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March 31
2026

3-D Ecosystem Design Corridor Optimization and Construction for Risk Reduction of Ecosystem Restoration Projects"

Source to Streams

David Bidelspach

riverSHARED.org

Presentation Outline

Introductions - RiverSHARED

1 -History and Definition 3-D

2 -MCDA and Optimization Tools

3 -RISK and Construction

4 -Beyond Current Restoration

Questions & Answers

Introductions

Who are we?

Why are we here?

Are we sharing and communicating with others?

- As an Industry Stream Restoration is in the Teenage years?
- Standards are needed for maturity in the industry?
- How do you get people to accept Standards or Rules?

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Teenagers

Introductions – How did you raise or wish you raised your teenager?

- Love → Sharing
- Be an example
- Allow them to have a decision
- Listening to their concerns

Former Design Philosophy

- Connect Goals and Objectives with Design Parameters
- Understand the System – Geomorphic and Watershed Assessment
- Quantify the Risk and Uncertainty
- Restoration to set the Trajectory of Stabilization
- Work with materials on-site
- Optimize the design – 3D design
- The Answers are in the River – Fieldwork
- Training and Education – Internal, Clients and Public

- Is this a Philosophy or a list of Tools?

Not Bad ... BUT, we can do better

Comparison of Philosophy and Tools

A theory or attitude held by a person or organization that acts as a guiding principle for behavior:

Philosophy

(Humans think Truth is found through)

- Nihilism – Nothing
- Existentialism – Anti-Hope
- Stoicism – Acceptance
- Hedonism – Pleasure
- Marxism – Anti-Capitalist
- Positivism – Logic
- Taoism – Humility
- Rationalism – Reason
- Relativism – Perspective
- Buddhism – Suffering

Stream Restoration Did not make the Top 10

Tools

(Humans use to carry out a particular function)

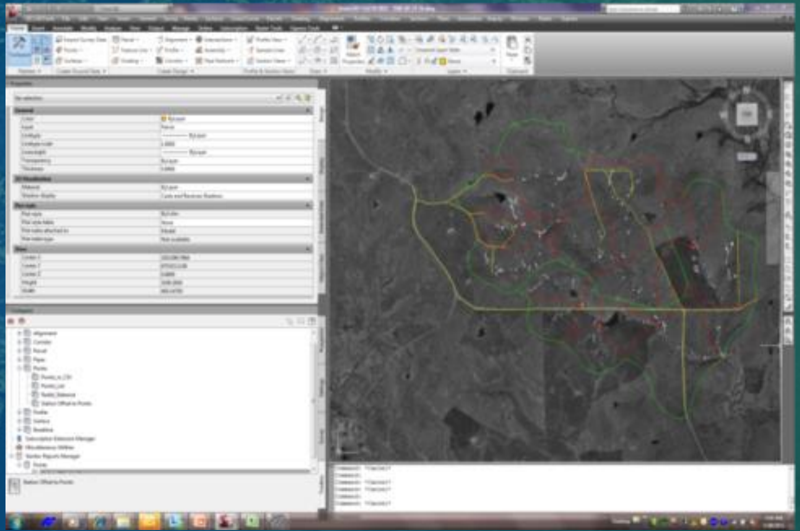
- Stage Zero Restoration
- Hay Bale Grade Control Structures
- Fly Links Ecosystem Sport
- AutoCAD 3-D design
- Beaver Dam Analogs
- Ground Based Lidar
- Functional Assessment
- Stream Quantification Tool
- Survey Grade GPS
- Innovative In-channel Structures

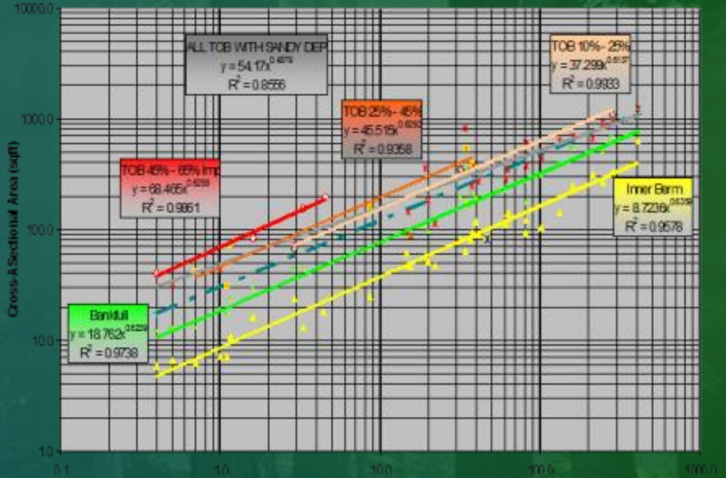
S.H.A.R.E.D. Philosophy

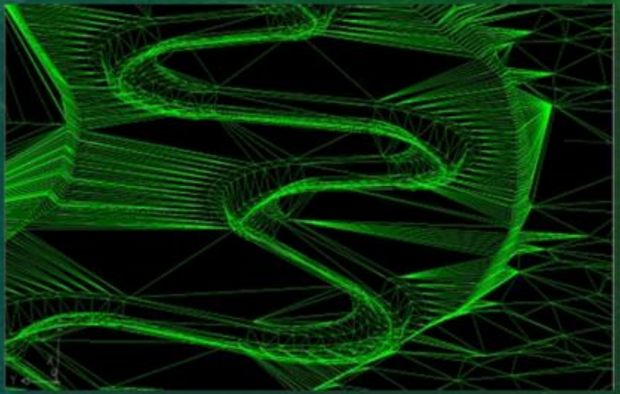
- **S**hare knowledge with humility.
- **H**ave patience and discernment for innovation.
- **A**dvocate excellence.
- **R**espect the risk and uncertainty in river systems.
- **E**mpower, challenge and question.
- **D**ocument and learn from unexpected results.

Share knowledge with humility

- Trade secrets are not good for maturing an industry, our understanding of river processes have come as a result of many other's sharing their knowledge and not keeping trade secrets.

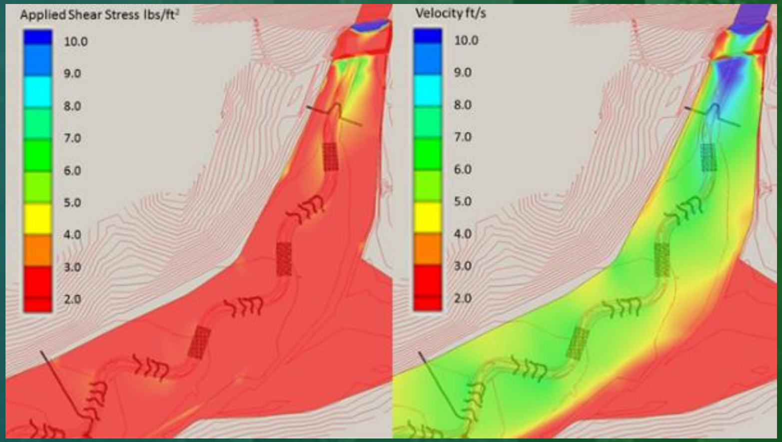






Have patience and discernment for innovation

- Innovation is great but, we must not rush innovation or lose sight of the established processes that have led to the innovation.



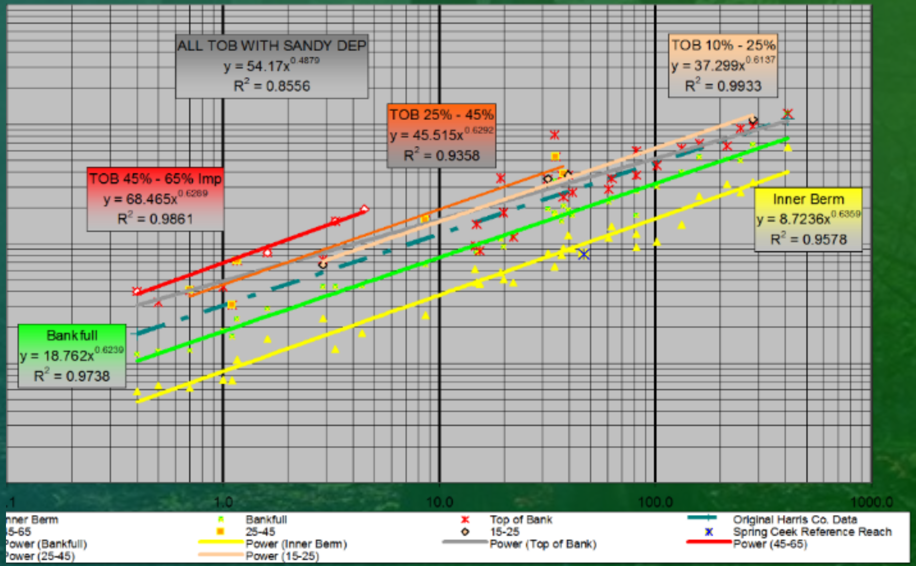
Advocate excellence

- Stay commitment to excellence and define excellence on all project. Strive to promote excellence throughout the profession

	Concept Option Description	Stream Stability GOAL: Stop in-stream headcutting (2)	Stream Stability GOAL: Self-sustaining, natural, stable stream (1)	Stream Stability GOAL: Stream and floodplain manage shear stresses (2)	Water Quality GOAL: Improve water quality and habitat of stream (1)	Water Quality GOAL: Reduce sediment deposition and supply (1)	Water Quality GOAL: Improve floodplain functions of water storage and habitat (1)	Water Quality GOAL: SW control feature in watershed (1)	Buffer GOAL: Minimize impacts to wetland vegetation (1)	Buffer GOAL: Improve riparian buffer functions of stability, habitat, and aesthetics (1)	*Linear Feet of Proposed Project*	*Required Fill (yd3)*	*Fill cost ($10/yd3)*	*Preliminary Cost Estimate of Proposed Project*	*UNIT COST*	MCDA Matrix Score	MCDA RANKING
Option #1	Tie into wetland floodplain as long as possible step down channel gradually; Higher slope at top, lower slope at bottom	1	1	3	1	1	1	0	1	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	**12**	3
Option #2	Tie into wetland floodplain as long as possible step down channel gradually; More-or-less consistent slope	1	1	2	1	1	1	0	1	1	1170	7000	$70,000	$ 1,340,000.00	$ 1,145.30	**10**	1
Option #3	Stay very high and flat coming out of the wetland	1	1	2	1	1	1	0	1	1	1170	10000	$100,000	$ 1,320,000.00	$ 1,128.21	**10**	1
Option #4	Lower in Wetland and then inbetween 1 and 2	2	1	2	1	1	1	0	1	1	1170	6500	$65,000	$ 1,335,000.00	$ 1,141.03	**12**	3
Option #5	60% Design as drafted	2	3	4	1	1	1	0	2	1	1170	500	$5,000	$ 1,270,000.00	$ 1,085.47	**19**	6
Option #6	30% Design as drafted	2	2	3	1	1	2	0	2	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	**16**	5

Respect the risk and uncertainty in river systems

- Rivers are complex, the more learned about riverine/riparian systems the more that is appreciated about the complexity of these systems. Innovation and modeling can be great tools, but the answers are still in the science and observation of the river.



Empower, challenge and question

- Empower others by encouraging them to question and challenge the design and geomorphic assumptions as well as conclusions. Others include, clients, design team, reviewers, regulators, grandmothers and others.

Document and learn from unexpected results

- Rivers are complex systems that have a high degree of uncertainty and sometimes our remedial alternatives produce unexpected results. Sometimes our results are very unexpected. Document uncertainty and learn from unexpected results so that we may have a better understanding of why the unexpected result has occurred.

Revival

- Share with Others
- Creating Forums
- Build a Community
- Provide Cooperative Value for the Community
- Building Trust in the Community
- Community and Industry Relationships
- Develop Industrial Standards and Frameworks
- Improve the Resources
- Strengthen Community and Industry
- Share with Others

S.H.A.R.E.D. Philosophy

- Share knowledge with humility.
- Have patience and discernment for innovation.
- Advocate excellence.
- Respect the risk and uncertainty in river systems.
- Empower, challenge and question.
- Document and learn from unexpected results.

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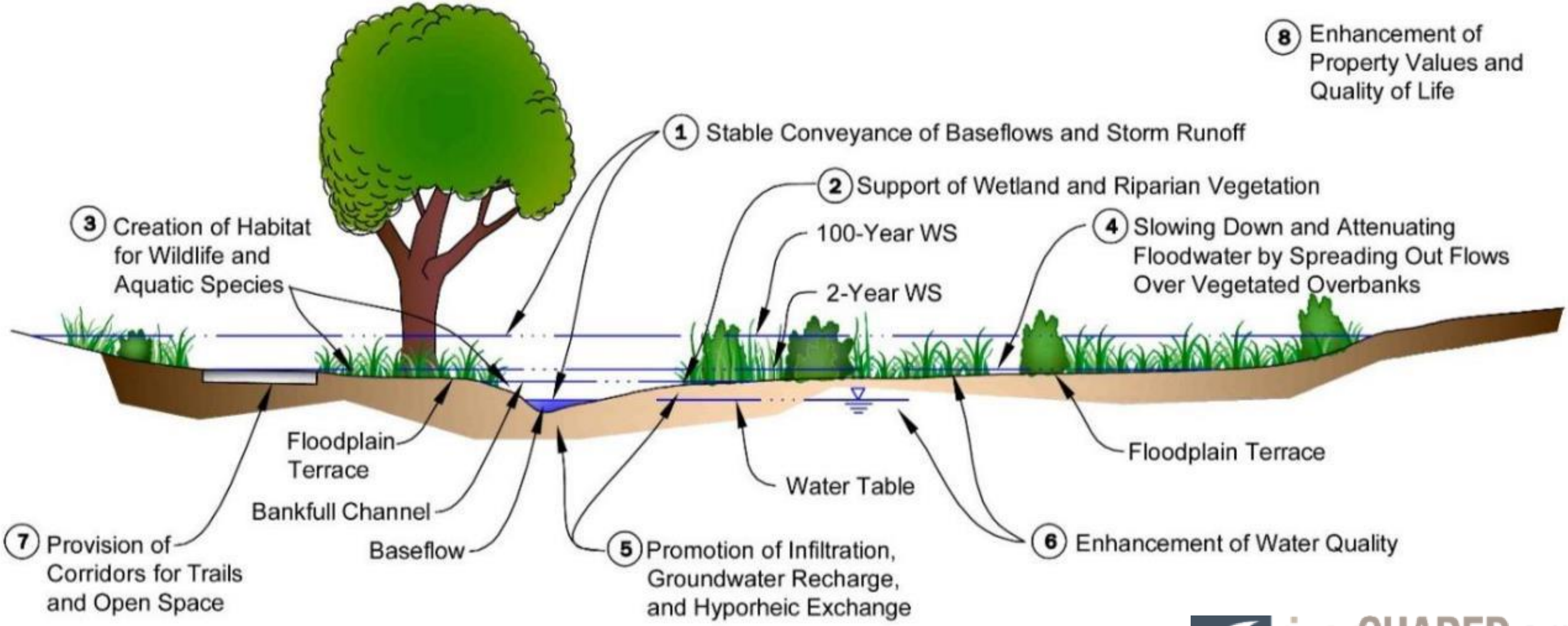
Stream Restoration?

- Nature Based Solutions
  - Ecosystem Restoration
    - Corridor Restoration

- Nature Based Solutions
- Ecosystem Restoration
- Corridor Design

Functions and Characteristics of Natural Stream Corridors



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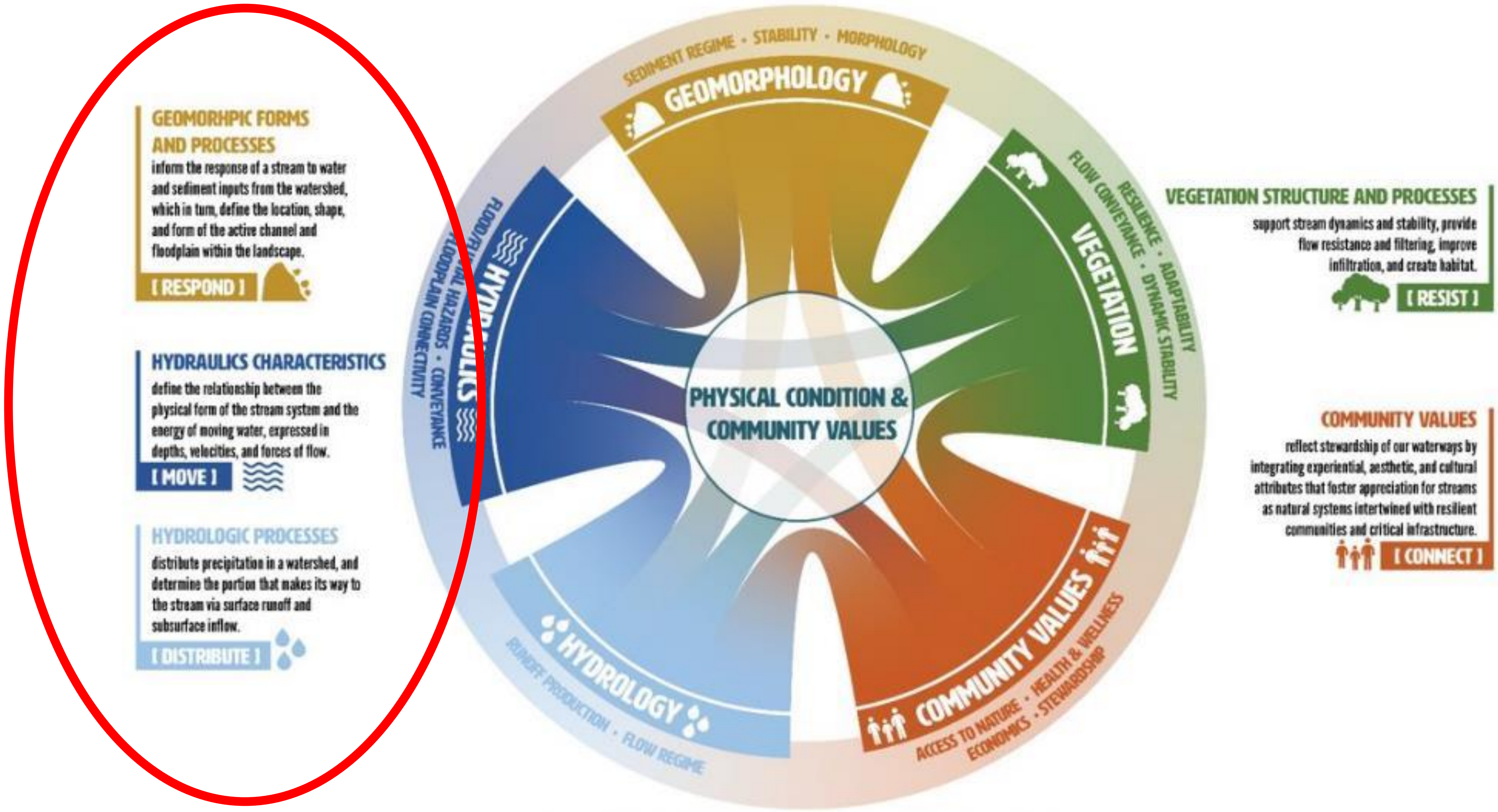
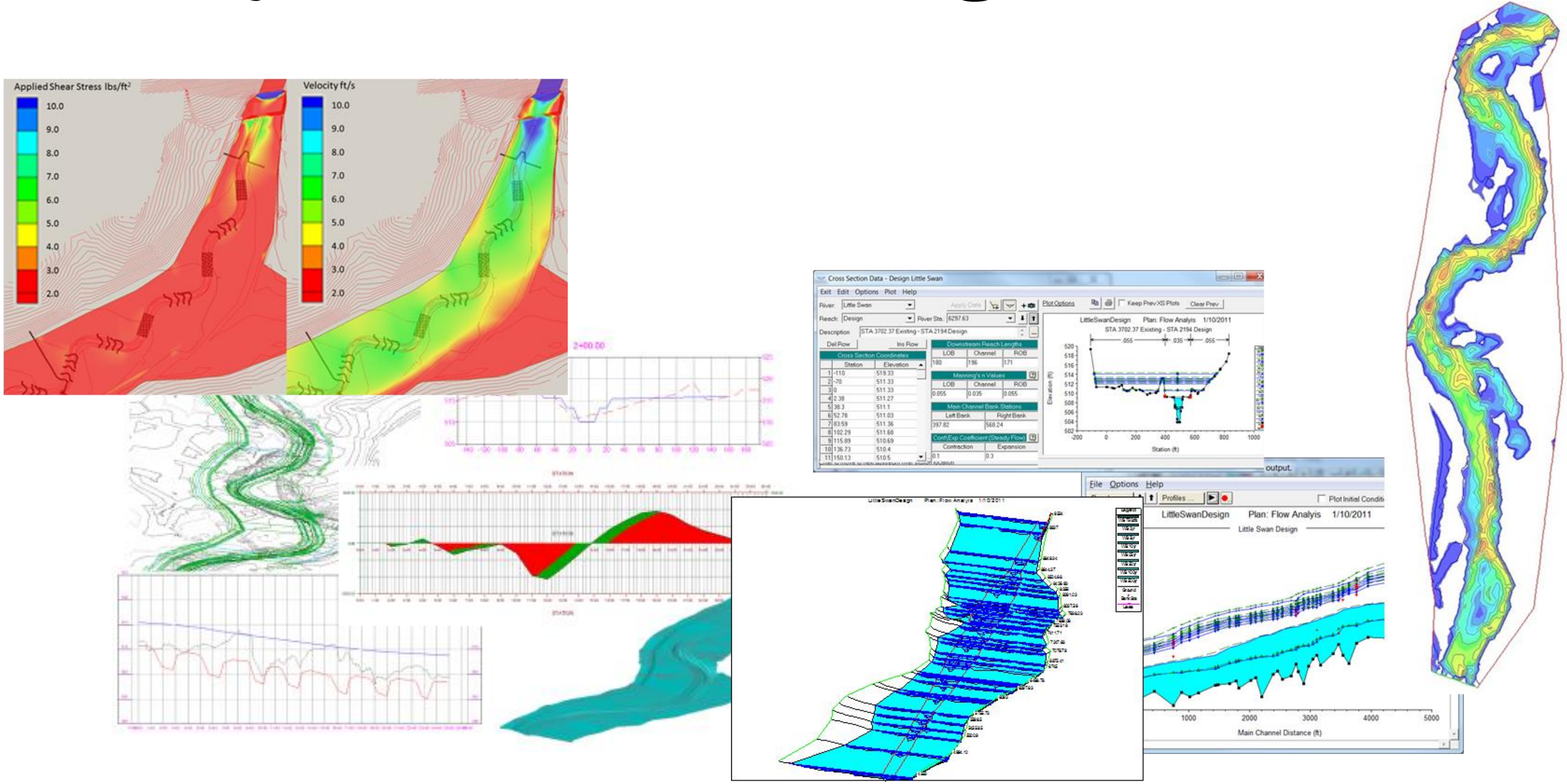
THE FIVE ELEMENTS OF URBAN STREAM FUNCTION



Colors represent each of the five elements of urban stream function and maintenance. Colored bands reflect the connections between these elements and that each element influences, and is influenced by, the other elements.

