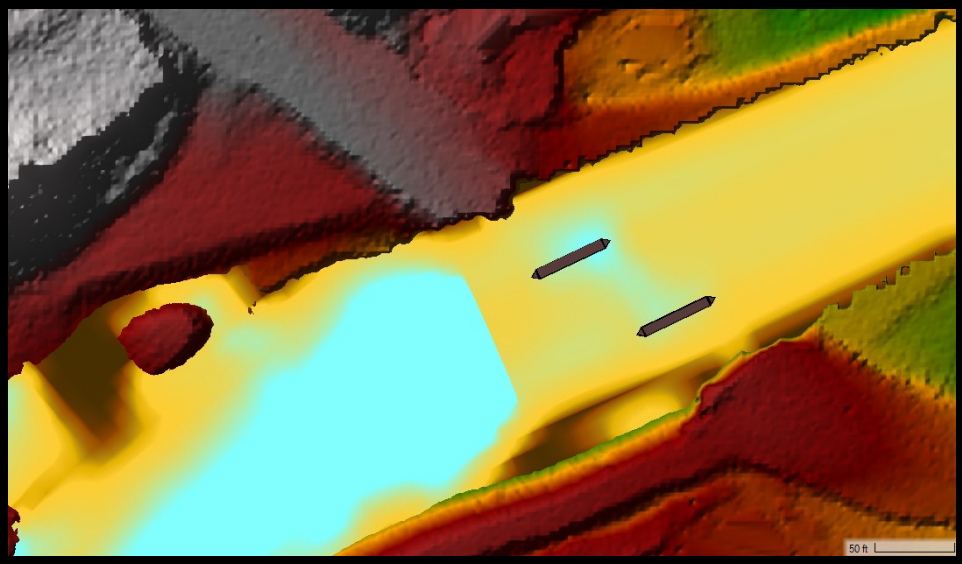
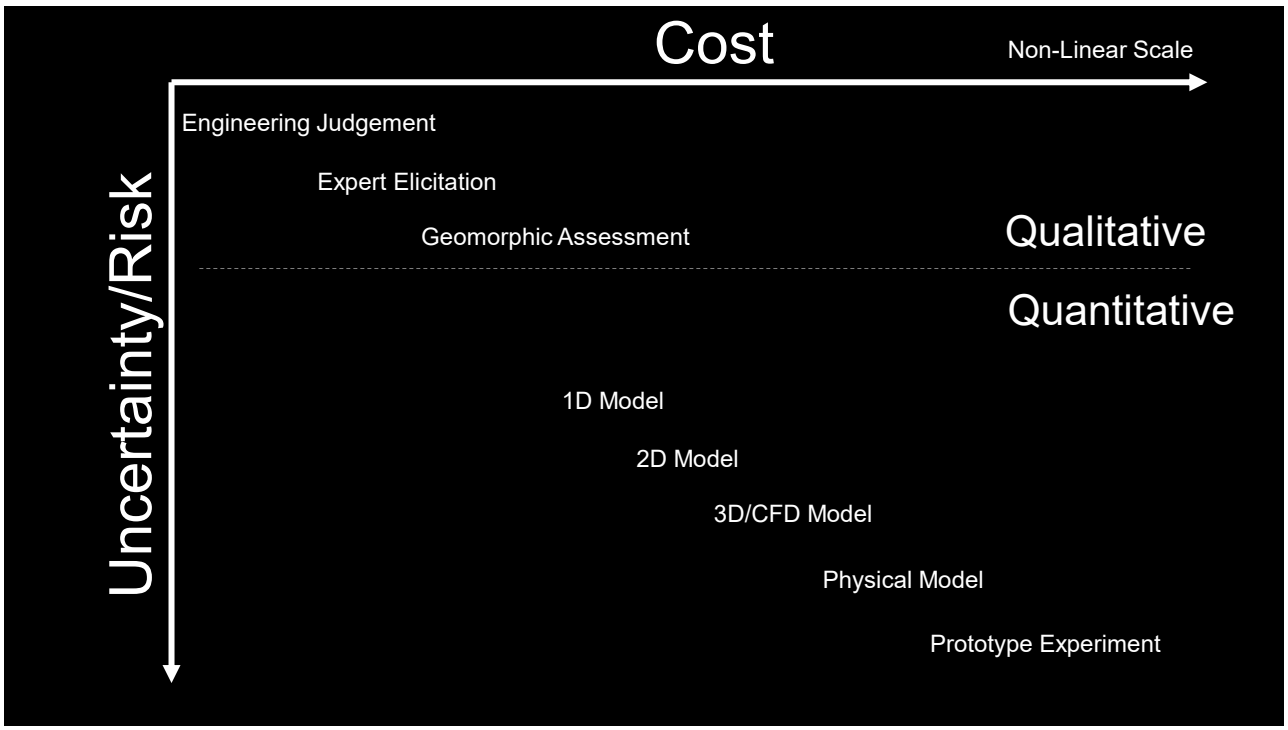
Fixed Bed Sediment Modeling



Stanford Gibson, PhD
Alex Sánchez, PhD

1



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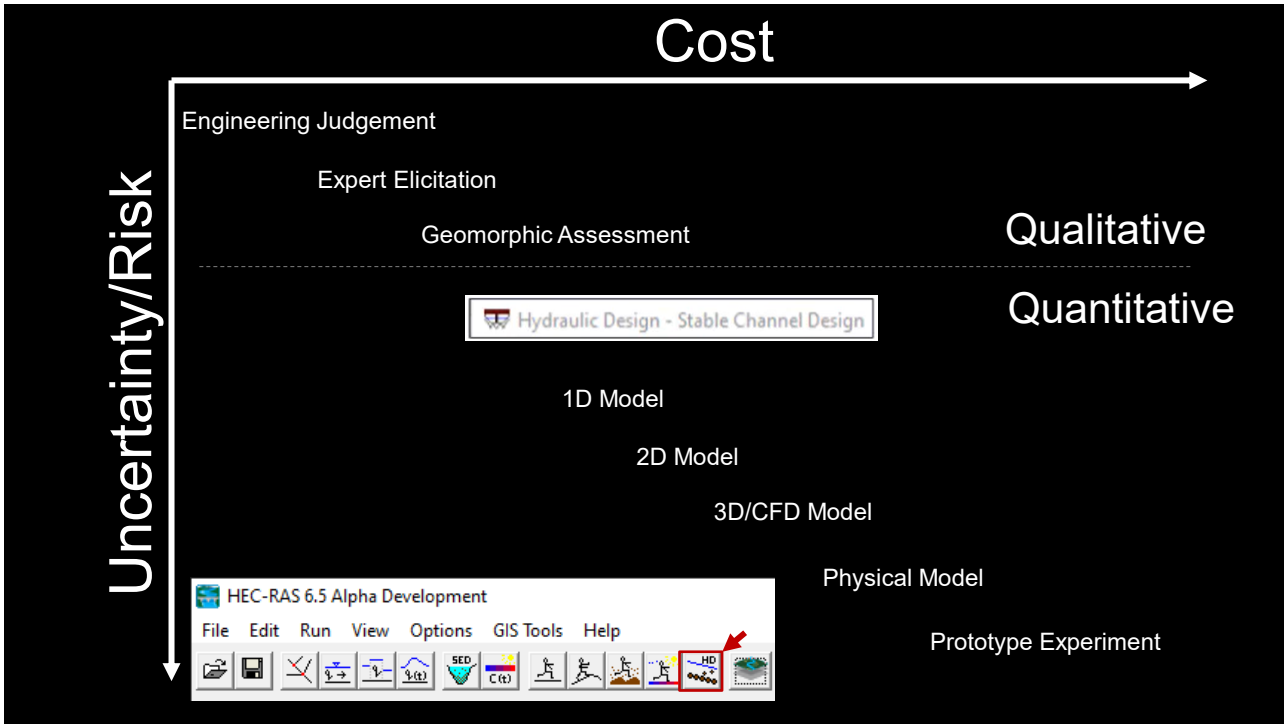


