LOW IMPACT DEVELOPMENT BEST MANAGEMENT PRACTICE GUIDELINE FOR DESIGN, INVESTIGATION, AND REPORTING

Urbanization impacts the water resources of Los Angeles County by decreasing the amount of stormwater that infiltrates the subsurface and by increasing the potential of transporting pollutants into watersheds and the flood control system. Low Impact Development (LID) Best Management Practice (BMP) is meant to partially mitigate these hydrological impacts. The goals of LID BMPs are to reduce stormwater runoff from the site and enhance groundwater recharge by using design techniques that store, infiltrate, evaporate, and/or detain the runoff.

Effective January 1, 2009, development in Los Angeles County must comply with the LID Ordinance, Title 12, Section 12.84, before the issuance of building or grading permits. The Los Angeles County LID Standards Manual was developed to help applicants meet the requirements of the ordinance. This Manual is available at the following link: http://dpw.lacounty.gov/wmd/LA_County_LID_Manual.pdf.

The requirements of the LID Ordinance specify that a development consisting of four or fewer residential units shall implement at least two alternative BMPs listed in the LID Standards Manual (see pages 16 through 17). A development consisting of five or more residential units, or a non-residential development, will be required to infiltrate onsite the post development runoff that exceeds the volume of the undeveloped runoff. Offsite infiltration at a regional facility may be used in certain circumstances (see pages 17 through 20).

Several LID BMP designs require evaluation and reporting by a geotechnical consultant. BMPs that require a geotechnical report include the following:

- Bioretention
- Dry Ponds
- Dry Wells
- Infiltration Basins
- Porous Pavement
- Infiltration Trenches
- Vegetated Buffers
- Vegetated Swales

Infiltration of stormwater shall not be permitted in any soil or bedrock condition that could result in: (1) slope failure; (2) settlement of structures or offsite property; (3) surcharge on retaining walls; (4) daylighting of flow at ground surface; or (5) seepage into buttress fill, basements, or retaining wall drains. These conditions must be evaluated and an infiltration rate provided in a geotechnical report.

The following information provides guidelines for geotechnical evaluation and reporting for LID BMP designs. It will be used by the Geotechnical and Materials Engineering Division's Development Review Section when determining compliance with the County's LID ordinance.

GENERAL SITING REQUIREMENTS

1. Infiltration facilities are not allowed in areas where pollutant or sewage effluent mobilization may be a concern.

2. The minimum infiltration rate is 0.5 inch per hour. Procedures for performing in-situ infiltration tests are described later in this guideline.

3. Infiltration facilities may be placed in areas underlain by fill materials as long as infiltration rates are equal to or greater than 0.5 inch per hour and approved by the geotechnical consultant.

4. The invert of the infiltration facilities listed below should be 10 feet or greater above Seasonal High Groundwater Elevation (SHGWE). Procedures for determining the SHGWE are described later in this guideline.

   - Bioretention
   - Dry Ponds
   - Dry Wells
   - Infiltration Basins
   - Infiltration Trenches

5. Infiltration facilities should not be located on slopes with gradients greater than 20 percent (5:1 horizontal to vertical).

6. Infiltration should not increase pore-water pressure acting on soil retaining structures on/or adjacent to the site, unless the structures are specifically designed for the increased pressure.

7. Infiltration should not increase the potential for static or seismic settlement of structures on/or adjacent to the site.

8. Infiltration facilities should not be located on expansive soil or rock.

9. Infiltration facilities must comply with the following setbacks:

INFILTRATION FACILITY SETBACKS*	
Setback from	**Distance**
Property lines and public right of way	5 feet
Any foundation	15 feet or within a 1:1 plane drawn up from the bottom of foundation
Face of any slope	H/2, 5 feet minimum (H is height of slope)
Private water wells used for drinking water	100 feet

* Unless otherwise recommended by a Soils Engineer and approved by Geotechnical and Materials Engineering Division.

GEOTECHNICAL INVESTIGATION

A site-specific geotechnical investigation is required to determine subsurface conditions, infiltration rates, the SHGWE, and impacts to site environs as listed in the General Siting Requirements. The investigation must be conducted by or under direct supervision of a State of California-licensed engineering geologist, geotechnical engineer, or civil engineer with experience in geotechnical engineering.

Subsurface Exploration

Exploration should be conducted to characterize the subsurface soil or rock through which water will percolate or be perched upon. Continuous observations to a depth of at least 15 feet below the proposed invert of the BMP should be recorded, either directly or through continuous sampling. The amount of subsurface exploration is dependent on the size of the site and the variability of the geotechnical conditions.

Groundwater Investigation

The SHGWE should be determined at sites where the elevation of historic high groundwater has been within 10 feet of the proposed BMP invert. Historic high groundwater elevations may be obtained from the Seismic Hazard Evaluation Open-File Reports prepared by the California Geological Survey. Unless the SHGWE has been determined in a previous investigation, at least two borings should be completed that are at least 15 feet deeper than the proposed BMP infiltration inverts. The borings must be monitored for a period of 24 hours and the water elevation must be recorded. Large facilities will require more borings. During the months of March, April, and May, the SHGWE is the elevation of groundwater recorded in the borings at the end of the monitoring period. The SHGWE is assumed to be 5 feet above the elevation of the groundwater noted in the borings during other months of the year, unless additional information supports an alternative level.

In-Situ Infiltration Testing

There are many testing methods that are published and commonly utilized for in-situ infiltration testing. The following five testing methods can be used in determining in-situ infiltration rates:

- Double-ring infiltrometer (ASTM D3385-09)
- Well permeameter test (USBR 7300-89)
- Percolation testing in a boring
- Percolation testing in a 1-cubic-foot excavation
- Percolation testing for High Flowrates

Information regarding these tests is provided later in this guideline.

Various testing methods will be given consideration for the determination of infiltration rates as soil data, test results, maintenance records, design versus actual infiltration rates, and additional information become available.

Infiltration rates must be reported in inches per hour. The minimum acceptable infiltration rate is 0.5 inch per hour.

Reporting

The geotechnical report should include an evaluation of the specific BMP design and its suitability for use at the site. Reports should include conclusions, recommendations, logs of subsurface exploration, depth to groundwater or seasonal high groundwater, layers resistive to infiltration, and infiltration testing procedures and results. The report must be signed by a State of California-licensed engineering geologist, geotechnical engineer, or civil engineer with experience in geotechnical engineering.

GENERAL GUIDELINES FOR INFILTRATION TESTS

Infiltration tests are necessary to determine whether the proposed BMPs will function as designed. The method and number of infiltration tests is dependent upon the size, type, number, and spacing of the proposed BMPs, and the variability of the subsurface materials. The following guidelines should be considered when infiltration tests are conducted on a subject site:

1. Infiltration tests must be performed close to the same elevation and location of the proposed BMP invert. Multiple test locations on a site may need to be considered if the location of the BMP has not been finalized or the location will be changed.

2. Where uniform geology or soils has been established, the results of the soil profile and infiltration testing conducted in the area may be used within a 35-foot-radius of the percolation test location. Locations of BMPs outside of this range may require additional testing to confirm or update design parameters.

3. For sites approximately a half-acre or less, the infiltration rate should be determined at two or more locations. For sites larger than a half-acre, or where geotechnical conditions are variable, the number of test locations should be increased appropriately.

4. *Dry Well Spacing* - In general, locations with low hydraulic conductivity values or shallow water will require greater spacing between dry wells. For locations with SHGW deeper than 30 feet, the recommended spacing to prevent overlap of groundwater mounds is five times the radius of the excavation for the dry well, or approximately 50 feet (this spacing is defined as the distance from center point to center point for the wells). Dry wells spaced more closely than these recommended rates may still be effective, but a reduction in infiltration rates should be applied.

