

# 2D Hydraulic Model Review Checklist

## 1. Pre-Review / Submittal Best Practices Considerations

- Use the Elements - Merge Triangles option (Top menu) to reduce the number of mesh elements by 25-30% and save CPU time
- Trim the model domain to exclude large areas outside of the floodplain
- For steady flow models use the Simulation End output option to avoid large file sizes
- Clean up and organize map project data to include only what is needed for review
- Name simulations and other coverages with short, easy to understand labels
- Complete the project metadata and notes to provide explanations where needed
- Consider using the Advanced Simulations option to run multiple flows for the same mesh (helps to declutter simulation list)
- Use the Steady Flow option for steady flows, unless the unsteady option is needed to improve stability
- Consider using initial conditions for each simulation to minimize runtime. Starting with a restart file or initial WSEL can significantly reduce runtime.
- Consider using an initial and secondary timestep to optimize runtimes (Model control/advanced settings)
- Optimize simulation timestep and simulation time to minimize CPU time
- Use restart or WSEL initial conditions to minimize CPU times
- Run the simulation Summary Report (rt click on any sim, select Tools – Summary Report) and provide electronic files to reviewer (In SMS all the files are contained in a Reports folder in the project directory)
- Perform internal Quality Control (QC) review prior to submittal

## 2. Project Information

- What is the project name and location?
- What is the objective of the project?
- What model and version were used to complete the analyses? Was the current version (at the start of the project) used? If not, why?
- Who did the modeling and when was the modeling performed?
- What are the modelers qualifications?
- What project files and simulations are to be reviewed?
- Are the modeling approach and assumptions provided in a hydraulic report or memo?
- Is the approach appropriate to meet the project objective?

### Terrain data review

- What are the project horizontal and vertical datums?
- Are there any local scaling factors or adjustments?
- Are the horizontal and vertical datums consistent (feet or meters)?
- What are the sources of terrain data (Lidar, photogrammetry, DEM, other?)
- Is metadata provided that documents the accuracy of the data? (i.e. Lidar data has quality specs, QL1, QL2, etc.)

- Was channel stamping used (approximated channel data)? This is appropriate upstream and downstream, but not for the area of interest, for detailed hydraulic analysis.
- Is supplemental site survey data included?
- Is supplemental bridge / culvert data provided (i.e., bridge deck and low chord profiles)
- Is supplemental data provided for other structures (i.e. weirs, gates, etc.)
- Has any Lidar data been processed to remove unwanted features (vegetation, structures, bridge decks, etc.)
- How is the channel bathymetry represented?
- Are the seams between channel and overbank data smooth and consistent? (bank contours should not protrude out into the channel between cross section data)
- Have bridge decks, railings, signs, and other raised features been removed from the terrain data? (Remnant bridge decks will act as dams if left in place)
- Are key features (hydraulic controls and conveyance) represented correctly and consistently? (i.e., no artificial dams along channels or cuts in embankments) (3D rotation features are helpful for this review)
- Is the average point spacing of the terrain data reasonable relative to the mesh size and project objective? (e.g., 10m DEM data is not sufficient for detailed hydraulic analyses)
- Are break lines used where necessary? (Typically along channels, ridges, and linear features, and transitions between coarse and higher resolution data)
- For 3D raster terrain files, is the pixel size appropriate? (3-10 ft pixel size is recommended for detail hydraulic modeling)

### 3. 2D Mesh

- Is the length of the modeled reach adequate? (As a rule-of-thumb, the recommended reach lengths are twice the floodplain width up and downstream of the project area. For shorter reaches, sensitivity analysis should be considered to assess influence of boundary conditions)
- How many elements are in the mesh? What are the range of sizes? (Most bridge hydraulic analysis meshes should have less than 100,000 elements)
- Are the element lengths (in direction of flow) generally equal to the flow depth or larger? (This helps to avoid simulation instability problems)
- Do the lateral limits of the mesh extend beyond the limits of the largest flood modeled? (If the flow encounters the edge of the mesh, a vertical wall is assumed.)
- Are key project features (channels, embankments, etc.) represented accurately in the mesh terrain? (Compare with original terrain data, rotating in 3D is helpful.)
- Do all hydraulic controls have a consistent edge of elements aligned consistently along the feature crest? (If not the feature will not be represented correctly.)
- Are embankment slopes and channel banks represented with at least two or more elements in areas where detailed hydraulic information will be used?
- Are the bridge embankments and channel geometry under the bridge represented correctly?
- Are bridge piers represented as holes in the mesh where detailed hydraulic information will be assessed?
- Is the pier footprint geometry represented appropriately? (Refer to Figure A.29 in the 2D modeling reference document)

