

# **SNL Water Power Program**

## **Building an SNL-EFDC Model**

**Jesse Roberts<sup>1</sup>, Scott James<sup>2</sup>, and Craig Jones<sup>3</sup>**

**<sup>1</sup>Sandia National Laboratories**

**<sup>2</sup>E<sup>x</sup>ponent Inc.**

**<sup>3</sup>Sea Engineering Inc.**



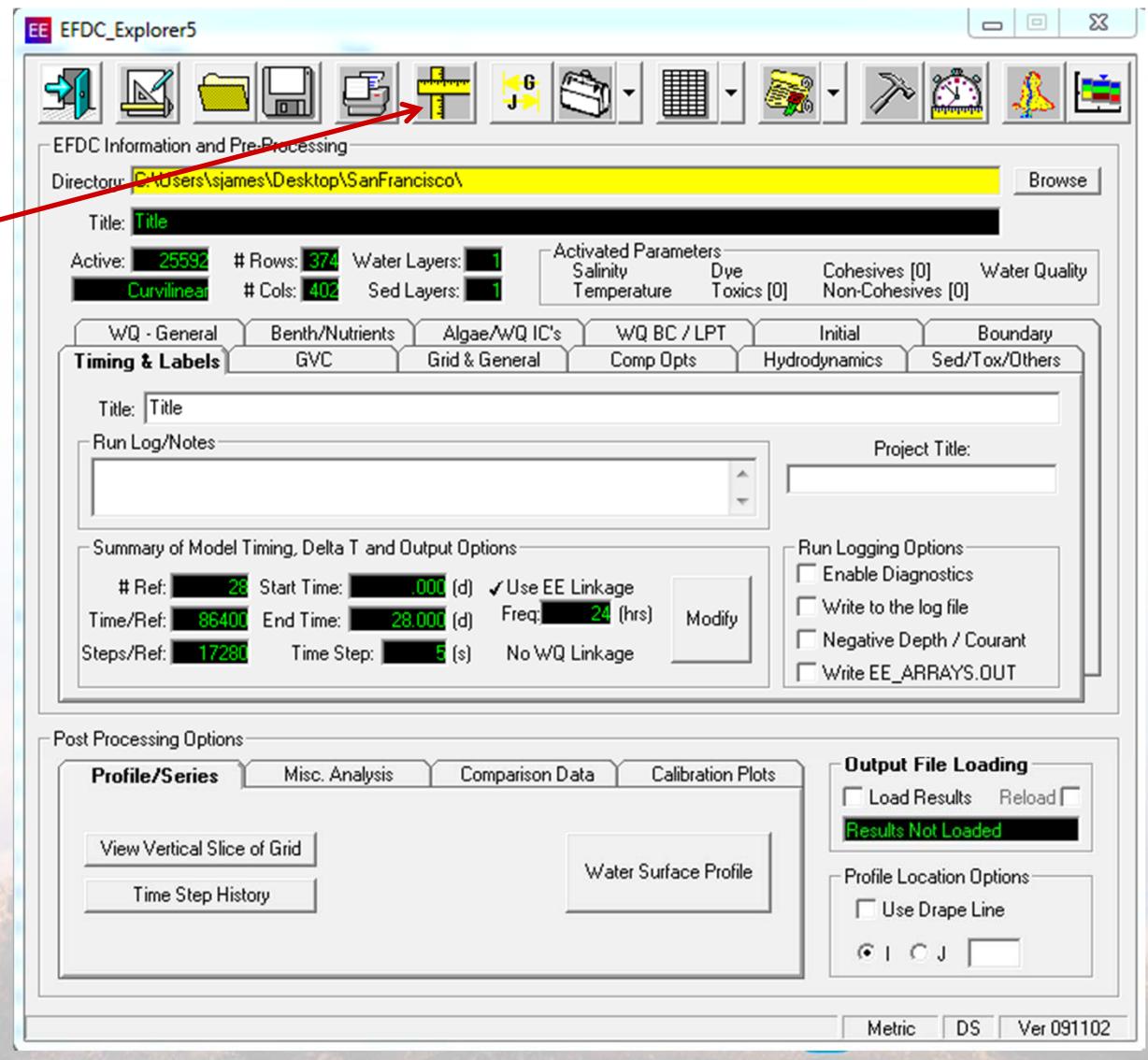
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,  
for the United States Department of Energy's National Nuclear Security Administration  
under contract DE-AC04-94AL85000.



**Sandia National Laboratories**

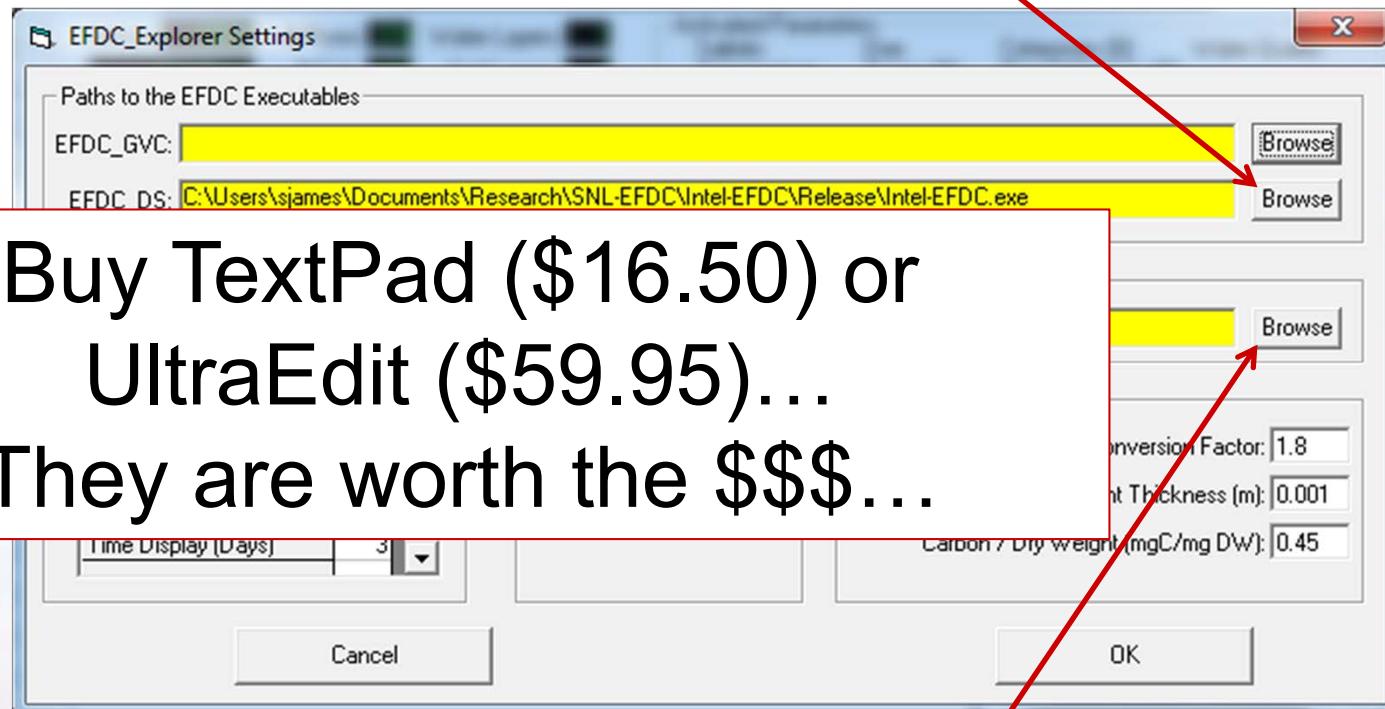
# Set Things Up

Click "Settings"



# Select the Executable

Select the proper executable (e.g., Intel-EFDC.exe)



Buy TextPad (\$16.50) or  
UltraEdit (\$59.95)...  
They are worth the \$\$\$...

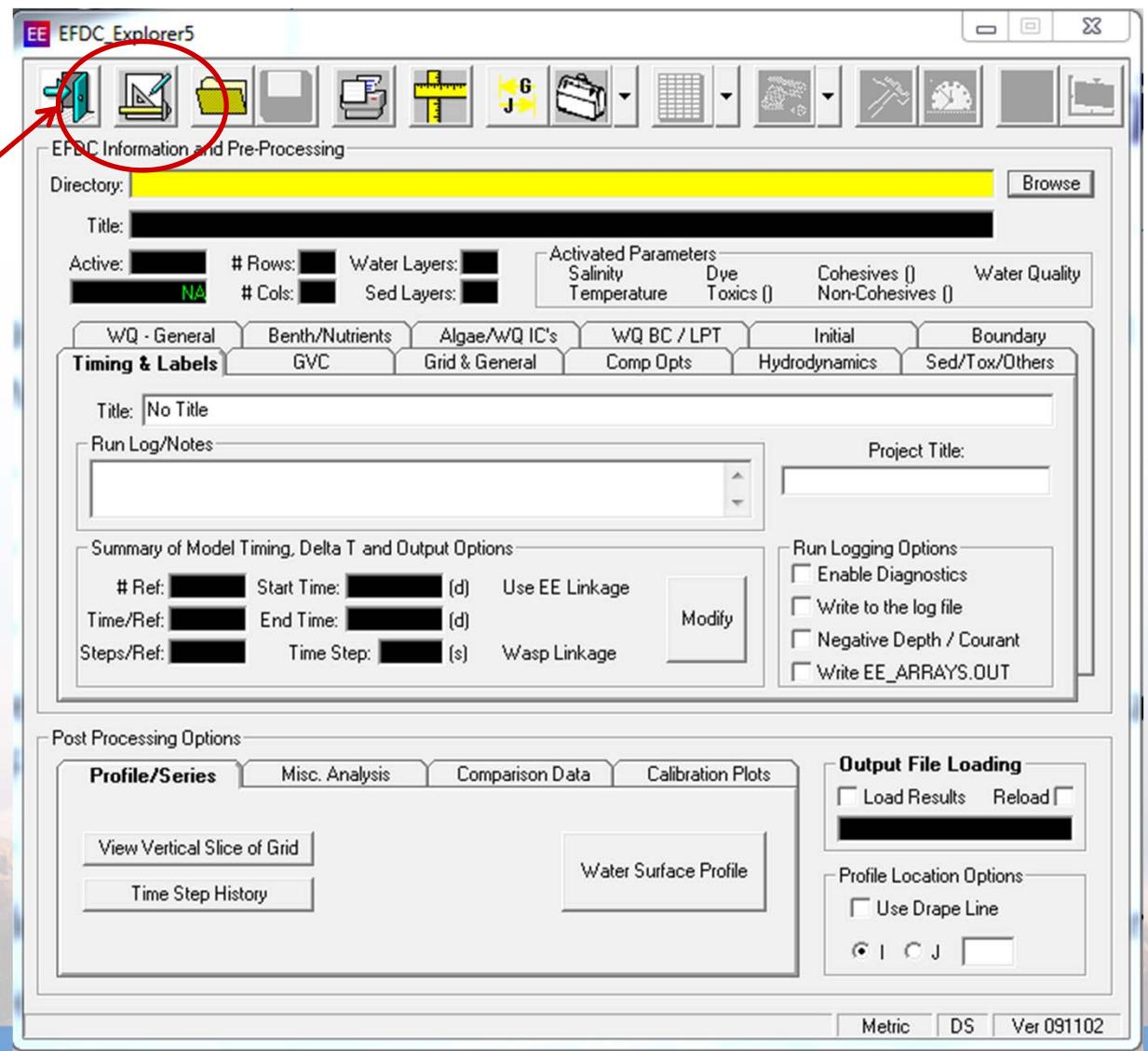
Select a “Text Editor” – like Notepad.exe



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# *Building a Grid (Using EE)*

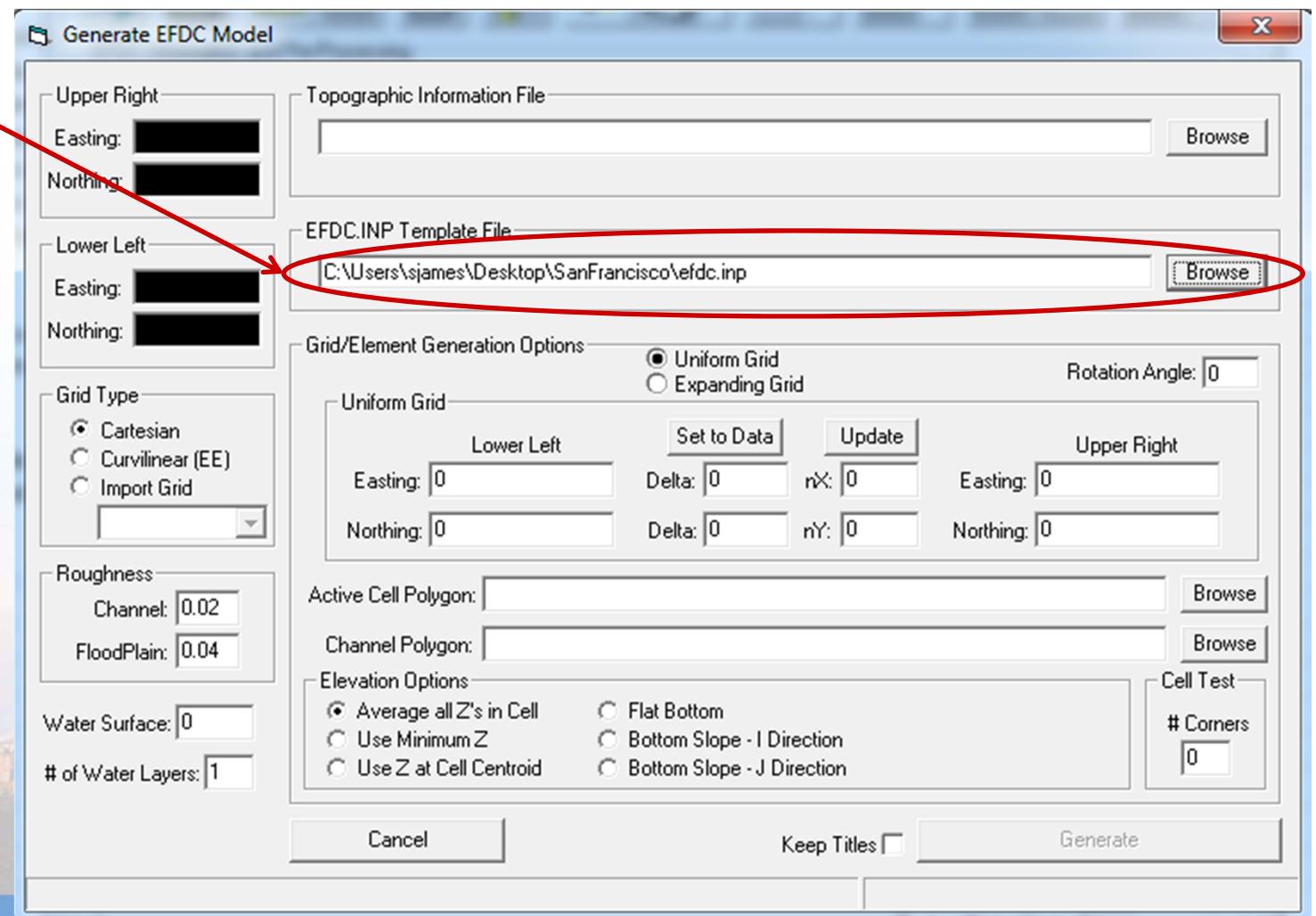
Click  
“Generate a New Model”



# *Building a Grid (Using EE)*

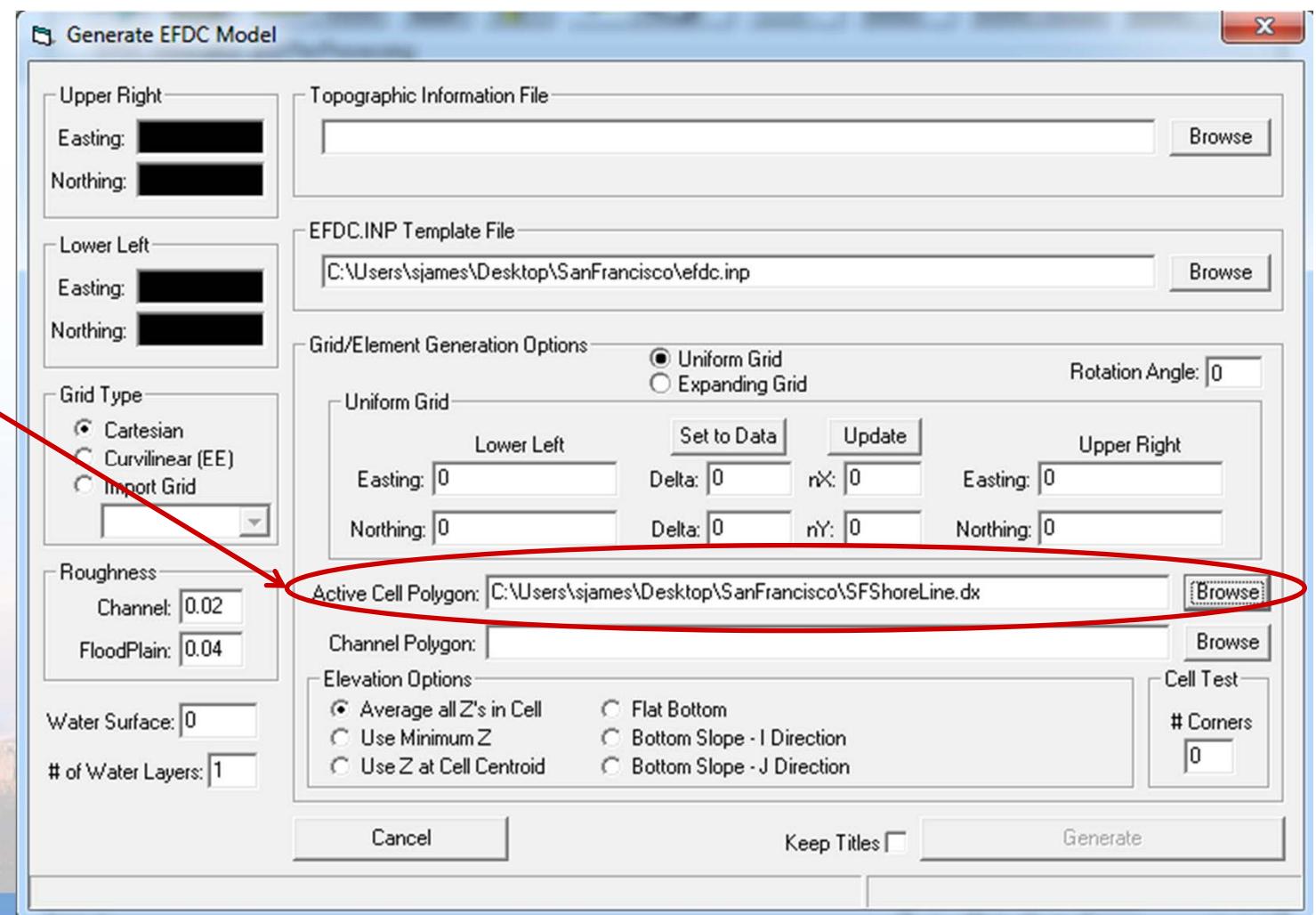
Select an appropriate efdc.inp template file

