Welcome to The Mars Hill Stormwater Demonstration Project

Sustainable Stormwater Management in the Mountains of Western North Carolina

LID Summit
March 26, 2014

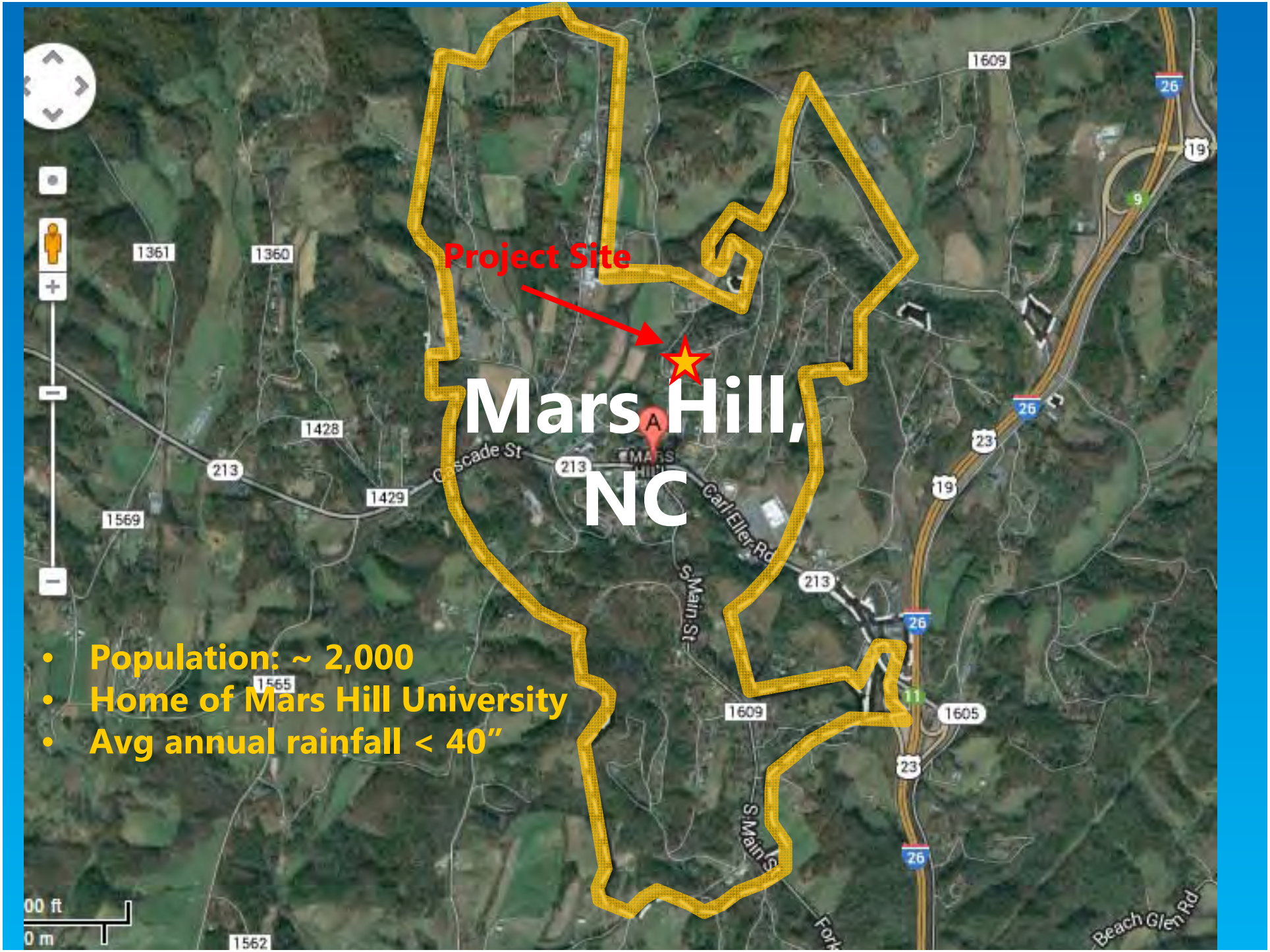
Tim Ormond, P.E.
HydroCycle Engineering

The Mars Hill Stormwater LID Demonstration Project

1) The Project
2) The Human Elements
3) The Research
4) The Take-Away

Mars Hill, NC

Source: visitnc.com


Project Site
Mars Hill, NC
• Population: ~ 2,000
• Home of Mars Hill University
• Avg annual rainfall < 40”
1609
26
19
9
1361
1360
1428
213
1429
1569
Cascade St
Carl Eller Rd
S Main St
23
11
1605
1565
1562
Beach Glen Rd

Quick Facts

- Mars Hill Town Hall
- 1.25-acre site
- Ivy River Watershed, 303(d) List
- Grant-Funding: DWR, PRF, CWMTF
- Sponsor: Madison County SWCD
- Partners: Mars Hill, Housing Authority
- Research/Planning/Design:
  - HydroCycle Engineering
  - Mary Weber ASLA
  - Living Systems Design

HydroCycle Engineering, PC


Town
Hall
Housing
Authority
Housing
Authority

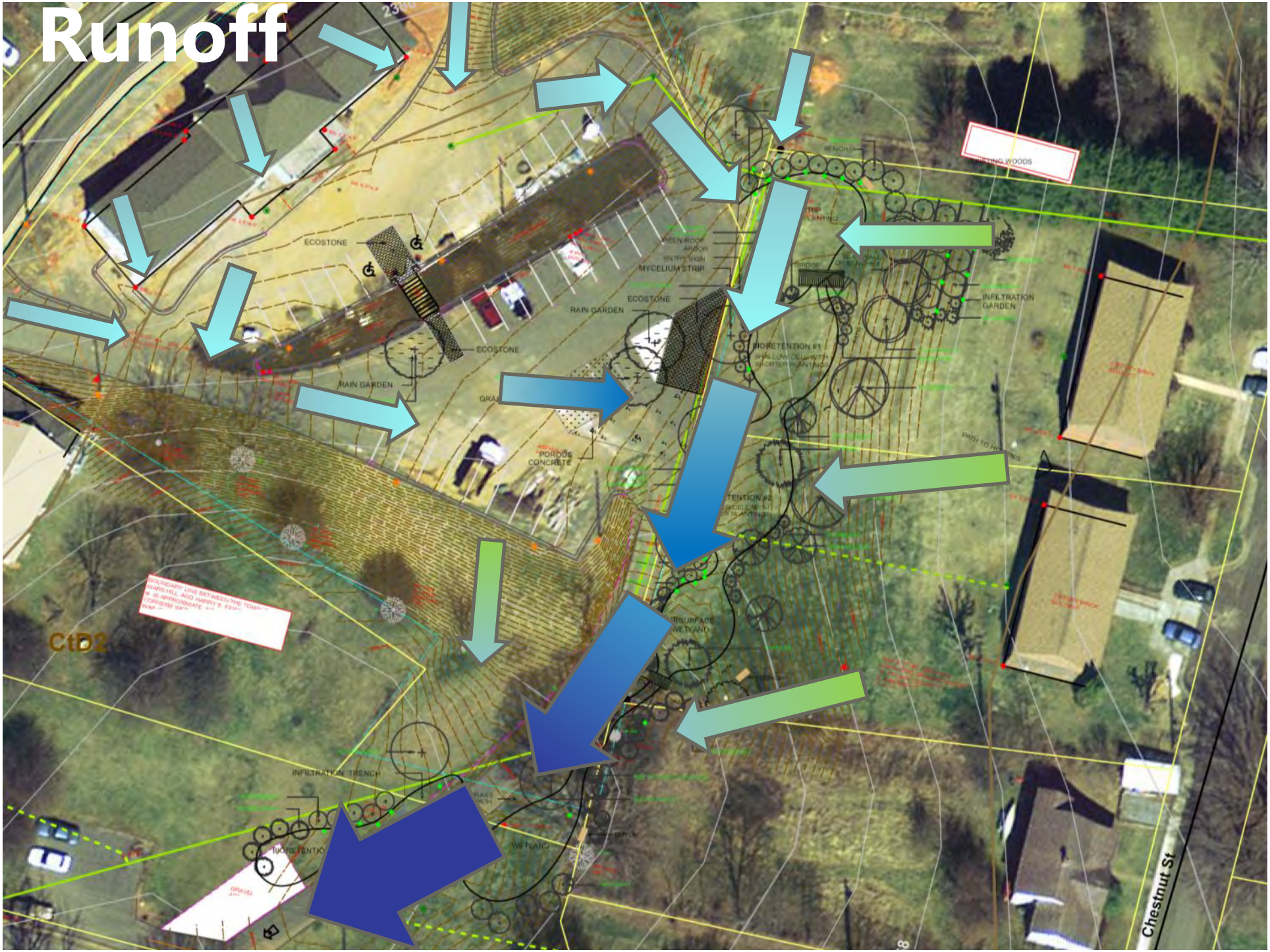
Before (Dry)

