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MONASH University Engineering
Institute for Sustainable Water Resources

FAWB
Facility for Advancing Water Biofiltration

Advancing Raingarden Design

Filter Media and Landscaping

June 2008

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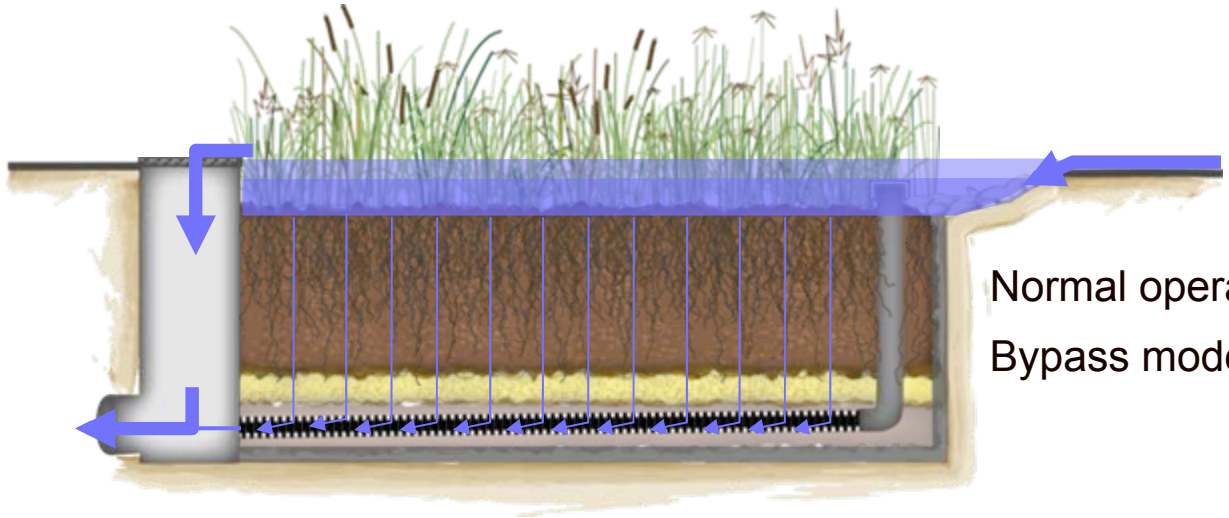
Filter media and drainage layers

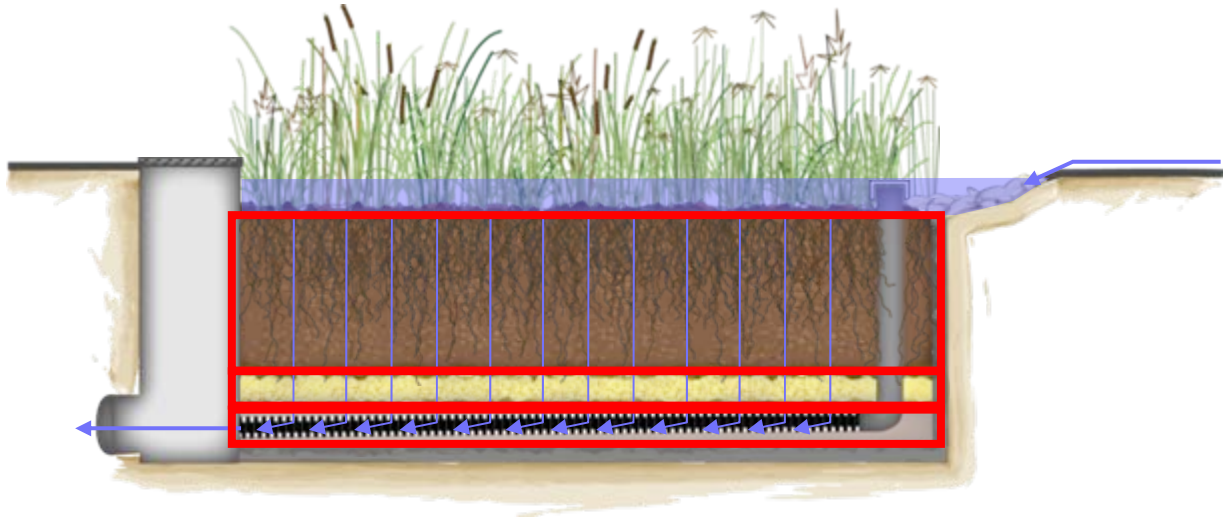
Drainage layers and filter media

- PRIMARY DESIGN OBJECTIVE: **Pollutant removal**



- Filter media and drainage layers influence pollutant removal efficiency by:
  - » Maintain healthy plant growth
  - » Control hydraulic conductivity
  - » Prevent leaching of pollutants

