

Appendix H

RIGHT-OF-WAY GUIDANCE MATERIALS

- ROW GEOTECHNICAL PROCEDURES



Environmental
Protection



NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF ENVIRONMENTAL PLANNING AND ANALYSIS

PROCEDURE GOVERNING

LIMITED GEOTECHNICAL INVESTIGATION

FOR

RIGHT-OF-WAY STORMWATER MANAGEMENT PRACTICES

NYC Stormwater Manual

July 2021

Table of Contents

1 General Guidelines 1

 1.1 Geotechnical Investigation Locations 1

 1.2 Geotechnical Investigation Methodology..... 2

 1.2.1 Soil Boring Procedure and Equipment..... 2

 1.2.2 Permeability Test Procedure and Equipment..... 3

 1.2.3 Geotechnical Investigation Depths..... 6

 1.3 Geotechnical Laboratory Testing 6

2 Geotechnical Report..... 7

 2.1 Geotechnical Investigation Data 7

 2.1.1 Geotechnical Report Summary Table 7

 2.1.2 Boring Logs..... 7

 2.1.3 Permeability Test Logs 8

 2.1.4 Laboratory Test Results 8

Attachments:

- Attachment A: Geotechnical Report Summary Table
- Attachment B: Soil Boring Log
- Attachment C: Falling-Head Borehole Test Log
- Attachment D: Soil Sampling Laboratory Test Results (Example)

Limited Geotechnical Investigation

1 General Guidelines

The Limited Geotechnical Investigation consists of:

- a) Soil borings to determine the soil characteristics (field observation and laboratory testing) as well as the depths to groundwater table and bedrock where encountered, AND
- b) In-situ soil permeability tests to determine infiltration rates of the existing soil.

The minimum required number of soil borings and permeability tests, collectively referred to as B/PTs, is as follows depending on the size (footprint area) of the proposed stormwater management practice (SMP):

- SMPs with areas less than 1000 SF: at least one B/PT per SMP
- SMPs with areas 1000 SF or more and less than 5000 SF: at least two B/PTs per SMP
- Additionally, the Qualified Professional¹ must make a reasonable determination based on the soil textural classifications and the standard penetration tests to determine if additional tests may be needed; this is particularly critical in areas of fill soils where characteristics will vary greatly over small distances.

Where two or more B/PTs are being conducted for a single SMP, the Qualified Professional must select appropriate locations and spacing between the B/PTs to ensure the geotechnical investigation results will be representative of the underlying soil across the footprint of the SMP.

The following sections provide more detail on the soil boring and PT procedures.

1.1 Geotechnical Investigation Locations

Soil borings and permeability tests shall be conducted in separate boreholes no closer than 5 ft apart. If a boulder or other obstruction is encountered during drilling for any SMP, another attempt shall be made within 5 ft - 10 ft of the original borehole. Each borehole should be given a name corresponding to the SMP ID and the test (B/PT) and an accurate coordinate (latitude and longitude) of each borehole should be recorded.

Soil borings and PTs must be performed within the footprint of the SMP. In the event that drilling cannot be conducted within the footprint area, drilling should be done no more than 10 ft beyond the footprint of the SMP.

¹ As defined in Chapter 19.1 of Title 15 of Rules of the City of New York

1.2 Geotechnical Investigation Methodology

1.2.1 Soil Boring Procedure and Equipment

The Qualified Professional shall approve the drilling method that will minimize disturbance to the soil tested from the following list of acceptable equipment:

- Direct Push Method with a 4-inch inner diameter casing
- Hollow-stem auger (HSA) with a 4-inch inner diameter hollow-stem
- Rotary Tri-cone Roller Bit cased by 4-inch inner diameter casing

In the event that no subsurface records (utility records such as water, sewer, etc) were obtainable for drilling and/or the Qualified Professional chooses, pneumatic and/or hand auger is an acceptable method of boring up to the depth of the first soil sample or PT (see **Section 1.2.3.** for soil sampling and PT depths). The reason for conducting this procedure must be properly documented and reported to DEP.

