Appendix E: Infiltration Testing

To properly size and locate stormwater management facilities, it is necessary to characterize the soil infiltration conditions at the location of the proposed facility. Projects following the Simple Method utilize assumed soil infiltration rates based on soil type. Projects following the Simple Method that will be adding >10,000 sf of impervious may want to perform an infiltration test to ensure that the assumptions used in developing the sizing factors on the Simple Sizing Form are appropriate for site conditions (e.g. soil infiltration rates, in inches per hour, assumed for soil types are A = 4"/hr, B = 2"/hr, C = 0.5"/hr, D = 0.1"/hr).

All projects following the Engineered Method must evaluate existing site conditions and determine the infiltration rate prior to facility design. An infiltration test is also required for sites trying to demonstrate that on-site infiltration is infeasible per **section 1.2.2**. Post installation infiltration testing is required for any infiltration facility installed outside the designated UIC area being designed to infiltrate the 100-year storm event

E.1 Infiltration Test Requirements

- Testing must be conducted or overseen by a qualified Professional Engineer, Registered Geologist, or Certified Engineering Geologist licensed in the State of Oregon
- The depth of the test must correspond to the facility depth. If a confining layer, or soil with a greater percentage of fines, is observed during the subsurface investigation to be within 4 feet of the bottom of the planned infiltration system, the testing should be conducted within that confining layer. Based on DEQ requirements, the boring log must be continued to a depth adequate to show separation between the bottom of the infiltration facility and the seasonal high groundwater level. (The boring depth will vary, based on facility depth).
- Tests must be performed in the immediate vicinity of the proposed facility. Exceptions can be made to the test location provided the qualified professional can support that the strata are consistent from the proposed facility to the test location. The test must be conducted in the twenty-four months prior to the date the plans were submitted for review.
- Infiltration testing should not be conducted in engineered or undocumented fill.

There are three infiltration testing methods that can be used to determine design infiltration rate:

1. Open pit falling head (see **section E.4**)
2. Encased falling head (see **section E.5**)
3. Double-ring infiltrometer (see **section E.6**)

The qualified professional who will be performing the infiltration test must exercise judgment in the selection of the infiltration test method.

Where satisfactory data from adjacent areas using similar infiltration testing methods is available that demonstrates infiltration testing is not necessary, the infiltration testing requirement may be waived by the City of Gresham design reviewer. A recommendation for forgoing infiltration testing must be submitted in a report which includes supporting data and is stamped and signed by the project geotechnical engineer or project geologist.

E.2 Minimum Number of Required Tests

- At least one infiltration test is required for any potential located where a stormwater facility will be sited
- Additional tests should be considered for every 10,000 square feet of project area
- Additional tests should be considered for every 100 lineal feet of infiltration facility
- No more than five tests are required per development (at the discretion of the qualified professional assessing the site, as well as the City of Gresham).

Tests performed for a proposed land division can be used at the building permit stage as long as the results of the test are submitted with the separate applications and were conducted within twenty-four months prior to the date the plans were submitted for review.

Where multiple types of facilities are used, it is likely that multiple tests will be necessary, since an infiltration test can test only a single location. It is highly recommended to conduct an infiltration test at each stratum used. City of Gresham staff may require additional testing. If additional testing is required during plan review, the applicant must provide 24-hours of notice to City of Gresham staff and specify the time and location that the test will take place.

E.3 Factor of Safety

For all of the testing methods described in this section, a **minimum allowable factor of safety of 2** shall be applied to field obtained infiltration rates for use in stormwater system design. To obtain the infiltration rate used in design, divide the infiltration rate measured in the field by the factor of safety. The factor of safety used in design should be chosen by collaboration between the geotechnical engineer or geologist overseeing the infiltration testing and the civil engineer designing the stormwater management system. Determination of the factor of safety should include consideration of project specific conditions such as soil variability, testing methods, consequences of system failure, complexity of proposed construction, etc.

E.4 Open Pit Falling Head Procedure Instructions

The open pit falling head procedure is performed in an open excavation and therefore is a test of the combination of vertical and lateral infiltration.

