D'Olive Creek Stream Restoration

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

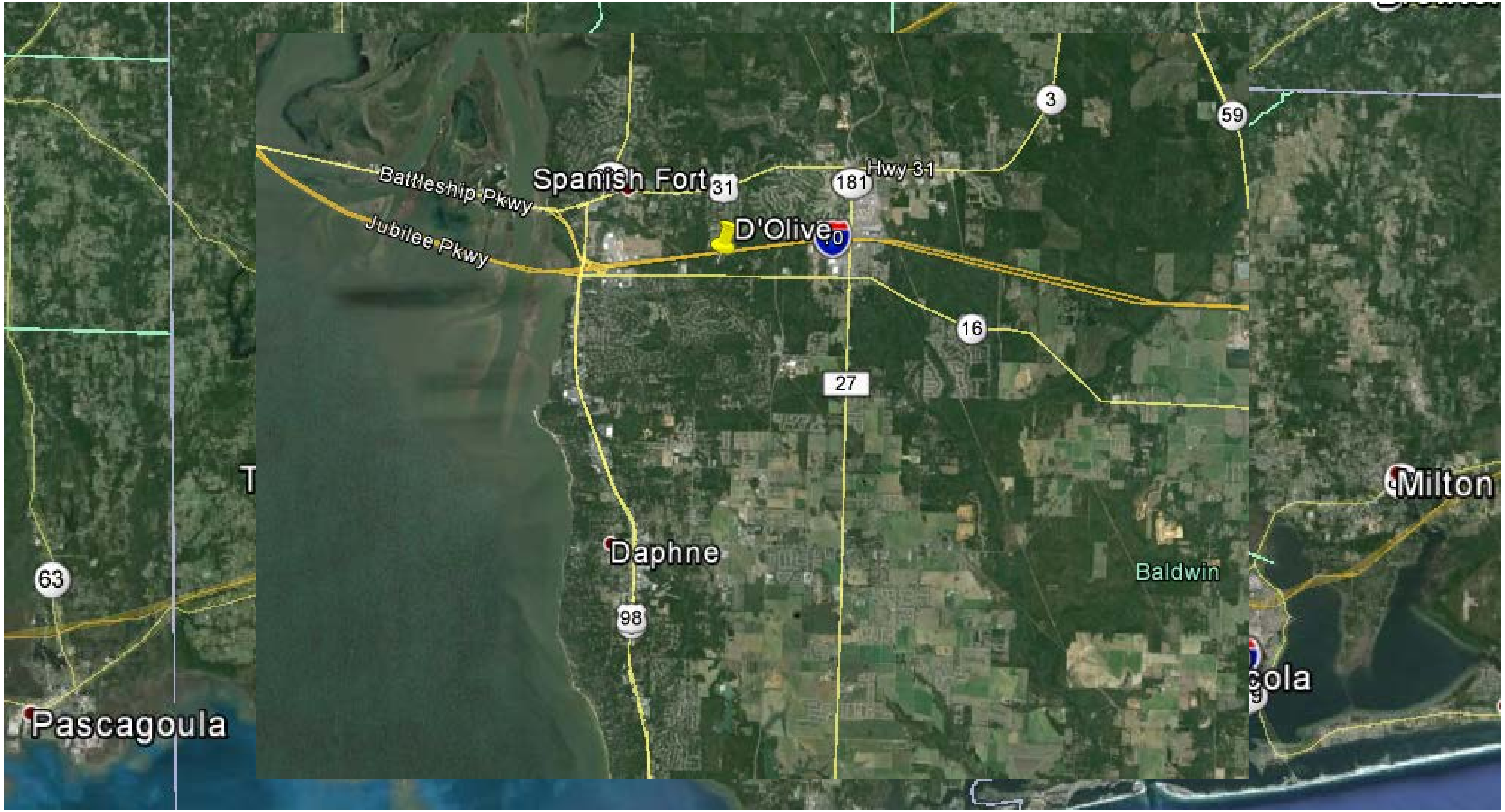
Design Iterations

Modeling

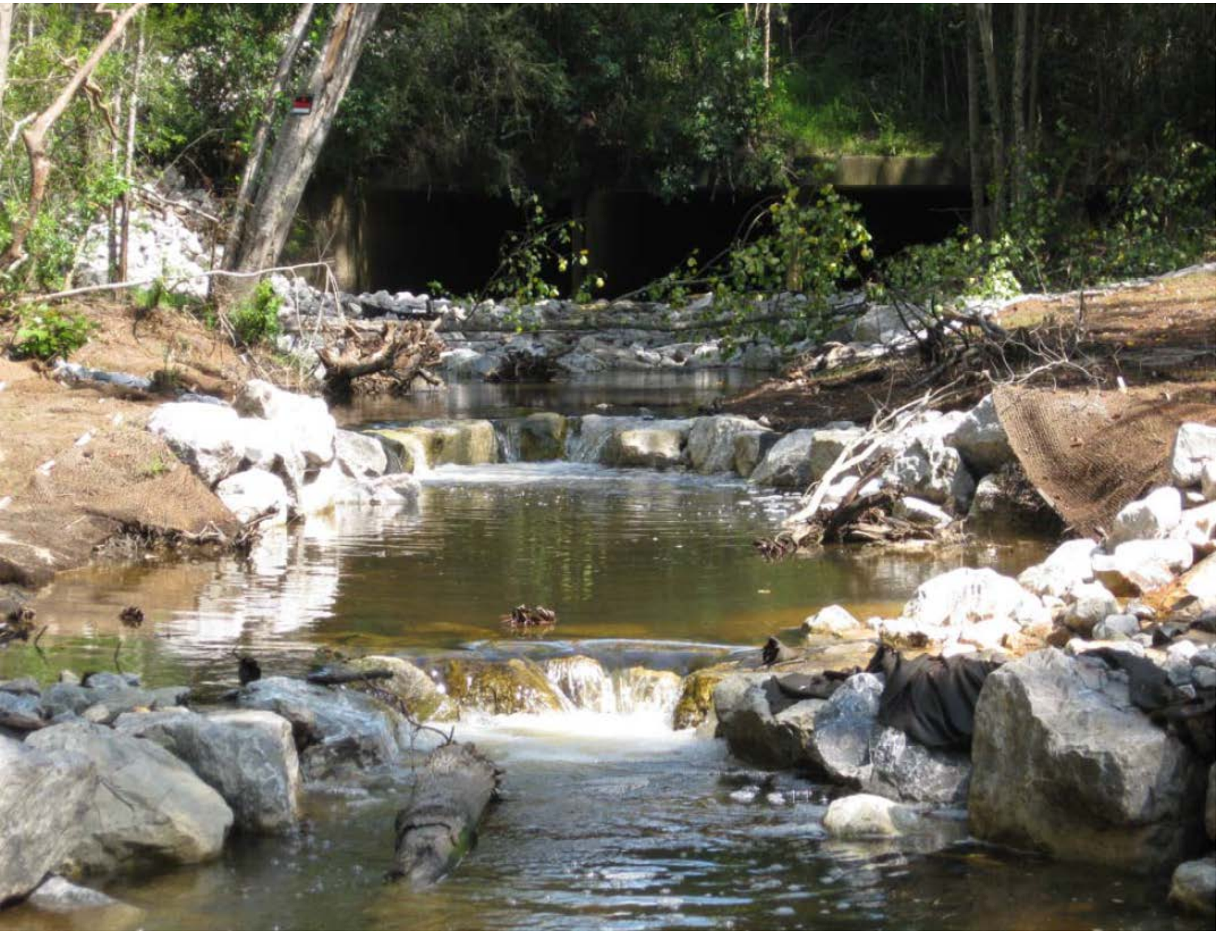
Optimization

GOODWYN | MILLS | CAWOOD

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

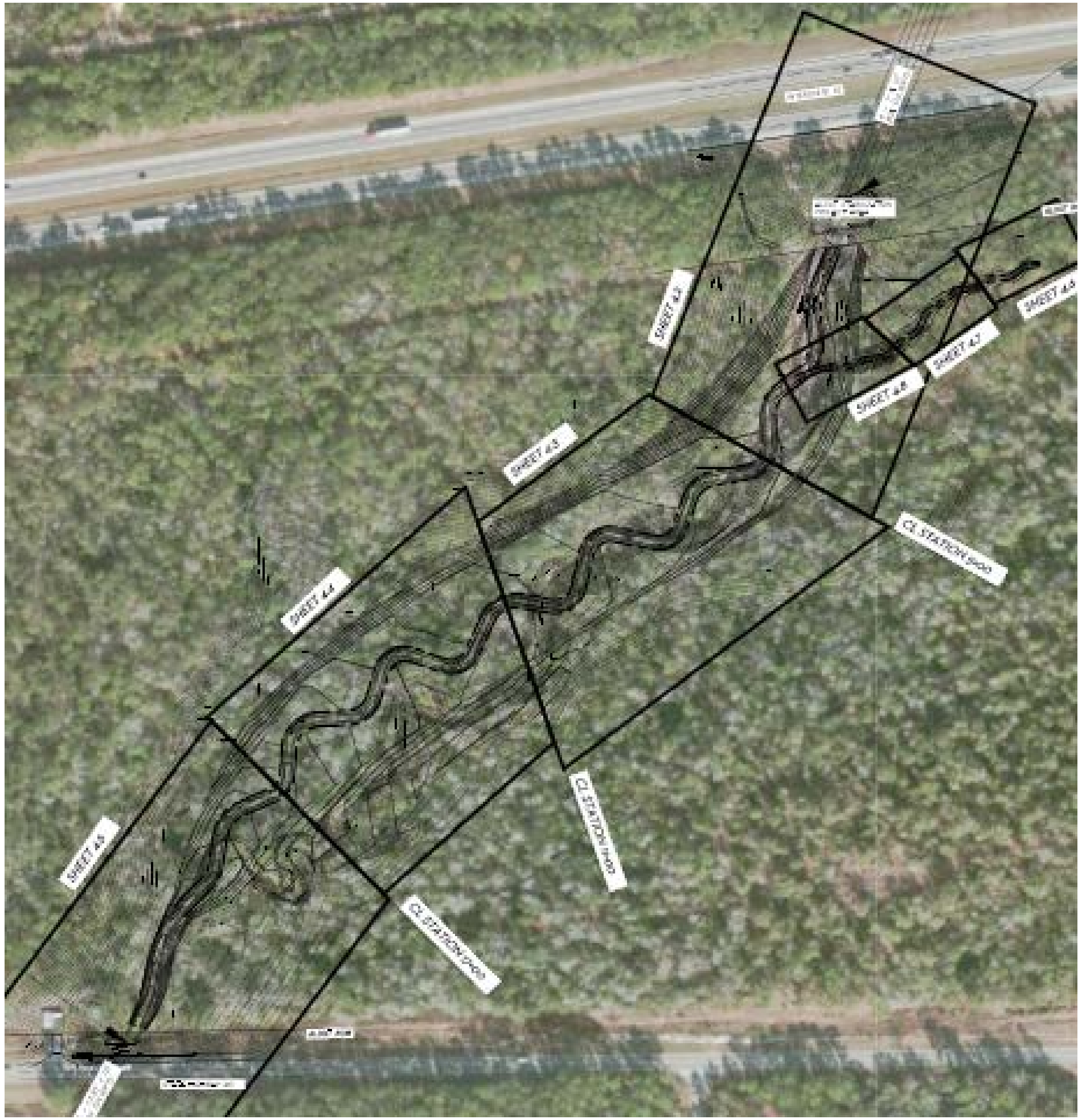
Objective #3: Design a stream and floodplain to handle design applied shear stresses without excess erosion or floodplain scour

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



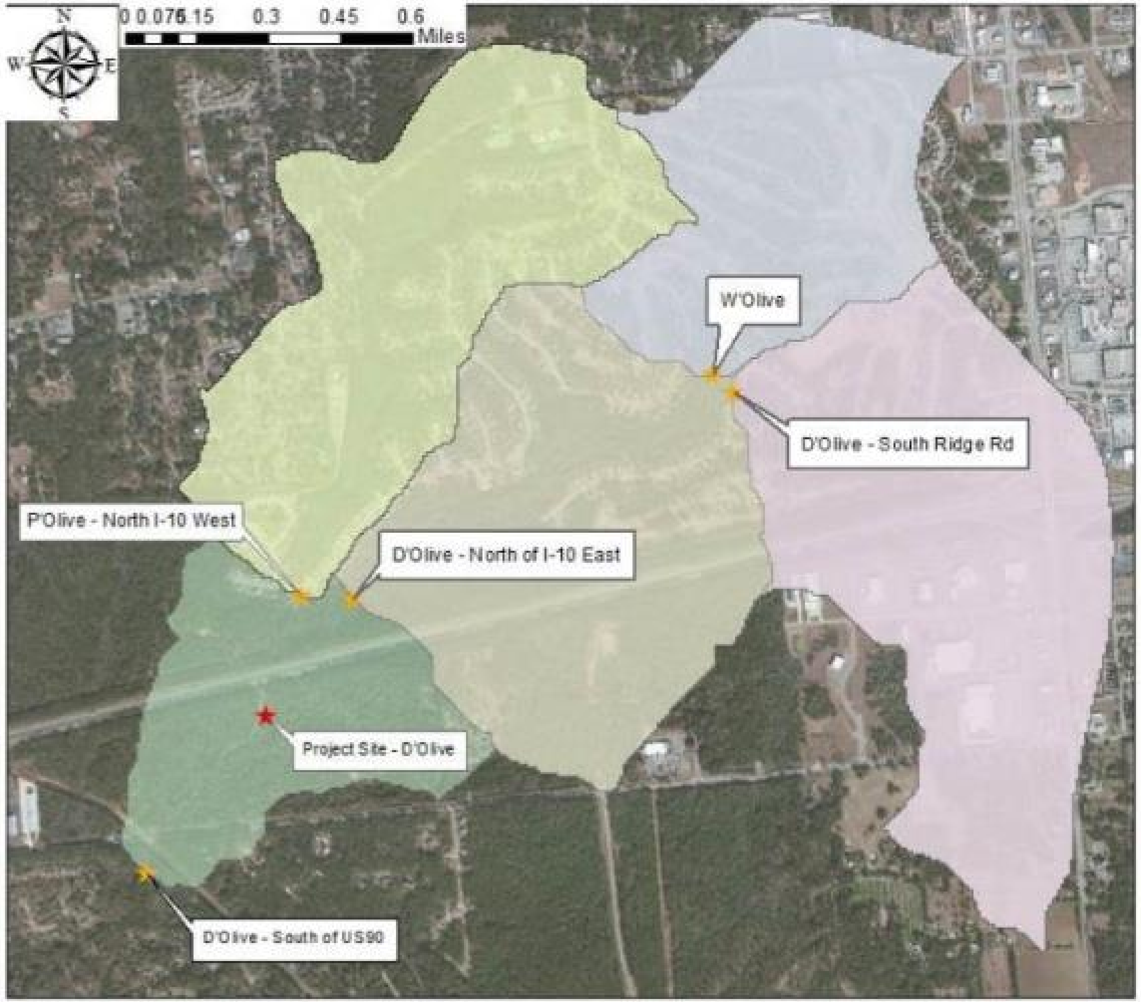
Design Approach

Natural Channel Design

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

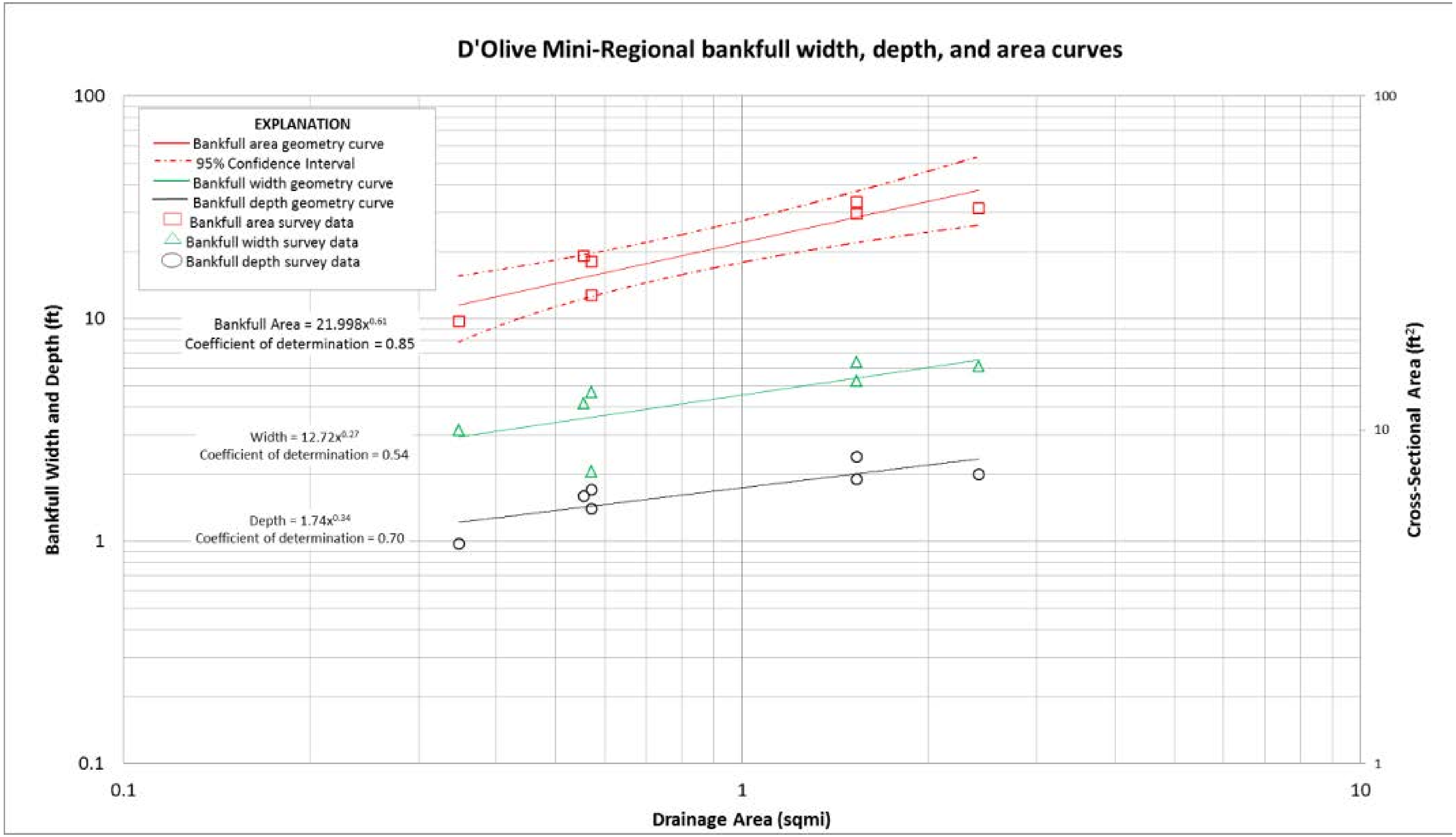
Parameter	Existing Stream			Design Stream			Potential Stream Evolution		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
Stream name	D'Olive Creek			D'Olive Creek			D'Olive Creek		
Stream type	F5			C5/4			E5/4		
Drainage area, DA (mi^2)	2.2			2.2			2.2		
Mean riffle depth, d_{bkf} (ft)	1.8	1.6	1.6	1.38	1.35	1.40	2.00	2.06	1.94
Riffle width, W_{bkf} (ft)	18.1	20.2	20.2	24.0	24.4	25.0	15.0	16.0	18.0
Width-to-depth ratio, [W_{bkf}/d_{bkf}]	9.9	12.3	12.4	17.5	18.0	18.5	7.5	7.8	9.3
Riffle cross-section area, A_{bkf} (ft^2)	33.0	33.0	33.0	33	33	35	30	33	35
Max riffle depth, d_{mbkf} (ft)	2.0	2.1	2.4	2.2	2.3	2.5	2.6	2.9	2.9
Max riffle depth ratio, [d_{mbkf}/d_{bkf}]	1.1	1.3	1.5	1.6	1.7	1.8	1.3	1.4	1.5
Mean pool depth, d_{bkp} (ft)	2.8	2.6	2.7	1.4	1.5	1.6	2.4	2.7	2.7
Mean pool depth ratio, [d_{bkp}/d_{bkf}]	1.5	1.6	1.7	1.5	1.6	1.6	1.2	1.3	1.4
Pool width, W_{bkp} (ft)	32.0	45.8	50.9	27.6	29.3	30.0	14.0	16.0	18.0
Pool width ratio, [W_{bkp}/W_{bkf}]	1.8	2.3	2.5	1.2	1.2	1.2	0.9	1.0	1.0
Pool cross-section area, A_{bkp} (ft^2)	88.8	117.8	138.9	39.6	42.9	49.0	33.6	42.9	49.0
Pool area ratio, [A_{bkp}/A_{bkf}]	2.7	3.6	4.2	1.2	1.3	1.4	1.1	1.3	1.4
Max pool depth, d_{mbkp} (ft)	2.6	3.3	4.0	3.6	3.7	3.9	4.0	4.5	4.9
Max pool depth ratio, [d_{mbkp}/d_{bkf}]	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_{mbkf}]	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_{bkf}]	1.45	1.20	1.30	1.5	4.9	7.6	2.4	7.5	10.6
Bankfull mean velocity, u_{bkf} = 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_{bkf} (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_{bkf}]	4.9	11.6	19.5	6.9	7.7	8.6	10.5	11.8	13.1
Radius of curvature, Rc (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_{bkf}]	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^2)	Bankfull Width (ft)	Bankfull depth (ft)	Bankfull cross-sectional area (ft^2)	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

