Technical Memorandum

To:	Sara Arkle, City of Boise Jim Purdy, City of Boise	Project:	City of Boise Phase II Water Park – Drop Structure No. 1 Modifications
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Subject:	Drop Structure No. 1 - Hydraulic Analysis		

Revision Log

Revision No.	Date	Revision Description
0	September 27, 2023	75% Design
1	December 15, 2023	Revised based on City review

1.0 Introduction

This Technical Memorandum (TM) presents the results of hydraulic analyses related to proposed structure modifications for the new J.A. and Kathryn Albertson Family Foundation Boise Whitewater Park Phase II (Project).

1.1 Purpose

The purpose of this TM is to present results of hydraulic analyses based on the proposed scope of modification to the Project which includes enhancements of the main spillway, modifications to the existing waveshaper to improve tailwater control and hydraulic jump stability, modifications to the controls vault, relocation of stilling wells, and miscellaneous updates to project features that address current challenges associated with the operation of the Project. Most relevant to the hydraulic analyses are the enhancements of the main spillway and modifications to the existing waveshaper.

2.0 Summary of Proposed Modifications

The proposed modifications to the Project include the following elements which have direct impact on the hydraulic design and performance of the structure. These modifications were developed based on the operational challenges identified and summarized under the previous TM Drop 1 Structure Modifications Scope of Work dated June 6, 2023 (McMillen 2023).

2.1 Spillway Modifications

McMillen proposes to split the current 20-foot-wide Gate 5 and Gate 6 to create four 10-foot-wide gates. A sketch of this concept is shown in Figure 1. This will provide increased flexibility for operations of the main spillway and provide flexibility in a variety of flow management situations as well as the following benefits:

- The majority of low flow scenarios flow could be managed with only one or two 10-foot-wide spillway gates particularly when the waveshaper is not in operation.
- Boaters who miss the bypass channel could pass down the main channel and be passed through the Drop 1 spillway with high velocity.
- Ability to shape flow to the center of the river channel using four smaller gates by having one or two center gates (Gate 6 and Gate 7) down and Gate 5 or Gate 8 partially down.

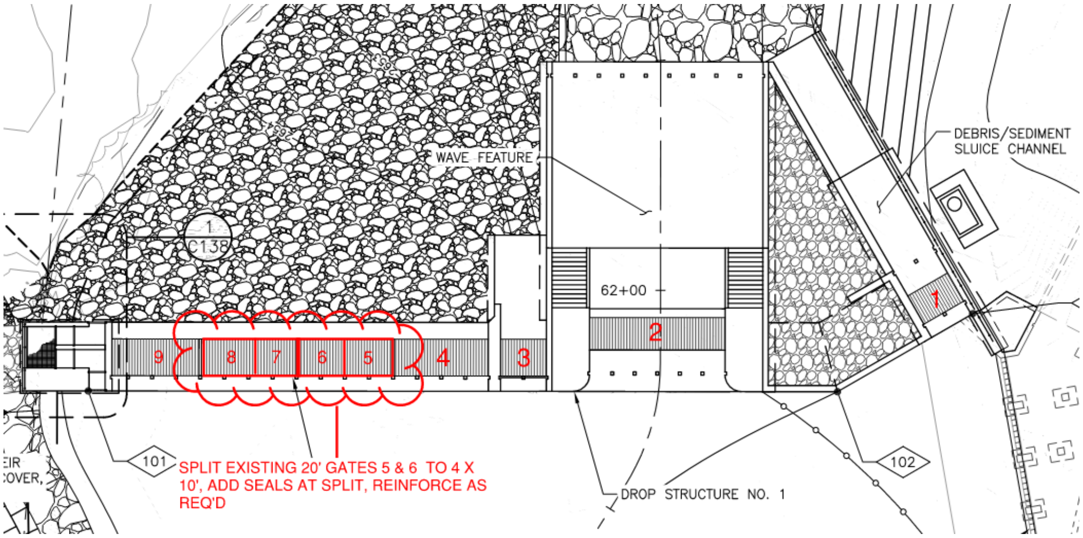

Figure 1 – Proposed Spillway Modifications

The work required to complete the modifications to this feature will include:

- Physical modification of the existing Obermeyer gates. McMillen has confirmed with Obermeyer that it is feasible and the best approach to modify the existing gates.
- Add new piping and electrical cable in the existing routing path from the control building to the new gates.

- Add additional inclinometers to the new gates to allow independent control of all gates.
- Add two gate control zones to the existing Obermeyer controls gates including new valving, piping and PLC programming.
- Dewatering of the drop structure to support construction.

In addition to the structural modifications of the spillway, a 5-feet-deep plunge pool will be excavated downstream of the new 10-feet-wide gates to provide better hydraulic conditions for rafters or tubers that may pass over the modified spillway gate section.

2.2 Waveshaper Modifications

Waveshaper modifications will be focused on downstream control and making the waveshaper less sensitive to changes in the overall river flowrate.

Through an alternatives analysis process, McMillen proposes constructing an adjustable “flip-lip” type feature on a new concrete slab downstream of the waveshaper gate for fine tuning of the tailwater. This feature would be adjustable from the riverbank without dewatering. This structure would consist of a new fully submerged Obermeyer gate downstream of the existing waveshaper structure. In the raised position, the gate would provide additional tailwater depth within the waveshaper feature to improve the operational range. During high river flows, the gate will be lowered to maximize the hydraulic capacity of the main river channel. The new gate would be 4-feet-high when fully raised and 40-feet-wide. The crest of the new Obermeyer gate when fully raised would be approximately 20 feet downstream of the end of the existing concrete waveshaper slab. Additional details related to the design of the new Obermeyer structure are provided under separate cover in the detailed design drawings.

3.0 Summary of Hydraulic Analyses

The following sections discuss the hydraulic analyses performed to assess the modifications proposed to the spillway and waveshaper gates. In general, the proposed modifications are intended to provide increased operational flexibility to adjust drop structure gate positions. Optimal gate positions for all gates should be selected during startup and testing after the modifications have been completed.

3.1 Spillway Gate Empirical Analysis

To assess the changes to the spillway hydraulics following the modification of the two central 20-feet-wide gates into four 10-feet-wide gates, McMillen performed an empirical analysis using a traditional weir equation. A critical assumption included in this analysis is the weir discharge coefficient. The weir coefficient selected for this analysis was based on a relationship of depth over the gate and discharge rate developed for the waveshaper gate. This relationship was estimated based on measurements manually collected at the site in 2019. The developed weir coefficients generally vary between 3.2 and 3.5 for the flow rates and depths evaluated. It is assumed that weir coefficient relationship developed for the waveshaper gate would be similar to that of the spillway gates. The rating curves developed for a 10-foot gate and 20-foot gate are shown in Figure 2.

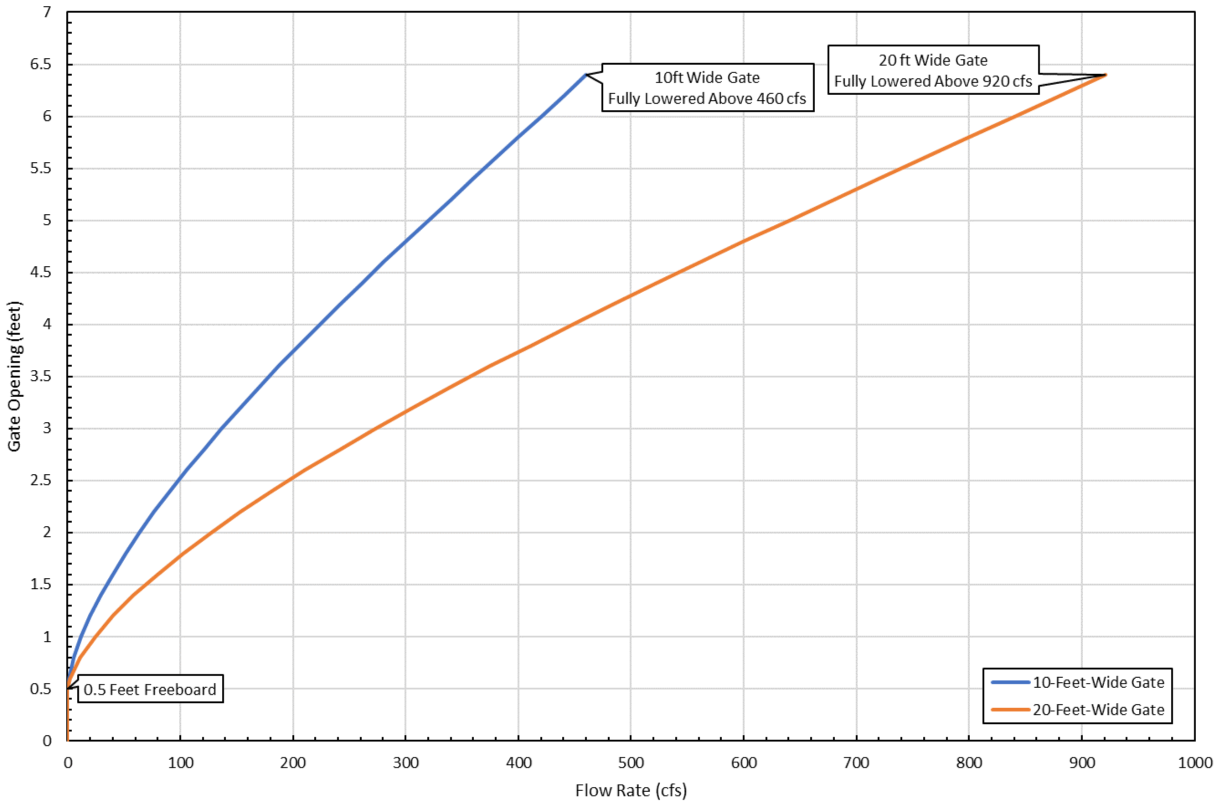

Figure 2 – Comparison of Rating Curves for Singular 10-feet-wide vs 20-feet-wide Gate

As can be seen in this figure, the capacity of a singular 10-feet-wide gate is half that of a 20-feet-wide gate. This leads to a capacity of approximately 460 cfs when a 10-feet-wide gate is fully opened as compared to 920 cfs for a 20-feet-wide gate. Based on these developed rating curves, a full operational curve for all of the spillway gates can be estimated as shown in Figure 3.

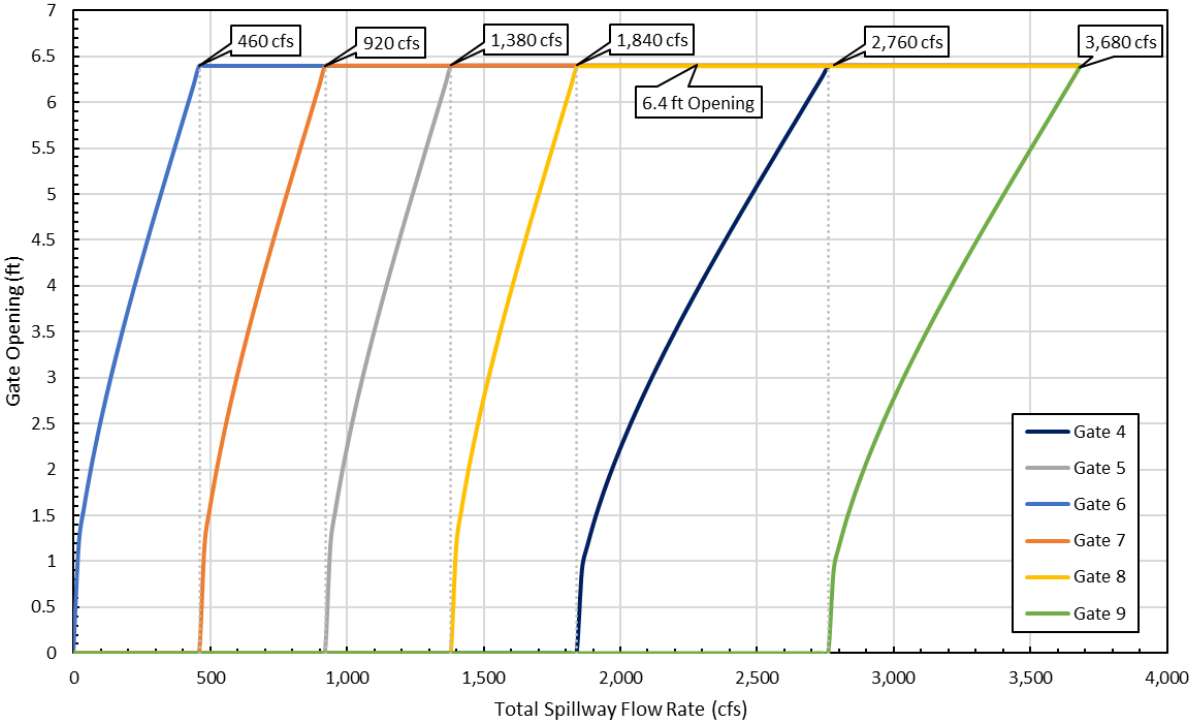

Figure 3 – Overall Spillway Operational Rating Curve

It can be seen in this figure that the modification of two of the 20-feet-wide gates into 10-feet-wide gates provides significantly more operational flexibility.

