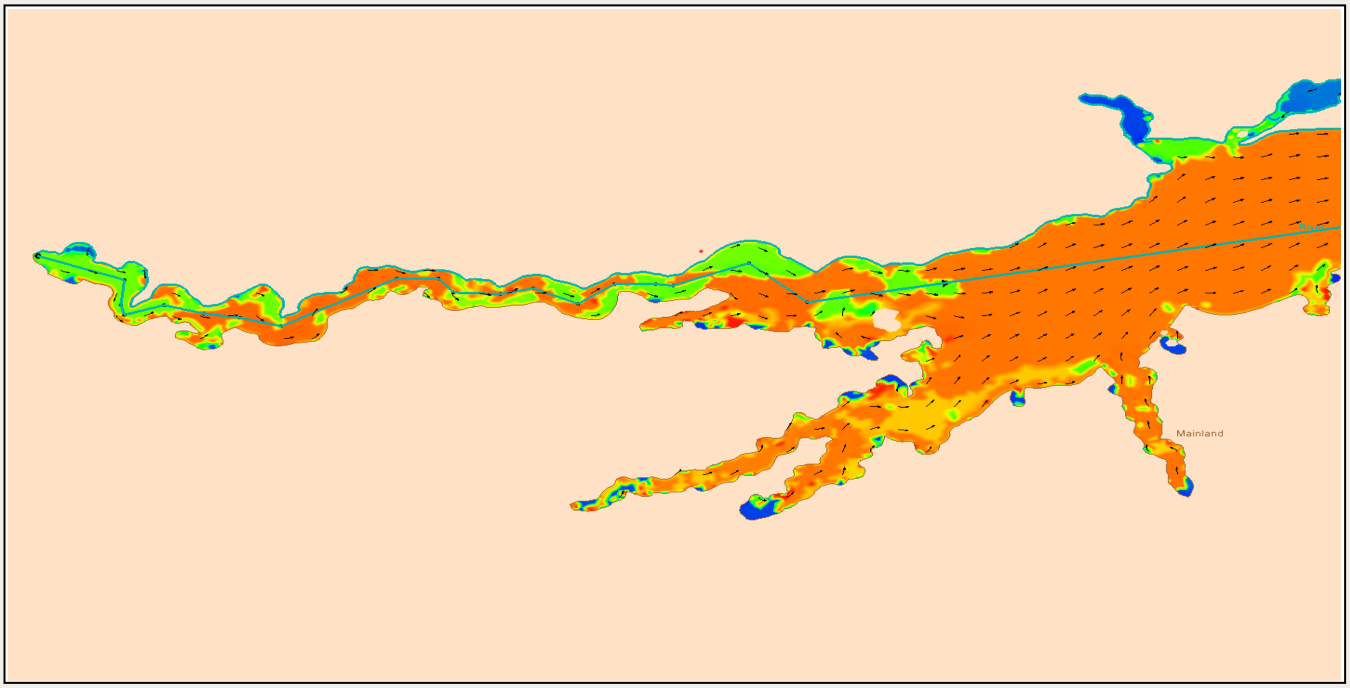
SMS 14.0 Training

Adding a River to an ADCIRC Simulation



Objectives

This tutorial demonstrates how to add a river to an ADCIRC simulation in SMS.

Prerequisite Tutorials

- Overview
- Map Module
- Raster
- Background Data
- Simulation Domain
- Mesh Generation
- Mesh Quality
- Levee Mesh Generation
- Levee Simulation
- Observation

Required Components

- SMS Core

Time

- 15–20 minutes

AQUAVEO™

1 Introduction

This exercise illustrates how to add a river to an ADCIRC simulation and define the flow for that river.

This exercise utilizes data from the region around Indian River Inlet located on Delmarva Peninsula along the Maryland coast between Delaware Bay and Chesapeake Bay. It commences with the simulation from the *Levee Options* exercise.

2 Getting Started

Start by importing a project file containing an existing mesh:

1. Launch the SMS application.
2. From the *Menu* bar, select the *File* | **Open…** menu command to bring up the *Open* dialog.
3. Navigate to the tutorial’s *data_files* folder.
4. Select the “start.sms” file.
5. Click the **Open** button to import the project and exit the *Open* dialog.
6. From the *Menu* bar, select the *File* | **Save As…** menu command to bring up the *Save As* dialog.
7. For the *File Name*, enter “IR_river.sms”.
8. Click the **Save** button to save the file and close the *Save As* dialog.

The initial project should appear similar to Figure 1.

