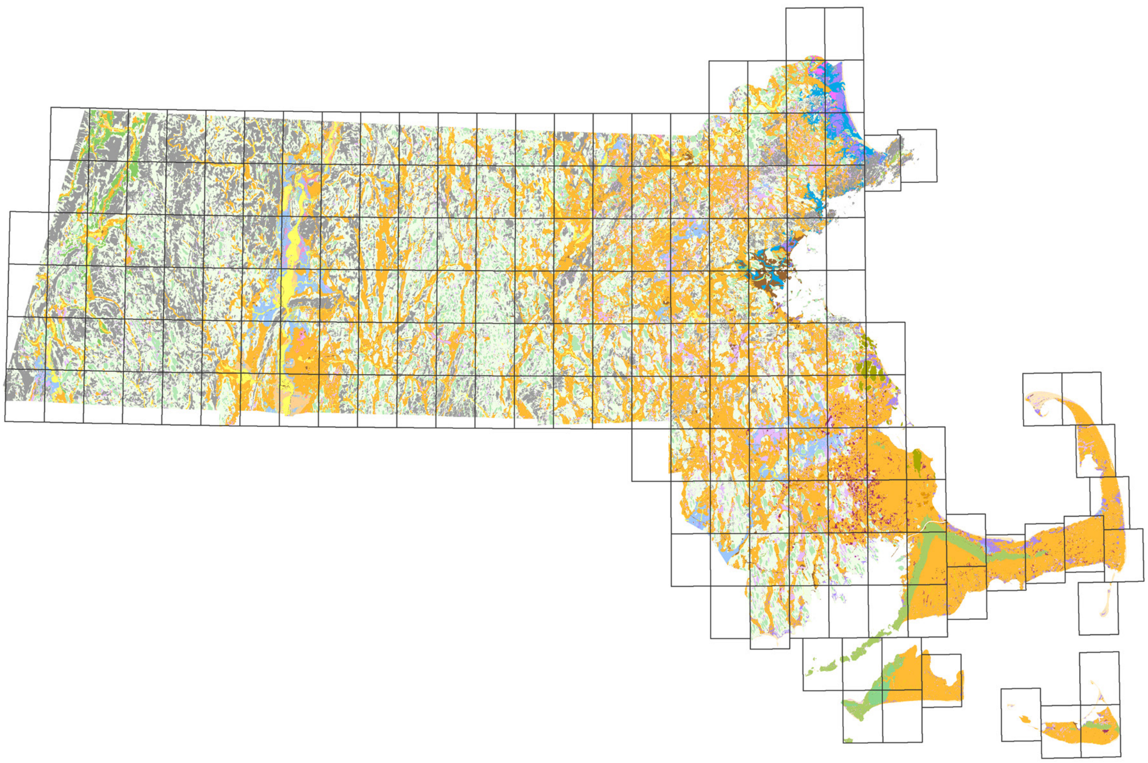
Prepared in cooperation with the Commonwealth of Massachusetts,
Massachusetts Geological Survey and Executive Office for Administration and Finance

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database



Pamphlet to accompany

Scientific Investigations Map 3402

Supersedes USGS Open-File Reports 2006–1260–A, –B, –C, –D, –E, –F, –G, and –I

U.S. Department of the Interior
U.S. Geological Survey

Cover. Map showing distribution of surficial materials in Massachusetts and the 7.5-minute quadrangle grid.

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database

Compiled by Janet Radway Stone, Byron D. Stone, Mary L. DiGiacomo-Cohen, and Stephen B. Mabee

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
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Contents

Map files

[Available for downloading at https://doi.org/10.3133/sim3402.]

Figures

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database

Compiled by Janet Radway Stone,[1] Byron D. Stone,[1] Mary L. DiGiacomo-Cohen,[1] and Stephen B. Mabee[2]

Introduction

The surficial geologic map database defines the distribution of nonlithified earth materials at the land surface in the 189 7.5-minute, 1:24,000-scale quadrangles that cover the Commonwealth of Massachusetts (index map), an area of approximately 10,554 square miles (mi^2). Across Massachusetts, these materials range in thickness from a few feet to more than 500 feet (ft). In some places, surficial materials are absent where bedrock is at the land surface. The geologic map database differentiates surficial materials of Quaternary age on the basis of their lithologic characteristics (such as grain size and sedimentary structures), constructional geomorphic features, stratigraphic relationships, and age. Surficial materials also are known in engineering classifications as unconsolidated soils, which include coarse-grained soils, fine-grained soils, and organic fine-grained soils. Surficial materials underlie and are the parent materials of modern pedogenic soils, which have developed in the surficial materials at the land surface. Surficial earth materials significantly affect human use of the land, and an accurate description of their distribution is particularly important for assessing water resources, construction-aggregate resources, and earth-surface hazards, and for making land-use decisions.

The mapped distribution of surficial materials that lie between the land surface and the bedrock surface is based on detailed geologic mapping of 7.5-minute topographic quadrangles, produced as part of an earlier (1938–1982) cooperative statewide mapping program between the U.S. Geological Survey (USGS) and the Massachusetts Department of Public Works (now Massachusetts Department of Transportation) (Page, 1967; Stone, 1982). Each of the 105 published geologic quadrangle maps presents a detailed description of local geologic map units, discusses the genesis of the deposits, and gives age correlations among units. Previously unpublished field compilation maps exist on paper or mylar sheets for 84 quadrangles, and these have been digitally rendered for the present map compilation. Regional summaries based on the Massachusetts surficial geologic mapping studies discuss the ages of multiple glaciations, the nature of glaciofluvial, glaciolacustrine, and glaciomarine deposits, and the processes of ice advance and retreat across Massachusetts (Koteff and Pessl, 1981; papers in Larson and Stone, 1982; Oldale and Barlow, 1986; Stone and Borns, 1986; Warren and Stone, 1986).

This compilation of surficial geologic materials defines the areas of exposed bedrock and the boundaries between glacial till, glacial stratified deposits, and overlying postglacial deposits at a 1:24,000-scale level of accuracy. The surficial geologic map database covering 189 quadrangles revises previous digital surficial geologic maps (Stone and others, 1993; MassGIS, 1999) that were compiled on base maps at regional scales of 1:125,000 and 1:250,000. The purpose of this study is to provide fundamental geologic data for the evaluation of natural resources, hazards, and land information within the Commonwealth of Massachusetts.

Surficial Materials in Massachusetts

Most of the surficial materials in Massachusetts (index map) are deposits of the last two continental ice sheets that covered all of New England in the latter part of the Pleistocene ice age (Schafer and Hartshorn, 1965; Oldale and others, 1982; Stone and Borns, 1986). The glacial deposits are divided into two broad categories, ***glacial till and moraine deposits*** and ***glacial stratified deposits***. Till, the most widespread glacial deposit, was laid down directly by glacier ice. Glacial stratified deposits are concentrated in valleys and lowland areas and were laid down by glacial meltwater in streams, lakes, and the sea in front of the retreating ice margin during the last deglaciation. ***Postglacial deposits***, primarily flood-plain alluvium and swamp deposits, make up a lesser proportion of the unconsolidated materials.

The bedrock surface in Massachusetts generally consists of relatively fresh, unweathered bedrock, but in some places such as in the Housatonic Valley (fig. 1) in the western part of the Commonwealth, there is a locally thick saprolitic cover.

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[1]U.S. Geological Survey.

[2]Massachusetts Geological Survey.

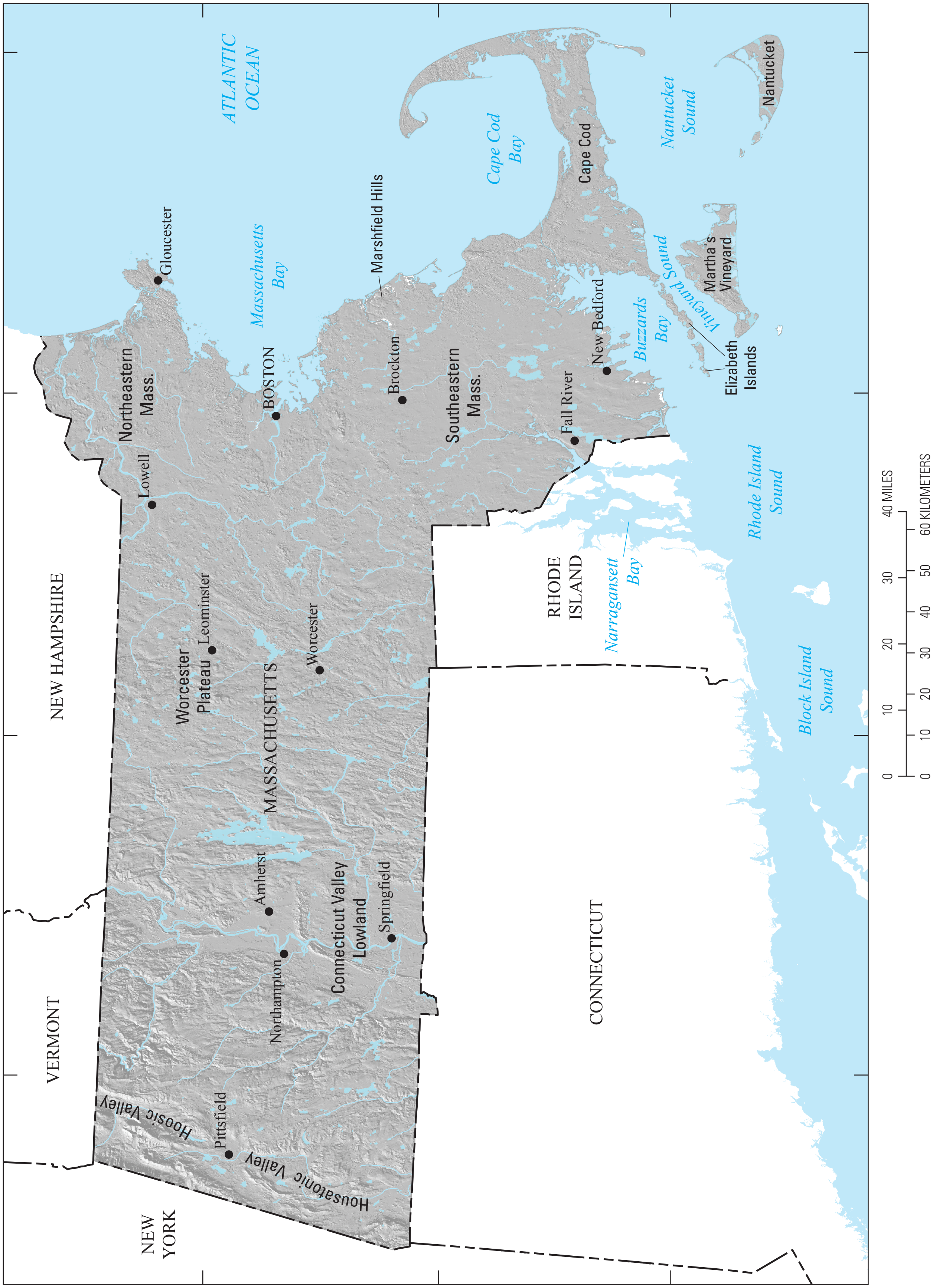

Figure 1A. Shaded-relief map of Massachusetts showing major cities, selected physiographic regions, and other cited features. Shaded relief is from Massachusetts Bureau of Geographic Information (MassGIS).

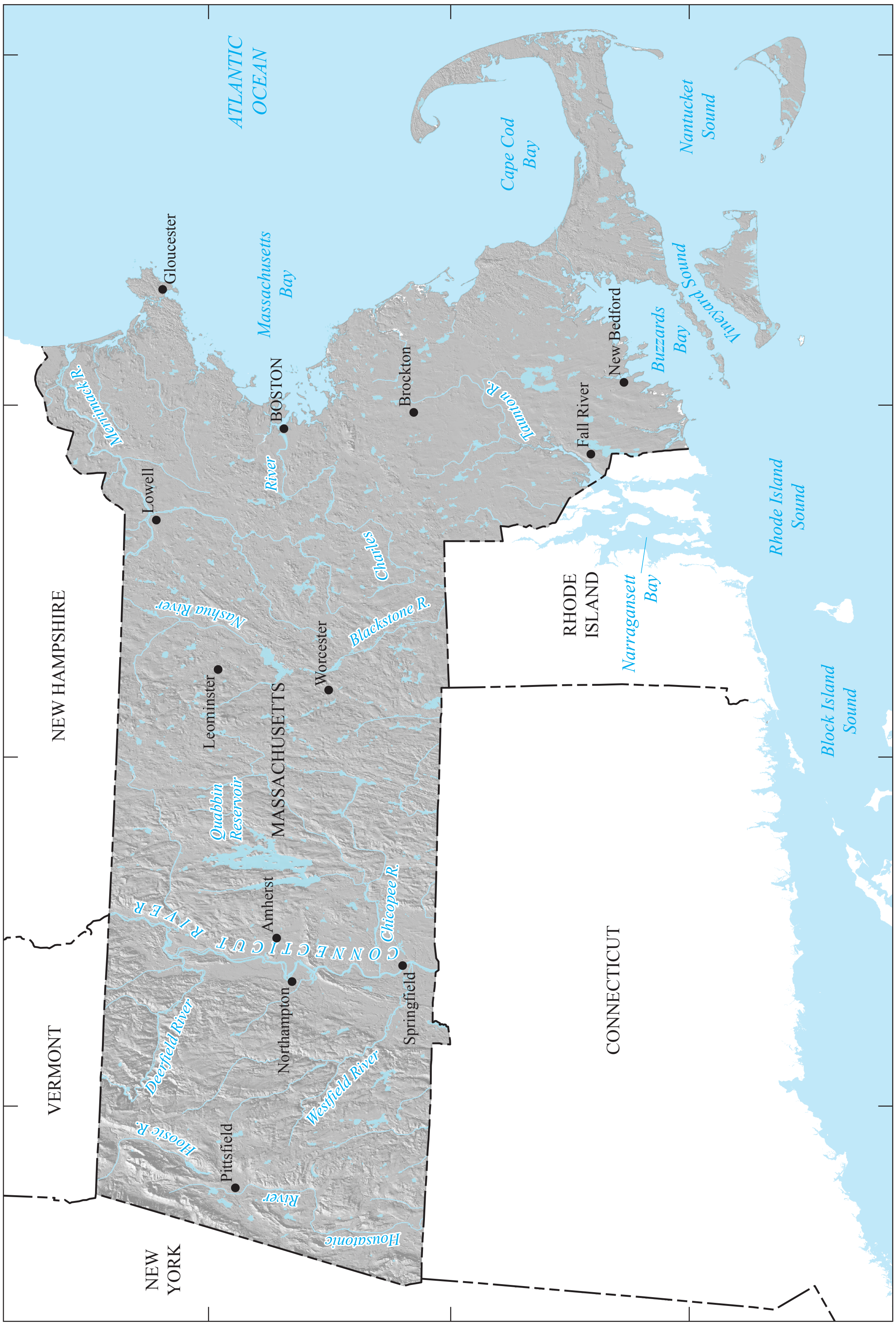

Figure 1B. Shaded-relief map of Massachusetts showing major rivers and major cities. Shaded relief is from Massachusetts Bureau of Geographic Information (MassGIS).

Glacial Till and Moraine Deposits

Glacial till deposits consist of nonsorted, generally nonstratified mixtures of mineral and rock particles ranging in grain size from clay to large boulders. The matrix of most tills is composed dominantly of fine sand and silt. Boulders, within and on the surface of tills, range from sparse to abundant. Some tills contain lenses of sorted sand and gravel, and less commonly, masses of laminated fine-grained sediments. The color and lithologic characteristics of till deposits vary across Massachusetts but generally reflect the composition of the local underlying and northerly adjacent bedrock, from which the till was derived (figs. 2, 3). Till blankets the bedrock surface in variable thickness, ranging from a few inches to more than 200 ft, and commonly underlies stratified meltwater deposits. Tills deposited during the last two glaciations occur in superposition within Massachusetts (Koteff, 1966; Newton, 1978; Weddle and others, 1989). The upper, younger till was deposited during the last (late Wisconsinan) glaciation; it is the most extensive till and commonly is observed in surface exposures, especially in areas where till thickness is less than 10 to 15 ft (thin-till unit). The lower, older till ("old" till) was deposited during an earlier glaciation (probably Illinoian). The lower till has a more limited distribution; it is principally a subsurface deposit that constitutes the bulk of material in drumlins and other hills, where till thickness is greater than 15 ft. On eastern Nantucket Island, sandy and bouldery upper till at the surface overlies glacial stratified deposits and marine beds of Sangamon age that overlie till of probable Illinoian age (Oldale and others, 1982), which is correlated with the lower till on the mainland. The distribution of lower till is shown primarily by the thick-till unit. The lower till generally is overlain by a thin mantle of upper till in these areas. In all exposures showing the superposed two tills, the base of the upper till truncates the weathered surface of the lower till. The lower part of the upper till commonly displays a zone of shearing, dislocation, and brecciation in which clasts of lower till were mixed and incorporated into the upper till during the last glaciation.

