Appendix D -

Retention Based Technical Infeasibility Determination Procedures Sizing Methods

Appendix D-1

The following guidance for determining a site's potential use for LID was prepared by the Joint Effort Reporting Team (JERT). A site deemed not appropriate for LID must evaluate the potential to utilize bio-retention techniques prior to making a technical infeasibility determination. See **Appendix D-2** for Bio-Filtration Feasibility Assessment Steps.

SOIL INFILTRATION ASSESSMENT
for
Low Impact Development

Introduction and Purpose

This document provides guidance for conducting a Soil Infiltration Assessment to support the use of shallow or deep infiltration based stormwater control measures (SCMs), such as low impact development. This guidance is intended to provide a universal starting point for assessment of the infiltration characteristics of each project site and provide useful data in a cost-effective manner. Consideration and discussion of the application of these guidelines among the jurisdiction, the design professional and the geotechnical engineer is encouraged. They should be modified using sound engineering and geologic judgment to accommodate the unique characteristics of each project as they relate to each unique site.

The guidelines walk the user through a step-wise process from an Initial Site Assessment to a level of soil/geotechnical methodology appropriate for the site. The concept is to obtain information to:

1. Assess the general potential within the site for infiltration based SCMs
2. Provide a preliminary methodology to obtain soil infiltration data while balancing the need for data with the cost of acquiring the data.
3. Provide an extended or more comprehensive soil/geotechnical methodology where the results from the preliminary methodology as well as other site considerations warrant a more thorough soil analysis to facilitate better SCM design.

Note: Throughout this document the term "boring" is used for the purpose of observing the soil profile. However, except as indicated otherwise, an "excavation" may be substituted for the same purpose. Similarly, the term "drill" is the term used as the means of creating the boring. Except as otherwise indicated, it is meant to be synonymous with "excavating" or "digging" of an excavation. The two methods are meant to be interchangeable.

THESE METHODS DO NOT ADDRESS HEALTH OR SAFETY ASPECTS ASSOCIATED WITH THEIR USE. HEALTH AND SAFETY OF PERSONEL

CONDUCTING THE METHODOLOGIES AND OF PEDESTRIANS, PASSERS-BY, SITE OWNERS OR TENANTS, ETC. SHOULD BE CONSIDERED. IT IS THE RESPONSIBILITY OF THE USER TO COMPLY WITH ALL APPLICABLE HEALTH AND SAFETY LAWS, REGULATIONS, POLICIES AND PROCEDURES, AND TO ENSURE THAT THE METHODOLOGIES ARE USED SAFELY.

The methodologies are guidelines only for the means of assessing the infiltration rates. Aspects related to permits, disposal of soil cuttings and samples, backfill, compaction, site restoration, etc. are not addressed. It is incumbent on the user to follow all laws, regulations, policies and procedures in decommissioning the borings.

Step 1: Initial Site Assessment

Initial Site Assessment is encouraged early in the design of post-construction SCMs. Infiltration SCMs may be required to comply with State post-construction stormwater control requirements. Various characteristics of a site may limit or preclude the use of infiltration SCMs including soil and geotechnical constraints. Early in the project planning phase, the Project Applicant should identify all site characteristics that may influence (both positively and negatively), the ability of the site to infiltrate stormwater. The list below relates to soil and geotechnical feasibility only and the Project Applicant is encouraged review the full list of possible infeasibility constraints as provided by the municipality.

Initial Site Assessment related to infiltration potential should include, but is not limited to:

- Slope / topography of parcel
- Descending slopes nearby
- Protected Vegetation (endangered species, heritage oaks, etc.)
- Springs, seeps
- Bedrock outcrops
- Soil types from USDA Soil Charts, local geologic and geotechnical knowledge, etc.
- Area(s) available for infiltration
- Nearby wells
- Soil of groundwater contamination
- Other geotechnical constraints that may impact public safety or property

Step 2: Interpretation of Initial Site Assessment

If the Initial Site Assessment indicates that there is documentation of characteristics that entirely preclude the use of shallow or deep infiltration based SCMs, go to **Step 2A**.

Examples of such characteristics might be unstable slopes throughout the site; high groundwater, shallow impervious bedrock throughout the site, etc. Note: poor soils do not necessarily preclude the use of infiltration based BMPs but may limit the amount of infiltration.

If the Initial Site Assessment indicates that site characteristics do not preclude the use of infiltration based SCMs, go to **Step 2B**.

Step 2A: Omit use of infiltration-based SCMs, Infiltration analysis complete.

When site conditions entirely preclude the use of infiltration-based SCMs, the Project Applicant will need to contact the municipal representative responsible for the project to determine any required documentation of the infiltration infeasibility and the adjusted post-construction requirements for the project.

