Relicensing Study 3.3.8

COMPUTATIONAL FLUID DYNAMICS MODELING IN THE VICINITY OF THE FISHWAY ENTRANCES AND POWERHOUSE FOREBAYS

Initial Study Report Summary

Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)

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1.1 Study Summary

The purpose of this study is to obtain information to determine the flow field conditions that exist at various locations at the Turners Falls Project. Per the Revised Study Plan (RSP), FirstLight is required to conduct Computational Fluid Dynamics (CFD) Modeling in the vicinity of the fishway entrances and powerhouse forebays. The Turners Falls Project consists of two hydroelectric facilities, Station No. 1 and Cabot Station, which utilize flow from the power canal to generate power. Upstream fish passage at the Project consists of three passage structures: the "Spillway Fish Ladder" (located at the Turners Falls spillway), the "Gatehouse Fish Ladder" (located at the Turners Falls Dam gatehouse), and the "Cabot Fish Ladder" (located at Cabot Station). Downstream passage routes at the Turners Falls Project include over the dam, through the powerhouses, or through the downstream fish passage sluice adjacent to Cabot Station. The objective of this study is to evaluate the flow field conditions in the vicinity of the fishway entrances and powerhouse forebays. Note that per the RSP, this study does not include CFD modeling of the Gatehouse Fish Ladder as this was previously conducted and the findings filed with FERC.

This study includes 6 CFD model production runs. Model 1 will cover the power canal and forebay in front of Station No. 1. Model 2 will cover the Station No. 1 intake rack, and will be run for similar flow conditions as Model 1. Model 3 will cover the Cabot Station forebay. Model 4 will cover the Cabot Station intake rack, and will be run for similar flow conditions as Model 3. Model 5 will cover the Cabot Fish Ladder entrance area, and Model 6 will cover the Spillway Fish Ladder entrance area.

1.2 Study Progress Summary

Task 1: Bathymetric Survey of the Study Areas

Bathymetric surveys at the Cabot Fish Ladder, Station No. 1 Forebay and the Cabot Forebay have been completed. The bathymetric survey data was collected using an Acoustic Doppler Channel Profiler (ADCP) linked to a GPS unit, and included the collection of both bathymetry and velocity data. Additional survey was collected using a real time kinematic (RTK) GPS to locate the edge of water and important structural features in the study area (e.g. top of wall elevations). All information was collected in the North American Vertical Datum of 1988 (NAVD88).

The bathymetry and velocity profile data was collected under the following scenarios:

- **Station No. 1 Forebay** – The bathymetric survey for the Station No. 1 Forebay was collected on March 28, 2014. When collecting bathymetry and velocity data at Station No. 1, all units were on at Station No. 1 (2,210 cfs) and Cabot was operating at its approximate minimum generation flow (2,288 cfs).

- **Cabot Forebay** - The bathymetric survey for the Cabot Forebay was collected on March 29, 2014. When collecting bathymetry and velocity data at Cabot, Cabot Units 1, 5 and 6 were generating (~6,864 cfs), and the log sluice was open approximately 10 feet (~1,288 cfs). Station No. 1 was not generating when the bathymetry at Cabot was being collected.

- **Spillway Fish Ladder** – These data have not yet been collected. We anticipate collecting them in early fall 2014. The flow conditions during data collection will be approximately 120 cfs from the fish ladder.

- **Cabot Fish Ladder** – Velocity and bathymetry data were collected in the vicinity of the Cabot Fish Ladder on August 6, 2014. The bypass reach flow was approximately 700 cfs, while the Cabot flow through the turbines was approximately 4,500 cfs. The Cabot Fisk Ladder was

passing normal operating flows during data collection as well. The log sluice was also discharging water that day, but the flow passing that structure has not been determined yet.

During post-processing, the bathymetric elevation data was converted from NAVD88 to the Turners Falls project datum which is the National Geodetic Vertical Datum of 1929 (NGVD29). A horizontal shift was also applied to the ADCP data for the Station No. 1 Forebay and the Cabot Forebay based on the survey collected with the higher accuracy RTK GPS unit. The Cabot Fish Ladder bathymetry has not been post-processed at this time.

