B6. Using CMS-Flow

The following files, located in the "**SessionA\CMS-Flow**" folder will be used for this tutorial on Using CMS-Flow:

- Workshop.materials
- Workshop.sms
- Refine_pts.map
- Workshop – Merged.h5

There is also an "**Image**" directory that holds a few image files image that we will be loading.

Go ahead and load the file "Workshop.sms" into your copy of SMS now.

B6.1. Add Rectified Aerial Photographs

Adding rectified aerial photographs to the SMS project as a background aids in locating key features that need to be represented in the CMS flow and wave grids. There is an automated method for extracting a coarse aerial photograph or a navigation chart through the SMS or you can load the images from files that you have on your computer. For the purpose of this tutorial, we will load a photograph manually.

- Click *File | Open* on the pull down menus. Then open the directory "Image".
- Click the TIFF image (.tif) file and click OK.

You should notice that on your screen that nothing seems to have changed, however an image is now loaded. In SMS 11.0, if the image doesn't line up with the bathymetry you have already loaded, then it is defined in a different plane and the user must define the projection that the image is saved in.

- Right click on the image in the data tree and choose the option "Set Image Projection", shown in Figure B 6.1-1.
- Choose "Set Projection", and then set the projection to "State Plane, NAD 83, US Survey Feet, New Jersey".
- Click OK twice to return to the Graphics window.
- Because of the density of the merged scatterpoint set, you may not be able to see the image.
  - Right click on the image in the data tree, and choose "Zoom to Image".
  - This will zoom the graphics window to the extents of the image so that you can see that the scatter points and photo overlap, as shown in Figure B 6.1-2.
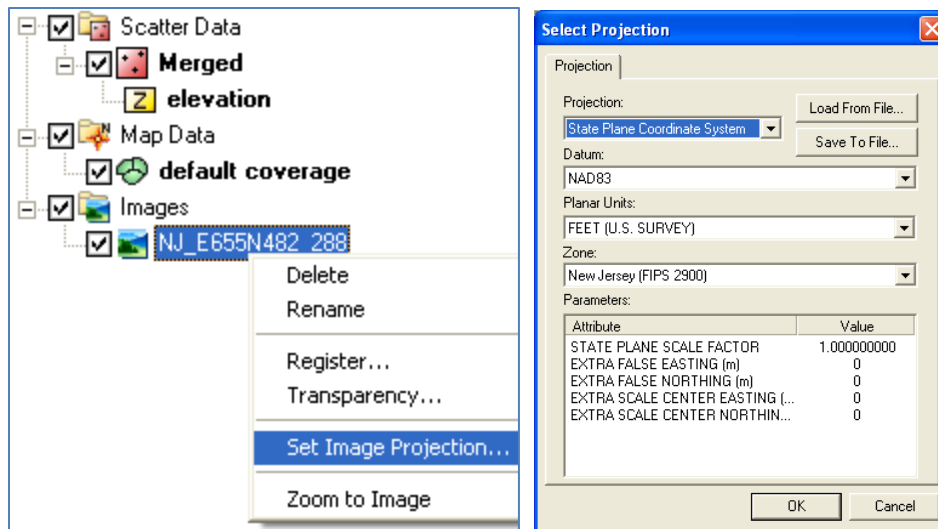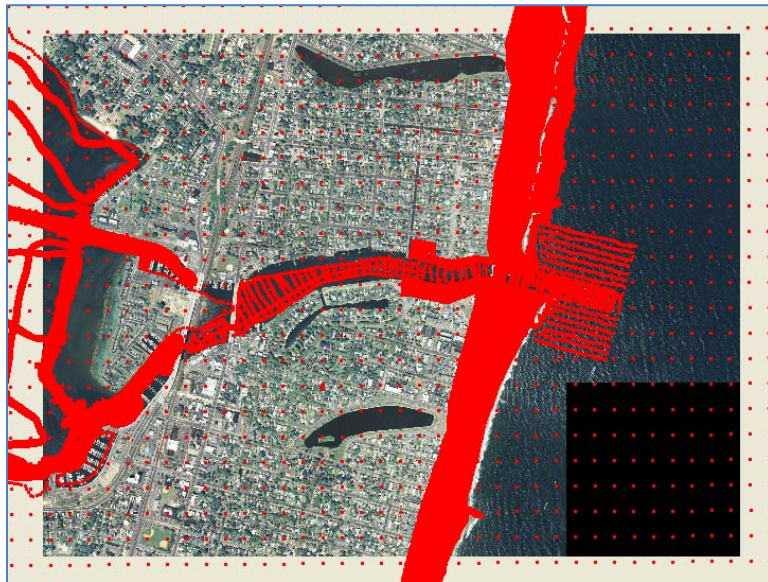
Figure B 6.1-1. Set Image Projection

Figure B 6.1-2. Scatterpoints overlapping on image.

B6.2. Grid Generation

For Shark River, the two grid options, constant and refined cell spacing, will run at more optimal speeds than a large project area such as a West Coast inlet or river mouth. Nevertheless, the refined option provides for more optimal CMS runtimes. The main inlet channel is the primary area of focus for capturing the correct current velocity with finer resolution, and should have 8-12 cells across it, limiting the cell size down to at least 10 m in the entrance channel. The two main back channels splitting off of the entrance, the north and south channel, also have large velocities (the north channel actually has the strongest current) and should be represented by at least several cells in width (minimum of 5 m in the narrow north channel).

- Set *Refine Points* for Grid Generation

1. Click the *Map Module* button , or Map Data

2. Rt-click on *default coverage*, and under *Type*, *Models*, select *CMS-Flow,*

3. Click the *Feature Point* button to generate Refine Points, and place points in area of refinement, focusing on the end of the jetty tips and down the entrance channel (setting maybe 2 to 4 points) and with varying resolution with larger base cell sizes for the area near the back bay since that area does not need as fine of resolution for flooding and drying,

4. Click the *Feature Point Selection* button and select the generated point or points, Rt-click and click on *Node Attributes* (Figure B 6.2-1), and set the base cell size for the area of the grid where the points are located.

5. The undo function does not yet exist in SMS, so be sure to save the project periodically (*Save Project*).
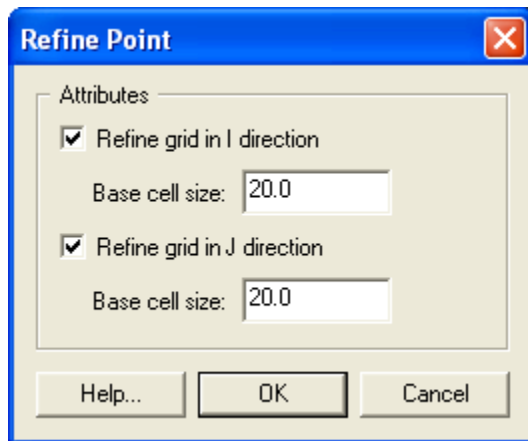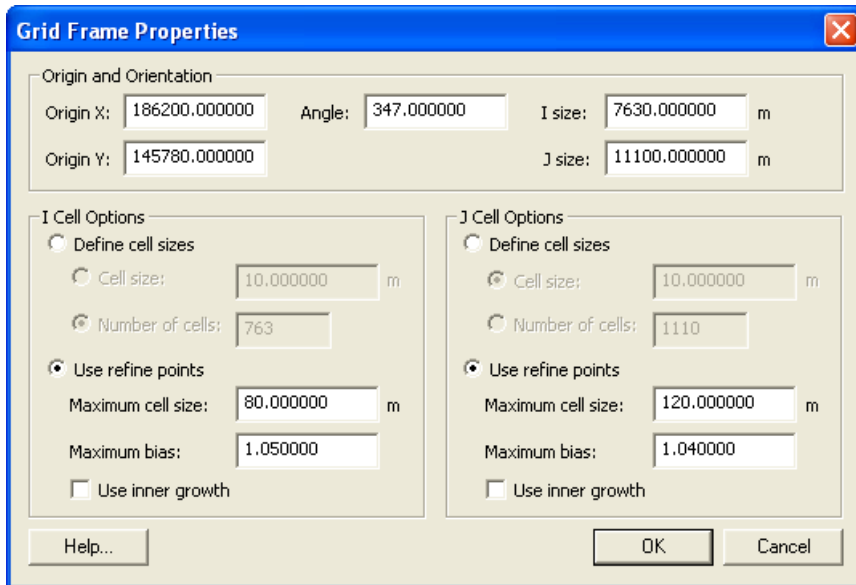

