Infiltration Best Management Practices

For

Southeast Pennsylvania Association of Conservation Districts

Presented by

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STRIVING TO MAKE STORMWATER GREEN
Agenda

• Topics based on common questions received:
  – Loading Ratios
    • Pretreatment for Infiltration
  – Infiltration in Floodplains
  – Failures – what to do next?

1. Reference: White Paper
   – A Risk-Based Approach for Sizing Stormwater Infiltration BMPs
   – Slides: ftp.state.pa.us/pub/dep/SWM/infiltrationBMPs03262010.pptx
LOADING RATIOS
What is a “Loading Ratio”

– A rule-of-thumb approach for sizing infiltration BMPs with the intent of:
  • Preventing hydraulic and pollutant overloading.
  • Sustaining a reasonable design life.
– Based purely on drainage area and BMP area:
  • Total DA or Impervious DA*
– Not a site-specific approach

Append. C, Pgs. 15 & 16
**Total** Loading Ratio = Total DA: BMP Area

Total Drainage Area to BMP = \( A \) (sf)

Infiltration BMP Area = \( X \) (sf)

Loading Ratio: \( \frac{A+X}{X} \)

Loading Ratio: 8 : 1 (or 12.5%)
**Impervious** Loading Ratio = Imp. DA : BMP Area

\[
\text{Impervious DA to BMP} = A_i \text{ (sf)}
\]

\[
\text{Loading Ratio: } \frac{A_i + X}{X}
\]

- Loading Ratio:  5 : 1  (or 20%)
- In Karst:  3 : 1  (or 33%)
Land Use Adjustment for Total Loading Ratio

- Woods = $A_W$ (sf)
- Lawn (undisturbed) = $A_{LU}$ (sf)
- Meadow (undisturbed) = $A_{MU}$ (sf)
- Impervious Area = $A_I$ (sf)
- Total Drainage Area to BMP = $A$ (sf) = $A_W + A_{LU} + A_{MU} + A_{LD} + A_I$

Infiltration BMP Area = $X$ (sf)

Loading Ratio: $(A_{ADJ} + X)/X$

Refer to White Paper for more info on $A_{ADJ}$
Diverting DA to Adjust Total Loading Ratio

Diverted Drainage

Storm Drain

Discharge to Stream

BMP

Better to put another BMP Here

Curb & Gutter Flow along Road
What is the “BMP” Area?

• Depends on the type of Infiltration BMP:
  – **Underground facilities** are limited to the footprint of the **bed bottom**. Sides are usually neglected.
  – **Surface facilities** typically have a larger footprint (side slopes) and take better advantage of the surrounding soil.
Underground Infiltration

Inflow

Peak Control Storage

Volume Control Storage

Outflow

Bed Bottom

Infiltration
Surface Infiltration

- Wetted Surface
- 2-year WSEL
- Design Depth
- Bottom Area
- Contour Area at Design Depth
- Wetted Surface Area (approx.)

Design
Depth

Wetted Surface Area (approx.)
Site Specific Approach

More than just DA and BMP Area:

- Soils
- Geology
- Vegetation/Surface Cover
- Topography
- BMP Strategy
  - Pretreatment
- Discharge Point/ Receiving Stream
SWM → Multi-Disciplinary

- Site-Specific Approach often needs to include other experts besides the PE.
  - Soil Scientist
  - Geologist
  - Ecologist
  - Others?
Pretreatment for Infiltration

- BMP manual doesn’t mandate pretreatment,
- However, SWM has evolved to a point where it is imperative for sustainability.
- Pretreatment is most critical for subsurface infiltration systems*.
- Target parameters:
  - Oil/Grease; trash; TSS; Phos; Nitrates

YOU WILL PRETREAT!!!
Subsurface Infiltration

- Roof Runoff is ideal
- Careful w/ leaf litter

There are no natural processes to aid in rejuvenating the soils permeability.
Surface Infiltration

- For low pollutant load areas, accomplishes pretreatment objectives.
- Additional Pretreatment may be needed depending on source.
Infiltration Best Management Practices

**Water Quality Adjustment for Total Loading Ratio**

- **Total Drainage Area to BMP =** \( A \) (sf)
- **WQ BMP Drainage Area =** \( Y \) (sf)
- **Infiltration BMP Area =** \( X \) (sf)

**Loading Ratio**

\[
\text{Loading Ratio} = \frac{(A-YR)+X}{X}
\]

or,

\[
\text{Loading Ratio} = \frac{0.5 \times (A+X)}{X}
\]

Whichever is greater.

Where,

- \( X \) = Infiltration BMP Area
- \( Y \) = WQ BMP Drainage Area
- \( R \) = WQ BMP Removal Efficiency
- \( A \) = Total DA to Infiltration BMP
INfiltration BMPs

BioInfiltration Traffic Island (BTI) at Villanova Univ.

- Total DA = 1.3 Ac
- 46% Impervious
- 10:1 IDA:IA

For more info go to: www.villanova.edu/VUSP
Porous Pavement

This set-up allows for some pretreatment

Inlet Box
Perforated Pipe

STANDARD

Design Guidelines for Subsurface Infiltration
Even better……

Promote longevity of recharge bed by managing first inch of runoff in bioretention areas.
Other Benefits to Surface Infiltration

• Quick Look at natural water balance.

\[ P = \text{Rainfall} \]
\[ R = \text{Runoff} \]
\[ F = \text{Infiltration} \]
\[ ET = \text{Evapo-Transpiration} \]

Infiltration Best Management Practices

- Rain Garden
- Infiltration Trench
- Vegetated Swale
- Porous Pavement

RAINFALL

Surface

Subsurface
Infiltration Best Management Practices

- Rain Garden
- Infiltration Trench
- Vegetated Swale
- Porous Pavement
Evapotranspiration:
• The “missing link”
• Dual processes at work.
• Occurs between storms – making storage essential.
  – Not event-based
  – Water Balance Model
Size does matter!!!