Look for the “SanFrancisco” folder in the “Models” directory

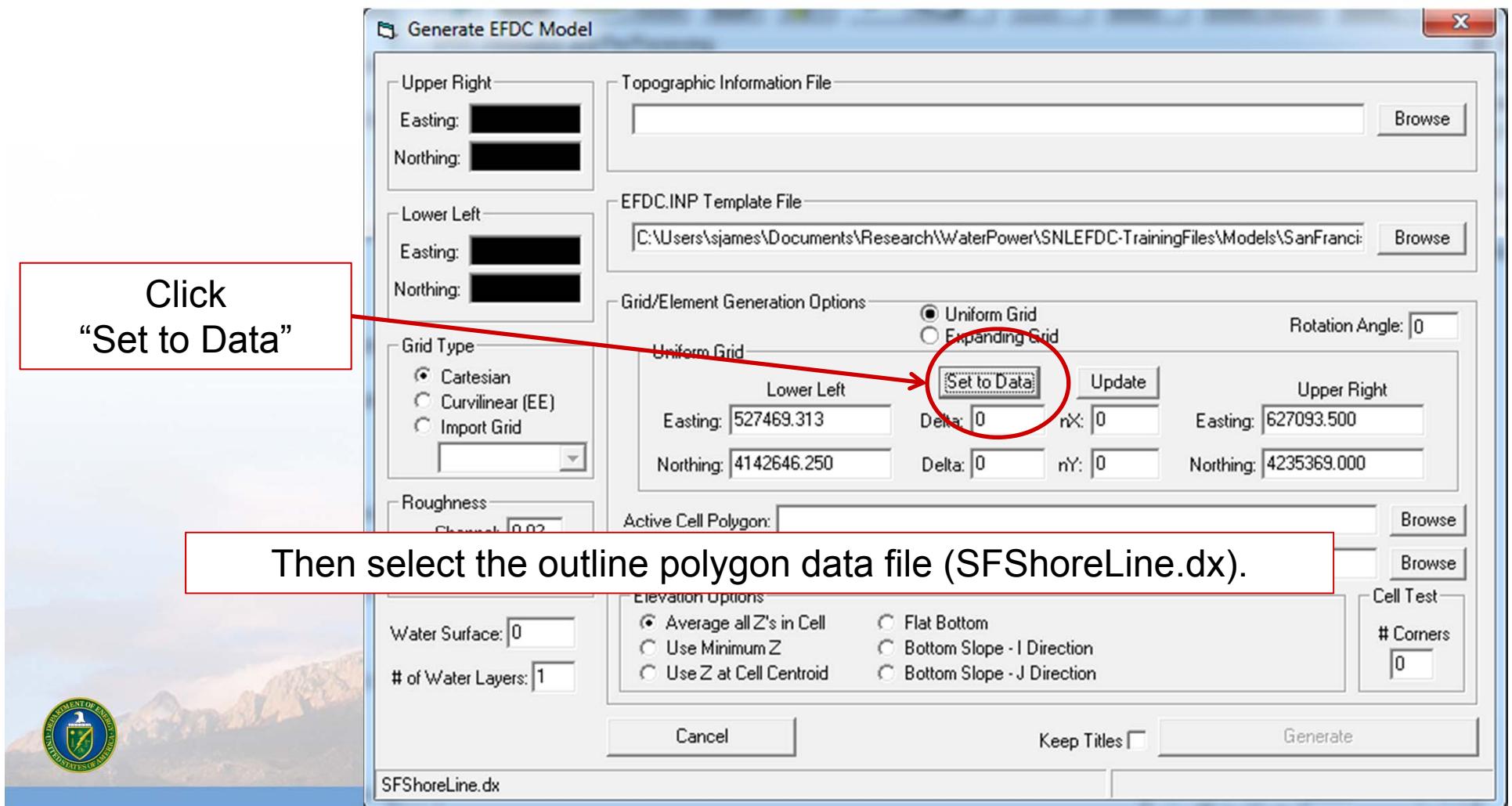


# *Building a Grid (Using EE)*

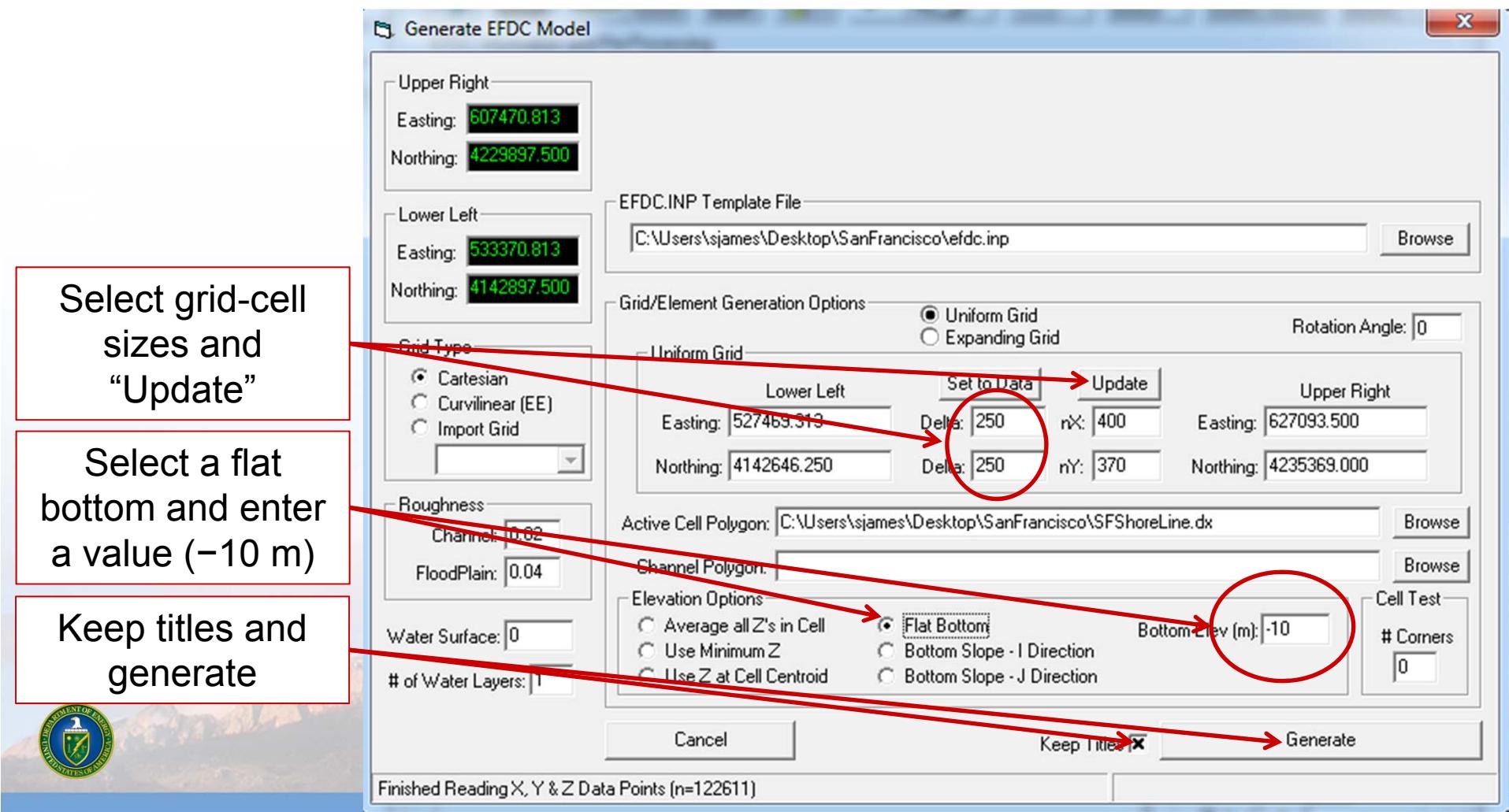
Select the  
shoreline data  
file



# *Building a Grid (Using EE)*



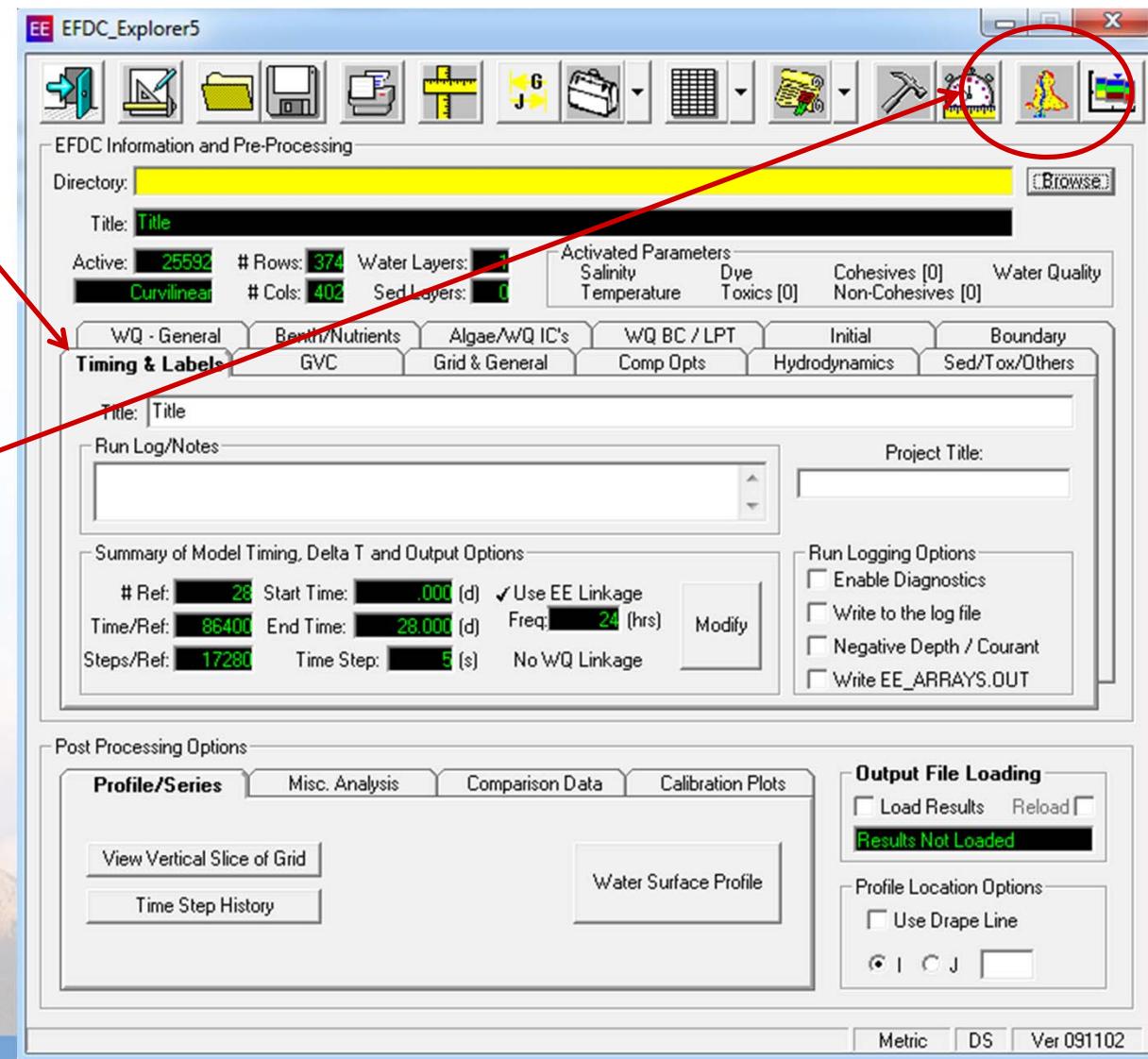
# *Building a Grid (Using EE)*



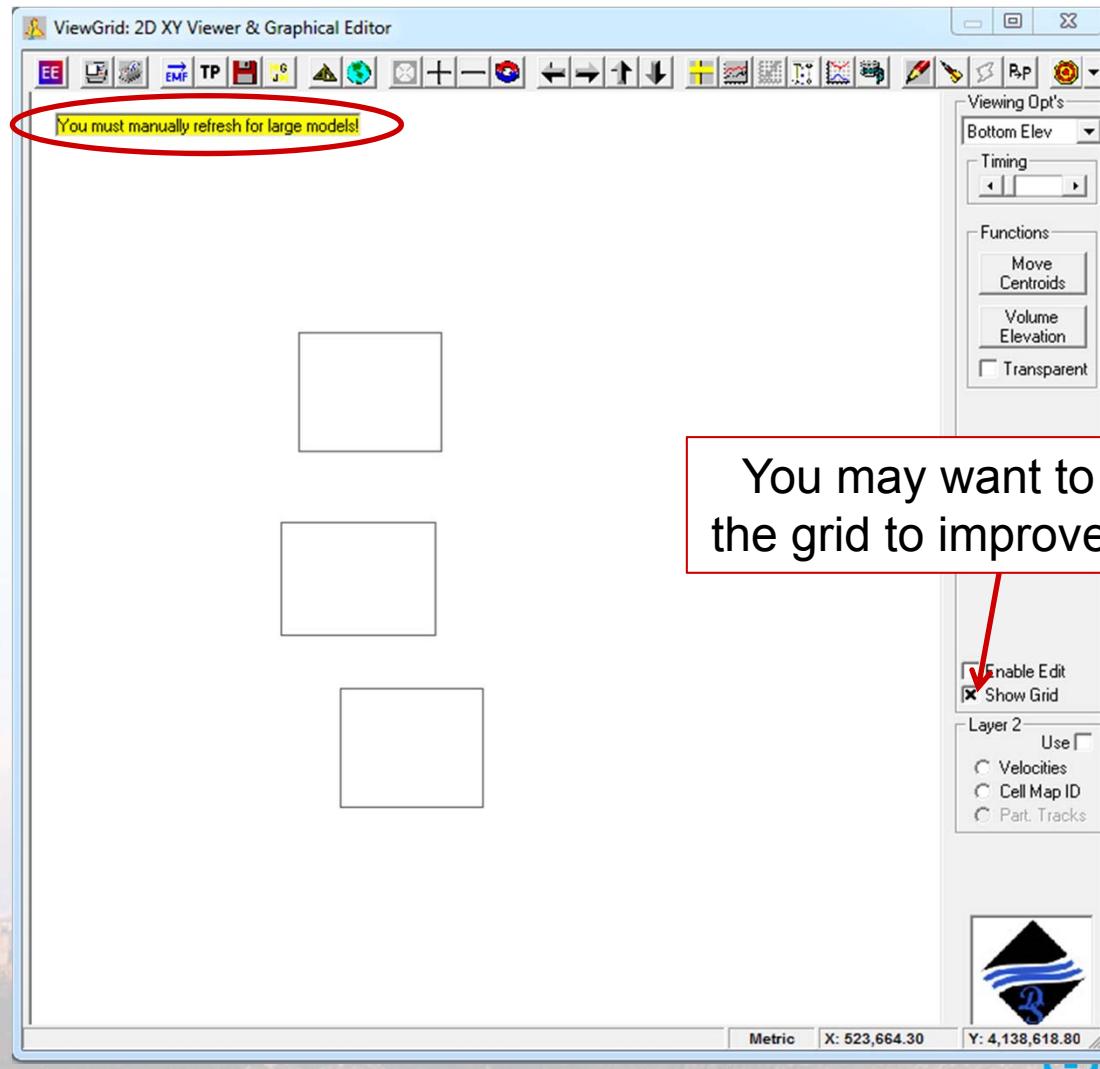
# Viewing the Grid (Using EE)

Note the 12 available tabs

Click  
“View Grid”



# Viewing the Grid (Using EE)



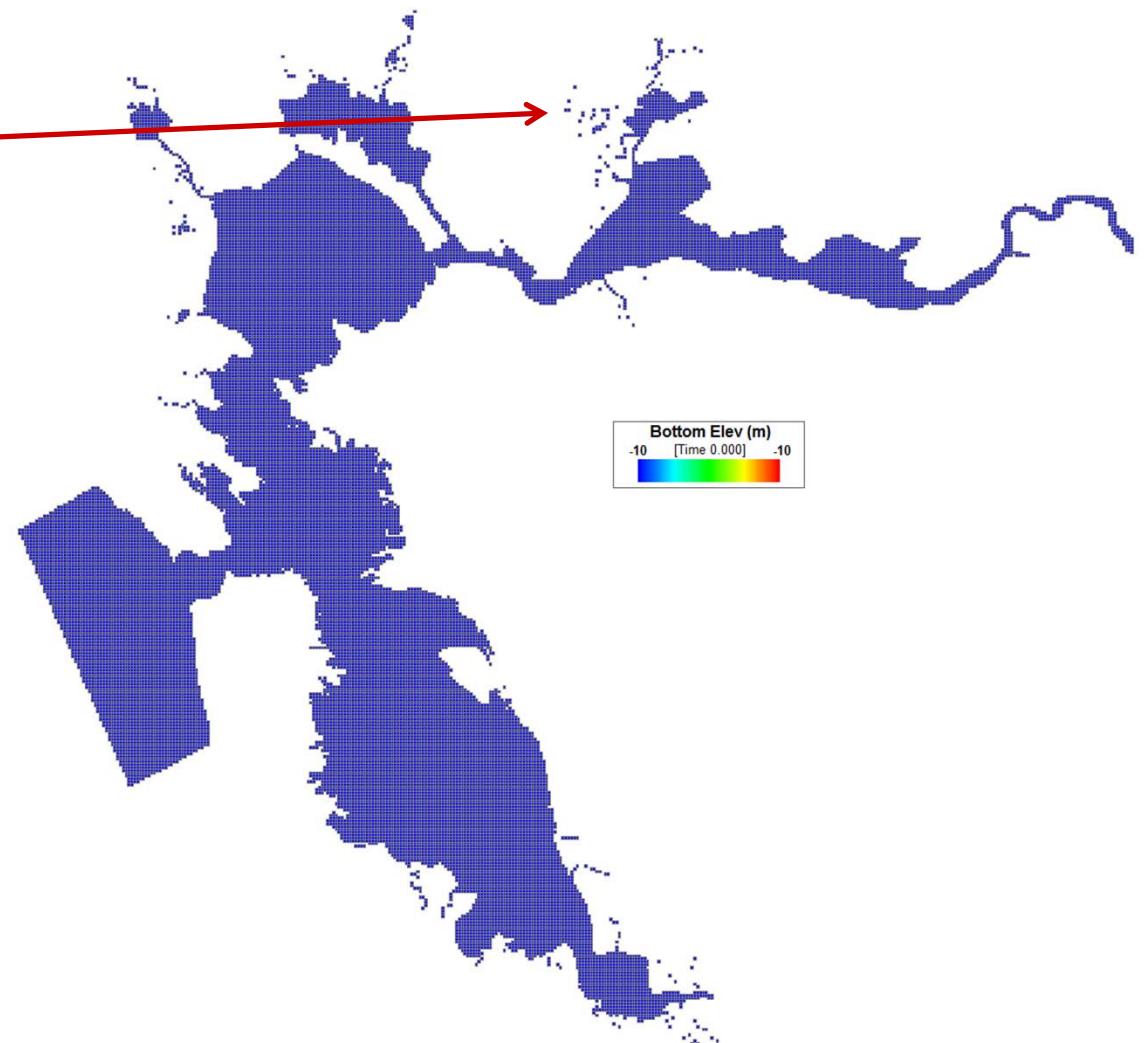
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# *Viewing the Grid (Using EE)*

You can see some disconnected cells. These can be manually deleted by checking the “Enable Edit” button, right clicking each cell, and then clicking “Deactivate.”

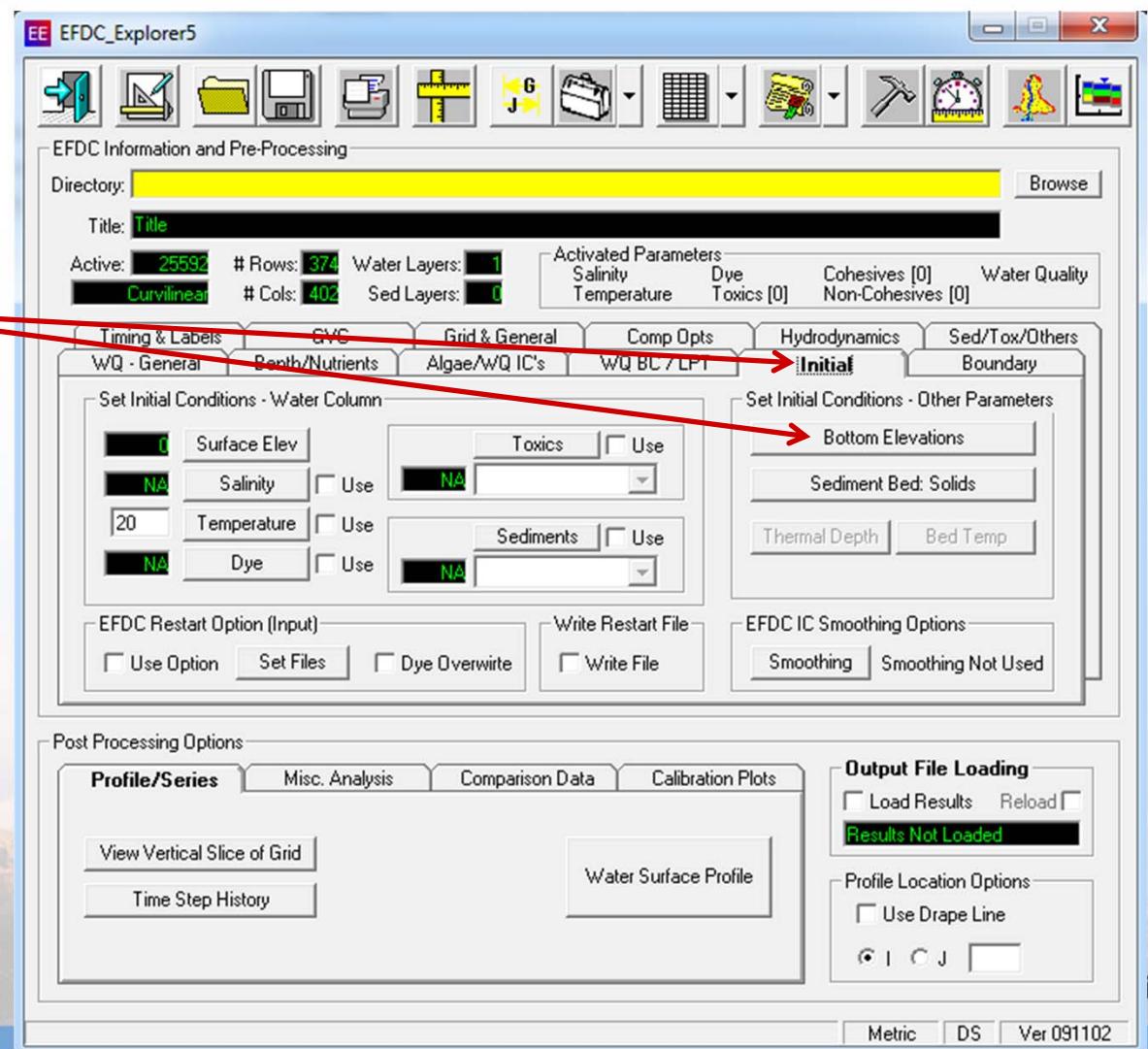
We will not worry about this for now.

Instead, we will assign bathymetry data now.



# Adding Bathymetry (Using EE)

Switch to the  
“Initial” tab and  
then click on  
“Bottom  
Elevations”



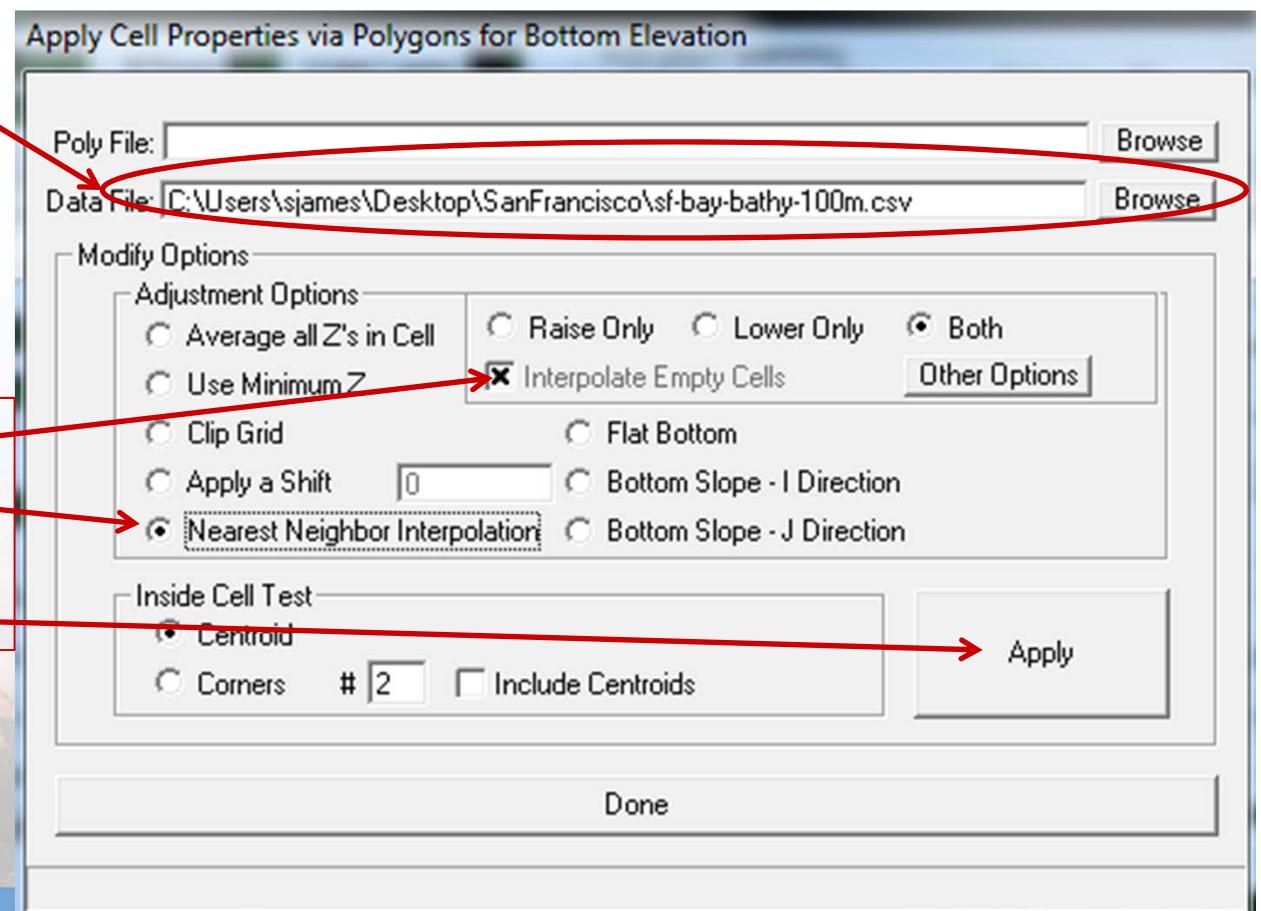
ies

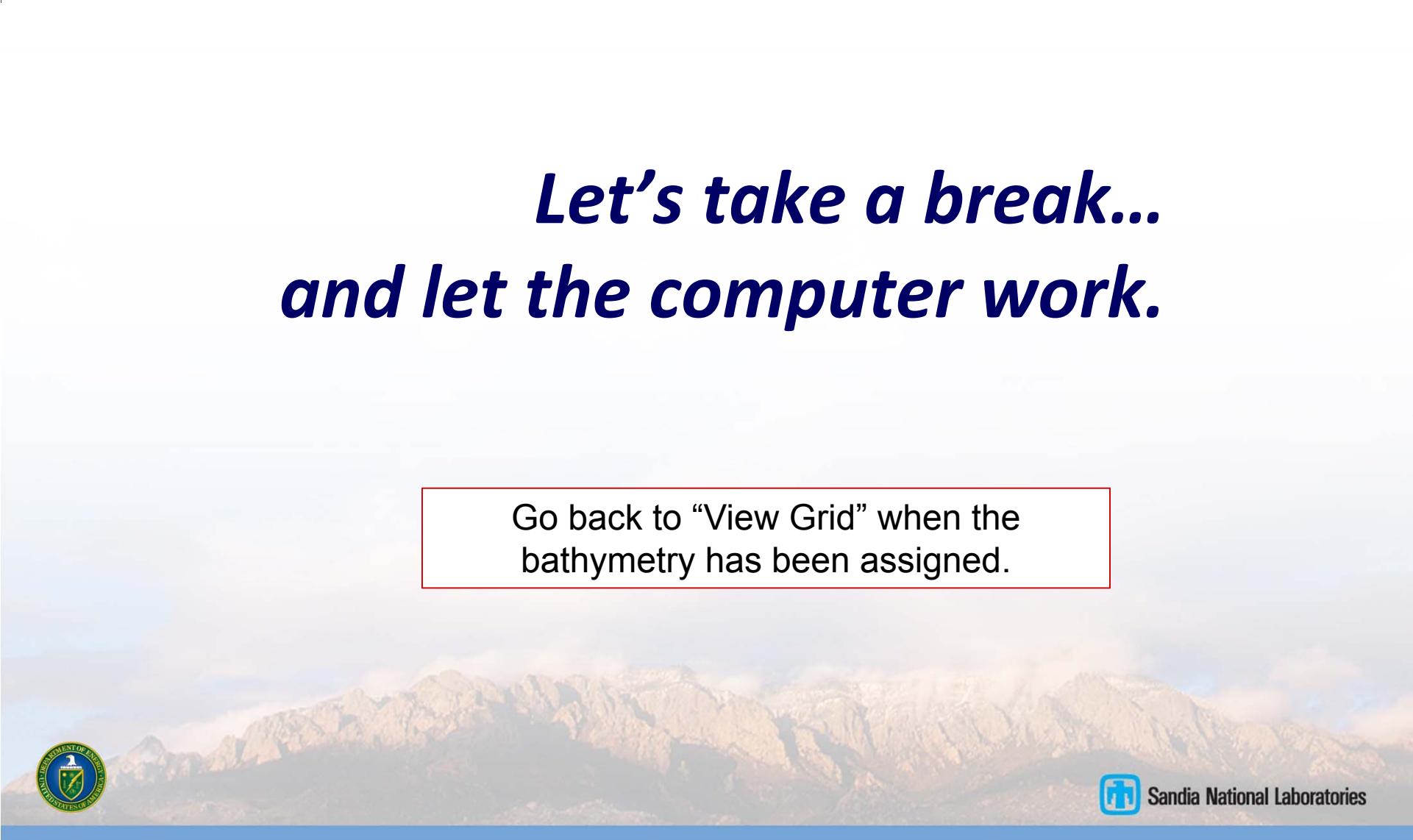
Metric DS Ver 091102

# *Adding Bathymetry (Using EE)*

Select the 100-m  
bathymetry data  
file

1. Interpolate Empty Cells
2. Nearest Neighbor  
Interpolation
3. Apply





*Let's take a break...  
and let the computer work.*

Go back to “View Grid” when the bathymetry has been assigned.



