City of Edmonds

Public Works Department, Engineering Division

121 5th Ave N
Edmonds, WA 98020

Checklist 4:
Methods for Determining Infiltration Rates

Per ECDC 18.30, all Category 1 projects must comply with Minimum Requirements No. 1 through No. 5, and all Category 2 projects must comply with Minimum Requirements No. 1 through No. 9. If infiltration facilities are proposed to meet Minimum Requirement Nos. 5, 6, and/or 7, soil infiltration rates must be measured using approved soil infiltration testing procedures.

Infiltration facilities shall be prepared in accordance with the Department of Ecology's Stormwater Management Manual for Western Washington (SWMMWW), ECDC 18.30, and the requirements in the Edmonds Stormwater Addendum (Addendum). Because the SWMMWW does not always include clear itemization of project procedural and/or submittal requirements, the City of Edmonds developed Appendix B of this Addendum (Methods for Determining Design Infiltration Rates) as well as this accompanying checklist to aid project proponents and plan reviewers in complying with the applicable SWMMWW requirements. In addition, City-specific requirements (i.e., requirements presented in ECDC 18.30 and the Addendum that are not included in the SWMMWW) are also included in the appendix and checklist.

This checklist reflects most, but not necessarily all, of the items that shall be performed by the project proponent, and documented for review by the Engineering Division. It is intended to be used as an aid for developers and plan reviewers by providing a foundation for clear and consistent infiltration evaluation processes in the City of Edmonds. However, all items may not be applicable to every project, and all items of concern to this office may not be covered on this checklist. Project proponents must review Appendix B in detail to identify complete infiltration testing requirements. Last, methods and procedures outlined herein can vary depending on the project. The headings outlined below represent the City's recommended process, though variations are acceptable as long as all of the required information is evaluated and documented.

Applicant:

Application #:

Within each blank cell, enter comment codes as follows: C = Complete R = Revise (i.e., make corrections) N/A = Not Applicable M = Missing (i.e., please include) IC = Incomplete		
		APPLICATIONS (SWMMWW Volume III, Section 3.3.5)
		Method 1 – Field Testing
1		*Large-Scale Pilot Infiltration Test (PIT) applies to infiltration facilities with drainage areas greater than 1 acre (i.e., projects that are using the "Detailed Method"- see Addendum Checklist 6), and may be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Minimum Requirement No. 5.*
2		*Small-Scale Pilot Infiltration Test (PIT) applies to infiltration facilities with drainage areas less than 1 acre (i.e., projects that are using the "Simple Method"- see Addendum Checklist 6), and may be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Minimum Requirement No. 5.*
3		*U.S. EPA Falling Head Percolation Test Procedure (as Modified for the City of Edmonds) may only be used for BMP performance verification testing. May not be used for BMP design or to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Minimum Requirement No. 5.*
		Method 2 – Soil Grain Size Analysis
4		*Soil Grain Size Analysis may only be used at project sites that are underlain by soils not consolidated by glacial advance (e.g., recessional outwash soils), and may not be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Minimum Requirement No. 5.*
		PROCEDURES (SWMMWW Volume III, Section 3.3.5 and 3.4)
5		See Addendum Appendix B – Methods for Determining Design Infiltration Rates, as well as Addendum Checklists 5 and 6.
		Correction Factor (SWMMWW Volume III, Section 3.3.6)
6		For application of correction factors for bioretention, permeable pavement, and rain gardens, refer to SWMMWW Volume III, Section 3.4; Addendum Appendix B; and Addendum Checklist 5: Field and Design Procedures for Bioretention, Permeable Pavement, Rain Gardens, and Downspout Infiltration Systems for application of correction factors.

