Relicensing Study 3.3.8

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

Updated 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

This study involved building three-dimensional computational fluid dynamic (CFD) models at four locations around the Turners Falls Hydroelectric Project (Project). The four study areas are the Station No. 1 forebay, the Cabot Station forebay, the Cabot fishway entrance and the Spillway fishway entrance. As noted in the Revised Study Plan (RSP) filed with the Federal Energy Regulatory Commission (FERC), the study objectives are:

1. Characterize the hydraulics of current (existing) conditions and any changes to:
    a. Fishway attraction flows;
    b. Turbine operations; and
    c. log sluice gates
2. Develop a series of velocity maps at select discharges showing approach velocities and flow fields that may create a response in fish;
3. Characterize the flow field in front of the Cabot Station and Station No. 1 intakes using velocity maps and cross-sectional plots;
4. Assess whether fish are directed to the surface bypass weir near Cabot Station;
5. Characterize the near-rack "sweeping" velocities at the Cabot Station and Station No. 1 intakes

Several "production runs" with each of the various models will be performed to evaluate each of the objectives above. The CFD model simulations for the CFD Study were conducted using the Flow-3D CFD code developed by Flow Science, Inc.

1.2 Study Progress Summary

Task 1: Bathymetric Survey of the Study Areas

Bathymetric surveys of the study areas are complete. Survey data were collected in all four study areas to define the shape of the below-water channel and canal areas. These data were combined with upland and riverbank topography based on field survey and Light Detection and Ranging (LiDAR) data to create comprehensive bed topography files for each of the study areas. An overhead map of some of the collected bathymetric and topographic data for the Spillway fishway CFD is shown in Figure 1, as an example of the type of data that were collected.

In addition to bathymetric data, water column velocity data and water surface elevation data were collected in all four study areas for use in validating the models.

Task 2: Compile Model Input Datasets in CAD

Flow-3D requires that model geometry be defined using solid models exported to the Stereolithography (STL) file format. All of the model input datasets have been imported into CAD and converted into stereolithography (STL) files. STL files are the electronic format that Flow3D software uses to import geometric data.

For the CFD Study, the solid models were developed using one of two different approaches, depending on the type of feature being represented. Generally the solid models for project structures, such as canal walls, bridges piers, intake racks, penstocks, fishway entrances, etc. were developed in AutoCAD Civil 3D, while the bathymetric surfaces were developed using a combination of ArcGIS, Meshlab, and Salome Platform. All solid models were ultimately exported as STL files for use in the CFD model.

The purpose of the solid model geometry is to define the areas where water flows in each model. Accordingly, outside of the canal, forebay or other areas of interest, the CAD model geometry was

artificially extended to fill the areas that are not being modeled. By blocking out areas where water is not expected to go, and where results are not required, the model runs are more efficient. Figure 2 shows an example of an 'artificially filled' area that was outside of the modeling area of interest.

This task is complete.

Task 3: Construct Three-Dimensional Model

A total of four (4) three-dimensional models were developed for CFD Study. Complete CFD models have been constructed for all four study areas. A paragraph briefly describing each model follows below.

The Station No. 1 Forebay CFD model includes the penstocks and intakes, forebay and a portion of the power canal in front of the forebay entrance. The power canal portion of the model extends from approximately 300 feet upstream of the forebay entrance to approximately 450 feet downstream of the forebay entrance, for a total length of approximately 750 feet. The forebay portion extends from the power canal through the entire forebay and into penstocks where the model terminates. Figure 3 shows the geometry input for this model.

The Cabot Station Forebay CFD model includes the penstocks and intakes, forebay and a portion of the power canal in front of the forebay entrance. The model extends from approximately 700 feet upstream of the power house, downstream to a point inside the penstocks where the model terminates. Figure 4 shows the geometry input for this model.

The Cabot Fishway Entrance CFD model extends along the full-width mainstem Connecticut River from approximately 1600 feet upstream of Cabot Station to approximately 500 feet downstream of Smead Island. Since the area around the Cabot fishway entrance is greatly influenced by surrounding river conditions, the modeling area was extended to a much larger portion of the river than was specified in the RSP. The model area that was outside of the study area was represented as a low-resolution grid that functioned as the boundary conditions for the detailed study area. Figure 5 shows the geometry input for the Cabot Fishway model.

The Spillway Fishway Entrance CFD model extends from the Turners Falls Dam to approximately 300 feet downstream of Peskeomskut Island. The model area extends beyond the study area described in the RSP, as the surrounding areas influenced river conditions in the study area. The model area that was outside of the study area was represented as a low-resolution grid that functioned as the boundary conditions for the detailed study area. Figure 6 shows the geometry input for the Spillway Fishway model.

This task is complete.

Task 4: Conduct Model Production Runs

This task is partially complete. The model production runs are complete for the Station No. 1 forebay and the Cabot Station forebay. The Cabot fishway and Spillway fishway production runs are still underway.

While it is beyond the scope of this status summary update to provide a detailed review and discussion of the preliminary CFD modeling results, several example results plots are shown in Figure 7, Figure 8, and Figure 9. These results are not yet final and should be considered preliminary at this time. They are, however, anticipated to be representative of the style and format that we anticipate providing the CFD model results in for the full study report.