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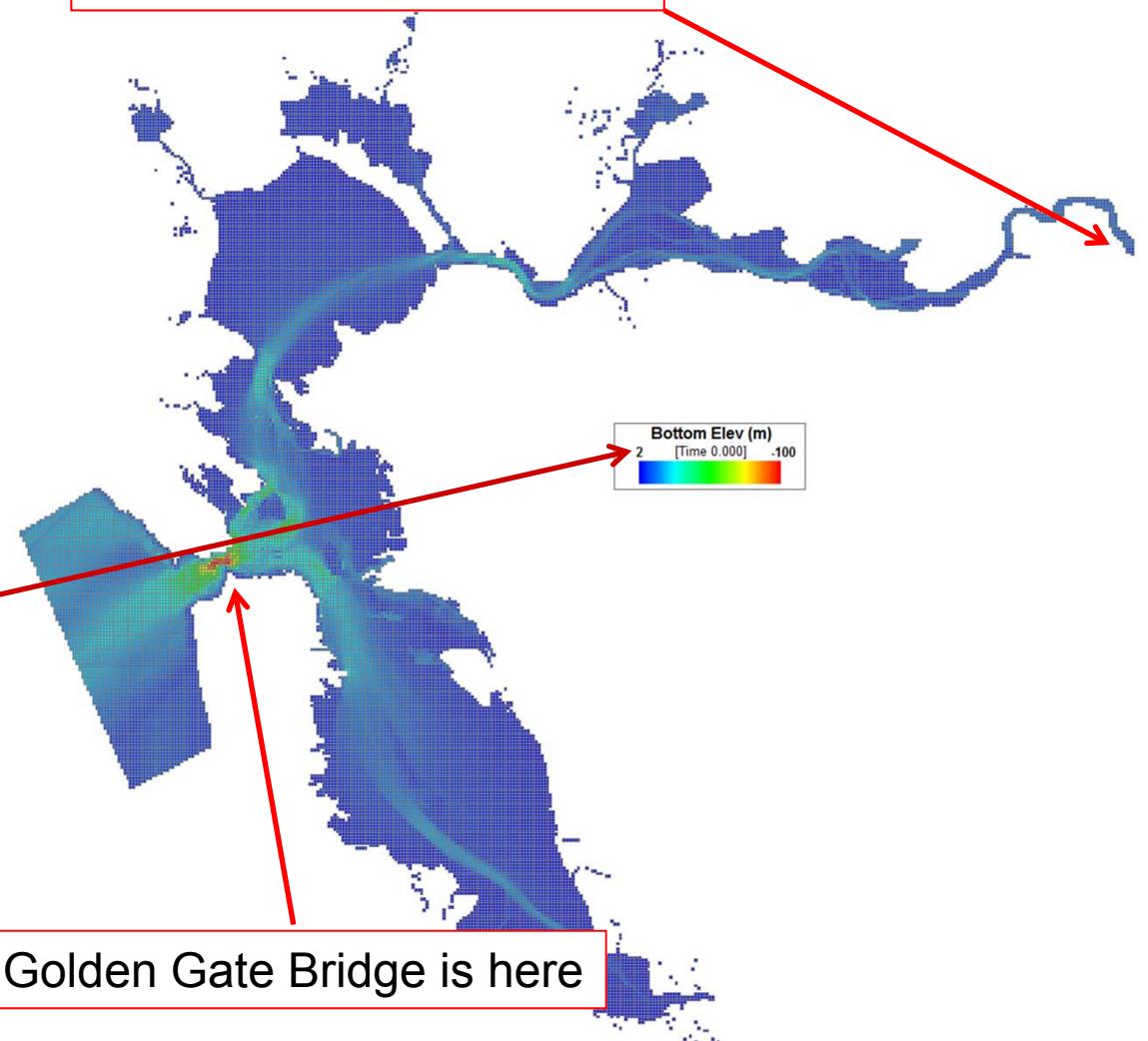
# *What Did We Get?*

You will need to click the  
“Refresh View” button.

Select “Bottom Elev” from  
the “Viewing Opt’s” in the  
upper right corner.

I right-clicked on the  
legend and adjusted the  
“Color Ramp” in the lower  
right corner.

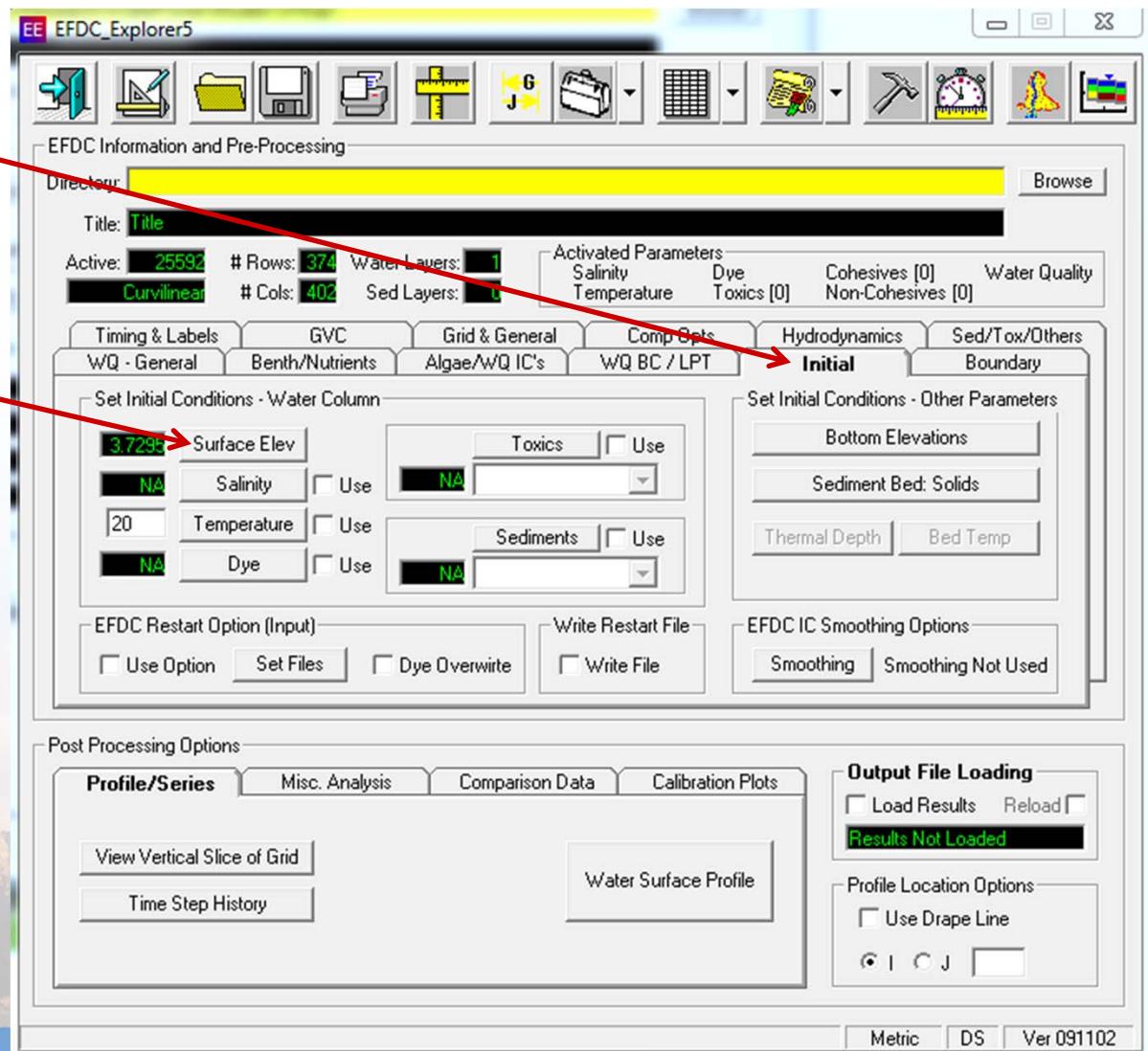
San Joaquin River is here



# Assigning Initial Conditions

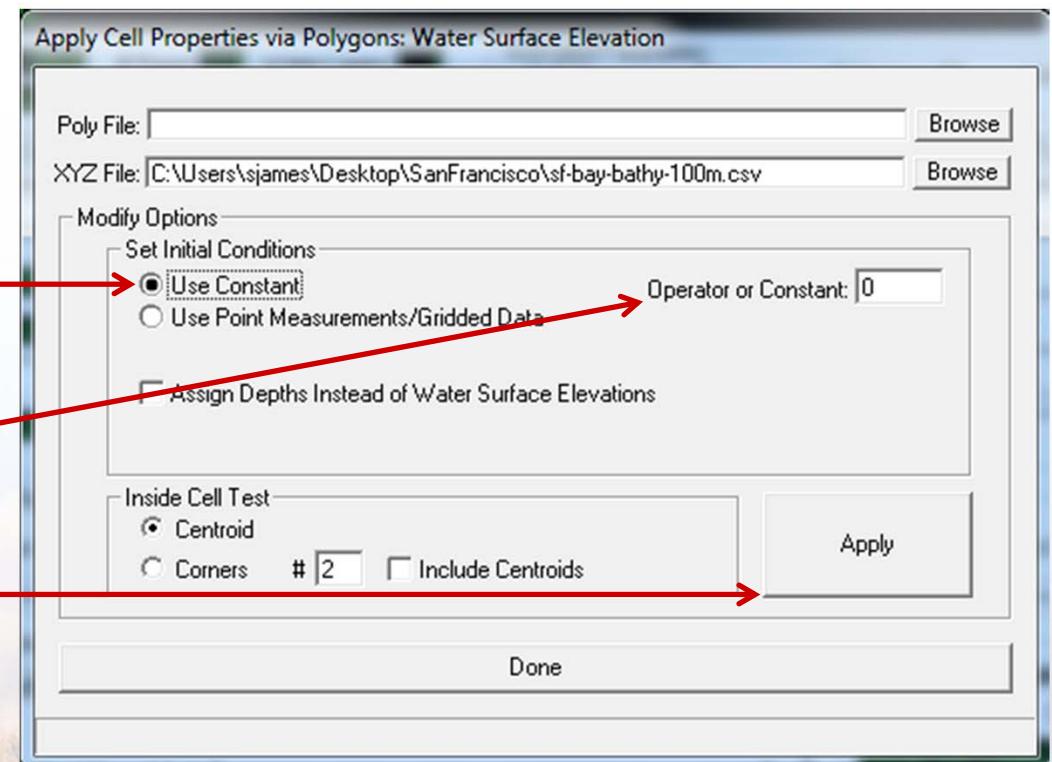
Click the “Initial” tab

Click “Surface Elev”



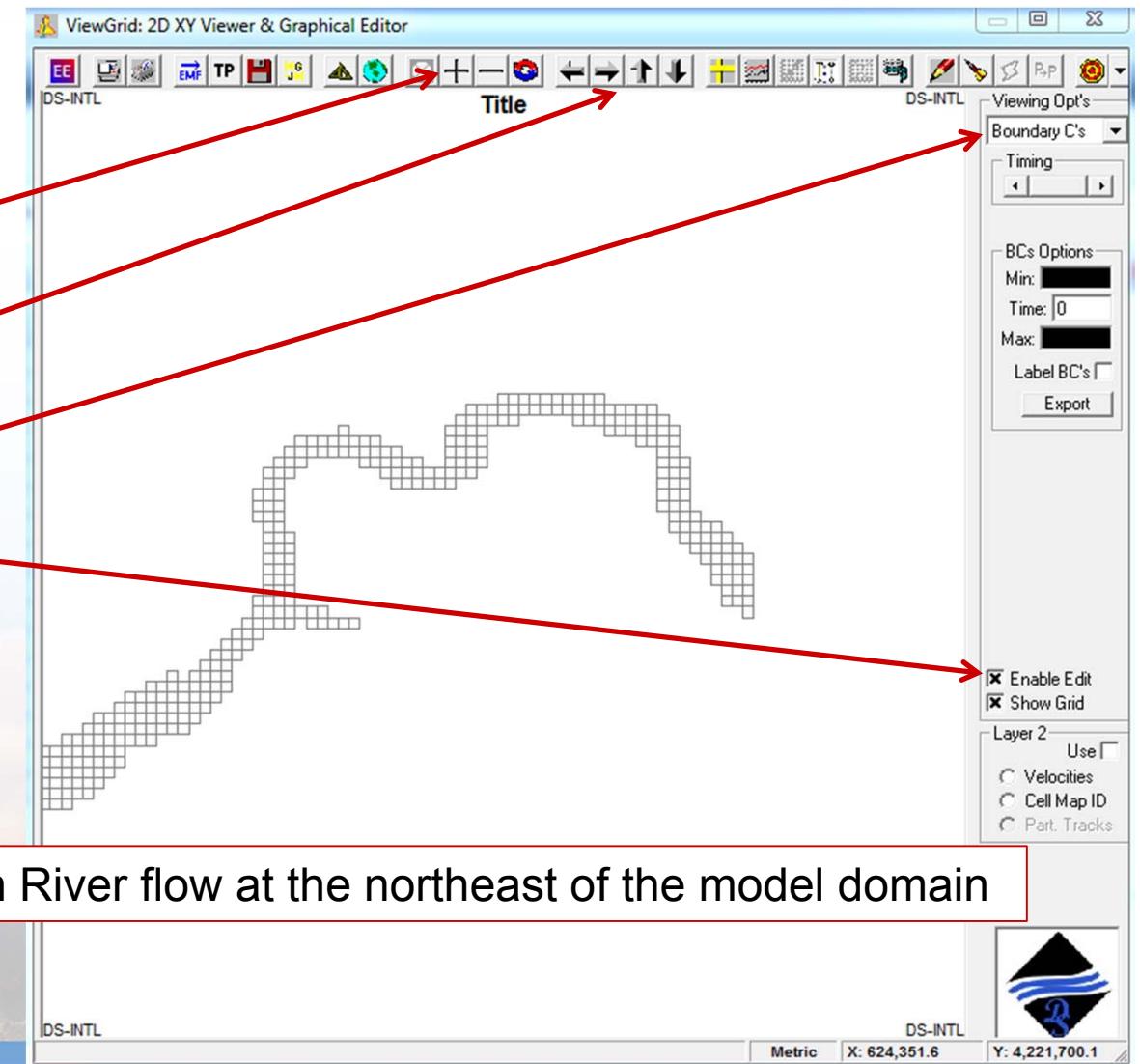
# Assigning Initial Conditions

Select “Use Constant.”  
Then enter the  
“Operator or Constant”  
(0 is fine).  
“Apply” this value.



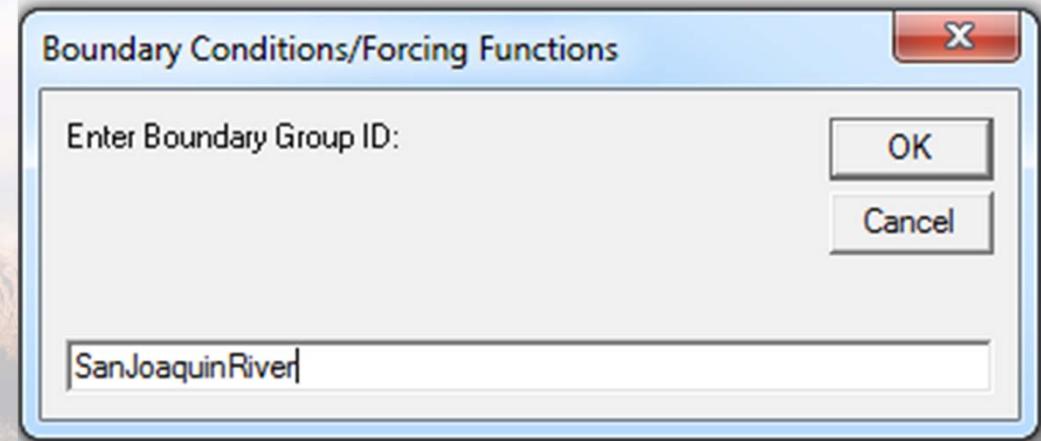
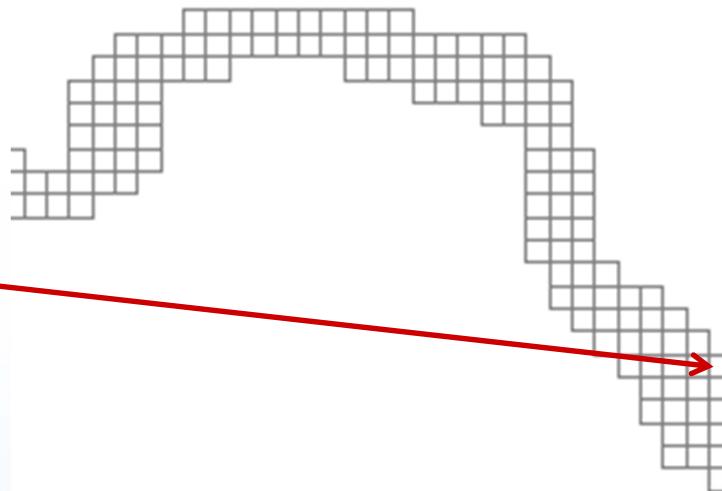
# Assigning Boundary Conditions

1. “Zoom in”
2. “Pan” appropriately
3. Select “Boundary C’s” from “Viewing Opt’s”
4. “Enable Edit”



# *Assigning Boundary Conditions*

1. Right-click this cell
2. Click “New”
3. Enter an appropriate name



# Assigning Boundary Conditions

1. Enter 1 for “Flow”
2. Then, just click “OK”  
(we will assign flows later)

Modify/Edit BC Properties

Boundary Condition Group Information

# BC Groups: 1      # of Time Series: 0      Current Group Type: Flow/Volume  
Cur Group: 1      Cur Group ID: SanJoaquinRiver

Boundary Condition Group

Cell by Cell     Polygon

Cell by Cell

# Cells in Current Group: 1      Add      Remove  
I: 400      J: 290      Remove All  
L: 21539      Bot Elev: 8.90156      Initial Depth: 10

Flow Definition (Cell by Cell)

Flow Table: None      Edit      All  
Factor: 0      Dist Factors      All  
Constant Flow: 0      Distr Q

Flow Parameters for Entire Boundary Group

Apply Flow Files

Flow Multiplier Switch

Type: Normal Inflow/Outflow (L\*L\*L/T)

Constant Concentrations

Constituent	Conc
Salinity (ppt)	0
Temperature (°C)	0
Dye (mg/l)	0
	0

Bottom      Surface

Concentration Tables (Time Variable)

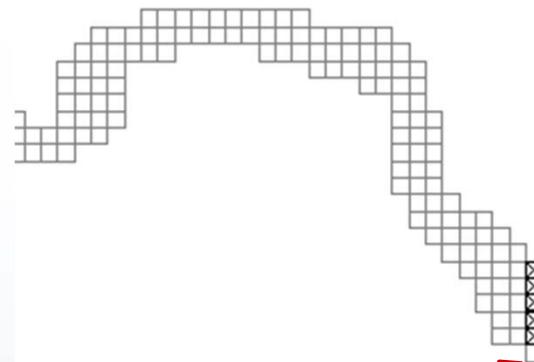
Salinity	E	Toxics	E
0	E	0	E
Temperature	E	Cohesives	E
0	E	0	E
Dye	E	Non-Cohesives	E
0	E	0	E
Shell Fish	E	Water Quality	E
0	E	0	E

Cancel      OK



# *Assigning Boundary Conditions*

Right-click consecutive adjoining cells and “Add to Adjacent”



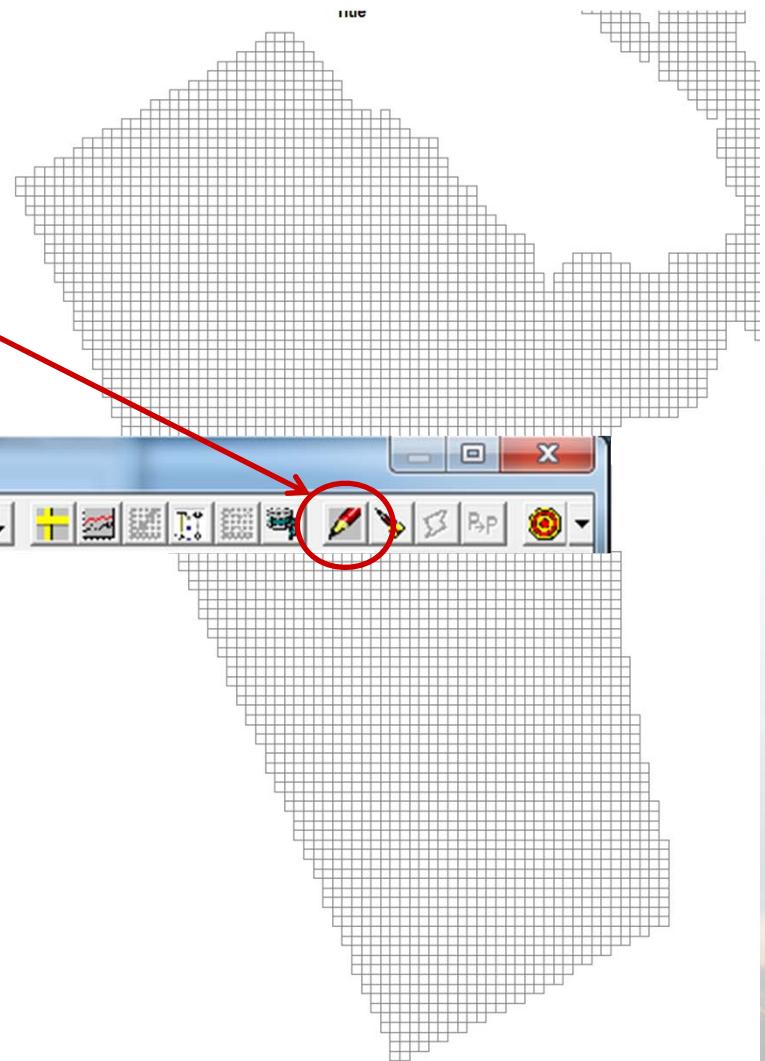
Why do we not assign this cell?



