TETRA TECH

Storm Water Best Management Practice

Inspection and Maintenance Workshop

April 6, 2011

think BLUE SAN DIEGO

Project Team

think BLUE SAN DIEGO

City Staff:

- Sumer Hasenin
- Jim Nabong
- Jim Hook

Tetra Tech Staff:

- Scott Struck
- Jason Wright
- Chad Helmle

North Carolina State University

- Bill Hunt
- Bill Lord

BMP I & M Workshop Agenda

WELCOME (8:30am)

- **Regulatory Overview & LID Concepts**
- **Fundamentals of BMP Maintenance & Examples from NC**
- **Bioretention/Bio Swales**
- **Infiltration Trenches**
- **Permeable Pavement**

LUNCH (12:00pm)

- **Planter Boxes**
- **Vegetated Filter Strips & Vegetated Buffers**
- **Sand Filters**
- **Vegetated Swales**
- **Simple "Green" BMPs: Cisterns/ Irrigation/ Green Roofs**
- **Wrap up**
- **Open Q&A**

ADJOURN (5:00pm)

Regulatory Background

- **Regulations Summary**
  - Clean Water Act
  - EPA delegates authority to State and Regional Water Boards
- **Regulatory Drivers**
  - The 2007 Municipal Stormwater Permit
    - ❖LID
    - ❖HMP
  - Total Maximum Daily Loads
  - Areas of Biological Significance

MS4 Permit Language

Permit Excerpt

(Order No. R9-2007-0001, Sec. D.1.d.(4)

Low Impact Development (LID) BMP Requirements

Each Copermittee shall require each Priority Development Project to implement LID BMPs which will collectively minimize directly connected impervious areas and promote infiltration at Priority Development Projects

MS4 Permit Language

Permit Excerpt

(Order No. R9-2007-0001, Sec. D.1.d.(6)(a and b)

Treatment Control BMP Requirements

Each Copermittee shall require each *Priority Development Project* (PDP) to implement treatment control BMPs which meet the following treatment control BMP requirements:

–mitigate (infiltrate, filter, or treat) the required volume or flow of runoff from developed project

–treatment control BMPs located to infiltrate, filter, or treat the runoff volume or flow prior to discharge

MS4 Permit Language

Permit Excerpt

(Order No. R9-2007-0001, Sec. D.1.g

Hydromodification

Each Copermittee shall collaborate with the other copermittees to develop HMP to manage increases in runoff discharge rates and durations from *all* Priority Development Projects, where such increased rates and durations are likely to cause increased erosion of beds and banks, sediment pollutant generation, or other impacts to beneficial uses and stream habitat…

MS4 Permit Language

Permit Excerpt *Sec. D.1.e.(1-4)*

Treatment Control BMP Maintenance Tracking

(2) Each Copermittee shall develop and implement a program to verify that approved treatment control BMPs are operating effectively and have been adequately maintained. At a minimum, the program shall include…

Infiltrate, Filter, or Treat…? What is LID?

- Low Impact Development is a comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds.

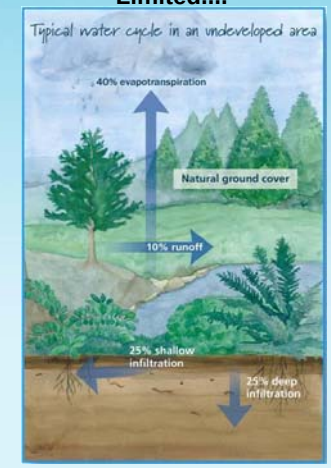
  Low Impact Development Center

- LID focuses on minimizing impervious surfaces and promoting infiltration and evaporation of runoff before it can leave the location of origination. Using small, economical landscape features, LID techniques work as a system to filter, slow, evaporate, and infiltrate surface runoff at the source.

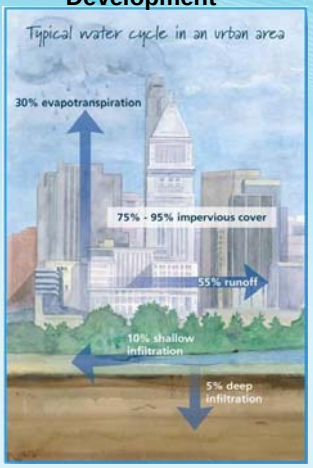
  San Diego County LID Manual

Low Impact Development Concepts

Under Natural Conditions Runoff is Limited....



....But increases After Development



Low Impact Development Concepts

How do we make this…

function more like this?

Low Impact Development Concepts

- **Preserve ecosystem functions in the built environment**
- **Use nature to mimic the natural water balance**
- **Use hydrology as fundamental design guide**
- **Deploy multiple systems beginning at the source**
- **Preserve runoff volume, frequency, rate and timing**

It's not just what we do but how we do it!

- **Hydrologically functional land design**
- **Engineer the site to mimic original hydrologic regime (using MEP and BPJ)**
- **Distribute and increase assimilative capacity**
- **Build redundancy**
- **Build multifunctional landscapes, buildings, and support infrastructure (roadways, etc.)**

Future Regulatory "Trends"

Inclusion of water quality goals or limits (e.g. TMDLs) in permits

- Numeric WQBELs in storm water permits
  - Clarify permit requirements and
  - Improve accountability ,and
  - Improve enforceability.
- Where MS4 discharges have the potential to cause or contribute to a water quality standard excursion, the NPDES permitting authority should include numeric effluent limitations as necessary to meet WQSs and to create objective and accountable means for controlling stormwater discharges.

"Better information on the effectiveness of stormwater controls to reduce pollutant loadings and address water quality impairments is now available."

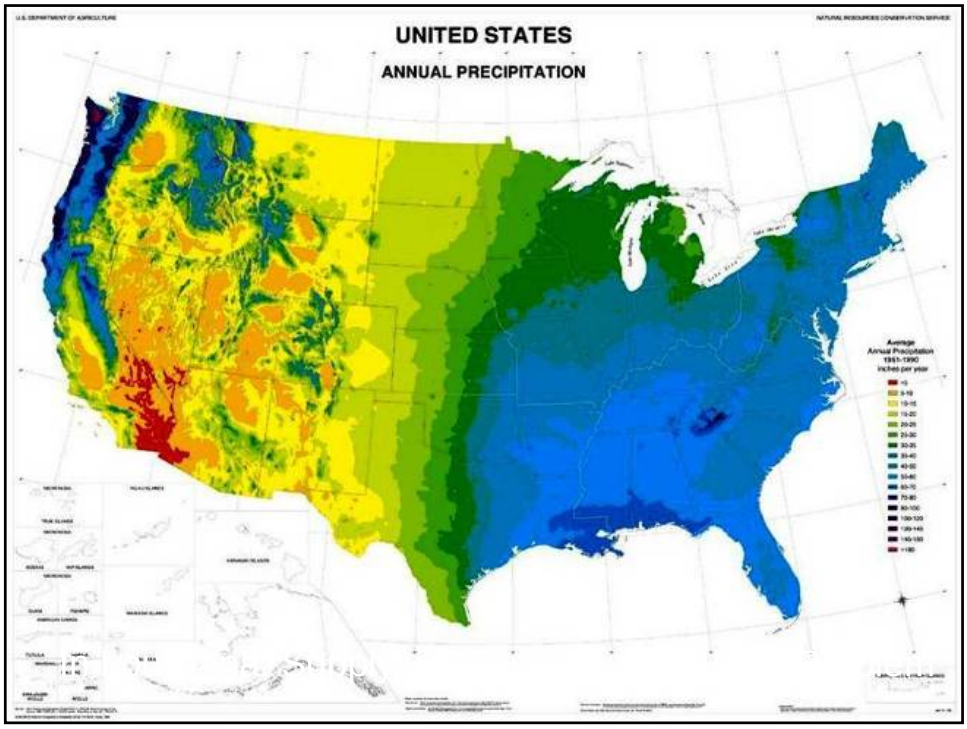
"Storm water discharges remain a impairment in many places and are a significant cause of water quality."

Why We Care About & Common Elements of BMP Maintenance

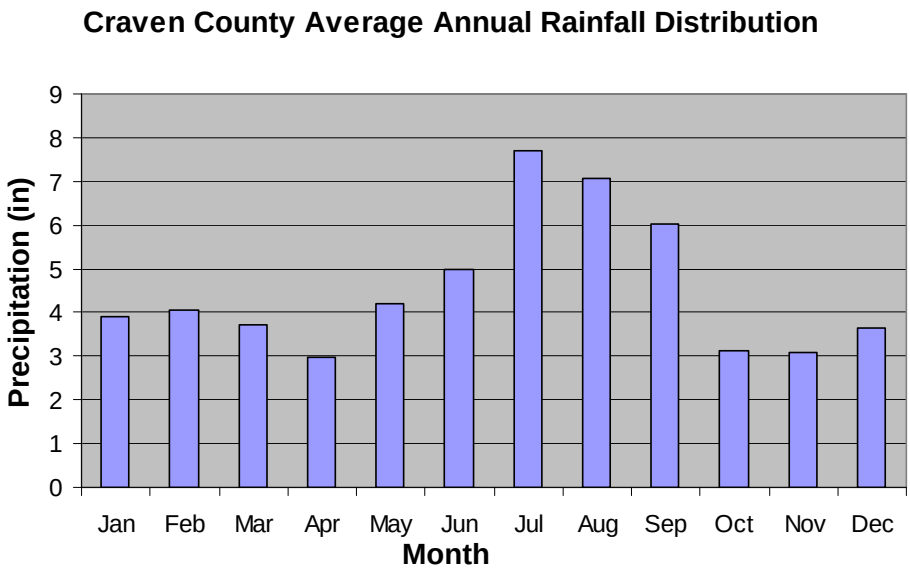
About North Carolina

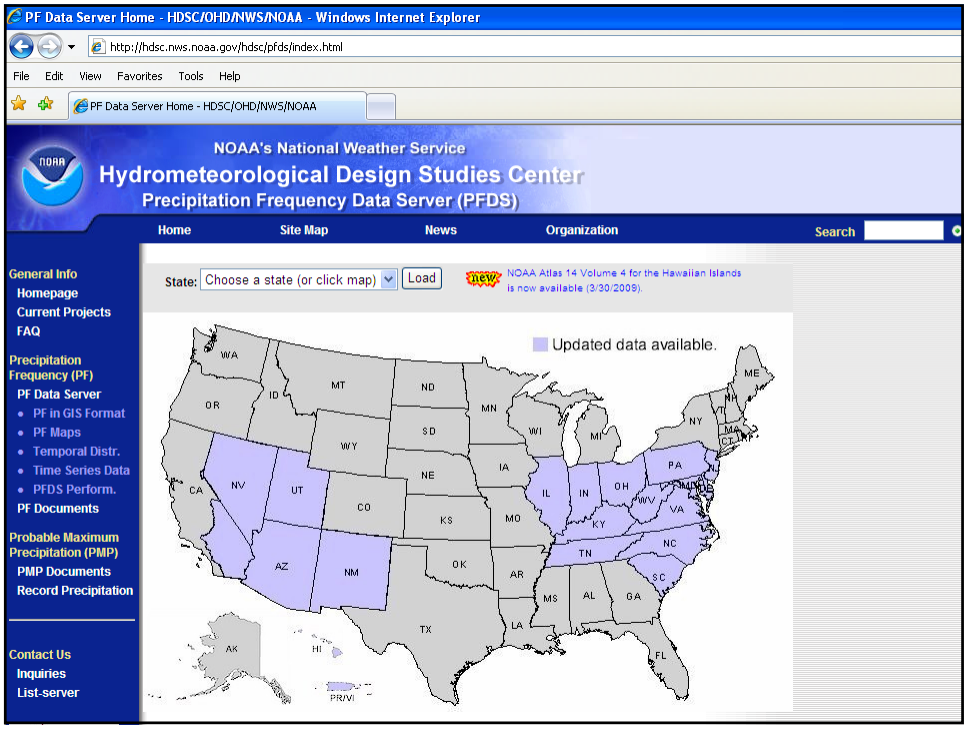
- 10th Most Populous State in USA
  - 9.5M
  - SD Co (3M+)
- 5th Fastest Growing Population (2005)
- Includes Coastline & Appalachian Mountains

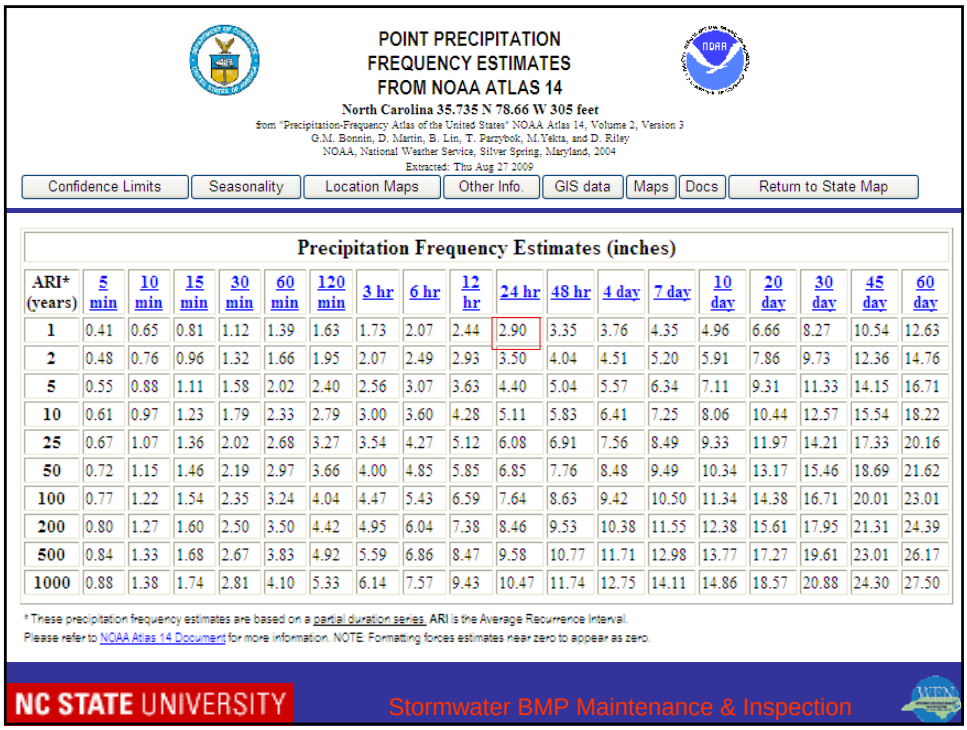
Precipitation: ~1000 - 1300 mm per year.
Average High in January = 9°C
Average High in July = 31°C



North Carolina's Rainfall Supply is Regular




PF Data Server Home - HDSC/OHD/NWS/NOAA - Windows Internet Explorer
http://hdsc.nws.noaa.gov/hdsc/pfds/index.html
File Edit View Favorites Tools Help
PF Data Server Home - HDSC/OHD/NWS/NOAA
NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)
Home Site Map News Organization Search
General Info
Homepage
Current Projects
FAQ
Precipitation Frequency (PF)
PF Data Server
PF in GIS Format
PF Maps
Temporal Distr.
Time Series Data
PFDS Perform.
PF Documents
Probable Maximum Precipitation (PMP)
PMP Documents
Record Precipitation
Contact Us
Inquiries
List-server
State: Choose a state (or click map) Load
new NOAA Atlas 14 Volume 4 for the Hawaiian Islands is now available (3/30/2009).
Updated data available.
WA OR CA ID NV MT WY UT AZ CO NM ND SD NE KS OK TX MN IA MO AR LA WI IL MS MI IN KY TN AL OH WV GA FL SC NC VA PA NY MD DE NJ CT RI MA VT NH ME AK HI PRVI


POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14
North Carolina 35.735 N 78.66 W 305 feet
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004
Extracted: Thu Aug 27 2009
Confidence Limits Seasonality Location Maps Other Info. GIS data Maps Docs Return to State Map
Precipitation Frequency Estimates (inches)
ARI* (years) | 5 min | 10 min | 15 min | 30 min | 60 min | 120 min | 3 hr | 6 hr | 12 hr | 24 hr | 48 hr | 4 day | 7 day | 10 day | 20 day | 30 day | 45 day | 60 day
1 | 0.41 | 0.65 | 0.81 | 1.12 | 1.39 | 1.63 | 1.73 | 2.07 | 2.44 | 2.90 | 3.35 | 3.76 | 4.35 | 4.96 | 6.66 | 8.27 | 10.54 | 12.63
2 | 0.48 | 0.76 | 0.96 | 1.32 | 1.66 | 1.95 | 2.07 | 2.49 | 2.93 | 3.50 | 4.04 | 4.51 | 5.20 | 5.91 | 7.86 | 9.73 | 12.36 | 14.76
5 | 0.55 | 0.88 | 1.11 | 1.58 | 2.02 | 2.40 | 2.56 | 3.07 | 3.63 | 4.40 | 5.04 | 5.57 | 6.34 | 7.11 | 9.31 | 11.33 | 14.15 | 16.71
10 | 0.61 | 0.97 | 1.23 | 1.79 | 2.33 | 2.79 | 3.00 | 3.60 | 4.28 | 5.11 | 5.83 | 6.41 | 7.25 | 8.06 | 10.44 | 12.57 | 15.54 | 18.22
25 | 0.67 | 1.07 | 1.36 | 2.02 | 2.68 | 3.27 | 3.54 | 4.27 | 5.12 | 6.08 | 6.91 | 7.56 | 8.49 | 9.33 | 11.97 | 14.21 | 17.33 | 20.16
50 | 0.72 | 1.15 | 1.46 | 2.19 | 2.97 | 3.66 | 4.00 | 4.85 | 5.85 | 6.85 | 7.76 | 8.48 | 9.49 | 10.34 | 13.17 | 15.46 | 18.69 | 21.62
100 | 0.77 | 1.22 | 1.54 | 2.35 | 3.24 | 4.04 | 4.47 | 5.43 | 6.59 | 7.64 | 8.63 | 9.42 | 10.50 | 11.34 | 14.38 | 16.71 | 20.01 | 23.01
200 | 0.80 | 1.27 | 1.60 | 2.50 | 3.50 | 4.42 | 4.95 | 6.04 | 7.38 | 8.46 | 9.53 | 10.38 | 11.55 | 12.38 | 15.61 | 17.95 | 21.31 | 24.39
500 | 0.84 | 1.33 | 1.68 | 2.67 | 3.83 | 4.92 | 5.59 | 6.86 | 8.47 | 9.58 | 10.77 | 11.71 | 12.98 | 13.77 | 17.27 | 19.61 | 23.01 | 26.17
1000 | 0.88 | 1.38 | 1.74 | 2.81 | 4.10 | 5.33 | 6.14 | 7.57 | 9.43 | 10.47 | 11.74 | 12.75 | 14.11 | 14.86 | 18.57 | 20.88 | 24.30 | 27.50
* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.
NC STATE UNIVERSITY
Stormwater BMP Maintenance & Inspection

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

California 33.833 N 117.579 W 1266 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Thu Aug 27 2009

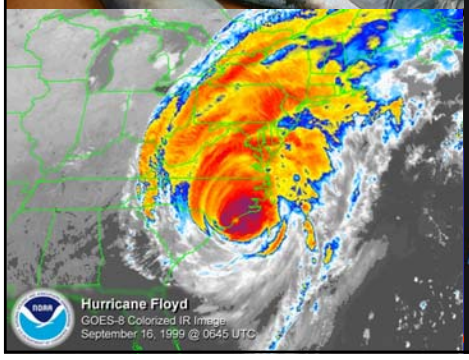
Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.35	0.43	0.63	0.81	1.18	1.56	1.93	2.15	2.54	2.92	3.25	3.89	4.60	5.18	5.98
2	0.17	0.27	0.33	0.44	0.55	0.80	1.02	1.49	2.00	2.50	2.81	3.36	3.88	4.32	5.17	6.14	6.94	8.01
5	0.23	0.35	0.44	0.59	0.73	1.04	1.31	1.92	2.61	3.35	3.87	4.70	5.51	6.10	7.32	8.74	10.04	11.53
10	0.28	0.42	0.53	0.71	0.88	1.24	1.55	2.26	3.09	4.00	4.69	5.72	6.76	7.47	8.98	10.70	12.46	14.28
25	0.35	0.54	0.66	0.89	1.11	1.53	1.91	2.74	3.73	4.89	5.84	7.12	8.51	9.38	11.29	13.39	15.88	18.12
50	0.41	0.63	0.78	1.05	1.30	1.77	2.19	3.12	4.24	5.59	6.76	8.21	9.90	10.89	13.12	15.51	18.67	21.24
100	0.48	0.74	0.91	1.23	1.52	2.03	2.49	3.52	4.77	6.33	7.74	9.36	11.37	12.49	15.07	17.73	21.65	24.56
200	0.56	0.85	1.05	1.42	1.75	2.31	2.81	3.94	5.32	7.09	8.77	10.56	12.90	14.16	17.10	20.03	24.83	28.09
500	0.67	1.02	1.26	1.70	2.11	2.72	3.28	4.52	6.05	8.13	10.21	12.20	15.06	16.50	19.96	23.20	29.36	33.09
1000	0.76	1.16	1.44	1.94	2.40	3.06	3.65	4.97	6.63	8.95	11.37	13.51	16.79	18.37	22.24	25.71	33.06	37.15

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Why NC Cares



Key to Acceptance of BMP Use & Maintenance: Get People to Relate

Is water related recreation important to North Carolina?

Tourism and Water ???

WRAL.com coverage you can count on

Obituaries
Because Every Life Has a Story...

4:42 pm · 5-13-09
71°
Tonight's Low: 58°
7 Day Forecast

Presented by HostedSolutions

Business

Visitor spending hits record $17.1B in N.C.

Posted: Aug. 5, 2008

RALEIGH, N.C. — Visitor spending increased 7.4 percent across North Carolina last year, to a record $17.1 billion, according to information released Tuesday by the state Division of Tourism, Film and Sports Development.

Wake County was one of six counties to register

All Triangle-area counties saw increased tourism spending, except for Lee County, which registered

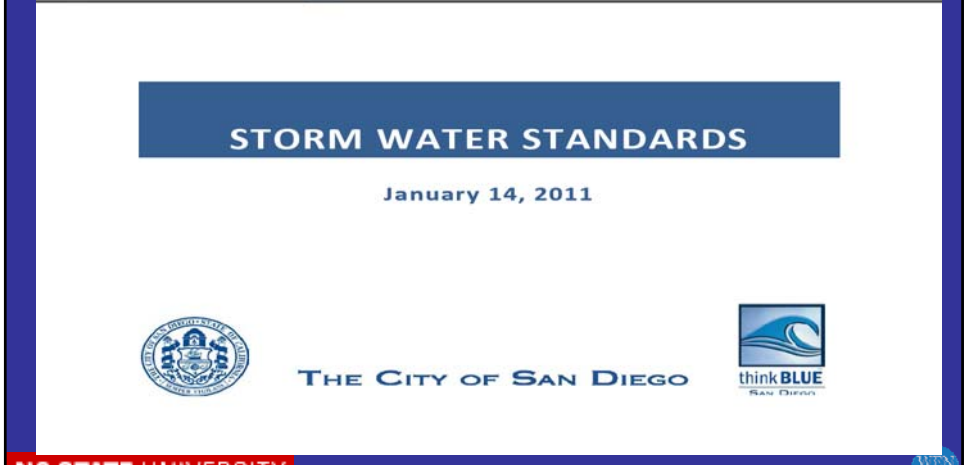
• 2007 N.C. visitor spending

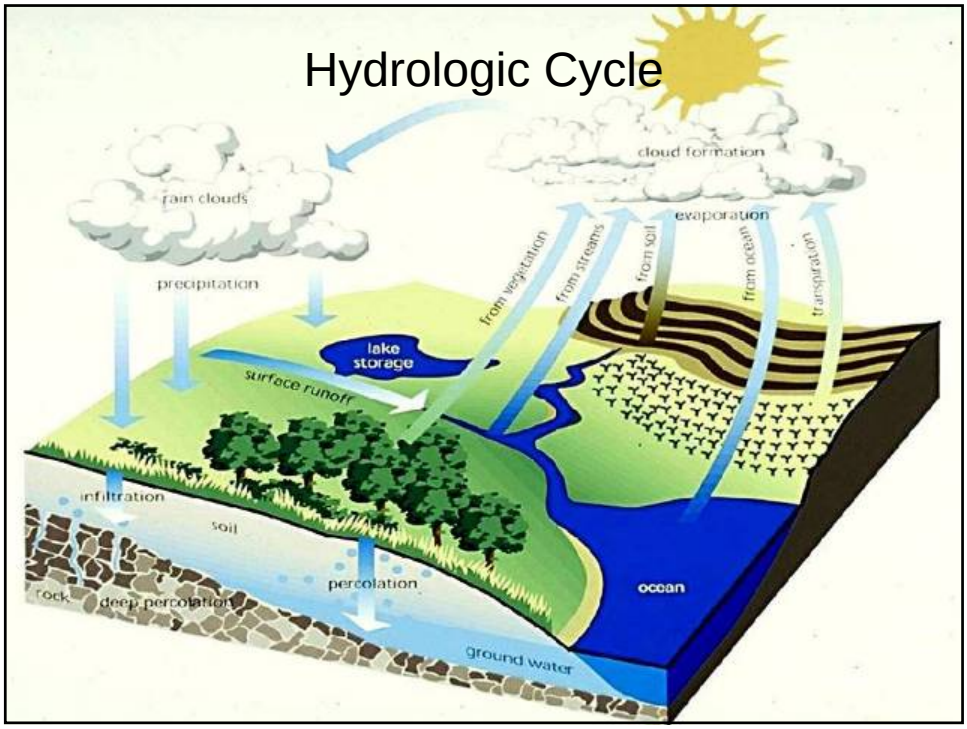
San Diego, Too

Tourism Big Business in S.D.

What Drives the Use of BMPs?

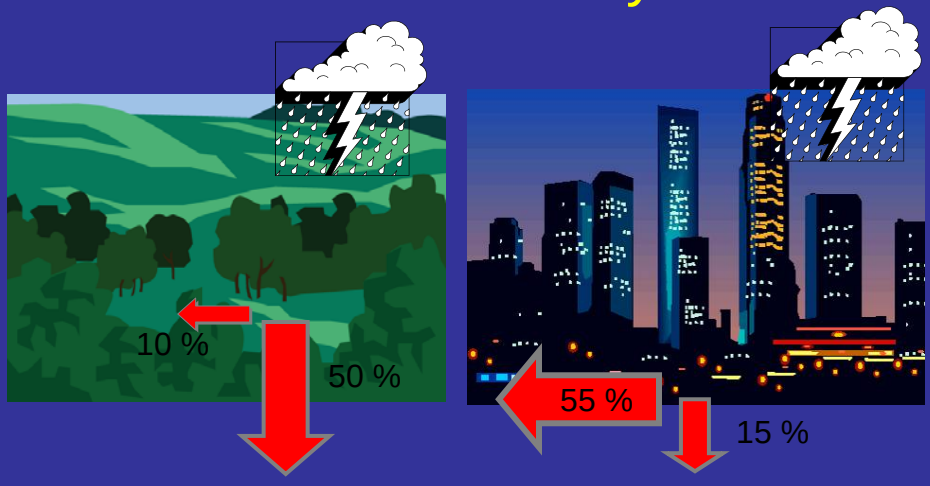
Regulations




Hydrologic Cycle
cloud formation
rain clouds
evaporation
precipitation
from vegetation
from streams
from soil
from ocean
transpiration
lake storage
surface runoff
infiltration
soil
percolation
rock
deep percolation
ocean
ground water


Water Cycle

Development Impacts on the Water Cycle



Effects of Water Pollution

- Closed shellfish areas and beaches

Stormwater BMP Maintenance & Inspection

Bacteria: Good for tourism?