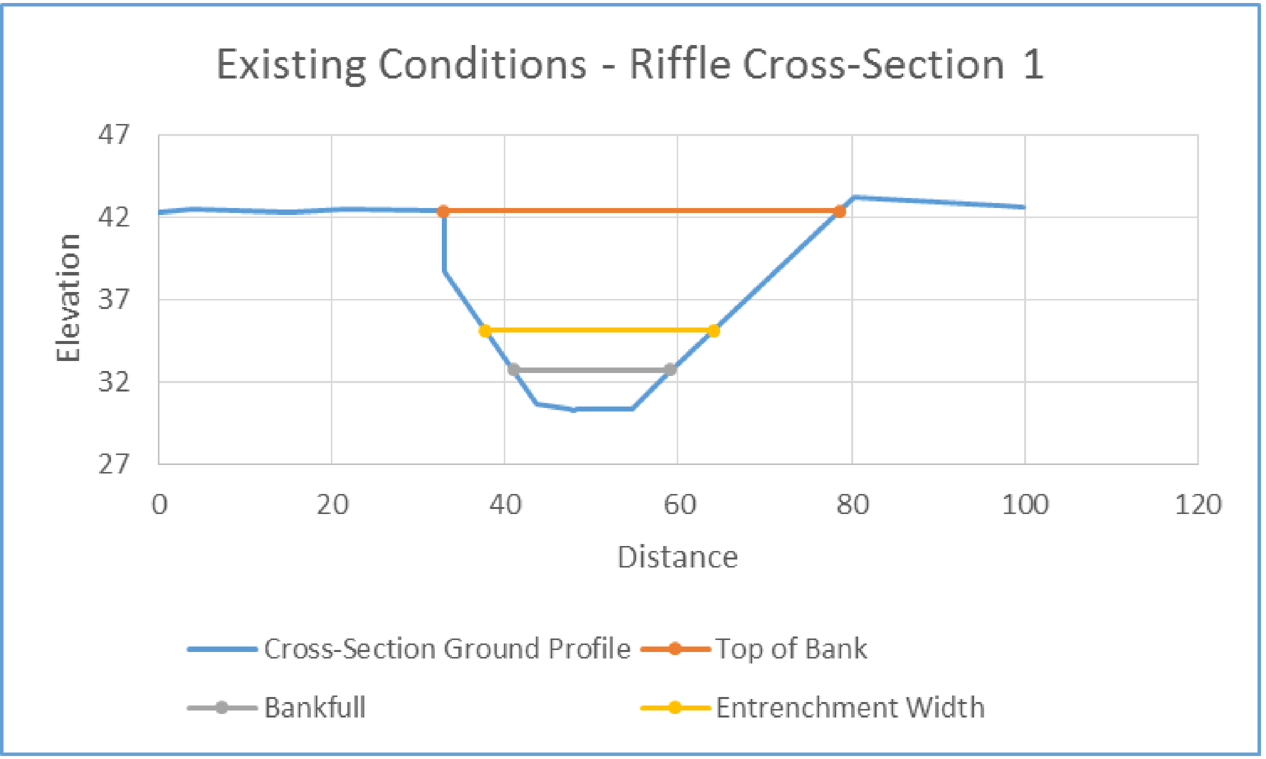
Mini Regional Curve Development

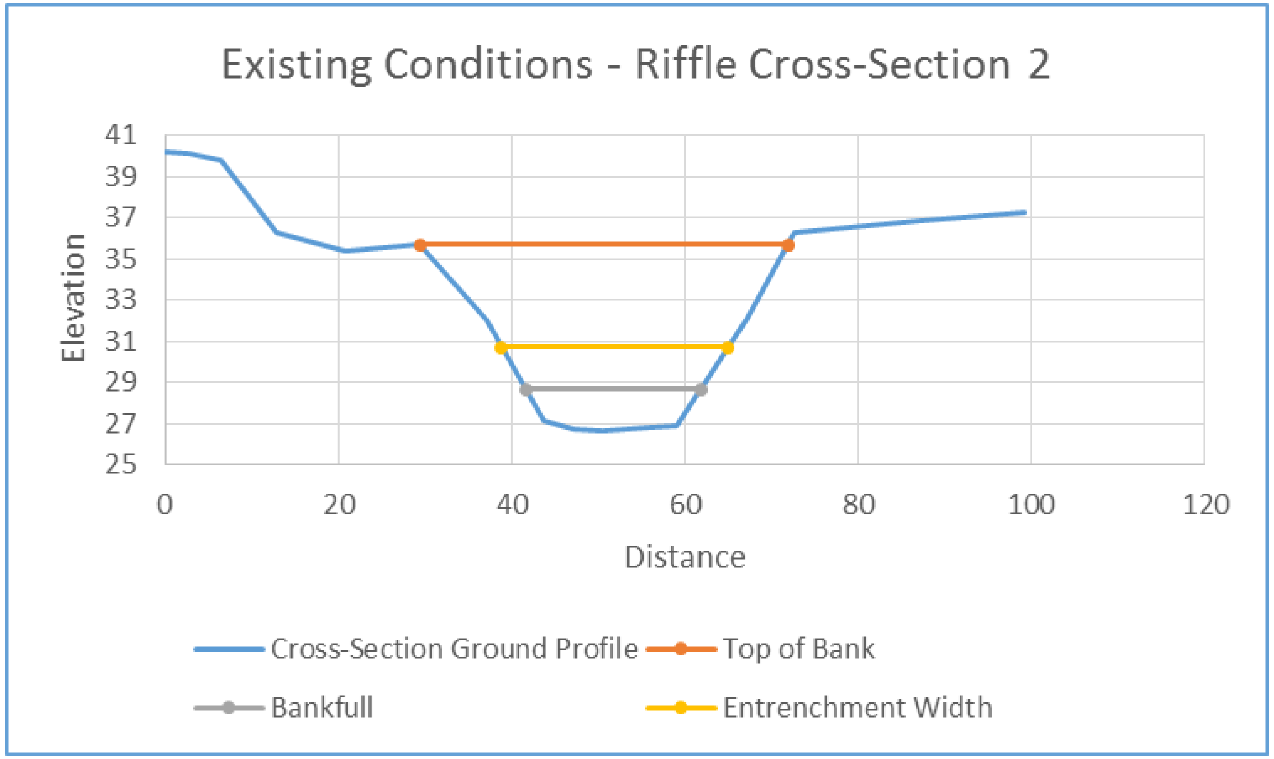


Stream Stability Assessment

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

Stream Stability Assessment





Stream Stability Assessment

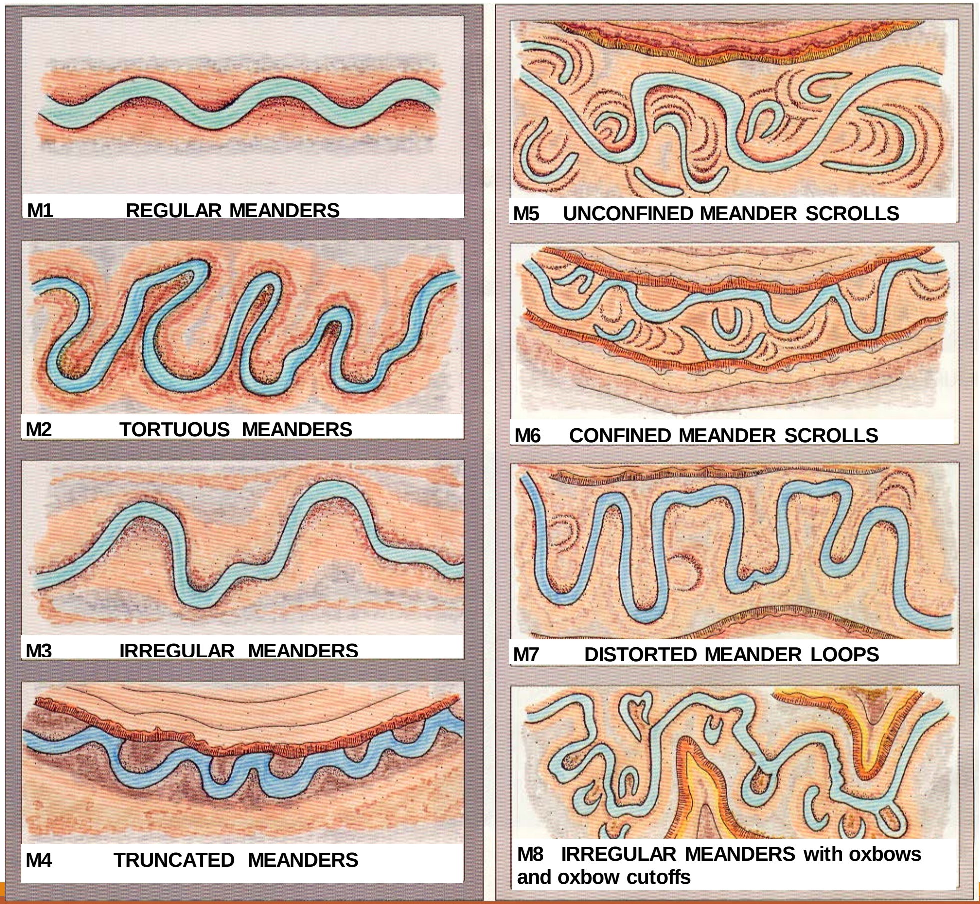
Meander Patterns

Stream: **D'Olive Creek - I-10 Project** Reach: **D'Olive Creek**

Observers: **DAB, MJG** Date: **6/13/2015**

List ALL CATEGORIES that APPLY ☞	M3	M4			

Various Meander Pattern variables modified from Galay et al. (1973)



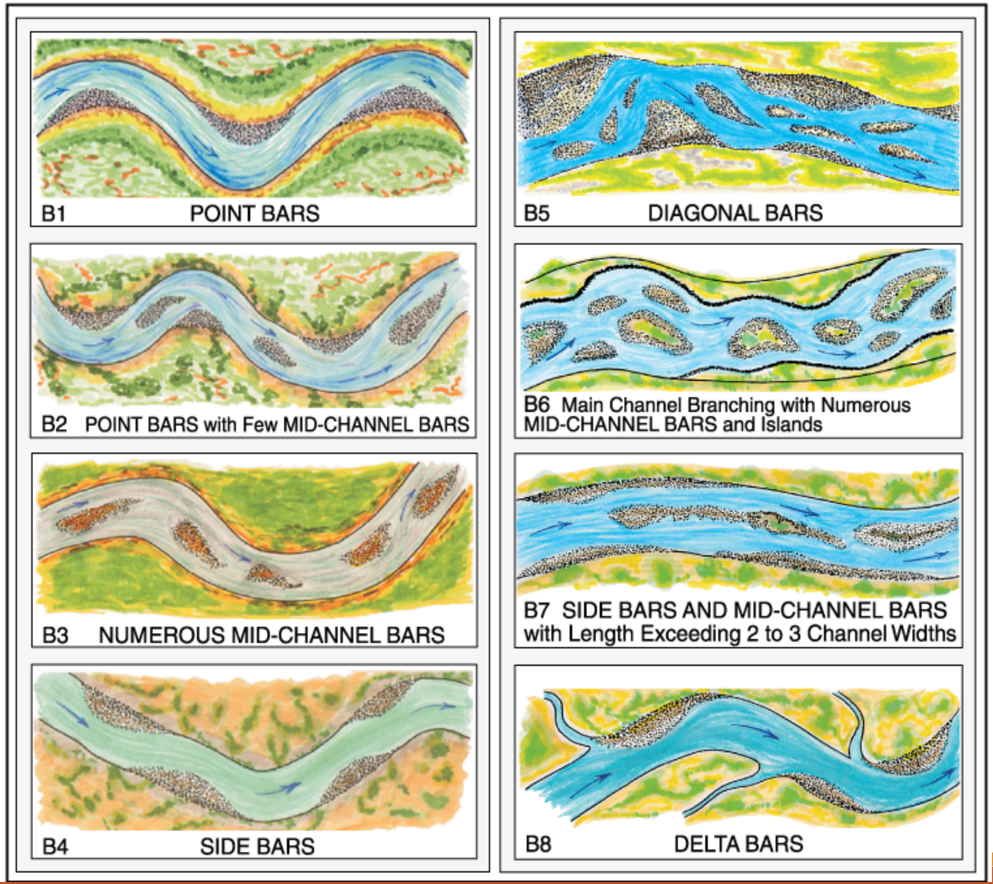
Depositional Patterns

Stream: **D'Olive Creek - I-10 Project** Reach: **D'Olive Creek**

Observers: **DAB, MJG** Date: **6/13/2015**

List ALL CATEGORIES that APPLY ☞	B1	B2	B4		

Various Depositional Features modified from Galay et al. (1973)