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7		For all other infiltration facilities, the design saturated hydraulic conductivity is calculated using the following equation: $Ksat_{design} = Ksat_{initial} \times CF_V \times CF_T \times CF_M$ CF_v = CF for site variability and number of test locations • 0.33 to 1.0 • High uncertainty in subsurface conditions = lower CF_V • High certainty in subsurface conditions = higher CF_V CF_T = CF for test method used • For the large-scale PIT method, CF_T = 0.75; • For the small-scale PIT method, CF_T = 0.50 • For other small-scale infiltration tests (e.g., EPA falling head), CF_T = 0.40 • For grain size analysis, CF_T = 0.40. CF_M = CF for influent control to prevent siltation and bio-build up = 0.9.
		Method 1 – Field Testing (SWMMWW Volume III, Section 3.3.6)
		Large-Scale Pilot Infiltration Test (PIT)
		Preparation of Test Hole
8		Excavate the test pit to the depth of the bottom of the proposed infiltration facility.
9		Lay back the slopes sufficiently to avoid caving and erosion during the test, or consider shoring the sides of the test pit.
10		The horizontal surface area of the bottom of the test pit should be approximately 100 square feet.
11		Accurately document the size, location, and geometry of the test pit.
12		Install a vertical measuring rod (minimum 5 feet long) marked in 0.5-inch increments in the center of the pit bottom.
13		Convey water to the pit using a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit.
		Soaking Period
14		Pre-soak: Add water to the pit at a rate that will maintain a water level between 6 inches and 12 inches above the bottom of the pit. *Note: For infiltration facilities serving large drainage areas, designs with multiple feet of standing water can have infiltration tests with greater than 1 foot of standing water. The depth must not exceed the proposed maximum depth of water expected in the completed facility.*
15		Every 15 to 30 minutes, record the cumulative volume and instantaneous flow rate (in gallons per minute) necessary to maintain the water level at the same point on the measuring rod.

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16		Add water to the pit until 1 hour after the flow rate into the pit has stabilized while maintaining the same pond water level (usually 6 hours). The total of the pre-soak time plus 1 hour after the flow rate has stabilized should be no less than 6 hours.
		Measurement of the Infiltration Rate
17		After the flow rate has stabilized for at least 1 hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty. Use 30-minute or 1-hour increments.
		Calculate the Design Infiltration Rate
18		Calculate and record the infiltration rate in inches per hour. Use the lowest hourly rate determined in row 17 above.
19		To compute the design infiltration rate ($Ksat_{design}$), adjust the final measured infiltration rates by the appropriate correction factors outlined above.
		Groundwater Mounding
20		Over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the design professional engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.
		Small-Scale Pilot Infiltration Test
		Preparation of Test Hole
21		Excavate the test pit to the estimated surface elevation of the proposed infiltration facility.
22		For bioretention, excavate to the estimated elevation at which the imported soil mix will lie on top of the underlying native soil.
23		For permeable pavements, excavate to the elevation at which the imported subgrade materials, or the pavement itself, will contact the underlying native soil.
24		Lay back the slopes sufficiently to avoid caving and erosion during the test, or consider shoring the sides of the test pit.
25		The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet.
26		Accurately document the size, location, and geometry of the test pit.
27		Install a vertical measuring rod that is marked in 0.5-inch increments in the center of the pit bottom.
28		Convey water to the pit using a rigid pipe with a splash plate on the bottom to convey water to the pit. Use a 3-inch-diameter pipe for pits on the smaller end of the recommended surface area, and a 4-inch pipe for pits on the larger end of the recommended surface area.
		Soaking Period
29		Pre-soak: Add water to the pit so that there is standing water for at least 6 hours. Maintain the water level at least 12 inches above the bottom of the pit.
30		Add water to the pit at a rate that will maintain a fixed 6- to 12-inch water level above the bottom of the pit over a full hour. The depth should not exceed the proposed maximum depth of water expected in the completed facility.

