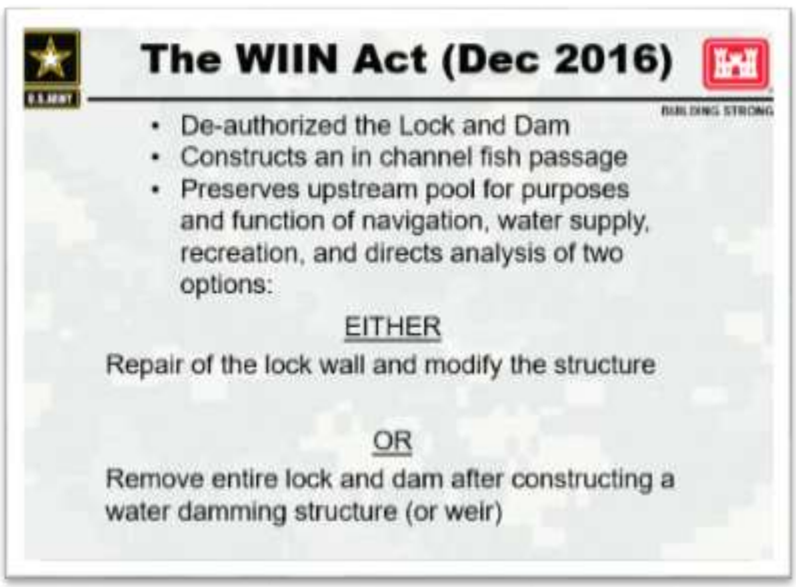
August 9, 2018
CE-SAS-EN-H

# Sedimentation Evaluation for SHEP Fish Passage at New Savannah Bluff Lock and Dam Savannah River, Georgia & South Carolina

**Background**: The Savannah Harbor Expansion Project (SHEP) includes a mitigation feature to provide fish passage at the New Savannah Bluff Lock and Dam (NSBLD) to address adverse impacts to shortnose and Atlantic sturgeon. In December 2016, the Water Infrastructure Improvements for the Nation (WIIN) Act was signed into law, requiring the Corps to study two in-channel options in lieu of the original fish passage design developed in 2012 and included in the SHEP GRR and EIS.




**Project Location and History**: The NSBLD is located along the Savannah River, approximately 13 miles downstream from Augusta, Georgia, and 187 river miles upstream from Savannah, Georgia (Figure 1). The NSBLD project was authorized by the 1930 and 1935 Rivers and Harbors Acts for the sole purpose of improving commercial navigation on the Savannah River between Augusta, Georgia and areas down river. Construction began in 1934 and was completed in 1937. The lock and dam continues to serve the City of Augusta, 13 miles upstream of the project area, but not in the same manner as initially intended. Presently, the use and need is for the structure to provide a stable pool of water. This stable pool of water no longer serves the original intended purpose of commercial navigation; however, it does serve water supply users including two municipalities and several industries. These water supply users are permitted for their withdrawal needs through the respective state in which they are located, Georgia or South

Carolina. The pool impounded by the dam also supports water-related recreation opportunities such as general boating and fishing, specialized rowing, powerboat race events, regional economic development and tourism. The lock was also operated to pass migratory anadramous fish species until it was closed in May of 2014 due to safety concerns with the stability of the lower riverside lock wall during lockages.

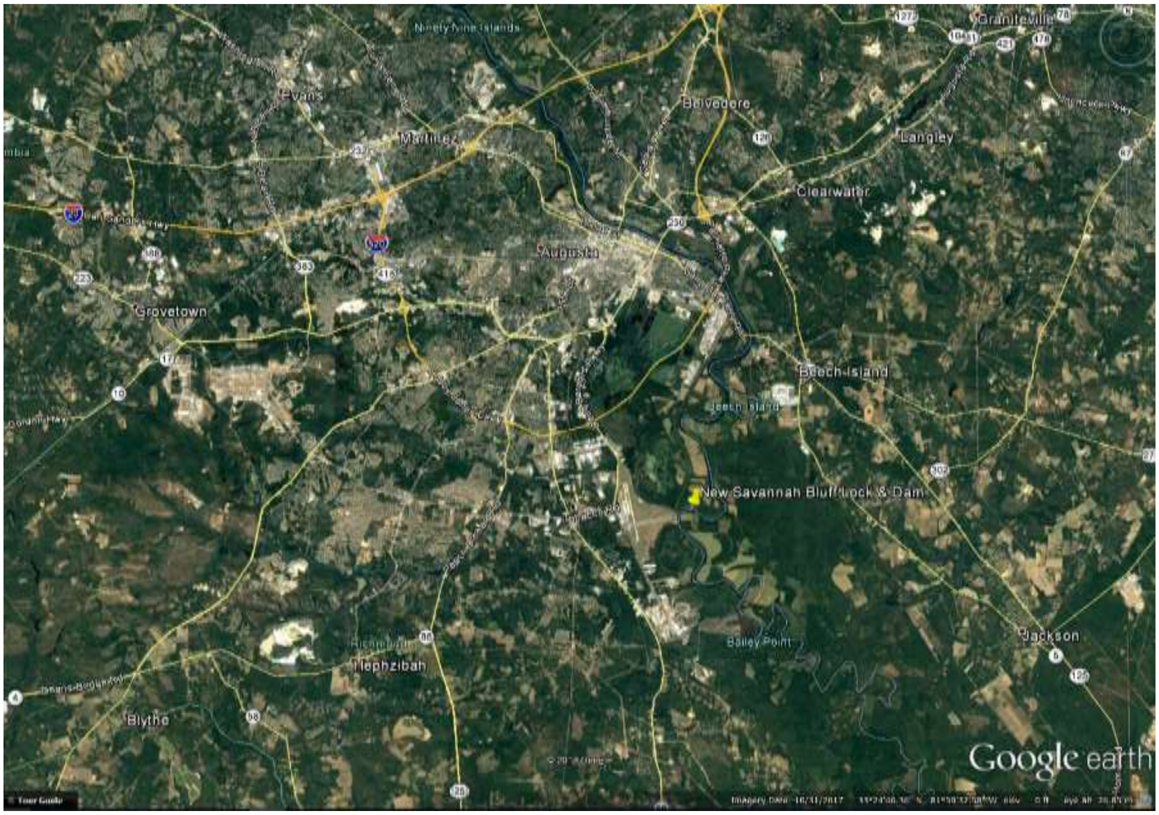



Figure 1: Project Location, on the Savannah River near Augusta, GA.

**Current Operations**: The NSBLD is a run-of-river project and consists of a 360 ft long concrete dam with five 60 ft wide steel vertical lift spillway gates and a 56 ft wide lock chamber (Figure 2). Two of the five spillway gates are overflow gates which allow for the passage of water and floating debris during typical operational conditions. The overflow gates are 12 ft high and the non-overflow gates are 15 ft high. Each of the gates are seated on a concrete sill with an operational range of 35.5 ft, meaning the gates can lift vertically allowing for a 35.5 ft opening for water to pass beneath them. The gates are remotely operated from J. Strom Thurmond Dam which is approximately 40 miles upstream. The gates are operated, lowered and raised, as necessary to maintain the pool between 112 and 115 ft NGVD29 elevation.


Figure 2: Bird's Eye View of current conditions at New Savannah Bluff Lock and Dam.

**Project Alternatives**: Currently the project has 5 viable alternatives under consideration that comply with the requirements stated in the WIIN Act. A brief description along with an artist rendering of each of the 5 alternatives are below. For one of the alternatives, 2-6, there are several variations on the weir height, and is why the naming convention includes a, b, c, and d options. Currently, all of the designs are conceptual at the 15% effort level. The design efforts to date do include detailed hydraulic modeling (2D HEC-RAS) to fully understand the flow of water across and around the structure under a variety of flow conditions in an effort to inform the design features and prevent any unintended consequences from its construction (i.e, flooding).

| Alternative 1-1 | Retain Dam with Georgia Side Fish Passage |
| --- | --- |
| Retains the current dam, includes repairs to the current dam, and includes removal of the lock gates, the landside lock wall and a portion of the Georgia bank adjacent to the lock. Includes construction of a fixed crest weir with fish passage through the former lock chamber and bank. |  |

<table>
<tr>
<td>Alternative 2-3<br><br>Requires full removal of the lock and dam from bank to bank down to the concrete foundation. Includes construction of a fixed crest weir and fish passage structure across the full width of the river.</td>
<td>Fixed Weir<br></td>
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<tr>
<td>Alternative 2-6a<br><br>Requires full removal of the lock and dam from bank to bank down to the concrete foundation. Includes construction of a fixed crest weir and fish passage structure across the full width of the river and a floodplain bench that is inundated frequently to pass high water flows.</td>
<td>Fixed Weir with Floodplain<br></td>
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<tr>
<td>Alternative 2-6b, 2-6c and 2-6d<br><br>Requires full removal of the lock and dam from bank to bank down to the concrete foundation. Includes construction of a fixed crest weir and fish passage structure across the full width of the river and a floodplain bench that is inundated less frequently than alternative 2-6a to pass high water flows.</td>
<td>Fixed Weir with Dry Floodplain<br><br><br>*Alternative 2-6d is the recommended plan.</td>
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| Alternative 2-8 | Gated Bypass Channel |
|---|---|
| Requires full removal of the lock and dam from bank to bank down to the concrete foundation. Includes construction of a fixed crest weir and fish passage structure across the full width of the river and a flood bypass channel with 2- 50 ft gates that would be operated to pass high water flows. |  |

**Issue and Concern**: Dams have the ability to hold water and trap sediment. As the water in a river or channel moves downstream the velocities decrease as the water approaches a dam which acts as an obstruction to flow. Sediments that have been suspended under the faster moving water will tend to fall from the water column or settle on the bottom of the riverbed. Depending on the location of the dam and the sediment load coming into the system this shoaling or accumulation of sediments can cause problems for the functionality of dams and their outlet works to the extent that it becomes a nuisance and/or a hazard requiring management. If the sediment accumulation is extensive and requires frequent maintenance this can be a costly burden for the owner of the dam and can affect the useful life of the project. This report will serve to document the district's evaluation of the potential for this issue to occur with the proposed alternatives for the SHEP fish passage structure at the lock and dam.

**Evaluation**:

<u>Sediment Supply</u>: Accumulation of river sediments within the pool formed by the NSBLD and areas just downstream of the dam has largely been due to local sediment sources as opposed to sediment migration from the headwaters and upper portions of the Savannah River watershed. There are three large multipurpose reservoirs upstream of the lock and dam pool that are owned and operated by the Corps: Hartwell, Richard B. Russell and J. Strom Thurmond. These dams serve as sediment traps for material migrating downstream from the headwaters in the foothills of the Appalachian Mountains. While there has not been an impact to project operations, sediment accumulation at these locations is almost certain to have occurred. In recent years, studies have been initiated to quantify the volume and rate at which these

sediments have accumulated behind these large dams, but results of those studies have not been finalized and are therefore not currently available for use or review.

