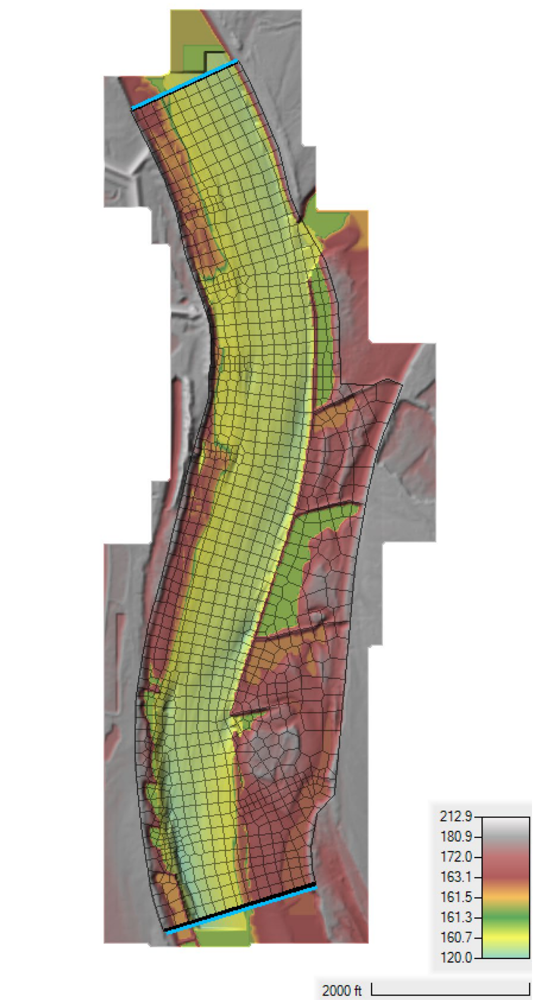
Parameter Sensitivity
Workshop

1 Objective

The goal of this workshop is to understand the sensitivity of model results to different model parameters, processes, and formulations. Specifically, the workshop covers hydraulic flow equations, transport functions, hiding and exposure, adaptation parameters, advection and diffusion, and the load correction factor.

2 Introduction

The model is based on a small reach of the Arkansas River. For the purposes of the workshop, the model is setup is relatively simple and fast. The model extent is relatively small model, and the mesh has a coarse resolution. The computational mesh, boundary condition lines, and terrain are shown in the figure below.

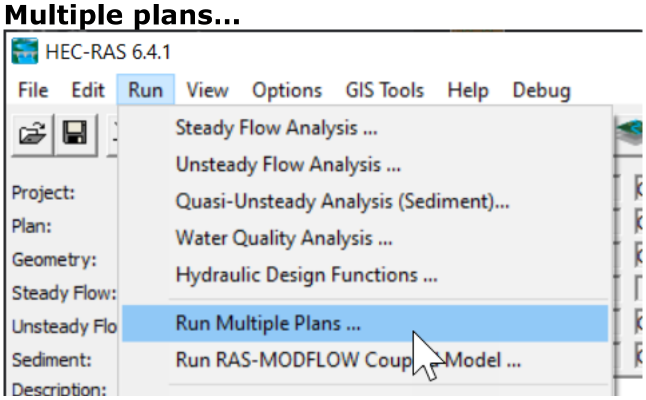


The base model has a constant flow upstream of 70,000 cfs, and a constant stage downstream of 172.936 ft. A morphologic acceleration factor of 10 is utilized to simulate 10 days of bed change over one day of simulation time. With this model setup, each run takes about 5-8 seconds to run which good for sensitivity analysis. It is important to note, that though the current model setup may not be good for final production runs of a project, the sensitivity analysis as applied here with a fast model setup is useful and recommended for projects.

3 Diffusion Wave vs Shallow Water Equations

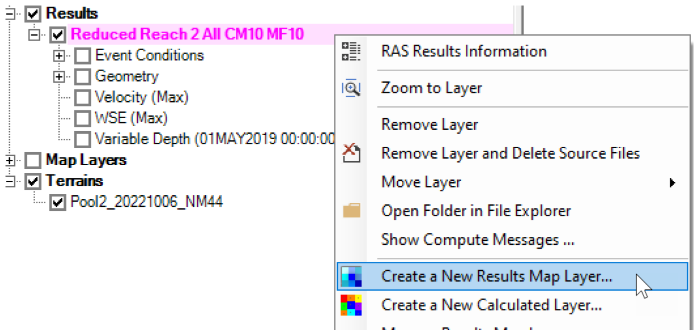
In this section, an equilibrium sediment transport model is setup and results are compared between the Diffusion Wave and Shallow Water Equation solvers. The Diffusive Wave solver ignores advection and diffusion of momentum. An equilibrium sediment model is setup by using very aggressive adaptation coefficients which forces the actual concentrations to be equal to the equilibrium concentrations and ignoring diffusion and load corrections.

