Fat Bikes & Sand Creek Channel Restoration

George Strait

Ron Howard

Fat Bikes & Sand Creek Channel Restoration

Walt Pennington

Adam Copper

Fat Bikes & Sand Creek Channel Restoration

Presenters:
Adam Copper, PE – City of Colorado Springs
Walt Pennington, PE, CFM – Merrick & Company

2019 CASFM Annual Conference

October 9, 2019

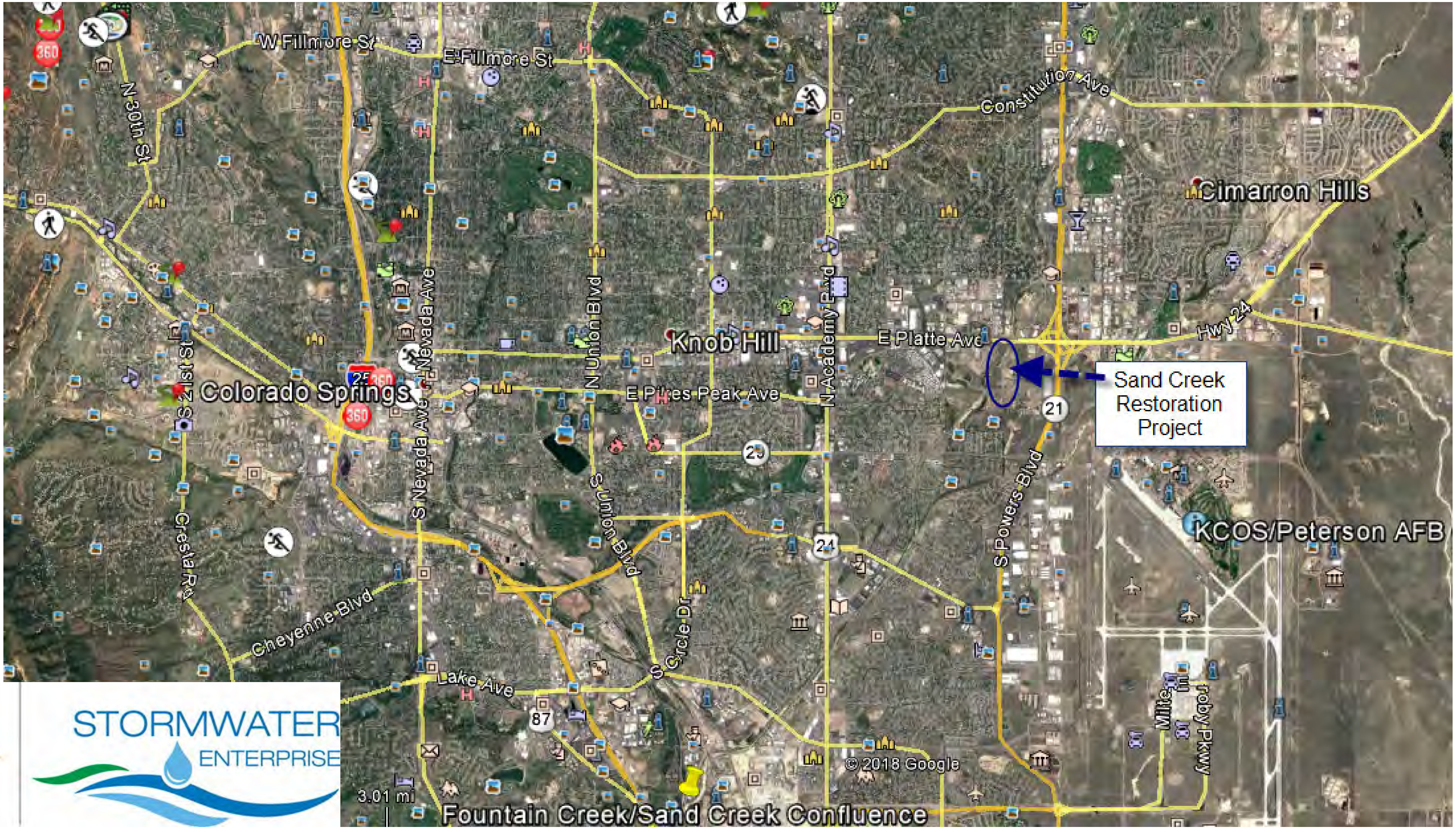
Project Team

- RESPEC – Civil Engineering
- The Architerra Group –Landscape Architect
- Corvus Environmental Consulting – Environmental
- Vivid Engineering Group – Geotechnical
- Clark Land Surveying – Topographic Surveying
- Tezak Heavy Equipment – Contractor

FAT TIRE


FAT TIRE
Amber Ale
NEW BELGIUM
BREWED AND BOTTLED BY
NEW BELGIUM BREWING • FORT COLLINS, CO USA
365beers.wordpress.com

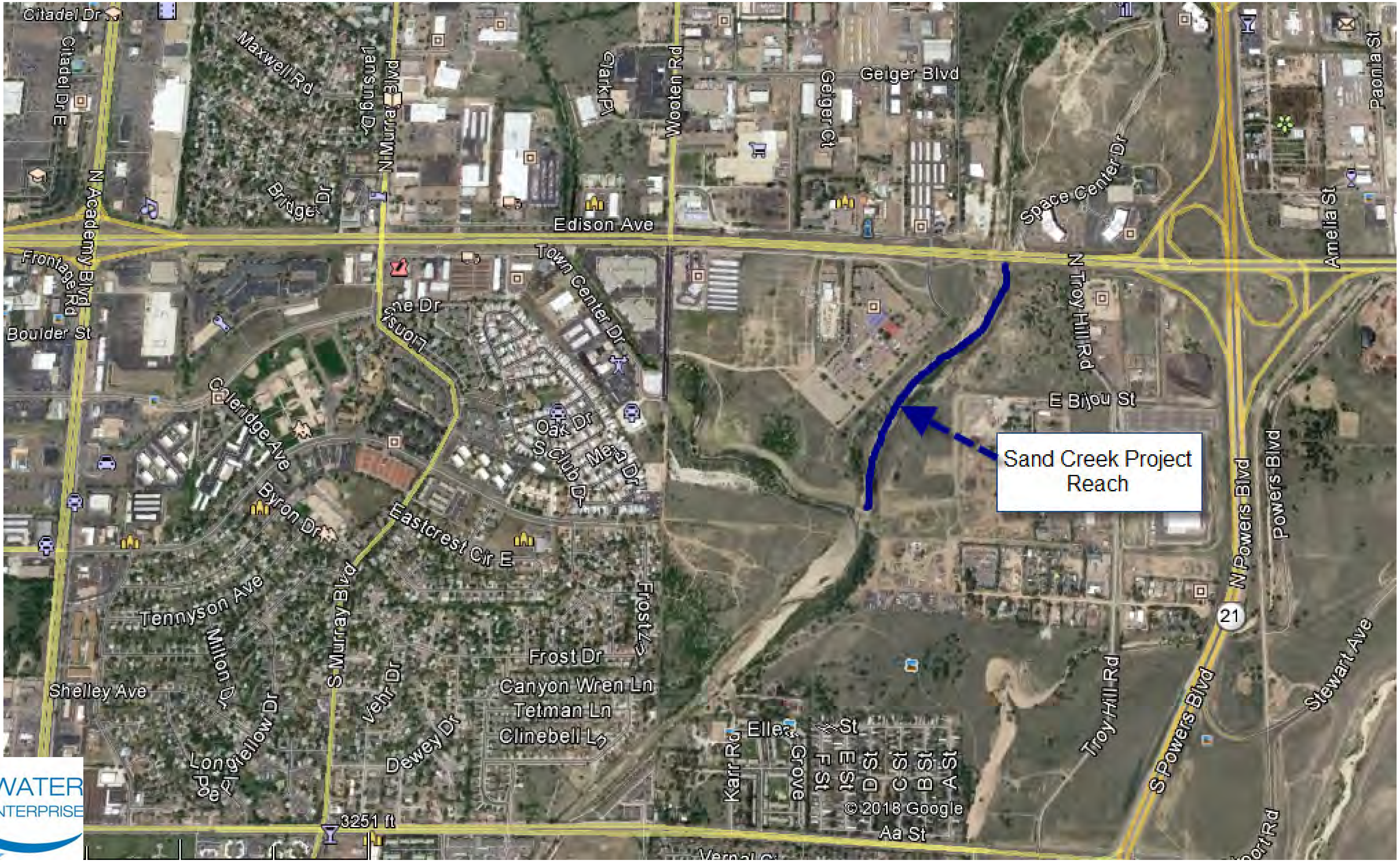
Location



COLORADO SPRINGS OLYMPIC CITY USA

STORMWATER ENTERPRISE

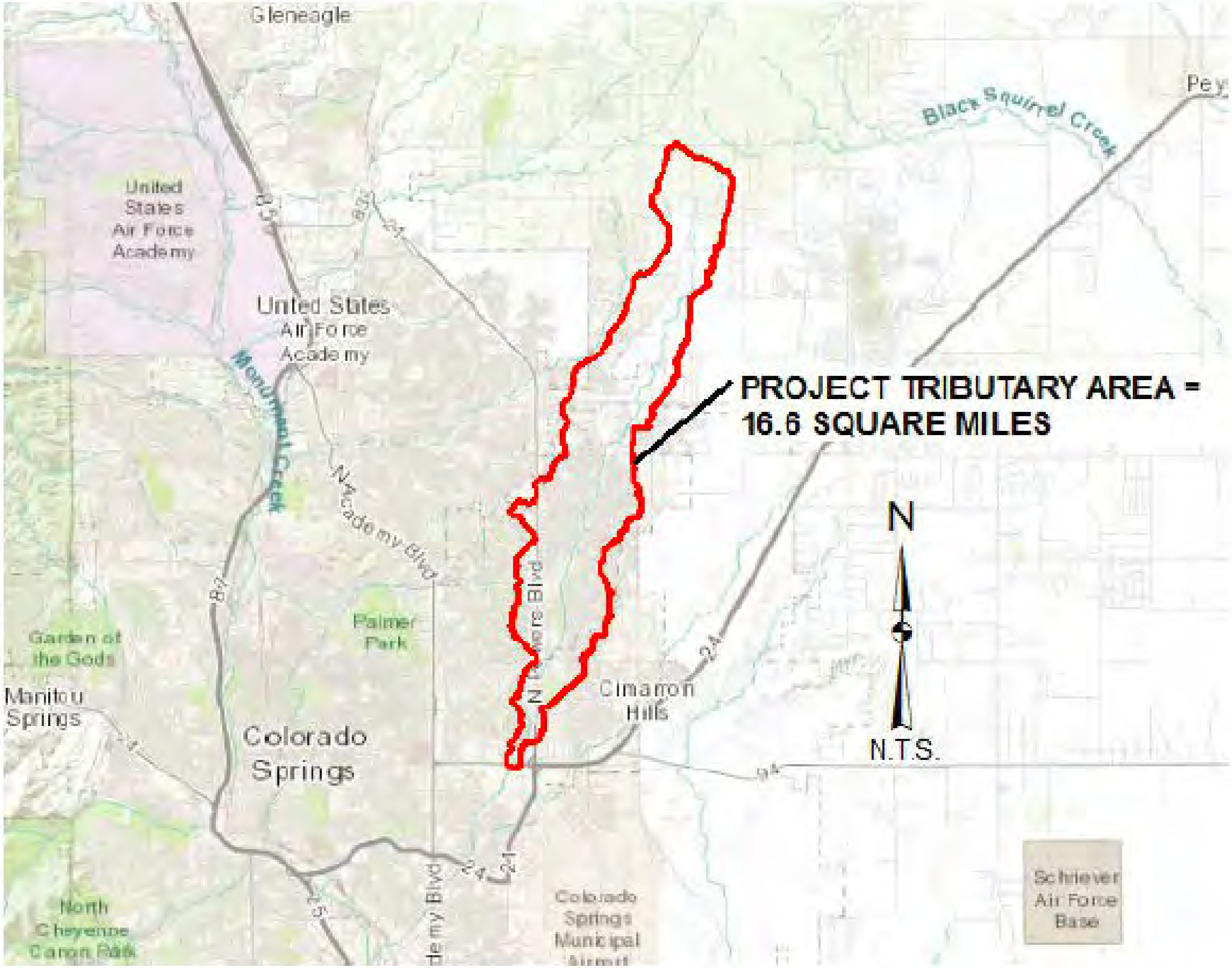
Location



COLORADO SPRINGS
OLYMPIC CITY USA

STORMWATER ENTERPRISE

Drainage Area



History of Problems – Drop Structure Failure (2006)

History of Problems

COLORADO SPRINGS OLYMPIC CITY USA | STORMWATER ENTERPRISE

Emergency Bridge Closure

Existing Grade Control Structure

- Total Height: 38-ft
- Original Construction in 2006 (Height: 10-ft)
- Structure extended in 2007 and 2008

2012 Rainfall-Runoff Event

COLORADO SPRINGS
OLYMPIC CITY USA
STORMWATER ENTERPRISE

Existing Channel Dimensions

Project Funding

- Sand Creek project – priority listing #9 out of 70
- City received FEMA (HMGP) grant
- City Contribution (property acquisition, earthwork import)
- Total Project Funding = $6.3 Million

COLORADO SPRINGS OLYMPIC CITY USA | STORMWATER ENTERPRISE

Project objectives

- Floodplain Management
- Channel Stabilization
- Bank stabilization
- Permitting
- Fat Tire Bike Access
- Maintenance and public access
- Landscape restoration
- Easements
- Ecological Improvements

COLORADO SPRINGS
OLYMPIC CITY USA
STORMWATER ENTERPRISE

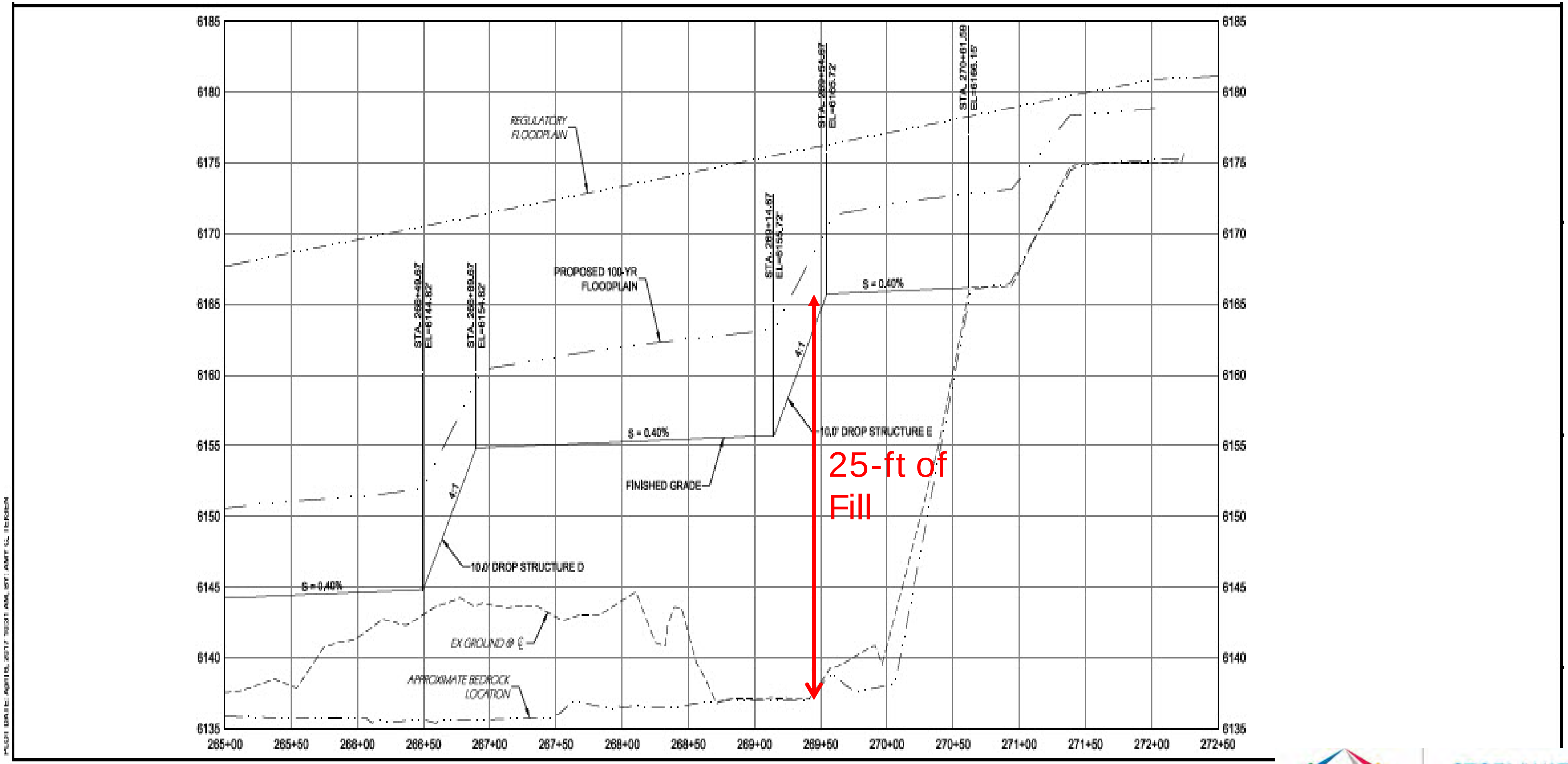
Grade Control Alternatives

Sculptured Concrete

Soil Cement

Grouted Boulders

Earthwork

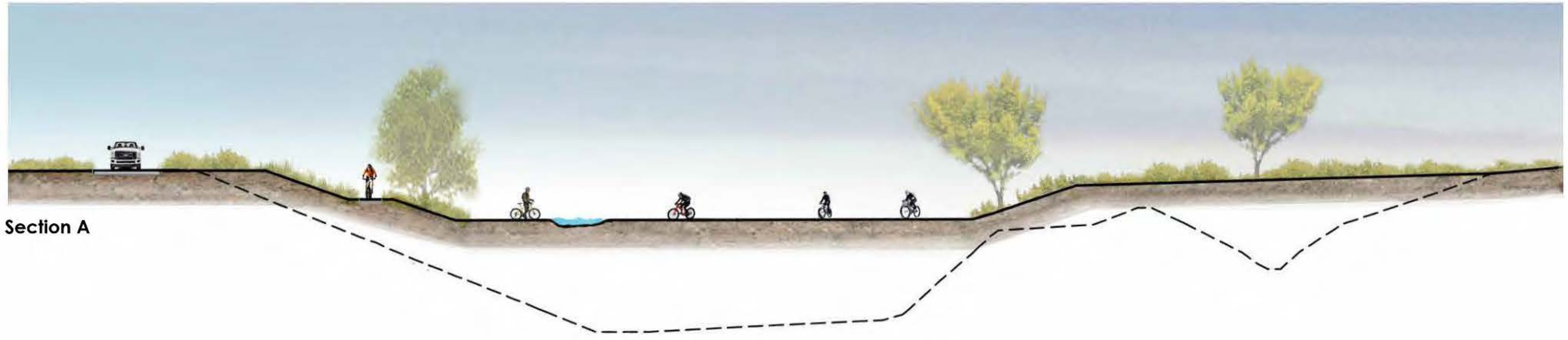


COLORADO SPRINGS OLYMPIC CITY USA
STORMWATER ENTERPRISE

Project Challenges

- Imported Fill (40,000 cy); Total Earthwork 66,000 cy
- Off-site Sources ($700,000 City Savings)
  - Upstream detention pond maintenance
  - Developers Export
- Boulder Supply (7,000 sy)(2 different quarries)
  - Varied Boulder sizes across structure ($50,000 Savings)
- Buried portions of the grade control structure (smaller footprint)

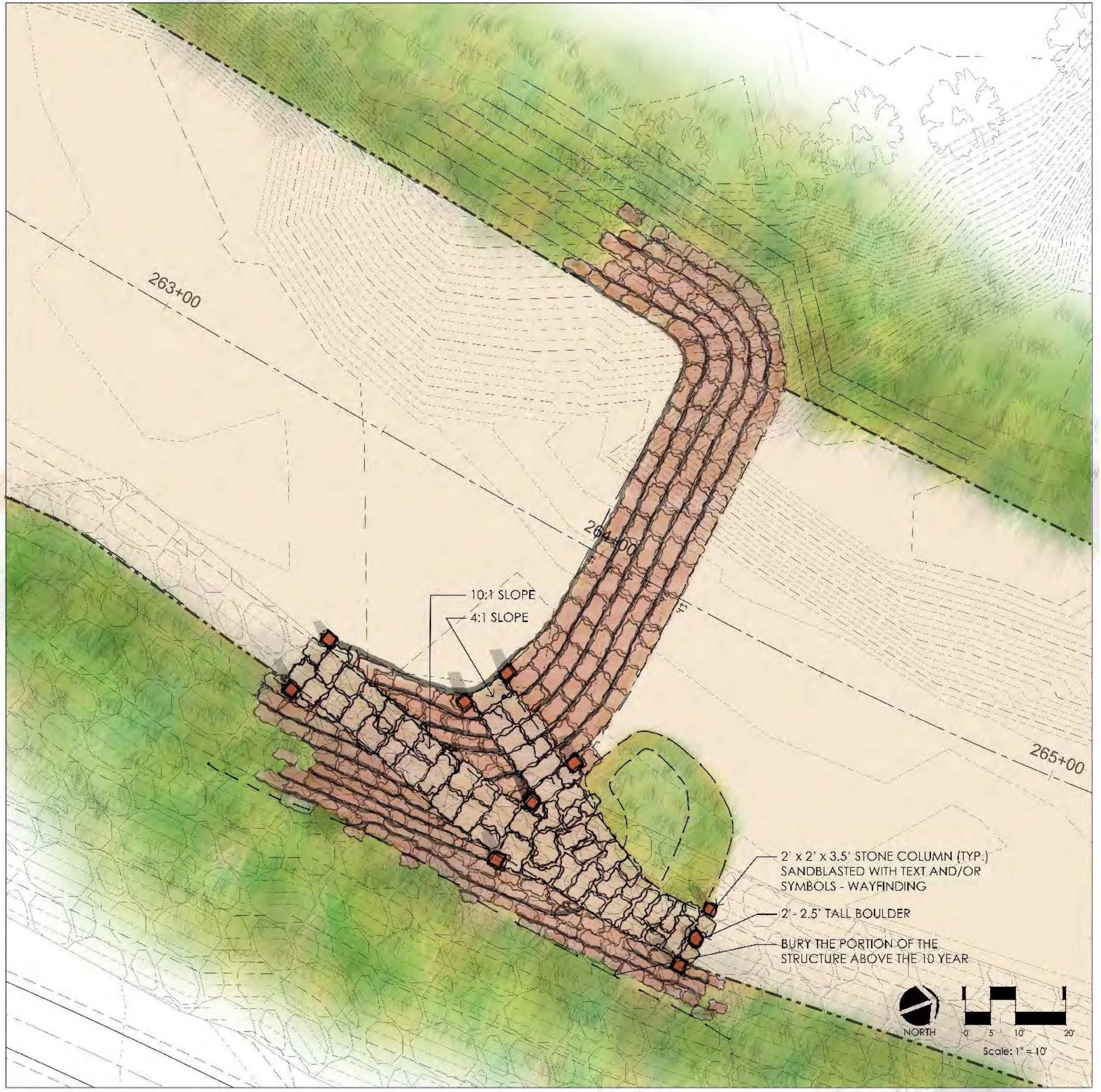
Access and Recreation



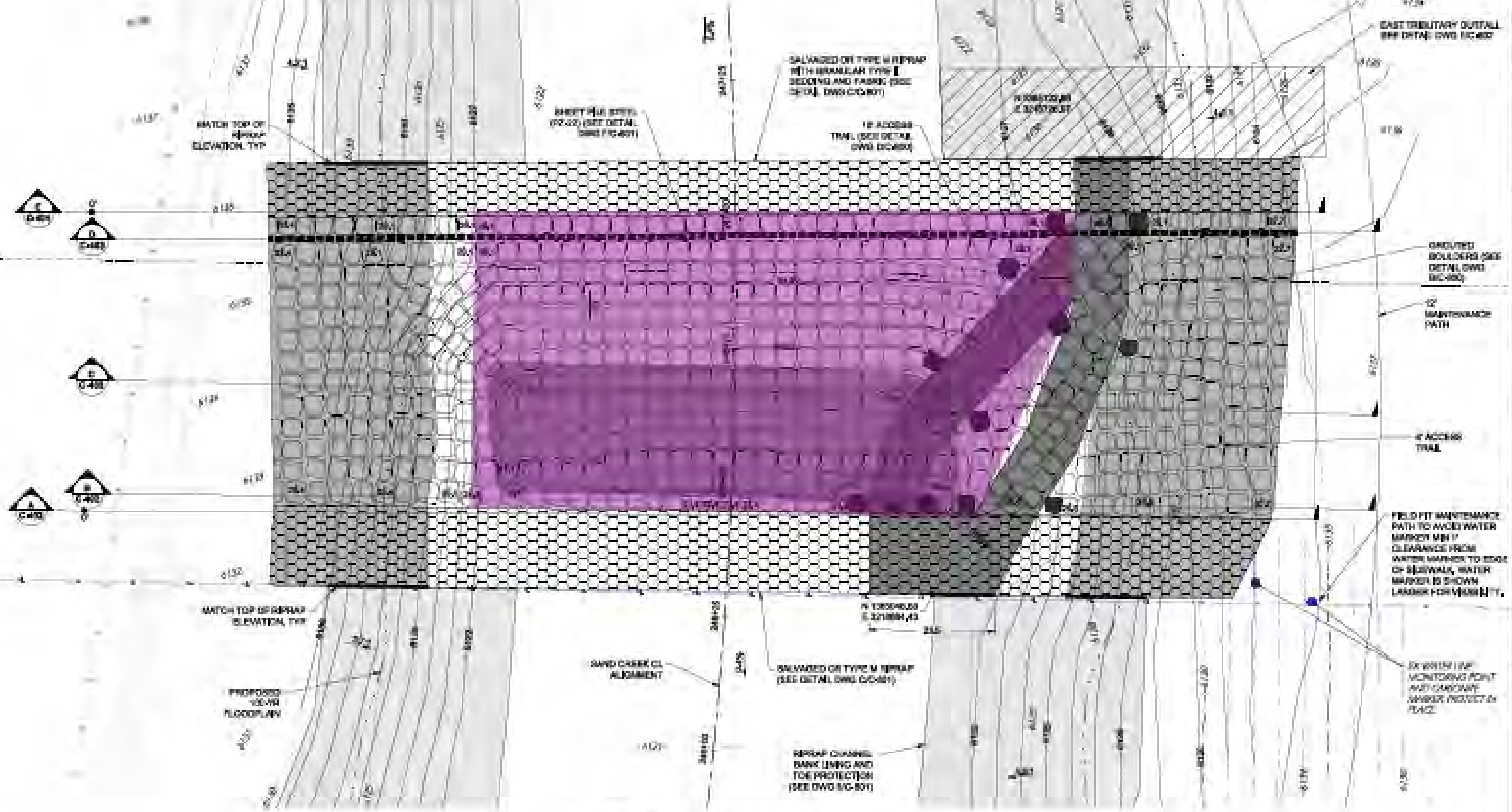
FAT BIKES

- Tires 4 – 5 inches in width
- Run at a very low inflation pressure
- Large footprint and massive grip
- Float across sand, snow, mud – untracked exploration

Navigable Drop Structure Plan



COLORADO SPRINGS OLYMPIC CITY USA | STORMWATER ENTERPRISE



DROP STRUCTURE A ENLARGEMENT

COLORADO SPRINGS
OLYMPIC CITY USA

STORMWATER ENTERPRISE

CITY OF COLORADO SPRINGS
30 S. NEVADA AVE., SUITE 401
COLORADO SPRINGS, CO 80903

SAND CREEK STABILIZATION & EROSION CONTROL PROJECT

DROP STRUCTURE A ENLARGEMENT

DRAWING NUMBER: C-400

SHEET NUMBER: 14

Public Relations

Global Fat Bike Day

COLORADO SPRINGS
OLYMPIC CITY USA
STORMWATER ENTERPRISE

Trail Defining Boulders

Remembrance

Media/Public Relations

https://www.kktv.com/content/news/Stormwater-project-a-new-playground-for-fat-bikers-501738371.html

Sand Creek Construction

February 2018

Sheet Pile Cutoff

Grouting Operation

Let’s mess with the construction inspector !!!