3

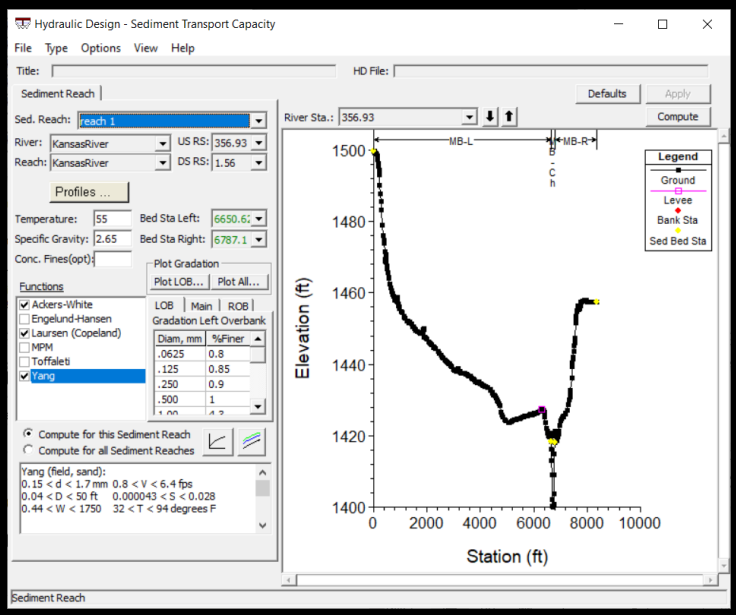
Iao Sediment Study

Debris Basin | High Gradient Concrete Channel | Alluvial (Eroding, Leveed) Reach | Low Gradient Concrete Channel

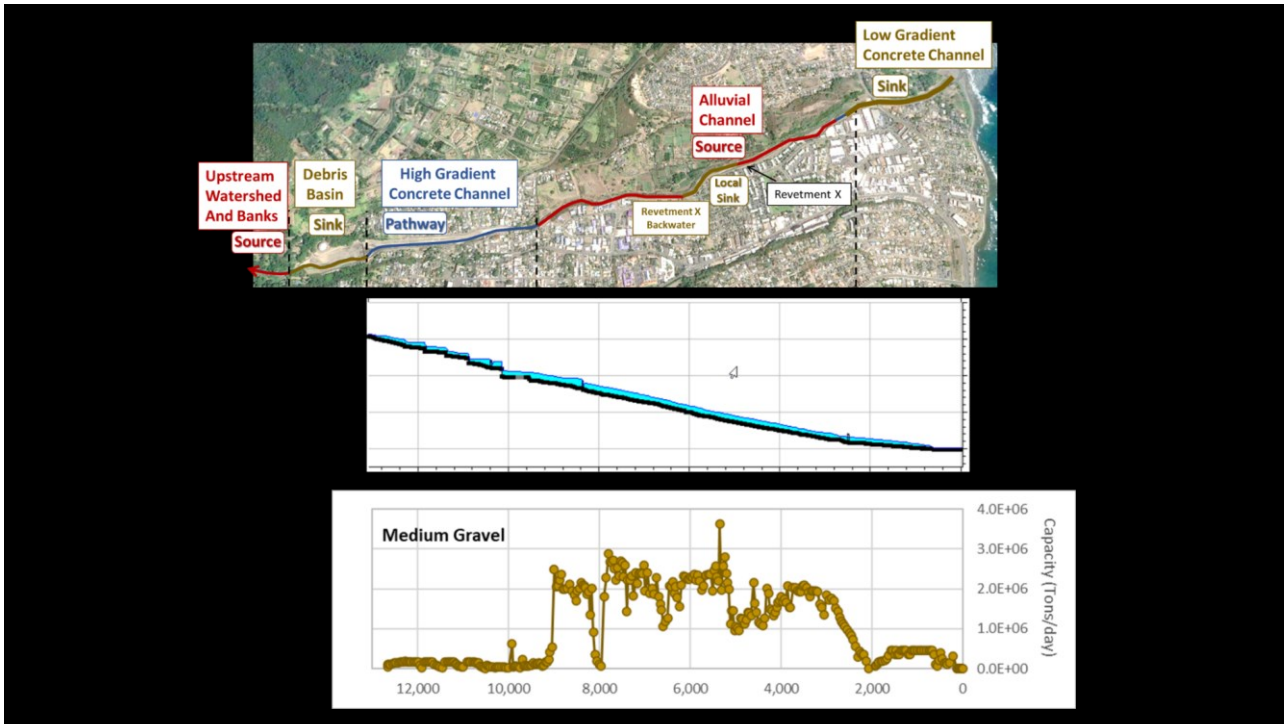
4

5

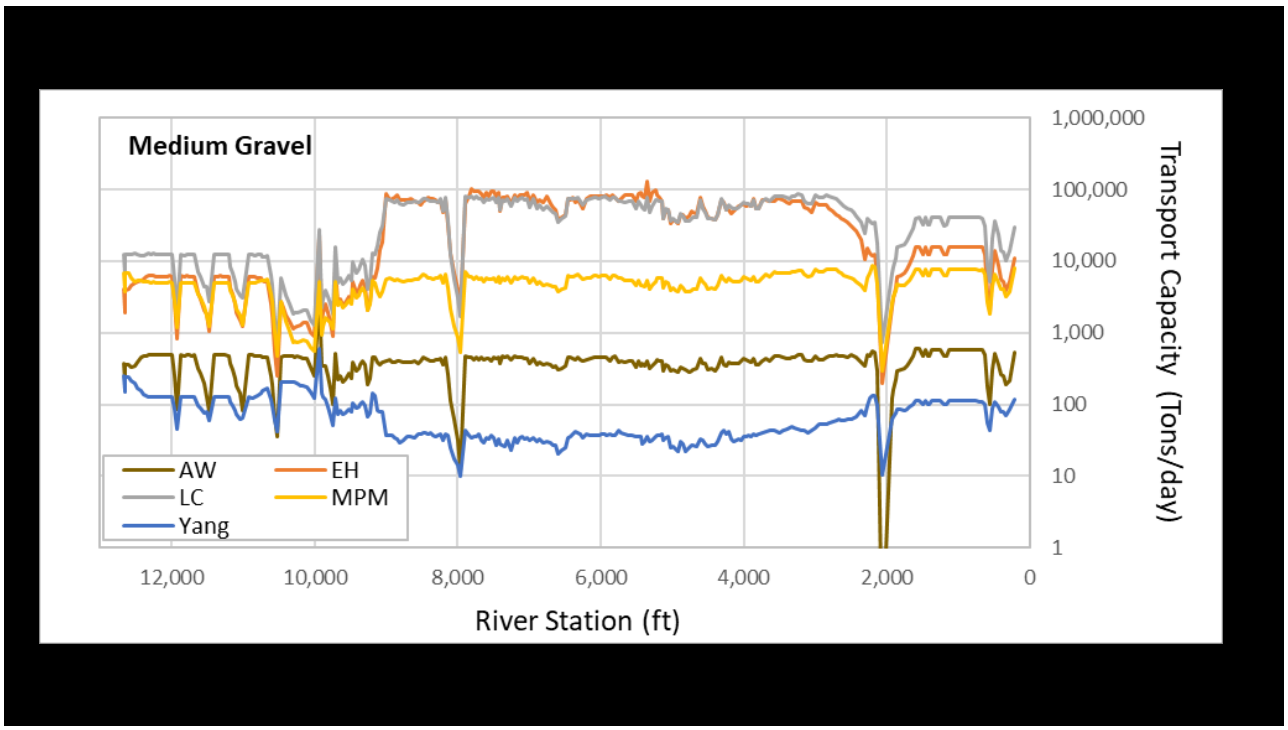
1D Sediment Transport Capacity Calculator