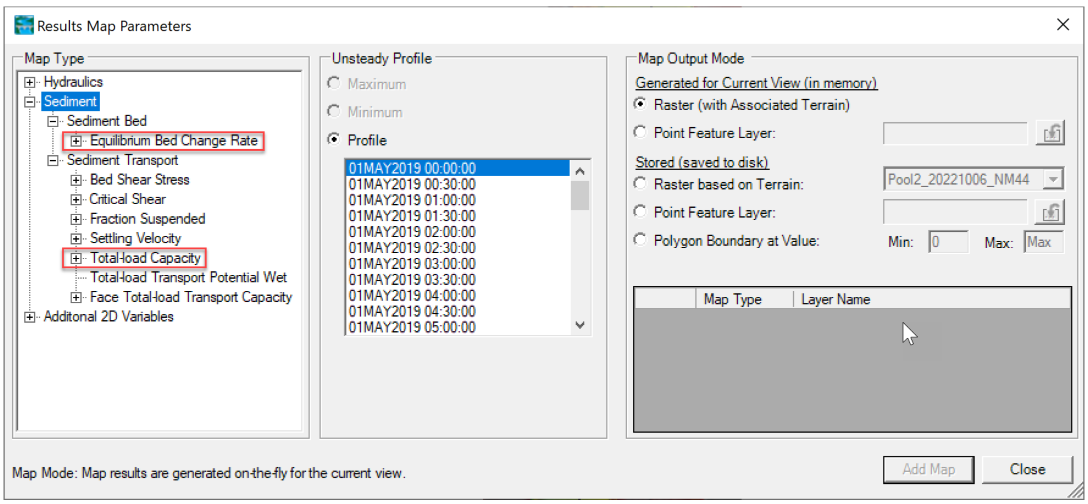
1. **Start HEC-RAS**.
2. **Open** the HEC-RAS project names “ArkansasPool2.prj” in the “Parameter Sensitivity” Workshop folder.
3. From the main HEC-RAS editor, click on the **Run** menu and select **Run Multiple plans…**



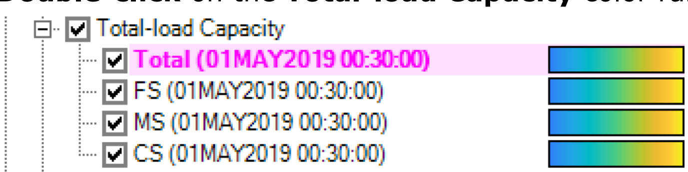
4. Click on “DW-Wu-CapacOnly” and “SW–Wu-CapacOnly” plans and then click on **Run All Checked Plans**.

   After the simulations are complete, open **RAS Mapper** .
5. Begin inspecting the results by looking at the hydraulics.
6. **Add** the Total-load Capacity, and variables to **Ras Mapper** by clicking on the plan **Results** layer and selecting **Create a New Results Map Layer…** as shown below