Figure 1, Figure 2 and Figure 3 show a plan view of the bathymetry and survey data collected at the Station No. 1 Forebay, Cabot Forebay and the Cabot Fish Ladder, respectively. Figure 4 shows the planned survey transect locations at the Spillway Fish Ladder.

It is anticipated that supplemental bathymetric survey will be collected at Station No. 1 during the 2014 Fall canal drawdown.

Task 2: Compile Model Input Datasets in CAD

The bathymetry data for the Cabot Forebay and the Station No. 1 Forebay have been post-processed and a three-dimensional (3D) surface generated. The 3D surface was generated in ArcGIS as a Triangulated Irregular Network (TIN) and converted to a stereolithography (STL) file as required for the CFD model. 3D surfaces have not yet been generated for the Cabot Fish Ladder and Spillway Fish Ladder bathymetry.

Project drawings and field survey were used to develop 3D CAD drawings of the pertinent project facilities (e.g. fish ladders, log sluice, intake racks, canal walls, etc.). The 3D CAD work was exported to an STL file as required for the CFD model.

Figure 5 and Figure 6 show 3D renderings of the STL files generated for the Station No. 1 Forebay and Cabot Forebay CFD models, respectively. These figures show both the processed bathymetry and the 3D CAD structural drawings. Figure 7 and Figure 8 show the 3D CAD work that has been completed at the Spillway Fish Ladder and the Cabot Fish Ladder.

Task 3: Construct Three-Dimensional Model

The Station No. 1 Forebay CFD model is currently (August 15, 2014) being set-up and initial runs made.

Task 4: Conduct Model Production Runs

The model production runs have not been started at this time, however, the flow scenarios for the Cabot Forebay and Station No. 1 Forebay model runs have been refined to reflect current operating procedures. These refinements are not considered a variance from the project plan. Table 1 and Table 2 show the scenarios outlined in the RSP for Models 1 through 4, while Table 3 and Table 4 show operational details relating to the refinements developed as part of this task (e.g. which turbines will be used).

No refinements to the Cabot Fish Ladder model scenario (Model 5) or the Spillway Fish Ladder model scenario (Model 6) have been required at this time. The flow scenarios proposed in the RSP for Model 5 and Model 6 are shown in Table 5 and Table 6, for reference, respectively.

Task 5: Report

A final report will be completed in the 2nd quarter of 2015.

1.3 Variances from Study Plan and Schedule

The only variances from the RSP are schedule related, as described below.

Assuming field efforts are completed by the end of September 2014, data post processing should be completed by late November 2014. CFD model development, testing and production runs will occur from Q3 2014 throughout Q1 2015. It is anticipated that study report will be completed by Q2 2015.

1.4 Remaining Activities

Under Task 1, field data collection at the Spillway Fish Ladder and supplemental field data collection for the Station No. 1 Forebay still need to be completed.

The development of CAD work described in Task 2 is effectively complete with minor edits anticipated as the 3D CFD models are developed, and 3D bathymetry surfaces at the Cabot Fish Ladder and Spillway Fish Ladder still need to be developed.

Tasks 3 and 4 are being actively worked on and Task 5 has not been started at this time.

Table 1: RSP-Proposed flow scenarios for CFD Model 1 and CFD Model 2.

Scenario Number	Models Run	Station No. 1 Flow (cfs)	Canal Pass-Through Flow (cfs)	Total Power Canal Flow (cfs)
1-1, 2-1	1 and 2	1,433 (current min flow)	200	1,633
1-2, 2-2	1 and 2	2,210 (Station No. 1 capacity)	200	2,410
1-3	1	2,210	13,928 (Cabot capacity of 13,728 cfs plus 200 cfs for log sluice)	16,138

Table 2: RSP-Proposed flow scenarios for CFD Model 3 and CFD Model 4.

Scenario Number	Models Run	Cabot Station Flow (cfs)	Log Sluice Flow (cfs)	Total Power Canal Flow (cfs)
3-1, 4-1	3 and 4	1,700	200	1,900
3-2, 4-2	3 and 4	7,500	200	7,700
3-3, 4-3	3 and 4	13,728 (Cabot capacity)	200	13,928

Table 3: Refined flow scenarios for CFD Model 1 and CFD Model 2.

