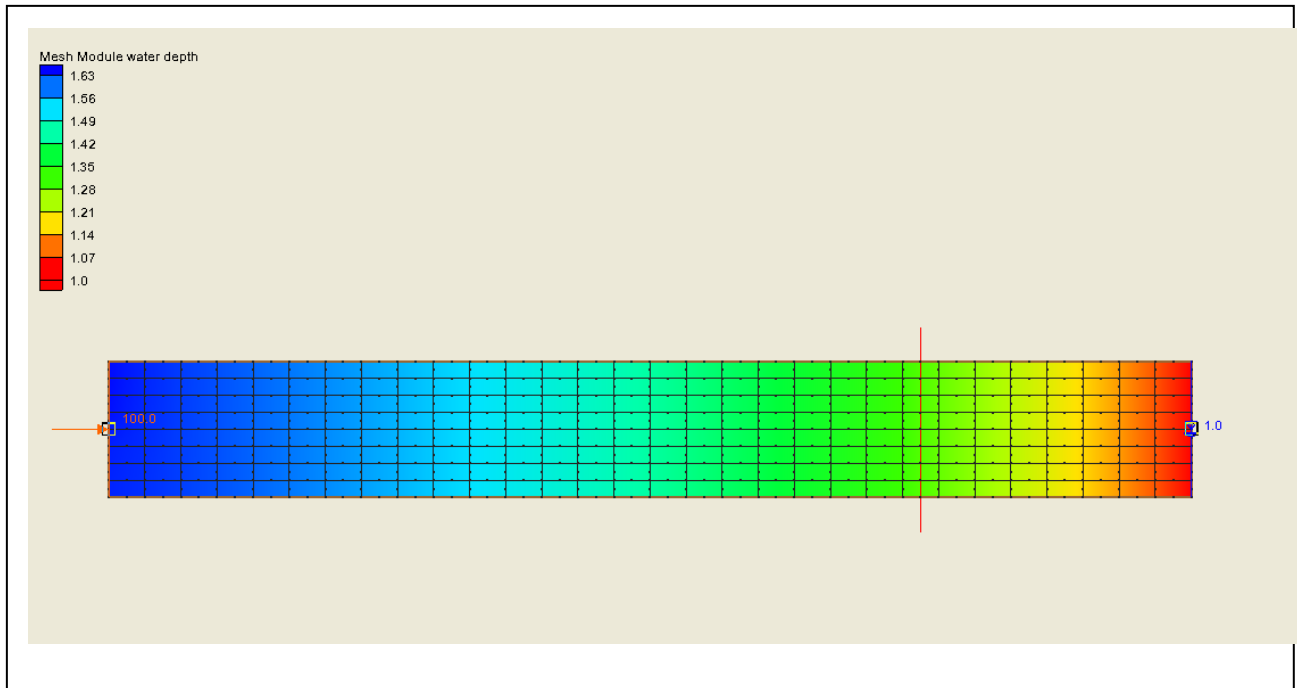*SMS 12.3 Tutorial*
RMA2 Sensitivity Analysis

Objectives

Learn how to analyze the effects of changes in Manning's roughness coefficients and kinematic eddy viscosity on various channel arrangements. Model calibration can benefit from understanding the effects of Manning's roughness and eddy viscosity.

Prerequisites

- RMA2 Tutorial

Requirements

- RMA2
- Map Module
- Mesh Module

Time

- 45–60 minutes

1   Simple Channel with Single Material

A flume 800 meters by 100 meters has been prepared for use in this tutorial. The flowrate is set at 100 m^3/s. The downstream water surface elevation is 1 meter. This flume has no slope and is comprised of a single material.

To open the file containing the necessary mesh, do the following:

1. Select *File | **Open…*** to bring up the *Open* dialog.

2. Select "Project Files (*.sms)" from the *Files of type* drop-down.

3. Browse to the *data files* folder for this tutorial and select "flumea1.sms".

4. Click **Open** to import the file and exit the *Open* dialog.

5. If geometry from a previous tutorial is open, a message will ask to delete existing data. If this happens, click **Yes**.
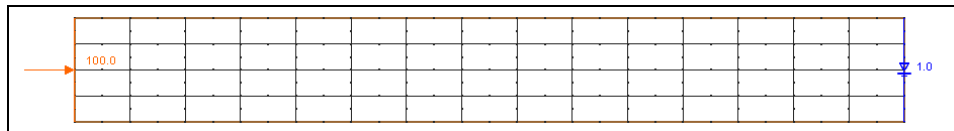
The Graphics Window should appear similar to Figure 1.