Figure B 6.2-1. Refine Point Options

Next, the grid boundary is set square to the general orientation of the coastline, with the computational direction, I & J (or IJ triad), set according to the model type. For the CMS-Flow coverage (which was selected in step 2), the point of origin will be automatically placed in the lower left corner of the grid after the grid has been created. This is default for CMS-Flow. This means that for most Atlantic coast (east facing) projects the IJ triad will be located over land on the lower left corner. Do not change the direction of the IJ, because this is specific to CMS-Flow.

- Generate the CMS-Flow Grid

  1. Click the *Create 2-D Grid Frame* button

  2. Draw two legs of the rectangular boundary for the model domain by clicking the lower-right ocean boundary corner point, then the upper ocean boundary corner, and then the upper landward boundary corner to close the box.

3. Use the *Select 2-D Grid Frame* button [icon] to select the center point of the purple outlined grid domain, adjust the edges by dragging the center point of each edge, and change the orientation by selecting the [icon] at the corner of the grid (Note that the IJ triad should be in the lower left corner),

4. Rt-click the highlighted center button and click *Properties* to further modify the dimensions of the grid boundary (Figure B 6.2-2),

Figure B 6.2-2. Grid Frame Properties

5. Correct the angle orientation if it is far from 347° (the general orientation of the coastline is 13 deg from North), and set the I and J Cell Options to *Use Refine Points* and choose a maximum cell size and bias (cell sizes increase in distance away from refine points), click *OK,*

6. Click *Feature Objects*, *Map→2D Grid,* and check that all the grid properties are set properly, *Use inner growth* is turned off, the *Interpolated Depth* (Figure B 6.2-3) from the merged file is selected, and define an elevation cutoff where cells will be non-computational land cells (i.e., these cells will always be dry and act as a wall) (Figure B 6.2-4), click *OK*.

Generating the first refined grid typically takes some trial and error testing to see how the grid looks. Be sure to modify the refine points to address areas of concern, particularly the number of cells across the entrance, north, and south channels, and groin cell width toward the lateral boundaries. Note that both the I and J directions do not need to be specified for each refine point, if refining only one direction is required.
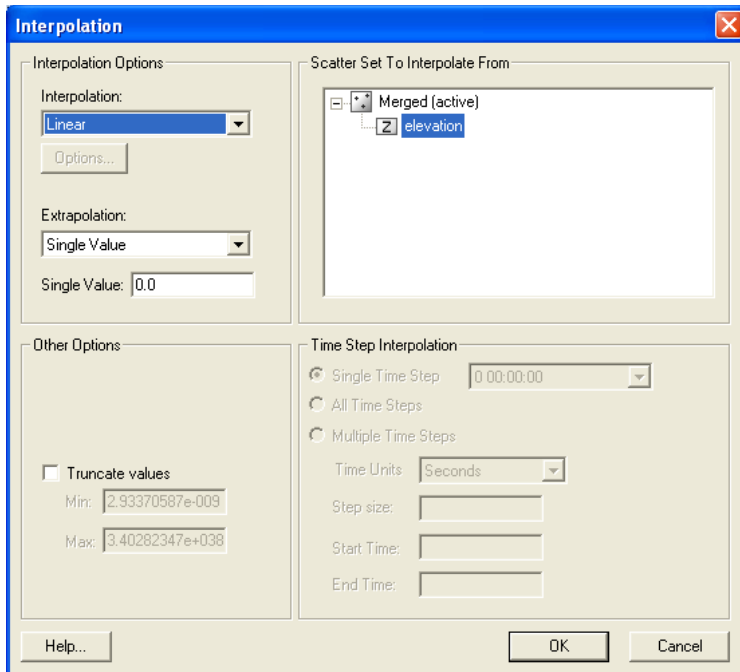
Figure B 6.2-3. Depth Interpolation options for the Map --> 2D function. Make sure to choose the Depth scalar dataset.

Figure B 6.2-4. Map -> 2D Grid options.

After the grid is generated, two pop ups warn of overlapping cellstrings and land-locked ocean cells. These land-locked ocean cells that are not to be in the computation should be changed to inactive land cells. Also, the bay should be bound by land cells, and so any open 'ocean' cells in the bay that lie on the grid boundary should similarly be changed to land cells.

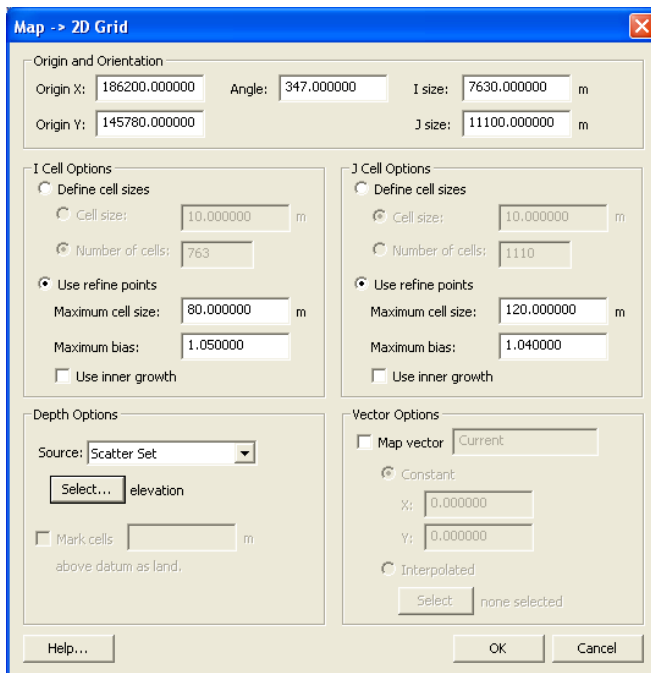To account for beach or berm cells to be wetted along the shoreline (cells with elevations higher than the land cell cutoff set in the grid generation section), sections of the beach should be changed to *Active Ocean* cells. This is difficult for Shark River because of the dense spacing of the groins as well as the fact that many of them are notched. Much of this information was retained in the LIDAR and subsequent generation of the bathymetric set provided for this example.

- Address Warnings: Fix Land-Locked Cells and Cellstring Warnings for the CMS-Flow Grid
  1. For changing land-locked ocean cells to land cells, click the *Select Grid Cell* button ⊞ if not already highlighted, and change the Z number to -1.0 (Figure B 6.2-5), or manually select cells by dragging the mouse over the target ocean cells and change the Z,

Figure B 6.2-5. Toolbar at top of SMS window containing the X,Y,Z, and S (scalar quantity) of the selected cell or an average Z of multiple selected cells.