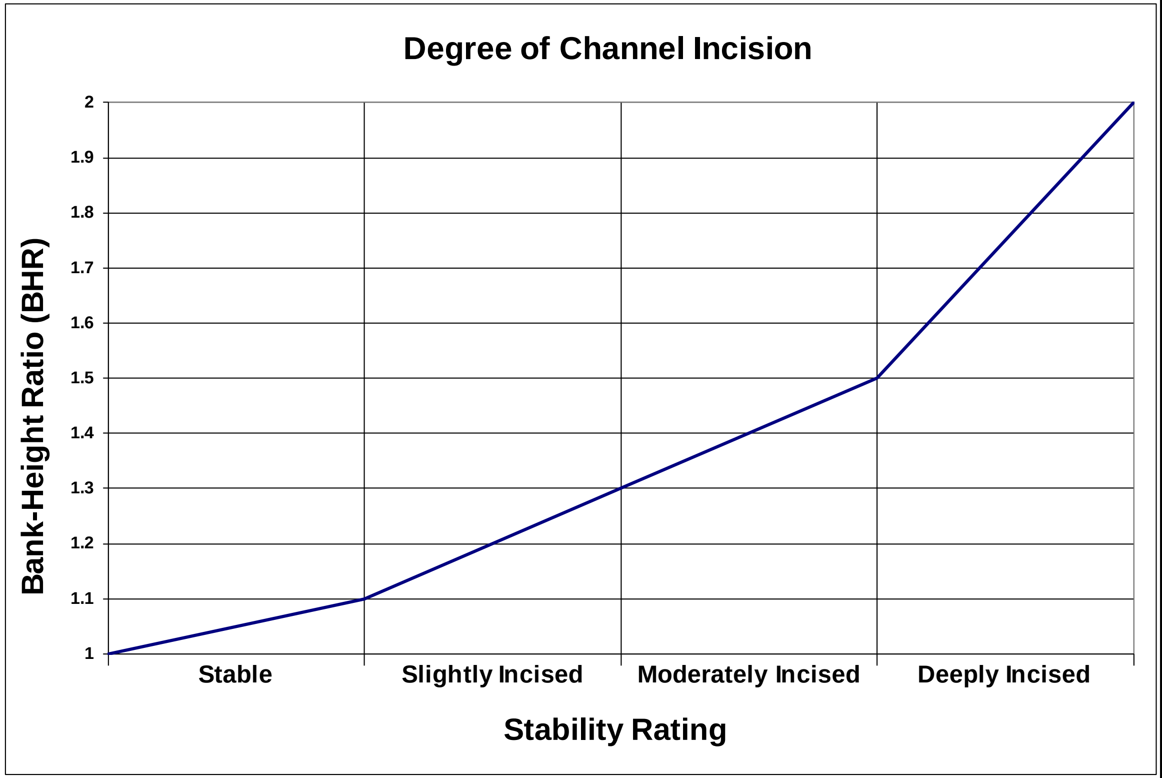
Stream Stability Assessment

Degree of Channel Incision

Low Bank Height:	6.5
Max Bankfull Depth:	2

Bank-Height Ratio:	3.3

Degree of Channel Incision Stability Rating ☞ **Deeply Incised**

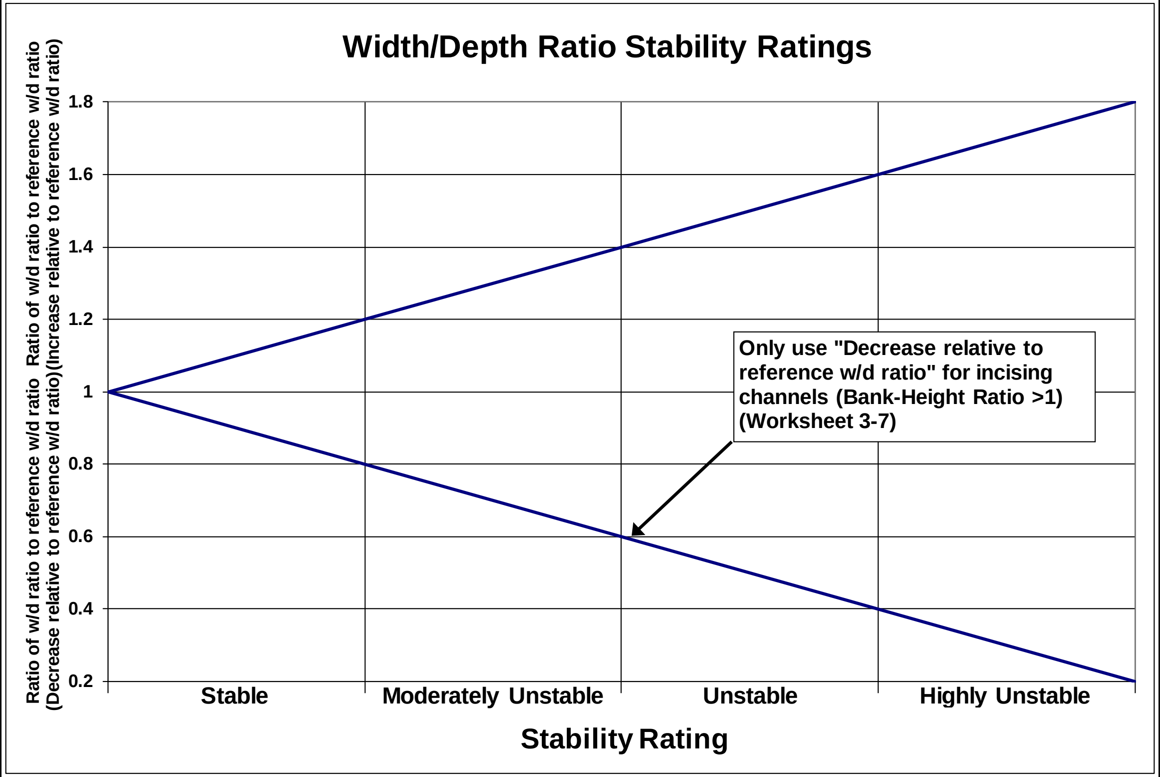


Width/Depth Ratio State

Existing Width/Depth Ratio:	12.4
Reference Width/Depth Ratio:	8.9

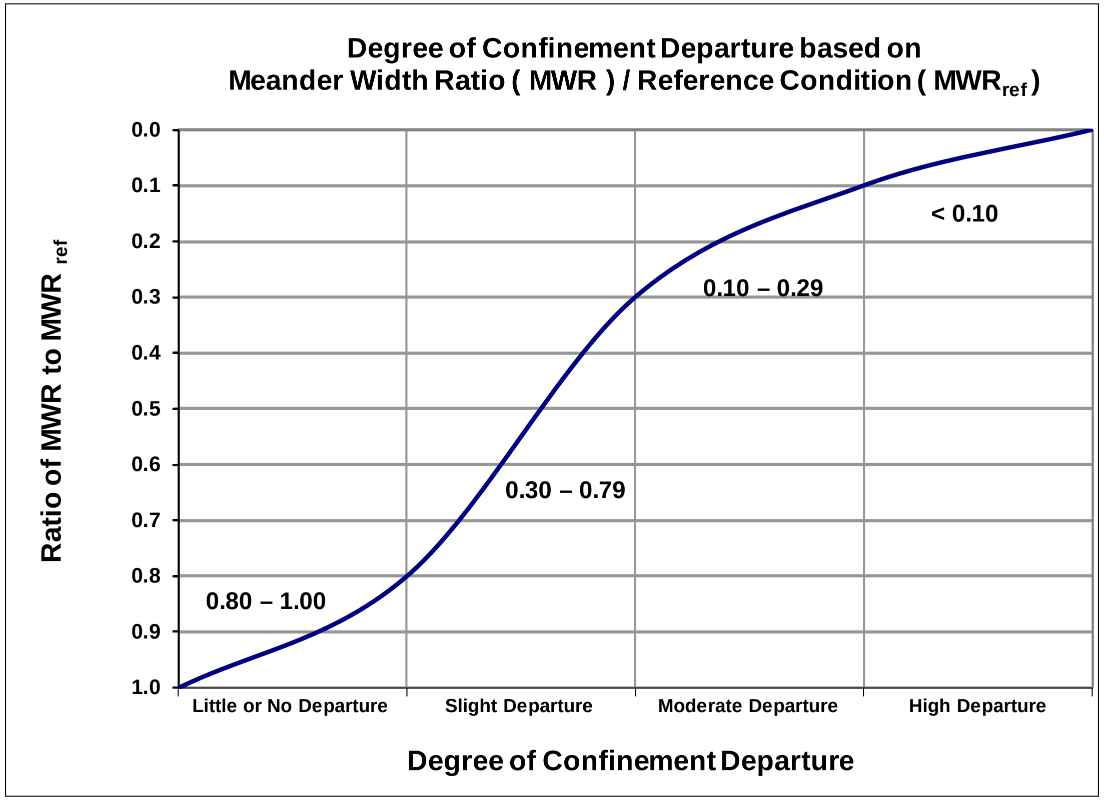
Ratio of existing W/d to reference W/d:	1.39

Width/Depth Ratio State Stability Rating ☞ **Moderately Unstable**



Stream Stability Assessment

Degree of Confinement			
Existing Meander Width Ratio (MWR):	2.4	Ratio of MWR to MWR_{ref}:	0.53
Reference Meander Width Ratio (MWR_{ref}):	4.5		
Degree of Confinement Stability Rating ☞	Slight Departure		



Stream: **D'Olive Creek**	Stream Type: **F5**
Location: **I-10**	Valley Type: **VIII**
Observers: **DAB, MJG**	Date: **04/13/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☑ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Stream Stability Assessment

Stream:	D'Olive Creek - I-10 Project	Stream Type:	F5/C5
Location:	I-10	Valley Type:	VIII
Observers:	DAB, MJG	Date:	04/13/2015

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 W/d Ratio State (Worksheet 3-8)	< 1.2 (2)	1.2 – 1.4 (4)	1.4 – 1.6 (6)	> 1.6 (8)	4
2 Depositional Patterns (Worksheet 3-5)	B1, B2 (1)	B4, B8 (2)	B3 (3)	B5, B6, B7 (4)	2
3 Meander Patterns (Worksheet 3-4)	M1, M3, M4 (1)		M2, M5, M6, M7, M8 (3)		1
4 Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)	< 0.006 (2)	0.006 - 0.04 (4)	0.041 - 0.07 (6)	> 0.07 (8)	8
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	> 0.8 (1)	0.3 – 0.79 (2)	0.1 – 0.29 (3)	< 0.1 (4)	2
				Total Points	**17**

Overall Lateral Stability Category (use total points and check stability rating)	Lateral Stability Category Point Range			
	Stable < 10 ☐	*Moderately Unstable* 10 – 12 ☐	*Unstable* 13 – 21 ☑	*Highly Unstable* > 21 ☐

Stream:	D'Olive Creek	Stream Type:	F5
Location:	I-10	Valley Type:	VIII
Observers:	DAB, MJG	Date:	04/13/2015

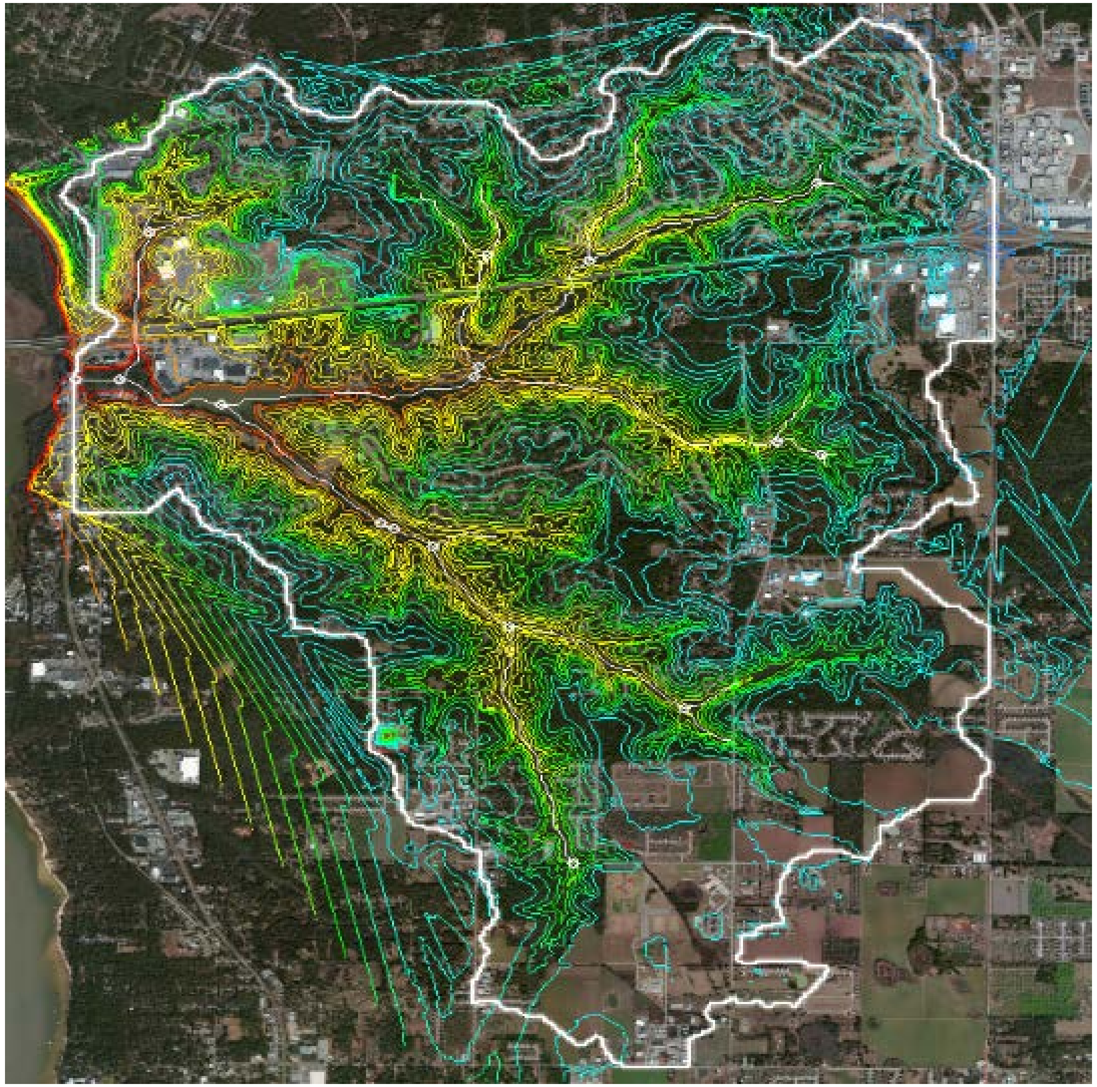
Vertical Stability Criteria (choose one stability category for each criterion 1–5)	Vertical Stability Categories for Channel Incision / Degradation				Selected Points (from each row)
	Not Incised	*Slightly Incised*	*Moderately Incised*	*Degradation*	
1 Sediment Competence (2-D FESWMS)	Does not indicate 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 Sediment Capacity (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 Degree of Channel Incision (BHR) (Worksheet 3-7)	1.00 – 1.10 (2)	1.11 – 1.30 (4)	1.31 – 1.50 (6)	> 1.50 (8)	8
4 Stream Succession States (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 Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	0.80 – 1.00 (1)	0.30 – 0.79 (2)	0.10 – 0.29 (3)	< 0.10 (4)	2
				Total Points	**30**

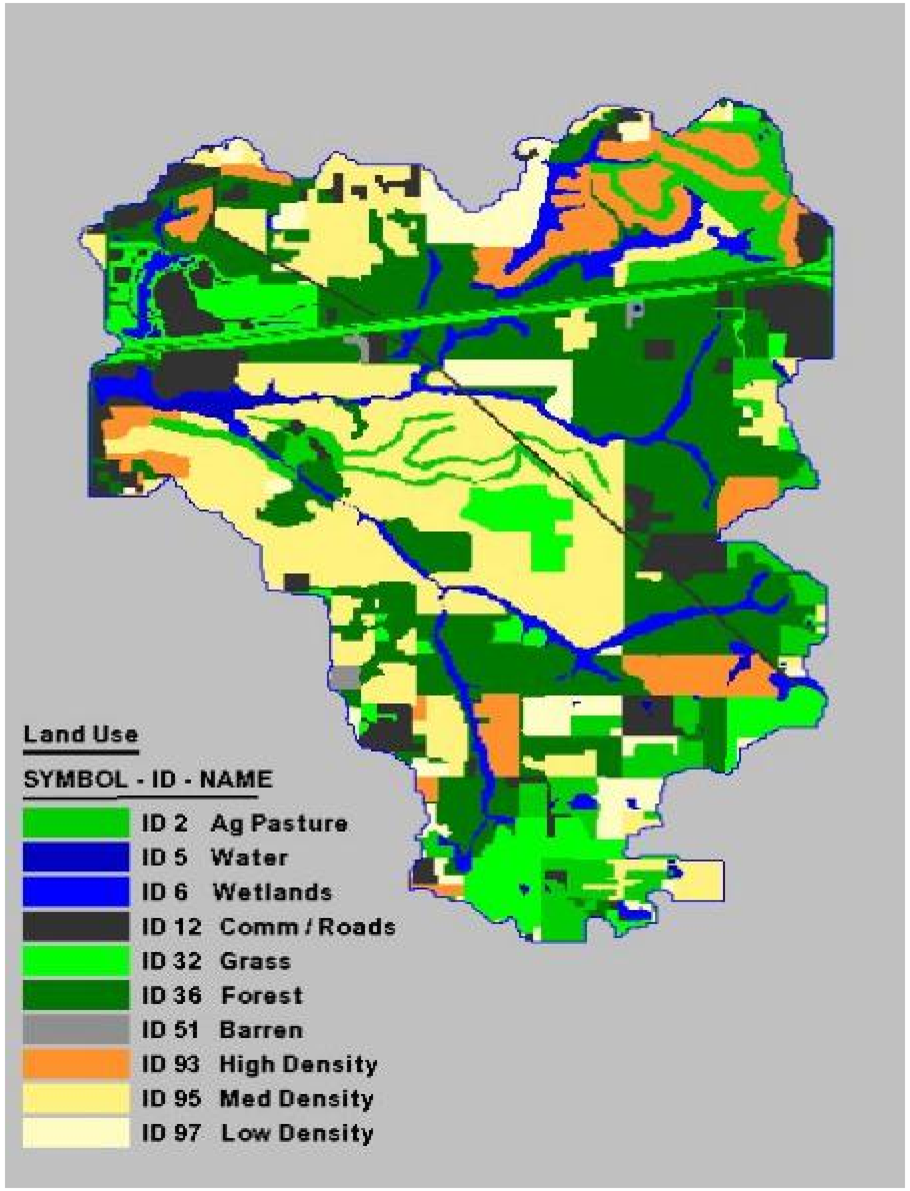
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	Vertical Stability Category Point Range for Channel Incision / Degradation			
	Not Incised < 12 ☐	*Slightly Incised* 12 – 18 ☐	*Moderately Incised* 19 – 27 ☐	*Degradation* > 27 ☑

Stream Stability Assessment

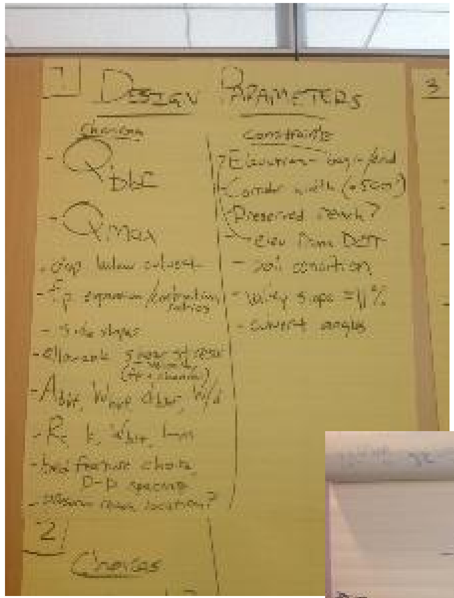
- Findings
  - Lateral Stability → Unstable System
    - Instream Depositional Features
    - Degree of Confinement
    - Streambank Erosion Potential
  - Vertical Stability → Degraded System
    - Incised System
    - Upstream Head Cut
    - Instream Energy during High Flows
- Conclusion
    - Major Channel Realignment
    - Adjustment of Profile
    - Floodplain Access
    - Decreased Shear Stress
    - Reduce Bank Erosion
    - Decrease Velocities

