

# D'Olive Creek Stream Restoration

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Dauphin Island Sea Lab

Mobile Bay National Estuary Program

Goodwyn, Mills, and Cawood, Inc.

Justin N. Barrett, PE



# Outline

Project Location

Former Conditions

Current Conditions

Project Objectives

Project Constraints

Geomorphic Assessment

Stream Stability Assessment

Hydrology Assessment

Conceptual Design

Design Approach

Design Iterations

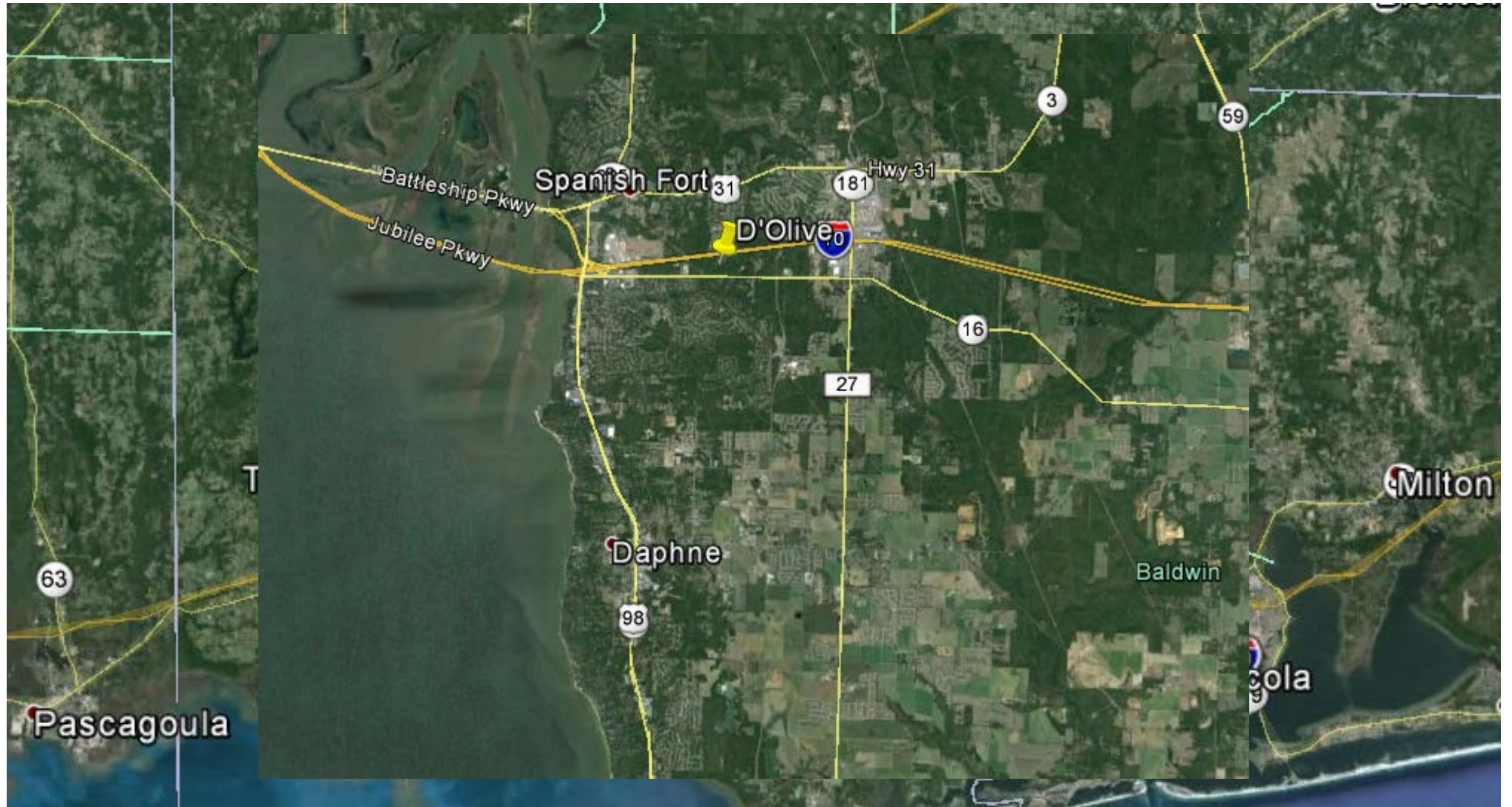
Modeling

Optimization





# Project Location





# Former Conditions





# Current Conditions



# Project Objectives

**Objective #1:** Design a self-sustaining, natural, stable stream

**Objective #2:** Reduce erosion and sediment supply through the reach

**Objective #3:** Design a stream and floodplain to handle design applied shear stresses without excess erosion or floodplain scour

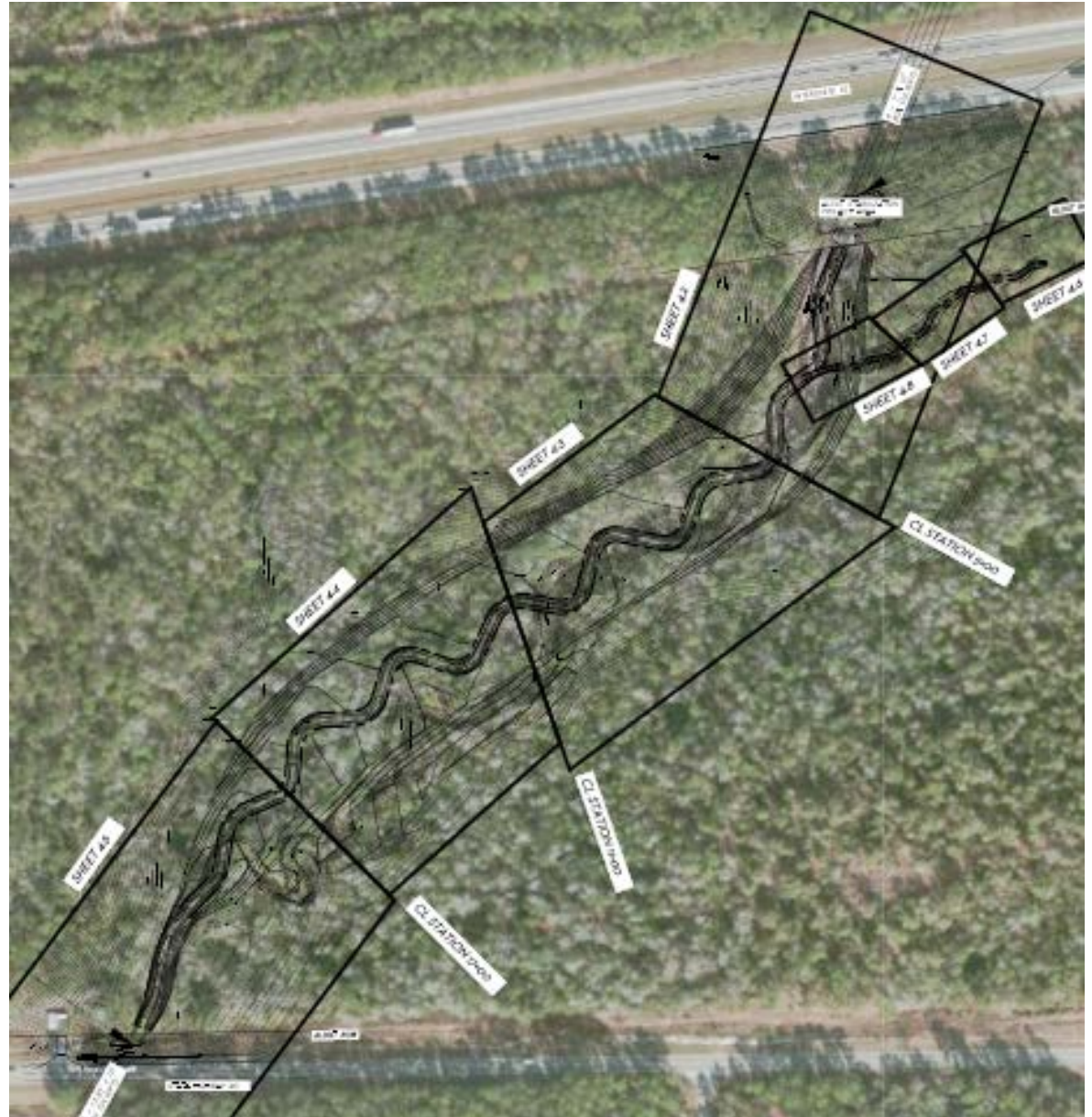
**Objective #4:** Improve the riparian buffer functions of stability, habitat, and aesthetics

**Objective #5:** Maintain the integrity and function of the culverts at I-10 and work in conjunction with the ALDOT design for a stilling basin



# Project Constraints

- Upstream and Downstream Culvert Grade Control
- Valley Topography
- Private Property
- Utilities



# Design Approach

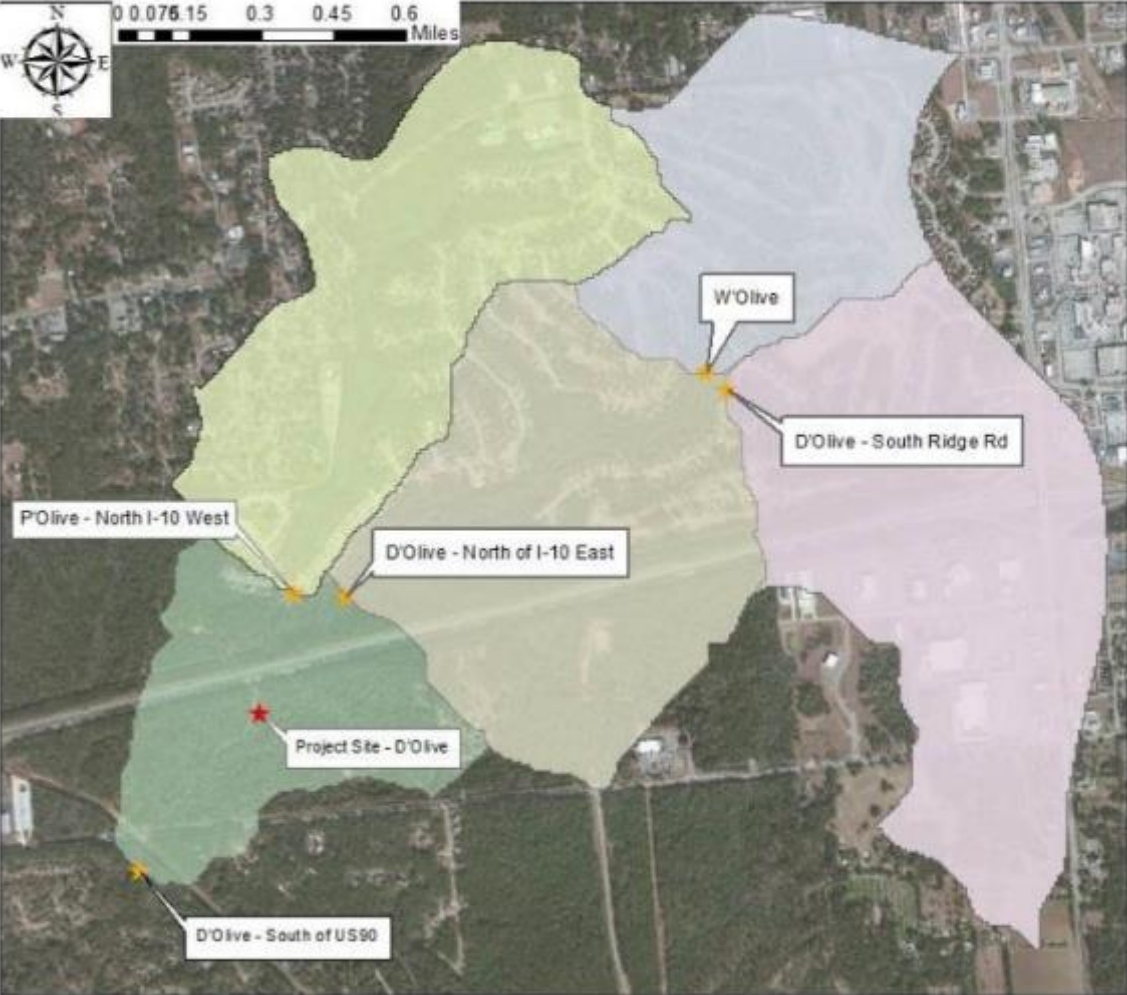
## Natural Channel Design

- Mini Regional Curve Development
- Watershed and Stream Stability Assessment
- Conceptual Design
- Preliminary Design
- Modeling
- Optimization
- Final Design
- Stability and Enhancement Structures

Parameter	Existing Stream			Design Stream			Potential Stream Evolution		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
Stream name	D'Olive Creek			D'Olive Creek			D'Olive Creek		
Stream type	F5			CS/4			ES/4		
Drainage area, DA (mi <sup>2</sup> )	2.2			2.2			2.2		
Mean riffle depth, $d_{wr}$ (ft)	1.8	1.6	1.6	1.38	1.35	1.40	2.00	2.06	1.94
Riffle width, $W_{wr}$ (ft)	18.1	20.2	20.2	24.0	24.4	25.0	15.0	16.0	18.0
Width-to-depth ratio, $[W_{wr}/d_{wr}]$	9.9	12.3	12.4	17.5	18.0	18.5	7.5	7.8	9.3
Riffle cross-section area, $A_{wr}$ (ft <sup>2</sup> )	33.0	33.0	33.0	33	33	35	30	33	35
Max riffle depth, $d_{wrm}$ (ft)	2.0	2.1	2.4	2.2	2.3	2.5	2.6	2.9	2.9
Max riffle depth ratio, $[d_{wrm}/d_{wr}]$	1.1	1.3	1.5	1.6	1.7	1.8	1.3	1.4	1.5
Mean pool depth, $d_{wp}$ (ft)	2.8	2.6	2.7	1.4	1.5	1.6	2.4	2.7	2.7
Mean pool depth ratio, $[d_{wp}/d_{wr}]$	1.5	1.6	1.7	1.5	1.6	1.6	1.2	1.3	1.4
Pool width, $W_{wp}$ (ft)	32.0	45.8	50.9	27.6	29.3	30.0	14.0	16.0	18.0
Pool width ratio, $[W_{wp}/W_{wr}]$	1.8	2.3	2.5	1.2	1.2	1.2	0.9	1.0	1.0
Pool cross-section area, $A_{wp}$ (ft <sup>2</sup> )	88.8	117.8	135.9	39.6	42.9	49.0	33.6	42.9	49.0
Pool area ratio, $[A_{wp}/A_{wr}]$	2.7	3.6	4.2	1.2	1.3	1.4	1.1	1.3	1.4
Max pool depth, $d_{wpm}$ (ft)	2.6	3.3	4.0	3.6	3.7	3.9	4.0	4.5	4.9
Max pool depth ratio, $[d_{wpm}/d_{wr}]$	1.4	2.0	2.5	2.6	2.7	2.8	2.0	2.2	2.5
Low bank height, LBH (ft)	8.2	9.1	12.0	2.2	2.3	2.5	2.6	3.0	3.4
Low bank height ratio, $[LBH/d_{wrm}]$	4.2	4.4	4.9	1.0	1.0	1.0	1.0	1.1	1.2
Width flood-prone area, $W_{fpa}$ (ft)	26.3	24.3	26.2	36	120	190	36	120	190
Entrenchment ratio, ER $[W_{fpa}/W_{wr}]$	1.45	1.20	1.30	1.5	4.9	7.6	2.4	7.5	10.6
Bankfull mean velocity, $u_{wf}$ - $Q/A$ (ft/s)	3.9	4.2	4.5	3.9	4.2	4.3	4.3	4.2	4.3
Bankfull discharge, $Q_{wf}$ (cfs)	130	140	150	130	140	150	130	140	150
Meander length, $L_m$ (ft)	89.0	234.5	393.0	168.0	188.0	210.0	168.0	188.0	210.0
Meander length ratio $[L_m/W_{wr}]$	4.9	11.6	19.5	6.9	7.7	8.6	10.5	11.8	13.1
Radius of curvature, $R_c$ (ft)	28.0	46.5	28.0	53.0	63.0	73.0	50.0	60.0	70.0
Radius of curvature ratio $[R_c/W_{wr}]$	1.5	2.3	1.4	2.2	2.6	3.0	3.1	3.8	4.4