3.2 Hydraulic Model Setup

To further assess the hydraulics of the drop structure and the proposed modifications, McMillen used computational fluid dynamics (CFD) modeling. The use of a CFD model was instrumental in assessing the hydraulics of the structure due to the dynamic wave hydraulics and complex gate structures. CFD simulations were performed using FLOW3D software (version 22.2.0.17). The CFD model was developed to include a portion of the river upstream of the drop structure, the sluice, waveshaper, bypass gate, spillway, non-overflow sections, and a portion of the river downstream past drop structure 3. The model geometry at drop structure 1 for existing conditions is shown in Figure 4.

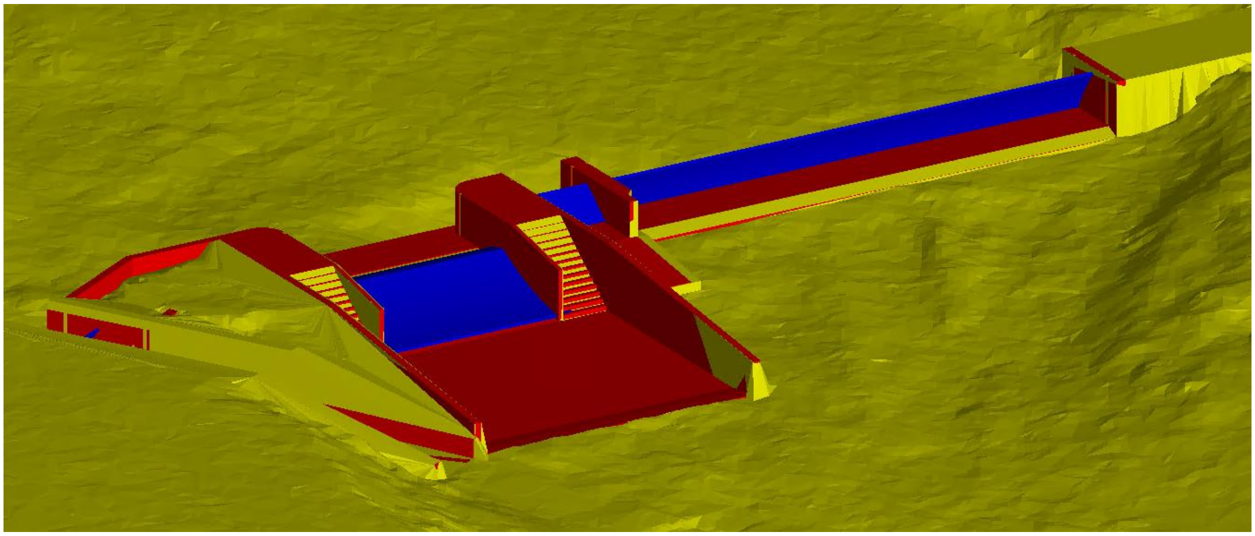

Figure 4 – CFD Model Geometry

Some additional modifications were made to the geometry to remove irregularities from the surveyed surface that did not appropriately represent the as-built conditions of the riverbed. The model domain extended from approximately 60 feet upstream of drop structure 1 to approximately 50 feet downstream of drop structure 3. These extents were selected to place the boundary conditions far enough away from drop structure 1 to not influence the results while also trying to maintain a small and computationally efficient model domain. The model domain was developed using mesh spacings from 0.25 to 1 foot. The smaller mesh spacings were used near the drop structure features to better capture the shallow flow depths as water passes over the gates. The model geometries and mesh were used to develop the mesh-generated Fractional Area Volume Obstacle Representation (FAVOR) geometry in the CFD model. The FAVOR method is used by FLOW3D to represent geometry by smoothly blocking out fractional portions of the grid cells filled with the solid geometry. A comparison of the original CAD geometry and the FAVOR generated geometry at the left side of the spillway approach is shown in Figure 5.

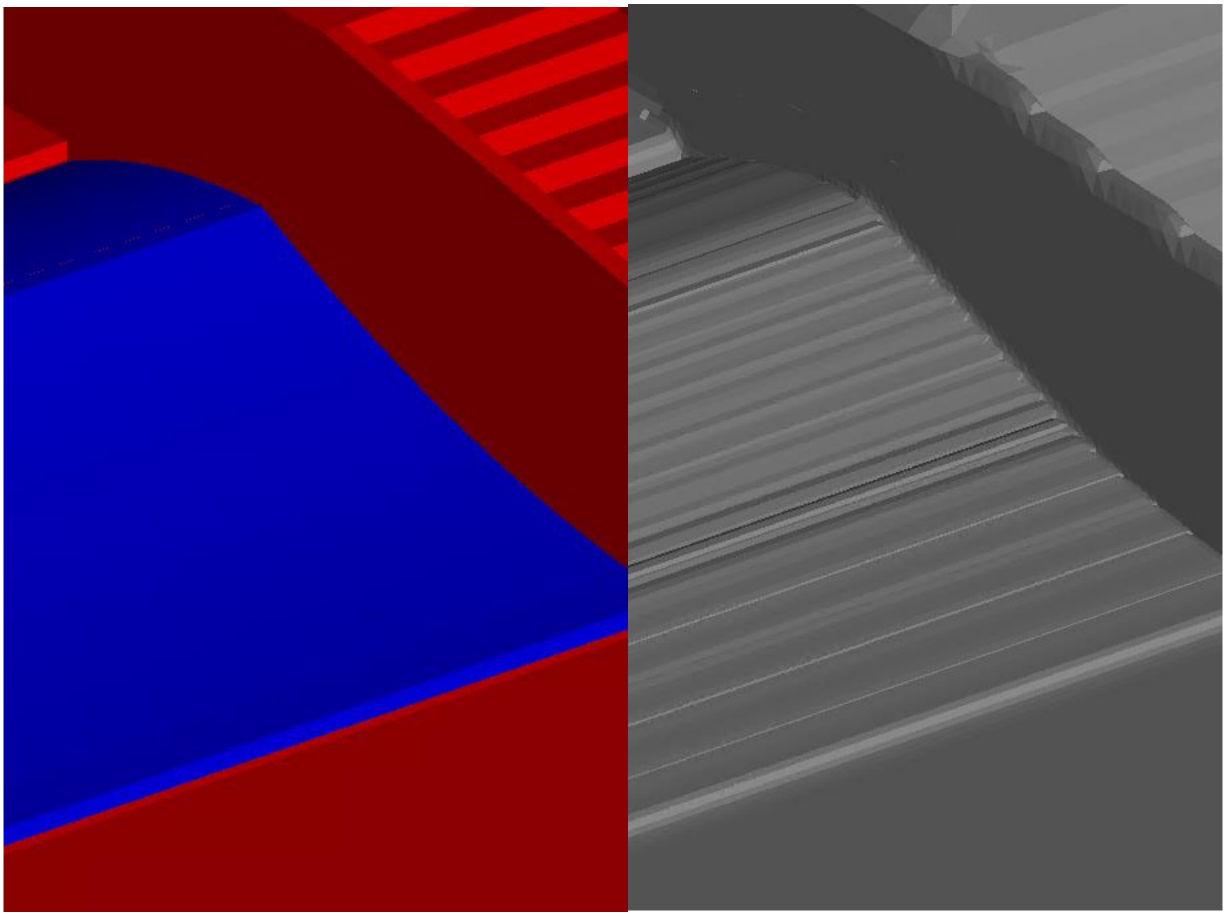

Figure 5 – Comparison of CAD and FAVOR Geometries

Within the FLOW3D model, parameters were selected to appropriately model the proposed waveshaper conditions. The FLOW3D model offers six different options for modeling turbulence. For this study, the k-ε Renormalization Group (RNG) model was used. Flow Science (the developers of FLOW3D) explains that this model is “known to describe low intensity turbulence flows and flows having strong shear regions more accurately”. Additionally, the Immersed Boundary Method (IBM) option was selected. This option is beneficial for evaluating force predictions near walls. Downstream of the proposed Obermeyer structure the shallow water modeling option within FLOW3d was used. This allows the model domain to expand significantly but utilizes simplified depth-averaged calculations to improve computation efficiency where high resolution results are non-critical. The CFD model utilizes a variable timestep that is dynamically computed based on convergence criteria set within the program. This allows the timestep to vary depending on the flow regime within the model domain allowing for a stable run without sacrificing runtime.

At the downstream boundary condition a tailwater rating curve was used. This curve was based on measurements taken in 2019 downstream of drop structure 3. The measurements extended up to a flowrate of 6,560 cfs, above which the curve was linearly extrapolated. At smaller river flowrate of less than about 1,800 cfs the tailwater rating curve was modified to account for diversions through the FUDC bypass. At large flow rates there are significant impacts from submergence at each drop structure and backwatering through the full river reach. The tailwater rating curve used for these analyses is shown in Figure 6.

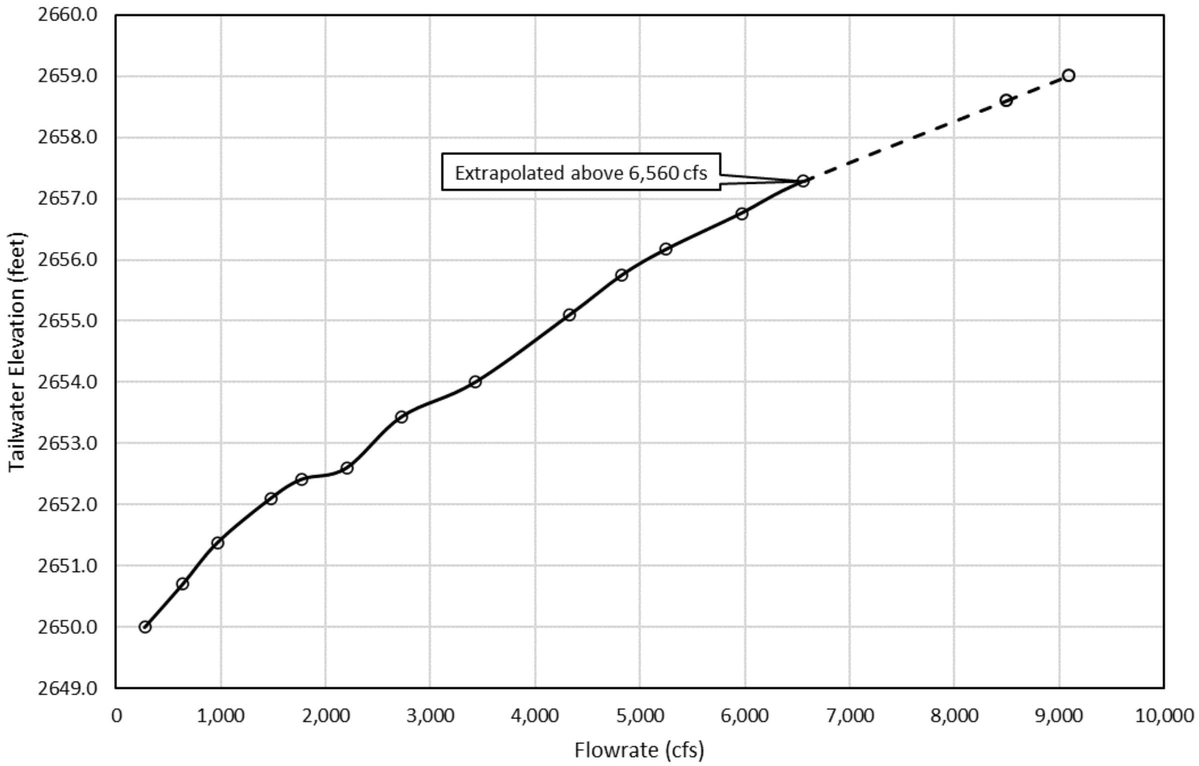

Figure 6 – Tailwater Rating Curve

3.3 Hydraulic Model Results

3.3.1 Waveshaper Gate

Within the FLOW3D model multiple hydraulic scenarios were prepared to evaluate the existing and proposed hydraulics of drop structure 1. These scenarios are summarized in Table 1.

