Surficial Geology and Hydrogeology of the Cabot 7.5 Minute Quadrangle, Vermont

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On the cover: View of the till uplands east of the Winooski River. Looking south from the Stecker Farm on Menard Road, Cabot. Photo by George Springston.

Table of Contents

Plates

Executive Summary

The purpose of this project was to conduct 1:24,000 scale mapping of the surficial geology of the Cabot 7.5 minute quadrangle and to integrate this with water well data in order to understand the hydrogeologic framework.

Glacial till is the most widespread surficial material in the study area. It is generally dense with a fine-sand to silt matrix. The till is of highly variable thickness, but large areas of the uplands consist of thin till and bedrock.

Several discontinuous sand and gravel deposits are found in the quadrangle. These are interpreted to have been formed in contact with melting glacial ice and are thus classified as ice-contact deposits. Kames, kettle holes, and a small esker are seen on the surface of the deposit on the north shore of Nichols Pond in Woodbury. Several additional small- to moderate-sized sand and gravel bodies are shown on Plate 1. A large sand and gravel deposit is exposed at the Walden Town Pit to the west of Smith Corner. The pit exposes probable esker sand and gravel that is overlain by lacustrine sands. These lacustrine deposits are above the level of glacial Lake Winooski and were thus probably formed in a short-lived lake that filled the Perkins Meadow Brook valley.

Glacial lake deposits occur in the Winooski River valley south of Cabot Village, in the northwest portion of the quadrangle near Hardwick Village, and in the north-central portion of the quadrangle (northwest of South Walden). These consist of fine-grained sediment ranging in grain size from fine sands to silty clay. The material is commonly laminated. In contrast to the deposits farther downstream in the Marshfield and Plainfield quadrangles, the lake deposits in the Winooski valley in this quadrangle are only a few meters thick.

Stream deposits and wetland deposits are found in most of the valley bottoms. Extensive floodplains are developed along the Winooski River from Cabot village southward and along Haynesville Brook in Walden. The deposits commonly consist of sands, silt, and lesser amounts of gravel.

Mean yields of bedrock water wells are somewhat above the statewide average (20.1 gpm versus 14.0 gpm statewide) and depths of bedrock water wells are somewhat below the statewide average (271.8 feet versus 290.0 feet statewide). Yields in the two major bedrock units (Waits River and Gile Mountain Formations) are similar. There was insufficient data to compare yields in the granitic intrusions (only one well).

The water level measurements from bedrock wells suggest that groundwater flow directions generally mimic the topography, with groundwater moving from recharge zones in the uplands towards discharge zones in the lowlands.

No areas with high potential to serve as surficial aquifers have been identified in the study area.

Most of the bedrock in the quadrangle is covered by relatively thin surficial deposits, suggesting that the potential for recharge of bedrock aquifers is generally good. Although there is abundant opportunity for groundwater recharge over much of the quadrangle due to the relatively thin surficial deposits, the recharge areas for many wells may be relatively small and thus the wells may not be able to sustain heavy withdrawal without excessive lowering of the water levels.

Introduction

The area is located in Caledonia and Washington Counties in northeastern Vermont. The area is ~54 square miles and includes parts of the towns of Cabot, Hardwick, Walden, and Woodbury (Figure 1). The quadrangle is underlain almost entirely by the Waits River and Gile Mountain Formations, with a small portion of the Devonian Knox Mountain granite exposed in the southeastern corner (Figure 2, after Ratcliffe and others, 2011). The Cabot quadrangle is located in the Vermont Piedmont physiographic province (Stewart and MacClintock, 1969). Most of the southern half of the quadrangle is in the Winooski River watershed while the northern portions are in the Lamoille River watershed. The stream network and the approximate extent of glacial Lake Winooski are shown in Figure 3.

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. Local glacial erratics 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. In much of the region, these in turn are overlain by sediments deposited in proglacial lakes. Although the study area is outside of the extents of the large regional proglacial lakes in the area, there may be deposits from small, short-lived water bodies formed between the ice margins and the steep hillsides. The modern valley bottoms are also the sites of Holocene alluvial fan deposition, fluvial activity, and the accumulation areas for colluvium.

