HEC-RAS 2D Sediment Workshop: Trouble Shooting

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Common Modeling Issues

- Running before Walking
- Terrain
  - Interpolation issues
  - Datum issues
  - Dataset boundaries
- Geometry
  - Distorted mesh
  - Mesh alignment
  - Small faces
- Boundary Conditions
  - Location and orientation
  - Improper BC type
  - Inconsistent data
- Initial Conditions
  - Inconsistent with BC's
  - Shocking the model
  - Bed gradations
- Numerical Parameters
  - Time step
  - Bed layer thickness
- Physical/Empirical Settings
  - DWE vs SWE
  - Transport formula
  - Hiding and exposure
  - Cohesive parameters
  - MORFAC, etc.

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Walk, Jog, then Run

- Start Simple and slowly increase complexity and resolution
- Start with a good hydraulic model
  - No chance of having a good sediment model without it
- Getting a good sediment setup requires many iterations
  - Accept it, budget for it, and have the patience for it
- Use exploratory runs to narrow model setup parameters
  - Coarse mesh, short time periods, morphologic acceleration factor, etc.
- Use model parameters to speed up initial simulations and increase stability
- Start with fewer grain classes (i.e. coarse resolution)
- Do sensitivity on parameters

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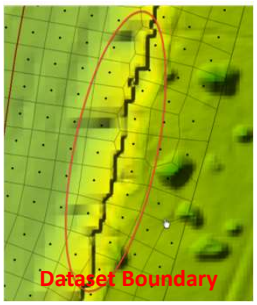
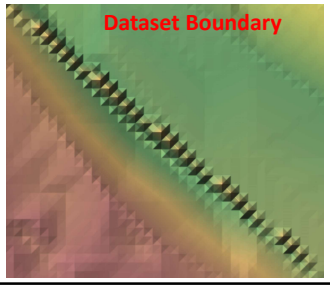
Terrain Issues

- Bathymetry Data
  - More difficult to collect
  - More variable in time
- Bathymetry Issues
  - Will show in bed change
  - Can lead to instabilities
  - Interpolation
  - Triangulation
  - Dataset Boundaries
  - Poor Resolution





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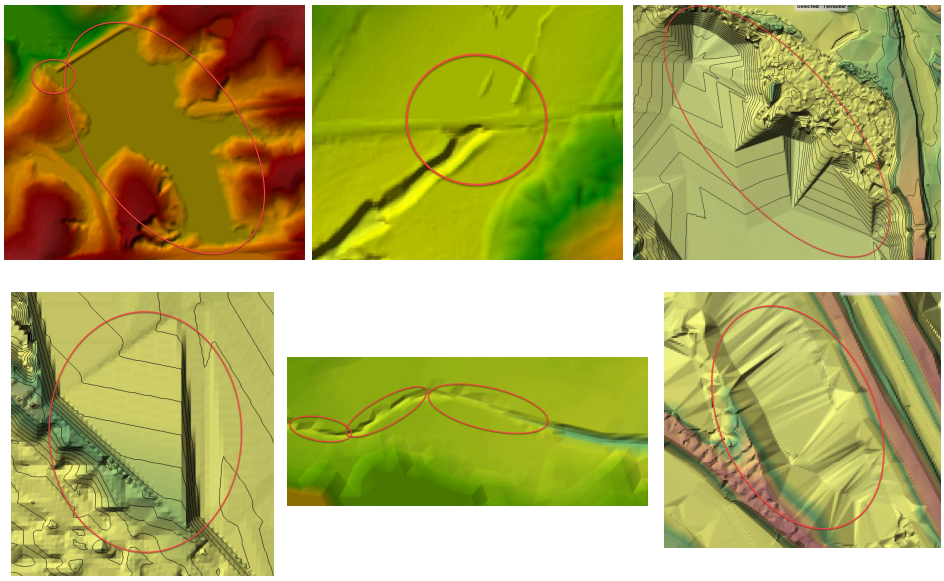
Terrain Issue Examples



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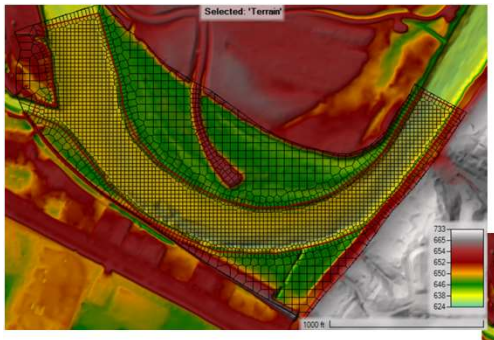
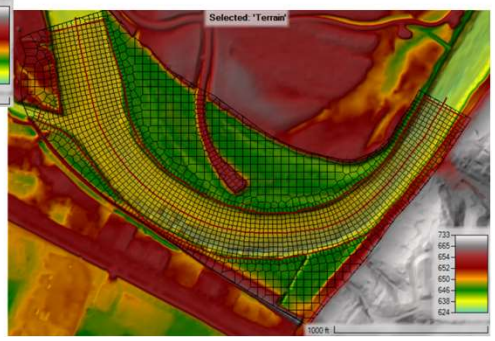
Geometry: Mesh Alignment