Only water from a hydrant or any clean potable water source shall be used as drilling fluid. It is not acceptable to recycle the drilling fluid or to use drilling mud. Proper sediment control must be used at all times to prevent runoff containing fine or coarse material from entering the catch basins or leaving the work zone.

The Qualified Professional shall be on-site to observe the soil boring operation and keep a continuous and accurate Boring Log for each location recording all pertinent data. Refer to **Section 2.1.1** for details on the Boring Log.

1.2.1.1 *Standard Penetration Test*

In each soil boring location, a Standard Penetration Test (SPT) shall be conducted continuously in accordance with ASTM D1586 (i.e. a 24-inch long, 2-inch outside diameter split-barrel-sampler driven by blows from a 140-pound hammer falling freely from a height of 30 inches) to the depth detailed in **Section 1.2.3.**

The number of blows required to drive the 24-inch split-barrel sampler every 6-inch increment will be recorded. The Standard Penetration Resistance (N-value) shall be determined as the sum of the blows required to drive the sampler to the second and third 6-inch increments, representing the number of blows per foot.

1.2.1.2 *Soil Sampling*

The Qualified Professional shall make observations of the soil samples at all depths during drilling and submit observations for each soil boring location as individual Boring Logs.

The Qualified Professional shall collect soil samples that are representative of the actual recovered soil at specific depths for laboratory analysis. Collected samples shall be stored in labeled jars, to be delivered to an approved AASHTO-certified laboratory for subsequent examination and testing. Samples shall be taken and tested as outlined in **Section 1.3.**

1.2.2 Permeability Test Procedure and Equipment

The recommended method for the in-situ permeability test is the falling-head borehole test as outlined below; however, the Qualified Professional may choose to conduct permeability tests following a percolation test or double-ring infiltrometer test procedure, depending on project or site conditions.

Prior to conducting any permeability test, the following conditions shall be checked:

- If a soil boring was conducted within 20 ft. of a planned PT location, the borehole from the soil boring must be completely backfilled before the PT is commenced.
- Clean water must be used in conducting PTs. PTs conducted using “dirty water” creates faulty results, which shall be rejected, and retest will be required.
- Permeability tests shall not be performed when the ambient temperature is below 0°C, in frozen soils, or with water at temperatures less than 5°C (see **Section 1.2.2.4** on temperature measurement requirements).

1.2.2.1 *Falling-head borehole test procedure*

The falling-head borehole test procedure is as follows:

- Drive the 4-inch inner diameter casing to the required test depth (refer to soil boring procedure for allowable equipment). The space (annulus) between the casing and borehole must be kept at a minimum. If the casing cannot be driven and a larger hole is first bored to allow for the casing, the annulus must be backfilled and packed with drill cuttings before any water is introduced for testing into the casing.
- Measure the depth to the bottom of the hole to the nearest inch.
- Ensure that the depth to the bottom of the hole is within 1 inch of the depth to the bottom of the casing.
- Place approximately 6 - 8 inches of coarse sand (4.75mm – 2mm) at the bottom of the casing.
- Wash out casing using a continuous flow of clean water at low water pressure (the water shall not disturb the coarse sand layer at the bottom of the casing) until the water exiting the casing runs clear with no discoloration.
- Saturate the soil beneath the bottom of the casing for at least thirty (30) minutes using clean water.
- Fill casing to the top with clean water and record the temperature of the water at the bottom of the casing at the start of the test (see **Section 1.2.2.4** for details on temperature measurement).
- Record the time at the beginning of the test.
- Record the falling water level in the casing at 1, 2, 3, 4, 5, 10, and 15 minutes after the beginning of the test or until the water level in the casing has stopped falling.

- At the conclusion of the test, fill the casing to the top with clean water and maintain the water at this level for five (5) minutes.
- Repeat the test once for each testing depth using the same procedure.