Before (Wet)

Housing Authority

Housing Authority

Valley


Runoff
ECOSTONE
MYCELIUM STRIP
ECOSTONE
RAIN GARDEN
ECOSTONE
RAIN GARDEN
INFILTRATION GARDEN
POROUS CONCRETE
CtD2
INFILTRATION TRENCH
WETLAND
Chestnut St

The Project

Project Goals

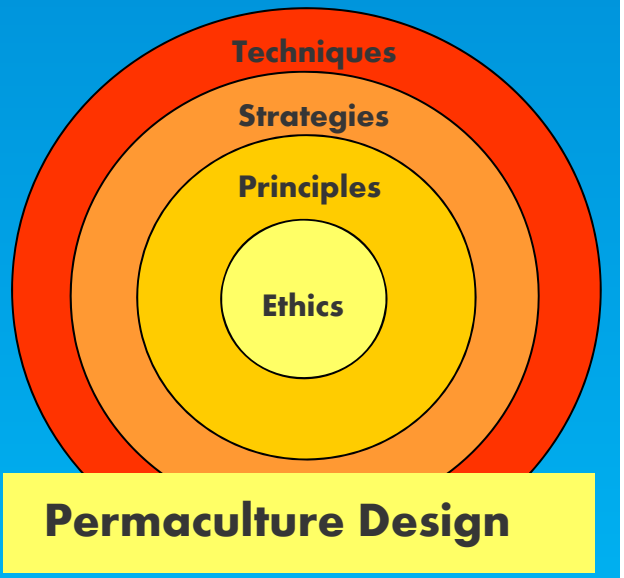
1) **Manage Stormwater**. Reduce the stormwater volume and improve the quality of stormwater leaving the Mars Hill Town Hall site in an effort to restore water quality in the Ivy River watershed.

2) **Educate and Inspire**. Create a demonstration project that will serve to educate and inspire the local community on the importance of stormwater management and LID solutions.

Design Philosophy

Inspired by Permaculture

- Ecological design system
- "Eco-mimicry"
- Understanding and designing interconnections
  - Create resiliency
  - Increase efficiency
  - Reduce or eliminate waste
- Views humans as vital part of the ecosystem



Design Goals

- Integrated system
- Wide variety of BMP types with proven effectiveness
- Treatment for the 90% water quality storm (~1.3”)
- Accommodate extreme storm events
- Simple, reproducible, cost-effective designs likely to be considered by local community
- Make site accessible and enjoyable, including circulation, seating, and shade
- Develop aesthetically pleasing design
- Develop low maintenance designs
- Provide opportunities for collaboration with students
- Provide BMP monitoring capabilities
- Minimize costs within limited grant-funded budget

MARS HILL
Stormwater Demonstration Project

Concept Design

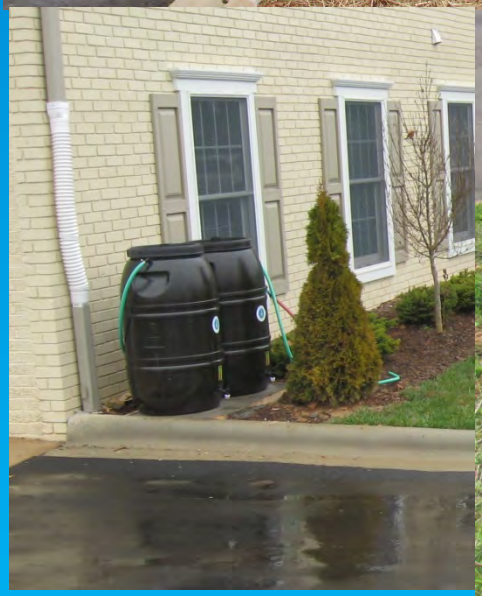
WHAT YOU'LL FIND HERE...

Take a map, follow the numbered trail, and discover the many stormwater Best Management Practices (BMPs) constructed on this site:

1) Cistern with Pump System
2) Arbor with Green Roof
3) Permeable Walking Trail
4) Eco-lawn with Native Grasses
5) Infiltration Garden with On-contour Swales
6) Bioretention Cell (Rain Garden)
7) Vegetated Swale
8) Deep Bioretention Cell (Rain Garden)
9) Subsurface Gravel Wetland
10) Stormwater Diversion Hump (Speed Bump)
11) Stormwater Wetland
12) Level Spreader
13) Rain Garden (Bioretention Cell)
14) Infiltration Trench
15) Mushroom Mycelia Filter Strip

On average, this 1.25 acre site gets about 40 inches of rain annually, which results in over 1 million gallons of stormwater runoff every year! As you walk around this site, think about what happens here