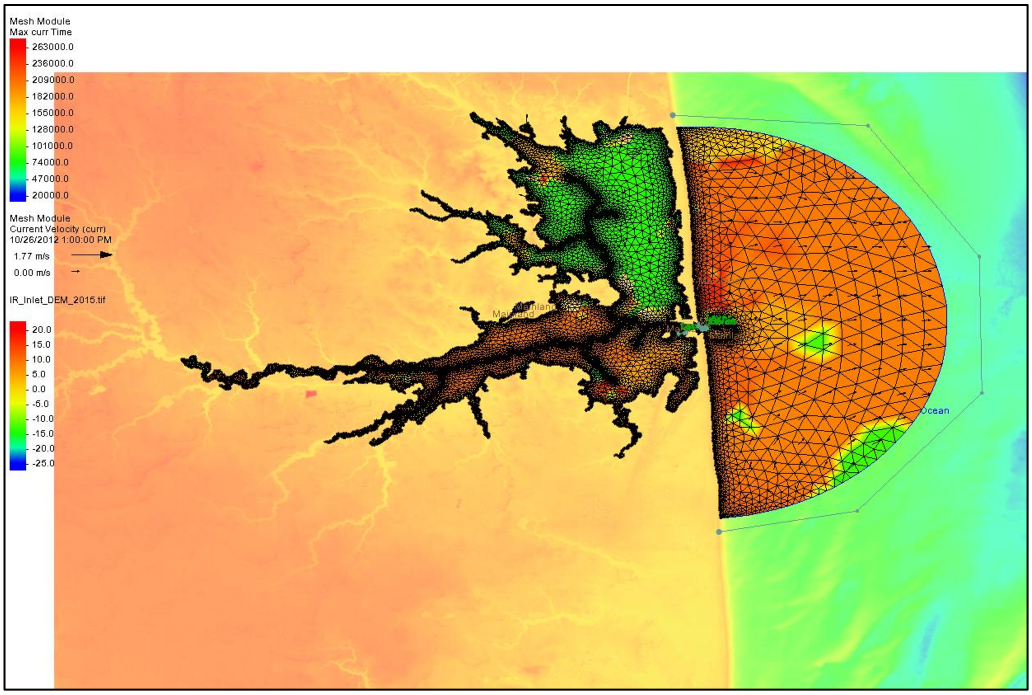


Figure 1 Initial project

Typically, adding a river to a simulation includes the following:

- Modifying the mesh. This was done in the previous tutorial.
- Adding a river arc to the boundary condition coverage
- Specifying the river flow

3 Modifying the ADCIRC Mesh

This step was completed in the *Levee Mesh Generation* tutorial. In that tutorial, a section of the mesh boundary, where river flow would enter the domain was defined as a section perpendicular to the river flow. This was done because ADCIRC assumes that river flow enters the domain perpendicular to the element edges assigned to be the location of the river. Typically, this will include at least two element edges. For larger rivers, it is recommended that you have more element edges to allow for variation of flow across the inflow segments. This could be as many as 10-20 element edges if the river is wide relative to the mesh resolution and the flow is varied.

In this case, the river is fairly small relative to resolution, so the mesh was generated to include three element edges across the river just downstream of the Millsboro Pond area (x = 549304.6, y = 104411.4 in Maryland State Plane coordinates.)

4 Adding a River to the Boundary Conditions

River boundary condition arc(s) are typically included in the boundary condition coverage that includes the ocean boundaries. They can also be included in a separate coverage.

Note: mainland and island boundaries don't need to be in any coverage since they are created as part of the simulation on export. This example does not include any mainland or island arcs.

1. Using the **Zoom** static tool, zoom into the Millsboro Pond area on the west edge of the model domain. Refer to the highlighted area in Figure 2.

