



U.S. ARMY



COASTAL MODELING SYSTEM: ADVANCED TOPICS USING CMS 5.1 AND SMS 13.0

DAY 2: USING STRUCTURES WITH CMS

DEMO WITH WEIRS AND RUBBLE MOUND JETTIES

Mitchell Brown, Honghai Li

Rubble Mound Jetties

CHETN-IV-93
August 2013



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Implementation of Structures in the CMS: Part I, Rubble Mound

Weirs

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Implementation of Structures in the CMS: Part II, Weir

Culverts

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Implementation of Structures in the CMS: Part III, Culvert

Tide Gates

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Implementation of Structures in the CMS: Part IV, Tide Gate

by Honghai Li, Alejandro Sanchez, and Weiming Wu

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes the mathematical formulation, numerical implementation, and input specifications of tide gates in the Coastal Modeling System (CMS) operated through the Surface-water Modeling System (SMS). A coastal application at an idealized inlet is provided to illustrate the implementation procedure and demonstrate the model capability.

INTRODUCTION: A tide gate is an opening structure built across a river or a channel in an estuarine system. By preventing saltwater intrusion to farm land and allowing freshwater drainage to the estuary, tide gates are commonly used for flow and flooding control, and salinity



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Documentation for Structures in CMS

Rubble Mound Jetties – CHETN IV-93

<https://erdc-library.erdc.dren.mil/xmlui/handle/11681/1989>

Weirs – CHETN IV-94

<https://erdc-library.erdc.dren.mil/xmlui/handle/11681/1991>

Culverts – CHETN IV-95

<https://erdc-library.erdc.dren.mil/xmlui/handle/11681/1983>

Tide Gates – CHETN IV-96

<https://erdc-library.erdc.dren.mil/xmlui/handle/11681/2000>



Options for Weir Structures

			CMS Cardname
Method for Calculating Flux	1 - Approach 1	2 - Approach 2	METH
Weir Coefficient	Pair of Values Required for each Weir [bay to sea] [sea to bay]		FLOW_COEFFICEINT
Crest Elevation (m) [positive Upward]	Values Required		CREST_ELEVATION
Weir Type	1 – Broad 2 – Sharp-crested	N/A	TYPE
Distribution Coefficient	Values Required	N/A	DISTRIBUTION_COEFFICIENT
Orientation [direction of sea side]	1-North, 2-East, 3-South, 4-West		ORIENTATION

Approach 1 follows the standard weir equation for a rectangular cross-section, where:

Q is the flow rate over the weir crest,

C_w is the weir coefficient,

L_w is the weir crest length,

h is the upstream water depth above the crest,

C_{dw} is the submergence correction factor

$$Q = C_{df} C_w L_w h^{1.5}$$

Approach 2 treats structure cells as normal flow cells by adding resistance force terms induced by weir structures in the depth-averaged momentum equations.

Weir Example - Open “Weir\StartFiles” folder and load project file



SMS 13.0.9 (64-bit) - [RudeeWeir.sms]

File Edit Display Data Cells Window Help

Project

- Quadtree Data
- Rudee_Weir
 - Z
 - ManningsN
- Map Data
 - Area Property
 - Boundary Conditions
 - Activity
- Simulation Data
 - CMS-Flow Simulations
 - Weir
 - Rudee_Weir
 - Boundary Conditions
 - Activity

StartFiles

File Home Share View

Pin to Quick access Copy Paste Cut Copy path Paste shortcut Move to Copy to Delete Rename New folder New item Easy access Properties Open Select all Select none Invert selection