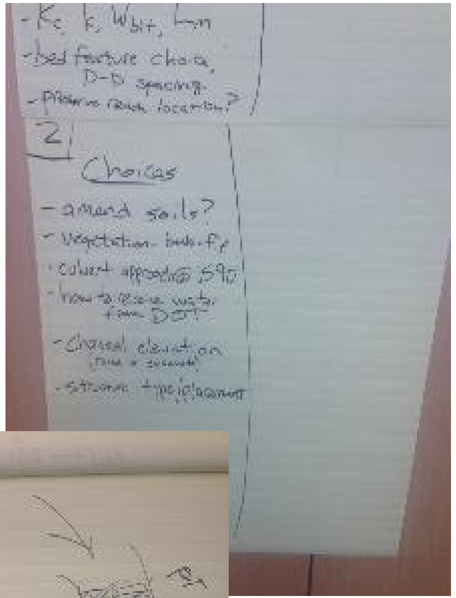
Hydrology Assessment

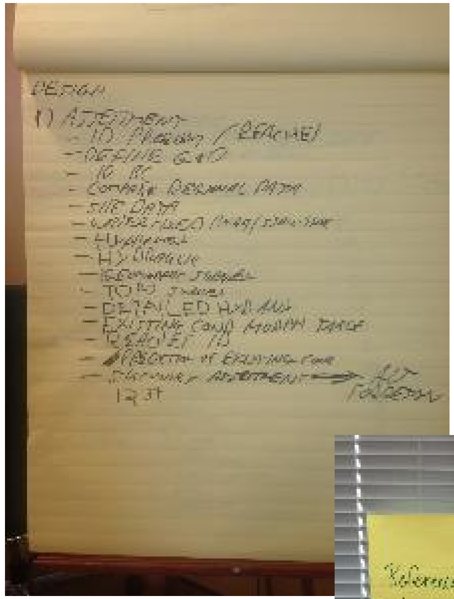


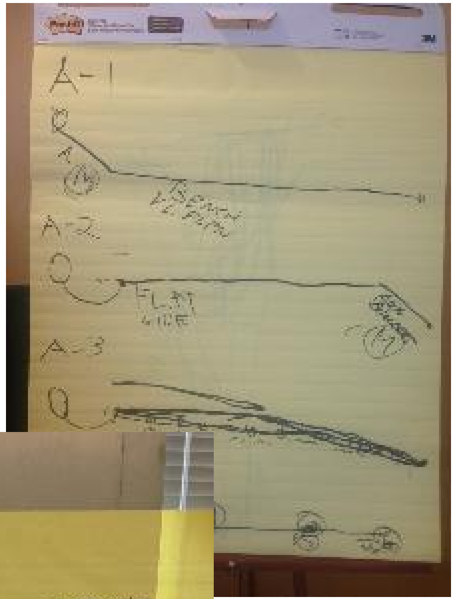


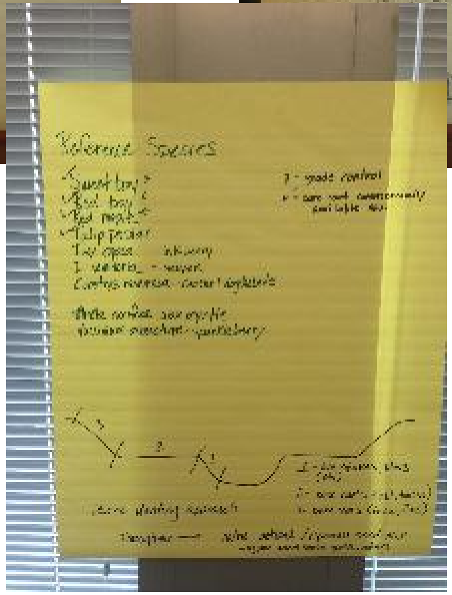
Conceptual Design



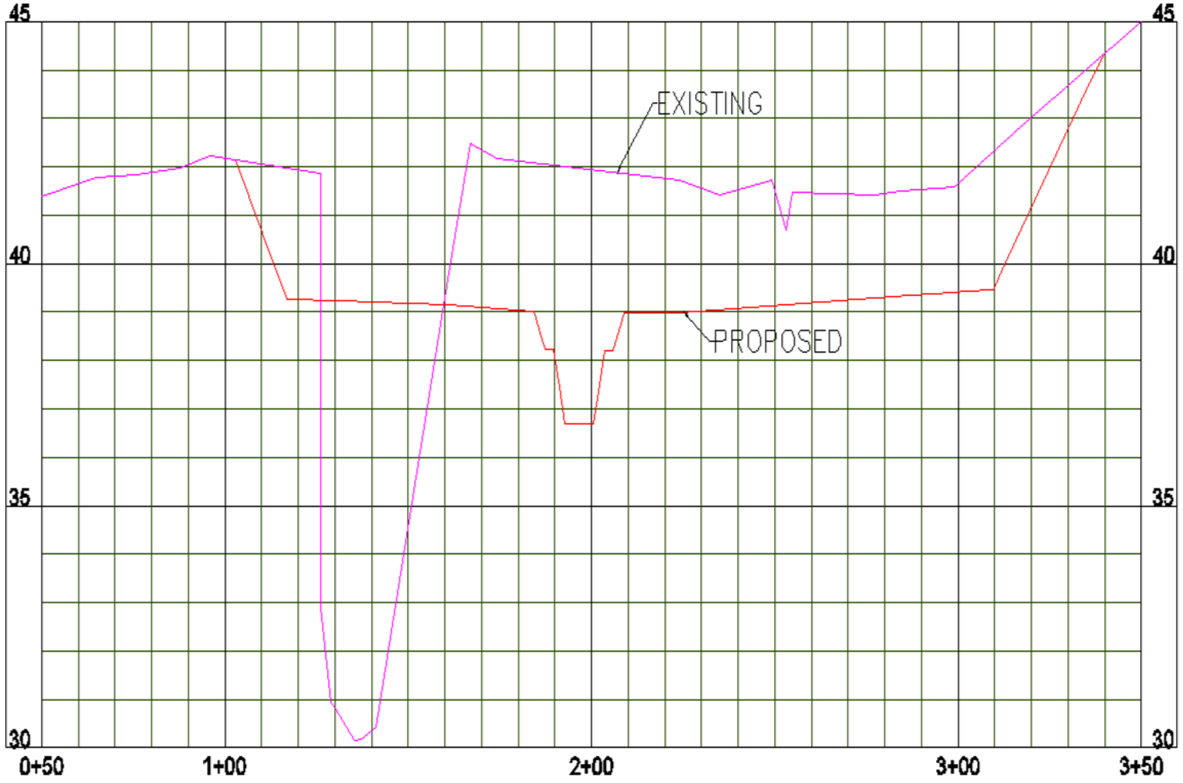


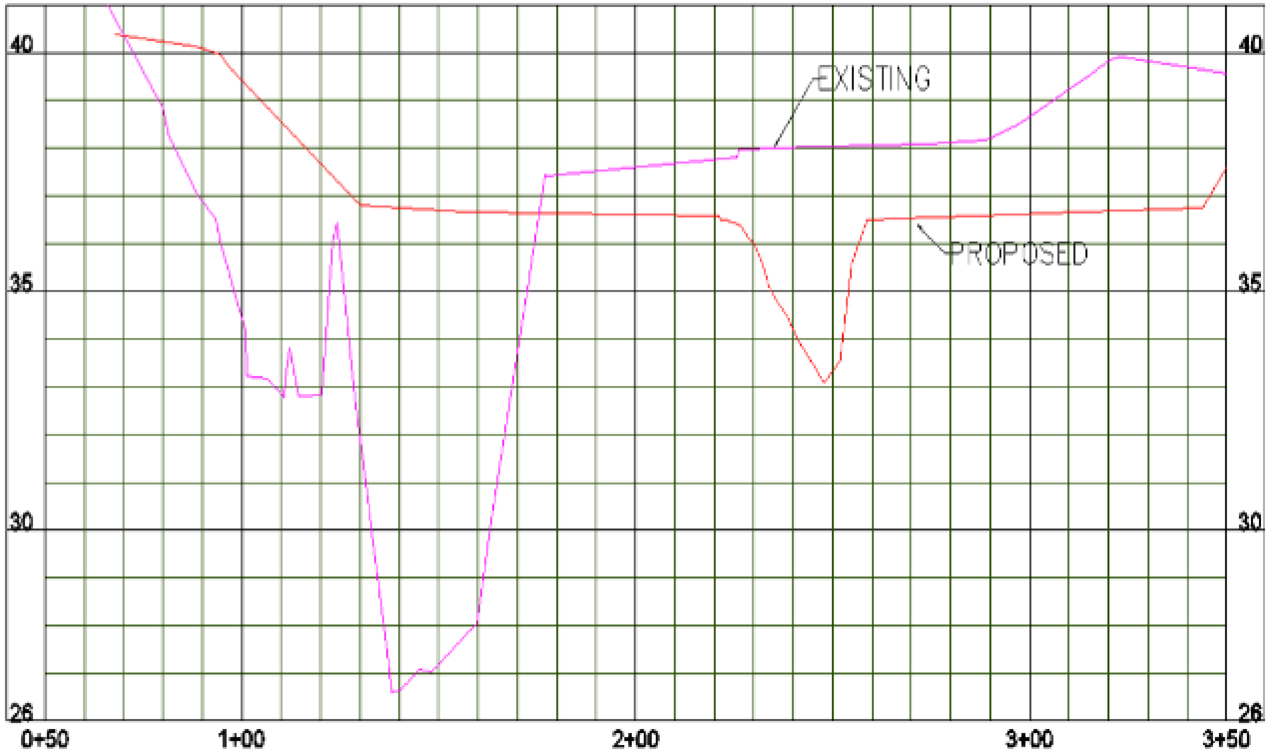




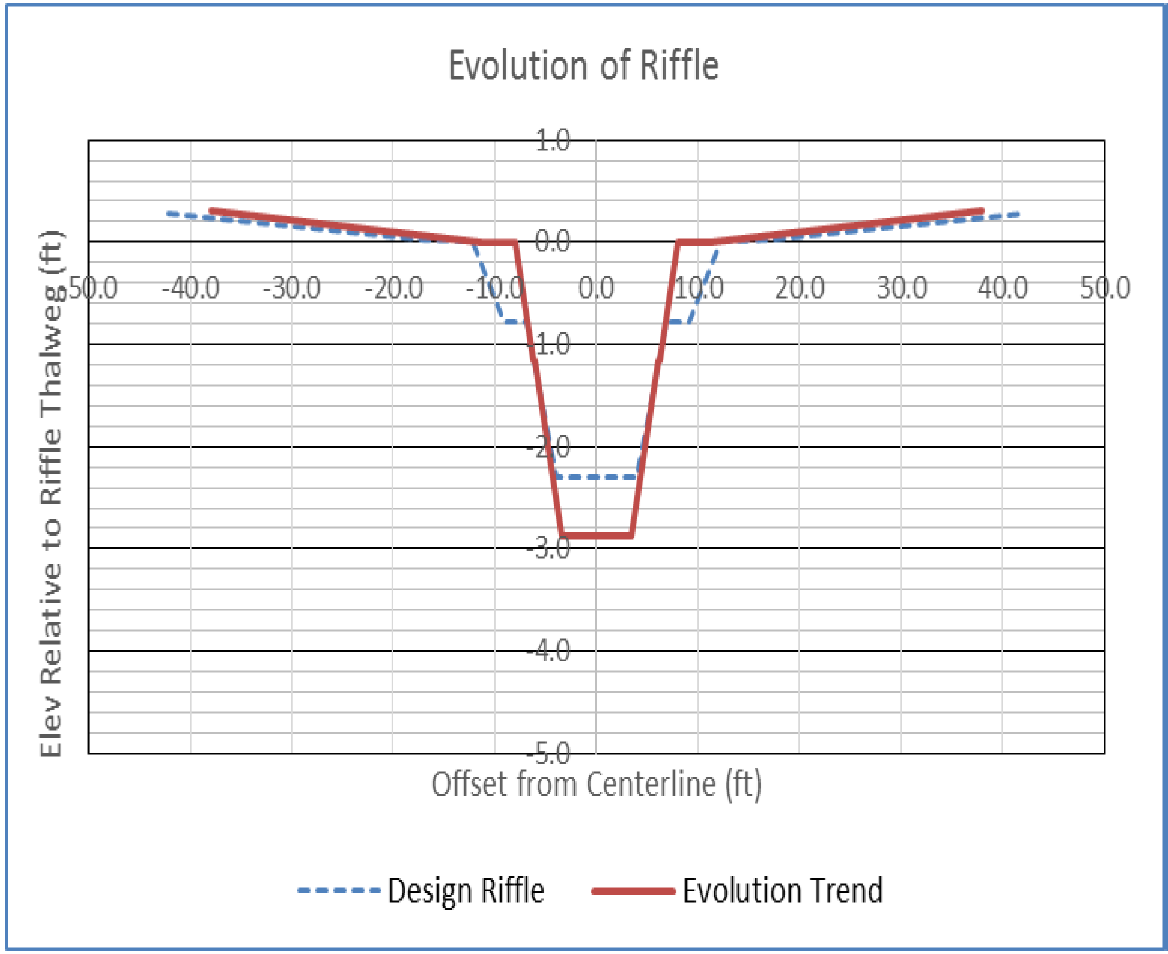


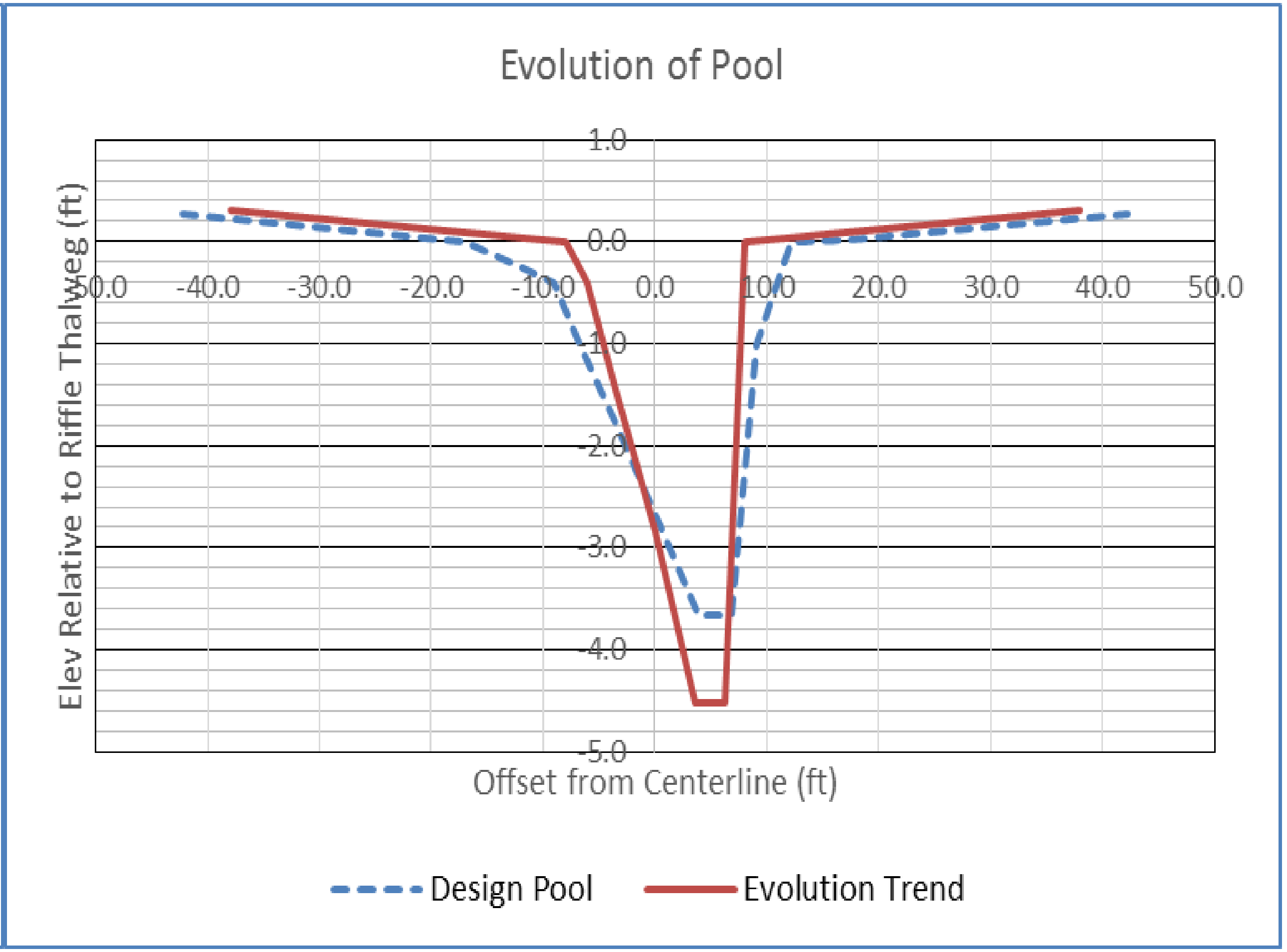
Design Approach





Design Approach



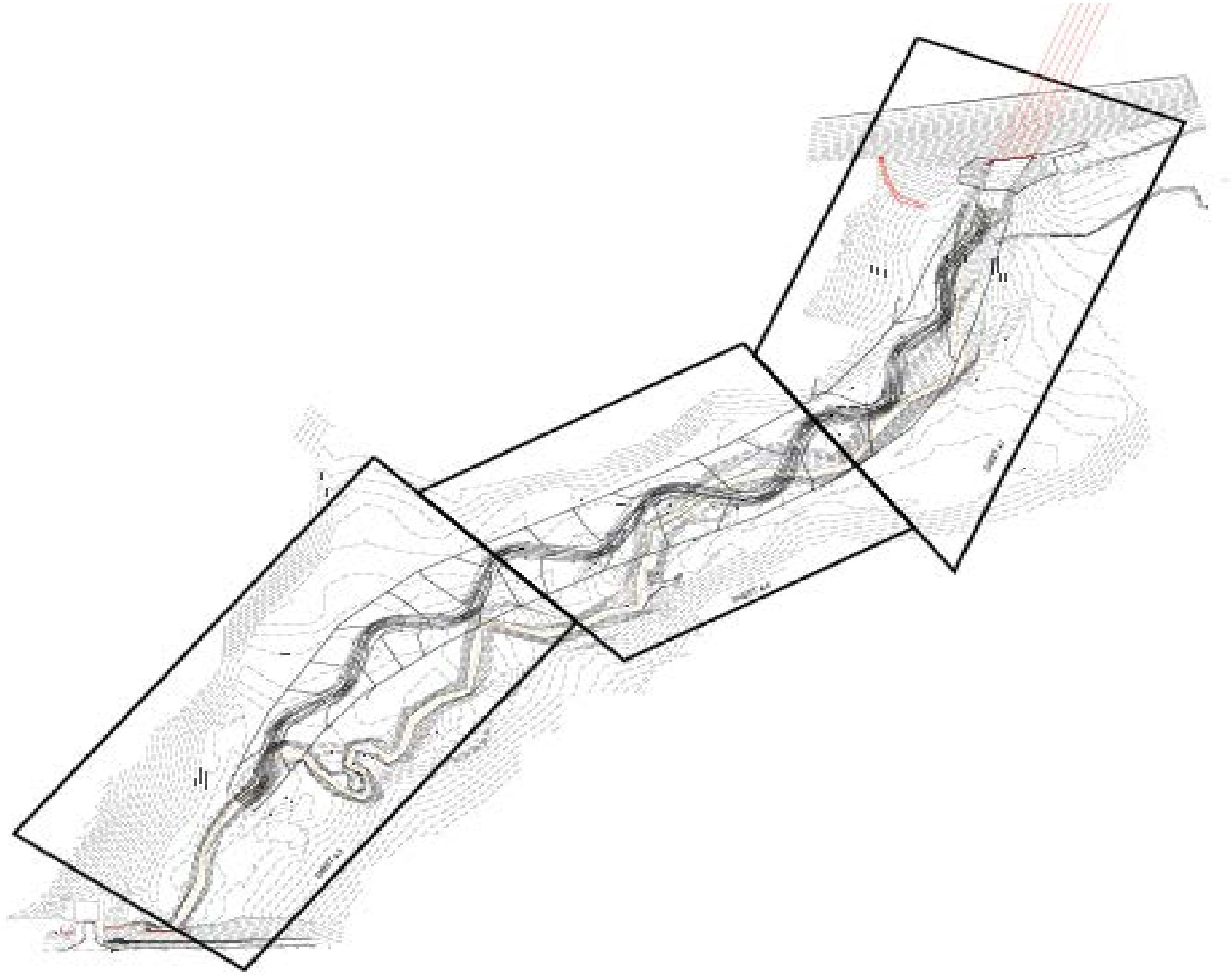


Design Approach

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		

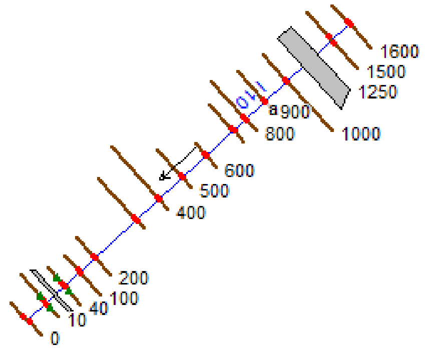
Preliminary Design (30%)