  2. Rt-click on the cells, select *Cell Attributes* (Figure B 6.2-6), and change the cell type from *Active Ocean* to *Inactive Land* cells, click *OK*,
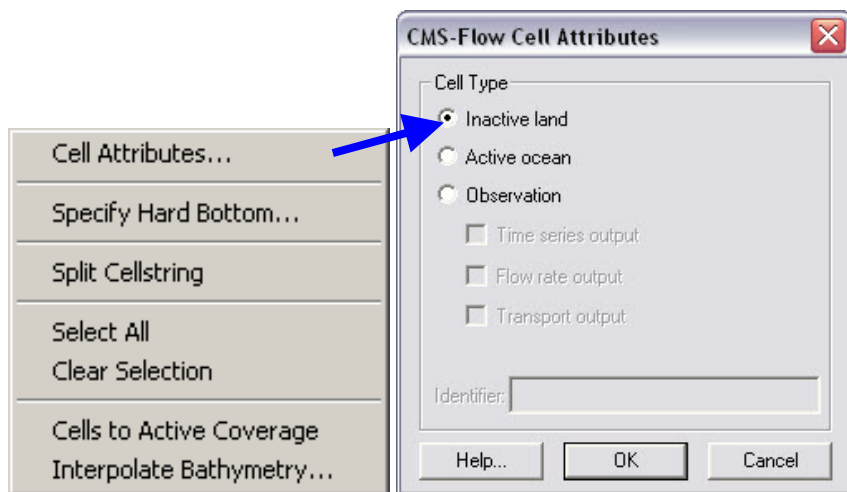

Figure B 6.2-6. Rt-click drop down menu; CMS-Flow Cell Attributes (cell type).

  3. The same process can be done for ocean cells that need to be changed to land cells along the bay edges (an aerial image will be useful for determining the proper widths of the channels); a simple way to check the entire land boundary is to use a directional selection method: hold down *ctrl* and click and drag the mouse along the outer edges of the landward side of the domain to highlight large sections,

  4. To grab multiple areas, hold down shift while selecting new cells, and all will stay highlighted,

  5. To change large sections of nearshore/beach cells that are land cells, select them with a polygon by clicking *Edit, Select with Poly* (clicking *Crtl + Shift* also initiates selecting by a polygon), and click a polygon covering a few cells across

the ocean/land interface along a section of beach from groin to groin, and change to *Active Ocean* cells,

6. Change all required stretches of beach to ocean, and check that the landward grid boundaries have all inactive cells.

7. Select the *Select Cellstring* ⬚ button and drag over the bay side of the grid to highlight the cellstrings generated there, and click delete (Figure B 6.2-7),

8. Click *Edit, Select All* (*Ctrl+A*), and check to see if only the one ocean cellstring remains, delete all others.

As always, be sure to save the project to save the grid files, which are otherwise stored temporarily. Note that all files currently opened in the SMS will be saved over and may be recreated in the folder (with a 2 behind it).
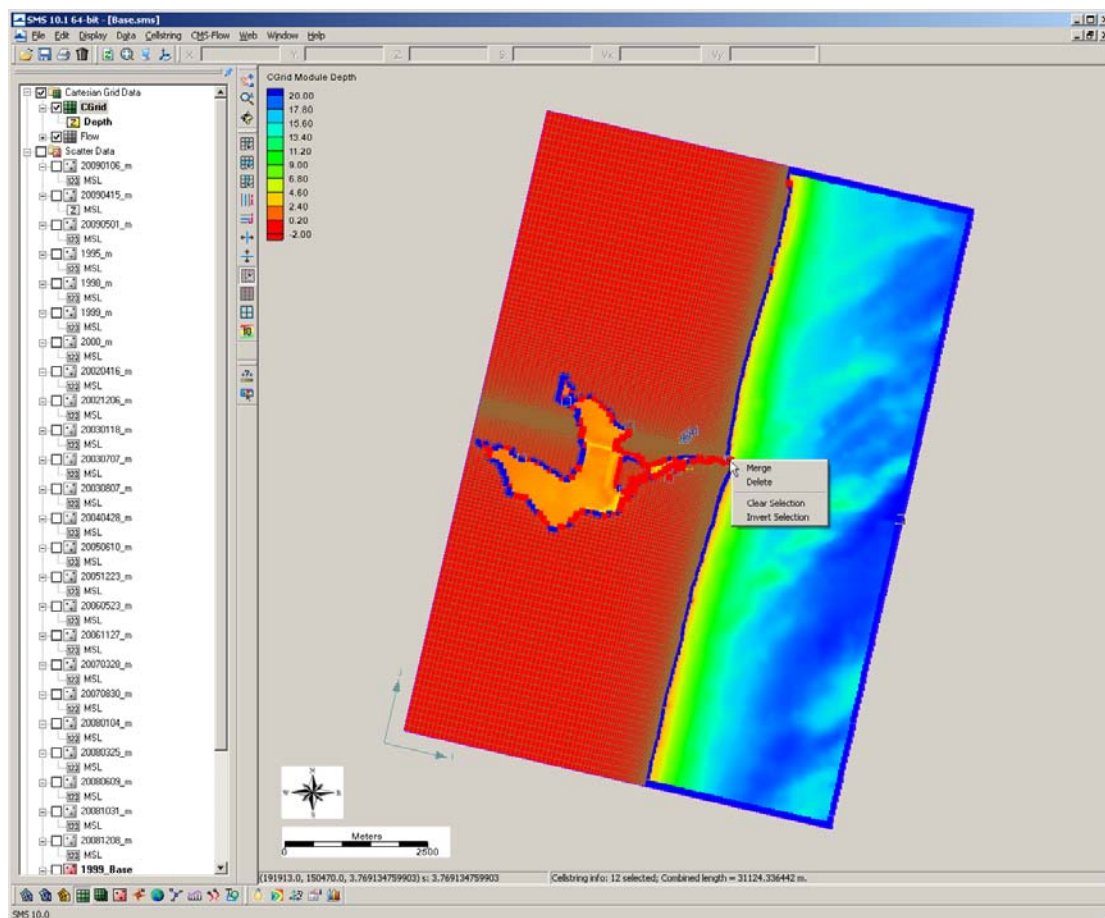

Figure B 6.2-7. Several cellstrings selected with rt-click drop menu.

B6.3. Bathymetry Preconditioning

Due to the nature of bathymetric data collection resulting in random data on the arbitrary day of the survey (as compared to the time frame of your project), certain areas of the grid may be poorly represented from scatter set triangulation and; therefore, from the final generation of the grid. It is necessary to smooth some features of the grid and leave other areas intact. Presently,

there is one option to smoothing grid bathymetry, and that is based on a weighted average of 3x3 or 5x5 cells in a rectangular selection of the grid.

The triangulated nearshore bathymetry of Shark River is uneven in places, and the beach is the only area of concern for morphology change. The inlet, ebb delta, north and south channels, and offshore transverse shoals with considerable relief should be left as close to the original bathymetry as possible. There are two ways to approach smoothing sections of the nearshore, both using the 3x3 and 5x5 weighting scheme. One would be to select entire rows (J) of the grid and smooth everything, which would also smooth the channel somewhat, and would result in less control over the smoothing (Figure B 6.3-1). The other is to smooth individual cells at a time.

