Regenerative Stormwater and Stream Conveyance

Biohabitats
SOUTHERN ROCKY MOUNTAIN BIOREGION
1732 Wazee St.
Denver, CO 80202

OUTLINE

Brief introduction

Nature of the problem

Regenerative stormwater conveyance

Regenerative Stream restoration

RSC performance

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What is Regenerative Stormwater Conveyance?

Also called: regenerative step pool storm conveyance *or* biofiltration conveyance

Design philosophy:

- Sand seepage wetlands mimic natural wetlands
- Regenerate by returning water to the system
- Reconnect stream to floodplain and re-establish natural habitat

Applies to various landscape positions:

- Ephemeral channels
  - in upper part of basins
  - retrofits for eroding gullies
  - at end of outfall pipe, tie-ins to stream
- Perennial streams
  - Spread stormflows onto floodplain
  - Use instream weirs and seepage wetland
- Other man-made
  - Roadside swales
  - Stormwater pond retrofits w/ inline bioretention (RSC)

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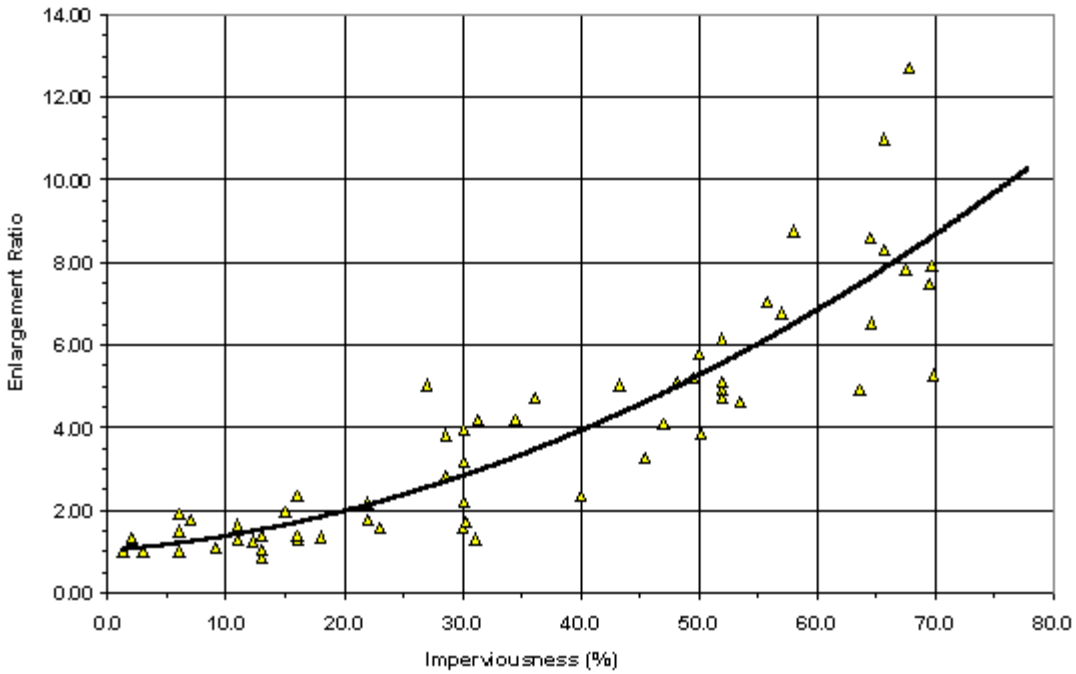
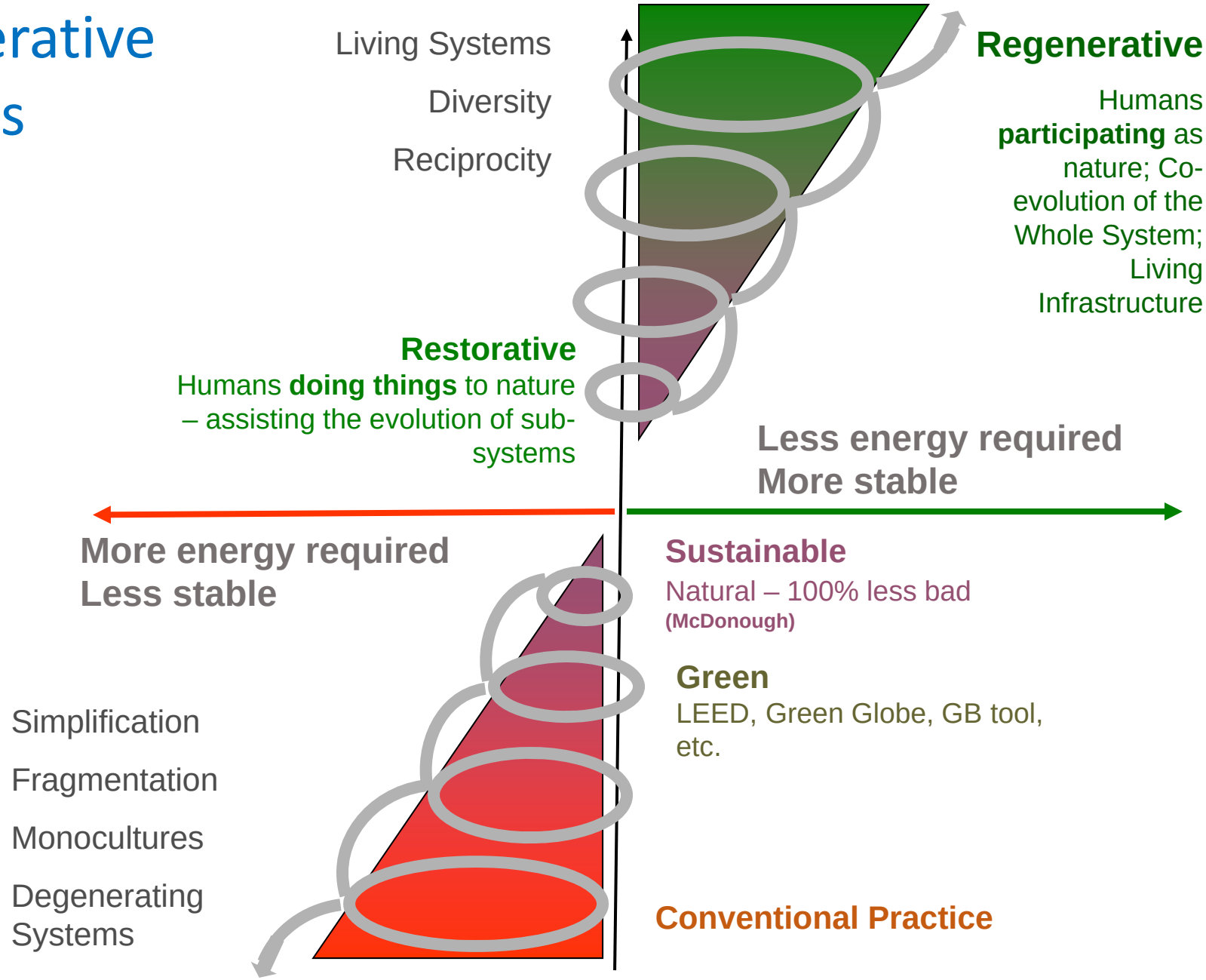
Negative Feedback Loop

Disturbance to a stream corridor system typically results in a causal chain of alterations to stream corridor structure and function.



Geomorphic Impacts

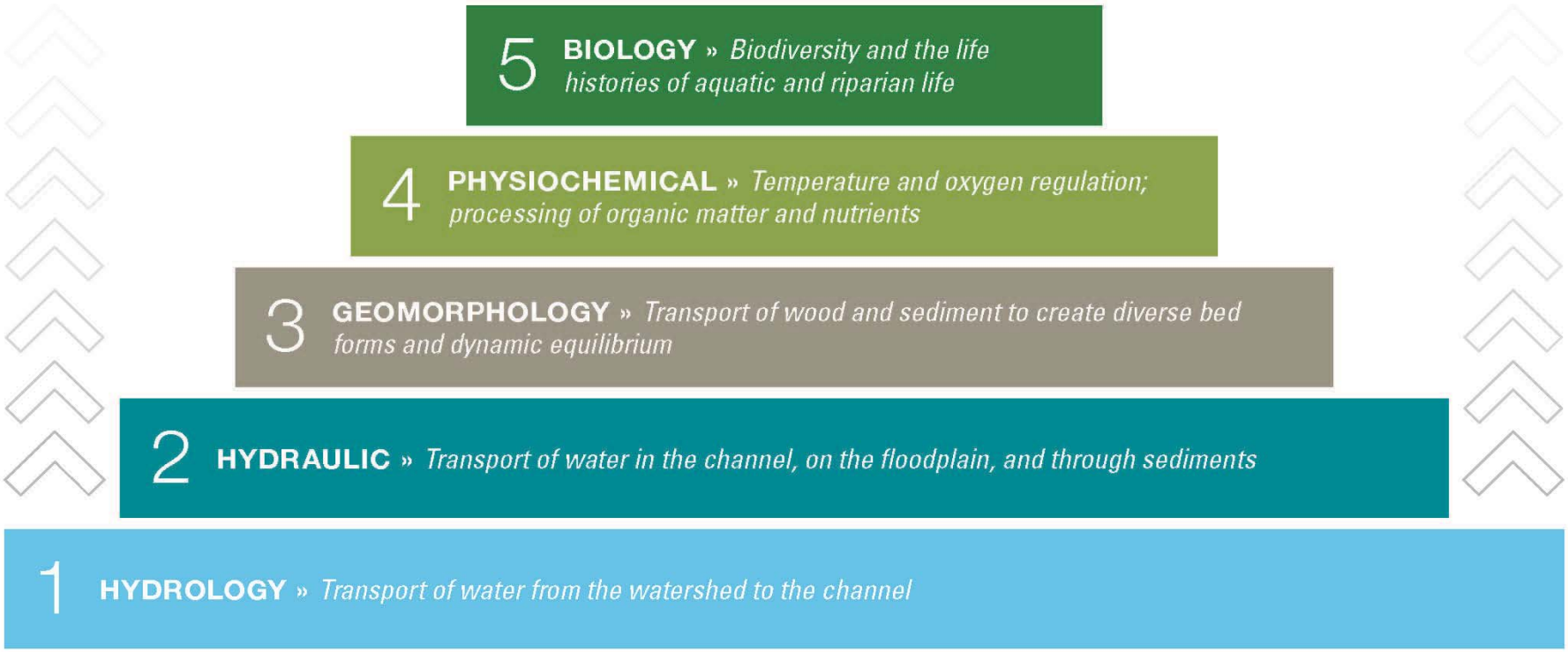
Regenerative Systems



Trajectory of Environmental Design (Reed, 2006; Modified by Bowers, 2007)

Stream Functions Pyramid

A Guide for Assessing & Restoring Stream Functions » OVERVIEW



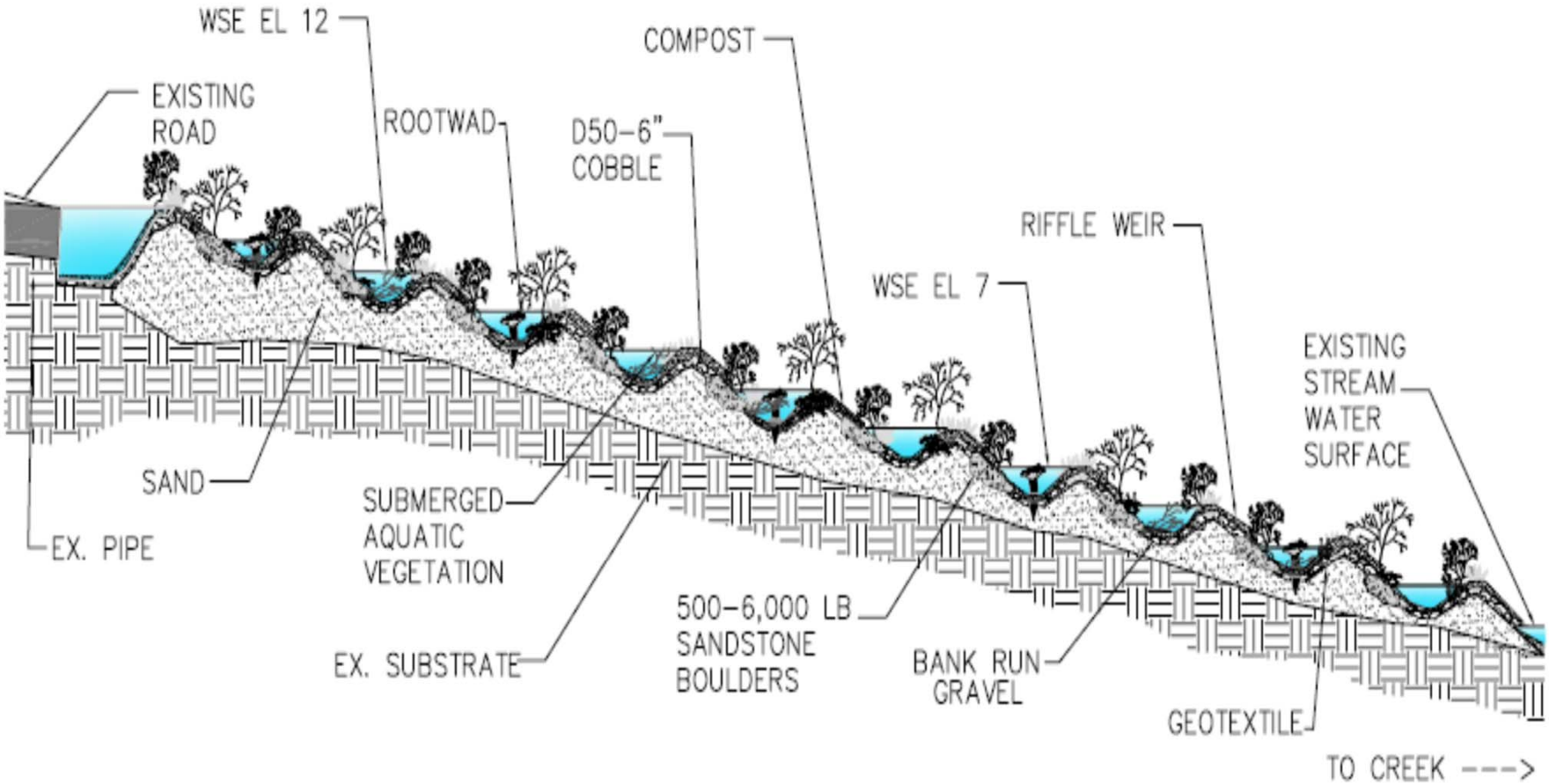
http://www.fws.gov/chesapeakebay/Newsletter/Fall11/Pyramid/pyramid_-overview.jpg

