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Filtration Fundamentals: The basics and why filtration matters today

Kentucky Stormwater Association Annual Conference

July 20, 2017

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Agenda

- Filtration Overview
- Filtration in Stormwater
- Filtration Innovation
- Discussion

What is filtration?

- The act or process of removing something unwanted from liquid, gas, etc., by using a filter (Merriam Webster Learners Dictionary)

- **Inert Media Filtration**: A unit process in which suspended solids and associated particulate pollutants are removed by use of a media such as sand or perlite.
  - Source: Minton, Stormwater Treatment Second Edition

- **Sorptive Media Filtration**: A unit process in which dissolved constituents are removed by attachment to a filter media at the molecular level.
  - Source: Minton, Stormwater Treatment Second Edition

Common Filters

Factors Affecting Filter Performance

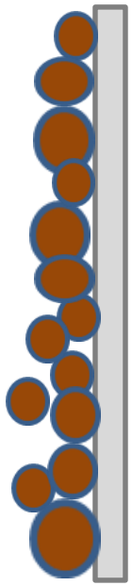
- Media Type
  - Active vs Inert
- Media Porosity/Gradation
  - Coarse vs Fine
- Media Shape
  - Irregular vs symmetrical
- Media Thickness
  - Depth vs Surface
- Hydraulic Loading Rate
  - Slow vs Fast

Filter Media Variables

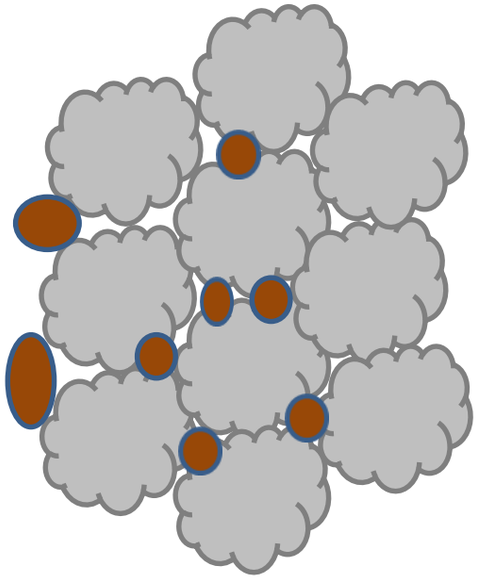
- Range of particle sizes better than uniform size
- Finer media more effective but limits flow
- Irregular shaped particles better than symmetrical
- High surface area improves reactive capacity
- All else equal deeper is better assuming bed filtration

