4.6 Infiltration Trench BMP Summary Fact Sheets

Description: Infiltration trenches are excavated trenches filled with stone aggregate used to capture and allow exfiltration of storm water runoff into the surrounding soils from the bottom and sides of the trench. Infiltration trenches are used to remove pollutants and to infiltrate storm water back into the ground. The infiltration also helps to reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutant removal is achieved through filtration of the runoff through the stone aggregate and soil as well as biological and chemical activity within the soil.

IMPORTANT CONSIDERATIONS

DESIGN REQUIREMENTS:
- Soil infiltration rate used for design shall be determined by soil testing performed on site.
- The aggregate graduation should be uniform sand, gravel, or crushed stone (uniformity coefficient of 2 or smaller).
- A sediment forebay and grass channel, or equivalent upstream pretreatment, must be provided.
- Pretreatment must be sized to hold 25 % of the water quality volume, 50% when underlying soil infiltration rates are greater than 2 inches/hour.
- Maximum contributing drainage area is 5 acres.
- Observation well to monitor exfiltration rates.
- The storage area above and within the filter media (usually stone aggregate) shall be sized to hold the water quality volume.
- The drawdown time for all stored runoff volume is 5 days.

ADVANTAGES/BENEFITS:
- Provides for groundwater recharge.
- Good for small sites with porous soils.
- For quantity control, eliminates downstream flooding problems often associated with detention facilities.
- Can be used to capture sheet flow from a drainage area or function as an offline device.

DISADVANTAGES/LIMITATIONS:
- Potential for groundwater contamination.
- High clogging potential and thus should not be used on sites with fine-particle soils (clays or silts).
- Significant setback requirements.
- Geotechnical testing often required, two borings per facility.

MAINTENANCE CONSIDERATIONS:
- Removal of sediment in pretreatment device; replacement of top several inches of aggregate; complete reconstruction when infiltration rate drops to unacceptable levels.
- Inspect for clogging.
- Check observation wells.
- Removal of trees in the vicinity of trench.

STORMWATER MANAGEMENT SUITABILITY

L = Low **M** = Moderate **H** = High

M	1-inch, 6-hr Water Quality Control
M	1-yr, 24-hr Channel Protection Volume
L	Peak Attenuation Control for 10-yr, 6-hr Storm
L	Peak Attenuation Control for 25-yr, 6-hr storm

IMPLEMENTATION CONSIDERATIONS

M	Land Requirements
H	Capital Cost
H	Maintenance Cost
H	Maintenance Considerations

PRIMARY POLLUTANT REMOVAL PROCESSES
- Filtration

POLLUTANT REMOVAL RATES

Effectiveness	Detention Time	Pollutant Removal Rates
Optimal Efficiency	Max 5 days	85% TSS and 70% TP

4.6   Infiltration Trench

4.6.1   General Description

Infiltration trenches are excavations typically filled with stone to create an underground reservoir for storm water runoff. This runoff volume gradually filtrates through the bottom and sides of the trench into the subsoil over a set design period (0.5-day minimum and 5-day maximum) and eventually reaches the water table. By diverting runoff into the soil, an infiltration trench not only treats the water quality volume, but also helps to preserve the natural water balance on a site and can recharge groundwater and preserve baseflow. Due to this fact, infiltration systems are limited to areas with highly porous soils where the water table and/or bedrock are located well below the bottom of the trench. Infiltration trenches must be carefully sited to avoid the potential of groundwater contamination.

Infiltration trenches are not intended to trap sediment and must always be designed with a sediment forebay and grass channel or filter strip, or other appropriate pretreatment measures to prevent clogging and failure. Due to their high potential for failure, these facilities must only be considered for sites where upstream sediment control can be ensured. Infiltration trenches are generally suited for medium-to-high density residential, commercial, and institutional developments where the subsoil is sufficiently permeable to provide a reasonable infiltration rate and the water table is low enough to prevent groundwater contamination. They are applicable primarily for impervious areas where there are not high levels of fine particulates (clay/slit soils) in the runoff and should only be considered for sites where the sediment load is relatively low.

Infiltration trenches can either be used to capture sheet flow from a drainage area or function as an off-line device. Due to the relatively narrow shape, infiltration trenches can be adapted to many different types of sites and can be utilized in retrofit situations. Unlike some other structural storm water controls, they can easily fit into the margin, perimeter, or other unused areas of developed sites.

To protect groundwater from potential contamination, runoff from designated hotspot land uses or activities must not be infiltrated. Infiltration trenches should not be used for manufacturing and industrial sites, where there is a potential for high concentrations of soluble pollutants and heavy metals. In addition, infiltration should not be considered for areas with a high pesticide concentration.

Figure 4.6.1 shows typical infiltration trenches and Figures 4.6.2 and 4.6.3 shows a schematic of an infiltration trench and observation well detail.
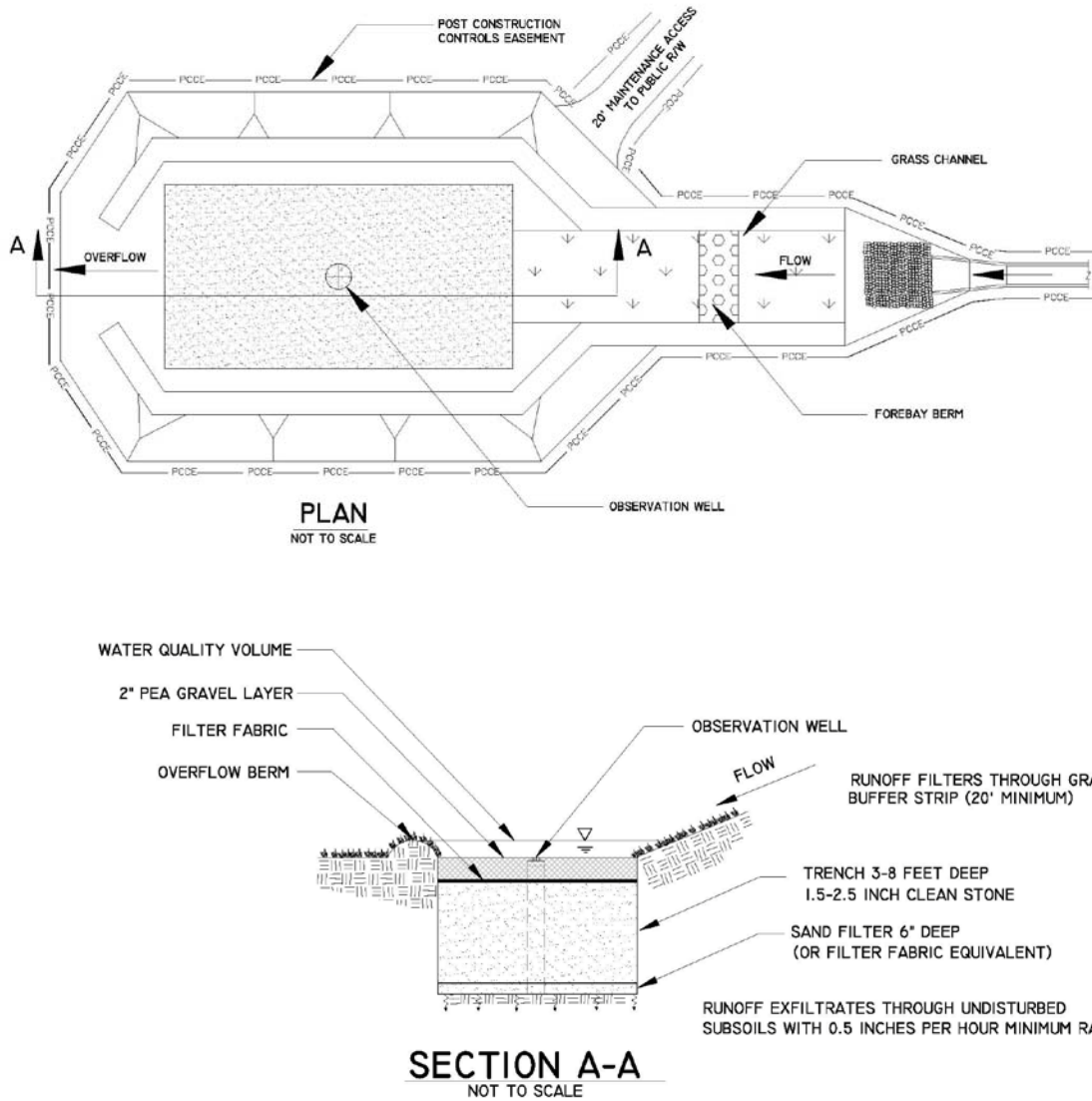