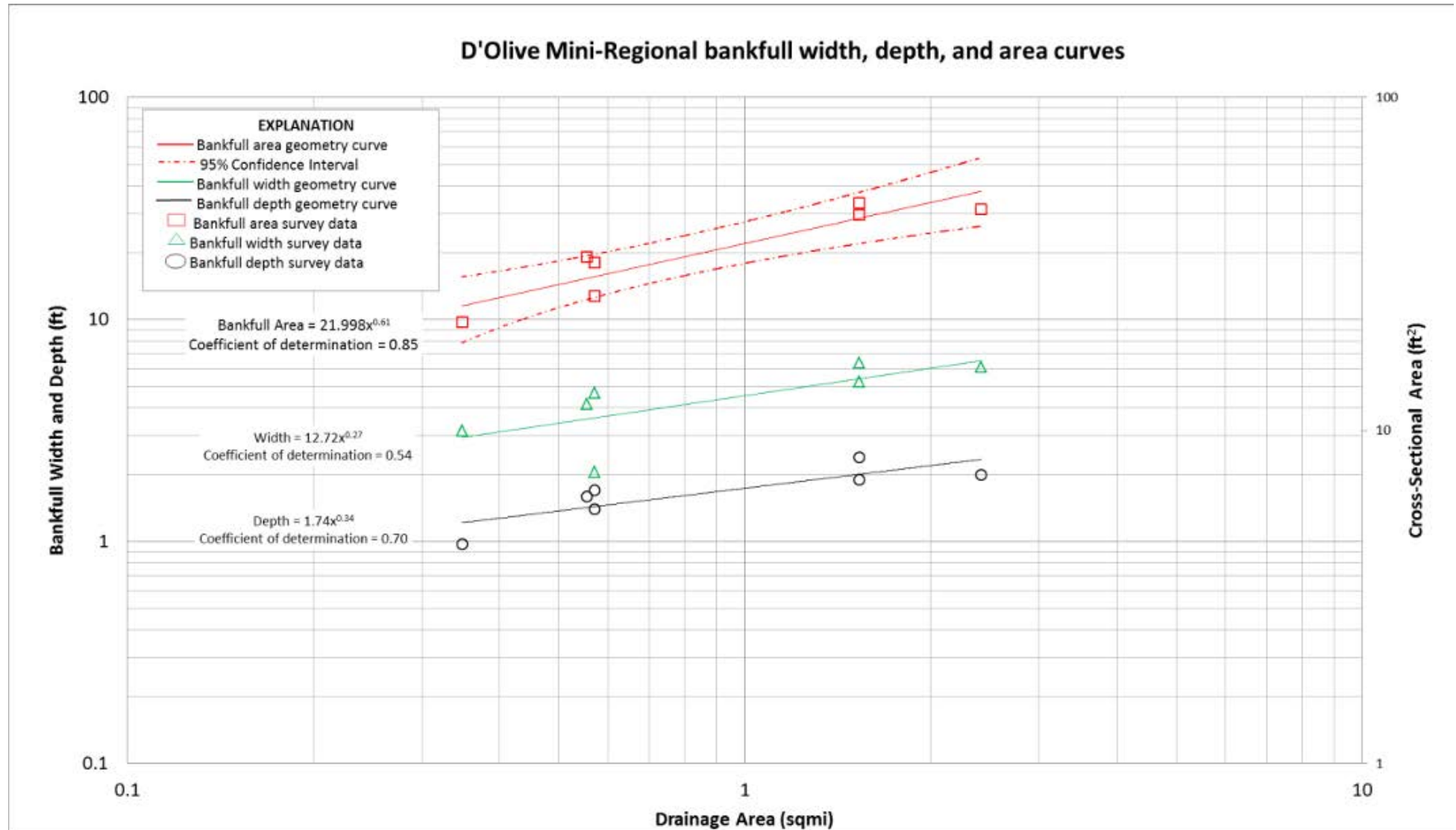
# Mini Regional Curve Development



Location	Channel Classification	Drainage area (mi <sup>2</sup> )	Bankfull Width (ft)	Bankfull depth (ft)	Bankfull cross-sectional area (ft <sup>2</sup> )	W/D Ratio
D'Olive - South of US 90 (XS1)	E5	2.415	15.5	2	31.4	7.8
D'Olive - North of I-10 East Branch (XS2)	E5	1.533	14	2.4	33.4	5.8
D'Olive - North of I-10 East Branch	E5	1.533	16	1.9	29.6	8.4
P'Olive - North of I-10 West Branch	E5	0.554	12	1.6	19.1	7.5
D'Olive - South of D'Olive Ridge Rd (East Trib XS1)	E5	0.57	13	1.4	18.1	9.3
D'Olive - South of D'Olive Ridge Rd (East Trib XS2)	E5	0.57	7.5	1.7	12.7	4.4
W'Olive - South of D'Olive Ridge Rd (West Trib)	E5	0.348	10	0.97	9.7	10.3



# Mini Regional Curve Development





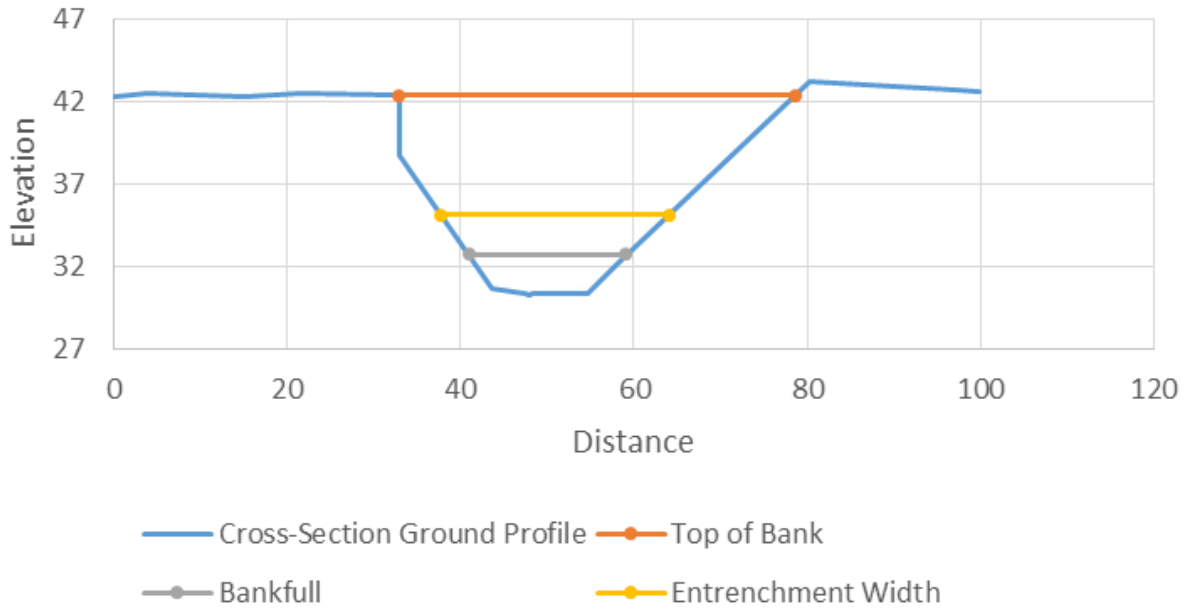
# Stream Stability Assessment

- Meander Patterns
- Depositional Features
- Degree of Incision
- Width to Depth Ratio State
- Degree of Confinement
- Stream Succession Stage Shifts

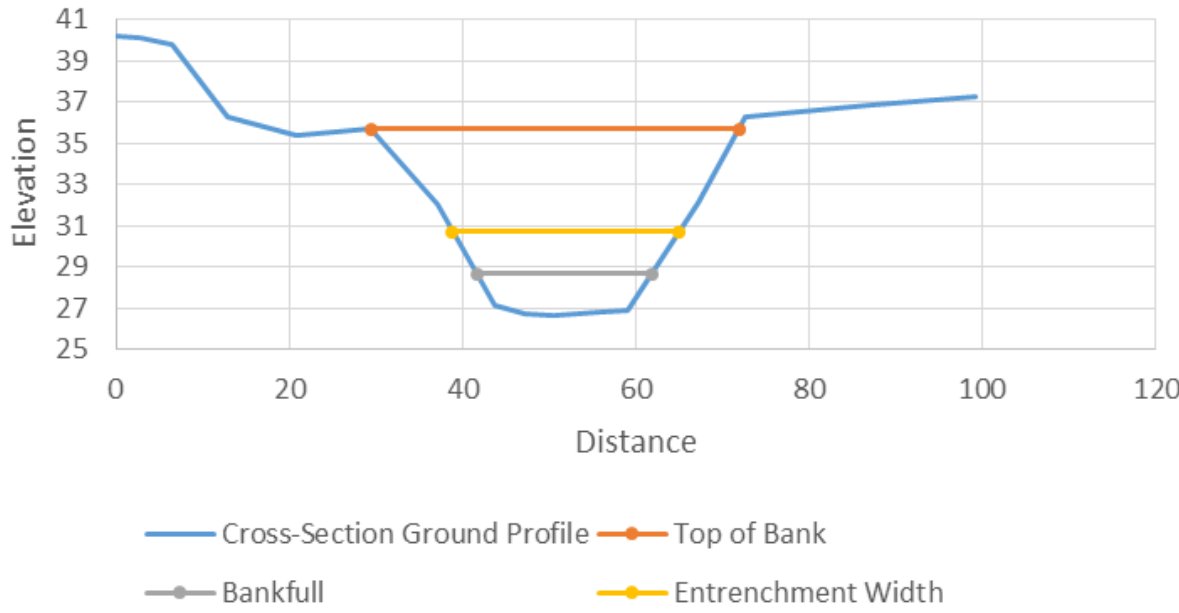


# Stream Stability Assessment

### Existing Conditions - Riffle Cross-Section 1



### Existing Conditions - Riffle Cross-Section 2



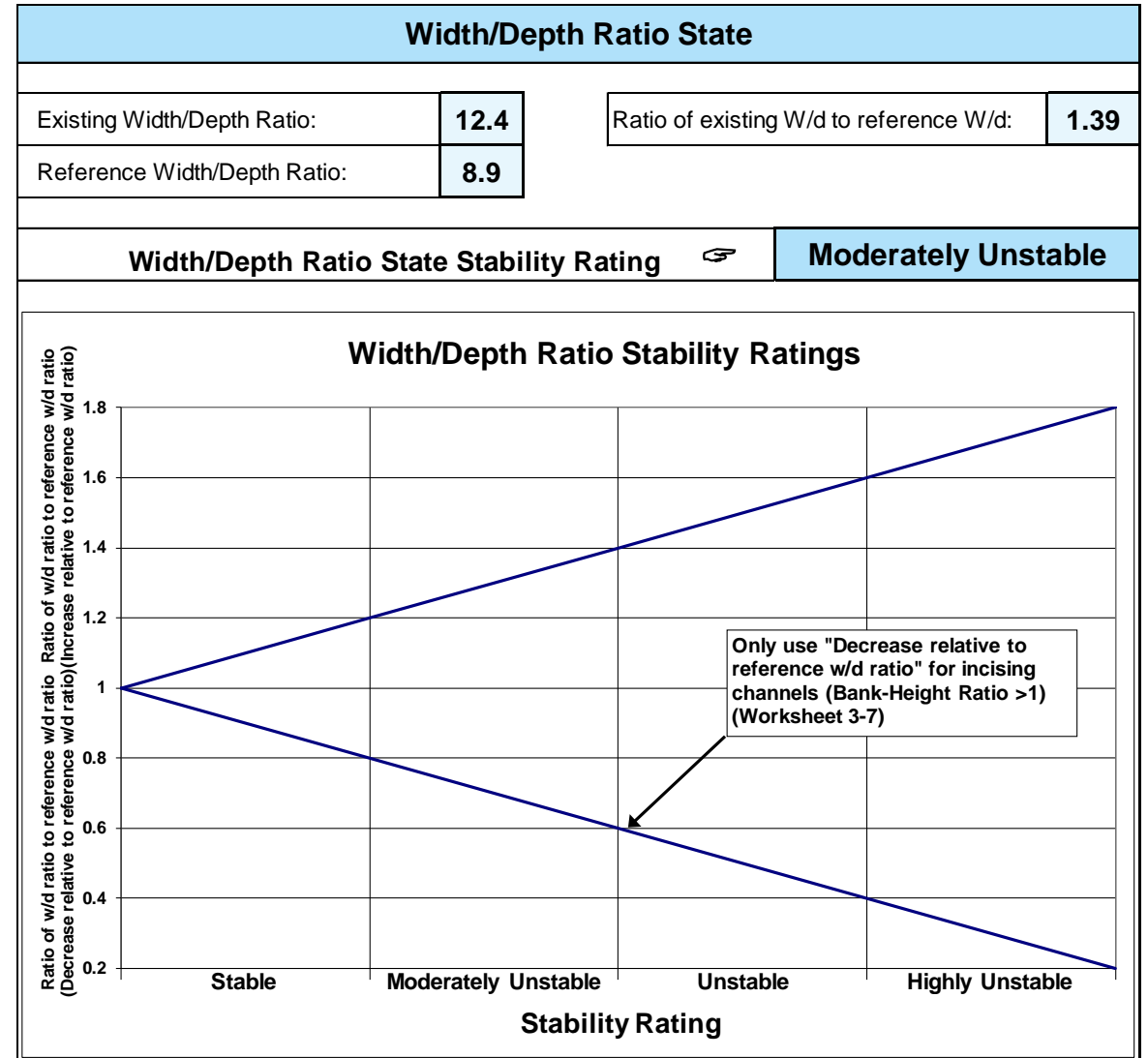
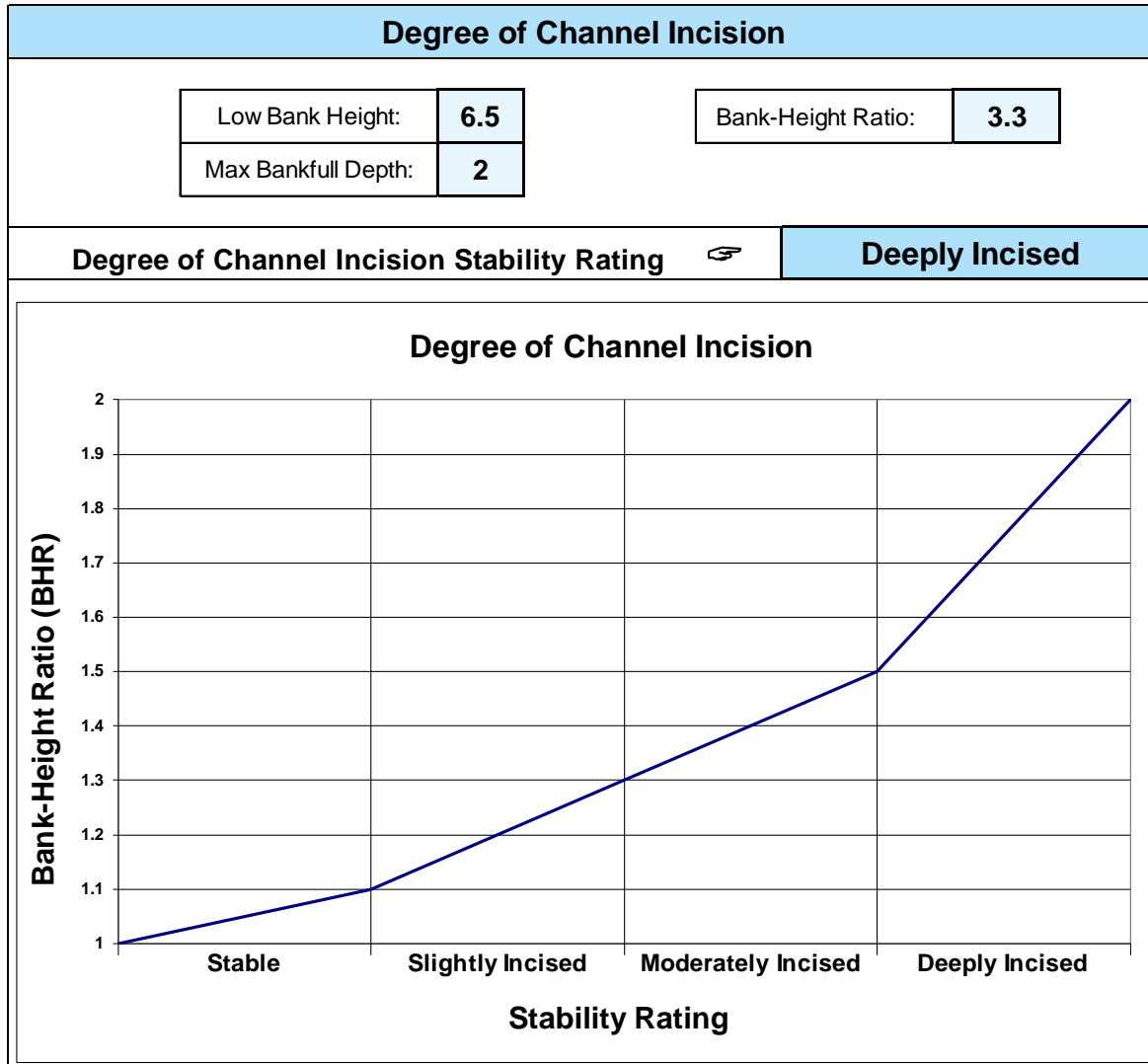


# Stream Stability Assessment

Meander Patterns				
Stream:	D'Olive Creek - I-10 Project		Reach: D'Olive Creek	
Observers:	DAB, MJG		Date: 6/13/2015	
List ALL CATEGORIES that APPLY	<input checked="" type="checkbox"/> M3	<input checked="" type="checkbox"/> M4	<input type="checkbox"/>	<input type="checkbox"/>
<i>Various Meander Pattern variables modified from Galay et al. (1973)</i>				
	<b>M1 REGULAR MEANDERS</b>			
	<b>M2 TORTUOUS MEANDERS</b>			
	<b>M3 IRREGULAR MEANDERS</b>			
	<b>M4 TRUNCATED MEANDERS</b>			
	<b>M5 UNCONFINED MEANDER SCROLLS</b>			
	<b>M6 CONFINED MEANDER SCROLLS</b>			
	<b>M7 DISTORTED MEANDER LOOPS</b>			
	<b>M8 IRREGULAR MEANDERS with oxbows and oxbow cutoffs</b>			