Table 1 – Model Scenario Summary

Scenario No.	Configuration	Drop Structure Flow Rate[1] and Open Gates	Objectives
1	Existing Conditions	500 cfs @ Waveshaper and Bypass	• Confirm undesirable hydraulics at low flow rates • Establish baseline for comparison to proposed conditions
2	Existing Conditions	1,400 cfs @ Spillway, Waveshaper, and Bypass	• Establish baseline for comparison to proposed conditions at an intermediate flow rate
3	Existing Conditions	8,000 cfs @ All Gates, Bankfull	• Establish baseline for comparison to proposed conditions at a high flow rate
4	Proposed Conditions	500 cfs @ Waveshaper and Bypass	• Evaluate wave hydraulics at low end of operational range • Confirm improved hydraulic jump conditions
5	Proposed Conditions	1,400 cfs @ Spillway, Waveshaper, and Bypass	• Evaluate operations of new Obermeyer gate at an intermediate flow rate
6	Proposed Conditions	830 cfs @ Waveshaper and Bypass	• Evaluate wave hydraulics at upper end of operational range
7	Proposed Conditions	7,950 cfs @ All Gates, Bankfull	• Evaluate impacts on overall river water surface and flow regime at a high flow rate

1. Flow rates indicated are over drop structure 1 and do not account for potential diversions through the FUDC bypass or additional flows from Esther Simplot Park which includes Sand Creek.

Except for scenarios 3 and 7, all scenarios were performed with the forebay at El. 2657.0 which has previously been established as beyond the upper bound of the original waveshaper design[1]. Within these scenarios, gate openings were modified to match the targeted flowrates and a discharge of approximately 40 cfs is included at the bypass gate. For scenarios 3 and 7, the

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[1] Previous design iterations by McLaughlin Whitewater included flows down to 300 cfs with a forebay of EL 2657.0 which is a challenging set of criteria for a wide gate for which the original waveshaper gate was not designed for. Per TM006 paragraph 2.3.2 the waveshaper design is designed for 700-1200 cfs. In practice the actual usable range with modification will likely allow for 500-1200 cfs over the waveshaper with a higher than original forebay of EL. 2657.0.

forebay elevation model boundary condition was held at the bankfull capacity (approximately El. 2660.0) with all gates fully lowered and the resulting river flow rates were measured.

3.3.1.1 Scenario 1 – Existing Conditions 500 cfs at Waveshaper

Through discussions with the City, it was established that the waveshaper does not produce desirable hydraulic conditions at low flows. This was exhibited by the CFD model which showed similarly unstable wave operations at low flows. The depth-averaged velocity regime for this scenario is shown in Figure 7.

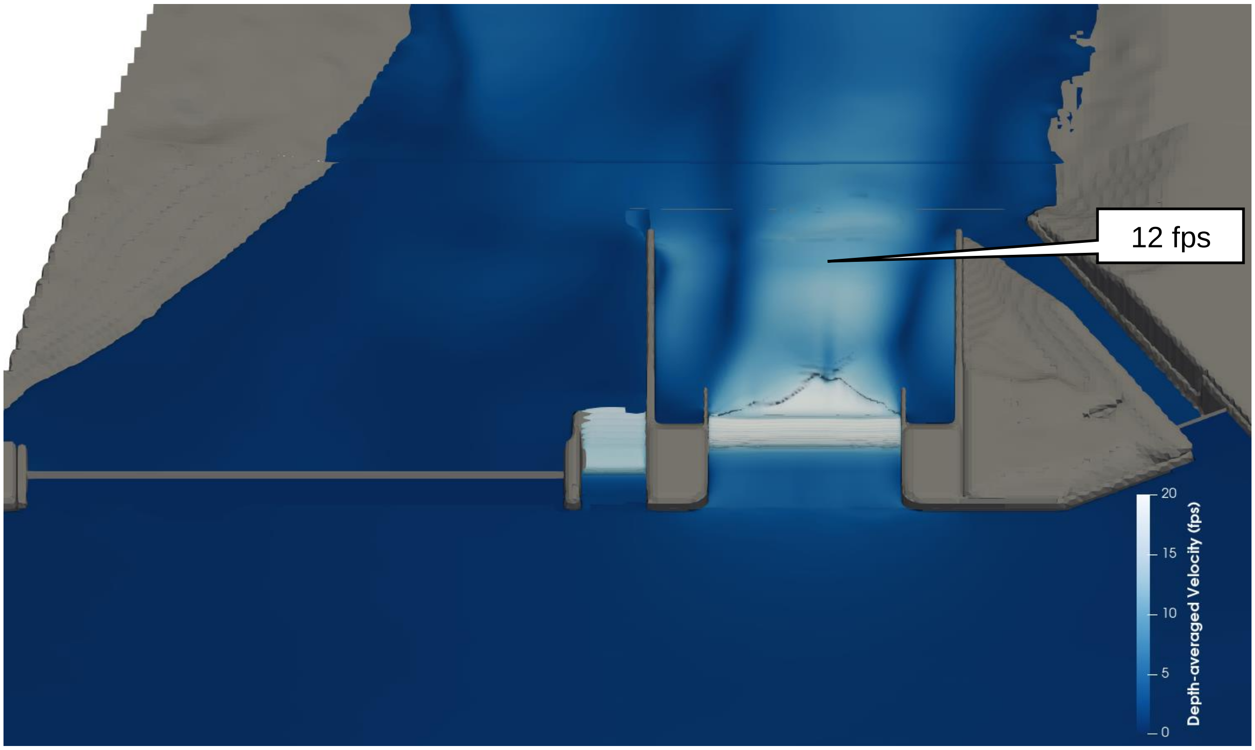

Figure 7 – Depth Averaged Velocities for Scenario 1 (Existing Conditions, 500 cfs)

As can be seen in this figure, a hydraulic jump is not well formed over the toe of the waveshaper gate. This agrees with general observations at the structure. Further, it can be seen that the majority of flows pass uniformly downstream towards drop structure 2 after exiting the waveshaper structure. This is expected as the existing conditions generally have no obstructions in the channel immediately downstream of the waveshaper.

3.3.1.2 Scenario 2 – Existing Conditions 1,400 cfs at Waveshaper and Spillway

Under existing operations for drop structure 1, flows beyond the capacity of the waveshaper gate and bypass channel are passed through the spillway gates starting from the right (looking downstream, Gate 4). McMillen evaluated a scenario where flows are passed through the waveshaper gate, bypass channel, and spillway. In this scenario, the crest of Gate 4 was lowered to El. 2651.85. which is approximately 5.15 feet below the forebay elevation which resulted in a flow rate of approximately 750 cfs through the spillway. Additionally, the waveshaper gate crest was lowered to El. 2653.2. The hydraulic capacity estimated by the CFD model for both the waveshaper and existing spillway gates is consistent with analyses performed during the initial drop structure design. An isometric of the depth-averaged velocities for scenario 2 is presented in Figure 8.

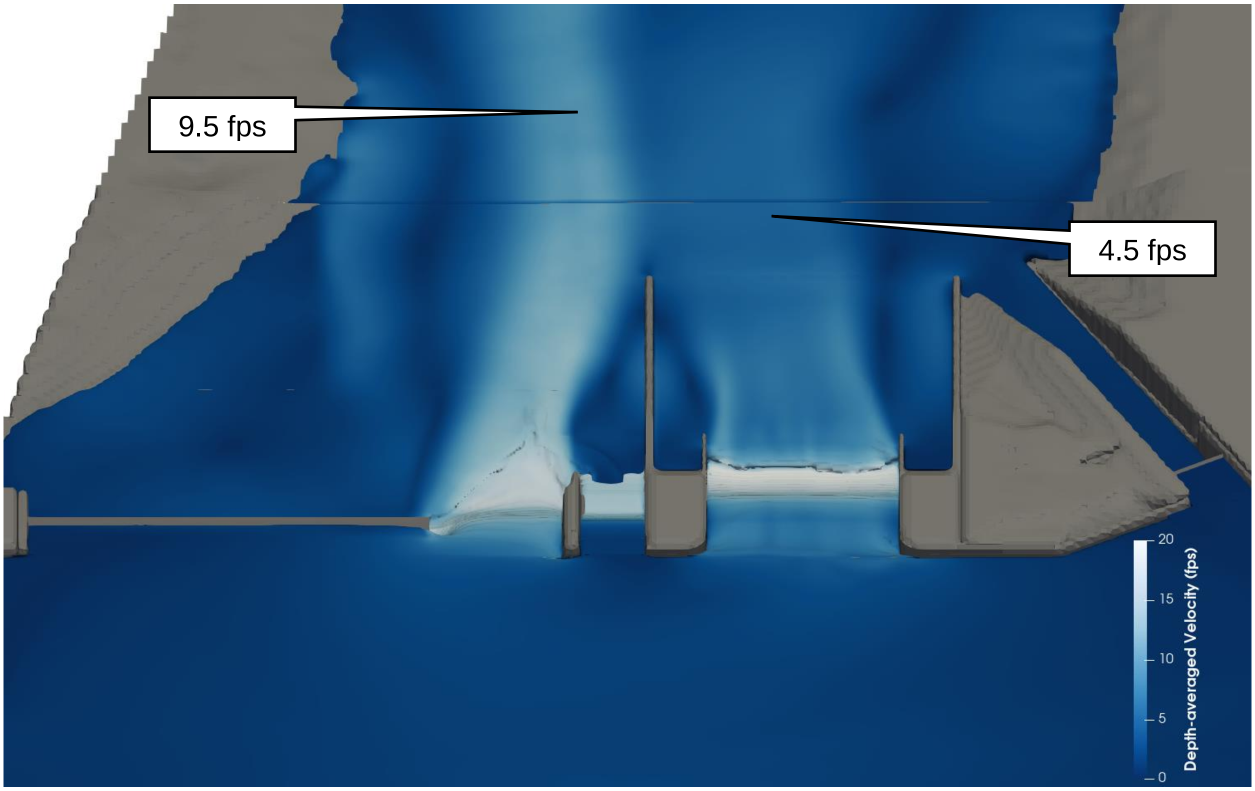

Figure 8 – Depth Averaged Velocities for Scenario 2 (Existing Conditions, 1,400 cfs)

As can be seen in this figure, the velocities downstream of Gate 4 are higher than at the waveshaper as a similar amount of flow to the waveshaper is passed through a narrower gate opening (20 ft vs 30 ft). At the waveshaper, a jump does form but exhibits some instability at the edges near the training walls.

3.3.1.3 Scenario 3 – Existing Conditions Bankfull Capacity

In the bankfull capacity scenario, all gates are fully lowered to pass their maximum capacity. Under existing conditions this bankfull capacity is estimated to be approximately 8,000 cfs. This capacity is significantly impacted by backwatering from the downstream structures and riverine hydraulics. This flowrate represents approximately 48% of the 100-year discharge (16,600 cfs). An isometric of the depth averaged velocities at drop structure 1 under a bankfull flow scenario is presented in Figure 9.