Surface Filtration vs. Bed Filtration

Surface/Membrane Filtration



Bed Filtration



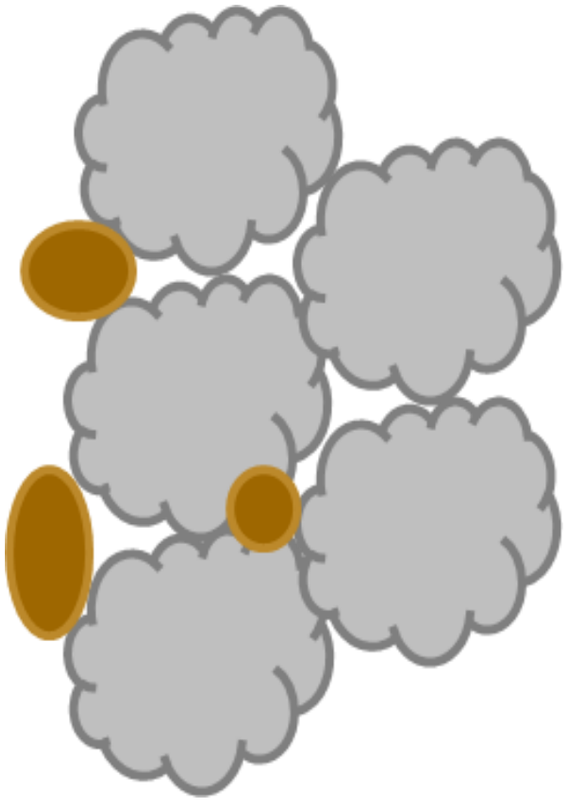
Critical Filter Design Considerations

- Pretreatment common to reduce load on media and extend maintenance cycle
  - Knock out the coarse stuff
- Media type and gradation
  - Often governed by pollutants of concern and performance goals
  - Leaching and toxicity can be media concerns
- Hydraulic Loading Rate (gpm/ft^2 of media surface area)
  - High loading rates result in smaller filters but all else equal need more maintenance
  - Loading rates in stormwater range from 0.05 - >10 gpm/ft^2
- Longevity
  - Filters must be designed with longevity in mind especially if frequent maintenance is not realistic

Physical/Inert Media Filtration

Examples: Screening, Media filters, Sand filters, Biofilters, Infiltration

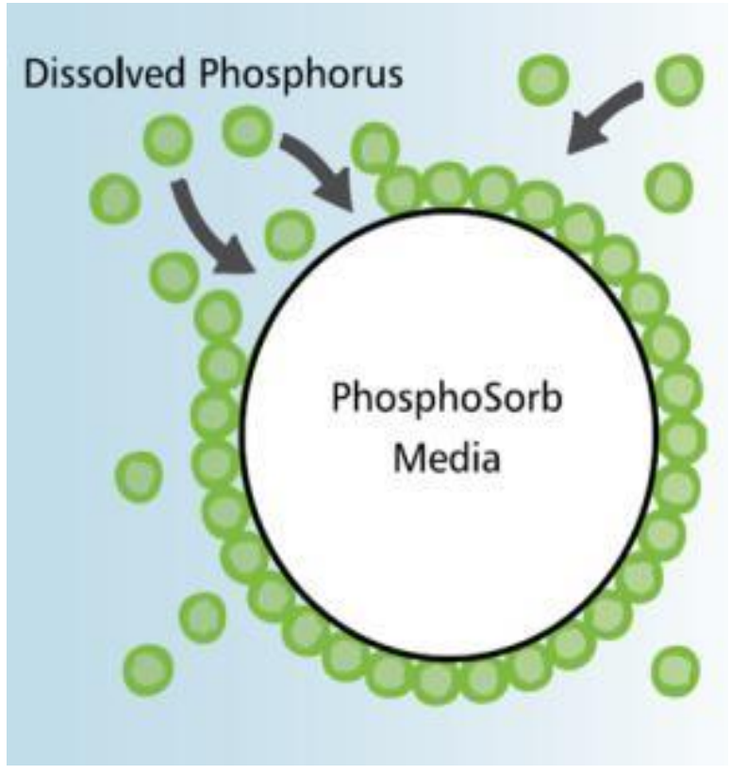
- Inert media is physical barrier to solid particles
- Sedimentation often plays major role in filter effectiveness
- Good control of solids and attached pollutants
- Removal of particulate bound pollutants (i.e. metals and phosphorus)
- No removal of dissolved/soluble pollutants
- Leaching possible
- Longevity must be considered