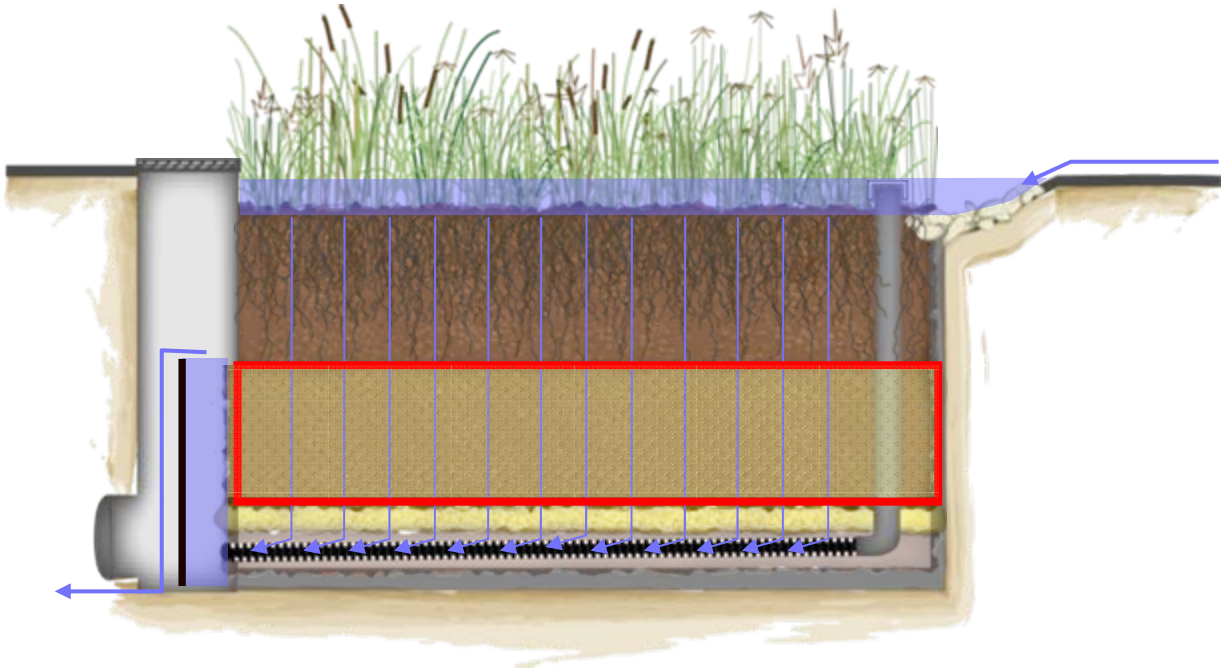
Drainage layers and filter media



For systems without a Saturated Zone (SZ), there are three important components:

- **Filter media**
- **Transition layer**
- **Drainage layer**

Drainage layers and filter media

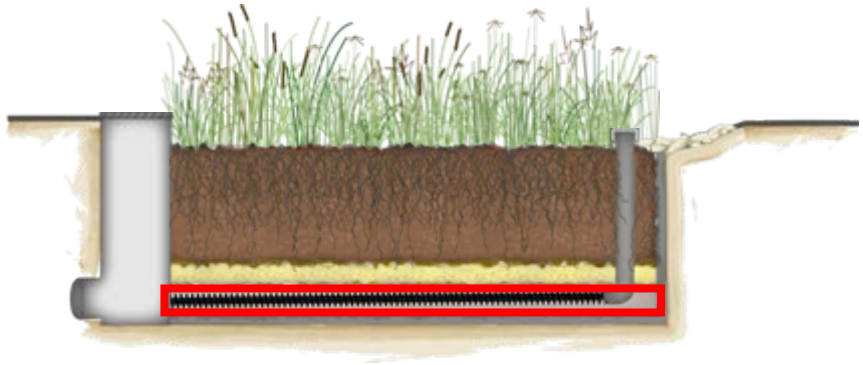


For systems with a saturated zone (SZ), there is also:

» **SZ filter media**

Detailed specification of drainage layers and filter media

Drainage Layer



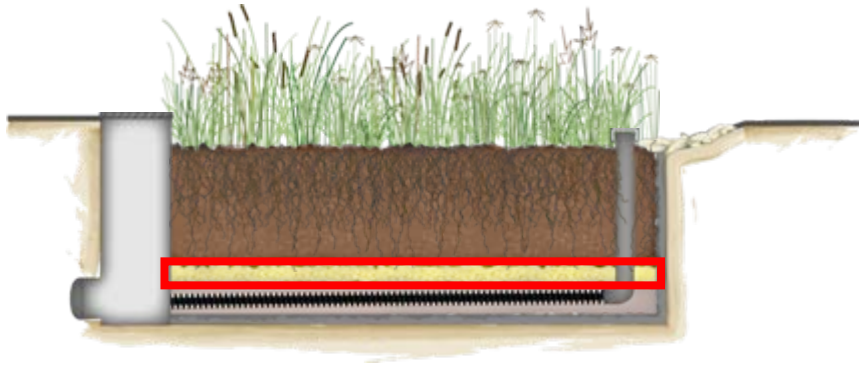
Important Functions

- Prevent loss of filter media
- Holds perforated drainage pipes

General Characteristics

- 2-5 mm screenings
- Fine gravel, or
- Future - crushed recycled concrete
  - » more sustainable if available
  - » must be washed

Transition Layer



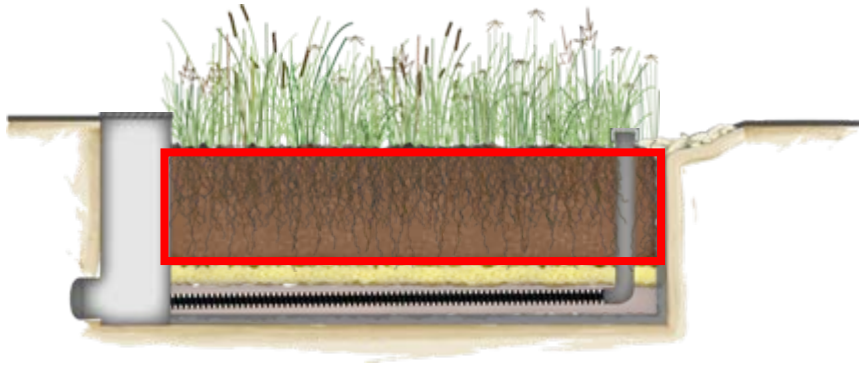
Important function

- Prevents migration of filter media into drainage layer

General Characteristics

- Sand/coarse sand
- Indicative particle size (% passing)
  - 1.4 mm (100 %)
  - 1.0 mm (80 %)
  - 0.7 mm (44 %)
  - 0.5 mm (8.4 %)

Filter Media



- KEY DESIGN OBJECTIVES:
  - » Supporting healthy plant growth – and therefore good root growth
  - » Maintaining hydraulic conductivity over time – and therefore maintain treatment efficiency
  - » Reducing leaching potential – particularly nutrients

How?

Selecting an appropriate filter media

FAWB Guidelines for Filter Media

GUIDELINES FOR SOIL FILTER MEDIA IN BIORETENTION SYSTEMS (Version 2.01)
March 2008

The following guidelines for soil filter media in bioretention systems have been prepared on behalf of the Facility for Advancing Water Biofiltration (FAWB) to assist in the development of bioretention systems, including the planning, design, construction and operation of those systems.

NOTE: This is a revision of the previous FAWB guideline specifications (published in 2006). It attempts to provide a simpler and more robust guideline. FAWB acknowledges the contribution of EDAW Inc., Melbourne Water Corporation, Dr Nicholas Somes (Ecodynamics), Alan Hoban (SEQ Healthy Waterways Partnership), and STORM Consulting to the preparation of the revised guidelines.

Disclaimer

The Guidelines for Soil Filter Media in Bioretention Systems are made available and distributed solely on an "as is" basis without express or implied warranty. The entire risk as to the quality, adaptability and performance is assumed by the user.

It is the responsibility of the user to make an assessment of the suitability of the guidelines for its own purposes and the guidelines are supplied on the understanding that the user will not hold EDAW Inc., Monash University, Sydney Environmental & Soil Laboratory Pty. Limited (SESL), Dr Peter May, The University of Melbourne, or Melbourne Water Corporation or parties to the Facility for Advancing Water Biofiltration (FAWB) ("the Licensor") liable for any loss or damage resulting from their use.

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1 GENERAL DESCRIPTION

The bioretention filter media guidelines require three layers of media: the filter media itself (400–600 mm deep or as specified in the engineering design), a transition layer (100 mm deep), and a drainage layer (50 mm minimum underdrainage pipe cover). The bioretention system will operate so that water will infiltrate into the filter media and move vertically down through the profile.

