CASFM 2018 Annual Conference

Green Infrastructure Sessions:

Session1: Quantifying Volume Reduction in Grass Buffers and Swales

Andrew Earles (Wright Water Engineers), Derek Rapp (Peak Stormwater), Jim Wulliman and Sara Johnson (Muller Engineering), Holly Piza (UDFCD)

Session2: Navigating the New Jersey & Washington State Stormwater Programs as Models for Approving Manufactured Treatment Devices

Mark B. Miller (AquaShield, Inc.)

Permaculture and Low Impact Development (LID)

Patrick Padden (Padden Permaculture)

Comprehensive Watershed Planning: Prioritize, Target and Implement Multipurpose Projects

Darren Beck (HR Green, Inc.)

Developing a Comprehensive Stormwater Infrastructure Master Plan

Drew Beck (Matrix Design Group)

Strategic Planning for Green Infrastructure in Boulder

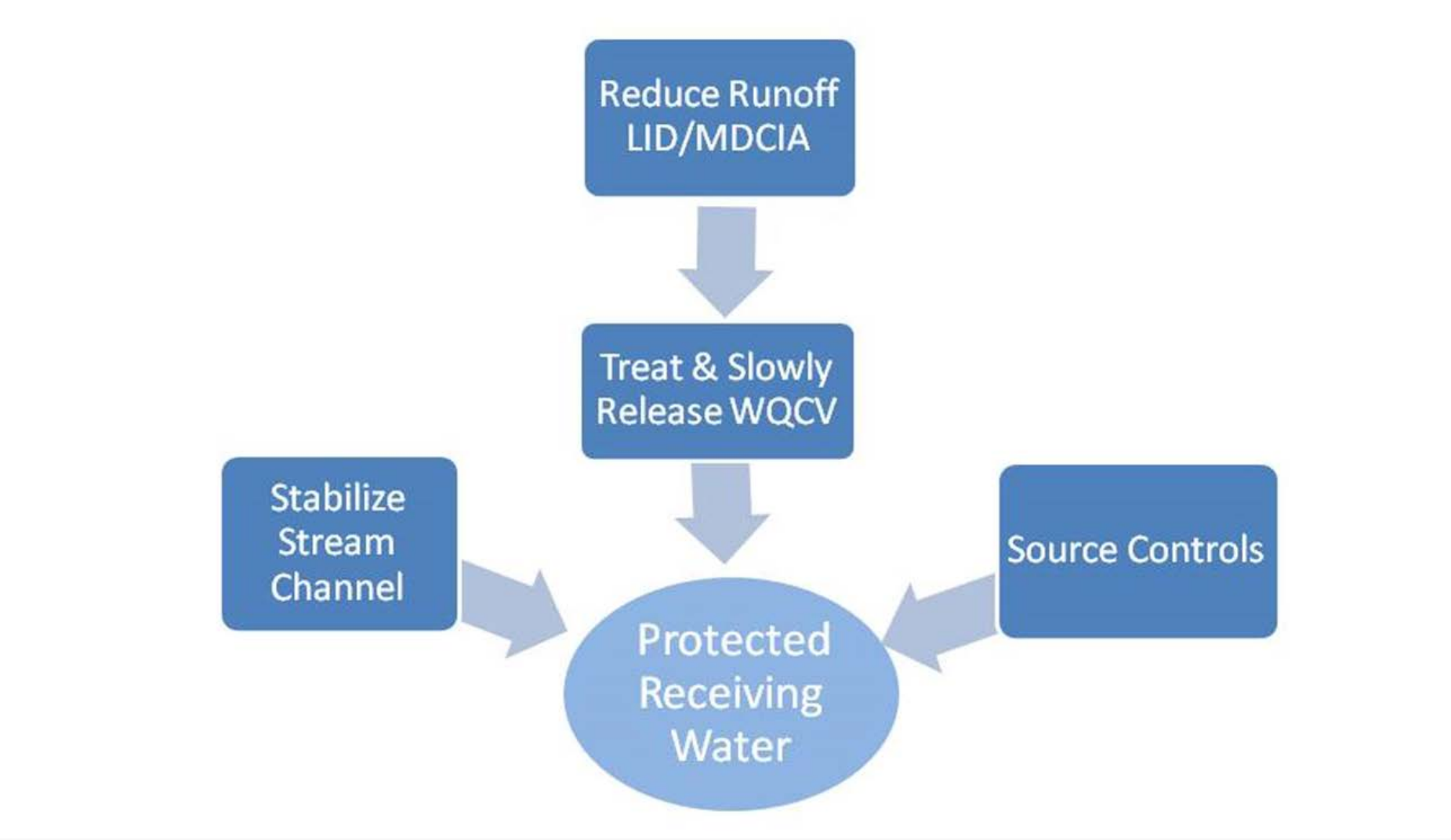
Candice Owen (City of Boulder)

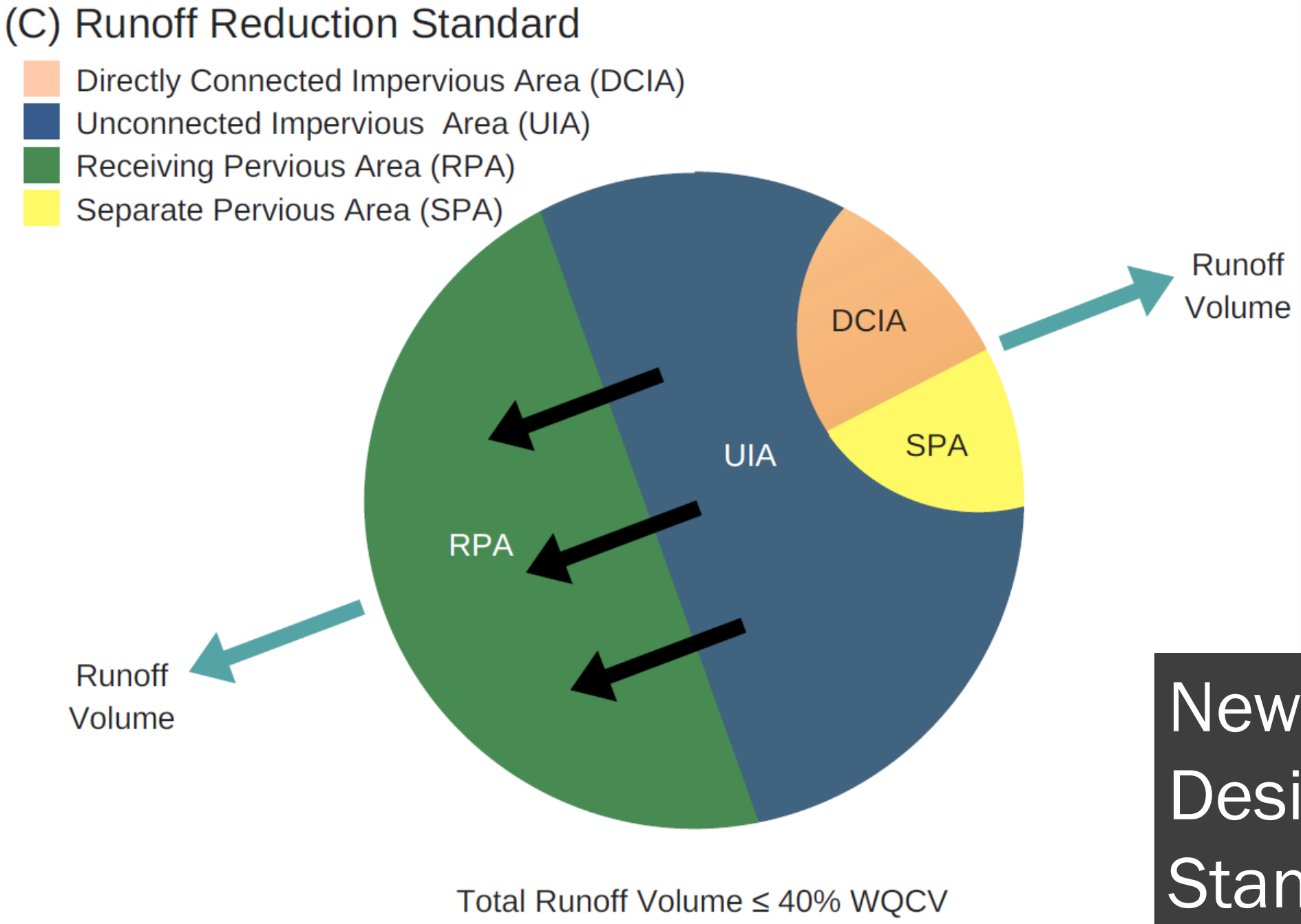
QUANTIFYING VOLUME REDUCTION IN GRASS BUFFERS AND SWALES

Andrew Earles, Wright Water Engineers
Derek Rapp, Peak Stormwater
Jim Wulliman and Sara Johnson, Muller Engineering
Holly Piza, UDFCD

CASFM 2018

4-Step Process

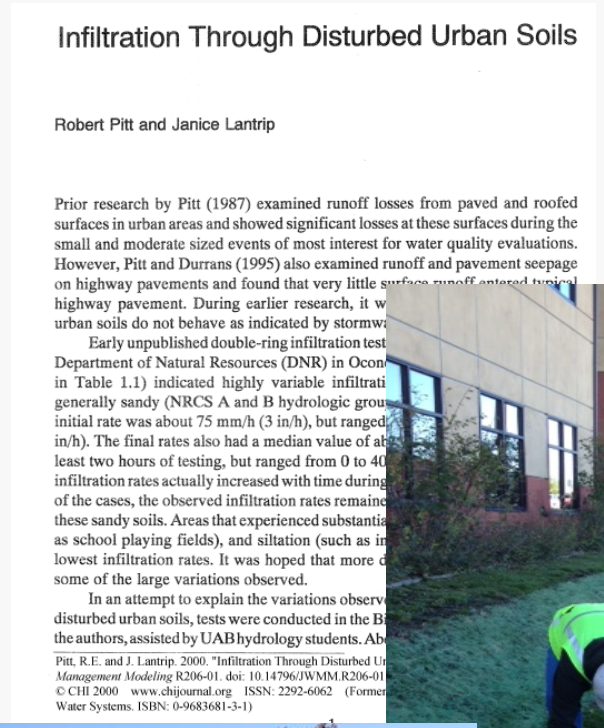




New MS4 Design Standard

Infiltration

- Infiltration Research
  - *Pitt and Lantrip, 2000*
  - *Colorado Field Studies*
- Soil
- Vegetation



Infiltration Through Disturbed Urban Soils

Robert Pitt and Janice Lantrip

Prior research by Pitt (1987) examined runoff losses from paved and roofed surfaces in urban areas and showed significant losses at these surfaces during the small and moderate sized events of most interest for water quality evaluations. However, Pitt and Durrans (1995) also examined runoff and pavement seepage on highway pavements and found that very little surface runoff entered typical highway pavement. During earlier research, it w urban soils do not behave as indicated by stormwa

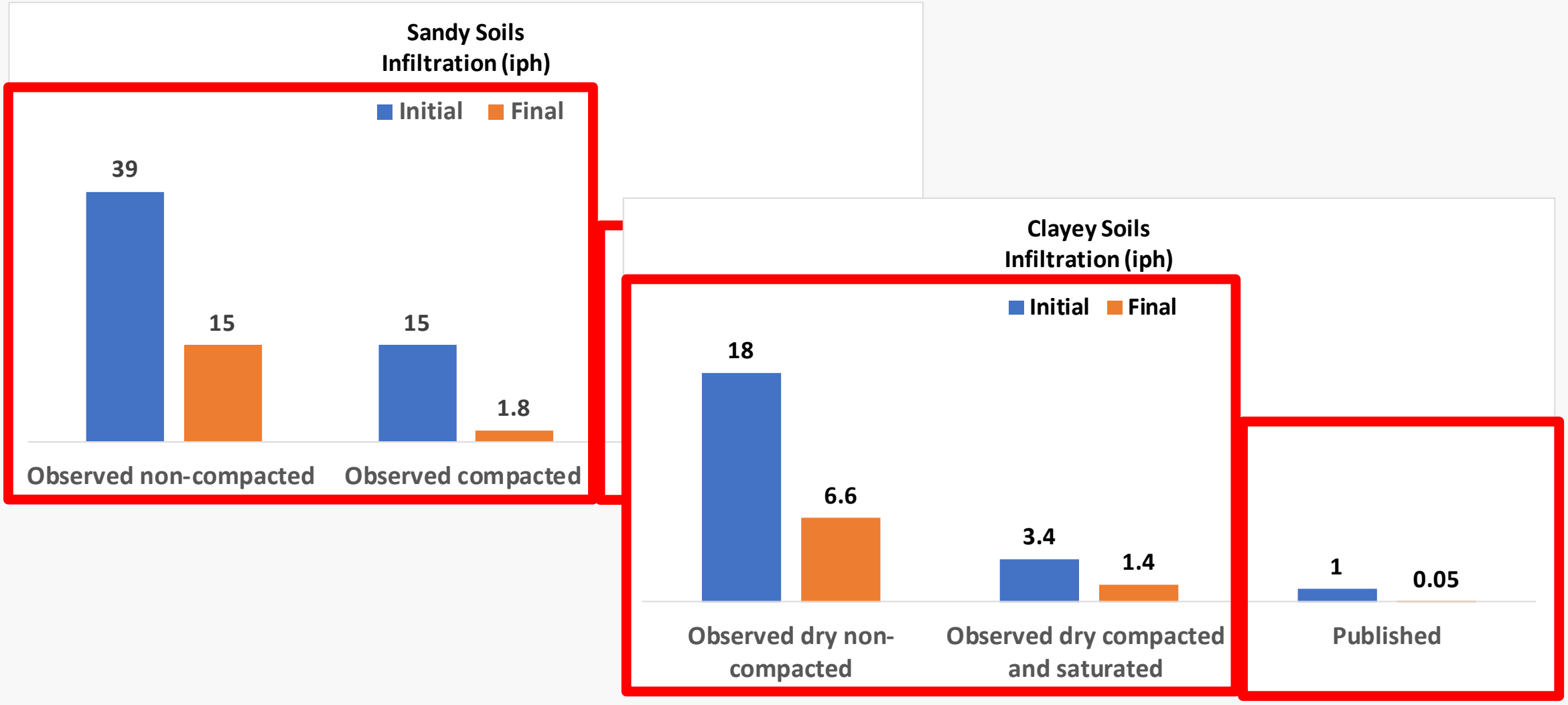
Early unpublished double-ring infiltration test Department of Natural Resources (DNR) in Ocon in Table 1.1) indicated highly variable infiltrati generally sandy (NRCS A and B hydrologic grou initial rate was about 75 mm/h (3 in/h), but ranged in/h). The final rates also had a median value of ab least two hours of testing, but ranged from 0 to 40 infiltration rates actually increased with time during of the cases, the observed infiltration rates remaine these sandy soils. Areas that experienced substantia as school playing fields), and siltation (such as in lowest infiltration rates. It was hoped that more d some of the large variations observed.

In an attempt to explain the variations observ disturbed urban soils, tests were conducted in the B the authors, assisted by UAB hydrology students. Ab

Pitt, R.E. and J. Lantrip. 2000. "Infiltration Through Disturbed Ur *Management Modeling* R206-01. doi: 10.14796/JWMM.R206-01 © CHI 2000 www.chijournal.org ISSN: 2292-6062 (Former Water Systems. ISBN: 0-9683681-3-1)

Infiltration Rates

(Pitt and Lantrip, 2000)

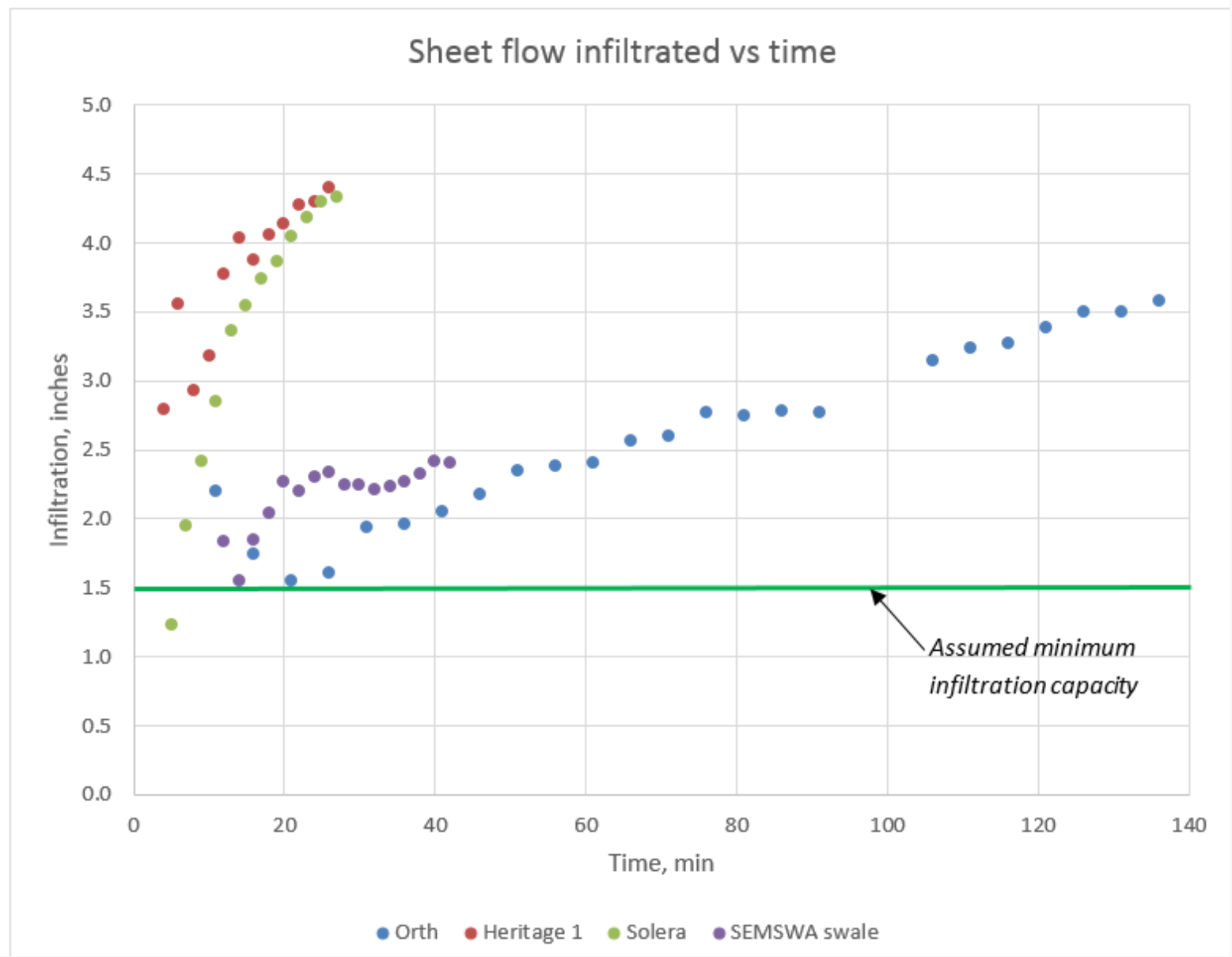


Central Colorado Field Studies

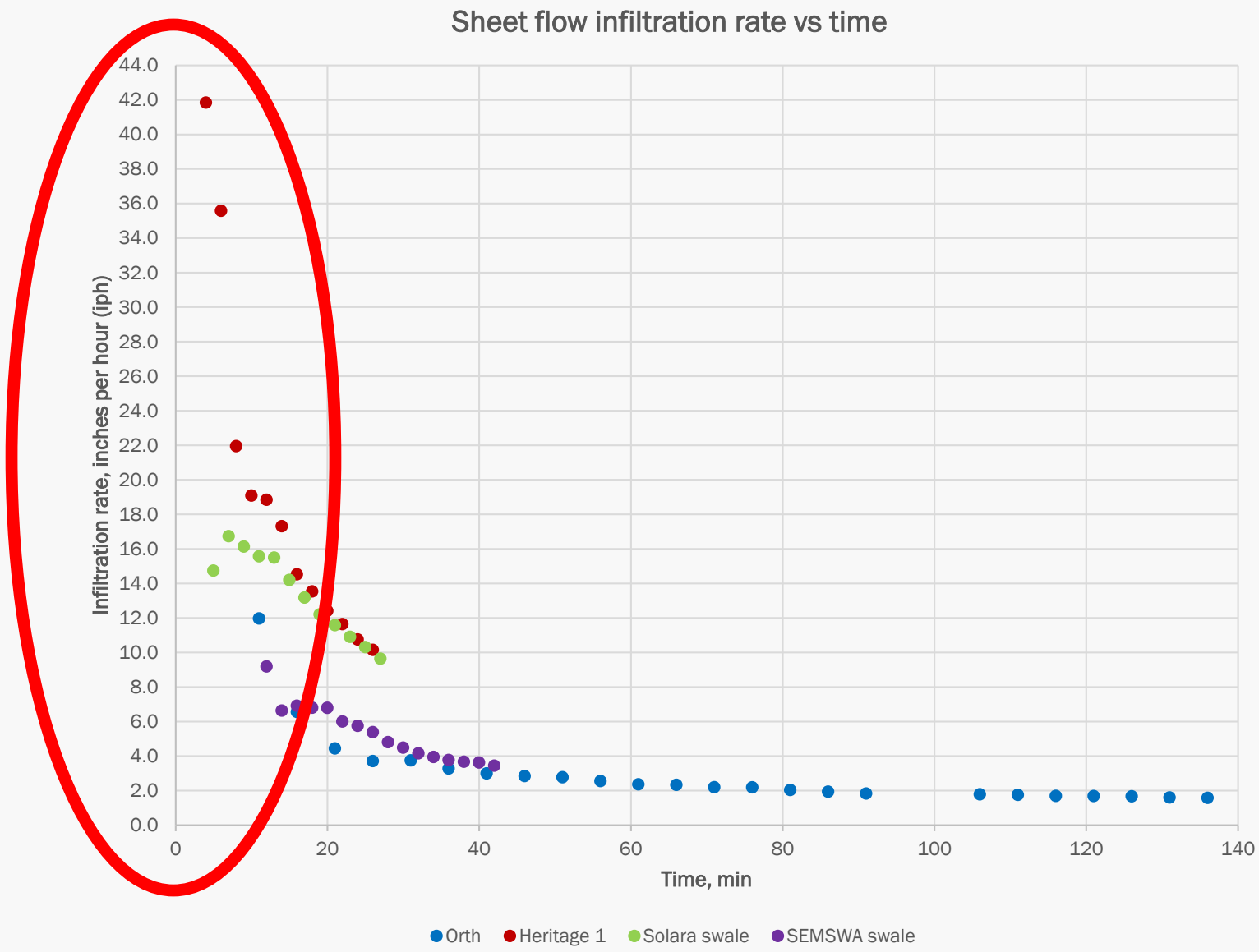
- Douglas County/SEMSWA
- 4 Sites (2012-2015)
  - *Residential*
  - *Park*
  - *Commercial*
  - *SEMSWA Office Swale*
- Soil types
  - *Sandy Loam*
  - *Clay Loam*
- Sheet flow infiltration

SEMSWA office swale

Central Colorado Field Studies



Central Colorado Field Studies



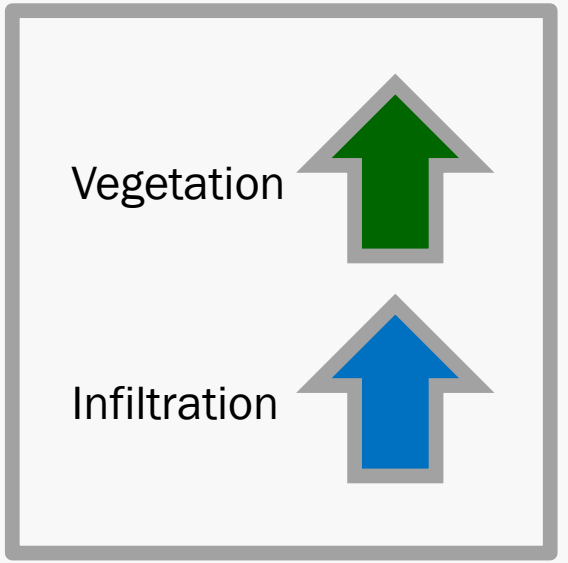
Two Ends of the Soil Spectrum

Property	Sandy	Clayey
Drainage rate	High	Low
Aeration	High	Low
Water holding capacity	Low	High
Organic content	Low	High
Ability to store plant nutrients	Low	High
Adsorption of pollutants	Low	High

Topsoil: “Searching for the Sweet Spot”

“SWEET SPOT”

Vegetation Studies



SWMM

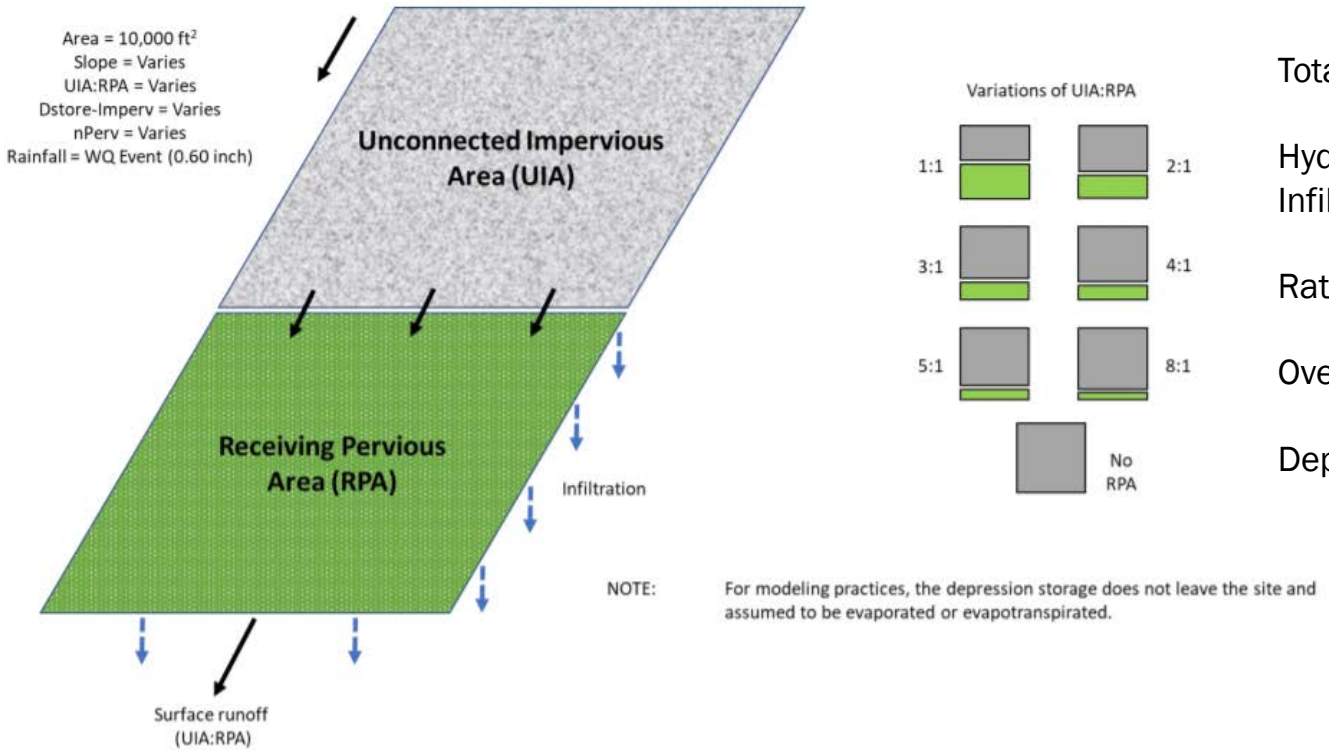


Figure 2 – Simplified SWMM Layouts for Varying UIA:RPA Ratios

Variables Considered

Total Area

Hydrologic Soil Group/ Horton Infiltration Parameters

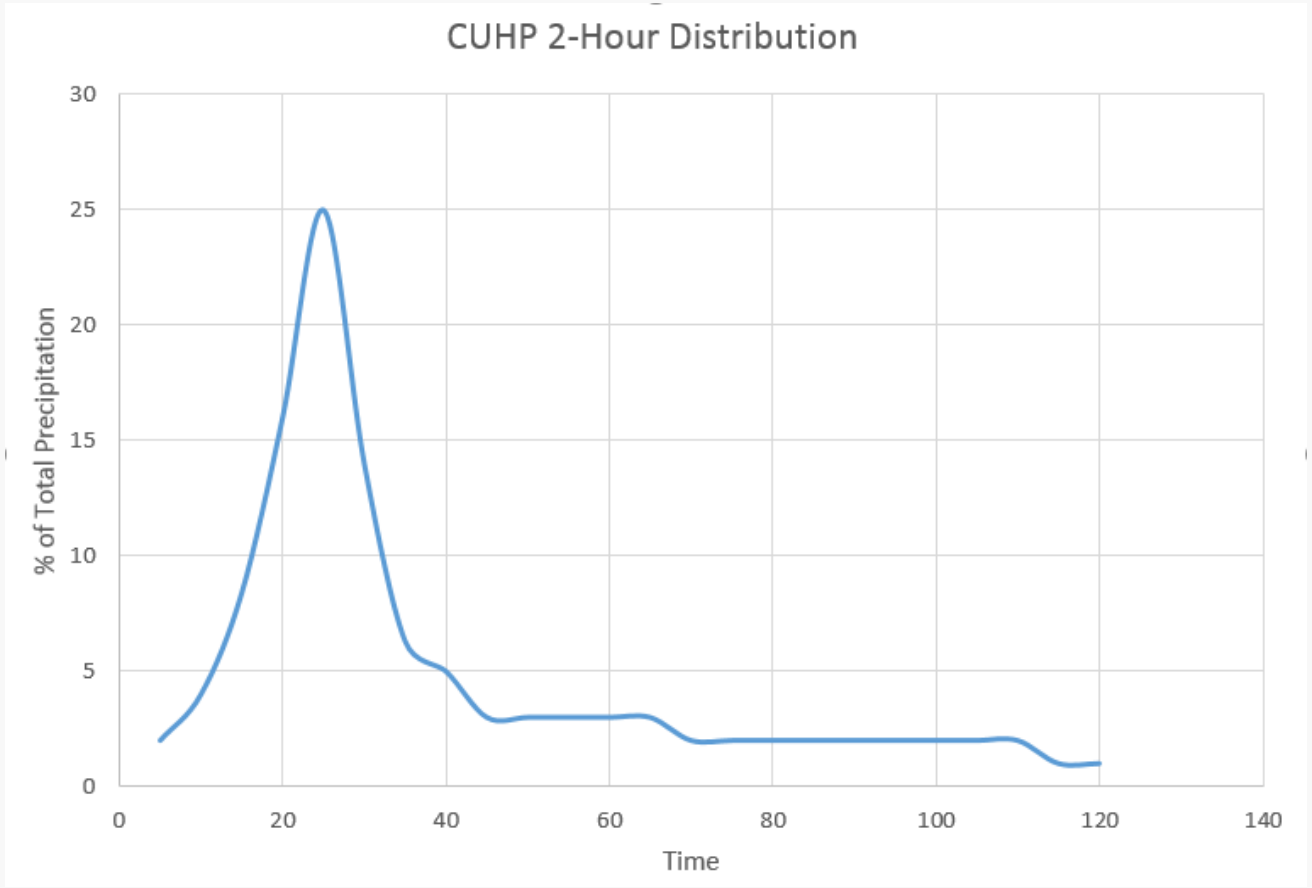
Ratio of UIA to RPA

Overland Slope

Depression Storage

Rainfall

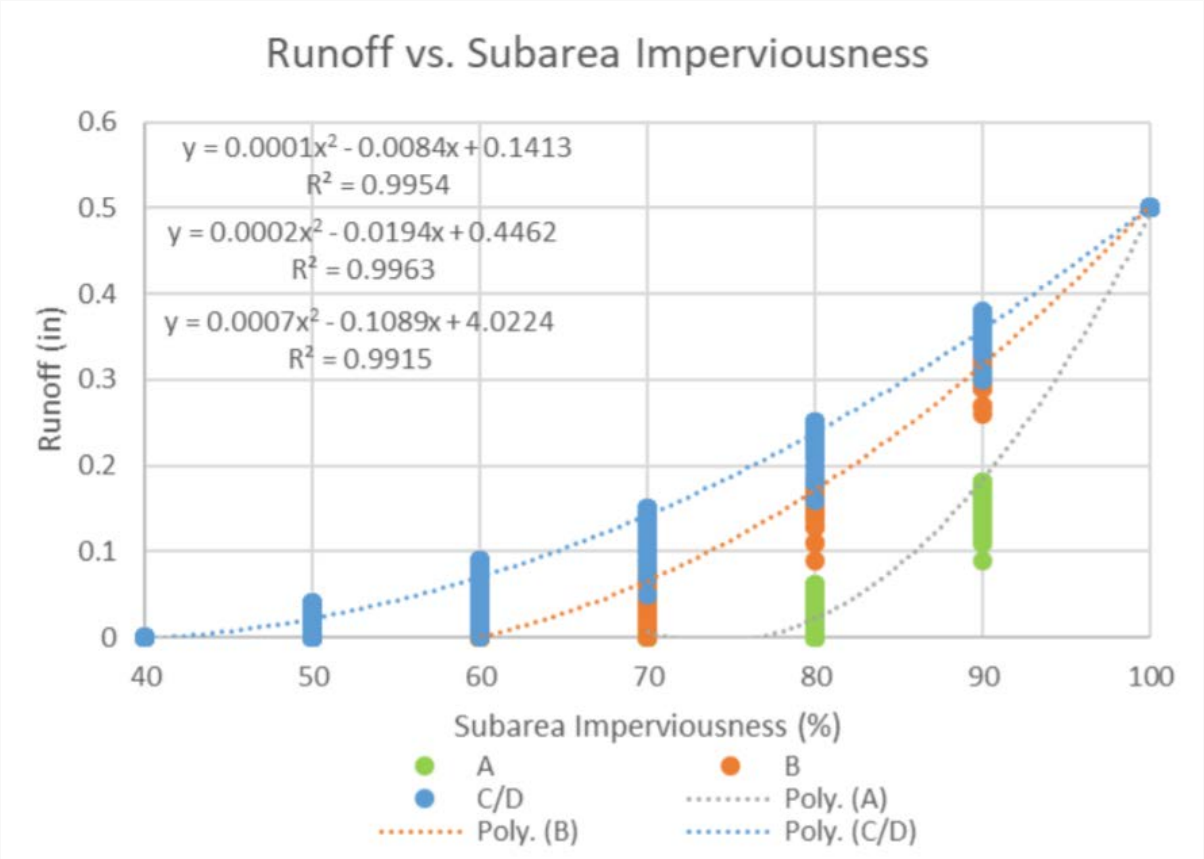
- Water Quality Capture Volume (WQCV) for Denver = 0.6 inches of rainfall
- 0.6 inches depth distributed over 2 hours using CUHP temporal distribution
- Analyzed range from 0.25 to 0.95 inches

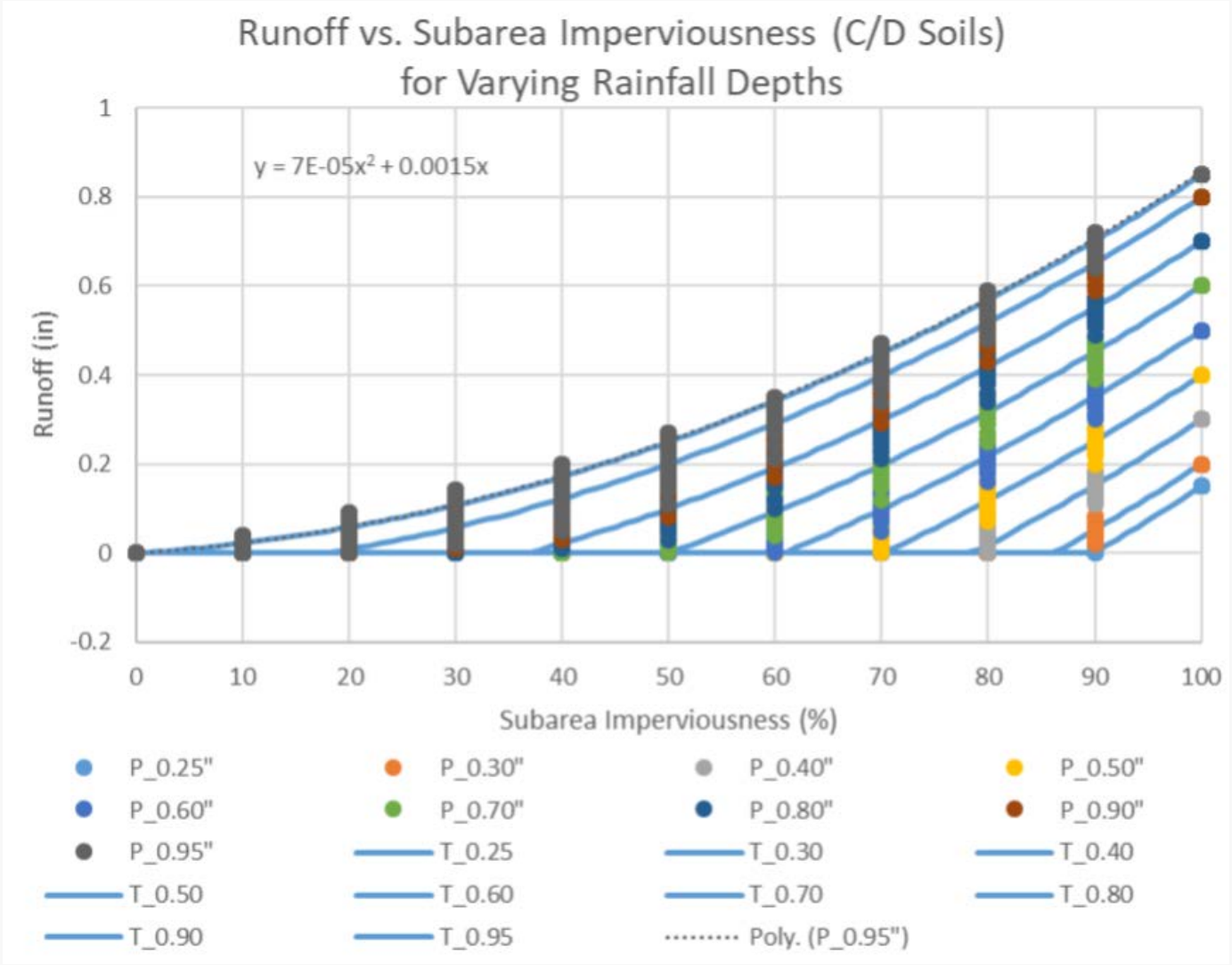


Largest impacts

- Soil Type
- UIA:RPA ratio

(imperviousness)




Runoff vs. Subarea Imperviousness (C/D Soils)
for Varying Rainfall Depths
y = 7E-05x² + 0.0015x
Runoff (in)
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
40
50
60
70
80
90
100
Subarea Imperviousness (%)
P_0.25"
P_0.30"
P_0.40"
P_0.50"
P_0.60"
P_0.70"
P_0.80"
P_0.90"
P_0.95"
T_0.25
T_0.30
T_0.40
T_0.50
T_0.60
T_0.70
T_0.80
T_0.90
T_0.95
Poly. (P_0.95")

$$Q = C_0 + C_1(0.95 - P_2) + C_2(Area) + C_3(L{:}W) + C_4(Slope) + C_5(Imp) + C_6 Imp^2 \quad \textbf{\textit{Equation 1}}$$

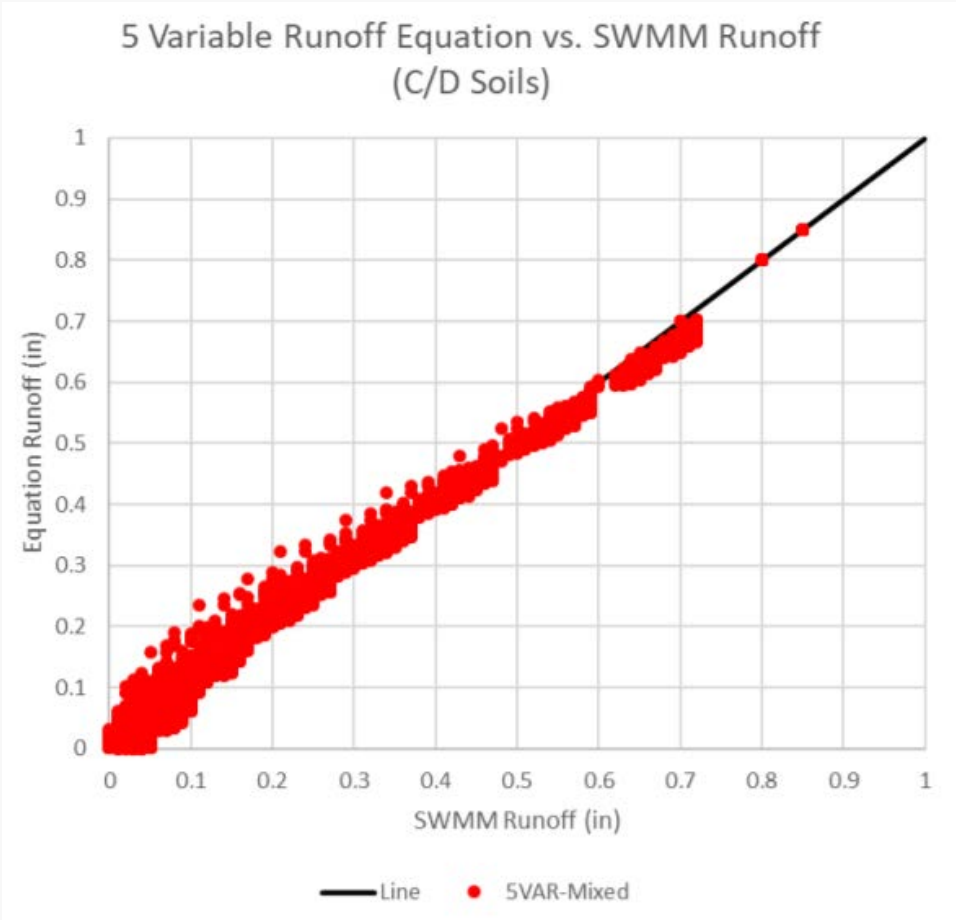
Where:

Q = Runoff (inches)
P_2 = 2-hour WQCV Rainfall Depth (inches)
Area = total subarea, sum of UIA and RPA (acres)
L:W = Ratio of total flow length to catchment width
Slope = average overland slope (%)
Imp = subarea imperviousness (%) calculated as (UIA / (UIA+RPA)) * 100
C_x = coefficients determined through regression analysis

Table 3: Empirical Runoff Equation Coefficients.