wharman@stream-mechanics.com

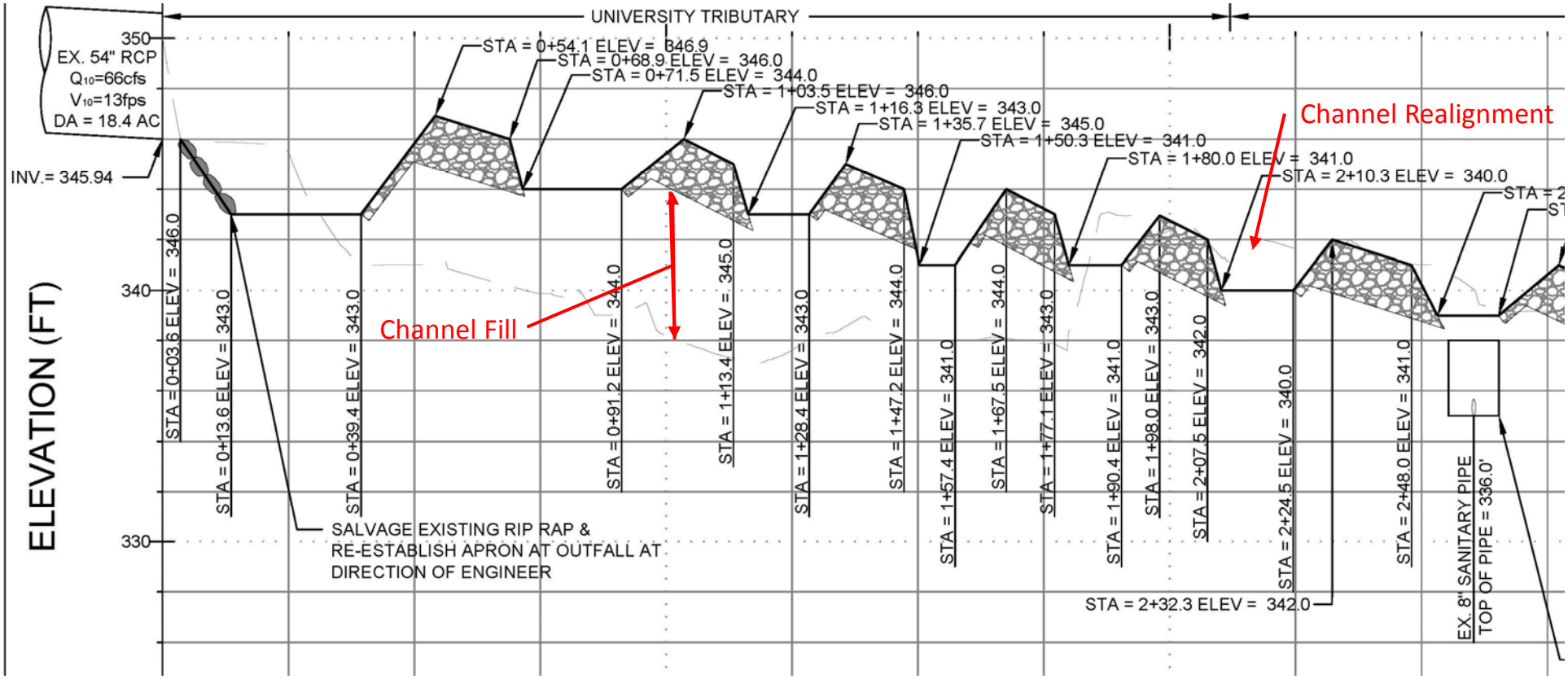
StreamMechanics


Effects of Channel Work
Associated with Increased
Runoff

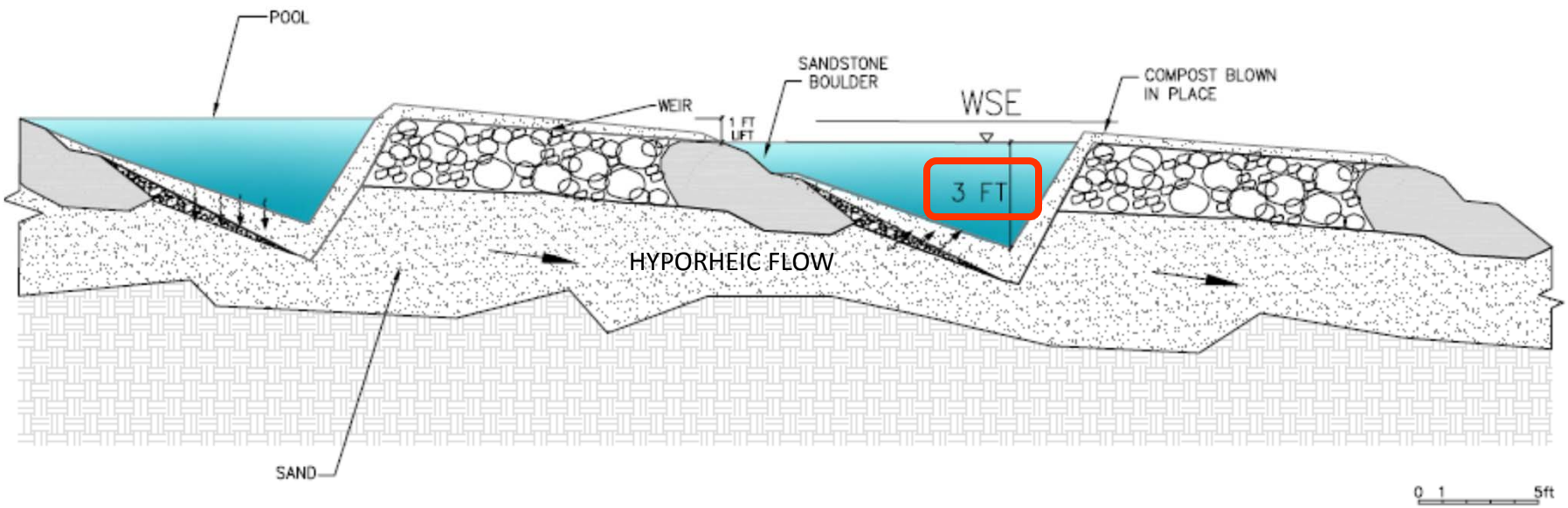
Regenerative Stormwater Conveyance



Biohabitats
SOUTHERN ROCKY MOUNTAIN BIOREGION


UNIVERSITY TRIBUTARY
ELEVATION (FT)
350
340
330
EX. 54" RCP
Q10=66cfs
V10=13fps
DA = 18.4 AC
INV.= 345.94
STA = 0+03.6 ELEV = 346.0
STA = 0+13.6 ELEV = 343.0
STA = 0+39.4 ELEV = 343.0
STA = 0+54.1 ELEV = 346.9
STA = 0+68.9 ELEV = 346.0
STA = 0+71.5 ELEV = 344.0
STA = 0+91.2 ELEV = 344.0
STA = 1+03.5 ELEV = 346.0
STA = 1+13.4 ELEV = 345.0
STA = 1+16.3 ELEV = 343.0
STA = 1+28.4 ELEV = 343.0
STA = 1+35.7 ELEV = 345.0
STA = 1+47.2 ELEV = 344.0
STA = 1+50.3 ELEV = 341.0
STA = 1+57.4 ELEV = 341.0
STA = 1+67.5 ELEV = 344.0
STA = 1+77.1 ELEV = 343.0
STA = 1+80.0 ELEV = 341.0
STA = 1+90.4 ELEV = 341.0
STA = 1+98.0 ELEV = 343.0
STA = 2+07.5 ELEV = 342.0
STA = 2+10.3 ELEV = 340.0
STA = 2+24.5 ELEV = 340.0
STA = 2+32.3 ELEV = 342.0
STA = 2+48.0 ELEV = 341.0
EX. 8" SANITARY PIPE
TOP OF PIPE = 336.0'
Channel Fill
Channel Realignment
SALVAGE EXISTING RIP RAP &
RE-ESTABLISH APRON AT OUTFALL AT
DIRECTION OF ENGINEER