Figure 1   Mesh for "flumea1"

1.1   Running the Model

The correct material properties have been set for the initial run. It is necessary to first run the model with the current settings.

1. Select *RMA2 | **Run RMA2*** to bring up the *GFGen* model wrapper dialog.

2. When GFGen is finished, click **Run RMA2** to close the *GFGen* model wrapper dialog and bring up the *RMA2* model wrapper dialog.

3. When RMA2 finishes, turn on *Load solution* and click **Exit** to close the *RMA2* model wrapper dialog.

1.2   Creating Profile Plots

Before making a profile plot, it is necessary to create a new observation coverage, with an observation arc to define the profile to plot. To create an observation coverage and profile arc, do the following:

1.   Select "🔵 Area Property" in the Project Explorer to make it active.

2.   Right-click on "🔵 Area Property" and select *Type* | *Generic* | **Observation**.

3.   Right-click on "🔵 Area Property" and select **Rename**.

4.   Enter "Observation" and press *Enter* to set the new name.

5.   Using the **Create Feature Arc** 〰 tool, create an arc down the center of the flume as shown in Figure 2.
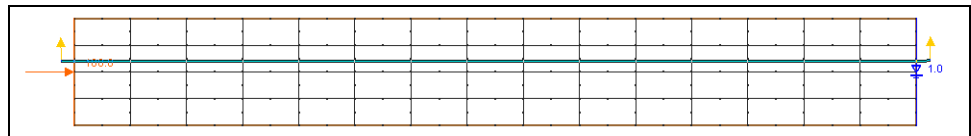

Figure 2   Mesh with observation arc

In SMS, profile plots can be created to visualize the results of a model run. To create a profile plot, do the following:

1.   Select *Display* | **Plot Wizard…** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.

2.   In the *Plot Type* section, select "Observation Profile" from the list on the left.

3.   Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.

4.   In the *Dataset(s)* section, select *Specified*.

5.   Turn on "water depth" in the tree.

6.   Click **Finish** to close the *Plot Wizard* dialog and bring up the *Plot 1* dialog.

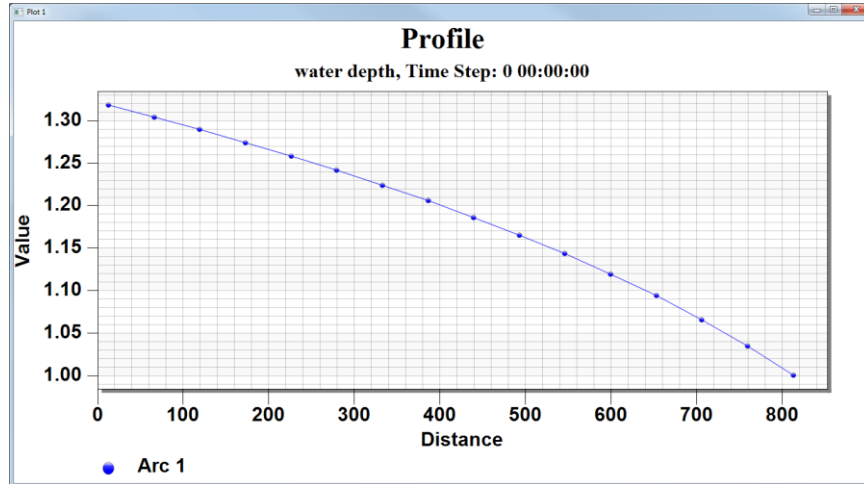The plot should appear similar to Figure 3.

Figure 3   Profile plot for initial RMA2 run

1.3   Varying Manning's Roughness

The next step is to change the material properties and rerun the model in order to compare the results.

To change the material properties:

1. Move the *Plot 1* dialog out of the way so the Main Graphics Window is visible.

2. Select "⬢ Mesh Data" in the Project Explorer.

3. Select *RMA2* | **Material Properties…** to open the *RMA2 Material Properties* dialog.

4. On the *Roughness* tab, enter "0.045" as the *Specify roughness value*.

5. Click **OK** to close the *RMA2 Material Properties* dialog.

6. Select *File* | **Save As…** to open the *Save As* dialog.

7. Enter "flumea2.sms" as the *File name*.

8. Click **Save** to save the project under the new name and close the *Save As* dialog.

9. Select *RMA2* | **Run RMA2** to bring up the *GFGen* model wrapper dialog.

10. When GFGen finishes, click **Run RMA2** to close the *GFGen* model wrapper dialog and bring up the *RMA2* model wrapper dialog.

