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Regenerative Stormwater Conveyance (RSC) Research & Design Thoughts and Sand Filter Research Update

Bill Hunt, Ph.D., PE

WNR Prof & Extn Specialist, NC State University

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Hydrologic Performance of Regenerative Stormwater Conveyance in the North Carolina Coastal Plain

Adrienne R. Cizek, Ph.D.[1]; William F. Hunt, Ph.D., P.E., M.ASCE[2]; Ryan J. Winston, Ph.D., P.E., M.ASCE[3]; and Matthew S. Lauffer, P.E.[4]

Abstract: Regenerative stormwater conveyance (RSC) is an open channel, sand-filtering system composed of a series of shallow aqu pools, riffle weirs, native vegetation, and underlying media beds. Surface runoff entering an RSC is conveyed as nonerosive surface flov subsurface seep through the media, and exits the system as surface flow, seep out, exfiltration into parent soil, or evapotranspiration (I Regenerative stormwater conveyances are expected to perform similar to other sand-media-based low-impact development (LID) stormw control measures (SCMs), but the hydrological and water quality efficiencies of RSC have not been sufficiently validated in a variety hydrogeological conditions to date. A RSC was installed in the coastal plain of North Carolina, receiving runoff from 5.2 ha. Surface flow reduced substantially through the RSC, with 84% of inflow converted to a shallow interflow-like seep, referred to in this paper as seep High groundwater levels resulted in small overall exfiltration rates, but increased evaporation rates due to extended ponding. The conver of surface runoff to seep out has significant implications for stormwater mitigation, releasing filtered water at slower rates than conventi conveyance channels, similar to undeveloped watersheds. The Brunswick RSC released similar fraction of seep out to that of shallow in flow observed in undeveloped watersheds. **DOI: 10.1061/(ASCE)EE.1943-7870.0001198.**

Introduction

The conversion of undeveloped, pervious land uses to urban and suburban, impervious landscapes results in increased surface runoff during storm events. This excess stormwater runoff has been linked to stream degradation (Horner et al. 2003; Klein 1979; Walsh et al. 2004), economic loss (Ajuzie and Altobello 1997), and public health concerns (Curriero et al. 2001; Gaffield et al. 2003). Stormwater mitigation efforts are active across the United States through the use of stormwater control measures [SCMs, also referred to as best management practices (BMPs)]. Stormwater management initially focused on efficiently routing runoff directly to streams using pipe networks; then evolved to reducing erosive peak flows, and therefore downstream flooding, through SCM retention strategies; and then to improving water quality. Recently, stormwater management has focused on maintaining the predevelopment (undeveloped land) hydrograph for a given watershed (LIDC 2007). In fact, the U.S. government approved the Energy Independence and Security Act of 2007 requiring all federal land postconstruction discharge conditions to match the predevelopment hydrograph when disturbed land is greater than 465 m^2 (5,000 ft^2) (U.S. Congress 2007). A given watershed hydrograph can include three possible flow pathways: (1) surface runoff, (2) shallow interfl and (3) groundwater from previous rain events (pre-event wa (Brown et al. 1999; Kendell et al. 2001). Cizek and Hunt (20 suggested that vegetated, filtration-based SCMs with water stor in the media include all three pathways and are therefore abl mimic predevelopment hydrology.

Regenerative stormwater conveyance (RSC) is an emerg media-based SCM. This SCM is an open channel system cons ing of a porous media bed with a series of riffle/weir step p (Fig. 1). Similar to other media-based SCMs, bed material wi high hydrologic conductivity is selected to promote infiltrat Unlike bioretention media (Hunt et al. 2012), RSC media inclu 20–30% by volume shredded hardwood mulch to increase org content and promote plant growth (Anne Arundel Cou Department of Public Works 2012). The other 70–80% is compo of ASTM C33 (ASTM 2016) specified sand, 0.02–0.04 in. in s The riffle/pool geometry absorbs energy and retains water by p moting ponding and nonerosive flows. A native plant commu may also increase both water quality and hydrologic bene through plant uptake, microbially-mediated pollutant transfor tion, and evapotranspiration.

Regenerative stormwater conveyances are designed to sa convey up to the 100-year average recurrence interval (ARI) event via nonerosive surface flows. During smaller rainfall eve water is expected to exit the system as seep out, or infiltrated face water percolating through the RSC sand media bed (cognat shallow interflow, or water that travels laterally through the up soil horizons during or immediately following a precipita event). Hydrologic TR-20 modeling of an RSC site receiving ru from 7.2 ha of low-density residential development showed a 7 reduction in peak flow during the 25-year storm event (Brown e 2010). Surface flow velocities during that event were predicte be a maximum, but nonerosive, 1 ms^{-1} with a max flow dept 0.15 m over the outlet weir. Field-scale monitoring of another R receiving water from a 5.7 ha medium-density residential neighl hood had no less than a 50% reduction in peak flow for rain events less than 3.8 cm (Filoso 2013).

[1]Engineer, Stormwater Solutions Engineering, LLC, 247 Freshwater Way, Suite 410, Milwaukee, WI 53204 (corresponding author). E-mail: adrienne.cizek@gmail.com

[2]WNR Professor and Extension Specialist, Dept. of Biological and Agricultural Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695.

[3]Research Scientist, Dept. of Food Agricultural Biological and Ecological Engineering, Ohio State Univ., 590 Woody Hayes Dr., Columbus, OH 43210.

[4]Assistant State Hydraulics Engineer, Hydraulics Unit, North Carolina Dept. of Transportation, 1590 Mail Service Center, Raleigh, NC 27699.

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Water Quality and Hydrologic Performance of a Regenerative Stormwater Conveyance in the Piedmont of North Carolina

Adrienne R. Cizek, Ph.D.[1]; William F. Hunt, Ph.D., P.E., M.ASCE[2]; Ryan J. Winston, Ph.D., P.E., M.ASCE Sarah E. Waickowski[4]; Karthik Narayanaswamy, Ph.D., P.E.[5]; and Matthew S. Lauffer, P.E.[6]

Abstract: Regenerative stormwater conveyance (RSC) is an open-channel, sand-filtering system composed of a series of shallow aqua pools, riffles and weirs, native vegetation, and underlying media beds. Surface runoff entering a RSC is conveyed as nonerosive surface fl or subsurface seepage through the media, and exits the system as surface flow, seepage out, exfiltration into the parent soil, or evapotra spiration (ET). While RSCs are expected to perform similarly to other sand-media-based low-impact development (LID) stormwater cont measures (SCMs), little field research on this emerging technology have been published to date in peer-reviewed literature. Hydrologic a water quality of a RSC in the Piedmont (Alamance County) ecoregion of North Carolina was monitored from July 2013–June 2014. T Alamance RSC reduced volume and peak flow by a median 78 and 76%, respectively, while mimicking both predevelopment hydrogra shape and hydrologic flow pathways. RSC outflow matches the modeled predevelopment hydrograph shape and pathway componen including both pre-event and event water, as determined by deuterium isotope concentrations. Optimal storm mitigation performance expected when RSCs include (1) a minimum of three pool/riffle cells, (2) established vegetation, and (3) exfiltration trenches to prom exfiltration into parent soils through extended subsurface ponding. By combining seep out water with surface flow from the RSC, the practi reduced incoming total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) loads by a median of 70, 20, a 26%, respectively, likely due to filtration. The potential exists for further nutrient reduction if vegetated, wetlandlike conditions are prese Moreover, locating the RSC over more permeable soils would likely improve hydrologic performance. **DOI: 10.1061/(ASCE)EE.194 7870.0001344.**

Introduction

The conversion of undeveloped (pervious) land uses to urban and suburban (impervious) land uses results in increased surface runoff rates, volumes, and borne pollutants. This excess stormwater runoff has been linked to stream degradation (Horner et al. 2003; Klein 1979; Walsh et al. 2004), economic loss (Ajuzie and Altobellow 1997), and public health concerns (Curriero et al. 2001; Gaffield et al. 2003). As a result, stormwater mitigation efforts are increasing across the United States and elsewhere through the use of stormwater control measures (SCMs) [also referred to as best management practices (BMPs)]. Since the 1980s, stormwater m igation has evolved from reducing erosive peak flows through SC retention strategies to improving water quality. Most recent stormwater mitigation in many regions of the United States h focused on maintaining the predevelopment (undeveloped) hyd graph for a given watershed (Low Impact Development Cen 2007). It is likely that stormwater mitigation across the Unit States will move toward the predevelopment hydrograph-bas stormwater goals; the Energy Independence and Security A passed by Congress and signed into law by President Bush 2007 includes a stormwater provision that requires all federal la postconstruction discharge conditions to match the predevelopme hydrograph when disturbed land exceeds 465 m^2 (5,000 (Energy Independence and Security Act 2007). Studies in und turbed watersheds have shown storm hydrographs to include th possible flow pathways: (1) surface runoff, (2) shallow interflo and (3) groundwater from previous rain events (pre-event wat (Brown et al. 1999; Kendell et al. 2001). Cizek and Hunt (201 suggested that vegetated, filtration SCMs with water storage in t media are able to simulate all three pathways when a watershed developed, and are therefore able to at least partially match pred velopment hydrology.

Regenerative stormwater conveyance (RSC) is a relatively n vegetated, media-based approach to stormwater manageme RSCs are open-channel systems consisting of a porous med bed with a series of riffle/weir step pools (Fig. 1). Similar to oth media-based SCMs, the bed material has a high hydrologic condu tivity to promote infiltration into the RSC media. Unlike reco mended bioretention media (Hunt et al. 2012), RSC med includes 20–30% shredded hardwood mulch to serve as a carb source for nutrient transformations (Anne Arundel Coun

[1]Engineer, Stormwater Solutions Engineering, LLC, 247 Freshwater Way, Suite 410, Milwaukee, WI 53204.

[2]WNR Professor and Extension Specialist, Dept. of Biological and Agricultural Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695 (corresponding author). Email: wfhunt@ncsu .edu

[3]Research Scientist, Dept. of Food, Agricultural Biological and Ecological Engineering, Ohio State Univ., 590 Woody Hayes Dr., Columbus, OH 43210.

[4]Extension Associate, Dept. of Biological and Agricultural Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695.

[5]Project Manager and Senior Environmental Engineering Consultant, URS Corporation, 1600 Perimeter Park Dr., Suite 400, Morrisville, NC 27560.

[6]Assistant State Hydraulics Engineer, Hydraulics Unit, North Carolina Dept. of Transportation, 1590 Mail Service Center, Raleigh, NC 27699.

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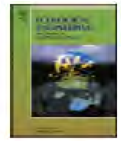

Hydrologic and water quality performance of regenerative stormwater conveyance installed to stabilize an eroded outfall

Kevin M. Koryto*, William F. Hunt, Jonathan L. Page

North Carolina State University, D.S. Weaver Labs, Campus Box 7625, Raleigh, NC 27695, USA

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ABSTRACT

Conveying concentrated urban runoff to outfall locations frequently leads to stream bank erosion, channel incision, and the formation of headcuts. Installed in an incised eroded channel, regenerative stormwater conveyance (RSC) is a grade-control and treatment system that uses a series of pools and cascades with an underlying sand bed. As a recently developed practice, RSC performance evaluations are needed to improve the design and guide regulatory accreditation. An eroded channel with a 10% longitudinal slope was stabilized with a five-cell system and monitored for a 14-month period. A small capture volume (6-mm design event) and groundwater intrusion resulted in minimal hydrologic benefit. Hydrologic mitigation was attained only for storms less than 12.7 mm. The RSC converted a substantial 50% of inflow to media flow at the second cell; however, the media flow entirely reemerged as surface flow in the saturated downstream pools. Small but statistically significant reductions in event mean concentrations occurred: 17% total suspended sediment (TSS), 17% total phosphorus (TP), and 3% total nitrogen (TN). Water quality improvements occurred primarily between the upstream and second cell, indicating limited processing by the wetter downstream pools. Comparisons between inter-event outflow grab samples and storm event outflow concentrations show nitrogen export during inter-event periods (47% increase in TN concentration). Due to elevated inter-event concentrations, overall mass loading of nitrogen increased. Hydrologic and water quality benefits were garnered only in the first three cells where groundwater intrusion was minimal. Future implementations of RSC are encouraged to account for seasonal high water table elevations that interact with the RSC media and adequately size pool and sand layer capture volumes.

1. Introduction

Conventional urban drainage plans have focused on conveying stormwater using sewers and ditches from paved surfaces to river networks to reduce flooding impacts (Roesner et al., 2001). The associated increase in runoff velocity and volume causes stream bank and channel erosion (Booth et al., 2005); reducing stream ecological function (Walsh et al., 2005), increasing sediment loading (Voli et al., 2013), and releasing bound pollutants (Walter et al., 2007). At stormwater outfalls, concentrated flow and changes in channel slope can result in headcut formation. If unstabilized, a headcut will continue to migrate upstream potentially causing infrastructure damage (Bennett et al., 2000). Stabilizing eroded outfalls provides an opportunity for water quality and economic benefit by retaining sediment.

Federal mandates require the use of stormwater control measures (SCMs) to meet water quantity and quality targets (US EPA, 2009). An emphasis on pollutant removal in nutrient sensitive watersheds has driven the creation of SCMs that incorporate media treatment; including permeable pavement, sand filters, and bioretention (Collins et al., 2010; Passeport et al., 2013). Regenerative stormwater conveyance (RSC) is a recently-developed SCM that incorporates a media layer and step-pool sequences, allowing installation within sloped linear channels. Installing RSC in eroded channels addresses both bank stabilization and runoff treatment (Brown et al., 2010; Underwood, 2008).

RSC is a series of shallow pools connected by boulder cascades and a subsurface media layer (Fig. 1). Design guidelines recommend a capture volume equivalent to runoff from the 25-mm rainfall event (Flores et al., 2012; West Virginia Department of Environmental Protection, 2012). By design, events smaller than 25 mm are detained within the pools and sand layer allowing for

* Corresponding author.
E-mail addresses: kmkoryto@ncsu.edu (K.M. Koryto), wfhunt@ncsu.edu (W.F. Hunt).

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Performance of Regenerative Stormwater Conveyance on the Removal of Dissolved Pollutants: Field Scale Simulation Study

Kevin M. Koryto, M.ASCE[1]; William F. Hunt, Ph.D., P.E., M.ASCE[2]; Consuelo Arellano, Ph.D.[3]; and Jonathan L. Page, P.E., M.ASCE[4]

Abstract: Regenerative stormwater conveyance (RSC) is a stormwater control measure (SCM) built in a channel that uses a series of riffles grade control structures, and pools with an underlying sand media layer to detain and treat stormwater runoff. A purpose-built experimenta field RSC was subjected to simulated hydrographs by mixing dissolved nitrogen and phosphorus into inflow from a managed retention pond The system storage capacity of 30.5 m^2 within the pools (14.2 m^2) and sand layer (16.3 m^2) was sized to store the runoff volume from th 25-mm event. Twelve storm simulations were conducted under varying conditions of storm depth (25 and 38 mm) and antecedent dry period (1 day and 3 days). Simulations confirmed that RSC can convert large portions of flow volumes from surface to subsurface flow; mea reductions in surface flow volumes were 80% for the 25-mm event and 40% for the 38-mm event. Reductions in dissolved pollutant con centrations in surface flow were insignificant or very minor for all analytes. However, mean reductions in subsurface flow concentrations wer high for both total Kjeldahl nitrogen (TKN, 79%) and orthophosphate (81%). Because of well-drained subsurface conditions, nitrification o TKN to nitrate was observed, leading to a 250% increase in nitrate concentration. Results of the simulation study indicate that microbia transformation and sorption mechanisms are present in RSC subsurface outflow. Subsurface flow contributed 66% of the total nitrogen loa and 42% of the total phosphorus load for the 25-mm event. When adequately sized, RSCs can provide substantial hydrologic mitigatio for urban drainage areas. As implementation of RSC continues, regulators and designers are encouraged to consider RSC subsurface flow as an important contribution to downstream pollutant load. Proper filter media selection and differentiated aerobic/anaerobic condition are essential to optimize subsurface flow treatment. **DOI: 10.1061/(ASCE)EE.1943-7870.0001374.** *© 2018 American Society of Civi Engineers.*

Introduction

Urban stormwater runoff contains pollutants that have been directly associated with the degradation of surface water quality (National Research Council 2008; USEPA 2005). Compacted and impervious urban areas increase runoff volumes, degrading receiving water bodies because of bank erosion and enlarged pollutant loads (Booth et al. 2005; Walsh et al. 2005). In nutrient-sensitive watersheds, nitrogen and phosphorus concentrations are of particular concern, causing eutrophication and impacting drinking water sources (NCDEQ 2007). Eutrophication is the driver of multiple environmental concerns, including algal blooms, habitat loss, fish kills, and hypoxic/anoxic conditions (National Research Counci 2008).