5. *Corrections for Siltation* - Siltation and plugging may reduce the equivalent hydraulic conductivity values of the facilities (dry wells, infiltration basins, etc.) by an order of magnitude or more over the course of its design life. This will result in a corresponding reduction in infiltration rate. If pretreatment of runoff cannot be provided, infiltration rates calculated may need to be reduced by a factor of 2 or more.

INFILTRATION TESTING PROCEDURES

The following five tests should be conducted in a wetted condition so that the infiltration rates properly model the design BMP, its related infiltration quantity, and infiltration will occur within policy and design requirements. The double-ring infiltrometer and well permeameter tests have significant soaking and data collection periods; therefore, a separate presoak is not warranted. When applying the following procedures during the dry season, additional quantities of water should be used to make sure BMPs will work within design infiltration rates during the wet season, when surrounding soils may have elevated moisture contents.

Double-Ring Infiltrometer Testing Procedures

A double-ring infiltrometer consists of two concentric metal rings. The rings are sufficiently driven into the ground to preclude leakage, and then filled with water. Water in the outer ring keeps the flow in the inner ring vertical. The drop in water level in the inner ring is used to establish the infiltration rate.

This testing procedure is useful for soils with a hydraulic conductivity between about 0.001 to 14 inches per hour. Procedures and example data forms for double-ring infiltrometer testing are provided in ASTM D3385. Use of the 4¼-inch infiltrometer requires ten times as many tests in a given area compared with using the 24-inch infiltrometer (see attached references and examples [Plates 1-A, B, C]).

Well Permeameter Testing Procedures

The United States Department of the Interior Bureau of Reclamation (USBR) has prepared guidelines for a Well Permeameter Test, to be used to determine the hydraulic conductivity rates of soils above a water table (USBR, Drainage Manual, 1993). Water used in these tests should be free of sediment and should be warmer than the soil. There are three conditions related to groundwater table described in these procedures. Procedures for Conditions I and II must be utilized for proposed BMPs. Details for this test can be found in either the Procedure for Performing Field Permeability Testing by the Well Permeameter Method (USBR 7300-89); or in Section 3.7 of the USBR *Drainage Manual, A Water Resource Technical Publication*, revised reprint 1993 (see attached references and examples [Plates 2-A through F]). Condition III describes the groundwater table above the test-hole bottom and therefore will not be considered viable for proposed BMPs (see General Siting Requirements above).

Boring Percolation Testing Procedures

The following procedures require the use of a reduction factor to account for nonvertical flow:

1. Using a hollow-stem auger, advance a 6-inch-diameter boring at least 12 inches below the invert of proposed BMP. Rotate the auger until all cuttings are removed. Care should be taken to ensure smearing of clayey soils does not occur along augered surface as this will dramatically reduce the final calculated infiltration rate. Record the boring diameter and depth to be tested.

2. Install through the auger, a 2- to 4-inch-diameter perforated PVC casing with a solid end cap. Perforations should be a 0.02 inch slot or larger. Pour filter pack down center of auger while withdrawing the auger such that the casing is surrounded by the filter pack. The filter pack and perforated casing must have a larger hydraulic conductivity than the soil or rock that is to be tested.

3. Presoak the hole immediately prior to the percolation testing. Presoaking of the test hole shall maintain a water level above the percolation testing level and a minimum of 12 inches above the bottom of the boring. Presoak in hole for at least 4 hours before conducting the infiltration testing. If the water seeps completely away within 30 minutes after filling the boring with 12 inches of water two consecutive times, and a thorough subsurface exploration and/or research has determined adequate permeable soils beneath the proposed BMP, presoaking can be considered complete and the testing can proceed immediately. A sounder or piezometer may be used to determine the water level. Record all water levels to the nearest ⅛-inch increment.

4. After presoaking, determine the time interval that will be used to measure the water drop readings for the percolation test. Fill the hole to a minimum depth of 12 inches above the bottom of the boring. Observe the drop in the water during the next 30 minutes and compare with the condition that applies below. This will determine the standard time interval for this test location:

    a. If no water remains in the hole, the time interval between readings should be 10 minutes.

    b. If water remains in the hole, the time interval between readings should be 30 minutes.

c. If the water drained faster than 10 minutes, the actual time to completely drain the hole should be used.

5. Once the time interval for the test has been determined, add water to the casing to the depth of soil to be tested. The water depth must be less than or equal to the water level used to presoak the hole and a minimum depth of 12 inches above the bottom of the boring. For each successive percolation test reading, the starting water level must be at this initial water depth.

6. Conduct the percolation test by taking readings of the water drop from the initial water depth. Record the time and record the drop in water level during the standard time interval determined in Step 4. Fill the boring back to the initial water depth.

7. Repeat the percolation test readings a minimum of eight times or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate may be assumed when the highest and lowest readings from three consecutive readings are within 10 percent of each other.

8. The drop that occurs in the final reading period or the average drop of the stabilized rate over the time interval is the preadjusted percolation rate at the test location, expressed in inches per hour. The preadjusted percolation rate must be reduced to account for the discharge of water from both the sides and bottom of the boring (i.e., nonvertical flow). Use the following formula to determine the infiltration rate:

   Infiltration Rate = (Preadjusted Percolation Rate)/(Reduction Factor)

   Reduction Factor (R_f) = $$R_f = \left(\frac{2d_1 - \Delta d}{DIA}\right) + 1$$

   With:
   d_1 = Initial Water Depth (in.)
   Δd = Water Level Drop of the Final Period or Stabilized Rate (in.)
   DIA = Diameter of the boring (in.)

   See attached figures and examples (Plates 3-A through D).

Excavation Percolation Testing Procedures

The following procedures require the use of a reduction factor to account for nonvertical flow:

1. Excavate a 1 cubic foot hole (1 foot deep x 1 foot wide x 1 foot long) at the elevation of the proposed BMP invert. Insert a wire-cage to support the walls. The actual excavation depth may be deeper than 12 inches; however, during the test the water should be limited to 12 inches in depth.

2. Presoak the hole immediately prior to the percolation testing. Presoak the excavation maintaining 12 inches of water for at least 4 hours before conducting the infiltration testing. If the 12 inches of water seeps completely away within 30 minutes two consecutive times, and a thorough subsurface exploration and/or research has determined adequate permeable soils beneath the proposed BMP, presoaking can be considered complete and the testing can proceed immediately. A sounder, piezometer, or marker may be used to determine the water level. Record all water levels to the nearest ⅛-inch increment.

3. After presoaking, determine the time interval for recording the water drop between readings. Fill the excavation 12 inches above the bottom. Observe the drop in the water during the next 30 minutes and compare with the condition that applies below. This will determine the standard time interval for this test location.

    a. If no water remains in the hole, the time interval between readings should be 10 minutes.

    b. If water remains in the hole, the time interval between readings should be 30 minutes.

    c. If the water drained faster than 10 minutes, the actual time to completely drain the hole should be used.

4. Once the time interval for the test has been determined, add water to 12 inches above the bottom of the excavation. For each successive percolation test reading, the starting water level must be at this initial water depth.

5. Conduct the percolation test by taking readings of the water drop from the initial water depth. Record the time and record the drop in water level during the time interval determined in Step 3. Fill the boring back to the initial water depth.

6. Repeat the percolation test readings a minimum of eight times or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate may be assumed when the highest and lowest readings from three consecutive tests are within 10 percent of each other.

