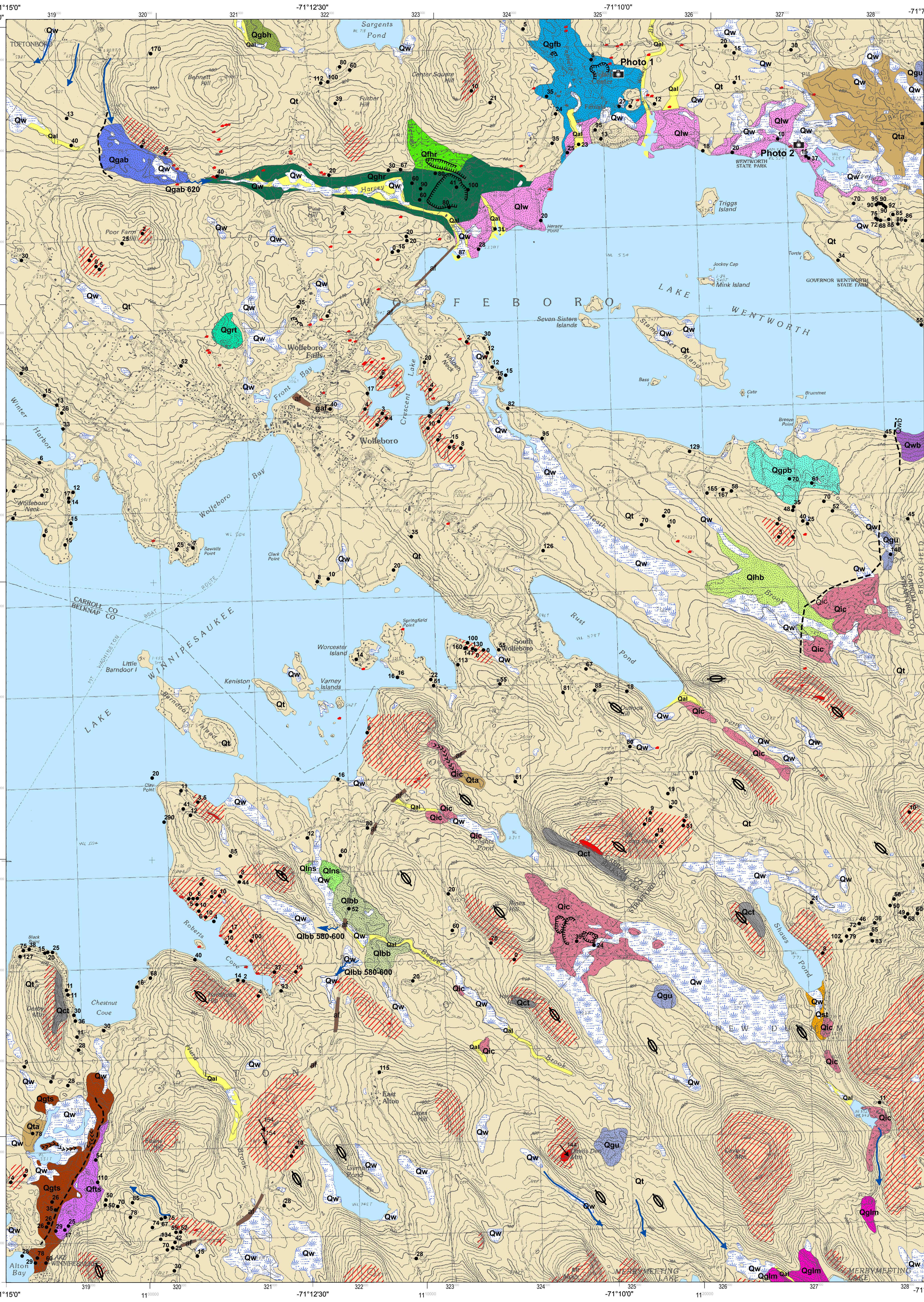
SURFICIAL GEOLOGIC MAP OF THE WOLFEBORO QUADRANGLE
Belknap, Carroll, and Strafford Counties, New Hampshire

