



**US Army Corps
of Engineers®**

Hydrologic Engineering Center

River Analysis System HEC-RAS

Release Notes

Version 5.0.2

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Introduction

Version 5.0.2 of the River Analysis System (HEC-RAS) is now available. This Version supersedes Version 5.0.1, and all previous versions.

A list of the bugs fixed between versions 5.0.1 and 5.0.2 can be found below under the "Problems Repaired" section of this document. Some new features were added to version 5.0.2. These features are the following:

- 1. Culvert Inlet/Outlet Control:** If the flow is low flow through the culvert, and the flow passes through critical depth at the entrance of the culvert, then Inlet Control is assumed to be the controlling flow regime, even if the Outlet control calculations comes up with a higher upstream energy. Previous versions of HEC-RAS would have selected the outlet control answer under this scenario.
- 2. Lateral Structures Connected to 2D Flow Areas:** A new option has been added for computing the flow from a 1D river reach over a lateral structure connected to a 2D Flow Area. Previous versions could only compute the overflow with a weir equation. With version 5.0.2 you can now select to use the "2D Flow Equations" or the "Weir" equation to compute the flow over the lateral structure. If the user selects the "2D Flow Equations" option, overflow is computed by treating the 1D riverine water surface as a Stage Boundary condition on each 2D cell it is connected to. Based on the stage at each cell the 2D Flow Equations can compute how much flow will come into the 2D Flow Area or leave the 2D Flow Area (on a cell by cell basis). If this option is selected, the weir coefficient and weir equation are not used. Currently this option cannot be combined with culverts, gates, rating curves, and time series outlets (This is only available when using the weir equation option).
- 3. RAS Mapper - Flow and Volume Time Series Output:** We have added the ability to plot flow verses time and volume accumulation verses time, across profile lines in 2D areas. This feature is tied into our profile lines in RAS Mapper. When you right-click a profile line in the Mapper window, a new menu item will now be present: "Time Series". When a user asks for a Flow plot, we intersect the profile line with the 2D area to find the collection of 2D faces that most closely matches the profile line. Then, we run through the time-series of face water-surface values and velocities, multiplying the face's wetted area by the perpendicular velocity to compute a flow across that face. The reported plot values aggregate every face along the profile line to create a flow summation for that time step. For the volume accumulation plot, we sum and track these flow values from the start to the end of the simulation. The final value in this plot is the total water volume to cross this profile line over the entire simulation. These plots will compute and compare any results that are checked in the tree view.
- 4. RAS Mapper - Max Velocity description:** We have removed the ability for particle-tracing and static arrows to be used on the maximum or minimum velocity profiles. The maximum velocity profile records the maximum velocity encountered for any particular face during the entire simulation. Then, the rendering engine interpolates between these values to

create a 2D map of maximum velocities. This presents a problem; the face velocities could have occurred at dramatically different points in time, and the water could have been moving in an entirely different direction. The maximum velocity map can provide some useful intuition about hazards at a glance, but we found too many people were taking these results at face value. These map values were interpolated between face velocities that did *not* occur at the same point in time, and the mapped velocities may never have actually occurred during the simulation. Further, the distorted velocity directions showed erroneous results when particle tracing was used; bridges and obstructions failed to show back-eddys, jarring vector changes at cell boundaries, etc. For these reasons, we have decided only to allow particle tracing at computed profiles. Particle tracing provided bad information and was frequently misinterpreted at the maximum profile for many datasets.

5. **RAS Mapper - profile point moving and tick marks:** We have added some extra polish to the RAS Mapper profile lines. Using the "Select features" mouse cursor, you can now move profile line points for the active (highlighted) profile line. You still cannot delete or add points via the RAS Mapper interface; editing tools will be greatly expanded in a future version of RAS Mapper. Editable profile line points show up as larger magenta dots along the selected profile line. We have also added tick-marks measuring distance along the selected profile line, which show up as highlighted textboxes on the Mapper window. This can be turned off via the "Show Profile Line Distance" option under the "Tools" menu.

6. **RAS Mapper – Legend:** The legend for the active layer now appears in the lower-right corner of the mapper window. If you wish to disable it, you can do so under "Show Legend" in the "Tools" menu.

7. **RAS Mapper - Describe sloping/hybrid modes:** The horizontal rendering mode attempts to be as true to the compute engine as possible. Since the compute engine reports a single water surface per cell, we render that flat water surface across the entire cell and intersect it with the terrain to show wet/dry areas. In steep terrain and shallow conditions, this has the effect of stair-stepping the water, showing separated bodies of water from cell to cell. It is also less realistic with large cells, since we don't interpolate potentially large water surface changes between them.

