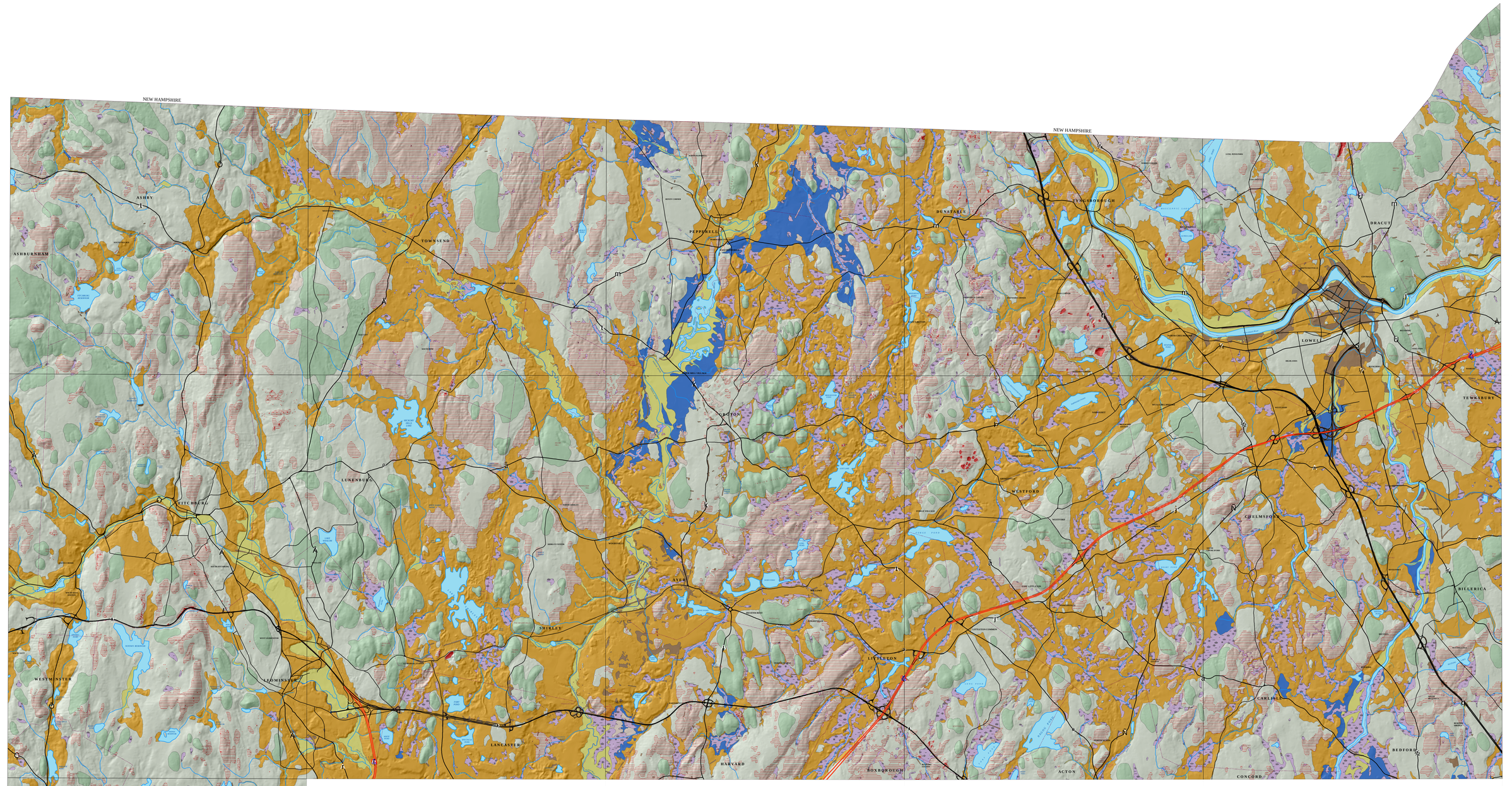
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
COMMONWEALTH OF MASSACHUSETTS
OFFICE OF THE STATE GEOLOGIST
AND EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS

OPEN-FILE REPORT 2006-1260C
Explanatory pamphlet accompanies map



DESCRIPTION OF MAP UNITS

POSTGLACIAL DEPOSITS

Artificial fill—Earth materials and manmade materials that have been artificially emplaced, primarily in highway and railroad embankments, and in dams; may also include landfills, urban development areas, and filled wetlands.

