Hydrologic Soil Indices and Ksat Values for New Hampshire Soils

Society of Soil Scientists of Northern New England
Special Publication No. 5
Proposed for adoption 12 September 2025

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Introduction

The Society of Soil Scientists of Northern New England (SSSNNE) is a non-profit professional organization of soil scientists, both in the private and public sectors, which is dedicated to the advancement of soil science. SSSNNE fosters the profession of soil classification, mapping and interpretation, and encourages the dissemination of information concerning soil science. With the intent of contributing to human welfare, SSSNNE seeks to educate the public on the wise use of soils and the associated natural resources.

Hydrologic Soil Indices

Hydrologic Soil Groups (HSG) were developed by the USDA-Natural Resources Conservation Service (NRCS) to categorize soil series into groups with similar precipitation infiltration characteristics. HSGs are primarily used to assess the capability of land to absorb precipitation. Soil series are assigned to one of four HSGs using data collected on controlled study plots and linking the data to known soil characteristics.

Site Specific Soil Maps in New Hampshire provide an HSG for each map unit, to help engineers design appropriate stormwater management systems for land development in a way that protects public interests, natural resources, and water quality. The Plans are reviewed by the New Hampshire Alteration of Terrain Bureau (NH-AOT) to ensure compliance with New Hampshire laws and regulations.

SSSNNE-publication 5, Ksat Values for New Hampshire Soils, 2009, listed HSG developed from NRCS data for soil series mapped in New Hampshire. Users of this publication have noted some inconsistencies, such as HSG values that are different for physically similar soils in different temperature regimes. Publication 5 did not assign HSG for human disturbed soil map units. In addition, Publication 5 needs to be updated to reflect newly named soil series, remove series no longer in use, and remove miscellaneous land types and non-soil areas from the listings.

The NRCS relies on the research data and experience of many professionals to prepare HSG values. While HSGs are excellent tools, SSSNNE believes a single purpose, New Hampshire-specific Hydrologic Soil Index (HSI) would be better for design of stormwater management systems. At least two other New England states have recognized the limitations of the NRCS-HSG and have developed State specific methods for determining stormwater infiltration and runoff potential. In 2022, SSSNNE established a work group to review the NRCS method for determining HSG and methods developed by other states. The considerable thought and work done in other states and by NRCS provided an important foundation for this document.

SSSNNE selected an approach like the one developed at the University of Rhode Island. The New Hampshire approach differs by creating the concept of a Hydrologic Soil Index (HSI) for each soil series and which can be readily applied to human disturbed soils. The term HSI was chosen so users would not confuse this New Hampshire-specific HSI with NRCS generated HSG values. Though the HSI concept was developed with helpful input from NRCS soil scientists and relies heavily on previous NRCS research, this is not a NRCS approved document. HSIs are calculated using three principal criteria: depth to the seasonal high water, depth to bedrock or a restrictive layer, and particle-size families. The values for these criteria are taken from the Official Series Descriptions.

HSI is a single purpose tool that can be derived from the attached Logic Matrix or Logic Triangle. They both yield the same result; users can select whichever is easier for them. Table 1 in this document lists the HSI for soils commonly mapped in New Hampshire. With this tool, a New Hampshire Certified Soil Scientist (NHCSS) can consistently determine an appropriate HSI for named soil series, human disturbed soils, and unnamed soils. Unnamed soils might include a soil that does not match the description of any soils mapped in NH, is outside the range of characteristics of mapped soils, or matches a soil but is in the wrong temperature regime. This makes HSI more useful for the Site

Specific Soil Mapping required for NH Alteration of Terrain permit applications.

The four HSI designations are A through D. Though they are specifically determined using the Logic Matrix or the Logic Triangle, they can be generally described as well.

Group A- Water is transmitted freely through the soil and internal free water is deep. Soils in this group have low runoff potential when thoroughly wet. Group A soils have sandy textures.

Group B- Water is transmitted through the soil at a moderate rate and free water occurrence is deep or moderately deep. Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have loamy sand or sandy loam textures.

Group C- Water is transmitted through the soil at a moderately rate and internal free water occurrence is neither shallow nor deep. Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil may be somewhat restricted. Group C soils typically are sandy loam to silt loam textures.