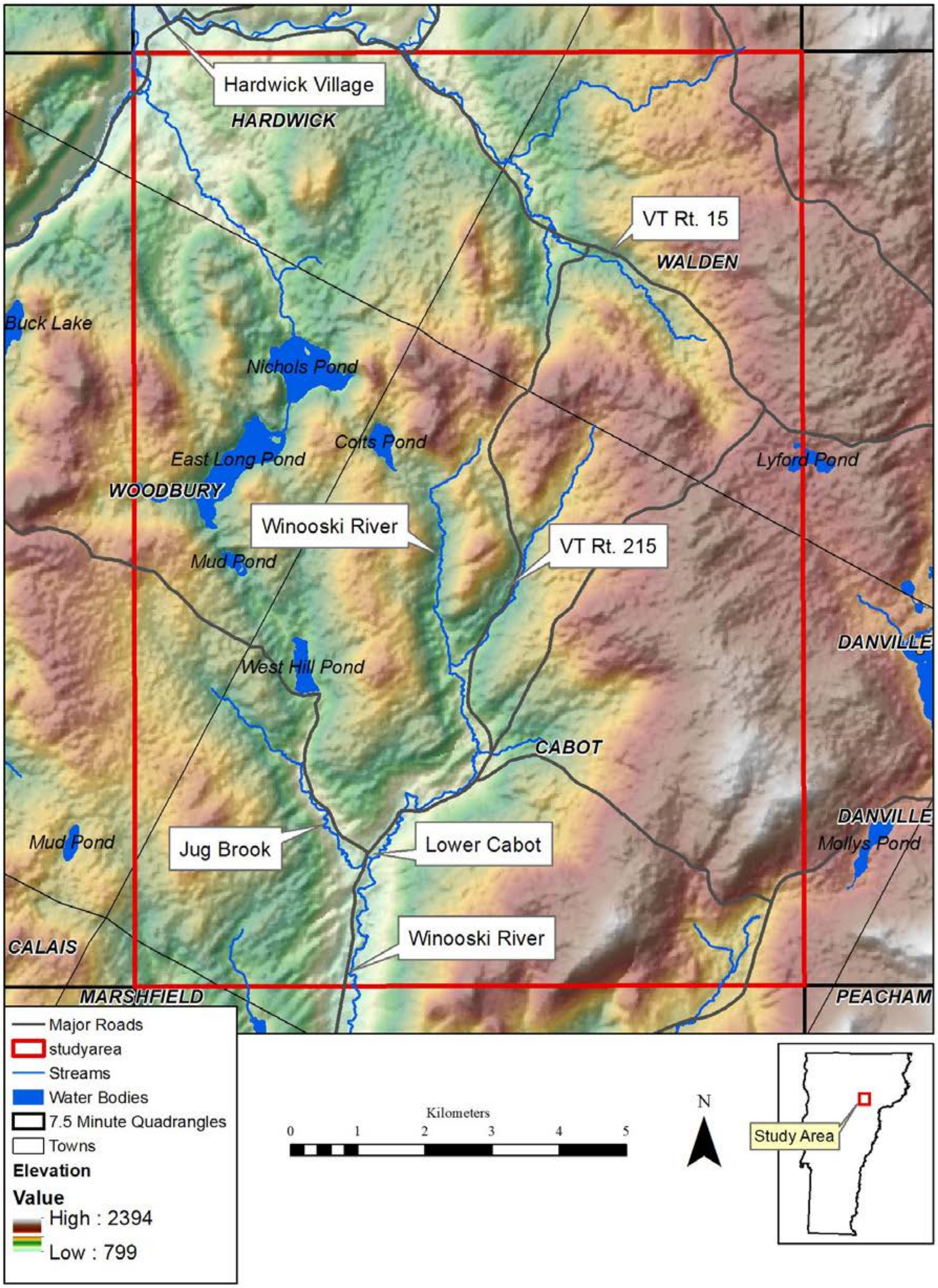


Figure 1. Location map.

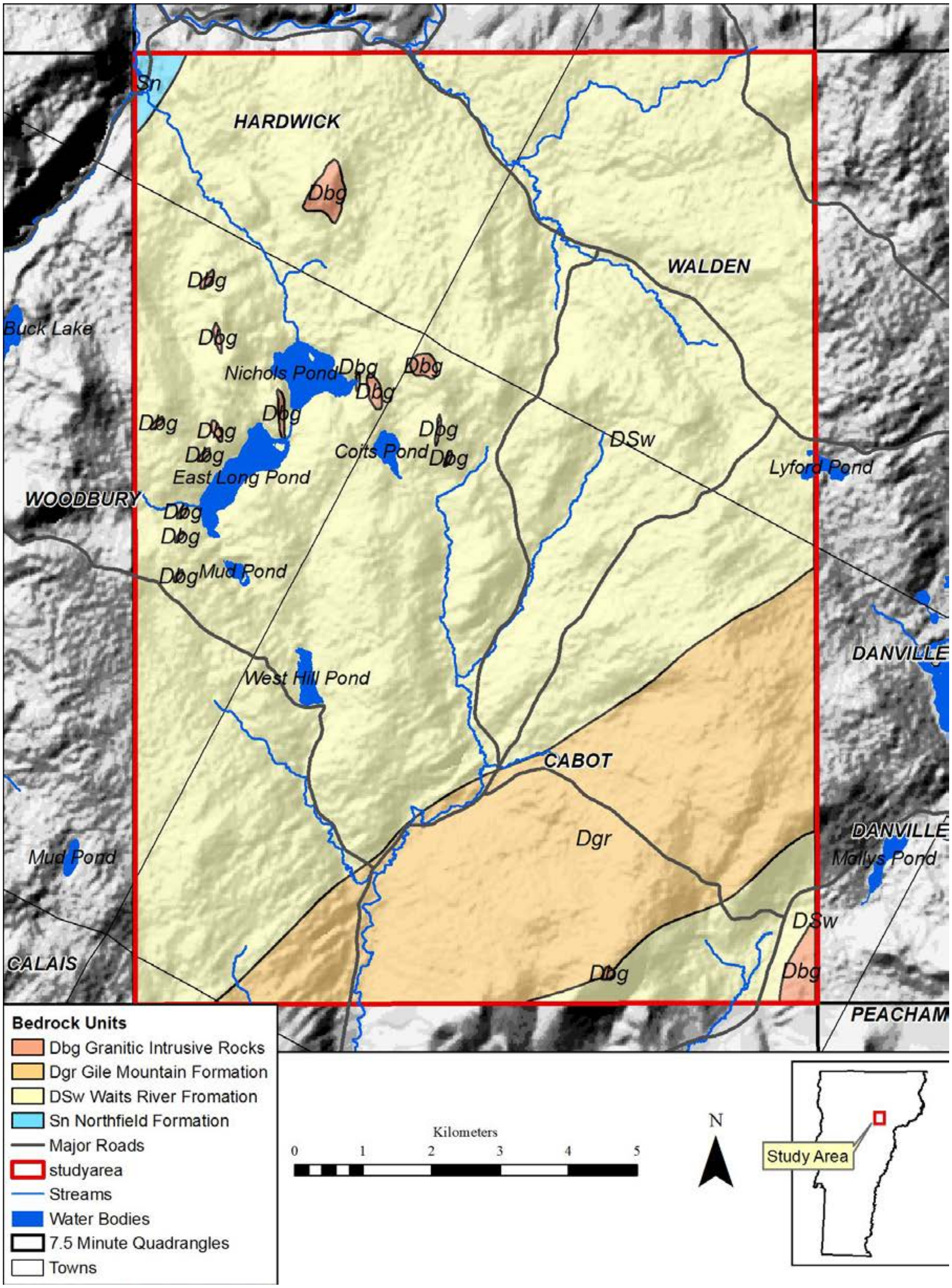


Figure 2. Bedrock geology (after Ratcliffe and others, 2011).