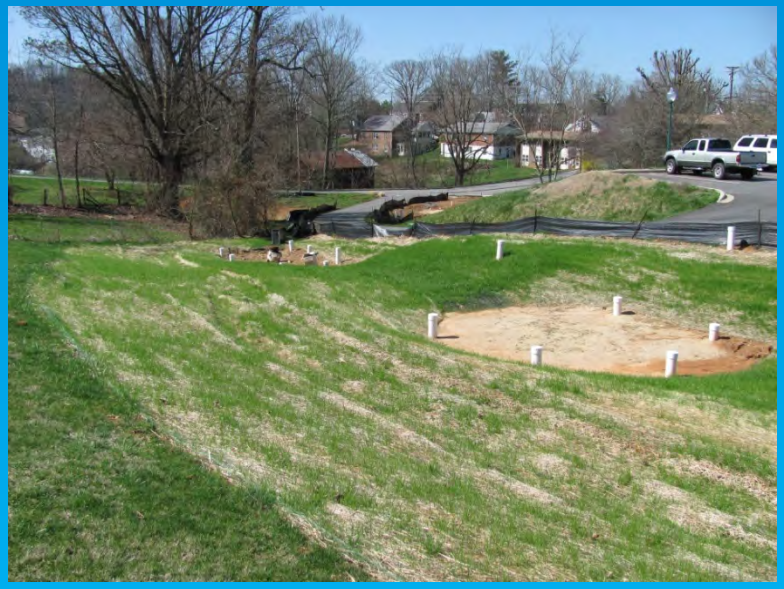
Rainbarrels and Cisterns



Living Roof

Vegetated Swales

Bioretention/Rain Gardens



Bioretention/Rain Gardens

Stormwater Wetlands

Stormwater Wetlands

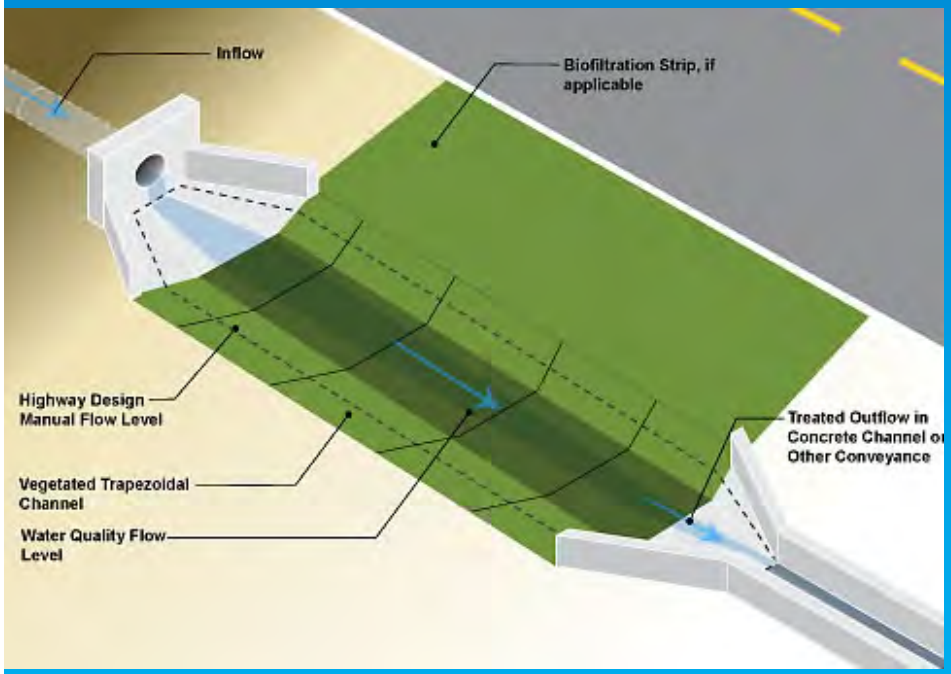
Permeable Walking Trail

And the Rest

“Do Try This at Home” BMPs

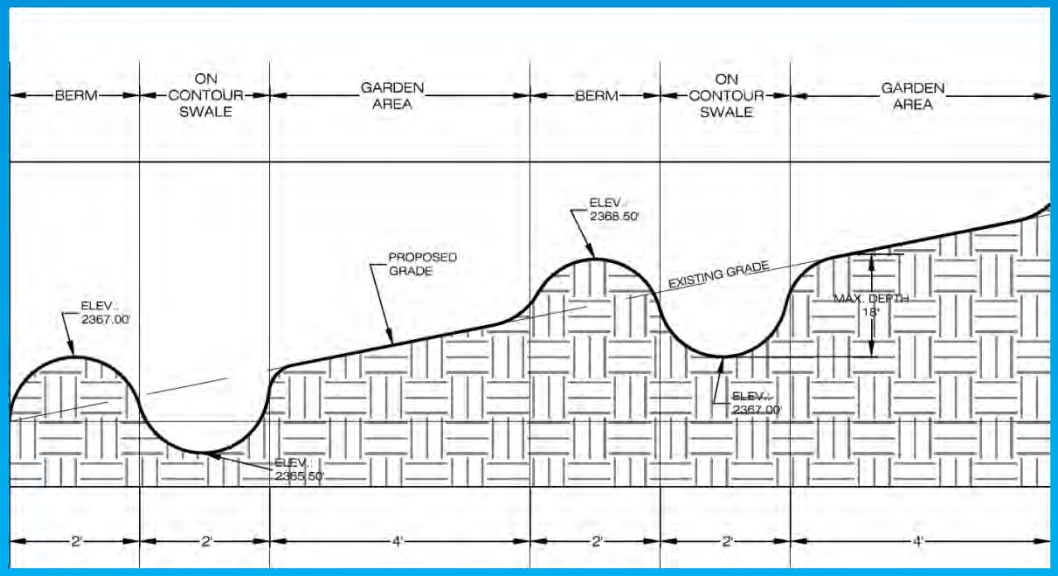
Vegetated Biofiltration Strip

Eco-lawn

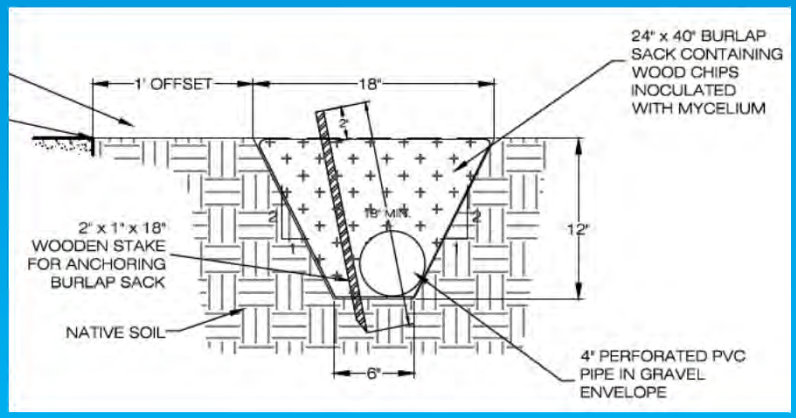


Source: Caltrans

Infiltration Garden



Mushroom Mycelium Filter

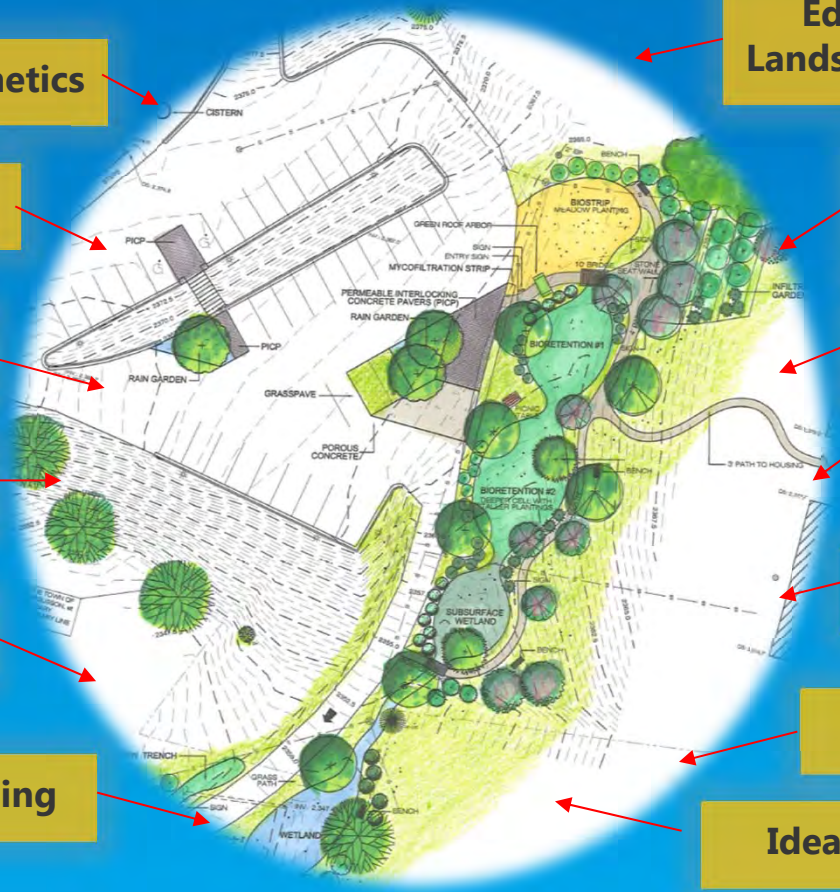


- **Oyster Mushroom**
- **Petroleum Hydrocarbons from 20,000 PPM to 200 PPM in 8 Weeks**