Downstream of the lowest large reservoir in the river system, J. Strom Thurmond Dam, are two additional smaller non-Federal dams, Stevens Creek Dam and the Augusta City Diversion Dam. The Stevens Creek Dam is located on the Savannah River just downstream of the last major tributary, Stevens Creek, which provides a source of water and sediment into the pool formed by the NSBLD. The channel bathymetry upstream of the Stevens Creek Dam is a known to accumulate sediments whose movement downstream has been impeded. The Augusta City Diversion Dam serves as a sediment trap as well as it slows the river flows and diverts water into the Augusta Canal. The Augusta Canal is known to have sediment deposit and accumulate requiring periodic maintenance by the local authorities.

These upstream obstructions have limited the sediment supply coming into the project area. The NSBLD pool has no known issues that impede commercial, recreational or water supply use of the river. There are no known issues of sediment accumulation to the levels requiring routine maintenance activities. Water withdrawn from the river for municipal and industrial use beginning more than 50 years ago has not experienced issues with high shoaling rates or sediment accumulation to the effect that operations of these facilities is impacted.

<u>High Shoaling Areas</u>: Despite the low sediment load provided by the headwaters of the river due to multiple obstructions, within the pool of the lock and dam there are two areas where sediment accumulation is known to occur.

1. The North Augusta side of the river behind a training wall constructed in the early 1900s (Figure 3), and
2. Across the fall line around the Sand Bar Ferry Roadway crossing as the geology noticeably changes from the rolling hills of the pediment to the flat coastal plain (Figure 4).

While these areas are well known by local citizens and frequent users of the river, shoaling in these areas has not caused an impact to use of the pool for the purposes of navigation, recreation and water supply. Sedimentation around river bends is natural in a meandering river system, like the Savannah River. Sediment often accumulates in bars on the inside curve of river bends, and the outside curve is scoured by faster moving water. Sediment accumulation at a bend in the river is not indicative of excessive shoaling.


Figure 3: Location of Training Wall near South Carolina river bank.


Figure 4: Location of Shoaling at Sand Bar Ferry Road Crossing.

<u>Gravel Bar</u>: The gravel bar that sits just downstream of the lock and dam is a result of erosive forces on the natural channel bottom located within the dam's tailrace (Figure 5). Since the time of construction, more than 80 years ago, a large scour hole has developed just downstream of the dam's concrete and rock apron. This eroded sediment has quickly deposited just downstream of the dam after the energy forces from the head difference over the dam dissipate forming the gravel bar. While the bar has not been surveyed over the years other than by means of visual observation; it has been noted to grow as the scour hole deepens and sediments are removed and re-deposited.

This gravel bar is not a hardened structure and has the ability to move and re-deposit depending on the currents, velocities and flows in the river. As velocities increase or change direction in the river the sediments can and often do move or shift. Under the SHEP fish passage alternatives it is anticipated that this gravel bar will again, shift move or migrate depending on the change in direction and magnitude of the velocities in the river. However, the change in direction and magnitude of the velocities in the river is not expected to be significantly different from the current conditions. The greatest variation would be expected to occur under the alternatives that involve large flow areas outside of the channel. See Attachment 1 for additional discussion of hydraulic modeling used to support this conclusion.


Figure 5: Gravel Bar and Location of Scour Hole, NSBLD.

**Conclusions**: While modifications to the NSBLD are being studied in support of 2016 legislation known as the WIIN Act it is not anticipated that these modifications will impact shoaling rates, accumulation or deposition in the pool upstream of the dam. Downstream of the dam, it is expected that all of the alternatives would better dissipate the energy and erosive force of the water as it falls across the structure thereby limiting the source of sediment to accumulate at the gravel bar. Due to the potential for change in flow patterns and conditions at the site with future project modifications it is expected that the gravel bar may shift and re-deposit in areas down river in ways that are natural for the morphological changes of the patterns of rivers as they meander their way from the fall line across the coastal plain to the Atlantic Ocean.

# Attachment 1 – Scour Hole and Gravel Bar Analysis

The existing NSBLD Fish Passage HEC-RAS model was modified to evaluate changes to water velocity and shear stress near the gravel bar immediately downstream of the dam, as a result of any changes to the scour hole. The underlying assumption is that replacing the dam and gates with a rock-weir structure will reduce erosive velocities downstream of the dam and ultimately lead to sediment filling in the scour hole. Of interest are the impacts to the gravel bar that serves as spawning habitat for sturgeon. This write up documents the model development process and summarizes results.

**Note:** The NSBLD Fish Passage HEC-RAS model is not a sediment transport model, and the flow dynamics downstream of the dam are by nature 3-dimensional. The scour hole and gravel bar were formed by sediment transport and 3-dimensional flow dynamics over decades. This effort is not meant to quantify impacts to sediment erosion or deposition and the HEC-RAS model lacks the ability to provide that type of information for the complex system in this area. The model has not been calibrated in any way for the area downstream of the dam and should be used for illustrative purposes only. This effort will present changes to 2D, vertically-averaged, flow velocities and shear stress in the area of interest, which may serve as a rough proxy for potential impacts for the with-project condition.

**Step 1 – Modify the Existing Computation Mesh**

The existing RAS model for fish passage was built primarily to asses impacts to changes in pool elevations upstream of the dam, with an average cells size of 250' x 250'. To evaluate impacts downstream of the dam the mesh was refined with an average cells size of approximately 60' x 60' for the scour hole and gravel bar. This change to the mesh allows for the use of the existing model configuration, with greater resolution in calculating velocities in the vicinity of the scour hole and gravel bar. The refined mesh in the vicinity of the gravel bar can be seen in Figure 1 below.

**Step 2 – Update channel bathymetry**

The bathymetry used in the existing model was obtained in late 2016, and provided good resolution of the channel upstream of NSBL&D. A more detailed survey of the gravel bar and scour hole was conducted in July 2012, but was not included in the HEC-RAS model originally developed for Fish Passage. For this effort the bathymetric survey from July 2012 was added to the HEC-RAS model as a new terrain. This terrain serves as the basis for the geometric configuration underlying the 2D computation mesh. The terrain from the 2012 Survey can be seen in Figure 2 below; this figure covers the same area as Figure 1, with NSBLD on the right edge of the figure. The scour hole can be clearly seen in blue, yellow, and green.

*Figure 1 – Refined Computational Mesh*

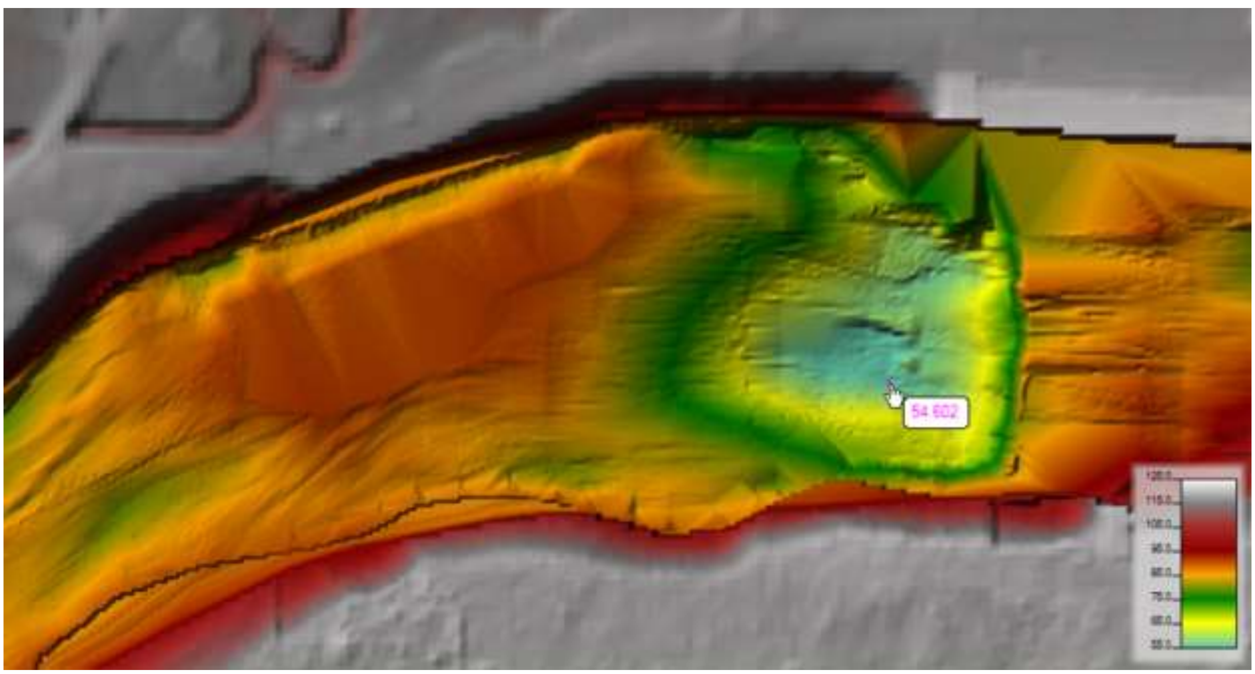

*Figure 2 – Terrain model from July 2012 Bathymetric Survey*

**Step 3 – Fill the scour hole**

The primary concern regarding the gravel bar is that removal of the dam gates will result in lower erosive velocities immediately downstream of the dam, filling the scour hole with sediment, and impact the gravel bar. It is unclear to what extent the scour hole would be filled under any of the fish passage alternatives, but if we assume that it will be filled (at least partially) we can evaluate potential changes to depth-averaged velocities.

The scour hole as seen in the terrain model in Figure 2 was filled to elevation 80’ using GIS modification tools. This new “filled scour hole” was included as an additional terrain in the HEC-RAS model. The elevation of 80’ is arbitrary, but not unreasonable as an upper limit of changes given that this would require more than 25’ of fill material in the deepest portions of the scour hole. Additional sensitivity runs in the future could use a different fill elevation to see how this might impact velocities. Over time, the river will reach an equilibrium elevation at this location regardless of the design elevation of any constructions efforts to fill the hole. The updated terrain model used to represent the “filled” conditions can be seen in Figure 3 below, with the arch rock-ramp terraces of Alt 2-6d seen on the right side of the figure. This terrain was used to evaluate with “with-project” condition, with a filled scour hole.

