Dr. Thomas Hardy
Dr. Rolan Raphelt

# Evaluation of Capes Dam

# A bit of Ecology

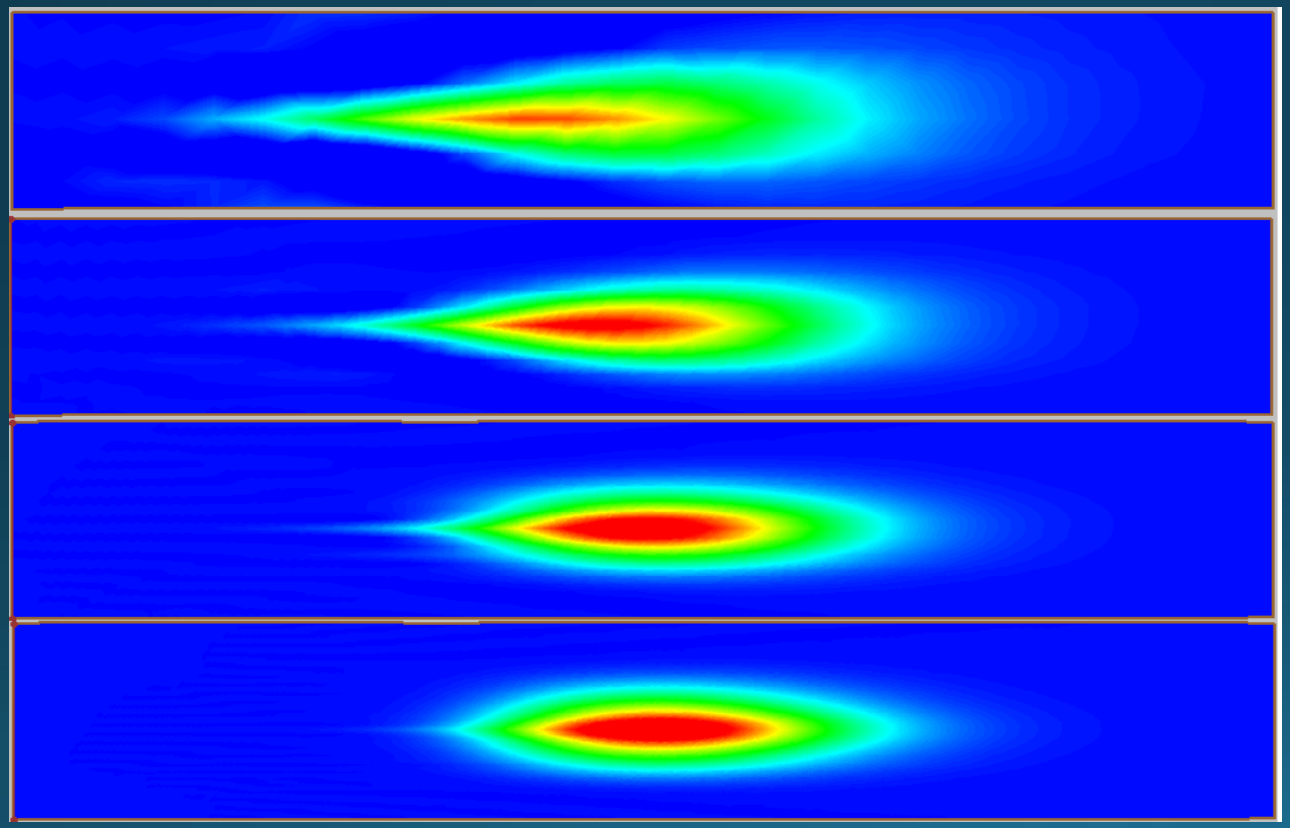
**TABLE 4-10**
**LONG-TERM BIOLOGICAL GOAL FOR TEXAS WILD-RICE**

| River Segment | Areal Coverage ($m^2$) | Reach Percentage of Total Areal Coverage |
|---|---|---|
| Spring Lake | 1,000 – 1,500 | n/a |
| Spring Lake Dam to Rio Vista Dam | 5,810 – 9,245 | 83 – 66 |
| Rio Vista Dam to IH-35 | 910 – 1,650 | 13 – 12 |
| Downstream of IH-35 | 280 – 3,055 | 4 – 22 |
| TOTAL | 8000 – 15,450 | 100 |

# Adaptive Hydraulics Modeling

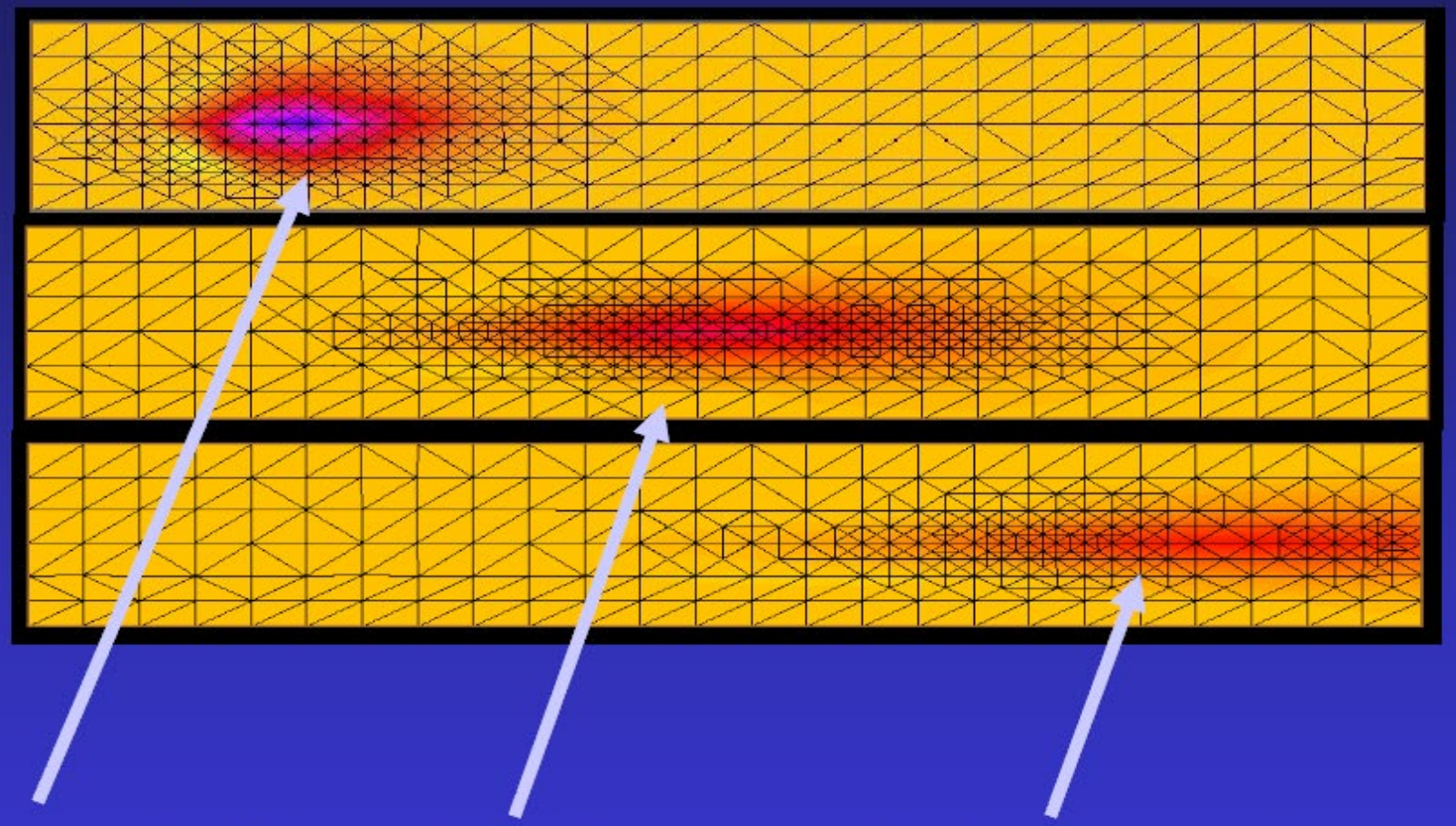
- ADH is a state-of-the-art Adaptive Hydraulics Modeling system developed by the Coastal and Hydraulics Laboratory, ERDC (ENGINEER RESEARCH AND DEVELOPMENT CENTER), USACE
- Capable of handling three-dimensional Navier-Stokes flow, and two- or three-dimensional shallow water problems.
- One of the major benefits of ADH is its use of adaptive numerical meshes that can be employed to improve model accuracy without sacrificing efficiency.
- ADH contains other essential features such as completely coupled sediment transport.