- To make sure each user starts from the same point for this section, a grid is provided in the *SessionA/CMS-Flow/InitialGrid* folder. Restart SMS and open the Base.sms project using the *File | Open* menu command.
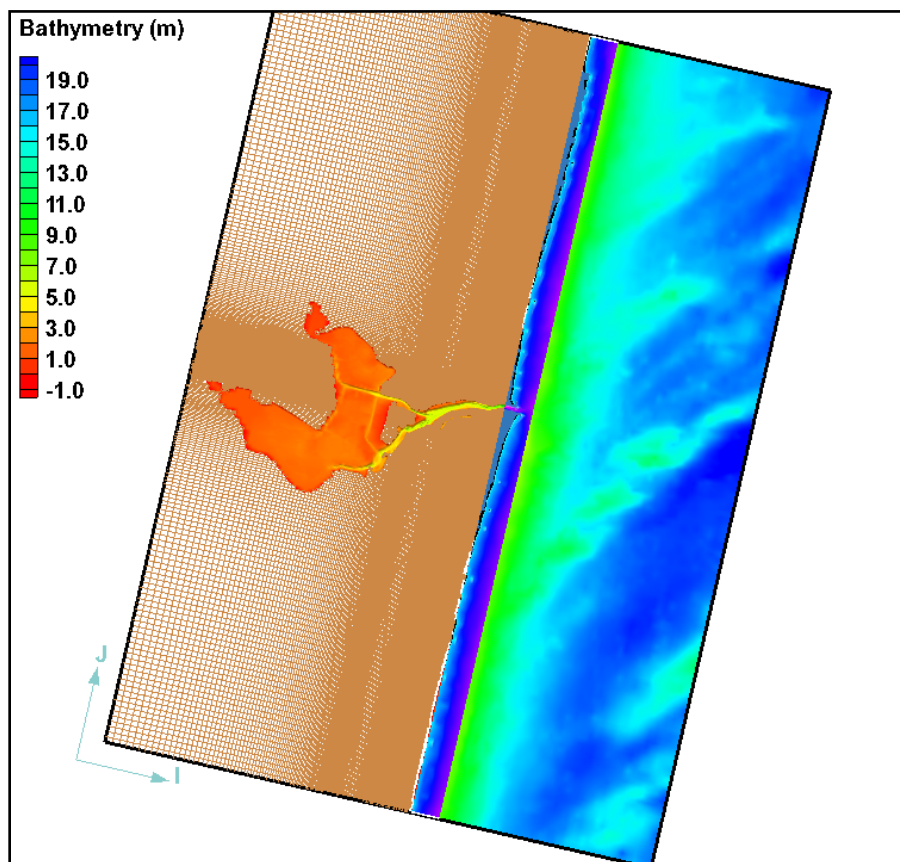

Figure B 6.3-1. Selection of several rows across the grid.

- Preconditioning the Nearshore
    1. Determine the bounding cell id by looking at the corner cells (that make up the rectangular area defining the nearshore that is to be smoothed) by clicking the *Select Grid Cell* button and clicking on each cell individually, the I and J id is listed along the lower portion of the SMS window (Figure B 6.3-2),
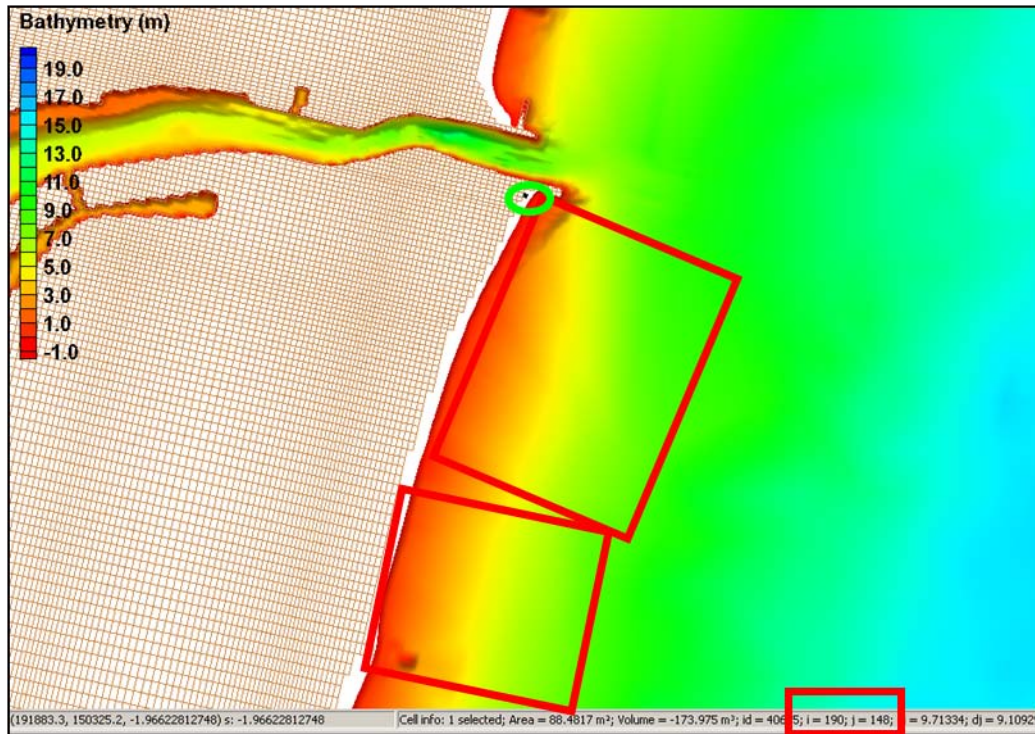
Figure B 6.3-2. Selection I and J IDs for smoothing sections of the grid at a time.

2. The I direction is that of the columns, and the J direction is that of the rows of the grid; record the I and J id of the bounding cells by step 1,

3. Rt-click the *Flow* under *Cartesian Grid Data* and click on *Smooth* (Figure B 6.3-3) and the *Cgrid Smoothing Options* will pop up,
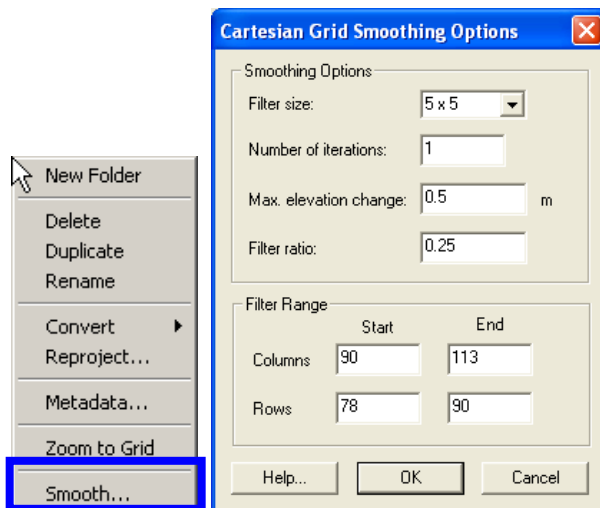

Figure B 6.3-3. Drop menu of Cgrid; Cgrid Smoothing Options.

4. Set the Filter Size to 5x5, iterate twice, and leave Max. elevation changes, and filter ratio to the default, and change the column's and row's *Start* ID and *End* IDs to what the bounding cells were (Figure B 6.3-2), *OK*,

5. Check the area that was smoothed; repeat the process for the other stretch of nearshore bathymetry, preferably smoothing both the North Spit and South Spit nearshore.

B6.4. Auxiliary Datasets

Other spatially variable, modifiable features for CMS-Flow include hardbottom (non-erodible levels), the D50 grain size, and the Manning's *n* (bottom friction). Hardbottom is the level at which CMS is not allowed to erode the bottom further. It is automatically set to -999.0 (this is a negative depth for CMS, or otherwise a positive elevation) over all cells in the grid and that means that the cells are fully erodible. Setting these to the bed depth will prevent that bed from being eroded, but it can still be flooded, is computational, and will allow deposition. This is a useful tool for defining coral reefs, rocky areas, or setting unusually or spuriously eroding cells in the model to hardbottom.