Floodplain alluvium—Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, beneath the floodplains of modern streams. The texture of alluvium commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. Along smaller streams, alluvium is commonly less than 5 ft thick. The most extensive deposits of alluvium on the map are along the Nashua, Squannacook, and Nissitissit Rivers where the texture is predominantly sand, fine gravel, and silt, and total thickness is as much as 25 ft. Alluvium typically overlies thicker glacial stratified deposits.

Swamp deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, stratified and poorly sorted, in kettle depressions or poorly drained areas. Most swamp deposits are less than about 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits.

Early postglacial inland dune deposits—Fine to medium, well-sorted sand, in transverse, parabolic, and hummocky dunes as much as 30 ft thick. Occur most commonly in large glacial lake basins where sand was derived from extensive glacial-lake deltas that were not yet vegetated and deposited in dune forms by early postglacial winds. Dune sand is now fixed by vegetation except where disturbed by human activities.

GLACIAL STRATIFIED DEPOSITS

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in particle size diagram) deposited in layers by glacial meltwater. These sediments occur as four basic textural units—gravel deposits, sand and gravel deposits, sand deposits, and fine deposits. On this interim map, gravel, sand and gravel, and sand deposits are not differentiated and are shown as *Coarse Deposits* where they occur at land surface. *Fine Deposits* also are shown where they occur at land surface. **Textural changes occur both areally and vertically, however subsurface textural variations are not shown on this interim map.**

Coarse deposits include: *Gravel deposits* composed mainly of gravel-sized clasts; cobbles and boulders predominate; minor amounts of sand within gravel beds, and sand comprises few separate layers. Gravel layers generally are poorly sorted and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay.

Glaciolacustrine Fine deposits include very fine sand, silt, and clay that occurs as well-sorted, thin layers of alternating silt and clay, or thicker layers of very fine sand and silt deposited in glacial lakes. Very fine sand commonly occurs at the surface and grades downward into rhythmically bedded silt and clay varves. Locally, this map unit may include areas underlain by fine sand.

GLACIAL TILL DEPOSITS

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; in areas where till is generally less than 10-15 ft thick and including areas of bedrock outcrop where till is absent. Predominantly upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places; a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer-grained lodgement facies deposited subglacially. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarser grained crystalline rocks. Fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut River lowland, marble in the western river valleys, and fine-grained schists in upland areas.

Thick till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders at the surface; in the shallow subsurface, compact, nonsorted matrix of silt, very fine sand, and some clay containing scattered small gravel clasts in areas where till is greater than 10-15 ft thick, chiefly in drumlin landforms in which till thickness commonly exceeds 100 ft (maximum recorded thickness is 230 ft). Although upper till is the surface deposit, the lower till constitutes the bulk of the material in these areas. Lower till is moderately to very compact, and is commonly finer grained and less stony than upper till. An oxidized zone, the lower part of a soil profile formed during a period of interglacial weathering, is generally present in the upper part of the lower till. This zone commonly shows closely spaced joints that are stained with iron and manganese oxides.

BEDROCK AREAS

Bedrock outcrops and areas of abundant outcrop or shallow bedrock— Solid color shows extent of individual bedrock outcrops; line pattern indicates areas of shallow bedrock or areas where small outcrops are too numerous to map individually; in areas of shallow bedrock, surficial materials are less than 5-10 ft thick.