11. When RMA2 finishes, turn on *Load solution* and click **Exit** to import the solution and close the *RMA2* model wrapper dialog.

12. In the *Plot 1* dialog, right-click on the plot and select **Plot Data** to bring up the *Data Options* dialog.

13. Right-click on the plot and select **Plot Data** to bring up the *Data Options* dialog.

14. Turn on the new "water depth" dataset (the one that is not turned on already) and click **OK** to close the *Data Options* dialog.

There should now be two plot profiles in the *Plot 1* dialog.

15. Repeat steps 3–14, entering "0.065" in step 4, and entering "flumea3.sms" as the *File name* in step 7.

The plot should now appear similar to Figure 4. The plot demonstrates the fact that, as the roughness increases, the upstream water surface elevation increases.

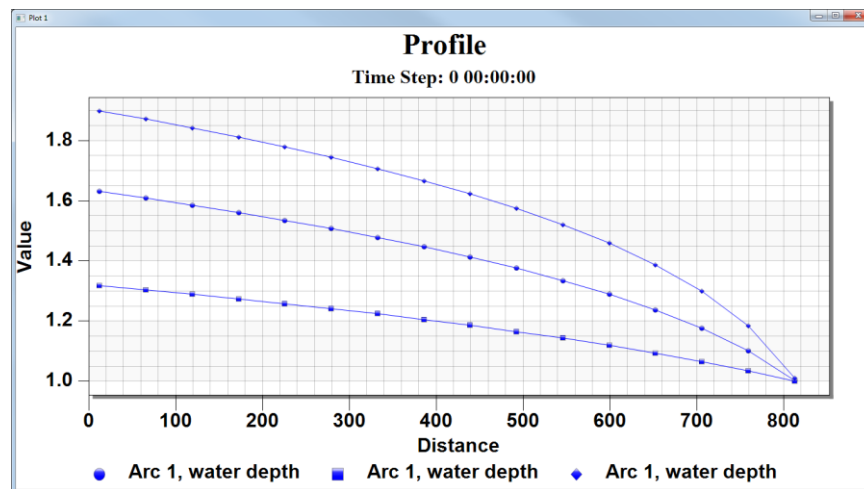16. Keep the profile plot window open, but move it out of the way.

Figure 4   Water depth with varied roughness parameters

1.4   Changes in Eddy Viscosity

Eddy viscosity is another parameter that can be modified to alter the model's solution. The exercise in this section will analyze the effects of various eddy viscosities while keeping Manning's coefficient constant.

To setup the first run:

1. Erase the old solutions by right-clicking on "📁 flumea1.sol" and selecting **Delete**.

2. If asked to confirm the deletion, click **Yes.**

3. Select *RMA2* | **Material Properties…** to bring up the *RMA2 Materials Properties* dialog.

4. On the *Turbulence* tab, enter "5.0" as the *Exx* (eddy viscosity).

5. On the *Roughness* tab, enter "0.035" as the *Specify roughness value*.

6. Click **OK** to close the *RMA2 Material Properties* dialog.

7. Select *File* | **Save As…** to open the *Save As* dialog.

8. Enter "flumeb1.sms" as the *File name*.

9. Click **Save** to save the project under the new name and close the *Save As* dialog.

10. Select *RMA2 | **Run RMA2*** to bring up the *GFGen* model wrapper dialog.

11. When GFGen finishes, click **Run RMA2** to close the *GFGen* model wrapper dialog and bring up the *RMA2* model wrapper dialog.

12. When RMA2 finishes, turn on *Load solution* and click **Exit** to import the solution and close the *RMA2* model wrapper dialog.

