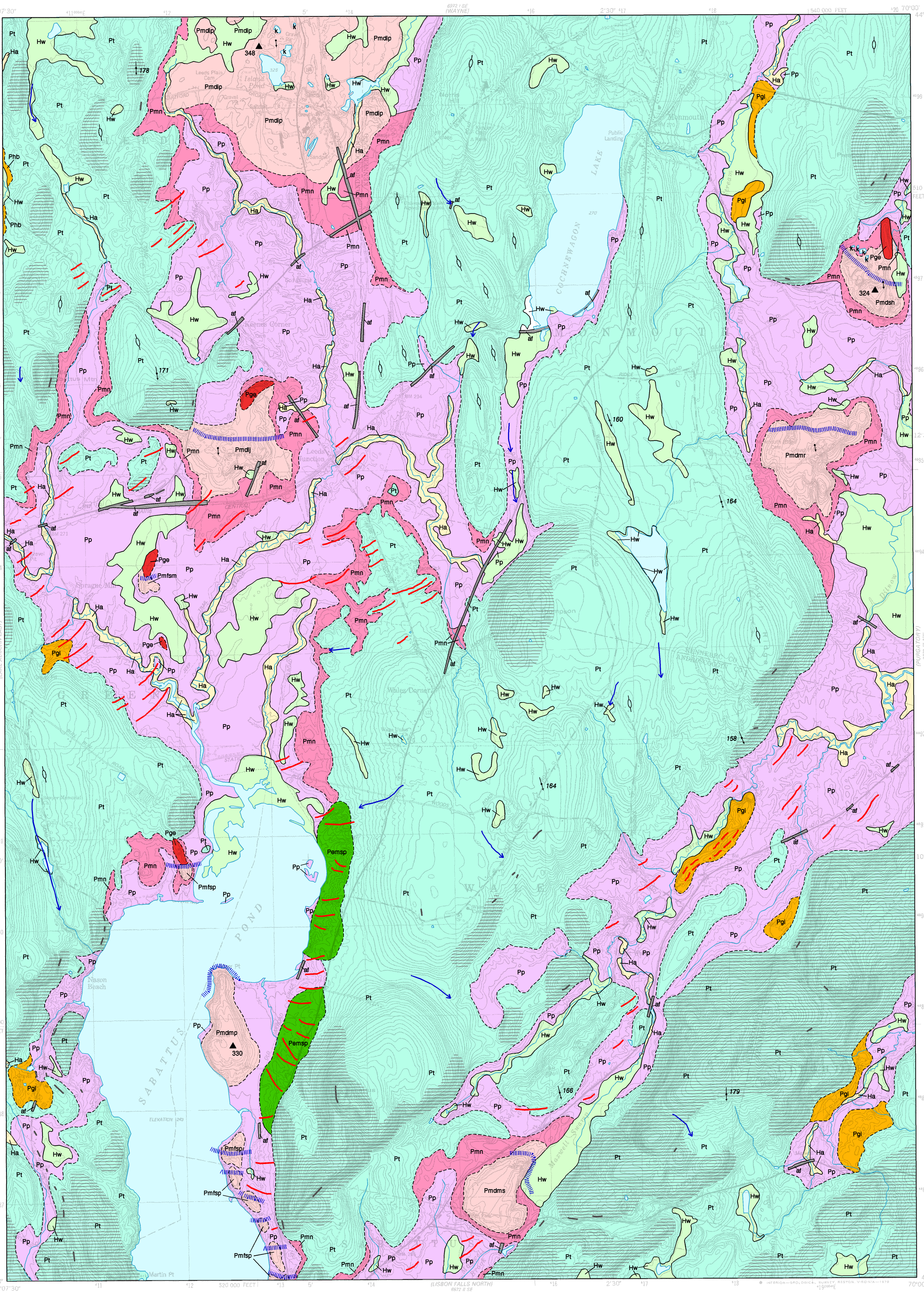
Surficial Geology



SOURCES OF INFORMATION

Modified in 2008 based on field work by Woodrow B. Thompson. Surficial geologic mapping by Michael E. Foley completed during the 2001-2002 field seasons; funding for this work provided by the U.S. Geological Survey STATEMAP program.

Quadrangle Location

SCALE 1 : 24,000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Monmouth 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.

af — **Artificial fill** - Includes landfills, highway, and railroad embankments. These units are mapped only where they are resolvable using the contour lines on the map, or where they define the limits of wetland units. Minor artificial fill is present in virtually all developed areas of the quadrangle.

Ha — **Stream alluvium** - Gray to brown fine sand and silt with some gravel. Comprises flood plains along present streams and rivers. Extent of alluvium approximates areas of potential flooding.

Hw — **Freshwater wetlands** - Muck, peat, silt, and sand. Poorly drained areas, often with standing water.

Pmn — **Marine nearshore deposits** - Pleistocene gravel, sand, and mud deposited as a result of wave activity in nearshore or shallow-marine environments; not associated with beach morphology.

Pp — **Presumpscot Formation** - Massive to laminated silty clay with rare dropstones and occasional shelly horizons, which overlie rock and till, and are interbedded with and overlie end moraines and marine fan deposits; includes sand deposited as a distal unit of submarine fans.