The primary focus of traditional stormwater control measure (SCMs) has been peak flow attenuation and removal of particulate through sedimentation or filtration processes (Clark and Pitt 2012 Kayhanian et al. 2012). Compared to particle-bound pollutants dissolved pollutants are more mobile, bioavailable, and difficul to remove, and quickly impact receiving water bodies (Correl 1998; Kayhanian et al. 2012). Dissolved phosphorus is presen in stormwater as orthophosphate ($H_XPO_4^{X-3}$), also referred to a soluble reactive phosphorus (SRP) (Stumm and Morgan 2012) Phosphorus is often assumed to be primarily particle-bound; however, a substantially dissolved fraction in the range 30–45% i typically found in urban runoff (Kayhanian et al. 2007; Miguntanna et al. 2013). Dissolved nitrogen species include nitrate/nitrit ($NO_{2,3}^-$), ammonia/ammonium (NH_3, NH_4^+), and organic nitrogen Nitrogen, unlike phosphorus, is predominantly dissolved with th sum of all dissolved species accounting for approximately 75% o total nitrogen loading in urban runoff (Taylor et al. 2005). A limite emphasis has been placed in stormwater management on th removal of dissolved pollutants (LeFevre et al. 2014).

SCMs such as sand filters and bioretention have begun to ad dress dissolved pollutant removal by incorporating media treatmen (Davis et al. 2009; Passeport et al. 2013). Research on bioretentio has highlighted two critical design factors (filter media selectio and differentiated aerobic/anaerobic zones) to treat dissolve pollutants:

1. Filter media selection: Both field (Hunt et al. 2006) and labora tory studies (Davis et al. 2006) have shown strong removal o

[1]Senior Staff Engineer, Engineer in Training, Geosyntec Consultants, Inc., 1376 Miner's Dr., Suite 108, Lafayette, CO 80026 (corresponding author). ORCID: https://orcid.org/0000-0002-3367-9131. E-mail: korytoke@gmail.com
[2]Professor and Extension Specialist, Dept. of Biological and Agricultural Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695. E-mail: wfhunt@ncsu.edu
[3]Research Associate Professor, Dept. of Statistics, North Carolina State Univ., Campus Box 8203, Raleigh, NC 27695. E-mail: consuelo_arellano@ncsu.edu
[4]Extension Associate, Dept. of Biological and Agricultural Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695. E-mail: jlpage3@ncsu.edu

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And Thanks to Ted Brown

Biohabitats

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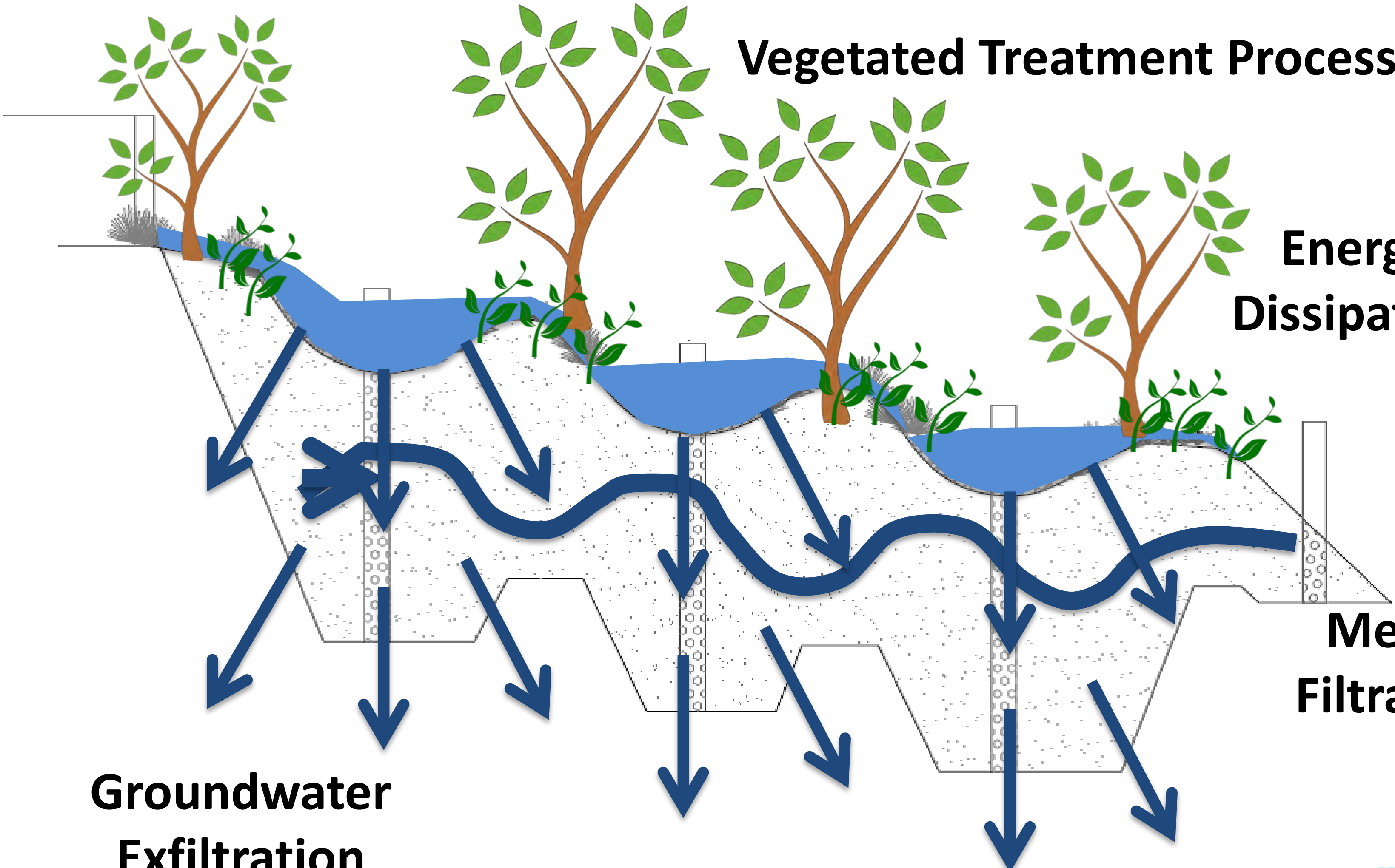
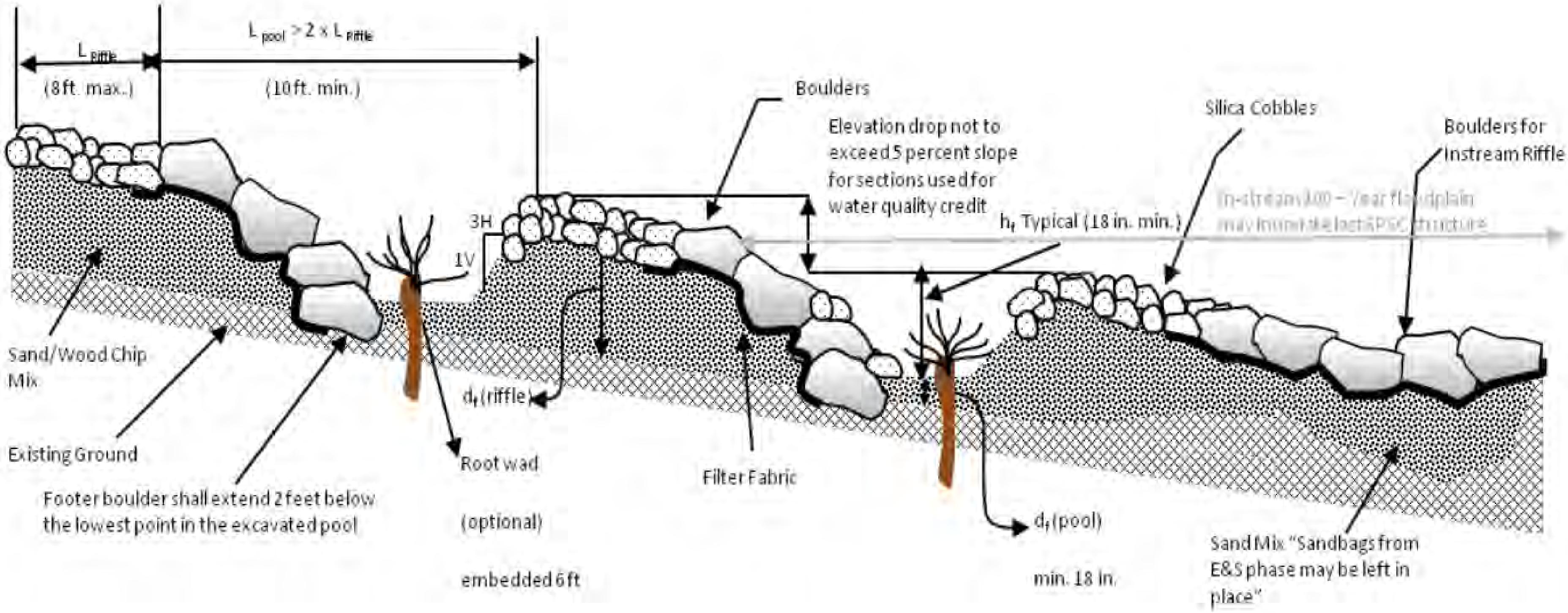
What can you do here? What Caused this?

RSCs are… a series of pools and riffles designed to convey, manage, and treat stormwater runoff



Design Elements of RSC (Flores et al., 2012)

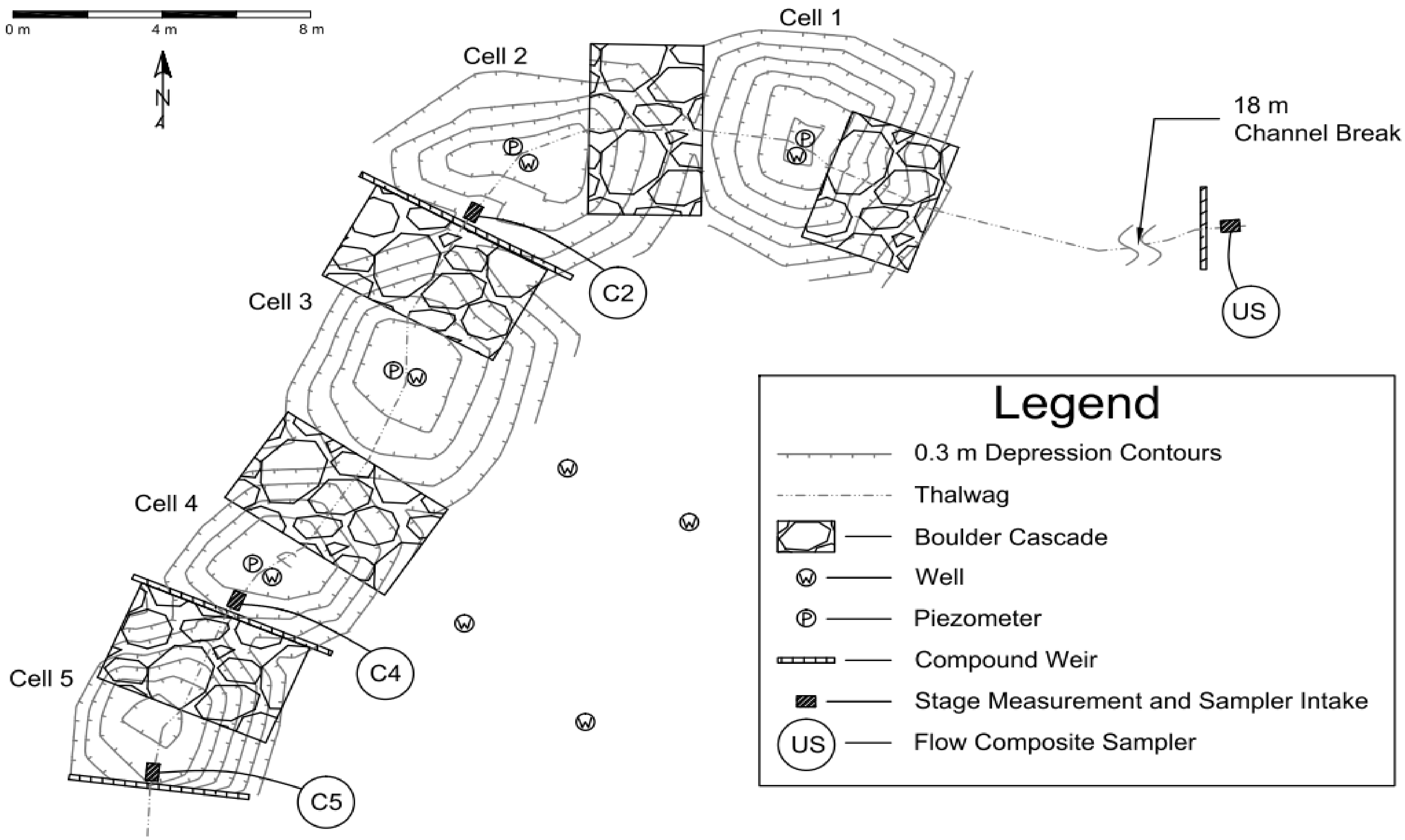


Construction - Sand Mulch Sublayer

Existing 2.4-m head cut, 0.5 to 0.8-m media depth in existing channel

Construction – Boulder Cascades

Downstream to upstream sequencing, preservation of trees


0 m
4 m
8 m
N
Cell 1
Cell 2
Cell 3
Cell 4
Cell 5
C2
C4
C5
US
18 m
Channel Break
Legend
0.3 m Depression Contours
Thalwag
Boulder Cascade
Well
Piezometer
Compound Weir
Stage Measurement and Sampler Intake
Flow Composite Sampler