Scenario Number	Units Generating	Flow Through Units (cfs)	Cabot Station Flow (cfs)	Log Sluice Flow (cfs)	Total Power Canal Flow (cfs)
1-1, 2-1	3, 5 ,7	475, 465, 493	1,433	200	1,633
1-2, 2-2	1, 2, 3, 5, 7	560, 140, 500, 490, 520	2,210	200	2,410
1-3	1, 2, 3, 5, 7	560, 140, 500, 490, 520	2,210	13,928	16,138

Table 4: Refined flow scenarios for CFD Model 3 and CFD Model 4.

Scenario Number	Units Generating	Flow Through Units (cfs)	Cabot Station Flow (cfs)	Log Sluice Flow (cfs)	Total Power Canal Flow (cfs)
3-1, 4-1	1	1,700	1,700	200	1,900
3-2, 4-2	1, 2, 3	2,288 each	6,864	200	7,064
3-3, 4-3	All Units	2,288 each	13,728	200	13,928

Table 5: RSP-proposed flow scenarios for CFD Model 5.

Scenario Number	Cabot Flow (cfs)	Bypass Reach Flow (cfs)	Cabot Fishway Flow (cfs)	Total Flow (cfs)
5-1	1,700	400	368	2,468
5-2	7,500	400	368	8,268
5-3	13,728	400	368	14,496
5-4	13,728	6,501	368	20,597 (April 75% exc.)
5-5	13,728	16,240	368	30,336 (April 50% exc.)

Table 6: RSP-proposed flow scenarios for CFD Model 6.

Scenario Number	Power Canal Flow[1] (cfs)	Spillway Ladder Flow (cfs)	Bascule Gate No. 1 Flow (cfs)	Other Bascule Gate Spill[2] (cfs)	Tainter Gate Spill[3] (cfs)	Total Turners Falls Flow (cfs)
6-1	7,282	318	400	0	0	8,000
6-2	15,938	318	4,341	0	0	20,597
6-3	15,938	318	7,500	6,580	0	30,336
6-4	15,938	318	7,500	12,460	10,000	46,216

[1] The power canal is not included in CFD model 6, but is included in this table to show the flow distribution.
[2] The bascule gates are typically operated in a set order of no. 1, no. 2, no. 4 and no.3, with gate no. 1 being opened first and closed last, and gate no. 3 being opened last and closed first. The bascule gates can be throttled as desired.
[3] The tainter gates are typically opened to maintain some flexibility in the bascule gates' available capacity. Since the bascule gates do not require manual operation like the tainter gates, station personnel generally prefer to not max out the bascule gate capacity. The tainter gates can be throttled as necessary, but the adjustments cannot be done remotely like it can for the bascule gates.

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N

0 62.5 125 250
Feet

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Figure 1 - Station No. 1 Forebay Bathymetry