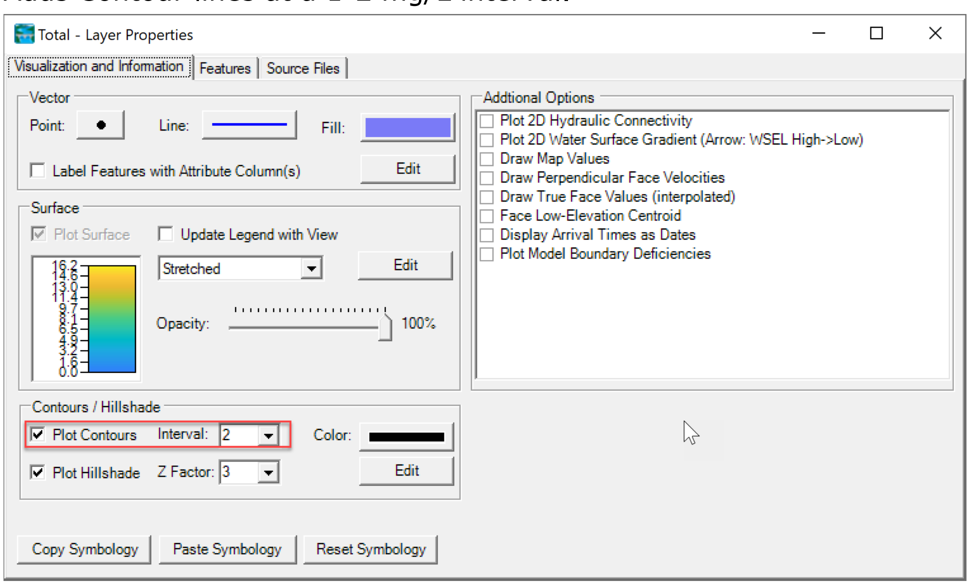




7. **Double-click** on the **Total-load Capacity** color ramp and



8. Adds Contour lines at a 1-2 mg/L interval.



9. Inspect the sediment capacities and equilibrium bed change rates.

Question: Based on the hydraulics alone, do expect the sediment transport results to be similar between Diffusion-Wave Equation (DWE) and Shallow Water Equations (SWE)?

Question: What is the difference in water surface elevations at the upstream end of the model and that different significant?

Question: Do you think it is appropriate to utilize the DWE model for river hydraulics?

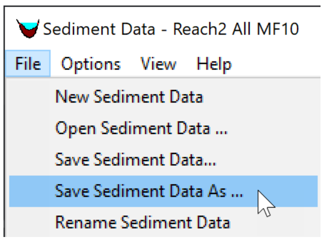
Question: Why are the DWE model water surfaces generally lower than the shallow water equations?

Question: Based on the SWE results, is the location of the upstream boundary condition well positioned if the goal is to study the effect of the dikes on the flow and sediment transport?

4 Sediment Transport Functions

In this section, several transport functions are compared. For simplicity, the simulations are run using **Capacity Only** simulation component, as in the previous section. This saves time and simplifies the analysis.

10. **Open** the plan called "SW-Wu-CapacConly".
11. **Open** the **Sediment Data** editor.
12. **Click** on **File | Save Sediment Data As...** and save the data as "VR CapacOnly"



13. In the **2D Bed Gradations** tab, select the **Van Rijn** from the **Transport Function** drop down menu.
14. **Save** the plan as "SW-VR-CapacOnly".
15. **Run** the plan.
16. Follow the same steps as above to create another plan using the **Ackers and White Transport Function** using the same naming conventions as above.
17. **Map** the sediment concentration capacities in **RAS Mapper**, and compare the **Capacity Only** plans with the three different transport functions.
18. **Plot** and **compare** the concentration capacities along the channel centerline and a few of the transverse profile lines.

Question: How much do the transport functions differ, in terms of magnitude and distribution?

5 Hiding and Exposure

In this section, the effect of hiding and exposure is studies by turning it off and comparing with using the Wu et al. (2000) hiding and exposure method.

19. **Open** the **Sediment Data** editor .
20. **Click** on **File | Save Sediment Data As…** and save the data as "VR CapacOnly NoHE"
21. **Save** the plan as "SW-VR-CapacOnly-NoHE".
22. **Run** the plan.
23. **Compare** the three **Capacity Only** plans with the **Van Rijn** transport function.

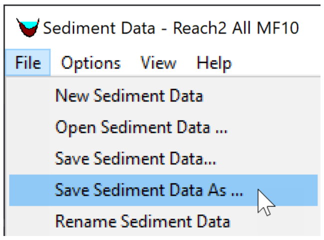
Question: Does hiding and exposure increase or reduce the overall transport rates in the model and why?

Question: Based on these results would increased hiding and exposure effects increase/decrease bed change and model stability?

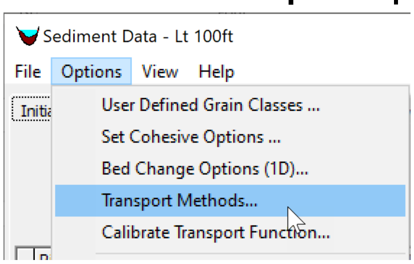
6 Total-load Adaptation Length

The default adaptation approach in HEC-RAS is the total-load adaptation length. For this reason, we'll begin by performing some sensitivity on this parameter.