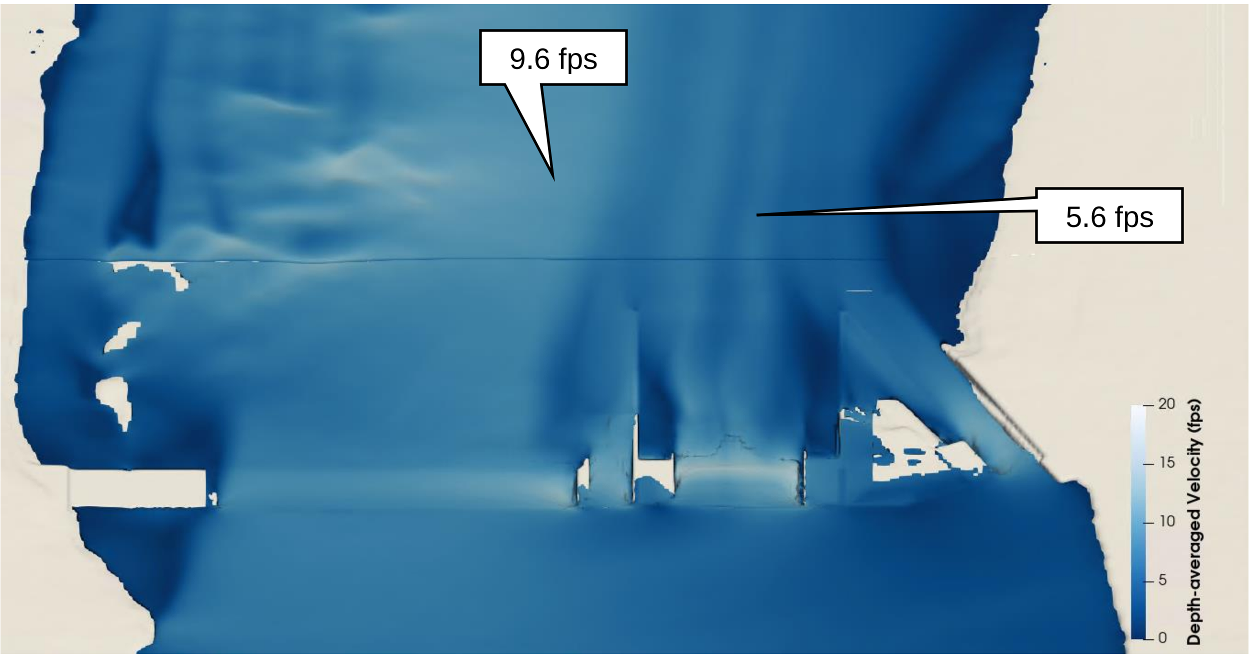

Figure 9 – Depth Averaged Velocities for Scenario 3 (Existing Conditions, Bankfull Capacity)

As can be seen in this figure there is significant overtopping of the portions of the drop structure between gates 1 and 2 (sluice and waveshaper). Velocities at the left side of the river downstream of the spillway are slightly higher than those at the right. This is similar to scenario 2 where more significant flows are passed through the spillway than the other gates. A submerged jump develops at the waveshaper gate but is well beyond the surfable range the structure is designed for.

This scenario was also developed to evaluate water surface elevations downstream of drop structure 1. A plan view of the water surface elevations in the reach between drop structure 1 and 2 is shown in Figure 10.

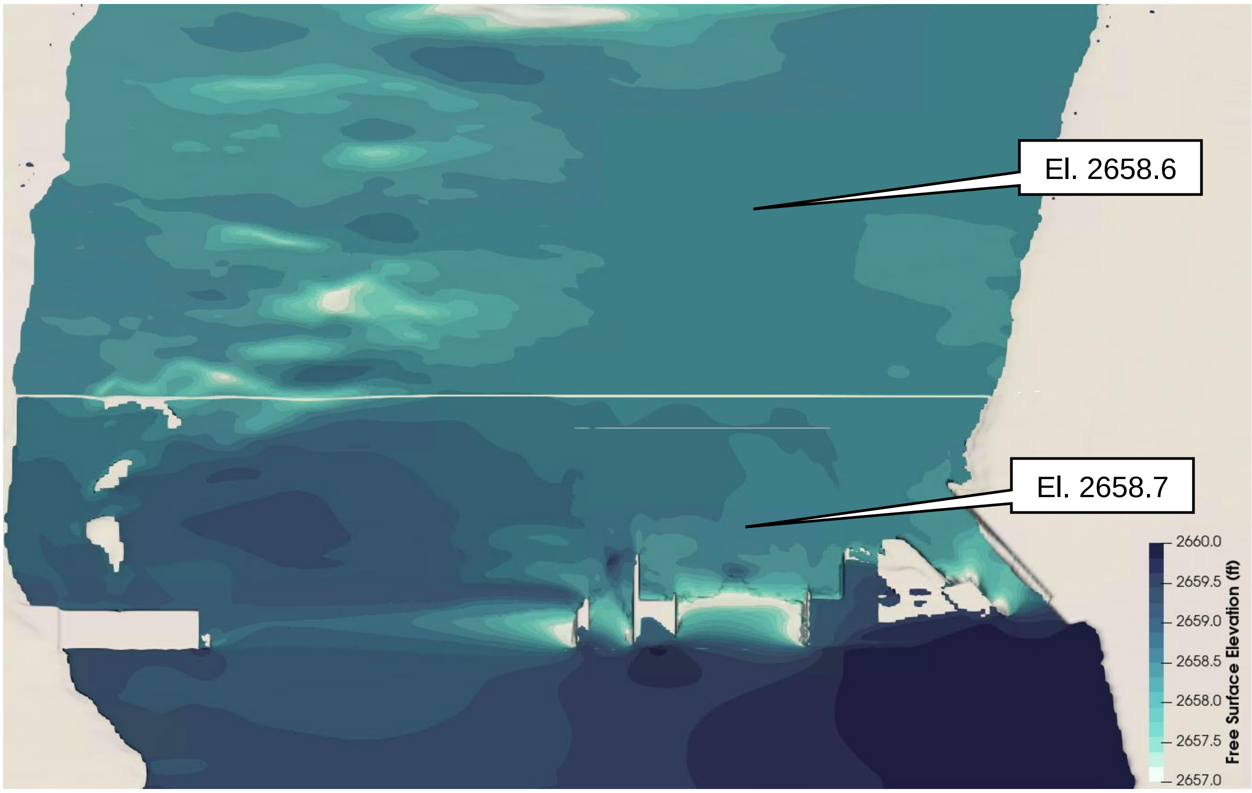

Figure 10 – Water Surface Elevations for Scenario 3 (Existing Conditions, Bankfull Capacity)

As can be seen in this figure the water surface elevations in this area are variable but within the main channel generally range from approximately El. 2658.7 to El. 2658.6. Some instability in the water surface elevations occurs at the left bank where flows would overtop the small island and enter the relatively undeveloped side channel.

3.3.1.4 Scenario 4 – Proposed Conditions 500 cfs at Waveshaper

Under proposed conditions at drop structure 1 the new Obermeyer gate downstream of the waveshaper would be fully raised during low flow conditions of 500 cfs represented by scenario 4. An isometric of the depth-averaged velocities at the waveshaper gate, bypass channel, and new Obermeyer is shown in Figure 11.

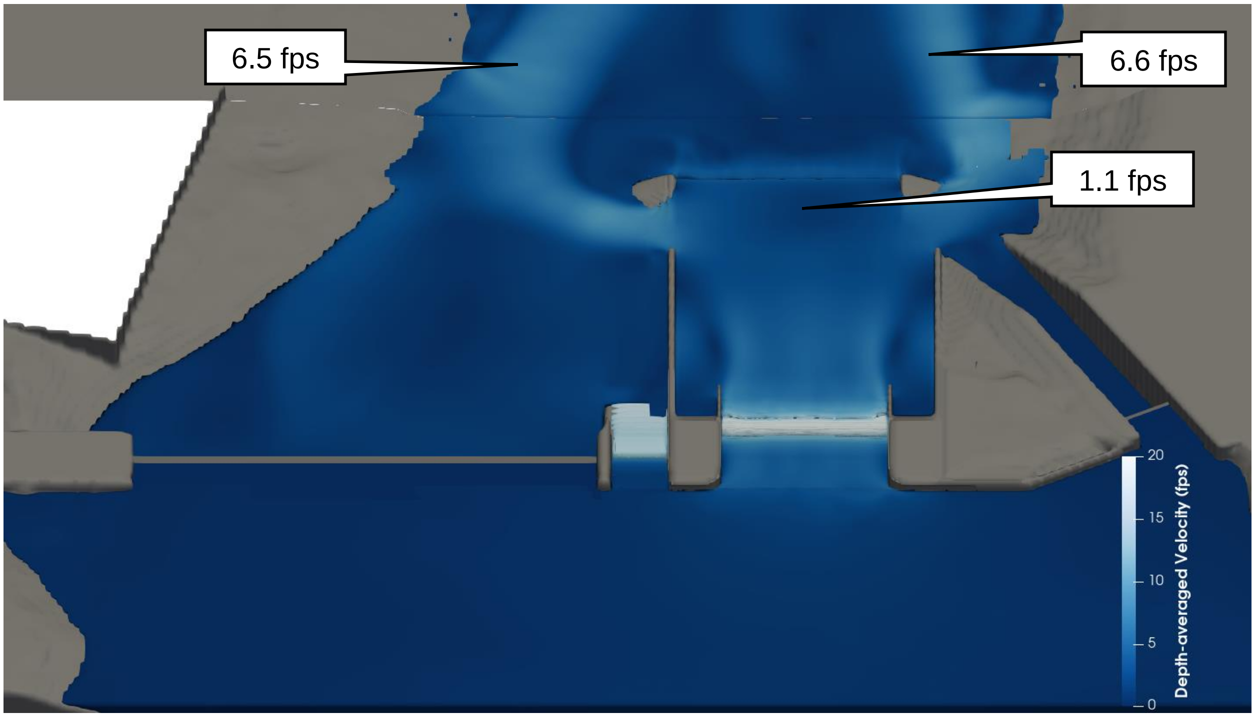

Figure 11 – Depth Averaged Velocities for Scenario 4 (Proposed Conditions, 500 cfs)

As can be seen in this figure, the CFD model indicates that the new Obermeyer is effective at producing a stable tailwater and hydraulic jump on the waveshaper gate. Velocities approaching the raised gate are approximately 1 fps and flow depths decrease to less than 6 inches over the crest of the new Obermeyer gate. The majority of flows are passed laterally towards the left and right banks around the Obermeyer structure. This can be seen in Figure 12 which shows the same depth-averaged velocities with flowpath streamlines overlaid. The streamlines exhibit how flows would split and pass over both the waveshaper and bypass gates.

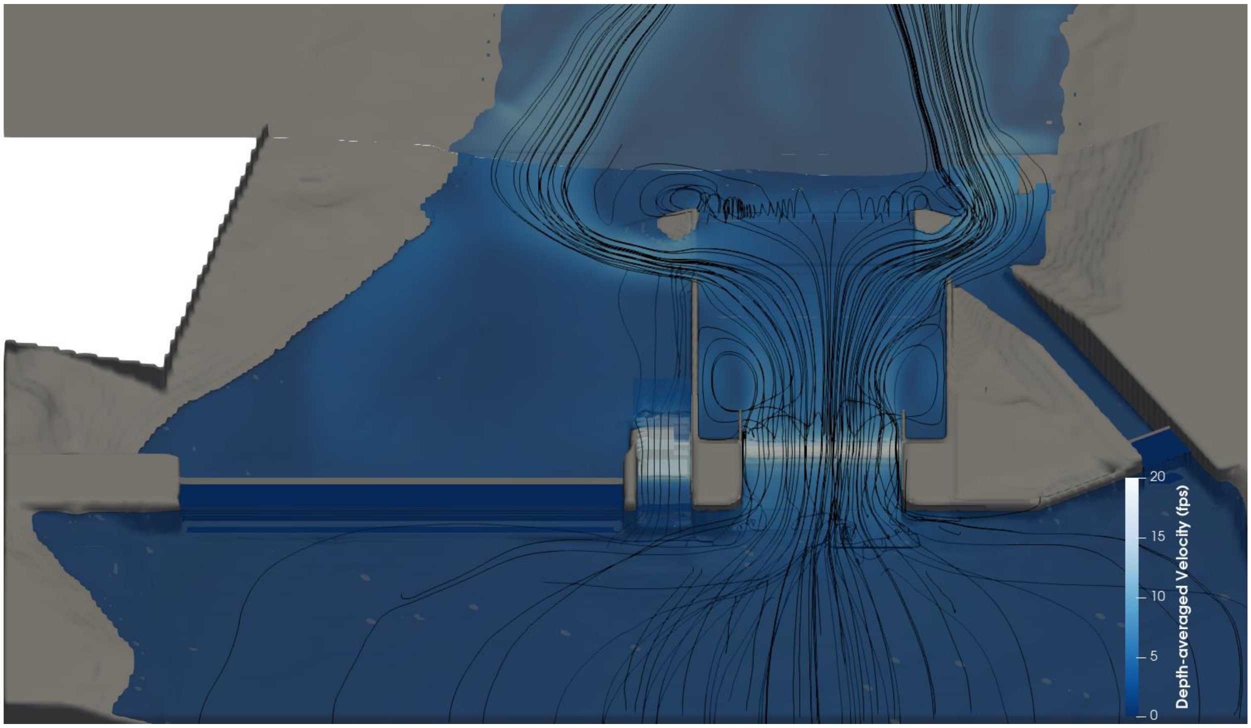

Figure 12 – Flowpath Streamlines for Scenario 4 (Proposed Conditions, 500 cfs)

The results shown in this figure also indicate that a small roller would form downstream of the new Obermeyer gate. However, this does not significantly draw from the flows that pass around the ends of the structure which represent the majority of the flows passing downstream. Detailed isometric views of the depth-averaged velocities and depths near the proposed Obermeyer structure are shown in Figure 13.

