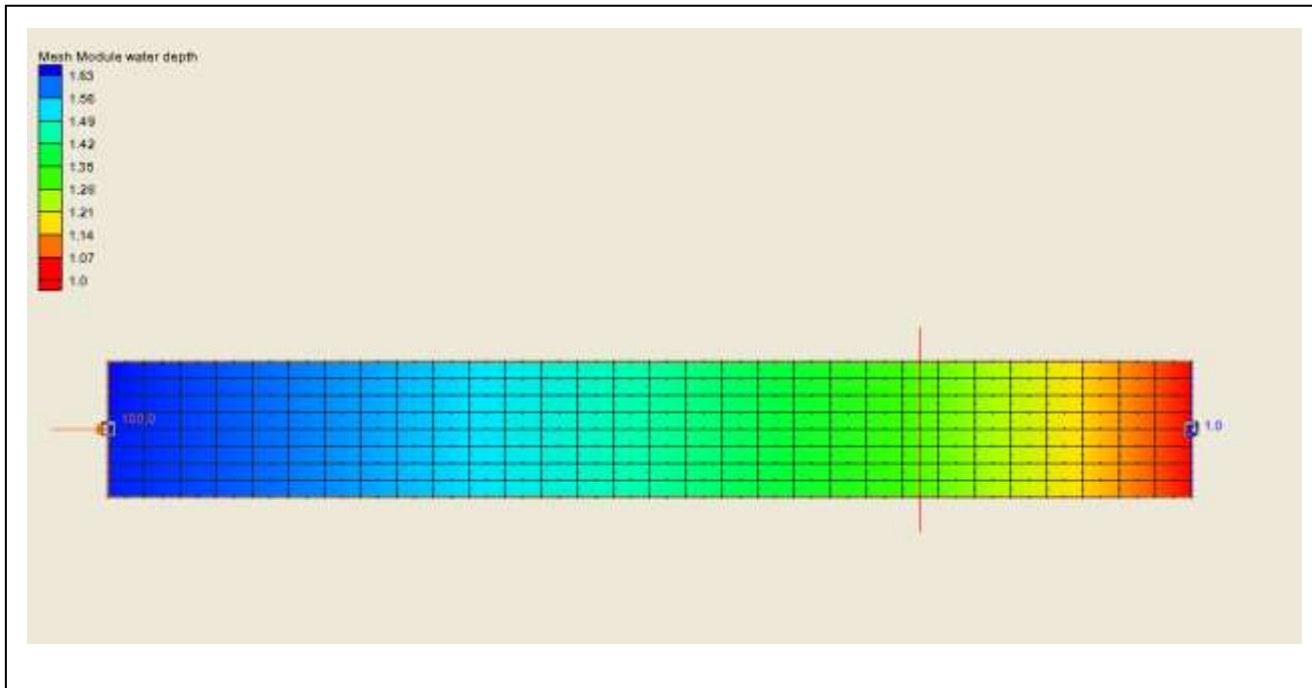


SMS 12.1 Tutorial

Sensitivity Analysis



Objectives

This lesson analyzes the effects of changes in Manning's roughness coefficients and of kinematic eddy viscosity on various channel arrangements. Understanding the effects of Manning's roughness and eddy viscosity are useful in model calibration.

Either *RMA2* or *FESWMS* may be used for this lesson. Generic solutions to the models generated by *RMA2* or *FESWMS* have been provided for those without the *RMA2* or *FESWMS* interface enabled.

Prerequisites

- RMA2 Tutorial
- FESWMS Tutorial

Requirements

- RMA2/FESWMS
- Mesh Module
- Map Module

Time

- 45-60 minutes

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1 Before Getting Started

***Note: If the *FESWMS* or *RMA2* interface is disabled, generic mesh files can be found of the format (*.2dm) with the solution to each model run (labeled *.h5) in the directory for this tutorial. For each project file (*.sms) referenced in this tutorial, it will be necessary to load both the mesh file and the corresponding solution from the Generic folder found in the directory for this tutorial. Likewise, any steps that reference running either *FESWMS* or *RMA2* models should be skipped and the generic solutions to each step should be loaded.