Figure 4.6.1 Examples of Infiltration Trench BMPs

PLAN
NOT TO SCALE

SECTION A-A
NOT TO SCALE

Figure 4.6.2 Schematic of Infiltration Trench

PERFORATION HOLES TO BE I/2 INCH DIAMETER AT 3 INCH
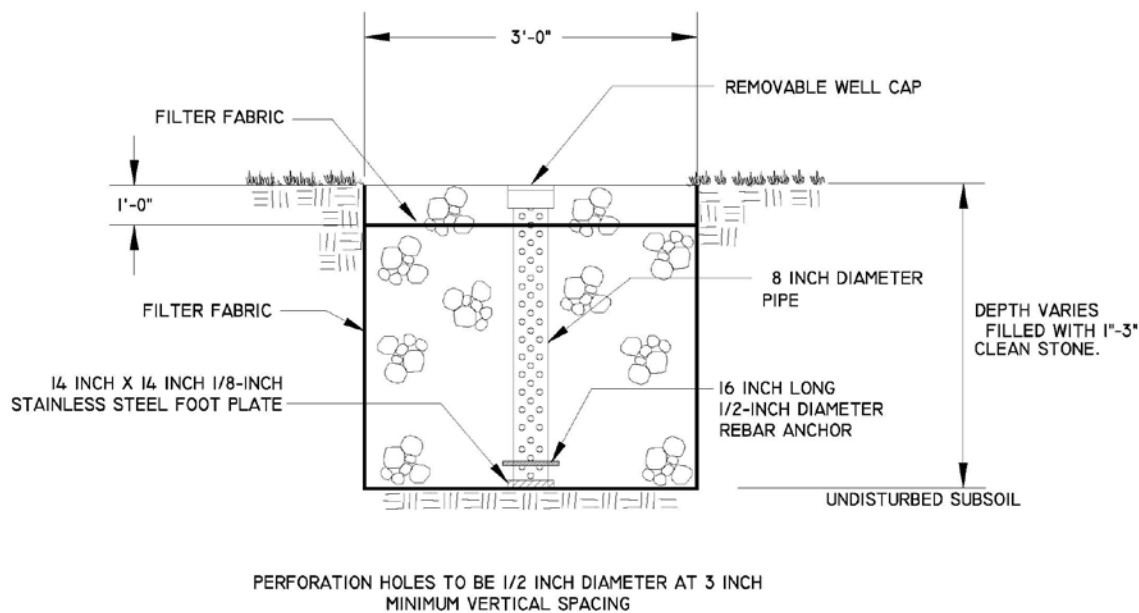MINIMUM VERTICAL SPACING

Figure 4.6.3 Observation Well Detail

4.6.1   Storm Water Management Suitability

Infiltration trenches are designed primarily for storm water quality, i.e. the removal of storm water pollutants. However, they can provide limited runoff quantity control, particularly for smaller storm events. For some smaller sites, infiltration trenches can usually be designed to capture, hold, and/or infiltrate the channel protection volume (CP_v) in addition to WQ_v. Typically, an infiltration trench will need to be used in conjunction with another structural control to provide flood control, if required.

Water Quality Control (WQ_v)

Using the natural filtering properties of surrounding soil, infiltration trenches can remove a wide variety of pollutants from storm water through filtration of the runoff through the stone aggregate and soil as well as biological and chemical activity within the soil. Sediment load and other suspended solids are removed from runoff by pretreatment measures in the facility that treats flows before they reach the trench surface.

Channel Protection Volume (CP_v)

For smaller sites, an infiltration trench may be designed to capture, hold, and infiltrate a portion of the entire channel protection volume CP_v. For larger sites, or where only WQ_v is diverted to the trench, another structural control must be used to control the CP_v.

Peak Attenuation Control

An infiltration trench can also provide storage to reduce the post-development peak flow of the 10-year and 25-year (Q_p) to pre-development levels (detention) for small drainage areas. Infiltration trench facilities must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the filter bed and facility from erosion.

4.6.3 Pollutant Removal Capabilities

One infiltration trench design has been developed for application in the Mecklenburg County area. The underline optimal efficiency design has the capability to remove 85% of the total suspended solids and 70% of the total phosphorus load. This design assumes urban post-development runoff conditions that has been observed in the Mecklenburg County area and that the facilities are sized, designed, constructed, and maintained in accordance with the appropriate recommended specifications contained in this manual. The design pollutant rates are desired from sampling data and computations completed for the development of this manual. In a situation where a removal rate is not deemed sufficient, additional controls may be put in placed at the given site in a series or treatment train approach. See section 4.6.4 for a discussion of design values and appropriate pollutant removal rates for specific designs.