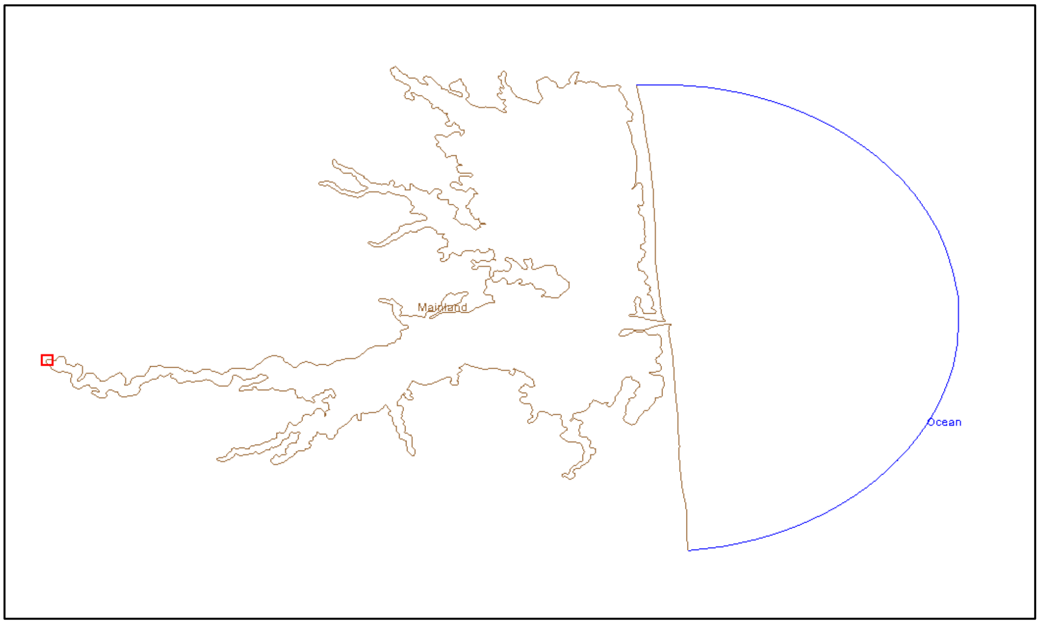


Figure 2 River input location

4.1 River Boundary Condition Coverage

1. In the Project Explorer, right-click on the " Map Data" folder and select the **New Coverage** context menu command to open the *New Coverage* dialog.
2. For the Coverage Type, select *Models* | *ADCIRC* | **Boundary Conditions**.
3. For the *Coverage Name,* enter "River 15 cms".
4. Click the **OK** button to close the *New Coverage* dialog.
5. Drag the " River 15 cms*"* coverage and drop into the " ADCIRC" map data folder, a black drop location line will appear.
6. Select the " River 15 cms*"* coverage to make it active.

4.2 Add the River Arc

In the new boundary condition coverage:

1. Using the **Create Feature Arc** dynamic tool, create an arc across where the river enters the domain.

The image should now appear similar to Figure 3.

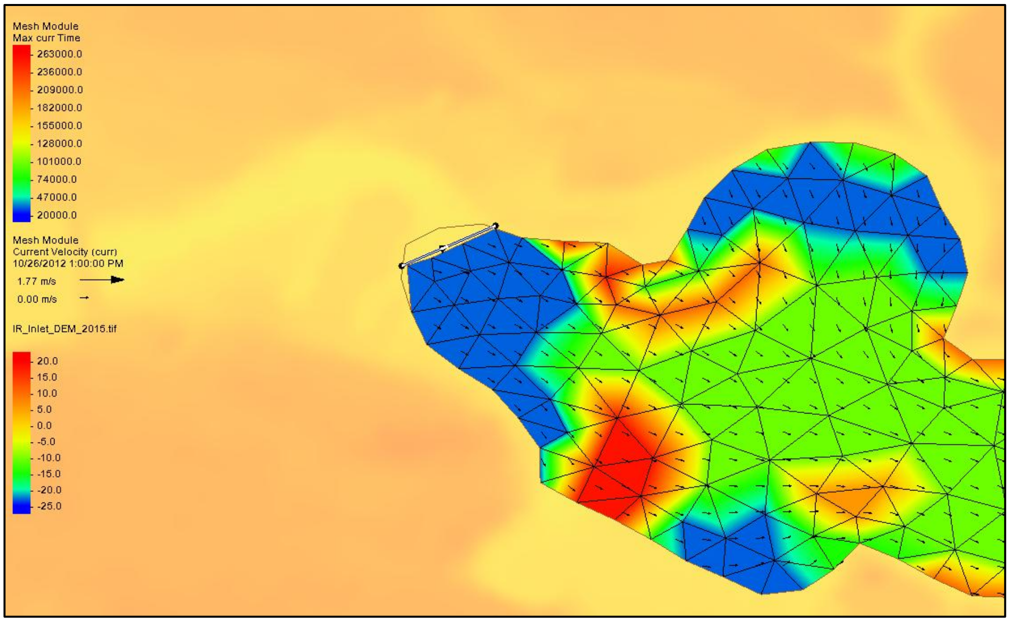


Figure 3 The river BC arc.

4.3 Assign the River Flow

1. Using the **Select Feature Arc** dynamic tool, double-click on the arc to open the *Assign Linear BC* dialog box.
2. In the *Linear boundary condition options* section, from the drop-down menu, select “River”.
3. In the *River options* section, turn on the *Use constant Q* checkbox.
4. For the *Use constant Q* value, enter “15.0” cms.
5. Click the **OK** button to close the *Assign Linear BC* dialog box.

5 Creating an Initial River Simulation

For this tutorial we will create two river simulations.

- The first is a constant river flow of 15 cms through Indian River (several times higher than the base flow of about 3 cms).
- The second will represent a hydrograph through Indian River representing a response to a storm event inland.

A river boundary condition is passed to ADCIRC as a series of unit flows (meters^2/second) for each node in the river boundary node. ADCIRC supports both periodic and non-periodic river flow. Since the ADCIRC community uses the periodic approach to represent water levels, a common practice has evolved to represent river flows as periodic flows. However, in practice this almost always has been accomplished by specifying a constant flow using a flow constituent with an infinite period.