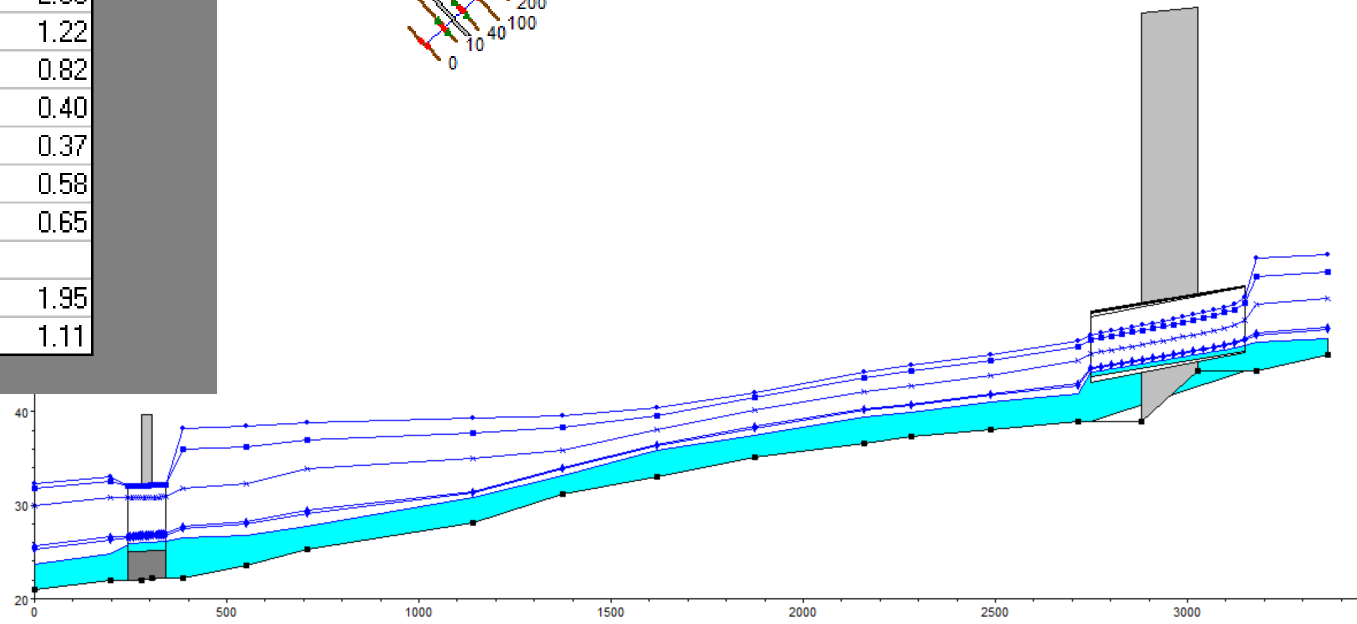


HEC-RAS Modeling

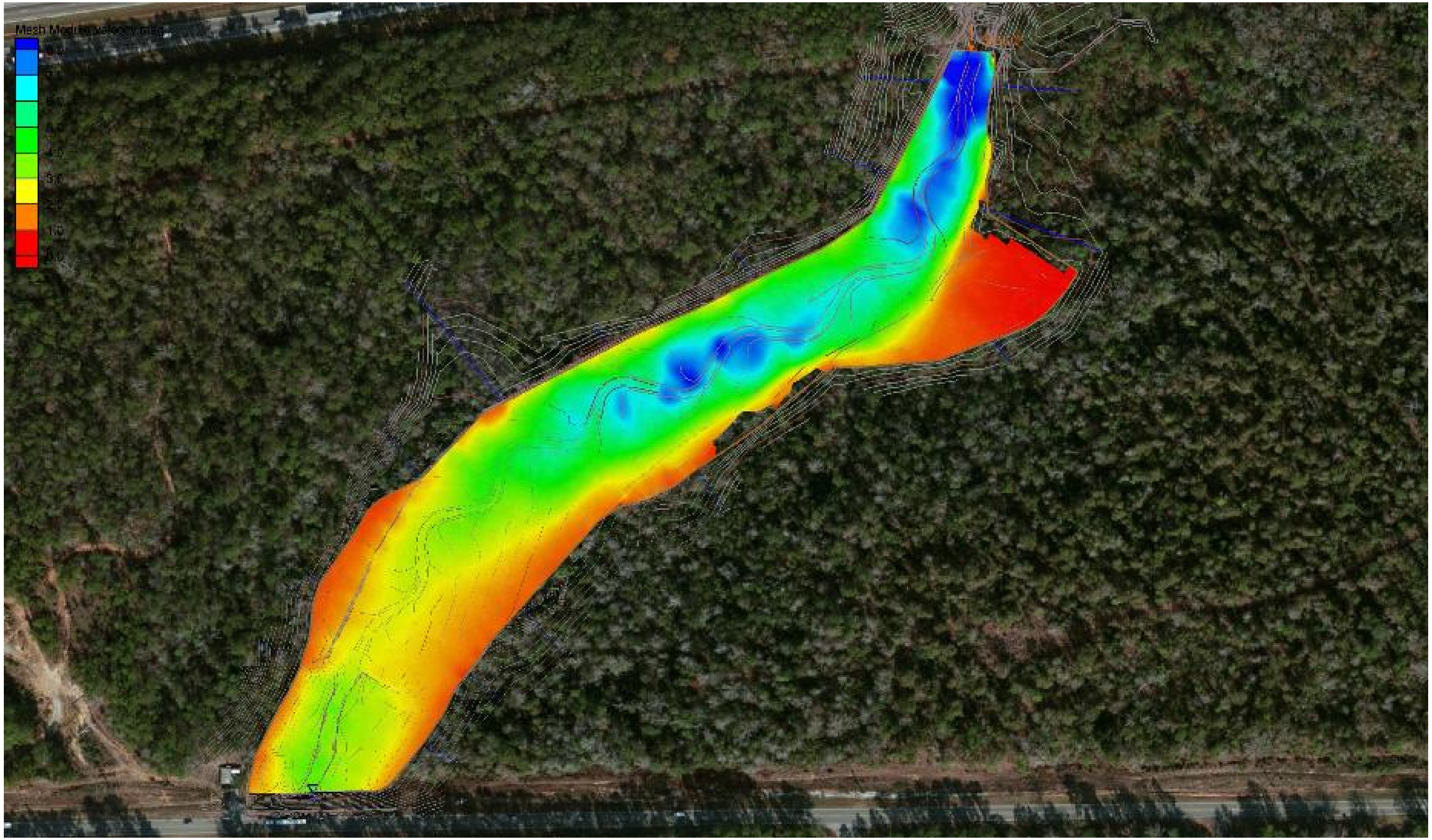
HEC-RAS Plan: Plan 08 River: I10

River Sta	Profile	Q Total	W.S. Elev	Vel Chnl	Shear LOB	Shear Chan	Shear ROB	Shear Total
		(cfs)	(ft)	(ft/s)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(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		Culvert						
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		Culvert						
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