Falling-head borehole tests may be terminated after the 30-minute saturation period and reported accordingly for the following conditions:

- If the casing is completely filled during the saturation period and there is no visible drop in water level after 30 minutes, the falling-head borehole test shall be reattempted for the same depth at another location between 5 ft to 10 ft away. If there is no visible drop in water level after 30 minutes at the reattempted location, the falling-head borehole test shall be terminated for that depth only and the soil permeability rate shall be reported as “0.000 in/hr”.
- If the casing cannot be filled due to rapid infiltration (RI) during the saturation period and no water is retained in the casing after 30 minutes, the falling-head borehole test shall be reattempted for the same depth at another location between 5 ft to 10 ft away. If rapid infiltration is observed during the saturation period for the reattempt, the falling-head borehole test shall be terminated for that depth only and the permeability coefficient reported as “RI”.

The Qualified Professional must log continuous data during this test and report them accurately in Falling-head Borehole Test Logs (FH Logs). Refer to the below and **Section 2.1.3** for details on the PT Log.

Average permeability rates shall be calculated based on a modification of ASTM D6391 using the following formula. The FH Log template with the formula and associated calculation methods is provided. In general, no permeability calculations are necessary at the time of drilling since permeability values (and other variables used to calculate permeability values) are automatically calculated in the FH Log once all the data recorded during the falling-head borehole test are inputted into the template.

$$K_m = \pi \cdot R_t \cdot \frac{D \cdot \left(\ln \frac{h_1}{h_2}\right)}{11 \cdot (t_2 - t_1)}$$

$$R_t = \frac{2.2902(0.9842^T)}{T^{0.1702}}$$

Where:	K_m	= Mean permeability [in/hr], and $K_m = \sqrt{k_h \cdot k_v}$
	k_h	= Horizontal permeability [in/hr]
	k_v	= Vertical permeability [in/hr]
	D	= Inner diameter of casing [in]
	h	= Height of water above bottom of casing at time t [in]
	t	= Time [hr]

R_t = Ratio of viscosity of water at test temperature to the viscosity of water at 20 °C

T = temperature [°C]

1.2.2.2 Percolation test procedure

Percolation tests are commonly used for on-site sewage (septic) and stormwater (dry well) systems. They differ from cased borehole tests in that there is no casing and there is no control for water lost at the sides of the test pit hole during percolation testing. The percolation test method shall not be utilized for proposed SMP locations less than 10 feet from buildings or underground structures. Percolation tests must be conducted in accordance with the NYS procedure² for onsite sewage treatment systems.

Following the above percolation test procedure will result in a measurement of the stabilized rate of percolation of the soil. This stabilized percolation rate must be translated to a permeability, or infiltration rate, using a reduction factor that accounts for water lost at the sides of the test pit. The following equation may be used to calculate the infiltration rate:

$$I = \frac{P_s}{R_f}$$

where:

I: infiltration rate (in/hr)

P_s : stabilized rate of percolation (in/hr)

R_f : Reduction factor of 1.92

The reduction factor assumes the percolation rate is affected by the depth of water in the test hole and that the percolating surface of the hole is in uniform soil. If there are site conditions that cause significant deviations from either assumption, such as noticeably different soil strata along the percolation test hole, then this methodology is not appropriate for determining infiltration rates.

1.2.2.3 Double-Ring Infiltrometer test procedure

Double-Ring Infiltrometer tests require less equipment compared to the other permeability test procedures but can be more difficult to use in very pervious or very impervious soils, in dry or stiff soils, or if the rings are fractured when installed. Double-Ring Infiltrometer tests shall be conducted in accordance with the latest version of ASTM D3385, the Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.