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31		Every 15 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 6 to 12 inches) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 to 12 inches).
		Measurement of the Infiltration Rate
32		After the flow rate has stabilized for 1 hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty. Use 15-minute increments if feasible.
		Calculate the Design Infiltration Rate
33		Calculate and record the infiltration rate in inches per hour. Use the lowest hourly rate determined in row 32 above.
34		To compute the design infiltration rate ($Ksat_{design}$), adjust the final measured infiltration rates by the appropriate correction factors outlined above.
		Groundwater Mounding
35		Over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The soils professional should judge whether a mounding analysis is necessary.
		Falling Head Percolation Test Procedure (as Modified for the City of Edmonds; for performance verification only)
36		Space tests uniformly throughout the area. If soil conditions are highly variable, more tests may be required.
		Preparation of Test Hole
37		The diameter of each test hole is 8 inches.
38		The depth of each test is to the proposed depths of the absorption systems or to the most limiting soil horizon.
39		To expose a natural soil surface, scratch the bottom of the hole with a sharp pointed instrument and remove the loose material from the test hole.
40		Set a PVC pipe (6 inch-inner-diameter, 4 foot long) into the hole and press into the soil 6 inches.
41		Place 2 inches of 0.5- to 0.75-inch rock in the pipe to protect the bottom from scouring when water is added.
		Soaking Period
42		In sandy soils with little or no clay, soaking is not necessary (proceed to Measurement of the Percolation Rate).
43		Carefully fill the pipe with at least 12 inches of clear water. Maintain the depth of water for at least 4 hours (and preferably overnight if clay soils are present).
44		If, after filling the pipe twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately (proceed to Measurement of the Percolation Rate).

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		Measurement of the Percolation Rate
45		Except for sandy soils, make percolation rate measurements 15 hours but no more than 30 hours after the soaking period began.
46		Adjust the water level to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel.
47		Immediately after adjustment, measure the water level from a fixed reference point to the nearest 1/16th inch at 30-minute intervals. Continue the test until two successive water level drops do not vary by more than 1/16 inch within a 90-minute period. At least three measurements are to be made.
48		After each measurement, readjust the water level to the 6-inch level.
49		Use the last water level drop to calculate the percolation rate.
50		In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, make water level measurements at 10-minute intervals for a 1-hour period. Use the last water level drop to calculate the percolation rate.
		Calculate the Design Infiltration Rate
51		Calculate the percolation rate for each test site by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in minutes/inch. To determine the percolation rate for the area, average the rates obtained from each hole. (If tests in the area vary by more than 20 minutes/inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.)
52		To compute the design infiltration rate ($Ksat_{design}$), adjust the final percolation rates by the appropriate correction factors outlined above.
		Method 3 – Soil Grain Analysis (SWMMWW Volume III, Section 3.3.6)
53		For infiltration basins and trenches, perform the grain size analysis for each defined layer below the infiltration facility to a depth below the facility bottom of 2.5 times the maximum depth of water in the pond, but not less than 10 feet.
54		For large infiltration facilities serving drainage areas of 10 acres or more, soil grain size analyses are performed on layers up to 50 feet deep (or no more than 10 feet below the water table).
55		For bioretention areas, each defined layer is analyzed below the top of the final bioretention area subgrade to a depth of at least 3 times the maximum ponding depth, but not less than 3 feet (1 meter).
56		For permeable pavement, each defined layer is analyzed below the top of the final subgrade to a depth of at least 3 times the maximum ponding depth within the base (reservoir) course, but not less than 3 feet (1 meter).
57		If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths may be considered when assessing the site's hydraulic conductivity characteristics.

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58		Use the following relationship to determine the initial hydraulic conductivity: $\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$ Where, D_{10}, D_{60}, and D_{90} are the grain sizes in mm for which 10 percent, 60 percent, and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the US #200 sieve (Ksat is in cm/s).
59		Compaction effects must be taken into account when estimating hydraulic conductivity where applicable.

Reviewer: _____

Review Date: _____

Reviewer Phone #: _____

Reviewer Comments: