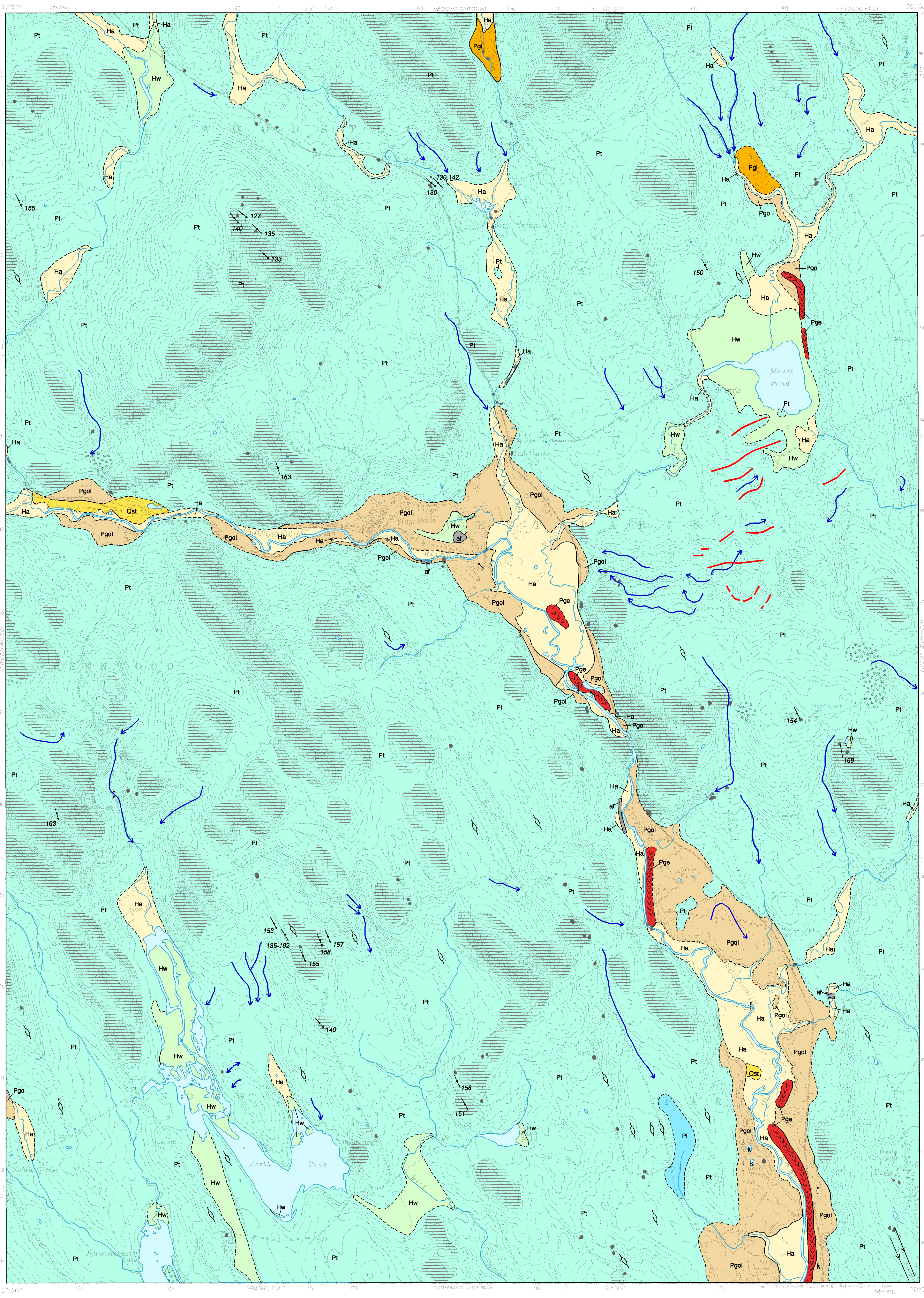
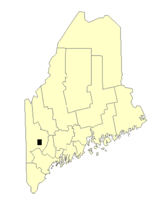
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the West Paris quadrangle was conducted by Woodrow B. Thompson in 1983 for the Maine Geological Survey's sand and gravel aquifer mapping program and in 2007 for the STATEMAP program. Additional data were collected during the 1980's and 1990's by W. B. Thompson.



Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey West Paris quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

West Paris Quadrangle, Maine

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SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys, eroding and transporting boulders and other rock debris for miles. The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the West Paris quadrangle.

The most recent "Ice Age" in Maine began about 30,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement. Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 calendar years ago, soon after it reached its southernmost position on Long Island (Ridge, 2004). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by about 16,000 years ago (Borns and others, 2004). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 420 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land rebounded as the weight of the ice sheet was removed, forcing the sea to retreat.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared. Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were deposited along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat.

The last remnants of glacial ice probably were gone from Maine by 12,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land, and worldwide sea level is gradually rising against Maine's coast.

References Cited

Borns, H. W., Jr., Doner, L. A., Dorion, C. C., Jacobson, G. L., Jr., Kaplan, M. R., Kreutz, K. J., Lowell, T. V., Thompson, W. B., and Weddle, T. K., 2004, The deglaciation of Maine, U.S.A., *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations – Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 89-109.

