Chapter 7 Infiltration and Bio-infiltration Treatment Facilities

7.1 Purpose

This Chapter provides site suitability, design, and maintenance criteria for infiltration treatment systems. Infiltration treatment Best Management Practices (BMPs) serve the dual purpose of removing pollutants from stormwater and recharging aquifers.

The infiltration BMPs described in this chapter include:

- BMP T710 Infiltration basins
- BMP T720 Infiltration trenches
- BMP T730 Bio-infiltration swales

7.2 Application

These infiltration and bio-infiltration treatment measures are capable of achieving the performance objectives cited in Chapter 3 for specific treatment menus. In general, these treatment techniques can capture and remove or reduce the target pollutants to levels that will not adversely affect public health or beneficial uses of surface and groundwater resources.

7.3 Site Suitability

The following site suitability criteria must be considered. When a site investigation reveals that any of the eight applicable criteria cannot be met, appropriate mitigation measures must be implemented so that the infiltration facility will not pose a threat to safety, health, and the environment.

For site selection and design decisions a geotechnical and hydrogeologic report must be prepared by a qualified engineer with geotechnical and hydrogeologic experience, or an equivalent professional acceptable to the City, under the seal of a registered Professional Engineer. The design engineer may utilize a team of certified or registered professionals in soil science, hydrogeology, geology, and other related fields.

7.3.1 Setback Criteria

Typical setbacks are outlined in Section 3.3.

Setback criteria for the various infiltration and dispersion facilities can be found in the design criteria for each BMP in this chapter. Below are conditions that the soils professional must evaluate to determine the need for additional or more stringent setbacks than outlined in this manual.

The professional must evaluate:

- Potential impacts to drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies.
- Potential impacts from roadways subject to deicers or herbicides which are likely to be present in the influent to the infiltration system.
- Potential impacts to all building foundations in the vicinity of the proposed infiltration facility. Recommend investigating all building foundations: within 100 feet upslope and 20 feet downslope from the facility.
• Potential impacts to all property lines within 20 feet of the facility.
• Potential impacts to a Native Growth Protection Easement (NGPE); ≥20 feet.
• Potential impacts to the top of slopes >20% and within 50 feet.
• On-site and off-site structural stability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties, especially on hills with known side-hill seeps.

7.3.2 Groundwater Protection Areas
A site is not suitable if the infiltration facility will cause a violation of Ecology’s Groundwater Quality Standards.

The City of Tacoma Public Works Department and Tacoma-Pierce County Health Department developed a guidance document that provides the circumstances and requirements for approval of infiltration facilities for managing pollution-generating stormwater runoff in the STGPD. The document, “Implementation of Stormwater Infiltration for Pollution-Generating Surfaces in the South Tacoma Groundwater Protection District” is available at www.cityoftacoma.org/stormwater.

See Chapter 2 of Volume 1 for geographic-specific requirements.

7.3.3 High Vehicle Traffic Areas
An infiltration BMP may be considered for runoff from areas of industrial activity and the high vehicle traffic areas described below. For such applications sufficient pollutant removal (including oil removal) shall be provided upstream of the infiltration facility to ensure that groundwater quality standards will not be violated and that the infiltration facility is not adversely affected.

High Vehicle Traffic Areas are:

• Commercial or industrial sites subject to an expected average daily traffic count (ADT) ≥100 vehicles/1,000 ft² gross building area (trip generation), and
• Road intersections with an ADT of ≥25,000 on the main roadway, or ≥15,000 on any intersecting roadway.

7.3.4 Soil Infiltration Rate/Drawdown Time for Treatment
7.3.4.1 Infiltration Rates: Short-term and Long-term
For treatment purposes, the short-term soil infiltration rate should be 2.4 in/hour, or less, to a depth of 2.5 times the maximum design pond water depth, or a minimum of 6 ft. below the base of the infiltration facility. This infiltration rate is also typical for soil textures that possess sufficient physical and chemical properties for adequate treatment, particularly for soluble pollutant removal (see Section 7.3.6). It is comparable to the textures represented by Hydrologic Groups B and C. Long-term infiltration rates up to 2.0 inches/hour can also be considered, if the infiltration receptor is not a sole-source aquifer, and in the judgment of the site professional, the treatment soil has characteristics comparable to those specified in SSC-6 to adequately control the target pollutants.

The long-term infiltration rate should be used for drawdown time and routing calculations.
7.3.4.2 Drawdown Time

Refer to Section 7.4 for infiltration rate determination. Document that the 91st percentile, 24-hour runoff volume (indicated by WWHM) can infiltrate through the infiltration basin surface within 48 hours. This can be calculated using a horizontal projection of the infiltration basin mid-depth dimensions and the estimated long-term infiltration rate.