Sand Creek Construction

April 2018

Photo 15 - Looking upstream towards Platte Avenue (Ayres, Sep 2008).

Sand Creek Construction

In progress

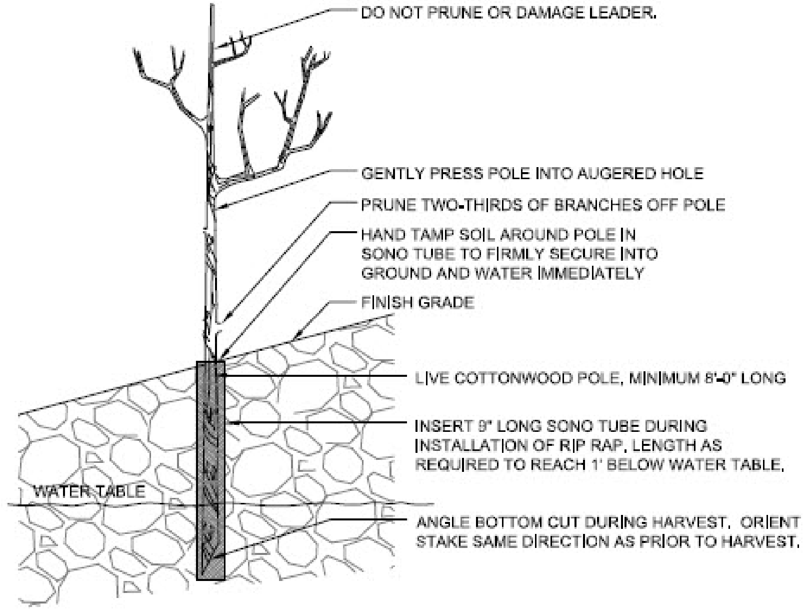
COLORADO SPRINGS OLYMPIC CITY USA

STORMWATER ENTERPRISE


CAT

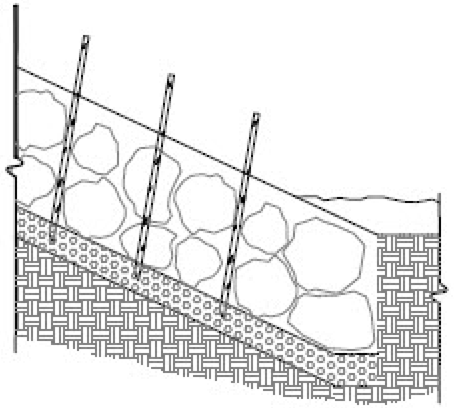
Landscaping/Mitigation:

- 10 acres seeding
- 104 cottonwood poles
- 315 shrubs
- 8000 willow stakes
- 5,300 CY of Topsoil import



NOTES:
1. DETERMINE GROUND WATER ELEVATION PRIOR TO PLANTING COTTONWOOD POLES.
2. ONLY PLANT COTTONWOOD POLES WHEN DORMANT (BEFORE LEAVES BUD OUT).

2 L-100 COTTONWOOD POLE WITH SONO TUBE SECTION/ ELEVATION NTS



NOTES:
1. INSTALL THREE ROWS OF WILLOW STAKES ALONG CREEK BANK. THE LOWEST ROW WILL BE INSTALLED 6" ABOVE THE EDGE OF THE CREEK BOTTOM, THE SECOND ROW WILL BE 1' ABOVE THE FIRST ROW, THE THIRD ROW WILL BE 2' ABOVE THE FIRST ROW.

3 L-100 WILLOW STAKE PLANTING SECTION/ ELEVATION NTS

Lessons Learned

- Leverage Creek Improvements to get Pvt Property owners to donate land
- Leverage local municipal resources to maintain project budget
- Salvaging riprap is timely and difficult – is it worth it?
- Using a range of boulder sizes was beneficial
- Hydraulic Interaction between Fat Bike path and stilling basin was complicated
- Don't cut a communication line to the air force base

Conclusion

- Initiate project before it get's to $6,000,000
- Use local resources for cost savings
- Maximize use of multiple stakeholders
- Consider trying Fat Tire Bike Riding if you get the chance

Questions

Thank You

The Application of Full Spectrum River Restoration Design in Colorado

Anthony Edwards

The Application of Full Spectrum River Restoration Design in Colorado

Travis Stroth

The Application of 'Full Spectrum' River Restoration Design in Colorado

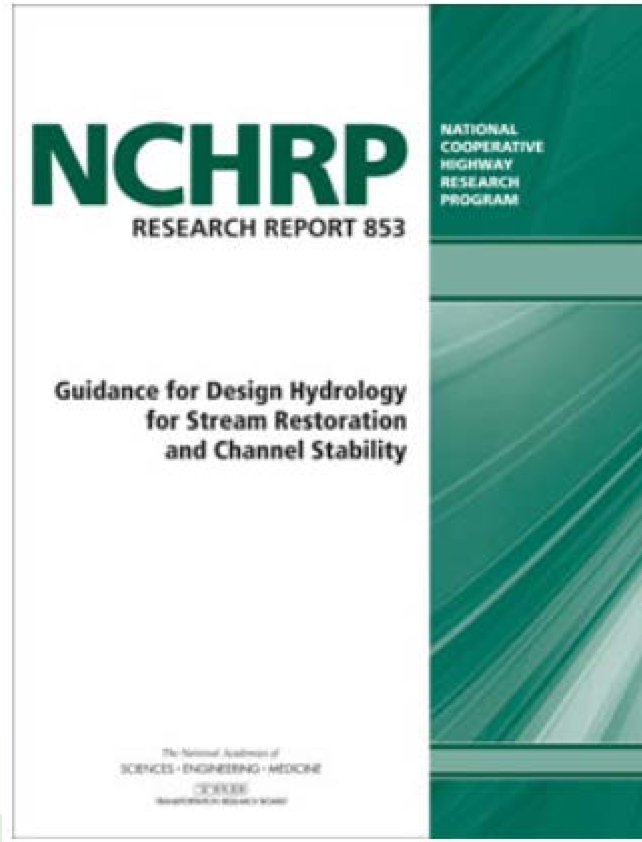
PREPARED BY
TRAVIS STROTH
STILLWATER SCIENCES
4845 PEARL EAST CIRCLE, SUITE 101
BOULDER, CO 80301

PREPARED FOR
CASFM CONFERENCE 2019
CRESTED BUTTE, CO

Overview/Background

COLORADO STATE UNIVERSITY (CSU)

- MASTER'S IN HYDRAULIC ENGINEERING/RIVER MECHANICS/STREAM RESTORATION
- NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM (NCHRP) RESEARCH REPORT 853
  - Dr. Brian Bledsoe
  - Dr. Peter Nelson
  - Dr. Dan Baker
  - Dr. Joel Sholtes
  - Tyler Rosberg
  - Travis Stroth



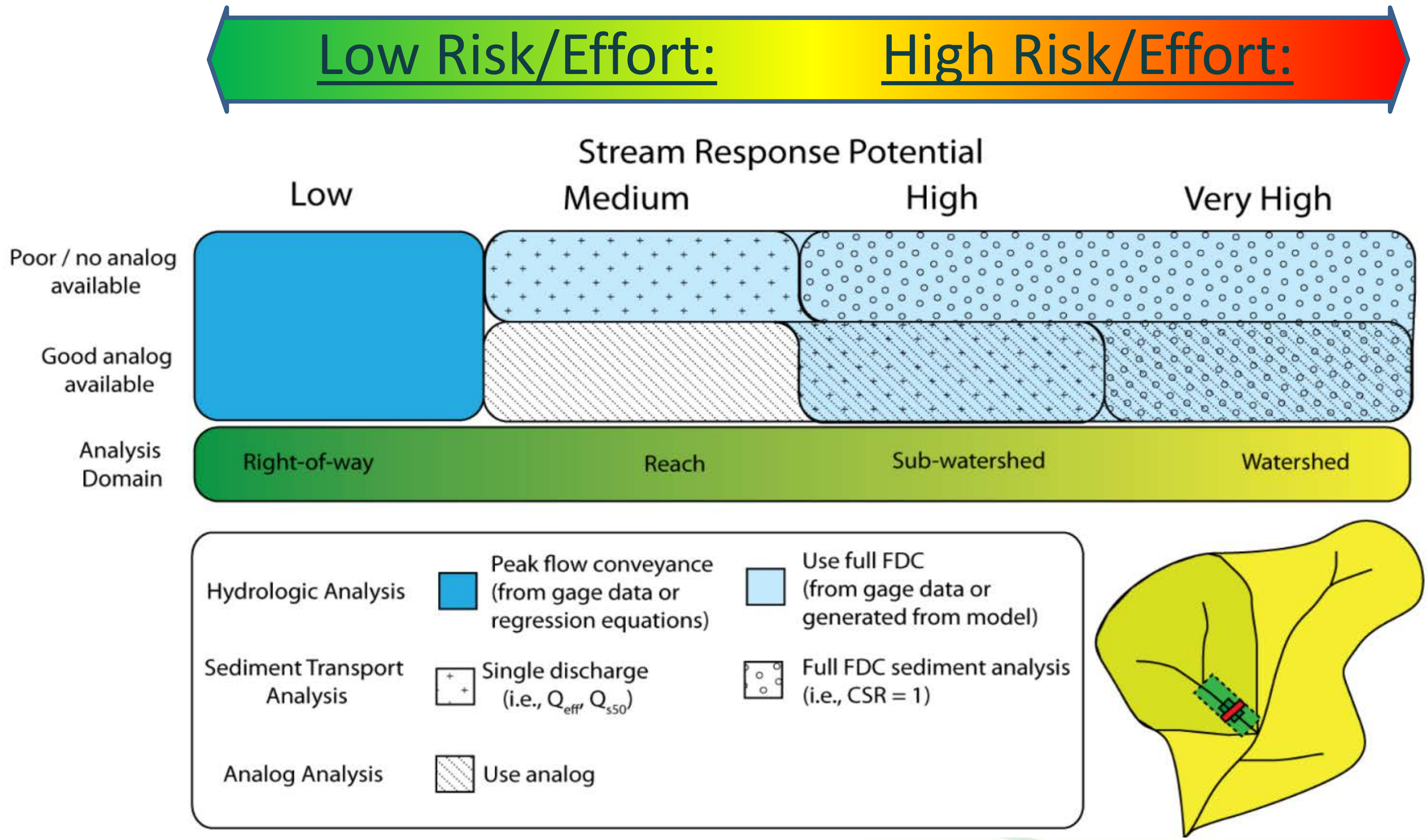
STILLWATER SCIENCES

- RIVER RESTORATION DESIGN AND GEOMORPHIC ASSESSMENTS
- GEOMORPHIC ENGINEERING

Stillwater Sciences

Level of Design Effort Based on Stream Response Potential/Risk

LEVEL OF DESIGN BASED ON STREAM RESPONSE POTENTIAL

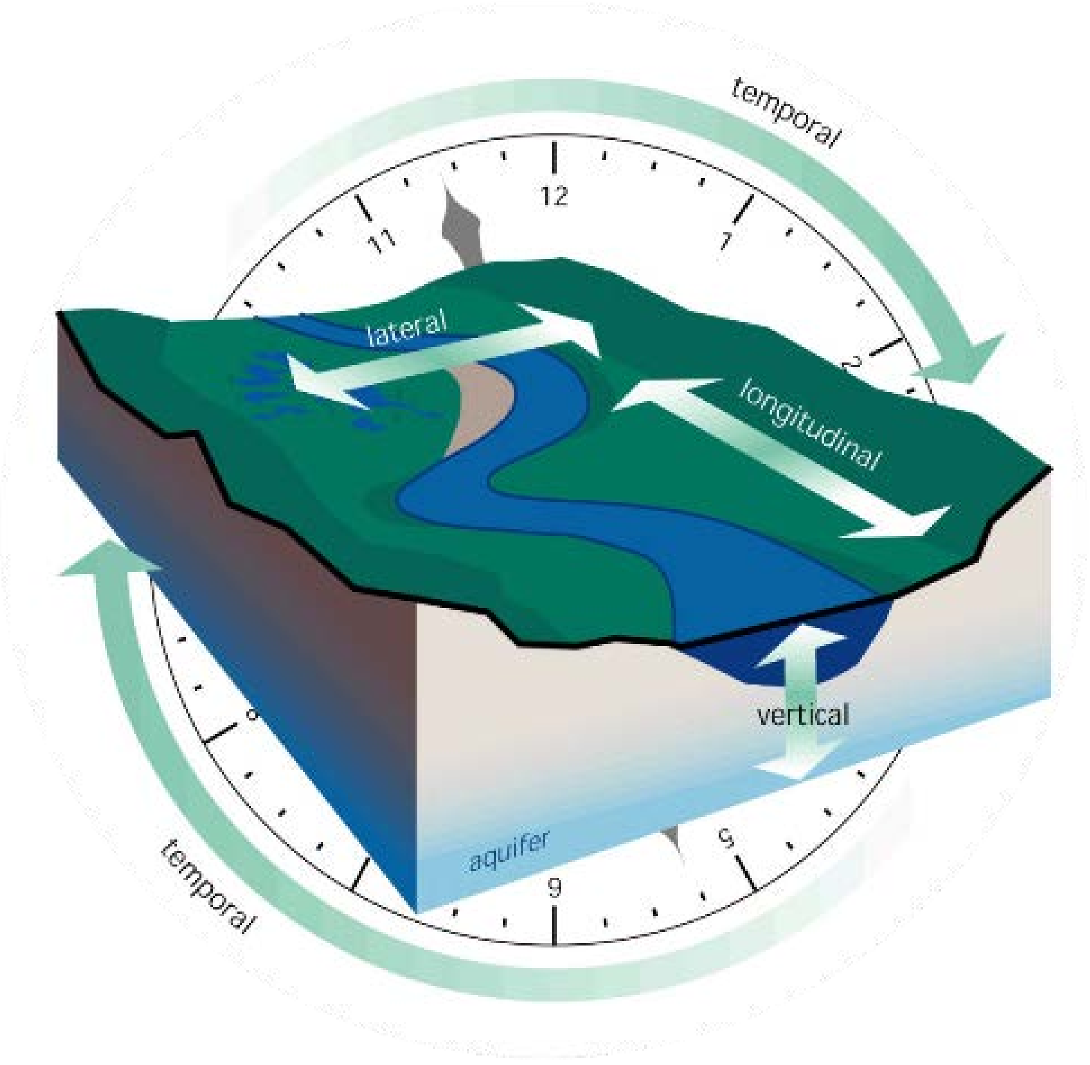


4-DIMENSIONAL FRAMEWORK

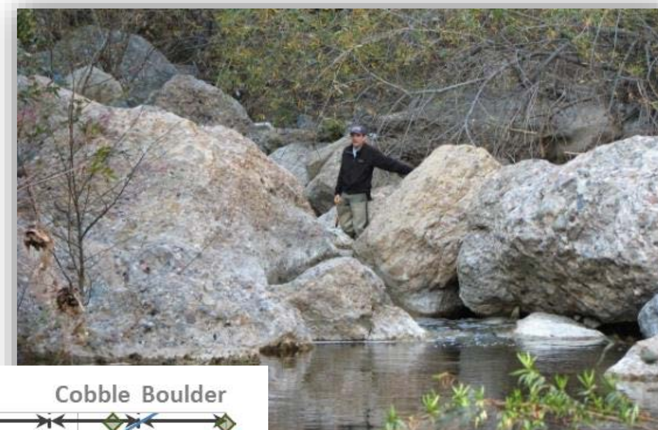
SPACE

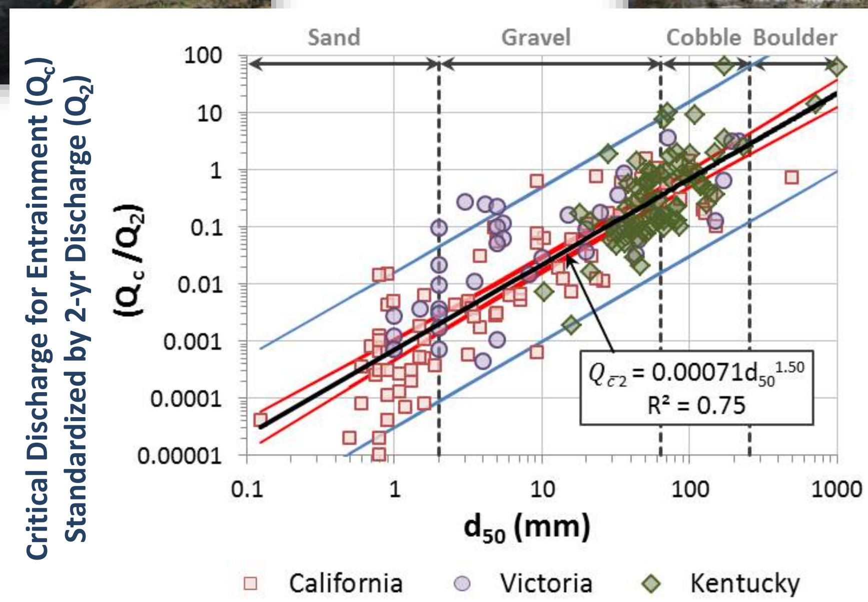
- VERTICAL
- LATERAL
- LONGITUDINAL

TEMPORAL



Bed Material Entrainment Threshold (Critical Discharge, Q_c) Varies by Orders of Magnitude across Size Classes





Adapted from Hawley and Vietz 2016, Freshwater Science

Bank Material Also Influences Channel Response/Risk

Gravel Bed, Weak Banks

d_{50} = 14.1 mm (medium gravel)

Cobble Bed, Strong Banks

d_{50} = 124 mm (~half the bed is ≥ large cobbles)

Bed Material = Medium to Coarse Gravel

Frequency of Hardpoint(s)	Strong Banks (bedrock/boulder/ coarse cobble)	Moderate (cohesive/ well vegetated)	Weak Banks (alluvium/ poorly vegetated)
None/infrequent	High	High	Very High
Intermediate	Med	High	High
Frequent	Low	Med	High

Bed Material = Small Cobbles/Very Coarse Gravel

Frequency of Hardpoint(s)	Strong Banks (bedrock/boulder/ large cobble)	Moderate (cohesive/ well vegetated)	Weak Banks (alluvium/ poorly vegetated)
None/infrequent	Med	Med	High
Intermediate	Low	Med	Med
Frequent	Low	Low	Med

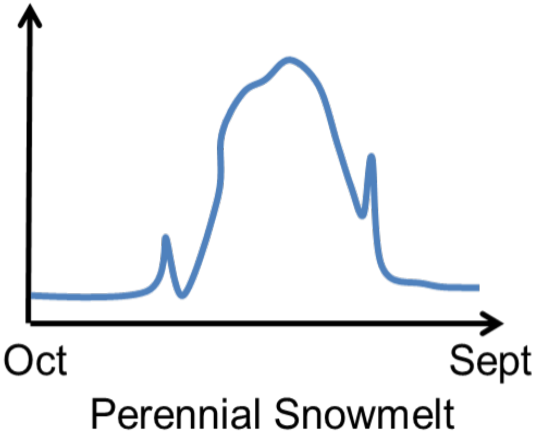
Bed Material = Large Cobbles

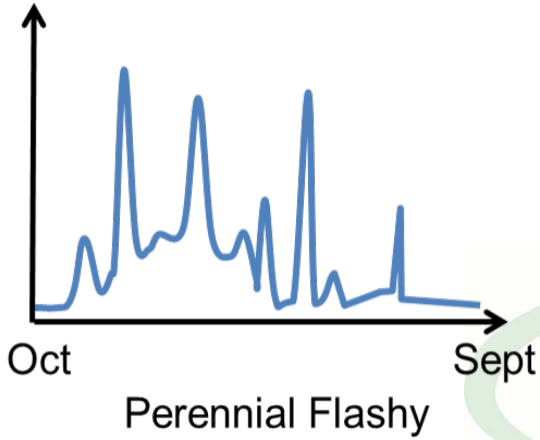
Frequency of Hardpoint(s)	Strong Banks (bedrock/boulder/ large cobble)	Moderate (cohesive/ well vegetated)	Weak Banks (alluvium/ poorly vegetated)
None/infrequent	Low	Med	Med
Intermediate	Low	Low	Med
Frequent	Low	Low	Low

Longitudinal Changes Also Influences Channel Response/Risk

- **HIGH-RISK SETTINGS CAN QUICKLY UNRAVEL**

Temporal Variability in Hydrology
Bed Material + Richards-Baker Flashiness Index





$$\text{R - B Index} = \frac{\sum_{i=1}^{n} |q_i - q_{i-1}|}{\sum_{i=1}^{n} q_i}$$