Group D- Water is transmitted through the soil at a slow rate or internal free water can be shallow. Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil may be slowed by restrictive horizons or saturation to the surface.

Saturated Hydraulic Conductivity (K_{SAT})

K_{sat} refers to the ease with which pores in a saturated soil transmit water. The estimates presented here are expressed in terms of inches per hour K_{sat} values are based on soil characteristics observed in the field, particularly structure, consistence, porosity, and texture.

Saturated flows occur when the soil water pressure is positive; that is, when the soil matric potential is zero. In most soils this occurs when about 95 percent of the total pore space is filled with water. The remaining 5 percent is filled with entrapped air. Saturated hydraulic conductivity cannot be used to describe water movement under unsaturated conditions.

Soil features (and thus soil data) for a particular soil series may be slightly different from one soil survey area to the next. For example, a Marlow soil in Carroll County may have a higher sand content in its B horizon than a Marlow soil in Coos County; resulting in a slightly different Ksat range for the B horizon.

The K_{sat} data for this publication was obtained from USDA-NRCS soil data. This data is presented in B and C horizons only as it is assumed that the topsoil (A or A_p horizon) will be removed in typical construction practices.

While the table below is not a complete New Hampshire Statewide legend, it includes soils commonly mapped and for which data was available at the time of this publication. For soils not found on this table and human disturbed soils, the Ksat value is best determined by actual field measurements.

Explanatory Notes

What is the difference between a Hydrologic Soil Group (HSG) and a Hydrologic Soil Index (HSI)?

A Hydrologic Soil Group is an interpretation of a soil's ability to infiltrate precipitation and is related to its hydrologic conductivity. HSGs are generated by the Natural Resources Conservation Service, based on national standards and calculated for specific regions. HGS's are dynamic and subject to revision. They are published on the Web Soil Survey. [1]

A Hydrologic Soil Index is a single-use interpretation of a soil's ability to infiltrate precipitation and is related to the soil characteristics. It is generated from the most current NRCS Official Series Descriptions with adjustments for correlation with the New Hampshire Statewide Soil Legend, and Site Specific Soil Mapping Standards in New Hampshire and Vermont[2]. HSIs are static and published by SSSNNE. They are intended to be used by soil scientists with Site Specific Soil Surveys for New Hampshire Department of Environmental Services, Alteration of Terrain Bureau permit applications.

How was the HSI table generated?

The table of HSI was generated using NASIS and SUREGO data provided by the NRCS. The raw data was adapted by SSSNNE to correlate with soil series known to be mapped in New Hampshire.
The NRCS Logic Matrix was cross-checked with HSI Logic Triangle parameters of particle-size family, drainage class and depth to bedrock or restrictive layers, as described in NRCS Official Series Descriptions.

How to calculate HSI for complexes and undifferentiated map units?

This process begins during the construction of a soil map, by selecting the appropriate map unit based on transect data collected while mapping. The field work should be sufficient to estimate the percentage of each component of the named soil series or miscellaneous area. A transect is a traverse across a map unit, in representative locations, where soil excavations and profile descriptions or detailed notes are collected at regular intervals. The number of observations along

[1] https://websoilsurvey.nrcs.usda.gov

[2] Society of Soil Scientists of Northern New England (SSSNNE), Site-Specific Soil Mapping Standards for New Hampshire and Vermont, Special Publication No. 3 Version 7.0, July 2021.

a transect is at the discretion of the NHCSS making the map. The accuracy of the estimated composition of the map unit is improved as the number of observations increases. Transect data is used to estimate the composition of complexes and undifferentiated map units. This information is incorporated in the map unit description.

- Example of a complex map unit: 281C – Berkshire-Tunbridge complex, very stony, 8 to 15% slopes. This map unit consists of 55% Berkshire soils, 30% Tunbridge soils with 10% dissimilar inclusions such as rock outcrop and soils that are less than 20 inches deep to bedrock, and 5% moderately well drained Sunapee soils…
- Example of an undifferentiated map unit: 273C – Berkshire, Monadnock and Hermon soils, extremely boulder, 8 to 15% slopes. This map unit consists of 50% Berkshire soils, 25% Monadnock soils and 15% Hermon, with 10% inclusions…

Once the map unit is established, a detailed break-down of the applicable HSIs can be listed. From the percentage of the map unit components provided by the NHCSS, the design engineer can select the most appropriate HSI for the proposed practice or use a weighted average.

