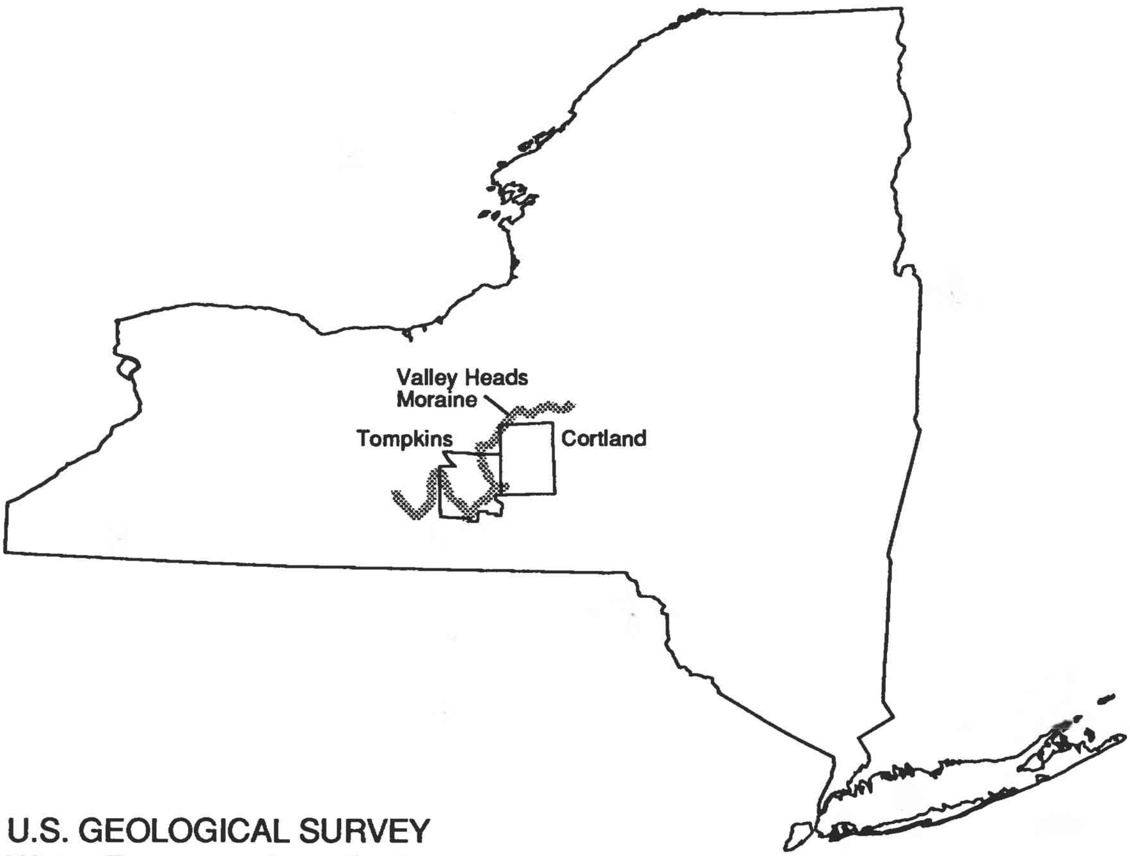
Glacial Geology and the Origin and Distribution of Aquifers at the Valley Heads Moraine in the Virgil Creek and Dryden Lake-Harford Valleys, Tompkins and Cortland Counties, New York



U.S. GEOLOGICAL SURVEY
Water-Resources Investigations
Report 90-4168

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By Todd S. Miller

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	*by*	*To obtain*
	Length	
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Flow	
gallon per minute (gal/min)	0.06309	liter per second

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

GLACIAL GEOLOGY AND THE ORIGIN AND DISTRIBUTION OF AQUIFERS AT THE VALLEY HEADS MORAINE IN THE VIRGIL CREEK AND DRYDEN LAKE - HARFORD VALLEYS, TOMPKINS AND CORTLAND COUNTIES, NEW YORK

By Todd S. Miller

Abstract

The Valley Heads moraine in the Dryden Lake - Harford through valley south of Dryden, N.Y. is composed of many thin, commonly discontinuous layers of till, fine-grained lake deposits, and coarse sand or gravel. Lake deposits decrease in abundance upward, and none were deposited at land surface during the final retreat of the ice. The upper 100 feet of the moraine consists mostly of till (50 percent), sand and gravel (30 percent), and lake deposits (20 percent). North of the divide between the Susquehanna River and Lake Ontario watersheds (backside of the moraine), this interval is predominantly till and lake deposits with two to four sand or gravel layers that each are 1 to 15 feet thick. Near and south of the divide, this interval is mostly sand-and-gravel outwash with two or three layers of till and lake deposits that pinch out southward. At depths of 100 to 200 feet, the amounts of lake deposits and till are approximately equal; sand and gravel is subordinate.

The drift contains both erratic stones carried by the glacier from outcrops several miles to the north and shale or siltstone clasts of local origin. The relative proportion of erratics tends to decrease upward and southward within the moraine, and is useful to some extent in correlating drift layers. The uppermost till in the southern part of the moraine is devoid of erratics.

The moraine contains at least five confined water-bearing zones. The uppermost is thin, discontinuous, mostly interstadial alluvium and(or) inwash whose upper surface is 5 to 20 feet below land surface. The next zone, which is also thin and discontinuous, and whose upper surface is 20 to 45 feet below land surface, is probably a supraglacial or kame deposit. The third is semicontinuous; the upper surface lies 80 to 90 feet below land surface, and its origin is uncertain. The fourth is continuous; the upper surface lies 90 to 125 feet below land surface, and is highly undulating in a manner typical of kames. This zone has a high potentiometric surface that suggests a high-altitude recharge area such as the kame moraine south of Dryden Lake or kame terraces along the valley walls. The upper surface of the fifth zone lies 157 to 215 feet below land surface and slopes southeastward (away from the ice), which indicates that the zone is probably ice derived. The moraine also contains several small, discontinuous, and thinly saturated unconfined aquifers that consist of alluvial fan, outwash, and kame deposits.

Sparse data from the Virgil Creek through valley, which joins Dryden Lake - Harford valley east of Dryden, indicate that the Valley Heads moraine consists largely of till and resedimented diamict; lake deposits predominate between the moraine and the Susquehanna River-Finger Lakes divide. Outwash is lacking in the Virgil Creek valley, apparently because meltwater was diverted across an interfluve of lower altitude to the Dryden Lake - Harford valley.

INTRODUCTION

The Valley Heads moraine, first identified by Chamberlin (1883), is a thick accumulation of glacial drift that was deposited at the terminus of the Wisconsin ice sheet when it occupied the major valleys at the north rim of the Allegheny Plateau in central New York (fig. 1). Parts or all of the older Valley Heads moraine segments in the central Finger Lakes region probably were formed during the Port Bruce stadial 13,500 to 14,500 years before present, whereas the youngest moraines of the Valley Heads system were formed from 10,400 to 13,320 years before present (Fullerton, 1980).

The Valley Heads moraine extends across western and central New York and is the largest moraine in the State. Many communities and rural residences on or near the moraine obtain their water supply from sand and gravel zones within the moraine, but little is known about the origin or distribution of those zones, which have been described as scattered gravel layers within fine-grained sediment (MacNish and Randall, 1982, p. 23; Crain, 1974, p. 70-73). Well logs indicate that the moraine includes several sand and gravel zones interbedded with till and lake deposits. Crain (1974) mapped the extent of water-table and confined zones in the western Oswego River basin at a scale of 1:125,000, including parts of the Valley Heads moraine, but did not discuss the moraine in detail. Randall and others (1988) briefly described the geohydrology at 18 localities along the moraine but emphasized the surficial outwash aquifers immediately to the south of the moraine.

In 1984, the U.S. Geological Survey began a hydrogeologic study of the Valley Heads moraine near the village of Dryden in the southeastern part of Tompkins County and the southwestern part of Cortland County (fig. 2). The study is part of the Survey's Regional Aquifer-System Analysis Program, which was established to determine the origin and distribution of glacial sediments that form the moraine, with emphasis on sand and gravel aquifers, in a representative setting in a north-flowing valley. The Dryden area was selected for study because well data are relatively abundant as a result of suburban development on the moraine. The glacial history of the Valley Heads episode as described herein provides a basis for determining the approximate location, extent, and geometry of aquifers in this geologic setting and includes information that could be used in the development and protection of these aquifers.

Purpose and Scope

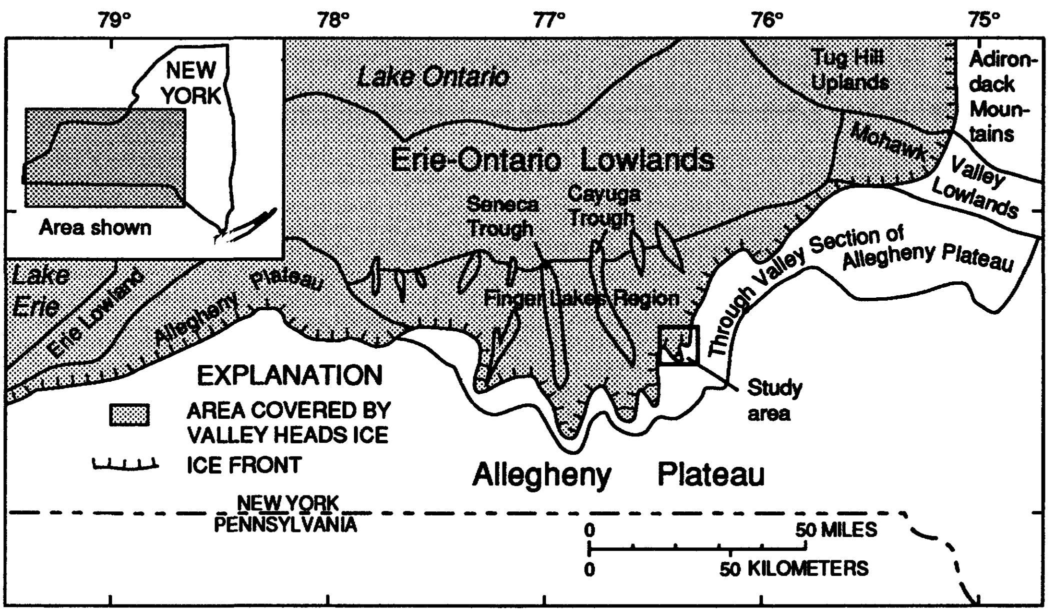
This report describes the geologic setting; the types of sediments that form the Valley Heads moraine; the processes of their deposition; their stratigraphy; and the origin, geometry, and distribution of aquifers in the study area. It also contains tables of water levels and data on wells completed in the aquifers and three plates showing (1) locations of wells and test holes, (2) surficial geology, and (3) geologic sections.

Methods

The work included a review of previous investigations, a well inventory, test drilling, examination of drill cuttings, lithologic counts of pebbles in the till and gravels collected from outcrops and split-spoon samples, field mapping, and water-level measurements. In addition, 25 wells were surveyed to obtain accurate elevations of stratigraphic units and water levels.

Examination of drift lithology is a potentially useful method for correlating stratigraphic units. MacClintock and Apfel (1944) and Moss and Ritter (1962) used differences in lithology to distinguish areas of Olean drift from Valley Heads drift in central New York. Moss and Ritter (1962) found that Valley Heads drift is "bright," whereas Olean drift is "drab" in the uplands and in minor valleys but is "bright" in some major through valleys. In this report drift is considered drab if more than 90 percent of the pebble and granule components consist of local rocks (in this case dark-gray shale and siltstone), moderately drab or moderately bright if 85 to 90 percent of the pebble and granule component consists of local material, and bright if less than 85 percent of the pebble and granule component consists of local rocks. Bright drift refers to rocks foreign to the study area. The relatively colorful appearance of bright drift is caused by numerous pebbles of limestone, chert, quartzite, crystalline rock, and other rocks foreign to the Allegheny Plateau.

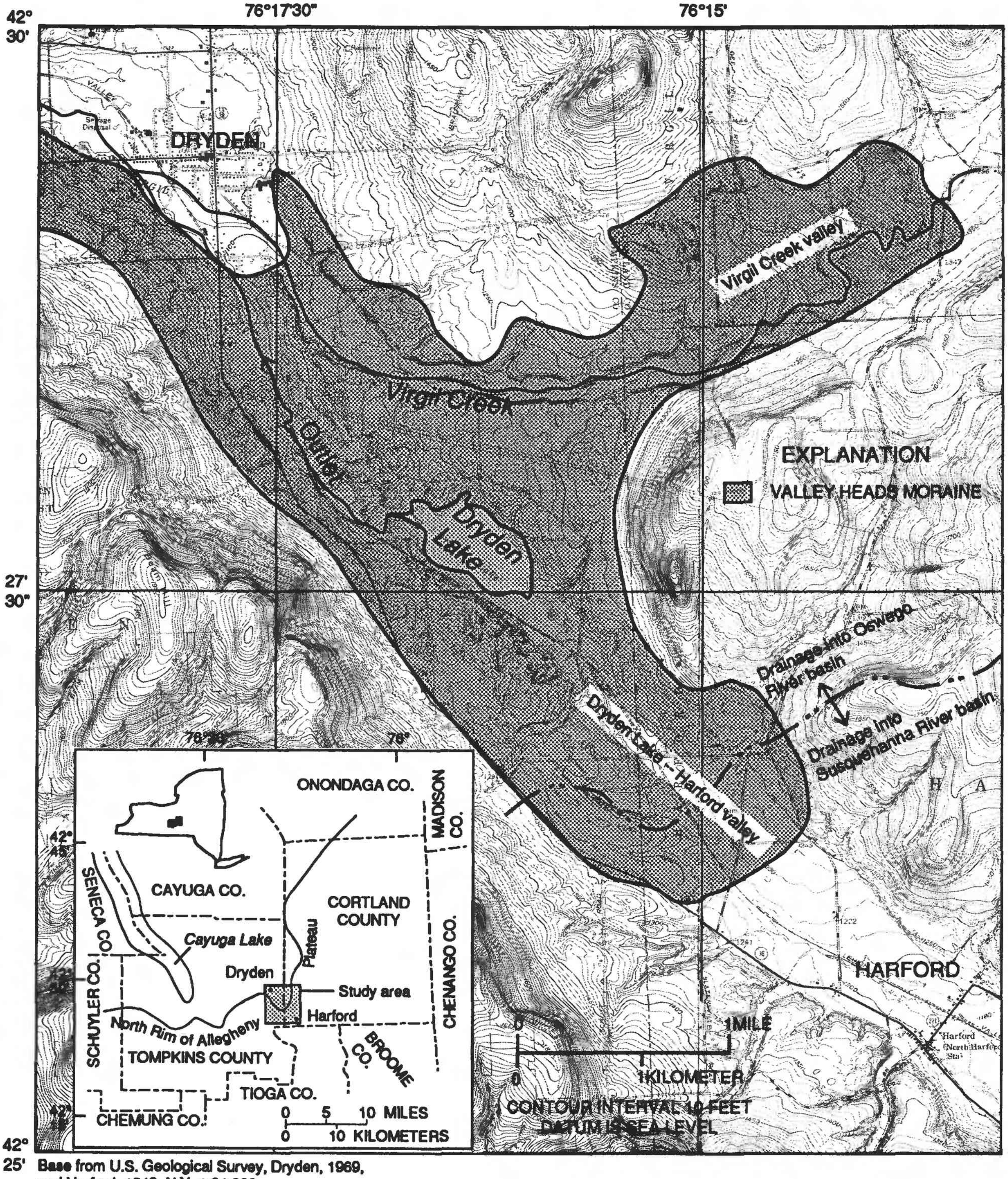
Valley Heads ice did not cover the uplands southeast of Dryden. The drift on these hills consists of drab Olean deposits. Streams that drain the uplands



Base from U.S. Geological Survey
State base map, 1:500,000, 1956

Figure 1.--Physiographic features and the southernmost extent of Valley Heads ice in central and western New York.

have eroded drab Olean drift and bedrock and transported these sediments to the valley, where some bright Valley Heads deposits are found. Therefore, the drab upland drift and fluvially transported upland material (inwash, interstadial alluvium, and Holocene alluvium) should be distinguishable from bright Valley Heads drift, which is found in the valleys. Rough pebble counts of selected split-spoon samples and sediment from streams and outcrops are given in table 4 (at end of report).



Base from U.S. Geological Survey, Dryden, 1969, and Harford, 1949, N.Y. 1:24,000

Figure 2.--Major physiographic features in the study area.

Description of Study Area

The study area occupies 8.9 mi^2 in the Virgil Creek and Dryden Lake - Harford valleys in the southeastern part of Tompkins County and southwest part of Cortland county in central New York (fig. 2).

Location and Physiographic Setting

Most of the study area drains north into the Oswego River, which flows into Lake Ontario (fig. 3). The southeastern part of the study area (Harford valley) drains south into the Susquehanna River basin (fig. 3).

The study area is in the through-valley section at the north rim of the Allegheny Plateau (fig. 1) that consists of rounded bedrock hills whose valley walls rise as much as 600 ft above the valley floor. The valleys may contain more than 300 ft of unconsolidated sediments, most of which were deposited during deglaciation. North of the study area (fig. 1) is the Finger Lakes region, characterized by relatively low-lying hills and elongated and roughly parallel troughs that contain the Finger Lakes.

Geologic Setting

Glacial deposits. Deglaciation of the Finger Lakes region during late Wisconsin time was interrupted by intervals of readvances and stillstands. Most of the upper glacial sediments in the Finger Lakes region were deposited during deglaciation of the last readvance of ice (Valley Heads), which overrode the area 13,500 to 14,500 years before present and deposited a large moraine known as the Valley Heads moraine in many through valleys near its terminus at the north rim of the Allegheny plateau (fig. 1). The interbedded deposits of glacial drift reflect a complex history of several glacial advances and recessions, meltwater activity, formation and subsequent drainage of glacial lakes, and recent fluvial erosion and deposition.