Figure 2. Exposure of red till derived from Mesozoic sedimentary rocks of the Connecticut Valley lowland, in the West Springfield quadrangle. Field of view is approximately 3 feet wide.

Figure 3. Exposure of gray till derived from metamorphic rocks in the Haverhill quadrangle. Note iron- and manganese-stained joints typical of lower, older till commonly found in the cores of drumlins. Shovel handle is 18 inches long.

Thin-till deposits of late Wisconsinan age are shown on the basal, subsurface layer of this database where drill-hole data indicate the nearly ubiquitous presence of compact, sandy till that lies directly on bedrock or, in southeastern Massachusetts, on Tertiary coastal-plain strata or early Pleistocene deposits.

End moraine deposits occur predominantly in southeastern Massachusetts and are composed mostly of bouldery ablation till (fig. 4), but locally may include sorted sediments especially at depth beneath the till. These deposits were laid down by glacial-melting and thrusting processes along active ice margins during retreat of the last (late Wisconsinan) ice sheet. End moraine deposits are composed of a surface layer, 6 to 30 ft thick, of sandy and bouldery ablation till, local compact sandy till, or a layered, sandy and bouldery sediment of probable debris-flow origin; these materials commonly overlie coarse stratified deposits. Sedimentary units in all the moraines have limited lateral extent and irregular thickness; stratification is deformed by collapse structures around kettle depressions and by glaciotectonic folds and thrust faults in some deposits. The Buzzard's Bay moraine in western Cape Cod and the Elizabeth Islands and the moraine along the north coast of Martha's Vineyard are largely ice-collapse ridges that overlie thick subsurface deposits of sorted and layered meltwater sediments, mainly sand and fine gravel and minor silt and clay, as reported in drill-hole descriptions. The Sandwich moraine in northern Cape Cod, and moraines in western Martha's Vineyard and Nantucket, are thrust moraine

Figure 4. Ablation till matrix surrounding numerous large boulders in the Dogtown moraine, Gloucester quadrangle. Boulder in left foreground is about 4 feet across.

Figure 5. Gravel deposit containing some sand beds in fluvial meltwater terrace sediments in the Woronoco quadrangle. Gravel clasts are derived predominantly from metamorphic rocks in the western uplands.

deposits that overlie glacially deformed older meltwater and marine deposits, mostly sand and gravel (Oldale and O'Hara, 1984). The Gay Head moraine on western Martha's Vineyard includes ice-thrusted beds of Tertiary fossiliferous sand, gravel, and silty clay deposits, and Pleistocene sand and silty clay beds (Shaler, 1898; Woodworth and Wigglesworth, 1934; Kaye, 1964). The extensive end moraines on Nantucket and Martha's Vineyard (index map) are related to the terminal position of the late Wisconsinan ice sheet; the end moraines on Cape Cod were formed along recessional positions. Less extensive end moraines are present locally elsewhere in southeastern Massachusetts, in the Boston area, and in the Gloucester-Rockport area of northeastern Massachusetts (index map).

Glacial Stratified Deposits

Glacial stratified deposits consist of layers of well-sorted to poorly sorted gravel, sand, silt, and clay laid down by flowing meltwater in glacial streams, lakes, and marine embayments that occupied the valleys and lowlands of Massachusetts during retreat of the last ice sheet. Textural variations within the meltwater deposits occur both areally and vertically because meltwater-flow regimes were different in glaciofluvial (stream), glaciodeltaic (where a stream entered a lake or the sea), glaciolacustrine (lake bottom), and glaciomarine (marine bottom) depositional environments. Grain-size variations also resulted from meltwater deposition in positions either proximal to, or distal from, the retreating glacier margin, which was the principal sediment source. A common depositional setting contained a proximal, ice-marginal meltwater stream in which horizontally bedded glaciofluvial gravel and (or) sand and gravel were laid down (fig. 5); farther down valley, the stream entered a glacial lake where glaciodeltaic sediments were deposited, consisting of horizontally layered sand and gravel delta-topset beds overlying inclined layers of sand in delta-foreset beds. Farther out in the glacial lake, very fine sand, silt, and clay settled out on the lake bottom in flat-lying, thinly bedded glaciolacustrine layers (figs. 6, 7). Thick sequences having these textural variations commonly are present in the vertical section of meltwater deposits across the region (Stone, J.R., and others, 1992).

Most of the meltwater sediments in Massachusetts were deposited in or graded to large and small glacial lakes. These large and small lakes formed in north-sloping valleys and basins where they were dammed by the ice margin

Figure 6. Sand deposit of delta bottomset beds containing cross-bedded sands interbedded with layers of very fine sand and silt, in the Southwick quadrangle. Reddish color of the sand is due to its derivation from Mesozoic rocks of the Connecticut Valley lowland.

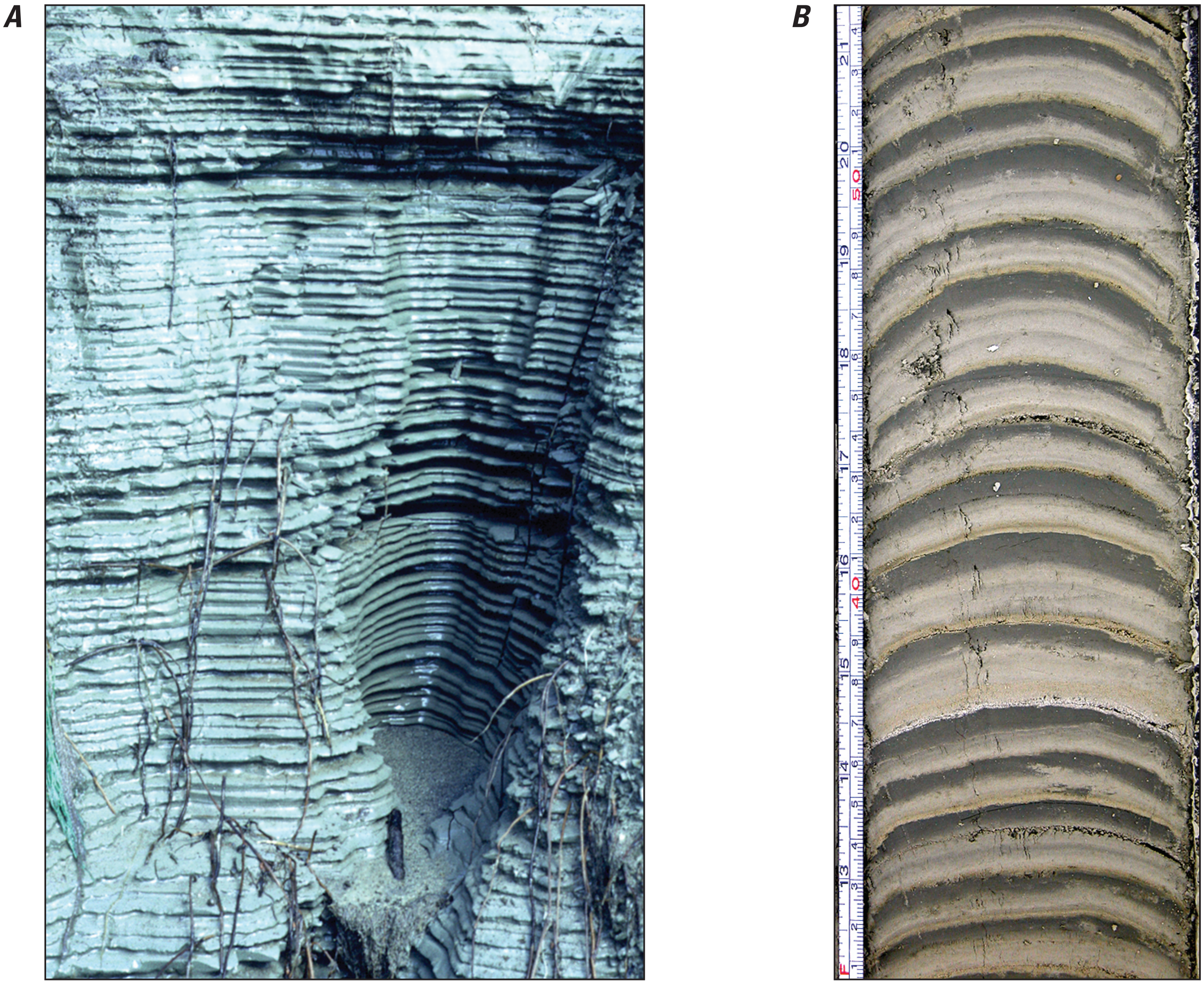

Figure 7. Varved silt and clay deposits (*A*, in outcrop; *B*, in core) deposited in glacial Lake Hitchcock in the Connecticut Valley lowland. Scale beside the core is in inches and centimeters; varves in both images are of similar thickness.

(ice-dammed lakes) and in south-sloping valleys and basins where they were dammed by slightly older deltaic sediments (sediment-dammed lakes). The largest glacial lake in Massachusetts was an extensive sediment-dammed lake (glacial Lake Hitchcock), which occupied the Connecticut Valley lowland at altitudes below 365 ft during the retreat of the last ice sheet. Glacial Lake Hitchcock was dammed behind a mass of older deltaic sediments in the Rocky Hill-Glastonbury area of central Connecticut, and the lake lengthened northward into northern Vermont and New Hampshire as the ice sheet retreated. In southeastern Massachusetts, an extensive sediment-dammed lake, glacial Lake Narragansett, expanded during ice retreat from the Narragansett Bay region of Rhode Island (Boothroyd, 2003; Boothroyd and August, 2008) into the coastal valleys of Block Island Sound and the Taunton River drainage basin in southeastern Massachusetts. Other large glacial lakes include glacial Lake Charles and glacial Lake Concord in the east-cental part of the State, and glacial Lake Bascom in the north-draining Hoosic Valley in the northwestern part of the State.

Detailed surficial geologic maps can show meltwater sedimentary units within each glacial lake or valley outwash system (Jahns, 1941, 1953; Koteff, 1966). These units, known as *morphosequences* (Koteff, 1974; Koteff and Pessl, 1981), are the smallest mappable stratigraphic units depictable on detailed geologic maps. Morphosequences are bodies of stratified meltwater sediments that are contained in a continuum of landforms, grading from ice-contact forms (eskers, kames) to non-ice-contact forms (flat valley terraces, delta plains) that were deposited simultaneously at and beyond the margin of the ice sheet, and were graded to a specific base level. Each morphosequence consists of a proximal part (head) deposited within or near the ice margin and a distal part deposited farther away from the ice margin. Both grain size and ice-melt collapse deformation of beds decrease from the proximal to the distal part of each morphosequence. The head of each morphosequence is either ice marginal (ice contact) or near ice marginal. The surface altitude of fluvial sediments in each morphosequence was controlled by a specific base level, either a glacial-lake or marine water plane or a valley knickpoint. Few morphosequences extend distally more than 6 mi, and most are less than 1 mi in length. The most extensive morphosequences in Massachusetts are the glaciodeltaic outwash plains of Cape Cod, Nantucket, and Martha's Vineyard. For example, the Harwich outwash plain in southern Cape Cod contains coarse fluvial topset deposits and sandy foreset beds, which overlie silt and clay bottomset lacustrine beds at depth (Cotton and Koteff, 1962).

In any one basin, individual morphosequences were deposited sequentially as the ice margin retreated systematically northward. Consequently, in many places the distal, finer grained facies of a younger morphosequence stratigraphically overlies the proximal, coarse-grained facies of a preceding morphosequence.

Figure 8 shows an example of the variability of sediment types in the subsurface of glacial stratified deposits. The figure shows schematically the relationship between coarse-grained deltaic deposits (sand and gravel, and sand) and extensive fine-grained lake (or marine) deposits (fine and very fine sand, silt, and clay) in the subsurface. Such coarse- and fine-grained units are common in most of the valleys and lowlands of Massachusetts (Langer, 1979; Stone and others, 1979; Stone, J.R., and others, 1992; Stone and others, 2005). On these maps, coarse-grained and fine-grained textural variations within glacial stratified deposits are shown only where they occur at the land surface. Subsurface textural variations are not shown.

The areal distribution of till and stratified deposits is related to the physiography of Massachusetts (fig. 1). The thickness of these materials varies considerably within the physiographic regions because of such factors as the high relief of the bedrock surface, changing environments of deposition during deglaciation, and various effects of postglacial erosion and removal of glacial sediments (fig. 9). In highland areas, notably in the western and central parts of the State, till is the major surficial material and is present as a discontinuous mantle of variable thickness over the bedrock surface. Till is thickest in drumlins (reportedly as much as 230 ft thick) and on the northwest slopes of most bedrock hills. Glacial meltwater deposits that average 50 ft in thickness (Stone and others, 1993) overlie the till in small upland valleys and north-sloping basins between bedrock hills. Glacial stratified deposits are the predominant surficial materials in the Connecticut Valley lowland, in lowlands in northeastern and southeastern Massachusetts, and on Cape Cod and the islands. These deposits generally overlie till; however, well logs indicate that in some places till is not present and the stratified deposits lie directly on bedrock. On Cape Cod and the islands, in much of the lowland in southeastern Massachusetts, and in parts of the Connecticut Valley lowland, these deposits completely cover the till-draped bedrock surface.

Postglacial Deposits

Postglacial deposits locally overlie the glacial deposits throughout the State. In some areas, early postglacial deposits, such as stream-terrace deposits and inland-dune deposits in the Connecticut Valley and marine regressive deposits in the northeastern part of the State, have been mapped. Over the entire area, alluvium underlies the flood plains of most streams and rivers. Swamp deposits occur in low-lying, poorly drained areas in upland and lowland settings, but are shown only where they are estimated to be at least 3 ft thick. Salt-marsh and estuarine deposits are present mainly along the tidal portions of streams and rivers entering the offshore areas. Beach and dune deposits occur along the shoreline.

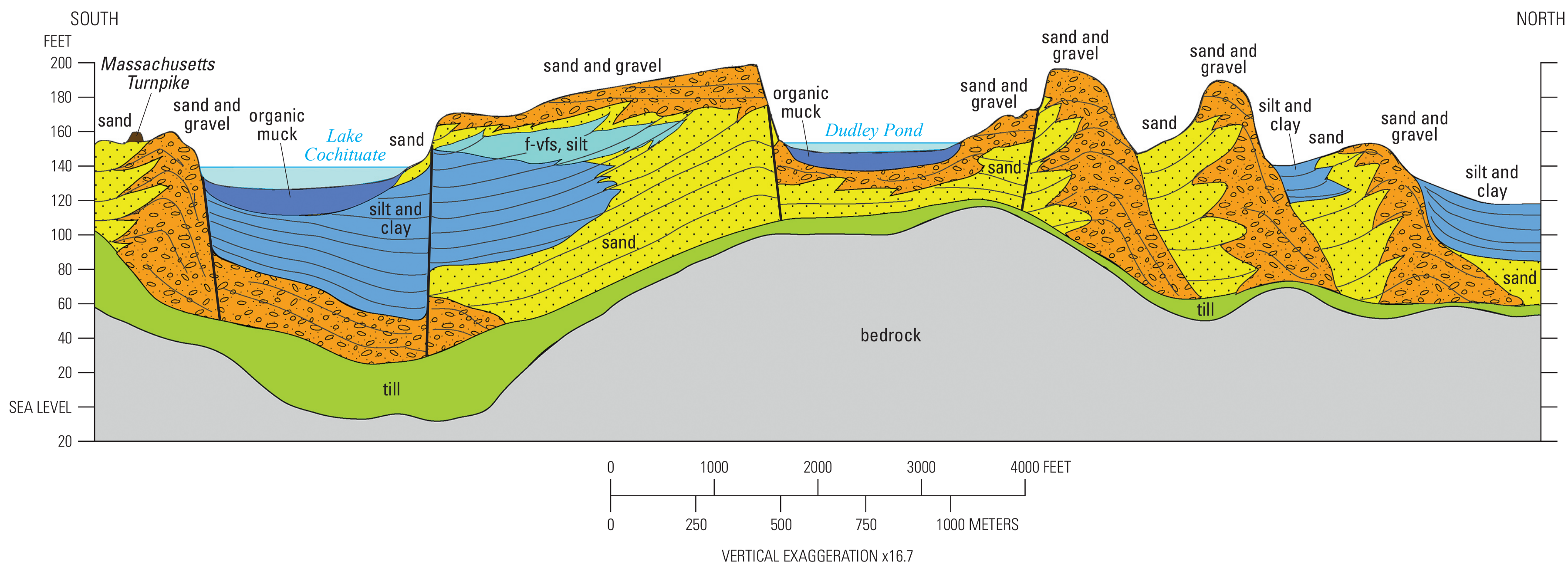

Figure 8. South-to-north cross section showing typical distribution of surficial materials in most valleys in Massachusetts, resulting from sequential morphosequence deposition by a northward-retreating ice sheet. Faults and collapse of sedimentary beds were caused by the melting of buried blocks of ice. Modified from Eggleston and others (2012, fig. 6). Abbreviation: f-vfs, fine to very fine sand.

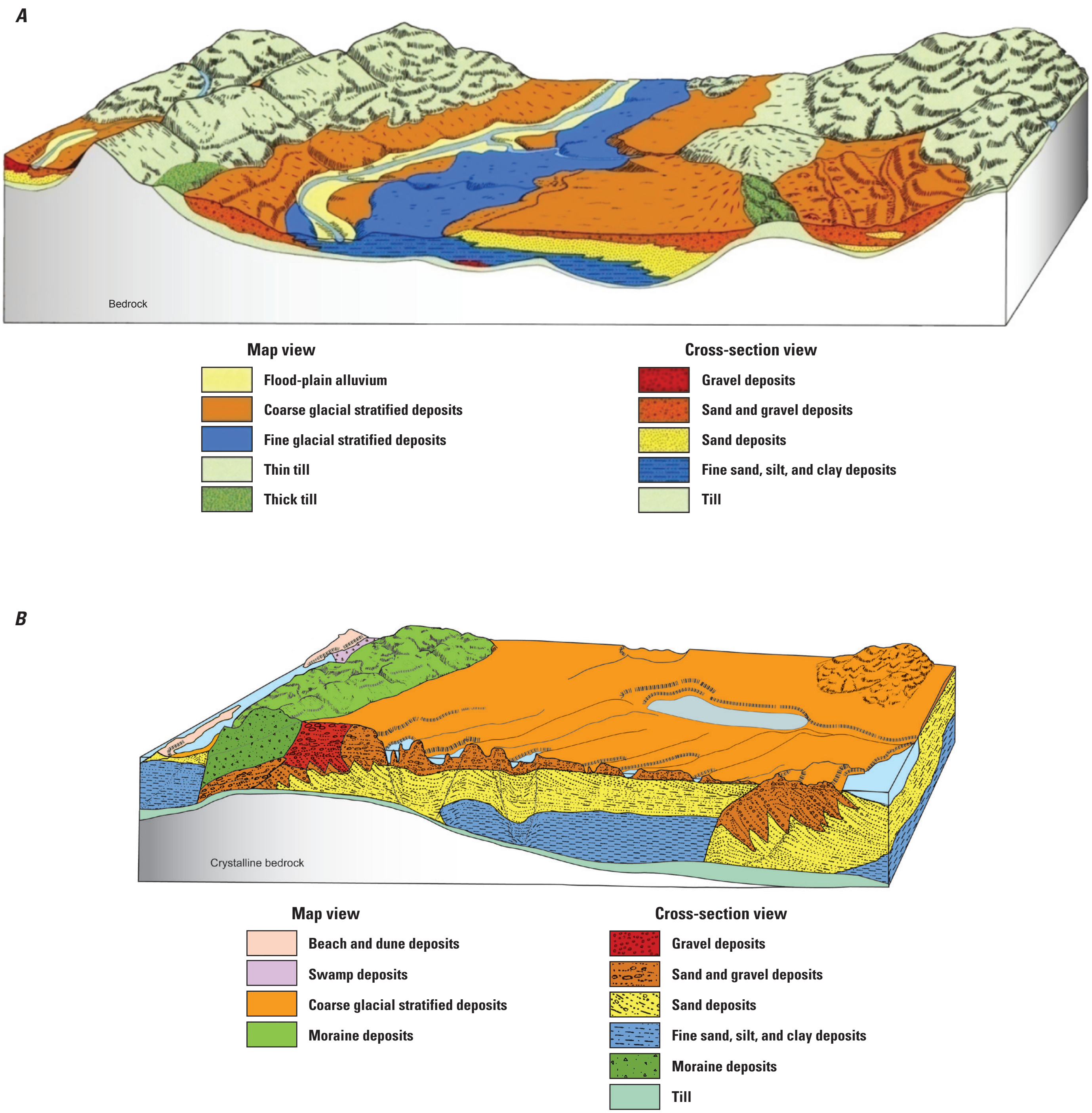

Figure 9. Block diagrams illustrating the typical areal (map view) and vertical (cross-section view) distribution of glacial and postglacial deposits overlying bedrock. *A*, in the Connecticut River valley (modified from Stone, J.R., and others, 1992). *B*, in the Cape Cod and islands region (modified from Strahler, 1966; Oldale, 1975a; and Masterson and others, 1997).

Map Compilation for Surficial Materials Quadrangle Maps

This geologic map database shows surficial materials in the 189 7.5-minute quadrangles in Massachusetts (fig. 10).

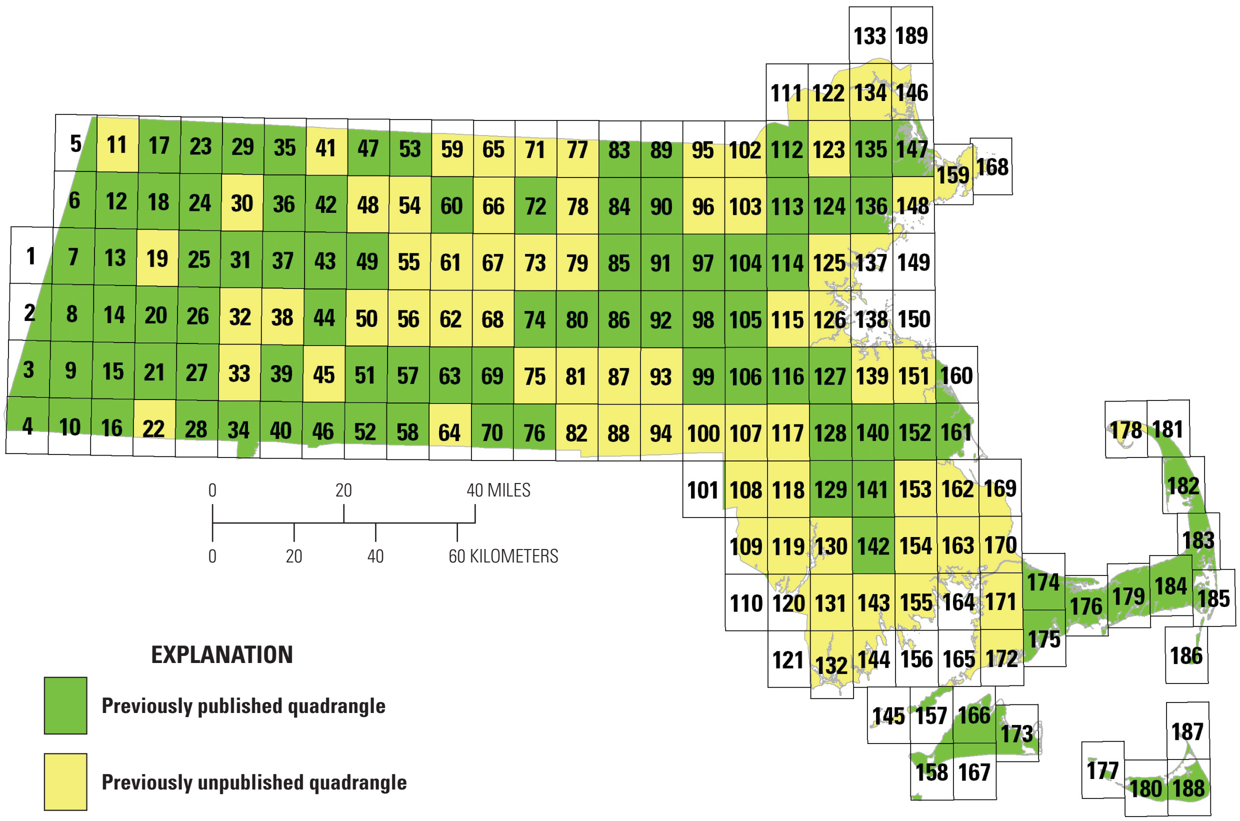

Figure 10. Index map of 7.5-minute, 1:24,000-scale quadrangles in Massachusetts. Quadrangle names and numbers are listed below:

1	Canaan	21	Otis
2	State Line	22	Tolland Center
3	Egremont	23	Rowe
4	Bashbish Falls	24	Plainfield
5	Berlin	25	Worthington
6	Hancock	26	Chester
7	Pittsfield West	27	Blandford
8	Stockbridge	28	West Granville
9	Great Barrington	29	Heath
10	Ashley Falls	30	Ashfield
11	Williamstown	31	Goshen
12	Cheshire	32	Westhampton
13	Pittsfield East	33	Woronoco
14	East Lee	34	Southwick
15	Monterey	35	Colrain
16	South Sandisfield	36	Shelburne Falls
17	North Adams	37	Williamsburg
18	Windsor	38	Easthampton
19	Peru	39	Mount Tom
20	Becket	40	West Springfield

Quadrangle names and numbers shown in figure 10—Continued

41	Bernardston
42	Greenfield
43	Mount Toby
44	Mount Holyoke
45	Springfield North
46	Springfield South
47	Northfield
48	Millers Falls
49	Shutesbury
50	Belchertown
51	Ludlow
52	Hampden
53	Mount Grace
54	Orange
55	Quabbin Reservoir
56	Winsor Dam
57	Palmer
58	Monson
59	Royalston
60	Athol
61	Petersham
62	Ware
63	Warren
64	Wales
65	Winchendon
66	Templeton
67	Barre
68	North Brookfield
69	East Brookfield
70	Southbridge
71	Ashburnham
72	Gardner
73	Wachusett Mountain
74	Paxton
75	Leicester
76	Webster
77	Ashby
78	Fitchburg
79	Sterling
80	Worcester North
81	Worcester South
82	Oxford
83	Townsend
84	Shirley
85	Clinton
86	Shrewsbury
87	Grafton
88	Uxbridge
89	Pepperell
90	Ayer
91	Hudson
92	Marlborough
93	Milford
94	Blackstone
95	Nashua South
96	Westford
97	Maynard
98	Framingham
99	Holliston
100	Franklin
101	Pawtucket
102	Lowell
103	Billerica
104	Concord
105	Natick
106	Medfield
107	Wrentham
108	Attleboro
109	East Providence
110	Bristol
111	Salem Depot
112	Lawrence
113	Wilmington
114	Lexington
115	Newton
116	Norwood
117	Mansfield
118	Norton
119	Somerset
120	Fall River
121	Tiverton
122	Haverhill
123	South Groveland
124	Reading
125	Boston North
126	Boston South
127	Blue Hills
128	Brockton
129	Taunton
130	Assonet
131	Fall River East
132	Westport
133	Exeter
134	Newburyport West
135	Georgetown
136	Salem
137	Lynn
138	Hull
139	Weymouth
140	Whitman

Quadrangle names and numbers shown in figure 10—Continued

141	Bridgewater
142	Assawompset Pond
143	New Bedford North
144	New Bedford South
145	Cuttyhunk
146	Newburyport East
147	Ipswich
148	Marblehead North
149	Marblehead South
150	Nantasket Beach
151	Cohasset
152	Hanover
153	Plympton
154	Snipatuit Pond
155	Marion
156	Sconticut Neck
157	Naushon Island
158	Squibnocket
159	Gloucester
160	Scituate
161	Duxbury
162	Plymouth
163	Wareham
164	Onset
165	Woods Hole
166	Vineyard Haven
167	Tisbury Great Pond
168	Rockport
169	Manomet
170	Sagamore
171	Pocasset
172	Falmouth
173	Edgartown
174	Sandwich
175	Cotuit
176	Hyannis
177	Tuckernuck Island
178	Provincetown
179	Dennis
180	Nantucket
181	North Truro
182	Wellfleet
183	Orleans
184	Harwich
185	Chatham
186	Monomoy Point
187	Great Point
188	Siasconset
189	Hampton

The statewide surficial geologic map was compiled in several steps:

1. Paper copies of the previously published surficial geologic maps for 105 quadrangles were scanned and georeferenced by the Massachusetts Bureau of Geographic Information (MassGIS).

2. The Office of the Massachusetts State Geologist (now the Massachusetts Geological Survey) vectorized the georeferenced images in order to digitally retain the original linework of the published maps (Mabee and others, 2004).

3. Digital geologic map units were compiled and grouped into basic units in four shapefiles, listed as follows:

    a. *Postglacial deposits* including artificial fill, cranberry bog deposits, flood-plain alluvium, swamp deposits, salt-marsh and estuarine deposits, and beach and dune deposits;

    b. *Early postglacial deposits* including alluvial-fan deposits, valley-floor fluvial deposits, stream-terrace deposits, marine regressive deposits, inland-dune deposits, and talus deposits;

    c. *Glacial stratified deposits* including coarse deposits, fine deposits, glaciomarine fine deposits, and stagnant-ice deposits;

    d. *Glacial till and bedrock* including end moraine deposits, thrust moraine deposits, thin-till deposits, thick-till deposits (drumlins), and bedrock outcrops, including areas of shallow bedrock. The distribution of glacial stratified deposits beneath adjacent overlying postglacial deposits and water bodies was inferred by the compilers.

4. The same basic units as those listed in step 3 above were compiled and digitized for 84 unpublished quadrangles from scanned field maps by USGS personnel.

5. The 189 individual quadrangle maps were joined and edge-matched in order to form a seamless digital geologic map layer. Discrepancies along quadrangle boundaries were resolved, and thick-till areas, glacially modified coastal-plain hill deposits, thick valley till and fine deposits, and shallow-bedrock areas were added by the compilers in quadrangles where these units had not been previously mapped.

6. Shapefiles, base maps, and source information were compiled into a geodatabase format.

All geologic mapping was completed at 1:24,000 scale (several quadrangles were previously published at 1:31,680 scale). The 1:24,000-scale topographic base maps (1944–1977 editions) used for this mapping effort, which nearly all have a 10-ft contour interval, are included as part of the digital data package in the BaseMaps folder. The geodatabase included with this report contains MapUnitPolys, MapUnitOverlayPolys, and OverlayPolys, which show the distribution of geologic units that cover the entire map area and are intended for use at quadrangle scale (1:24,000). These data layers can be clipped by quadrangle or by town boundary. Unlike the units in conventional geologic maps, the digitally defined MapUnitOverlayPolys are arranged in order according to superposition. The polygons for till and bedrock are on the bottom and are overlain by the succeeding stratified deposits; these materials are shown everywhere they occur, including beneath postglacial deposits such as swamp deposits, and also beneath water bodies. The postglacial deposits are on top because these materials overlie the other, older deposits. Instructions for using the digital files are included in the README file and in the metadata in the geodatabase (see links at https://doi.org/10.3133/sim3402). Figure 11 illustrates the stacking of geologic units in a portion of the Mount Toby quadrangle (no. 43).

In addition to the seamless digital layers that cover the entire compilation area, Adobe PDF map files of the surficial geology layers shown with 1:24,000-scale topographic base-map images have been generated for each quadrangle (see maps of quadrangles 1–189, indexed in figure 10).

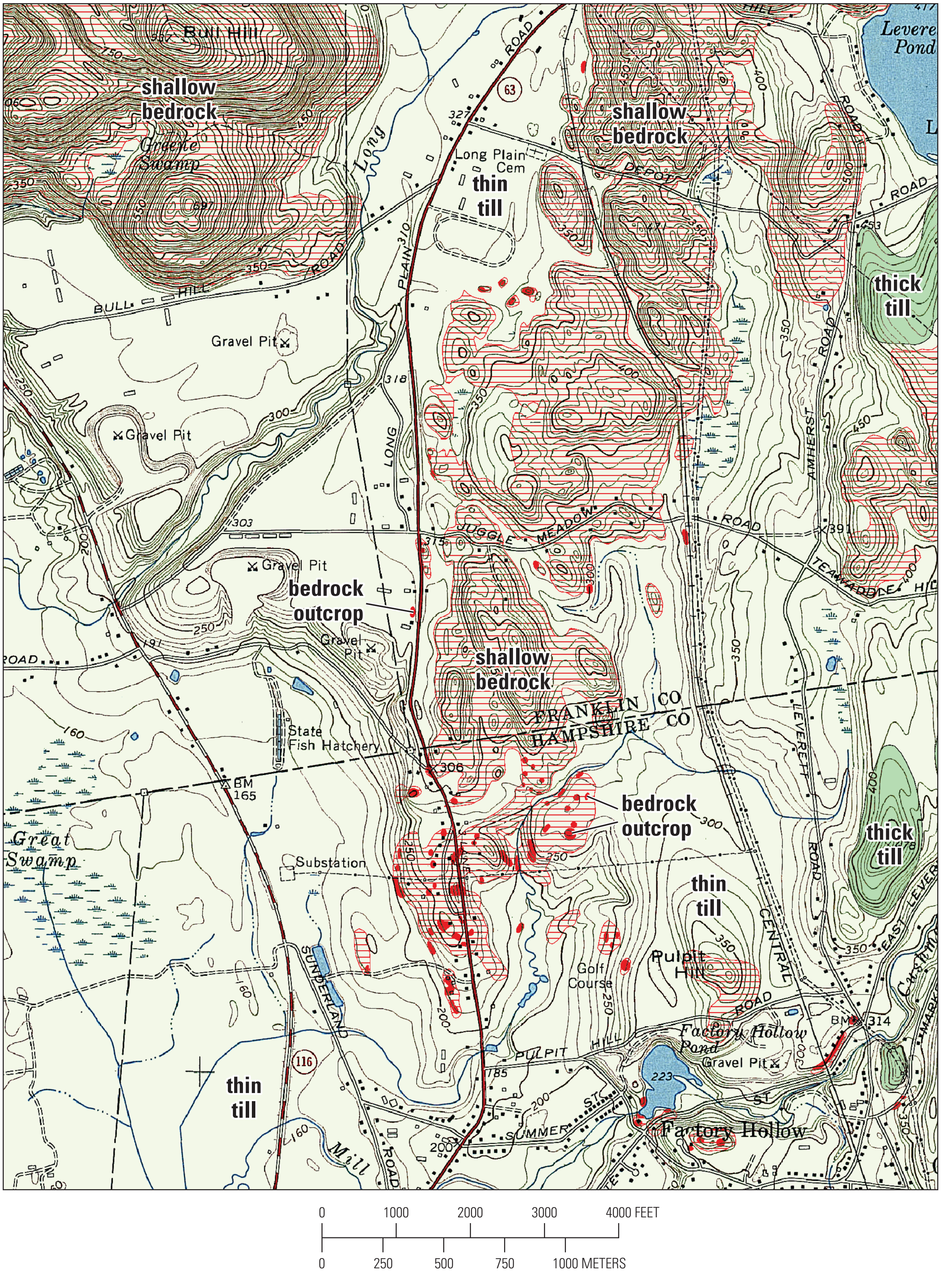

Figure 11*A*. Glacial till and bedrock polygons in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units.

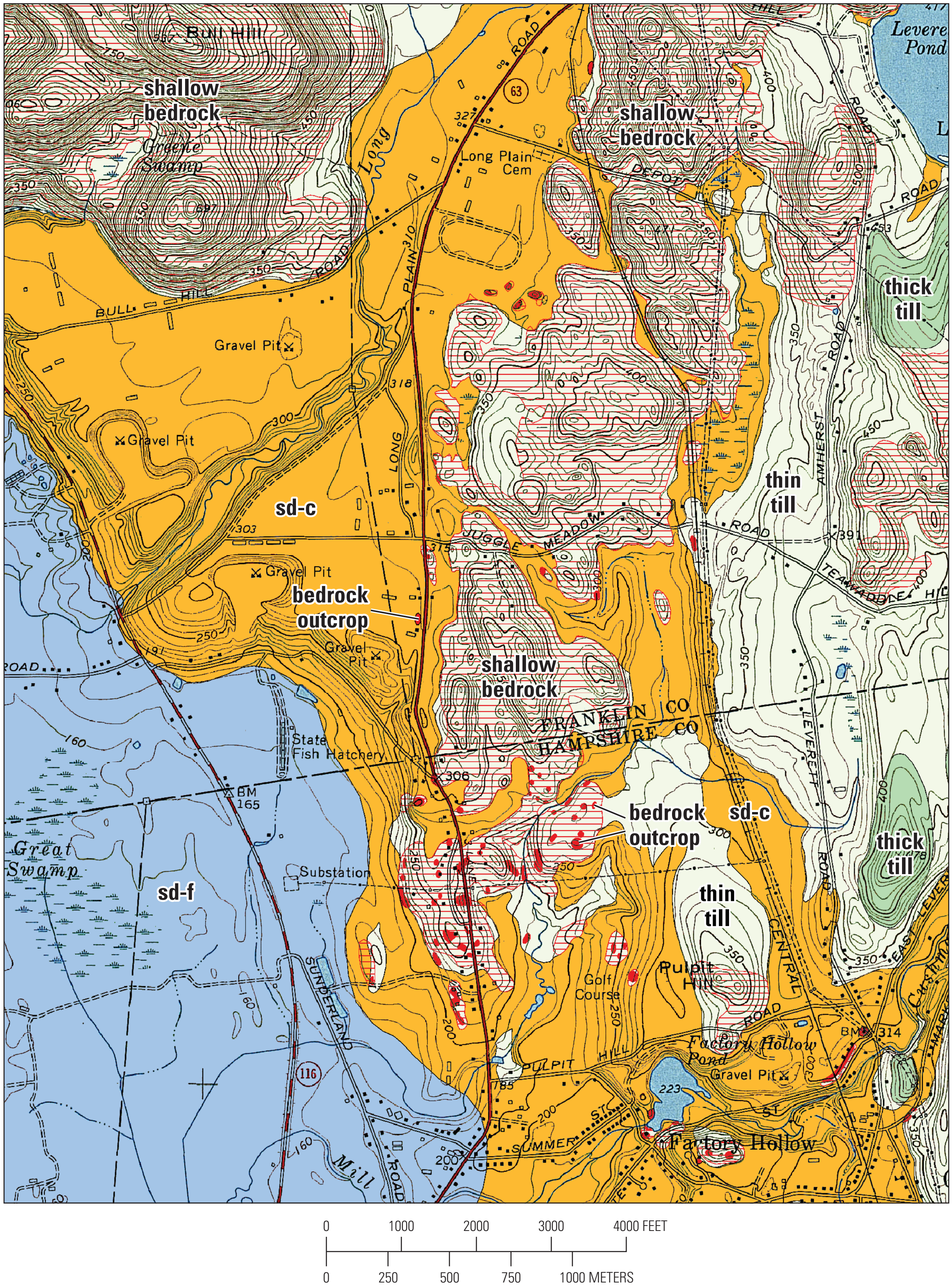

Figure 11*B*. Glacial stratified deposits polygons (sd-c and sd-f) overlying till and shallow bedrock in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: sd-c, coarse stratified deposits; sd-f, fine stratified deposits.

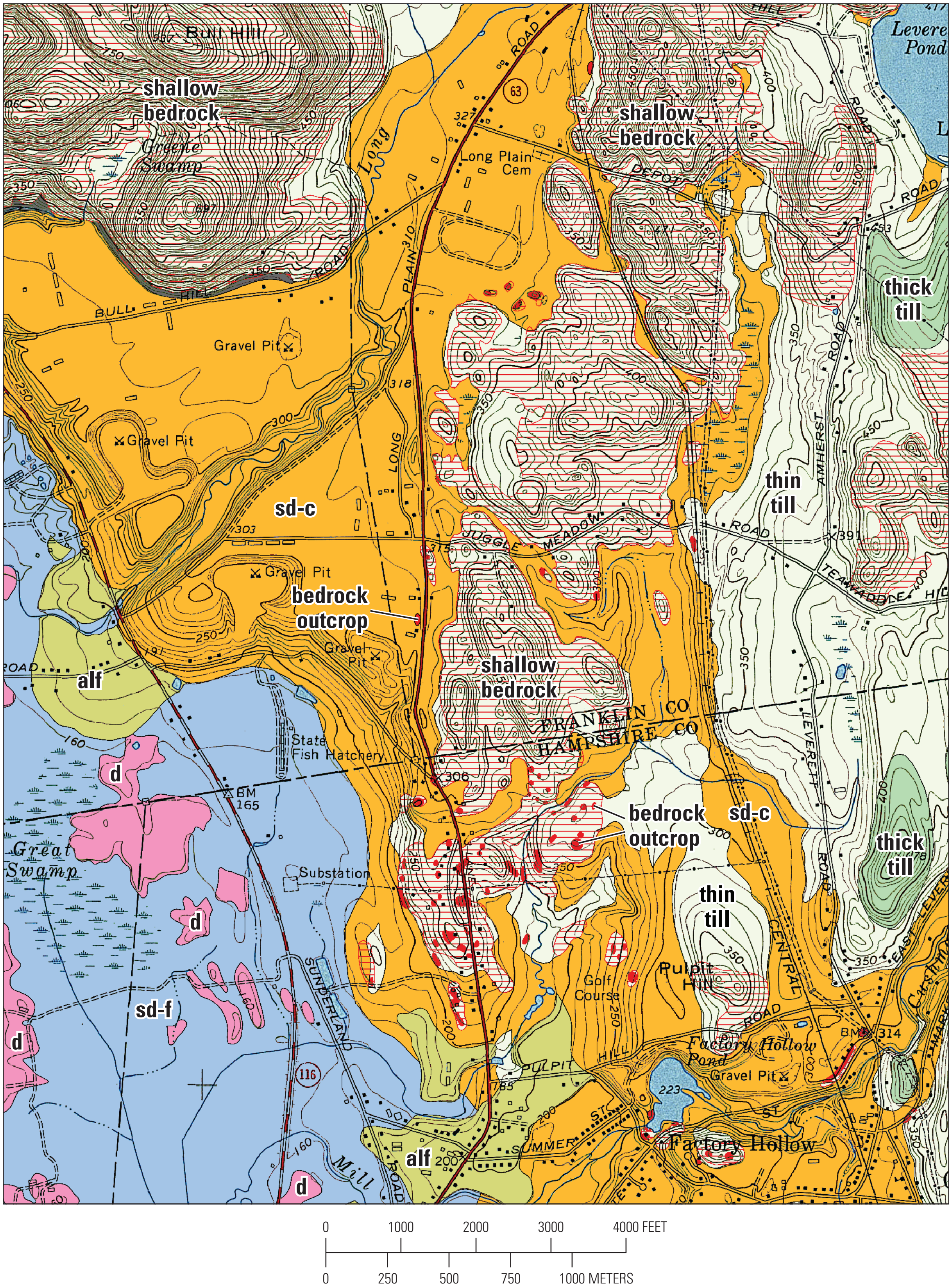

Figure 11*C*. Early postglacial deposits polygons (alf, d) overlying glacial stratified deposits (sd-c, sd-f) in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: alf, alluvial-fan deposits; d, inland-dune deposits; sd-c, coarse stratified deposits; sd-f, fine stratified deposits.

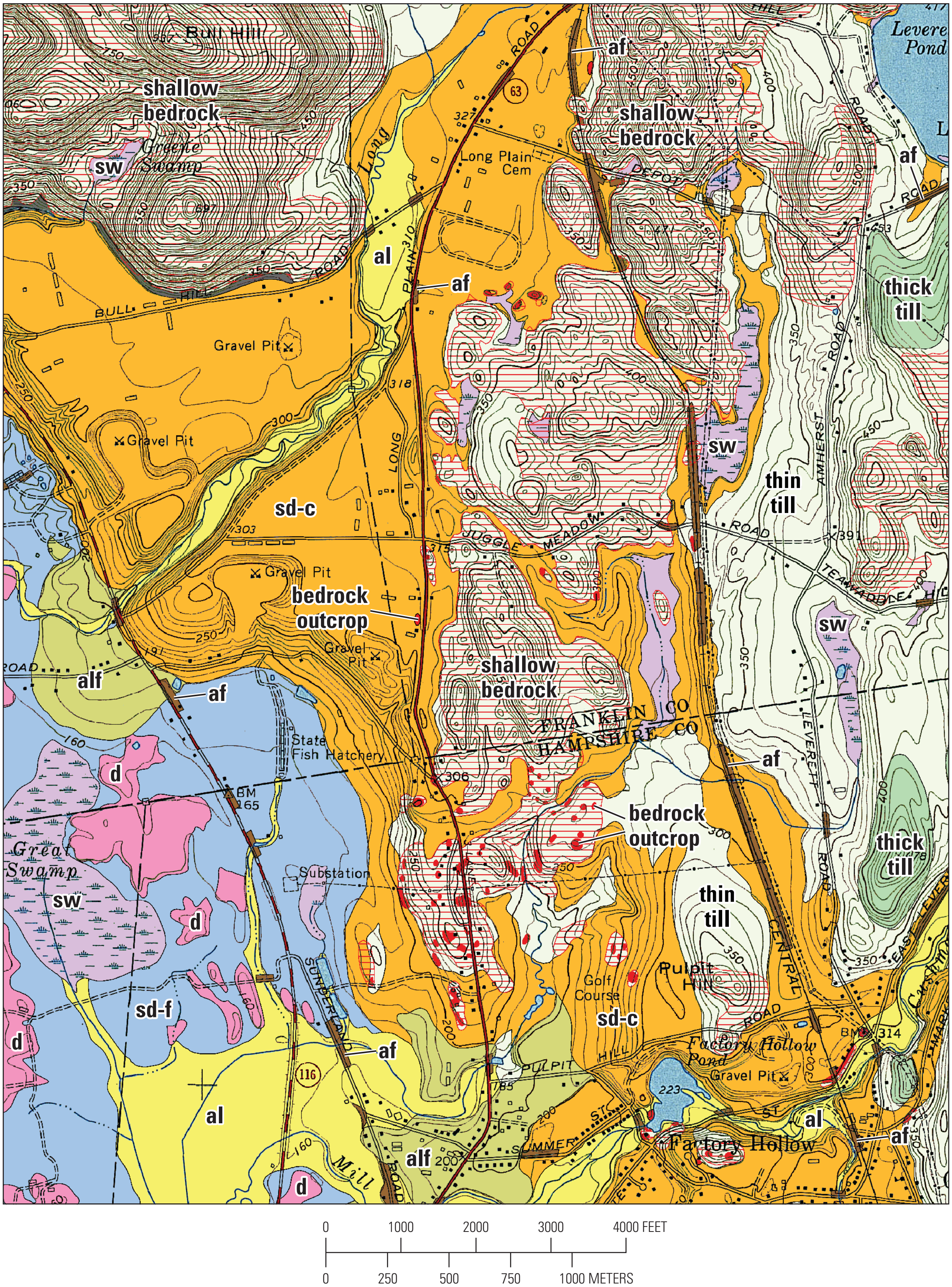

Figure 11*D*. Postglacial deposits polygons (af, al, sw) overlying all older deposits in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: af, artificial fill; al, flood-plain alluvium; alf, alluvial-fan deposits; d, inland-dune deposits; sd-c, coarse stratified deposits; sd-f, fine stratified deposits; sw, swamp deposits.

List of Surficial Materials Maps of Quadrangles 1–189

[A zipped folder containing the PDF map files can be found at https://doi.org/10.3133/sim3402. Map files can also be accessed individually. Numbering corresponds to numbering used in figure 10 above and on the 1:250,000-scale index map]

1. Surficial Materials Map of the Canaan quadrangle, Massachusetts
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3. Surficial Materials Map of the Egremont quadrangle, Massachusetts
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82. Surficial Materials Map of the Oxford quadrangle, Massachusetts
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84. Surficial Materials Map of the Shirley quadrangle, Massachusetts
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86. Surficial Materials Map of the Shrewsbury quadrangle, Massachusetts
87. Surficial Materials Map of the Grafton quadrangle, Massachusetts
88. Surficial Materials Map of the Uxbridge quadrangle, Massachusetts
89. Surficial Materials Map of the Pepperell quadrangle, Massachusetts
90. Surficial Materials Map of the Ayer quadrangle, Massachusetts
91. Surficial Materials Map of the Hudson quadrangle, Massachusetts
92. Surficial Materials Map of the Marlborough quadrangle, Massachusetts
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156. Surficial Materials Map of the Sconticut Neck quadrangle, Massachusetts
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158. Surficial Materials Map of the Squibnocket quadrangle, Massachusetts
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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; unit may also include landfills, urban-development areas, and filled coastal wetlands

Cranberry bog deposits—Natural freshwater swamps or peat bogs overlain locally by artificially emplaced sand or other fill; these deposits occur primarily in southeastern Massachusetts and on Cape Cod. Commonly, cranberry bogs also are created by excavation into sand and gravel deposits that form the bed; peat and other organic material are then artificially emplaced over the bed, and water drainage pathways are diverted into the area to control seasonal flooding of the bog

Flood-plain alluvium—Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, beneath the flood plains 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 feet (ft) thick. The most extensive deposits of alluvium in Massachusetts are along the Housatonic, Deerfield, Westfield, Connecticut, Nashua, Merrimack, and Blackstone Rivers. Alluvium typically overlies thicker glacial stratified deposits

Swamp deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, are stratified and poorly sorted, and occur in swamps and freshwater marshes, in kettle depressions, or in poorly drained areas. Unit is shown only where deposits are estimated to be at least 3 ft thick; most deposits are less than 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits

Salt-marsh and estuarine deposits—Peat and organic muck interbedded with sand and silt, deposited in saltwater or brackish-water environments of low wave energy along the coast and in river estuaries. Salt-marsh deposits are dominantly peat and muck, generally a few feet to 25 ft thick. In the major estuaries, these deposits locally overlie estuarine deposits (not mapped), which are sand and silt with minor organic material and are as much as 30 to 80 ft thick. Salt-marsh and estuarine deposits generally are underlain by adjacent glacial material, consisting of till, coarse stratified deposits, or glaciomarine fine deposits

Beach and dune deposits—Sand and fine gravel deposited along the shoreline by waves and currents, and by wind action. The texture of beach deposits varies over short distances and is generally controlled by the texture of nearby glacial materials exposed to wave action. Sand beach deposits are composed of moderately sorted, very coarse to fine sand, and are commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Gravel beach deposits are composed of granule- to cobble-size clasts in moderately sorted thin beds; deposits contain minor amounts of sand within gravel beds, and thin beds of sand as alternating layers. Beach deposits are rarely more than a few feet thick. Dune deposits are composed of moderately sorted to well-sorted, fine to medium sand, and are variably massive, laminated, and crossbedded. Dune deposits are as much as 100 ft thick. Unit includes artificial sand deposits in locally replenished beaches

Early Postglacial Deposits

Alluvial-fan deposits—Generally coarse gravel and sand deposits on steep slopes where high-gradient streams entered lower gradient valleys. Alluvial fans in some places were graded to lowering levels of glacial lakes. Fans continue to form today at some locations in Massachusetts

Valley-floor fluvial deposits—Sand, gravel, and minor silt, stratified and moderately to poorly sorted, beneath flat floors of valleys, called furrows (Mather and others, 1942), that are eroded into glacial outwash plains. The texture of the fluvial deposits commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. The fluvial deposits overlie thick glacial stratified deposits in the upper, dry reaches of the furrow valleys and probably are less than 20 ft thick. Swamp deposits and deformation of bedding related to melting of buried ice in kettles interrupt the fluvial deposits. The deposits probably extend beneath salt-marsh and estuarine deposits in coastal valley reaches. The most extensive valley-floor fluvial deposits are on upper Cape Cod along Quaker Run and the Coonamessett, Childs, and Quashnet Rivers, and on Martha's Vineyard in Quampache Bottom

Stream-terrace deposits—Sand, gravel, and silt deposited by meteoric water (locally distal meltwater) on terraces cut into glacial meltwater sediments along rivers and streams. These deposits are shown where they overlie glaciolacustrine deposits (fine deposits map unit) and glaciomarine fine deposits; elsewhere, stream-terrace deposits are included in the coarse deposits map unit. Most stream-terrace deposits are less than 10 ft thick and overlie thicker glacial deposits; textures are commonly similar to those of underlying glacial meltwater deposits. Many stream terraces in the Connecticut River valley are composed of fine to medium sand and overlie lake-bottom silt and clay

Marine regressive deposits—Sand and minor gravel deposited along former, higher shorelines in northeastern Massachusetts by waves and currents, and by wind action on beaches and spits. These deposits are shown where they overlie glaciomarine fine deposits. Regressive beach and nearshore deposits are composed of moderately sorted, very coarse to fine sand, commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Regressive beach and nearshore deposits are rarely more than a few feet thick. Regressive spit deposits are 10 to 30 ft thick

Inland-dune deposits—Fine to medium, well-sorted sand in transverse, parabolic, and hummocky dunes as much as 60 ft thick. Deposits occur mostly in the glacial Lake Hitchcock basin (in the Connecticut Valley lowland), where sand derived from extensive glacial-lake deltas that were not yet vegetated was deposited in dune forms by early postglacial winds. Dune sand is now fixed by vegetation except where disturbed by human activities

Talus deposits—Angular, loose blocks of basalt and diabase accumulated by rockfall and creep at the base of bedrock cliffs along linear traprock ridges in the Mesozoic lowland (Connecticut Valley lowland). Talus deposits form steep, unstable slopes. Generally less than 20 ft thick

Glacial Stratified Deposits

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in the particle-size diagram, figure 12, below), 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 surficial geologic map, gravel deposits, sand and gravel deposits, and sand deposits are not differentiated and are shown as *Coarse Deposits* where they occur at the land surface. *Fine Deposits* also are shown where they occur at the land surface. Textural changes occur both areally and vertically (fig. 9); however, subsurface textural variations are not shown on this map.

PARTICLE DIAMETER										
10	2.5	.16	.08	.04	.02	.01	.005	.0025	.00015	inches
256	64	4	2	1	.5	.25	.125	.063	.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		

Figure 12. Grain-size classification used in this report, modified from Wentworth (1922). Abbreviation: mm, millimeter.

Coarse deposits consist of *gravel deposits*, *sand and gravel deposits*, and *sand deposits*, not differentiated in this report. *Gravel deposits* are composed of at least 50 percent gravel-size clasts; cobbles and boulders predominate; minor amounts of sand occur within gravel beds, and sand comprises a 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* occur as mixtures of gravel and sand within individual layers and as layers of sand alternating with layers of gravel. Sand and gravel layers generally range between 25 and 50 percent gravel particles and between 50 and 75 percent sand particles. Layers are well sorted to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* are 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

Fine deposits include very fine sand, silt, and clay that occur as well-sorted, thin layers of alternating silt and clay (varves), or as thicker layers of very fine sand and silt. Very fine to fine sand commonly occurs at the surface of these lake-bottom deposits and grades downward into rhythmically bedded silt and clay varves. In some places on the lake-bottom surface of glacial Lake Hitchcock (in the Connecticut Valley lowland) and glacial Lake Narragansett (in southeastern Massachusetts), fine deposits are overlain by as much as 30 ft of fine to medium sand, deposited as the lake level lowered or the lake shallowed; this sand has not been mapped separately. Locally, this map unit may include areas underlain by fine sand

Glaciomarine fine deposits include clay, silty clay, fine sand, and some fine gravel deposited in a higher-level sea in environments of low wave energy along the coast and in river estuaries. Fine to very fine sand, massive and laminated, commonly is present at the surface and grades downward into interbedded very fine sand, silt, silty clay, and clay. The lower silty clay and clay is massive and thinly laminated. Total thickness is generally a few feet to 75 ft

Stagnant-ice deposits—Surface coarse sediments include scattered large surface boulders, gravel deposits, and sand and gravel deposits, totaling 5 to 30 ft thick, that overlie predominantly sand deposits. Sand deposits contain deltaic foreset bedding and interlayered beds of fine sand, silt, and a little clay. Sand and silty sand deposits extend downward to basal till and bedrock. Flowtill sediments are interlayered under ice-contact slopes. Stratification in surface and underlying sediments is generally distorted and faulted due to postdepositional collapse related to melting of buried ice. Stagnant-ice deposits are confined to irregular hummocky hills, bounded by ice-contact slopes, present on tops of till hills or extending more than 30 ft above the altitudes of adjacent meltwater morphosequences in lowlands. Deposits are aligned in belts parallel to the retreating ice margin

Glacial Till and Moraine Deposits

End moraine deposits—Composed predominantly of boulders and ablation-facies sandy upper till; lenses of stratified sand and gravel occur locally within the till. In the larger deposits on Cape Cod and Martha's Vineyard, the surface ablation till is as much as 30 ft thick and overlies sand, gravel, and silty sand meltwater deposits. Some end moraine deposits include thrusted sheets of glacial meltwater deposits resulting from readvance of the ice margin (Oldale and O'Hara, 1984). Stratification in underlying sediments may also be deformed, the result of postdepositional collapse caused by melting of buried ice. Surface boulders on end moraine deposits are generally more numerous than on adjacent till surfaces; dense concentrations of boulders are present in some places. Deposits occur as freestanding hummocky landforms, commonly in ridges that trend east-northeast to west-southwest, and range in height from 10 to 100 ft

Thrust moraine deposits—In western Martha's Vineyard, thrusted moraine deposits stand as high as 300 ft in altitude and are composed of allochthonous, ice-thrusted Cretaceous, Tertiary, and older Quaternary sediments, locally overlain by thin surface till and boulders. These coastal-plain beds are fossiliferous, semi-consolidated sand, gravel, and silty clay in tilted strata that were thrust up by glacial ice into positions well above the autochthonous coastal-plain surface, which lies below sea level. Numerous northeast-southwest-trending ridges within the thrust moraine unit mark the edges of these tilted and thrusted strata

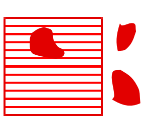
Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered pebble, cobble, and boulder clasts; large surface boulders are common; unit was mapped where till is generally less than 10 to 15 ft thick including areas of shallow bedrock. Predominantly consists of upper 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 coarse-grained crystalline rocks. Across Massachusetts, fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut Valley 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 pebbles, cobbles, and boulders in the shallow subsurface; at greater depths consists of compact, nonsorted matrix of silt, very fine sand, and some clay containing scattered small gravel clasts. Mapped in areas where till is greater than 10 to 15 ft thick, mostly in drumlin landforms in which till thickness commonly exceeds 100 ft (maximum recorded thickness is 230 ft). Although upper till of late Wisconsinan age is the surface deposit, lower till of probable Illinoian age constitutes the bulk of the material in thick-till 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

Glacially modified coastal-plain hill deposits—In the Marshfield Hills area (Scituate, Cohasset, Hanover, and Duxbury quadrangles) and in the Pine Hills area (Manomet quadrangle), very compact till and older glacial stratified deposits overlie thrusted blocks of Tertiary coastal-plain strata that are semi-consolidated dark clay layers. Miocene-age green sand deposits have also been reported at depth. These hills in many places were sculpted by the last ice sheet, but they are generally larger (3–4 miles [mi] long and 1–2 mi wide) than typical drumlins

Thick valley till and fine deposits—Composed of sandy surface till with boulders, 3 to 20 ft thick, overlying finer grained till, or fine sand, silt, or clay, local boulders, and local weathered limestone and dolostone bedrock; total thickness of all sediments is 6 to 135 ft, averaging 50 ft. Materials reported in drillers' records include four descriptions usually synonymous with till: hardpan with no boulders; boulders and clay; gravelly hardpan; and clay with few boulders. Unit includes materials probably defining glaciolacustrine fine sediments or various weathered carbonate bedrock materials, listed as follows: gray clay, gray and yellow clay, black soft rock, and weathered bedrock. The subsurface fine sediments are exposed only in fresh, temporary landslide slopes or shallow excavations, where silty-clayey fine sand typically appears to be sheared, deformed, or disaggregated. Original laminations are difficult to discern. Surface morphology of the thick valley till and fine deposits includes (1) a glacially smoothed surface without bedrock outcrops or any relief related to bedrock structure; (2) locally a streamlined shape similar to small drumlins composed of thick till in other parts of Massachusetts; (3) landslide scarps and stream-cut banks commonly having 5 to 10 ft of relief, locally as much as 50 ft; and (4) dry, meltwater-carved channels 3 to 10 ft deep. These deposits extend almost continuously along lower valley slopes in the Housatonic and Hoosic River valleys, and their tributary valleys, that are underlain by marble, dolostone, or limestone and shale bedrock (Zen and others, 1983). The deposits appear to extend beneath the edges of glacial meltwater deposits in the valley bottoms, but their extent beneath thick glacial deposits in the centers of the valleys is not known. Some of these deposits are present in north-draining upland valleys in areas that also contain thick till deposits in drumlins

Bedrock Areas



Bedrock outcrops and areas of abundant outcrop or shallow bedrock—Solid color shows extent of individual bedrock outcrops; horizontal-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 to 10 ft thick. These units were not mapped consistently among all quadrangles; see note at beginning of appendix 1 for information on bedrock outcrop mapping by quadrangle

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Appendix 1. Sources of Data and Information on Map Units and Mapping, by 7.5-Minute Quadrangle

[Number beside quadrangle name corresponds to number shown in figure 10 and on the 1:250,000-scale index map. For all quadrangles, some units were mapped or revised on the basis of recent field studies, analysis of topography, and analysis of MassGIS 2005 orthophoto images. For quadrangles where light detection and ranging (lidar) data were available, areas of thick till and (or) areas of shallow bedrock were mapped or revised on the basis of analysis of the lidar data, mapped outcrops, and soils data (Natural Resources Conservation Service [n.d.]). Additional bedrock outcrops and shallow-bedrock areas may be present, particularly within thin-till areas that have steep slopes and irregular topography]

1 Canaan Quadrangle

Map units were modified from Holmes (1965a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to small glacial lakes in the Furnace Brook valley. Thick-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from structure symbols shown by Ratcliffe (1978). The shallow-bedrock unit represents areas of abundant outcrops, as indicated by rock structure symbols from Ratcliffe (1978).

2 State Line Quadrangle

Map units were modified from Holmes (1964b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Flat Brook, Baldwin Brook, Alford Brook, and upper Williams River valleys, and graded to glacial Lake Great Falls in the lower Williams River valley. Bedrock outcrops are from Ratcliffe (1974b).

3 Egremont Quadrangle

Map units were modified from Holmes (1964a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Green River, Seekonk Brook, Hubbard Brook, and Williams River valleys, and similar sediments graded to small glacial lakes in the Karner Brook and Alford Brook valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from Zen and Ratcliffe (1971).

4 Bashbish Falls Quadrangle

Map units were modified from Zen and Hartshorn (1966). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Race Brook, Dry Brook, lower Schenob Brook, and Willard Brook valleys, and similar sediments graded to small glacial lakes in the upper Schenob Brook valley (ice-contact unit Qcd and outwash unit Qo of Zen and Hartshorn, 1966).

5 Berlin Quadrangle

Map units were modified from Holmes (1965b); from Warren, C.R., and Stone, B.D., 1982, unpublished field map; and from Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps of the town of Williamstown. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the West Branch Green River and Sweet Brook valleys (ice-contact deposits Qic, deltaic deposits Qfd, fine lacustrine deposits Ql, and alluvial-fan deposits Qaf of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps). Shallow-bedrock areas include areas of “bedrock” and most areas of “thin till and bedrock” of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps.

6 Hancock Quadrangle

Map units were modified from Holmes (1967c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Bascom in the West Branch Green River valley, and similar sediments graded to small glacial lakes in the Kinderhook Creek and Sachem Brook valleys and occurring at the eastern end of Brodie Mountain Road.

7 Pittsfield West Quadrangle

Map units were modified from Holmes (1965d) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Housatonic in the West Branch Housatonic River valley, and similar sediments graded to small glacial lakes in the valleys of Daniels Brook, Hawthorne Brook, Smith Brook, May Brook, Lilly Brook, and Shaker Brook. Bedrock outcrops are from Ratcliffe (1978).

8 Stockbridge Quadrangle

Map units were modified from Holmes (1964c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the lower Housatonic River valley and glacial Lake Housatonic in the upper Housatonic River valley, and similar sediments graded to small glacial lakes in the Konkapot Brook and Williams River valleys. Bedrock outcrops are from Ratcliffe (1974c).

9 Great Barrington Quadrangle

Map units were modified from Holmes (1964d) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Housatonic River valley and the lower Williams River valley, and similar sediments graded to small glacial lakes in the Muddy Brook and Konkapot River valleys. Bedrock outcrops are from Ratcliffe (1974a).

10 Ashley Falls Quadrangle

Map units were modified from Holmes and Newman (1971). Glacial stratified deposits include predominantly coarse glaciodeltaic sediments and fine lake-bottom sediments of glacial Lake Great Falls in the Housatonic River valley (outwash unit Qo and stream-terrace unit Qst3 of glacial Lake Falls Village from Holmes and Newman, 1971), and deposits of small glacial lakes in the Konkapot River valley (ice-contact unit Qcd3 and units Qo, Qst2, and Qcd2 of Holmes and Newman, 1971). Bedrock outcrops and shallow-bedrock areas, defined as “areas of closely spaced outcrops,” were modified from Holmes and Newman (1971).

11 Williamstown Quadrangle

Map units were modified from Dohrenwend, J.C., 1979, unpublished map; from Warren, C.R., and Stone, B.D., 1982, unpublished field map; and from Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps of the town of Williamstown. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River and Green River valleys (ice-contact deposits Qic, deltaic deposits Qd and Qfd, and fine lacustrine deposits Ql of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps). Some bedrock outcrops are from Ratcliffe and others (1993). Shallow-bedrock areas include areas of “bedrock” and most areas of “thin till and bedrock” of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps.

12 Cheshire Quadrangle

Map units were modified from Holmes (1968a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Bascom in the Hoosic River valley, and similar sediments graded to small glacial lakes in the Muddy Brook, Town Brook, and Green River valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic (lidar) analysis. Some bedrock outcrops are from Ratcliffe and others (1993) and Herz (1958).

13 Pittsfield East Quadrangle

Map units were modified from Holmes (1968c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Housatonic in the lower East Branch Housatonic River valley, and similar sediments graded to small glacial lakes in the upper East Branch Housatonic River valley, the Wahconah Falls Brook valley, and the Unkamet Brook valley. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis (lidar). Bedrock outcrops are from Ratcliffe (1984b).

14 East Lee Quadrangle

Map units were modified from Holmes (1967b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Housatonic in the Housatonic River valley, and similar sediments graded to small glacial lakes in the Greenwater Brook valley. Bedrock outcrops are from Ratcliffe (1985).

15 Monterey Quadrangle

Map units were modified from Holmes (1964e) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Hop Brook, Konkapot River, and Clam River valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from Ratcliffe (1984a).

16 South Sandisfield Quadrangle

Map units were modified from Holmes (1964f) and Harwood (1979), and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Umpachene River, Riiska Brook, and Thousand Acre Swamp valleys. Deposits include scattered postglacial alluvial and swamp deposits. Bedrock outcrops are from Harwood (1979).

17 North Adams Quadrangle

Map units were modified from Holmes (1968b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River valley, and similar sediments graded to small glacial lakes in the Tunnel Brook, Canyon Brook, and Hudson Brook valleys. Bedrock outcrops are from Ratcliffe and others (1993) and Herz (1961).

18 Windsor Quadrangle

Map units were modified from Holmes (1965e) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River valley; similar sediments graded to small glacial lakes in the Dry Brook valley; and glaciofluvial sediments in the upper Westfield River valley. Bedrock outcrops are from Norton (1967).

19 Peru Quadrangle

Map units were modified from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Cady Brook and East Branch Housatonic River valleys and in the Tracy Brook, Windsor Brook, and Weston Brook valleys. Bedrock outcrops are from Norton (1974).

20 Becket Quadrangle

Map units were modified from Holmes (1967a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Spark Brook, Cushman Brook, and Walker Brook valleys; and small glaciofluvial deposits in other valleys. Bedrock outcrops are from Norton (1958).

21 Otis Quadrangle

Map units were modified from Holmes (1965c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Farmington River and Spark Brook valleys.

22 Tolland Center Quadrangle

Map units were modified from Holmes, G.W., 1967, unpublished field map, and Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Farmington River, Taylor Brook, and Richardson Brook valleys.

23 Rowe Quadrangle

Map units were modified from Chidester and others (1967) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River valley (ice-channel unit Qic, ice-contact unit Qcd, and stream-terrace unit Qst of Chidester and others, 1967). Bedrock outcrops are from Chidester and others (1967).

24 Plainfield Quadrangle

Map units were modified from Osberg and others (1971) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Chickley River and Deerfield River valleys; and glaciofluvial sediments in the Westfield River valley. Bedrock outcrops are from Osberg and others (1971).

25 Worthington Quadrangle

Map units were modified from Hatch (1969) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Alder Meadow Brook, Tower Brook, and Westfield River valleys; and glaciofluvial sediments in other valleys. Bedrock outcrops are from Hatch (1969).

26 Chester Quadrangle

Map units were modified from Hatch and others (1970) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments in the West Branch Westfield River and Middle Branch Westfield River valleys. Bedrock outcrops are from Hatch and others (1970).

27 Blandford Quadrangle

Map units were modified from Hatch and Stanley (1976) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Westfield River valley; and scattered small deposits in other valleys. Bedrock outcrops are from Hatch and Stanley (1976).

28 West Granville Quadrangle

Map units were modified from Schnabel (1973) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of Exit Brook and Valley Brook. Bedrock outcrops are from Schnabel (1973). The shallow-bedrock unit represents “areas of closely spaced outcrops” of Schnabel (1973).

29 Heath Quadrangle

Map units were reproduced from Hatch and Hartshorn (1968). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River, West Branch North River, and Mill Brook valleys, in the West Branch Brook valley, and in the Hartwell, Avery, Wilder, and Taylor Brook valleys.

30 Ashfield Quadrangle

Map units were reproduced from Hartshorn, J.H., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River, Clesson Brook, Clark Brook, and South River valleys. Distribution of bedrock outcrops and some shallow-bedrock areas is from Hatch (1981).

31 Goshen Quadrangle

Map units were modified from Hatch and Warren (1982). Glacial stratified deposits include ice-marginal glacial-lake deposits in the Chapel Brook and West Branch Mill River valleys, which drained eastward toward the retreating ice lobe in the Connecticut River valley, and remnants of sediment-dammed glacial-lake deposits in the Westfield River valley. Bedrock outcrops include only those examined in the field during bedrock mapping (Hatch and Warren, 1982).

32 Westhampton Quadrangle

Map units were reproduced from Warren, C.R., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in the Sodom Brook and North Branch Manhan River valleys, which drained eastward toward the retreating ice margin. Remnants of coarse, sediment-dammed glacial-lake deposits are present in the south-draining Westfield River valley. Distribution of bedrock outcrops is from Clark (1987).

33 Woronoco Quadrangle

Map units were reproduced from Warren, C.R., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in upland areas, and coarse and fine deposits of glacial Lake Westfield in the lowlands. Distribution of bedrock outcrops is from Stanley and others (1982).

34 Southwick Quadrangle

Map units were reproduced from Schnabel (1971). Glacial stratified deposits include ice-dammed glacial-lake deposits in the Dickinson Brook and Munn Brook valleys, sediment-dammed glacial-lake deposits in the vicinity of Congamond Lakes, and coarse deposits of glacial Lake Westfield in the northeastern part of the quadrangle. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Schnabel (1971). The shallow-bedrock unit is defined as areas of abundant outcrops and patches of thin surficial material.

35 Colrain Quadrangle

Map units were modified from Segerstrom (1955a). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Green River, Hinsdale Brook, and North River valleys and several tributary valleys. Coarse and fine deposits of glacial Lake Hitchcock are in the southeast corner of the quadrangle. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Segerstrom (1955a) and includes some areas within his Qgt unit. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1955a), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

36 Shelburne Falls Quadrangle

Map units were modified from Segerstrom (1959). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small ice-dammed glacial lakes in the South River, Bear River, and Deerfield River valleys. Coarse and fine deposits of glacial Lake Hitchcock are in the eastern part of the quadrangle. The thick-till unit is modified from the Qgd (drumlins) unit of Segerstrom (1959) and includes some areas within his Qgt unit. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1959), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

37 Williamsburg Quadrangle

Map units were reproduced from Segerstrom (1955b). Glacial stratified deposits include ice-marginal glacial-lake deposits in the Roaring Brook and West Brook valleys, which drained eastward toward the retreating ice lobe in the Connecticut Rvier valley, and sediment-dammed glacial-lake deposits in the Mill River valley, in the southwestern part of the quadrangle. Coarse and fine deposits of glacial Lake Hitchcock are in the eastern part of the quadrangle. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Segerstrom (1955b). Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1955b), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

38 Easthampton Quadrangle

Map units were reproduced from Larsen, F.D., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in the Roberts Meadow Brook, Turkey Brook, Mill River, and North Branch Manhan River valleys, which drained eastward toward the retreating ice margin. Coarse and fine deposits of glacial Lake Manhan and glacial Lake Hitchcock are present in the lowland areas.

39 Mount Tom Quadrangle

Map units were reproduced from Larsen (1972). Glacial stratified deposits include coarse and fine deposits of glacial Lake Westfield in the western part of the quadrangle, glacial Lake Manhan in the northern part, and glacial Lake Hitchcock in the eastern part. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Larsen (1972). The shallow-bedrock unit is defined as areas of abundant outcrops.

40 West Springfield Quadrangle

Map units were reproduced from Colton and Hartshorn (1970). Glacial stratified deposits in the eastern half of the quadrangle include coarse and fine deposits of glacial Lake Hitchcock; the western half of the quadrangle includes predominantly coarse deposits of glacial Lake Westfield. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Colton and Hartshorn (1970). The shallow-bedrock unit is defined as large areas of nearly continuous bedrock outcrop.

41 Bernardston Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map, and Larsen, F.D., 1977, unpublished field map. Mapping in the southern half of the quadrangle is based on an unpublished M.S. thesis by Retelle (1979). Glacial stratified deposits include coarse and fine deposits of glacial Lake Hitchcock in the Green River, Fall River, and Connecticut River (Dry Brook) valleys, and deposits of local higher-level lakes. Distribution of bedrock outcrops and shallow-bedrock areas is from Balk (1956a). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

42 Greenfield Quadrangle

Map units were reproduced from Jahns (1966). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock in the Green River, Deerfield River, and Connecticut River valleys; other glaciofluvial and glaciolacustrine deposits graded to higher level ice-dammed lakes are in tributary valleys. The thick-till unit is modified from the Qgd (drumlins) unit of Jahns (1966). The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Jahns (1966), which is defined as “generally thin deposits of ground moraine (till) with many exposures of bedrock.”

43 Mount Toby Quadrangle

Map units were reproduced from Jahns (1951). Glacial stratified deposits include predominantly coarse and fine deposits of glacial Lake Hitchcock. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Jahns (1951), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock;” this unit is more extensive than in other quadrangles and is probably overmapped. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Jahns (1951).

44 Mount Holyoke Quadrangle

Map units were modified from Balk (1957) using unpublished field maps from Larsen, F.D., 1976, and Stone, J.R., 1976. Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock. The shallow-bedrock unit is modified from the areas shown as bedrock units on the map of Balk (1957); these areas are likely to contain abundant bedrock outcrops.

45 Springfield North Quadrangle

Map units were reproduced from Larsen, F.D., 1976, unpublished field map. Glacial stratified deposits include coarse and fine deposits of glacial Lake Hitchcock.

46 Springfield South Quadrangle

Map units were reproduced from Hartshorn and Koteff (1967). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock. Thick-till areas were mapped based on topographic analysis, on well and test-hole data, and on the position of drumlin axes shown on the map of Hartshorn and Koteff (1967). The shallow-bedrock unit is defined as areas of scattered outcrops and areas of thinly veneered bedrock.

47 Northfield Quadrangle

Map units were reproduced from Campbell and Hartshorn (1980). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock in the Connecticut River valley. Thick-till areas were mapped based on topographic analysis and the position of drumlin axes shown on the map of Campbell and Hartshorn (1980). The shallow-bedrock unit represents areas of thin surficial deposits and numerous bedrock outcrops.

48 Millers Falls Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Sawmill River and Millers River valleys and their tributary valleys. In the Connecticut River valley, coarse and fine sediments of glacial Lake Hitchcock are present. Distribution of bedrock outcrops and shallow-bedrock areas is modified from Balk (1956b).

49 Shutesbury Quadrangle

Map units were reproduced from Stone, J.R. (1978). Glacial stratified deposits include deposits of ice-dammed glacial lakes in the west-draining valleys of Amethyst Brook and its tributaries, Dean Brook, Roaring Brook, and the Sawmill River, and deposits of sediment-dammed lakes in the south-draining valleys of the West Branch Swift River and Doolittle Brook. Coarse and fine deposits of glacial Lake Hitchcock are present in the southwestern part of the quadrangle. The shallow-bedrock unit is defined as areas where bedrock is inferred to be less than 10 ft beneath the surface and where numerous bedrock outcrops are likely to be found.

50 Belchertown Quadrangle

Map units were reproduced from Caggiano (1978). Glacial stratified deposits include coarse deposits of sediment-dammed glacial lakes in the Jabish Brook and Broad Brook valleys and an ice-dammed glacial lake in the Knights Pond valley, and coarse and fine deposits of glacial Lake Hitchcock in the western part of the quadrangle. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Caggiano (1978). The shallow-bedrock unit is defined as areas where surficial material is less than 10 ft thick.

51 Ludlow Quadrangle

Map units were modified from Leo (1974), using unpublished field maps by Larsen, F.D., 1976. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in upland tributary valleys of the Chicopee River, and coarse deltaic deposits of glacial Lake Hitchcock in the western part of the quadrangle. The shallow-bedrock unit is defined as areas of abundant outcrops.

52 Hampden Quadrangle

Map units were reproduced from Hildreth and Colton (1982). Glacial stratified deposits include coarse deposits of a lowering series of ice-dammed glacial lakes in the upper Scantic River valley and its tributaries, and coarse deposits of sediment-dammed glacial lakes in the lower Scantic River valley and the North Branch and South Branch Mill River valleys. Coarse deltaic deposits of glacial Lake Hitchcock are present in the northwestern part of the quadrangle. Thick-till areas were mapped based on topographic analysis, on well and test-hole data, and on the position of drumlin axes shown on the map of Hildreth and Colton (1982). The shallow-bedrock unit is defined as areas of closely spaced outcrops and areas where surficial materials are less than 10 ft thick.

53 Mount Grace Quadrangle

Map units were reproduced from Hadley (1949). Glacial stratified deposits include units Qk and Qe of Hadley (1949), which are predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the West Branch Tully River, Mirey Brook-Mountain Brook, Darling Brook, and Hodge Brook. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

54 Orange Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map, and Larsen, F.D., 1980, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial lakes in the valleys of the Millers River and tributaries, Middle Branch Swift River, and Whetstone Brook. Distribution of bedrock outcrops and shallow-bedrock areas is from Robinson (2008).

55 Quabbin Reservoir Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to a series of glacial lakes in the East, Middle, and West Branch Swift River valleys; today these deposits lie mostly underwater beneath the Quabbin Reservoir. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

56 Winsor Dam Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the Swift River, Beaver Brook, Flat Brook, and Muddy Brook valleys; today these deposits lie mostly underwater beneath the Quabbin Reservoir. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

57 Palmer Quadrangle

Map units were reproduced from Peper (1978). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the valleys of the Swift River, Ware River, and Quaboag River and their tributaries. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Peper (1978). The shallow-bedrock unit is defined as "areas of abundant outcrop and thin surficial cover."

58 Monson Quadrangle

Map units were reproduced from Peper (1977). Glacial stratified deposits include predominantly coarse glaciodeltaic sediments laid down in an ice-dammed glacial lake in the valleys of the north-draining Chicopee Brook, Twelvemile Brook, Vinica Brook, Conant Brook, and Foskett Mill Stream. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Peper (1977). The shallow-bedrock unit is defined as "areas of abundant outcrop and thin drift."

59 Royalston Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map, and Larsen, F.D., 1980, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the East Branch Tully River, Lawrence Brook, Beaver Brook, and Millers River. Few bedrock outcrops were mapped in the field; some outcrops in the northwestern part of the map area were mapped from the position of structure symbols shown by Springston (1990, pl. 2). Some outcrops were mapped where visible on 2005 orthophoto images.

60 Athol Quadrangle

Map units were modified from Eschman (1966). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the Millers River valley and tributary valleys, and in the valleys of the East Branch Swift River, Riceville Brook, and Beaver Brook. Thick-till areas were mapped based on topographic analysis and on well and test-hole data. The shallow-bedrock unit is defined as "areas of numerous small scattered exposures or where bedrock is very near the surface and controls the topography" (Eschman, 1966).

61 Petersham Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the East Branch Swift River valley. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

62 Ware Quadrangle

Map units were modified from Mulholland (1975). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of the Ware River, Muddy Brook, Mill Brook and tributaries, and Winimusset Brook. Fine deposits occur in the subsurface in the Winimusset Brook valley (Stone, B.D., and others, 1992). Thick-till areas were mapped based on topographic analysis and on well and test-hole data. Some bedrock outcrop areas are from Field (1976). The shallow-bedrock unit represents areas of closely spaced outcrops.

63 Warren Quadrangle

Map units were reproduced from Pomeroy (1977). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial lakes in the Quaboag River valley and its tributary valleys. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Pomeroy (1977). The shallow-bedrock unit is defined as "closely spaced outcrops where surficial deposits are thin."

64 Wales Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Quinebaug River valley and its tributary valleys. Bedrock outcrops and shallow-bedrock areas were reproduced from Seiders (1976), where the shallow-bedrock unit is defined as "areas of thin till and abundant outcrop."