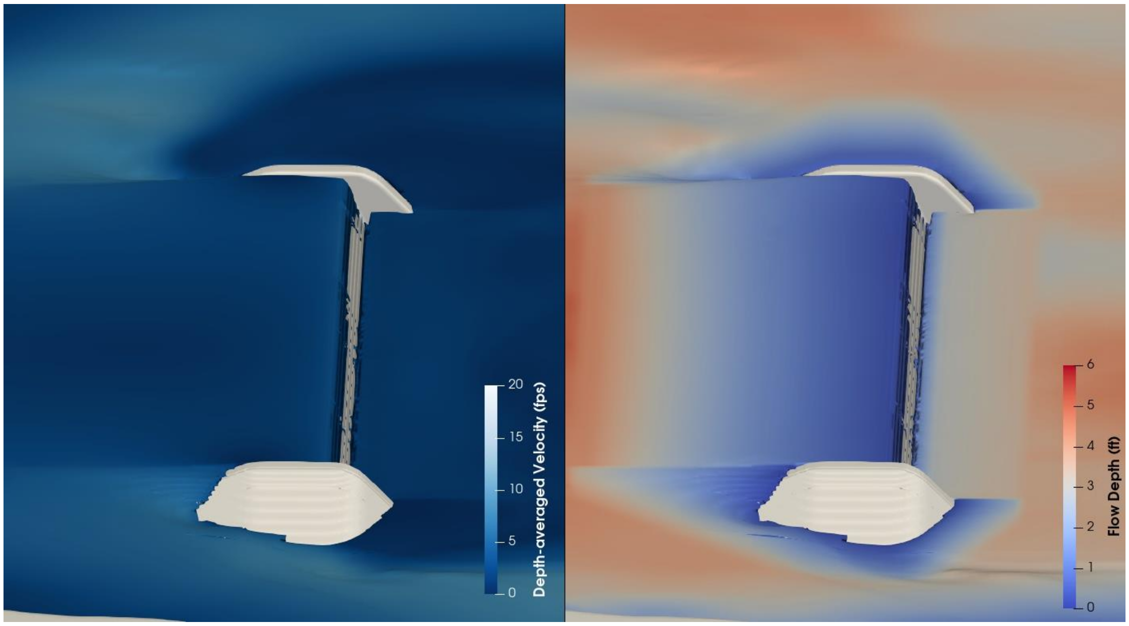

Figure 13 – Isometric Views of Proposed Obermeyer Structure (500 cfs)

3.3.1.5 Scenario 5 – Proposed Conditions 1,400 cfs at Waveshaper and Spillway

McMillen evaluated a scenario where flows are passed through the waveshaper gate, bypass channel, and spillway. In this scenario the new spillway gate numbers 6 and 7 could be lowered to pass approximately 750 cfs downstream. Similar to scenario 2, the waveshaper gate crest would be lowered to El. 2653.2 to pass approximately 650 cfs. The new Obermeyer gate was assumed to be in a fully raised position for this model scenario. An isometric view of the depth-averaged velocities at drop structure 1 for this scenario is shown in Figure 14.

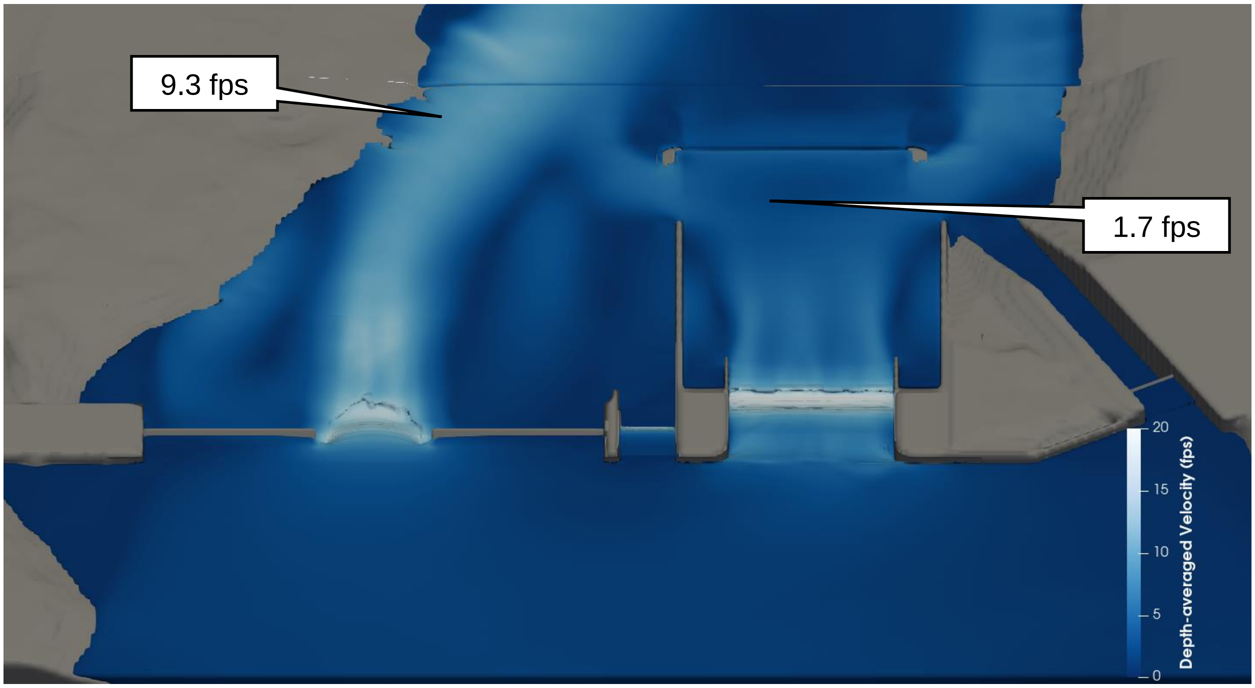

Figure 14 – Depth Averaged Velocities for Scenario 5 (Proposed Conditions, 1,400 cfs)

As can be seen in this figure, the flow regimes downstream of drop structure 1 are relatively similar to that of scenario 2. The most significant difference is that the spillway flows are shifted from the right end of the spillway structure to be more centrally located within the spillway. This leads to a reduction in mixing between flows from the waveshaper and the spillway portions. However, flows passing the new Obermeyer are still directed laterally around the new structure towards the left and right banks. A well developed jump forms at the waveshaper under these flow conditions. Velocities approaching the Obermeyer are approximately 1.7 fps, which is slightly higher than those of scenario 4. A similar flowpath streamline analysis was developed for this scenario and is shown in Figure 15.

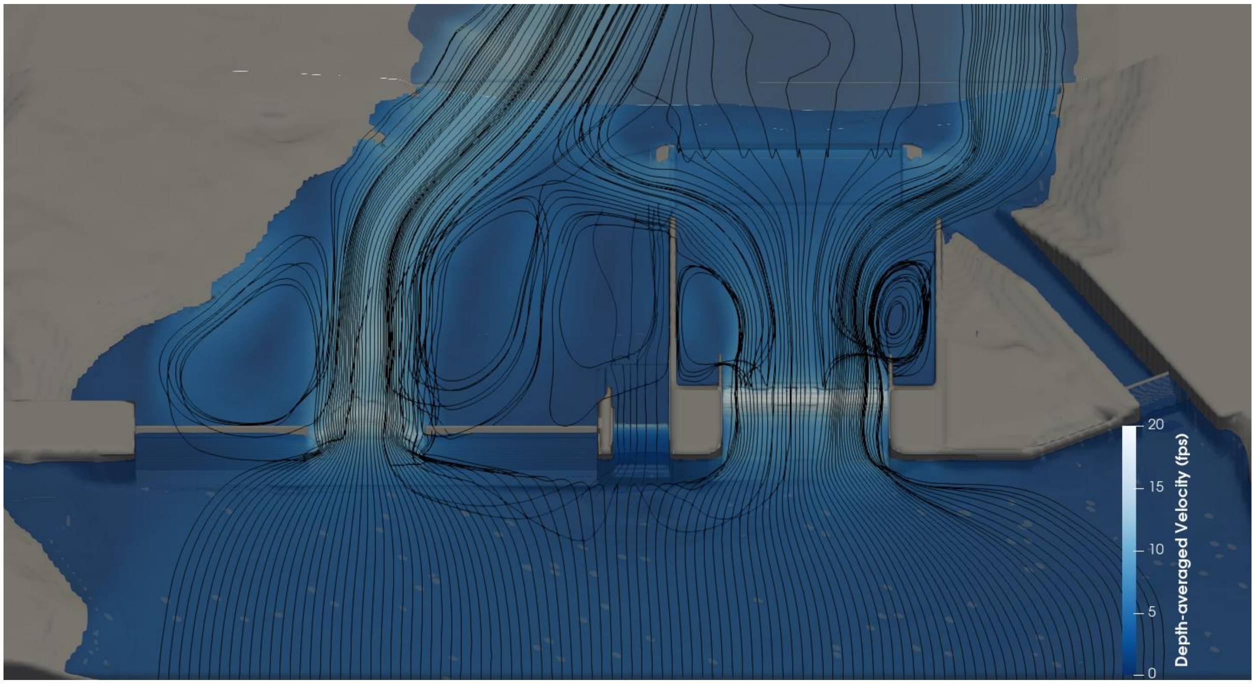

Figure 15 – Flowpath Streamlines for Scenario 5 (Proposed Conditions, 1,400 cfs)

Similar to the streamlines shown in Figure 12 for scenario 4, a small roller forms downstream of the new Obermeyer gate. However, this is largely limited to flows passing directly over the new gate structure. These flows passing over the new gate represent a larger portion of the flows than in scenario 4, however, they are still considerably less than the flows which pass around the structure abutments. To further evaluate the ability of the new Obermeyer gate to regulate tailwater elevations downstream of the waveshaper gate a cross section through the flow in this area is shown in Figure 16.

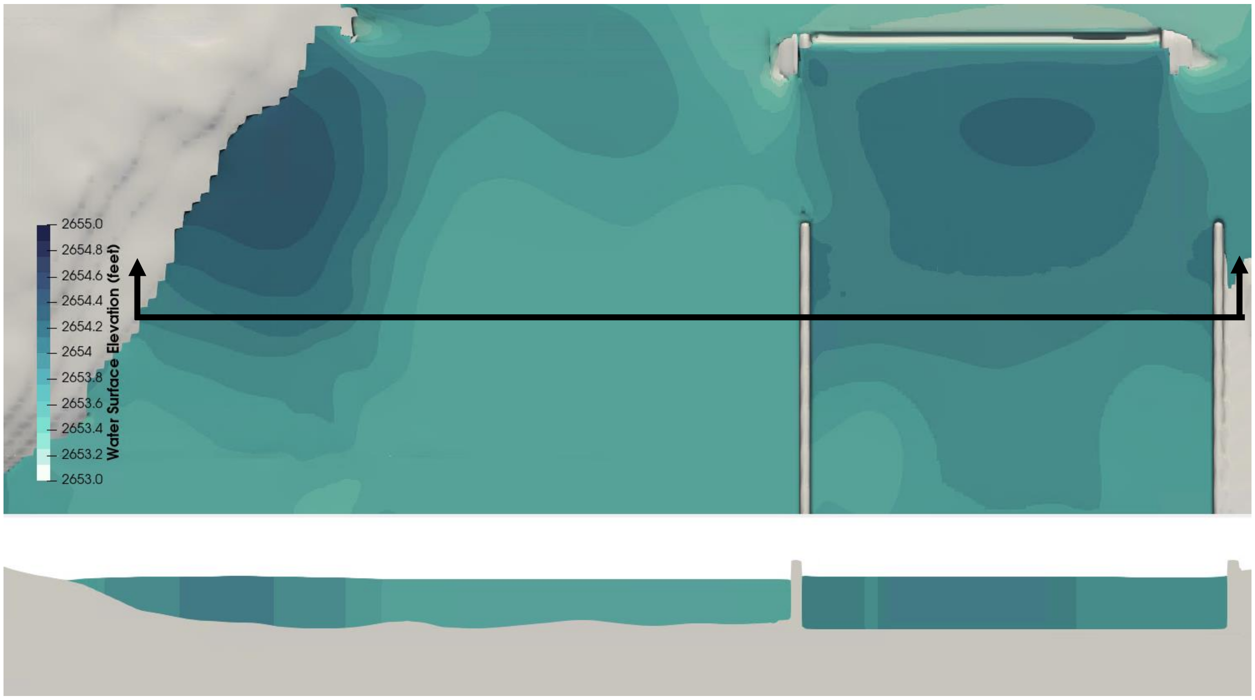

Figure 16 – Cross Section of Results of Scenario 5 (Proposed Conditions, 1,400 cfs)

As can be seen in this figure the new Obermeyer gate increases the tailwater elevation downstream of the waveshaper gate by approximately 0.5 feet when compared to the tailwater elevations downstream of the spillway. Additional increases in the tailwater elevation differential are observed when comparing points directly in front of the new Obermeyer to points downstream of the spillway gates.

