Rhode Island Method for Determining Hydrologic Soil Group by Site Specific Soil Mapping

FINAL DRAFT

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Abstract: The hydrologic soil group (HSG) classification system places soils into groups based on their runoff producing characteristics under storm events and ground cover conditions. Soils are specifically classified as based on depth to the average seasonal high water table (SHWT), depth to water impermeable layer and saturated hydraulic conductivity of the least transmissible layer (Ksat) (USDA-NRCS, 2009). Implementation of a standard method used to define hydrologic soil groups (HSGs) is difficult in practice due to constantly changing standards, outdated soil surveys, and variability in field measurements. Accurate determination of a soils HSG is very important due to the outcomes related to site planning and development as based on HSG placement. HSGs are important in relation to soil hydrology, specifically in calculation of the curve number; a method that has become standard to predict runoff (Nielsen et al., 1998). Additionally, the HSG of a site is necessary to plan for site development. Specifically, implementation of low impact development (LID), best management practices (BMP's) and septic system requirements.

Soils are classified at varying scales based on the intended use of the resulting soil survey. Since land use decisions are determined from soil evaluations completed at local scales, it has become essential that a field method be developed which allows soils to be accurately classified into HSGs; the same mapping scale which their determination has influence. The field method in this document coincides with the 2015 update to the, "*Standards and Procedures for Site Specific Soil Mapping in Rhode Island*", which documents the process of mapping soils at a local scale, also referred to as site specific soil mapping (SSSM), to create a site specific soil survey (SSSS).
This document further explains the importance of identifying HSGs during field mapping through SSSM and outlines a protocol to HSG identification specifically for Rhode Island derived from the 2009 NRCS National Engineering Handbook (NEH) (USDA-NRCS, 2009); the most current national standard published to identify HSGs.

The NEH Hydrologic Soil Groups Classification System

Within the NEH, soils are assigned to four hydrologic groups and three dual groups.

Group	Description
A	• Contains soils having a high infiltration rate when thoroughly wet and therefore have a low runoff potential.
B	• Has moderate infiltration a low runoff potential.
C	• Has slow infiltration and higher runoff potential.
D	• Lists soils having a very slow infiltration rate and thus the highest runoff

	potential.
Dual Groups (A/D, B/D and C/D)	• Certain wet soils are placed in group D based solely on the presence of a high water table even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

The most recent update by the NRCS to determination of HSG was published in the 2009 National Engineering Handbook. This document was originally printed in 1964 with minor revisions in 1972 and an update in 1985.

In the 1985 NEH HSGs were classified based on runoff-producing characteristics, wetness characteristics, water transmission after prolonged wetting, permeability, depth to seasonal high water table, and depth to very slowly permeable layers (USDA-NRCS, 2009). These parameters are based on soils which are thoroughly wet, not frozen, have bare soil surface and are at a maximum swelling of expansive clays. Classifications were determined by measuring "the minimum rate of infiltration obtained for a bare soil after prolonged wetting," which generates the run-off potential (USDA-NRCS, 1985, Chapter 7). Infiltration is defined as "the rate at which water enters the soil at the surface and which is controlled by surface conditions (USDA-NRCS 1989, Chapter 2)." Ultimately, a soil is placed into the appropriate HSG as based on its most water limiting property (USDA-NRCS, 2009).

The 1985 NEH does not provide specific details on how to assign HSGs to a soil series as based on calculation of the Ksat (saturated hydraulic conductivity) or depth to the water table, and is therefore general in nature and description. Commonly, HSGs are assigned by comparing soil profiles to previously classified profiles so that soils with similar properties are assigned to the same HSG. The premise is that similar soil properties will result in similar soil hydrology and therefore be contained within the same HSG. Typically, the most prevalent HSG is described, though more than one may be present (USDA-NRCS 2009, Chapter 7).