65 Winchendon Quadrangle

Map units were reproduced from Stone, J.R., 1979, unpublished field map. Glacial stratified deposits include coarse glaciodeltaic sediments graded to, and fine lake-bottom sediments deposited in, glacial lakes in the Otter River and Millers River valleys and their tributary valleys. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

66 Templeton Quadrangle

Map units were reproduced from Stone, J.R., 1979, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, ice-dammed glacial lakes in the valleys of the Otter River and tributaries, and coarse sediments graded to sediment-dammed glacial lakes in the Burnshirt River-Trout Brook valley. The shallow-bedrock unit represents areas of small scattered bedrock outcrops and where bedrock is interpreted to be within 10 ft of the land surface.

67 Barre Quadrangle

Map units were reproduced from Larsen, F.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the Ware River valley and its tributary valleys. Bedrock outcrop areas are from Tucker (1977). The shallow-bedrock unit represents areas of closely spaced outcrops.

68 North Brookfield Quadrangle

Map units were reproduced from Larsen, F.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to sediment-dammed glacial lakes in the Ware River, Sevenmile River, and Fivemile River valleys and graded to ice-dammed glacial lakes in the north-draining Bell Brook and Burrow Brook valleys. Most bedrock outcrops were not mapped in the field. Those shown on the map are visible on 2005 orthophoto images.

69 East Brookfield Quadrangle

Map units were reproduced from Pomeroy (1975). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Quaboag River valley and its tributary valleys. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Pomeroy (1975). The shallow-bedrock unit is defined as “closely spaced outcrops where surficial deposits are thin.”

70 Southbridge Quadrangle

Map units were modified from Moore (1978). Glacial stratified deposits include coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Quinebaug River valley and its tributary valleys. Bedrock outcrops were reproduced from Moore (1978), and many areas of abundant small outcrops were included in the shallow-bedrock unit.

71 Ashburnham Quadrangle

Map units were reproduced from Stone, B.D., 1978, unpublished field map. Glacial stratified deposits are predominantly coarse glaciofluvial and glaciodeltaic sediments in the Phillips Brook valley and in headwater valleys of the Millers River. Bedrock outcrops and shallow-bedrock areas in the eastern part of the quadrangle were reproduced from Peterson (1984, pl. 3). Some outcrops were mapped where visible on 2005 orthophoto images.

72 Gardner Quadrangle

Map units were reproduced from Stone, B.D. (1978). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the Whitman River and Mahoney Brook and their tributaries. The shallow-bedrock unit is defined as “areas where surficial deposits are generally less than 3 meters (m) (10 ft) thick, and may contain numerous small bedrock outcrops.”

73 Wachusett Mountain Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the valleys of the East Branch Ware River and tributaries, West Branch Ware River, and Wachusett Brook. Bedrock outcrop areas are from Tucker (1977). The shallow-bedrock unit represents areas of closely spaced outcrops.

74 Paxton Quadrangle

Map units in the western part of the quadrangle were reproduced from Stone, B.D., 1982, unpublished field map. Map units in the eastern part of the quadrangle were reproduced from Stone (1980). Glacial stratified deposits include coarse sediments graded to glacial lakes in the Sevenmile River, Turkey Hill Brook, and Asnebumskit Brook valleys. The shallow-bedrock unit in the eastern part of the quadrangle is defined as “areas where surficial deposits are generally less than 3 m (10 ft) thick, locally containing numerous bedrock outcrops.” Some bedrock outcrops were taken from Walsh (2002).

75 Leicester Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the French River and Cranberry River valleys and their tributary valleys. Bedrock outcrops were not mapped in the field. Those shown on the map are visible on 2005 orthophoto images. A few outcrops were located from structure symbols shown on the map of Barosh and Johnson (1976).

76 Webster Quadrangle

Map units were modified from Barosh (1973). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Quinebaug River and French River valleys and their tributary valleys. Thick-till areas were modified from the Qt3 unit and from the position of drumlin axes, both shown on the map of Barosh (1973). Bedrock outcrops and areas of shallow bedrock are from Barosh (2009), where the shallow-bedrock unit is defined as “areas of abundant outcrops and areas where bedrock lies within 3 m (10 ft) of the surface.”

77 Ashby Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the South Brook, Willard Brook, and Pearl Hill Brook valleys, in the Walker and Mason Brook valleys, and in the Trapfall Brook valley.

78 Fitchburg Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Nashua in the Nashua River valley; and glaciofluvial and glaciodeltaic sediments in other tributary valleys.

79 Sterling Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Quinapoxet River and Stillwater River valleys and other tributary valleys.

80 Worcester North Quadrangle

Map units were reproduced from Stone (1980). Glacial stratified deposits include deposits of glacial Lake Nashua, and other glaciofluvial and glaciolacustrine deposits. Some thick-till areas were reproduced from the drumlin till unit (Qtd) and the mixed-till unit (Qtm) of Stone (1980). The shallow-bedrock unit is defined as “areas where surficial deposits are generally less than 3 m (10 ft) thick, locally containing numerous bedrock outcrops.”

81 Worcester South Quadrangle

Map units were reproduced from Haselton, G.M., and Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Blackstone River valley and tributary valleys and in the Wellington Brook and Dark Brook valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Stone on their 1982 unpublished field maps. Bedrock outcrops are from Walsh and Merschat (2015) and from Dixon, H.R., 1977, unpublished field maps.

82 Oxford Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the French River valley and the Whitin Reservoir valley. Distribution of bedrock outcrops is from Barosh, P.J., 2005, unpublished field map, and Barosh (1976).

83 Townsend Quadrangle

Map units were reproduced from Koteff and Stone (1990). Glacial stratified deposits include deposits of glacial Lakes Nashua and Nissitissit, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown by Koteff and Stone (1990). Not all bedrock outcrops were mapped in thin-till areas, and the shallow-bedrock unit is defined as “areas of abundant exposures and areas where surficial deposits are less than 10 ft thick, mapped in part from aerial photographs.”

84 Shirley Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map, with minor contributions from Allmendinger and Schneider (1976). Glacial stratified deposits include deposits of glacial Lake Nashua and other smaller valley deposits.

85 Clinton Quadrangle

Map units were reproduced from Koteff (1966). Glacial stratified deposits include deposits of glacial Lakes Nashua, Assabet, and Leominster, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include glacial Lake Nashua lake-bottom deposits (unit Qnbb of Koteff, 1966). Areas of thick till were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff (1966). Shallow-bedrock areas are defined as “areas of abundant exposures where surficial deposits are thin; mapped largely from aerial photographs.”

86 Shrewsbury Quadrangle

Map units were reproduced from Shaw (1969). Some additional outcrops are from Hepburn (1978) and Barosh (1978). Glacial stratified deposits include deposits of glacial Lakes Assabet and Nashua, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Shaw (1969). Shallow-bedrock areas are defined as “areas of abundant outcrops, compiled in part from aerial photographs.”

87 Grafton Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Blackstone, Quinsigamond, and West River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Distribution of most bedrock outcrops is from Walsh and others (2011). Shallow-bedrock areas are areas of abundant bedrock exposures.

88 Uxbridge Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Mumford and Blackstone River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Bedrock outcrops are from Walsh (2014) and from Dixon, H.R., 1977, unpublished field maps.

89 Pepperell Quadrangle

Map units were reproduced from Koteff and Volckmann (1973). Glacial stratified deposits include deposits of glacial Lakes Nashua and Nissitissit, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Nashua and Nissitissit (units Qnb and Qnib of Koteff and Volckmann, 1973). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff and Volckmann (1973). Not all bedrock outcrops were mapped by Koteff and Volckmann (1973) in thin-till areas, and their shallow bedrock is defined as “areas of abundant exposures and thin surficial deposits;” their mapping of the extent of bedrock exposures in till was in part from aerial photographs.

90 Ayer Quadrangle

Map units were reproduced from Jahns (1953). Glacial stratified deposits include deposits of glacial Lake Nashua and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Nashua (unit Qnl of Jahns, 1953). Some thick-till areas were reproduced from Jahns (1953). The shallow-bedrock unit is defined as “areas where exposures are small and scattered.”

91 Hudson Quadrangle

Map units were reproduced from Hansen (1956). Glacial stratified deposits include various glacial lake and stream deposits. Most thick till shown was reproduced from the drumlin till unit on the published map. Shallow-bedrock areas are large areas where Hansen (1956) mapped numerous outcrops.

92 Marlborough Quadrangle

Map units were reproduced from Hildreth and Stone (2004); bedrock outcrops and shallow-bedrock areas in part are from Kopera and others (2006). Glacial stratified deposits include deposits of glacial Lake Assabet and other glacial lakes in the Cedar Swamp and Sudbury Reservoir valleys. Shallow-bedrock areas are defined as “areas of abundant exposures and areas where surficial deposits are generally less than 10 ft thick.”

93 Milford Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the West River and Charles River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Most bedrock outcrops in the southern part of the quadrangle are from Shaw, C.E., Jr., 1966, unpublished field map. Shallow-bedrock areas are areas of abundant bedrock exposures.

94 Blackstone Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Mill River and Blackstone River valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Most bedrock outcrops in the northern part of the quadrangle are from Shaw, C.E., Jr., 1966, unpublished field map. In the southern part of the quadrangle, most bedrock outcrops are from McKniff (1964) and from Goldsmith, R., 1978, unpublished field map.

95 Nashua South Quadrangle

Map units were reproduced from Holland, W.R., compiler, 1982, unpublished field map, and from Jahns and others (1946). Some bedrock outcrops are from Walsh and others (2013). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Merrimack River valley and its tributary valleys.

96 Westford Quadrangle

Map units were reproduced from Hartshorn, J.H., compiler, 1980, unpublished field map, and from Jahns and others (1946). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Nashoba Brook and Stony Brook valleys and their tributary valleys.

97 Maynard Quadrangle

Map units were reproduced from Hansen (1956). Glacial stratified deposits include various glacial lake and stream deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Sudbury (parts of unit Qsg of Hansen, 1956). Most thick till was reproduced from the drumlin till unit on the published map. Shallow-bedrock areas are large areas where Hansen (1956) mapped numerous outcrops.

98 Framingham Quadrangle

Map units were reproduced from Nelson (1974b). Glacial stratified deposits include deposits of glacial Lakes Charles and Sudbury, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Charles and Sudbury (units Qlsb and Qlcb of Nelson, 1974b). Some contacts between till and glacial stratified deposits have been modified from Nelson (1974b). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Nelson (1974b). Shallow-bedrock areas are defined as “closely spaced outcrops where surficial deposits are 10 ft thick or less.”

99 Holliston Quadrangle

Map units were reproduced from Volckmann (1975a). Glacial stratified deposits include deposits of glacial Lake Medfield, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Medfield (unit Qm2 of Volckmann, 1975a). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Volckmann (1975a). Shallow-bedrock areas are defined as “large areas of abundant outcrop and generally thin drift.”

100 Franklin Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Lyons (1977) and from Goldsmith, R., 1978, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Peters River, Charles River, Miscoe Brook, and Mine Brook valleys and their tributary valleys.

101 Pawtucket Quadrangle

Map units were reproduced from Chute (1949). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Abbott Run valley.

102 Lowell Quadrangle

Map units were reproduced from Hartshorn, J.H., compiler, 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Merrimack River valley and its tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown on the unpublished field map.

103 Billerica Quadrangle

Map units were reproduced from Holland (1980) and Castle (1950). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Concord River valley and its tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown in Holland (1980).

104 Concord Quadrangle

Map units were reproduced from Koteff (1964b). Glacial stratified deposits include deposits of glacial Lakes Sudbury and Concord, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Sudbury and Concord (units Qlsb and Qlcb of Koteff, 1964b). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff (1964b). Shallow-bedrock areas are defined as "areas of abundant exposures where surficial deposits are thin." Some bedrock outcrops are from Bell (1976).

105 Natick Quadrangle

Map units were reproduced from Nelson (1974a). Glacial stratified deposits include deposits of glacial Lakes Charles and Sudbury, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Sudbury (unit Qlsb of Nelson, 1974a). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Nelson (1974a). Shallow-bedrock areas are defined as "closely spaced outcrops where surficial deposits are thin."

106 Medfield Quadrangle

Map units were reproduced from Volckmann (1975b). Glacial stratified deposits include deposits of glacial Lake Medfield, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Volckmann (1975b). Shallow-bedrock areas are areas of abundant outcrop.

107 Wrentham Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Stone's unpublished field maps and from Lyons (1977) and Williams and Willey (1973). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Ten Mile, Mill, and Neponset River valleys and their tributary valleys.

108 Attleboro Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Stone's unpublished field maps and from Lyons (1977) and Willey and others (1978). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Abbott Run valley, the Ten Mile, Sevenmile, and Bungay River valleys, the Bliss Brook valley, and the Wading River valley.

109 East Providence Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Narragansett in the Runnins River, Ten Mile River, and Palmer River lowlands. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978) and Lyons (1977), and from Stone's 1982 unpublished field map. The shallow-bedrock unit represents areas of numerous outcrops.

110 Bristol Quadrangle

Map units were reproduced from Smith (1955). Glacial stratified deposits include fine glaciofluvial sediments of outwash-plain deposits (unit Qop of Smith, 1955), which grade to glacial Lake Narragansett deposits in the eastern Narragansett Bay lowland.

111 Salem Depot Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

112 Lawrence Quadrangle

Map units were reproduced from Castle (1958). Glacial stratified deposits include deposits of glacial Lake Methuen, and other glaciofluvial and glaciolacustrine deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Methuen (unit Qml of Castle, 1958). Deposits mapped as morainal ice-contact deposits (unit Qmi of Castle, 1958) have been included here as coarse stratified deposits. Some thick-till areas were reproduced from the drumlin till unit (Qgd of Castle, 1958).

113 Wilmington Quadrangle

Map units were reproduced from Castle (1959). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments. Some thick-till areas were reproduced from the drumlin till unit (Qgd of Castle, 1959).

114 Lexington Quadrangle

Map units were modified from LaForge (1932) and Chute (eastern part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial-stream outwash deposits, eskers, and kames of LaForge [1932]; outwash units of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes, and glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in the Boston basin. Other coarse stratified sediments are in local ice-contact deposits in the uplands. Fine deposits (Qcl of Chute, 1959) at the surface and in the subsurface of the Little River-Fresh Pond lowland are mainly glaciolacustrine deposits of a local glacial lake. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932) or was delineated based on topographic analysis. Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Moraine deposits are part of the Fresh Pond moraine (Chute, 1959). Bedrock outcrops were reproduced from Chute (1959). Some additional outcrops are from Bell (1976). Shallow bedrock, in the eastern part of the quadrangle, is from Chute (1959) and represents areas where outcrops are “too abundant to map separately.”

115 Newton Quadrangle

Map units were modified from LaForge (1932) and Chute (northeastern part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits, eskers, and kames of LaForge [1932]; glacial-lake and glacial stream deposits of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to glacial Lake Charles (Clapp, 1904; Nelson, 1974a) and graded to small glacial lakes in the East Dedham, Roslindale, and Faneuil areas, and in the valleys of Cheese Cake Brook and the Charles River. Other coarse stratified sediments are in local ice-contact deposits in the uplands and in large, high-standing deposits in the Mount Auburn Cemetery area. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were reproduced from Kaye (1980); some additional outcrops are from Thompson (2015).

116 Norwood Quadrangle

Map units were reproduced from Chute (1966). Glacial stratified deposits include predominantly coarse deposits graded to a series of glacial lakes in the Neponset River valley. Bedrock outcrops and “groups of closely spaced outcrops” were reproduced from Chute (1966).

117 Mansfield Quadrangle

Map units were reproduced from Stone, B.D., and Peper, J.D., 1982, unpublished field map. Glacial stratified deposits are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Neponset River valley.

118 Norton Quadrangle

Map units were reproduced from Stone, B.D., and Peper, J.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Threemile River and Wading River valleys and the Palmer River, Segreganset River, and Rumford River valleys; and sediments graded to glacial Lake Taunton in the middle Threemile River, Canoe River, and Mulberry Meadow Brook valleys. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Willey (1973). Distribution of bedrock outcrops is from Williams and Willey (1973), Lyons (1977), and Willey and others (1978), and from Stone and Peper on their 1982 unpublished field map. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

119 Somerset Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments graded to glacial Lake Narragansett in the Palmer River, Cole River, and Taunton River valleys, and graded to small glacial lakes in the upper Rocky Run, upper Cole River, and Segreganset River basins. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978), Williams and Willey (1973), and Lyons (1977), and from Peper and Stone on their 1982 unpublished field map. The shallow-bedrock unit represents areas of numerous outcrops.

120 Fall River Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Distribution of bedrock outcrops is from Lyons (1977) and Willey and others (1978), and from Peper on his 1982 unpublished field map. Glacial stratified deposits include glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Cole River, Lee River, and Taunton River valleys. Thick-till areas were delineated based on topographic analysis.