2 Simple Channel with Single Material

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

2.1 Open the Simulation

To open the file that contains the necessary mesh.

1. Select *File* | **Open**.
2. In the *Open* dialog, select "flumea1.sms" file and click **Open**. (Use the *RMA2* directory if using *RMA2*, the *FESWMS* directory for *FESWMS*, or the Generic directory for generic model files in the Data Files Folder.) If there is geometry open from a previous tutorial, a message will ask if wanting to delete existing data. If this happens, click the **Yes** button.

The graphics window should appear similar to **Error! Reference source not found.** below.

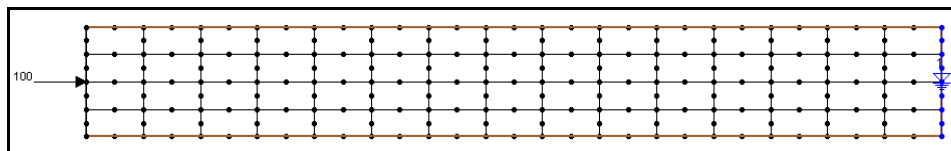


Figure 1 Mesh for "flumea1"


2.2 Running the Model

The correct material properties have been set for the initial run. It's necessary to run the model with the current settings. For instructions on running RMA2, see the RMA2 model tutorial. For instructions on how to run FESWMS, see the FESWMS model tutorial.

1. Run either the RMA2 or FESWMS model using the appropriate **Run Model** command.
2. Select **Exit** when the model run finishes.

2.3 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:

1. Select "Area Property" coverage in the Project Explorer to activate it.
2. Right-click on "Area Property" coverage, go to *Type / Generic*, and change the coverage type to **Observation**.
3. Right-click on the "Area Property" coverage and **Rename** it "Observation".
4. Select the **Create Feature Arc**  tool from the toolbox.
5. Create an arc down the center of the flume as shown in Figure 2.

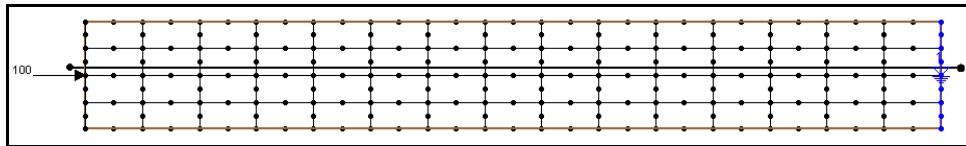



Figure 2 Mesh with observation arc

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

1. Select *Display | Plot Wizard*. The *Plot Wizard* should appear.
2. In the dialog, select the *Observation Profile* option from the menu on the left and click **Next**.
3. In the *Dataset(s)* section choose *Specified* to use specified datasets. Select "water depth". Click the **Finish** button. The plot should now appear on the screen.

2.4 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. Click on the Mesh Data object in the Project Explorer or click the Mesh Module  macro below the project explorer to switch to the Mesh Module.

2. If using RMA2, select *RMA2* | **Material Properties**. If using FESWMS, select *FESWMS* | **Material Properties**.
3. If using RMA2, in the *Roughness Parameters* tab change the roughness value to “0.045”. If using FESWMS, in the *Roughness Parameters* tab change the Manning’s roughness (n1 and n2) to “0.045”. Click **OK**.
4. Select *File* | **Save As**.
5. In the *Save As* dialog, name the new project as “flumea2.sms” and click **Save**.
6. Rerun the model with the new roughness value by following steps 1-2 in section 2.2. The new solution file should be read in automatically.
7. Right-click on the plot and select **Plot Data**. The *Data Options* dialog should appear.
8. Select the newly computed “water depth” dataset to add it to the plot and click **OK**.
9. Repeat steps 2-8 except change the n value to “0.065”, and save the file as “flumea3.sms”. The plot should now look like Figure 3.

The plot demonstrates the fact that as the roughness increases, the upstream water surface elevation increases. Keep the profile plot window open.