•3-D Ecosystem Corridor Design Process



Michael Geenen, PE
President, Watershed Restoration LLC
Michael@watershedrestorations.com

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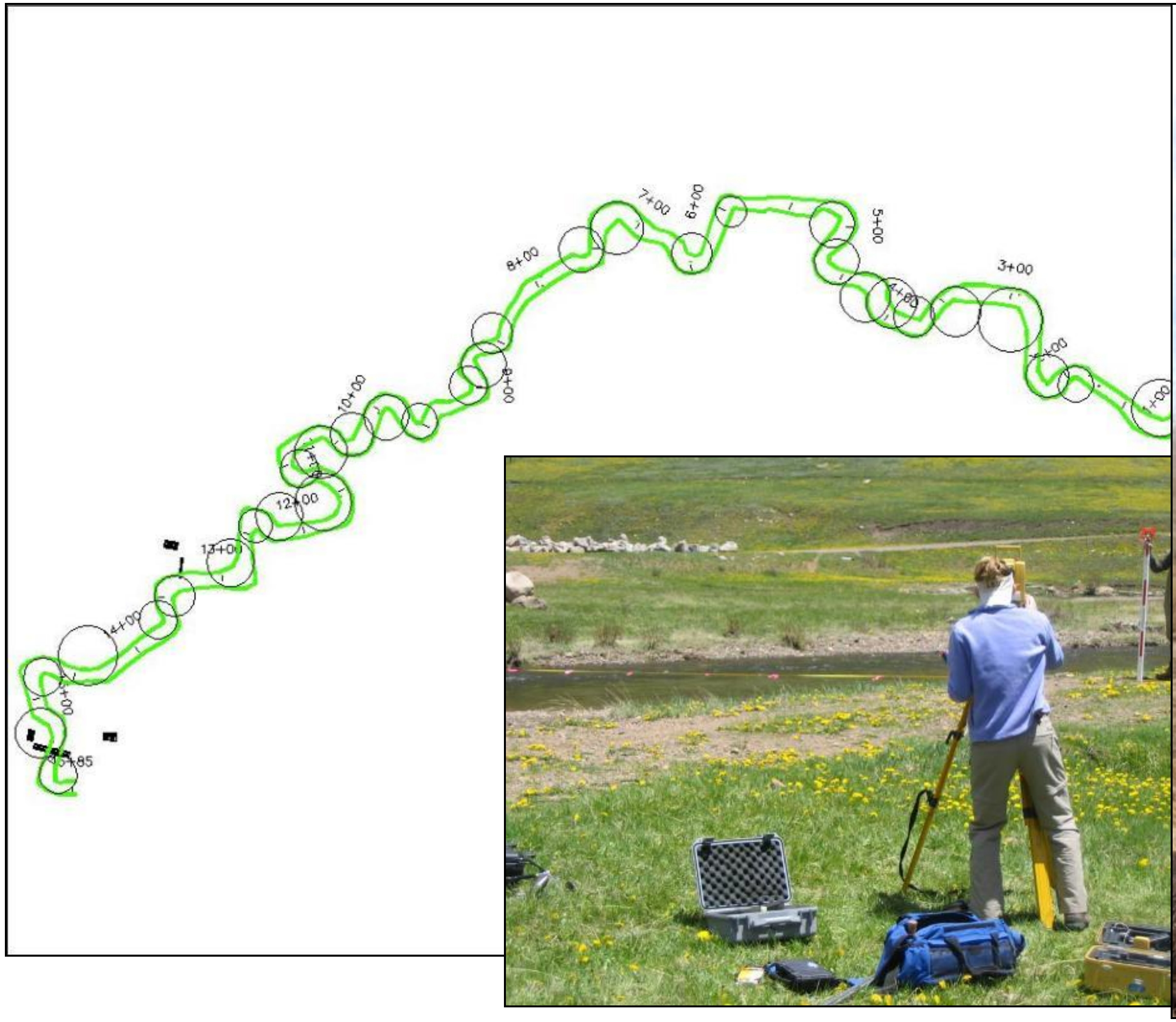
Base Mapping Geomorphic Assessment



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Base Mapping
Geomorphic Assessment

- Shows current condition of the project
- Compares current condition to previous years
- Shows how stream is functioning
- Shows trends and direction
- Allows for Calculation of Variables

Base Mapping
Existing Surface

- Collect Breaklines
- Collect Ground Shots
- Use Geomorphic Data
  - Build a 3D Surface for Existing Conditions
  - Used for Design

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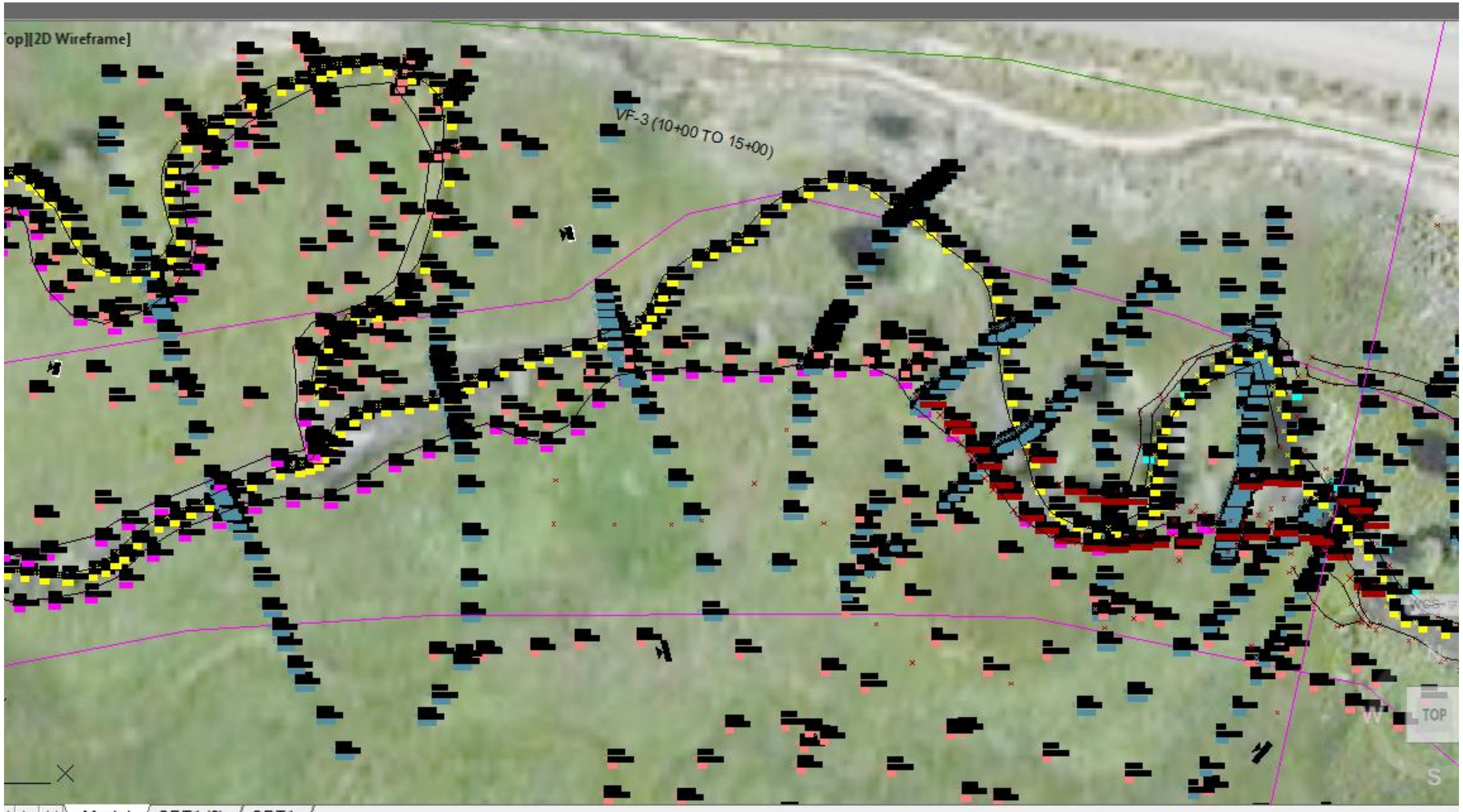
Bae Mapping
Geomorphic Assessment



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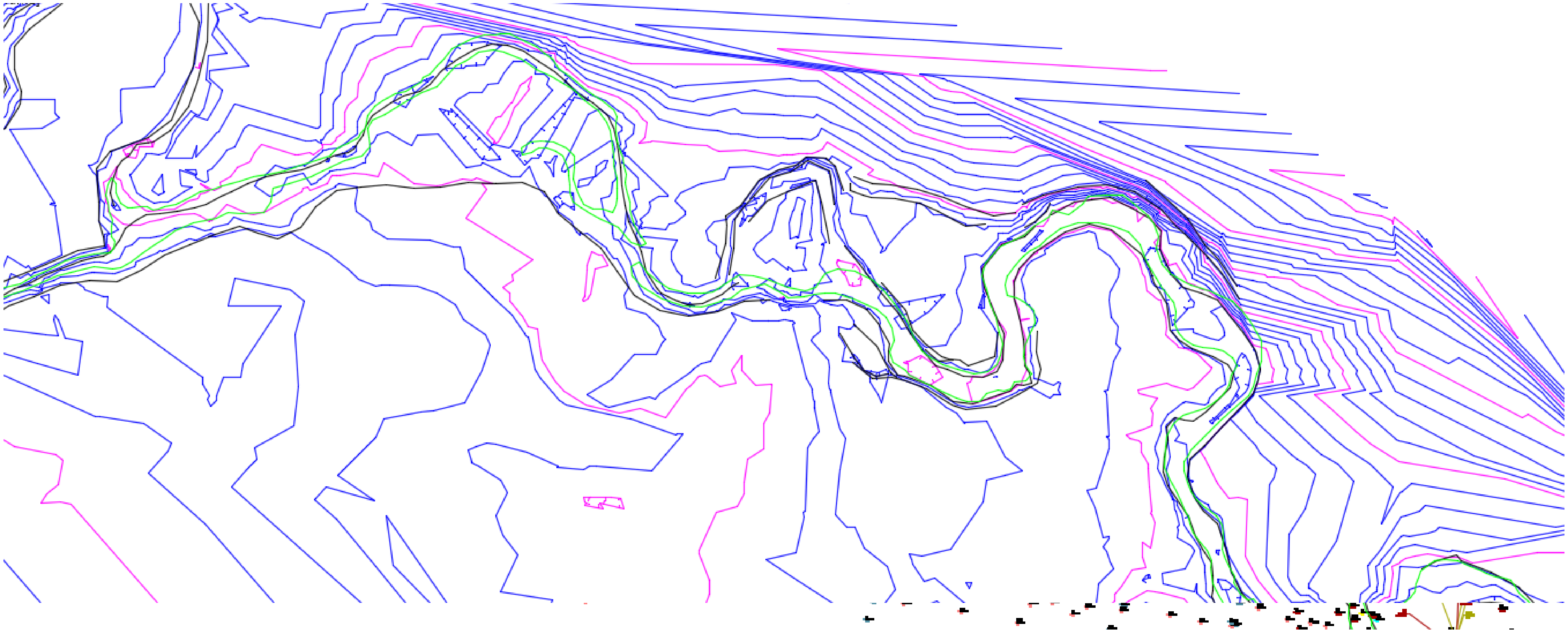
Bae Mapping
Existing Surface



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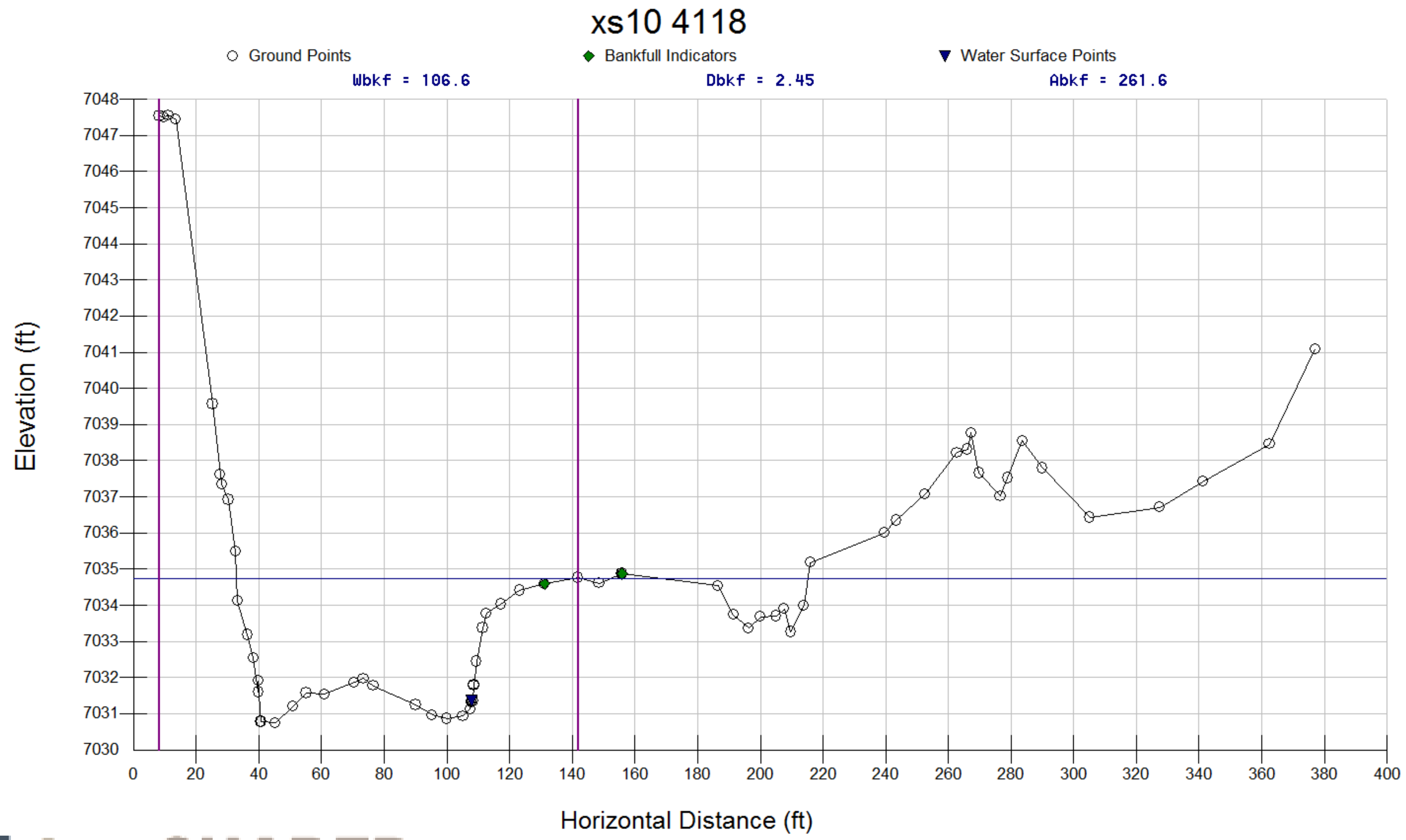
3-D Survey Data



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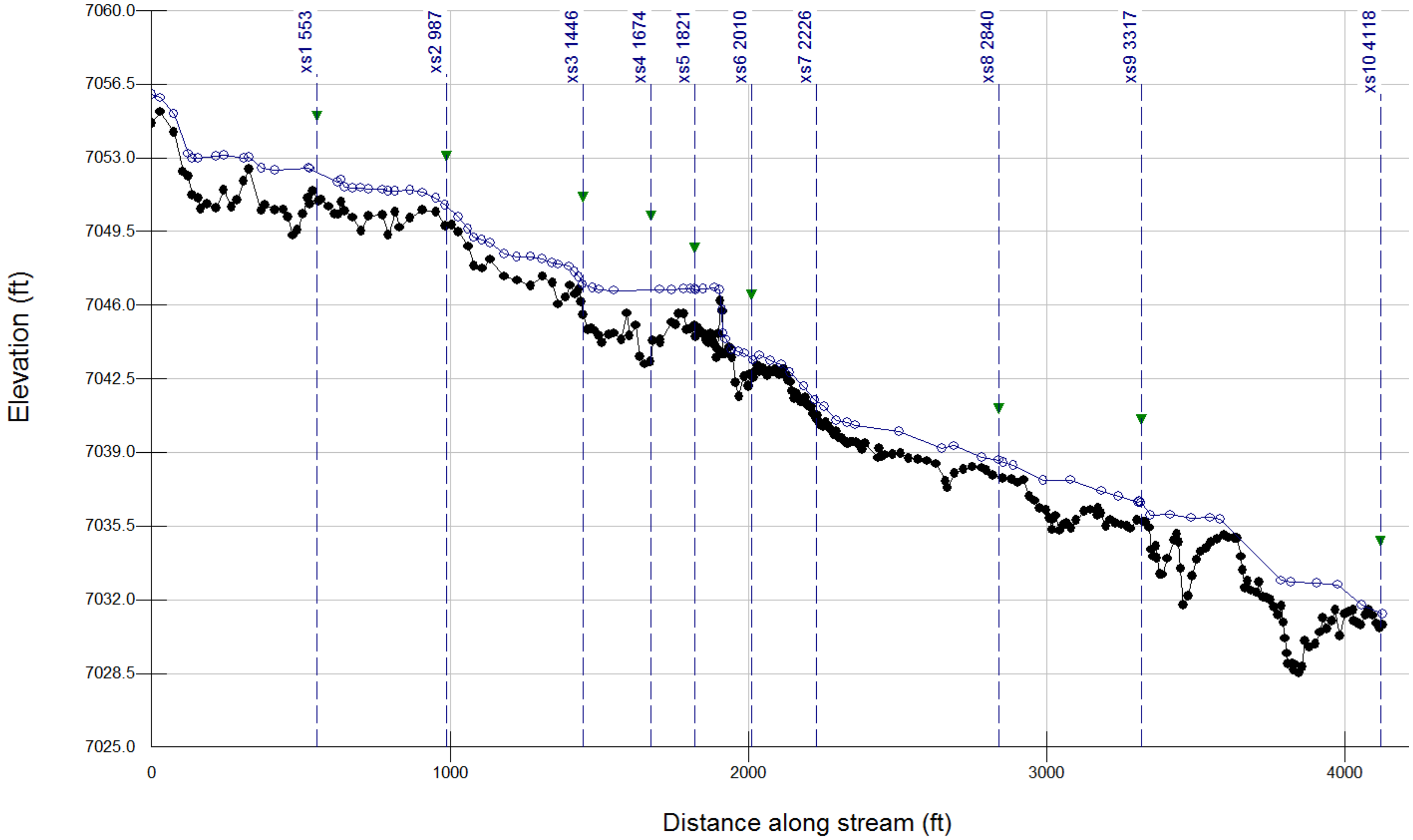
Bear River - Existing Conditions Profile



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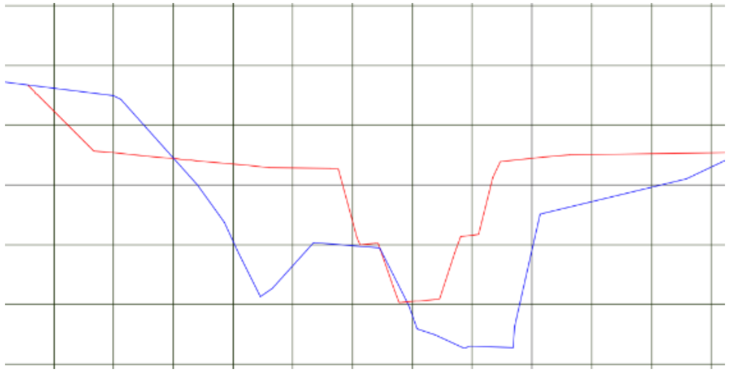
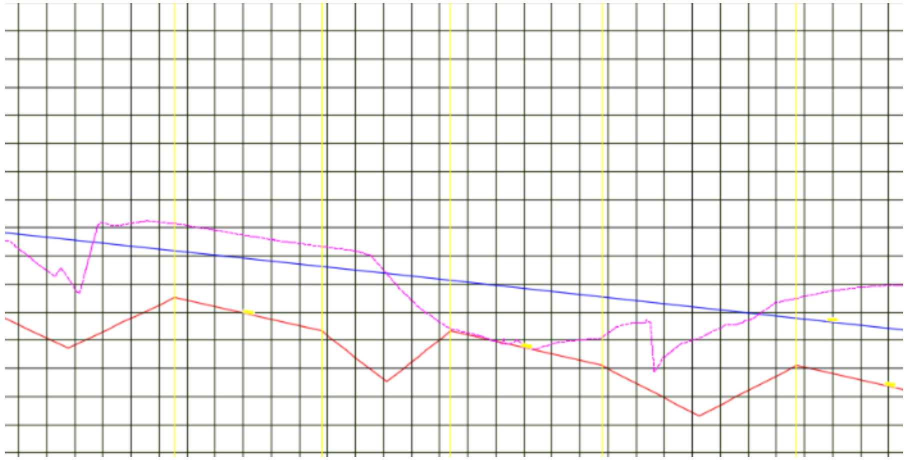
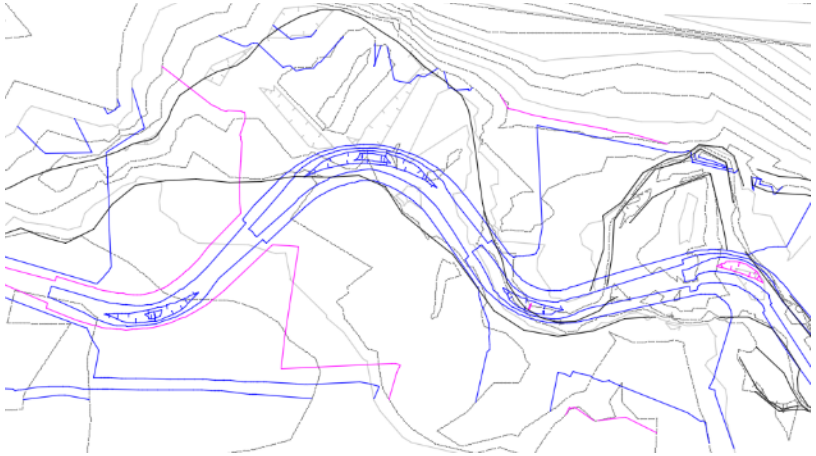
3-D Design Process



- Existing Base
- Create Alignment (1D)
- Apply Typical Cross-Sections (1D)
- Create Profile (2D)
- Create Surface from Breaklines (3D)
- Still Meeting Design Criteria





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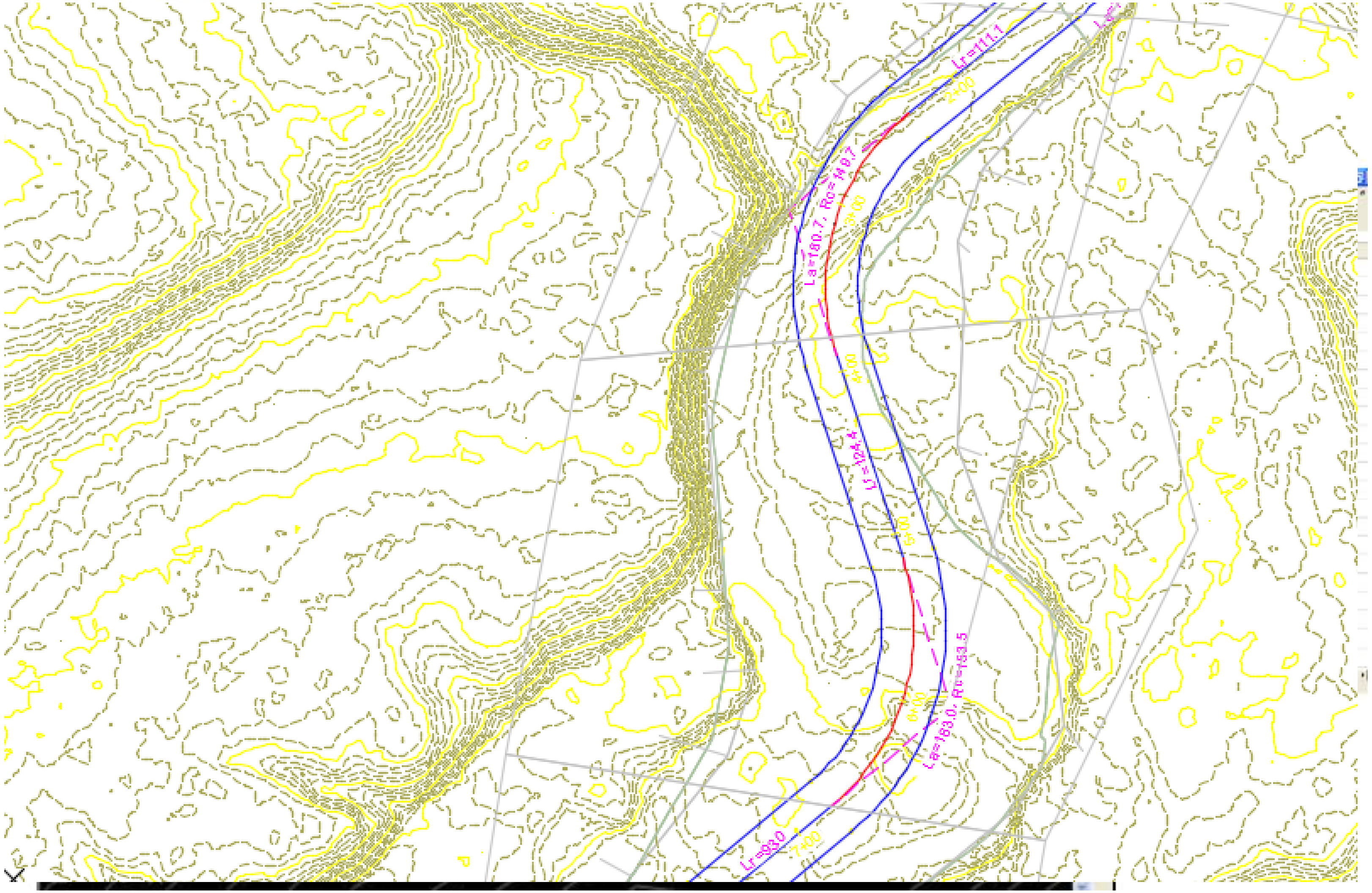
3-D Design