Common urban runoff pollutants

- Trash

Fertilizer

Jordan Lake Rules

Local & State

Home / Local & State

Counties: Wake | Durham | Orange | Johnston | Chatham **Topics:** Crime & Safety | Health & Science | Education | Growth | Q | Corrections
Columnists: John Drescher | Barry Saunders | Ruth Sheehan | Road Worrier

Comments (0) | Recommend (0)

BOOKMARK E-MAIL PRINT TEXT SIZE:

Welcome
BECOME A MEMBER| Sign In

Advertisements

New cleanup rules for Jordan Lake move forward

BY JIM WISE - STAFF WRITER
Published: Wed, May. 06, 2009 02:00AM Modified Tue, May. 05, 2009 11:56PM

RALEIGH -- With even its sponsor admitting the bill's imperfections, the House Environment and Natural Resources Committee voted Tuesday to send revised rules for cleaning up Jordan Lake a step closer to approval.

"This is one of those things you just got to hold your nose and move it on down the road a little bit and hope it'll get better," said Rep. Pryor Gibson of Anson and Union counties. Gibson sponsored the bill along with Reps. Lucy Allen of Halifax, Nash and Franklin counties and Alice Bordsen of Alamance.

The bill, "Restore Water Quality in Jordan Reservoir," contains revisions to proposed environmental-protection rules. The revisions are meant to ease requirements for local governments while bringing the lake into compliance with state and federal water-quality standards.

The City of Durham, which would feel the greatest financial effect from the proposed rules, supports the Gibson-Allen-Bordsen version, but environmental groups support the original regulations.

Under the revisions, local governments would not have to take steps to reduce stormwater pollution from existing development until at least 2016.

"That's too long to wait," said Elizabeth Ouzts,

JORDAN LAKE FORUM

The Durham People's Alliance will hold a forum on proposed Jordan Lake management regulations at 6:30 p.m. May 13 in the Herald-Sun Building Community Room, 2828 Pickett Road in Durham.

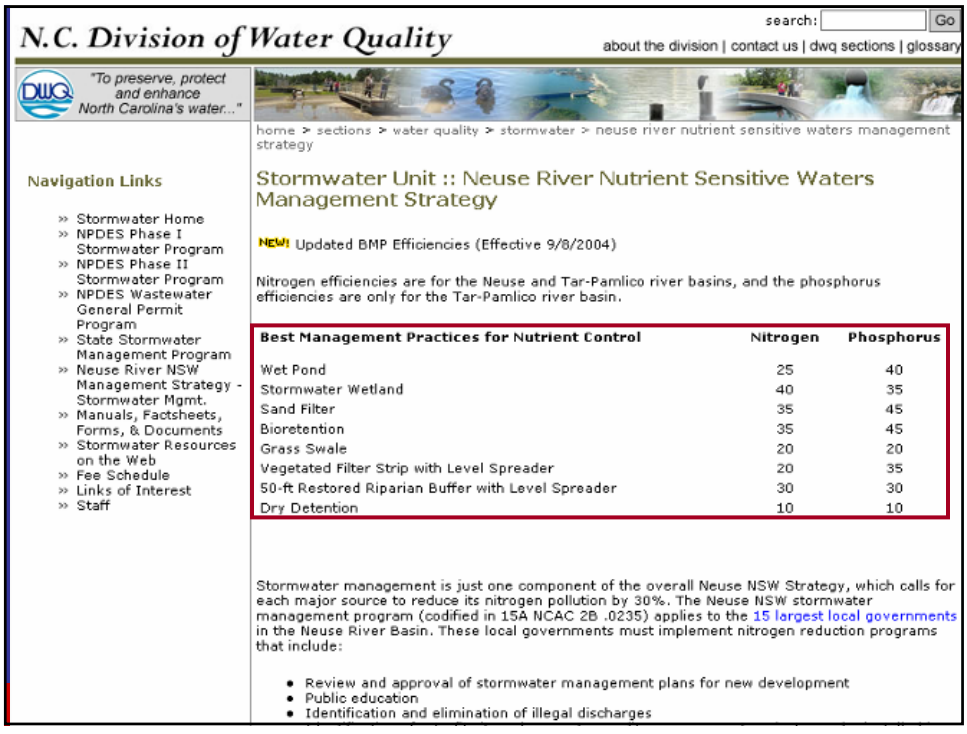
The forum will address the cost, effectiveness and fairness of the regulations and whether they have been based on the best available data.

Speakers include John Cox of Durham's stormwater

Most Popular

Done Internet | Pro

NC STATE UNIVERSITY Stormwater BMP Maintenance & Inspection



N.C. Division of Water Quality

search: Go
about the division | contact us | dwq sections | glossary

"To preserve, protect and enhance North Carolina's water..."

home > sections > water quality > stormwater > neuse river nutrient sensitive waters management strategy

Navigation Links

- Stormwater Home
- NPDES Phase I Stormwater Program
- NPDES Phase II Stormwater Program
- NPDES Wastewater General Permit Program
- State Stormwater Management Program
- Neuse River NSW Management Strategy - Stormwater Mgmt.
- Manuals, Factsheets, Forms, & Documents
- Stormwater Resources on the Web
- Fee Schedule
- Links of Interest
- Staff

Stormwater Unit :: Neuse River Nutrient Sensitive Waters Management Strategy

NEW! Updated BMP Efficiencies (Effective 9/8/2004)

Nitrogen efficiencies are for the Neuse and Tar-Pamlico river basins, and the phosphorus efficiencies are only for the Tar-Pamlico river basin.

Best Management Practices for Nutrient Control	Nitrogen	Phosphorus
Wet Pond	25	40
Stormwater Wetland	40	35
Sand Filter	35	45
Bioretention	35	45
Grass Swale	20	20
Vegetated Filter Strip with Level Spreader	20	35
50-ft Restored Riparian Buffer with Level Spreader	30	30
Dry Detention	10	10

Stormwater management is just one component of the overall Neuse NSW Strategy, which calls for each major source to reduce its nitrogen pollution by 30%. The Neuse NSW stormwater management program (codified in 15A NCAC 2B .0235) applies to the 15 largest local governments in the Neuse River Basin. These local governments must implement nitrogen reduction programs that include:

- Review and approval of stormwater management plans for new development
- Public education
- Identification and elimination of illegal discharges

From Prior Slide… BMP Removal Credits

Best Management Practices for Nutrient Control	Nitrogen	Phosphorus
Wet Pond	25	40
Stormwater Wetland	40	35
Sand Filter	35	45
Bioretention	35	45
Grass Swale	20	20
Vegetated Filter Strip with Level Spreader	20	35
50-ft Restored Riparian Buffer with Level Spreader	30	30
Dry Detention	10	10

- BMPs “Assigned” Pollutant Load Removal Rates.

A New “Breed” of BMP Arrived: Constructed Stormwater Wetlands

www.bae.ncsu.edu/stormwater

Rainater Harves

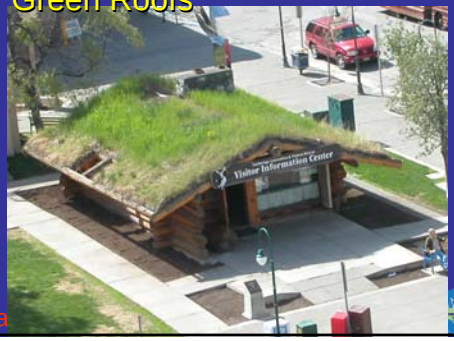
www.bae.ncsu.edu/stor
nwater/

NC STATE UNIVERSITY

Stormwater BMP Main

Permeable Pavement
Level Spreader – VFS

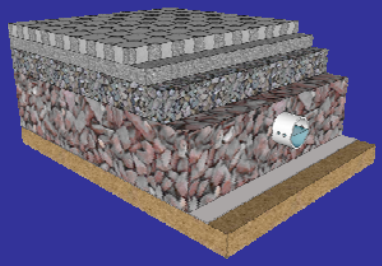
Bioretention Cells
Green Roofs



nwa

Well, Our San Diego Soils Don't Perc!

- That's OK!
- BMPs – even some LID Practices – still function
  - More "catch, treat, and release" than infiltration



- Permeable Pavement with an impermeable liner + underdrain

A Lined BMP Treating an SD issue

Beach and Bay Status Report

Water quality closures and advisories for
San Diego County Beaches
April 5, 2011 1:30 PM.

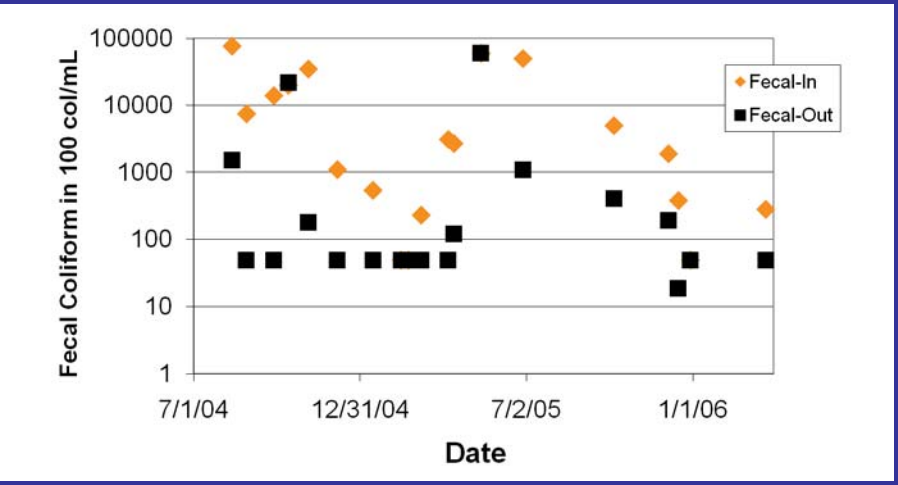
Signs warning of contaminated water are posted at the following locations.

Closures:
These beaches are closed to water contact due to sewage spills that may impact ocean or bay waters.

South County -- The ocean shoreline from U.S. / Mexico border to the North End TJ Estuary (S End of Seacoast Drive.)
Stations: Border Field State Park & the Tijuana Slough National Wildlife Refuge Shoreline
Status Since: Dec 18.
Reason: Sewage-contaminated runoff from the Tijuana River

Advisories: Water contact should be avoided at the following beaches due to

Bioretention – Indicator Bacteria



Land Grant School Mission

- Serve the Needs of the State
- Through Applied Research & Education/ Training
- Cooperation with Extension Agents/ Localities

What Makes NC State Different?

We Research Stormwater BMPs Which FORCES us to Observe their Function

What We Saw….

"Caked" Bioretention with Dead Vegetation

What We Saw…

Cattails Clogging
Drawdown Structures

What We Saw…

Clogged Permeable Pavement due
to “Rogue” Construction

What We Saw: Cary Stormwater BMPs (2007)

- Approximately 425 BMPs in Cary
- According to one of Cary's inspectors: Timothy Grady, RLA:
- 95% of BMPs failed initial inspection as they require repairs
- Most repairs are maintenance related: erosion, trash removal, tree removal

Enter the…BMP Inspection & Maintenance Certification

Who offers this Certification?

- NC State University Cooperative Extension Service
- Muni's and Counties can choose to Adopt it
  - Several Have

www.bae.ncsu.edu/topic/bmp-im

NCSU BMP Inspection and Maintenance Certification

Overview/Main | Certification Description | Upcoming Classes and Registration Information
Typical Agenda | Sample Powerpoint | Meet the Instructors | List of Certified Professionals

Why is Stormwater BMP Inspection and Maintenance Needed?

Communities across the State of North Carolina must manage rainfall that runs off roads, streets and parking lots. This runoff is called stormwater. To manage stormwater, many treatment devices, called BMPs, have been built. These devices include: wet retention ponds, bioretention areas, stormwater wetlands, permeable pavement, and level spreaders. *BMPs must have annual, and sometimes more frequent, maintenance to perform as intended.* Maintenance includes hydrologic and water quality function, aesthetic and human health concerns. Some communities are considering hiring contractors to do this work, but it is a specialized area, making education and training important before you begin. As a result of his training you will:

- Understand stormwater, how it affects water quality, and regulations associated with it
- Understand stormwater management devices used in North Carolina and how they function
- Understand inspection and maintenance requirements of each stormwater practice

About the Training

This workshop offers 7 PDHs (professional development hours) for professional engineers and surveyors, as authorized by the NC Board of Examiners for Engineers and Surveyors. Other professionals may appeal to their respective boards to obtain professional education credits. All participants who pass an examination at the end of the course will be certified by NC State Cooperative Extension. Certificates of Completion will be U.S. mailed to all attendees upon the posting of Exam Results.

NCSU-BAE is also a registered provider of continuing eduction for AICP and ASLA.

List of Certified Professionals

NCSU BMP Inspection and Maintenance Certification

Overview/Main | Certification Description | Upcoming Classes and Registration Information
Typical Agenda | Sample Powerpoint | Meet the Instructors | List of Certified Professionals

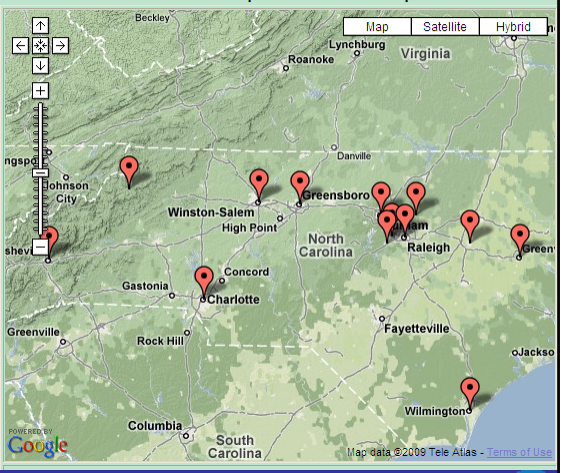
Click on the column headings to sort the table

Certification #	Name	Test Location	Test Date	Expiration Date
001	Bill Adams	Cary, NC	5/15/06	12/31/09
002	Kenneth Abrecht	Cary, NC	5/15/06	12/31/09
003	Mark Altman	Cary, NC	5/15/06	12/31/09
004	James Bailey	Cary, NC	5/15/06	12/31/09
005	Jenny Baines	Cary, NC	5/15/06	12/31/09
006	Thomas Baines	Cary, NC	5/15/06	12/31/09
007	Ozan Bas	Cary, NC	5/15/06	12/31/09
008	Ricky Beasley	Cary, NC	5/15/06	12/31/09
009	Jeremy Beckett	Cary, NC	5/15/06	12/31/09
010	Robbie Bell	Cary, NC	5/15/06	12/31/09
011	Taylor Blakely	Cary, NC	5/15/06	12/31/09
012	Kurt H. Bland	Cary, NC	5/15/06	12/31/09
013	Brian Burchett	Cary, NC	5/15/06	12/31/09
014	Melanie Clerkley	Cary, NC	5/15/06	12/31/09
015	David Dunn	Cary, NC	5/15/06	12/31/09
016	Cecil J. Dykes	Cary, NC	5/15/06	12/31/09

How Popular is the Certification?

- As of April 1, 2011 – more than 1500 people had been certified
- Over 30 classes offered, most sell out

Locations of previous workshops



Success… Across State Borders

- I&M program has been offered in
- California (LA), Georgia (2X), Illinois, and New Zealand
- And (now) San Diego

Has it worked?
Cary Stormwater BMPs (2007)

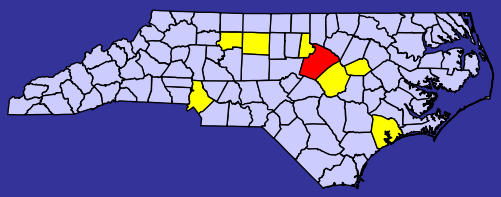
- Approximately 425 BMPs in Cary
- According to one of Cary's inspectors: Timothy Grady, RLA:
- 95% of BMPs failed initial inspection as they require repairs
- Most repairs are maintenance related: erosion, trash removal, tree removal

Has it Worked?
Cary BMPs… (now)

- ~ 95% pass, as owners better appreciate value of maintenance after investing in repairs…

Cities and Counties requiring BMP I&M Training

- Greensboro
- Wilson
- Cary
- Durham
- Apex
- Jacksonville
- Charlotte/Mecklenburg
- Forsyth County
- Johnston County




One Day in
Durham


12/04/2007
12/04/2007
r BMP Maintenance & Inspection

Our (Initial) Target Audience…

Landscape maintenance ‘happens’ and many BMPs are landscape features

The man with the mower…

- ‘Walks’ the property every time he mows
- Should be trained to recognized early signs of problems such as:
- Erosion, clogged outlets, security breaches, etc

And Now… the Common BMP Inspection and Maintenance Elements

BMPs are specialized landscape features designed to control stormwater quantity and quality

- Regular inspections are needed
- Inspect during rainfall events
- Use a maintenance checklist
- Focus on preventive maintenance to avoid costly corrective maintenance and repairs

BMP Maintenance Falls Into 3 Main Categories

- Function
  - Hydrologic (Water)
  - Water Quality
- Aesthetics
- Safety

BMPs need

- Regular inspection of components

BMPs need

- Specialized mowing – not scalping

BMPs need

- Specialized pruning

BMPs need

- Plant management

BMPs need

- Water level management

BMPs need

- Protection from sediment

BMPs need

- Regular trash cleaning

BMPs can be damaged by…

- Fertilizer
- Sediment from traffic or outparcels
- Poor grass or mulch maintenance
- Roundup and other herbicides
- Excessive or too low mowing
- Compaction

BMPs can be damaged by…

- Fertilizer

BMPs can be damaged by…

- Sediment from traffic or outparcels

BMPs can be damaged by…

- Excessive Sediment from upstream

BMPs can be damaged by…

- Poor grass or mulch maintenance

BMPs can be damaged by…

- Poor vegetation management
- (Roundup)

BMPs can be damaged by…

- Excessive mowing or mowing too low

Finally, never underestimate… The Role of Good Housekeeping

- Prevention of problems is always best
- Dirty watersheds = dirty BMPs

Remember…Storm drains lead to streams *and* BMPs

The solution

- Learn how and why stormwater BMPs work
- Develop specialized maintenance program for stormwater BMPs

Bioretention Maintenance

Why Bioretention?

- A water quality and quantity BMP is needed or required
- The site is dry – no shallow water table, no running water
- The watershed is stable – low probability of sediment deposition
- The 'look' of a landscape bed is desired, with shrubs, trees, or grass

Attribute		LID practice type															
		Bioretention[a]		Bioswale		Permeable pavement[b]		Infiltration trench	Planter boxes	Sand filter		Vegetated filter strip	Vegetated swale	Cisterns/rain barrels
		(no UD)	(UD)	(no UD)	(UD)	(no UD)	(UD)			(no UD)	(UD)			
Contribute drainage area (acres)		< 5		< 2		N/A		< 2	< 0.35	< 5		< 1	< 2	Rooftop
Soil infiltration rate (inches/hour)		> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	N/A	> 0.5	< 0.5	Any soil except fill	> 0.5	N/A
Water table separation (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	N/A	> 10 ft	≥ 2 ft	> 10 ft	> 10 ft	Below-grade tanks must be above the water table and bedrock
Depth to bedrock (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	N/A	> 10 ft	≥ 2 ft	> 10 ft	> 2 ft	
Unit slope		< 2%		< 2%		< 6%		<2%	N/A	< 6%		< 6%	< 4%	<5%
Pollutant removal	Sediments	High		High		High		High	High	High		High	Medium	Pollutant removal provided by downstream BMP, refer to specific BMP for removal efficiency.
	Nutrients	Medium		Medium		Low		Medium	Medium	Low		Low	Low	
	Trash	High		High		High		High	High	High		Medium	Low	
	Metals	High		High		Medium		High	High	Low		High	Medium	
	Bacteria	High		High		Medium		High	High	Medium		Low	Low	
	Oil & grease	High		High		Medium		High	High	Medium		High	Medium	
	Organics	High		High		Low		High	High	Medium		Medium	Medium	
Runoff volume reduction		High	Medium	High	Medium	High	Medium	High	Low	Medium	Low	Low	Low	Medium
Peak flow control		Medium		Medium		Medium		Medium	Low	Medium		Low	Low	Medium
Groundwater recharge		High	Low	High	Low	Medium	Low	High	N/A	Medium	Low	Low	Low	Low
Setbacks (ft)	Structures	> 10 ft		> 10 ft		> 10 ft		> 10 ft					> 10 ft	> 5 ft
	Steep slopes	> 50 ft		> 50 ft		> 50 ft		> 50 ft					> 50 ft	> 50 ft

Notes:
UD: Underdrain
a. If lined, see the Planter box column
b. If lined, see the Sand filter with underdrain column
c. For tank outlet and overflow

Stormwater Management vs. 'Drainage'

- Agriculture and Engineering have emphasized drainage for centuries – get the water off-site ASAP
- Stormwater management is fundamentally different…
- "Best Management Practices (BMPs) are installed to treat, *slow*, and *reduce* stormwater runoff"

Stormwater Management vs. Landscaping

- BMPs are built for control of runoff and flooding
- BMPs are built for water quality improvement
- Landscape and aesthetic value is tertiary
- Think about it: Why hire an engineer to design a landscape bed??????

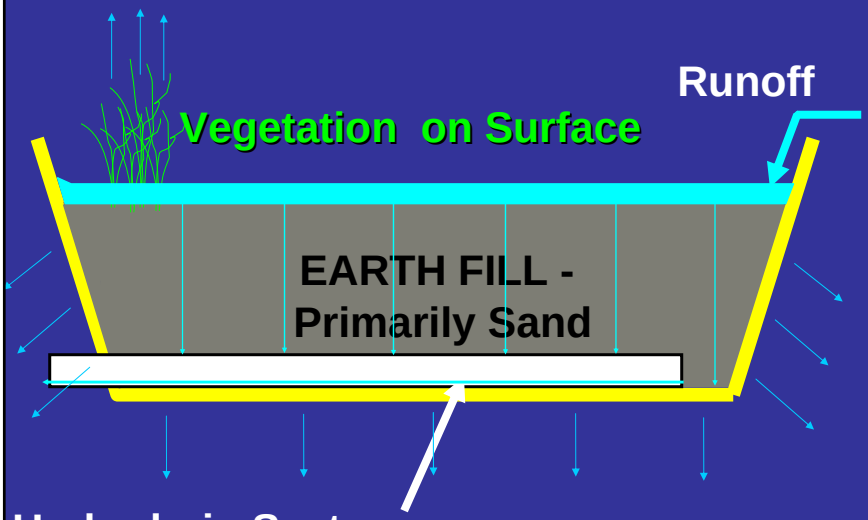
So…

- Fundamentally stormwater BMPs are water quality treatment devices NOT landscape features
- So, *think clean water*, not *lush landscape*
- Avoid fertilizers and pesticides
- But, plant vigor must be maintained, particularly in BMP critical areas

How Bioretention Works

- Water flows in
- Water is held temporarily – to reduce flooding and to remove pollutants
- Water moves through media for treatment
- Some water evaporates, some transpires through plants, some exfiltrates to surrounding soil, some goes out of underdrains

Bioretention Schematic



Bioswales

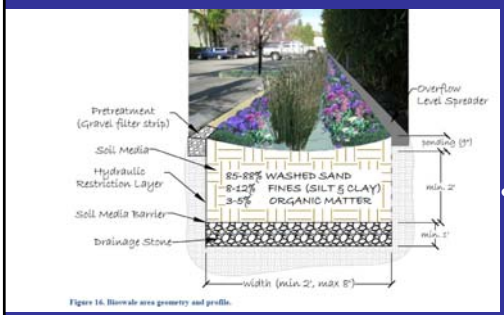


Figure 14. Bioswale area geometry and profile.

- Bioswales have similar standards to bioretention areas except that they are typically long and narrow with widths between 2 and 8 feet
- Bioswales have a maximum ponding depth of 12 inches, with 9 inches preferred

2 Bioswales

How Bioretention Works:

- What the mulch, media, plants, and temporary water storage zone do:
- Filtration
- Sedimentation
- Adsorption (metals, P, stick to particles)
- Microbial processes – breakdown and denitirfication
- Absorption (acts like a sponge)
- Evapotranspiration
- Plant uptake

Major Bioretention Problems

- Sediment clogging and slow or no drainage from improper media seleIction
- Plant death
- Displacement of water storage zone with sediment or mulch

Bioretention is NOT a sediment basin

- Bioretention is designed to work AFTER construction is completed and the watershed is STABLE

Sediment basin

Designing Bioretention

- Design for first ¾ inch of rainfall
- Typically 3-8% of drainage area
- Design for ponding depth of 9 inches
- Design for 12 hour drawdown
- Drop inlet for excess flow
- Plant selection is critical
- Mulch and Maintenance should be specified

Design guidelines

- Design tells you how to maintain practice
- Ask for set of plans to review design
  - For example: water storage depth
    - Need to know average storage depth of bed
    - Need to know the media composition
    - Need to know how quickly the bed is supposed to drain
    - Question: Is the bed meeting its design specifications?

Communication with the owner is important

- Explain bioretention
  - Why it is there
  - How it is designed
  - How it works
  - How to maintain it so it continues to function as designed
  - How long the BMP will last if maintained
  - What the liability is if bed fails

Bioretention Components: The 'bowl' or pit where water ponds

- Maintenance implications:
- What is the underlying soil type?
- Where is the water table
- How was the bed excavated?
- Where is the bed in the landscape?