6

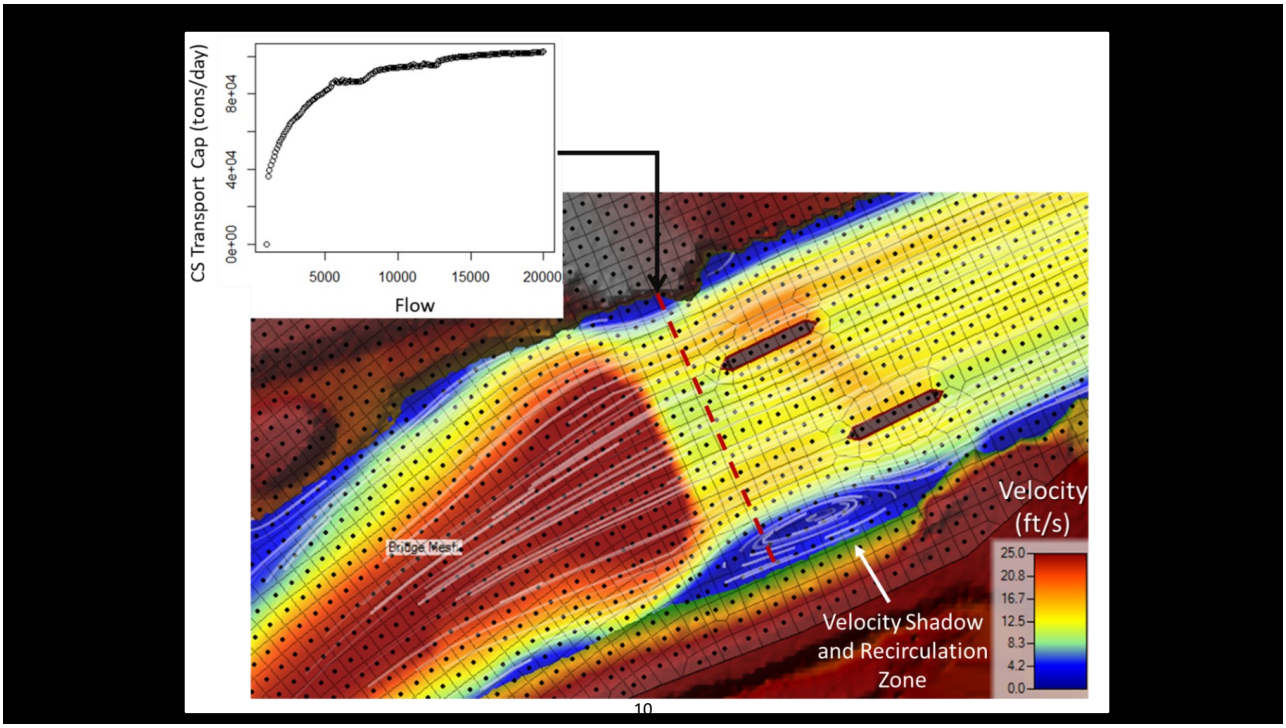

Low Gradient Concrete Channel
Sink
Alluvial Channel
Source
Upstream Watershed And Banks
Source
Debris Basin
Sink
High Gradient Concrete Channel
Pathway
Local Sink
Revetment X
Revetment X Backwater
Medium Gravel
4.0E+06
3.0E+06
2.0E+06
1.0E+06
0.0E+00
Capacity (Tons/day)
12,000
10,000
8,000
6,000
4,000
2,000
0

7

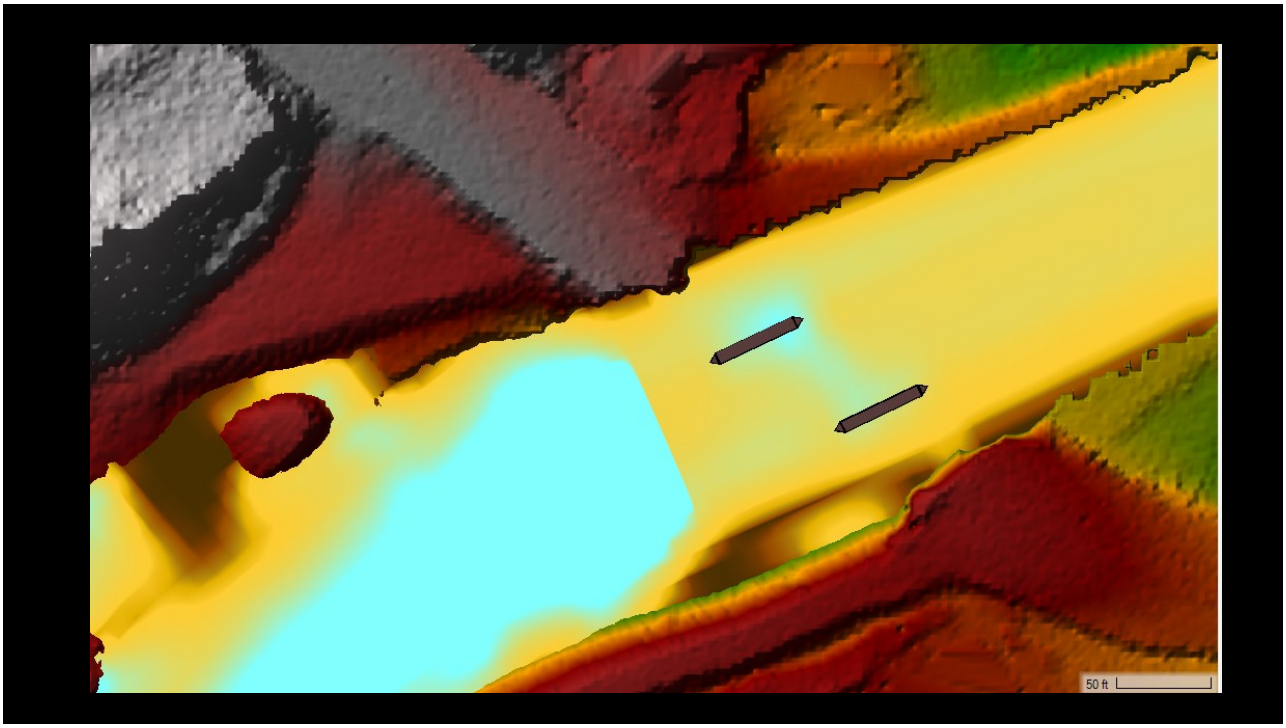

Medium Gravel
AW
EH
LC
MPM
Yang
1,000,000
100,000
10,000
1,000
100
10
1
Transport Capacity (Tons/day)
12,000
10,000
8,000
6,000
4,000
2,000
0
River Station (ft)

8

9


CS Transport Cap (tons/day)
0e+00
4e+04
8e+04
5000
10000
15000
20000
Flow
Bridge Mesh
Velocity
(ft/s)
25.0
20.8
16.7
12.5
8.3
4.2
0.0
Velocity Shadow
and Recirculation
Zone
10