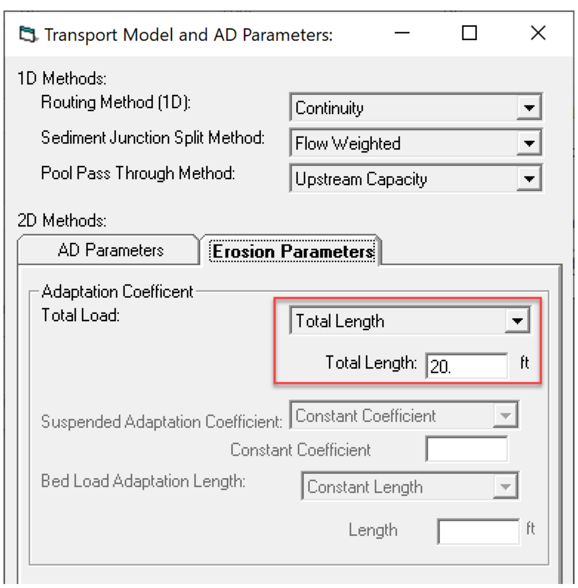
24. **Open** the plan called "SW-Wu-Lt200". This plan has all simulation components turned on (i.e. concentrations, bed gradations, and bed change). It utilizes the Wu et al. (2000) transport function and a total-load adaptation length of **200 ft**.
25. **Run** the plan.
26. **Click** on **File | Save Sediment Data As…** with the name "Wu Lt20"



27. **Click** on the menu **Options | Transport Methods** as shown below

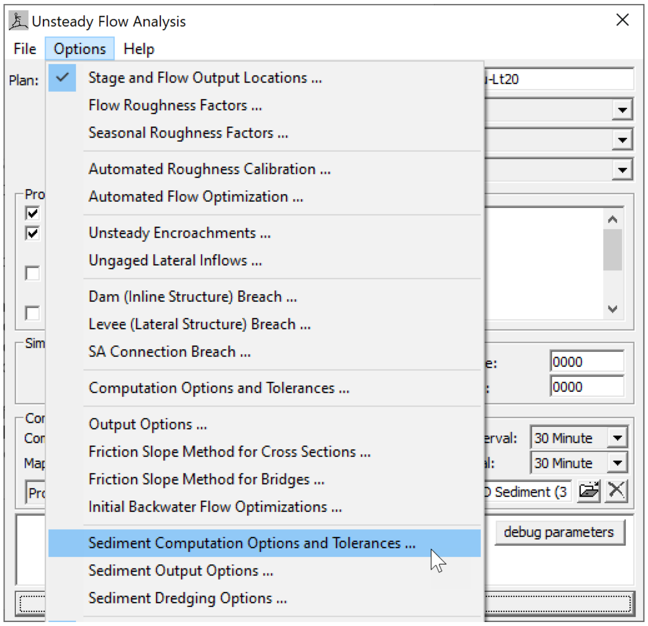


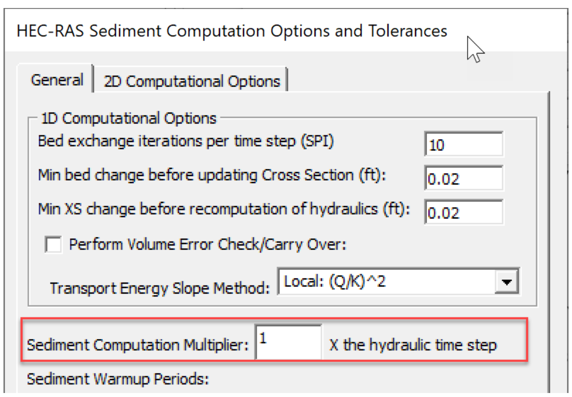
28. In the **Erosion Parameters** tab, set the **Total-load Adaptation Length** to **20 ft** as shown below.



29. **Save** a new Plan with the **Title** and **Short ID** "SW-Lt20".

30. **Set** the **Sediment Computation Multiplier** to 1, by going to the Unsteady Flow Analysis editor, and clicking on Options | Sediment Computation Options and Tolerances… and then entering the value as shown in the figures below.





This plan has a relatively large time step with morphologic acceleration. Using a **Sediment Computation Multiplier** larger than 1, will cause erosion limiters to reduce the sediment transport capacities. This feature is intended to prevent a single active layer from eroding in a single time step but can cause problems for artificially small adaptation lengths, since this greatly increases the magnitude of the erosion rates.