Bioretention Components: Drop Inlet – for high flow bypass and underdrains

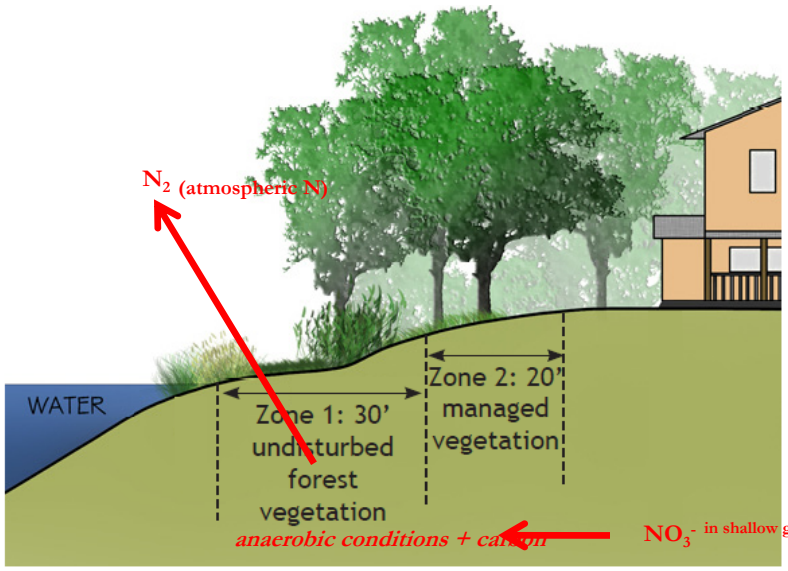
Bioretention Components: Underdrains

- Serve to drain water from bottom of bed
- Usually paired – redundancy
- Should have clean-out fittings
- May have invert to keep bottom of bed wet
- If located in sandy soil there may be no underdrains

Denitrification

- Natural process in which microorganisms convert nitrate nitrogen (dissolved in water) to harmless atmospheric nitrogen
- Occurs in wet soils that have organic matter
- This is a major N pollution removal mechanism

Denitrification in Riparian Buffers



Bioretention Components: underdrain cleanouts

- Maintenance issues:
- May need to clean out underdrains
- Should be capped
- Should be high enough or sealed to prevent water and debris flow into them

Underdrain cleanouts

Bad **Better**

Improperly designed and poorly placed underdrain cleanout

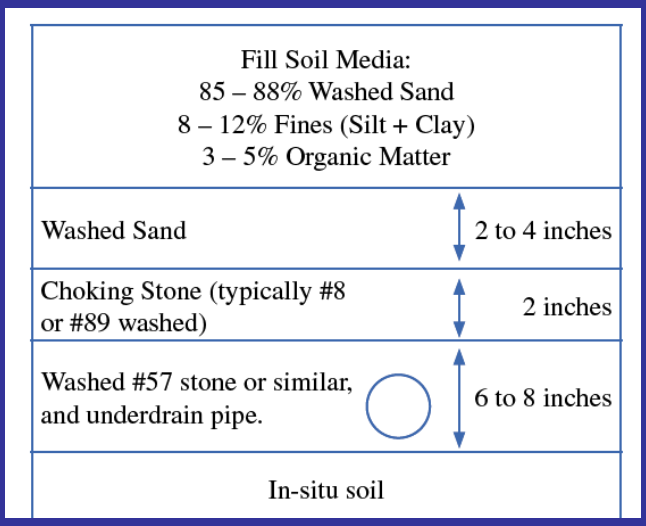
Bioretention Components: Washed Rock, Filter Fabric

- Washed rock helps water move down and sideways to underdrains
- Filter fabric keeps fines, sediment, and tree roots out of underdrains, but may clog

TRM Separation Layer

- Turf reinforcement mat or other matrix to separate media and stone layer that will not glaze with sediment – allows fines to pass through

Bioretention Bed Components: In lieu of filter fabric



What if you need to replace the soil or media?

Bioretention Components: Custom Soil

- Chosen for specific porosity – infiltration of stormwater
- May have special characteristics to treat or absorb nutrients and other pollutants
- We create dual purpose soils to treat stormwater and grow plants

Question: What's the Ideal Fill Media?

Simple Components:

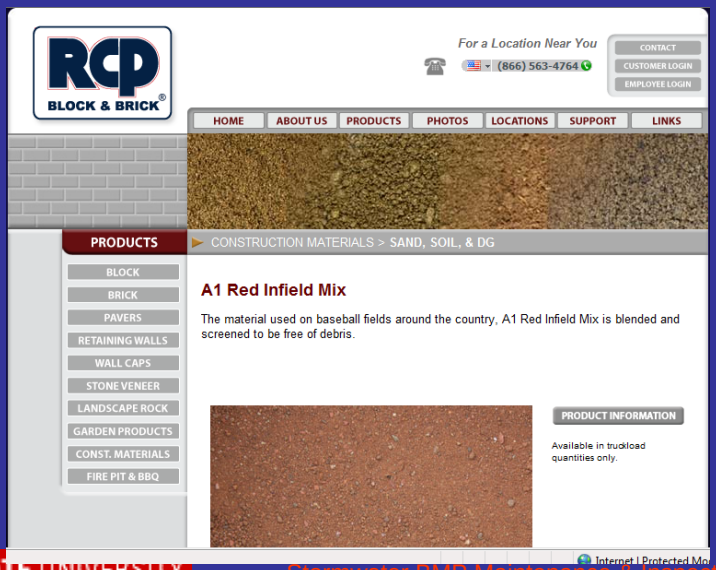
- 85-88% washed Sand
- 8-12% Fines (Clay+Silt passing # 200 sieve)
- 3-5% Organics – eg: aged bark fines or peat

Ball Field Mix

- 60% coarse sand
- 40% (red) clay
- Cut with coarse sand to 10% clay
- Fe , Al and Ca in the clay are fixing the P in the stormwater

PETCO Park

San Diego sources…



San Diego sources…

BEDROCK
BOULDERS & LANDSCAPE PRODUCTS
www.bedrockboulders.com

Phone 619-442-0574
Fax 619-442-0448
1998 Chase Ave El Cajon, CA 92020
E-mail info@bedrockboulders.com

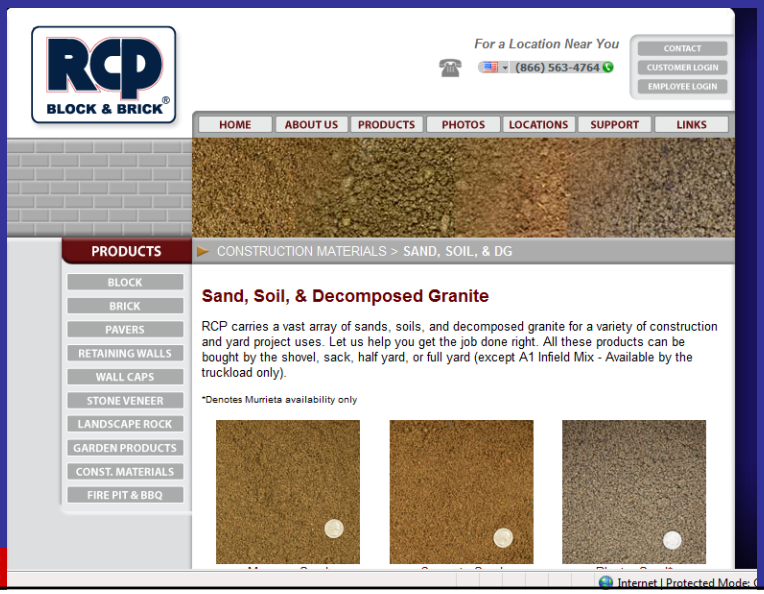
Product Specifications

Product: DG
Name: Red Diamond Infield Mix
Product #: SIO6576
Available Sizes: 2mm minus

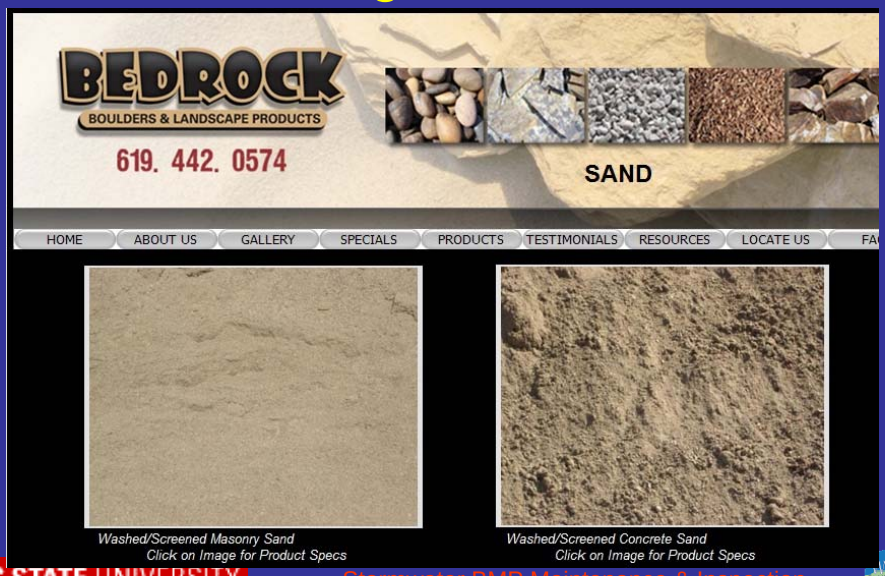
Description: Red
Ball Field DG
Coverage: 160 Sq. Ft. per yard
Sales Unit: Yards,Tons

Coverage is an estimate only. Installation techniques can vary coverages.

San Diego sources…



San Diego sources…



San Diego is serious about infield dirt…

Even ***more*** serious

Will Plants Grow in Bark and Sand?

Standard Nursery Mix
5 parts bark, 1 part sand

Replacement Soil Examples

- 'Ball field' mix
- 85% sand, 10% fines, 2-5% OM
- $16.20/cu.yd or $12/ton (2011quote) wgt 2700 lbs/cy

- Permatil mix
- 80% Permatil, 10% approved compost, 10% pine bark fines
- $37.50/cu.yd. or $48/ton FOB(2011 quote) wgt 1565 lbs/cy

Can Compost be used in BMPs?

- Remember, BMPs are water quality and quantity treatment devices, NOT landscape features
- Soil test all components for pH and P levels
- Compost can have very high nutrient levels

Use compost to remediate poor soils, do not use inside BMPs

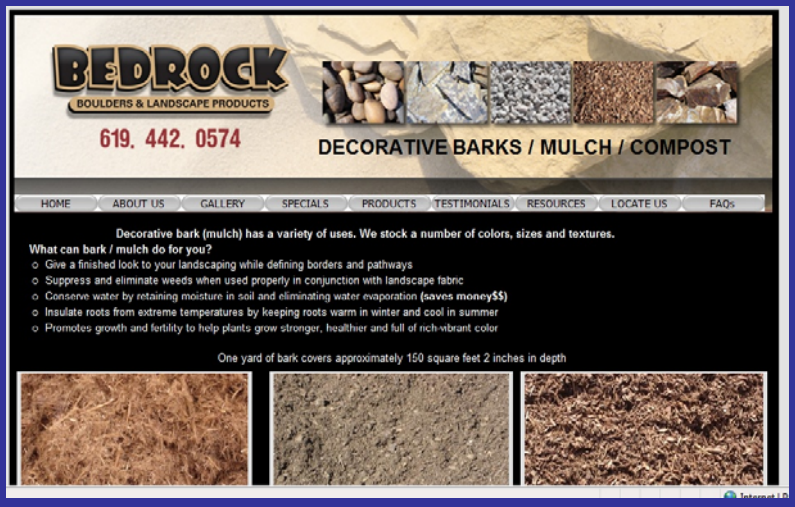
Bioretention Components: Mulch

- Prevents weeds from sprouting
- Adds organic matter, active zone for micro-organisms
- Conserves moisture during dry periods
- Cools soil
- Should be attractive
- Should not float

We use shredded hardwood bark, You use Gorilla Hair

Figure 18. Gorilla hair mulch.

Mulch Sources…



BEDROCK
BOULDERS & LANDSCAPE PRODUCTS
www.bedrockboulders.com

Phone 619-442-0574
Fax 619-442-0448
1956 Chase Ave El Cajon, CA 92020
E-mail info@bedrockboulders.com

Product Specifications

Product:	Decorative Bark
Name:	Red WoodGorilla Hair
Product #:	PV0616
Available Sizes:	Shredded

Description:	Finelly Shredded preferred for Native Landscaping Natural rich redish/brown
Coverage:	Per Yard Sq. Ft. 140-160
Sales Unit:	Cubic Yards

Coverage is an estimate only. Instillation techniques can vary coverages.

Mulch Management

- Mulch should be renewed as needed
- Maintain mulch depth of 3 inches
- Mulch will darken over time, can be ‘fluffed’ to improve appearance and infiltration
- Too much mulch displaces water storage and kills plants

Bioswale Mulch Management

- If water flows *through* the bioswale mulch may wash and float and cause problems
- Possible solutions:
- check dams
- Plant dense vegetation to slow and spread water flows – grasses, lirope, other spreading vegetation

Maintenance Trigger: Mulch

- Mulch renewal – if oxidized or compacted
- Mulch removal – if too deep
- Mulch replacement – if contaminated or clogged
- Mulch (and media) contamination 'Hot Spots' are where water first enters BR cell, this is where you find metals, hydrocarbons in highest concentrations

Pine Bark Will Float and Wash

Wood Chips Will Float

Inspect Outlets Regularly

- Remember, the bioretention beds probably contain the only drains in the parking lot or landscape
- All mulch floats some at first
- Clogged outlets = flooded parking lots and landscapes

Maintenance Trigger
Outlet clean-off

- Clean off outlets after every storm – can clog with mulch or trash

Bioretention Components: Plant Material

- Provides uptake of nutrients and water
- Provides carbon for denitrification
- Stabilizes bed
- Should be an attractive part of landscape

Plants for Bioretention

- Plant selection is much wider now that we have developed consistent, well-drained custom media for bioretention
- Early-on, many plants drowned and died

Three types of BR beds…

- Shrub/Tree

  - Grass

- Natural

Natural

- Not too common
- Dry stream bed look is good
- Totally natural = neglect = failure
- BR beds need maintenance

Tree/Shrub beds

- Most common form
- Less maintenance than turf

San Diego BMP Plants

- 1. Plant materials must be tolerant of summer drought, ponding fluctuations, and saturated soil conditions for 10 to 48 hours.
- 2. It is recommended that a minimum of three tree, three shrubs, and three herbaceous groundcover species be incorporated to protect against facility failure from disease and insect infestations of a single species. Plant rooting depths must not damage the underdrain, if present. Slotted or perforated underdrain pipe must be more than 5 feet from tree locations (if space allows).
- 3. Native plant species or hardy cultivars that are not invasive and do not require chemical inputs are recommended to be used to the maximum extent practicable.
- 4. Shade trees should be free of branches below the following heights:

Caliper (in)	Height (ft)
0.5 to 2.5	5
3	6

San Diego - Trees

Plant List for Bioretention Areas in the City of San Diego

Trees		San Diego Co. Native - SD California Native - CA Non Native - X	Wet Tolerances: Seasonal Flooding? (✓) Seasonally Moist (O)	Mature Size (height x width)	Irrigation Demands: High - H Low - E Moderate - M Low - E Drought Deci... - N	Light Requirements Sun - SU • Shade - SH, Part Shade - PS	Season Evergreen - E, Deciduous - D, Semi-Evergreen - SE	Coastal Exposure? Yes - Y	Sunset Zones Notes: 1. Most of San Diego are in Zones 23 & 24. 2. (-) indicates no data is available for species
Acer macrophyllum	Big-Leaf Maple	SD	✓	30-75' x 30-50'	M-H	SU, PS	D	Y	2-9, 14-24
Aesculus californica	California Buckeye	CA	✓	10-20' x 30'	H	SU	D	Y	3-10, 14-24
Alnus rhombifolia	White Alder	SD	✓	50-90' x 40'	H	SU, PS, SH	D	Y	1b-10, 14-21
Cercis occidentalis	Western Redbud	SD	✓	10-18' x 10-18'	M	SU, PS	D		2-24
Chilopsis linearis	Desert Willow	SD	✓	15-30' x 10-20'	L-M	SU	D		3b, 7-14, 18-23
Gleditsia triacanthos var. inermis	Thornless Honeylocust	X	✓	35-70'x 25-35'	M-H	SU	D		1-16, 18-20
Ilex vomitoria	Yaupon Holly	X	✓	15-20' x 10-15'	H	SU, PS	E		4-9, 11-24
Juglans californica	Southern CA Black Walnut	SD	✓	15-30' x 15-30'	N	SU	D		18-24
Liquidambar styraciflua	Sweet Gum	X	✓	60' x 20-25'	M-H	SU	D		3-9, 14-24
Magnolia grandiflora	Southern Magnolia	X	✓	80' x 60'	H	SU, PS	E	Y	4-12, 14-24, H1, H2
Metasequoia glyptostroboides	Dawn Redwood	X	✓	90' x 20'	H	SU	D		A3, 3-10, 14-24
Myrica californica	Pacific Wax Myrtle	CA	✓	10-30 x 10-30'	M	SU	E	Y	4-9, 14-24
Olneya tesota	Desert Ironwood	SD	O	15-30' x 15-30'	N-M	SU	E		8,9,11-14, 18-23
Platanus acerifolia	London Planetree	X	O	40-80' x 30-40'	M-H	SU	D		2-24
Platanus racemosa	California Sycamore	SD	✓	30-80' x 20-50'	M-H	SU	D	Y	4-24
Populus fremontii	Western Cottonwood	SD	✓	40-60' x 30'	H	SU	D		1-12, 14-21

San Diego - Shrubs

Shrubs		San Diego Co. Native - SD California Native - CA Non Native - X	Wet Tolerances: Seasonal Flooding? (✓) Seasonally Moist (O)	Mature Size (height x width)	Irrigation Demands: High - H Low - E Moderate - M Low - E Drought Deci... - N	Light Requirements Sun - SU • Shade - SH, Part Shade - PS	Season Evergreen - E, Deciduous - D, Semi-Evergreen - SE	Coastal Exposure? Yes - Y	Sunset Zones Notes: 1. Most of San Diego are in Zones 23 & 24. 2. (-) indicates no data is available for species
Arctostaphylos densiflora 'Harmony'	Harmony Manzanita	CA	✓	2-4' x 3-6'	L-M	SU, PS	E		7-9, 14-21
Baccharis pilularis 'Pidgeon Point'	Dwarf Coyote Bush	CA	✓	1-2' x 6'	L-M	SU	E	Y	5-11, 14-24
Carpenteria californica	Bush Anemone	CA	✓	4-6' x 4-6"	L-M	SU, PS	E		5-9, 14-24
Heteromeles arbutifolia	Toyon	SD	O	6-10' x 6-10'	M	SU, PS	E	Y	5-9, 14-24
Ilex burfordii 'Nana'	Dwarf Burford Holly	X	✓	6' x 6'	H	SU, PS	E		4-24
Iva hayesiana	San Diego Marsh Elder	SD	O	1' x 5'	N	SU, PS	SE	Y	17, 23-24
Mahonia aquifolium	Oregon Grape	CA	✓	6' x 5'	L-H	SU, PS	E		2-12, 14-24
Mahonia aquifolium 'Compacta'	Compact Oregon Grape	CA	✓	2-3' x 5'	L-H	SU, PS	E		2-12, 14-24
Mahonia repens	Creeping Oregon Grape	CA	O	1' x 3'	N-L	SU, PS	E		2B-9, 14-24
Philadelphus lewisii	Wild Mock Orange	CA	O	4-10' x 4-10'	M-H	SU, PS	E		1-10, 14-24
Potentilla fruticosa	Bush Cinquefoil	CA	✓	3' x 3'	M	SU, PS	D		A1-A3, 1-11, 14-21
Rhamnus californica 'Little Sur'	Dwarf California Coffeeberry	SD	✓	3-4' x 3'	N-M	SU, PS	E	Y	4-9, 14-24, H1, H2
Rhododendron occidentale	Western Azalea	SD	✓	4-6' x 5'	H	PS	D	Y	4-7, 14-17, 19-24
Ribes aureum var. gracillimum	Golden Currant	CA	✓	3-6' x 3-6'	M-H	SU, PS	D		6-10, 14-24
Ribes sanguineum var. glutinosum	Red Flowering Currant	CA	✓	5-12' x 5-12'	L-M	SU, PS	D		A3, 4-9, 14-24

San Diego - Perennials

Perennials		San Diego Co. Native - SD California Native - CA Non Native - X	Wet Tolerances: Seasonal Flooding? (✓) Seasonally Moist (O)	Mature Size (height x width)	Irrigation Demands: High - H Moderate - M Low - L Drought Tolerant - N	Light Requirements Sun - SU Part Shade - PS Shade - SH	Season Evergreen - E, Deciduous - D, Semi-Evergreen - SE	Coastal Exposure? Yes - Y	Sunset Zones Notes: 1. Most of San Diego are in Zones 23 & 24. 2. (-) indicates no data is available for species
Achillea millefolium	Common Yarrow	SD	✓	1-2'x2-3'	L-M	SU	SE	Y	A1-A3, 1-24
Aquilegia formosa	Western Columbine	SD	O	1-3' x 1.5'	H	SU, PS	SE		A1-A3, 1-11, 14-24
Artemisia palmeri	San Diego Sagewort	SD	O	2-3'x3'	H	SU, PS	SE	Y	-
Asarum caudatum	Wild Ginger	CA	O	1' x 3'	H	SH	E		4-6, 14-24
Dietes bicolor	Fortnight Lily	X	✓	2-3' 2-3'	M-H	SU, PS	E	Y	8-9, 12-24, H1, H2
Fragaria chiloensis	Beach Strawberry	CA	✓	4-8" x 4-8"	H	SU, PS	E	Y	4-24
Hemerocallis spp.	Daylily	X	O	2-4' x 2-4'	H	SU, PS	E	Y	1-24, H1, H2
Iris douglasiana	Pacific Coast Iris	CA	✓	2' x 2'	M	SU, PS	E	Y	4-9, 14-24
Iris missouriensis	Western Blue Flag Iris	SD	✓	2' x 2'	M-H	SU, PS	D		1-10, 14-24
Jaumea carnosa	Jaumea	SD	✓	<1' x 3-15'	H	SU	E		-
Lathyrus vestitus	Pacific Pea	SD	✓	1-4' (trailing)	M-H	PS	D		-
Lathyrus vestitus var. alefeldii	San Diego Pea	SD	O	3-10' (trailing)	M-H	PS	SE		-
Limonium californicum	Coastal Statice	SD	✓	1' x 2'	H	SU, PS	SE	Y	-
Limonium perezii	Sea Lavender	X	O	3' x 3'	M	SU	E	Y	13, 15-17, 20-24
Lobelia laxiflora	Mexican Cardinal Flower	X	✓	3' x 3-6'	L	SU, PS	E		7-9, 12-24
Lupinus latifolius var. Parishii	Stream Lupine	SD	O	2-4' x 2-4'	M	SU	E		-
Mimulus cardinalis	Scarlet Monkeyflower	SD	✓	2.5' x 2.5'	H	SU, PS, SH	E	Y	2-24

San Diego - Grasses

Grasses & Grass-Like Plants		San Diego Co. Native - SD California Native - CA Non Native - X	Wet Tolerances: Seasonal Flooding? (✓) Seasonally Moist (O)	Mature Size (height x width)	Irrigation Demands: High - H Moderate - M Low - L Drought Tolerant - N	Light Requirements Sun - SU Shade - SH, Part Shade - PS	Season Evergreen - E, Deciduous - D, Semi-Evergreen - SE	Coastal Exposure? Yes - Y	Sunset Zones Notes: 1. Most of San Diego are in Zones 23 & 24. 2. (-) indicates no data is available for species
Bouteloua gracilis	Blue Grama	CA	O	1-2' x 1'	L	SU	D		1-3, 7-11, 14, 18-21
Carex praegracilis	California Field Sedge	SD	✓	1' x 2'	M-H	SU, PS, SH	E	Y	-
Carex spissa	San Diego Sedge	SD	✓	5' x 5'	H	SU, PS	SE	Y	7-9, 14-17, 19-24
Carex spp.	Sedge	X	O	varies	varies	varies	varies	varies	varies
Chondropetalum tectorum	Small Cape Rush	X	✓	3-4' 3-4'	H	SU, PS	E	Y	8-9, 14-24
Danthonia californica	California Oat Grass	CA	✓	18" x 18"	M	SU, PS	SE		-
Deschampsia cespitosa	Tufted Hairgrass	CA	✓	1-2' x 2'	M-H	SU, PS	E	Y	2-24
Distichlis spicata	Salt Grass	SD	✓	1'x3'	M-H	SU, PS	D	Y	-
Eleocharis macrostachya	Common Spike Rush	SD	✓	1-3'x2'	H	SU, PS	E	Y	-
Festuca californica	California Fescue	CA	✓	2-3' x 1-2'	M-R	SU, PS	E	Y	4-9, 14-24
Festuca rubra	Creeping Red Fescue	CA	✓	1-2' x spreading	H	SU, PS	E		A2-A3, 1-10, 14-24
Juncus effusus	Soft Rush	SD	✓	2.5' x 2.5	M-H	SU, PS	E		1-24, H1
Juncus mexicanus	Mexican Rush	SD	✓	2' x 2'	M-H	SU, PS	E		-
Juncus patens	California Gray Rush	CA	✓	2' x 2'	L-H	SU, PS	E		4-9, 14-24
Leymus triticoides	Creeping Wildrye	SD	✓	2-3' x 6'	M	SU, PS	E		-
Melica imperfecta	California Melic	SD	O	1-3' x 2'	L	SU, PS	E	Y	-

San Diego – Annuals and Vines

Annuals & Vines		San Diego Co. Native - SD California Native - CA Non Native - X	Wet Tolerances: Seasonal Flooding (✓) Seasonally Moist (O)	Mature Size (height x width)	Irrigation Demands: High - H Low - L Moderate - M Very Low - N	Light Requirements Sun - SU Part Shade - PS Shade - SH	Season Evergreen - E, Deciduous - D, Semi-Evergreen - SE	Coastal Exposure? Yes - Y	Sunset Zones Notes: 1. Most of San Diego are in Zones 23 & 24. 2. (-) indicates no data is available for species
Eschscholzia californica	California Poppy	SD	O	8-24" x 8-24"	L	SU		Y120	1-24, H1
Limnanthes douglasii	Meadowfoam	CA	✓	6-12" x 6-12"	H	SU			1-9, 14-24
Limnanthes gracilis ssp. Parishii	Parish Meadowfoam	SD	O	6-12" x 6-12"	H	SU			-
Lupinus bicolor	Dove Lupine	SD	O	12" x 12"	N-L	SU			-
Mimulus guttatus	Golden Monkeyflower	SD	✓	1-3' x 3'	H	SU, PS			-
Vitis californica	California Grape	SD	✓	30' (vine)	N-L	SU, PS	D		4-24

1. (✓) Seasonal Flooding for bioretention areas is typically 9" deep (maximum) for up to 72 hours (the typical design infiltration period for a bioretention area). If parts of the bioretention area are to be inundated for longer durations or greater depth the designer should develop a plant palette with longer term flooding in mind. Several of the species listed as tolerant of seasonal flooding may be appropriate, but the acceptability of each species considered should be researched and evaluated on a case by case basis.

2. (O) Plants that are not listed as tolerant of seasonal flooding may be used in seasonally moist areas, but may not survive in locations that will be inundated during and after storm events.