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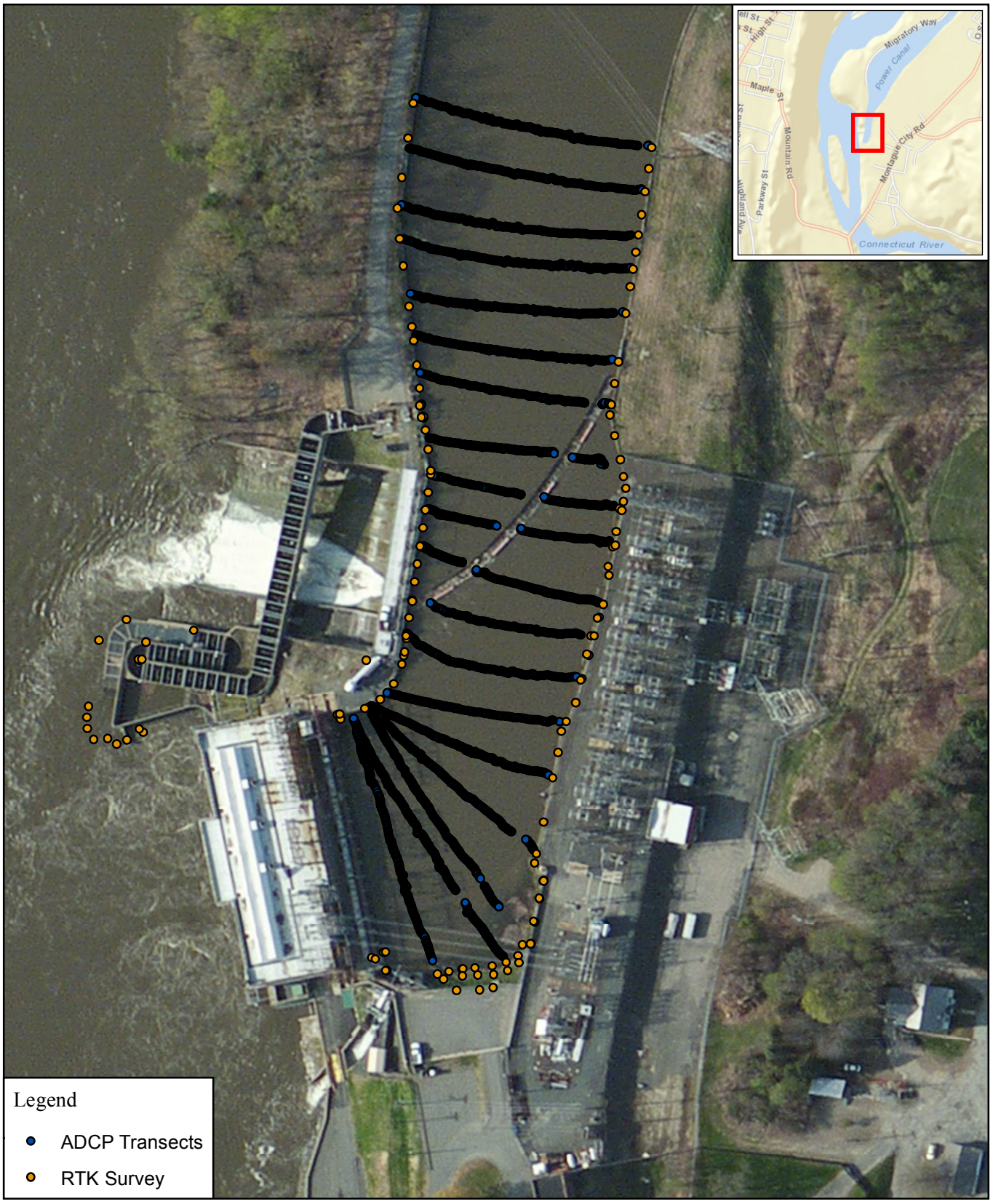

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N

0 62.5 125 250 Feet

Figure 2 - Cabot Forebay Bathymetry

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0 250 500 1,000 Feet

Figure 3 - Cabot Fishway Bathymetry and Velocity Measurement Coverage

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0 62.5 125 250
Feet

Figure 4 - Planned Bathymetry and Velocity CFD Transects at the Spillway Fishway.