# Grid Resolution Results…




at timestep = 380 seconds

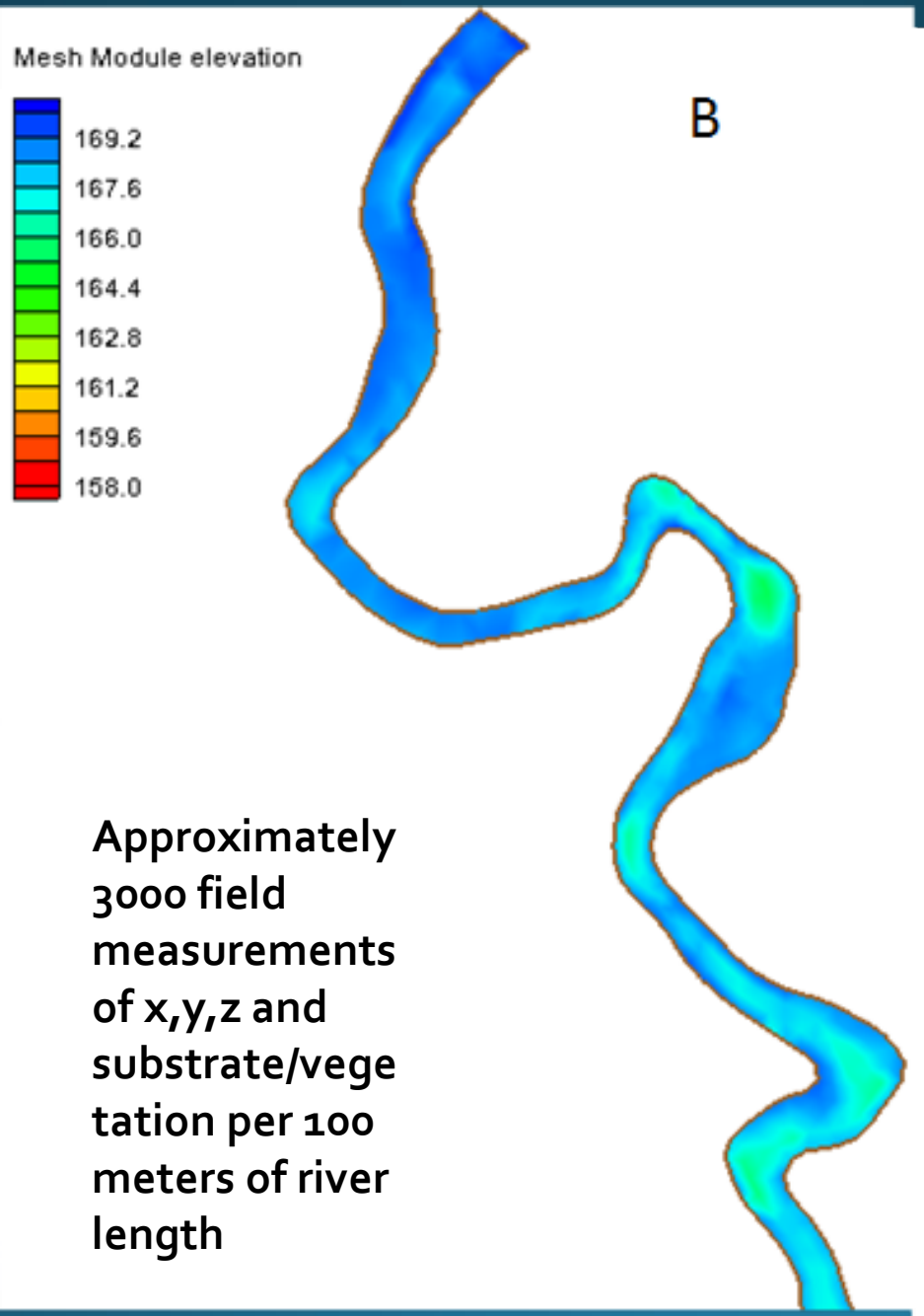
# Adaption - Concentration Cloud



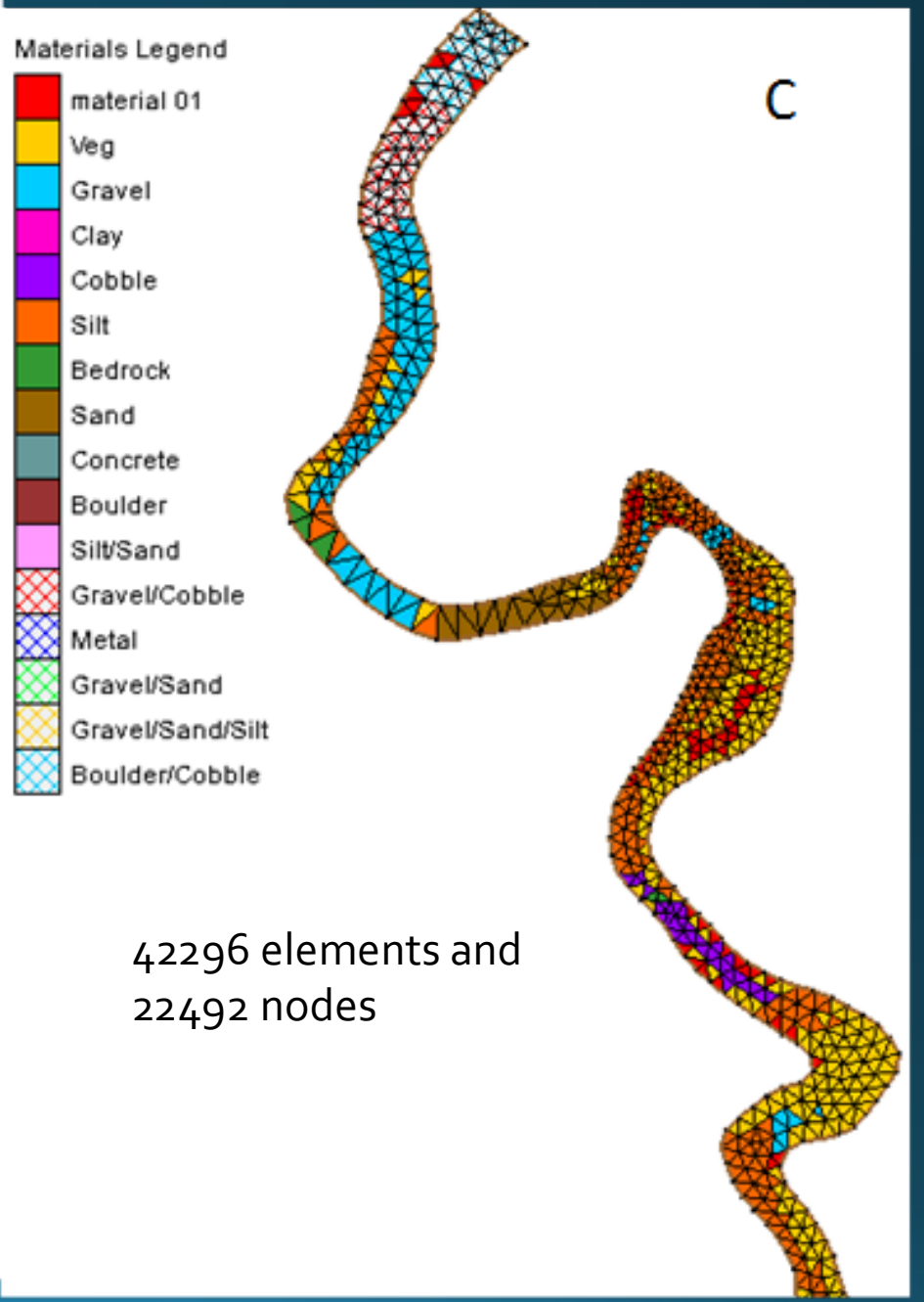
Mesh refines and unrefines to resolve the concentration cloud as it progresses along the flume

# Modeled Stretch of River

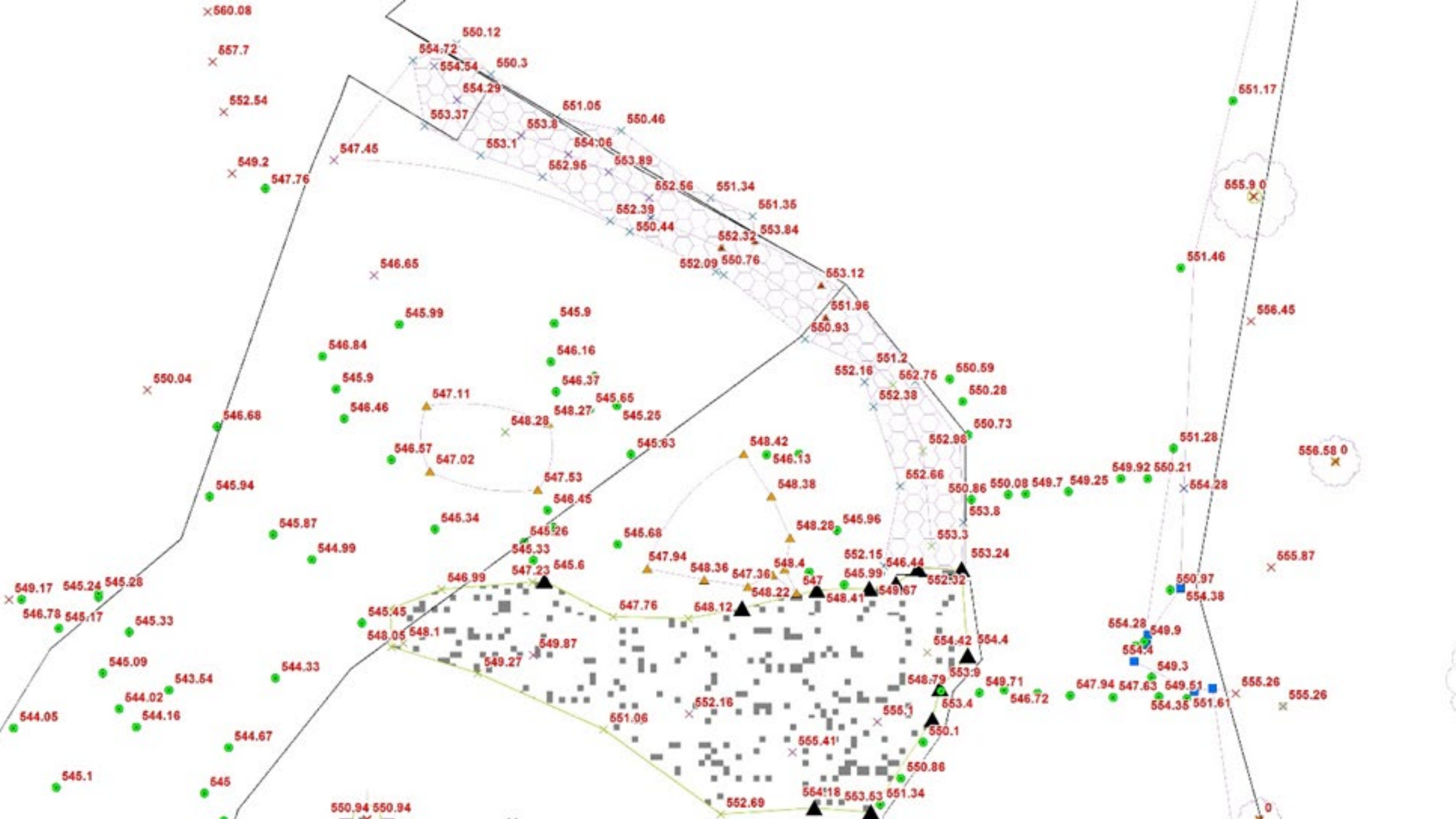
Rio Vista was not included because under most flow regimes the backwater affects from Cape's Dam stop downstream