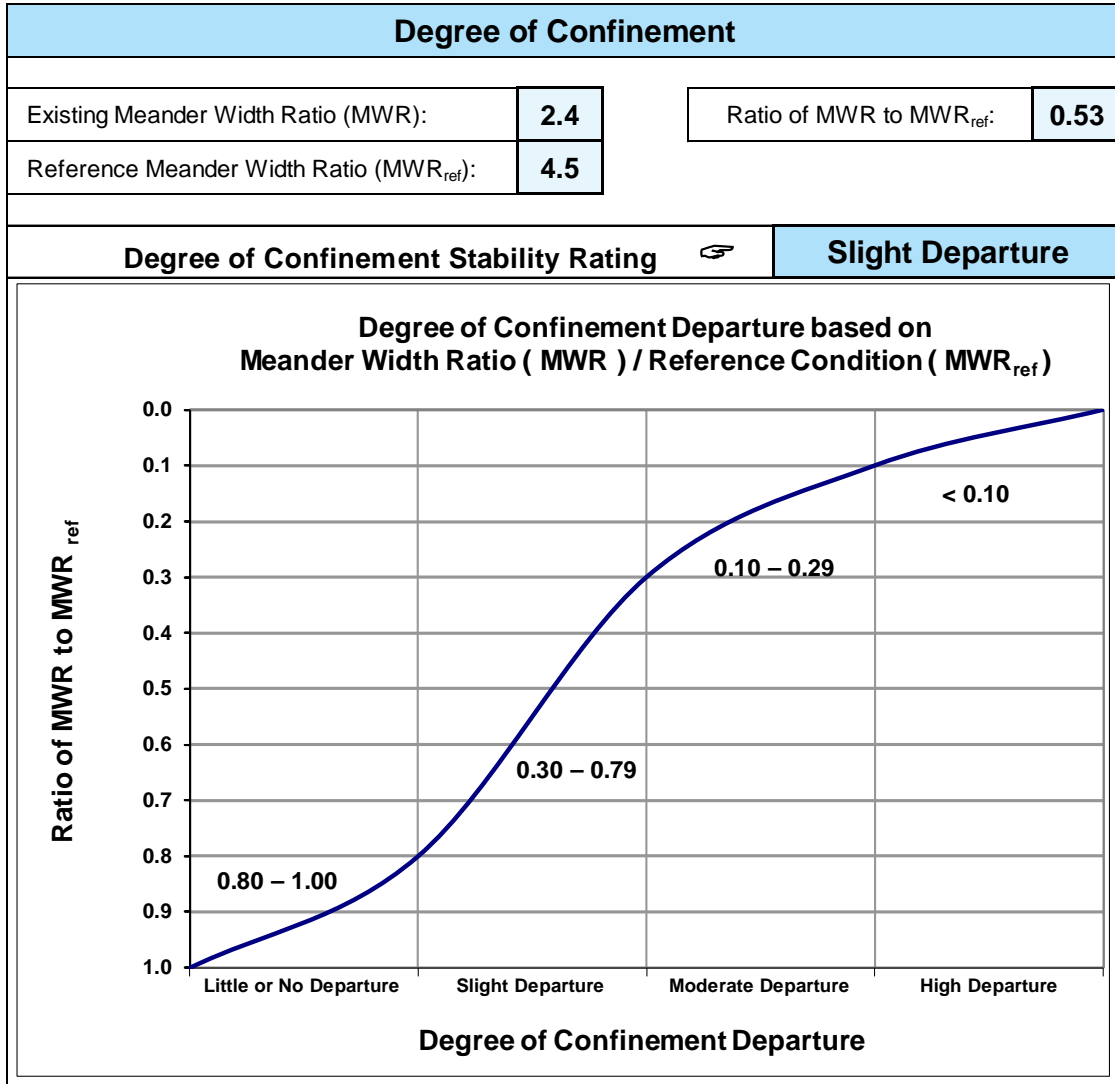
Depositional Patterns				
Stream:	D'Olive Creek - I-10 Project		Reach: D'Olive Creek	
Observers:	DAB, MJG		Date: 6/13/2015	
List ALL CATEGORIES that APPLY	<input checked="" type="checkbox"/> B1	<input checked="" type="checkbox"/> B2	<input checked="" type="checkbox"/> B4	<input type="checkbox"/>
<i>Various Depositional Features modified from Galay et al. (1973)</i>				
	<b>B1 POINT BARS</b>			
	<b>B2 POINT BARS with Few MID-CHANNEL BARS</b>			
	<b>B3 NUMEROUS MID-CHANNEL BARS</b>			
	<b>B4 SIDE BARS</b>			
	<b>B5 DIAGONAL BARS</b>			
	<b>B6 Main Channel Branching with Numerous MID-CHANNEL BARS and Islands</b>			
	<b>B7 SIDE BARS AND MID-CHANNEL BARS with Length Exceeding 2 to 3 Channel Widths</b>			
	<b>B8 DELTA BARS</b>			

# Stream Stability Assessment





# Stream Stability Assessment



Stream: <b>D'Olive Creek</b>	Stream Type: <b>F5</b>
Location: <b>I-10</b>	Valley Type: <b>VIII</b>
Observers: <b>DAB, MJG</b>	Date: <b>04/13/2015</b>
Stream Type Stage Shifts (Figure 3-14)	Stability Rating (Check Appropriate Rating)
Stream Type at potential, (C→E), (F <sub>b</sub> →B), (G→B), (F→B <sub>c</sub> ), (F→C), (D→C)	<input type="checkbox"/> Stable
(E→C), (B→High W/d B), (C→High W/d C)	<input type="checkbox"/> Moderately Unstable
(G <sub>c</sub> →F), (G→F <sub>b</sub> ), (F→D), (C→F)	<input checked="" type="checkbox"/> Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	<input type="checkbox"/> Highly Unstable

# Stream Stability Assessment

Stream: <b>D'Olive Creek - I-10 Project</b>		Stream Type: <b>F5/C5</b>			
Location: <b>I-10</b>		Valley Type: <b>VIII</b>			
Observers: <b>DAB, MJG</b>		Date: <b>04/13/2015</b>			
Lateral stability criteria (choose one stability category for each criterion 1-5)	Lateral Stability Categories				Selected Points (from each row)
	Stable	Moderately Unstable	Unstable	Highly Unstable	
1 <b>W/d Ratio State</b> (Worksheet 3-8)	< 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	> 1.6 (8)	4
2 <b>Depositional Patterns</b> (Worksheet 3-5)	B1, B2 (1)	B4, B8 (2)	B3 (3)	B5, B6, B7 (4)	2
3 <b>Meander Patterns</b> (Worksheet 3-4)	M1, M3, M4 (1)		M2, M5, M6, M7, M8 (3)		1
4 <b>Streambank Erosion: Unit Rate (Tons/yr/ft)</b> (Worksheet 3-13)	< 0.006 (2)	0.006 - 0.04 (4)	0.041 - 0.07 (6)	> 0.07 (8)	8
5 <b>Degree of Confinement (MWR / MWR<sub>ref</sub>)</b> (Worksheet 3-9)	> 0.8 (1)	0.3 – 0.79 (2)	0.1 – 0.29 (3)	< 0.1 (4)	2
<b>Total Points</b>					<b>17</b>
<b>Lateral Stability Category Point Range</b>					
<b>Overall Lateral Stability Category</b> (use total points and check stability rating)	Stable < 10 <input type="checkbox"/>	Moderately Unstable 10 – 12 <input type="checkbox"/>	Unstable 13 – 21 <input checked="" type="checkbox"/>	Highly Unstable > 21 <input type="checkbox"/>	

Stream: <b>D'Olive Creek</b>		Stream Type: <b>F5</b>			
Location: <b>I-10</b>		Valley Type: <b>VIII</b>			
Observers: <b>DAB, MJG</b>		Date: <b>04/13/2015</b>			
Vertical Stability Criteria (choose one stability category for each criterion 1-5)	Vertical Stability Categories for Channel Incision / Degradation				Selected Points (from each row)
	Not Incised	Slightly Incised	Moderately Incised	Degradation	
1 <b>Sediment Competence</b> (2-D FESWMS)	Does not indicate excess competence (2)	Trend to move larger sizes than $D_{100}$ of bar or $D_{84}$ of bed (4)	$D_{100}$ of bed moved (6)	Particles much larger than $D_{100}$ of bed moved (8)	8
2 <b>Sediment Capacity</b> (2-D FESWMS)	Does not indicate excess capacity (2)	Slight excess energy: up to 10% increase above reference (4)	Excess energy sufficient to increase load up to 50% of annual load (6)	Excess energy transporting more than 50% of annual load (8)	8
3 <b>Degree of Channel Incision (BHR)</b> (Worksheet 3-7)	1.00 – 1.10 (2)	1.11 – 1.30 (4)	1.31 – 1.50 (6)	> 1.50 (8)	8
4 <b>Stream Succession States</b> (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation (2)	If BHR > 1.1 and stream type has W/d between 5-10 (4)	If BHR > 1.1 and stream type has W/d less than 5 (6)	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) (8)	4
5 <b>Confinement (MWR / MWR<sub>ref</sub>)</b> (Worksheet 3-9)	0.80 – 1.00 (1)	0.30 – 0.79 (2)	0.10 – 0.29 (3)	< 0.10 (4)	2
<b>Total Points</b>					<b>30</b>
<b>Vertical Stability Category Point Range for Channel Incision / Degradation</b>					
<b>Vertical Stability for Channel Incision/ Degradation</b> (use total points and check stability rating)	Not Incised < 12 <input type="checkbox"/>	Slightly Incised 12 – 18 <input type="checkbox"/>	Moderately Incised 19 – 27 <input type="checkbox"/>	Degradation > 27 <input checked="" type="checkbox"/>	



# Stream Stability Assessment

- Findings

- Lateral Stability → Unstable System

- Instream Depositional Features
    - Degree of Confinement
    - Streambank Erosion Potential

- Vertical Stability → Degraded System

- Incised System
    - Upstream Head Cut
    - Instream Energy during High Flows

- Conclusion

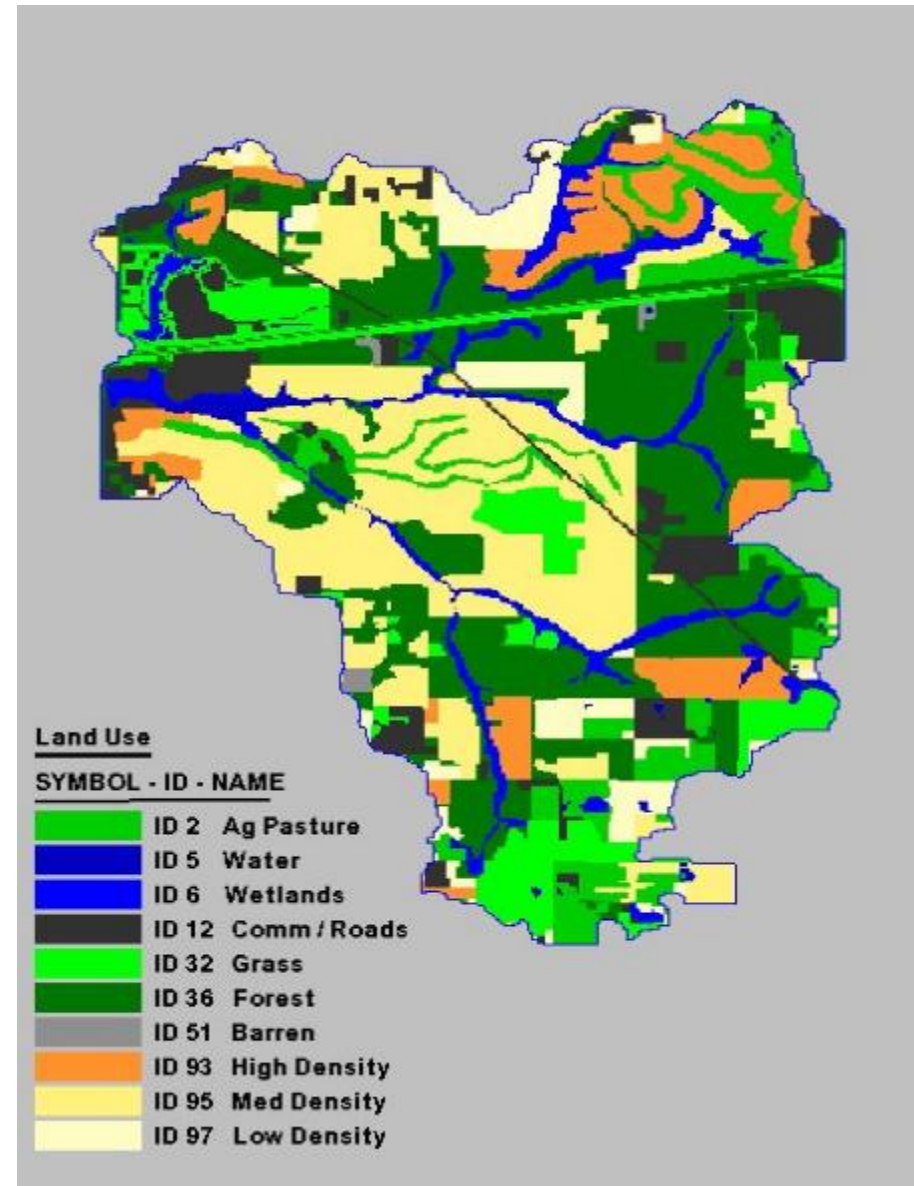
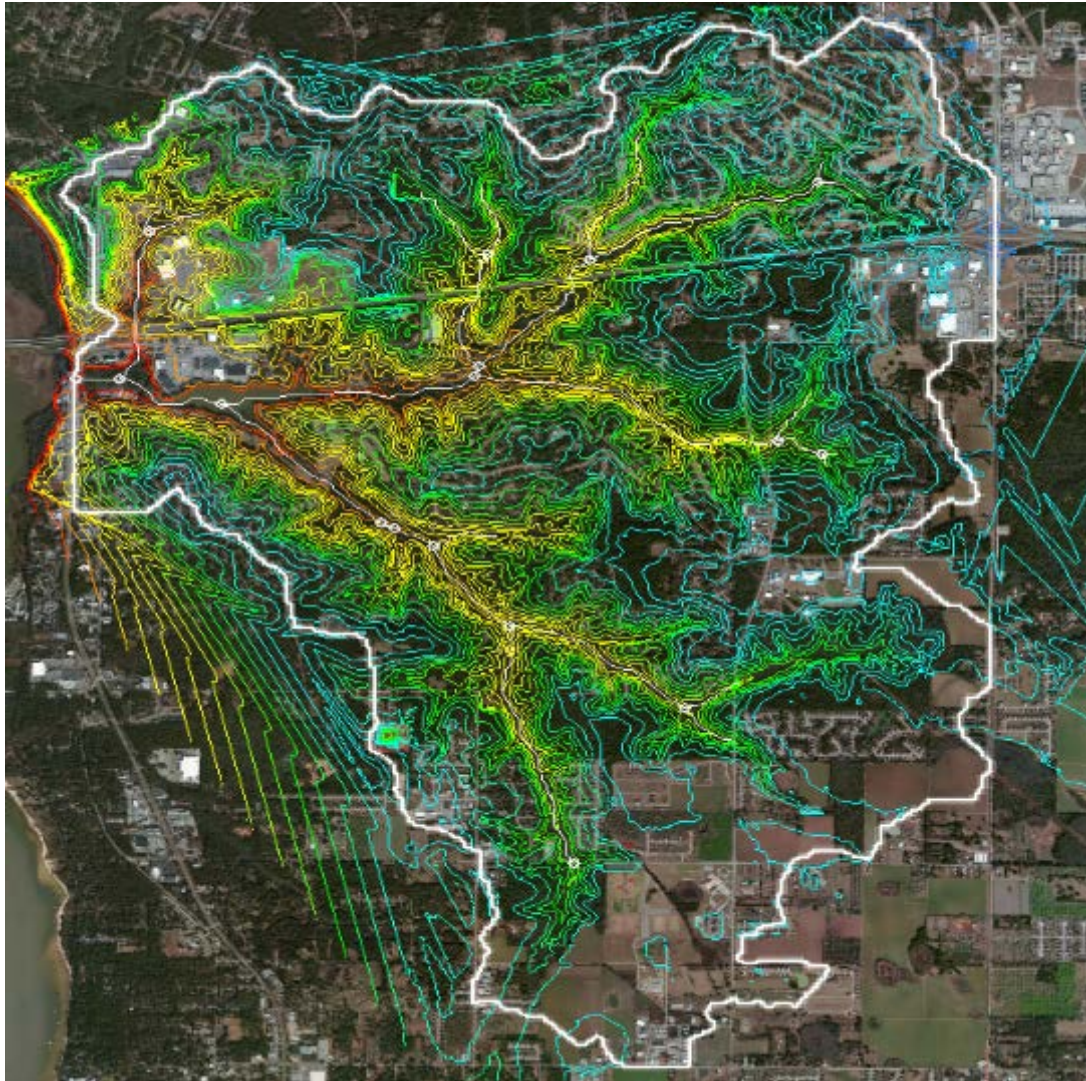
- Major Channel Realignment
  - Adjustment of Profile
  - Floodplain Access
  - Decreased Shear Stress
  - Reduce Bank Erosion
  - Decrease Velocities





# Hydrology Assessment

HYDRO ENGINEERING SOLUTIONS  
A DIVISION OF TRIMBLE





# Conceptual Design

**DESIGN PARAMETERS**

**1] DESIGN PARAMETERS**

**Characteristics**

- Q<sub>DLF</sub>
- Q<sub>MAX</sub>
- slope below culvert
- F<sub>p</sub> expansion/contraction ratios
- side slopes
- allowable speed of flow (for channel)
- Alt. Water elev. W/D
- R, k, W<sub>bit</sub>, L<sub>m</sub>
- bed feature choice, D-D spacing
- stream reach location?