CMS-Flow presently only simulates single variable D50 values, which can be spatially variable, for calculating initiation of transport, transport, and deposition. (Sediment mixtures will be added in a future CMS version.) The grid can interpolate a grain size scatterset if data are available for the area. Such data are not available for Shark River Inlet. However, changing the grain size to a larger value in the deep part of the entrance channel (where the channel thalweg is located) will suppress the erosion potential as it will require greater velocities to initiate sediment entrainment and represents channel armoring (fines winnowed away).

The option to modify the friction is useful for representing areas with restricted flow or with significant interference from structures. A good example of this at Shark River is the densely spaced bridge pilings for the three bridges spanning the main channels. Modifying the friction near the piling locations is one way to represent the impedance on flow around bridge pilings.

- Modify the Hardbottom, D50, and Mannings *n* of the Grid
    1. Modify the hardbottom cells by selecting *Hardbottom* under the Grid list of datasets. Click the *Select Grid Cell* button and clicking on each cell individually around the area of the main entrance channel thalweg,
    2. Figure B 6.4-1 shows what the hardbottom contours should look like after modifying them. Note that groins can also be changed to ocean cells but have modified hardbottom values (so that they cannot erode, but can receive accumulated sand),
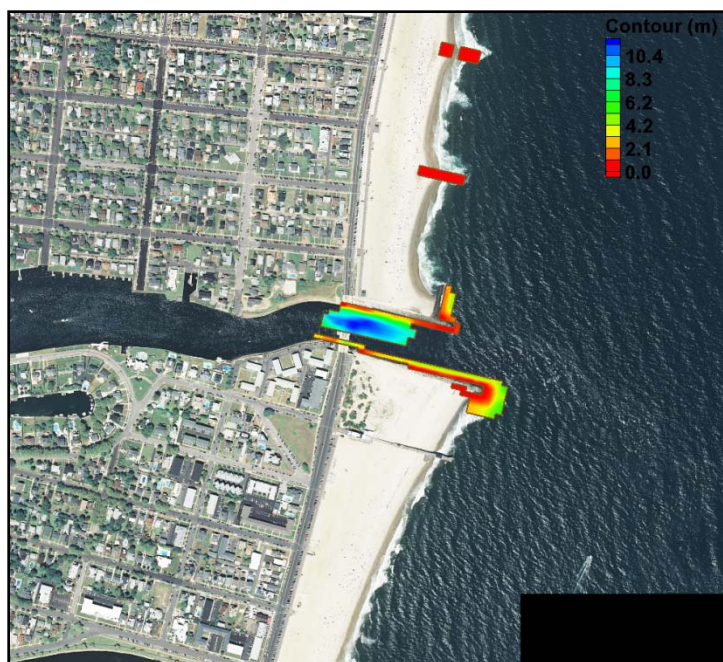
Figure B 6.4-1. Hardbottom contours after modifying the channel entrance channel and local groin cells.

3. Rt-click on the selected cells, and select *Specify Hardbottom*, and then select *Use bathymetric cell depth* (non-erodible cell) (Figure B 6.4-2), *OK*.
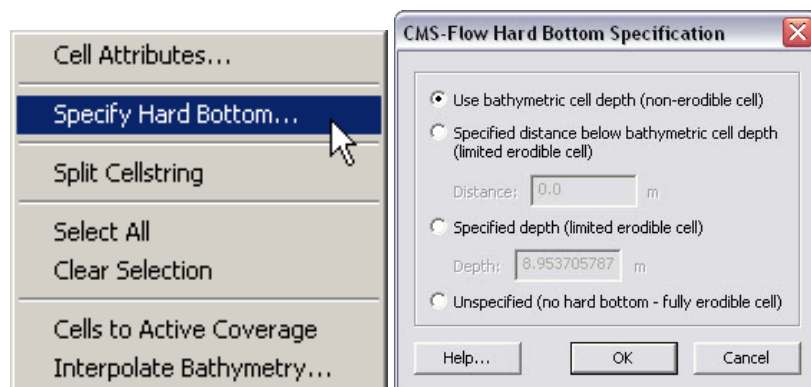

Figure B 6.4-2. Rt-click cell options to specify hardbottom; CMS-Flow Hard Bottom Specification Options.

4. To modify the D50, select *D50* under the Grid list of datasets. Click the *Select Grid Cell* button and click a polygon around the area of the main entrance channel thalweg,

5. Change the *S* value (Figure B 6.4-3) from 0.26 mm (the SMS changes the decimal, but its close enough) to 0.40 and 0.50 mm similar to Figure B 6.4-4,
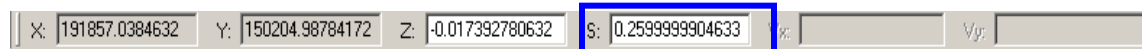

Figure B 6.4-3. Toolbar at top of SMS window giving the X,Y,Z, and S (scalar) value of each cell or an average of the cells selected.
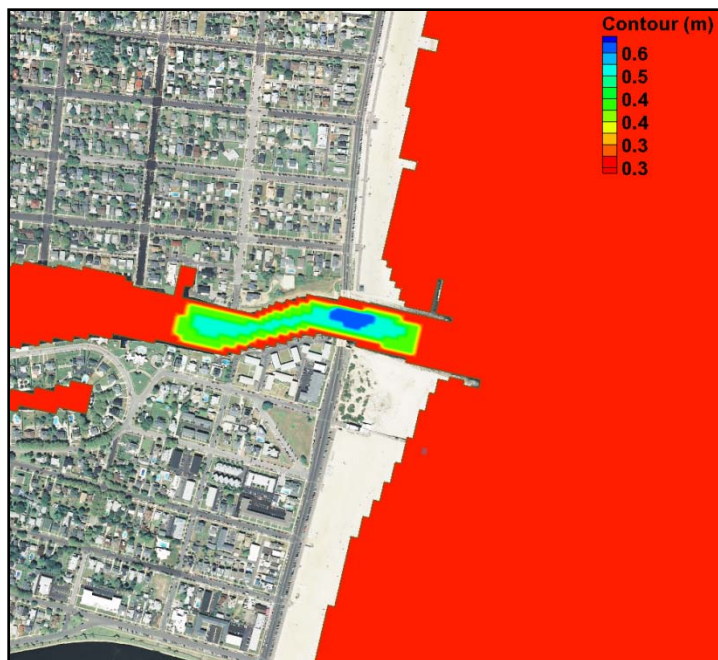
Figure B 6.4-4. D50-contours after modifying the entrance channel.

