THE PALEOFLUVIAL RECORD OF GLACIAL LAKE IROQUOIS IN THE EASTERN MOHAWK VALLEY, NEW YORK

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ABSTRACT

During the final retreat of Laurentide ice from New York State, the Mohawk Valley played a major role in the routing of glacial meltwater. The Mohawk Valley contained the Iromohawk River, which drained Glacial Lake Iroquois, in the Ontario Basin, into Hudson Valley glacial lakes Albany II, Quaker Springs, Coveville and Fort Ann. Iromohawk drainage occurred for a period of approximately 500 years while the St. Lawrence Lowland remained glaciated and the Mohawk Valley was ice free.

Iromohawk drainage developed a network of distributary channels across the Hudson-Mohawk Lowland, as well as carving the modern Mohawk channel between Schenectady and Cohoes. Progradation of these channels occurred as the Iromohawk drained toward lowering Hudson Valley glacial lake levels. Depositional and erosional surfaces associated with distributary and modern channels have been used to establish a chronology of channel development and usage relative to Hudson Valley glacial lakes. This chronology constrains the timing and duration of later Hudson Valley lake phases between ~12,500 and 12,000 years BP.

Sedimentologic evidence in the Scotia Gravel at Scotia, one of the principle Iromohawk deposits in the valley, indicates Iromohawk drainage was a long-term, high-discharge event with cyclic (probably seasonal) variation in flow.

INTRODUCTION AND HISTORICAL REVIEW

The Mohawk Valley has long been recognized as the outlet for Glacial Lake Iroquois, the largest Late Pleistocene glacial lake to occupy the Lake Ontario Basin. Much attention has been given to Late Pleistocene water bodies in the basin (MacClintock and Stewart, 1965; Muller and Prest, 1985; Clark and Karrow, 1984; Pair and Rodrigues, 1993), but very little work has addressed the effect of Iroquois drainage on the Mohawk Valley and Hudson-Mohawk Lowland. As will be discussed, the duration of this event is short in geologic terms, but drainage during this period was the primary sculptor of modern Mohawk Valley and Hudson-Mohawk Lowland morphology.

Eastern Mohawk Valley fluvial cobble gravel deposits (Scotia Gravel) have been the subject of debate concerning both their emplacement mechanism and implications for Hudson-Mohawk Lowland morphologic development. Newly observed sedimentary structures in the Scotia Gravel indicate the drainage associated with their emplacement was a single, long-term, high-discharge event. The first author has correlated their emplacement with Lake Iroquois outflow and developed a theory regarding how Lake Iroquois outflow formed the present morphology in the Hudson-Mohawk Lowland.

Scarcity of quality datable material in the Hudson Valley has forced a relative dating scheme for eastern New York State deglacial events. Only a poor sense exists of how long most events lasted and where the set of events fits chronologically. Absolute timing constraints from the Lake Ontario Basin provide an opportunity to use eastern Mohawk Valley and Hudson-Mohawk Lowland evidence of Lake Iroquois drainage to chronologically link deglacial events in the Ontario Basin and Hudson Valley.

The area in the Mohawk Valley and Hudson-Mohawk Lowland influenced by the Iromohawk River is expansive, and as such, this trip will cover a lot of ground. As the terrain and associated geology changes very quickly, we've made the road log fairly detailed so follow the mileage carefully. The geologic interpretation of this area has been debated since the turn of the century, we invite you to continue this tradition.

Much of the following text is from the first authors' dissertation (Wall, 1995). The text is divided into three sections. The first section, "Introduction and Historical Review", gives a fairly detailed summary of background information and the evolution of thought regarding the field area. The second section, "Scotia Gravel", presents a description and detailed discussion on the principle Iromohawk River deposit in the Mohawk Valley. The third section presents our current understanding regarding the evolution of Hudson-Mohawk Lowland morphology.

Great (glacial) Lakes Drainage

Two periods of drainage from the Lake Ontario Basin to the Hudson Valley occurred during the late Pleistocene. Morner and Dremanis (1973) postulated eastward drainage of Lake Leverett from the Lake Erie basin during the Erie Interstade. They had no direct evidence of the event in New York, only that drainage toward the Ontario Basin and through the Mohawk and Hudson Valleys was the likely lake outlet. Ridge (1991) identified the

In Garver, J.I., and Smith, J.A. (editors), Field Trips for the 67th annual meeting of the New York State Geological Association, Union College, Schenectady NY, 1995, p. 173-203.