• BMP Size → Drainage Area
• For sustainability of Infiltration BMP:
  – Keep DA per BMP relatively low.
    • Keep below 5 acres.
      – Below 1 acre is preferable.
    • DA>5 acres may not be able to seek loading ratio adjustments.
    • In some cases, BMPs with large DA’s may need more conservative loading ratios.
Infiltration Goals

• Utilize several smaller BMPs, dispersed through entire site – close to the source.

• Incorporate vegetative component, where feasible.

• On-lot BMPs are ideal for individual roof and driveway runoff in LID,

• Keep BMPs for common drainage off of private lots.
Recommendations

- Soil Infiltration Testing:
  - Avoid using the “perc” test
  - Use acceptable infiltration test.
  - Use a minimum Factor of Safety of 2
- Avoid hydraulic head > 2’.
- Dewater in less than 72 hours.
- Follow Loading Ratio or other acceptable sizing criteria.
Examples of Improving Infiltration
IMPORTANT POINTS:

- BMPs spread across the site. (each lot)
- Separate BMPs for the road.
- No Detention Basin.

Source: RGS Associates
Single Lot

- Drainage area is basically the property line.
- Long lot w/ house relatively close to frontage.
- Surface drainage around house and septic field.
- Infiltration BMP w/ emergency spillway.
- Designed to 100 year storm to comply w/ local rate control requirements.
= storm drains that directly discharge to underground infiltration beds without any pretreatment.

Source: Stantec
INFILTRATION IN FLOODPLAINS
Since floodplain development is allowed, infiltration BMPs are also allowable.

- Discourage “floodway” areas for BMPs
- Seek “floodway fringe” areas for BMPs.

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**Floodplain vs. Floodway**

Discouraged

OK – w/ precautions
Surface BMP in Floodplain

Floodplain

Floodway

BMP

2-yr. WSEL

Normal Flow
O&M Plan will need to include steps to take after significant floods that inundate the BMP.
For Subsurface BMPs - If Backflow Prevention not possible, then the bed bottom will need to be kept at a higher level such as the 10-year storm.
Infiltration Berms /Bio-Detention

ROCK BERM
- Screens coarse sediment and trash
- Dispenses concentrated flow to sheet flow

STORMSEWER OUTFALL
- Concentrated flow

EVAPOTRANSPIRATION

RECEIVING WATER

VEGETATED FILTER - NATIVE GRASSES
- Slows flow
- Vegetative filtering
- Nutrient uptake
- Evapotranspiration
- Infiltration

VEGETATIVE BARRIER - GRASS
- Traps sediment
- Maintains sheet flow
- Nutrient uptake
- Evapotranspiration
- Increases infiltration

INfiltration
- Soil filtering
- Increased soil water
- Pollutants available for biological activity
- Groundwater recharge
- Reduces runoff and associated pollutants
- Helps maintain base flow

undesirable shape for a berm

desirable shape for a berm

runoff
Summary for Floodplain Infiltration

• It can be done.
  – Need to follow certain precautions.

• Higher likelihood of shallow water table.

• Higher risk* category

• May be better to look at infiltration berms rather than any excavation.

• DEP is not condoning Floodplain Dev.
  – Floodplain Dev. is controlled at local level
FAILURES – WHAT TO DO NEXT?
Infiltration - Risk Based Approach

- Infiltration should be undertaken more responsibly.
- Elements of risk should be assessed:

**High Risk**
- No pretreatment
- Large Subsurface Seepage Beds
- High Pollutant Areas (Hot Spots)
- Utilized for E&S during Construction
- Low Permeability (< 0.25 in/hr)

**Moderate Risk**
- Pretreatment Provided
- Medium Subsurface Seepage Beds
- Moderate Pollutant Areas
- Moderate Permeability (0.25-0.75 in/hr)

**Low Risk**
- Small Subsurface Seepage Beds
- Surface (Vegetated) BMPs
- Low Pollutant Areas
- High Permeability (> 0.75 in/hr)
Proactive vs. Reactive

- Better Design
  - Analyze Risk
  - Loading Ratios
- Better Construction Techniques
- Construction Oversight
- Post construction Monitoring

- Retrofit
- Complete Replacement
- Abandon and build another BMP
Infiltration Basin - Subsurface

Native grasses, meadow, or other low-growing, dense vegetation

12 - 18” (Minimum) permeable soil cover

Uncompacted Subgrade

Wrapped non-woven geotextile

Level bed bottom

Infiltration Basin - Subsurface
Vegetated Systems
Permit Compliance

• Projects will be expected to comply with the terms of the permit that was issued.
• If unable to meet the permit terms, then it is the permittee’s responsibility to find other suitable alternatives.
• Permit non-compliance leads to stream degradation and pollution.
• Can face enforcement action & penalties.
Checklist for Success

• Fully analyze risk with design.
  – Higher risk situations will need to be designed more conservatively.

• Select reputable contractor
  – Ideal to coordinate design with contractor upfront.

• Provide Construction Oversight of BMPs

• Develop a hearty O&M Plan.
Groundwater Mounding

- GW Mounding can become an issue when:
  - Shallow bedrock
  - Shallow water table
  - Perched aquifer
  - Infiltration BMPs with large footprint
Transmissivity

The larger dimension between L & W of Basin Bottom
For Large DA’s, keep infiltration BMPs off-line