10

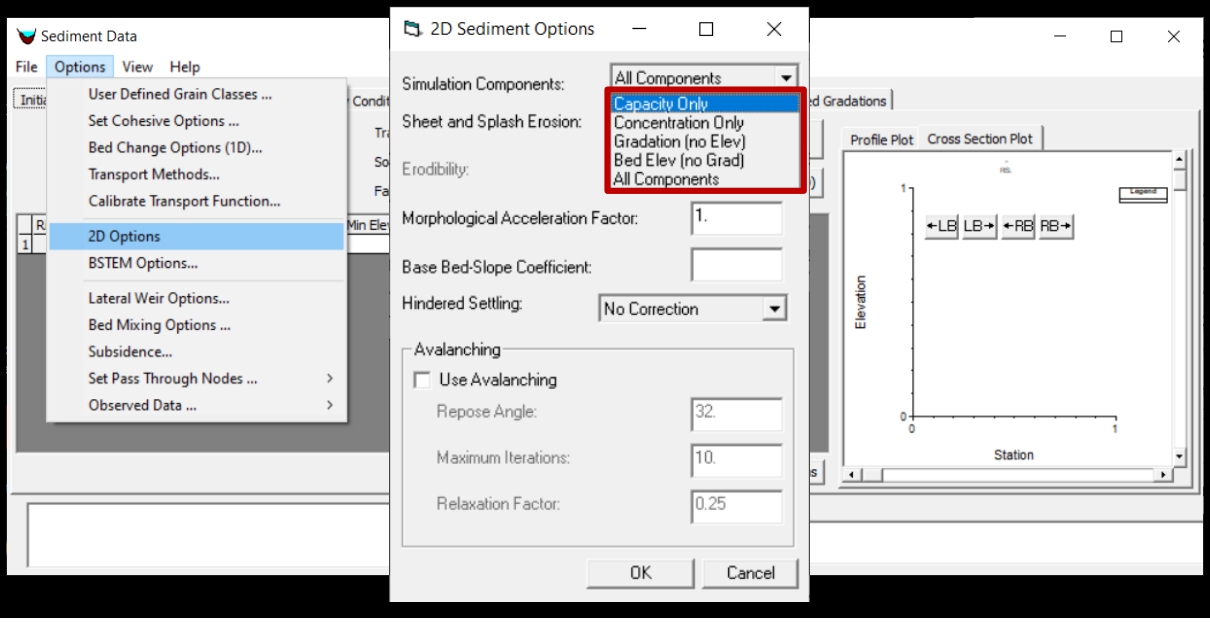


11

12

13

Fixed Bed Sediment Modeling Approaches



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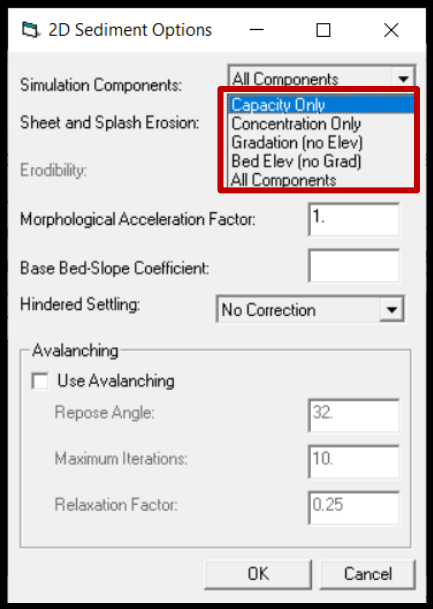
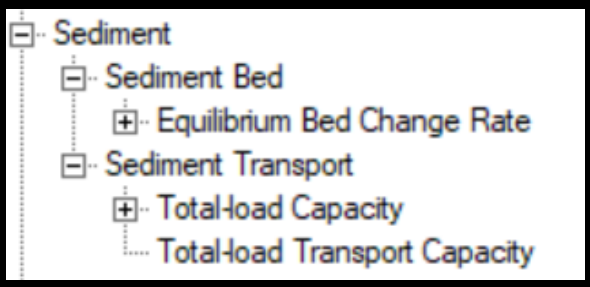
Fixed Bed Sediment Modeling Approaches



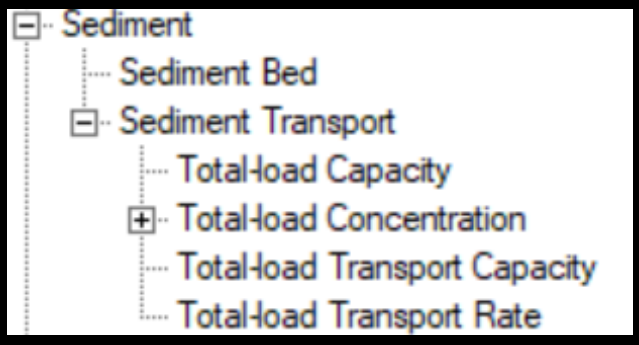
Capacity Only	Concentration Only
Solves Transport Eqn	Solves Transport Eqn + AD
Needs Bed Gradations	Needs Bed Gradations
Does not use BCs	Routs Boundary Condition
Does not Compute Deposition or Erosion	Computes Deposition and Erosion But Does Not Δ Bed Elev or Grad

15

Capacity Only



Concentration Only



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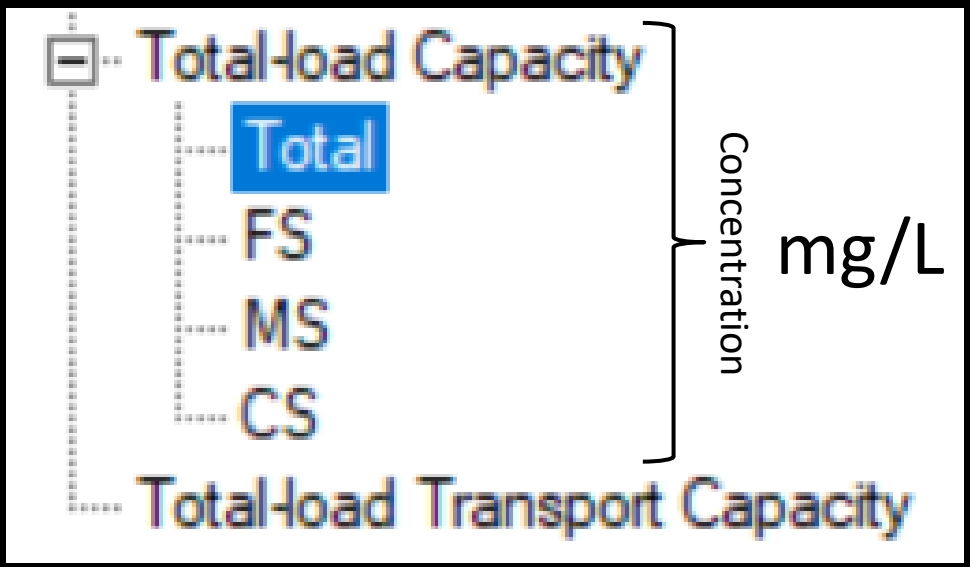
Capacity Units



Unit Flux
mass/time/length
lb/s/ft
kg/s/m

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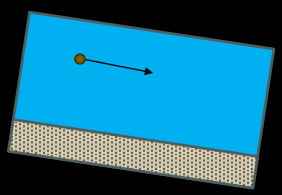
Governing Sediment Equations

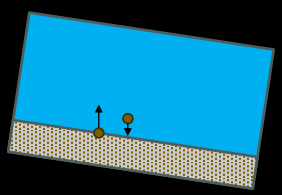
- Total-load Transport Equation

$$\frac{\partial}{\partial t}\left(\frac{hC_{tk}}{\beta_{tk}}\right) + \nabla \cdot (h\mathbf{U}C_{tk}) = \nabla \cdot (\varepsilon_{tk} h \nabla C_{tk}) + E_{tk} - D_{tk}$$



- Bed Change Equation

$$\rho_{sk}(1-\phi_b)\left(\frac{\partial z_b}{\partial t}\right)_k = D_{tk} - E_{tk} + \nabla \cdot (\kappa_{bk}|q_{bk}|\nabla z_b)$$



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All Components

$$\frac{\partial}{\partial t}\left(\frac{hC_{tk}}{\beta_{tk}}\right) + \nabla \cdot (h\mathbf{U}C_{tk}) = \nabla \cdot (\varepsilon_{tk} h \nabla C_{tk}) + E_{tk} - D_{tk}$$

$$\rho_{sk}(1-\phi_b)\left(\frac{\partial z_b}{\partial t}\right)_k = D_{tk} - E_{tk} + \nabla \cdot (\kappa_{bk}|q_{bk}|\nabla z_b)$$

Concentration Only

$$\frac{\partial}{\partial t}\left(\frac{hC_{tk}}{\beta_{tk}}\right) + \nabla \cdot (h\mathbf{U}C_{tk}) = \nabla \cdot (\varepsilon_{tk} h \nabla C_{tk}) + E_{tk} - D_{tk}$$

Capacity Only

$$\rho_{sk}(1-\phi_b)\left(\frac{\partial z_b}{\partial t}\right)_k = D_{tk} - E_{tk} + \nabla \cdot (\kappa_{bk}|q_{bk}|\nabla z_b)$$

19

Technical Leads:
Edmund Howe (SWL)
Kathryn Martin (SWL)