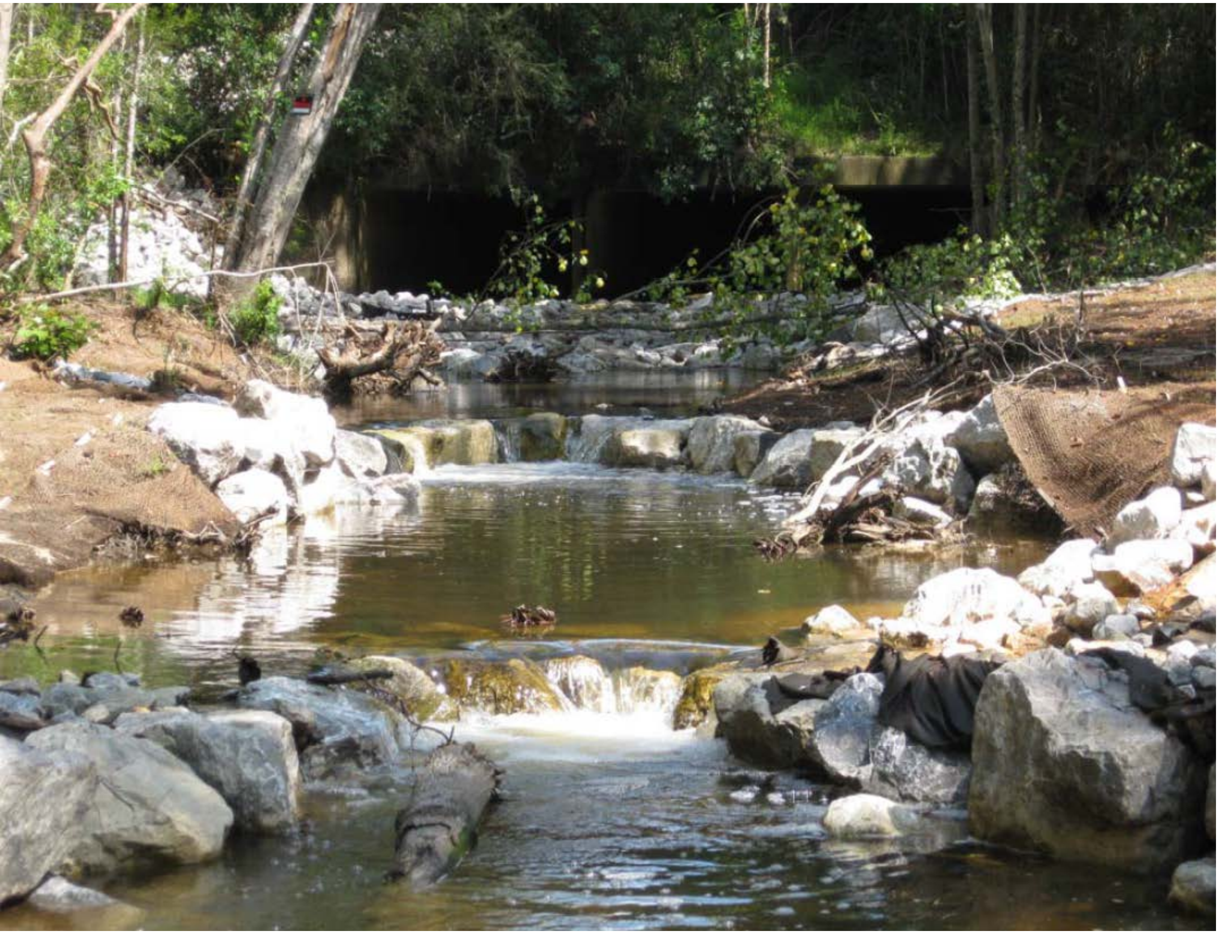




2-D Hydraulic Modeling
30% Design 3750 cfs

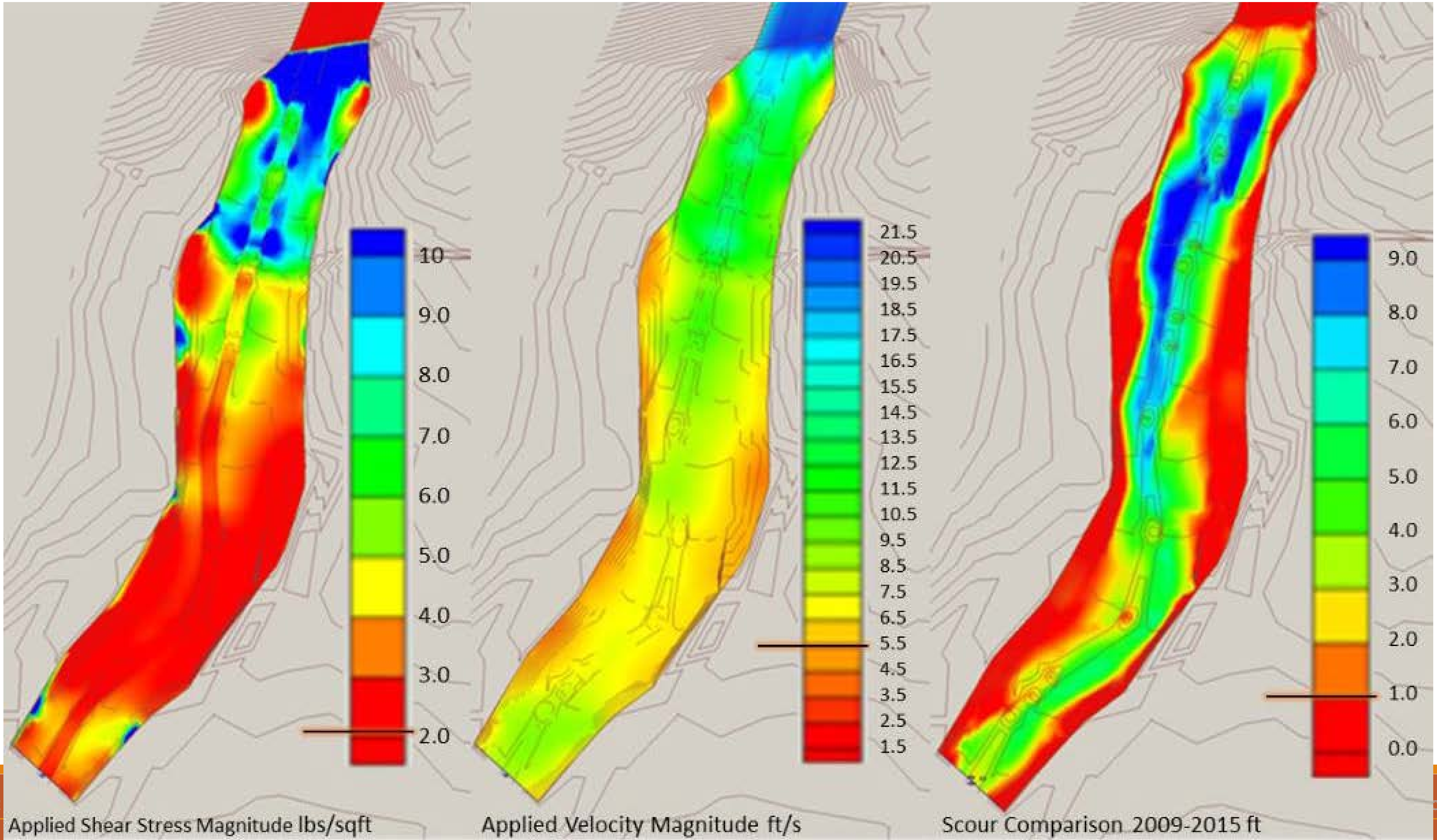


Former Conditions

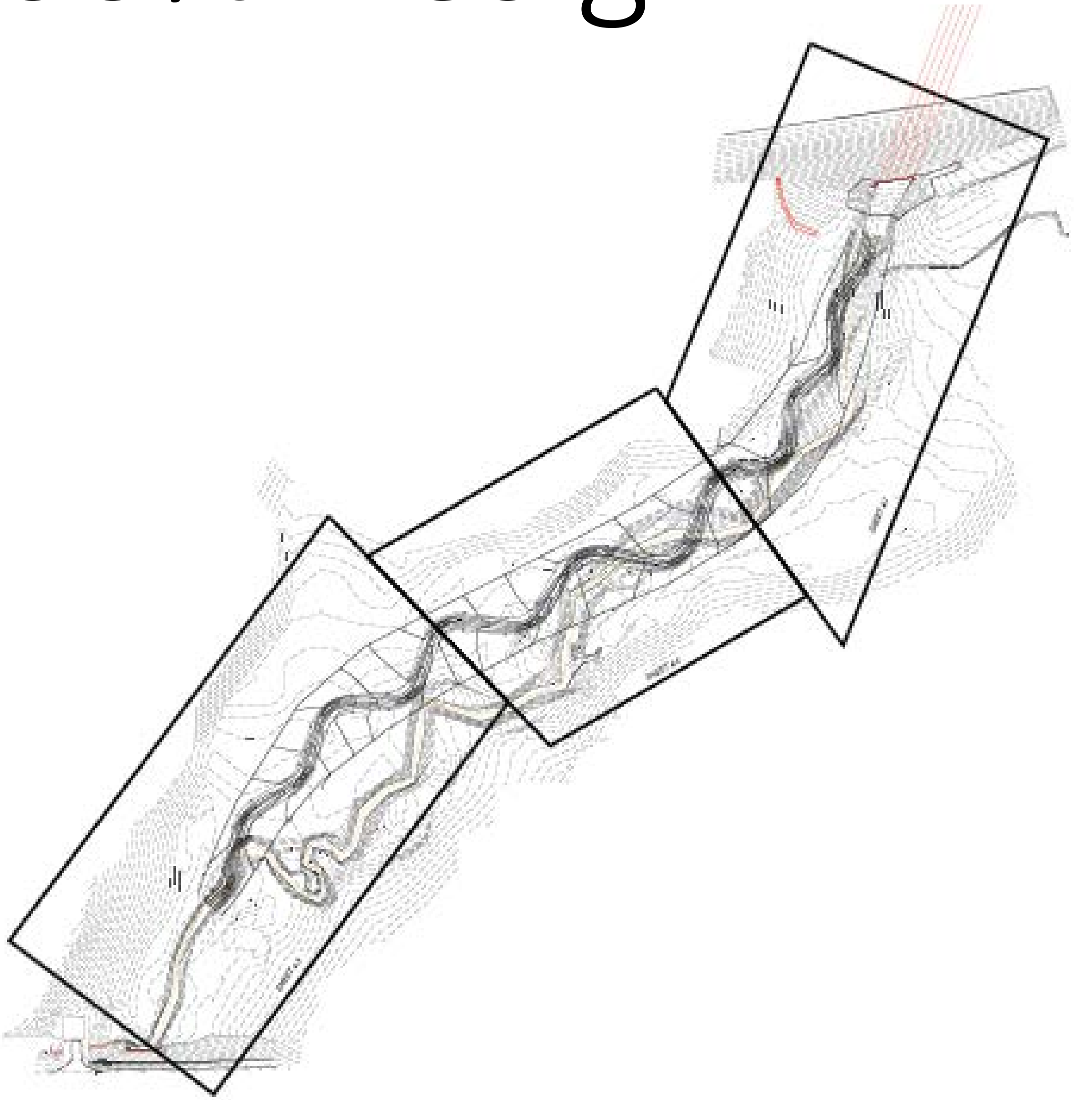


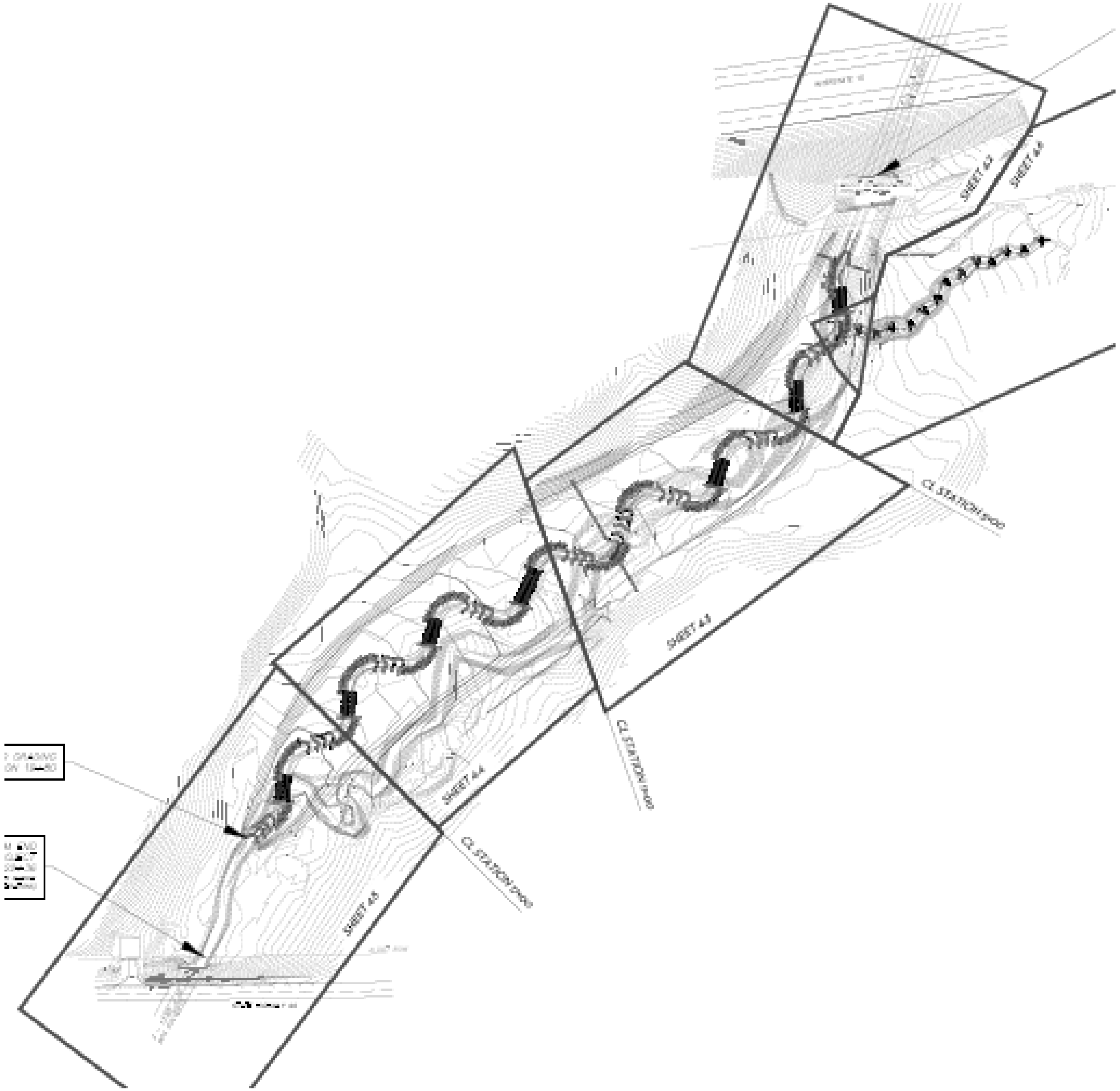
Former Conditions

HYDRO ENGINEERING SOULTIONS
A DIVISION OF TRIMBLE

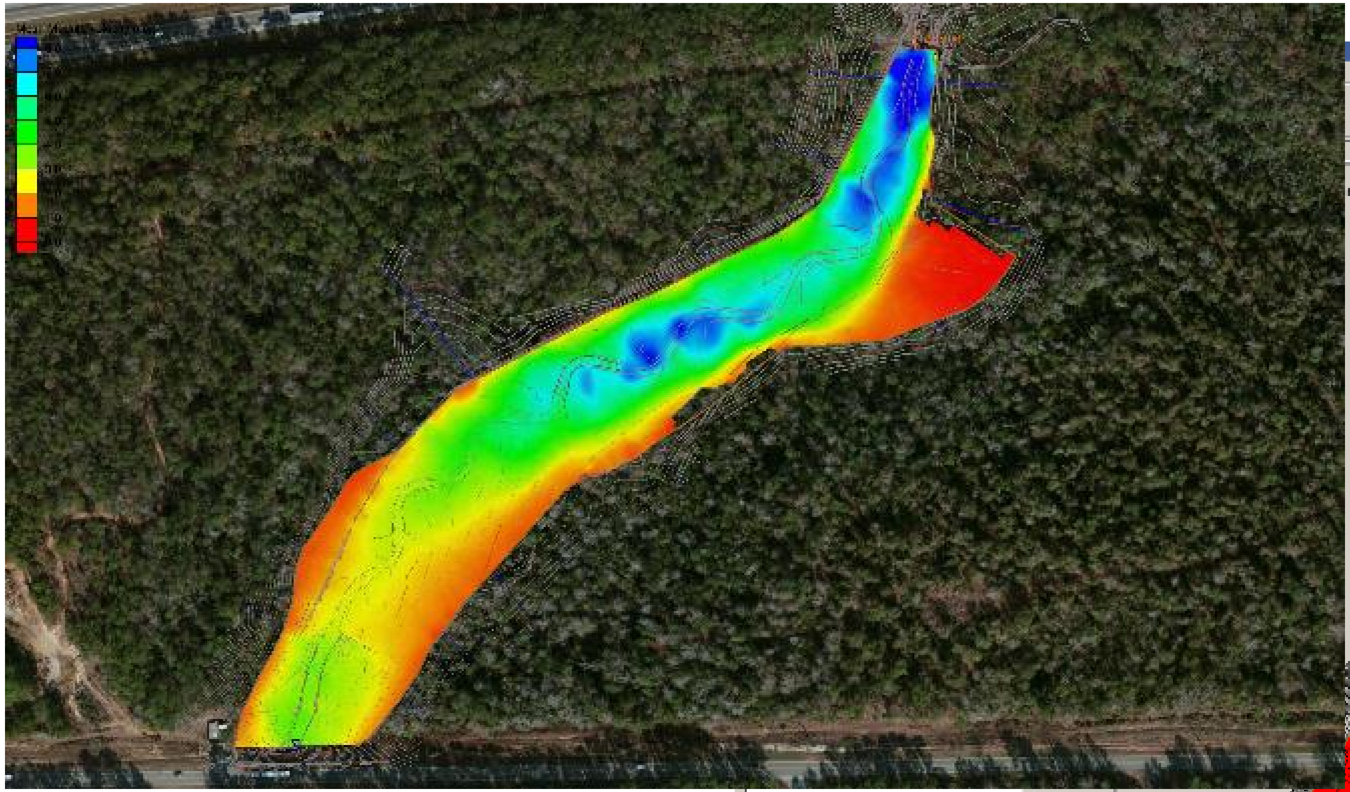


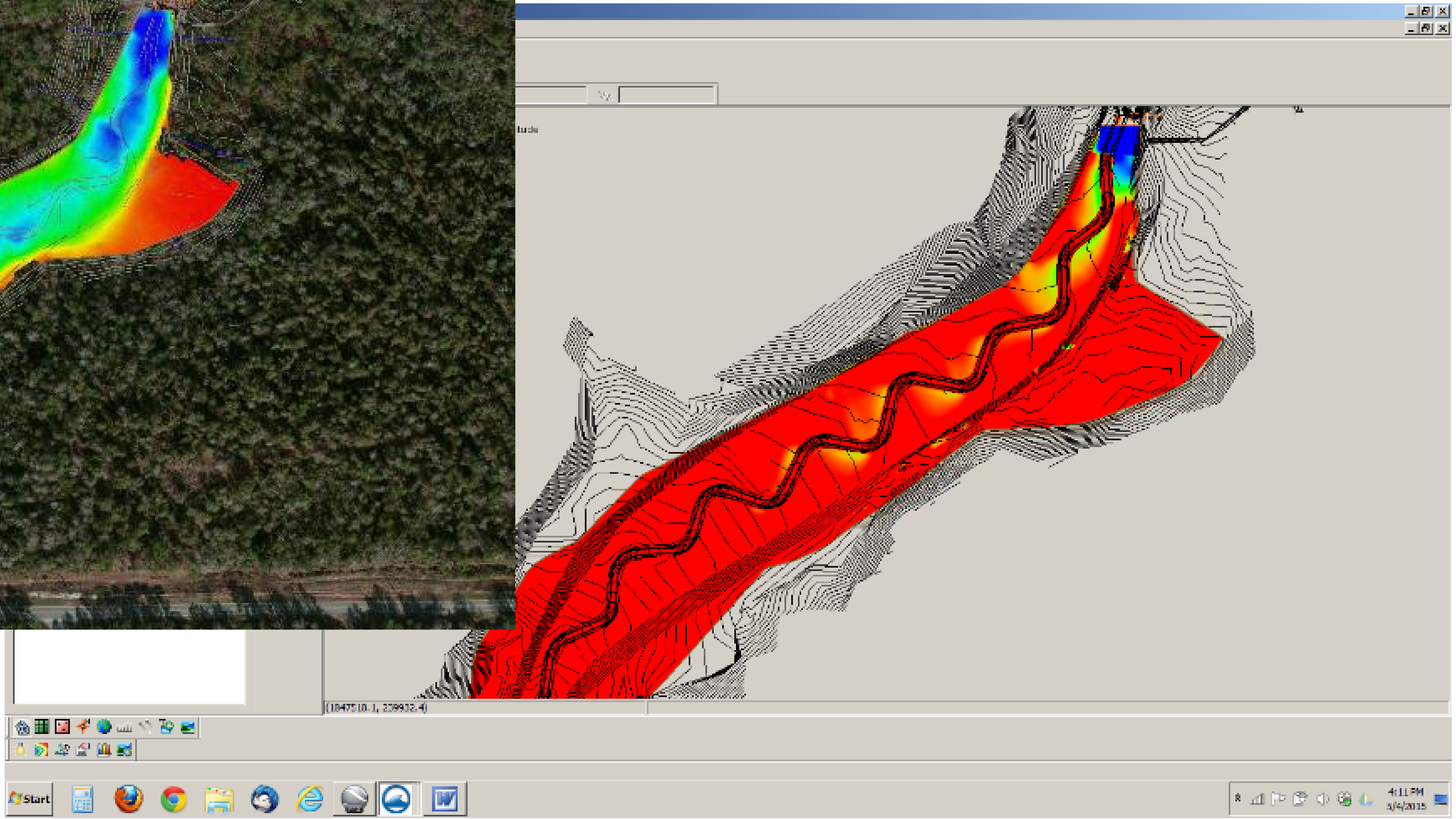
60% Design



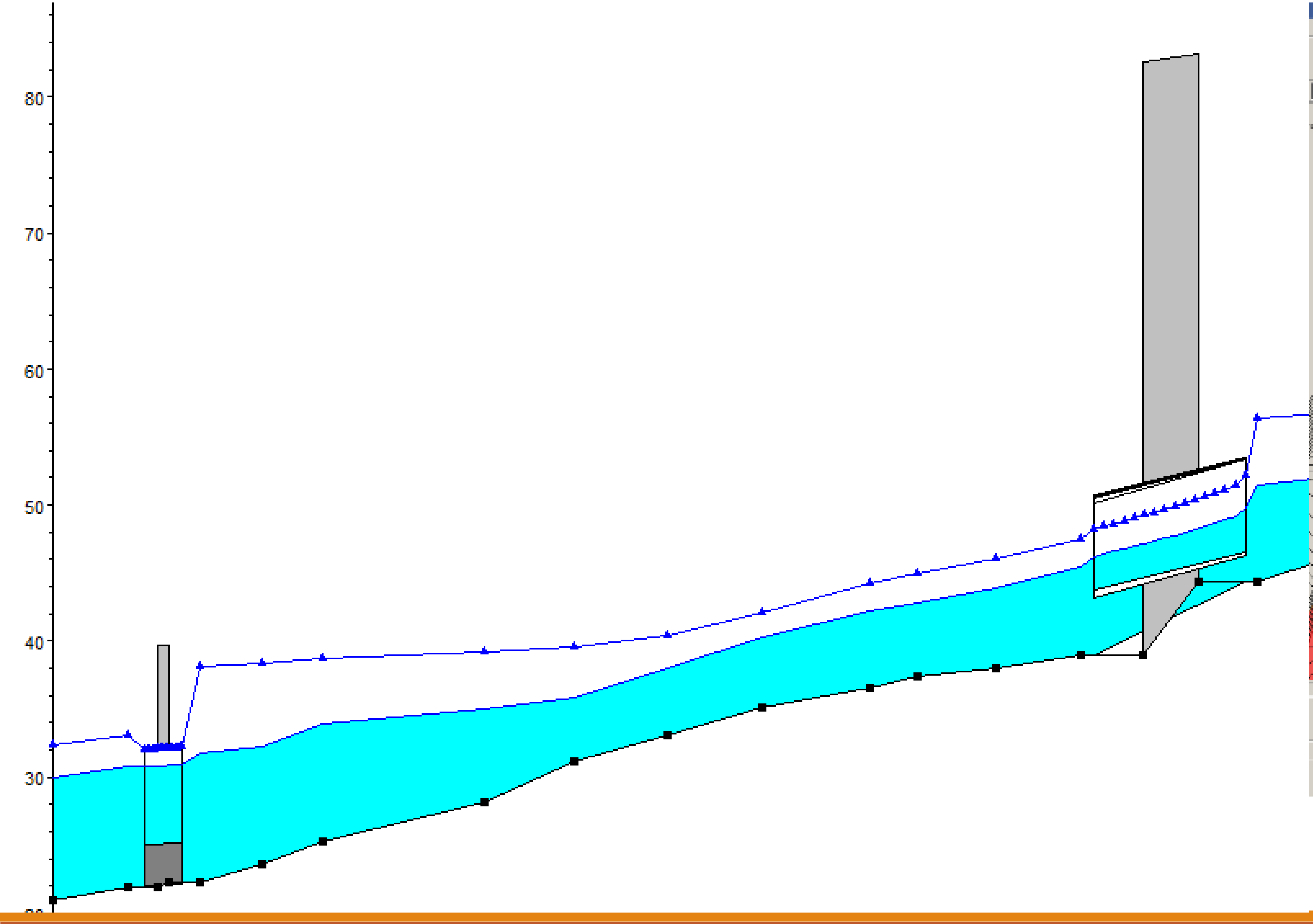


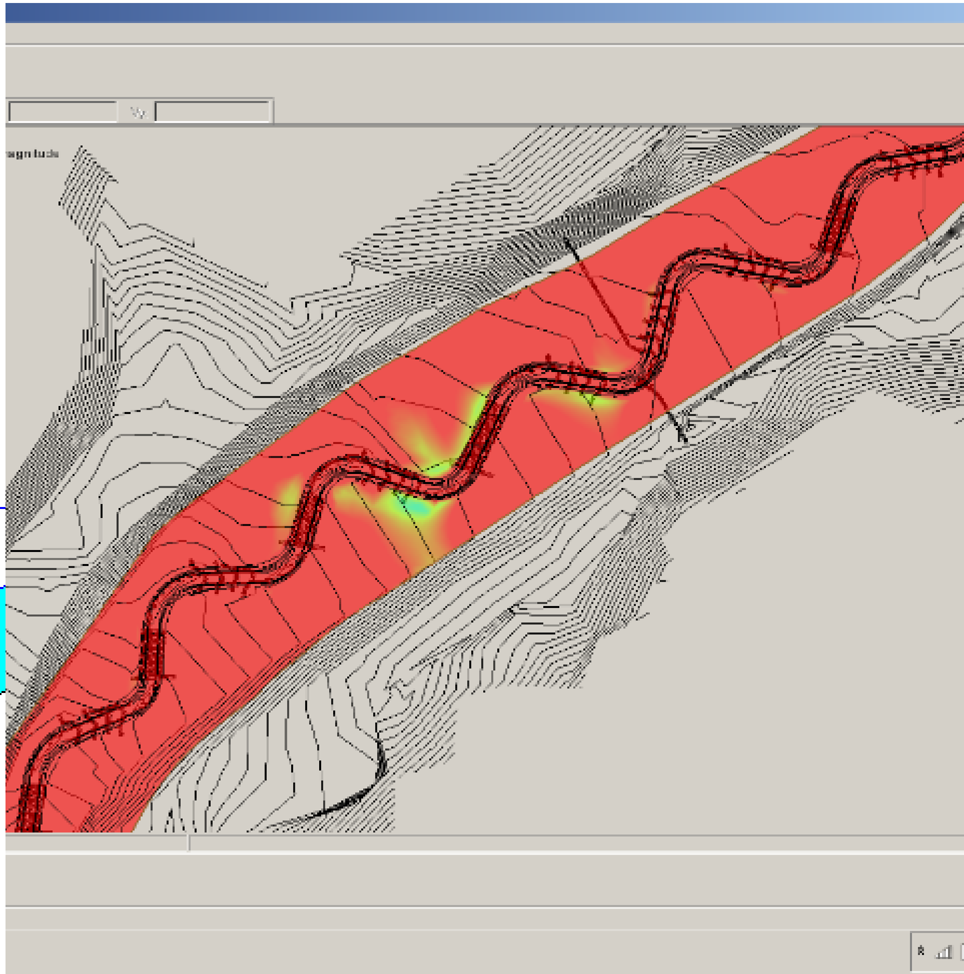
2-D Hydraulic Modeling