The filter media is required to support a range of vegetation types (from groundcovers to trees) that are adapted to freely draining soils with occasional flooding. The material should be based on natural soils or amended natural soils and can be of siliceous or calcareous origin. In general, the media should be a **loamy sand** with an appropriately high permeability under compaction and should be free of rubbish, deleterious material, toxicants, declared plants and local weeds (as listed in local guidelines/Acts), and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content.

Bioretention Filter Media Guidelines (Version 2.01). Prepared by the Facility for Advancing Water Biofiltration (FAWB), March 2008.

"GUIDELINES FOR SOIL FILTER MEDIA IN BIORETENTION SYSTEMS (Version 2.01) March 2008"

- Describes the relationship between filter media and other design components (size, EDD)
- Describes the important components of the soil media and drainage layers
- Assists in determining the most suitable soil available

Refer to Facility for Advancing Water Biofiltration (FAWB) website

http://www.monash.edu.au/fawb/products/index.html

Selecting an appropriate filter media

- Loamy sand as a starting point
- Use AS4419 specs as a starting point to choose soils for further testing

Selecting an appropriate filter media

1. Hydraulic Conductivity (permeability)

- Typical design range 100 – 400 mm/hr
- Must demonstrate prescribed hydraulic conductivity
  - » In Australia: ASTM F1815-06 method
  - » http://www.monash.edu.au/fawb/products/index.html
- Test to ensure it will remain permeable under compaction due to:
  - » placement of material (gentle compaction)
  - » natural settlement (gravity)
  - » hydraulic compaction (settlement caused by wetting and drying)

Selecting an appropriate filter media

2. Particle Size Distribution (PSD)

- <3% silt + clay
  - » to ensure soil structure
  - » flexible in the larger particle size range
  - » still provides adsorption capacity

Clay/silt	***<3%***	***(<0.05mm)***
Very Fine Sand	*5-10%*	*(0.05-0.15 mm)*
Fine Sand	*10-25%*	*(0.15-0.25 mm)*
Medium to Coarse Sand	*60-70%*	*(0.25-1.0 mm)*
Coarse Sand	*7-10%*	*(1.0-2.0 mm)*
Fine Gravel	*<3%*	*(2.0-3.4 mm)*

Selecting an appropriate filter media

3. Soil Properties

- Does not leach nutrients
  - Low phosphorus (<100mg/kg)
  - Organic matter (<5% w/w)

- Does not inhibit growth
  - EC
  - pH

} Within a range for healthy plant growth

Selecting an appropriate filter media

SAZ Filter Media

- Course sand – (may not require additional transition layer)
- Carbon source
  - » Short term – e.g. pea straw
  - » Long term – e.g. hardwood chips (approx. 6mm grading)
- Volume of Carbon source calculated based on C:N ratio expected in stormwater
  - » Approx. 5% by volume
- Typical Recipe

98 L sand (by volume)
500 g pea straw
1.5 kg red gum woodchips

Important design consideration - GEOFABRIC

Geotextile fabrics not recommended anywhere within the soil profile or around drainage pipes

Important design considerations - ADDITIVES

- Filter media can be constructed from in-situ soil
  - » *Generally requires amendment*
- Variation to media when targeting specific pollutants
  - » *Activated carbon for targeting heavy metals*
  - » *Also commercial products with high adsorption capacities that target specific pollutant such as phosphorous*

Installation

- Light compaction during installation to prevent migration of fine particles.
- Small systems:
  - » a single pass with a vibrating plate
- Large systems:
  - » a single pass with roller machinery (e.g. a drum lawn roller)

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Vegetation selection

Role of vegetation

Research to date has demonstrated the importance of vegetation for raingardens. Some of the important functions of plants include:

- Direct pollutant uptake
- Facilitation of other physical and chemical processes to remove nutrients
- Prevents erosion of the soil media
- **Maintains hydraulic conductivity (Ksat) of the filter media**

