VG2019-1: Surficial Geology and Hydrogeology of Huntington, Vermont by George Springston, Report plus 1 map plate.

Surficial Geology and Hydrogeology of Huntington, Vermont

George Springston
Norwich University Department of Earth and Environmental Sciences
108 Harmon Drive
Northfield, VT 05663
802-485-2734
gsprings@norwich.edu

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On the cover: View looking west from Camels Hump across Huntington towards Lake Champlain

Executive Summary

The purpose of this project was to conduct 1:24,000 scale mapping of the surficial geology of the Huntington 7.5 minute quadrangle and to investigate the hydrogeology of the Town of Huntington.

Bedrock outcrops are abundant in large portions of the study area. Outcrops are especially abundant on the upper flanks of Camels Hump and the Green Mountain Range.

Glacial till is the most widespread surficial material in the study area. It is generally dense to very dense, unsorted to very poorly sorted, fine-sandy-silt to silt matrix till.

Striations and grooves in bedrock indicated that dominant ice motion directions ranged from 120 to 169°, Where cross-cutting relationships can be observed, the more southerly striations are younger than the southeasterly ones. Late striations on the crest of the Green Mountains have orientations of around 250°. See Wright (2015) for more details on these late, southwest-directed striations.

Numerous features mapped as till benches are found on both flanks of the Green Mountains crest in the study area. Similar features on both flanks of Mount Mansfield to the north of the study area have been interpreted to be moraines by Wright (2019). A non-genetic term is used here as their origin is still under investigation.

Glacial lake deposits are widespread in the study area and provide evidence of a series of Late Pleistocene lakes that occupied the valley bottoms in the study area during deglaciation.

The Pleistocene deposits in the study area have been extensively reworked by fluvial processes. The history of glacial lakes in the Huntington River valley and subsequent reworking of the deposits by streams is discussed in detail in Whalen (1998) and Wright and others (1997). Numerous alluvial fans are found at tributary mouths on both sides of the Huntington River valley. Several of the Holocene fans have been studied in detail by Zehfuss (1996) and Whalen (1998). This study identified additional alluvial fans and mapped their extents more fully.

Descriptive statistics were produced for 328 located bedrock wells in the Town of Huntington: The median depth of the wells is 300 feet, the median depth to bedrock is 30 feet, and the median yield is 8 gallons per minute. Although wells can vary significantly within very small geographic areas, this data may provide guidance for estimating the depth, yield and likely costs for new wells.

The hydrogeologic analysis suggests that the main valley bottoms are underlain by surficial materials that may be able to allow groundwater or wastewater to penetrate to depth with relative ease. This has implications for wastewater disposal in these areas insofar as any insufficiently treated wastewater might potentially be able to penetrate to considerable depths.

Introduction

The purpose of this project was to conduct 1:24,000 scale mapping of the surficial geology of the Huntington 7.5 minute quadrangle and to investigate the hydrogeology of the Town of Huntington (Figure 1).

General Geology

The surficial materials in the region are dominantly of glacial origin and were deposited in the late Pleistocene while the area was covered by the Laurentide ice sheet and during and shortly after the retreat of that ice. Typical of most of New England, the upland areas are covered by till that varies considerably in thickness, composition, and texture. Glacial boulders are common. Bedrock exposures are abundant at the higher elevations and occur at scattered locations in the valley bottoms. Till in the stream valleys may be overlain by a variety of ice- contact sediments deposited during ice retreat. The valley bottoms are underlain by thick glacio- lacustrine deposits. The modern valley bottoms are also the sites of extensive Holocene alluvial fan deposition, fluvial activity, and the accumulation areas for colluvium.

The study area is primarily underlain by late Precambrian to Cambrian metamorphic rocks. The dominant lithologies are shown on Figure 2, after Ratcliffe et al., 2011).

The area is located in the Green Mountains physiographic province (Stewart and MacClintock, 1969). The terrain is steep with narrow valleys and includes Camels Hump. The view westward from Camels Hump is shown in Figure 3.

Methods

Field work involved visits to exposures of surficial deposits and bedrock outcrops. The locations of additional bedrock outcrops were obtained from previous geologic mapping projects and compiled by the Vermont Geological Survey. Additional surficial geologic information was obtained by analysis of 328 water well logs. The logs were derived from databases managed by the Drinking Water and Groundwater Protection Division of the Vermont Department of Environmental Conservation. The water well locations are shown on Plate 1. As many of the older wells have uncertain locations, only wells with verified locations are used in this analysis. Extensive water well location work by Colin Dowey of the Vermont Geological Survey greatly increased the number of located wells. Newer wells with driller-reported GPS locations or E911 addresses are assumed to be close to the correct locations.

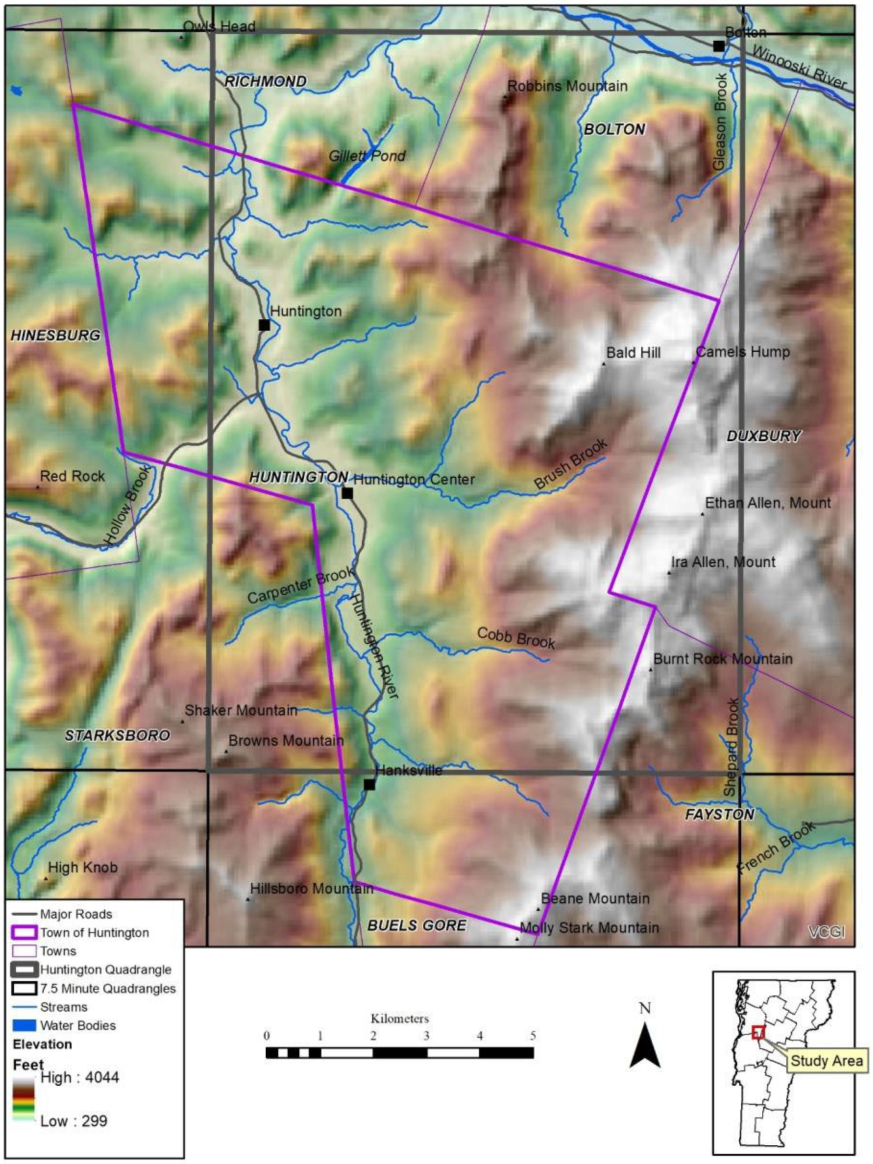

Figure 1. Location map showing the Town of Huntington and the Huntington Quadrangle.

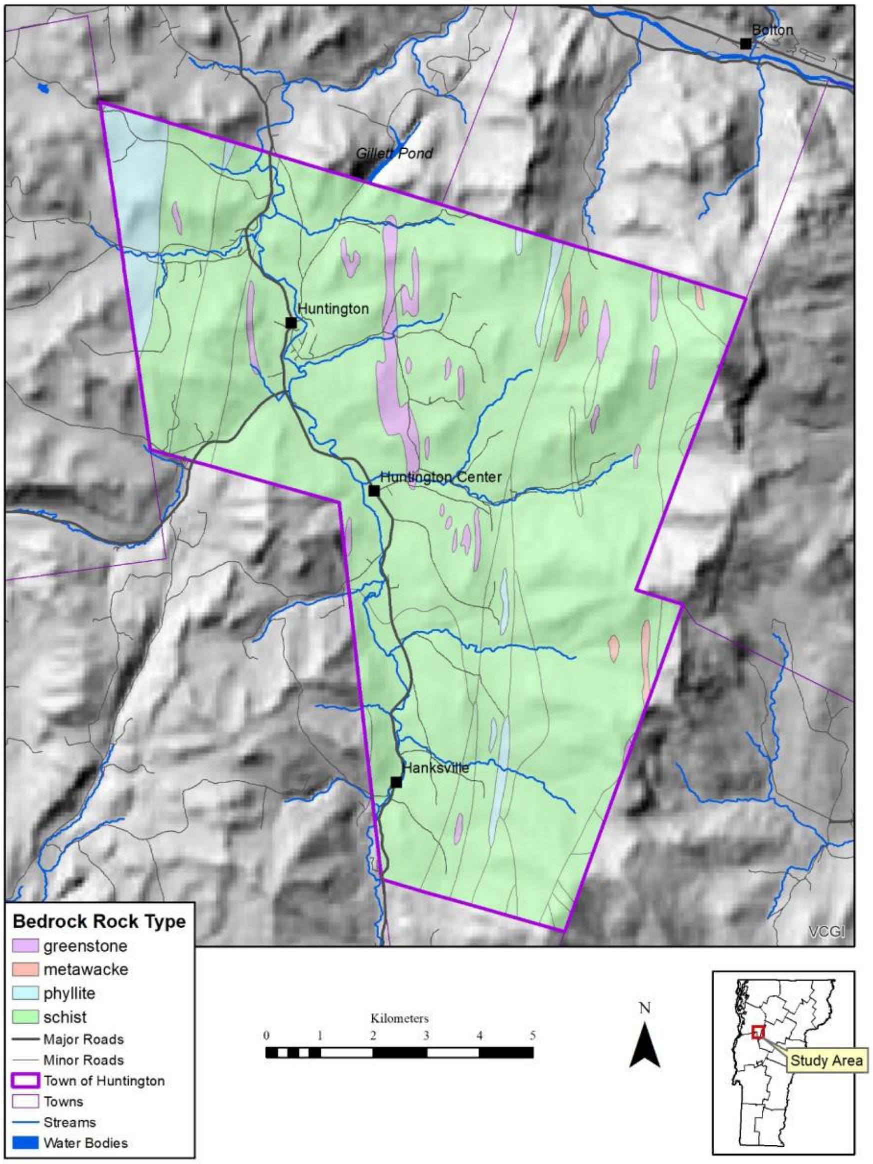

Figure 2. Principal bedrock types in the Town of Huntington. From Ratcliffe and others (2011).

Figure 3. View from Camels Hump looking west over Brush Brook valley and Huntington River valley to Hollow Brook (notch at right) and Champlain Valley.

Surficial Geology

Ice-movement Indicators

Striations and grooves in bedrock indicated that dominant ice motion directions ranged from 120 to 169°, Where cross-cutting relationships can be observed, the more southerly striations are younger than the southeasterly ones (Figure 4). Late striations on the crest of the Green Mountains have orientations of around 250°. See Wright (2015) for more details on these late, southwest-directed striations. The glacially-plucked south face of Camels Hump is shown in Figure 5.

Figure 4. Glacial striations on outcrop south of Sherman Hollow Road. Older striations (148 degrees, pencil on right) are crosscut by younger ones (169 degrees, pencil on left).

Figure 5. Looking east at southern face of Camels Hump. Face has been steepened by glacial plucking as the ice rode over the peak from the north.

Stratigraphy

Pleistocene Deposits

Although the Pleistocene Epoch ranges from about 11,700 years before present back to about 2.58 million years (Cohen and others, 2017), all of the glacial deposits in the study area are thought to belong to the last stage of the Pleistocene, the Wisconsinan Glacial Stage, which extends from about 71,000 to 11,700 years before present.

Till is very dense to loose, unsorted to very poorly sorted material deposited directly from glacial ice. It contains a wide range of grain sizes, from clay or silt up to large boulders. The matrix is commonly dominated by the fine sand to silt fraction. The areas mapped as till include small areas of talus (fans or aprons of fallen rock at the bases of cliffs) and colluvium (slope- wash deposits on the lower portions of slopes).

Numerous features mapped as till benches are found on both flanks of the Green Mountains crest in the study area (Plate 1.) Similar features on both flanks of Mount Mansfield to the north of the study area have been interpreted to be moraines by Wright (2019). A non- genetic term is used here as their origin is still under investigation.

Glacial lake deposits are widespread in the study area and provide evidence of a series of Late Pleistocene lakes that occupied the valley bottoms in the study area during deglaciation. The earliest lake in the study area, glacial Lake Jerusalem, formed in the upper Huntington River valley as the ice retreated northward. Drainage was southward, eventually into the Coveville phase of glacial Lake Vermont. Continued retreat of the ice exposed a lower threshold northwest of Carpenter Brook that allowed lowering of the waters to form glacial Lake Huntington 1. Continued retreat of the ice opened up an even lower drainage route through the Hollow Brook valley and formed glacial Lake Huntington 2. Meanwhile, glacial Lake Winooski was impounded in the main Winooski River valley by the remaining ice in the Huntington River valley and in the main Winooski River valley near Richmond. Lake Winooski drained south through Williamstown Gulf into glacial Lake Hitchcock. As ice began to melt out of the Huntington River valley, a new drainage route opened up, allowing the waters impounded in the Winooski River valley to drain out over the Gillett Pond threshold into Lake Huntington 2 and thence westward through the Hollow Brook valley into the Coveville lake. The lake that formed in the Winooski River valley behind the Gillett Pond threshold was glacial Lake Mansfield 1. The Gillett Pond outlet is shown in Figure 8. Delta deposits southwest of Gillett Pond record the outflow of Lake Mansfield 1 into Lake Huntington 2. Continued retreat of the ice eventually opened up the main Huntington River valley and the lake level dropped to a level controlled by the Hollow Brook threshold, forming glacial Lake Mansfield 2. This lake lasted until the ice margin retreated west of Richmond and opened the Winooski valley to the waters of the Coveville lake. Coveville deltas were mapped in the lower part of the Gleason Brook valley, in the unnamed tributary in the northwest corner of the Huntington Quadrangle, and in the lower part of Texas Hill Brook valley.

The Pleistocene deposits in the study area have been extensively reworked by fluvial processes. The history of glacial lakes in the Huntington River valley and subsequent reworking of the deposits by streams is discussed in detail in Whalen (1998) and Wright and others (1997). A correlation diagram for the various lakes is shown in Figure 6. A typical exposure of the lake deposits is shown in Figure 7.

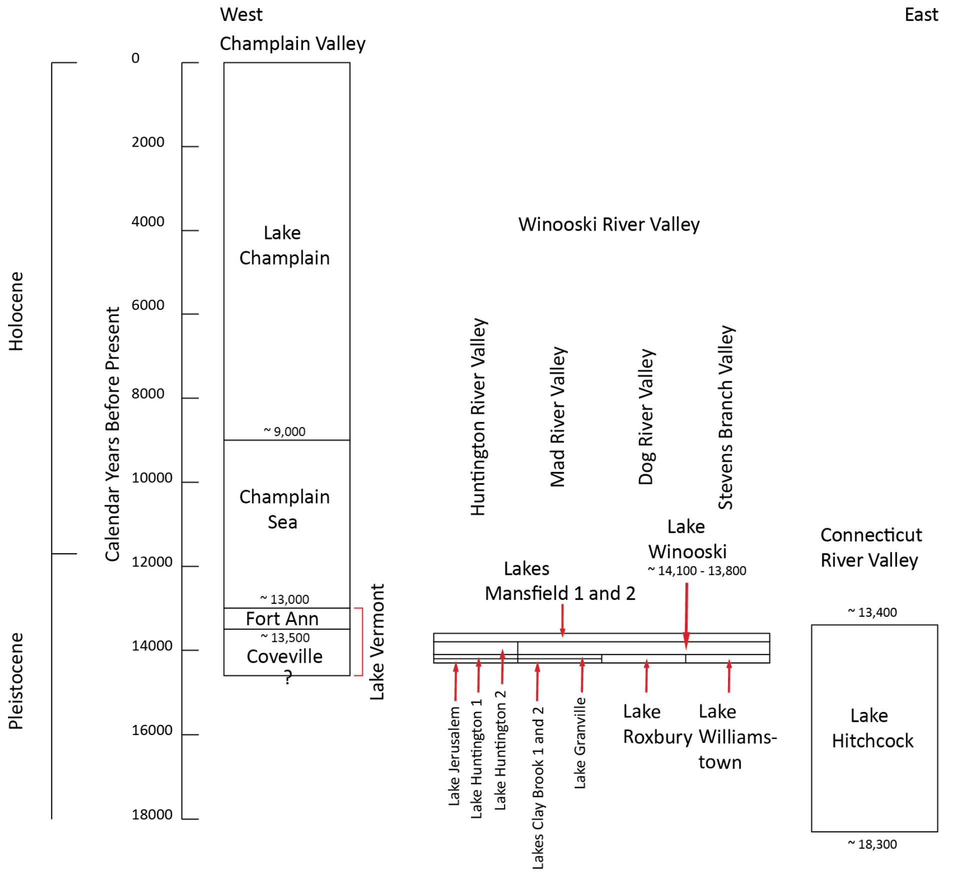

Figure 6. Late Pleistocene and Holocene lakes of central Vermont. Ages are approximate and are in calendar years.

Figure 7. Lake deposits in gully north of Sherman Hollow Road. Bedded very fine sand and fine sand with widely spaced laminae of silty clay.

Figure 8. Looking northeast up Gillett Pond valley, which served as the drainage route for glacial Lake Mansfield 1.

The Holocene deposits are described briefly below and are shown on Plate 1. These are less than about 12,000 years old. Cohen and others (2017) give 11,700 years before present as the base of the Holocene.

Artificial Fill: Artificially-emplaced material along road beds, embankments and in developed areas. Material varies from natural sand, gravel, or till to various artificial waste materials. Thickness varies.

Alluvium: Silt, sand, and gravel deposited by modern streams. Includes stream channel, bar, and floodplain deposits. Wetland deposits are common within these areas and are not distinguished. Thickness in tributary valleys is typically less than 3 meters, although the depth may be much greater in the valleys of the larger streams.

Alluvial Terrace Deposits: Silt, sand, and gravel deposited on terraces above the modern floodplains of streams (Figure 9.) Composed of a variety of channel, bar, and floodplain deposits. Generally less than 5 meters thick.

Alluvial Fan Deposits: Boulder, pebble, and cobble gravel and pebbly sand deposited at sites where steep, stream gradients are sharply reduced. Common at the mouths of steep tributaries where they meet the main stream. Numerous alluvial fans are found at tributary mouths on both sides of the Huntington River valley. Several of the Holocene fans have been studied in detail by Zehfuss (1996) and Whalen (1998). This study identified additional alluvial fans and mapped their extents more fully.

Wetland Deposits: Accumulations of organic matter and/or clastic sediment in low-lying areas. Includes a wide variety of wetland types. Commonly overlying other deposits such as alluvium, lacustrine sediment, or till. Only a few larger deposits are shown.

Figure 9. Eroding bank of Huntington River exposing alluvial terrace deposit (sand and pebble to cobble gravel) over dense, very fine sandy silt-matrix till (gray).

Hydrogeology

The distribution and quantity of groundwater have been studied by analysis of the surficial geologic data collected for this project and by analysis of water well data derived from databases managed by the Drinking Water and Groundwater Protection Division of the Vermont Department of Environmental Conservation. The water well locations are shown in the following figures. As many of the older wells have uncertain locations, only wells with verified locations are used in this analysis. Newer wells with driller-reported GPS locations or E911 addresses are assumed to be close to the correct locations. Other well locations have been verified by use of State records of hazardous waste sites and septic systems, searches of town records, local knowledge, or online searches to verify that the listed owner has a residence at the location shown.

Bedrock well statistics are shown in Table 1 and will be discussed in the paragraphs below. Note that the percentile values and histograms for depth to bedrock, yield, and well depth are all skewed to the left. For each of these the median value serves as a better measure of central tendency than the mean.

Table 1. Descriptive statistics for all located bedrock wells in the Town of Huntington (N = 328). Well depth and depth to bedrock in feet, yield is in gallons per minute.

Variable	N	Mean	St.Dev.	Minimum	25th Percentile	Median	75th Percentile	Maximum
Overburden (ft)	328	42.48	36.59	0.00	12.00	30.00	68.00	195.00
Well Depth (ft)	328	327.05	176.22	47.00	199.00	300.00	441.25	1100.00
Yield (gpm)	328	16.83	21.71	0.00	3.00	8.00	23.75	125.00

Well depths are shown as a histogram in Figure 10. The mean depth is 327 feet and the median is 300 feet.

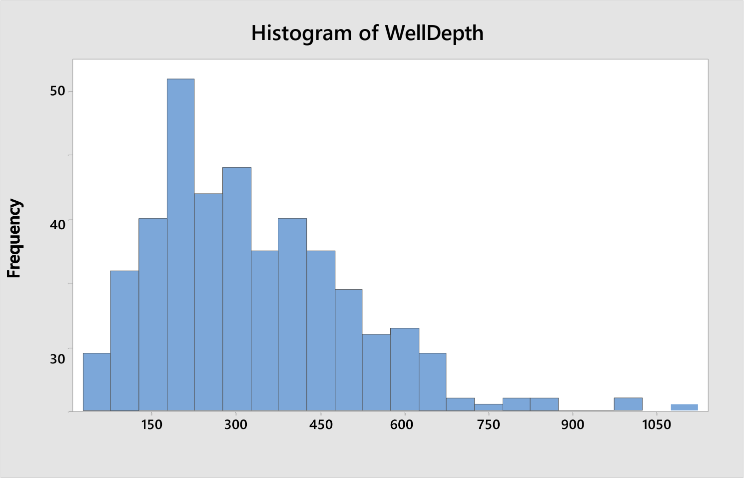

Figure 10. Well depth in feet.

Depth to Bedrock

Depth to bedrock or overburden depth is shown in Figures 11 and 12. A histogram of the water well data is shown in Figure 11. As shown in Table 1, the mean depth to bedrock is 42.5 feet and the median depth to bedrock is 30 feet. In Figure 12 depth to bedrock is shown as areas of 0 to 20 feet, 20 to 60 feet, 60 to 100 feet, and greater than 100 feet. Note that only limited areas have a depth to bedrock that is greater than about 40 feet. The depth is more certain in areas with abundant water well logs and/or bedrock outcrops and less certain in areas where this information is sparse. The information provides guidance for casing and associated well drilling costs, for hydrogeologic modelling for groundwater and contamination, and for any major project work.

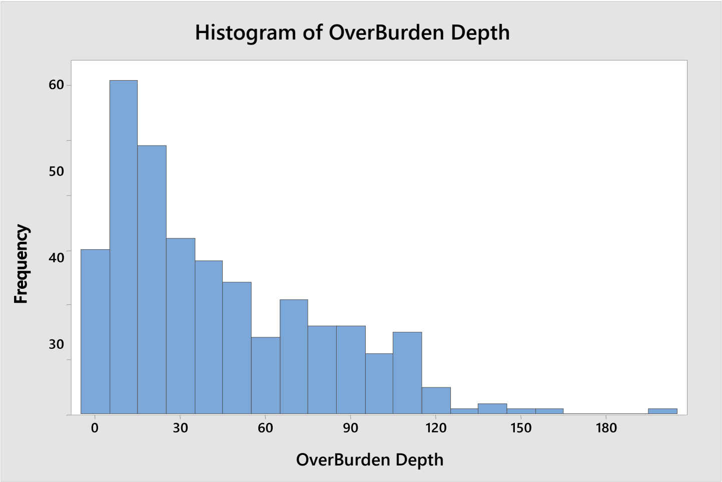

Figure 11. Depth to bedrock in feet.

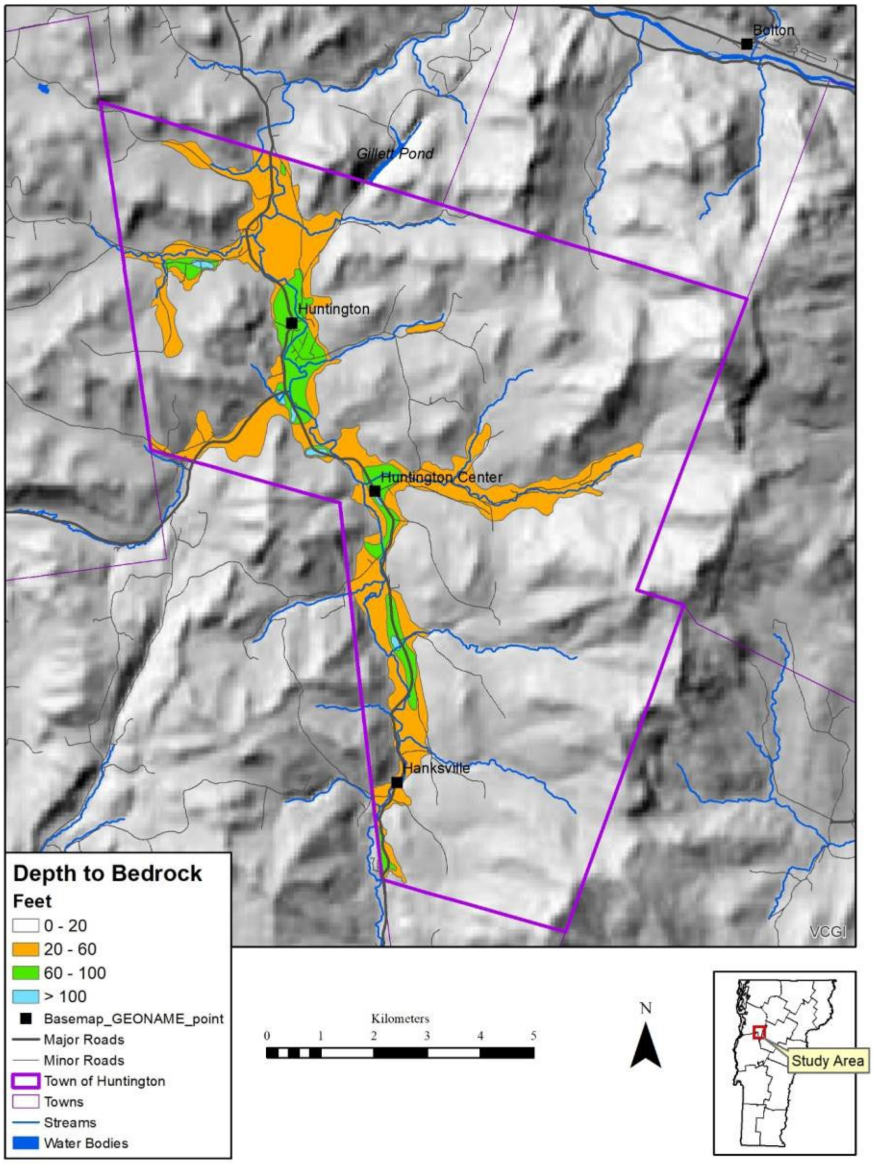

Figure 12. Depth to bedrock.

Yields

Driller's estimates of yields of bedrock wells are shown in Figures 13 and 14. A

histogram of the data is shown in Figure 13. The mean yield is 16.8 gallons per minute. Statewide, the mean yield of bedrock wells is 14 gallons per minute (Gale and others, 2014). Thus, the wells in the quadrangle have yields that are similar to the average.

Figure 14 is a map of well yields in the town. Yields (in gallons per minute) are indicated by the colors, as well as by the size of the symbols. Yields are generally high in the bottoms of the larger valleys, with low yields largely limited to upland sites away from the larger streams.

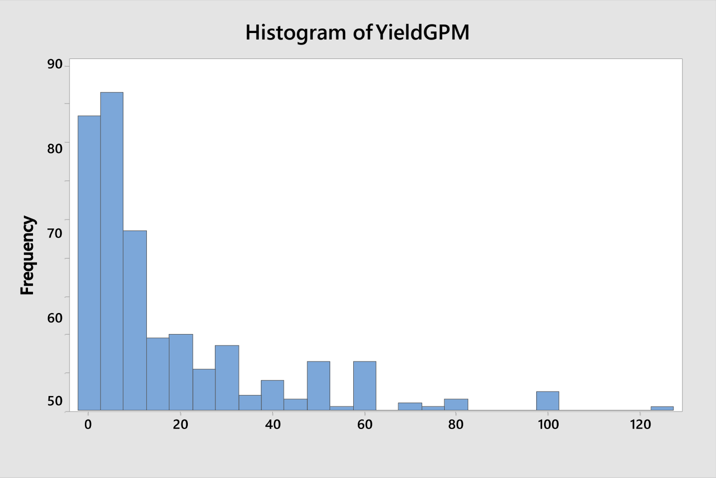

Figure 13. Well yield in gallons per minute.

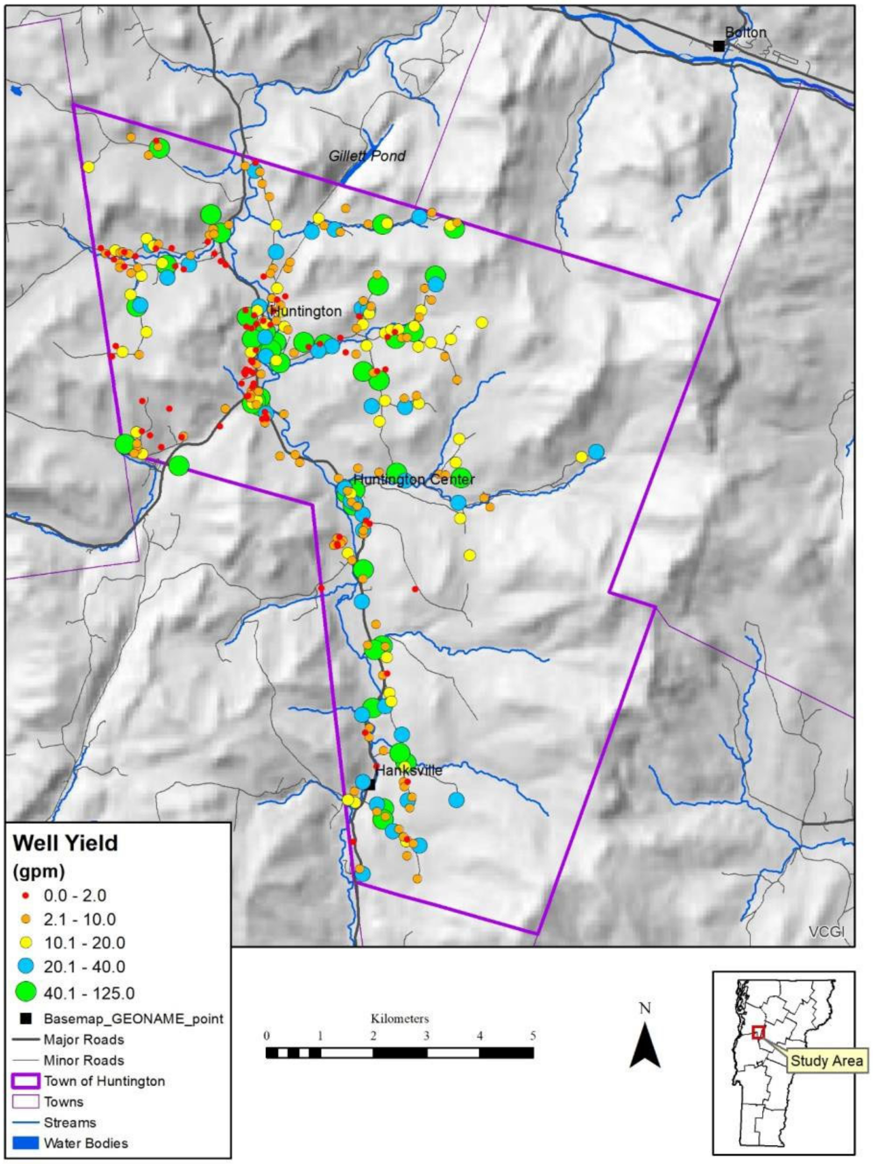

Figure 14. Estimated yields from private wells in gallons per minute.

Static Water Levels and Groundwater Flow Directions

Figure 15 contains information on groundwater flow directions and schematic contours showing the approximate levels of the ground water surface (static water levels). Static water levels are collected during well installation and are subject to considerable seasonal variation. Labels indicate the depth to the water surface in feet. If the groundwater flowing through the bedrock and surficial deposits is unconfined, then the groundwater will tend to move from higher areas to lower areas and converge towards the streams, ponds, and wetlands. In that case, contours of equal elevation on the groundwater surface would be roughly parallel to the topographic contours shown on the map. However, any confining layers in the surficial deposits or within the bedrock units would result in wells that have water levels higher than the topography would indicate.

Although there is abundant opportunity for groundwater recharge over much of the quadrangle due to the relatively thin surficial deposits (see Figure 12), the recharge areas for many wells in the uplands away from the main stream valleys may be relatively small and thus the wells may not be able to sustain heavy withdrawal without excessive lowering of the water levels.

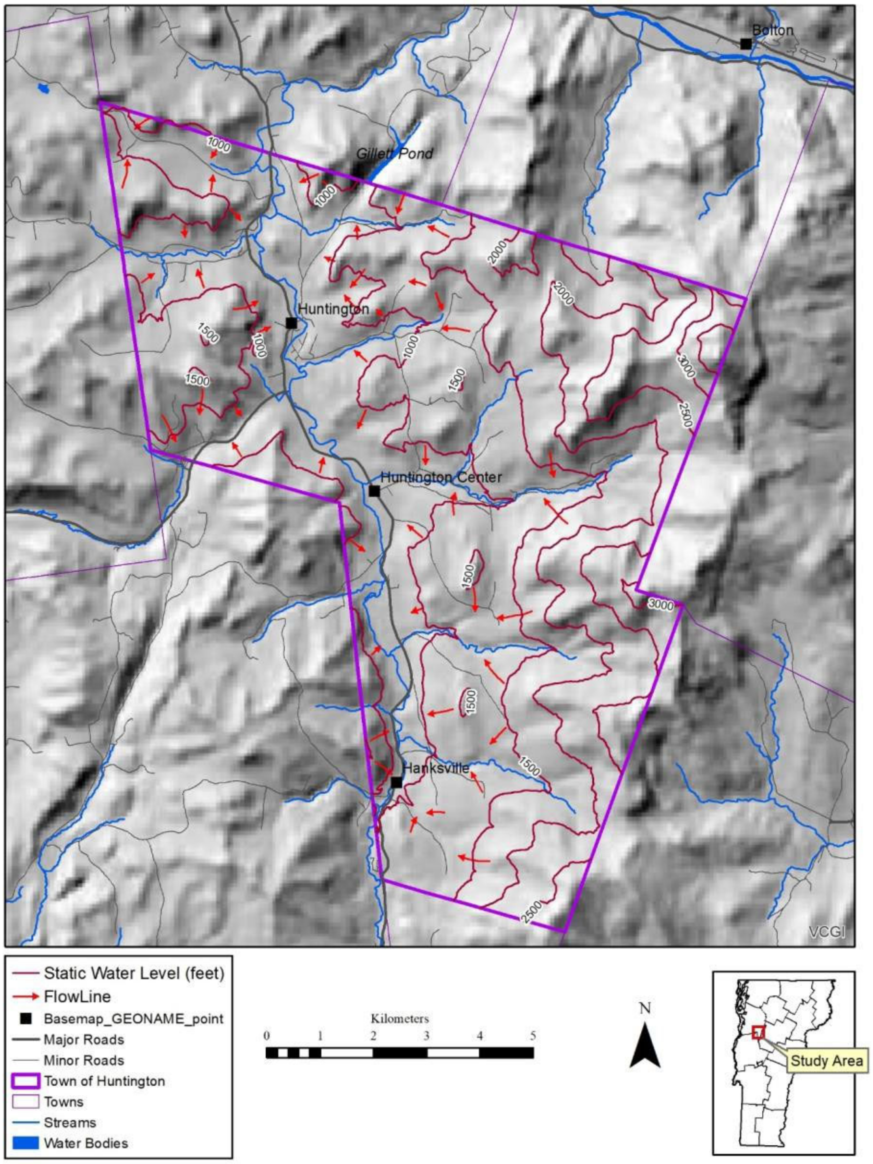

Figure 15. Generalized directions of groundwater flow (red arrows) and schematic contours of static water levels (500 foot contours).

Surficial Aquifer Potential

Figures 15 and 16 show a hydrogeologic interpretation of private water well logs to estimate the surficial aquifer potential of the surficial deposits in the quadrangle. Figure 16 is a close-up view of the central Huntington River valley. Wells classed as High are interpreted as having a high surficial aquifer potential due to the presence of thick coarse-grained deposits overlain by finer grained deposits. These are shown as large green squares. Wells coded as Moderate are interpreted to have a moderate surficial aquifer potential as they have thick coarse- grained deposits but these are not overlain by a fine-grained deposit that could serve to prevent direct infiltration of surface water. These are shown as orange triangles. Wells coded as Low do not have a thick coarse-grained deposit and therefore have a low potential to serve as a surficial aquifer. These are shown as small red dots.

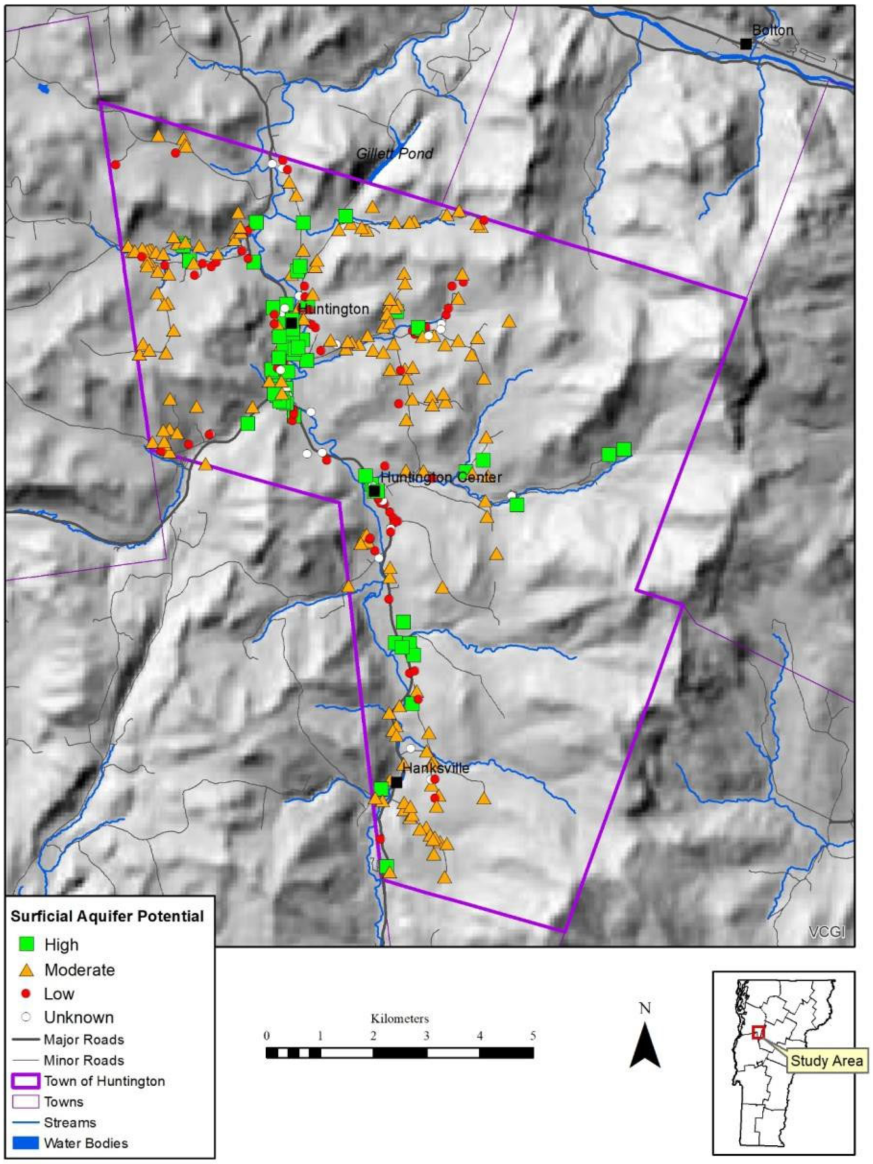

Figure 16. Surficial aquifer potential based on analysis of water well logs.

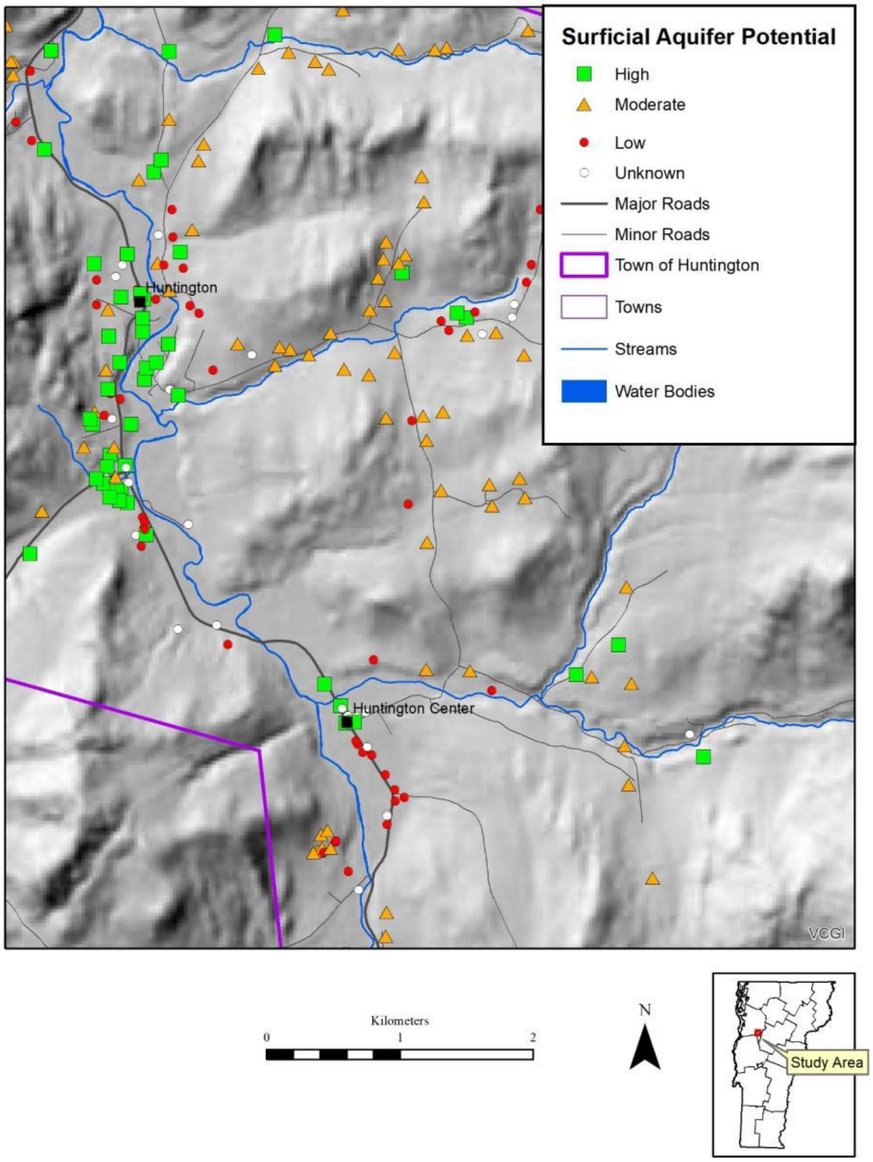

Figure 17. Surficial aquifer potential based on analysis of water well logs in the central Huntington River valley.

Figure 18 shows the recharge potential based on the surficial geologic mapping. This figure is intended to show the relative permeability of the surface units (the material indicated on Plate 1) to the surficial or bedrock units that are immediately below. The general picture that emerges from this figure is that the main valley bottoms are underlain by surficial materials that may be able to allow groundwater or wastewater to penetrate to depth with relative ease. This has implications for wastewater disposal in these areas insofar as any insufficiently treated wastewater might potentially be able to penetrate to considerable depths, given favorability of other variables (e.g. porosity, grain size, thickness, slope) that determine infiltration potential.

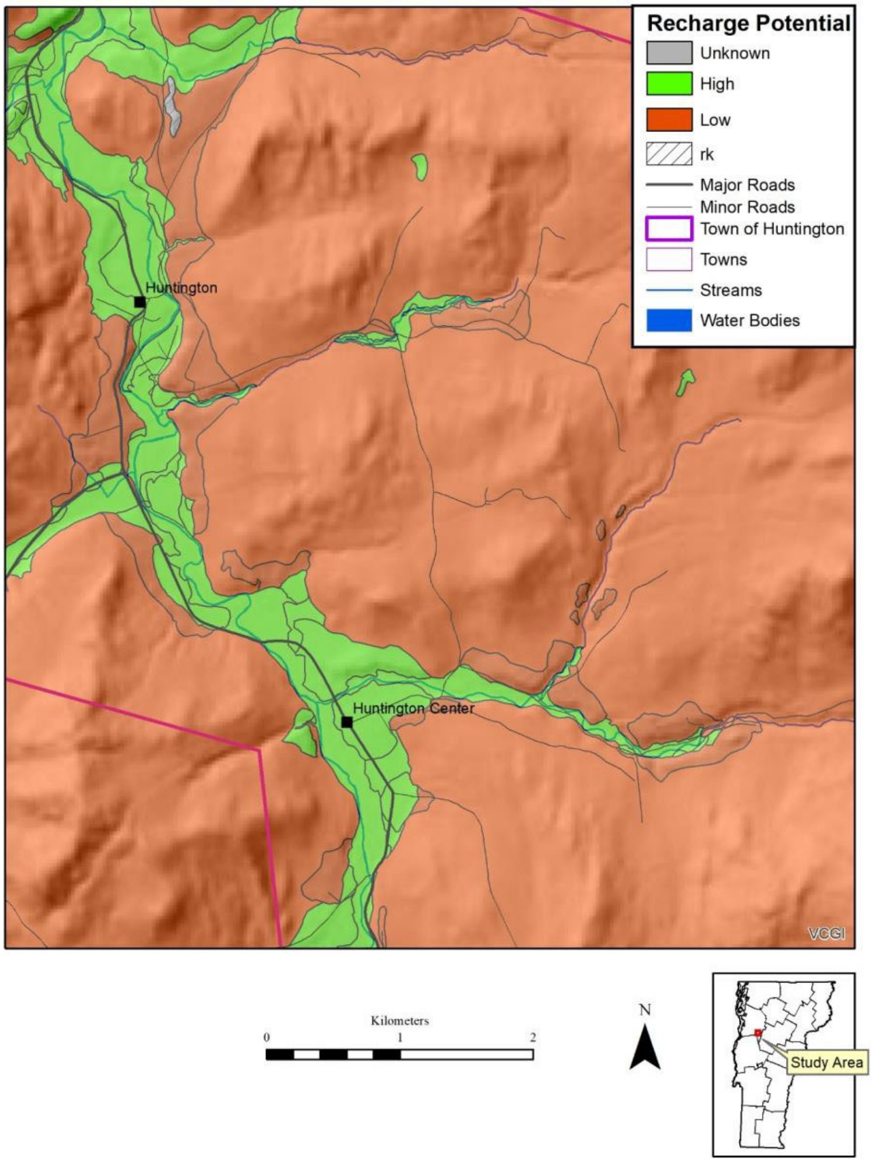

Figure 18. Recharge potential to underlying surficial units. This is a map of permeability of the upper parts of the surficial deposits.

Acknowledgements

Many individuals helped with the project. Thanks to Stephen Wright and Paul Bierman for kindly sharing the results of their research. Colin Dowey of the Vermont Geological Survey assisted with field work and undertook water well location work, which greatly increased the number of located wells available for analysis. Everett Marshall shared his knowledge of the town and assisted in field work. Caroline Alves and Charles Ferri lent their time and expertise to understanding the soils in the area.

Finally, many thanks to the landowners who kindly allowed access to researchers over the past several decades.

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