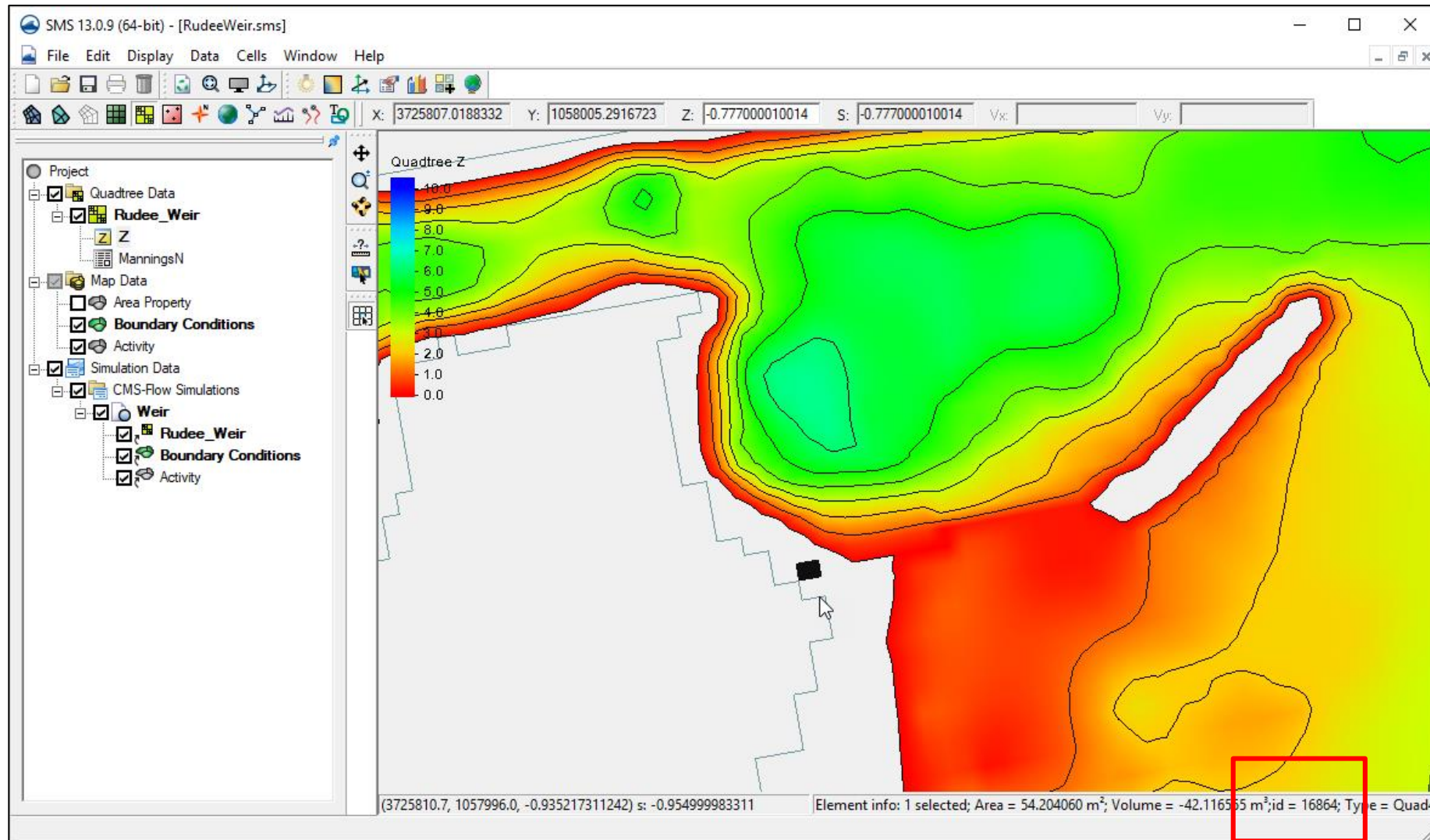
« Brown » !Data » CIRP » IFY19 » Webinars » AdvCMS » Day2 » StartFiles

Name	Date modified	Type	Size
RudeeWeir_datasets	9/9/2019 4:54 PM	File folder	
RudeeWeir.map	9/9/2019 4:54 PM	MAP File	226 KB
RudeeWeir.materials	9/9/2019 4:54 PM	MATERIALS File	1 KB
RudeeWeir.sms	9/9/2019 4:54 PM	SMS File	164 KB
RudeeWeir_dynamicDb.db3	9/9/2019 4:47 PM	DB3 File	688 KB
RudeeWeir_quadtrees.h5	9/9/2019 4:54 PM	H5 File	8,598 KB
RudeeWeir_quadtrees_1.vtu	9/9/2019 4:54 PM	VTU File	1,232 KB

7 items 1 item selected 163 KB

Grid with bathymetry and boundary conditions has already been created and saved.

Gather Cell IDs for Weir location(s)



Click each cell which will be part of a weir and note the Cell ID at the bottom of the screen.



Add Weir options/parameter values to “advanced.cmcards” file. **Note: This file must be in same directory as exported CMS files from project.**