Task 4: Study Report

The report is well underway, with the Station No. 1 forebay and Cabot forebay sections nearly complete. The Cabot fishway and Spillway fishway sections are not yet complete as the model production runs are still underway.

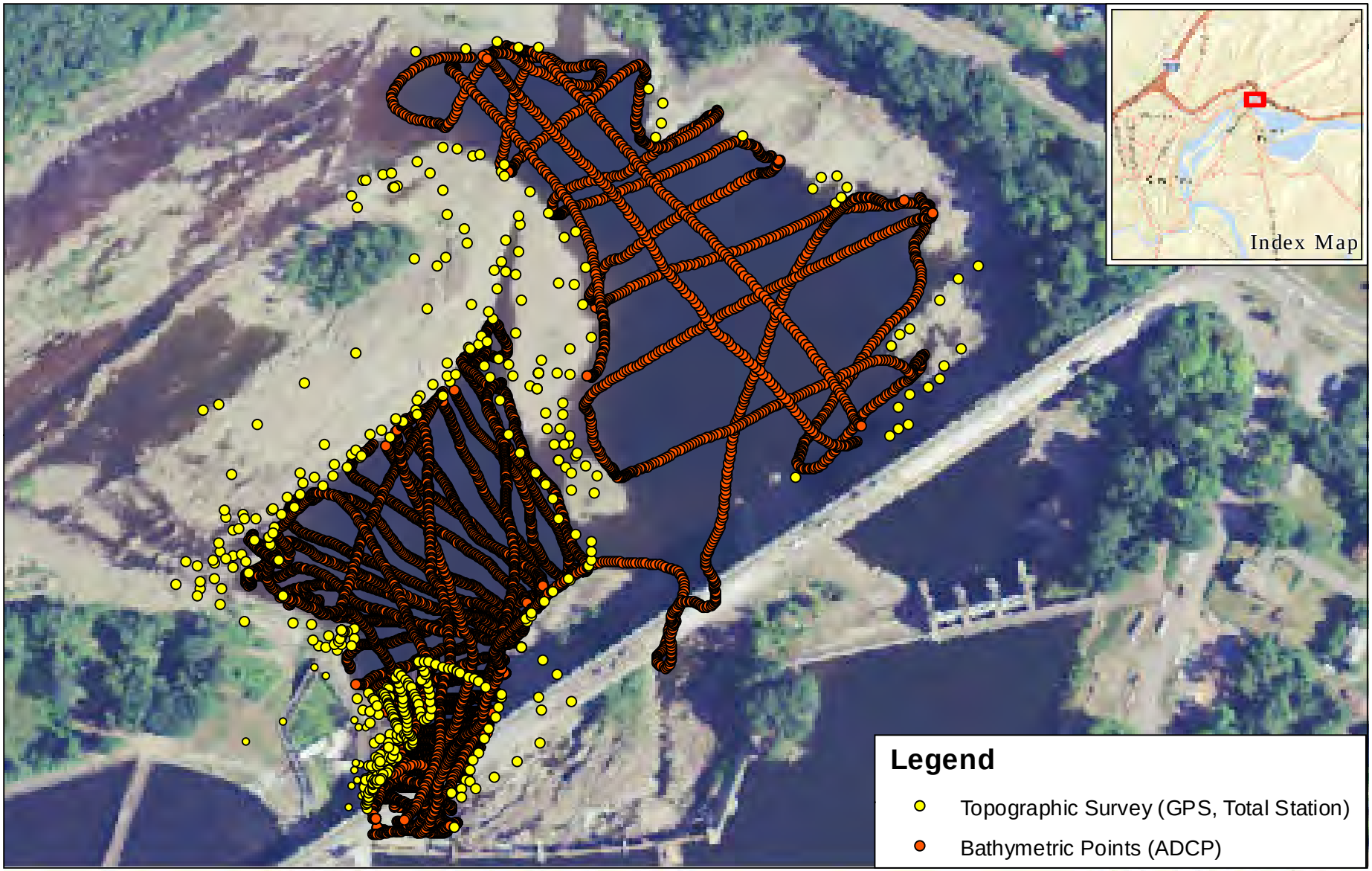
A final report is estimated to be completed by December 1, 2015.

1.3 Variances from Study Plan and Schedule

The RSP envisioned that a separate sub-model of the Station No. 1 Forebay (Model 2) and Cabot Station Forebay (Model 4) would be used to evaluate the flow field conditions at the face of the intake racks to assess approach velocities and sweeping velocities. The Cabot Forebay model (Model 3) and the Station No. 1 Forebay (Model 1) have a 1-foot grid resolution in the area directly in front of the intakes racks which is sufficient for evaluating the approach and sweeping velocities. Because the approach and sweeping velocities are typically evaluated approximately 1 foot in front of an intake rack face, we determined that a highly detailed model of the intake rack was not necessary to meet this study's objectives. In addition, the time and computational resources required to complete a model with the level of detail necessary to resolve the individual rack bars was not compatible with this study.

1.4 Remaining Activities

- Complete model production runs for the Cabot fishway and Spillway fishway areas.
- Complete the study report.



Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays

Bathymetric and Topographic Map of Spillway Fish Ladder Entrance Area

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Figure 1: Example data collection plan map for the Spillway fishway CFD model study area.