NEW HAMPSHIRE GEOLOGICAL SURVEY
SURFICIAL GEOLOGIC MAP GEO-113-024000-SMAP

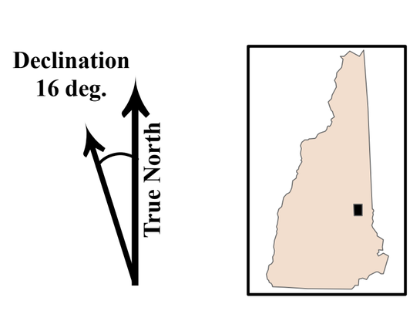


Base map (provisional) by the U.S. Geological Survey, 1987, Wolfeboro, New Hampshire. 10,000-foot grid ticks based on New Hampshire coordinate system. 1000-meter Universal Transverse Mercator grid ticks, Zone 19. Horizontal Datum: 1927 North America

SCALE 1:24,000

Miles: 1, 0.5, 0, 1
Feet: 1,000, 0, 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 9,000, 10,000
Meters: 1,000, 0, 1,000, 2,000

Contour Interval 20 Feet



Quadrangle Location
GRANIT Tile No. 113

DESCRIPTION OF MAP UNITS

gaf — **Graded or Reworked Surfaces of Artificial Fill**

af — **Artificial Fill (Holocene)**

Qw — **Wetland Deposits (Holocene)** - Muck, peat, silt, and sand. Generally 5 to 10 feet (1.52 to 3.05 m) thick.

Surface Water

Bedrock Exposure

NON-GLACIAL DEPOSITS (Pleistocene to Holocene)

Qal — **Alluvium (Holocene)**- Sand, pebbles, cobbles, and boulders in active floodplains along rivers and streams; up to 20 feet (6.10 m) thick.

Qst — **Stream Terrace Deposit (Pleistocene to Holocene)** - Sand to boulders on terraces created by post-glacial deposition or erosion of glacial deposits. Up to 20 feet (6.10 m) thick.

Qct — **Talus (Pleistocene to Holocene)** - Colluvial material deposited subaerially as a non-sorted deposit of angular boulders, usually on steep slopes beneath extensive outcrop. Deposits up to 80 feet (24.38 m) thick.

Qlw — **Lake Wentworth Deposit (Pleistocene to Holocene)** - Sand to pebbles graded to an elevation of approximately 540 feet (164.59 m). Deposit is a depositional/erosional surface of a previous lake level. Sediments derived from post-glacial streams and reworking of glacial deposits. Deposit includes areas of till. In addition, erosional surface extends into area of till bordering deposit, but at the same elevation.

UNCORRELATED GLACIOLFLUVIAL DEPOSITS (Pleistocene)

Qic — **Ice Contact/Glaciofluvial Deposit (Pleistocene)** - Fluvial deposits laid down within or in close proximity to the ice margin. Deposits are generally coarse-grained, with limited sorting, but grade to well-sorted sands away from the ice margin. Eskers, ice-channel fills, and kames are found locally. Up to 60 feet (18.29 m) thick.

Qgu — **Uncorrelated Glaciofluvial Deposit (Pleistocene)** - Glaciofluvial deposit of sand to gravel deposited by meltwater. Correlation to other map units is unclear.

GLACIOFLUVIAL AND GLACIOLACUSTRINE DEPOSITS (Pleistocene)

Qgab — **Abenaki Deposit** - Sand and pebbles, minor silt and cobbles. Glaciofluvial to glaciolacustrine deposit graded to an approximately 620 foot (188.98 m) elevation spillway just west of the Harvey Brook deposit. Lake may have been continuous with, or at a slightly higher elevation than, Lake New Durham. Deposit up to

Qgbh — **Bennett Hill Deposit** - Sand to pebbles. Glaciofluvial to glaciolacustrine deposit that developed in a small glacial lake located east of a spillway at an elevation of approximately 740 feet (225.55 m).

Glacial Lake New Durham Deposits

Glacial Lake New Durham, named for the location of its spillway, was first described by Goldsmith (1995) during his mapping of the Alton Quadrangle. During the recession of the glacier through the area, this glacial lake remained in contact with the ice margin and a series of glaciolacustrine deposits graded to the lake level. The elevations of these deposits, and the paleo lake surface,

Qgrt — **Radio Tower Deposit** - Small deposit of silty sand to pebbles graded to an elevation of approximately 600 feet (182.88 m).

