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Surficial materials of the Limerick quadrangle, Open-File 98-170

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Surficial Geology of the Limerick 7.5-minute Quadrangle, York County, Maine

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INTRODUCTION

The surficial geology of the Limerick 7.5-minute quadrangle provides a record of late Wisconsinan glaciation and deglaciation in southwestern Maine. In general, the area is blanketed by till, which is overlain by glaciofluvial and glaciolacustrine deposits in the lowlands. Smith (1977) mapped surficial deposits of the Limerick quadrangle at a scale of 1:62,500 on the basis of reconnaissance field work and air photo interpretation. A more detailed field study was undertaken in 1992, which is the basis of this report.

Two maps are associated with this report: a materials map (Wilch, 1998) and a surficial geologic map (Wilch, 1999). Both maps were constructed on the 7.5-minute Limerick topographic quadrangle map at a scale of 1:24,000 and contour interval of 20 feet. The materials map shows the thickness, texture, and composition of surficial deposits. This map is mostly a compilation of data from gravel pits, roadcuts, and shovel test holes. It also includes some archived borehole and well records from the Maine State Highway Commission (1970) and Maine Geological Survey (Lanctot and Tolman, 1985, and unpublished data). Some rock outcrops were inferred from air photos and from York County soil survey maps (National Cooperative Soil Survey, 1982). The geologic map shows the distribution of surficial deposits and landforms in the quadrangle and delineates glacial ice flow and meltwater flow direction indicators. This map is based on detailed field observations and topographic map and air photo interpretations.

The Limerick 7.5-minute quadrangle is located in York County, southwestern Maine, approximately 25 miles west of Portland. The boundaries of the quadrangle extend from 43^{o}37'30"N to 43^{o}45'N and from 70^{o}45'W to 70^{o}52'30"W. The quadrangle covers 55 square miles (143 square kilometers), including parts of five townships (Limerick, Cornish, Parsonsfield, Newfield, and Waterboro) and the villages of East Parsonsfield, Limerick, Limerick Mills and Newfield.

The general physiography of the northern two-thirds of the quadrangle is characterized by northwest-southeast trending hills and drainages. The southern third of the area is bisected by the east-flowing Little Ossipee River, which flows east and then north until it joins the Saco River near South Limington. Most drainage in the quadrangle is directed toward the Little Ossipee River or natural lakes and ponds. The highest elevation in the quadrangle is about 1200 feet above sea level (asl) at Sawyer Mountain in the northeast corner of the quadrangle. Maximum local relief is about 800 feet, from the top of Sawyer Mountain to the Leavitt Brook drainage. The lowest elevation is 307 feet asl at the surface of Lake Arrowhead, southeast of Limerick. Wetland deposits are abundant in lowland areas, particularly adjacent to small streams and ponds.

Glacial deposits and landforms suggest that the modern physiography of the quadrangle is mostly unchanged since retreat of the late Wisconsinan continental ice sheet, which occurred about 14000-13000 years before present (B.P.) (Thompson and Borns, 1985a, 1985b). Numerous streamlined bedrock and till hills indicate that late Pleistocene ice flow was directed toward the southeast. The topography along the principal drainage paths is either very hummocky with abundant elongate esker ridges and kettle holes, characteristic of glaciofluvial ice-contact deposits, or consists of relatively flat parallel benches, characteristic of glaciofluvial terraces. Sand plains, interpreted as ice-contact glaciolacustrine delta deposits, occur in broad lowlands mostly in the eastern and southern parts of the quadrangle.

BEDROCK GEOLOGY

Hussey (1985) summarized the basement geology of southern Maine. In the Limerick quadrangle the bedrock is characterized by Silurian to early Devonian age sediments that were metamorphosed during the Devonian Acadian orogeny and later intruded by Devonian and Mesozoic plutons. The metasediments are assigned to the Lower Member of the Rindgemere Formation of the Shapleigh Group. They are dominated by a sequence of folded and metamorphosed pelites and argillaceous sandstones that include minor thin discontinuous belts of calcareous sediments and rusty-weathered pelites. Two Devonian age oval-shaped plutons occur in the area: a two-mica granite body (5 x 4 km) is situated southwest of Sawyer Mountain, and a biotite granodiorite body (4 x 14 km) extends across the southwest corner of the quadrangle in the Newfield area (Gilman, 1972). The metasediments and Devonian plutons exhibit a northwest-southeast structural trend that is attributed to intrusion of the Sebago batholith in Mississippian time (Hussey, 1985). The bedrock structural trend roughly parallels the glacial ice-flow direction in the area.