**Approximately 3000 field measurements of x,y,z and substrate/vegetation per 100 meters of river length**



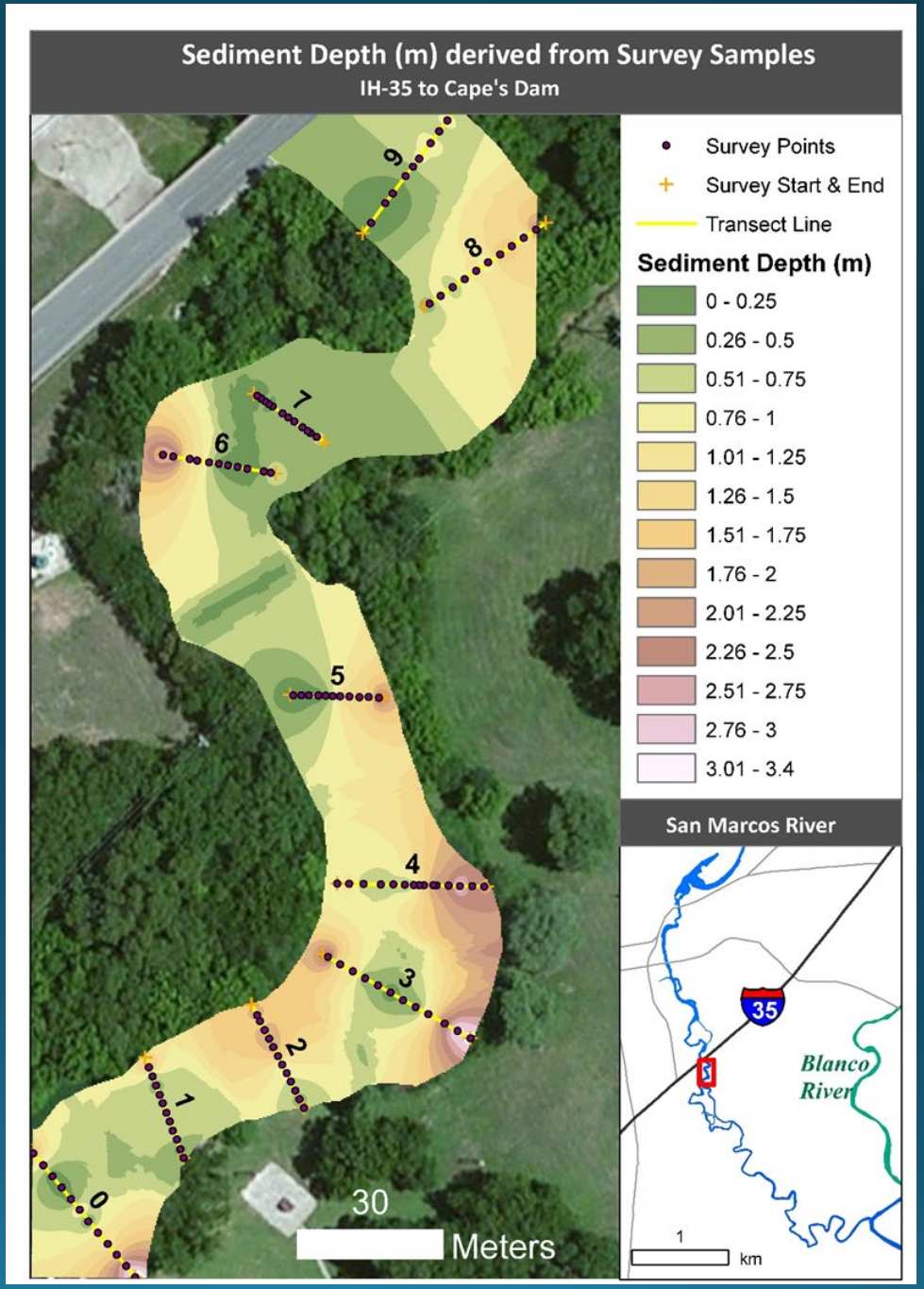

42296 elements and 22492 nodes

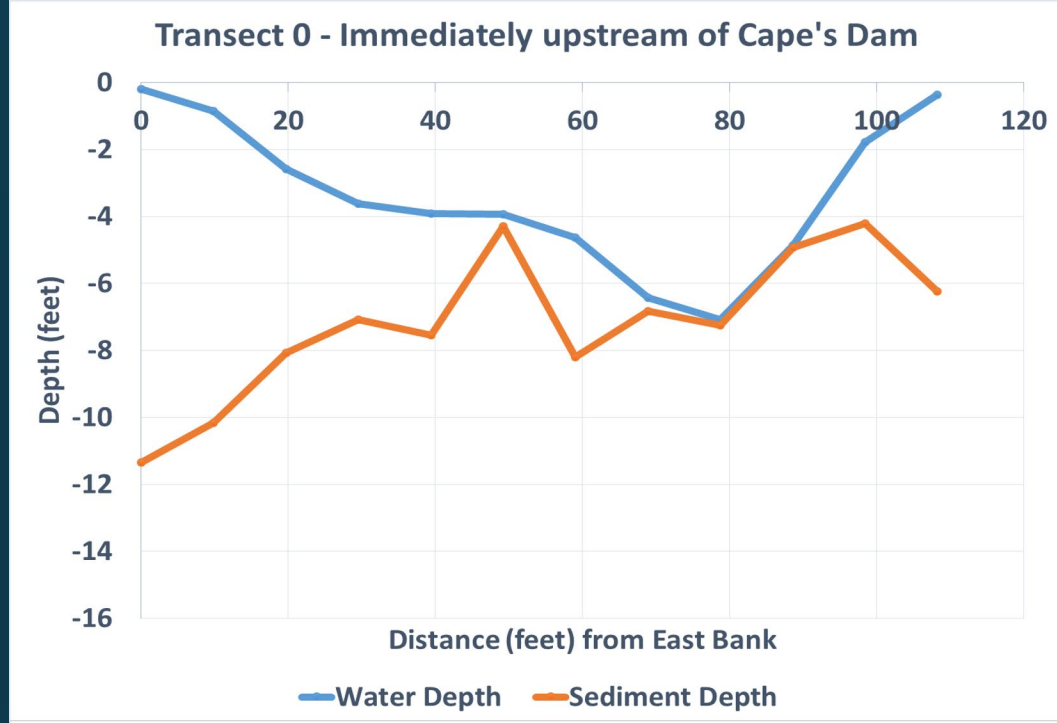

560.08
550.12
554.72
554.54
550.3
554.29
557.7
552.54
553.37
551.06
553.8
550.46
553.1
554.06
547.45
549.2
547.76
552.96
553.89
552.56
551.34
551.35
552.39
550.44
552.32
553.84
552.09
550.76
553.12
546.65
551.96
545.99
545.9
550.93
546.84
546.16
551.2
552.16
552.75
550.59
550.04
546.37
545.9
550.28
547.11
545.65
552.38
546.46
548.27
545.25
548.28
550.73
546.68
552.98
545.63
548.42
546.57
546.13
547.02
551.28
552.66
547.53
548.38
545.94
550.86
550.08
549.7
549.25
549.92
550.21
554.28
546.45
553.8
545.87
545.34
548.28
545.96
545.26
545.68
553.3
544.99
545.33
547.94
552.15
546.44
553.24
549.17
545.24
545.28
547.23
545.6
548.36
547.36
548.4
552.92
546.99
547
548.22
548.41
549.67
546.78
545.17
545.33
547.76
548.12
545.45
548.05
548.1
554.42
554.4
549.87
549.27
554.28
549.9
554.4
549.3
545.09
544.33
543.54
548.79
553.9
549.71
547.94
547.63
549.51
555.26
544.02
544.16
552.16
553.4
546.72
554.35
551.61
555.26
544.05
556.1
550.1
555.41
544.67
550.86
545.1
545
564.18
563.53
551.34
552.69
550.94
550.94
551.17
555.9 0
551.46
556.45
556.58 0
555.87
0

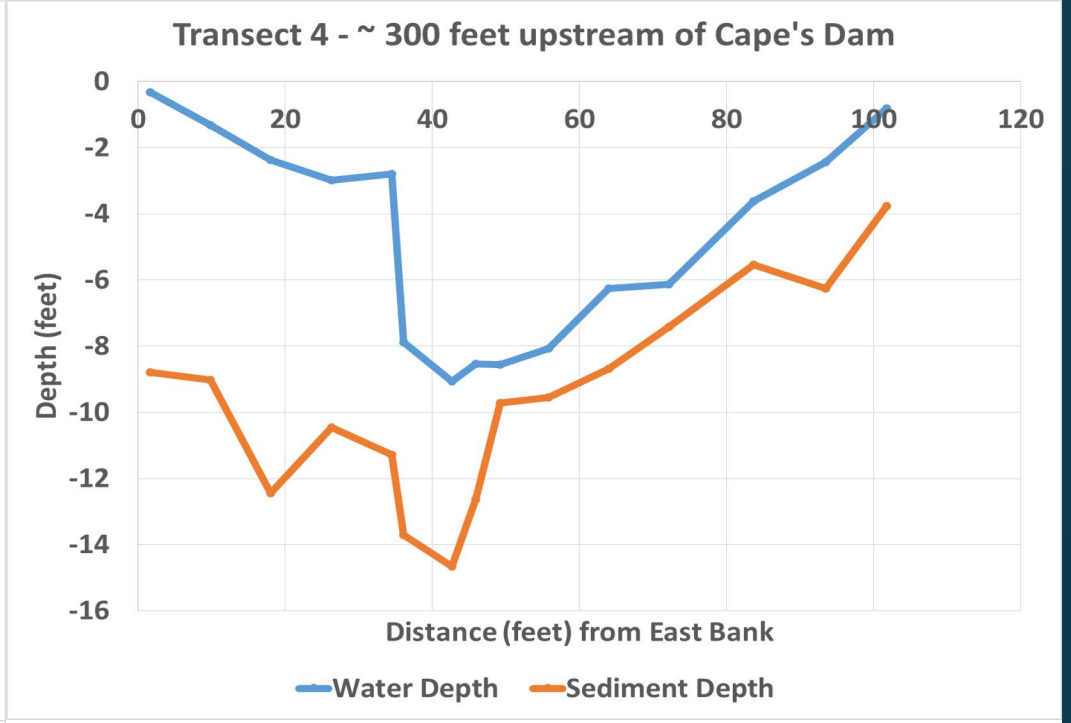
# Depth of Sediment

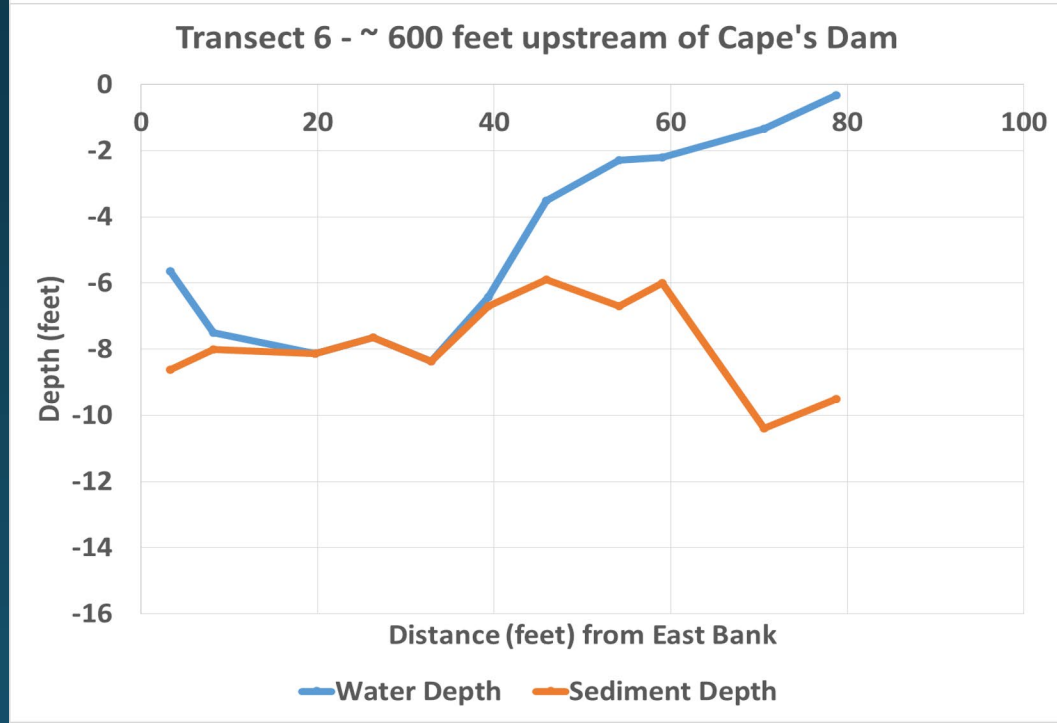
The reservoir deposits were probed at 100 locations along 10 transects to assess potential sediment storage behind Capes Dam, which would be available for mobilization following dam removal.

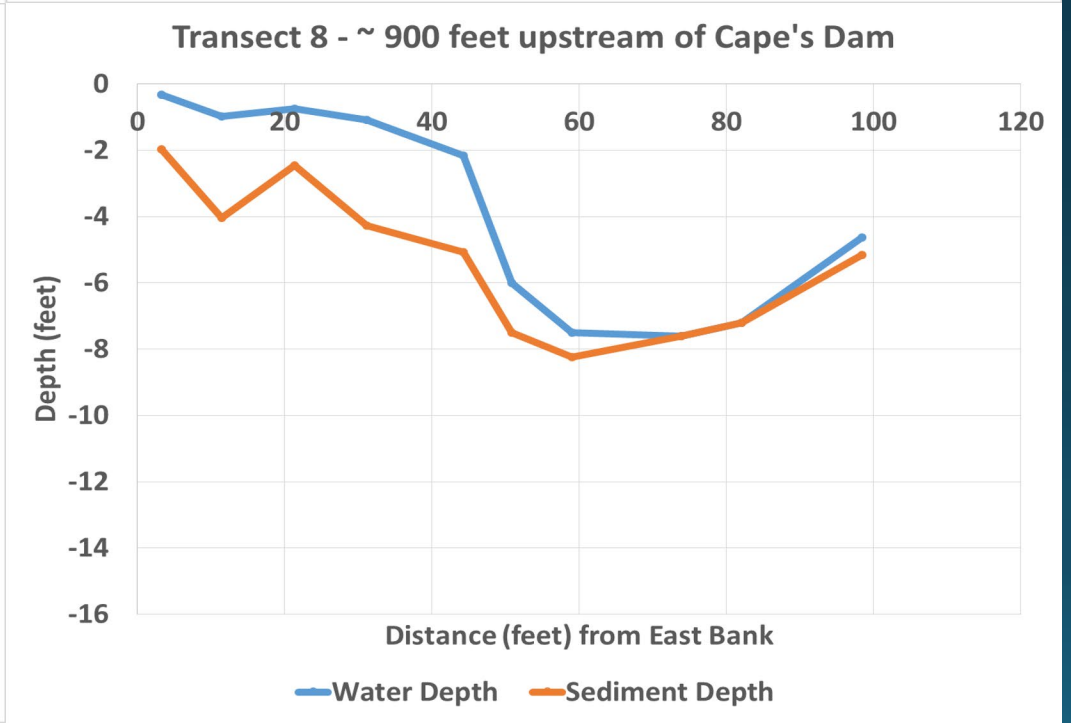
The volume of soft sediment stored that could potentially be mobilized in Capes reservoir is estimated at 6,762 m^3. This is considered a minimum estimate. (Paul Hudson, UofT.)




Transect 0 - Immediately upstream of Cape's Dam
0
-2
-4
-6
-8
-10
-12
-14
-16
0
20
40
60
80
100
120
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 4 - ~ 300 feet upstream of Cape's Dam
0
-2
-4
-6
-8
-10
-12
-14
-16
0
20
40
60
80
100
120
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 6 - ~ 600 feet upstream of Cape's Dam
0
-2
-4
-6
-8
-10
-12
-14
-16
0
20
40
60
80
100
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 8 - ~ 900 feet upstream of Cape's Dam
0
-2
-4
-6
-8
-10
-12
-14
-16
0
20
40
60
80
100
120
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth

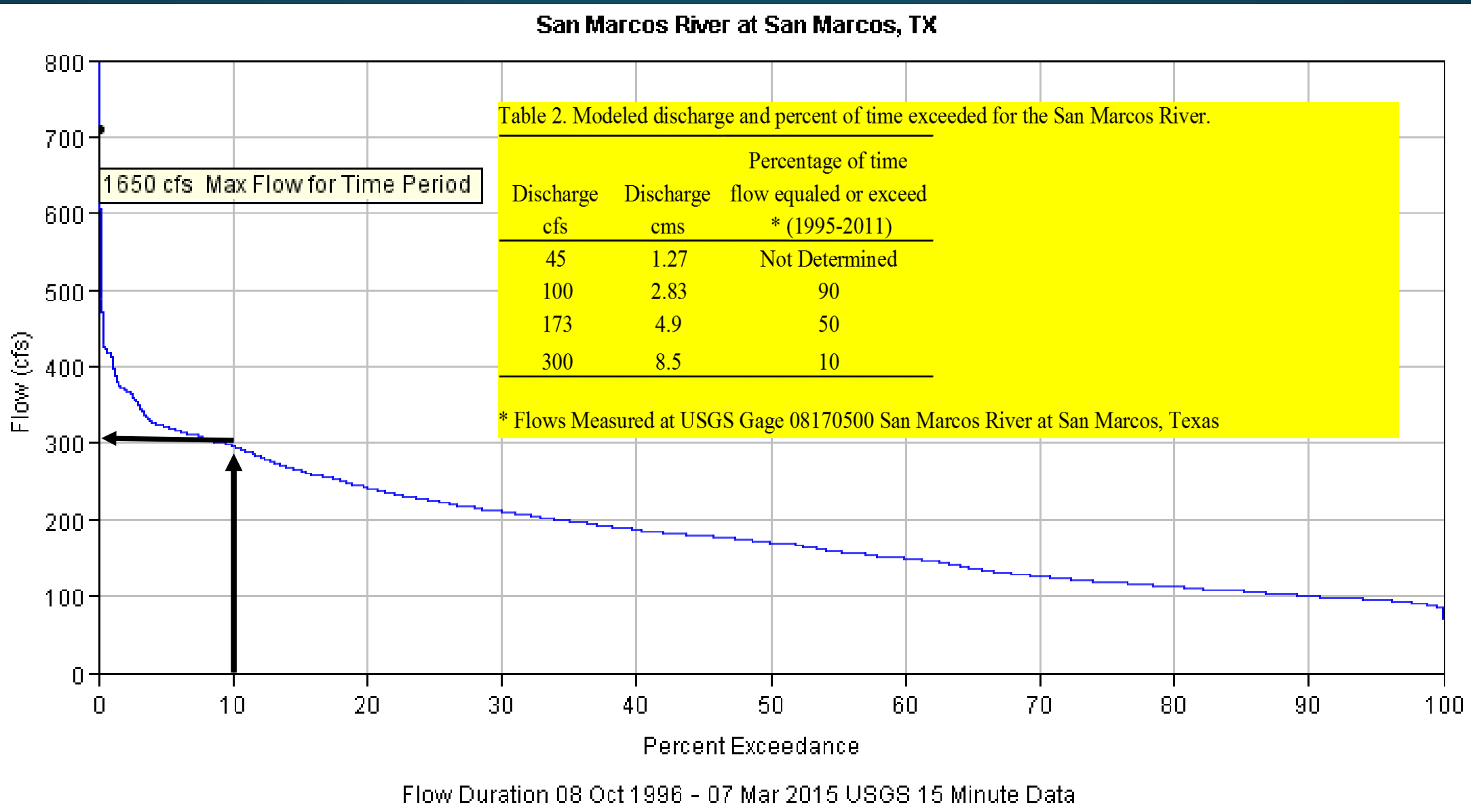



Table 2. Modeled discharge and percent of time exceeded for the San Marcos River.