**Constraints**

- 7Elevation - long - bed
- 8order width (+50m)
- 9Preserved reach?
- 10Elev. from DOT
- 11soil conditions
- 12W<sub>dy</sub> slope = 11%
- 13culvert angle

**2] Choices**

- R, k, W<sub>bit</sub>, L<sub>m</sub>

- bed feature choice, D-D spacing

- stream reach location?

**2] Choices**

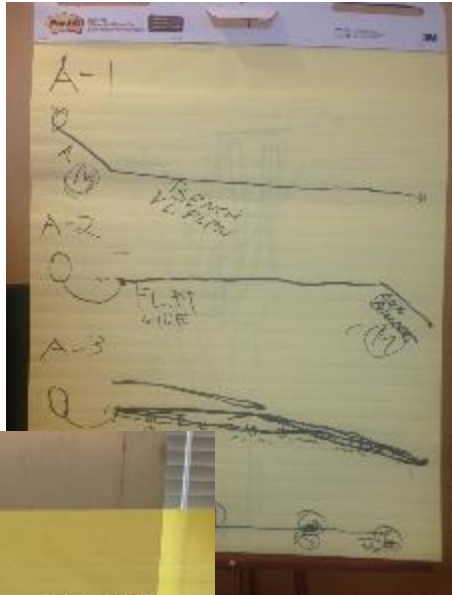
- amend soils?
- vegetation - herb. fr.
- culvert approach SFO
- how to raise water from DOT
- channel elevation (flow + structure)
- stream + vegetation

**DESIGN**

**1] ATTENTION**

- 10. PROBLEM / REACH
- DESIGN GOAL
- R, k
- COMPLEX DESIGN PATH
- SITE DATA
- WATER LEVELS (long / short run)
- HYDROLOGY
- HYDROLOGY
- CHANNEL STABILIZATION
- TOPO. STUDIES
- DETAILED HAND-OUT
- EXISTING COND. MEASUREMENTS
- REMOVE IT
- PROTECTIVE OR EXISTING CON.
- STRUCTURE + APPROACH

12.37



**Reference Species**

- 1- Quant. level
- 2- Qual. level
- 3- Bed level
- 4- Top level
- 5- Top level - velocity
- 6- Velocity - water
- 7- Velocity - water
- 8- Velocity - water
- 9- Velocity - water
- 10- Velocity - water
- 11- Velocity - water
- 12- Velocity - water
- 13- Velocity - water
- 14- Velocity - water
- 15- Velocity - water
- 16- Velocity - water
- 17- Velocity - water
- 18- Velocity - water
- 19- Velocity - water
- 20- Velocity - water

2- grade control

3- slope control

4- slope control

5- slope control

6- slope control

7- slope control

8- slope control

9- slope control

10- slope control

11- slope control

12- slope control

13- slope control

14- slope control

15- slope control

16- slope control

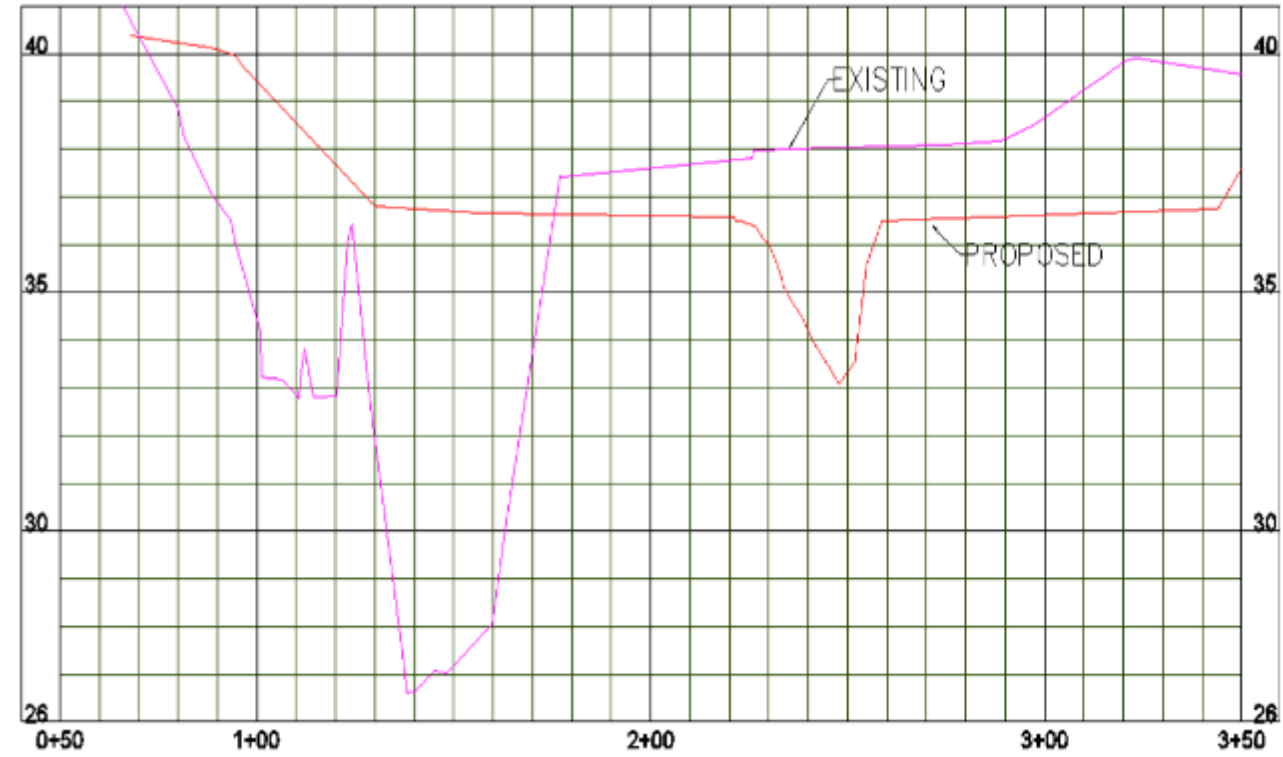
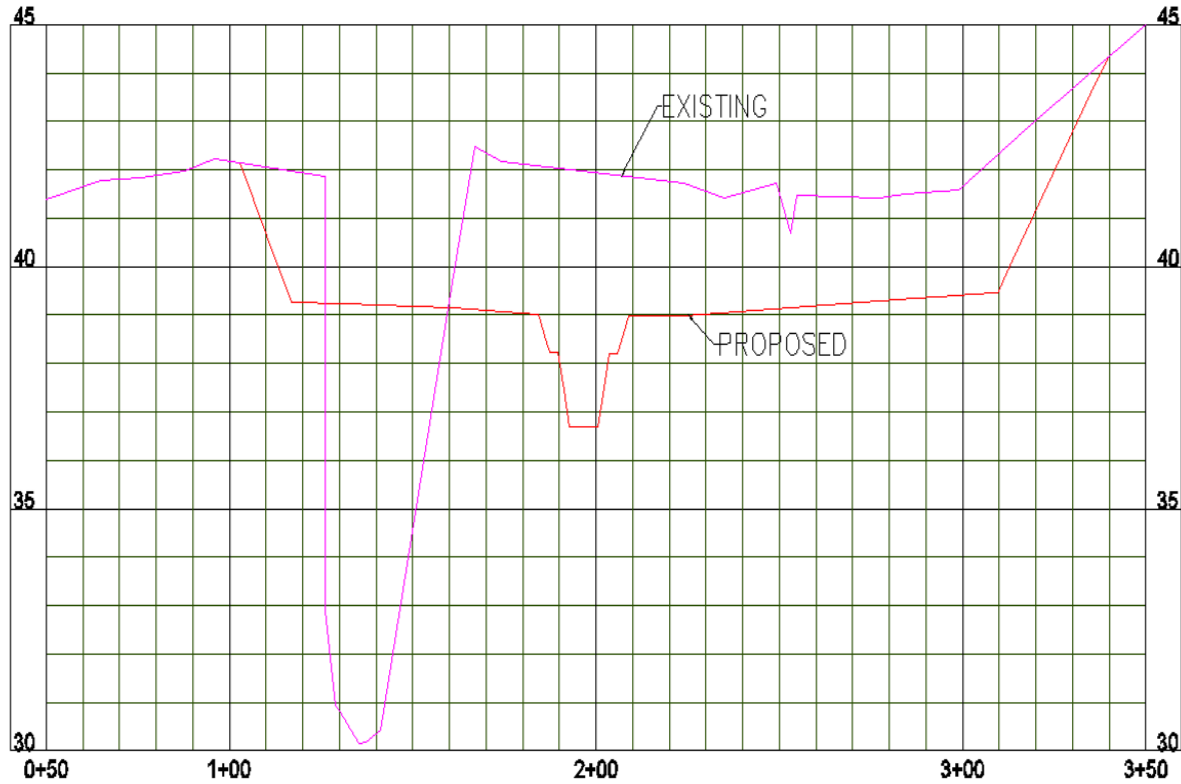
17- slope control

18- slope control

19- slope control

20- slope control

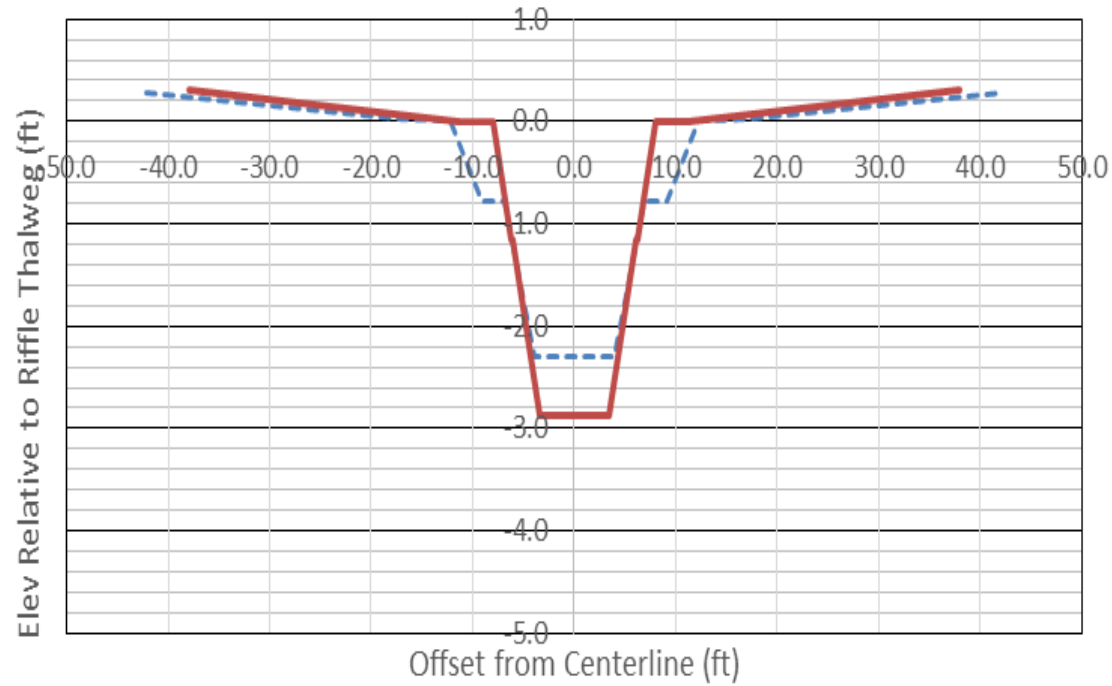
# Design Approach





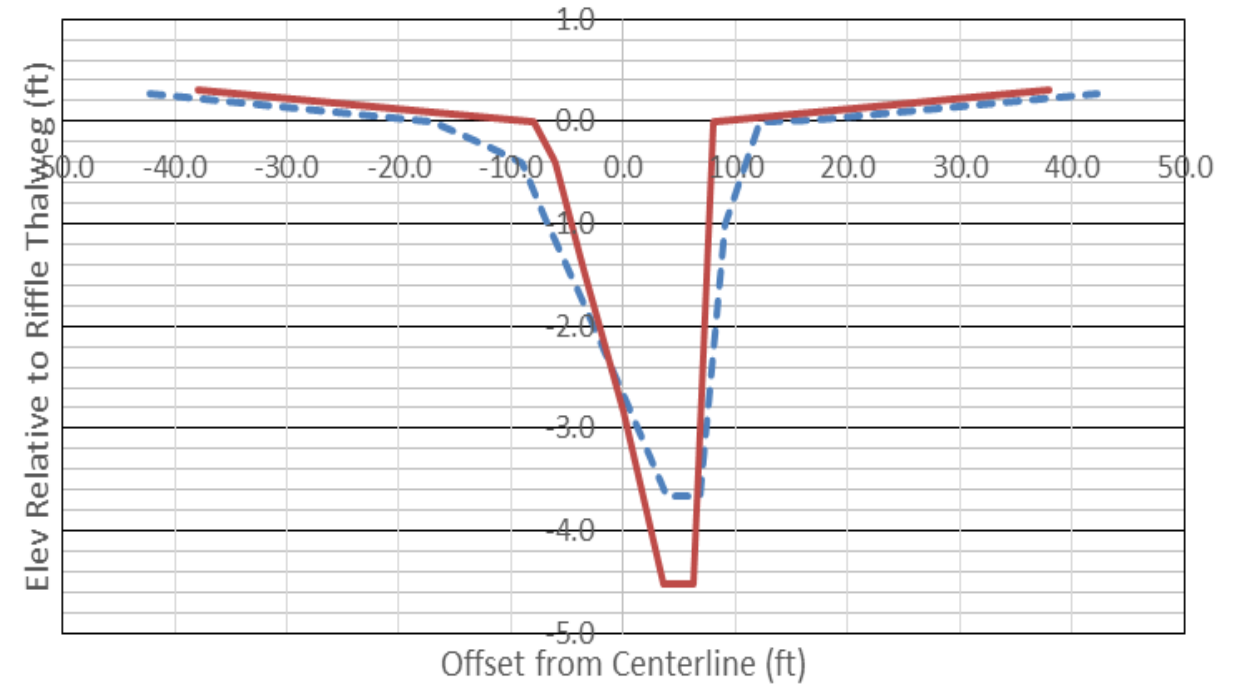
# Design Approach

Evolution of Riffle



--- Design Riffle    — Evolution Trend

Evolution of Pool



--- Design Pool    — Evolution Trend

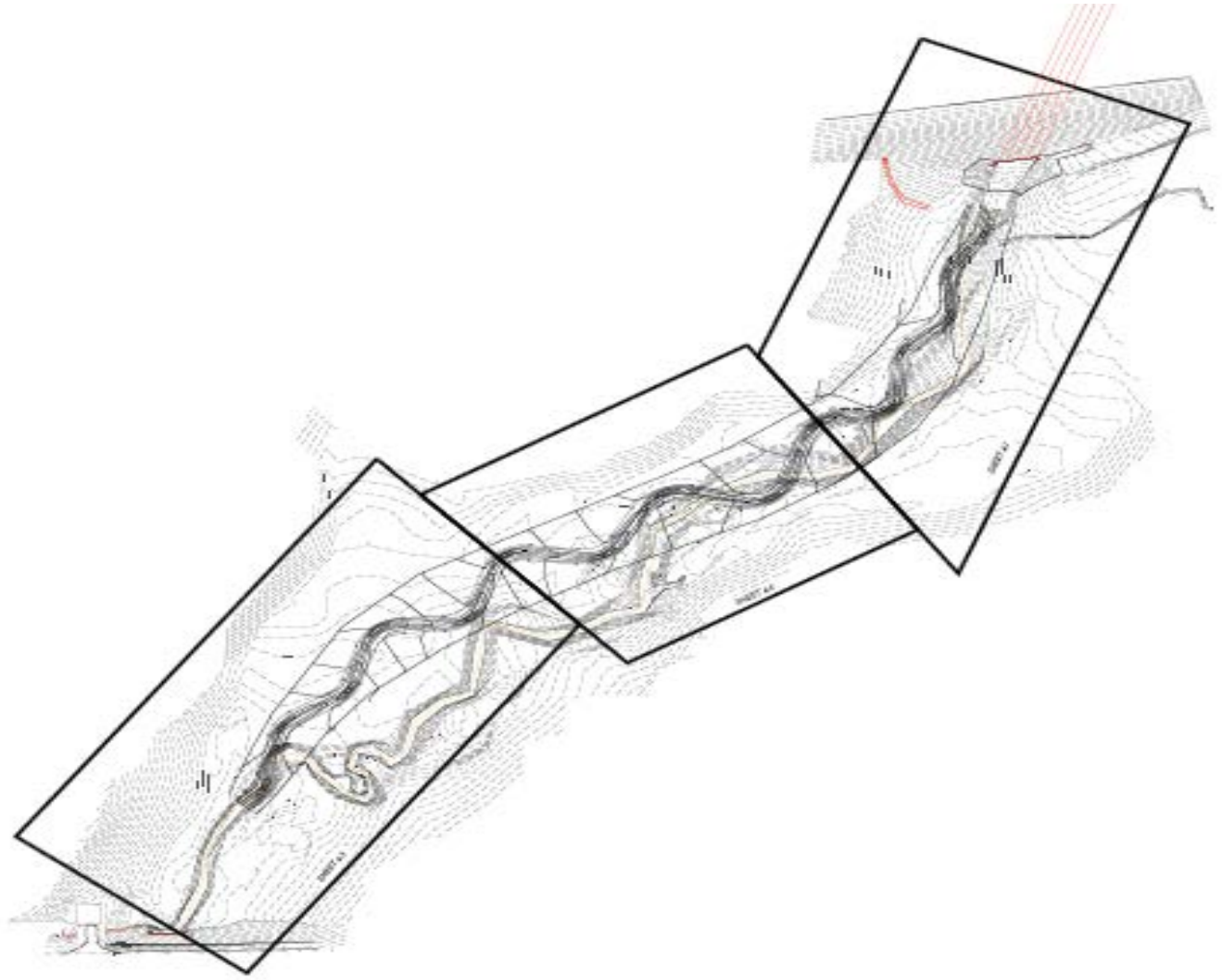
# Design Approach

## STREAM MORPHOLOGY TABLE

Stream name	D'Olive Creek		
Stream type	C5/4		
Drainage area, DA (sq mi)	2.2		
Design Parameters	Minimum	Median	Maximum
Mean riffle depth, dbkf (ft)	1.38	1.35	1.40
Riffle width, Wbkf (ft)	24.0	24.4	25.0
Width-to-depth ratio, [Wbkf/dbkf]	17.5	18.0	18.5
Riffle cross-section area, Abkf (sq ft)	33	33	35
Max riffle depth, dmbkf (ft)	2.2	2.3	2.5
Pool width, Wbkfp (ft)	27.6	29.3	30.0
Pool cross-section area, Abkfp (sq ft)	39.6	42.9	49.0
Max pool depth, dmbkfp (ft)	3.6	3.7	3.9
Riffle length, Lrif (ft)	39.0	56.1	73.2
Pool length, Lp (ft)	48.0	61.0	75.0
Entrenchment ratio, ER [Wfpa/Wbkf]	1.5	4.9	7.6
Bankfull discharge, Qbkf (cfs)	130	140	150
Meander length, Lm (ft)	168	188	210
Belt width, Wblt (ft)	73	85	98
Radius of curvature, Rc (ft)	53	63	73
Pool-to-pool spacing, p-p (ft)	100	115	135
Valley slope, VS (ft/ft)	0.0081		
Average water surface slope, S (ft/ft)	0.0073		
Sinuosity, $k = SL/VL$ (ft/ft)	1.11		