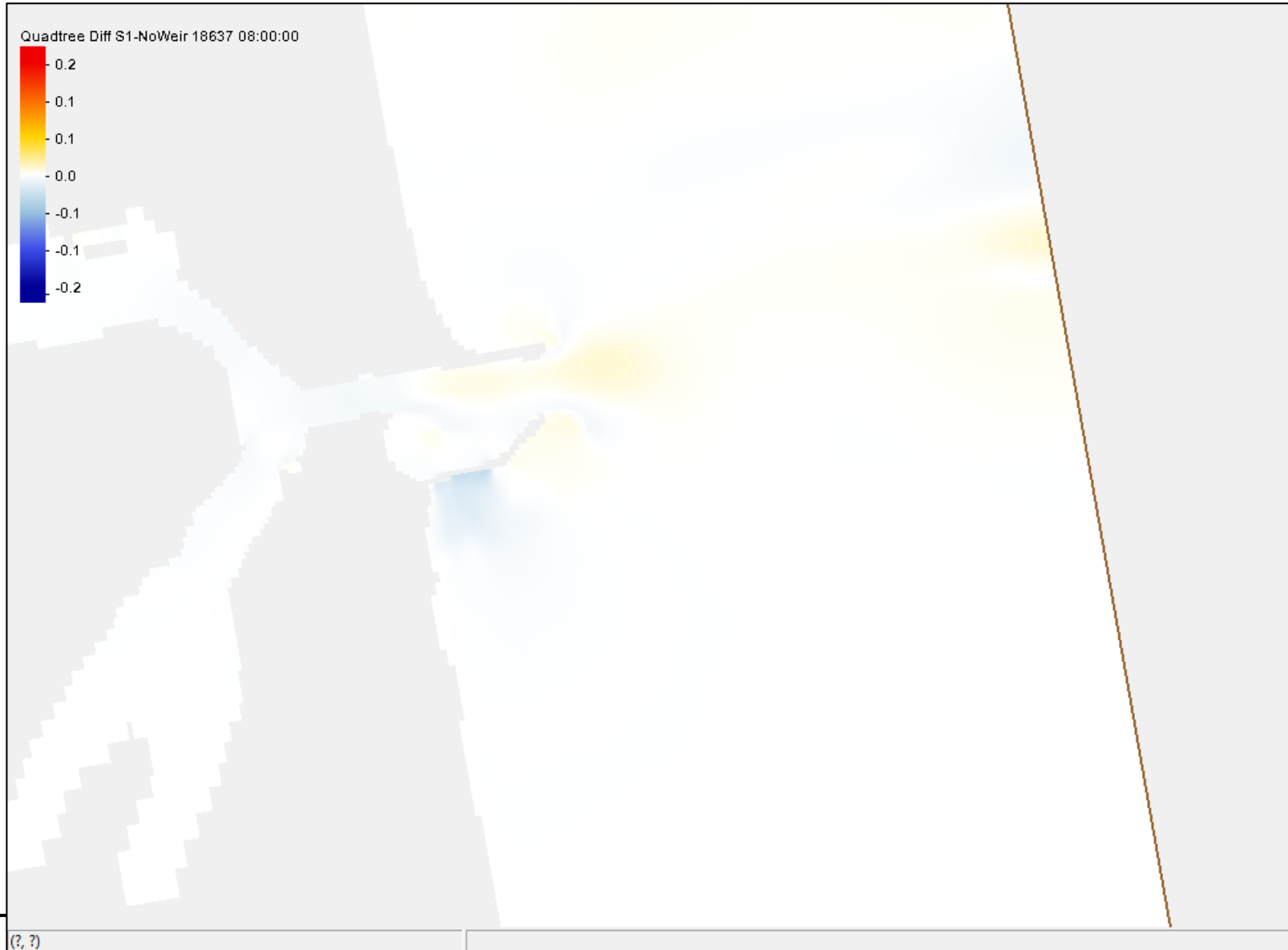
```

1 WEIR_BEGIN
2   NUMBER_WEIRS 2
3   NUM_CELL_WEIRS 8 8
4   CELLS 16864 16865 16866 16867 16868 16869 16870 16871 17247 17248 17249 17250 17251 17252 17253 17254
5   DISTRIBUTION_COEFFICIENT 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
6   ORIENTATION 3 3
7   TYPE 2 2
8   FLOW_COEFFICIENT 0.46 0.46 0.46 0.46
9   CREST_ELEVATION 0.0 -0.22
10  METH 1 1
11 WEIR_END

```

- In this example, there are two weirs, consisting of 8 cells each.
- The Cell IDs are listed in sequence for each weir all on the same ‘CELLS’ line.
- The Distribution Coefficient for each cell is given in the same order of the Cell IDs.
- Direction of the sea side (Orientation) for each weir is given. [1- North, 2- East, 3- South, 4- West]
- Type of each weir [1- Sharp-crested, 2- Broad-crested]
- Pairs of Flow Coefficient for each weir is given [Bay-to-Sea, followed by Sea-to-Bay]
- Crest Elevation (m) is also given [Positive values are upward water surface]
- Approach 1 is being used for both weirs [METH 1 1]

Save, export, and launch the simulation



After the simulation is complete, the solutions can be viewed and any comparisons made



Options for Rubble Mound Structures

	CMS Cardname for Dataset
Cell IDs for segment	RUBBLE_MOUND_DATASET
Rock Diameter [m]	ROCK_DIAMETER_DATASET
Porosity of Rubble Mound segment	STRUCTURE_POROSITY_DATASET
Depth of Base [m]	STRUCTURE_BASE_DEPTH_DATASET
Method Type [1, 2, or 3]	FORCHHEIMER_COEFF_METHOD_DATASET

Calculation of Forchheimer a and b coefficients
(D= rock diameter, n=porosity, v= water kinematic viscosity)

Method 1 uses the Sidiropoulou method (2007):

$$a = 0.0033D^{-1.5}n^{0.06} \text{ and } b = 0.194D^{-1.265}n^{-1.14}$$

Method 2 uses the Kadlec and Knight method (1996):

$$a = \frac{255v(1-n)}{gn^{3.7}D^2} \text{ and } b = \frac{2(1-n)}{gn^3D}$$

Method 3 uses the Ward method (1964):

$$a = \frac{360v}{gD^2} \text{ and } b = \frac{10.44}{gD}$$

Rubble Mound Example - Open “RubbleMound\StartFiles” folder and load project file



SMS 13.0.9 (64-bit) - [DanaPt_RM_test.sms]

File Edit Display Feature Objects Window Help

Project

- Quadtree Data
 - dana-pt
 - Z
 - D50
 - Hard Bottom
 - ManningsN
- Map Data
 - Area Property
 - Boundary Conditions
 - Activity
- Simulation Data
 - CMS-Flow Simulations
 - RubbleMound_Test
 - dana-pt
 - Boundary Conditions
 - Activity