3. Before specifying plants that are listed, availability should be confirmed by local nurseries. The designer may need to specify on plans that certain species are to be contract grown and that the contractor will need to make these arrangements well in advance of planting, as certain plants may not be available on short notice.

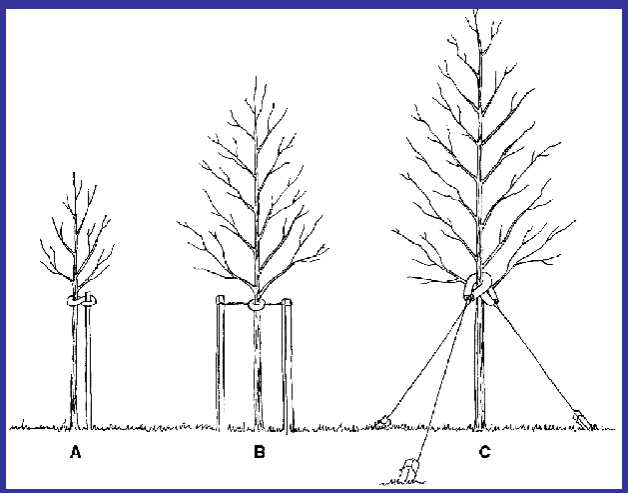
FINAL DRAFT

Plant Placement & Replacement in Bioretention

Maintenance Trigger: Plant replacement

- Replace dead plants ASAP with more tolerant plants
- Plant new plants on mounds or edges of bed for aeration

Staking ?



Staking

- Bioretention soils are usually shallow and provide very little root support for trees
- Plant trees on edges of bed

Pruning/Plant Density

- BR beds need to be 'open' to allow:
- Trash pick-up
- Sunlight penetration for E/T, pathogen kill
- Lines-of-sight
- Safe parking lots

Too Dense?

???

No Plants

Bacterial Contamination of Bioretention Beds?

- Remember, all runoff flows to the bioretention bed
- Sunlight helps kill bacteria and other microorganisms

Trash Pickup

- Remember, <u>all</u> parking lot trash flows to the bioretention beds

Turf for Bioretention

Advantages of Turf

- Simple installation
- Very stable material (unlike mulch)
- Easy routine maintenance
- Simple renovation
- Easy to remove trash from turf
- Excellent sunlight penetration
- Bagged clippings remove nutrients and avoid outlet clogging

Potential turf BR problems

- Uninformed maintenance – fertilization
  - Turf will not need fertilizer in BR
  - Rainfall gives the equivalent of 117 pounds per acre of 10-10-10 per year in NC
- Clippings can clog drop inlets
- Cool season grasses can die under drought and heat stress
- pH lowers over time and grass dies out

Grassed Bioretention

Avoid clay-based sod

Washed Sod…

What's the Dirt on Washed Sod?

Bridget Ruemmele, Ph.D., and
Noel Jackson, Ph.D.
University of Rhode Island
Kingston, R.I.

Turf establishment using washed sod has increased dramatically with the introduction of equipment to strip soil from the turf prior to shipment and establishment. This is beneficial for establishment of sod in locations containing soil types differing from those on production fields. Removing the original soil avoids deleterious interfaces between the two soils, which may impede water infiltration and proper rooting. Washed sod may also weigh less, reducing shipping costs. An added benefit of washed sod is its potential to establish faster than sod with soil attached.

Bermuda sod over Permatil

Mowing regimens?

Avoid scalping grass

Table 2. Guidelines for Mowing Heights

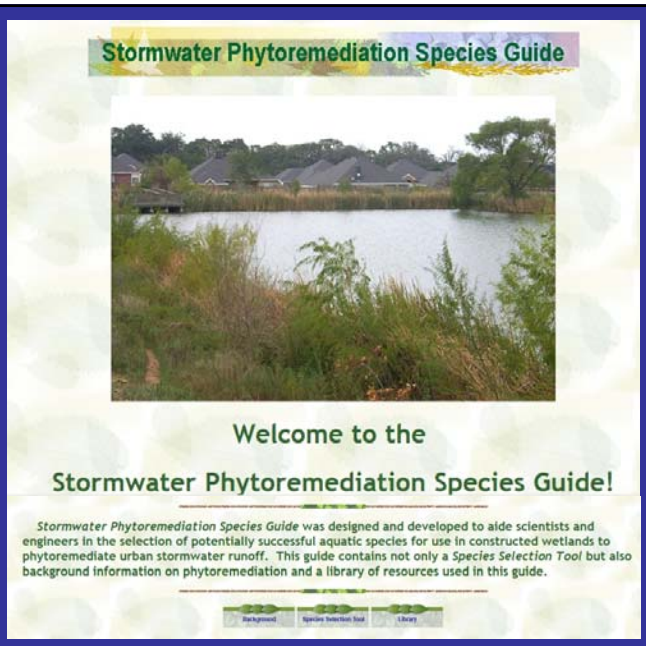
Lawngrass	Height after Mowing (inches)
Bermudagrass	3/4 to 1 1/2
Zoysiagrass	3/4 to 1 1/2
Centipedegrass	1 to 1 1/2
Kentucky bluegrass, fine fescue, or perennial ryegrass	1 1/2 to 2 1/2
Tall fescue	2 1/2 to 3 1/2

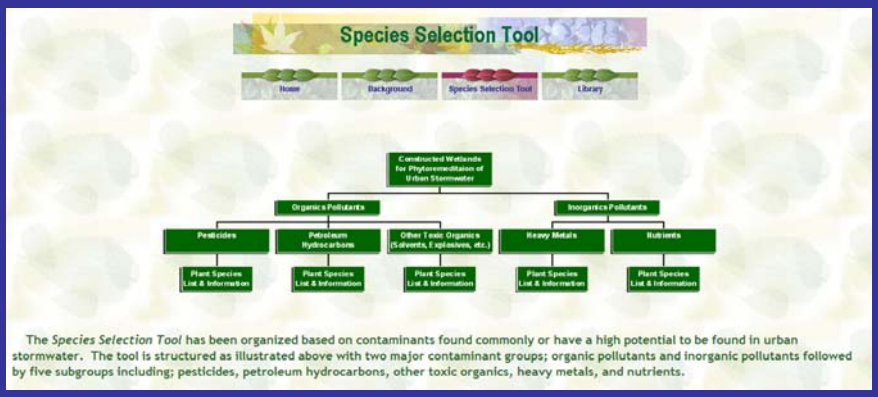
Plant Removal

- Are we at the point where we want to harvest plants from stormwater control measures to remove nutients?

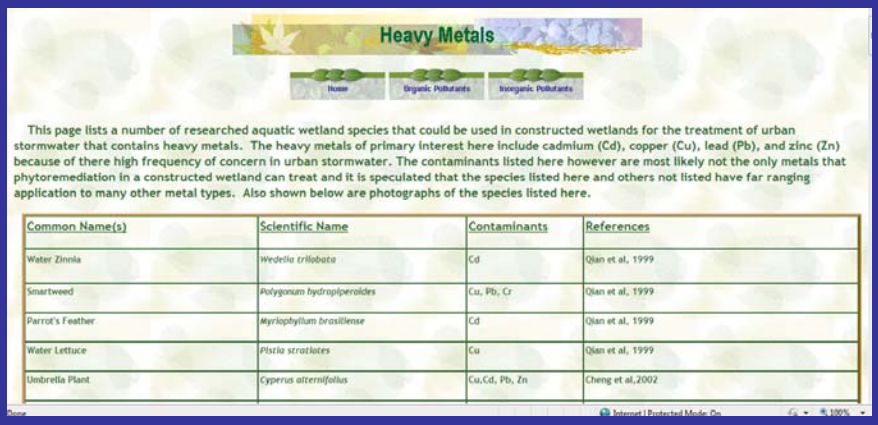
Phytoremediation

Plant physiologist Leon Kochian (left) and molecular biologist



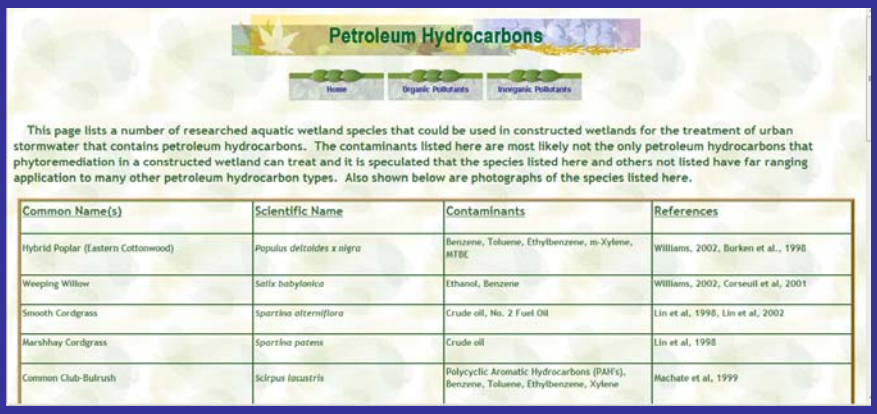


Heavy Metals



Common Name(s)	Scientific Name	Contaminants	References
Water Zinnia	*Wedelia trilobata*	Cd	Qian et al, 1999
Smartweed	*Polygonum hydropiperoides*	Cu, Pb, Cr	Qian et al, 1999
Parrot's Feather	*Myriophyllum brasiliense*	Cd	Qian et al, 1999
Water Lettuce	*Pistia stratiotes*	Cu	Qian et al, 1999
Umbrella Plant	*Cyperus alternifolius*	Cu,Cd, Pb, Zn	Cheng et al,2002

Hydrocarbons



Petroleum Hydrocarbons

Home | Organic Pollutants | Inorganic Pollutants

This page lists a number of researched aquatic wetland species that could be used in constructed wetlands for the treatment of urban stormwater that contains petroleum hydrocarbons. The contaminants listed here are most likely not the only petroleum hydrocarbons that phytoremediation in a constructed wetland can treat and it is speculated that the species listed here and others not listed have far ranging application to many other petroleum hydrocarbon types. Also shown below are photographs of the species listed here.

Common Name(s)	Scientific Name	Contaminants	References
Hybrid Poplar (Eastern Cottonwood)	*Populus deltoides x nigra*	Benzene, Toluene, Ethylbenzene, m-Xylene, MTBE	Williams, 2002, Burken et al., 1998
Weeping Willow	*Salix babylonica*	Ethanol, Benzene	Williams, 2002, Corseuil et al, 2001
Smooth Cordgrass	*Spartina alterniflora*	Crude oil, No. 2 Fuel Oil	Lin et al, 1998, Lin et al, 2002
Marshhay Cordgrass	*Spartina patens*	Crude oil	Lin et al, 1998
Common Club-Bulrush	*Scirpus lacustris*	Polycyclic Aromatic Hydrocarbons (PAH's), Benzene, Toluene, Ethylbenzene, Xylene	Machate et al, 1999

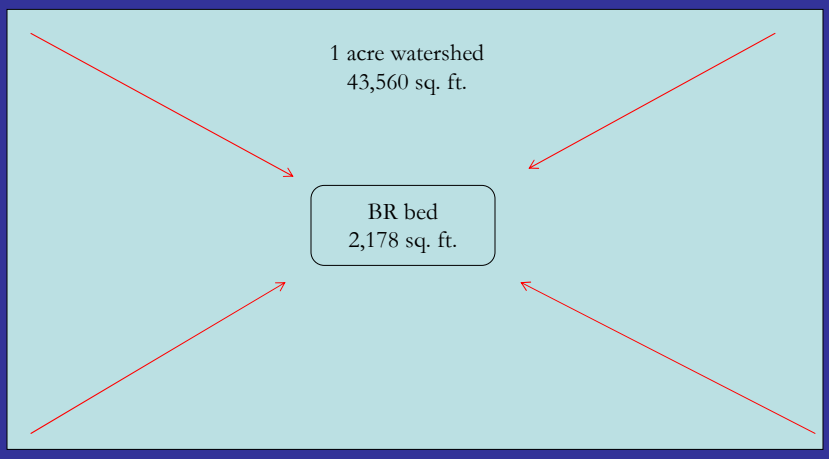
Bioretention is a nutrient rich environment

- Then…

- Now

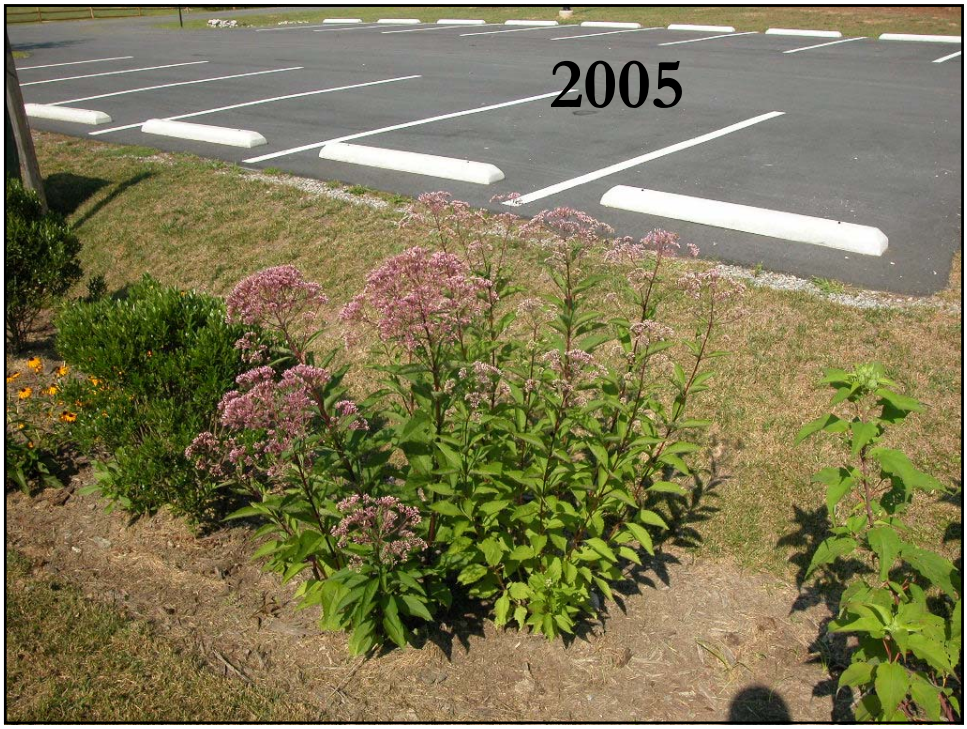
Lime, or acidify if needed
Fertilizer, seldom if ever

Runoff Concentration Effect: 20:1 ratio @ 5%



Bioretention Nutrient Delivery

- Louisburg bioretention study 2004-2006


2005


2006

Ponding zone – set by elevation of drop inlet, 9-12 inches normally

Maintenance Trigger: Dirty watershed

- Dirty/poorly maintained watersheds = clogged bioretention beds

Why sediment accumulation is bad

Seals bioretention cell, converts bioretention into a wetland

Takes away water storage volume

Good housekeeping





Beware of outparcel neglect and development

Ponding zone full of sediment

Infiltration Rates

- 1-2 inches per hour is optimum
- Need residence time to remove pollutants
- Will slow over time
- Media with 12% fines is used for targeted N removal
- 8% fines is used for targeted P removal
- 10% fines is a good average

Key Maintenance Test

- Visit site within 24 hours of 1 inch rain event (avg 11-12 /yr)
- If water is still ponded site has clogged
- Action needed
- Do this once or twice per year

+ 4 Hours

+18 Hours

Nashville Wal Mart Case Study

Sediment protection during construction

‘Crusher Run’ Base

When to remove sediment

- When storage volume is decreased 20 % (2 inches of sediment)
- When it takes more than 24 hours to drain bed
- Maintenance crew needs to know design depth

Water delivery to BR beds

- Object: still, slow, spread, and filter water
- These are high wear-and-tear, high maintenance areas…

Curb cut

Rip rap

Gravel verge

Gravel verges and grass filter strips = Treatment train

Gravel Verge Maintenance

NC STATE UNIVERSITY

Bioretention Forebays

Bioretention Forebays

BR Inspection
#1 Get a set of plans

- How deep is ponding zone?
- How deep is media?
- Is there an IWS (internal water storage – elbow in underdrain)?
- Media composition?
- Plants?

BR Inspection
2 Look at surface of bed

- Look for sediment
- Look at mulch
- Look at watershed – look for signs of instability

3 Look for evidence of underdrain drainage

BR Inspection
4 Look at plants

- Are they dead or alive?
- Why?

5 Pull soil cores

Pull 10 soil cores once per year – examine for mottling or odor

BR Inspection #6 dig a hole

Examine the soil

#7 Time bed drainage

- Visit site within 24 hours of 1 inch rain event (avg 11-12 /yr)
- If water is still ponded site has clogged
- Action needed
- Do this once or twice per year

Beds That Drain too Fast???

- Look for holes in sides of drop inlet
- Look for broken underdrain cleanouts
- Look for sinkholes in bed indicating short circuiting
- Were underdrains properly grouted into side of riser structure?

Sinkhole next to drop inlet

Poorly grouted underdrain

Water my rain garden?

- Right after planting
- First growing season
- During droughts later

Inspection and Maintenance Checklist for a Bioretention Area

Property Address: _____ Property Owner: _____

Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season ☐ After heavy runoff ☐ Other: _____

Inspector(s): _____

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
1. Standing water	Water stands in the bioretention area between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. Any of the following could apply: sediment or trash blockages removed, improved grade from head to foot of bioretention area, scarify media surface, flush underdrains.
2. Trash and debris accumulation	Trash and debris accumulated in the bioretention area and around the inlet and outlet.			Trash and debris removed from bioretention area and disposed of properly.
3. Sediment	Evidence of sedimentation in bioretention area.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased or overgrown.			Vegetation is healthy and attractive.
6. Mulch	Mulch is missing or patchy. Areas of bare earth are exposed or mulch layer is less than 3 inches deep.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even, at a depth of 3 inches.
7. Sod (for sodden bioretention)	Sod is dead or requires mowing			Sod is healthy and maintained at least 3 inches in height.
8. Inlet/outlet	Sediment accumulations			Inlet/outlet is clear of sediment and allows water to flow freely
9. Miscellaneous	Any condition not covered above that needs attention for the bioretention area to function as designed.			Meet the design specifications.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist for a Bioswale

Property Address: _____ Property Owner: _____

Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season ☐ After heavy runoff ☐ Other: _____

Inspector(s): _____

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
1. Standing water	When water stands in the bioswale between storms and does not drain within 24 hours after rainfall			There should be no areas of standing water once inflow has ceased. Any of the following may apply: sediment or trash blockages removed, improve grade, scarify media surface, flush underdrains.
2. Trash and debris accumulation	Trash and debris accumulated in the bioswale and around the inlet and outlet			Trash and debris removed from the bioswale and disposed of properly.
3. Sediment	Evidence of sedimentation in the bioswale			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or other evidence of erosion			Obstructions and sediment removed so that water flows freely and disperses throughout the bioswale. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased, or overgrown			Vegetation is healthy and attractive.
6. Mulch (for mulched bioswales)	Mulch is missing or patchy. Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even, at a depth of 3 inches.
7. Sod (for sodden bioswales)	Sod is dead or requires mowing			Sod is healthy and maintained at least 3 inches in height.
8. Inlet/outlet	Sediment accumulations			Inlet/outlet is clear of sediment and allows water to flow freely
9. Misoellaneous	Any condition not covered above that needs attention for the bioswale to function as designed			Meet the design specifications.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

TETRA TECH

Inspection, Operation & Maintenance of Infiltration Trenches

Scott Struck, Ph.D., PWS

Inspection & Maintenance Workshop
April 6th, 2011

think BLUE SAN DIEGO

Infiltration Trench Description

think BLUE SAN DIEGO

- Long, narrow, often rock filled trench for small drainage areas designed to store and infiltrate runoff
- Water is stored in the void spaces between the rock and water exfiltrates through the sides and bottom of the trench
- Include pretreatment swales, forebays, or filter strips to prevent sedimentation and prolong life of BMP
- Need 10 ft. separation between bottom of basin and seasonal high water table

Infiltration Trench Examples

Hybrid Trench Design

Hybrid Trench Design

Hybrid Trench Design

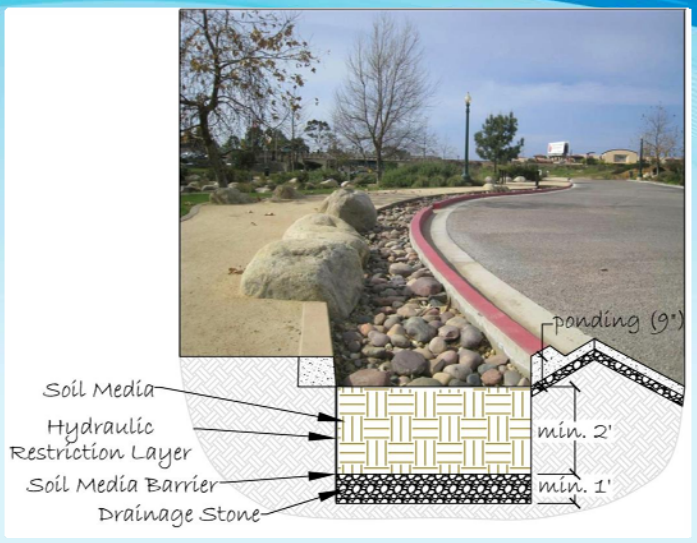
Infiltration Trenches - Advantages

- **Hydrologic benefits:**
  - reduce peak runoff rates for more frequent storms,
  - reduce runoff volumes, and
  - recharge groundwater if soil conditions allow
- **Useful for space limited applications**
- **Integrated into transportation ROW**
- **Can be used as landscaping feature**

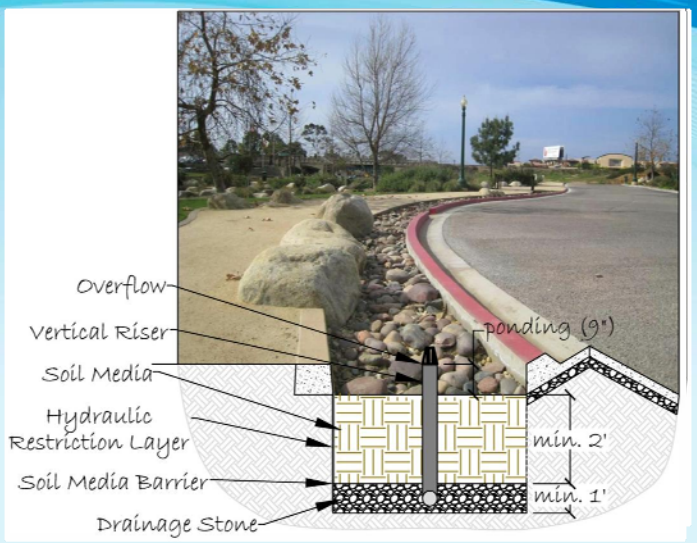
Infiltration Trenches - Disadvantages

- **Infiltration trenches may have limited treatment**
- **When located in high infiltration rate areas - short residence time**
- **Primarily recharge groundwater**
- **Can have higher failure rate due to clogging if not designed and maintained**

Typical Design Cross Section



Typical Design Cross Section



Erosion Control

- Inspect flow entrances, ponding area, and surface overflow areas periodically during the rainy season
- replace gravel and soil in areas if erosion has occurred and stabilize

Expected Flow Velocities

Inlet

- The inlet to the infiltration trench should be inspected after the first storm of the season and then monthly during the rainy season
  - check for sediment accumulation and erosion
  - accumulated sediment that impedes flow into the infiltration trench should be removed and properly disposed

Inlets and Pretreatment

Inlets and Pretreatment

Inlet Design and Other

Outlets

Overflow and Underdrains:

- **Sediment accumulation in the overflow device or underdrain system can cause prolonged ponding**
  - more than 72 hours, the underdrain system should be flushed with clean water until infiltration is restored
- **The underdrain systems should be designed so that it can be flushed and cleaned as needed**
- **Outlets should be inspected after the first storm of the season, then monthly during rainy season**
- **Remove sediment and prevent mulch/media/rock accumulation around the overflow**

Outlets

Outlets

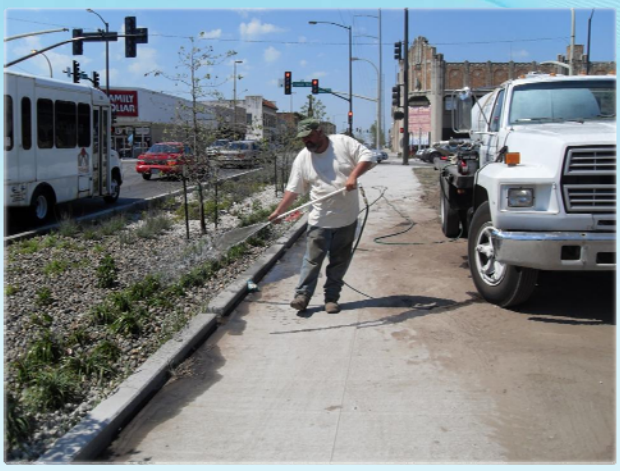
- Ponded water for longer than 48 hours…

Underdrains

General Maintenance

If Vegetation….

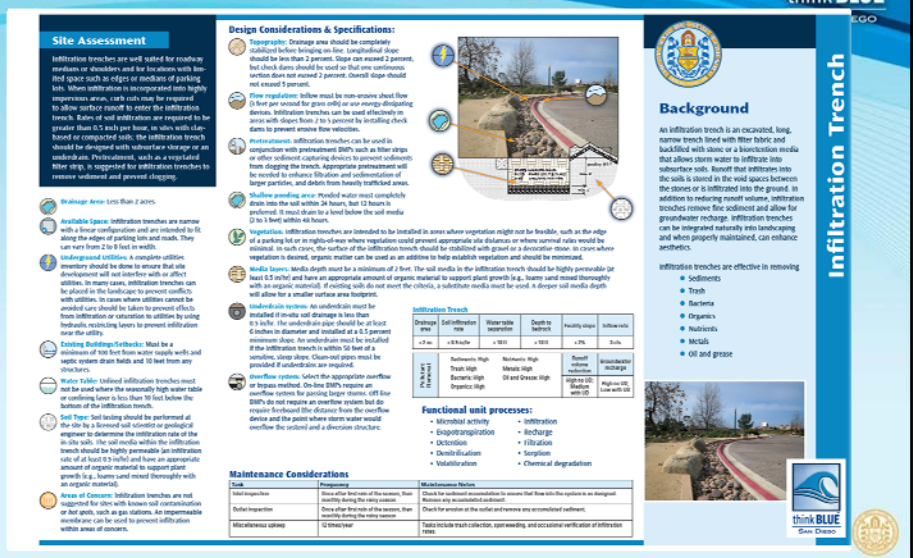
- You May Need to Irrigate



Maintenance Guidance

Task	Frequency	Maintenance notes
Inlet Inspection	Once after first rain of the season, then monthly during the rainy season	Check for sediment accumulation to ensure that flow into the system is as designed. Remove any accumulated sediment.
Outlet Inspection	Once after first rain of the season, then monthly during the rainy season	Check for erosion at the outlet and remove any accumulated sediment.
Miscellaneous upkeep	12 times/year	Tasks include trash collection, spot weeding, and removing mulch from overflow device.