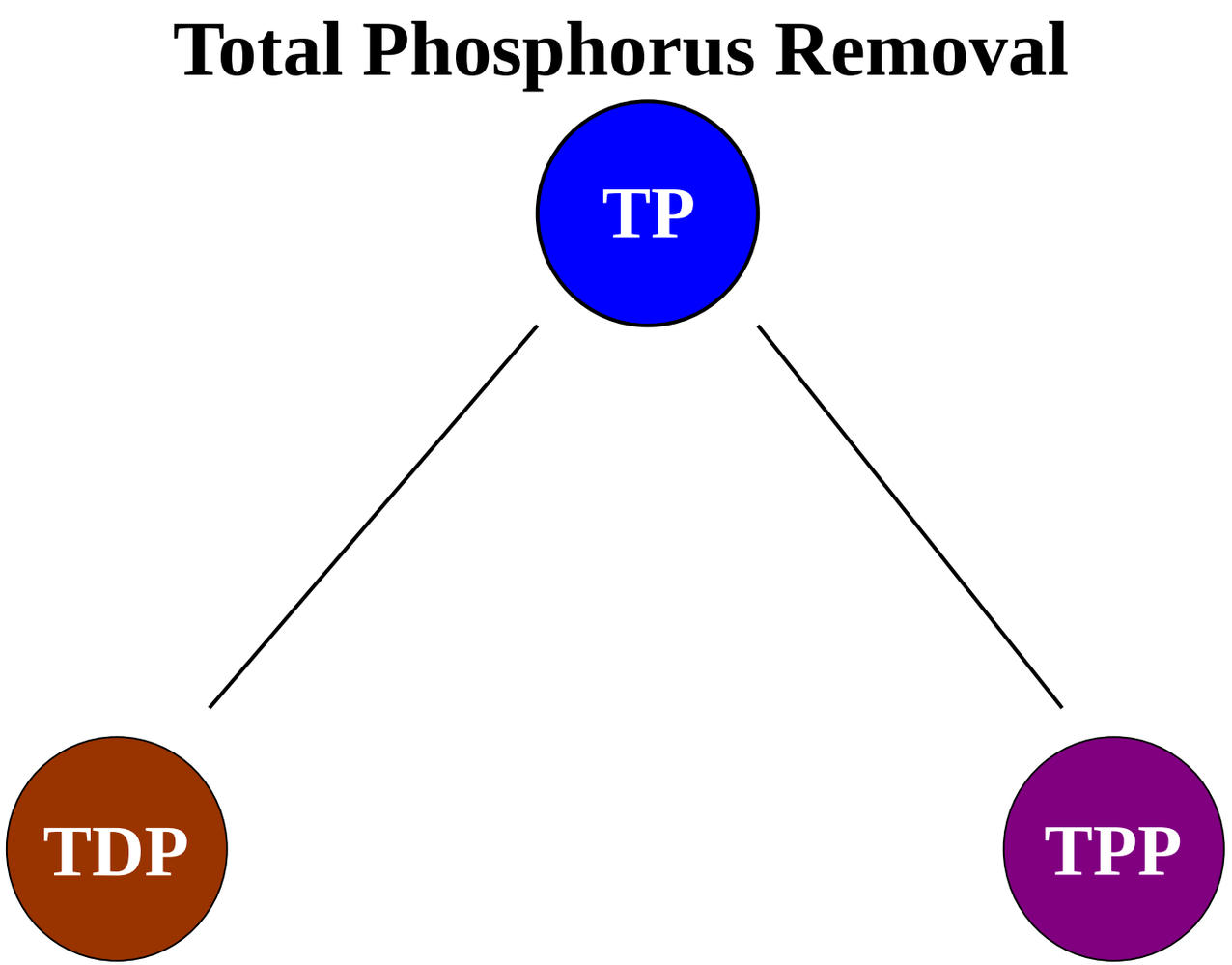
Reactive Filtration

Reactive filtration media with an affinity for target pollutants

- Works in parallel with physical filtration and/or sedimentation
- Target pollutant is bound to media via adsorption, ion exchange etc.
- Effective removal of soluble/dissolved pollutants
- Boosts overall pollutant load reduction
- Prevents leaching



Maximizing Load Reduction



Sand Filter (Sedimentation, Physical Filtration)

Sizing a Sand Filter

$$A_f = \frac{WQ_v d_f}{k(h_f + d_f)t_f}$$

Where:

Af	=	Surface area of filter bed (ft2)
WQv	=	Water Quality Volume(cf)
df	=	Filter bed depth (ft)
k	=	Coefficient of permeability of filter media (ft/day)
hf	=	Average height of water above filter bed (ft)
tf	=	Design filter bed drain time (days) (1.67 days or 40 hours is recommended maximum t_f for sand filters, two days for bioretention)

Sand: 3.5 ft/day (City of Austin 1988)
Peat: 2.0 ft/day (Galli 1990)
Leaf compost: 8.7 ft/day (Claytor and Schueler, 1996)
Bioretention Soil: 0.5 ft/day (Claytor and Schueler, 1996)