The position and size of the Valley Heads moraine was controlled by bedrock topography and possibly by adjustments in glacier flow of the Laurentian ice sheet to differential rebound of land during ice retreat. Krall (1977) reasoned that rebound in the Champlain and Hudson valleys (fig. 4) reduced the gradient controlling ice flow from the Laurentian ice mass to eastern New York. Consequently, a lower and more streamlined path, the St. Lawrence trough, became more favorable for ice movement, and more ice reached the Erie-Ontario lowlands and caused ice to advance southward into the Finger Lakes region. The central Finger Lakes region has smooth topography, deep troughs (Finger Lakes troughs) aligned in the direction of glacial flow, and lower ridge tops than areas to the south, east, and west, all of which favored

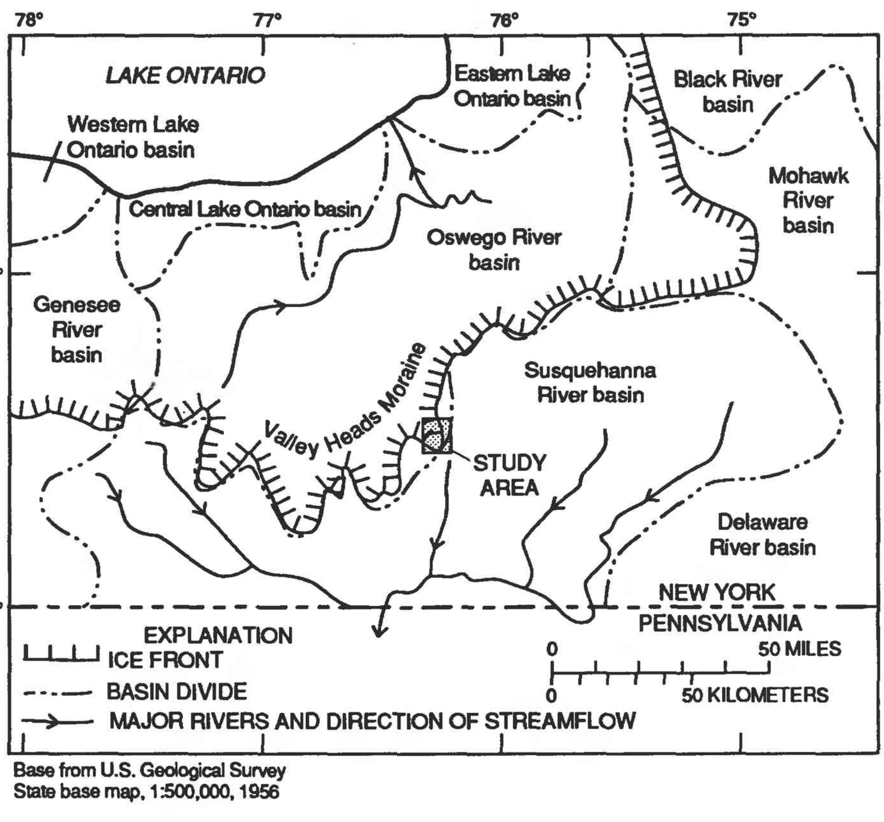


Figure 3.--Relation of Valley Heads moraine to major river basins in central New York.

the southward advance of Valley Heads ice south of the Finger Lakes region to the northern rim of the Allegheny Plateau (fig. 1).

When the main ice sheet abutted against the northern rim of the Allegheny plateau, tongues of ice extended several miles southward into the intrusive through valley-section of the plateau (figs. 1 and 5). The position where the ice stopped in the through valleys coincides approximately with a steep rise in the bedrock floor in at least some of these valleys (Faltyn, 1957; Miller and others, 1982; Mullins and Hinchey, 1989). Then, 13,500 to 14,500 years ago, the Champlain-Hudson River Valley trough in eastern New York (fig. 4) again became the major flow path for the ice because it had a lower outlet than the through valleys in central New York (Krall, 1977). Thus, the continued presence of the ice margin against the northern rim of the Allegheny Plateau for several hundred years and the consequent deposition of the Valley Heads moraine were mainly the result of bedrock topography and ice dynamics.

During early stages of Valley Heads ice, meltwater probably deposited subaqueous outwash, deltaic, and lake-bottom sediments into water ponded between the advancing ice front and either older drift that choked the valleys to the south or rising bedrock surface south of the Finger Lakes region. If the lake became filled with sediment, fluvial outwash would have aggraded on top of it, or if no lake had formed in front of the ice, fluvial outwash would have aggraded on top of older drift. Further advancement of the ice would have overridden the lake and fluvial deposits and reworked at least the upper parts of them.

During the more advanced stages of Valley Heads ice in the through valleys, meltwater flowed southward from the ice tongues into the Susquehanna drainage system (fig. 3) and deposited valley trains that typically extend several miles to several tens of miles south of the ice front. In most valleys occupied by Valley Heads ice, multiple advances and retreats of the ice formed moraines that partly filled the valleys with deposits of interbedded till, lacustrine fine sand, silt and clay, and some sand and gravel.

The Valley Heads moraine forms a semicontinuous looped belt of hummocky topography that extends roughly east-west several miles south of the Finger Lakes (fig. 1). The moraine is thicker in the valleys than in the uplands, where it is less developed or absent because the ice was thinner and laden with less sediment. In many through valleys, the moraine forms the divide between southward drainage into the Susquehanna River basin and northward drainage into the Oswego River basin (fig. 3).

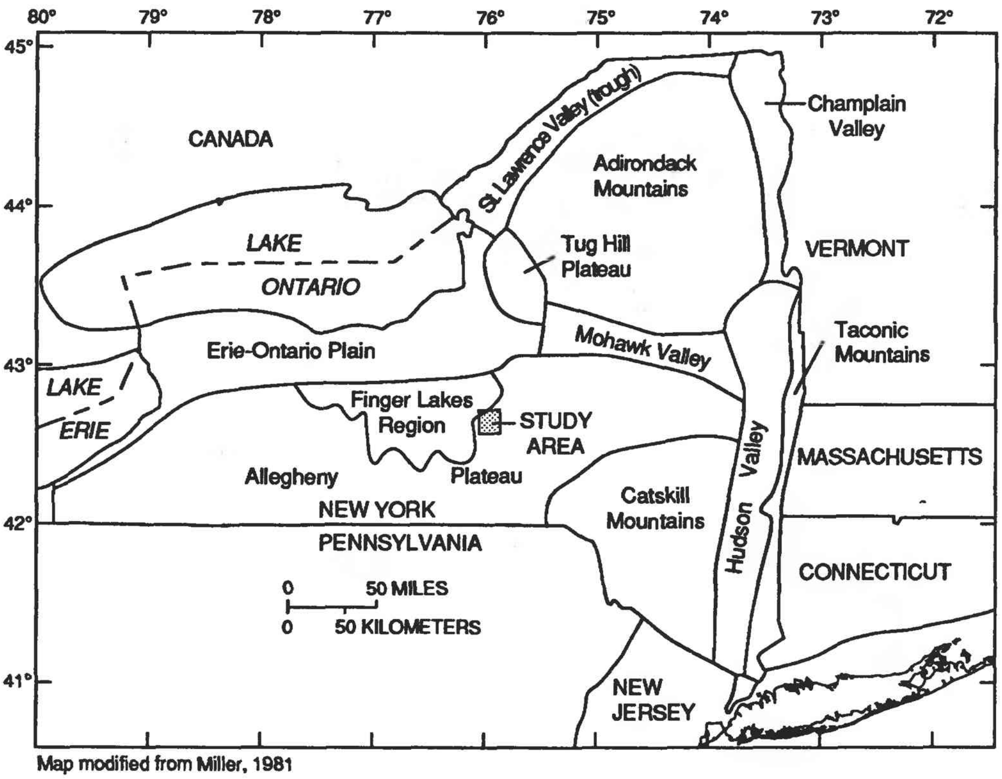


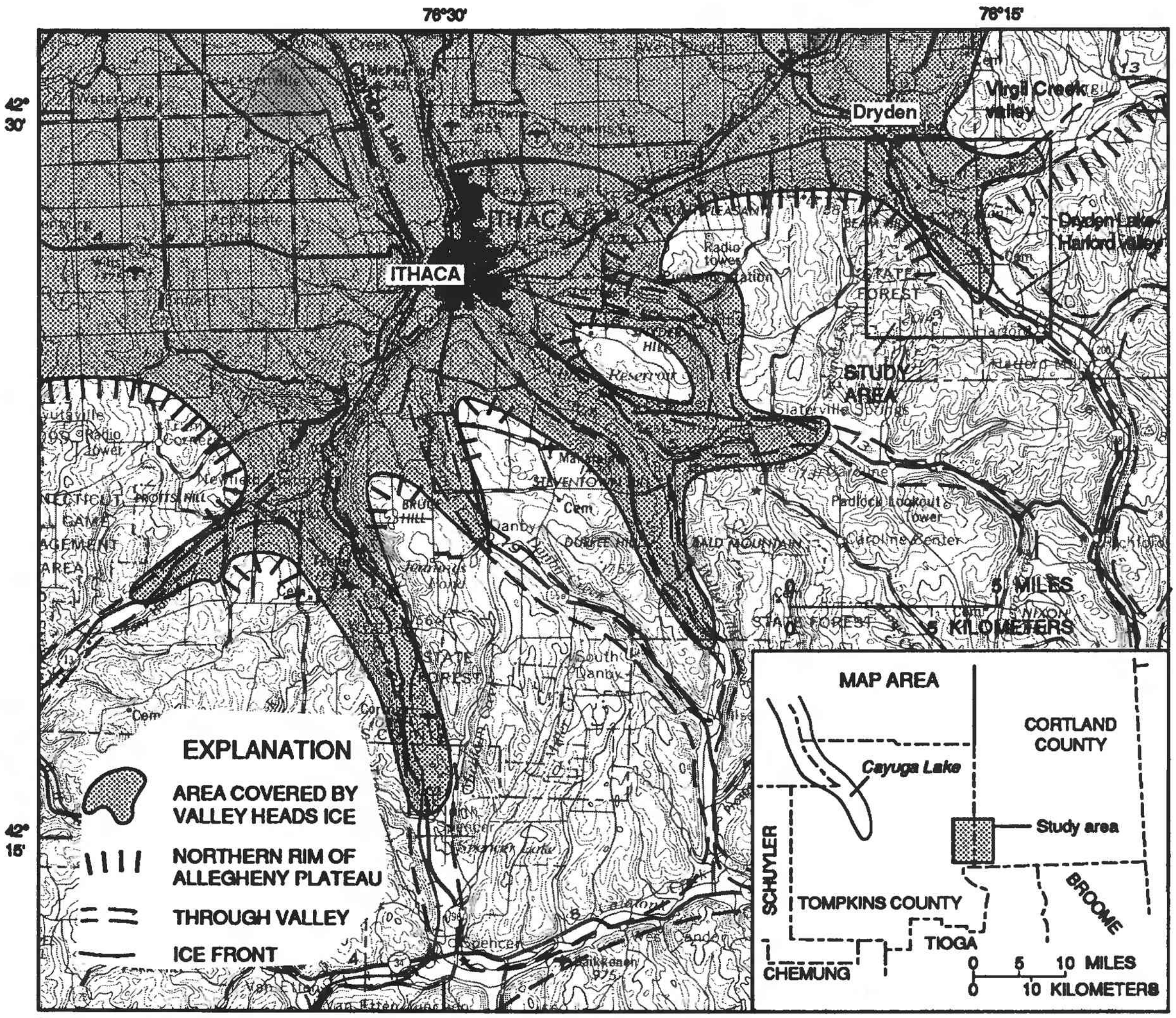
Figure 4.--Physiographic features in New York and location of study area. (Modified from Miller, 1981.)

In north-draining valleys at the north rim of the Allegheny Plateau, proglacial lakes typically formed in the depressions between the receding ice front and the Valley Heads moraine (Fairchild, 1934). During early stages of ice retreat, ice tongues filled most of the valleys and blocked the northward escape of ponded water. Each valley had an outlet channel at the moraine that controlled the initial lake level (Fairchild, 1934). Lake levels remained unchanged as ice melted until an interfluve at a elevation lower than lake level became exposed to the north, whereupon either the lake abruptly drained dry or dropped to the level of the interfluve or the level of a lower lake in an adjacent valley. Most of these initial lakes were shorter lived than later low-level lakes.

Holocene deposits. Some stream erosion and deposition has occurred in the study area during postglacial time. Virgil Creek has incised a 20- to 50-ft-deep gorge into the moraine, and small streams that drain uplands have eroded steep gullies in till and bedrock. Channel erosion in other areas, such as the inlet and outlet of Dryden Lake, has been minimal, however.

The only significant recent channel and flood-plain deposit in the study area (A1, pl. 2) is along Virgil Creek gorge in the moraine. The Virgil Creek flood plain is 3 mi long and 300 to 700 ft wide. The flood-plain deposits are thin, typically 3 to 10 ft thick, and the creek flows on till in many places. Springs emerge at the interface between the alluvium and till in several locations.

Alluvial fans (alf, pl. 2) formed where streams that drained uplands flowed onto the valley flat and deposited some of their coarse sediment load. Sediment eroded from the moraine by Virgil Creek was deposited as a 10- to 20-ft-thick alluvial fan in the valley flat now occupied by the village of Dryden. Several small alluvial fans formed along the edges of



Base from Army Service Maps, 1:250,000

Figure 5.--Position of Valley Heads ice tongues that extended into through valleys at northern rim of Allegheny Plateau.

the valley flat where small streams that drain uplands deposited 10 to 20 ft of silty sand and gravel on top of outwash and(or) till.

Previous Hydrogeologic Studies

Apfel (1963) identified two sand and gravel aquifers near the Village of Dryden from the surficial geology of the Virgil Creek valley and drillers' logs of two wells in the south part of the village. He concluded that the surficial aquifer consists of morainal sand and gravel and extends 5 mi southeast from the southern part of the village into the Virgil Creek and Dryden Lake valleys. He also described a buried sand and gravel aquifer that was deposited in an ice-dammed lake by floodwater from the uplands and(or) meltwater from the ice and later became covered with fine-grained lake deposits.

LaFleur (1978) recognized three separate sand and gravel zones on the northern slope of the Valley Heads moraine: (1) A shallow deposit at land surface, which he ascribed to deposition by postglacial streams; (2) an extensive buried sand and gravel zone, whose upper surface is 80 to 110 ft below land surface, inferred to represent an interstadial channel deposited by a north-flowing stream; and (3) another, deeper interstadial channel deposit about 200 ft deep, as inferred from data from two widely spaced wells.

Randall and others (1988) described at least two sand and gravel zones that are separated by till and lacustrine layers in front of the Valley Heads moraine in the Town of Harford, about 5 mi southeast of Dryden (fig. 2). In the Harford valley, surficial outwash was deposited as a 50- to 80-ft-thick valley train that extends as a southeastward-sloping wedge away from the moraine. Near the drainage divide on the moraine, thin outwash and alluvial deposits, partly saturated, overlie a 5- to 30-ft thick layer of till that in turn overlies a thin sand and gravel zone. A second, slightly deeper layer of till and(or) lacustrine silty clay extends over at least part of the same area and overlies a thicker sand and gravel zone. Randall and others (1988) suggests that the two till layers resulted from brief readvances of the fluctuating ice margin. The association with lacustrine silty clay suggests that whenever the ice margin withdrew, water became ponded between the ice and the valley train.

GLACIAL GEOLOGY

The upper part of the valley fill in the Virgil Creek and Dryden Lake - Harford valleys was deposited mostly during the successive advances, oscillations, and retreats of Valley Heads ice, although pre-Valley Heads drift is on the uplands southeast of Dryden, and some may be buried in the valleys. Land-surface exposures and well records show the valleys in the study area to be partly filled with several hundred feet of interbedded till, glaciofluvial deposits, and glaciolacustrine deposits. Postglacial deposits overlie Valley Heads drift in some areas; these include swamp deposits that accumulated in kettles and thin recent alluvium in flood plains. The correlation diagram in figure 6 shows the equivalence in relative geologic age and stratigraphic positions of geologic units at the Valley Heads moraine near Dryden.

Pre-Valley Heads Deposits

The origin and distribution of deposits older than Valley Heads age in drift-filled valleys are little known because surficial exposures are lacking as a result of (1) the readvance of Valley Heads ice, which destroyed, altered, or buried previous deposits and altered drainage patterns, (2) scant deep-well data, and (3) lack of lithologic distinction between the older drift (Olean) in through valleys and Valley Heads drift, because both have similar clast lithology (Moss and Ritter, 1962). Identification of pre-Valley Heads deposits in the valleys is mostly rough conjecture based on evidence from adjacent areas and geologic principles.

Olean Drift

Olean till mantles the upper parts of bedrock hills adjacent to the Virgil Creek and Dryden Lake - Harford valleys where Valley Heads ice did not reach. The deeper zones in the Virgil Creek and Dryden Lake - Harford valleys may contain older glacial sediments deposited by the Olean ice sheet, which covered the region before the Valley Heads readvance, but little is known of their extent.

Interstadial Alluvial Deposits

During the early stages of the Valley Heads episode, when ice was tens of miles north of Dryden, the ice probably had no effect on the study area. During this interstadial period, northward-flowing streams in the Virgil Creek valley and Dryden Lake area probably deposited alluvial channel and flood-plain material in the valley, and streams that drained uplands deposited alluvial fans and on top of the older Olean drift along the edges of the valley (Moss and Ritter, 1962).

Valley Heads Deposits

Most of the upper part of the unconsolidated deposits in the Virgil Creek valley and the Dryden Lake - Harford valley were deposited by Valley Heads ice.