Qghr — **Harvey Brook Deposit** - Sand to pebble glaciofluvial to glaciolacutrine deposit grading to approximately 620 foot (188.98 m) lake level. Significant delta developed at the eastern end of the deposit. Delta up to approximately 100 feet (30.48 m) thick.

Qfhr — **Harvey Brook Alluvium Fan Deposit** - Sand to cobbles deposited contemporaneously with or following the deposition of the Harvey Brook Deposit. Subaerial deposit developed downstream of glacial meltwater channel.

Qgfb — **Fernald Brook Deposit** - Sand to pebbles, glaciofluvial to glaciolacustrine deposit graded to a lake elevation of approximately 610 to 620 feet (185.93-188.98 m). Distal (southern) portion of deposit likely did not build to lake level. Deposit up to approximately 60 feet (18.29 m)

Qgpb — **Point Breeze Deposit** - Sand with minor pebbles, glaciofluvial to glaciolacustrine deposit at an elevation of approximately 600 to 610 feet (182.88 to 188.98 m).

Qlhb — **Heath Brook Deposit** - Sand and minor pebbles, glaciolacustrine deposit graded to an elevation of approximately 580 to 600 feet (176.78 to 182.88 m). Sediments derived from glacier and from the reworking of ice contact sediments at the eastern end of the deposit.

Qlns — **Uncorrelated Lake New Durham Deposit** - Glaciolacustrine deposit of reworked sediment from Glacial Lake Beaver Brook, following recession of the ice margin into Glacial Lake New Durham (560-580 feet (170.69-176.78 m)). Deposit consists of sand to cobbles in foreset beds, overlain by sand and minor silt. Up to 40 feet (12.19 m) thick.

Tenant Swamp Deposits

The Tenant Swamp deposits are comprised of two primary units. On the eastern margin, an alluvial fan (Qfts) developed as a meltwater channel eroded deeply into the hillside. Meltwater was forced down this channel from the ice-dammed valley of Hurd Brook and Gilman Pond. Eroded material was deposited along the ice margin. Following ice margin retreat, a shallow embayment of Glacial Lake New Durham filled the area between the fan deposit and the ice front. Ice-contact glaciofluvial deposits laid down between stagnant ice blocks grade into well-sorted sands of the lake bottom deposits

Qgts — **Tenant Swamp Deposits** - Interspersed ice-contact glaciofluvial and glaciolacustrine sand and gravel. Ice contact deposits are sand to boulders laid down between or proximal to stagnant ice blocks and locally grade into ablation till. Those deposits were quickly sorted into sandy bottom sediments of Glacial Lake New

Qfts — **Tenant Swamp Alluvial Fan Deposit** - Coarse-grained alluvial fan material, transitioning to more well-sorted glaciofluvial material to the north and south, along the ice margin. Up to 40 feet (12.19 m) thick.

Glacial Lake Beaver Brook Deposits

Glacial Lake Beaver Brook was dammed by the retreating ice margin when it occupied the northwest-trending Beaver Brook Valley. Drainage from the lake was via multiple spillways (580 to 600 feet (176.78 to 182.88)) on the southwestern edge of the ice margin. The ice marginal dam held Glacial Lake Beaver Brook approximately 20 to 40 feet (6.10 to 12.19 m) higher than Glacial Lake New Durham. Once the ice dam receded, the Glacial Lake Beaver Brook deposits were stranded and a new delta was established into Glacial Lake New Durham (Qlns).

Qlbb — **Glacial Lake Beaver Brook Deposits** - Glaciolacustrine deposits of sand to cobbles, including ice-contact deltas and lake bottom sediments building out from the ice margin, interspersed locally with coarse-grained, ice-contact (crevasse fillings or eskers) deposits. Up to 60 feet (18.29m) thick.

Warren Brook Area Deposit

Warren Brook Deposit of Koteff and Boudette (2005). Kame terrace deposited in pond between ice and valley wall.

Qwb — **Warren Brook Deposit** - Fine sand to cobbles. Flat terrace at top deposit constructed to an elevation of approximately 660 to 680 feet (201.17 to 207.26 m).

Merrymeeting Lake Deposits

Glaciofluvial and glaciolacustrine deposits grading to an ice-blocked Glacial Merrymeeting Lake at an elevation of 740 to 760 feet (225.55 to 231.65 m) (Goldsmith, 1995). This deposit was fed from glacial meltwater channels east and west of Caverly Mountain.