6. Next, modify the Manning's *n* value from 0.25 to 0.3 underneath the locations of the bridges as shown in Figure B 6.4-5,

7. Save the progress of this grid by either saving the project again, or saving the grid only by clicking *File*, *Save As*, and choose the *Save As Type* as a *CMS-Flow Simulation File* (.cmcards).
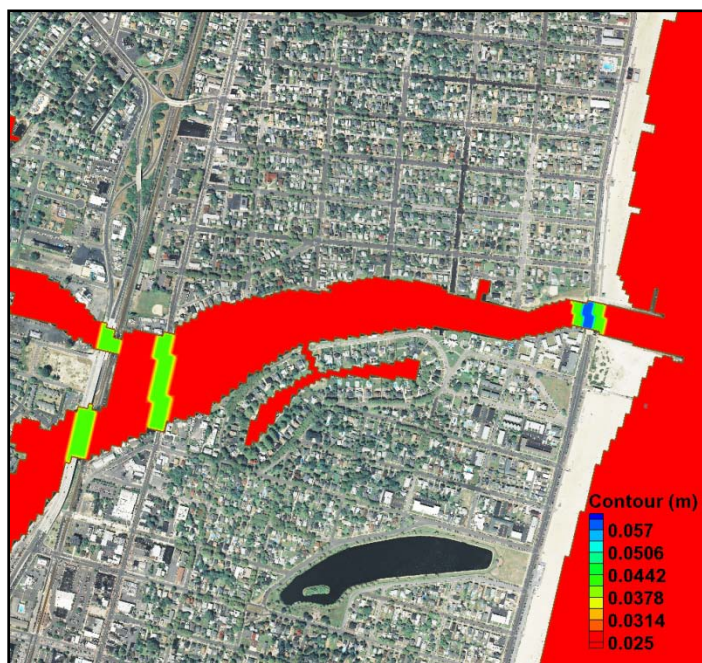

Figure B 6.4-5. Manning *n* contours after modifying the areas under all three bridges.

B6.5. Boundary Conditions

The boundary conditions for CMS-Flow are assigned with cellstrings. When a CMS-Flow grid is generated, cellstrings are automatically generated along all of the boundaries. The user has the option to use any of these cellstrings or to create new cellstrings. In this case, all of the cellstrings may be deleted from the initial grid generation except the ocean cellstring. If all of the cellstrings are deleted, then the user must create the ocean cellstring by clicking at the start of the cellstring and double–clicking at the end of the cellstring. Note that the ocean cellstring should cover the whole offshore domain and therefore start and end at the land-ocean boundary.

For Shark River, there is little appreciable freshwater discharge, and so it is not included in the CMS simulation. The ocean boundary condition is set to the measured water surface elevations from Sandy Hook, verified with a tide gauge located inside the bay on the marine at the end of the South Channel. Data from the month of August 2009 are located in the folder *SessionA/CMS-Flow/Tide*.

- Setting the Tide Boundary Condition
    1. Open one of the generated grids
    2. Select the *Select a Cellstring* button   .
    3. A dialog may come up that is shown in Figure B 6.5-1. This message means that we must tell SMS that we are working in the Grid Projection. Click Ok.
    4. Rt-click the **Flow** label in the data tree and select "Work in grid projection" from the resulting dialog, shown in Figure B 6.5-2.
    5. Again, select the *Select a Cellstring* button.
    6. Rt-click the blue cellstring along the ocean boundary (if this cannot be selected it is because all cellstrings were deleted; this can be regenerated by clicking   and clicking around the ocean cells or selecting *Cellstring* and *Generate Along Boundary*), select *Assign BC* (Figure B 6.5-3),
    7. Select the *WSE-forcing* boundary condition, and click curve undefined (Figure B 6.5-3)
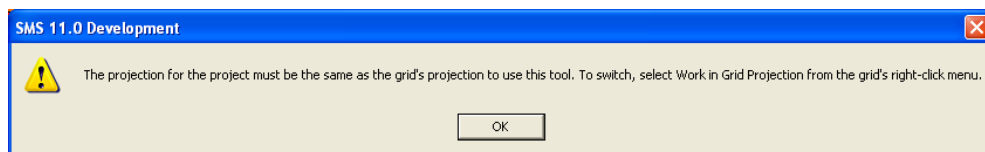

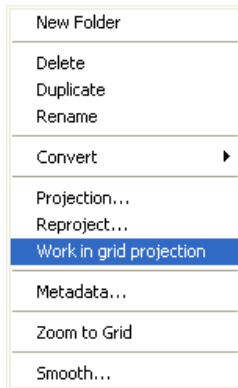**Figure B 6.5-1. Work in Grid Projection Message.**

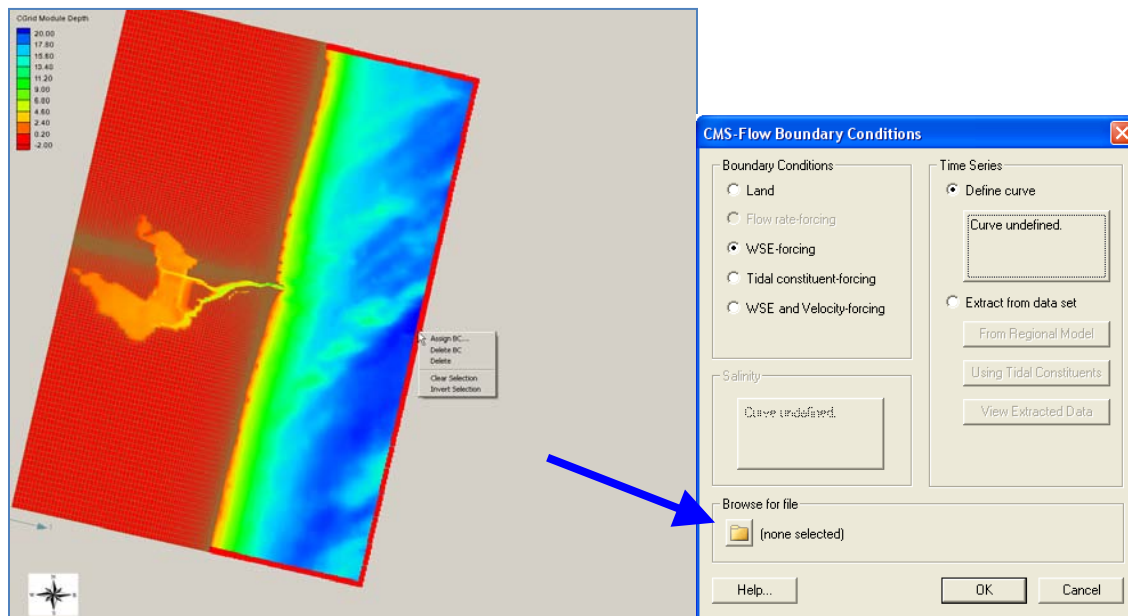**Figure B 6.5-2. Work in Grid Projection Dialog.**

Figure B 6.5-3. Selecting the cellstring along the ocean boundary, and clicking on *Define curve* under the WSE-forcing option.