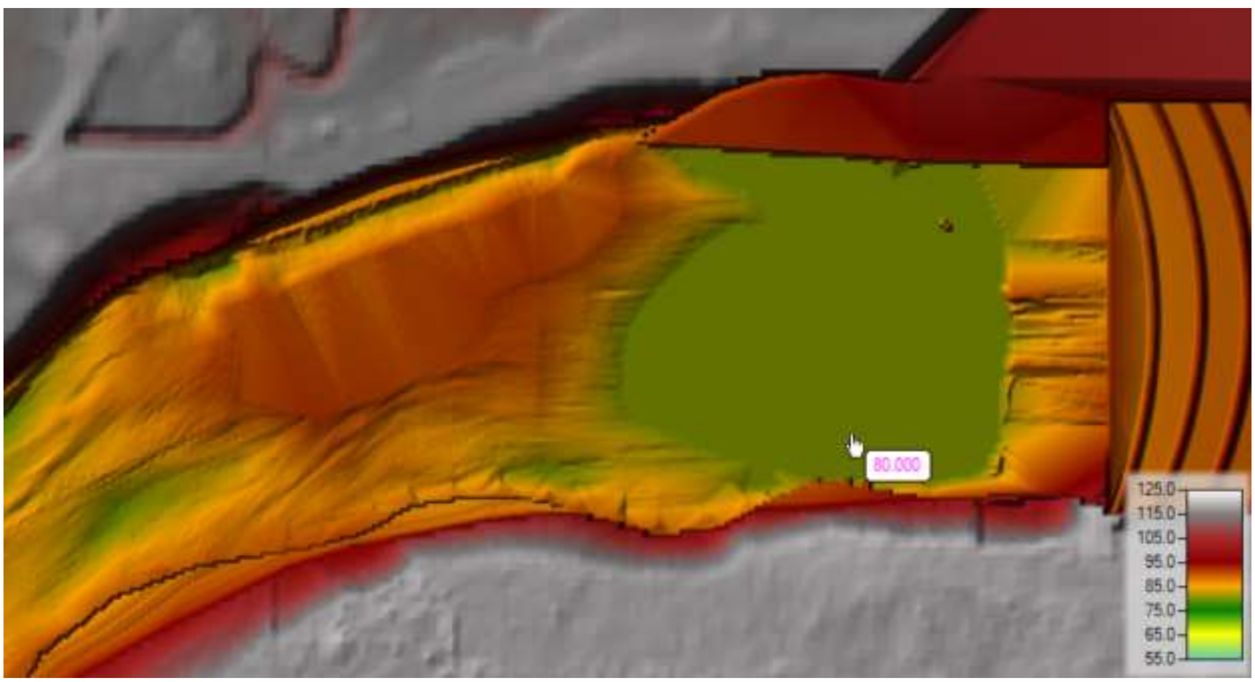


*Figure 3 – Terrain Model with Alt 2-6d and Scour Hole filled to Elevation 80’*

**Step 4 – Model simulation**

Six model runs were created using the terrain models and mesh configuration discussed above. These runs used the lock and dam configuration in the "existing conditions" geometry, which includes the lock and dam as it is configured at the time of model development. The six model runs are:

1) Existing scour hole at 5,000cfs
2) Filled scour hole at 5,000cfs
3) Existing scour hole at 8,000cfs
4) Filled scour hole at 8,000cfs
5) Existing scour hole at 33,000cfs
6) Filled scour hole at 33,000cfs

These flow values were used in the primary analysis for fish passage, as discussed in the *Integrated Post Authorization Analysis Report and Supplemental Environmental Assessment*. 5,000cfs and 8,000cfs represent normal flow conditions, while 33,000cfs is closer to the channel forming discharge; flows greater than 30,000cfs are primarily in the overbank areas. It is unclear what flow condition is the primary driver of scour and deposition in the area of interest, but these flows likely bracket the conditions responsible for the scour hole/gravel bar formation.

The model runs were simulated using a constant inflow hydrograph. Gates were operated for the 5,000cfs and 8,000cfs runs to maintain a pool within the normal operational range upstream of the dam. The result is that flow is passed through only one or two dam gates. For the 33,000cfs run, all gates are fully opened. For the with-project condition there are no gates and water flows over the rock-ramp weir and adjacent floodplain bench. The model was ran using the full-momentum equation set for 2D flow with a computational time step of 5 seconds.

**Step 5 – Model Results**

Three transect lines were placed across the channel to evaluate relative to velocity and shear stress changes for the model runs discussed above, and can be seen in pink in Figure 4 below.

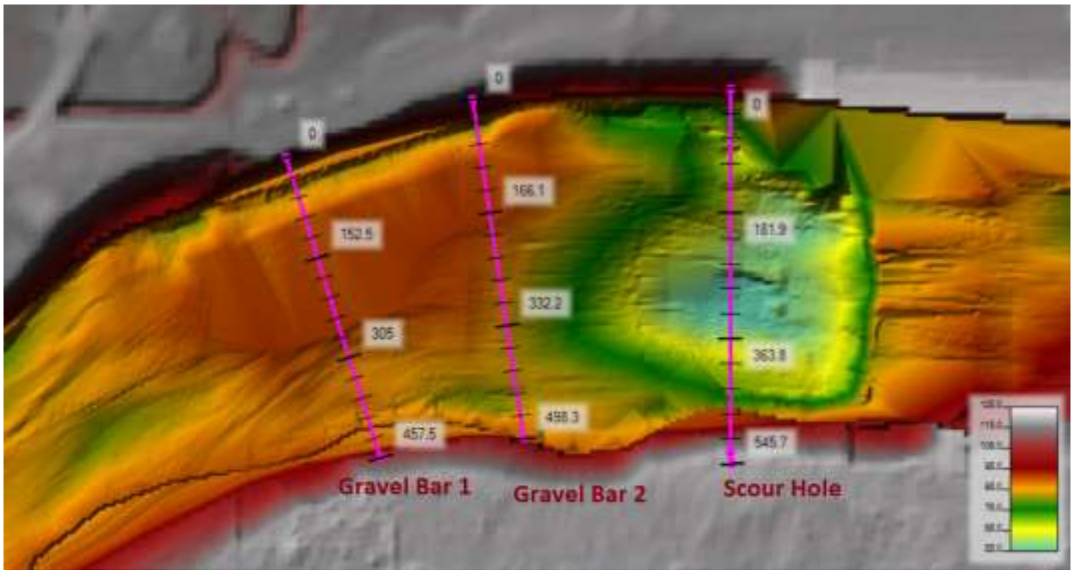


*Figure 4 – Transect lines used to display model output.*

Figures 5 – 7 below display plots of depth-averaged velocity at these transect lines for the six model runs discussed in Step 4 above. Each of the plots use the same color scheme for model runs:

With Scour Hole @ 5,000cfs - Bright Blue
Filled Scour Hole @ 5,000cfs - Turquoise
With Scour Hole @ 8,000cfs - Dark Blue
Filled Scour Hole @ 8,000cfs - Pink
With Scour Hole @ 33,000cfs - Purple
Filled Scour Hole @ 33,000cfs - Yellow

The computed velocity output for each of the flow conditions and terrain configurations can be seen in Figures 8 – 13. Velocity arrows show the direction and relative magnitude of computed velocities. The transect lines can be seen in light pink for reference.

As seen in the transect plots and 2D plots of velocity, there is no appreciable difference in velocities for the with-project condition at either of the gravel bar transects. At the Scour Hole transect (Figure 5) there is an appreciable difference between the with and without project condition for all flow levels evaluated, with depth-averaged velocities being higher for the with-project (filled scour hole) condition. This makes sense physically as there is significantly less depth available for flow conveyance for the filled condition, so water much faster in a smaller area to pass the same amount of flow. It is unclear if this would result in a stable channel configuration or if additional scour/degradation would occur at this location.

Figure 14, 15, and 16 display plots of shear stress at the transect lines for the six model runs and use the same color scheme as used in the velocity plots. Bed load movement and sediment transport is a function of shear stress. The same trend seen in the velocity plots is seen in the shear stress plots as well; there are no appreciable differences at the gravel bar transects, but the scour hole transect shows increases in shear stress for the filled conditions, for all flow levels.

It is important to note that all of these plots present depth-averaged values, as HEC-RAS is only a two-dimensional model. The flow dynamics responsible for the formation of the scour hole are almost certainly three-dimensional in nature, meaning that velocities vary as one moves up and down the water column. The modeled scenarios show that there would be a change in average velocity and shear stress in the vicinity of the scour hole and not near the gravel bar. Based on this simplified representation of the system, there is unlikely to be a significant change to the conditions at the gravel bar but a more detailed analysis may yield different results.