7. The drop that occurs in the final reading period or the average drop of the stabilized rate over the time interval is the preadjusted percolation rate at the test location, expressed in inches per hour. The preadjusted percolation rate must be reduced to account for the discharge of water from both the sides and bottom of the boring (i.e., non-vertical flow). Use the following formula to determine the infiltration rate:

   Infiltration Rate = (Preadjusted Percolation Rate)/(Reduction Factor)

   Reduction Factor (R_f) = $$R_f = \left(\frac{2d_1 - \Delta d}{13.5}\right) + 1$$

   d_1 = Initial Water Depth (in.)
   Δd = Water Level Drop of Final Period or Stabilized Rate (in.)
   DIA = 13.5 (Equivalent Diameter of the boring) (in.)

   See attached Plates 3-A through D.

High Flowrate Percolation Testing Procedures

If the water is draining faster than an infiltration rate of 14 inches per hour during the previous testing procedures, a modified test may be performed to record the infiltration rate. This test is conducted in the following manner:

1. Determine the surface area (sides and bottom) through which the water is infiltrating.

2. Flood that area in a suitable manner where the rate of water discharging into the test pit can be measured.

3. Calculate the infiltration rate by dividing the rate of discharge (i.e., cubic inches per hour) by the infiltration surface area (i.e., square inches).

RESOURCE DOCUMENTS

1. American Standard Test Method (ASTM) Standards, Section 4, Volume 04.08, Designation: D 3385, *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.*

2. American Standard Test Method (ASTM) Standards, Section 4, Volume 04.08, Designation: D 422, *Standard Test Method for Particle-Size Analysis of Soils.*

3. Los Angeles County, Department of Public Health, *Onsite Wastewater Treatment System Guidelines*, September 2009.

4. Los Angeles County, Department of Public Works, Land Development Division, Stormwater Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems, January 2009 (http://dpw.lacounty.gov/ldd/index.cfm?p=improvement).

5. Mitchell, James K., *Fundamental of Soil Behavior*, second edition, 1993.

6. Southeast Michigan Council of Governments (SEMCOG), Low Impact Development Manual for Michigan: *A Design Guide for Implementors and Reviewers*, 2008 (http://www.semcog.org/lowimpactdevelopmentreference.aspx).

7. State of California, Department of Transportation, Division of Engineering Services, *Soil and Rock Logging, Classification, Presentation Manual, 2010* (http://www.dot.ca.gov/hq/esc/geotech/sr_logging_manual/srl_manual.html).

8. Terzaghi, K., Peck, Ralph B., and Mesri, G., *Soil Mechanics in Engineering Practice*, Third Edition, 1996.

9. United States, Environmental Protection Agency, When are Storm Water Discharges Regulated as Class V Wells?, 2003 (http://www.epa.gov/npdes/pubs/sw_class_v_wells_fs.pdf).

10. United States Department of the Interior, Bureau of Reclamation (USBR) *Drainage Manual, Revised Reprint 1993* (http://www.usbr.gov/pmts/wquality_land/DrainMan.pdf).

11. United States Department of the Interior, Bureau of Reclamation (USBR), *Procedure for Performing Field Permeability Testing by the Well Permeameter Method*, USBR 7300-89 (http://www.usbr.gov/pmts/geotech/rock/EMpart_2/USBR7300.pdf).

12. *Washington State,* Department of Transportation (WSDOT), Research Office, Research Report 589.1: *An Approach for Estimating Infiltration Rates for Stormwater Infiltration Dry Wells*, April 2004 (http://www.wsdot.wa.gov/research/reports/fullreports/589.1.pdf).

13. *Washington State, Department of Tra*nsportation (WSDOT), Project Delivery Memo #02-03 *Interim Infiltration Design Guidance*, December 18, 2002 (http://www.wsdot.wa.gov/publications/fulltext/ProjectDev/ProjectDeliveryMemos/Memo02-03.pdf).

DOUBLE-RING INFILTROMETER TEST
(use ASTM D 3385)

Project: Practice Infiltration Testing

Test Location: 123 Drive Road, Alhambra, CA

Water Source: Potable Water pH: 7.5

Tested By: BDS, YH, & WM

Depth to water table: 17 ft

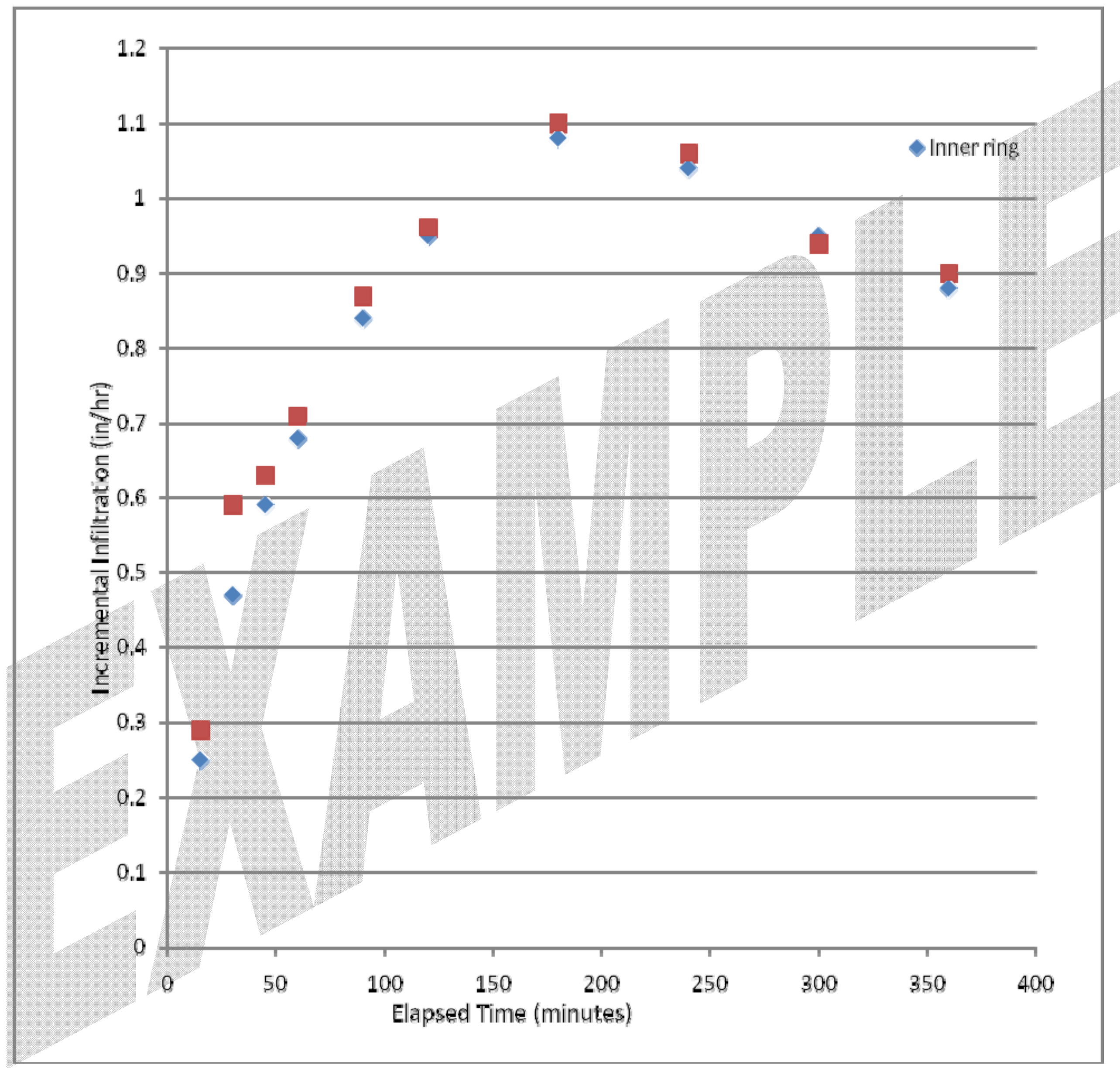
Constants	Area (in^2)	Depth of water (in)	No.	Water Containers Volume/ΔH (in^2/in)
Inner Ring	109.59	1.57	1	4.8
Annular Space	326.43	1.61	2	10.78