31. **Run** the plan.
32. **Add** the bed change, sediment concentration capacities, and concentrations sediment results layers in **RAS Mapper**.
33. **Compare** the Total-load Concentrations and Capacities as before. Remember to copy-paste the layer symbology so that the result maps being compared have the same color ramp and data limits. Below is an example of the what the fields should look at the end of the simulation.
34. **Compare** the bed change for the plans with 20-ft and 200-ft adaptation lengths. Remember to copy-paste the colormap limits so that the results can be compared directly. Toggle quickly between the two get a better understanding of the differences.

Question: Does reducing the adaptation length, make the actual concentrations more like the capacities and why?

Question: What would happen if the adaptation length were set to a very small number?

Question: What effect did reducing the adaptation length cause on the bed change results?

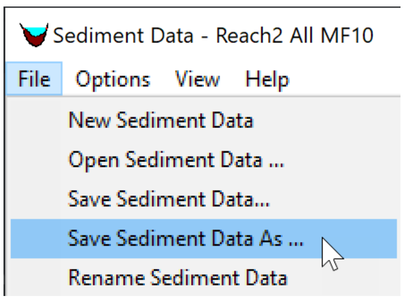
7 Advection and Diffusion

In this section, several new plans are created and compared with the previous plan with only advection. In total, three plans are created in section with different settings for the diffusion coefficient calculation method.

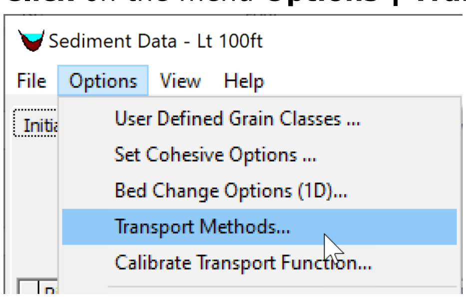
7.1 Constant Diffusion Coefficient

The simplest method for the diffusion coefficient is a constant value. In this section, diffusion is introduced by specifying a constant diffusion coefficient.

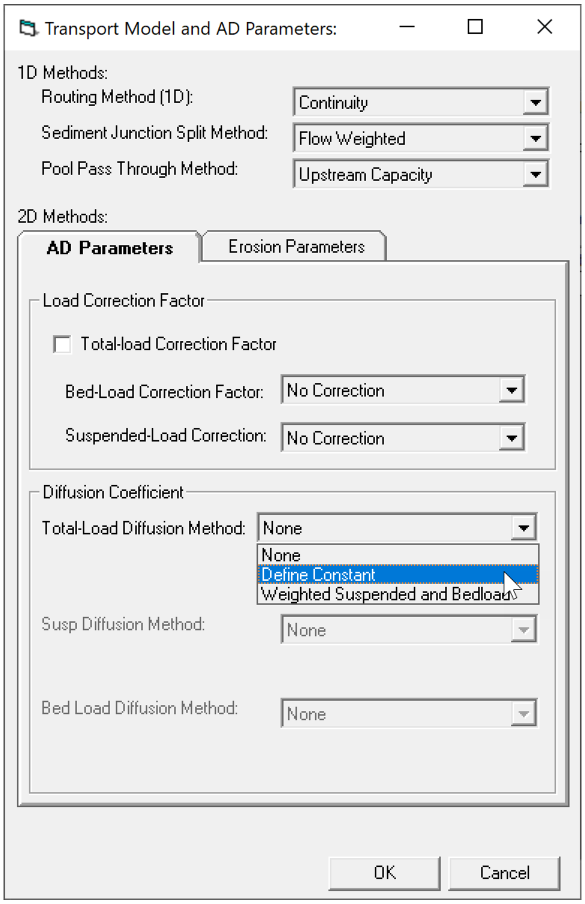
35. **Open** the plan titled "SW-Wu-Lt200".
36. **Open** the **Sediment Data** editor .
37. **Click** on **File | Save Sediment Data As…** and save the data as "Wu Lt200 K10"



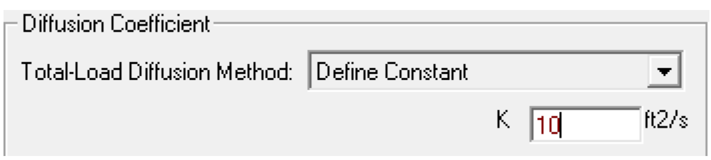
38. **Click** on the menu **Options | Transport Methods** as shown below



39. In the **Transport Model and AD Parameters** editor, under the **Diffusion Coefficient** section, select the drop-down menu for the **Total-load Diffusion Method** and select the **Define Constant** option as shown in the figure below.



