up. The fish ladder was not included in the model as it is expected to convey minimal overall flow.

2.4.4 Huroc Dam

The Huroc Dam and pedestrian bridge are integrated with the spillway and therefore were modeled as a single inline structure spillway, similar to the Flat Rock Dam, with fully open gates since the pedestrian bridge is positioned directly over the spillway. The spillway was represented as the base of the gate, the bridge piers were represented as the space between the gate openings, and the bridge deck was represented as the top of weir. The entire area between the pedestrian walkway and roof was assumed to be blocked. See **Figures 9 and 10**.

2.4.5 Boundary Conditions

The downstream boundary is located between Telegraph Road and the Huroc dam, which is approximately 1,600 ft downstream of Flat Rock dam. The downstream boundary was set to a normal slope of 0.0002 ft/ft for flood flows, and 0.001 ft/ft for low flows, based on FEMA flood water surface elevations and calibrated observed low flow water surface elevations, respectively. The upstream boundary is located approximately 14,200 ft upstream of the Flat Rock dam. The upstream boundary was based on the flows in Table 1. The steady flow simulations were run with 1D steady flow, using subcritical flow regimes.

2.4.6 Comparison to FEMA Model

The 100-year event was run as a steady flow plan, and the results were compared to the FEMA 100-year water surface profile. The simulated water surfaces were within 0.25 ft of FEMA elevations, apart from the cross section immediately below the Flat Rock dam, which was within 0.75 ft. The larger difference in water surface at Flat Rock dam is likely due to differences in how the structure was modeled in the original FEMA model, which was built with HEC-2 software, an older software system. It should be noted that while the current hydraulic modeling effort follows industry standards of practice for hydraulic analysis, it is not intended to be a direct comparison with FEMA Base Flood Elevations or utilized for letter of map revision.

2.4.7 Comparison to Surveyed Water Surface Elevations

A suite of low flows was run as a steady flow plan, and the results were compared to surveyed water surface elevations in June and July of 2023. The simulated low flows were within 0.3 ft of the surveyed water surface elevations.

2.5 Unsteady Flow Modeling

Following the 1-D steady modeling to validate the model against FEMA elevations and surveyed water surface elevations, several1-D unsteady plans were set up to model multiple flood events and evaluate attenuation. The unsteady flow hydrographs were set up as 24-hour events starting and ending at the harmonic mean of 270 cfs. as baseflow, with the peak defined by the flood flow peaks in Table 1, using the SCS type II distribution. The models were run with an adaptive time step based on Courant numbers between 0.45 and 1.

2.5.1 Full Dam Removal Scenario

The full dam removal scenario was modeled using the existing conditions model geometry extents. This included the entire Flat Rock impoundment, with a modified channel centerline alignment that was determined based on recent depth of refusal data, as well as historic 1920's survey data, in an effort to restore the Huron River channel back to its original location where logistically feasible. The model geometry was updated to represent the proposed conditions. The inline structures were removed and replaced with existing Flat Rock and Huroc bridge data. Cross sections along the proposed centerline alignment from approximately 100 ft downstream of Huroc bridge to approximately 8,000 ft upstream of Flat Rock bridge were modified by applying a cross section template with channel specifications including a 5 ft bankfull depth, 150 ft bankfull top width, and 2:1 side slope. Manning's *n* values were set to 0.035 for the design channel, and 0.050 for the bankfull bench cut. All other model parameters were kept the same as the existing conditions model. The proposed model results were compared against the existing conditions model results to verify no rise in water surface elevations during the prescribed flood events.

The full dam removal model was run with the same unsteady flow hydrographs and computation settings as described above, and the results were compared to the existing conditions model.

3 Results

The results show minimal change in peak flow attenuation between existing conditions and full dam removal (**Table 2**). Peak flow attenuation is generally greater than 70% for all flows. This attenuation is likely due to good floodplain access in the Flat Rock impoundment for both existing conditions and proposed full removal design conditions.