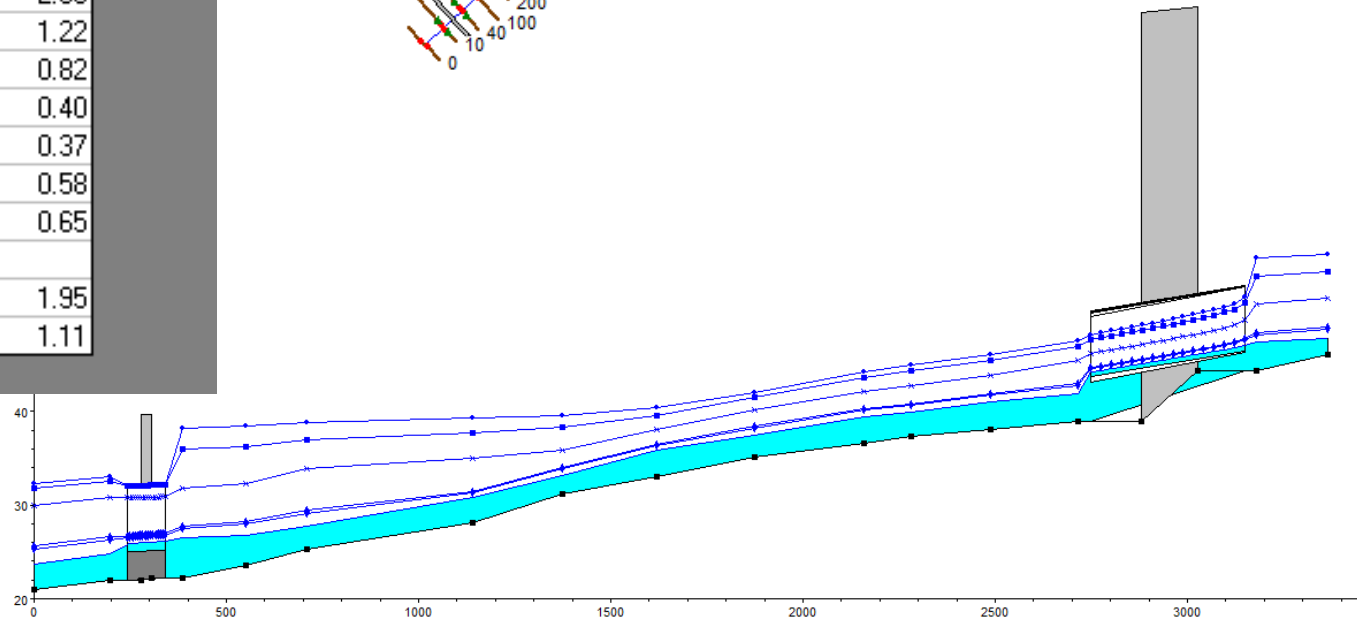
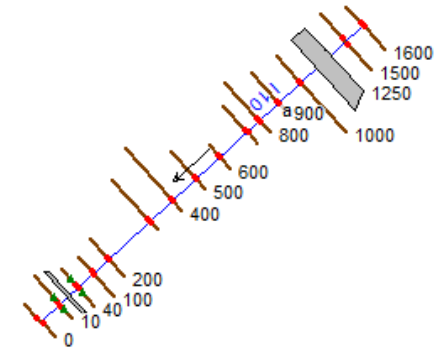
# Preliminary Design (30%)



# HEC-RAS Modeling

HEC-RAS Plan: Plan 08 River: I10

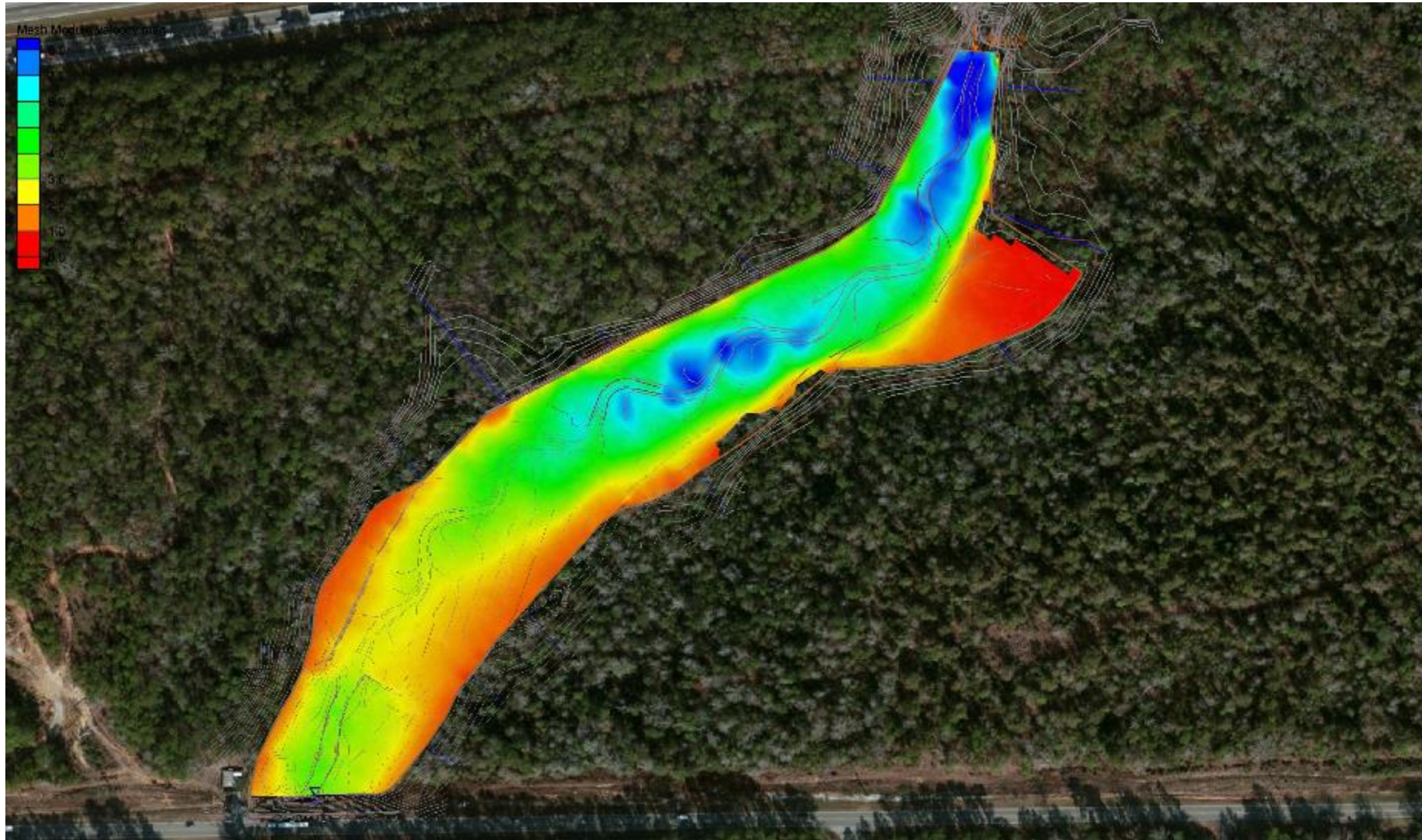
River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Shear LOB (lb/sq ft)	Shear Chan (lb/sq ft)	Shear ROB (lb/sq ft)	Shear Total (lb/sq ft)
1600	April 29 GSSHA	3750.00	56.79	4.37	0.35	0.63	0.38	0.40
1500	April 29 GSSHA	3750.00	56.44	4.80	0.25	0.75	0.34	0.43
1250								
1000	April 29 GSSHA	3750.00	47.52	10.78	2.87	4.24	2.91	3.16
900	April 29 GSSHA	3750.00	46.08	8.79	2.06	2.88	1.44	1.71
800	April 29 GSSHA	3750.00	45.01	7.39	1.58	2.07	1.11	1.38
700	April 29 GSSHA	3750.00	44.25	8.01	1.83	2.43	0.96	1.36
600	April 29 GSSHA	3750.00	42.04	9.06	2.31	3.25	2.15	2.35
500	April 29 GSSHA	3750.00	40.47	7.34	1.53	2.07	1.02	1.22
400	April 29 GSSHA	3750.00	39.62	5.96	1.01	1.29	0.70	0.82
300	April 29 GSSHA	3750.00	39.26	4.67	0.56	0.72	0.34	0.40
200	April 29 GSSHA	3750.00	38.78	4.80	0.35	0.71	0.34	0.37
100	April 29 GSSHA	3750.00	38.42	5.95	0.53	1.13	0.46	0.58
40	April 29 GSSHA	3750.00	38.17	5.31	0.51	0.88	0.57	0.65
20								
10	April 29 GSSHA	3750.00	33.10	9.29	0.55	3.10	1.22	1.95
0	April 29 GSSHA	3750.00	32.34	7.34	0.79	2.04	0.56	1.11





# 2-D Hydraulic Modeling 30% Design 3750 cfs

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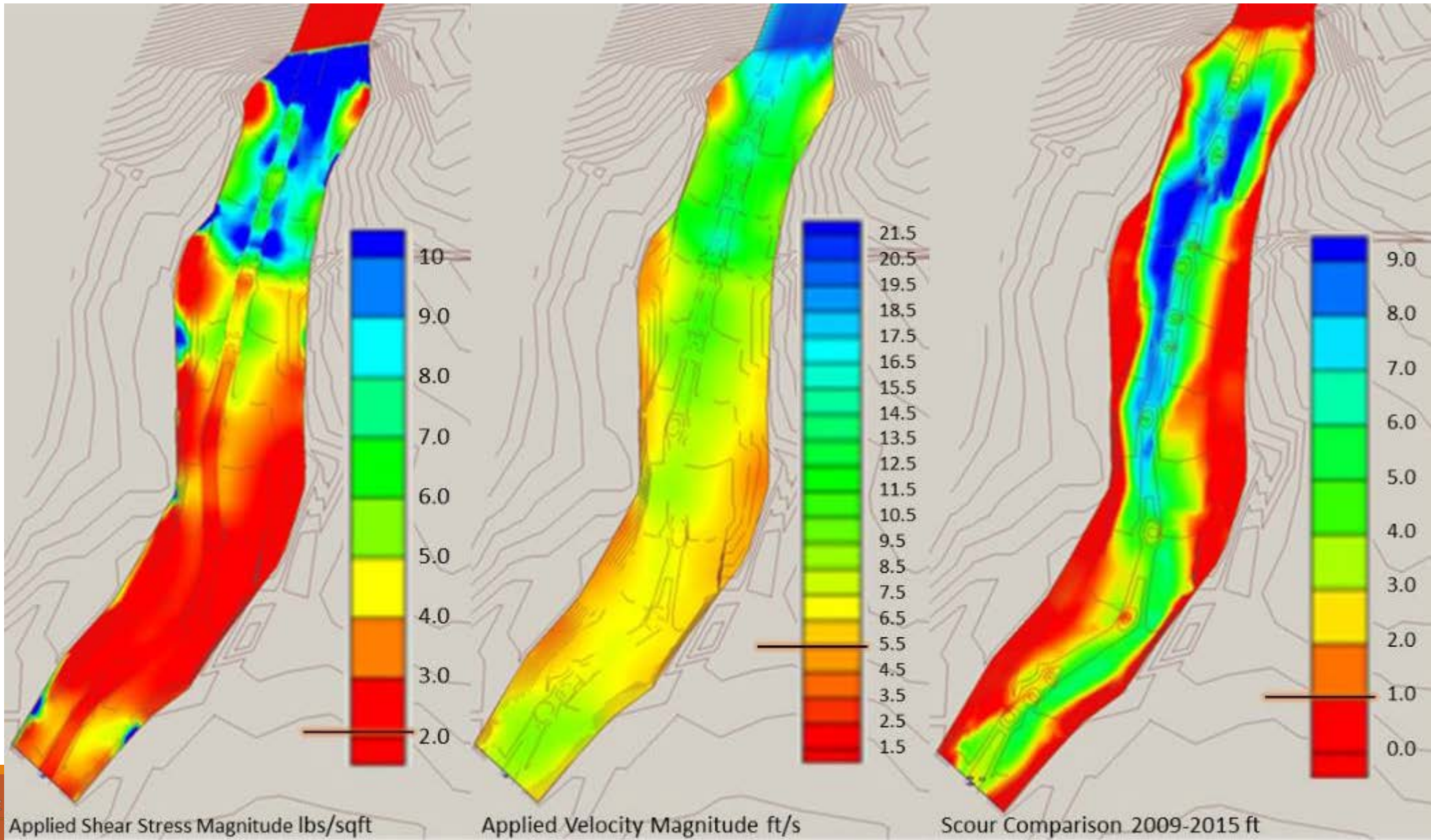