1. Excavate a hole with dimensions of approximately 2 feet wide by 2 feet long into the native soil to the depth of the proposed facility bottom. The test can be conducted in a machine-excavated pit or a hand-dug pit using a shovel, post hole digger, or hand auger. If smooth augering tools or a smooth excavation bucket are used, scratch the sides and bottom of the hole with a sharp pointed instrument, and remove the loose material from the bottom of the test hole.

2. Fill the hole with clean water a minimum of 12 inches and maintain this depth of water for at least 4 hours (or overnight if clay soils are present) to pre-saturate the native material.

3. Determine how the water level will be accurately measured. The measurements should be made with reference to a fixed point. A lath placed in the test pit prior to filling or a sturdy beam across the top of the pit are convenient reference points. The tester and excavator should conduct all testing in accordance with OSHA regulations.

4. After the pre-saturation period required in step 2, refill the hole with water to 12 inches and record the draw-down time. Alternative water head heights may be used for testing provided the pre-saturation height is adjusted accordingly and the water head height used in infiltration testing is no more than 50 percent of water head height in the proposed stormwater system during the design storm event. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower draining soils) or until all the water has drained. In faster draining soils (sands and gravels), it may be necessary to shorten the measurement interval to obtain a well-defined infiltration rate curve. Constant head tests may be substituted for falling head tests at the discretion of the professional overseeing the infiltration testing.

5. Repeat the infiltration test until the change in measured infiltration rate between two successive trials is no more than 10 percent. The trial should be discounted if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level must be readjusted to the 12-inch level. Enter results into the data table (See **section E.8**).

6. The average infiltration rate over the last trial should be used to calculate the design infiltration rate without a factor of safety applied. Alternatively, the infiltration rate measured over the range of water head applicable to the project stormwater system design may be used at the discretion of the professional overseeing the testing. The final rate must be reported in inches per hour.

7. Upon completion of the testing, the excavation must be backfilled.

8. For very rapidly-draining soils, it may not be possible to maintain a water head above the bottom of the test pit. If the infiltration rate meets or exceeds the flow of water into the test pit, conduct the test in the following manner:
    A. Approximate the area over which the water is infiltrating.
    B. Using a water meter, bucket, or other device, measure the rate of water discharging into the test pit.
    C. Calculate the infiltration rate by dividing the rate of discharge (cubic inches per hour) by the area over which it is infiltrating (square inches).

    Note that a maximum infiltration rate of 20 inches per hour can be used in stormwater system design.

E.5 Encased Falling Head Procedure Instructions

The encased falling head procedure is performed with a 6-inch casing that is embedded approximately 6 inches into the native soil. The goal of this field test is to evaluate the vertical infiltration rate through a 6-inch plug of soil, without allowing any lateral infiltration. The test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

1. Embed a solid 6-inch diameter casing into the native soil at the elevation of the proposed facility bottom (see **section E.8**). Ensure that the embedment provides a good seal around the pipe casing so that percolation will be limited to the 6-inch plug of the material within the casing. This method can also be used when testing within hollow stem augers, provided the driller and tester are reasonably certain that a good seal has been achieved between the soil and auger.

2. Fill the pipe with clean water a minimum of 1 foot above the soil to be tested and maintain this depth for at least 4 hours (or overnight if clay soils are present) to pre-saturate the native material. Any soil that sloughed into the hole during the soaking period should be removed. In sandy soils with little or no clay or silt, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