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# Assigning Boundary Conditions

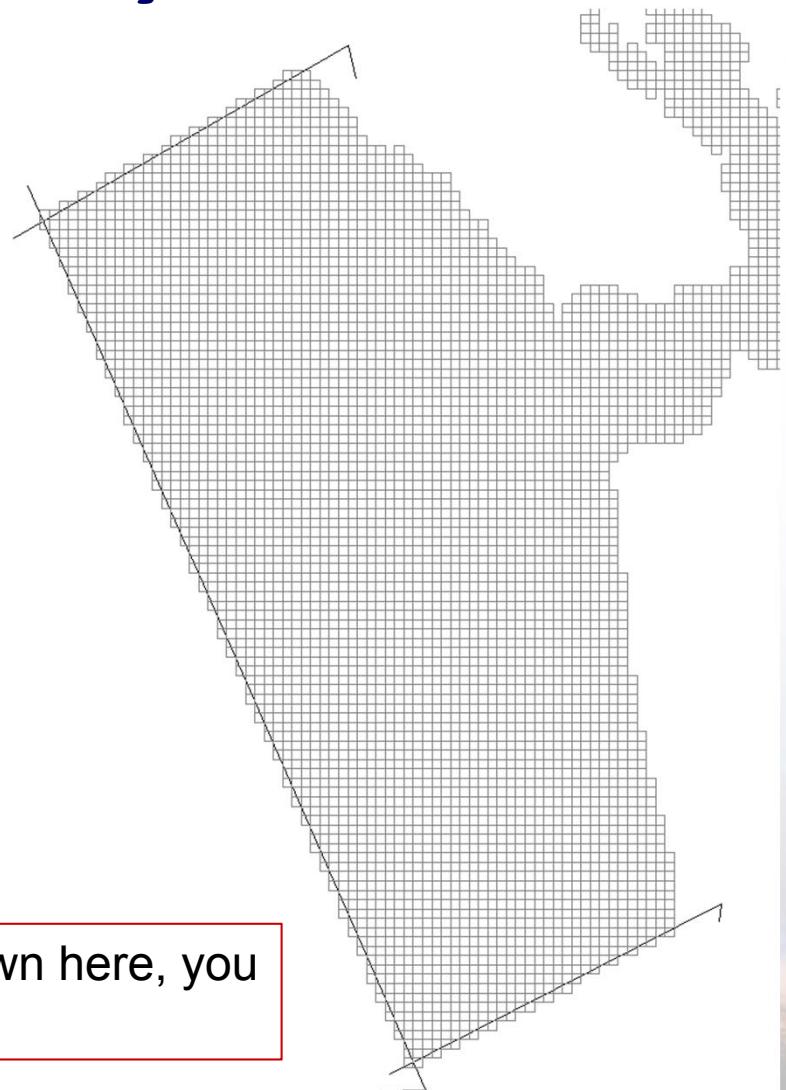
We will assign the numerous open-ocean boundary cells using the “Active Polyline Tools.” Click it (after zooming in on the open-ocean region).



# Assigning Boundary Conditions

1. First click “Cancel” as we will be creating three polylines (and not opening one).
2. Carefully follow the directions in the yellow box to create a polyline that intersect one of the three boundary edges (north, west, or south).
3. Enter “StringID” (name).
4. Unclick “Active Polyline Tools”
5. Enter a file name to save the file.
6. Do this three times (once for each boundary).
7. Exit the Grid Viewer.

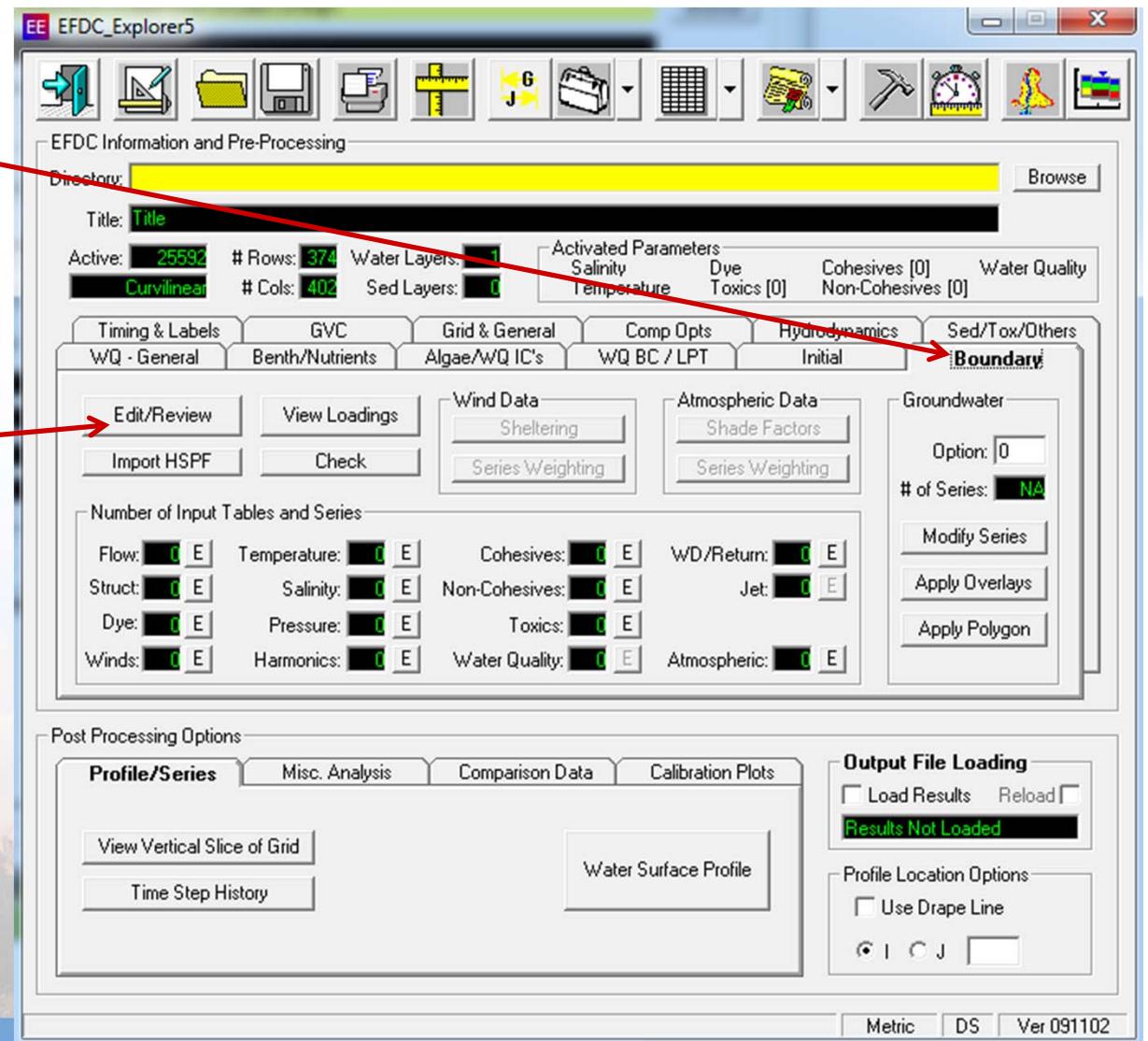
All three of my polylines are shown here, you will do one at a time.



# Assigning Boundary Conditions

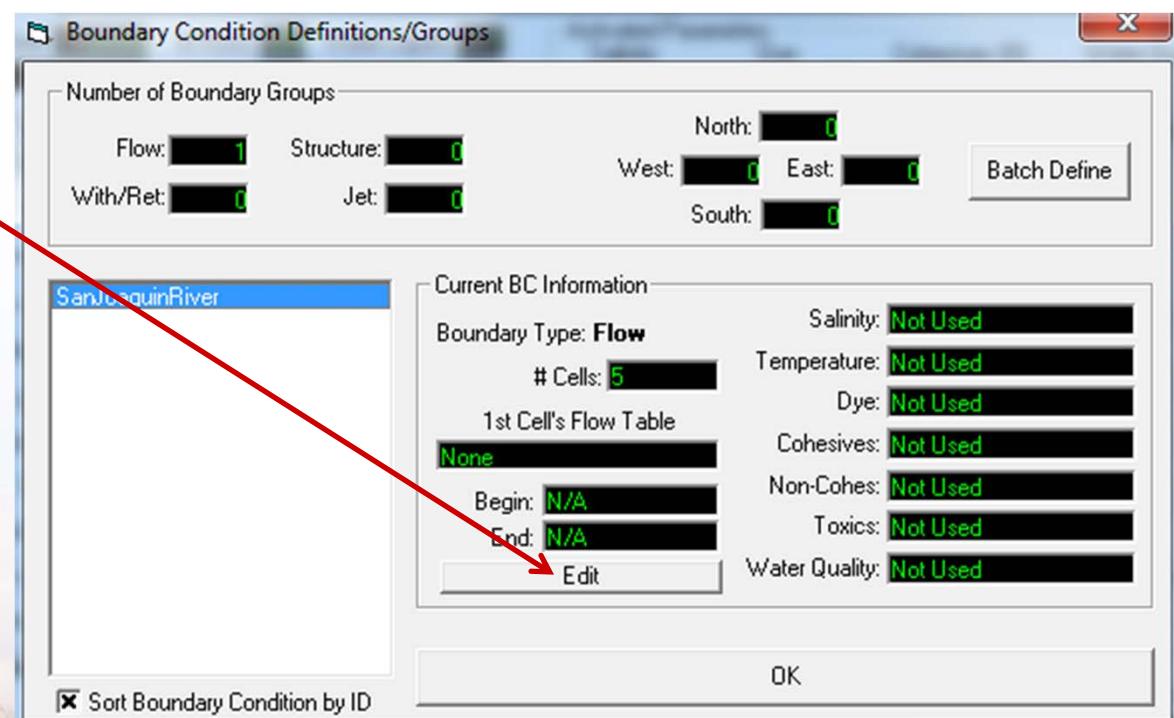
Switch to the  
“Boundary” tab

Click “Edit/Review”



# San Joaquin River Steady Flow

Click "Edit"



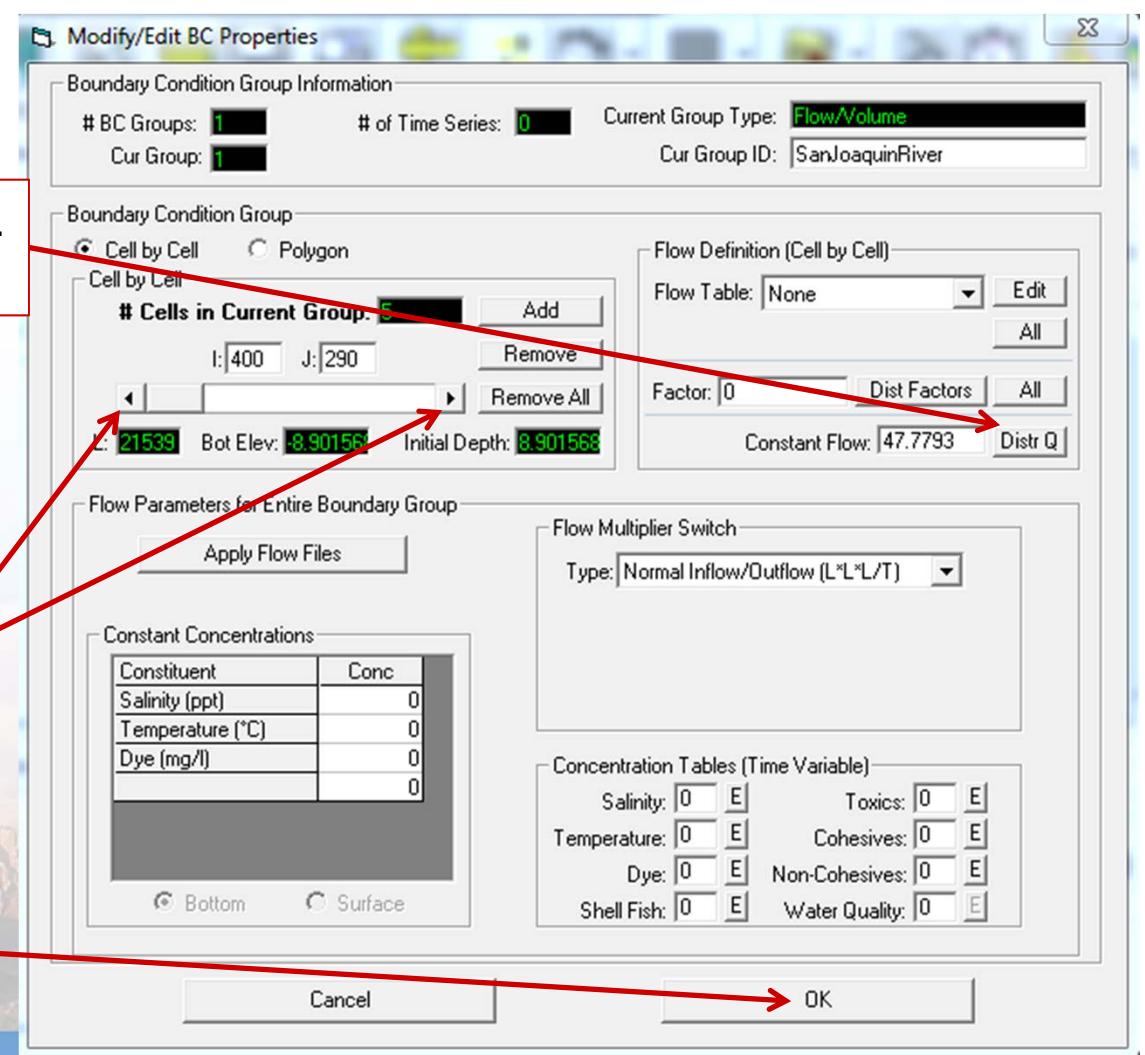
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# San Joaquin River Steady Flow

Click “Distr Q” and enter a flow rate.  
I used 180 m<sup>3</sup>/s (cms).

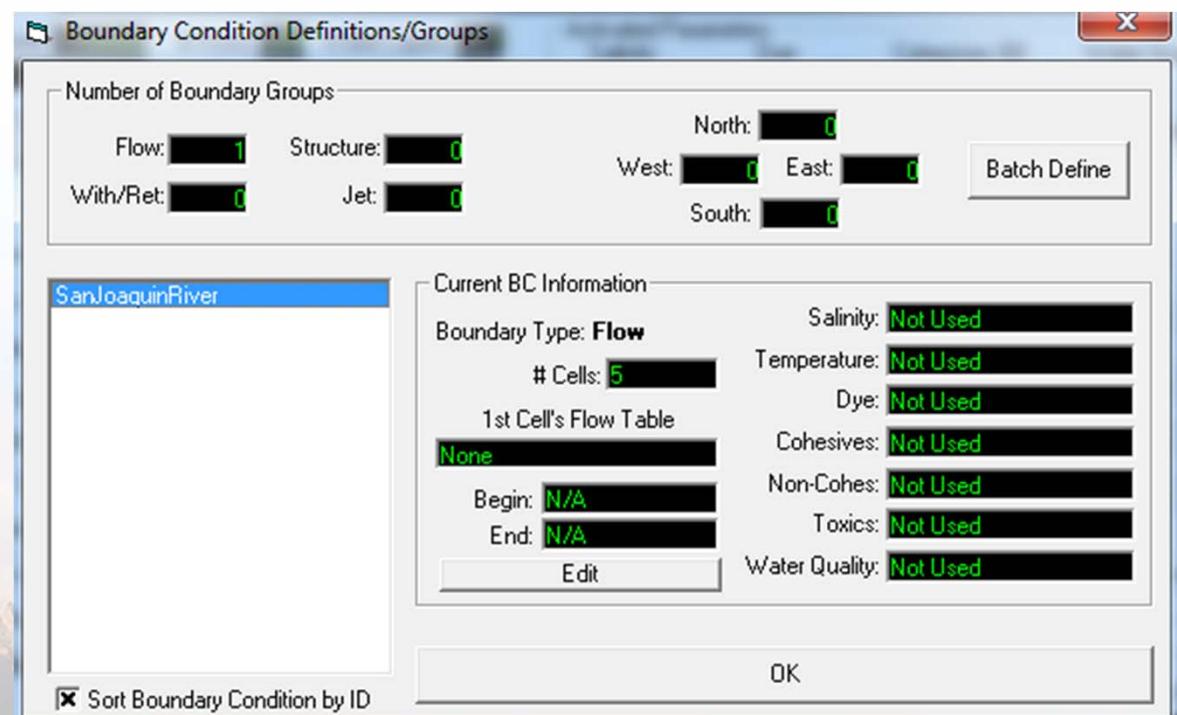
You can click here to  
see the flow applied to  
each of the five  
boundary cells.  
Why are they different?

Click OK



# Open Ocean Heads

Click the Insert button on your keyboard  
(after mouse clicking in the white space).  
Enter a name for the Open Ocean Boundary.  
Click “OK”

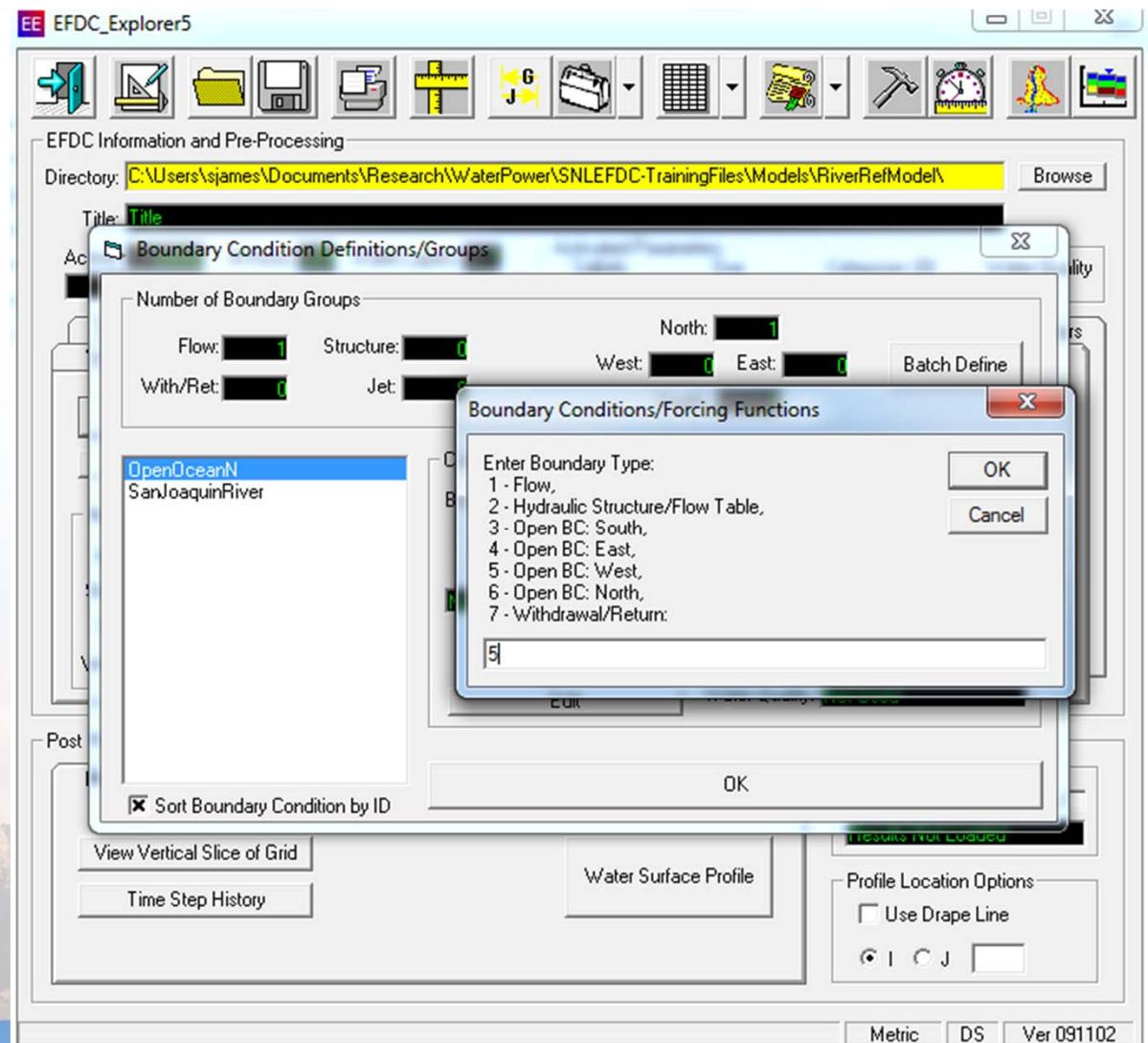


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# Open Ocean Heads

Enter (the appropriate) Boundary Type:  
“Open BC:” on the

- “South” - 3
- “West” - 5
- “North” - 6



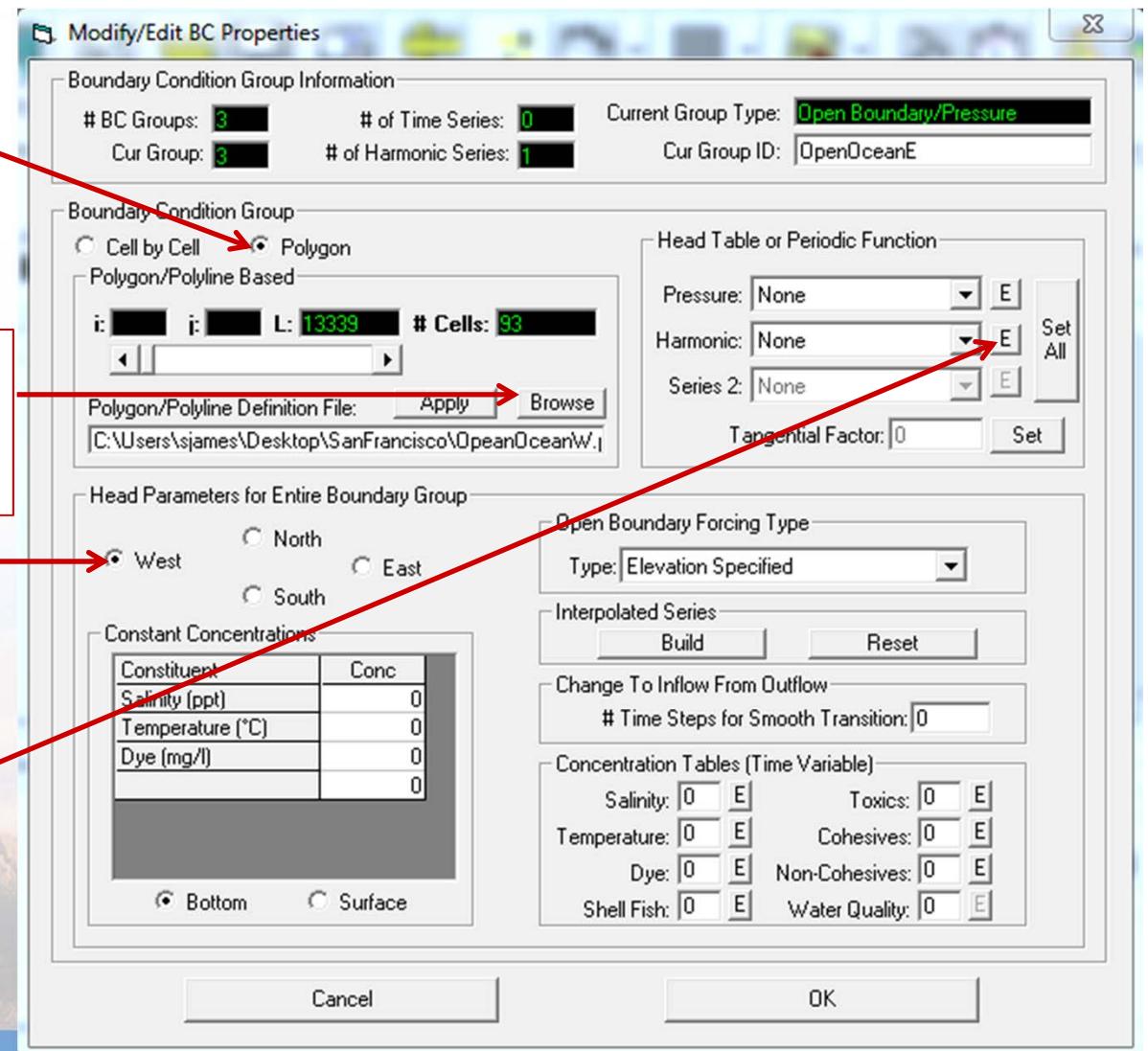
# Open Ocean Heads

Assign the  
“Boundary Condition Group”  
by “Polygon”

Select the appropriate  
“Polygon/Polyline Definition File”  
and “Apply”

Make sure this agrees...