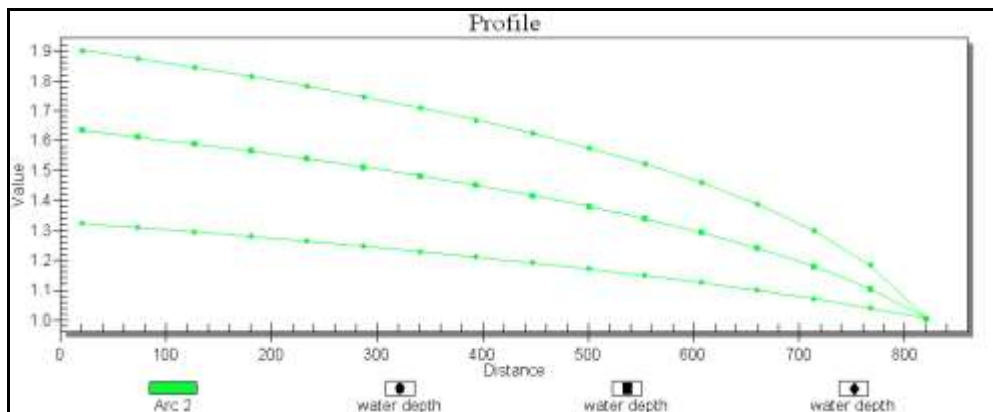


Figure 3 Water depth with varied roughness parameters.

2.5 Changes in Eddy Viscosity

Eddy Viscosity is another parameter that can be modified to alter the model’s solution. This section will analyze the effects of various eddy viscosities while keeping Manning’s coefficient constant. To setup the first run:

1. First erase the old solutions by right-clicking on “flumea1.sol” and choosing **Delete** . If asked to confirm deleting, click **Yes**.
2. If using RMA2, select *RMA2* | **Material Properties**. If using FESWMS, select *FESWMS* | **Material Properties**.
3. Change the material_01 roughness value to “0.035”.

4. If using RMA2, in the *Turbulence* tab change the *Eddy Viscosity* (E_{xx}) to “5.0”. If using FESWMS, in the *Turbulence Parameters* tab change the *Viscosity* (V_o) to “1.0 m²/s”. Click **OK**.
5. Select *File* | **Save As**.
6. In the *Save As* dialog, name the project as “flumeb1.sms” and click **Save**.
7. Rerun the model with the new model parameters.
8. Now create two new solutions using steps 2-8. For RMA2 use viscosities of “100” and “500,000”. For FESWMS use viscosities of 10 and 100 m²/s. When saving, name the files as “flumeb2.sms” and “flumeb3.sms”.
9. Right-click on the profile plot and select **Plot Data** to bring up the *Data Options* dialog.
10. Make certain the *Dataset(s)* is set to *Specified* and that all “water depth” datasets are activated. Click **OK**.

The plots should look like Figure 4 for RMA2 and Figure 5 for FESWMS.

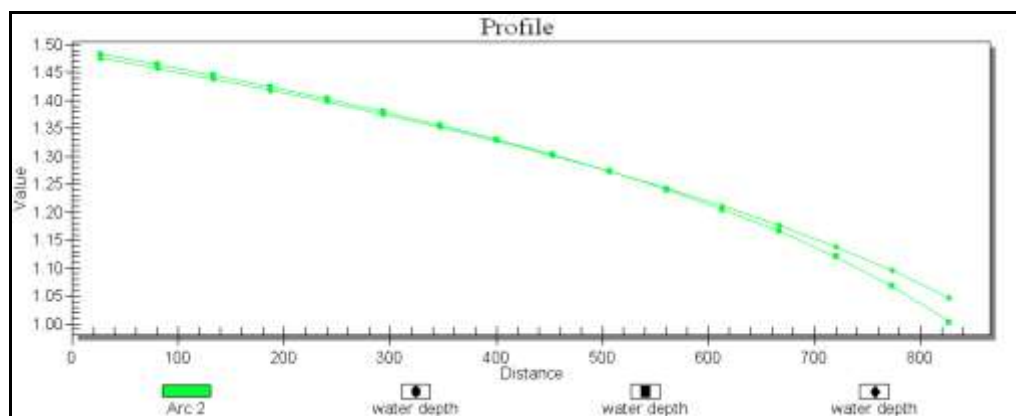


Figure 4 Eddy Viscosities of 5, 100, 500,000 with $n = 0.035$ using RMA2.