Qglm — **Deposit at Merrymeeting Lake** - Glaciolacustrine deltas composed of sand to cobbles in the fluvial sections, and generally sandy foreset beds. No exposed topset/foreset contacts identified. Up to 40 feet thick (12.19 m).

GLACIAL TILL

Qta — **Ablation Till** - Non-sorted to poorly sorted mixture of silt, sand, cobbles, and boulders. Ablation till is moderately compact to loose, generally light brown, and contains less than 10% silt/clay. Locally, pods of sand are intermixed with the till. Land morphology shows irregular piles of debris and thickness is generally interpreted to be more than 10 feet (3.05 m).

Thin Till - Area of bedrock exposures and till deposits interpreted be less than 10 feet (3.05 m) thick.

Qt — **Till** - Non-sorted to poorly sorted mixture of silt, sand, pebbles, and boulders. Basal till is very compact and light to dark gray, and limited to only a few exposures. May be overlain by bedded lacustrine sand, silt, and clay in areas of low relief

EXPLANATION OF MAP SYMBOLS

- Retreatal position of stagnant ice margin *Label indicates associated surficial unit.*
- Meltwater spillway *Labels indicate associated surficial unit and elevation of spillway in feet.*
- Meltwater channel
- Esker or ice-channel filling
- Gravel pit extent
- Striation *Number posted is in degrees east of north. Observation point is at tip of arrow.*
- Drumlin or Stream-lined Hills
- Photo 1 Location of photograph on map.
- NHGS Well Data *Depth to bedrock in feet.*