40. **Enter** a constant diffusion coefficient of **10 ft²/s**.



41. **Save** the **Sediment Data**.

42. **Save** a new plan with the Title and Short ID "SW-Wu-Lt200-K10".

43. **Run** the plan

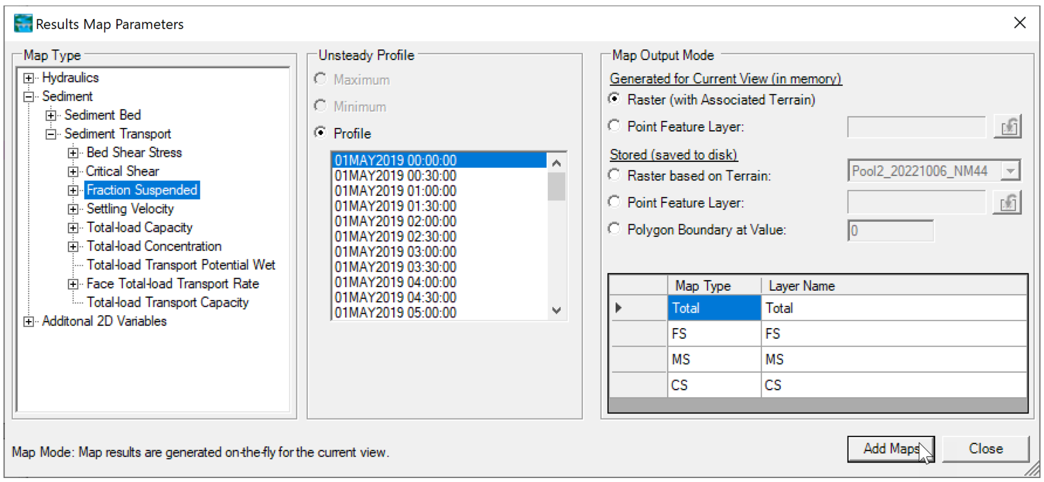
44. **Open RAS Mapper** and **add** the same sediment variables as described before.

45. **Map** the total-load concentration for both plans in RAS Mapper.

46. **Plot** the total-load concentration for both plans along one of the profiles to compare how diffusion affects the sediment concentrations. Do this by turning on the **Profile Lines** layer in the **Features** node. And then **right-click** on one of the profile lines, and select **Plot Profile | Total-load Concentration | Cell Total-load Concentration – Total** as shown in the figures below.

Question: Why does the plan with diffusion show a lower peak concentration in the transverse profile plot?

47. **Add** the fraction of suspended sediments called **Fraction Suspended**.



The fraction of suspended sediments should look something like the figure below.

Question: For this model, would the results be sensitive to changes in the bedload diffusion coefficient and why?