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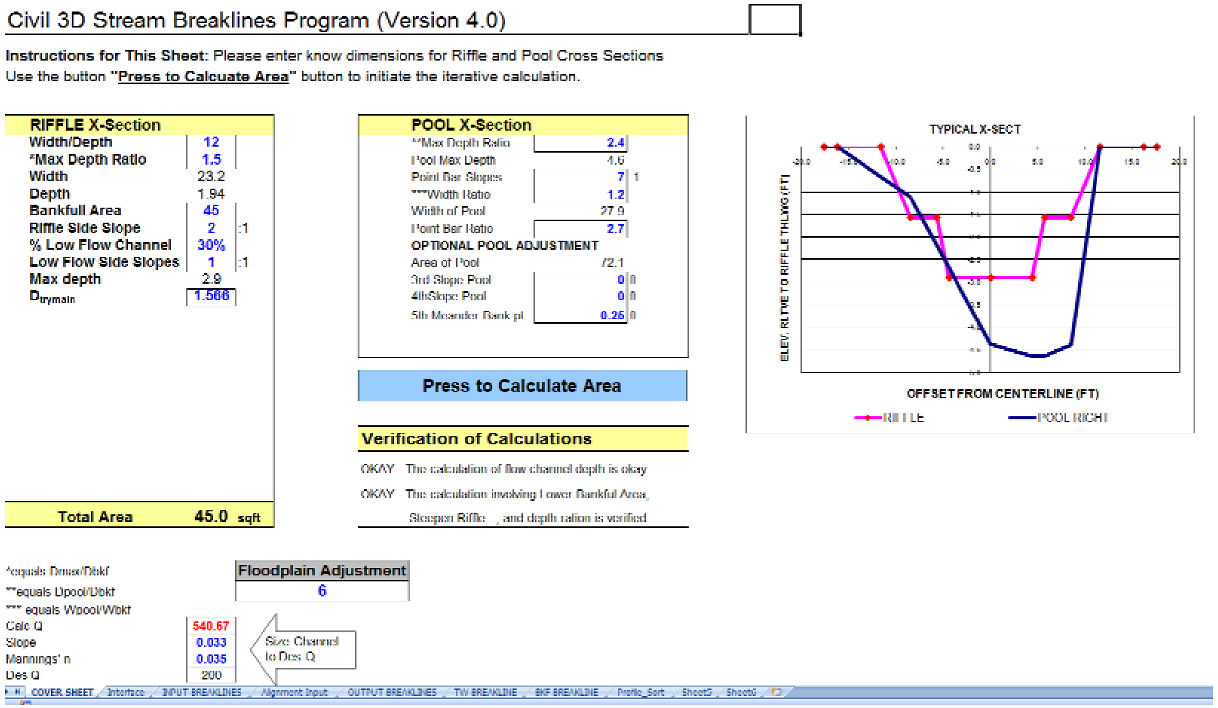
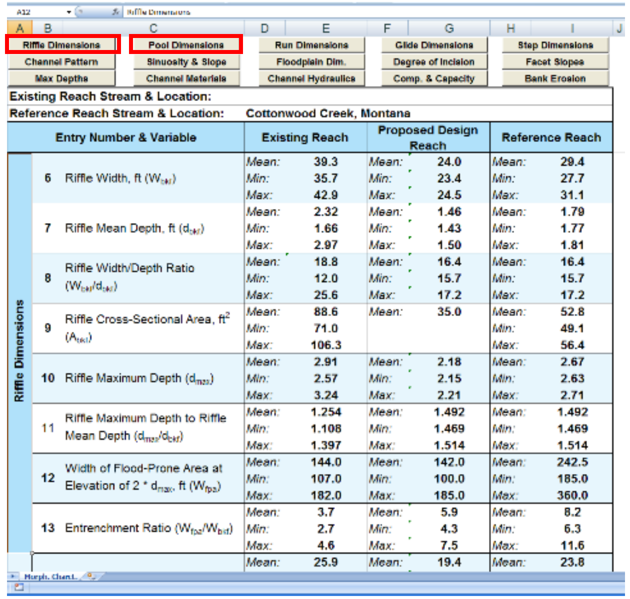
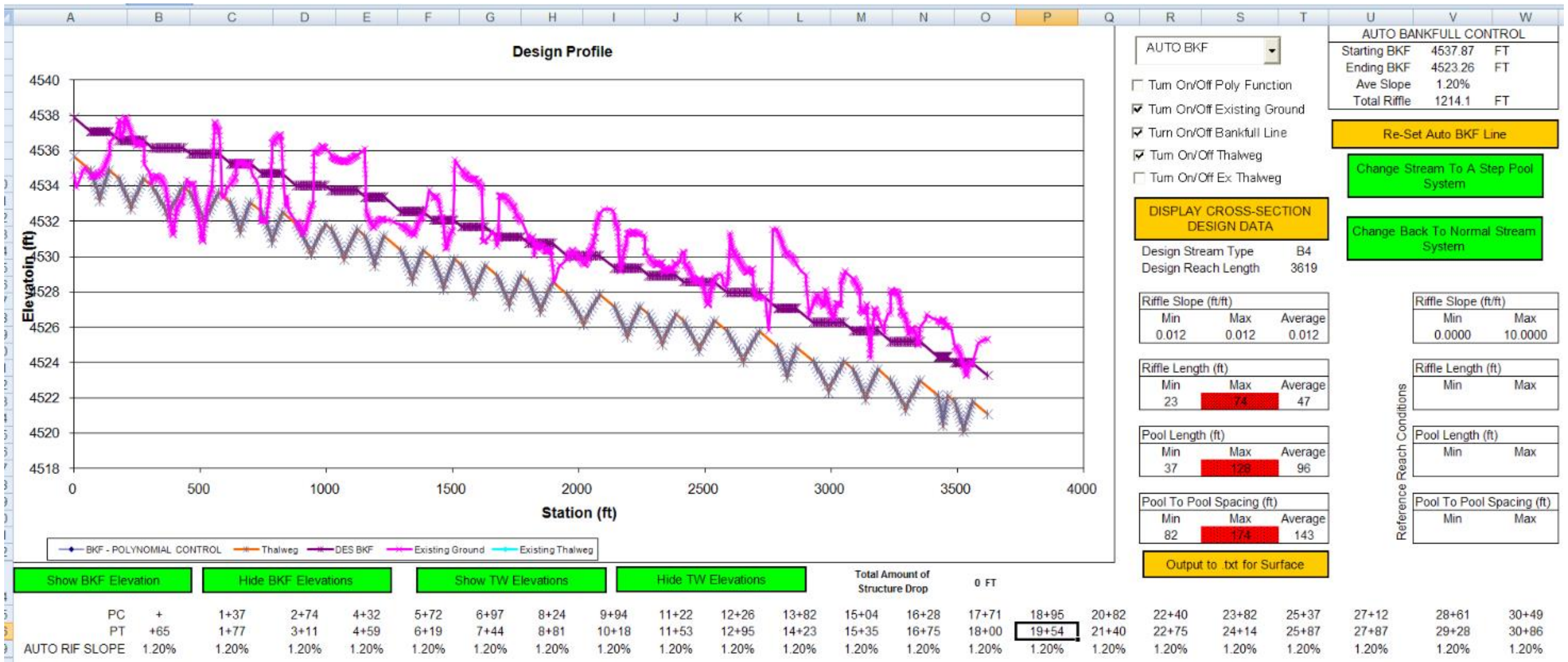
3-D Design





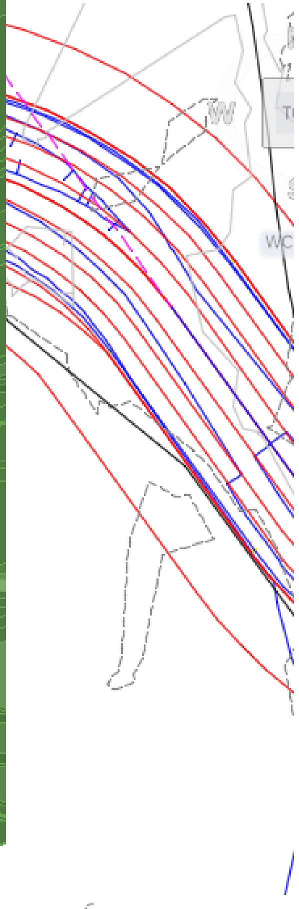
Entry Number & Variable		Existing Reach		Proposed Design Reach		Reference Reach	
6	Riffle Width, ft (W_{bkf})	Mean:	39.3	Mean:	24.0	Mean:	29.4
		Min:	35.7	Min:	23.4	Min:	27.7
		Max:	42.9	Max:	24.5	Max:	31.1
7	Riffle Mean Depth, ft (d_{bkf})	Mean:	2.32	Mean:	1.46	Mean:	1.79
		Min:	1.66	Min:	1.43	Min:	1.77
		Max:	2.97	Max:	1.50	Max:	1.81
8	Riffle Width/Depth Ratio (W_{bkf}/d_{bkf})	Mean:	18.8	Mean:	16.4	Mean:	16.4
		Min:	12.0	Min:	15.7	Min:	15.7
		Max:	25.6	Max:	17.2	Max:	17.2
9	Riffle Cross-Sectional Area, ft^2 (A_{bkf})	Mean:	88.6	Mean:	35.0	Mean:	52.8
		Min:	71.0			Min:	49.1
		Max:	106.3			Max:	56.4
10	Riffle Maximum Depth (d_{max})	Mean:	2.91	Mean:	2.18	Mean:	2.67
		Min:	2.57	Min:	2.15	Min:	2.63
		Max:	3.24	Max:	2.21	Max:	2.71
11	Riffle Maximum Depth to Riffle Mean Depth (d_{max}/d_{bkf})	Mean:	1.254	Mean:	1.492	Mean:	1.492
		Min:	1.108	Min:	1.469	Min:	1.469
		Max:	1.397	Max:	1.514	Max:	1.514
12	Width of Flood-Prone Area at Elevation of 2 * d_{max}, ft (W_{fpa})	Mean:	144.0	Mean:	142.0	Mean:	242.5
		Min:	107.0	Min:	100.0	Min:	185.0
		Max:	182.0	Max:	185.0	Max:	360.0
13	Entrenchment Ratio (W_{fpa}/W_{bkf})	Mean:	3.7	Mean:	5.9	Mean:	8.2
		Min:	2.7	Min:	4.3	Min:	6.3
		Max:	4.6	Max:	7.5	Max:	11.6
		Mean:	25.9	Mean:	19.4	Mean:	23.8

3-D Design

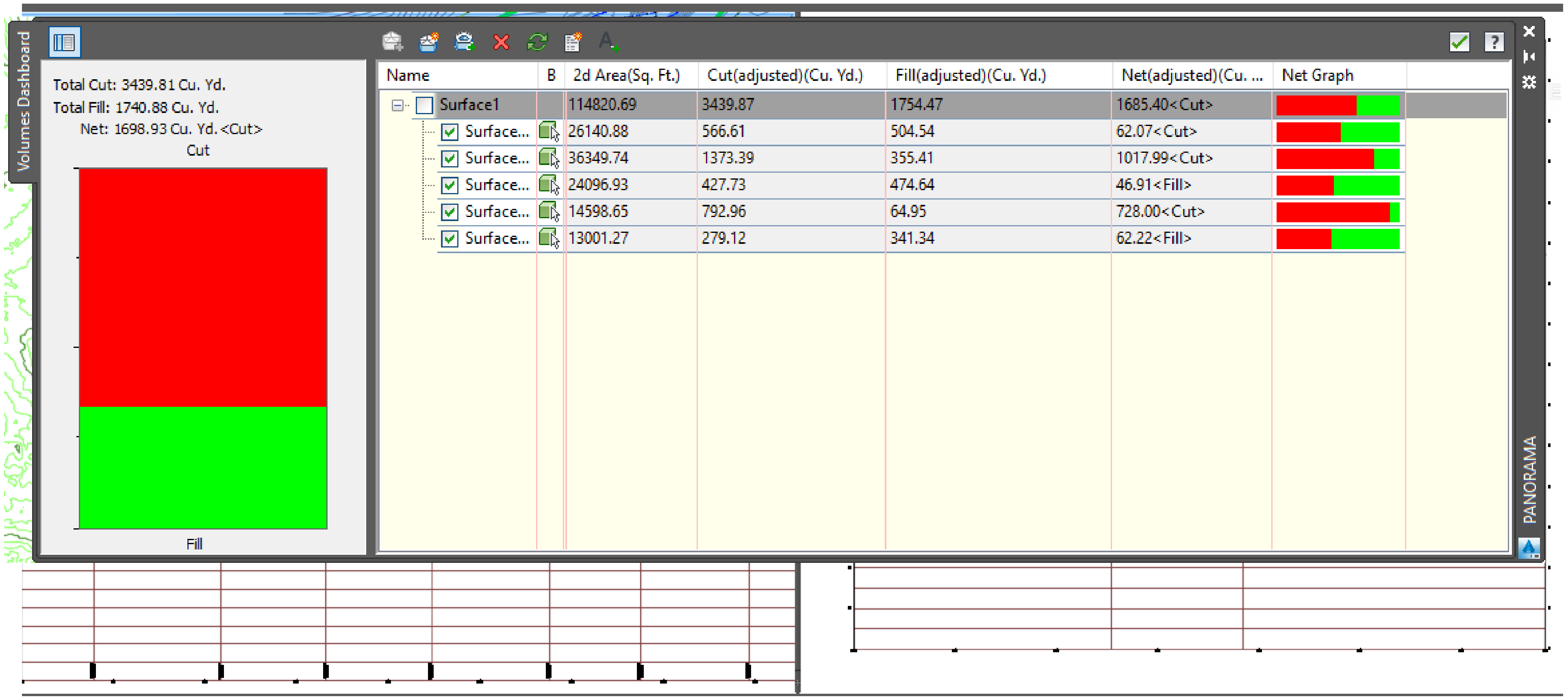


Design Profile
Elevatoin (ft)
Station (ft)
BKF - POLYNOMIAL CONTROL
Thalweg
DES BKF
Existing Ground
Existing Thalweg
AUTO BKF
Turn On/Off Poly Function
Turn On/Off Existing Ground
Turn On/Off Bankfull Line
Turn On/Off Thalweg
Turn On/Off Ex Thalweg
AUTO BANKFULL CONTROL
Starting BKF 4537.87 FT
Ending BKF 4523.26 FT
Ave Slope 1.20%
Total Riffle 1214.1 FT
Re-Set Auto BKF Line
Change Stream To A Step Pool System
Change Back To Normal Stream System
DISPLAY CROSS-SECTION DESIGN DATA
Design Stream Type B4
Design Reach Length 3619
Riffle Slope (ft/ft)
Riffle Length (ft)
Pool Length (ft)
Pool To Pool Spacing (ft)
Min
Max
Average
Reference Reach Conditions
Output to .txt for Surface
Show BKF Elevation
Hide BKF Elevations
Show TW Elevations
Hide TW Elevations
Total Amount of Structure Drop
0 FT
PC
PT
AUTO RIF SLOPE

3-D Design



3-D Design



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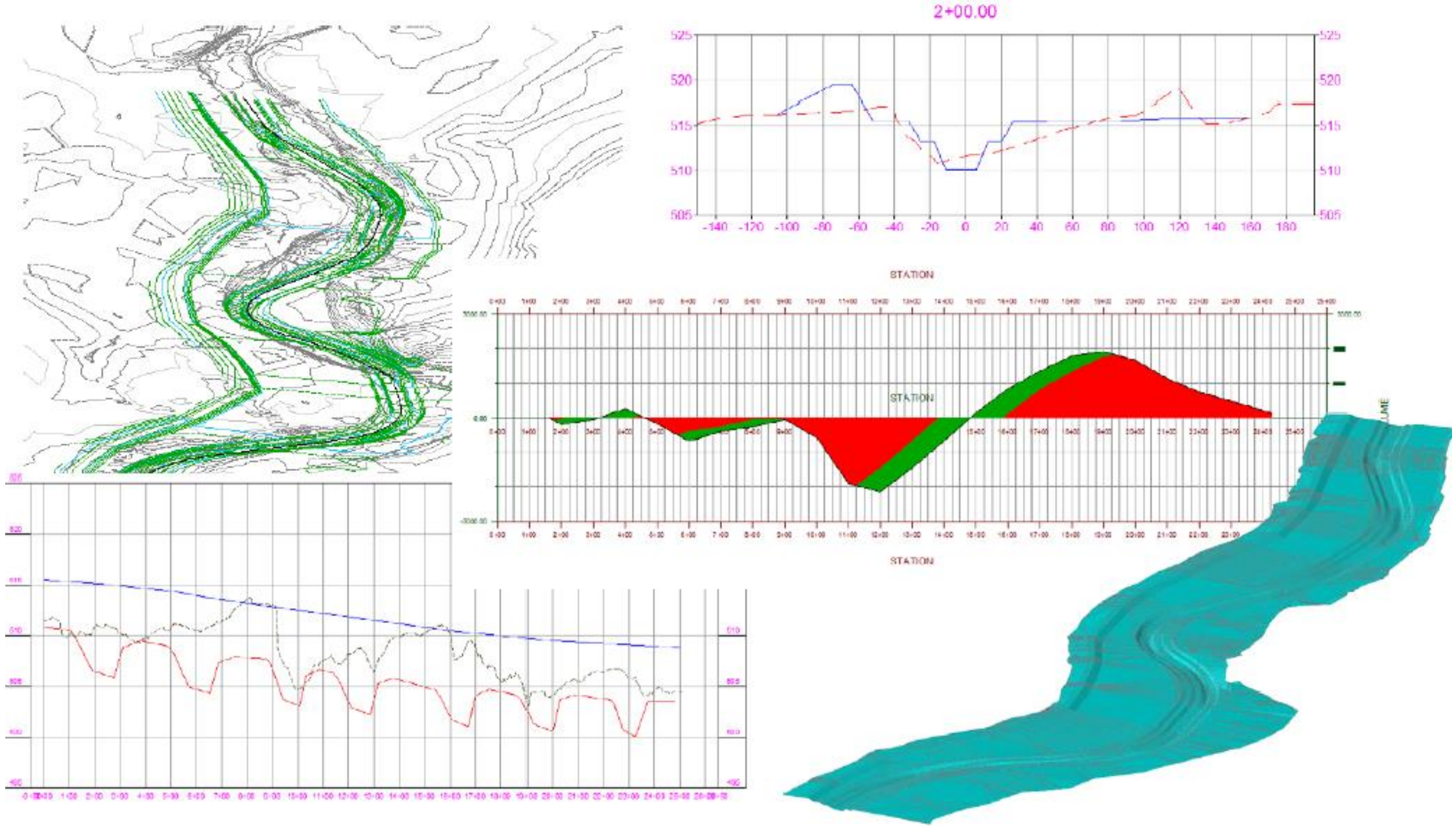
3-D Design



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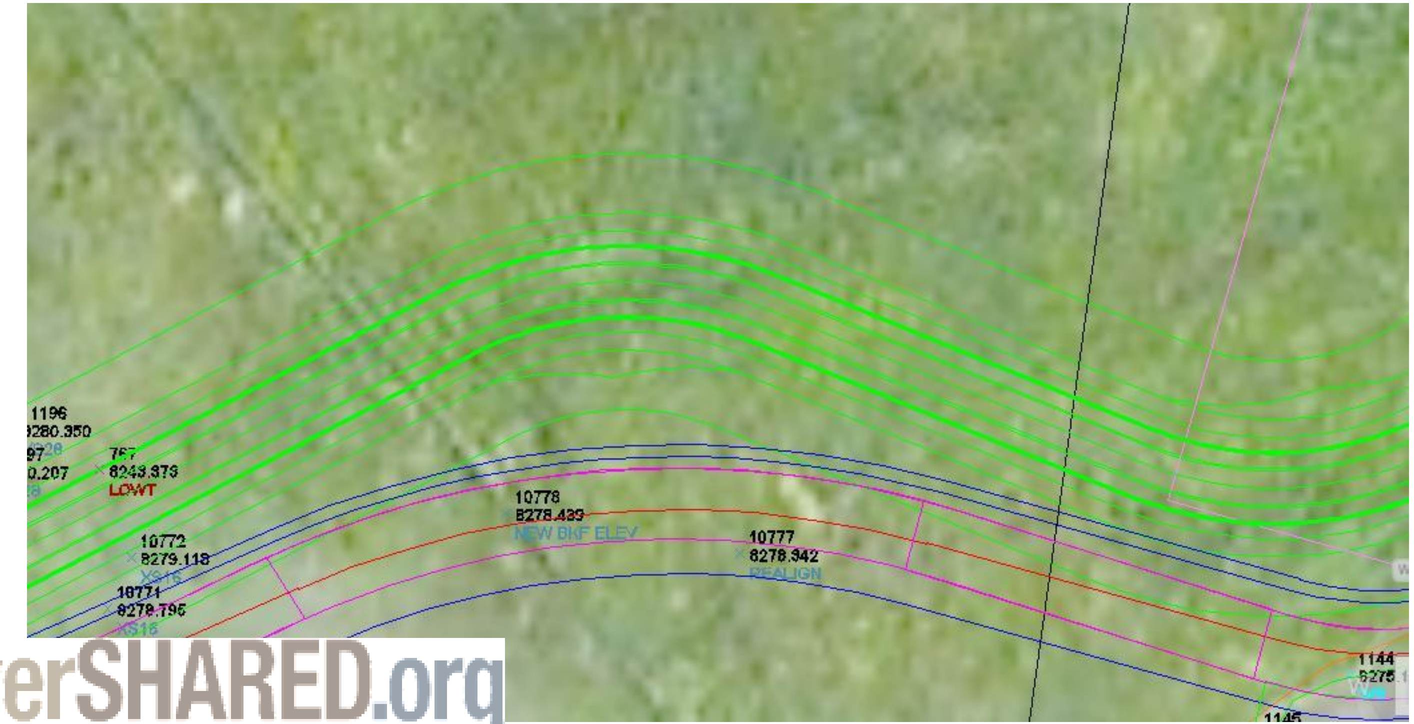
3-D Design

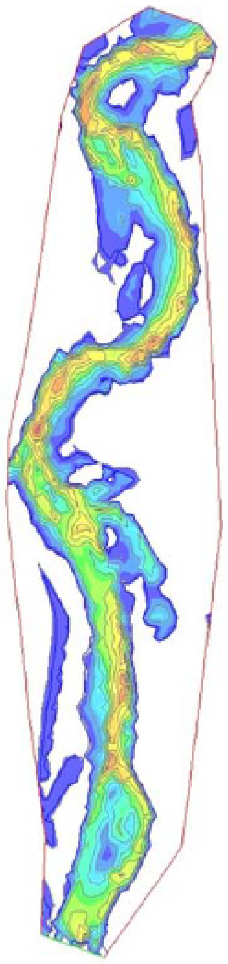
- 30% Design
  - Walk Site – Additional Data
  - Review - Material on Site? Constraints?
  - Re-Adjust Design



3-D Design

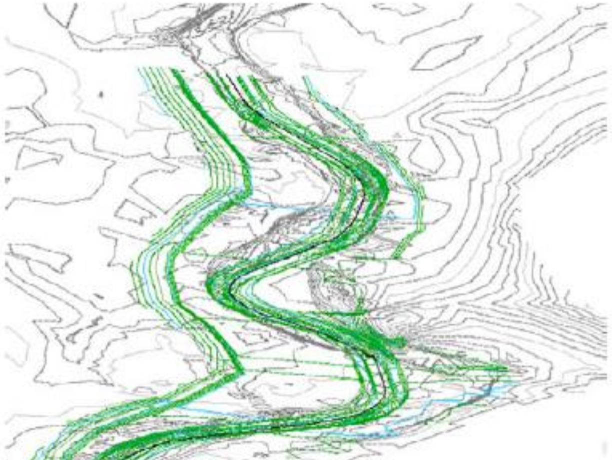
- Engineering to Check and Design
  - Sediment, Backwater, Velocity, & Shear Stress

- HEC-RAS Limitations
  - 1-D only
    - cannot model actual flow around bends, in constrictions, or other 2-D, 3-D flows
    - cannot model channel-floodplain interactions



3-D Design

Optimization



- Hydraulic Modeling is Not Limited
- Grading is a Major Construction Cost
- Easier to Create Design Revisions and Iterations
- Assist in Construction Stakeout
- GPS Guided Construction Equipment
- Local Balanced based on equipment and site conditions
- Good Check for On-site Stupidity During Construction

3-D Construction

- Limited Construction Stakes
- As-built Conditions Surveyed During Construction
- Efficient Digging

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3-D Ecosystem Corridor Design vs. Ecosystem Restoration

What is Ecosystem Restoration?