Soil Type	Constant C_0	Rainfall (in) C_1	Area (ac) C_2	L:W C_3	Slope (%) C_4	%Imp C_5	%Imp^2 C_6
A	5.81E-01	-7.79E-01	-1.45E-02	-1.93E-03	7.03E-04	-2.49E-02	2.64E-04
B	-7.77E-02	-9.25E-01	-1.07E-02	-1.45E-03	5.02E-04	-1.36E-04	9.24E-05
C/D	-1.13E-02	-8.99E-01	-1.17E-02	-1.57E-03	5.45E-04	3.55E-03	4.64E-05

Equation vs. SWMM Runoff

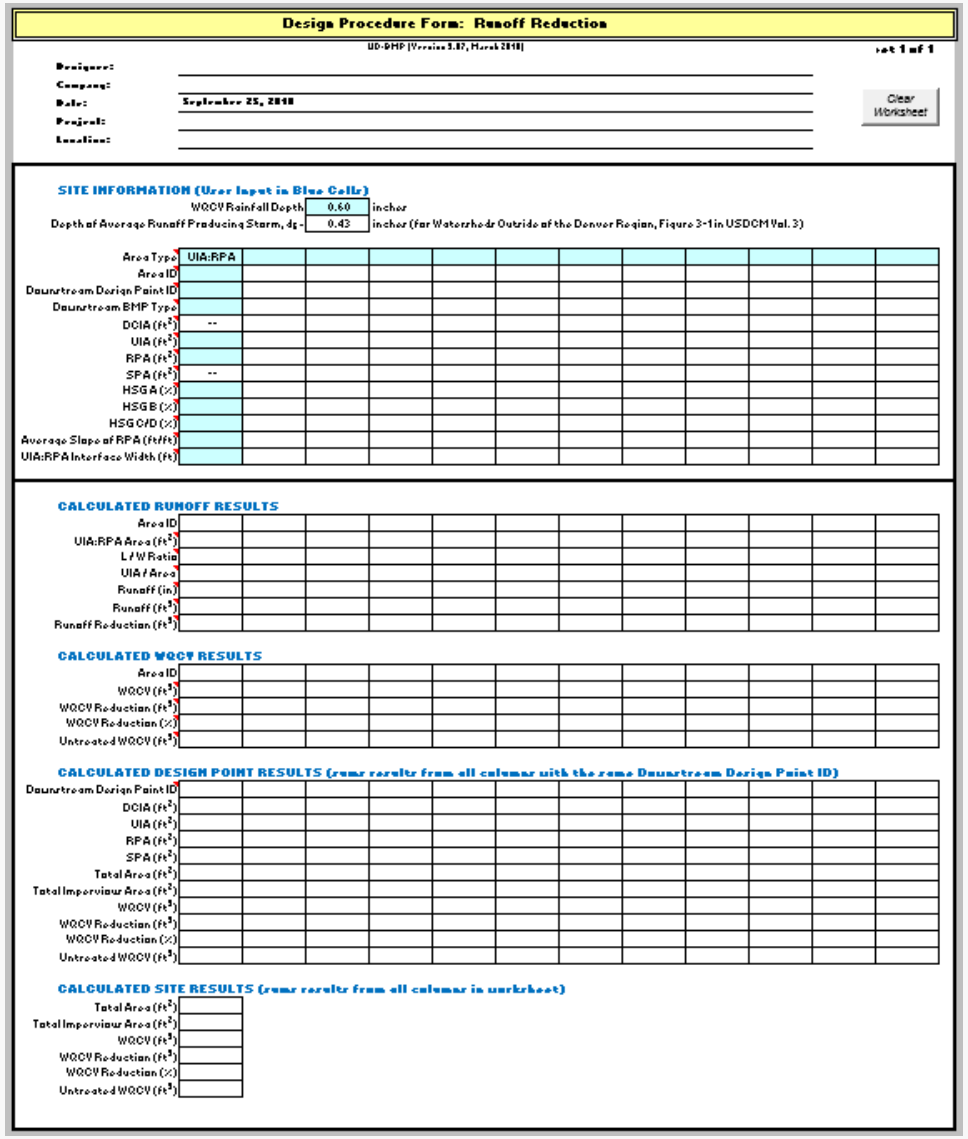


Recommended Constraints

- 0.25 inches < Precipitation <0.95 inches
- 0.025 acres < Area < 2.0 acres
- 0.0625 < L:W ratio < 16.0
- 0.5% < Slope < 33%

Quantifying Runoff Reduction

- Intro to UD-BMP – Runoff Reduction
- Examples



Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 1

Designer:
Company:
Date: September 25, 2018
Project:
Location:

Clear Worksheet

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth = 0.60 inches

Depth of Average Runoff Producing Storm, d_5 = 0.43 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA												
Area ID													
Downstream Design Point ID													
Downstream BMP Type													
DCIA (ft^2)	--												
UIA (ft^2)													
RPA (ft^2)													
SPA (ft^2)	--												
HSG A (%)													
HSG B (%)													
HSG C/D (%)													
Average Slope of RPA (ft/ft)													
UIA:RPA Interface Width (ft)													

CALCULATED RUNOFF RESULTS

Area ID												
UIA:RPA Area (ft^2)												
L / W Ratio												
UIA / Area												
Runoff (in)												
Runoff (ft^3)												
Runoff Reduction (ft^3)												

CALCULATED WQCV RESULTS

Area ID												
WQCV (ft^3)												
WQCV Reduction (ft^3)												
WQCV Reduction (%)												
Untreated WQCV (ft^3)												

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID												
DCIA (ft^2)												
UIA (ft^2)												
RPA (ft^2)												
SPA (ft^2)												
Total Area (ft^2)												
Total Impervious Area (ft^2)												
WQCV (ft^3)												
WQCV Reduction (ft^3)												
WQCV Reduction (%)												
Untreated WQCV (ft^3)												

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	
Total Impervious Area (ft^2)	
WQCV (ft^3)	
WQCV Reduction (ft^3)	
WQCV Reduction (%)	
Untreated WQCV (ft^3)	

Quantifying Runoff Reduction

Intro to UD BMP – Runoff Reduction

- Inputs
  - *Site Information*
    - Area Type and how much of each
      - *UIA/RPA*
      - *DCIA*
      - *SPA*
    - Soils
    - HSG A, B, C/D (%)
    - Average Slope of RPA
    - Interface width (Area Type UIA:RPA only)

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth	0.60	inches
Depth of Average Runoff Producing Storm, d_6 =	0.43	inches

Area Type				
Area ID				
Downstream Design Point ID				
Downstream BMP Type				
DCIA (ft^2)				
UIA (ft^2)				
RPA (ft^2)				
SPA (ft^2)				
HSG A (%)				
HSG B (%)				
HSG C/D (%)				
Average Slope of RPA (ft/ft)				
UIA:RPA Interface Width (ft)				

Quantifying Runoff Reduction

Intro to UD BMP – Runoff Reduction

- Runoff Output/Results
  - *Total Area*
  - *L/W Ratio*
  - *UIA/Area*
  - *Runoff (from UIA:RPA pair)*
    - Depth
    - Volume
    - Reduction (Infiltration into RPA+ Depression Storage)

CALCULATED RUNOFF RESULTS

Area ID				
UIA:RPA Area (ft^2)				
L / W Ratio				
UIA / Area				
Runoff (in)				
Runoff (ft^3)				
Runoff Reduction (ft^3)				

Quantifying Runoff Reduction

Intro to UD BMP – Runoff Reduction

- WQCV Output/Results
  - *Calculated WQCV based on impervious area only*
  - *WQCV Reduction (as volume and as %)*
  - *Untreated WQCV*

CALCULATED WQCV RESULTS

Area ID				
WQCV (ft^3)				
WQCV Reduction (ft^3)				
WQCV Reduction (%)				
Untreated WQCV (ft^3)				

Quantifying Runoff Reduction

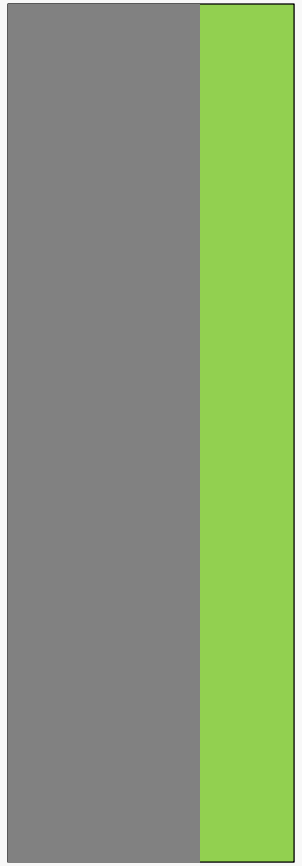
- Regional Trail 10 ft wide x 100 ft long
  - *B Soils*

CALCULATED RUNOFF RESULTS

Area ID	Trail 1
UIA:RPA Area (ft^2)	1,500
L / W Ratio	0.15
UIA / Area	0.6667
Runoff (in)	0.00
Runoff (ft^3)	0
Runoff Reduction (ft^3)	42

CALCULATED WQCV RESULTS

Area ID	Trail 1
WQCV (ft^3)	42
WQCV Reduction (ft^3)	42
WQCV Reduction (%)	100%
Untreated WQCV (ft^3)	0

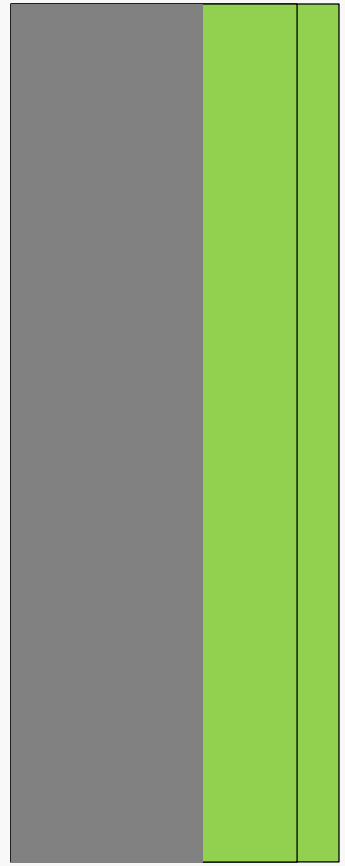


Quantifying Runoff Reduction

- Regional Trail 10 ft wide x 100 ft long
  - *C\D Soils – 852 ft²*

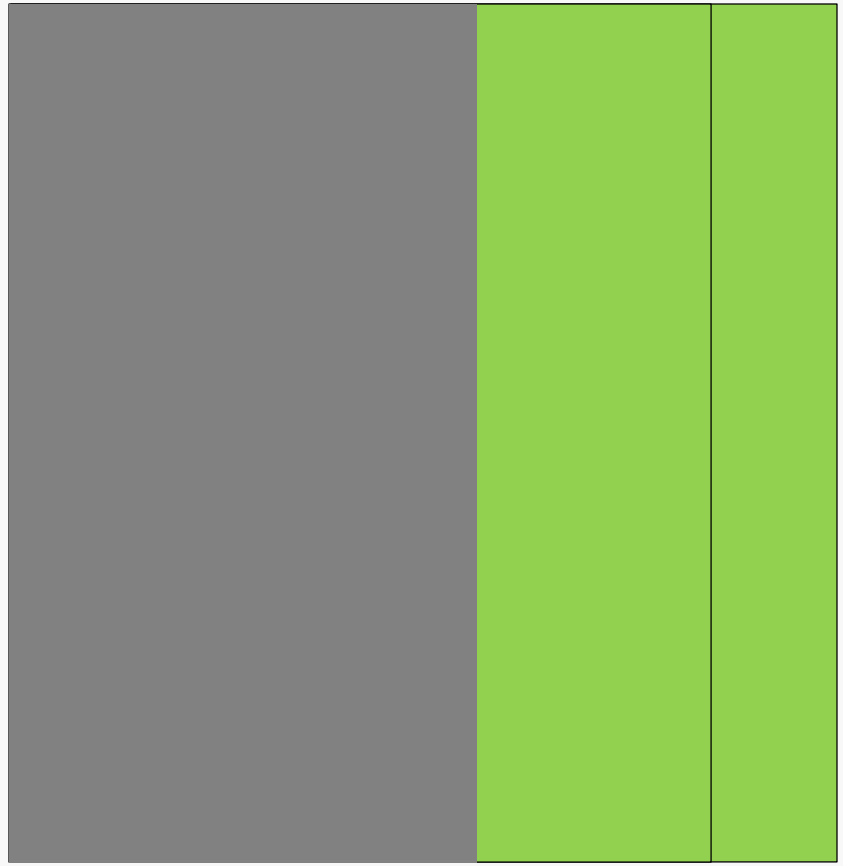
Quantifying Runoff Reduction

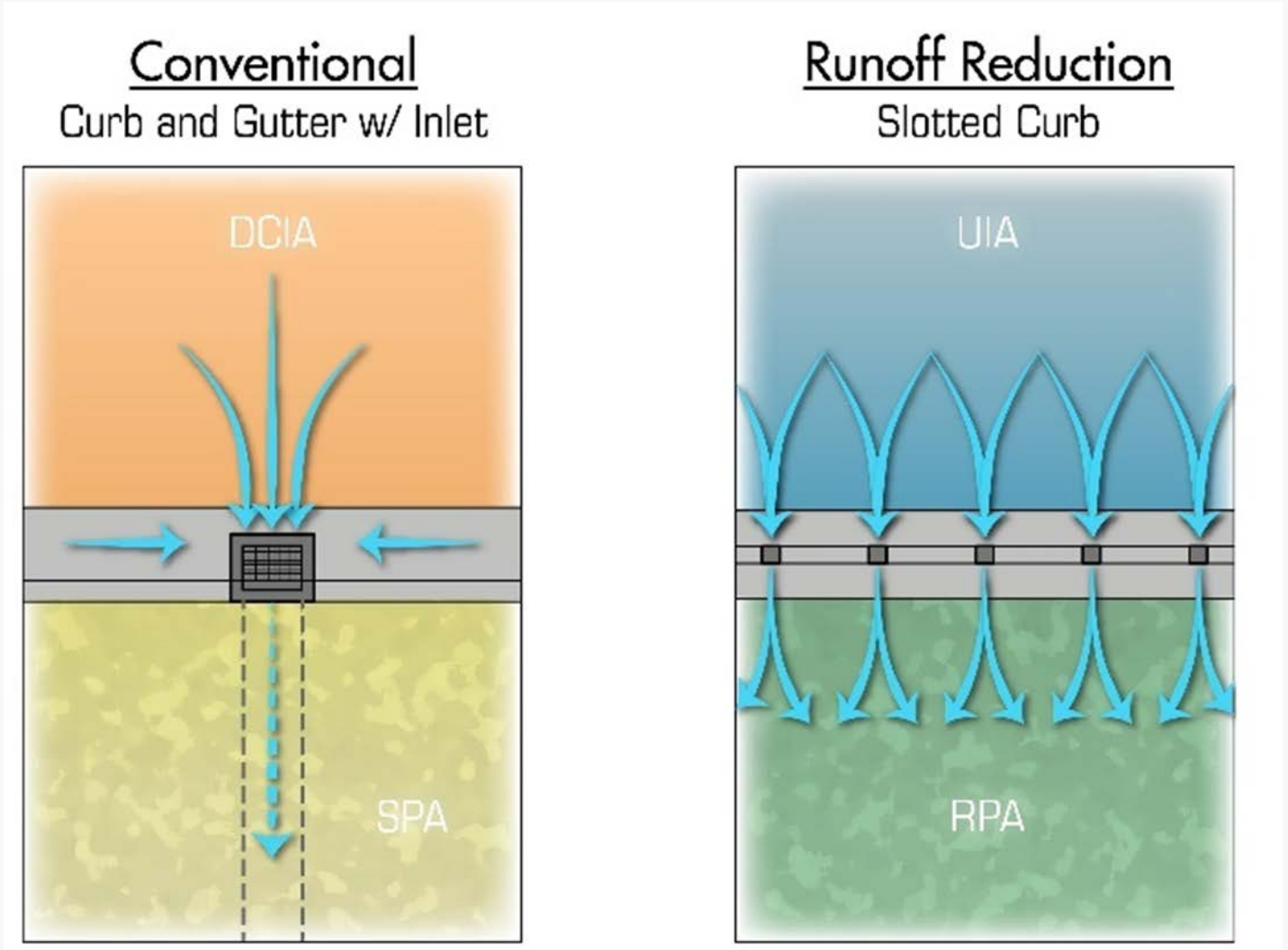
- Regional Trail 10 ft wide x 100 ft long
  - *B Soils – RPA 5 feet wide along the 100 ft trail*
  - *C/D Soils – RPA 8.5 feet wide along the 100 ft trail*



Quantifying Runoff Reduction

- Parking Lot 7,000 ft^2
  - *B Soils – RPA = 3,500 ft^2*
  - *C/D Soils – RPA = 5,910 ft^2*




Conventional
Curb and Gutter w/ Inlet
DCIA
SPA
Runoff Reduction
Slotted Curb
UIA
RPA
Unconnected Impervious Area (UIA)
Receiving Pervious Area (RPA)
Directly Connected Impervious Area (DCIA)
Separate Pervious Area (SPA)

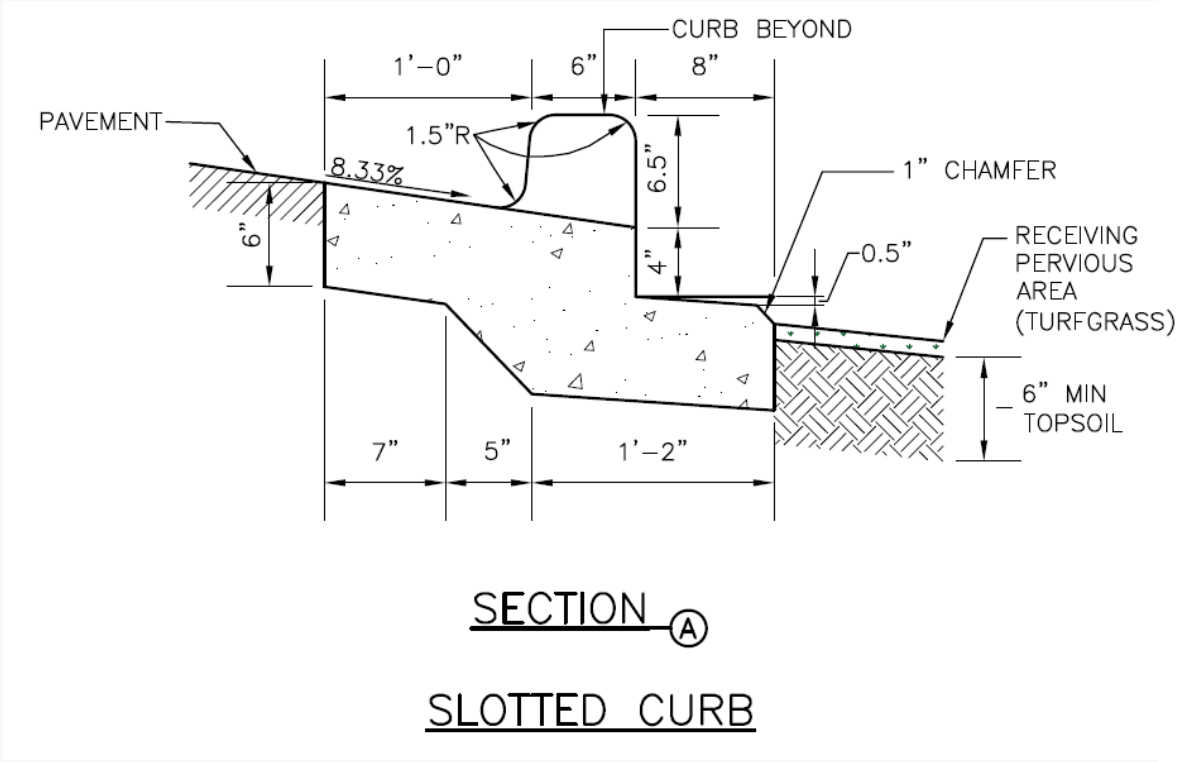
Verifying Soil Type

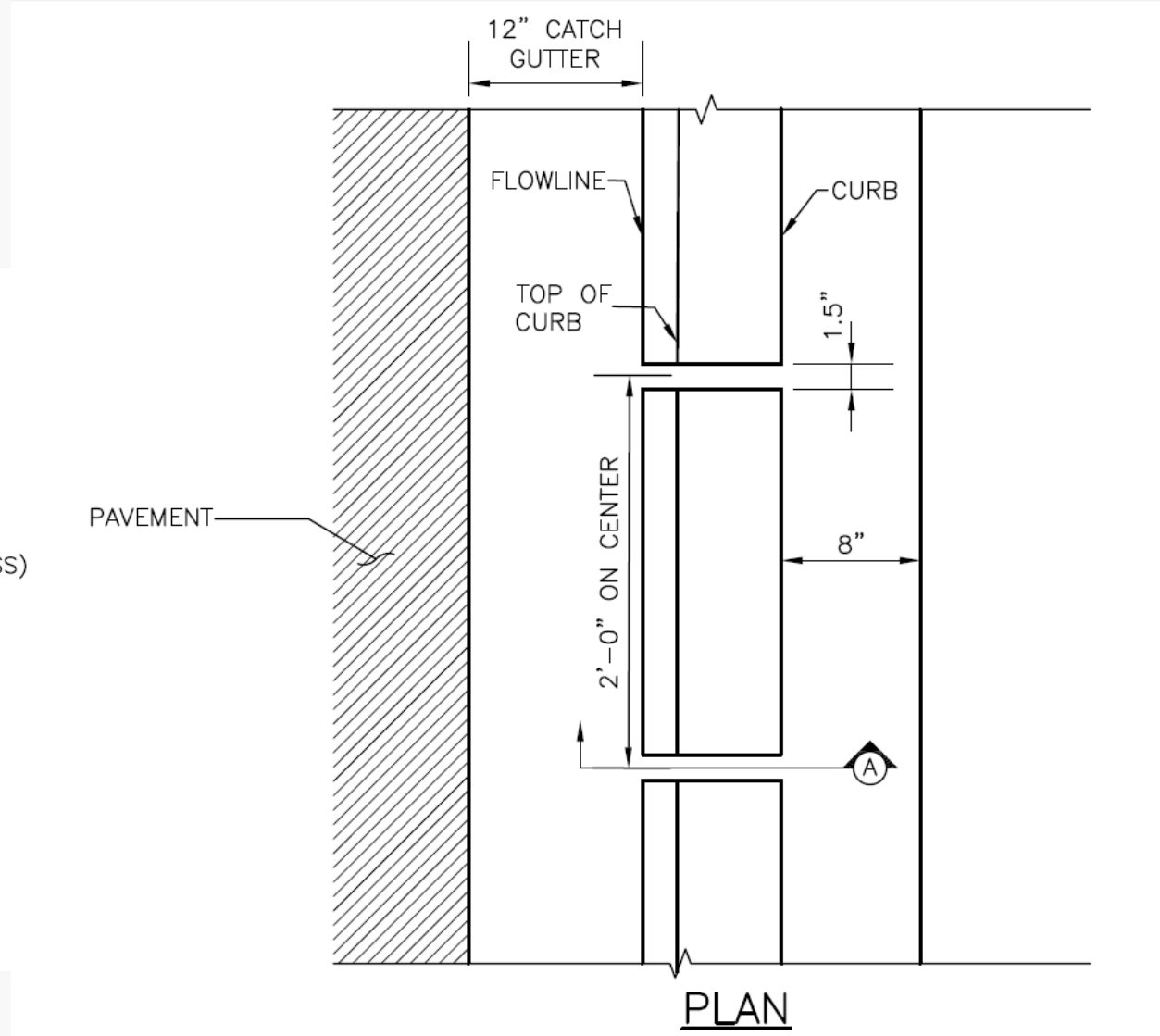
Run-on ratio

When you need a level spreader (?)

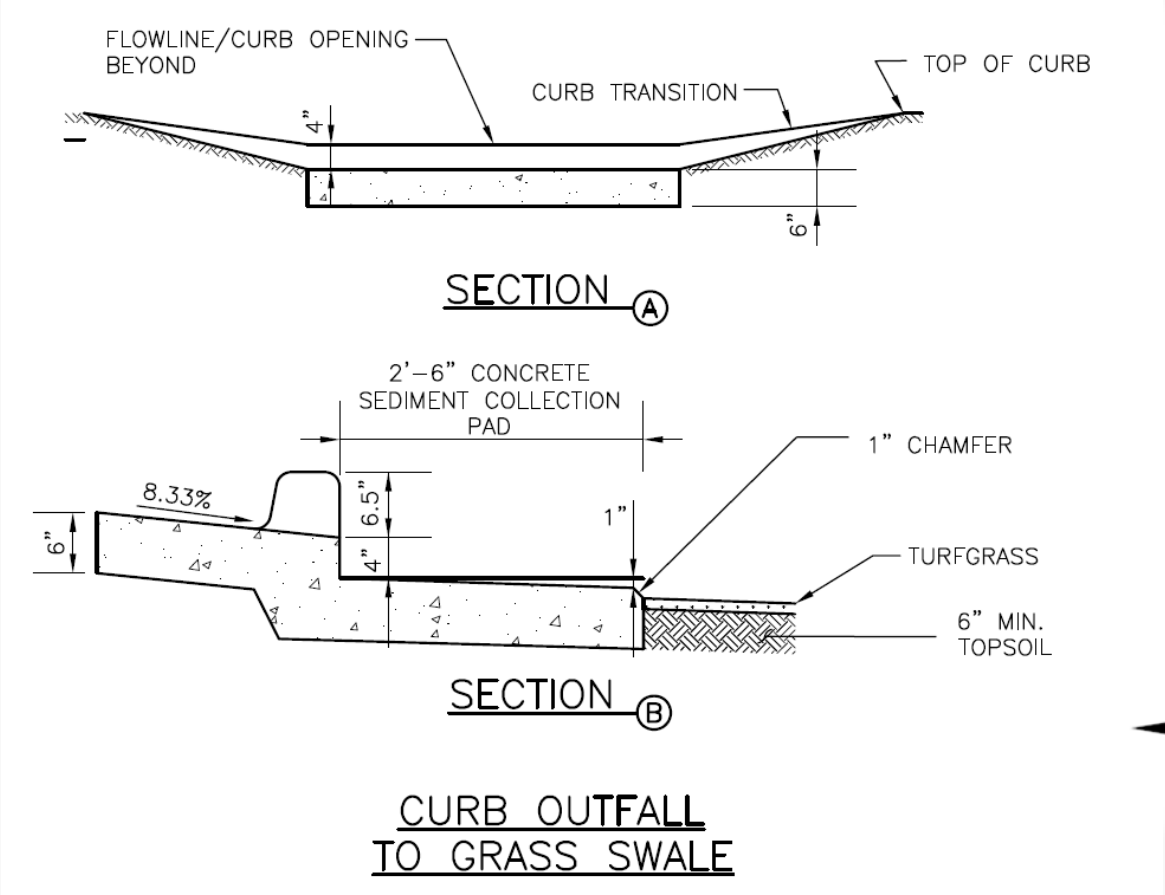
Defining the RPA

Slotted Curb





Sediment Pad at Swale Entry



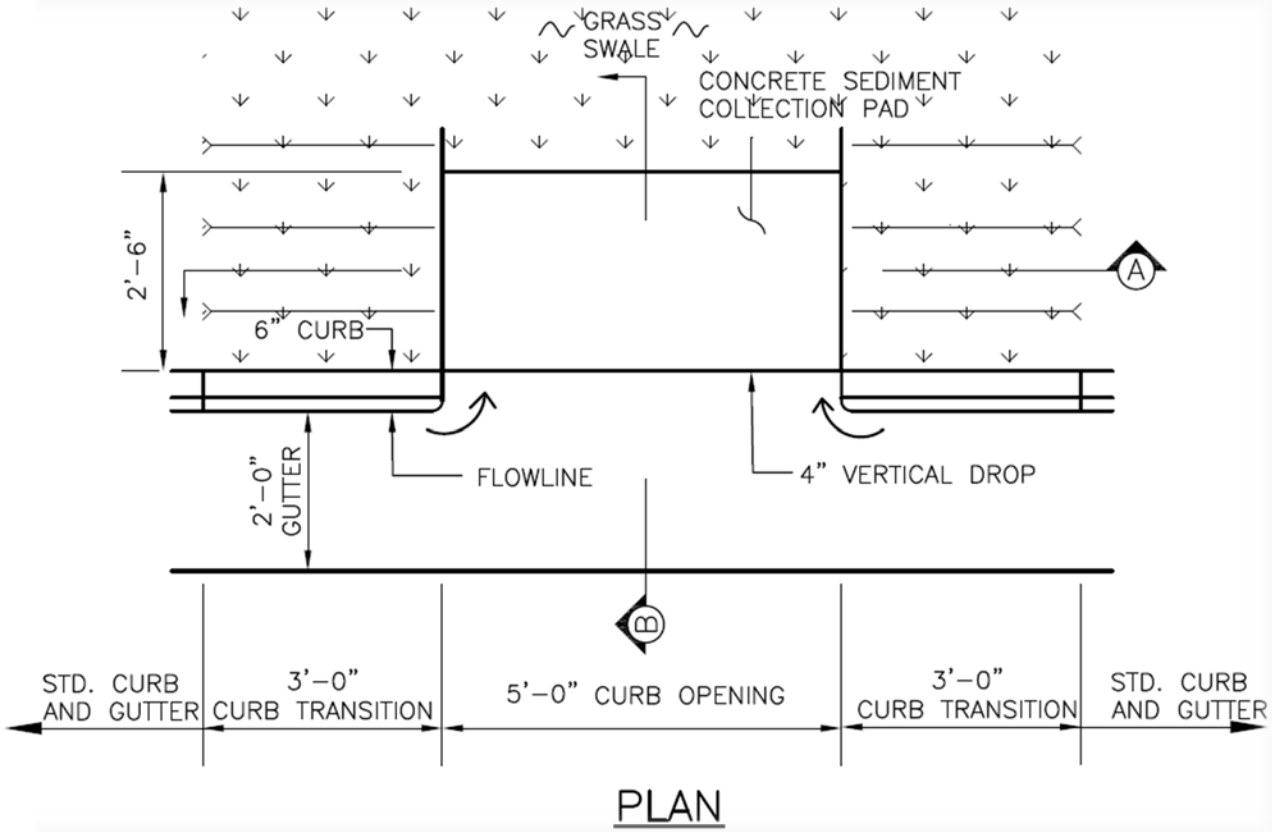


Photo Courtesy Bill Wenk

More Information Available

www.UDFCD.org

- *Technical Memorandum, Determination of Runoff Reduction Method Equations (UIA to RPA) based on Multivariable SWMM Analysis, Piza and Rapp 2018*
- *Criteria Manual, Volume 3, Fact Sheet T-0*
- *UD-BMP (Excel Based Tool for calculating runoff)*
- *Flood Control District Youtube video for using UD-BMP*

Coming soon

Topsoil Management Guidance

Thank You

PEAK STORMWATER ENGINEERING, LLC

DOUGLAS COUNTY COLORADO

MULLER ENGINEERING COMPANY

Southeast Metro Stormwater Authority

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

WWE WRIGHT WATER ENGINEERS, INC.

Navigating the New Jersey & Washington State Stormwater Programs as Models for Approving Manufactured Treatment Devices

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Research Scientist
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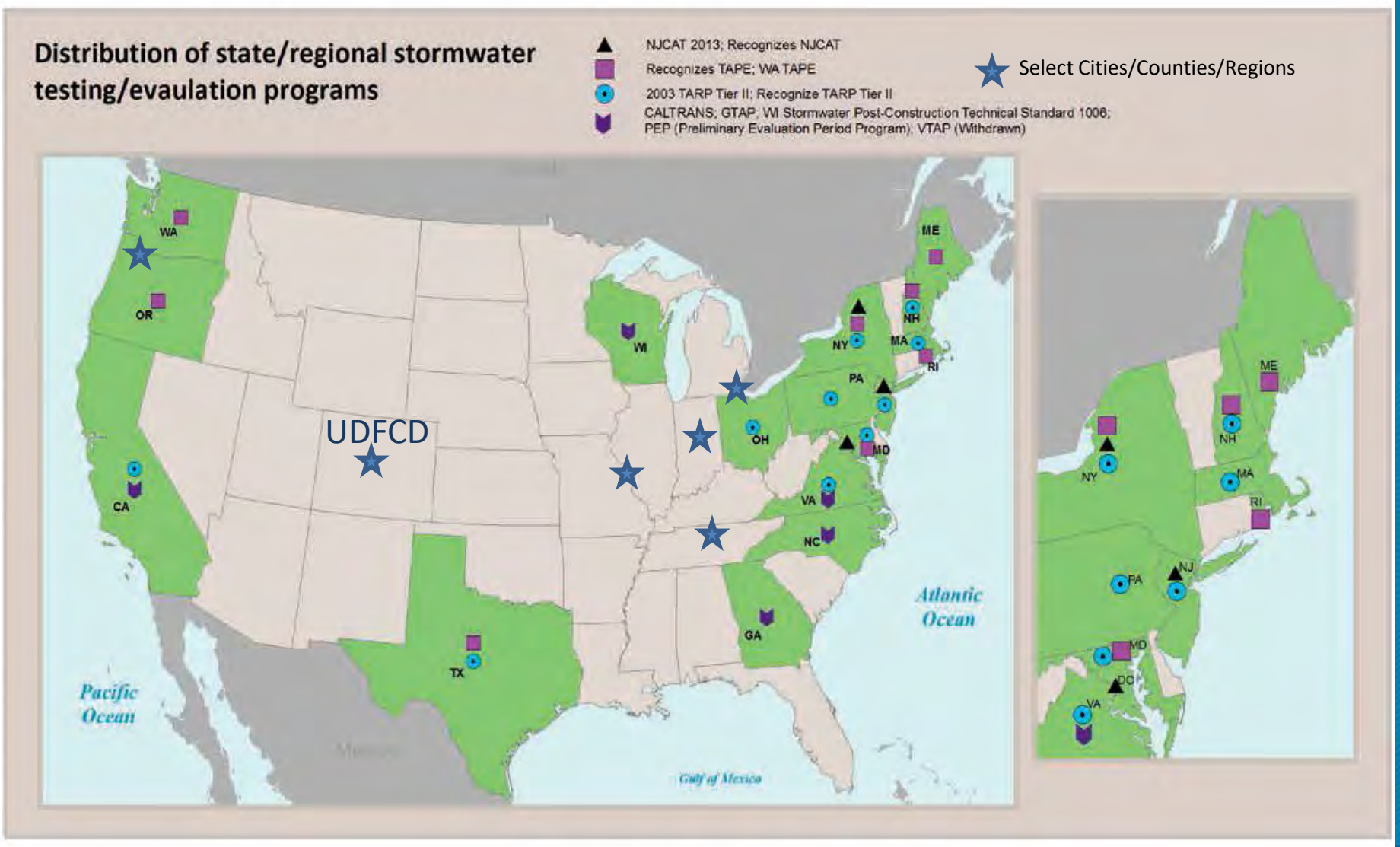
Chattanooga, Tennessee
(888) 344-9044

Colorado Association of Stormwater & Floodplain Managers
September 25-28, 2018
Snowmass Village, CO

AquaShield
WATER TREATMENT SOLUTIONS

A bunch of stormwater Quality programs



Modified from www.werf.org, Executive Summary, Document #INFR2R14

AquaShield WATER TREATMENT SOLUTIONS

Colorado Urban Drainage & Flood Control District
- Urban Storm Drainage Criteria Manual Volume 3 -

Underground BMPs T-11

To evaluate performance of an underground proprietary BMP, data should be provided to the local jurisdiction to demonstrate that anticipated BMP performance will be comparable to that of surface-based BMPs such as extended detention basins, constructed wetland basins, sand filter basins, or retention ponds. Underground BMPs approved for standalone treatment should be capable, on an annual basis, of producing effluent quality with a median TSS concentration of no more than 30 mg/L. This level of treatment is comparable to the long-term effluent median concentrations from the International Stormwater BMP Database for surface-based BMPs.