Map Unit Number	Map Unit Components By Soil Series	Percentage of Map Unit	HSI
281C	Berkshire	55	B
	Tunbridge	30	C
273C	Berkshire	50	B
	Monadnock	25	B
	Hermon	15	A

Presentation of the Data

SSSNNE publishes HSI data in tabular and graphic format. The tabular format follows the convention used in SSSNNE Special Publication No. 5. This format provides a quick reference to the HSI assigned for each soil series mapped in New Hampshire.

How to select an HSI for disturbed soil map units?

The HSI Logic Triangle and Logic Matrix were specifically designed to help Soil Scientists produce consistent results when assigning an HSI to disturbed soil map units. Use the soil particle-size family (soil textures listed), soil drainage class, and depth to bedrock or restrictive layers to calculate a custom HSI for each disturbed soil map unit described in the Site Specific Soil Map report.

Status of the New Hampshire Statewide Numerical Soils Legend

The New Hampshire Statewide Numerical Soil Legend was last published by the USDA, NRCS as issue #10, January 2011. Since then, it has been frequently updated electronically, but no new publication has been produced.
This document includes soils commonly mapped in New Hampshire for which data, legend numbers, and soil descriptions were available.

How is particle-size family determined?

For soils with Official Series Descriptions, the particle-size family is given in that description and used for making the HSI determination. For other soils, such as human disturbed soils, the dominant particle-size family in the particle-size control section (generally 10 to 40 inches) is used.

Why is there missing data for some soils?

In the table below, some soils note ‘no horizon’ in the Ksat columns. Not all soils have B and/or C horizons. For example, some organic soils have no B horizon, and some shallow to bedrock soils have no C horizon.

The table is not a complete list of all soils mapped in New Hampshire, but has the commonly mapped soils for which data is available.

Table 1. Logic Matrix

Depth To Restrictive Layer	Depth To Seasonal High Water Table	Particle-size Family (Texture)	HSI
< 20 inches (50.8 cm)	**All**	**All**	**D**
20 to 40 inches (50.8 to 101.6 cm)	**< 15 inches** (38.1 cm) (very poorly drained, poorly drained, somewhat poorly drained)	**All**	**D**
20 to 40 inches (50.8 to 101.6 cm)	**≥ 15 inches** (38.1 cm)	Sandy	**B**
		Loamy	**C**
		Coarse Silty	**C**
		Fine Silty and Clayey	**D**
>40 inches (101.6 cm)	**< 15 inches** (38.1 cm) (very poorly drained, poorly drained, somewhat poorly drained)	**All**	**D**
	15 to 40 inches (38.1 to 101.6 cm) (moderately well drained)	Sandy	**B**
		Loamy	**B**
		Coarse Silty	**C**
		Fine Silty and Clayey	**D**
	> 40 inches (101.6 cm) (well drained, somewhat excessively & excessively drained)	Sandy	**A**
		Loamy	**B**
		Coarse Silty	**B**
		Fine Silty and Clayey	**D**

(When a soil has more than one particle size family, the finer particle size family is used)

Figure 1. Logic Triangle

(When a soil has more than one particle size family, the finer particle size family is used)