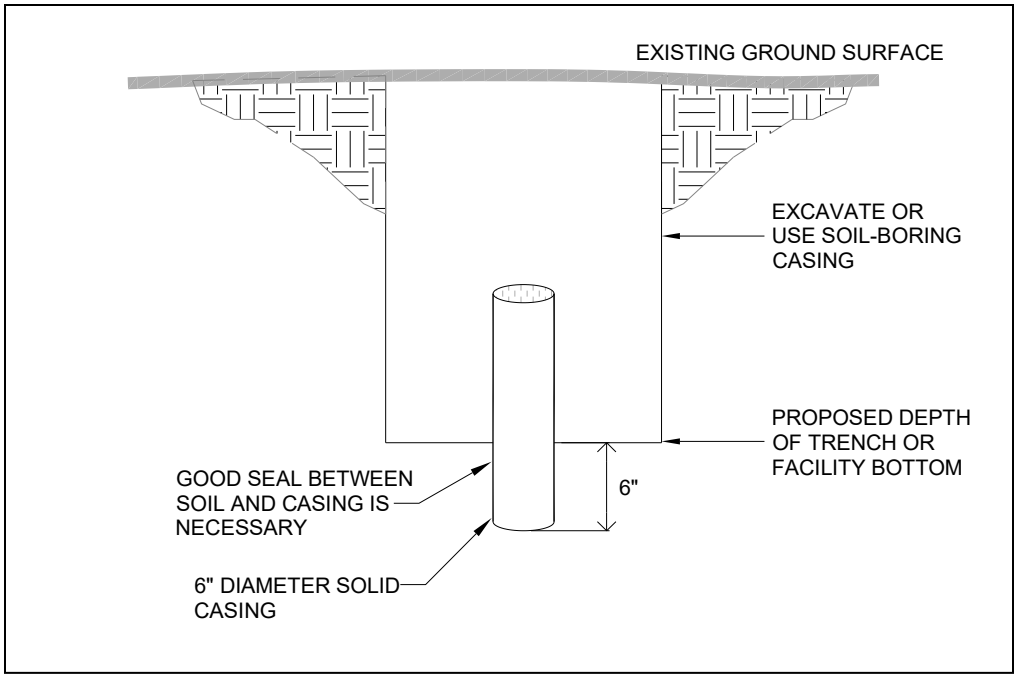
3. To conduct the first trial of the test, fill the pipe to approximately 12 inches above the soil and measure the water level to the nearest 0.01 foot (⅛ inch). Alternative water head heights may be used for testing provided the pre-saturation height is adjusted accordingly and the water head height used in infiltration testing is 50 percent or less than the water head height in the proposed stormwater system during the design storm event. The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.

4. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all the water has drained. In faster draining soils (sands and gravels), it may be necessary to shorten the measurement interval in order to obtain a well-defined infiltration rate curve. Constant head tests may be substituted for falling head tests at the discretion of the professional overseeing the infiltration testing. Successive trials should be run until the percent change in measured infiltration rate between two successive trials is minimal. The trial should be discounted if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level is readjusted to the 12-inch level. Enter results into the data table (see **section E.8**).

5. The average infiltration rate over the last trial should be used to calculate the unfactored infiltration rate. Alternatively, the infiltration rate measured over the range of water head applicable to the project stormwater system design may be used at the discretion of the professional overseeing the testing. The final rate must be reported in inches per hour.

6. Upon completion of the testing, the casing should be pulled and the test pit backfilled.

Figure E-1. Encased Falling Head Procedure



E.6 Double Ring Infiltrometer Test

The double-ring infiltrometer test procedure should be performed in accordance with ASTM 3385-94. The test is performed within two concentric casings embedded and sealed to the native soils. The outer ring maintains a volume of water to diminish the potential of lateral infiltration through the center casing. The volume of water added to the center ring to maintain a static water level is used to calculate the infiltration rate. The double-ring infiltrometer is appropriate only in soils where an adequate seal can be established.

E.7 Infiltration Test Report Requirements

The Infiltration Test Report must be attached to the project's Site Plan and Stormwater Report. The following information must be included in the Infiltration Testing Report:

1. Statement of project understanding (proposed stormwater system).

2. Name, contact information, professional license information and qualifications of the person conducting the infiltration test.

3. Summary of subsurface conditions encountered, including soil textures and the depth that they were found.

4. Summary of pre-saturation timing.

5. Summary of infiltration testing including location and number of tests and testing method used. Discussion of how the tests were performed (i.e. pipe type or diameter or test pit dimensions).