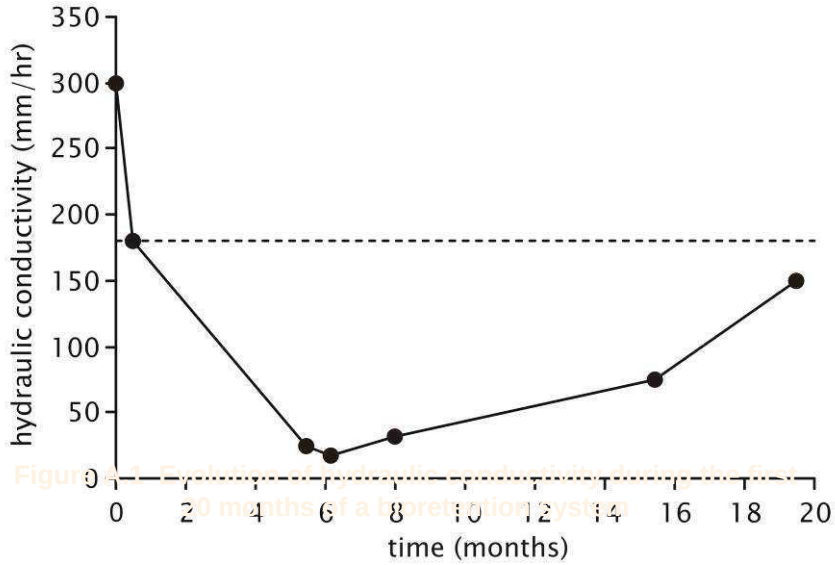


Figure 5.1 Evolution of hydraulic conductivity during the first 20 months of a bioretention system

Selecting appropriate plant species – STEPS

Selecting appropriate plant species

- **Obtain species lists**
- Native or Introduced Species
  - » Depends on site & objectives
  - » Surrounding landscape influence
- Local species lists
  - » Local Council
  - » Nurseries
  - » Reference books

Selecting appropriate plant species

- **Assess hydrologic requirements of the plants**
- Drought tolerant – subject to extended dry periods
- Tolerant of freely draining sandy soil
- Tolerant of occasional inundation

Selecting appropriate plant species

- **Growth form**
- Extensive fibrous root structures
- Not shallow rooted
- Avoid clumping structures such as bulbs or large corms
- Dense linear foliage with spreading growth form rather than clumping

Selecting appropriate plant species

- **Other selection criteria – site specific**
  - » Frost tolerance
  - » Shade tolerance
  - » Landscape requirements (height restrictions etc)

Selecting appropriate plant species

- **Consider hydraulic conductivity of filter media**
  - » High hydraulic conductivities are likely to require specialized plant species

Design considerations for vegetation

Brisbane Terrace, Kingston

Dense planting (6-10 plants/m2)

- high densities increase root densities, protect surface porosity, promote even distribution of flows, increases evaporative losses

Consider zoning in oversize systems

- areas away from inlets may need to be particularly hardy

Range of species!

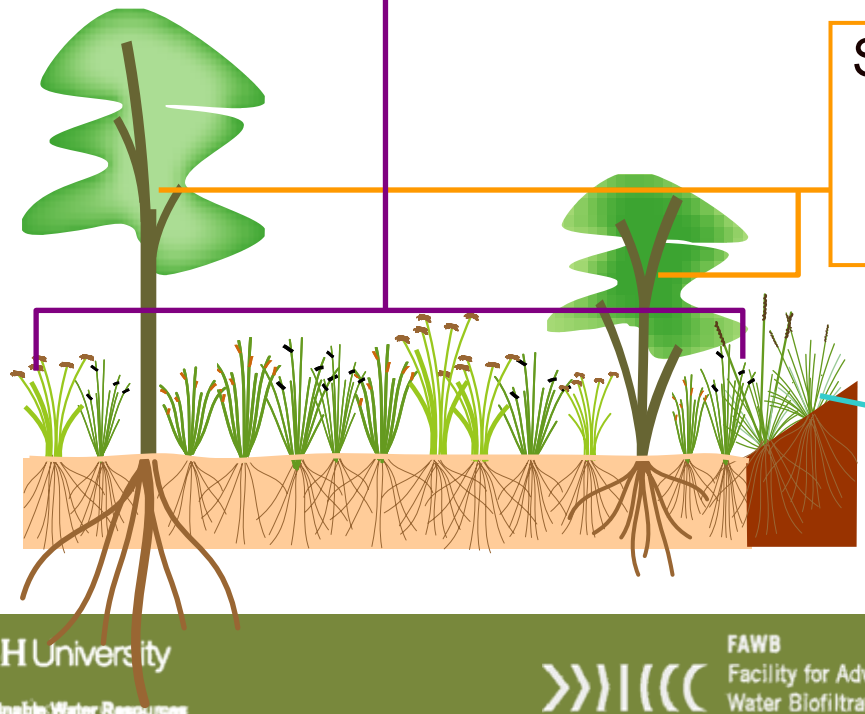
- increases robustness – e.g. Leucophyta brownii
- accounts for variability in nutrient removal other processes

Range of growth forms where possible

Layout of vegetation

Dominant Species

- Extensive planting
- 6-10 plants/m^2 depending on plant growth form



Shrubs and trees

- Occasional planting according to landscape requirements
- <1 plant/m^2

Batter planting

- Drier species


Raingarden
Typical garden bed

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Establishment phase

No organic mulch

- Floats (blocks pits; redistributed)
- Alternatively take planted area off line

Gravel mulch

- Can restrict plant growth – shallow layer only
- Not for conveyance systems
- Ideally increase plant densities to manage weeds

Plants may require irrigation during establishment

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Long term WSUD maintenance and resetting

What is the objective of long term maintenance?