Data collected to substantiate performance of proprietary BMPs should meet the following criteria:

1. Testing must consist of field data (not laboratory data) collected in compliance with the criteria in Table UG-1. Laboratory studies and/or vendor-supplied studies without third party involvement or verification should not be considered. The Technology Acceptance Reciprocity Partnership (TARP) Protocol for Stormwater Best Management Practice Demonstrations may provide additional useful information on development of a monitoring program for evaluation of underground BMPs. Information on the TARP program can be found in several locations on the internet, including http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/. Forthcoming field testing guidelines from the American Society of Civil Engineers Urban Water Resources Research Council (ASCE UWRRC) Task Committee developing Guidelines for Certification of Manufactured Stormwater BMPs (Sansalone et al. 2009) may also be applicable in the future.

2. Data collected in environments similar to the Colorado Front Range (i.e., semi-arid with freezing and thawing in the winter) are preferable. This is particularly important for flow based devices where differences in rainfall intensity and duration may affect performance.

3. Data should be collected and analyzed in accordance with the guidance provided in *Urban Stormwater BMP Performance Monitoring* (Geosyntec and WWE 2009; available online at www.bmpdatabase.org). When reviewing performance data, it is important to recognize that the use of percent removal may be more reflective of how "dirty" the influent water is rather than how well the BMP is actually performing (Jones et. al. 2008). Instead, look at effluent concentrations for a range of influent concentrations. **The device should have performance data that demonstrates the ability to meet a median TSS effluent concentration of approximately 30 mg/L or lower on an annual basis.**

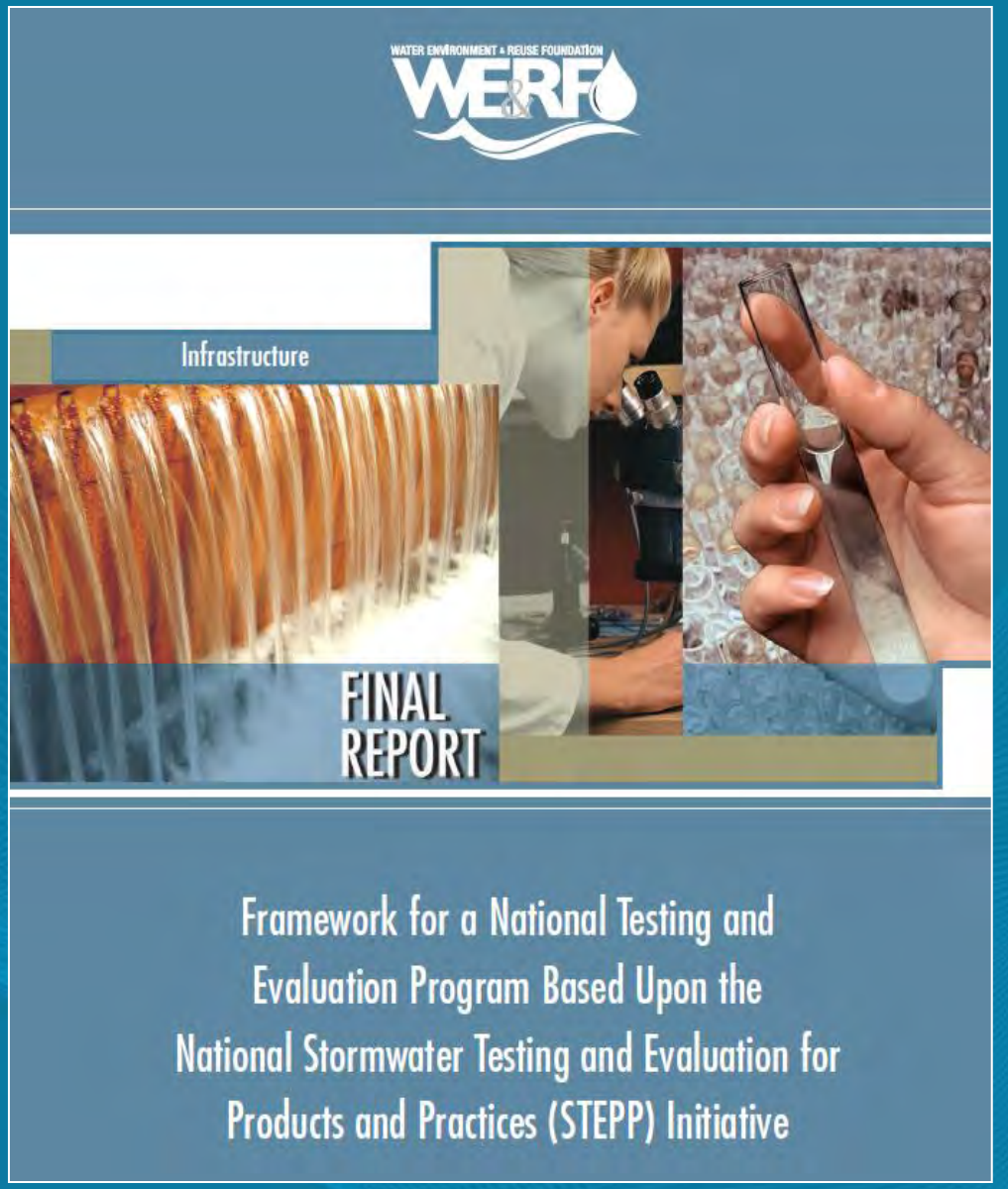
4. Data should be collected or verified by independent third parties in accordance with good Quality Assurance/Quality Control (QA/QC) procedures.

Many studies have been conducted over the past decade to document the performance of underground BMPs. Sources of data that may be used to support using a proprietary BMP include the following:

- New Jersey Corporation for Advanced Technology (NJCAT) Technology Verification Program. (http://www.njcat.org/verification/protocol.cfm).
- Washington State Department of Ecology (2002). Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology (TAPE), October 2002 (Revised June 2004), Publication Number 02-10-037. (http://www.ecy.wa.gov/biblio/0210037.html).
- International Stormwater BMP Database (www.bmpdatabase.org).
- University of Massachusetts Amherst Stormwater Technologies Clearinghouse (www.mastep.net).

Then in mid-2016…

- ***Proposes a National program to evaluate products and practices.***
- ***Draws upon New Jersey & Washington State stormwater programs for MTD evaluations.***



From WERF 2016

AquaShield
WATER TREATMENT SOLUTIONS

Let's look at 2 stormwater programs as models for approving (evaluating) Manufactured Treatment Devices (MTDs)…

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NJ STORMWATER.ORG
Stormwater in New Jersey

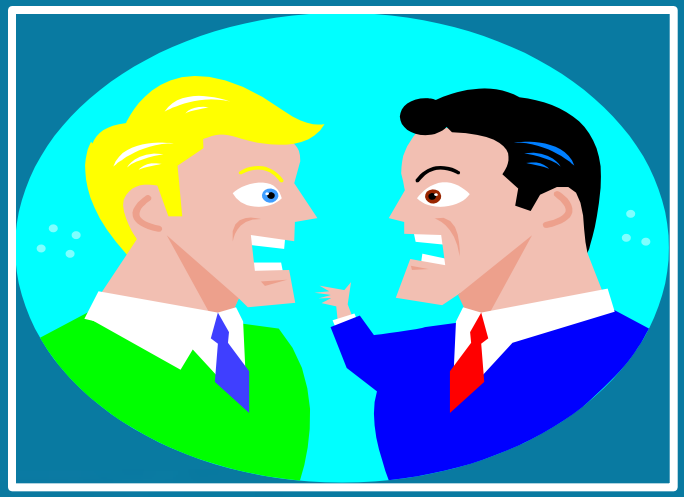
Lab testing protocol

DEPARTMENT OF
ECOLOGY
State of Washington

Field testing protocol

AquaShield
WATER TREATMENT SOLUTIONS

A Spirited Debate: Lab vs. Field Testing



- *Lab testing* provides repeatable and defensible results under controlled conditions to allow for side by side comparsions of MTD performance testing.
- *Field testing* is a logical progression from lab testing and provides long term, real world results under random storm conditions under which an MTD would be expected to encounter.

Two Step Process for NJDEP "Certification"

Step 1: NJCAT "Verification"

NJCAT Corporation for Advanced Technology

www.njcat.org

Step 2:
NJDEP "Certification"
(if eligible)

State of New Jersey
Department of Environmental Protection
NJ Stormwater.org
Stormwater in New Jersey

www.njstormwater.org/treatment.html

AquaShield
WATER TREATMENT SOLUTIONS

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NJ STORMWATER.ORG
Stormwater in New Jersey

NJCAT Verification vs. NJDEP Certification

- ***NJCAT Verification provides independent documentation of a protocol-based performance claim for an MTD in either a lab and/or field test setting.***

- ***NJDEP Certification allows an eligible MTD to be specified within New Jersey under conditions specific to state stormwater rules.***

We'll talk about eligibility later…..

Process for Approval of MTDs

New Jersey Department of Environmental Protection
Process for Approval of Use for Manufactured Treatment Devices
January 25, 2013

This document outlines the process for a stormwater manufactured treatment device (MTD) to be approved by the New Jersey Department of Environmental Protection (NJDEP) in compliance with the Stormwater Management rules, N.J.A.C. 7:8. Prior to a MTDs entrance into the NJDEP process, the MTD must obtain Verification through the New Jersey Corporation for Advanced Technology (NJCAT). The process for NJCAT Verification is available at www.njcat.org entitled "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology: For use in accordance with the Stormwater Management Rules, N.J.A.C. 7:8". In addition to these process documents there are protocols for sedimentation and filtration MTDs that must be used for approval, the protocols are available at www.njstormwater.org.

NJDEP Process

Upon successful completion of the technical and regulatory standards and the completion of the reporting of those standards in the NJCAT Verification Report, NJCAT will provide NJDEP's Stormwater Management Unit a link to their website where the Verification Report can be found. In addition to the Verification Report link, NJCAT will supply the MTD name, the MTD manufacturer name and the respective TSS percent removal rate.

The NJCAT Verification will include the following components: Description of Technology, Laboratory Test Setup, Performance Claims, Supporting Documentation, Design Limitations, Maintenance Plans, Statements of Compliance and a Verification Appendix. The Verification Appendix will highlight and translate the design specifications found in the rest of the Verification Report to the design engineer.

Formal representation of a NJDEP approval will be established on the NJDEP stormwater website at www.njstormwater.org. The website will contain the MTD name, the MTD manufacturer name and the respective TSS percent removal rate. Upon approval, the MTD can be used for compliance with the Stormwater Management rule as long as the conditions of the NJCAT Verification are met.

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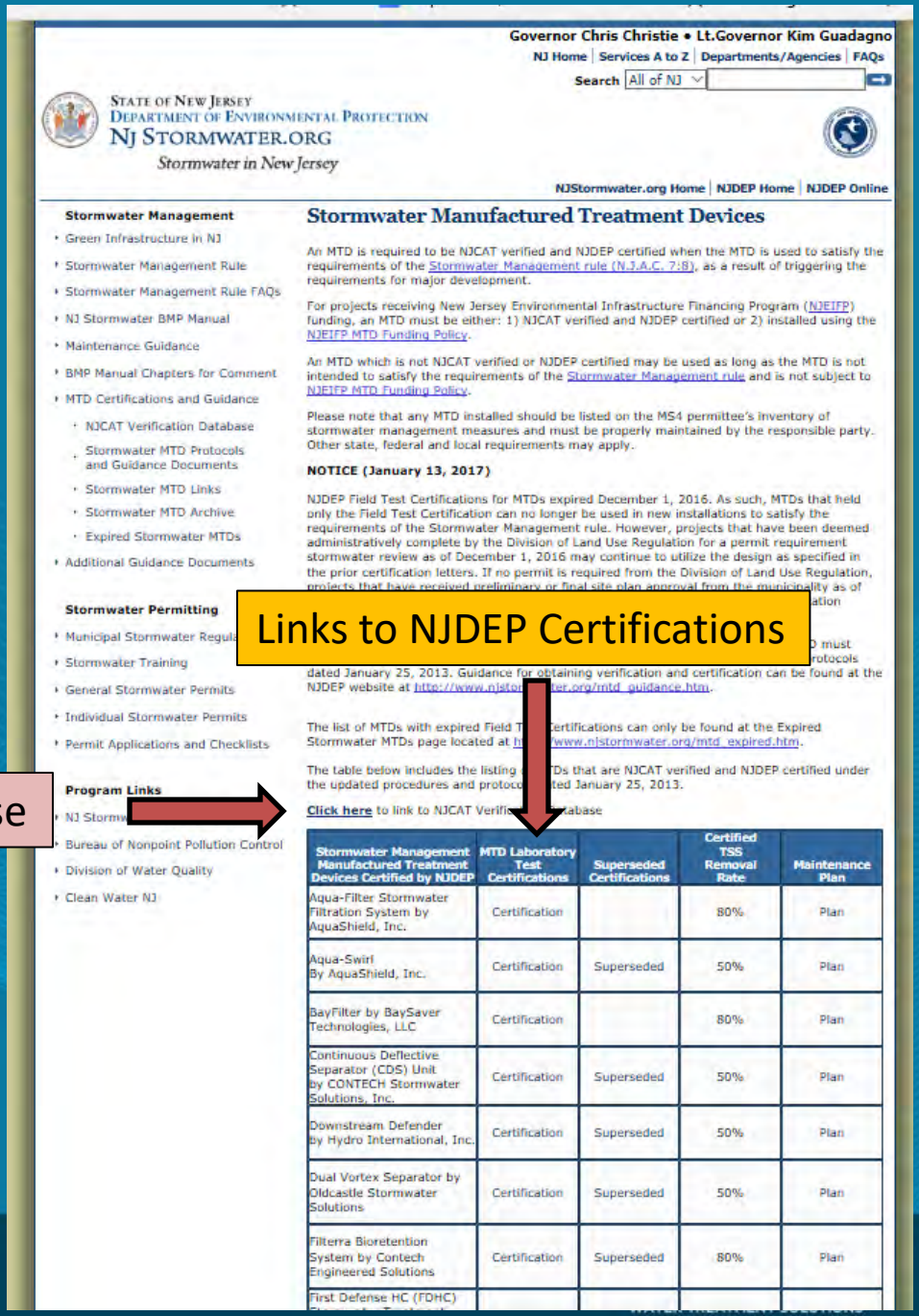
NJDEP Lists MTD Certifications @
www.njstormwater.org/treatment.html

Link to NJCAT Verification Database

Links to NJDEP Certifications



Governor Chris Christie • Lt.Governor Kim Guadagno
NJ Home | Services A to Z | Departments/Agencies | FAQs
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Department of Environmental Protection
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Stormwater in New Jersey

NJStormwater.org Home | NJDEP Home | NJDEP Online

Stormwater Management
- Green Infrastructure in NJ
- Stormwater Management Rule
- Stormwater Management Rule FAQs
- NJ Stormwater BMP Manual
- Maintenance Guidance
- BMP Manual Chapters for Comment
- MTD Certifications and Guidance
  - NJCAT Verification Database
  - Stormwater MTD Protocols and Guidance Documents
  - Stormwater MTD Links
  - Stormwater MTD Archive
  - Expired Stormwater MTDs
- Additional Guidance Documents

Stormwater Permitting
- Municipal Stormwater Regul
- Stormwater Training
- General Stormwater Permits
- Individual Stormwater Permits
- Permit Applications and Checklists

Program Links
- NJ Stormw
- Bureau of Nonpoint Pollution Control
- Division of Water Quality
- Clean Water NJ

Stormwater Manufactured Treatment Devices

An MTD is required to be NJCAT verified and NJDEP certified when the MTD is used to satisfy the requirements of the Stormwater Management rule (N.J.A.C. 7:8), as a result of triggering the requirements for major development.

For projects receiving New Jersey Environmental Infrastructure Financing Program (NJEIFP) funding, an MTD must be either: 1) NJCAT verified and NJDEP certified or 2) installed using the NJEIFP MTD Funding Policy.

An MTD which is not NJCAT verified or NJDEP certified may be used as long as the MTD is not intended to satisfy the requirements of the Stormwater Management rule and is not subject to NJEIFP MTD Funding Policy.

Please note that any MTD installed should be listed on the MS4 permittee's inventory of stormwater management measures and must be properly maintained by the responsible party. Other state, federal and local requirements may apply.

NOTICE (January 13, 2017)

NJDEP Field Test Certifications for MTDs expired December 1, 2016. As such, MTDs that held only the Field Test Certification can no longer be used in new installations to satisfy the requirements of the Stormwater Management rule. However, projects that have been deemed administratively complete by the Division of Land Use Regulation for a permit requirement stormwater review as of December 1, 2016 may continue to utilize the design as specified in the prior certification letters. If no permit is required from the Division of Land Use Regulation, projects that have received preliminary or final site plan approval from the municipality as of

dated January 25, 2013. Guidance for obtaining verification and certification can be found at the NJDEP website at http://www.njstor

The list of MTDs with expired Field T certifications can only be found at the Expired Stormwater MTDs page located at h www.njstormwater.org/mtd_expired.htm.

The table below includes the listing TDs that are NJCAT verified and NJDEP certified under the updated procedures and protoc ted January 25, 2013.

Click here to link to NJCAT Verifi tabase

Stormwater Management Manufactured Treatment Devices Certified by NJDEP	MTD Laboratory Test Certifications	Superseded Certifications	Certified TSS Removal Rate	Maintenance Plan
Aqua-Filter Stormwater Filtration System by AquaShield, Inc.	Certification		80%	Plan
Aqua-Swirl By AquaShield, Inc.	Certification	Superseded	50%	Plan
BayFilter by BaySaver Technologies, LLC	Certification		80%	Plan
Continuous Deflective Separator (CDS) Unit by CONTECH Stormwater Solutions, Inc.	Certification	Superseded	50%	Plan
Downstream Defender by Hydro International, Inc.	Certification	Superseded	50%	Plan
Dual Vortex Separator by Oldcastle Stormwater Solutions	Certification	Superseded	50%	Plan
Filterra Bioretention System by Contech Engineered Solutions	Certification	Superseded	80%	Plan
First Defense HC (FDHC)				

www.njcat.org

NJCAT Corporation for Advanced Technology

Promoting Emerging Energy and Environmental Technologies

- About Us
- Verification Process

Technology Verification

The Energy and Environmental Technology Verification (EETV) Act at N.J.S.A. 13:1D-134 et seq., establishes the guidelines for a verification and certification process to approve the use of innovative energy and environmental technologies that benefit the environment and economy of New Jersey. The New Jersey Legislature found that, in establishing the technology verification and certification program, it is in the public's interest to encourage the commercial development and use of new technology-based environmental and energy related products, services and systems that abate and prevent environmental pollution and promote energy conservation in the most cost-effective and environmentally efficient manner in the State.

Highlights

Although innovative environmental and energy technologies often consume fewer natural resources than traditional methods, they encounter numerous technical, financial and regulatory impediments. Over the years, NJCAT has broken down many of the barriers, but there are still daunting challenges facing innovative technologies.

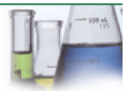
Stormwater Treatment Systems

Stormwater Management Technologies in particular are difficult to evaluate. Pollutant removal performance depends upon many factors, e.g., influent particulate size distribution, influent pollutant concentration (loading), stormwater flow rate, sump design and capacity, and maintenance. NJCAT involvement and activities over the past decade in identifying and evaluating a number of pre-manufactured stormwater treatment devices has created the knowledge and experience base necessary to effectively and confidently assess anticipated sediment removal performance.

The New Jersey Stormwater rules (35 N.J.R. 154) clearly establish that manufactured stormwater

News

About NJCAT



NJCAT was created to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy. NJCAT provides innovators with the regulatory, commercial, and technological assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

*** advance policy strategies and regulatory mechanisms to promote technology commercialization,**

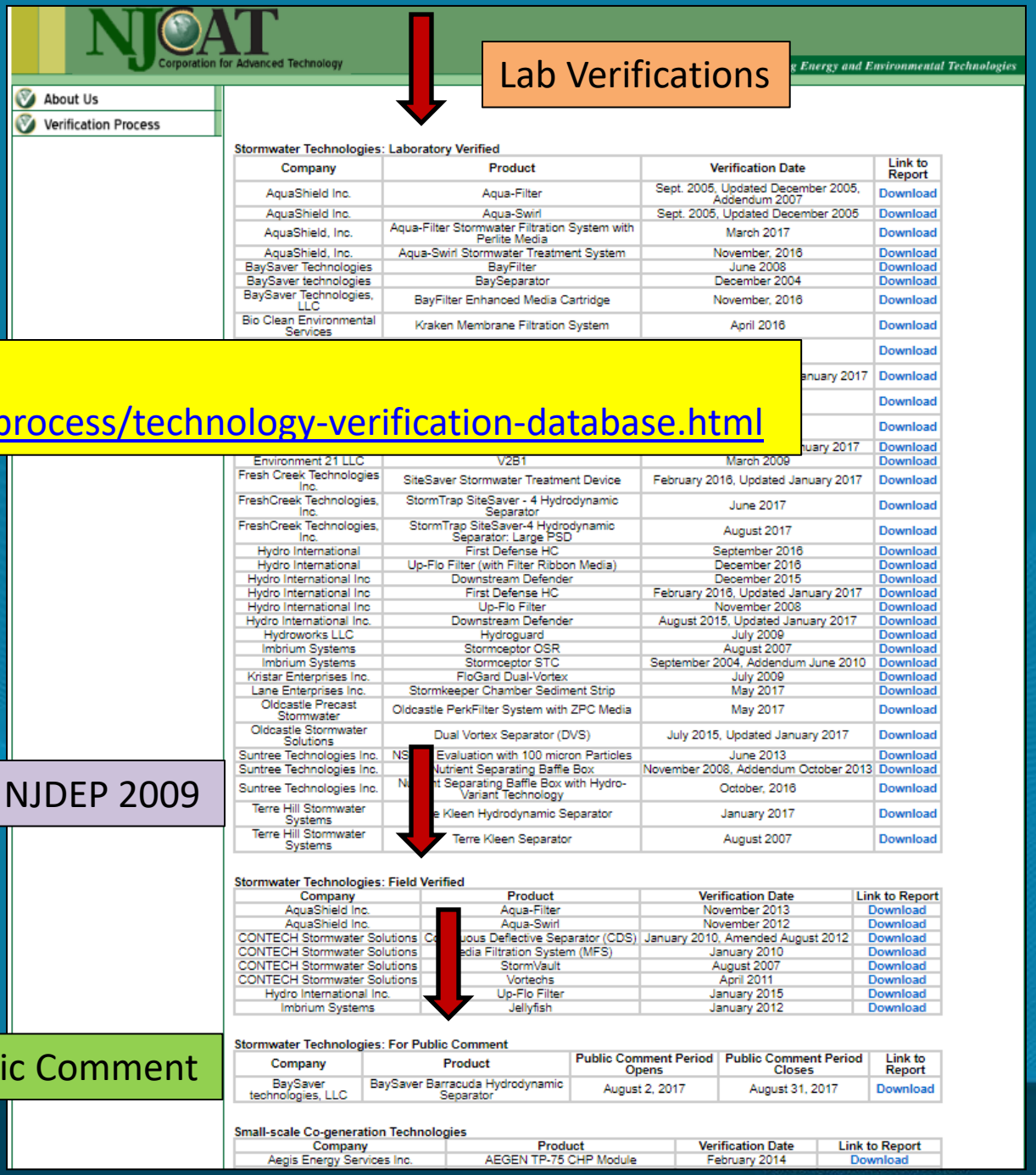
*** identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated,**

*** establish relationships/alliances to bring new technologies to market and new business to the state, and**

*** assist in the identification of markets and applications for commercialized technologies.**

Operating as a public private partnership is the cornerstone of the NJCAT programs; in this manner, the commercial marketplace has direct input to the technology development and commercialization process and the public sector gains confidence in technology solutions through reliance on an independent honest broker examination of technology performance.

Richard S. Magee Sc.D., P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental Systems
Stevens Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030
973-879-3056 (M) rsmagee@rcn.com

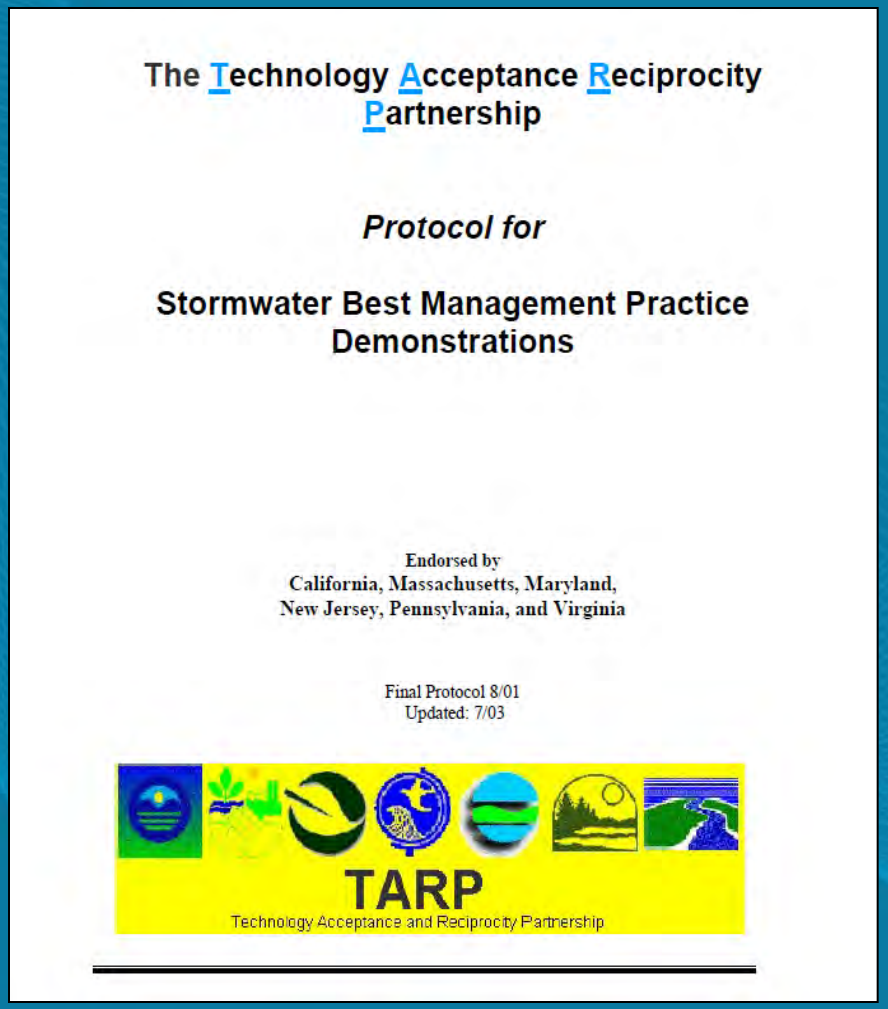


NJCAT MTD Verifications @ www.njcat.org/verification-process/technology-verification-database.html

Field Verifications per TARP or NJDEP 2009

Lab Verifications open for Public Comment

Ever heard of TARP? Well, it is no longer applicable to NJDEP



The Technology Acceptance Reciprocity Partnership

Protocol for

Stormwater Best Management Practice Demonstrations

Endorsed by
California, Massachusetts, Maryland,
New Jersey, Pennsylvania, and Virginia

Final Protocol 8/01
Updated: 7/03

TARP
Technology Acceptance and Reciprocity Partnership

Original NJDEP Certification Process

NJCAT Lab Verification, no standard protocol

NJDEP Issued "Conditional Interim Certification"

Find a field test site + QAPP

TARP Tier II Field Test

NJCAT Field Verification Report

NJDEP Final Certification

There was no TARP Tier I

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STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NJ STORMWATER.ORG
Stormwater in New Jersey

New Jersey Lab Testing Protocols for HDSs and Filters

New Jersey Department of Environmental Protection
Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device

January 25, 2013

New Jersey Department of Environmental Protection
Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device

January 25, 2013

http://www.njstormwater.org/treatment.html

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WATER TREATMENT SOLUTIONS

http://www.njstormwater.org/mtd_guidance.htm

NJCAT
Corporation for Advanced Technology

Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology

For use in accordance with the Stormwater Management Rules, N.J.A.C. 7:8

January 25, 2013

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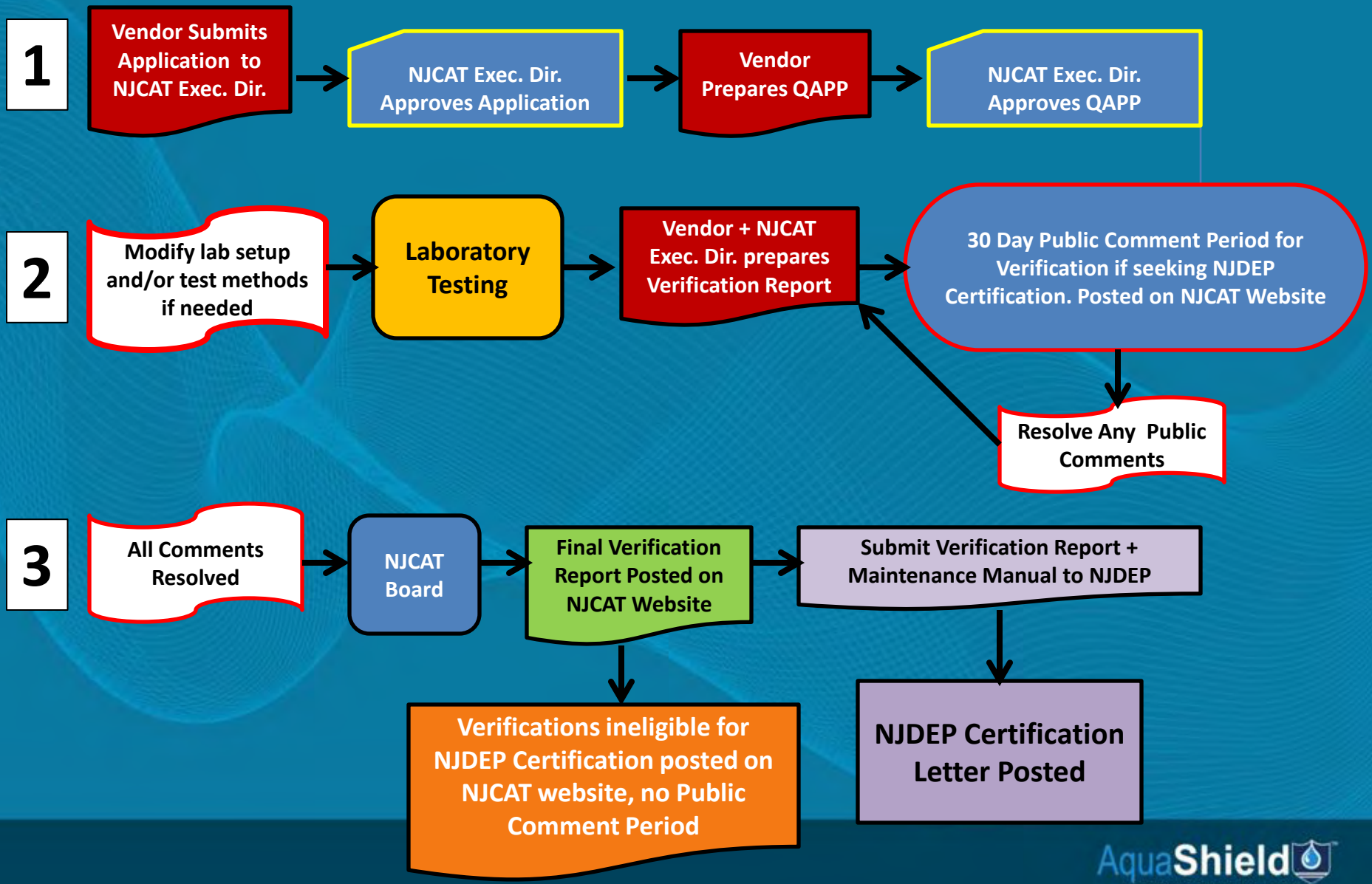
NJCAT Verification + NJDEP Certification Process



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Example NJDEP Certification Letter (1st page)

NJDEP Limits:

HDSs to 50% annual TSS

Filters to 80% annual TSS

Regardless of whether the NJCAT Verification is for a greater annual TSS removal efficiency percentage.

KIM GUADAGNO

CHRIS CHRISTIE
Governor

Lt. Governor

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Nonpoint Pollution Control
Division of Water Quality
401-02B
Post Office Box 420
Trenton, New Jersey 08625-0420
609-633-7021 Fax: 609-777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

BOB MARTIN
Commissioner

March 15, 2017

Mark B. Miller, Research Scientist
AquaShield™, Inc.
2733 Kanasita Drive, Suite 111
Chattanooga, Tennessee 37343

Re: Revised MTD Lab Certification
Aqua-Swirl® Stormwater Treatment System by AquaShield™, Inc.

TSS Removal Rate 50%

Dear Mr. Miller:

This revised certification letter supersedes the Department's prior certification dated December 1, 2016. This revision only removes the Required Sediment Removal Interval column from Table A-1 in order to avoid confusion regarding maintenance requirements. All other conditions of the certification remain unchanged.

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7 (c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). AquaShield™, Inc. has requested an MTD Laboratory Certification for the Aqua-Swirl® Stormwater Treatment System, which is a vortex hydrodynamic separator.

The verification is subject to the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advance Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix (dated November 2016) for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

? If following NJDEP as a model for local approval…

Require only NJCAT Verification?

NJCAT Corporation for Advanced Technology

Then which Verification?

- 2013 Lab + MTDs Ineligible for Certification
- CIC Lab (Certifications expired)
- NJDEP 2009 Field (Certifications expired)
- TARP Tier II Field (Certifications expired)

OR…

State of New Jersey
Department of Environmental Protection
NJ STORMWATER.ORG
Stormwater in New Jersey

Require NJDEP Certification per 2013 Protocol?

"***Level Playing Field***", all hold Final Certification

Consider 4 fundamental aspects of the NJDEP/NJCAT MTD Process

1. NJDEP Certification is specific to New Jersey stormwater rules. An MTD must hold NJDEP Certification in order to be specified in New Jersey.

2. NJDEP Certification does not necessarily carry a higher level of technical scrutiny beyond that of an NJCAT Verification. However, NJDEP reviews maintenance manuals, NJCAT does not. NJDEP Certifications includes Maintenance Manual as part of Cert. Letter.

3. Not all NJCAT Verifications for an MTD are eligible for NJDEP Certification when there is a deviation from the protocol. This has significant ramifications for MTD sizing outside of NJ.

4. An NJCAT Verification can be issued for an MTD *technology* that is not recognized by NJDEP to be eligible for Certification. This has significant ramifications for MTD technology approval outside of NJ.