District	Modeler(s)	Pool
HEC/ SWL	Stanford Gibson, Edmund Howe	2
MVM	Grayson Holt, Cole Stonebrook	5
SWL	Katie Martin	8
MVM	Grayson Holt, Cole Stonebrook	10
SWL	Cathy Funkhouser	12
SWL/ HEC	Forrest Kolle/ Brennan Beam	7
SWL	Joshua McLarty	9
SWL	Katie Martin	3
SWL	Katie Martin	4
SWT	Meredith Street	13
SWT	Alex Petersen	15
SWT	Alex Petersen	16

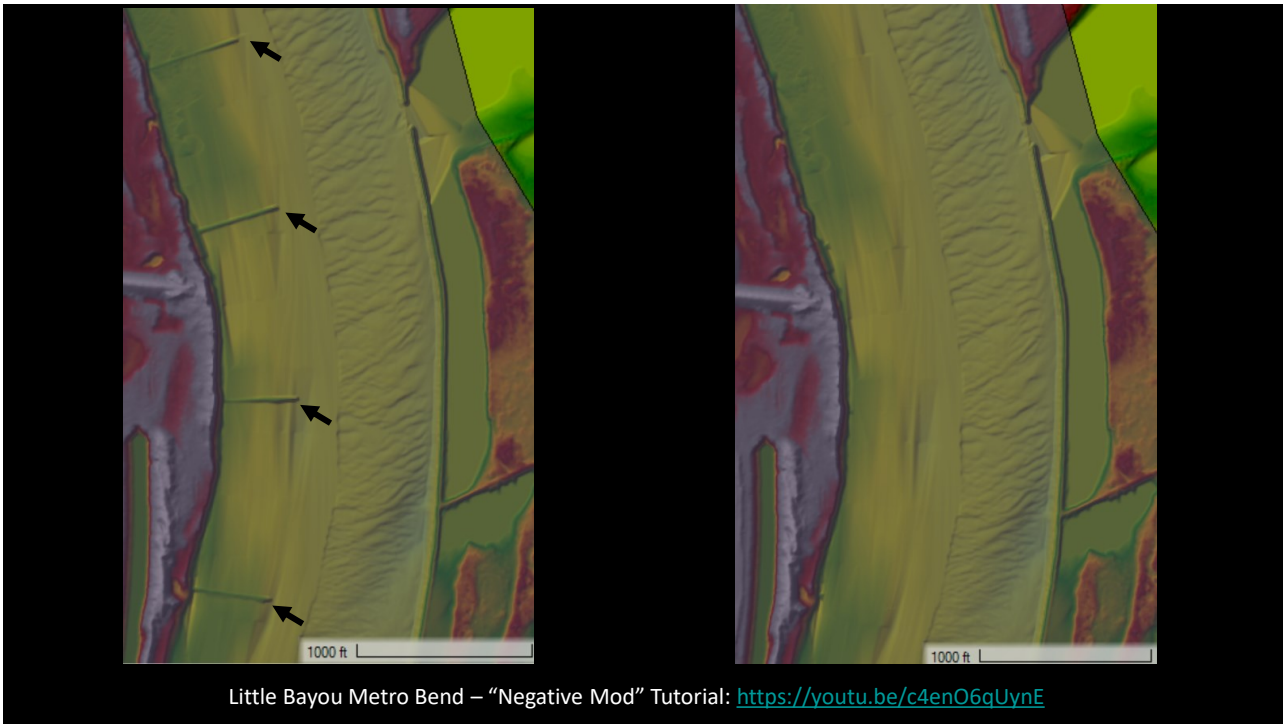
Arkansas River Navigation Project

- 11 Pools/11 Modelers
- 336 Miles/540 km
- 3.1 Million Tons of Rock
- 1,970 Proposed Mods

(from the 2004 Feasibility Study)