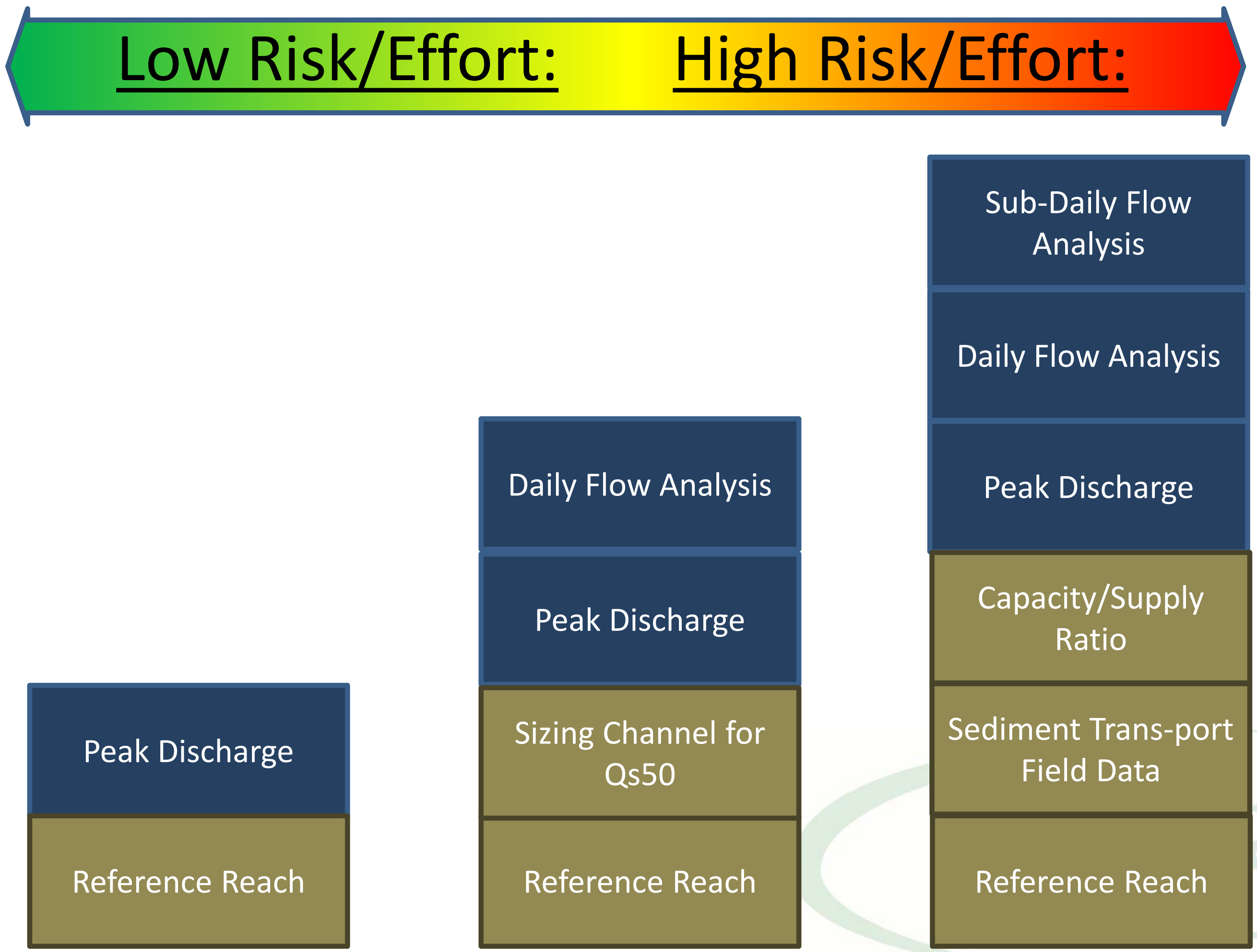
where:

q = daily-averaged discharge [m^2/s];

i = day; and

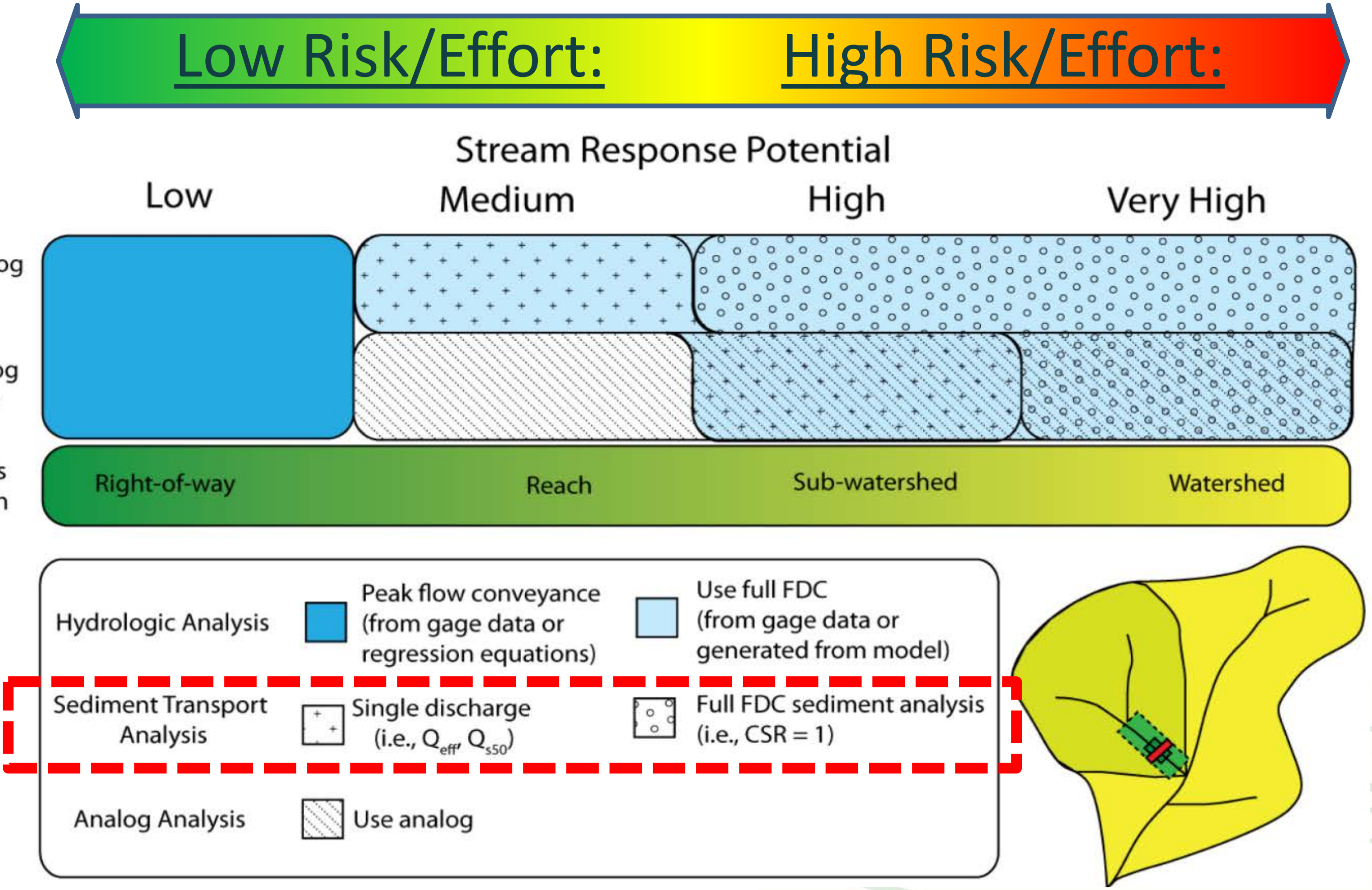
n = total number of days in the flow record.

More Risk, More Lines of Evidence

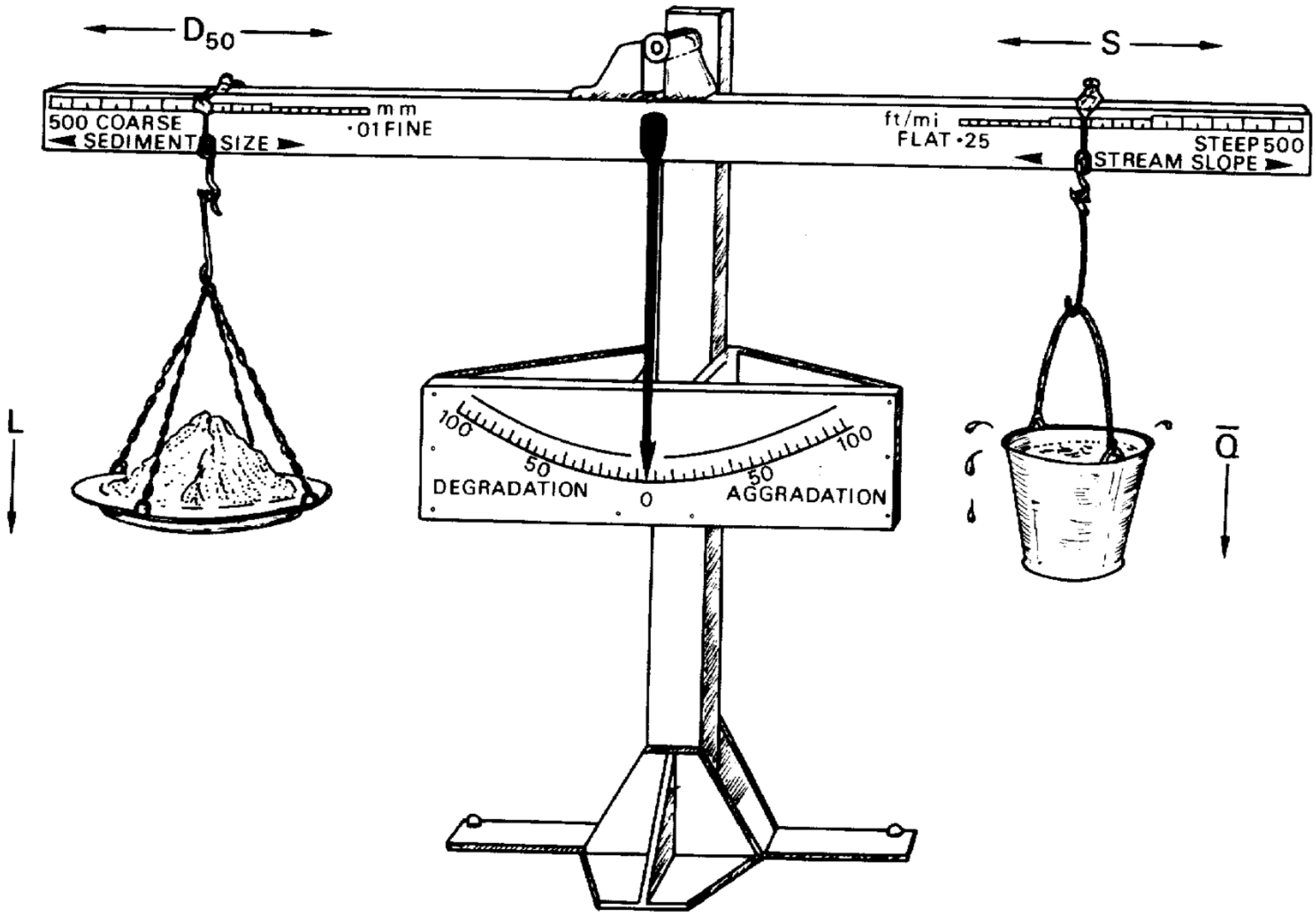


Channel Design Using Sediment Transport & CSR Tool

LEVEL OF DESIGN BASED ON STREAM RESPONSE POTENTIAL

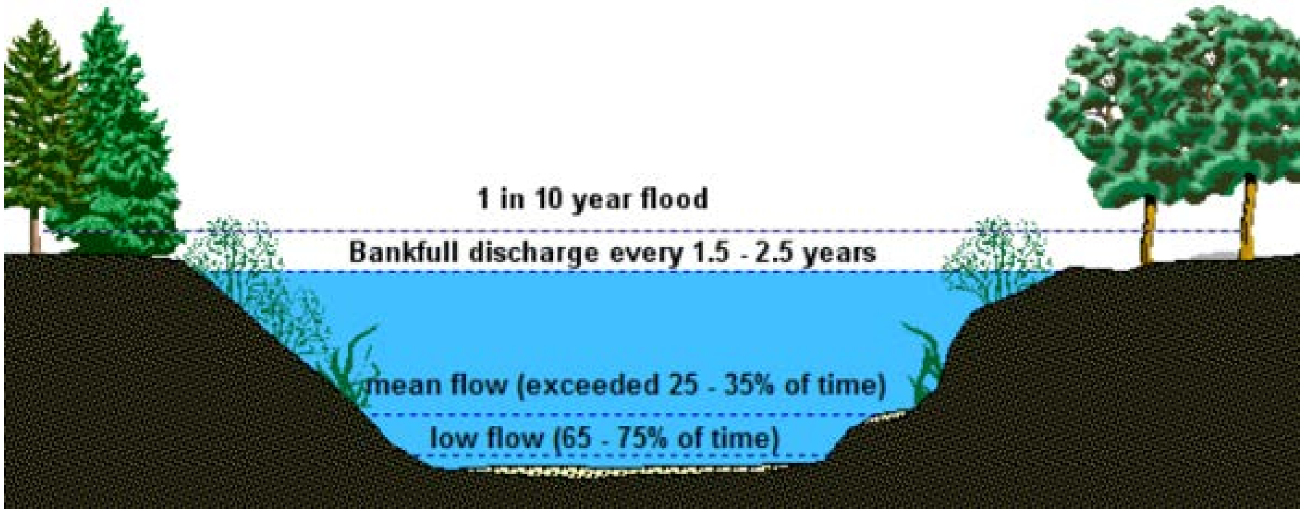


Balance of Water and Sediment in Streams



Channel Design Discharges

- What flow(s) should be used to estimate sediment transport?
- What flows dictate channel form?



What flows dictate channel form?

THEORETICAL BASED:

- **Dominant Discharge:** would produce the same channel geometry that is produced by the long-term hydrograph if constantly maintained in an alluvial stream over a long period of time

FIELD BASED:

- **Bankfull Discharge:** fills a stable alluvial channel to the elevation of the active floodplain

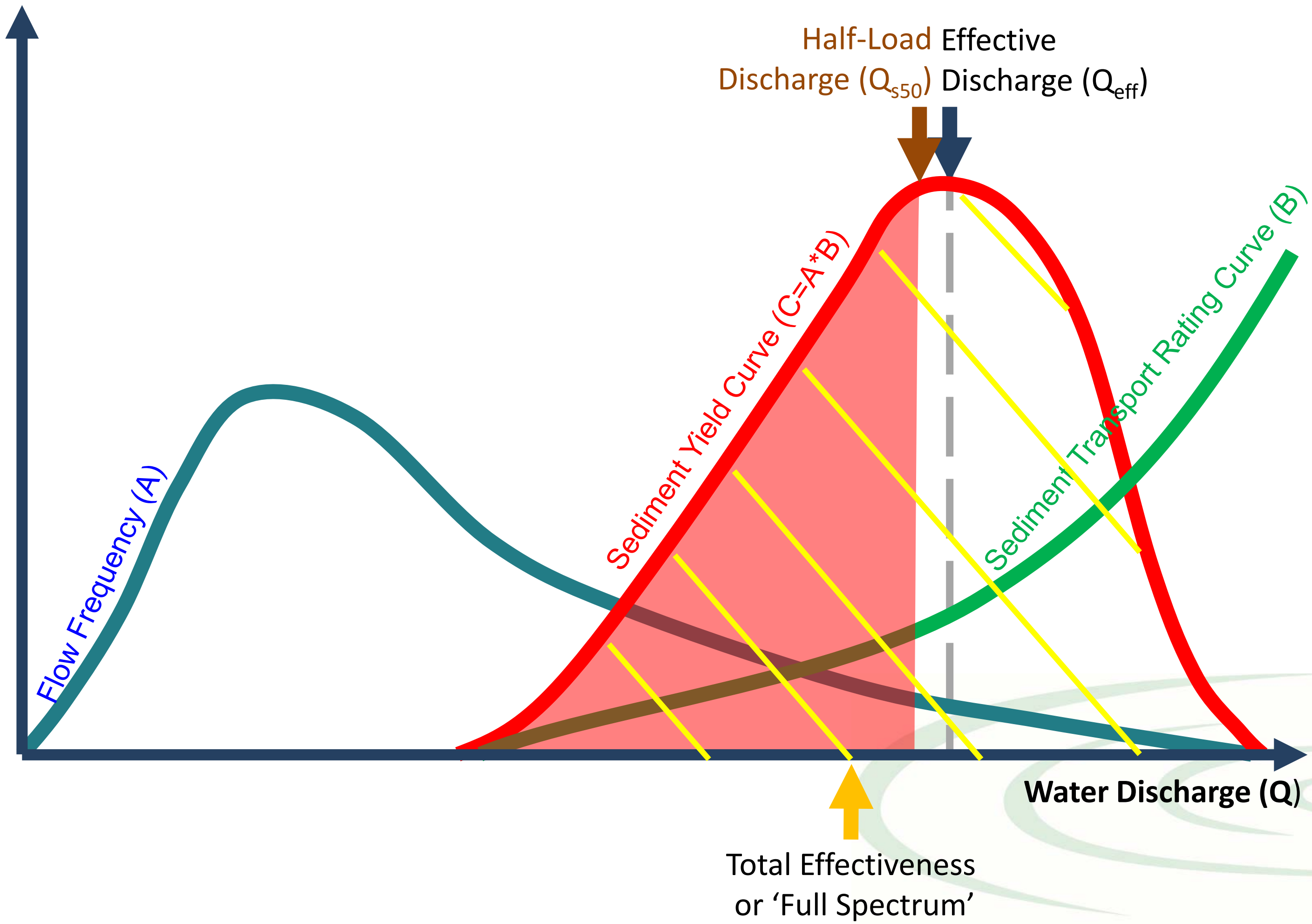
HYDROLOGY BASED:

- **$Q_{1.5}$ or Q_2:** recurrence interval discharges used as proxy of dominant discharge

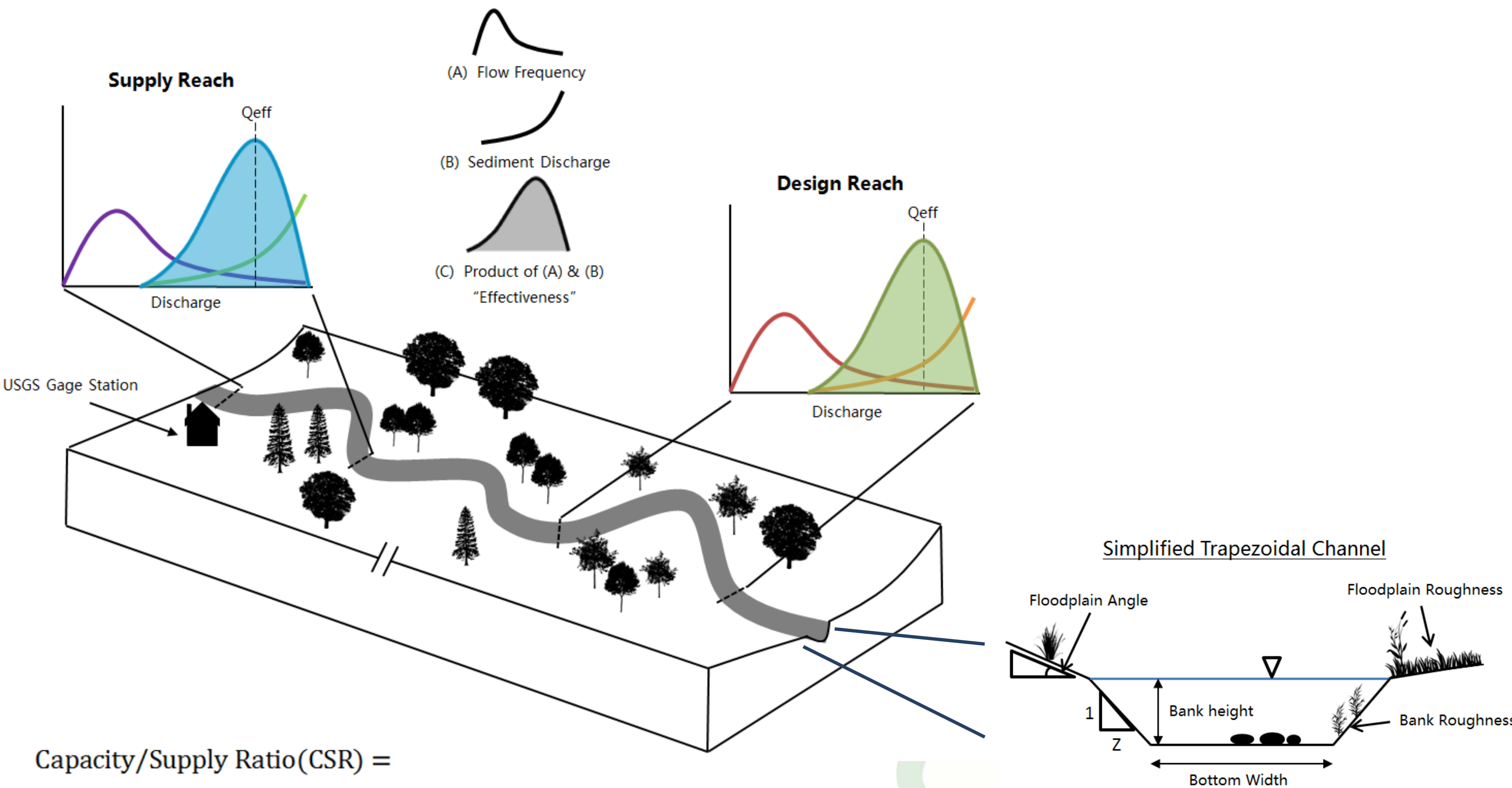
CALCULATATION BASED:

- **Effective discharge:** transports the largest percentage of the sediment load over a period of many years.
- **Half-yield discharge:** Flow that transport half of the total sediment yield
- **Total Effectiveness (All flows)**: Sediment supply and capacity are balanced over all flows through a channel

‘Full Spectrum’ Sediment Transport Capacity



Capacity/Supply Ratio Tool (CSR Tool)



Capacity/Supply Ratio(CSR) =

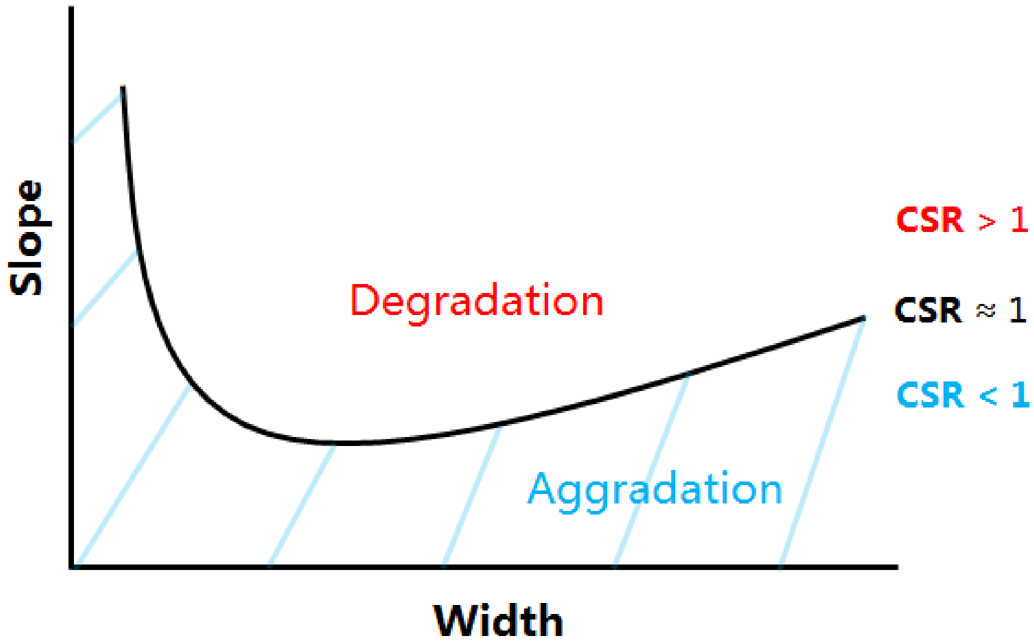
$$\frac{\int_{\text{time}} \text{Sediment transport capacity of Design Reach}}{\int_{\text{time}} \text{Sediment transport capacity of Supply Reach}}$$

CSR Tool Solutions

Capacity/Supply Ratio(CSR) =

$$\frac{\int_{time} \text{Sediment transport capacity of Design Reach}}{\int_{time} \text{Sediment transport capacity of Supply Reach}}$$

Stable Channel Design Curve

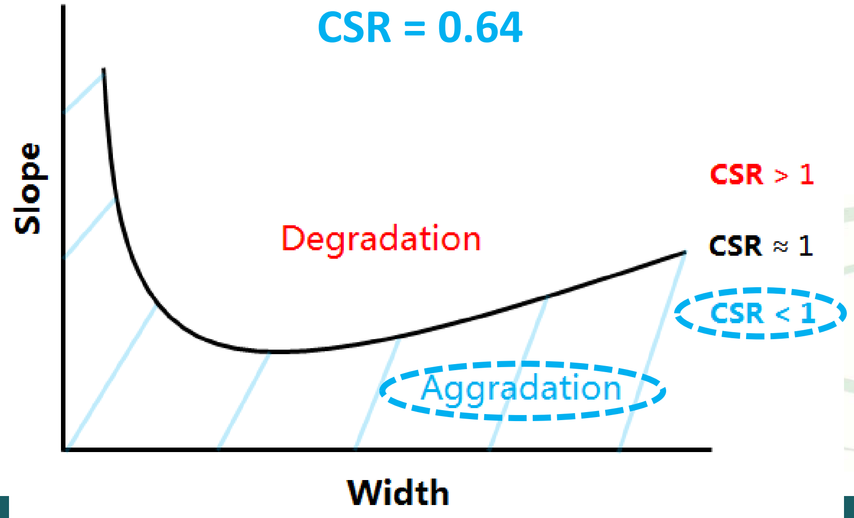


Using 'Full Spectrum' Capacity Balance

White Marsh Run, Maryland

September 1996

November 1998



SOAR AND THORNE (2001)

Application of ‘Full Spectrum’ River Restoration and CSR Tool

River Bluffs Open Space River Restoration

Cache la Poudre River near Windsor, CO

¾ Mile Reach but worked focused on downstream half

$1.3 million budget (~150k for design)