Both the requirement to pass unit flowrates, and the use of periodic flows are non-intuitive and difficult to apply. Therefore, the SMS interface has been modified to simplify the process.

5.1 Converting Total Flow to Unit Flow

The first issue, specifying unit flow, is difficult to apply because it requires distributing the flow associated with each node on the river segment. This depends on the length of the segment, the elevation of the points on the segment and the roughness of the segment. These amounts are not generally known and must be approximated.

As a result, it has become common practice to simplify the distribution to be a constant unit flow along all segments of the river. While this is easy for the user, it does not represent a typical river flow distribution.

SMS has embedded a cross-section conveyance weighting tool to the river section. This allows the user to specify a total flowrate.

5.2 Specifying Constant or Timeseries Flowrates

As mentioned above, common practice has evolved in the ADCIRC community to represent a constant flow as a periodic flow with an infinite period. This is not intuitive.

If the flow is period, meaning it is inside of the tidal prism, using a periodic flow rate can be powerful. However, even in that situation, defining what those constituents would be is generally not available.

The SMS interface still retains the option of specifying flow boundary conditions using periodic forcing. This is specified on the ADCIRC boundary condition coverage. (Note: in a single ADCIRC simulation, all rivers must be periodic, or non-periodic. A mixed representation is not supported.)

This tutorial illustrates how to specify non-periodic flow rates:

1. In the Project Explorer, right click on the " River 15 cms" map data coverage and select the **Forcing Options…** context menu command to open the *Boundary Conditions Forcing Options* dialog.
2. In the *Flow forcing* section of the dialog, turn off the *Use periodic flow forcing* checkbox.
3. For the *Flow time step*, enter "3600" and for the time units select "seconds".
4. Click the **OK** button to close the *Boundary Conditions Forcing Options* dialog.

Note: For each river boundary, specify the flow rate as a temporally constant value (as specified above), or using a hydrograph. If using a hydrograph, ensure that the hydrograph covers the entire duration of the simulation.

5.3 Setting up the River Simulation Parameters

Set up a simulation:

1. In the Project Explorer, right-click on the existing " Levees varied Zc" simulation and select the **Duplicate** context menu command.
2. Right-click on the " Levees varied Zc (2)" simulation, select the **Rename** context menu command, enter "River 15 cms" and click the *Enter* key to set the new name.
3. Right click on the " River 15 cms" coverage and select the *Apply to* | **ADCIRC Simulation → River 15 cms** context menu command.

4. Right click on the " River 15 cms" simulation and select the **Map Boundary Conditions...** context menu command. The *Applying Boundary Conditions* dialog appears while the command is running, it will close automatically when it completes successfully.
5. Right click on the " River 15 cms" simulation and select the **Model Control** context menu command. The *ADCIRC Model Control* dialog appears.
6. In the *Geneal Parameters* tab, in the *Simulation description* section, change the *Project title* to "Indian River 15 cms 10/24/2012".
7. Click the **OK** button to close the *ADCIRC Model Control* dialog.

5.4 Running the Simulation

To save the project and run the simulation:

1. From the *Menu* bar, select the *File* | **Save as…** menu command.
2. For the *File Name,* enter "IR_river_sim.sms".
3. Click the **OK** button to save the file and close the *Save As* dialog.
4. In the Project Explorer, right-click on the " River 15 cms" simulation and select the **Save Project, Simulation and Run** context menu command.
5. If asked to renumber coverages, click the **Yes** button.
6. The *Simulation Run Queue* dialog opens showing the progress of the simulation. This takes about 20 minutes to complete.
7. When the simulation is complete in the *Simulation Run Queue* dialog, click the **Load Solution** button to load the solution into SMS.

5.5 Reviewing the Simulation Results

Step through the timesteps and note how the flow does not reverse as the tide comes in at the upstream end of the river like it did in the tidal simulation.

1. In the *Time Step* window, step through the timesteps. Note how the flow does not reverse as the tide comes in at the upstream end of the river. Refer to Figure 4.