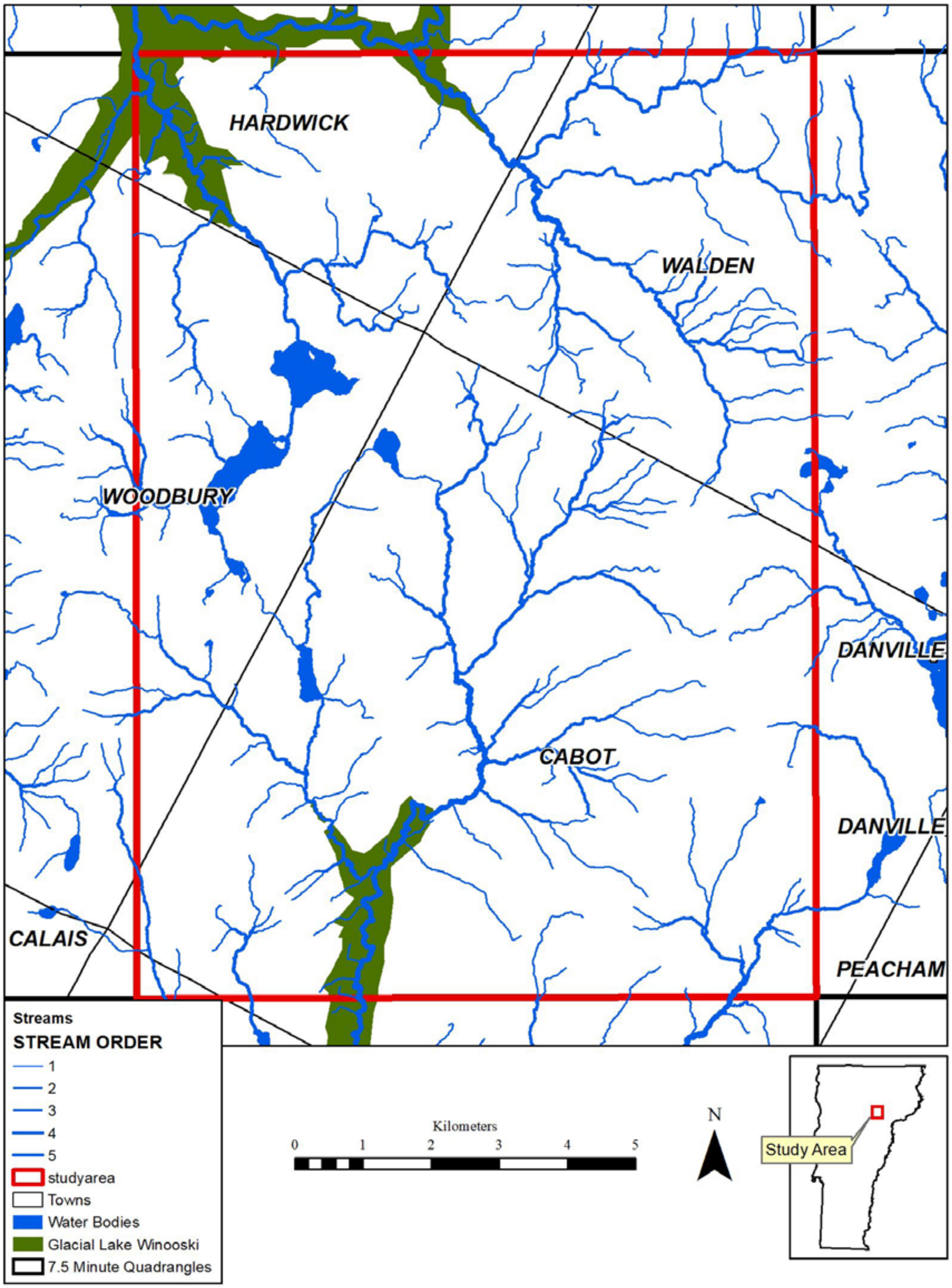


Figure 3. Waterbodies and extent of glacial Lake Winooski. Glacial Lake Winooski shorelines have been tilted by post-glacial isostatic rebound and are accordingly projected using shoreline tilt of 4.7 feet per mile to the N21W from a threshold at Williamstown Gulf (after Larsen, 1987).

Surficial Geology

Glacial till in the study area is generally dense with a fine-sand to silt matrix. Boulders, cobbles, and pebbles in the till are also predominantly of local origin. Figure 4 shows a typical closeup of dense till. Although this photo is from the nearby Woodbury quadrangle, the material in the study area looks quite similar. Granitic boulders from the Woodbury Granite bodies are widely distributed in the western third of the quadrangle (Figure 5). The till is of highly variable thickness, but large areas of the uplands consist of thin till and bedrock. Many of the first-order streams have cut down to bedrock (Figure 6). The mainstem of the Winooski River itself has cut through the relatively thick surficial deposits, with bedrock grade control visible at several locations (Figures 7 and 8).

Boulder-floored glacial meltwater channels were observed at several locations to the west of East Long Pond and Nichols Pond (Figure 9). Several other meltwater channels in the northern third of the map were delineated from stereoscopic interpretation of aerial photos.

Several discontinuous ice-contact sand and gravel deposits are found in the quadrangle. Kames, kettle holes, and a small esker are seen on the surface of the deposit on the north shore of Nichols Pond in Woodbury (Figure 10). Crudely bedded ice-contact gravelly sand is exposed in a small pit on the side of a road on the north shore of Nichols Pond (Figure 11). Several additional small- to moderate-sized sand and gravel bodies are shown on Plate 1. A large sand and gravel deposit is exposed at the Walden Town Pit to the west of Smith Corner. The pit exposes probable esker sand and gravel that is overlain faulted lacustrine medium and fine sands which are in turn overlain by lacustrine medium sand to silty very fine sands (Figures 12 and 13). These lacustrine deposits are above the level of glacial Lake Winooski and were thus probably formed in a short-lived lake that filled the Perkins Meadow Brook valley.

Glacial lake deposits occur in the Winooski River valley south of Cabot Village, in the northwest portion of the quadrangle near Hardwick Village, and in the north-central portion of the quadrangle (northwest of South Walden). Those in the Winooski River valley are clearly part of a northern arm of glacial Lake Winooski. Figure 14 is a view looking southwest across the valley. The higher terraces on the valley margins are underlain by fine sands, silts, and silty clay of glacial Lake Winooski while the lower terraces and floodplain in the center of the valley are underlain by ancient and modern alluvial sediments (sands, silts, and lesser amounts of gravel) deposited by the river. The deposits near Hardwick Village are also probably formed by an arm of the lake. The shorelines of this Late Pleistocene water body have been tilted by post-glacial isostatic rebound and are accordingly projected using shoreline tilt of 4.7 feet per mile to the N21W from a threshold at Williamstown Gulf (after Larsen, 1987). As projected, these shorelines fall below the upper limits of some of the lacustrine deposits. In particular, a well-developed terrace at the cemetery east of Hardwick Village extends above the projected shoreline. This is consistent with observations made in other parts of the Winooski Valley and suggests that revisions are needed to the direction and magnitude of the tilt. It is unclear if the deposits to the northwest of South Walden were formed in glacial Lake Winooski or in an as-yet unmapped higher-level lake.