Pem — **End moraines** - Linear ridges consisting of bedded sand and gravel interbedded with Presumpscot Formation silty clay. May be overlain by till on the ice-proximal faces of the moraines. One series of moraines has been assigned the unique geographic name listed below:

Pemsp - Sabattus Pond moraines

Pmd — **Marine delta** - Glacial-marine delta composed primarily of sorted and stratified sand and gravel. Deposit was graded to surface of late-glacial sea and is distinguished by flat top and foreset and topset beds. Deltas have been assigned the unique geographic name listed below:

Pmdip - Island Pond delta; topset-foreset contact at elevation 348 feet (Thompson and others, 1989).
Pmdlj - Leeds Junction delta.
Pmdmp - Marr Point delta; topset-foreset contact at elevation 330 feet (Bernotavicz, 1994).
Pmdms - Maxwell Swamp delta.
Pmdmr - Monmouth Ridge delta.
Pmdsh - Sawyer Hill delta; topset-foreset contact at elevation 324 feet (Thompson and others, 1989).

Pmf — **Submarine outwash fans** - Thick sand and gravel accumulations formed at the mouth of subglacial tunnels along the receding late Pleistocene ice margin. The sand and gravel is interbedded with and overlain by Presumpscot Formation clay at the distal edges of the fans, and may be interlayered with and overlain by till at their ice-contact faces. Some fans, or groups of fans have been assigned a unique geographic name listed below:

Pmfsp - Sabattus Pond fans
Pmfsm - Sprague Mills fan

Phb — **Glaciofluvial and glaciomarine deposits of Hooper Brook valley** - Sand, silt, gravel, and mud. Consists of fluvial, subaqueous fan, and outwash deposits graded to the contemporary sea. In places, coated with unmapped thin dune deposits.

Pgi — **Ice-contact deposits** - Sand and gravel deposited against remnant masses of glacial ice; massive to well stratified; commonly has collapse features and irregular topography.

Pge — **Esker deposits** - Sand and gravel deposited by glacial meltwater flowing in tunnels within or beneath the ice.

Pt — **Till** - Gravelly to bouldery, sandy, or silty diamicton. Weakly to non-stratified. Deposited directly from glacial ice.

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). Gray areas and dots show individual outcrops.

Contact between units; dashed where inferred.

135 — **Glacial striations or grooves** - observations made at dot. Number indicates azimuth (in degrees) of ice-flow direction.

End moraine - Ridge of till, sand, and gravel deposited and/or deformed by glacial ice, often mantled by Presumpscot Formation.

Meltwater channel - Channel eroded by meltwater or later meteoric runoff.

Ice margin position - Line shows an approximate position of the ice margin during glacial retreat.

Drumlin or glacially streamlined hill.

k — **Kettle** - Depression created by melting of buried glacial ice and collapse of overlying sediments.

▲350 — **Glaciomarine delta** - Elevation (in feet) of contact between topset and foreset beds, which indicates position of corresponding sea level at the time of deposition (from Thompson and others, 1989 and Bernotavicz, 1994).

Dip of cross-bedding - Arrow shows average dip direction of cross-bedding in fluvial or deltaic deposits, which indicates direction of stream flow or delta progradation. Point of observation at tip of arrow.

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 may include landforms which may record a specific type of environment or climate, 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. Locke, D. B., and Foley, M. E., 2002, Surficial materials of the Monmouth quadrangle, Maine: Maine Geological Survey, Open-File Map 02-160.
2. Neil, C. D., 1998, Significant sand and gravel aquifers of the Monmouth quadrangle, Maine: Maine Geological Survey, Open-File Map 98-225.

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Monmouth 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 (**Figure 1**), eroding and transporting boulders and other rock debris for miles (**Figure 2**). 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 Monmouth 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 (**Figure 3**). 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 (**Figure 4**) 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 (**Figure 5**). 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 constructed 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 (**Figure 6**).

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 (**Figure 7**). 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 (**Figure 8**), and worldwide sea level is gradually rising against Maine's coast.

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Figure 1: "The Bubbles" and Jordan Pond in Acadia National Park. These hills and valleys were sculpted by glacial erosion. The pond was dammed behind a moraine ridge during retreat of the ice sheet.

Figure 2: Daggett's Rock in Phillips. This is the largest known glacially transported boulder in Maine. It is about 100 feet long and estimated to weigh 8,000 tons.

Figure 3: Granite ledge in Westbrook, showing polished and grooved surface resulting from glacial abrasion. The grooves and shape of the ledge indicate ice flow toward the southeast.

Figure 4: Glaciomarine delta in Franklin, formed by sand and gravel washing into the ocean from the glacier margin. The flat delta top marks approximate former sea level. Kettle hole in foreground was left by melting of ice.

Figure 5: Esker cutting across Kezar Five Ponds, Waterford. The ridge consists of sand and gravel deposited by meltwater flowing in a tunnel beneath glacial ice.

Figure 6: Aerial view of moraine ridges in blueberry field, Sedgwick (note dirt road in upper right for scale). Each bouldery ridge marks a position of the retreating glacier margin. The ice receded from right to left.

Figure 7: Sand dune in Wayne. This and other "deserts" in Maine formed as windstorms in late-glacial time blew sand out of valleys, often depositing it as dune fields on hillsides downwind. Some dunes were reactivated in historical time when grazing animals stripped the vegetation cover.

Figure 8: Songo River delta and Songo Beach, Sebago Lake State Park, Naples. These deposits are typical of geological features formed in Maine since the Ice Age.