The Game Show

Add Tools

Limiting Factors Analysis for a Successful River Restoration Project

- Lack of Knowledge
- Lack of Communication
  - Mixed messages
    - Jargon
    - Personalities
    - Poor Documentation
  - Muddled messages
    - Personalities
    - Poor Documentation
  - Mute messages
    - Insecurities
    - Time

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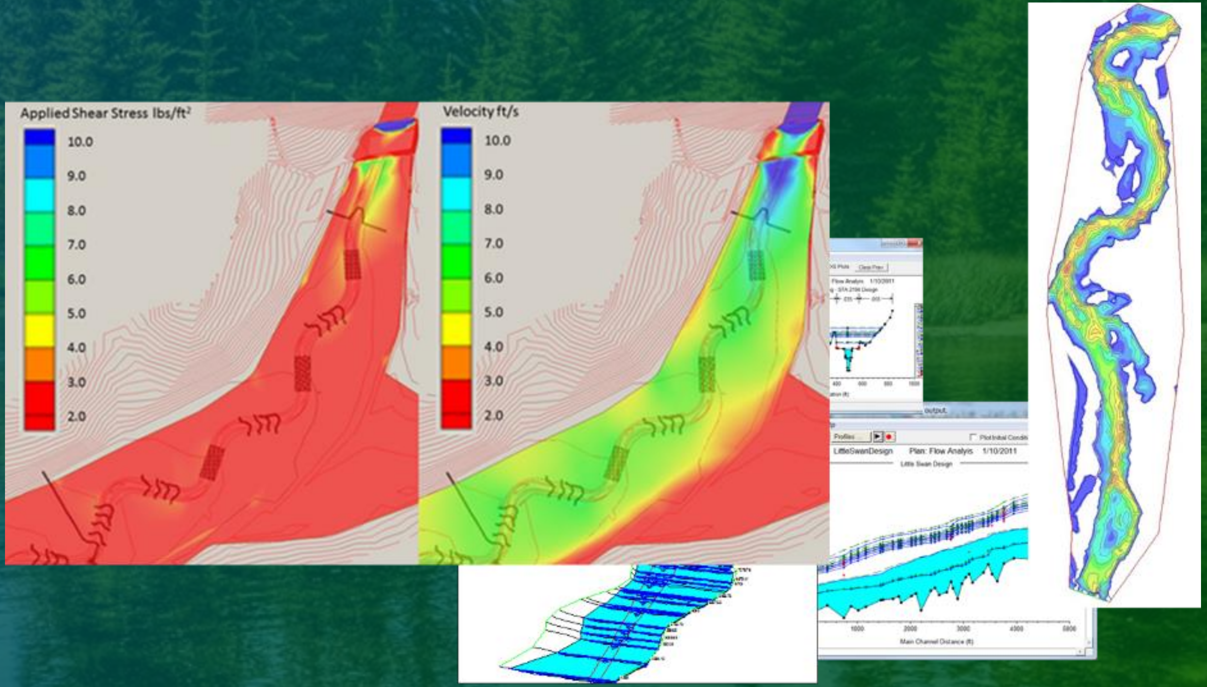
Engineering Jargon

- Jargon: Special words or expressions that are used by a particular profession or group and are difficult for others to understand.

  - Bankfull
  - Shear Stress
  - Risk Analysis
  - Unit Stream Power
  - Radius of Curvature
  - Meander Width Ratio
  - Stream Type
  - J-Hook
  - Flood Recurrence
  - Thalweg
  - BEHI/NBS
  - Reynolds – Near-bed
  - NCD



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Biological Jargon

- Jargon: Special words or expressions that are used by a particular profession or group and are difficult for others to understand.

  - Nitrogenous Waste
  - Spawning Gravels
  - Chemical Treatment
  - Cottonwood Recruitment
  - Detritus
  - Invertebrates
  - Thalweg
  - Trophic Level
  - Drift
  - Riffle

MCDA Jargon

- Michigan Cannabis Development Association
- Maine Career Development Association
- Multnomah County District Attorney
- Military and Civil Defense Assets

- Multiple Criteria Decision Analysis
  - Goal: An overarching principle that guides decision making
    - Habitat Improvement
  - Objective: Are specific, measurable steps that can be taken to meet a goal.
    - 50% increase In pool depth to provide cover for fish
  - Criteria: Objective based variable scale as compared with other alternatives
    - Depth of pool cover post construction

#2

Have patience and discernment for innovation

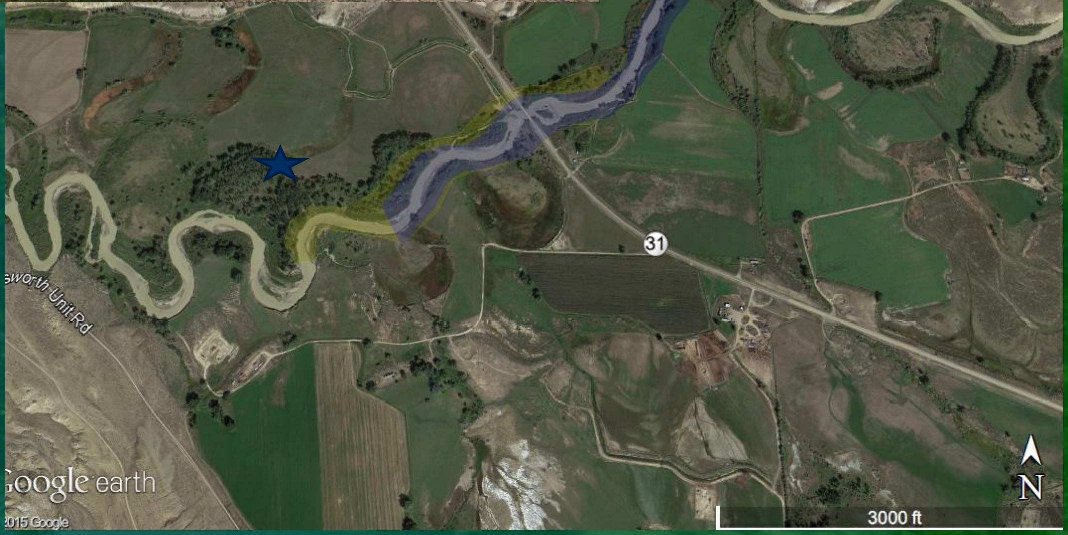
- Let Goals and Objective help decide field techniques and design tools

Goals

1. Provide year-round fish passage at the Harmony Diversion site (except for when a call is placed on the river) for all species of fish that occupy the Nowood and Bighorn Rivers;
    a. Specifically shovelnose sturgeon and sauger;
2. Provide reliable supply of irrigation water for ditch user at all discharges;
3. Design and construct an improved instream diversion that can divert the entire river if needed during a call and minimizes instream maintenance;
    a. Designs can in no way compromise the integrity of the existing highway bridge that is upstream of the diversion site.
4. Improve transport of sediment and debris through diversion to avoid entry into headgate/screening structure;
5. Any design should be able to withstand significance ice flow events.

Objectives

1. Designs that leave the channel open and in a more natural state are preferred over designs that rely on a fish ladder to provide fish passage.
2. Designs must allow the landowner to take all flow (no more than 1-3 cfs can flow past the diversion) if the landowner has to put a call on the river.
3. If a fishway were to be considered: Fishway attraction flow of 2-4 ft/s within thalweg of channel and flow depths of 4 ft or more. Fishway passage velocity of 3-4 ft/s is preferred for shovelnose, but shovelnoses have negotiated velocities between 0.8 - 6.0 ft/s (White 2002).
4. New headgate structure and ISI cone shaped fish screens are designed for 40 cfs (20 cfs each screen). The irrigator holds senior water rights which can result in putting a call on the river, so Joyce can receive his water. The State Engineer requires him to divert all water from the river with only 1-3 cfs leaking through.
5. Somehow design an instream structure that will not be a complete dam or barrier. I feel that being in the fish passage program our goals are to remove dams, not to be constructing them. Maybe still look at using an Obermeyer weir. Construct a new structure that requires less maintenance and man hours for the landowner/irrigator.
6. Come up with a design that WYDOT will okay, since their bridge is about 55 ft upstream of the diversion site.



#2

Have patience and discernment for innovation

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3. If a fishway were to be considered: Fishway attraction flow of 2-4 ft/s within thalweg of channel and flow depths of 4 ft or more. Fishway passage velocity of 3-4 ft/s is preferred for shovelnose, but shovelnoses have negotiated velocities between 0.8 - 6.0 ft/s (White 2002).
4. New headgate structure and ISI cone shaped fish screens are designed for 40 cfs (20 cfs each screen). The irrigator holds senior water rights which can result in putting a call on the river, so Joyce can receive his water. The State Engineer requires him to divert all water from the river with only 1-3 cfs leaking through.
5. Somehow design an instream structure that will not be a complete dam or barrier. I feel that being in the fish passage program our goals are to remove dams, not to be constructing them. Maybe still look at using an Obermeyer weir. Construct a new structure that requires less maintenance and man hours for the landowner/irrigator.
6. Come up with a design that WYDOT will okay, since their bridge is about 55 ft upstream of the diversion site.

#3

Advocate excellence

- Use a Multi-Criteria Decision Analysis (MCDA) tool to define Excellence based on Goals and Objectives

Criteria

Weighting Factors

Options

				Fish Passage GOAL				Water Delivery and Reliability GOAL			LOW RISK GOAL			Morphology GOAL						
				100% Fish Passage	Natural Lo[illegible] Channel	Velocity [illegible]fps and [illegible]wer than 6fps [illegible]KF	[illegible]o Dam	[illegible]0% of the flows if call is [illegible]ace	[illegible]aximiz[illegible]out a [illegible]ushup Dam	Mainten[illegible]ce [illegible] Cleaning [illegible]ut sedi[illegible]nt	No Increase in Future [illegible]ability	No Increase of Flooding Upstream to Bridge	Ease of A[illegible]al Process	Laterial Bank Migration	Sustainable Sediment Transport Balance					
	Concept Option Description	Low Flow Diversion	Fish Passage Concept	1	1	1	1	1	1	1	2	1	1	1	1	*Linear Feet of Proposed Project*	*Preliminary Cost Estimate of Proposed Project*	*UNIT COST*	MCDA Matrix Score	MCDA RANKING
Option #1	Concrete Dam with Bypass	Pushup Dam at Low Flow	Bypass Natural Channel	1	5	1	5	1	1	4	5	5	5	5	5	200	$ 900,000.00	$ 4,500.00	**48**	10
Option #2	Natural Channel Design Dam with Large Step-Pools with Bypass	Pushup Dam at Low Flow at Designed Glide	Bypass Natural Channel	1	4	1	5	1	1	5	5	5	4	4	5	1000	$ 700,000.00	$ 700.00	**46**	9
Option #3	Natural Channel Design Channel Downstream	Pushup Dam at Low Flow at Designed Glide	Natural Channel Main Reach	1	2	1	4	1	1	4	4	4	4	2	3	5000	$ 1,100,000.00	$ 220.00	**35**	6
Option #4	Natural Chann[illegible] Desi[illegible] Channel Bala[illegible] ProfileUpstre[illegible] and D[illegible]eam	[illegible]up Dam at Low Flow at [illegible]ed Glide	Natural Channel Main [illegible]ch	1	1	1	2	3	2	3	2	3	3	1	2	3000	$ 660,000.00	$ 220.00	**26**	3
Option #5	Change of Po[illegible] of Di[illegible]sio[illegible] with Culvert under Bridge	P[illegible] Dam [illegible] Flo[illegible] Upstream	Existing Channel	2	4	2	2	1	2	4	2	3	3	3	3	200	$ 250,000.00	$ 1,250.00	**33**	4
Option #6	Culvert under Road ~700ft west of north of the Bridge	Pushup Dam at Low Flow Upstream	Existing Channel	2	3	2	2	1	2	2	1	2	2	2	3	200	$ 200,000.00	$ 1,000.00	**25**	2
Option #7	Fabric Inflatable Dam with Bypass or Fishway	Fabric Dam at Low Flow	Fishway or Engineered Bypass	2	5	1	3	2	2	4	3	3	3	3	4	200	$ 1,000,000.00	$ 5,000.00	**38**	8
Option #8	Do Nothing but Lower Fish Screens	Pushup Dam at Low Flow	Existing Channel	4	3	3	3	3	4	3	1	2	1	4	3	200	$ 100,000.00	$ 500.00	**35**	6
Option #9	Do Nothing	Pushup Dam at Low Flow	Existing Channel	4	3	3	3	3	4	2	1	2	1	4	3	200	$ -	$ -	**34**	5
Option #10	Replace Bridge in adition to Option 3 and Upstream Channel Adjustments	Pushup Dam at Low Flow		1	2	1	2	1	2	2	1	1	2	1	1	200	$ 2,600,000.00	$ 13,000.00	**18**	1

Components of MCDA tool

No Increase Risk			Water Quality GOAL				Buffer GOAL			
Flooding to Downstream County Road	Dam Failure	Upstream flooding	Improve water quality and habitat of stream	Reduce sediment deposition and supply	Improve floodplain functions of water storage and habitat	SW control feature in watershed	Minimize impacts to wetland vegetation	Improve riparian buffer functions of stability, habitat, and aesthetics	**MCDA Matrix Score**	**MCDA RANKING**
2	***3***	***1***	***1***	***1***	***2***	***1***	***2***	***1***		
1	1	1	5	5	5	5	2	2	**82**	**5**
1	4	5	4	1	1	1	5	4	**61**	**4**
1	1	2	2	2	3	4	3	3	**51**	**3**
1	1	1	1	2	2	3	4	2	**44**	**2**
1	1	1	1	1	1	3	1	1	**25**	**1**

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#6

Document and learn from unexpected results

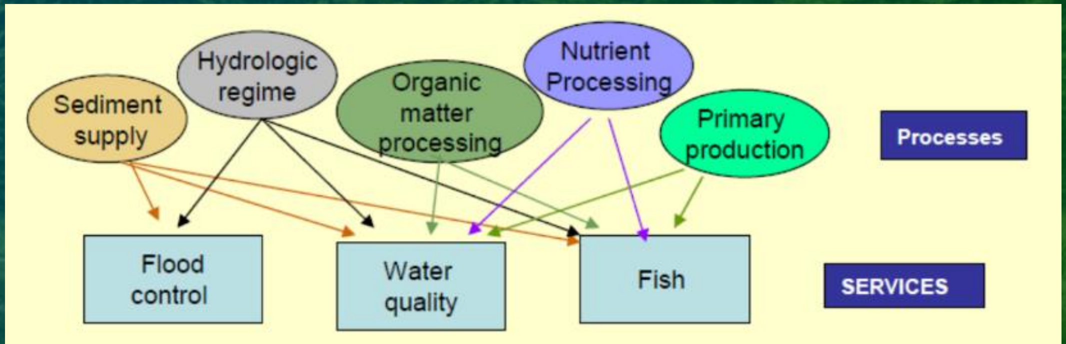
- Always define Goals and Objectives with stakeholders and allow for flexibility in the MCDA Documentation

Goals

1. Provide year-round fish passage at the Harmony Diversion site (except for when a call is placed on the river) for all species of fish that occupy the Nowood and Bighorn Rivers;
    a. Specifically shovelnose sturgeon and sauger;
2. Provide reliable supply of irrigation water for ditch user at all discharges;
3. Design and construct an improved instream diversion that can divert the entire river if needed during a call and minimizes instream maintenance;
    a. Designs can in no way compromise the integrity of the existing highway bridge that is upstream of the diversion site.
4. Improve transport of sediment and debris through diversion to avoid entry into headgate/screening structure;
5. Any design should be able to withstand significance ice flow events.

Objectives

1. Designs that leave the channel open and in a more natural state are preferred over designs that rely on a fish ladder to provide fish passage.
2. Designs must allow the landowner to take all flow (no more than 1-3 cfs can flow past the diversion) if the landowner has to put a call on the river.
3. If a fishway were to be considered: Fishway attraction flow of 2-4 ft/s within thalweg of channel and flow depths of 4 ft or more. Fishway passage velocity of 3-4 ft/s is preferred for shovelnose, but shovelnoses have negotiated velocities between 0.8 - 6.0 ft/s (White 2002).
4. New headgate structure and ISI cone shaped fish screens are designed for 40 cfs (20 cfs each screen). The irrigator holds senior water rights which can result in putting a call on the river, so Joyce can receive his water. The State Engineer requires him to divert all water from the river with only 1-3 cfs leaking through.
5. Somehow design an instream structure that will not be a complete dam or barrier. I feel that being in the fish passage program our goals are to remove dams, not to be constructing them. Maybe still look at using an Obermeyer weir. Construct a new structure that requires less maintenance and man hours for the landowner/irrigator.
6. Come up with a design that WYDOT will okay, since their bridge is about 55 ft upstream of the diversion site.



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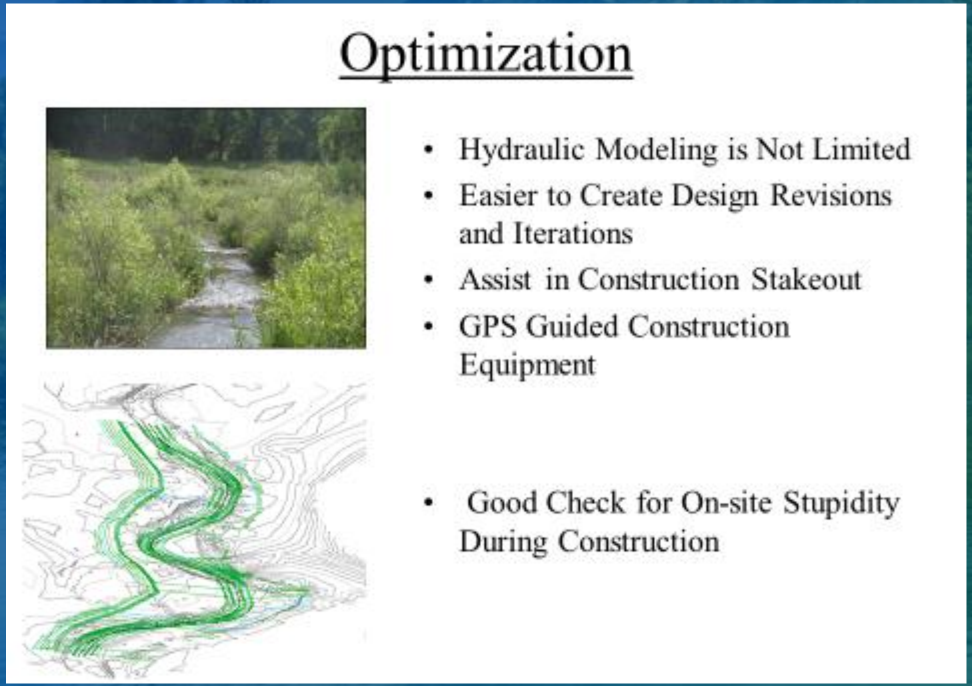
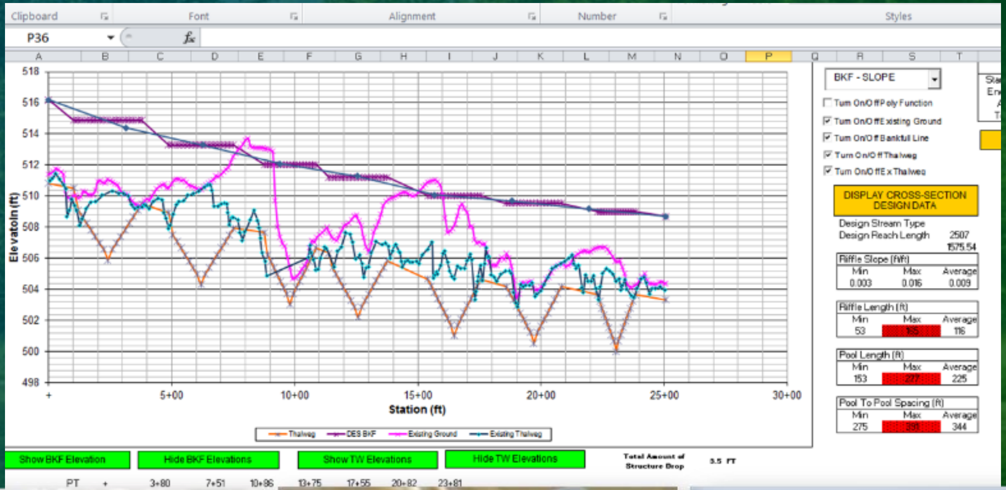
#3
Advocate excellence

- 3-D Design Optimization based on MCDA and Goals and Objectives

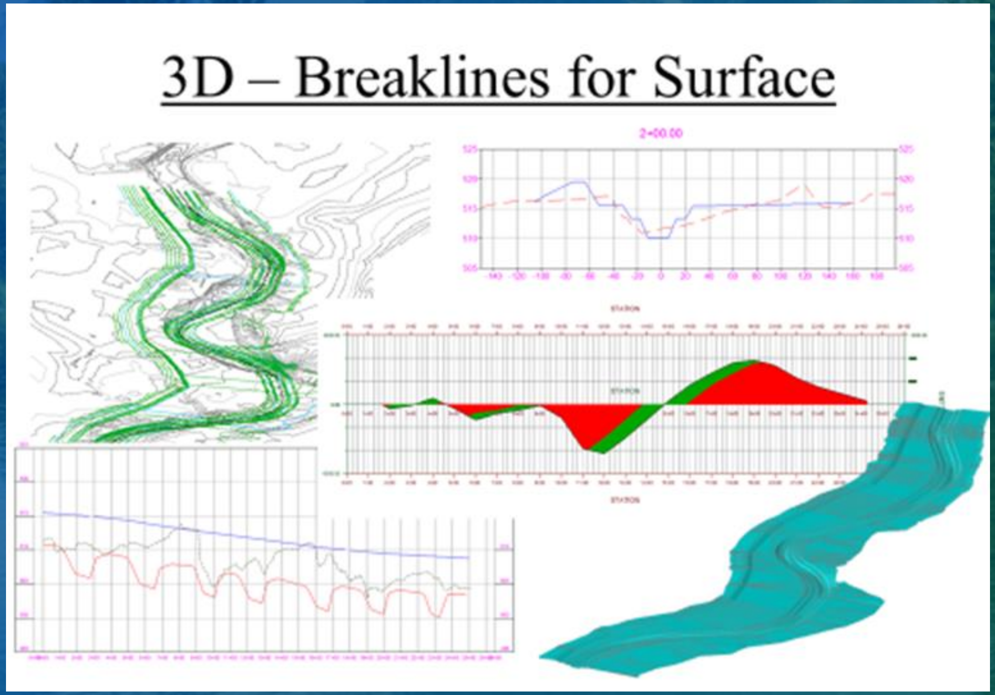




#3

Advocate excellence

- 3-D Design Optimization based on MCDA and Goals and Objectives



#3

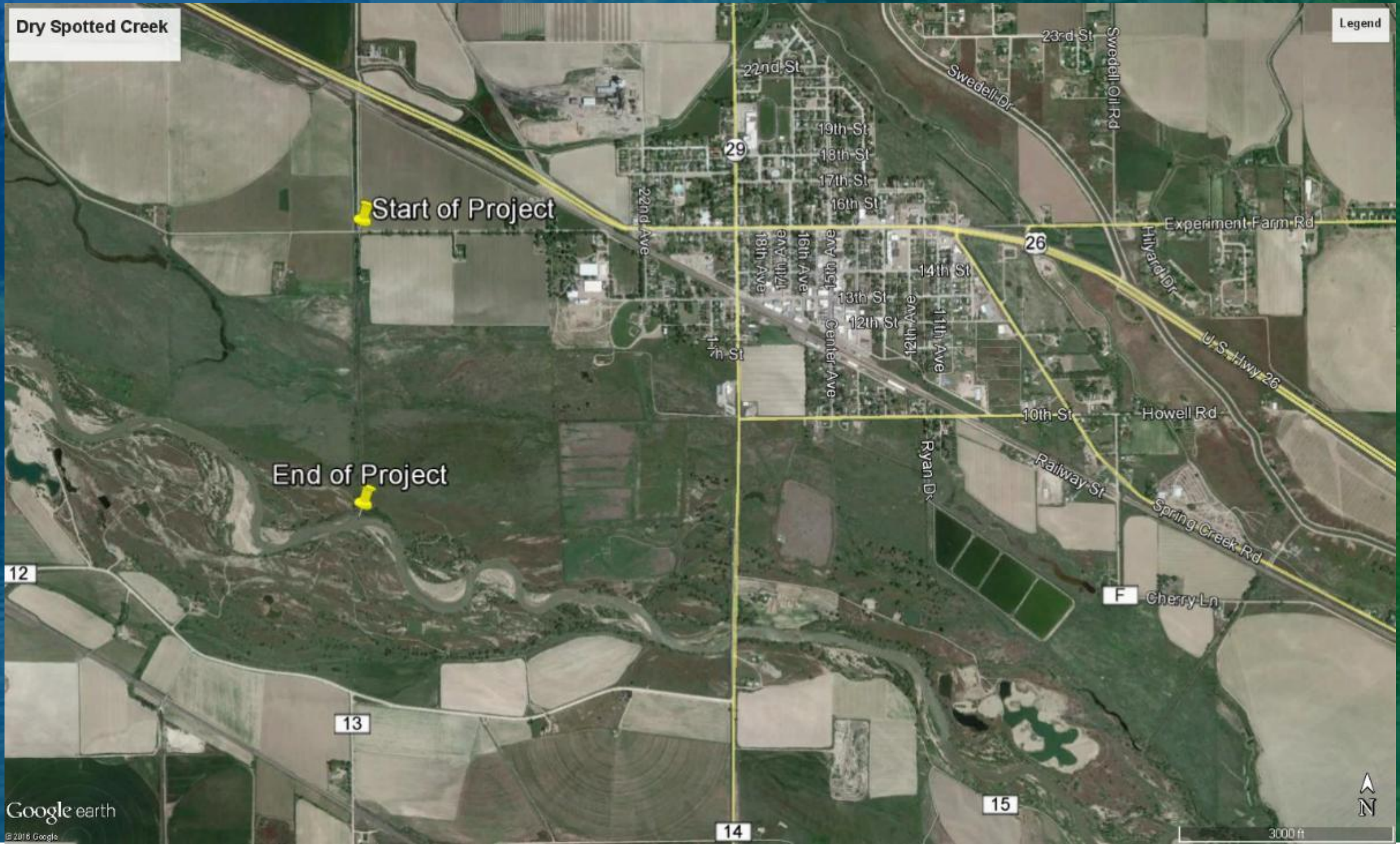
Advocate excellence

- 3-D Design Optimization based on MCDA and Goals and Objectives

		Stream Stability GOAL			Water Quality GOAL				Buffer GOAL								
		Stop in-stream headcutting	Self-sustaining, natural, stable stream	Stream and floodplain manage shear stresses	Improve water quality and habitat of stream	Reduce sediment deposition and supply	Improve floodplain functions of water storage and habitat	SW control feature in watershed	Minimize impacts to wetland vegetation	Improve riparian buffer functions of stability, habitat, and aesthetics							
	Concept Option Description	***2***	***1***	***2***	***1***	***1***	***1***	***1***	***1***	***1***	***Linear Feet of Proposed Project***	***Required Fill (yd3)***	***Fill cost ($10/yd3)***	***Preliminary Cost Estimate of Proposed Project***	***UNIT COST***	**MCDA Matrix Score**	**MCDA RANKING**
Option #1	Tie into wetland floodplain as long as possible step down channel gradually; Higher slope at top, lower slope at bottom	1	1	3	1	1	1	0	1	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	**12**	3
Option #2	Tie into wetland floodplain as long as possible step down channel gradually; More-or-less consistent slope	1	1	2	1	1	1	0	1	1	1170	7000	$70,000	$ 1,340,000.00	$ 1,145.30	**10**	1
Option #3	Stay very high and flat coming out of the wetland	1	1	2	1	1	1	0	1	1	1170	10000	$100,000	$ 1,320,000.00	$ 1,128.21	**10**	1
Option #4	Lower in Wetland and then inbetween 1 and 2	2	1	2	1	1	1	0	1	1	1170	6500	$65,000	$ 1,335,000.00	$ 1,141.03	**12**	3
Option #5	60% Design as drafted	2	3	4	1	1	1	0	2	1	1170	500	$5,000	$ 1,270,000.00	$ 1,085.47	**19**	6
Option #6	30% Design as drafted	2	2	3	1	1	2	0	2	1	1170	6000	$60,000	$ 1,330,000.00	$ 1,136.75	**16**	5
Option #7	Do Nothing	5	5	5	5	5	5	0	3	4	1170	0	$0	$ -	$ -	**37**	7