| Discharge cfs | Discharge cms | Percentage of time flow equaled or exceed * (1995-2011) |
|---|---|---|
| 45 | 1.27 | Not Determined |
| 100 | 2.83 | 90 |
| 173 | 4.9 | 50 |
| 300 | 8.5 | 10 |

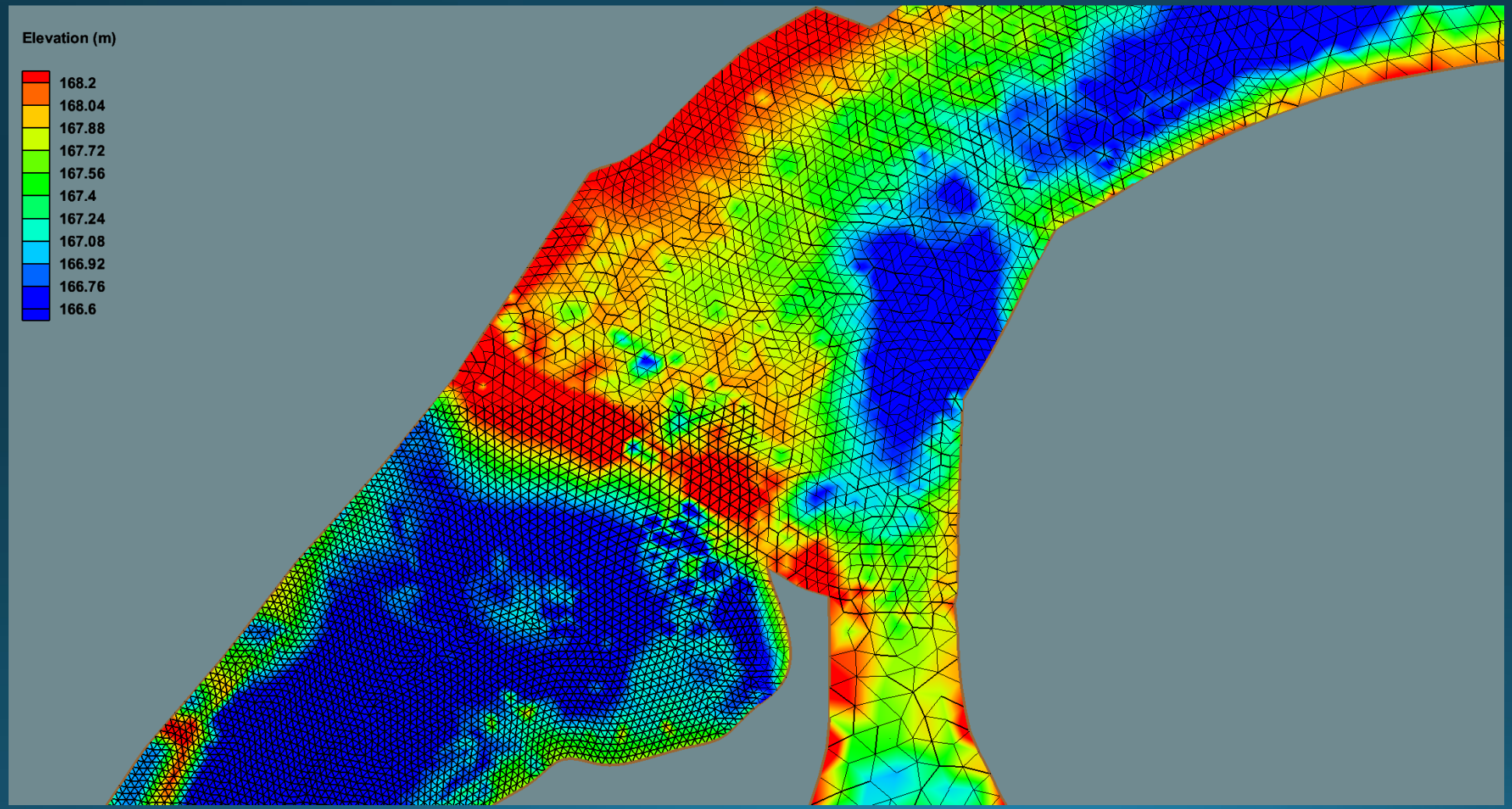
* Flows Measured at USGS Gage 08170500 San Marcos River at San Marcos, Texas

# ADH Modeling

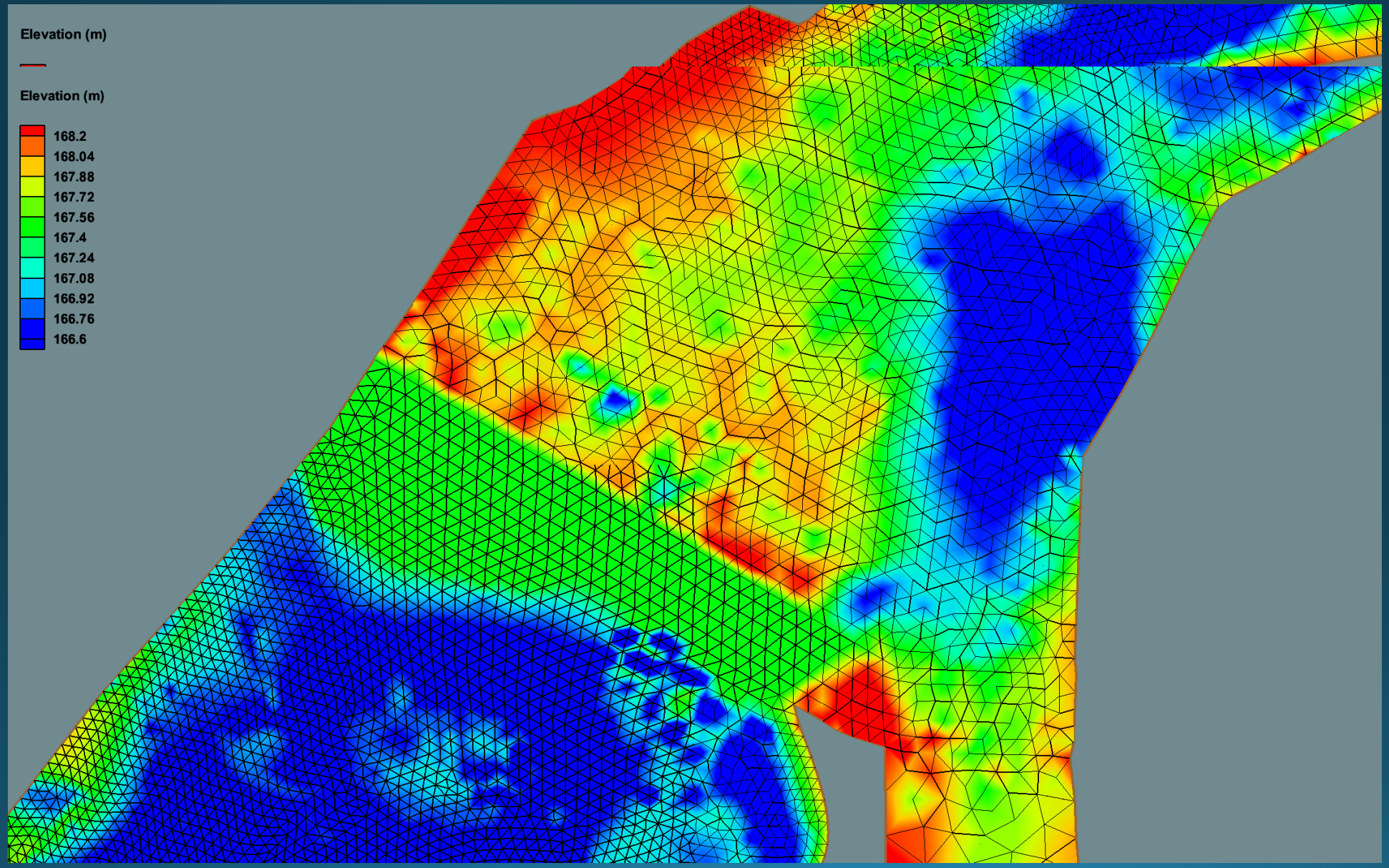
Bed Evolution was evaluated by running 300 cfs for 30 days

Runs were completed on a 64 node parallel processor and execution times were approximately 23 hours per simulation run to reach convergence at a given discharge

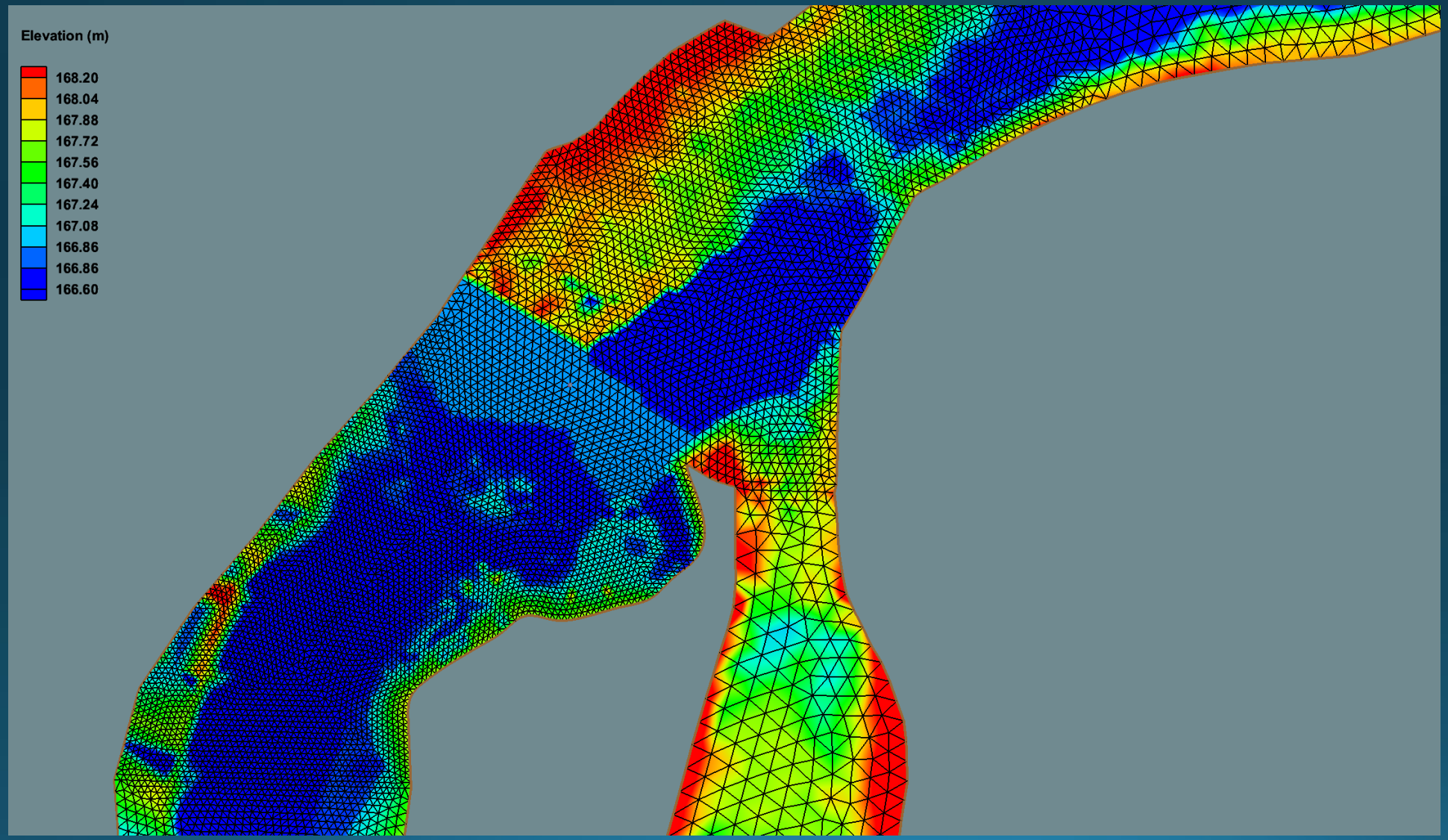
# Existing (~full height) Bed Elevation Conditions