² Full procedure available at the following links (accessible as of July 2021):

https://www.dec.ny.gov/docs/water_pdf/2014designstd.pdf or

https://www.health.ny.gov/environmental/water/drinking/wastewater_treatment_systems/docs/design_handbook.pdf

1.2.2.4 Temperature Measurement

Temperatures shall be measured in °C using equipment meeting the specifications as shown in Table 1 and calibrated against a National Institute of Standards and Technology (NIST) Standard or with certified calibration traceable to NIST.

Table 1 – Acceptable Temperature Measurement Equipment

Equipment	Specifications
Liquid-in-glass thermometer (nonmercury)	<ul style="list-style-type: none"> • Temperature range, at least -5 to +45°C • 0.5°C gradations or smaller • Calibrated accuracy within 1 percent of full scale or 0.5°C, whichever is less
Thermistor	<ul style="list-style-type: none"> • Calibrated accuracy within 0.1 to 0.2°C • Digital readout to at least 0.1°C

1.2.3 Geotechnical Investigation Depths

The minimum depth for all soil borings is 20 ft or 5 ft below the SMP base (i.e. the depth of the infiltrating surface), whichever is deeper.

Bulk soil samples for laboratory testing shall be collected and analyzed for every 2 ft of soil depth, starting at the 3-5 ft depth then every 2 ft interval thereafter to the extent possible to the full soil boring depth. If different soil strata are encountered within an interval, the Qualified Professional is recommended to recover separate samples for each stratum.

PTs must be conducted at the depth of the SMP base. Qualified Professionals are recommended to conduct additional PTs at depths beyond the SMP base if soils with high fines are observed at the shallow depths and sandy soils are observed at deeper depths, which may allow for the use of stone columns for infiltration.

For example, a SMP that infiltrates at 5 ft depth requires, at a minimum:

- Soil boring to 20 ft
- Soil samples collected and analyzed at the following depths: 3-5 ft, 5-7 ft, 7-9 ft, 9-11 ft, 11-13 ft, 13-15 ft, 15-17 ft, 17-19 ft
- PT at 5 ft

Qualified Professionals should take into account any proposed surface elevation changes when determining appropriate geotechnical investigation depths.

1.3 Geotechnical Laboratory Testing

Laboratory tests shall be conducted by an AASHTO-certified laboratory to determine the distribution of particle sizes of the soil – particularly the fines (silts and clays) content – in accordance with ASTM D422.

2 Geotechnical Report

2.1 Geotechnical Investigation Data

Geotechnical reports must include a Geotechnical Report Summary Table, detailed boring logs, and permeability test logs. Additionally, field-measured B/PT locations must be accurately recorded and submitted on a map that also shows the location of the SMP(s).

2.1.1 Geotechnical Report Summary Table

Pertinent data from the soil borings, PTs, laboratory test results, and any other information acquired during the geotechnical investigation shall be summarized in the Geotechnical Report Summary Table format provided (see Attachment A).

2.1.2 Boring Logs

Separate boring logs must be prepared for all soil borings. An example boring log template is provided as Attachment B. At a minimum, boring logs must include the information listed below:

- Identification number (ID No.)
- Soil boring location and coordinates (latitude/longitude)
- Description of equipment (drilling, SPT, soil sampling, etc)
- Weather
- Number of blows per 6-inch intervals of continuous penetration
- Length of sample recovery (inches) for each 2-ft interval
- Depths of soil samples retrieved for laboratory analysis
- Thickness of each soil stratum encountered (including pavement, fill or topsoil layers).
- Characteristics of the soil (based on field observations) for all depths, including:
 1. Soil description per Modified Burmister
 2. Soil classification per Unified Soil Classification System (USCS), in parentheses
 3. Color
 4. Soil moisture (dry, moist, or wet)
 5. Soil consistency:
 - a. for Cohesive soil: very soft, soft, medium stiff, stiff, very stiff, hard
 - b. for Granular soils: very loose, loose, medium dense, dense, very dense
 6. If present:
 - a. Debris (brick, concrete, wood, glass, etc.)
 - b. Cobbles, boulders, etc.
 - c. Odor (organic, chemical, etc.)
 - d. Notable soil formations which may affect permeability (e.g. "bull's liver", glacial till, etc.)
 - e. Indication of possible contamination (ash, petroleum, slag, etc.)
 - f. Decomposed vegetation
- Depth to groundwater and/or bedrock, if encountered
- Other subsurface conditions encountered during drilling (e.g. utilities, structures, etc.)

