INFILTRATION TRENCH

PLANNING, DESIGN, AND INSTALLATION

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Wisconsin Department of Natural Resources

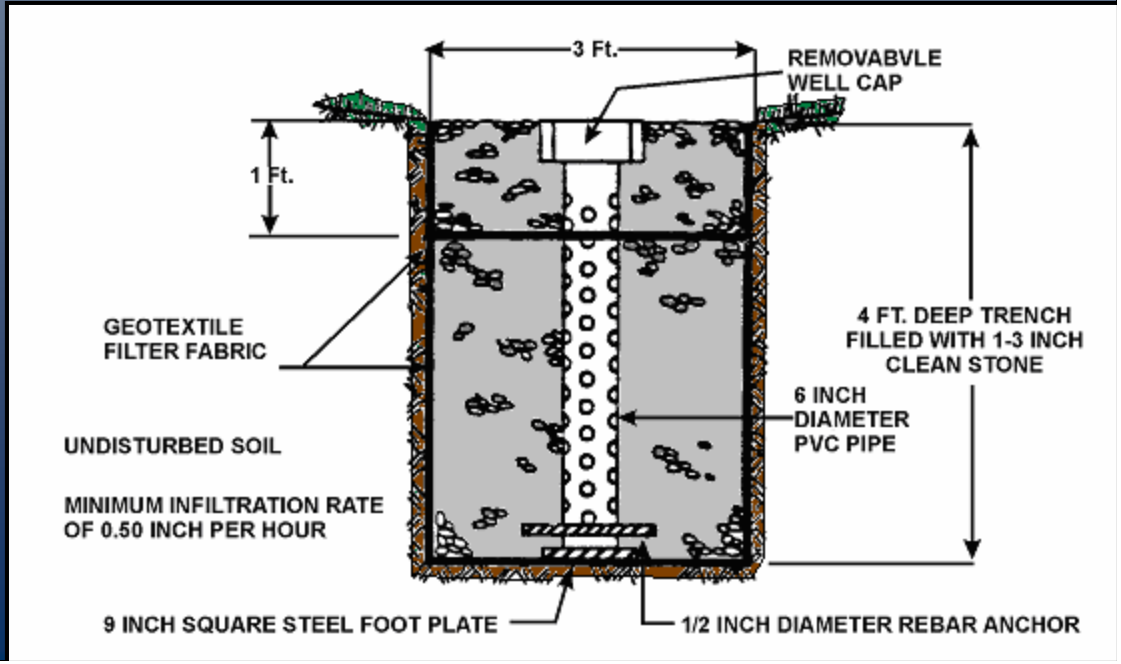
OVERVIEW

- Definition, Purpose, and Applicability
- Advantages and Disadvantages
- Design Standards
- Performance
- Planning and Site Design
- Installation
- Maintenance
- Problems and Solutions

DEFINITION

- Post-construction storm water BMP for the purposes of providing temporary storage and infiltration of storm water runoff into the subsurface soils
- An excavation 2 – 10 feet deep typically longer than it is wide, lined with geotextile fabric, and backfilled with stone aggregate
- Can be exposed or located beneath grass swales
- Primary outlet provided by exfiltration through native soils

- Other components include:
  - Observation well
  - Sand layers
  - Overflow



DEFINITION

Question:

Could a storm water infiltration trench also be considered an "injection well?"

Answer:

Yes.

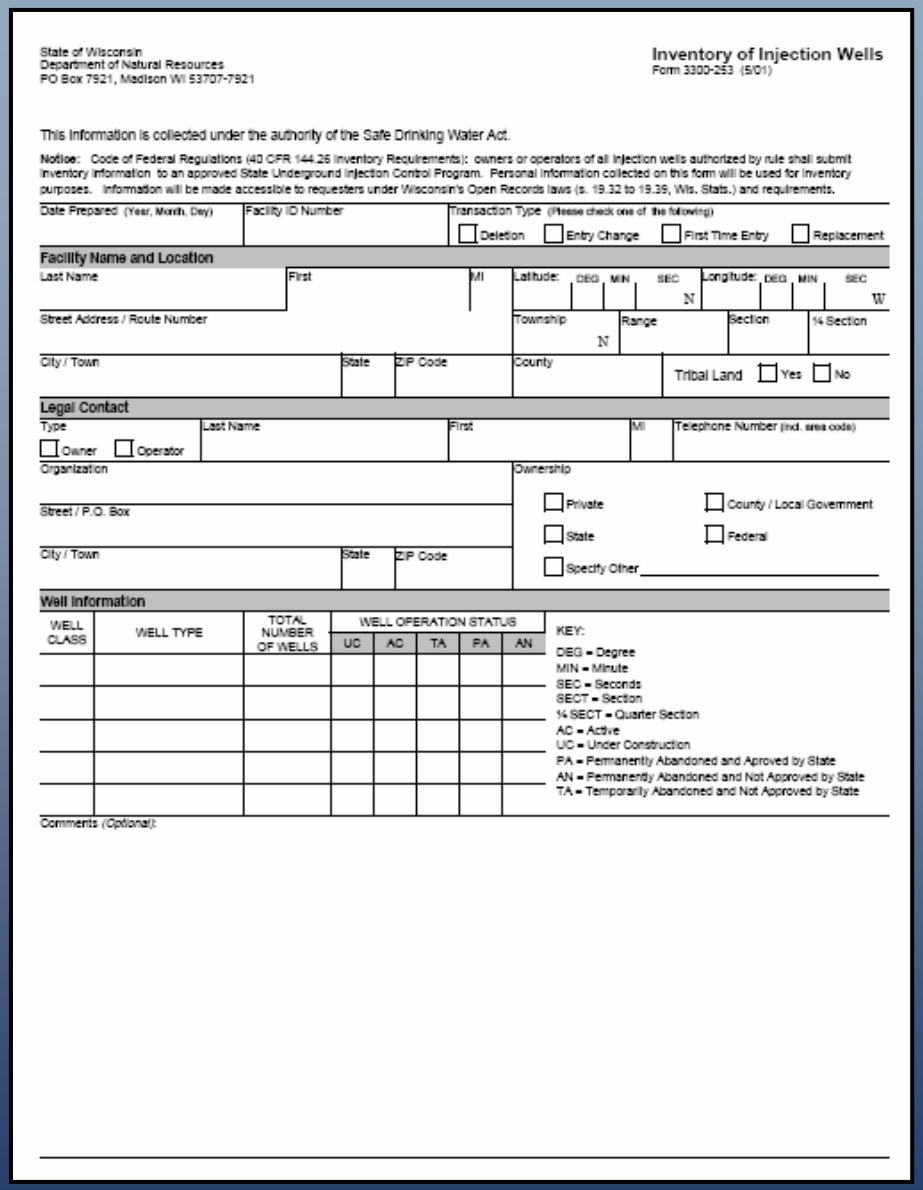
Class V Injection Well:

A well is defined by USEPA in 40 CFR §144.3 as a bored, drilled or driven shaft, or a dug hole, **whose depth is greater than the largest surface dimension.** The federal UIC regulations also specifically define Class V injection wells to include "drainage wells used to drain surface fluid, primarily storm runoff, into a subsurface formation" (40 CFR 146.5(e)(4)).

DEFINTIION

- Owner or operator must notify the State of Wisconsin by completing the Injection Well Inventory Form
- Submit to DNR's Bureau of Drinking Water and Groundwater
- Form must be completed prior to construction
- Operate well in a manner that does not endanger the quality of the groundwater system

KEEP HAZARDOUS SUBSTANCES AWAY



State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921

Inventory of Injection Wells
Form 3300-253 (5/01)

This information is collected under the authority of the Safe Drinking Water Act.

Notice: Code of Federal Regulations (40 CFR 144.26 Inventory Requirements): owners or operators of all injection wells authorized by rule shall submit inventory information to an approved State Underground Injection Control Program. Personal information collected on this form will be used for inventory purposes. Information will be made accessible to requesters under Wisconsin's Open Records laws (s. 19.32 to 19.39, Wis. Stats.) and requirements.

Date Prepared (Year, Month, Day) | Facility ID Number | Transaction Type (Please check one of the following) ☐ Deletion ☐ Entry Change ☐ First Time Entry ☐ Replacement

Facility Name and Location

Last Name | First | MI | Latitude: DEG MIN SEC N | Longitude: DEG MIN SEC W

Street Address / Route Number | Township N | Range | Section | ¼ Section

City / Town | State | ZIP Code | County | Tribal Land ☐ Yes ☐ No

Legal Contact

Type ☐ Owner ☐ Operator | Last Name | First | MI | Telephone Number (incl. area code)

Organization | Ownership ☐ Private ☐ County / Local Government ☐ State ☐ Federal ☐ Specify Other _____

Street / P.O. Box

City / Town | State | ZIP Code

Well Information

WELL CLASS	WELL TYPE	TOTAL NUMBER OF WELLS	WELL OPERATION STATUS				
			UC	AC	TA	PA	AN

KEY:
DEG = Degree
MIN = Minute
SEC = Seconds
SECT = Section
¼ SECT = Quarter Section
AC = Active
UC = Under Construction
PA = Permanently Abandoned and Aproved by State
AN = Permanently Abandoned and Not Approved by State
TA = Temporarily Abandoned and Not Approved by State

Comments *(Optional)*:

More Information:

http://dnr.wi.gov/org/water/dwg/UIW/classification.htm

http://www.epa.gov/safewater/uic/class5/index.html

PURPOSE

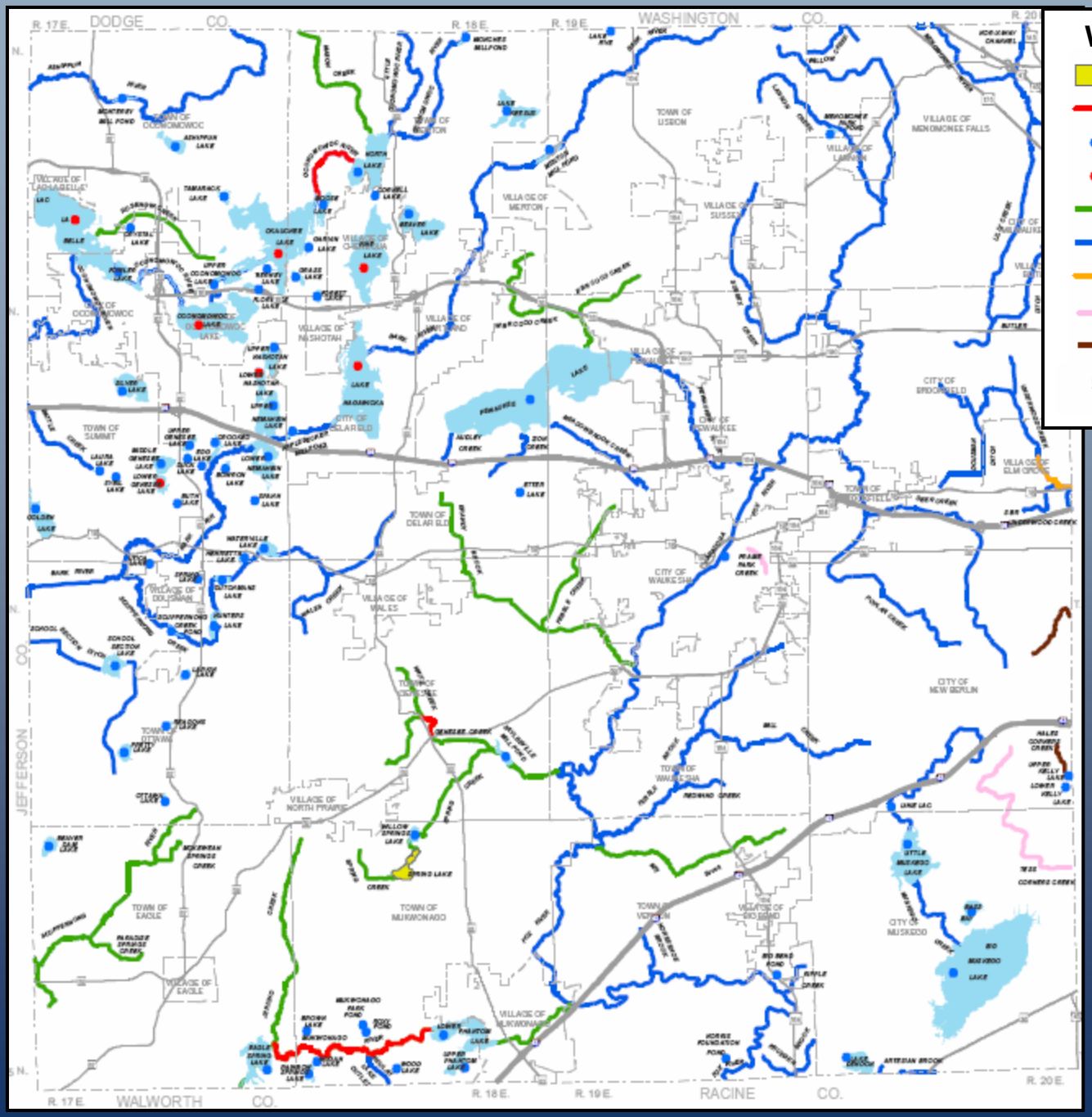
- Enhance stormwater infiltration to recharge groundwater
- Reduce discharge of stormwater pollutants to surface and ground waters
- Decrease runoff peak flow rates and volumes
- Preserve stream base flow
- Reduce runoff temperature

3 NR 151 Birds with 1 Stone:

1. TSS Removal
2. Runoff rate and volume reduction
3. Infiltration

APPLICABILITY

- Smaller drainage areas where space is limited
- Reach underlying permeable soils
- Projects located in close proximity to cold water habitat where thermal mitigation is a primary concern
- More suitable for runoff from cleaner source areas (rootops and small landscaped areas)
- Sized for small to moderate storms
- Urban retrofitting projects



Water Classification Codes

- Outstanding Resource Water (ORW)
- Exceptional Resource Water (ERW)
- Lake Supports Fish and Aquatic Life (FAL)
- Lake Supports Cold Water Species (Cold)
- Cold Water Streams (Cold)
- Fish and Aquatic Life (FAL)
- Special Variance Waters
- Limited Forage Fish (LFF)
- Limited Aquatic Life (LAL)

Source: WDNR, SEWRPC & Waukesha County

FACT:

Waukesha County contains **over 72 stream miles** that are capable of supporting a cold water community!

More Information: http://www.waukeshacounty.gov/page.aspx?SetupMetaId=7928&id=9488

ADVANTAGES

- Very effective for sediment and other particulate pollutant removal from small drainage areas (less than 2 acres)
- Decreases peak runoff rates and volumes
- Reduce the size and cost of downstream detention facilities
- Provides excellent thermal mitigation
- Provides groundwater recharge and maintains baseflow in streams
- Can be installed in limited space
- Can be easily incorporated into the existing landscape
- Can be constructed deep enough to tap into more permeable soil layers