The surficial deposits in the Winooski River valley in the vicinity of Lower Cabot are much thinner than those in the Winooski Valley bottom to the south and west in the Marshfield and Plainfield quadrangles. At Lower Cabot the deposits are generally less than 6 to 10 meters thick while at Plainfield and East Montpelier they exceed 30 meters.

Striations and grooves in bedrock indicated that ice motion directions ranged from 140 to 192°. Compared to the Woodbury quadrangle to the west, striations and grooves were uncommon and poorly developed. However, enough were seen to see that the patterns are similar. No cross-cutting relationships were observed in this study area, but in the Woodbury quadrangle at station WO872 the 194° striations cross-cut the 164° striations and are thus younger. This relationship has been seen at many other sites in the region and Wright (2015) has interpreted this to suggest an earlier regional ice flow trending roughly 160° with a later more southerly re-orientation of flow.

Figure 4. Closeup of a typical exposure of dense till. This site is from the Woodbury quadrangle to the west, but the till in the study area is quite similar in appearance. Site WO470, south of King Pond Road.

Figure 5. Large granitic boulder west of East Long Pond in Woodbury. The western third of the area contains abundant granitic glacial boulders derived from the nearby Woodbury Granite exposures.

Figure 6. Bedrock grade control in stream east of Cabot village, Site CA-337.

Figure 7. Looking upstream at an abandoned sawmill with a dam built on ledge. Site is on Winooski River north of Sawmill road, downstream of Lower Cabot.

Figure 8. Ledge of phyllite of the Gile Mountain Formation exposed at the base of dam. Same site as Figure 7.

Figure 9. Bouldery meltwater channel southwest of Nichols Pond in Woodbury. View looking up channel to SSW.

Figure 10. Kames underlain by ice-contact sand and gravel deposits on the northeast side of Nichols Pond, Woodbury.

Figure 11. Ice-contact gravelly sand exposed in a small pit on the east side of an access road, north shore of Nichols Pond.

Figure 12. Collapsed ice-contact sand and gravel at the Walden Town Pit west of Smith Corner.

Figure 13. Faulted ice-contact sands at the Walden Town Pit. Material ranges in size from medium sand to silty very fine sand.

As discussed in Larsen and others 2003), there is substantial evidence in central Vermont for a late Wisconsinan readvance, which appears to correlate with the Bethlehem-Littleton readvance in New Hampshire. More recent discoveries of thick dense till over lacustrine sediments at several locations in Washington County support this interpretation (Dunn and others, 2011; Dunn and others, 2015). Thick deposits in some of the valleys are reminiscent of till-over-lacustrine sequences seen in nearby areas, but no clear evidence of a readvance was found during this study.

Early reconnaissance surficial mapping within the Plainfield 15-minute quadrangle by Paul MacClintock is reported by Stewart and MacClintock (1969) and shown on Doll (1970). This mapping delineated an extensive moraine complex (Danville Moraine) that extends across the northeastern portion of the quadrangle. Mapping by Springston and Haselton in the St. Johnsbury 7.5 minute quadrangle (1999a and b) to the east of the study area casts doubt on the existence of this moraine. No evidence in support of the moraine was found during this mapping. Where examined, the areas that had been mapped as moraine were generally thin, dense, silt-matrix till. Bedrock outcrops were common in these areas. Further work in the Joes Pond quadrangle will provide additional opportunities to examine this moraine question.

Unlike in the Woodbury quadrangle to the west, there is no clear evidence that any of the valleys functioned as major glacial drainage routes. However, the lacustrine deposits in the northern portions of the quadrangle were poorly exposed and additional work may reveal more indications of eskers and other ice-contact deposits.

For a brief discussion of the Holocene deposits see the Description of Map Units below. Much of Cabot Village itself is underlain by stream terrace deposits. Borings at the Cabot School for a wood chip boiler facility reveal approximately 15 feet of sand, gravel, and silt with lenses of peat over glacial till. The areas delineated as graded or filled in Cabot Village were originally mostly stream terrace deposits on the west side and glacial till on the east side. The Holocene deposits are mostly of limited size except for extensive areas of modern alluvium in the valleys of the Winooski River downstream of Cabot.

Description of Map Units

The Holocene deposits are less than about 12,000 years old.

Artificial Fill. Artificially-emplaced earth along road beds, embankments and in low-lying areas.

Graded or Filled. Area of extensive artificial excavation or filling.

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

Wetland Deposits. Accumulations of clastic sediment and/or organic matter. Commonly overlaying other sediments such as alluvium, lacustrine deposits, or till. Only a few of the larger deposits are shown.

Wetland Deposits, Peat or Muck. Thick accumulation of organic matter with minor clastic sediment. Commonly overlaying other sediments such as alluvium, lacustrine deposits, or till. Thickness of organic horizon ranges from 0.3 meter to greater than one meter.

Stream Terrace Deposits. Silt, sand, pebble, cobble, and boulder gravel deposited on terraces above the modern floodplains of streams. They represent former floodplains that have been dissected by younger streams.

Talus. Fans or aprons of fallen rock at the base of cliffs. May contain colluvial (slope-wash) deposits as well. Of variable thickness.

Colluvium. Fans or aprons of sediment at the base of steep slope segments. Slope-wash deposits of variable thickness.

Pleistocene Deposits

The Pleistocene deposits are greater than about 12,000 years old. Although the Pleistocene epoch extends back to between 1.8 million and 2.58 million years, all of the glacial deposits in the study area are believed to belong to the last stage of the Pleistocene, the Wisconsinan Glacial Stage, which extends from about 71,000 to 12,000 years before present.

Lake Deposits, undifferentiated. Coarse- to fine-grained lake deposits. Largely deposited in arms of glacial Lake Winooski, excerpt in the northern part of the study area to the east of Hardwick village, where the deposits may grade to a higher-level glacial lake.