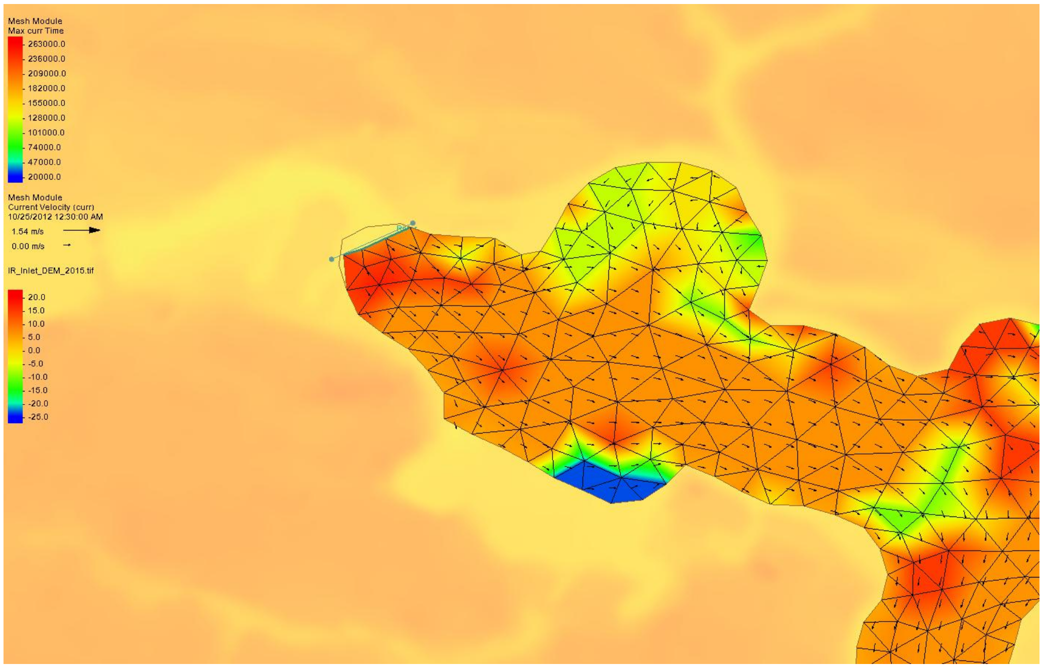


Figure 4 River 15 cms simulation result

6 Preparing and Visualizing River Profiles in ADCIRC

To better understand flow behavior in the model domain, a profile can be created along the centerline of the river and used to visualize changes in water surface elevation over time. This is particularly useful for comparing tidal and river-dominated conditions in an ADCIRC simulation within Aquaveo SMS.

1. In the Project Explorer, turn off the " IR_Inlet_DEM_2015.tif" GIS dataset and the " Tide - Constant", " Levees constant Zc", and " Levees variable Zc" simulation checkboxes, to reduce visual clutter.
2. In the Project Explorer, right-click on the " Map Data" folder and select the **New Coverage** context menu command to open the *New Coverage* dialog.
3. In the *Coverage Type* section, select *Generic* | **Observation**.
4. For the *Coverage Name*, enter "Observation Profile".
5. Click the **OK** button to exit the *New Coverage* dialog.
6. Drag the " Observation Profile" coverage and drop into the " ADCIRC" map data folder, a black drop location line will appear.
7. In the Project Explorer, select the " Observation Profile" coverage to make it active.

6.1 Creating a Centerline Profile

Begin by defining a profile arc that follows the center of the river channel:

1. Switch to the Map Module.

2. Using the **Create Feature Arc** dynamic tool, create a new arc that traces the approximate centerline of the river from upstream to downstream, from where the river enters the model to the ocean boundary.

   Note: Ensure that the arc spans the full region of interest where water surface elevation (WSE) changes are expected.

3. Using the **Select Feature Arc** dynamic tool, double-click on the arc to open the *Observation Coverage* dialog box.
4. In the *Measurements* section, from the *Feature object type* drop-down, select “points”.
5. In the *Name* column on row 1 of the spreadsheet, enter “WSE”.
6. In the *Dataset* column, from the drop-down menu, select “Water Surface (eta)”.
7. In the *Observation Points* section, enter the values shown in the table below for *Name*, *x* and *y* coordinates, *Observed Value*, and *Interval*.
8. For the *Name,* enter “Point 1”.
9. Turn on the *Observe* checkbox.
10. For *x*, enter "-75.195”.
11. For *y*, enter "38.588”.
12. For *Observed Value*, enter "2.5”.
13. For *Interval*, enter "0.25”.
14. Click the **OK** button to exit the *Observation Coverage* dialog. The Graphics Window should appear similar to Figure 5.

The observation point may not be exactly on the arc, depending on where the arc was drawn, but will be considered part of the arc as the point was created from the observation coverage dialog. For more information, see the SMS Observation tutorial.