- To maintain treatment function

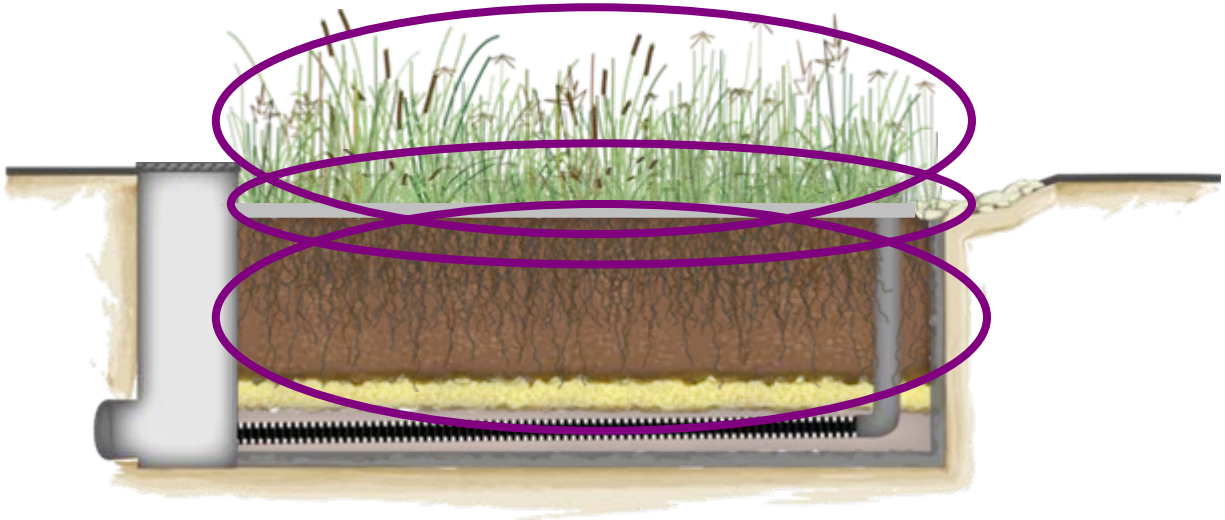
  (pollutant removal efficiency)

- To maintain aesthetics

  (individual sites, budgets etc)