Historically channelized and bermed in 50's

Main goal of project is to increase riverine health and function

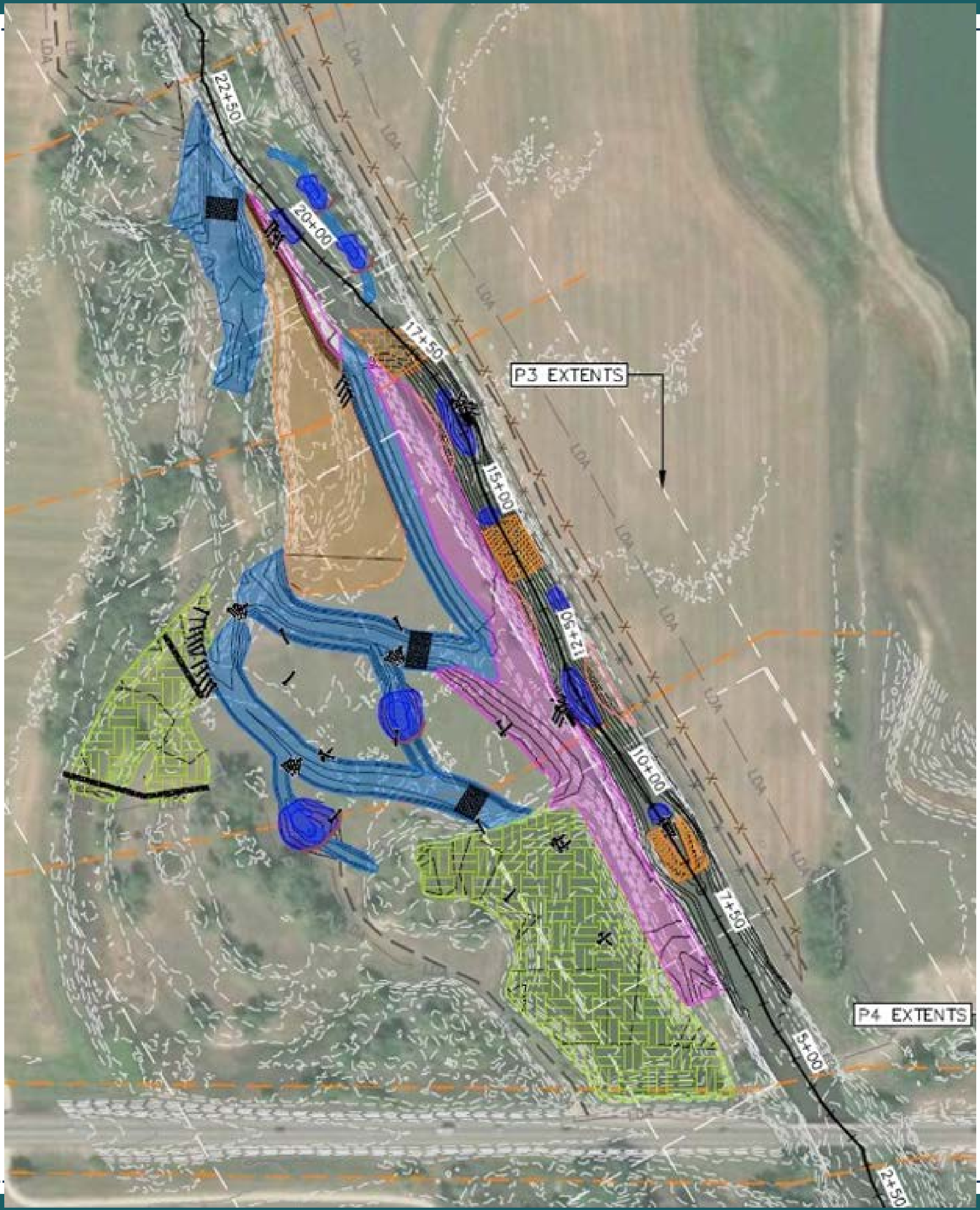
River Bluffs Design

Cutting down berms

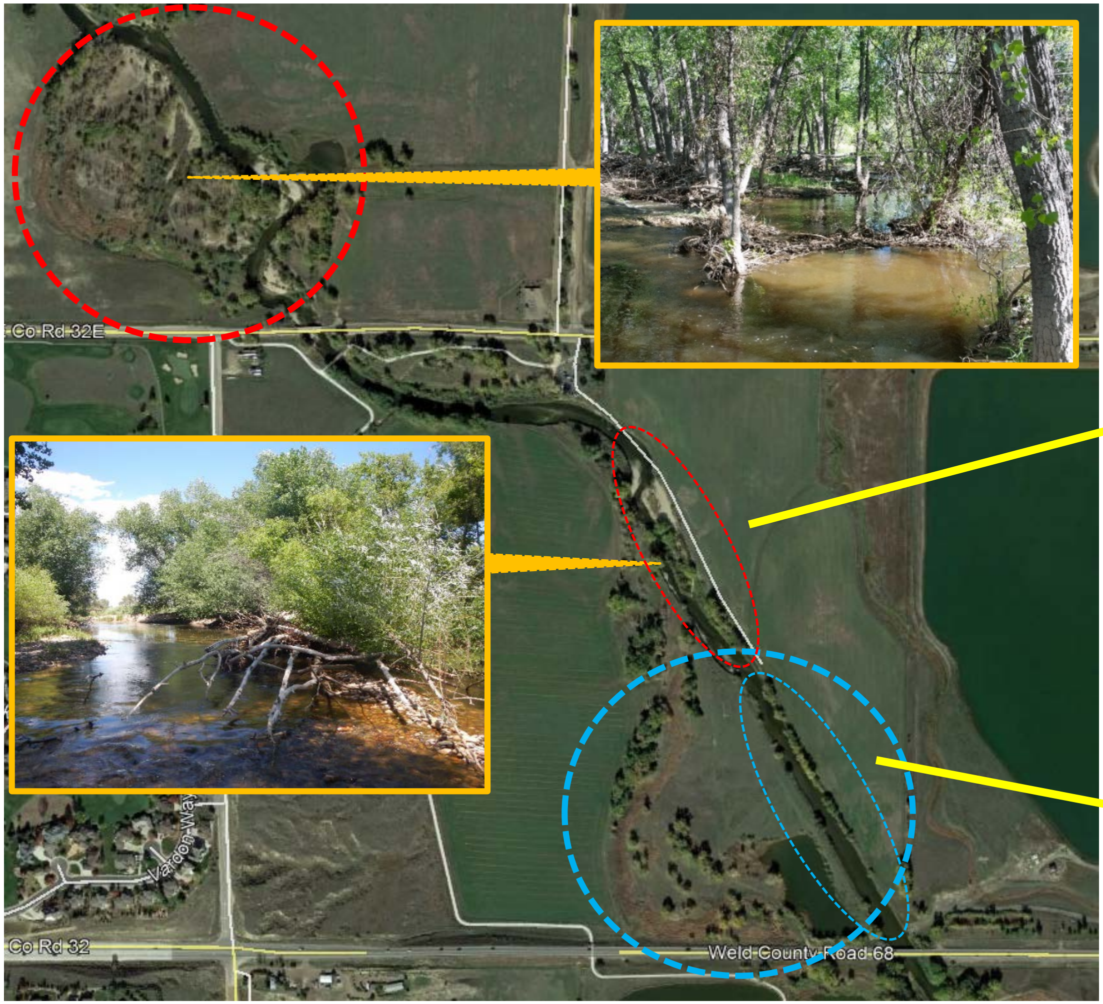
Reconnecting relic channel as overflow path with multiple flow paths back to river

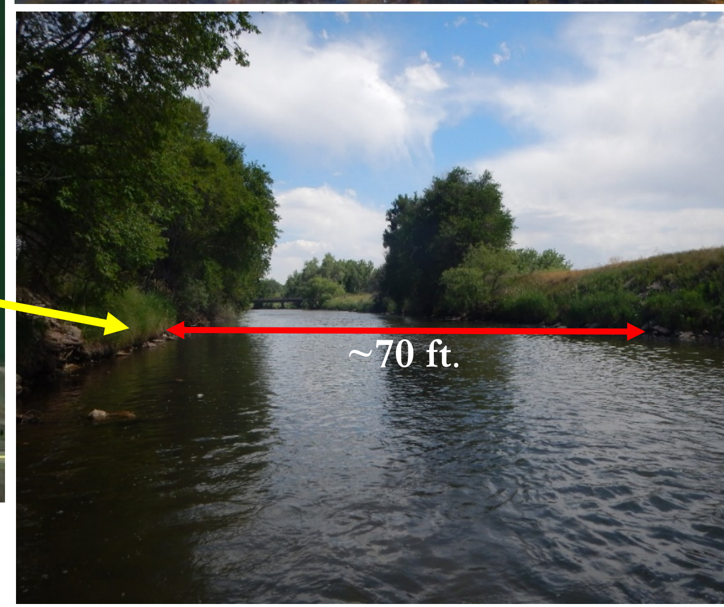
Narrowing and reconnecting main channel

Installed over 100 pieces of wood in ELJs



Supply Reach & Reference Areas






Pre-Construction

Post-Construction

Pre-Construction

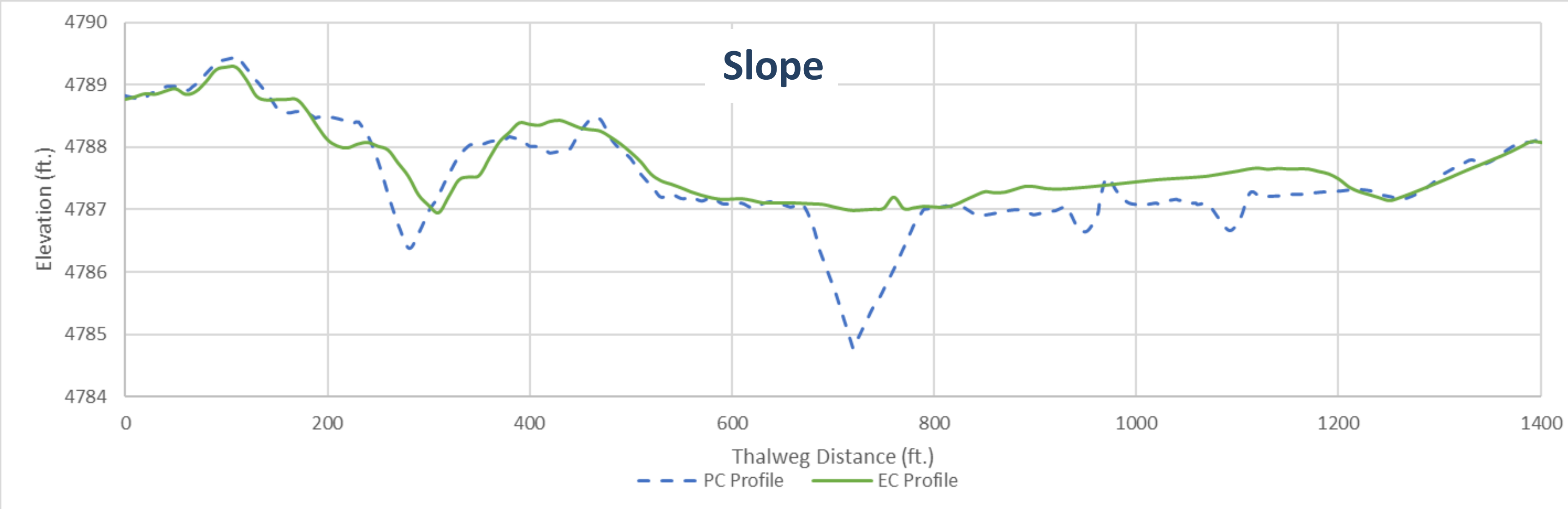
Post-Construction

Engineered Log Jams (ELJs)

BAR APEX JAM

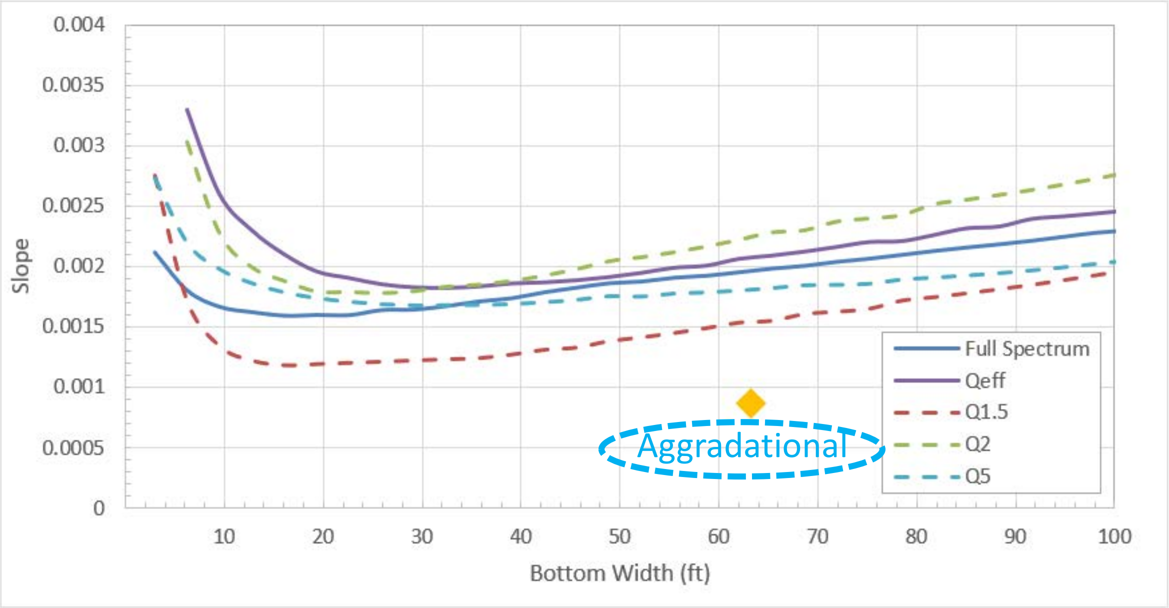
SMALLER LOG JAMS

INSTALLED ~140 PIECES OF LARGE WOOD


Slope
4790
4789
4788
4787
4786
4785
4784
Elevation (ft.)
0
200
400
600
800
1000
1200
1400
Thalweg Distance (ft.)
PC Profile
EC Profile

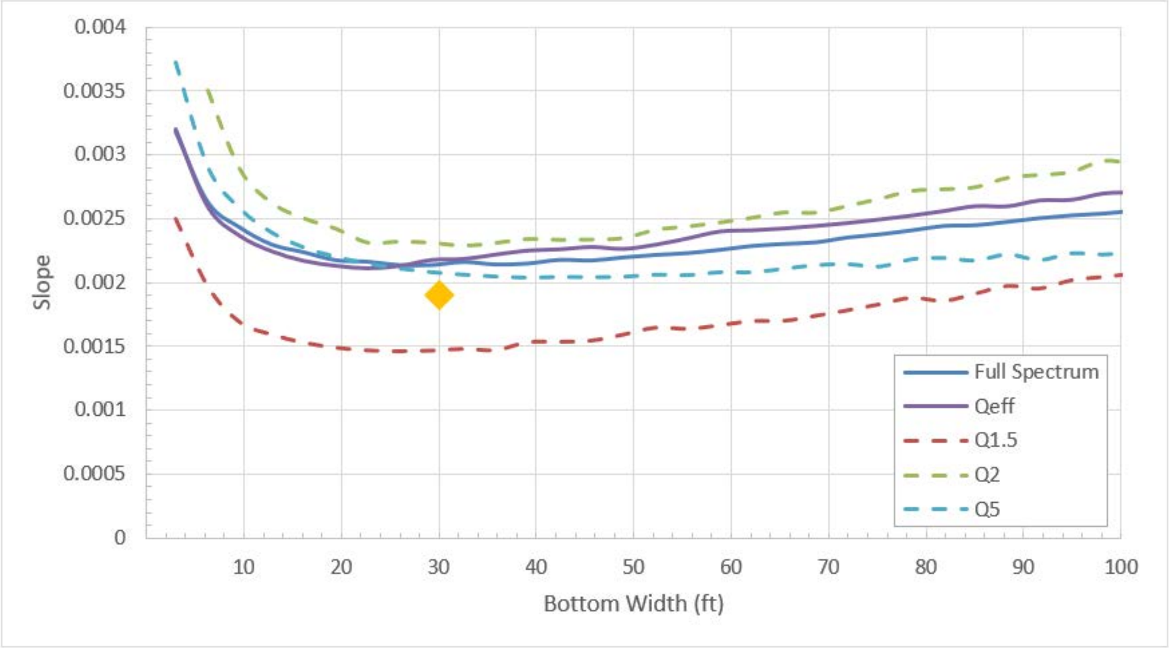

Width

Existing Conditions



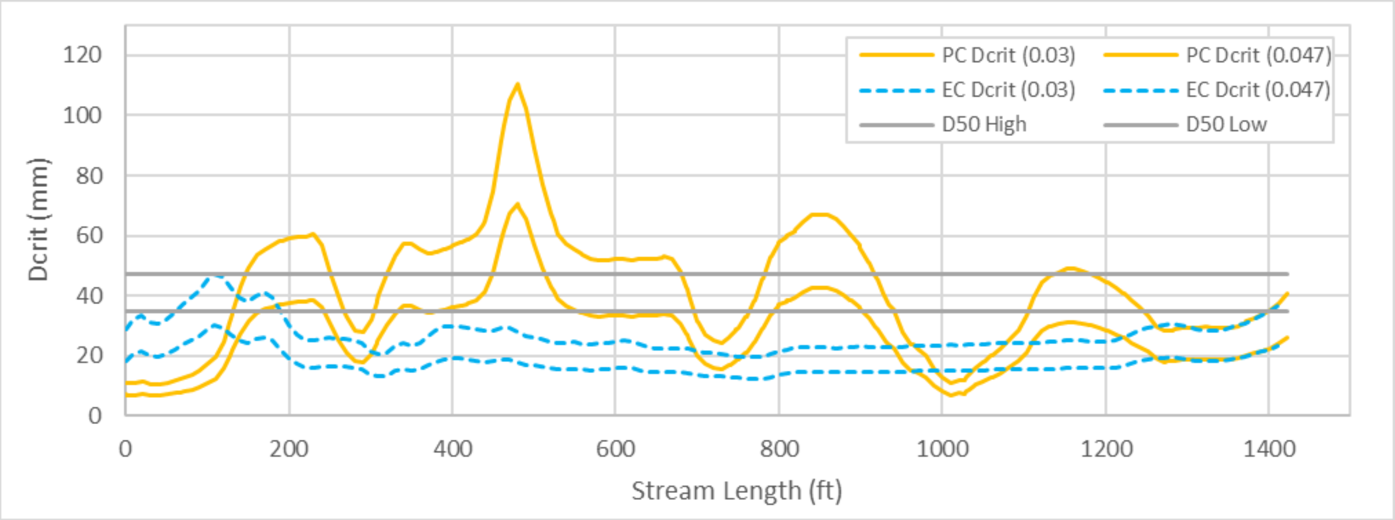
- CSR predicts very aggradational

Proposed Conditions



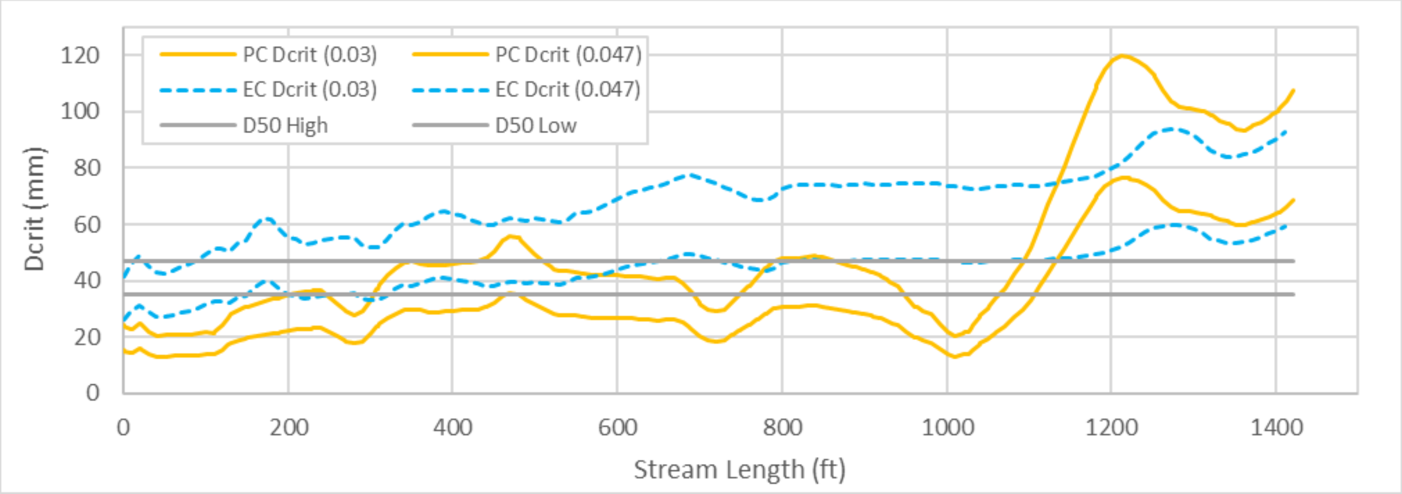
- CSR predicts close to balance through time

Incipient Motion using 2D Outputs



USING $Q_{1.5}$

INCREASED CAPACITY AND VARIABILITY



USING Q_5

DECREASED CAPACITY

CSR Tool Challenges/Next Steps

CHALLENGES

- 1D hydraulic model with simplified trapezoidal cross section
- Sediment transport equations have a lot of uncertainty
- Finding a ‘stable’ sediment supply reach is difficult
- Requires a lot of hydrology data
  - eRAMS
- Sediment in, equals sediment out (CSR =1) may not always be desirable

NEXT STEPS

- Continued monitoring
  - Geomorphological
  - Ecological
- Collaborating with UNC and CSU to continue monitoring

Google: “NCHRP Report 853”

Supplemental Slides

Engineering/Geomorphology as a Spectrum

HOW DO WE PERCEIVE CHANNEL STABILITY?

TRADITIONAL ENGINEERING

- NO CHANGE/RESPONSE EQUALS STABILITY

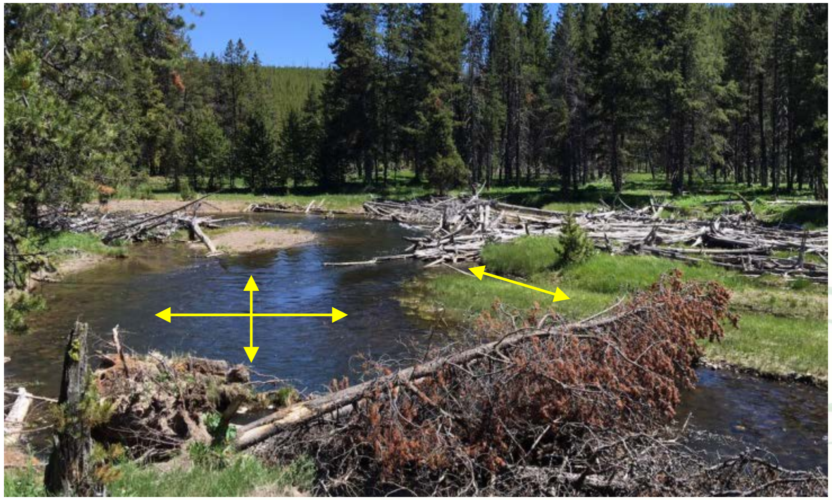
FLUVIAL GEOMORPHOLOGY/ECOLOGY

- THE ABILITY TO CHANGE/RESPOND EQUALS STABILITY

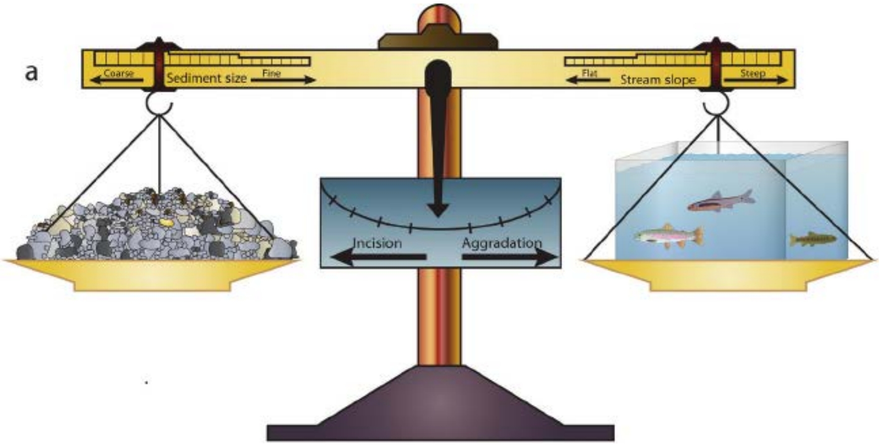
Channel Stability

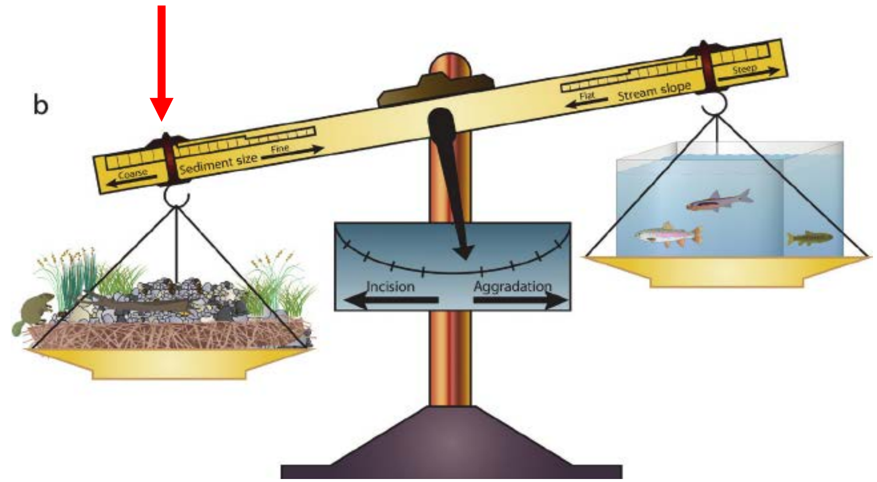
Static

Dynamic



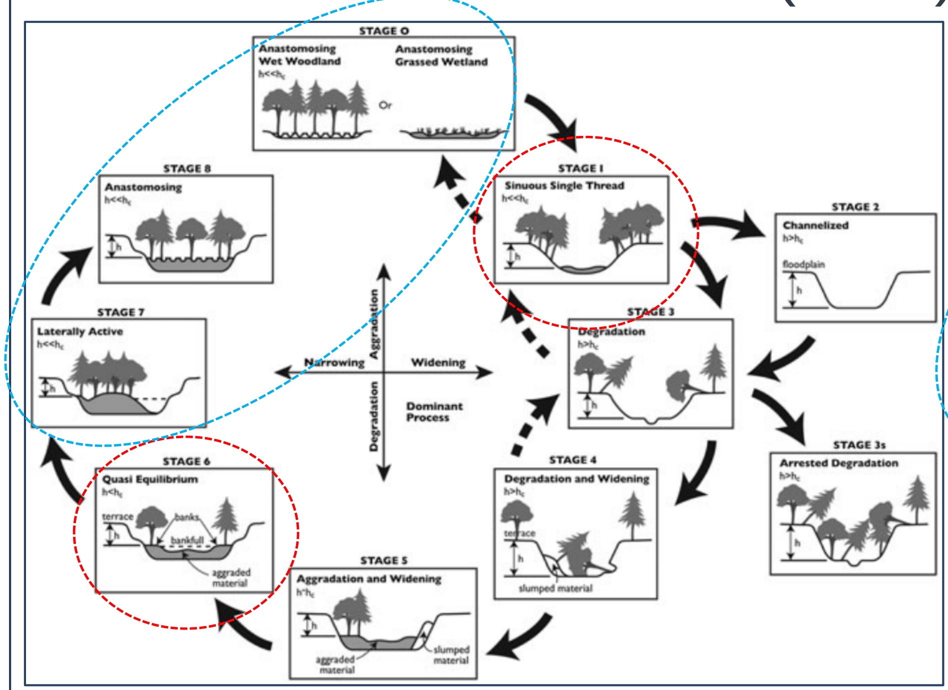
Sediment Transport Balance (CSR =1)