The 2099 update is expected to result in changes to the current HSG classification of many soil series. Therefore, when planning for site development, it is highly recommended that the HSG currently defined by a soil series not be used in place of field testing. Through being more specific in HSG determination, the changes within the 2009 NEH has allowed for the HSG classification system to become more transferrable from the method to practice in the field. Additionally, the 2009 NEH makes clear that if there is no reliable Ksat data available then HSG determination can be done through observing soil properties in the field including texture, bulk density, soil structure, clay mineralogy and organic matter (USDA-NRCS, 2009).

It has been evident that this national document has been difficult to apply. In general, soil scientists continue to use soil properties and their best judgments to assign HSGs. The purpose of this document is describe an applicable field method to use by scientists which will mitigate discrepancies when identifying the HSG for a soil, through SSSM in the state of Rhode Island so HSG classification can occur at scales of development.

It is important to reiterate that use of the Rhode Island Soil Survey to identify the HSG of a soil at SSSM scales is inadvisable. The scale of the current RI Soil Survey is at a scale of 1:15,840 (though it was mapped at 1:12000) (Soil Survey Staff, 1993). These maps are primarily used for solving hydrologic issues with community planning, watershed assessments, and flood prevention. While these applications are feasible at this scale, other applications are not. Site specific maps provide a more detailed, accurate, and comprehensive view of an area for land applications and are at a scale of 1:2400, 1:600 or larger, depending on the intended use of the map. Additionally, the RI Soil Survey was last updated in 1981 and therefore, is out of date with the new 2009 NEH specifications.

From Site Specific Soil Mapping to HSG Determination to Land Development

SSSM aids municipal officials in decision making by surveying soil properties at a mapping scale, comparable to that of the field investigations made when assessing suitability of land for development. (Stolt, 2007). Results of site specific mapping can be applied to onsite waste water systems, stormwater planning and design, and planning of building sites and roads. SSSM is the best approach in assessing for hydrologic issues related to construction because the process provides visual confirmation of site constraints which lead to better decision making. SSSM also guides in selecting the most suitable field test sites for water table monitoring, well placement, permeability testing and test pit evaluations for wastewater treatment. This method is less expensive and less invasive as only hand held tools are required.

The accurate determination of a soils HSG is important specifically at local scales when assessing for soil hydrology and in determining site suitability. HSG identification is necessary when calculating the curve number (CN) which is used to implement protocol for hydrologic modeling as outlined in the Technical Release 55 (TR-55) (Horsley Witten Group, 2010). The CN is a number that references rainfall (inches) vs direct runoff (inches). This helps determine how much runoff per inch of rainfall will be received for a specific type of land use cover type. From this, storm runoff volume, peak discharge rates and other numerical estimates essential when preparing for land development calculated. Specifically, results of these models assist in determining necessary site development and management related to Low Impact Developments (LIDs; i.e. rain gardens) and Best Management Practices (BMPs; i.e. infiltration basins and sediment retention ponds).

Stormwater treatment has come a long way in recent years as scientific advancement has increased understanding of water quality and the impacts of development to stormwater runoff. Management practices are now concentrating on water quality and quantity, including volume and peak runoff. New techniques in site planning and design have reduced the amount of runoff produced through LID methods and small-scale management practices. In Rhode Island, the use of natural systems (i.e. LIDs), rather than end-of-pipe treatment for stormwater are required by the Smart Development for a Cleaner Bay Act (RI Gen L § 45-61.2-2 (2014)). Benefits of LID include a reduction to the burden on municipal infrastructure, a decrease of surface runoff from impervious surface, stream lining the development application processes (saving money and time), and increasing overall environmental health for the public (Stolt, 2007).

Methods for Identification of HSGs with use of Rhode Island SSSM

In order to make the manual on Standards and Procedures for Site Specific Soil Mapping in Rhode Island more valuable in its applications, identification of HSGs were added. The criteria to identify HSGs utilizes the 2009 NEH, as well as integrates the RI DEM storm water standards and LID practices. The soil properties used to determine a soils HSG during SSSM are depth to seasonal high water table, depth to restrictive layer and subsurface texture of the least transmissible layer. The latter of the three characteristics is used in place of testing for Ksat.