Three smaller plutons, assumed to be Mesozoic in age, occur along the western border of the quadrangle (Gilman, 1972). The granitic Picket Mountain stock (3 x 4 km) and syenitic Symmes Pond stock (1 x 1 km) intrude the Devonian granodiorite pluton in the Newfield area. The syenitic and trachytic Randall Mountain stock (1 x 3 km), centered on Randall Mountain southwest of East Parsonsfield, intrudes metasediments of the Rindgemere Formation.

Extensive rock outcrops occur on several hilltops in the quadrangle, including Knox Mountain and Picket Mountain in the southwest corner; Randall Mountain along the western border; and from Bald Head to Sawyer Mountain along the northern border. Numerous small outcrops occur on hilltops and in roadcuts throughout the area. On the surficial geologic map accompanying this report, rock outcrops are denoted `rk' and delineated by solid black dots and patches. A rock quarry, owned and operated by F. R. Carroll of Limerick, is located west of Sawyer Mountain in the Devonian granite pluton.

SURFICIAL DEPOSITS

Surficial deposits in the quadrangle are dominated by glacial, glaciofluvial, and glaciolacustrine sediments that are attributed to the late Wisconsinan ice advance and retreat from New England. Postglacial stream and swamp and modern artificial fill deposits are superimposed on the late-glacial landscape. Surficial deposits are described below in general stratigraphic succession from oldest to youngest (see Figure 1 for interpretation of chronology.)

Thin drift

Thin drift areas, defined as places where sediment cover over bedrock is generally less than 10 feet thick, are common on highlands in the quadrangle. These areas are approximately delineated on the map (horizontal ruled pattern) on the basis of bedrock outcrop distributions, field observations, and air photo interpretation. Thin drift is generally composed of a patchy veneer of glacial till and/or erratic boulders (described below). South-directed glacial striations (azimuth 160°-185°) are abundant on exposed bedrock in thin drift areas on Hosac Mountain, located in the northeast corner of the area.

Till

Till (map unit Pt) blankets the hillslopes and hilltops throughout the area. Much of the till occurs in the thin drift areas described above. The till consists of poorly sorted, weakly stratified to non-stratified diamicton with a silty-sandy matrix that mantles hills and upland valleys in the area. Particle sizes in till range from clay to boulder. Pebble- to boulder-size clasts are commonly striated and faceted as a result of glacial abrasion. The color of unoxidized till matrix is light olive gray to light brownish gray (Munsell colors from 2.5Y 6/2 to 5Y 7/4). Two varieties of till, indurated silty-clayey basal till and unconsolidated silty-sandy ablation till, were recognized on the materials map (ds and dt), but were not differentiated on the geologic map. The ablation till was observed more commonly.

The till unit also includes erratic boulders that are dispersed on till and exposed bedrock surfaces. Areas with concentrations of surface boulders larger than 3 feet (1 meter) in diameter are designated on the map by clusters of small circles. A maximum surface boulder size of 12 feet (4 meters) in diameter was observed on Pickerel Hill northeast of Limerick Mills.