- Additional observations noted during soil boring

2.1.3 Permeability Test Logs

Permeability test logs must be submitted for all PTs, including those that were terminated. At a minimum, PT logs must include the following:

- Permeability test method
- PT ID number
- Weather and ambient temperature
- PT location and coordinates (latitude/longitude)
- Description of equipment utilized
- PT depth
- Depth to groundwater and/or bedrock, if encountered
- Water temperature at the start of the test
- All water depth readings as required by test procedure
- Calculation steps
- Resulting permeability rates

Falling-head borehole test results shall be reported on the FH Log (see Attachment C). The following are additional notes for reporting on falling-head borehole test results:

- Early termination of falling-head borehole tests shall be noted in the “Inspectors Remarks” section of the FH Logs and in the Geotechnical Report Summary Table under “General Geotech Notes”. No field data shall be reported as “Depth (in)”, and no permeability values shall be calculated for terminated falling-head tests.
- The FH Log template contains default time values of 1, 2, 3, 4, 5, 10, and 15 minutes after the start of the test. If the water level drops below the casing before the 15-minute measurement period, these default values must be modified to the actual time values for which water depth measurements were recorded.
- If the permeability rate cannot be calculated (for example, due to RI), the FH Log shall clearly indicate that calculations are not valid.

2.1.4 Laboratory Test Results

Laboratory testing and reporting must include a sieve analysis of soil samples and plotting of gradation curves, as well as soil classification based on the USCS.

The following USCS-classified sieve sizes are to be included with data points for all sampled depths overlaid on the same gradation curve:

4"
3"
1-1/2"
3/4"
3/8"
#4
#10

#20

#40

#60

#100

#200

An example of an acceptable format for reporting soil sieve analyses and gradation curves is provided as Attachment D.



Project: [Project Description]
 Prepared By: [Consultant/Sub Name]

Geotechnical Report Summary Table

SMP ID No.	Soil Laboratory Results				Permeability Analysis				Groundwater Table Depth (ft)	Bedrock Depth (ft)	General Geotechnical Notes	Additional Notes
	Boring ID No.	Depth (ft)	USCS Symbol	% Passing No 200 Sieve	Permeability Test ID No.	PT Method	Permeability Test Depth (ft)	Average Permeability Rate (in/hr)				

Notes:
 Only numbers should be inputted in the '% Passing No 200 Sieve', 'Average Permeability Coef. (ft)', 'Groundwater Table Depth (ft)', and 'Bedrock Depth (ft)' columns.
 For the '% Passing No. 200 Sieve' column, values must be between 0 and 1. (i.e. use either 0.15 or 15% not 15). Numbers greater than 1 will not be accepted.
 Please refer below for allowable exceptions and other specific instructions:
 (NE = not encountered, NR = no record, NP = not performed)

<u>Column</u>	<u>Exception(s)</u>
'USCS Symbol', '% Passing No 200 Sieve'	If soil sampling was cancelled due to groundwater, bedrock, obstructions, etc., enter "NP" (details should be included in the 'General Geotech Notes' column) If soil sample could not be obtained or recovery was too low to be analyzed, enter "NR"
Average Permeability Coef. (ft)	For high permeabilities where the water level drop rate could not be measured, enter "RI" If a PT could not be conducted at specific depths, input depth with "NP" as the Permeability Rate (details should be included in the 'General Geotech Notes' or 'Additional Notes' as applicable)
Groundwater Table Depth (ft)	Enter the depth that groundwater was encountered. If groundwater was not encountered, enter "NE" If perched water was encountered, enter "NE" (but include in the 'General Geotech Notes' column)
Bedrock Depth (ft)	Enter the depth that bedrock was encountered. If bedrock was not encountered, enter "NE"

Relevant information to include under General Geotechnical Notes include (but not limited to): refusal (please provide possible cause of refusal), suspected contamination, perched water, etc.