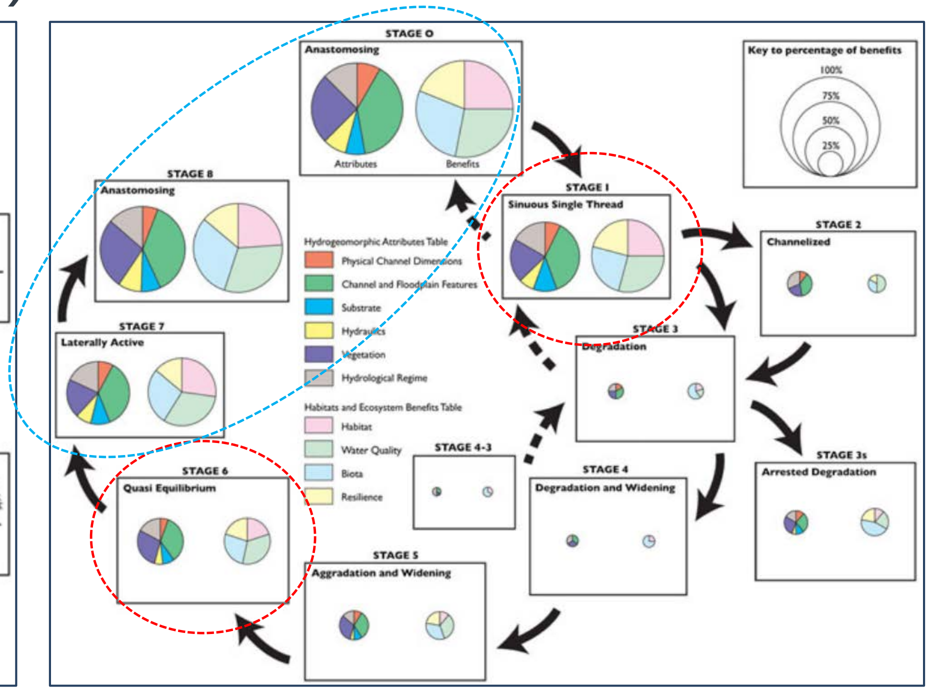




Perfect Balance is Not Always Desired

Stream Evolution Model (SEM)





Cluer and Thorne 2013

GOLDSMITH GULCH

Using Contemporary Design to Restore a Healthy Channel

City of Greenwood Village

The Architerra Group

Muller Engineering

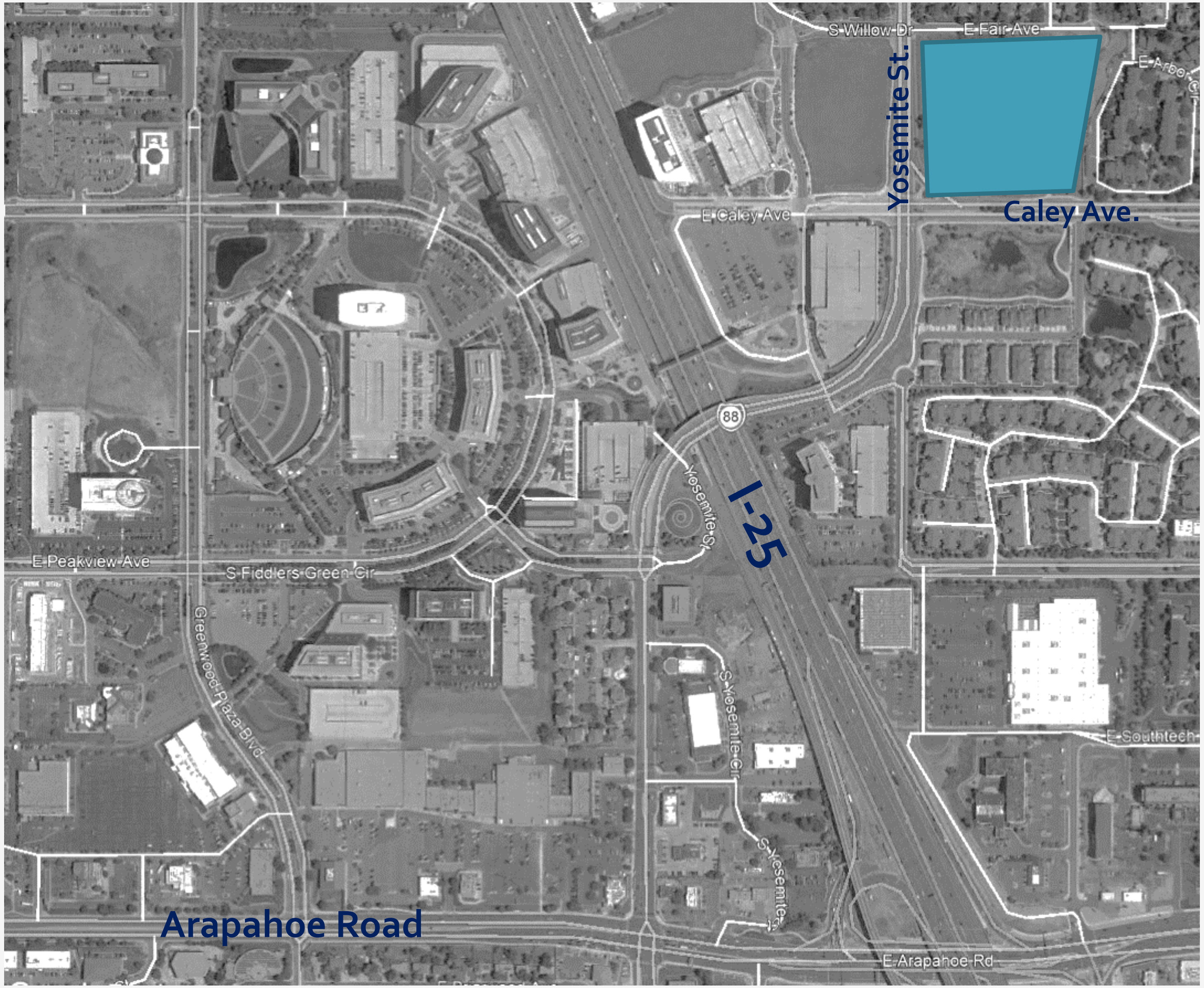
ERO Resources

Introduction and Key Project Players

City of Greenwood Village	The Architerra Group	Muller Engineering	ERO Resources	American Civil Constructors
Owner	Landscape Architect	Civil Engineer	Natural Resources	Contractor

Arapahoe County Open Space	Mile High Flood District	CDOT
Funding and Oversight	Funding and Oversight	Funding and Oversight

SITE HISTORY AND PROJECT BACKGROUND

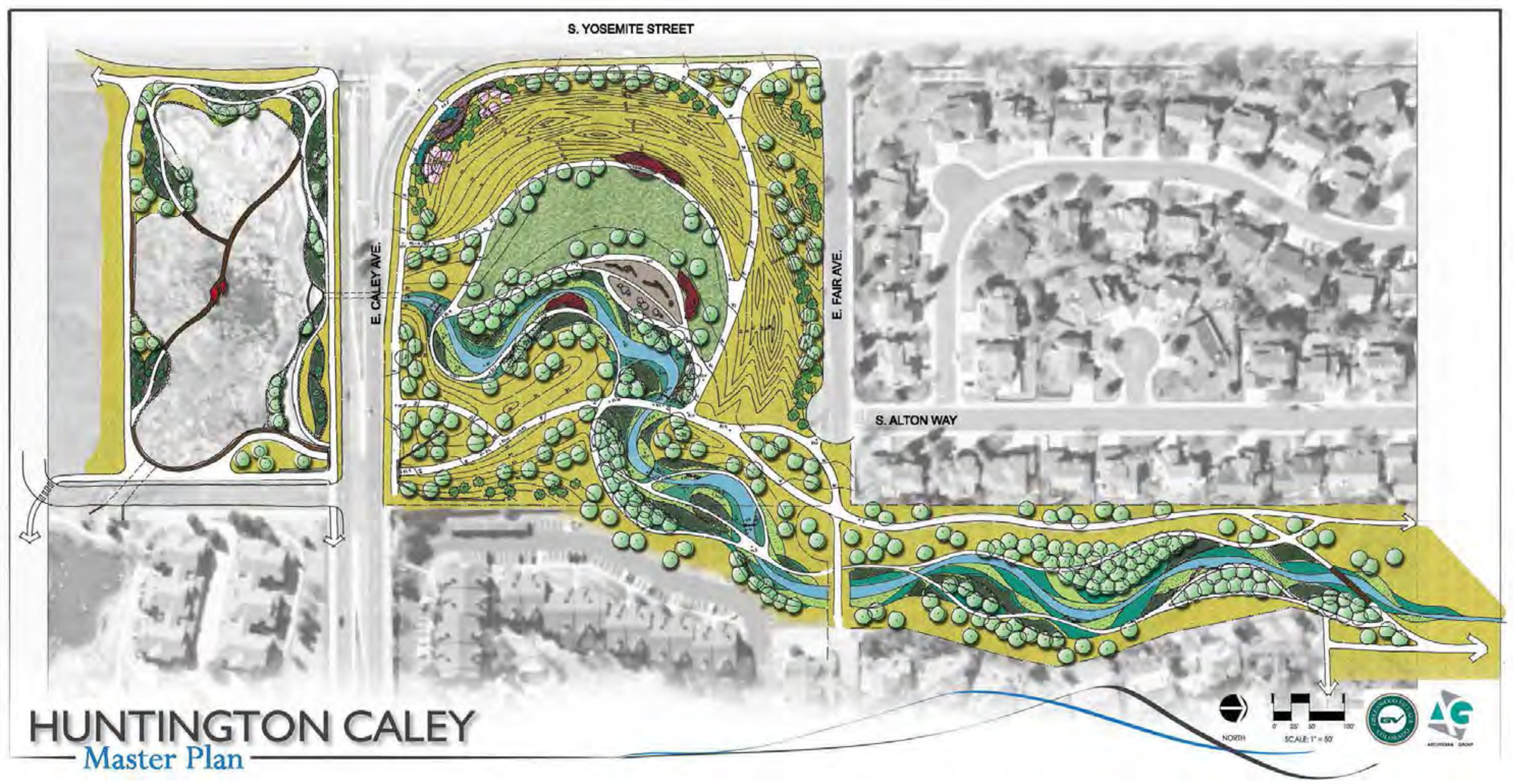


SITE HISTORY AND PROJECT BACKGROUND

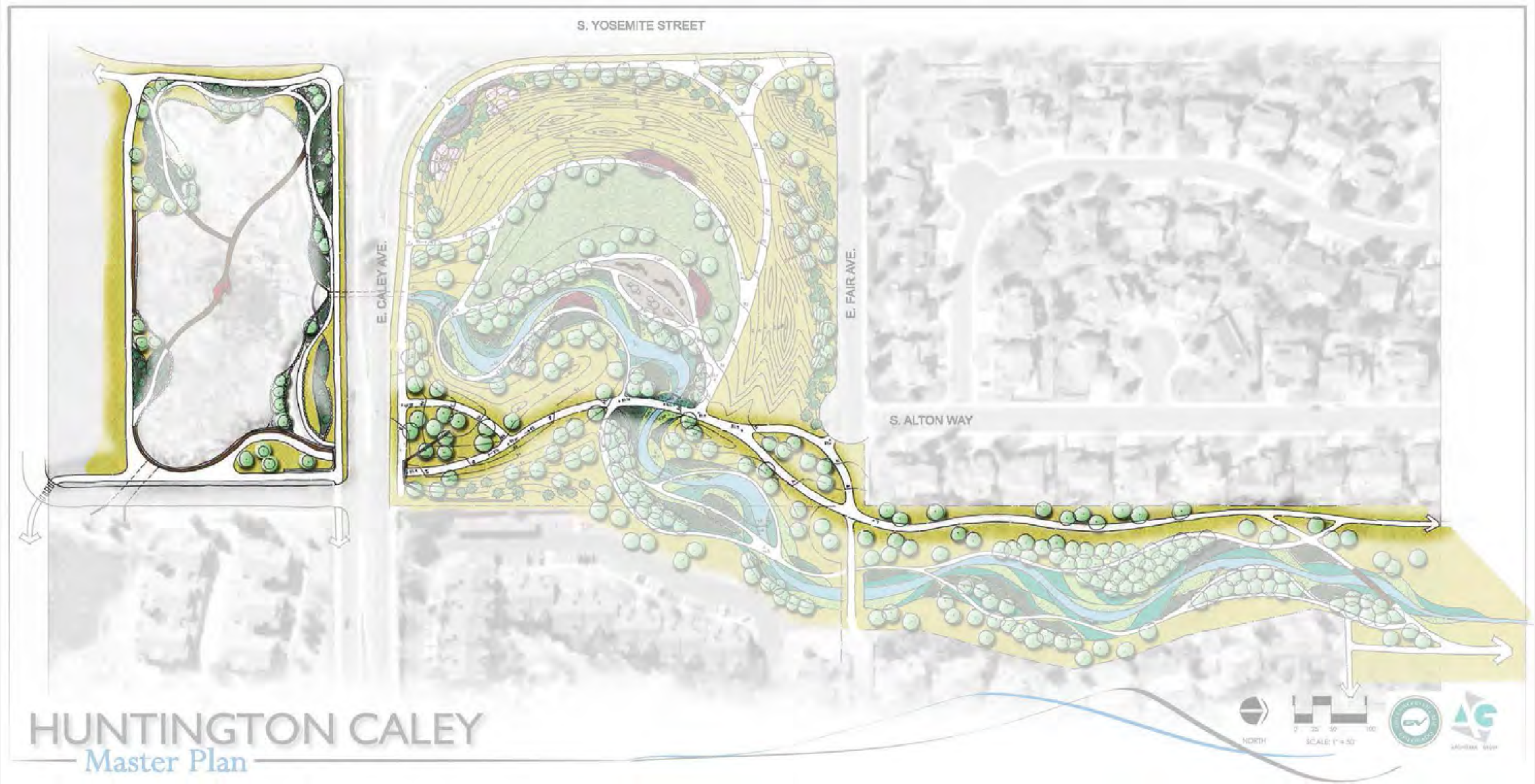
SITE HISTORY AND PROJECT BACKGROUND

IMPLEMENTATION:

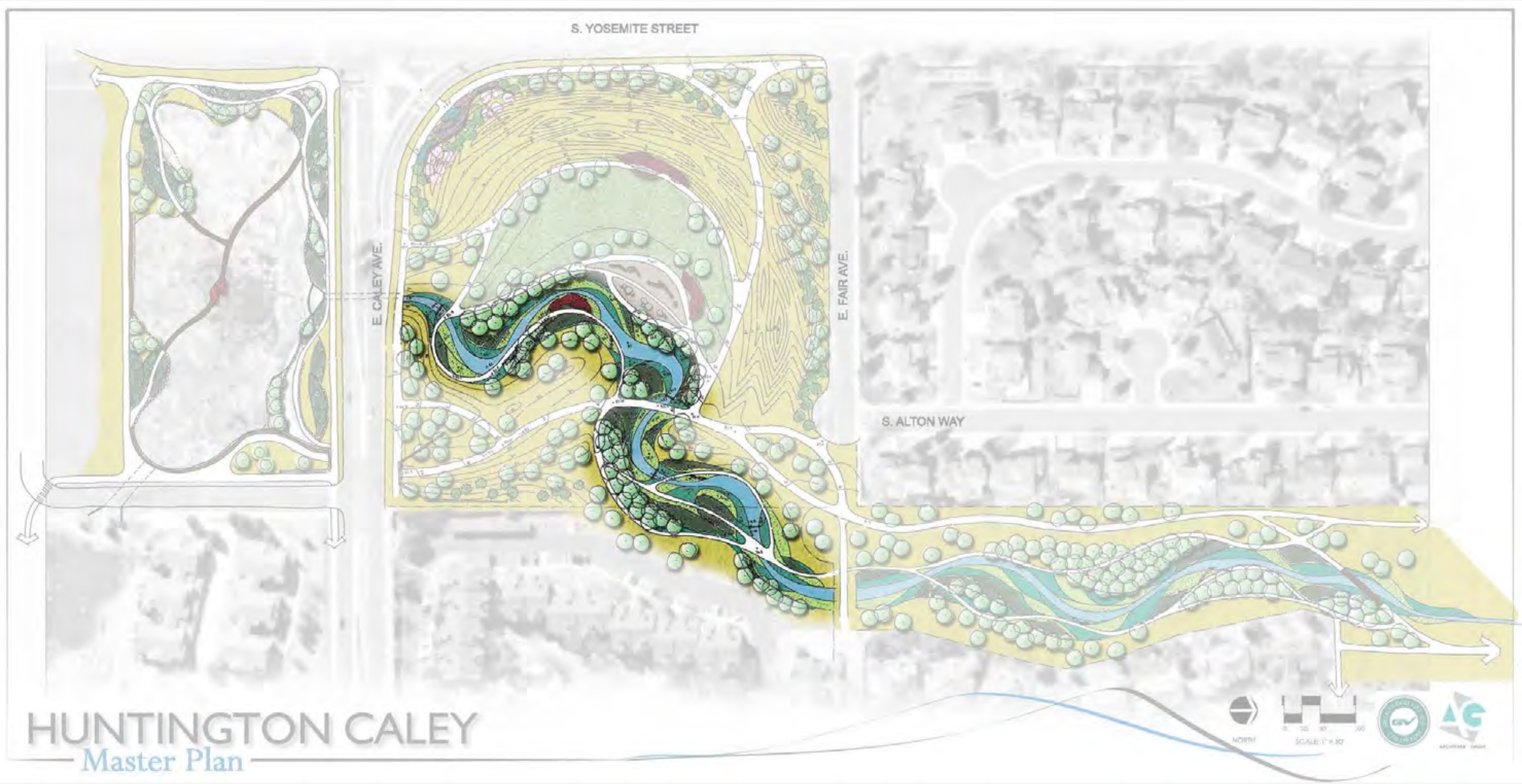
FINAL MASTER PLAN



PHASE 1


S. YOSEMITE STREET
E. CALEY AVE.
E. FAIR AVE.
S. ALTON WAY
HUNTINGTON CALEY
Master Plan
NORTH

PHASE 2


S. YOSEMITE STREET
E. CALEY AVE.
E. FAIR AVE.
S. ALTON WAY
NORTH
HUNTINGTON CALEY
Master Plan

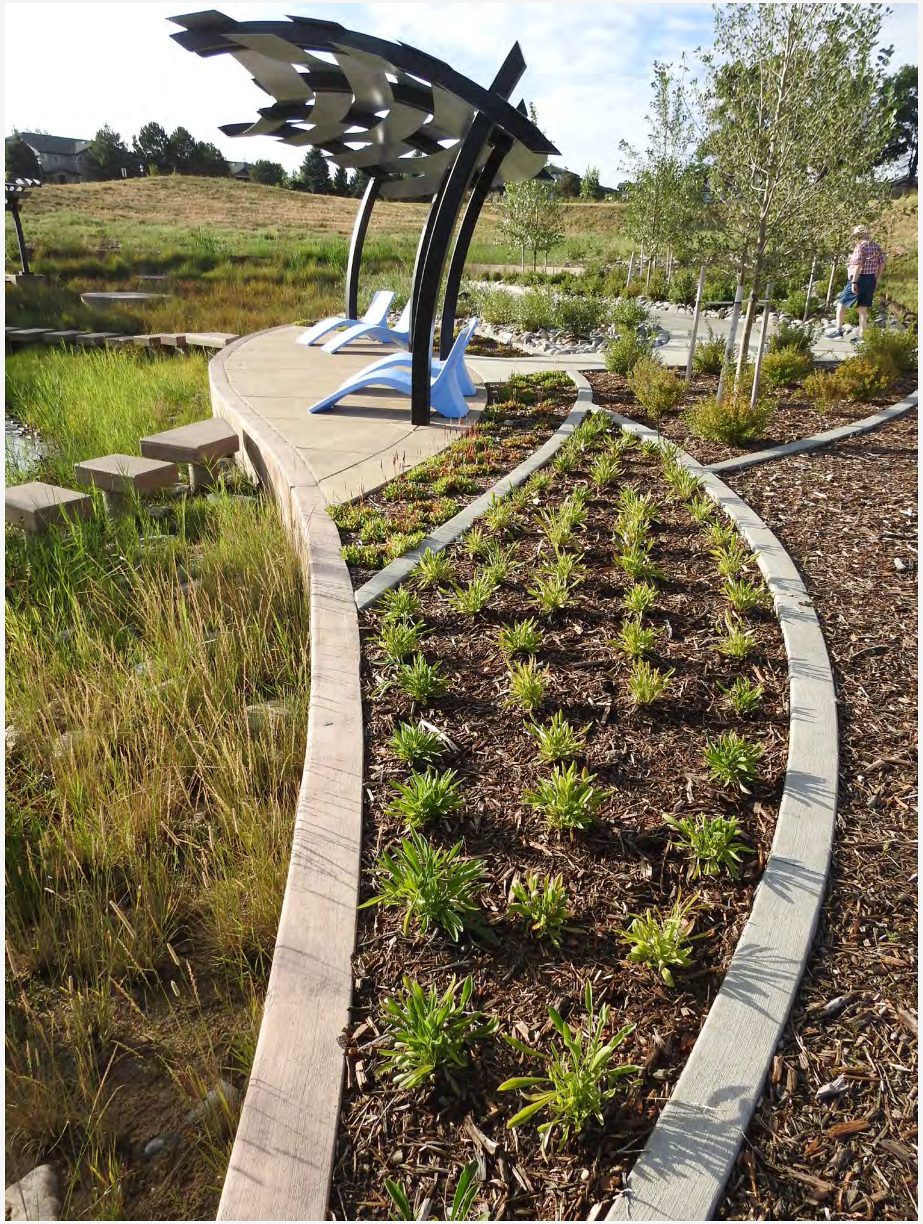
RIFFLE-POOL CHANNEL DESIGN

VOID FILLED RIPRAP

DROP STRUCTURE

DROP STRUCTURE

BRAIDED GARDENS



BRAIDED GARDENS

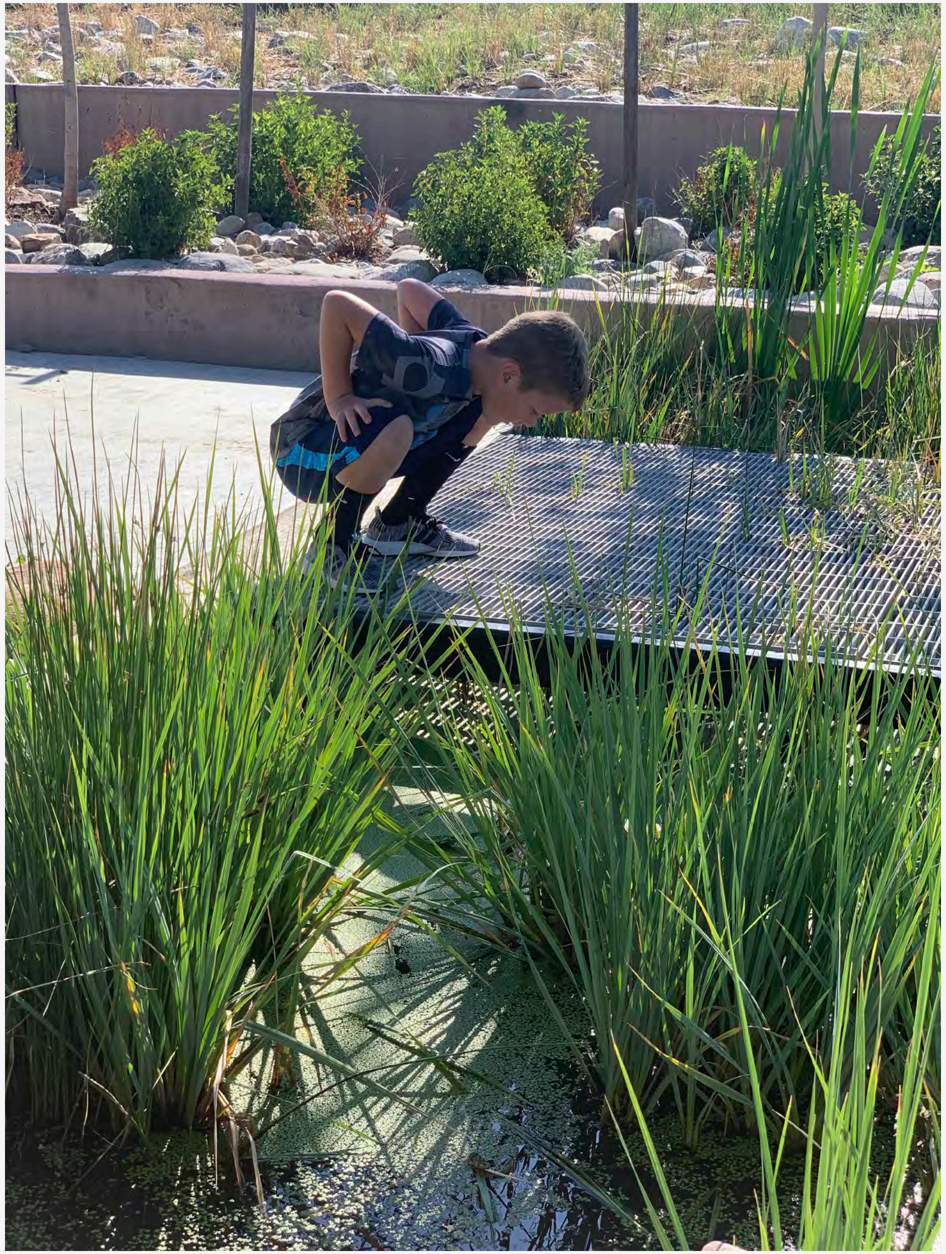
BRAIDED GARDENS

WETLANDS

WETLANDS

WETLANDS

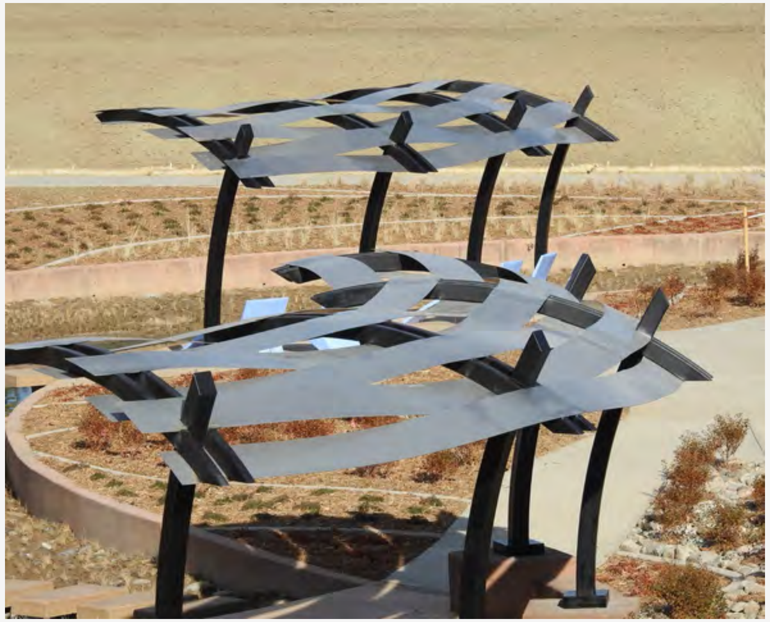
WETLANDS

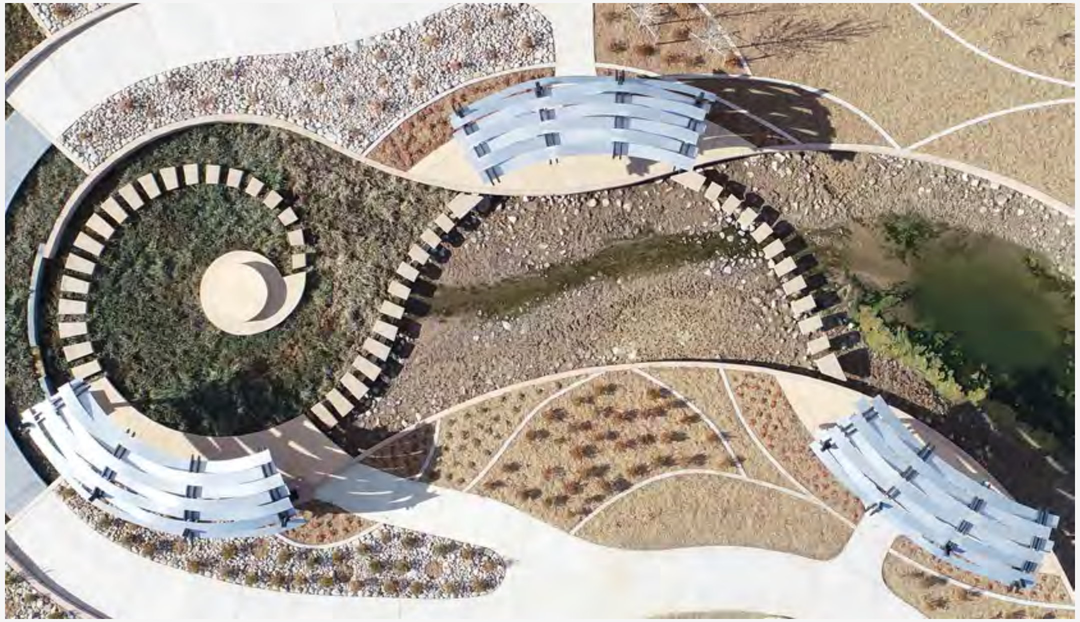


STEEL GRATED WALKWAYS

STEEL GRATED WALKWAYS

SEATING AREAS





SEATING AREAS

SEATING AREAS

CONCRETE STEPPING PLATFORMS

CONCRETE STEPPING PLATFORMS

CONCRETE STEPPING PLATFORMS

CONCRETE STEPPING PLATFORMS

CHALLENGES AND LESSONS LEARNED

VOID FILLED RIPRAP

VOID FILLED RIPRAP

VOID FILLED RIPRAP

WETLANDS

WEIRS

WEIRS

ECOLOGICAL FUNCTION OF CHANNEL

ECOLOGICAL FUNCTION OF CHANNEL

ECOLOGICAL FUNCTION OF CHANNEL

INSPIRES EXPLORATION

MAINTENANCE

A New Model for Park Design: Integrating Nature Play with HFLM Streams

Robin Wright

Brent Kaslon

Javier Bardem

A New Model for Park Design: Integrating Nature Play with HFLM Streams

Robin Wright

Hugh Jackman

Javier Bardem

A New Model for Park Design: Integrating Nature Play with HFLM Streams

Cassie Kaslon

Frans Lambrechtsen

Jerry Naranjo

First Creek Park:

A new model for Park Design

2019 CASFM Conference Presentation

Cassie Kaslon

Managing Principal

Valerian

Frans Lambrechtsen

Water Resource Engineer

Jacobs Engineering Group

Jerry Naranjo

President

Naranjo Civil Constructors

VALERIAN
LANDSCAPE ARCHITECTURE | PLANNING | IRRIGATION

JACOBS

EST. 1982 NARANJO CIVIL CONSTRUCTORS

I-70
PENA BLVD.
AVE.
I-225
C-470
C-470
BROADWAY
UNIV
COLO
PLA
AR
Globeville Landing Park
39th Ave GREENWAY
ST.CHARLES PARK
CITY PARK
FIRST CREEK PARK
WESTWOOD PARK
JOHNSON HABITAT PARK
GRANT FRONTIER PARK
PASQUINEL'S LANDING
CHERRY CREEK VALLEY
ECOLOGICAL PARK

NATURE PLAY IN THE BUILT ENVIRONMENT

DESIGN STANDARDS AND GUIDELINES

DENVER PARKS & RECREATION

MHFD

VALERIAN
LANDSCAPE ARCHITECTURE | PLANNING | IRRIGATION

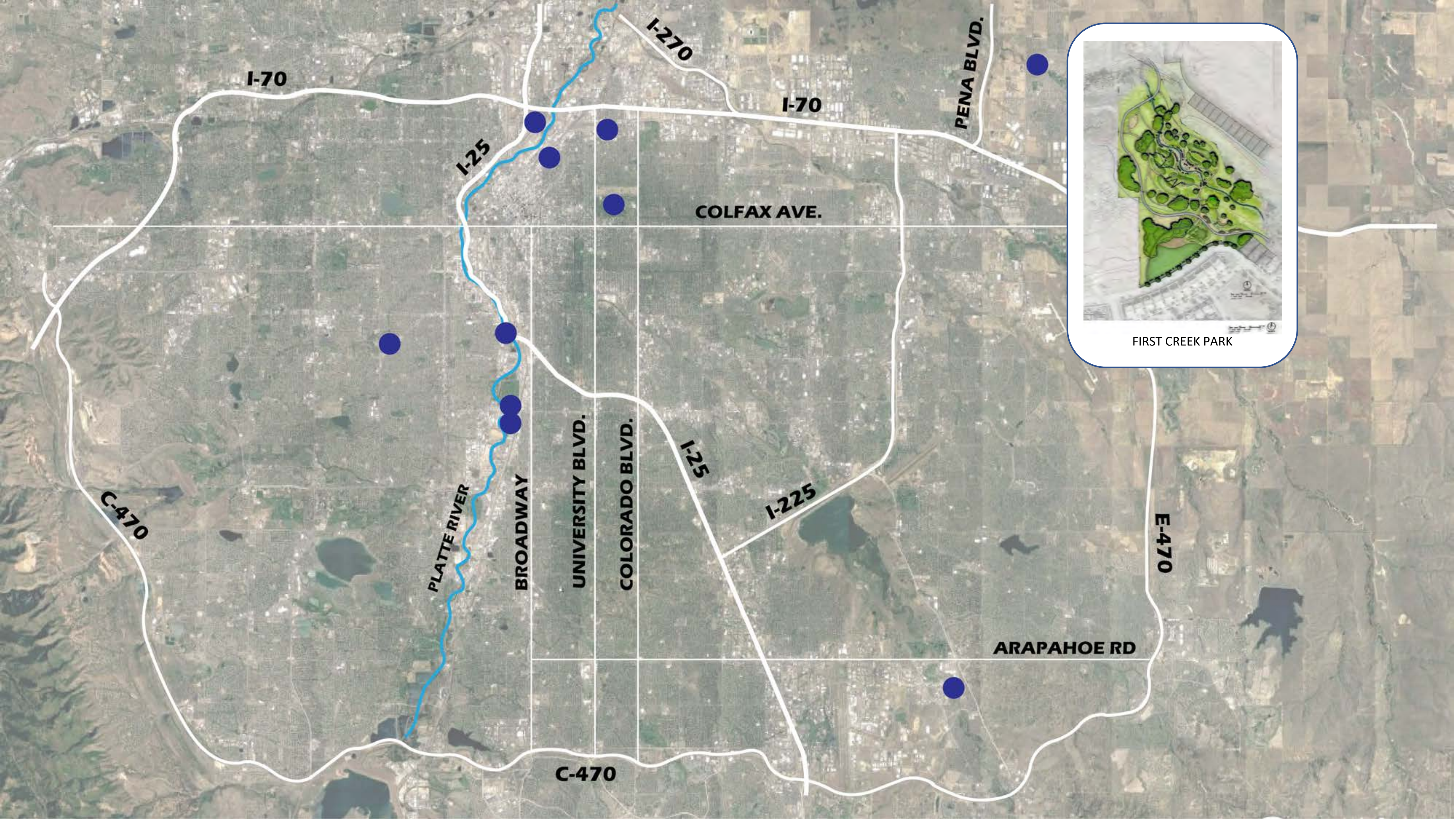
JACOBS

bienenstock natural playgrounds

What's in the Guidelines

- Nature Play Benefits
- Site Selection
- Public Engagement
- Inclusion in Nature Play
- Design Development
- Construction Document Guidelines
- Project Construction Period
- Post Occupancy
- Case Studies

- Over 70 pages of riveting information!


I-70
I-270
PENA BLVD.
I-70
I-25
COLFAX AVE.
I-25
I-225
C-470
PLATTE RIVER
BROADWAY
UNIVERSITY BLVD.
COLORADO BLVD.
E-470
ARAPAHOE RD
C-470
FIRST CREEK PARK

First Creek Park

Ownership:

DENVER PARKS & RECREATION

MHFD
MILE HIGH FLOOD DISTRICT

Design Team:

VALERIAN
LANDSCAPE ARCHITECTURE | PLANNING | IRRIGATION

JACOBS®

GREATecology
ENVIRONMENT + DESIGN

bienenstock
natural playgrounds

5 | SMOOTH STONES
RESTORATION PLLC

CORVUS
Environmental Consulting LLC

Construction Team:

EST. N 1982
NARANJO
CIVIL CONSTRUCTORS

Nature's
INSTRUMENTS

WESTERN STATES
RECLAMATION, INC.

Habitat Management
Environmental & Natural Resource Services

First Creek Park

Project Size: 6 acres
Year Completed: Summer 2019
Location: Denver, Green Valley Ranch
Budget: $1.3 Million

First Creek Park

Project Size: 6 acres
Year Completed: Summer 2019
Location: Denver, Green Valley Ranch
Budget: $1.6 Million

¾ of the site is inside the floodplain

First Creek Park: Existing Conditions

First Creek Park: Community Engagement

- **Preserve existing trees**
- **Provide access to the creek**

- **Activities for wide range of ages**
- **Flowers!**

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play

Hidden Elements of Play


Floodplain
Interface

First Creek Park

HFLMS Principles and Components

- Multi-stage channel
- Connected floodplain bench
- Active (bankfull) channel
- Sinuosity, pool to pool spacing
- Riffle grade control
- Riparian vegetation

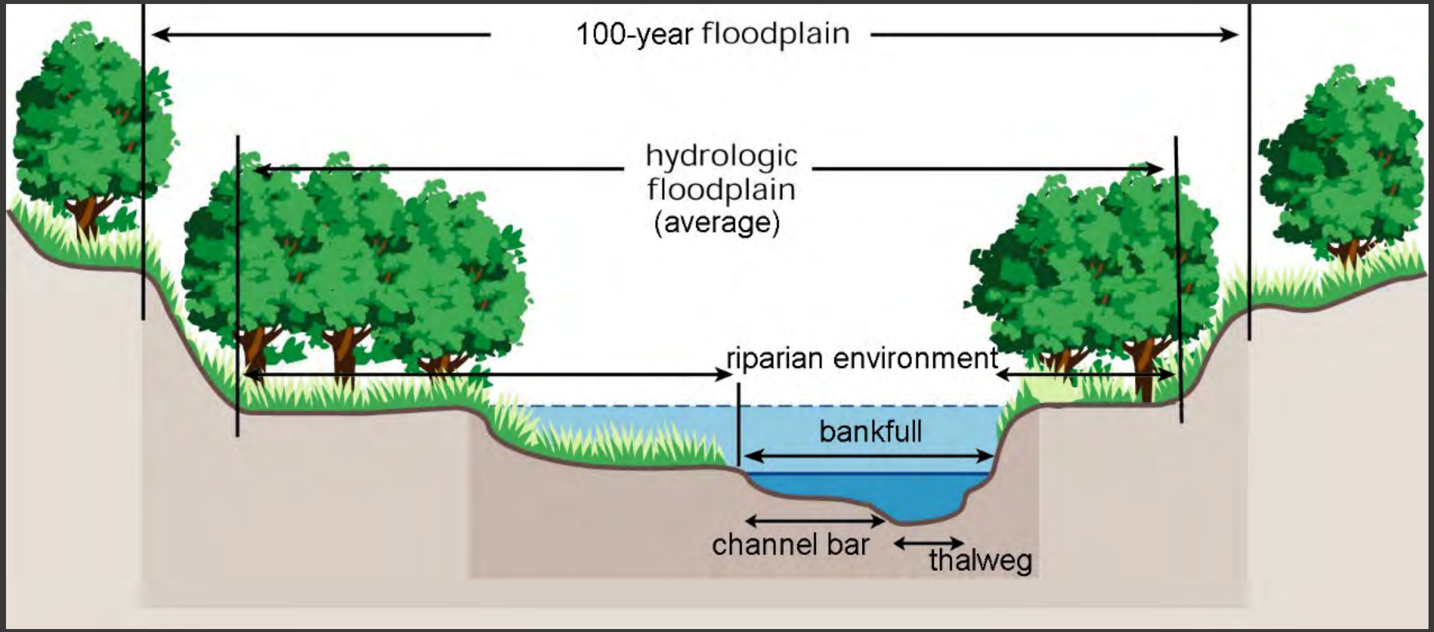


Figure from presentation by ERC through the Stream Management Academy

HFLMS = High Functioning Low Maintenance Stream

First Creek Park

HFLMS Principles and Components

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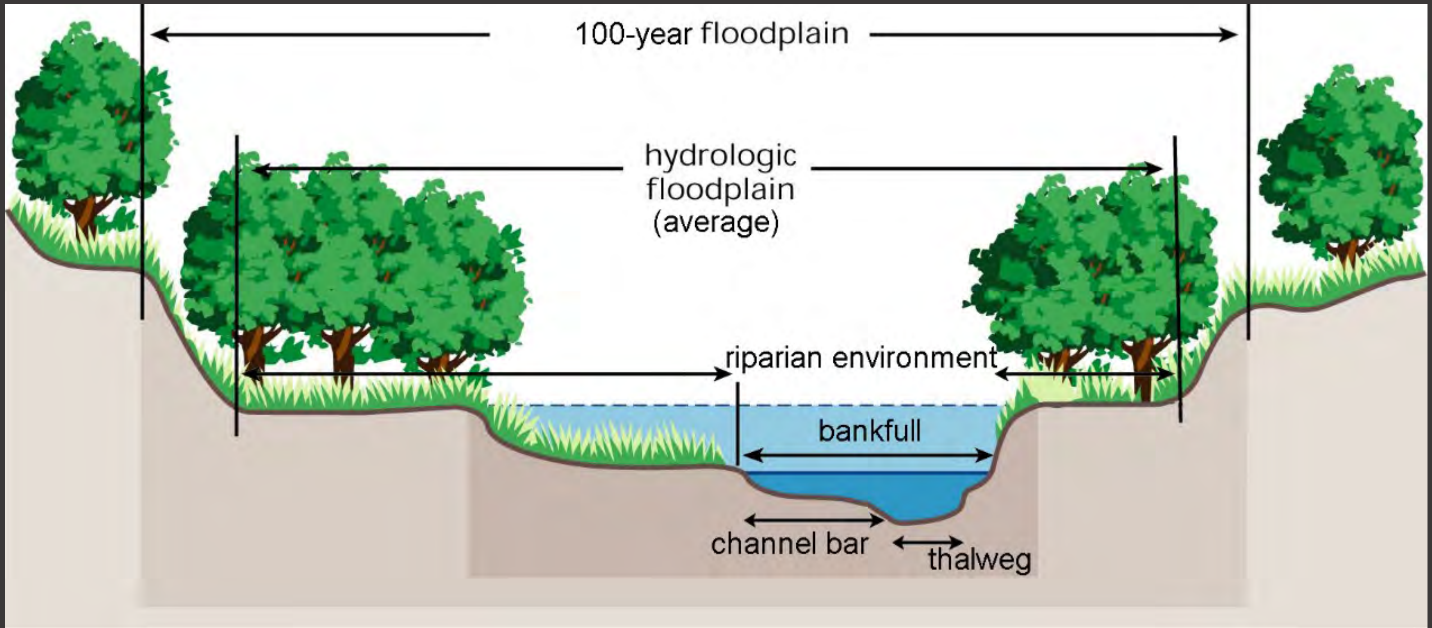

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HFLMS Principles and Components

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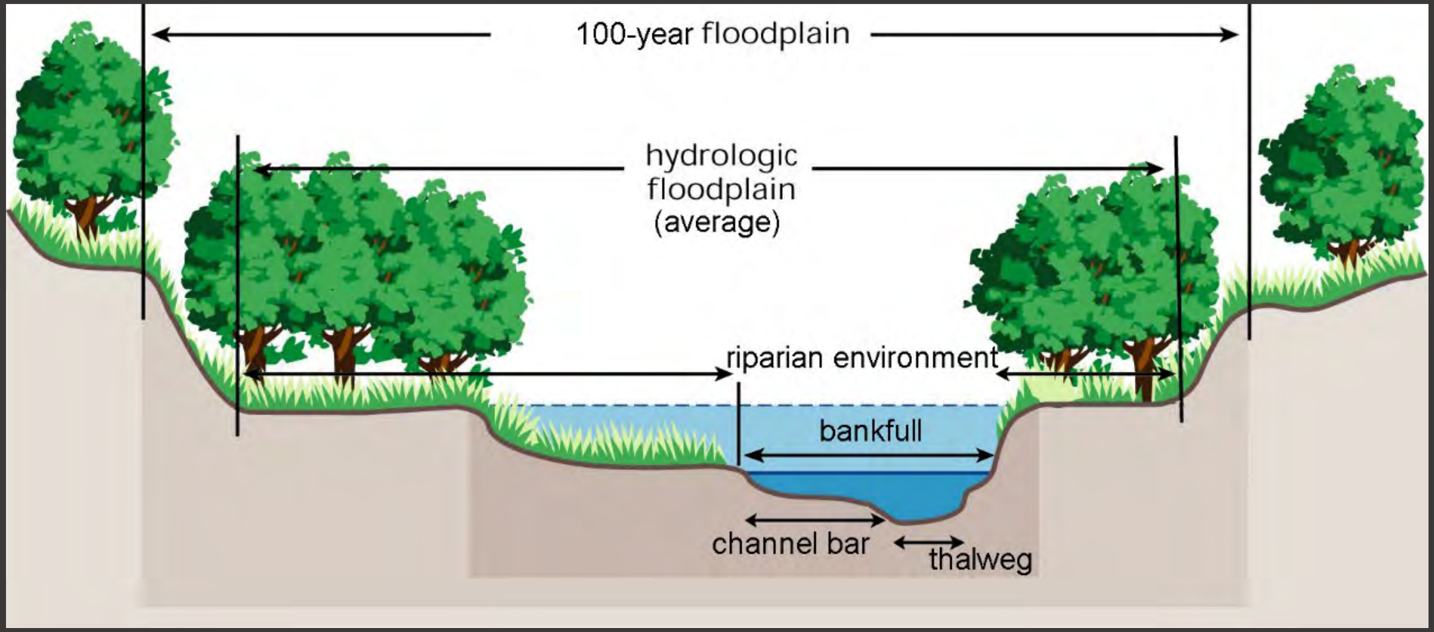

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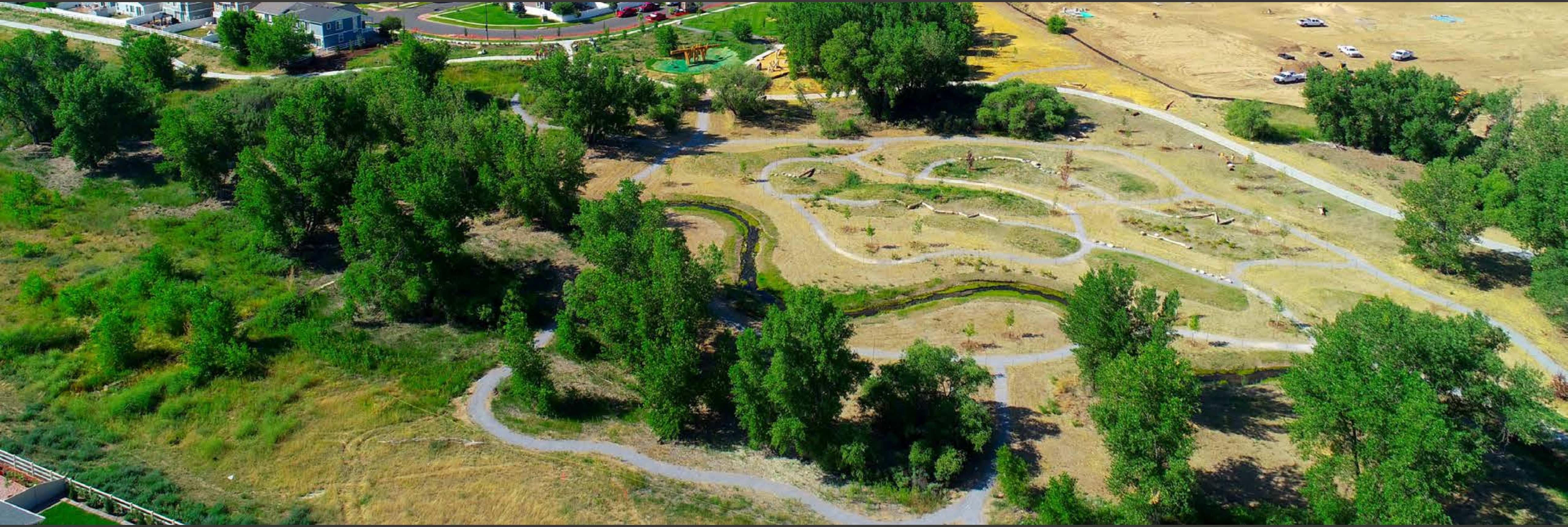
First Creek Park