Advancing Ice And Proglacial-Lake Deposits

As the Valley Heads ice advanced southward, it blocked the flow of water in northward-draining basins and caused water to become ponded in front of it. As lower outlets to the north became successively blocked by the ice, continually rising proglacial lakes formed before the advancing ice in the northward-draining basins and drowned the lower reaches of the streams. The material deposited by these streams at the south edges of the lakes formed deltas consisting of fine sand and silt; the finer sediments were carried into deeper, quieter water, where they settled to form lake-bottom sediments consisting of silt and clay.

Advanced Ice Stages

During the advanced stages of the Valley Heads episode, the main ice sheet abutted against the north rim of the Allegheny Plateau northwest of Dryden, and an ice tongue extended several miles southeast from the main ice massif into the Y-shaped Virgil Creek and Dryden Lake - Harford valleys. Two miles southeast of Dryden, the ice split into two tongues, one extending 2 mi up Virgil Creek valley, and the other 1.5 mi up the Dryden Lake - Harford valley (fig. 2). In the Virgil Creek and Dryden Lake - Harford valleys, as in most other intrusive or through valleys along the northern rim of the Allegheny Plateau that were occupied by tongues of Valley Heads ice, a massive moraine was deposited in the vicinity of the ice margin. As in other through valleys crossed by the moraine, the moraine in the Dryden Lake - Harford valleys forms the surface-water divide between the Susquehanna and St. Lawrence drainages (fig. 3). An atypical hydrologic setting is present in the Virgil Creek valley, however, where the westward-flowing creek, which originates in front and east of the moraine, has incised a channel through the moraine such that the entire valley drains westward and northward.

Moraine and lake deposits in the Virgil Creek valley. During the advanced stages of the Valley Heads episode, a moraine formed where the tongue of ice extended into the Virgil Creek valley, and lake sediments settled in a 3-mi-long proglacial lake (Virgil Lake) that formed in the depression between the ice front and an outlet at elevation 1,400 ft, 1 mi east of Virgil (not shown on pl. 2). The upper parts of the moraine in the Virgil Creek valley consist of till, debris flow, and lesser amounts of ice-contact deposits. Soil maps, field observations by this author, and test hole 46-19 (pl. 1), which was drilled in the lower part of the moraine and penetrated mostly very stony till, indicate meltwater deposits to be relatively scarce in the moraine in Virgil Creek valley.

Typically, meltwater deposited a valley train (outwash) in front (south) of the Valley Heads moraine, but in the Virgil Creek valley there is no evidence of fluvial outwash at land surface in front of the moraine.

Moraine in the Dryden Lake - Harford valley. A large morainal ridge (pl. 2) that consists of a cobbly till mixed with dirty sand and gravel was deposited immediately south and southeast of Dryden Lake and

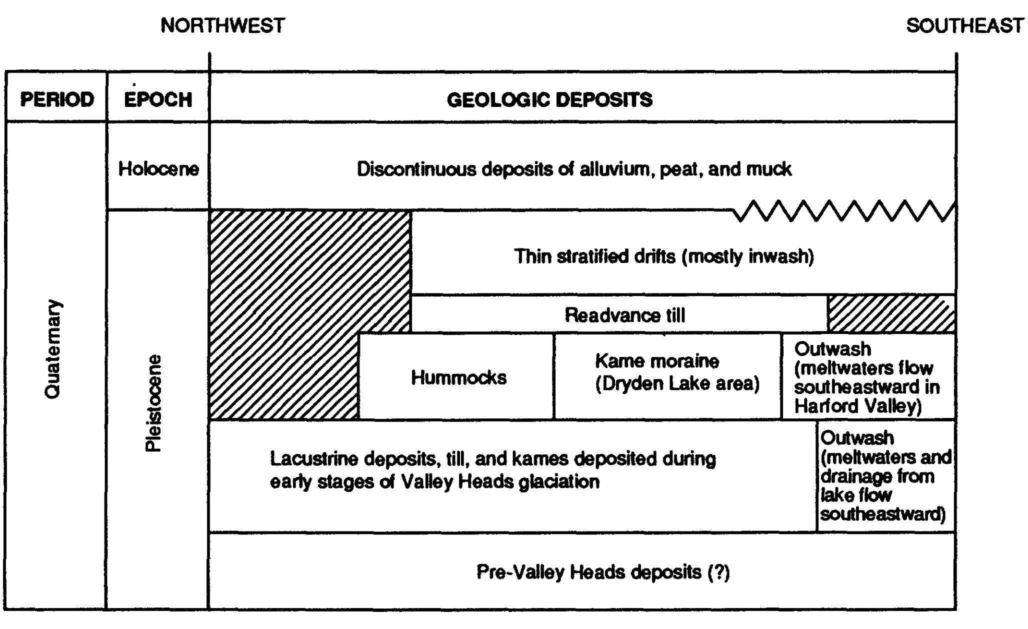


Figure 6.--Correlation of geologic deposits in the Dryden area.

probably represents relatively long stillstand of ice during the advanced stages of the Valley Heads episode. Little or no expression of the moraine remains in the middle of the valley, where it may have been buried by subsequent deposits of outwash and till. A valley train slopes gently southeastward away from the moraine, but the proximal (ice side) drops steeply, 120 to 150 ft within 1,500 ft, toward Dryden Lake and its outlet.

Fluvial outwash in front (south) of the moraine, highly irregular topography (kames and kettles), and abundant boulder and cobble erratics on the moraine indicate a depositional environment that was close to the ice margin. Fluvial and(or) debris-flow sediments were deposited adjacent to and in front of the ice, and some accumulated on top of the ice and were subsequently laid down as the ice melted. At least one layer of till was deposited during a later readvance near or on top of some parts of the moraine, as evidenced by standing water at land surface, soil maps, and records of wells in the area.

Disintegration of ice

The Valley Heads ice melted 13,500 to 14,500 years ago during which time extensive moraines were formed at the ice margins in valleys (Fullerton, 1980). The moraines in the study area are characterized by ice-disintegration features such as kame terraces, kames, outwash heads, kettles, collapsed sediments, and hummocky ablation drift (pl. 2).

Drainage of Virgil Lake and meltwater in Virgil Creek valley to Harford valley. When the interfluve between the two-pronged Virgil Creek and Dryden Lake - Harford valley became free of ice, proglacial Virgil Lake and meltwater in the Virgil Creek valley drained south through a channel (elevation 1,260 ft) across the interfluve (pl. 2) and into the Dryden Lake valley, where it flowed either southward from the ice front to the Harford valley or northward through crevasses or a subglacial system to a lower outlet elsewhere. For Virgil Lake and meltwater in the Virgil Creek valley to drain southward to the Dryden Lake valley and then southward to the Harford valley would require a lower outlet in the Harford valley than the Virgil Creek valley. The maximum elevation of ice-contact features in the Virgil Creek valley, and of the outlet for Virgil Lake, is about 1,400 ft above sea level, whereas the maximum elevation of ice-contact features and the outwash head in the Dryden Lake - Harford valley was lower—from 1,290 to 1,350 ft. Therefore, meltwater in the Virgil Creek valley and proglacial Virgil Lake must have drained southward to the Dryden Lake - Harford valley once the interfluve between the two valleys was breached.

An outwash head in the Harford valley at about the same elevation as the interfluve channel (both about 1,260 ft above sea level) supports the hypothesis that some meltwater flowed from the Virgil Creek valley to the Harford valley. The channel across the interfluve has been subsequently covered by till deposited by a readvance of ice.

Outwash in the Harford valley. During disintegration of the ice in the study area, meltwater deposited outwash south of the moraine in the Harford valley. Two layers of till are interbedded with the outwash just beyond the divide on the moraine (Randall and others, 1988, and section A-A′, pl. 3 of this report). Here two outwash heads are found—one along the western valley wall near the intersection of West Lake Road and Route 38 at an elevation of 1,290 ft, the other near the intersection of Cotterill Lane and Willow Crossing Road at an elevation of about 1,255 ft (pl. 2). The western outwash head ends at thick ice-contact deposits at the southern side of Dryden Lake and indicates the area where meltwater drained from the ice tongue that occupied the Dryden Lake area.

The outwash head on the eastern side of the Dryden Lake - Harford valley does not terminate at a large ice-contact deposit but, rather, grades up to the eastern valley wall to the point where Daisy Hollow Brook flows into the Harford valley. This eastern outwash head was probably deposited by meltwater from both the Virgil Creek valley and the eastern side of the ice tongue in the Dryden Lake - Harford valley. Some of the outwash is mixed with some inwash and has been subsequently covered by 10 to 25 ft of alluvium deposited by Daisy Hollow Brook (pl. 2).

Hummocks. An area of irregular hummocky moraine north of Dryden Lake (H and D1/H, pl. 2) consists of a complex of till and debris-flow, glaciofluvial, and glaciolacustrine deposits. During the early stages of ice-disintegration, when the ice was still thick and its surface was relatively high, the depositional environment was probably dominated by melt-out, debris-flow, and glaciofluvial processes. During ablation of the ice, debris within and on top of the ice became concentrated on the surface, and as relief developed on the ice surface by differential melting, most of the sediment accumulated in troughs between ice-cored ridges. Ponding would have been more likely during later stages of ice disintegration, when meltwater could have accumulated in depressions on the ice or when the ice surface melted below the saddle elevation (about 1,220 ft) at the moraine (fig. 7). The final relief after the melting of the ice resulted in topographic inversion, where the former sediment-filled troughs were left as mounds and former ice-cored ridges as depressions. The types of sediments depended on the depositional environment, which could have been one or a combination of the following: (1) Melt-out till and supraglacial debris deposited where downmelting occurred without ponds or meltwater streams, (2) glaciofluvial material deposited where meltwater streams flowed in troughs, and (3) glaciolacustrine material deposited where ponds occupied the troughs (figs. 7 and 8).

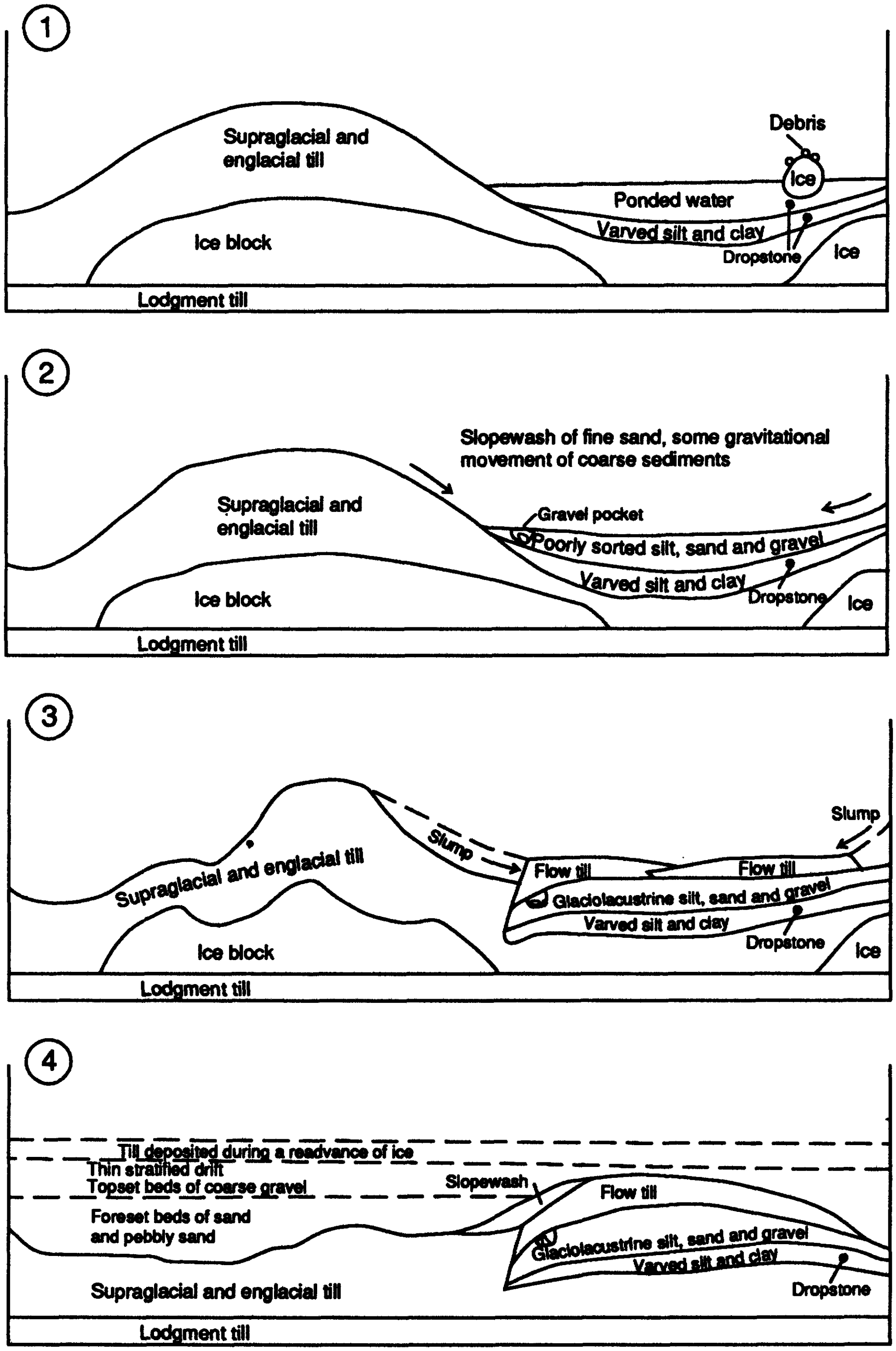
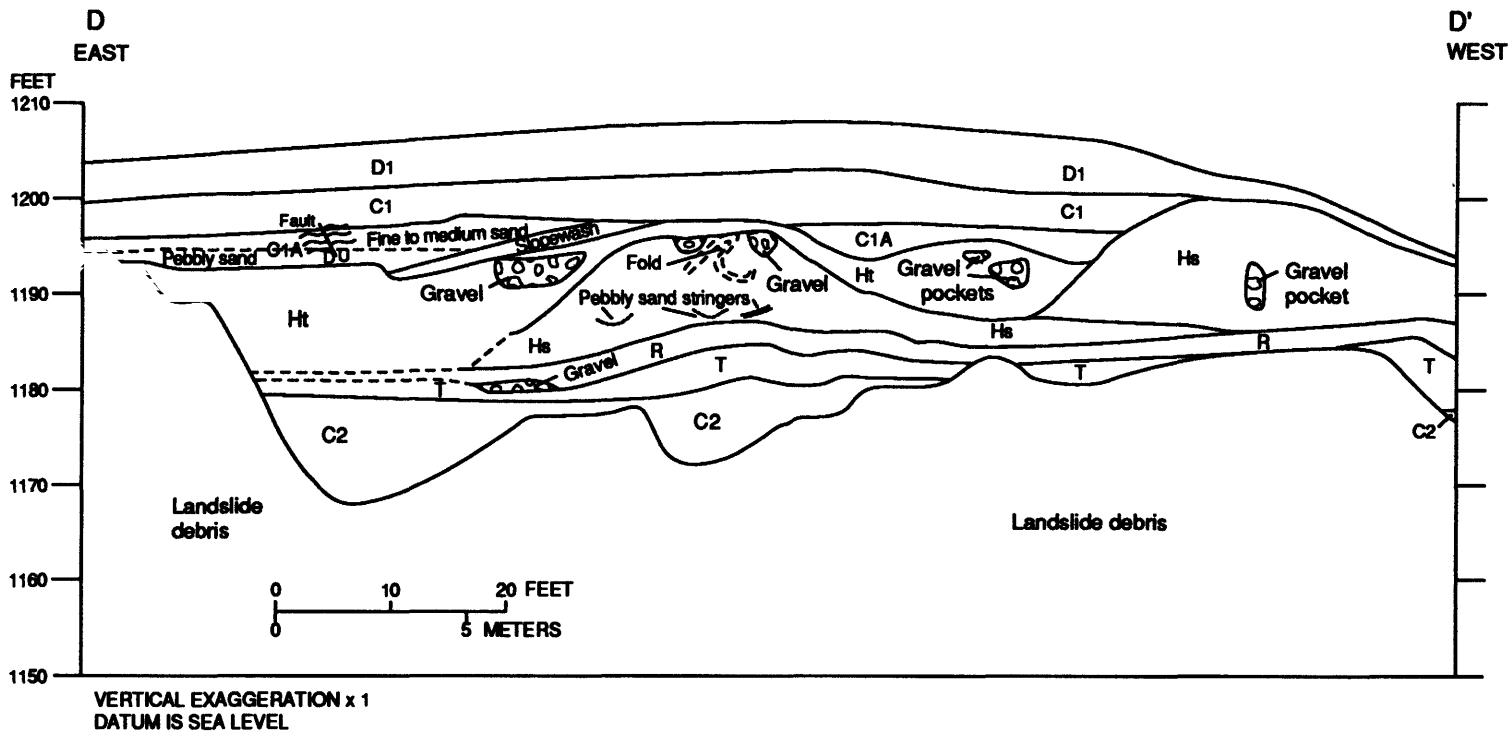


Figure 7.--Idealized formation of hummocks.



EXPLANATION

D1	TILL--drab, sandy clayey silt matrix, sparse stones
C1	CONFINED ZONE 1 (upper part)--coarse cobble gravel, moderately bright
C1A	CONFINED ZONE 1 (lower part)--pebbly sand, moderately bright, approximately horizontal bedding
Ht	HUMMOCK TILL--silt matrix, moderately stony, moderately bright, some gravel pockets
Hs	HUMMOCK SILT--massive bedding with some sand stringers; rare pebbles, gravel pockets, and folded bedding
R	RHYTHMITE--varied silt and clay with some dropstones
T	TILL--moderately bright, very bright, similar lithology as below
C2	CONFINED ZONE 2--coarse cobble gravel, very bright, poorly stratified

Figure 8.--Exposure of a hummock in a cutbank along Virgil Creek at Southworth Road, viewed from north. (Location shown on plate 2.)

In some areas, sand and(or) gravel (stipples over H, pl. 2) and(or) till (D1/H, pl. 2) drapes over the hummocks; this represents post-hummock episodes of sedimentation. Hummocks overlie melt-out and(or) lodgment-till layers that in turn overlie older drift that together may be more than 300 ft thick in the center of the Dryden Lake - Harford valley.

Last Readvance

Thin, drab stratified drift and a thin, drab layer of till over most of the earlier ice-disintegration deposits in the Dryden Lake - Harford valley indicates that the last effect of glaciation in the southeastern part of the study area was a readvance of Valley Heads ice to or just beyond the divide in the valley. Readvancing ice deposited a till layer over older drift, and as the ice melted, relatively small amounts of stratified drift that were in, on, and at the bottom of the ice were laid down on top of the till. The dull-gray appearance characteristic of drab drift is caused by gray or greenish-gray shale and siltstone of local origin that constitutes more than 90 percent of the pebbles in the drift.

Drab upper till. The drab upper till layer (D1, pl. 2) lies at or near land surface from just south of the divide at the moraine in the Dryden Lake - Harford valley north to test hole 46-48 (near the outlet to Dryden Lake) and the Southworth Road outcrop (pl. 2). Test holes 46-48, 58-35, 51-05, 55-04, and 31-00 penetrated the drab till (table 4, at end of report). The till is generally less than 10 ft thick and, in some places, is absent.

Thin stratified drift. In some places, the drab upper till is covered by thin, drab stratified deposits (stippled and Sd areas in pl. 2), that consist partly of outwash and kames but chiefly of inwash that grades to postglacial alluvial fans. The stratified drift is generally less than 15 ft thick.

Absence of surficial lacustrine deposits. Fairchild (1934) stated that proglacial lakes in front of the retreating ice were typical of most north-draining valleys, and described such a lake that occupied the Virgil Creek and Dryden Lake - Harford valleys during the retreat of the ice north of the village of Dryden. The outlet to the lake (elevation 1,220 ft) was on the Valley Heads moraine in the Harford valley (pl. 2). Surficial lake deposits are absent between the village of Dryden and the moraine, however, which indicates that no lake occupied the Dryden Lake and Virgil Creek valleys during the final retreat of the ice. Although thick drift, including lacustrine fine sand, silt, and clay, was deposited during the early advances and retreats of Valley Heads ice, only a thin layer of till that is overlain in some areas by thin outwash, kame deposits, and inwash was deposited during the last readvance of ice to or just beyond the divide on the moraine. No lacustrine material is found at land surface in the areas below the saddle (elevation 1,220 ft) on the moraine that would have been the outlet.

A possible explanation for the absence of surficial lake deposits in Virgil Creek and Dryden Lake - Harford valleys may be that meltwater drained north to a lower outlet through crevasses or a subglacial drainage system throughout the readvance, or at least began to do so before the ice between the village and moraine had melted below the saddle elevation (A. D. Randall, U.S. Geological Survey, written commun., 1988). Some of the other north-draining valleys crossed by the Valley Heads moraine contain well-preserved outlet channels on the moraine and corresponding lake deposits at land surface to the north, but most north-draining valleys are similar to the Virgil Creek and Dryden Lake valleys in that the backslope of the moraine consists mostly of till or thin deposits of sand and gravel rather than lacustrine sediments. Some valleys have lake deposits much lower than the saddle of the moraine (Muller and Cadwell, 1986), however, which may indicate a lower lake whose outlet was elsewhere, rather than a lake that drained across the moraine.

Glacial Stratigraphy in Selected Areas

Well logs from eight U.S. Geological Survey test holes in the Dryden area, ranging in depth from 63 to 106 ft, indicate that the most abundant type of sediment in the upper part of the moraine is till, which forms about 50 percent of the drift, followed by sand and gravel (approximately 30 percent) and lake deposits (approximately 20 percent). Most of the holes penetrated at least two and as many as six till zones interbedded with lacustrine fine sand, silt, and clay, and(or) sand and gravel. Thickness of each till layer typically ranged from 2 to 30 ft and averaged 13 ft.

The test holes typically penetrated two or more sand and gravel layers, except for test hole 46-19 in the Virgil Creek valley (pl. 1), in which only till was encountered. Excluding recent alluvium, the sand and gravel zones penetrated were relatively thin and typically ranged from 2 to 14 ft thick and averaged about 7 ft thick, except in test hole 35-30, low on the backside of a large kame moraine deposit of the south side of Dryden Lake (pl. 1), where a sand and gravel unit at least 66 ft thick was penetrated.

Lake deposits form one to three zones that typically range from 1 to 15 ft thick and average 9 ft thick. The thickest lacustrine deposit penetrated was 38 ft thick in test hole 46-48 near the outlet of Dryden Lake. Although less detailed than the U.S. Geological Survey logs, information from about 60 water-well-drillers' logs indicated generally similar thicknesses of till, sand and gravel, and lacustrine deposits.

Virgil Creek Valley

Test hole 46-19 is near Virgil Creek (pl. 1) where the creek is incised at least 70 ft into the moraine. It penetrated 62 ft of mostly stony till. An exposure in a nearby roadcut revealed a mixture of till and debris-flow, with lesser amounts of ice-contact deposits. No geologic logs of the upper part of the moraine or depths below that penetrated by test hole 46-19 were available.

The upper part of the valley fill in front of the moraine (east), where a proglacial lake once inundated the valley to the level of an outlet at elevation 1,400 ft, consists of lake deposits overlain in some places by alluvial sand and gravel. A driller's log of a well in the hamlet of Virgil, 1.2 mi east of the front of the moraine (not shown on pl. 1), indicated that the top 70 ft of the valley fill contains mostly lake deposits and possibly some till.

Area South of Dryden Lake

During the last glacial readvance, the ice deposited thin, discontinuous stratified drift and a thin till layer atop the outwash in the vicinity of the divide and atop the moraine north of the divide in the Dryden Lake valley (pls. 2, 3). Southeast of the divide, the deposits from the last readvance overlie a thin sand and gravel layer (zone 2 on section A-A′, pl. 3) that overlies a thin till layer (less than 10 ft thick), that in turn overlies a thick sand and gravel zone. The deeper sand and gravel zone ranges from 10 ft to more than 50 ft thick. On the moraine and north of the divide (to at least test hole 58-35), a thin lake deposit (less than 10 ft thick) underlies zone 2. Most of these units can be correlated over a distance of several thousand feet. The interbedded till, sand and gravel, and lake deposit represent deposition by an oscillating ice front, in which till was deposited during the advance and possibly the disintegration of ice, followed by meltwater and inwash deposition on top of the till in front of the divide. North of the divide, a small, high-level lake formed between the ice front and the lowest point in the divide at that time (elevation 1,200 ft); here a thin lake deposit formed between zone 2 and the top of sand and gravel or till.

The geologic log of test hole 35-30 (102 ft deep), on the south side of Dryden Lake and low on the large kame moraine, indicates the presence of mostly sand and gravel except for a thin lacustrine layer and a thin till layer between depths 29 and 35.5 ft. The thick sand and gravel deposit below 35.5 ft is probably part of the main moraine, which was deposited during a major stillstand of the ice.

Test hole 46-48, near the outlet of Dryden Lake, penetrated little or no gravel below the upper 20 ft of drab sand and gravel (section A-A′, pl. 3). A 38-ft-thick, fine sand deposit, from depths of 32 to 70 ft, may represent the filling in of the kettle now occupied by Dryden Lake, by either deltaic or lake-bottom sediments.

Area North of Dryden Lake

Stratigraphy in the hummocky area north of Dryden Lake is more complex than in the area to the south. Even though the hummocky area has many well records, correlation between geologic units is difficult (pl. 3) because the deposits are of many types, discontinuous, and irregular in shape. The complexity of the hummocky zone is probably due to a sequence of differing depositional environments.

The southeastern part of the hummocky area is overlain by thin, discontinuous stratified drift, typically 3 to 12 ft thick, and a 3- to 8-ft-thick drab till, both of which were deposited during the last readvance of the ice. The hummocks consist of an irregular, 10- to 30-ft-thick complex of till, lake deposits (some of which were reworked by ice or gravity flow), and glaciofluvial sediments that were deposited during disintegration of stagnant ice. The structure and stratigraphy observed in the hummocks (figs. 7 and 8) are so complex that correlation of geologic units in plate 3 is speculative. Underlying the hummocks is a thin, possibly discontinuous layer of lodgment till that was laid down during the readvance of ice that deposited the hummocks.

The hummocks are underlain by a thin and discontinuous 3- to 12-ft-thick sand and gravel deposit, generally found between depths of 20 and 45 ft (zone 2 in pl. 3). Pebbles in zone 2 are bright, which suggests a glaciofluvial origin such as outwash or ice-contact deposits.

The zone 2 sand and gravel unit is underlain in most areas by 2 to 20 ft of till (although some drillers' logs indicate that this zone may be underlain by 10 to 35 ft of lacustrine deposits). Since till underlies zone 2 in most areas, the stratigraphy suggests that zone 2 is an ice-contact deposit laid down during disintegration of stagnant ice.

Where the lacustrine deposit underlies zone 2, it is in turn underlain by an undulating 10- to 20-ft-thick till unit (sections A-A′ and B-B′, pl. 3), which indicates that water was ponded between the ice front and the divide on the moraine during either an advance or a retreat of ice. The till overlies or drapes over a 3- to 25-ft-thick sand and gravel deposit (zone 3) with an undulating upper surface that in turn is underlain by till commonly found between 75 and 100 ft below land surface (sections A-A′ and B-B′, pl. 3). The undulating upper surface of zone 3 and the position of the sand and gravel zone between two tills suggest that it is an ice-contact deposit that formed during disintegration of stagnant ice and was covered by till during a subsequent glacial readvance.

Data from seven drillers' logs of deep wells drilled between depths of 100 and 200 ft in the Dryden area reveal interlayered lake, till, and subordinate sand and gravel deposits. At depths below 100 ft, the lacustrine deposits become slightly more common than till, although individual layers are relatively thin, typically ranging from 20 to 30 ft. Lacustrine sediments may be more abundant below depths of 100 ft because less sediment had accumulated in the valley during the early stages of Valley Heads glaciation, and the valley floor was deeper; therefore, lake environments could have been more common in a deep valley than during later oscillations, when subsequent sediments and buried ice blocks had accumulated in the valley.

Three wells and test holes near (and drilled for) the Village of Dryden that were drilled to depths of 175 to 300 ft penetrated mostly till and lacustrine deposits and a sand and gravel zone. Wells 05-49 and 55-43 penetrated sand and gravel (zone 4 in section A-A', pl. 3) at depths of 170 to 184 ft and 193 to 217 ft, respectively. Well 58-28, which is 300 ft deep and in the southeastern part of Dryden, penetrated mostly lacustrine material and some till below zone 3.

Comparison with Other Valleys

Some concepts developed within this locality could also apply to other valleys crossed by the Valley Heads moraine in central New York despite some differences in the hydrologic setting and some stratigraphic features that may be unique to the Dryden area, such as the Y-shaped Virgil Creek and Dryden Lake - Harford valley system. In most major valleys in central New York that are crossed by the Valley Heads moraine, the moraine forms the divide between the southern drainage into the Susquehanna River basin and north drainage into the Oswego River basin (fig. 3). In the Dryden area, however, it forms a divide in the Dryden Lake - Harford valley but not in the Virgil Creek valley because Virgil Creek has eroded a shallow gorge through the upper part of the moraine that allows northwestward flow.

Another difference is the depositional environment during deglaciation. Meltwater typically deposited an outwash train in front of the Valley Heads moraine, but in the Virgil Creek valley, the area in front of the moraine was occupied by a lake. The absence of outwash in front of the moraine in the Virgil Creek valley indicates early diversion of meltwater to other valleys.

A significant stratigraphic difference between the Virgil Creek and Dryden Lake - Harford valleys and other valleys crossed by the Valley Heads moraine is that the upper 100 ft of drift in the Virgil Creek and Dryden Lake - Harford valleys consists mostly of till interbedded with minor thicknesses of lacustrine deposits and sand and gravel, whereas the upper 100 ft of drift in several other lower north-draining valleys contains large amounts of lacustrine sediments (Dunn Geoscience, 1985; Crain, 1974). The abundance of till in the Virgil Creek and Dryden Lake - Harford valleys indicates that the deglaciation environment here was dominated by ice, whereas in many other valleys it was dominated by lakes.

Lithology as a Clue to Origin of Deposits

Because Valley Heads drift in this study area ranges from "drab" to "bright" (most other studies reported mostly "bright" drift), and typically "drab" Olean drift is "bright" in some through valleys, such as this study area, no clear lithologic distinction is evident between the two drifts. A lithologic distinction was noted between Valley Heads drift and recent deposits in some parts of the study area, however. In the study area, the lithology of the pebbles in the Valley Heads drift ranges from drab to bright, and the erratics constitute 3 to 52 percent of the pebble content. Some parts of the Valley Heads moraine contain drab and moderately drab drift, whereas other parts contain bright drift. In general, the drab drift is found mostly in the eastern part of the study area, and the proportion of erratics in the drift increases with depth.

Distribution of Drab and Bright Sediments

Holocene alluvium. Alluvium in the study area is drab to moderately drab. Alluvium contains fewer erratic stones in Dryden Lake basin (3 to 10 percent) than in Virgil Creek basin (7 to 12 percent), probably because the drainage basin of Dryden Lake contains predominantly drab till and bedrock in the uplands, and a drab upper till at or near land surface in the valley. Streams in the Dryden Lake - Harford valley have not eroded through the drab upper till into the underlying bright drift, as Virgil Creek has.

Although Virgil Creek flows through a 3-mi-long gorge with erratic-rich cutbanks, the pebbles of the channel deposits are drab to moderately drab. Locally derived shale and siltstone pebbles make up from 88 to 93 percent of the alluvium at four sites from which samples were collected from the channel, and limestone formed from 1 to 5 percent of the samples. The drab to moderately drab pebble content with slightly increasing limestone content downstream suggests that most of the alluvium is derived from the erosion and transport of clasts from bedrock and drab till in the uplands. The slight increase in limestone content downstream indicates some incorporation of limestone-rich morainal sediments that are exposed in cutbanks along the sides of the gorge.

A 10- to 20-ft-thick alluvial fan was deposited in the Village of Dryden area where Virgil Creek flowed north from the moraine and onto the broad valley flat. At test hole 09-54, in the southern part of the village (pl. 1), pebbles in the lower part of the fan (12 to 19 ft) were moderately bright; 85 percent consisted of local clasts, 10 percent of limestone, and 5 percent other erratics. These percentages are similar to those of readvance deposits found in the moraine, excluding the drab upper till in the southern part. The lower part of the alluvial deposit may have formed predominantly during erosion of the gorge, which has similar pebble lithology. The upper part of the alluvial deposit is drabber than the lower part, which may indicate that the rate of erosion in the gorge decreased and more alluvium was derived from the uplands.

Small streams that drain uplands deposited 10- to 20-ft-thick alluvial fans at the edges of the valleys. These fans generally overlie outwash and(or) till. Their high drab-pebble content (97 percent local clasts) attests to an upland source of clasts derived from erosion of bedrock and drab upland till.

Drab stratified drift and uppermost till. The moraine in the southeastern part of the study area is covered by a thin, drab till layer (D1, pl. 2) from just south of the divide to the Southworth Road outcrop (pl. 2). The upper till layer represents the last readvance of ice to or just beyond the divide, where the ice then dissipated, leaving no more than thin till and discontinuous stratified drift deposits (A. D. Randall, U.S. Geological Survey, written commun., 1986). The pebbles in the upper till consist mostly of local shale and siltstone (94 to 100 percent) with only a trace of limestone. The discontinuous stratified deposits (shown as stippled areas and Sd on pl. 2) consist of some outwash and kames but mostly inwash that grades to postglacial alluvial fans. The drabness of the clasts in the stratified deposits indicates that, during the last readvance, either alluvium was deposited by local tributaries in crevasses and on top of stagnant ice, or the frontal reach of the ice tongue contained drab drift that became sorted by meltwater and then laid down as outwash and kames as the ice melted.

Moderately bright tills. Most tills in the upper 100 ft of drift are moderately bright, with an erratic-pebble content typically ranging from 15 to 25 percent; 10 to 20 percent of the pebbles are dark-gray limestones. The number of erratic pebbles in the till increases with depth at some test-hole sites and outcrops (31-00, 58-35, 03-54, and Southworth Road outcrop) but not at others. A trend of increasing bright-pebble content with depth is more distinct in sand and gravel deposits than in till. (Lithology of sand and gravel deposits are discussed in the aquifer section, farther on.)

Bright tills. Tills in which erratics constitute more than 30 percent of the pebbles were found overlying very bright gravel at sites such as the Southworth Road outcrop, test hole 07-30, and near the southern valley wall at the intersection of State Route 38 and Keith Lane (pl. 1 and table 4, at end of report). The lowest till (depth 55-73 ft) encountered in test hole 07-30 probably overlies bedrock. The pebbles in the lowest till are 50 percent erratics, of which most were limestone (table 4). Although the test hole did not penetrate bedrock, other nearby wells in bedrock indicate the base of the test hole was near bedrock.

Dilution of Bright Drift

The difference between the drab till in the southeastern part of the study area, in conjunction with drab drift that becomes slightly brighter with depth throughout the study area and the relatively erratic-rich till to the north that also becomes slightly brighter with depth, may reflect the amount of drab inwash that was deposited on, into, and in front of the ice by Virgil Creek and other streams that drained the adjacent hillsides and uplands. During the early stages of Valley Heads glaciation of the southern Finger Lakes region, ice flowed southward, completely covering the north-draining basins of the Ontario Plain (fig. 1). Lakes formed in front of the advancing ice. Little drab sediment flowed onto the ice because the source area (the relatively flat plain to the north) was covered by ice and because lakes in the valleys in front of the glacier trapped much of the inwash from northward-draining streams flowing from the Allegheny Plateau before it could reach the ice. As the ice advanced southward, lakes formed in depressions at successively higher levels, and the fine-grained lacustrine material that settled in these lakes buried the previous inwash. Some of these buried inwash deposits could have been incorporated into the ice as it overrode and eroded through the lacustrine deposits. Therefore, when ice was just north of Dryden, most of the drift in the ice was derived from relatively bright drift transported from the north as well as drab drift eroded and incorporated into the ice from underlying deposits, which included bedrock, previously deposited glacial drift, and lacustrine sediments.

As tongues of ice extended from the main ice massif and intruded into the northern rim of the Allegheny Plateau and partly filled the north-draining Dryden Lake - Harford and Virgil Creek valleys where the adjacent uplands were higher than the ice tongue, the ice replaced the lake that had formed in front of the advancing ice. During the early stages of glaciation, the ice tongue contained relatively erratic-rich sediments, some of which were deposited to form the moraine, and some were deposited by southward-flowing meltwater streams as outwash in front of the moraine in the Harford valley. During the late stages of deglaciation, when the ice underwent a temporary recession and(or) stagnation, the low outer margin of the tongue may have been mantled with drab inwash that was deposited by Virgil Creek and the many streams that drained the adjacent hillsides and uplands (A. D. Randall, U.S. Geological Survey, written commun., 1988). The sediment load of the outer 1 or 2 mi of ice probably was relatively drab; therefore, as the ice readvanced it deposited relatively drab drift southward and in the area where much inwash had flowed on and in the ice. Farther north, in the vicinity of the Village of Dryden, the drift is brighter because the source of drab inwash (streams draining the northern rim of the Allegheny Plateau) was farther away.

ORIGIN AND DISTRIBUTION OF AQUIFERS

The Valley Heads moraine aquifer system in the Dryden area contains at least five significant confined zones and possibly several small areas of thin unconfined (water-table) aquifers. The five confined zones generally are stacked vertically, but some are discontinuous and, therefore, are absent in some areas. The confined system consists of supraglacial debris, kames, collapsed outwash, and possibly interstadial alluvium. The unconfined aquifers consist of alluvial flood-plain material and fans deposited recently by streams, and thin outwash and kames deposited in the low areas during final retreat of the ice.

Wells in the Dryden area tap water from four of the five confined zones in the Valley Heads moraine aquifer system. Only one well (24-41) from which a geologic log is available is known to tap an unconfined aquifer in the moraine—a kame deposit at the southern end of Dryden Lake. Test borings revealed other small unconfined aquifers in some low areas. The large unconfined outwash aquifer that extends southward from the front of the moraine in the Harford valley is mostly outside the study area and is not discussed here.

Unconfined Aquifers

The small, discontinuous, and(or) thinly saturated unconfined aquifers consist of alluvial fan and flood-plain, outwash, and kame deposits. Those that consist of outwash and kame material were deposited during the last readvance of Valley Heads ice into the Dryden Lake area; the alluvial fan and flood-plain material was deposited by Virgil Creek and other small tributary streams during postglacial time.

Alluvial Deposits

The flood-plain deposits of Virgil Creek are poor aquifers because they are only 3 to 10 ft thick and are likely to be saturated only seasonally. Upland runoff that seeps into the aquifer and most of the precipitation that falls on the flood plain drains rapidly along the interface between the alluvium and underlying till and discharges into Virgil Creek.

The Virgil Creek alluvial fan in the southern part of the Village of Dryden is also relatively thin (10-20 ft thick) but is perennially saturated. Test hole site 09-58, drilled in the alluvial deposits in the southern part of the village (pl. 1) during the summer of 1984, revealed alluvium that was 20 ft thick, of which 11 ft was saturated.

The alluvial fans along the edges of the valley also form small aquifers. Precipitation provides some recharge to the fans, but most recharge is from infiltration of water from losing reaches of the tributary streams that flow on the fans. The fans are saturated as long as streams are flowing, but probably drain dry during dry periods where streams flow intermittently.

Surficial Outwash and Kames

As ice of the last readvance melted, it left thin, drab outwash and kame deposits over till in some places (shown as Sd in pl. 2). Most of these deposits are largely unsaturated, but those in low areas are commonly saturated, especially near surface-water bodies such as Dryden Lake and streams. Test-hole 46-48, on a kame deposit adjacent to the outlet of Dryden Lake (pl. 1 and hydrogeologic section A-A′ on pl. 3), penetrated 20 ft of drab surficial gravel, of which 7 ft was saturated. Test hole 35-30, on a kame adjacent to Dryden Lake, showed 28 ft of surficial gravel, of which 16 ft was saturated. Only one well (24-41, at the south end of Dryden Lake) from which a geologic log was available is known to tap an unconfined aquifer.

Confined Aquifer System

The confined aquifer system in the Valley Heads moraine has five confined zones that are separated by fine-grained confining beds such as till, and by lacustrine fine sand, silt, and clay. Mapping and discerning the origin of the sediments in the confined zones was difficult because deposition in the zone of decaying ice was complex, especially where readvances had reworked some of the older deposits, and because the quality of well logs was variable. Some uncertainties in correlation between well logs were due to the variable nomenclature and degree of detail used by different drillers to describe sediments. For example, "clay and gravel" as reported by drillers could be till or silty gravel. Lacustrine deposits could not always be distinguished from till because sedimentary structures were not usually noted in well logs and because some lake deposits were reworked by overriding ice to form silt- and clay-rich till with only trace amounts of small pebbles that might not have been noted. The drillers' term "clay with some stones" could be till (reworked lacustrine with few stones) or lake deposits with dropstones.

Zone 1

The several thin and discontinuous sand and gravel lenses, or patches that underlie the upper till in the hummocky area north of Dryden Lake, are designated zone 1 in this report (pl. 3, sections A-A′ and C-C′). Several wells penetrated 1- to 5-ft-thick sand and gravel that typically is found 5 to 20 ft below land surface, but few wells were installed in these deposits because it is thin, shallow, and only partly or seasonally saturated in many places.

Pebbles were collected from zone 1 at test-hole sites 07-30 (near Keith Lane) and 17-13 (on Kimberly Drive) and at the Southworth Road outcrop (fig. 8) and examined for lithologic content. The pebbles are drab, which suggests an alluvial and(or) inwash origin. The sand and gravel at the Southworth Road outcrop that forms zone 1 is stratified and dips to the west, which suggests deposition by a westward-flowing stream, possibly inwash from the Virgil Creek valley.

Zone 2

The thin, moderately bright to bright, discontinuous sand and gravel zones that are typically found near the bottom of the hummock deposits (north of Dryden Lake) or between tills, or till and lake deposits (south of Dryden Lake) are designated as zone 2 in this report (pl. 3). Zone 2 is typically found 20 to 45 ft below land surface.

Zone 2 probably consists of supraglacial sediments such as debris-flow, glaciofluvial, and kame deposits that make up part of the hummocks. Evidence in support of these origins are: (1) An exposure of a hummock along Virgil Creek at Southworth Road (fig. 8) that reveals several small, clearly discontinuous sand and gravel zones, and (2) moderately bright pebbles suggestive of an ice source for the gravel. Gravel pockets in the exposed hummock along Southworth Road and in the upper part of test holes 17-13 and 03-54 have moderately bright to bright clasts, 12 to 40 percent of which are erratics, and 7 to 28 percent of which are limestone.

Measurement and comparison of water levels between zones 2 and 3 was feasible at only one site, the Keith Lane apartments, which have two wells; one taps zone 2, and the other zone 3. The water level in the 42-ft-deep well (09-04) in zone 2 was 3 ft higher than in the 71-ft well (09-05) in zone 3, which suggests little or no hydraulic connection between the two zones.

Zone 3

Zone 3 is semicontinuous to continuous, has an undulating surface in some areas and a flat surface in others that slopes northwestward, and has a variable thickness ranging from 5 to 15 ft (pl. 3, sections A-A′ and B-B′). In high areas, such as the southeastern part of Lake Road, the top of zone 3 typically is 80 to 90 ft below land surface, but in low areas, such as Kimberly Drive and the valley flat in the vicinity of Dryden, it typically is 25 to 50 ft deep. Wells completed in this zone in the low areas (below elevation 1,110 ft) commonly flow at land surface during the spring.

Many wells obtain water from this zone, including most homes along Lake Road, some along Kimberly Drive, and two municipal wells for the Village of Dryden. Bail tests of open-end wells by drillers indicate yields of 12 to 30 gal/min. Aquifer tests at the two screened municipal wells (57-27 and 59-29) indicate yields of 100 and 115 gal/min, respectively.

The origin of zone 3 is uncertain because its lithology and geometry differ from place to place. If the correlations shown in section A-A′ and B-B′ in plate 3 are correct, the top of zone 3 is gently undulating in some areas and has level surfaces in other areas. Most well logs indicate that till overlies the aquifer, suggesting that ice overrode the aquifer and may have partly eroded and modified its original surface. If erosion by ice of the top of the aquifer were negligible, the nearly level, north-sloping surface with a gradient similar to that of Virgil Creek suggests an interstadial alluvial origin, but the undulating parts of the aquifer suggests that it is a kame or a collapsed outwash deposit. The surface of zone 3 could have been eroded and flattened by the advancing ice in some areas and left as an undulating surface elsewhere.

Results of lithologic analyses of pebbles to determine the origin of the deposit were contradictory. The pebble lithology at test hole 09-58, in the southern part of the village (pl. 1), is variable within the gravel zone that probably correlates with zone 3. The dirty gravel in the upper part of the zone (depth 22-23 ft) is drab, whereas pebbles in the underlying gravel (depth 23-24 ft) are bright (table 4).

Pebbles from gravel, observed during drilling of well 28-14 (pl. 3, section B-B′ and table 4) installed in zone 3 along Lake Road, were also drab, whereas those from the permeable zone (depths of 35 to 42 ft) that possibly correlates with zone 3 at test hole 17-13 along Kimberly Drive were bright. Of all the pebbles at this site, 14 percent were limestone (table 4).

In summary, correlation between zones is likely to be more complex than shown on plate 3, and the unit shown as zone 3 could actually consist of two or more discontinuous zones of slightly differing age and origin.

Zone 4

Deposits correlated as zone 4 are semicontinuous and have a highly irregular surface and a variable thickness. The zone's highly undulating surface is best defined by well logs along Kimberly Drive (section A-A′) and Lake Road (section B-B′), where at least 18 wells tap this zone. Thickness typically ranges from 5 to 30 ft. In high-elevation areas, such as along Lake Road, zone 4 is typically 90 to 125 ft deep, whereas along Kimberly Drive, which is 10 to 30 ft lower than Lake Road, the aquifer is typically 70 to 115 ft deep. Bail tests by drillers of open-ended, cased wells indicate the yield of water to wells that tap zone 4 range from 10 to more than 30 gal/min.

In low areas, generally below elevation 1,150 ft, wells in zone 4 commonly flow at land surface for at least part of the year. Well 36-28, on Kimberly Drive (top of casing 1,141.2 ft), typically flows from December to July, and well 42-34, lower on Kimberly Drive (top of casing 1,123.0 ft), flows all year.

Results of synoptic water-level measurements showed evidence of hydraulic continuity that helped distinguish the zones that certain wells tap. At the site of four wells within 300 ft of each other on Kimberly Drive, water levels in the two deep wells that tap zone 4 were nearly identical (table 1) and were 2 ft higher than levels in the two adjacent shallow wells that tap zone 3; these levels also were nearly identical.

Another hydraulic characteristic that distinguishes zone 3 from zone 4 is the range of annual water-level fluctuation. The water level in zone 4 fluctuates about 20 ft between spring and late fall, whereas fluctuations in zone 3 are about 10 ft (table 2). The difference in water level between zones 3 and 4 is greatest during the spring. During the first week in May 1970, the water level in well 24-17 in zone 4 on Kimberly Drive was 12 ft higher than in well 24-20, 200 ft away in zone 3 (table 2), which suggests that zone 4 has a higher recharge area than zone 3, such as the moraine to the south or kame terraces on the valley walls. The difference between water levels in zones 3 and 4 decreased to 2 ft during late fall, when zone 4 had higher water levels than zone 3.

Zone 4 is probably an ice-contact deposit, as indicated by the following characteristics: (1) it has a highly undulating surface that is typical of kame deposits in ice-stagnation areas (flat, sloping surface would support an interstadial alluvium or outwash deposited in front of the ice); and (2) water levels during the spring that were as much as 12 ft higher in zone 4 than in zone 3 suggest a higher recharge area for zone 4, such as the kame moraine at the southern side of Dryden Lake.

Table 1.--Water levels in zones 3 and 4 in wells on Kimberly Drive, October 29-30, 1985.

[Locations are shown on pl. 1.]

Well number	Confined-zone number	Depth of well, in feet below land surface	Water level, in feet above sea level
24-20	3	42	1,134.8
23-19	3	43	1,135.3
23-16	4	99	1,137.5
24-17	4	113	1,137.2

Zone 5

Zone 5, the deepest (157 to 215 ft) of the confined water-bearing zones identified, is penetrated by only three wells (05-49, 55-43, and 06-54), all within 1,500 ft of each other in the southern part of the Village of Dryden (pl. 1). Only one other well in the study area was drilled deeper than 215 ft; well 58-28 was drilled to a depth of 300 ft and did not penetrate a sand and gravel zone below a depth of 110 ft (including zone 5) or bedrock.

Table 2.--Seasonal fluctuation of water levels in confined zones 3 and 4.

[>, greater than. Well locations shown in pl. 1.]

Well number	Confined-zone number	Measurement date	Water level, in feet above sea level	Measurement date	Water level, in feet above sea level	Difference, in feet
24-20	3	5-1-70	1,145.2	10-29-85	1,134.8	10.4
14-05	3	4-29-66	1,160.6	10-17-85	1,153.3	7.3
24-17	4	5-4-70	1,157	10-30-85	1,137.2	19.8
36-28	4	Dec.-July	flows	10-31-80	1,121.3	>18.0

During nonpumping conditions, the three wells that tap zone 5 are normally flowing and have heads from 6 to 12 ft above land surface (Apfel, 1963). Water levels in these wells are affected by pumping of any one well, which indicates hydraulic connection among the wells.

Available information suggests that zone 5 is an ice-contact deposit because (1) the driller's log of well 55-43 notes "colored stones," which probably are crystalline erratic pebbles derived from the glacier; and (2) the top of the zone slopes downward to the south (pl. 1, section A-A′), the direction opposite to that which would occur if the zone had been deposited by an interstadial northward-draining stream.

SUMMARY

Valley Heads ice abutted the north rim of the Allegheny Plateau about 13,500 years before present. Tongues of ice extended several miles south of the main ice massif into the through-valley section of the plateau and deposited large moraines (Valley Heads moraines) in the through valleys near its terminus, including the Virgil Creek and Dryden Lake - Harford valleys. The moraine consists of interbedded till and glaciofluvial and glaciolacustrine deposits that, in some areas, are overlain by thin postglacial alluvium.

Glacial Geology

Lake sediments accumulated in a lake that formed in front of the moraine in the Virgil Creek valley. The upper parts of the moraine in the Virgil Creek valley consist of till and debris-flow with lesser amounts of ice-contact deposits. The moraine in the Dryden Lake - Harford valley is mostly along the southern side of the valley and consists of a cobbly till mixed with dirty sand and gravel. Meltwater deposited outwash south of the moraine in the Harford valley, and two layers of till are interbedded with the outwash for about 1 mi south of the drainage divide.

The last glaciation in the southeastern part of the study area was a readvance of Valley Heads ice to just beyond the modern divide in the Dryden Lake - Harford valley. The ice deposited thin stratified drift and a thin layer of drab till over most of the ice-disintegration deposits in the Dryden Lake - Harford valley. This discontinuous stratified drift, which consists of outwash deposited by meltwater and inwash deposited by upland streams, was deposited on the ice and then laid down as the ice melted. Surficial lake deposits are absent between the village of Dryden and the moraine, however, indicating that no lake was present in the Dryden Lake and Virgil Creek valleys during the final retreat of the ice. The notable absence of surficial lake deposits in the Dryden area is atypical of the Valley Heads geologic setting. Apparently meltwater began to drain through a lower outlet to the north, across the ice or through a subglacial drainage system, before the ice melted below the level of the divide, thereby preventing the formation of lakes.

Geologic logs from eight U.S. Geological Survey test holes drilled at the Valley Heads moraine in the Dryden area, ranging in depth from 63 to 106 ft, indicate that till is the most abundant material in the upper part of the moraine. It represents about 50 percent of the drift, followed by sand and gravel (approximately 30 percent) and lake deposits (approximately 20 percent). Most holes penetrated at least two, but as many as six, till layers interbedded with lacustrine fine sand, silt, and clay, and(or) sand and gravel. Thickness of individual till layers typically ranges from 2 to 30 ft and averages 13 ft.

The test holes typically penetrated two or more sand and gravel zones, except for a test hole in the Virgil Creek valley that did not penetrate sand or gravel. Excluding Holocene alluvium, the sand and gravel zones penetrated were relatively thin, with a typical thickness of 2 to 14 ft and an average thickness of about 7 ft. An exception was test hole 35-30, located on a large kame moraine south of Dryden Lake, where a sand and gravel zone at least 66 ft thick was penetrated.

Lake deposits form one to three buried layers that typically range from 1 to 15 ft in thickness. The thickest single lacustrine layer penetrated was 38 ft in test hole 46-48 near the outlet of Dryden Lake. Lacustrine layers average about 9 ft thick.

About 60 water-well-drillers' logs are generally similar to logs of U.S. Geological Survey test holes, although less detailed. Drillers' logs of seven deep wells in the Dryden area revealed that the drift between a depth of 100 and 200 ft consists of lake deposits interlayered with till and with less abundant sand and gravel deposits. In this depth interval, lake deposits are slightly more common than till, although individual layers rarely exceed 30 ft in thickness.

Olean drift in the uplands and Holocene alluvium transported from uplands are drab, whereas the Valley Heads drift is considered bright. Accordingly, drab deposits derived from fluvially transported upland material (Holocene alluvium, inwash, and interstadial alluvium) should be distinguishable from bright Valley Heads drift in the valley. The lithologic data collected during this study do not show a clear distinction between the two source terranes, however. The content of erratics in Valley Heads drift ranges from 3 to 52 percent. Some parts of the Valley Heads moraine consist of drab and moderately drab-to-bright drift, and other parts consist of bright drift. In general, the drab drift is found mostly in the upper parts of the moraine in the eastern part of the study area. The proportion of erratics typically increases with depth and also increases from southeast to northwest. South of Southworth Road, the uppermost till and stratified drift are quite drab. These contrasts may be due to the amount of drab inwash that was deposited on, into, and in front of the ice by Virgil Creek and streams that drained the adjacent hillsides and uplands. During the early stages of glaciation, the ice tongue contained relatively erratic-rich sediments. During the late stages of deglaciation, when a temporary recession and (or) stagnation of the ice occurred, the low, outer margin of the tongue could have been mantled with drab inwash deposited by Virgil Creek and the many streams that drained the adjacent hillsides and uplands. The sediment load of the outer 1 or 2 mi could have been relatively drab; therefore, as ice readvanced, it incorporated some of the relatively drab drift and deposited it on the southern parts of the moraine, in the area where much inwash had flowed on and within channels in the ice.

Origin and Distribution of Aquifers

In the Dryden area, the Valley Heads moraine aquifer system contains at least five confined water-bearing zones and several small areas of thinly saturated unconfined aquifers. Most wells (including the village wells) obtain water from the deep confined zones. Only one well is known to tap an unconfined aquifer—a kame deposit at the southern end of Dryden Lake—but test borings indicate the presence of other small unconfined aquifers in alluvial-fan and flood-plain, outwash, and kame deposits.

The five major confined zones of the Valley Heads moraine aquifer system are numbered sequentially starting from the top. Zone 1 is thin, discontinuous, 5 to 20 ft below land surface, and overlain by till. It consists of a mixture of interstadial alluvium and(or) inwash.

Zone 2 is also thin and discontinuous, 20 to 45 ft below land surface, and contains bright pebbles. Zone 2 is probably a glaciofluvial deposit.

Zone 3 is 80 to 90 ft below land surface and is semicontinuous to continuous. It has an undulating surface in some areas and a flat surface in other areas that slopes to the northwest. Thickness typically ranges from 5 to 15 ft. The origin is uncertain because the pebble lithology and aquifer geometry indicate contradictory origins.

Zone 4 ranges from 5 to 30 ft thick and is typically 90 to 125 ft deep. It is inferred to be an ice-contact deposit because it has (1) a highly undulating surface typical of kames; and (2) high-altitude water levels suggestive of a high-elevation recharge area, such as the kame moraine south of Dryden Lake or kame terraces along the valley walls.

Zone 5 is 157 to 215 ft deep. It probably is an ice-derived deposit because a driller reported that it contained many bright pebbles and because the top of the deposit slopes southeastward, opposite to the direction of slope if it were a north-draining alluvial deposit. Its areal extent is probably small.

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Table 3.--Records of wells in the Dryden area, N.Y.
[--, no data available.]

Location: Latitude ° ' "	Location: Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422600	761411	NYS College Agriculture	11-11-78	49	1,213.5	22.9	11-21-78	P. Sand and gravel 0-50, m-c sand 50-52 ft.
422617	761450	NYS College Agriculture	1971	80	--	3.7	03-24-71	Gravelly hardpan 0-28; sand & gravel, water 28-80, silty sand 80-81 ft.
422618	761451	NYS College Agriculture	12-01-70	64	1,216.0	10.8	04-11-83	Soil, sand 0-5, gravelly hardpan 5-30, water 30-85 ft.
422619	761452	NYS College Agriculture	1971	79	--	7.8	04-28-71	Gravelly hardpan 0-30, sand & gravel, water 30-79, cemented gravel 79-80 ft.
422627	761431	NYS College Agriculture	11-01-78	51	1,238.4	32.2	11-16-78	P. Sand and gravel 0-8, till 8-12, sand and gravel 12-52 ft.
422627	761445	NYS College Agriculture	--	50	1,233.5	22.9	04-06-74	Water level 39.85 ft, Dec. 11, 1973.
422630	761445	--	--	45	1,234	--	--	--
422631	761500	NYS College Agriculture	04-01-74	37	1,224.0	12.6	04-06-74	P. Gravel 0-8, till 8-15, sand and gravel 15-18, till 18-28, sand and gravel 28-36, sand 36-37 ft. Second well this location, depth 20 ft.
422635	761438	NYS College Agriculture	01-01-78	--	1,240	1.1	04-17-80	--
422636	761510	NYS College Agriculture	10-16-80	41	1,219	25.0	10-22-80	Second well at this site, depth 11 ft.
422640	761443	NYS College Agriculture	04-01-74	52	1,244.8	48.8	10-15-80	--
422641	761505	NYS College Agriculture	10-17-80	64	1,228.5	29.6	10-22-80	A shallower paired well is nearby.
422641	761505	NYS College Agriculture	10-17-80	26	1,224.6	19.4	10-22-80	Deeper of paired wells is nearby.
422647	761443	NYS College Agriculture	08-18-58	62	1,251	33.0	04-06-74	--
422647	761504	NYS College Agriculture	04-23-74	8	1,217.1	3.8	04-23-74	--
422648	761451	NYS College Agriculture	04-24-74	9	1,231.8	4.2	04-26-74	--
422649	761433	Baird, C.	--	85	1,275	27	05-01-62	Water enters 75-85 ft, unconsolidated 0-14, bedrock 14-85 ft.
422650	761434	Ketter, W.	04-10-58	76	1,275	36	01-01-67	--
422650	761458	Overbaugh, J.	01-01-70	63	1,242.9	27.3	04-06-74	--
422651	761505	Heidt, R.	09-01-70	52	1,232.6	20.1	04-06-74	Gravel 0-6 ft.

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422651	761510	Austin, I.	01-01-10	38	1,217.6	8.1	04-06-74	--
422652	761621	Kimmick, L.	11-06-80	180	1,308	--	--	Till 0-10, gravel (dry) 10-20, till 20-30, sand and gravel 30-50, gray shale 50-180 ft.
422655	761504	NYS College Agriculture	05-01-74	40	1,237.7	25.76	05-08-74	P. Sand and gravel 0-12, till 12-23, silty sand and gravel 23-37, f-c pebby sand 37-47 ft.
422658	761535	U.S. Geological Survey	06-21-84	103	1,230	--	--	P. sand and gravel 0-3, sand 3-5, till 5-33, silty gravel 33-45, till 45-47, silt 47-55, till 55-58, dirty gravel 58-60, till 60-97, sand and gravel 97-103 ft.
422724	761541	Ryan, F.	10-23-61	52	1,160	25	10-23-61	--
422735	761630	U.S. Geological Survey	04-15-85	102	1,162	flowing	04-15-85	P. Silty gravel 0-28, silt 28-30, till 30-34, silty vfs 34-35, till 35-36, sand and gravel 36-102.
422744	761709	Armstrong, D.	06-05-73	171	1,215	--	--	Dry gravel and hardpan 0-45, bedrock 45-171 ft.
422746	761648	U.S. Geological Survey	06-19-84	88	1,168	11.0	06-19-84	P. Sand and gravel 0-19, silt 19-23, till 23-32, vf-f sand 32-70, dirty gravel 70-74, till 74-88 ft.
422752	761717	Cosner, O.	--	--	1,200	49.4	10--23-85	--
422754	761556	Dryden Golf Course	1963	82	1,230	76	--	--
422756	761720	Hamilton, R.	--	84	1,192	--	--	--
422758	761722	Clark, R.	10-16-74	82	1,175	--	--	Dry gravel 0-30, sand and gravel 30-50, hardpan gravel 50-64, sand and gravel 64-70, dry gravelly hardpan 70-79, sand and gravel 79-82 ft.
422759	761724	Acme Pest	04-08-72	50	1,185	16 23.6	04-08-72 10-30-85	Dry gravel 0-20, sand and gravel 20-35, pea gravel and small cobbles 35-41, sand 41-48, gravel 48-50 ft.
422800	761741	Florence, J.	--	41	1,268	--	--	--
422801	761651	Williams	1963	79	1,170	50.6	10-25-85	Till 0-74, gravel 74-79 ft.

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Lati-tude ° ' "	Longi-tude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422803	761654	U.S. Geological Survey	09-12-87	92	1,210	49.0	09-12-87	P. Sand 0-21, silty clay with trace of pebbles (till?) 21-31, sand 31-33, till 33-48, silty sand 48-56, till 56-59, silty sand and gravel 59-62, till 62-81, silt 81-88, till 88-90, sand and gravel 90-92 ft.
422804	761646	Campbell	09-02-65	84	1,200	45.8	10-31-85	Sand and gravel 67-70, sand and gravel 70-74, gravel 74-84 ft.
422805	761653	Eckenroth, J.	08-10-84	95	1,205	30	08-10-84	Sand and gravel 0-20, till 20-30, gravel, sand, and clay 30-90, sand and gravel 90-95 ft.
422807	761730	U.S. Geological Survey	11-13-87	73	1,177	30.0	11-13-87	P. Pebbly sand 0-8, till 8-18, sand and gravel 18-32, till 32-35, varved silt 35-38, silty vf sand 38-48, silt interbedded with gravel 48-50, sand and gravel 50-55, till 55-73 ft.
422808	761649	Fellow, R.	09-22-80	102	1,200	41 42.7	09-22-80 10-16-85	Sand 0-10, clay and gravel 10-25, hardpan and gravel 25-38, sandy clay 38-61, clay with stones 61-69, gravel and clay 69-72, clay 72-85, clay and gravel 85-99, sand 99-100, clay, sand and f gravel 100-102 ft. Another hole was drilled to 195 ft and casing was removed. Its geologic log was as follows: Sand 0-8, hardpan and gravel 8-12, clay (till?) 12-30, hardpan and gravel 30-50, sandy clay 50-83, gravel and clay 83-88, clay and little gravel 88-95, clay 95-114, gravel and clay 114-118, sand and gravel 118-123, till 125-130, clay 130-145, till 145-150, sandy clay 150-195 ft.
422808	7617141	Country Garden Apartments	07-07-63	267	1,228	135	07-07-63	--
422809	761655	Liddington	04-27-84	83	1,190	40 34.8	04-27-84 10-17-85	--
422809	761657	Dellow	10-15-61	98	1,200	50	10-15-81	--
422809	761700	Lake Road Apartments	1967	32	1,185	--	--	--
422809	761704	Keith Lane 1 Apartments	1972	42	1,188	24	10-16-84	--

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422809	761705	Keith Lane 2 Apartments	1970	71	1,188	23	06-15-84	--
						28.4	10-21-84	
						25.0	10-21-84	
422809	761711	Keech, H.	08-04-71	56	1,185	20	08-04-71	--
422809	761721	Bradley Apartments	05-16-78	157	1,145	flows	05-16-78	Gravel 0-30, till 30-50, clay, sand, gravel 50-100, clay, gravel 100-103, clay 103-110, clay and gravel 110-137, quicksand 137-144, sandy clay 144-145, sand and gravel 154-157 ft.
422810	761702	Bradley Apartments	1966	66	1,185	--	--	--
422811	761711	Armitage	09-06-68	58	1,180	20	09-06-68	Clay and gravel 0-57, gravel 57-58 ft.
						21.2	10-29-85	
422813	761704	Randall	05-05-66	60	1,186.0	30	05-05-66	Soil 0-10, sand 10-12, clay and gravel 12-45, clay 45-57, gravel 57-61 ft.
422813	761710	McCormick	10-28-68	69	1,184.7	36	10-28-68	Clay and gravel 0-50, gray till 50-59, sand and gravel 59-67, gravel 67-70, clay 70 ft.
422814	761705	Tomkins	01-29-66	62	1,189.6	30	04-29-66	Topsoil 0-8, clay with little gravel 8-45, gravel 45-46, clay and gravel 46-60, gravel 60-62 ft.
						37.3	10-17-85	
422815	761708	Wikerd	03-29-68	78	1,195.8	43	03-29-68	Gravel 0-10, till 10-30, sandy f gravel 30-44, f sand and gravel 44-58, f sand 58-70, f sand and gravel 70-78, gravel 78 ft.
422817	761713	U.S. Geological Survey	04-12-85	106	1,175	12	04-12-85	P. Sand and gravel 0-2, till 2-10, pebbly sand 10-17, till 17-18, vfs 18-19, silty vfs with traces of pebbles 19-26, till 26-35, silty sand and gravel 35-42, till 42-64, clayey silt 64-90, till 90-106 ft.
422818	761752	Chase, R.	12-20-78	105	1,230	--	--	Hardpan and gravel 0-37, shale 37-105 ft.
422819	761751	Chase, W.	04-25-75	62	1,200	0	04-24-75	Hardpan and gravel 0-40, bedrock 40-62 ft.
422820	761709	Lucente	09-16-67	65	1,203.7	55	09-16-67	Sand and gravel 0-45, clay 45-60, sand and gravel 60-68, clay at 68 ft.
						53	10-25-85	
422822	761715	Smith	--	114	1,166.6	--	--	Sand and gravel 0-30, clay 30-45, till 45-60, clay 60-110, sand and gravel 110-114 ft.
422823	761711	Shackelton	05-26-66	65	1,204.6	--	--	--

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422823	761716	Cobb	10-17-68	99	1,167.0	30 29.6	10-17-68 10-29-85	Sand and gravel 0-5, gravel 5-30, clay 30-50, sand and gravel 50-60, sand and gravel and clay 60-70, sand and gravel 70-75, ? 75-80, sand and clay 80-90, coarse sands and gravel and hardpan 90-99 ft.
422823	761719	Linquist	04-07-71	43	1,151.0	16.4	10-29-85	Hardpan, clay and gravel (till) 0-43, gravel 43 ft.
422823	761757	Brong, K.	06-28-71	57	1,245	--	--	Gravel 0-10, till 10-50, gravel 50-57 ft.
422824	761717	Bickford	05-04-70	113	1,162.0	5 24.4	05-04-70 10-30-85	Topsoil 0-7, sandy clay, gravel 7-21, clay 21-101, clay gravel 101-112, c sand 112-114 ft.
422824	761720	Haney	05-01-70	42	1,152.2	7 17.4	05-01-70 10-29-85	Topsoil 0-10, sandy clay and f gravel 10-30, hard clay and c gravel 30-40, sand and gravel 40-42 ft.
422824	761813	Cotterill, C.	05-07-70	160	1,335	9	05-07-70	Hardpan 0-79, shale 79-160 ft.
422825	761721	Stiles	09-20-71	118	1,144.2	flows	09-20-71	Sandy loam 0-10, clay and gravel 10-15, gravel and clay 15-20, gravel 20-30, f sand and f gravel 30-35, sandy clay 35-96, till 96-116, gravel 116-118 ft. Flowing well.
422826	761719	Werner	08-17-70	40	1,154.0	27	08-17-70	Sandy clay and gravel 0-30, gray clay 30-38, gravel 38-40 ft.
422826	761723	Ashman	12-31-71	90	1,140.8	--	--	Possibly redrilled to 97 ft.
422820	761709	--	--	128	1,182	--	--	--
422827	761719	Good	03-24-71	31	1,150.4	14	03-24-71	Sand 0-10, clay and little hardpan 10-20, clay and gravel 20-28, gravel, little clay 28-31 ft.
422827	761811	Borer, F.	08-24-76	185	1,305	65	08-21-76	Hardpan and clay 0-60, shale 60-185 ft.
422828	761617	Pleasant View Mobile Home Park	08-29-80	104	1,175	flows	08-29-80	Hardpan gravel 0-15, clay 15-70, quicksand 70-90, quicksand, some gravel 90-96, gravel, some sand 96-100, c gravel 100-104 ft. Flowing well.
422828	761714	--	1987	82	1,192	--	--	P. Well ends in gravel.
422828	761721	Streeter	04-12-71	98	1,149.7	--	--	Hardpan gravel 0-40, hardpan clay and gravel 40-80, clay and gravel 80-97, gravel 97-98 ft.