Quadtree Z

116.0
92.0
68.0
44.0
20.0
-4.0
-28.0
-52.0
-76.0
-100.0

StartFiles

File Home Share View

Pin to Quick access Copy Paste Cut Copy path Move to Copy to Delete Rename New folder New item Easy access Properties Open Select all Select none Invert selection

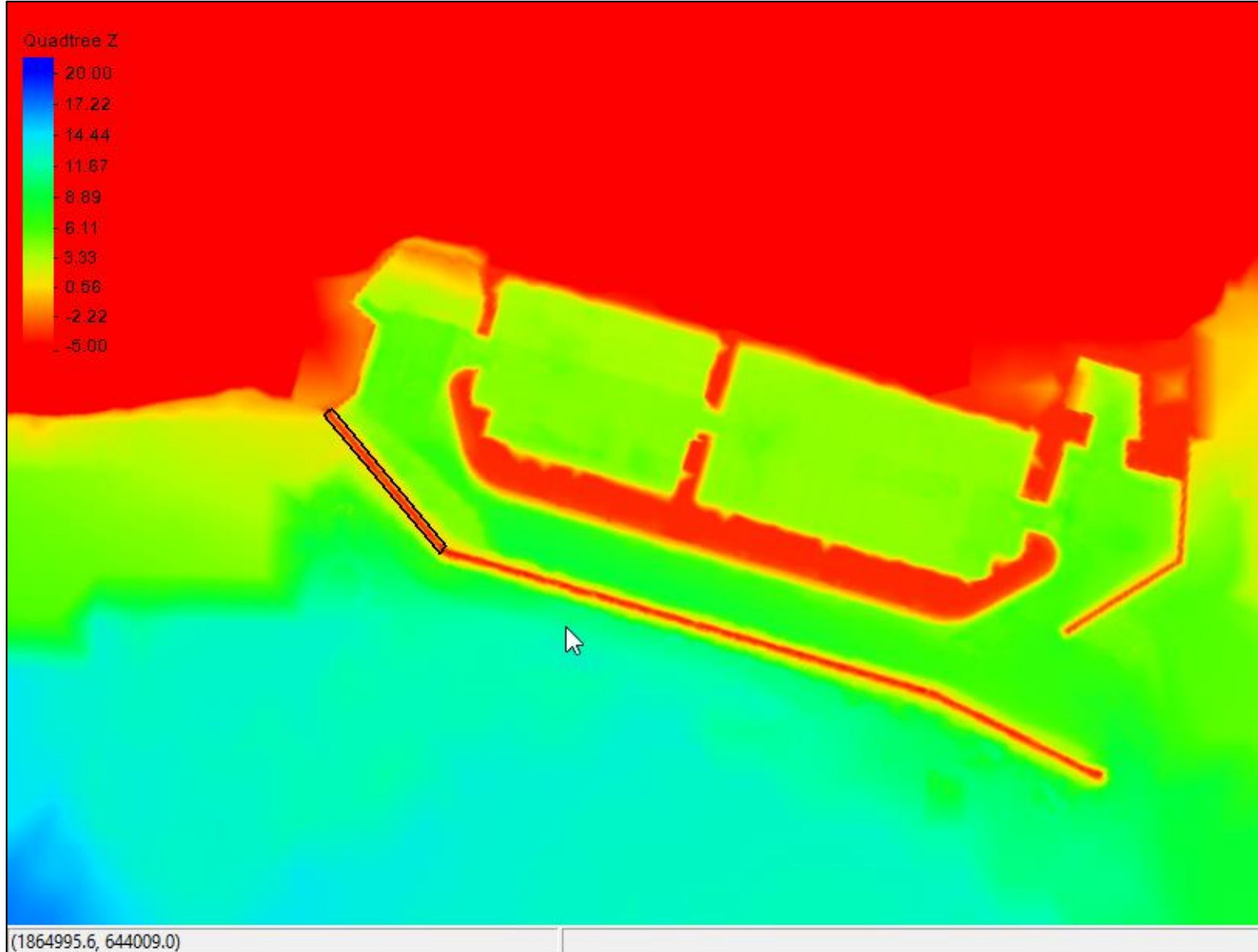
Clipboard Organize New Open Select

My Passport (E:) > !AdvWebinar > Day2 > RubbleMound > StartFiles

Name	Date modified	Type	Size
DanaPt_RM_test_datasets	9/16/2019 5:00 PM	File folder	
DanaPt_RM_test.map	9/16/2019 5:00 PM	MAP File	216 KB
DanaPt_RM_test.materials	9/16/2019 5:00 PM	MATERIALS File	1 KB
DanaPt_RM_test.sms	9/16/2019 5:00 PM	SMS File	164 KB
DanaPt_RM_test_dynamicDb.db3	9/16/2019 4:57 PM	DB3 File	720 KB
DanaPt_RM_test_quadtree.h5	9/16/2019 5:00 PM	H5 File	9,280 KB
DanaPt_RM_test_quadtree_1.vtu	9/16/2019 5:00 PM	VTU File	4,113 KB