Glaciolacustrine Deposits

Two glaciolacustrine delta complexes, the Glacial Lake Mousam delta (Plmd and Plmdi) and the Glacial Lake Arrow-

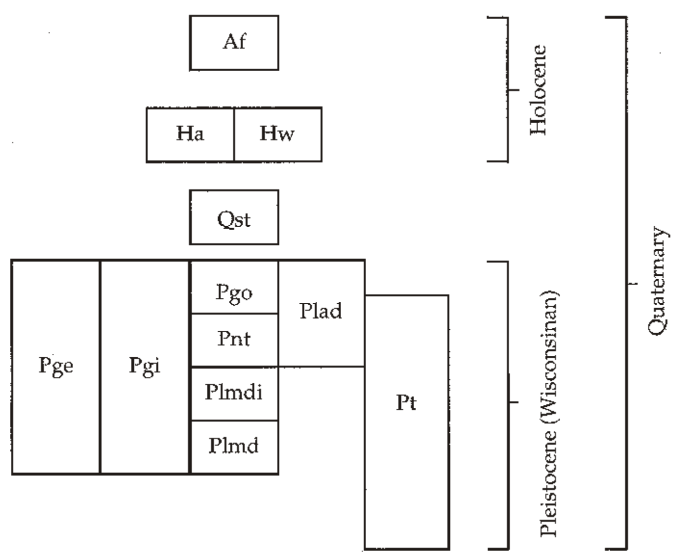

Figure 1. Provisional relative age chronology of map units in the Limerick quadrangle.

head delta (Plad), were mapped in the southwestern and eastern parts of the quadrangle, respectively. These deltas are located in sandy areas with relatively flat topography. Both delta complexes formed in proglacial paleo-lakes that extended to the south and east of the quadrangle. The Glacial Lake Mousam delta complex (Plmd and Plmdi), situated in an upland position (to 500 feet asl) relative to the Glacial Lake Arrowhead delta (Plad) (360 feet asl), is considered to be the older delta complex.

Glacial Lake Mousam delta deposits (Pldm) are located south of the village of Newfield, where sandy and gravelly-sandy stratified and cross-stratified sediments reach elevations of 480-500 feet. These delta deposits are generally poorly exposed except in small roadcuts near Silver Lake. The Pldm unit extends southward into the Mousam Lake 7.5-minute quadrangle (Meglioli, 1997a,b). In the Limerick quadrangle, the delta deposits represent the northern limit of Glacial Lake Mousam, a paleo-lake that Megioli (1997a,b) suggested formed by damming of the drainage south of Mousam Lake. Drainage of the northern part of Glacial Lake Mousam was locally blocked by bedrock hills to the west and by glacial ice in the Little Ossipee River valley to the east.

Southeast of the village of Newfield, an unusual and very prominent ice-disintegration landform (Plmdi) has a maximum elevation over 500 feet asl, with more than 100 feet of relief. This feature extends from south of the Little Ossipee River, along the east side of Silver Lake, and continues into the Mousam Lake quadrangle. The top surface consists of a series of ridges that trend roughly N80^{o}E, approximately perpendicular to Wisconsinan ice-flow in the area. The top surface is pitted with closed depressions interpreted as kettles. The deposits are composed of sand and minor gravel. Internal sedimentary structures and contacts of the deposits are poorly exposed. The sandy nature of the deposits, and upper elevations similar to nearby Glacial Lake Mousam delta deposits, suggest that these deposits are deltaic in origin. The hummocky topography and prominent ridges suggest that the deposits formed in the collapsed ice-marginal zone at the head of the Glacial Lake Mousam delta.

Glacial Lake Arrowhead delta deposits (Plad) can be traced south from near Limerick Mills along Lake Arrowhead toward Ossipee Mills, where they extend upstream in the Little Ossipee River and Pendexter Brook drainages. The delta reaches a maximum elevation of approximately 360 feet asl. Delta deposits around Lake Arrowhead and Ossipee Mills extend across the southwest corner of the Limington quadrangle to the head of Little Ossipee Pond (Meglioli, 1999a,b).

The best exposures of the Glacial Lake Arrowhead delta deposits (Plad) are in gravel pits (map data stations L16 and L18) east of Limerick Mills and south of Pickerel Pond, where the upper surface of the sand facies is at approximately 340 feet asl. In these pits, approximately 7 feet of crudely bedded sandy gravel overlies more than 12 feet of rippled and cross-bedded medium to very fine sand. Foreset beds dip generally toward the south, although there is not a single preferred direction. In most other places the delta foreset deposits are dominated by medium sand, with lesser amounts of coarse and fine sand. The topography of many of the delta surfaces is disrupted and slightly irregular, which is attributed to post-depositional melting of buried ice blocks. Prominent eskers project above the Plad deposits west of Lake Arrowhead. These eskers formed in subglacial tunnels either prior to or at the time of delta formation.

Glaciofluvial Deposits

Glaciofluvial deposits in the quadrangle include undifferentiated ice-contact deposits (Pgi), esker ridges (Pge), the Newfield stream terraces (Pnt), and outwash deposits (Pgo). These deposits are exposed in gravel pits throughout the quadrangle. They are concentrated mostly along several stream valleys, including the Little Ossipee River valley, and often occur adjacent to each other. Several abandoned meltwater channels were identified on the map.

Ice-contact deposits (Pgi and Pge) are generally characterized by very irregular surface topography, with esker ridges (Pge) being the most conspicuous ice-contact landform. The Pgi and Pge units are recognizable on air photos and the out-of-print 1958 version of the Newfield, Maine-N.H. 15-minute quadrangle. Several esker ridges are obscured or absent on the 1983 Limerick 7.5-minute quadrangle. Flat-topped kames and kame terraces occur commonly in drainages near esker ridges, but are not differentiated from other Pgi deposits on the geologic map. Ice-contact deposits are well exposed in numerous commercial borrow pits and are composed mostly of interbedded sand and gravel. Sandy facies are dominated by coarse to medium sands; gravelly facies are dominated by cobbles to pebbles with some boulders. Separate facies are up to several feet thick and tend to be well-sorted although the overall sorting of deposits is moderate to poor. Other sedimentary facies, including diamicton and laminated silt and clay, occur locally.

Primary and secondary sedimentary structures in ice-contact deposits record deposition by fluvial processes, followed by post-depositional collapse. Gravelly facies may be clast-supported and imbricated and often occur as discrete lenses. Sandy facies are very well bedded and often are cross-bedded. Contacts between sedimentary facies vary from concordant to discordant and vertical. Collapse structures, such as normal faulting, draped and contorted bedding, slumping, and discordant contacts are common. Where collapse is prevalent, beds often parallel the morphology of the land surface and cross--bedding dips in divergent directions. In eskers, cross-bedding and imbrication directions generally parallel the long axis of the ridge and indicate a south-southeast direction of meltwater flow. In other ice-contact deposits, such directional indicators are obscured by post-depositional collapse caused by melting of buried ice blocks.

Eskers are common and form elongate but discontinuous steep-walled ridges, many with curvilinear shapes. Individual esker segments are up to 60 feet high, 200 feet wide, and 1000 feet long. Esker deposits are similar to other ice-contact deposits, except that they tend to be less disrupted by ice-disintegration processes. Kettles often occur adjacent to eskers. Some eskers bisect relatively flat-lying delta deposits and presumably predate delta formation.

Two major esker systems are recognized in the quadrangle. One esker system originates northwest and north of Limerick Mills, along the Brown Brook and Leavitt Brook drainages. Here, two segmented esker trains can be traced 6.3 miles down the Brown Brook drainage and 3.7 miles down the Leavitt Brook drainage until they merge south of Limerick Mills and continue for 2.3 miles through and around Lake Arrowhead. This esker system continues southeastward to the head of Little Ossipee Lake in the Limington quadrangle (Meglioli, 1999a,b). Thus, this esker system, referred to here as the Limerick-Waterboro esker, extends nearly 12 miles through the townships of Limerick and Waterboro. Deposition of the Limerick-Waterboro esker was presumably time-transgressive, with the southern segments forming in association with the oldest stagnant ice zone as the glacier receded.

The second major esker system is located north of Newfield, principally along the Chellis Brook and the north portion of Pendexter Brook drainages. In the Chellis Brook drainage, these eskers trace former subglacial tunnels that delivered glacial meltwater and sediment toward the south, possibly to the headward parts of the Glacial Lake Mousam delta (Pldm and Pldmi) south of the village of Newfield. Eskers along the northern parts of Pendexter Brook may delineate former pathways for release of glacial meltwater either toward the south near Newfield or the southeast near Ossipee Mills.