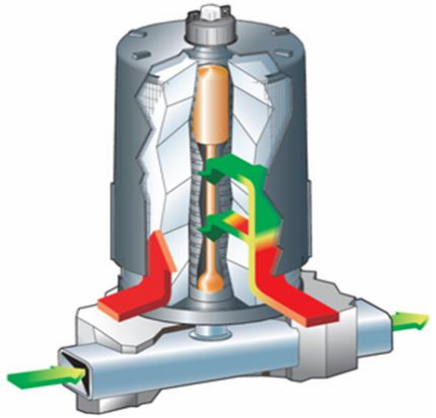
Source: NYSDEC Stormwater Manual 2015

Key Considerations

- New media typically has substantially more hydraulic capacity
- Sand filter design accounts for loss of hydraulic conductivity over time
- Surface area of a filter is determined based on the amount of runoff to be treated and hydraulic capacity of the media

Evolution of Filter Technology: Horizontal to Radial

- Increased longevity
- Smaller structures
- Easier maintenance
- Custom filter media options



Horizontal Bed Filter

Manhole StormFilter

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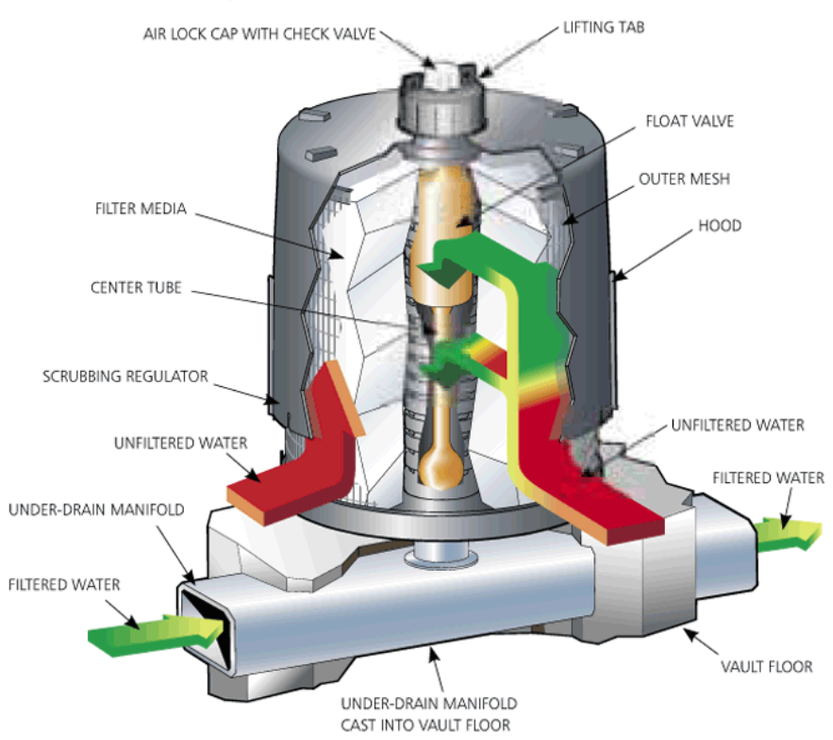
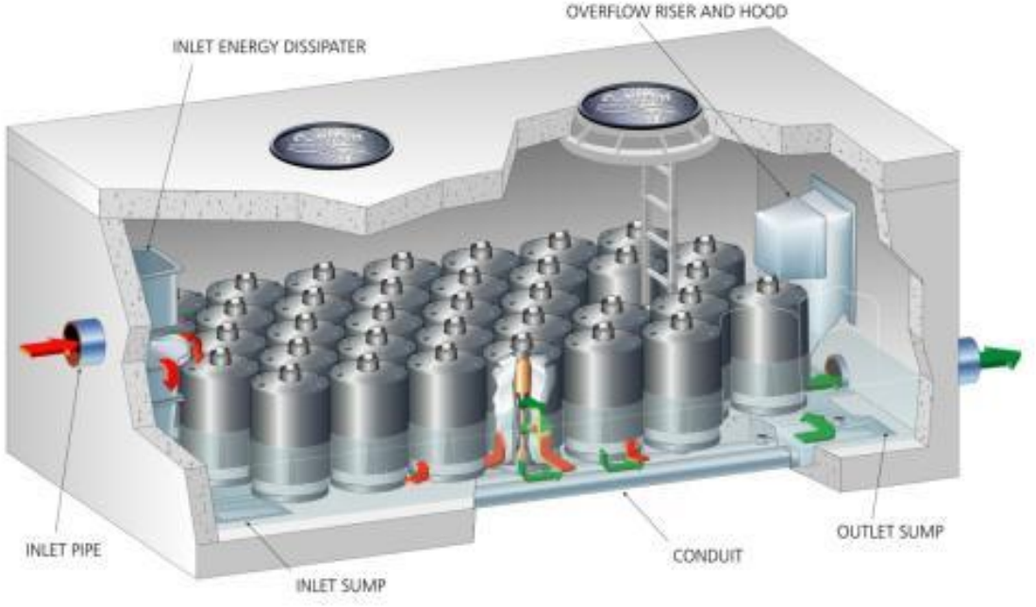
Innovative Media Filtration