Source: P. Stamets

The Human Elements

Human Elements



Housing Authority Residents

Aesthetics

Respite

Local Colleges

Research

Education

Local Students (K-12)

Nature

Stormwater Nerds

Training

Edible Landscaping

Town Hall Employees

Picnic Area

Visitors

Curiosity

Town Residents

Learning

Inspiration

Educators

Income

Local Businesses

Ideas

Meet, Think, and Eat Berries

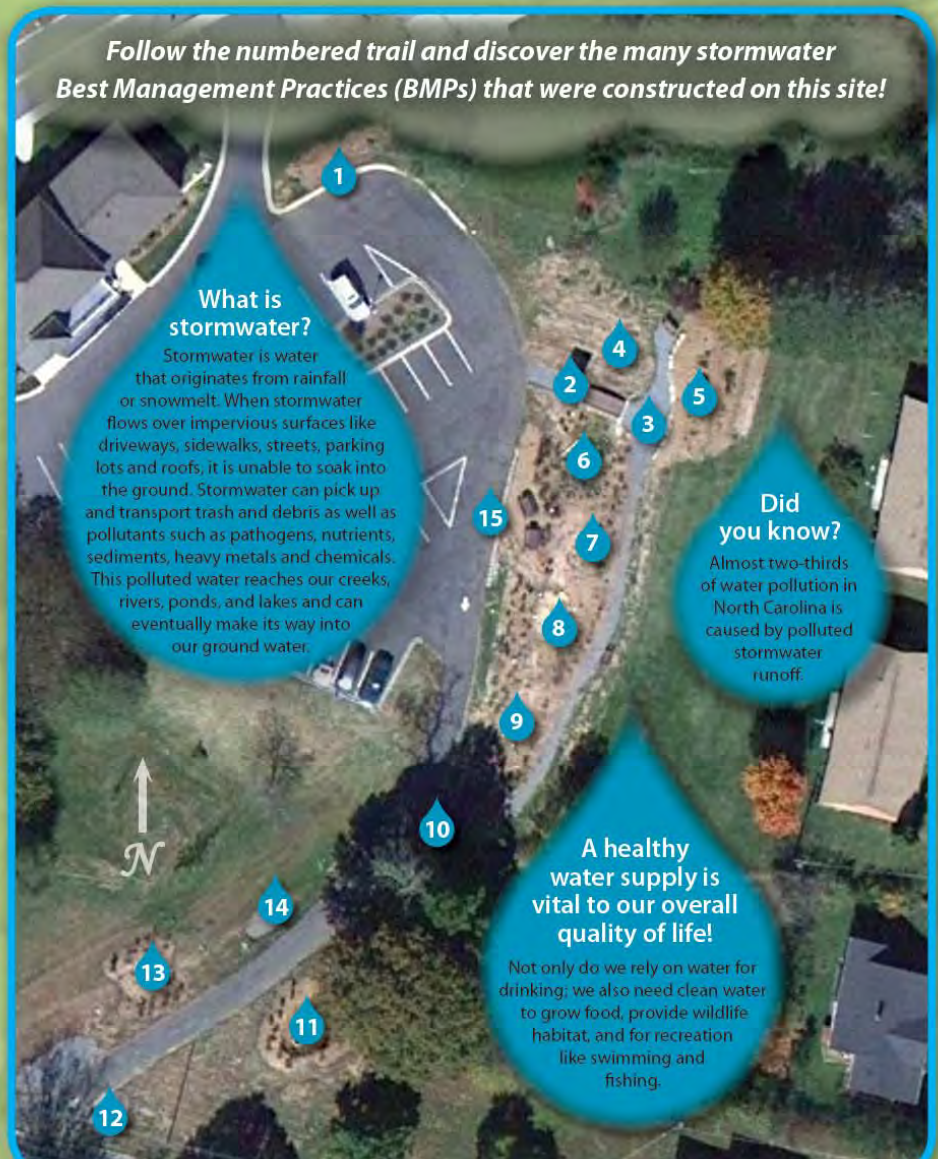
Native and Edible Vegetation

- 21 tree species
- 18 shrub species
- 19 wetland plant species
- 29 native perennials and grasses
- 31 of 87 species with secondary benefits as food, medicine, spice, etc.

Educational Signage

Interactive Trail Map

(Fun for All Ages)



On average, this 1.25-acre site receives about 40 inches of rain annually, which results in over 1 million gallons of stormwater runoff every year! As you walk around this site, think about what happens here when it rains. How might these stormwater BMPs help?

1 Cistern with Pump System

The cistern consists of underground plastic tanks which collect rainfall from the roof of the town hall building through a series of gutters, downspouts and buried pipes. The tanks hold up to 3,000 gallons of roof runoff. A pump system allows this water to be used for landscaping all around the town hall. Notice the three *access hatches* at the toe of the slope. Rain barrels are a similar, but smaller, technique that can be installed at your home to collect rain for watering your garden and landscaping. ***How else could you use rain water?***

2 Arbor with Green Roof

This arbor was constructed from black locust, a native tree resistant to rotting. The green roof includes a waterproof membrane, a root barrier and a lightweight growing media, 4 inches deep. Hardy, low-growing, drought-resistant plants capture 65 to 100% of roof runoff. Green roofs can last 30 years or more, help to reduce heating and cooling costs, improve air quality and aesthetics. This installation was done by Living Roofs, Inc., a local company. ***Can you think of any other benefits of green roofs?***

3 Permeable Walking Trail

Roads, driveways, parking lots and other paved surfaces are major contributors to polluted stormwater runoff. Various permeable pavement technologies have been developed to allow stormwater to percolate through the paved surface and to minimize runoff. This permeable walking trail consists of a 2-inch gravel base layer and a 3-inch washed gravel surface layer. A product called "Klingstone Paths" was applied to the washed gravel layer as a binder. The resulting walking trail allows stormwater to filter through the trail into the ground below. ***Can you think of any other uses for permeable pavement?***

4 Eco-Lawn

Maintenance of conventional lawns can take up time and energy and generate greenhouse gases through mowing. The application of chemical fertilizers and pesticides can contaminate stormwater runoff and pollute our creeks and rivers downstream. Eco-Lawn, a seed mix blend of seven fescue grasses, was developed to reduce the maintenance needs of lawns. It grows in both sunny and shady conditions, is drought-tolerant, and requires less fertilizing and mowing, saving time and expense. When left to grow longer, Eco-Lawn can act as an even more effective filter for stormwater and reduce the amount of runoff. ***Can you find***

5 Infiltration Garden with On-Contour Swales

A "swale" is a long, shallow depression in the ground, designed to collect or redirect water. "On-contour swales" are dug along level contour lines to capture stormwater runoff as it flows downhill. These swales hold the water in place and allow it to infiltrate into the ground to provide water for plants on the adjacent soil berms. Water-loving plant species such as elderberry were planted in the soil berms. ***Can you think of any sloped ground at your home that could benefit from this on-contour swale technique?***