7 items 1 item selected 163 KB

Define areas for Rubble Mound Jetty location

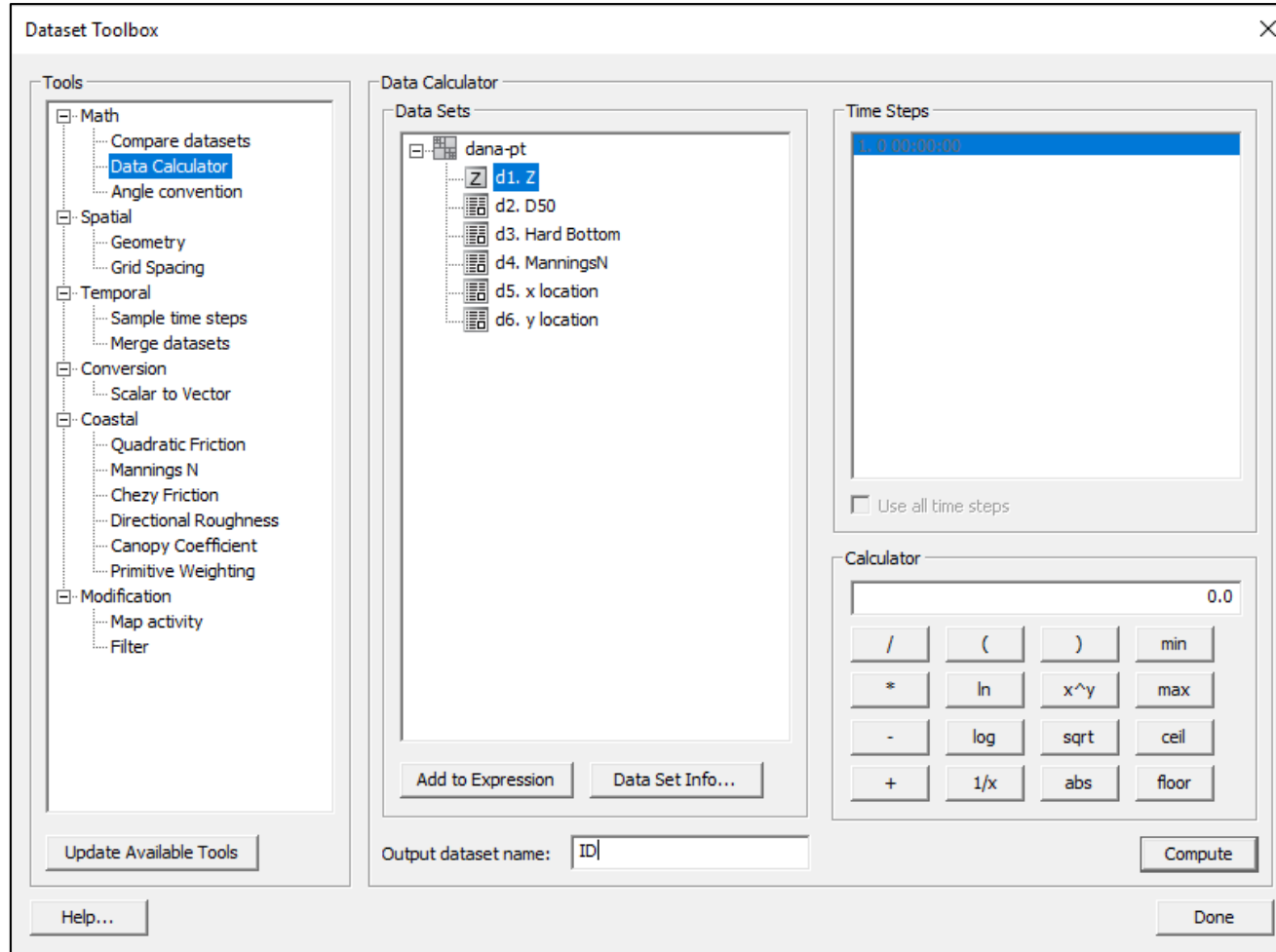


Create one coverage in Map Module of any type (default is “Area Property”).

Define arcs and build polygons for Rubble Mound location(s)

Feature polygons can also come in from ArcGIS shape files.