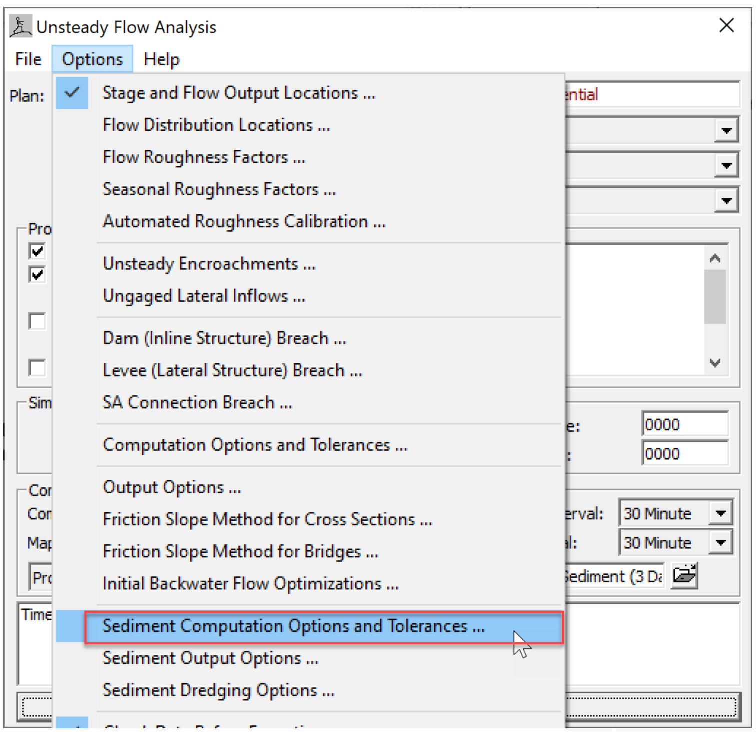
7.2 Exponential Scheme

The **Exponential Scheme** is linear scheme based on an analytical solution of the 1D steady-state advection diffusion. If you look at how this scheme is implemented, it is basically the upwind scheme with a reduction of the diffusion term to account for "excess" diffusion from the upwind scheme. The scheme also has the benefit of being inexpensive and linear which means it does not require significant additional computations or iterations to solve. In this section, a plan is setup and run with the **Exponential Scheme**.

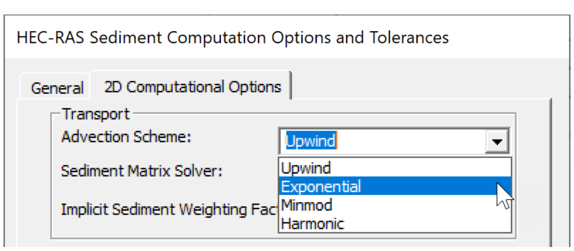
48. **Open** the **Unsteady Flow Analysis** window .

49. **Click on File | Save Plan As** and create a new plan with the Title and Short ID "Exponential".

50. **Click** on the menu **Options | Sediment Computation Options and Tolerances** as shown in the figure below.



51. **Click** on the **2D Computational Options** tab and within the section called select the **Transport** set the **Advection Scheme** to **Exponential** as shown in the figure below.



52. **Click OK** and **close** the **Sediment Computation Options and Tolerances** editor.

53. **Run** the plan.

54. **Open RAS Mapper** and **Add** the same sediment variables as described in Section 3.

55. **Compare** new results with previous two plans.

Question: How does the Exponential Scheme compare to the other plans?

Question: Considering the level of uncertainty in sediment transport, are the differences between the different concentration fields with different diffusion settings significant?

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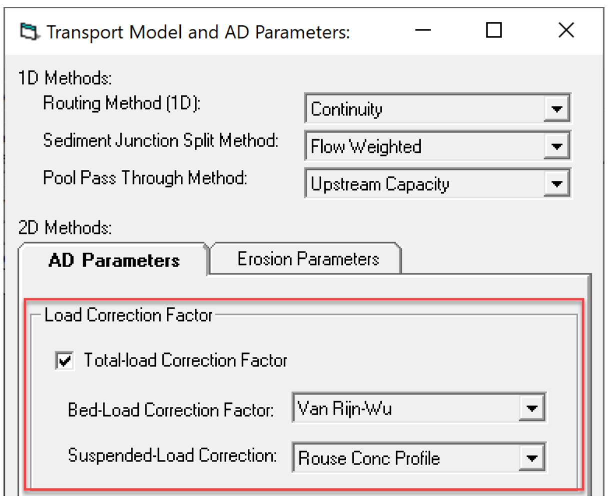
8 Load Correction Factor

The 2D sediment transport model in HEC-RAS uses a velocity-weighted concentration. This means that the model does not have advection coefficients and instead has a load-correction factor in the temporal term. The load-correction factor is more important for dynamic datasets with rapid changes in hydraulics.

56. **Open** the **Sediment Data** editor .

57. **Click** on **File | Save Sediment Data As...** and save the data as "Lt200-K10-Exp-Bt"
58. **Click** on the menu **Options | Transport Methods** as shown below
59. In the **Transport Model and AD Parameters** editor, under the **Load Correction Factor** section, **check** the box next to **Total-load Correction Factor**, and set the methods as shown below.



60. **Save** the **Sediment Data**.
61. **Save** a new plan with the Title and Short ID "SW-Lt200-K10-Exp-Bt".
62. **Run** the plan.
63. **Open RAS Mapper** and **add** the same sediment variables as described in the previous section.
64. **Plot** a time series of concentrations comparing the "SW-Lt200-K10-Exp" and "SW-Lt200-K10-Exp-Bt" plans.

    Question: Are differences significant?

    Question: Where in the time series are the largest differences and why?