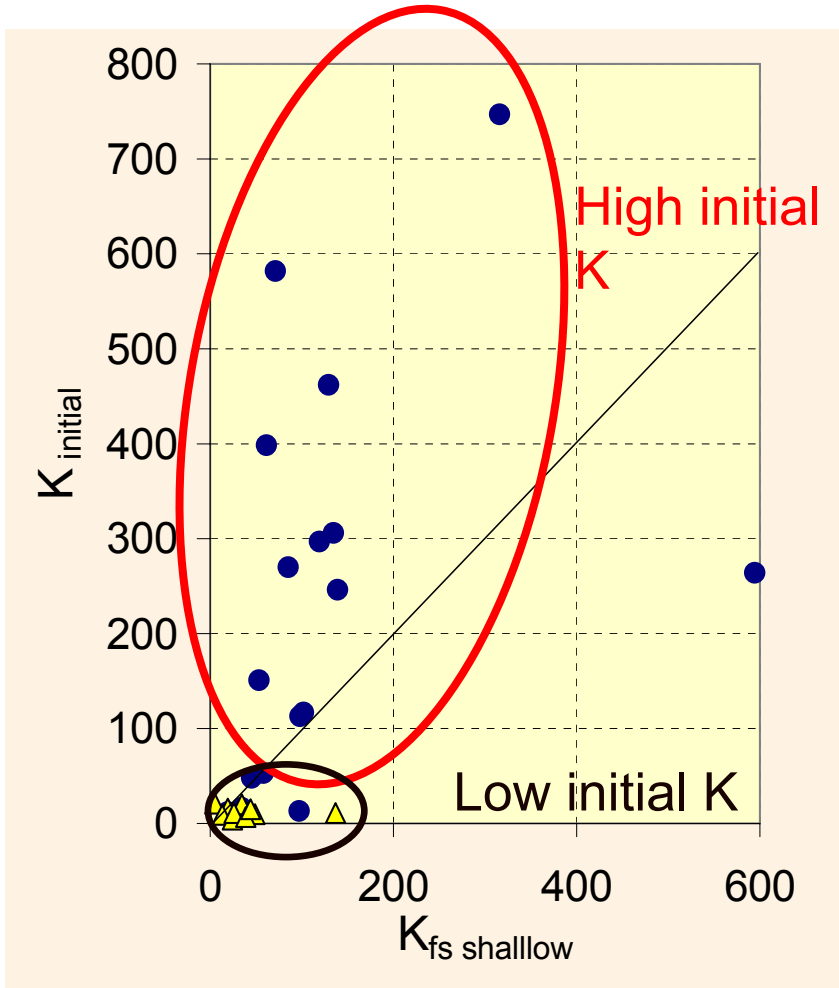
Key elements to long term function

- Three elements key elements in design and construction
  - Correct filter media
  - Dense vegetation cover
  - Protection during construction
- Result - Long tem maintenance is predictable



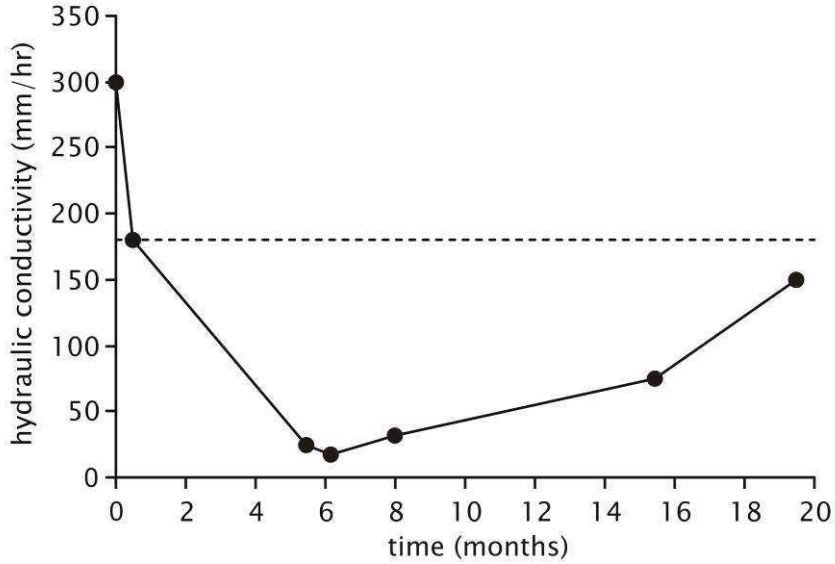
1. Filter media specification

- Correct specification
  - Hydraulic conductivity
  - PSD
  - Soil properties
  - Soil nutrition
- Correct installation
  - light compaction



2. Dense vegetation cover

- Pollutant removal efficiency related to root structure and density
- Plants have a role in the recovery of infiltration capacity (hydraulic conductivity) as they mature



3. Protection during construction phases

- Protection of the raingarden while its being constructed

our

Geofabric and turf (for aest

Silt fence (to prevent vehic

Temporary creation of sediment forebay

Long Term Maintenance Activities

Four areas of maintenance

- Horticultural
- Drainage
- Filter media
- Observation after rainfall to check infiltration

Horticultural maintenance

- Maintain high plant densities
  - » *replacement lost plants (large losses – check shade and frost tolerance etc)*
  - » *limit trimming*
- Control weeds (manual)
  - » *manage/reduce herbicide use to prevent overspray*
- Assess for and treat plant pests & disease

Drainage maintenance

- Remove blockages from inlets, outlet and overflows
- Check for structural integrity of pits and other civil works
- Remove sediment from pits and entry sites etc. (likely to be irregular occurrence in mature catchment)