4.6.4 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of an infiltration trench. Items listed in Section 4.1.4.A through 4.1.4.I. are requirements and must be addressed in the design. Items listed in Section 4.1.4.J. are recommendations and are optional.

A.   Design Requirements

Following is a list of design requirements that must be followed in the design of infiltration trench BMPs.

- Following are the design values that are required for the infiltration trench design that is available for application in Mecklenburg County. The appropriate minimum design values and associated pollutant removal rates for the design are given in Table 4.6.1.

Table 4.6.1 Design Values and Pollutant Removal Rates

Effectiveness	Detention Time	Pollutant Removal Rates
Optimal Efficiency	Max. 5 days	85% TSS and 70% TP

- The aggregate graduation should be uniform sand, gravel, or crushed stone (uniformity coefficient of 2 or smaller).

- To be suitable for infiltration, underlying soils should have an infiltration rate (f_c) of 0.5 inches per hour or greater when the drainage area is large when compared to the size of the infiltration device. The infiltration rate is initially determined from NRCS soil texture classification and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken with the proposed limits of the facility). Infiltration trenches cannot be used in fill soils.

- A sediment forebay and grass channel, or equivalent upstream pretreatment, must be provided.

- Pretreatment must be provided sized to hold 25% of the water quality volume, 50% when underlying soil infiltration rates are greater than 2 inches/hour.

- The maximum contributing drainage area is 5 acres.

- One or more observation wells are required to monitor percolation and to show how quickly the trench dewaters or to determine if the device is clogged. A minimum of one observation well shall be provided at close to the center of the system unless the sub-grade is terraced; in that case, there shall be one well for each terrace. In addition, a second observation well will be required if a cell exceeds 20,000 ft2.

- The storage area above and within the filter media (usually stone aggregate) must be sized to hold

the water quality volume and quantity volume if used for quantity control.

- The drawdown time for water quality runoff volume should be at least 0.5 days.

- The drawdown time for all stored runoff volume is 5 days.

- Minimum setback requirements for infiltration trench facilities:

    - From a property line – 10 feet
    - From a building foundation – 25 feet
    - From a private water supply well – 100 feet
    - From a public water supply well – 1,200 feet
    - From a septic system tank/leach field – 100 feet
    - From class SA waters – 30 feet, surface waters – 30 feet
    - From surface drinking water sources – 400 feet (100 feet for a tributary)

- Infiltration trenches are designed for intermittent flow and must be allowed to drain and allow re-aeration of the surrounding soil between rainfall events. They must not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

- All elements of inspection, design, and construction (including scarification of subgrade) for infiltration that are contained in Section 16.3.5 and 16.3.6 of Chapter 16 (with the exception of the minimum infiltration rate of 0.52 inches per hour) and Sections 18.3.1, 18.3.4 through 18.3.7, and 18.4 through 18.4.5 of Chapter 18 of NCDENR Stormwater BMP Manual should be considered in the design of any infiltration measure.

C.   Physical Specifications/Geometry

The required trench storage volume is equal to the water quality control volume (WQ_v). For small sites, an infiltration trench can be designed with a larger storage volume to include the channel protection volume (CP_v).

The slowest infiltration rate obtained from tests performed at the site should be used in the design calculations.

Trench depths should be between 3 and 8 feet, to provide for easier maintenance. The width of a trench must be less than 25 feet.

Broader, shallow trenches reduce the risk of clogging by spreading the flow over a larger area for infiltration.

The surface area required is calculated based on the trench depth, soil infiltration rate, aggregate void space, and fill time (assume a fill time of 2 hours for most designs). In addition, the surface area is computed as 300 ft^2/acre.

The bottom slope of a trench should be flat across its length and width to evenly distribute flows, encourage uniform infiltration through the bottom, and reduce the risk of clogging.

The stone aggregate used in the trench should be washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40%. Aggregate contaminated with soil must not be used. A porosity value (void space/total volume) of 0.32 should be used in calculations, unless aggregate specific data exist. A P_{index} of 0.1 is required.

A 6-inch layer of clean, washed sand is placed on the bottom of the trench to encourage drainage and prevent compaction of the native soil while the stone aggregate is added.