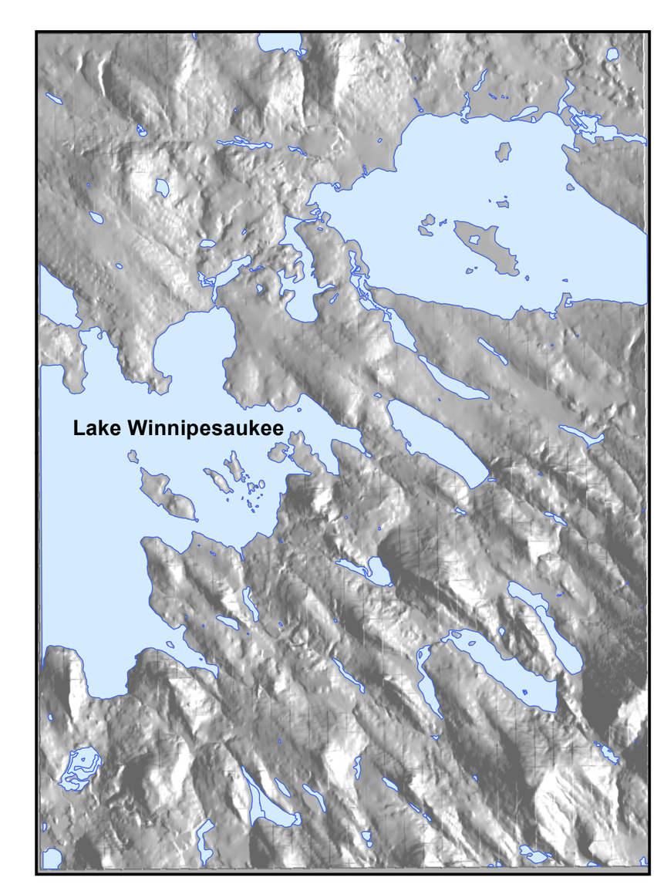
LEGEND FOR SEDIMENT TEXTURES

- **Gravel**
- **Mixed sand and gravel**
- **Sand, minor silt**

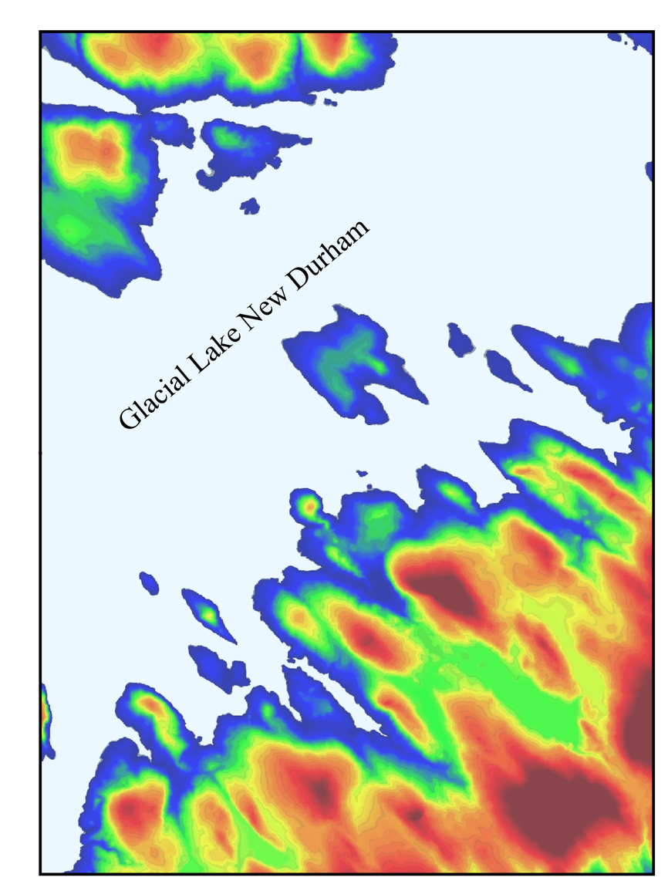
Representative Photographs of the Map Area

Photo 1: Fernald Brook sand to pebble glaciofluvial glaciolacustrine deposit.

Photo 2: Flat topography of the Lake Wentworth Deposit.



Inset 1: Shaded relief Digital Elevation Model (DEM) data showing the southeast trending glacial topographic features within the Wolfeboro Quadrangle.



Inset 2: Color Contoured DEM Data with approximate maximum extent of Glacial Lake New Durham shown in light blue.

Glacial Geology of the Wolfeboro Quadrangle

The surficial geologic map of the Wolfeboro, New Hampshire, 7.5-minute Quadrangle shows the lateral distribution of the unconsolidated surficial materials (e.g. glacial till, sand and gravel) and bedrock exposed at the ground surface. The unconsolidated sediments largely reflect deposition related to the most recent period of continental glaciation (which ended approximately 14,000 years ago), and to a lesser extent, post-glacial deposition along streams and rivers. The advance and retreat of the glacial ice resulted in the deposition of an assortment of surficial deposits and the formation of a variety of landforms.

As the continental glacier advanced through the area, it scoured the paleo-landscape, mobilizing vast quantities of pre-glacial sediment and bedrock fragments. These materials were entrained at the bottom of the glacier, where they were crushed and then re-deposited directly beneath the ice mass as till deposits, which are present as a thin veneer of poorly-sorted sediments over a majority of the Wolfeboro Quadrangle. In some cases, ablation till has been mapped, reflecting areas where deposits came directly off the ice mass, resulting in irregularly-shaped piles of relatively loose, poorly-sorted debris.

In addition, the glacial scouring and re-deposition resulted in the shaping of southeast-trending streamlined hills and till drumlins whose long axes parallel the direction of glacial advance (Inset 1). The direction of glacial movement (approximately 140 degrees east of north) is also indicated by the orientations of striations and grooves on exposed rock surfaces. These features were created by the continental ice sheet as it dragged rock fragments embedded in the ice across the bedrock surface.

As the glacial period ended, the ice sheet began to melt and retreat through the Wolfeboro Quadrangle. Meltwater flowing from and along the surface of the glacier carried much of the sediment that was previously entrained within the advancing glacial ice. The flowing water sorted the sediments such that coarse sediments were deposited close to the glacier, and finer sediments were deposited downstream in fluvial (river) and lacustrine (lake) environments (Photo 1).

The first deposits in the Wolfeboro Quadrangle to form beyond the ice margin were two deltas deposited into Glacial Lake Merrymeeting (Qglm). The sediments forming these glaciofluvial/glaciolacustrine deposits were carried by meltwater channels east and west of Caverly Mountain. The lacustrine (lake) deltas extend into the Alton Quadrangle to the south, where Goldsmith (1995) first mapped them. As the recession of the ice margin continued to the northwest, several small deposits of ice-marginal glaciofluvial sand and gravel (Qgu and Qwb) were deposited. In addition, subglacial deposits (such as crevasse fillings and eskers; Qic) were formed within tunnels in the melting ice mass and remain as steep-sided, narrow piles of coarse-grained debris identified as ice-contact deposits.