Lake Deposits, Coarse-grained. Well-sorted sand, pebbly sand and/or sandy gravel deposited in shoreline, shallow waters, or lake bottom environments of glacial Lake Winooski or in higher-level glacial lakes of limited areal extent. Parts of the coarse-grained deposits between Lower Cabot and Cabot in the Winooski River valley and in the lower Jug Brook valley may be delta or shoreline deposits, but more detailed mapping would be needed to distinguish these.

Lake Deposits, Fine-grained. Clay, silt, and very fine to fine sand deposited in deeper waters. Commonly varved. Deposited in lake bottom environments of glacial Lake Winooski or in higher-level glacial lakes of limited areal extent.

Ice-contact Deposits. Unsorted to poorly-sorted sand, gravel, and silt deposited in contact with glacial ice. Kettle holes and a small esker are visible on the ice-contact deposits north of Nichols Pond. A probable esker buried by collapsed lacustrine sands and silts is exposed in the sandpit west of Smith Corner in Walden.

Till. Dense to very dense, unsorted to very poorly sorted, fine-sand- to silt-matrix till. Surface boulders are common, with boulders of the local Woodbury Granite common in the western third of the study area. Thickness of the till is highly variable, from less than 3 meters to greater than 30 meters.

Till, Thin. Descriptions as in preceding unit. Thickness highly variable but generally less than 3 meters and bedrock outcrops are very common.

Bedrock. Area of extensive bedrock exposures. Most outcrops visited during this study are indicated by point symbols.

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 on Plate 2. 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.

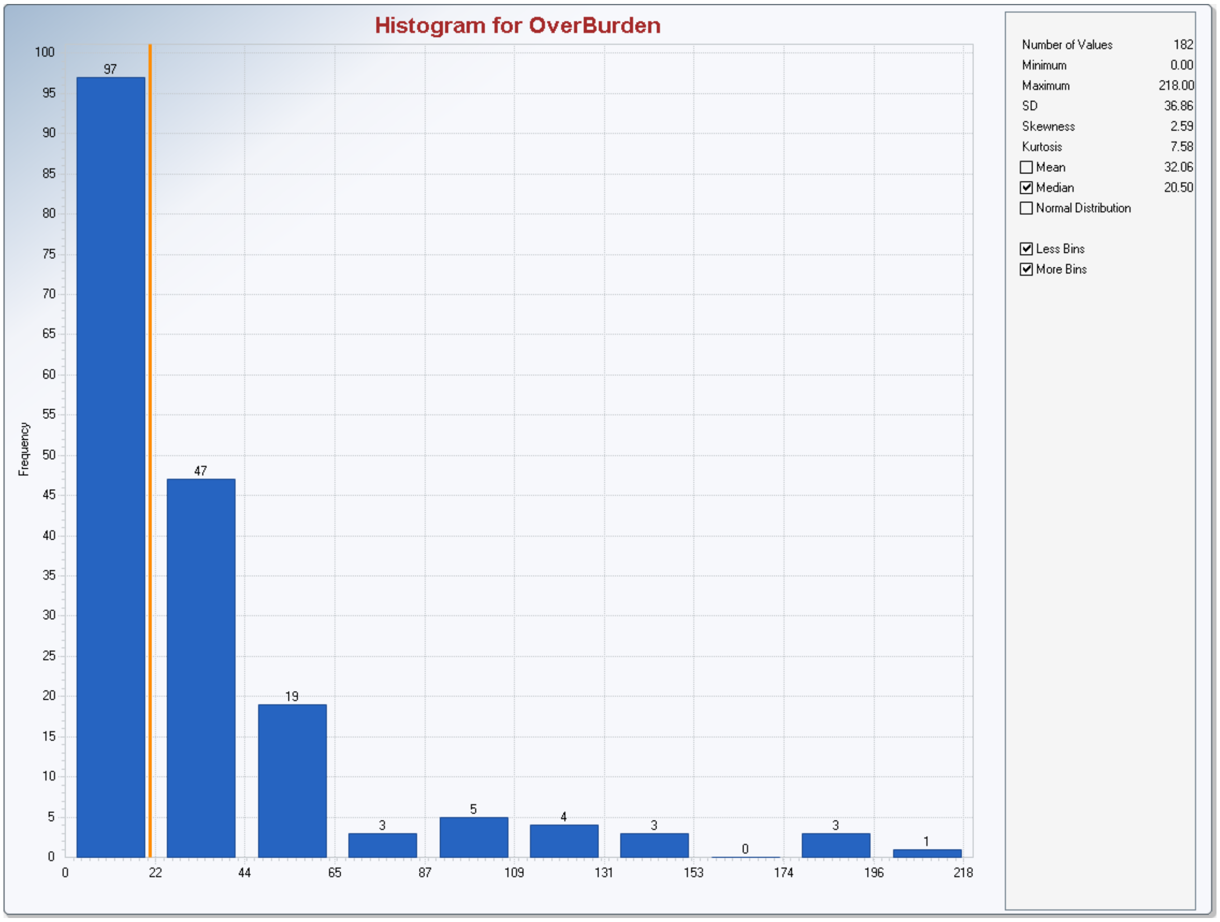
Bedrock well statistics are shown in Table 1 and will be discussed in the paragraphs below. Note that the percentile values and histograms for depth to bedrock, yield, and well depth are all skewed to the left. For each of these the median value serves as a better measure of central tendency than the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

Table 1. Descriptive statistics for all located bedrock wells in the Cabot quadrangle (N = 182). Well depth and depth to bedrock in feet, yield in gallons per minute.

	Minimum	Maximum	Mean	SD	10th Percentile	25th Percentile	50th Percentile (Median)	75th Percentile	90th Percentile
Well Depth	79	625	271.8	122.7	142.3	182.8	240	342	442
Yield	0	300	20.12	30.79	1	5	10	25	40
Depth to Bedrock	0	218	32.06	36.86	6	9	20.5	39.5	71.3

Depths of bedrock wells in the quadrangle have a mean of 271.8 feet and a median of 240 feet. These statistics can be compared to statewide water well data. Statewide, bedrock wells average 14 gallons per minute and have a mean depth of 290 feet (Gale and others, 2014). By these measures, wells in the quadrangle are yielding somewhat above the statewide average and are completed at less than average depths.