Calculating the Ksat of a soil is time consuming and cumbersome as equipment and water would have to be brought to field sites for testing. Typically testing of hydraulic conductivity in the field includes use of an Aardvark, Amoozemeter, or a double ring infiltrometer. Each of these tests has advantages and disadvantages including cost, weight of equipment, ease of use, time, and required calculations. It is well known that measuring Ksat in the field results in variation in results as based on current site conditions and use of a device to measure this parameter.

<u>Depth to Water Impermeable Layer</u>

The impermeable layer will be a layer which prevents the continued infiltration of water and is root restrictive. Specifically, an impermeable layer, "has a Ksat less than 0.01 μm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost (USDA-NRCS, 2009)."

Depth to Restrictive layer is placed into three categories in the NEH and two categories in the Site Specific Soil Mapping guide. Categories are <20", 20"-40", >40" in the NEH and just <20" and 20"-40" in the SSSM guide. During field mapping the mapper will characterize the soil to a depth of 40". Therefore, if a restrictive layer is not found within 40" it is assumed to be >40". To streamline the length of the mapping units a restrictive layer of >40" will not be included. Additionally, if a restrictive layer is identified at <40", it will be distinguished if the layer is densic (D) or bedrock (R). A soil with a restrictive layer of <20" it is automatically placed in HSG D regardless of other soil properties.

<u>Depth to Seasonal High Water Table</u>

Refers to the average depth the water table sits below the surface over the course of a year. "Soils that have impeded drainage and/or have high water tables during certain periods of the year usually exhibit redoximorphic features. These features can be categorized as redox depletions and redox concentrations (formerly called low and high chroma mottles, respectively), and a gleyed matrix (State of Rhode Island et al., 2008).” The depth of the SHWT is determined when common concentrations or depletions are found within the soil profile. Refer to the DEM Soil Evaluation Guidance Document for a more thorough explanation of in situ classification.

Site Specific Mapping has the Depth to Seasonal High Water Table in six categories: 0”-12”, >12”-18”, >18”- <24”, ≥24-30”, >30-40” and > 40”. The 2009 NEH has the Depth to High Water Table divided at <24, <24-40”, and >40”.

A soil with a SHWT of <24” (a SHWT class of 0, 1 or 2) it is automatically placed in HSG D regardless of other soil properties.

<u>Subsurface Texture of Least Transmissible Layer</u>

Refers to the soil texture class of the layer within the soil profile which has the lowest saturated hydraulic conductivity (Ksat). Ksat is, “a measure of the ease of water movement in soil (Soil Survey Staff, 1993).” In referencing the soil textural triangle, textures composed of sands will have the highest Ksat rates, followed by silts and then clays (Figure 1). Additionally, soil classified by a coarse fragment modifier will be higher Ksat rates due to an increased pore size.

Textures described within the soil description note card include surface, substratum and parent material. The map unit legend includes texture by describing general particle size class based on the substratum soil textures. For determination of HSG, it is important to select for the texture of the least transmissible layer >10” thick.

In some cases there may be an eolian layer on the soil surface with a substratum of loamy sands and sands. The eolian layer, while the least transmissible layer, would only be included in HSG determination if it is greater than 10” thick.

<u>Removal of Dual HSGs</u>

Dual HSGs, found within the NEH guide, were removed as options within the RI HSG method. These groups were removed from the Rhode Island Soil Survey and the RI DEM storm water manual and therefore, it was not applicable to add them into this method.

Final Results

The following table is intended to be used in conjunction with the SSSM guide so that field identification of HSG can become an addition to the derived map unit symbols determined in the field by soil scientists.