6. Infiltration testing results in inches per hour for each interval as well as the average for the entire testing period

7. Recommended design infiltration rate.

8. Groundwater observations within exploration and an estimate of the depth to seasonal high groundwater.

9. Site plan showing location of infiltration tests.

10. Boring or test pit logs. Boring or test pit logs will be required when an applicant's proposal relies on the presence of specific subsurface strata that allows infiltration. The logs must include an associated soil classification consistent with ASTM D2488-00, Standard Practice for Classification for Description and Identification of Soils (Visual-Manual Procedure). The logs must also include any additional pertinent subsurface information, such as soil moisture conditions, depth and description of undocumented or engineered fill, soil color and mottling conditions, soil stiffness or density, and approximate depth of contact between soil types.

11. A summary of the entire Infiltration Test

E.8 Infiltration Test Data Form

An example Infiltration Test Data Form is provided below, and then a blank form that can be used with an infiltration test report submittal is included at the end of this appendix.

Location: Lot 105, Point Heights Subdivision	**Date:** 3/27/2018	**Test Hole Number:** 3
Depth to bottom of hole: 63 inches	**Dimension of hole:** 0.5 feet diameter	**Test Method:** Encased Falling Head
Tester's Name: Guy Holeman **Tester's Company:** Infiltrator Brothers **Tester's Contact Number:** (503) 123-4567		
Depth (feet):	**Soil Texture:**	
0-0.5	Black Top Soil	
0.5-1.7	Brown SM	
1.7-2.9	Brown ML	
2.9-5.25	Brown CL	
Presaturation Start Time: 9:00 am		

Presaturation End Time: 1:00 pm					
Time:	**Time interval (minutes):**	**Measurement (feet):**	**Drop in water level (feet):**	**Infiltration rate (inches per hour):**	**Remarks:**
1:00	0	3.75	-		Filled with 6”
1:20	20	3.83	0.08		
1:40	20	3.91	0.08	2.88	
2:00	20	3.98	0.07	2.52	
2:20	20	4.04	0.06	2.16	
2:40	20	4.11	0.07	2.52	
3:00	20	4.17	0.06	2.16	
3:20	20	4.225	0.055	1.98	
			Average Infiltration rate =	2.37	
			Factor of Safety =	2	(minimum of 2)
			Design Infiltration Rate =	1.18	

E.9 Drywell Capacity Testing

When capacity testing is required as a condition of acceptance or approval of a drywell, the following procedure shall be used. Note that conducting this test will require getting approval from the local water provider for use of one or two hydrants.

1. Fill drywell with water at an initial rate equivalent to the minimum required design flow rate, or 300 gallons per minute (gpm), whichever is less.
    a. Record the water surface elevation below the drywell rim after 5 minutes
    b. Maintain the initial flow rate, recording the water surface elevation every 5 minutes, until the water surface elevation stabilizes.
2. If/when the water surface elevation stabilizes, and there is additional capacity in the hydrant or access to a second hydrant, increase the flow rate by another 300 gpm. Continue recording the water elevation every 5 minutes.
3. Repeat step 2 until:
    a. The drywell has reached the design capacity, or
    b. The drywell has reached the maximum allowable capacity for a single drywell, or
    c. The drywell has reached its actual in-place capacity, or
    d. The maximum flow rate from the water source has been reached*
4. Cease discharge of water to the drywell and record the water surface elevation every minute until the drywell is empty, or the water surface elevation has remained constant for a period of 5 minutes

*Note: the minimum peak inflow for a test to be considered valid shall be 600 gpm, unless this exceeds the design capacity of the drywell.

Only clean water shall be delivered to the drywell or sedimentation manhole for capacity testing. The introduction of silts, sediments, gravels, or any other foreign material shall not be permitted.

Infiltration Test Data Form

Location:	**Date:**	**Test Hole Number:**
Depth to bottom of hole:	**Dimension of hole:**	**Test Method:**
Tester's Name: **Tester's Company:** **Tester's Contact Number:**		

Depth (feet):	**Soil Texture:**

Presaturation Start Time:
Presaturation End Time:

Time:	**Time Interval (minutes):**	**Measurement (feet):**	**Drop in water level (feet):**	**Infiltration rate (inches per hour):**	**Remarks:**
			Average Infiltration rate =		
			Factor of Safety =		(minimum of 2)
			Design Infiltration Rate =		