Create datasets to specify values for structure parameters

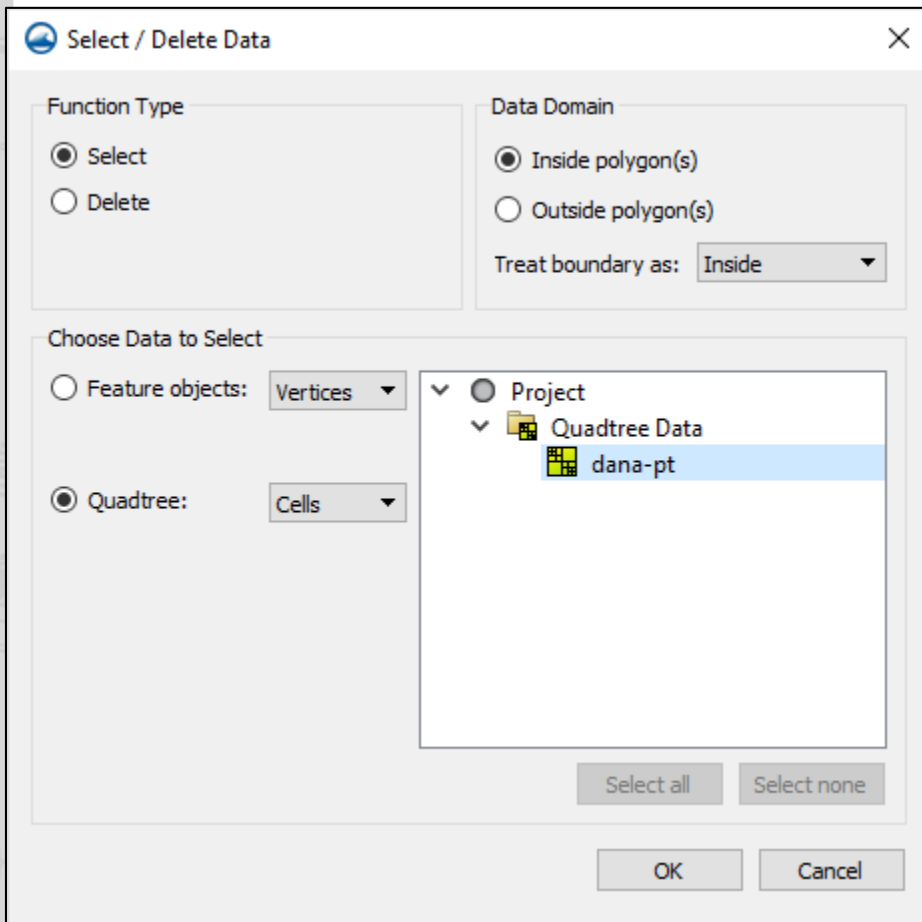


Using the Data Calculator, create datasets to specify the Cell IDs, Rock Diameter, Porosity, Base Depth, and Method.

Set the default value for each to 0.0.

Later steps will modify the values for each dataset depending on type.

Select cells from polygons and modify values



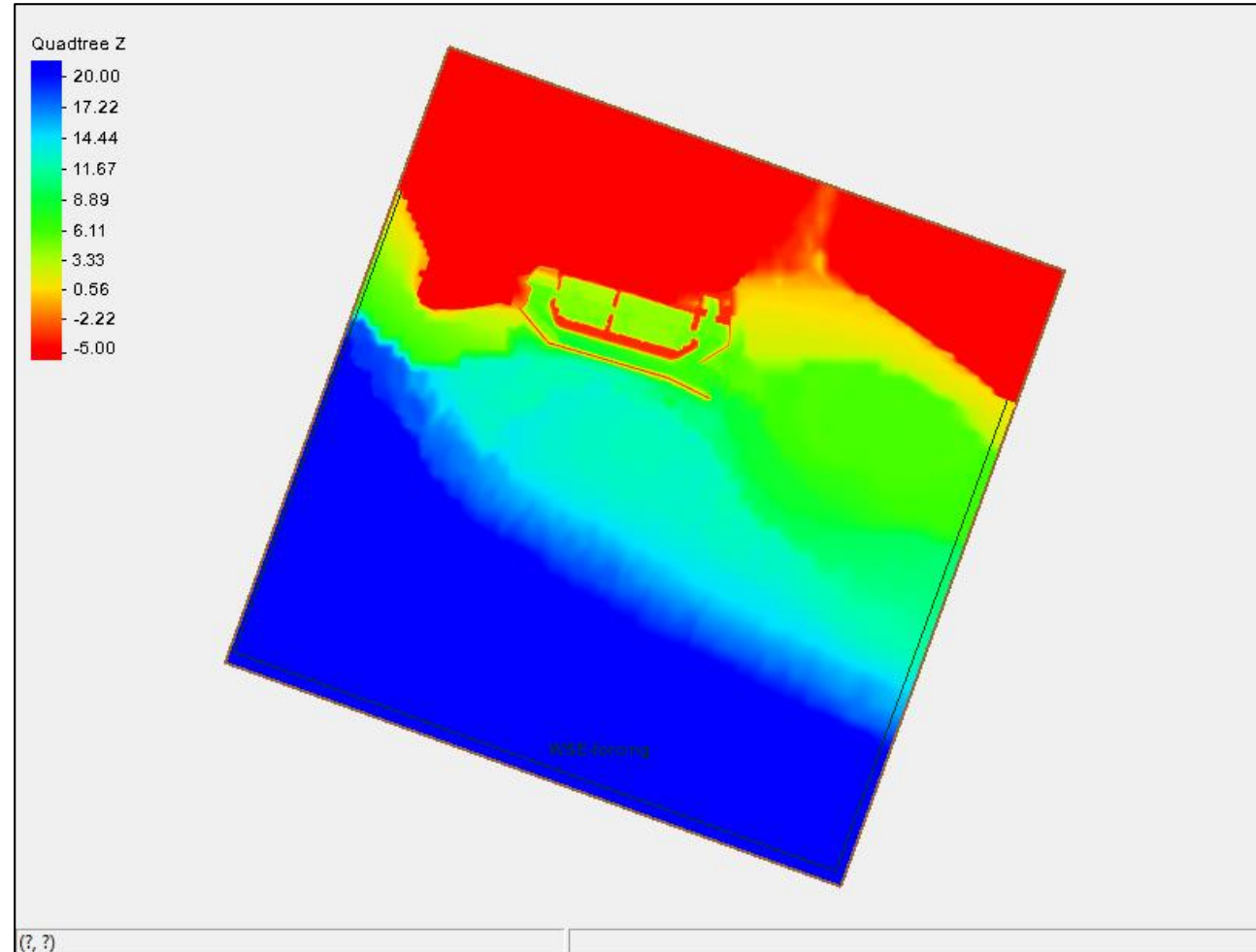
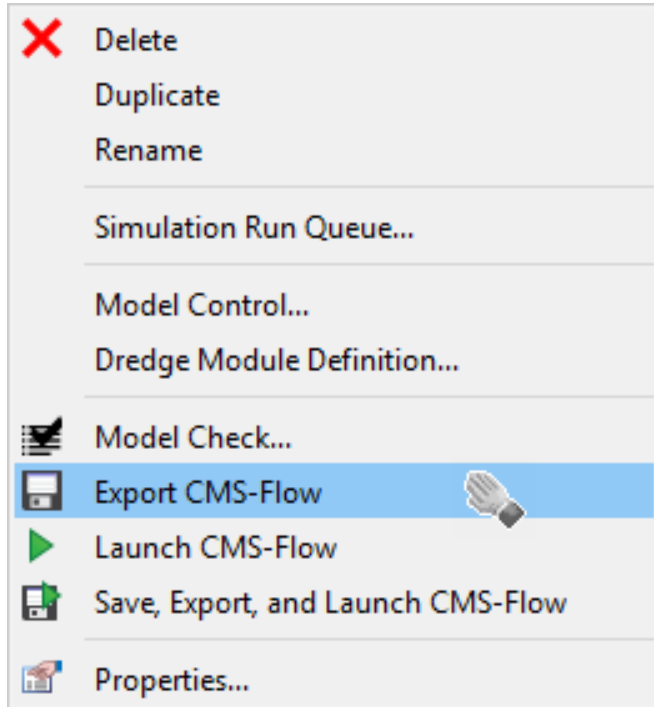
1.0