3.3.1.6 Scenario 6 – Proposed Conditions 830 cfs at Waveshaper

McMillen evaluated a scenario where the waveshaper gate crest is fully lowered (El. 2652.1) and flows are passed only through the waveshaper gate and bypass channel. The resulting flow rate at the waveshaper in this scenario is approximately 830 cfs. With the waveshaper gate fully lowered the crest loses some discharge efficiency and begins to act more as a broad crested weir than sharp crested. The resulting back-calculated weir coefficient for the fully lowered waveshaper gate is approximately 2.6. This significantly reduced discharge coefficient is typical of shallow flow over weirs that are relatively long in the direction of flow. The new Obermeyer gate downstream of the waveshaper was assumed to be in a fully raised position for this model scenario. An isometric view of the depth-averaged velocities at drop structure 1 for this scenario is shown in Figure 17.

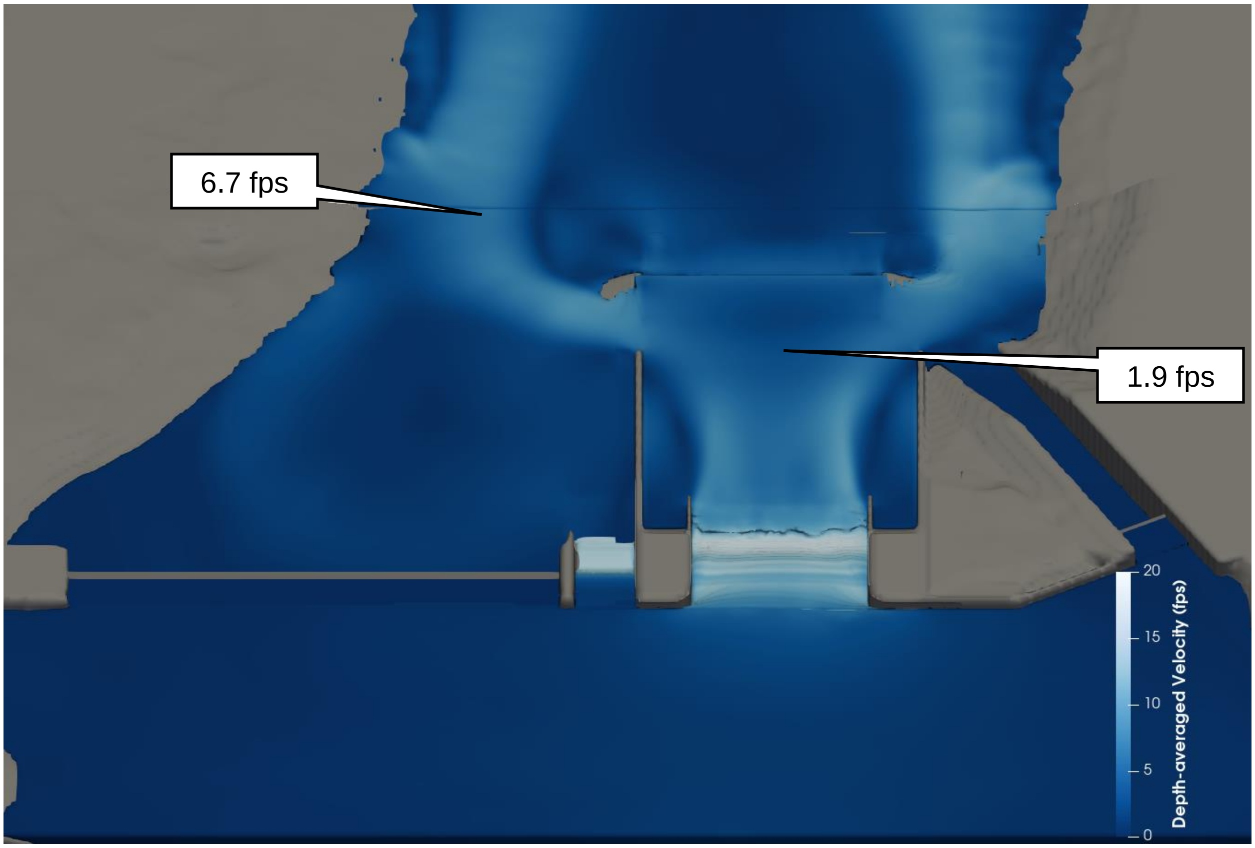

Figure 17 – Depth Averaged Velocities for Scenario 6 (Proposed Conditions, 830 cfs)

As can be seen in this figure, the flow regimes downstream of drop structure 1 are relatively similar to that of scenario 4. As anticipated, based on the larger flow rate, the depth-averaged velocities are slightly higher through the downstream reach. Velocities approaching the Obermeyer are approximately 1.9 fps, which is slightly higher than those of scenario 4. A similar flowpath streamline analysis was developed for this scenario and is shown in Figure 18.

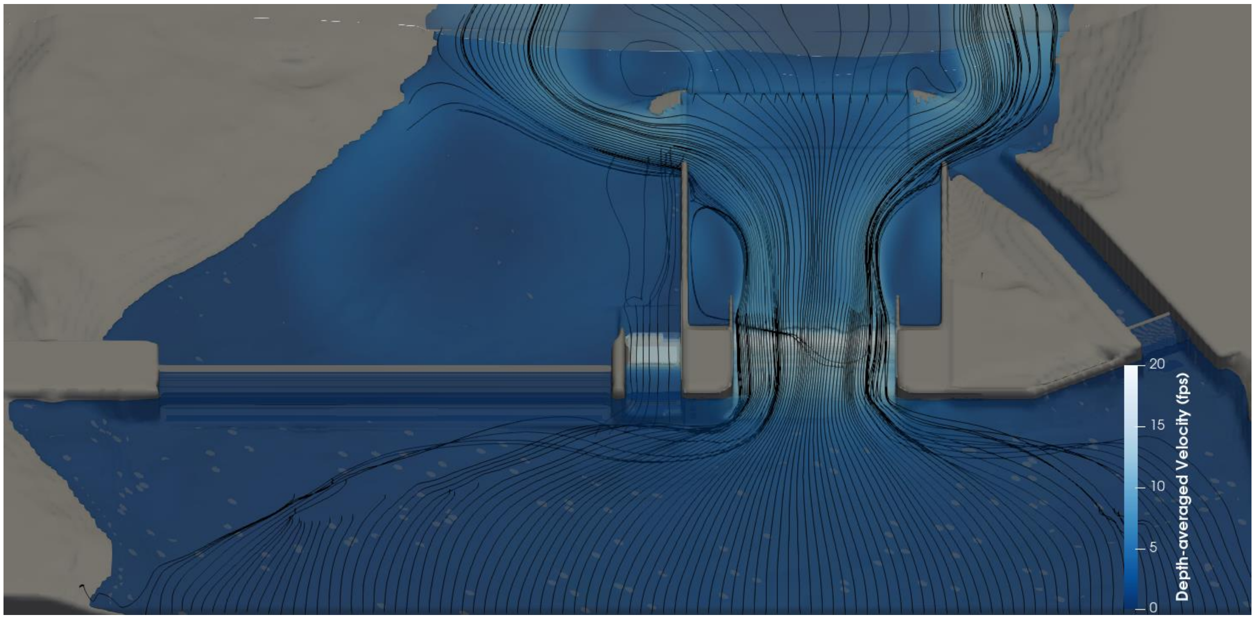

Figure 18 – Flowpath Streamlines for Scenario 6 (Proposed Conditions, 830 cfs)

Similar to the streamlines shown in Figure 12 for scenario 4, a small roller forms downstream of the new Obermeyer gate and a majority of flow passing over the waveshaper is diverted left of the new Obermeyer structure. To further evaluate the ability of the new Obermeyer gate to regulate tailwater elevations downstream of the waveshaper gate a cross section through the flow in this area is shown in Figure 19.

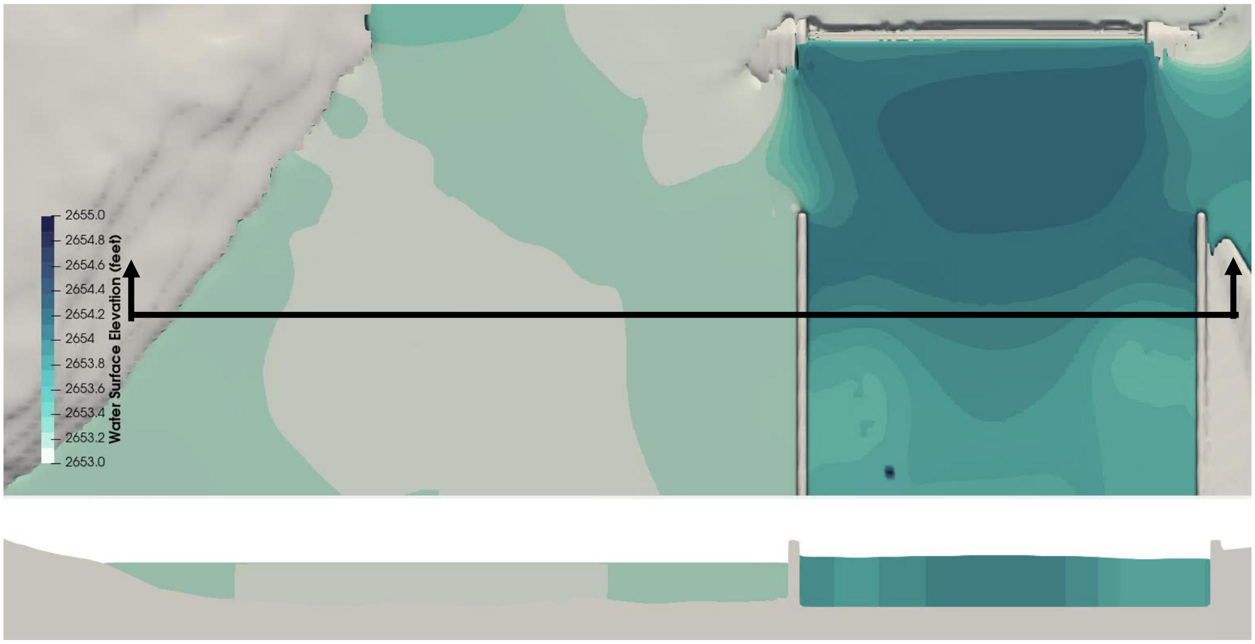

Figure 19 – Cross Section of Results of Scenario 6 (Proposed Conditions, 830 cfs)

As can be seen in this figure, the Obermeyer gate increases the tailwater elevation downstream of the waveshaper gate by approximately 1 foot when compared to the tailwater elevations downstream of the spillway. Additional increases in the tailwater elevation differential are observed when comparing points directly in front of the new Obermeyer to points downstream of the spillway gates.

3.3.1.7 Scenario 7 – Proposed Conditions Bankfull Capacity

In the bankfull capacity scenario, all gates are fully lowered to pass their maximum capacity in addition to the new Obermeyer proposed downstream. Under proposed conditions the bankfull capacity is estimated to be approximately 8,000 cfs which is equal to that of the existing conditions. An isometric of the depth-averaged velocities is shown in Figure 20.

Figure 20 – Depth Averaged Velocities for Scenario 7 (Proposed Conditions, Bankfull Capacity)

Similar to the existing conditions there is significant overtopping of the portions of drop structure 1 between gates 1 and 2 (sluice and waveshaper). In general, the estimated velocity regime for the proposed conditions is only slightly different in localized areas when compared to that of the existing conditions.

It is also important to evaluate the water surface elevations under this scenario to compare to the existing conditions to understand the implications of the new Obermeyer structure on the no-net-rise requirement. A plan view of the water surface elevations within the reach between drop structure 1 and drop structure 2 is shown in Figure 21.