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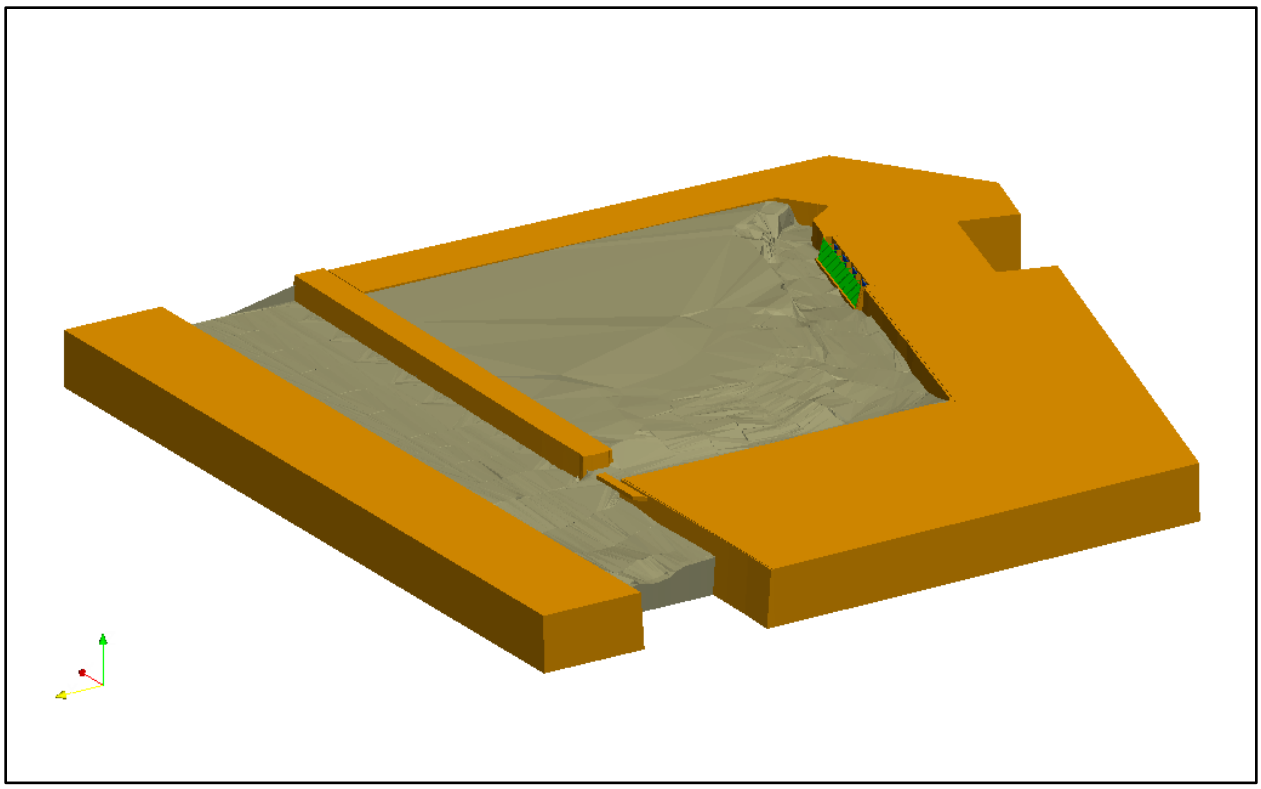

Figure 5: Station No. 1 Forebay three-dimensional rendering.