Fact Sheets



Site Assessment

Design Considerations & Specifications:

Maintenance Considerations

Functional unit processes:

Background

Infiltration Trench

Inspection and Maintenance Checklist

Inspection and Maintenance Checklist for an Infiltration Trench

Property Address: _____ Property Owner: _____

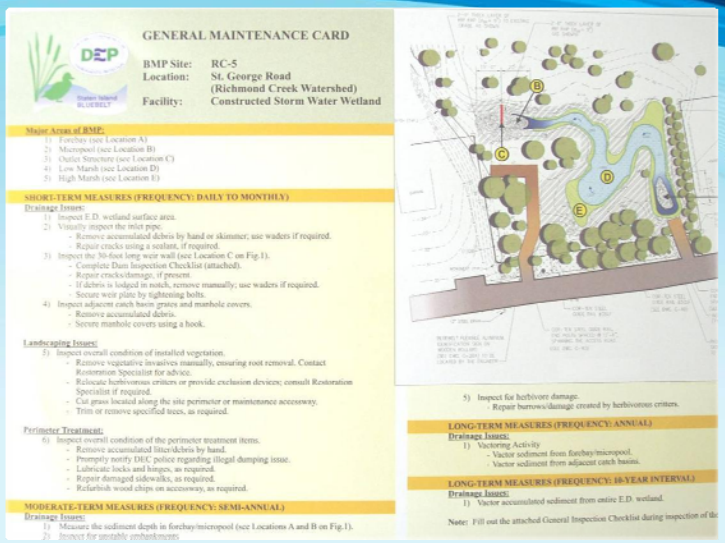
Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season ☐ After heavy runoff ☐ Other: _____

Inspector(s): _____

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
1. Standing water	When water stands in the infiltration trench between storms and does not drain within 24 hours after rainfall			There should be no areas of standing water once inflow has ceased. Any of the following can apply: sediment or trash blockages removed, improved grade, scarify media surface, flush underdrains.
2. Trash and debris accumulation	Trash and debris accumulated in the infiltration trench and around the inlet and outlet			Trash and debris removed and disposed of properly
3. Sediment	Evidence of sedimentation accumulation			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or other evidence of erosion			Obstructions and sediment removed so that water flows freely and disperses throughout the infiltration trench. Obstructions and sediment are disposed of properly.
5. Surface materials	Material is missing or patchy, areas of bare earth are exposed			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even, at a depth of 3 inches.
6. Inlet/outlet	Sediment accumulations			Inlet/outlet is clear of sediment and allows water to flow freely
7. Miscellaneous	Any condition not covered above that needs attention for the infiltration trench to function as designed			Meet the design specifications.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Facility Field Card?



GENERAL MAINTENANCE CARD

BMP Site: RC-5
Location: St. George Road (Richmond Creek Watershed)
Facility: Constructed Storm Water Wetland

Major Areas of BMP:
1) Forebay (see Location A)
2) Micropool (see Location B)
3) Outlet Structure (see Location C)
4) Low Marsh (see Location D)
5) High Marsh (see Location E)

SHORT-TERM MEASURES (FREQUENCY: DAILY TO MONTHLY)

Drainage Issues:
1) Inspect E.D. wetland surface area.
2) Visually inspect the inlet pipe.
- Remove accumulated debris by hand or skimmer; use waders if required.
- Repair cracks using a sealant, if required.
3) Inspect the 30-foot long weir wall (see Location C on Fig.1).
- Complete Dam Inspection Checklist (attached).
- Repair cracks/damage, if present.
- If debris is lodged in notch, remove manually; use waders if required.
- Secure weir plate by tightening bolts.
4) Inspect adjacent catch basin grates and manhole covers.
- Remove accumulated debris.
- Secure manhole covers using a hook.

Landscaping Issues:
5) Inspect overall condition of installed vegetation.
- Remove vegetative invasives manually, ensuring root removal. Contact Restoration Specialist for advice.
- Relocate herbivorous critters or provide exclusion devices; consult Restoration Specialist if required.
- Cut grass located along the site perimeter or maintenance accessway.
- Trim or remove specified trees, as required.

Perimeter Treatment:
6) Inspect overall condition of the perimeter treatment items.
- Remove accumulated litter/debris by hand.
- Promptly notify DEC police regarding illegal dumping issue.
- Lubricate locks and hinges, as required.
- Repair damaged sidewalks, as required.
- Refurbish wood chips on accessway, as required.

MODERATE-TERM MEASURES (FREQUENCY: SEMI-ANNUAL)

Drainage Issues:
1) Measure the sediment depth in forebay/micropool (see Locations A and B on Fig.1).
2) Inspect for unstable embankments.

5) Inspect for herbivore damage.
- Repair burrows/damage created by herbivorous critters.

LONG-TERM MEASURES (FREQUENCY: ANNUAL)

Drainage Issues:
1) Vactoring Activity
- Vactor sediment from forebay/micropool.
- Vactor sediment from adjacent catch basins.

LONG-TERM MEASURES (FREQUENCY: 10-YEAR INTERVAL)

Drainage Issues:
1) Vactor accumulated sediment from entire E.D. wetland.

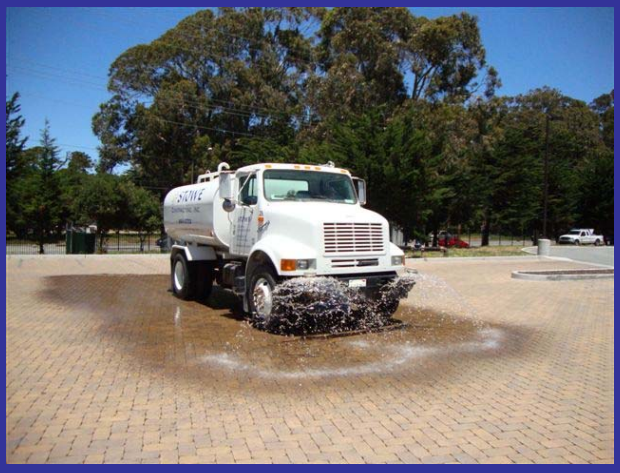
Note: Fill out the attached General Inspection Checklist during inspection of the

Problems?

Know your watershed!


think BLUE
San Diego
Questions?

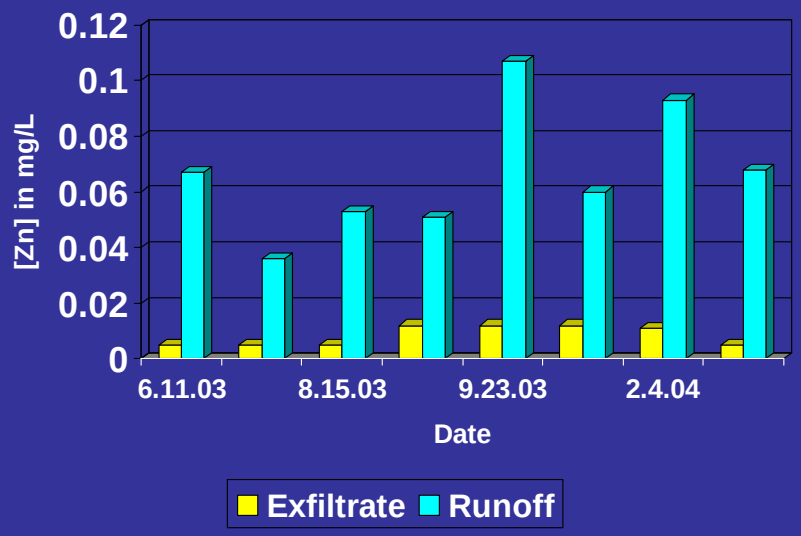
Maintaining Permeable Pavement



Why Permeable Pavement ?

- State Law (in NC)
  - State especially promotes it in Sandy Soils
- Allows stormwater to infiltrate pavement and soak into the soil – reduces flooding
- Best sited on sandy soils that allow infiltration
- It can be an attractive surface – texture/color
- Can remove pollutants

Goldsboro PICP Lot: Zn Concentrations

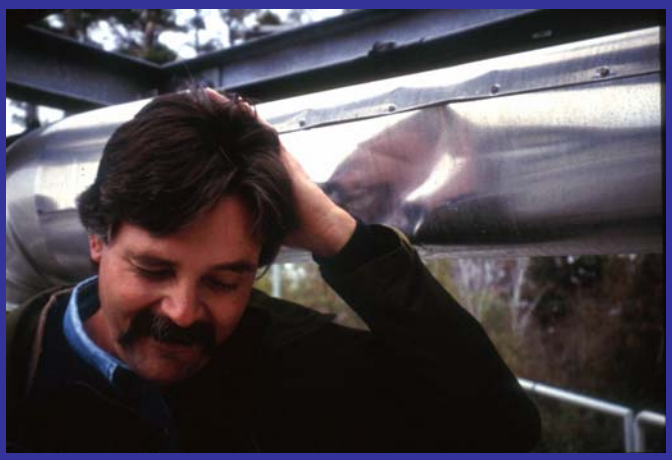


But…

- Not suitable for heavy traffic or heavy vehicles but excellent for parking spaces
- More expensive to make work in “tight” soils
- Stormwater must be relatively ‘clean’ for permeable pavement to work

If not maintained, “permeable” pavement becomes Impervious

Remember our Wary Regulator/Engineer…



The Many Forms of Permeable Pavement
(variable maintenance)

What is Permeable Pavement?

- AKA: Pervious pavement, porous pavement
- Several Types:

Permeable Interlocking Concrete Pavers (PICP)

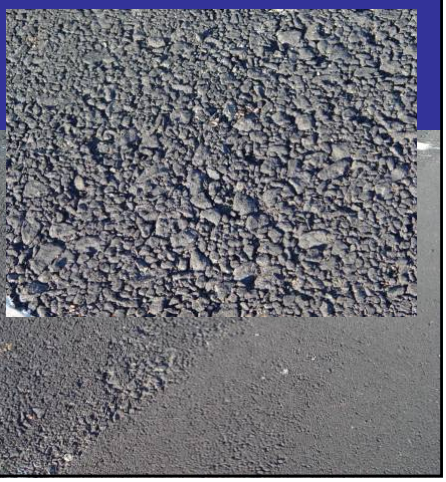
Concrete Grid Pavers (CGP)

Coronado Boathouse

Types of Permeable Pavements

Pervious Concrete

Pervious Asphalt



Permeable Concrete Profile

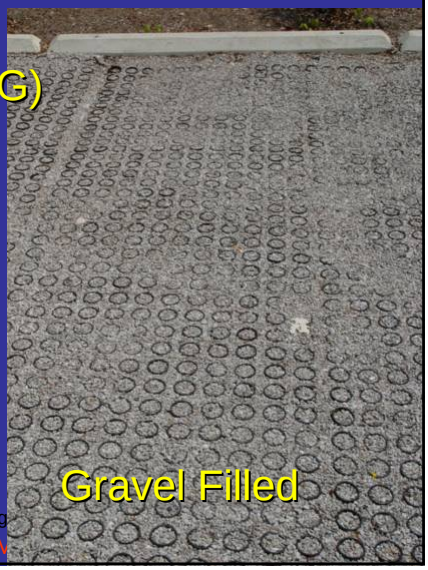
Photo courtesy of
Rob Traver,
Villanova University

Permeable Concrete Rendering

Types of Permeable Pavements

Plastic Reinforcing Grids (PG)

Soil Filled for Grass Growth



Gravel Filled

Permeable Pavement Problems: Ground-in leaves and acorns

Overhanging Trees: Problematic

NC S

Permeable Pavement Problems: Mud and Silt

Where does mud come from?

Permeable Pavement Problems: Sediment

Unstable Catchment →

Permeable Pavement Problems: Sediment

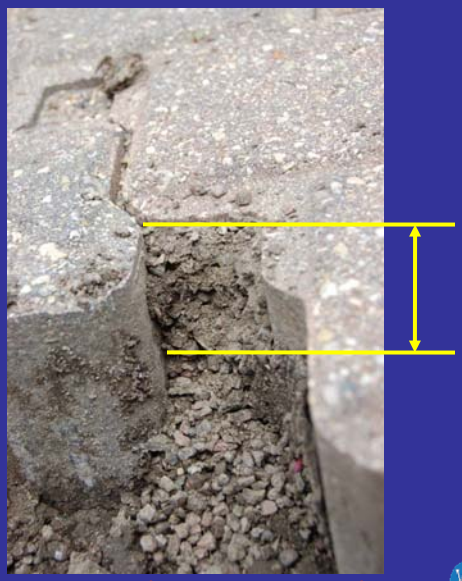
Permeable Pavement Maintenance:

Clean the Catchment - Street Sweeper

Permeable Pavement - Clean the Catchment: Blowing

Permeable Pavement Clogging

Where does it happen?



Depth of Clogging Apparent

Different PP Systems Clog @ Different Locations

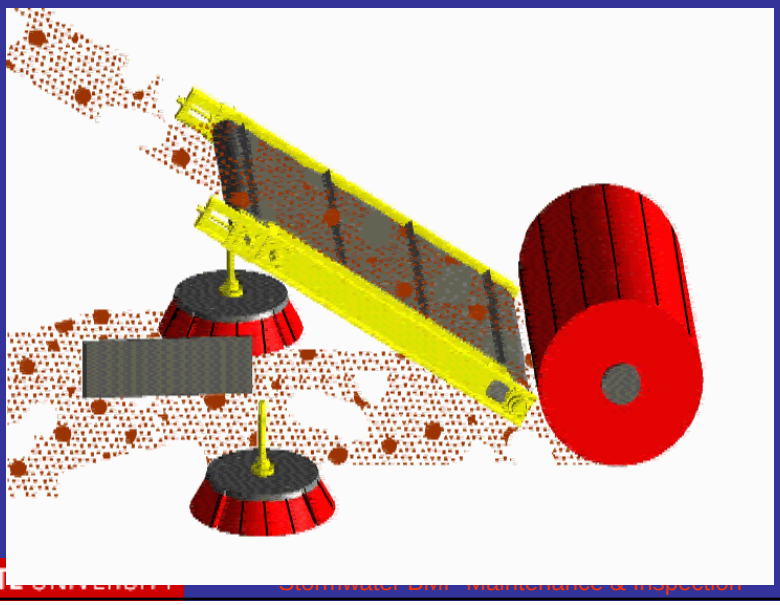
- PICP – Top 40mm
- CGP – Top 5 to 15mm
- Pervious Concrete and Pervious Asphalt – Bottom of Cut (may be 100-200mm from surface)

Permeable Pavement Maintenance: Sweeper/Vacuum Truck

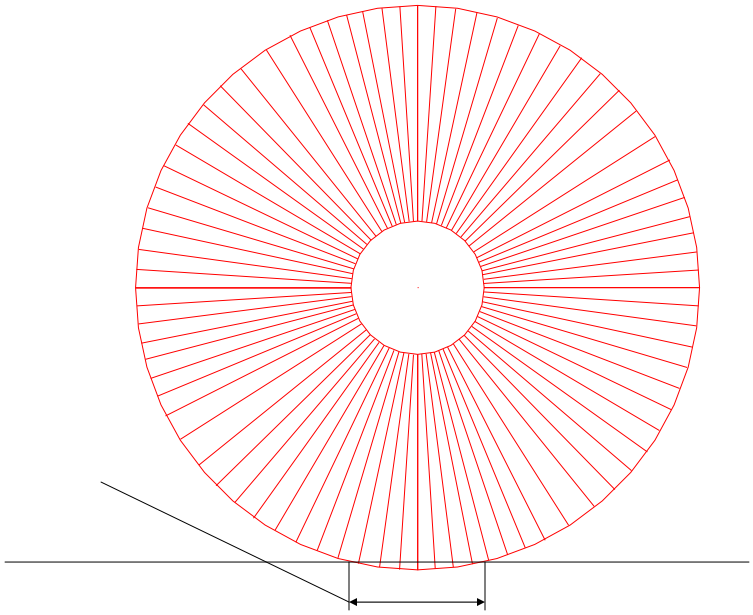
Different Types of Sweepers for Different Types of Permeable Pavements:

Mechanical Sweeper vs. Regenerative Air Sweeper vs. Vacuum Sweeper

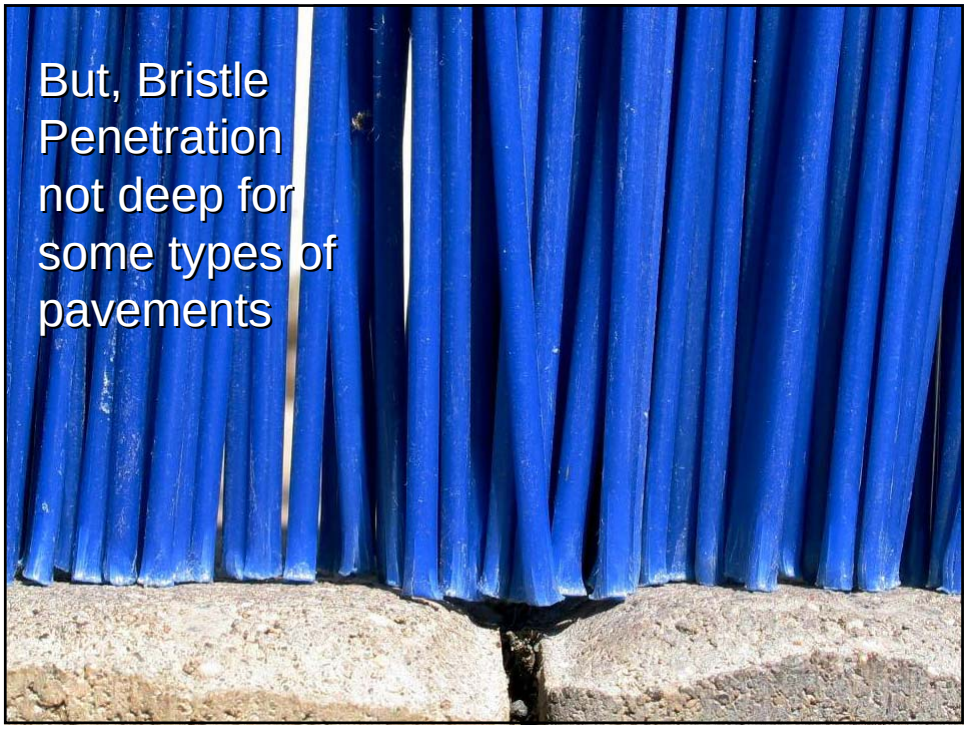
Standard Mechanical Broom Sweeper Mechanism
(e.g., Elgin Pelican and Eagle)



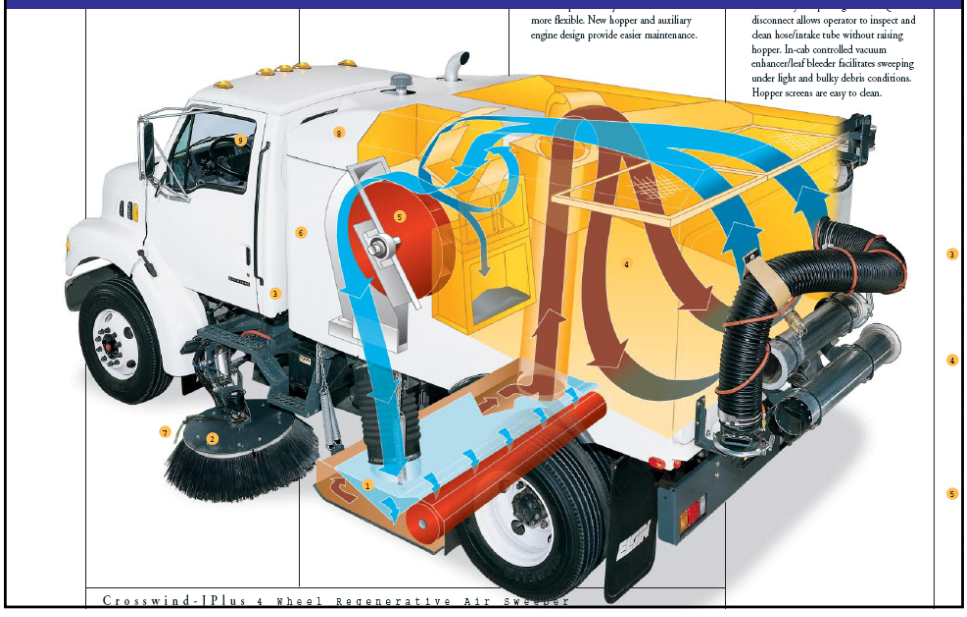
Reach of Bristles



Mechanical Sweeper Good only for CGP



Regenerative Air Street Sweeper



Preventative Maintenance

- Regenerative Air Street Sweeper good for preventative maintenance for:
  - PICP
  - Pervious Concrete
  - Pervious Asphalt
- May not work for Restorative Maintenance

Most Powerful Sweeper: The Vac Truck

Potential for Restorative Maintenance

Vacuum Sweeper Results

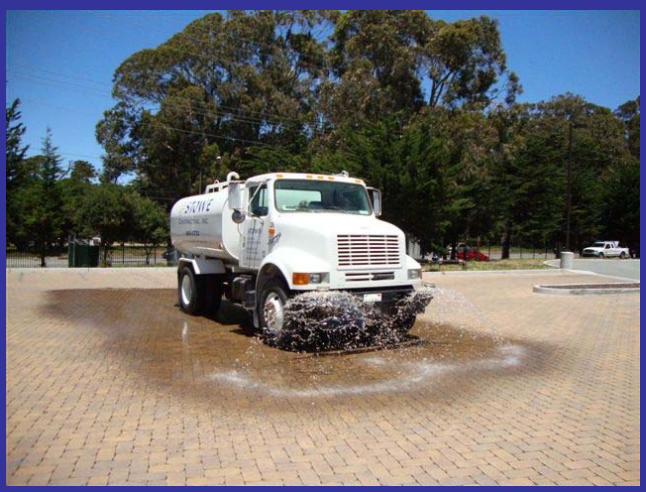
Pre- v. Post- Sweep

Note “clean” basecourse

If “really” clogged, may take multiple passes

- Test conducted at Monterey, California
- Portions of the Parking Lot needed to be swept twice to remove clogging layer

Post Sweep/Vacuum Test?



Testing in Action: Clogged Surface Run-on to Swept Surface

Besides Sweeping: Other Causes Include Differential Settling and…

Fill Voids Post Vacuum

Filling gaps with gravel

Excess Gravel

Permeable pavement plus tree pits

Topping Off Incomplete

One more thing on Vacuums

1800 rpm

2000 rpm

The extra 200 rpm matters. Must “Fine Tune” for each application.

Permeable Pavement Maintenance: Blower

If landscaping, avoid placing mulch on PP.

Permeable Pavement Maintenance: Water Blasting?

Yeah… No.

Permeable Pavement Problems: Weeds and Moss

Grass growth is a sign of Sediment Accumulation

Permeable pavement weed control

- Systemic herbicides like Roundup - Preferred
- Flame weed killers – LP gas fueled – Be careful. Could ignite Concrete!

Grassed Permeable Pavement

You might have to mow it!

Permeable pavement weed control "dos and don'ts"

- Don't pull large weeds – can pull up pavers and fill gravel
- Do control weeds when they are small – if killed when large, dead weed biomass can clog pavement
- Some permeable pavements are meant to be vegetated – be careful

Permeable Pavement Problems: Oil and Grease

Emulsify with Biodegradable Detergent?

Add Stain Remover…

Let it soak, then water blast

Perhaps Coating Used to Prevent Stains ($)

Permeable Pavement Maintenance Tasks and Schedule

TASK	SCHEDULE
Regular sweeping and vacuuming	Semi-annual to Quarterly
Gravel replacement	Post-Vacuuming
Oil and grease cleaning	As needed per clientele
Avoidance of landscape debris (grass clippings, leaves)	Each landscape maintenance
Spray/$_{Flame}$ Weeds and Moss with Herbicides	Monthly during growing season
Adjoining land and watershed stabilization	Keep watch

Planter Box Maintenance

Why Planter Boxes?