Assign a “Harmonic” series



# Open Ocean Heads

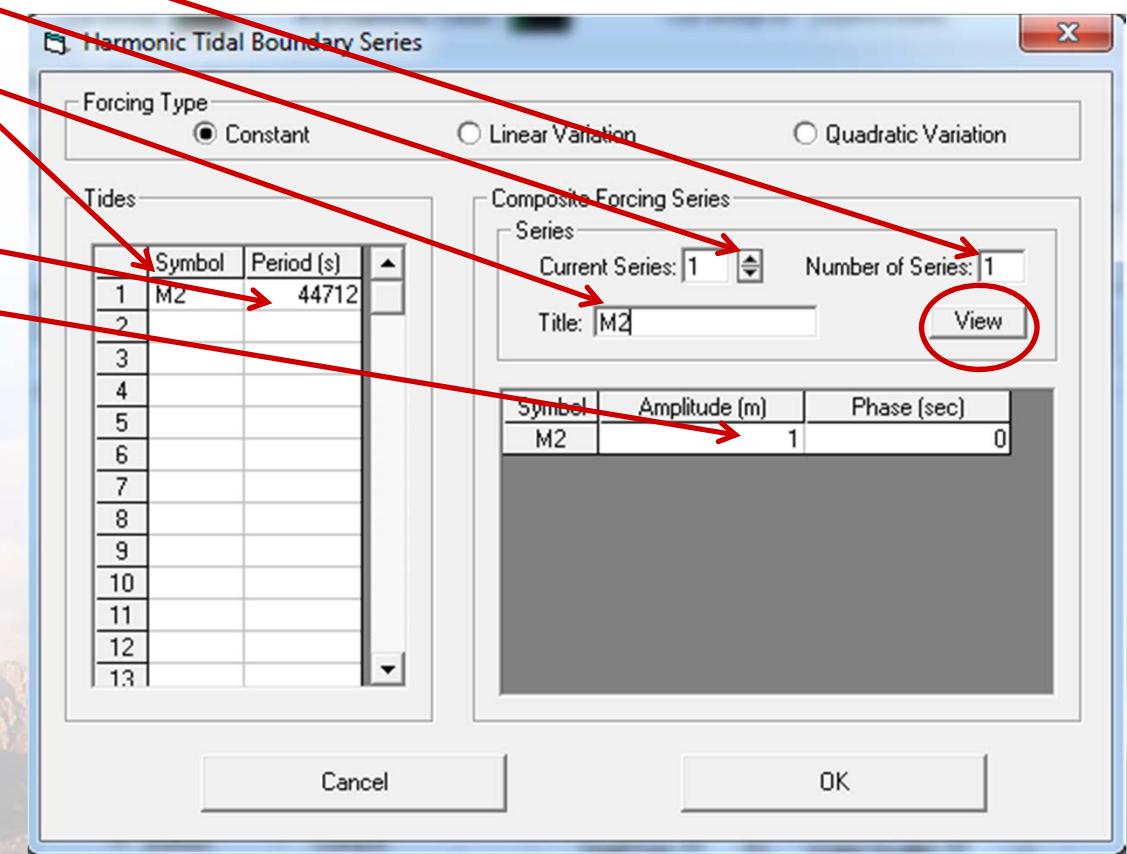
First, enter the “Number of Series” (1 - Enter)

Second, click the “Current Series” to 1

Third, enter “Symbol” and “Title” (M2)

Fourth, enter the “Period” (44712, which is 12.42 hr)

Fifth, enter the “Amplitude” (1)  
Sixth, “View” the results  
Seventh, click “OK”

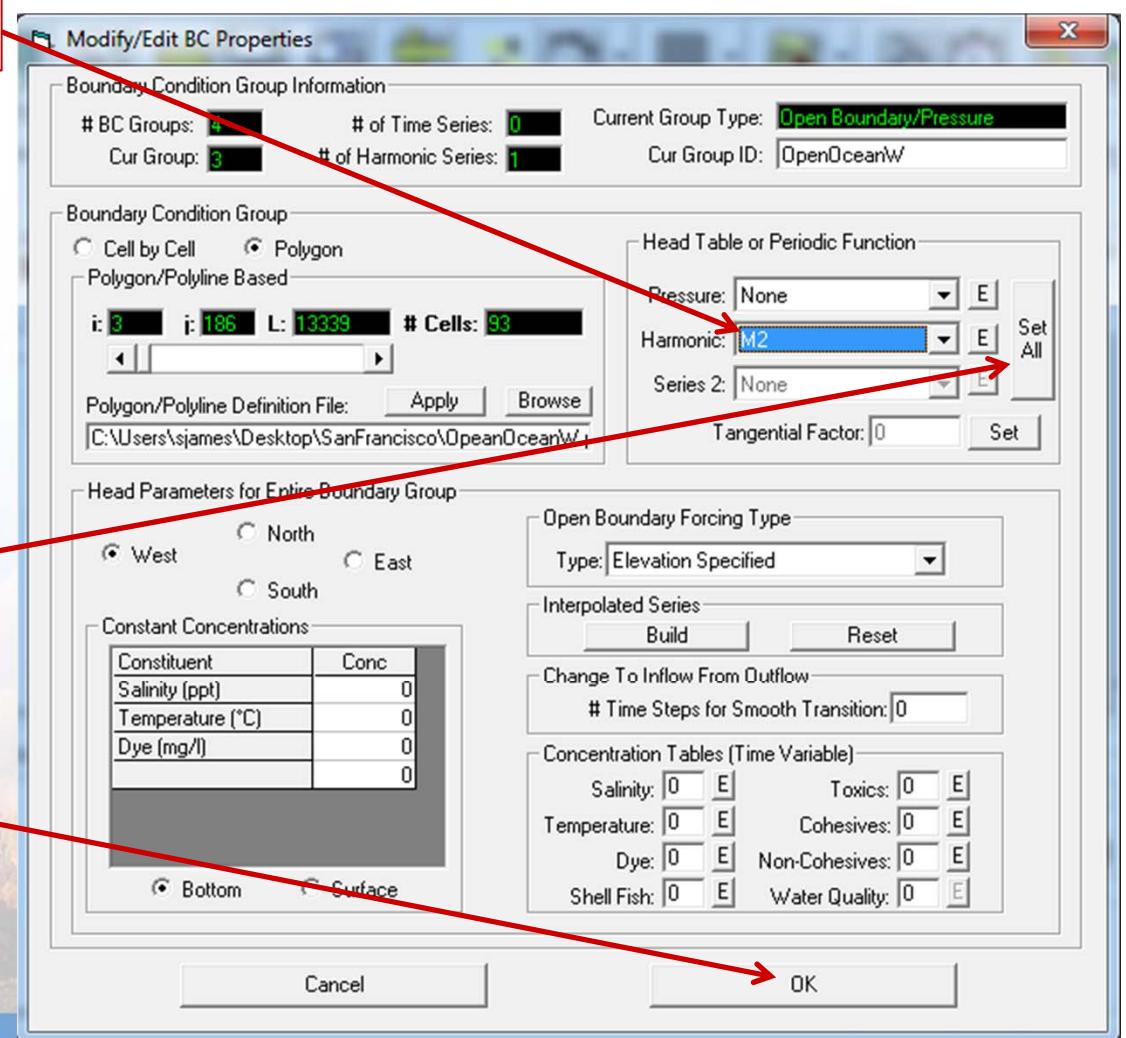


# Open Ocean Heads

Select the “M2” Harmonic data

“Set All” of the cells in this group to this boundary condition.

Click “OK”





# *Open Ocean Heads*

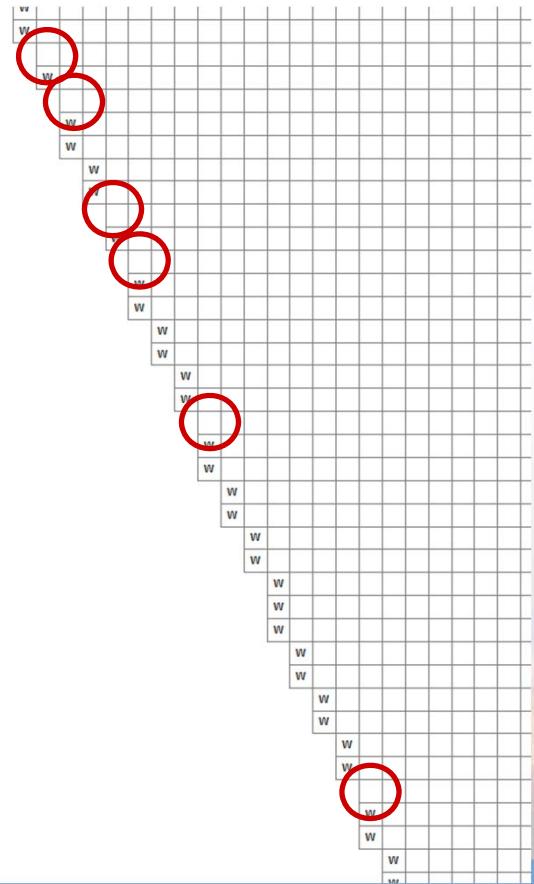
1. Repeat the same steps twice more to assign the remaining of the north, west, or south boundaries.
2. Then, lets look at the boundary conditions in the “Grid Viewer.”
3. We will need to clean up our boundaries, make sure you “Enable Edit.”
4. Make sure your “Viewing Opt’s” are set to “Boundary Cs.”



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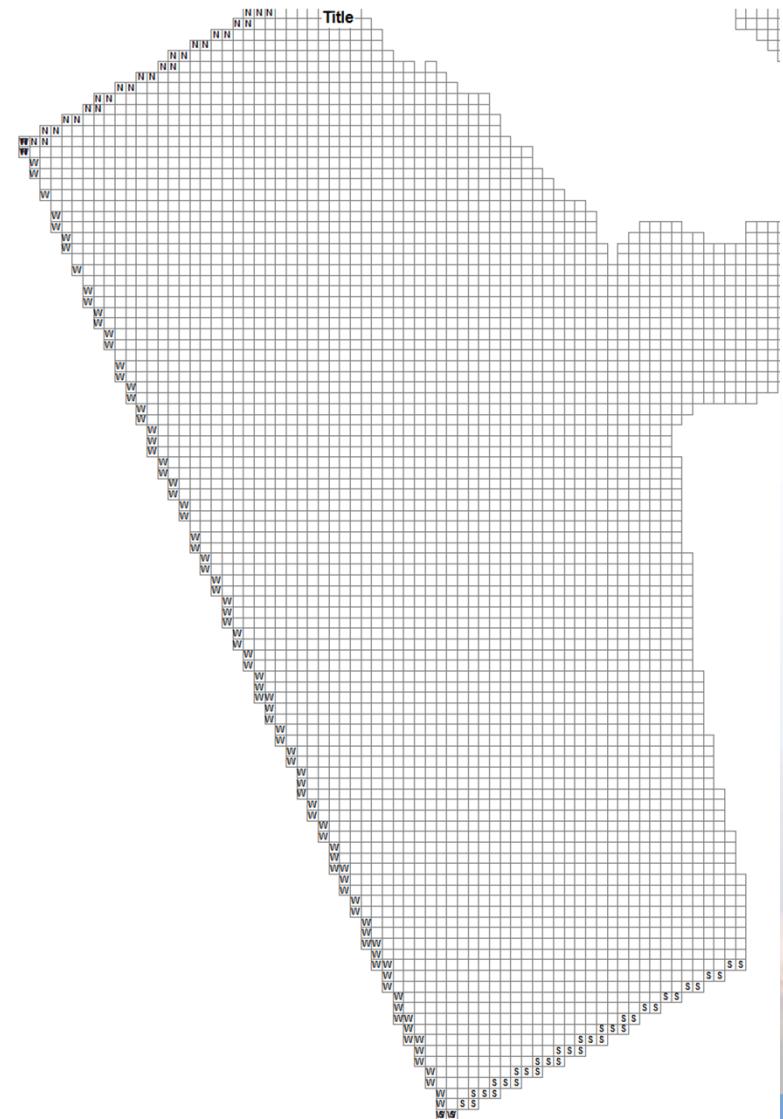
# Open Ocean Heads

I see several cells that need to be assigned boundary conditions



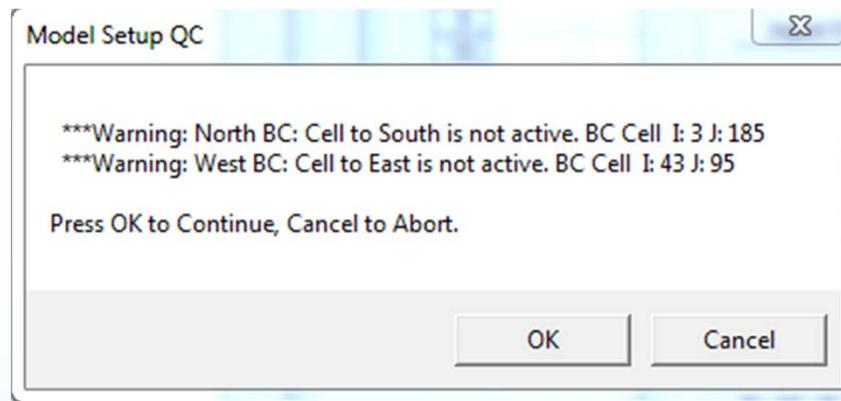
Right click and  
“Add to  
Adjacent”

Exit and Save



# Open Ocean Heads

Are there any problems?



There may be more than just this, let's clean up the boundary cells.



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# Open Ocean Heads

Don't need N boundary conditions to the south of N BC's

Extraneous  
(and double assigned)

Left click on the problem cells  
and write down their I,J  
locations.

Then, right click on a boundary cell and  
click "Edit"



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# Open Ocean Heads

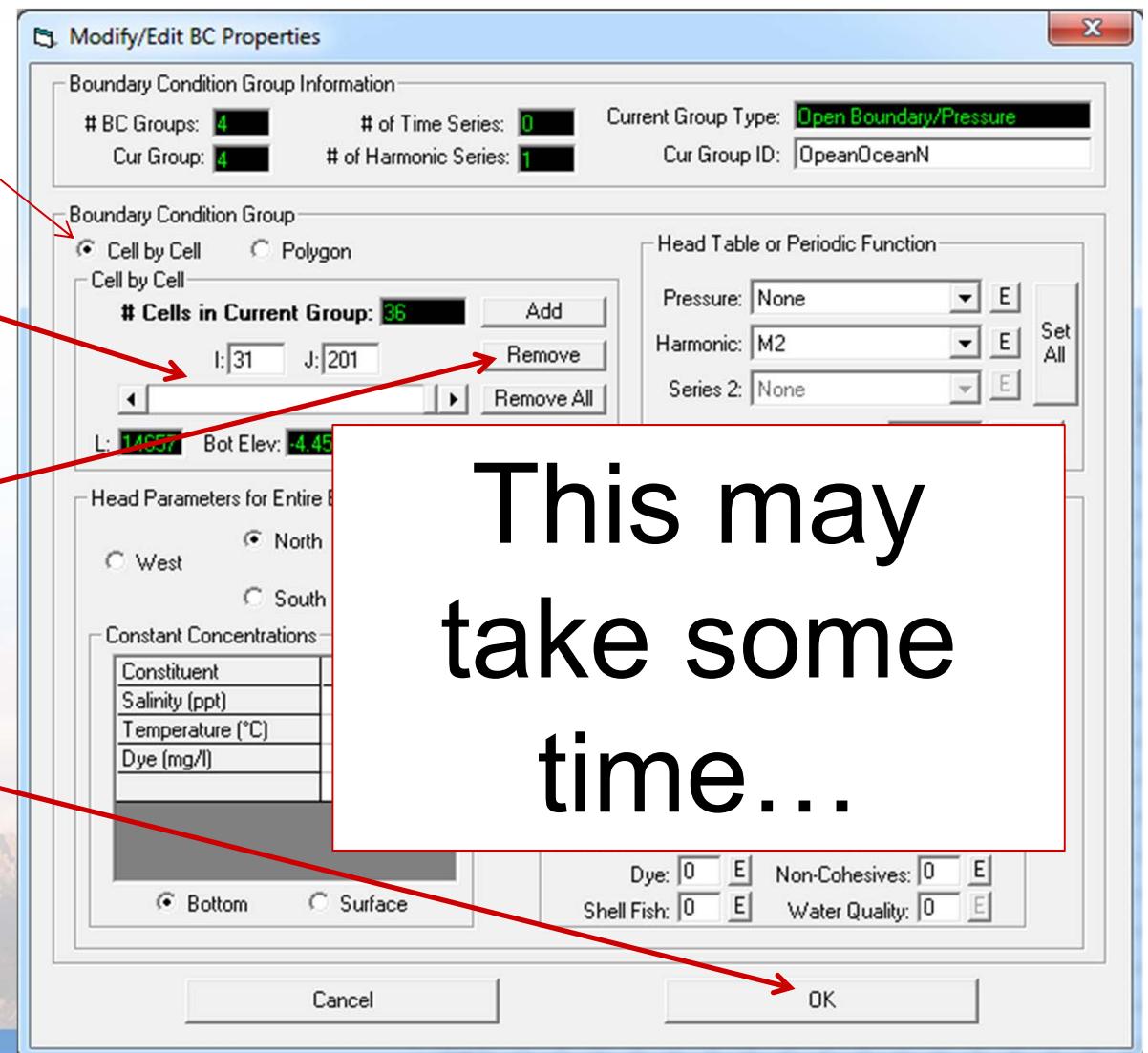
Click “Cell by Cell”

Cycle through and find the bad cells.

Remove them

Click OK when done

This may take some time...

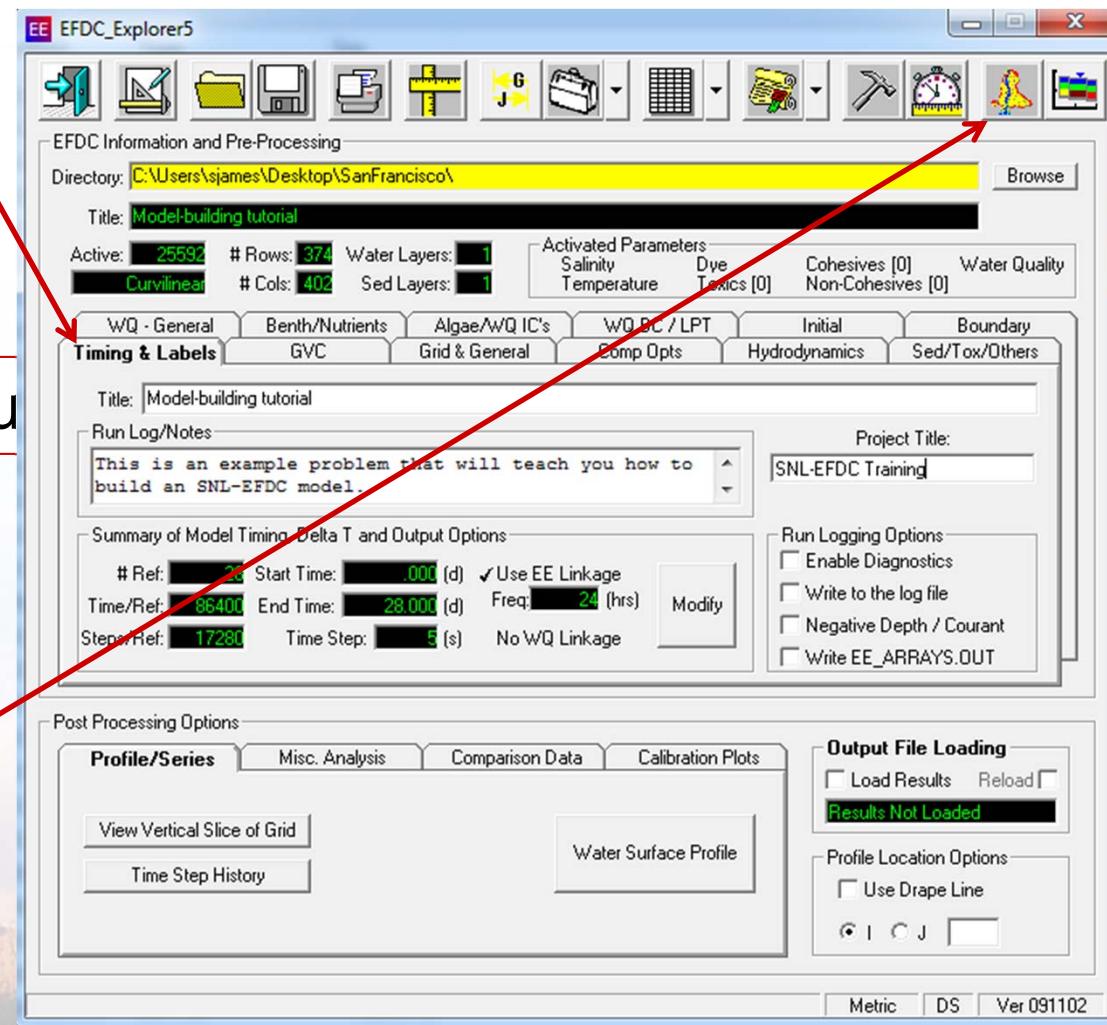


# The Time Step

Click the  
“Timing & Labels”  
tab

Let's run through

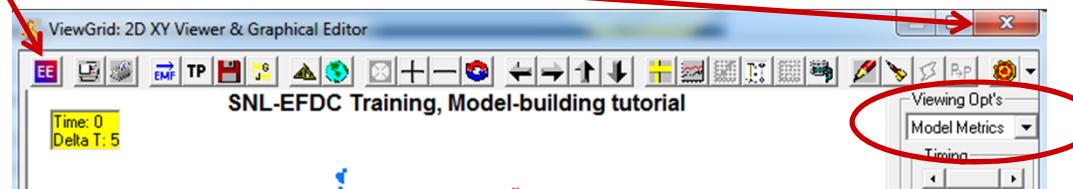
Before we  
“Modify” the  
time step, we  
should know  
what value to  
use.