DISADVANTAGES

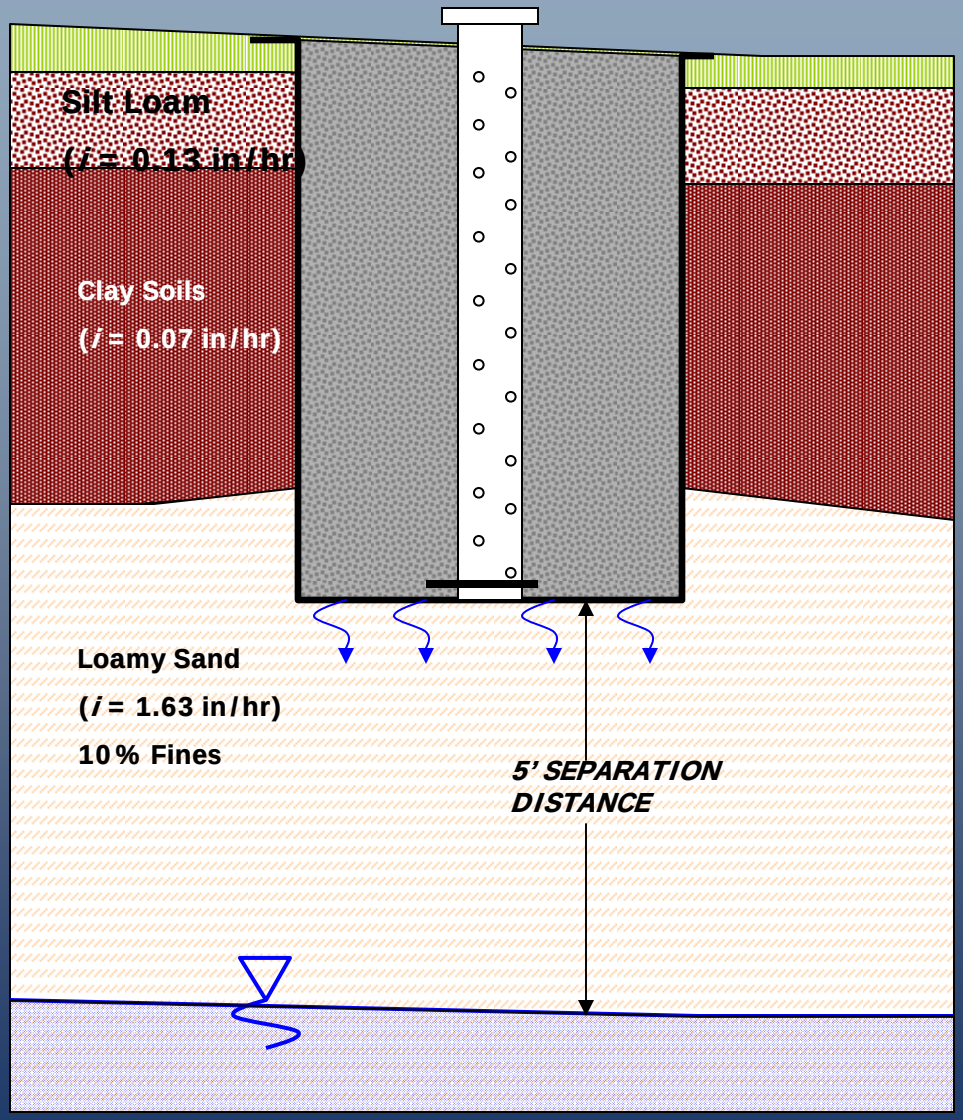
- Potential for groundwater contamination
- Not directly suitable for industrial and commercial sites
- High likelihood of failure if not constructed and maintained properly
- High maintenance, frequent inspections
- Design can be limited by restricting factors: subsoil type, drainage area characteristics, and separation distances
- Pretreatment must be provided for drainage areas with high influent levels of sediments or hydrocarbons
- Runoff water quality must meet NR 151 TSS removal requirements prior to discharge to trench for industrial or commercial sites

DESIGN STANDARDS – Site Criteria

- Drainage area slopes must not exceed 20%
- Drainage area less than 5 acres
- Best suited for runoff from “cleaner” sources (no industrial or commercial runoff without careful consideration and pretreatment)
- Runoff from rooftops and small landscaped areas can be routed directly to trench, other areas require pretreatment
- Follow guidelines for “disconnecting impervious areas” to ensure sheet flow drainage:
    - Source area flow length < 75’
    - Graded for positive drainage and sheet flow
    - Upland area slope should not exceed 8%

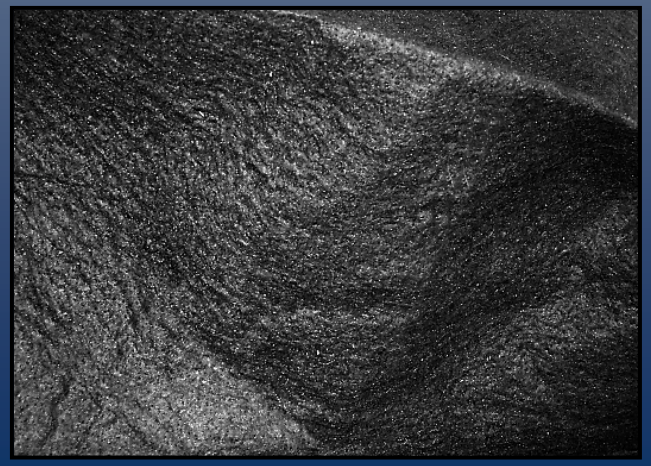
DESIGN STANDARDS – Site Criteria

- Measured infiltration rate must be at least 0.6 in/hr at bottom of trench
- Refer to Table 2 of WDNR Technical Standard 1002 for design static infiltration rates of different soil textures
- Suggested maximum infiltration rate of 5.0 in/hr (must meet percent fines requirements)
- Bottom of trench should be below the frost line to ensure operation during winter conditions