Table 2. Modeled Flow Attenuation Comparison for Existing Conditions and Full Removal (Full Version of Model Geometry)

	Existing Conditions			Full Removal			
Recurrence Interval	Upstream Cross Section Peak Flow (CFS)	Downstream Cross Section Peak Flow (CFS)	Attenuation (%)	Upstream Cross Section Peak Flow (CFS)	Downstream Cross Section Peak Flow (CFS)	Attenuation (%)	Percent Difference between Existing Conditions & Full Removal (%)
Baseflow	270	271	0.5	270	276	2.1	1.6
2yr	3700	1003	-72.9	3700	1145	-69.1	3.8
5yr	5300	1278	-75.9	5300	1426	-73.1	2.8
10yr	6500	1505	-76.8	6500	1624	-75.0	1.8
25yr	7900	1753	-77.8	7900	1870	-76.3	1.5
50yr	8800	1996	-77.3	8800	2022	-77.0	0.3
100yr	10400	2437	-76.6	10400	2297	-77.9	-1.3
200yr	11700	2617	-77.6	11700	2502	-78.6	-1.0

4 Literature Cited and Reference Materials

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Federal Emergency Management Agency, October 21, 2021. Flood Insurance Study Wayne County, Michigan (All Jurisdictions). 26163CV001C.

Federal Emergency Management Agency, February 2, 2012. Flood Insurance Rate Map (FIRM) Wayne County, Michigan (All Jurisdictions). 26163C0506E.

U.S. Army Corps of Engineers, 2022. HEC-RAS River Analysis System. Version 6.3.1.