13. Repeat steps 3–12, entering "100.0" in step 4 and "flumeb2.sms" in step 8.

14. Repeat steps 3–12, entering "500000.0" in step 4 and "flumeb3.sms" in step 8.

15. In the *Plot 1* dialog, right-click on the profile plot and select **Plot Data** to open the *Data Options* dialog.

16. In the *Dataset(s)* section, select *Specified* and turn on all three "water depth" datasets in the tree.

17. Click **OK** to close the *Data Options* dialog.

The plots should appear similar to Figure 5. The results changed little even for the unrealistic value of "500,000.0".
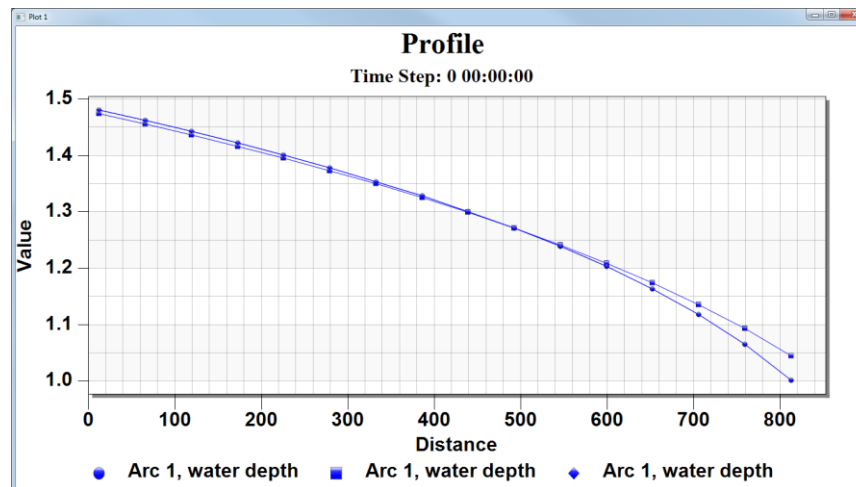

Figure 5   Eddy viscosities of "5.0", "100.0", and "500000.0" with n = 0.035

2   Constrained Flume with Single Material

The second example channel was designed to show the effect of roughness coefficients and eddy viscosities when large velocity gradients occur in the longitudinal flow direction. This channel has the same dimensions as the first flume, but it is constricted to 20 m wide through the middle. The channel has gradual contractions and expansions above and below the constricted section. The flowrate will remain 100 m³/s. The downstream water surface

elevation will remain 1 meter.

To open the new mesh:

1. Leave the *Plot 1* dialog open, but feel free to move it out of the way.

2. Select *File* | **Delete All**.

3. Click **Yes** to delete all existing data.

4. Select *File* | **Open…** to bring up the *Open* dialog.

5. Select "flumec1.sms" and click **Open** to import the project and exit the *Open* dialog.

6. Select " flumec1" to make it active.

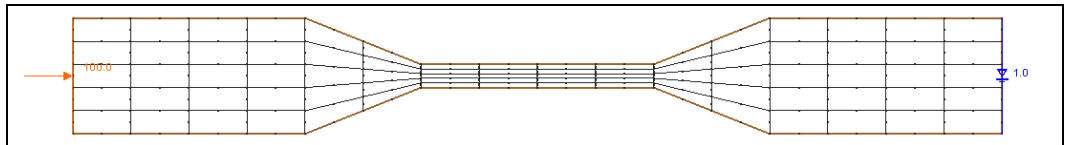The Graphics Window should appear similar to Figure 6.

Figure 6   Initial mesh appearance

2.1   Varying Manning's Coefficient

1 . Using the **Select Nodestring** tool, select the left boundary nodestring.

2 . Select *Nodestrings* | **Renumber Nodestrings**.

3 . Click **OK** when advised the numbering has been modified.

4 . Repeat the steps outlined in sections 1.1 to 1.3, replacing any instances of "flumea" in file names with "flumec".

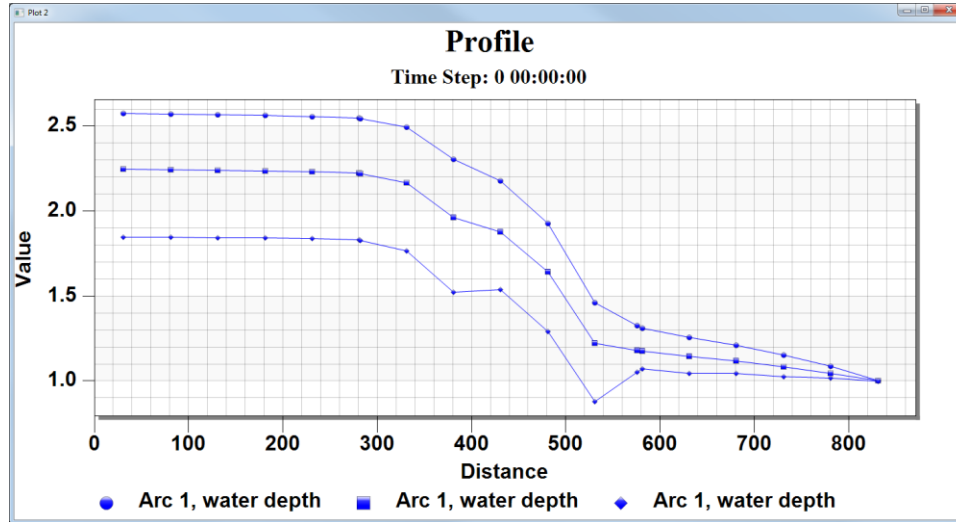When finished, the plots should look like Figure 7.