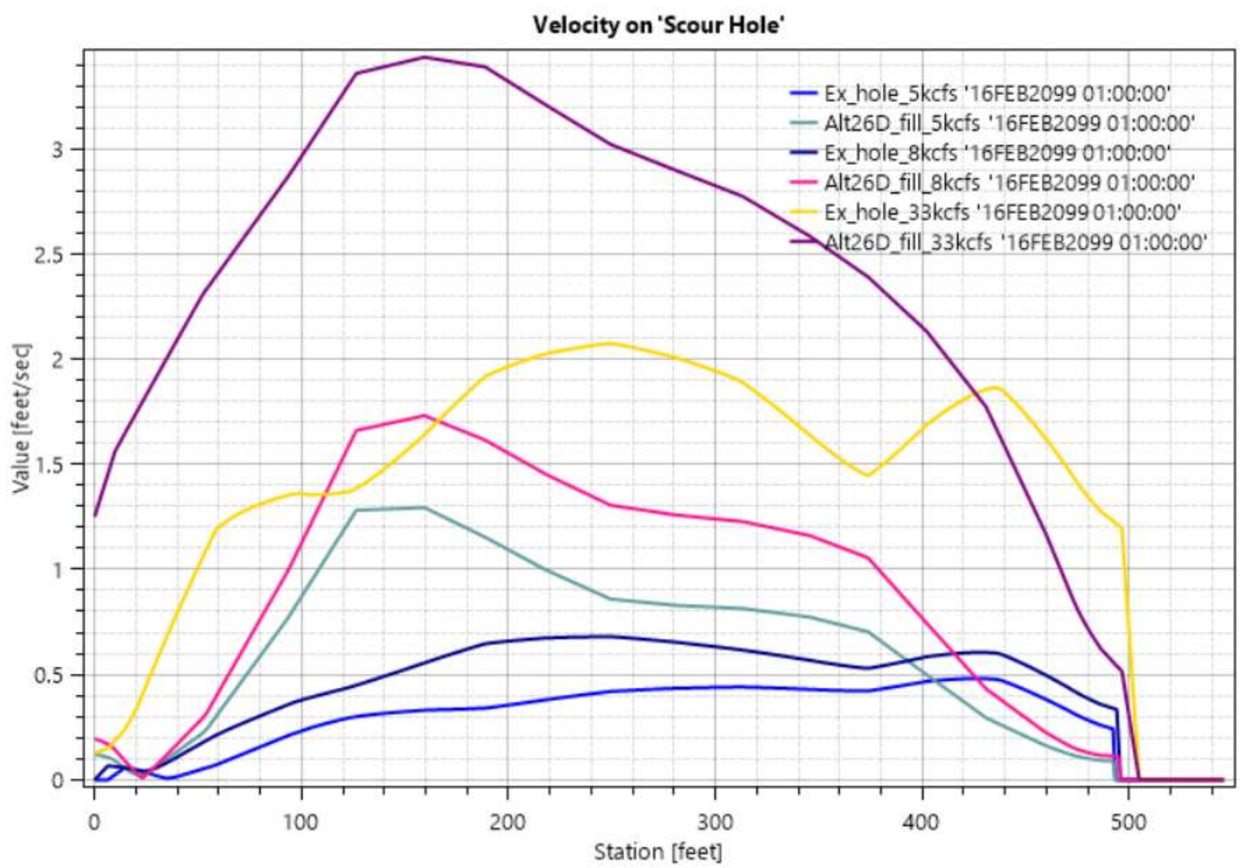


*Figure 5 – Depth Averaged Velocity at the "Scour Hole" Transect*

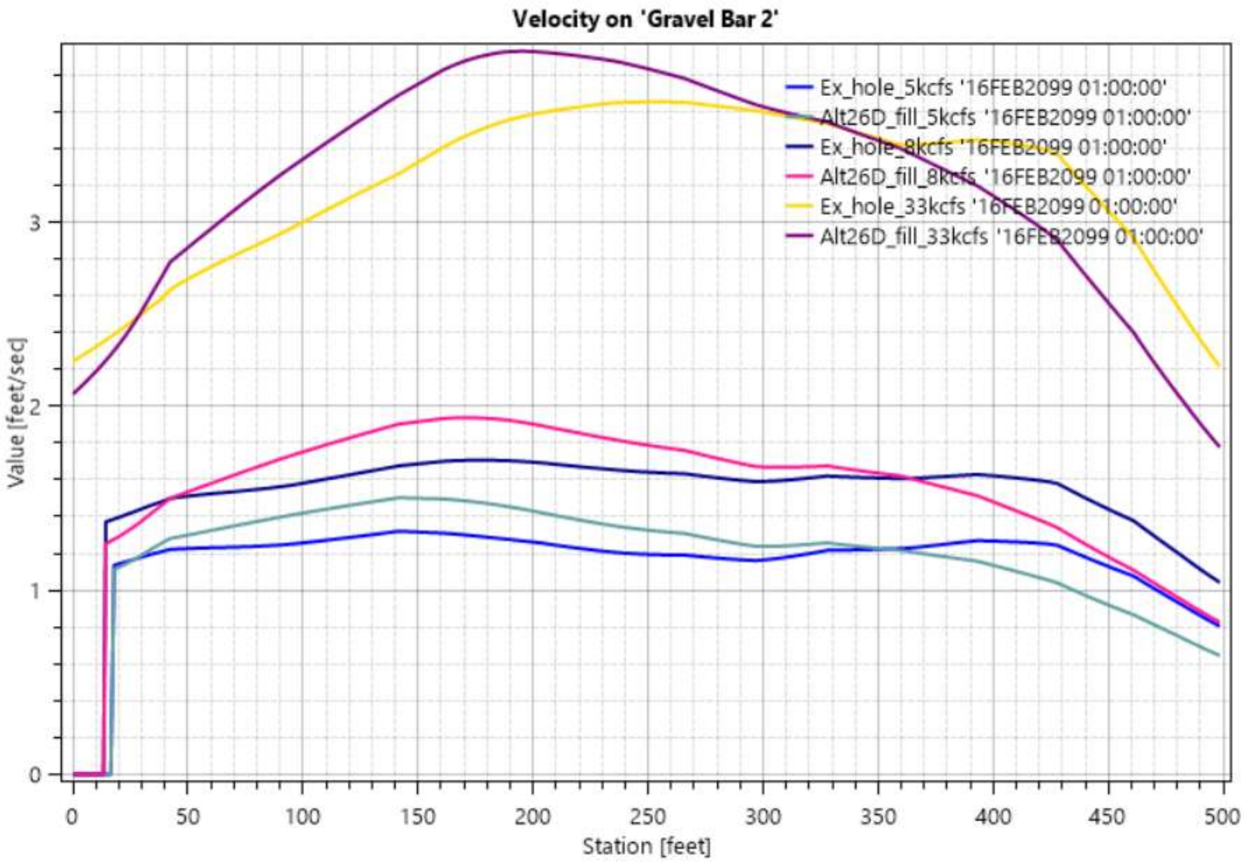


*Figure 6 – Depth Averaged Velocity at the "Gravel Bar 2" Transect*

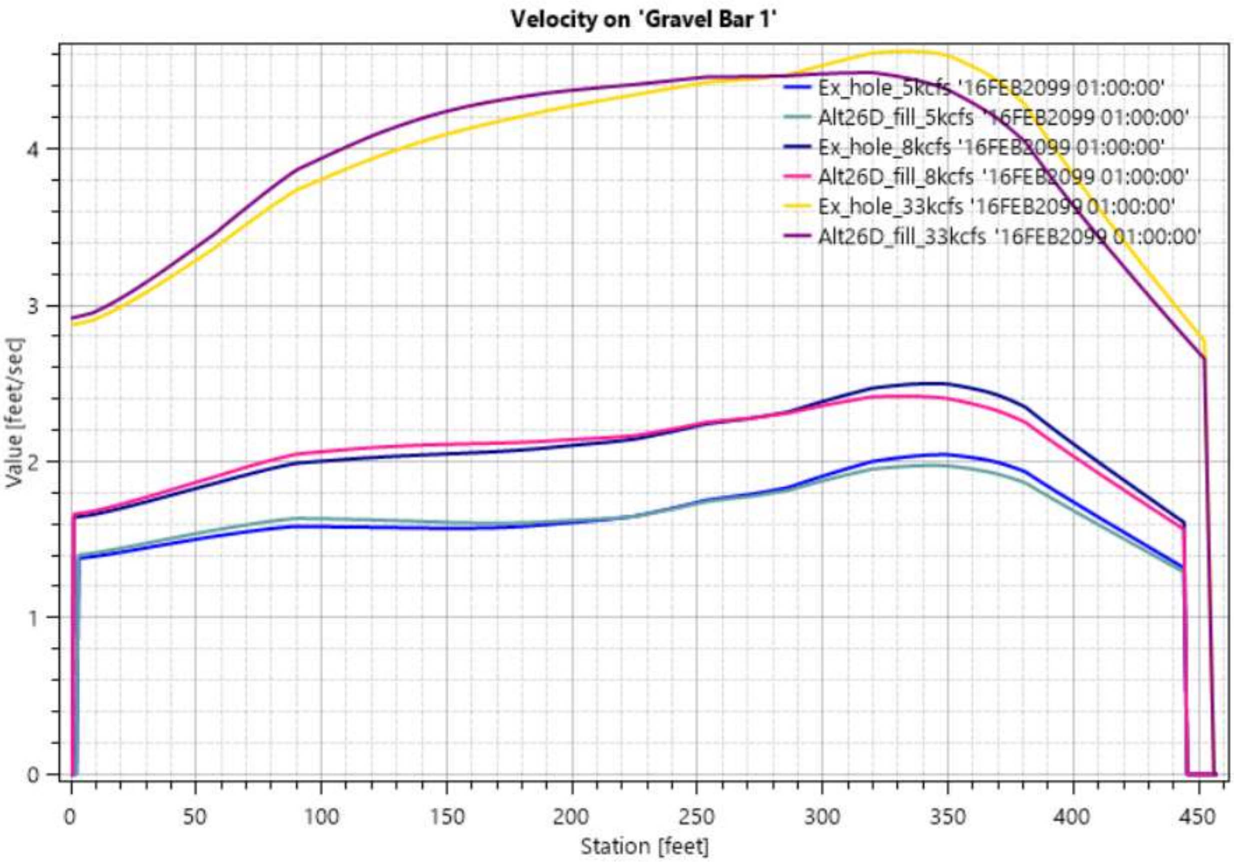


*Figure 7 – Depth Averaged Velocity at the "Gravel Bar 1" Transect*

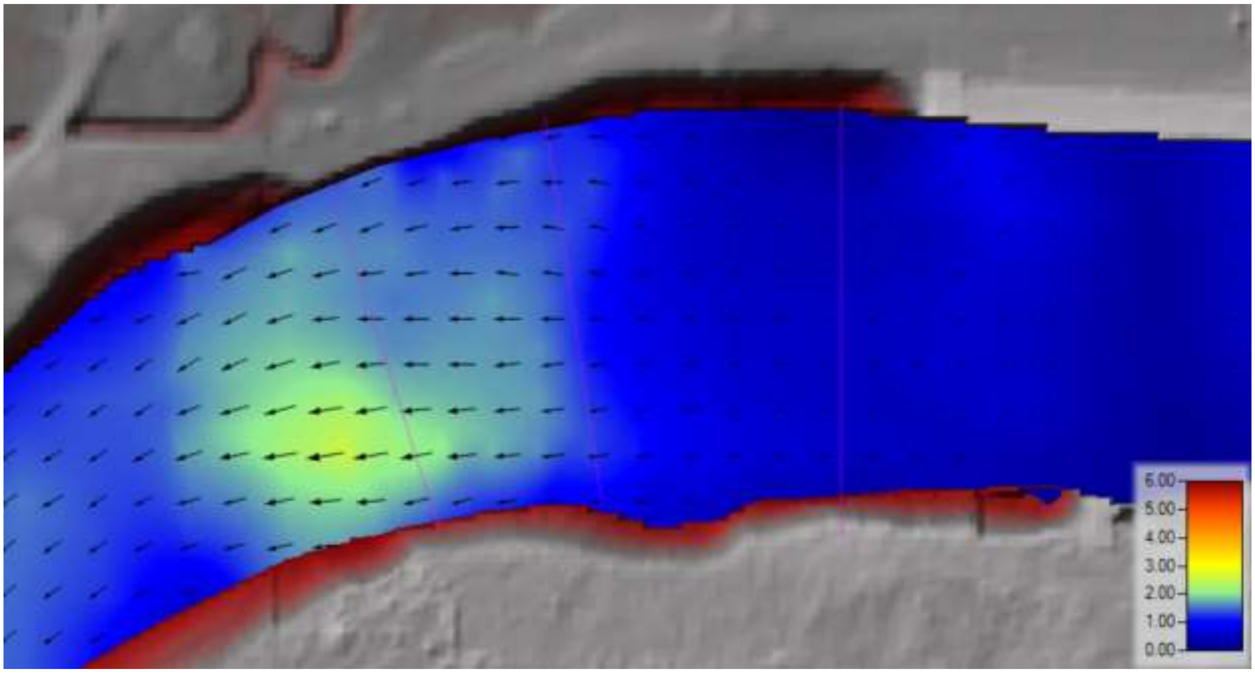