Step 2B: Conduct Quick Infiltration Testing

If Initial Site Assessment indicates that use of shallow infiltration-based SCMs (e.g. vegetated swales, bioswales, bioretention facilities, shallow infiltration basins, etc.) may be feasible, a "Shallow Quick Infiltration Test" may provide information to refine shallow SCM siting within the project and associated sizing calculations. See **Attachment 1** for Shallow Quick Infiltration Test methodology.

If Initial Site Assessment indicates that use of deep SCMs (e.g. seepage pits, deep infiltration basins, etc.) may be feasible, a "Deep Quick Infiltration Test" may provide information to refine deep SCM siting within the project and associated sizing calculations. See **Attachment 2** for Deep Quick Infiltration Test methodology.

Step 2C: Interpretation of Quick Infiltration Test Results

If results of the "quick" test (shallow or deep) are 5 inches/hour or slower (moderate to poor soils), then no further data are needed and soil infiltration assessment is complete. Design of SCMs should be based upon the data acquired, as modified by appropriate factors (i.e. factors for size and scale of the SCM, anticipated maintenance, initial and final silt loading, etc.)

Similarly, if results of the Quick Infiltration Testing (shallow or deep) indicate good soils (infiltration rates faster than 5 inches/hour), AND no further data are considered to be necessary for the SCM design, soil infiltration assessment is complete. Design of SCMs should be based upon the data acquired, as modified by appropriate factors (i.e. factors for size and scale of the SCM, anticipated maintenance, initial and final silt loading, etc.).

If results of the Quick Infiltration Testing (shallow or deep) indicate good soils (i.e. infiltration rates faster than 5 inches/hour), AND other considerations may necessitate more soil data, then “Extended Infiltration Testing” should be conducted. See **Attachment 3** for Extended Infiltration Testing methodology.

ATTACHMENT 1

Shallow Quick Infiltration Testing Methodology

1. For small sites with limited areas for infiltration-based SCMs, drill 1 profile boring and 2 infiltration test borings in each potential SCM area.

2. For acreage and unconstrained sites:
   - Up to 5 acres: drill 1 profile boring and 2 infiltration test borings per acre potentially usable for SCMs.
   - Over 5 acres: drill 1 profile boring and 2 infiltration test borings per geologic unit that may be usable for SCMs, with 2 to 4 infiltration test borings associated with each profile boring.

3. Profile borings should be 6" to 12" diameter. Where the planned SCMs will be constructed near the site's existing grade, borings should be 10' to 15' deep. If significant cuts will be necessary to install the SCMs, the borings should extend 5' to 10' below the invert of the planned SCM. The boring cuttings should be observed and the soils in the borings sampled as necessary to allow accurate logging. Where excavations are utilized to determine the profile, they should be no wider than necessary to facilitate logging of the strata with the same level of detail as for borings.

4. All soil strata should be identified on the logs as to USCS classification, consistency, presence of moisture or free water, color, impermeable and permeable zones, and any other characteristics that may be pertinent to infiltration potential. All logs should include the boring identification, date of drilling, auger type and diameter, sampling methods, and surface elevation (known or assumed).

5. Infiltration test borings should also be 6" to 12" diameter. They should be of depths such that the zone tested will range from about the elevation of SCM invert, to about 2' below the elevation of the invert.

6. Infiltration test excavations should be dug by any means to approximately the elevation of the *top* of the planned SCM. From the elevation of the top of the planned SCM to 2' below the elevation of the *invert* of the SCM, a hand auger or hand shovel should be used to excavate the actual test zone. Preferably, the test zone should be 6" to 12" in diameter; if conditions mandate a larger diameter, it should be as close to 12" as is practicable.

7. A perforated pipe, of a diameter that will facilitate the taking of the test measurements should be placed in each test boring or in the test zone of each test excavation.

8. The annulus between each perforated pipe and the boring sidewall should be filled with fine gravel.

9. A suitable elevation datum should be established from which each measurement can be taken. The elevation of the datum relative to the elevation of the top of the SCM should be noted.

10. Using a hose equipped with a water meter, a graduated water tank, or other suitable means of measuring water volume, add water to the approximate elevation of *top* of the planned SCM and maintain the head for 30 minutes.

11. At the end of the 30-minute period, shut off water and record volume of water that entered the test boring.

12. As the water level falls, measure from the datum to the water level at suitable intervals. Measurements should be to the degree of precision practicable (usually 1/8-inch or 0.01 foot) for a period of 2 hours. Depending upon the rate of fall, intervals between measurements may need to be from 1 minute to 30 minutes. Intervals should be as uniform as is practicable, however, as the water level falls and the head is reduced, the infiltration rate may decrease and the measurement intervals may need to be incrementally lengthened.

13. If a test boring runs dry within 2-hour measurement period, refill the boring and continue measuring the falling head to end of original 2-hour period. If it runs dry again, refill and continue measurements to the end of the original 2-hour period. If it runs dry a third time, do not refill, the testing of that boring is complete.