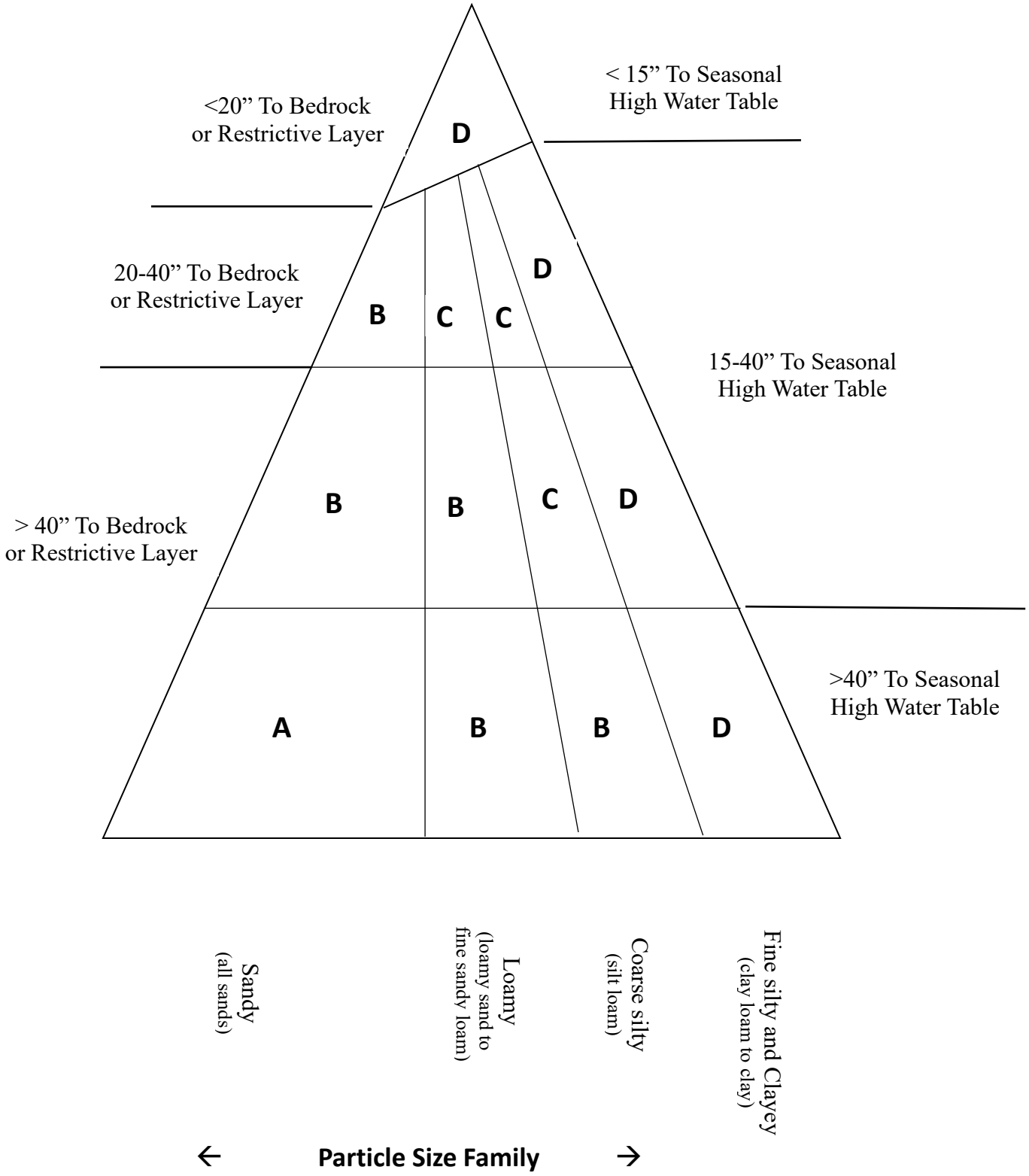

Table 1. HSI and Ksat Values for New Hampshire Soils

Soil Series	Legend Number	HSI	Low Ksat (B) inches/hour	High Ksat (B) inches/hour	Low Ksat (C) inches/hour	High Ksat (C) inches/hour
Abenaki	501	B	0.6	2	6	99
Abram		D			No Horizon	
Acton	146	A	2	20	2	20
Adams	36	A	6	20	20	99
Agawam	24	B	6	20	20	100
Allagash	127	B	0.6	2	6	20
Bangor	572	B	0.6	2	0.6	2
Becket	56	C	0.6	2	0.06	0.6
Belgrade	532	C	0.6	2	0.06	2
Bemis	224	D	0.6	0.2	0	0.2
Berkshire	72	B	0.6	6	0.6	6
Bernardston	330	C	0.6	2	0.06	0.2
Bice	225	B	0.6	6	0.6	6
Biddeford	234	D	0	0.2	0	0.2
Binghamville	534	D	0.2	2	0.06	0.2
Boscawen	220	A	6	20	20	100
Boxford	32	D	0.1	0.2	0	0.2
Brayton	240	D	0.6	2	0.06	0.6
Buckland	237	C	0.6	2	0.06	0.2
Bucksport	895	D	No Horizon		No Horizon	
Burnham	131	D	0.2	6	0.02	0.2
Buxton	232	D	0.1	0.6	0	0.2
Cabot	589	D	0.6	2	0.06	0.2
Caesar	526	A	20	100	20	100
Canaan	663	D	2	20	2	20
Canterbury	166	C	0.6	2	0.06	0.6
Canton	42	B	2	6	6	20
Cardigan	357	C	0.6	2	0.6	2
Catden	296	D	No Horizon		No Horizon	
Champlain	35	A	6	20	20	100
Charles	209	D	No Horizon		0.6	100
Charlton	62	B	0.6	6	0.6	6
Chatfield	89	C	0.6	6	No Horizon	
Chesuncook	126	C	0.6	2	0.02	0.2
Chichester	442	B	0.6	2	2	6
Chocorua	395	D	No Horizon		6	20
Cohas	505	D	0.6	2	0.6	100