Davis, R. B., and Jacobson, G. L., Jr., 1985, Late-glacial and early Holocene landscapes in northern New England and adjacent areas of Canada: Quaternary Research, v. 23, p. 341-368.

Ridge, J. C., 2004, The Quaternary glaciation of western New England with correlations to surrounding areas, *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations – Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 169-199.

Stone, B. D., and Borns, H. W., Jr., 1986, Pleistocene glacial and interglacial stratigraphy of New England, Long Island, and adjacent Georges Bank and Gulf of Maine, *in* Sibrava, V., Bowen, D. Q., and Richmond, G. M. (editors), Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 39-52.

Thompson, W. B., Locke, D. B., Neil, C. D., and Rawcliffe, R. J., 2000, Investigation of sub-till glacial fan gravels in western Maine using ground-penetrating radar (abs.): Geological Society of America, Abstracts with programs, v. 32, no. 1, p. A78-A79.

Figure 1: Bedrock outcrop on northeast side of Route 26 in Woodstock. As the ice flowed southeast over the ledge (toward upper left in photo) rock debris in the base of the glacier engraved parallel striations on the ledge surface. Glacial abrasion has also polished the surface, making it brightly reflective in sunlight. The pencil is oriented in the direction of ice flow.

Figure 2: Exposure of very dense silty-sandy glacial till in bottom of pit located east of Witt Hill in Norway. This material is lodgement till, which was greatly compacted at the base of an ice sheet. Its age is unknown, and it may have been deposited during the penultimate glaciation of Maine. It is overlain by the stratified gravel shown in Figure 3.

Figure 3: Compact, well-stratified gravel and gravelly sand in the same pit as Figure 2. Elsewhere in pit, this unit is overlain by lodgement till that presumably was deposited during the most recent (late Wisconsinan) glaciation. The origin of the gravel is uncertain, but similar deposits of compact gravel overlain by till occur on the south sides of bedrock hills elsewhere in Oxford County. They seem unrelated to surface meltwater drainage and possibly formed in subglacial cavities or as proglacial outwash fans that were overridden by advancing ice (Thompson and others, 2000). Field tests at this locality and a similar deposit in Lovell, Maine, showed that ground-penetrating radar can be used as a prospecting tool to locate these stratified gravels in places where the till cover is not too thick.

Figure 4: Pit showing cross-section of esker ridge on west side of Route 26 in Paris. Eskers mark the paths of ice-walled tunnels in which meltwater streams flowed rapidly under pressure along the base of the last glacial ice sheet. The subglacial streams carried sand and gravel that eventually filled parts of the tunnels and remained as esker ridges when the surrounding ice melted. Eskers are important sources of ground water and sand and gravel for construction. The example seen here is part of a segmented esker system extending from the Quebec border south to Gray, Maine.

Figure 5: View north across meltwater channel in West Paris. As the glacier margin retreated north from the Moose Pond Brook basin, meltwater draining along the front of the ice sheet eroded a series of channels on the south side of the basin. The channels were cut in glacial till. In this example, stream flow was to the west (right to left in photo). Ridges and mounds of till (end moraines) were deposited south of Moose Pond, as shown on the map.

Figure 6: Waterfall on the Little Androscoggin River at west border of the quadrangle. This gorge may have been initiated by a glacial meltwater stream. It shows potholes and undercut ledges.

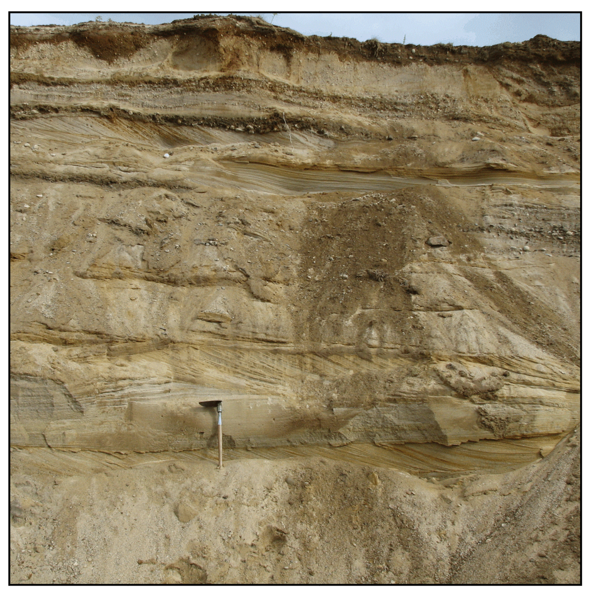

Figure 7: Glacial outwash (map unit **Pgol**) on west side of the Little Androscoggin Valley in Paris. Direction of stream flow was from left to right (generally southward). Pit face is about 30 ft high.

Figure 8 : Wetland (center) in northern arm of North Pond in Norway. This appears to be a drowned alluvial deposit, possibly resulting from damming of the pond outlet.

Explanation of Map Units

- **Ha** — **Stream alluvium** - Sand, silt, gravel, and organic sediment. Deposited on flood plains of streams. Unit includes some wetland areas, and may also include low terraces that are not flooded often.
- **Hw** — **Wetland deposits** - Peat, muck, silt, and clay. Deposited in poorly drained areas on valley floors. Unit may grade into or include areas of stream alluvium.
- **Qst** — **Stream terraces** - Sand and gravel terraces in the Little Androscoggin River valley. Formed by postglacial erosion and deposition along the river. The terraces are former flood plains, and their elevations are higher than the modern flood plain but lower than adjacent (older) glacial outwash surfaces.
- **Pl** — **Glacial lake deposit** - Silt and sand deposited in a small glacial lake that is inferred to have been dammed by ice in the Little Androscoggin Valley.
- **Pgo** — **Outwash deposits** - Sand and gravel deposited by glacial meltwater streams along the Bog Brook valley and one of its tributaries, and in a small unnamed valley in the southwest part of the quadrangle.
- **Pgol** — **Outwash deposits** - Sand and gravel deposited by glacial meltwater streams in the Little Androscoggin River valley.
- **Pgi** — **Ice-contact deposits** - Sand and gravel deposits formed in contact with remnants of glacial ice.
- **Pge** — **Esker deposits** - Sand and gravel deposited by meltwater streams in subglacial tunnels that developed in valleys.
- **Pt** — **Till** - Loose to very compact, poorly sorted, massive to weakly stratified mixture of sand, silt, and gravel-size rock debris deposited by glacial ice. Locally includes lenses of water-laid sand and gravel.
- **Bedrock outcrops/thin-drift areas** - Ruled pattern indicates areas where outcrops are common and/or surficial sediments are generally less than 10 ft thick (mapped partly from air photos). Dots show individual outcrops.
- **af** — **Artificial fill** – Earth, rock, and man-made debris along roads, railroads, and in landfills.

Map Symbols

- **Contact** - Boundary between map units. Dashed where approximately located.
- **Glacially streamlined hill** - Symbol shows trend of long axis, which is parallel to former glacial ice-flow direction.
- **Fluted till** - Narrow ridges of till shaped by flow of glacial ice.
- **Glacial striation locality** - Arrow shows ice-flow direction inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction.
- **End moraine** - Red line indicates the axis of a till ridge which is inferred to have been deposited at the margin of the last ice sheet in late-glacial time. A swarm of moraines and meltwater channels formed as the ice margin retreated from the south side of the Moose Pond basin. Dashed where inferred.
- **Meltwater channel** - Channel eroded by a glacial meltwater stream. Arrow shows inferred direction of water flow.
- **>>>>>** **Crest of esker** - Shows trend of esker ridge. Chevrons point in direction of glacial meltwater flow.
- **Area of large boulders** - Area of glacial till where there are many large boulders, typically 3-5 ft or larger, scattered over the ground surface. These areas have been mapped only where observed, and they are likely to occur elsewhere in the till-covered uplands.
- **Dip of cross-bedding** - Arrow shows average dip direction of cross-bedding in sand and gravel deposits formed in a glacial or postglacial stream. This indicates the direction of water flow. Dot marks point of observation.
- **k** **Kettle** - "k" indicates a depression left by the melting of a stagnant glacial ice mass.

USES OF SURFICIAL GEOLOGY MAPS

A surficial geology map shows all the loose materials such as till (commonly called hardpan), sand and gravel, or clay, which overlie solid ledge (bedrock). Bedrock outcrops and areas of abundant bedrock outcrops are shown on the map, but varieties of the bedrock are not distinguished (refer to bedrock geology map). Most of the surficial materials are deposits formed by glacial and deglacial processes during the last stage of continental glaciation, which began about 25,000 years ago. The remainder of the surficial deposits are the products of postglacial geologic processes, such as river floodplains, or are attributed to human activity, such as fill or other land-modifying features.

The map shows the areal distribution of the different types of glacial features, deposits, and landforms as described in the map explanation. Features such as striations and moraines can be used to reconstruct the movement and position of the glacier and its margin, especially as the ice sheet melted. Other ancient features include shorelines and deposits of glacial lakes or the glacial sea, now long gone from the state. This glacial geologic history of the quadrangle is useful to the larger understanding of past earth climate, and how our region of the world underwent recent geologically significant climatic and environmental changes. We may then be able to use this knowledge in anticipation of future similar changes for long-term planning efforts, such as coastal development or waste disposal.

Surficial geology maps are often best used in conjunction with related maps such as surficial materials maps or significant sand and gravel aquifer maps for anyone wanting to know what lies beneath the land surface. For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or pottery. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or siting new homes may be better planned with a good knowledge of the surficial geology of the site. Refer to the list of related publications below.

OTHER SOURCES OF INFORMATION

1. Thompson, W. B., and Locke, D. B., 2008, Surficial materials of the West Paris quadrangle, Maine: Maine Geological Survey, Open-File Map 08-34.
2. Neil, C. D., 2008, Significant sand and gravel aquifers of the West Paris quadrangle, Maine: Maine Geological Survey, Open-File Map 08-58.
3. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
4. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.