This drawdown restriction is intended to meet the following objectives:

- Restore hydraulic capacity to receive runoff from a new storm,
- Maintain infiltration rates,
- Aerate vegetation and soil to keep the vegetation healthy, and
- Enhance the biodegradation of pollutants and organics in the soil.

7.3.5 Depth to Bedrock, Water Table, or Impermeable Layer

The base of all infiltration basins or trench systems shall be $\geq 5$ feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the groundwater mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the site professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

7.3.6 Soil Physical and Chemical Suitability for Treatment

The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants. The following soil properties must be carefully considered in making such a determination:

- Cation exchange capacity (CEC) of the treatment soil must be $\geq 5$ milliequivalents CEC/100 g dry soil (USEPA Method 9081). Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of $>5$ meq/100g are expected in loamy sands, according to Rawls, et al.
- Depth of soil used for infiltration treatment must be a minimum of 18 inches.
- Organic content shall be a minimum of 5%. Organic content shall be measured on a dry weight basis using ASTM D2974.
- Waste fill materials should not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.

Engineered soils may be used to meet the design criteria in this chapter and the performance goals in Chapter 2 and Chapter 3. The treatment liners must not leach pollutants into the groundwater table or underground piping. Pollutants can include but not be limited to high or low pH, phosphorus and heavy metals. Environmental Services may require that additional testing be conducted on the treatment liner. Animal manures must be sterilized because of the potential for bacterial contamination.

7.3.7 Seepage Analysis and Control

Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots or sloping sites.
7.3.8 Cold Climate and Impact of Roadway Deicers


Potential impact of roadway deicers on potable water wells must be considered in the siting determination. Mitigation measures must be implemented if infiltration of roadway deicers can cause a violation of groundwater quality standards.

7.4 Site Characterization

Use the following guidelines to determine if the site suitability criteria have been met.

7.4.1 Field Methods used to Determine Subsurface Characterization

7.4.1.1 Test Holes or Pits

- Dig test holes or pits to a depth below the base of the infiltration facility of at least 5 times the maximum design depth of ponded water proposed for the infiltration facility.

- Conduct pit/hole exploration during the wet season (December 1st through April 30th) to provide accurate groundwater saturation and groundwater information.

- Take soil samples (representative samples from each soil type and/or unit within the infiltration receptor) to a depth below the base of the infiltration facility of 2.5 times the maximum design ponded water depth, but not less than 6 feet.
  - For basins, at least one test pit or test hole per 5,000 ft² of basin infiltrating surface (in no case less than two per basin) is required.
  - For trenches, at least one test pit or test hole per 50 feet of trench length (in no case less than two per trench) is required.

The depth and number of test holes or test pits and samples should be increased if, in the judgment of a licensed engineer with geotechnical expertise (P.E.) or other licensed professional acceptable to the City, the conditions are highly variable and such increases are necessary to accurately estimate the performance of the infiltration system. The exploration program may also be decreased if, in the opinion of the licensed engineer or other professional, the conditions are relatively uniform and the borings/test pits omitted will not influence the design or successful operation of the facility. In high water table sites the subsurface exploration sampling need not be conducted lower than two (2) feet below the groundwater table.

- Prepare detailed logs for each test pit or test hole and a map showing the location of the test pits or test holes. Logs must include at a minimum, depth of pit or hole, soil descriptions, depth to water, presence of stratification.

Soil characterization for each soil unit (soils of the same texture, color, density, compaction, consolidation and permeability) encountered must be based upon the method used for determining the long-term infiltration rate (see Section 7.4.2) and must include:
  - Percent clay content (include type of clay, if known)
- Cation exchange capacity (CEC) and organic matter content for each soil type and strata. For soils with low CEC and organic content, deeper characterization of soils may be warranted.
- Soil contamination.
- Color/mottling.
- Variations and nature of stratifications.
- Grain-size distribution (ASTM D422 or equivalent AASHTO specification).
- Textural class (USDA) (see Figure 3 - 11).

### 7.4.1.2 Infiltration Rate Determination

Determine the representative infiltration rate of the unsaturated vadose zone based on field infiltration tests and/or grain size/texture determinations. Field infiltration rates can be determined using the Pilot Infiltration Test (see PIT-Appendix B). Such site testing should be considered to verify infiltration rate estimates based on soil size distribution and/or texture. Infiltration rates may also be estimated based on soil grain-size distributions from test pits or test hole samples. This may be particularly useful where a sufficient source of water does not exist to conduct a pilot infiltration test. As a minimum, one soil grain-size analysis per soil stratum in each test hole shall be performed within 2.5 times the maximum design water depth, but not less than 6 feet.

The infiltration rate is needed for routing and sizing purposes and for classifying the soil for treatment adequacy.

### 7.4.1.3 Infiltration Receptor

The requirements of this section will be applied as directed by Environmental Services.