Completed System: UNC-Charlotte

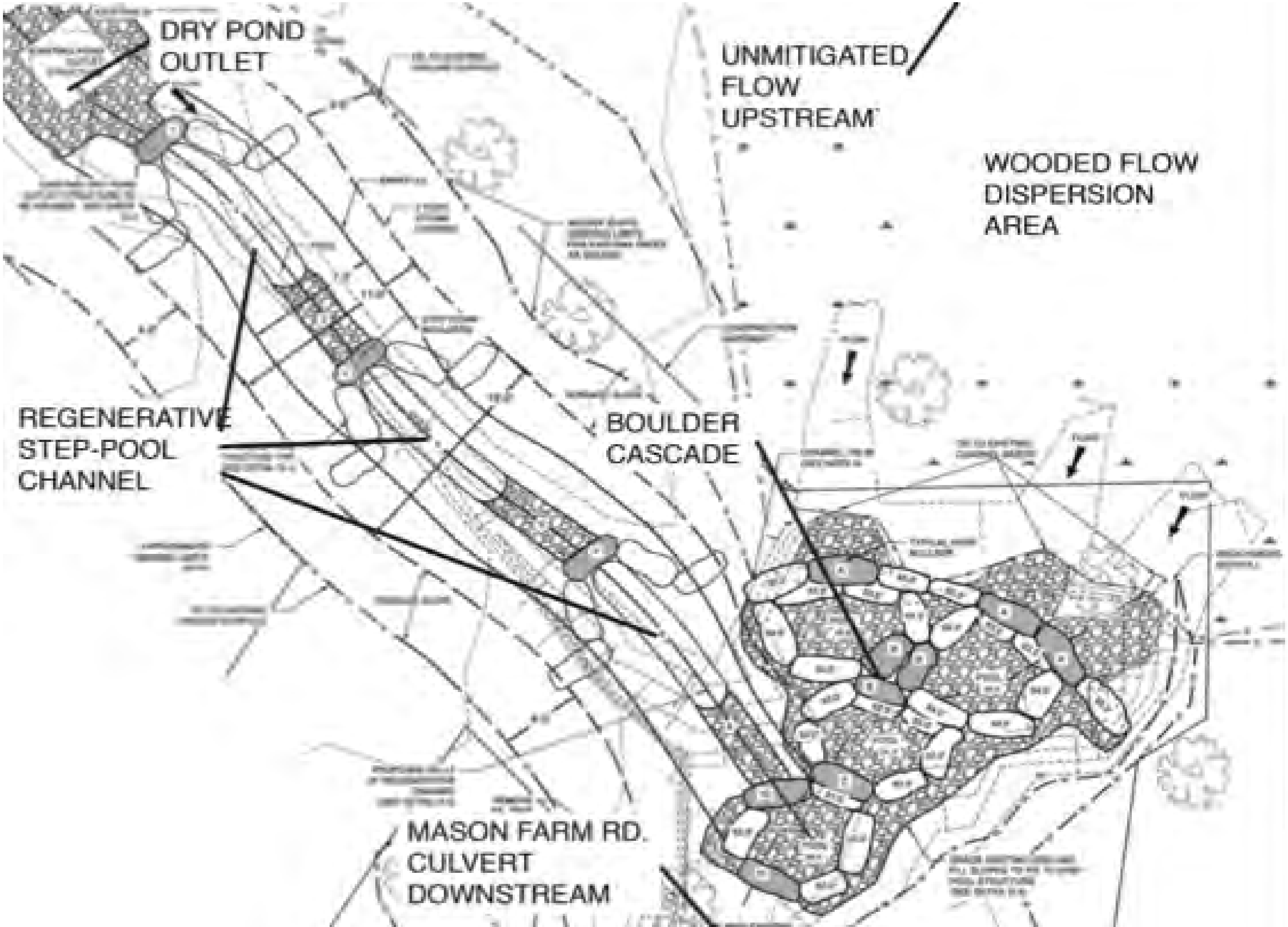
Knoxville, TN

Watauga County, NC

Brunswick Co. NC

Alamance Co. NC

Morrisville, NC


DRY POND
OUTLET
UNMITIGATED
FLOW
UPSTREAM
WOODED FLOW
DISPERSION
AREA
REGENERATIVE
STEP-POOL
CHANNEL
BOULDER
CASCADE
MASON FARM RD.
CULVERT
DOWNSTREAM

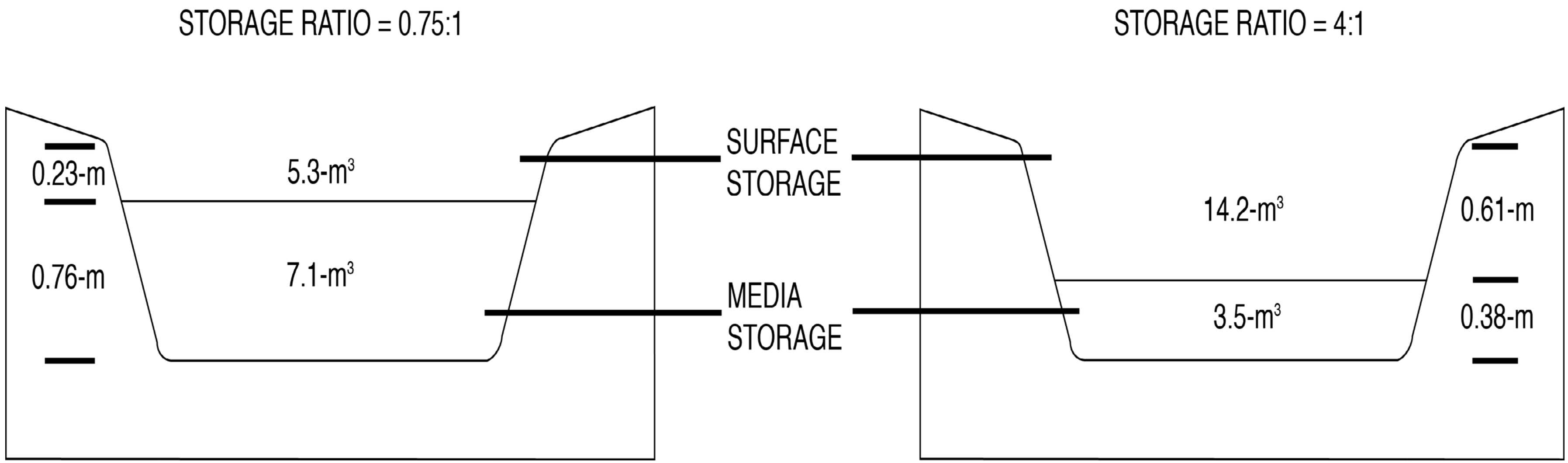
List of Important RSC Design Elements

1. Surface Area
2. Watershed Size: Surface Area Ratio
3. Capture Volume
4. Slope
5. Pool Storage
6. Media Volume
7. Media Type
8. Media Storage
9. Pool: Media Storage Ratio
10. Boulder Structures
11. Vegetation Type
12. Pre-Treatment (e.g., Forebay)
13. Infiltration Trench

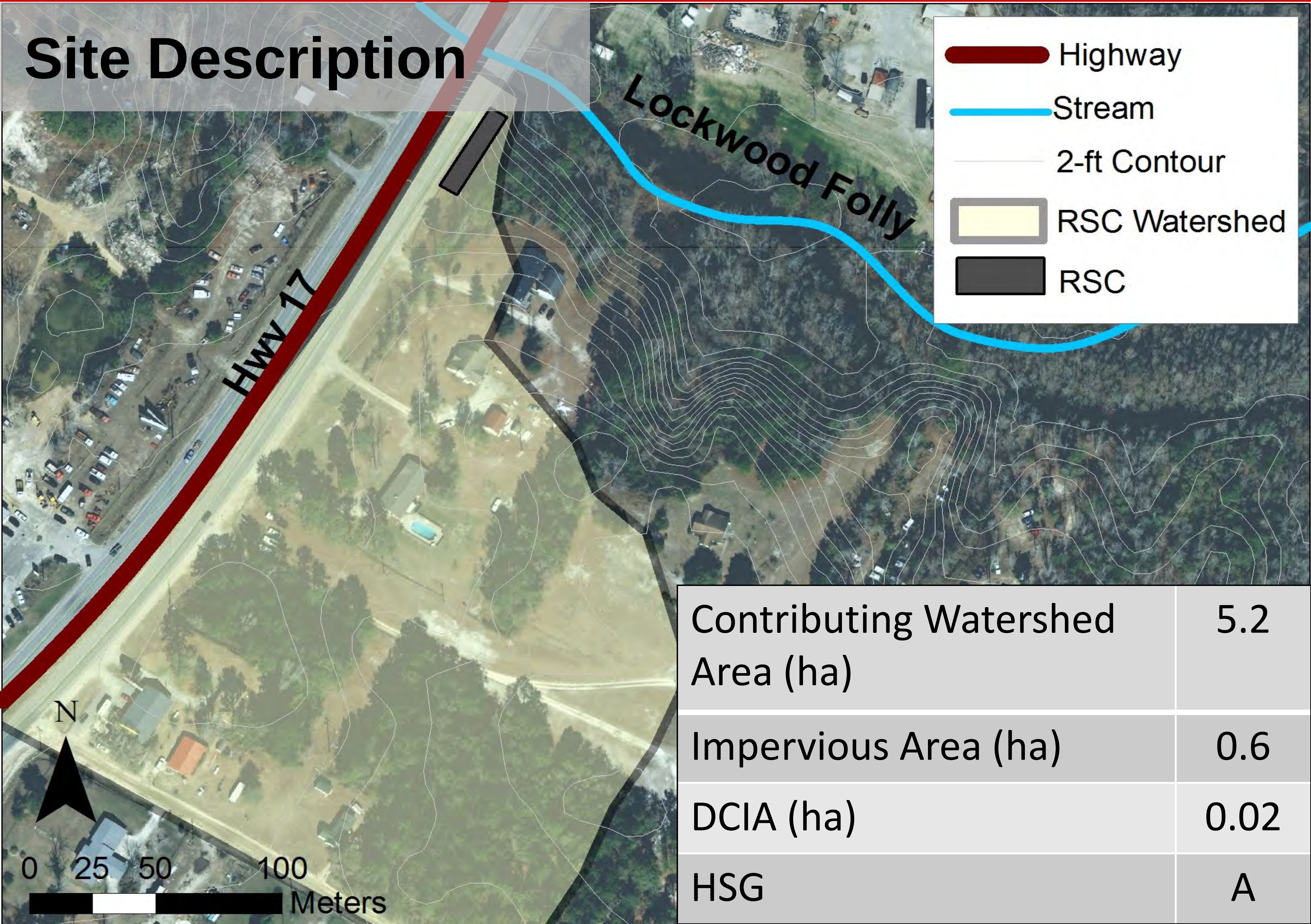
$$1)\ Loading\ Ratio = \frac{Watershed\ Area}{SCM\ Area}$$

$$2)\ Storage\ Ratio = \frac{Surface\ Storage\ Volume}{Media\ Storage\ Volume}$$

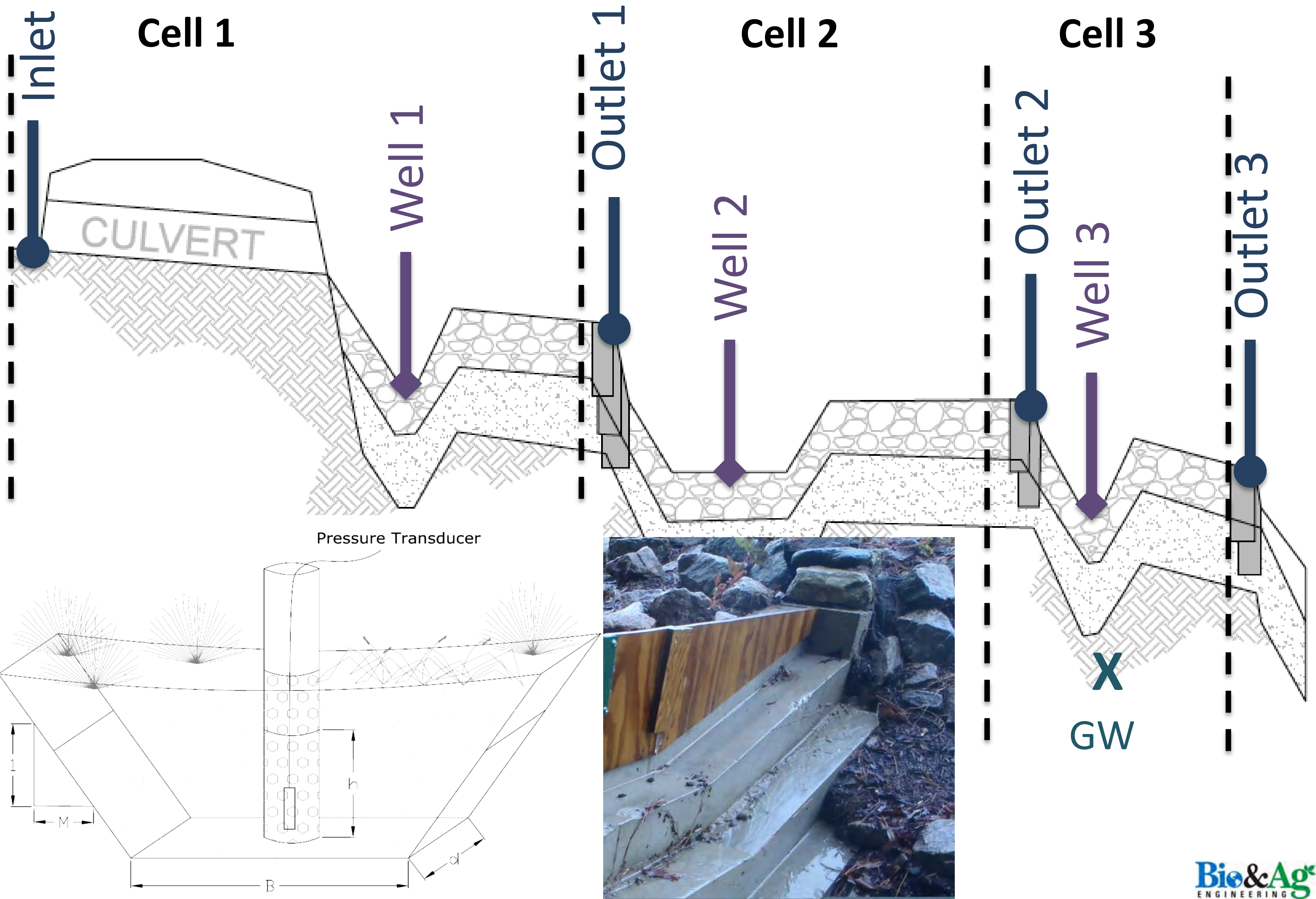
Storage Ratio Comparison



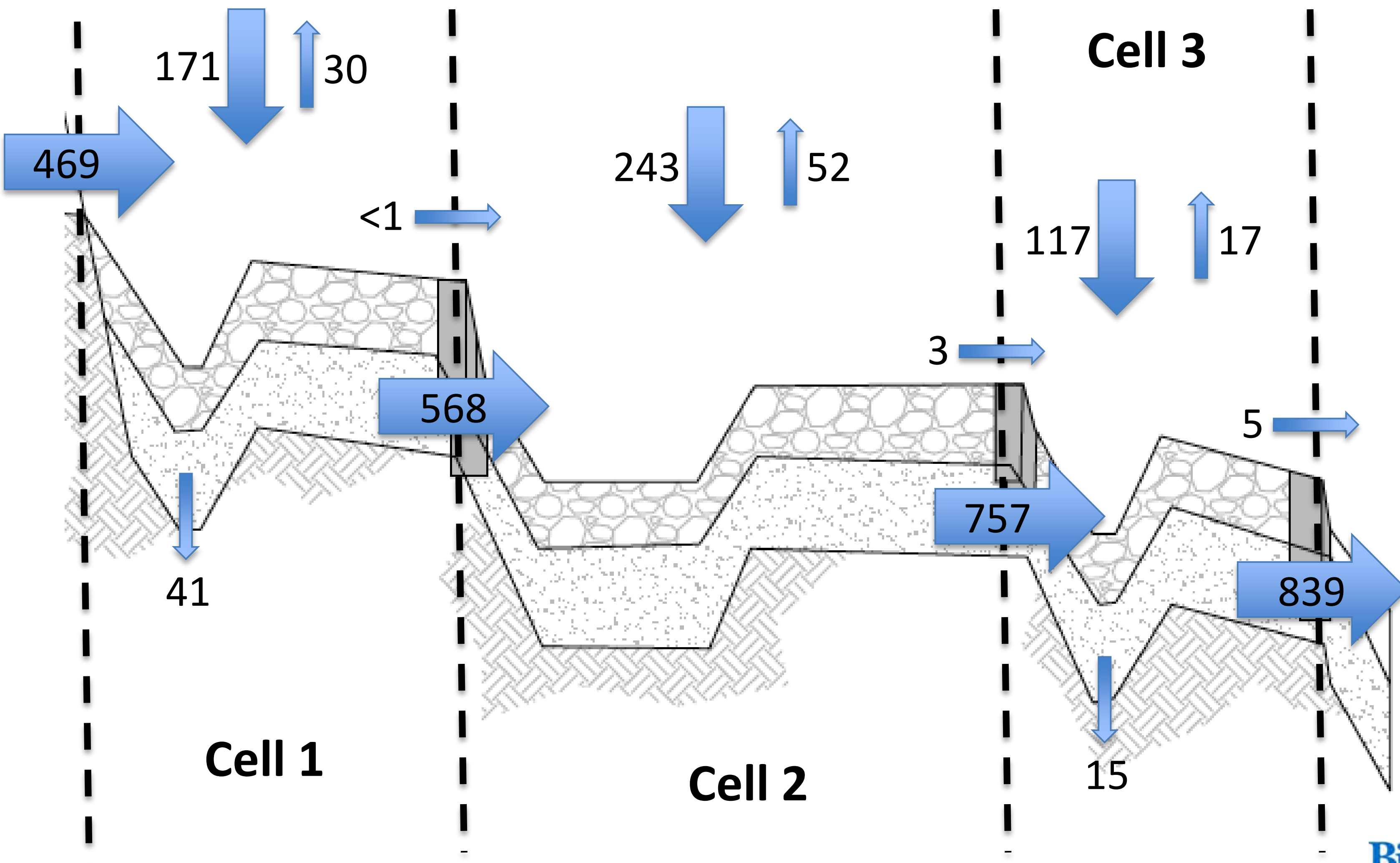
Site Description

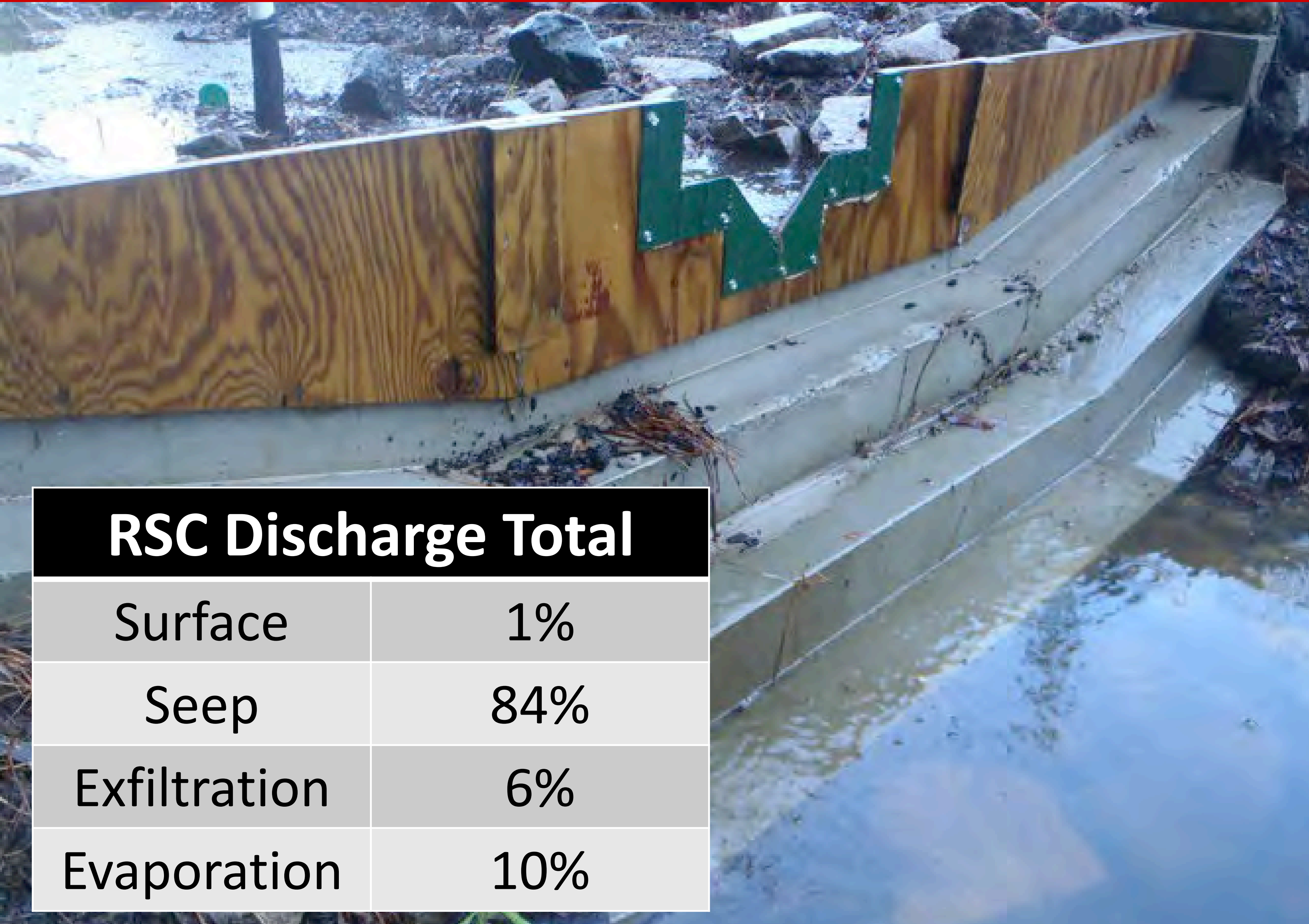


Contributing Watershed Area (ha)	5.2
Impervious Area (ha)	0.6
DCIA (ha)	0.02
HSG	A


Inlet
Cell 1
Outlet 1
Cell 2
Cell 3
CULVERT
Well 1
Well 2
Outlet 2
Well 3
Outlet 3
X
GW
Pressure Transducer
1
M
h
B
d

Overall Water Balance (L per 1000 L)





RSC Discharge Total	
Surface	1%
Seep	84%
Exfiltration	6%
Evaporation	10%

Take Home Points: Brunswick Co

- RSCs can “swallow” large storms, given the “right” design
- Seepage seems to be important

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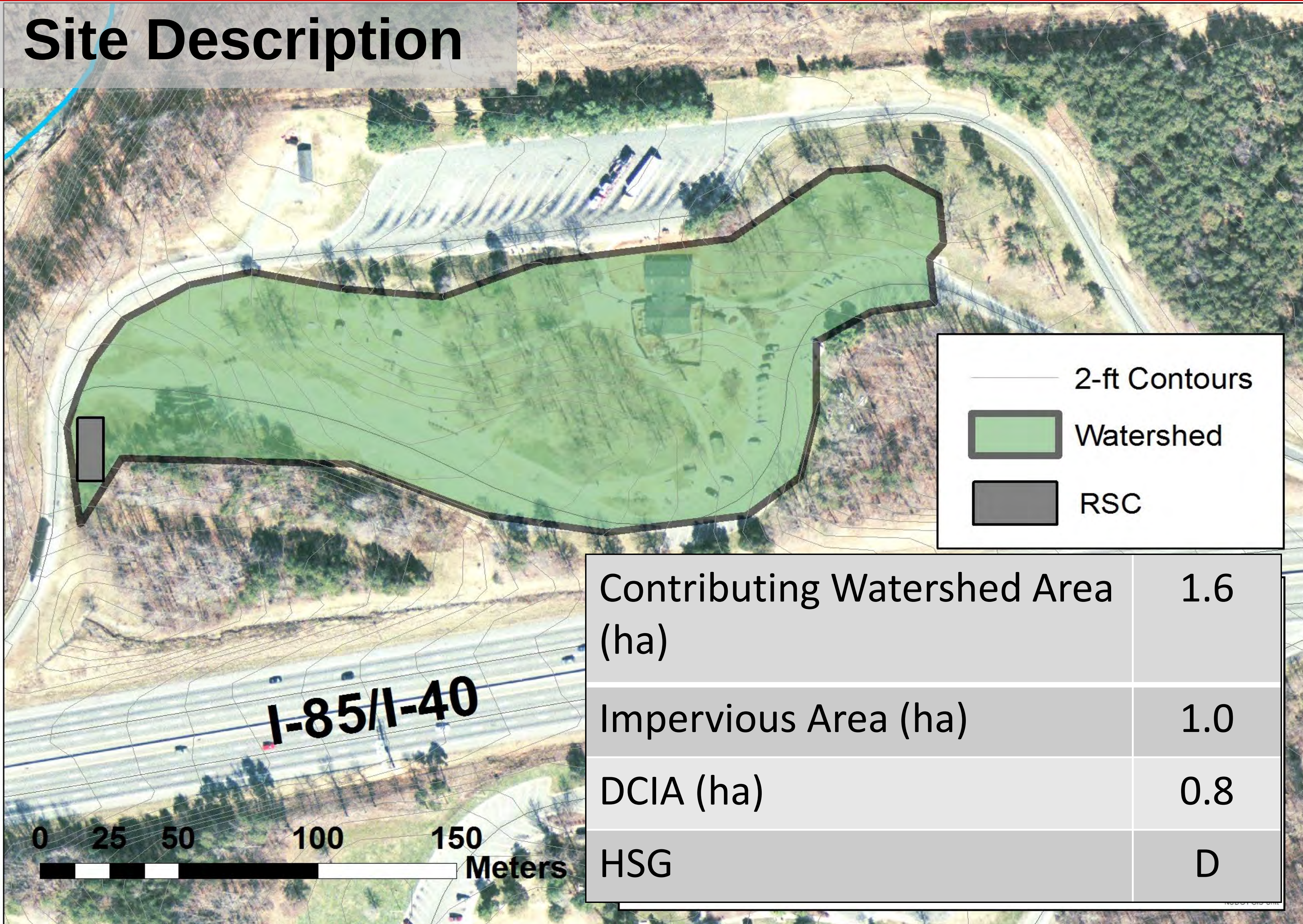
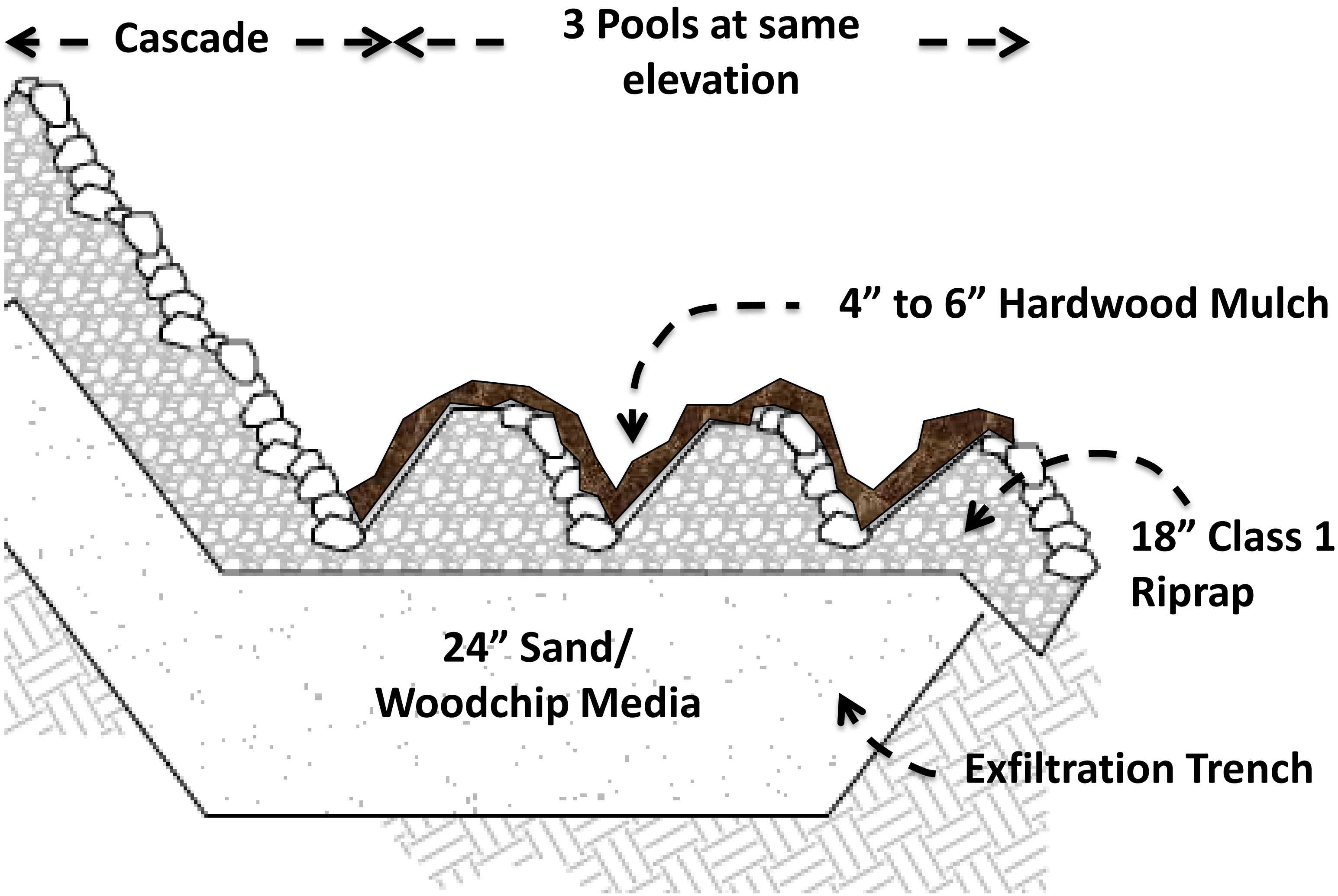
Alamance County

Site Description

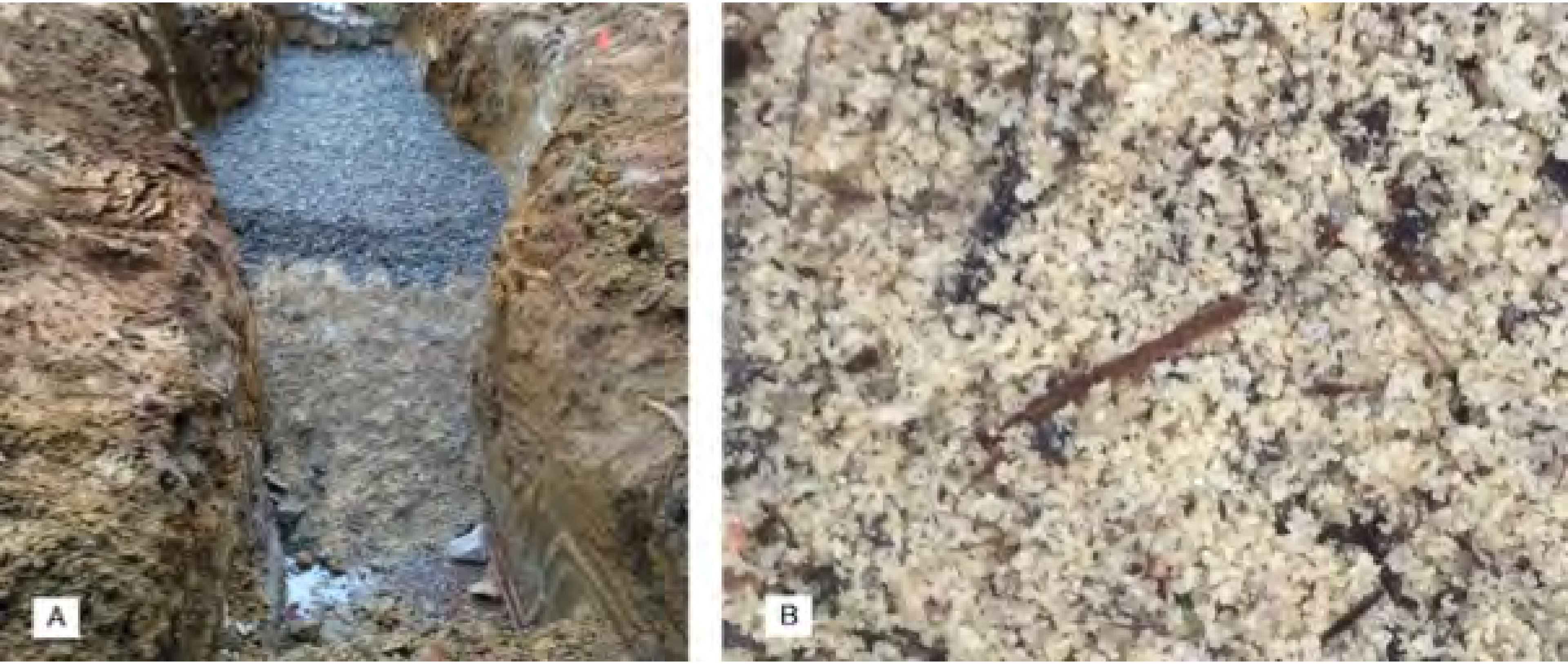


Contributing Watershed Area (ha)	1.6
Impervious Area (ha)	1.0
DCIA (ha)	0.8
HSG	D