The sloping rendering method uses the computed water surfaces to intuit a more natural water transfer between cells. If water goes over a face, we assume that water is sloping between the two cells. Because of this, neighboring cells can affect each other's rendered water surface. This results in better rendered images, but comes with its own set of problems. Because the sloping water surface allows neighboring cells to drag results up or down, the rendered images are not true to the water volumes computed by the RAS 2D engine. These errors are dramatic in certain situations. Steep terrain with very shallow flow (like a rainfall-runoff model) can actually show large expanses of dry areas because the cells don't have enough water to connect to each other and render above the terrain. Another error-prone situation comes up when shallow water is flowing through a ravine. If a cell bounds a ravine such that the center of the cell covers low-ground, but the 4 corners (face-points) are on higher-ground, the water-surface will try to render across the four corners, creating dramatically more water over the low-ground center than actually exists. Because of these weak points in the sloping

method, we've created a 3rd rendering mode that attempts to bridge the deficiencies of both.

The hybrid rendering method takes the best parts of the sloping method and attempts to make it more accurate when it detects the potential for failure. We do this with a couple of tricks to raise and lower the water surface as needed. When shallow flow is detected, we fall back to the horizontal rendering mode for that particular 2D cell since the horizontal method renders low-volumes much more accurately. This will show the water stair-stepping, but won't incorrectly show large areas of dry land. We also add extra weight to the water-surfaces computed at the center of a face, so the downhill ravine case won't be so dramatically affected by the high-ground face points. Finally, we make an adjustment to the computed face-point values to drag them up or down so their average matches the computed cell water surface. This allows us to create a sloping water-surface, but ensures that we don't dramatically over-estimate or under-estimate the rendered volume.

Several new simulation features have been added to the HEC-RAS version 5.0. software. Version 5.0, 5.0.1, and 5.0.2 of HEC-RAS includes the following new features:

1. Two-dimensional and combined 1D/2D Unsteady Flow Modeling
2. New HEC-RAS Mapper capabilities and enhancements
3. Automated Manning's n value calibration for 1D unsteady Flow
4. Simplified Physical Breaching algorithm for Dam and Levees
5. Breach Width and development time calculator
6. New Hydraulic outlet features for Inline Structures
7. Sediment Transport Modeling Enhancements: Including unsteady flow sediment transport analyses; Reservoir flushing and sluicing; as well as channel stability using BSTEM integrated within HEC-RAS
8. Completely new 2D User's manual
9. Several new example applications within the Applications Guide
10. Updates User's Manual, Hydraulic Reference manual, Applications Guide, and Help System

Other minor enhancements were also added. The development team has also continued careful and systematic testing of the software since the last release. The results of that testing in combination with reports from users has allowed the identification and repair of various problems. Some minor problems that did not affect results but caused problems in the software interface have been repaired without being specifically documented.

Installation

The installation program and all documentation are available on the HEC website at <http://www.hec.usace.army.mil> . This new release is installed independently of any previous versions of the program. Users may have the new version and previous versions of HEC-RAS software installed simultaneously for parallel use or testing. This new version is fully compatible with projects developed in any previous version of the program. However, once a project has been opened in Version 5.02 and saved, it may not be possible to open it with an older version of the software and reproduce the old results.

The new installation package is designed to be easy to use. It will take you through the steps of selecting a directory for the program files and making other settings. Use the following steps to install the program on the Microsoft Windows® operating system:

1. Download the installation package from the HEC website to a temporary folder on the computer.
2. Run the installation program. In Windows Explorer, double-click the icon for the installation program. You must have administrator privileges to run the installer.
3. Follow the on-screen prompts to install the program.