- A water quality and quantity BMP is needed or required
- The site is dry – ~~no shallow water table~~, no running water
- The watershed is stable – low probability of sediment deposition
- The 'look' of a landscape bed is desired, with shrubs, trees, or grass
- Infiltration is not feasible
- Limited space (directly adjacent to a structure)

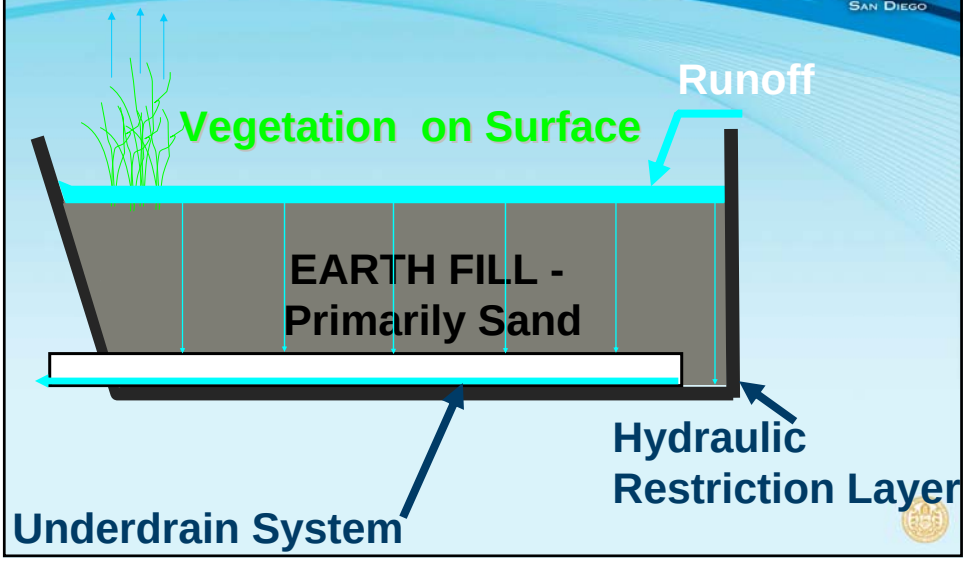
Attribute		LID practice type																	
		Bioretention[a]		Bioswale		Permeable pavement[b]			Infiltration trench	Planter boxes		Sand filter			Vegetated filter strip	Vegetated swale	Cisterns/rain barrels
		(no UD)	(UD)	(no UD)	(UD)	(no UD)	(UD)					(no UD)	(UD)				
Contribute drainage area (acres)		< 5		< 2		N/A			< 2	< 0.35		< 5			< 1	< 2	Rooftop
Soil infiltration rate (inches/hour)		> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	< 0.5		> 0.5	N/A		> 0.5	< 0.5		Any soil except fill	> 0.5	N/A
Water table separation (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft		> 10 ft	N/A		> 10 ft	≥ 2 ft		> 10 ft	> 10 ft	Below-grade tanks must be above the water table and bedrock
Depth to bedrock (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft		> 10 ft	N/A		> 10 ft	≥ 2 ft		> 10 ft	> 2 ft	
Unit slope		< 2%		< 2%		< 6%			<2%	N/A		< 6%			< 6%	< 4%	<5%
Pollutant removal	Sediments	High		High		High			High	High		High			High	Medium	Pollutant removal provided by downstream BMP, refer to specific BMP for removal efficiency.
	Nutrients	Medium		Medium		Low			Medium	Medium		Low			Low	Low	
	Trash	High		High		High			High	High		High			Medium	Low	
	Metals	High		High		Medium			High	High		Low			High	Medium	
	Bacteria	High		High		Medium			High	High		Medium			Low	Low	
	Oil & grease	High		High		Medium			High	High		Medium			High	Medium	
	Organics	High		High		Low			High	High		Medium			Medium	Medium	
Runoff volume reduction		High	Medium	High	Medium	High	Medium		High	Low		Medium	Low		Low	Low	Medium
Peak flow control		Medium		Medium		Medium			Medium	Low		Medium			Low	Low	Medium
Groundwater recharge		High	Low	High	Low	Medium	Low		High	N/A		Medium	Low		Low	Low	Low
Setbacks (ft)	Structures	> 10 ft		> 10 ft		> 10 ft			> 10 ft							> 10 ft	> 5 ft
	Steep slopes	> 50 ft		> 50 ft		> 50 ft			> 50 ft							> 50 ft	> 50 ft

Notes:
UD: Underdrain
a. If lined, see the Planter box column
b. If lined, see the Sand filter with underdrain column
c. For tank outlet and overflow

How Planter Boxes Work

- Water flows in
- Water is held temporarily – to reduce flooding and to remove pollutants
- Water moves through media for treatment
- Some water evaporates, some transpires through plants, ~~some exfiltrates to surrounding soil~~, most goes out of underdrains

Planter Box Schematic



How Planter Boxes Work:

- **What the mulch, media, and plants do:**
- Filtration
- Sedimentation
- Adsorption (metals, P, stick to particles)
- Microbial processes – breakdown and denitirfication
- Absorption (acts like a sponge)
- Evapotranspiration
- Plant uptake

Major Planter Box Problems

- Sediment clogging and slow or no drainage from improper media selection
- Plant death
- Inlet clogging causing backup onto impervious areas

Designing Planter Boxes

- Design for first ¾ inch of rainfall
- Typically drainage areas less that 0.35 acres
- Design for max. ponding depth of 9 inches
- Minimum 2 feet of soil media
- Design for 12 hour drawdown
- Vertical riser and overflow for excess flow
- Hydraulic Restriction Layer
- Plant selection is critical
- Mulch and Maintenance should be specified

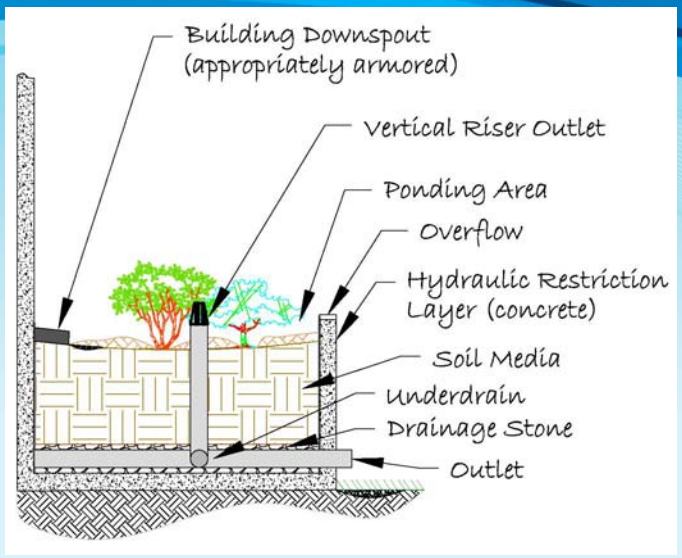
Design guidelines

- **Design tells you how to maintain practice**
- **Ask for set of plans to review design**
  - For example: water storage depth
    - Need to know average storage depth of bed
    - Need to know the media composition
    - Need to know how quickly the bed is supposed to drain
    - Question: Is the bed meeting its design specifications?

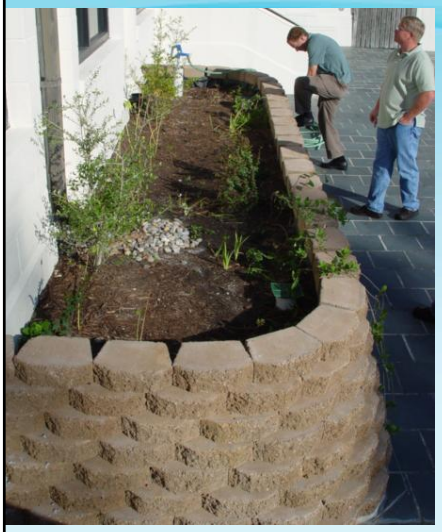
Communication with the owner is important

- **Explain planter box**
  - Why it is there
  - How it is designed
  - How it works
  - How to maintain it so it continues to function as designed
  - How long the BMP will last if maintained
  - What the liability is if bed fails

Planter Box Components:

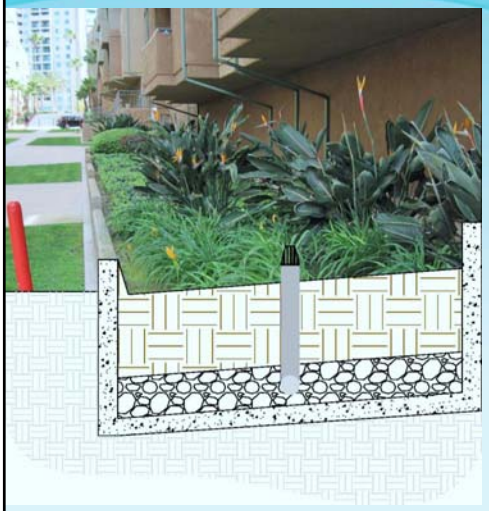


Planter Box Components:
The 'bowl' or pit where water ponds

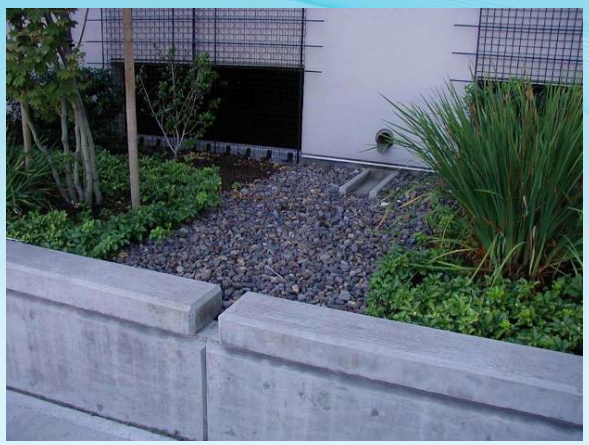


- **Maintenance implications:**
- **What is the media type?**
- **Effect on adjacent surfaces?**

Planter Box Components: Vertical Riser– for overflow and underdrains



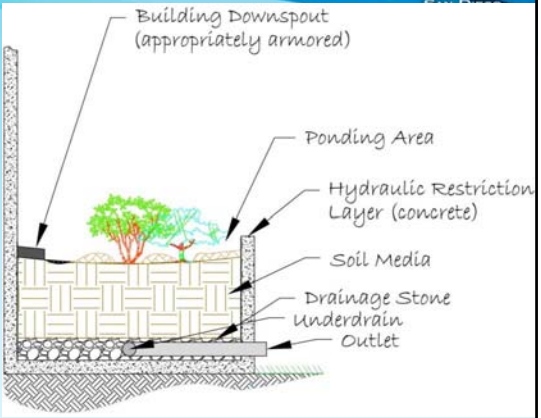
Planter Box Components: Overflow– for high flow bypass



Source: Low Impact Development Center, Inc.

Planter Box Components: Underdrains

- Serve to drain water from bottom of bed
- Moves water away from foundations
- Usually paired – redundancy
- Should have clean-out fittings



Planter Box Components: underdrain cleanouts

Maintenance issues:

- May need to clean out underdrains
- Should be capped
- Should be high enough or sealed to prevent water and debris flow into them
- Vertical riser can serve as the cleanout
  (cap with “spider cap”)

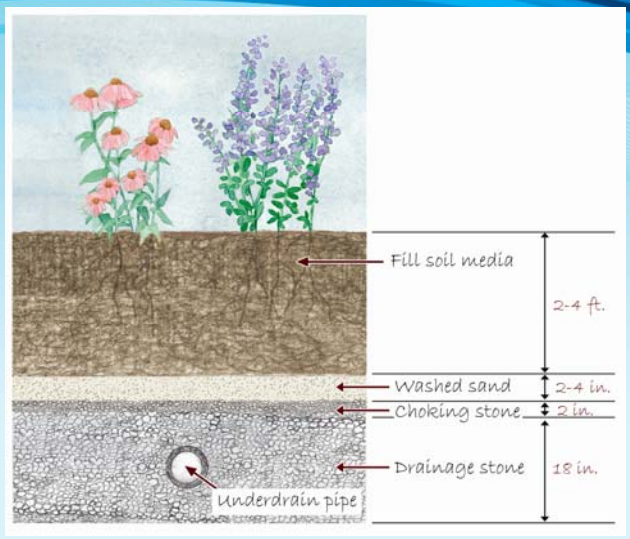
Planter Box Components: Washed Rock, Filter Fabric

- Washed rock helps water move down and sideways to underdrains
- Filter fabric keeps fines, sediment, and tree roots out of underdrains, but may clog

TRM Separation Layer

- Turf reinforcement mat or other matrix to separate media and stone layer that will not glaze with sediment – allows fines to pass through

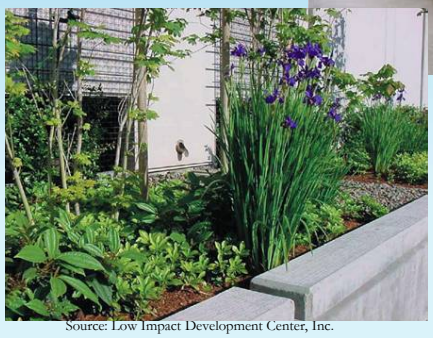
Planter Box Bed Components: In lieu of filter fabric



Inspect Outlets Regularly

- Remember, All mulch floats some at first
- Clogged outlets = ponded water

Source: Low Impact Development Center, Inc.



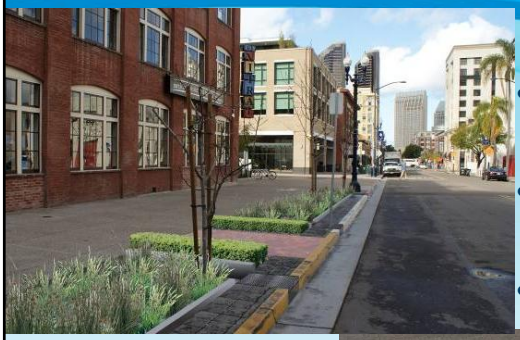
Source: Low Impact Development Center, Inc.

Water delivery to Planter Boxes

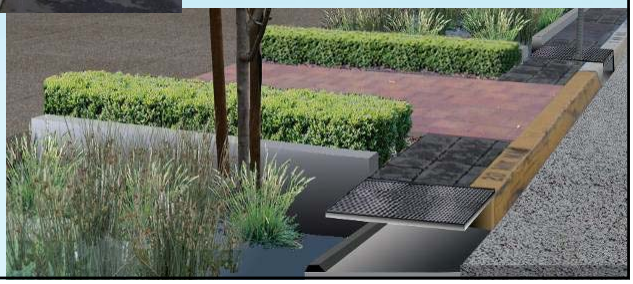
Source: Low Impact Development Center, Inc.

- Object: still, slow, spread, and filter water
- Direct water into the planter boxes

Water delivery to Planter Boxes



- Object: still, slow, spread, and filter water
- Direct water into the planter boxes
- Remove gross solids

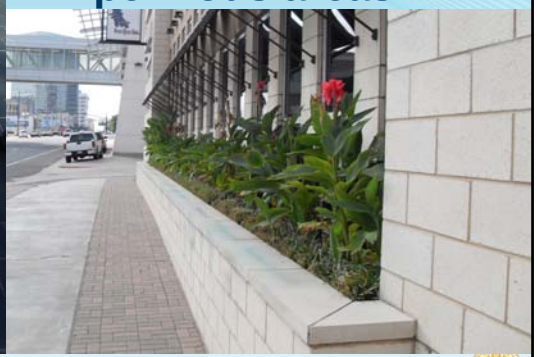


Planter Box Components: Hydraulic Restriction Layers

- Object: protect surrounding infrastructure
- Concrete or 30 mil plastic liner
- Be careful not to damage while performing maintenance

Planter Box Components: Hydraulic Restriction Layers

- Check integrity of seals
- Impacts to surrounding impervious areas



Inspection and Maintenance Checklist for a Planter Box

Property Address: _____ Property Owner: _____
Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season
☐ After heavy runoff
Inspector(s): _____ ☐ Other: _____

Defect	Conditions When Maintenance Is Needed	Maintenance Needed? (Y/N)	Comments[1]	Results Expected When Maintenance Is Performed
1. Standing Water	When water stands in the planter box between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. Any of the following may apply: sediment or trash blockages removed, replace mulch, scarify soil media surface, flush underdrains.
2. Trash and Debris Accumulation	Trash and debris accumulated in the planter box and around the inlet and outlet.			Trash and debris removed and disposed of properly.
3. Sediment	Evidence of sedimentation in the planter box.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, and/or other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased and/or overgrown.			Vegetation is healthy and attractive in appearance.
6. Mulch	Mulch is missing or patchy in appearance. Areas of bare earth are exposed, or mulch layer is less than 3 inches in depth.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even in appearance, at a depth of 3 inches.
7. Sod (for sodden planter boxes)	Sod is dead or requires mowing			Sod is healthy and maintained at least 3 inches in height.
8. Inlet/Outlet	Sediment accumulations			Inlet/Outlet is clear of sediment and flows freely
9. Impacted impervious areas or structures	Obvious impacts to surrounding impervious areas or structures.			Hydraulic restriction layers prevent impacts from infiltration to surrounding structures.
10. Miscellaneous	Any condition not covered above that needs attention in order for the planter box to function as designed.			Meet the design specifications.

1 Describe maintenance completed and if needed maintenance was not conducted, note when it will be done

Level Spreader, Riparian Buffer & Vegetated Filter Strip Maintenance

Stormwater Engineering

NC STATE UNIVERSITY

Bill Hunt

Extension Specialist

Bio. and Ag. Engineering Department

North Carolina State University

Level Spreaders, Riparian Buffers & Vegetated Filter Strips

- Why are they used?
  - LS-RB
    - State Law associated with riparian buffer protection in several large watersheds

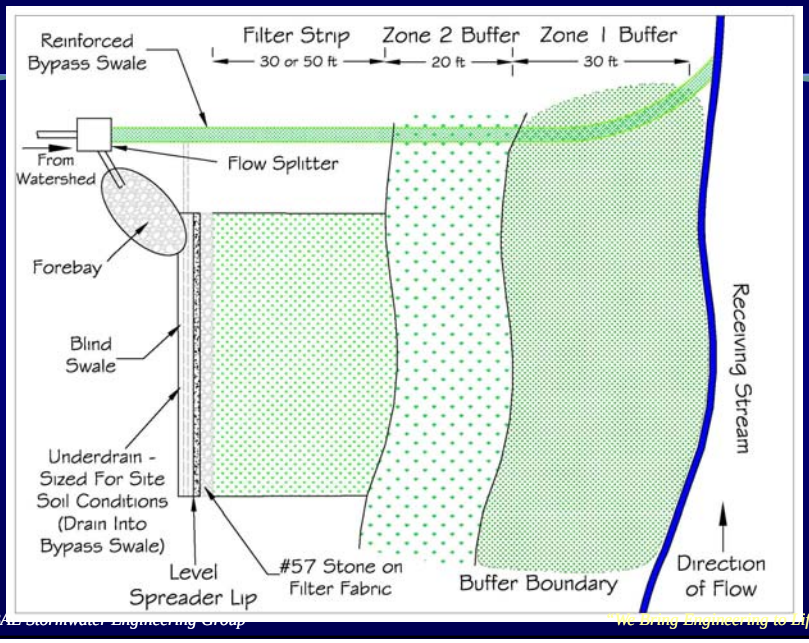
Level Spreaders, Riparian Buffers & Vegetated Filter Strips

- Why are they used?
  - LS-VFS
    - Studies show runoff reduction when LS-VFS are well designed and installed
    - Can be used in locations with somewhat seasonally high water tables.

Filter Strips: Part of Transportation Systems

Filter Strip: CA Roadside

Maintenance By Design Feature



Debris and Sediment Removal

Inspect Splitter/ Diversion Box in Case of Blockage

Trash Accumulation in LS Forebay

BAE Stormwater Engineering Group

"We Bring Engineering to Life"

Trash Collected in Level Spreader Channel

BAE

"We Bring Engineering to Life"

May be a Shovel & Wheel Barrow Exercise

Accessibility issues

"We Bring Engineering to Life"

Debris and Sediment Removal

What if we don't remove debris and sediment?

That is, what if we "practice" gross neglect?

1.5 year old Level Spreader: Sediment Collection with Veg.

Debris and Sediment Removal

Debris and Sediment Removal

BAE Stormwater Engineering Group

"You can pay me now or you can pay me later."

BAE Stormwater Engineering Group

"We Bring Engineering to Life"

Cattail Removal from Behind LS + Forebay

Floating Trash + Cattails Harbor Mosquitoes

Matted Cattails

Good Mosquito Habitat

BAE Stormwater Engineering Group

Mosquito Maintenance: Cattail Control with Aquatic Glyphosate

BAE St

Backpack Sprayer – If "Covered Up"

Can I Let the Blind Swale Fill in with Wetland Veg?

- Yes (sometimes).
- Particularly in out-of-the-way LS locations
  - Away from people
- Provide modest additional N removal benefit
- Want to "oversize" the wetland swale

Inspect and Repair Damaged Level Spreader

- Level Spreaders can erode over time
  - Especially if constructed of earth
  - Rock level spreader can fall apart
- They must be repaired if the level lip has been damaged

Large Stemmed Vegetation and Tree Removal

- Trees on level spreader lip cause water to re-concentrate
- Remove trees, shrubs and large stemmed vegetation from "Level Lip"
  - Large stemmed vegetation and trees can obstruct flow over lip
  - Ideally, only grass and small plants grow on level spreader lip
- Remove trees that have fallen on level spreader

Large Stemmed Vegetation Removed from Level Spreader "Lip"

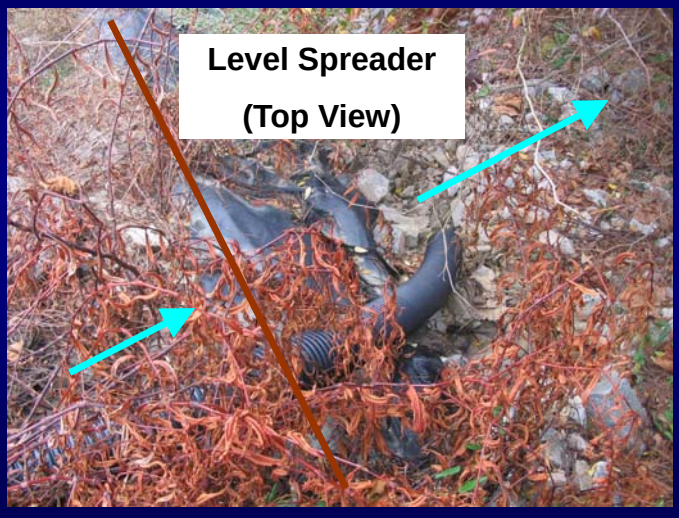
BAE Stormwater Engineering Group *"We Bring Engineering to Life"*

Remove Fallen Trees

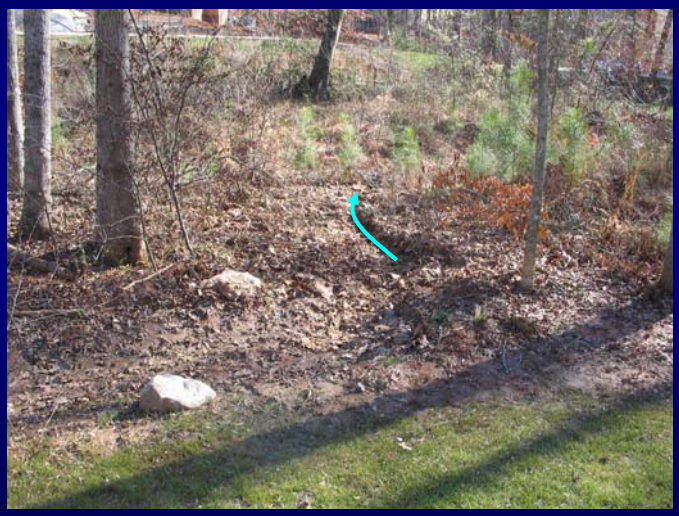
BAE Stormwater Engineering Group *"We Bring Engineering to Life"*

Inspect and Repair Level Spreader

Other – Level Spreader Follies



Other – Level Spreader Follies



Other – Level Spreader Follies

Inspect and Repair Buffer

- Inspect Riparian Buffer
  - Check for signs of erosion
- Repair Erosion
  - Place down erosion control matting
  - Fill in channels that have formed
  - Reseed exposed areas
- "Working in Zone 2 [outer 20 feet] only provided that diffuse flow and health of existing vegetation in Zone 1 [inner 30 feet] is not compromised and disturbed areas are stabilized" - Neuse Buffer Rule Exemptions

Look for Signs of Concentrated Flow near L.S.

Recollection in Buffer – Hard to Repair

Recollection in Buffer – Hard to Repair

Inspect and Repair Filter Strip – Easier to Repair

BAE Stormwater Engineering Group *"We Bring Engineering to Life"*

Inspect Filter Strip – Easier to Repair

BAE Stormwater Engineering Group *"We Bring Engineering to Life"*

"Worst Case" Scenario

- Regrade & Re-sod

No EMC approval needed for Maintenance

Filter Strip Maintenance

Typical maintenance activities (associated with lawns) may not always work in Filter Strips

Mowing

- Don't Mow after rain/ soggy conditions
- Be careful with lowering mower – scarring
- Probably best to move parallel to level spreader (on grade)
  - Might be wishful thinking

Avoid Scalping Grass

Table 2. Guidelines for Mowing Heights

Lawngrass	Height after Mowing (inches)
Bermudagrass	3/4 to 1 1/2
Zoysiagrass	3/4 to 1 1/2
Centipedegrass	1 to 1 1/2
Kentucky bluegrass, fine fescue, or perennial ryegrass	1 1/2 to 2 1/2
Tall fescue	2 1/2 to 3 1/2

BAE

Fertilizer + Pets

- Consider “No Fertilizing” Signs as requirement
- Filter Strip could be an attractive spot for dogs

BAE Stormwater Engineering Group

“We Bring Engineering to Life”

A Bit More on Fertilizer

- A one-time initial, slow-release fertilization is OK
- Couple this with a soil test
- May need to lime for pH, too
- After that, let N+P in runoff do the work

By the way… a "no-no"

Riparian Buffers V. Vegetated Filter Strips

- Vegetated Filter Strips are grassed "designed" systems
  - Graded evenly
  - Typically grassed filled
  - Can be various widths
- Maintenance/ working in the VFS is allowable

Grassed Filter Strip Maintenance

- Mowing
  - And, therefore, inspection every time mowed
- "Overhaul" maintenance: if channelization in VFS
  - Re-grade and sod

Grass Health in Bypass?

Summary of Activities

Action	Frequency
Remove Sediment and Debris from Forebay and From Behind Lip (From Diversion if Present)	Twice per Year
Remove Large Stemmed Vegetation From Level Spreader	Once per Year
Remove Trees that have fallen on Level Spreader	As Needed
Inspect and Repair Level Spreader	Inspect Monthly – Repair as Needed
Inspect and Repair Riparian Buffer/ VFS and Bypass Channel	Inspect Monthly – Repair as Needed
Mowing VFS & Other	As Needed

Questions ?

Sand Filter & Proprietary Filters

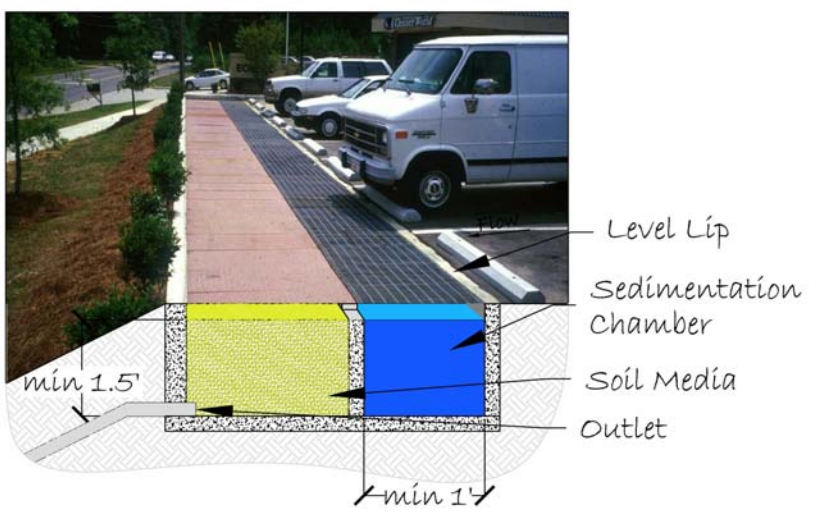
Why A Sand Filter?