- Is the mesh quality reasonable? (In SMS/SRH-2D review the interior element angles, as small angles can cause instabilities, or simply require a smaller time step to achieve a good solution.)
- Is the mesh efficient? Are small elements used where detail is needed and large elements elsewhere? Other options that can be used to improve mesh efficiency include: 1) Constant Paving Density Meshing, 2) Merging Triangles (mesh), 3) Feature Extractions (to highlight controls), 4) Bias and Double Bias vertex distribution to optimize mesh transitions, and 5) mesh quality improvements.

#### 4. Boundary Conditions

- Are all flow events clearly identified and labeled?
- Are boundary conditions (arcs) located in the appropriate location? (Use Snap Preview in SMS/SRH-2D to review where boundary conditions are applied)
- Are steady or unsteady inflow boundary conditions used?
- Are simulations executed as steady or unsteady? (In SRH-2D, the steady flow option may be used to reduce computer run time.)
- Do the flows specified in boundary condition coverages compare with the report values?
- Are the boundary conditions consistent between existing and proposed conditions?
- For inflow boundary conditions (Inlet-Q) should use the conveyance distribution option for natural channels.
- For the downstream boundary condition(s) (Exit-H), what is the source? (Normal depth, critical depth, known WSEL?) Is it appropriate?
- Are the appropriate downstream boundary conditions used for each flood event?

#### 5. Material Roughness

- What are the sources of material/land use delineations? (field investigation, photo references, calibration, etc.)
- Are the different materials represented in reasonable detail that is consistent with the project objective?
- How were the Manning's n values for each material type determined?
- Were sources and determination of n values documented in the report or summary?
- Are the values within reasonable ranges?
- Do the material limits extend to or beyond the limits of the mesh?
- Were the Manning's n values calibrated based measured flows and high water marks or flood inundation limits?
- If no calibration data were available, were sensitivity analyses performed to assess the impact of changing the roughness values?

#### 6. Hydraulic Structures

##### Bridges and 2D Culverts

- Is the channel geometry and abutment geometry represented in the terrain by the mesh?
- Is the mesh size and density through the bridge opening appropriate for detailed hydraulic analyses (5-7 elements per bridge span is a good minimum for detailed analyses)
- Are bridge piers represented as holes in the mesh where detailed hydraulic analyses are needed? Bridge piers at other locations may be represented as blocked obstructions.

- If pressure flow exists, is the bridge footprint represented by boundary condition arcs or a 3D bridge? (If no pressure flow, the bridge deck does not need to be represented.)
- Do the arcs or 3D bridge span the entire embankment opening? (If not, flow may bypass. It is ok to have the bridge extend into the mesh embankment)
- Do the pressure boundary condition arcs or 3D bridge definition align to clearly define a rectangular pressure zone area?
- Are the low chord and bridge deck elevation (or profile for 3D bridge) correctly represented in the boundary conditions?
- Is the bridge deck overtopping option used? If so, is the width of the weir flow correctly assigned as the length of the bridge deck?
- What Manning's roughness coefficient is used for the ceiling? (A value of 0.05 to 0.08 is recommended for most girder type bridges.)
- If vertical walls are represented with holes in the mesh, are the appropriate elevations represented in the mesh elements on either side of the wall? (The source terrain data may need to be edited to ensure correct terrain representation.)

### 1D Culverts

- Are mesh elements defined to represent the approximate limits of the culvert crossing?
- Are the mesh elevations at the culvert inverts consistent with the culvert elevations?
- Are the upstream and downstream arcs assigned correctly?
- Is the road crest length in HY-8 set to equal the BC arc (width of 1D culvert zone)? If set wider, overtopping flow will be doubly accounted for.
- If the 2D overtopping option is used (SMS 13.1 and later), is the road crest length set minimally (e.g. 0.1 ft) to exclude 1D overtopping from being computed in HY-8?
- Is the 'Use Total Head' option use for crossings that have an approach velocity? (It is recommended)
- Is the correct crossing in HY-8 assigned to the culvert boundary arcs in SMS?