60% 3750 cfs



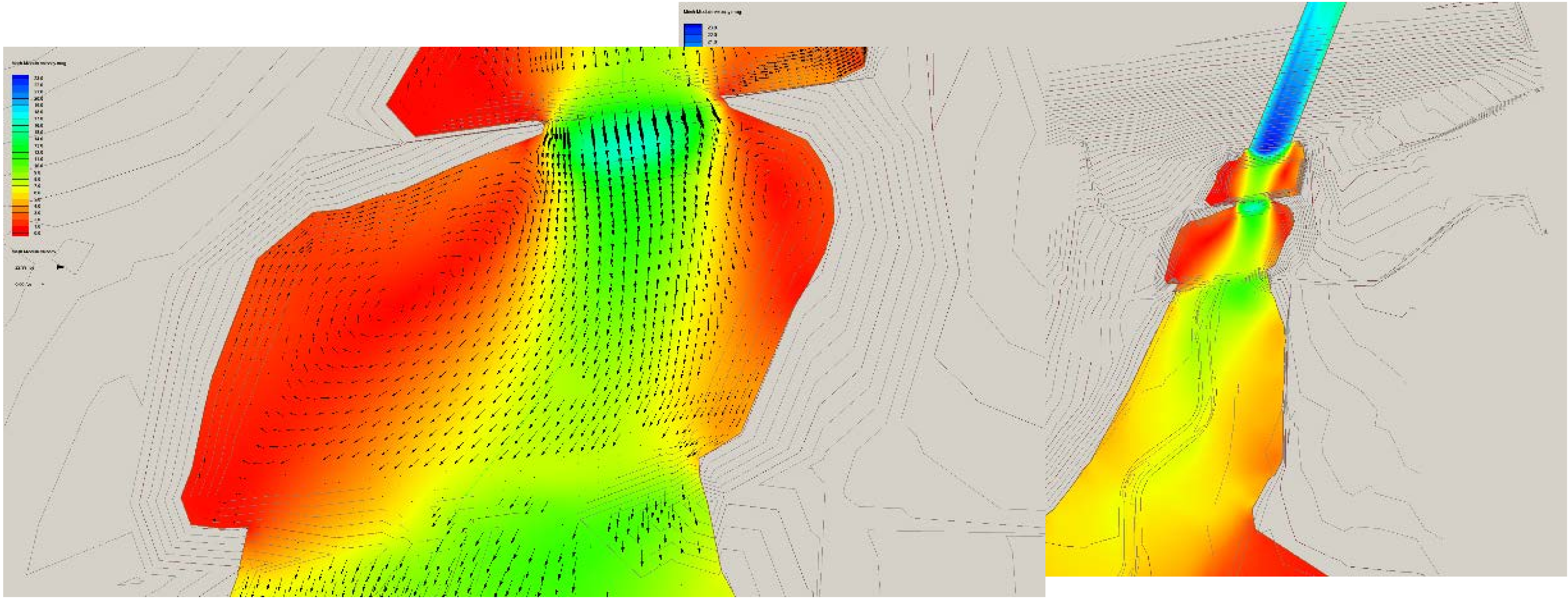


2-D Hydraulic Modeling
60% 1680 cfs

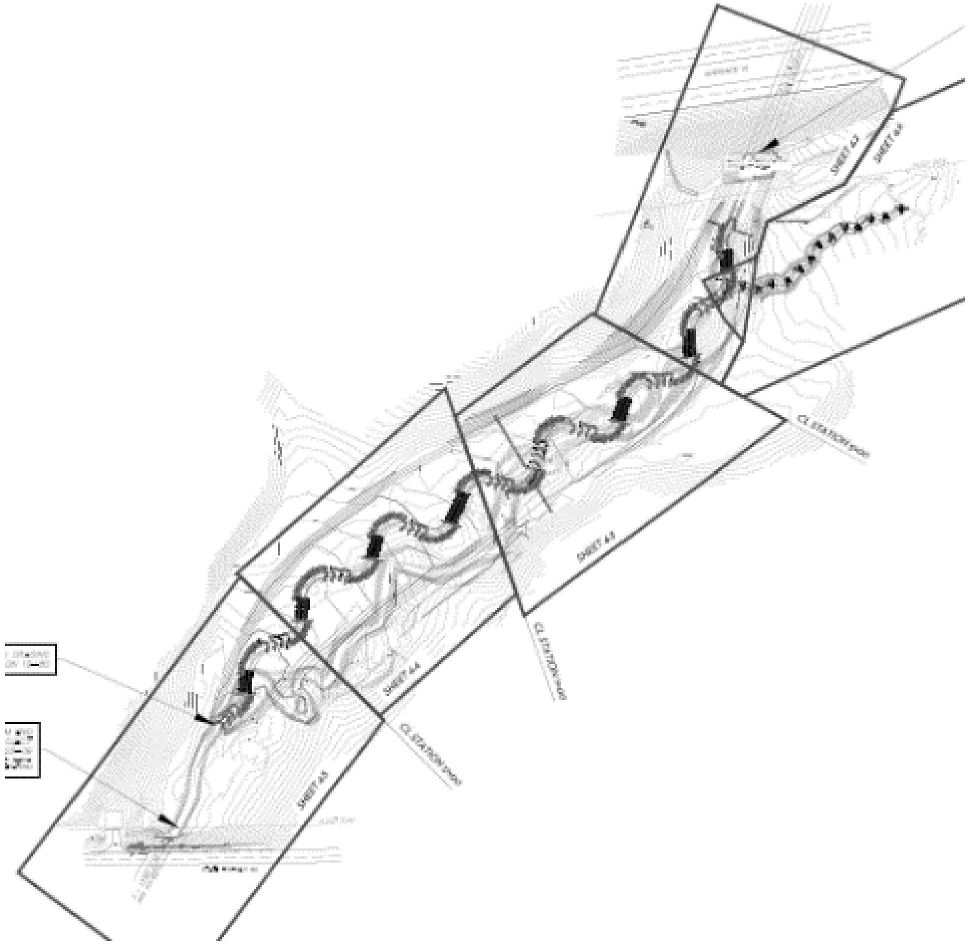


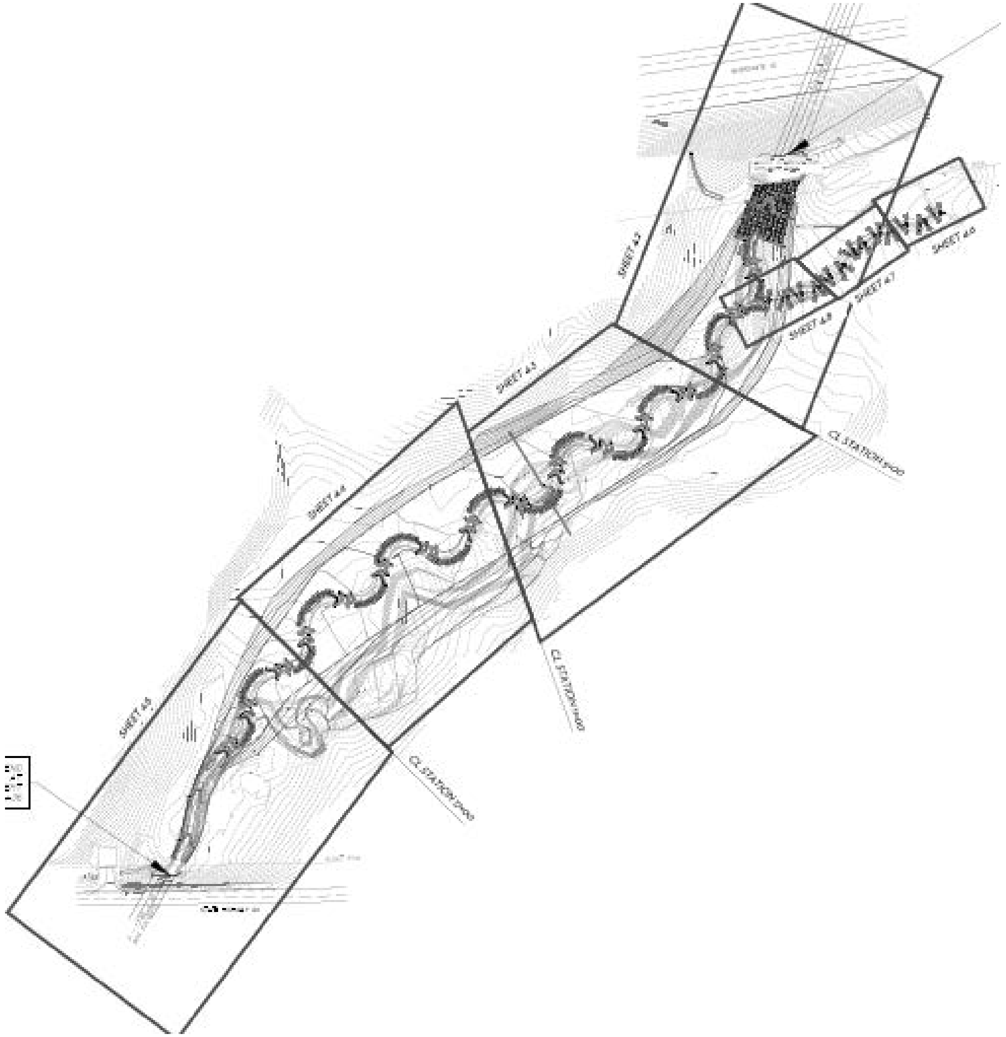


Culvert Outlet Modeling

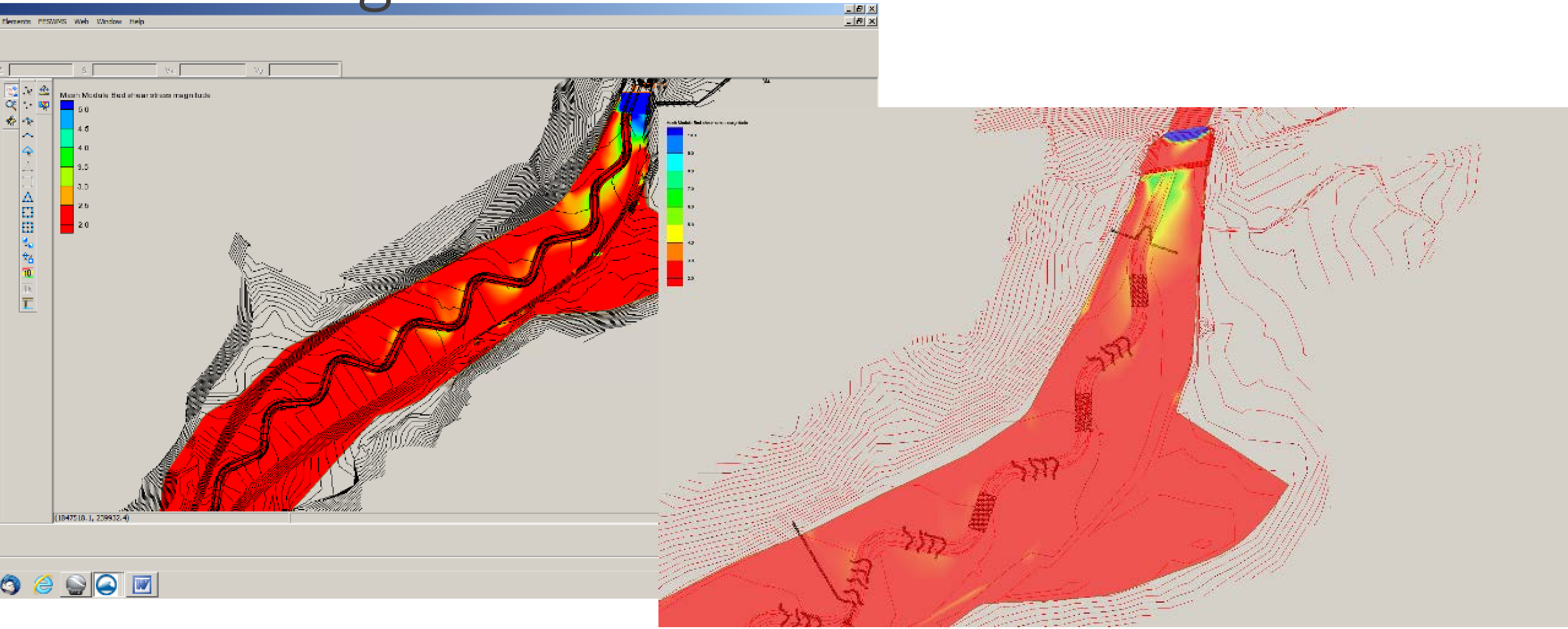


90% Design

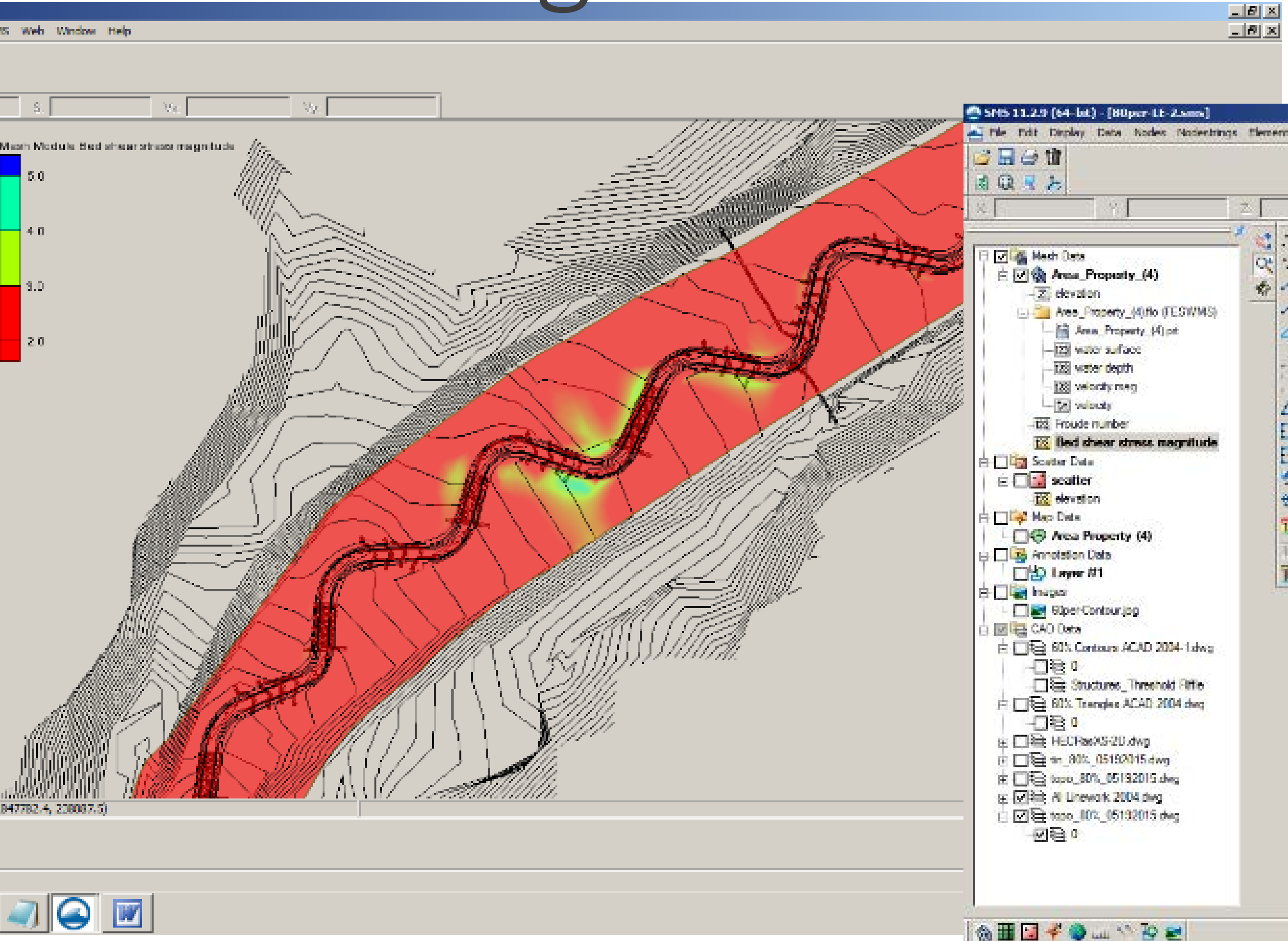


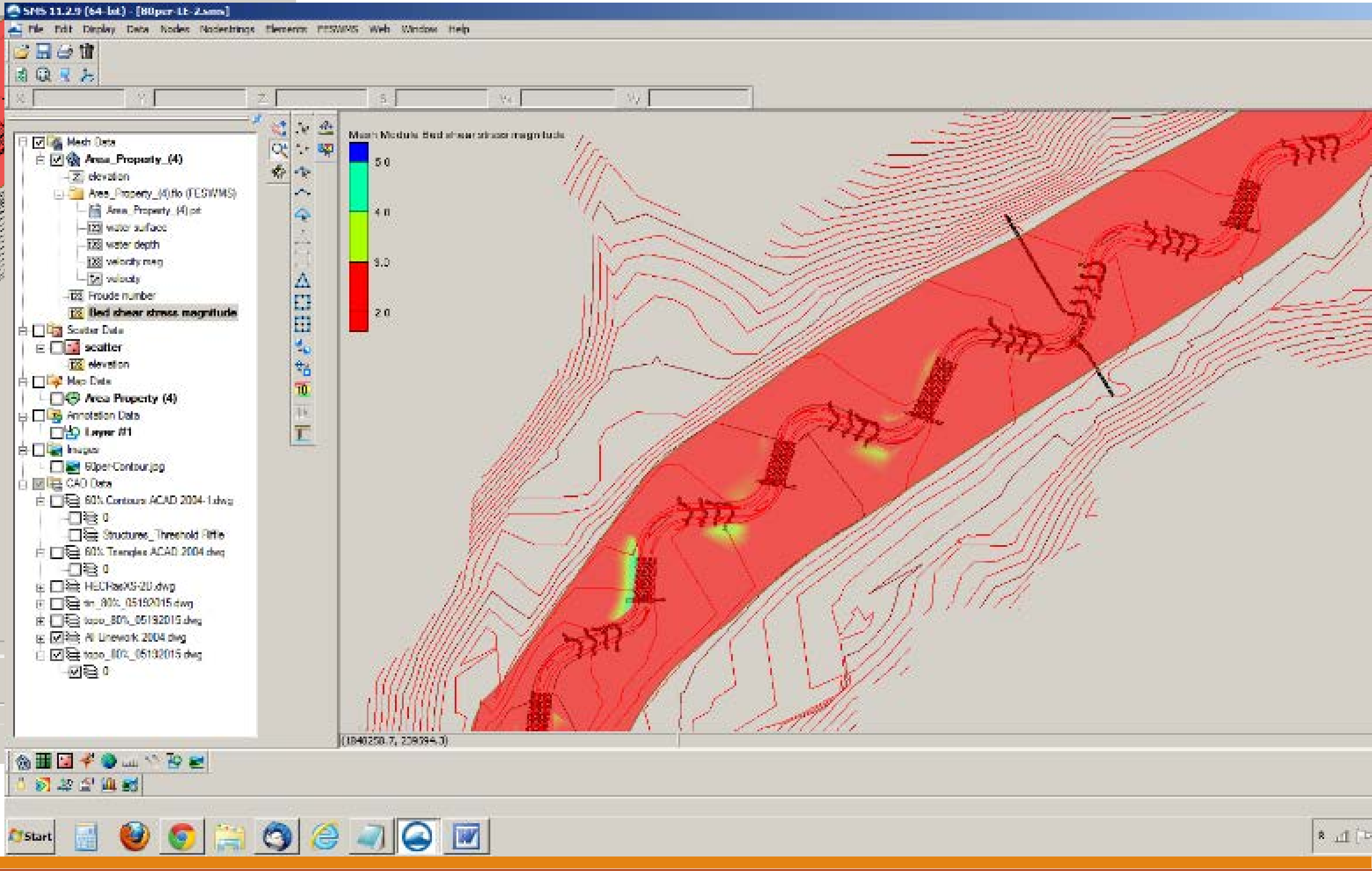


2-D Hydraulic Modeling 90% Design 3750 cfs



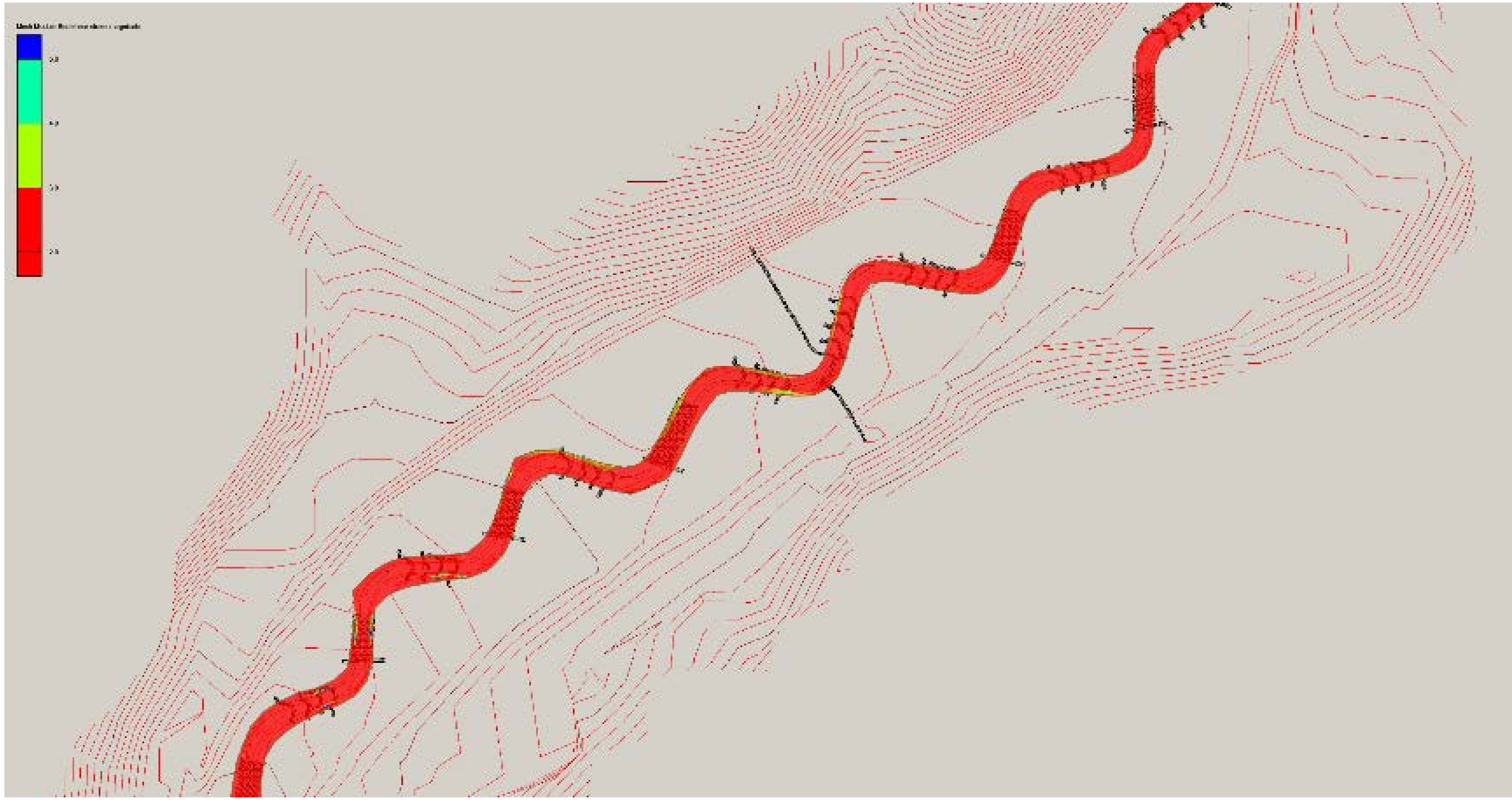
2-D Hydraulic Modeling
90% Design 1680 cfs



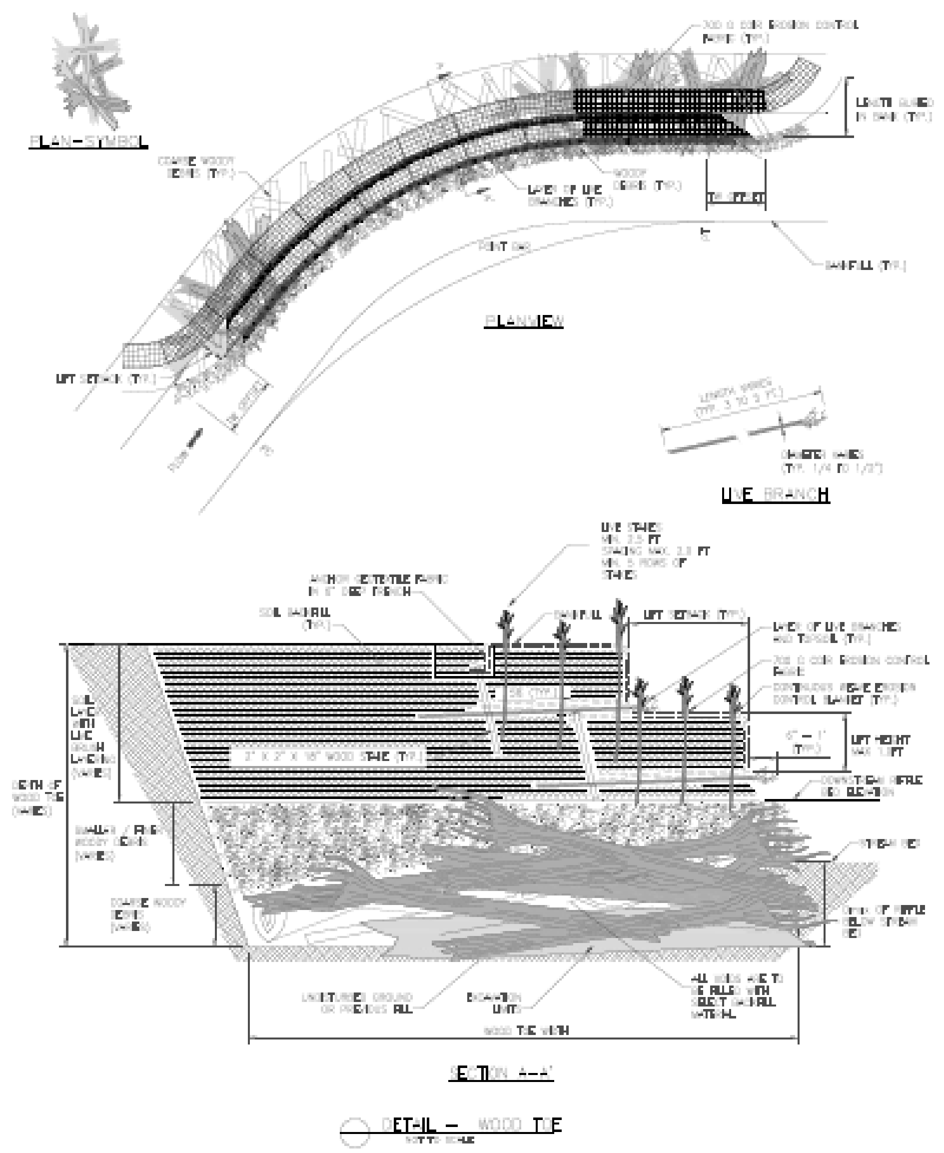