*Figure 8 - With Scour Hole – Velocity @ 5,000cfs*

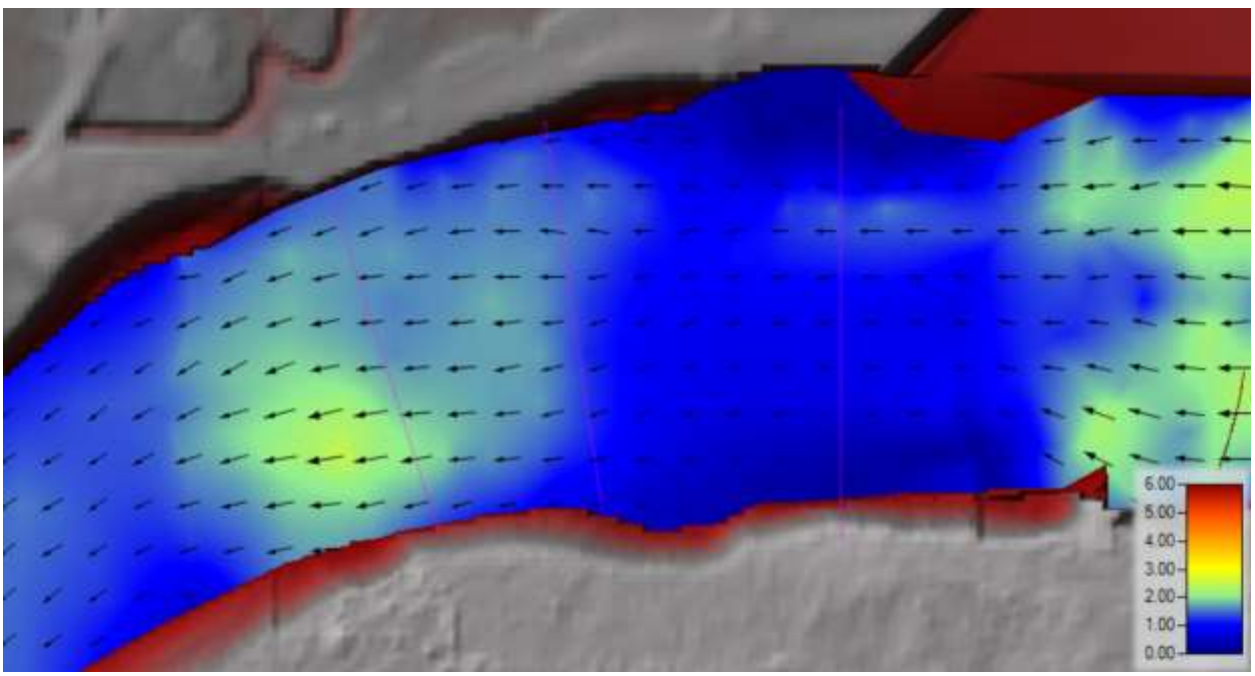


*Figure 9 - Filled Scour Hole – Velocity @ 5,000cfs*

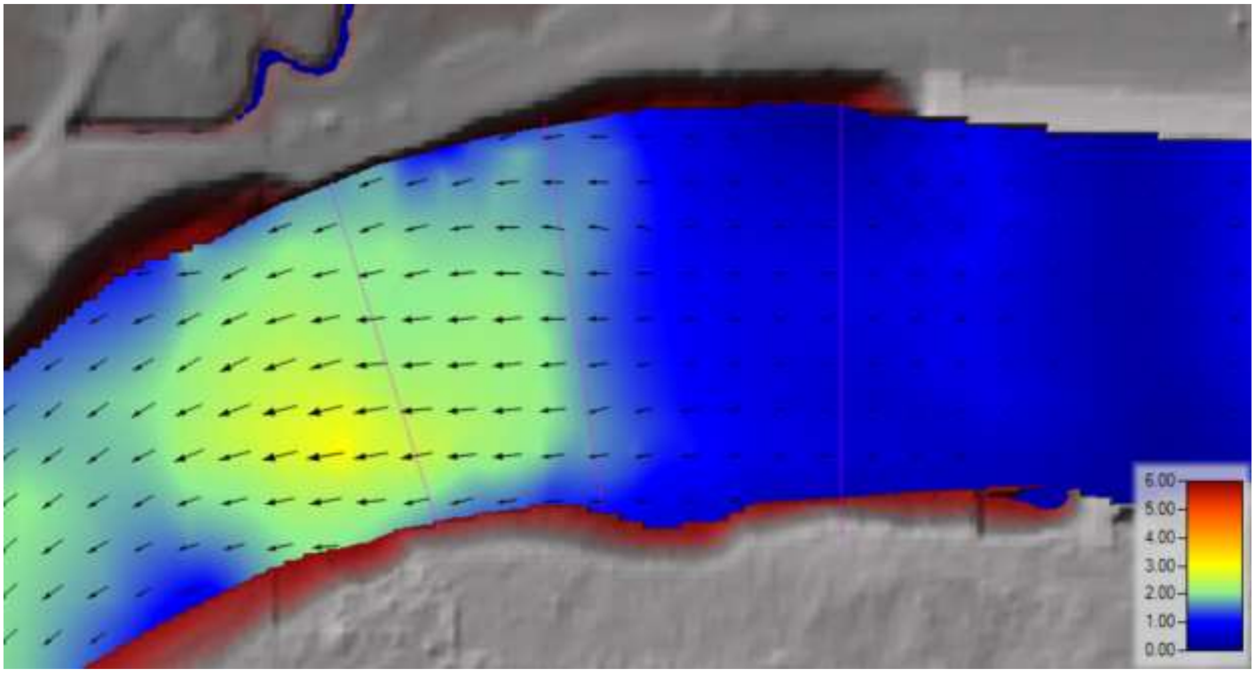


*Figure 10 - With Scour Hole – Velocity @ 8,000cfs*

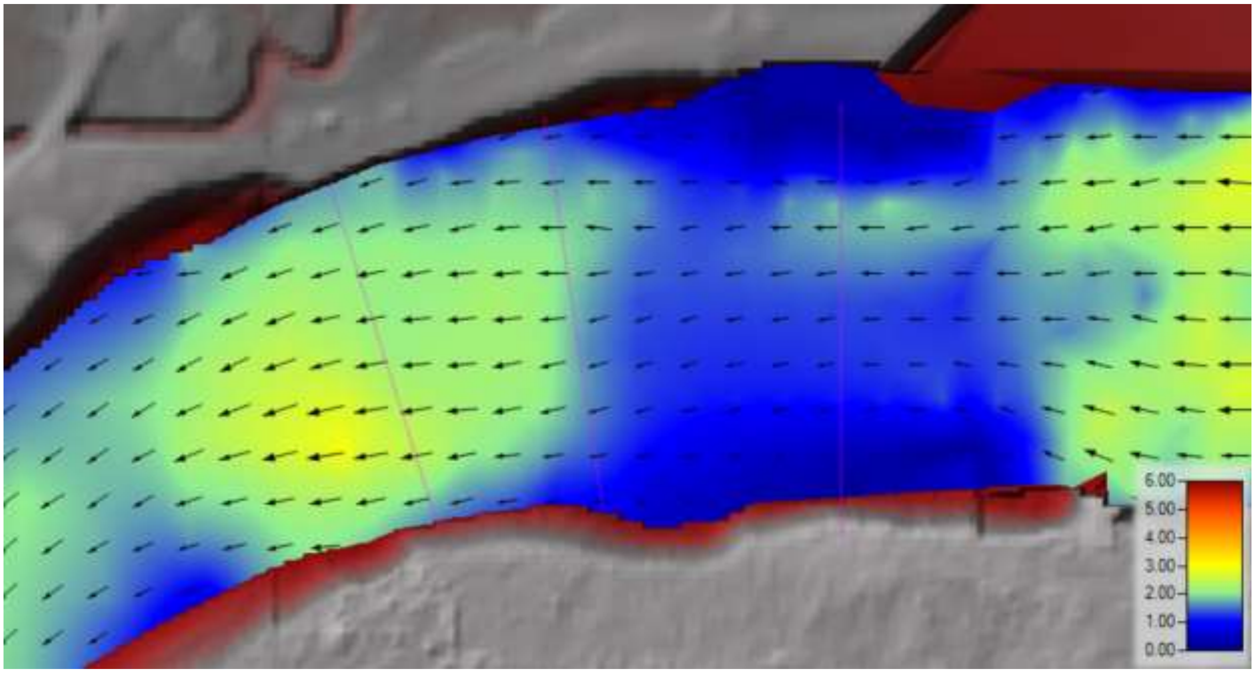


*Figure 11 - Filled Scour Hole – Velocity @ 8,000cfs*