Because the retreating ice margin was roughly parallel with the shoreline of Lake Winnipesaukee, the deposition of late-glacial sediments was the result of a complex interplay between the elevation and extent of the ice margin, the shape and elevation of the hills to the southeast of the ice margin, and the flow of water within the ice and along the ice margin. For example, many of the glacial deposits to the southeast of Lake Winnipesaukee formed within temporary lakes that developed between the glacier (the temporary dam) and the northwest-trending valleys (e.g., Qlbb and Qlhb). Ice-dammed water backed up until the lowest spillway available allowed water to drain to the next lowest valley. In some cases, the escaping water carved significant meltwater channels that carried deposits downstream forming alluvial fans (e.g., Qfts).

Many of the lower elevation deposits in the Wolfeboro Quadrangle are graded to the level of Glacial Lake New Durham (present elevation between 560 and 600 feet), a large proglacial lake whose elevation was controlled by a spillway in New Durham, to the south (Goldsmith, 1995). Glacial Lake New Durham dominated much of the Wolfeboro Quadrangle until the ice margin receded north of Belknap Point (to the west, in Gilford), allowing the lake to drain to the Merrimack River drainage. The final extent of glacial Lake New Durham within the Wofleboro Quadrangle is shown in Inset 2.

As the ice front receded further to the northwest across the area of Lake Wentworth, glaciofluvial to glaciolacustrine deposits formed within several valleys, building deltas into several arms of Glacial Lake New Durham (e.g., Qgpb, Qgfb, and Qghr). After the drainage of Glacial Lake New Durham, many of the deposits were stranded at elevations above the level of present day Lake Wentworth (Photo 2). Post-glacial reworking of many of the sediments eroded from the stranded deposits resulted in an extensive lake deposit (Qlw) along the northern shore of Lake Wentworth. The lake deposit is several feet higher than Lake Wentworth, having formed before the lake's outlet eroded to its present elevation.

Following deglaciation, post-glacial fluvial processes have re-worked many of the glacial deposits into stream terraces and alluvium. Wetlands and ponds have formed throughout the irregular glacial landscape and poorly-drained till areas, and within lowlands that were filled with stagnant ice during deposition of the surrounding glacial deposits.

References:

Goldsmith, R., 1995, Surficial Geologic Map of the Alton Quadrangle, Belknap and Strafford Counties, New Hamsphire:New Hampshire Geological Survey Publication Geo-126-024000-SMOF, scale 1:24,000.

Goldthwaite, R.P., 1968, Surficial Geology of the Wolfeboro-Winnipesaukee Area, New Hampshire: 60 p. with illustrations and map. New Hampshire Geological Survey Publication Geo-034-062500-SBSM scale 1:62500

Koteff, C., and Boudette, E.L., 2005, Surficial geologic map of the Sanbornville 7.5 minute quadrangle, Carroll and Strafford Counties, New Hampshire. New Hampshire Geological Survey Publication Geo-114-024000-SMOF, NHGS STATEMAP 2004, scale 1:24,000

Tinkham, D.J. and Brooks, J.A., 2004, Surficial Geologic Map of the West Alton Quadrangle, Belknap & Carroll Counties, New Hampshire. New Hampshire Geological Survey Publication Geo-112-024000-SMOF. NHGS STATEMAP 2003, scale 1:24,000.

Other Sources of Data:

Swamp deposits and boundaries of lakes were modified from NH GRANIT GIS database layers for the National Wetland Inventory (NWI) and surface water, respectively. Well information was obtained from the NHGS Water Well Inventory.