Media Filtration




	PhosphoSorb™	Perlite	CSF® Leaf Media	ZPG
Sediments	■	■	■	■
Phosphorous	■			■
Oil and Grease	■	■	■	■
Soluble Metals	■		■	■
Organics			■	■
Nutrients	■	■	■	■

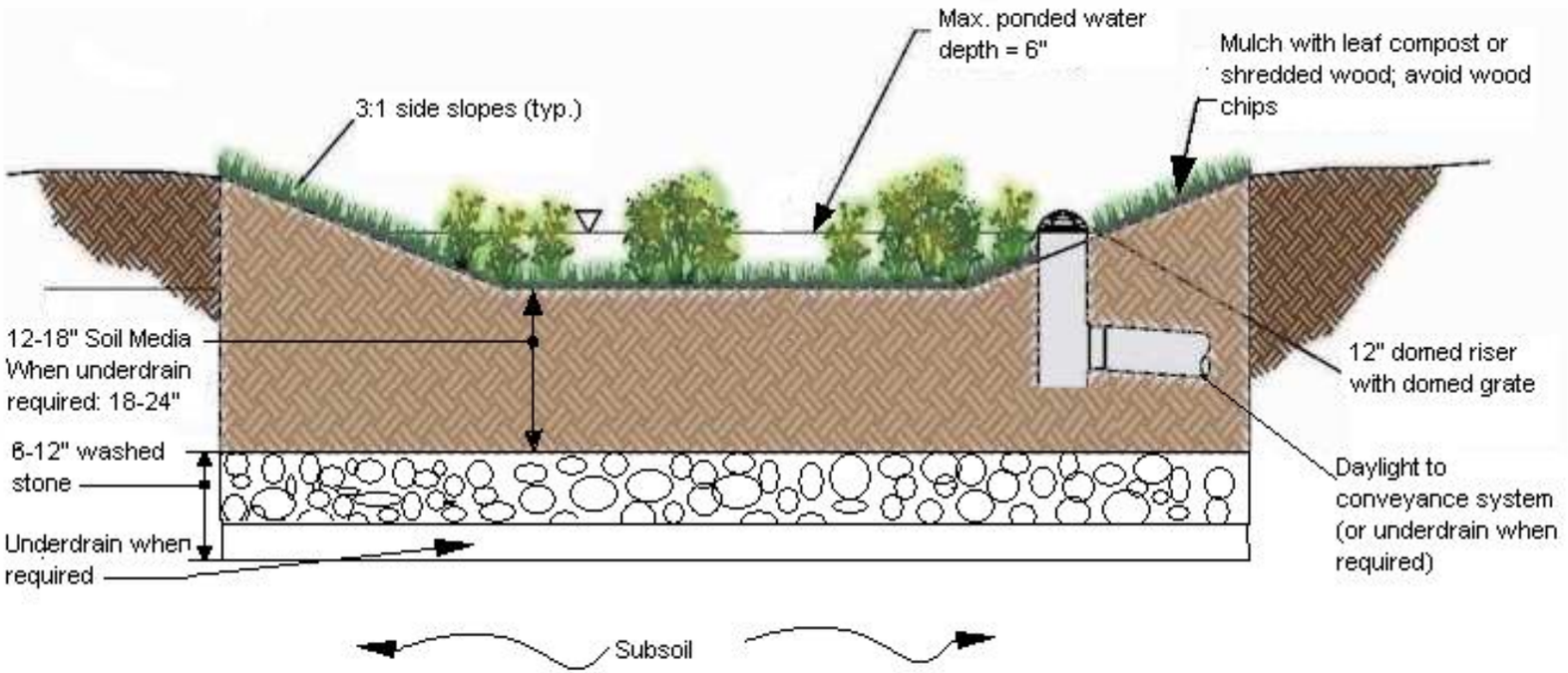
Innovative Membrane Filtration

Evolution of Filter Technology:
Maximum Surface Area in Compact System