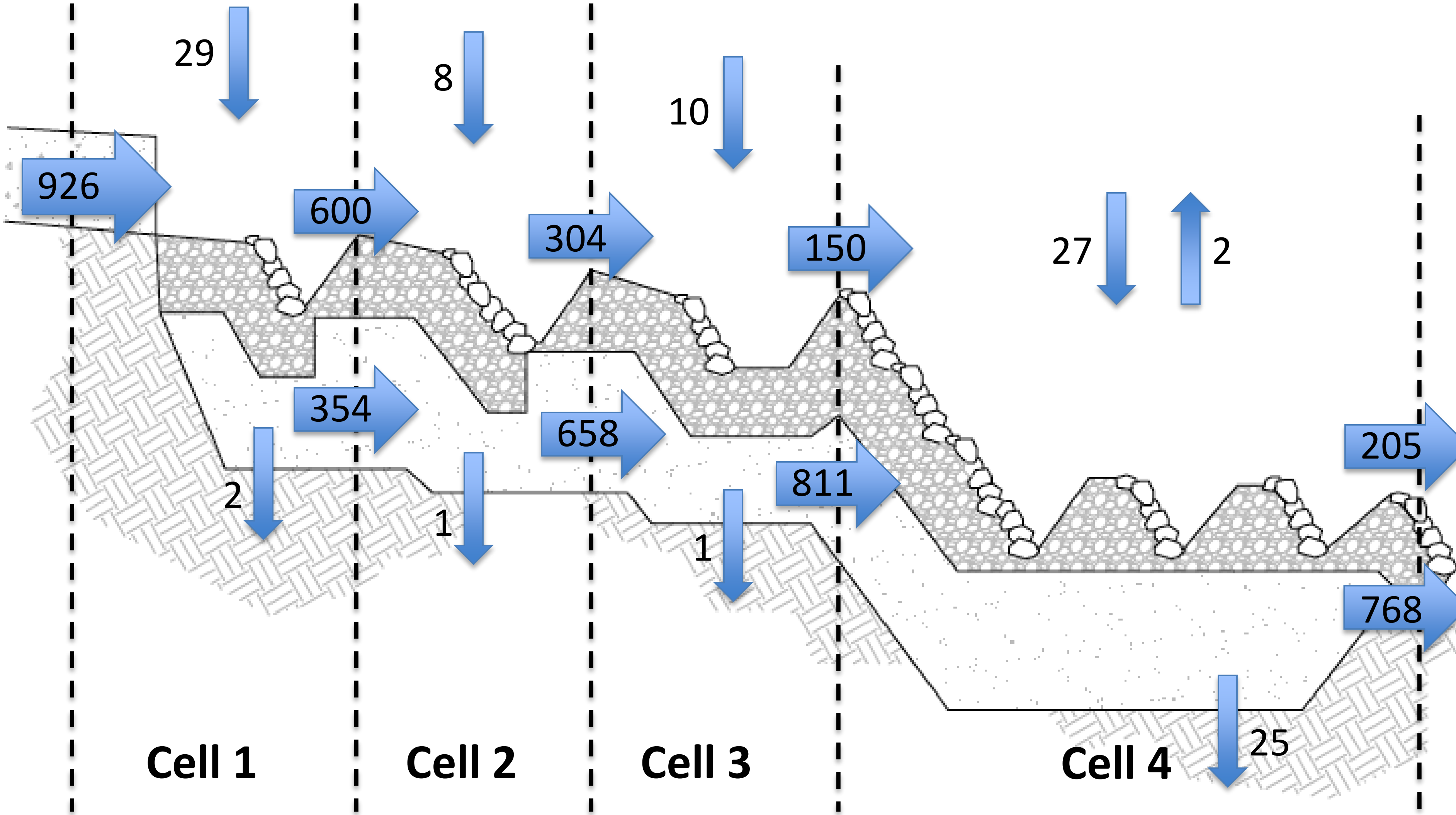
Cell 4


Cascade
3 Pools at same elevation
4” to 6” Hardwood Mulch
18” Class 1 Riprap
24” Sand/ Woodchip Media
Exfiltration Trench

Exfiltration Trench (A), Media Type (B)

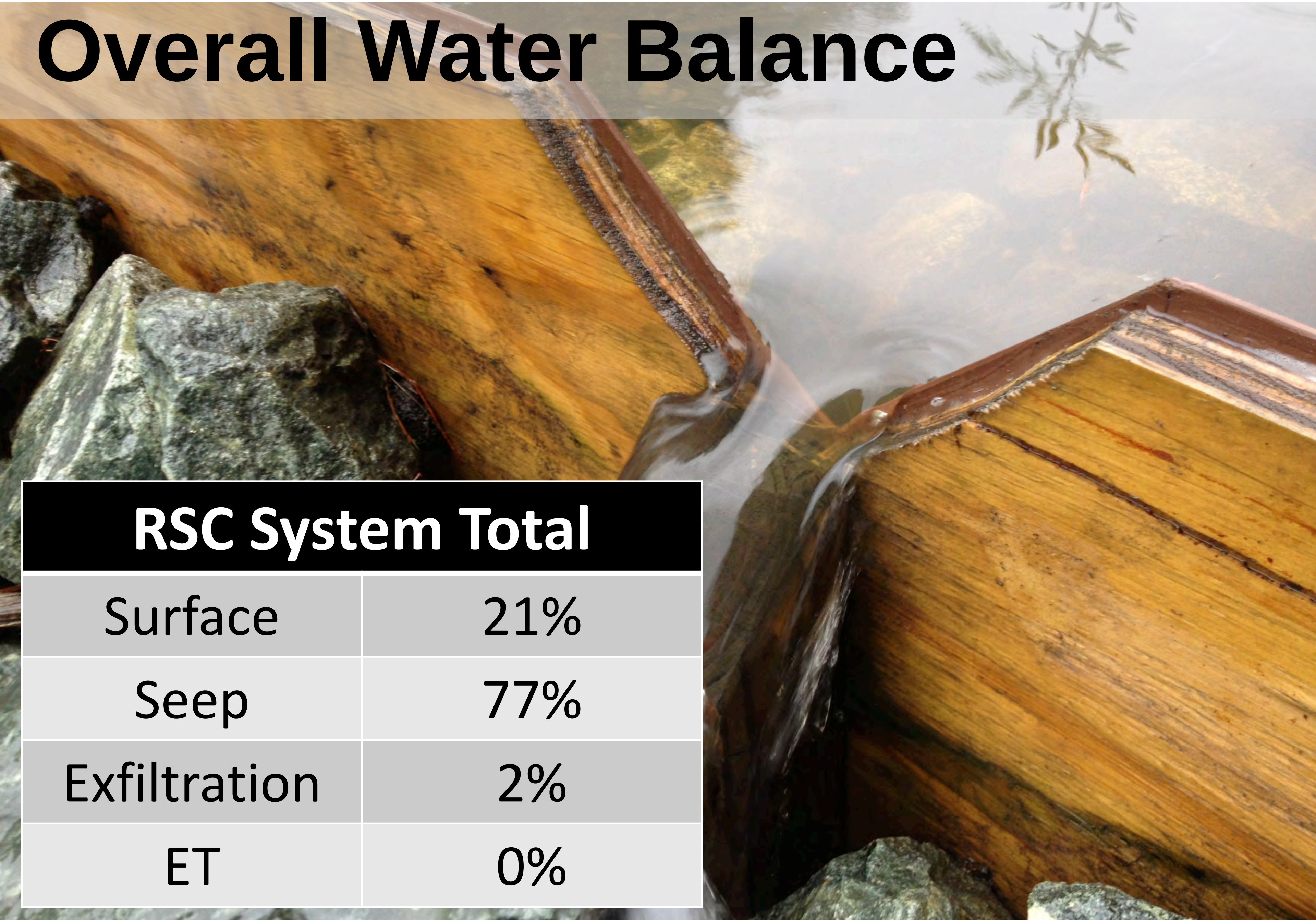


Overall Water Balance (L per 1000 L)



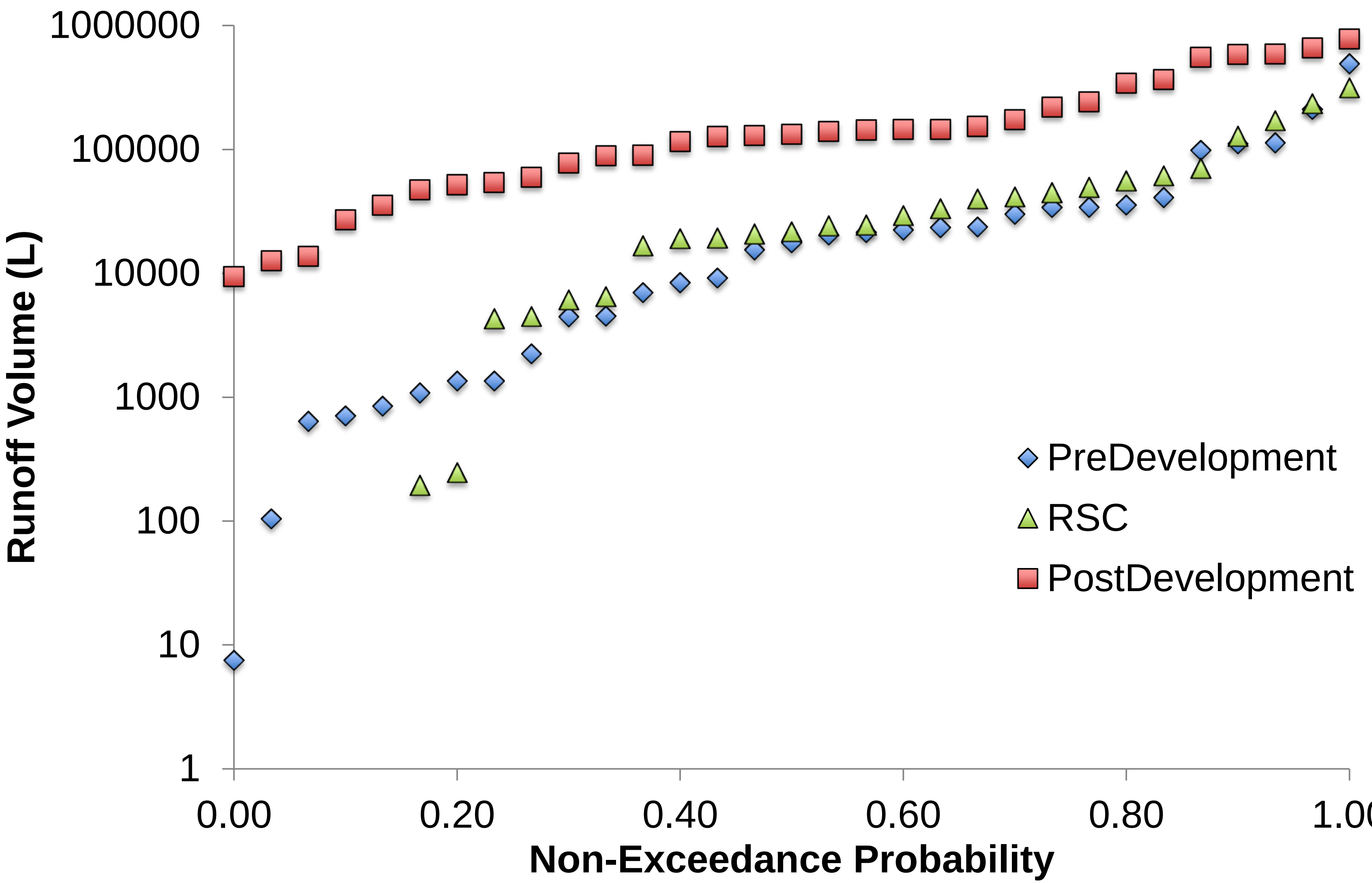
What did we gain by having our exfiltration trench?