Figures

Figure 1. Site Location Map

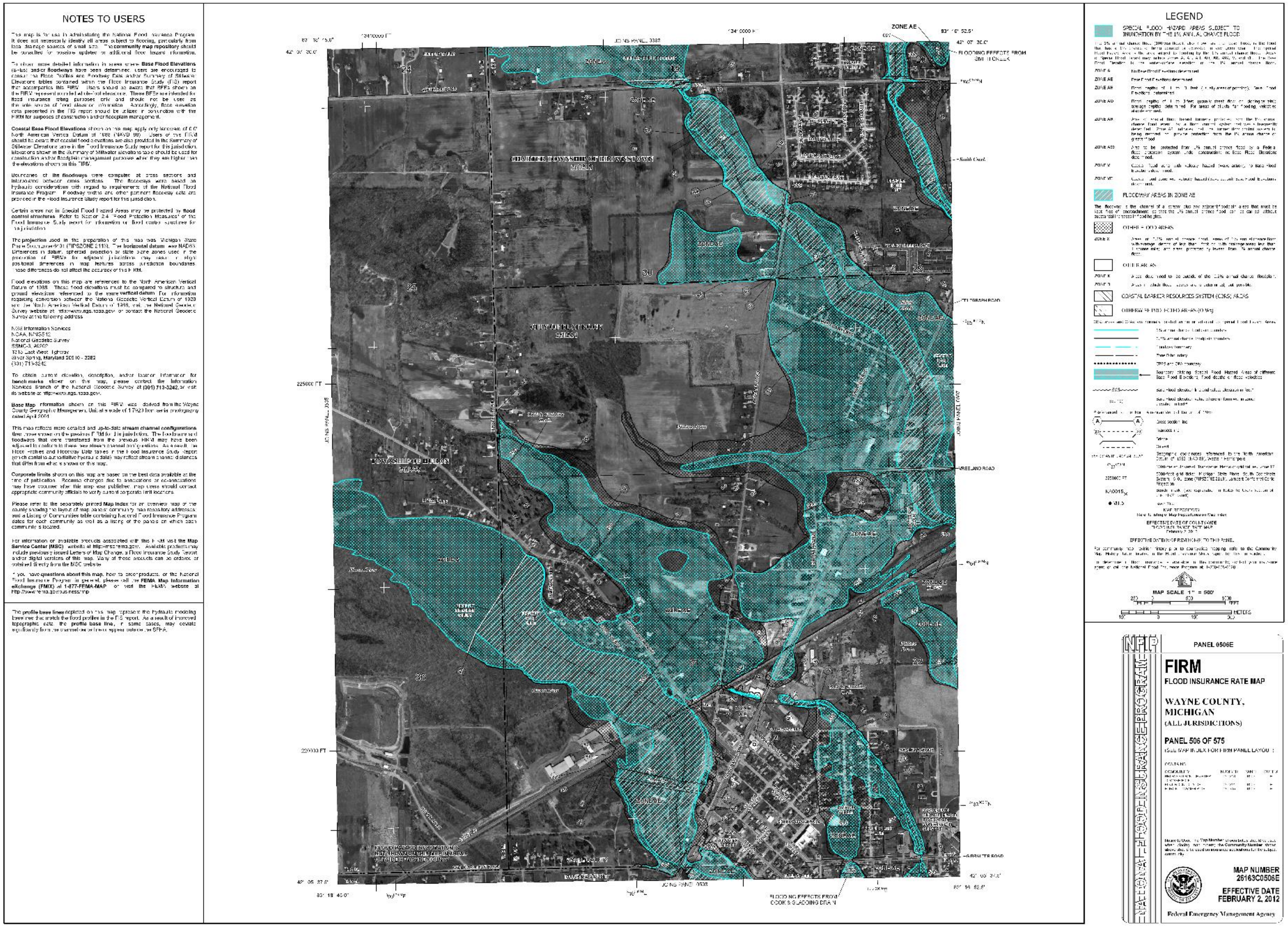

Figure 2. FEMA FIRM Panel (FEMA, 2012)