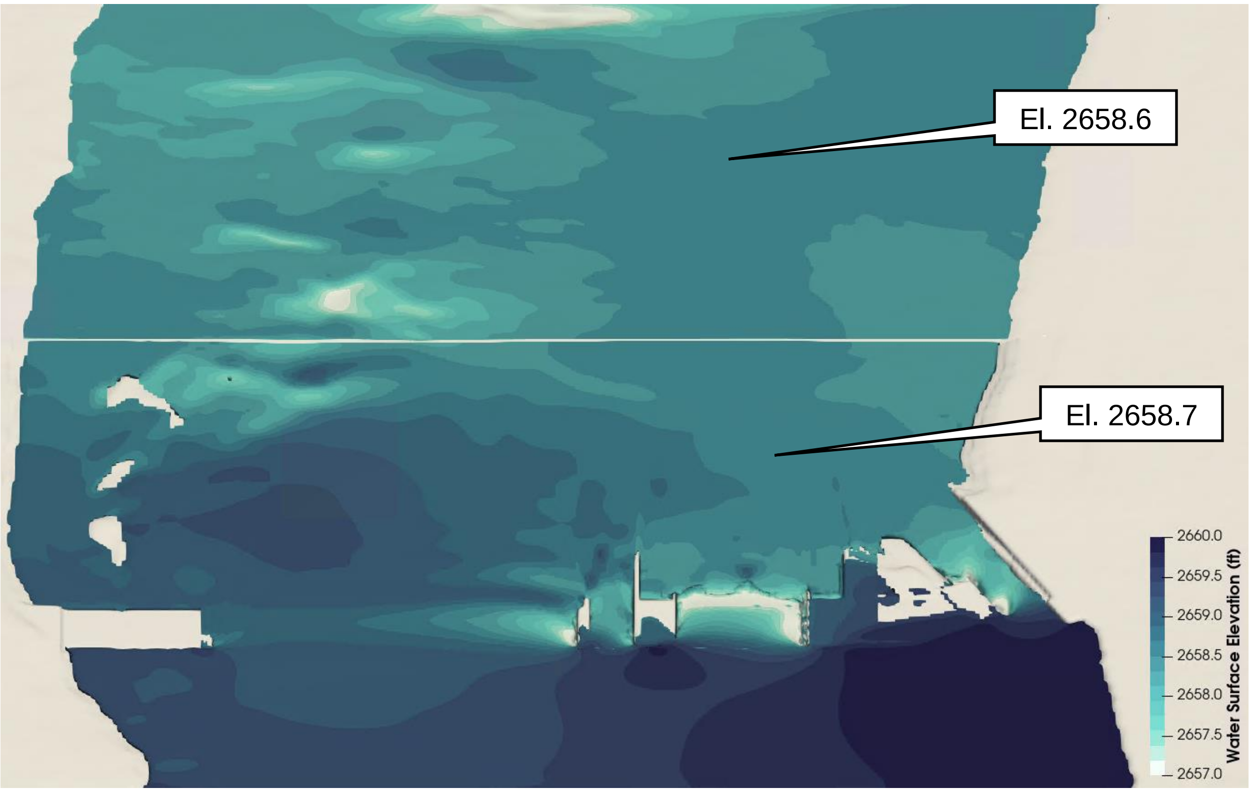

Figure 21 – Water Surface Elevations for Scenario 7 (Proposed Conditions, Bankfull Capacity)

As can be seen in this figure the water surface elevations in this area are variable but within the main channel generally range from approximately El. 2658.7 to El. 2658.6. Figure 22 shows a side-by-side comparison of the water surface elevations estimated for the existing conditions and proposed scenarios under bankfull conditions.

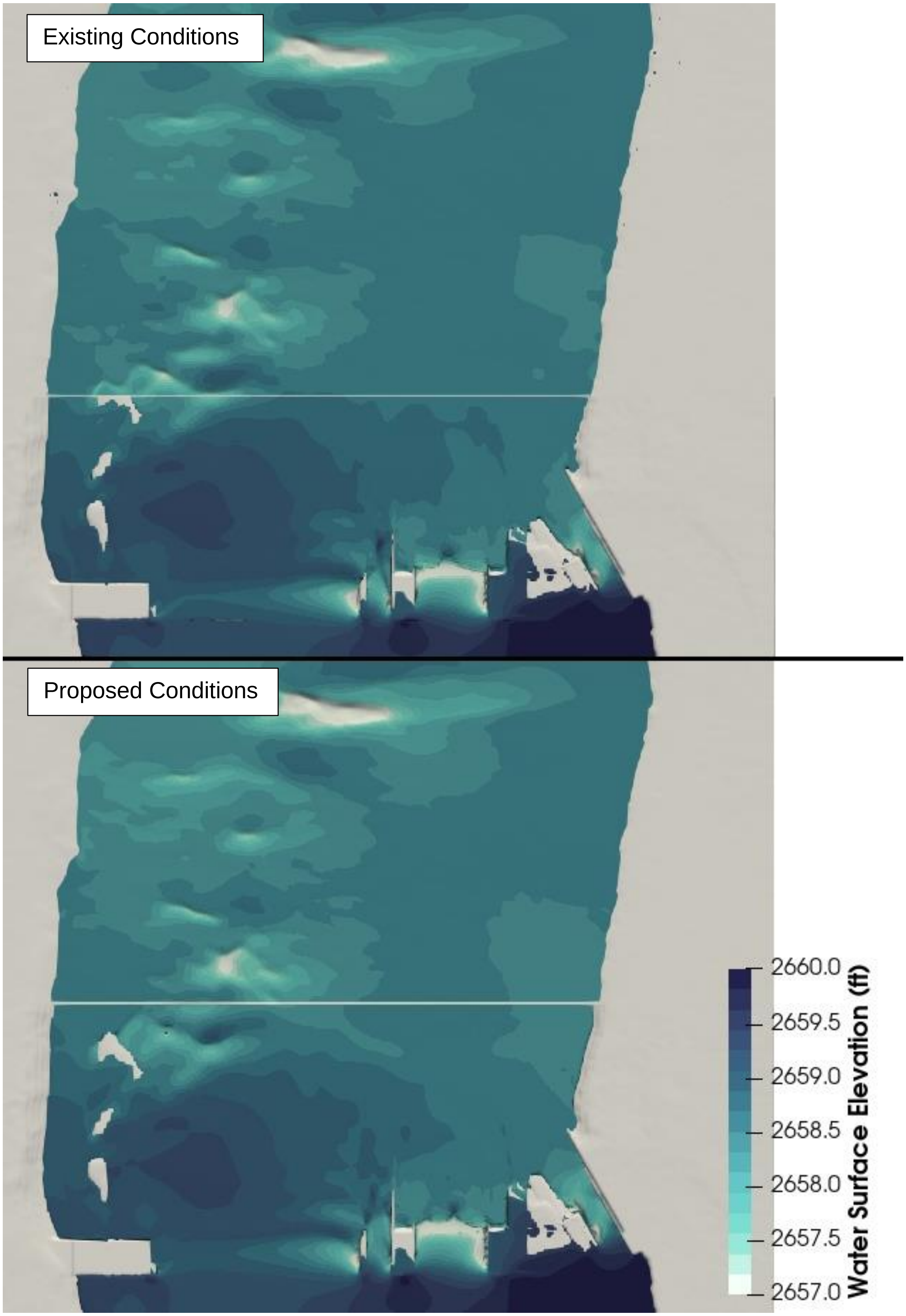

Figure 22 – Water Surface Elevations at Bankfull Capacity for Existing and Proposed Conditions

As can be seen in this figure, the water surface elevations downstream of drop structure 1 vary by less than 0.1 feet within the majority of the area of interest. Some slight variations are observed in localized areas which could be contributed to minor model instabilities which are inherent to the dynamic nature of CFD modeling.

3.3.2 Spillway Gates

The CFD model was also used to assess the hydraulic conditions of the modified spillway gates and new plunge pool. Two scenarios were specifically evaluated for the spillway gates: 1) New Gate 6 half lowered, and 2) Gate 6 fully lowered and Gates 5 and 7 half lowered. The results of these hydraulic analyses are discussed in the following sections.

3.3.2.1 Spillway Scenario 1 – Gate 6 Half Lowered

The first spillway scenario includes the crest of Gate 6 lowered to approximately El. 2654.3 which is equivalent to approximately half lowered. The results indicate that this gate would pass approximately 260 cfs in this configuration with the forebay at El. 2657.0. This is approximately 75 percent more than the empirically developed rating curve which indicates a discharge of approximately 150 cfs for this configuration. This can likely be attributed to the flows that pass over the left and right edges of the gate which are lower than the crest and are not accounted for in the empirical calculation. An isometric of the results of this scenario is shown in Figure 23.

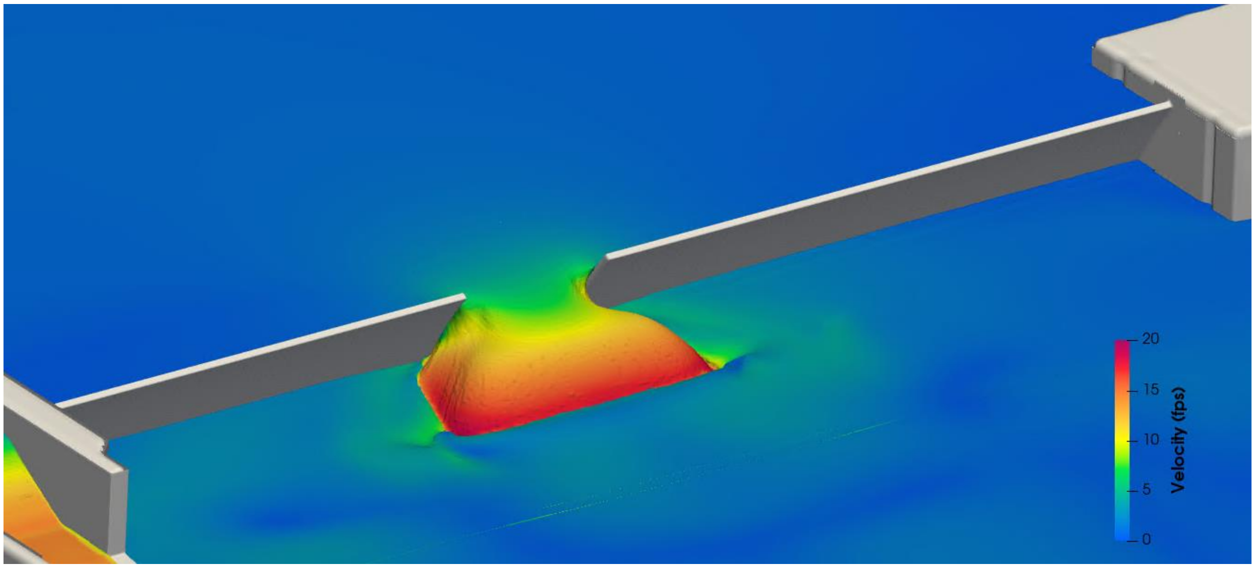

Figure 23 – Spillway Scenario 1 Isometric

As flows pass over the gate, the plunging nappe would impinge at the downstream end of the spillway slab into relatively shallow water. Velocities over the tip of the gate would reach approximately 18 fps. A cross section of the results is provided in Figure 24.

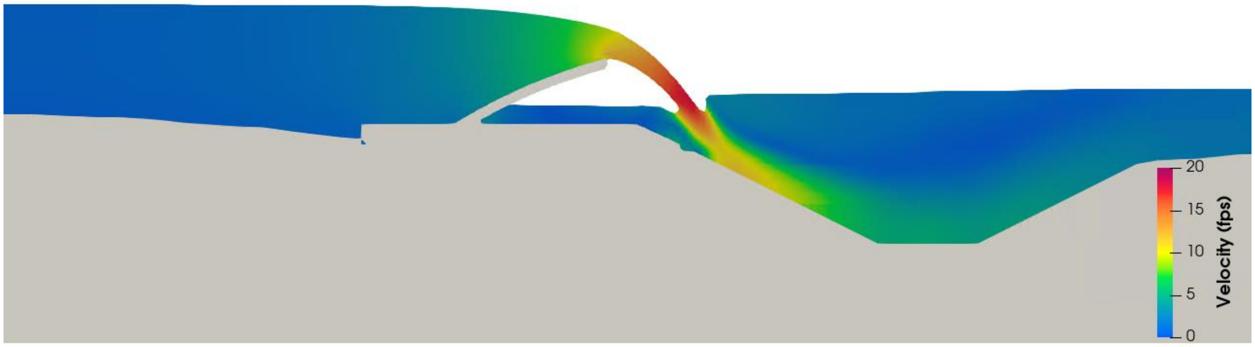

Figure 24 – Spillway Scenario 1 Cross Section

As can be seen in this figure, the velocities of the jet would be dissipated quickly but would generally be concentrated along the bottom of the plunge pool before rising to exit at the downstream end. Some slight backwards flow towards the gate would develop within the pool however velocities would be relatively low compared to the main flows directed downstream.