Example Project – Demonstration Coldwater Fishery

- Dry Spotted Creek, Mitchell NE Tributary to NPR



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Example Project – Demonstration Coldwater Fishery

- Dry Spotted Creek, Mitchell NE Tributary to NPR

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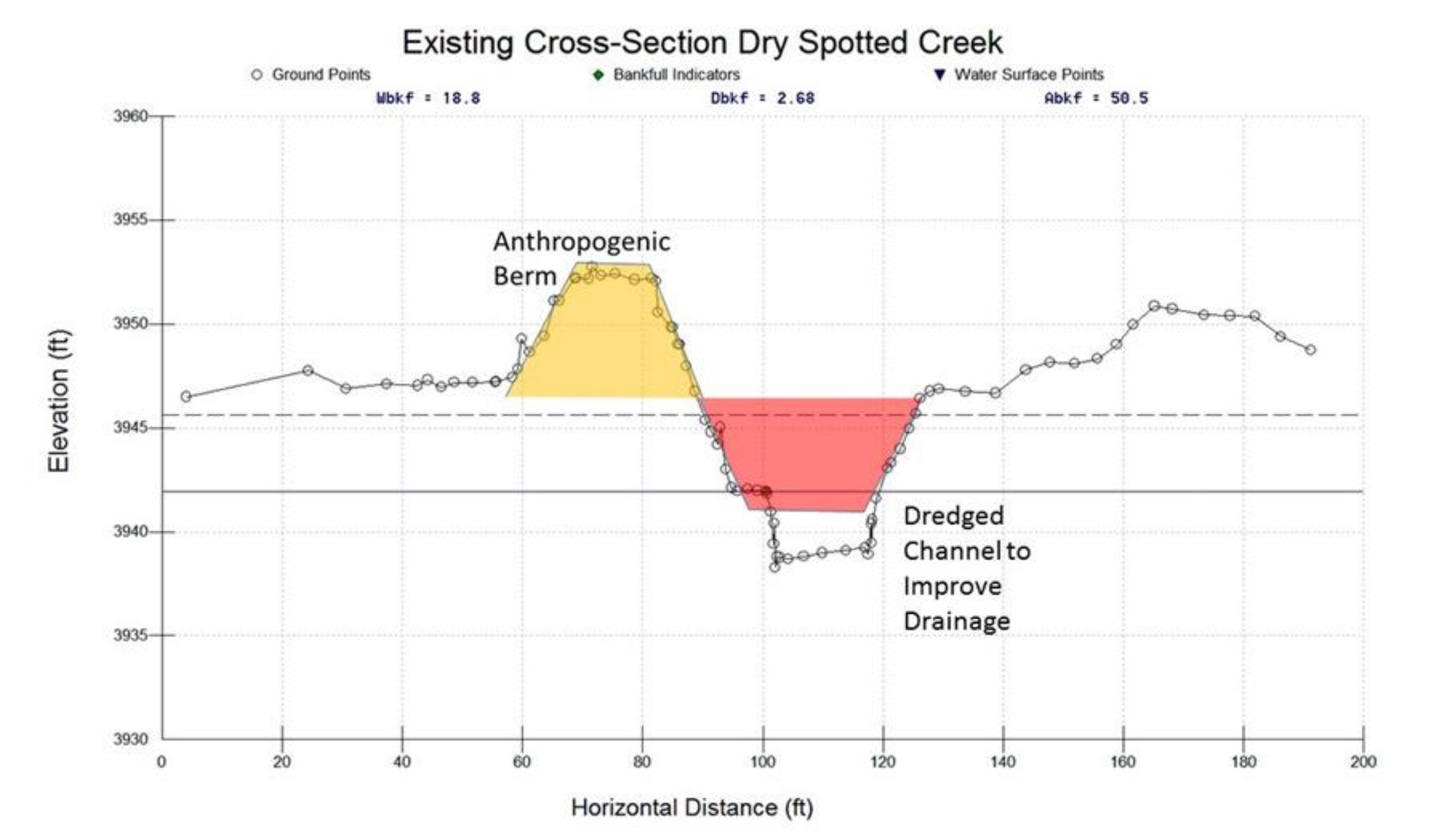
Example Project

- Dry Spotted Creek



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Example Project – Demonstration Coldwater Fishery

- Dry Spotted Creek, Mitchell NE Tributary to NPR

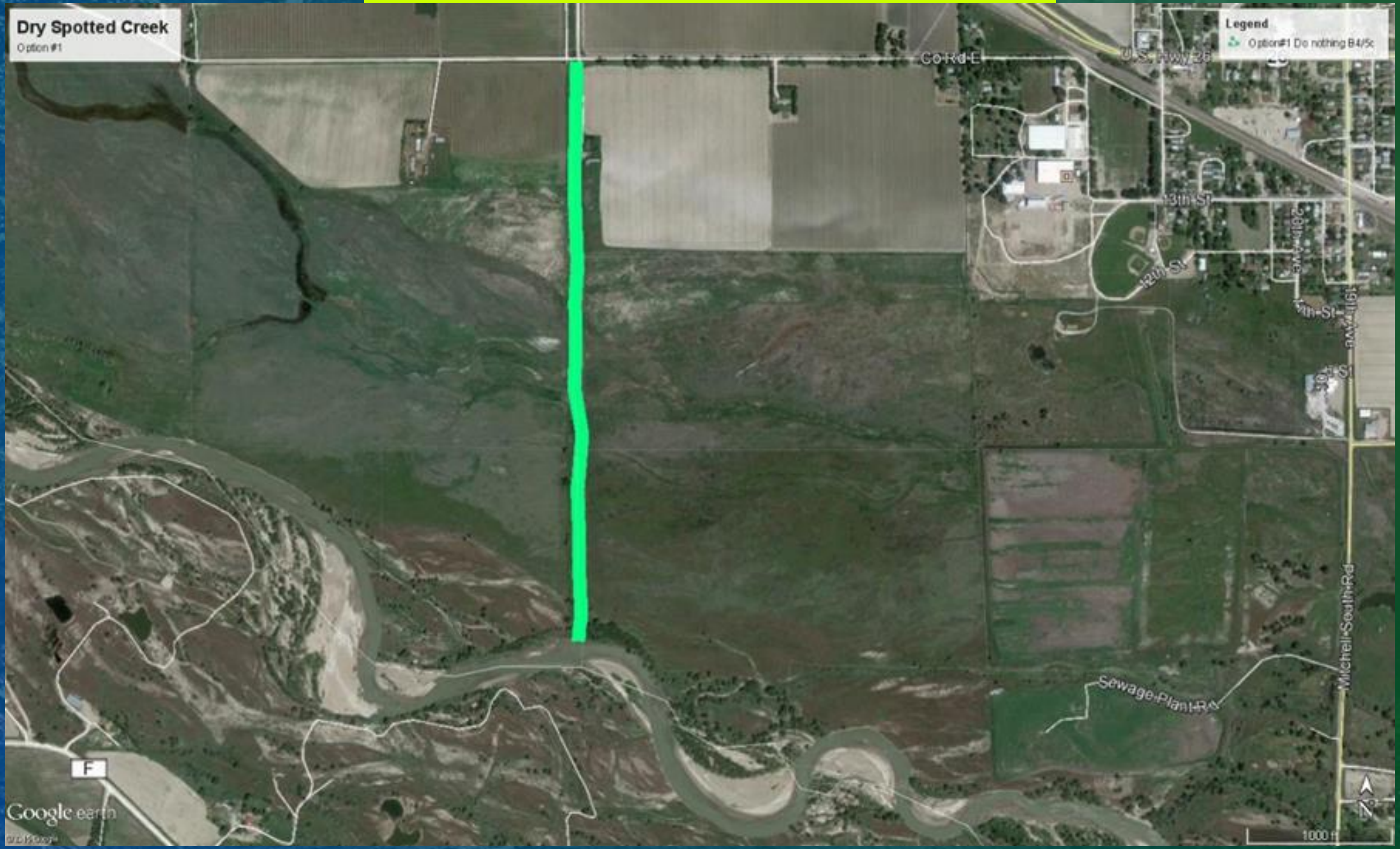
Example Goals

- Fisheries and Habitat Improvement for Salmonids Goal
- Drainage, Irrigation and Water Rights Goal
- Low Project RISK Goal
- Demonstration Project Goal
- Funding Goal
- Land Management and Conservation Goal
- River Morphology and Stability Goal

Fisheries and Habitat Improvement for Salmonids GOAL

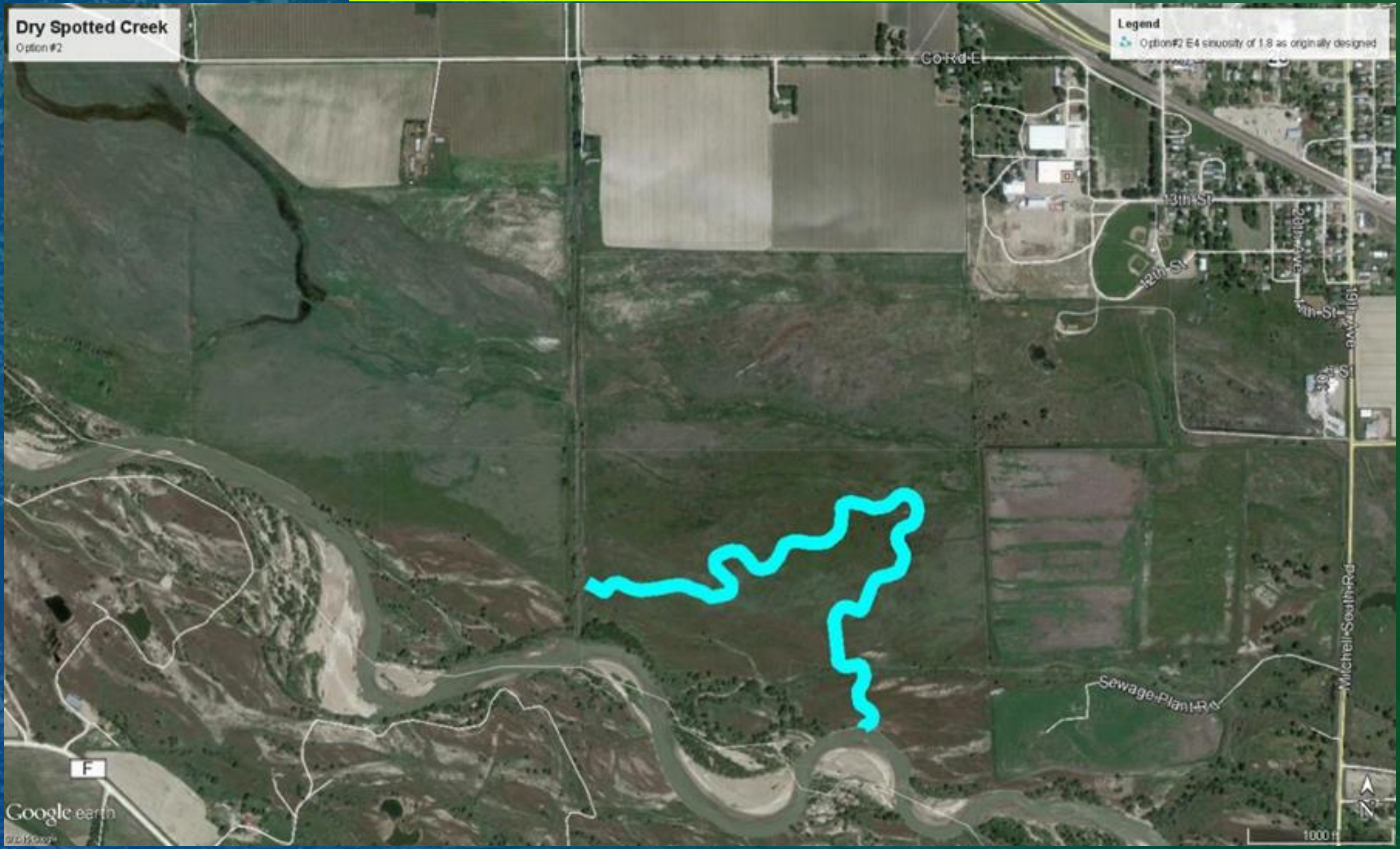
Option	Description	Groundwater Influenced Coldwater Fishery	Re-establish Riparian Wetlands through PRBE property	Establish Riparian Native Vegetation	Deep Sustainable Pools	Overhead Cover in-bank	Sustainable Spawning Gravels for Riffles 40-70mm	Connectivity to North Platte	Potential Barrier from North Platte	Coldwater Fishery	No additional Heating through in-line Ponds	Increased Fisheries Length
			1	1	1	1	1	1	1	1	1	1
			5	4	3	3	4	2	4	4	1	5
			5	4	3	3	4	2	4	4	1	5
			2	1	2	1	3	2	2	3	5	2
			1	1	2	1	2	1	1	2	4	2
			1	1	1	1	3	1	1	2	3	1
			5	3	2	3	3	2	3	3	1	4
			5	3	3	3	4	2	4	4	1	5
Option #7	E4 sinuosity of 1.8 start at middle elevation	2	1	1	1	1	1	1	1	2	4	2
Option #8	Upstream C4/5 with bankfull bench and MINOR realignment 75% within existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	1	1	1	1	1	1	1	1	1	1	1

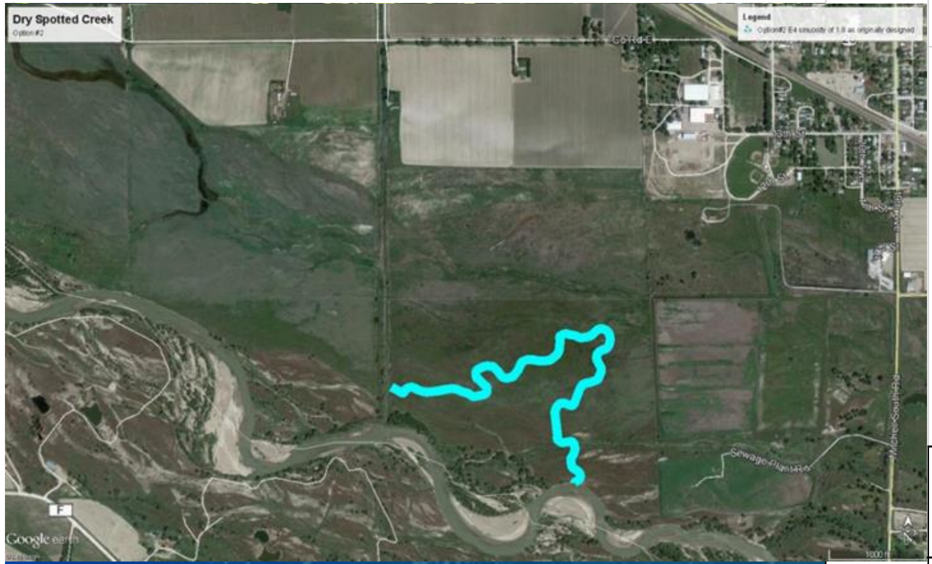
Option #1B—fencing and pathway enhancements



	Concept Option Description	Groundwater Influenced Coldwater Fishery	Re-establish Riparian Wetlands through PRBE property	Establish Riparian Native Vegetation	Deep Sustainable Pools	Overhead Cover in-bank	Sustainable Spawning Gravels for Riffles 40-70mm	Connectivity to North Platte	Potential Barrier from North Platte	Coldwater Fishery	No additional Heating through in-line Ponds	Increased Fisheries Length
		Fisheries and Habitat Improvement for Salmonids GOAL										
	Concept Option Description	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Option #1	Do nothing G4/5c and B4/5c with a sinuosity of 1.01	5	5	4	3	3	4	2	4	4	1	5
Option #1b	Do nothing G4/5c and B4/5c with a sinuosity of 1.01 Trail Access, Fencing and Replanting	5	5	4	3	3	4	2	4	4	1	5
Option #2	Original DU Design - E4 sinuosity of 1.8 as originally designed	2	2	1	2	1	3	2	2	3	5	2
Option #3	E4 sinuosity of 1.8 start at middle elevation	2	1	1	2	1	2	1	1	2	4	2
Option #4	sinuosity of 1.8 maximize head upstream Re-alignment	1	1	1	1	1	3	1	1	2	3	1
Option #5	C4/5 with sinuosity of 1.1 MINOR re-alignment within existing Ditch footprint	5	5	3	2	3	3	2	3	3	1	4
Option #6	Grade bankfull bench Inplace with no channel work B4/5c sinuousity 1.01 No Re-Alignment	5	5	3	3	3	4	2	4	4	1	5
Option #7	E4 sinuosity of 1.8 start at middle elevation	2	1	1	1	1	1	1	1	2	4	2
Option #8	Upstream C4/5 with bankfull bench and MINOR realignment 75% within existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	1	1	1	1	1	1	1	1	1	1	1

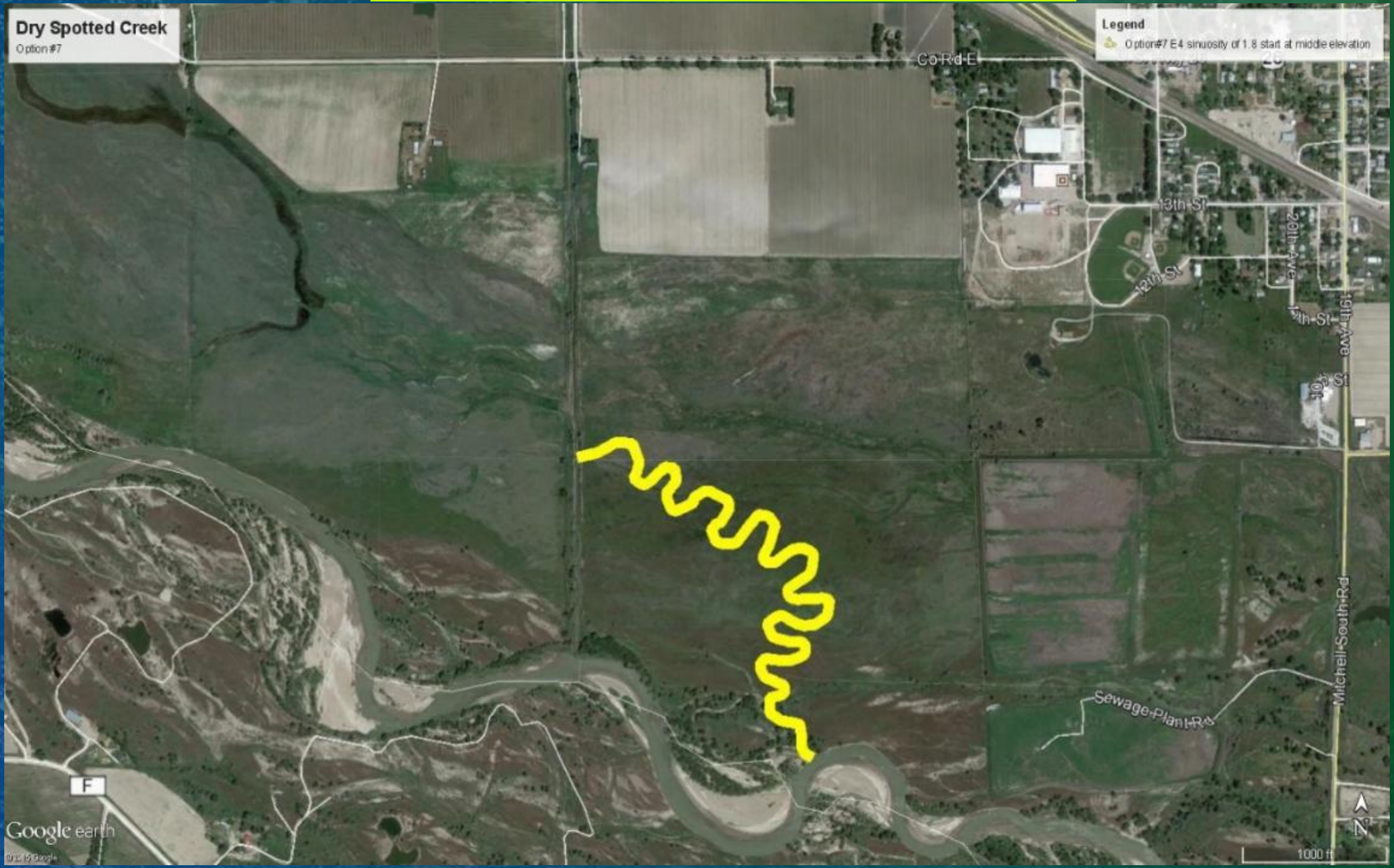
Option #2—Original Client concept design minimum downstream head





		Fisheries and Habitat Improvement for Salmonids GOAL										
		Groundwater Influenced Coldwater Fishery	Re-establish Riparian Wetlands through PRBE property	Establish Riparian Native Vegetation	Deep Sustainable Pools	Overhead Cover In-bank	Sustainable Spawning Gravels for Riffles 40-70mm	Connectivity to North Platte	Potential Barrier from North Platte	Coldwater Fishery	No additional Heating through in-line Ponds	Increased Fisheries Length
	Concept Option Description	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Option #1	Do nothing G4/5c and B4/5c with a sinuosity of 1.01	5	5	4	3	3	4	2	4	4	1	5
Option #1b	Do nothing G4/5c and B4/5c with a sinuosity of 1.01 Trail Access, Fencing and Replanting	5	5	4	3	3	4	2	4	4	1	5
Option #2	Original DU Design - E4 sinuosity of 1.8 as originally designed	2	2	1	2	1	3	2	2	3	5	2
Option #3	E4 sinuosity of 1.8 start at middle elevation	2	1	1	2	1	2	1	1	2	4	2
Option #4	sinuosity of 1.8 maximize head upstream Re-alignment	1	1	1	1	1	3	1	1	2	3	1
Option #5	C4/5 with sinuosity of 1.1 MINOR re-alignment within existing Ditch footprint	5	5	3	2	3	3	2	3	3	1	4
Option #6	Grade bankfull bench Inplace with no channel work B4/5c sinuousity 1.01 No Re-Alignment	5	5	3	3	3	4	2	4	4	1	5
Option #7	E4 sinuosity of 1.8 start at middle elevation	2	1	1	1	1	1	1	1	2	4	2
Option #8	Upstream C4/5 with bankfull bench and MINOR realignment 75% within existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	1	1	1	1	1	1	1	1	1	1	1

Option #7—priority I restoration and major re-alignment



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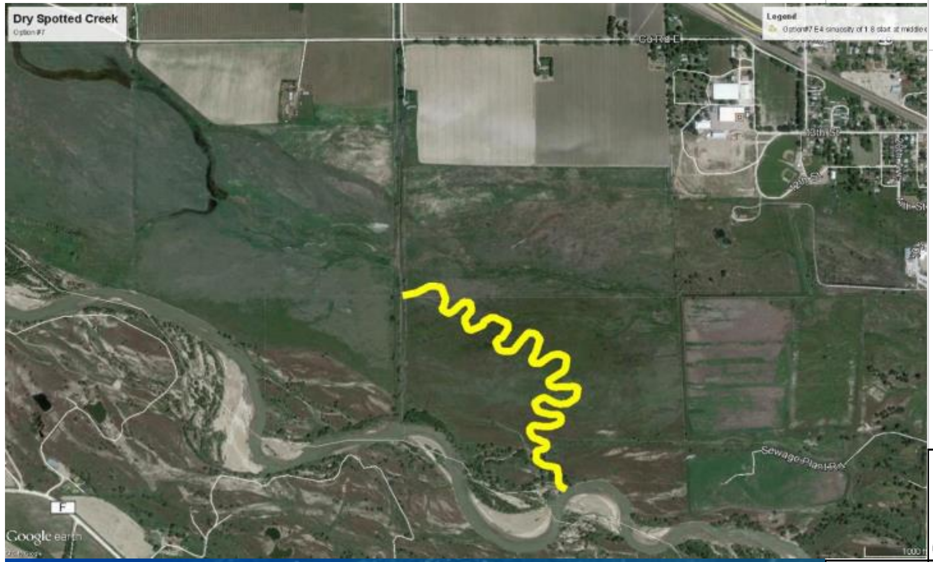

		Fisheries and Habitat Improvement for Salmonids GOAL										
		Groundwater Influenced Coldwater Fishery	Re-establish Riparian Wetlands through PRBE property	Establish Riparian Native Vegetation	Deep Sustainable Pools	Overhead Cover in-bank	Sustainable Spawning Gravels for Riffles 40-70mm	Connectivity to North Platte	Potential Barrier from North Platte	Coldwater Fishery	No additional Heating through in-line Ponds	Increased Fisheries Length
	Concept Option Description	1	1	1	1	1	1	1	1	1	1	1
Option #1	Do nothing G4/5c and B4/5c with a sinuosity of 1.01	5	5	4	3	3	4	2	4	4	1	5
Option #1b	Do nothing G4/5c and B4/5c with a sinuosity of 1.01 Trail Access, Fencing and Replanting	5	5	4	3	3	4	2	4	4	1	5
Option #2	Original DU Design - E4 sinuosity of 1.8 as originally designed	2	2	1	2	1	3	2	2	3	5	2
Option #3	E4 sinuosity of 1.8 start at middle elevation	2	1	1	2	1	2	1	1	2	4	2
Option #4	sinuosity of 1.8 maximize head upstream Re-alignment	1	1	1	1	1	3	1	1	2	3	1
Option #5	C4/5 with sinuosity of 1.1 MINOR re-alignment within existing Ditch footprint	5	5	3	2	3	3	2	3	3	1	4
Option #6	Grade bankfull bench Inplace with no channel work B4/5c sinuousity 1.01 No Re-Alignment	5	5	3	3	3	4	2	4	4	1	5
Option #7	E4 sinuosity of 1.8 start at middle elevation	2	1	1	1	1	1	1	1	2	4	2
Option #8	[illegible] existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	1	1	1	1	1	1	1	1	1	1	1

MCDA – Got it ??