Depth to bedrock (in feet) is shown on Plate 3. Depth is indicated by the size of the green symbols at each well location. Bedrock outcrops are shown as black dots. The red lines are approximate contours at depths of 20, 40, 60, 80, and 100 feet. A histogram of the data is shown in Figure 14 below. As shown in Table 1, the median depth to bedrock in the wells is 20.5 feet. Note that most of the areas with more than 20 feet to bedrock are in Hardwick and Walden. 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.

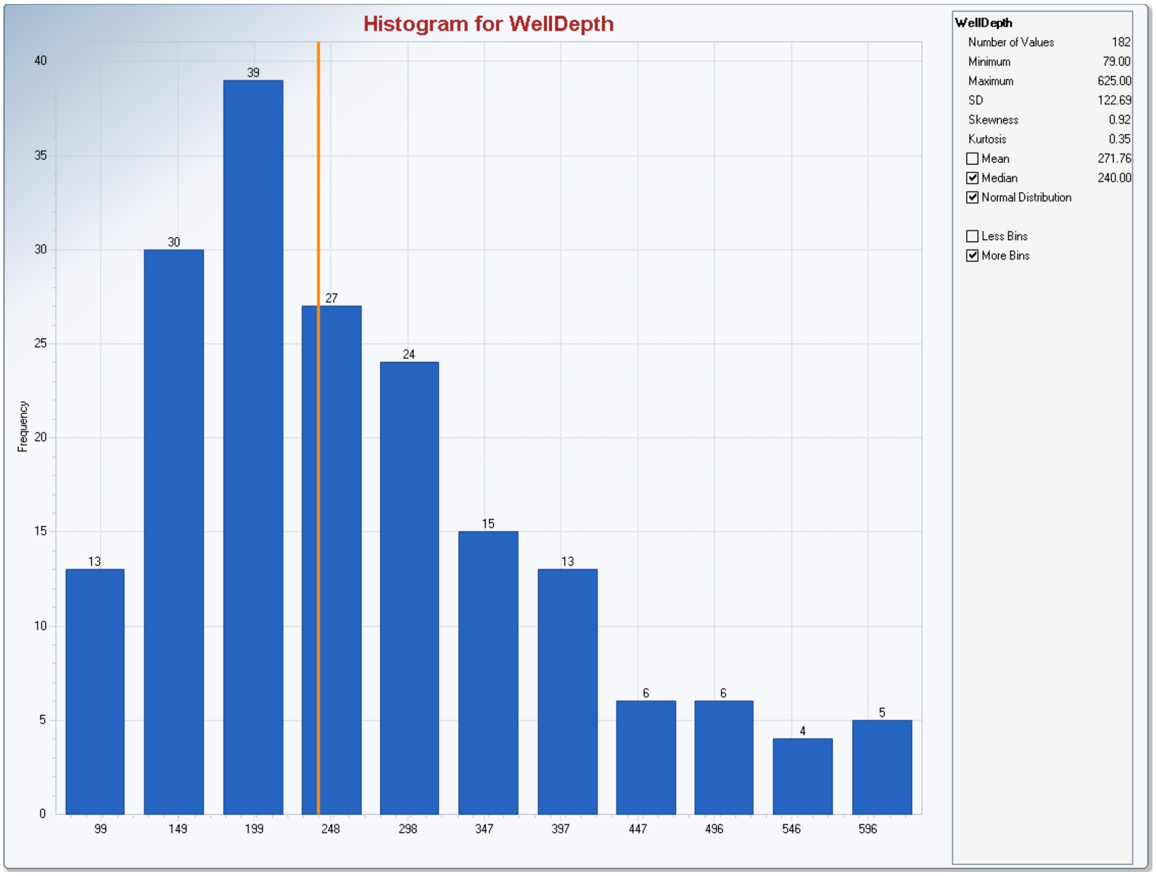


Number of Values	182
Minimum	0.00
Maximum	218.00
SD	36.86
Skewness	2.59
Kurtosis	7.58
☐ Mean	32.06
☑ Median	20.50
☐ Normal Distribution	

☑ Less Bins
☑ More Bins

Figure 14. Histogram of depth to bedrock in feet for all bedrock wells within the quadrangle. Median depth to bedrock of 20.5 feet shown by orange vertical line.

Bedrock well depths are shown on Plate 4. Depths (in feet) are indicated by the labels, as well as the size of the green symbols. A histogram of well depths is shown in Figure 15 below. The mean well depth is 271.8 feet and the median value is 240 feet. Statewide, the mean depth of bedrock wells is 290 feet. Thus, the wells in the quadrangle are being completed at depths that are somewhat less than the statewide average.