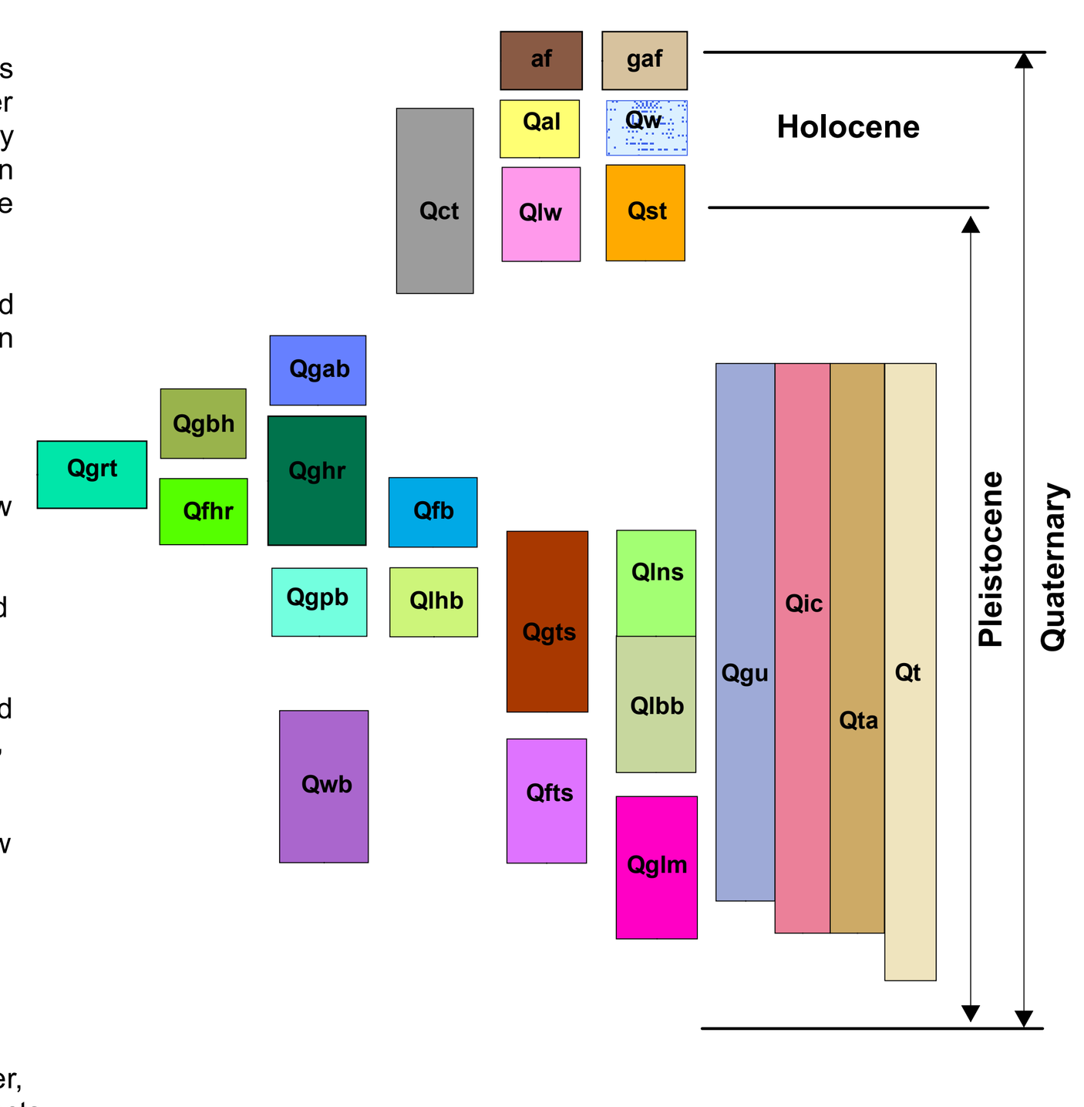
MAP PREPARATION

Surficial mapping completed by John A. Brooks and Daniel J. Tinkham (consulting geologists at Emery & Garrett Groundwater, Inc.) during the 2008 field season. Unit designations and contacts

matched to adjacent quadrangles (Goldsmith, 1995, Koteff and Boudette, 2005, and Tinkham and Brooks, 2004).

Digital map published 2012

Wolfeboro Quadrangle
Surficial Geology Correlation Chart



Surficial Geologic Map of the Wolfeboro Quadrangle Belknap, Carroll, and Strafford Counties, New Hampshire

By John A. Brooks and Daniel J. Tinkham

Surficial Geologic Map GEO-113-024000-SMAP

Digital Compilation By: Emery & Garrett Groundwater, Inc.

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