					Fisheries and Habitat Improvement for Salmonids GOAL											Drainage, Irrigation and Water Rights Goal					Low Project RISK GOAL						Demonstration Project Goal							Funding GOAL			Land Management and Conservation Goal					River Morphology and Stability GOAL				
					Groundwater Influenced Coldwater Fishery	Re-establish Riparian Wetlands through PRBE property	Establish Riparian Native Vegetation	Deep Sustainable Pools	Overhead Cover in-bank	Sustainable Spawning Gravels for Riffles 40-70mm	Connectivity to North Platte	Potential Barrier from North Platte	Coldwater Fishery	No additional Heating through in-line Ponds	Increased Fisheries Length	No Irrigation structures Impacts	No Drainage Obstruction	No Impacts to Adjacent Landowners Drainage	No Impacts Gage Control Structure	No increase in Evaporative Losses	No Increase or transfer in Future Liability	EMERGENCY PLUG 100yr Design and Overflow	Regulated flows in Design Re-Alignment Channel	No Increase of Scour to Bridge	No Increase of Flood stage on CO 12	Ease of Approval and Permit Process	Walk-in Fishery and Pathway	ADA Access for Fishing and Hiking	Potential Training Courses	Potential Project Phasing	Volunteer involvement Opportunities	Flagship Project and Demo	Opportunities for TU Chapter involvement	Successful NET grant application based on design	Opportunities for others to fund design	Timeline Limitations of Design	Grazing Management Plan	Fencing for Exclusion	Preserve Prairie Dog Town	Exotic Vegetation Removal	Seasonal Wetland Management	Reduction of Bank Erosion and Lateral Bank Migration	Sustainable Sediment Transport Balance	Future Maintenance River		
	Concept Option Description	Length of Unadjusted reach	Length of Restored Re-Aligned Spotted Creek	Upstream Potential Additional Fishery Improvements	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	MCDA Matrix Score	MCDA RANKING
Option #1	Do nothing G4/5c and B4/5c with a sinuosity of 1.01	3975	0	0	5	5	4	3	3	4	2	4	4	1	5	1	1	1	1	1	1	1	5	2	1	1	4	5	5	5	5	5	5	5	5	1	5	5	2	5	5	3	3	3	132	9
Option #1b	Do nothing G4/5c and B4/5c with a sinuosity of 1.01 Trail Access, Fencing and Replanting	1000	0	2975	5	5	4	3	3	4	2	4	4	1	5	1	1	1	1	1	1	1	5	2	1	1	2	3	5	5	3	5	3	4	5	2	1	1	1	4	5	3	3	3	114	8
Option #2	Original DU Design - E4 sinuosity of 1.8 as originally designed	3600	5200	0	2	2	1	2	1	3	2	2	3	5	2	2	2	3	2	5	2	3	3	2	2	4	2	3	2	2	1	2	1	2	2	3	1	1	1	3	1	2	3	3	90	5
Option #3	E4 sinuosity of 1.8 start at middle elevation	2600	5200	0	2	1	1	2	1	2	1	1	2	4	2	2	3	4	2	5	2	2	2	2	3	4	2	3	2	2	1	2	1	2	2	3	1	1	1	3	1	2	3	3	85	4
Option #4	sinuosity of 1.8 maximize head upstream Re-alignment	1800	6200	0	1	1	1	1	1	3	1	1	2	3	1	3	3	4	2	5	2	1	2	2	3	4	2	3	2	2	1	2	1	2	2	3	1	1	5	2	1	1	2	2	82	3
Option #5	C4/5 with sinuosity of 1.1 MINOR re-alignment within existing Ditch footprint	0	4200	0	5	5	3	2	3	3	2	3	3	1	4	1	1	1	1	1	1	1	5	2	1	1	2	3	3	3	1	3	1	3	4	3	1	1	1	3	5	2	2	2	93	6
Option #6	Grade bankfull bench Inplace with no channel work B4/5c sinuousity 1.01 No Re-Alignment	0	0	3975	5	5	3	3	3	4	2	4	4	1	5	1	1	1	1	1	1	1	5	2	1	2	3	4	4	4	2	3	2	3	4	3	1	1	1	4	5	2	3	2	107	7
Option #7	E4 sinuosity of 1.8 start at middle elevation	2600	3800	0	2	1	1	1	1	1	1	1	2	4	2	2	3	4	2	5	2	2	2	2	3	4	2	3	2	2	1	2	1	2	2	3	1	1	1	2	1	2	3	2	81	2
Option #8	Upstream C4/5 with bankfull bench and MINOR realignment 75% within existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	0	3800	2600	1	1	1	1	1	1	1	1	1	1	1	2	3	3	1	1	1	2	1	2	3	3	1	1	1	1	1	1	1	1	1	3	1	1	1	2	1	1	1	2	55	1

	Concept Option Description	MCDA Matrix Score	MCDA RANKING
Option #1	Do nothing G4/5c and B4/5c with a sinuosity of 1.01	132	9
Option #1b	Do nothing G4/5c and B4/5c with a sinuosity of 1.01 Trail Access, Fencing and Replanting	114	8
Option #2	Original DU Design - E4 sinuosity of 1.8 as originally designed	90	5
Option #3	E4 sinuosity of 1.8 start at middle elevation	85	4
Option #4	sinuosity of 1.8 maximize head upstream Re-alignment	82	3
Option #5	C4/5 with sinuosity of 1.1 MINOR re-alignment within existing Ditch footprint	93	6
Option #6	Grade bankfull bench Inplace with no channel work B4/5c sinuousity 1.01 No Re-Alignment	107	7
Option #7	E4 sinuosity of 1.8 start at middle elevation	81	2
Option #8	Upstream C4/5 with bankfull bench and MINOR realignment 75% within existing Ditch FootPrint - Downstream E4 sinuosity of 1.8 start at middle elevation	55	1

NEBRASKA GAME PARKS

resourceful. naturally. BARR

MCDA - Consensus

- 9 Alternatives (Included 3 design toolbox-philosophies) and ~ 35 tools
- 7 Goals
- 39 Objectives
- 18 Stakeholders
- One day to reach consensus
- Preferred Alternative was optimized with later design phases

NEBRASKA GAME PARKS

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3 Design Toolbox - Philosophies – Ecosystem Restoration

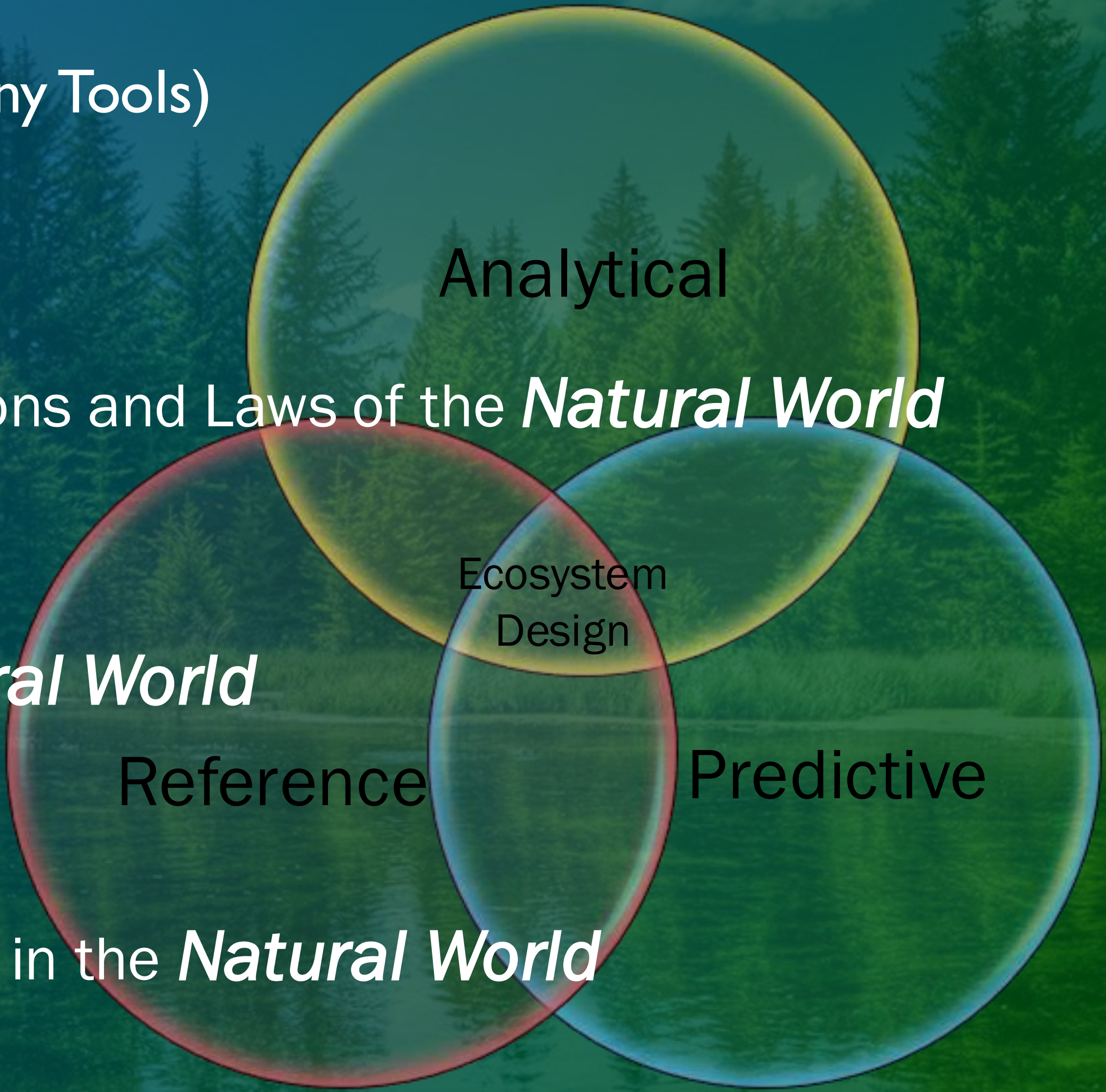
- Analytical Based Design
  - Understanding of ***Scientific*** Equations and Laws of the ***Natural World***

- Reference Based Design
  - ***Scientific*** observation of the ***Natural World***

- Predictive Based Design
  - ***Scientific*** prediction of interactions in the ***Natural World***

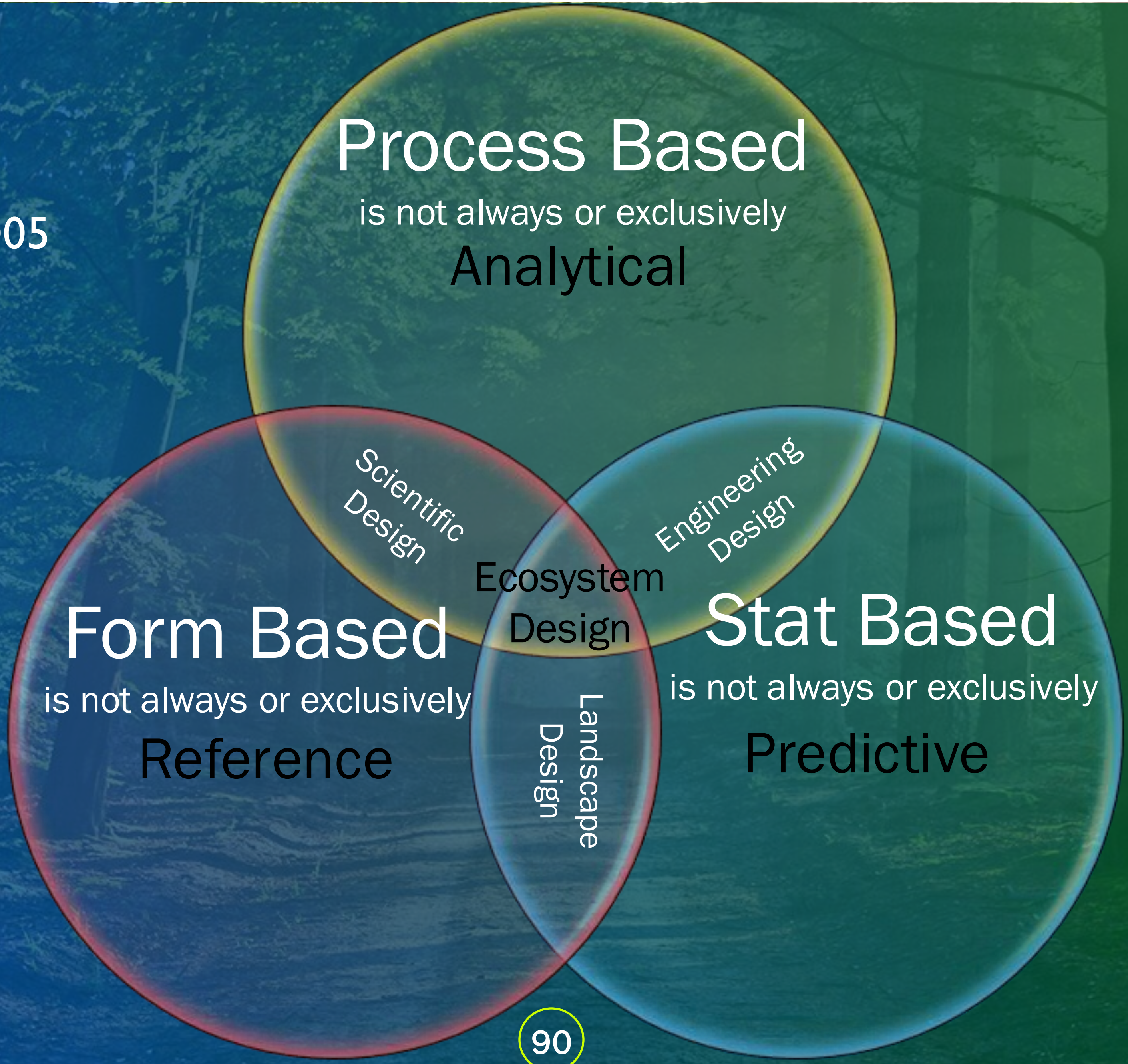
Ecosystem Design (Many Tools)

- Analytical Based Design
  - Understanding of ***Scientific*** Equations and Laws of the ***Natural World***
- Reference Based Design
  - ***Scientific*** observation of the ***Natural World***
- Predictive Based Design
  - ***Scientific*** prediction of interactions in the ***Natural World***

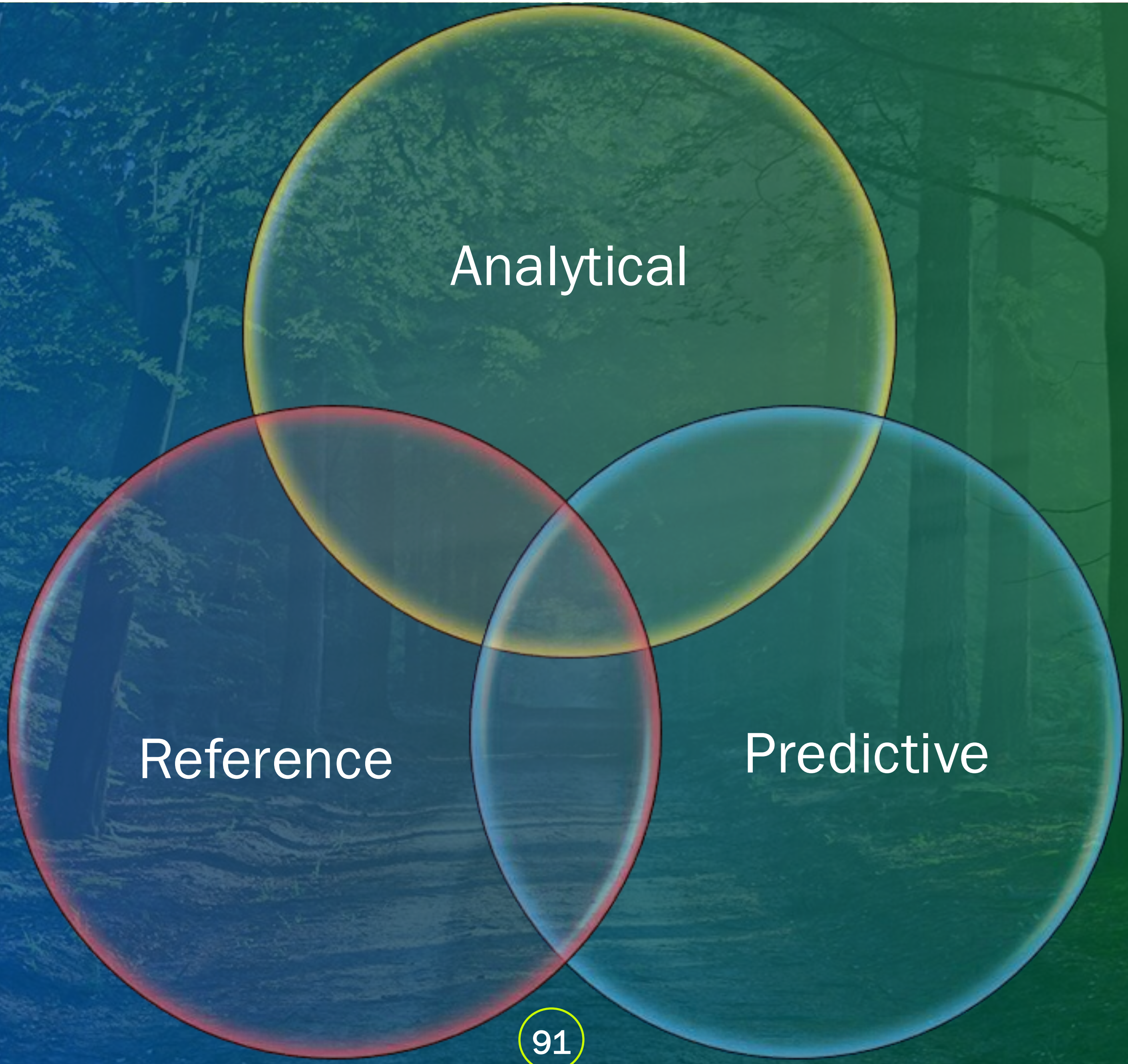


(Many Tools)
Process vs. Form

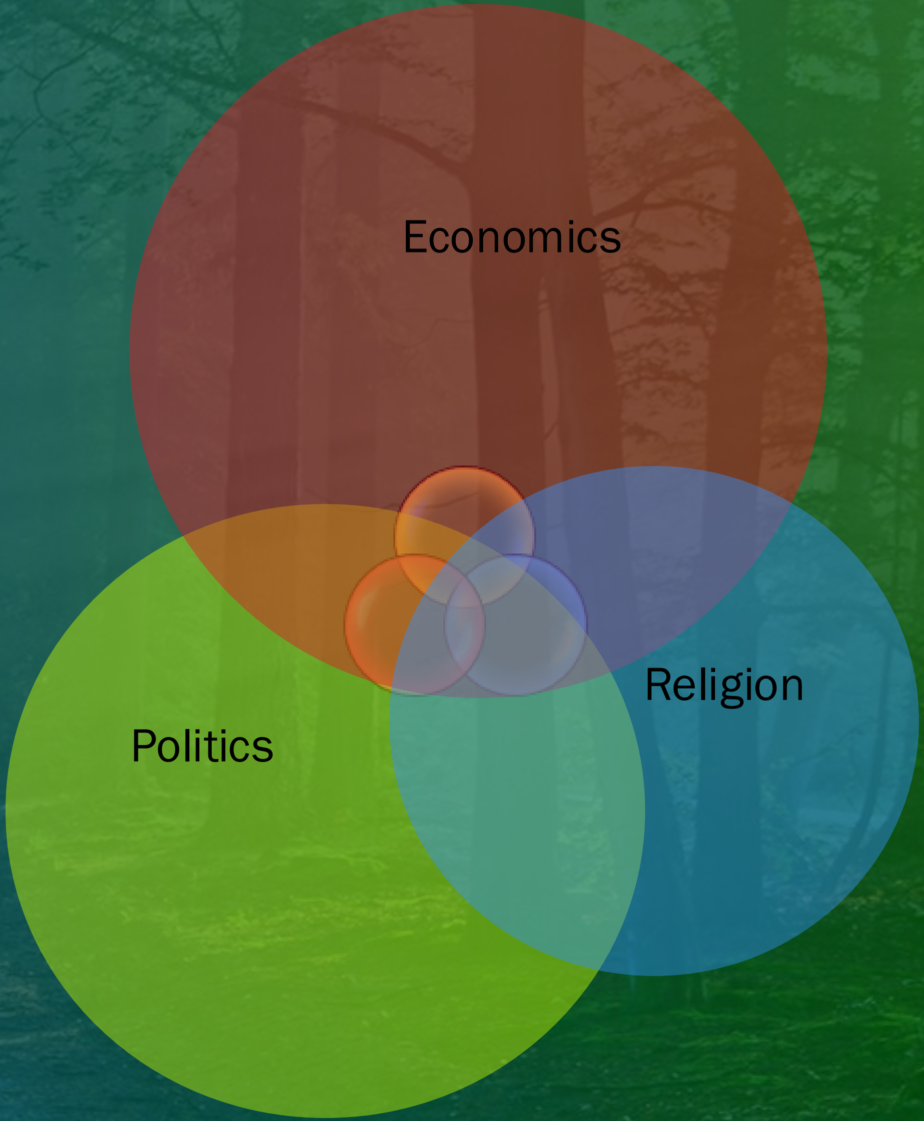
Motgomery, 1999
Bernhardt, et al, 2005
Kondolf, et al, 2006
Kasprak, et al, 2016



(Many Tools)
Class – Example
Bundling Tools



(Many Tools)
Class – Example
Parallel Universes (Scientific American, 2022)
Statement – "I Hate the Multiverse" LWF



Risky Business living in the Multiverse?
What is RISK?