WellDepth

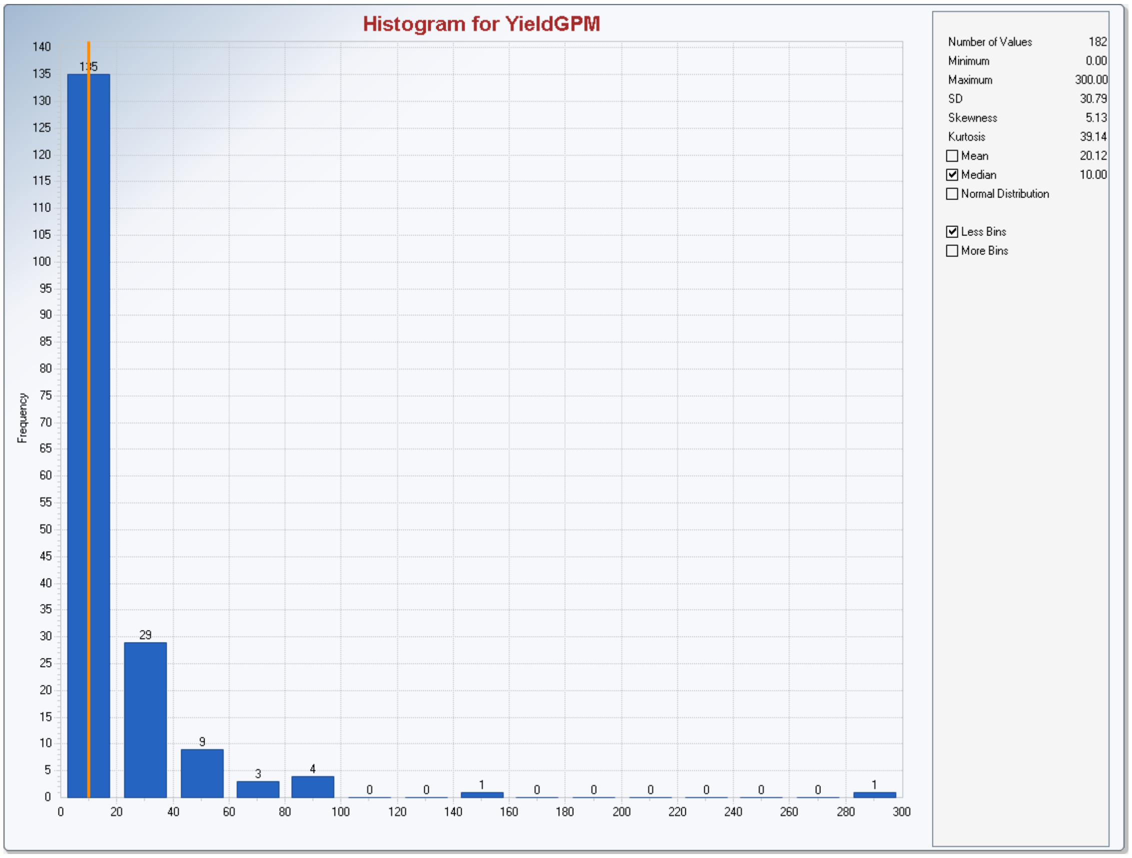
Number of Values	182
Minimum	79.00
Maximum	625.00
SD	122.69
Skewness	0.92
Kurtosis	0.35
☐ Mean	271.76
☑ Median	240.00

☑ Normal Distribution

☐ Less Bins
☑ More Bins

Figure 15. Histogram of well depth for all bedrock wells within the quadrangle. Median depth (240 feet) shown by orange vertical line.

Driller's estimates of yields of bedrock wells are shown on Plate 5. Yields (in gallons per minute) are indicated by the labels, as well as by the size of the green symbols. Bedrock geologic units are also shown. The mean well yield is 20.1 gallons per minute and the median value is 10.0 gallons per minute. A histogram of the data is shown in Figure 16. Statewide, the mean yield of bedrock wells is 14 gallons per minute. Thus, the wells in the quadrangle have yields that are somewhat higher than average.



Number of Values	182
Minimum	0.00
Maximum	300.00
SD	30.79
Skewness	5.13
Kurtosis	39.14
☐ Mean	20.12
☑ Median	10.00
☐ Normal Distribution	

☑ Less Bins
☐ More Bins

Figure 16. Histogram of driller’s estimates of well yield in gallons per minute for all bedrock wells within the quadrangle. Median yield (10 gpm) shown by orange vertical line.

Yields in the Waits River and Gile Mountain Formations are compared below. No wells were located in the Northfield Formation and only a single well was located in the areas mapped as granitic intrusives.

Table 2 compares yields in the major bedrock units in the quadrangle; the Waits River and Gile Mountain Formations. Wells in the Waits River Formation have a mean yield of 18.9 gallons per minute and a median yield of 11.5 gallons per minute while those in the Gile Mountain Formation have a mean yield of 21.2 gallons per minute and a median yield of 9.0 gallons per minute. The median yield values were compared using a Wilcoxon-Mann-Whitney test. With a 90% confidence limit the Waits River Formation is found to be statistically higher than the Gile Mountain Formation. However, with a 95% confidence limit (which is the commonly accepted standard) the yields are not statistically different.

Table 2. Comparison of driller’s estimates of yields of bedrock wells drilled in the Waits River and Gile Mountain Formations. Values are in gallons per minute.

	Number of Wells	Minimum	Maximum	Mean	Standard Deviation	Median
Waits River Formation	130	0	100	18.9	20.3	11.5
Gile Mountain Formation	50	0	300	21.2	47.7	9.0

Static Water Levels and Groundwater Flow Directions

Plate 6 contains information on the height of water levels in existing wells (static water levels) and groundwater flow directions. Static water levels (collected during well installation) are available for about 1/3 of the water wells in the quadrangle. Labels indicate the depth to the water surface in feet. The dark blue lines are approximate 100-foot contours of the groundwater surface. The contours are drawn on the assumption that groundwater flowing through the bedrock and surficial deposits is unconfined and that the contours on the groundwater surface will run roughly parallel to topographic contours. The red arrows are idealized groundwater flow lines. These are drawn on the assumption that groundwater will flow perpendicular to the contours on the groundwater surface and converge towards the streams, ponds, and wetlands.

The groundwater contours and flow lines shown on the map are drawn on the assumption that groundwater is generally moving from higher areas to lower areas. Confining layers in the surficial deposits or within the bedrock units may, however, result in wells that have water levels higher than the contours would indicate.

The water level measurements from bedrock wells suggest that groundwater flow directions generally mimic the topography, with groundwater moving from recharge zones in the uplands towards discharge zones in the lowlands.

Hydrogeologic Interpretation of Water Well Logs

The purpose of the hydrogeologic classification shown on Plate 7 is to rank how easily ground water can move through the surficial materials. The classification is made using water well logs and is based almost entirely on the coarseness of the surficial materials, with the assumption that ground water will be able to flow easier through coarser materials than through finer ones (Table 3). Interpretations based on this data will be shown on other plates in this report. As the driller’s logs are not very detailed and vary widely in accuracy and completeness, these interpretations are of limited accuracy. They are perhaps most useful in areas where several nearby well logs all show similar stratigraphy.

Relatively thin, coarse-grained surface horizons that are less than about 20 feet thick are ignored in this classification as they are likely to be of little importance either as significant aquifers or as barriers to prevent or slow infiltration of ground water. In the classification below a "thick" surface horizon measures 20 feet or more.

Surficial deposits that are less than about 40 feet in **total** thickness are not considered to be good candidates for surficial aquifers. Even if such deposits can supply sufficient yields during dry seasons, they are quite likely to be at risk from contamination from surface waters.

Table 3. Hydrogeologic classification of water well logs.