6 Bioretention Cell (Rain Garden)

Bioretention cells, often called "rain gardens," are living ecological systems that act as natural filters for stormwater. They are typically shallow depressions filled with sandy soil, topped with mulch, and planted with dense vegetation. Together, the soil, plants and microbes capture and treat stormwater to remove pollutants. Bioretention cells are usually designed to allow temporary ponding to a depth of 6-9 inches and include an overflow outlet to prevent flooding. Since the soils at this site are dense clay with slow infiltration rates, this bioretention cell has a perforated pipe underdrain system to allow an additional escape point for the treated water. This cell is over 4 feet deep, with an 8" gravel layer, a 4" sand layer, a 24" soil layer, a 3" mulch layer, and a 9" ponding layer. Nine different native plant species, including species that attract butterflies and other beneficial insects, were planted here. ***How many different stormwater pathways can you see in this rain garden?***

7 Vegetated Swale

Vegetated swales, sometimes called "bioswales", are broad, shallow channels with a dense stand of vegetation covering the side slopes and bottom. They are designed to remove pollutants as the stormwater flows through. Unlike the on-contour swales (#5) which capture stormwater, this vegetated swale is designed to direct stormwater downhill. This particular swale has a mesh matting you might see if you look closely. The matting is there to prevent soil erosion in the fast-moving stormwater. ***Can you find the 4 other vegetated swales on this site?***

8 Deep Bioretention Cell

Like the Bioretention Cell in #6, this bioretention cell is comprised of stacked layers of gravel, sand, soil and mulch. But this one is 12 inches deeper and contains a different sandy soil mixture in order to test the pollutant removal effectiveness of different types of soil. ***Can you notice any other differences between this cell and #6?***

Interactive Trail Map

9 Subsurface Gravel Wetland

Subsurface gravel wetlands, also called "submerged gravel wetlands" are a type of stormwater wetland. Instead of a permanent shallow water surface like traditional wetlands, the water level in this wetland is below a layer of crushed rock. Because there is a permanent water level, this BMP can also support wetland plants. Stormwater flows through the root zone of the gravel wetland where pollutant removal takes place. ***How deep do you think the water level is below the surface? How is it maintained at that depth?***

10 Stormwater Diversion Hump (Speed Bump)

This stormwater diversion hump, sometimes called a "water bar," is a simple device that intercepts stormwater flowing down this steep driveway and diverts it into a stable vegetated swale. This helps to slow down the water velocity, prevent erosion, and carry the stormwater into a wetland where it will be treated before flowing offsite. ***Can you follow the path of water after it flows into this stormwater diversion hump?***

11 Stormwater Wetland

Stormwater wetlands are constructed wetlands that incorporate wetland plants in a shallow pool. As stormwater runoff flows through the wetland, pollutants settle to the bottom and are absorbed by the plants. Stormwater wetlands are among the most effective stormwater BMPs in terms of pollutant removal. They also provide a habitat type that is less common in our mountain region. This wetland was constructed with a 12-inch compacted clay liner to ensure that it holds water. ***There were 10 different species of wetland plants planted here, including various rushes and reeds. How many different types of wetland plants can you identify here today?***

12 Level Spreader

Level spreaders are BMPs that are designed to uniformly spread a concentrated water flow over a larger vegetated area. They are constructed at a virtually zero percent grade. Level spreaders effectively filter and slow runoff as concentrated flow is turned into sheet flow. Pollutants are removed through settling and filtration. There are many level spreader design options available. This simple level spreader consists of lumber and a gravel apron on the downstream side. ***Can you tell where the flow is concentrated and where it becomes sheet flow? Where is the flow fastest and slowest? Where would the pollutants settle out the most and why?***

13 Rain Garden (Bioretention Cell)

This is the smallest of the three rain gardens on site. However, it is the second deepest at a depth of 4.5 feet. It includes gravel, sand, soil and mulch layers as well as an underdrain pipe system. There were 9 species of rain garden plants planted here, including grasses, sedges, rushes and flowers which attract beneficial insects. ***How many different types of insects can you find living in this rain garden? Can you think of a location in your yard for a rain garden?***

14 Infiltration Trench

Infiltration trenches are narrow subsurface basins filled with gravel or crushed stone. that capture, filter, and infiltrate stormwater runoff. They can be used on sites with limited space for managing stormwater. Infiltration trenches effectively remove pollutants such as suspended solids, pathogens, nutrients and metals. This infiltration trench contains a rock layer that is 4 feet deep. ***Where does the water go after entering this infiltration trench? What types of plants do you see growing here? Why are there so few plants?***

15 Mushroom Mycelia Filter Strip

Mycelia are the thread-like body of a fungus which live below ground, while the mushrooms we see are just the small visible fruit of the fungus. Mushrooms "bloom" much like flowers do, during certain times of the year when the conditions are right. Mushroom mycelia can effectively remove pollutants from stormwater, including pathogens (protozoa, bacteria, viruses), silt and sediment, and chemical toxins (including petroleum hydrocarbons). This mushroom mycelia filter strip consists of burlap sacks filled with wood chips and inoculated with oyster mushroom spores. As the mycelia grow and eat the wood chips, they also intercept and remove pollutants from the parking lot runoff. ***Can you see any mycelia? Can you find any mushrooms? What type of pollutants would you expect from the parking lot runoff?***

Native Plants

One goal of this project was to create a diverse native habitat for many plant, insect and other animal species. The project involved planting 87 different plant species, including:

- 21 tree species
- 18 shrub species
- 19 wetland plant species
- 29 native perennials and grasses
- 31 of 87 species with secondary benefits as food, medicine, spice, etc.

How many different plants can you identify here? How do they help to manage stormwater at this site?

Bringing the Message Home

Now is your chance to take what you've learned and apply it! Many of the stormwater practices demonstrated at this site can be applied on a smaller scale at our homes, schools and neighborhoods. Rain barrels, rain gardens and wetlands are some of the many techniques used by homeowners in our region and beyond. Not only do they help protect and improve our water resources, but they can reduce costs for watering landscapes and increase the enjoyment, and even the value of your property.

You can call the Madison County Soil and Water Conservation District for more information at 828.649.3313 x3

Want to learn more?

North Carolina Stormwater Page
www.ncstormwater.org

Center for Watershed Protection
www.cwp.org

U.S. Environmental Protection Agency
water.epa.gov

Build your own rain garden
www.bae.ncsu.edu/topic/raingarden/Building.htm

PROJECT PARTNERS
Town of Mars Hill, Madison County Soil and Water Conservation District, Mars Hill Housing Authority, Mountain Valleys RC&D, Mars Hill University, HydroCycle Engineering

PROJECT FUNDING AND DONATIONS
NC Division of Water Resources, Pigeon River Fund, EPA 319, Town of Mars Hill, Madison County SWCD, Mars Hill Housing Authority, HydroCycle Engineering, Mary Weber Landscape Architecture, Stalite PermaTill, Hedrick Quarries, Klingstone Inc.

DESIGN AND CONSTRUCTION TEAM
Project Manager: Bailey Mundy, Madison County SWCD
Engineer: Tim Ormond, P.E., HydroCycle Engineering
Landscape Architect: Mary Weber Landscape Architecture
Watershed Coordinator: Sara Nichols, Madison County SWCD
Permaculture Consultant: Zev Friedman
Mycelium Consultant: Asheville Fungi
Interpretative Signs and Brochure: Tony Geiger
Construction: CLS Inc.
Landscaping: Hawks Landscaping

Thanks for visiting!

MARS HILL Stormwater Demonstration Project

Welcome to The Mars Hill Stormwater Demonstration Project

Sustainable Stormwater Management in the Mountains of Western North Carolina

This stormwater demonstration project was created in an effort to improve water quality and advance stormwater management practices in our region.