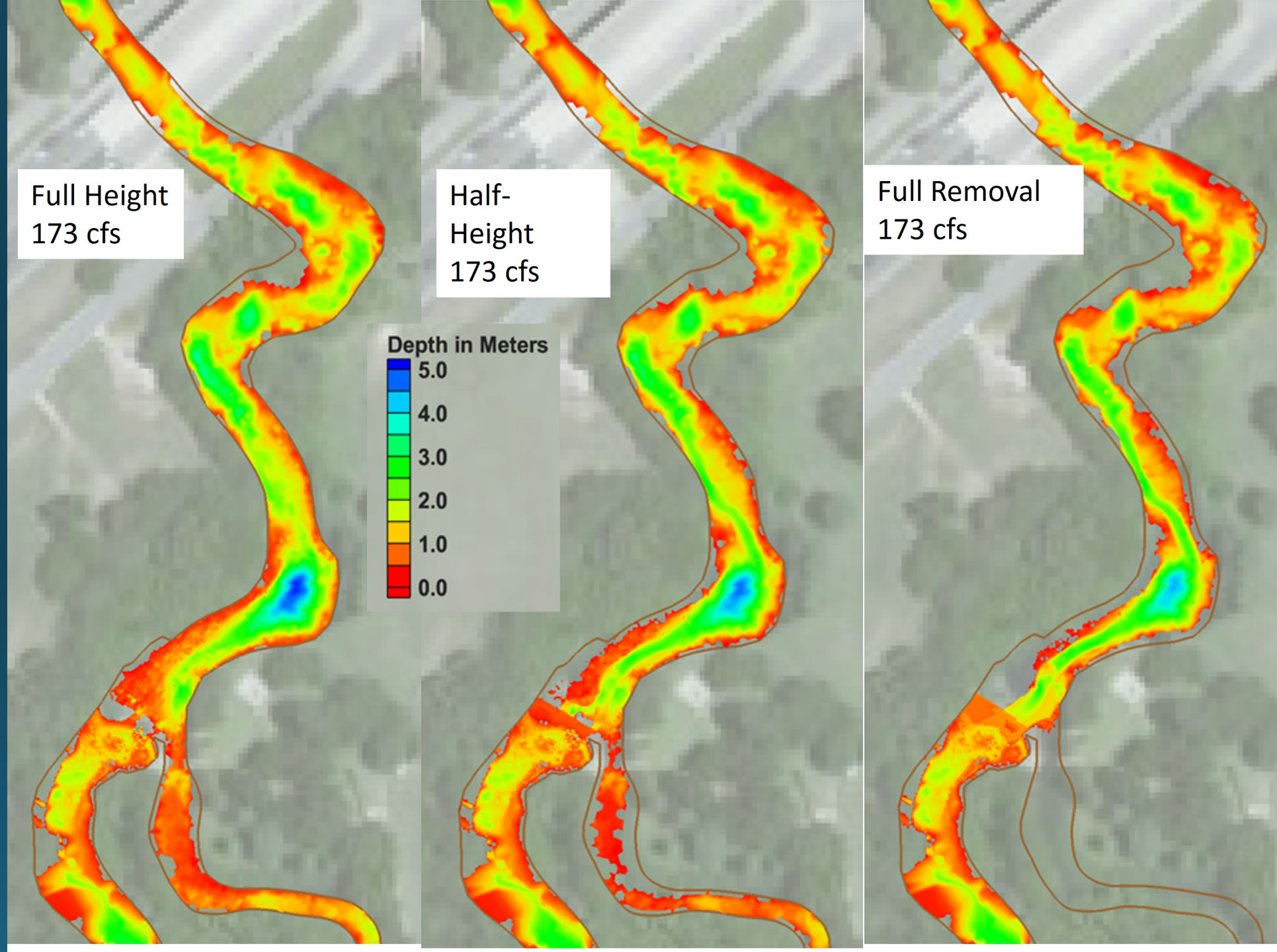
# Assumed Half Height Elevations



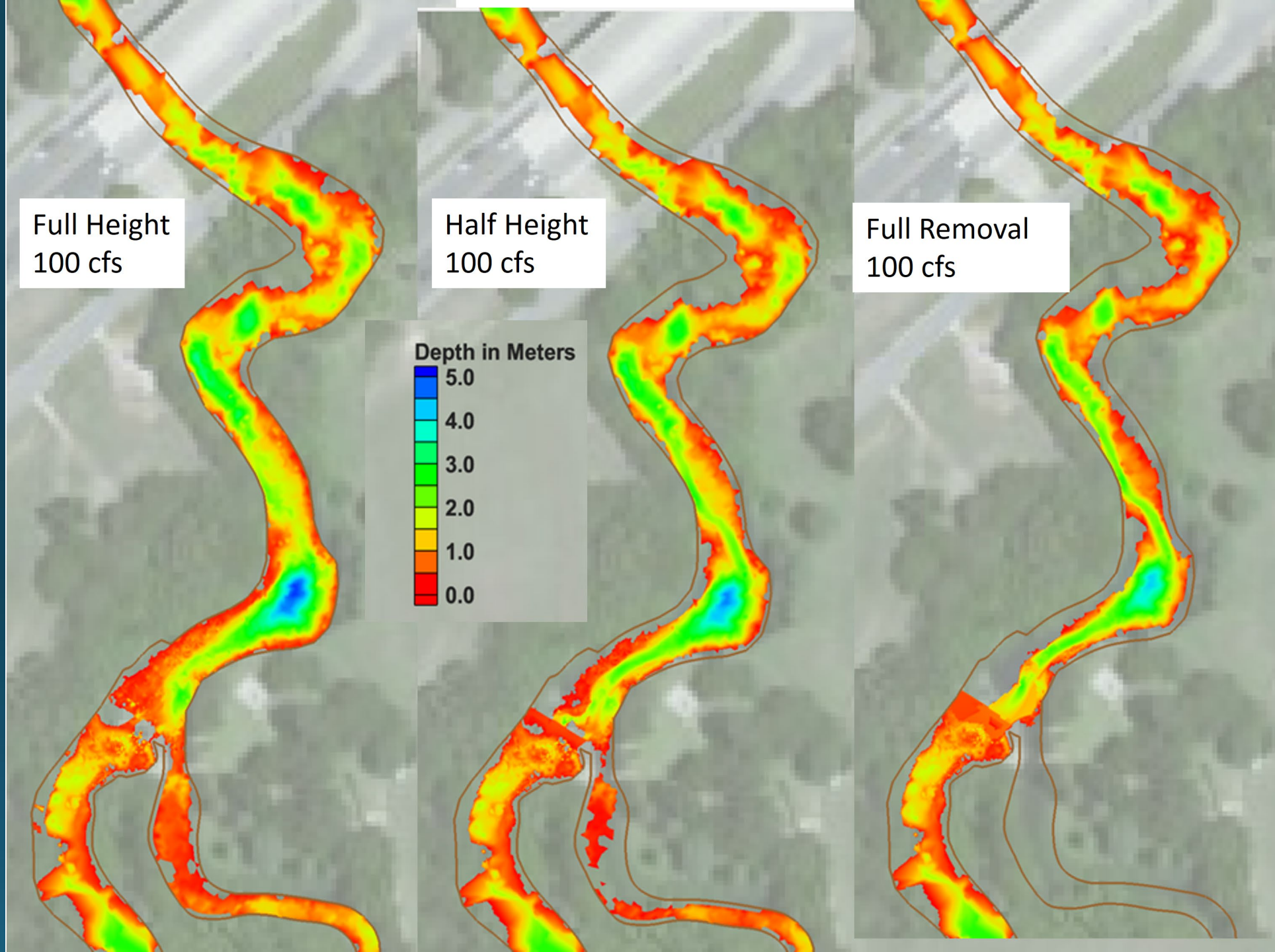
# Assumed Full Dam Removal Elevations



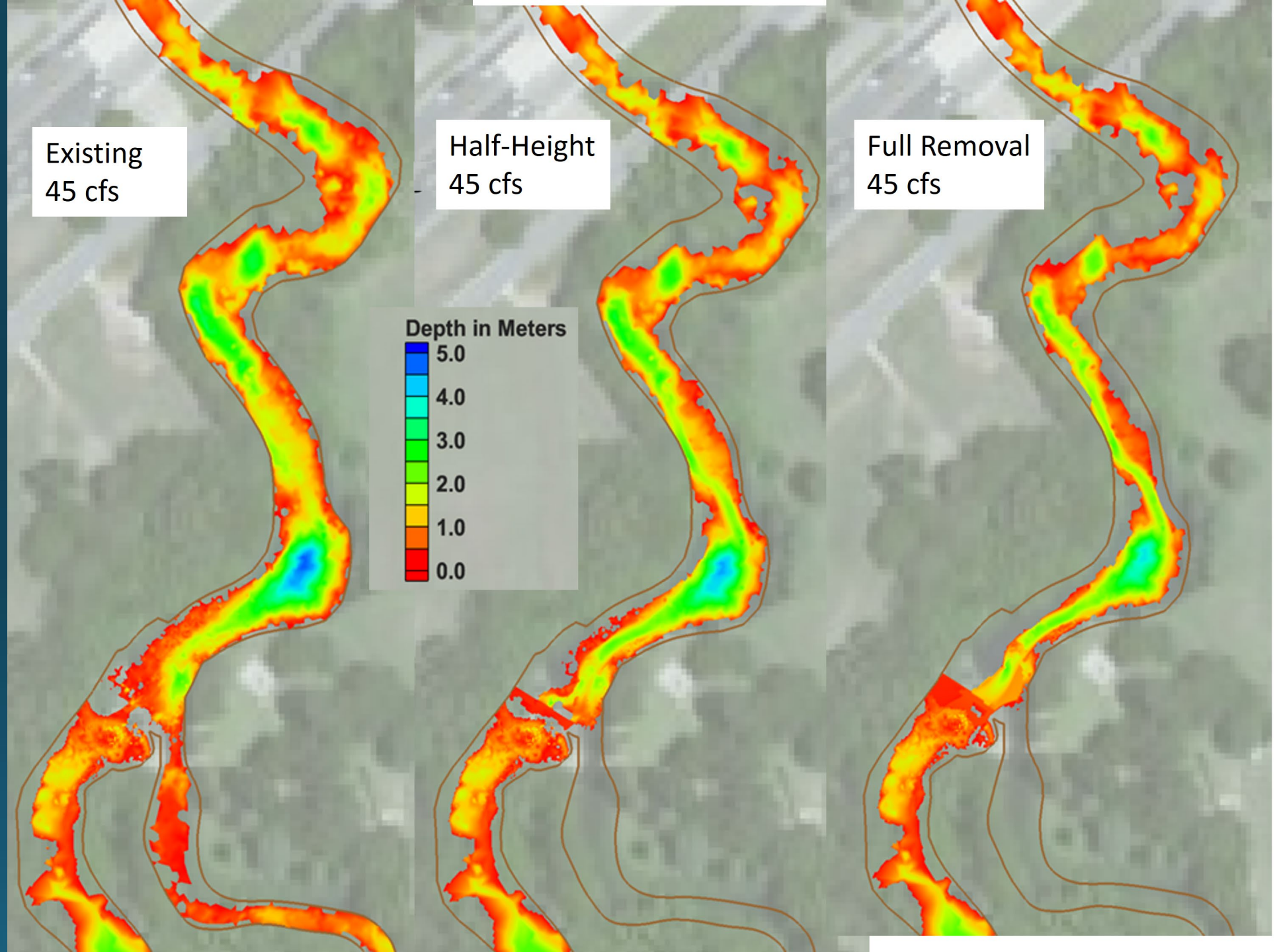
# DEPTH


Full Height
173 cfs
Half-
Height
173 cfs
Full Removal
173 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