Key to identification of HSGs with use of Rhode Island SSSM

1. Depth to impermeable layer	**2.** Depth to high water table	**1.** Subsurface Texture of least transmissible layer	**HSG**
<20 in	___	N/A	D
20 to 40 in	<24 in	N/A	D
	≥24 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands and Sandy Loams	B
		Fine Sandy Loams and Silt Loams	C
		Clay Loams and Clay	D
>40 in	<24 in	N/A	D
	24 to 40 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		Silt Loams	C
		Clay Loams and Clay	D
	>40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		Fine Sandy Loams and Silt Loams	B
		Clay Loams	C
		Clay	D

Note on Compacted Soils

It is important to consider the possibility of previous soil disturbance as a factor which can alter the HSG classification for a soil. Disturbance can result in compaction and the general guidelines for HSG determination no longer applies (USDA-NRCS, 2009). Compaction could be due to many factors including foot and vehicle traffic, construction, tillage and erosion (UDEL, 2009). Signs of soil compaction can be noticed specifically when testing for soil consistence and excavation difficulty. Refer to the DEM Soil Evaluation Guidance Document and Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of OWTS for methods placement into a soil category. If a soil is classified as a soil category 8-10 as based on consistence and evacuation difficulty as opposed to morphology, it is likely the soil has been compacted. While up to the discretion of the soil scientist preforming the site survey, it is recommended that a soil be classified into a stricter HSG if the soil is severely compacted.

Conclusion:

Accurate identification of HSGs are necessary when determining applicable land use and development for an area. The HSG classification relates to soil hydrology specifically concerning, runoff, flooding and soil permeability. These parameters are integrated by use of the TR-55 method, a standard in Rhode Island which directly integrates HSG classification into its calculations. Results go on to determine applicable LID and BMP's which will be put in place to mitigate environmental problems of flooding and water quality degradation.

It is essential that the scales at which site mapping is done match the geographical extent of the area to be altered by the mapping. In the case of land development, it is best to work at a local scale and therefore, the creation of a site specific soil map to identify the HSG for an area is a logical standard to work with, so the optimum results are achieved.

It should be noted that there may be some cases where HSG is difficult to determine as based on this method. A few examples are when there is a hanging water table, identification of redoximorphic features is difficult or when site conditions during field mapping are inconsistent with typical conditions such as drought. It is then suggested that monitoring occur over a longer period of time to determine conditions and place a soil into the appropriate HSG.

Appendix A. Derivation of the Rhode Island Hydrologic Soil Group Classification Method

Table 1. Unit conversation table for saturated hydraulic conductivity (Ksat)

µm/s		in/hr	m/s	cm/day	cm/hr
100	=	14.2	10^{-4}	864.0	36.0
10	=	1.42	10^{-5}	86.4	3.60
1	=	0.142	10^{-6}	8.64	0.360
0.1	=	0.014	10^{-7}	0.864	0.0360
0.01	=	0.0014	10^{-8}	0.0864	0.00360

Note. Retrieved from Chapter 3 of the USDA-SCS National Soil Survey Handbook. Copyright 1993 by the U.S. Gov. Print. Office, Washington, DC.

Table 2. 2009 USDA-NRCS criteria for HSG determination.

Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

Depth to water impermeable layer [1/]	Depth to high water table [2/]	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG [3/]
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 μm/s (>5.67 in/h)	0 to 60 cm [0 to 24 in]	A/D
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D
		≤1.0 μm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D
	≥60 cm [≥24 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D
		>4.0 to ≤10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D
	60 to 100 cm [24 to 40 in]	>40.0 μm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 μm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 μm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 μm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
	>100 cm [>40 in]	>10.0 μm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A
		>4.0 to ≤ 10.0 μm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B
		>0.40 to ≤4.0 μm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C
		≤0.40 μm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D

1/ An impermeable layer has a K_{sat} less than 0.01 μm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

7–4 (210–VI–NEH, January 2009)

Note. Retrieved from Chapter 7 of the USDA-NRCS National Engineering Handbook, 630. Copyright 2009 by the USDA, Washington, D.C.

Table 3. Simplified version of table 1 with added consistency with soils in RI.
Dual groups have been removed.