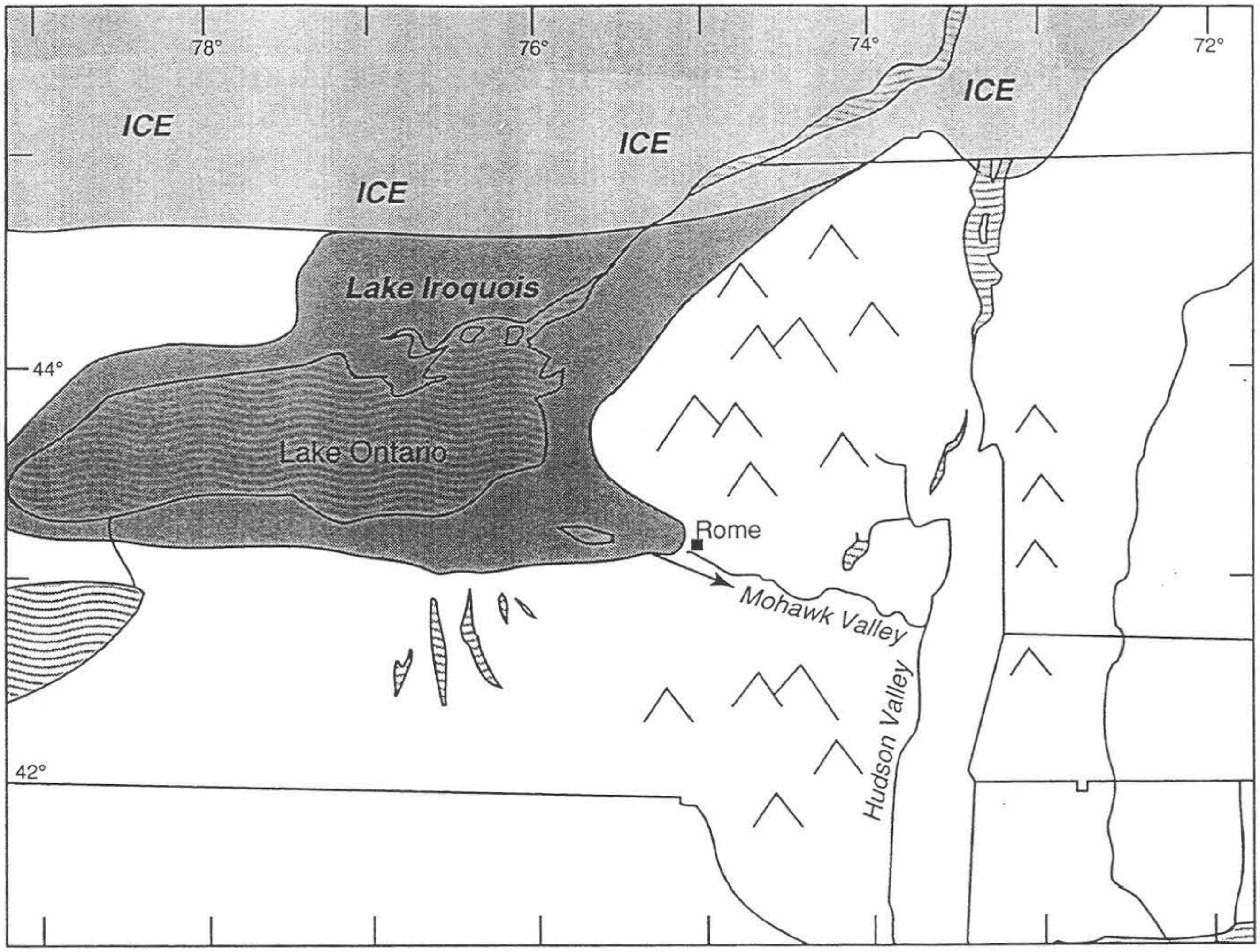


Figure 1: Cartoon map of Glacial Lake Iroquois.

Shed Brook Discontinuity and Little Falls Gravel (LFG) in the western Mohawk Valley and postulated an Erie Interstade age. Dineen and Hanson (1992) note a similar discontinuity and gravel in the Hudson Valley and postulated a correlation with Ridge's Mohawk Valley observations.

Lake Iroquois was the second Late Wisconsin water body to drain through the Mohawk Valley (Figure 1). Lake Iroquois beaches were first recognized by Thomas Roy in 1837, and named "Iroquois" by Spencer in 1890 "in memory of the aborigines who trailed over its gravel ridges" (Chute, 1979). Muller and Prest (1985) adapt the convention of defining Ontario Basin glacial lakes by their outlet:

> *"Drainage of the Ontario Basin by the Rome outlet to the Mohawk River is considered to define a single lake, that is, Lake Iroquois, in spite of changing extent and complexity of strandlines. Glacial Lake Iroquois ceased to exist, however, when outflow from the Ontario Basin shifted north of the Adirondack Mountains."*

Fairchild (1909) refers to lakes in the western Ontario Basin, which ultimately found their outlet at Rome but were impounded by ice west of the Genesee Valley, as "Hyper-Iroquois". Chute (1979) details several stillstands of Lake Iroquois in the Syracuse area. Clark and Karrow (1984) attribute their Level I and II strandlines at Covey Hill (northern Adirondacks) to two levels of Lake Iroquois. Pair and Rodrigues (1993) identify two Iroquois waterplanes: 1) Iroquois - Watertown phase, which extended into the lowland as far north as Watertown, and 2) Iroquois - Main phase, which extended through the Lowland to Covey Hill.