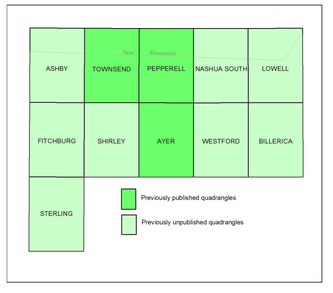
SCALE 1:50,000

1 0.5 0 1 2 3 4 Miles

1 0.5 0 1 2 3 4 Kilometers

PARTICLE DIAMETER										
10	2.5	0.16	0.08	0.04	0.02	0.01	0.005	0.0025	0.00015	in.
256	64	4	2	1	0.5	0.25	0.125	0.063	0.004	mm
Boulders	Cobbles	Pebbles	Granules	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
GRAVEL PARTICLES				SAND PARTICLES				FINE PARTICLES		

Grain-size classification used in this report, modified from Wentworth (1922)



7.5-minute quadrangles in this compilation

SOURCES OF DATA

See explanatory pamphlet for references

Ashby Quadrangle
Stone, B.D., 1982, Unpublished field maps

Townsend Quadrangle
Map units were reproduced from Koteff and Stone (1990). Glacial Stratified Deposits in this quadrangle include deposits of glacial lakes Nashua and Nissitissit and other smaller valley deposits. Thick till areas shown on this map were inferred from photographic-image and topographic analysis, well data, and drumlin symbols shown by Koteff and Stone (1990).

Pepperell Quadrangle
Map units were reproduced from Koteff and Volckmann (1973). Glacial Stratified Deposits in this quadrangle include deposits of glacial lakes Nashua and Nissitissit, and other smaller valley deposits. Fine-grained glacial stratified deposits at land surface include lake-bottom deposits of glacial Lakes Nashua and Nissitissit (units Qnb and Qnlb of Koteff and Volckmann 1973); these units have been extended beneath adjacent water bodies and postglacial deposits on this map. Thick till areas shown on this map were inferred from photographic image and topographic analysis and drumlin symbols shown by Koteff and Volckmann (1973).

Nashua South Quadrangle
Unknown compiler, 1980-82, Unpublished field maps

Lowell Quadrangle
Unknown compiler, 1980-82, Unpublished field maps

Fitchburg Quadrangle
Stone, B.D., 1982, Unpublished field maps

Shirley Quadrangle
Primary source of map units was Stone, B.D., 1982, Unpublished field maps; minor contributions from Allmendinger and Schneider (1975).

Ayer Quadrangle
Map units were reproduced from Jahns (1953). Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Nashua and other smaller valley deposits. Fine-grained glacial stratified deposits at land surface include lake-bottom deposits of glacial Lake Nashua (unit Qnl of Jahns, 1953); these units have been extended beneath adjacent water bodies and postglacial deposits on this map. Drumlin till unit was reproduced from the published map; other areas of thick till were inferred from photographic-image and topographic analysis.

Westford Quadrangle
Unknown compiler, 1980-82, Unpublished field maps

Billerica Quadrangle
Map units reproduced from Holland, W.R. (1980).

Sterling Quadrangle
Stone, B.D., 1982, Unpublished field maps

SURFICIAL GEOLOGIC MAP OF THE ASHBY-LOWELL-STERLING-BILLERICA 11-QUADRANGLE AREA IN NORTHEAST-CENTRAL MASSACHUSETTS

Compiled by Byron D. Stone and Janet R. Stone
2007

All base map data from MassGIS:
1:5,000-scale Shaded Relief
1:100,000-scale Hydrography
1:5,000-scale EOT Major Roads
1:25,000-scale Digital Quadrangle Template
1:25,000-scale Community Boundaries (Towns)
1:24,000-scale Geographic Place Names

Geology mapped by authors of individual quadrangles, 1953-1990.
Geology compiled by Byron D. Stone and Janet R. Stone, 2004-2007.
Vectorization of published quadrangles by the Office of the Massachusetts State Geologist, 2003.
Digital compilation and cartography by Mary L. DiGiacomo-Cohen, 2006-2007.