- 2D sediment much more sensitive to mesh alignment than flow



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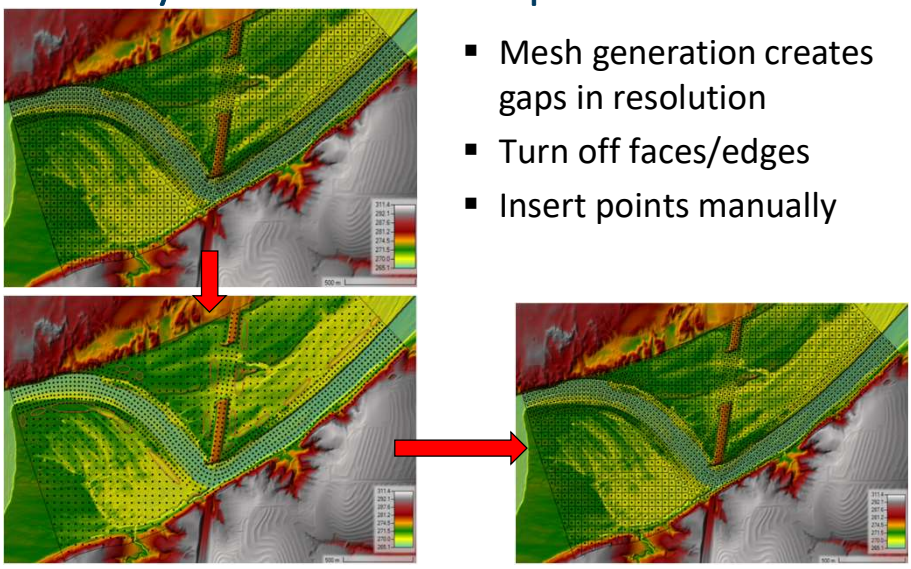
Geometry: Resolution Gaps



- Mesh generation creates gaps in resolution
- Turn off faces/edges
- Insert points manually

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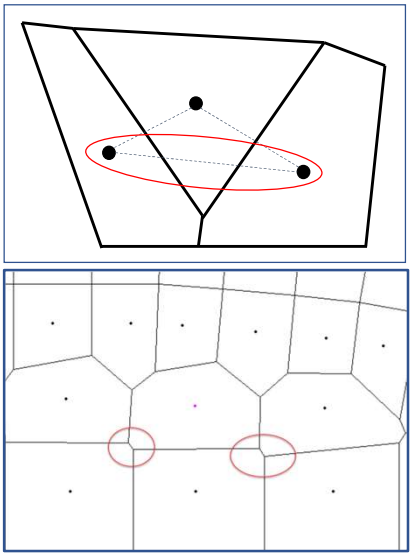
Geometry: Mesh Quality

- Mesh Skewness
  - Leads to significant errors in flow and sediment errors
- Small faces
  - Reduce stability and increase computational time and memory
- Fixes
  - Increase **Minimum Face Length Tolerance**
  - Manually nudging Computational Points



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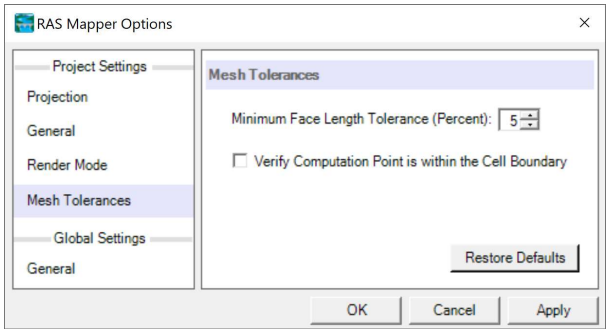
Minimum Face Length Tolerance

- Default is 5%
- **Increase to 15-25%**
- Larger values will improve mesh quality but lead to more errors in the mesh which must be fixed manually



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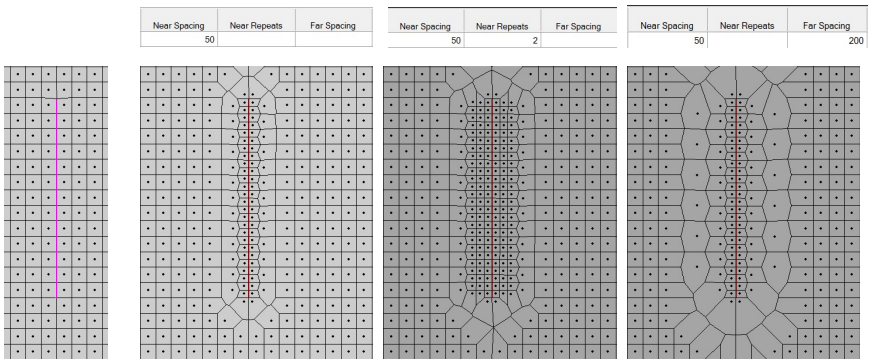
Breakline Issues

- Grid spacing = 100



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Weird Shaped Cells/Small Faces

- Cells need to transition in size slowly
  - No more than 50% change in size
- Cells with one face that is very small compared to other faces and cells – this may cause excessive model iterations.
- Minor adjustments in either moving the cell centers, deleting cells, or adding additional cells to smooth out the transitions, and remove small faces can get rid of model iteration issues.