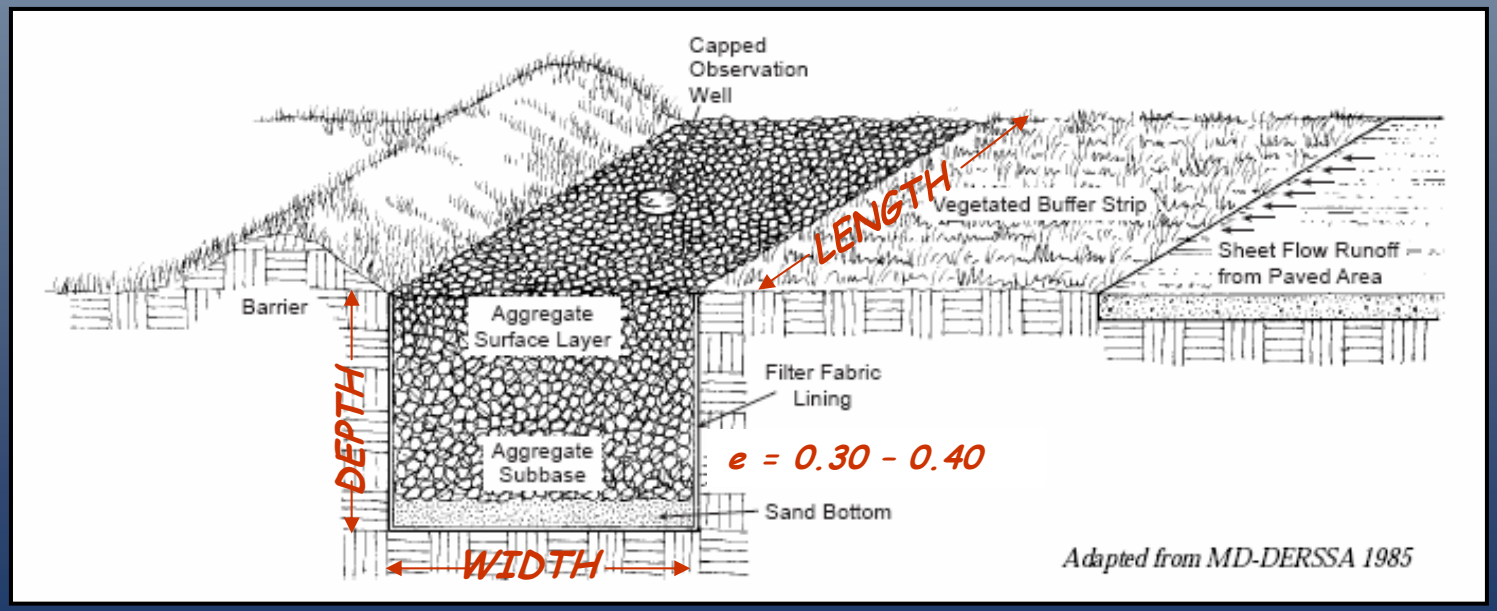
DESIGN STANDARDS - Materials

- Storage Medium - must be a uniform clean washed stone aggregate
- Observation Well – Must be included for every trench. One per every 200 linear feet of trench. Pipes must be anchored and terminated with a removable watertight cap.
- Fabric Lining – must line the entire trench with Type DF fabric to retain soils at trench walls while allowing water flow without clogging
- An overflow spillway must be provided to bypass the 100 year event