Overall Water Balance

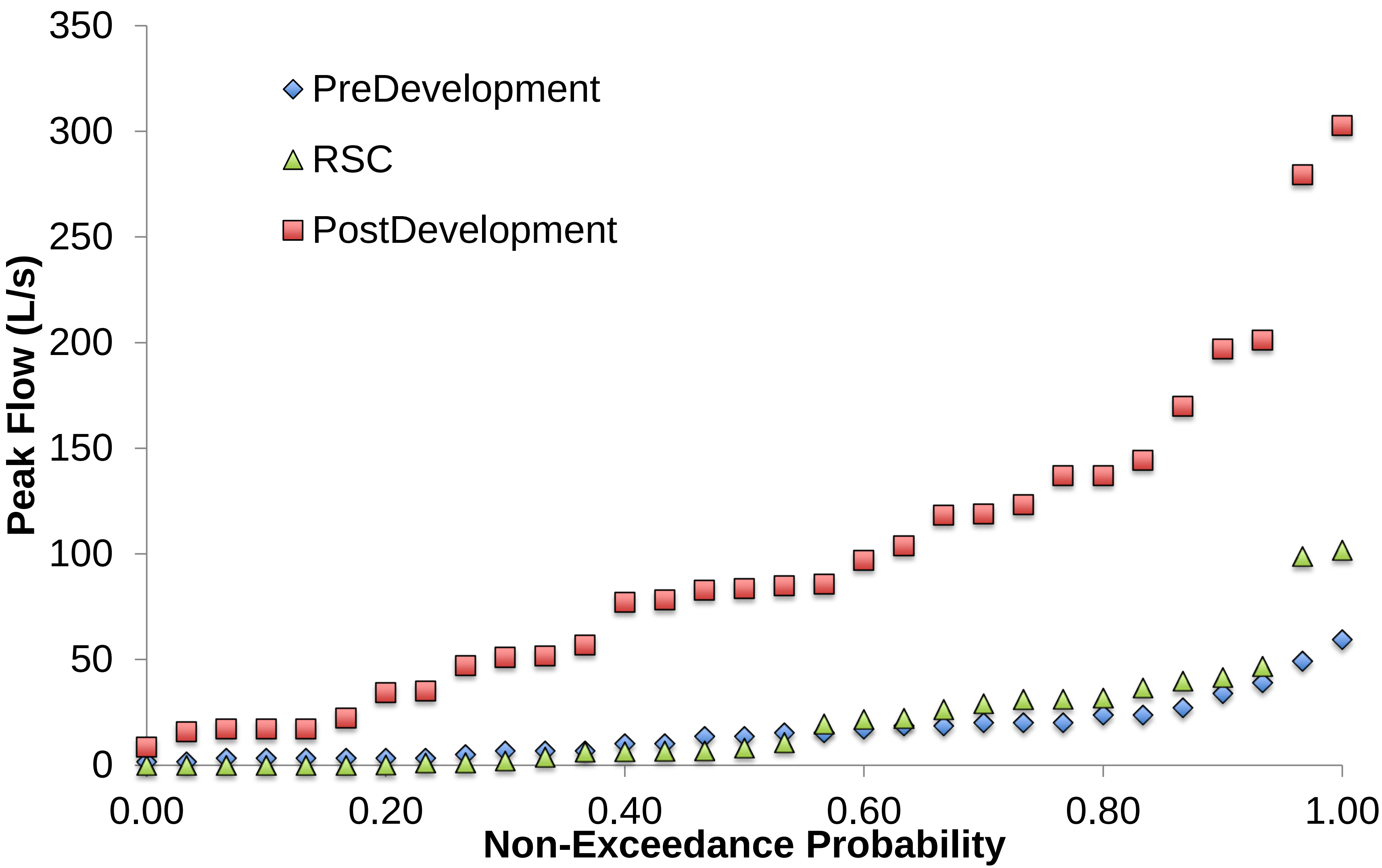


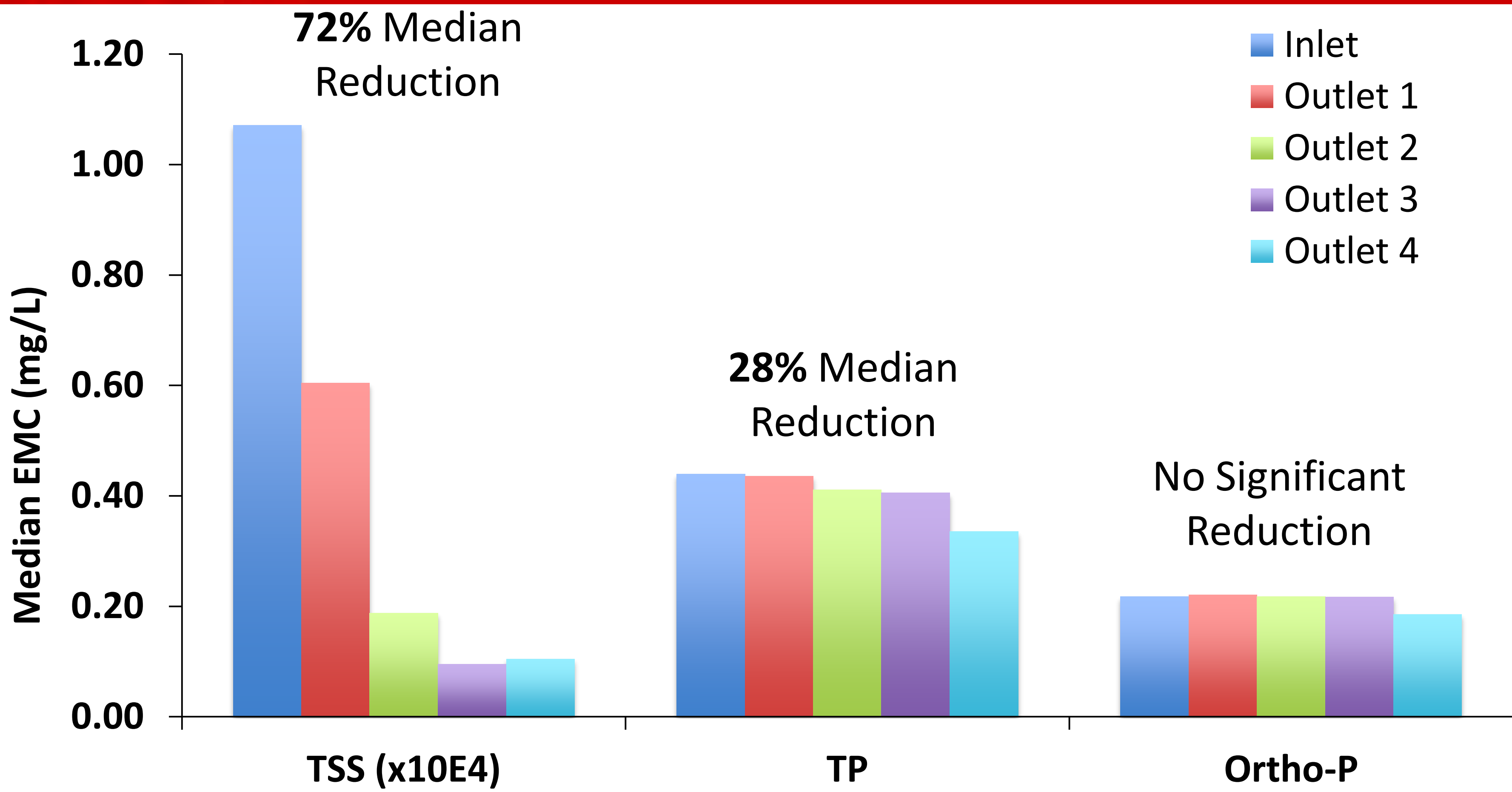
RSC System Total	
Surface	21%
Seep	77%
Exfiltration	2%
ET	0%

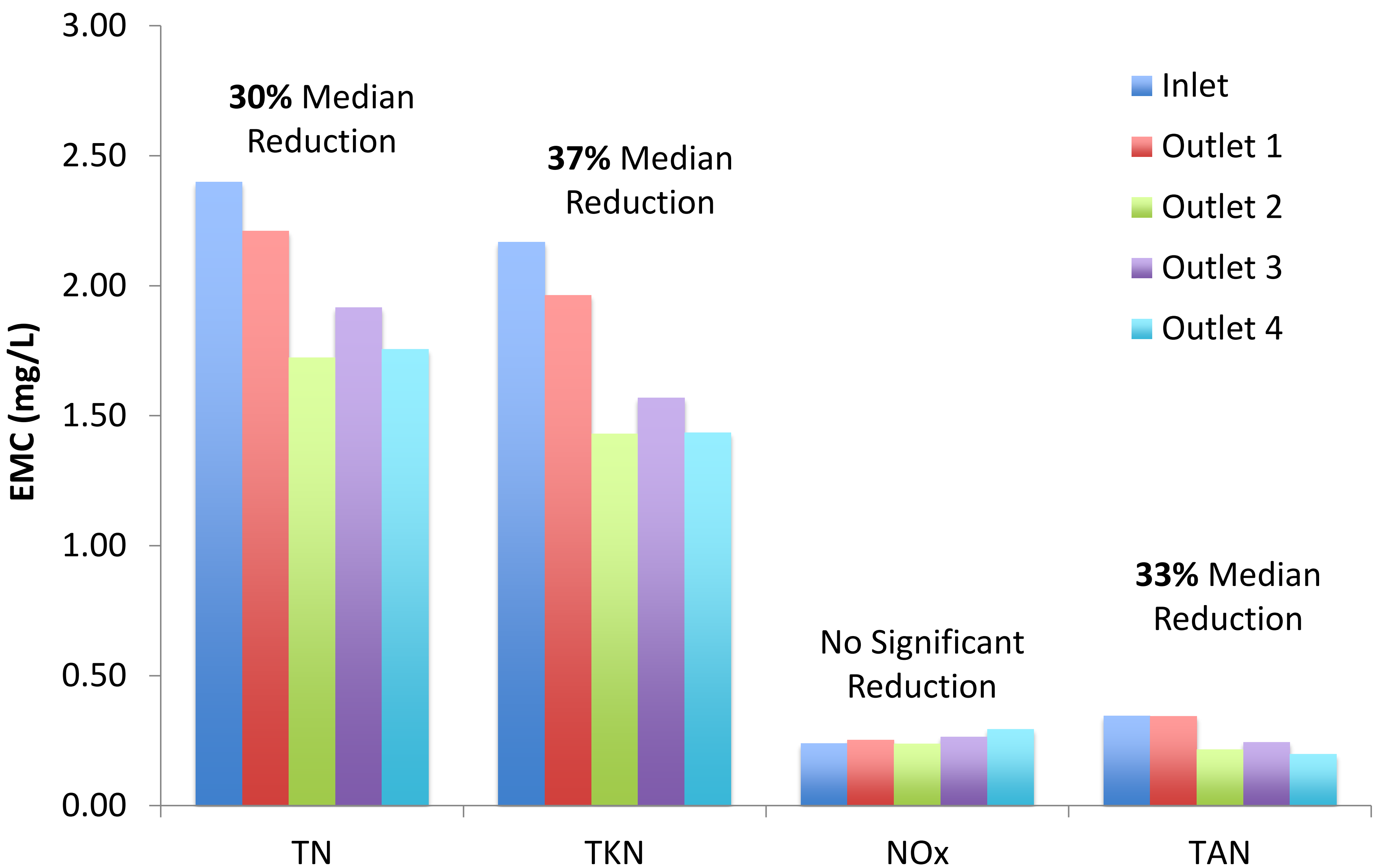
Runoff Volume: Alamance DOT



Peak Flow: Alamance DOT




72% Median Reduction
28% Median Reduction
No Significant Reduction
Median EMC (mg/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
TSS (x10E4)
TP
Ortho-P
Inlet
Outlet 1
Outlet 2
Outlet 3
Outlet 4


3.00
2.50
2.00
1.50
1.00
0.50
0.00
EMC (mg/L)
30% Median Reduction
37% Median Reduction
No Significant Reduction
33% Median Reduction
Inlet
Outlet 1
Outlet 2
Outlet 3
Outlet 4
TN
TKN
NOx
TAN

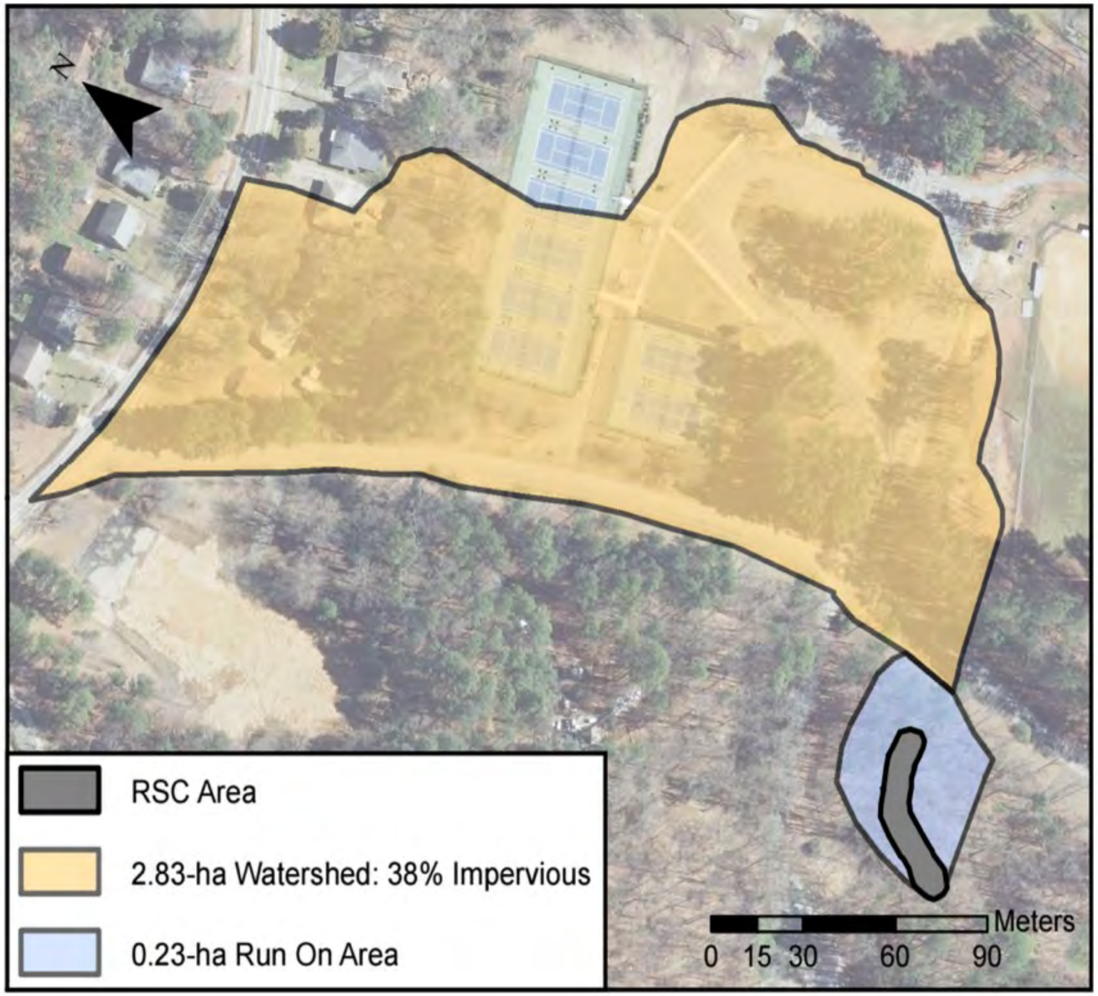
Take Home Points: Alamance Co

- By Isolating Surface Flow, Volumes & Rates were mitigated to Pre-Development
- Some broad Water Quality Improvement
- Seepage remains important
- Infiltration trench not so much
- Cell 1 *de facto* forebay

Durham RSC Site Characteristics

Southern Boundaries Park
Durham, NC
Installed Nov 2014

Watershed: 2.83 ha (7 ac)
- 38% impervious
- Additional run-on area
- Triassic soils
  HSG D (0 – 1.5 mm/hr)