Pleated Membrane Filter

Jellyfish Filter

Bioretention/Biofiltration



Source: NYSDEC Chap. 5 NYS Stormwater Management Design Manual

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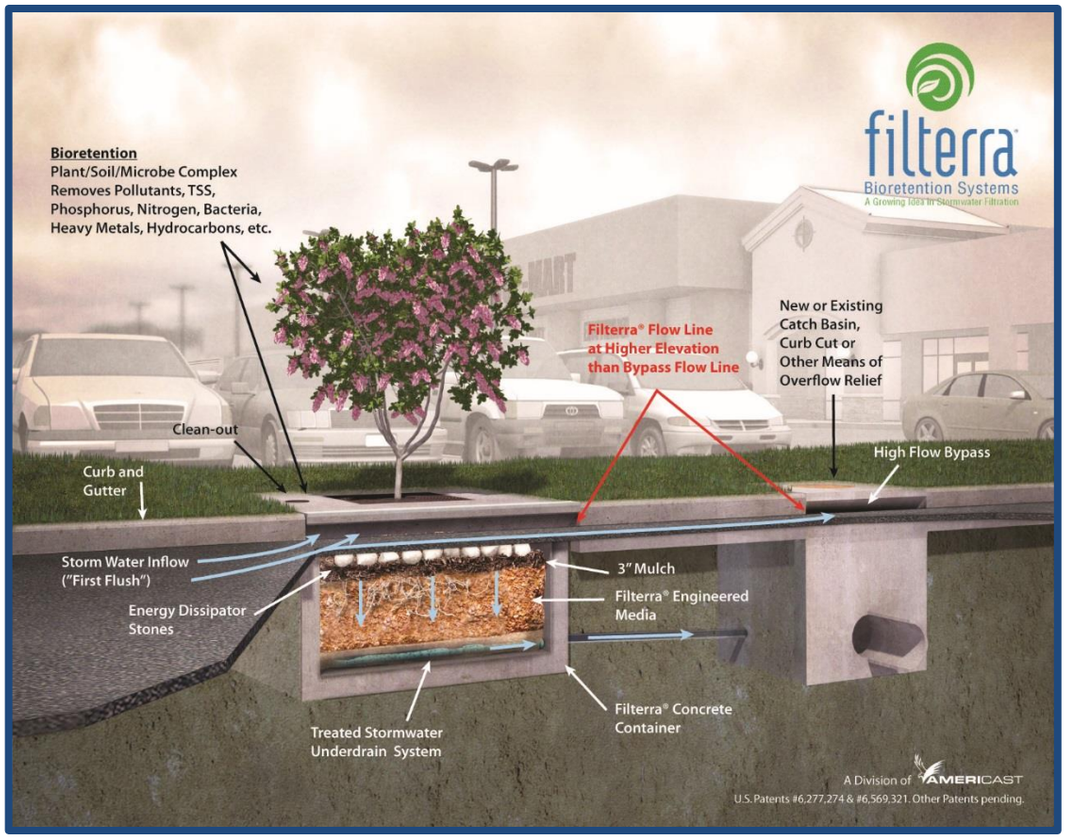
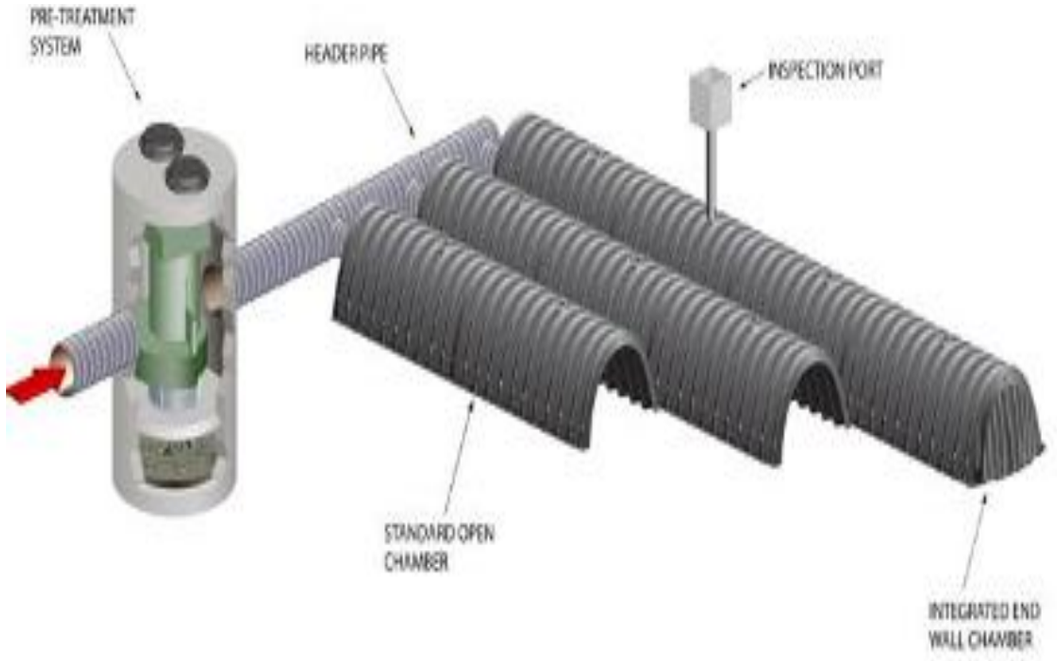
Engineered High Rate Biofiltration