The infiltration trench is lined on the sides and top by an appropriate geotextile filter fabric that prevents soil piping but has greater permeability than the parent soil. The top layer of filter fabric is located 2 to 6 inches from the top of the trench and serves to prevent sediment from passing into the stone aggregate. Since this top layer serves as a sediment barrier, it will need to be replaced more frequently and must be readily separated from the side sections.

The top surface of the infiltration trench above the filter fabric is typically covered with pea gravel. The pea gravel layer improves sediment filtering and maximizes the pollutant removal in the top of the trench. In addition, it can easily be removed and replaced should the device begin to clog. Alternatively, the trench can be covered with permeable topsoil and planted with grass in a landscaped area.

One or more observation wells must be installed in every infiltration trench and should consist of a perforated PVC pipe, 4 to 6 inches in diameter, extending to the bottom of the trench (see Figure 4.6.3 for an observation well detail). The observation well will show the rate of dewatering after a storm, as well as provide a means of determining sediment levels at the bottom and when the filter fabric at the top is clogged and maintenance is needed. It should be installed along the centerline of the structure, flush with the ground elevation of the trench. A visible floating marker should be provided to indicate the water level. The top of the well should be capped and located to discourage vandalism and tampering.

The trench excavation should be limited to the width and depth specified in the design. Excavated material should be placed away from the open trench so as not to jeopardize the stability of the trench sidewalls. The bottom of the excavated trench must not be loaded in a way that causes soil compaction, and should be scarified prior to placement of sand. The sides of the trench must be trimmed of all large roots. The sidewalls must be uniform with no voids and scarified prior to backfilling. All infiltration trench facilities should be protected during site construction and should be constructed after upstream areas have been stabilized.

D.   Pretreatment/Inlets

Pretreatment facilities must always be used in conjunction with an infiltration trench to prevent clogging and failure.

For a trench receiving sheet flow from an adjacent drainage area, the pretreatment system should consist of a vegetated filter strip with a minimum 25-foot length. A vegetated buffer strip around the entire trench is required if the facility is receiving runoff from both directions. If the infiltration rate for the underlying soils is greater than 2 inches per hour, 50% of the WQ_v should be pretreated by another method prior to reaching the infiltration trench.

For an off-line configuration, pretreatment should consist of a sediment forebay, vault, plunge pool, or similar sedimentation chamber (with energy dissipaters) sized to 25% of the water quality control volume (WQ_v). Exit velocities from the pretreatment chamber must be non-erosive for the 10-year design storm. Remove sediment after 50 percent of the total pretreatment capacity has been lost.

E.   Outlet Structures

Outlet structures are not required for infiltration trenches.

F.   Emergency Spillways

Typically, for off-line designs, there is no need for an emergency spillway. However, a non-erosive overflow channel should be provided to pass safely flows that exceed the storage capacity of the trench to a stabilized downstream area of watercourse.

G.   Maintenance Access

Adequate access must be provided to an infiltration trench facility for inspection and maintenance.

## H.	Safety Features

In general, infiltration trenches are not likely to pose a physical threat to the public and do not need to be fenced.

## I.	Landscaping

Vegetated filter strips and buffers must fit into and blend with surrounding area. Native grasses are preferable, if compatible. The trench may be covered with permeable topsoil and planted with grass in a landscaped area.

## J.	Design Recommendations

In addition to the design requirements and variables, following are some design recommendations that should be considered for infiltration trench design.

- Soils on the drainage area tributary to an infiltration trench should have a clay content of less than 20% and a silt/clay content of less than 40% to prevent clogging and failure.

- There must be at least 4 feet between the bottom of the infiltration trench and the elevation of the seasonally high water table.

- Clay lenses, bedrock or other restrictive layers below the bottom of the trench will reduce infiltration rates unless excavated.

- Elevation difference needed at a site from the inflow to the outflow is 1 foot.

- When used in an off-line configuration, the water quality control volume (WQ_v) is diverted to the infiltration trench through the use of a flow splitter. Storm water flows greater than the WQ_v are diverted to other controls or downstream using a diversion structure or flow splitter.

- To reduce the potential for costly maintenance and/or system reconstruction, it is recommended that the trench be located in an open or lawn area, with the top of the structure as close to the ground surface as possible. Infiltration trenches should not be located beneath paved surfaces, such as parking lots.

## 4.6.5	Design Procedure

Step 1 - Using the BMP Selection Matrix at the beginning of Chapter 4, determine if the development site and conditions are appropriate for the use of an infiltration trench.