Water level maintained using: ☐ Flow valve ☐ Float valve ☒ Mariotte tube

Penetration of rings: Inner: 3.0 in Outer: 6.9 in

Trial No.		Date 1982	Time (24hr format) hh:mm	Elapsed Time Δ/(total), min	Flow Readings: Inner Ring Reading in	Flow Readings: Inner Ring Flow in^3	Flow Readings: Annular Space Reading in	Flow Readings: Annular Space Flow in^3	Water Temp. °F	Incremental Infiltration Inner in/hr	Incremental Infiltration Annular in/hr	Remarks: weather conditions, etc.
1	S	10/14	10:00	15	1.18	6.96	0.87	23.74	59	0.25	0.29	Cloudy, slight wind
	E	" "	10:15	(15)	1.75		1.73		59			
2	S	" "	10:15	15	1.75	12.94	1.73	48.51	59	0.47	0.59	
	E	" "	10:30	(30)	2.81		3.5		59			
3	S	" "	10:30	15	2.81	16.05	3.5	51.75	59	0.59	0.63	
	E	" "	10:45	(45)	4.13		5.39		59			
4	S	" "	10:45	15	4.13	18.67	5.39	57.67	59	0.68	0.71	
	E	" "	11:00	(60)	5.67		7.5		60			
5	S	" "	11:00	30	5.67	46.26	7.5	141.82	60	0.84	0.87	
	E	" "	11:30	(90)	9.47		12.68		61			
6	S	" "	11:30	30	9.47	51.75	12.68	157.44	61	0.95	0.96	Refilled tubes
	E	" "	12:00	(120)	13.72		18.43		62			
7	S	" "	12:10	60	1.38	118.63	0.87	360.16	62	1.08	1.1	" "
	E	" "	13:10	(180)	11.12		14.02		63			
8	S	" "	13:20	60	0.94	114.54	1.26	347.22	64	1.04	1.06	" "
	E	" "	14:20	(240)	10.35		13.94		64			
9	S	" "	14:30	60	1.69	103.5	1.85	308.41	64	0.95	0.94	" "
	E	" "	15:30	(300)	10.2		13.11		64			
10	S	" "	15:40	60	0.87	96.78	1.77	295.48	64	0.88	0.9	" "
	E	" "	16:40	(360)	8.82		12.56		64			Cloudy, slight wind

Graphical Representation of Data from Example



DOUBLE-RING INFILTROMETER TEST
(use ASTM D 3385)

Project: ______________________

Test Location: ______________________

Water Source: ______________ pH: ______

Tested By: ____________

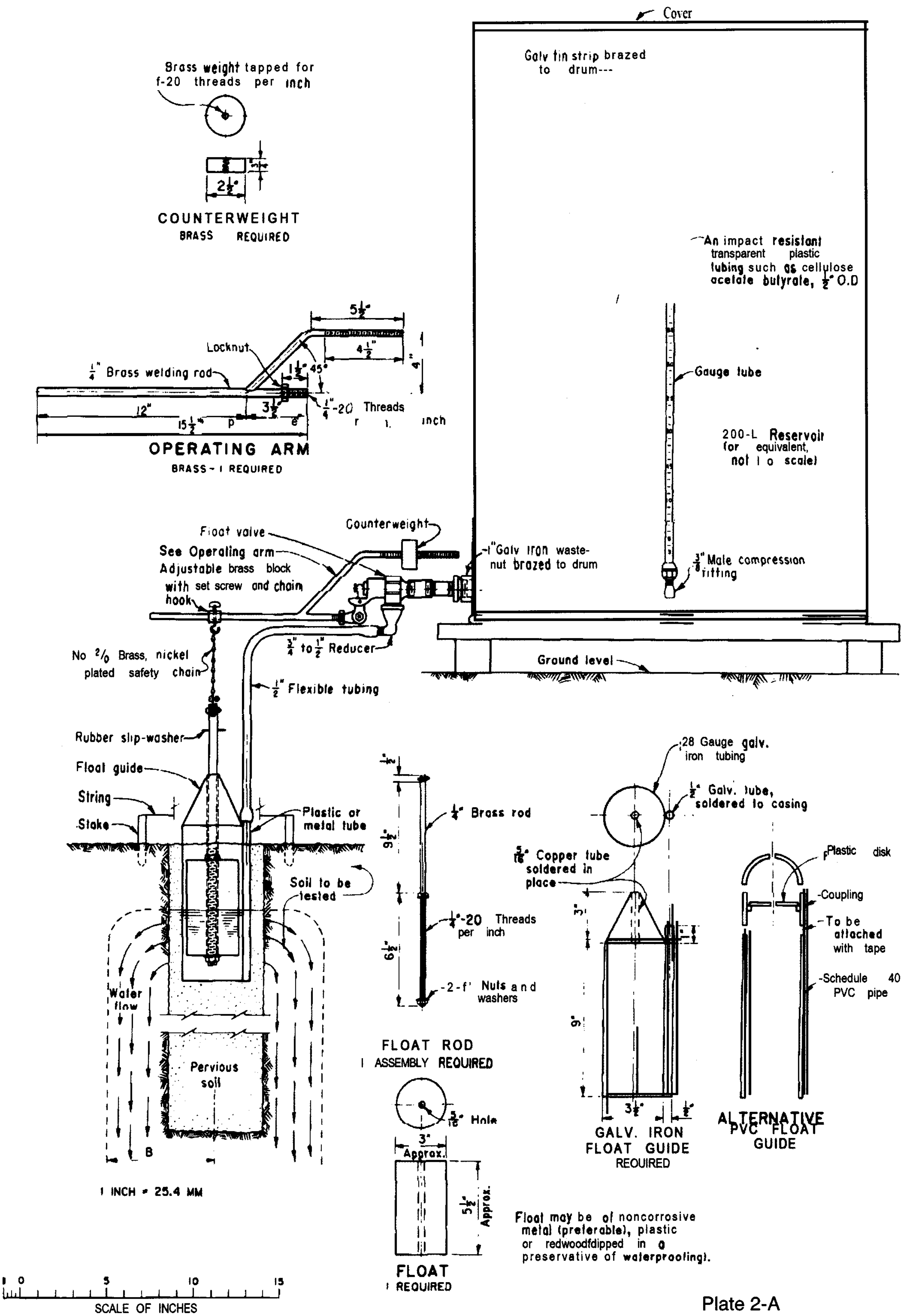
Depth to water table: ______

Constants	Area (in^2)	Depth of water (in)	Water Containers No.	Water Containers Volume/ΔH (in^2/in)
Inner Ring				
Annular Space				

Water level maintained using: ☐ Flow valve ☐ Float valve ☐ Mariotte tube

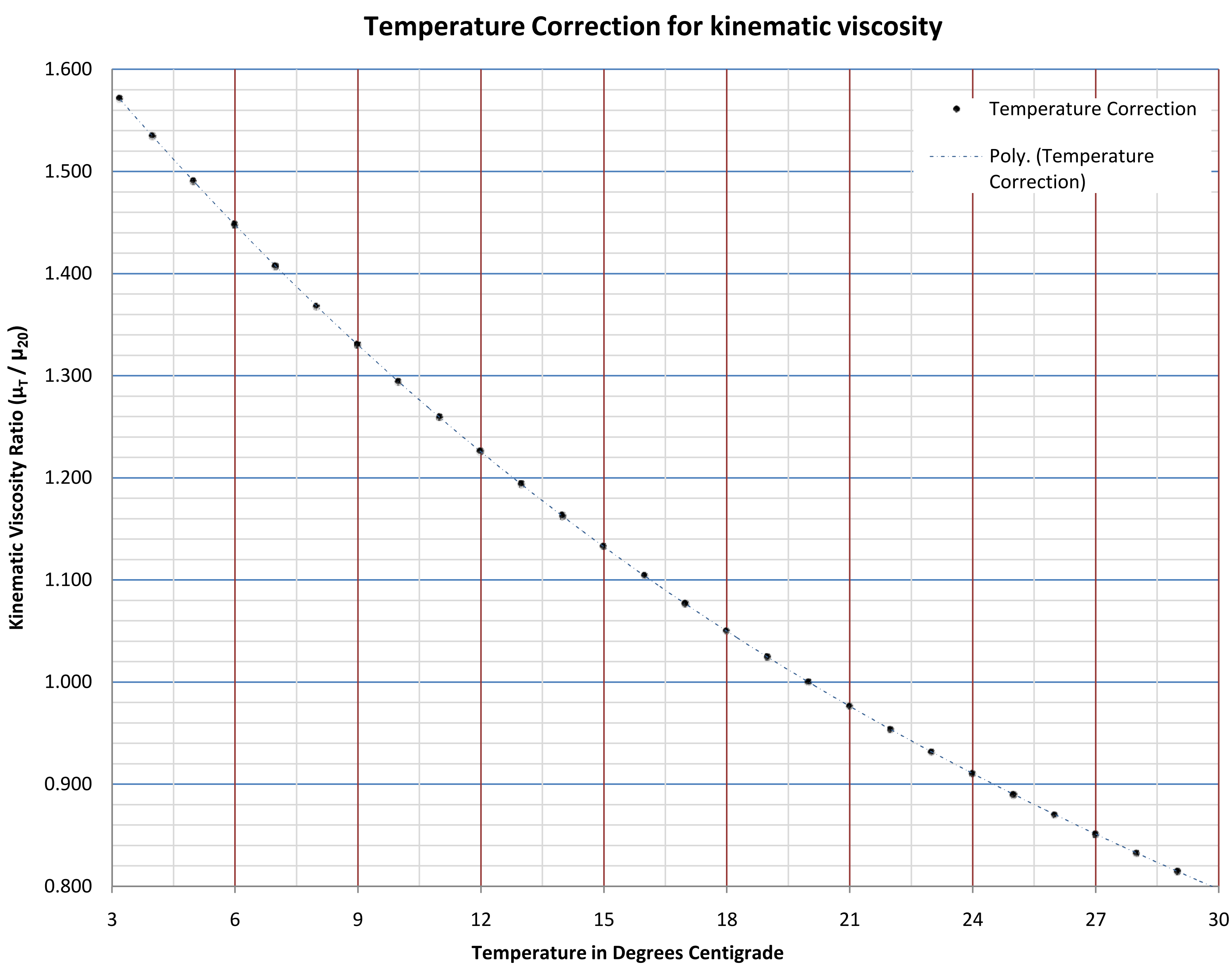
Penetration of rings: Inner: ______ Outer: ______

Trial No.		Date	Time (24hr format)	Elapsed Time Δ/(total),	Flow Readings				Water Temp.	Incremental Infiltration		Remarks: weather conditions, etc.
					Inner Ring		Annular Space			Inner	Annular	
		____	hh:mm	min	Reading in	Flow in^3	Reading in	Flow in^3	°F	in/hr	in/hr	
1												



Cover
Galv tin strip brazed to drum---
Brass weight tapped for f-20 threads per inch
2½"
COUNTERWEIGHT
BRASS REQUIRED
An impact resistant transparent plastic tubing such as cellulose acetate butyrate, ½" O.D
5½"
4½"
Locknut
¼" Brass welding rod
1½" 45°
4"
3½"
¼-20 Threads r 1. inch
12"
15½"
OPERATING ARM
BRASS - I REQUIRED
Gauge tube
200-L Reservoir (or equivalent, not to scale)
Float valve
Counterweight
See Operating arm
Adjustable brass block with set screw and chain hook
-I"Galv iron waste-nut brazed to drum
⅜" Male compression fitting
No 2/0 Brass, nickel plated safety chain
¾" to ½" Reducer
Ground level
½" Flexible tubing
Rubber slip-washer
Float guide
String
Stake
Plastic or metal tube
Soil to be tested
Water flow
Pervious soil
B
¼" Brass rod
9½"
¼-20 Threads per inch
6½"
-2-f' Nuts and washers
FLOAT ROD
I ASSEMBLY REQUIRED
5/16" Hole
3" Approx.
5½" Approx.
FLOAT
I REQUIRED
28 Gauge galv. iron tubing
½" Galv. tube, soldered to casing
5/16" Copper tube soldered in place
3"
9"
3½"
GALV. IRON FLOAT GUIDE
REQUIRED
Plastic disk
-Coupling
-To be attached with tape
-Schedule 40 PVC pipe
ALTERNATIVE PVC FLOAT GUIDE
Float may be of noncorrosive metal (preferable), plastic or redwood(dipped in a preservative of waterproofing).
I INCH = 25.4 MM
0 5 10 15
SCALE OF INCHES

Plate 2-A


Temperature Correction for kinematic viscosity
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
Kinematic Viscosity Ratio (μT / μ20)
3
6
9
12
15
18
21
24
27
30
Temperature in Degrees Centigrade
Temperature Correction
Poly. (Temperature Correction)

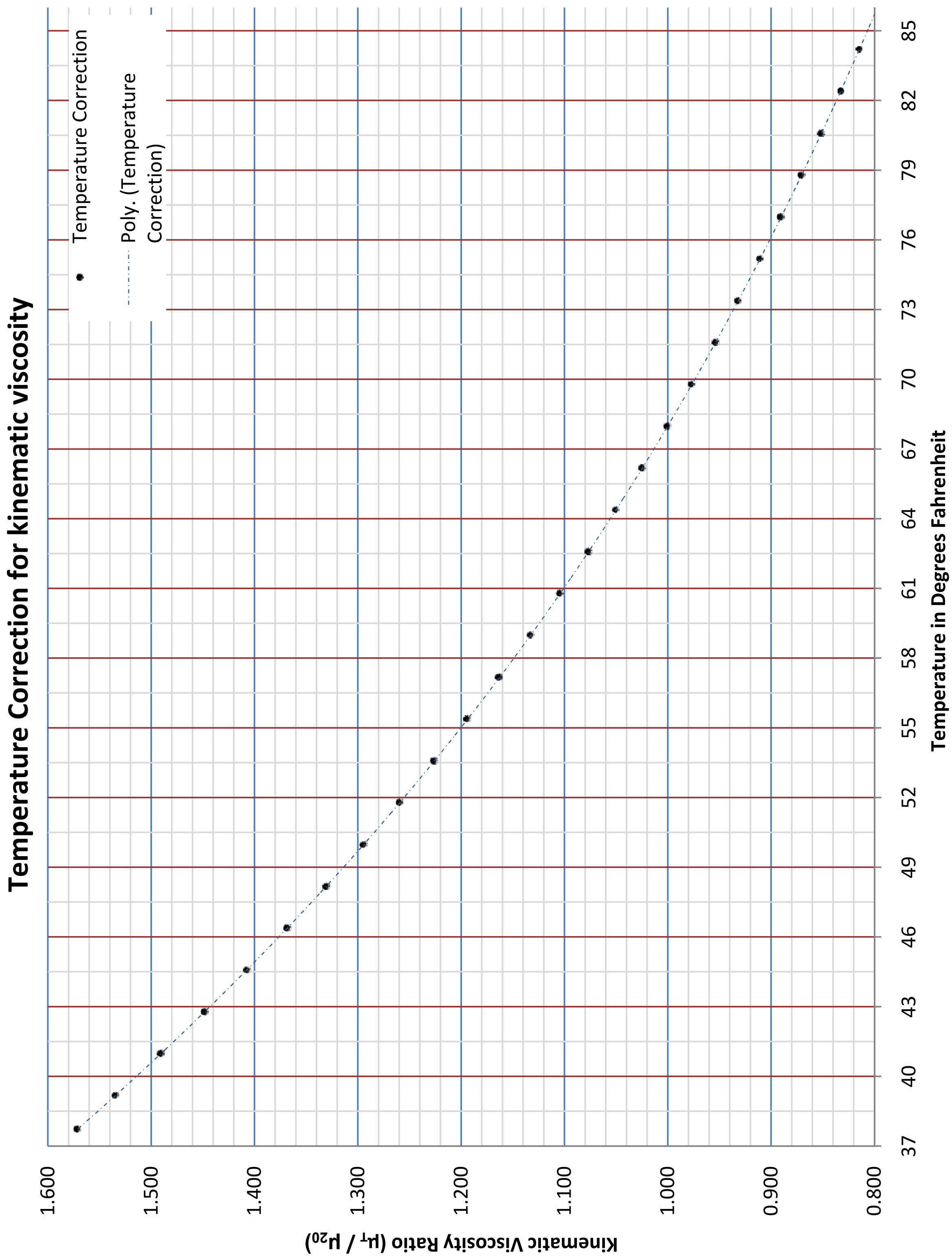

Temperature Correction for kinematic viscosity
Temperature Correction
Poly. (Temperature Correction)
Kinematic Viscosity Ratio (μ_T / μ_{20})
Temperature in Degrees Fahrenheit
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
37
40
43
46
49
52
55
58
61
64
67
70
73
76
79
82
85

Plate 2-C

WELL PERMEAMETER TEST
(reference USBR 7300-89)

Project: Practice Infiltration Testing
Test Location: 123 Drive Road, Alhambra, CA
N33° 53' 12.1" W118° 21' 27.6"

BMP Invert: 5' below existing ground surface
Water Source: Potable Water
Turbidity:
Tested By: YH & CM

Boring/Test Number:
r, radius of boring: 0.5 ft Date: 5/4/1990
D, boring depth below ground surface: 6.0 ft
h, depth of water maintained from bottom of hole: 3.5 ft
W, water table, or impervious layer, depth below ground surface: 7.0 ft
T_u, depth to water table or impervious layer from surface of water maintained: 4.5 ft Note: $T_u = W - D + h$

Condition I: $T_u \geq 3h$ ☐
Condition II: $h \leq T_u \leq 3h$ ☒ X

Water level determined by: ☒ X Flow meter ☐ Float valve ☐ Calibrated tank
S, Anticipated Specific Yield: 0.15 $S \approx 0.1$ for fine grained & 0.35 for course grained.

$$V_{min} = 2.09S\left\{h\frac{2}{\sqrt{\ln\left(\frac{h}{r}+\sqrt{\left(\frac{h}{r}\right)^2+1}\right)-1}}\right\}^3$$

Example: h = 3.5 ft, r = 0.5 ft, and S = 0.15, then the minimum water volume (V_{min}) needed for testing is 51 ft^3 or 381 gal.

$V_{max} = 2.05V_{min}$

Example: maximum water volume needed for testing, 381 gal(2.05) = 781 gal.

Trial No.	Date	Time (24hr format) hh:mm	Time Interval min	Accumulated Time min	Flow Meter / Tank Readings gallons	Δ (gallons)	Accumulated Flow gallons	Water Temp. °F	Flow Rate, Q gpm	Flow Rate, Q ft^3/min	Remarks: weather conditions, etc.
1	10/8	08:00	180	180	0	45.8	45.8	61	0.254	0.034	70's slightly cloudy, used one 55-gal drum. Refilled before next test.
	" "	11:00			45.8						
2	" "	11:15	180	360	0	44.6	90.4	64	0.248	0.0331	
	" "	14:15			44.66						
3	" "	14:30	240	600	0	44.9	135.3	65	0.187	0.025	Connected 2 55-gal drums together for trial no. 4.
	" "	18:30			44.9						
4	" "	19:00	690	1290	0	92.8	228.1	63	0.134	0.018	
	10/9	06:30			92.8						
5	" "	06:40	360	1650	0	51.0	279.1	61	0.142	0.019	
	" "	12:40			51						
6	" "	12:55	390	2040	51	57.2	336.3	66	0.147	0.0196	disturbed some soil into hole when observing for turbidity
	" "	19:25			108.2						
7	" "	19:30	690	2730	0	90.5	426.8	55	0.131	0.0175	
	10/10	07:00			90.5						
8	" "	07:20	360	3090	0	49.6	476.4	60	0.138	0.0184	
	" "	13:20			49.6						