8. Open the excel file (*SandHook_vs_Belmar.xls*) in the *SessionA/CMS-Flow/Tide* folder, and select the time series in yellow for Sandy Hook with the time in hours on the left, and paste it into the *XY Series Editor* (Figure B 6.5-4),
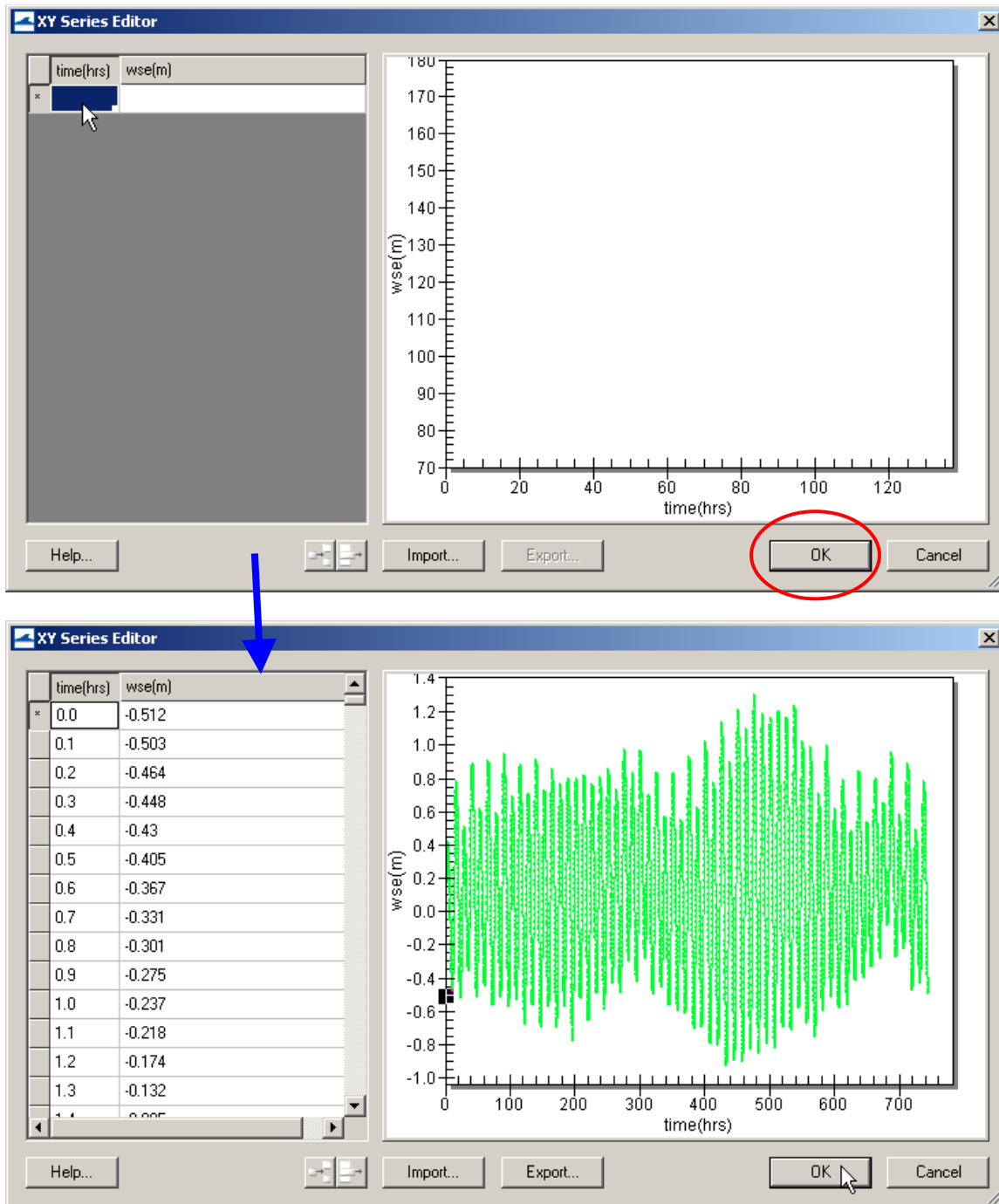
Figure B 6.5-4. Top: is the blank XY Series Editor; Bottom: after the data is pasted in.

9. Zoom in on the graph on the right (Figure B 6.5-4) to view the data up close,

10. Click export to save the xys (time series file) of the tide for use in other of the Shark River grid's cellstrings, and save in the Tide folder, click *OK* when finished inspecting the pasted data, click *OK*.

11. Save the *CMS-Flow Simulation File* (.cmcards) in the original folder this alternative was saved in, and the new cellstring information will be saved with the card file, or SAVE your project.

B6.6. Model Parameters

All of the CMS-Flow model parameters, settings, and output options are controlled from the CMS-Flow Model Control window. The window also has a section for Advanced Cards in which new features which have not been incorporated into the SMS interface yet or more advanced model features more experienced users.

- Setting Model Control for CMS-Flow

    1. Click on *CMS-Flow*, *Model Control*, and set each tab as the following figures (Figure B 6.6-1 through Figure B 6.6-4),

    2. For *Time Control*, change the *Simulation duration* to 744.0 hours, *Ramp* to 24 hours, and *Hydrodynamic time step* to 1.0 (must be tested by running CMS-Flow only),

    3. For *Transport Parameters*, change the *Transport rate* to 1.0 and the *Morphologic time* step to 10 seconds, check *Use non-equilibrium transport* and set the parameters as those in Figure B 6.6-2,
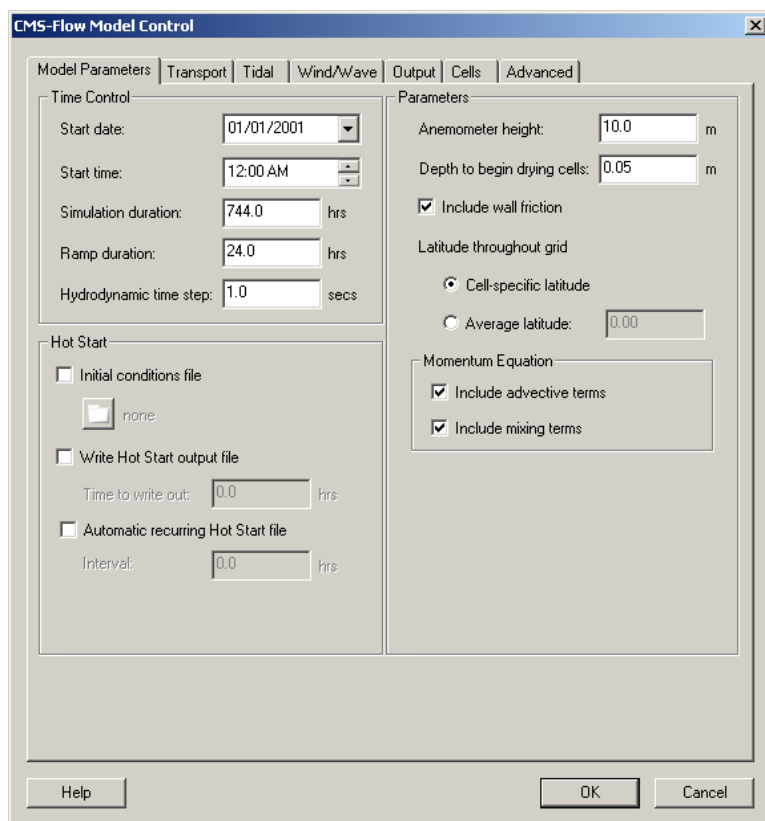