# DEPTH

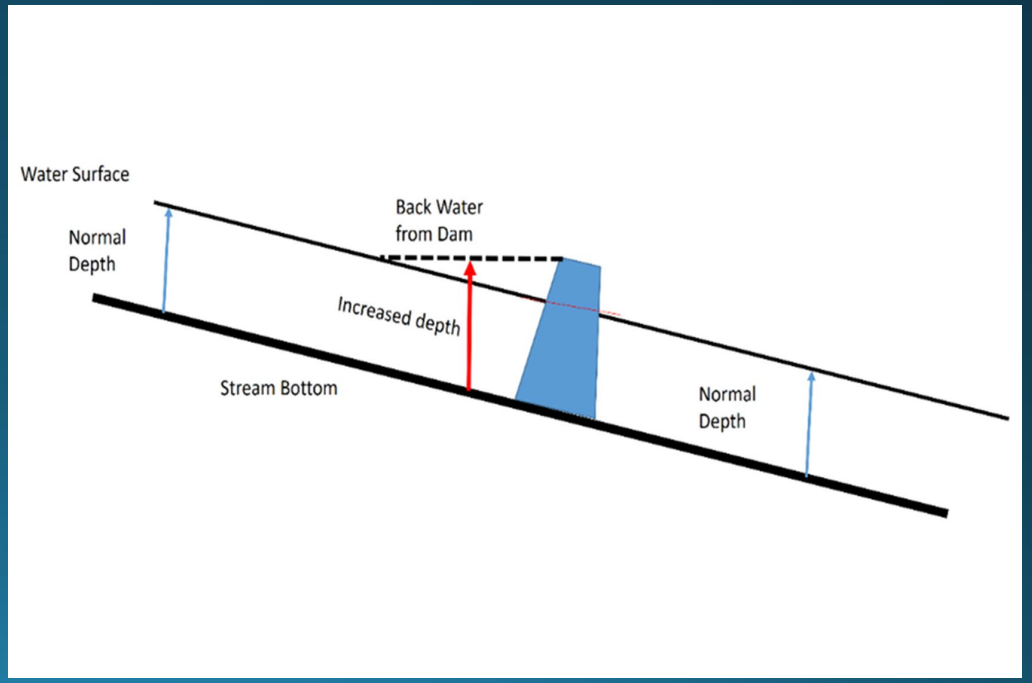

Full Height
100 cfs
Half Height
100 cfs
Full Removal
100 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

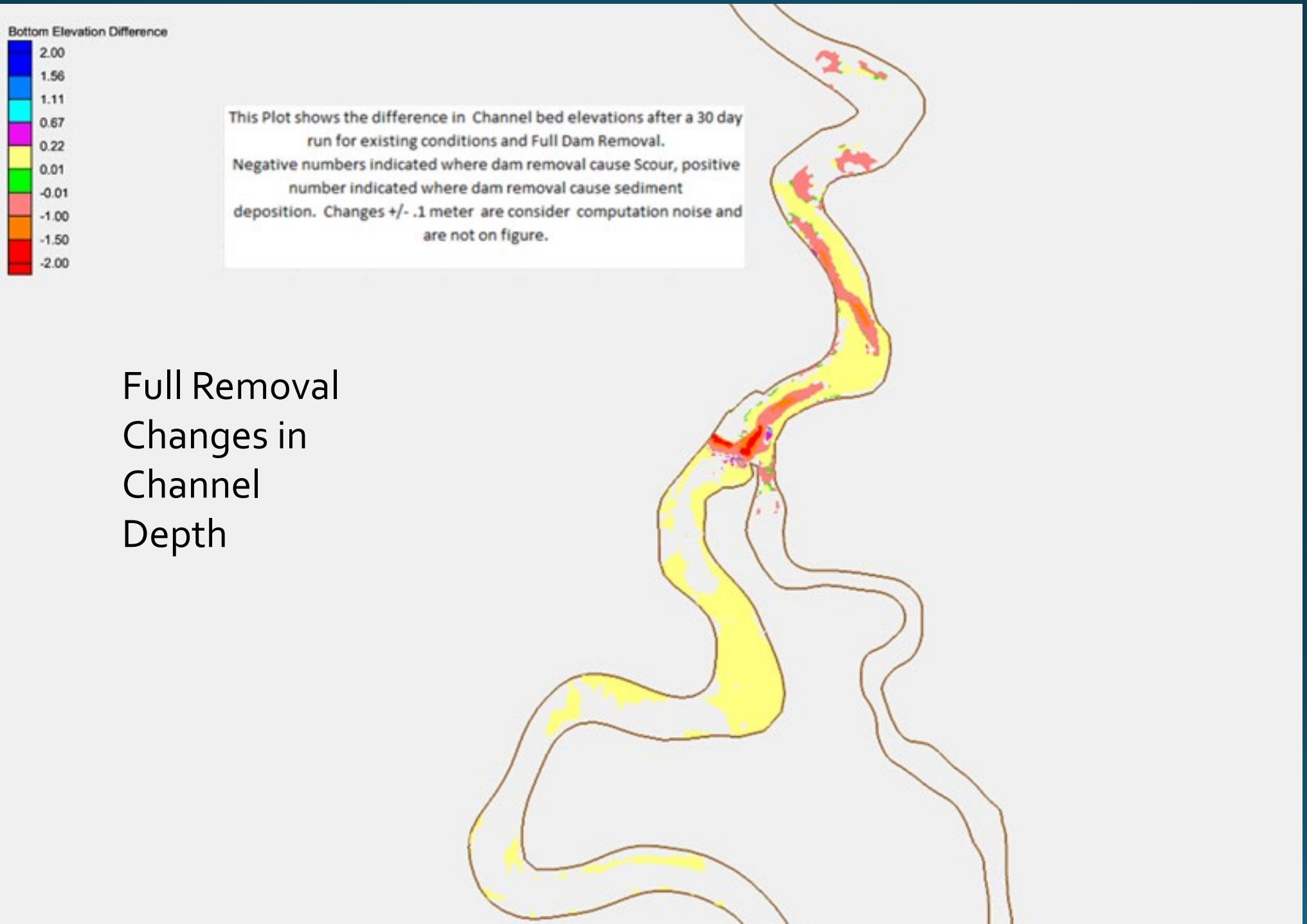
# DEPTH


Existing
45 cfs
Half-Height
45 cfs
Full Removal
45 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

# Key Conclusions

- *Channel Changes*
- **Removal of Cape's Dam will result in reestablishment of normal depths equivalent to depths currently observed upstream of the backwater section and the channel below the confluence with the Mill Race return flows.**
- **Removal of Capes Dam will restore natural fish and other aquatic organism passage.**



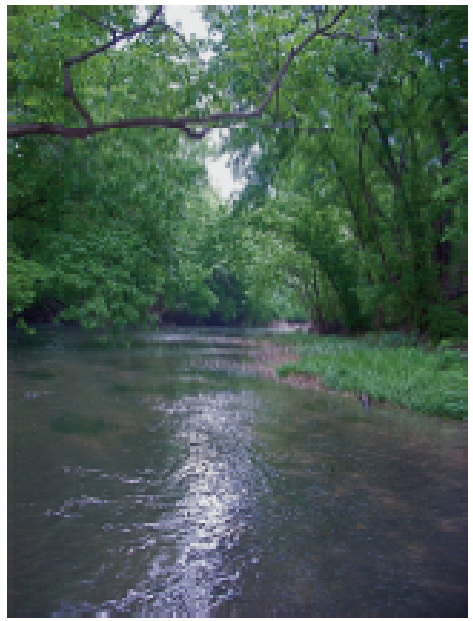



# Full Removal Changes in Channel Depth

**GEOMORPHIC MONITORING OF THE UPPER SAN MARCOS RIVER, TEXAS TO ASSESS CHANNEL ADJUSTMENT IN RESPONSE TO REMOVAL OF AN INVASIVE EXOTIC WATER PLANT, *CRYPTOCORYNE BECKETTII***