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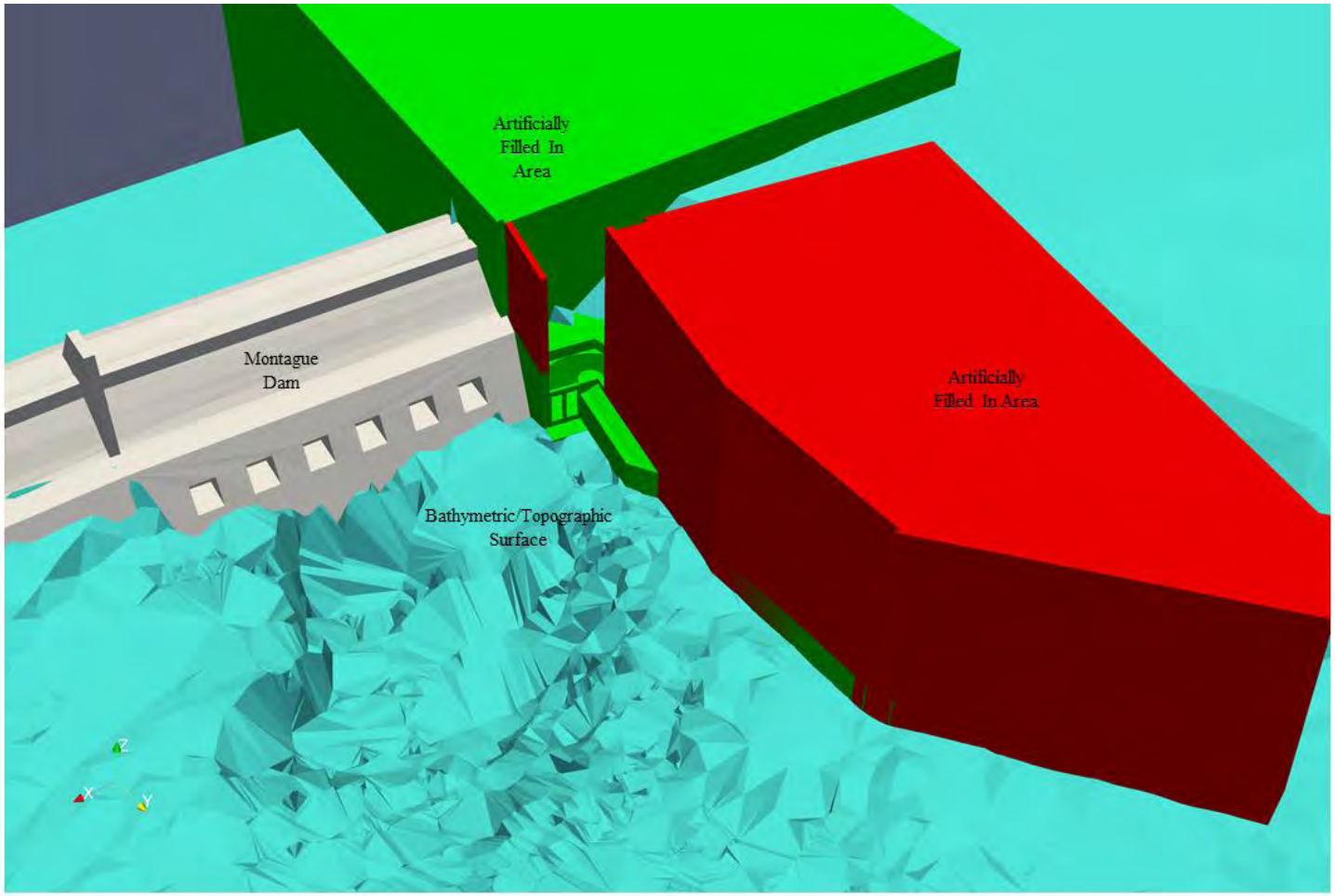

Figure 2: Example of a 'blocked out' area. This example shows the spillway fishway is artificially filled in since it is outside of the modeling area of interest.