# Former Conditions

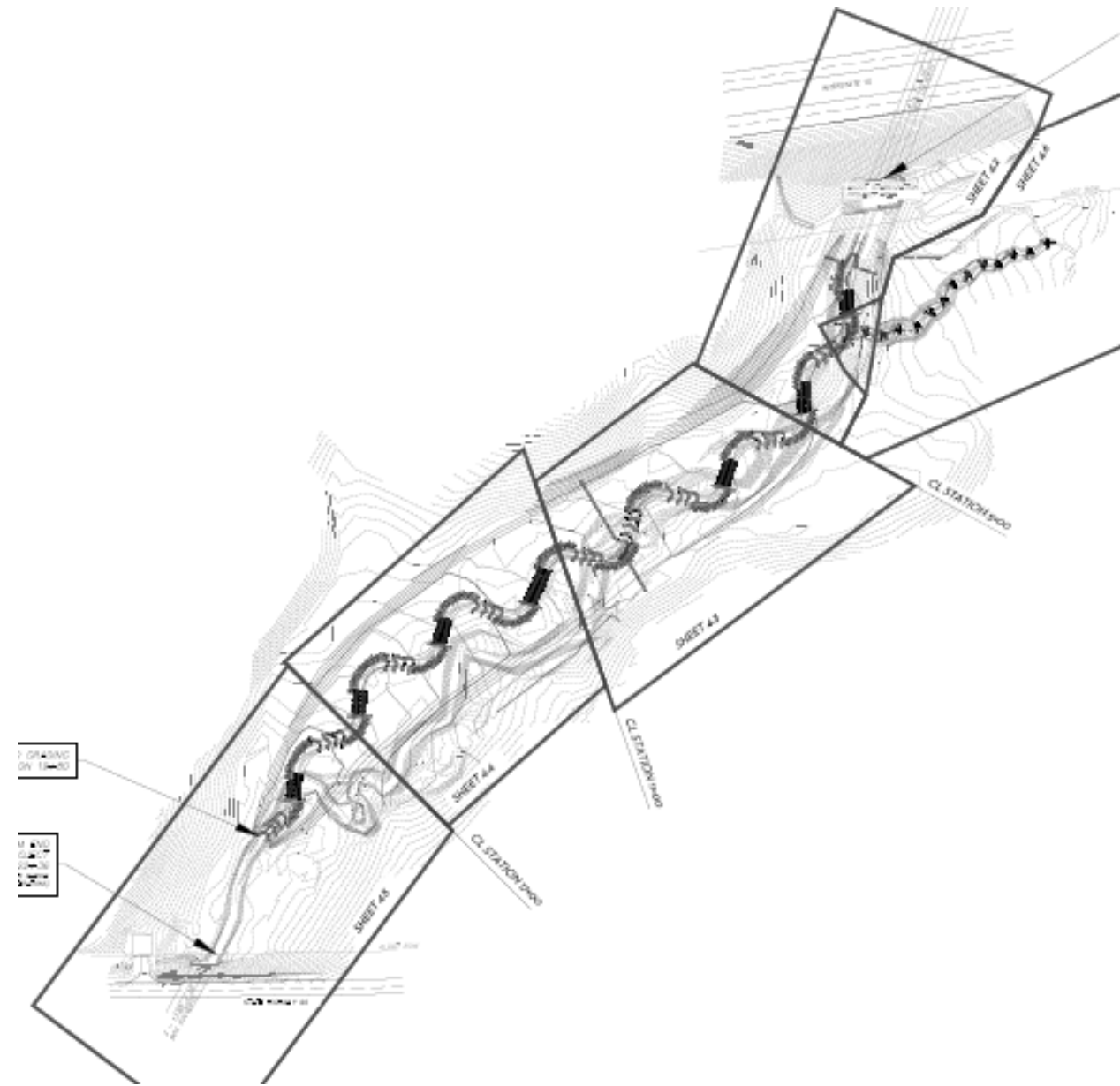
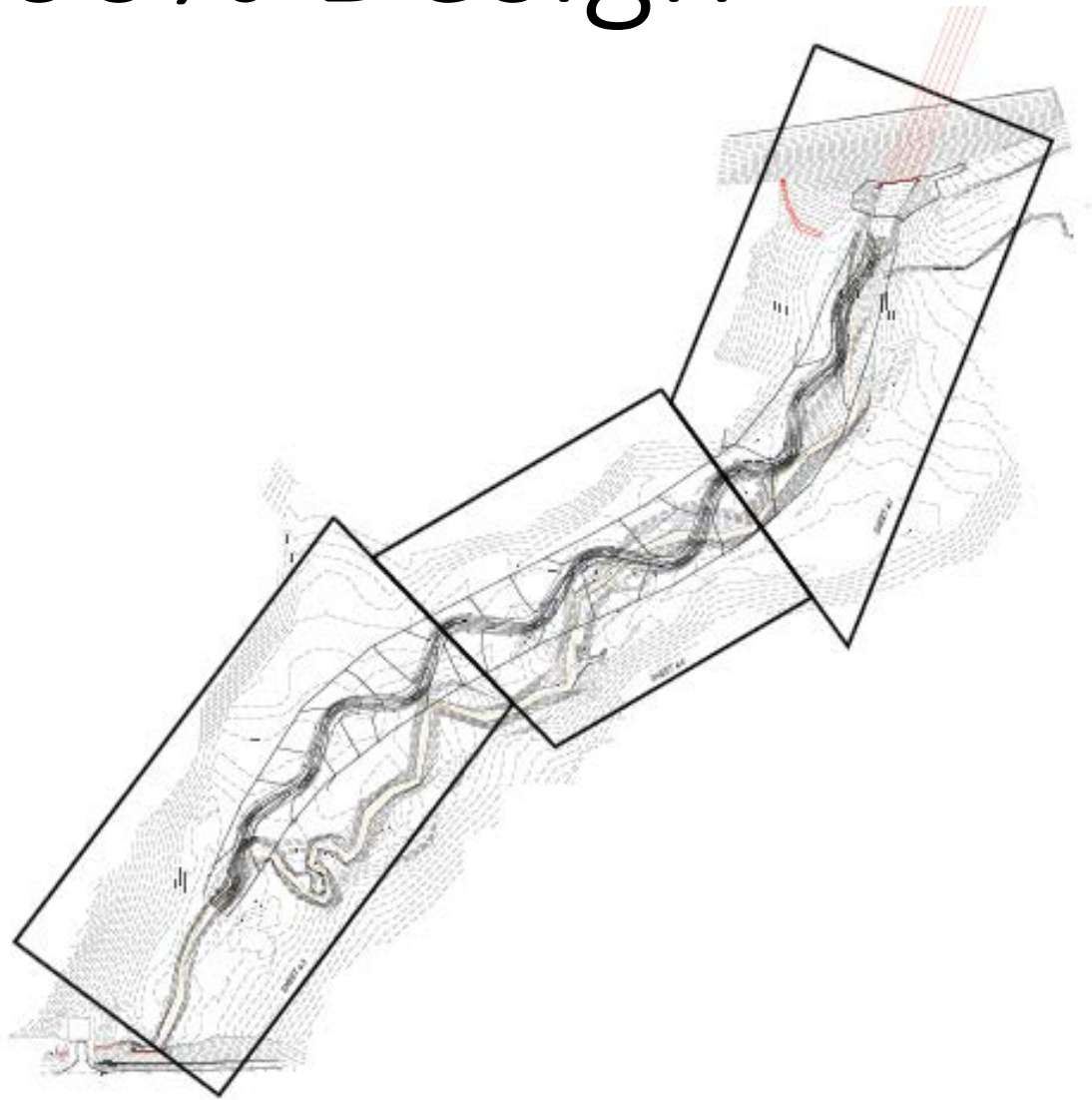




# Former Conditions



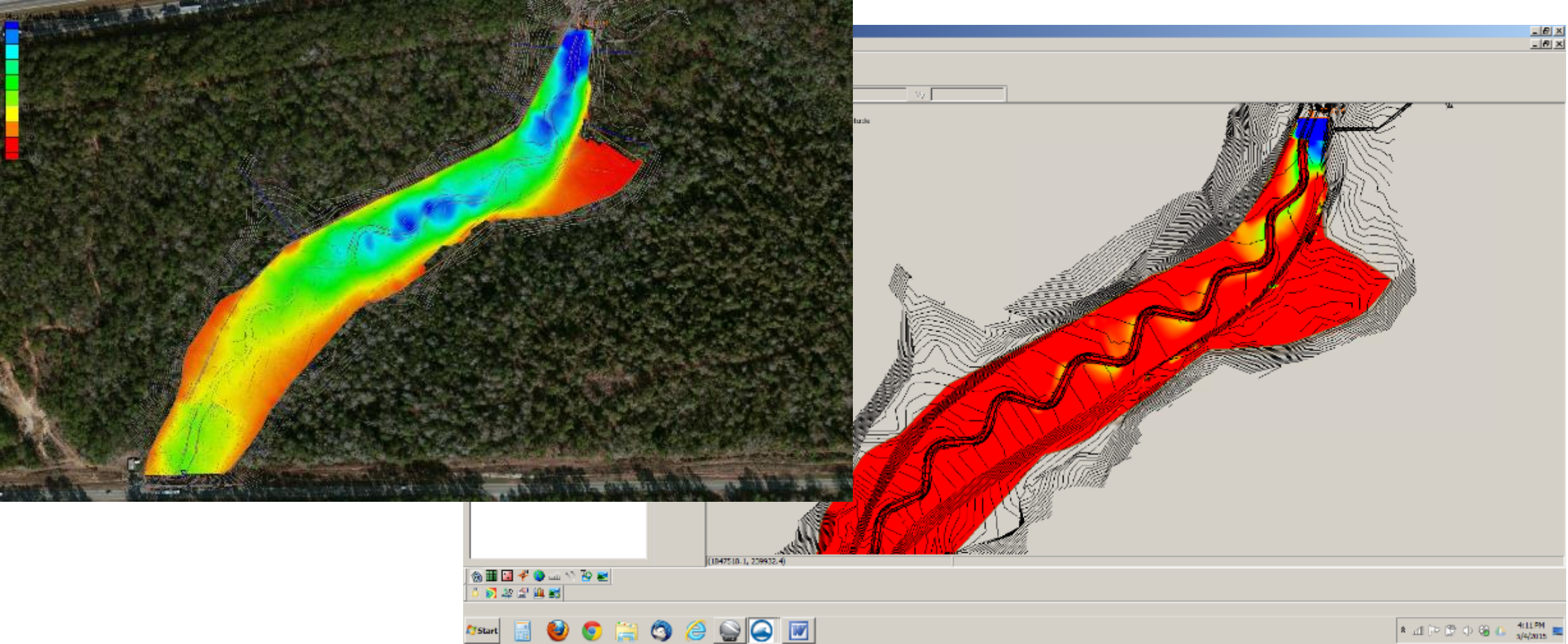
# 60% Design





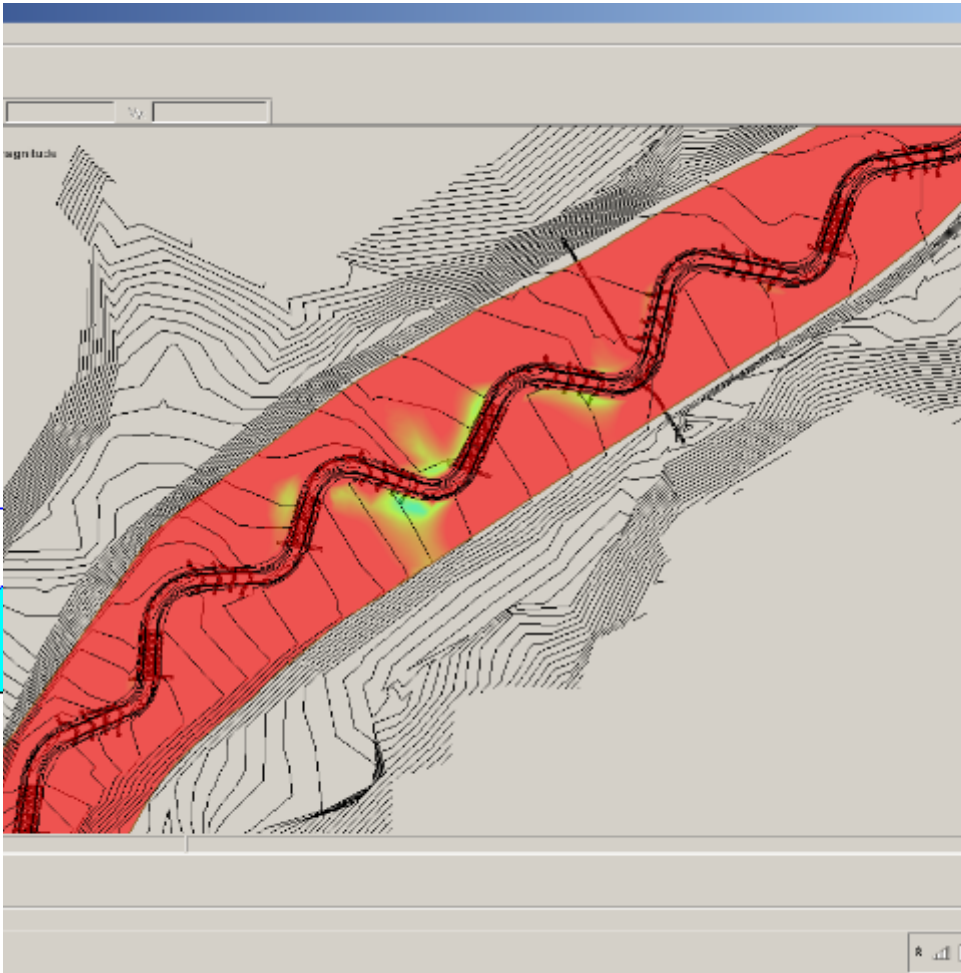
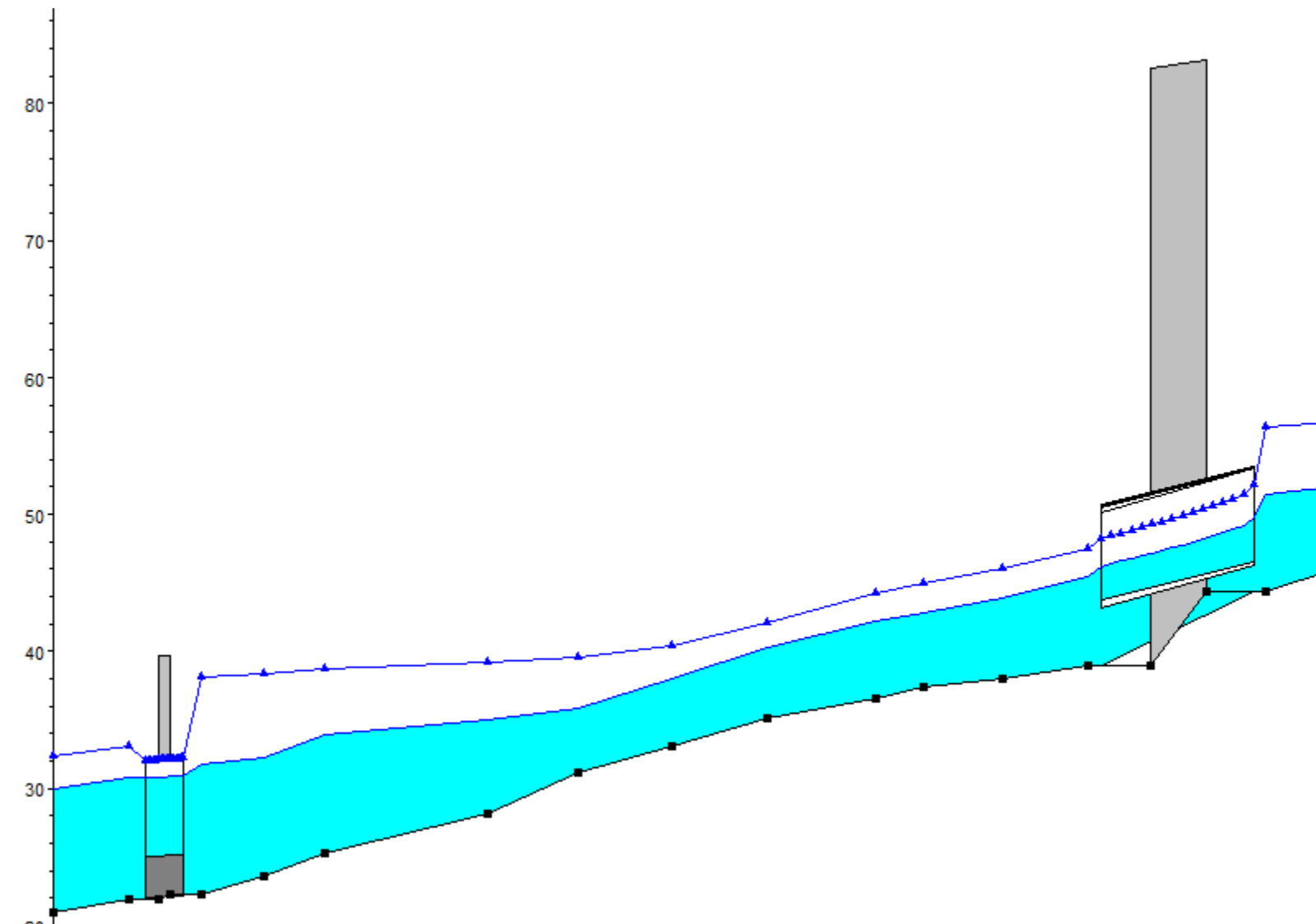
# 2-D Hydraulic Modeling