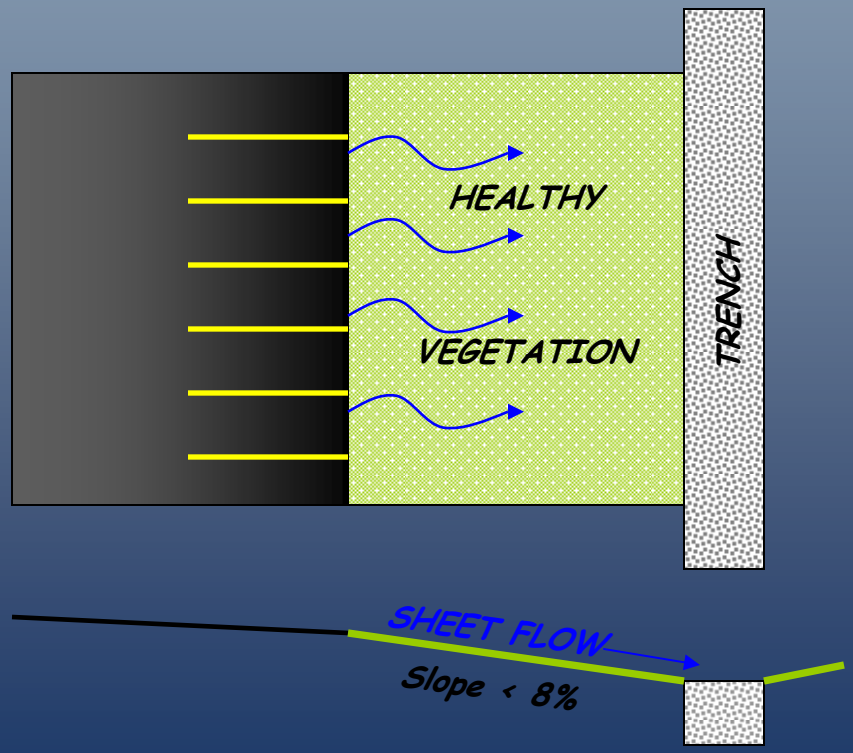
DESIGN STANDARDS – Dimensions

- Storage volume = Depth x Width x Length x Void Ratio of Storage Medium
- Bottom area of the trench is the effective infiltration area
- Size to meet NR 151 requirements for maximum drawdown time of 72 hours



DESIGN STANDARDS - Pretreatment

- Must remove total suspended solids at rates required by NR 151 prior to infiltration for applications on industrial and commercial sites
- Catch Basins, wet detention basins, grass swales, plunge pool to swale
- Pretreatment can be provided by establishing and maintaining a vegetative filter strip
- Filter strip must be at least 20' wide, but may need to be greater depending on sheet flow length from source area



PERFORMANCE

EPA Estimated Infiltration Trench Pollutant Removals

Pollutant	**Typical Percent Removal Rates**
Sediment	90%
Total Phosphorous	60%
Total Nitrogen	60%
Metals	90%
Bacteria	90%
Organics	90%
Biochemical Oxygen Demand	70-80%

Source: Schuler, 1992

- Increased removals can be achieved by adding a sand layer to the storage medium or by overlying trench with engineered soil mix

PERFORMANCE

Biofiltration Control Device

Land Use: Outfall

Biofilter Number 1

Device Properties

Top Area (sf)	100
Bottom Area (sf)	100
Total Depth (ft)	6.00
Typical Width (ft) (Cost est. only)	10.00
Native Soil Infiltration Rate (in/hr)	1.630
Native Soil Infiltration Rate COV	N/A
Infil. Rate Fraction-Bottom (0-1)	1.00
Infil. Rate Fraction-Sides (0-1)	0.00
Rock Filled Depth (ft)	5.00
Rock Fill Void Ratio (0-1)	0.33
Engineered Soil Type	
Engineered Soil Infiltration Rate (in/hr)	0.00
Engineered Soil Depth (ft)	0.00
Engineered Soil Void Ratio (0-1)	0.00
Percent solids reduction due to Engineered Soil (0 -100)	0.00
Inflow Hydrograph Peak to Average Flow Ratio	3.80
Number of Devices in Source Area or Land Use	1

Add Outlet/ Discharge

Outlet/Discharge Options

- 1. Sharp Crested Weir
- 2. Broad Crested Weir
- 3. Vertical Stand Pipe
- 4. Evaporation
- 5. Rain Barrel/Cistern
- 6. Underdrain Outlet

Edit Existing Outlet

Selected Outlets

1 - Broad Crested Weir

Change Geometry

Copy Biofilter Data | Paste Biofilter Data

Select Native Soil Infiltration Rate

- Sand - 8 in/hr
- Loamy sand - 2.5 in/hr
- Sandy loam - 1.0 in/hr
- Loam - 0.5 in/hr
- Silt loam - 0.3 in/hr
- Sandy silt loam - 0.2 in/hr
- Clay loam - 0.1 in/hr
- Silty clay loam - 0.05 in/hr
- Sandy clay - 0.05 in/hr
- Silty clay - 0.04 in/hr
- Clay - 0.02 in/hr
- Rain Barrel/Cistern - 0.00 in/hr

Use Random Number Generation to Account for Infiltration Rate Uncertainty

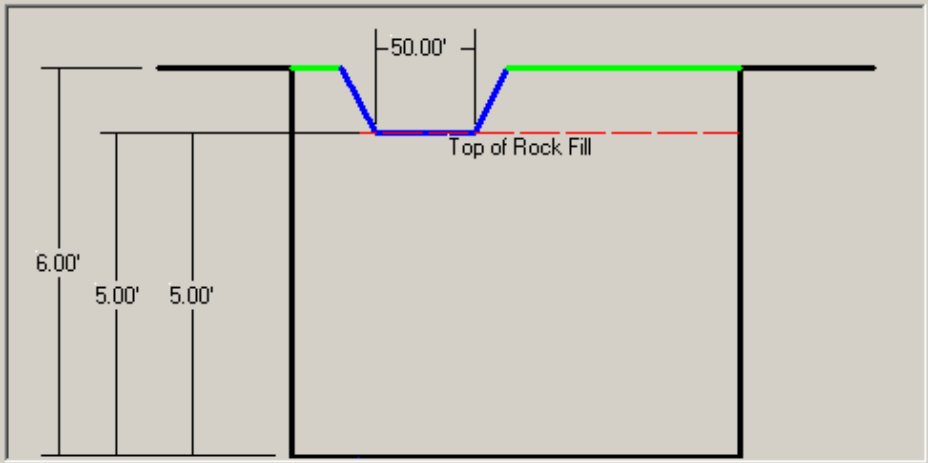
Select Particle Size File

Source Areas from Land Use that Contribute Runoff to Biofiltration Control Device(s)