3.3.2.2 Spillway Scenario 2 – Gate 6 Fully and Gates 5 and 7 Half Lowered

The second spillway scenario includes Gate 5 fully lowered and the crest of Gates 6 and 7 lowered to approximately El. 2654.3 which is equivalent to approximately half lowered. The results indicate that the gates would pass a cumulative flow rate of approximately 870 cfs in this configuration with the forebay at El. 2657.0. Similar to the first scenario, this is more than estimated by the empirical analysis which indicates a capacity of approximately 770 cfs for this gate operation. This is approximately a 13 percent difference. This is closer to the empirical analysis then spillway scenario 1 as the internal edges of each gate are significantly submerged by the neighboring gates. An isometric of the results of this scenario is shown in Figure 25.

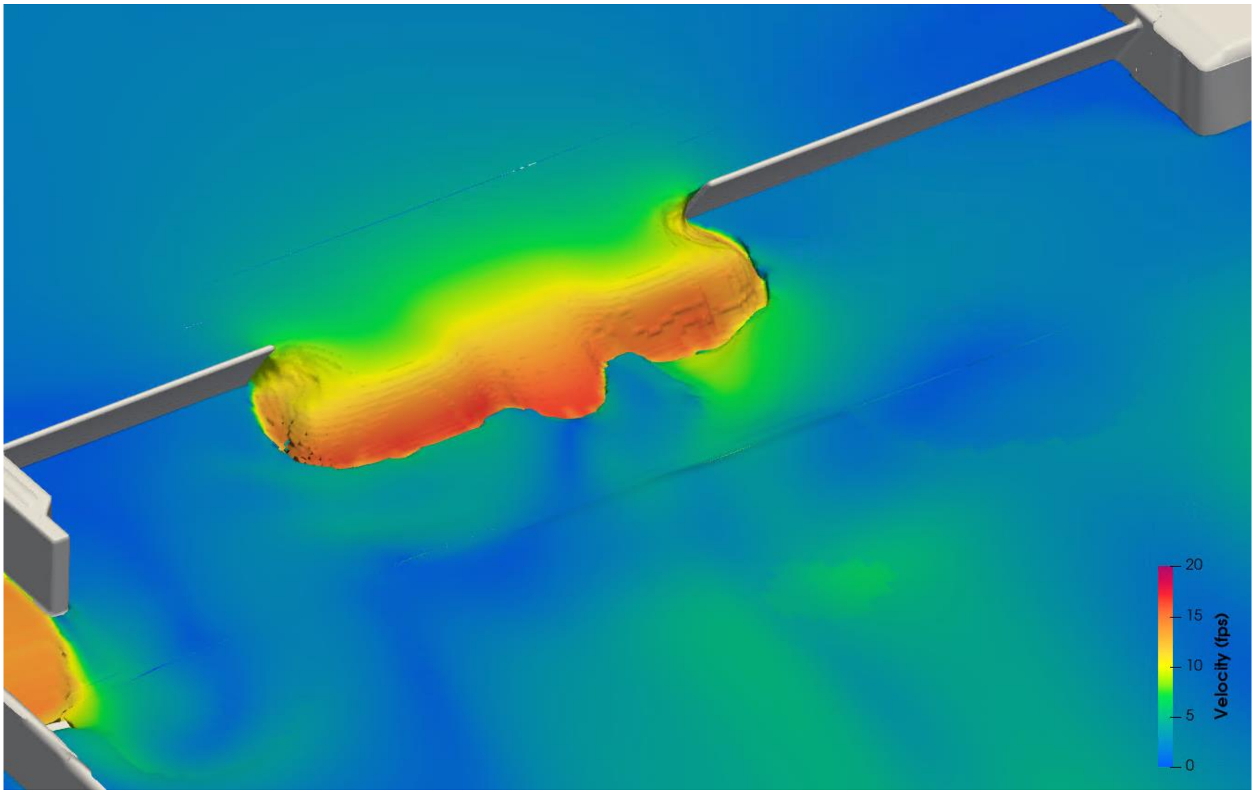

Figure 25 – Spillway Scenario 2 Isometric

As can be seen in this figure, velocities over the lowered gates reach approximately 17 fps with higher velocities concentrated near the center of the fully lowered Gate 6. Further, the same isometric with flow streamlines added is shown in Figure 26.

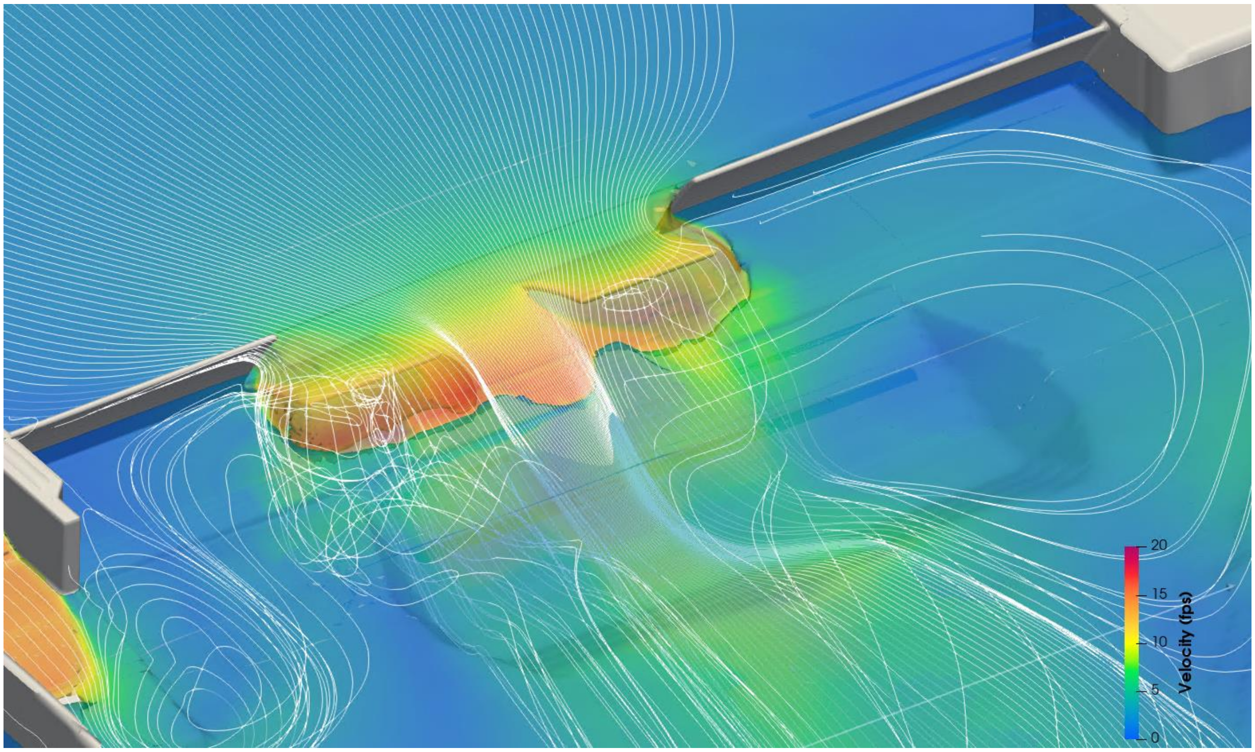

Figure 26 – Spillway Scenario 2 Isometric with Flow Streamlines

As can be seen in this figure, the majority of the streamlines from upstream of the gate are concentrated towards the central fully lowered gate. Some eddying is observed to the left and right of the gates though this is mainly due to flows deflecting off the river bank and the outside of waveshaper structure wall. Some flows are shown being pushed between the upper face of the center gate and lower faces of the side gates. These flows would likely be reduced by the Obermeyer gate bladders which are not included in the CFD model. Figure 27 shows cross sections through each spillway gate.

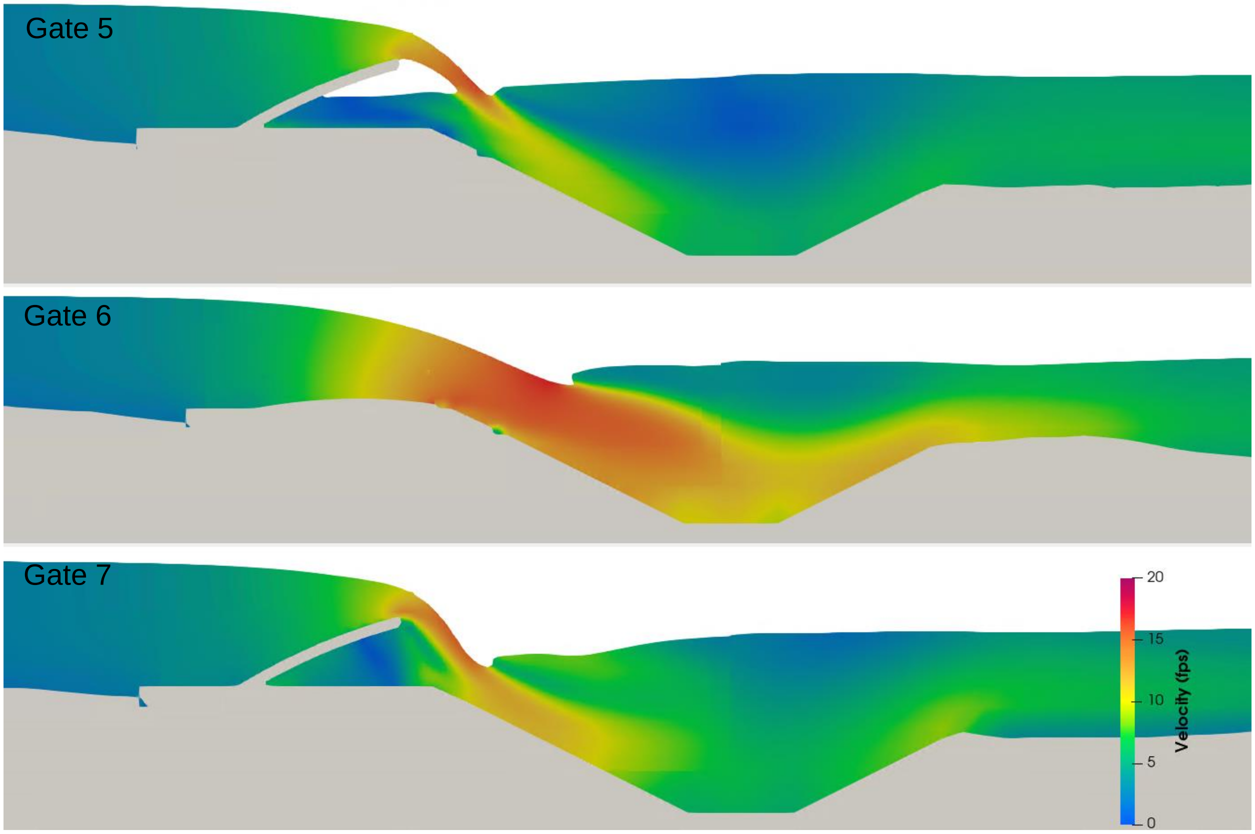

Figure 27 – Spillway Scenario 2 Cross Sections

As can be seen in this figure the hydraulics are variable at each gate but generally indicate a similar flow pattern of high velocities over the gate and entering the basin which dissipate in the plunge pool and are passed downstream. At gate 7 the nappe flow is depressed which is likely due to the dynamic CFD simulation and short time periods modeled. Over long term flows it is likely that the hydraulics would be more similar to those observed at Gate 5. Similar to the first spillway scenario, some slow recirculating velocities are observed within the new plunge pool but are generally minimal compared to the velocities passing downstream through the plunge pool.

4.0 Conclusions

McMillen has prepared a series of hydraulic analyses in support of the modification designs being developed for the J.A. and Kathryn Albertson Family Foundation Boise Whitewater Park Phase II. The results of the analyses presented in this TM show that the new Obermeyer gate proposed for downstream of the existing waveshaper gate could help to expand the operational range of the structure. Further, the proposed Obermeyer gate could be operated to limit impacts to the hydraulic regime within the Boise River during high flow events. The modifications to the spillway will help to improve the operational flexibility and the new plunge pool could allow for improved boater passage if they were to inadvertently pass over the spillway structure.

5.0 References

McMillen, Inc. (2023). *Technical Memorandum – Drop 1 Structure Modifications Scope of Work*. Boise, ID.