0	Thick, coarse-grained, stratified deposits over till over coarse-grained stratified deposits.
1	Fine-grained stratified deposits over coarse-grained stratified deposits.
2	Fine-grained stratified deposits over coarse-grained stratified deposits over fine-grained stratified deposits or till.
3	Thick, coarse-grained, stratified deposits over fine-grained stratified deposits over coarse-grained stratified deposits.
4	Sand-matrix till over coarse-grained stratified deposits.
5	Silt-to-clay-matrix till over coarse-grained stratified deposits.
6	Thick, coarse-grained, stratified deposits.
7	Thick, coarse-grained, stratified deposits over fine-grained stratified deposits and/or till.
8	Thick section of sand-matrix till.
9	Thick section of silt-to-clay matrix till over fine-grained stratified deposits.
10	Thick section of fine-grained stratified deposits over silt-to-clay-matrix till or directly over bedrock.
11	Thick section of silt-to-clay-matrix till.
12	Thin surficial deposits or no surficial deposits overlying bedrock. Includes the very common case of thin till over bedrock. Generally less than 40 feet thick.
13	Other. Commonly, this is a thick section of surficial deposits with either no details of stratigraphy or highly variable stratigraphy.
-999	Problem record. Usually due to location being suspect.

Surficial Aquifer Potential

Plate 8 uses the hydrogeologic classification of private water well logs shown on Plate 7 to estimate the surficial aquifer potential of the surficial deposits in the quadrangle. Hydrogeologic Classes 0 through 5 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 dots. Classes 6 and 7 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 dots. Classes 8 through 13 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.

Out of the 195 well logs examined, only 7 are classified as having high potential and 16 as having moderate potential. As these are scattered throughout the areas with thicker surficial deposits, there do not appear to be any areas in the quadrangle with high potential as surficial aquifers. However, as only a few well logs are available from the valley bottoms in the Hardwick and Walden portions of the quadrangle, it remains possible that these areas could turn out to have greater surficial aquifer potential.

This study area is unusual in that there are only two located wells that end in the surficial deposits (these are often called “gravel wells” but as they do not necessarily contain significant gravel, the term should therefore be avoided).

Bedrock Aquifer Recharge Potential

Plate 9 contains information on the favorability of recharge to bedrock aquifers. It is based on an interpretation of the hydrogeologic classification of water well logs shown on Plate 7. Hydrogeologic Classes 0, 1, 3 through 6, and 12 are interpreted as having a high bedrock aquifer recharge potential due to the presence of either thick coarse-grained deposits at the base or else the presence of thin surficial deposits. These are shown as green dots. Classes 2, 7, and 8 are interpreted to have a low potential for bedrock aquifer recharge as there is a thick deposit of fine-grained materials at the base of the surficial deposits. These are shown as small red dots.

No significant areas with low aquifer recharge potential have been identified in the quadrangle. Only 35 out of the 195 wells are interpreted as having low aquifer recharge potential and these are scattered throughout that quadrangle. Considering the relatively thin surficial deposits throughout most of the quadrangle (see Plate 3), and the extensive areas mapped as thin till (medium gray polygons on Plate 1 and Plate 9), this suggests that there is ample opportunity for groundwater recharge over much of the quadrangle. However, the recharge areas for many wells may be relatively small and thus the wells may not be able to sustain heavy withdrawal without excessive lowering of the water levels.

Actual groundwater recharge will depend heavily on the detailed stratigraphy of the surficial deposits, as well as the bedrock units present and the distribution, length, orientation, spacing, and openness of fractures in the bedrock. The bedrock characteristics are not considered here.

Summary

Glacial till is the most widespread surficial material in the study area. It is generally dense with a fine-sand to silt matrix. The median value of depth to bedrock for located water wells is 20.5 feet.

Striations and grooves in bedrock indicate that ice motion directions ranged from 140 to 192°. Compared to the Woodbury quadrangle to the west, striations and grooves were uncommon and poorly developed.

No evidence in support of the Danville Moraine of Stewart and MacClintock (1969) was found during this mapping. Where examined, the areas that had been mapped as moraine were generally thin, dense, silt-matrix till. Bedrock outcrops were common in these areas. Further work in the Joes Pond quadrangle will provide additional opportunities to examine this moraine question.

Several discontinuous ice-contact sand and gravel deposits are found in the quadrangle. Kames, kettle holes, and a small esker are seen on the surface of the deposit on the north shore of Nichols Pond in Woodbury. Several additional small- to moderate-sized sand and gravel bodies are shown on Plate 1. A large sand and gravel deposit is exposed at the Walden Town Pit to the west of Smith Corner. The pit exposes probable esker sand and gravel that is overlain by lacustrine sands. These lacustrine deposits are above the level of glacial Lake Winooski and were thus probably formed in a short-lived lake that filled the Perkins Meadow Brook valley.

Glacial lake deposits occur in the Winooski River valley south of Cabot Village, in the northwest portion of the quadrangle near Hardwick Village, and in the north-central portion of the quadrangle (northwest of South Walden).

The surficial deposits in the Winooski River valley in the vicinity of Lower Cabot are much thinner than those in the Winooski Valley bottom to the south and west in the Marshfield and Plainfield quadrangles. At Lower Cabot the deposits are generally less than 6 to 10 meters thick while at Plainfield and East Montpelier they exceed 30 meters.

Mean yields of bedrock water wells are somewhat above the statewide average (20.1 gpm versus 14.0 gpm statewide) and depths of bedrock water wells are somewhat below the statewide average (271.8 feet versus 290.0 feet statewide).

Yields in the two major bedrock units (Waits River and Gile Mountain Formations) are similar. There was insufficient data to compare yields in the granitic intrusions (only one well).

The water level measurements from bedrock wells suggest that groundwater flow directions generally mimic the topography, with groundwater moving from recharge zones in the uplands towards discharge zones in the lowlands.

No areas with high potential to serve as surficial aquifers have been identified in the study area.

Most of the bedrock in the quadrangle is covered by relatively thin surficial deposits, suggesting that the potential for recharge of bedrock aquifers is generally good. Although there is abundant opportunity for groundwater recharge over much of the quadrangle due to the relatively thin surficial deposits (see Plates 3 and 9), the recharge areas for many wells may be relatively small and thus the wells may not be able to sustain heavy withdrawal without excessive lowering of the water levels.

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