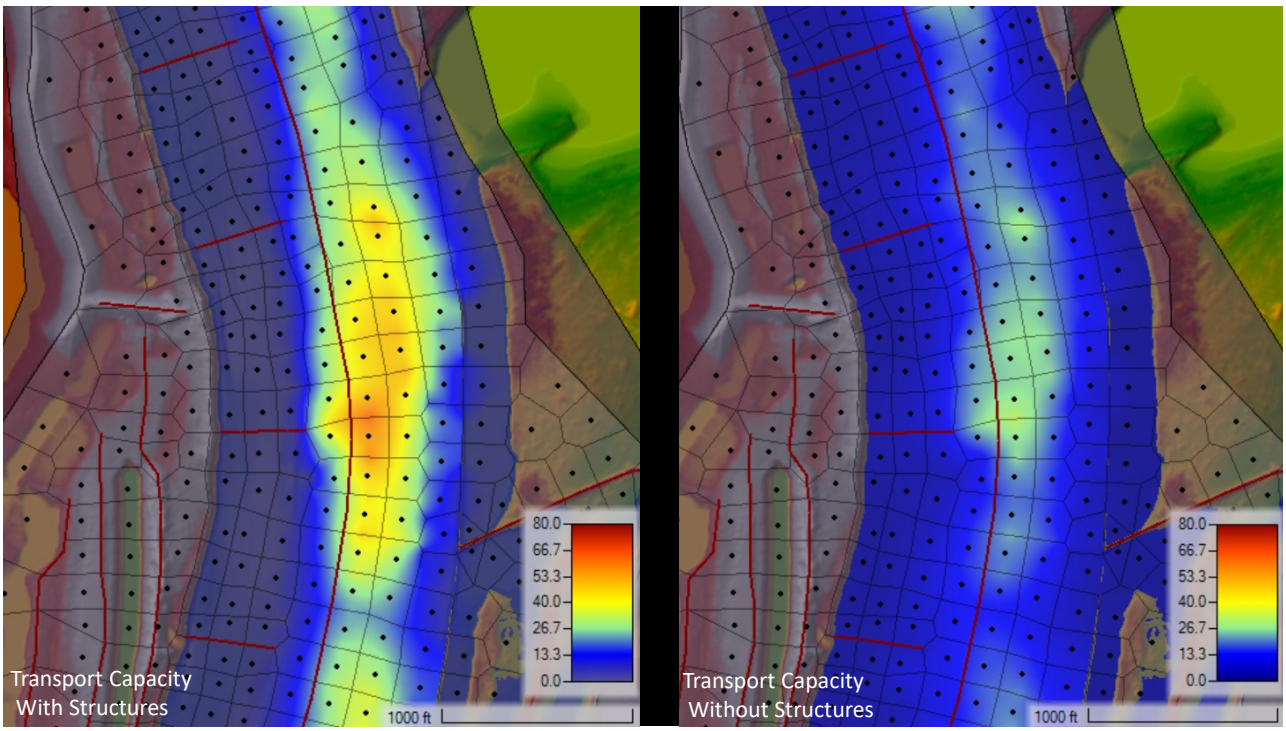
20

20

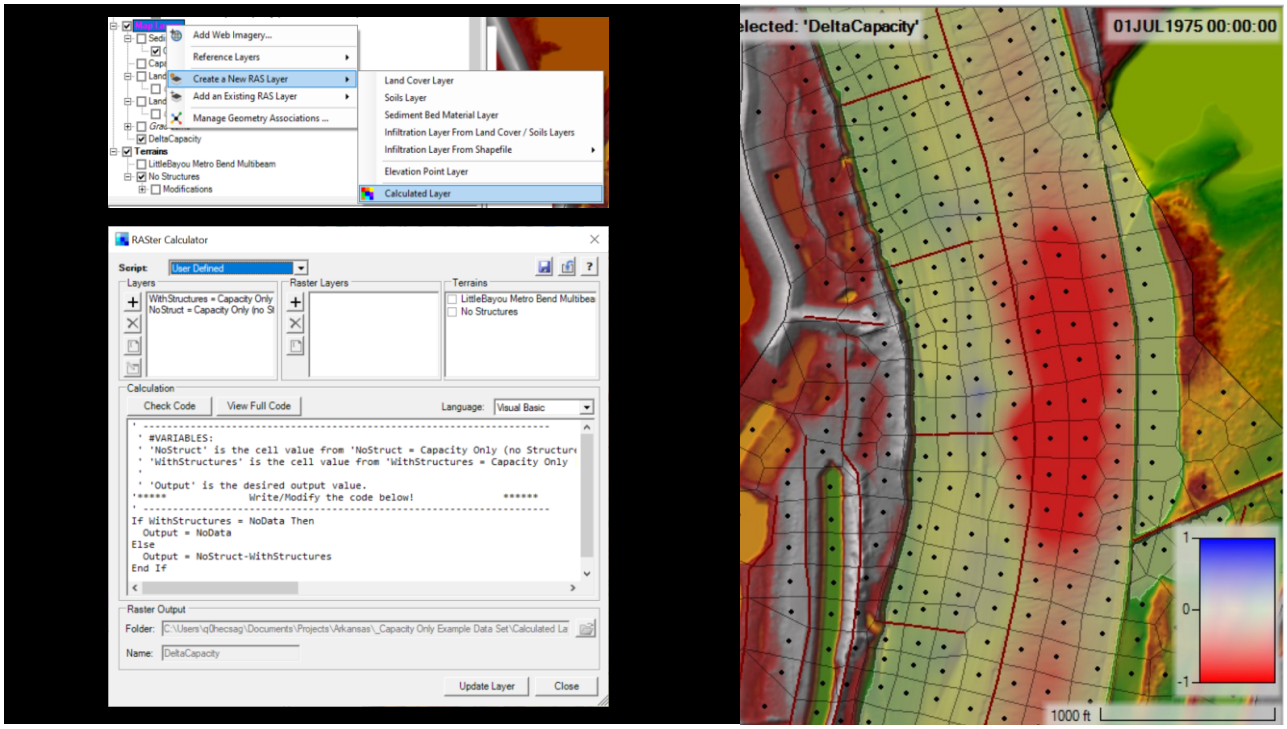


Little Bayou Metro Bend – "Negative Mod" Tutorial: https://youtu.be/c4enO6qUynE

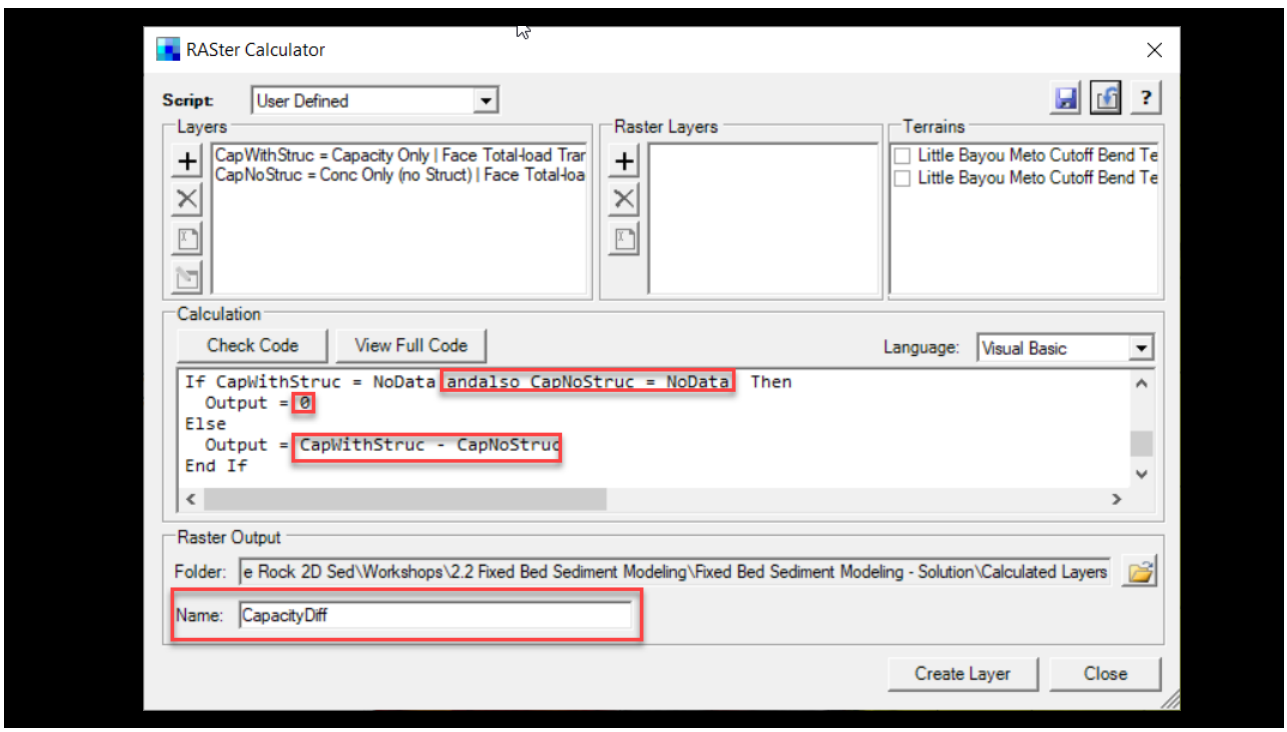
21



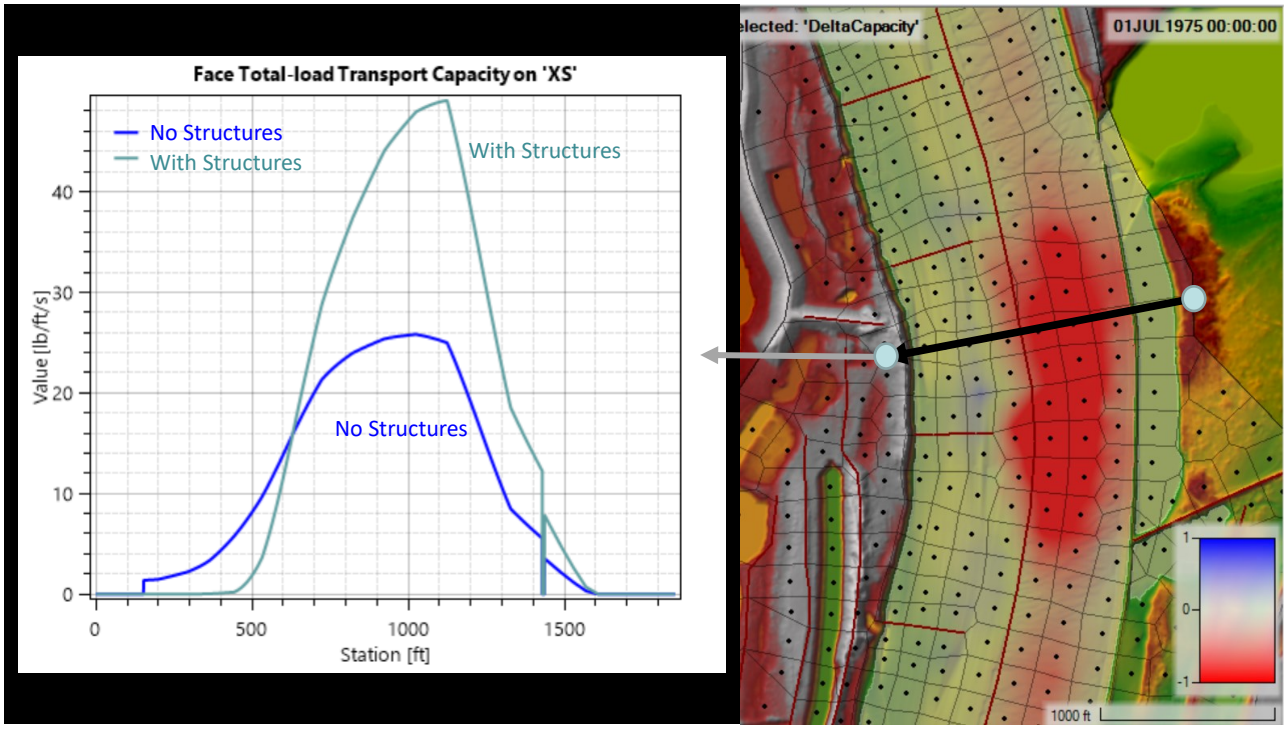
22


Add Web Imagery...
Reference Layers
Create a New RAS Layer
Add an Existing RAS Layer
Manage Geometry Associations ...
Land Cover Layer
Soils Layer
Sediment Bed Material Layer
Infiltration Layer From Land Cover / Soils Layers
Infiltration Layer From Shapefile
Elevation Point Layer
Calculated Layer
DeltaCapacity
Terrains
LittleBayou Metro Bend Multibeam
No Structures
Modifications
RASter Calculator
Script:
User Defined
Layers
Raster Layers
Terrains
WithStructures = Capacity Only
NoStruct = Capacity Only (no St
LittleBayou Metro Bend Multibea
No Structures
Calculation
Check Code
View Full Code
Language:
Visual Basic
' #VARIABLES:
' 'NoStruct' is the cell value from 'NoStruct = Capacity Only (no Structure
' 'WithStructures' is the cell value from 'WithStructures = Capacity Only
' 'Output' is the desired output value.
'****** Write/Modify the code below! ******
If WithStructures = NoData Then