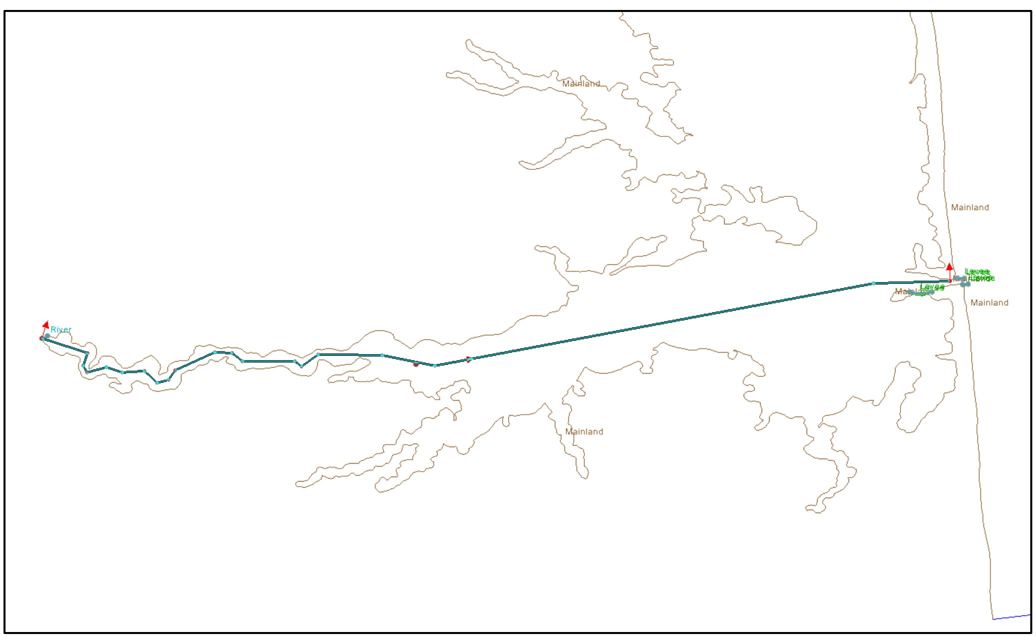


Figure 5 River centerline and observation point

6.2 Setting up an Observation Profile

1. Click the **Plot Wizard** macro to bring up the *Plot Wizard – Step 1 of 2* dialog.
2. For the *Plot Type*, select "Observation Profile".
3. Click the **Next** button to go to *Plot Wizard – Step 2 of 2* dialog.
4. Accept the defaults and click the **Finish** button. The *Plot* window will appear, refer Figure 6.

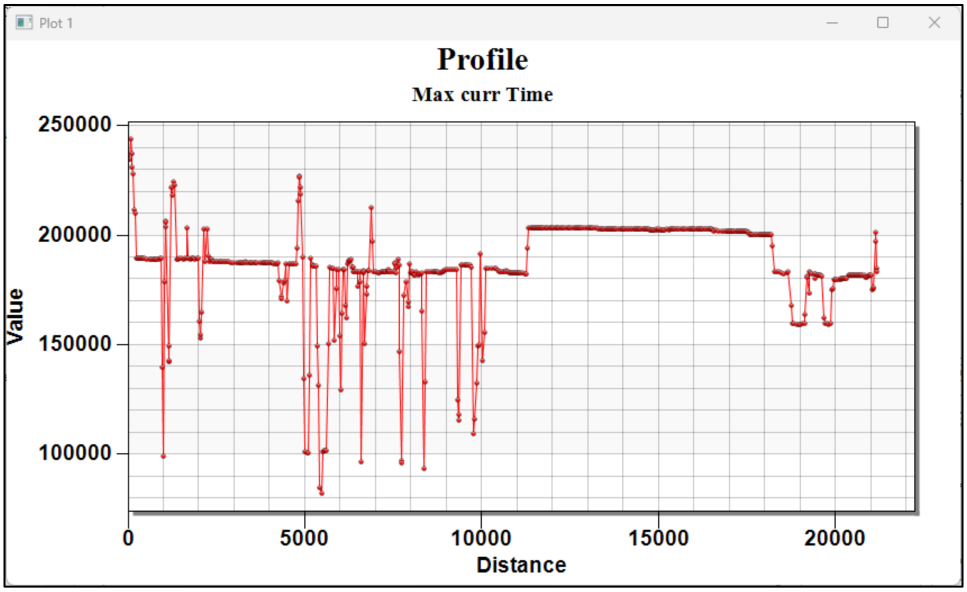


Figure 6 Profile observation point plot

7 Specifying a River Hydrograph

Hydrograph data can be added to the simulation to make it more accurate.

7.1 Adding Hydrograph Data Boundary Condition

Create a new ADCIRC BC Coverage named "River Hydrograph"

1. In the Project Explorer, right-click on the " Map Data" folder and select the **New Coverage** context menu command to open the *New Coverage* dialog.
2. For the *Coverage Type*, select *Models* | *ADCIRC* | **Boundary Conditions**.
3. For the *Coverage Name*, enter "River Hydrograph".
4. Click the **OK** button to close the *New Coverage* dialog.
5. Select the " River Hydrograph" coverage to make it active.
6. Drag the " River Hydrograph" coverage and drop into the " ADCIRC" map data folder, a black drop location line will appear.
7. Select the " Observation Profile" coverage to make it active.
8. Using the **Select Objects** dynamic tool, select the *Profile observation arc.*

9. Right-click on the *Profile observation arc* and select the **Copy to Coverage…** context menu command to open the *Select Coverage* dialog.
10. Select the *Project* | *Map Data* | *ADCIRC* | **River Hydrograph** coverage.
11. Click the **OK** button to close the *Select Coverage* dialog.
12. Turn off the " Observation Profile" coverage checkbox.