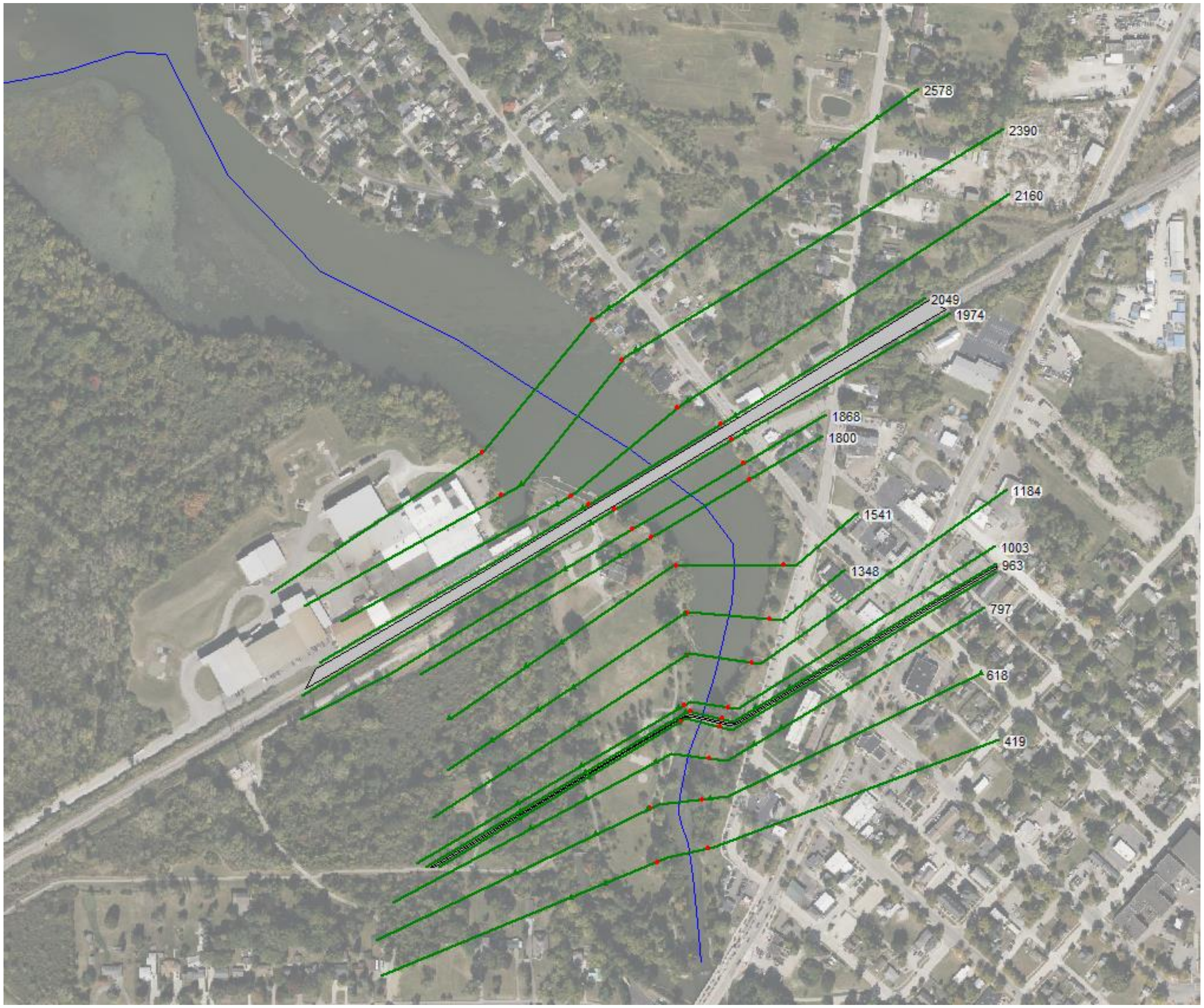

Figure 3. Model Geometry

Figure 4. Looking Upstream from Flat Rock Dam at Forested Floodplain

Figure 5. Looking Downstream Towards Flat Rock Dam and Railroad Bridge

Figure 6. Looking Upstream Towards Flat Rock Dam and Railroad Bridge

Figure 7. Looking Upstream Towards Flat Rock Dam and Railroad Bridge Zoomed In

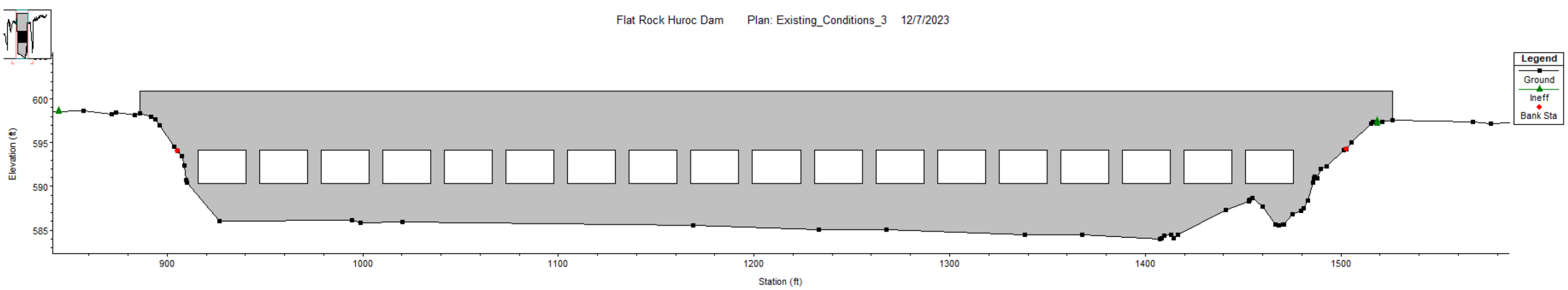

Figure 8. Flat Rock Dam Model Representation (Looking Downstream)

Figure 9. Looking Upstream Towards Huroc Dam and Pedestrian Bridge

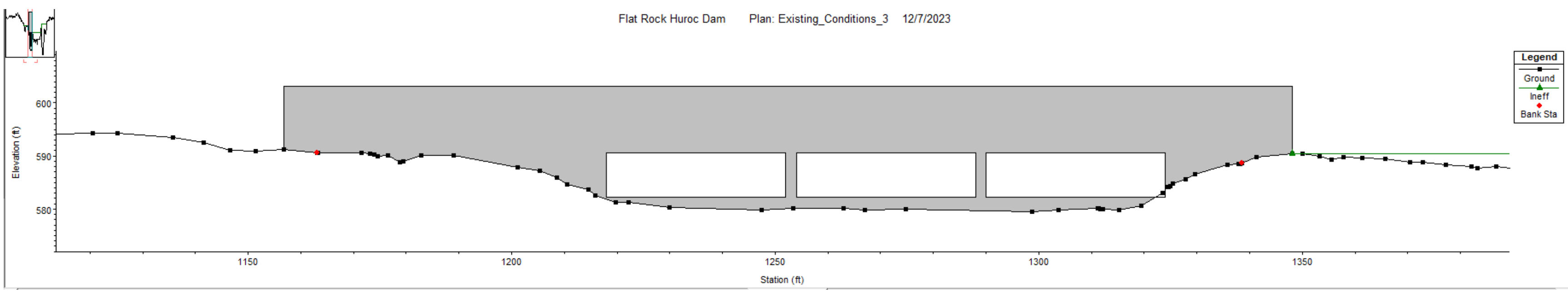

Figure 10. Huroc Dam and Pedestrian Bridge Model Representation (Looking Downstream)