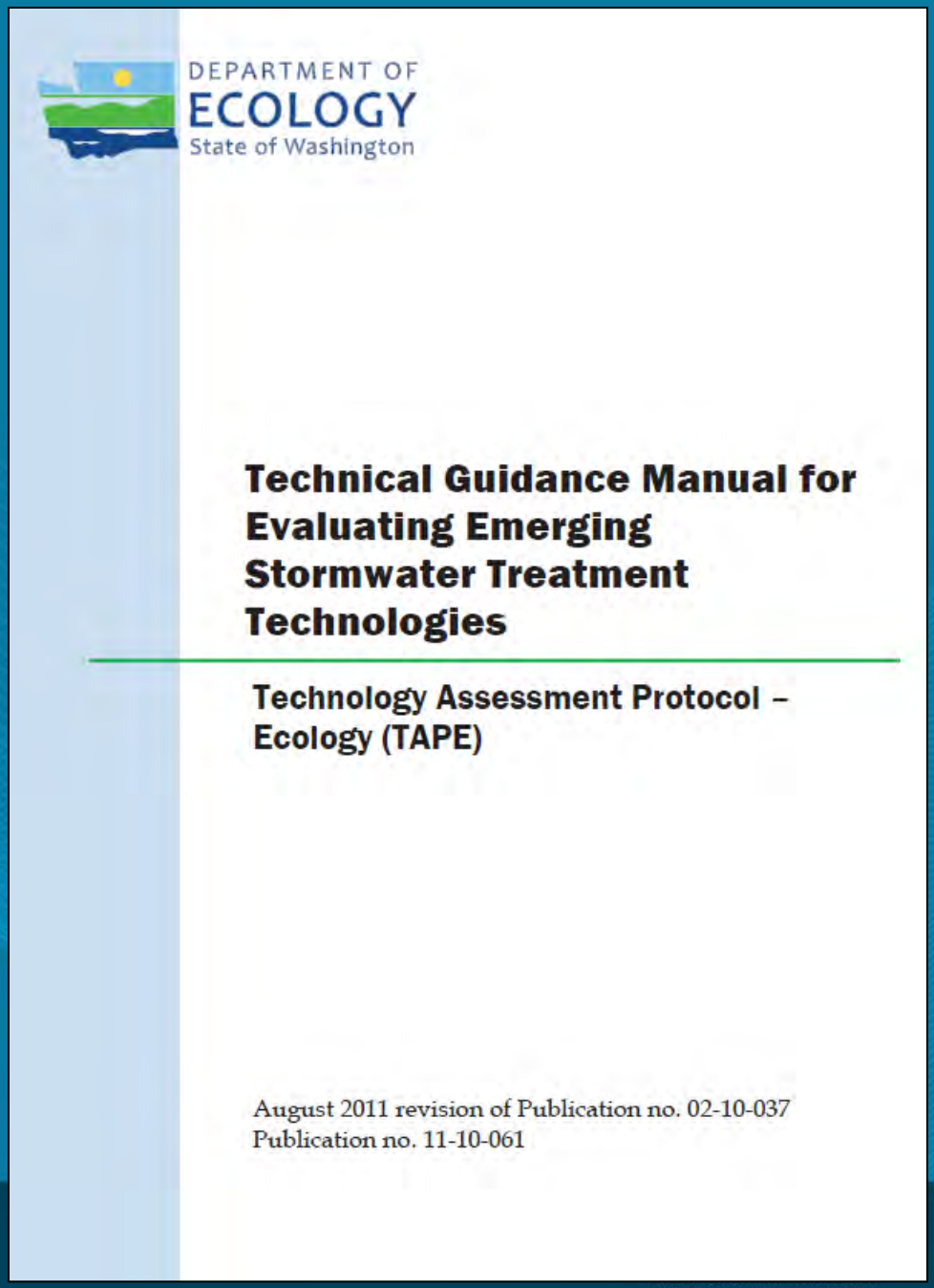
Let's look closer at NJCAT/NJDEP Aspects #3 & #4

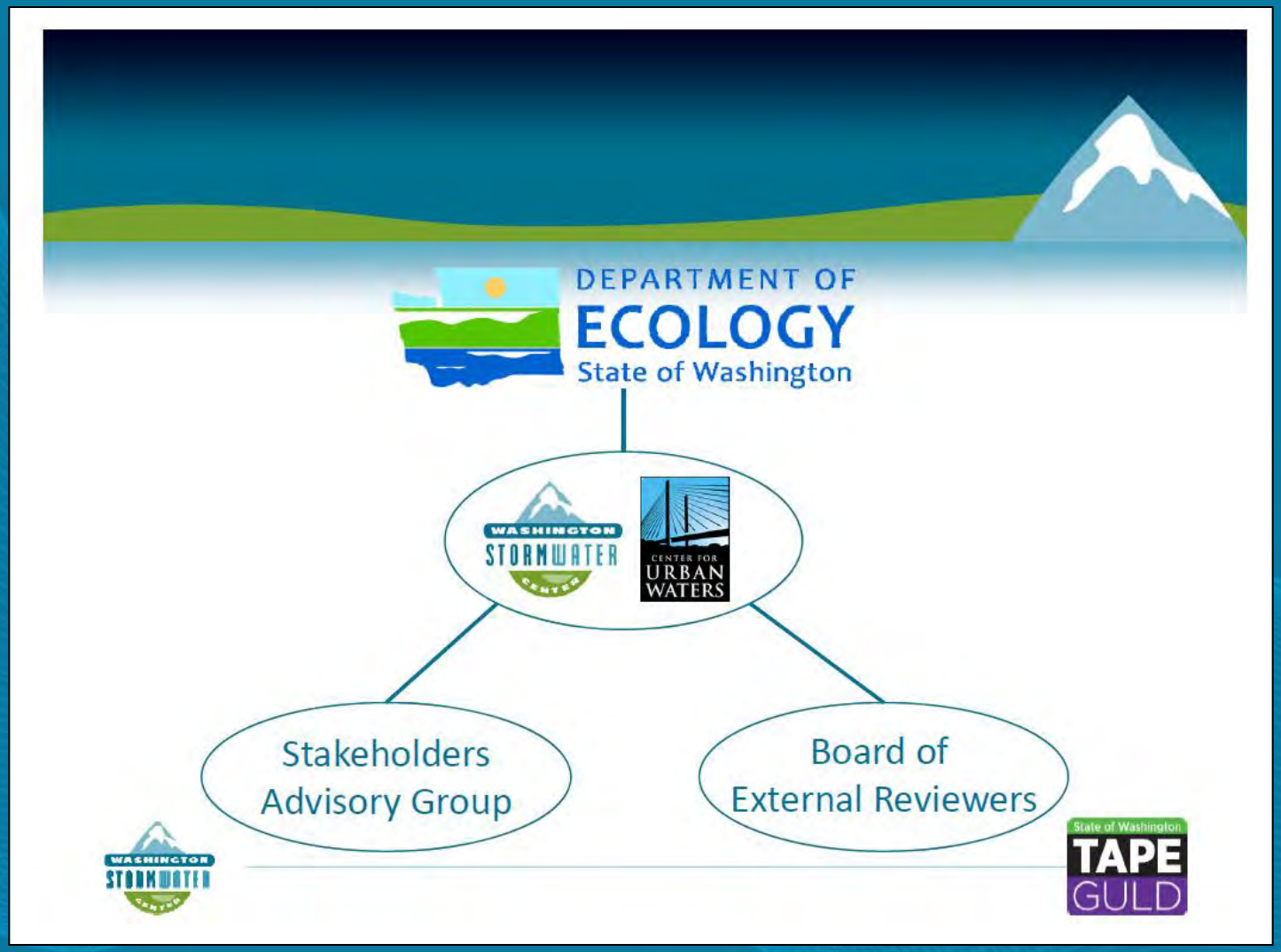
#3: Deviation from Protocol - Sizing: **An MTD test follows the protocol but uses a coarser PSD. An NJCAT Verification could still be obtained but that test would *not be eligible* for NJDEP Certification since the test purposefully deviated from the protocol to obtain a more favorable performance result. If an agency outside of NJ accepts NJCAT verifications only, then this test would allow for MTD sizing to be more favorable (smaller MTD) compared to those MTDs that tested to the protocol using the finer specified PSD (larger MTD). *Could this lead to undersizing?***

#4: Ineligible Technology for Certification: **The NJCAT Application will identify whether an MTD technology is accepted by NJDEP, and whether the proposed MTD test will be eligible for NJDEP Certification. For example, NJDEP considers underground infiltration structures (inclusive of fabric) not to be filtration MTDs and not eligible for Certification. However, NJCAT can issue a Verification for that technology as a pretreatment device but not NJDEP eligible. Agencies outside of New Jersey can then make their determination whether (a) that technology is an MTD, or (b) to allow the Verification (and sizing) for pretreatment and/or filtration.**

- **"TAPE" is Ecology's process for approving emerging & proprietary technologies (MTDs)**
- **Current TAPE is August 2011, Revised Version in progress**

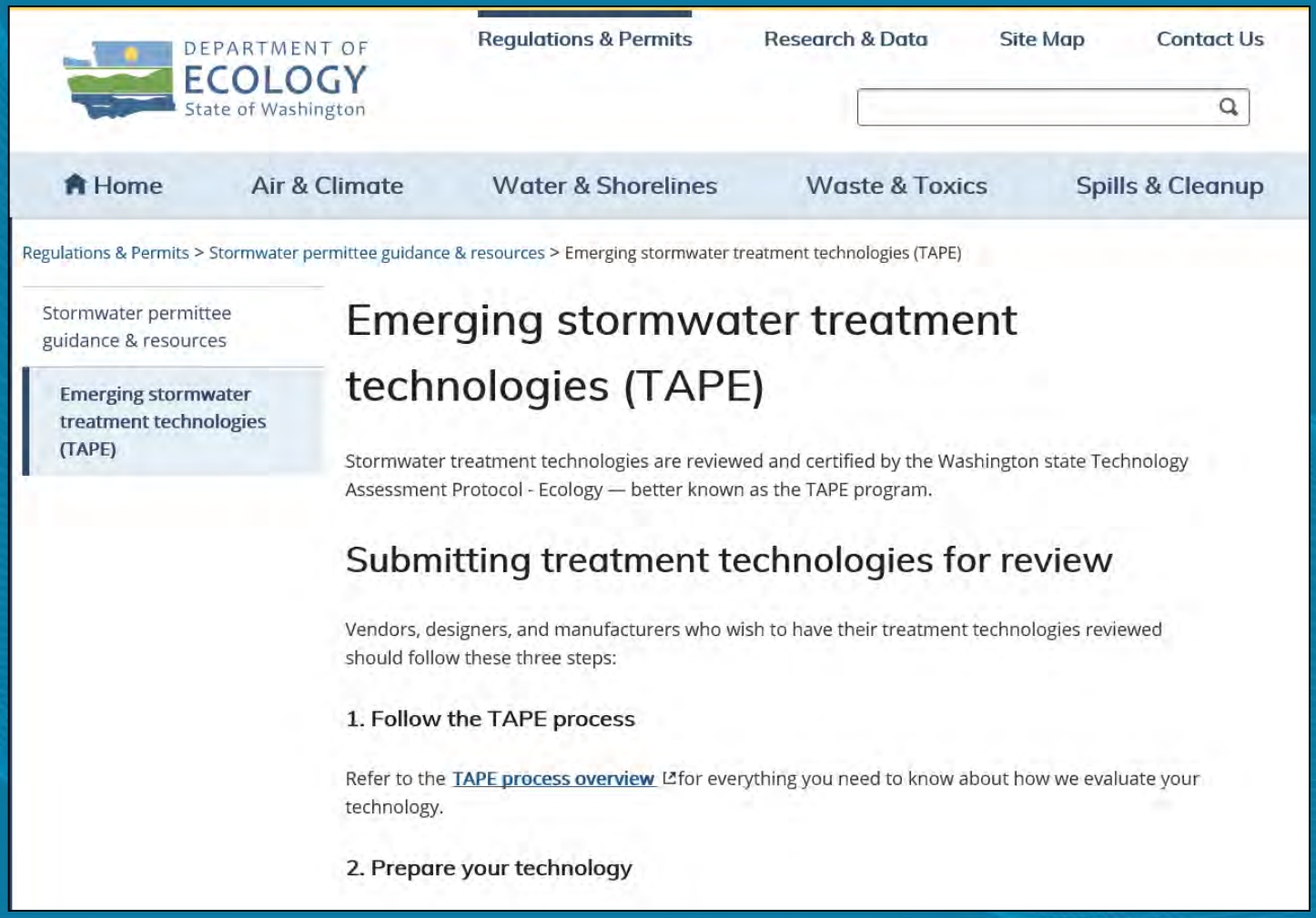
How hard could it be to get some field samples? Well, 73 pages worth.





Select WDOE/TAPE slides taken from presentation at Washington State Municipal Stormwater Conference, May 17, 2017, Carla Milesi, WSC

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies



AquaShield WATER TREATMENT SOLUTIONS

DEPARTMENT OF ECOLOGY
State of Washington

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2. Prepare your technology

Refer to the 2011 TAPE guidance manual as you prepare your technology for review and certification.

3. Send in your application

The application form and fee must be submitted **both** as a hard copy and digitally to:

TAPE Program
Washington State Department of Ecology
Cashiering
PO Box 47611
Olympia, WA 98504-7696

Email: douglas.howie@ecy.wa.gov

We also review chemical technologies

We also accept applications to the Chemical Technology Assessment Protocol – Ecology (C-TAPE) program. See the construction site chemical technology guidance for more information.

DEPARTMENT OF ECOLOGY
State of Washington

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Approved technologies

The following table lists the devices that have received a designation through the TAPE process.

In addition to our certification, local jurisdiction approval is required (and not guaranteed) for installation of treatment technologies we have evaluated and given a use designation.

All | Pretreatment | Oil | Enhanced | Basic | Phosphorus | Construction

Manufacturer	Device Name	Treatment Type	Use Designation
AquaShield, Inc.	Aqua-Filter System, Aqua-Blend C Filter Media	Basic Treatment	Pilot Level
AquaShield, Inc.	Aqua-Filter System, Coarse Perlite Filter Media	Basic Treatment	Cond Level
BaySaver Technologies, Inc.	BayFilter w/ BFC Media	Basic Treatment	Gene Level
BaySaver Technologies, Inc.	BayFilter w/EMC Media	Basic Treatment	Gene Level
BaySaver Technologies, Inc.	BayFilter w/GAC Media	Basic Treatment	Pilot Level

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Example GULD for Pretreatment (50% TSS per storm)

(Page 1 of 5)

April 2017

GENERAL USE LEVEL DESIGNATION FOR PRETREATMENT

For
AquaShield™, Inc.'s Aqua-Swirl® Stormwater Treatment System

Ecology's Decision:

Based on AquaShield™, Inc. application submissions, Ecology hereby issues the following use level designations:

1. **General Use Level Designation (GULD) for the Aqua-Swirl® for pretreatment use (a) ahead of infiltration treatment, or (b) to protect and extend the maintenance cycle of a Basic or Enhanced Treatment device (e.g., sand or media filter)**

2. **The following table shows flowrates associated with various Aqua-Swirl models**

Model	Diameter (ft)	WQF (cfs)
AS-2	2.5	0.25
AS-3	3.5	0.64
AS-4	4.5	1.31
AS-5	5	1.78
AS-6	6	2.98
AS-7	7	4.63
AS-8	8	6.78
AS-9	9	9.48
AS-10	10	12.80
AS-11	11	16.79
AS-12	12	21.52
AS-13	13	27.03

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TAPE Use Level Designations

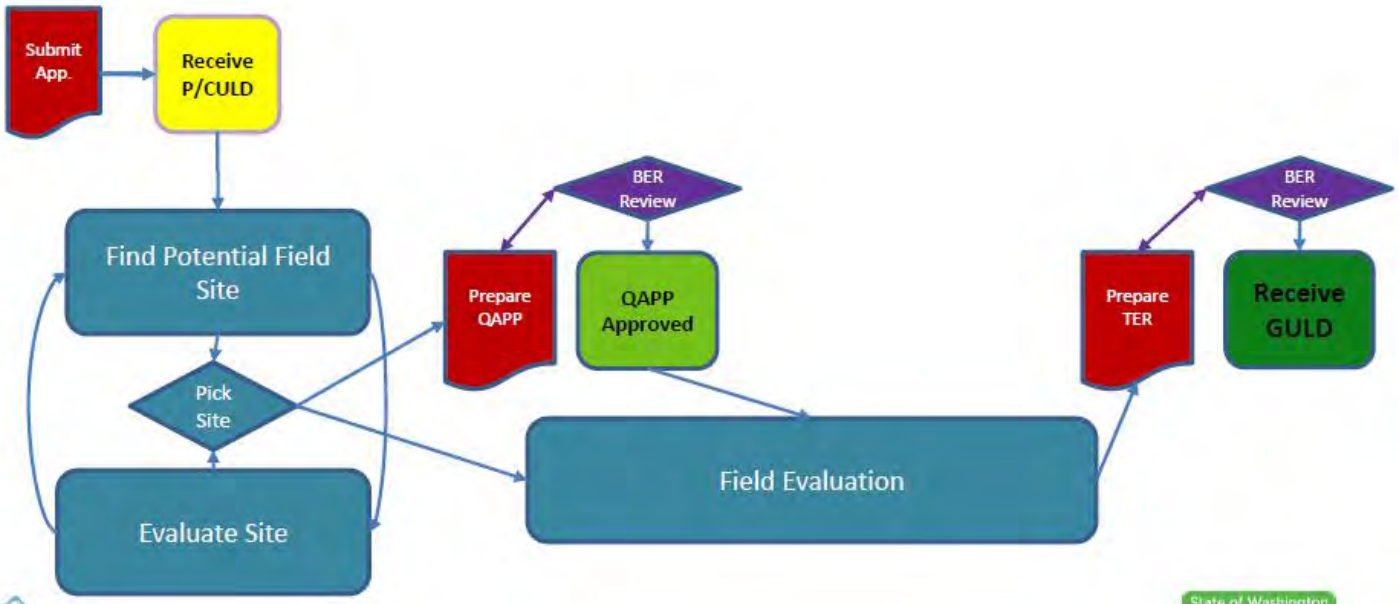
Use Level Designation	Minimum Data	Months (justified extensions allowed)	Max. # of Installations in WA	Field Testing Required
Pilot (PULD)	Lab data	30	5, Unlimited for Retrofits	All installation sites to be monitored. At least 1 indicative of or in Pacific NW
Conditional (CULD)	Field data, lab data may supplement	30	10, Unlimited for Retrofits	1 site indicative of or in Pacific NW
General (GULD)	Field data, lab data may supplement	Unlimited	Unlimited	None

Requirements for New/Redevelopment

- Treatment Facilities
  - Pretreatment (Total Suspended Solids)
  - Basic (Total Suspended Solids)
  - Enhanced (Dissolved Copper and Zinc)
  - Phosphorus (Total Phosphorus)
  - Oil (motor oil fraction of Total Petroleum Hydrocarbons)

TAPE Approval Timeline

~ 3 years, $250K



WASHINGTON STORMWATER CENTER

State of Washington TAPE GULD

AquaShield WATER TREATMENT SOLUTIONS

TAPE Performance Goals (*per event*)

Performance Goal	Influent Range	Criteria	Required Water Quality Parameters
Basic Treatment	20-100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS [a]	TSS
	100-200 mg/L TSS	≥ 80% TSS removal [b]	
	> 200 mg/L TSS	> 80% TSS removal [b]	
Dissolved Metals Treatment	Dissolved copper 0.005 – 0.02 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 30% dissolved copper removal [b,d]	TSS, hardness, total and dissolved Cu and Zn
	Dissolved zinc 0.02 – 0.3 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 60% dissolved zinc removal [b,d]	
Phosphorus Treatment	Total phosphorus (TP) 0.1 to 0.5 mg/L	Must meet basic treatment goal and exhibit ≥ 50% TP removal [b]	TSS, TP, orthophosphate
Oil Treatment	Total petroleum hydrocarbons (TPH) > 10 mg/L [e]	1) No ongoing or recurring visible sheen in effluent 2) Daily average effluent TPH concentration < 10 mg/L [a,e] 3) Maximum effluent TPH concentration of 15 mg/L [a,e] for a discrete (grab) sample	NWTPH-Dx, visible sheen
Pretreatment	50-100 mg/L TSS	Effluent goal ≤ 50 mg/L TSS [a]	TSS
	≥ 100 mg/L TSS	> 50% TSS removal [b]	

AquaShield
WATER TREATMENT SOLUTIONS

And in conclusion…

- Both the NJDEP/NJCAT & Ecology MTD approval processes provide robust performance testing programs to serve as models to assist other state/local regulators to evaluate MTD performance claims with greater confidence.
- MTD testing presents many challenges in the field and lab. Understanding the limitations of both is critical for any performance evaluation.
- The NJDEP/NJCAT lab-based approach allows for side-by-side comparison of MTD performance claims.
- Ecology's field-based approach provides long term, real-world performance and functionality to support MTD performance claims based on initial laboratory testing.
- NJDEP MTD certifications are specific to New Jersey to allow for MTD sales in New Jersey. Just because an MTD may hold NJCAT Verification, that verification may not be eligible for NJDEP Certification. Has significant marketplace implications outside of NJ.

It's all about good clean water…

Tennessee River, Chattanooga

AquaShield
WATER TREATMENT SOLUTIONS

Thank you.

AquaShield
WATER TREATMENT SOLUTIONS

INNOVATING GOOD CLEAN WATER

Mark Miller mmiller@aquashieldinc.com

2733 Kanasita Drive, Suite 111
Chattanooga, Tennessee 37343
888-344-9044

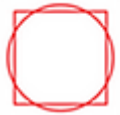
www.AquaShieldInc.com

Permaculture and Low Impact Development (LID)

By Patrick Padden

CASFM Annual Conference

September 27, 2018



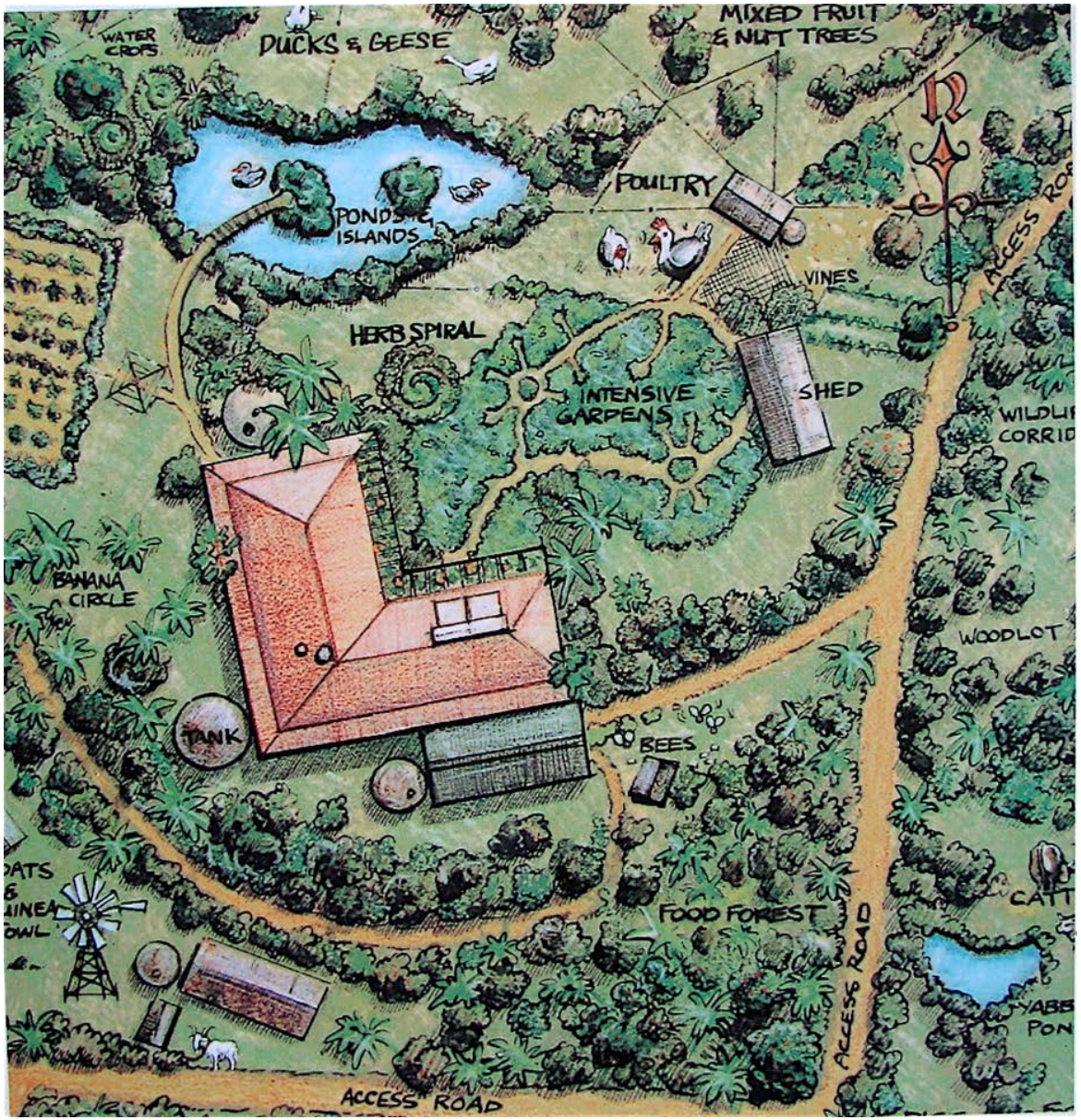
PADDEN PERMACULTURE

Ecological Landscape Design and Build

970-999-4306

Permaculture is a combination of sustainable site design, energy smart technology, edible landscaping, and innovative water management practices.

PERMACULTURE

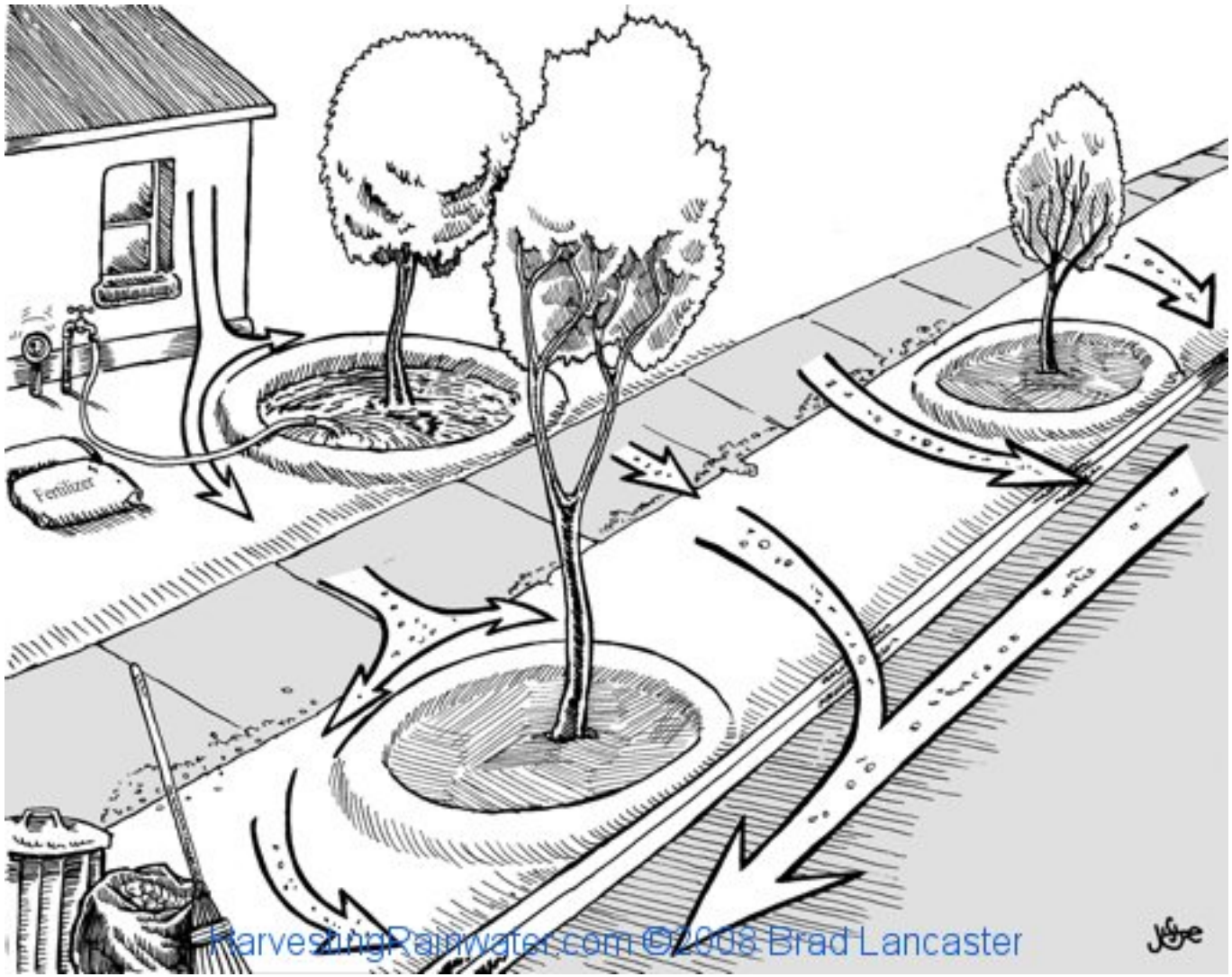


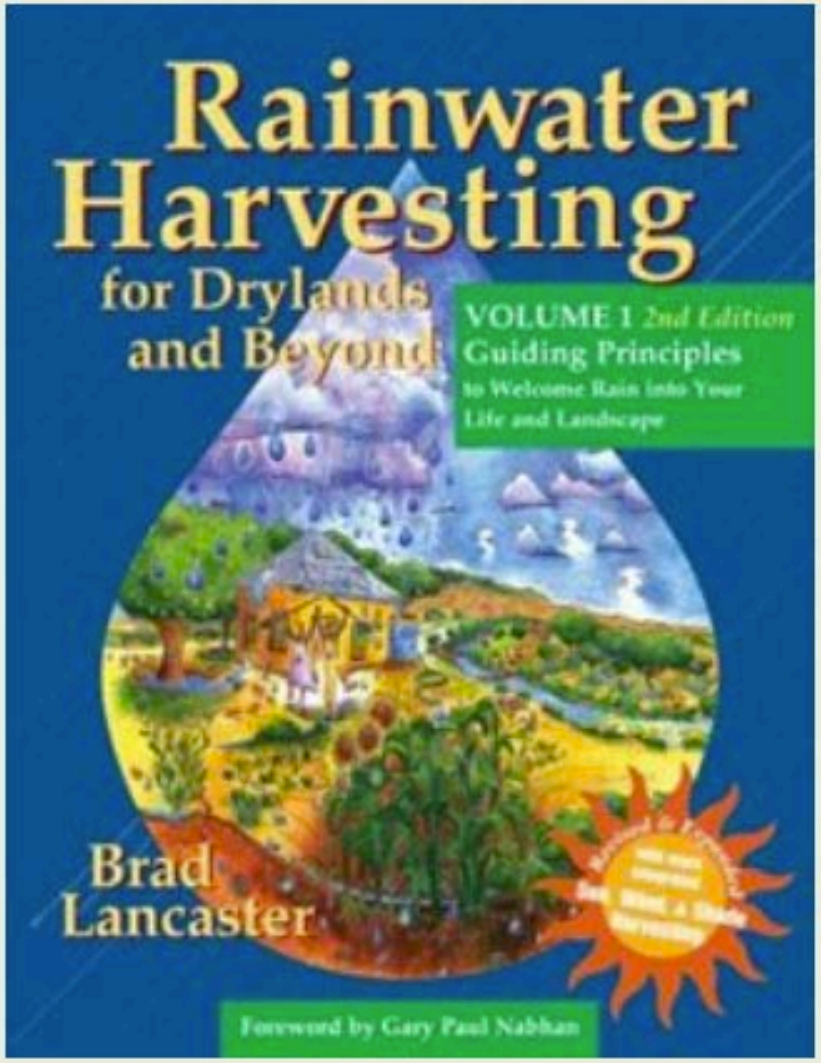
Bill Mollison's *Permaculture One*

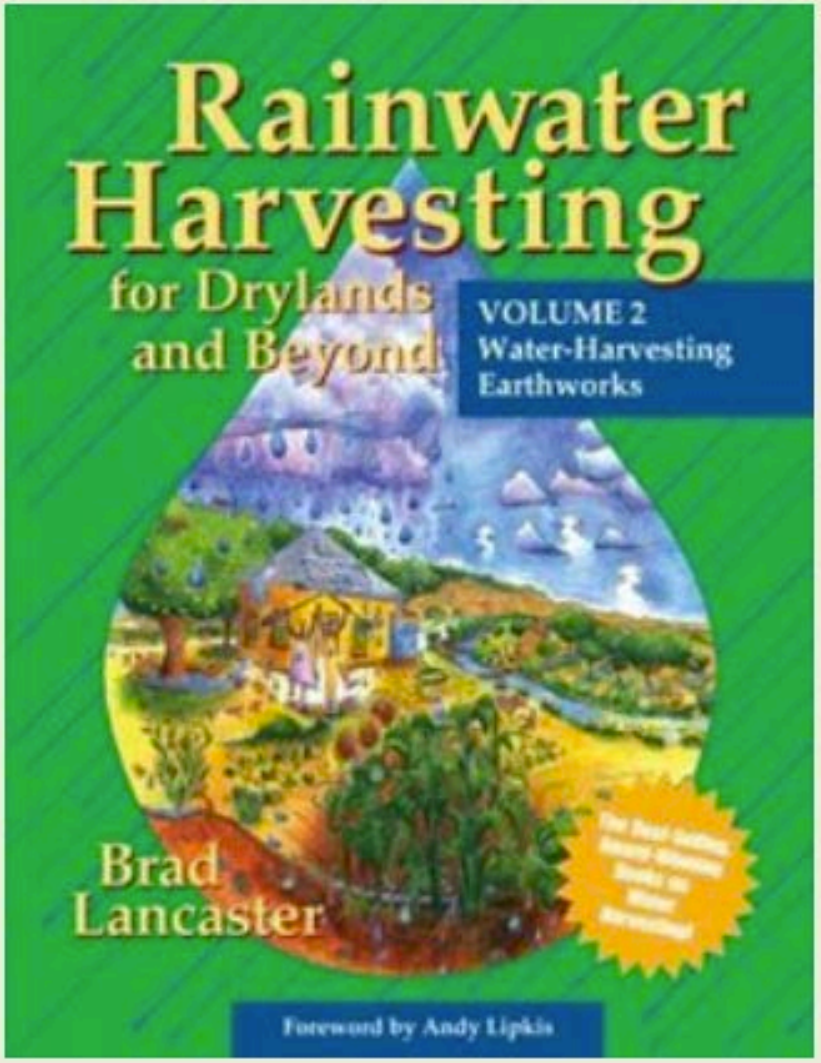
Joseph Jenkins Humanure *Handbook*


Established Pattern
Front Range Cities, Colorado

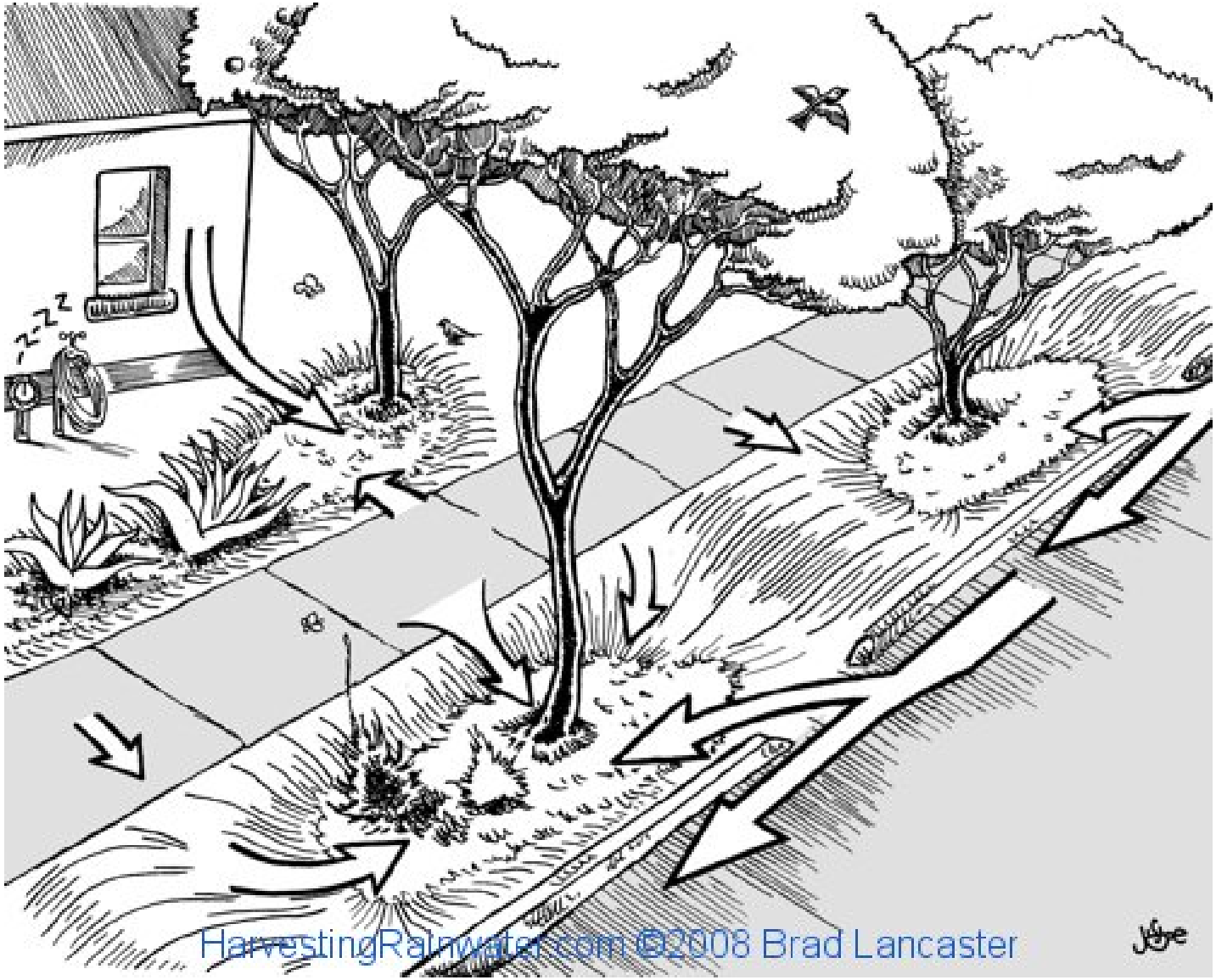
A landscape on the wasteful path to scarcity. Rain, runoff, and topsoil are quickly drained off the landscape to the street where the sediment-laden water contributes to downstream flooding and contamination. The landscape is dependent upon municipal/well water irrigation and imported fertilizer

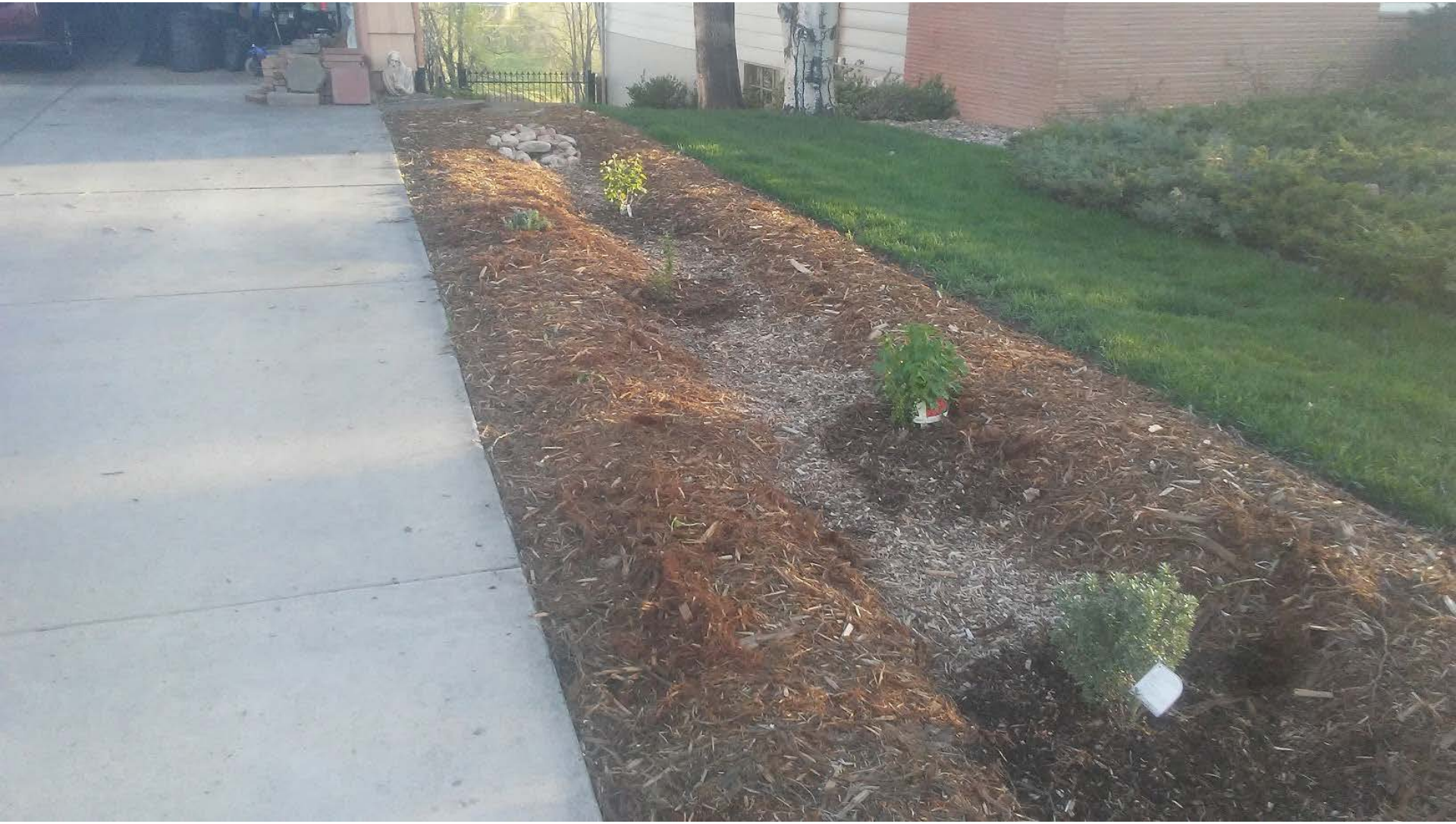



Rainwater Harvesting
for Drylands and Beyond
VOLUME 1 2nd Edition
Guiding Principles
to Welcome Rain into Your Life and Landscape
Brad Lancaster
Foreword by Gary Paul Nabhan


Rainwater Harvesting
for Drylands and Beyond
VOLUME 2
Water-Harvesting Earthworks
Brad Lancaster
Foreword by Andy Lipkis

A landscape on the stewardship path to abundance. Rain, runoff, leaf drop, and topsoil are harvested and utilized with the landscape contributing to flood control and enhanced water quality. The system is self-irrigating with rain and self-fertilizing with harvested organic matter.