Infiltration receptor (unsaturated and saturated soil receiving the storm water) characterization should include:

- Installation of groundwater monitoring wells. Use at least three per infiltration facility, or three hydraulically connected surface and groundwater features. This will establish a three-dimensional relationship for the groundwater table, unless the highest groundwater level is known to be at least 50 feet below the proposed infiltration facility. The monitoring wells will:
  - Monitor the seasonal groundwater levels at the site during at least one wet season, and,
  - Consider the potential for both unconfined and confined aquifers, or confining units, at the site that may influence the proposed infiltration facility as well as the groundwater gradient. Other approaches to determine groundwater levels at the proposed site could be considered if pre-approved by the City of Tacoma, and,
  - Determine the ambient groundwater quality, if that is a concern.
- An estimate of the volumetric water holding capacity of the infiltration receptor soil. This is the soil layer below the infiltration facility and above the seasonal high-water mark, bedrock, hardpan, or other low permeability layer. This analysis should be conducted at a conservatively high infiltration rate based on vadose zone porosity, and the water quality runoff volume to be infiltrated. This, along with an analysis of groundwater movement, will be useful in determining if there are volumetric limitations that would adversely affect drawdown.
  - Determination of:
Depth to groundwater table and to bedrock/impermeable layers.

Seasonal variation of groundwater table based on well water levels and observed mottling.

Existing groundwater flow direction and gradient.

Lateral extent of infiltration receptor.

Horizontal hydraulic conductivity of the saturated zone to assess the aquifer’s ability to laterally transport the infiltrated water.

Impact of the infiltration rate and volume at the project site on groundwater mounding, flow direction, and water table; and the discharge point or area of the infiltrating water. A groundwater mounding analysis shall be conducted at all sites where the depth to seasonal groundwater table or low permeability stratum is less than 15 feet and the runoff to the infiltration facility is from more than one acre. The site professional can consider conducting an aquifer test, or slug test and the type of groundwater mounding analysis necessary at the site.

7.4.2 Design Infiltration Rate Determination

Use the guidance in Volume 3, Section 6.5 to determine the design infiltration rate.

7.4.2.1 General Sizing Criteria

This information is applicable to infiltration basins, trenches, and bio-infiltration facilities.

Size the device by routing 91% of the runoff volume, as predicted by the Western Washington Hydrology Model (WWHM) through the facility.

Infiltration facilities for treatment can be located upstream or downstream of detention and can be offline or online.

- **Online** treatment facilities placed *upstream or downstream* of a detention facility must be sized to infiltrate 91% of the runoff file volume directed to it.

- **Offline** treatment facilities placed *upstream* of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by WWHM, to the treatment facility. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

- **Offline** treatment facilities placed *downstream* of a detention facility must have a flow splitter designed to send all flows at or below the 2-year flow frequency from the detention pond, as predicted by WWHM, to the treatment facility. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

7.4.2.2 General Design Criteria

- Slope of the base of the infiltration facility should be <3 percent.

- Spillways/overflow structures – A nonerodible outlet or spillway with a firmly established elevation must be constructed to discharge overflow. Ponding depth, drawdown time, and storage volume are calculated from that reference point. Refer to Volume 3, Section 7.1.3 for overflow structure design details.

- For infiltration treatment facilities, side-wall seepage is not a concern if seepage occurs through the same stratum as the bottom of the facility. However, for engineered soils or for soils with very low permeability, the potential to bypass the treatment soil through the side-walls may be significant. In those cases, the side-walls must be lined, either with an
impervious liner or with at least 18 inches of treatment soil, to prevent seepage of untreated flows through the side walls.

### 7.4.2.3 General Construction Criteria

- Initially excavate to within 1-foot of the final floor elevation of the infiltration facility. Do not excavate to the final grade until all disturbed areas in the upgradient watershed have been stabilized or protected. Remove all accumulated sediment in the final phase of excavation.
- Post-construction, all water must be conveyed through a pretreatment device to prevent sedimentation.
- Infiltration facilities should not be used as temporary sediment traps during construction.
- Use light-tracked equipment for excavation to avoid compaction of the floor of the infiltration facility. The use of draglines and trackhoes should be considered. The infiltration area should be flagged or marked to keep equipment away.

### 7.4.2.4 Maintenance Criteria

Per Minimum Requirement #10, an operation and maintenance plan shall be prepared for all stormwater management facilities. See Volume 1, Appendix C for specific maintenance requirements. Maintenance shall be a basic consideration in design and cost-determination of the stormwater management facility.

Any standing water removed during maintenance operation must be disposed of in a City approved manner. See the dewatering requirements in Volume 4 of this manual. Pretreatment may be necessary. Solids must be disposed of in accordance with state and local waste regulations.

Facilities shall be constructed such that the facility can be easily inspected by one person. This may require construction of additional inspection ports or access manholes to allow inspection acces to be opened by one person.