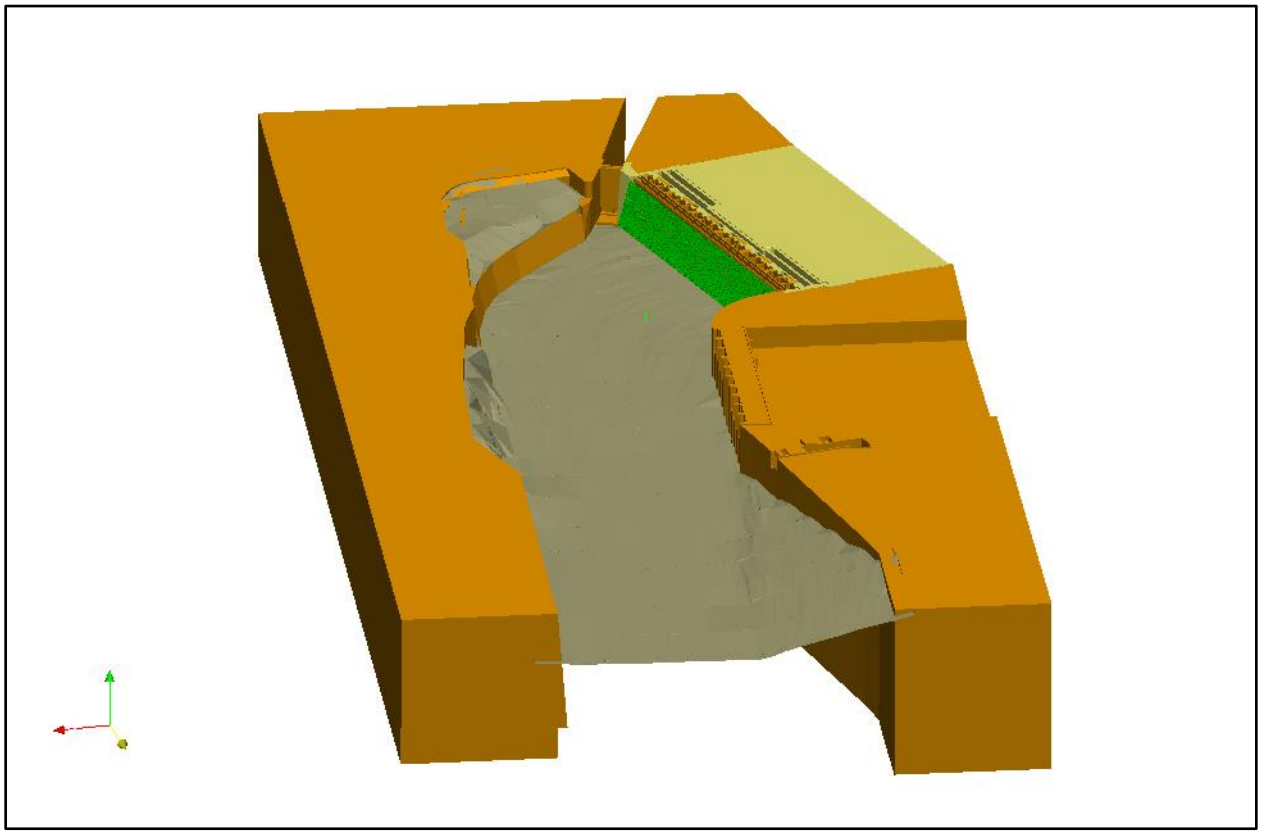

Figure 6: Cabot Forebay three-dimensional rendering.