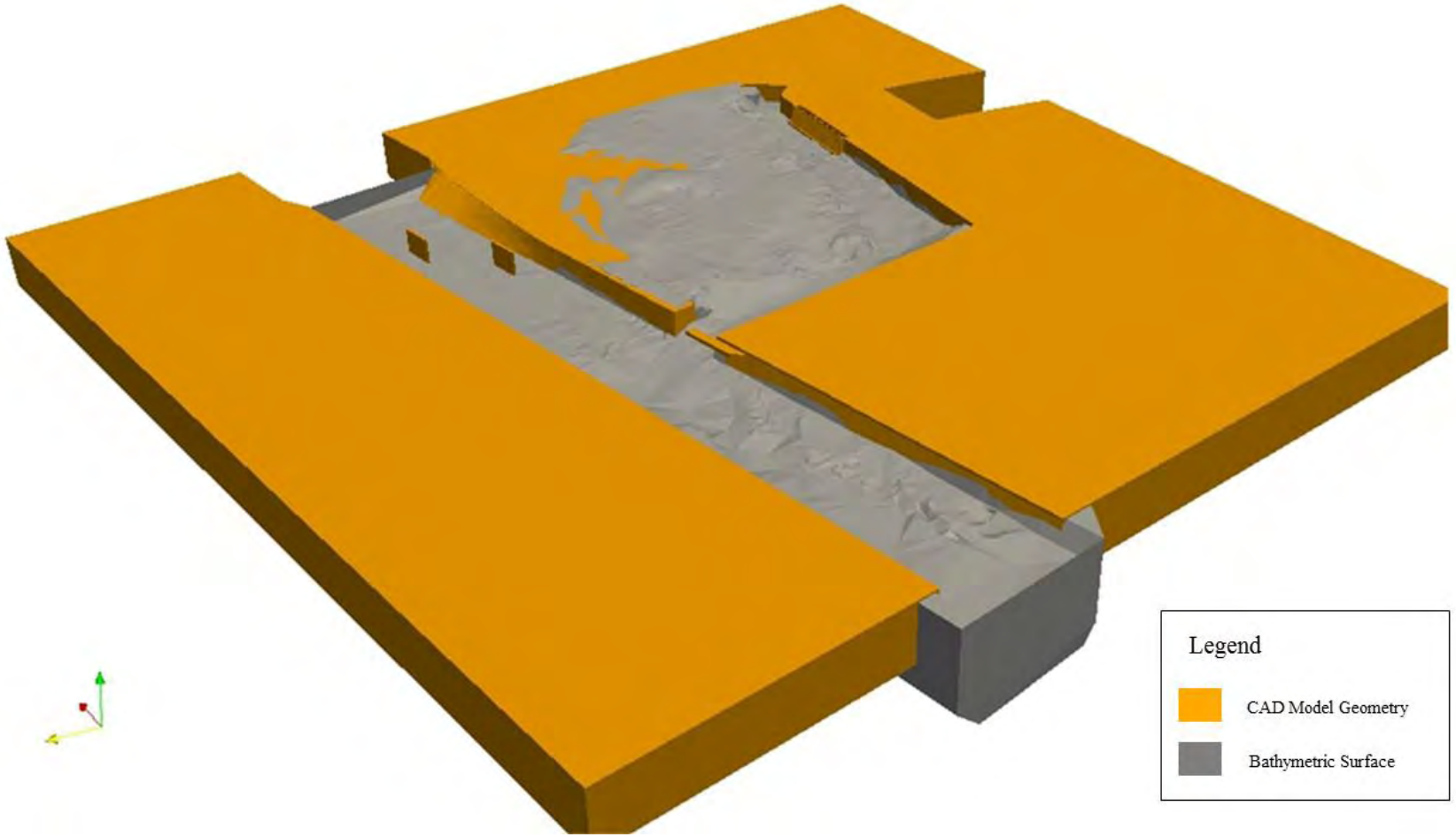

Figure 3: Input geometry for the Station No. 1 forebay CFD model.