- Rooftop 1
- Rooftop 2
- Rooftop 3
- Rooftop 4
- Rooftop 5
- Paved Parking/Storage 1
- Paved Parking/Storage 2
- Paved Parking/Storage 3
- Unpaved Prkng/Storage 1
- Unpaved Prkng/Storage 2
- Playground 1
- Playground 2
- Driveways 1
- Driveways 2
- Driveways 3
- Sidewalks/Walks 1
- Sidewalks/Walks 2
- Street Area 1
- Street Area 2
- Street Area 3
- Large Landscaped Area 1
- Undeveloped Area
- Small Landscaped Area 1
- Small Landscaped Area 2
- Small Landscaped Area 3
- Other Pervious Area
- Other Dir Cnctd Imp Area
- Other Part Cnctd Imp Area
- Paved Land and Shoulder 1
- Paved Land and Shoulder 2
- Paved Land and Shoulder 3
- Paved Land and Shoulder 4
- Paved Land and Shoulder 5
- Large Turf Areas
- Undeveloped Areas
- Other Pervious Areas
- Other Directly Conctd Imp
- Other Partially Conctd Imp

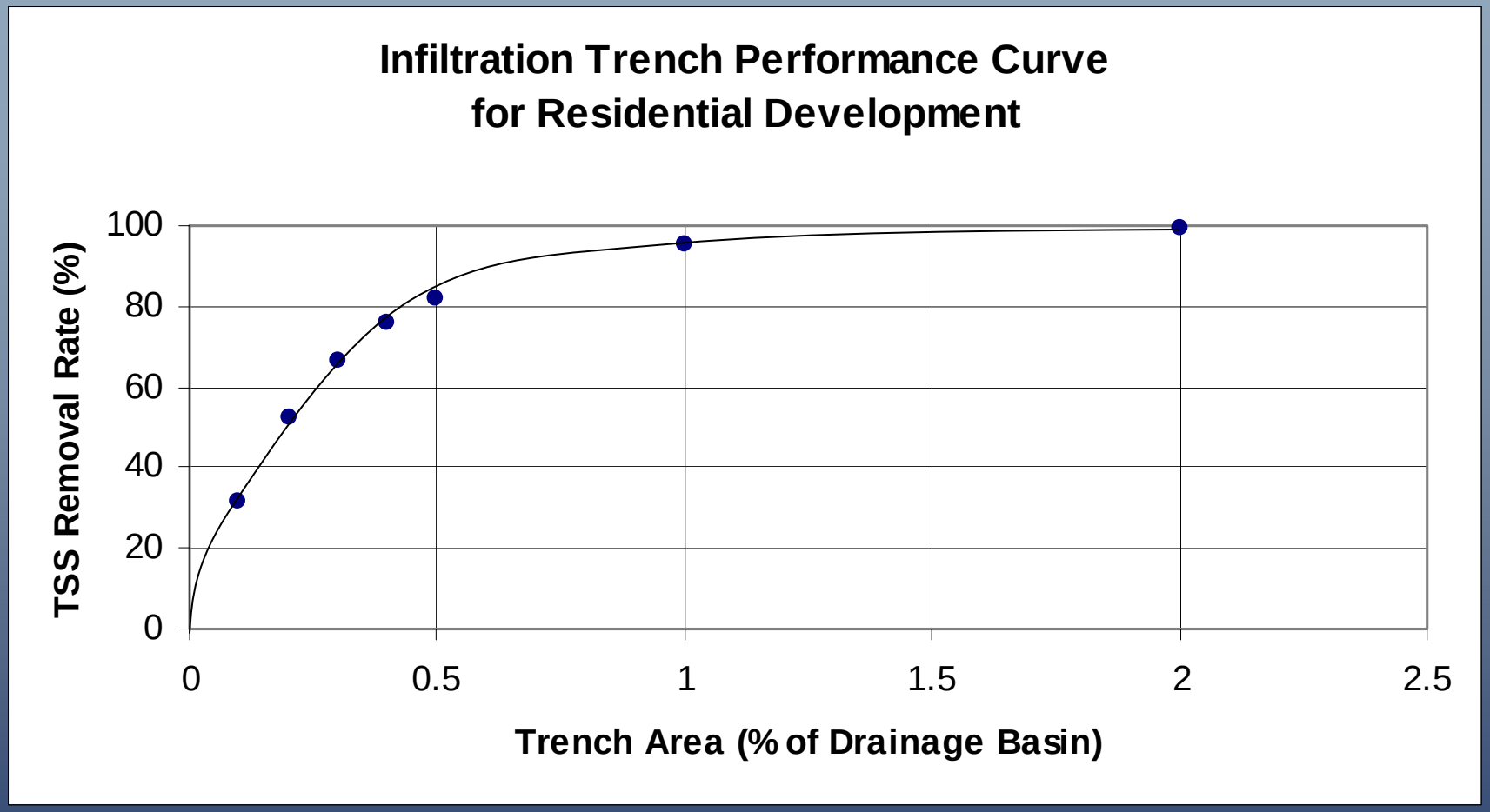
1 Fraction of Runoff from Outfall Routed to Outfall Biofilters (0 - 1)