Riffle Pool Profile Section




Sand seepage bed


Riffle Grade Controls

Source of Photos: Underwood & Associates

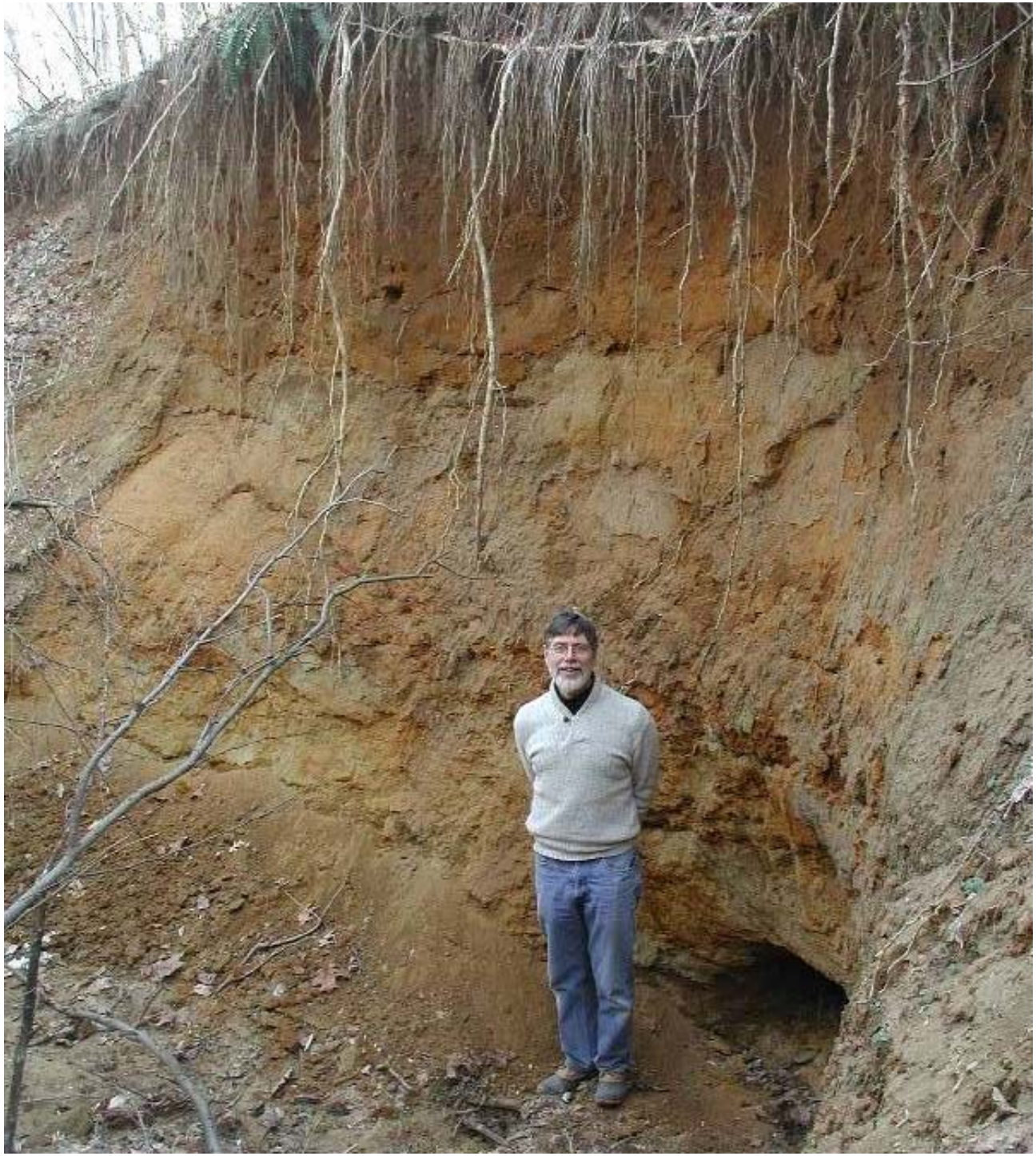
PRE RESTORATION

POST RESTORATION

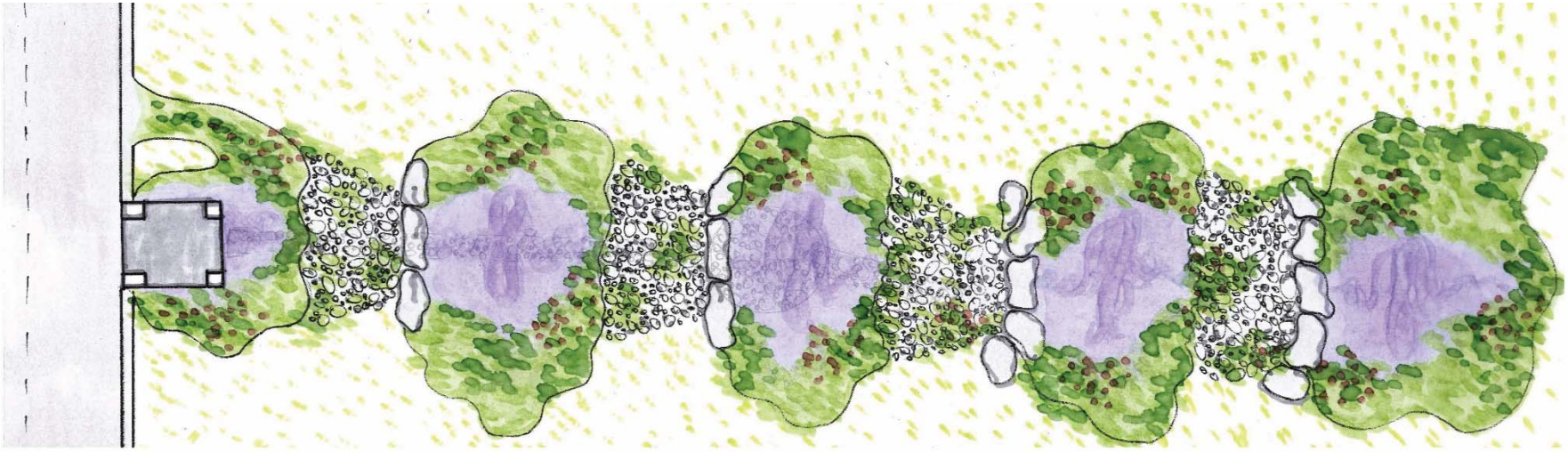
Carriage Hills

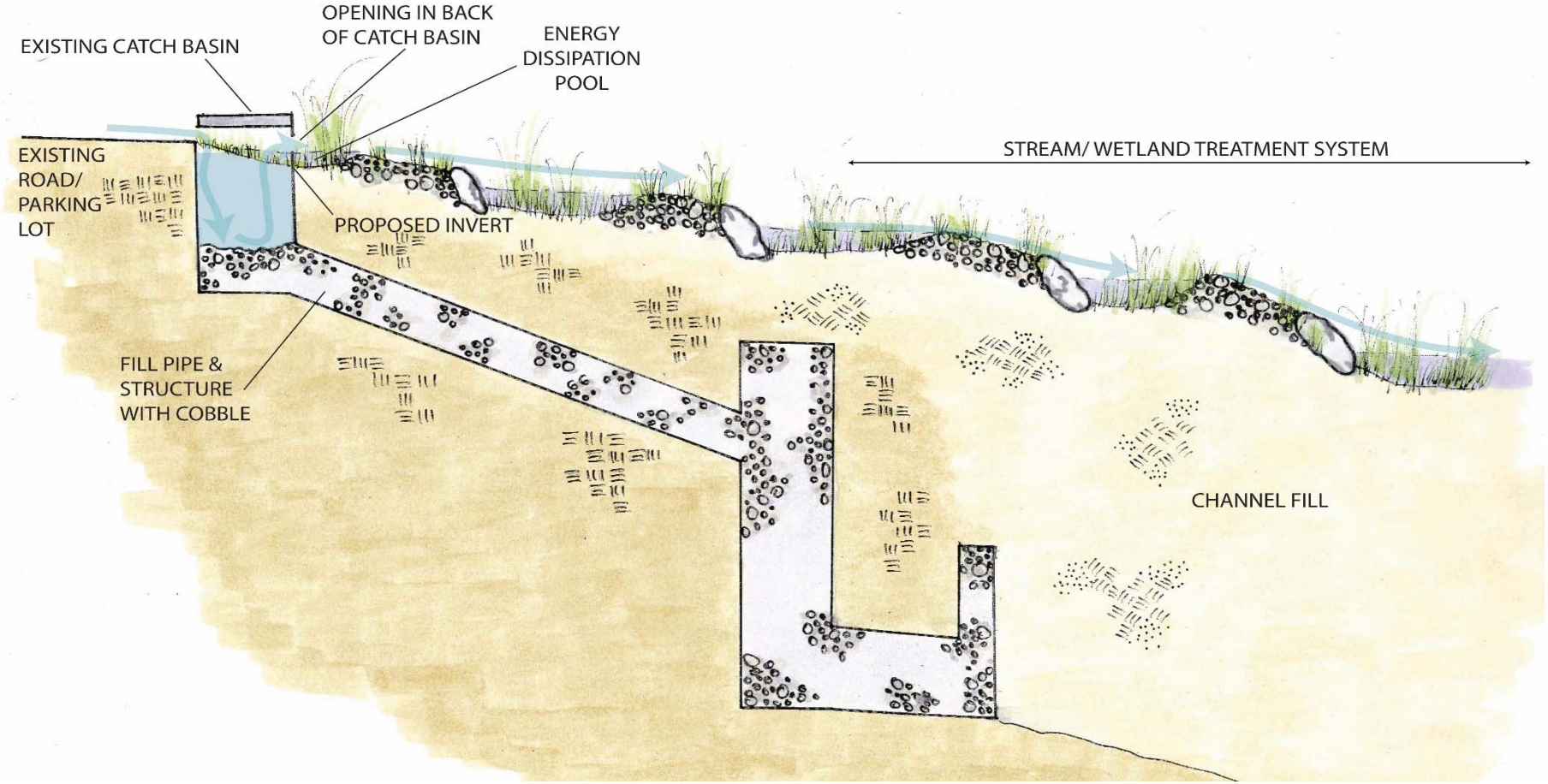
22-ft incised

Adverse effect on shallow groundwater and downstream flows

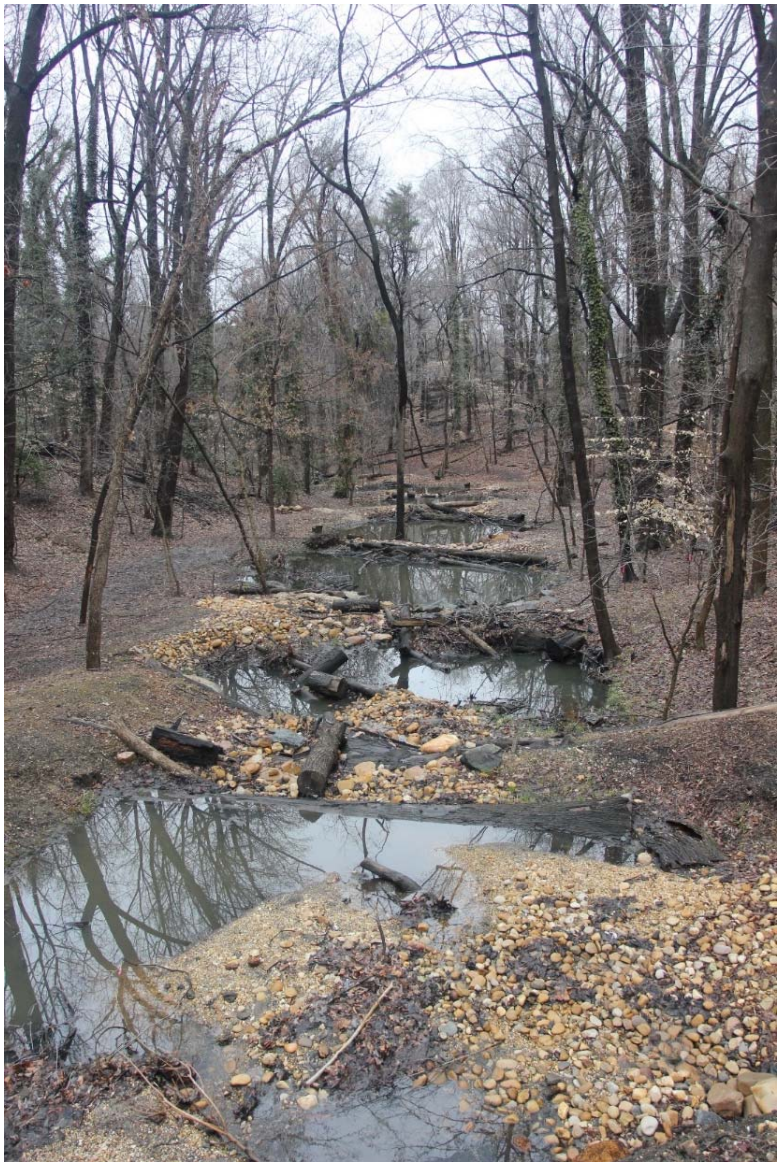


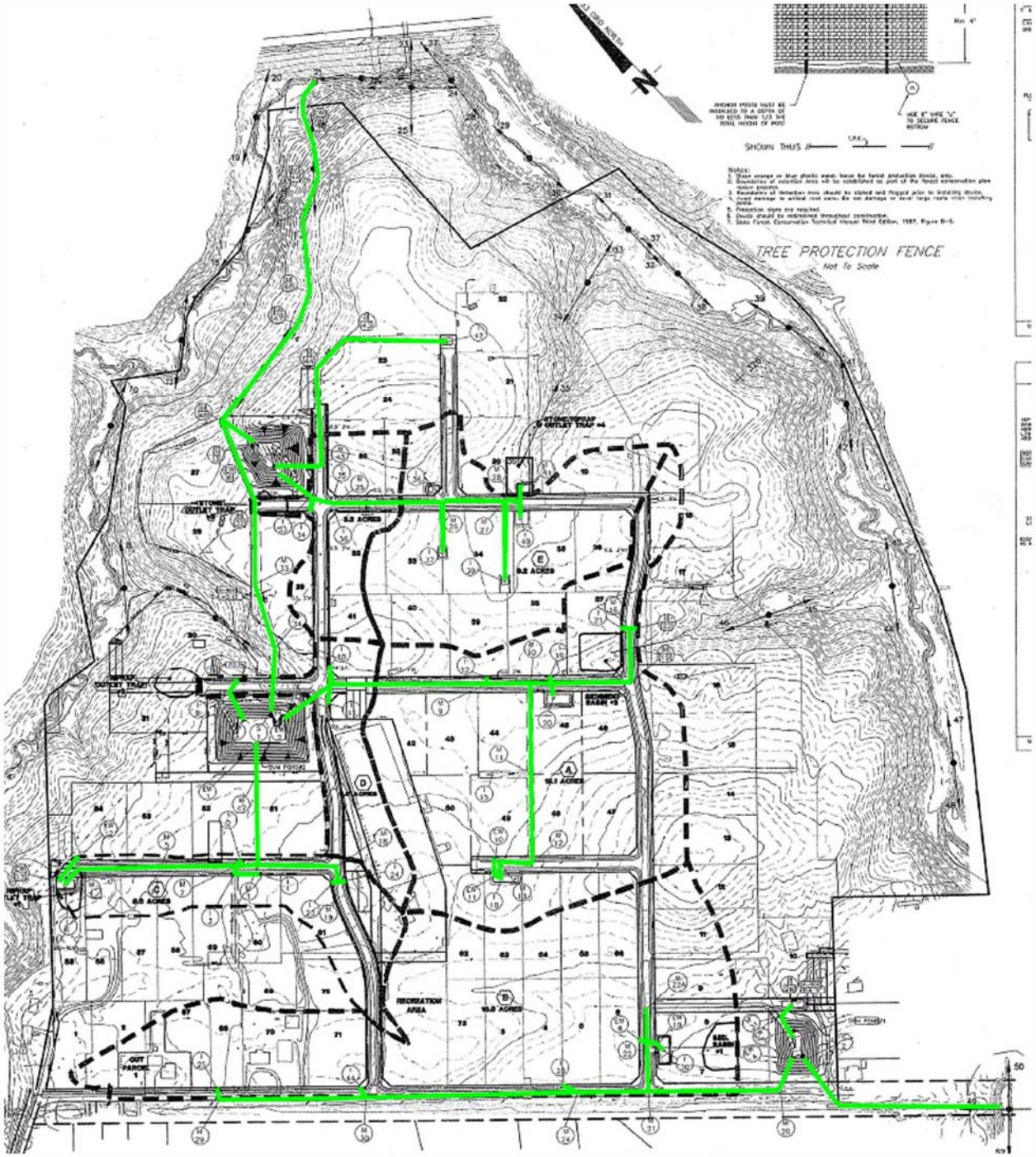

Carriage Hills Post-restoration



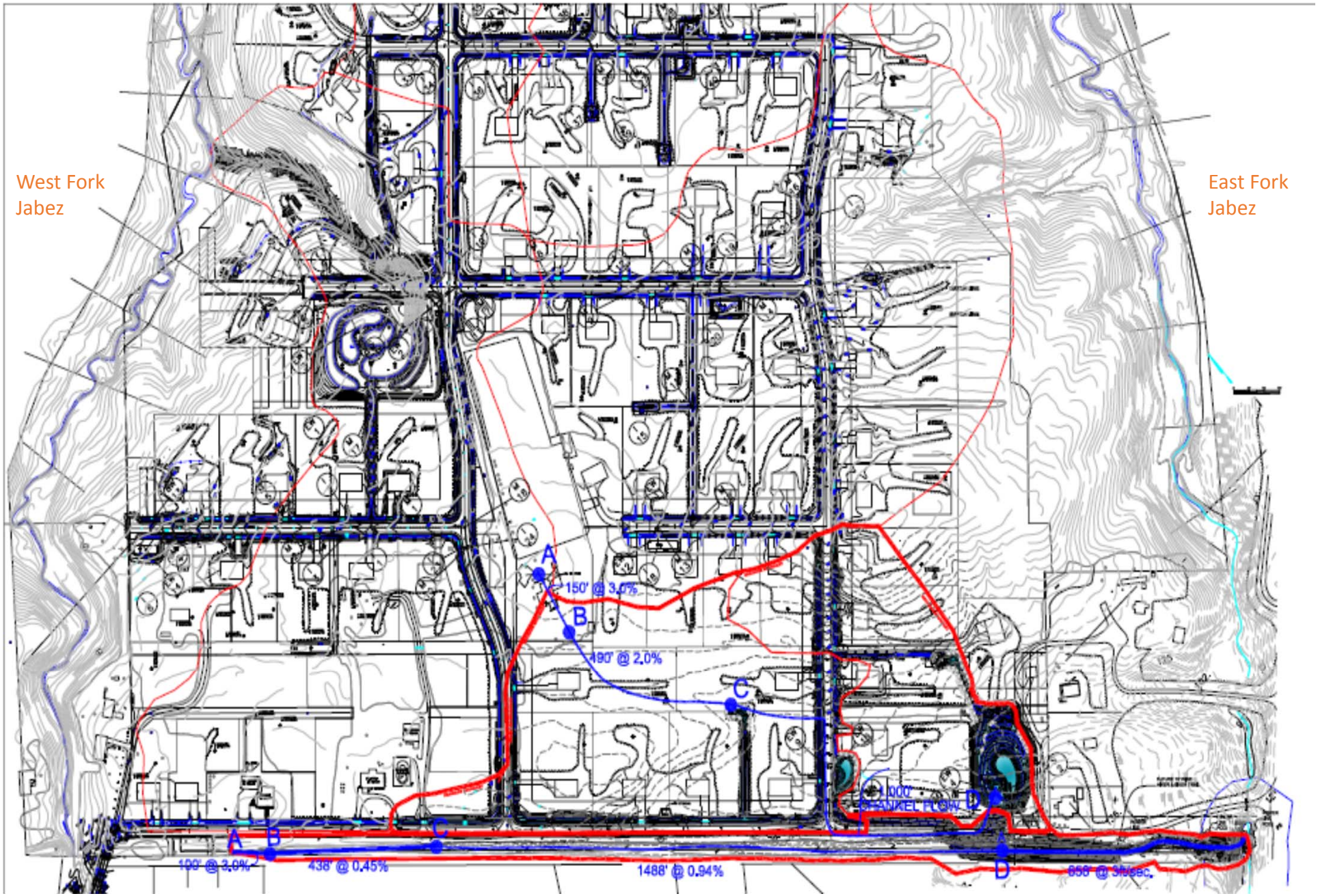

EXISTING CATCH BASIN
OPENING IN BACK OF CATCH BASIN
ENERGY DISSIPATION POOL
STREAM/ WETLAND TREATMENT SYSTEM
EXISTING ROAD/ PARKING LOT
PROPOSED INVERT
FILL PIPE & STRUCTURE WITH COBBLE
CHANNEL FILL

Linnean Park
RSC

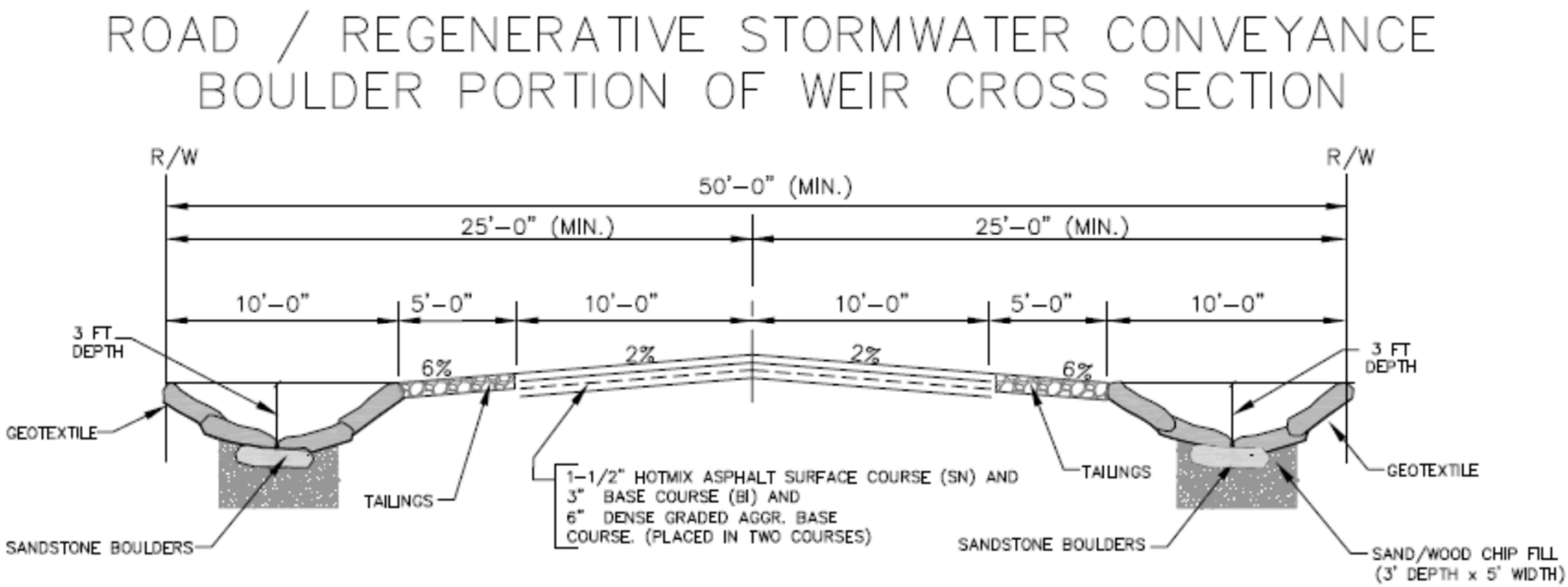



TREE PROTECTION FENCE
Not To Scale
SHOWN THUS
RECREATION AREA

Holladay Park



Roadside RSC



Holladay Park- Cost Comparison

Phase 1-Original Design

Pipe	LF
15"	1453
18"	408
21"	48
24"	517
27"	470
30"	523
12" x14"	50
Total LF	3469

		Costs
SWM Pond	$	216,710.00
RCP	$	592,158.75
SWM Access Rd	$	8,900.00
Fences for SWM Pond	$	10,700.00
Total	**$**	**828,468.75**

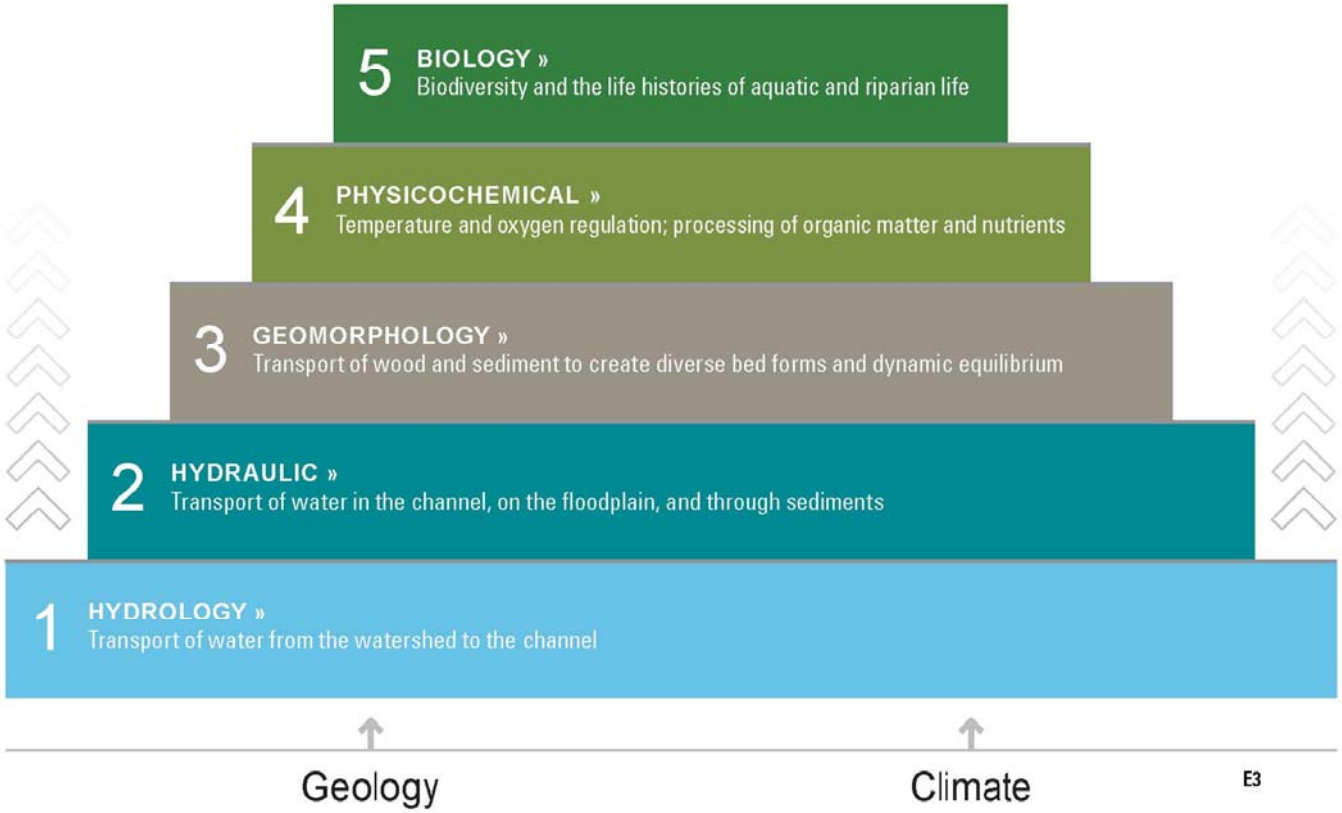
Layout	$44,934.00
Sediment Controls	$21,971.00

Current Costs

Grading/Excess	$248,750.00
SWM Pond	$80,131.00
Pipe	$23,194.00
Risers/structures/headwalls	$30,000.00
24" Pipe	$8,420.00
Sandstone Weirs	$14,360.00
Total	**$404,855.00**

Stream Functions Pyramid

A Guide for Assessing & Restoring Stream Functions » OVERVIEW

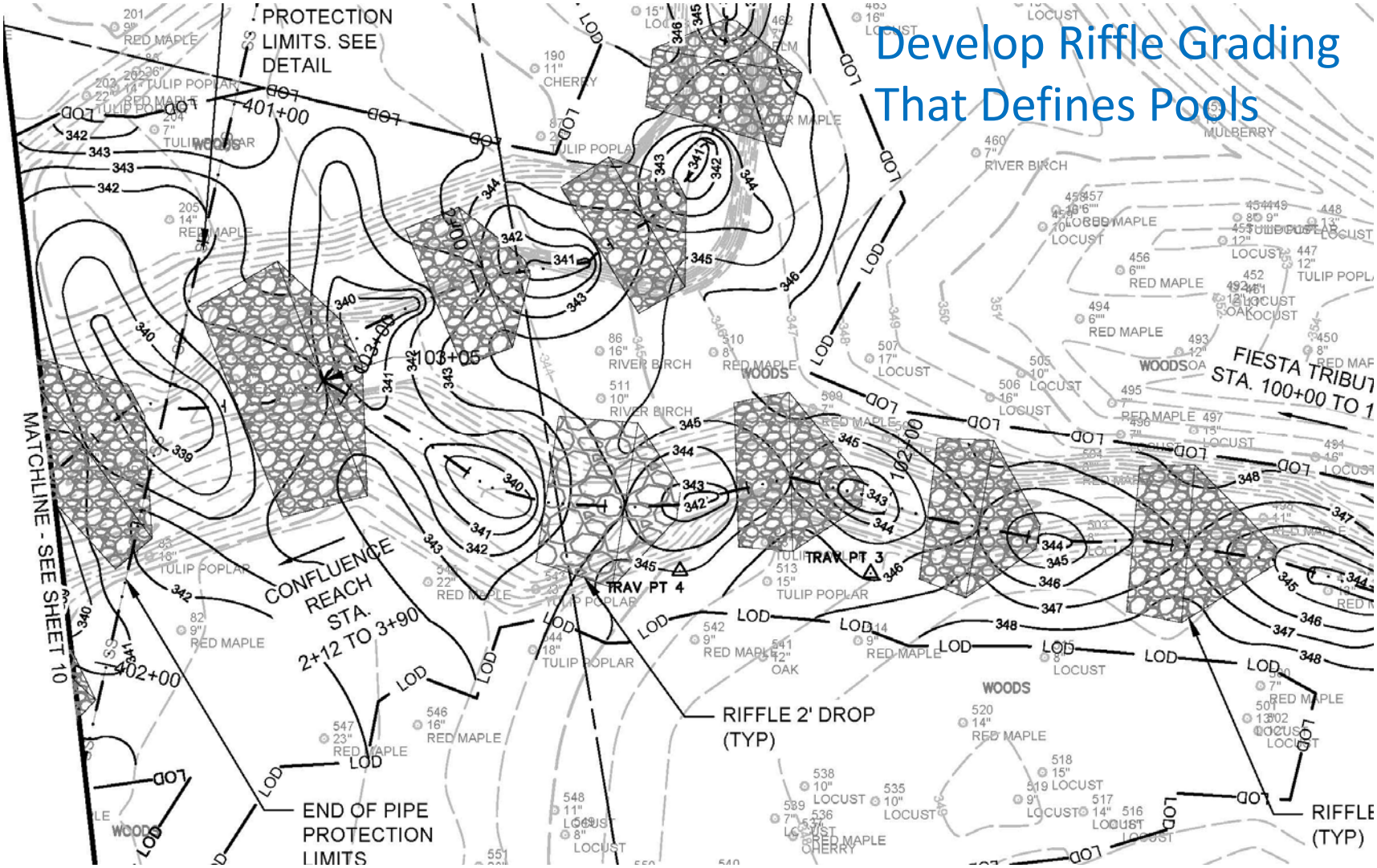


E3

StreamMechanics

Natural Channel Restoration

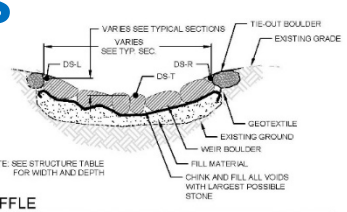
Develop Riffle Grading That Defines Pools



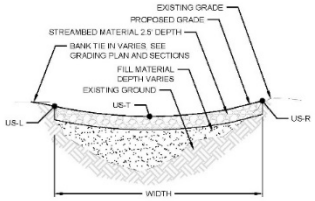
PRE RESTORATION

POST RESTORATION

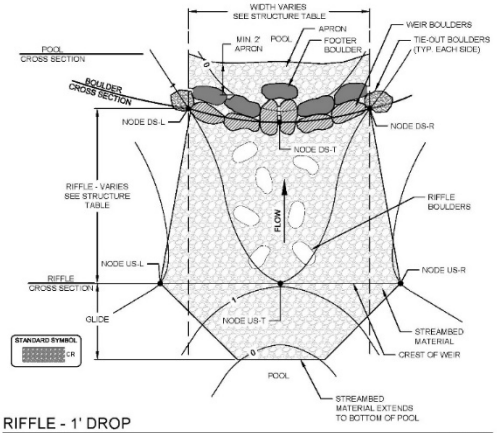
Design Plan Relationships Construction Details



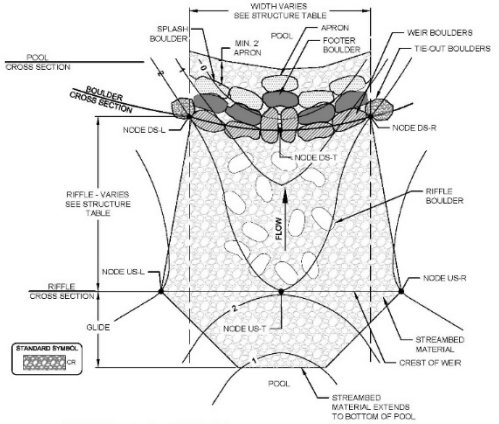
RIFFLE
BOULDER CROSS SECTION
NOT TO SCALE



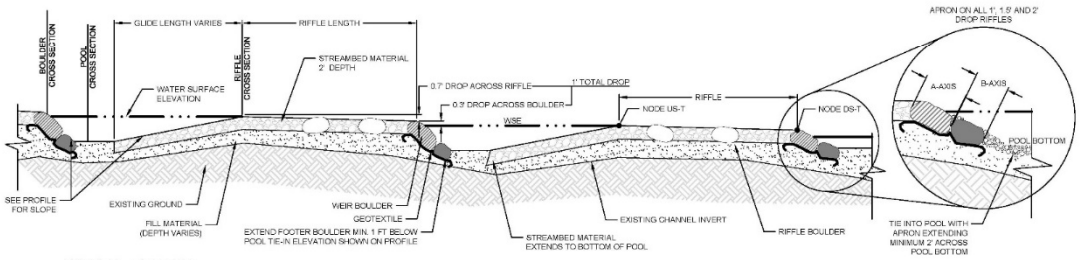
RIFFLE
CROSS SECTION
NOT TO SCALE



RIFFLE - 1' DROP
PLAN VIEW
NOT TO SCALE



RIFFLE - 1.5' - 2' DROP
PLAN VIEW
NOT TO SCALE



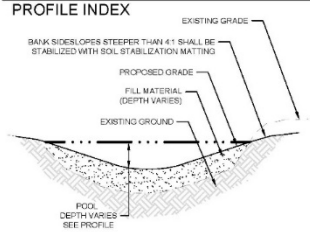
RIFFLE - 1' DROP
PROFILE INDEX
NOT TO SCALE

GRADATION TABLE	STREAMBED MATERIAL		GRAVEL
	ALL REACHES 1' DROP RIFFLE	ALL REACHES 1.5' & 2' DROP RIFFLE	ALL REACHES
CUMULATIVE % FINER	SIZE (IN)	SIZE (IN)	SIZE (IN)
0	1.0	1.0	1/4
16	6.0	6.0	X
35	8.0	10.0	1/2
50	10.0	15.0	1
84	12.0	18.0	2
100	13.0	20.0	3

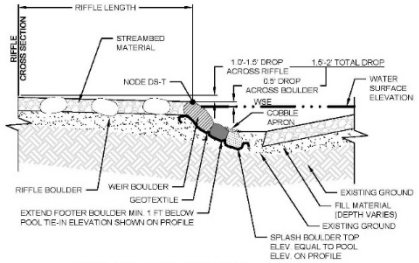
NOTE: IMPORTED GRAVEL SHALL BE INCORPORATED INTO STREAMBED MATERIAL AT AN APPROXIMATE RATIO OF 75% STREAMBED MATERIAL TO 25% GRAVEL.

RIFFLE NOTES:

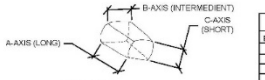
1. TIE-OUT BOULDER SHALL EXTEND PAST THE CORNER NODES DS-R & DS-L A MIN. OF ONE BOULDER LENGTH INTO EXISTING BANK. WHERE THIS CONFLICTS WITH EXISTING TREE ROOTS OR BEDROCK, TIE-OUT BOULDER MAY BE ELIMINATED OR ADJUSTED AT DIRECTION OF OWNER.
2. SEE TYPICAL SECTIONS FOR DEPTH AND WIDTH AT BOULDER CROSS SECTION.
3. RIFFLE BOULDERS SHALL BE INCORPORATED IN A RANDOM PLACEMENT WITHIN MIDDLE THIRD OF SECTIONS TO COVER APPROXIMATELY 25% OF THE RIFFLE SURFACE AREA FOR 1' DROP RIFFLES, AND 40% OF THE RIFFLE SURFACE AREA FOR 1.5' AND 2' DROP RIFFLES. TOP OF RIFFLE BOULDERS SHALL EXTEND A MAXIMUM OF 2" ABOVE STREAM BED MATERIAL SURFACE.
4. APRON MATERIAL SHALL CONSIST OF THE SAME SIZE CLASS OF MATERIAL AS SHOWN ABOVE.
5. NUMBER OF BOULDERS VARIES DEPENDING ON TYPICAL SECTIONS AND BOULDER DIMENSIONS.
6. STREAMBED MATERIAL DEPTH IS MINIMUM 2.5'.



RIFFLE
POOL CROSS SECTION
NOT TO SCALE



RIFFLE - 1.5' - 2' DROP
PROFILE INDEX
NOT TO SCALE



RIFFLE
BOULDER AXIS
NOT TO SCALE

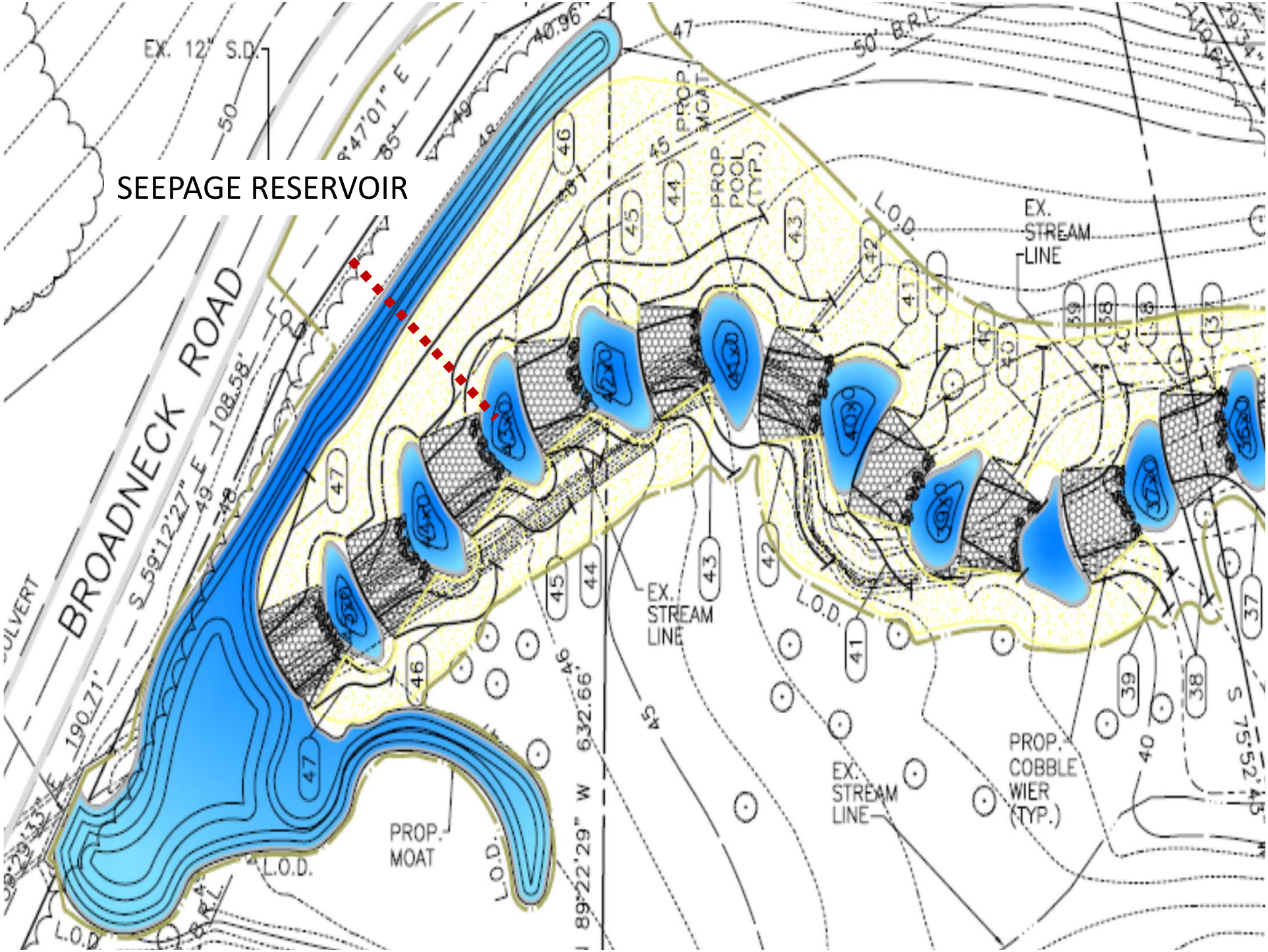
BOULDER DIMENSIONS (FT)			
BOULDER TYPE	A-AXIS	B-AXIS	C-AXIS
WEIR	3-4	2.5-3.5	1.5-2
FOOTER	3-4	2.5-3.5	1.5-2
TIE-OUT	2.5-3.5	2-3	1.5-2
SPLASH	3-4	2.5-3.5	1.5-2
RIFFLE	2-3	1-2	1.5-2

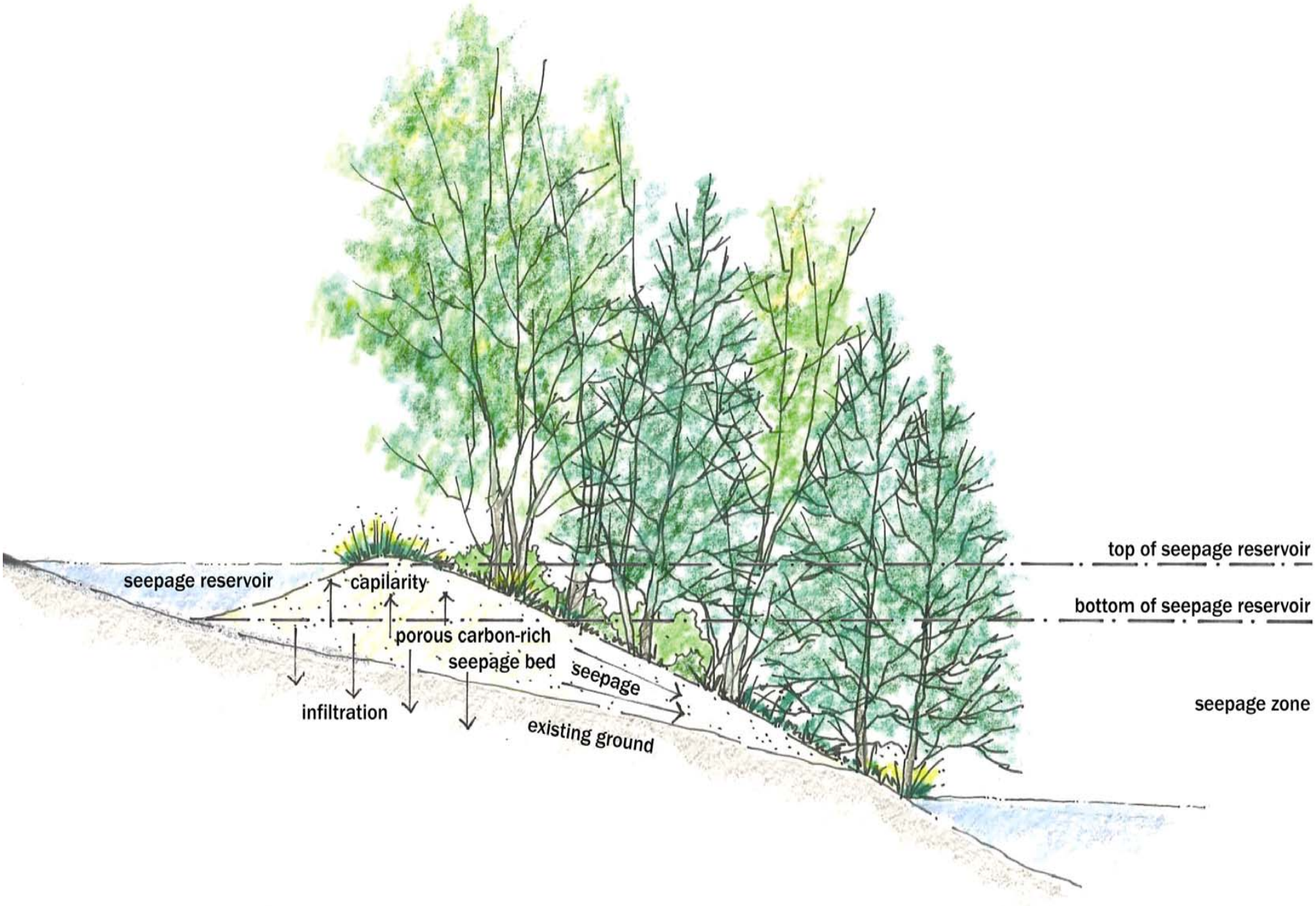
Milkhouse Ford RSC

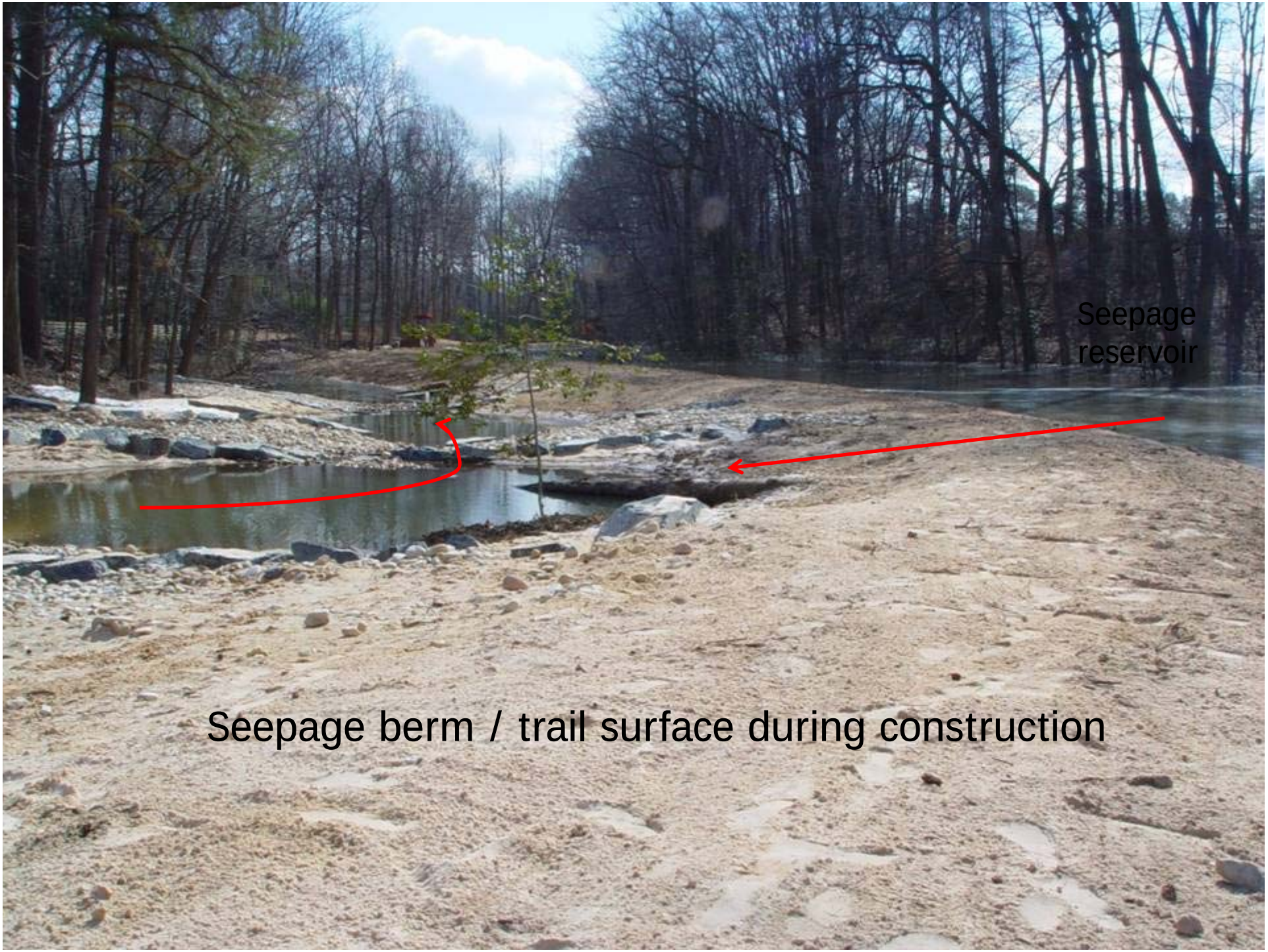
See the equipment in the channel?

Milkhouse Ford RSC – 4 yrs later

Linnean Park RSC Floodplain Reconnection


SEEPAGE RESERVOIR
BROADNECK ROAD
EX. 12" S.D.
PROP. MOAT
PROP. POOL (TYP.)
EX. STREAM LINE
L.O.D.
PROP. COBBLE WIER (TYP.)
B.R.L.
S 59°12'27" E 108.58'
190.71'
S 75°52'45" E
632.66'
N 89°22'29" W


top of seepage reservoir
bottom of seepage reservoir
seepage reservoir
capilarity
porous carbon-rich
seepage bed
seepage
infiltration
existing ground
seepage zone


Seepage
reservoir
Seepage berm / trail surface during construction

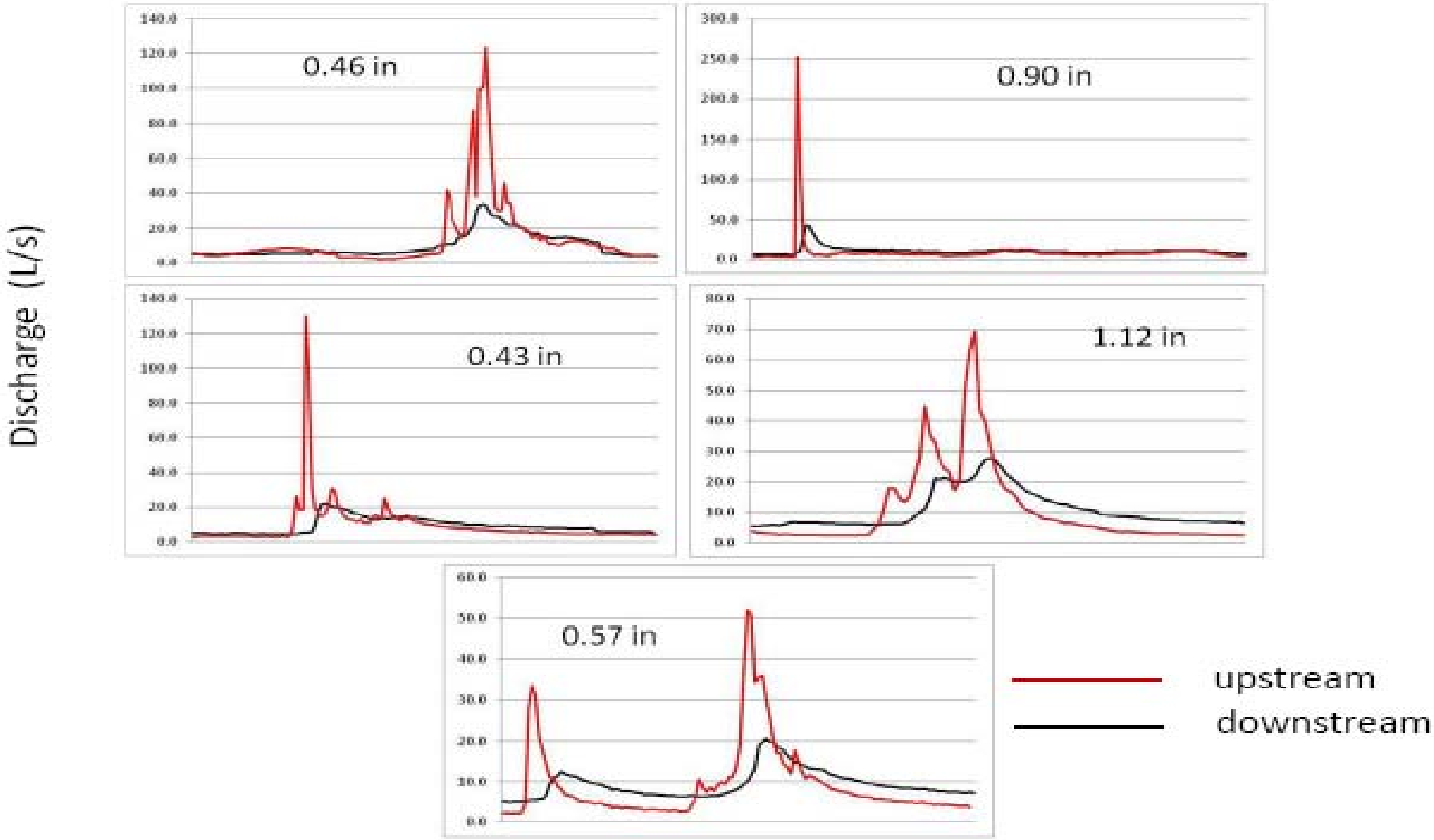

Berms allow infiltration
from the water stored at
higher elevation and
exfiltration into the stream
channel as base flow

Wetland condition on upslope side of sand seepage berm /trail


Dynamic soil system, not static sand bed

How this approach performs

Hydrographs during individual storms- Wilelinor



Source: Solange Filoso, University of Maryland

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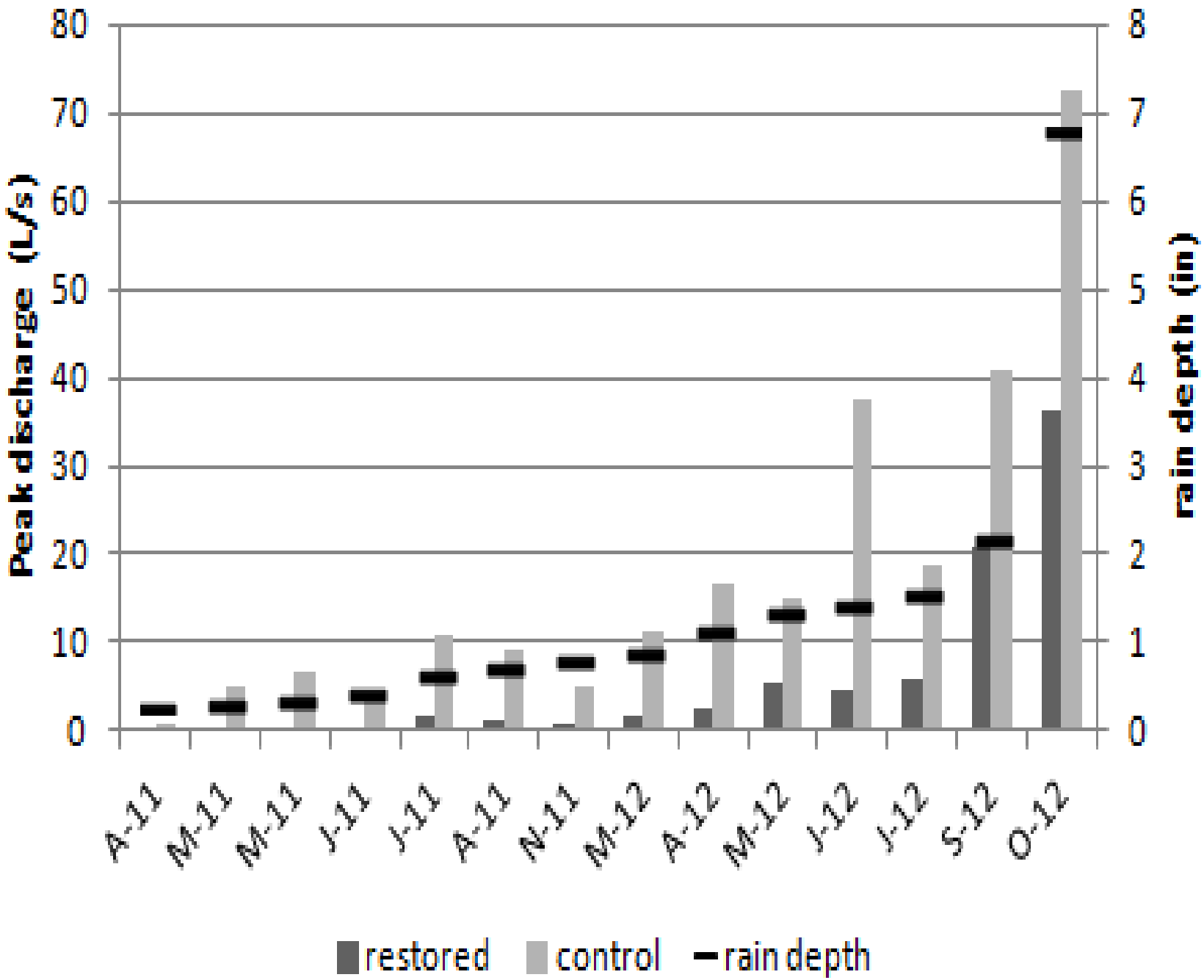
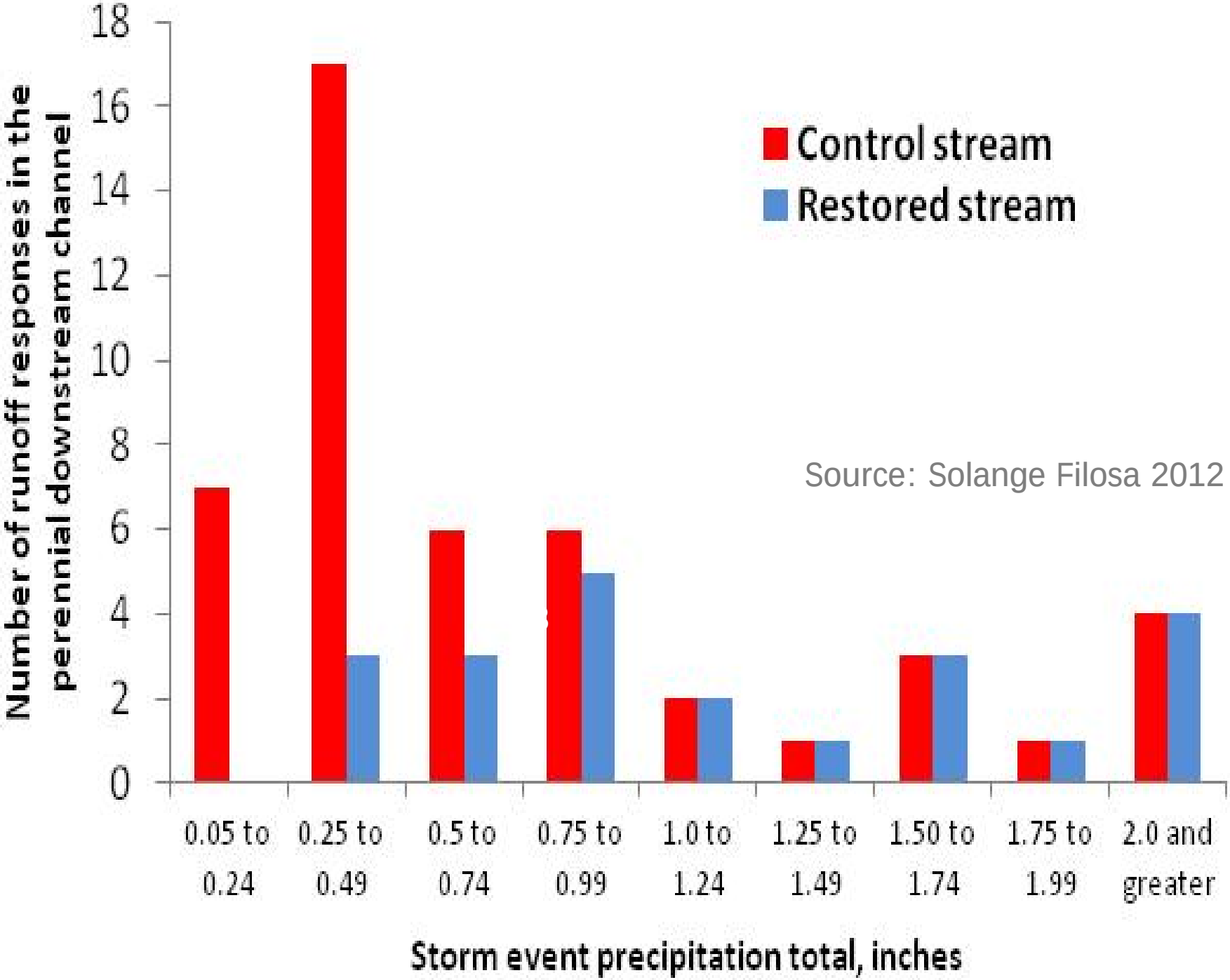
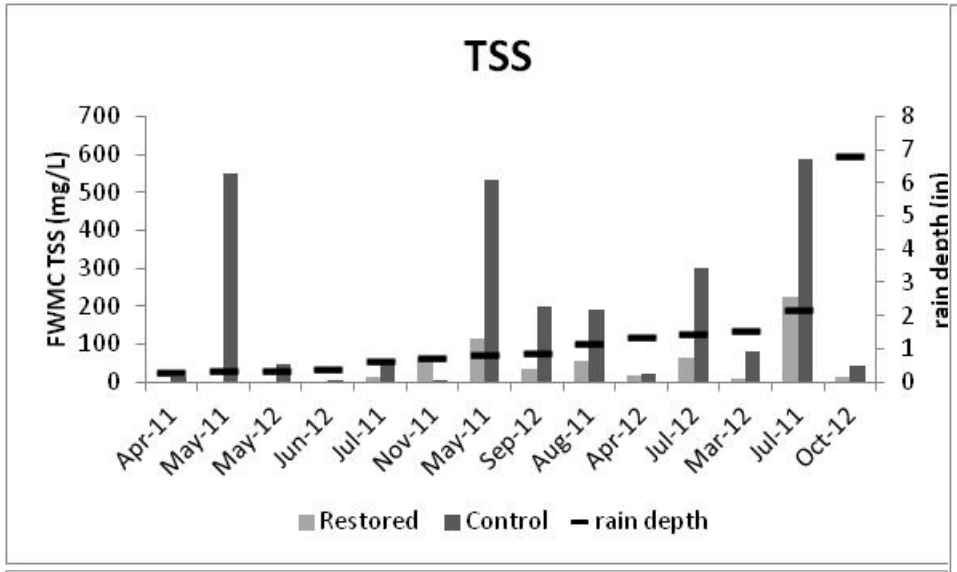
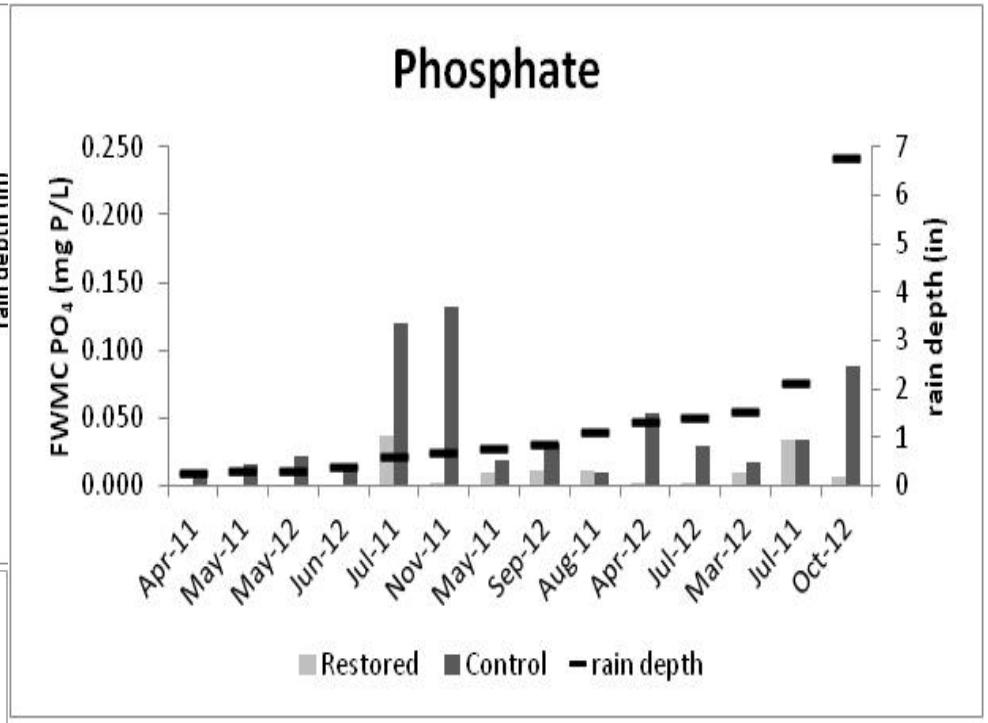
SOUTHERN ROCKY MOUNTAIN BIOREGION

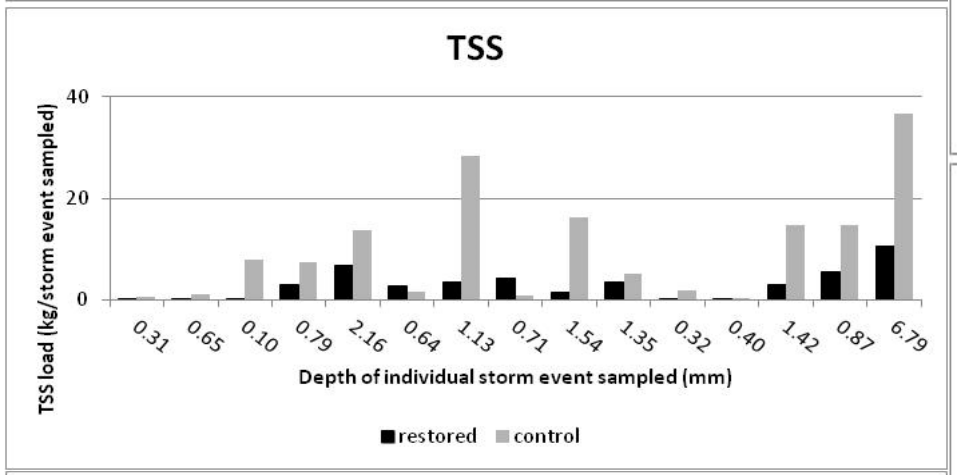


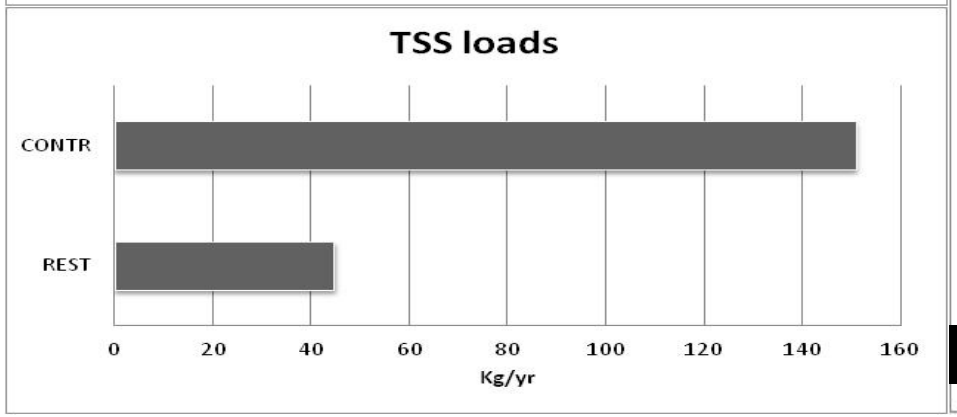
Source: Solange Filosa 2012

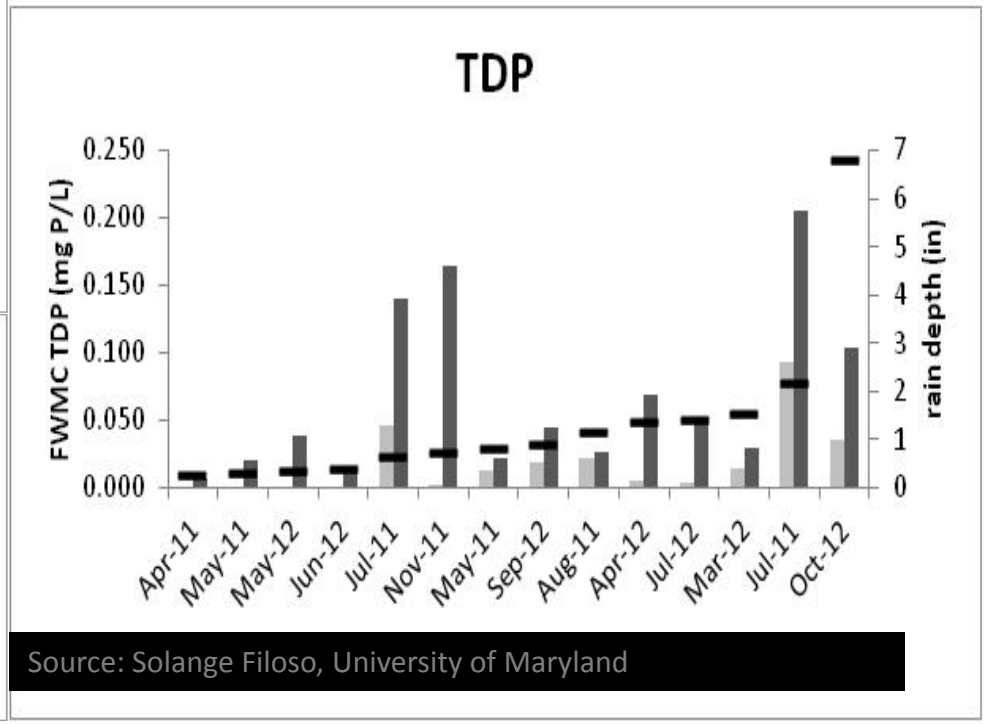

Number of runoff responses in the perennial downstream channel
18
16
14
12
10
8
6
4
2
0
Control stream
Restored stream
Source: Solange Filosa 2012
0.05 to 0.24
0.25 to 0.49
0.5 to 0.74
0.75 to 0.99
1.0 to 1.24
1.25 to 1.49
1.50 to 1.74
1.75 to 1.99
2.0 and greater
Storm event precipitation total, inches