Step 2 - Consider any special site-specific design conditions and determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 3 - Compute water quality volume (WQ_v) using equations 5.2 and 5.3 – $WQ_v = 1.0R_vA/12$.

Step 4- Compute site hydrologic parameters using the SCS procedures and/or computer models that use the SCS procedures.

Step 5 - Compute water quality peak flow (WQ_p) using equation 5.4 for a modified curve number and the SCS hydrograph procedures with a 1-inch, 6-hr, balanced storm event.

Step 6 - Compute channel protection volume (CP_v) using the SCS method and a 1-yr, 24-hr storm event. Estimate approximate storage volume for channel protection using the SCS method.

Step 7 - Size flow diversion structure, if needed, to divert the water quality volume to the infiltration trench.

Step 8 - Compute the release rates for the water quality control and channel protection volume control.

Step 9 - Compute pretreatment volume (if included in the design). The forebay should be sized to contain 25% of the water quality control volume (WQ_v) for off-line configurations, 50% for underlying soil infiltration rates greater than 2 inches/ hour.

Step 10 - Size infiltration trench using 300 ft^2/acre of drainage area.

Check the area of the trench using the following equation (the greater of the two surface area values should be selected):

$$\frac{WQ_v}{(nd + kT / 12)}$$

where:

A = Surface Area
WQ_v = Water quality control Volume (or total Volume to be infiltrated)
n = stone porosity
d = trench depth (feet)
k = percolation (inches/hour)
T = Fill Time (time for the practice to fill with water), in hours

A porosity value n – 0.32 should be used.

A fill time T=2 hours can be used for most designs.

Check the infiltration into the surrounding soils to ensure that the infiltration trench contains a portion of WQ_v longer than 0.5 days and releases the entire WQ_v within 5 days. The following derivation of Darcy's equation can be used to check infiltration into the surrounding soils.

$$A_f= (WQ_v)(d_f) / [(k)(h_f + d_f)(t_f)]$$

where:

A_f = surface area of ponding area (ft^2)
WQ_v = water quality control volume (or total volume to be captured)
d_f = depth of soil that is effective for infiltration (assume equal to infiltration media depth)
k = coefficient of permeability of surrounding soil
h_f = average height of water above infiltration trench bed (ft)
t_f = design drain time (days)

Step 11 - Design Spillway(s)

Adequate storm water outfalls should be provided for the overflow exceeding the capacity of the trench, ensuring non-erosive velocities on the down-slope.

4.6.6   Inspection and Maintenance Requirements

Specific maintenance inspections and requirements are contained in the Administrative Manual.

4.6.7   Design Procedure Form

Design Procedure Form: Infiltration Trench

INFILTRATION TRENCH FEASIBILITY

1. Is the use of an infiltration trench appropriate?

2. Confirm design criteria and applicability.

PRELIMINARY HYDROLOGIC CALCULATIONS

3. Compute, WQ_v volume requirements
   Compute Runoff Coefficient, R_v
   Compute WQ_v volume requirements

4. Compute site hydrologic input parameters
   Development Conditions
   Area
   CN
   Adjusted CN
   Time of concentration

5. Compute WQ_p peak flow
   Compute modified SCS curve number

6. Compute CP_v
   Compute S
   Compute 1-yr, 24-hr total rainfall depth
   Compute q_d
   Compute CP_v
   7 Size flow diversion structure

8. Compute release rates
   Compute WQ_v release rate
   Compute CP_v release rate

INFILTRATION TRENCH DESIGN

9. Pretreatment volume (for off-line designs)
    $Vol_{pre} = 0.25 (WQ_v)$ or $0.50 (WQ_v)$

10. Size infiltration trench
     Width must be less than 25 ft

11. Design spillway(s)

NOTES:

Rv = _____
WQ_v = _____ acre-ft

Pre-developed   Post-developed
_____ acres   _____ acres
_____   _____
_____   _____
_____ hours   _____ hours

WQ_p = _____ cfs
CN = _____

S = _____
Rainfall Depth = _____ inches
Q_d = _____ inches
CP_v =___ acre-ft

Release Rate = _____ cfs
Release Rate = _____ cfs

Vol_{pre} = _____ft3

Area = _____ ft^2
Width = _____ft
Length = _____ft^3

Length = _____ft

Notes: _____

_____

4.6.8   Design Example

There is not currently a design example for the infiltration trench. A design example will be developed in the future.