7.2 Assigning Hydrograph Data

1. Select the " River Hydrograph" coverage to make it active.
2. Using the **Select Objects** dynamic tool, double-click on the *Profile observation arc* to open the *Assign Linear BC* dialog.
3. In the *Linear boundary condition options* section, from the drop-down menu, select "River".
4. In the *River options* section, turn off the *Use constant Q* checkbox.
5. Click the **Define hydrograph…** button to open the *Define Q* dialog.
6. In the *Define Q dialog,* click the **Import…** button to open the *Open* dialog.
7. From the F*ile type* drop-down menu, select "CSV (Comma delimited) Files".
8. Select the "Flow Hydrograph.csv" file.
9. Click the **Open** button to import the file, close the *Open* dialog, and open the *Define Q* dialog.
10. In the *Define Q* dialog, the spreadsheet is populated with hydrographic readings, and the plot graph is displayed, similar to Figure 7.

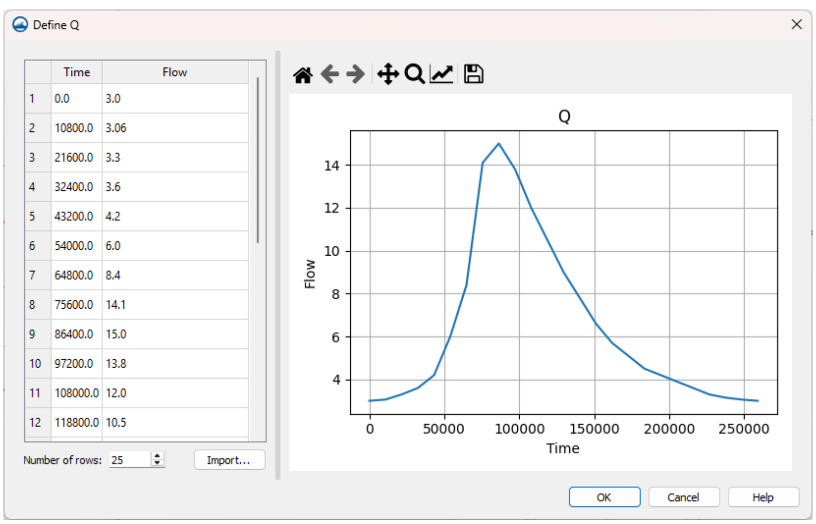


Figure 7 Hydrograph plot

11. When done, click the **OK** button to close the *Define Q* dialog.
12. Click the **OK** button to close the *Assign Linear BC* dialog.

7.3 Creating Hydrograph Simulation

1. In the Project Explorer, right-click on the existing " River 15 cms" simulation and select the **Duplicate** context menu command.
2. Right-click on the " River 15 cms (2)" simulation, select the **Rename** context menu command, enter "River Hydrograph" and click the *Enter* key to set the new name.
3. In the " River Hydrograph" simulation, right-click on the " River 15 cms" coverage link and select the **Remove** context menu item.
4. In the " Map Data" folder, right click on the " River Hydrograph" coverage and select the *Apply to* | **ADCIRC Simulation** → **River Hydrograph** context menu command.
5. Right click on the " River Hydrograph" simulation and select the **Map Boundary Conditions...** context menu command. The *Applying Boundary Conditions* dialog appears while the command is running, it will close automatically when it completes successfully.
6. Right click on the " River Hydrograph" simulation and select the **Model Control** context menu command. The *ADCIRC Model Control* dialog appears.
7. In the *Geneal Parameters* tab, in the *Simulation description* section, change the *Project title* to "Indian River Hydrograph 10/24/2012".
8. Click the **OK** button to close the *ADCIRC Model Control* dialog. The Graphics Window will appear similar to Figure 8.