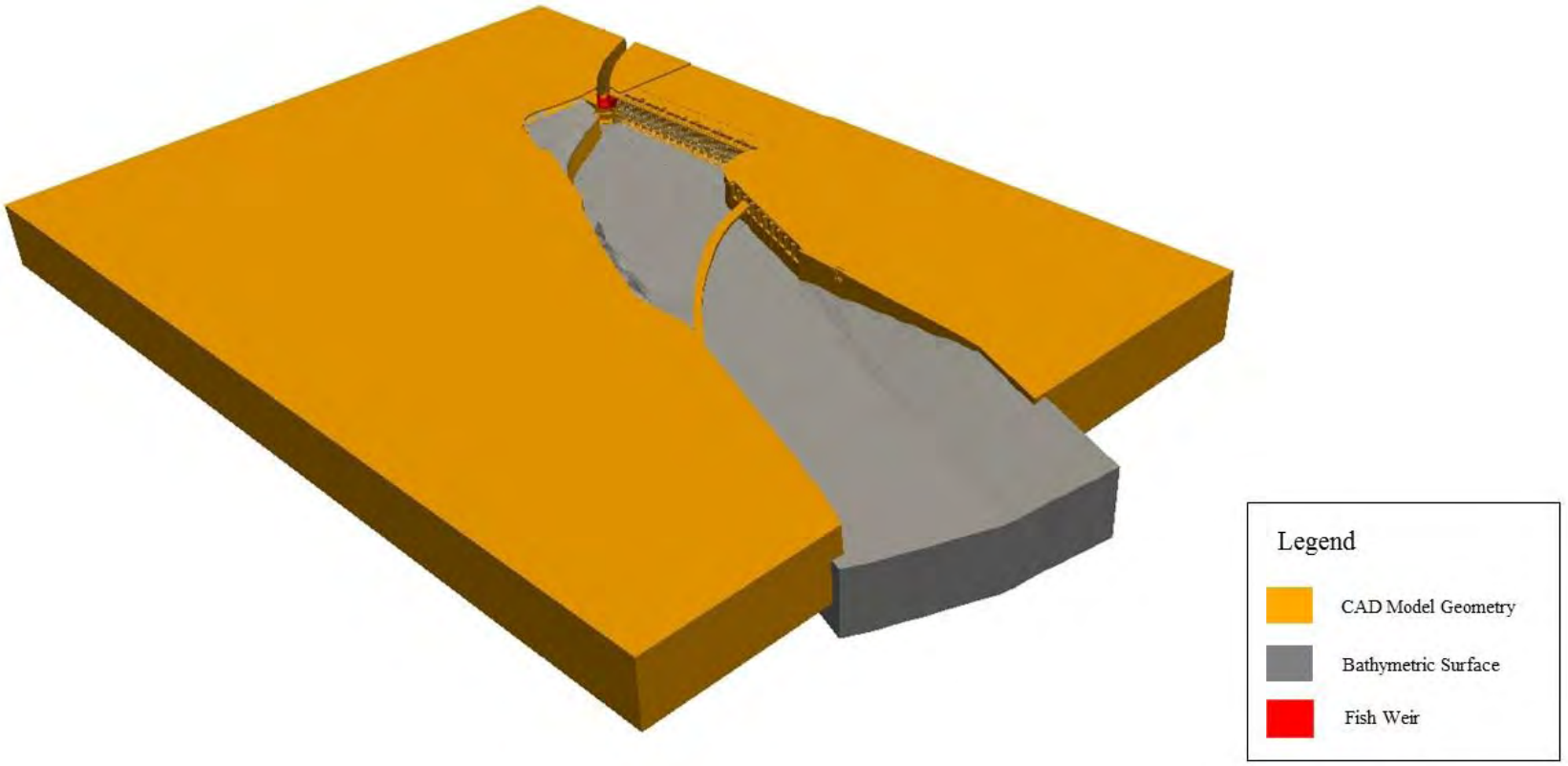

Figure 4: Geometry input for the Cabot forebay CFD model.

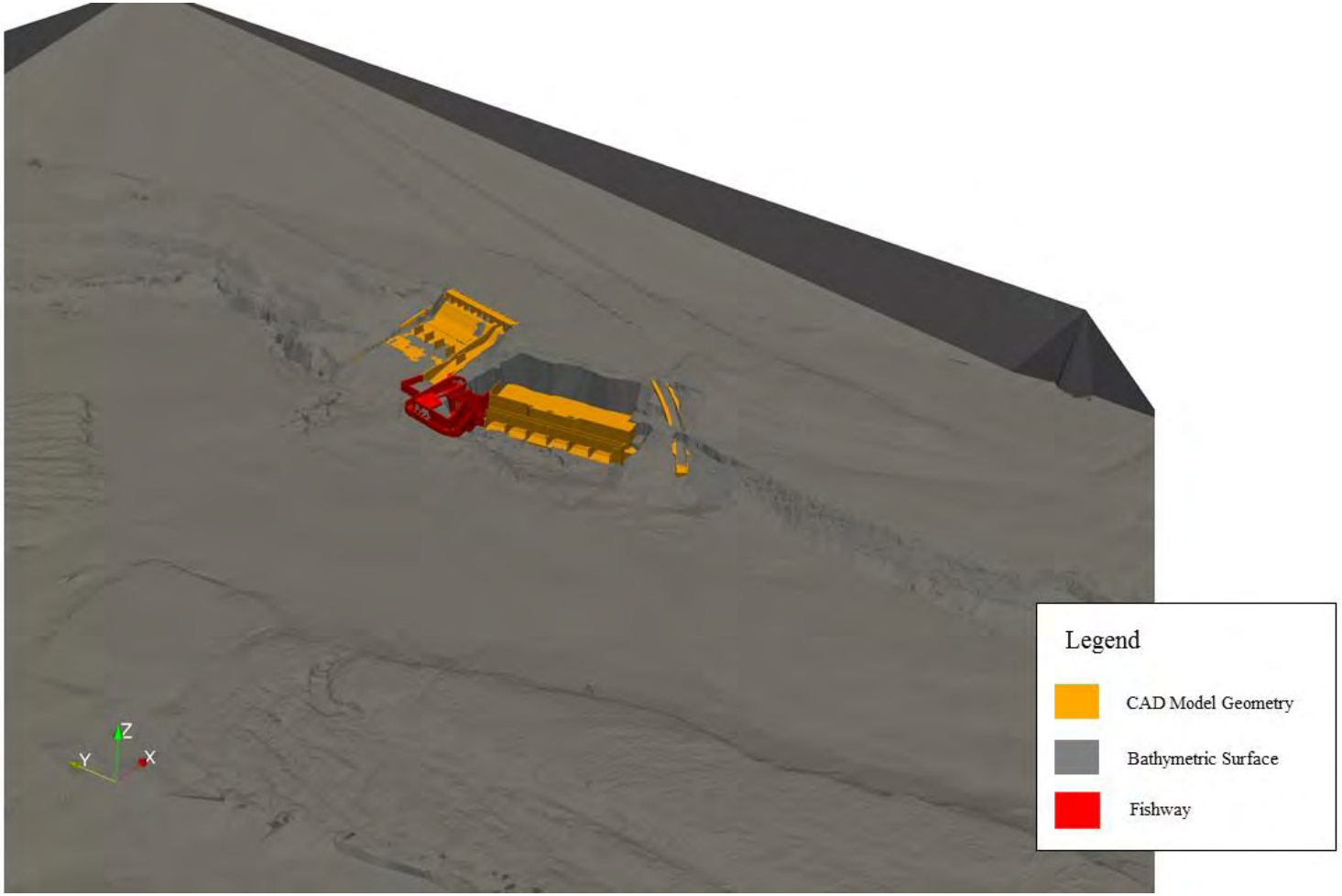

Figure 5: Geometry input for the Cabot fishway CFD model.