First Creek Park



First Creek Park

First Creek Park

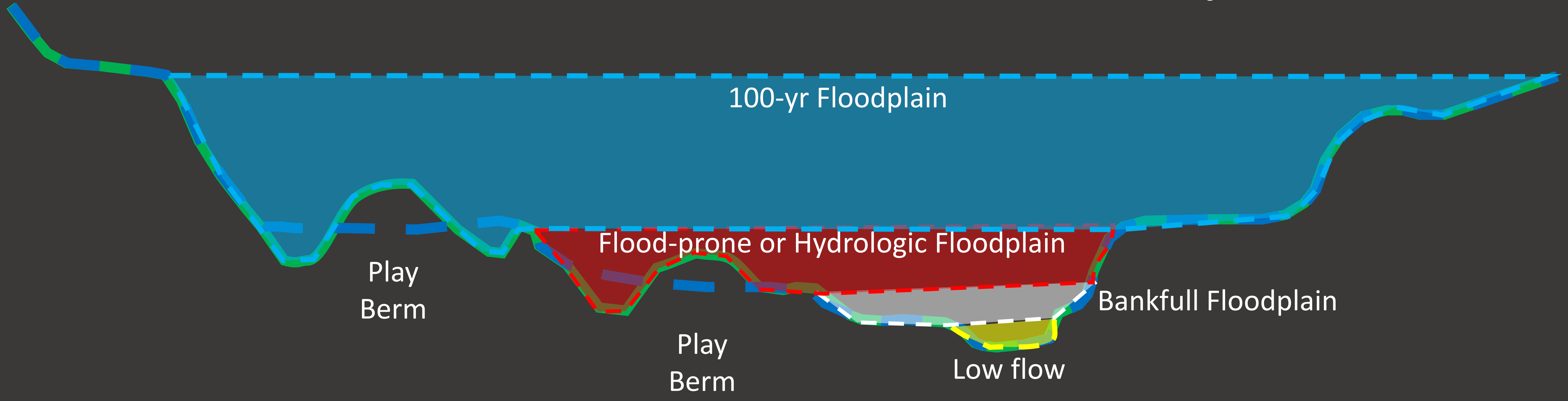
First Creek Park

Human Connection with Floodplain Preservation

Floodplain Preservation with Elements to Add Diversity and Fun

First Creek Initial Design

Let’s Create Some Nature Play



Cross-section

Human Connection with Floodplain Preservation

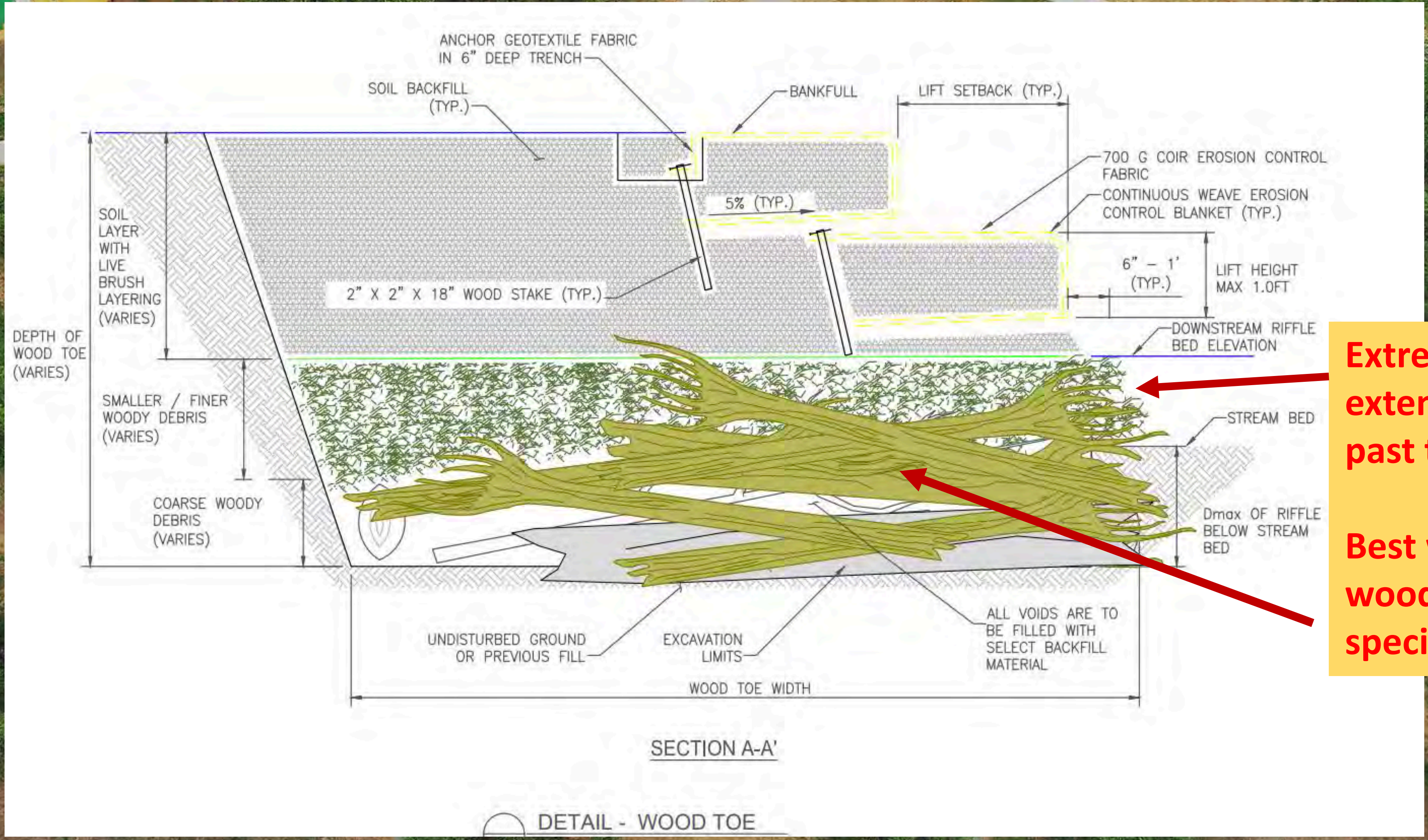
Lessons Learned

Lessons Learned

Lessons Learned

Lessons Learned

Lessons Learned



Extremely important to extend this woody toe past the soil lift above

Best way to anchor wood toe – very site specific.

Questions?

Thank You!

Designing Hydroseres for Riparian and Wetland Restoration

John Giordanengo, M.S., CERP

970-420-7346

john@aloterraservices.com

AloTerra Restoration Services

The Tropical Forests of the West

Riparian areas:

< 1% of the land area of western states (Cooperrider, Boyd, and Stuart, 1986).

80% of wildlife species in the west are dependent upon riparian areas for survival (Wayland, 1997).

Benefits of Diverse Riparian Restoration

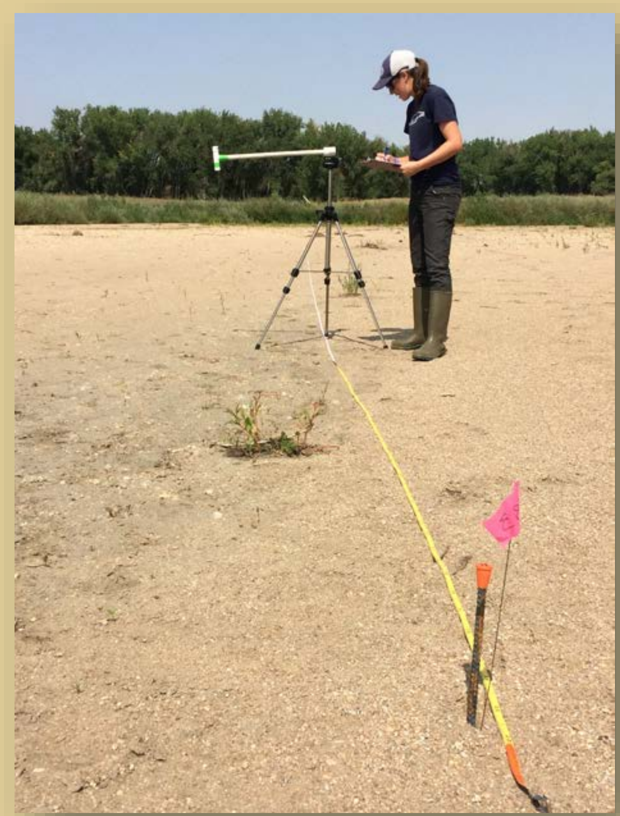
Increased floodplain roughness & bank stability

Increased biodiversity (& structural diversity)

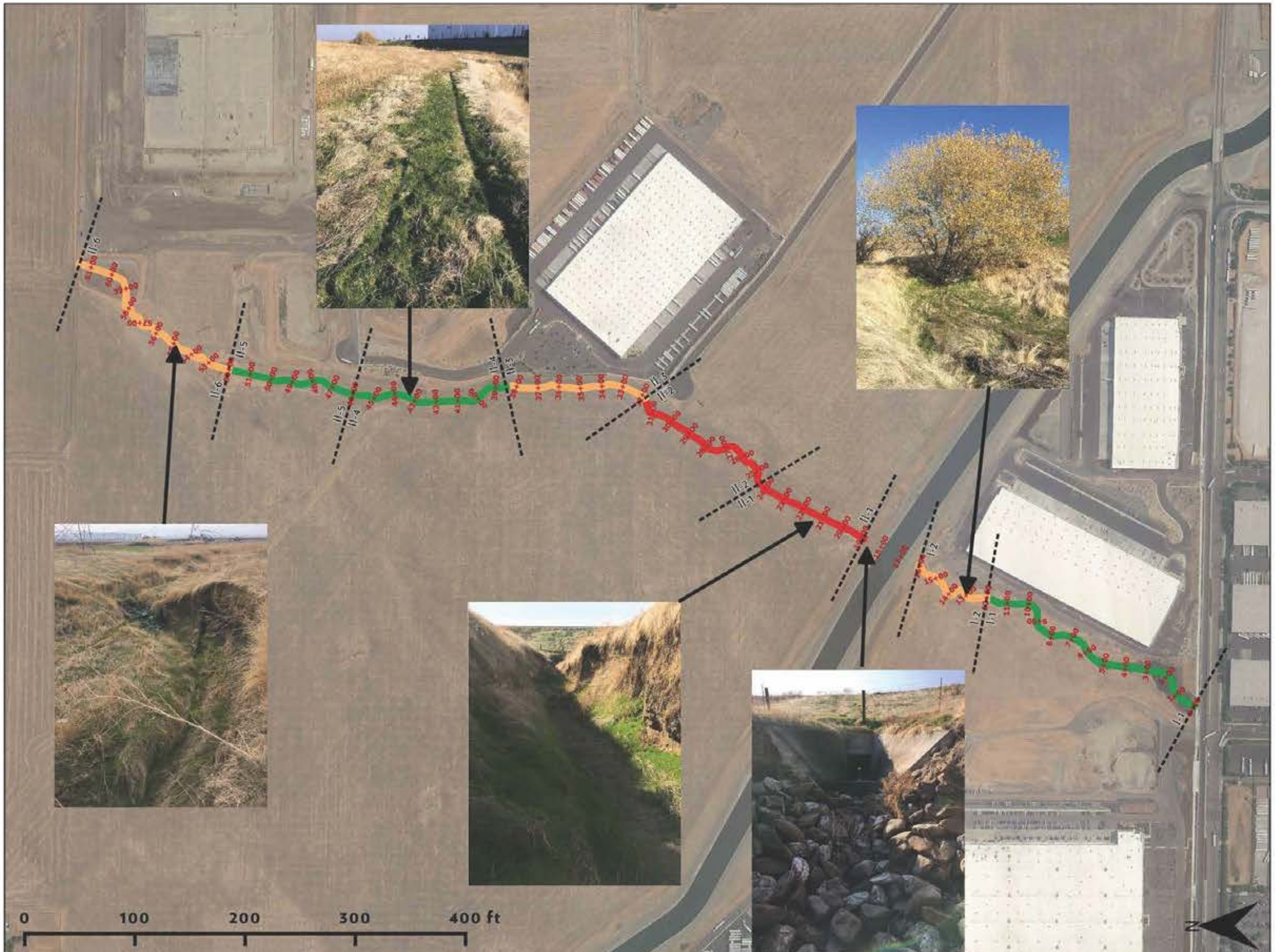
Increased organic inputs to stream & stream shading

Improved water quality (sediment, temperature, DO)

Good Design Begins with Accurate (and adequate) Assessments



1. Condition of Plant Community
2. Potential Natural Community
3. Topography & Infrastructure
4. Soils
5. Hydrology
6. Regulatory Compliance



IPC Arroyo Stream Stability Assessment

LEGEND:

---- Matchlines

Stream Stability Score

- 50.0000 - 59.6000
- 59.6000 - 69.2000
- 69.2000 - 78.8000
- 78.8000 - 88.4000
- 88.4000 - 98.0000

*Stream stability scores are percentages.

The scores are ranked lowest (green) to highest (red) which correspond to least to most bank erosion respectively.

PREPARED FOR:

PREPARED BY:

AloTerra Restoration Services

LAYER PROJECTION:	NAD 83/ California Zone 3
SOURCE OF MAP:	Google Satellite Imagery
DATE ISSUED:	01/25/2018
DRAWING NO:	LAND-1

Restoring the ecological integrity of a floodplain is essential to maintaining resilience and proper floodplain function (over time)

Remember: **SQT places the Riparian Vegetation parameter in the Geomorphology Category**

Absent Goals…

Nothing Else Matters

- Increase Functional Lift for SQT (< LF needed for mitigation)
- Stabilize Eroding Banks?
- Improved Wildlife Habitat?
- Pure Ecological Restoration?
- Other?

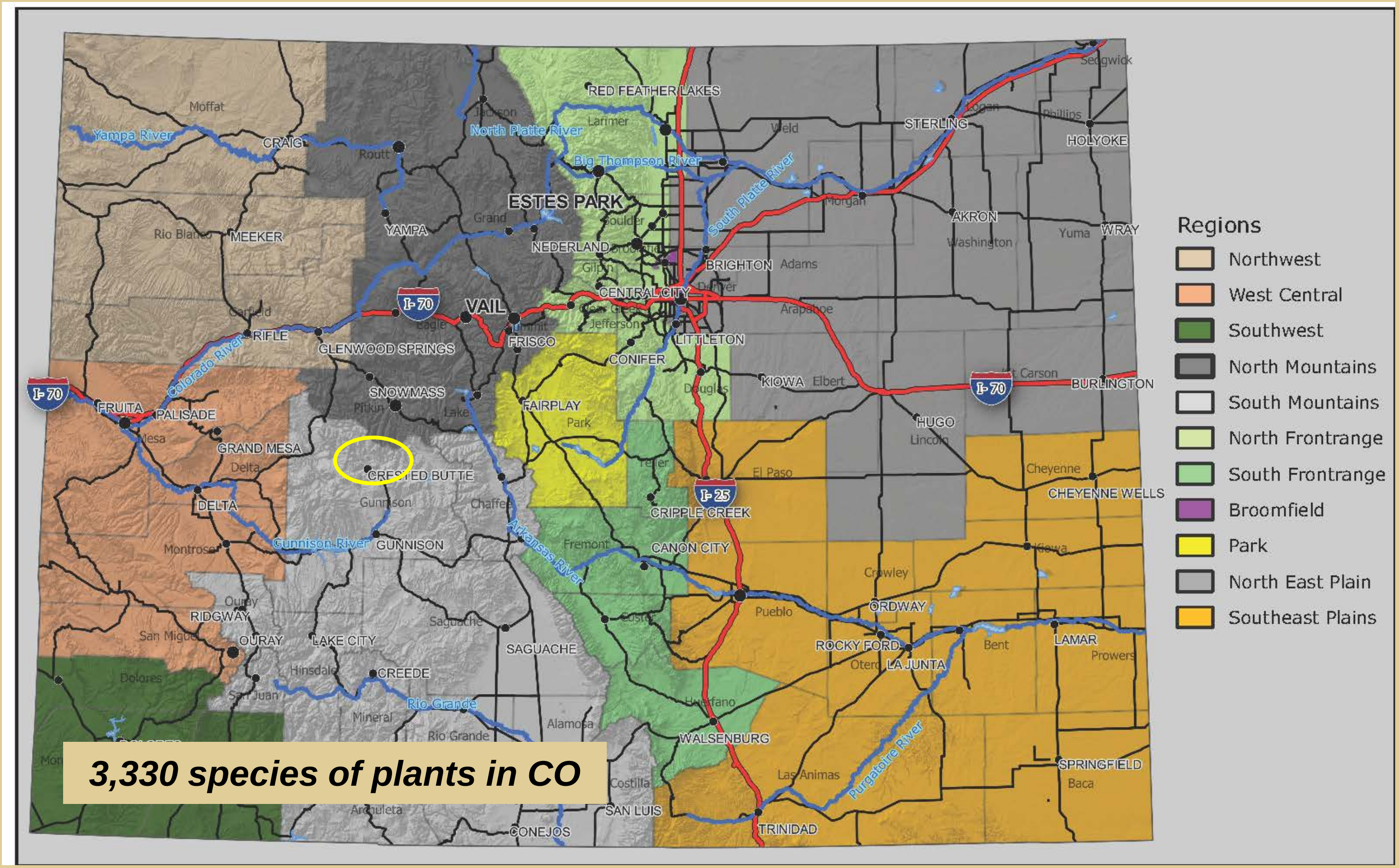
Restoration Goals are Like Soup Ingredients

- They don't work well in isolation
- When you add more than one, a beneficial synergy is produced.
- They must be compatible
(Salt, Fat, Acid, Heat)

Which of these Goals is <u>not</u> Like the Rest

- Natural Landscape?
- Stabilize Eroding Banks?
- Improved Wildlife Habitat?
- Mowed green lawn to edge of river?
- Improved Bee Forage?

Where to Start with Reveg. Design?



3,330 species of plants in CO

Elevation and Geographic Location of Restoration Site

Native Plants for Restoration in Crested Butte (Slate River or Coal Creek)

240 species available for restoration

SEED

CONTAINERS

CUTTINGS

Grouping Species by Life History Traits

<u>TYPICAL LIFE HISTORY TRAITS</u>
Native Perennial Forb
Native Annual Grass
Native Tree
Introduced Perennial Grass…

<u>FUNCTIONAL TRAITS</u>
Erosion Control (banks)
Floodplain Roughness
Pollinator Species
Structural Diversity
Late Season Forage
Aesthetics
Bioengineering
Species Specific (trout, PMJM, bald eagle, etc.)

Berry Producing Shrubs

Scientific Name (Ackerfield, with authority)	Scientific Name (USDA)	Common Name (USDA)	Min Elev (resto)	Max Elev (resto)	Life History
Juniperus communis L. var. depressa Pursh	*Juniperus communis*	common juniper	6500	12000	NS
Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg.	*Prunus virginiana var. me*	black chokecherry	4000	9000	NS
Ribes cereum Dougl.	*Ribes cereum*	wax currant	4300	10500	NS
Ribes inerme Rydb.	*Ribes inerme*	whitestem gooseberry	6900	9800	NS
Rosa woodsii L.	*Rosa woodsii*	Wood's rose	3700	9200	NS
Rubus deliciosus Torr.	*Rubus deliciosus*	delicious raspberry	5400	10000	NS
Shepherdia canadensis (L.) Nutt.	*Shepherdia canadensis*	russet buffaloberry	8000	10800	NS
Symphoricarpos albus (L.) Blake	*Symphoricarpos albus*	common snowberry	6000	8800	NS

8 (30 total)

Pollinator Species

117

Willow Species

Native Perennial Grass & Grass-Like Species

Refining Species Selection

Soils, Geology, Hydrology, Ecology, and Environmental

Soils
pH
Electrical Conductivity/Salinity
Texture
Trace metals
Macronutrients
Mictonutrients
Organic Matter

Ecology/Biology
Reference Community
- % Cover
- Diversity/richness
- Composition
- Structural Diversity
- Wildlife Needs

Abiotic
Hillslope angle
Elevation/Frost-free Season
Aridity
- Precipitation
- Geography
- Topography

Hydrology

Regulatory, Land Use, and Resource Constraints

Post-restoration Land Use & Goals
Recreation
Grazing
Wildlife
Ecological Uplift
Protection of Infrastructure

Resource Constraints
Plant Materials Availability
Budget Limitations
Funding Schedules

Regulatory
Bond Release
Weeds
Cover
Composition
Species-specific

Type of Plant Material

SEED
- Inexpensive per acre
- Easy way to add diversity to site
- Potential for high vegetation cover quickly

CONTAINERS
- Can be designed to not require irrigation (D60 – deep pots)
- Higher cost per acre
- Should secure further in advance than seeds

CUTTINGS
- Inexpensive per unit
- Easy to acquire as ecotypic stock (local genetics)
- Irrigation typically not necessary

Expected Niche vs. Restoration Niche

<u>Expected (i.e., fundamental) Niche</u>

A plant's expected location on the landscape, based on natural means of recruitment (i.e., seed rain or fecal matter)

<u>Restoration Niche</u>

Where the plant may be located based on means of establishment (i.e., seed, container, cutting).

Influenced by risk of drought or scour.

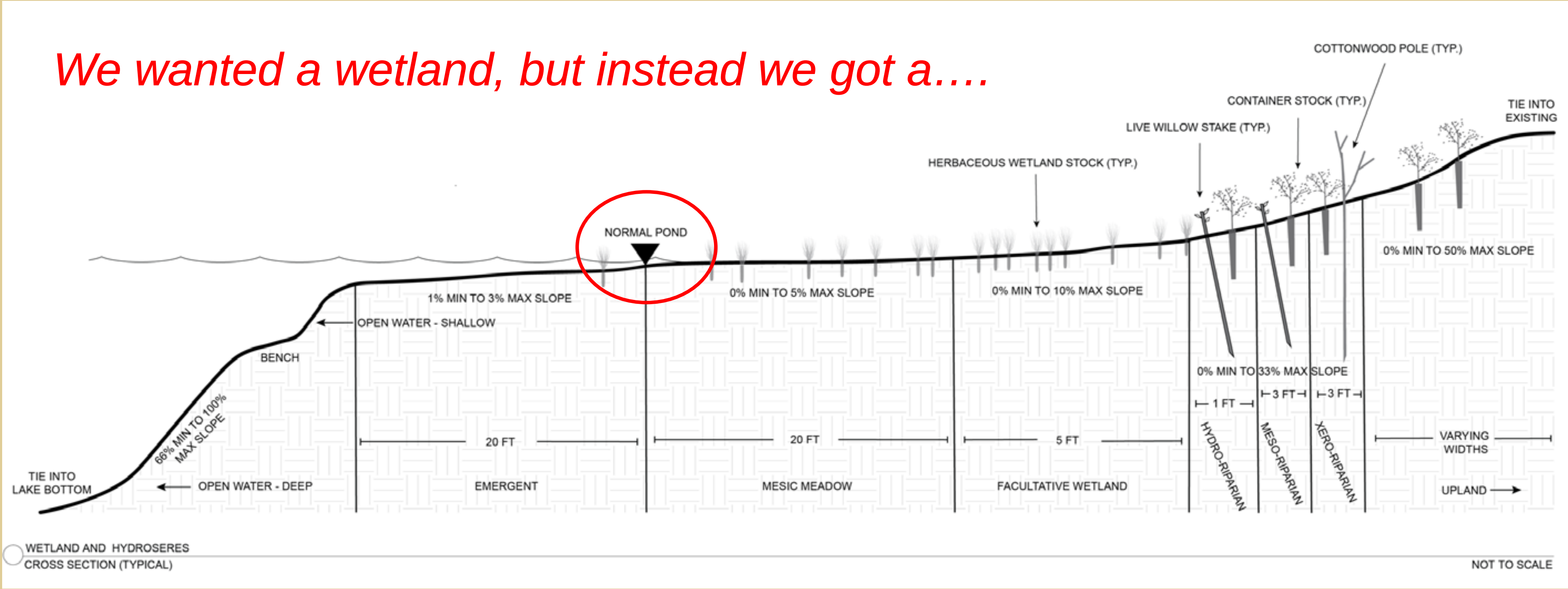
Restoration Niche is often narrower than fundamental niche.

Riparian Hydrosere

A riparian plant community whose composition and structure is influenced primarily by hydrology, landform, and frequency of disturbance.