	COMPANY NAME/LOGO	Boring ID No. <XXXX>
Project: <Project Name/Description>		Location: <Description of Location>
INSPECTOR: <name>	DRILLER: <name>	Start Date: <date>
CONTRACTOR: <name>	HELPER: <name>	Start Time: <time>
OVERSIGHT: <name>		Weather: <weather>
Total Boring Depth: <##> ft	Drill Bit Type: <type>	Weight of Hammer for casing: <##> lbs
Rig Type: <type>	Casing Inner Diameter: 4 in	Weight of Hammer for spoon: <##> lbs
	Depth of Casing: <##> ft	Type of Hammer: <type>
Depth to Groundwater Table (bgs): <##> ft		Drop: <##> in
Depth to Bedrock (bgs): <##> ft		Split Spoon Diameter: <##> in

<XXXX> BORING LOG

Depth Below Ground Surface (ft)	Soil Sample Retrieval and Sample No.	Soil Description (Field Observations)	SPT Blows per 6"	N Value	Recovery Length (inches)	Remarks
---------------------------------	--------------------------------------	---------------------------------------	------------------	---------	--------------------------	---------

0		asphalt pavement				
5						
10						
15						
20						

Boring terminated at xx feet below ground surface

Latitude: <latitude> Longitude: <longitude>

Inspector's Remarks:

Falling-Head Borehole Test Log

COMPANY NAME/LOGO	PT ID No. <ID> Sheet <#> of <#>
-------------------	---

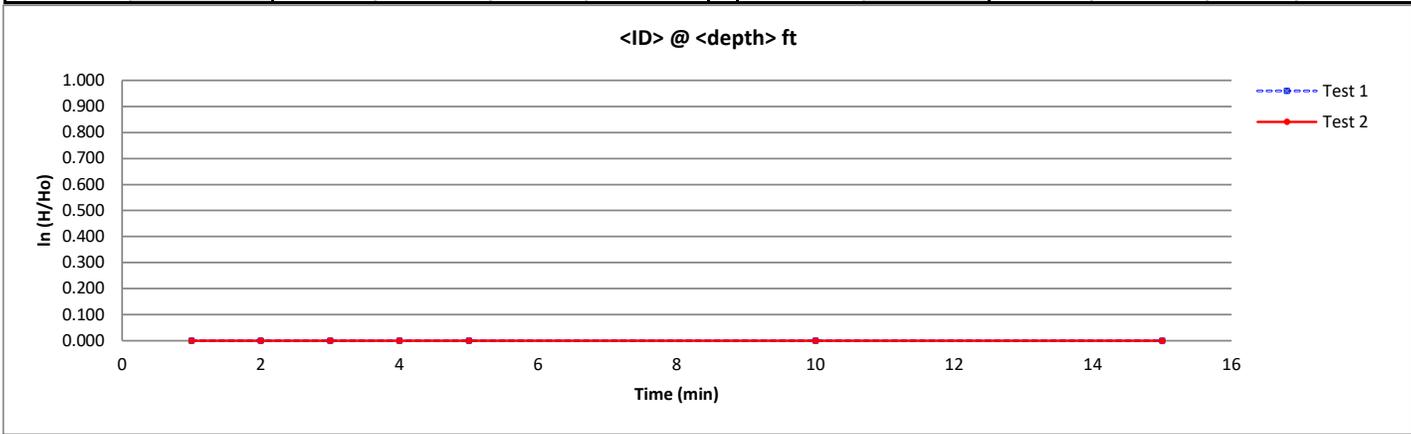
Project: <Project Name/Description>	LOCATION: <Location>
--	---