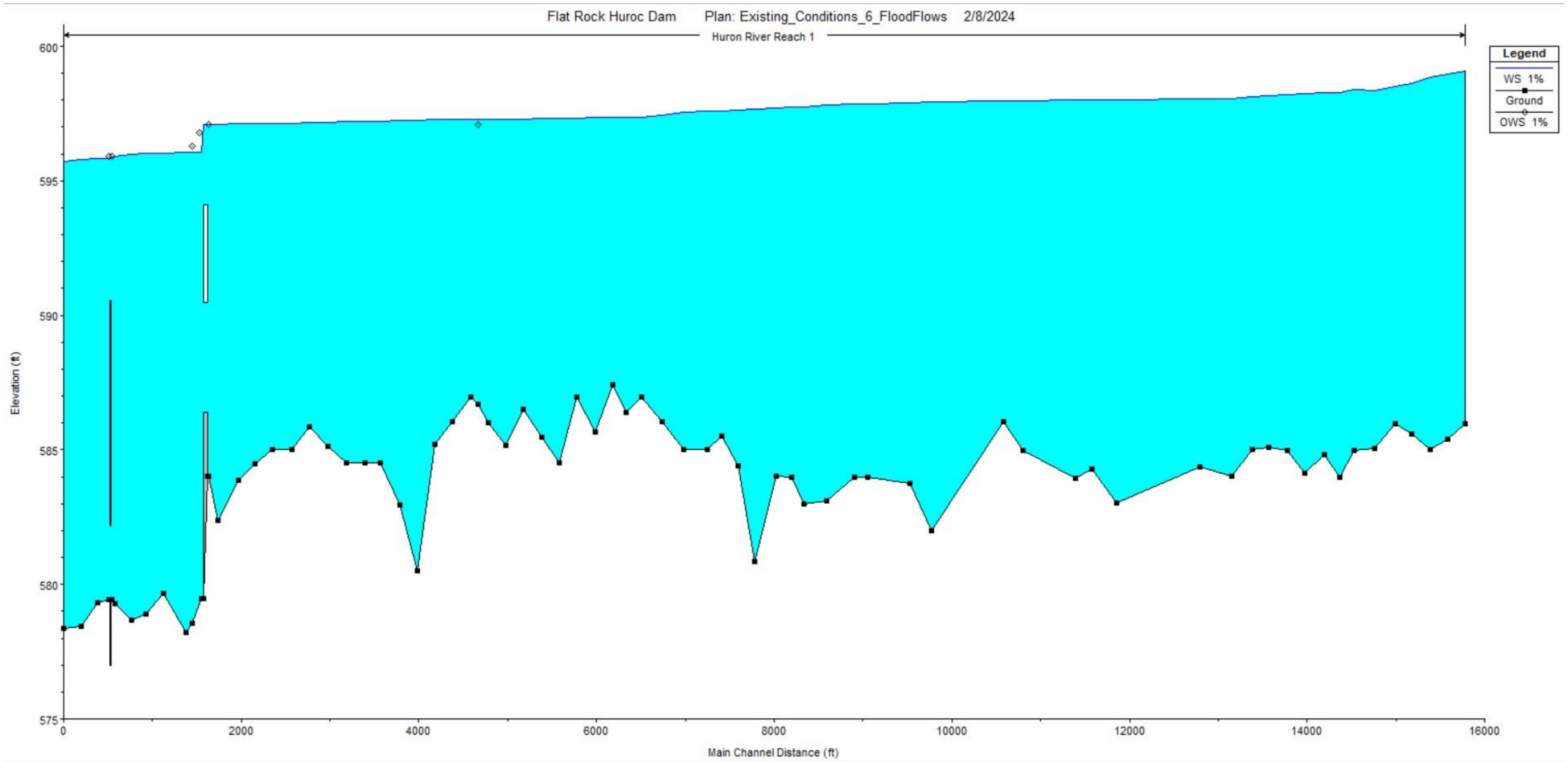

Figure 11. FEMA Comparison (Diamond-Shaped Data Points Representative of FEMA 100-year Water Surface Elevations