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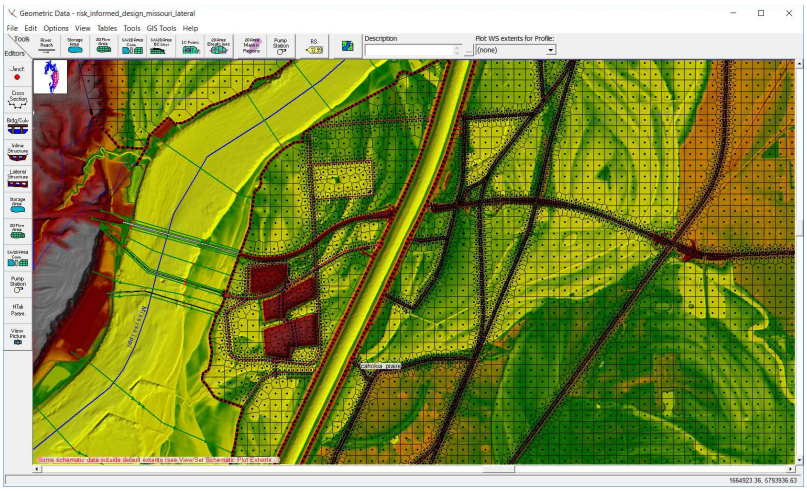
Breaklines

- In general people do not use enough breaklines
- Use breaklines along high ground barriers to flow in order to align faces
  - This will improve accuracy
  - This will improve model stability



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Channel Alignment and Cell Size

- Need to define the channel portion of the 2D mesh appropriately
- 2D Faces need to be aligned with high ground separating channel from floodplain
- Channel needs to have enough cells across the channel in order to get a good velocity profile. Recommend at least 7 to 10 cells across channel
- Fewer cells ok for water surface only
- Use Polygon Refinement tool to accomplish this

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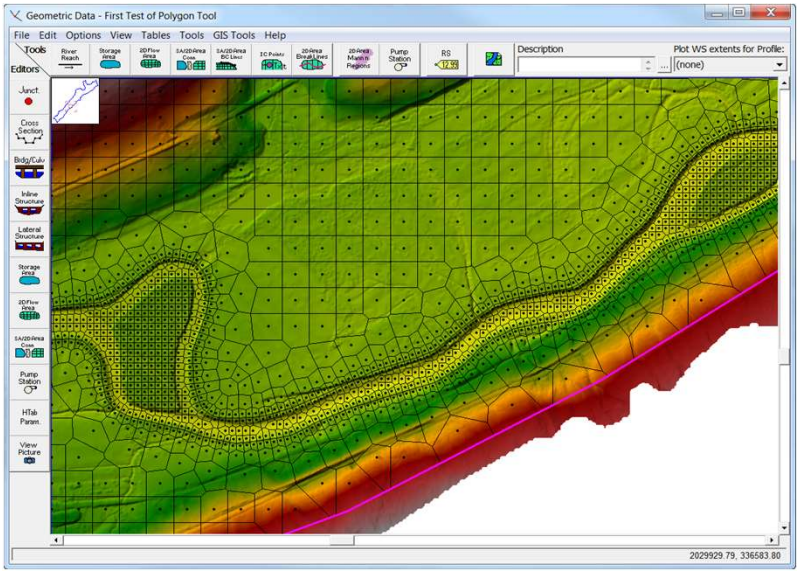
Example of Polygon Refinement Tool for Main Channel



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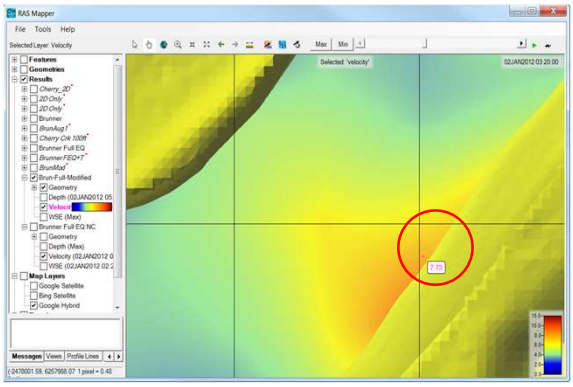
Partial Cell Wetting Issue

- Excessive model iteration can occur when just a corner of a cell has flow and the velocity is high
- This will be even more unstable when flow comes into a cell through a small portion of a face but can leave over a much larger portion of another face
- Adjust cell sizes, use breaklines and polygon refinement tool to fix