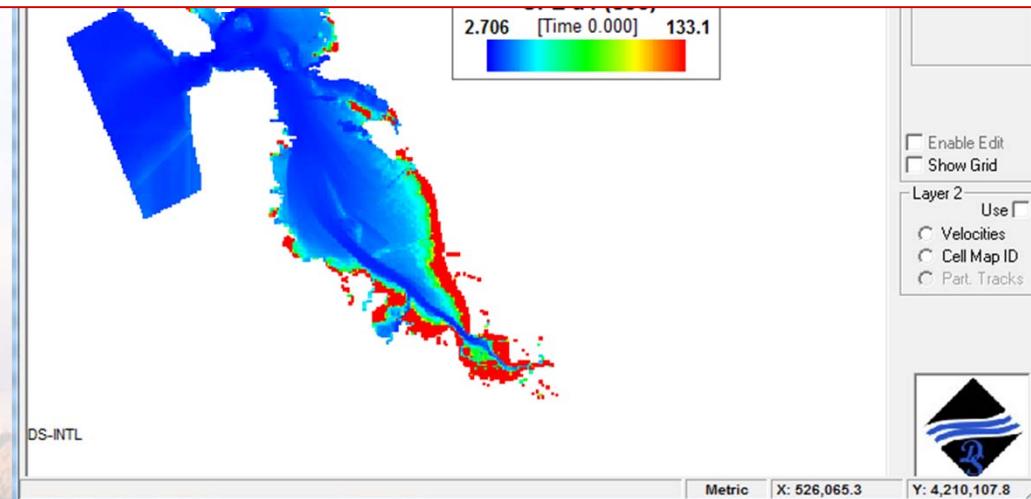
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# The Time Step

Exit out of the Grid Viewer



This is a map of the stable time step to be used for hydrodynamic modeling. For flow simulations only, the time step can often be slightly increased beyond the minimum. For dye and temperature transport, sediment dynamics, and water-quality simulations, you may need to use a smaller time step than indicated.



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# Timing & Labels

EE EFDC\_Explorer5

Shared

EFDC Information and Pre-Processing

Directory: C:\Users\sjames\Desktop\SanFrancisco\

Browse

Title: Model-building tutorial

Active: 25592 # Rows: 374 Water Layers: 3 Activated Parameters  
Curvilinear # Cols: 402 Sed Layers: 1 Salinity ✓ Dye  
Temperature Toxics [0] Cohesives [0] Water Quality  
Non-Cohesives [0]

W/Q General Benth/Nutrients Algae/WQ IC's WQ BC / LPT Initial Boundary  
Timing & Labels GVC Grid & General Comp Opt Hydrodynamics Sed/Tox/Others

Title: Model-building tutorial

Run Log/Notes: This is an example problem that will teach you how to build an SNL-EFDC model.

Project Title: SNL-EFDC Training

Summary of Model Timing, Delta T and Output Options

# Ref: 10 Start Time: .000 (d) ✓ Use EE Linkage  
Time/Ref: 86400 End Time: 10.000 (d) Freq: 4 (hrs)

Steps/Ref: 28800 Time Step: 3 (s) No WQ Linkage

Run Logging Options

- Enable Diagnostics
- Write to the log file
- Negative Depth / Courant
- Write EE\_ARRAYS.OUT

Post Processing Options

Profile/Series

Output File Loading

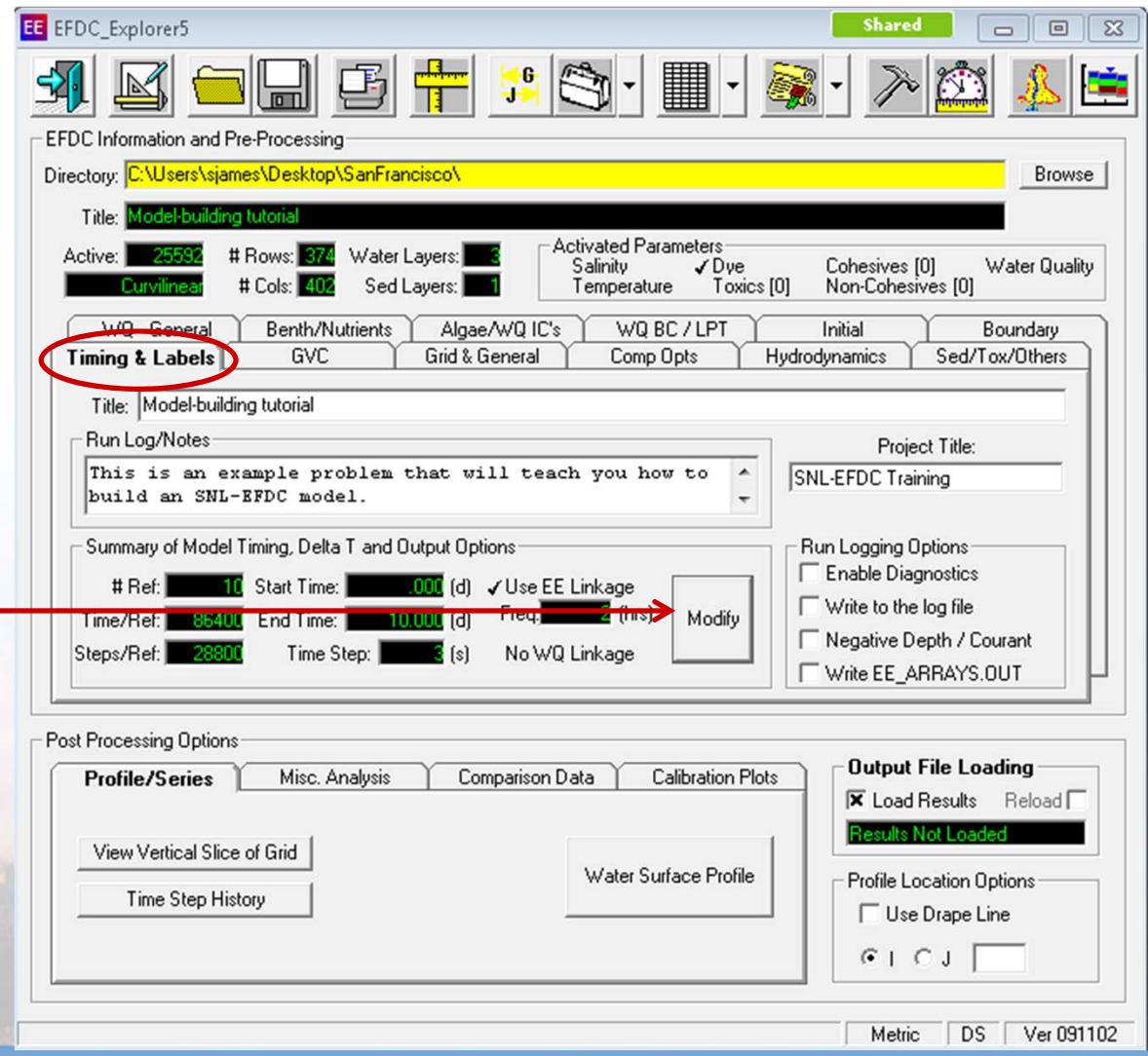
Load Results  Reload  
**Results Not Loaded**

Profile Location Options

Use Drape Line  
 I  J

Metric DS Ver 091102

Click "Modify"

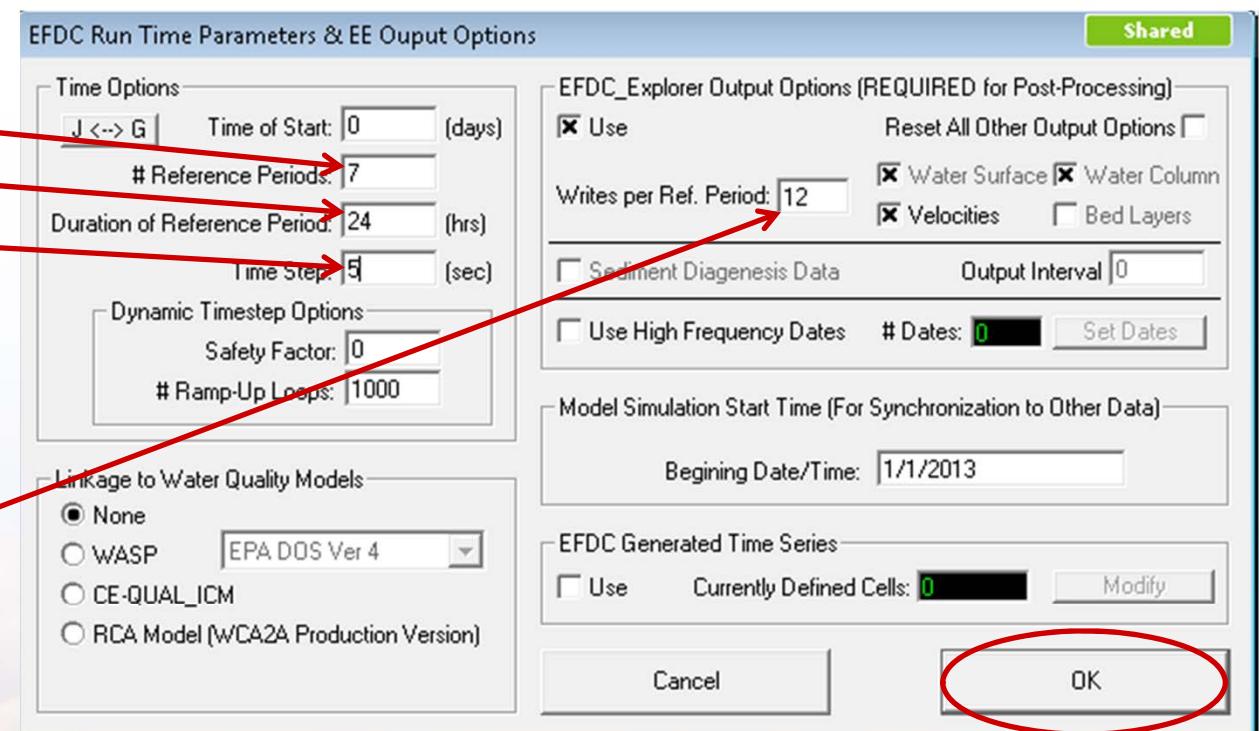


# Timing & Labels

Click “Modify” on the “Timing & Labels” tab

Let's simulate a week of 1-day reference periods using a 5-sec time step

Select the number of writes per reference period. Careful! This could generate large output files.



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# Grid & General

Select the number of layers.  
Note: Computation time scales linearly with this number.

Allow “Wetting & Drying”

Screen display

Careful with this value. While it will cause numbers to stream on the screen faster, it will also make a **HUGE** output file called “tecplot2d.dat”

EE EFDC\_Explorer5

EFDC Information and Pre-Processing

Directory: C:\Users\sjames\Desktop\SanFrancisco\

Title: Model-building tutorial

Active: 25592 # Rows: 374 Water Layers: 1 Activated Parameters: Salinity, Temperature, Dissolved Toxics [0], Cohesives [0], Non-Cohesives [0], Water Quality

Curvilinear # Cols: 402 Sed Layers: 1

WQ - General Benth/Nutrients Algae/w/o IC's WQ BC / LPT Initial Boundary

Timing & Labels GVC Grid & General Comp Opt's Hydrodynamics Sed/Tox/Others

Water Layers

Lay	Frac
3	0.33333
2	0.33333
1	0.33333

Wetting & Drying

Flag: -99  
Dry Depth: 0.05  
Wet Depth: 0.1  
Dry Step: -1

Masks

No.: 3 Use:  Modify

Run Time Status

Type: I: 75, J: 176

Print Interval: 1000

Water Depth Settings

Additive Factor: 0  
Multiplicative Factor: 1  
Minimum Height: 0.05

Bottom Elev. Adjustments

Additive Factor: 0  
Multiplicative Factor: 1

Post Processing Options

Profile/Series Misc. Analysis Comparison Data Calibration Plots

View Vertical Slice of Grid Water Surface Profile

Time Step History

Output File Loading

Load Results  Reload  Results Not Loaded

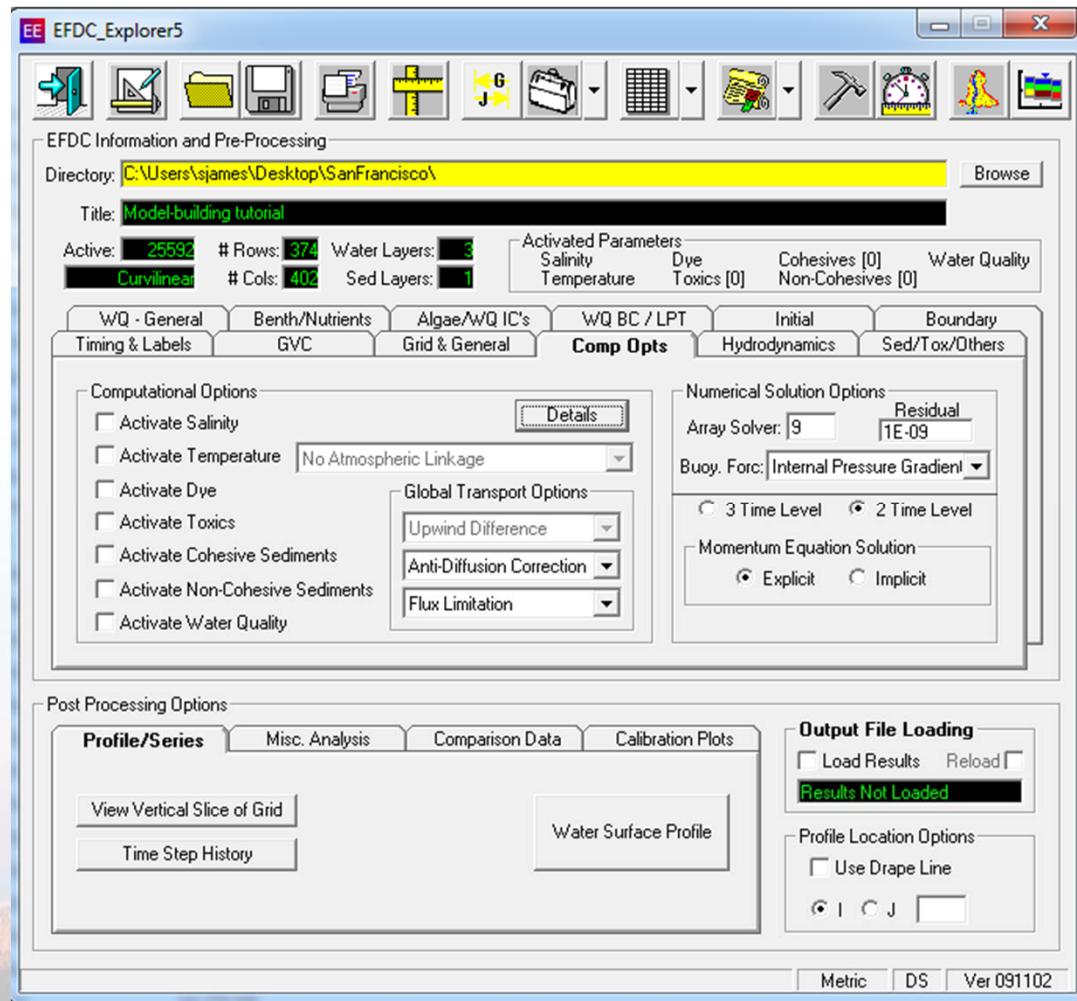
Profile Location Options

Use Drape Line  I  J

Metric DS Ver 091102

# Comp Opt

Activate Dye



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# Hydrodynamics

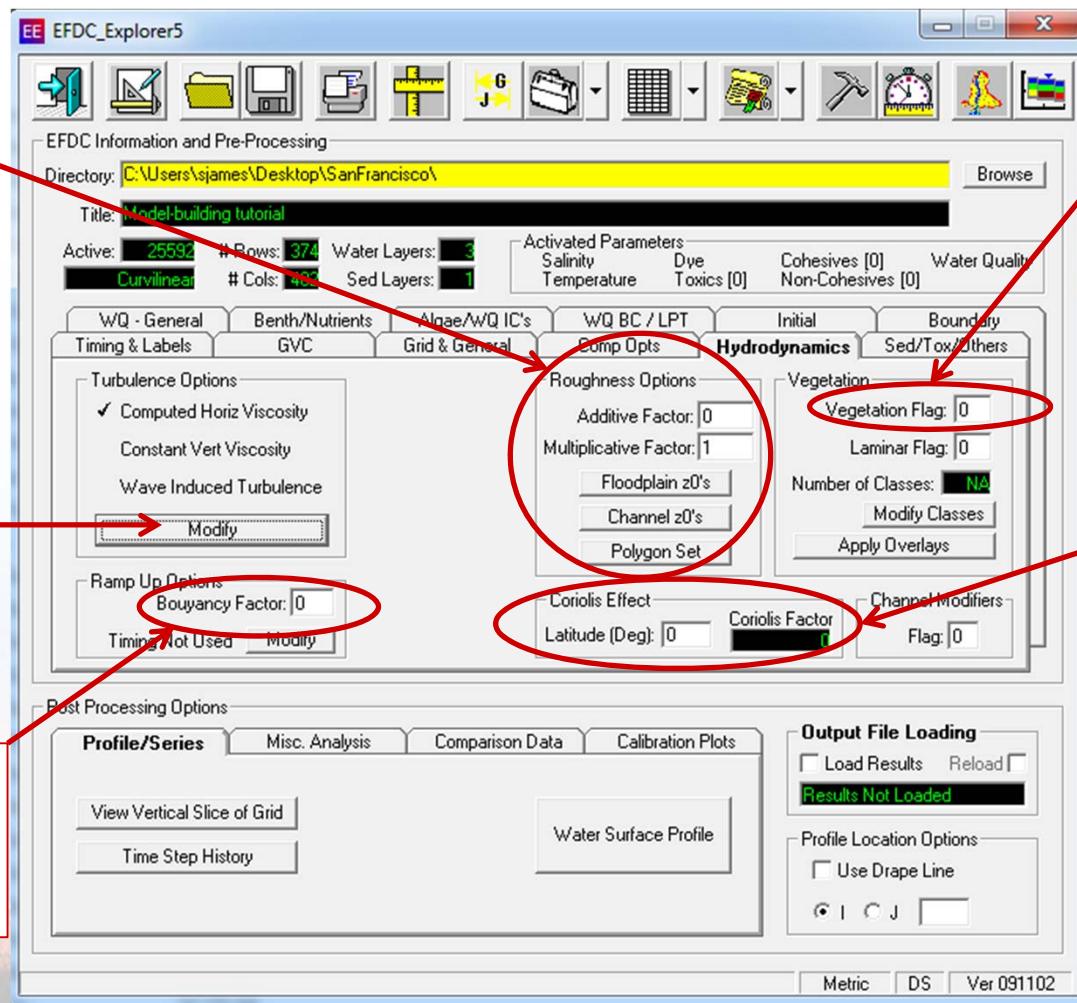
Assign bottom roughnesses here (calibration parameter)

Important parameters!!!  
Click here!

Buoyant forces are off ( $T$  and  $S$ ). Set to 1 to turn on.

We will turn on MHKs here (later)

Coriolis forces are off



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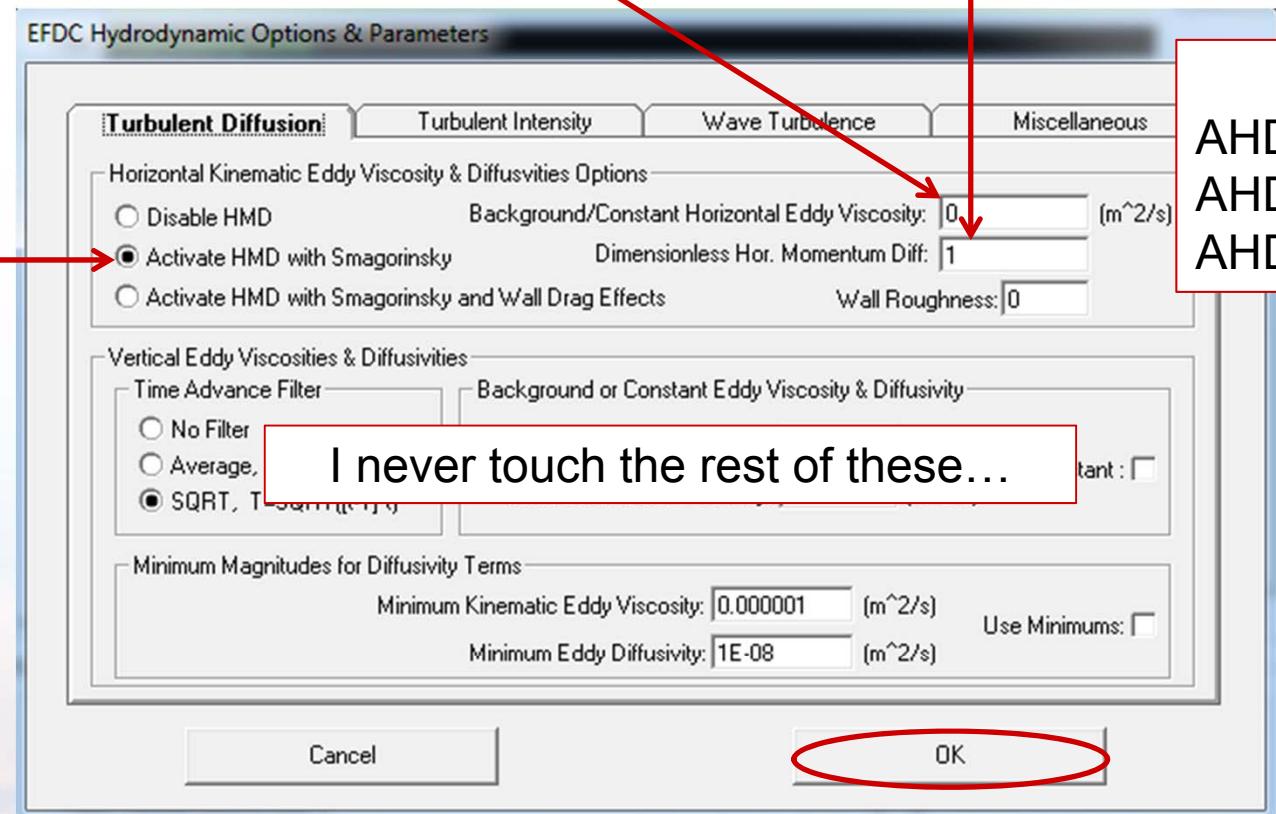
# Modify the Turbulence Options

AHO should be between 0 and 0.25

AHD (calibration parameter)