Figure 7   Constricted flume water depths with various roughness factors

2.2   Varying Eddy Viscosities

To analyze the effect of changing eddy viscosities:

1. Move the *Plot 1* dialog out of the way.

2. Erase the old solutions by right-clicking on "📁 flumec1.sol (RMA2)" and selecting **Delete**.

3. Click **Yes** when asked to confirm deletion.

4. Repeat steps 3–12 in section 1.4, entering "flumed1.sms" in step 8.

5. Repeat steps 3–12 in section 1.4, entering "100.0" in step 4 and "flumed2.sms" in step 8.

6. Repeat steps 3–12 in section 1.4, entering "2000.0" in step 4 and "flumed3.sms" in step 8.

7. In the *Plot 1* dialog, right-click on the profile plot and select **Plot Data** to open the *Data Options* dialog.

8. In the *Dataset(s)* section, select *Specified* and turn on all three "water depth" datasets in the tree.

9. Click **OK** to close the *Data Options* dialog.

As shown in Figure 8, eddy viscosities have a much larger effect when there are large longitudinal velocity gradients. For realistic values of eddy viscosity, differences in depth at the upstream end of the channel are small.
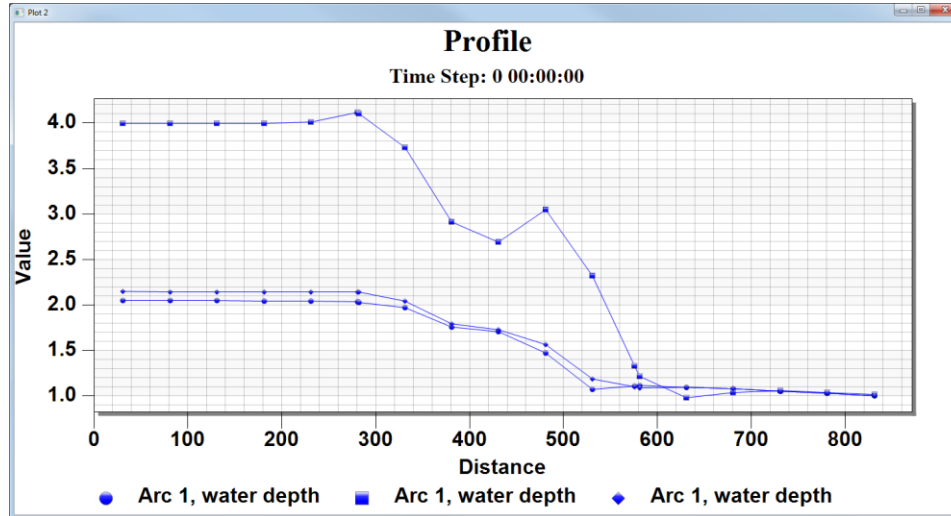
Figure 8   *Constricted flume depths with various eddy viscosities*

3   Simple Channel with Two Materials

This example channel has the same dimensions and boundary conditions as the first one. The elements are smaller and the channel has two material types rather than one (shown in Figure 9). Next to examine the effects the lateral roughness variation has on velocity.
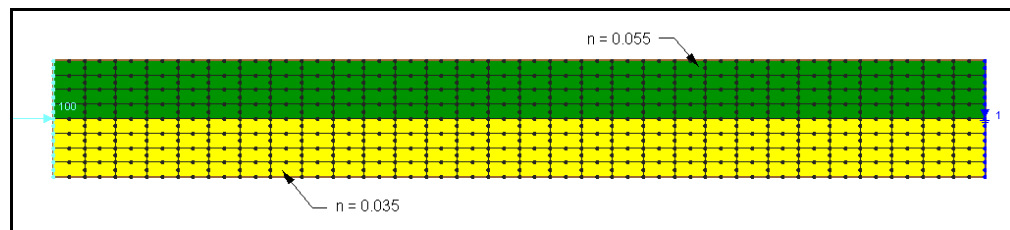