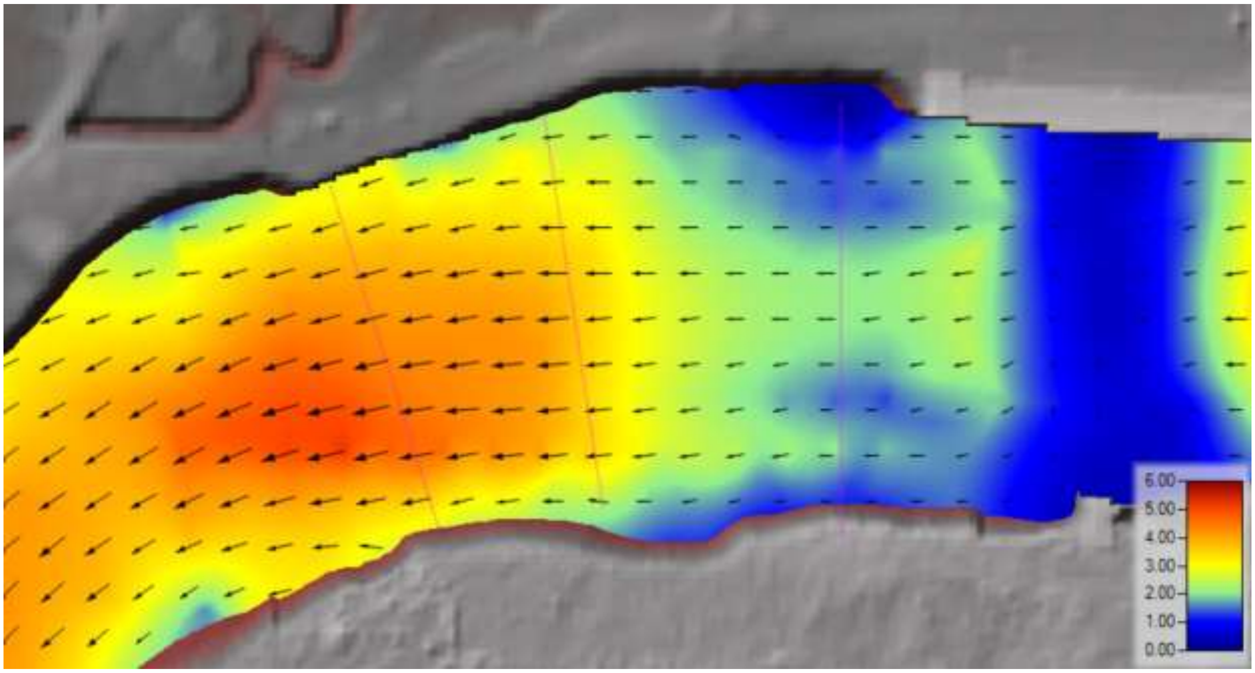


*Figure 12 - With Scour Hole – Velocity @ 33,000cfs*

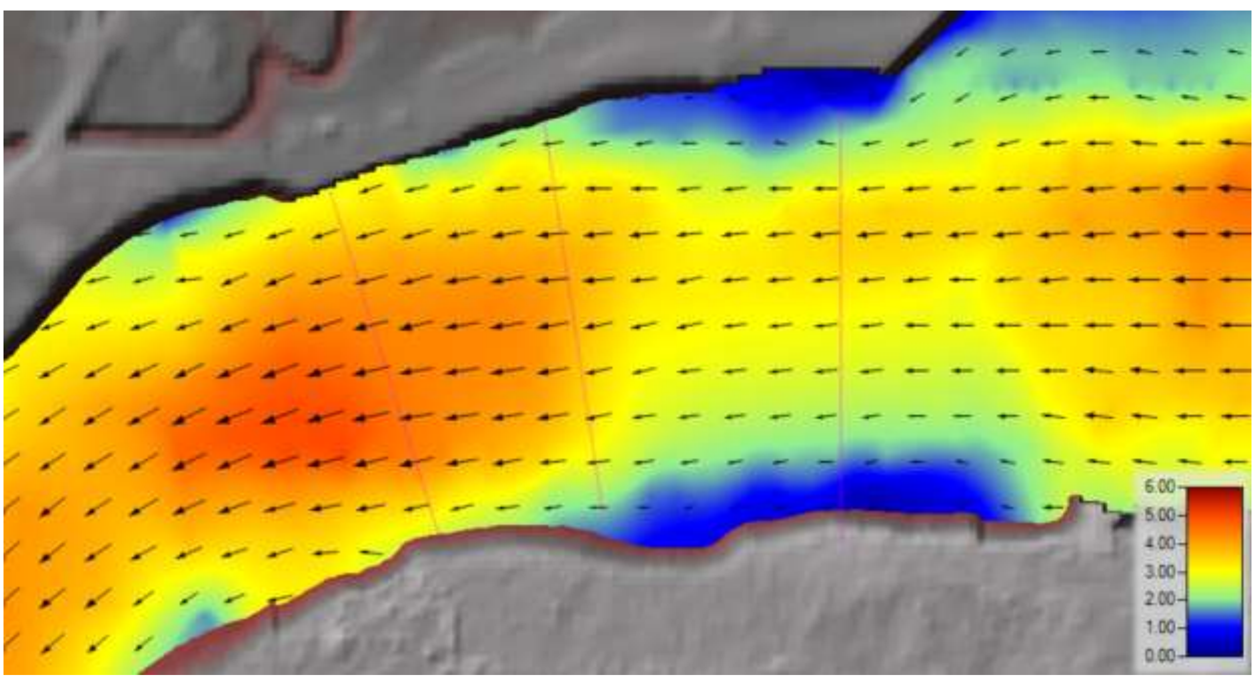


*Figure 13 - Filled Scour Hole – Velocity @ 33,000cfs*

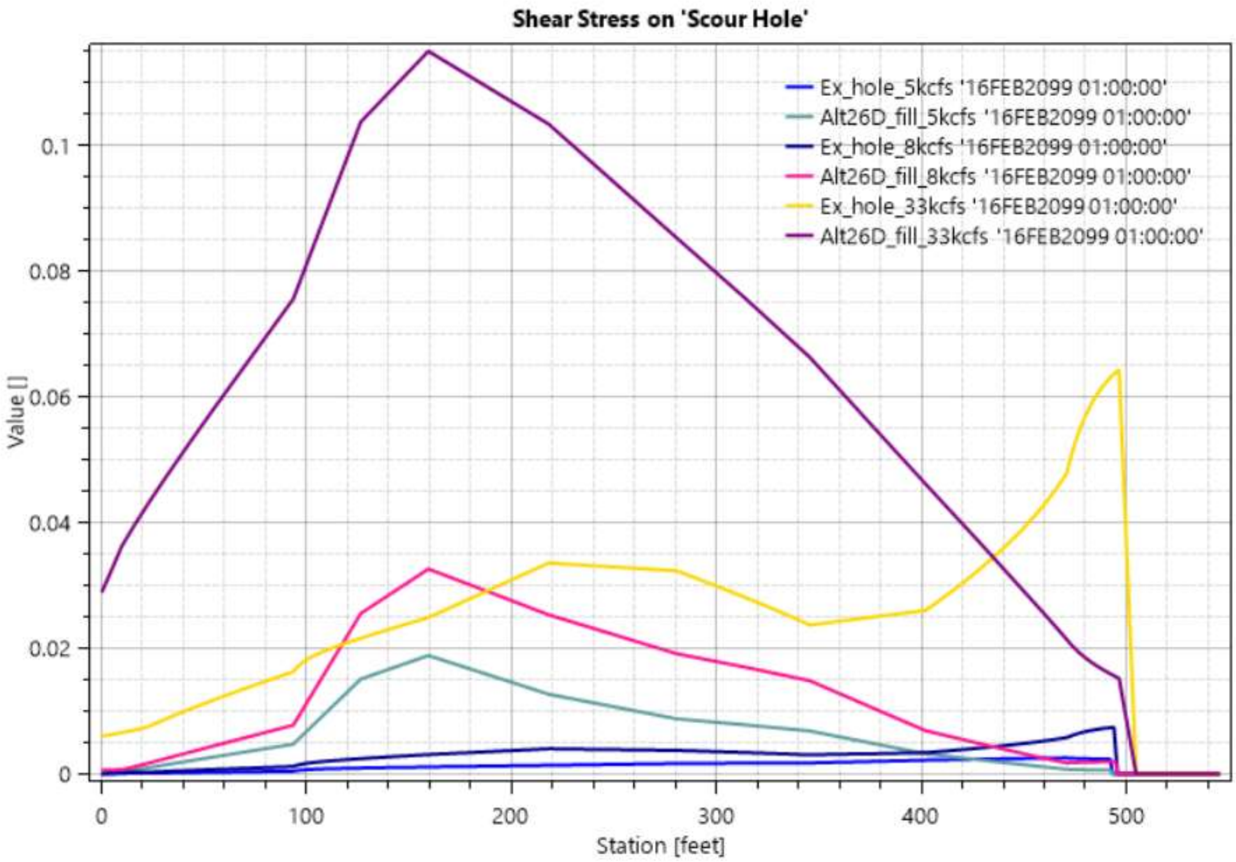


*Figure 14 – Shear Stress at the "Scour Hole" Transect*

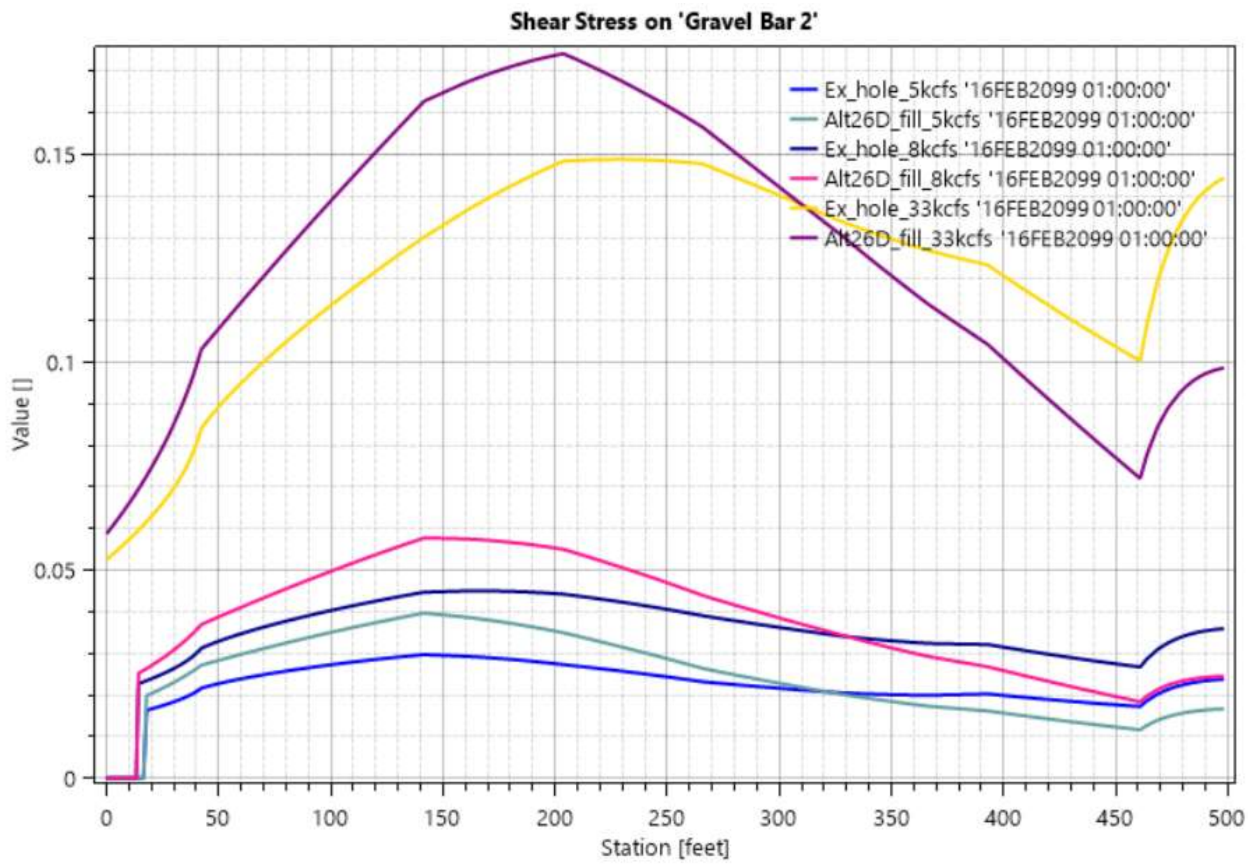


*Figure 15 – Shear Stress at the "Gravel Bar 2" Transect*