INSPECTOR: <name>	DRILLER: <name>	Start Date: <date>	Weather: <weather and ambient temperature>
CONTRACTOR: <name>	HELPER: <name>	Start Time: <time>	
OVERSIGHT: <name>			

Depth of PT: <depth> ft	Drill Bit Type: <type>	Weight of Hammer for casing: 140 lbs	
Rig Type: <type>	Casing Internal Diameter: 4 in	Type of Hammer: <type>	
	Casing Length: <length> in		

<p>ASTM D-6391 PERMEABILITY COEFFICIENT (Km) FORMULA:</p> $K_m = \pi R_t \times \frac{D \left\{ \ln \left(\frac{h_1}{h_2} \right) \right\}}{11 \times (t_2 - t_1)}$ <p>where:</p> $R_t = 2.2902(0.9842^T) / T^{0.1702}$	<p>General Formula:</p> $K_m = \pi R_t \times \frac{D \left\{ \ln \left(\frac{h_1}{h_2} \right) \right\}}{11 \times (t_2 - t_1)}$ <p>Formula for 4" internal diameter casing (in/hr):</p> $K_m = 1.142 R_t \times \frac{\left[\ln \left(\frac{h_1}{h_2} \right) \right]}{(t_2 - t_1)}$
--	---

<ID> @ <depth> ft											
TEST 1						TEST 2					
Water temperature (°C), T: Rt= -						Water temperature (°C), T: Rt= -					
FIELD DATA			CALCULATED DATA			FIELD DATA			CALCULATED DATA		
Time (min)	Depth (in)	Height (in)	Ln (H/Ho)	(t ₁ -t ₂)	*Kv (in/hr)	Time (min)	Depth (in)	Height (in)	Ln (H/Ho)	(t ₁ -t ₂)	*Kv (in/hr)
1		-	-	0.017	-	1		-	-	0.017	-
2		-	-	0.017	-	2		-	-	0.017	-
3		-	-	0.017	-	3		-	-	0.017	-
4		-	-	0.017	-	4		-	-	0.017	-
5		-	-	0.017	-	5		-	-	0.017	-
10		-	-	0.083	-	10		-	-	0.083	-
15		-	-	0.083	-	15		-	-	0.083	-



TEST 1 FINAL RESULTS	TEST 2 FINAL RESULTS
Time Weighted Average Permeability Coefficient K_m= 0.0000 in/hr	Time Weighted Average Permeability Coefficient K_m= 0.0000 in/hr