CONTRACT NO. 05-222-GM

FINAL REPORT



Submitted to Texas Parks and Wildlife

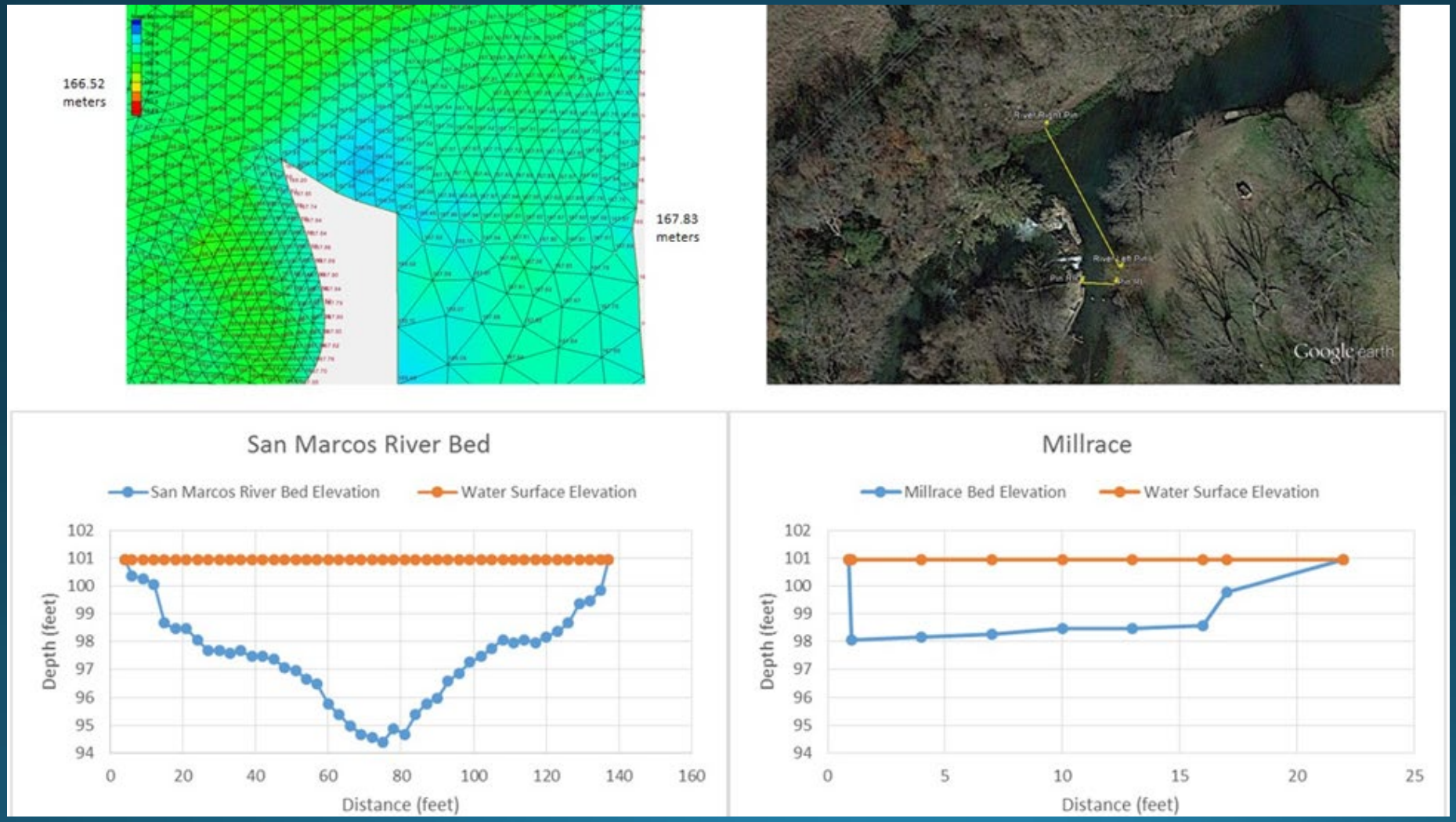
March 12, 2012

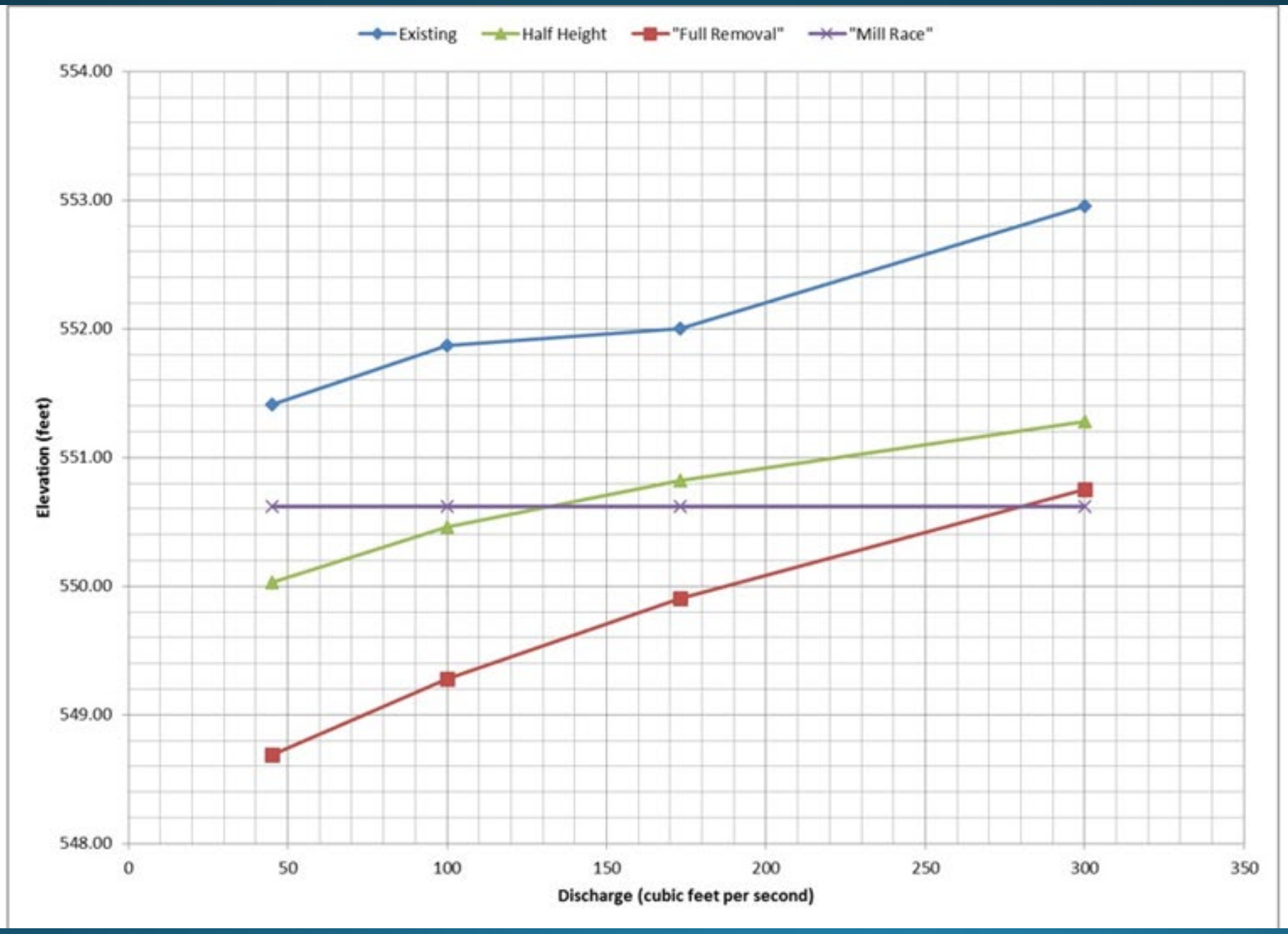
Paul F. Hudson, Ph.D.
Department of Geography and the Environment

University of Texas at Austin

Additionally, bank erosion rates were 1.8 inches per year along the channel, and did not spatially vary. The cohesive (clayey) bank material likely represents an inherent geomorphic buffer along the San Marcos River, thereby reducing the rivers sensitivity to erosion.

# Mill Race


166.52
meters
167.83
meters
Google earth
San Marcos River Bed
San Marcos River Bed Elevation
Water Surface Elevation
Depth (feet)
Distance (feet)
Millrace
Millrace Bed Elevation
Water Surface Elevation
Depth (feet)
Distance (feet)

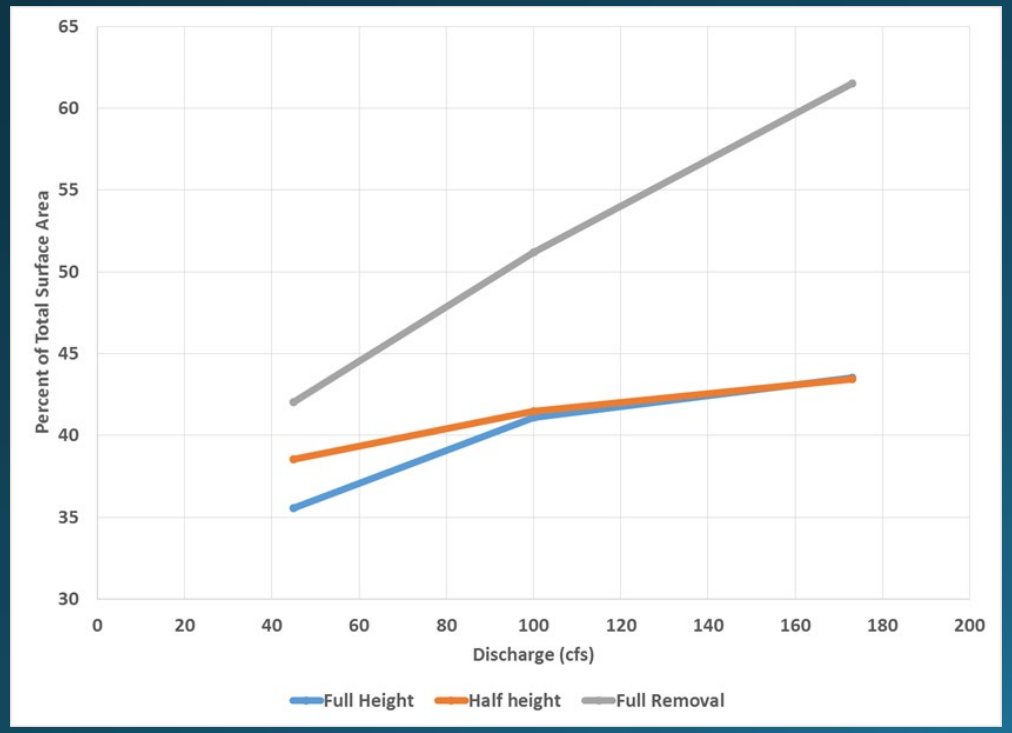

Existing
Half Height
"Full Removal"
"Mill Race"
554.00
553.00
552.00
551.00
550.00
549.00
548.00
Elevation (feet)
0
50
100
150
200
250
300
350
Discharge (cubic feet per second)

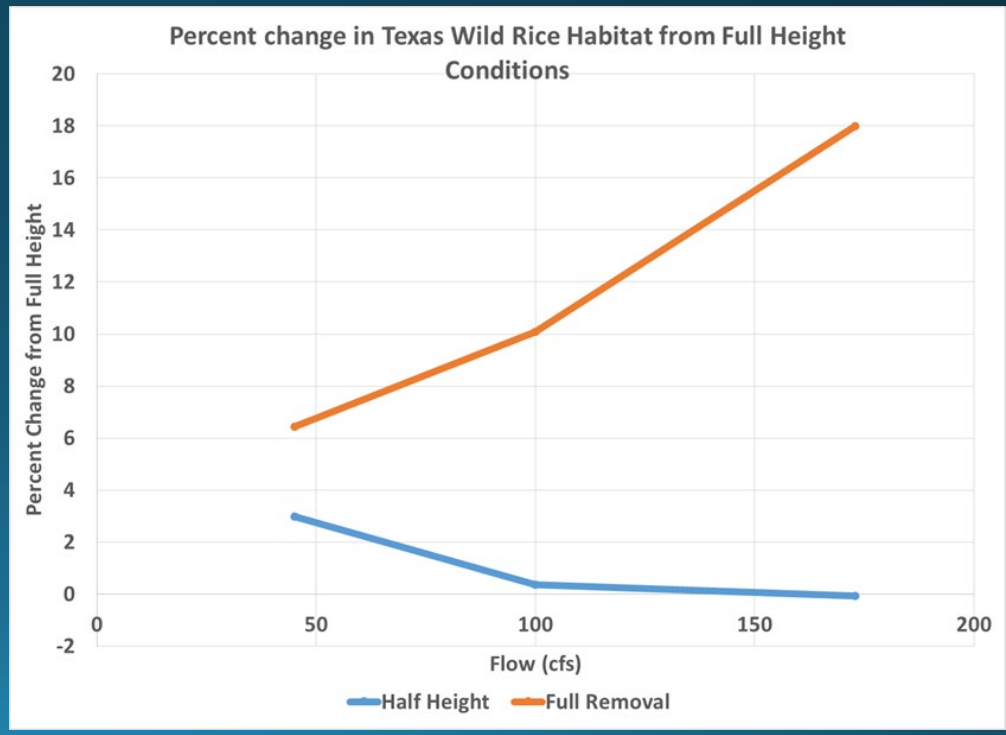
# Key Conclusions

- ***Implications on Flows in the Mill Race***
-
- **Reduction in Cape's Dam to half height will result in a reduction of the amount of time that flows will enter the Mill Race. Under full removal flows will only occur at flow rates equaled or exceeded about 10-15 percent of the time.**
- **Diversion of flows into the Mill Race will continue to reduce the quantity and quality of aquatic habitats in the main stem San Marcos River which are already stressed during low-flow periods.**

# Key Conclusions

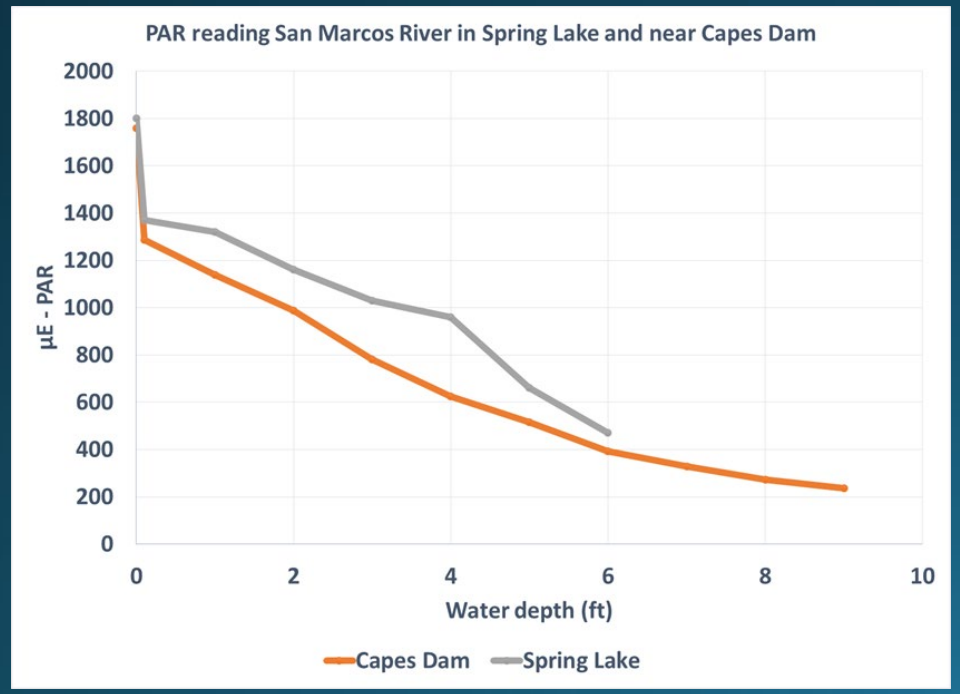
- *Texas Wild Rice*
- **Removal of Cape's Dam represents the best ecological benefits to improving habitat for Texas wild rice.**



# Key Conclusions

- ***Photosynthetically Active Radiation (PAR)***
  - **The decrease in depths within the existing backwater section of the river with removal of Cape's Dam will result in an increase in available PAR reaching the stream bottom which will promote increased TWR and other aquatic macrophyte growth in this section of the river.**




| Species | San Marcos River Reach | | | | | |
|---|---|---|---|---|---|---|
| | Sewell Park | Above City Park | City Park | Purgatory Creek | Cypress Island-Rio vista | Total |
| Ludwigia repens | 2,657 | 2,393 | 6,461 | - | 768 | 12,279 |
| Heteranthera dubia | 622 | 475 | 2,169 | - | 2,544 | 5,810 |
| Zizania texana | 1,886 | 4,269 | 16,140 | 384 | 7,752 | 30,431 |
| Sagittaria | 673 | 1,560 | 1,121 | 133 | 305 | 3,792 |
| Potamogeton | 55 | 124 | 54 | - | - | 233 |
| Hydrocotyle | - | 42 | - | - | - | 42 |

# Key Conclusions

- ***Velocity and Gas Exchange Dynamics in Aquatic Plants***
  - **Increased distribution of higher velocities in the backwater section of the river with dam removal will promote higher growth rates of TWR and other aquatic macrophytes.**