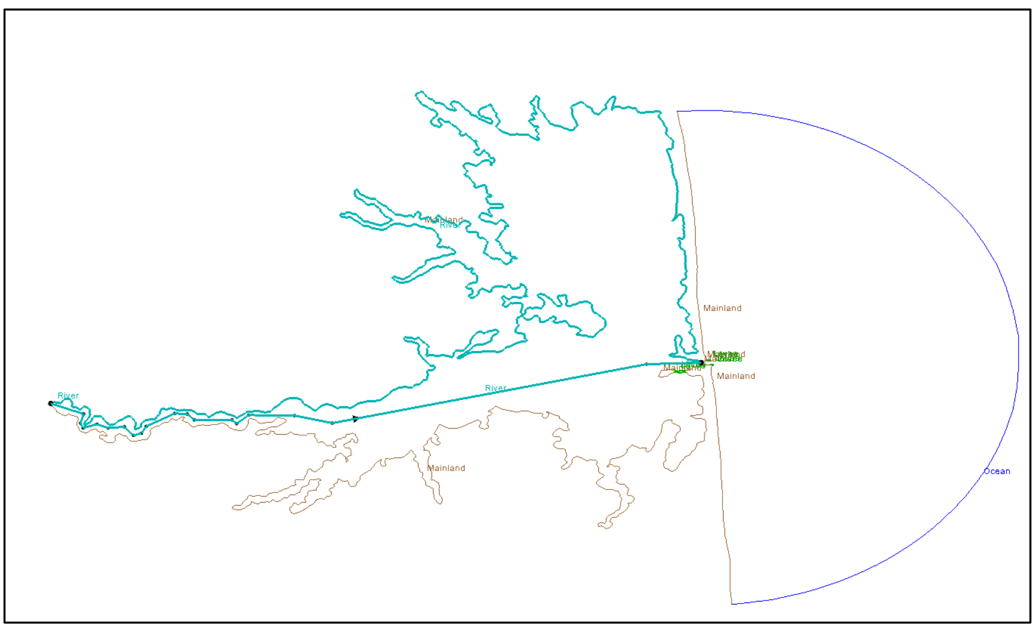


Figure 8 Hydrograph profile

7.4 Running a Hydrograph Simulation

To save the project and run the simulation:

1. From the *Menu* bar, select the *File* | **Save as…** menu command.

2. For the *File Name,* enter “IR_river_hydro.sms”.
3. Click the **OK** button to save the file and close the *Save As* dialog.
4. In the Project Explorer, right-click on the “ River Hydrograph” simulation and select the **Save Project, Simulation and Run** context menu command.
5. The *Simulation Run Queue* dialog opens showing the progress of the simulation. This takes about 20 minutes to complete.
6. When the simulation is complete in the *Simulation Run Queue* dialog, click the **Load Solution** button to load the solution into SMS.
7. In the Project Explorer, turn on the “ patch inlet 50-1000m” mesh link checkbox.
8. Click on the **Display Options** macro to open the *Display Options* dialog.
9. From the list on the left, select the *2D Mesh* item. Under the *2D Mesh* tab, turn on only the *Contours* and *Vectors* checkboxes.
10. Click the **OK** button to close the *Display Options* dialog.
11. Click the **Frame** macro to zoom to the extents of the project.

The simulation should look similar to Figure 9.

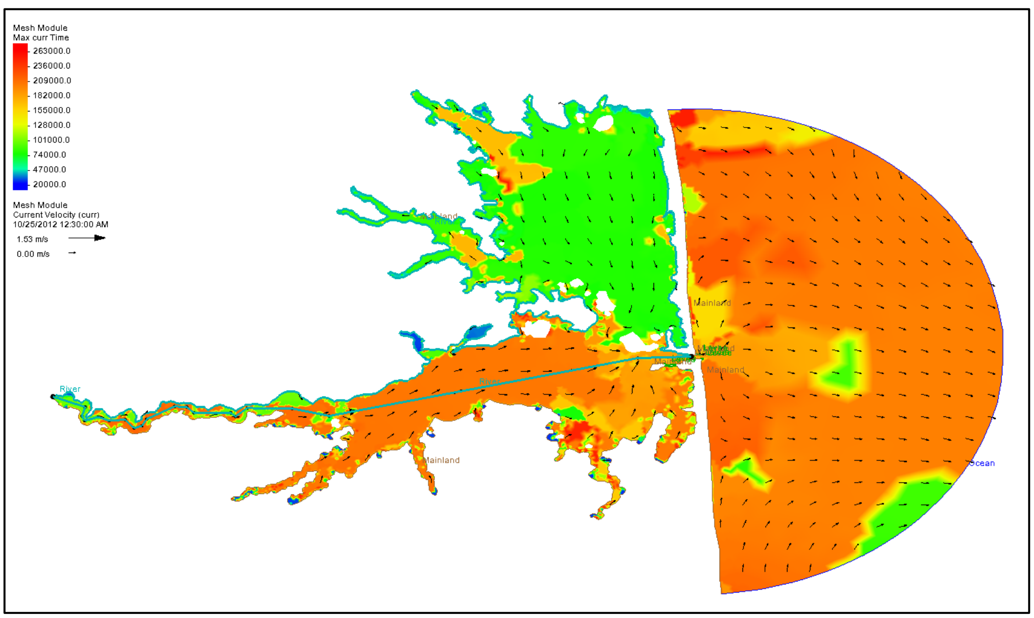


Figure 9 Hydrograph simulation

8 Conclusion

This concludes the “ADCIRC Rivers” exercise. Several features have been demonstrated including:

- Assigning river boundary conditions as constant flow rates.
- Reviewing the mapped unit flow rates.
- Assigning a river boundary condition as a hydrograph

If time permits, you may wish to try experimenting with:

- Try other flow rates or hydrographs.