Output = NoData
Else
Output = NoStruct-WithStructures
End If
Raster Output
Folder:
C:\Users\q0hecsag\Documents\Projects\Arkansas_Capacity Only Example Data Set\Calculated La
Name:
DeltaCapacity
Update Layer
Close
elected: 'DeltaCapacity'
01JUL1975 00:00:00
1
0
-1
1000 ft

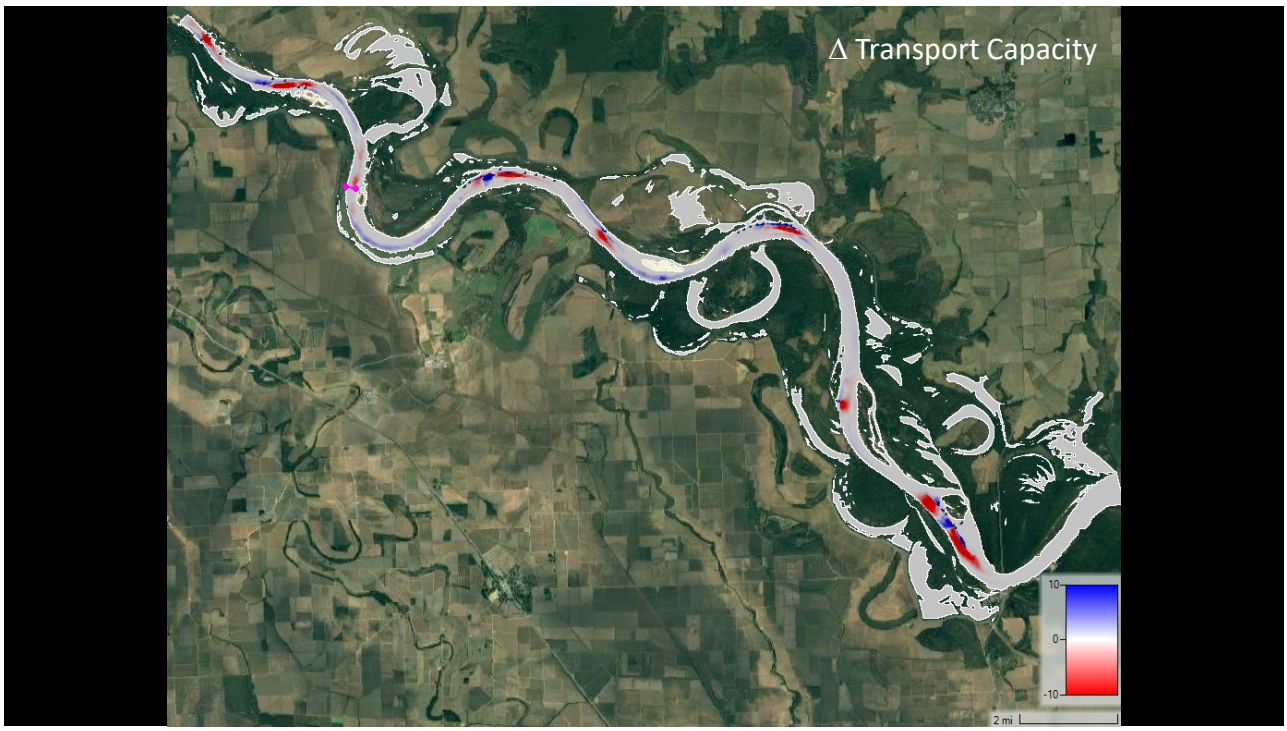
23


RASter Calculator
Script:
User Defined
Layers
CapWithStruc = Capacity Only | Face Total-load Trar
CapNoStruc = Conc Only (no Struct) | Face Total-loa
Raster Layers
Terrains
Little Bayou Meto Cutoff Bend Te
Little Bayou Meto Cutoff Bend Te
Calculation
Check Code
View Full Code
Language:
Visual Basic
If CapWithStruc = NoData andalso CapNoStruc = NoData Then
Output = 0
Else
Output = CapWithStruc - CapNoStruc
End If
Raster Output
Folder:
e Rock 2D Sed\Workshops\2.2 Fixed Bed Sediment Modeling\Fixed Bed Sediment Modeling - Solution\Calculated Layers
Name:
CapacityDiff
Create Layer
Close

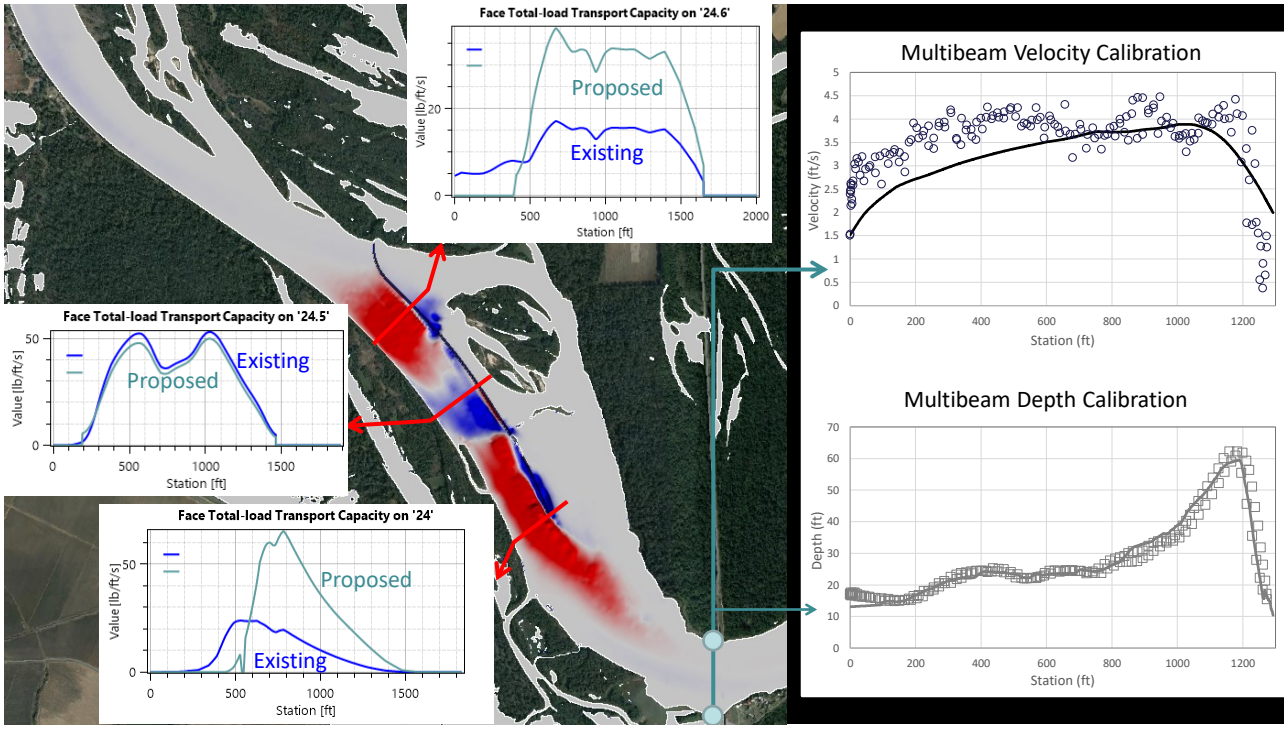
24


Face Total-load Transport Capacity on 'XS'
No Structures
With Structures
With Structures
No Structures
Value [lb/ft/s]
Station [ft]
0
10
20
30
40
0
500
1000
1500
elected: 'DeltaCapacity'
01JUL1975 00:00:00
1
0
-1
1000 ft