14. If the fall recorded in any test boring is less than 6” in 2 hours, continue taking measurements for an additional 2 hours (4 hours total).

15. See **Attachment 4** for a discussion of how to report the test results.

ATTACHEMENT 2

Deep Quick Infiltration Testing Methodology

1. For small sites with limited areas for infiltration-based SCMs, drill 2 profile / test borings in each potential deep SCM area.

2. For acreage and unconstrained sites:
   - Up to 5 acres: drill 3 profile / test borings per acre potentially usable for SCMs.
   - Over 5 acres: drill 4 profile / test borings per geologic unit that may be usable for SCMs.

3. Profile / test borings should be 6" to 12" diameter. The borings should extend 5' to 10' below the bottom of the planned SCM. The boring cuttings should be observed and the soils in the borings sampled as necessary to allow accurate logging. Use of excavations for deep testing is probably not practical.

4. All soil strata should be identified on the logs as to USCS classification, consistency, presence of moisture or free water, color, permeable and impermeable zones, and any other characteristics that may be pertinent to infiltration potential. All logs should include the boring identification, date of drilling, auger type and diameter, sampling methods, and surface elevation (known or assumed).

5. A perforated pipe, of a diameter that will facilitate the taking of test measurements should be placed in each profile / test boring.

6. The annulus between each perforated pipe and the boring sidewall should be filled with fine gravel.

7. A suitable elevation datum should be established from which each measurement can be taken. The elevation of the datum relative to the elevation of the top of the SCM should be noted.

8. Using a garden hose equipped with a water meter, a graduated water tank, or other suitable means of measuring water volume, add water to approximate elevation of *top* of the planned SCM and maintain the head for 30 minutes.

9. At the end of the 30-minute period, shut off water and record volume of water that entered the test boring.

10. As the water level falls, measure from the datum to the water level at suitable intervals. Measurements should be to the degree of precision practicable

(usually 1/8-inch or 0.01 foot) for a period of 2 hours. Depending upon the rate of fall, intervals between measurements may need to be from 1 minute to 30 minutes. Intervals should be as uniform as is practicable, however, as the water level falls and the head is reduced, the infiltration rate may decrease and the reading intervals may need to be incrementally lengthened.

11. If a test boring runs dry within the 2-hour measurement period, refill the boring and continue measuring the falling head to end of original 2-hour period. If it runs dry again, refill and continue measurements to the end of the original 2-hour period. If it runs dry a third time, do not refill, the testing of that boring is complete.

12. If the fall recorded in any test boring is less than 6” in 2 hours, discontinue testing as deep infiltration is not practical.

13. See **Attachment 4** for a discussion of how to report the test results.

ATTACHMENT 3

Extended Test Methodology

The following "extended" methodology is intended to provide more comprehensive soil/geotechnical information where the results from the Initial Site Assessment and/or Quick methodology, as well as other site and design considerations warrant a more thorough soil analysis to facilitate better SCM design.

1. Extended test methodology for *deep* SCMs is too complex an issue to be adequately addressed in these guidelines. Test locations, depths, methods, etc. should be discussed among the jurisdiction, the design professional and the geotechnical engineer and a consensus reached as to the appropriate means of securing the data required for design of the deep SCMs on the specific site.

2. For *shallow* extended testing, locations, depths, continuity of subsurface conditions, etc. should be discussed among the jurisdiction, the design professional and the geotechnical engineer. Consideration should be given to drilling and testing at least twice as many test borings as recommended under Quick Testing.

3. Extended shallow test methodology should be essentially the same as Steps 3 through 14 under Quick Testing, except for the following:
    a. Consideration should be given to presoaking the test borings for up to 24 hours prior to commencing testing.
    b. Measurements for extended testing should continue for 4 hours or more, regardless of infiltration rates.
    c. The 30-minute constant head period may be excluded if adequate constant head data were obtained during Quick Testing.

4. See **Attachment 4** for a discussion of how to report the test results.

ATTACHMENT 4

Reporting of Test Results

1. Reporting of test results, whether quick or extended, shallow or deep, should contain essentially the same information.

2. For each test boring, tabulate the test data showing:
   a. Test identification
   b. Date drilled
   c. Date tested
   d. Test boring diameter
   e. Perforated pipe diameter
   f. Test boring depth
   g. Stratum present in the test zone
   h. Elevation of top of SCM (known or assumed)
   i. Elevation of invert of SCM (known or assumed)
   j. Test duration
   k. Volume introduced between commencement of filling and the end of the 30-minute constant head period, typically in units of cubic feet
   l. Head during initial 30-minute period
   m. Time of the first falling head measurement and depth to the water surface
   n. Time of each subsequent measurement and depth to the water surface
   o. Intervals between measurements
   p. Incremental drop between measurements
   q. Infiltration rate between measurements, typically in units of inches per hour

3. Provide a map showing the approximate locations of all profile and test borings, as well as property lines, landmarks, planned improvements and SCM locations (if known), and other pertinent features that will help the user better understand the boring and testing program.