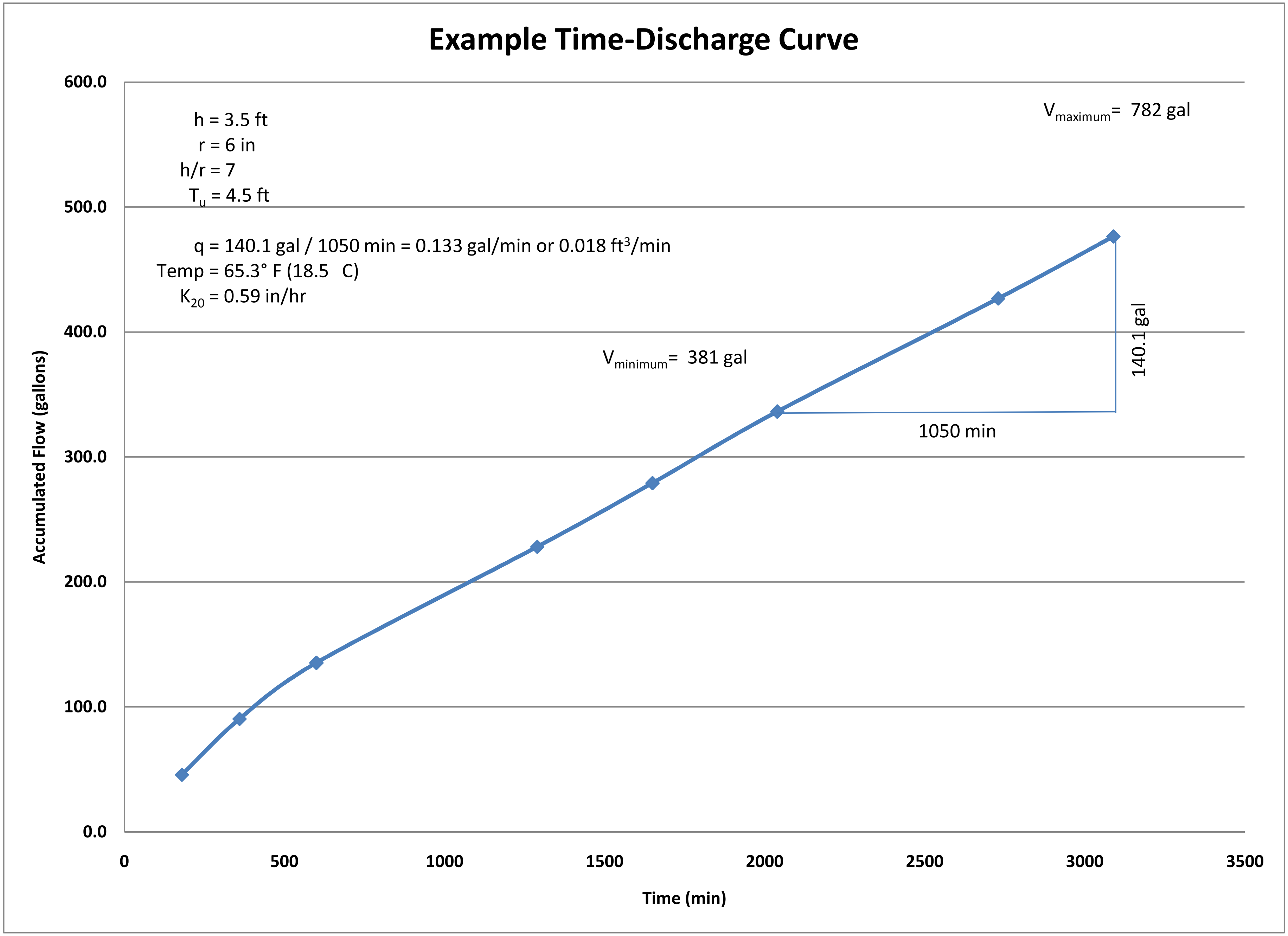

Example Time-Discharge Curve
h = 3.5 ft
r = 6 in
h/r = 7
T_u = 4.5 ft
q = 140.1 gal / 1050 min = 0.133 gal/min or 0.018 ft^3/min
Temp = 65.3° F (18.5 C)
K_{20} = 0.59 in/hr
$V_{maximum}$ = 782 gal
$V_{minimum}$ = 381 gal
140.1 gal
1050 min
Accumulated Flow (gallons)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
500
1000
1500
2000
2500
3000
3500
Time (min)

Plate 2-E

WELL PERMEAMETER TEST
(reference USBR 7300-89)

Project: ____________________

Test Location: ____________________

____

BMP Invert: ____________________

Water Source: ____________________

Turbidity: ____________________

Tested By: ____________________

Boring/Test Number: [ ]

r, radius of boring: ____ ft

Date:

D, boring depth below ground surface: ____ ft

h, depth of water maintained from bottom of hole: ____ ft

W, water table, or impervious layer, depth below ground surface: ____ ft

T_u, depth to water table or impervious layer from surface of water maintained: ____ ft

Note: $T_u = W - D + h$

Condition I: $T_u \geq 3h$ [ ]

Condition II: $h \leq T_u \leq 3h$ [ ]

Water level determined by: [ ] Flow meter [ ] Float valve [ ] Calibrated tank

S, Anticipated Specific Yield: $S \approx 0.1$ for fine grained & 0.35 for course grained.

$$V_{min} = 2.09S\left\{h\frac{2}{\sqrt{\ln\left(\frac{h}{r}+\sqrt{\left(\frac{h}{r}\right)^2+1}\right)-1}}\right\}^3$$

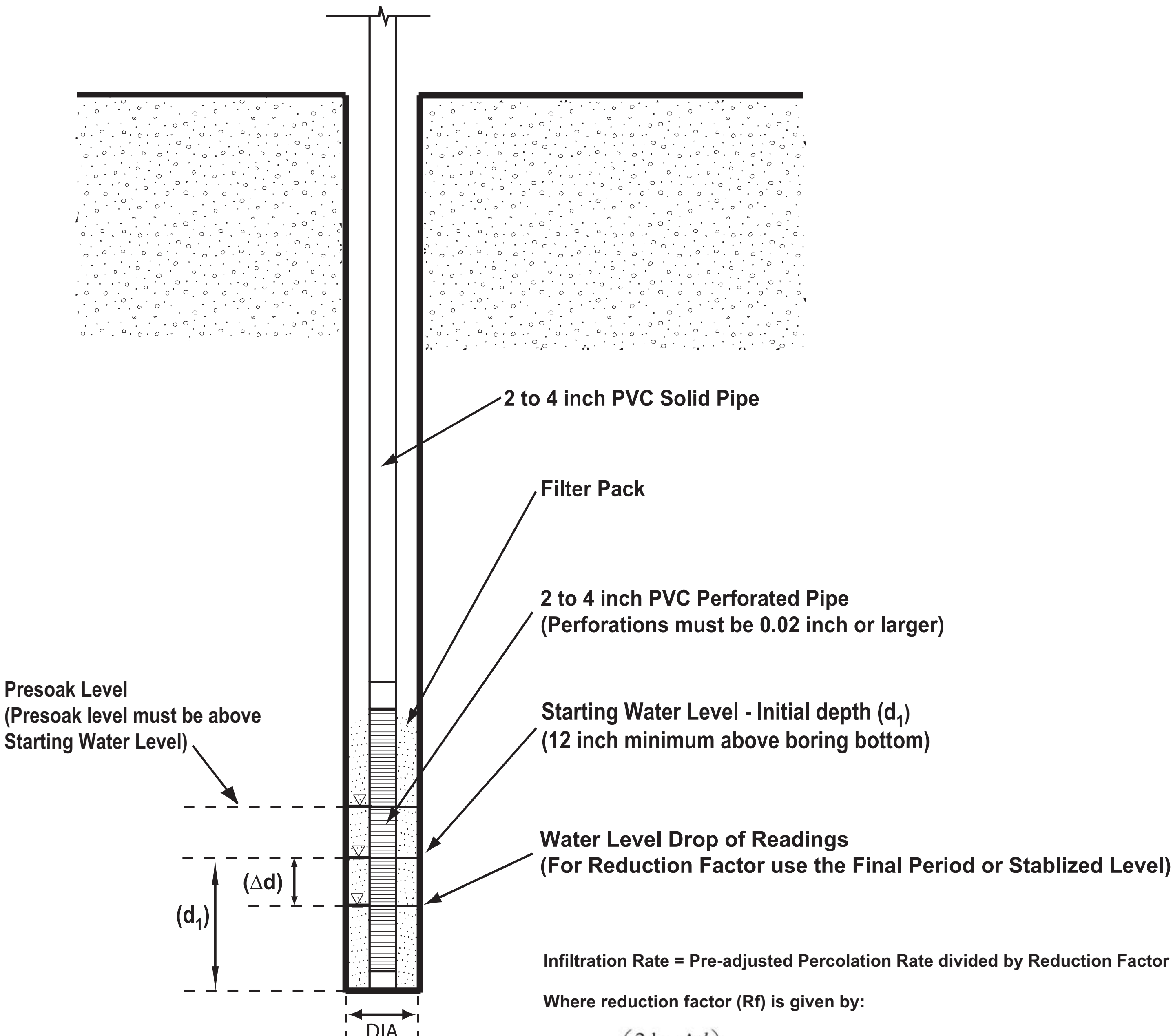
Example: h = 3.5 ft, r = 0.5 ft, and S = 0.15, then the minimum water volume (V_{min}) needed for testing is 51 ft^3 or 381 gal.

$V_{max} = 2.05V_{min}$

Example: maximum water volume needed for testing, 381 gal(2.05) = 781 gal.