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422828	761724	Olds	04-15-71	97	1,137.3	--	--	Sand and gravel 0-20, quicksand 20-50, clay and cobbles (till) 50-80, sand and gravel 80-97 ft.
422828	761752	Portzline, M.	09-08-71	84	1,158	47	09-08-71	Sand and gravel 0-40, till 40-60, hardpan gravel mix 60-80, gravel 80-84 ft.
422829	761806	Bobnick, J.	03-31-71	175	1,275	65	03-31-71	Till 0-55, clay 55-85, bedrock 85-175 ft.
422830	761647	Snyder, N.	1976	33	1,150	--	--	--
422830	761713	--	1987	80	1,180	--	--	--
					1,187	38.6	10-25-85	
422830	761755	Ellis	04-02-75	62	1,180	5	04-02-75	Dry gravel 0-20, sand and gravel 20-60, gravel 60-62 ft.
422830	761804	Roberts, H.	05-07-70	52	1,255	25	05-07-70	Hardpan 0-20, gravel 20-50 ft.
422830	761808	McNaughton, R.	04-14-71	57	1,275	32	04-14-71	Hardpan and gravel 0-57 ft.
422830	761812	Skeps, P.	10-13-75	161	1,310	--	--	Bedrock at 50 ft.
422831	761752	Flourde, R.	03-26-68	91	1,150	57	03-26-68	Topsoil 0-3, sandy muck 3-10, sand and f gravel 10-20, sandy clay 20-36, gravel and clay 36-39, gravel, clay and sand 39-47, sand and clay 47-52, sand and clay, some stones 52-58, ? 58-65, sand and gravel 65-76, clay and gravel 76-87, gravel 87-91 ft.
422833	761718	Riis	12-17-64	60	1,169.4	42.7	10-25-85	--
422834	761715	Bradley, L.	1964	125	1,180	44	--	Sand and gravel 0-37, till 37-46, sand and gravel 46-50, brn clay and gravel (dirty gravel?) 50-55, blue hardpan 55-66, f sand 66-105, clay 105-121, sand and gravel 121-125 ft.
422834	761719	Christel	03-01-67	50	1,164.1	33	03-01-67	--
422835	761716	--	1967	125	1,160	--	--	Sand and gravel 0-16, sand, silt, and clay 16-40, sand and gravel 40-58, sand 58-68, sand silt and clay 68-122, sand and gravel 122-126, till 126-130 ft.
422836	761721	Besley	09-04-64	50	1,159.7	35.64	10-25-85	--

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422836	761728	Murphy, J.	10-31-80	92	1,139.3	18	10-31-80	Sand 0-5, till 5-8, gravel 8-36, (12 gal/min) sand and gravel 36-64, (30 gal/min), sand 64-73, sand/silt or till 73-88, sand and gravel 88-92 ft. Owner reports well flows from Dec.-July.
422837	761719	Payne	10-14-65	66	1,156	49	10-14-65	Gravel 0-66 ft.
						38.6	10-25-85	
422838	761755	Murphy, J.	12-15-83	53	1,150	20	12-15-83	Dry gravel 0-20, sand and gravel, some water 20-40, gravel 40-50, sand and gravel 50-53 ft.
422839	761724	Steponkus	1967	60	1,159.7	39.9	10-25-85	Casing perforated at 39 ft.
422840	761723	Bradley, L.	1965	90	1,158	40	08-01-65	--
422842	761734	Conner	--	102	1,119.9	flows	all year	Sand and gravel 0-10, till 10-20, sand and gravel 20-30, till 30-40, sand and clay 40-90, till 90-100, coarse sand 100-102 ft.
422844	761724	Gilbert	07-28-65	97	1,157.6	37	08-01-65	Topsoil 0-5, clay and gravel 5-30, sandy clay 30-40,
						45.4	10-25-85	gravel with some clay, (little water) 40-65, clay and sand 65-94, gravel 94-97 ft.
422846	761419	U.S. Geological Survey	06-20-84	62	1,270	--	--	Roadfill 0-7, till 7-52, silt 52-54, till 54-62 ft.
422847	761750	Clark, R.	1950	55	1,127	--	--	--
422848	761750	Clark, G., Jr.	1981	60	1,125	--	--	Till at surface.
422848	761735	Shaw, B.	09-21-78	96	1,126.8	14	09-21-78	Dry gravel 0-40, sand and clay 40-70, till 70-80,
						17.1	10-29-85	gravel and hardpan 80-88, gravel 88-96 ft.
422849	761733	Richmond, L.	08-14-78	52	1,133.3	20	08-14-78	Sandy topsoil 0-3, till 3-10, sandy clay 10-30, sand and gravel 30-52 ft.
422850	761729	Bentley, R.	01-30-69	75	1,142.1	28	01-30-69	--
422850	761735	Chabot, G.	09-13-78	103	1,126.8	16	09-13-78	Hardpan and gravel 0-5, hardpan 5-15, clay and gravel 15-45, sandy clay 45-65, sandy clay and some gravel 65-70, silt and dirty gravel 70-84, silt and dirty gravel 84-100 (30 gal/min), coarse to fine sand 100-103 ft.
422850	7611751	Clark, G., Jr.	1954	50	1,125	19.1	10-18-85	--

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Lati-tude ° ' "	Location Longi-tude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422852	761731	Witco	09-28-85	95	1,130	30.1	10-11-85	--
422855	761743	Village of Dryden	03-07-77	217	1,106	-6.00	03-07-77	Gravel and hardpan 0-22, water-bearing sand and gravel 22-36, f sand 36-42, silty sand and gravel 42-71, till 71-90, soft clay 90-100, sandy clay and hardpan 100-120, soft clay 120-134, hard clay 134-170, gravel 170-172, till 172-179, hard clay 179-183, sand and gravel 193-217 ft.
422857	761727	Village of Dryden	01-01-63	53	1,100	--	--	Sand and gravel 0-12, till 12-30, sand and gravel 30-45, clay till 45-46 ft. Yield = 100 gal/min.
422858	761716	Alexander, L.	1978	47	1,135	29.02	10-16-84	--
422858	761728	Village of Dryden	--	300	1,100	--	--	Gravel 0-10, till 10-20, till and gravel 20-30, gravel 30-40, silty sand 40-70, hardpan and sand 70-80, sand 80-90, sand and gravel 90-110, till 110-120, clay 120-150, clay and sand 150-180, f sand 180-255, till 255-270, f sand 270-300 ft.
422859	761719	Village of Dryden	1964	51	1,100	--	--	Till 0-29, clay 29-35, gravel 35-40, gravel and hardpan 40-45, gravel and till 45-51 ft. Yield = 115 gal/min.
422905	761449	Village of Dryden	01-01-48	176	1,090	--	--	? 0-30, clay and hardpan 30-39, gravel 39-42, till 42-46, clay 46-73, gravel 73-76, silt 76-85, till 85-97, clay 97-127, till 127-143, soft clay 143-167, clay and gravel 167-170, sand and gravel 170-176 ft.

Table 3.--Records of wells in the Dryden area, N.Y. (continued).
[--, no data available.]

Location Latitude ° ' "	Location Longitude ° ' "	Owner	Date drilled	Depth of well or test hole (feet)	Elevation of land surface (feet)	Water level in feet below land surface	Date water level measured	Remarks (P. = Pebble lithologic analysis, vf = very fine, f = fine, m = medium, and c = coarse. Numbers refer to depths below land surface, gal/min = gallons per minute.)
422905	761749	Village of Dryden	02-09-46	192	1,090	0.00	02-01-46	Clay with some gravel (till?) 0-27, sand and gravel 27-31, clay and sand and gravel 31-42, sand and gravel with some clay (water bearing, static water level 8.0 ft) 42-48, clay and some gravel (till?) 48-71, sand and gravel and clay 71-76, clay and sand and gravel 76-110 (till?), silty clay 110-125, f sand with some gravel 125-128, clay and sand and gravel 128-131, c sand 131-132, clay and sand and gravel 132-157, sand and gravel with clay layers (flows 6 gal/min) 177-184, clay, sand and silt 184-192 ft.
422906	761754	Formerly Borden	--	170	1,095	flows	--	--
422909	761758	U.S. Geological Survey	06-22-84	73	1,095	11.0	06-22-84	P. Sand and gravel 0-26, silt and clay 26-28, till 28-36, silty gravel or till 36-44, till 44-50, dirty gravel 50-58, silt 58-61, f sand 61-63, till 63-73 ft.
422929	761850	Allis, R.	10-02-73	52	1,095	--	--	Sand and gravel and hardpan 0-30, sand and gravel 30-52 ft.
422932	761821	Draper, R.	01-25-72	67	1,074	12	01-25-72	Gravel with clay and sand 0-20, sand and gravel 20-30, hardpan 30-57, hardpan and gravel 57-61, sand and gravel 61-67 ft.
422933	761821	Draper, R.	--	57	1,074	--	--	Gravel, sand and clay 0-20, clay 20-26, hardpan 26-30, sand and clay 30-40, sand 40-50, sand and gravel 50-56 ft.

Table 4.--Pebble lithology of glacial deposits in the Dryden area
[in percent of sample population].

Location and type of geologic deposit	Depth below land surface (in feet)	Local shale and silt-stone	Lime-stone	Red sand-stone and silt-stone	Chert and quart-zite	Other sand-stone	Igneous and meta-morphic	Total counted
			<u>Test Holes</u>					
Test well 4226000761411								
a. Sand and gravel	10	100	0	0	0	0	0	30
b. Sand and gravel	19	94	6	0	0	0	0	33
c. Sand and gravel	40	46	27	4	0	23	0	26
d. Sand and gravel	46	64	32	0	0	0	4	25
Test well 4226270761431								
a. Sand and gravel	5	100	0	0	0	0	0	33
b. Sand and gravel	25	50	33	3	0	8	6	36
c. Sand and gravel	50	91	0	0	3	3	3	38
Test well 4226310761500								
a. Till	10	100	0	0	0	0	0	13
b. Sand and gravel	15	79	5	3	3	10	0	39
c. Till	20	92	0	0	0	8	0	25
d. Till	25	78	9	0	4	0	9	23
e. Sand and gravel	28	76	14	0	5	5	0	42
f. Sand and gravel	31	73	22	0	2	3	0	63
g. Sand and gravel	36	64	21	3	0	9	3	58
Test well 4226550761504								
a. Sand and gravel	5	91	0	3	3	3	0	33
b. Sand and gravel	10	93	0	3.5	0	3.5	0	30
c. Till	16-20	95	5	0	0	0	0	19
d. Sand and gravel	25	81	12	2	0	5	0	43
e. Sand and gravel	46	100	0	0	0	0	0	34
Test hole 4226580761535								
a. Till	10	97	0	0	3	0	0	34
b. Till	16-18	80	1	9	0	9	0	55
c. Till	21-33	68	22	9	0	0	0	22
d. Gravel (dirty)	36-43	75	10	8	0	4	2	48
e. Till	88-97	74	19	6	0	0	1	130
f. Gravel	101	70	23	2	2	1	2	231
Test hole 4227350761630								
a. Dirty gravel	12	94	0	4	0	0	2	54
b. Till or dirty gravel	20-26	91	2	2	0	5	0	46
c. Gravel	30-31	80	16	2	0	0	2	46
d. Till	35-35.5	89	10	0	1	0	0	55
e. Gravel	35.5-36	69	12	5	6	4	4	58
f. Gravel	39-56	58	26	4	3	5	4	252
g. Gravel	79-81	48	36	4	0	6	6	84

Table 4.--Pebble lithology of glacial deposits in the Dryden area [in percent of sample population]--continued.

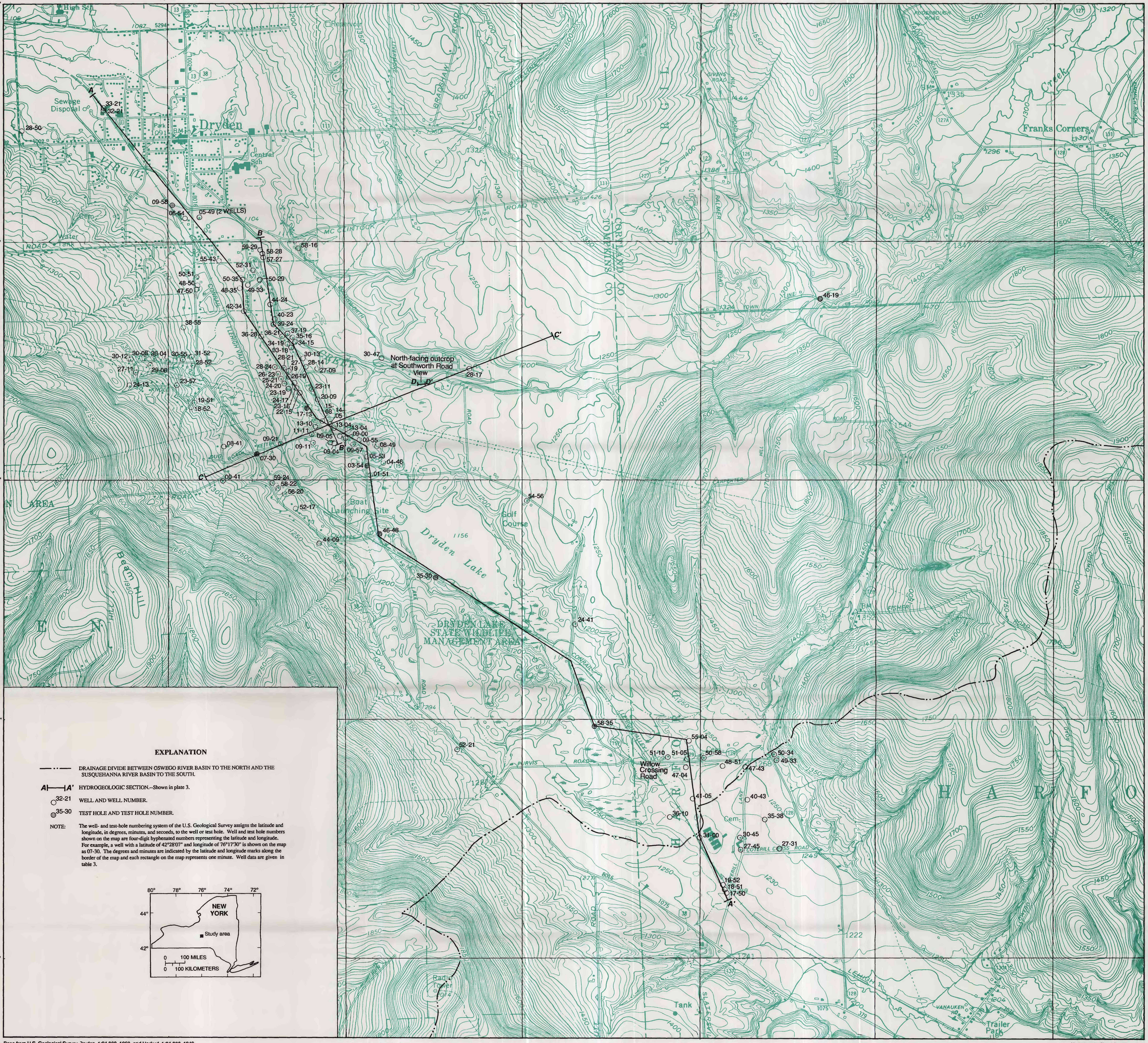
Location and type of geologic deposit	Depth below land surface (in feet)	Local shale and silt-stone	Lime-stone	Red sand-stone and silt-stone	Chert and quart-zite	Other sand-stone	Igneous and meta-morphic	Total counted
Test Holes								
Test hole 4227460761648								
a. Gravel	11-13	96	0	1	1	1	1	80
b. Till	31-32	100	0	0	0	0	0	8
c. Till or dirty gravel	71-73	81	15	2	0	0	2	41
d. Till	76-88	86	12	0	2	0	0	52
Test hole 4228030761654								
a. Till	21-31	82	6	0	6	0	6	16
b. Till	33-48	73	16	3	0	0	8	37
c. Sand and gravel	60-62	60	28	4	0	4	4	53
d. Till	62-81	75	20	2.5	0	2.5	0	40
e. Sand and gravel	90-91.5	69	12.5	0	6	12.5	0	16
Test hole 4228070761730								
a. Till	9-10.5	74	20	0	0	3	3	30
b. Sand and gravel	18-32	91	0	6	0	0	3	63
c. Sand and gravel	48-55	68	18	7	0	7	0	40
d. Till	55-73	50	30	4	1	4	11	56
Test hole 4228170761713								
a. Gravel	0	90	4	2	0	2	2	139
b. Till	6	74	26	0	0	0	0	35
c. Pebbly sand	12-14	91	6	1	1	0	1	115
d. Silty gravel (diamict?)	21-23	91	5	1	0	3	0	79
e. Till	29-30	73	27	0	0	0	0	15
f. Gravel	35.5-41	80	14	1	1	2	2	163
g. Till	44-54	80	18	1	0	1	0	86
h. Till	59-64	75	21	0	0	1	3	71
i. Till	74-76	79	16	0	0	0	5	19
j. Till	90-106	83	14	0	0	0	3	30
Test hole 4228280761714								
a. Sand and gravel	80-82	96	0	1	1	1	1	90
Test hole 4228460761419								
a. Till	8-47	80	10	2.5	2.5	2.5	2.5	39
b. Till	57-63	86	8	0	1	0	5	66
Test hole 4229090761758								
a. Sand and gravel	12-19	85	10	0	2	0	3	52
b. Till	22-23	94	2	0	2	0	2	49
c. Sand and gravel	23-24	81	15	0	4	0	0	27
d. Till	27-58	83	10	3	1	0	3	69
e. Till	63-69	82	13	0	3	0	2	38

Table 4.--Pebble lithology of glacial deposits in the Dryden area [in percent of sample population]--continued.

Location and type of geologic deposit	Depth below land surface (in feet)	Local shale and silt-stone	Lime-stone	Red sand-stone and silt-stone	Chert and quart-zite	Other sand-stone	Igneous and meta-morphic	Total counted
Miscellaneous Sites								
1a. Alluvial gravel from channel of Virgil Creek at bridge, Lake Rd.	Land surface	91	5	0	1	1	2	220
b. Till exposed in channel of Virgil Creek at Lake Road bridge.	5	85	11	2	0	2	0	97
c. Gravel from gravel pocket in till exposed in channel of Virgil Creek at Lake Road bridge.	6	86	11	1	0	1	1	253
2a. Alluvial gravel from channel of tributary to Virgil Creek at culvert at Southworth Rd.	Land surface	93	3	1	1	1	1	238
b. Till, in channel of tributary to Virgin Creek at culvert at Southworth Rd.	Land surface	82	15	1	0	0	2	110
3a. Alluvial gravel from channel of Virgil Creek near Southworth Rd. and Pleasant View Trailer Park.	Land surface	88	1	2	1	4	4	220
b. Till, upper till near top of cutbank.	3	94	0	3	0	3	0	108
c. Coarse cobble gravel below upper till.	5	85	2	0	5	7	1	125
d. Pebbly sand below coarse cobble gravel.	6	86	9	1	2	1	1	242
e. Till below pebbly sand.	12	89	7	2	1	0	1	109
f. Gravel pocket in till (5e).	13	88	7	2	1	0	2	120
g. Till below varied silt/clay.	25	68	21	3	1	8	0	139
h. Sand and gravel below till (5e).	35	70	33	3	1	2	2	222

Table 4.--Pebble lithology of glacial deposits in the Dryden area
[in percent of sample population]--continued.