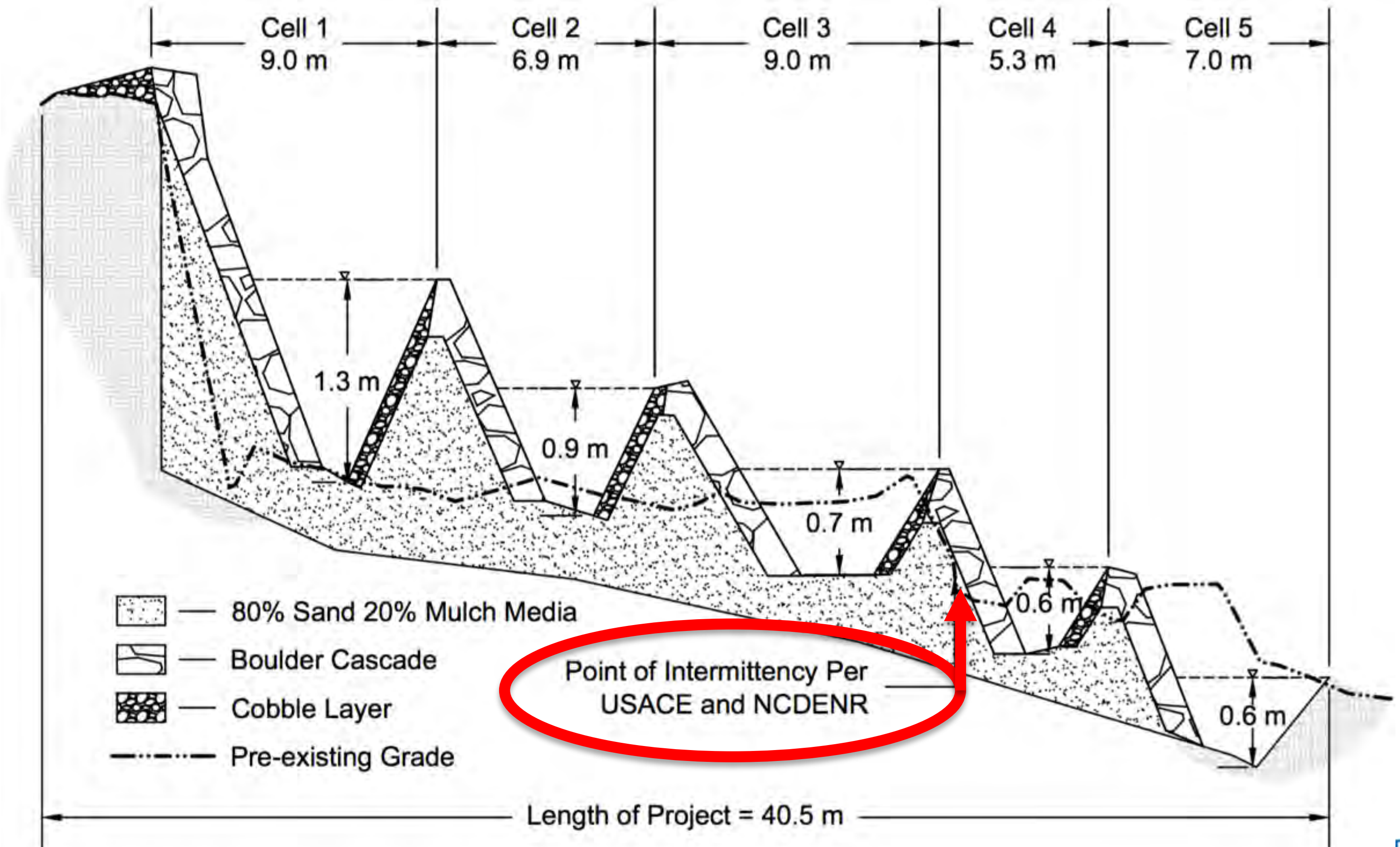


NC STATE UNIVERSITY

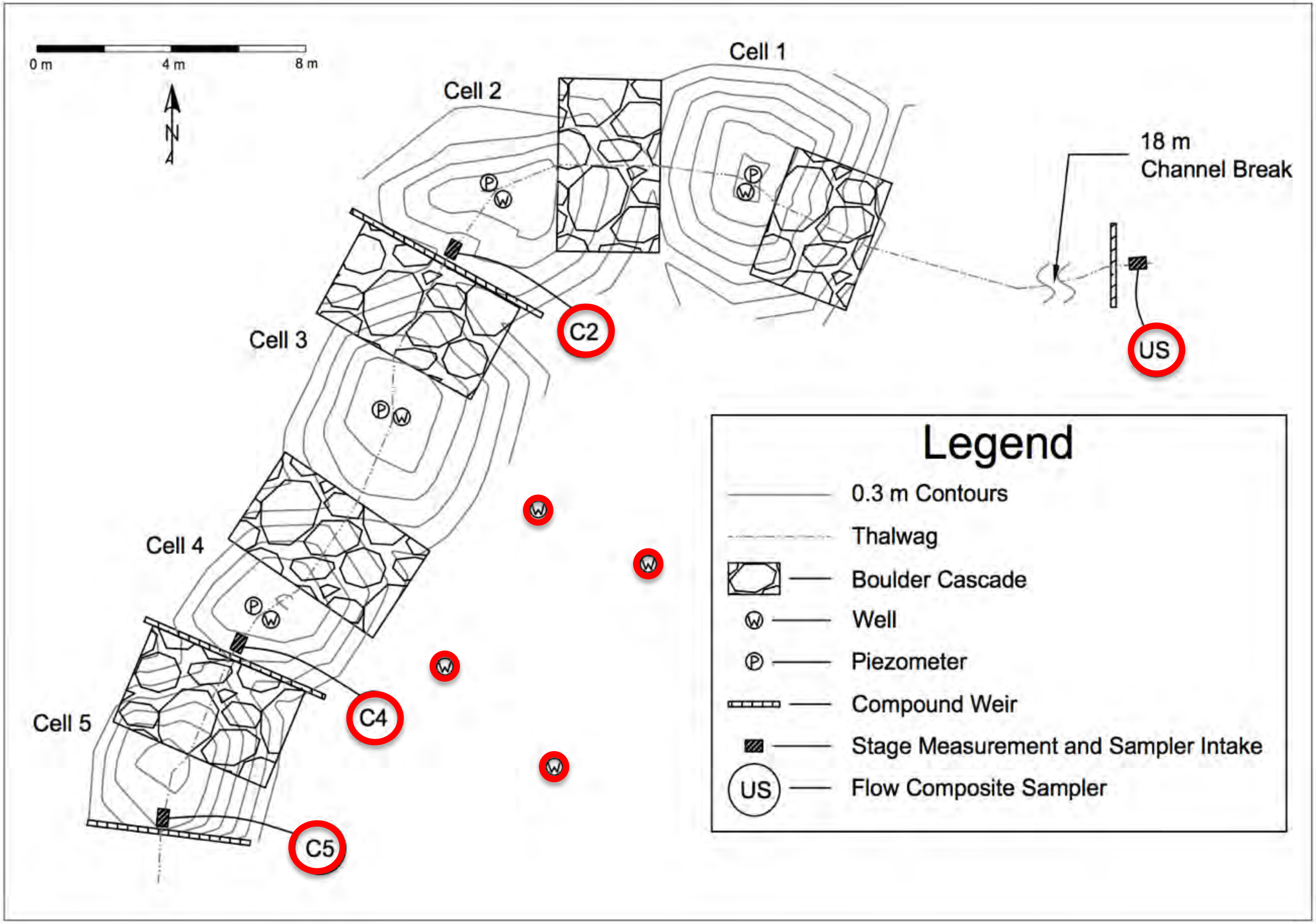
Durham RSC

The Durham RSC

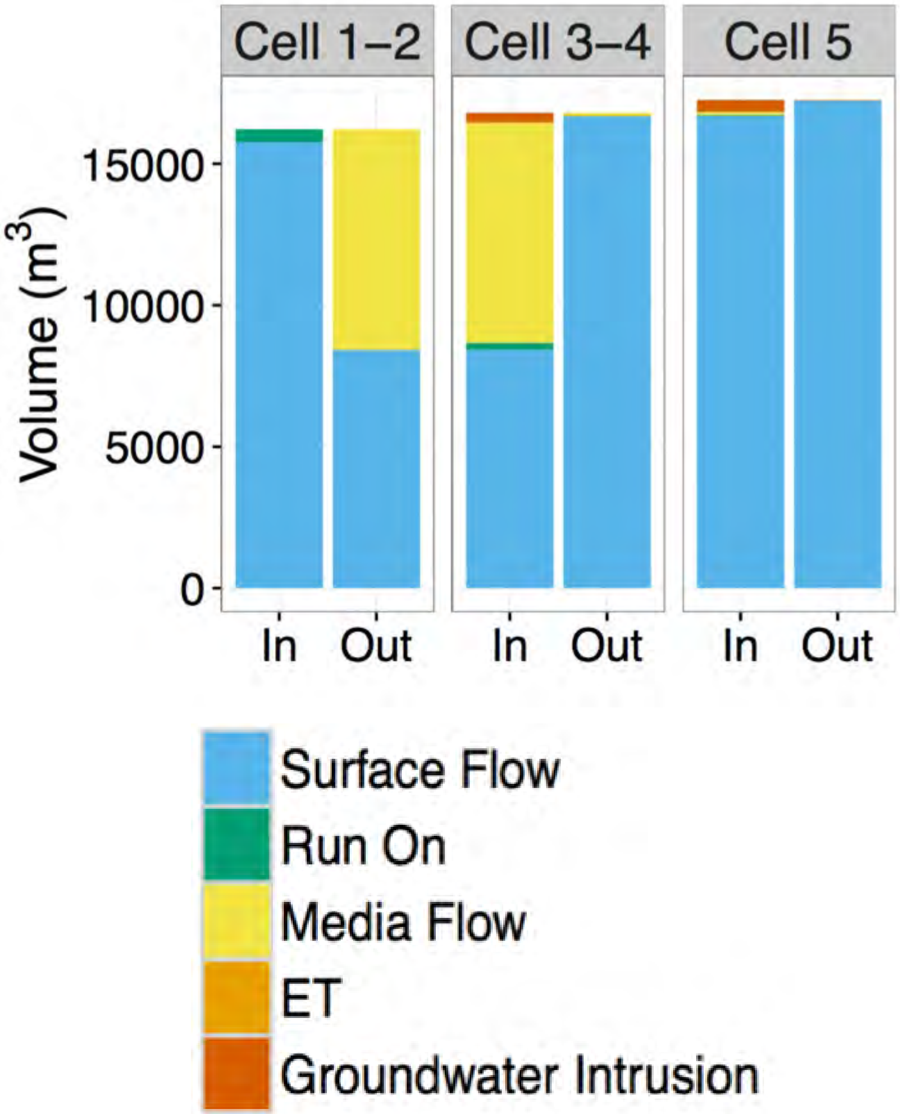
- 10% slope
- 43-m^3 capture volume = 6 mm (0.25 in) event
- Ephemeral to intermittent at Cell 4



An Overview of Instrumentation



Hydrology: Water Balance



50% Media Flow: Cell 2

Reemerges as surface flow

10% Surface Flow Increase

- GW intrusion (6%)
- Additional run on (4%)

ET Losses Negligible

- Unvegetated system and high loading ratio
- Does impact water table

Hydrology: An Instantaneous Look

At 8:34 AM on August 31st, 2015…

Flowrates:

US = 3.9 L/s

C2 = 0.5 L/s

C4 = 7.0 L/s

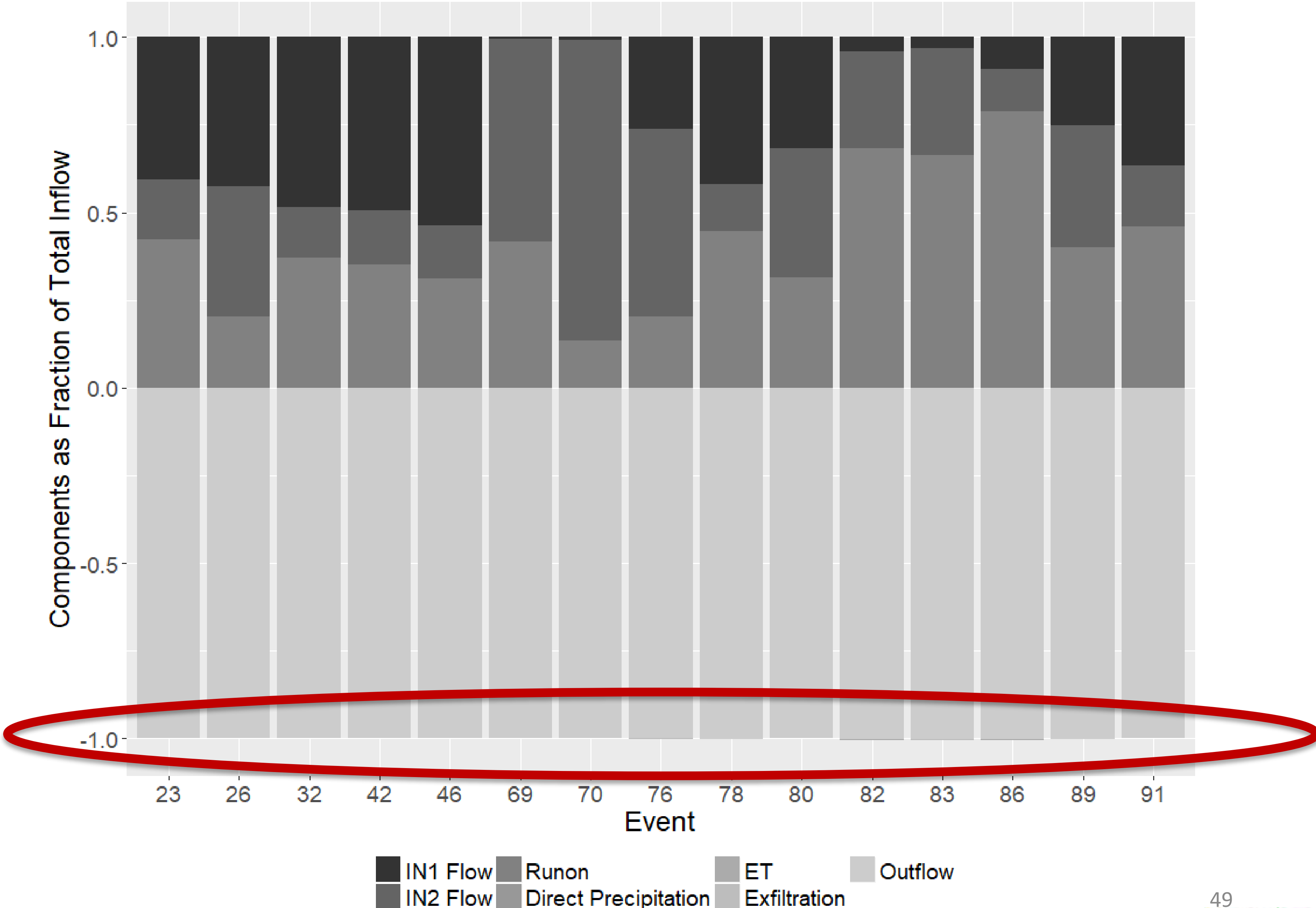
C5 = 7.4 L/s

Take Home Points: Durham

- Ya gotta know your point of intermittency!
- Filtration important
- Intersecting water table + limited filtration = minimal improvement
- Maybe configure “wet cells” differently?

Morrisville Pre (A & B) & Post (C&D)

RSC Contributing Areas


Components as Fraction of Total Inflow
1.0
0.5
0.0
-0.5
-1.0
23
26
32
42
46
69
70
76
78
80
82
83
86
89
91
Event
IN1 Flow
IN2 Flow
Runon
Direct Precipitation
ET
Exfiltration
Outflow

Event	Base Flow		Storm Flow	
Pollutant	Median RE (%)	Significance (p-value)	Median RE (%)	Significance (p-value)
TKN	16.5	0.005*	4.0	0.4
TAN	13.8	0.6	10.9	0.7
$NO_{2,3}$-N	44.0	0.03*	(77.0)	0.3
ON	21.4	0.005*	7.4	0.2
TN	22.3	0.01*	3.4	0.8
OP	(4.1)	0.4	(52.5)	0.002*
PBP	23.0	0.2	37.0	0.007*
TP	2.6	0.8	25.6	0.1

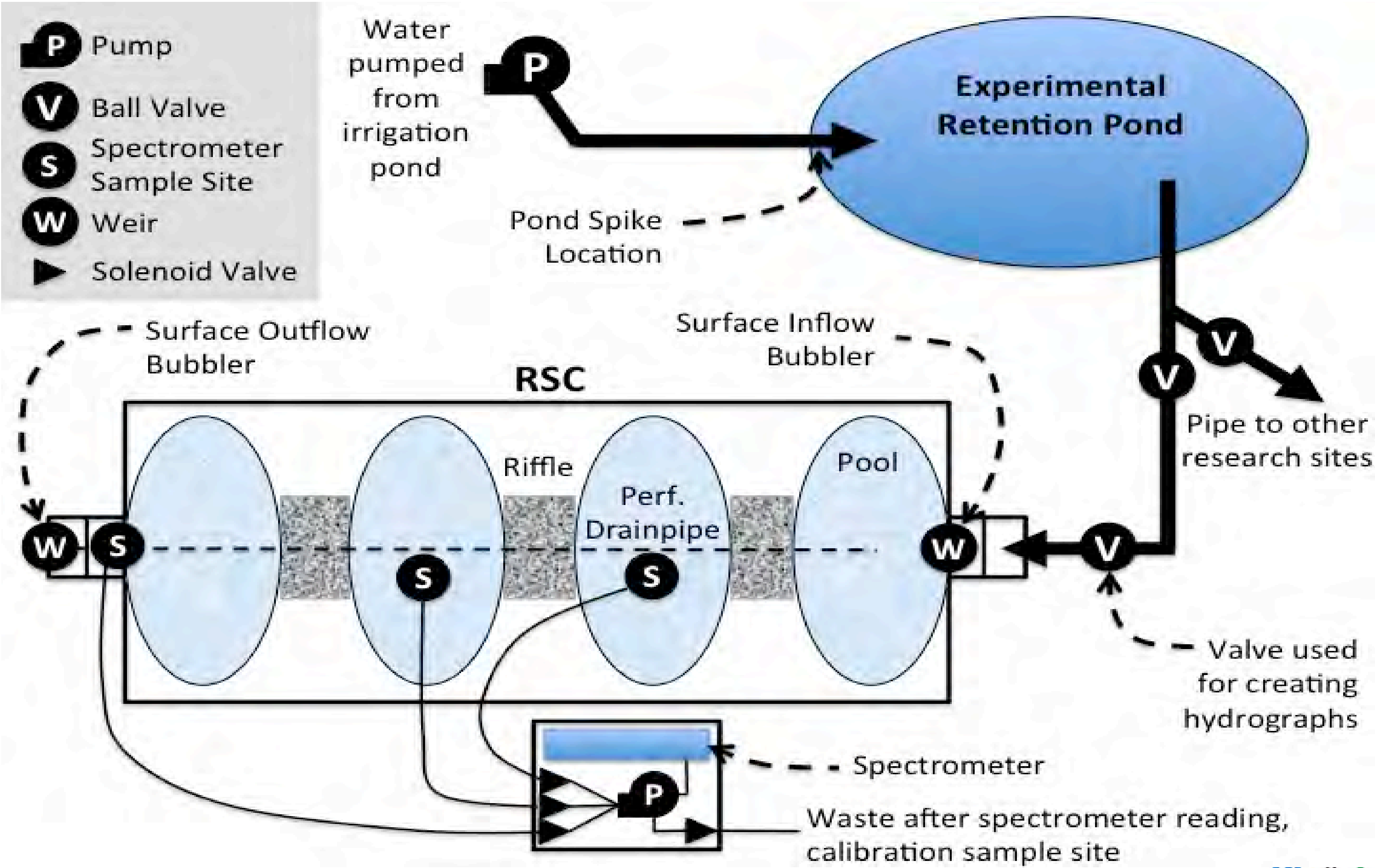
Take Home Point: Morrisville

- When grossly undersized..

While you can make modest improvements during baseflow, is it usually worth the expense?