Figure B 6.6-1. CMS-Flow Model Control: Model Parameters tab for specifying time series output of CMS-Flow calculated datasets.
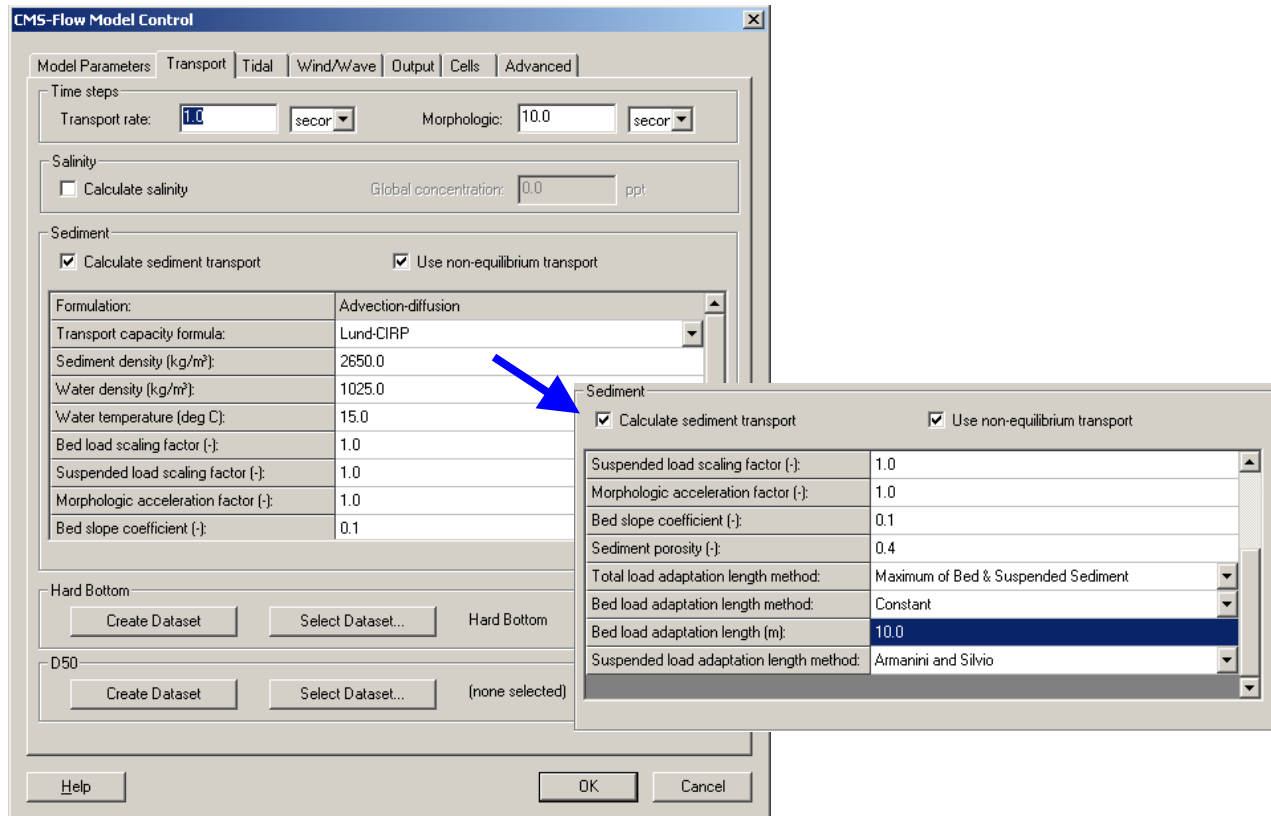
Figure B 6.6-2. CMS-Flow Model Control: Transport tab for specifying time series output of CMS-Flow calculated datasets.

1. Set the time series output for the *water surface elevation* and *velocity* to the same output interval of 30 minutes, similar to Figure B 6.6-3, by highlighting *Output Times 1*, setting the *Start Time* to 0.0 hr, *Increment* to 0.5 hr, and *End Time* to 744.0 hr, and clicking *Add*,
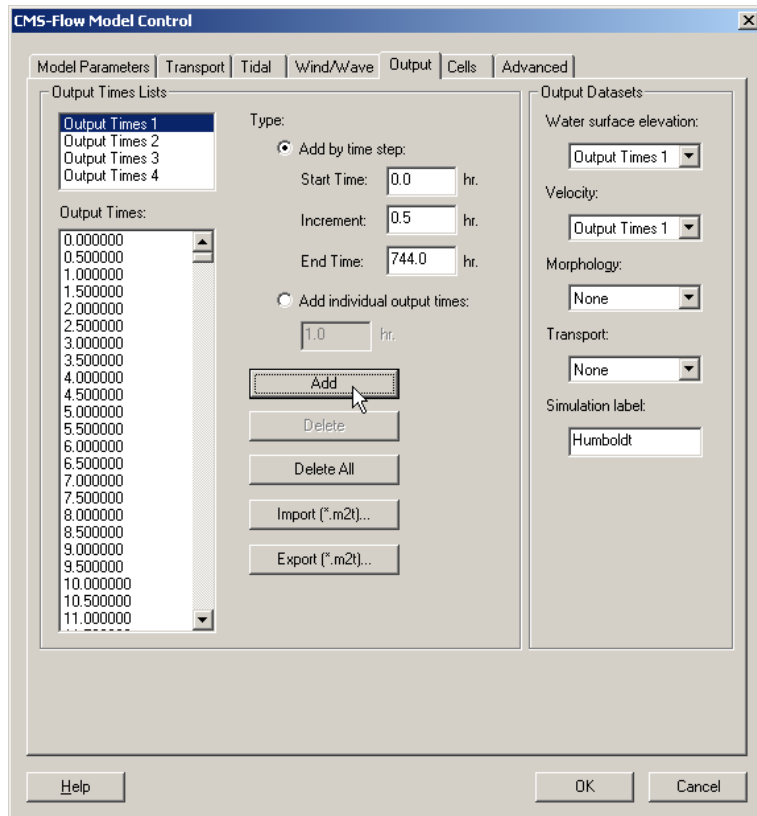
Figure B 6.6-3. CMS-Flow Model Control: Output tab for specifying time series output of CMS-Flow calculated datasets.

2. Set *Output Times 2* for *Morphology* output at a 3-hr interval, by changing the *Increment* to 3.0 and adding, and selecting that on the drop down menu for Morphology,

3. The same can be done for *Transport*, which should normally be set to an *Increment* on the order of the tide or wave time series (<3 hr; typically 0.5-1.5hr), and it is suggested that it be set to 1-hr output increment for *Output Times 3* (Figure B 6.6-4), *OK*.
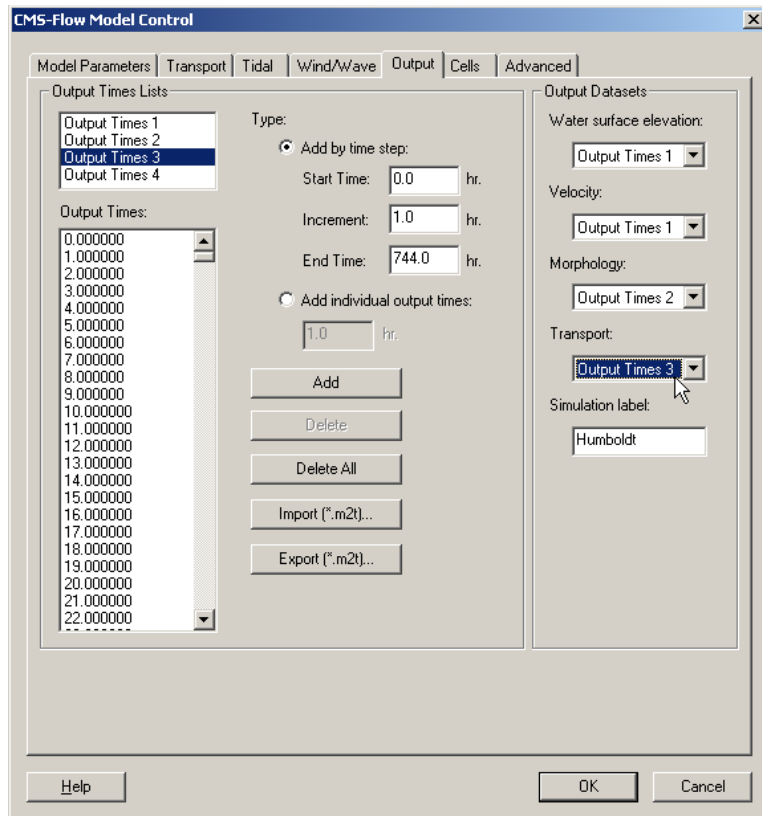
Figure B 6.6-4. CMS-Flow Model Control: Output tab for specifying time series output of CMS-Flow calculated datasets.