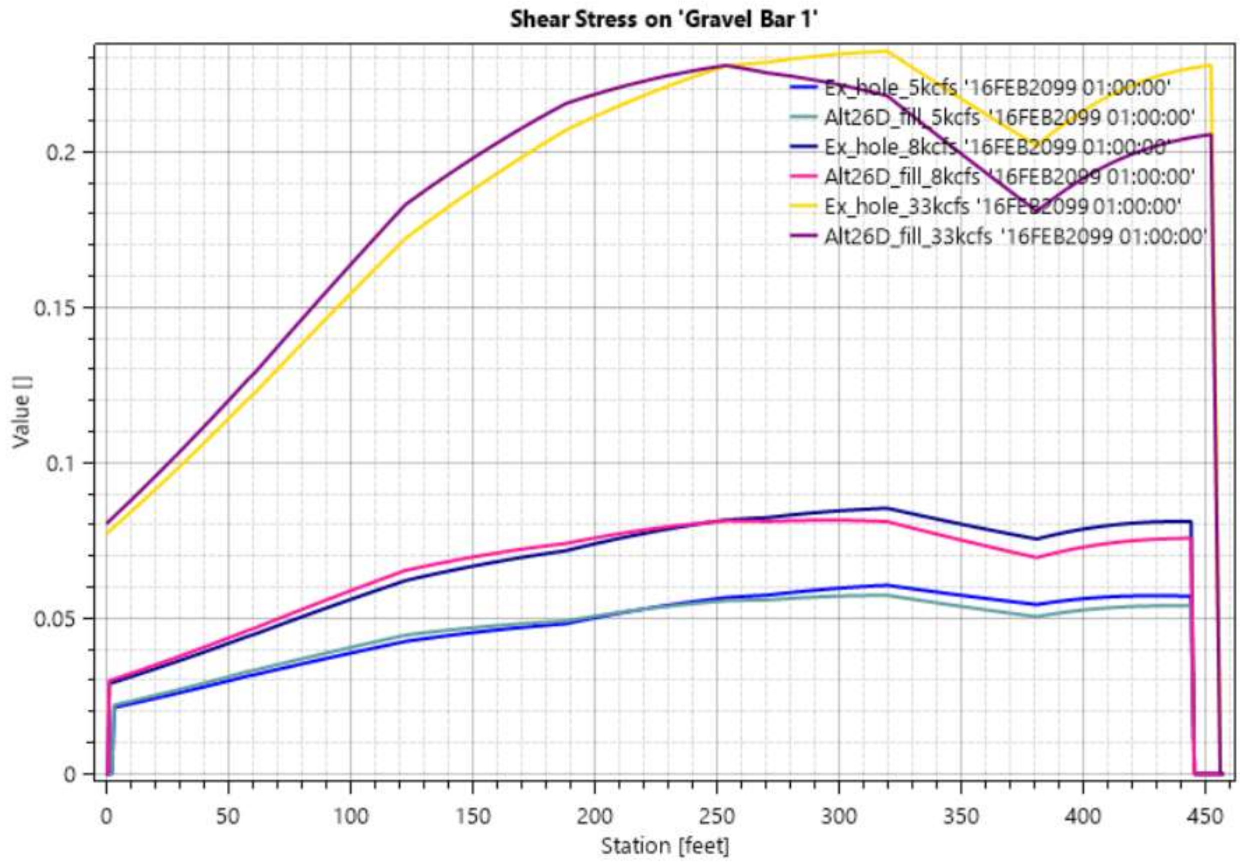


*Figure 16 – Shear Stress at the "Gravel Bar 1" Transect*

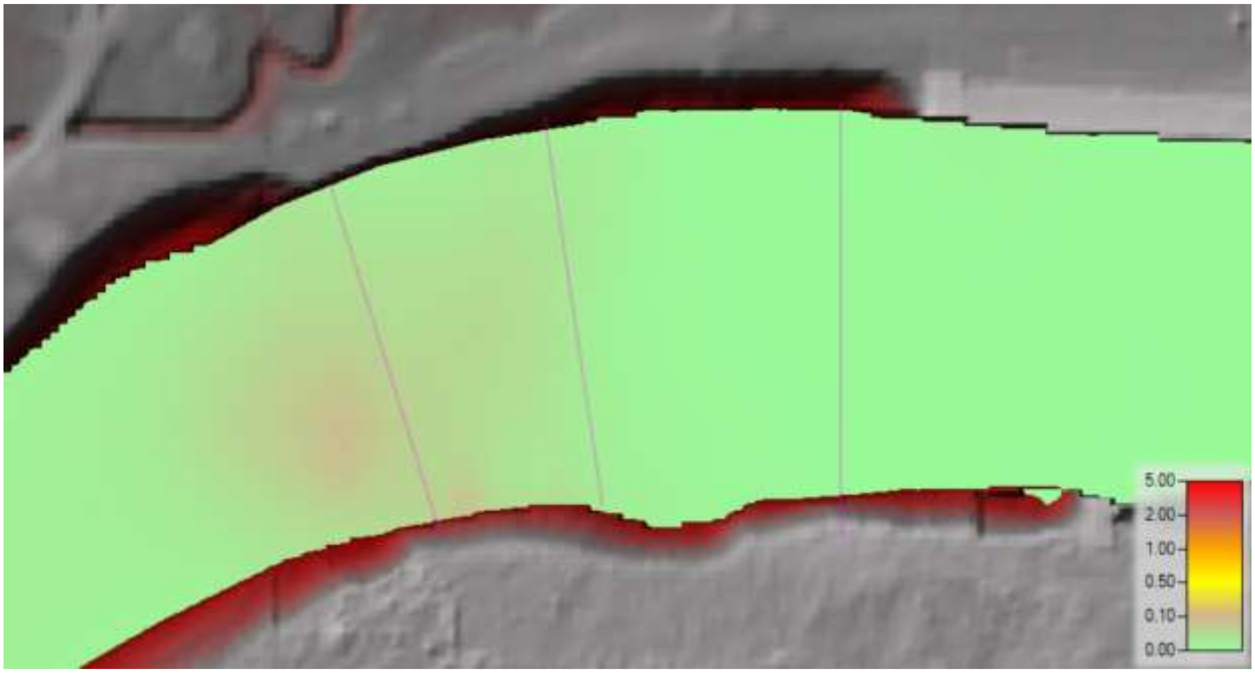


*Figure 17 - With Scour Hole – Shear Stress @ 5,000cfs*

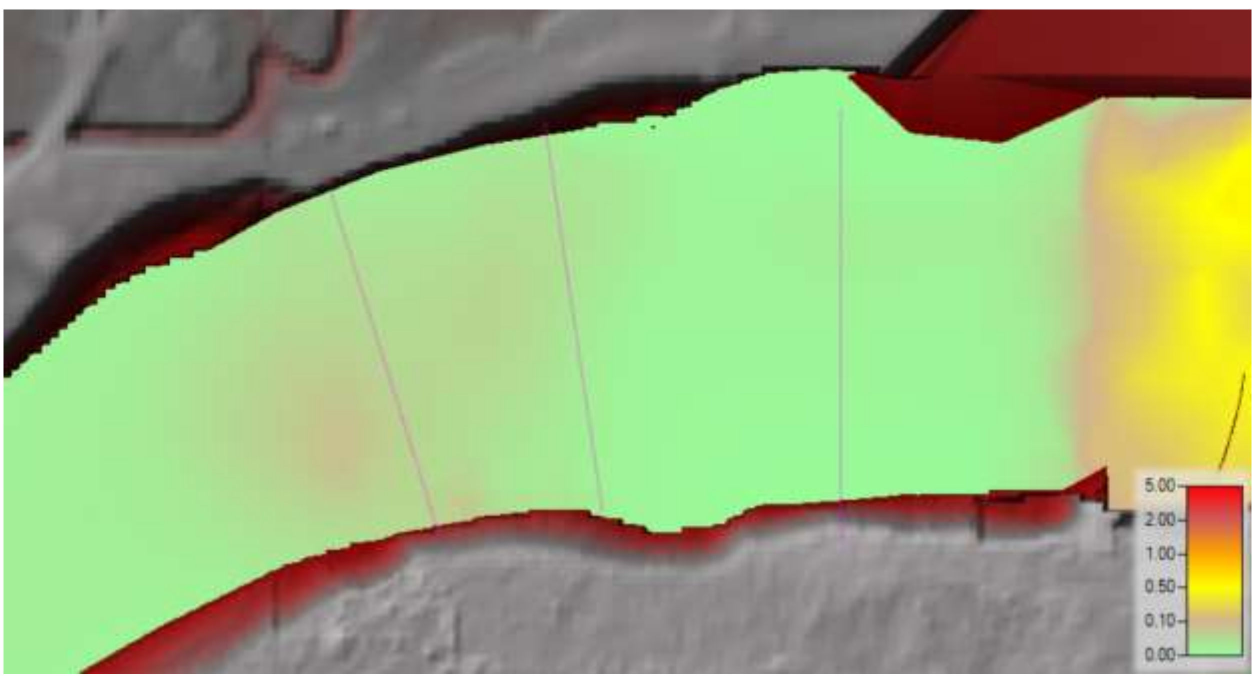


*Figure 18 - Filled Scour Hole – Shear Stress @ 5,000cfs*

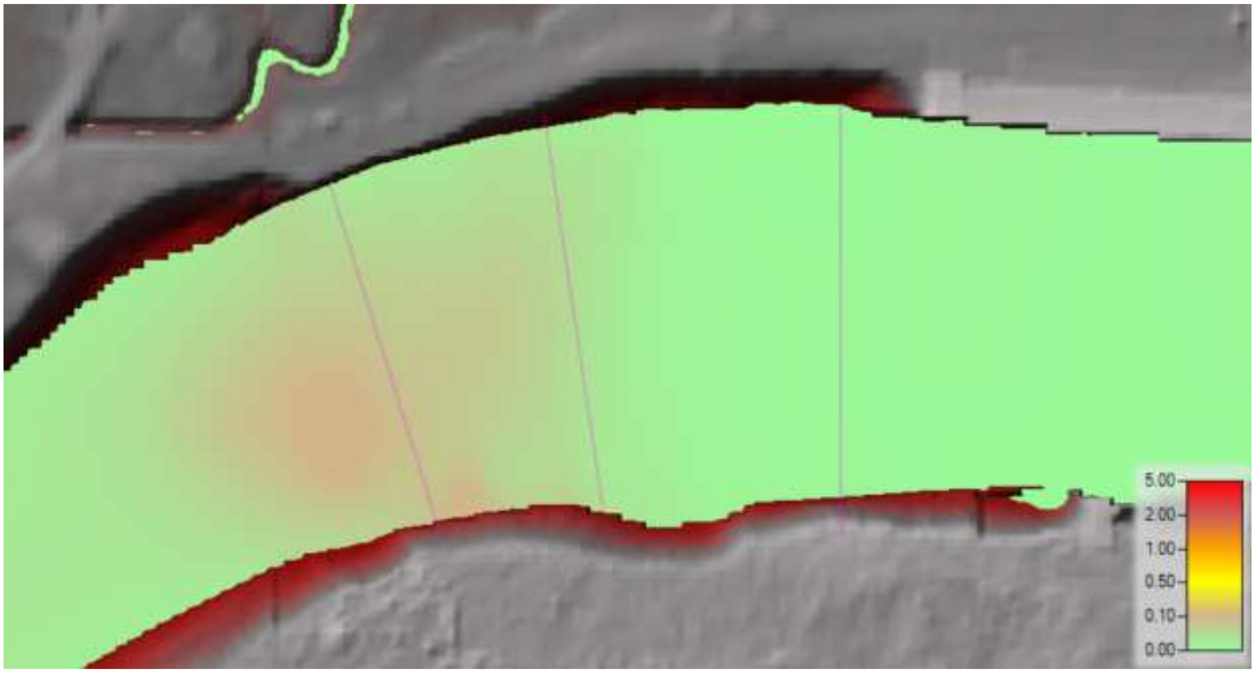