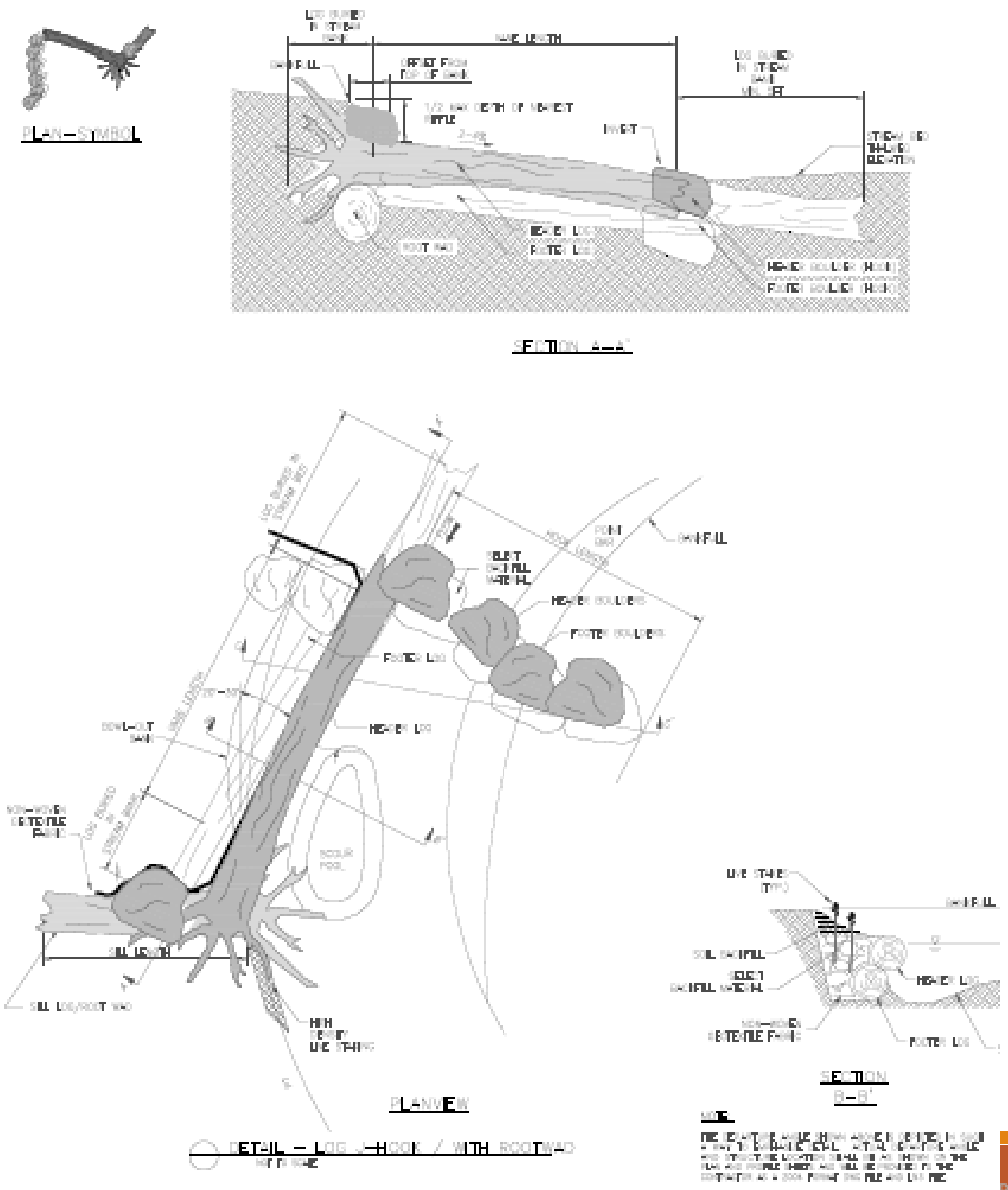
ARCHITECTURE ENGINEERING ENVIRONMENTAL GEOTECHNICAL INTERIOR DESIGN LANDSCAPE PLANNING SURVEYING TRANSPORTATION

2-D Hydraulic Modeling
90% Design Bankfull Discharge

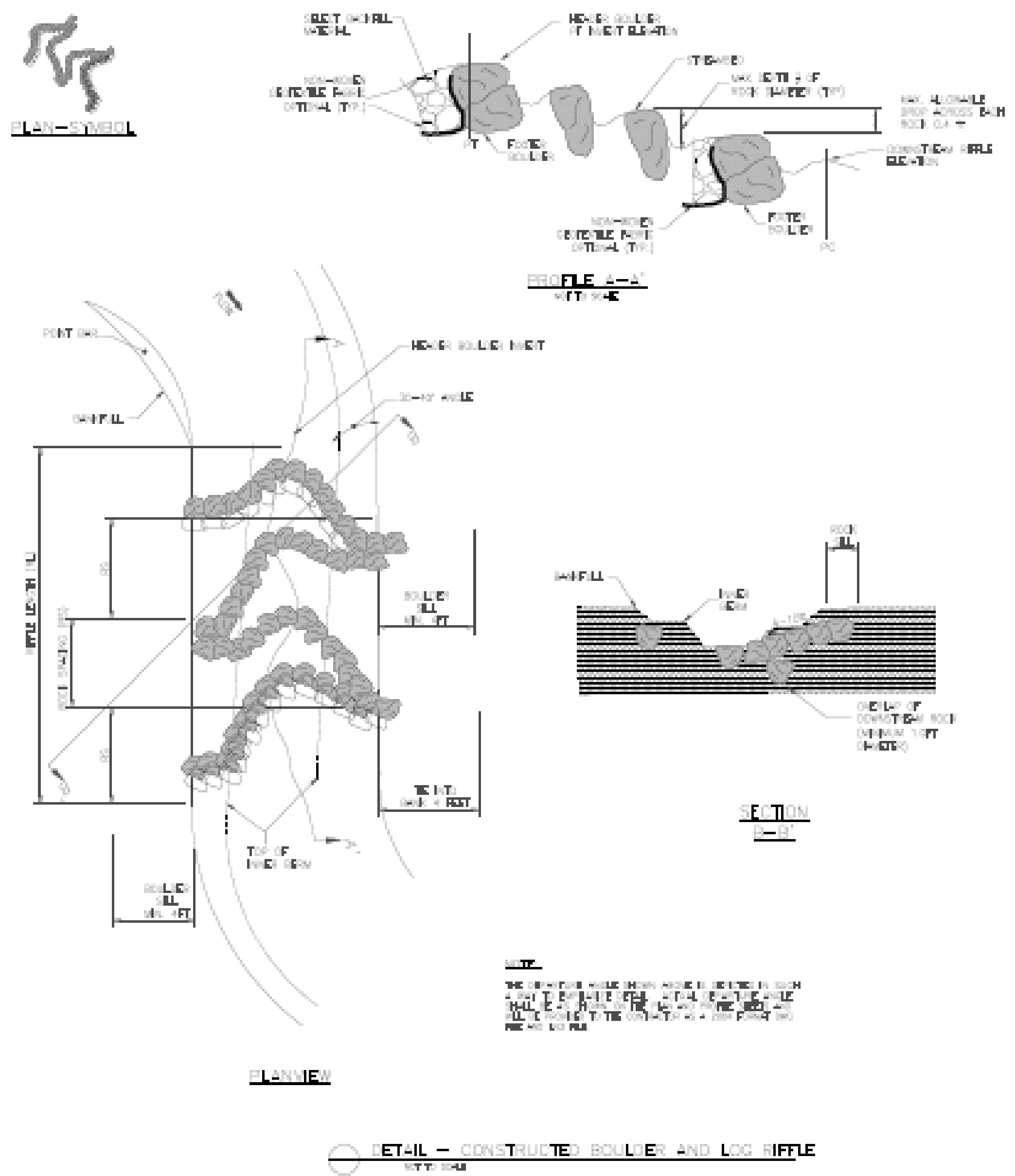


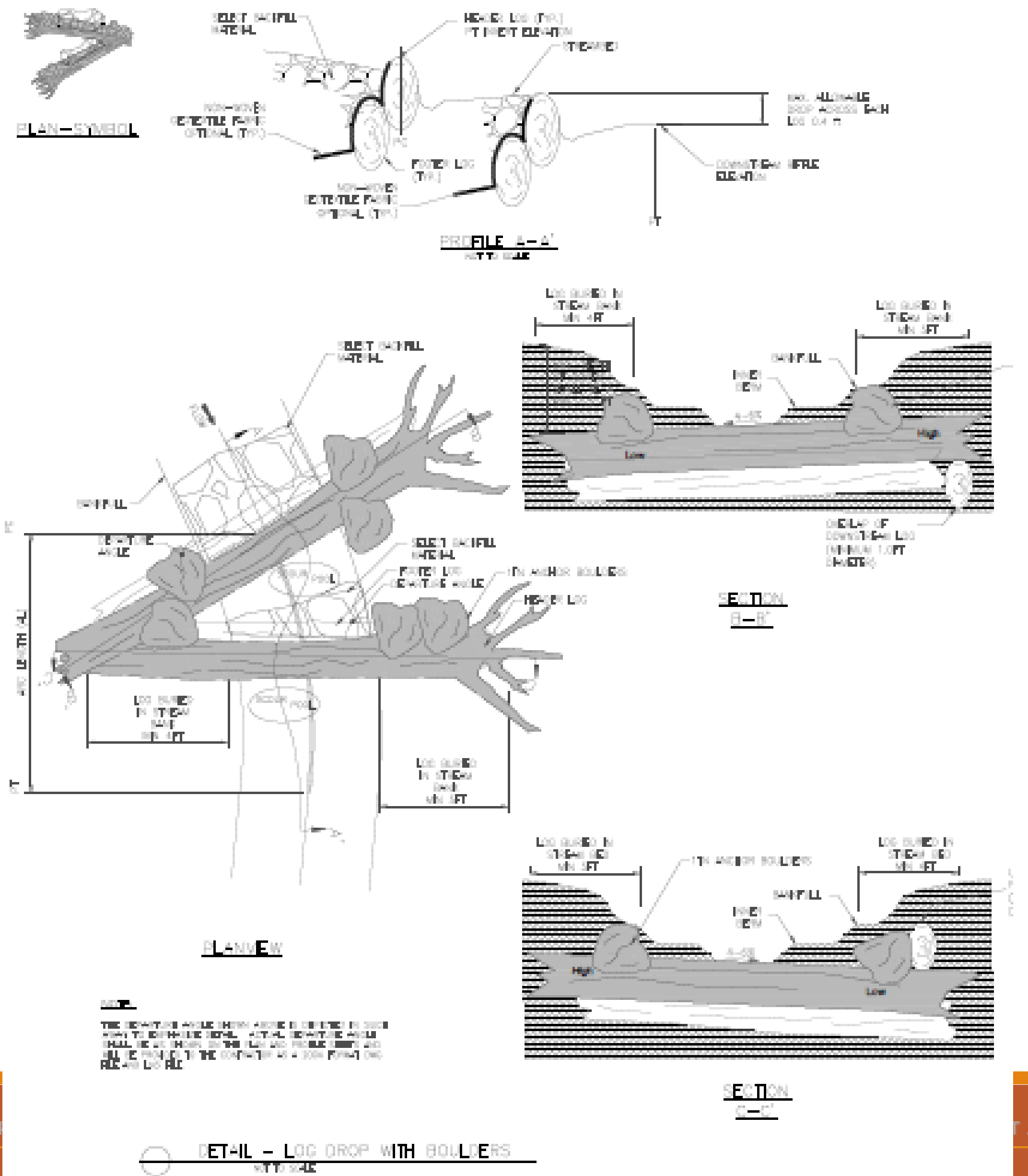
Stability and Enhancement Structures





Stability and Enhancement Structures





Questions?

Goodwyn, Mills, and Cawood, Inc.
Justin N. Barrett, PE
justin.barrett@gmcnetwork.com

GOODWYN | MILLS | CAWOOD