### Obstructions

- Are all obstructions included/defined in a single coverage?
- Are the elevations of each point or arc set to the bottom elevation of the obstruction?
- Are the obstruction width and drag coefficient set correctly?
- Are the obstructions placed appropriately?

### Other Structures

- Are others structures represented (weirs, gates, link BCs with rating curves, sinks/sources (storm drains), etc.)
- Are all 1D structures represented with two arcs (one upstream and one downstream)? (sinks/sources are an exception)
- Are all geometric and other input parameters correct and consistent (with hydraulic report)?

## 7. Simulation Parameters (Model Controls)

- How many simulations are included and to be reviewed?

- Are all simulations clearly labeled? (SMS/SRH-2D model results are organized by simulation name)
- What time step is used? (For SRH-2D 1s-20s is most common. Use the largest time step that results in continuity and stability.)
- What is the simulation's time and is it adequate? (For steady flows, the simulation should run long enough to reach a steady state condition).
- Have the turbulence model and coefficient been changed? (The default method and coefficient should be used (Parabolic and 0.7).)

## 8. Model Results

### Simulation Dashboard Plots

- Does the Net Q reach zero (for a steady flow condition)?
- Does the Mass Balance Plot indicate negligible errors (Typically less than 1-2% with limited oscillations)?
- For steady flow simulations, do the number of wet elements reach a nearly constant condition?
- Do the monitoring point plots show stable results?
- Do the monitoring line plots show stable results and continuity?

### Output Datasets

- Are there any unrealistic spikes in the shear stress results? (Often indicates bad mesh geometry)
- Are the Froude numbers predominantly less than 1.0, except in limited locations? (Long reaches with values greater than 1.0 indicate that the assigned Manning's roughness values are too low.)
- Are velocities within reasonable ranges? (Unrealistically high local velocities are often associated with small interior mesh angles or other instabilities.)
- Do the velocity vectors reflect expected flow patterns? (Abnormal circulation areas or flow directions can indicate model instabilities or issues.)
- Are there any abrupt changes in depth? Do they reflect the terrain? If not, they are worth a closer look.
- Do the WSEL limits (flood limits) and flow paths look reasonable? In areas of shallow flow and overtopping, the mesh representation of the terrain should be reviewed.

### Cross Section and Profile Data

- Do cross sections through the project area look reasonable?
- Does a profile along the channel center line with WSELs look reasonable?
- In the vicinity of hydraulics structures and approach embankments with overtopping, do the water surface elevations seem reasonable? (i.e. with pressure flow the water surface should dip under the deck)

### Dataset Comparisons

- For comparisons of two conditions (i.e. existing vs proposed) are differential surface contour datasets generated? Do the differences look reasonable?
- Are profile and cross section comparison plots generated?
- Are the simulation components (input data and model controls) the same for both data sets being compared? (Aside from differing terrain data or structures)

- Has a summary table been generated for the data set comparisons?

#### Bridge Scour Hydraulic Parameters

- Identify the number of scour coverages and events that were evaluated for scour.
- Verify the source of soil gradation that was used to define the d50 for scour analyses.
- Verify that the contracted section arc is aligned with the bridge and spans the bridge opening
- Verify that the approach section is located upstream of the bridge at a location upstream of where the velocity vectors indicate overbank flow returning to the channel.
- Verify that the approach section is NOT located in a locally high velocity area (this will underpredict scour)
- Verify that the bank arcs are located at the toe of slope or top of bank at the approach and contracted sections. The location should be consistent.
- Verify that the Pier Arcs are aligned with the center of the piers and the pier arc properties are set appropriately.
- Verify that the Abutment Toe arcs are located in the general abutment toe location, within the flow area, and the configuration type is set correctly.
- Verify that all arcs are set as the correct type
- For non-SMS/SRH-2D analysis, verify that the hydraulic parameters were extracted to represent averaged hydraulic conditions in the main channel and each overbank.
- For non SMS/SRH-2D analysis, verify that the contracted section hydraulic parameters are adjusted to reflect bridge skew and pier skew.