For each polygon, select the cells from the CMS grid and modify the values.

- Select polygon, then Feature objects | Select/Delete data
 - “Select”, “Inside Polygon”, “Quadtrees | Cells”
 - Select correct Grid, then click OK.
- Then, click the appropriate dataset in the data tree and modify the Scalar value.

For ID, set the value for each cell to 1.
 For Method, set values to 1, 2 or 3. [1]
 For others, use the Porosity [0.2], Rock Diameter [1.5], or Base Depth [2.0], as needed.

Go through Model Control and set values, then Save project and Export files.





Add RM options/parameter values to “advanced.cmcards” file. **Note: This file must be in same directory as exported CMS files from project.**

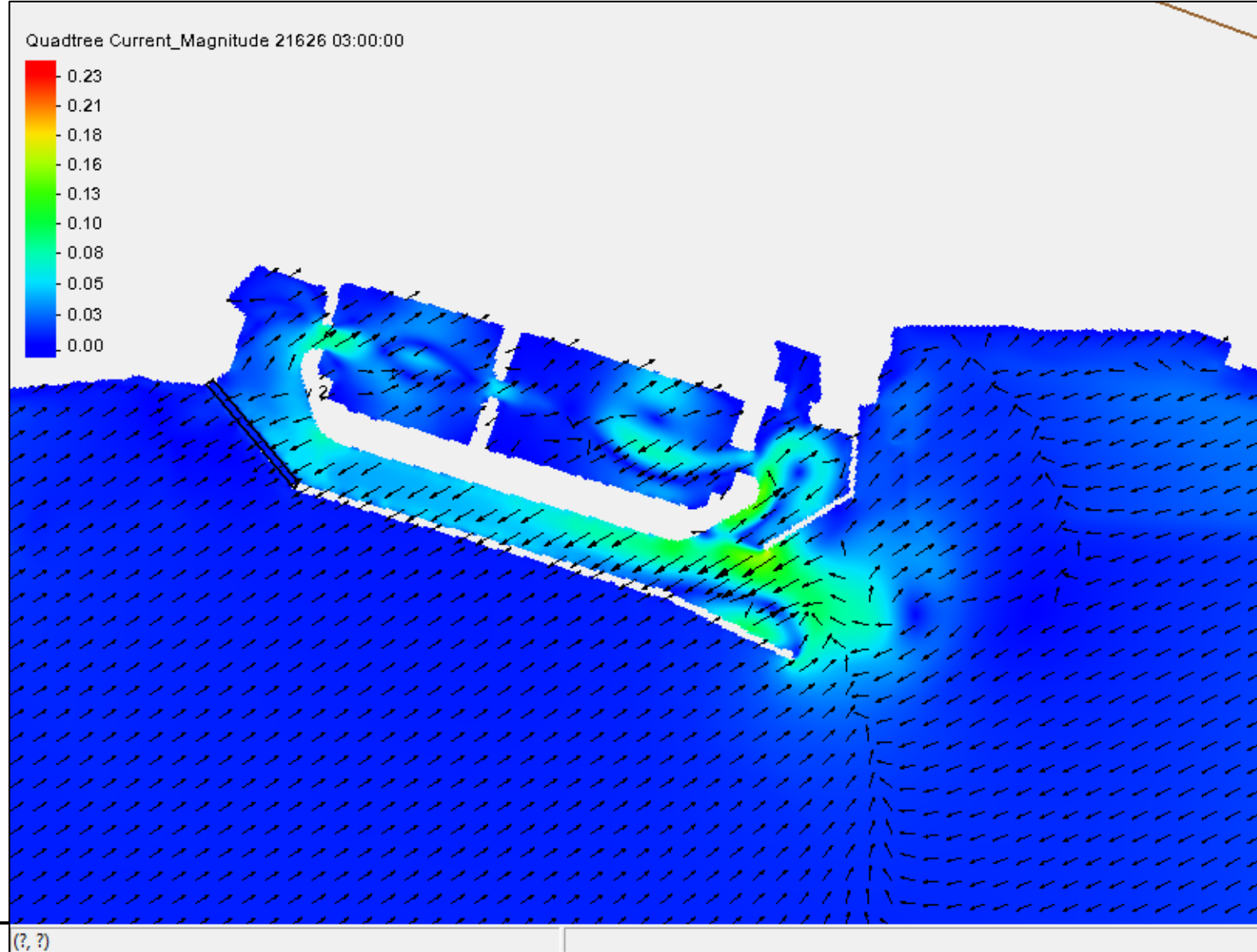
```

1 RUBBLE_MOUND_BEGIN
2   RUBBLE_MOUND_DATASET           "dana-pt_ID.h5"         "Datasets/ID"
3   ROCK_DIAMETER_DATASET          "dana-pt_Rock_D.h5"      "Datasets/Rock_D"
4   STRUCTURE_POROSITY_DATASET      "dana-pt_Porosity.h5"   "Datasets/Porosity"
5   STRUCTURE_BASE_DEPTH_DATASET    "dana-pt_Base_D.h5"     "Datasets/Base_D"
6   FORCHHEIMER_COEFF_METHOD_DATASET "dana-pt_Method.h5"    "Datasets/Method"
7 RUBBLE_MOUND_END
  