Xeriscape Projects

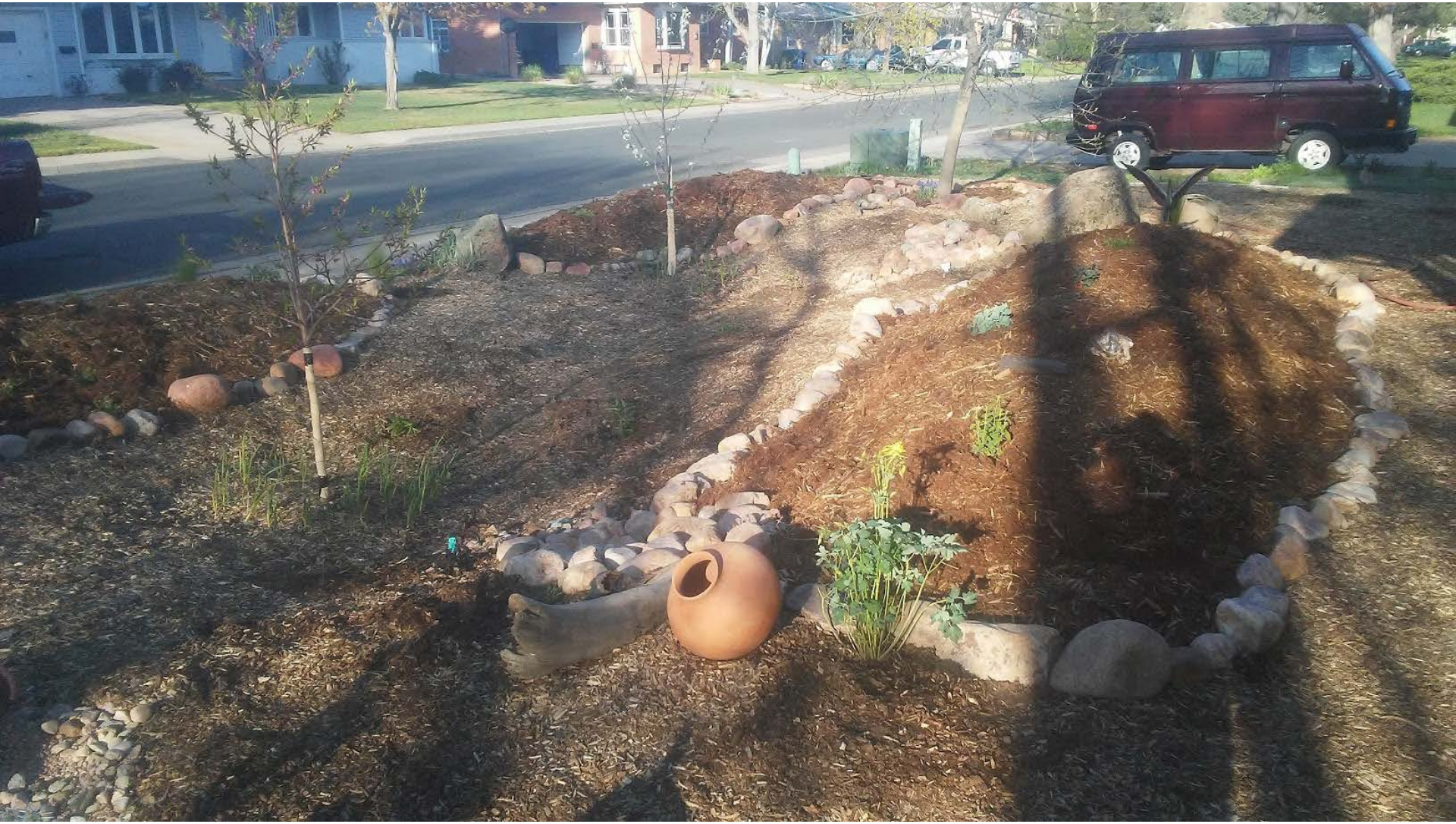
Xeriscape is not one particular style or look –
it's the creation of a healthy, attractive landscape that conserves water.

Xeriscape
•Provides a diversity of seasonal colors and textures
•Lowers outdoor water use 30-50 percent
•Reduces yard maintenance

PADDEN PERMACULTURE

PADDEN PERMACULTURE

Padden Permaculture



Patio Projects

Perennial Polycultures
I group plants together in a way that mimics natural ecosystems, but I select species that are especially productive for humans.

Plant List
-Toka Plum
-Stanley Plum
-Golden Raspberry
-Blackberry
-Strawberry
-Lead Plant (Nitrogen Fixer)
-Comfery (Dynamic Accumulator for soil fertility)
-Goji Berry
-Western Sand Cherry
-Black and Red Currant
-Culinary Herbs
-Alliums and Citronella for Insect repellent

Rainwater Harvesting Patios
I always design an infiltration basin around the perimeter of my patios. This feature allows runoff to passively irrigate useful plants

Downspout Incorporation
The runoff from downspouts is often an under valued resource in conventional landscape designs, but is always integrated in a Padden Permaculture Design


STOP

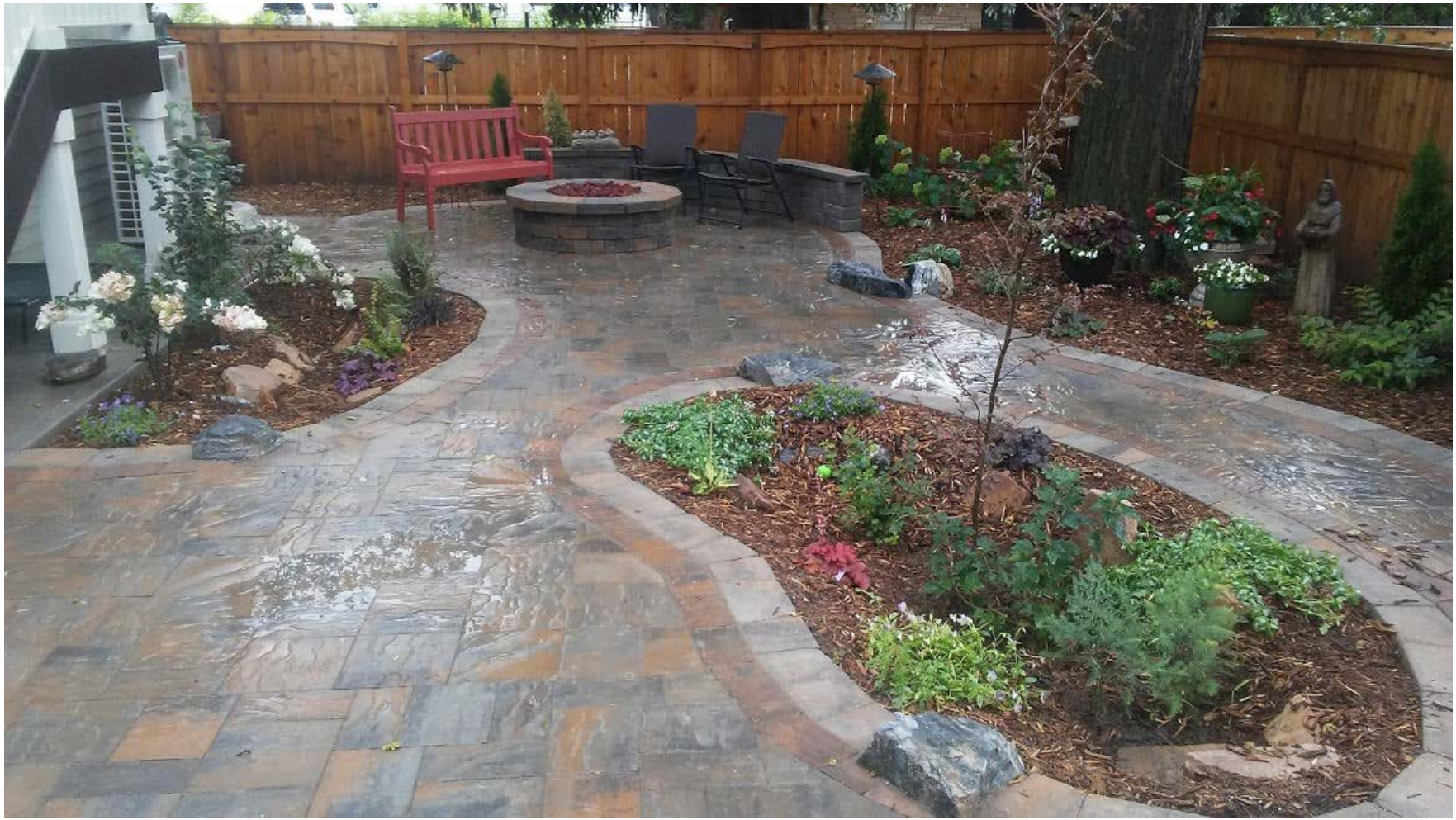

HITACHI

PADDEN PERMACULTURE

Greywater Harvesting Laundry Machine

Brad Lancaster Design

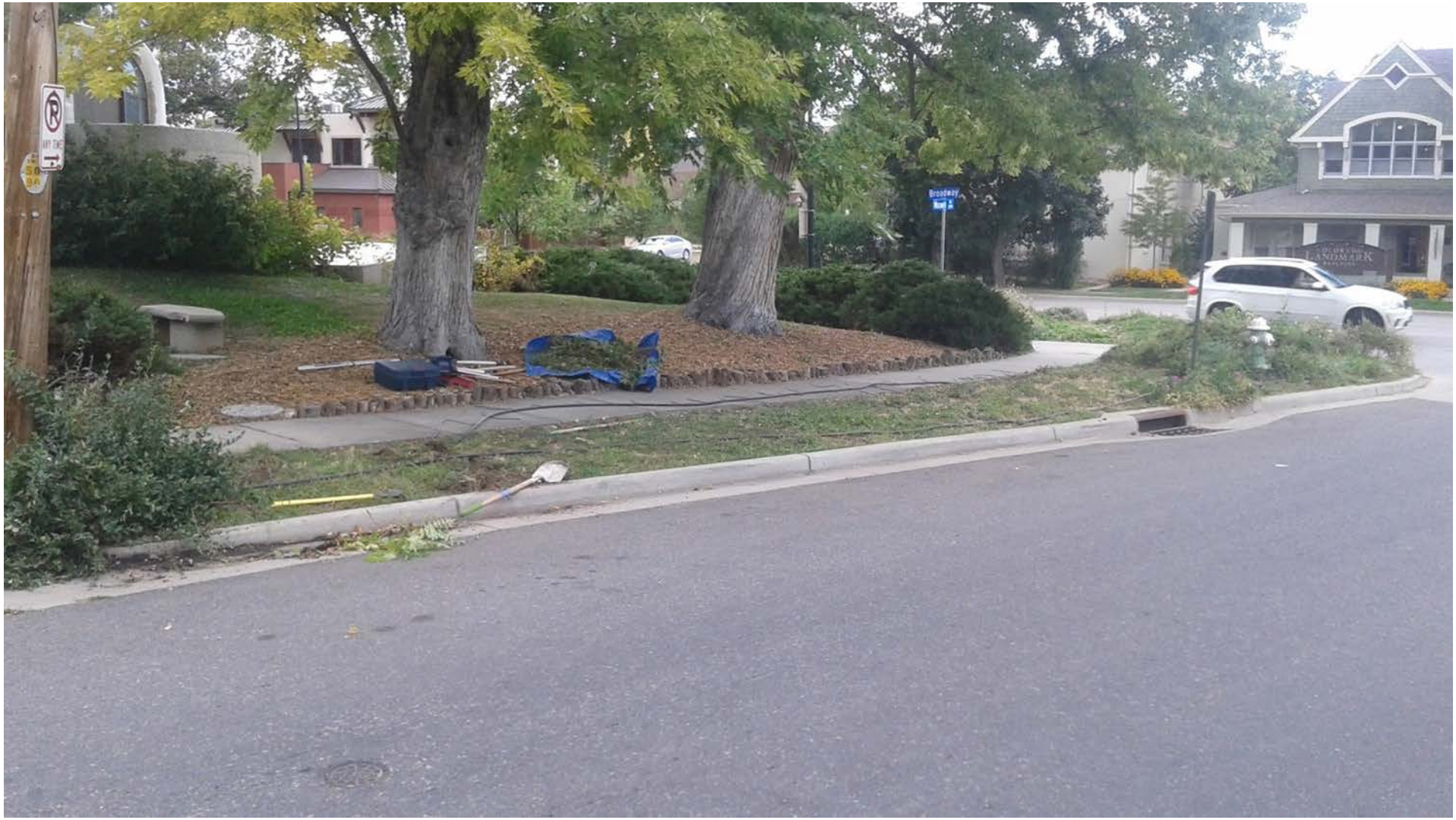
Tucson, Arizona



Padden Permaculture

Edible Landscaping

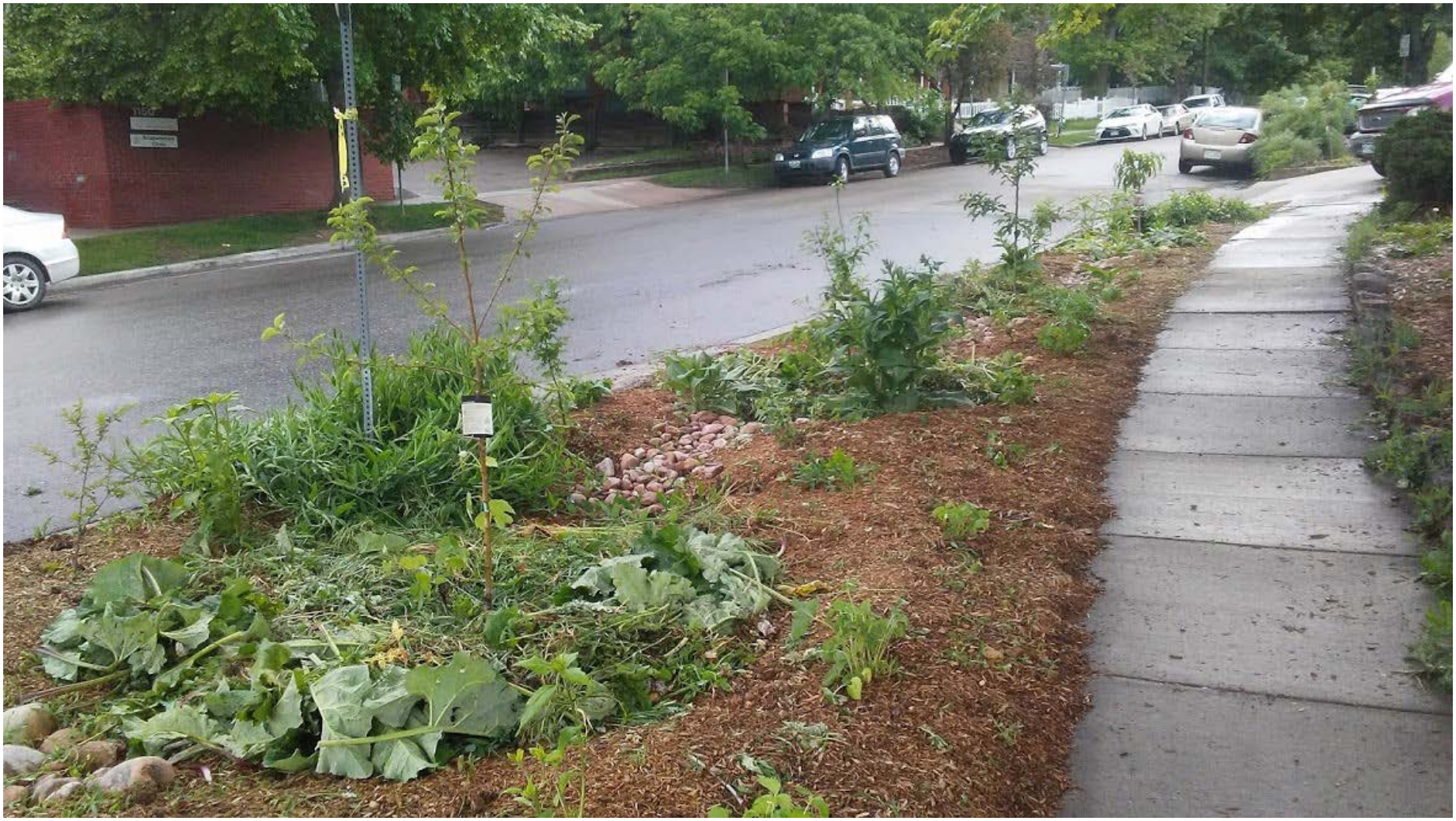
Landscapes designed with permaculture in mind will often incorporate groupings of fruits and veggies, usually perennial varieties to make the most efficient use of space


Broadway
LANDMARK


STOP

Padden Permaculture


LANDMARK



PADDEN PERMACULTURE

White Mulberry

Concord Grape

Siberian Pea Shrub

Sea Berry

Storm Water Overflow Apron

Desert four o'clocks

Nanking Cherry

Lavender

Sweet Pea

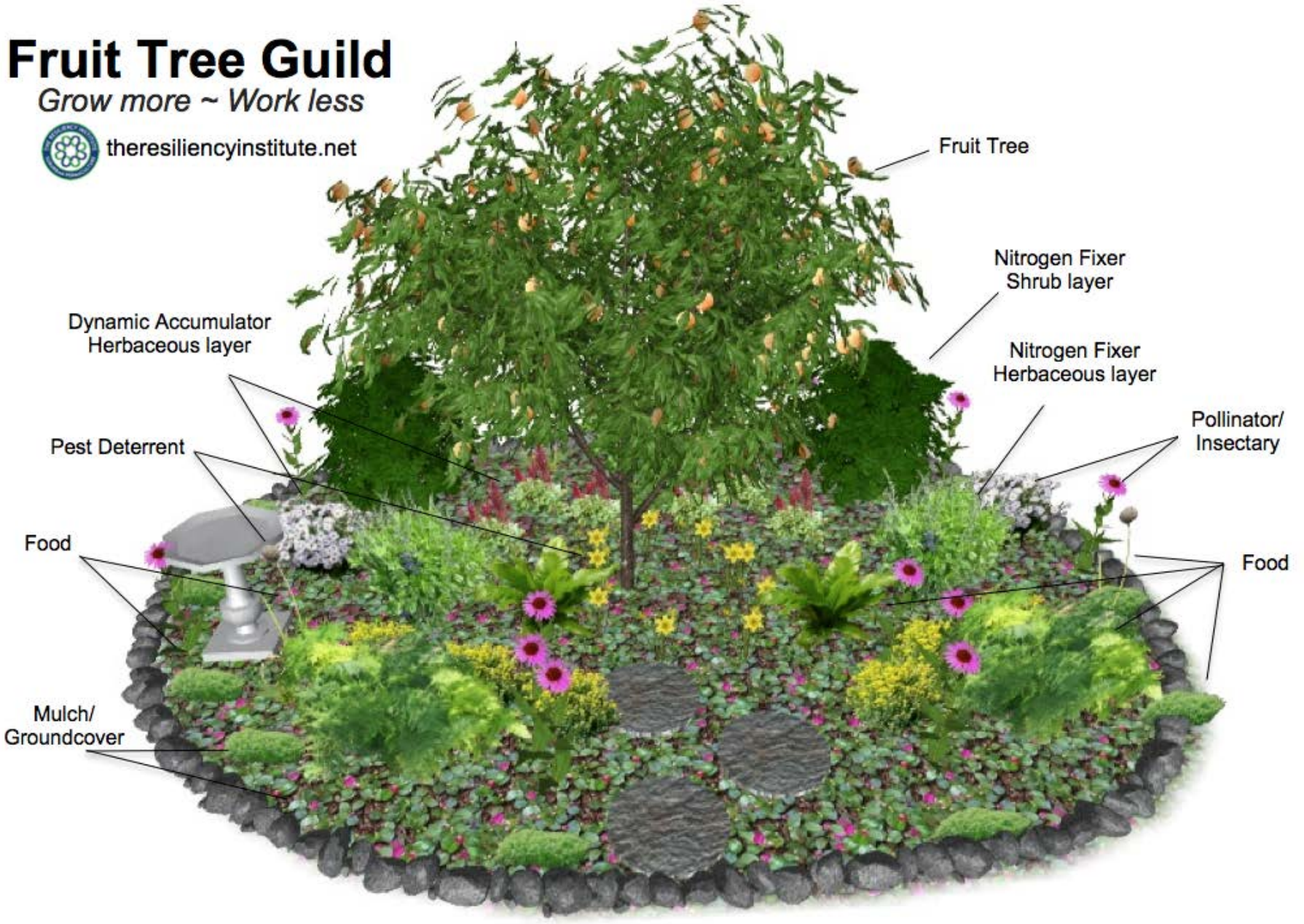
Strawberry

Collection Basin

Fruit Tree Guild

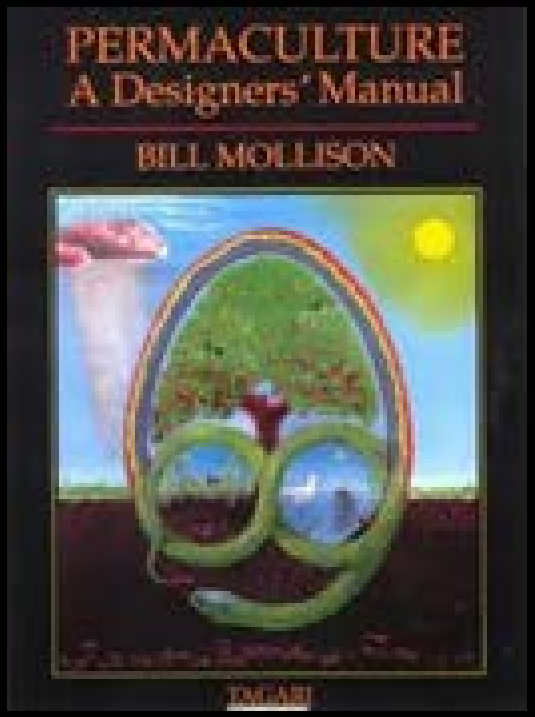
Grow more ~ Work less

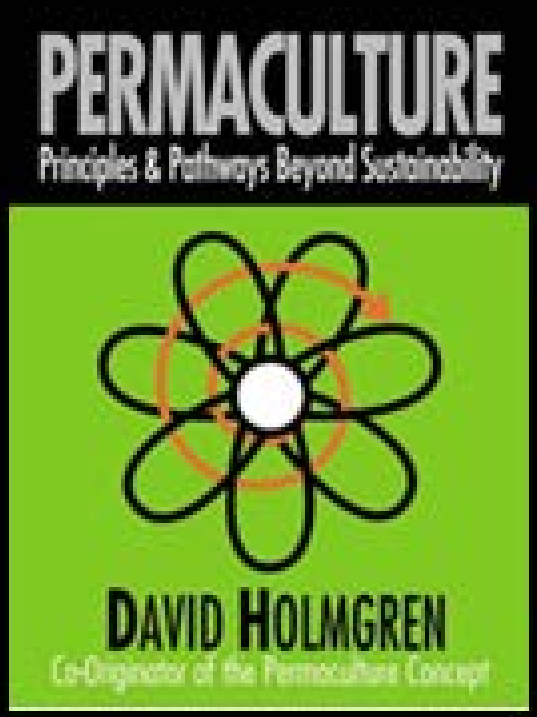
theresiliencyinstitute.net

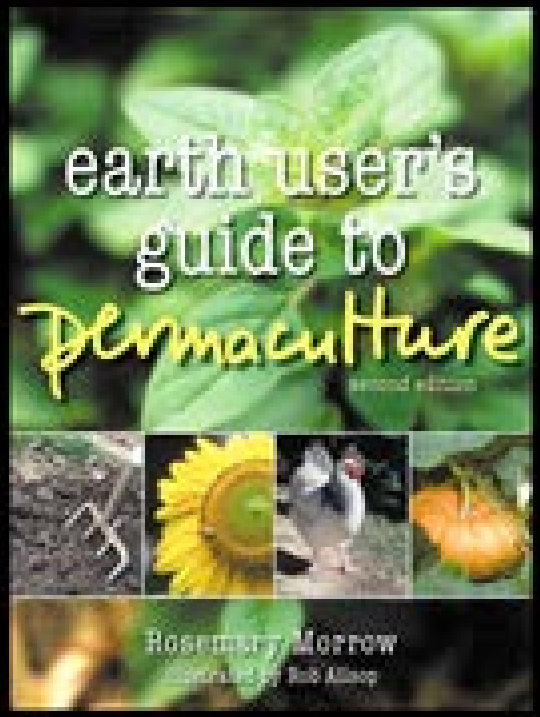


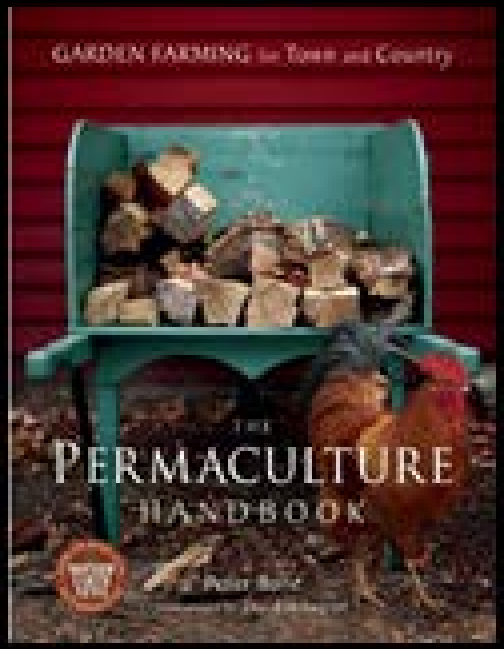

P
NO PARKING
ANYTIME

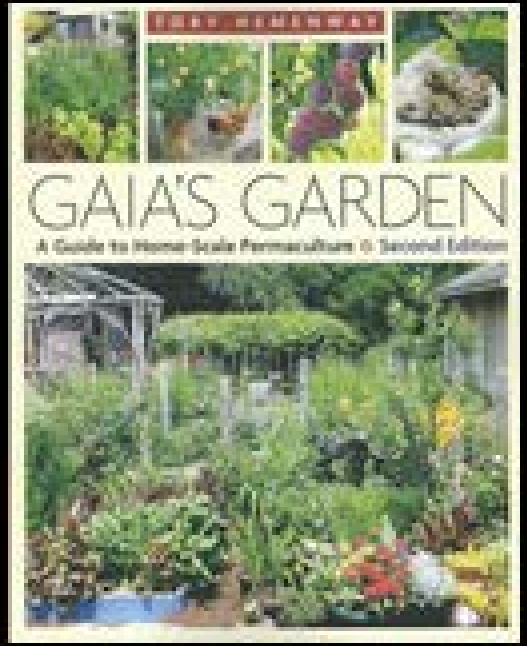

Harvesting Street Runoff
People's Food Co-op
Portland, Oregon

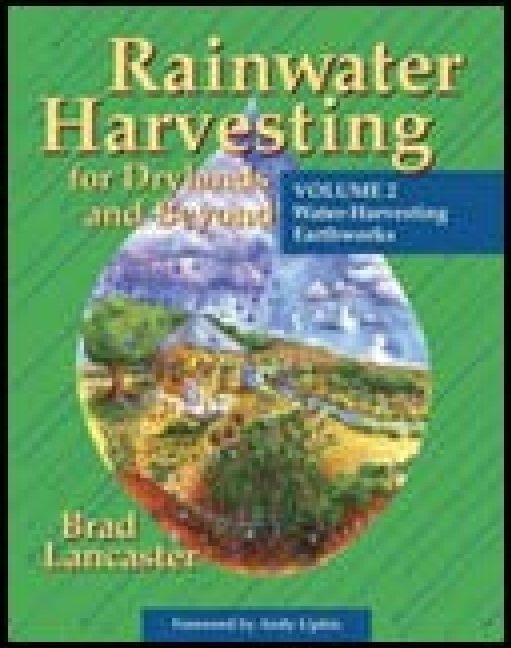

PERMACULTURE
A Designers' Manual
BILL MOLLISON


PERMACULTURE
Principles & Pathways Beyond Sustainability
DAVID HOLMGREN
Co-Originator of the Permaculture Concept


earth user's guide to
Permaculture
Rosemary Morrow


GARDEN FARMING for Town and Country
THE
PERMACULTURE
HANDBOOK


GAIA'S GARDEN
A Guide to Home-Scale Permaculture


Rainwater
Harvesting
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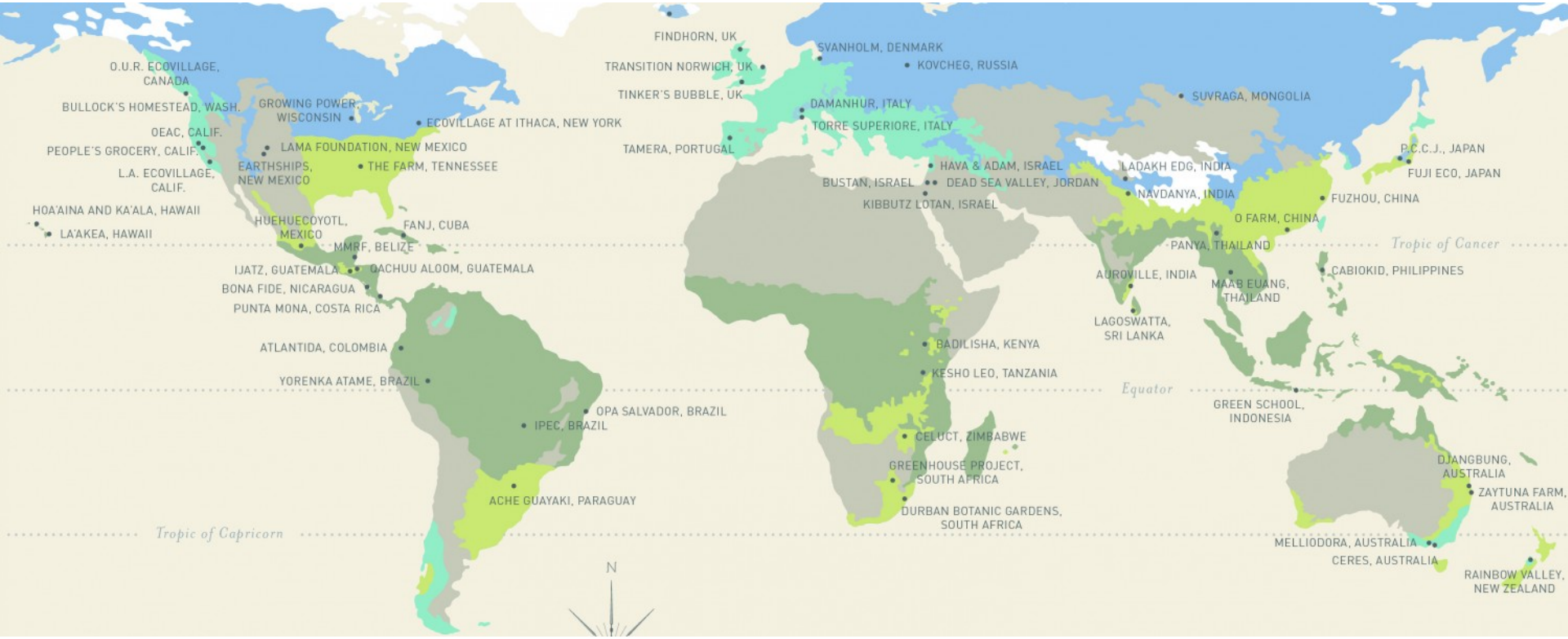
VOLUME 2
Water Harvesting
Earthworks
Brad
Lancaster

Permaculture Sites Around the World



Permaculture is a global movement that is providing solutions to many of the world's social and ecological challenges.

Permaculture Action Day, Loveland Colorado 2015

SUNRISE RANCH

Permaculture Design Certificate (PDC)

July 20— Aug. 1, 2019
Sunrise Ranch, Colorado

11 day permaculture course

-permaculture design process

-rainwater harvesting and earthworks

-natural building and appropriate technology

-regenerative tools and techniques

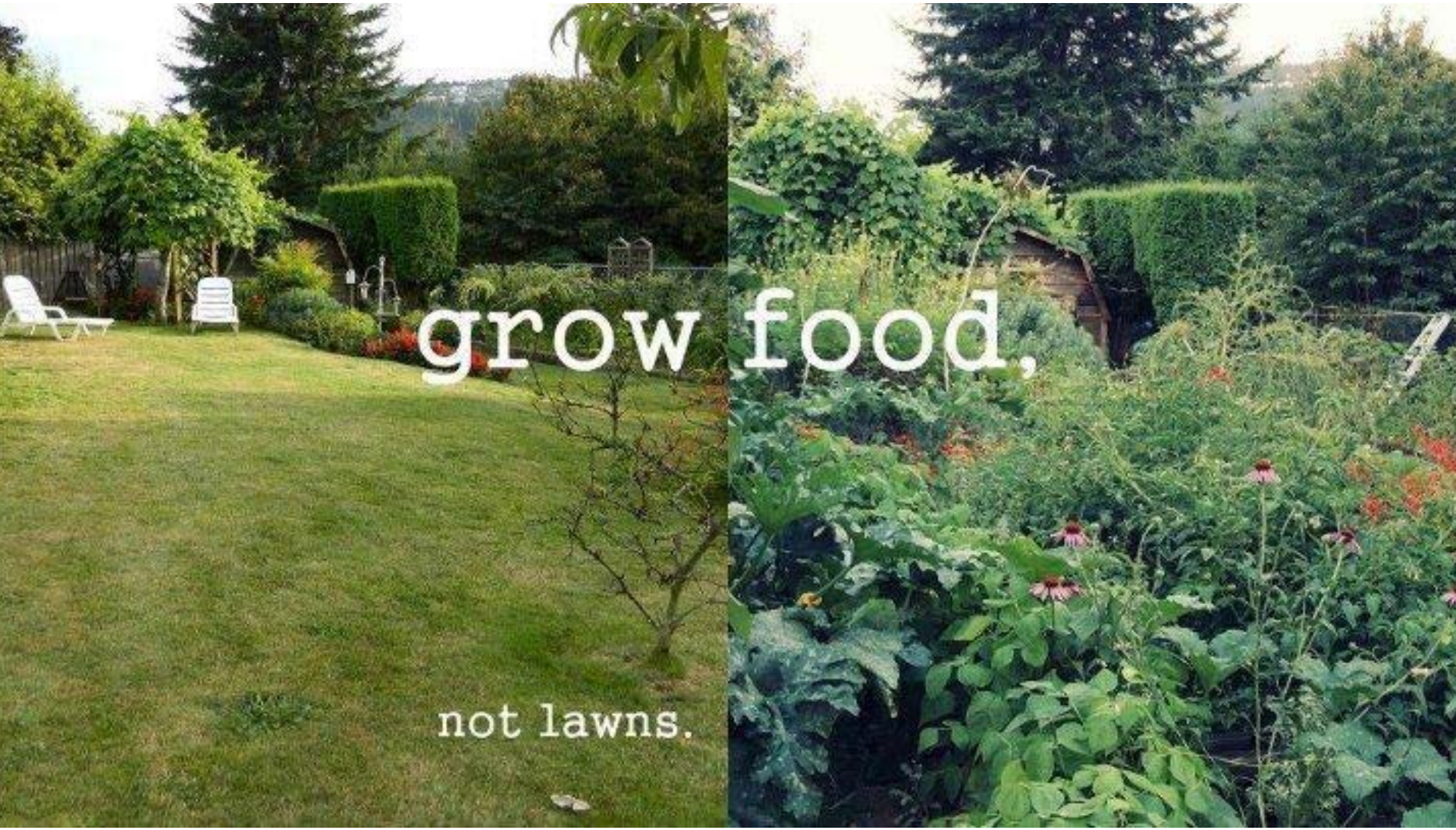
-permaculture gardening and food forestry

-animals, soils, compost

Padden Permaculture

Ecological Landscape Design and Build

970-999-4306


grow food,
not lawns.

Comprehensive Watershed Planning: Prioritize, Target and Implement Multipurpose Projects

2018 Annual CASFM Conference
Texas Floodplain Management Association

HRGreen

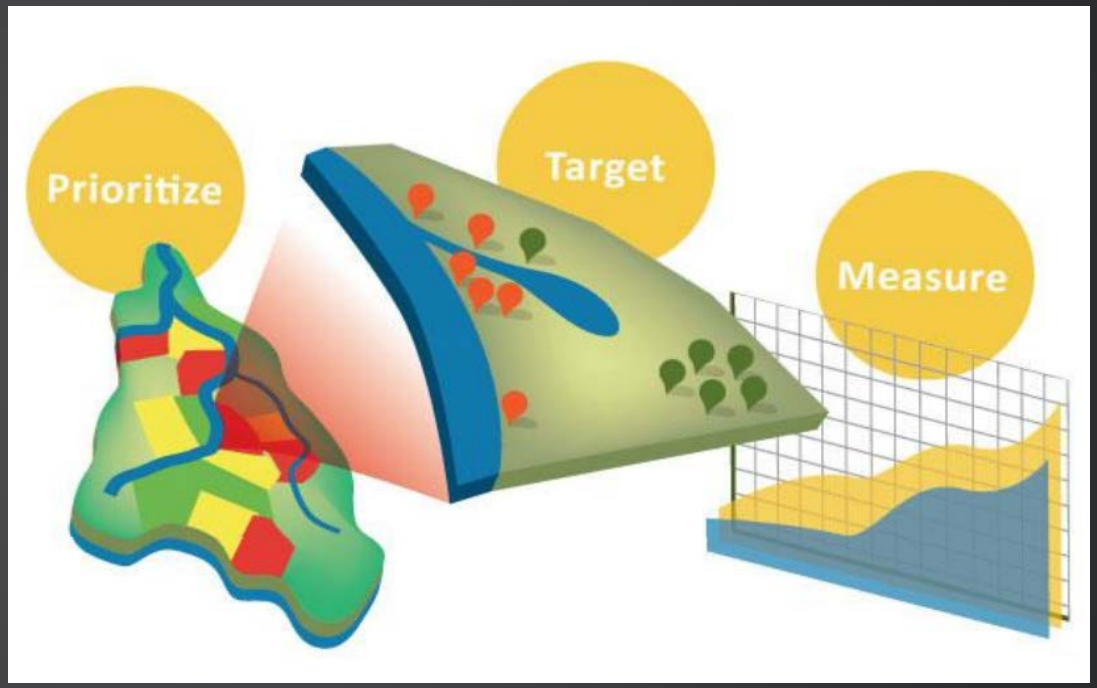
Introduction

- PART 1
  - What is 1W1P?
  - How it came to be
  - Planning funding
  - Operation of plan
  - Implementation funding
- PART 2
  - Case study

PART ONE – 1W1P OVERVIEW

What is 1W1P?