Soil Series	Legend Number	HSI	Low Ksat (B) inches/hour	High Ksat (B) inches/hour	Low Ksat (C) inches/hour	High Ksat (C) inches/hour
Colonel	927	D	0.6	2	0.06	0.6
Colton	22	A	6	20	20	100
Croghan	613	B	20	100	20	100
Dartmouth	132	C	0.6	2	0.06	0.6
Deerfield	313	B	6	20	20	100
Dixmont	578	B	0.6	2	0.6	2
Duane	413	B	6	20	6	20
Dutchess	366	B	0.6	2	0.6	2
Eldridge	38	B	6	20	0.06	0.6
Elliottsville	128	C	0.6	2	0.6	2
Elmwood	338	D	2	6	0	0.2
Fryeburg	208	B	0.6	2	2	6
Gilmanton	478	C	0.6	2	0.06	0.6
Glebe	671	C	2	6	2	6
Gloucester	11	A	6	20	6	20
Grange	433	D	0.6	2	0.6	2
Groveton	27	B	0.6	2	0.6	6
Hadley	8	B	0.6	2	0.6	6
Haven	410	B	0.6	2	20	100
Henniker	46	C	0.6	2	0.06	0.6
Hermon	55	A	2	20	6	20
Hinckley	12	A	6	20	20	100
Hitchcock	130	B	0.6	2	0.06	0.6
Hogback	91	D	2	6	2	6
Hollis	86	D	0.6	6	No Horizon	
Hoosic	510	A	2	20	20	100
Howland	566	C	0.6	2	0.06	0.2
Kearsarge	359	D	0.6	2	0.6	2
Kinsman	614	D	6	20	6	20
Leicester	514	D	0.6	6	0.6	20
Lim	3	D	0.6	2	6	20
Limerick	109	D	0.6	2	0.6	2
Lombard	259	B	0.6	6	2	20
Lovewell	307	C	0.6	2	0.6	2
Lyman	92	D	2	6	2	6
Lyme	246	D	0.6	6	0.6	6
Machias	520	D	2	6	6	20
Macomber	252	C	0.6	2	0.6	2
Madawaska	28	B	0.6	2	6	20

Soil Series	Legend Number	HSI	Low Ksat (B) inches/hour	High Ksat (B) inches/hour	Low Ksat (C) inches/hour	High Ksat (C) inches/hour
Marlow	76	C	0.6	2	0.06	0.6
Masardis	23	A	6	20	6	20
Mashpee	315	D	6	20	6	20
Maybid	134	D	0	0.2	0	0.2
Meadowsedge	894	D	No Horizon		No Horizon	
Medomak	406	D	0.6	2	0.6	2
Melrose	37	D	2	6	0	0.2
Merrimac	10	A	2	20	6	20
Metacomet	458	C	0.6	2	0.06	0.6
Metallak	404	B	6	100	6	100
Millsite	251	C	0.6	6	0.6	6
Monadnock	142	B	0.6	2	2	6
Monarda	569	D	0.2	2	0.02	0.2
Monson	133	D	0.6	2	0.6	2
Montauk	44	C	0.6	6	0.06	0.6
Moosilauke	414	D	6	20	6	20
Mundal	610	C	0.6	2	0.06	0.6
Natchaug	496	D	No Horizon		0.2	2
Naumburg	214	D	6	20	6	20
Newfields	444	B	0.6	2	0.6	2
Nicholville	632	C	0.6	2	0.6	2
Ninigret	513	B	0.6	6	6	20
Occum	1	B	0.6	2	6	20
Ondawa	101	B	0.6	6	6	20
Ossipee	495	D	No Horizon		0.2	2
Pawcatuck	497	D	No Horizon		20	100
Paxton	66	C	0.6	2	0	0.2
Peacham	549	D	0.6	2	0	0.2
Pemi	633	D	0.6	2	0.06	0.6
Pennichuck	460	C	0.6	2	0.6	2
Pillsbury	646	D	0.6	2	0.06	0.2
Pittstown	334	C	0.6	2	0.06	0.2
Plaisted	563	C	0.6	2	0.06	0.6
Podunk	104	B	0.6	6	6	20
Pondicherry	992	D	No Horizon		6	20
Poocham	230	B	0.6	2	0.2	2
Pootatuck	4	B	0.6	6	6	20
Quonset	310	A	2	20	20	100
Rawsonville	98	C	0.6	6	0.6	6