This project helps to:

- Capture and treat over 90% of all stormwater on site
- Improve water quality on site and in the Ivy River Watershed
- Reduce downstream flooding and erosion
- Establish native vegetation
- Provide habitat for wildlife
- Recharge groundwater
- Reduce water usage for landscaping
- Provide learning opportunities for students of all ages
- Demonstrate stormwater practices that can be applied at your own home

We invite you to tour this site and learn more about the importance of stormwater and how we can all better manage it together.

The Research

Research as a Connection

Warren Wilson College

UNCA

A-B Tech

Mars Hill College

Haywood Community College

Madison SWCD

- Sampling ports at each BMP
- Innovative BMPs
- Living Laboratory
- Outreach to Colleges
- Tours – Guided and Self-Guided

Steep Slope Bioretention

Bioretention with Mycelium

U.S. DEPARTMENT OF ENERGY

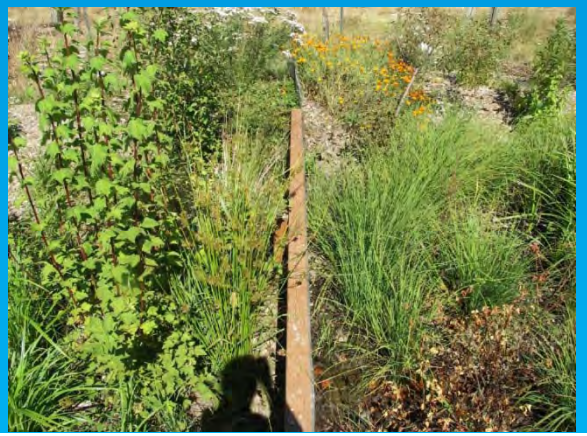
PNWD-4054-1

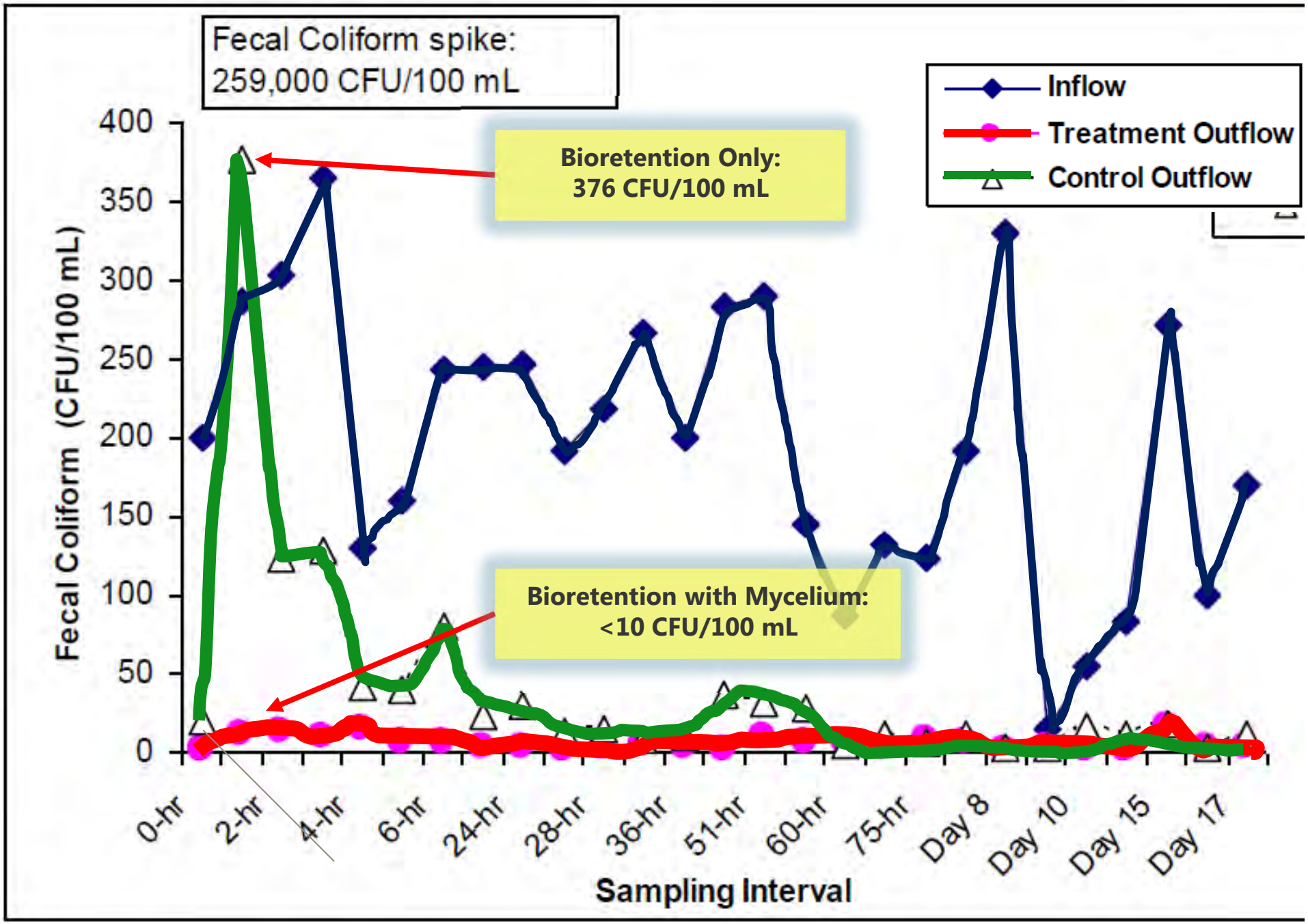
Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Field Demonstration of Mycoremediation for Removal of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington

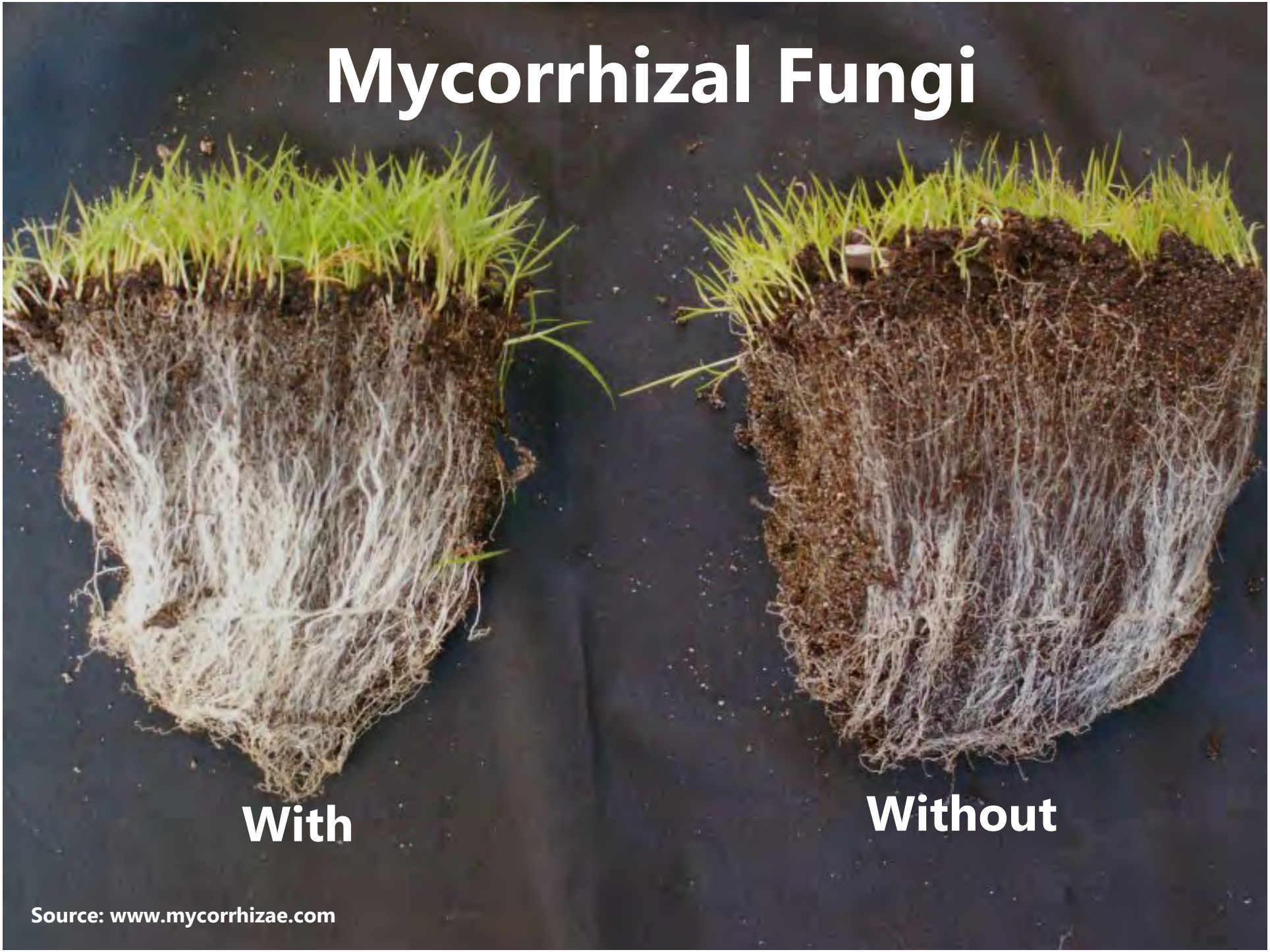
SA Thomas
LM Aston
DL Woodruff
VI Cullinan

Final Report
March 2009



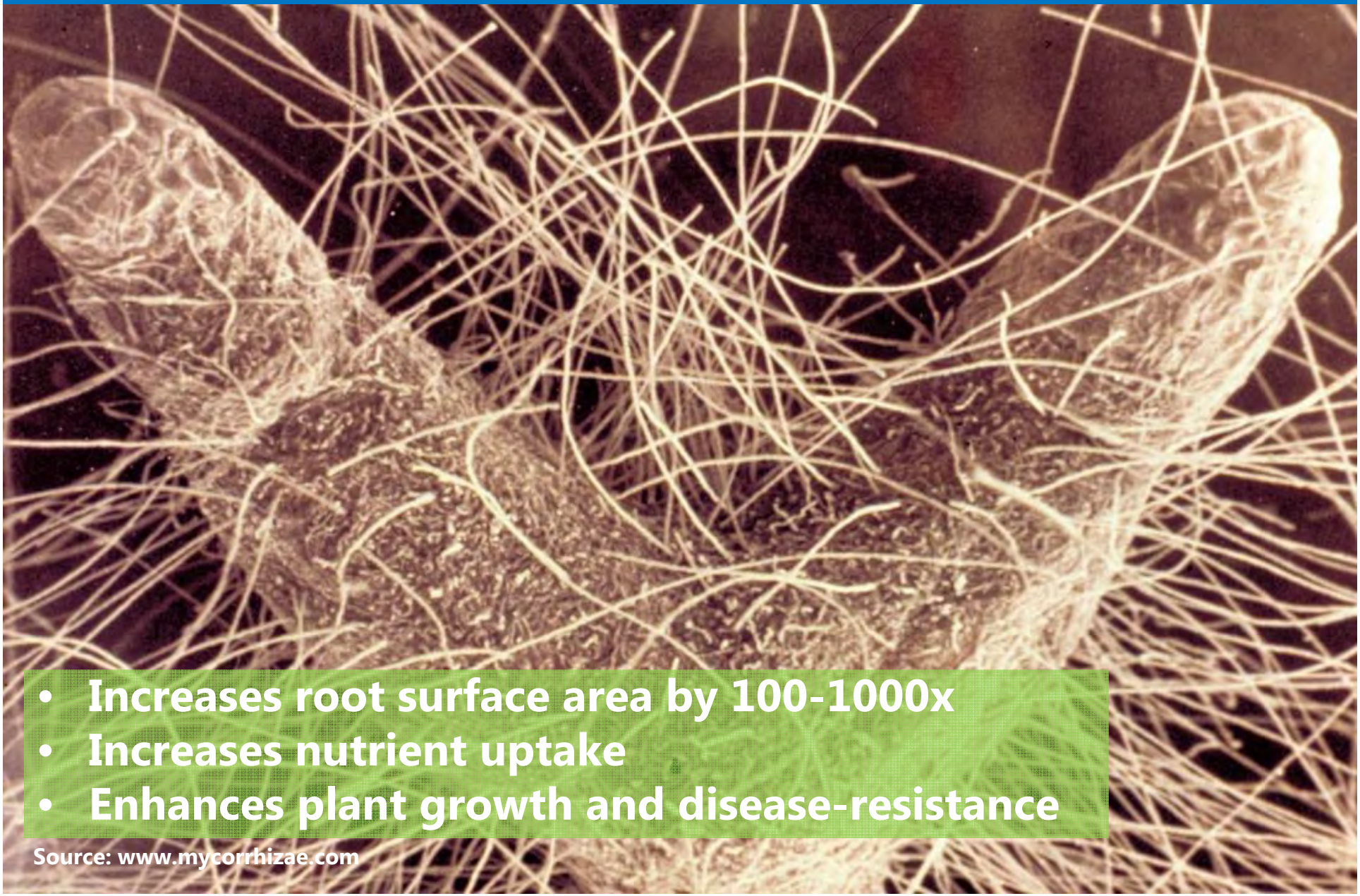

Fecal Coliform spike:
259,000 CFU/100 mL
Inflow
Treatment Outflow
Control Outflow
Bioretention Only:
376 CFU/100 mL
Bioretention with Mycelium:
<10 CFU/100 mL
Fecal Coliform (CFU/100 mL)
400
350
300
250
200
150
100
50
0
0-hr
2-hr
4-hr
6-hr
24-hr
28-hr
36-hr
51-hr
60-hr
75-hr
Day 8
Day 10
Day 15
Day 17
Sampling Interval

Mycorrhizal Fungi



Source: www.mycorrhizae.com

Mycorrhizal Fungi



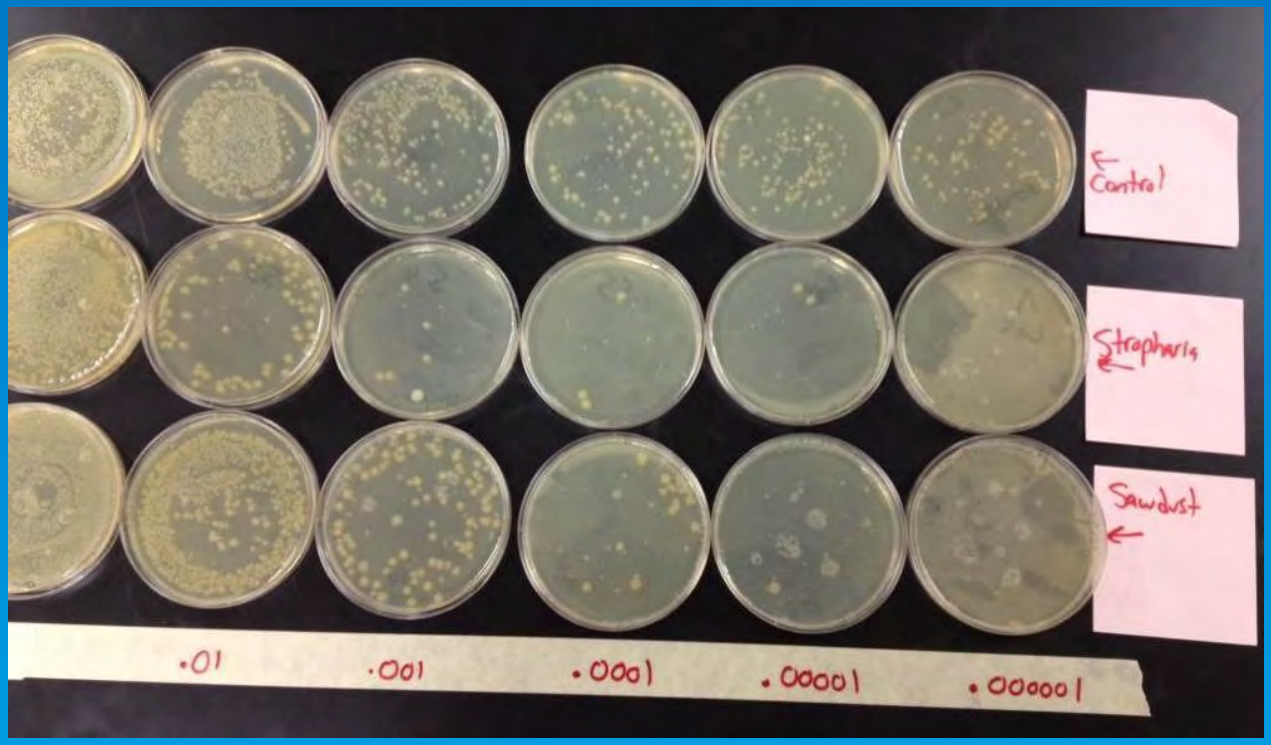
- Increases root surface area by 100-1000x
- Increases nutrient uptake
- Enhances plant growth and disease-resistance

Source: www.mycorrhizae.com


Asheville
Fungi
Mushroom
Central
OPEN

Mycelium Filter Pilot Study

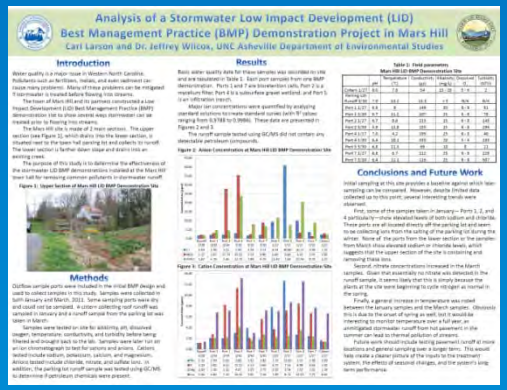
Bench Scale Study



- A-B Technical Community College
- King Stropharia Mushroom Mycelium
- 93% Reduction in E. coli vs. Control Filter

Bioretention with Mycelium

Research



Analysis of a Stormwater Low Impact Development (LID) Best Management Practice (BMP) Demonstration Project in Mars Hill

Carl Larson and Dr. Jeffrey Wilcox, UNC Asheville Department of Environmental Studies

Introduction

Results

Methods

Conclusions and Future Work

Stormwater Mycelium Filter Pilot Project
Madison County, North Carolina

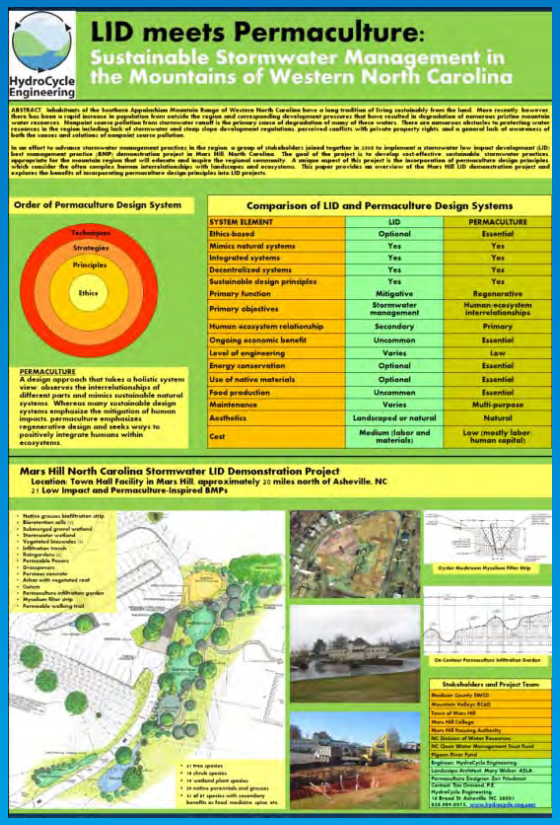
Madison County Soil and Water Conservation District

Final Report

Prepared by

HydroCycle Engineering, PC
16 Broad St
Asheville, NC 28801

February 27, 2014



LID meets Permaculture:
Sustainable Stormwater Management in the Mountains of Western North Carolina

HydroCycle Engineering

Order of Permaculture Design System

Comparison of LID and Permaculture Design Systems

SYSTEM ELEMENT	LID	PERMACULTURE
Ethics-based	Optional	Essential
Mimics natural systems	Yes	Yes
Integrated systems	Yes	Yes
Decentralized systems	Yes	Yes
Sustainable design principles	Yes	Yes
Primary function	Mitigative	Regenerative
Primary objectives	Stormwater management	Human-ecosystem interrelationships
Human-ecosystem relationship	Secondary	Primary
Ongoing economic benefit	Uncommon	Essential
Level of engineering	Varies	Low
Energy conservation	Optional	Essential
Use of native materials	Optional	Essential
Food production	Uncommon	Essential
Maintenance	Varies	Multi-purpose
Aesthetics	Landscaped or natural	Natural
Cost	Medium (labor and materials)	Low (mostly labor; human capital)

Mars Hill North Carolina Stormwater LID Demonstration Project

Location: Town Hall Facility in Mars Hill, approximately 20 miles north of Asheville, NC

21 Low Impact and Permaculture-Inspired BMPs

- 4 Local Colleges
- 5 Senior Research Projects
- 1 Bench Scale Study
- 2 LID Conferences

Bio filtration of *Escherichia coli* by the Basidiomycete Fungus *Stropharia rugosaannulata*

Joseph Allawos

Asheville-Buncombe Technical Community College

Advisor: Dr. Mark Brenner

Natural Science Seminar Thesis

EFFECTIVENESS OF A MYCOFILTER AT REDUCING BIOLOGICAL OXYGEN DEMAND, PHOSPHOROUS, AMMONIA, AND SUSPENDED SOLIDS FROM

Effectiveness of a mycofilter on reducing coliforms in agricultural runoff

Marie Orton

Advisor: Mark Brenner

The Take-Away

Lessons Learned

- Humans are Vital part of the Ecosystem
- Plan and design for human connections
- Greater connections = Greater long-term project success and resilience
- Work with many stakeholders and funding sources for broad input and support
- Partner with Colleges and Other Schools
- Consider research as a connection
- Incorporate simple, understandable “try this at home” BMPs
- Applied mycelium research

Before

Construction

Construction

Construction

Complete

Complete

Fully Alive

Thank you.