Filter media maintenance

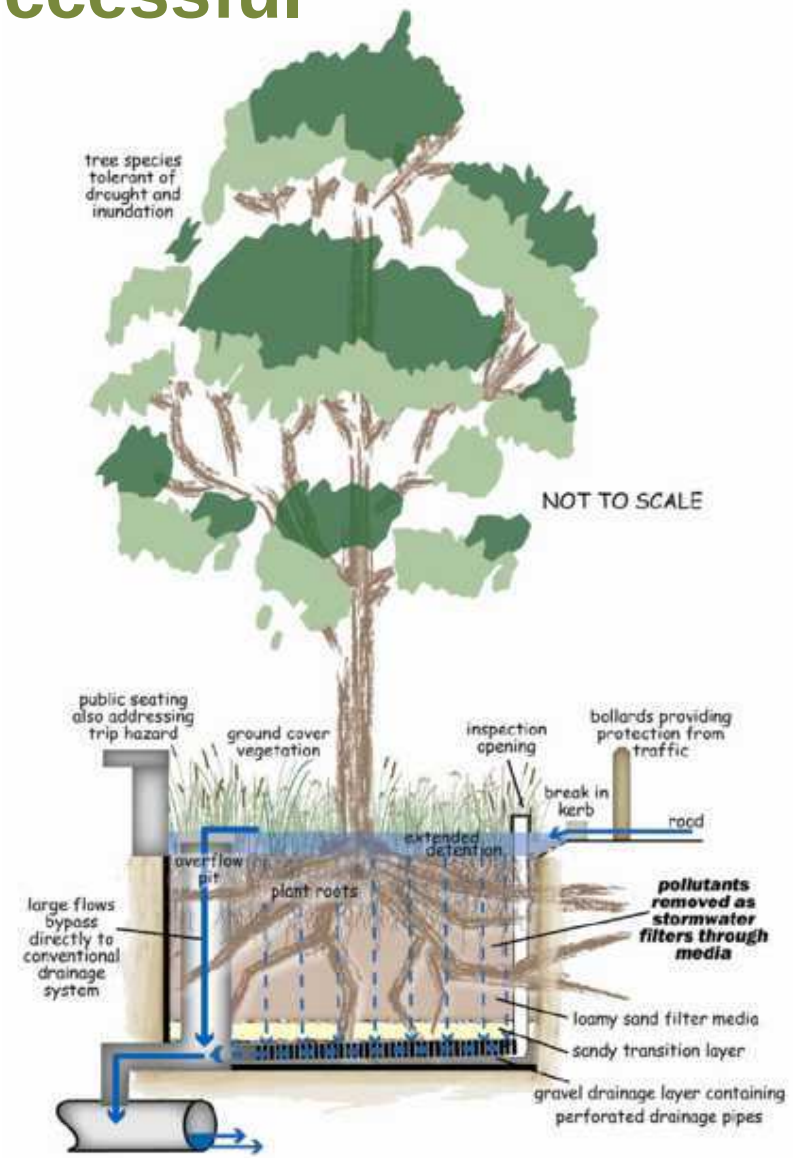
- Remove sediment build up
  - » *from forebays in raingardens and on surface of street tree raingardens*
- Infill any holes in the filter media
- Check for erosion or scour
- Remove anthropogenic litter
  - » *remove leaf litter from tree pits where there is no groundcover vegetation present*

Observations

- Occasionally observe raingarden after a rainfall event to check infiltration
  - » Check for poor drainage
  - » Check landuse
    - › *Has it altered or does it vary from design capacity (e.g. unusually high sediment loads may require installation of a sediment forebay)*

Other considerations for successful maintenance

- Maintenance plan
  - » *Include description and sketch of how the system operates*
- Identify maintenance jurisdiction
- Delineate raingarden
  - » *Defines area where the maintenance is required*



Maintenance plan - TEMPLATE

Raingardens and Bioretention Tree Pits
MAINTENANCE PLAN

EXAMPLE

April 2008

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Refer to Facility for Advancing Water Biofiltration (FAWB) website

http://www.monash.edu.au/fawb/products/index.html

Key elements during design and construction

- Correct filter media
- Dense vegetation cover
- Protection during construction

Predictable long term maintenance activities

- Horticultural
- Drainage
- Filter media
- Observation after rainfall event

Questions?

Other considerations

- Roots in drainage pipes
- Harvesting of plants only to open canopy and promote groundcover growth

Resetting

- Two reasons why raingardens require setting
  - » Clogging
  - » Pollutant breakthrough

Clogging

Assuming correct media specification and placement

Observation indicate surface of filter media is clogged

(e.g. extended ponding on surface, plant failure)

1. Poor plant growth or low densities → Re-establish plants to manage surface porosity

2. Plant growth ok → filter media failure → replace top 200-300 mm filter media and check catchment landuse

Pollutant breakthrough

- Soil media has reached capacity (e.g. for retaining metals) and leaching occurs

RECENT RESULT ON BREAKTHROUGH OF METALS

- For a typically sized biofilter - 2% of imp. catchment area, 0.5 m deep
- Preliminary results indicate breakthrough will not occur for at least 15 years
- Conservative because testing was done at a low pH (~5.6)
- At a neutral pH it is expected typical raingarden will demonstrate an even longer lifespan