25


Δ Transport Capacity
10
0
-10
2 mi

26



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Arkansas River Navigation Project

- 4 of 11 Pools Analyzed
- 475,000 ton reduction
- $38 Million Savings (so far)
- <9 Months

Technical Leads:
Edmund Howe (SWL)
Kathryn Martin (SWL)

District	Modeler(s)	Pool
HEC/ SWL	Stanford Gibson, Edmund Howe	2
MVM	Grayson Holt, Cole Stonebrook	5
SWL	Katie Martin	8
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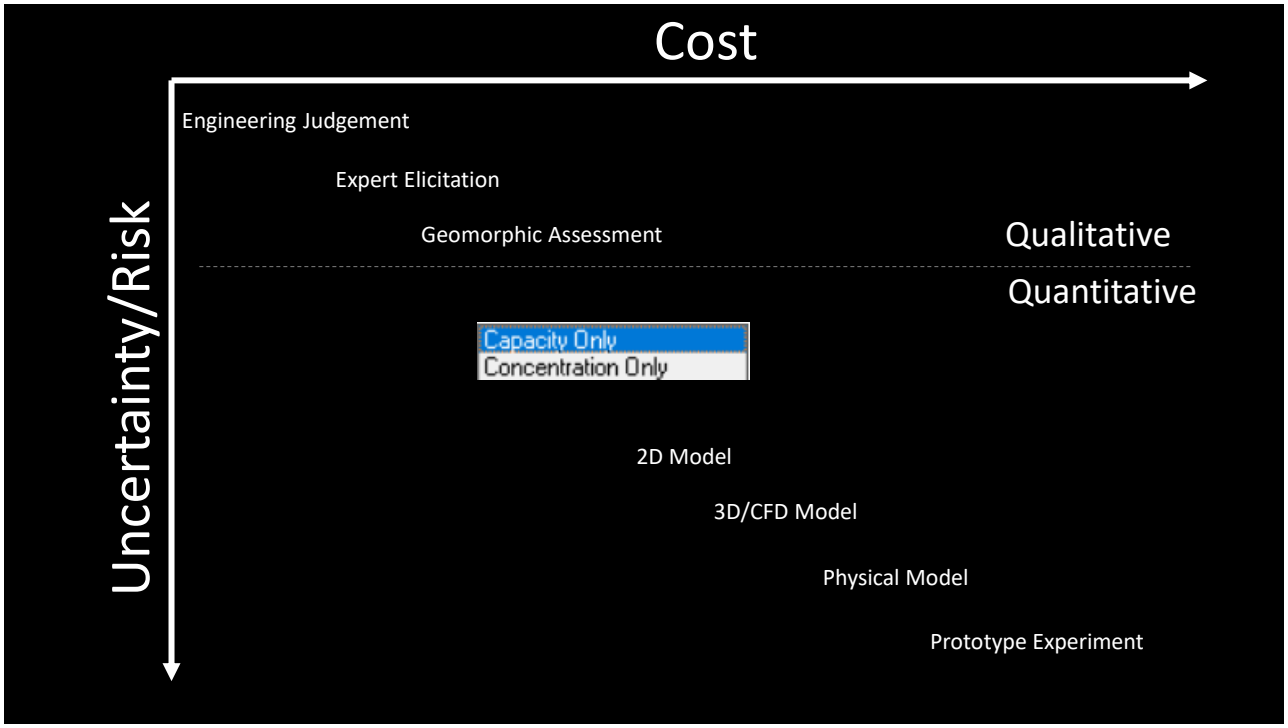
SWL	Katie Martin	3
SWL	Katie Martin	4
SWT	Meredith Street	13
SWT	Alex Petersen	15
SWT	Alex Petersen	16

28



29

Calibrate and refine your hydraulic model *before* you add sediment.

Stages of Sediment Calibration

	Flow	Bed Elevation
Stage 1: Hydraulic Calibration	Variable	Fixed
Stage 2: Steady Flow Mobile Bed Analysis	Fixed	Variable
Stage 3: Dynamic Calibration	Variable	Variable

If Possible:

Stage 4: "Validation" (Multiple Time Series Analysis)	Variable	Variable

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Calibrate and refine your hydraulic model *before* you add sediment.

Stages of Sediment Calibration

	Flow	Bed Elevation	
Stage 1: Hydraulic Calibration	Variable	Fixed	
Fixed Bed Sediment Transport Analysis	Either/Both	Fixed…But	Δ Capacity
Stage 2: Steady Flow Mobile Bed Analysis	Fixed	Variable	
Stage 3: Dynamic Calibration	Variable	Variable	

If Possible:

Stage 4: "Validation" (Multiple Time Series Analysis)	Variable	Variable

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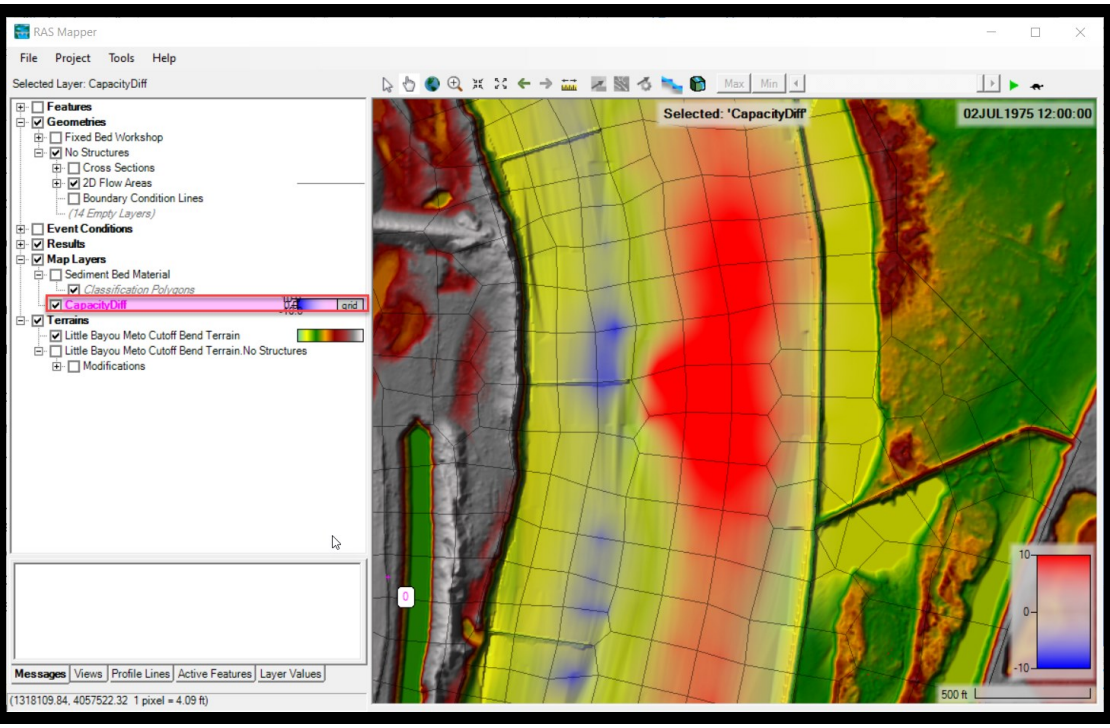

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