Soil Series	Legend Number	HSI	Low Ksat (B) inches/hour	High Ksat (B) inches/hour	Low Ksat (C) inches/hour	High Ksat (C) inches/hour
Raynham	533	D	0.2	2	0.06	0.2
Raypol	540	D	0.6	2	6	100
Redstone	665	B	2	6	6	20
Ricker	674	D	2	6	2	6
Ridgebury	656	D	0.6	6	0	0.2
Rippowam	5	D	0.6	6	6	20
Roundabout	333	D	0.2	2	0.06	0.6
Rumney	105	D	0.6	6	6	20
Saco	6	D	0.6	2	6	20
Saddleback	673	D	0.6	2	0.6	2
Salmon	630	B	0.6	2	0.6	2
Scantic	233	D	0	0.2	0	0.2
Scarboro	115	D	No Horizon		6	20
Scio	531	C	0.6	2	0.6	2
Scitico	33	D	0	0.2	0	0.2
Scituate	448	C	0.6	2	0.06	0.2
Searsport	15	D	No Horizon		6	20
Sheepscot	14	B	6	20	6	20
Sisk	667	C	0.6	2	0	0.6
Skerry	558	C	0.6	2	0.06	0.6
Squamscott	538	D	6	20	0.06	0.6
Stetson	523	A	0.6	6	6	20
Stissing	340	D	0.6	2	0.06	0.2
Success	154	A	2	6	6	20
Sudbury	118	B	2	6	6	20
Suffield	536	D	0.6	2	0	0.2
Sunapee	168	B	0.6	2	0.6	6
Suncook	2	A	6	20	6	20
Sunday	202	A	6	20	6	20
Surplus	669	C	0.6	2	0	0.6
Sutton	68	B	0.6	6	0.6	6
Swanton	438	D	2	6	0	0.2
Telos	123	D	0.6	2	0.02	0.2
Timakwa	393	D	No Horizon		6	100
Tunbridge	99	C	0.6	6	0.6	6
Unadilla	30	B	0.6	2	2	20
Vassalboro	150	D	No Horizon		No Horizon	
Walpole	546	D	2	6	6	20
Wareham	34	D	6	20	6	20

Soil Series	Legend Number	HSI	Low Ksat (B) inches/hour	High Ksat (B) inches/hour	Low Ksat (C) inches/hour	High Ksat (C) inches/hour
Warwick	210	B	2	6	20	100
Waumbek	58	B	2	20	6	20
Westbrook	597	D	No Horizon		0	2
Whitman	49	D	0	0.2	0	0.2
Windsor	26	A	6	20	6	20
Winooski	9	C	0.6	6	0.6	6
Wonsqueak	995	D	No Horizon		0.2	2
Woodbridge	29	C	0.6	2	0	0.6
Woodstock	93	D	2	6	2	6

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Method for Determining Hydrologic Soil Group by Site Specific Soil Mapping
FINAL DRAFT Jillian Phillips, Research Assistant, University of Rhode Island Cooperative Extension. Mark Stolt, Professor of Pedology, University of Rhode Island Lorraine Joubert, RI Nonpoint Education for Municipal Officials James Turenne, Certified Professional Soil Scientist, USDA-NRCS

Maine Association of Professional Soil Scientists Method for Onsite Assignment of Hydrologic Soil Group, 23 December 2019

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