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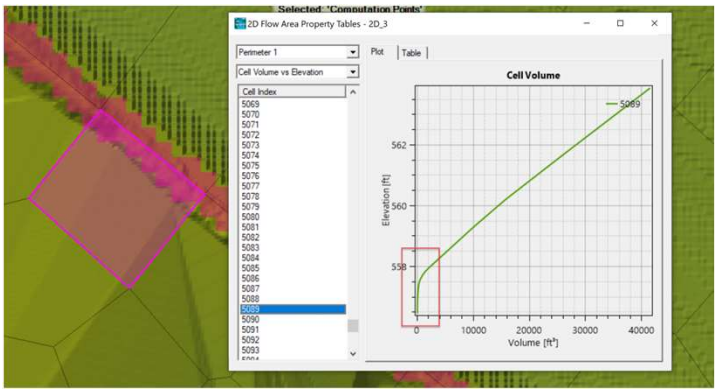
Steep Volume-Elevation Curve

- When the lower portion of the cell volume-elevation is steep, this can cause excessive model iteration
- Small changes in volume produce large changes in water surface
- Iterations have a hard time converging
- Large water surface errors represent small volume errors



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Internal Hydraulic Structures

- To small of cell sizes at invert of culvert or gate.
  - Small cells have less volume
  - Flow/volume for the culvert is computed over the time step as V = Q x T
- Highly submerged weirs with culverts and gates can have stability issues. “Weir and Gate Flow Submergence decay exponents”
- Flow over the embankment can be computed as weir flow or 2D Flow Equations
  - Use Weir options when the is a high embankment
  - Use 2D flow option for non weir flow situations

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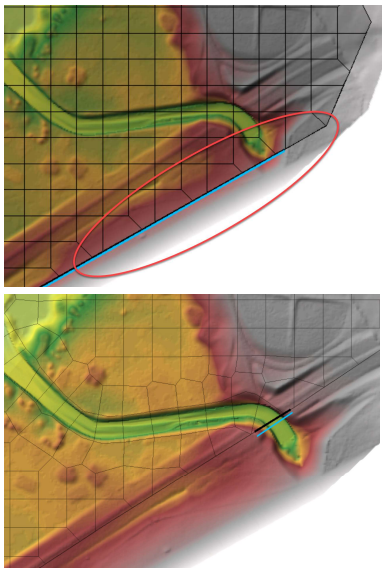
Boundary Conditions

- BC Line General Guidance
  - Far away project area
  - Away from geomorphic transition areas
  - 1D flow (no recirculation, away from bends, etc.)
  - Perpendicular to flow



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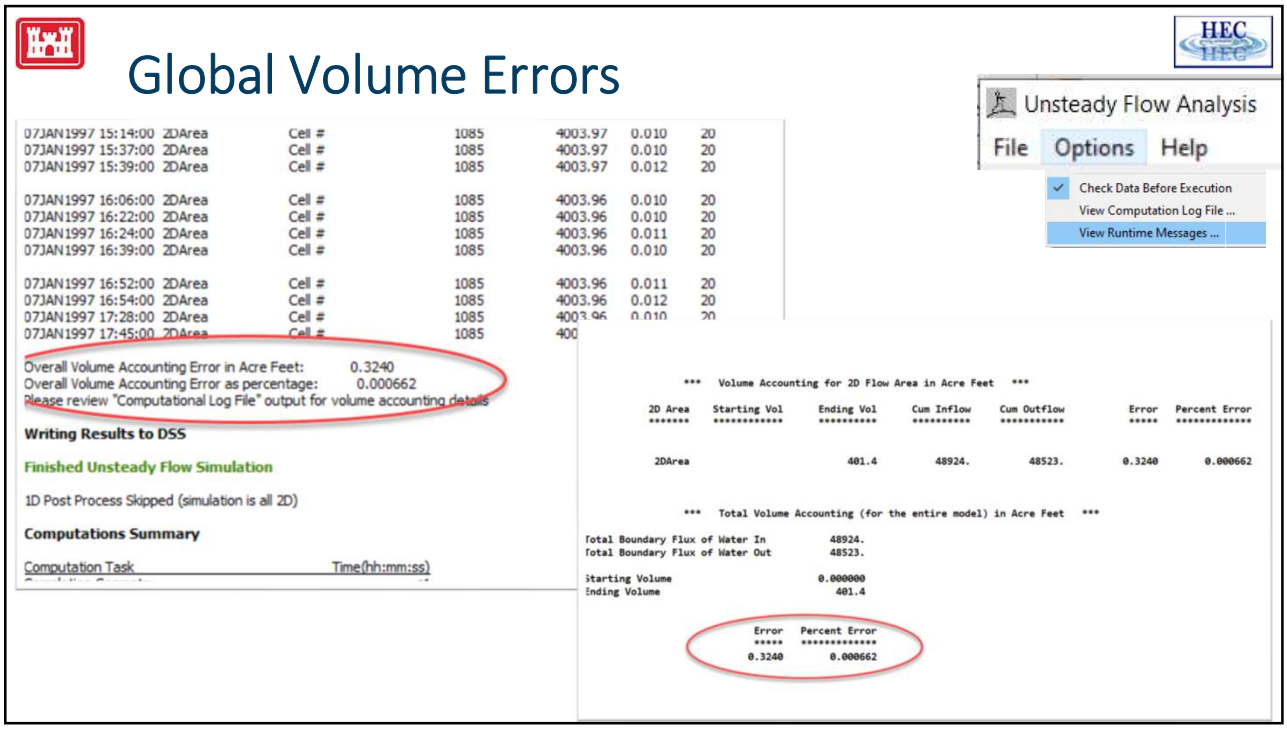
Global Volume Errors