New Capabilities for version 5.0

Two-dimensional and combined 1D/2D Unsteady Flow Modeling

HEC has added the ability to perform two-dimensional (2D) hydrodynamic routing within the unsteady flow analysis portion of HEC-RAS. Users can now perform one-dimensional (1D) unsteady-flow modeling, two-dimensional (2D) unsteady-flow modeling (Saint Venant equations or Diffusion Wave equations), as well as combined 1D and 2D unsteady-flow routing. The 2D flow areas in HEC-RAS can be used in number of ways. The following are examples of how the 2D flow areas can be used to support modeling with HEC-RAS:

1. Detailed 2D channel modeling
2. Detailed 2D channel and floodplain modeling
3. Combined 1D channels with 2D floodplain areas
4. Combined 1D channels/floodplains with 2D flow areas behind levees

5. Directly connect 1D reaches into and out of 2D flow areas
6. Directly connect a 2D flow area to 1D Storage Area with a hydraulic structure
7. Multiple 2D flow areas in the same geometry
8. Directly connect multiple 2D flow areas with hydraulic structures
9. Simplified to very detailed Dam Breach analyses
10. Simplified to very detailed Levee Breach analyses
11. Mixed flow regime. The 2D capability (as well as the 1D) can handle supercritical and subcritical flow, as well as the flow transitions from subcritical to super critical and super critical to subcritical (hydraulic jumps).

For more information about the new 2D modeling capabilities, please review the new 2D Modeling User's manual.

New HEC-RAS Mapper capabilities and enhancements

Geospatial capabilities are available in HEC-RAS to assist the hydraulic engineer to more efficiently create and refine the geometry of the hydraulic model. Using the RAS Mapper, HEC-RAS users can quickly analyze model results through the geospatial visualization with geometric data to more readily identify hydraulic model deficiencies and make model improvements. Primary visualization datasets are inundation boundary polygons and flood depth grids determined through evaluation of water surface elevations with a digital terrain model. The terrain model format support is the GeoTIFF file format. Raster data can be generated either on-the-fly or stored to disk for flood depth, velocity, arrival time and many other parameters. Velocity vector and velocity tracing plots can be generated dynamically through the interpolation of computed results. Raster results can also be exported for visualization in web-based mapping.

HEC-RAS 5.0 has also introduced the capability for directly using web imagery for basemap layers and the ability to reproject and display data using the GDAL open source library within RAS Mapper. The implementation of the GDAL tools allows for the visualization of many different file formats in different projections for analysis with RAS data. Additional geospatial options in RAS Mapper allow the user to take advantage of the National Levee Database and National Land Cover Database during model construct.

For more details on RAS Mapper, see Chapter 20 in the main HEC-RAS User's manual.

Automated Manning's n value calibration for 1D unsteady Flow

In order to assist engineers in the calibration of unsteady flow models, we have added an automated Manning's n value calibration feature. This Option requires observed stage time series data (flow time series is optional) in order to be used. Manning's n values are calibrated on a reach basis. One or more reaches can be calibrated within the same run. Hydrographs are broken into flow zones from low to high in order to allow Manning's n values to vary with flow rate. The results from using this feature are a set of flow versus roughness factors for each reach that it is applied to.

This automated calibration feature can be applied in either a "Global" or "Sequential" optimization mode. The "Global" mode optimizes Manning's n values for all reaches at the same time. While the "Sequential" mode optimizes Manning's n values for one reach at a time, working from upstream to downstream. Manning's n values are optimized (adjusted) for each flow zone until the maximum flow zone error is less than a user entered tolerance, or until a maximum number of iterations is reached.

For details on how to use the new Automated Manning's n value calibration feature, please review Chapter 16 of the User's Manual.

Simplified Physical Breaching algorithm for Dam and Levees

The Simplified Physical breaching method allows the user to enter velocity versus breach down-cutting and breach widening relationships, which are then used dynamically to figure out the breach progression versus the actual velocity being computed through the breach, on a time step by time step basis. This method can be used for overtopping and piping breaches.

For details on how to use the simplified physical breaching option for unsteady flow modeling in HEC-RAS, please review Chapter 16 of the User's Manual.

Breach Width and development time calculator

To assist users in estimating the Breach dimensions and development time, HEC has added a "Parameter Calculator" to the Breach Data editor. To use this calculator select the Parameter Calculator Tab from the breach editor.

The Breach Parameter Calculator contains five regression equations (MacDonald\Langridge-Monopolis); Froehlich 1995; Froehlich 2008; Von Thun and Gillette; and Xu & Zhang 2009). The user is required to enter several parameters that describe the Dam and the volume of water behind the structure at the time of failure. These parameters include: Top of Dam elevation; Breach Bottom Width; Pool elevation at Failure; Pool Volume at Failure; Failure Mode; Dam Crest width, upstream and downstream embankment slopes; Earth Fill Type; Dam Type; and Dam Erodibility factor. Not all values are used for all regression equations as noted on the editor. Some of the variables are specific to the MacDonald equation, and the last two are specific to the Xu & Zhang equation. Once the values are entered the calculator computes Breach Bottom Width; Side Slopes; and Breach Development Times from each of the regression equations. The user can

then select the answers from one of the equations to by pressing the Select button next to the equation results that they would like to use.

