Standard Test Method for Permeability of Synthetic Turf Sports Field Base Stone and Surface System by Non-confined Area Flood Test Method[1]

This standard is issued under the fixed designation F2898; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method may be used to determine the permeability rate of synthetic turf playing field systems, playing field systems with pad or premolded drainage boards, or both, playing field systems with premolded panel base systems, porous and non porous pavement systems, or base stone systems in the field, or a combination thereof, by non-confined area flood test method. This system is suitable for use on the finish synthetic turf playing surface and on the stone base system below the playing system.

1.2 This test method is applicable for synthetic turf playing field systems and stone bases where system is designed for permeability through the synthetic turf surface and or through a base stone surface. It is also suitable for synthetic turf playing systems that are directly underlined with resilient and nonresilient pre-molded drainage boards systems and porous pavement base systems. The method tests a larger surface area than confined ring test methods and decreases the effect lateral flow within the surface and or stone base system due to the large increase in the ratio of test surface area to the synthetic turf playing system and stone base system thickness. The method is intended to more accurately mimic natural storm flow conditions by eliminating the effect of head pressure created by the water column height which creates a pressure flow condition at the surface of the test area that does not exist naturally.

1.3 This test method is intended for finish-graded and compacted stone or finished surfaces that are installed with cross-slope gradients of less than 2.0 % or under conditions where the effect of cross-slope is mitigated by high system permeability. High sloping systems tend to have high sloping base systems which may impact results due to increases in the lateral flow within the section caused increased hydraulic energy caused by larger slopes.

1.4 This test method is not applicable for conditions or locations in-which surface flow, due to high surface cross-slope or proximity, carries water flow from the test site to surface and subsurface drainage trenches or structures.

1.5 Further, this test method may be impacted if preformed directly after a significant rainfall event in cases where the downstream capacity of the receiving drainage system is taxed to the extent that water backs up in the downstream system.

1.6 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1551 Test Methods for Comprehensive Characterization of Synthetic Turf Playing Surfaces and Materials

3. Terminology

3.1 *Definitions:*

3.1.1 *area of test site, n*—the area of test site is the surface area in square feet of the test site area.

3.1.1.1 *Discussion*—This surface area represents an approximated and simplified shape of equal area such as a rectangle that includes the full wetted area. Small fingers of non-wetted surface within the wetted area shall be ignored in the surface approximation. It is assumed that these small fingers of non-wetted area are wetted below the surface within the test site.

3.1.2 *dry surface, n*—a dry surface after testing or saturation is defined as follows:

3.1.2.1 *dry stone base surface, n*—a surface where water is no longer visible as ponded water on or above the surface of the stone.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.2.2 *Discussion*—After saturation or testing the surface will be moist and water may be visible within the surface voids.

3.1.2.3 *dry synthetic turf surface, n*—a surface where water is no longer visible on the surface, and water will no longer pump to the surface when walked upon.

3.1.2.4 *Discussion*—After saturation or testing the surface will be moist and water maybe visible within the fiber and or infill matrix.

3.1.3 *flow rate control valve, n*—located between the on-off valve at the outlet hose and the water supply source valve, it is intended to allow the flow rate to be throttled back to a lower flow rate if needed.

3.1.3.1 *Discussion*—This secondary valve is needed in cases where the unmodified source flow rate exceeds 10 gal per minute. A flow rate of 10 gal per minute will fill the 5-gal container in 30 s which makes the procedure subject to flow rate errors due to the time necessary to open flow and record times. The secondary valve is necessary to mitigate such errors.

3.1.4 *hydrophobicity, n*—the physical property of a molecule that is repelled from a mass of water.

3.1.4.1 *hydrophobic, n*—materials that repel water and may prevent water molecules from passing through a field cross-section.

3.1.5 *on-off valve, n*—located on the discharge end of the hose nearest to the water discharge point, it will allow the tester to turn the water from the fully off position to the fully open position with minimal variation in flow during the period that the valve is turned from the open to closed positions or vice a versa.

3.1.5.1 *Discussion*—A quarter turn ball valve or similar quick on-off valve must be used at this location.

3.1.6 *permeability, n*—a measure of the ability of a porous material to transmit fluids.

3.1.6.1 *Discussion*—For the purpose of this standard, permeability applies to transmission of water both vertically and horizontally through a system.

3.1.7 *surface system, n*—the finish grade top surface of the synthetic turf playing field and any resilient padding and or pre-molded drainage boards and or pre-molded panel base systems located directly below the synthetic turf carpet.

3.1.8 *surfactant, n*—wetting agents that lower the surface tension of a liquid, allowing easier spreading, and lower the interfacial tension between water molecules and other materials. Surfactants can be used to reduce hydrophobicity.

3.1.9 *test flow rate, n*—the water flow rate of the water supply at the hose outlet for the water source used during the test period.

3.1.10 *test site area, n*—the area observed during the test to be wetted as a result of the 25-gal test procedure.

3.1.11 *water supply source valve, n*—the shutoff valve or hose bib at the source.

4. Summary of Test Method

4.1 A plastic or other waterproof lightweight material container of 5 US gal (18.95 L), full volume, is filled using a water source with a relatively constant flow to determine test flow rate, and which is then allowed to overflow the container at the calculated flow rate onto the test site area in an unconfined manner. The amount of time, in seconds, required to fill the container to the point of overtopping (overflowing) is set as the 5-gal flow rate of the test.

4.2 The container shall be leveled using the water level across the top of the container as the gauge. Leveling the container is accomplished using wood wedges, shims or similar devices. This leveling is intended to allow a somewhat uniform flow overtopping the full circumference of the top edge of the container.

4.3 A splash board made of plywood or other material can be placed below the container to control the erosive forces associated with the falling water on the test surface. This is not required however may be helpful during the procedure.

4.4 The test site area is pre-saturated by a volume of approximately 50 US gal (189.5 L) of water which has overflowed the container onto the surface and allowed to spread in an unconfined manner. This volume of water is then allowed to dissipate into the surface system or stone base until the surface is considered to be a dry surface. The 50 US gal (189.5 L) volume is metered based on the multiplying the time to fill the 5 gal container by a factor of 10.0. The 50 US gal (189.5 L) volume represents a volume equivalent to 1.0 in. (25.4 mm) of rain, applied without the effect of a hydraulic head, over an 80 ft^2 (7.43 m^2) area. At the point when the pre-wetted area on the surface is considered a dry surface the site is considered pre-saturated and ready for the 25 gal test volume.

4.5 The site is then flooded by the unconfined container overflow of 25 US gal (94.75 L) of water which has overflowed the container onto the surface and allowed to spread in an unconfined manner. This volume of water is then allowed to dissipate into the surface system or stone base until the surface is considered to be a dry surface. The 25 US gal (94.75 L) volume is metered based on the multiplying the time to fill 5 gal container by a factor of 5.0. The 25 US gal (94.75 L) volume represents an approximate volume equivalent to 0.5 in. (12.7 mm) of rain, applied without the effect of a hydraulic head, over an 80 ft^2 (7.43 m^2) area. The inclusive time period in seconds, from the start of container overflow to the point when the wetted surface of the test area is considered to be a dry surface, is recorded. This time period is identified as the time to dry. The wetted surface area of the test site is measured to determine the area of test site. Using the measured area of the test site and the actual volume of the 25 US gal test, a permeability rate is calculated.

5. Significance and Use

5.1 This test method can be used to determine in-place permeability of synthetic turf playing field systems, playing field systems with pad and or premolded drainage boards, playing field systems with premolded panel base systems, porous and non porous pavement systems in order to confirm compliance with design specifications and or evaluate existing as-built conditions. The simplicity of the test method, the quickness of the procedure, and the limited requirement for special tools and apparatus' makes this ideal for performing a large quantity of tests over a large area such as a sports field.

5.2 Synthetic turf field systems tend to drain under several flow regimes. The first flow regime is surface flow where water travels across the surface from typically higher elevations to lower elevations. The second flow regime is flow through the turf surface and base system. The third flow regime is lateral flow, which has two parts. Lateral flow within the section of the turf surface and lateral flow within the pre-molded drainage board, porous pavement and or base stone system below the turf. These are depicted diagrammatically in Fig. 1.

5.3 This test method can provide owners, designers and turf system builders with a clear indication of actual in-field permeability flow rates with limited effect of lateral flow through base systems and no effect from head pressure.

5.4 This test method can be used to determine the effectiveness of treatments intended to reduce the effect of hydrophobicity which has been known to decrease the permeability of some synthetic turf infill materials and components.

5.5 The observable performance of the test method enables one to determine permeability by both a quantitative and qualitative measure.

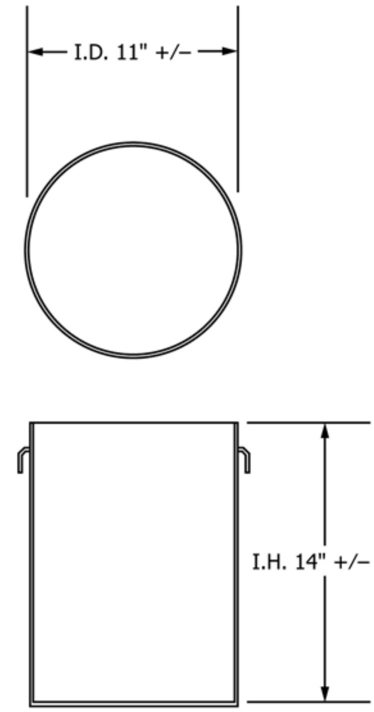

FIG. 2 Test Container Diagram

6. Interferences

6.1 The test site should be free from surface drains or other conditions that would result in nonrepresentative permeability rates. Other conditions such as open graded clean stone directly exposed at the surface would be expected to impact the test results.

6.2 In fields where collector piping backfill is open-graded and brought to the stone surface, care should be taken to located test sites such that impact from these areas is avoided or clearly noted in the test report.

7. Apparatus

7.1 *Plastic Container,* with a measured and confirmed volume of approximately 5 US gal (18.95 L). See Fig. 2.

7.1.1 The container shall be container clean of any debris or chemicals that may act as a surfactant.

NOTE 1—Soap residue can act as a surfactant which may reduce hydrophobicity and impact the results of the test method.

7.1.2 The container volume must be measured and confirmed prior to the test and the actual measured volume recorded in the test report. Volume shall be measured to the nearest 0.1 US gal (0.4 L).

NOTE 2—For ease of calculation, the container volume can be measured and a base fill line near the container bottom representing the excess volume over the 5.0 gal quantity can be added to allow the testing volume to be consistently 5.0 gal. In this case, the base fill line represents the point at which 5.0 gal of volume is above the line.

7.1.3 The container should be equipped with a suitable handle for moving the full bucket into and out of the test site.

NOTE 3—It is recommended that water from the container not be poured onto the test site until the procedure is completed and that care should be taken to avoid damaging fine graded surfaces by aggressively pouring excess water from the container onto the test area.

7.2 *Constant Water Source:*

7.2.1 A source of water capable of supplying a constant flow rate throughout the test period must be used. Water supplies, whether public, private well or construction tank tend to vary over time and must be measured and reconfirmed for each test and test location. This method requires that for each test a new time to fill the container must be obtained. Should a test be

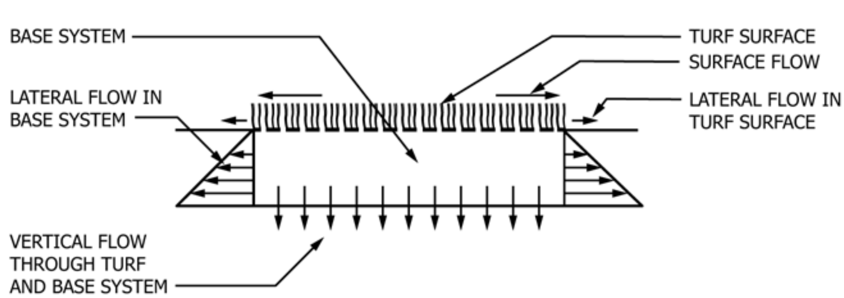

FIG. 1 Basic Flow Regime Diagram

delayed such that the period of time between the time to fill measurement and the actual test is greater than one hour the time to fill the container shall be re-measured. This procedure allows variations in water source system flow rate to be accounted for.

7.2.2 A minimum flow rate from the water source of 2.0 gal in 60 s (2.0 gal per minute) is recommended. This, 2.0 gal in 60 s (2 gal per minute), will result in approximately 150 s (2 min, 30 s) to fill the bucket. Depending on the permeability of the test area, supply flow rates less than 2.0 gal in 60 s (2 gal per minute) may not be adequate to produce a wetted area of 4.0 ft^2 or greater.

7.2.3 Further, at 4.0 ft^2 of test area or less, the ratio of the area of the test site to the effective surface area of the base system section below the test area starts to decrease thus increasing the potential for significant impact due to lateral flow in the base section. This concept is diagramed in Fig. 3.

7.2.4 The maximum flow rate shall be less than 10.0 gal per 60 s (10 gal per minute). A flow rate of 10.0 gal per 60 s (10 gal per minute) will fill the 5-gal container in 30 s, which makes the procedure subject flow errors due to the time necessary to open flow and record times. For every test the flow rate must be capable of saturating the test area around the test site and capable of wetting the test area with the 25-gal test volume to a minimum of 4 ft^2 in order to limit the effect of lateral flow on the test results.

7.3 *Water Supply Hose and Valves*—A water supply hose with a minimum cross-sectional area capable of delivering the required water supply without excessive head-losses shall be used. A minimum ½ in. (12.7 mm) inside diameter hose is recommended. The hose shall be attached to a quarter-turn ball type shutoff valve capable of turning on and shutting off the flow without impact to flow rates at the outlet end, a throttling valve located between the source valve and the outlet valve. The shutoff valve shall be located at the container end of the hose for quick control by the tester.

7.4 *Stop Watch*—A stop watch or watch for measuring time is required. It must be capable of measuring time to the nearest second. The timing device must not only be capable of measuring total time elapsed but must also be capable of providing intermediate times for determining the point at which the 25-gal test volume is applied. Measuring time based on hour, minutes and seconds of day time allows a standard watch containing a second-hand to be used.

7.5 *Tape Measure*—The tape measure must be capable of measuring lengths of up to 25 ft (7.62 m) to the nearest inch (25.4 mm).

7.6 *Area Marking Flags, Cones, Tokens, or Rope*—The area must be marked to outline the limits of the wetted area that results from both the application of the pre-saturation volume and the application of the 25 US gal test volume. The edge shall be marked using flags, cones, tokens or a rope to allow measurement of the approximate area at the completion of the test. A rope that can be knotted at the limit of the wetted area may prove easiest to use to approximate a rectangle, however, the resulting rectangular shape must still approximate the actual surface area to avoid errors created due to shape.

8. Calibration and Conditioning

8.1 The actual volume of the container used for the test must be confirmed by comparing it to a known volume. This shall be accomplished using gallon, half gallon or quart container metered to an 8 oz (one cup) accuracy. The test container shall be filled using a known volume and the total volume recorded.

NOTE 4—It is recommended that the container volume be marked directly on the container using a waterproof marker. If a 5.0 gal base line is added to the container to allow all volumes to be based on 5.0 gal, this shall be marked using a waterproof marker and labeled as, "5.0 GALLON VOLUME ABOVE THIS LINE".

8.2 Prior to each test the flow rate of the water source must be calibrated. Calibration of the flow rate shall be based on measured time it takes to fill the container divided by the actual volume of the container when full to the top.

8.3 The site test area must be pre-saturated prior to the application of the actual test volume. The test area shall be pre-saturated with 50 US gal (189.5 L) of water. This volume of water is then allowed to dissipate into the surface system or stone base until the surface is considered to be a dry surface. Once complete the test area is considered saturated. The saturation volume is applied by running the water source an equivalent period of time equal to (10) ten times the 5 gal container fill period. The limit of the area wetted during saturation shall be clearly marked using flags, tokens, cones or other marking devices.

9. Procedure

9.1 Record basic data related to the test site and environmental conditions:

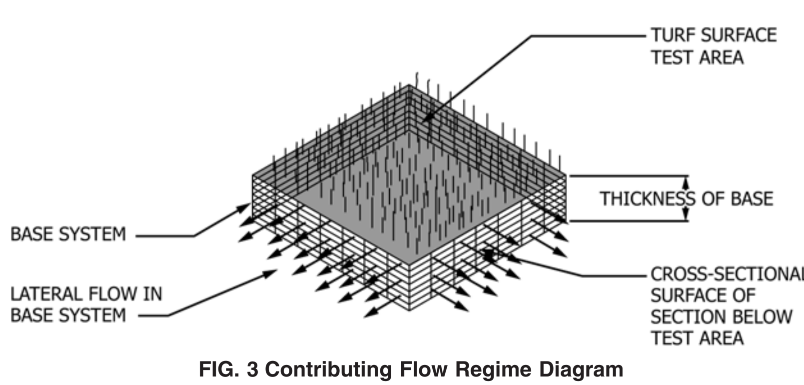

FIG. 3 Contributing Flow Regime Diagram

9.1.1 Record the general weather conditions for each day of testing (sunny, light rain, gusting wind, etc.).

9.1.1.1 Record the air temperature and surface temperature at the test site.

(1) Measure and record the air temperature at a point 3 ft above the ground.

(2) Measure and record the surface temperature. Make note if surface temperature is at or below freezing, 32.0°F (0.0°C).

NOTE 5—Frozen ground conditions may negatively impact the test results.

9.1.2 Record the condition of the field as influenced by the weather (damp, dry, areas of standing water, ice, etc.).

9.1.3 Record test point locations with enough detail that each is fully and uniquely identified.

9.2 The actual volume of the 5-gal container is measured and recorded to the nearest 0.1 US gal, $V_{container}$.gal. The volume of the container in cubic is then calculated as follows:

$$V_{cubic\ feet} ft^3 = V_{container}. gal/7.48\ gal/ft^3$$

9.3 The 5 US gal container of confirmed volume is filled using a uniform flow rate supply to determine the flow rate of the water source, Q_{source}. The time to fill the container is recorded as t_{fill}. This length of time is measured and recorded in seconds to the nearest second. The flow rate is recorded as Q_{source} gallons = $V_{container}$.(gallons)/ t_{fill} (sec). The flow rate is then converted from gallons per second time period to cubic feet per second Q_{source} ft^3 = $V_{cubic\ feet}$ ft^3/s based on the following conversion:

$$Q_{source} ft^3 = Q_{source}\ gallons/7.48\ gal/ft^3$$

9.4 The test site is then pre-saturated using a volume of approximately 50 gal. The actual saturation volume, V_{50}, ft^3, is the product of $V_{cubic\ feet}$ ft^3 times 10.0. The application is based on the following approximation. The time required to fill the container, t_{fill} is multiplied by 10.0 to determine required time test site saturation, $t_{50\ gal}$ sec.

$$t_{50\ gal} sec = t_{fill} \times 10.0$$

9.5 The water source is turned to the on position for the period of time $t_{50\ gal}$ sec. This volume of water is then allowed to dissipate into the surface system or stone base until the surface is considered to be a dry surface. Once complete the site is considered saturated. The limit of the area wetted during saturation is clearly marked by using flags, cones, tokens or other marking devices. The marking devices shall be a different material or color to allow differentiation between the area created by saturation and the area created by the test volume.

9.6 The test volume of 25 gal is then applied to the site. The actual test volume, V_{25}, ft^3, is the product of V_{cubic} feet ft^3 times 5.0. The application is based on the following approximation. The time required to fill the container, t_{fill} is multiplied by 5.0 to determine required time test site saturation, $t_{25\ gal}$ sec.

$$t_{25\ gal} sec = t_{fill} \times 5.0$$

$$V_{25}, ft^3 = V_{cubic\ feet} ft^3 \times 5.0$$

9.7 The water source is turned to the on position for the period of time $t_{25\ gal}$ sec. This volume of water is then allowed to dissipate into the surface system or stone base until the surface is considered to be a dry surface. The total time inclusive, from the start of the container overtopping the top edge of the container until the point at which the test area is considered a dry surface is recorded as the time to dry, t_{dry} sec.

9.8 The wetted area created by the 25 US gal test volume is measured and recorded, A_{wet} ft^2. Prior to measuring the area, the approximate limits of the wetted area must be marked using flags, cones, tokens, rope or other suitable marking method. The extent of the area wetted due to the test volume of 25 gal shall be completely within the marked area created by the pre-saturation process to assure that the test area has been saturated. If the test area was not completely within the pre-saturated area, the test is considered void and must be completely rerun. The shape of the wetted area shall be approximated using the marking method by approximating a rectangle, or other suitable shape, of equal area superimposed over the wetted location. Wetted surface areas may be complex forms and not equivalent to the areas of wetted strata located below the surface. To approximate a rectangle, dry areas at rounded corners and wetted areas within the general body of the wetted area should be approximated in order to provide an area of similar size. Areas such as a finger of dry surface reaching into the wetted area shall be ignored. The two dimensions of the approximated rectangle are measured and recorded. From these measurements the wetted area, A_{wet} ft^2, is calculated. See Fig. 4.

$$A_{wet} ft^2 = Length \times Width$$

9.9 The wetted area created by the 25 US gal test volume shall be photo graphed for inclusion in the report.

10. Calculations

10.1 The calculation of the average permeability, $P_{average}$ inches/hour, is a function of the effective depth of the actual test volume, V_{25}, ft^3, distributed over the wetted area A_{wet} ft^2, divided by the time to dry, t_{dry} sec adjusted to hours. The average permeability shall be calculated for each test area.

10.2 The effective depth, $d_{effective}$ inches, of the actual test volume applied to the wetted area is calculated by dividing the test volume in cubic feet V_{25}, ft^3, by the calculated wetted area A_{wet} ft^2 and multiplying by 12.0 to convert to inches as follows:

$$d_{effective}\ inches = (V_{25}, ft^3/A_{wet} ft^2) \times 12.0\ inches/ft$$

10.3 The average permeability, $P_{average}$ inches/hour, of the test volume at the subject test location represents the flow rate of the test in units of inches per second multiplied by 3600 to arrive at inches per hour and is calculated as follows:

$$P_{average}\ inches/hour = (d_{effective}\ inches \times 3600 sec/hour)/t_{dry} sec$$

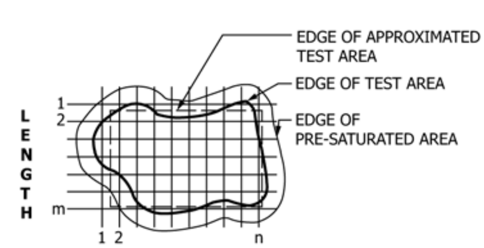

FIG. 4 Wetted Area Diagram

11. Report

11.1 Each test location shall be recorded on a separate sheet with a test identification number. A sketch of the field area with test locations is suggested. The report shall include the following:

11.1.1 Field identification and institution or other naming identification,

11.1.2 Test identification number,

11.1.3 Date of test,

11.1.4 Weather conditions and temperature (ambient at 3.0 ft above the ground surface and on the turf system surface),

11.1.5 Sketch of field and written description of test locations as referenced from permanent edge conditions (two dimensions, referenced tie points and a compass referenced area suggested),

11.1.6 Description of water source (public, private well, construction tank truck or other),

11.1.7 Measured volume of the container, $V_{container}$.(gallons)/,

11.1.8 Time to fill the container to the top, t_{fill},

11.1.9 Calculated time to saturate site, $t_{50\ gal}$ sec,

11.1.10 Calculated time to apply 25 US gal test volume, $t_{25\ gal}$ sec,

11.1.11 Start time and completion time for application of saturation volume as determined by stop watch or watch,

11.1.12 The total time for application of 25 gal test volume,

11.1.13 Time to dry (includes time to apply 25 gal test volume plus additional time beyond application period required for water to dissipate into wetted area),

11.1.14 Time to dry converted into seconds, $t_{25\ gal}$ sec, this includes the time to apply the 25 US gal to the test site and the additional time to dry after the application of the test volume,

11.1.15 Length, width and calculated area of wetted area, L ft, W ft, A_{wet} ft^2,

11.1.16 Calculated effective depth, $d_{effective}$ inches,

11.1.17 Calculated average permeability, $P_{average}$ inches/hour,

11.1.18 Comments and observations related to flow conditions such as: water quickly and uniformly dissipated into stone, water traveled a considerable distance down-gradient before dissipating into stone, water sat on the surface of the stone before slowly dissipating into surface.

11.1.19 Photograph of the test site while wetted to depict the extent of the test site and serve as a photographic record of the test.

12. Precision and Bias

12.1 The test method outlined herein is a new test method and therefore precision and bias has not yet been completed.

13. Keywords

13.1 backing; infill; permeability; porosity; stone base; synthetic turf