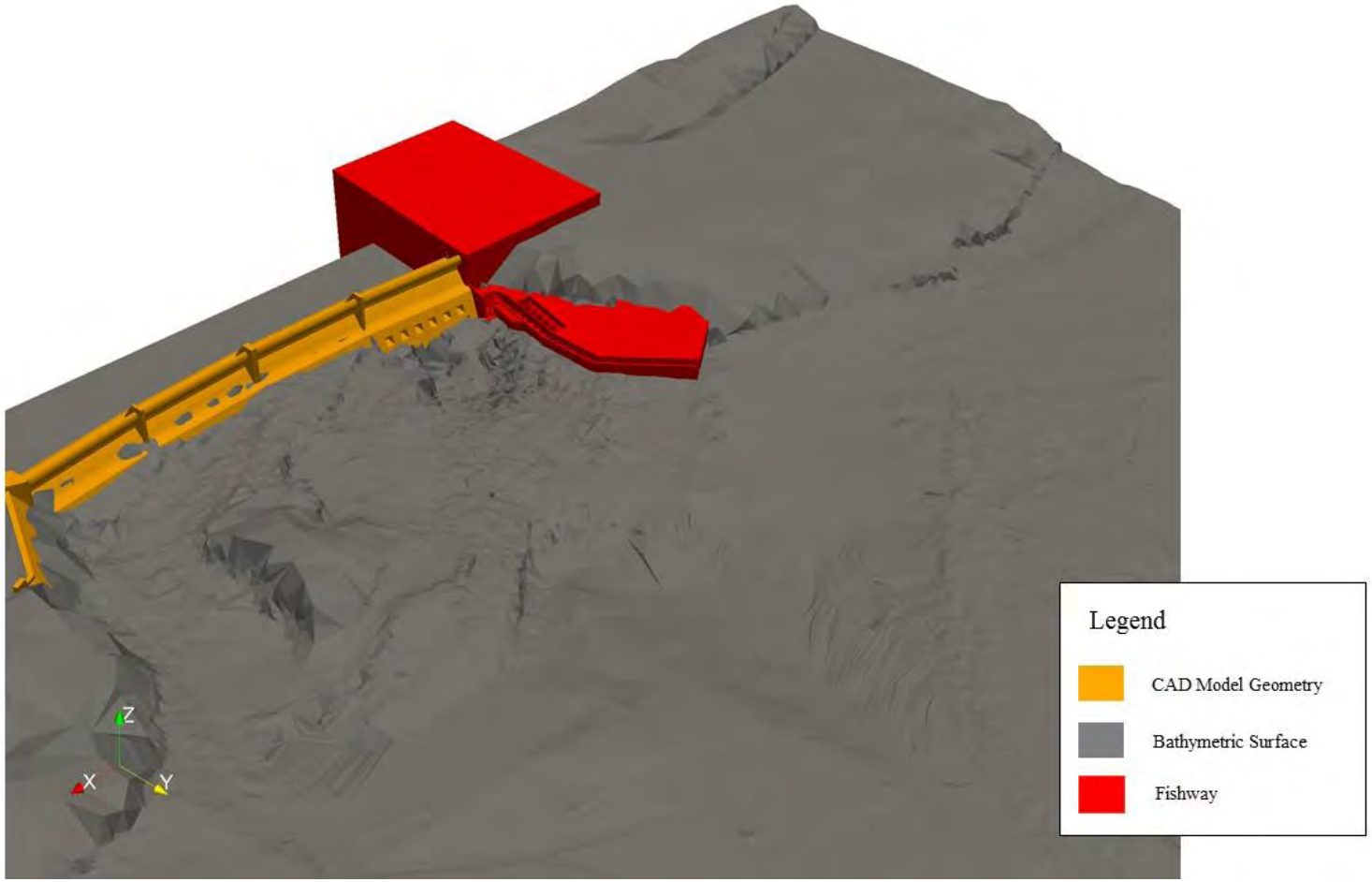

Figure 6: Geometry input for the Spillway fishway CFD model.