For details on how to use the Breach width and development time calculator option in HEC-RAS, please review Chapter 16 of the User's Manual.

New Hydraulic outlet features for Inline Structure

Several new outlet types have been added to the HEC-RAS Inline Structure capability. These new outlet types include: culverts; user defined rating curves; and a time series outlet in which the user can specify a flow release with time (this is a handy feature for representing hydropower flows through the penstocks).

For details on the new Inline structure outlet options in HEC-RAS, please review the section on Inline Structures in Chapter 6 of the User's Manual.

Sediment Transport Modeling Enhancements: Including unsteady flow sediment transport analyses; Reservoir flushing and sluicing; as well as channel stability using BSTEM integrated within HEC-RAS

Previous versions of HEC-RAS modeled sediment transport with the quasi-unsteady assumption. HEC-RAS 5.0 integrates the mobile bed, sediment transport modeling capabilities with unsteady flow. Coupling sediment transport with unsteady flow makes most of the features native to the HEC-RAS unsteady flow environment available for sediment transport analysis, including lateral structures and operational rules. HEC-RAS 5.0 includes new operational parameters (e.g. sediment concentration and bed elevation) and options in the Rules editors to operate structures for sediment objectives. Unsteady sediment transport makes reservoir modeling easier and more precise, particularly sustainable reservoir sediment alternatives like flushing and sluicing.

Previous versions of HEC-RAS adjusted cross sections in response to sediment deficit or surplus by adjusting nodes vertically. Cross sections could not change laterally. HEC-RAS 5.0 includes the USDA-ARS Bank Stability and Toe Erosion Model (BSTEM), which couples vertical bed change from classic sediment computations with lateral processes. Using BSTEM with sediment transport in HEC-RAS can predict cross section evolution in two dimensions and simulate the feedbacks between incision, lateral scour, and geotechnical bank failure processes. The USDA-ARS Bank Stability and Toe Erosion Model (BSTEM) capabilities are still considered Beta in HEC-RAS 5.0 and have a separate user manual released with the software.

Other new sediment features include: new HDF 5 output, gradational hotstarts, specific gage capabilities, the Copeland (Exner 7) bed mixing methods, the Dietrich fall velocity equation, bed roughness predictors (i.e. equations that update bed roughness as a function of dynamic sediment properties), a simplified channel evolution model for dam removal and flushing erosion, an alternate reservoir deposition option, sediment flow

splits, the integrated Toffaleti-MPM transport function, gradation specific cohesive parameters and several others.

For details on how to use the Ground Water Interflow Options for river reaches or storage areas in HEC-RAS, please review the boundary conditions section of Chapter 8 of the User's Manual.

HEC-RAS Manuals and Help System

The HEC-RAS User's Manuals has been completely updated for the 5.0 software release. All of the chapters have received updated text and graphics. New information has been added to several of the Chapters. A completely new 2D Modeling User's Manual has also been developed. Additionally several new example applications have been added to the Applications Guide. The HEC-RAS help system has been updated to reflect the software changes. The new help system directly uses the user's manual PDF file. The software still has context sensitive help, in that, while on any editor if you select the help menu option or press the F1 key, a help window will appear with the correct section of the manual displayed.

Problems Repaired

The following is a list of bugs that were found in version 5.0.1 and fixed for version 5.0.2:

1. **Floodway Encroachments at Culverts:** Floodway Encroachments method 1 was not working correctly for culverts. This bug was introduced in version 5.0.1 when we fixed a problem with encroachments at bridges. Both Culverts and bridges are now working correctly with all encroachment methods.
2. **Flow Distribution at Bridges:** The flow distribution output was not working correctly for the cross sections inside of a bridge.
3. **2D Flow Area Internal Hydraulic Structures.** Previously internal hydraulic structures with culverts or gates was attempting to compute a sloping water surface upstream and downstream of the culvert/gate, based on the water surface in all the cells connected to and just outside of the culvert/gate entrance and exit. This was causing many instability problems with internal culverts/gates inside of 2D Flow Areas. This has been changed to just use a flat water surface inside of each cell connected to the upstream and downstream end of any culvert/gate inside of a 2D Flow Area.
4. **SA/2D Area Connection and Rules.** If you tried to use Rules for controlling gates in an SA/2D Area Connection, when connecting a storage area to another storage area, the Rules editor would not allow you to put in the initial conditions of the gate, as well as the gate opening and closing rates.
5. **Simplified Physical Breaching.** If the simple, physical breaching option was selected, and the mass wasting option was not being used, there was a bug and the breach would not start correctly.
6. **Breach with a Restart File Option.** An Unsteady flow run that started with a restart file was not breaching correctly.
7. **Breaching with Lateral Structures.** The flow through the breach was not being displayed correctly in the detailed Lateral Structure output table. It was being computed correctly.
8. **Zero Manning's n value in 2D Flow Areas.** User's were allowed to enter a zero value for Manning's n values within a 2D Flow Area. This is no longer allowed.
9. **Unsteady Flow Encroachment Editor.** The Unsteady Flow Encroachment editor would not allow the user to leave a left or right encroachment as a blank (meaning no encroachment on that side).
10. **RAS Mapper.** Several minor RAS Mapper interface and plotting bugs were fixed.
11. **RAS Mapper- Exporting 1D Cross Sections as Terrain.** There was a bug in exporting 1D cross sections as a terrain file. If you had

a river reach on a sharp bend, and you had very few cross sections through the bend, the program would not stay within the main channel bank stations for the 1D terrain export.

The following is a list of bugs that were found in version 5.0 and fixed for version 5.0.1:

1. **Unsteady Flow with Pumps:** A pumping station that is connected "From" a storage area had a bug that could generate an "access violation" error.
2. **Unsteady flow with rating curves at structures:** The rating curves for: inline structure outlet rating curve, lateral structure outlet rating curve, and user defined gate rating curves (both inline and lateral) have been changed so that unsteady will no longer extrapolate past the top or bottom of the curve. A warning will be generated the first time this happens.
3. **Unsteady flow with an SA/2D Hydraulic Conn between two 2D areas:** There was a bug when a SA/2D connector has a 2D area on the upstream side. This bug would sometimes show up as an "access violation" error.
4. **Steady Flow Analysis (Encroachments at Bridges):** There was a bug when type 1 encroachments were specified immediately adjacent to a bridge opening. The encroachment was being set to the opening. The left encroachment was set to the left side of the bridge opening and the right encroachment was being set to the right edge of the opening.
5. **Unsteady flow with 2D areas/Internal Hydraulic connector:** For a hydraulic connector inside of a 2D area, the DSS output for headwater and tailwater had a bug. The reported values were "one cell" away from the intended values. For a connection that was entirely inside of a single cell, this resulted in a reported water surface of "0.0". This was only a reporting issue.
6. **1D Velocity plotting in HEC-RAS Mapper for metric data sets:** 1D HEC-RAS Mapper maximum velocity plot was wrong for SI data sets.
7. **Unsteady flow Lateral Structure connected to a 2D flow area:** For a lateral structure connected between a 1D river and a 2D area, the lateral structure was pulling the water out of the river at the wrong cross section location. The flow was being removed from the 1D river upstream of the location it should have been removing it from.
8. **User Interface – Right Bank of Main channel:** If you had a cross section with a vertical wall at the right bank of the main channel, the interface was displaying the main channel bank station at the bottom of the vertical wall. The computations were correct, this was just a visual problem in the interface.

9. **User Interface – Storage Area Elevation Volume Curves:** A new option to compute elevation vs volume curves for storage areas was occasionally coming up with negative volumes.
10. **User Interface – FIPS Compliance:** The interface was using a routine to compare data that was determined to not be FIPS compliant. This routine has been removed and we are using one that is FIPS compliant

The following is a list of bugs that were found in version 4.1 and fixed for version 5.0:

1. **Unsteady (user defined gate curves):** User defined gate curves for storage area connections were not working.
2. **Unsteady Flow Post processing (pump):** If a pump group had more than one pump that was on, only the flow from one pump was being summed. So the total flow of the pump group was wrong as was the total flow of the pump station. This bug did not affect the unsteady flow pump computations nor the pump DSS output.
3. **Steady flow (bridges/cross sections with lids):** For the internal bridge cross sections (or other cross sections with lids), if there was more than one Manning's n value in the channel, the program was not correctly compositing the channel Manning's n value. For bridges, this would only affect the answers using the energy method (the other methods, such as pressure/weir were not affected).
11. **Unsteady Flow Post processing:** The inline structure output was not showing the breach flow and breach velocity. This has been fixed.
12. **Steady flow (bridge/WSPRO):** The WSPRO method uses its own methodology to compute the friction/expansion loss between the exit cross section and the cross section immediately downstream/outside of the bridge. This computation was not correct and tended to slightly over predict the energy losses.
13. **Steady flow (bridge/WSPRO):** For the WSPRO bridge method, the energy downstream of the bridge was not being correctly outputted. (The WSPRO method recomputes the downstream water surface. The displayed/outputted energy did not reflect the recomputed water surface.)
14. **Unsteady Flow Post processing (overflow gate):** For lateral structures, the flow through an overflow gate was not always being output.
15. **SI Sediment Volume Bug:** HEC-RAS 4.1 did not convert sediment mass into volume correctly in SI units, generally under predicting deposition volume substantially.
16. **Wilcock Transport Function:** HEC-RAS 4.1 included a bug in the Wilcock transport function that generally caused it to substantially under predict transport.

17. **Lateral Structures:** A lateral structure that is connected "to a point between two XS's" could get a wrong error message that the "the distance to the upstream cross section is greater than cross section length".
18. **Unsteady (advanced rules):** For the advanced rules, using the "lookback" option (lag, average, etc.) was not working for storage areas.
19. **Steady flow (Inline structures):** The program was not allowing the water surface upstream of an inline structure to be less than water surface downstream. In rare cases, it is possible that the hydraulic computations should give an answer where the upstream energy is higher than the downstream energy, but the upstream water surface is lower than the downstream. This can happen for a weir that is highly submerged but still has a high enough velocity that the upstream velocity head is significantly larger than the downstream velocity head.
20. **Steady flow (Bridges):** If the edge of the bridge opening is a vertical wall, and the water surface is within this vertical wall (that is, the water surface is above the bottom of the wall and below the top of the wall), the wetted perimeter of this wall was not being included in the computations).
21. **Steady flow (Weir):** For highly submerged, sharp crested weirs the program was computing slightly too much flow.
22. **Steady flow (lateral structures):** A lateral structure that only has a rating curve (no weir, culvert, no gates) had an output problem that could cause the output for the next cross section downstream to be wrong.
23. **Steady flow (culvert):** If the elevation of the road/weir dropped below the bottom/invert of the lowest culvert, the program could not converge on a "weir only" solution.
24. **Unsteady flow HTAB (culvert):** If the elevation of the road/weir dropped below the bottom/invert of the lowest culvert, the curves were not correct.
25. **Steady flow (culvert storage connector):** For a storage area connector where the water surface in the two storage areas was less than 0.5 feet and there were at least two culverts with an invert (minimum elevation for flow) greater 0.5 feet, the program could lock up.
26. **Steady flow (blocked obstruction with bridge/lid):** If a cross section with a lid (or a bridge cross section) had a blocked obstruction that "poked through" the lid, the wetted perimeter was not being computed correctly.
27. **Unsteady flow (junctions):** The "Energy Balance Method" for a junction flow split (the flow splits into multiple reaches in the downstream direction), was not always working correctly.

28. **Unsteady flow (roughness factors):** The flow roughness factor and the seasonal roughness factor associated with geometric data had a bug that caused them to be applied to the wrong range of cross sections. This bug did not affect the roughness factors that were entered as part of the Plan data, only those entered in the geometric editor.
29. **Unsteady flow (Modpuls/Hydrologic routing):** Having both multiple Modpuls regions and lateral inflows in the same reach was causing a bug that was screwing up the lateral inflows.
30. **Unsteady flow (Navigation Dams):** For navigation dams, the starting gate open was being set to the minimum which usually caused a very high starting water surface behind the dam. The gate setting is now being determined based on the target water surface.
31. **Unsteady flow (Advanced Rules):** If an advanced rule operation had been used to set a desired flow (for a given gate group) and then a later rule operation set a specific gate opening height (for that gate group) the program was continuing to use the desired flow operation instead of overwriting it with the designated gate opening height.
32. **Steady flow (culvert):** For a steep culvert, where the flow at the inlet starts out supercritical (and the inlet is not submerged) but the flow has a hydraulic jump (and the outlet is submerged) the program was using the outlet answer (and reporting outlet control) when it should have been using the inlet control answer.
33. **Steady flow (culvert):** For a steep culvert, where the outlet is submerged and the original, subcritical outlet answer, shows that the inlet is not submerged, but the inlet answer shows a submerged inlet and "drowned" hydraulic jump, the program was not reporting the correct, full flowing outlet answer.
34. **Unsteady flow (hydraulic curves):** For the hydraulic bridge curves and hydraulic rating curves, the program was sometimes incorrectly reporting a, "extrapolated above rating curves" when in fact it had not had to extrapolate.
35. **Sediment (Long Cum Mass Change):** minor bug when erosion punched through the cover layer and eroded down into the surface layer during a single computation increment.
36. **All (rating curve/bridges):** If a cross section immediately upstream of a bridge has a rating curve, it was causing the program to crash.
37. **Sediment (overbank deposition):** Material that was being deposited in the overbank, outside of the moveable limit, was not being removed from the sediment going to the next cross section. It was being double accounted.
38. **Sediment (dredging/cumulative out):** The longitudinal cumulative mass output was not correctly including dredged output. Output bug only.
39. **Sediment (Exner7):** the Exner7 bed mixing option had several bugs.

40. **Sediment (hydraulic averaging):** the hydraulic averaging between cross sections was improved so as to not allow hydraulic average over cross sections with big flow changes.
41. **Steady flow (Culverts):** For a culvert that was partially filled in with sediment, the reported depths for critical depth and normal depths were not correct. The depths included the filled in depth. This was only a reporting error, not a computation error.
42. **Sediment (scour bottom):** If a cross section had a large amount of scour in a single computation interval, and this scour exceeded the scour bottom (maximum allowable scour) the extra scour was not being handled correctly (it was being allowed to "overshoot").
43. **Unsteady (Modified Puls):** If a model has multiple modified puls regions and the different modpuls regions have not been entered from upstream to downstream, this could have caused an error in RAS.
44. **Sediment (mass correction):** Didn't work correctly if xsec was scouring and depositing at the same time (overbank deposition, channel scour).
45. **Sediment Hydraulic Design:** The hydraulic design computations for sediment transport capacity had a problem with transport through bridges.
46. **Sediment (retention option):** This option did not work at junctions.
47. **Unsteady (Levee Breaching and User Specified XS):** There was a bug if the user had entered a levee breach at a lateral structure that also had user specified cross sections on the tailwater side.
48. **Sediment (active method/krone):** The Krone deposition method was not working correctly for the sediment active layer method.
49. **Geometry (Lateral Structure):** If the Lateral Structure was set up to have multiple cross sections on the Tailwater side, and it was set to use Default computed intersections (on the TW side), and the LS extended past the end of the reach, RAS was reporting the wrong error message.
50. **Unsteady (Levee and Dam breach):** For the levee and dam breach, the right side slope was being ignored. The left side slope was being applied to both the left and right sides.
51. **Unsteady (Navigation Dam):** If the user had selected to use a gate change time increment (e.g. only operate the gates every four hours), the gate(s) were incorrectly limited to moving only for a single time step. For instance, if the gate open rate was 0.5 feet/minute and the time step was set to one minute, when it came time to operate the gate, the gate would only raise a maximum of 0.5 feet. If the time step was thirty seconds, the gate would only raise a maximum of 0.25 feet (until the next time increment for the gate operations).
52. **Unsteady (Junctions):** For unsteady flow at junctions, if the user selected the energy balance method, RAS was computing the energy

losses based on the downstream reach lengths entered in the cross section editor. This has been fixed so that it is now using the reach lengths entered in the junction editor.

53. **Unsteady (Dam/Levee breach):** The default growth shape was changed so that the vertical erosion rate is equal to the horizontal erosion rate for version 5.0. Version 4.1 used different erosion rates for vertical vs horizontal growth, and was computed to get to the maximum depth and width at the same time. This change can make a big difference to the computed peak flow vs the HEC-RAS 4.1 version. If you need to reproduce the 4.1 results, you can specify the vertical/horizontal growth rate ratio.
54. **Steady flow (Supercritical/Mixed flow):** For supercritical flow, the reported friction loss was the friction loss between the current cross section and the upstream cross section (instead of the current and the downstream). This same issue also applied to reported headloss, friction slope and contraction and expansion losses. This was an output problem, and not a computational issue
55. **Sediment (Exner5/Partheniades):** For the Exner5 bed mixing option, when using the Krone/Partheniades option, if the given cross section has more than 10% clay that was a bug that could artificially limit the amount of erosion or prevent erosion altogether.
56. **Unsteady (Post Processor):** Setting the Detailed Output Interval to "Max Only" did not work correctly. (Post processor would not run.)
57. **Unsteady (Warmup):** The program previously did at least one warmup time step (even if number of warmup time steps was set to zero). This is no longer the case. If the number of warmup time steps is set to zero, the initial results/output (at time zero) are from the initial steady flow backwater.
58. **Unsteady (Flow vs. roughness):** The flow roughness factors for negative flows (reverse flows) was not correct. The program will now take the absolute value of the flow before performing the roughness lookup.
59. **Unsteady (Flow roughness):** If the flow was smaller than the first value in the table (the first value was not zero) then the program was transitioning the roughness to 1.0 (no change) as the flow went to zero. Instead, it now uses the bottom value in the table, and not transitioning.
60. **Steady/Unsteady (Rating curve on Lateral Structure):** The distance field on the lateral rating curve (for a lateral structure) was not being used correctly. It is now being used (and the value is based on the lateral structure stationing not the distance to the upstream cross section.
61. **Unsteady (SA Connector with Breach):** If a Storage Area Connection had a breach and the SA connector was set to "Compute Using Curves" the breach was being ignored.

62. **Unsteady (pump rules):** For the advanced pump rules (these are the rules specific to pumps, not the general Advanced Rules), there was a bug if a day of month was entered as a single digit. For example, "1Jan2012" would not work, but "01Jan2012" was ok.
63. **Sediment (Concentration):** The sediment concentration output was wrong. This has been fixed.
64. **Unsteady (navigation dam):** The option to use both hinge control and pool control was sometimes not working.
65. **Steady and Geometric PreProcess (bridges/cuverts):** Cross sections with ineffective flow areas can have multiple critical depths. The program was sometimes not using the best answer. The most likely situation that this bug would show up is for the unsteady flow preprocess internal boundary curves where the curve suddenly "shot up" for no apparent reason.
66. **Unsteady (IB Stage/Flow at Inline Structure with elevation controlled gates):** When using the IB Stage/Flow option at an inline structure to force a known stage or known flow, the program will now operate the gates in order to match the gate opening to the forced stage or flow. When the user entered IB Stage/Flow "runs out", the program will revert to "normal" gate flow for the inline structure. For the case where the inline structure is using elevation controlled gates (as opposed to time series gates), the gate openings should match the flow condition when the IB runs out.
67. **Preprocess/Unsteady (HTAB points):** The number of allowable points in the cross section lookup tables has been increased to 500.
68. **Converting bridge to cross sections with lids is no longer supported.** This option was causing stability problems in some unsteady flow models. We felt that computing the bridge curves was a much better option.
69. **Unsteady (Inline culvert flap gates):** For culverts in an inline structure, the positive flap gate option was not working correctly.
70. **Unsteady/steady (lateral structure crossing bridge):** A lateral structure that crossed a bridge showed flow leaving the river between the bridge sections when in fact flow was not being removed from the river. No lateral structure flow is removed between the bridge sections and the output now reflects this.
71. **Unsteady (culvert/encroachments):** For unsteady flow, encroachments adjacent to culverts were not working correctly causing the internal boundary curves to be incorrect.
72. **Unsteady flow (ungaged area computations):** If the preprocessor was run by itself, and then unsteady was run by itself, and that unsteady plan had ungaged areas, the ungaged option may not work correctly.

73. **Unsteady flow (ungaged area computations):** If the gage for an ungaged area was next to a lateral structure that had user specified intersections, there was a problem.
74. **Unsteady flow (Lateral Structures):** The computations (derivatives) for highly submerged lateral structures was adjusted for speed and stability. This may cause differences in answers for some data sets.
75. **Unsteady flow (ungaged area computations):** If the ungaged area option was used with a data set that had time slicing (and this includes the "Flow Monitor" on hydrographs) a bug would result.
76. **Unsteady flow (IB Stage/flow):** The internal boundary flow (IB stage/flow hydrograph) option was not using the user specified flow during the initial backwater.
77. **Unsteady flow (SA to SA connector):** The interpolation methodology was changed from a horizontal to a vertical method.
78. **Unsteady flow (Htab):** A bug in how the curves transitioned from open flow to pressure flow. (Subroutine HBS_LIM3)
79. **Unsteady flow (Lateral Structure):** The user specified cross section intersections did not work for some data sets.
80. **Unsteady flow (SA connector with culvert):** There was a bug for when the invert of a culvert was higher than the low point in the weir.
81. **Unsteady flow (DSS hydrograph output):** Monthly DSS hydrograph output was not being output correctly to DSS.

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U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616 USA.