121 Tiverton Quadrangle

Map units were modified from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, a local glacial lake in the Stony Brook (Sawdy Pond) valley. Distribution of bedrock outcrops is from Willey and others (1978) and from Stone on his 1982 unpublished field map. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

122 Haverhill Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

123 South Groveland Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Some bedrock outcrops are from Bell (1976).

124 Reading Quadrangle

Map units were reproduced from Oldale (1962); some additional bedrock outcrops are from Bell (1976). Glacial stratified deposits include glaciofluvial and glaciolacustrine deposits in the Saugus River, Suntaug Lake, and Ipswich River valleys. Fine glacial stratified deposits at the land surface include glacial-lake deposits (unit Ql of Oldale, 1962). Some thick-till areas were reproduced from the drumlin till (unit Qgd of Oldale, 1962). The shallow-bedrock unit is defined as areas "where individual outcrops are not plotted."

125 Boston North Quadrangle

Map units were modified from LaForge (1932) and Chute (western part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial-stream outwash deposits, eskers, and kames of LaForge [1932]; one outwash unit of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Aberjona River, Malden River, Crystal Lake, Mill River, Bennetts Pond Brook, and Saugus River valleys, and glaciofluvial and glaciodeltaic sediments graded to a probable upland ice-dammed basin in northern Revere. Other glaciofluvial and glaciodeltaic sediments underlying Medford and parts of Malden and Revere are graded to the glaciomarine sea level in the Boston basin. Fine deposits in the subsurface beneath marsh deposits are glaciomarine sediments. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Moraine deposits are part of the Fresh Pond moraine (Chute, 1959). Bedrock outcrops and areas of shallow bedrock (from "area of numerous bedrock outcrops") were reproduced from Kaye (1980). Some additional outcrops are from Bell (1976).

126 Boston South Quadrangle

Map units were modified from LaForge (1932) and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge [1932]) are coarse glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in the Boston basin, and glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Muddy River and Neponset River valleys. Fine deposits (some unlabeled units of Kaye [1978]) at the surface and in the subsurface beneath marsh and coarse stratified deposits are glaciomarine sediments. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were reproduced from Kaye (1980).

127 Blue Hills Quadrangle

Map units were modified from Chute (1965a). Glacial stratified deposits include predominantly coarse deposits graded to a series of glacial lakes in the Neponset River valley and tributaries, and in the Monatiquot River valley. Bedrock outcrops were reproduced from Chute (1965a). The shallow-bedrock unit is defined as "areas of numerous outcrops not separately mapped."

128 Brockton Quadrangle

Map units were reproduced from Chute (1950). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the Trout Brook and Salisbury Plain River valleys; and coarse glaciofluvial and glaciodeltaic sediments and finer glaciolacustrine deposits in the Hockomock River valley and tributary valleys.

129 Taunton Quadrangle

Map units were modified from Hartshorn (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as a group of glaciofluvial landforms (units Qic, Qk, Qkt, Qkp, Qow, and Qgf of Hartshorn [1967] included in his glaciofluvial deposits, and kame delta [unit Qkd of Hartshorn, 1967] included in his glaciolacustrine deposits). These deposits were graded to glacial Lake Taunton in the Taunton River lowland. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qk of Hartshorn, 1967). The thick-till unit is from the Qd (drumlin) unit of Hartshorn (1967). Distribution of bedrock outcrops is from Hartshorn (1967) and Williams and Willey (1973). The shallow-bedrock unit represents areas of numerous exposures.

130 Assonet Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Taunton River and Assonet River valleys. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977), and from Stone, 1982, unpublished field map. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

131 Fall River East Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Distribution of bedrock outcrops is from Williams and Willey (1973), Lyons (1977), Willey and others (1978), and Peper (1982 unpublished field map). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the East Branch Westport River, Shingle Island River, and Copicut River valleys. Similar coarse sediments lie along and beneath North Watuppa Pond, and in the upland basin of Queen Gutter Brook. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

132 Westport Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Glacial stratified deposits in the lower East and West Branch valleys include predominantly coarse glaciofluvial and glaciodeltaic sediments graded to the glacial lake in Rhode Island Sound. Coarse glaciofluvial and glaciodeltaic sediments in the upper East Branch and Destruction Brook valleys were graded to small glacial lakes. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978). The shallow-bedrock unit represents areas of abundant outcrop.

133 Exeter Quadrangle

Map units were modified from Goldsmith (2001). Glacial stratified deposits include coarse deposits and glaciomarine fine deposits in the Back River valley and tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Goldsmith (2001).

134 Newburyport West Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock are from Shride (1976); the shallow-bedrock unit represents "areas where surficial deposits are mostly less than 2 m (6 ft) thick; individual outcrops, commonly numerous, are not everywhere shown."

135 Georgetown Quadrangle

Map units were reproduced from Cuppels (1969). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include parts of marine and estuarine deposits (unit Qm of Cuppels, 1969); the fine unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Cuppels (1969).

136 Salem Quadrangle

Map units were reproduced from Oldale (1964); some outcrops are from Bell (1976). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include marine clay deposits (unit Qmd of Oldale, 1964); the fine unit has been extended beneath adjacent water bodies and postglacial deposits on this map. The shallow-bedrock unit is defined as “where individual outcrops are not plotted.”

137 Lynn Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1976, unpublished field map, and Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock (patterned areas are where outcrops are “too abundant to map separately”) were modified from Bell (1977). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Glacial stratified deposits (glacial stream deposits, eskers, and kames of LaForge [1932]; some unlabeled units of Kaye [1976 unpublished field map]) are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Sluice Pond and Spring Pond valleys, and glaciofluvial and glaciodeltaic sediments underlying the cities of Lynn and Marblehead and graded to the glaciomarine sea level in Massachusetts Bay. Fine deposits (some unlabeled units of Kaye (1976 unpublished field map) at the surface and in the subsurface beneath marsh and coarse stratified deposits are glaciomarine deposits. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932).

138 Hull Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1969, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge [1932]; outwash sand and gravel deposit of Kaye [1969 unpublished field map]) are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Town River Bay, Rock Island Cove, and Weymouth River valleys. The distribution of thick-till deposits was modified from the drumlins units of LaForge (1932) and Kaye (1969 unpublished field map). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops were reproduced from Kaye (1969 unpublished field map). Shallow-bedrock areas contain numerous bedrock outcrops.

139 Weymouth Quadrangle

Map units were modified from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the valleys of the Monatiquot River, Weymouth River and tributaries, Weir River and tributaries, and Cushing Brook. A few bedrock outcrop areas are from Lyons (1977).

140 Whitman Quadrangle

Map units were reproduced from Petersen and Shaw (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the French Stream, Beaver Brook, Shumatuscacant River, and Poor Meadow Brook valleys; and finer glaciolacustrine deposits in the Town River, Matfield River, and Satucket River valleys. The shallow-bedrock unit in the northwestern part of the quadrangle is defined as “areas where exposures are numerous.”

141 Bridgewater Quadrangle

Map units were modified from Hartshorn (1960). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as a group of glaciofluvial landforms (units Qic, Qk, Qkt, Qkp, Qow, and Qou of Hartshorn [1960] included in his glaciofluvial deposits, and kame delta [unit Qkd of Hartshorn, 1960] included in his glaciolacustrine deposits). These deposits were graded to glacial Lake Taunton in the Taunton River lowland and to local glacial lakes in the Nemasket River lowland in the southeastern part of the map area. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Taunton (unit Ql of Hartshorn, 1960). Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qk of Hartshorn, 1960). Distribution of bedrock outcrops is from Hartshorn (1960). The shallow-bedrock unit represents areas of numerous exposures.

142 Assawompset Pond Quadrangle

Map units were reproduced from Koteff (1964a). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments grouped in meltwater sequence deposits (units Qc_1, Qc_2, Qc_5–Qc_7, Qce_3, Qce_4, Qcw_3, and Qcw_4 of Koteff [1964a]) and noncorrelated deposits (units Qc and Qsg of Koteff [1964a]). These deposits were graded to local glacial lakes in the Fall Brook and Squam Brook valleys and the Nemasket River lowland. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qc) by Koteff (1964a). Small moraine deposits composed of coarse gravel and sand are unit Qem_2 of Koteff (1964a). Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Willey (1973). Distribution of bedrock outcrops is from Koteff (1964a). The shallow-bedrock unit was modified from the ruled pattern area of bedrock exposures of Koteff (1964a), which is defined as “areas of abundant exposures and thin surficial deposits.”

143 New Bedford North Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Haley, J.C., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, a large glacial lake in the lower Acushnet River valley and small glacial lakes in the valleys of the Paskamanset River and upland Acushnet Cedar Swamp. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

144 New Bedford South Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., assisted by Powars, D.A., and Haley, J.C., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Slocums River and Little River valleys and small glacial lakes in the Paskamanset River valley. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper and Stone (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

145 Cuttyhunk Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field map, and from Stone, B.D., 1982, unpublished field map. Moraine deposits are deposits of the Buzzards Bay moraine.

146 Newburyport East Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock are from Shride (1976); the shallow-bedrock unit represents “areas where surficial deposits are mostly less than 2 m (6 ft) thick; individual outcrops, commonly numerous, are not everywhere shown.”

147 Ipswich Quadrangle

Map units were reproduced from Sammel (1963). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include marine and estuarine clay deposits (unit Qmc of Sammel, 1963). Some thick-till areas were reproduced from the drumlin till unit (Qd) of Sammel (1963).

148 Marblehead North Quadrangle

Map units were modified from Carnevale (1979).

149 Marblehead South Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1976, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge, 1932) are coarse glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in Massachusetts Bay. Fine deposits in the subsurface beneath marsh deposits are glaciomarine deposits. Thin-till deposits are areas of ground moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were modified from Bell (1977). Shallow-bedrock areas were modified from patterned areas of Bell (1977) where outcrops are “too abundant to map separately.”

150 Nantasket Beach Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1969, unpublished field map, and Stone, B.D., 1982, unpublished field map. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932) and Kaye (1969 unpublished field map). Thin-till deposits are areas of ground moraine and deposits of LaForge (1932). Bedrock outcrops were reproduced from Kaye (1969 unpublished field map). Shallow-bedrock areas contain numerous bedrock outcrops.

151 Cohasset Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map, and from Crosby (1900). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of Herring Brook and the North River and their tributaries. A few bedrock outcrop areas are from Lyons (1977).

152 Hanover Quadrangle

Map units were reproduced from Shaw and Petersen (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as sequential outwash plains.

153 Plympton Quadrangle

Map units were reproduced from Goldthwait, R.P., and Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Carver outwash plain (Mather and others, 1942; Larson, 1982) in the southeastern part of the quadrangle, as kames and kame deltas in the northeastern part of the quadrangle, and as kames and kame deltas that were graded to glacial Lake Taunton in the Taunton River lowland in the northwestern part of the quadrangle (Lake Taunton of Larson, 1982; Stone and Peper, 1982). Other parts of these deposits were graded to local glacial lakes in the Shorts Brook and upper Winnetuxet River lowlands in the southwestern and central parts of the quadrangle. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977).

154 Snipatuit Pond Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Weweantic River and Sippican River valleys. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977).

155 Marion Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Nasketucket River, Sippecan River, and Mattapoisett River valleys, and coastal valleys. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper and Stone (1982 unpublished field map).

156 Sconticut Neck Quadrangle

Map units were reproduced from Peper, J.D., assisted by Buchanan, J., 1982, unpublished field map. Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper (1982 unpublished field map).

157 Naushon Island Quadrangle

Map units were modified from Kaye (1972); from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field map; and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Buzzards Bay moraine.

158 Squibnocket Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

159 Gloucester Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

160 Scituate Quadrangle

Map units were modified from Chute (1965c). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of the North River and its tributaries. Coastal-plain sediments described by Chute (but only mapped as exposed at Third Cliff) have been expanded upon in this report in description (glacially modified coastal-plain hill deposits) and extent to include the Marshfield Hills and other hills previously mapped as drumlins or Qgm by Chute (1965c).

161 Duxbury Quadrangle

Map units were reproduced from Chute (1965b). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as outwash plains, and finer glaciolacustrine deposits in the Jones River valley. Coastal-plain sediments described by Chute (but only mapped by him as exposed at Third Cliff in the Scituate quadrangle) have been expanded upon in this report in description (glacially modified coastal-plain hill deposits) and extent to include the Marshfield Hills and other hills previously mapped as Qgm by Chute (1965b).

162 Plymouth Quadrangle

Map units were reproduced from Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped (1) as part of the Wareham, King's Pond, and Carver outwash plains and as collapsed sand and gravel sediments of the Ellisville and Hog Rock moraines (Mather and others, 1942; Larson, 1982) in the southwestern part of the quadrangle; (2) as deposits of the Plymouth kame field in the northeastern part of the quadrangle; and (3) as kames and kame deltas graded to a glacial lake in the Jones River lowland (Larson, 1982; Stone and Peper, 1982). Small moraine deposits composed of till overlying gravel and sand are modified from deposits of the Monk's Hill moraine of Thiesmeyer (1940 unpublished field map). Distribution of bedrock outcrops is from Thiesmeyer's unpublished field map and from Stone (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

163 Wareham Quadrangle

Map units were reproduced from Goldthwait, R.P., and Thiesmeyer, L.R., 1940, unpublished field maps, and Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Wareham and King's Pond outwash plains and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders (Mather and others, 1942; Larson, 1982). Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

164 Onset Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the coastal valley; these deposits were mapped as part of the Wareham outwash plain and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Other parts of these deposits were graded to local glacial lakes in the southeastern and northeastern parts of the quadrangle. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

165 Woods Hole Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Buzzards Bay moraine.

166 Vineyard Haven Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

167 Tisbury Great Pond Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

168 Rockport Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

169 Manomet Quadrangle

Map units were modified from Goldthwait, R.P., and Thiesmeyer, L.R, 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments, mapped as part of the Wareham outwash plain. These deposits also include the collapsed sand and gravel sediments of the Ellisville moraine (Mather and others, 1942; Larson, 1982) in the southwestern part of the quadrangle, deposits of the Plymouth kame field in the northwestern part of the quadrangle, and kames and kame deltas graded to glacial Lake Cape Cod Bay (Larson, 1982; Stone and Peper, 1982) in the eastern part of the quadrangle. The glacially modified coastal-plain hill deposits beneath the Pine Hills, Indian Hill, and Telegraph Hill are known from geophysical studies and drill-hole samples (Hansen and Lapham, 1992) and from exposures in the sides of the hills.

170 Sagamore Quadrangle

Map units were modified from Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Wareham outwash plain and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Other parts of these deposits were graded to local glacial lakes in the southeastern and northeastern parts of the quadrangle. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders. Moraine deposits are part of the Sandwich moraine (Thiesmeyer, L.R., 1940, unpublished field map) in the southern part of the quadrangle. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

171 Pocasset Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Sandwich and Buzzards Bay moraines. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

172 Falmouth Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Buzzards Bay moraine. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

173 Edgartown Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits are glaciofluvial sediments.

174 Sandwich Quadrangle

Map units were reproduced from Oldale (1975b). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1975b).

175 Cotuit Quadrangle

Map units were reproduced from Oldale (1975a). Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits.

176 Hyannis Quadrangle

Map units were reproduced from Oldale (1974b). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1974b).

177 Tuckernuck Island Quadrangle

Map units were reproduced from Oldale (1985). Glacial stratified deposits are glaciofluvial sediments.

178 Provincetown Quadrangle

Map units were reproduced from Hartshorn, J.H., 1967, unpublished field map.

179 Dennis Quadrangle

Map units were reproduced from Oldale (1974a). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial, glaciolacustrine, and kame deposits.

180 Nantucket Quadrangle

Map units were reproduced from Oldale (1985). Moraine deposits are part of the Nantucket moraine. Glacial stratified deposits are glaciofluvial sediments.

181 North Truro Quadrangle

Map units were reproduced from Koteff and others (1967). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments.

182 Wellfleet Quadrangle

Map units were reproduced from Oldale (1968). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay.

183 Orleans Quadrangle

Map units were reproduced from Oldale and others (1971). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale and others, 1971).

184 Harwich Quadrangle

Map units were reproduced from Oldale (1969). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale, 1969).

185 Chatham Quadrangle

Map units were reproduced from Oldale and Koteff (1970). Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits.

186 Monomoy Point Quadrangle

Map units were reproduced from Koteff and others (1968).

187 Great Point Quadrangle

Map units were reproduced from Oldale (1985).

188 Siasconset Quadrangle

Map units were reproduced from Oldale (1985). Moraine deposits are part of the Nantucket moraine. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

189 Hampton Quadrangle

Map unit was reproduced from Koteff and others (1989).

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