Figure 9   *Channel #3 simple flume with two materials*

1. Delete all the existing data by selecting *File |* **Delete All** and clicking **Yes** to continue deleting all data.

2. Select *File |* **Open…** to bring up the *Open* dialog.

3. Select "flumee1.sms" and click **Open** to import the project and exit the *Open* dialog.

4. Repeat steps 1–3 in section 1.1.

5. Select *RMA2 |* **Material Properties…** to bring up the *RMA2 Materials Properties* dialog.

6. Select "material_01" from the list on the left.

7. On the *Turbulence* tab, enter "500.0" as the *Exx* (eddy viscosity).

8. Repeat step 7 after selecting "material_02" from the list on the left.

9. Select *File | **Save As…*** to bring up the *Save As* dialog.

10. Enter "flumee2.sms" as the *File name* and click **Save** to close the *Save As* dialog.

11. Repeat steps 1–3 in section 1.1.

12. Repeat steps 5–11, entering "5000.0" in steps 7–8 and "flumee3.sms" in step 10.

13. Repeat steps 5–11, entering "50000.0" in step 7–8 and "flumee4.sms" in step 10.

14. Create an observation coverage by repeating steps 1–4 in section 1.2.

15. Using the **Create Feature Arc** ⌢ tool, and create a vertical arc from top to bottom across the flume at about 200 meters from the downstream boundary as shown in Figure 10.
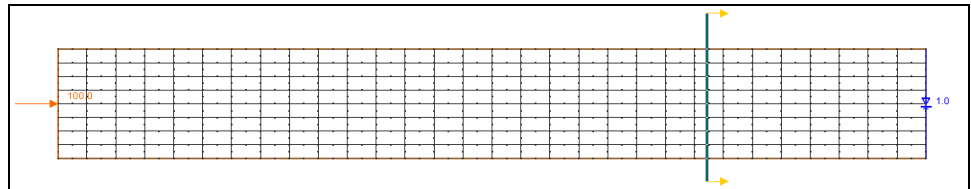

Figure 10   Placement of vertical observation arc

16. Select *Display | **Plot Wizard…*** to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.

17. Select "Observation Profile" from the list on the left and click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.

18. In the *Coverage* section, select "Model Intersections" from the *Extract profile from* drop-down.

19. In the *Dataset(s)* section, select *Specified*.

20. Turn on all four "velocity mag" datasets in the tree.

21. Click **Finish** to exit the *Plot Wizard* dialog and bring up the *Plot 1* dialog.

The plot should appear similar to Figure 11. Notice that smaller eddy viscosities allow larger transverse velocity gradients to appear in the solution plot profile.
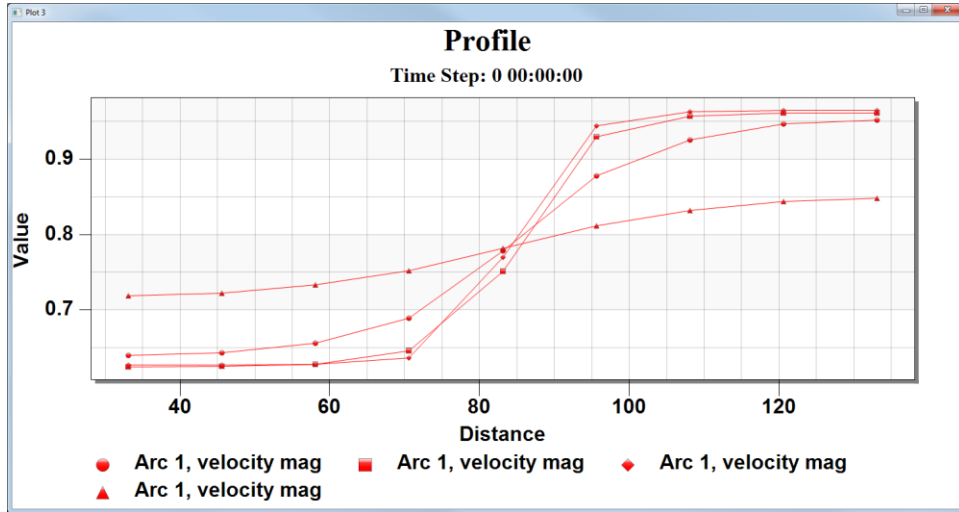
Figure 11   Plot of RMA2 solution for various eddy viscosities for channel #3

4   Conclusion

This concludes the "RMA2 Sensitivity Analysis" tutorial. If desired, experiment further with different channel arrangements and watch the effects of changing roughness and viscosity values. When done exit the program.