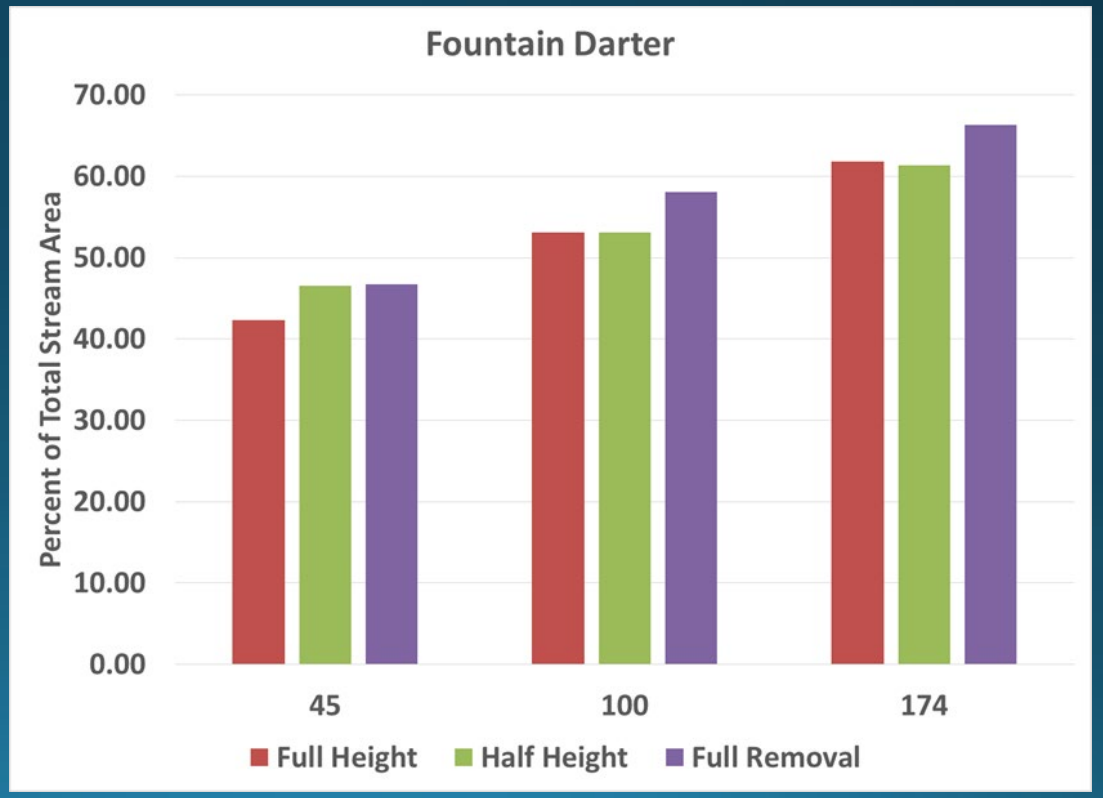
    **Increased water velocities at the leaf surface have been shown to increase the photosynthetic rates in several aquatic macrophytes due to reduction in the thickness of the DBL (Black et al., 1981). Powers (1996) demonstrated that for TWR the stem density was greater in fast flowing water (0.40-0.49 m/s) than in either moderate (0.12-0.24 m/s) or slow flowing (0.05-0.12 m/s) water. Hardy et al. (2015) harvested thousands of free floating TWR tillers from the San Marcos River and showed > 90% success rate for propagation of TWR exposed to moderate velocities.**

# Key Conclusions

- ***Implications on Reproduction and Genetic Integrity***
  - **Reduction of depths with removal of Cape's Dam will provide an increase in areas suitable for sexual reproduction of TWR important for maintenance of genetic integrity of the population.**

# Key Conclusions

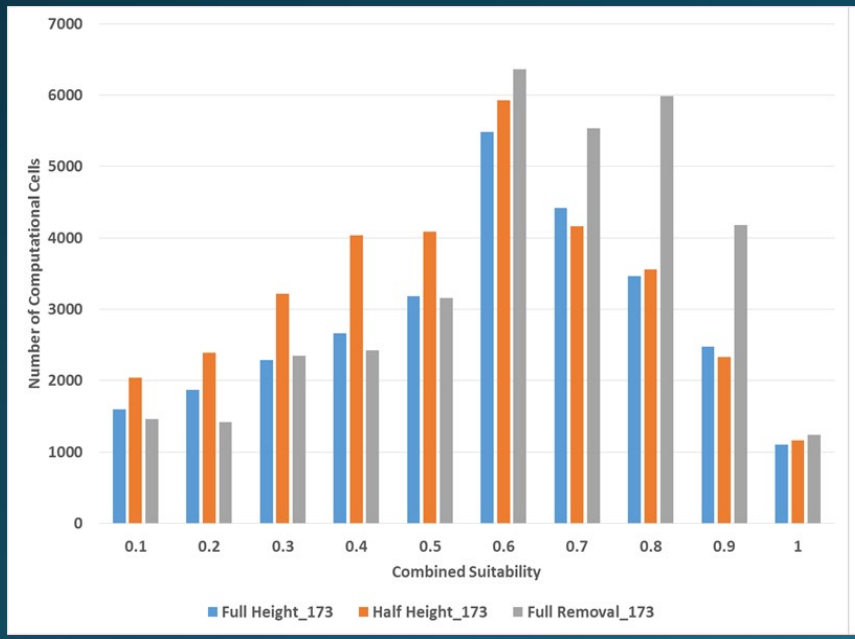
- ***Habitat Quantity***
  - **Removal of Cape's Dam will provide an increase in the area of fountain darter habitat due to both improved hydraulic conditions (i.e., depth and velocity) as well as aquatic macrophyte expansion.**



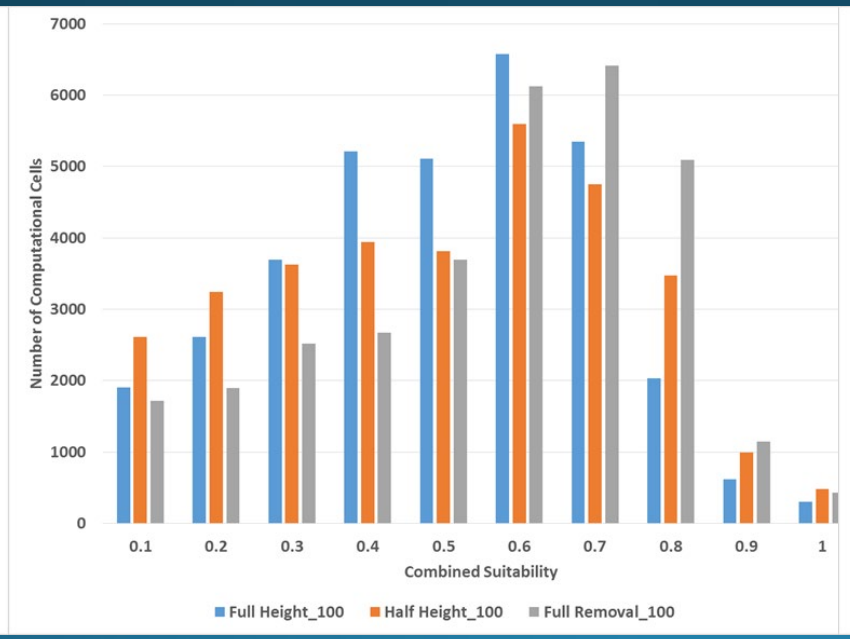
# Key Conclusions

- ***Habitat Quality***
  - **Removal of Cape's Dam will provide an increase in the quality of fountain darter habitat over all flow ranges compared to full height or half height dam scenarios.**

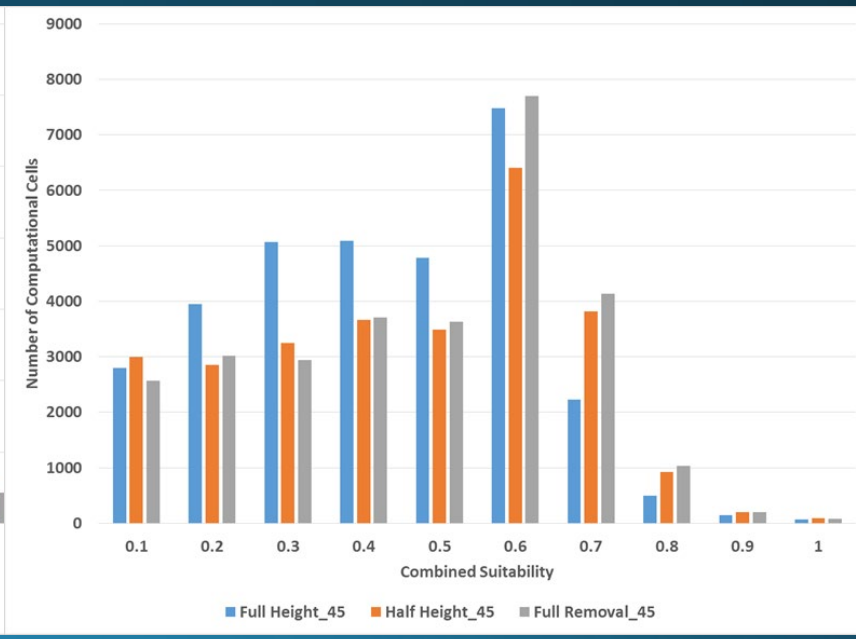
173 cfs




100 cfs




45 cfs

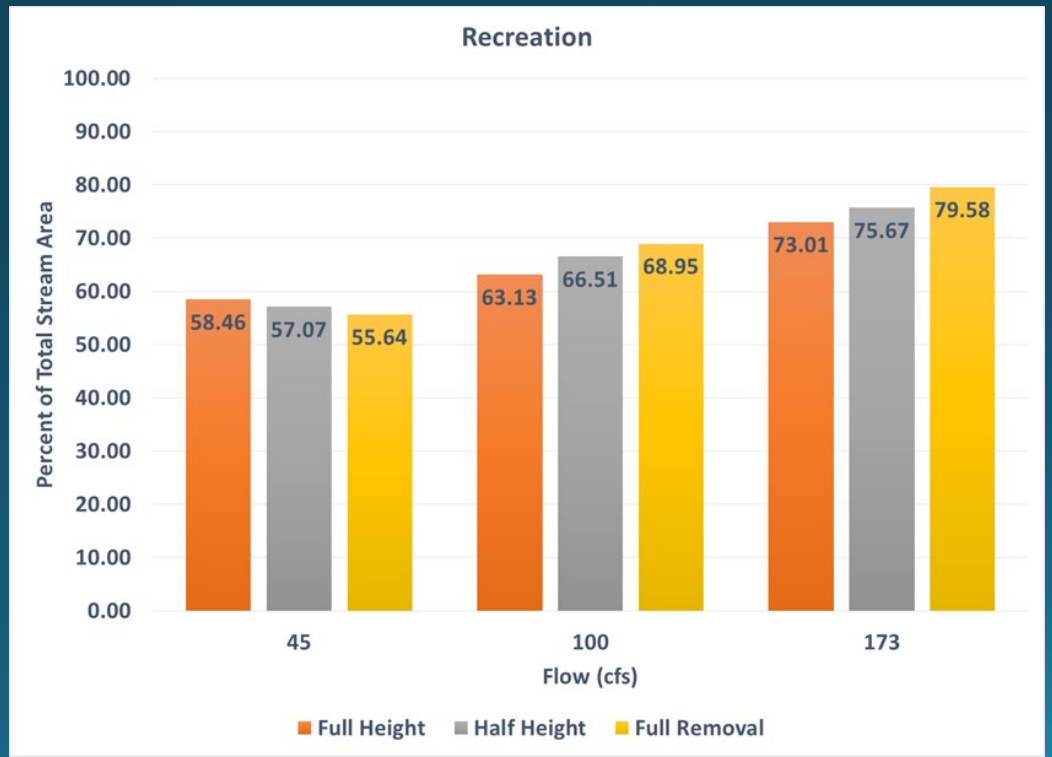


# Key Conclusions

- ***Impacts of Low Head Dams***
  - **Removal of Cape's Dam will eliminate known ecological impacts associated with low head dams such as adversely affecting warmwater stream fish, aquatic macroinvertebrates, and aquatic/riparian plants by blocking migration pathways, degrading habitat and water quality, and fragmenting the river landscape, which results in a loss of native species diversity.**
  - **Backwaters from Low Head Dams are known to encourage the proliferation of introduced aquatic plant and fish species which are detrimental to the native flora and fauna within the San Marcos River. Introduced fish directly compete for space and food resources and are known predators or many native larval fish.**
  - **Low head dams can impact the height of flood waters**

# Key Conclusions

- *Recreation*
  - **Removal of Cape's Dam will provide a safe and sustainable recreation corridor that will accommodate, swimming, tubing, canoeing, kayaking and paddle boarding without a demonstrable negative impact relative to full height or half height dam scenarios for these water based recreation activities.**



# Summary

- Dam removal represents the best "cost/benefit" environmentally
- Removal results in increases in both fountain darter and Texas wild rice habitat and does not negatively impact opportunities for contact recreation
- Dam removal will not functionally impact recreation at flow levels that are equaled or exceeded over 90 percent of the time
- Simulations support that dam removal will result in improved aquatic vegetation production with concomitant increases in the endangered fountain darter (and other aquatic organisms) habitat
- Existing empirical data from this section of river clearly shows very little potential for bank erosion or lateral migration if the dam were removed
- Multi-Year monitoring of channel changes after dredging in this reach showed no evidence of head-cuts

# Summary

- Under existing conditions that Capes Dam backs up the water surface elevation and flows enter the Mill Race over a wide range of discharges.
- Under half-height conditions, where the height of the water backed up behind Capes Dam would be lower, that water would enter the Mill Race when the San Marcos River discharge is approximately 130 cfs. This flow rate is equaled or exceeded approximately 53 percent of the time.
- Under full dam removal, water would enter the Mill Race when San Marcos flows are greater than about 280 cfs. This average daily flow rate is equaled or exceeded only about 10-13 percent of the time over the indicated period of record.