Activate  
Horizontal  
Momentum  
Diffusion

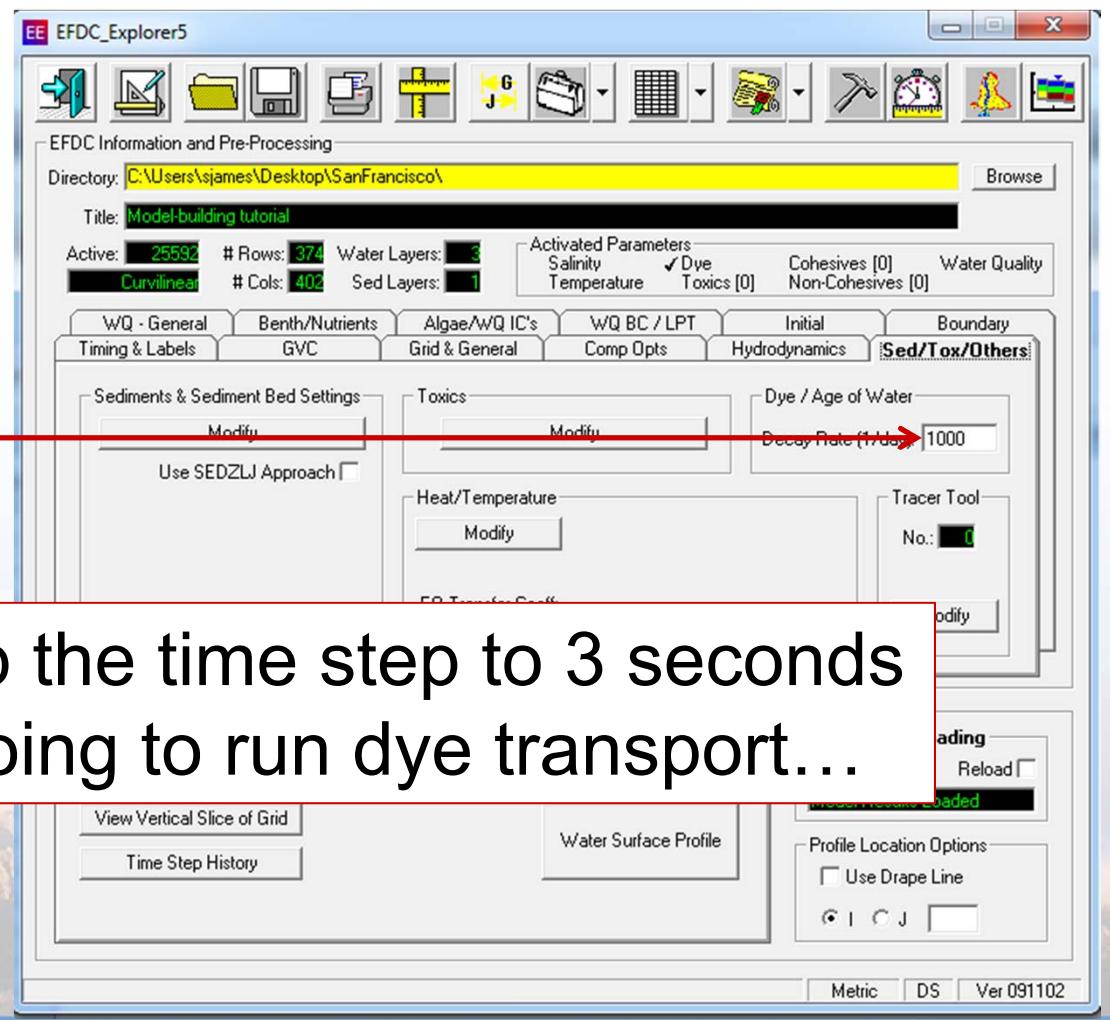
In General  
 $AHD > 0.1$   
 $AHD = \Delta x \Delta y / 1000$   
 $AHD < 5$



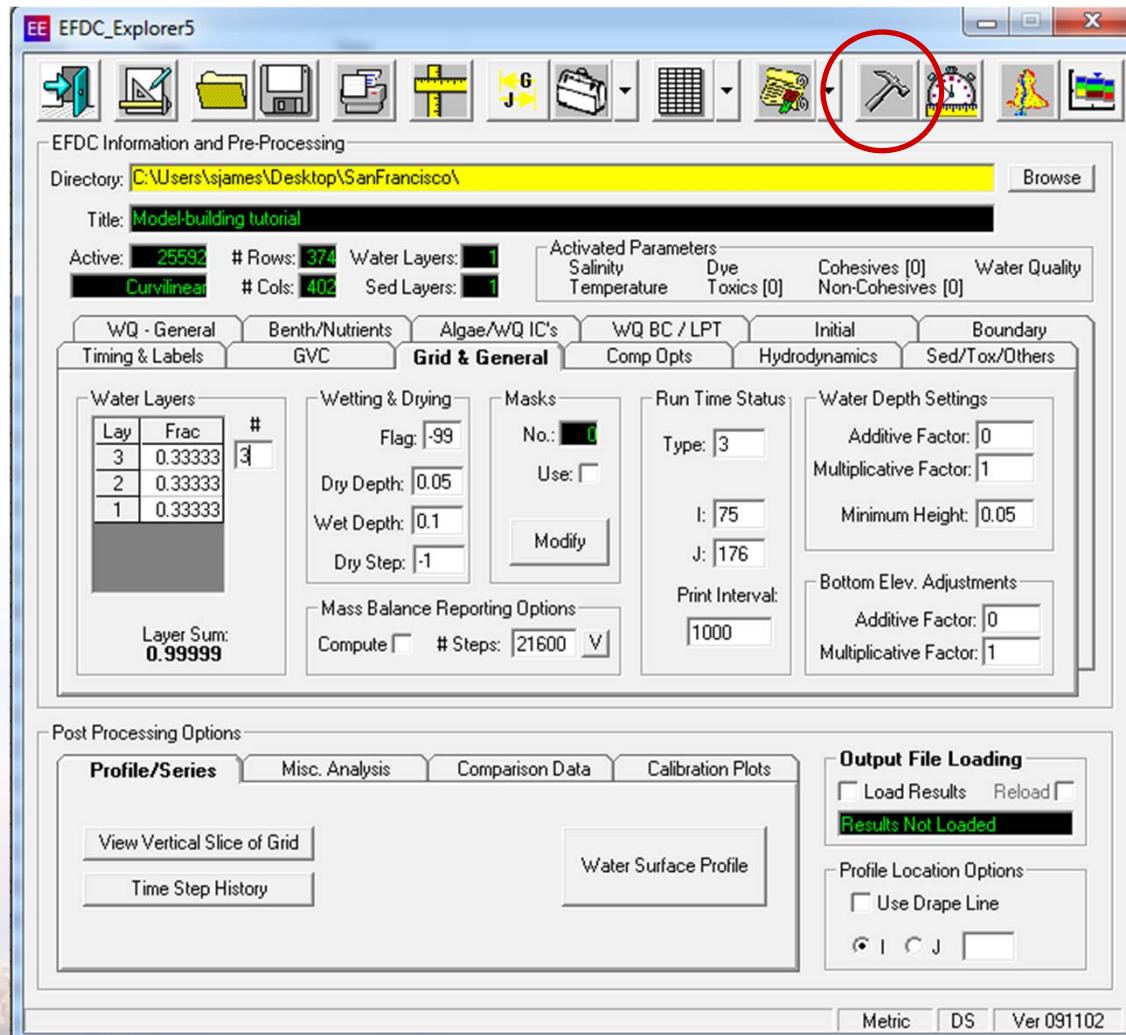
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# Should We Add Dye?

“Activate Dye” in the “Comp Opt” tab.



# Run the Model



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*Run the Model*

Let's take lunch...

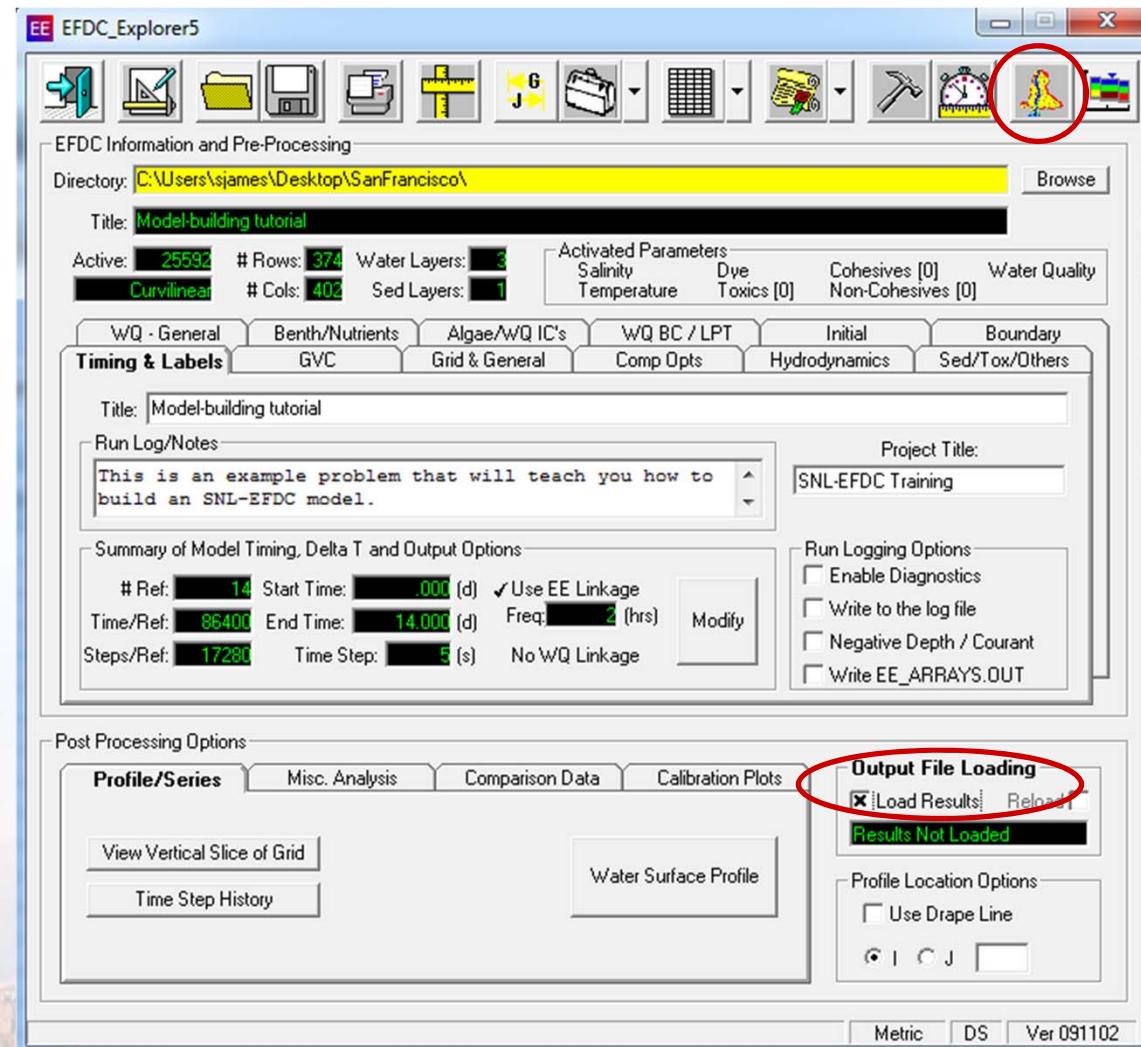


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# View the Results

“Load Results”  
from  
“Output File  
Loading”

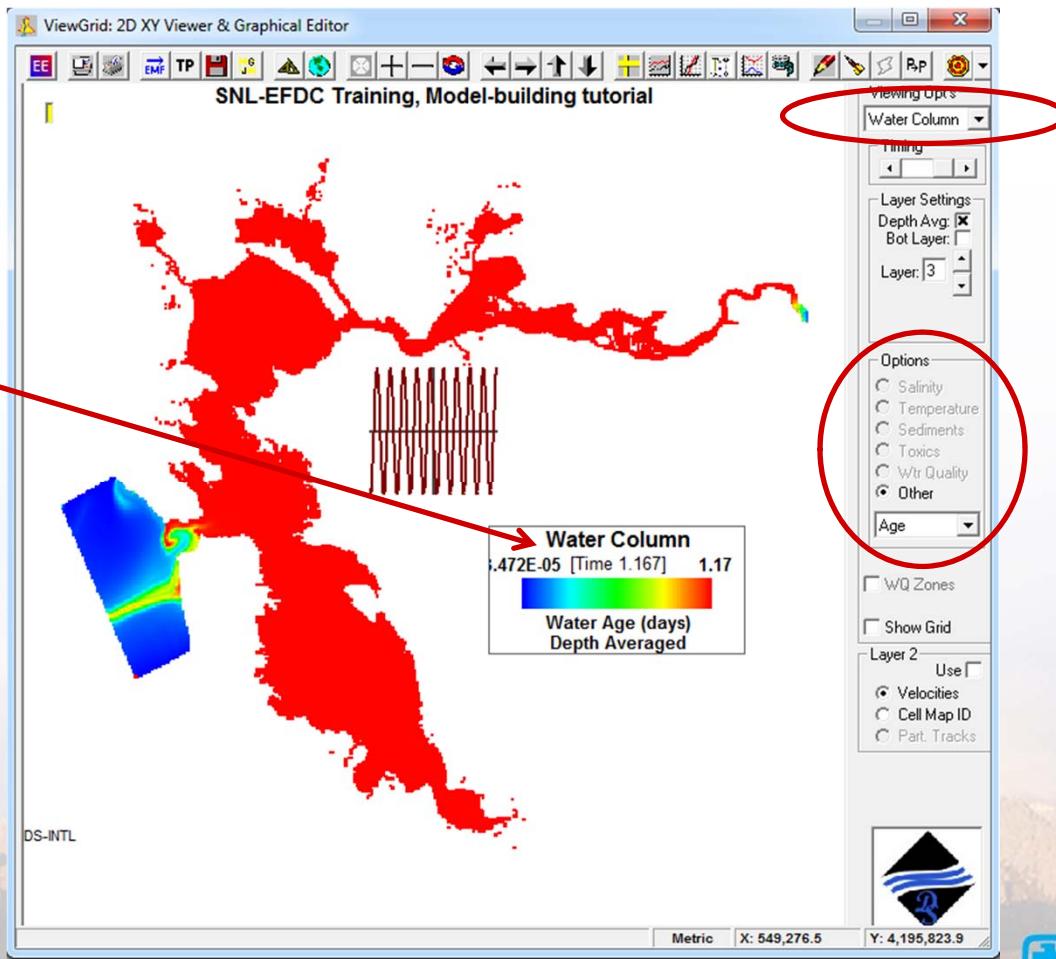
Then “View Grid”



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# View a Water-Age Animation

Select “Water Column” from “Viewing Opt’s”  
Select “Other” and “Age” from “Options”

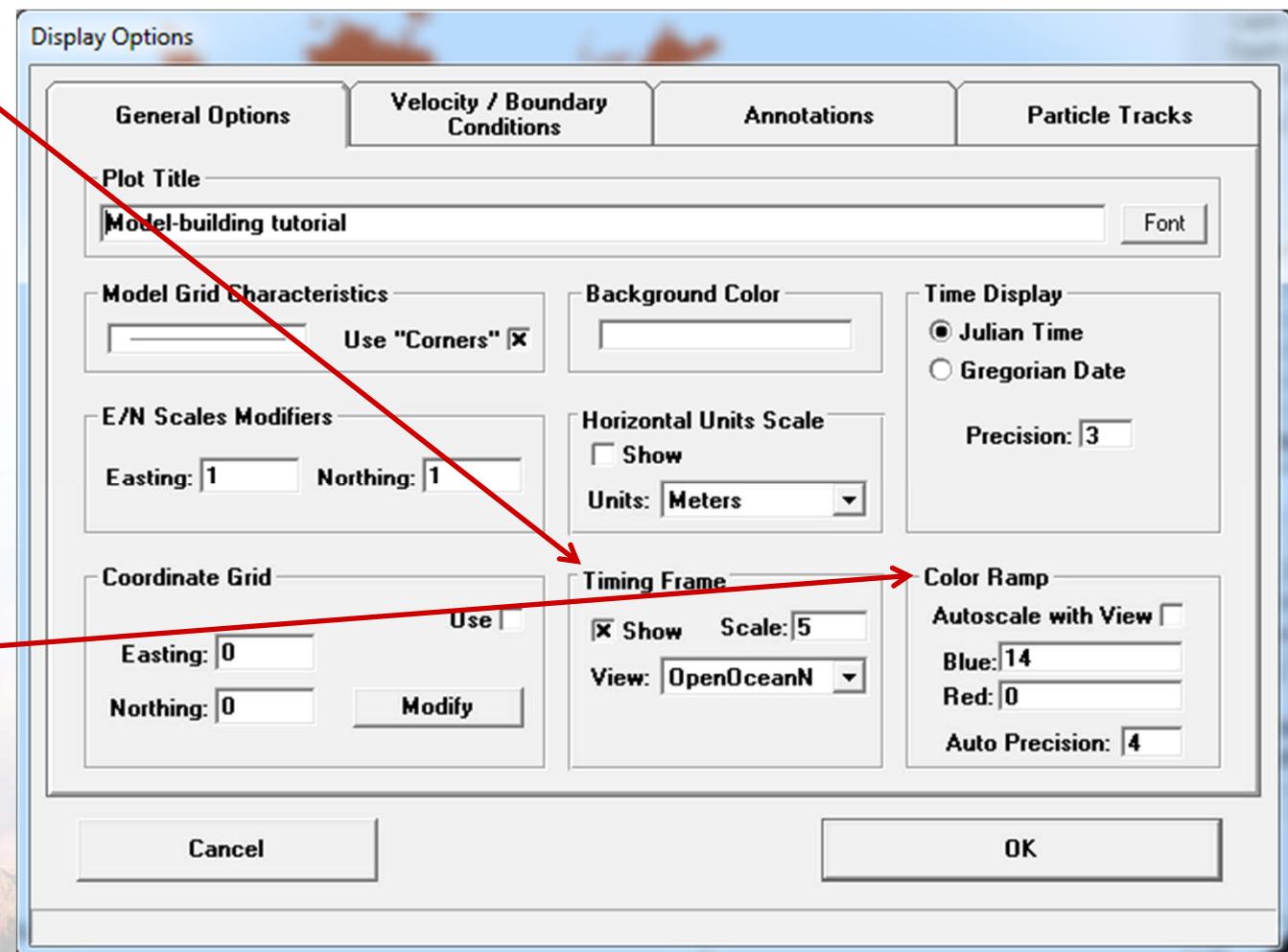


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# View a Water-Age Animation

Show the “Timing Frame” and “View” an ocean BC

Change the “Color Ramp” (if you like)



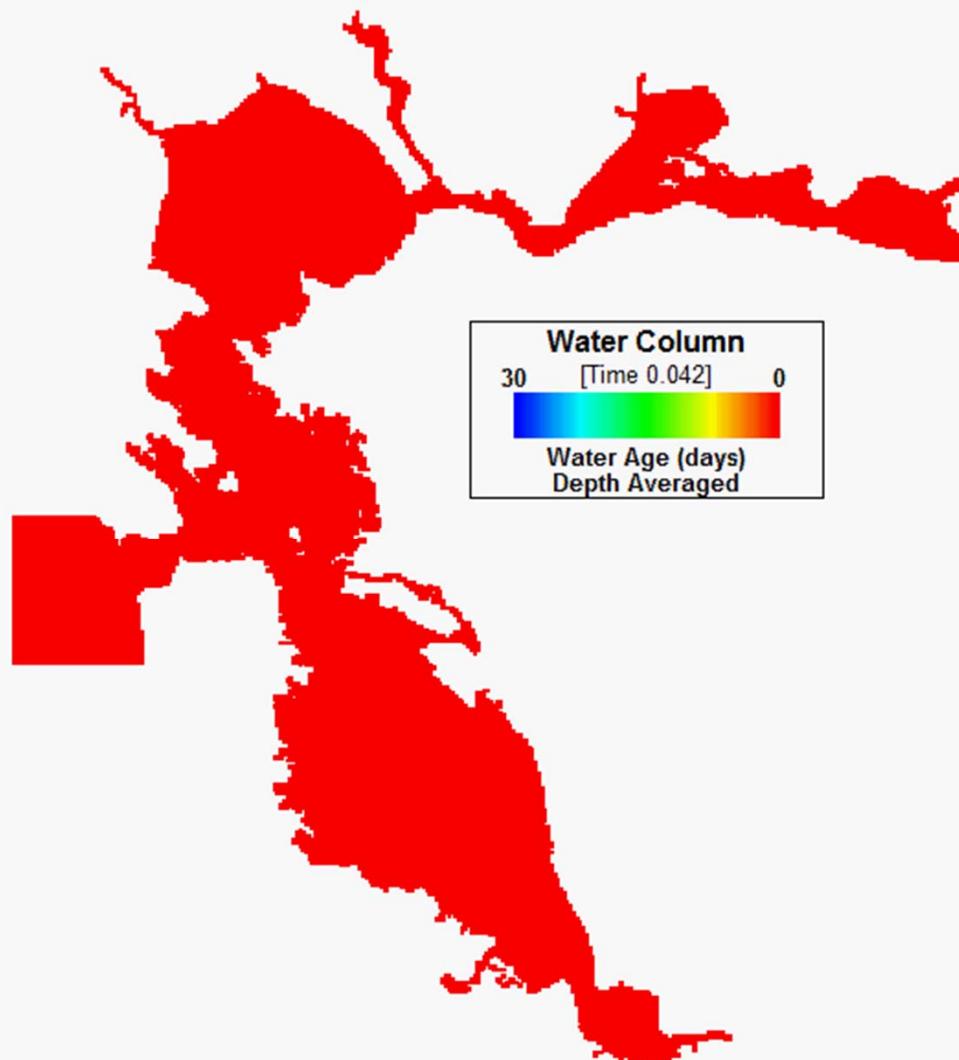
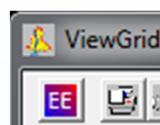
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# *View a Water-Age Animation*

DS-INTL

Title

DS-INTL



DS-INTL

DS-INTL

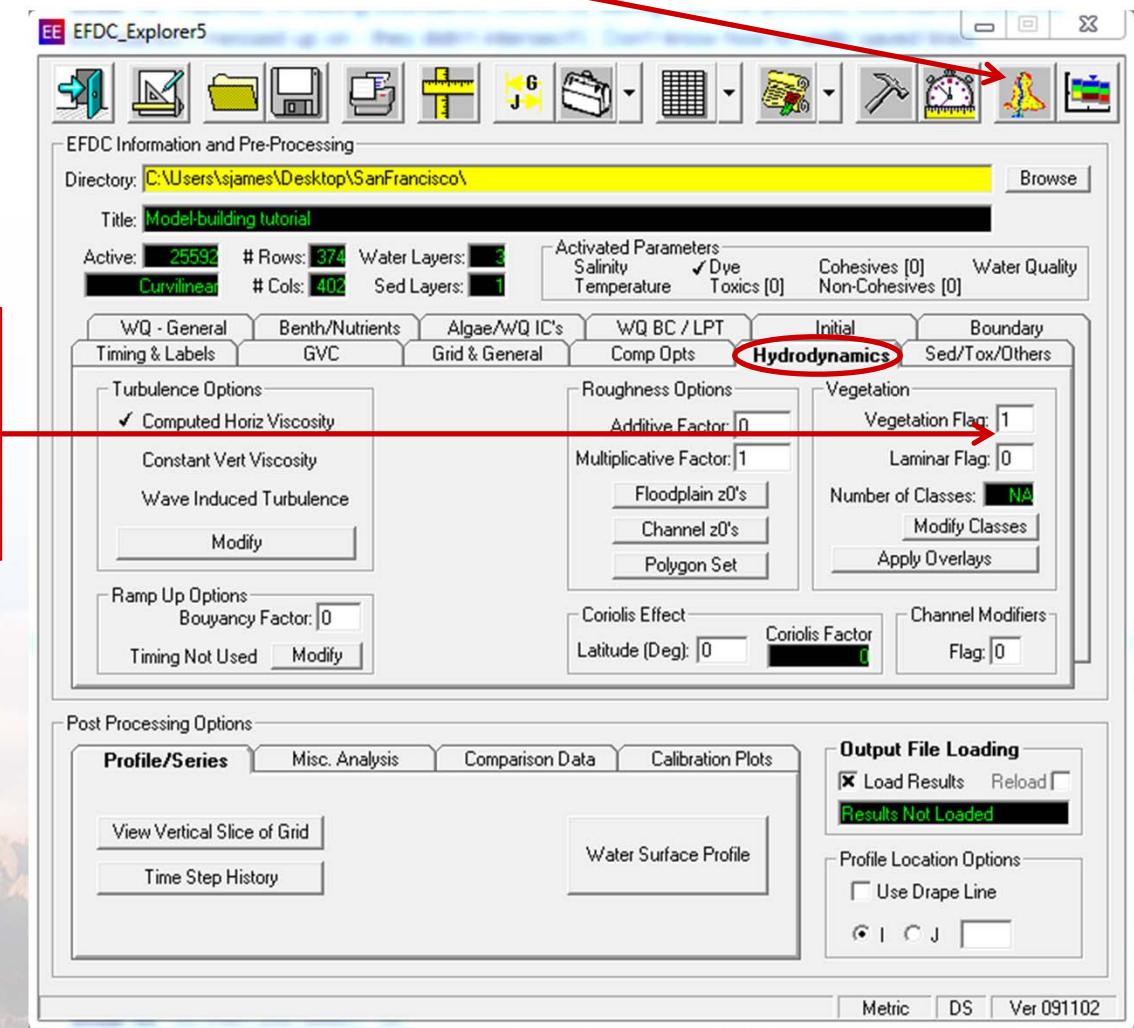


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# The MHK Module

Let's add some devices

By changing the  
“Vegetation Flag” to 1 you  
can introduce vegetation  
AND MHK devices.