```

Datasets that were created are saved under the “[project]_datasets” folder. User must either:

- 1) Copy needed files from that folder to the CMS folder, or
- 2) Specify relative path (ie. “..\..\..\DataPt_RM_test_datasets\data-pt_ID.h5”)

Save, export, and launch the simulation



After the simulation is complete, the solutions can be viewed and any comparisons made

Structures Interface planned for **SMS 13.1**



New interface

Rudee Inlet, VA

Arc Structure Definition

Options

Name: Rudee Inlet

Type: Weir

Distribution Coefficient: 0.95

Sea Side Orientation: South

Weir Type: Sharp Crested

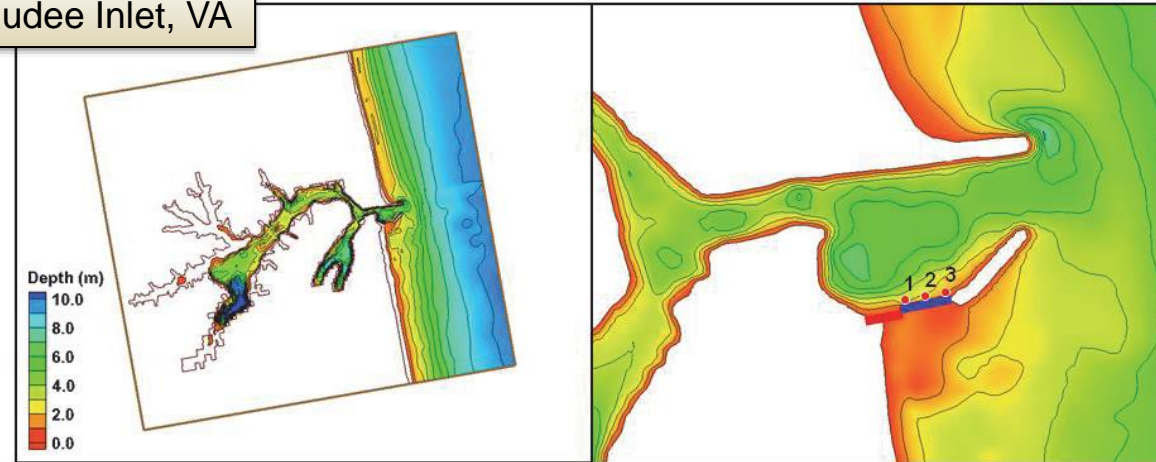
Bay to Sea Flow Coefficient: 0.46

Sea to Bay Flow Coefficient: 0.46

Crest Elevation (positive is upward): 0.0

Weir Method: Approach 1

Help... OK Cancel



Weir Example – Rudee Inlet, VA

Before – User had to search and keep track of every cell ID that makes up each weir. Parameter values were assigned using advanced cards. Had to know the exact values associated with different parameter options.

After – User will have a nice interface to describe the weir properties assigned to feature arcs. Drop-down selection boxes for options. The information automatically gets written to the parameter file after Save.