*Figure 19 - With Scour Hole – Shear Stress @ 8,000cfs*

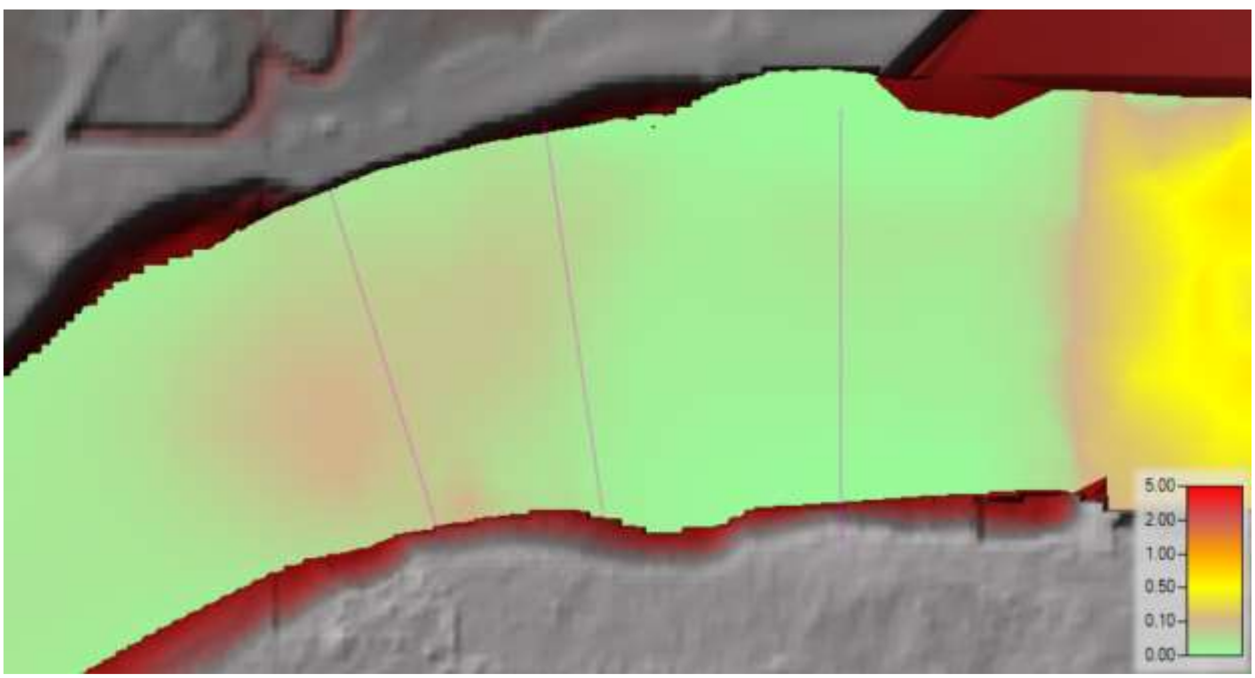


*Figure 20 - Filled Scour Hole – Shear Stress @ 8,000cfs*

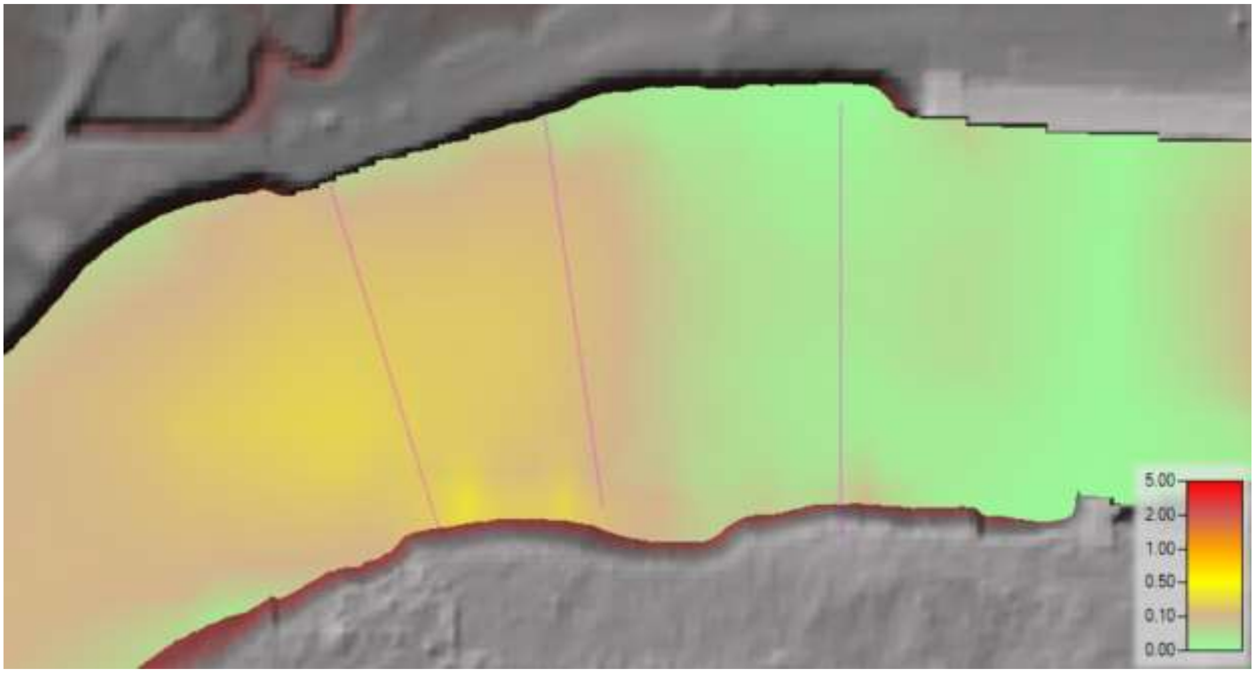


*Figure 21 - With Scour Hole – Shear Stress @ 33,000cfs*

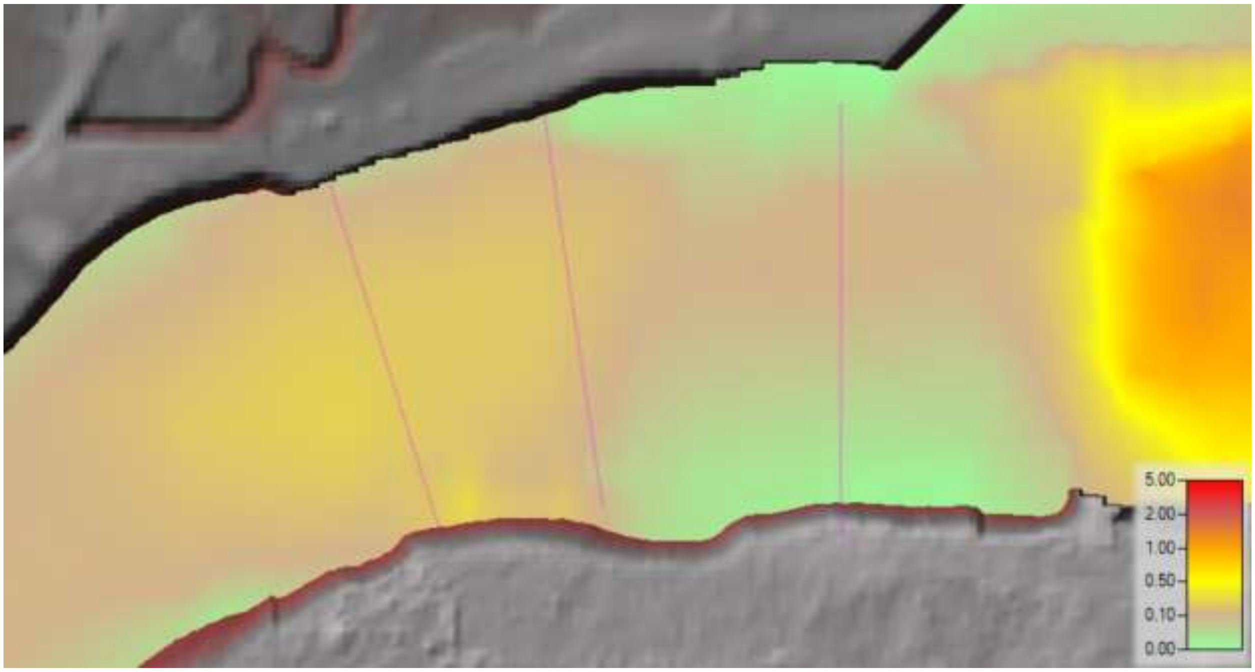


*Figure 22 - Filled Scour Hole – Shear Stress @ 33,000cfs*