USACOE definition on risk analysis

http://corpsriskanalysisgateway.us/lms/course.cfml?crs=5&crspg=218

Risk = Probability x Consequence

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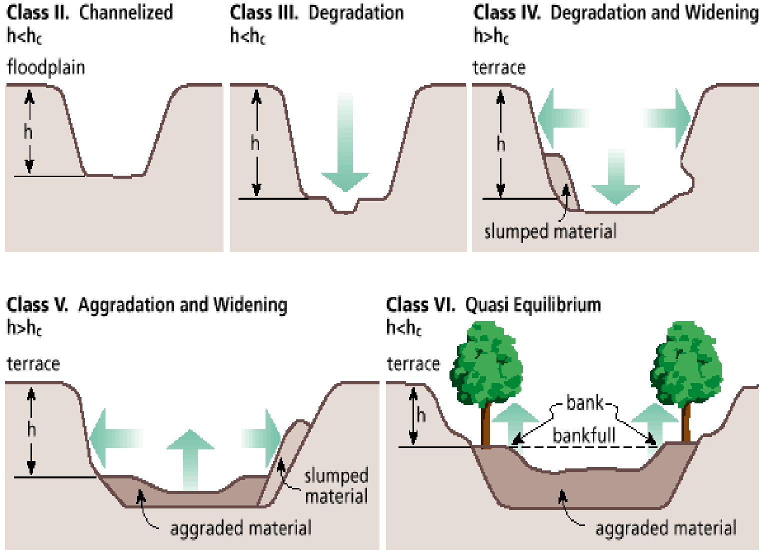
Risk of Channel Evolution?

- Similar response from both watershed and channel hydromodification



Simon's (1989) model of channel response in disturbed alluvial channels

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Current Stormwater BMPs

We now attempt to correct hydromodification through structural stormwater Best Management Practices (BMPs) <u>on</u> the <u>watershed</u>.

- Silt Fences
- Hydromulching & Sodding
- Sediment Capture Ponds
- Regional and Onsite Detention/Retention
- Low Impact Development (LID) & Pre-Development Hydrology!!!

Sounds good…so what's the problem?

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Problems with Current Stormwater BMPs

- Deal only with the watershed and not the channel
- Don't address in-channel processes or channel evolution in response to:
  - Past watershed hydromodification
  - Continued prescribed channel hydromodification of MS4 (drainage and flood control) channels
  - Increased channel instability from peak-flow stormwater detention
- Channel evolution is a major source of stream impairment

Probability of Upland/Hillslope vs. In-Channel Sediment Loads

- Sediment from stream channels account for as much as 85% of watershed sediment yields, and streambank retreat rates as high as 7.26 m/yr have been documented (Simon, A. et al, 2000)

200′ long x 15′ tall eroding failing/ retreating channel bank = 631,000 tons eroded during seven months, or:

X 42,000

1 acre x 5″ erosion over 1-yr period = 670 cy x 1.1 tons/cy = 740 tons

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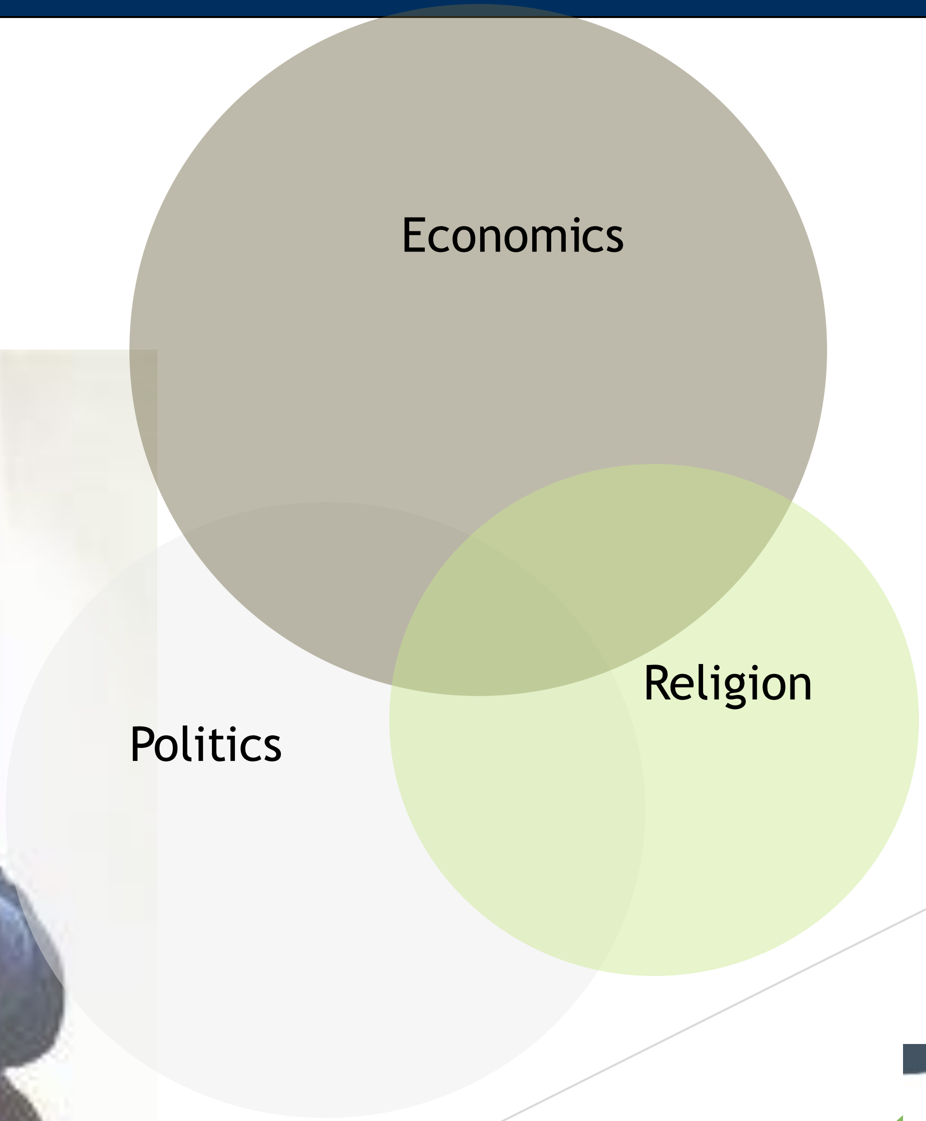
What are some other Types of Risk?



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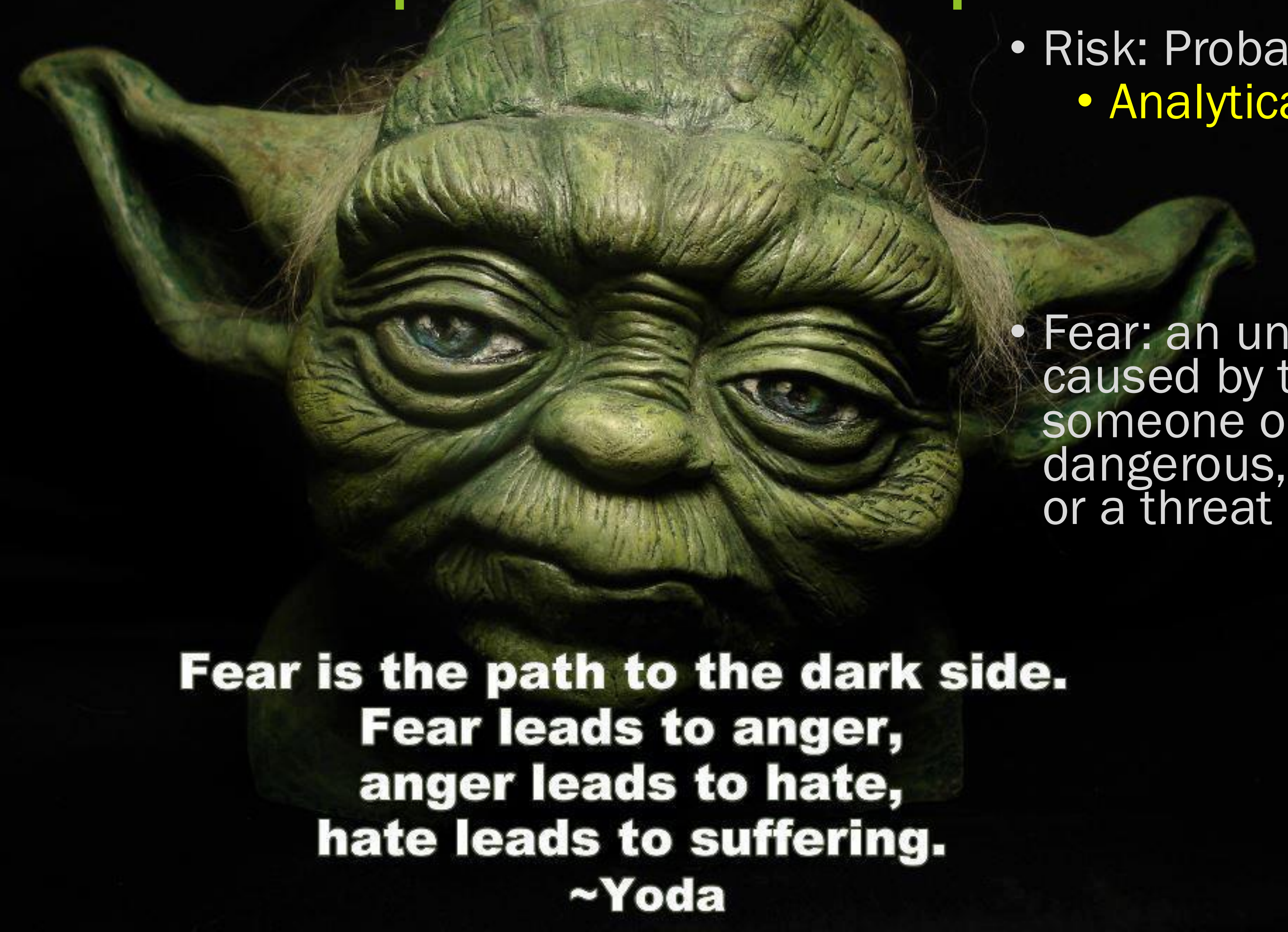
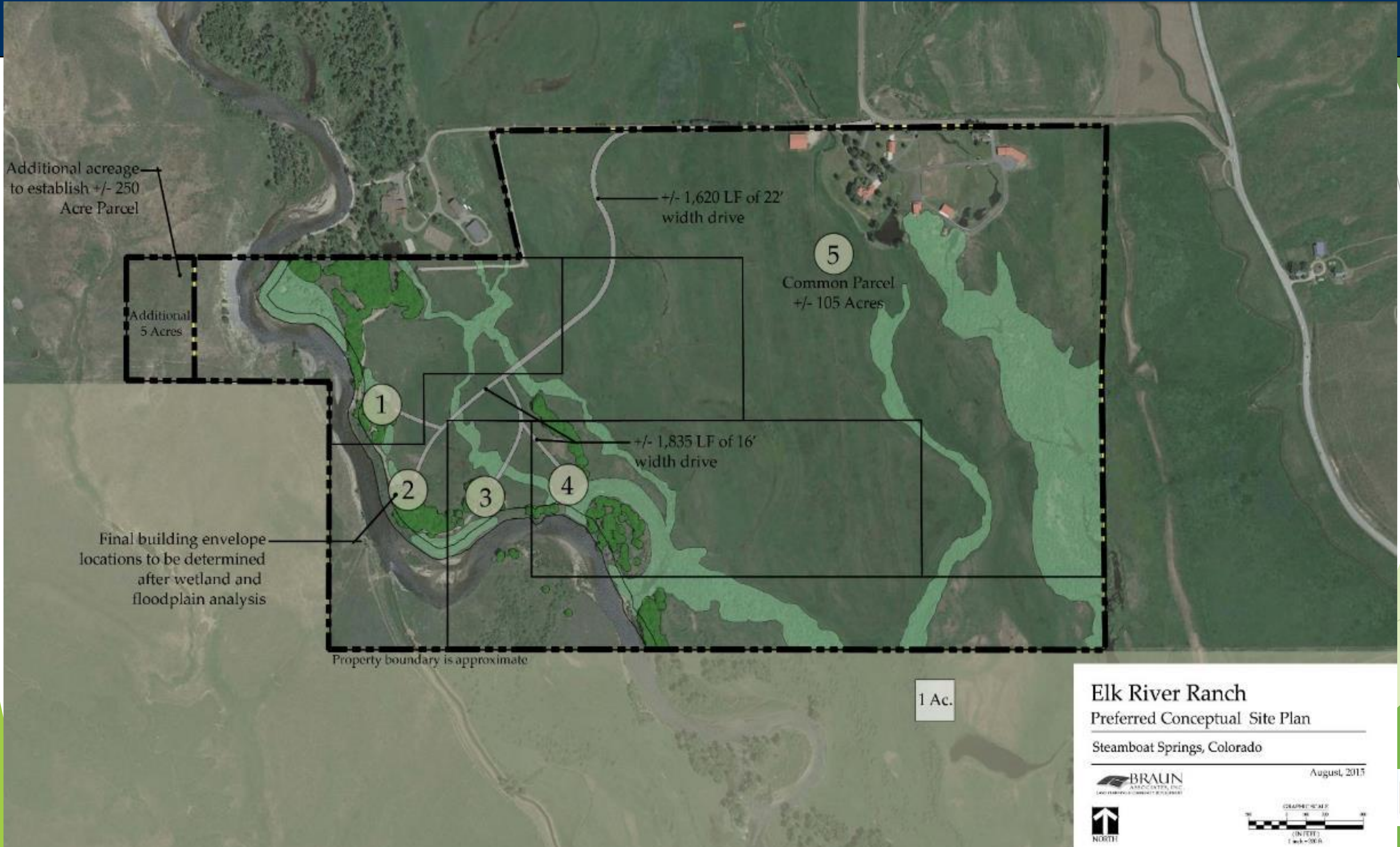
Can we keep risk and fear separated?

- Risk: Probability x Consequence
    - Analytical equation

- Fear: an unpleasant emotion caused by the belief that someone or something is dangerous, likely to cause pain, or a threat



What are Types of Risk?



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Enter an address, place, or coordinates:

Clark, CO

This locator map shows flood map boundaries with the map for your location selected. You can choose a new flood map by changing the view and selecting a point or entering a new location in the search box. The buttons to the left let you view and print the selected flood map, download the flood map image, open an interactive flood map (if available), or expand the search to all products to view effective, preliminary, pending, or historic maps, and risk products for the community.

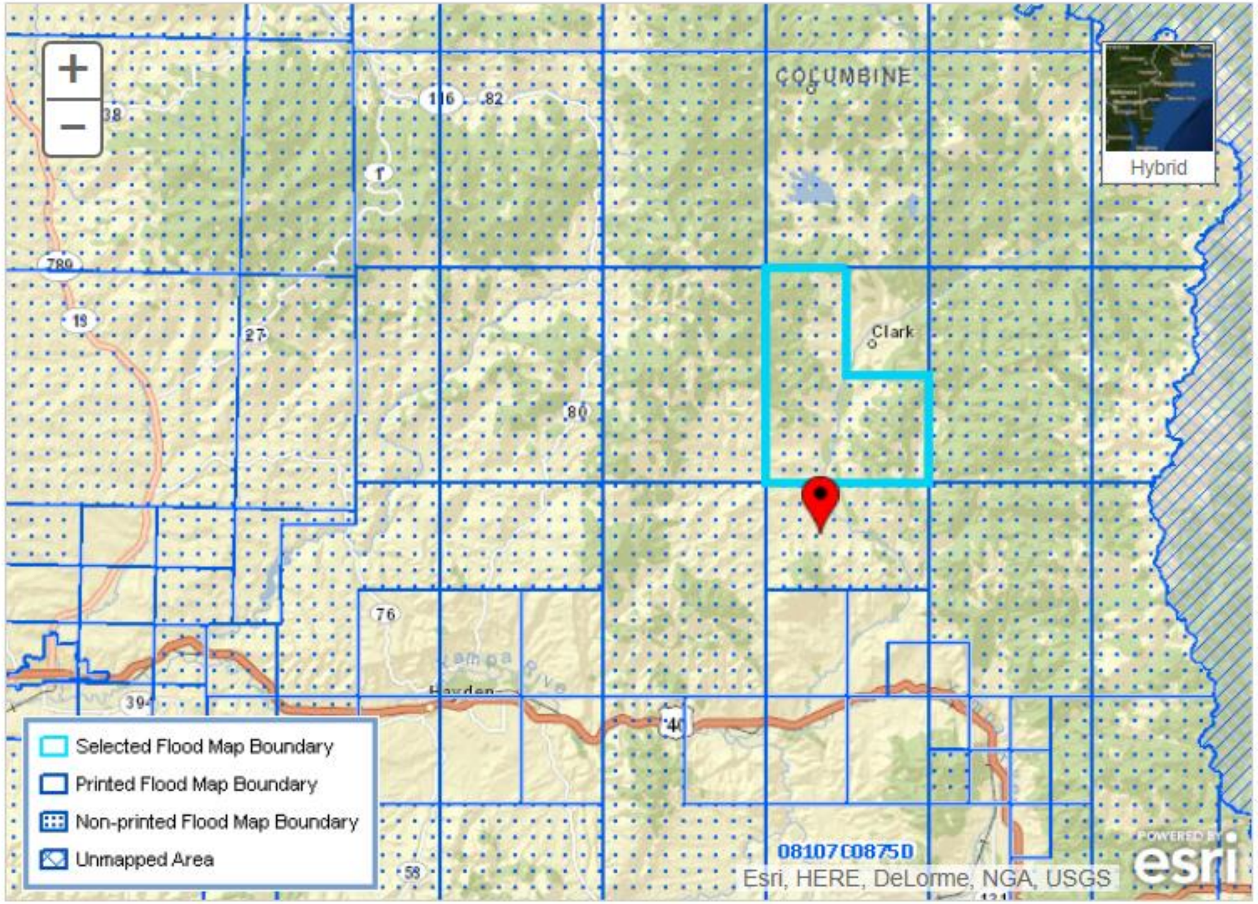
You have selected a location in

ROUTT CO*

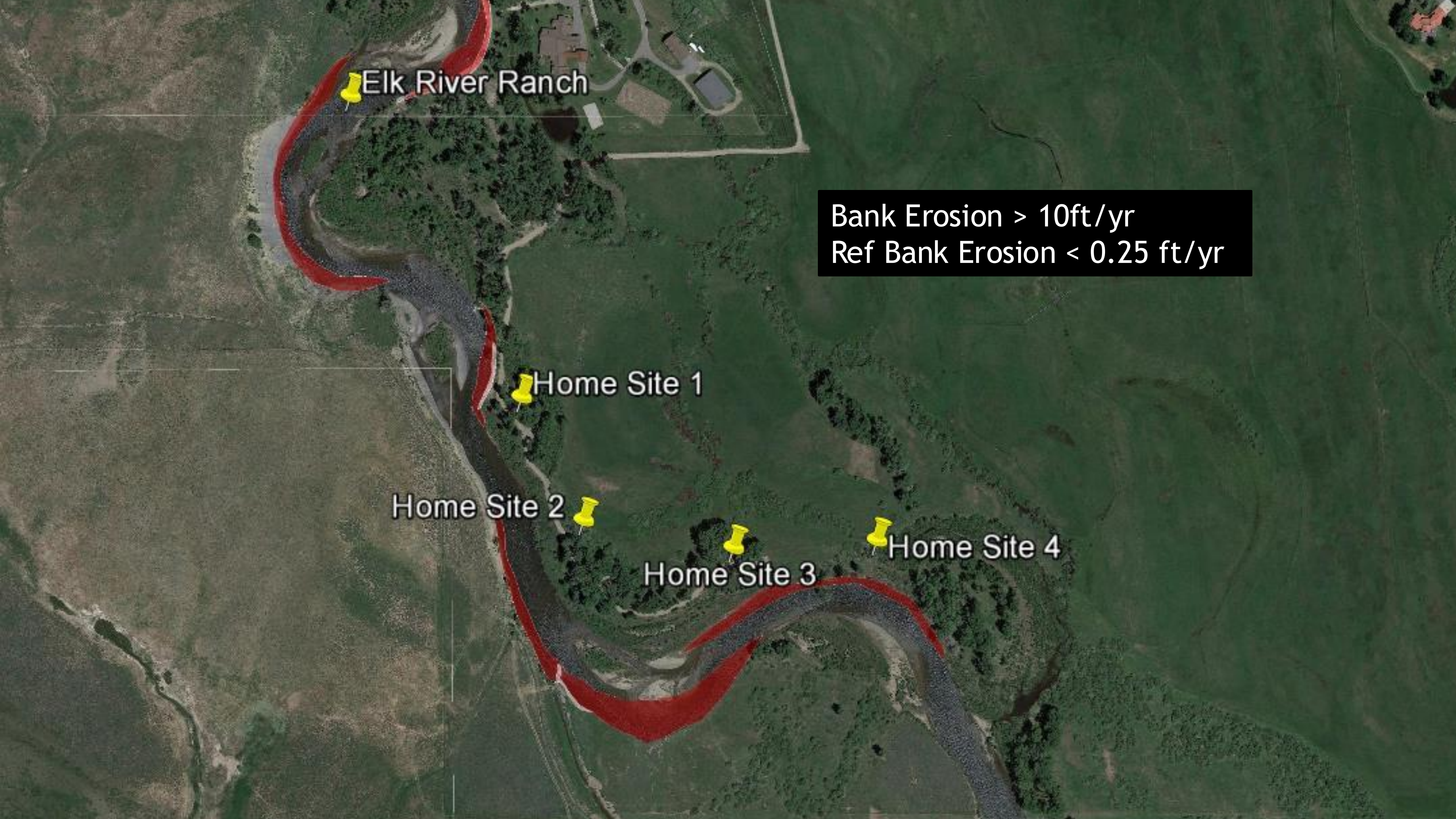
There is no flood map printed for the selected location. A digital version of the map panel for the selected location in the National Flood Hazard Layer (NFHL) can be viewed by clicking the "Interactive Map" icon below. Here you can track the status of effective Letters of Map Revision (LOMR) and Amendment (LOMA), and search details regarding individual map panels. You can view or download the FIRM Panel Index by selecting the "Show all products for this area" link at the bottom of this section.

INTERACTIVE MAP

Show **all products** for this area




Elk River Ranch
Home Site 1
Home Site 2
Home Site 3
Home Site 4


Elk River Ranch
Bank Erosion > 10ft/yr
Ref Bank Erosion < 0.25 ft/yr
Home Site 1
Home Site 2
Home Site 3
Home Site 4

Construction Risk?