Other sediments deposited by glacial meltwater streams include units Pnt, Pgo, and possibly some of the Qst deposits. These deposits are composed of interbedded sand and gravel and are distinguished from deltas and ice-contact deposits by their lower elevations and flat or low-relief topography. Topographic undulations in Pgo areas are attributed either to channeling or melting of buried ice blocks after outwash deposition. Both Pnt and Qst deposits, as well as some Pgo deposits, form terraces that grade down the Little Ossipee River valley. The most extensive meltwater stream deposits are located in the Little Ossipee River drainage, between Newfield and Ossipee Mills.

Postglacial to Modern Wetlands, Alluvium, and Artificial Fill

Wetland deposits (Hw) are localized in poorly drained areas, often with standing water. They have developed on both till and meltwater deposits, and probably have rather impermeable substrates. Wetland deposits in the quadrangle are located along streams and in isolated depressions; many probably fill kettle holes. Subsurface wetland data from the Maine State Highway Commission (1970) for three bogs along State Route 5 about 2.5 to 3.5 miles north of Limerick show that in these locations, peat is up to 50 feet thick. The peat is commonly underlain by a thin layer of clay and silt (0-8 ft thick) and a mixture of gravelly sand. The vegetation in wetland areas ranges from trees to grasses. Swamps, heaths, and marshes occur in the quadrangle, but are not differentiated on the map.

Holocene alluvial deposits (Ha) consist of reworked silt, sand, and gravel deposited on flood plains of modern streams and rivers. Most alluvium in the quadrangle occurs adjacent to the Little Ossipee River. Quaternary stream terrace deposits (Qst) occur just above the Holocene alluvium in the Little Ossipee River drainage near Newfield, and may have been formed either in late Wisconsinan or Holocene time. Alluvial deposits often interfinger with wetlands.

Artificial fill (af) was mapped at a few locations in the quadrangle where the original topography and deposits have been obscured by artificially deposited till, sand and gravel, rock, or refuse. Artificial fill sites are mostly restricted to landfills and road construction sites. The original topography of many meltwater deposits has also been altered by sand and gravel mining in the quadrangle. The areas of large sand and gravel pits are designated on the geologic map by diagonal lines.

GLACIAL AND POSTGLACIAL HISTORY

During the advance of continental ice over southern Maine, indurated lodgement till (some Pt) was deposited subglacially in parts of the Limerick quadrangle. Presumably, this till was derived from the most recent (late Wisconsinan) glaciation, when glacial ice reached its maximum position at the continental shelf break (Thompson and Borns, 1985a, 1985b). Numerous streamlined bedrock and till hills in the Limerick area indicate that the dominant ice flow direction was toward the southeast. Glacial striations on bedrock on Hosac Mountain (located west of Sawyer Mountain in the northeast part of the quadrangle) suggest that local ice flow may have been directed more to the south (average striation azimuth is 175^{o}).

The active ice margin began to retreat by about 17000 yr B.P. and had retreated north of the Limerick area by about 13000 yr B.P. (Thompson and Borns, 1985a, 1985b). Dead ice may have remained in some valleys for a longer time period. The ice retreat occurred before isostatic rebound of the depressed land surface, so coastal lowland regions and many inland river drainages were inundated with sea water. No marine sediments were found in the Limerick quadrangle, supporting the local marine submergence limit of 285 feet asl in the adjacent Limington quadrangle, just 2.5 miles east of the Limerick quadrangle border.

During ice retreat, a series of ice-marginal landforms and sequences of sedimentary facies were deposited as described by the morphosequence concept of Koteff and Pessl (1981). The abundance of sand-rich ablation till (some Pt) and ice-contact deposits (Pgi, Pge, Pldmi) in the Limerick area supports the model of a stagnant ice zone which probably receded systematically northward and northwestward at a similar rate to the active "live" ice margin that lay to the north. Ablation till and ice-contact deposits were probably being deposited at the same time at any given location. There is no evidence in the Limerick quadrangle that ice readvanced over meltwater deposits.

Two series of lacustrine and fluvial or fluvial-lacustrine morphosequences (as defined by Koteff and Pessl (1981)) occur in the quadrangle: here named the Newfield and Limerick Mills morphosequences. The Newfield morphosequences include glaciolacustrine and glaciofluvial deposits in the western half of the quadrangle, centered in the vicinity of the village of Newfield; the Limerick Mills morphosequences include a similar series of deposits in the eastern half of the quadrangle, centered in the village of Limerick Mills. The Newfield and Limerick morphosequences resulted from subglacial and proglacial deposition during local ice stagnation and formation of proglacial lakes. Development of Glacial Lake Mousam and deposition of the associated glaciolacustrine Plmd unit (480-500 feet asl) of the Newfield morphosequence series is inferred to predate the adjacent, but lower-elevation Glacial Lake Arrowhead and associated glaciolacustrine Plad unit (340-360 feet asl) of the Limerick Mills series (Figure 1). The glaciolacustrine deltas (Plmd, Plmdi, and Plad) formed contemporaneously with at least some of the ice-contact deposits in the quadrangle (Figure 1).

The Newfield morphosequences are defined by deposits associated with Glacial Lake Mousam, including deltas (Plmd and Plmdi), ice-contact deposits (Pge, Pgi), and some late-stage stream terrace deposits (Pnt and Pgo, both exhibiting some collapse features) that resulted from base-level lowering. Ice-contact deposits are assumed to be older in the south, where eskers are surrounded by delta deposits, but were probably laid down in a time-transgressive series before, during, and after delta formation. Ice-contact sediments along the Chellis Brook and the northern portion of Pendexter Brook drainages may have been deposited by meltwater that flowed southward into Glacial Lake Mousam. The spillway threshold for Lake Mousam was apparently located south of the quadrangle, in the Mousam Lake quadrangle. Meglioli (1997a,b) stated that the Glacial Lake Mousam delta deposits near Mousam Lake range in elevation from 520 to 560 feet asl and were deposited when the southern outlet of Lake Mousam was dammed by an ice block. In the Limerick quadrangle, Glacial Lake Mousam delta deposits are lower in elevation (480-500 feet asl) and may represent a late-stage lowering of the lake when ice retreat opened a lower outlet. The lack of topset beds near Newfield allows for higher lake levels in the Limerick quadrangle and the possibility of a single high (520-560 feet asl) upper level for Glacial Lake Mousam. The Newfield stream terraces (Pnt) are the highest (460+ to 400 feet asl) and therefore presumably the oldest fluvial deposits in the quadrangle. These Pnt deposits appear to be graded to the meltwater channel cut into the till hill southwest of Ossipee Mills. The steep gradient of these deposits indicates that they may be fluvial terraces cut into earlier Glacial Lake Mousam deposits when the paleo-lake level fell. A second set of stream terraces (Pgo), also situated along the Little Ossipee River drainage, is lower (400+ to 380 feet asl) and presumably younger than the Newfield terraces (Pnt). The Pgo deposits in this area probably resulted from continued downcutting and reworking of older sediments by meltwater drainage from the adjacent West Newfield quadrangle. The channel southwest of Ossipee mills may have continued to be the base-level control at this time. Southward meltwater draingage from the small valleys north and northeast of Newfield village also would have contributed to the formation of units Pnt and Pgo in the Little Ossipee Valley. A third and even lower set of stream terraces (Qst) is situated just above the modern Little Ossipee River flood plain and formed either in late-glacial or early postglacial time.

The Limerick Mills morphosequences, defined by deposits associated with development of Glacial Lake Arrowhead, followed a progression similar to the Newfield series. Just south of Pickerel Pond, convoluted ice-contact and glaciofluvial deposits interfinger, suggesting a morphosequence association. Ice-contact (Pgi) deposits in the Brown Brook and Leavitt Brook drainages may have resulted from meltwater flow into Glacial Lake Arrowhead near Limerick Mills, slightly before and during emplacement of the youngest Plad deposits. The Plad units in the Limington (Meglioli, 1999a,b) and Limerick quadrangles are correlated on the basis of similar upper elevations at about 340-360 feet asl. This glaciolacustrine delta appears to have been deposited in a relatively stable (not affected by progressive base level lowering) proglacial lake that was formed when an ice block dammed the south end of Little Ossipee Pond, as suggested by Meglioli (1999a,b). In the Leavitt Brook drainage, outwash deposits (Pgo) are similar to, but less collapsed than, ice-contact deposits (Pgi) and probably are closely associated in time.