- Commonly used in 'ultra' urban environments –expensive land, built-out watersheds
- Can drive on some of them
- Very effective at filtering TSS and oil and grease

Sand filter limitations

- Expensive to build and maintain
- Easily clogged

How Sand Filters Work:




NC STATE UNIVERSITY


Accessing Chambers maybe Strenuous

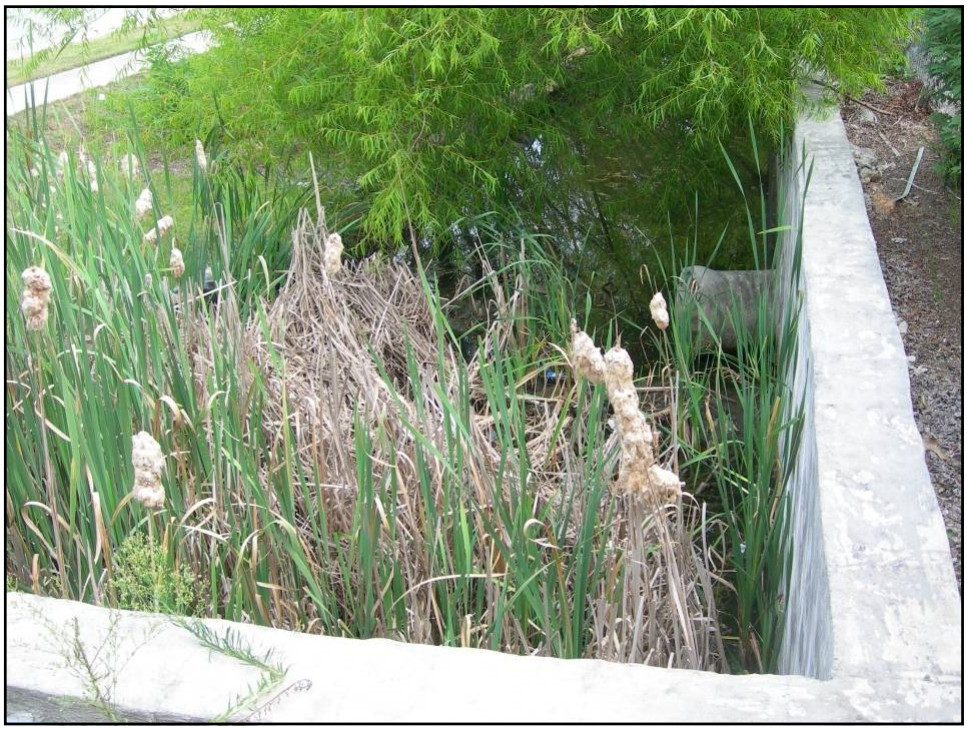
Don’t Let Smutzdecke ruin the infiltration rate

- Break up crusty layer on top of Sand once per year, on average
- Garden Rake works

Disposal Options

- Take to Landfill
  - Sedimentation Chamber + Top of Sand Chamber
- Research may mandate other options in future


You can pay me now or pay me later



NC STATE UNIVERSITY

Stormwate

r BMP Maintenance & Inspection

Sand Filter Maintenance Tasks and Schedule

•TASK	•SCHEDULE
Street sweep parking lot	•Quarterly
Clean trash	•As needed
•Skim/ Break up sand media	•Annual
•Pump oil & grit from sedimentation chamber	•Annual to tri-annual
Replace sand media	•When clogged – expect 3 years or when sedimentation chamber cleaned

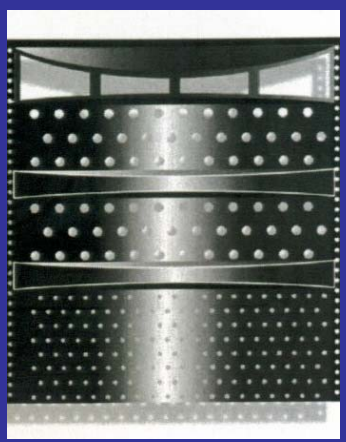
Proprietary Devices

- Examples:
  - BaySaver
  - CDS Technologies
  - Stormceptor
  - Stormfilter
  - Vortechs
  - And many more

Why A Proprietary Device?

- Usually sited in urban environments where there is no room for a biological BMP
- Almost all are located underground – can drive or build over them

Can Be Simple….like Special Inlet Devices



Trash Guard™

Proprietary Devices

NC STATE UNIVERSITY

Parking Lot BMP?

Lock Lid for Safety

Task Committee: ASCE

- In 2008, NC State hosted a Manufactured Practice Maintenance Task Force
- Group included Academia, Consulting, Government, and Vendors
- The Group **by consensus** agreed to certain maintenance elements.

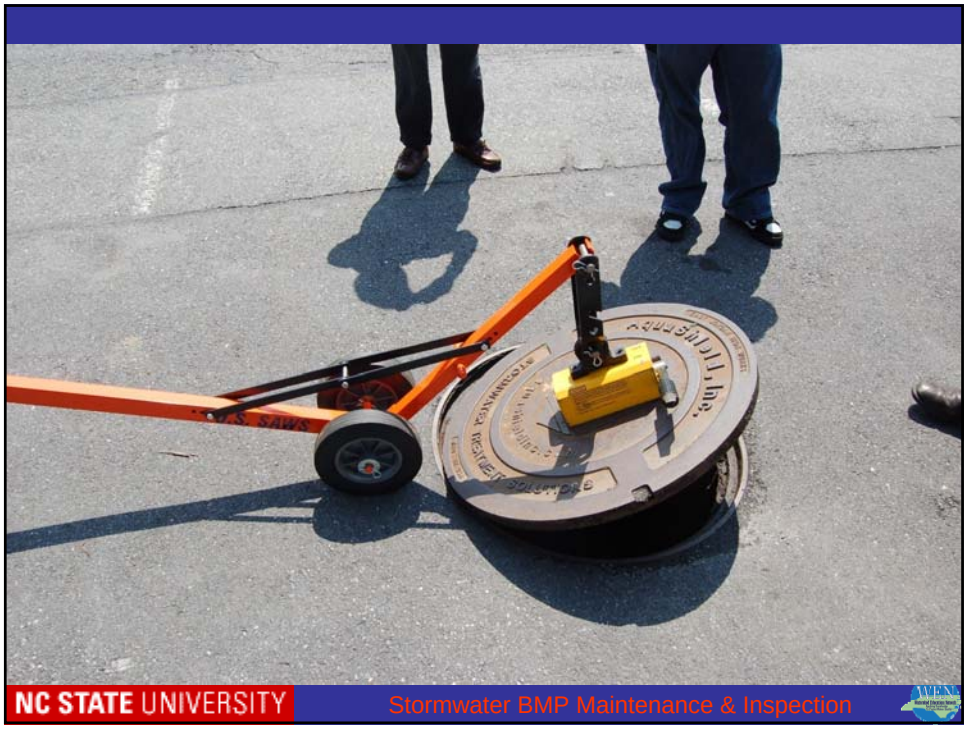
How Proprietary Devices Work:

- By way of filtration, settling, and other separation techniques:
  - Separate oil and grease
  - Retain grit and trash
  - Remove suspended solids and associated pollutants
  - Every system is unique

Some Common Agreed Upon Elements of Maintenance…

Accessing the “insides”

Manhole:
30” min
36” pref.



Confined Space Certification

http://www.osha.gov

Gas Detection Meters a MUST

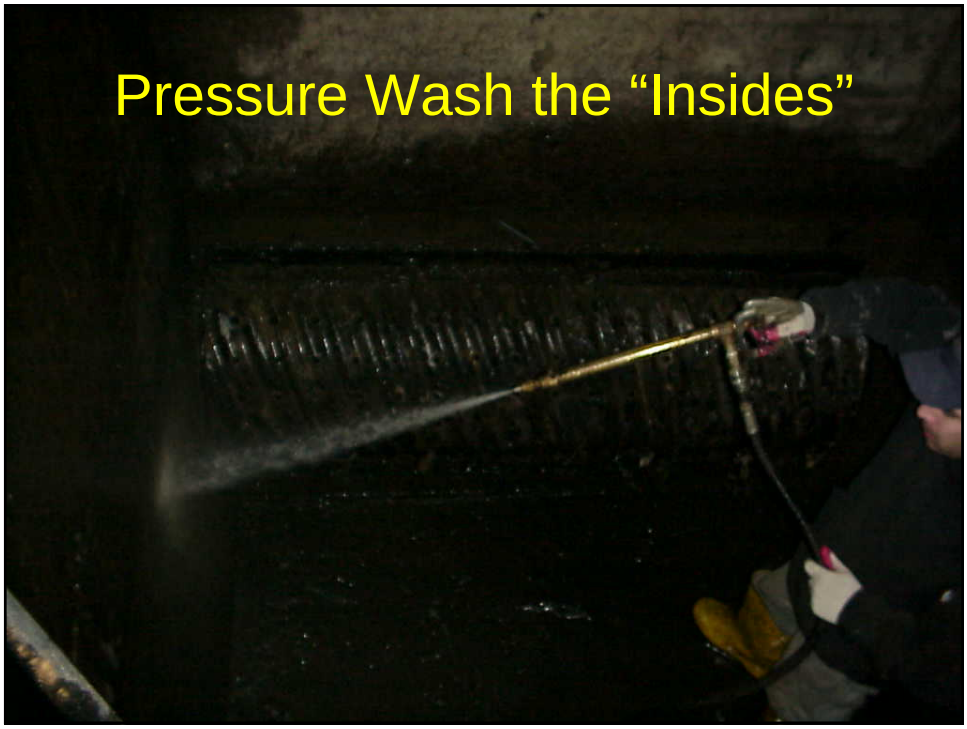
CanarySense.com

Environmental Equipment & Supply

Occasionally, Extra Precaution


Inspect Trench Drains serving BMP


Clean Out Inlet Pipes, too


Pressure Wash the “Insides”


Considerations: Outfall Drain Plug (keep dirty h2o in BMP)

Proprietary Device: Dirty Slurry

How do you get rid of this? Where does this go?

Vac-Truck

Inspect & Replace Filters

Filtration Device Maintenance

Images courtesy of Lowe's™

Remove Old Filters

Images courtesy of Lowe's™

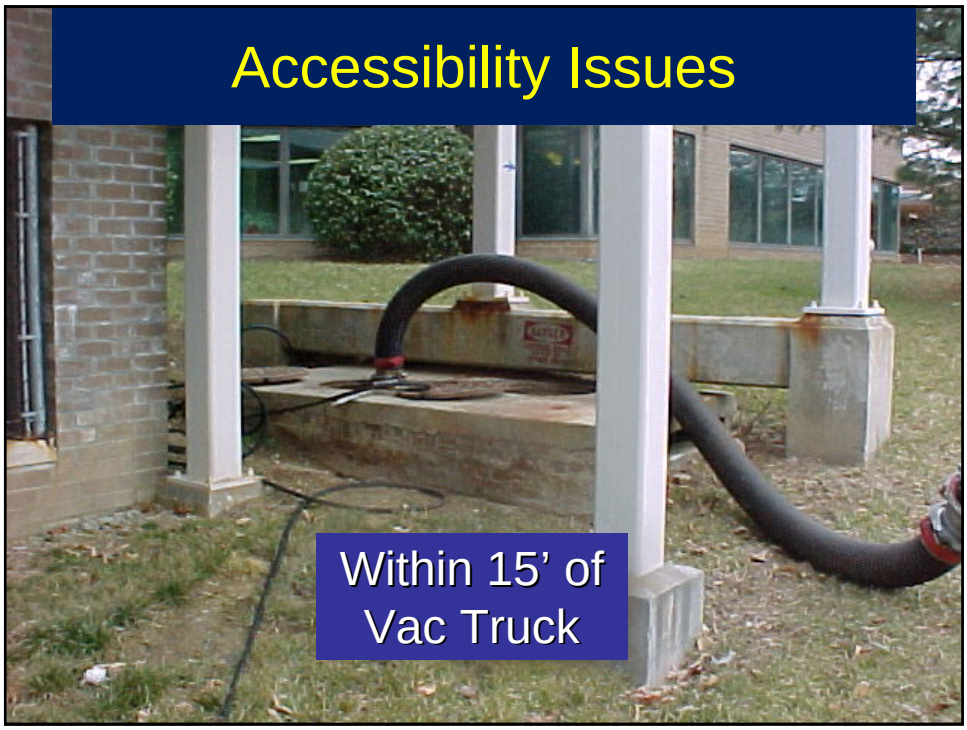
- Old filters unscrew from threaded base in vault
- Using Vac-Truck and rope, remove each filer from the vault
- Units can weigh up to 250 pounds each.

Prepping Old Filters – Removing Filter Media

- Using Vac-Truck, remove the filter media and sediment
- Reassemble the empty filter for return shipment

Images courtesy of Lowe's™

Accessibility Issues



Sufficient Boom Length

Easy Access: Raleigh, NC

Proprietary Device Maintenance

- Consult manufacture of product for exact maintenance recommendations
- Common “ASCE” Maintenance Elements:
  - Accessing the Insides (includes Safety)
  - Powerwashing
  - Pumping sediment, grit
  - Replacing filters

Grassy Swales

Why A Grassy Swale?

- An alternative to curb and gutter
- An alternative to a steep sided, eroding ditch or rip-rap
- Runoff must be transported
- Inexpensive to construct relative to curb and gutter, rip rap, and pipes
- Easy to maintain
- Receive pollutant removal credit

Attribute		LID practice type																	
		Bioretention[a]		Bioswale		Permeable pavement[b]		Infiltration trench	Planter boxes	Sand filter				Vegetated filter strip		Vegetated swale		Cisterns/rain barrels	
		(no UD)	(UD)	(no UD)	(UD)	(no UD)	(UD)			(no UD)	(UD)								
Contribute drainage area (acres)		< 5		< 2		N/A		< 2	< 0.35	< 5				< 1		< 2		Rooftop	
Soil infiltration rate (inches/hour)		> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	< 0.5	> 0.5	N/A	> 0.5	< 0.5			Any soil except fill		> 0.5		N/A	
Water table separation (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	N/A	> 10 ft	≥ 2 ft			> 10 ft		> 10 ft		Below-grade tanks must be above the water table and bedrock	
Depth to bedrock (feet)		> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	≥ 2 ft	> 10 ft	N/A	> 10 ft	≥ 2 ft			> 10 ft		> 2 ft			
Unit slope		< 2%		< 2%		< 6%		<2%	N/A	< 6%				< 6%		< 4%		<5%	
Pollutant removal	Sediments	High		High		High		High	High	High				High		Medium		Pollutant removal provided by downstream BMP, refer to specific BMP for removal efficiency.	
	Nutrients	Medium		Medium		Low		Medium	Medium	Low				Low		Low			
	Trash	High		High		High		High	High	High				Medium		Low			
	Metals	High		High		Medium		High	High	Low				High		Medium			
	Bacteria	High		High		Medium		High	High	Medium				Low		Low			
	Oil & grease	High		High		Medium		High	High	Medium				High		Medium			
	Organics	High		High		Low		High	High	Medium				Medium		Medium			
Runoff volume reduction		High	Medium	High	Medium	High	Medium	High	Low	Medium	Low			Low		Low		Medium	
Peak flow control		Medium		Medium		Medium		Medium	Low	Medium				Low		Low		Medium	
Groundwater recharge		High	Low	High	Low	Medium	Low	High	N/A	Medium	Low			Low		Low		Low	
Setbacks (ft)	Structures	> 10 ft		> 10 ft		> 10 ft		> 10 ft								> 10 ft		> 5 ft	
	Steep slopes	> 50 ft		> 50 ft		> 50 ft		> 50 ft								> 50 ft		> 50 ft	

Notes:
UD: Underdrain
a. If lined, see the Planter box column
b. If lined, see the Sand filter with underdrain column
c. For tank outlet and overflow

How Grassy Swales Work:

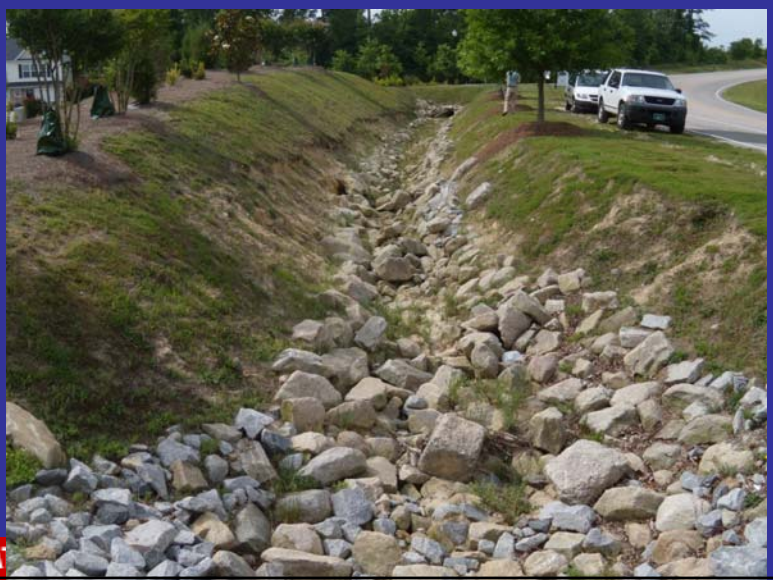
- Swales should have relatively flat bottoms, loose permeable soils, and lots of grass to:
  - **Spread out water and slow it down to allow**:
    - **Infiltration**
    - **Filtration**
    - **Sedimentation**

Curb and gutter

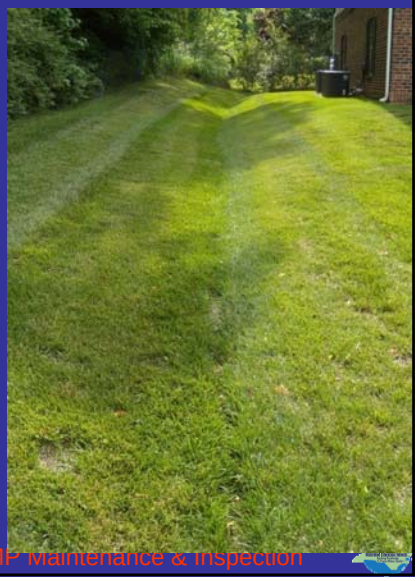
Grassy swales

Swales=Alternative to Rip Rap

Alternative to steep ditches…



Swales can be simple



…And Now

Swales in action Transylvania Co. N.C.

Swale Grass Establishment

- Use sod rather than seed
- (If seeded, use matting to prevent erosion)
- Irrigate sod until established – 3 weeks
- Watch carefully for erosion
- Warm or cool season grass?
- Reinforce with TRM?

Wheat Straw and Netting

Coir or fiber matting

ecoFabriks
solutions for the environment

Email Print

HOME | OVERVIEW | PRODUCTS | SPECIFICATION | APPLICATIONS | INSTALLATIONS | ADVANTAGES | CONTACT US


Eco Mesh CM 400


Eco Mesh CM 700


Eco Mesh CM 900

Coir Fiber Matting

Coir fiber matting also called an erosion control fabric are woven matting with different mesh size, to perform different functions like filtration, separation, drainage, reinforcement and erosion control. They have high tensile strength, water absorption capabilities (can hold up to 3 times of its own weight) and arrest run-off top soil. It is biodegradable and complete degradation in 3 to 5 years. Its unique properties include right strength, durability to prevent slopes against erosion and helps natural vegetation to take root.

A higher density means a tighter mesh and less open area in the netting. The lighter grades of coir fiber matting are suitable for prompt erosion control of all kinds of green areas. The netting can also be used at places like garbage dumps and mining areas, where land changes shape frequently.

The heavier grades can be used on embankments and slopes where there is little or no vegetation. Other advantageous applications are on ski slopes, and as a bottom reinforcing material in watercourses. Coir has good properties for use underwater. There the natural degradation is considerably slower, since microorganisms are generally less active.

Compost Blanket
cost: $.019/sq. ft.

Turf reinforcing mats/ TRM

Target pH for Plant Growth

Table 1. Target pH for a variety of North Carolina plants when produced on mineral soils*.

Plant group	*Target pH*	*Species*
Field crops	6.0	Corn, millet, small grains, sorghum, soybeans, tobacco
	6.2	Cotton
Vegetables	6.0	Beans, cucurbits, cole crops, potato, spinach, sweetpotato
	6.5	Asparagus, tomato
Small fruits	4.5	Blueberry
	6.0	Blackberry, grape, strawberry
Forage grasses	6.0	Fescue, orchardgrass, and timothy (maintenance); bahiagrass; bluegrass; sudangrass
	6.5	Fescue, orchardgrass, and timothy (establishment); bermuda
Forage legumes	6.0	Crimson and white clover, lespedeza
	6.5	Alfalfa, ladino, and red clover
Lawns/gardens	5.0	Azalea, camellia, mountain laurel, rhododendron
	5.5	Centipedegrass
	6.0	Other lawn grasses, flower garden, shrubbery, shade trees
	6.5	Rose, vegetable garden
Nursery	5.0	Ginseng, native ornamentals, rhododendron
	6.0	Most other flowers
	6.5	Gypsophila
Trees/Orchards	5.5	Fir and Northern spruce Christmas trees, pine
	6.0	Apple (maintenance), pecan, hardwoods

Lower pH – Alkaline soils

Table 1.
Pounds of Sulfur Needed to Lower Soil pH 1

Material	pH Change	Pounds per 100 square feet 2
Sulfur	7.5 to 6.5 8.0 to 6.5 8.5 to 6.5	1.5 3.5 4.0
Iron sulfate	7.5 to 6.5 8.0 to 6.5 8.5 to 6.5	12.5 29.0 33.2

1 Effective only on soils without free lime, do the vinegar test!
2 Higher rates will be required on fine-textured clayey soils and soils with a pH of 7.3 and above

Check Dams

- Swales with check dams slow flow of water
- Located at NC art museum
- Rocks added as natural visual element but serve as check dams to slow water flow and aid infiltration

In Swales…..

Poor cover

Ca Grass Varieties

University of California • Agriculture and Natural Resources
UC IPM Online
STATEWIDE INTEGRATED PEST MANAGEMENT PROGRAM

The UC Guide to Healthy Lawns

Turf adaptations and tolerances Back to start

Turf species best adapted to most California conditions

Turf species	Tolerance						Temperature adaptation	Planting method
	Heat	Cold	Drought	Shade	Salinity	Wear/ Traffic		
Bermudagrass	High	Low	High	Low	High	High	Warm-season	Seed, sod, stolons, sprigs, plugs
Kentucky bluegrass*	Low	High	Low	Mod	Low	Mod	Cool-season	Seed, sod
Perennial ryegrass*	Low	High	Low	Low	Mod	High	Cool-season	Seed, sod
Red fescue*	Low	High	Mod	High	Low	Mod	Cool-season	Seed, sod
St. Augustinegrass	High	Low	Mod	High	High	Mod	Warm-season	Sod, stolons
Tall fescue	Mod-high	Mod	Mod	Mod	Mod	Mod-high	Cool-season	Seed, sod

University of California • Agriculture and Natural Resources

UC IPM Online

STATEWIDE INTEGRATED PEST MANAGEMENT PROGRAM

The UC Guide to Healthy Lawns

Turf adaptations and tolerances Back to start

Turf species not adapted to hot climates

Turf species	Tolerance					Temperature adaptation	Planting method
	Cold	Drought	Shade	Salinity	Wear/Traffic		
Annual ryegrass	Low	Low	Low	Low	Low	Cool-season	Seed
Colonial bentgrass	High	Low	Moderate	Low	Low	Cool-season	Seed, sod, plugs
Creeping bentgrass	High	Low	Moderate	Moderate	Low	Cool-season	Seed, sod, plugs
Hard fescue	High	High	High	Low	Low	Cool-season	Seed, sod
Kentucky bluegrass*	High	Low	Moderate	Low	Moderate	Cool-season	Seed, sod
Perennial ryegrass*	High	Low	Low	Moderate	High	Cool-season	Seed, sod
Red fescue*	High	Moderate	High	Low	Moderate	Cool-season	Seed, sod
Rough bluegrass	High	Low	High	Low	Low	Cool-season	Seed

Turf species somewhat adapted to summer heat

Turf species	Tolerance					Temperature adaptation	Planting method
	Cold	Drought	Shade	Salinity	Wear/Traffic		
Dichondra	Low	Low	Moderate	Low	Low	Warm-season	Seed, plugs

Turf species well adapted to summer heat

Turf species	Tolerance					Temperature adaptation	Planting method
	Cold	Drought	Shade	Salinity	Wear/Traffic		
Bermudagrass	Low	High	Low	High	High	Warm-season	Seed, sod, stolons, sprigs, plugs
Buffalograss	Moderate	High	Low	Low	Low	Warm-season	Seed, sod, plugs
Kikuyugrass	Low	High	Moderate	Moderate	High	Warm-season	Sod, stolons
Seashore paspalum	Low	Moderate	Moderate	High	Moderate	Warm-season	Sod, stolons
St. Augustinegrass	Low	Moderate	High	High	Moderate	Warm-season	Sod, stolons
Tall fescue*	Moderate	Moderate	Moderate	Moderate	Moderate-high	Cool-season	Seed, sod
Zoysiagrass	Low - moderate	High	Moderate-high	Moderate	High	Warm-season	Sprigs, sod

‘Spreaders vs. ‘Clumpers’

- “Clumpers”
- Natural growth habit may encourage concentration of flow
- Some very common grasses are “clumpers”

- “Spreaders”
- Natural growth habit encourages diffuse flow
- Some very common grasses are “spreaders”
- But, “spreaders” can be invasive by nature

Tall Fescue -Classic clumper

- Endophyte issues may affect wildlife?
- Non-native, marginally invasive
- Limited shade tolerance

Use heavy seeding rates to avoid clumps - 6 lbs/seed/1000 sq. ft.

Weeping love grass

- Ornamental grass but very ‘clumpy’
- Tolerant of light shade

Spreaders

- Bermuda
- Many forms, from common to many hybrids
- Very persistent and hardy,
- Invasive warm season

Crabgrass????

- Pervasive
- It comes up anyway
- Why not seed it and encourage crabgrass and goose grass?
- ‘Red River Crabgrass’ is one brand

English Ivy Swale

Turfgrass and Trees

- We also like to grow grass under tree canopies
- Very common condition in residential yards, some swales, and in VFS
- Grass does not compete well against trees
- Issues with root competition and shading

Grass/Tree Competition

Mowing regimens?

Avoid scalping grass

- There is a direct relationship between the height of the shoots and the depth of the roots
- Tall grass encourages infiltration, filtration, transpiration

Table 2. Guidelines for Mowing Heights

Lawngrass	Height after Mowing (inches)
Bermudagrass	3/4 to 1 1/2
Zoysiagrass	3/4 to 1 1/2
Centipedegrass	1 to 1 1/2
Kentucky bluegrass, fine fescue, or perennial ryegrass	1 1/2 to 2 1/2
Tall fescue	2 1/2 to 3 1/2

More mowing heights

Mowing Height Adaptation	Drought Tolerance
High cut	High
Tall fescue	Hybrid bermudagrass
Red fescue	Zoysiagrass
Kentucky bluegrass	Common bermudagrass
Perennial ryegrass	St. Augustinegrass
St. Augustinegrass	Kikuyugrass
Common bermudagrass	Tall fescue
Zoysiagrass	Red fescue
Dichondra	Kentucky bluegrass
Kikuyugrass	Perennial ryegrass
Colonial bentgrass	Highland bentgrass
Highland bentgrass	Creeping bentgrass
Hybrid bermudagrass	Colonial bentgrass
Creeping bentgrass	Dichondra
Low cut	Low

The man with the mower…

- Perhaps the lowest paid crew member? But…
- 'Walks' the swale every time he mows
- Should be trained to recognized early signs of problems such as:
- Erosion, ruts, dead grass, poor growth, invasive weeds

Compaction

- Compacted soils shed water and encourage concentration of flow
- Compacted soils discourage plant growth and root penetration

Aerification: core aerator

Drought Stress

- Compaction?
- Poor soil fertility?