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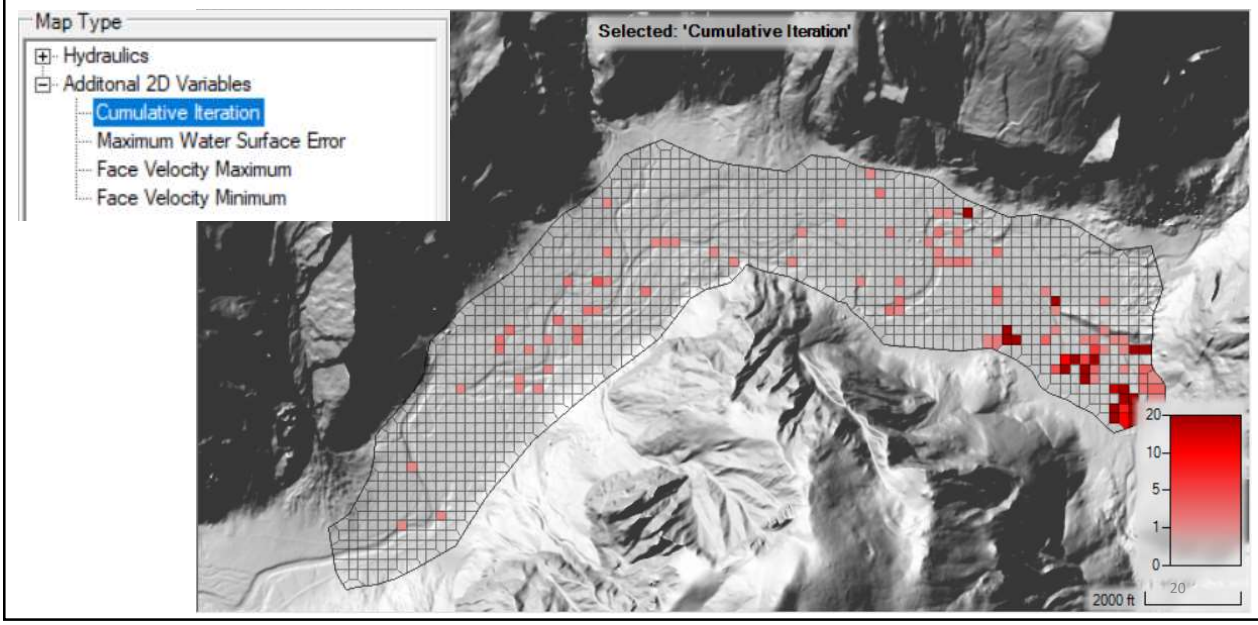
Cumulative Iterations



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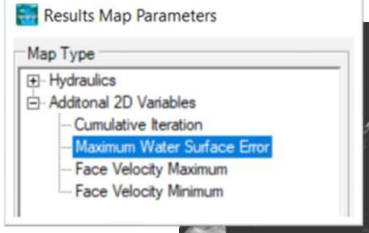
Max WSE Error



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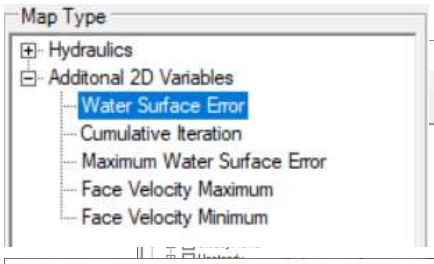
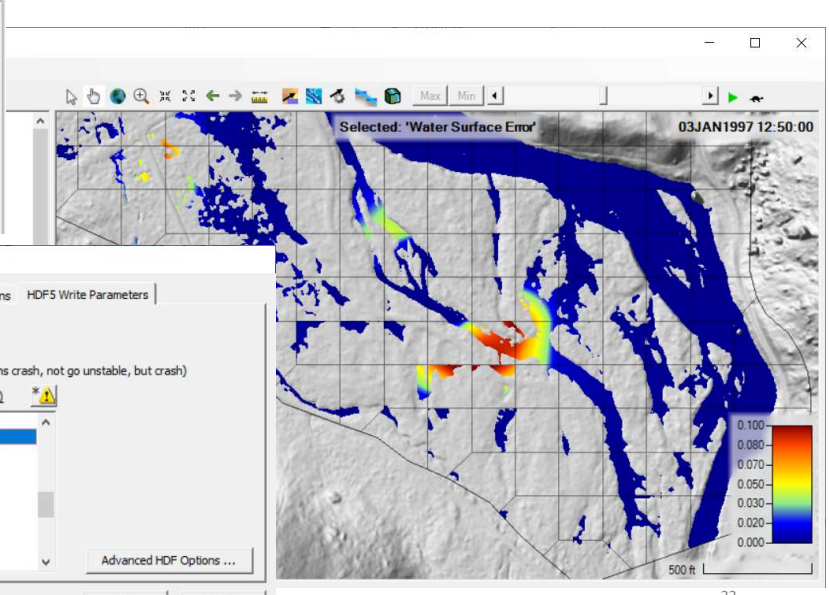
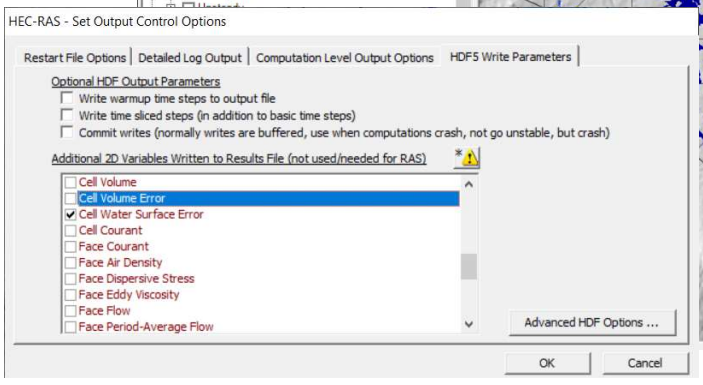
Water Surface Errors