Trial No.	Date	Time (24hr format) hh:mm	Time Interval min	Accumulated Time min	Flow Meter / Tank Readings gallons	Flow Meter / Tank Readings Δ (gallons)	Accumulated Flow gallons	Water Temp. °F	Flow Rate, Q gpm	Flow Rate, Q ft^3/min	Remarks: weather conditions, etc.
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

County of Los Angeles Administrative Manual
Low Impact Development - Best Management Practice GS200.1
Infiltration Testing Procedures
Boring Percolation Testing Method



Infiltration Rate = Pre-adjusted Percolation Rate divided by Reduction Factor

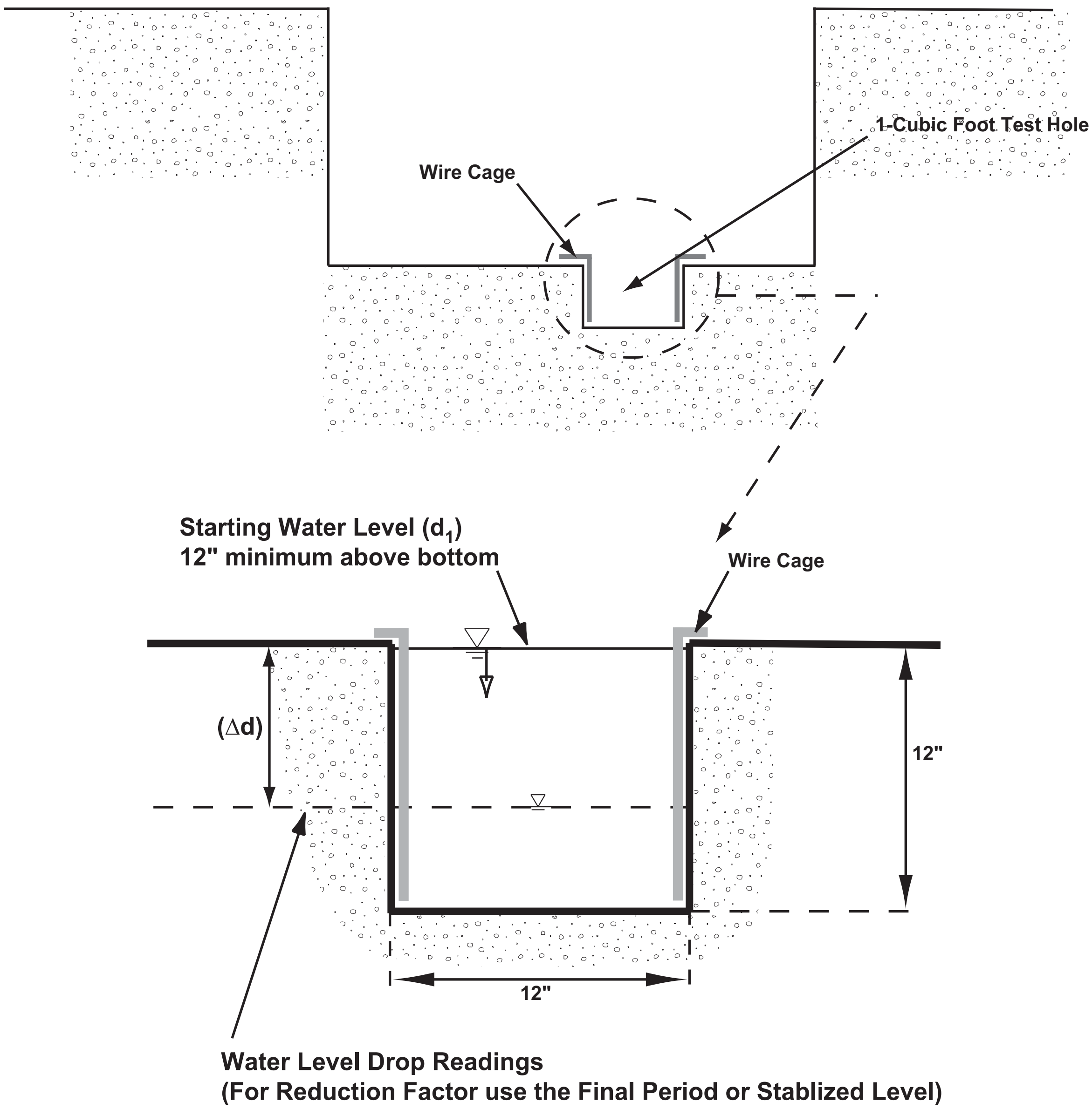
Where reduction factor (Rf) is given by:

$$R_f = \left(\frac{2d_1 - \Delta d}{DIA}\right) + 1$$

With:
d1 = Initial Water Depth (in.)
Δd = Water Level Drop of Final Period or Stablized Level (in.)
DIA = Diameter of the boring (in.)

Plate 3-A

County of Los Angeles Administrative Manual
Low Impact Development - Best Management Practice GS200.1
Infiltration Testing Procedures
Excavation Percolation Testing Method



Infiltration Rate = Pre-adjusted Percolation Rate divided by Reduction Factor

Where reduction factor (Rf) is given by:

$$R_f = \left(\frac{2d_1 - \Delta d}{DIA}\right) + 1$$

With:
d1 = Initial Water Depth (in.)
Δd = Water Level Drop of Final Period or Stablized Level (in.)
DIA = 13.5 (Equivalent Diameter of the Boring)(in.)

Boring/Excavation Percolation Testing Field Log

Date 2/20/2011

Project Location 900 S. Fremont Ave. Project
Earth Description Alluvial Fan
Tested by YM
Liquid Description Clear Clean Tap Water
Measurement Method Sounder

Boring/Test Number Boring 2 / Test 1
Diameter of Boring 6” **Diameter of Casing** 2”-4”
Depth of Boring 6’
Depth to Invert of BMP 5’
Depth to Water Table 30’
Depth to Initial Water Depth (d_1) 12”

Time Interval Standard
Start Time for Pre-Soak 9:30am
Start Time for Standard 10:00am

Water Remaining In Boring (Y/N) Yes Water in Boring
Standard Time Interval Between Readings 30min/10min

Reading Number	Time Start/End (hh:mm)	Elapsed Time Δtime (mins)	Water Drop During Standard Time Interval Δd (inches)	Percolation Rate for Reading (in/hr)	Soil Description/Notes/Comments
1	10:30am 11:00am	30	3.00	6.00	SM, ML Moist, light brown
2	11:00am 11:30am	30	2.00	4.00	Water refilled every 30 mins to maintain initial water depth
3	11:30am 12:00pm	30	1.75	3.00	
4	12:00pm 12:30pm	30	1.50	3.50	
5	12:30pm 1:00pm	30	1.25	2.50	
6	1:00pm 1:30pm	30	1.10	2.20	
7	2:00pm 2:30pm	30	1.00	2.00	Stabilized Rate Achieved with Δd Readings 6, 7, and 8
8	3:00pm 3:30pm	30	1.00	2.00	

Boring/Excavation Percolation Testing Field Log

Date ________

Project Location ____________________
Earth Description ____________________
Tested by ____________________
Liquid Description ____________________
Measurement Method ____________________

Time Interval Standard
Start Time for Pre-Soak ____________________
Start Time for Standard ____________________

Boring/Test Number ____________________
Diameter of Boring ________ Diameter of Casing ________
Depth of Boring ____________________
Depth to Invert of BMP ____________________
Depth to Water Table ____________________
Depth to Initial Water Depth (d_1) ____________________

Water Remaining In Boring (Y/N) ____________________
Standard Time Interval Between Readings ____________________

Reading Number	Time Start/End (hh:mm)	Elapsed Time Δtime (mins)	Water Drop During Standard Time Interval Δd (inches)	Percolation Rate for Reading (in/hr)	Soil Description/Notes/Comments