60% 3750 cfs



# 2-D Hydraulic Modeling

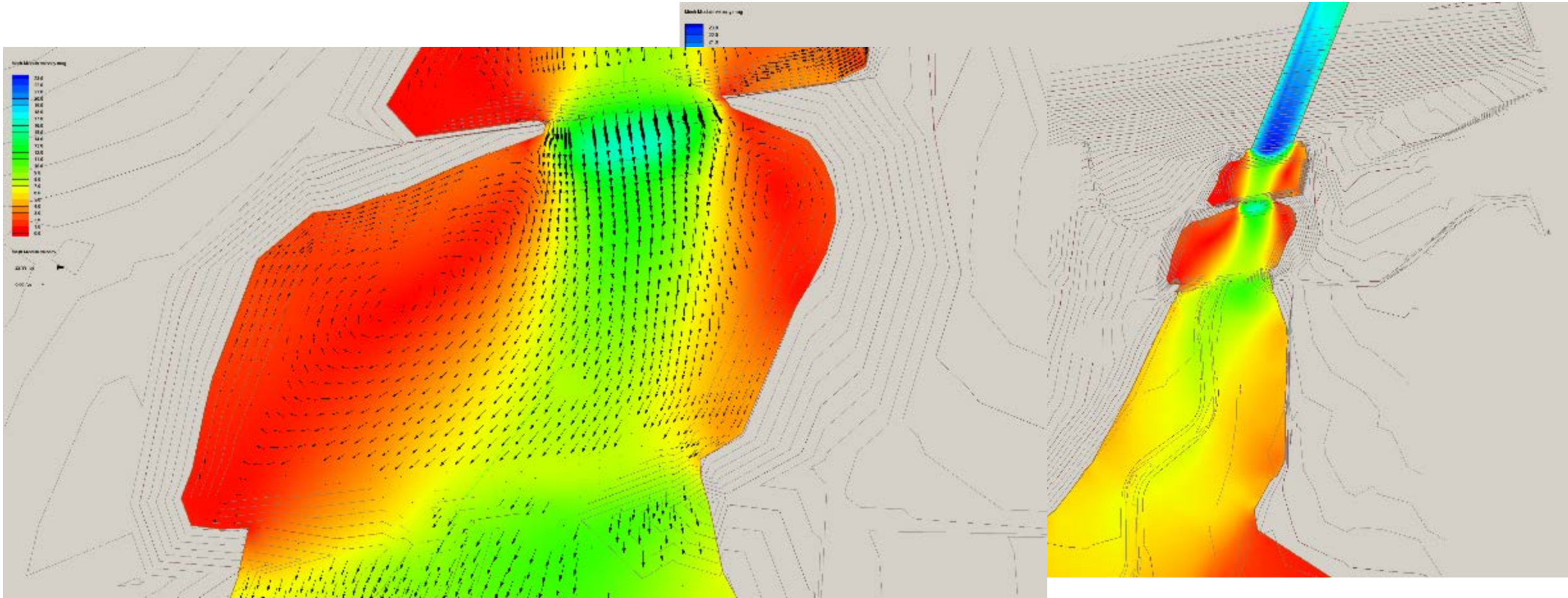
60% 1680 cfs



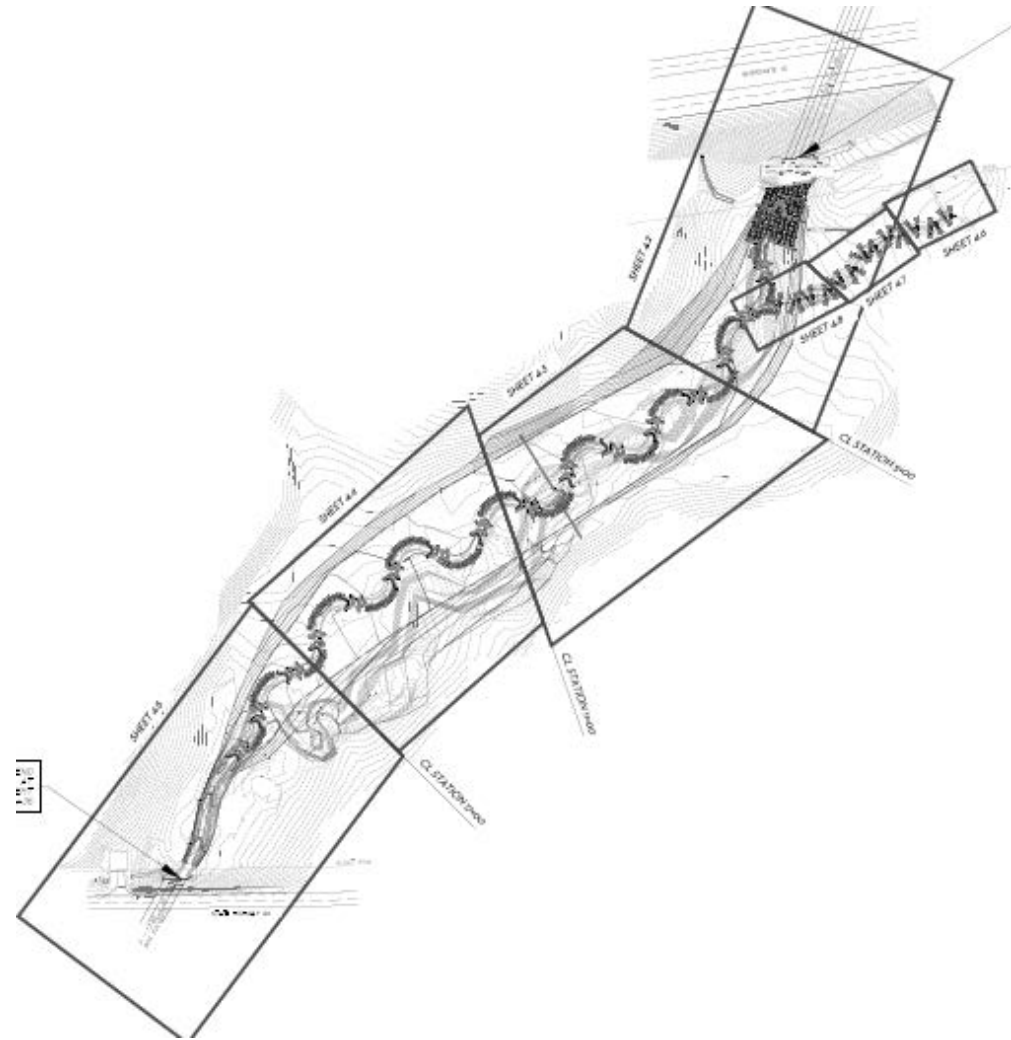
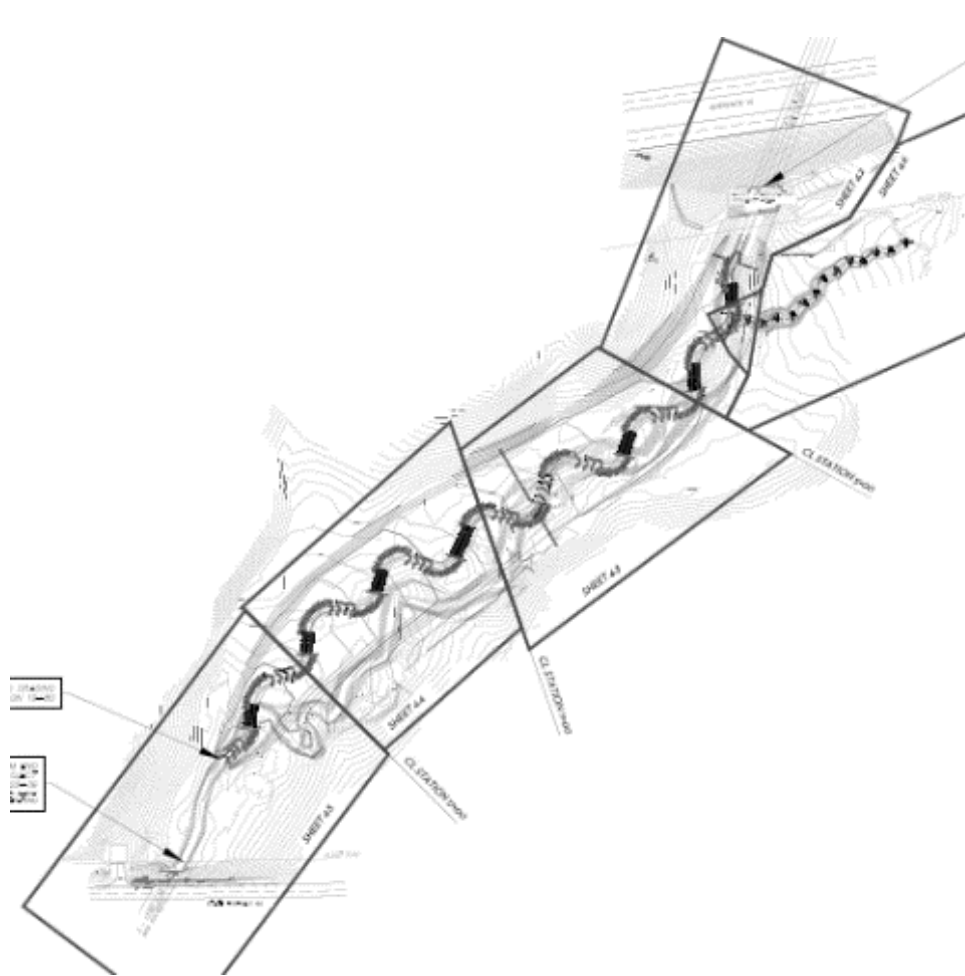


# Culvert Outlet Modeling

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# 90% Design

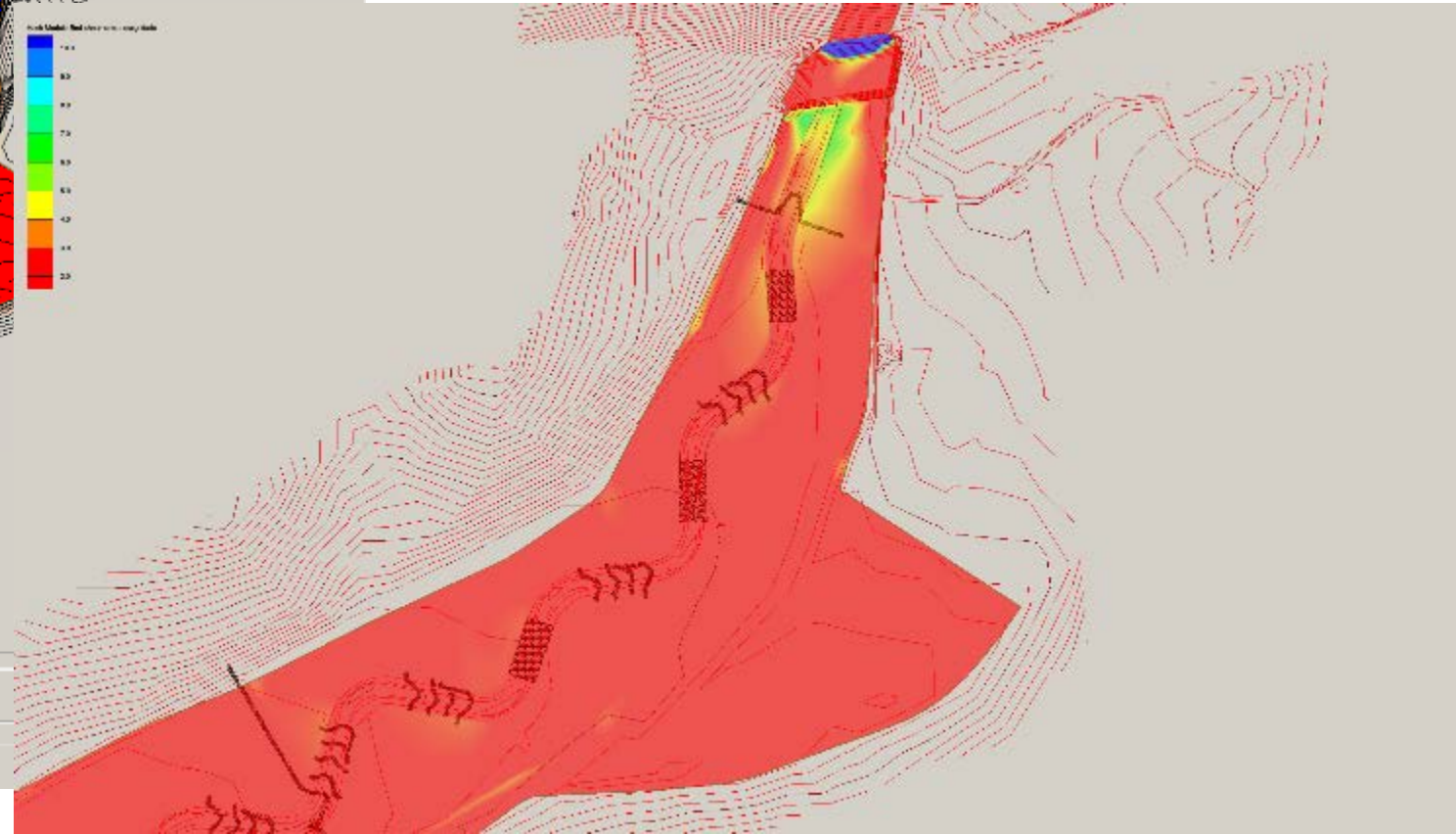
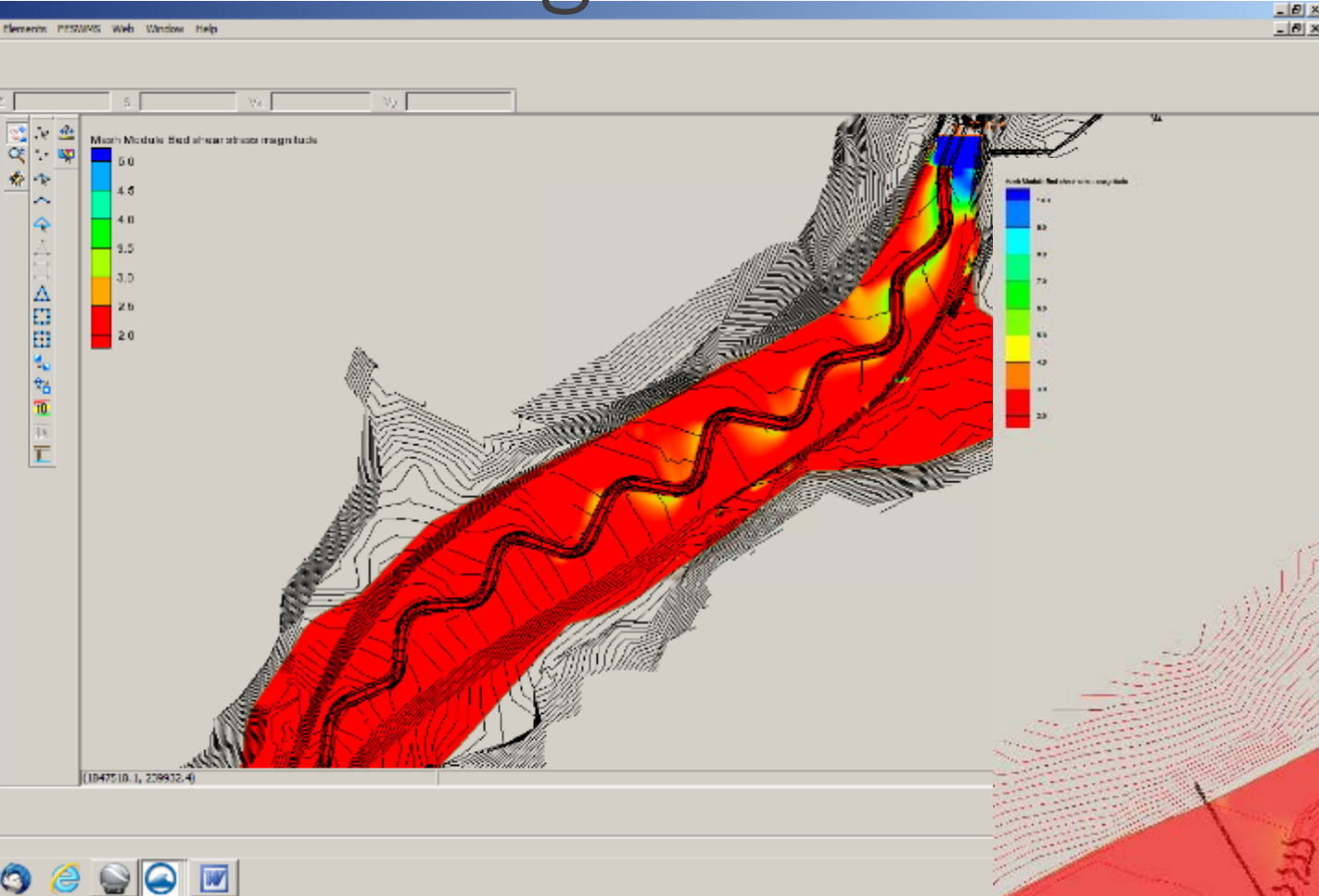