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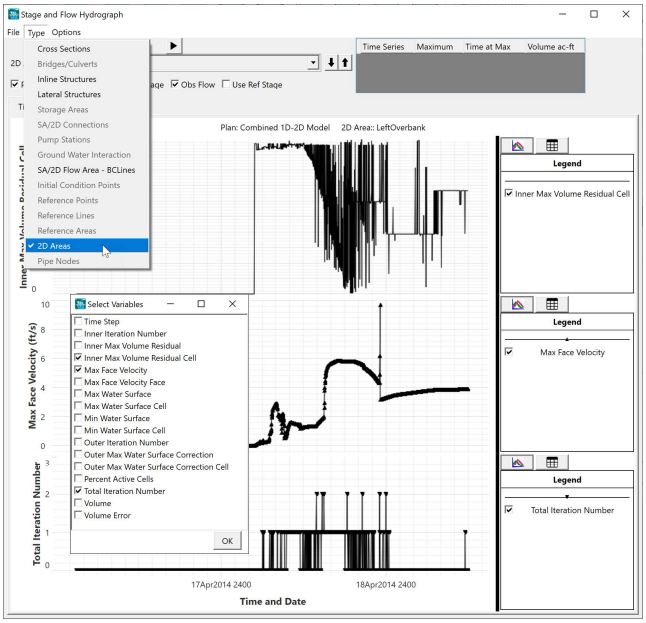
Convergence Parameter Time Series

- Hydrograph Plotter
- Contains 2D Area specific time series
- Sediment variables will be added in HEC-RAS 6.6
- For now sediment variables have to be plotted from HDF5



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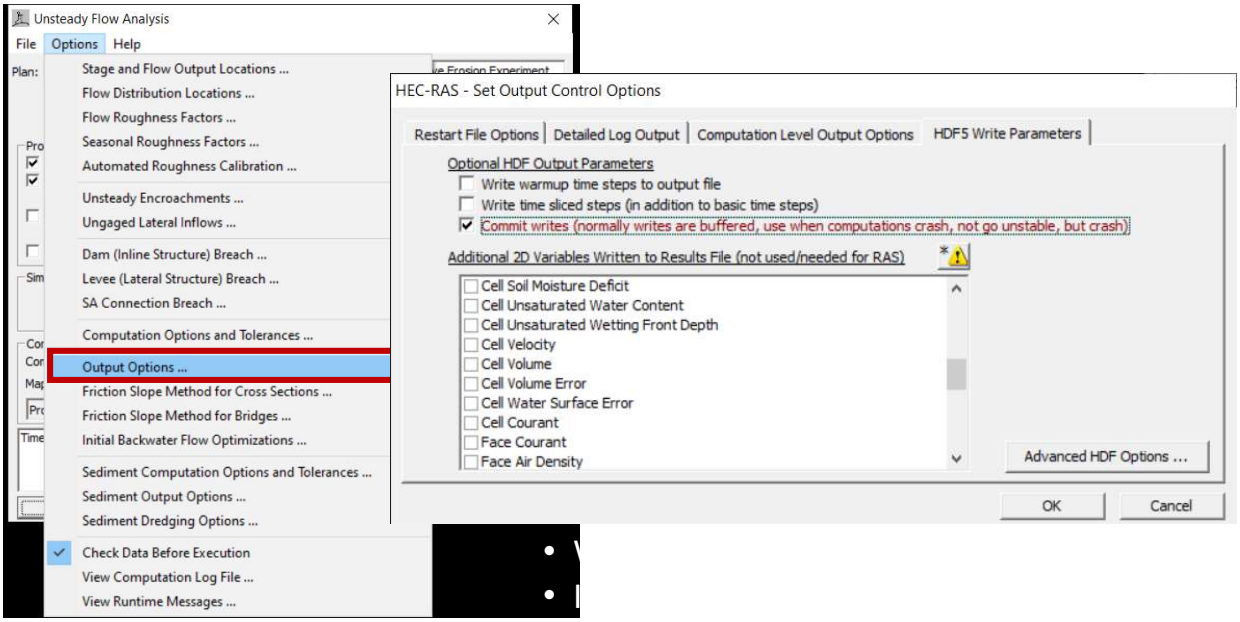
Commit HDF5 Writes



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Initial Conditions

- Initial conditions period
  - For each 2D area
- Warm-up period
  - For all 1D reaches and 2D areas
- Ramp-up period
  - Period over which boundary conditions are modified to help the model reach a dynamic equilibrium
- Spin-up period
  - Period over which the initial condition has an effect on the results
  - Can be difficult to estimate

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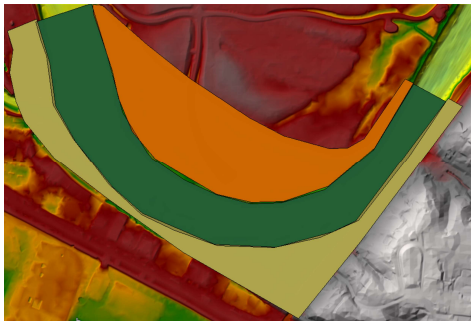
Initial Conditions

- Initial bed gradations by classification usually very approximate
- It may take a long time for the effects of the initial condition to disappear
- Spin-up of bed gradations
  - Can be done in Initial Conditions but since there is no output
  - Best done as a pre-simulation time period



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Calibration Issues

- Starting with a bad model
  - Bad Flow Model, Geometry, and/or Terrain
- Calibrating the wrong parameters/options
- Calibrating the right parameters badly
  - Using unrealistic values (possible to get good results for the wrong reasons)
  - Over-calibrating (e.g. spending too much time calibrating one or a few parameters precisely)
- Calibration of 2D sediment requires expertise
  - Too expensive to run automated calibrated methods
  - User needs to narrow down which methods and the coefficients needed

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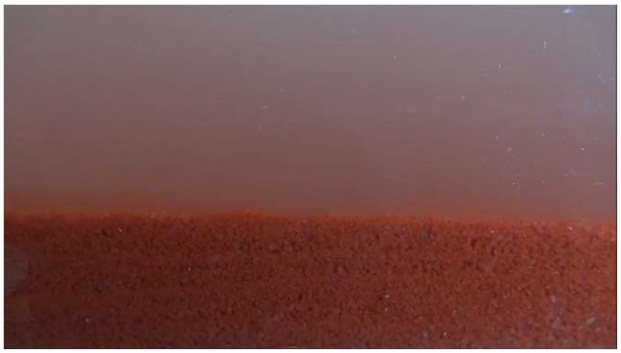
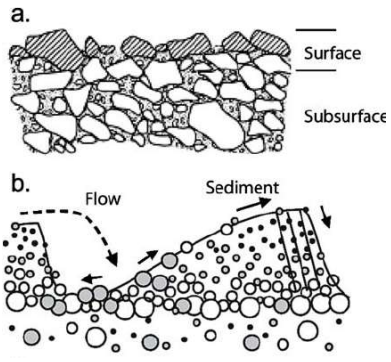
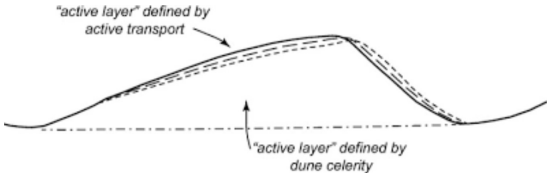
Active Layer Thickness

- Larger layer thicknesses are more stable
- Active layer (first top layer) is extremely important for model stability
- Can't erode more than the active layer thickness
- Active layer should be thicker for very dynamic models or models with coarse grids and large time steps







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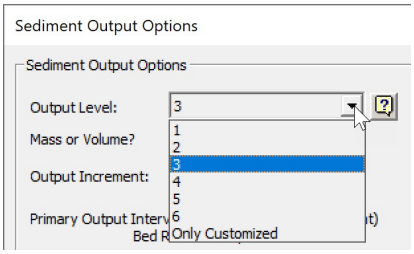
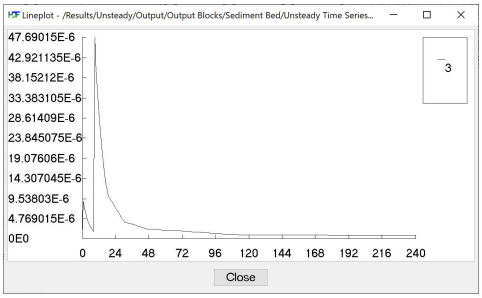
Model Convergence

- Detecting and fixing model convergence is essential for model accuracy, stability, and speed
- Monitoring Convergence
  - Number of iterations
  - Concentration and grain fraction residuals or errors
  - Concentration and bed change values
- Ways to monitor convegence
  - Computation Log File
  - HDF5 File