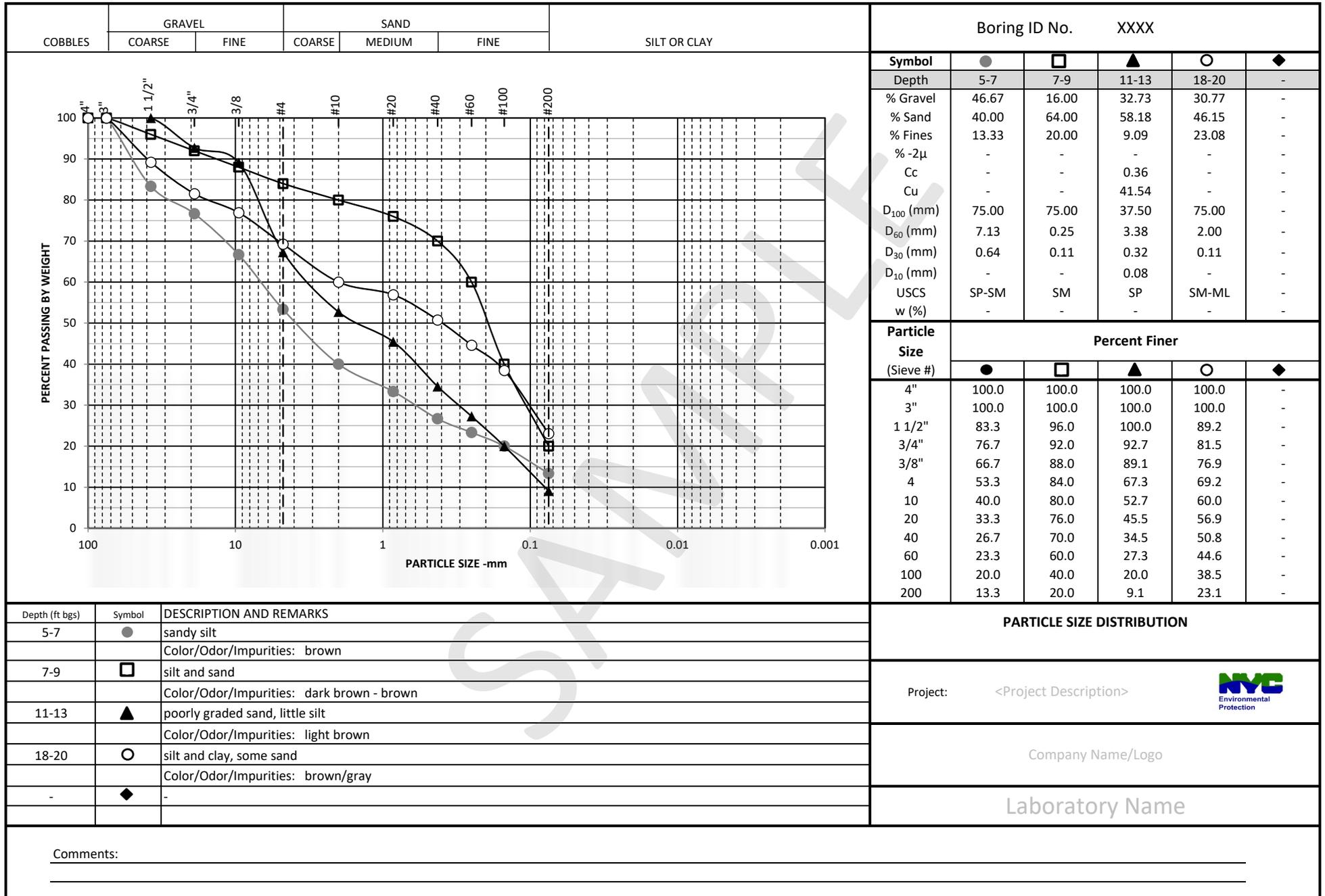
AVERAGE <ID> @ <depth> ft Time Weighted Average Permeability Coefficient *K_m= 0.0000 in/hr	Coordinates: Longitude: <longitude> Latitude: <latitude>
--	--

Inspectors Remarks:

DEFINITION OF VARIABLES

*K_m= Mean permeability rate
 T = Temperature of permeant (water), in °C
 Ln = Natural Logarithmic
 t₁ = Time at the start of the test in the same units selected for Km
 R_t = Ratio of viscosity of water at test temperature to the viscosity of water at 20°C

t₂= Time at the end of the test in the units selected for Km
 h₁= Height of the water above the bottom of the casing at the start of the test in the same units selected for Km
 h₂= Height of the water above the bottom of the casing at the end of the test in the same units selected for Km



Depth (ft bgs)	Symbol	DESCRIPTION AND REMARKS
5-7	●	sandy silt Color/Odor/Impurities: brown
7-9	□	silt and sand Color/Odor/Impurities: dark brown - brown
11-13	▲	poorly graded sand, little silt Color/Odor/Impurities: light brown
18-20	○	silt and clay, some sand Color/Odor/Impurities: brown/gray
-	◆	-

PARTICLE SIZE DISTRIBUTION

Project: <Project Description>



Company Name/Logo

Laboratory Name

Comments: _____