Pool (1914: p 189, in *Plant Succession: An Analysis of the Development of Vegetation*, Clements, Frederic. E., 1916)

Importance of Defining Hydroseres for Riparian/Wetland Restoration



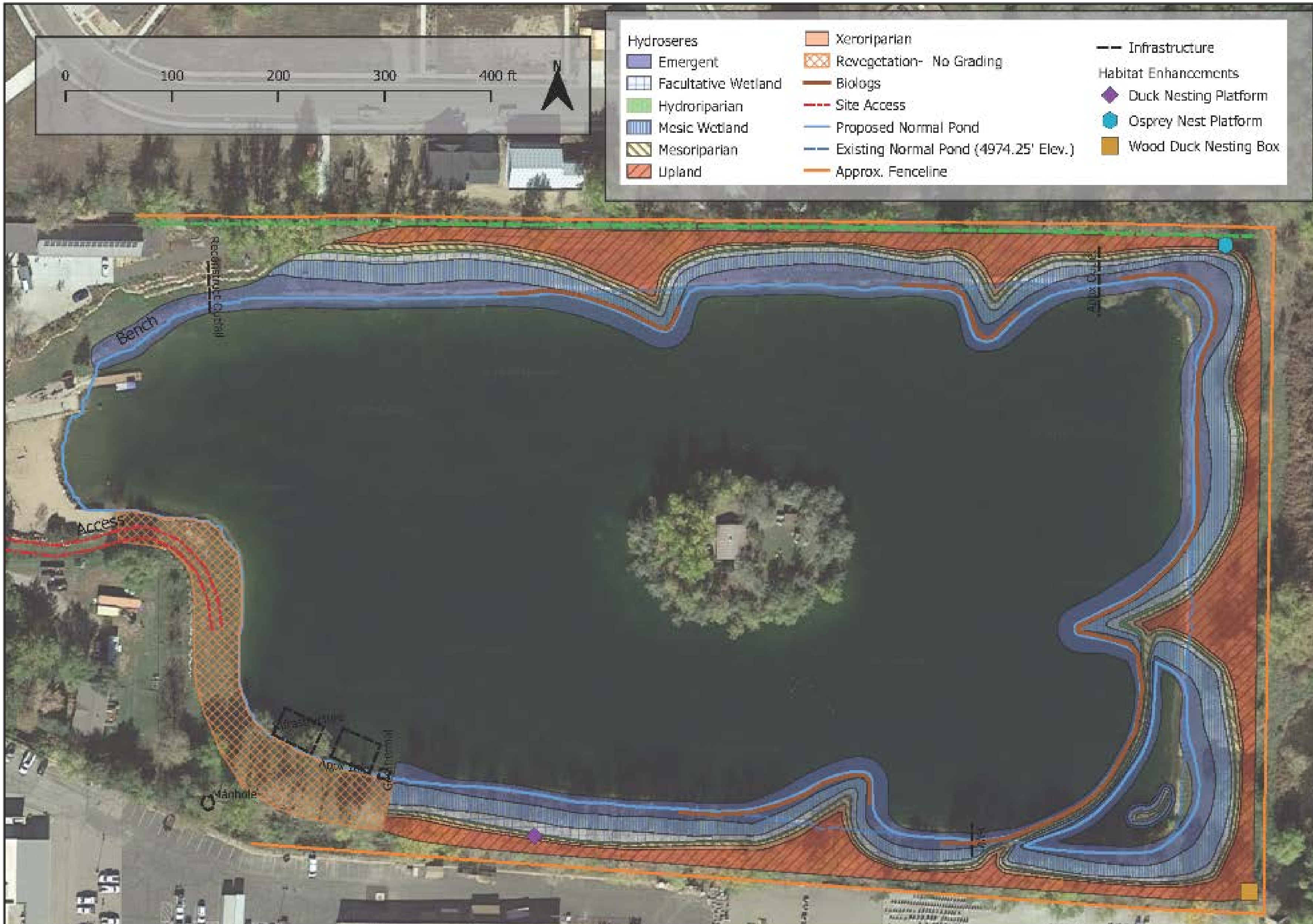
Define a hydrologic point of reference appropriate for the project

Design the right community in the right place

Specify the right plants in the right place

Define Hydroseres Relative to Point of Reference

Hydrosere	Water depth relative to normal pond (ft)	Water Depth for grading surface (ft a.s.l.)	Min. Horizontal Extent of grading surface (ft)	Min slope (%)	Max Slope (%)
Open water slope to lake bottom	deeper than -.75	< 4973.5	various	66%	100%
Emergent Wetland	-.75 to +0.25	4973.5 - 4974.5	20	0.5	2
Normal Pond*	0	4,974.25	0.25	n/a	n/a
Normal Pond (Max)*		4,975.00	0.25	n/a	n/a
Mesic Wetland	+0.25 to 1.0	4,974.5 - 4,975.25	20	0.5	3
Facultative Wetland	+1.00 to 1.5	4,975.25 - 4,975.75	5	0.5	3
Hydroriparian	+1.5 to 1.75	4,975.75 to 4,976.0	1	0	33
Mesoriparian	+1.75 to 2.50	4,976.0 to 4,976.75	3	0	33
Xeroriparian	+2.5 to 3.25	4,976.75 to 4,977.5	3	0	33
Upland	> 3.5	> 4,977.5	various	0	50


0
100
200
300
400 ft
N
Hydroseres
Emergent
Facultative Wetland
Hydroriparian
Mesic Wetland
Mesoriparian
Upland
Xeroriparian
Revegetation- No Grading
Biologs
Site Access
Proposed Normal Pond
Existing Normal Pond (4974.25' Elev.)
Approx. Fenceline
Infrastructure
Habitat Enhancements
Duck Nesting Platform
Osprey Nest Platform
Wood Duck Nesting Box
Bench
Access
Manhole

Designing Without Irrigation in Mind

Hunters Overlook

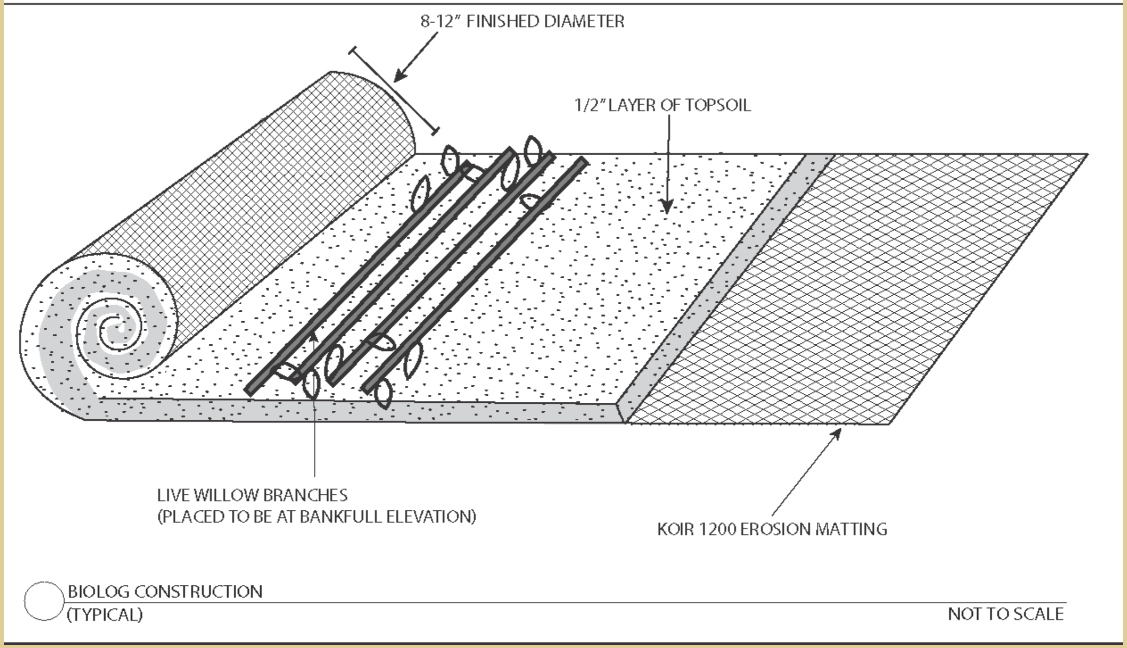
- Mesoriparian shrubs locate immediately below edge of the capillary fringe.
- Xeroriparian shrubs located at or just above capillary fringe

No Need for Irrigation

Hunters Overlook

- 3 months after installation

Vegetated Soil Lifts
(what hydrosere is this?)



Biologs

<u>Others:</u> Fascines, joint planting, live brush trenches, dense cuttings, sod transplants….

Questions?

john@aloterraservices.com

Stream Restoration Projects – The Revegetation Side of the Story

Drew Barrymore

Jenny Slate

Stream Restoration Projects – The Revegetation Side of the Story

Janelle Kreutzer

Moneka Worah

Stream Restoration Projects - *The Revegetation Side of the Story*

CASFM 2019

Jenelle Kreutzer and Moneka Worah

ERO Consultants in Natural Resources and the Environment

Topics

Ecological restoration 101

- 3 primary components
- Ecosystems in CO

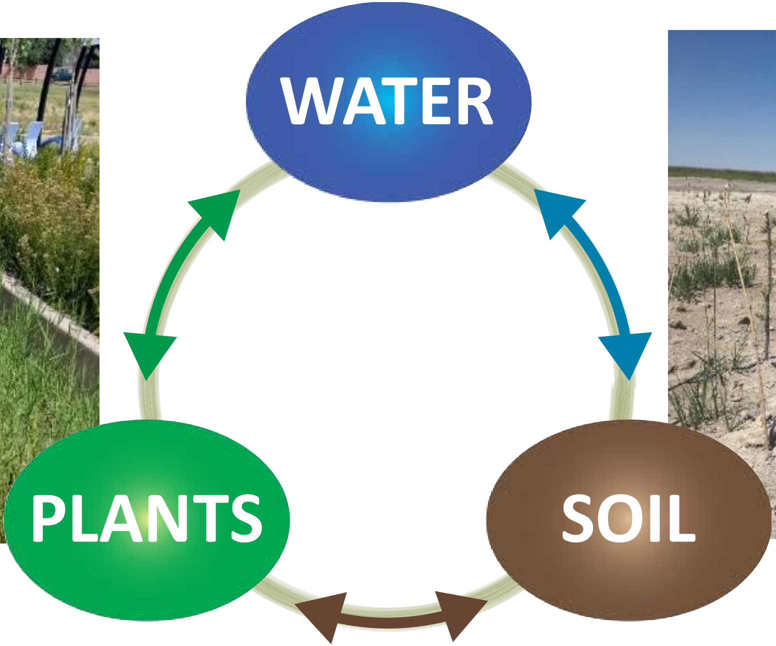
Tips for revegetation success

- Project start-up
- Design
- Construction
- Post-construction/monitoring

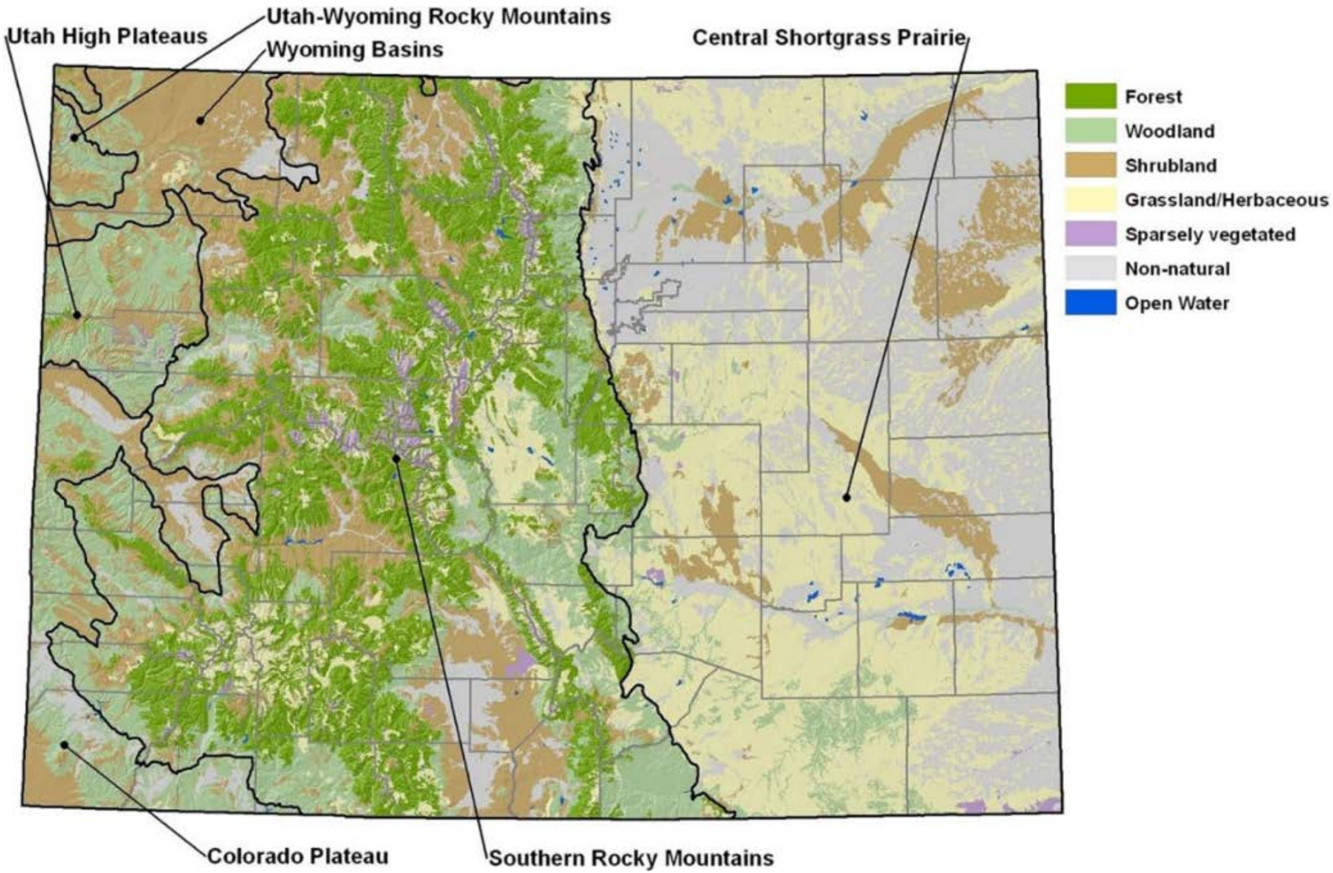
Takeaways

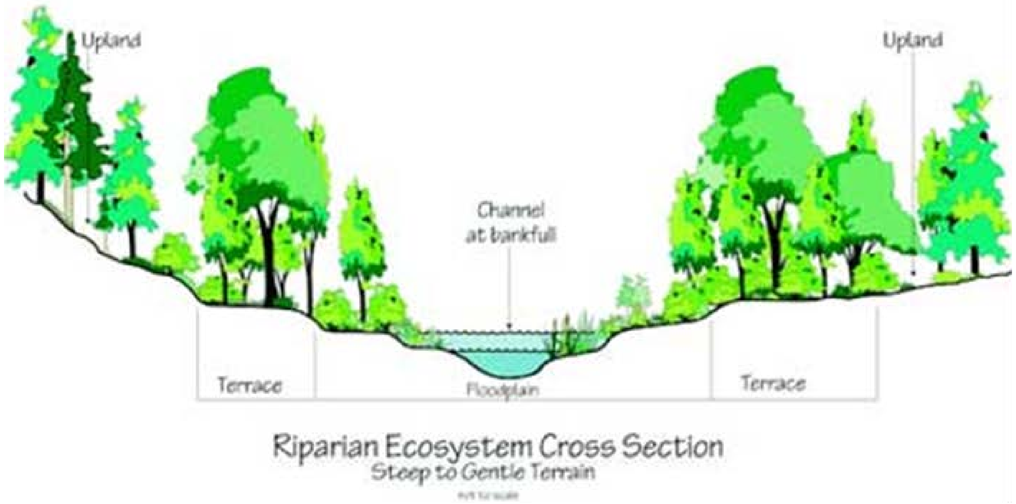
Ecological restoration 101

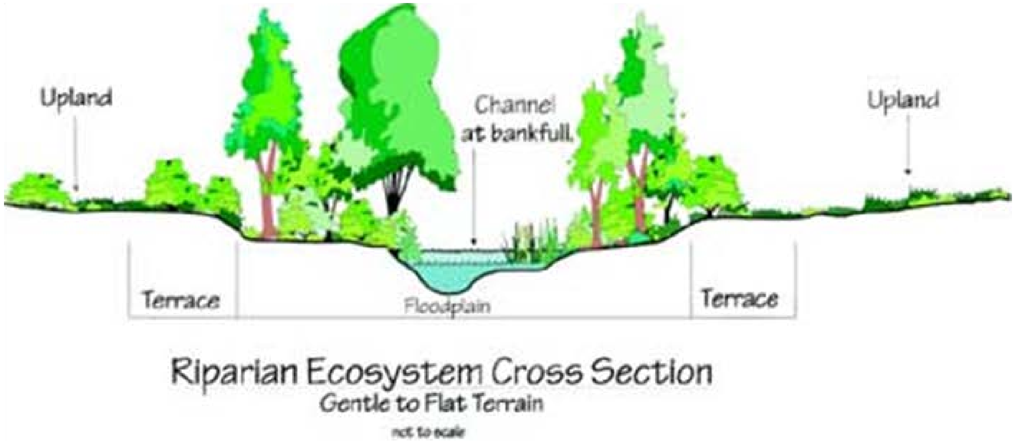
Ecological restoration 101



Ecological restoration 101

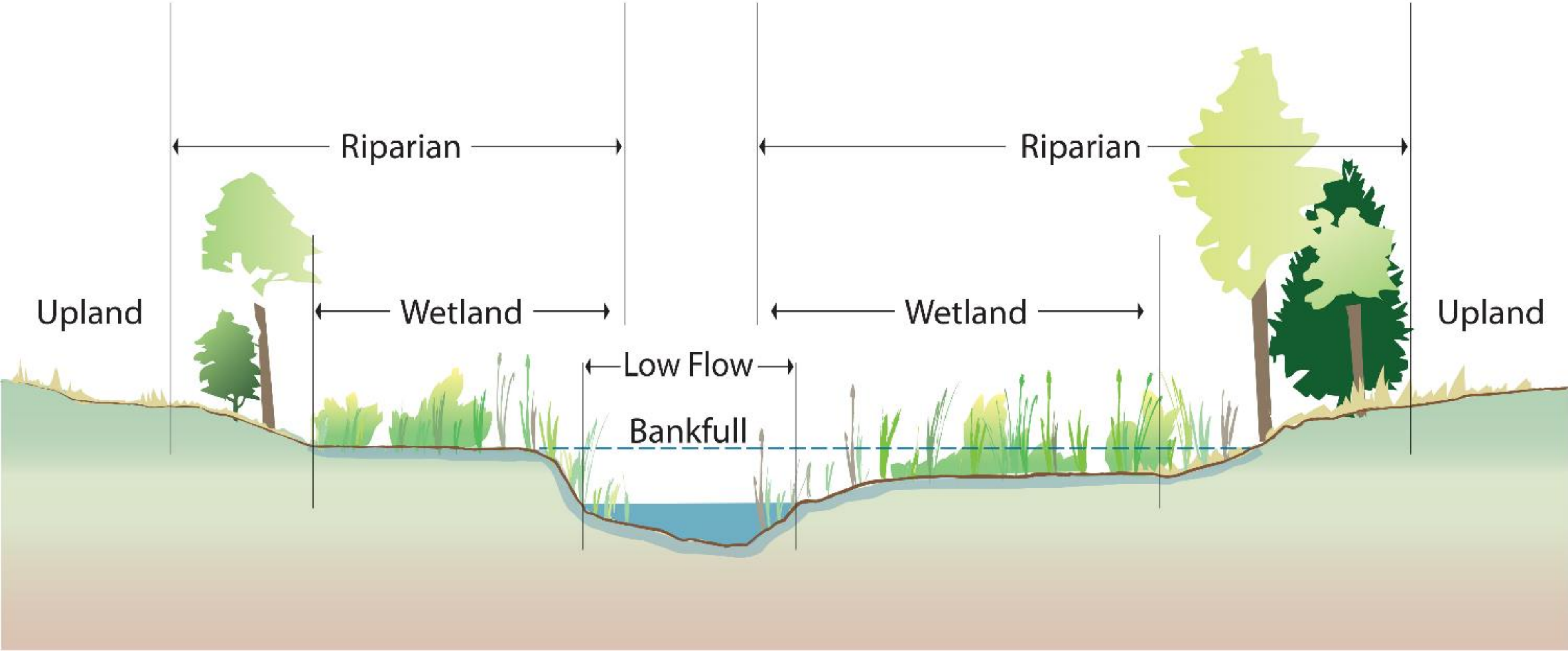






Ecological restoration 101

Ecological restoration 101



Ecological restoration 101

Tips for revegetation success

Tips for revegetation success

Project start-up – Ecologist from project beginning to end

- Know ecological setting and existing site conditions
- Identify restoration potential
- Develop a vegetation management plan

Tips for revegetation success

Project start-up – Regulatory compliance

"Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." - Definition of wetlands as used by the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) since the 1970s for regulatory purposes.

Tips for revegetation success

Project start-up – Identify revegetation goals and objectives

What constitutes revegetation success?

- Cover
- Composition
- Structural or plant diversity

What is the role of vegetation in the project?

- Aesthetics
- Meeting environmental permitting requirements
- Lateral migration/bank stability

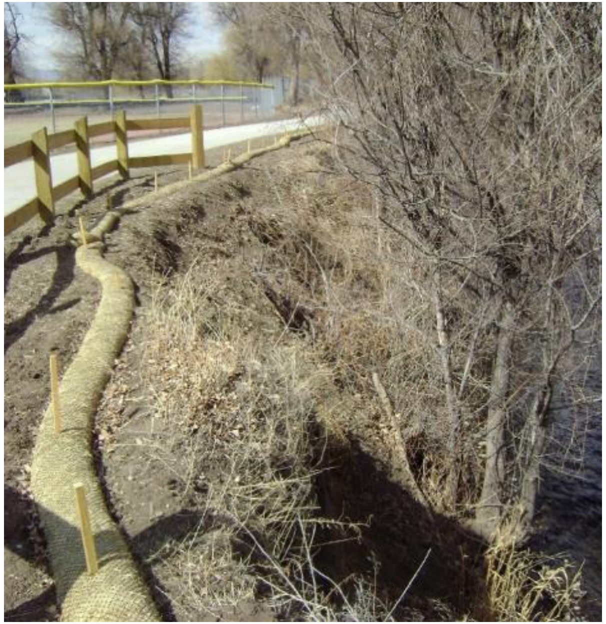
Tips for revegetation success

Design –

- Avoid and minimize
- Use more vegetation
- Salvage material and live transplants

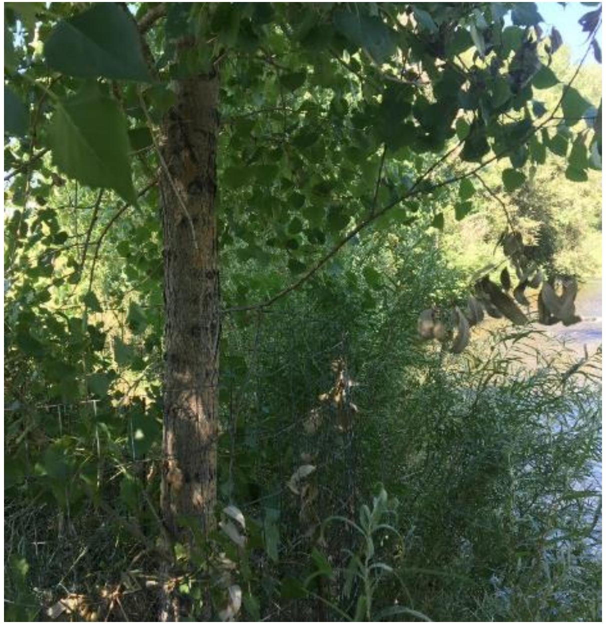
Tips for revegetation success

Design – Avoid and minimize



Tips for revegetation success

Design – Use more vegetation!

Tips for revegetation success

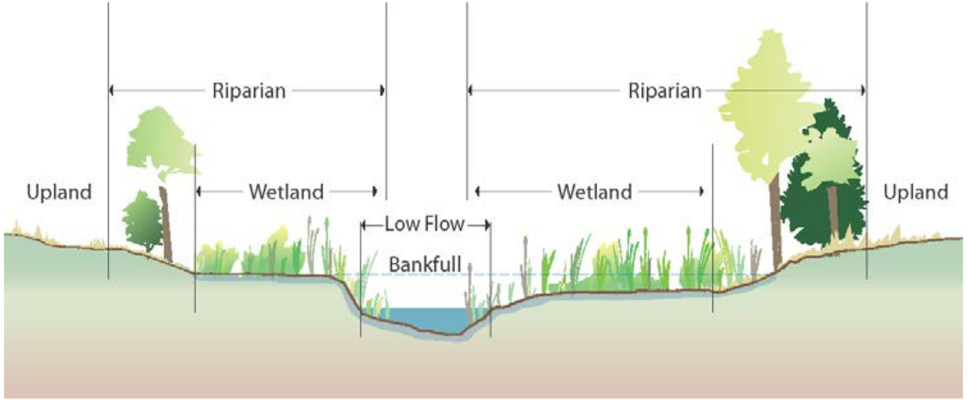
Design – Use more vegetation!

Tips for revegetation success

Design – Hydrology

Understand/define the following:

- Flow type
- Watershed Hydrologic regime
- Wetland vs Riparian
- Low-flow elevation



Tips for revegetation success

Design – Hydrology

Tips for revegetation success

Design – Soils

Understand/define the following:

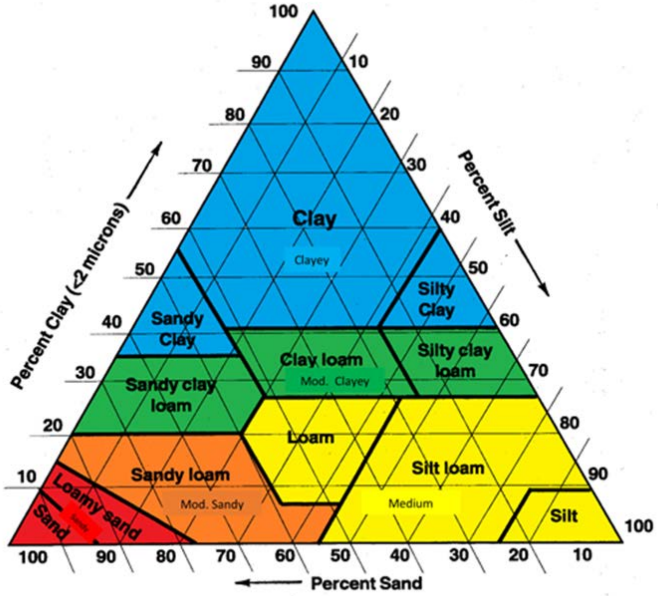
- Existing soils condition/health
- Plan for soil testing
- Imported material
- Topsoil management
- What’s in the top 6-12” when replaced?

Tips for revegetation success

Design – Soils

Tips for revegetation success

Design – Soils



Tips for revegetation success

Design – Soils

Understand/define the following:

- Existing soils condition/health
- Topsoil management
- What's in the top 6-12" when replaced?
- Plan for soil testing

Tips for revegetation success

Design – Plants

Understand/define the following:

- Weed management
- Elevation/landscape position
- Ordering materials
- Timing

Design – Plants

Pre-Treatment of Noxious Weeds

Tips for revegetation success

Tips for revegetation success

Design – Plants

- Species composition and selection
- Structural Diversity

Tips for revegetation success

Design – Plants

- Pre-ordering material from venders
- Time of year for planting

Tips for revegetation success

Construction

- Ecologist for construction observation
- Phasing planting

Tips for revegetation success

Construction - Salvage materials and live transplants

Tips for revegetation success

Post construction

Supplemental watering

Noxious weed control

Tips for revegetation success

Post construction

- Planting as-built
- Implementing your monitoring and vegetation management plan

Takeaways

Top tips for revegetation!

- Remember the 3 components – soils/hydrology/plants in your design
- Ecologist start to finish
- Balancing project goals and objectives with the permit/wetland mitigation requirements
- Avoid and minimize
- Consider soil testing during design and construction
- Remember to order plant material early on

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ERO Consultants in Natural Resources and the Environment