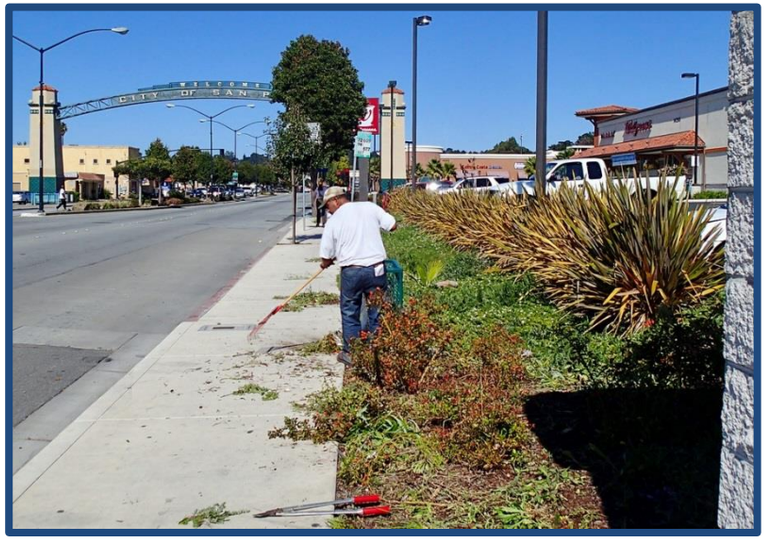
Underground Infiltration

Perforated CMP System

Open Bottom Chamber System



Maintenance



- **Longevity, Longevity, Longevity…..**
- All filters clog eventually
- Must strike balance between loading rate and longevity
- Ensure maintainability

Discussion

- We rely on many different filtration systems and fundamentals are key to success/functionality
  - Choose right tool for the job
  - What are targeted pollutants?
- Inspection & Maintenance
  - Consider pretreatment and treatment trains
- Innovative is essential but don’t overlook the fundamentals
  - Will it remove target pollutants
  - Is sizing realistic
  - Life cycle cost

Questions?

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