# 2-D Hydraulic Modeling

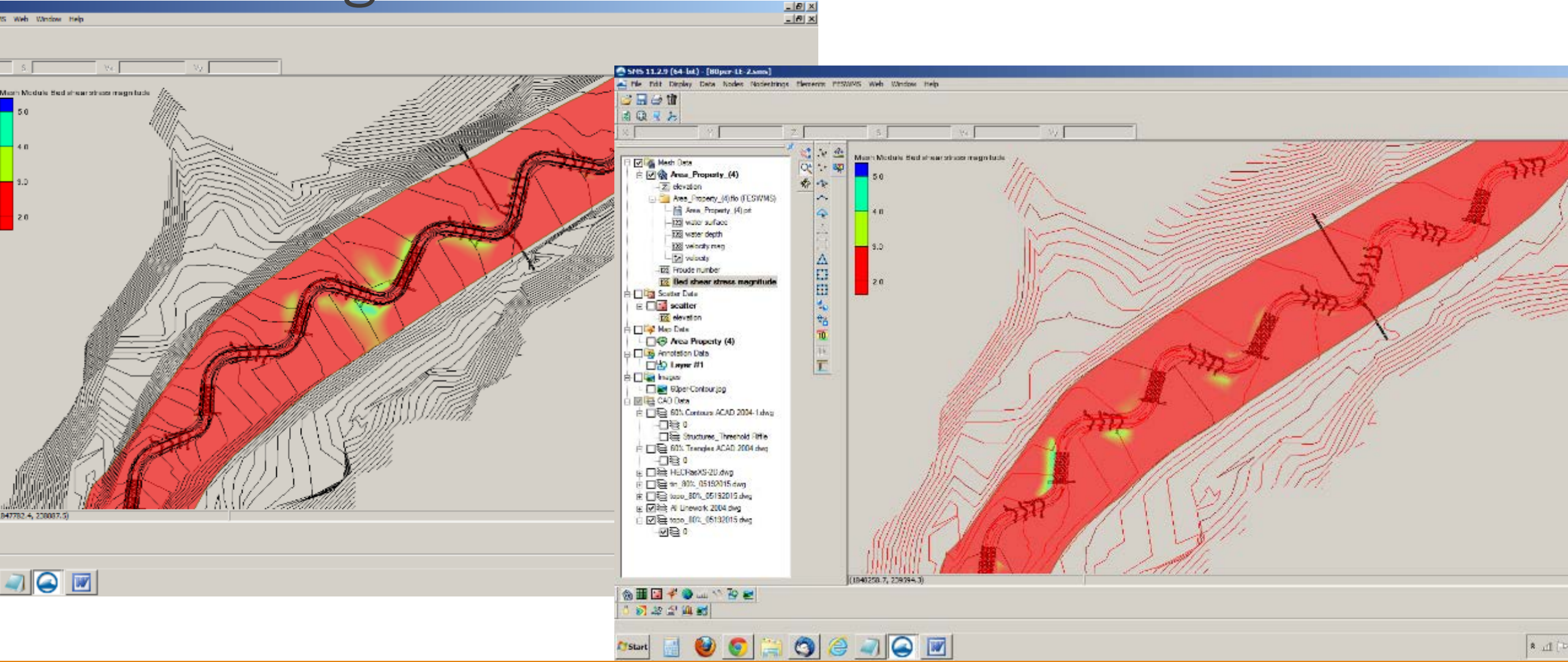
## 90% Design 3750 cfs

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# 2-D Hydraulic Modeling

## 90% Design 1680 cfs

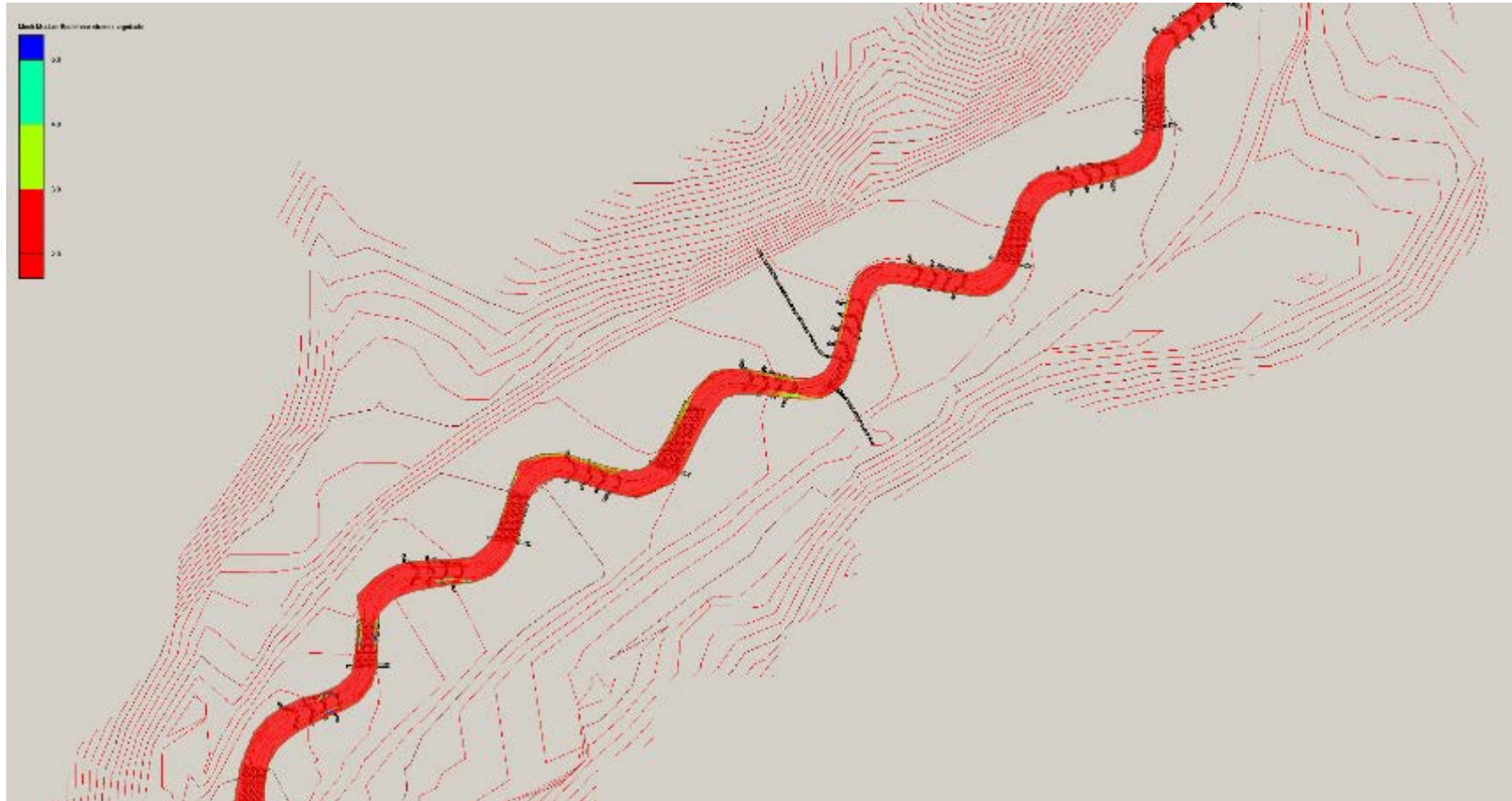




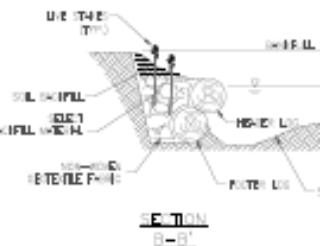
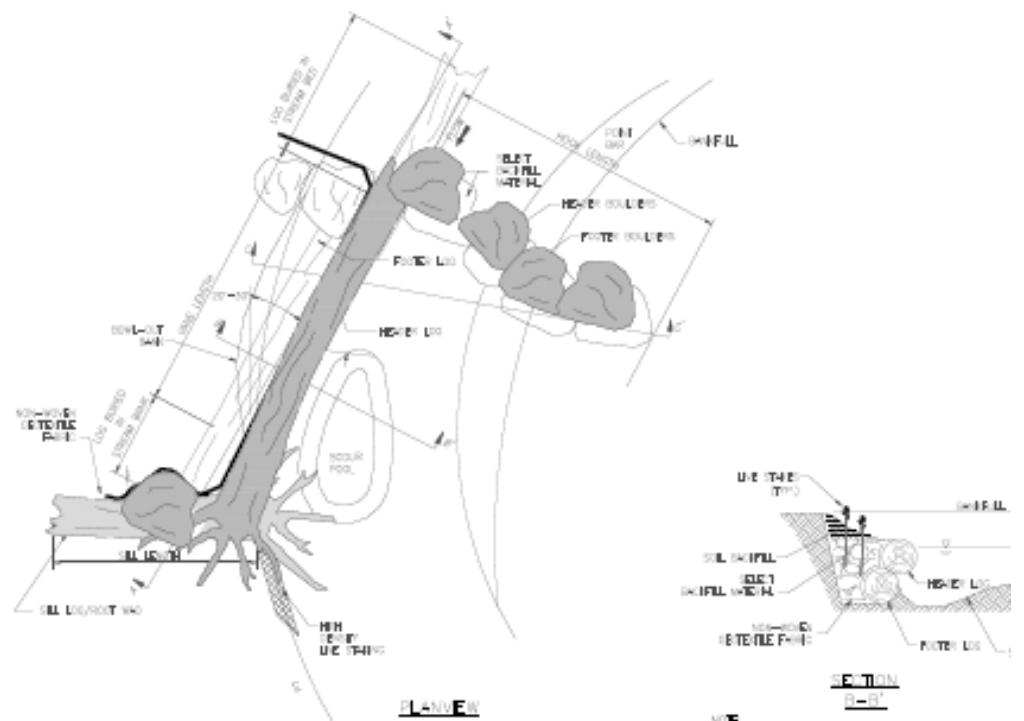
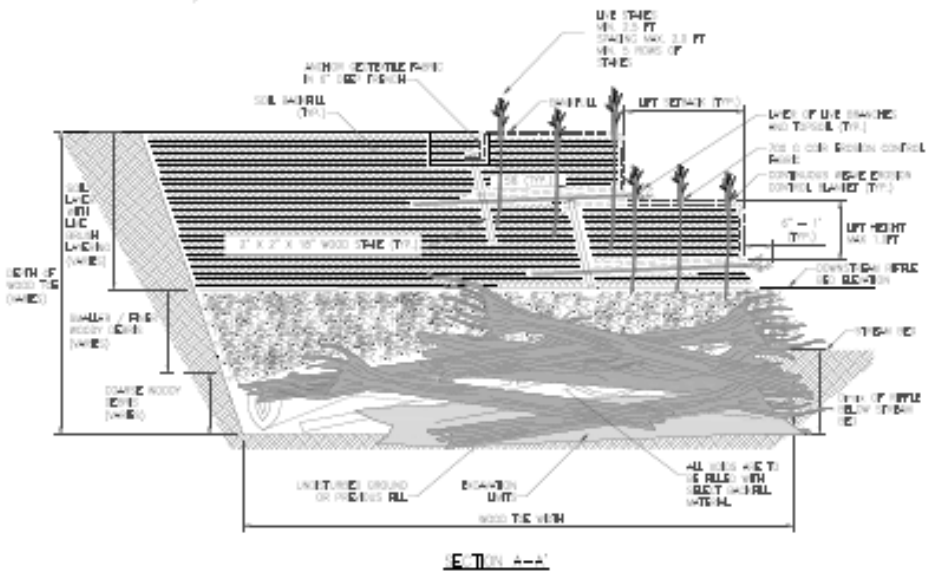
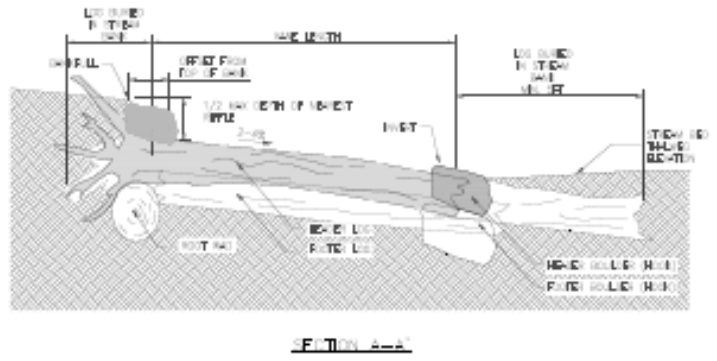
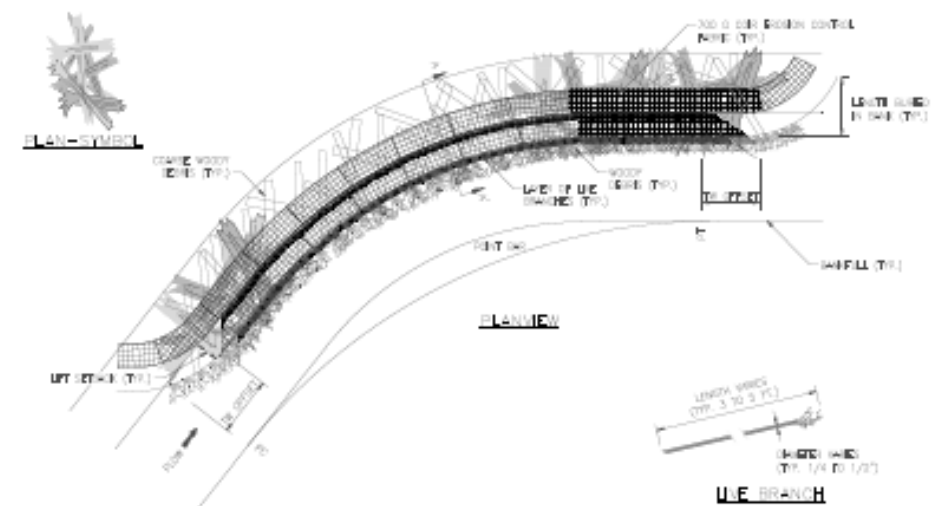
# 2-D Hydraulic Modeling

## 90% Design Bankfull Discharge

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# Stability and Enhancement Structures



**NOTE:** THE LENGTH OF THE LIVE BRANCH SHALL BE SUFFICIENT TO PROVIDE A MINIMUM OF 12" OF LIVE BRANCH TO THE SHOULDER AND SHALL BE PROVIDED TO THE SHOULDER AT A 30% ANGLE TO THE LIVE BRANCH.

○ DETAIL - WOOD TIE

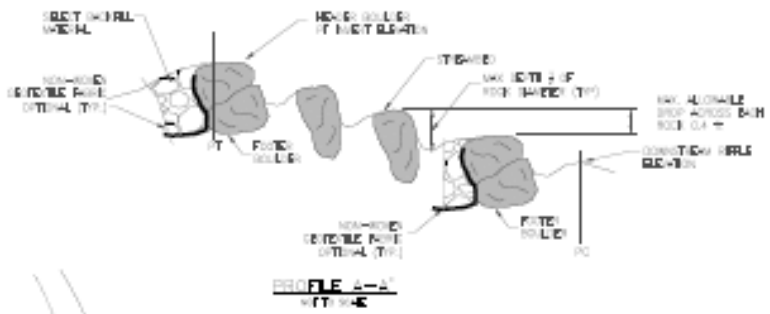
○ DETAIL - LIVE BRANCH / WITH ROOTS



# Stability and Enhancement Structures



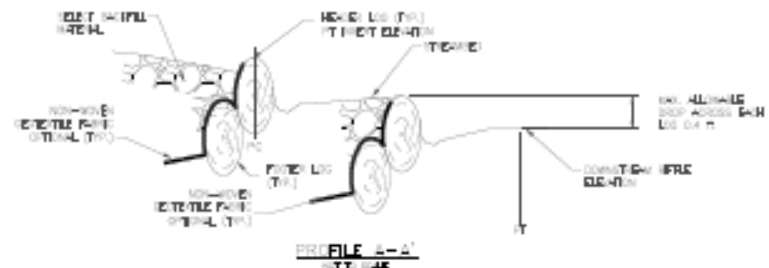
PLAN - SYMBOL



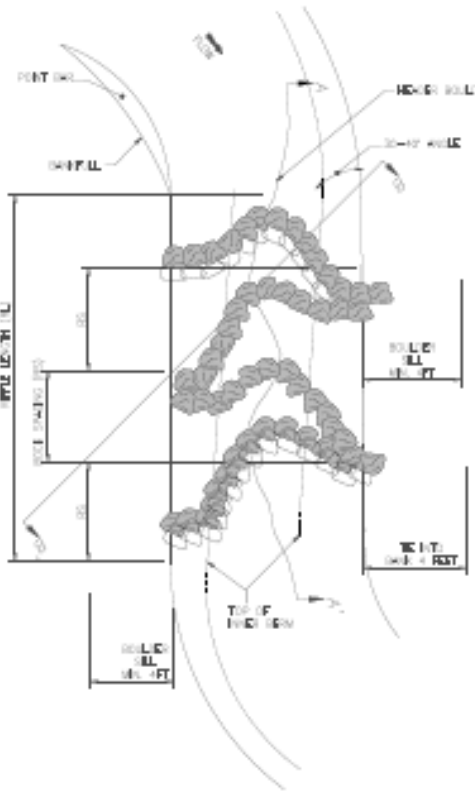
PROFILE A-A' WITH SHALE



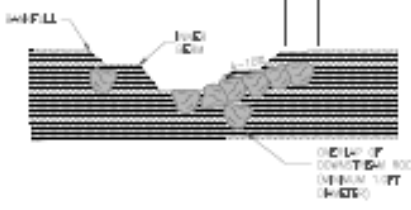
PLAN - SYMBOL



PROFILE A-A' WITH SHALE



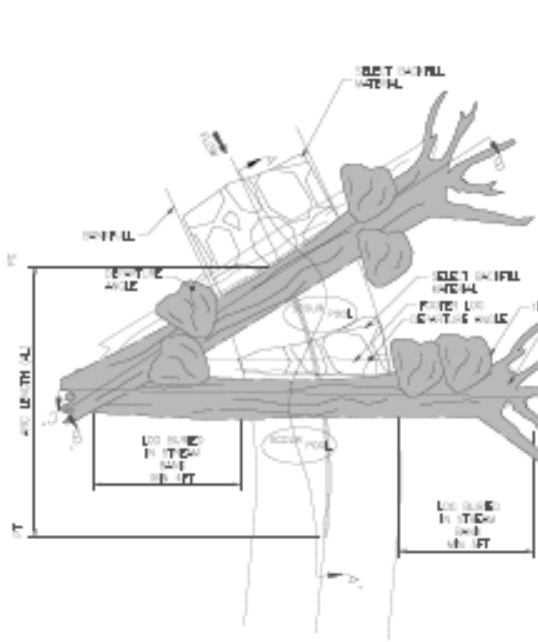
PLANVIEW



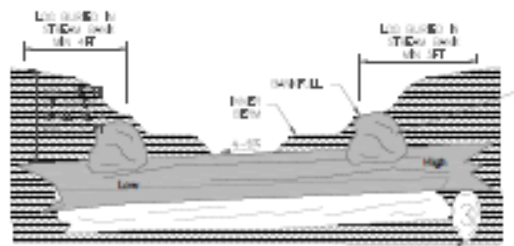
SECTION B-B'

**NOTE:**  
THE DOWN-TOPT SHOULD BE CONSTRUCTED IN SUCH A MANNER THAT THE DOWN-TOPT SHOULD BE ABLE TO HOLD THE LOGS IN PLACE AND NOT ALLOW THEM TO BE WASHED AWAY BY THE CURRENT AT A DOWN POINT BAR AND LOGS TO FAIL.

DETAIL - CONSTRUCTED BOULDER AND LOG RIFFLE WITH SHALE



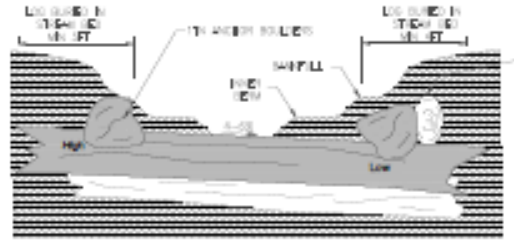
PLANVIEW



SECTION B-B'

**NOTE:**  
THE DOWN-TOPT SHOULD BE CONSTRUCTED IN SUCH A MANNER THAT THE DOWN-TOPT SHOULD BE ABLE TO HOLD THE LOGS IN PLACE AND NOT ALLOW THEM TO BE WASHED AWAY BY THE CURRENT AT A DOWN POINT BAR AND LOGS TO FAIL.

DETAIL - LOG DROP WITH BOLLERS WITH SHALE



SECTION B-B'

# Questions?

Goodwyn, Mills, and Cawood, Inc.  
Justin N. Barrett, PE  
[justin.barrett@gmcnetwork.com](mailto:justin.barrett@gmcnetwork.com)