- Aligns local water planning towards watershed-based implementation
- 63 HUC8 (~700 mi^2)
- Comprehensive
- Formal agreements
- No new governing agency



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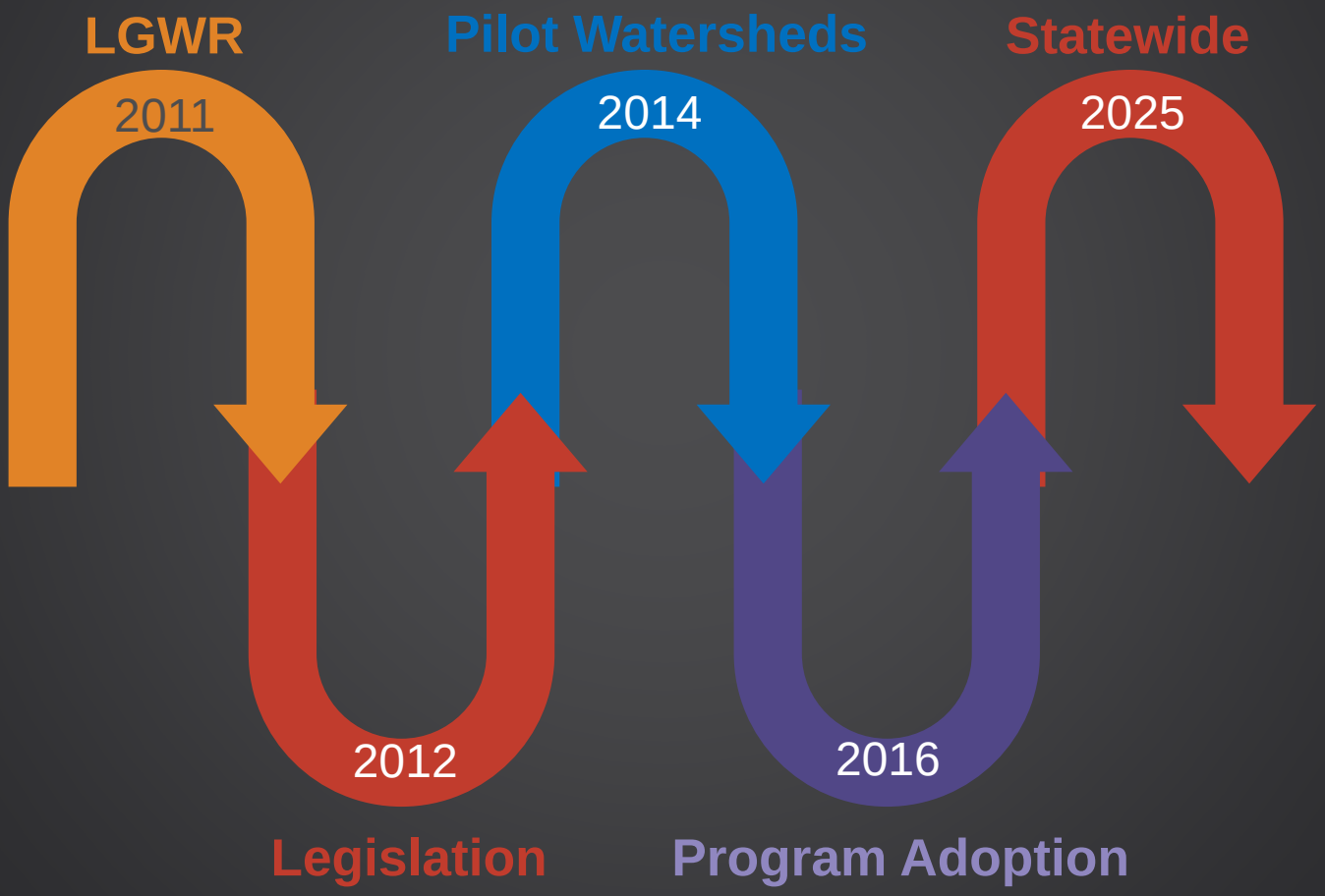
- Assemblage of all locally-relevant plans, programs and studies
- Statement of existing watershed status
- Unified agreement on priority values
- Vision of long-term management goals by value
- Selection of 10-year management targets
- Identification of implementation actions
- Prioritization of actions based on ability to meet multiple goals
- Prioritized, targeted and measurable goals

What is 1W1P?

Part of MN's 10-yr management cycle

1. Monitoring
2. Issues and stressors
3. WRAPS
4. 1W1P
5. Voluntary implementation

How it came to be



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Planning funding

Nov 2008 voters approved CWF to:

- Protect drinking water sources
- Protect, enhance, and restore lakes, rivers, streams, and groundwater
- Protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat
- Support parks and trails
- Preserve arts and cultural heritage

Operation of plan development

Planning Groups	Description
Policy Committee	Local plan authorities purposed with making final decisions about plan content and regarding expenditure of planning funds. Final owner and operator.
Advisory Committee	Various local, State, Federal, Tribal and NGO technical members. Makes recommendations on plan content and implementation to the Policy Committee.
Work Planning Group / Steering Committee	A small group of local staff, BWSR Board Conservationist, and consultants for the purposes of logistical and process decision-making in the plan development process.

Plan partners

- Municipalities/Townships
- Counties
- Soil and Waters Conservation Districts
- Watershed Districts
- Flood Management Authorities
- State BWSR, DNR, DOT, DOH, etc.
- USFS, USACE, USFWS
- Tribal Government
- NGOs and Public

Required
Voluntary

Planning process

Plan content

- Executive summary
- Land and Water narrative
- Priority resources and issues
- Measurable goals
- Targeted implementation schedule
- Plan implementation programs
- Plan administration and coordination

Operation of plan implementation

Type of Governance Agreement	Description
Memorandum of Agreement (MOA)	An agreement between multiple parties; method of formally recognizing a partnership; specifies mutually-accepted expectations and guidelines
Joint Powers Agreement (JPA)	Agreement to jointly deliver a service or a product
Joint Powers Board (JPB)	Type of JPA that specifically establishes a new entity or board that operates autonomously from the members. Risk is transferred to this entity.
Watershed District (WD)	Formal local unit of government, defined by hydrologic boundary and formed by a local petition process

Implementation funding

- Watershed-based funding
- $4,875,000 Y1
- $4,875,000 Y2
- 10% non-State match (cash or in-kind)
- Eligible activities

PART TWO – CASE STUDY

Case study – Leech Lake River 1W1P

- 1,335 mi^2
- 3 counties
- Leech Lake Bank of Ojibwe
- 277 river miles
- 750 lakes (166,374 acres)
- Northern Lakes and Forest Ecoregion
- Largely forested
- 46% privately held land
- Some of most pristine lands in MN

Case study – Leech lake River 1W1P

Planning Groups	Description
Policy Committee	Cass Environmental Services Dept, Cass SWCD, Hubbard County, Hubbard SWCD
Advisory Committee	Cities, Chamber of Commerce, Counties, The Nature Conservancy, USACE, MNDNR, USFS
Work Planning Group / Steering Committee	Cass and Hubbard SWCD Administrators, BWSR BC, Leech Lake Band of Ojibwe, Leech Lake Area Watershed Foundation, Consultants

Case study – Leech Lake River 1W1P

Natural Resources

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Case study – Leech Lake River 1W1P

Climate and Risk

Case study – Leech Lake River 1W1P

Leadership

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Case study – Leech Lake River 1W1P

Quality of Life

Case study – Leech Lake River 1W1P

1. High Quality Lakes
2. Recreational Lakes
3. Impoundments
4. Impaired Lakes
5. High Value/Priority Rivers and Streams
6. Declining, Impaired and Channelized Rivers and Streams
7. Wetlands
8. Groundwater
9. Upland Resources – Forests
10. Upland Resources – Habitat
11. Upland Resources - Working lands
12. Upland Resources - Cities and towns

Case study – Leech Lake River 1W1P

PRIORITY NATURAL WORLD VALUES AND THE 10-YEAR PLAN GOAL ATTAINMENT LEVEL

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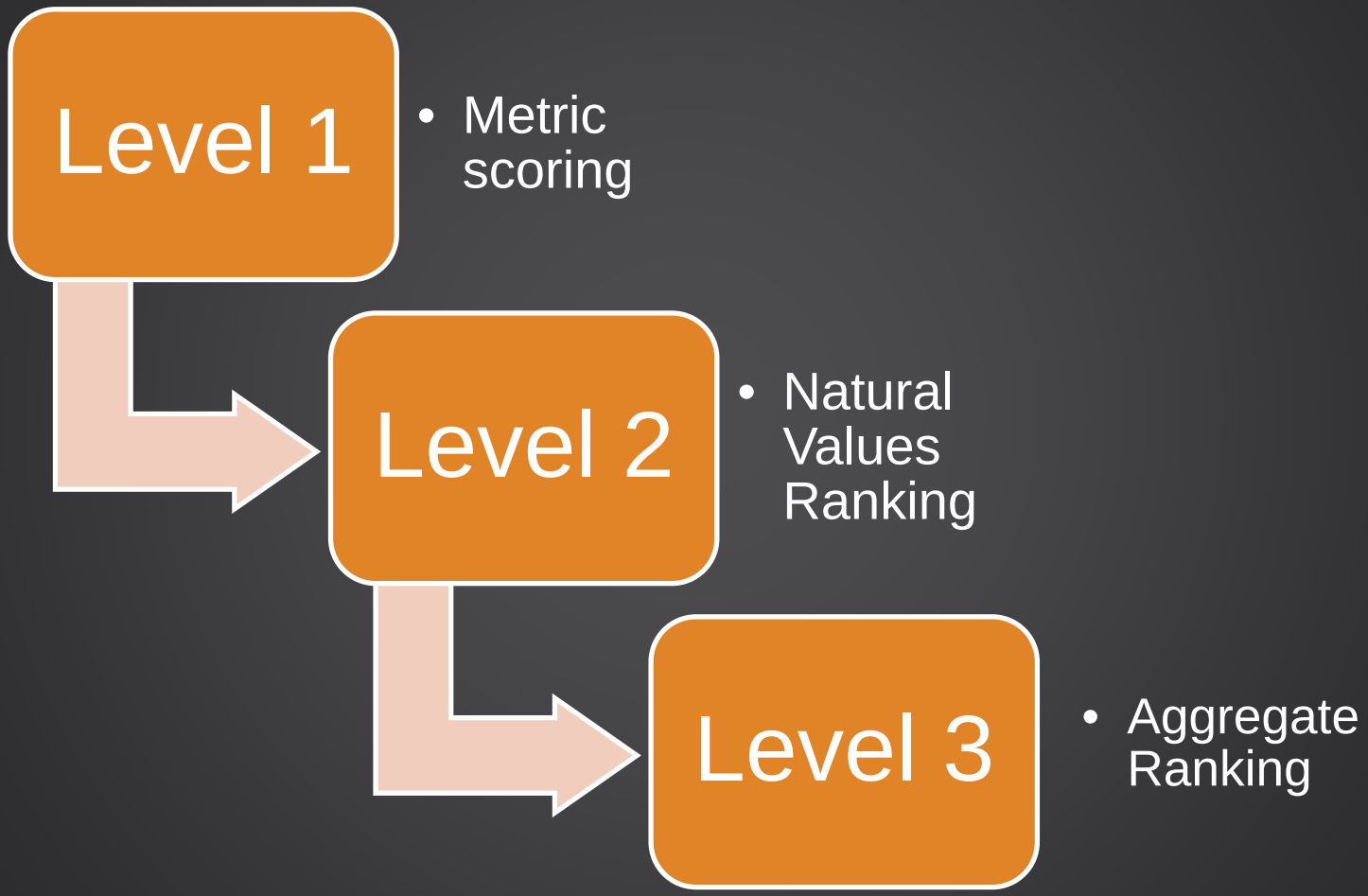
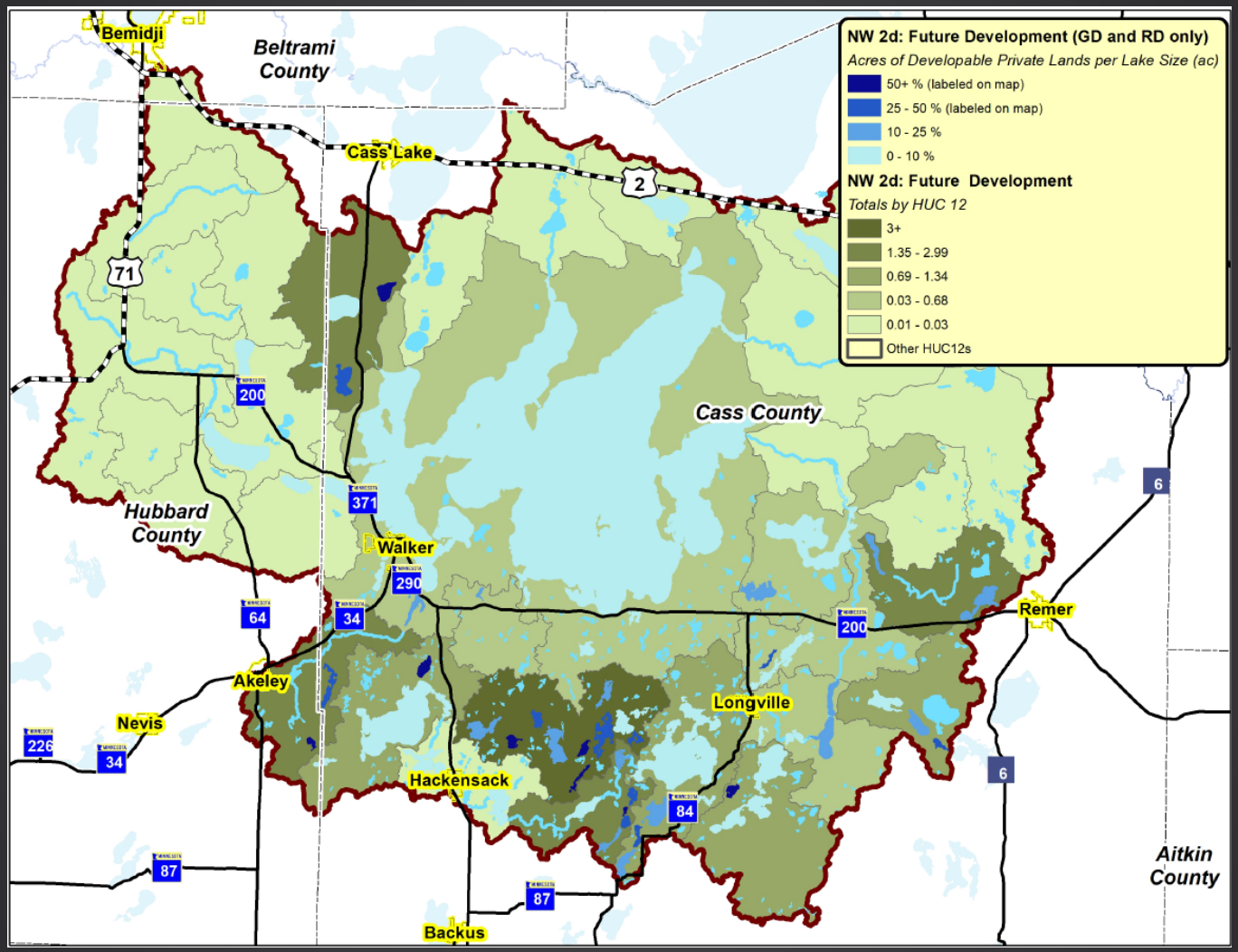
Case study – Leech Lake River 1W1P



Case study – Leech Lake River 1W1P

HIGH QUALITY LAKES METRICS	SCORING	DATA SETS
Coldwater Habitat Presence	Yes = 1, No = 0.01	WRAPS
P-Sensitivity Lake Presence	0.33, 0.66 and 1.0; high, higher highest	State 2108 data
WQ Trend	Close to threshold = 1 Declining trend = 0.66 No data = 0.33; rising = 0.01	State 2017 data
Forest	Composite score above mean = 1 (X=99.08; range = 15 – 175)	Forests of the Future data
Terrestrial Biodiversity	Yes = 1, No = 0.01	State MCBS Biodiversity data
WRAPS Priority Lake	Yes = 1, No = 0.01	WRAPS
Lakes of Biological Significance	Outstanding =1 High = 0.66 Moderate = 0.33	WRAPS
Wild Rice Lake	High = 1 (local = high and/or DNR List = high) High = 0.66 Moderate = 0.33 No data or zero value = 0.01	State Top 350 lakes and Local Preference data

Case study – Leech Lake River 1W1P



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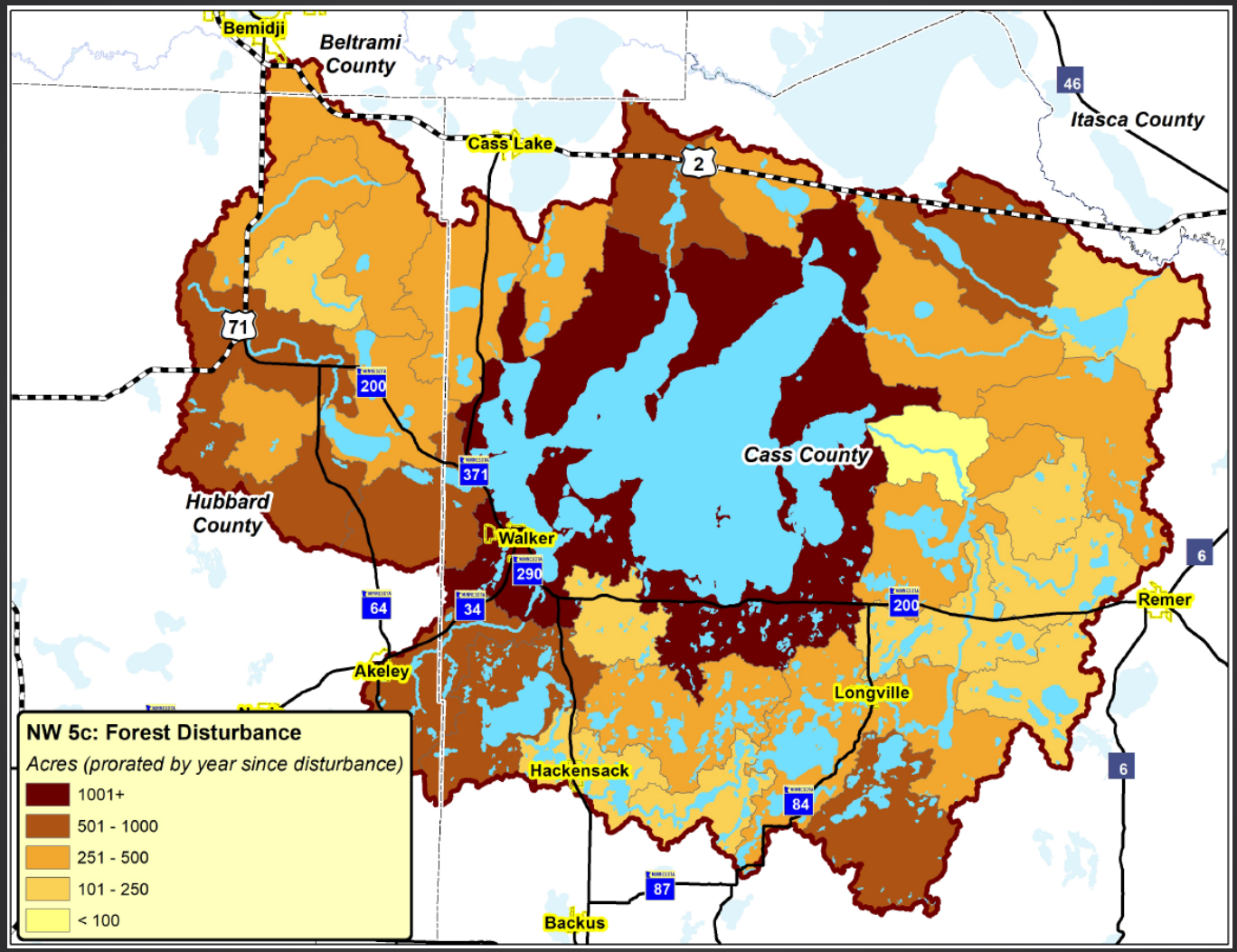
Case study – Leech Lake River 1W1P



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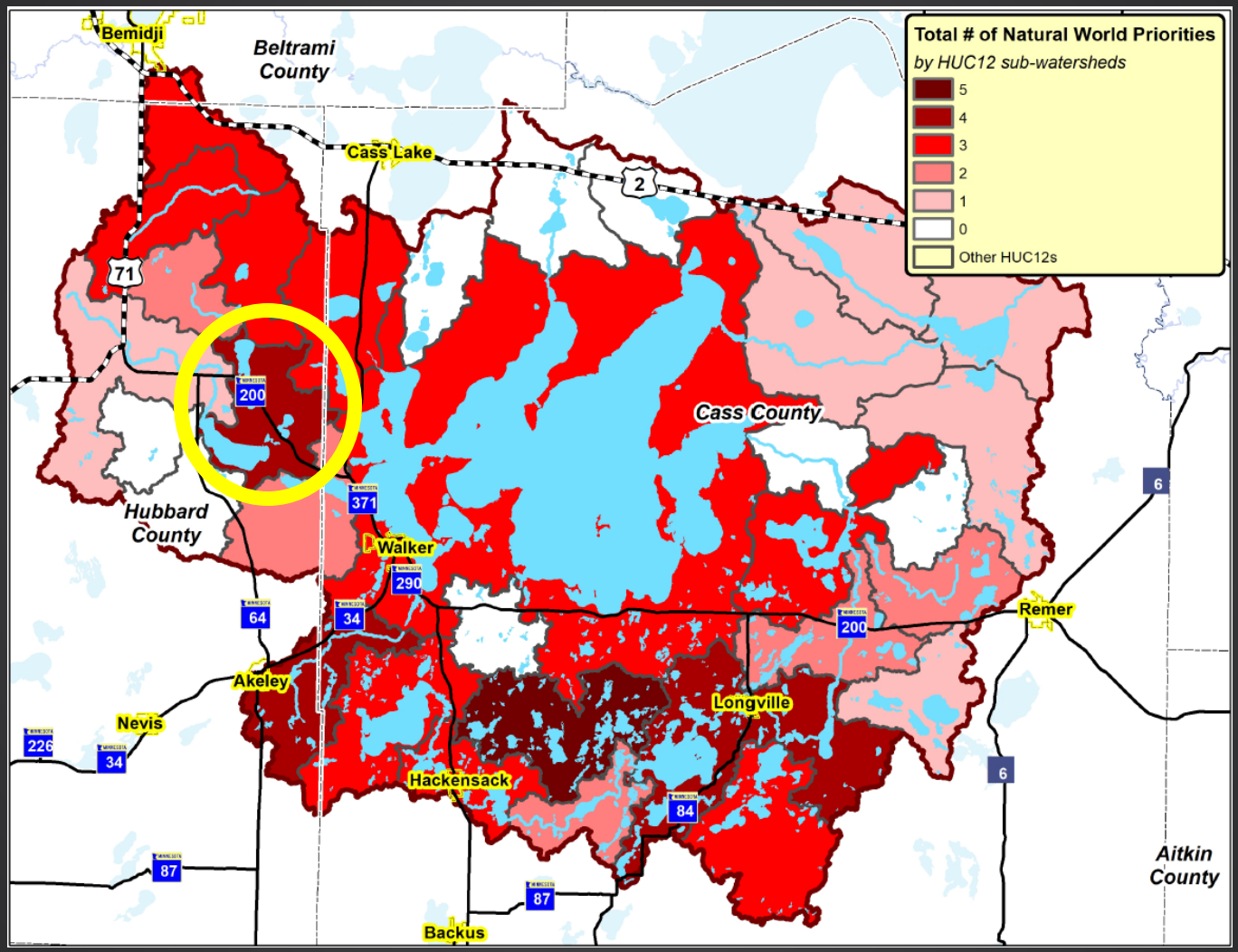
Case study – Leech Lake River 1W1P



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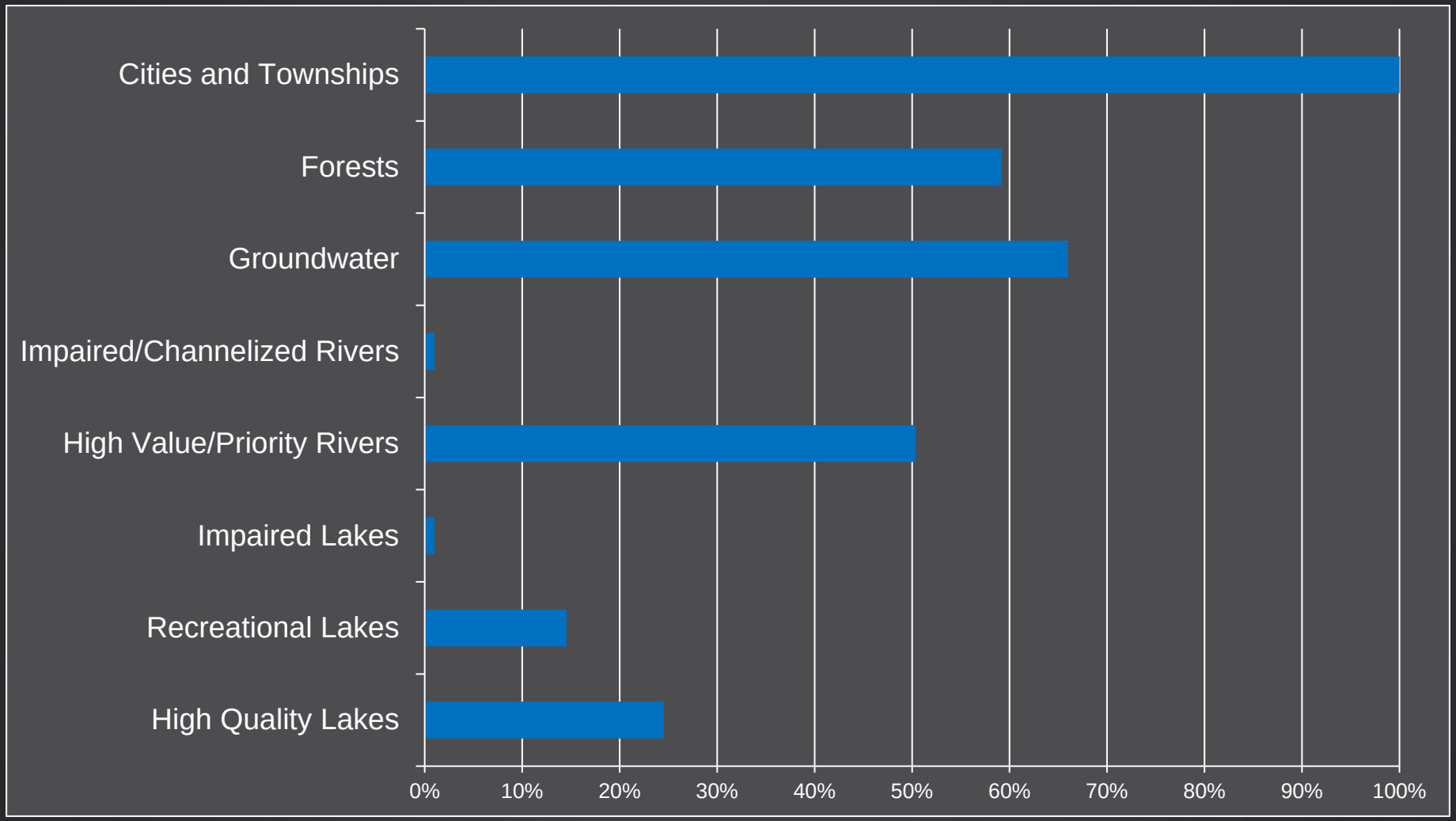
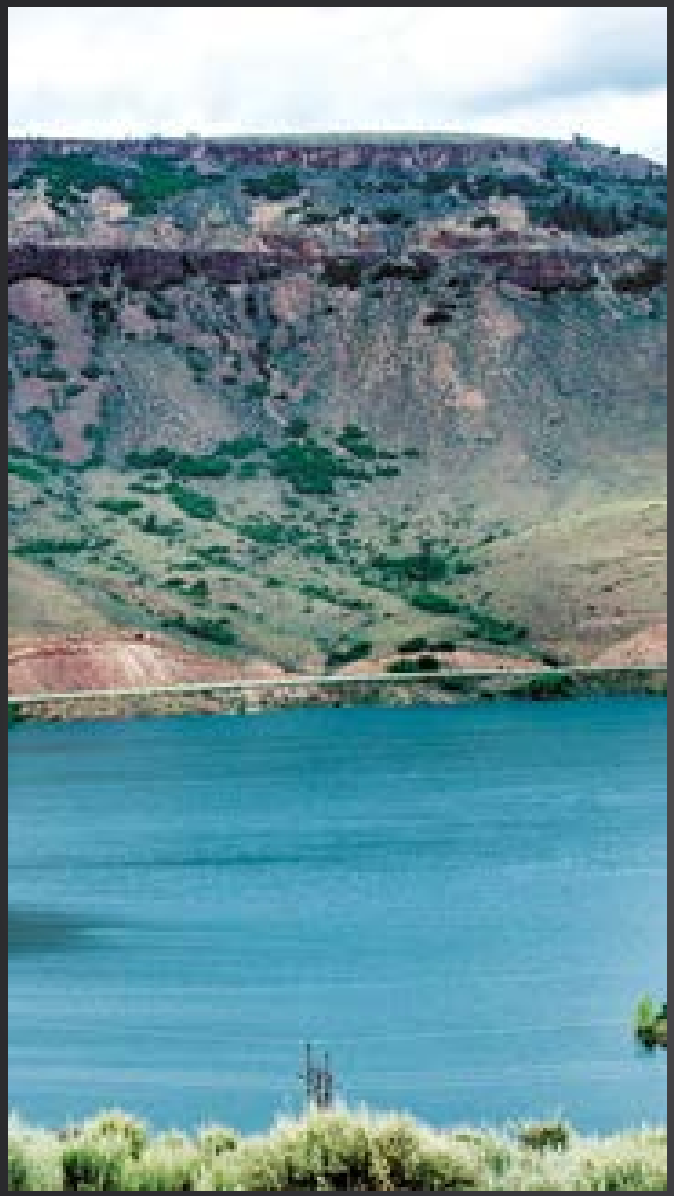
Case study – Leech Lake River 1W1P



Case study – Leech ake River 1W1P

Resource	Management Strategy
Cities and Townships	1. Urban stormwater management for City of Laporte (particular attention to highway runoff) 2. Update stormwater management. 3. Stormwater management plan for future development including land development and Stormwater ordinance updates.
Groundwater	1. Update ground water plan with Geologic Atlas and shallow well data. 2. Targeted well-monitoring. 3. SSTS Management (inventory, functional assessment) for Garfield Lake 4. Groundwater/Wetland management in Garfield Lake lakeshed.
Forests and Working Lands	1. Conservation easements and forestry management incentives on private lands (riparian and non-riparian) in Garfield and Kabekona lakesheds.
Kabekona River	1. SSTS Management (inventory, functional assessment, regulatory) 2. River corridor regulation 3. Wild Rice easements 4. Riparian easements and acquisitions 5. Riparian conservation and stewardship 6. Stormwater water quality and temperature stormwater BMPs 7. Culvert hydraulic, hydrologic, sediment transport and fish barrier inventory and assessment priority. 8. Pasture management.

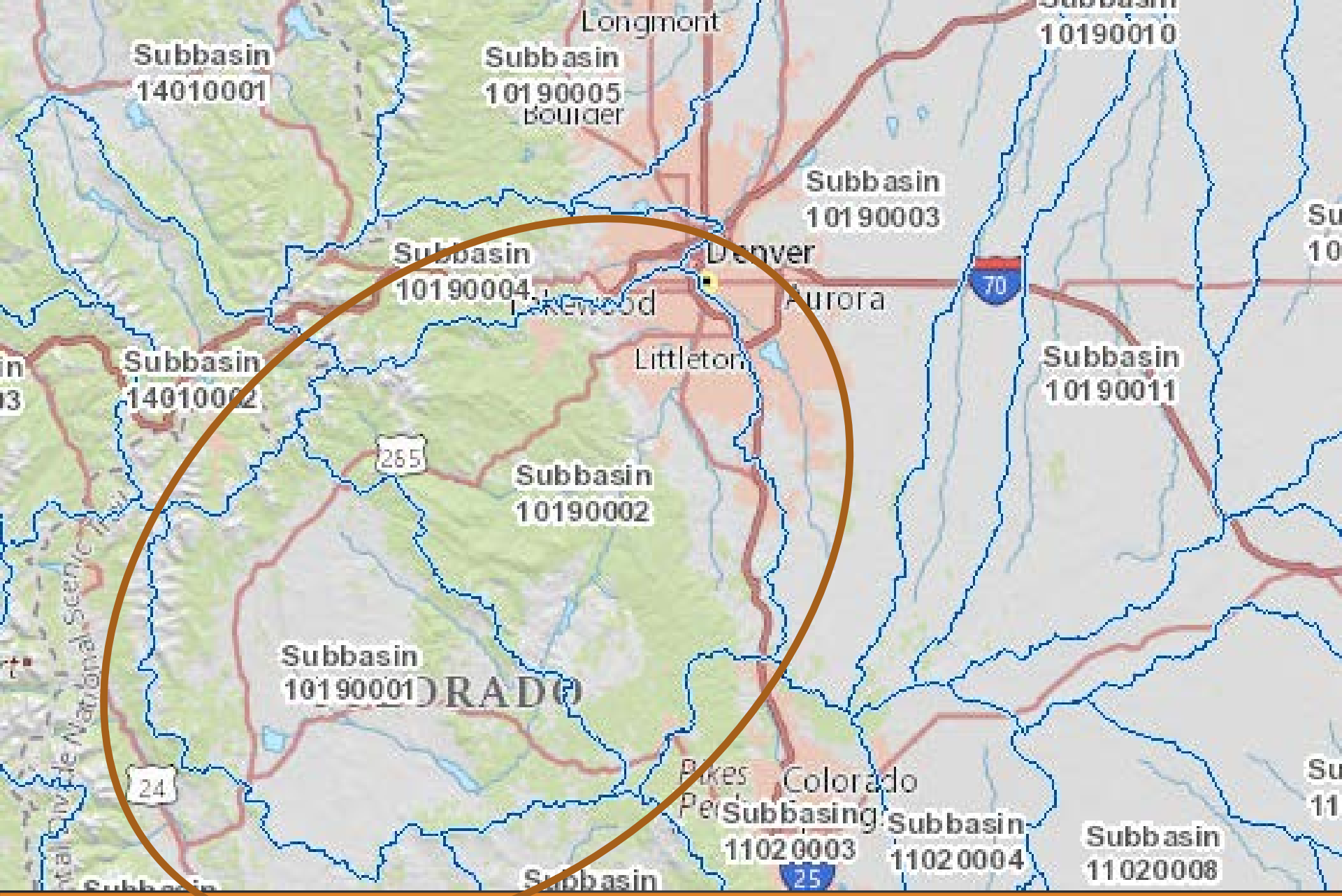
PART THREE – LOCAL EXAMPLE



COLORADO WATER PLAN

"Productive economy, vibrant and sustainable cities, productive agriculture, strong environment, robust recreational industry"

Social, Economic and Environmental Values for Vision to shape mission of plan.


Subbasin
14010001
Longmont
Subbasin
10190005
Boulder
Subbasin
10190010
Subbasin
10190003
Subbasin
10190004
Denver
Aurora
Lakewood
Littleton
70
Subbasin
14010002
Subbasin
10190011
285
Subbasin
10190002
Subbasin
10190001
COLORADO
24
Colorado
Springs
Subbasin
11020003
Subbasin
11020004
Subbasin
11020008
25

MANAGEMENT GROUPS

- Federal Agencies
  - USACE
  - USFS
  - USFWS
  - NRCS
- State of Colorado
  - CO Water Cons. Board
  - CO Watershed Assembly
  - DNR
  - DOT
  - DOA
- Local drainage authorities
  - Urban Drainage and Flood Control District
- Counties
- Conservation Districts
- Municipalities/Townships
- NGO's
  - The Greenway Foundation
  - Trout Unlimited

EXAMPLE PLANS

- Colorado Water Plan
- Statewide Water Supply Initiative
- Basin Improvement Plans
- Stream Management Plans
- Watershed Protection Plans
- …several others

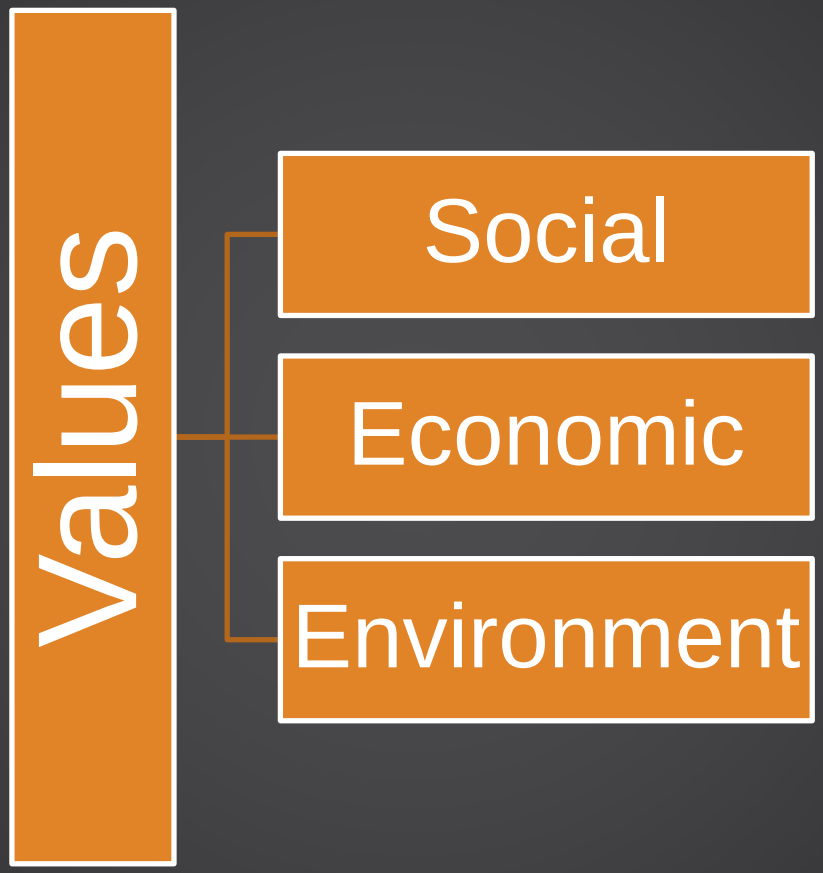
LOCAL POLICY COMMITTEE & PLAN OWNER/OPERATOR

- Urban Drainage and Flood Control District
- Conservation Districts
- Colorado Watershed Assembly

STEERING COMMITTEE

- The Greenway Foundation
- USACE
- USFS
- USFWS
- NRCS
- DNR
- Co Water Cons. Board.
- DOT
- DOA
- Municipalities/Townships
- Trout Unlimited

- Colorado Water Plan
- Basin Improvement Plans
- Stream Management Plans
- Watershed Protection Plans
- Statewide Water Supply Initiative
- Local drainage authorities (e.g., Urban Drainage and Flood Control District, Denver area)
- Federal Agencies
- NGO/Special interest Groups
  - Greenway Foundation
  - Trout Unlimited



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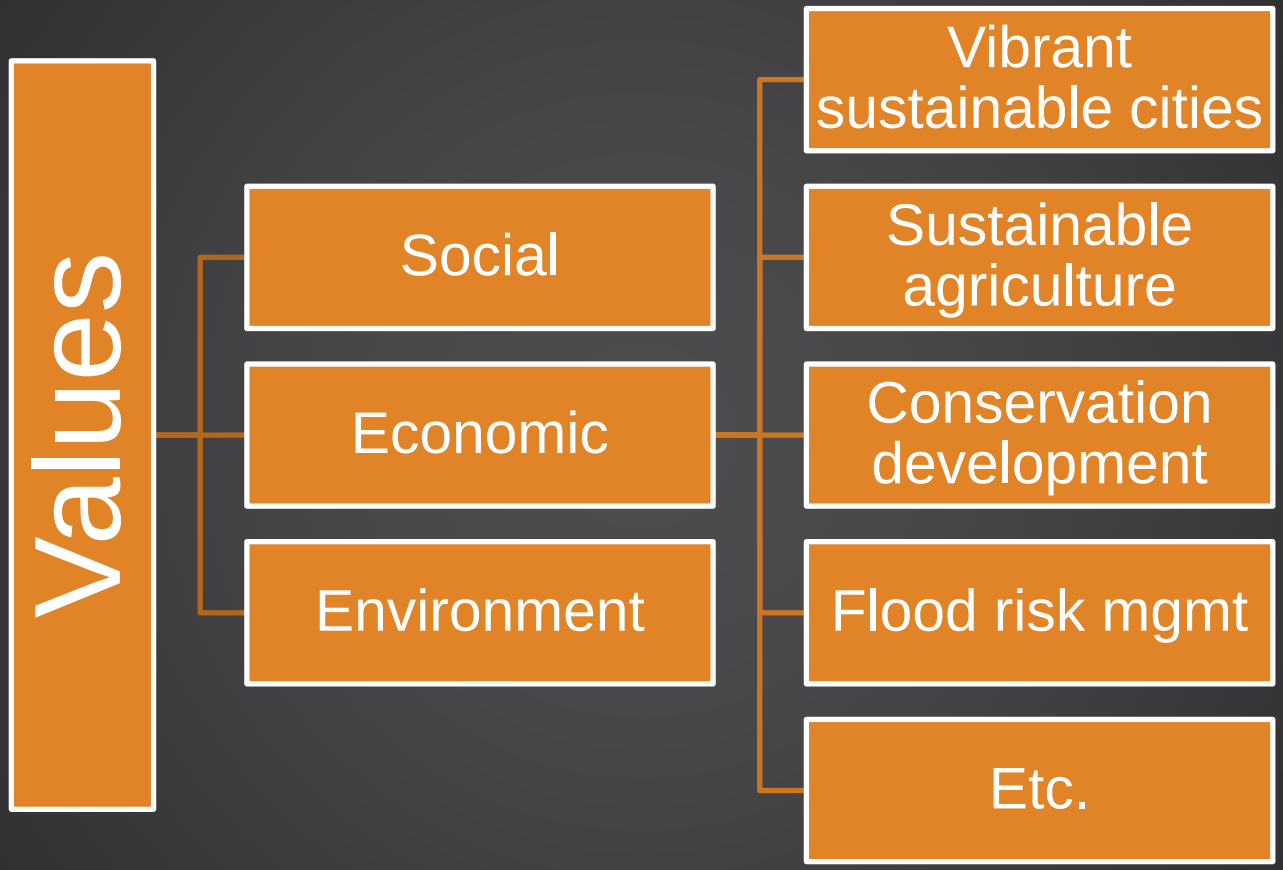
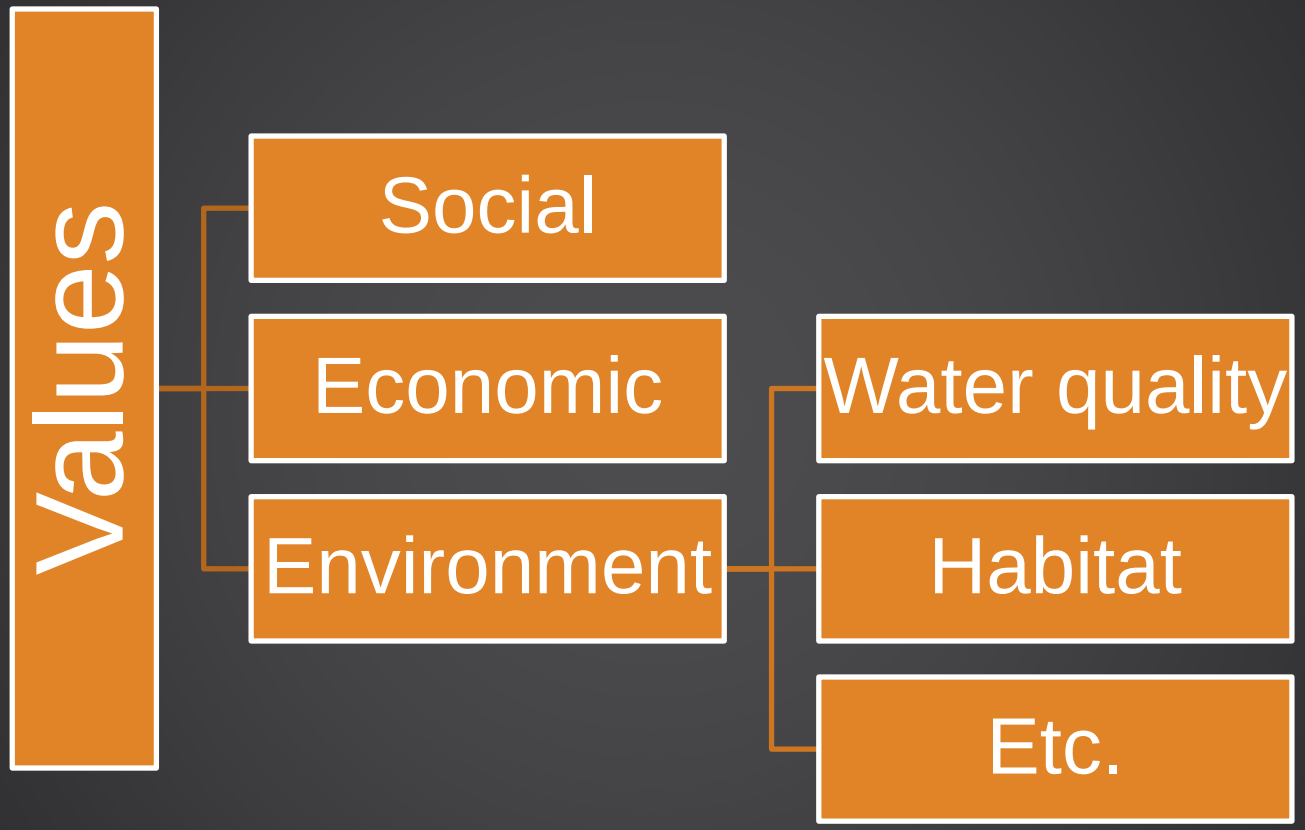
Values
Social
Economic
Environment
Quality of life, way of life
Hunting, fishing, recreation
Water supply
Etc.