Location and type of geologic deposit	Depth below land surface (in feet)	Local shale and silt-stone	Lime-stone	Red sand-stone and silt-stone	Chert and quart-zite	Other sand-stone	Igneous and meta-morphic	Total counted
		Miscellaneous Sites						
4a. Gravel from cutbank along Virgil Creek 500 ft east of Pleasant View Trailer Park.	20	66	23	3	4	1	3	107
b. Till below gravel (6a).	30	65	23	4	0	5	3	93
5a. Alluvial gravel from channel of Virgil Creek at Town Line Road bridge Cortland County (Harford Quadrangle).	Land surface	93	3	1	1	0	2	224
b. Till at outcrop along Town Line road near bridge at Virgil Creek.	Land surface	92	0	2	2	2	2	118
c. Till at outcrop along Town Line Road near bridge at Virgil Creek.	1-2	98	0	1	0	1	0	111
d. Till, debris flow within lacustrine deposit.	2.5	97	0	0	0	0	3	32
e. Till below lacustrine unit.	4	97	0	1	0	1	1	63
f. Till.	7-8	86	12	1	1	0	0	69
g. Till at base of outcrop.	10	88	0	0	1	4	6	67
6a. Alluvial gravel from channel of outlet to Dryden Lake at Keith Lane.	Land surface	90	0	2	1	3	4	241
7a. Alluvial gravel from channel of inlet to Dryden Lake at East Lake Rd., 2,000 ft southeast of Dryden Lake.	Land surface	94	1	2	1	1	1	170
8a. Alluvial gravel from tributary near intersection of Route 38 and Purvis Road.	Land surface	97	0	0.5	1	1	0.5	219
9a. Alluvial gravel from inlet to Dryden Lake at Willow Crossing East Lake Road.	Land surface	97	0	2	0.5	0	0.5	188



Base from U.S. Geological Survey Dryden, 1:24,000, 1969, and Harford, 1:24,000, 1949

Hydrology by Todd S. Miller, 1988

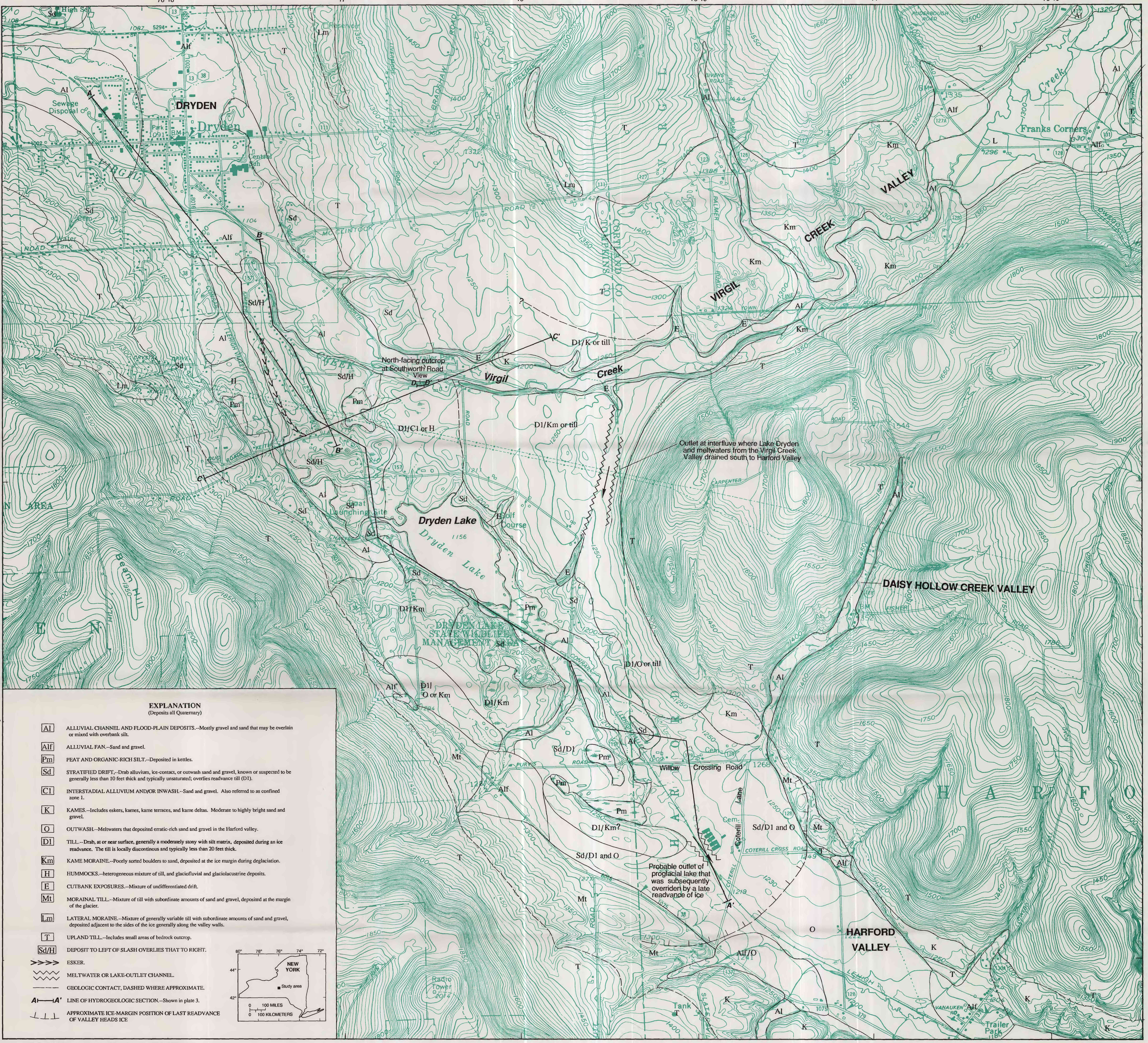
SCALE: 0 – 1/2 – 1 MILE; 0 – 1000 – 2000 – 3000 – 4000 – 5000 FEET; 0 – 1/2 – 1 KILOMETER

Miller, T.S., 1993, Glacial geology and the distribution of aquifers at the Valley Heads Moraine in the Virgil Creek and Dryden Lake-Harford Valleys, Tomkins and Cortland Counties, New York: U.S. Geological Survey Water-Resources Investigations Report 90-4168

LOCATION OF WELLS, TEST HOLES, AND HYDROGEOLOGIC SECTIONS IN THE VIRGIL CREEK AND DRYDEN LAKE-HARFORD VALLEYS NEAR DRYDEN, NEW YORK

By
Todd S. Miller

1993



Base from U.S. Geological Survey Dryden, 1:24,000, 1969, and Harford, 1:24,000, 1949

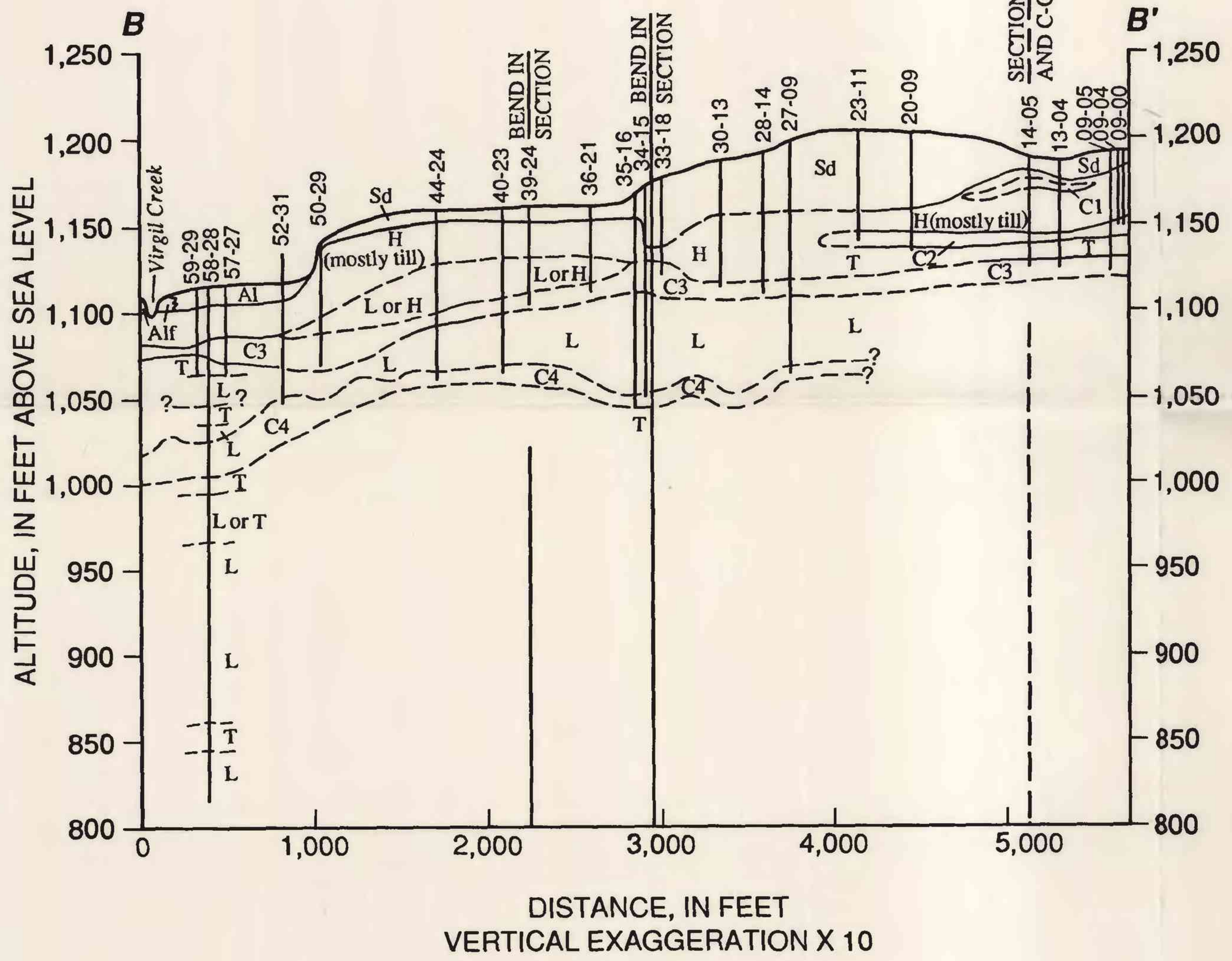
Geology by Todd S. Miller, 1987

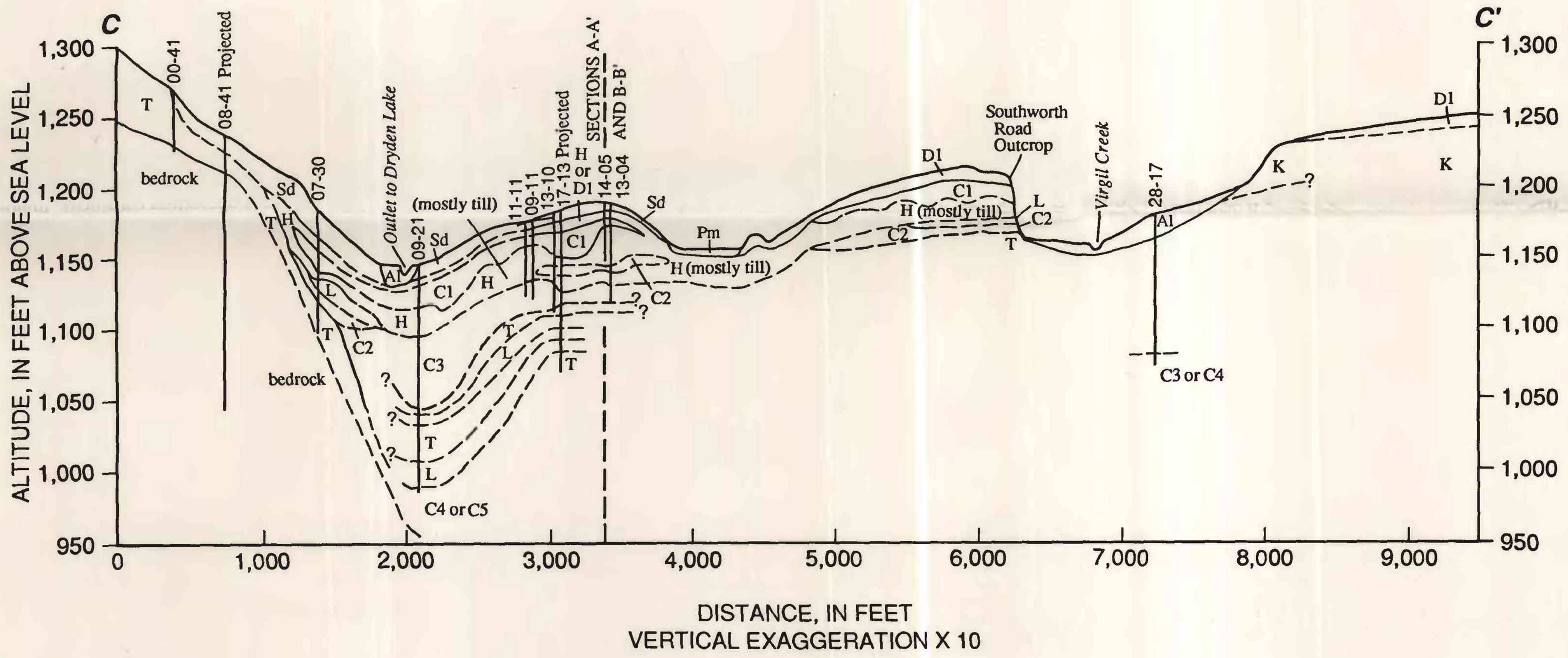
Miller, T.S., 1993, Glacial geology and the distribution of aquifers at the Valley Heads Moraine in the Virgil Creek and Dryden Lake-Harford Valleys, Tomkins and Cortland Counties, New York: U.S. Geological Survey Water-Resources Investigations Report 90-4168

SCALE
0 1/2 1 MILE
0 1000 2000 3000 4000 5000 FEET
0 1/2 1 KILOMETER

SURFICIAL GEOLOGY OF THE VIRGIL CREEK AND DRYDEN LAKE-HARFORD VALLEYS NEAR DRYDEN, NEW YORK

By
Todd S. Miller
1993





EXPLANATION

(Symbols shown as stacked units in plate 2 are depicted as individual units in geologic sections.)

Al ALLUVIAL CHANNEL AND FLOOD-PLAIN DEPOSITS.--Mostly gravel and sand that may be overlain or mixed with overbank silt.

Alf ALLUVIAL FAN.--Sand and gravel.

Pm PEAT AND ORGANIC-RICH SILT.--Deposited in kettles.

Sd STRATIFIED DRIFT.--Alluvial, kame, outwash, and inwash sand and gravel deposited during retreat of last Valley Heads readvance; typically 3 to 10 feet thick; generally unsaturated except in low areas which have unconfined conditions. (Shown as Sd/H, Sd/D1 and Sd/0 on surficial geology map (pl. 2) where Sd overlies these other deposits.)

D1 DRAB TILL.--Uppermost till deposited during last readvance.

H HUMMOCKS.--Complex of till and debris flow, glaciofluvial and glaciolacustrine deposits.

T TILL.--May be any till unit older than Dl; moderate to bright clasts.

L LAKE DEPOSITS.--Fine sand, silt, and clay.

K KAME.--Ice-contact deposit of sand and gravel.

CONFINED ZONES IN THE VALLEY HEADS AQUIFER SYSTEM

C1 CONFINED ZONE 1.--Thin and discontinuous sand and gravel lenses that underlie the upper till in the hummocky area in the central part of the aquifer; drab pebbles suggest an alluvial or inwash origin; partly or seasonally saturated.

C2 CONFINED ZONE 2.--Thin and discontinuous sand and gravel; bright pebbles suggest a glaciofluvial origin such as outwash or ice-contact deposits.

C3 CONFINED ZONE 3.--Semicontinuous to continuous sand and gravel in the northern part of the study area; origin is uncertain.

C4 CONFINED ZONE 4.--Continuous and extensive sand and gravel; an undulating surface and bright clasts suggest an ice-contact origin such as kames.

C5 CONFINED ZONE 5.--Extent determined only in a small area in the northern part of the study area; consists of silty sand and gravel; bright pebbles and an upper surface that slopes to the southeast suggest an ice-contact origin.

——— – – GEOLOGIC CONTACT.--Dashed where approximate.

31-00 WELL AND WELL NUMBER.--Numbers assigned to wells and test holes are seconds of latitude and longitude, for example, a well with latitude 42°26'31" and longitude 76°15'00" would have a well number of 31-00.

LINES OF SECTIONS SHOWN ON PLATES 1 AND 2

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HYDROGEOLOGIC SECTIONS IN THE VIRGIL CREEK AND DRYDEN LAKE-HARFORD VALLEYS NEAR DRYDEN, NEW YORK

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Todd S. Miller
1993