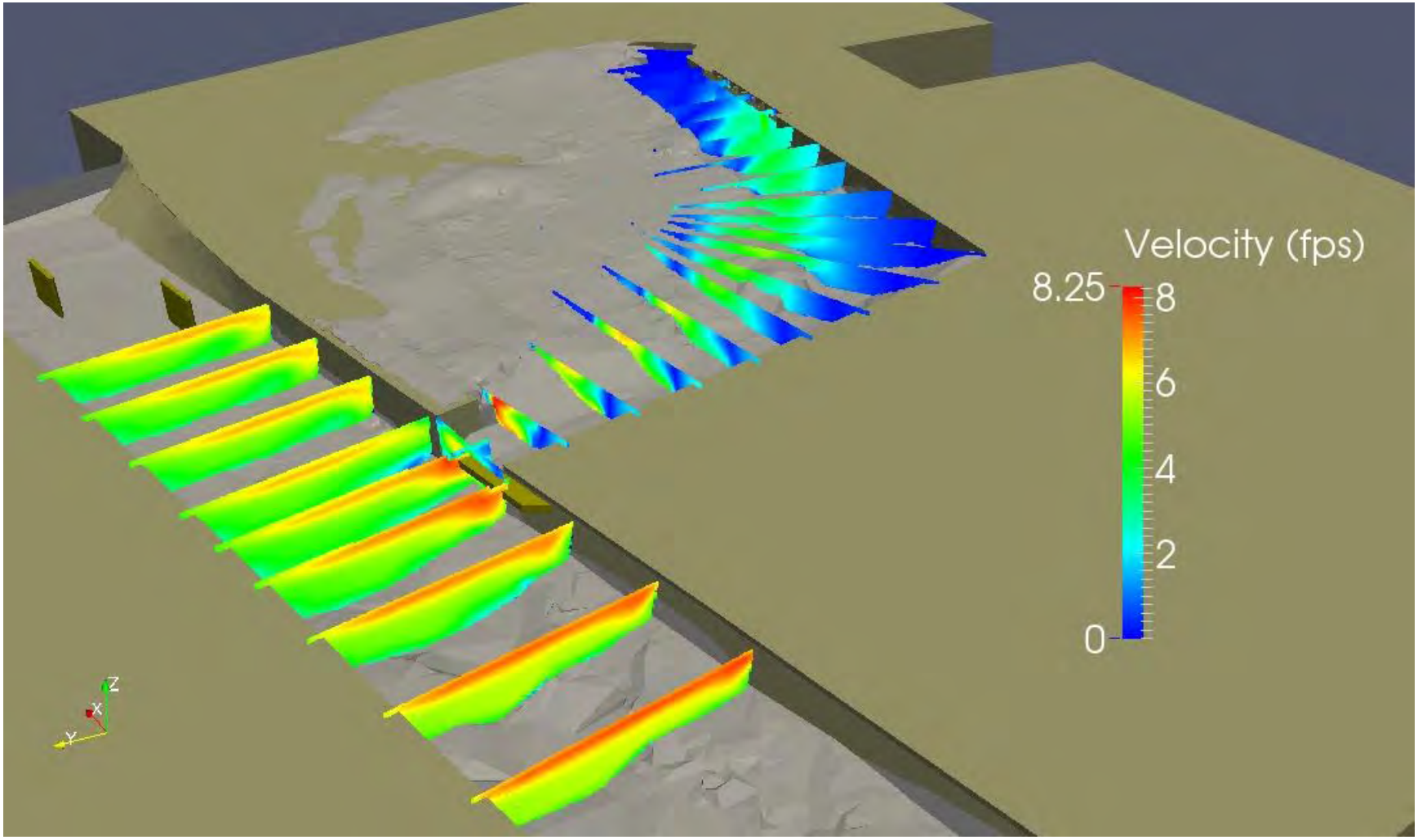

Figure 7: An example of model velocity outputs for the Station No. 1 forebay CFD model production run number 1-3. Results are still preliminary at this time.