4. Provide log of each profile boring

5. Provide report summarizing data and discussing the potential for use of infiltration based SCMs on the site or area(s) tested.

Appendix D2: Biofiltration Infeasibility Criteria

If Low Impact Development is not technically infeasible, the project may utilize the checklist below to determine if the project is also exempt from using biofiltration measures:

- ☐ Biofiltration is not compatible with surrounding drainage system
- ☐ Location available for biofiltration facility is in an area with identified erosion or landslide hazards
- ☐ Location available for biofiltration facility is on a slope equal to or in excess of 8 percent.
- ☐ Location available for biofiltration facility is within 50-feet from the projected top of the slope (using projected angle of repose) that is great than 20%
- ☐ Areas where runoff potentially contains industrial wastes
- ☐ Areas where there is a higher risk of concentrated spills (such as gas stations, truck stops)
- ☐ _____

The checklist above is not absolute, and still requires County concurrence.

Appendix D3: Ten Percent Adjustment to Retention Volume

Calculation Instructions

When full on-site compliance with the Runoff Retention Performance Requirement is prevented due to technical infeasibility, on-site retention of the full Retention Volume is not required and the Regulated Project is required to dedicate no less than ten percent of the Regulated Project's Equivalent Impervious Surface Area to retention-based Stormwater Control Measures.

The Water Quality Treatment Performance Requirement is not subject to this adjustment, i.e., mitigation to achieve full compliance is required on- or off-site.

1) Calculating Ten Percent of a Project's Equivalent Impervious Surface Area

The area of the project that must be dedicated to structural SCMs to waive off-site compliance with the Runoff Retention Requirement is equal to ten percent of the project's Equivalent Impervious Surface Area, defined as:

Equivalent Impervious Surface Area (ft^2) = (Impervious Tributary Surface Area (ft^2) + (Pervious Tributary Surface Area (ft^2))

Impervious Tributary Surface Area is defined as the sum of all of the site's conventional impervious surfaces. When calculating Impervious Tributary Area:

Do include: concrete, asphalt, conventional roofs, metal structures and similar surfaces
Do not include: green roofs

Pervious Tributary Surface Area is defined as the sum of all of the site's pervious surfaces, corrected by a factor equal to the surface's runoff coefficient. When calculating Pervious Tributary Surface Area:

Do include surfaces such as: unit pavers on sand; managed turf[1]; disturbed soils; and conventional landscaped areas (see Table 1 for correction factors).

Example:

Project Site includes 500 ft^2 of unit pavers on sand.
Pervious Tributary Surface Area = 500 ft^2 x C = 50 ft^2
Where C = Correction Factor for unit pavers, 0.1, from Table 1.

Do not include: Infiltration SCM surfaces (e.g., SCMs designed to specific performance objectives for retention/infiltration) including bioretention cells, bioswales; natural and undisturbed landscape areas, or landscape areas compliant with the Model Water Efficient Landscape Ordinance (California Code of Regulations, Title 23. Waters, Division 2.

[1] Managed Turf includes turf areas intended to be mowed and maintained as turf within residential, commercial, industrial, and institutional settings.

Department of Water Resources, Chapter 2.7.), or a local ordinance at least as effective as the Model Water Efficient Landscape Ordinance.

TABLE 1: Correction Factors[2] for Use in Calculating Equivalent Impervious Surface Area

Pervious Surface	**Correction Factor**
Disturbed Soils/Managed Turf (dependent on original Hydrologic Soil Group)	A: 0.15 B: 0.20 C: 0.22 D: 0.25
Pervious Concrete	0.60
Cobbles	0.60
Pervious Asphalt	0.55
Natural Stone (without grout)	0.25
Turf Block	0.15
Brick (without grout)	0.13
Unit Pavers on Sand	0.10
Crushed Aggregate	0.10
Grass	0.10

[2] Factors are based on runoff coefficients selected from different sources: Turf and Disturbed Soils *from Technical Memorandum: The Runoff Reduction Method*. Center for Watershed Protection & Chesapeake Stormwater Network. p.13, April 18, 2008.
http://town.plympton.ma.us/pdf/land/scheuler_runoff_reduction_method_techMemo.pdf.
All other correction factors from *C.3 Stormwater Handbook, Santa Clara Valley Urban Runoff Pollution Prevention Program, Appendix F*, p. F-9., May 2004.
http://www.sanjoseca.gov/planning/stormwater/pdfs/appendices_files/Appendix_F_Final.pdf