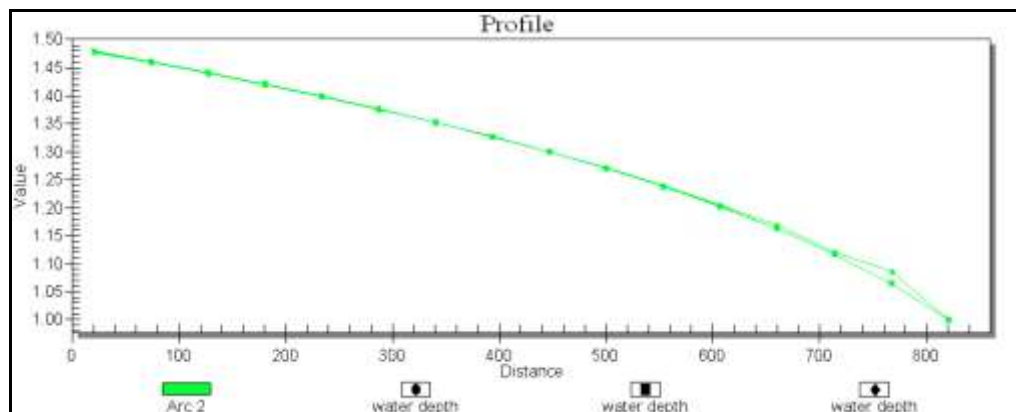


Figure 5 Eddy Viscosities of 1, 10, 100 m²/s with $n = 0.035$ using FESWMS.

The results in RMA2 changed little even for the unrealistic value of 500,000. FESWMS also had very little difference even for values as high as 100 m²/s.

3 Constrained Flume with Single Material

The second 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 $100 \text{ m}^3/\text{s}$. The downstream water surface elevation will remain 1 m.

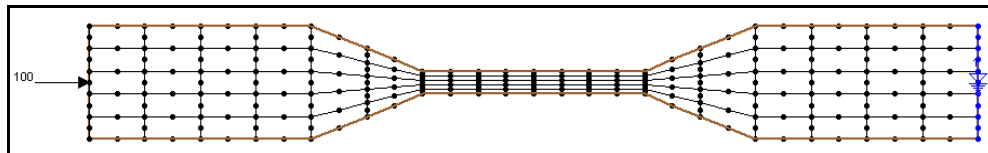



Figure 6 Test Channel #2.

3.1 Open the Simulation

To open the new mesh:

1. First Select *File* / **Delete All**. Click **Yes** to delete all existing data.
2. Select *File* | **Open** .
3. In the *Open* dialog, select the file “flumec1.sms”, and click **Open**.

3.2 Varying Manning's Coefficient

- 1 . Using the **Select Nodestring** tool, select the left boundary nodestring and select *Nodestrings* / **Renumber Nodestrings**.
- 2 . Then repeat the same procedure as was outlined in sections 2.2 to 2.4.
 - a. First, run the model as configured.
 - b. Create an observation coverage.
 - c. Use n values of “0.045” and “0.065” in the *Roughness* tab of the *Material Properties* dialog for the subsequent model runs.
 - d. Save the files as “flumec2.sms” and “flumec3.sms”.
 - e. Make sure to add all three solutions into the profile plot.

When finished, the plots should look like Figure 7 for RMA2 and Figure 8 for FESWMS.