Source: Solange Filoso, University of Maryland

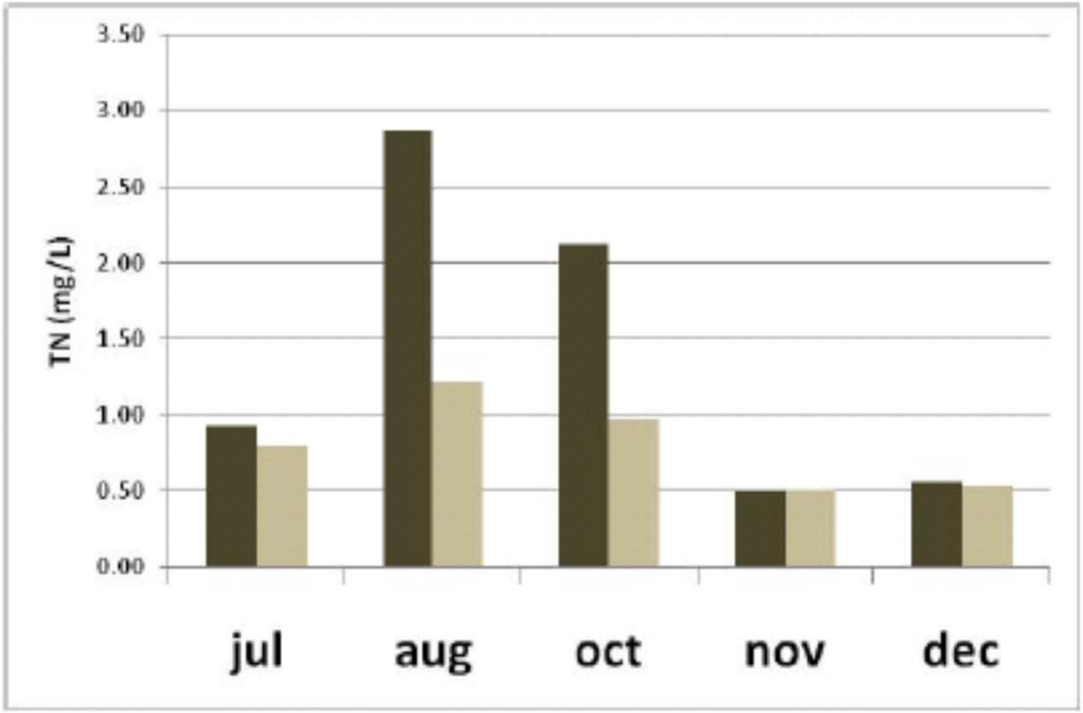


Figure 17. Discharge-weighted mean concentrations of TN in stormflow samples collected during different storms at Howard's Branch. The dark bars represent concentrations upstream of the restored reach and the light bars represent concentrations downstream.

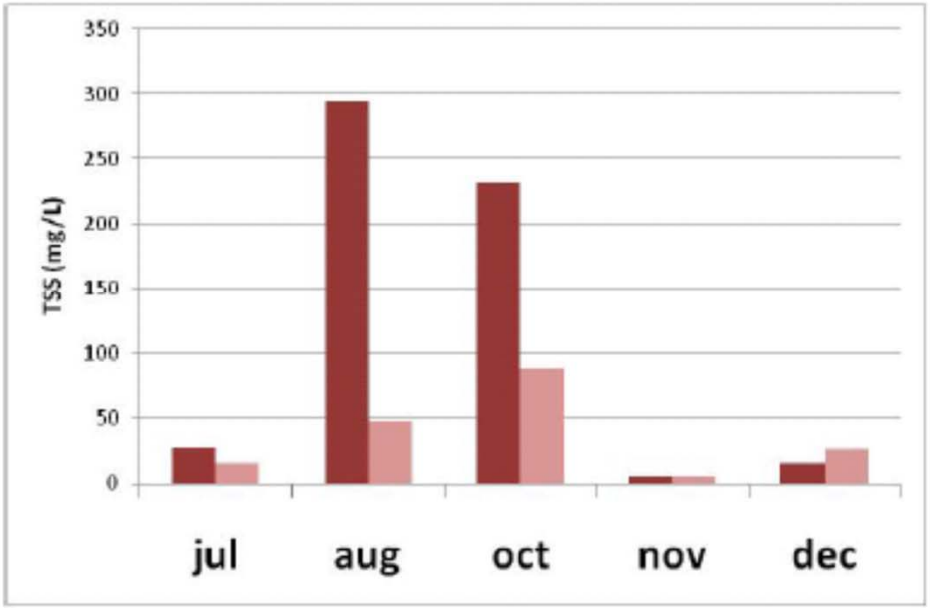
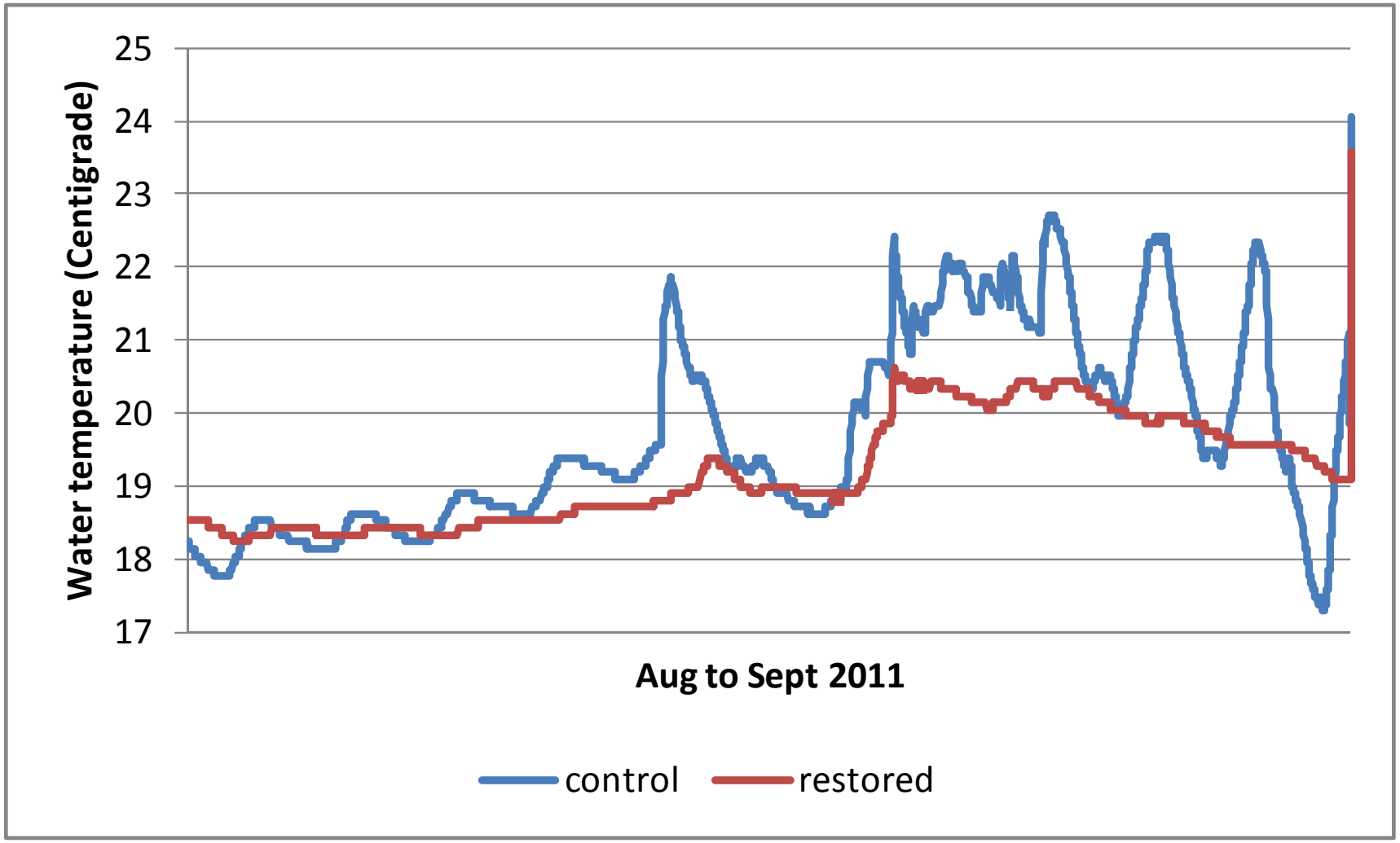


Figure 19. Discharge-weighted mean concentrations of TSS in stormflow samples collected during different storms at Howard's Branch. The dark bars represent concentrations upstream of the restored reach and the light bars represent concentrations downstream.

Source: Palmer and Filoso, 2009



Solange Filoso, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory

Benefits of Regenerative Stormwater Conveyance

- Dissipates energy at outfall discharge points
- Improves water quality through infiltration, retention, & microbial activity in hyporheic zone
- Provides stable conveyance of 100-year storm events
- Attenuates stormwater peak discharge
- Reduces construction impacts to adjacent trees
- Enhances ecological functions through groundwater recharge, creation of riffle-pool complex, and supports riparian vegetation

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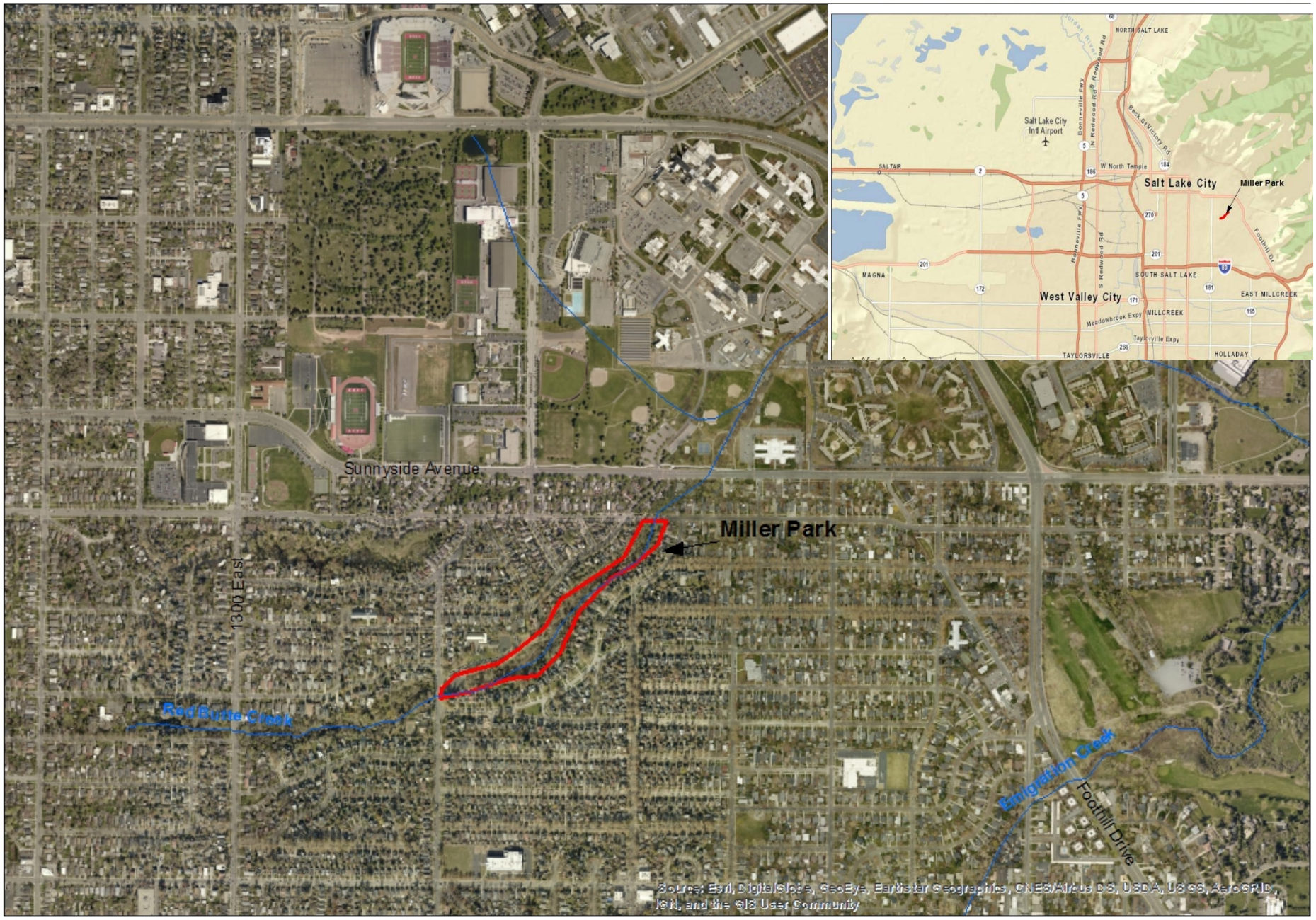

0 1,000 2,000 Feet

N

Miller Park RSC Restoration Site
Salt Lake City


Red Butte Creek in
Miller Park Bird Refuge
and Nature Preserve
Salt Lake City

Thank you!

For more information:

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