The postglacial history of the Limerick quadrangle includes the stabilization of the land surface by vegetation, the establishment of modern drainage networks, and the development of wetlands areas. Stone walls throughout the quadrangle preserve evidence of extensive clearing and development for farming in the 18th and 19th centuries. More recently, the surface morphology and surficial deposits have been altered locally by road construction and gravel mining. Sand and gravel deposits, particularly the Plad deposits in the Limerick Mills area, have been and continue to be a valuable economic resource.

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APPENDIX A: DETAILED SITE OBSERVATIONS

(FIELD DATA SHEETS DESCRIBING DETAILS OF SITES L1-L25 ON FILE AT THE MAINE GEOLOGICAL SURVEY)

Sedimentology and Glacial Meltwater Flow Direction Data

No.	UTM E	UTM N	Materials†	Type	Azimuth	Dip
L1*	^{3}57.6	^{48}42.6	30SG	IMBRICATION*	120	
L2	^{3}56.4	^{48}41.3	6 c-s/ 1 ms	foreset	~180	
L3	^{3}57.6	^{48}36.8	3 gs/ 8 fs	channel	~180	
L4*	^{3}52.3	^{48}44.2	2 gs/8 fs	foreset*	150-155	22 SE
L5*	^{3}57.7	^{48}36.2	5 s/gs	foreset*	200	26 SW
L6	^{3}49.9	^{48}40.4	4 sg, s/ 5 ds			
L7	^{3}53.4	^{48}42.35	6 dt			
L8	^{3}50.05	^{48}39.75	4 s, gs/ 3 c	deformed bed	150	20 NW
L8	^{3}50.05	^{48}39.75		deformed bed	185	25 NE
L9*	^{3}56.4	^{48}41.4	0-7 gs, sg/ 5-10 ms, fs, vfs	imbrication*	170-180	
L10*	^{3}58.3	^{48}40.3	12 gs	linear ridge, imbrication*	170 ±210	
L11	^{3}58.15	^{48}39.7	6 gs/ 15s, c-p			
L12	^{3}55.9	^{48}35.4	3 gs/ 1 s, st			
L13	^{3}57.3	^{48}38.5	Halford Lot eskers	linear ridges	119-165	
L14	^{3}51.3	^{48}35.9	3 gs/ 6 s			
L16	^{3}57.5	^{48}39.4	1 gs/ 12 s	bedding	120	30SE
L16				bedding	235	26SW
L17	^{3}57.6	^{48}39.3	5 gs			
L18	^{3}57.3	^{48}39.4	6 s			
L19	^{3}58.95	^{48}39.65	20 gs			
L20	^{3}53.0	^{48}33.4	60 s, sg	ice disintegration ridges	80	
L21	^{3}57.9	^{48}36.4	30 b-s	linear ridges	140-160	
L22*	^{3}57.98	^{48}36.2	18 b, c, sg	imbrication*	130-170	
L23	^{3}56.95	^{48}39.3	2 gs/ 3 s, st/ 8 gs, sg	foreset	195	35SW
L24*	^{3}54.95	^{48}39.95	6 gs, s, st	foreset*	140-160	
L25	^{3}58.25	^{48}39.4	18 gs			
	^{3}51.9	^{48}36.0		foreset*	215	35 SW

†Numbers are thicknesses in feet; see materials map (Wilch, 1998) for explanation of letter symbols.

*Glacial meltwater flow direction indicators that are on surficial geologic map. Other direction indicators were not included because data were for linear esker ridges (which are shown schematically on map by chevrons) or results were ambiguous.

Ice Flow Direction Data

UTM E	UTM N	Type	Azimuth
^{3}56.5	^{48}44.65	striations	180
			170
			175
			170
			177
			180
		mean of six measurements	175