Field Scale RSC – Lake Wheeler, NCSU

Experimental Setup

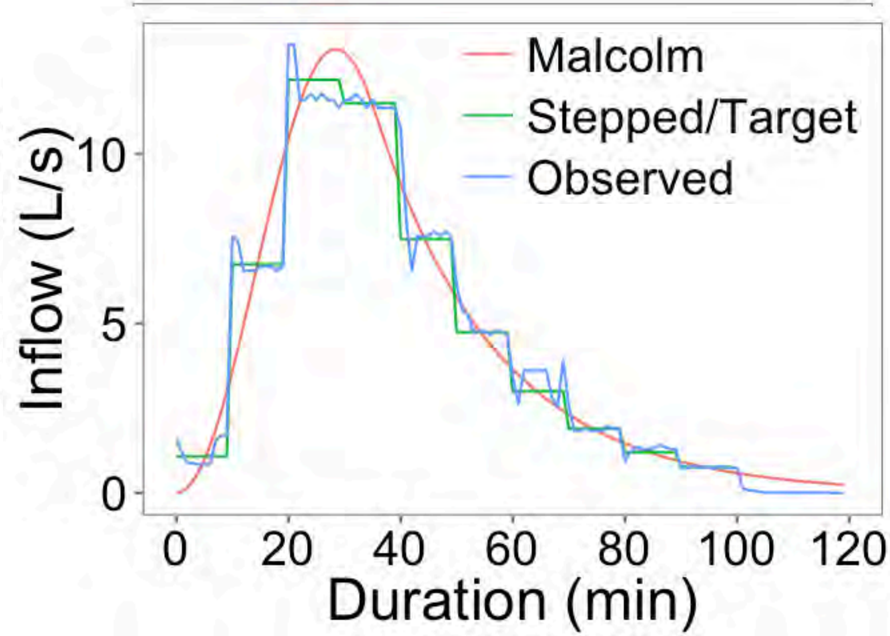


Simulation Method

Hydrograph Creation

1. ***Theoretical:***
   Curve number & TR-55
   → Malcolm's Method (1989)
2. ***Target:***
   10-min step function
3. ***Observed:***
   Valve controlled

Inflow Comparison



Surface vs. Media Flow Treatment

Analyte	Mean Removal Efficiency*	
	Surface Flow	Media Flow
$NO_{2,3}$-N	--	-250%
TKN	3.8%	79%
TN	--	50%
O-PO_4^{3-}	--	87%
TP	--	83%

* Repeated measured ANOVA, Tukey Kramer adjustment for multiple comparisons

- ***Surface Flow:*** Insignificant or minimal removal
  Sedimentation only treatment mechanism

- ***Media Flow:***
  - Substantial ***TKN*** and ***P*** removal: Media sorption & filtration
  - Increase in ***$NO_{2,3}$-N***: Aerobic conditions,
  TKN → mineralization → TAN → nitrification → $NO_{2,3}$-N

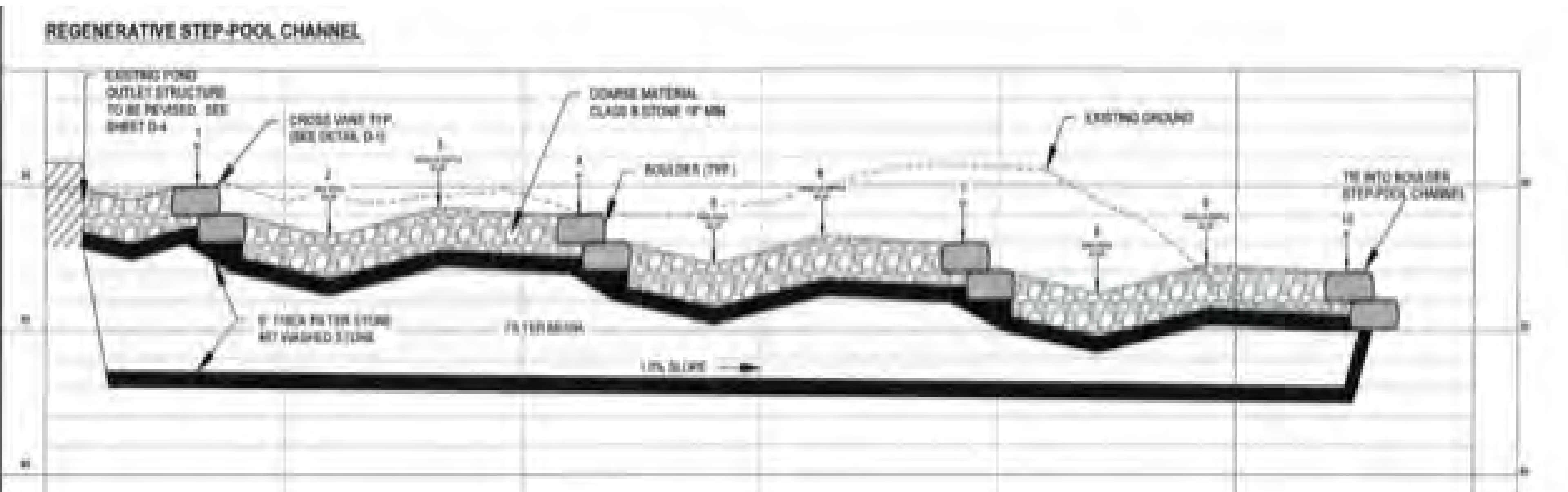
Take Home Point: Outdoor Lab Studies

- Media Matters
- Filtration Matters
- Drainage configuration matters

Revisiting Design Elements: What do you say is important?

$$1)\ Loading\ Ratio = \frac{Watershed\ Area}{SCM\ Area}$$

$$1)\ Storage\ Ratio = \frac{Surface\ Storage\ Volume}{Media\ Storage\ Volume}$$



Also…

- Identify your Point of Intermittency
- Recognize that Cell #1 is likely a Forebay
- Encourage Vegetation

Any RSC Questions?

Sand Filter Update

Thank you to our cooperators

NC Policy Collaboratory

cleanwater
MANAGEMENT TRUST FUND

City of Fayetteville
North Carolina
STORMWATER

GREENSBORO
NORTH CAROLINA

We are monitoring 4 Sites

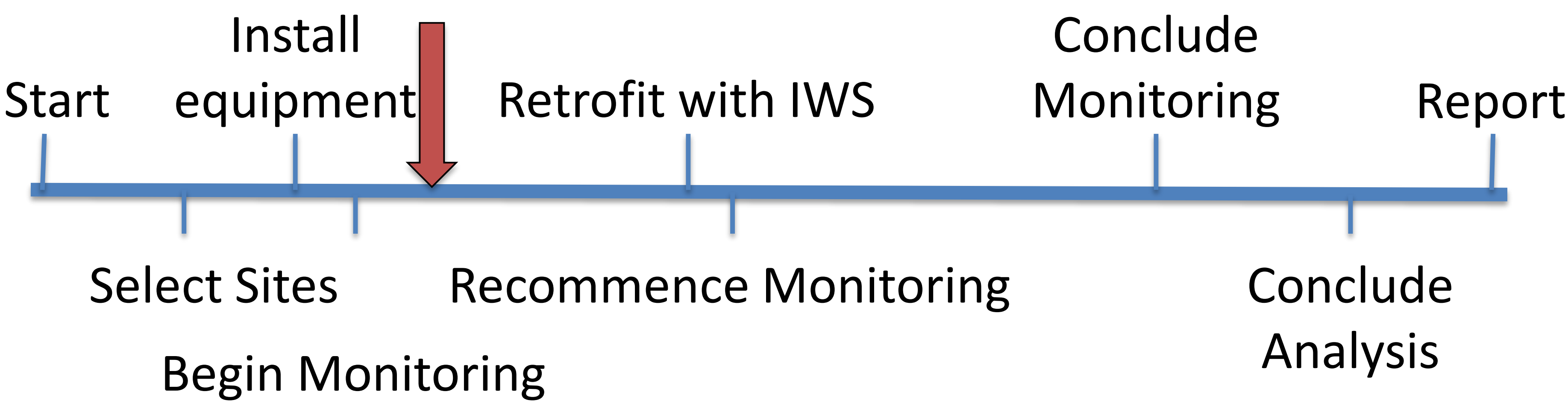
Greensboro (2)

Fayetteville (2)

Proposed Order of Experiment

- Identify 4 Sites
- Monitor them in current condition
- Equip them with IWS
- Monitor them in retrofitted condition
- Analyze and Tell Everyone

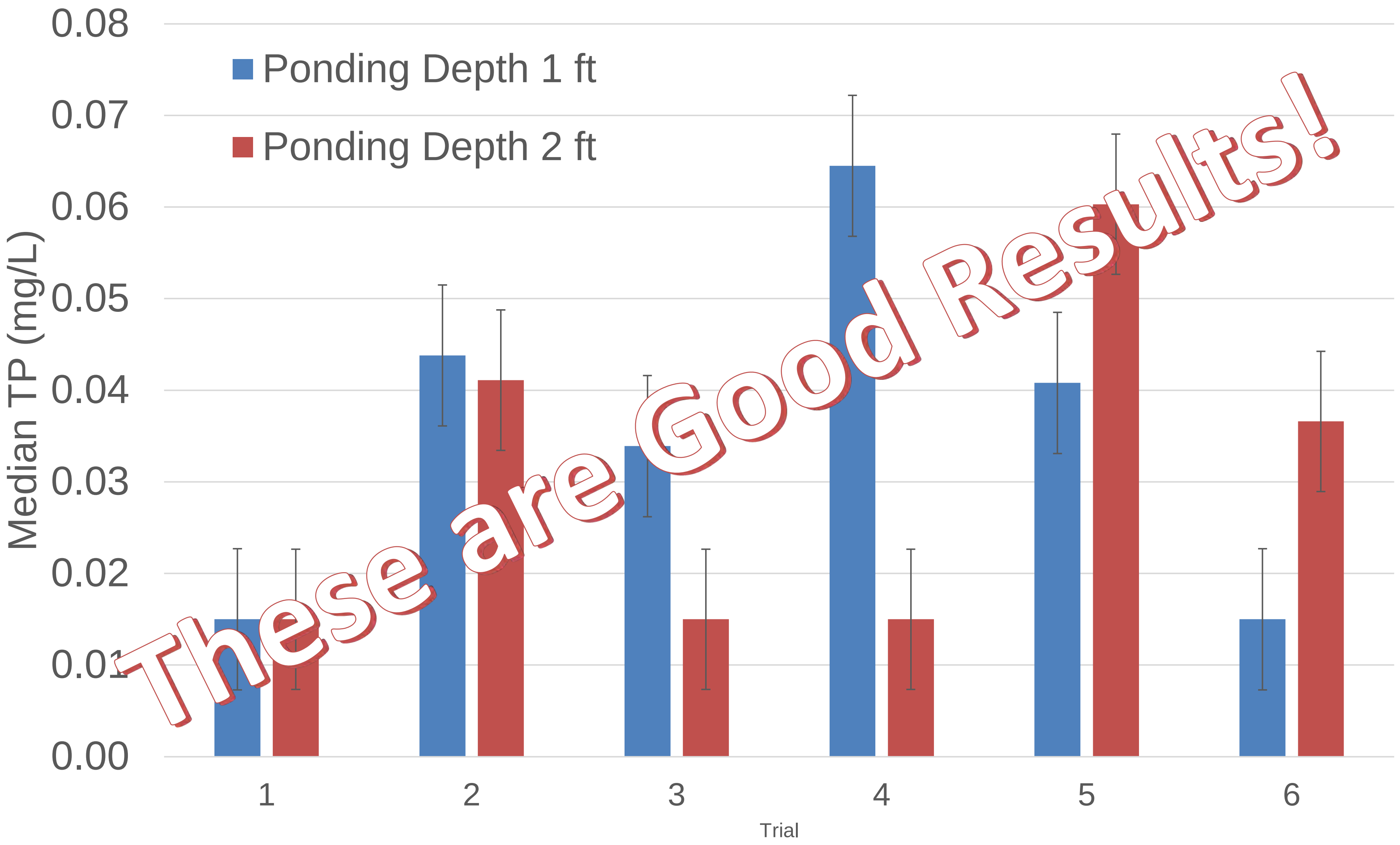
Timeline

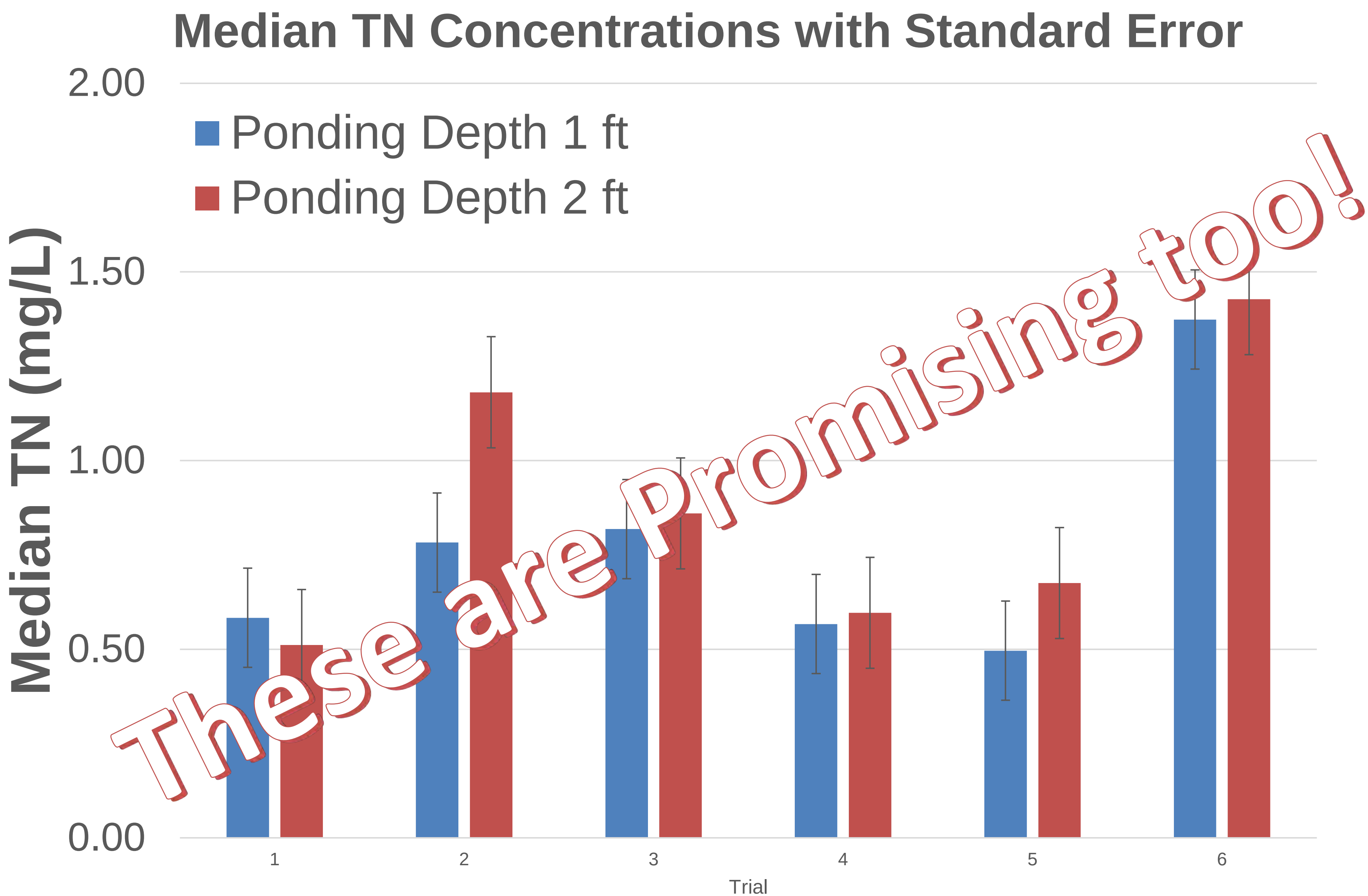


- 9 storms collected at G1, 5 each at G2, F1, F2

But…

Median TP Concentrations with Standard Error





Bio&Ag ENGINEERING

Sand Filter Update

- **A lot** more data by this summer
- Initial results promising

Thank you for your attention!