1. Depth to impermeable layer	2. Depth to high water table	3. Ksat of least transmissive layer	Ksat depth range	HSG
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<24 in	—	—	D
	≥24 in	>5.67 in/h	0-20 in	A
		>1.42 to ≤5.67 in/h		B
		>0.14 to ≤1.42 in/h		C
		≤1.14 in/h		D
>100 cm [>40 in]	<24 in	—	—	D
	≥24 to 40 in	>5.67 in/h	0-20 in	A
		>1.42 to ≤5.67 in/h		B
		>0.14 to ≤1.42 in/h		C
		≤0.14 in/h		D
	>40 in	>1.42 in/h	0-40 in	A
		>0.57 to ≤1.42 in/h		B
		>0.06 to ≤0.57 in/h		C
		≤0.06 in/h		D

Table 4. Amended general guide to saturated hydraulic conductivity in relation to soil texture

Since the goal is to have HSG be determined in the field from texture instead of measuring Ksat, the NRCS table is used which correlates textures with Ksat ranges.

This is a general guide. Bulk density of the soil may alter the defined rates.

Texture	General Textural Class	Permeability Class	Ksat Rate in/hr	Ksat Rate µm/sec
Gravel Coarse Sand	N/A	Very Rapid	>20.0	>141.14
Loamy Sand Loamy Fine Sand Loamy Coarse Sand Sand Fine Sand Coarse Sand	Coarse	Rapid	6.0-20.0	42.34-141.14
Coarse Sandy Loam Sandy Loam Find Sandy Loam	Mixed	Moderately Rapid	2.0-6.0	14.11-42.34
Very fine sandy loam Loam Silt Loam Silt	Mixed	Moderate	0.6-2.0	4.23-14.11
Clay Loam Sandy Clay Loam Silty Clay Loam	Mixed	Moderate Slow	0.2-0.6	1.41-4.23

Note. Retrieved from Chapter 3 of the USDA-SCS National Soil Survey Handbook. Copyright 1993 by the U.S. Gov. Print. Office, Washington, DC.

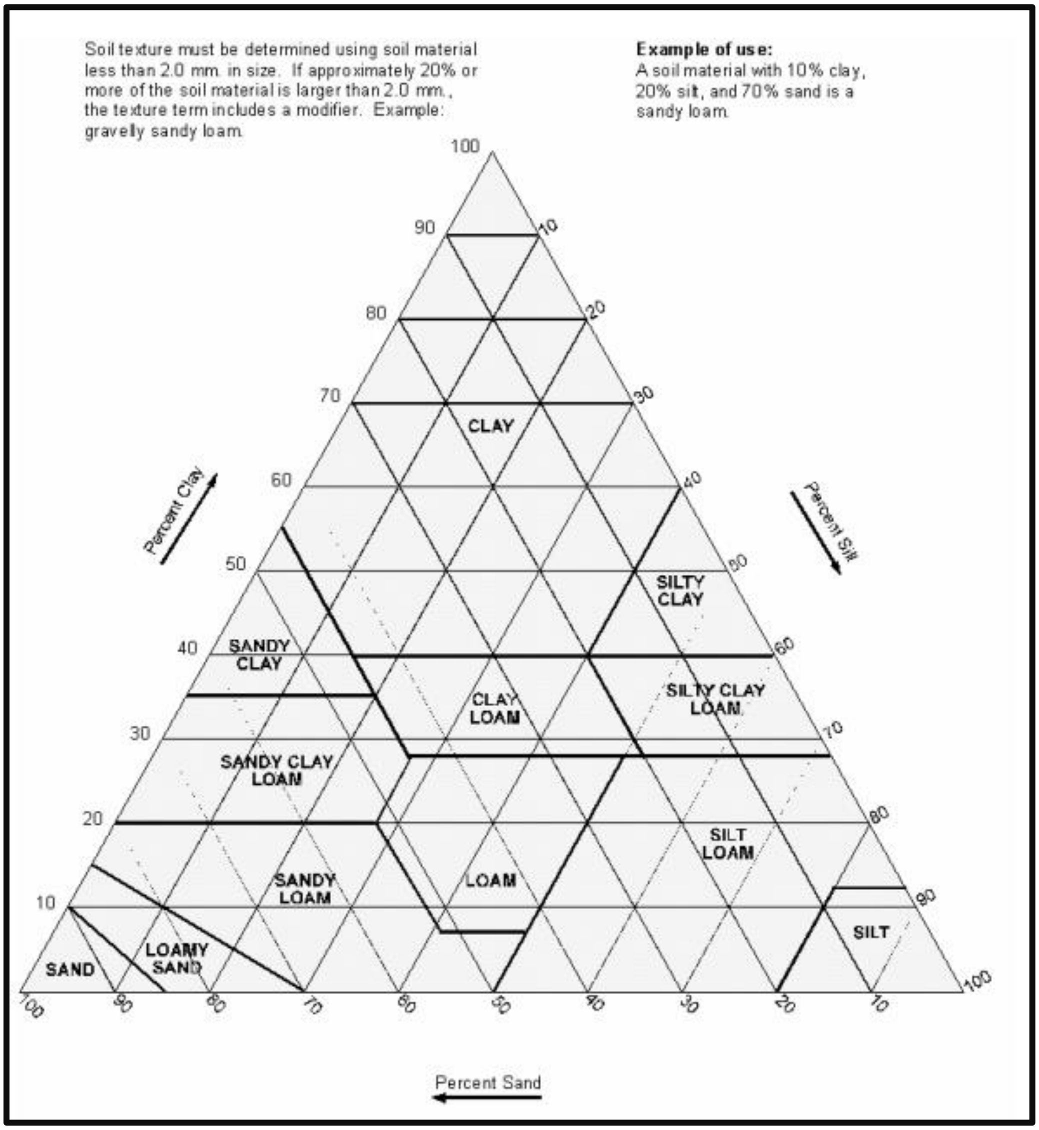
Table 5. Table 2 with addition of texture classes.

1. Depth to impermeable layer	2. Depth to high water table	3. Ksat of least transmissive layer	Ksat depth range	Textures	HSG
<50 cm [<20 in]	—	—	—	N/A	D
50 to 100 cm [20 to 40 in]	<24 in	—	—	N/A	D
	≥24 in	>5.67 in/h	0-20 in	Skeletal, Sands and Loamy Sands	A
		>1.42 to ≤5.67 in/h		Fine Sands and Sandy Loams	B
		>0.14 to ≤1.42 in/h		Fine Sandy Loams and Silt Loams	C
		≤1.14 in/h		Clay Loams and Clay	D
>100 cm [>40 in]	<24 in	—	—	N/A	D
	24 to 40 in	>5.67 in/h	0-20 in	Skeletal, Sands and Loamy Sands	A
		>1.42 to ≤5.67 in/h		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		>0.14 to ≤1.42 in/h		Silt Loams	C
		≤0.14 in/h		Clay Loams and Clay	D
	>40 in	>1.42 in/h	0-40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		>0.57 to ≤1.42 in/h		Fine Sandy Loams and Silt Loams	B
		>0.06 to ≤0.57 in/h		Clay Loams	C
		≤0.06 in/h		Clay	D

Table 6. Rhode Island field method of HSG determination.

1. Depth to impermeable layer	**2.** Depth to high water table	**2.** Subsurface Texture of least transmissible layer	**HSG**
<20 in	__	N/A	D
20 to 40 in	<24 in	N/A	D
	≥24 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands and Sandy Loams	B
		Fine Sandy Loams and Silt Loams	C
		Clay Loams and Clay	D
>40 in	<24 in	N/A	D
	24 to 40 in	Skeletal, Sands and Loamy Sands	A
		Fine Sands, Sandy Loams and Fine Sandy Loams	B
		Silt Loams	C
		Clay Loams and Clay	D
	>40 in	Skeletal, Sands, Loamy Sands, Fine Sands and Sandy Loams	A
		Fine Sandy Loams and Silt Loams	B
		Clay Loams	C
		Clay	D

Figure 1. Soil Texture Triangle



Note. Retrieved from the Rhode Island Department of Environmental Management and Office of Water Resources. Copyright 2008 by the RI DEM, Providence, RI.

Figure 2. Rhode Island Field Method to HSG Determination

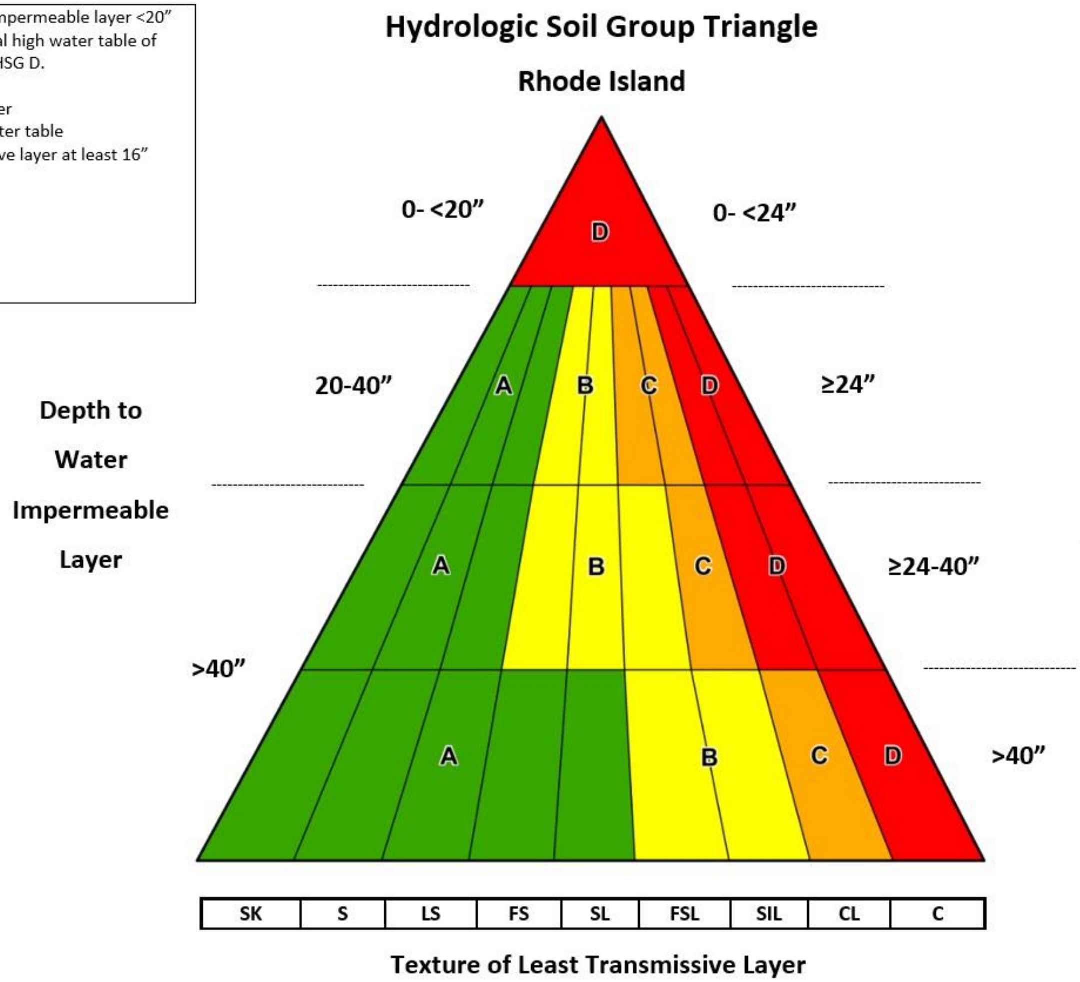
All soils with a depth to water impermeable layer <20" and/or a depth to the seasonal high water table of <24"will be in HSG D.

Steps:

1. Depth to impermeable layer
2. Depth to seasonal high water table
3. Texture of least transmissive layer at least 16" thick

Example:

1. Depth to IL= 35"
2. Depth to SHWT=28"
3. Texture= Sandy Loam
4. HSG= B



SK	Skeletal
S	Sand
LS	Loamy Sand
FS	Fine Sand
SL	Sandy Loam
FSL	Fine Sandy Loam
SIL	Silt Loam
CL	Clay Loam
C	Clay

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