Biofilter Geometry Schematic



Refresh Schematic | **Delete** | **Cancel** | **Continue**

PERFORMANCE



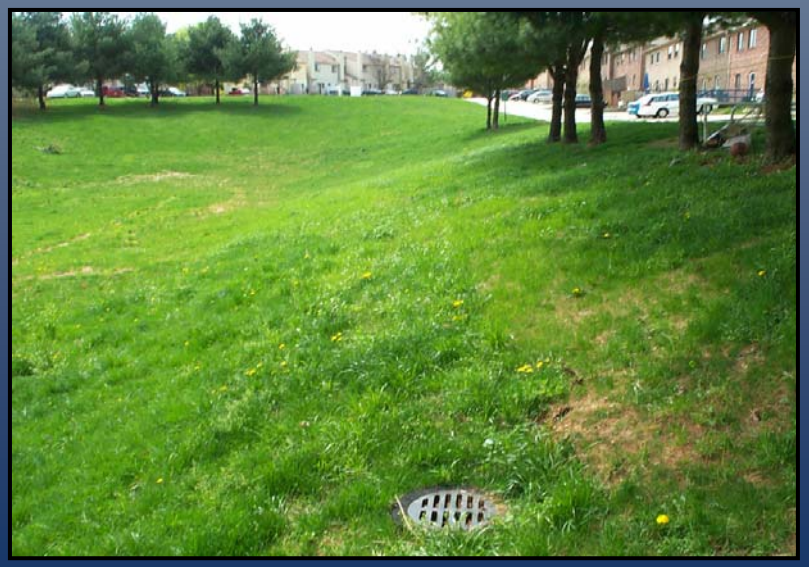
- Based on a 5 acre – Medium Density Development with Silty Soils
- For 80% TSS removal:

Effective Infiltration Area of Trench = 1,020 sf

PLANNING AND SITE DESIGN

Determine suitability by considering:

- Separation distances
- Drainage area size
- Source areas and pretreatment options
- Physical constraints of the site



- Soils investigation per WDNR Technical Standard 1002 to determine:
  - Depth to limiting factor (seasonal high groundwater table or bedrock)
  - Design infiltration rates based on soil texture
  - Soil properties below proposed bottom of trench to limiting factor (must meet % fines requirement)

PLANNING AND SITE DESIGN

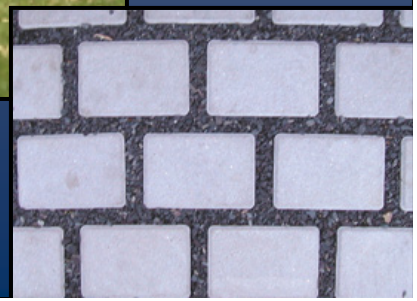
- Investigate pretreatment options for source areas with heavy pollutant loads (parking lots, streets, etc.)
- What structures are located down gradient?
- Divide larger drainage areas into subcatchments
- Maintain sheet flow and disperse flow evenly across length of trench
- Greatest dimension of trench parallel to contour
- Identify conveyance flow path for overflow device
- Recommend constructing a winter drawdown outlet if trench is covered with topsoil and vegetation

INSTALLATION

- Suspend construction when soil moisture content is high to prevent soil smearing or clumping
- Bring trench online only when upland drainage area has reach 90% final stabilization or full build out
- Avoid compaction by heavy equipment tracking
- Compaction mitigation may be necessary
- Excavation must be clean and shear walls should be roughened to promote infiltration through trench sidewalls
- Provide enough filter fabric to overlap the top of the trench
- **Stone aggregate must be washed and free of fine sediment**

INSTALLATION

One lesson learned during the construction arose when the crushed stone arrived at the site for installation. The stone was specified to be "clean washed." However, the stone clearly had not been washed and contained fine sediment that could decrease the life expectancy of the BMP.
(Stormwater Magazine, July-August 2005: Constructing an Infiltration Trench Retrofit BMP)



MAINTENANCE

- Remove accumulated sediment from pretreatment device
- Remove accumulated material/debris on surface of trench immediately
- Do not pile snow directly on top of infiltration trench
- Measure water depth in observation well after rainfall events 0.5 inches or more. Monitor frequently in the first year.
- Repair eroded areas at inflow and outflow structures
- Repair and minimize upstream erosion
- Replace first layer of aggregate and filter fabric if clogging at the surface (applicable for trenches with sand or topsoil top layer)
- Total rehabilitation of trench if drawdown time exceeds 72 hours or storage volume is limited to 10% of original capacity

Maintenance Costs: 5 – 20% of capital cost

PROBLEMS AND SOLUTIONS

PROBLEMS	SOLUTIONS
Premature clogging within first foot of trench	Replace top foot of trench with pea gravel to collect smaller debris
Soils too tight for infiltration	Excavate soils with low permeability and replace with amended soil mix
Soils too loose to protect groundwater system	Amend soils to include more fines. Determined from textural triangle
Frozen soils during winter period ~ zero infiltration	Construct winter drawdown device to minimize compaction from standing water
Premature clogging at native soil interface	Wash stone aggregate before placement, minimize upstream erosion, provide pretreatment, direct only “cleaner” runoff

Questions?