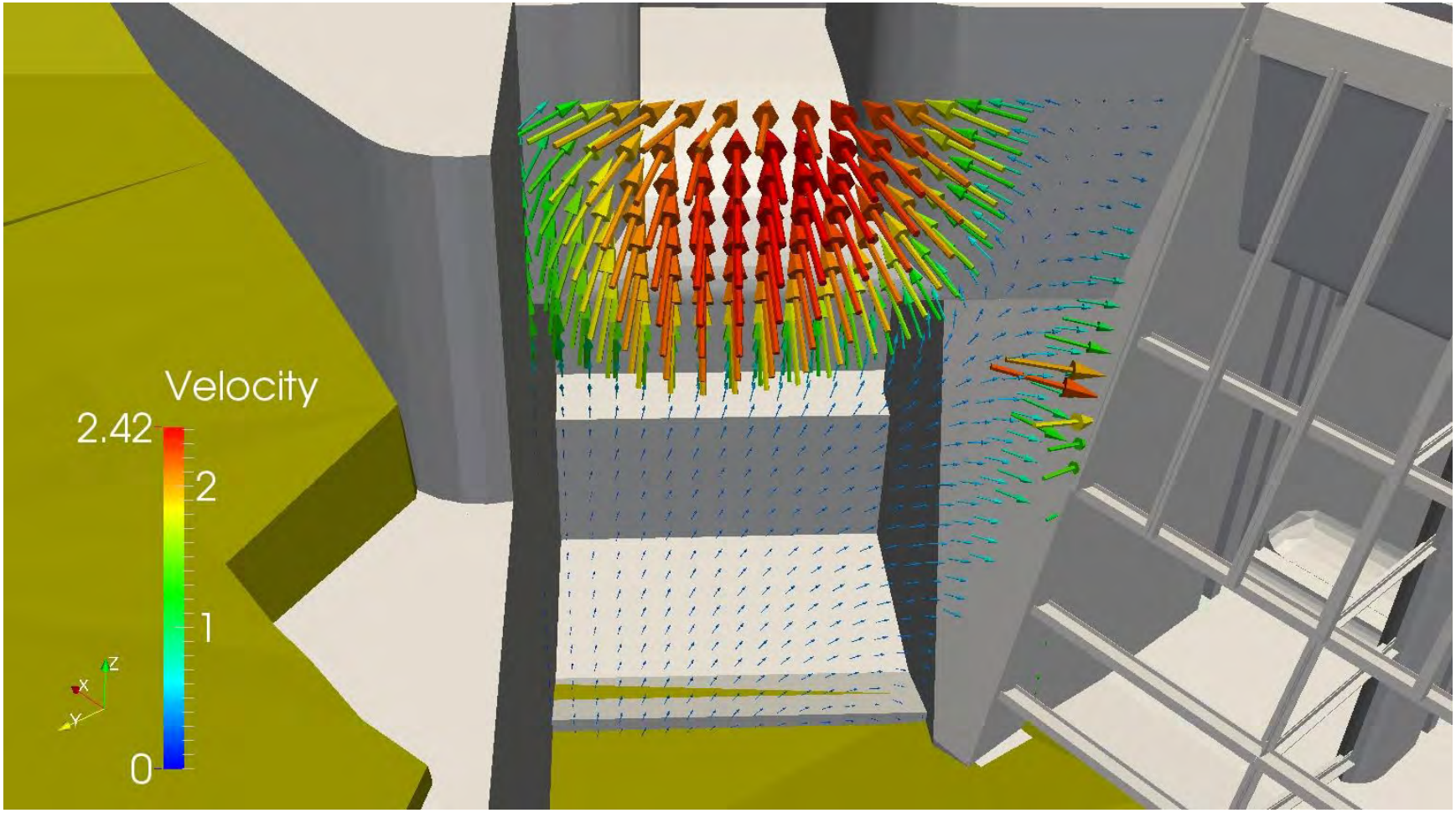

Figure 8: An example vector plot, showing water velocities near the entrance of the Cabot log sluice, for production run number 3-1. Results are still preliminary at this time.

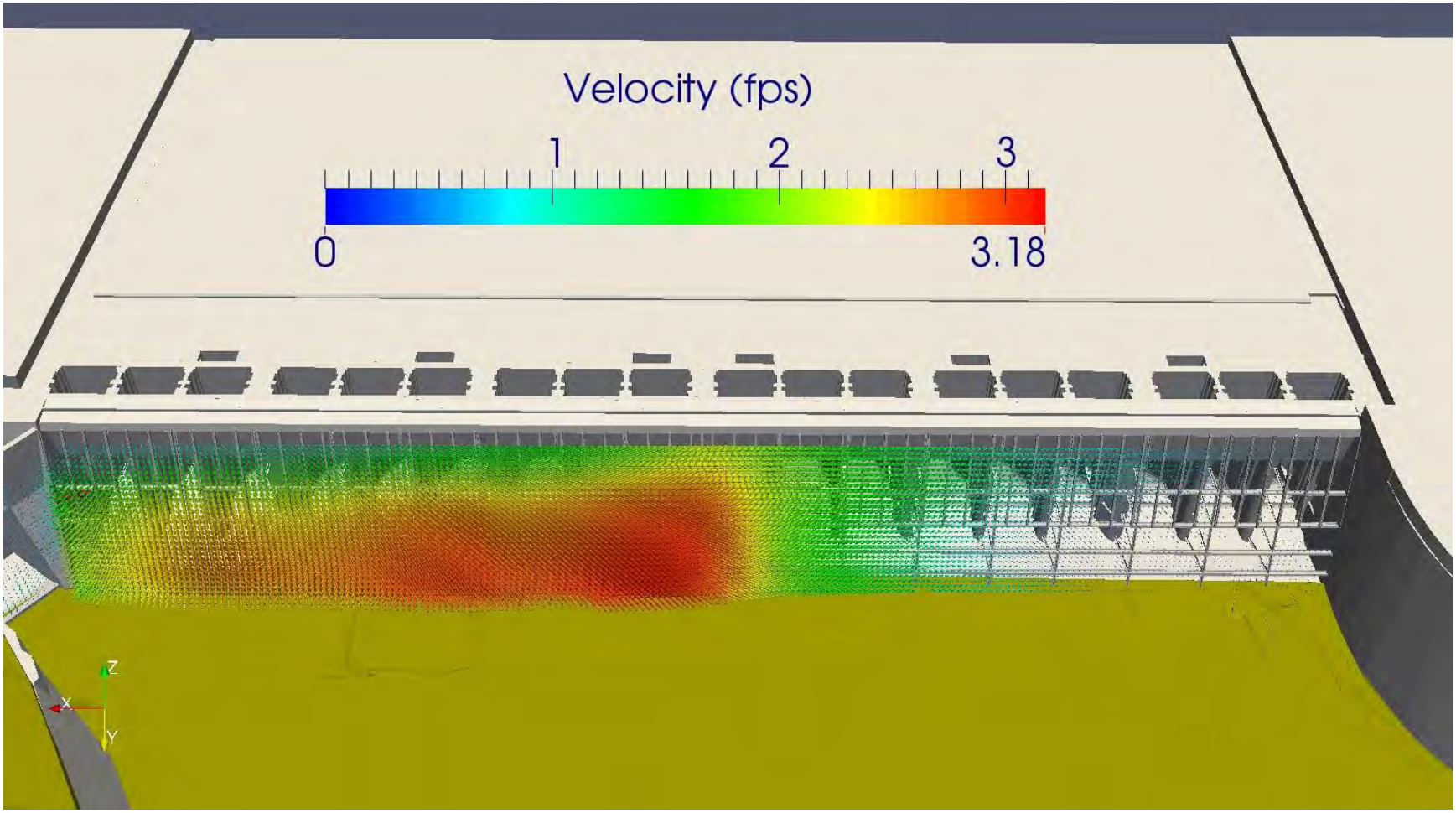

Figure 9: An example of model velocity outputs for the Cabot Station forebay CFD model production run number 3-2, with Cabot Station flow of 7,500 cfs. Results are still preliminary at this time.