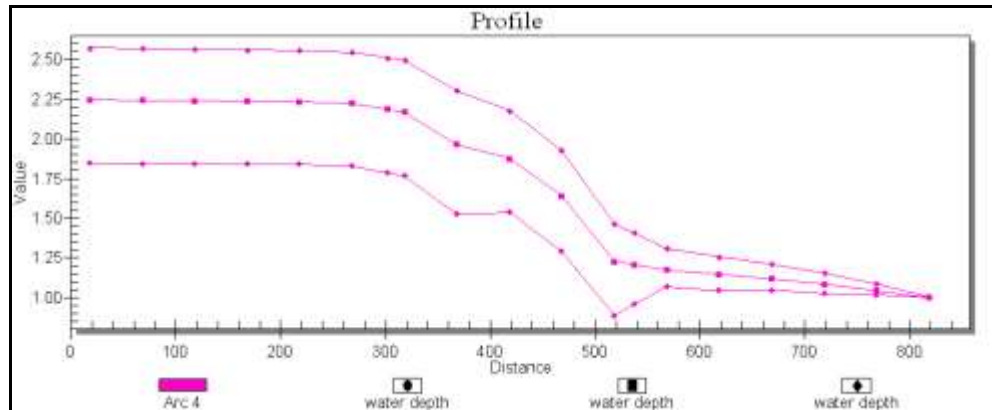


Figure 7 Constricted flume water depths with various roughness factors for RMA2.

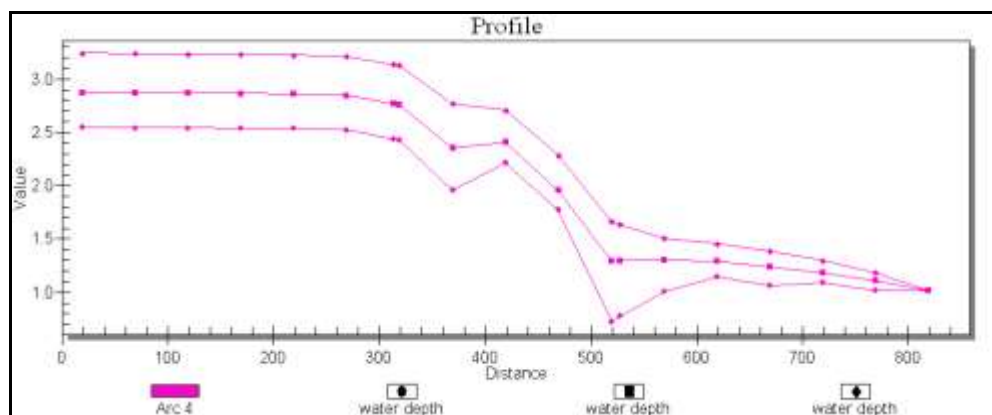



Figure 8 Constricted flume water depths with various roughness factors for FESWMS.

3.3 Varying Eddy Viscosities

To analyze the effect of changing eddy viscosities:

1. Erase the old solutions by right-clicking on them and choosing **Delete** .
2. In the *Material Properties* dialog change the Manning's *Roughness* value to "0.035".
3. If using RMA2, under *Turbulence*, make sure the Eddy Viscosity (*Exx*) is "5".
4. If using FESWMS, under *Turbulence Parameters*, make sure the Viscosity (*Vo*) is "1 m²/s".
5. Click **OK** to close the *Material Properties* dialog.
6. Select *File* | **Save As**.
7. Save the file as "flumed1.sms".
8. Run the model.
9. Now create two new solutions using steps 2-8 outlined above.
 - a. For RMA2 use viscosities of "100" and "2,000".

- b. For FESWMS use viscosities of “10” and “100” m²/s.
- c. Name the files “flumed2.sms” and “flumed3.sms” respectively.

10. Add the “water depths” for all three solutions into the profile plot.

As shown in Figure 9 and Figure 10, 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.

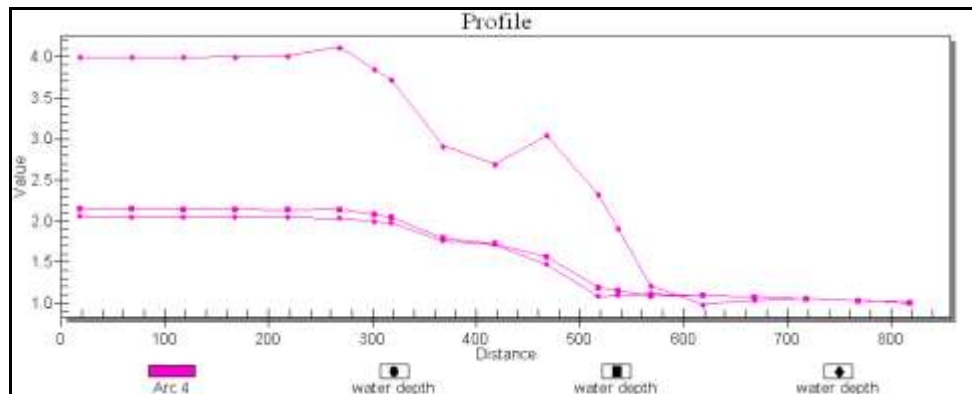


Figure 9 Constricted flume depths with various eddy viscosities for RMA2.

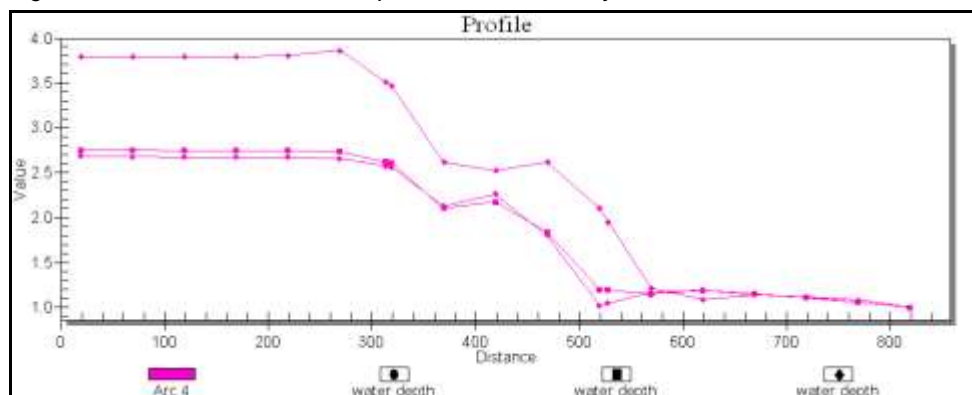


Figure 10 Constricted flume depths with various eddy viscosities for FESWMS.

4 Simple Channel with Two Materials

This 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. Next to examine the effects the lateral roughness variation has on velocity.

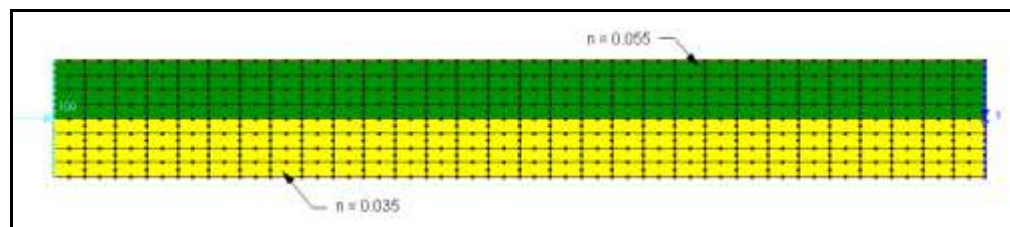


Figure 11 Channel #3 simple flume with two materials

1. Delete all the existing data by selecting *File* | **Delete All** and clicking **Yes** to continue deleting all data. The *Open* dialog will appear.
2. Open the file “flumee1.sms” by selecting the file and clicking **Open**.
3. Run the simulation with the current settings.
4. For RMA2 rerun the model with viscosities of “500” for both materials.
5. For FESWMS rerun the model with viscosities of “5”, “50”, and “100” for both materials.
6. Use **Save As** and name the simulation file “flumee2.sms”,
7. For RMA2, rerun the model two more times with viscosities of “5000”, and “50,000” for both materials.
8. For FESWMS rerun the model two more times with viscosities of “50”, and “100” for both materials.
9. Use **Save As** and name the simulation files “flumee3.sms”, and “flumee4.sms”.
10. Create an observation coverage.
11. Create an observation arc across the flume from top to bottom at about 200 m from the downstream boundary as shown in Figure 12.

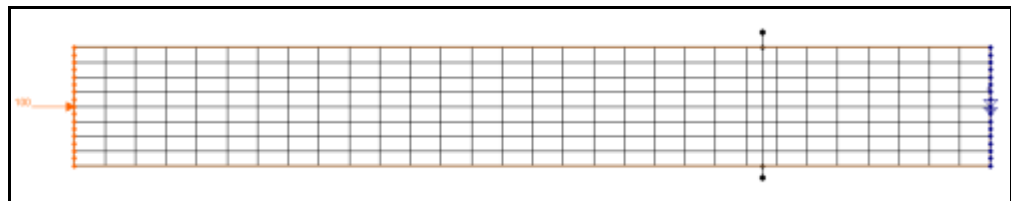


Figure 12 Channel #3 showing placement of observation arc.

12. Create an observation profile plot turning on the “velocity mag” function for each solution. Make sure that in step 2 of the *Plot Wizard* to set the *Extract profile from:* to “Model Intersections”.

The plot should look like Figure 13 for RMA2 or Figure 14 for FESWMS. Notice in the graph, smaller eddy viscosities allow larger transverse velocity gradients to appear in the solution.

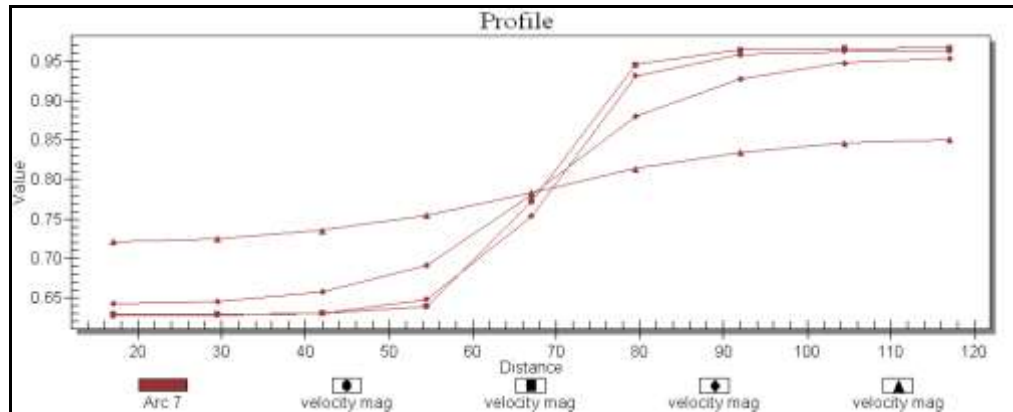


Figure 13 Plot of RMA2 solution for various eddy viscosities for channel #3.

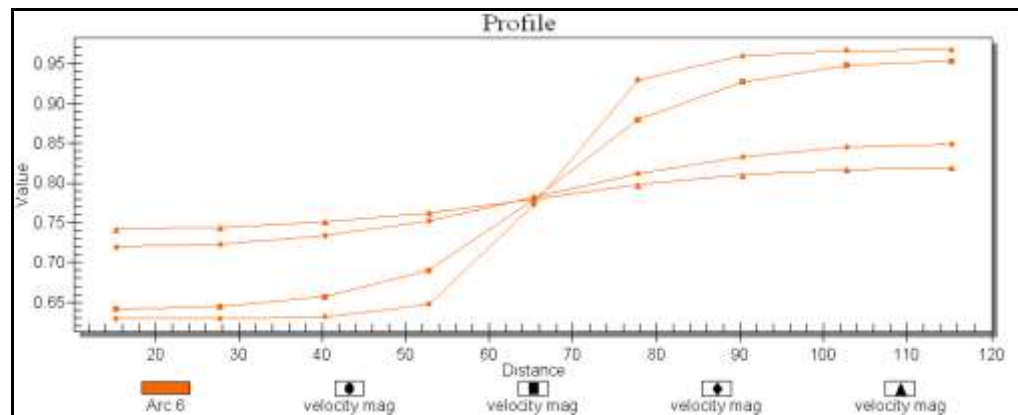


Figure 14 Plot of FESWMS solution for various eddy viscosities for channel #3.

5 Conclusion

This concludes the *Sensitivity Analysis* tutorial. Users may wish to experiment further with different channel arrangements and watch the effects of changing roughness and viscosity values.