# The MHK Module

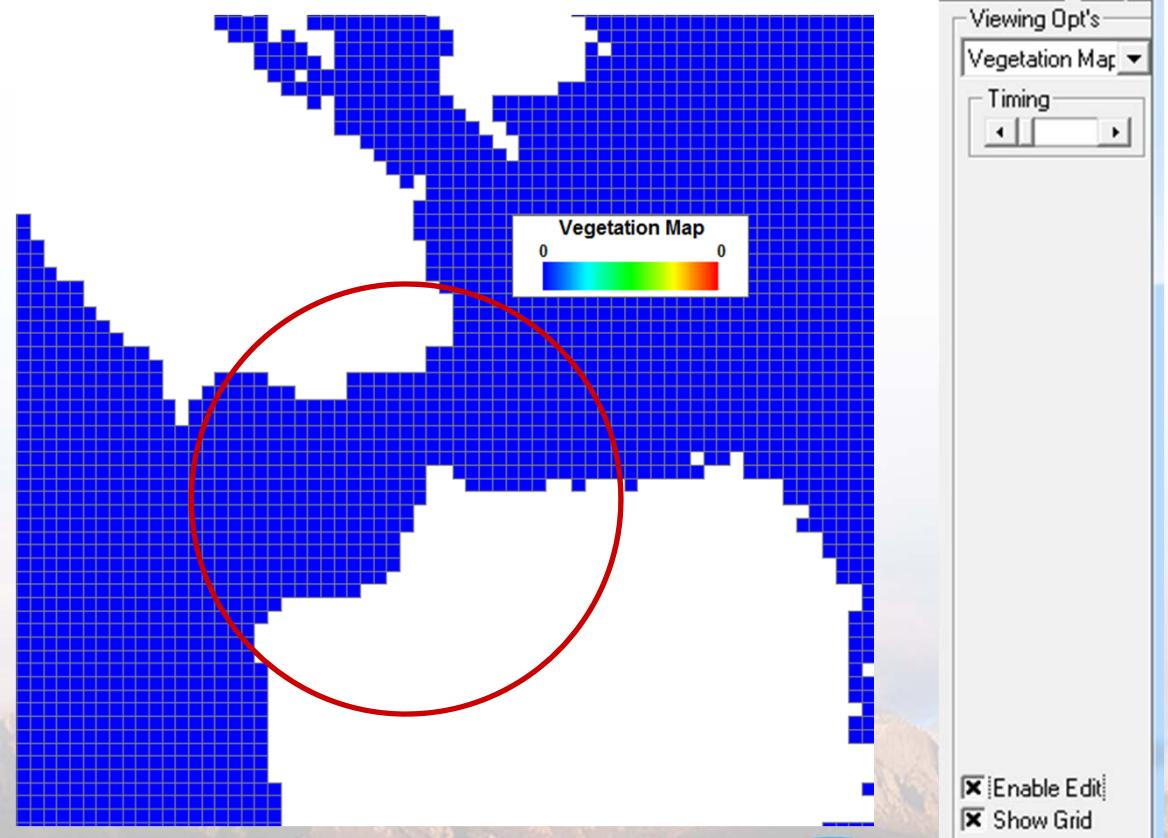
Turn on the “Vegetation Flag” in the “Hydrodynamics” tab...

...and re-enter the “Grid Viewer.”

Then, select the “Vegetation Map” under “Viewing Opt’s”...

...and “Enable Edit.”

Right click some  
(non-boundary) cells  
and add some  
turbines under the  
Golden Gate Bridge.



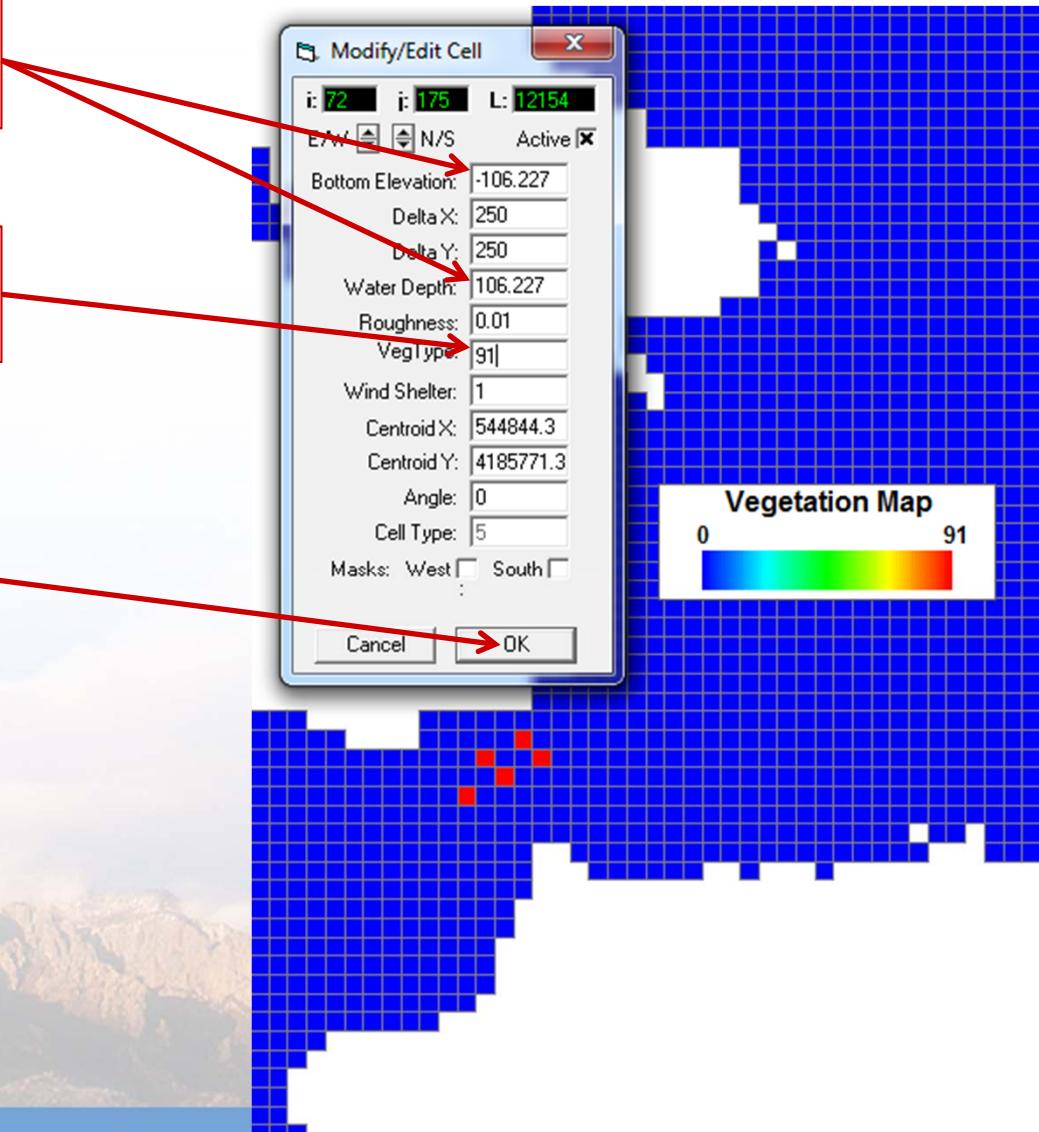
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# Add MHK Devices

Ensure that the water is sufficiently deep.

Enter a “Veg Type” of 91 (or greater)

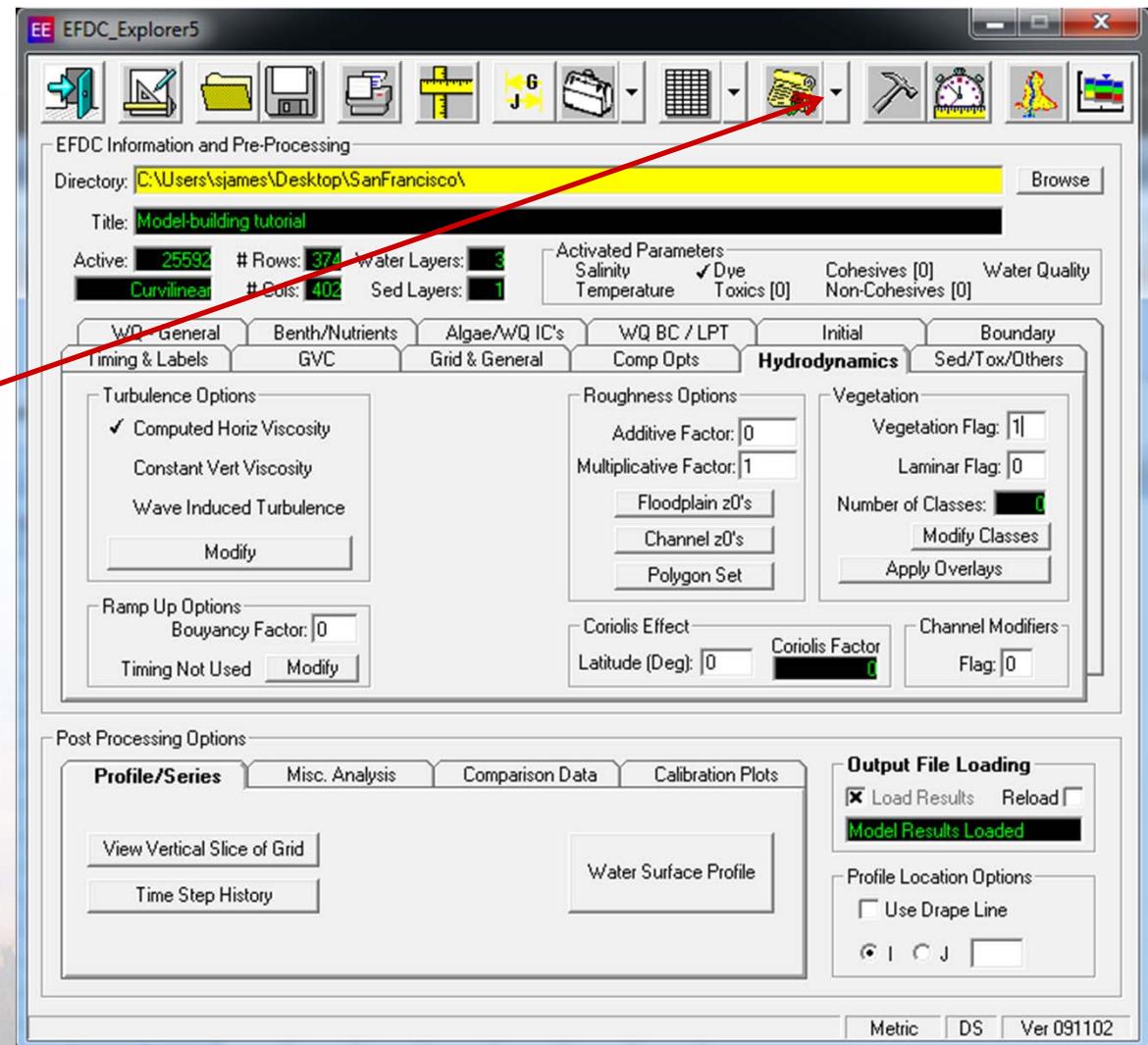
Click “OK” and add as many as you like...



ories

# We Must Hand Edit MHK.INP

In the “Text Editor,” select “Other.INP” and open the MHK.INP file. No need to change anything unless you want to change the size/characteristics of the MHK devices.



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# MHK.INP

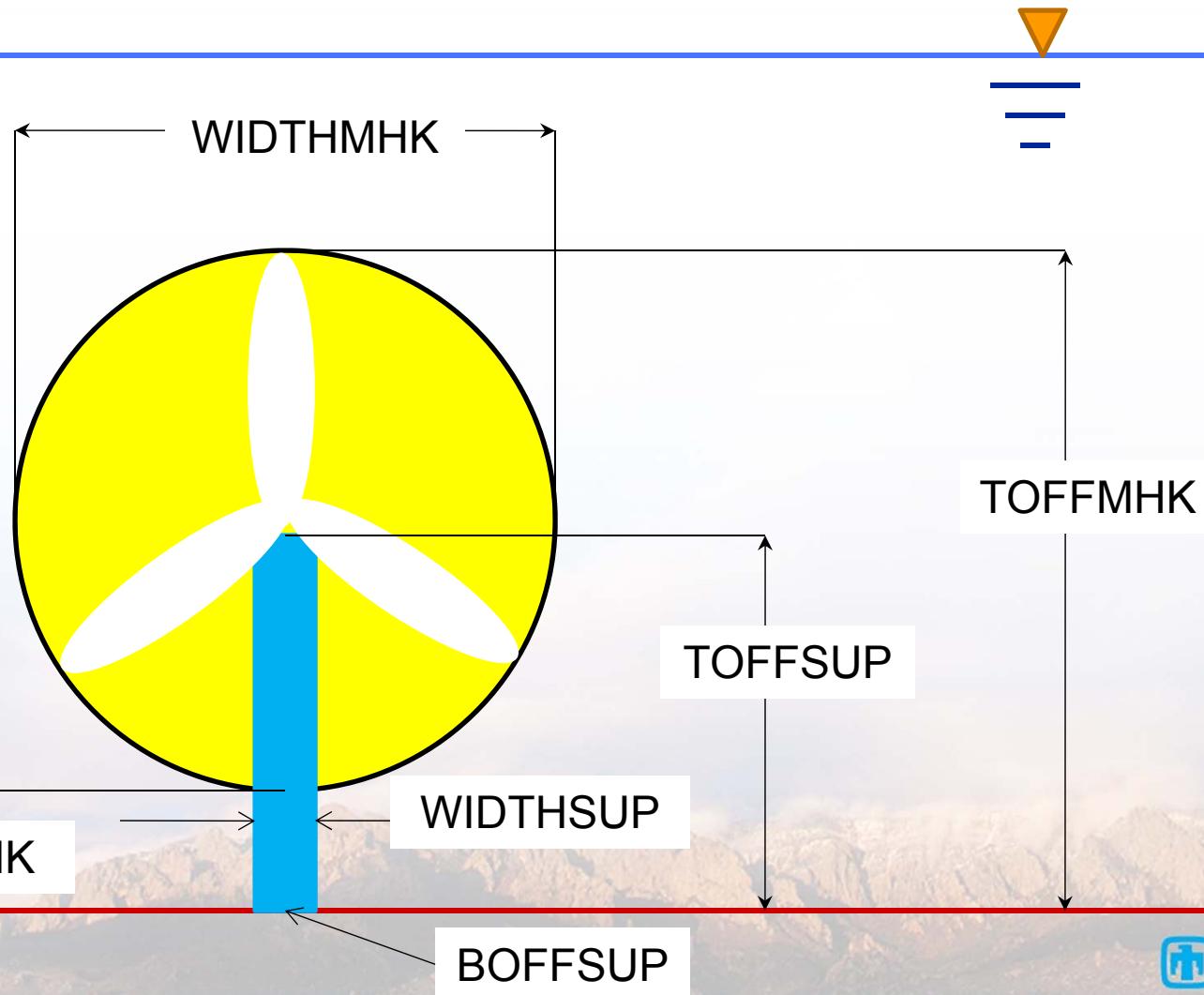
- C WIDTHMHK is the width of MHK device type
- C WIDTHSUP is the width of MHK support structure type
- C BOFFMHK is the bottom offset of the MHK device type (how far from the bottom)
- C BOFFSUP is the bottom offset of the MHK support structure type
- C TOFFMHK is the top offset of the MHK device type
- C TOFFSUP is the top offset of the MHK support structure type
- C CTMHK is the thrust coefficient of MHK device type
- C CDSUP is the coefficient of power dissipation of MHK support structure type
- C VMINCUT is the minimum velocity cut-in for MHK device type power curve
- C VMAXCUT is the maximum velocity cut-out for MHK device type power curve
- C DENMHK is the number of MHK devices in a cell

Look at the values I entered for you.  
Change them if you like.  $C_T < 1$ ;  $C_D = 1.2$  (for cylinders)  
Don't put too many devices in a cell  $DENMHK \leq 5$ .



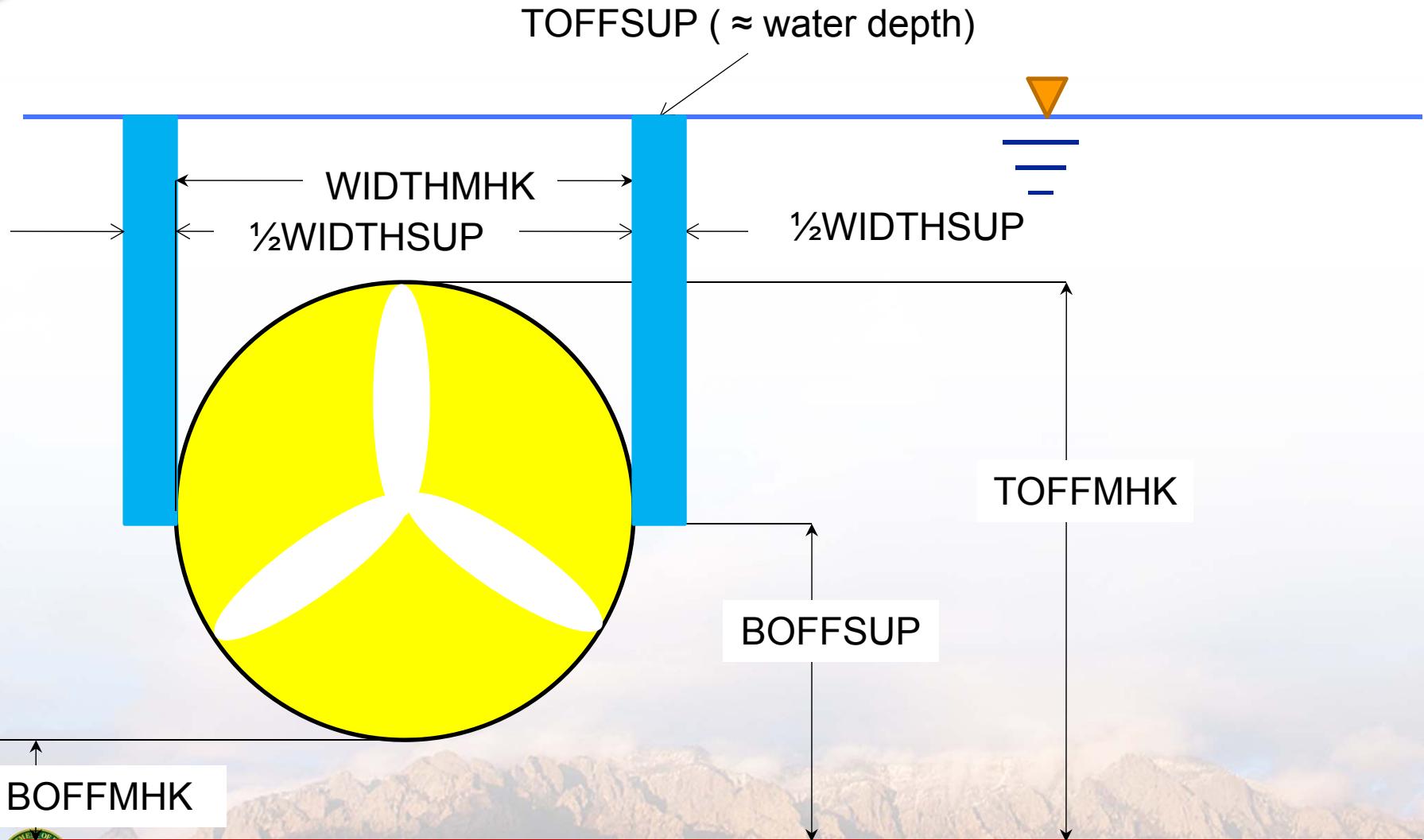
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# *Bottom-Mounted MHK*



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# Top-Mounted MHK

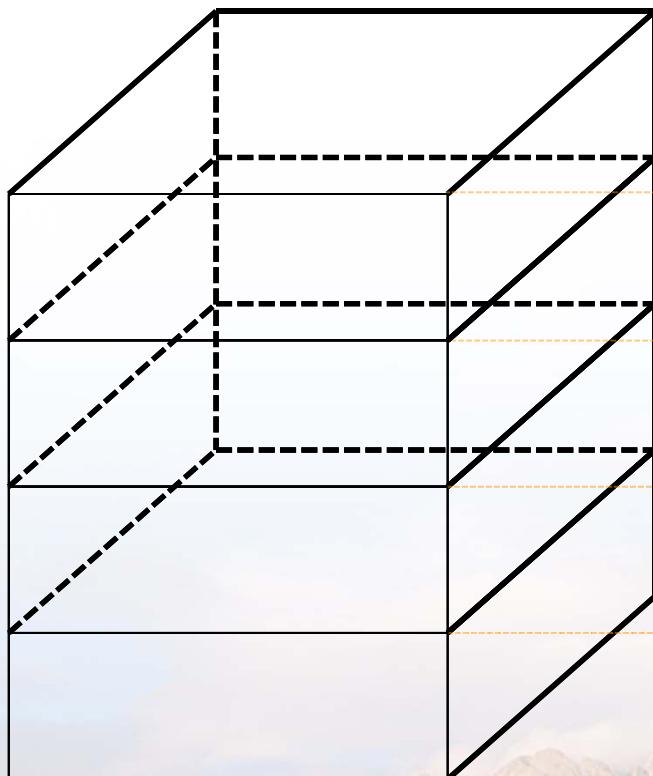


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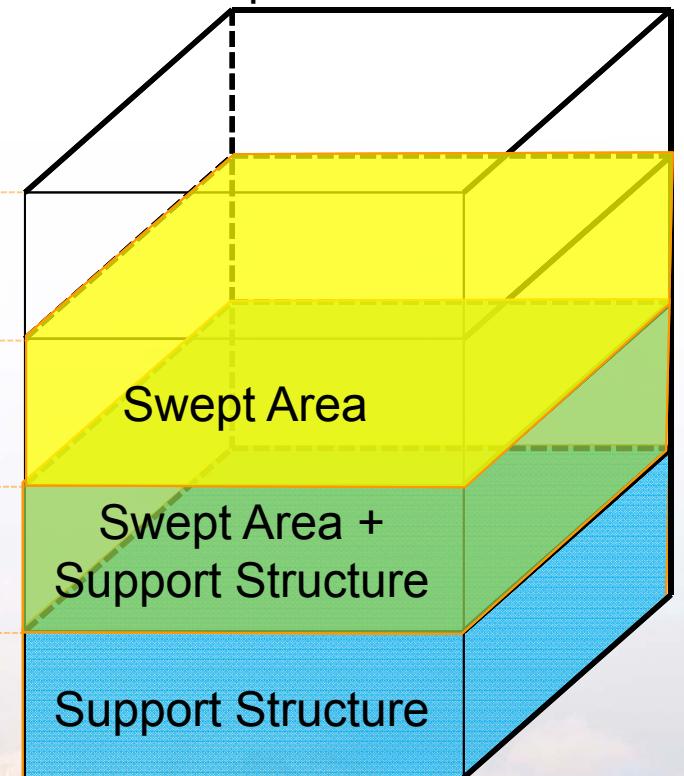
# Porous Approximation

- MHK can be represented with multiple cells or contained within a single cell
- MHK can occupy an entire cell or a fraction of a cell

Hydrodynamic Model Grid



Hydrodynamic Model Grid  
+  
SNL-EFDC Turbine  
Representation



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***Save the Model Run it Later...***



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