Values
Social
Economic
Environment
Vibrant sustainable cities
Sustainable agriculture
Conservation development
Flood risk mgmt
Etc.


Values
Social
Economic
Environment
Water quality
Habitat
Etc.

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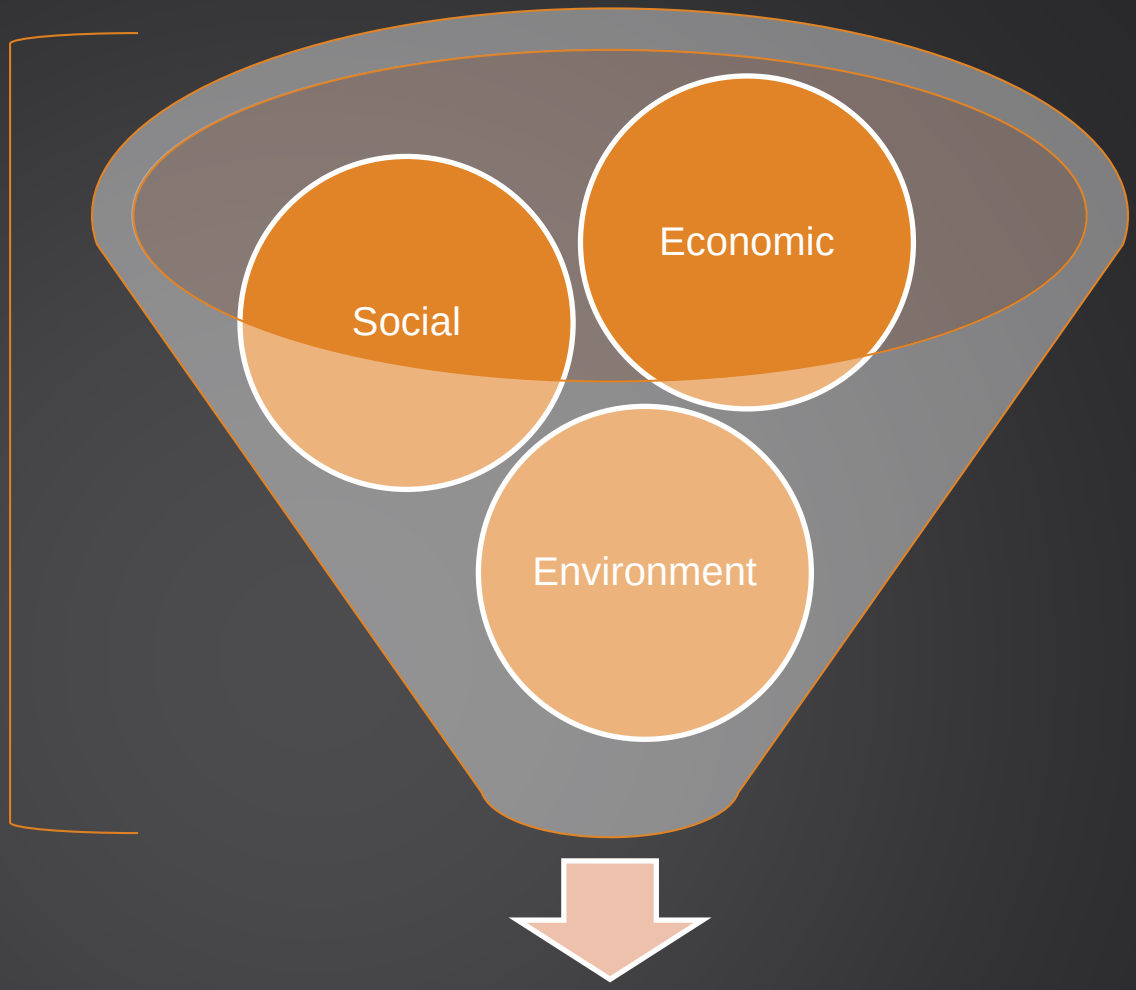
- Synthesis of existing information.
- Based on right project, right location, right costs



Prioritized, targeted and measurable local 10-yr implementation plan

Contact Information

Shawn Tracy, Water Resource Project Manager
651.659.7747
stracy@hrgreen.com

One Watershed, One Plan
http://www.bwsr.state.mn.us/planning/1W1P/index.html

CASFM 2018 – Snowmass, CO

Developing a Comprehensive Stormwater Infrastructure Master Plan

COLORADO SPRINGS
OLYMPIC CITY USA

Drew Beck, PE, CFM
Tim Biolchini, PE
Richard Mulledy, PE

September 27, 2018

Matrix DESIGN GROUP

WILSON & COMPANY

Enginuity ENGINEERING SOLUTIONS

DDS DIGITAL DATA SERVICES, INC.

FDR

ICON ENGINEERING, INC

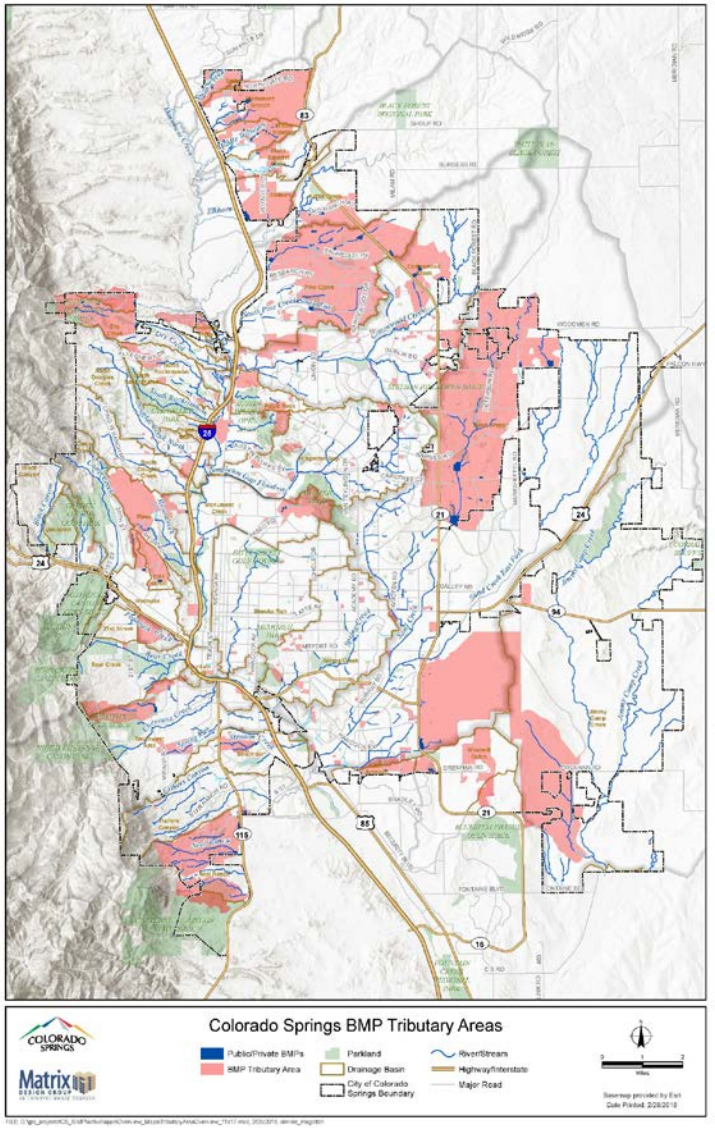
Outline

- Background
- Goals
- Approach
- Database and Web Application
- Takeaways

Problems

Project Goals

- GIS-based web application for CIP planning
- Existing infrastructure gaps
- CIP prioritization and budgeting tool
- Create a Stormwater Channel Assessment Program framework
- BMP tracking system



Strategic Vision

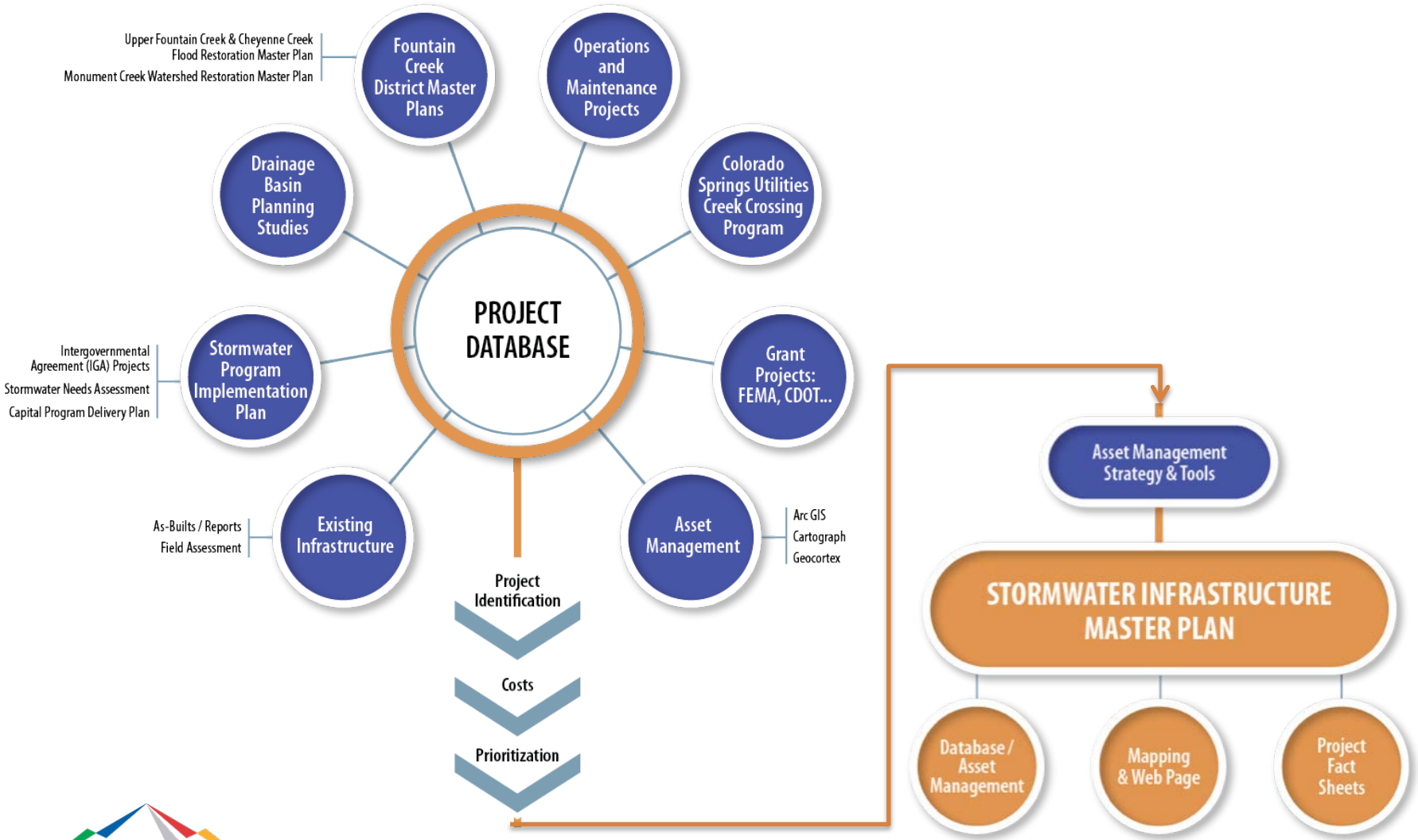
- Colorado Springs Utilities
- Operations & Maintenance
- Development Review
- Fountain Creek Watershed Flood Control & Greenway District
- CIP Delivery
- Parks & Open Space
- GIS and IT

Benchmarking

- City of Aurora
- City & County of Denver
- Urban Drainage & Flood Control District

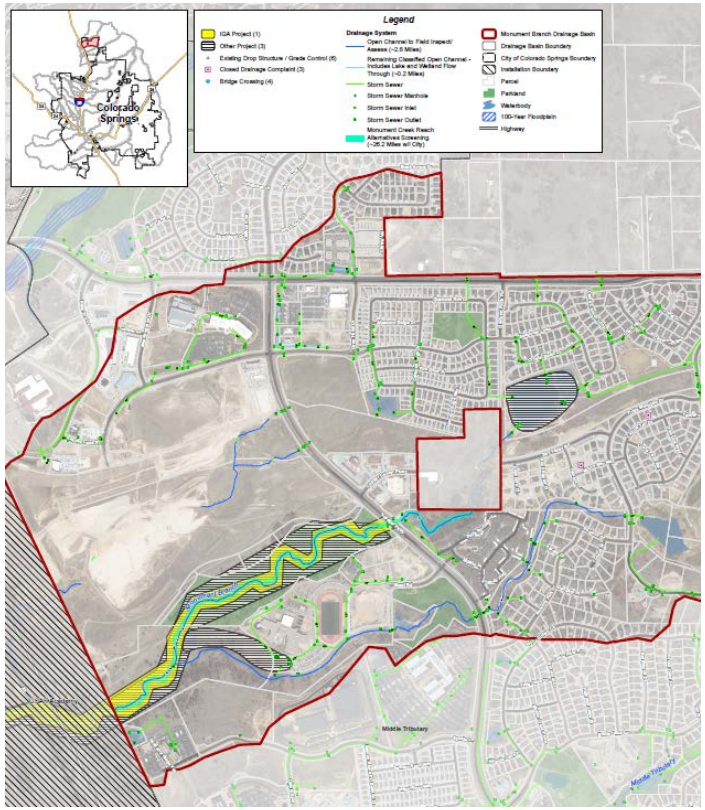
- Project Definitions
- Sub-Projects
- Prioritization
- Querying
- Cut Sheets
- Work Flow
- Cost Index
- Editability
- Accessibility

Approach


Upper Fountain Creek & Cheyenne Creek Flood Restoration Master Plan
Monument Creek Watershed Restoration Master Plan
Fountain Creek District Master Plans
Operations and Maintenance Projects
Drainage Basin Planning Studies
Colorado Springs Utilities Creek Crossing Program
PROJECT DATABASE
Intergovernmental Agreement (IGA) Projects
Stormwater Needs Assessment
Capital Program Delivery Plan
Stormwater Program Implementation Plan
Grant Projects: FEMA, CDOT...
As-Builts / Reports
Field Assessment
Existing Infrastructure
Asset Management
Arc GIS
Cartograph
Geocortex
Project Identification
Costs
Prioritization
Asset Management Strategy & Tools
STORMWATER INFRASTRUCTURE MASTER PLAN
Database / Asset Management
Mapping & Web Page
Project Fact Sheets

Data Collection – Field Review

- Over 258 mi of open channel
  - 37 major drainage basins
  - 63 mi improved/195 unimproved
  - 1,260 grade control structures
  - 800+ existing BMPs
- GIS data
  - Tablet data collection
  - Geolocated photos



Data Collection – Field Review

- Parameters collected
  - Location - GPS
  - Improvement type
  - Condition
    - Tier 1
    - Tier 2
  - Height
  - Vegetation

Data Collection – Field Review

Tier 1 – Infrastructure Condition

- Health/safety/flooding
- Channel stability
- Utility risks
- Road/bridge/structure risk
- Criteria – headcuts, unstable banks, severe floodplain disconnect, undermined drop structures

Tier 2 – Corridor Function

- Recreation
- Habitat/riparian function
- Aesthetics
- Criteria – geomorphic floodplain connection, vegetation quality and connection, bedrock

Field Assessment

- Tier 1 – Infrastructure Condition: Examples
- Good (green) – healthy stream corridor; sustainable [35%/67%]
- Fair (yellow) – some instability but no adjacent risks; at risk in large flood; maintenance [50%/28%]
- Poor (orange) – instability with adjacent risks; could need a CIP [10%/4%]
- Critical (red) – needs immediate attention; imminent risk [<5%/<1%]

Field Assessment

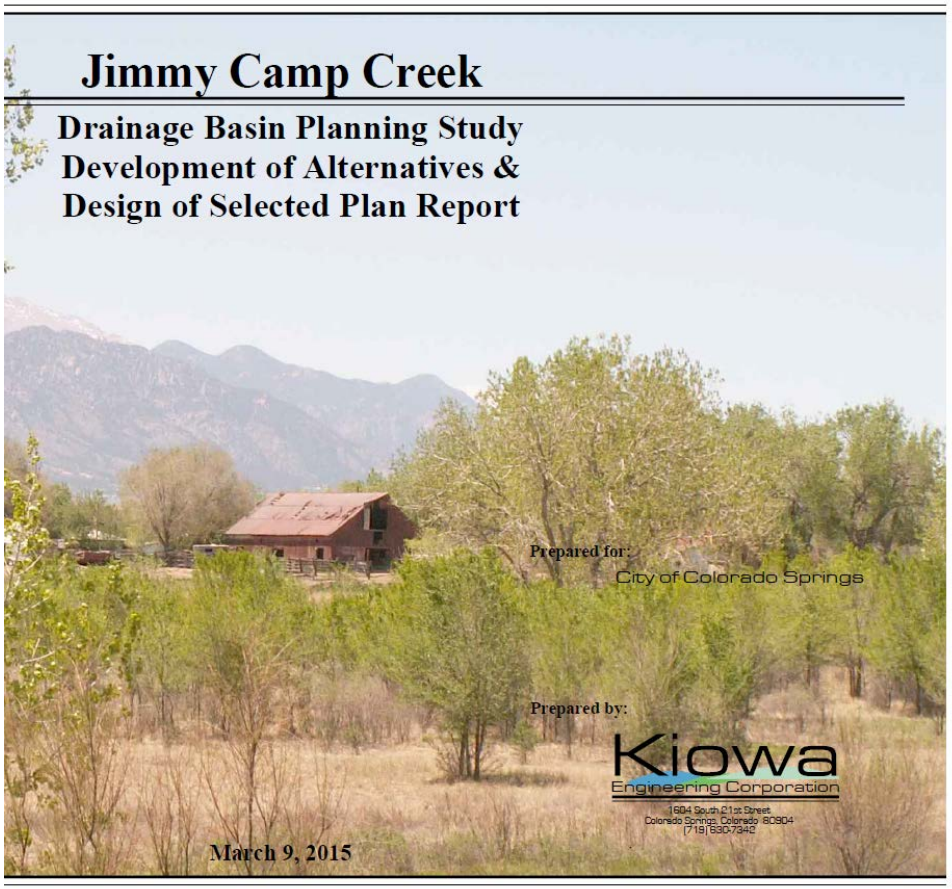
- Tier 2 – Corridor Value: Examples
- Good (green) – healthy stream corridor; high aesthetic and habitat value [30%/48%]
- Fair (yellow) – some impaired habitat but mostly functioning [45%/35%]
- Poor (orange) – disconnected floodplain, sparse vegetation [20%/16%]
- Critical (red) – minimal habitat value[<5%/<1%]

Field Assessment

- Examples
- Tier 1 – Good
- Tier 2 - Poor

Data Collection - Documents

- Over 400 documents
  - Plans/Reports
  - IGA Projects
  - Needs Assessment
  - Databases
  - Spreadsheets
  - Hand written notes
  - Individual staff knowledge
- GIS data



Project Identification

- Over 462 Potential Projects
  - 326 Channel projects
  - 55 Detention projects
  - 81 Storm drain projects

PROJECT ORGANIZATION: INVENTORY SPREADSHEET

No.	ID	Cost Table (SIMP ID) (NEW)	Attribute Only (SIMP ID) (New)	IGA ID (NEW)	Improvement Name	Location (Street Names)	Drainageway	...	Category	Description	Unit	Quantity	Unit Cost	Cost Subtotal	...	Status	...
1	1-0				**Sand Creek DBPS - Detention Basin Cost Estimate**	**Sand Creek Basins**	-		**0 - Project summary**	-	-	**LS**	**1**	**$$$**			
1	1-1	**SC-C6**		-	Sand Creek DBPS	Lower Sand Creek	Sand Creek		X - Channel - Grade Control	Grade control	EA	6	$27,000	$162,000		Constructed	
1	1-2	**SC-C6**		-	Sand Creek DBPS	Lower Sand Creek	Sand Creek		X - Channel - Lining	Sel linings (1 side)	LF	350	$127	$44,450		Not constructed	
1	1-3	**EFSC-C8**		-	Sand Creek DBPS	East Fork Sand Creek Tributaries	East Fork Sand Creek		X - Channel - Lining	Selective riprap lining	LF	5700	$85	$484,500		Not constructed	
1	1-4	**EFSC-D1**		-	Sand Creek DBPS	Constitution Ave and East Fork Sand Creek	East Fork Sand Creek		X - Detention	Public regional 100-year detention with water quality (278 AF)	AC-FT	278	$10,000	$2,795,000		Not constructed	
1	1-5	**EFSC-D1**		-	Sand Creek DBPS	Constitution Ave and East Fork Sand Creek	East Fork Sand Creek		X - Detention	Land acquisition	AC	26.9	$15,900	$427,710		Not constructed	
1	1-6	**EBSC-B160**		-	Sand Creek DBPS - Roadway Culvert Crossing Cost Estimate	Bridlespur Road	East Bierstadt Creek		X - Culvert	2-8'Hx10'W CBC	LF	160	$750.00	$120,000		Not constructed	
1	1-7	**EBSC-B47A**		-	Sand Creek DBPS - East Fork Sand Creek Bridge Crossing Cost Estimate	Unnamed Roadway	East Bierstadt Creek		X - Bridge / Full span	2-10'Hx14'W CBC	LF	250	$1,250.00	$312,500		Not constructed	

Document Summary

Improvement

Improvement

Project Organization

Project Organization

Legend:

Summary of costs by document.

Project Improvements identified in the reviewed document.

Steps in inventory spreadsheet to define project organization.

Middle Tributary

MT-D2 Detention

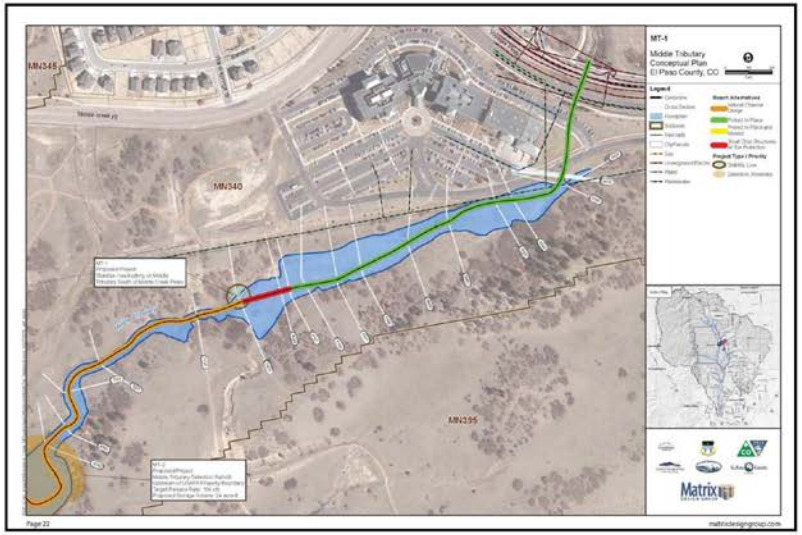
Priority:

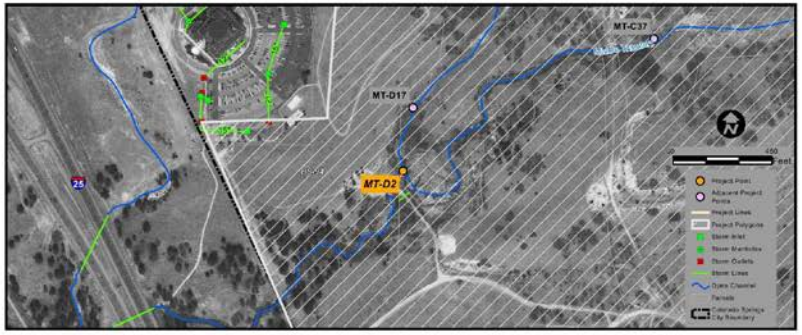
Date Generated: 8/15/2018

Matrix DESIGN GROUP AN EMPLOYEE-OWNED COMPANY

Project Description:

Middle Tributary Detention Retrofit Upstream of USAFA Property Boundary





Cost Analysis:

MT-D2	UNIT	QUANTITY	UNIT COST	COST SUBTOTAL
Erosion control blanket	SY	10,285	8.00	$82,280
Grouted 2' Dia boulder rundown	SY	108	216.80	$23,414
Outlet structure trash rack, screen and railing	LS		0.00	$5,000
6' conc. trickle channel (6" thick, 6" deep)	LF	375	44.00	$16,500
Access road (12' wide, 8" class 6 gravel)	LF	700	9.00	$6,300
Outlet pipe, RCP	LF	50	91.00	$4,550
Outlet pipe protection - FES w/ riprap	EA	1	1,230.00	$1,230
Concrete crest wall, 12" thick	CY	59	892.56	$52,661
EmergenCY spillway (Type M riprap)	CY	990	75.97	$75,210
Excavation (haul)	CY	5,796	30.00	$173,870
Excavation/ embankment (onsite)	CY	901	14.01	$12,619
Forebay riprap (Type L) w/ bedding	CY	114	69.88	$7,966
Inlet/ forebay (8" conc. Bottom)	CY	448	299.87	$134,340
Outlet structure - 8" walls	CY	8	722.00	$5,776
Place topsoil	CY	4,571	12.00	$54,853
Stockpile topsoil	CY	4,571	10.00	$45,711
Mulching	AC	9	566.67	$5,100
Seeding, native	AC	9	585.56	$5,270
Contingency	%	20	7,150.00	$143,000
Design / Engineering	%	15	7,133.33	$107,000

Total: $962,650

Potential Partnership:

Prioritization

- Planning
  - Drainage Basin Planning Studies
  - Existing Infrastructure Needs Assessment
- Condition
- Capacity

Planning Prioritization

Technical (60%)									Situational Awareness (40%)	Weighted Score
Drainage Basin	DBPS Published Date	Age of DBPS	Design Standard	Degree of Future Development	Existing Regional Detention	Future Regional Detention	Potential Natural Stream Preservation/ Restoration Opportunities	Closed Basin	City-Input (based on economic, social and political climate at the time of ranking)	
Score Range	-	0-3	0-4	0-3	0-3	0-3	0-1	0-1	0-5	0-100
Scaling Multiplier	-	5	5	12	1	1	10	6	5	
Black Canyon	2/1/1980	1	3	2	3	1	1	1		63
Black Squirrel Creek	1/1/1989	2	3	3	1	1	0	1		61
North Douglas Creek	3/1/1981	1	4	2	3	2	0	1		57
South Douglas Creek	3/1/1981	1	4	2	3	2	0	1		57
Mesa	3/1/1986	1	4	2	2	1	0	1		57
Sand Creek (including Upper Sand Creek)	3/1/1996	3	2	3	1	3	0	1		57
Camp Creek	10/1/1964	0	4	1	3	1	1	1		56
Westside	10/1/1975	0	4	1	2	1	1	1		55
Peterson Field (Sand Creek)	8/1/1984	1	4	1	3	1	1	1		55

Project Prioritization

- DCM Principles
  - Regional implications
  - Infrastructure integration
  - Land allocation
  - Runoff mitigation
  - Multi-purpose
  - Natural systems
  - Downstream impacts
  - Maintenance
  - Flood hazard
  - Legal/permit obligations
- Technical criteria
  - Channels
  - Detention
  - Storm drains
- Decision Matrix

Technical Criteria - Channels

Channel Technical Criteria	DCM Principle
Tier 1 Score (Infrastructure condition)	Downstream Impacts Maintenance Flood Hazard
Tier 2 Score (Corridor function)	Multi-Purpose Preservation
Bank Risk	Infrastructure Integration Downstream Impacts Maintenance
Bank Height	
Improvement type (if any)	
K-Factor score (susceptibility to erosion)	
303(d) impairments	Downstream Impacts Legal/Permit
Adjacent utilities, institutions, and facilities	Infrastructure Integration

Technical Criteria - Detention

Detention Technical Criteria	DCM Principles
Location in watershed	Runoff Mitigation Downstream Impacts Flood Hazard
Closed basins & Parcel ownership	Land Allocation
Proposed detention pond volume	Runoff Mitigation Downstream Impacts Flood Hazard
Underlying Hydrologic Soil Group	Preservation Natural Systems
Maximizing BMP treatment area within the City	Preservation Multi-Purpose Downstream Impacts

Decision Matrix

Provide protection for people as permanent and recreational users?		Protect or improve habitat, water quality, and geomorphology?			Contribute to achieving MS4 requirements?	
Infrastructure Integration, Flood Mitigation, Flood Hazard, Downstream Impacts, Multi-Purpose		**Preservation**			**Downstream Impacts, Legal/Permit**	
Permanent user protection? Applicable justifications: Neighborhood access Heavily traveled road Other (specify)	Recreational user protection? Applicable justifications: Trail users Golf course users Other (specify)	Protects or improves water quality? Applicable justifications: Treats WQCV Stabilizes highly erodible banks/channels Natural channel preservation/ design Other (specify)	Protects or improves habitat? Applicable justifications: Reconnects channel and floodplain Re-vegetation of stream corridor Other (specify)	Protects or improves geomorphology? Applicable justifications: Preserves/ reclaims stream corridor Crossings promote floodplain connectivity Other (specify)	Meets MS4 requirements and brings existing system up to compliance?	Meets MS4 requirements and the existing system is already in compliance?

Decision Matrix

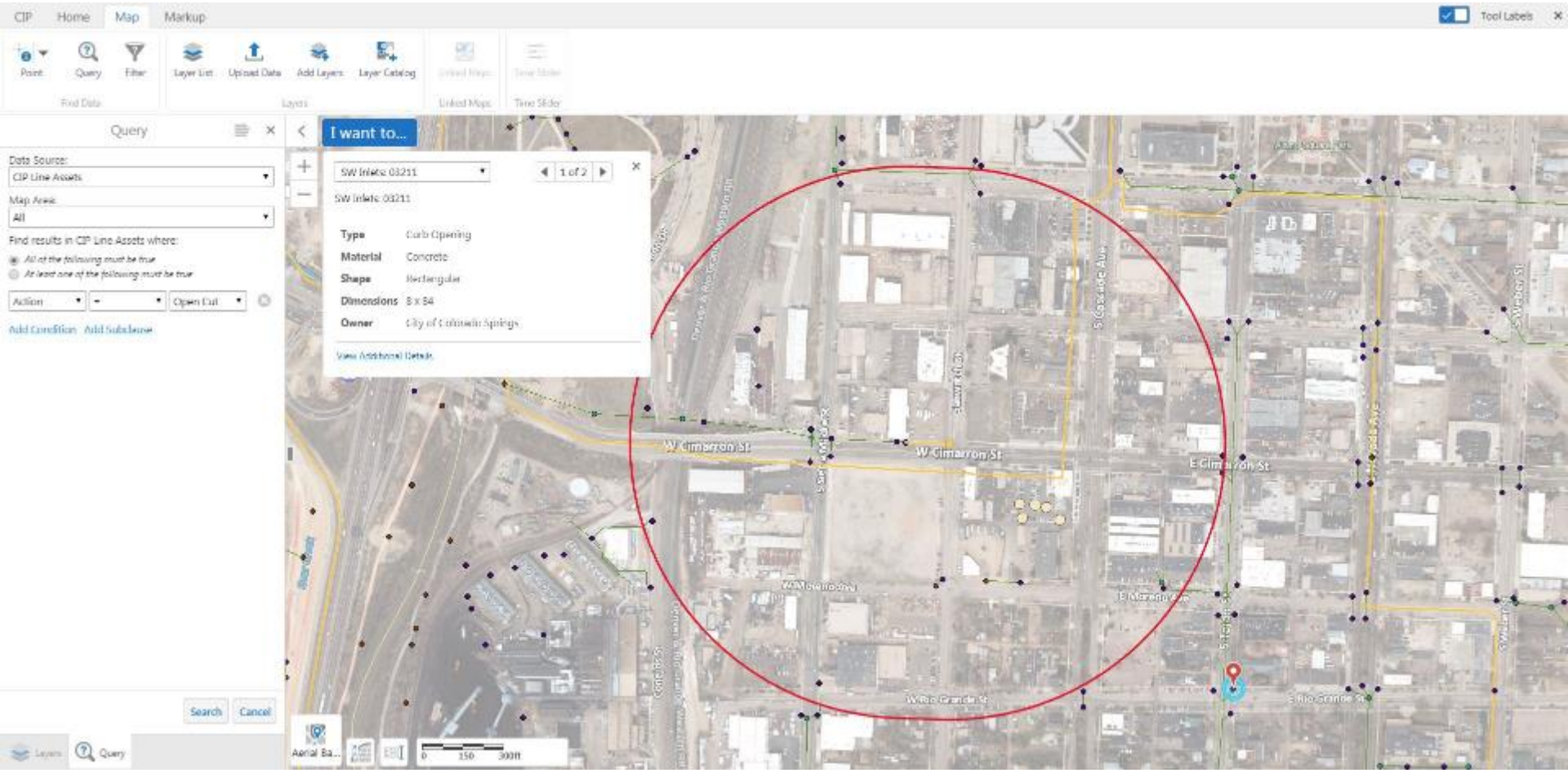
Create infrastructure investments that are high value and reasonable to construct?	Improve downstream conditions?	Serve a large population?
Infrastructure Integration, Land Allocation, Maintenance	**Downstream Impacts, Flood Hazard**	**Regional Implications**
Applicable justifications: Low maintenance needs Low cost, high return Moderate to high cost, but foundational Closed basin Land acquisition Other (specify)	Applicable justifications: Improves downstream channel Reduces downstream flooding Other (specify)	Applicable justifications: Project benefits at community-level Other (specify)

Technical Score

Decision Score

Priority Rank

Web Application



Takeaways

- Evolution is painful
- Deferred maintenance is not the sum of its parts
- Leverage existing data
- Listen to users
- Communicate

Special Thanks

City Project Manager – Tim Biolchini
Engineering Stormwater Division Manager – Richard Mulledy
Stormwater Capital Programs Manager – Brian Kelley

Questions

Strategic Planning for Green Infrastructure in Boulder

Candice Owen, P.E.