Water delivery to swale

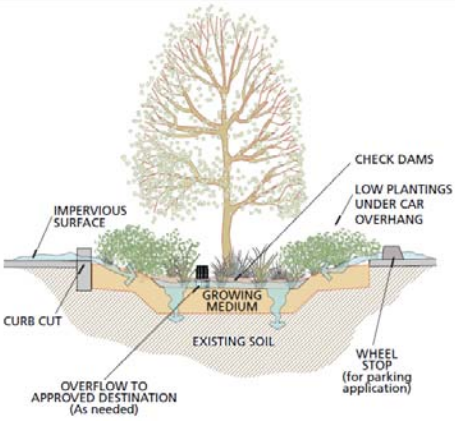
Curb cut feeding pre-treatment swale

Watch for erosion around inlets

Pop-out Swale

- Created from parking space
- Make curb cuts, use native soil
- Adds green landscape feature

Vegetated Swale Portland



Examples

OMSI and PCC annex parking lots, 1945 S.E. Water Ave.

Water Pollution Control Lab, 6543 North Burlington Ave.

Parkrose Middle School, 11800 NE Shaver

Glencoe Elementary School, 825 SE 51st Ave.

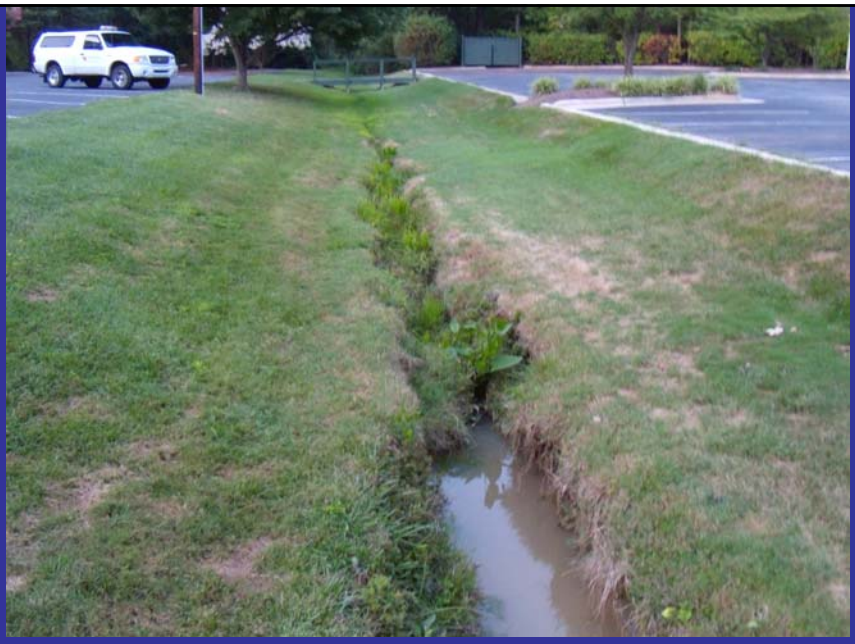
Siskiyou Green Street, NE Siskiyou between 35th Place and 36th Ave.

Tree/Shrub Swale

3 IN 1 Swale

Standing Water in Swale

Erosion in Swales



Spraying Roundup in Ditch Bottoms: Invitation for Erosion

Poorly Maintained Ditch/Swale

Inspection and Maintenance Checklist for a Vegetated Swale

Property Address: _____ Property Owner: _____

Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season ☐ After heavy runoff ☐ Other: _____

Inspector(s): _____

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
1. Sediment accumulation	Sediment depth exceeds 2 inches or covers vegetation			Sediment deposits should be removed without significant disturbance of the vegetation. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water after inflow has ceased.
2. Trash and debris accumulation	Any trash and debris that exceeds 5 cubic feet per 1,000 square feet (one standard garbage can)			Trash and debris are removed from the swale.
3. Standing water	When water stands in the swale between storms and does not drain freely			There should be no areas of standing water after inflow has ceased. Outlet structures and underdrain (if installed) should drain freely.
4. Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width			Spreader leveled and cleaned such that flows are distributed evenly over the entire swale width.
5. Excessive shading	Vegetation growth is poor because sunlight does not reach swale			Overhanging limbs and brushy vegetation on side slopes are trimmed back.
6. Erosion/scouring	Eroded or scoured swale bottom due to flow channelization or higher flows			No erosion or scouring in swale bottom. For ruts or bare areas less than 12 inches wide, damaged areas repaired by filling with crushed gravel. Over time the grass will have started to cover the rock.
7. Visual contaminants and pollution	Any visual evidence of oil, gasoline, contaminants, or other pollutants			No visual evidence of contaminants or pollutants present.
8. Vegetation length	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over			Vegetation trimmed or mowed, and nuisance vegetation removed so that flow is not impeded. Vegetation/grass should not be trimmed shorter than 4 to 6 inches (depending on landscape requirements). Grass clippings removed.
9. Inlet/outlet blockage	Inlet/outlet areas clogged with sediment or debris			Inlet/outlet is clear of material and allows water to flow freely

San Diego Low Impact Development

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
10. Low-flow channel overflow	Nuisance flows are ponding, swale is continually wet			Low-flow channel media is renewed to adequately convey nuisance flows.
11. Constant baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded muddy channel has formed in the swale bottom			A low-flow pea gravel drain can be added to the length of the swale, or an underdrain can be installed, to prevent an eroded or muddy channel.
12. Poor vegetation coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom			Vegetation coverage is in more than 90% of the swale bottom. Poorly vegetated areas of the swale bottom should be re-planted with plugs of grass from the upper slope and reseeded in locations where plugs were taken. Plugs should be planted in the swale bottom with no gaps, or reseeded into loosened, fertile soil.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Green Roofs

Why A Green Roof?

- Reduce urban heat island effect
- Improve urban air quality
- Prolong roof life and add insulation
- Add green feature to roof top or urban environment – create living space
- Reduce volume of stormwater runoff
- Help improve urban biodiversity
- Soundproofing

How Green Roofs Work:

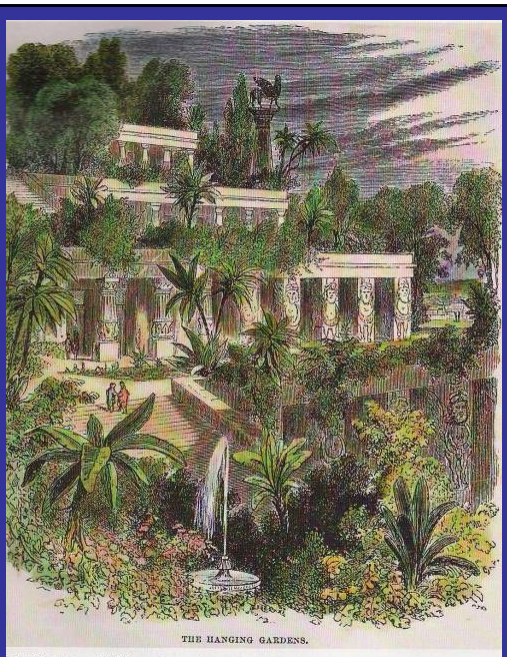
- Rain water is stored in the media and drainage layers on the green roof.
- Water is used by plants (transpiration) and can evaporate from media (evapotranspiration or ET)
- Plants and soil cool the air via ET and absorption – urban heat island effect
- Media protects roof and insulates roof

Extensive vs. Intensive

- Green roofs are divided into two categories:
- 1) extensive green roofs, which are 6 inches or shallower and are frequently designed to satisfy specific engineering and performance goals, and
- 2) intensive green roofs, which may become quite deep and merge into more familiar on-structure plaza landscapes with promenades, lawn, large perennial plants, and trees.

Green Roof Requirements

- Load capacity of building
- Slope issues – flat is best, or < 12º
- Drainage – well drained but maintain soil moisture
- Materials access during construction
- Access for maintenance



Green Roofs: Southern Style

Green Walls?

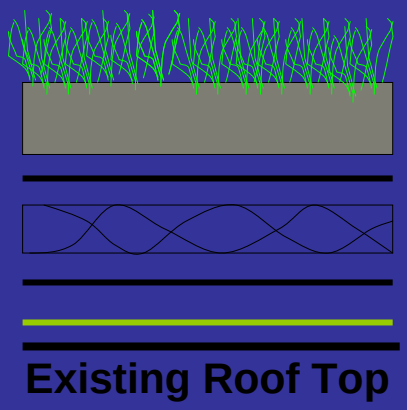
The Federal Reserve Bank of Richmond – Charlotte Branch

60,000 sq. ft. Green Roof

Green Roof Justification

- Needed roof replacement
- Most cost effective option
- $1.5 million project
- 10 year pay-back

Cross-Section of Green Roof



Vegetation
Substrate Soil
Filter/ Separator
Drainage Element
Root Barrier
Vapor Barrier
Existing Roof Top

Green Roof Soil Loss

- Wind erosion
- Organic matter oxidation

Green Roof Fertilization

- Green Roofs need some fertilization to survive
- 1 oz 10-10-10 slow release fertilizer per sq. yard per year (Ed Snodgrass)
- Overfertilization
  - Creates water pollution from nutrient runoff
  - Encourage excessive weed growth

Green roof runoff quality?

Send GR water to another BMP

Green Roof Weeds

- Can penetrate waterproof membrane – trees and other aggressive weeds
- Can dry out and create a fire hazard
- Can shade out green roof plants
- Can be unsightly
- Can create debris to clog downspouts
- Should be pulled or herbicide wiped as soon as noticed

Green Roof Plants

- Low growth height
  Rapid growth / spreading
- High drought tolerance
  Fibrous root as opposed to tap roots to protect roofing membranes
- No special irrigation or nutritional requirements
- Low maintenance - trimming, weeding, feeding
- Plants shouldn't generate airborne seeds in order to prevent the green roof plants invading other landscaping

Plant Die-off

Green Roof Issues

- Watch gutters and scuppers – green roofs generate more debris than regular roofs
- Confine visitors to walkways
- Remind visitors of no smoking, potential for high winds, and to be careful near edges – it is still a roof

July 20, 2009

SOOKIE
Green roofs are expected to proliferate with a Toronto bylaw mandating them for new buildings.

Insurance

Concerns raised over fire safety for green roofs

PETER KENTER
correspondent

California brush fires frequently make the news as they destroy homes and businesses.

However, what happens if a brush fire occurs on top of a downtown highrise?

"I don't believe that the insurance industry has caught up with the increased risk of fire that may result from

Green Roof Maintenance Tasks and Schedule

•TASK	•SCHEDULE
Regular cleaning – debris removal - down spout check	•Monthly
Watering?	•As needed, summer and droughts
•Fertilization? Via compost or fertilizer	•Annual
•Plant replacement	•Annual
•Weeding (trees and volunteers	•Quarterly
•Soil replacement	•Annual

Cistern Maintenance

Basilica Cistern - Istanbul

Carbillo Light House


Old Cistern
Built in 1883
to store rain water


Rain
Catchment
Basin

Where is the cistern???

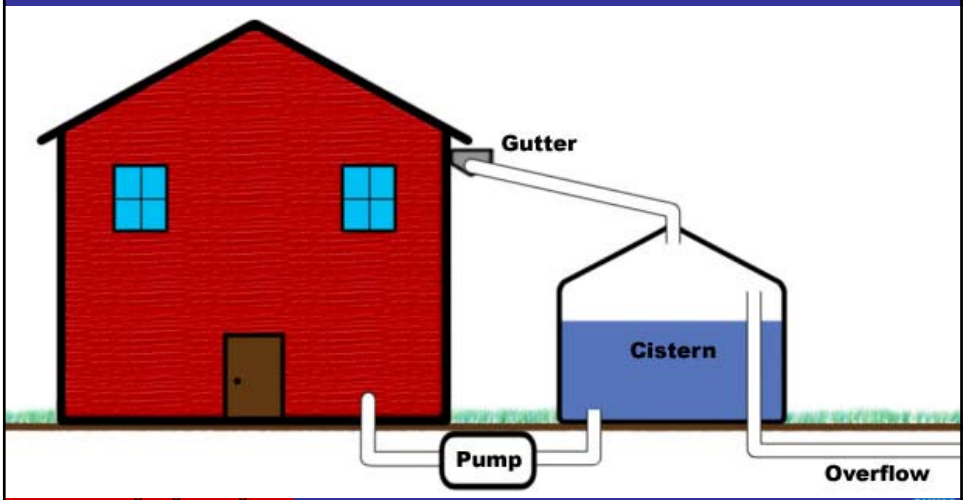
Why A Cistern

- Cisterns store rain water
- Rain water can be used for any non-potable use such as irrigation, vehicle washing, toilet flushing
- Saves potable water
- Stored water does not contribute to runoff
  - Reduces stormwater 'footprint'

How Cisterns Work:

- 1000 sq ft roof catching 1 inch of rain produces 650 gallons of water
- First flush diverter diverts pollen/leaves, etc. so clean water enters cistern
- Cistern is sized to match roof size and intended use
- A pump is needed for pressure
- May need protection from freezing

Water Harvesting Layout



Terminolgy

- Detention
- Single-Purpose
- Dual-Purpose

Detention

- Reduces peak stormwater runoff by storing rainwater from the roof and other hard surfaces (parking lots, etc.) and slowly releases the rainwater through a small diameter orifice
- Two outlets: small orifice for drawdown (10-35 mm) at bottom of tank and large overflow pipe connected to storm drain

Single-Purpose

- Provides a non-potable water supply.
- Collects water from rooftops only and is used for household use.
- Parking lot water is too polluted for household use
- Small outlet at bottom for plumbing connection and large overflow pipe at top for bypass of large flows

Dual Purpose

- Provide non-potable water supply and reduce peak flows.
- Collects water from roof only.
- Two small outlets, one overflow outlet
- One small outlet midway down side of tank to slowing release detention water
- One small outlet at bottom to feed pump for household non-potable uses

Jobs | Cars.com | Real Esta

LAT Home | Print Edition | All Sections

Los Angeles Times | National

You are here: LAT Home > National News

National

» Washington
» Science

News/Opinion

California | Local
National
World
Business
Sports
Washington
Science
Environment
Opinion

Arts/Entertainment

Entertainment
The Guide
Company Town
Arts & Culture

Who owns Colorado's rainwater?

Environmentalists and others like to gather it in containers for use in drier times. But state law says it belongs to those who bought the rights to waterways.

By Nicholas Riccardi
March 18, 2009

Reporting from Denver -- Every time it rains here, Kris Holstrom knowingly breaks the law.

Holstrom's violation is the fancifully painted 55-gallon buckets underneath the gutters of her farmhouse on a mesa 15 miles from the resort town of Telluride. The barrels catch rain and snowmelt, which Holstrom uses to irrigate the small vegetable garden she and her husband maintain.

»L.A. water rates revised to penalize heavy users

»Lawmakers seek billions to expand,

Cistern water is non-potable unless it is treated

Kitty Hawk, NC
Over 6000 gallons of storage for one house

‘Cisterns’ come in all shapes and sizes…

Examples of Cisterns

Raleigh, NC commercial building

Algae & Cisterns

- Clear or Translucent Cisterns Could Spawn Algae Growth
- Algae Need Sunlight

SOLUTION: If Outside, use Black or Green Cistern

‘Stinky’ Cistern Water

- A rotten egg odor or sulphur odor in water can be from dissolved hydrogen sulfide gas or certain bacteria in your water
- A sulfurous smell or rotten egg smell may also be due to the combination of loss of oxygen in water (hypoxia), or low oxygen levels, combined with algae which feeds and then dies

Shock Chlorination

- Use 32 fluid oz unscented chlorine bleach (5.25% chlorine) per 1000 gallons of water (=10 ppm chlorine)
- Can go as high as 50 ppm
- Contact time 24 hours
- Maintenance Chlorination (2-5 ppm) = 6.5 oz bleach per 1000 gallons

Cistern Disinfection

Material	% Chlorine in material	Amount to add per 1000 gal. to produce 50 ppm chlorine	Amount to add per 1000 gal. to produce 5 ppm chlorine
Sodium Hypochlorite (liquid laundry bleaches such as Clorox or Purex)	5.25	1 gallon	1 ½ cups
Sodium Hypochlorite Commercial Strength	12	7 cups	¾ cup
Chlorinated Lime (powder)	25	3½ cups	5 tablespoons
Calcium Hypochlorite (B.K. Powder)	50	1½ cups	2½ tablespoons
Calcium Hypochlorite (H.T.H., Perchloron, etc.)	70	1 1/8 cups	2 tablespoons

Note: 16 Tablespoons = 1 cup and 256 tablespoons = 1 gallon.
For materials not listed above, the percent of available chlorine will be found on the label under "active ingredients."

Mosquitoes & Cisterns

- Popular Fear: Mosquitoes Breed in Cisterns

Manufacturers have developed well plumbed devices. Screens keep mosquitoes out

Mosquitoes and Safety

- Cover tops and ports to prevent mosquito breeding or access by children
- Secure rain barrels to avoid tipping over

Cistern plumbing

- Keep an eye open for ‘creative’ plumbing
- Pumps required for water pressure
- May have disconnected inflow pipe from potable system to maintain water level during dry times

Pumps

We use Leader Pumps Divertron 1000 120v - gives 25gpm @ 25psi

- Have pumps professionally inspected every 2-3 years
- Submersibles are good
- Clean intakes or use floating intakes
- Bury tank 1-2 feet if freezing is an issue

Floating intake – avoids 'gunk' on top & bottom of tank

Floating intake

Inflow pipes

- Can have inflow from roof or other water source for back-up
- Probably activated by float valves
- Must be disconnected – no cross connections to potable water!

Screen Overflow Outlets

- Must be kept clean or water can back up into downspouts and gutters
- Screen to prevent rodent and insect access

Keep Overflow Outlets Clear

- Clogged outlets can mean overflowing cistern – can undermine cistern base

Gutters

Is water getting to the system?

Gutters….

- Consider gutter guards
- If gutters must be cleaned plug downspout opening to prevent debris flow to cistern
- Blow-out gutters rather than wash-out

Why is my cistern water brown? Tannic Acid….

Check Inlet Screens

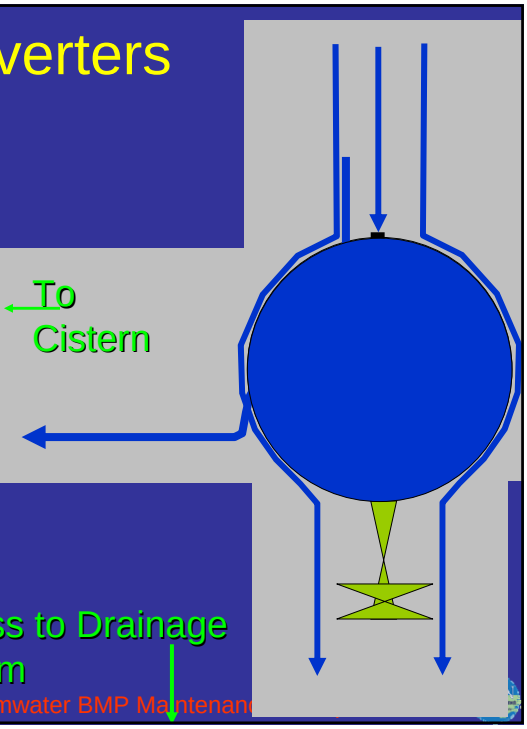
- Keep gutter debris out
- Keep rodents and reptiles out of cistern

What is that yellow stuff floating in my cistern?

First flush diverter & screen

Diverter Screen

First flush diverters



First Flush Screen Must Be Cleaned

Sediment

- Clean sediment if > 8 inches
- Measure sediment with ruler
- May require professional cleaner – vac-truck, confined space
- Consider quality of sediment – directly related to roof covering

If Used for Back-up Water Supply

- Monitor float valves – prone to leak and jam with debris
- The next water bill will tell you if valve is leaking…..
- Check backflow valve on water line

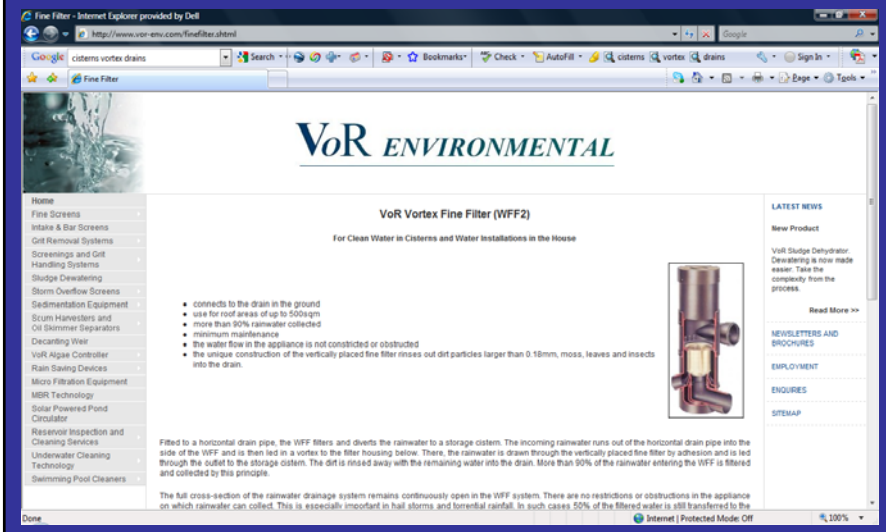
Float Valves

- Water enters tank from cistern
- When tank runs dry, well back-up activates

Filters

- Change filter cartridges as needed

Vortex Filters



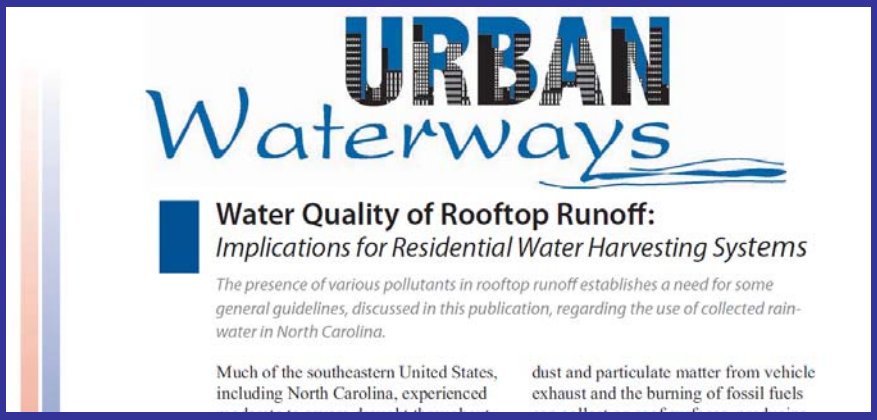
Consider Quality of Water Source for Cistern – A.C.

20 gallons per day

Zinc from galvanized roof

Cu from copper roof

See our publication for details



URBAN Waterways

Water Quality of Rooftop Runoff:
Implications for Residential Water Harvesting Systems

The presence of various pollutants in rooftop runoff establishes a need for some general guidelines, discussed in this publication, regarding the use of collected rain-water in North Carolina.

Much of the southeastern United States, including North Carolina, experienced

dust and particulate matter from vehicle exhaust and the burning of fossil fuels

Trim or Clear Overhanging Branches

- Lowers debris loading of roof and gutters
- Eliminates roosting points for birds
- Eliminates access points for rodents (rats and squirrels)

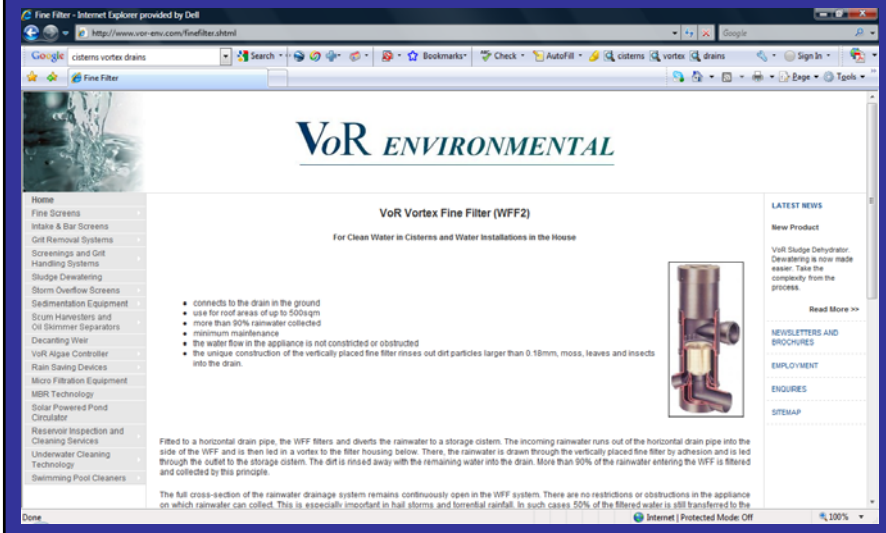
Check Hatches and Covers

- Check fit and seal to prevent child and insect access

‘Gunk’ Collection in Bottom of Cistern

- Look for cisterns with vortex drain valves that ‘self clean’ the bottom of the cistern.

Vortex Filters



Protect fittings from freezing

Cistern Use

- Major problem with cisterns is lack of use
- Not ‘convenient’
- Plumbing code issues
- ‘Anti-LID’ attitudes

- Examples of well-used cisterns….

Boone Public Works Cistern

Mountain Welcome Center

28,000 gallons – toilet flushing

Guilford Co. Extension Center

1500 gallons

1500 gallons


22
23

Inspection and Maintenance Checklist for a Cistern

Property Address: _____ Property Owner: _____

Treatment Measure No.: _____ Date of Inspection: _____ Type of Inspection: ☐ Monthly ☐ Pre-Wet Season ☐ End of Wet Season ☐ After heavy runoff ☐ Other: _____

Inspector(s): _____

Defect	Conditions when Maintenance is Needed	Maintenance Needed? (Y/N)	Comments[a]	Results Expected when Maintenance is Performed
1. Low flow	Gutters are full of debris and overflowing			When gutters are cleaned appropriately and gutter guards or screens are installed, gutters should be clear and free-flowing.
2. Inlet	Filters are clogged or full			Filters are clean and free of trash and debris.
3. First flush diverter	First flush filter is full or clogged causing permanent flow to the cistern			When first flush diverter valve is removed and cleaned, the first flush will be diverted away from the cistern.
4. Cistern does not drain within 48 hours	Outlet is clogged			Cistern completely drains within 48 hours.
5. Cistern drains in less than 24 hours	Cistern leaks or outlet allows excessive flows			Cistern drains in 24 to 48 hours.
6. Miscellaneous	Any condition not covered above that needs attention for the infiltration trench to function as designed			Meet the design specifications.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.