### 7.4.2.5 Verification Testing of the Completed Facility

Verification testing of the completed full-scale infiltration facility is recommended to confirm that the design infiltration parameters are adequate. The site professional should determine the duration and frequency of the verification testing program, including the monitoring program for potentially impacted groundwater. The groundwater monitoring wells installed during site characterization (see Section 7.4.1.3) may be used for this purpose. Long-term (more than two years) in-situ drawdown and confirmatory monitoring of the infiltration facility would be preferable. The City of Tacoma may require verification testing on a case-by-case basis.
7.5 Best Management Practices (BMPs) for Infiltration Treatment

The three BMPs discussed below are recognized currently as effective treatment techniques using infiltration and bio-infiltration. Selection of a specific BMP should be based on the Treatment Facility Menus provided in Chapter 2.

7.5.1 BMP T710 Infiltration Basins

7.5.1.1 Description

Infiltration basins are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff.

7.5.1.2 Design Criteria Specific for Basins

- Complete a site suitability analysis per Section 7.3.
- Provide access for vehicles to easily maintain the forebay (presetting basin) area and not disturb vegetation, or resuspend sediment any more than is absolutely necessary.
- The slope of the basin bottom should not exceed 3% in any direction.
- Provide a minimum of one foot of freeboard when establishing the design ponded water depth. Freeboard is measured from the rim of the infiltration facility to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.
- Establish vegetation on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Provide erosion protection of inflow points to the basin (e.g., riprap, flow spreaders, energy dissipators (See Chapter 3). Seed mixture shall be a Low-Growing Turf Seed Mix (see Volume 2, Table 2 - 3). The use of slow-growing stoloniferous grasses will permit longer intervals between mowing. The use of fertilizers is prohibited.
- Lining material – Basins can be open or covered with a 6 to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. A nonwoven geotextile should be selected that will function sufficiently without plugging (see geotextile specifications in Appendix C). The filter layer shall be replaced or cleaned when/if it becomes clogged.
- Stabilize and plant embankment, emergency spillways, spoil and borrow areas, and other disturbed areas. Without healthy vegetation the surface soil pores would quickly plug.

7.5.1.3 Maintenance Criteria for Basins

- See Volume 1, Appendix C, Maintenance Checklist #2 for specific maintenance requirements for infiltration ponds and basins.

7.5.2 BMP T720 Infiltration Trenches

7.5.2.1 Description

Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff gradually infiltrates into the surrounding soil. The surface of the trench can be covered with grating and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in a stone trench.
7.5.2.2 Design Criteria

- Complete a site suitability analysis per Section 7.3.
- Include an access port or open or grated top for accessibility to conduct inspections and maintenance.
- Use clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches to fill trench. Void space for these aggregates should be in the range of 30 to 40 percent.
- Line sides of trench with an engineered geotextile material. Geotextile should surround all of the aggregate fill material except for the top one-foot, which is placed over the geotextile. Geotextile fabric with acceptable properties must be carefully selected to avoid plugging (see Appendix C).
- The bottom sand or geotextile fabric as shown in the attached figures is optional.
- Overflow Channel - Because an infiltration trench is generally used for small drainage areas, an emergency spillway is not necessary. However, a non-erosive overflow channel leading to a stabilized watercourse should be provided.
- Trench can be placed under a porous or impervious surface cover to conserve space.
- Install an observation well at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. Figure 5 - 7 illustrates observation well details. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter and it should be constructed flush with the ground elevation. For larger trenches a 12-36 inch diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. Cap the top of the well to discourage vandalism and tampering.

7.5.2.3 Construction Criteria

- Trench Preparation – Place excavated materials away from the trench sides to enhance trench wall stability. Keep excavated material away from slopes, neighboring property, sidewalks and streets.
- Stone Aggregate Placement and Compaction – Place the stone aggregate in lifts and compact using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.
- Potential Contamination - Prevent natural or fill soils from intermixing with the stone aggregate. Remove all contaminated stone aggregate and replace with uncontaminated stone aggregate.
- Overlapping and Covering - Following the stone aggregate placement, fold the geotextile over the stone aggregate to form a 12 inch minimum longitudinal overlap. When overlaps are required between rolls, overlap the upstream roll a minimum of 2 feet over the downstream roll in order to provide a shingled effect.
- Voids behind Geotextile – Avoid voids between the geotextile and excavation sides. Remove boulders or other obstacles from the trench walls. Place natural soils in voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. Soil piping, geotextile clogging, and possible surface subsidence will be avoided by this remedial process.
• **Unstable Excavation Sites** - Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.

### 7.5.2.4 Maintenance Criteria

• See Volume 1, Appendix C, Maintenance Checklist #3 for specific requirements for infiltration trenches.

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**Figure 5 - 7. Observation Well Details**