3+72.94 C-3.40

3-D Construction

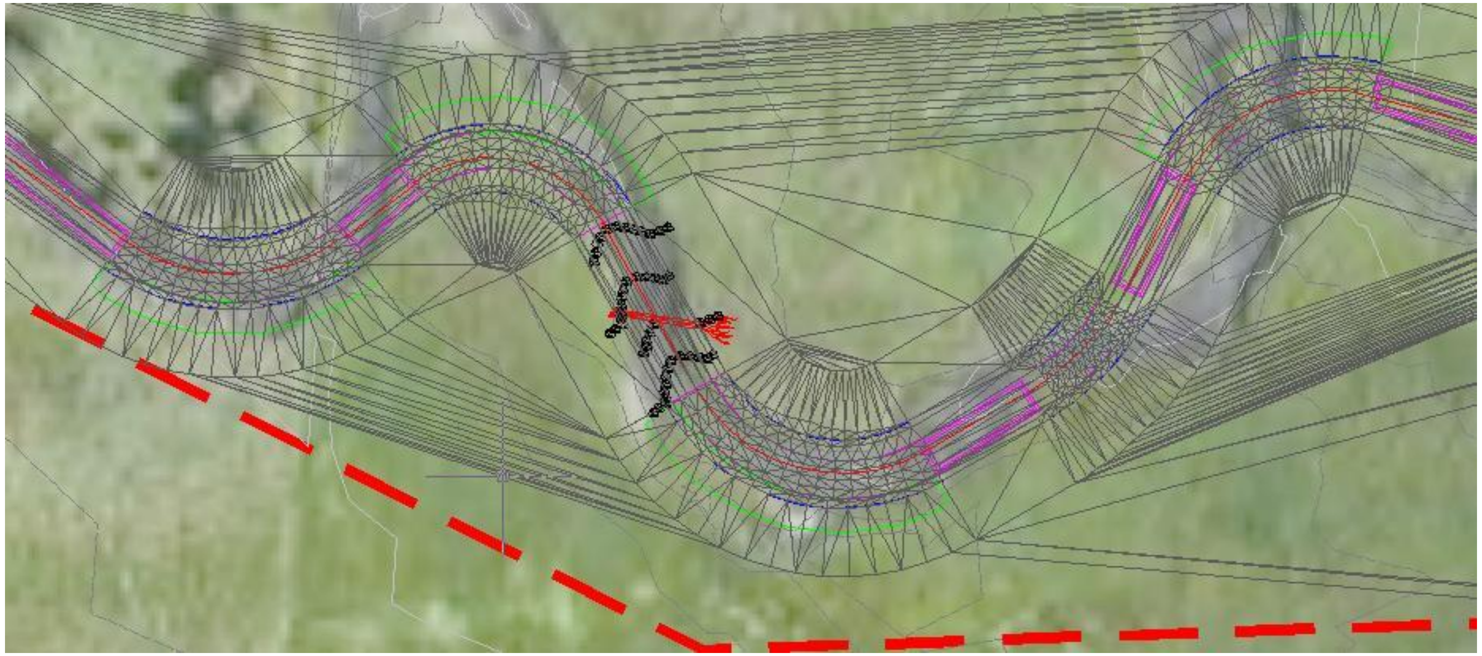
GPS Technology

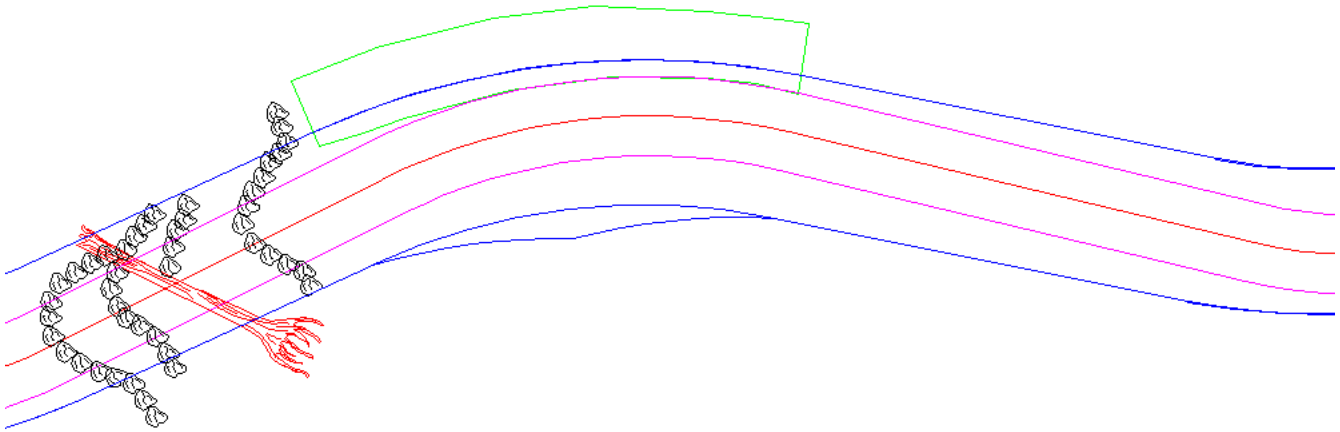
3-D Construction

3-D Construction

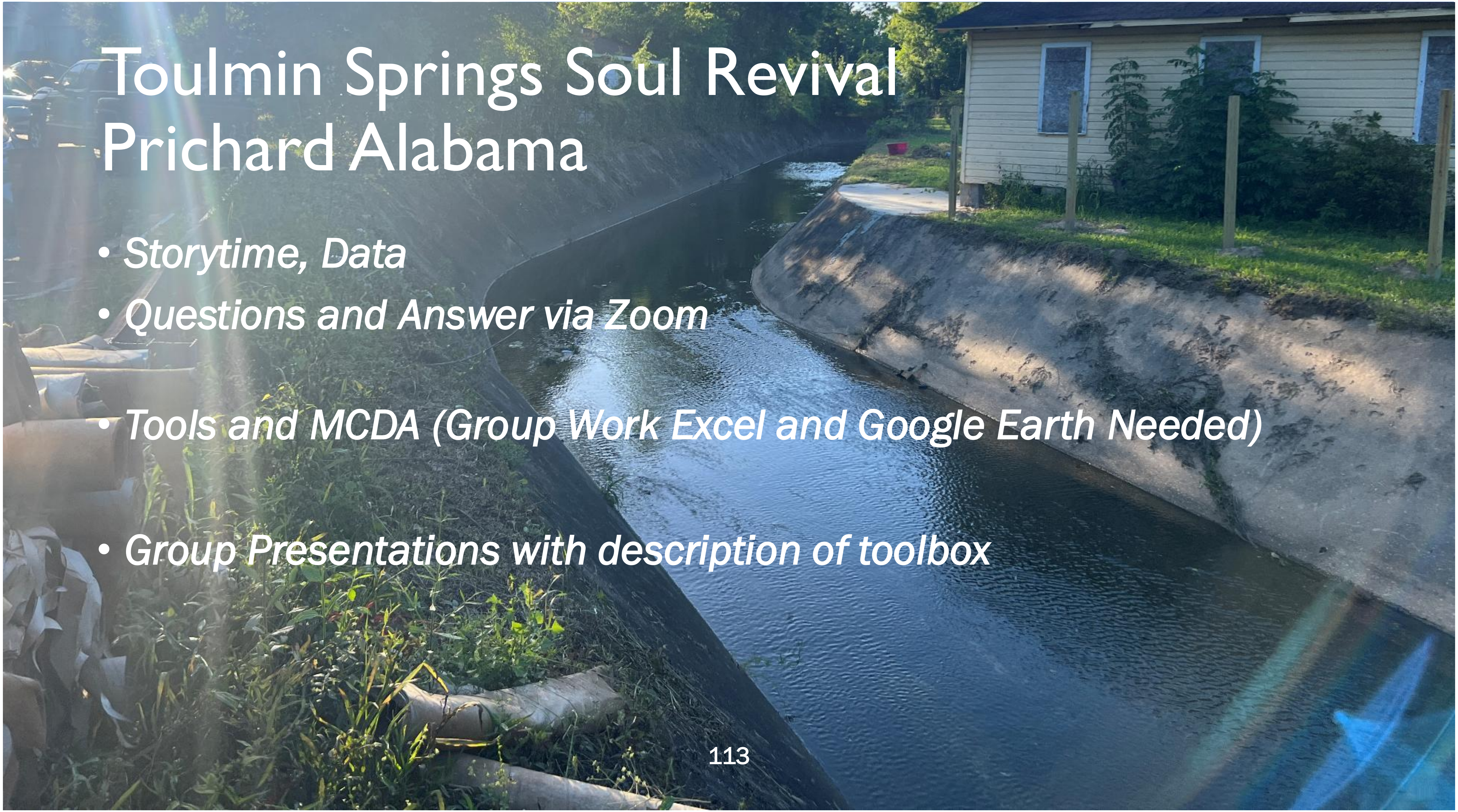
3-D Construction

3-D Construction





3-D Construction



Toulmin Springs Soul Revival Prichard Alabama

- *Storytime, Data*
- *Questions and Answer via Zoom*
- *Tools and MCDA (Group Work Excel and Google Earth Needed)*
- *Group Presentations with description of toolbox*

Prichard Alabama 1960 post WWII

- *Est. 1925 from Africatown*
- Schooner ***Clotilda 1860***

Prichard Alabama 2017

- https://247wallst.com/special-report/2019/02/04/worst-cities-to-live-in/9/
- Top 50 Worst Cities to Live in the USA
- Likely Pritchard would rank higher than 12th in 2023

Source: Michael Rivera / Wikimedia Commons

12. Prichard, Alabama

> **Population:** 22,063

> **Poverty rate:** 35.1% (top 10%)

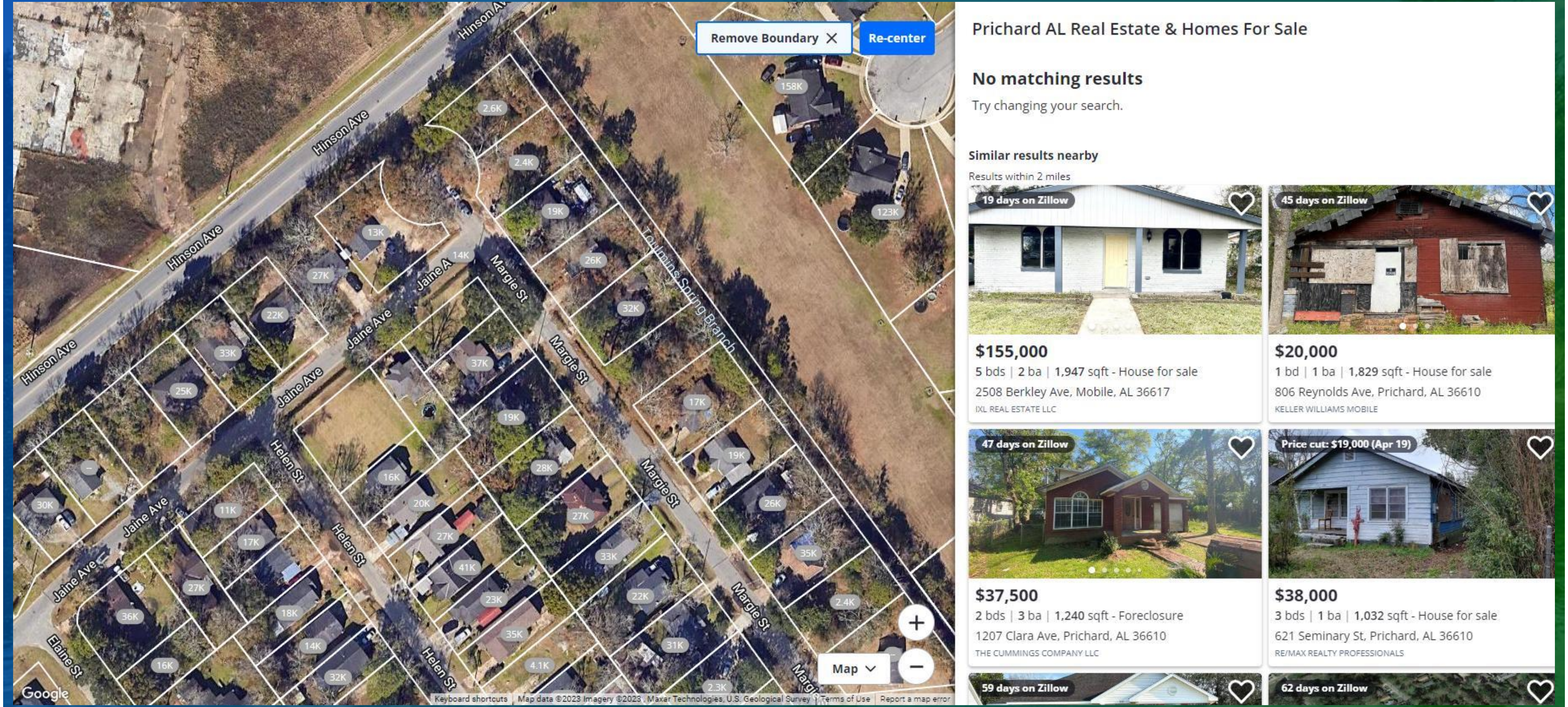
> **2017 violent crimes per 100,000 people:** 1,826 (top 10%)

> **Median home value:** $67,400 (bottom 10%)

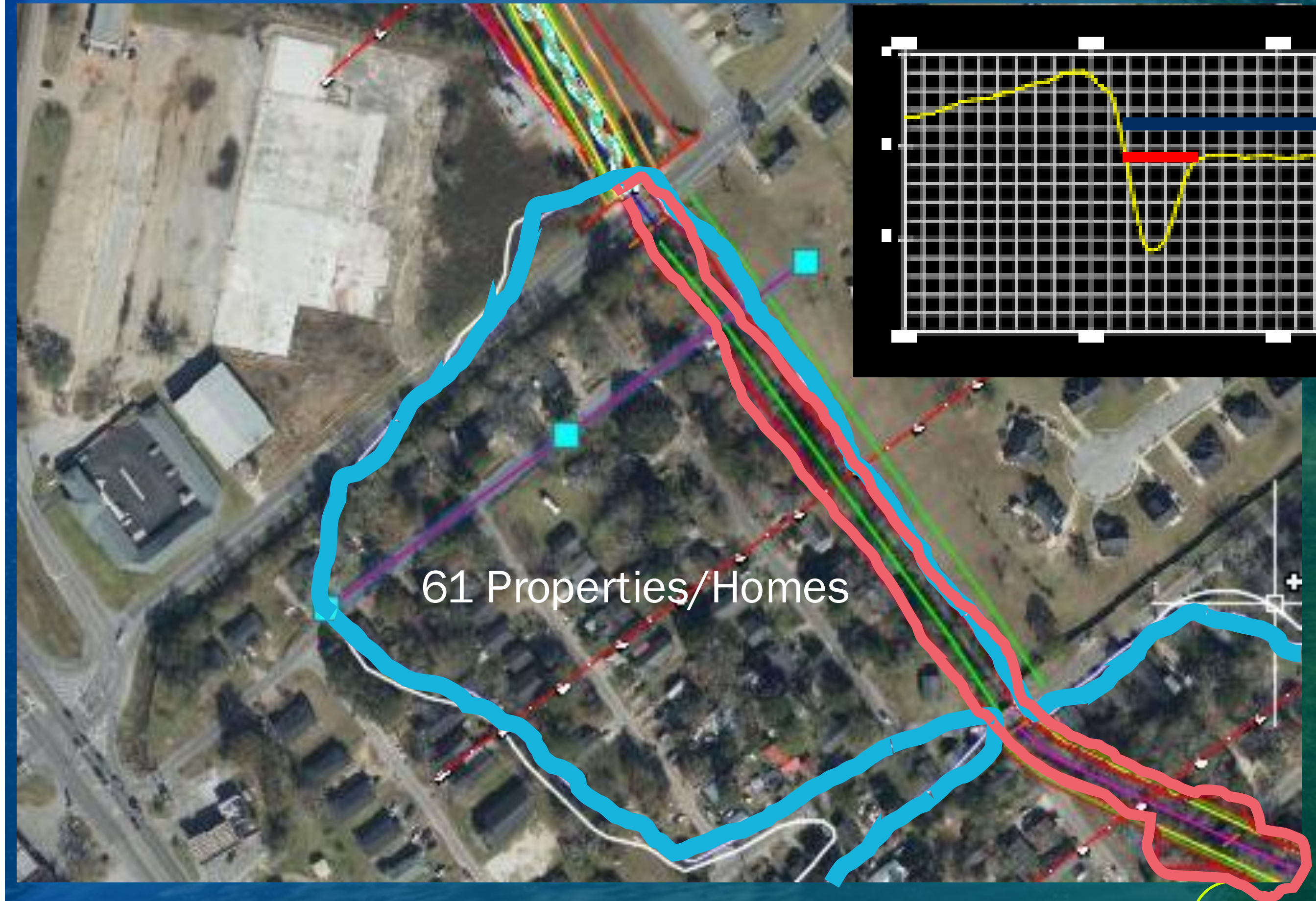
Over the past five years, the number of jobs in Prichard, Alabama has decreased by nearly 17%, one of the highest rates of job losses anywhere in the country. Over the same period, employment climbed 6.1% nationwide.

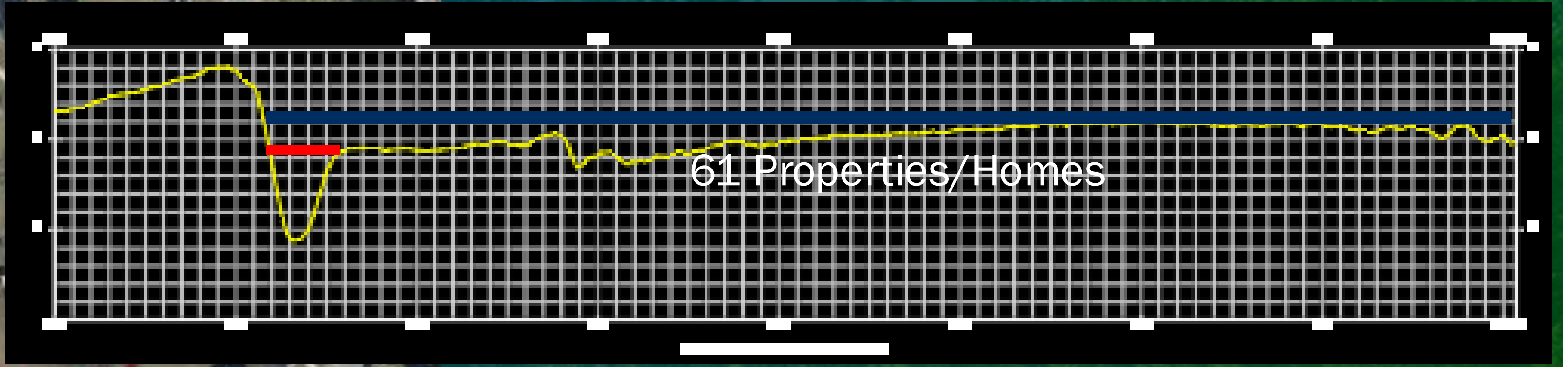
Prichard, near Mobile in southern Alabama, has a median annual household income of $25,818 — less than half of the U.S. median. Prichard, like many other low income areas on this list, is losing residents. In the last five years, Prichard's population dropped by 3.4%.

Prichard Alabama 2023



Data Toulmin Springs -FEMA





What could be done?
Toulmin Springs is a "Problem"

Why are these Tools being used for Ecosystem Restoration?

- They are relatively good to set a system on the Trajectory of Ecosystem Restoration – **They work**
- They are relatively simple to set a system on the Trajectory of Ecosystem Restoration – **I understand them**
- They provide me with credit for my effort/involvement– **They are mine**
- Other Potentials
  - Mental Health Recovery
  - Community Revival

"Let your light shine before others that they may see your good deeds and glorify your Father in heaven"

Jesus

"If we have seen further, it is by standing on the shoulders of Giants"

Isaac Newton

"Truth without Humility would be an arrogant caricature"

M.K. Gandhi

Mental Health – Hope and Humility

HOPE	Pride - **Hubris**	Humility - **Grounded**
Hopeful	Combatant	Disciple
Hopeless	Cynic	Exhausted

AWE

HUMILITY

Fishing Links Ecosystem Sport - Tool

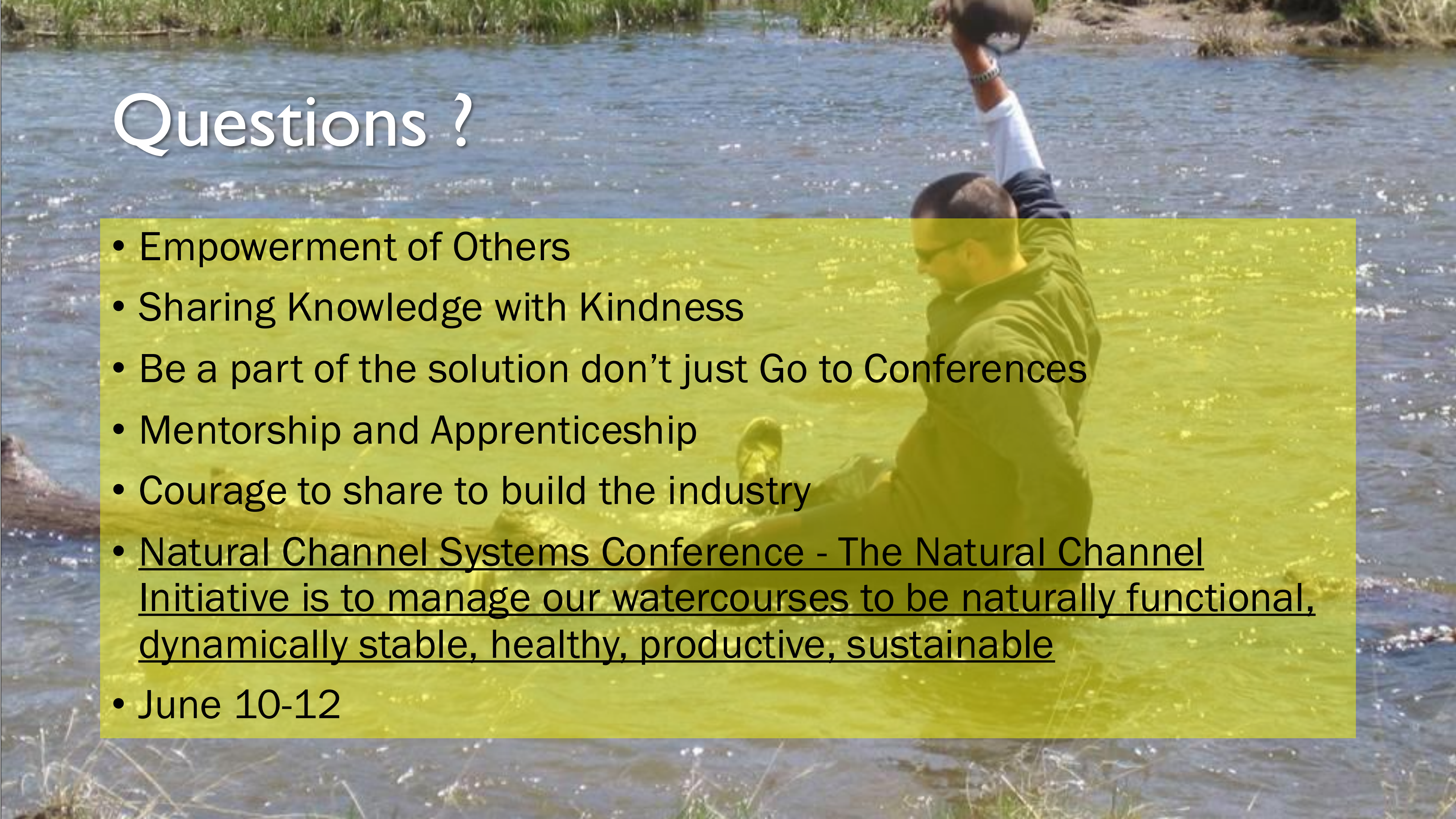
- Demonstration of ecosystem function
- 3-hr journey at defined location
- Promote native species
- Digital applications
- Connect to wonderment and awe

3-D Ecosystem Restoration Toolboxes

Need to be organized for the job and sometimes we need new tools

Thoughts should allow us to stay child-like and be amazed by Truth

Dreams can be a reflection to honor the Truth



Questions ?

- Empowerment of Others
- Sharing Knowledge with Kindness
- Be a part of the solution don't just Go to Conferences
- Mentorship and Apprenticeship
- Courage to share to build the industry
- Natural Channel Systems Conference - The Natural Channel Initiative is to manage our watercourses to be naturally functional, dynamically stable, healthy, productive, sustainable
- June 10-12

THANK YOU!

riverSHARED.org

David Bidelspach

Phone
919-218-0864

Email
dave@fivessr.com

Workshop 4 – 3-D Process Based Natural Corridor Design

Facilitated by: David Bidelspach, 5 Smooth Stones Restoration, PLLC

David Bidelspach (P.E., P.Eng.) is a Design Engineer and Partner at 5 Smooth Stones Restoration, PLLC. He has been recognized as a 3-D River Restoration specialist with a broad range of experience restoring damaged ecosystems.

Mr. Bidelspach's academic and research background includes University, Government, Engineering Consultant and Equipment Operator, where he has provided assessment, design, and construction oversight services on many restoration projects.

Teaching professional training courses related to river assessment, restoration design, and construction for over 20 years, Mr. Bidelspach is passionate about sharing the gift of ecosystem restoration with the next generations. He also worked for nine years as the river restoration technical leader for Stantec Consulting.

He has been involved in more than 150 river restoration/channel stabilization projects in 32 states, 7 Canadian Provinces/Territories, Costa Rica and Ecuador. He has been blessed to be tagging along with the teaching of Fluvial Geomorphology and Stream Restoration Sciences since 2002.

Fee: $200+ HST

Time: Wednesday June 10, 1:30 p.m. to 5:00 p.m., Thursday June 11, 9:00 a.m. to 5:00 p.m., and Friday June 12 9:00 a.m. to noon

Where: Peter George Centre for Living and Learning (PCGLL) Room TBA

Limited to 40 Participants

Requirements: Participants will need a laptop and stationery items (notebook and pen/pencil)

Included:

- Parking on campus for the day(s)
- Wednesday Buffet Lunch
- Thursday Breakfast (coffee, tea and pastries)
- Thursday Boxed Lunch
- Friday Breakfast (coffee, tea and pastries)

Course Outline:

Wednesday p.m.: 3-D Ecosystem Corridor Design – History and Current Tools

- Welcome
- What is Ecosystem Corridor Design (Breakout Groups)
- Ancient Reference Based Channel Design
- Classical Fluvial Geomorphology
- Bankfull Flow and Natural Channel Design
- Beyond or Beneath Channel Forming
- Corridor Restoration with Stormwater BMPS
- Introduction Ancaster Creek on McMaster University Campus (Potential Site Visit)
- Why – 3-D Ecosystem Corridor Design or Restoration (Breakout Groups)

Thursday a.m.: 3-D Process Based Natural Corridor Design (PB-NCD) Optimization Tools

- Goals and Objectives – Ancaster Creek

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