September 27, 2018


VOLS

WORK IN PROGRESS

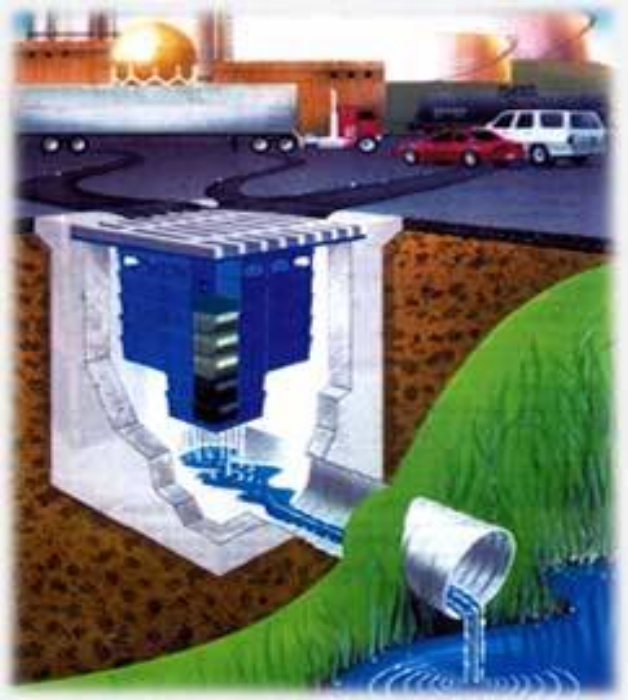
Overview

- Background
- Project Components
  - Stakeholder Group
  - Process and Policy
  - Prioritization and Pilots
- Next Steps

Shifting Paradigms..
The GI Way of Thinking

Gray infrastructure:

- Use **basins, pipes** & **ditches** to **remove** pollutants from **stormwater** where it collects



Green infrastructure:

- Use **soil** and **vegetation** to manage **rainwater** close to where it falls

Source: Tompkins County NY (Bioswale)

Shifting Paradigms..
The GI Way of Thinking

Soil & **Vegetation** are now Infrastructure

At the pre-design stage:
LID Opportunities

During design & construction:
BMP Design Elements

After construction:
BMP Maintenance Elements

Background: Stormwater in Boulder

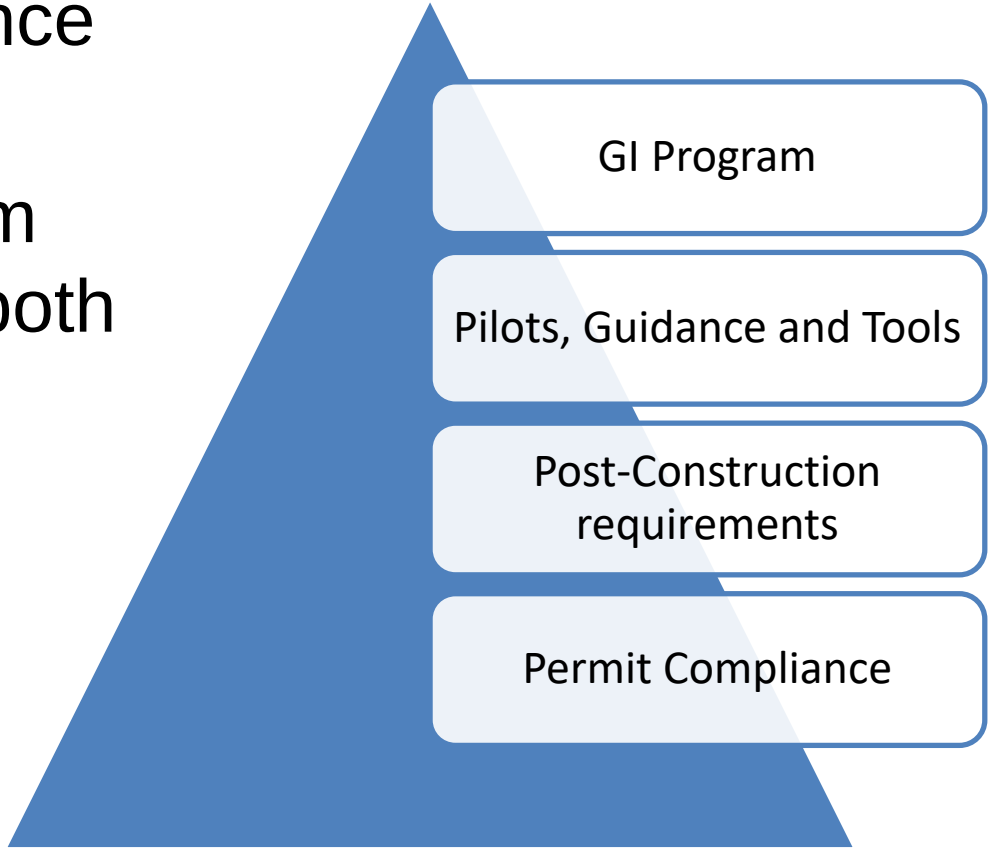
- Boulder is mostly infill on marginally draining urban soils
- Many sites are dense and space is very valuable
- Approval process for changing criteria is challenging
- New MS4 permit requirements posed challenges

How do we do this in Boulder?

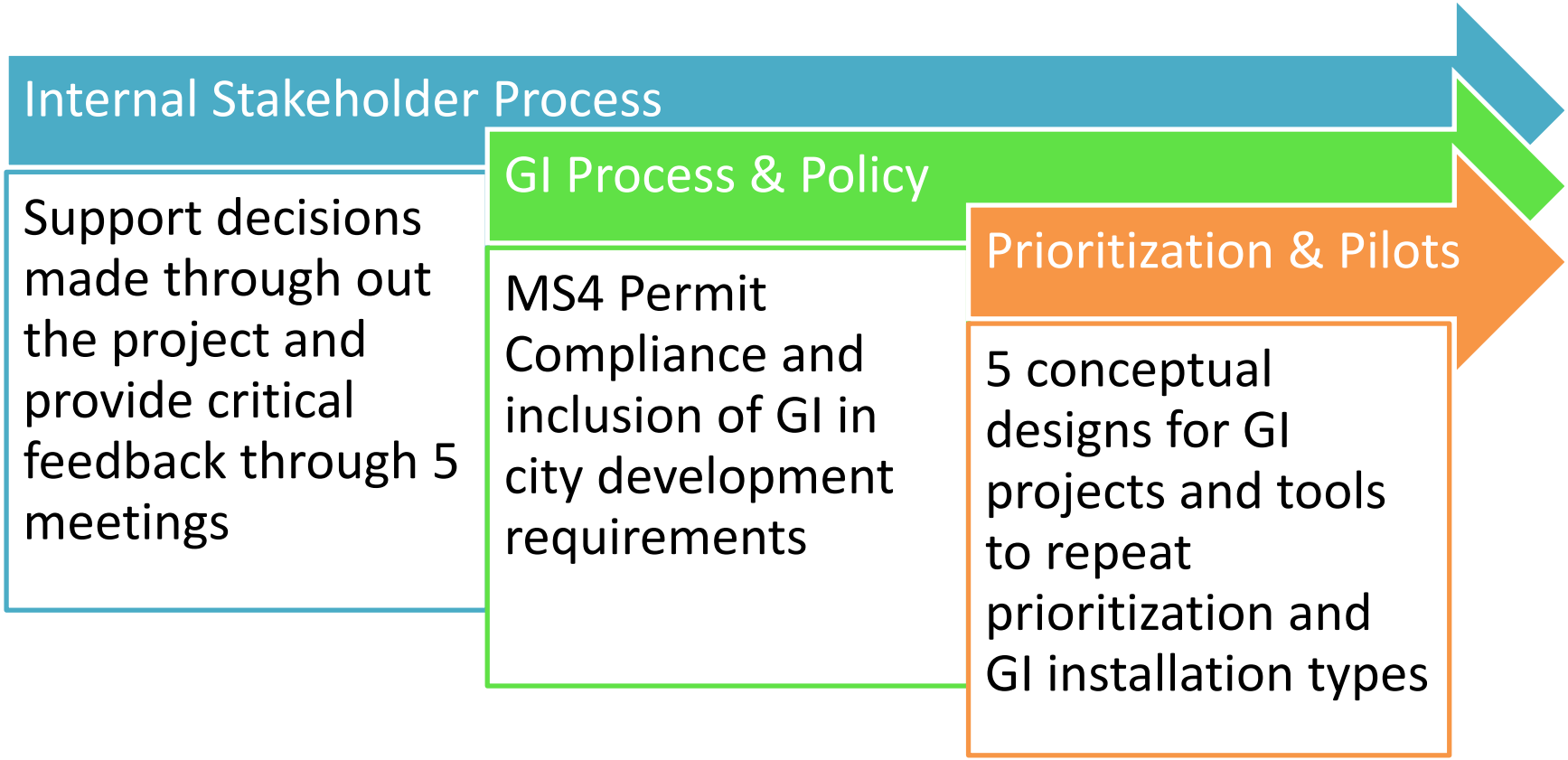
- What are we required to do?
  - *MS4 permit requirements*
- What can we do?
  - *Understand ability to infiltrate*
- What should we do?
  - *Set by stakeholder group*

Project Goals

- MS4 Permit Compliance
- Build a Green Infrastructure Program that promotes GI on both Private and Public Projects



Project Design



STAKEHOLDER GROUP PROCESS

5 Stakeholder Meetings

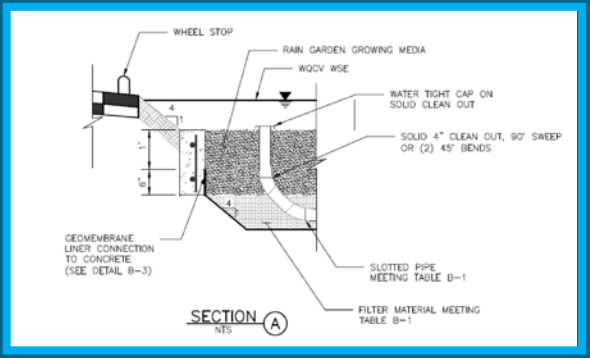
VISION

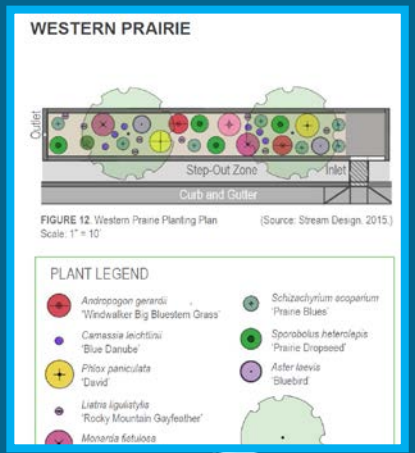
What do YOU envision for the final outcome of this project?

CRITICAL SUCCESS FACTORS

What must this project and process accomplish in order for you to think it has been successful?

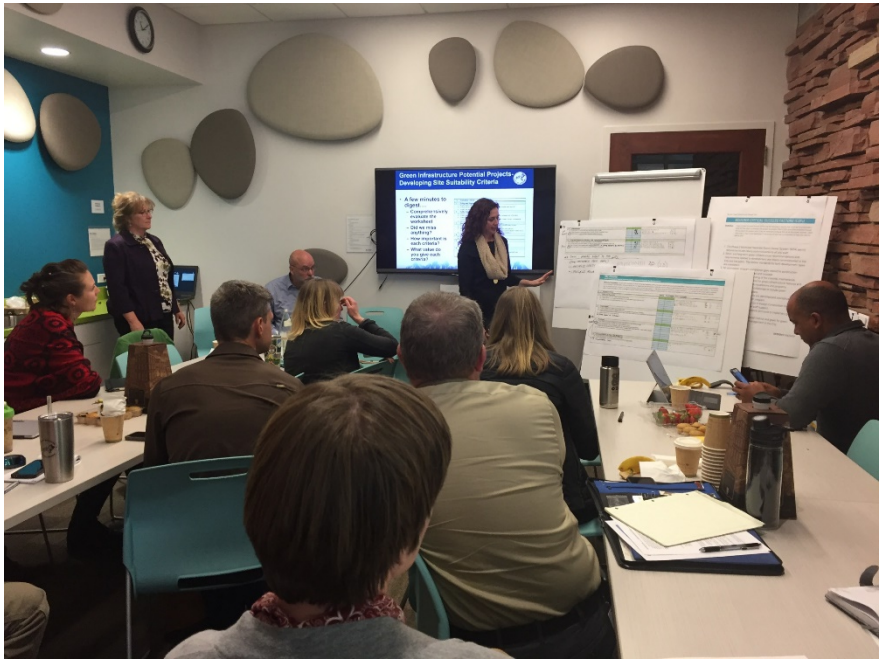
Making policy & process changes


WHEEL STOP
RAIN GARDEN GROWING MEDIA
WQCV WSE
WATER TIGHT CAP ON SOLID CLEAN OUT
SOLID 4" CLEAN OUT, 90° SWEEP OR (2) 45° BENDS
GEOMEMBRANE LINER CONNECTION TO CONCRETE (SEE DETAIL B-3)
SLOTTED PIPE MEETING TABLE B-1
FILTER MATERIAL MEETING TABLE B-1
SECTION A
NTS


WESTERN PRAIRIE
Outlet
Step-Out Zone
Inlet
Curb and Gutter
FIGURE 12. Western Prairie Planting Plan
Scale: 1" = 10'
(Source: Stream Design. 2015.)
PLANT LEGEND
Andropogon gerardii 'Windwalker Big Bluestem Grass'
Camassia leichtlinii 'Blue Danube'
Phlox paniculata 'David'
Liatris ligulistylis 'Rocky Mountain Gayfeather'
Schizachyrium scoparium 'Prairie Blues'
Sporobolus heterolepis 'Prairie Dropseed'
Aster laevis 'Bluebird'

Resulting Policies

- Prioritization factors for pilot projects
- MEP of LID for <1 acre development
- Do as much GI as practicable on city projects



POLICY AND PROCESS

Code and Design Standards Revisions

details.

(B) Technical Report

The technical report shall provide a description of t
and developed runoff conditions, approximate stor
water quality and erosion control measures, storm
measures, proposed storm water utility improveme
of study data sources, methods and findings, and in

(1) **Background:** Provide a written statement
development that includes the following i

(a) Site location, including legal desc
characteristics, identifying land de
networks and storm water systems
sewers) in the surrounding area.

(b) Site description, including the tota
ground cover, wetlands, groundwa
ditch systems.

(2) **Development Proposal:** Provide a gener
development, including land use, density,
water planning concepts.

(3) **Existing Condition Hydrology:** Provide

(a) land cover, denoting by type all fe
landscaped areas, designated open
etc.), crops or orchards, pastures,
buildings, pavement, compacted g

(b) natural features, including streams
seeps, springs, sinkholes, rock out
areas,

(c) floodplains and floodways, known
shallow bedrock, and clay lenses,

(d) natural soil identified by correspo
D), and urban (compacted or fill)

(e) untreated Ash trees and treated As

(f) areas where infiltration of storm w
soil contamination areas (known
where subsurface utilities are pres

(g) areas of cultural, historic, or arche
State Historic Preservation Office

(4) **Existing Storm Water Basins and Drain**
storm water basins and drainage patterns t

(a) Offsite drainage patterns and thei

(b) Onsite drainage patterns, existing

(c) Previous drainage studies for the s

the exposed area o
time".

(ix) "Bulk storage struc
have adequate prot
material from entar

(x) "Any disturbance t
replaced within 48

(xi) "The property own
continued compli
construction activi

(xii) "All temporary ero
disposed within 30
temporary measure

(4) Protection of green infrastructur

(a) Green infrastructure practi
times during construction b
be established to prevent en
vehicles, and foot traffic un

(b) Green infrastructure practi
times during construction b
sediment. The use of these
stockpiles, parking, and sto
pollutants is prohibited.

(c) The areas that discharge to
practices shall be fully stabi
of the practice, with no are
sequencing is considered a
infrastructure. Ideally, the
surfaces are constructed an
use of these areas for const
storage of construction mat
construction of green infra

(C) Permanent Storm Water Quality M

~~The UDFCD Drainage Criteria Manual shall be appli~~
~~and erosion control for all proposed projects and dev~~

(1) All proposed projects and develop
"Minimize Directly Connected Imp
Criteria Manual.

(2) All projects and developments shal
Practices" as defined in the UDFCD

~~(3) All proposed projects and develop~~
~~a larger development, shall provid~~
~~Outlet in accordance with the UDF~~
~~quality facilities are approved by th~~

(3) Applicable development sites (or

(A) Required

The Director of Public Works may require the inspection of storm water quality measures after their installation to confirm their conformance with the approved final storm water report and plan and the record drawing for the applicable development site, and to evaluate if the storm water quality measures and the larger storm water system and facilities of the property are clean, free of sediment and debris, and in full operational condition The Director of Public Works may order corrective actions before construction closure will be approved.

7.16 Storm Water Quality Measure Maintenance

(A) Required

(1) The property owner shall be responsible for maintaining permanent storm water quality measures. Maintenance shall be as recommended by the BMP Inspection and Maintenance Field Guide published by the Colorado Stormwater Center (preferred), the UDFCD Drainage Manual, the Denver Ultra-Urban Guidelines, or other regionally-appropriate source of maintenance guidance and shall be performed such that full function and operation of the measures as designed are preserved.

(2) The use of storm water quality measures for materials stockpiles, parking, and storage of equipment, construction materials, wastes, or pollutants is prohibited.

(3) The area that discharges to a green infrastructure practices shall be fully stabilized with permanent vegetation with no areas of bare soil or erosion to prevent the discharge of sediment to, and clogging of, the practice. The area shall at all times be kept clean to prevent the discharge of sediment and pollutants to the practice. Use of the area for construction or maintenance staging, materials stockpiles, car washing, storage of equipment, wastes, or pollutants is prohibited.

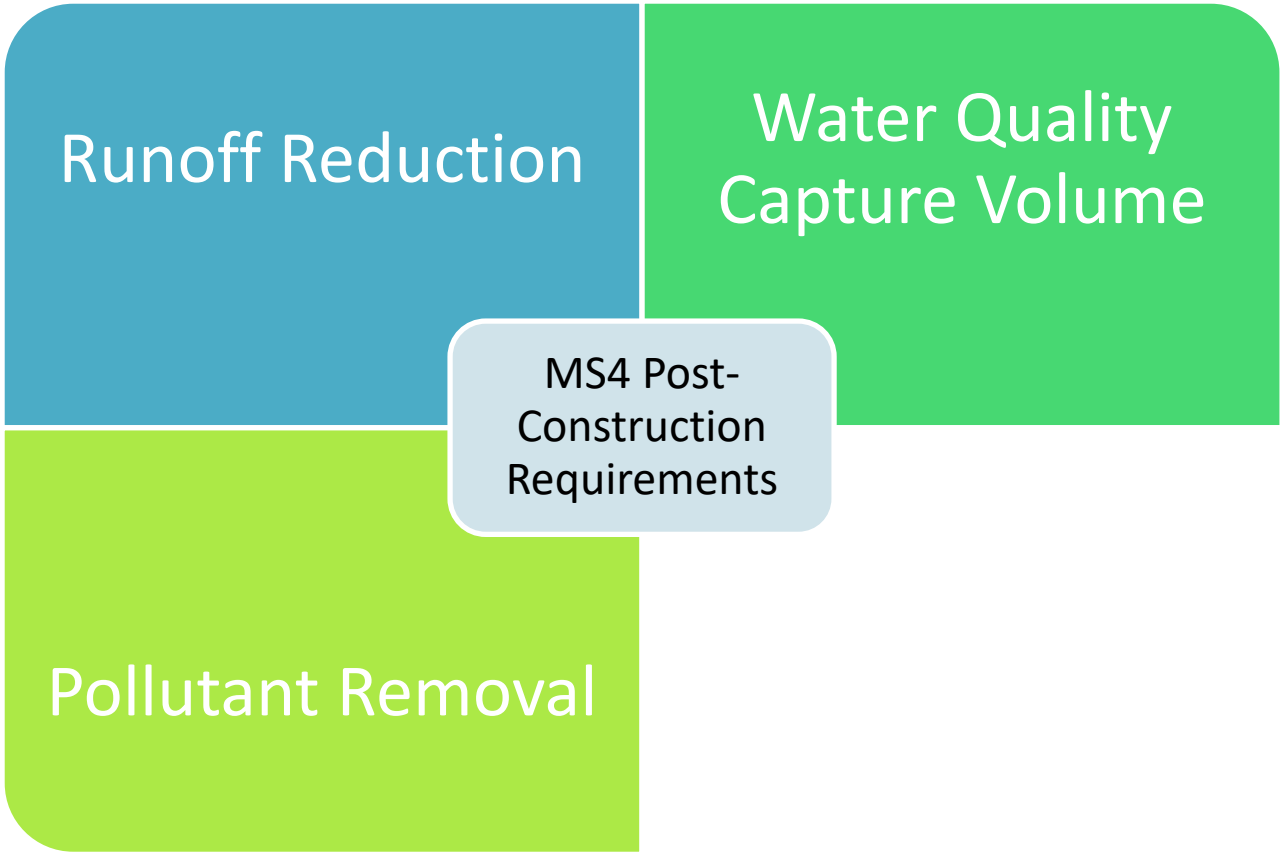
(1) Green infrastructure practices should be protected from soil compaction. Controls should be established to prevent encroachment by equipment and vehicles, and foot traffic unrelated to their maintenance.

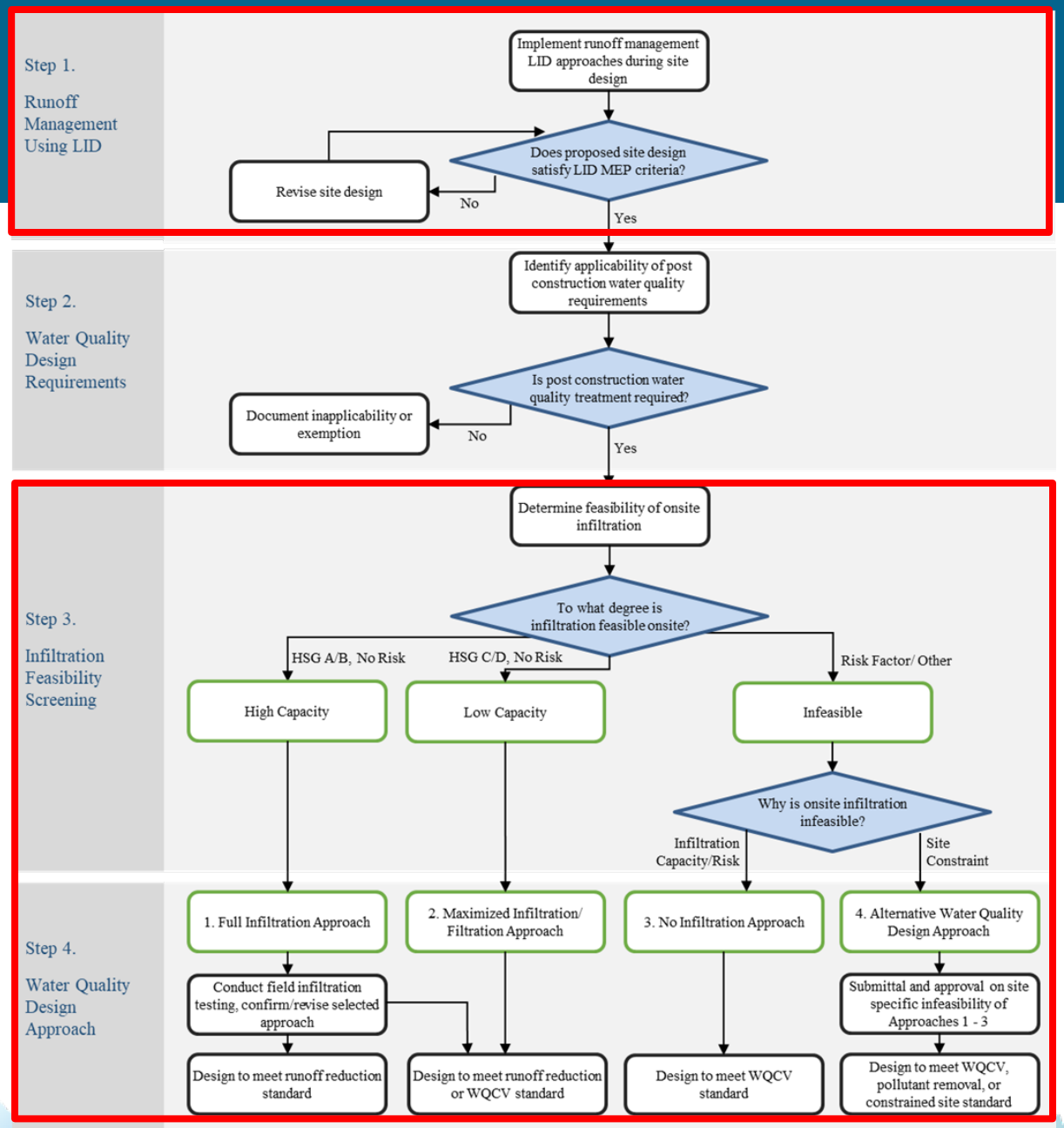
Code and Design Standards Revisions

Policy & Process Questions

- What does MS4 compliance and GI look like in Boulder?
- What happens <1 acre?
- How can we best integrate with capital projects throughout the city to install GI?
- How do we create better, clearer policy and back that up with assisting documents and guidance?

MS4 Post-Construction Requirements




Step 1.
Runoff Management Using LID
Implement runoff management LID approaches during site design
Does proposed site design satisfy LID MEP criteria?
Revise site design
No
Yes
Step 2.
Water Quality Design Requirements
Identify applicability of post construction water quality requirements
Is post construction water quality treatment required?
Document inapplicability or exemption
No
Yes
Step 3.
Infiltration Feasibility Screening
Determine feasibility of onsite infiltration
To what degree is infiltration feasible onsite?
HSG A/B, No Risk
HSG C/D, No Risk
Risk Factor/ Other
High Capacity
Low Capacity
Infeasible
Why is onsite infiltration infeasible?
Infiltration Capacity/Risk
Site Constraint
Step 4.
Water Quality Design Approach
1. Full Infiltration Approach
2. Maximized Infiltration/ Filtration Approach
3. No Infiltration Approach
4. Alternative Water Quality Design Approach
Conduct field infiltration testing, confirm/revise selected approach
Submittal and approval on site specific infeasibility of Approaches 1 - 3
Design to meet runoff reduction standard
Design to meet runoff reduction or WQCV standard
Design to meet WQCV standard
Design to meet WQCV, pollutant removal, or constrained site standard

MOUs for Permit Compliance

City of Boulder, CO

DRAFT POLICIES
STANDARD OPER
PROCEDURE

for th
Design and Construct
Quality BMPs In

Document Owner	Water Quality and Environ
Revision Number	
Effective Date	

RECORD OF AP

DEPARTMENT	NAME
Public Works - Utilities	
Public Works - Facilities and Asset Management	
Open Space and Mountain Parks	
Parks and Recreation	
Public Works- Planning & Development Services	
Public Works - Transportation	

Version: July 2019

City departments responsible for the design
subject to penalties and enforcement action
must abide by the policies and processes es

B. WQES, P&DS, and City Project Managers mu
in every five year period. The preferred cou
Design and Design Review training offered
CSU. Certification documentation for all tra
WQES. In the event that CSU training is no
responsible for identifying other suitable tr

2. PROCESS

Figure 1 illustrates the general process for implem
document. It starts at the time a City project is
follows the project through construction. Furth
sections that follow.

Figure 1. General Process for BMP Desig

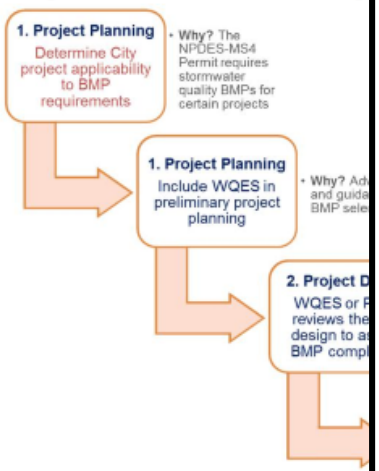
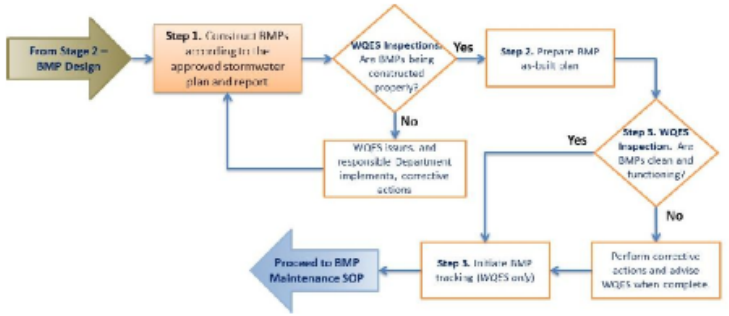


Figure 4. Project Construction Flowchart



3-D. REQUIRED DOCUMENTATION

Table 5. Construction Stage Documentation

Department Responsible	Required Documentation
Department responsible for *applicable* City project	Stormwater BMP as-built plan, prepared in accordance with BRC Title 11, Chapter 5 and the DCS.
Water Quality and Environmental Services (WQES)	1. Documentation of construction inspections and final inspection, including corrective action reporting to the responsible department/contractor. 2. Create and maintain data for City BMP tracking.

GLOSSARY

Applicable City project – An applicable City project is subject to the water quality improvement requirements in Boulder Revised Code, Title 11, Chapter 5 *Storm Water and Flood Management Utility.*

Best Management Practice (BMP) – For purposes of this document only, a BMP is a single, engineered, structural control that is designed and constructed to address

Supporting Documents

- Compliance “Packet”
  - Checklists
- Example GI projects
- MEP LID Guidance

PILOT PROJECTS

Project Components

- Unique GI
  - Based on GIS analysis and prioritization
- CIP project opportunities
- Planning for future use of capital funds

GI Potential Capital Projects- Compiling the List

CITY OF BOULDER POTENTIAL PILOT PROJECT SCORING

Overall 'Bucket' Category					Policy / Regulatory		Public Impact			Engineering / Resiliency Effects			Economic			Administrative			Costs
Weighting Factor					2	1	1	2	1.5						1	3	1	1	3
WEIGHTED TOTAL	RA SC	OJECT ID	PROPOSED P ECT	PROPOSED CIP DESCRIPTION	PROJECT ALIGNS WIT GI STRATEG PLAN GOALS Completely Somewhat No = 0	TER LITY LIANCE TIAL = 3 w = 1 None = 0	PROJECT VISIBILITY/ LOCATED IN PUBLIC AREA Yes = 3 No = 0	ADDRESSES RESIDENT COMPLAINTS 4 or more = 3 2-4 = 2 None = 0	PROVIDES CONNECTIVITY OR NATURE BASED RECREATION Yes = 3 Some = 2 None =0	POTENTIAL TO MITIGATE STORMWATER /FLOODING ISSUE Severe = 3 Moderate = 2 Minor = 1 None = 0	POTENTIAL TO MITIGATE RECURRING MAINTENANCE ISSUE (times per yr) 4 or more = 3 2 to 4 = 2 1 time/yr = 1	ENHANCED HABITAT / ECOLOGICAL BENEFIT High = 3 Moderate = 1 Low = 1 None = 0	IMPROVES AREA AESTHETICS (Neighborhood Stability) Yes = 3 No = 0	PROMOTES ECONOMIC DEVELOPMENT (In desirable area) Yes = 3 No = 0	OTHER TBL BENEFITS Yes = 3 No = 0	CONFLICTS W/ OTHER DEPT PLANS, GOALS No = 3 Yes = 0	REQD PERMITTING - FLOODWAY, FLOODPLAIN, WETLAND, OTHER None = 3 Standard = 2 Complex = 0	LONG TERM MAINTENANCE REQUIREMENTS Low = 3 Standard = 2 Complex = 0	COORDINATION WITH CIP PROJECT /OTHER FUNDING P3 Opportun = 3 CIP List =2 Grant/Loan Fund = 1 Multiple = 3 None=0	PROJEC Stande Innovat Unprove
#REF!	3	1	North Bou Site B	Integrated SW mgmt w/ hybrid swale in landscape; PICP paver & storage in parking; educational signage															
#REF!	6	2	New Fir Site B	28th & Glenwood; 20,000sf bldg			3	0	3										
#REF!	0	3	Alpine & Bal Streetscap	Permeable Pavement, Stormwater Planters, PaveDrain Shoulder; Focal Point w/Rtank															
#REF!	0	4	Broadway C Streetscap	Bioretention planters; linear stormwater management															
#REF!	0	5	Iris & B Roadwa	Bioretention planters; linear stormwater management															
#REF!	0	6	55th & Arapa Roadwa	Inform plan with concept roadway corridor GI - PICP parking, FocalPoint, Bioretention planters															
#REF!	0	7	Sumac & Neighborhood Dra	Hybrid drainage swale w/ bioretention cells & staged stormwater inlets - risers															
#REF!	0	8	Fourmil Roadwa	0															
#REF!	0	9	Twomile Co Runoff Collecti	PaveDrain Shoulder with sub-surface conveyance															
#REF!	0	10	Ongoing Mainte	Detention pond conversion; constructed wetland; stormwater swale															
#REF!	0	11	Wonderland Creek	0															
#REF!	0	12	Potential project at one of Open Space facilities? Site Based GI	0															

Public Impact		
1	2	1.5
PROJECT VISIBILITY/ LOCATED IN PUBLIC AREA Yes = 3 No = 0	ADDRESSES RESIDENT COMPLAINTS 4 or more = 3 2-4 = 2 None = 0	PROVIDES CONNECTIVITY OR NATURE BASED RECREATION Yes = 3 Some = 2 None =0
0	3	0
3	0	3

1 - Define Projects

2- Assign weighting factor importance to site suitability categories

3- Assign numerical ranking to detailed evaluation criteria for each project

4- Review project raw score and weighted total for project prioritization

5- Sort the list by the weighted total to list in order of prioritization

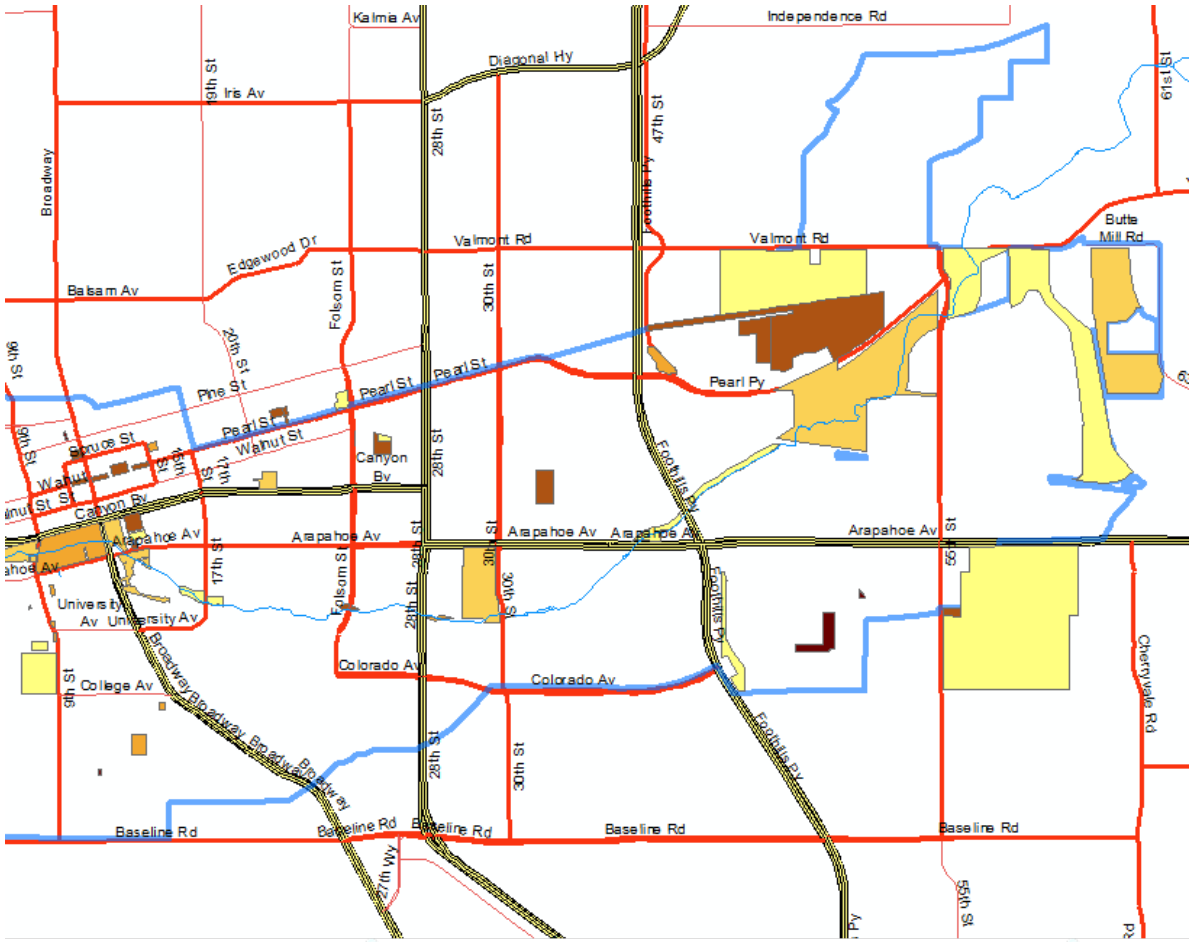
Green Infrastructure Potential Projects- Evaluation

TABLE X Boulder - PRIORITY RANKING

OVERALL PRIORITY RANKING	WEIGHTED TOTAL	PROJECT ID	PROPOSED PROJECT	PROPOSED CIP DESCRIPTION	CIP PROJECT COST	GI - STORMWATER EST COST
1	74.5	7	Sumac & 19th Street (Wonderland Creek 2) Neighborhood Drainage Improvements	PaveDrain & Hybrid drainage swale w/ bioretention cells & staged stormwater inltets - risers	$748,200	
2	74	11	Valmont City Park Development	Integrated SW mgmt w/ hybrid swale in landscape; bioretention; PICP paver & storage in parking; educational signage	$5,000,000	
3	65.5	18	CU South Planned Open Space	Passive GI and regional storage	TBD	
4	62	9	Twomile Canyon Creek-1 Runoff Collection & Conveyance	Kalmia & Jupiter improvements PaveDrain Shoulder & Bioswale with sub-surface conveyance and capacity improvements to creek/road crossing	$1,000,000	
5	60.5	1	North Boulder Library Site Based GI	Integrated SW mgmt w/ hybrid swale in landscape; PICP paver & storage in parking; educational signage	$5,000,000	
6	60.5	2	New Fire Station Site Based GI	Integrated SW mgmt w/ hybrid swale in landscape; PICP paver & storage in parking; educational signage	$12,500,000	
7	59	3	Alpine & Balsam Area Plan Streetscape / Landscape	Permeable Pavement, Stormwater Planters, PaveDrain Shoulder; Focal Point w/Rtank	$1,000,000	
8	58	13	30th & Colorado Bike/Ped Underpass	Inform plan with concept roadway corridor GI - PICP parking, FocalPoint, Bioretention planters	$5,900,000	
9	56	16	Elmer's Twomile Creek-2 - New and Replacement Storm Sewer	Integrated stormwater management mix of GI bioretention swale, infiltration trenches w/storm collection system	$3,874,000	

Project Categories
Runoff Collection & Conveyance GI
LID/Greenspace/ Passive Recreation GI
Site Based GI Practices
Streetscape /Urban Landscape GI
Neighborhood Drainage/Flooding Improvements
Ongoing Maintenance GI Retrofit
Roadway Corridor GI Practices

Unique GI Projects



NEXT STEPS

Next Steps

- Two more Stakeholder Meetings
- Finalize Pilot Projects – Format
- Path forward with funding for GI projects
- Incorporate Code and policy changes
- Finalize compliance tools

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5 Stakeholder Meetings

- What is our vision for this program?
- What level of stormwater management is enough?
- How do we incorporate these concepts in city projects and on private development?