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Computation Log File

- Detecting and fixing model convergence is essential for model accuracy, stability, and speed
- Monitoring Convergence
  - Computation Log File
  - HDF5 Files

```
STATUS: Sediment: Pool2, Time (hrs): 21.50000, Time Step (s): 300.0000
  Transport Convergence:
    Outer Convergence: Converged
      Iter  State  MaxAbsCor(  cell)     RMSCor       Units      Status
        3     1     8.370E-04(  1099)    4.324E-05      mg/L     Converged
        3     2     1.166E-04(  1099)    5.848E-06      mg/L     Converged
        3     3     4.731E-06(   115)    2.424E-07      mg/L     Converged
  Sparse Matrix Solver Convergence:
    State Outer  Inner   Error     Status
      1     3     6    3.870E-13  Converged
      2     3     6    4.868E-14  Converged
      3     3     4    9.377E-13  Converged
  Active Layer Grain Class Fractions (%):
      Iter   Grain   MaxAbsCor(  cell)    Status
        3      1     4.697E-04(   113)   Converged
        3      2     4.249E-04(   113)   Converged
        3      3     4.486E-05(   113)   Converged
```

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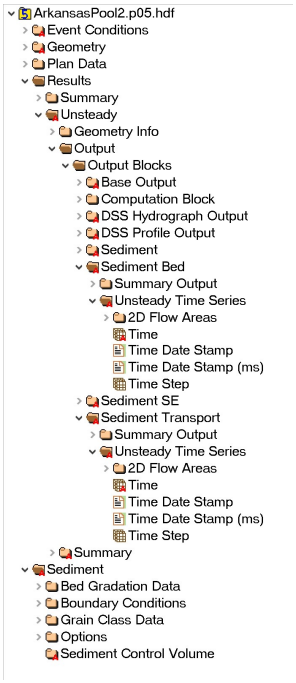
HDF5 Log Output

- Detecting and fixing model convergence is essential for model accuracy, stability, and speed
- Monitoring Convergence
  - Computation Log File
  - HDF5 Files



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Calibration Parameters

- Calibration Parameters
  - ► Inflow sediment load and gradation
  - ► Transport Function and Parameters
  - ► Cohesive Parameters
  - ► Adaptation Parameters
  - ► Hiding and exposure
  - ► Boundary conditions
  - ► Bed Composition
  - ► Bed-Slope Coefficient
  - ► Sheet and Splash Erosion Coefficient
- Fixed Parameters
  - ► Grain classes
  - ► Temperature
  - ► Fall velocity
  - ► Shape Factor
  - ► Bed layer thicknesses
  - ► Computational parameters
  - ► etc.

	Insensitive	Sensitive
Low Uncertainty	Fixed	Fixed
Uncertain	Fixed	Calibrated

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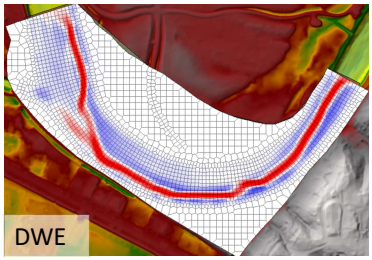
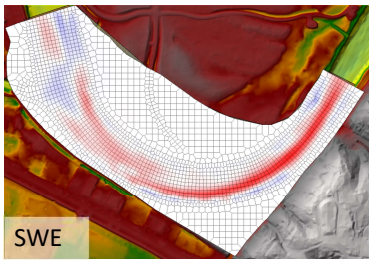
Physical/Empirical Parameters

- Flow equations
  - DWE scour problem
- Transport formula
  - Applying the transport formula outside of the intended range can lead to unrealistic results
    - Grain size
    - Flow conditions
    - Etc.
- Not including a process
  - **Hiding and exposure**
  - Cohesion





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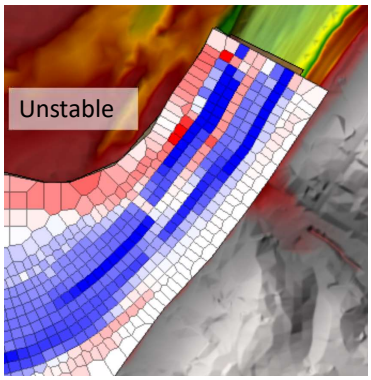
WARNING

- Model can be too robust
- Easy to have a model that "pushes through" a bad model setup and produces bad results
- Signs you have a "bad" model setup
  - Oscillations in flow or sediment (duh)
  - Flow or Sediment are iterating a lot (goal should be to have very few iterations)
  - Unreasonably large bed change
  - Positive-Negative (red-blue) bed change



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Limitations

- No hot start with 2D Sediment
- 1D and 2D sediment coupling
- No structures such as culverts, gates, and bridges
- Subsidence not in UI yet
- No secondary flow effects
- No vegetation or woody debris

- No percolation
- Cannot modify terrain
- No partial grid solution
- Adaptive time stepping does not consider sediment transport or bed change

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Thank You!

HEC-RAS Website:
https://www.hec.usace.army.mil/software/hec-ras/

Online Documentation:
https://www.hec.usace.army.mil/confluence/rasdocs

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