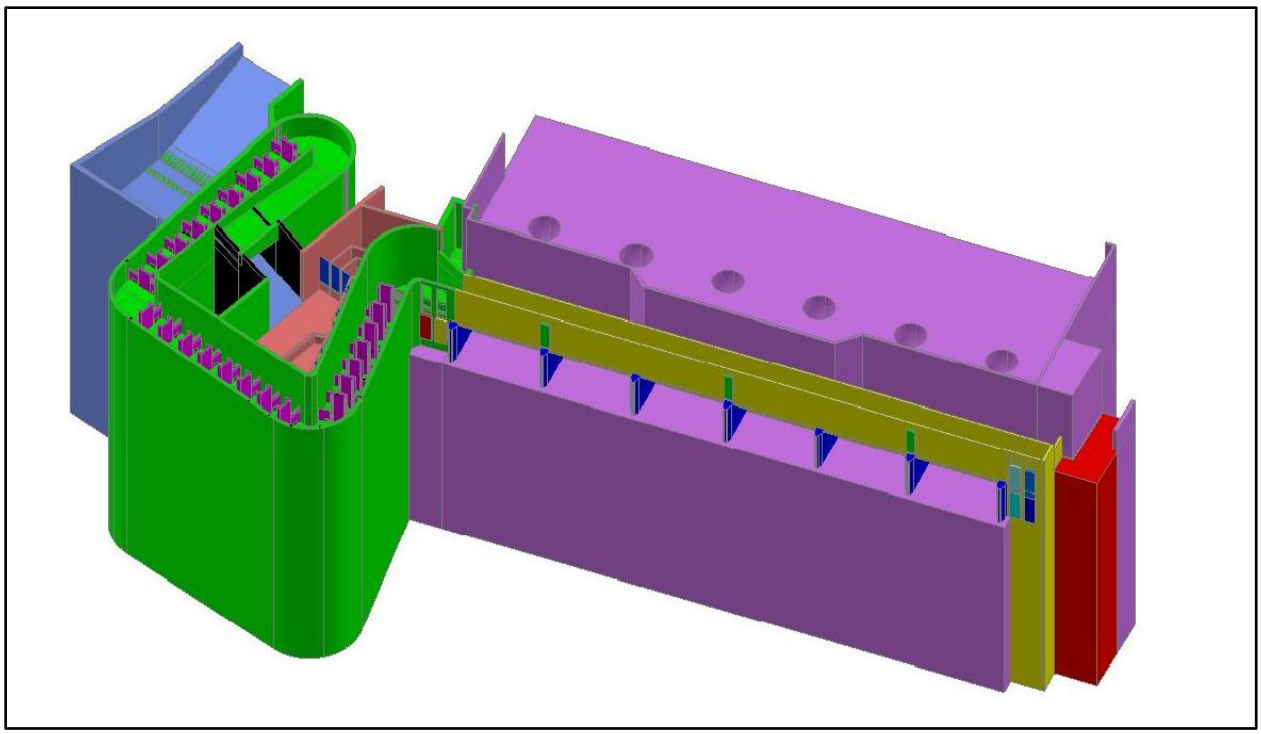

Figure 7: Cabot fishway three-dimensional rendering.

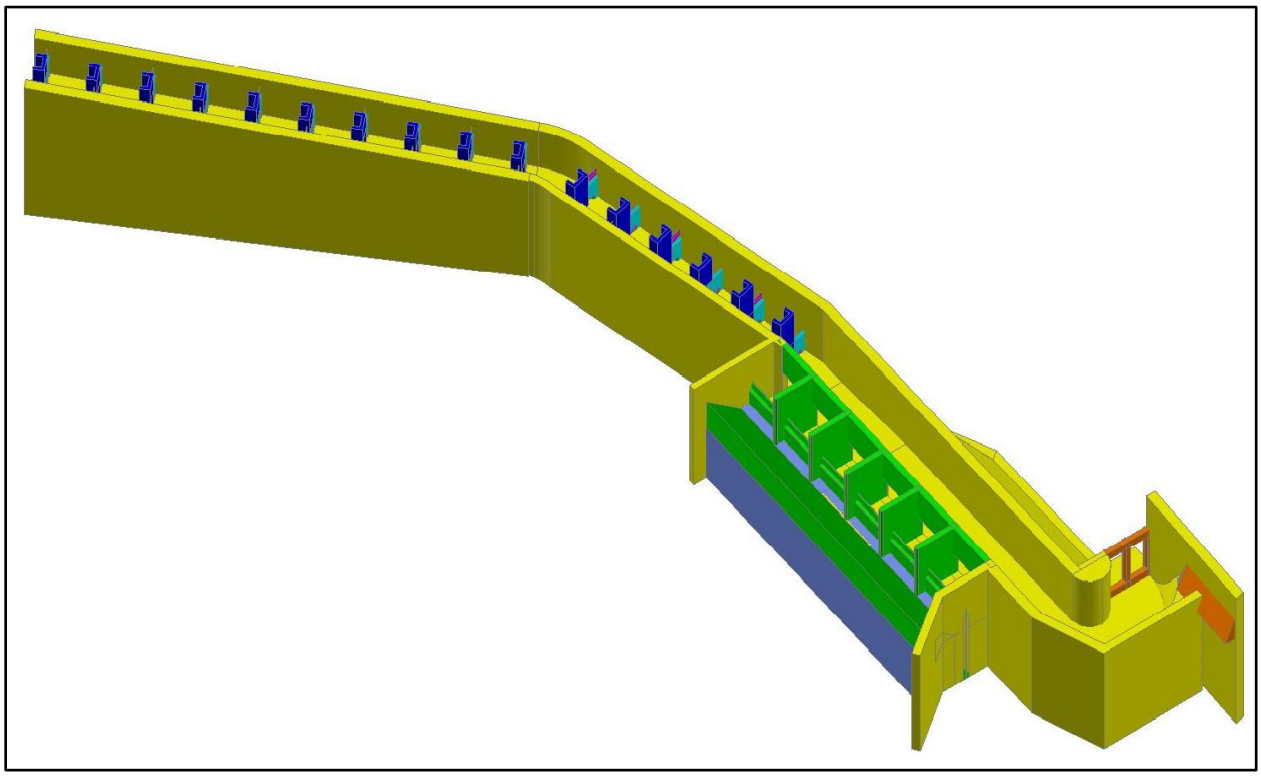

Figure 8: Turners Falls Dam spillway fishway three-dimensional rendering.