Rome is commonly referred to as the outlet for Lake Iroquois (Prest, 1970; Denny, 1974; Muller and Prest, 1985). However, the level of the Rome outlet may have been controlled by downcutting of the bedrock channel at Little Falls assuming no differential uplift between Little Falls and Rome (Fullerton, 1980). Pair and Rodrigues (1993) suggest the Little Falls sill controlled initial water levels of Lake Iroquois.

Lake Iroquois Drainage and Iroquois (Scotia) Gravel

The morphology of the gravel deposit at Scotia, NY was recognized by Brigham in 1898. He mistakenly thought the deposit to be composed of sand and built as a bar or shoal into ponded waters. Woodsworth (1905), Stoller (1911), and Fairchild (1917) attributed gravels at Scotia to Iroquois outflow and consider their deposition to be contemporaneous with the Schenectady Delta. Brigham (1929) related the locations of gravel at Scotia and Yosts (Randall) to valley expansions. He considered the deposits to be made in an extension of Lake Albany (the largest Hudson Valley glacial lake) up the Mohawk Valley to Little Falls, evidently contending that the momentum of Iroquois outflow was enough to transport coarse gravel over 70 miles in standing water. The gravels at Scotia were studied by Winslow (1965) from a hydrogeologic perspective, but little attempt was made at understanding the deposit from a geologic point of view. LaFleur (1979) first coined the name Scotia Gravel for the gravels at Scotia, and advocated a series of at least three post-Lake Albany, high-discharge, glacial lake outbursts to erode and transport gravel downvalley (LaFleur, 1975, 1979, 1983). He proposed that an initial outburst eroded gravel east of Little Falls (later named Little Falls Gravel (Ridge 1991)), and redeposited it at Randall. A second outburst eroded the Randall deposit and redeposited it as valley fill at Scotia. The third outburst eroded portions of the Scotia Gravel, leaving it with two distinct terrace surfaces as it appears today. LaFleur (1979, 1983) suggested that the last lake outburst correlates with the draining of Lake Iroquois.

Timing of Late Wisconsin Glacial/Deglacial Events

Radiocarbon dates (fossil wood) for Fairchild's "Hyper-Iroquois" at Lewiston are 12,660 ± 400 BP and 12,080 ± 300 BP (Muller and Prest, 1985). Lake Iroquois east of this impoundment was already draining through the Rome outlet (Muller and Prest, 1985). Prest (1970) dates the maximum development of Lake Iroquois between 12,500 and 12,400 BP. Calkin (1982) suggests formation of Lake Iroquois prior to 12,200 BP. Clark and Karrow (1984) use four radiocarbon dates on wood to obtain an average age of 12,100 BP. Pair and Rodrigues (1993) give a minimum age for deglaciation of the northwestern Adirondack flank and incursion by Lake Iroquois of 12,500 ± 140 BP (radiocarbon date of kettle lake organics). Anderson and Lewis (1985) note the curvature of a well dated (11,400 BP) early Lake Ontario water plane that closely paralleled that of Lake Iroquois, and suggest only a few hundred years had elapsed between lakes. Anderson and Lewis (1985) bracket the existence of Lake Iroquois between ~12,500 and 12,000 years BP. Denny (1974) suggests a range between 12,700 and 12,000 years BP for deglaciation of the northern Adirondack flank. Muller and Calkin (1993) suggest Lake Iroquois only existed for a "few centuries" and came into existence between 12,500 and 12,100 BP. Prest (1970) suggests 12,200 BP for a stable strand of Lake Frontenac, which succeeded Lake Iroquois.

Hudson-Mohawk Lowland

Woodsworth (1905) was the first to comprehensively review Hudson Valley post-glacial deposits, and presented evidence for a water body that followed the retreating ice north. He named the water body "Lake Albany" after the Albany clay in the valley which was named by Ebenezer Emmons in 1846. Fairchild (1917) suggested that Lake Albany was not a lake, but rather a marine strait between New York City and the St. Lawrence Lowland. Stoller (1919) cited topographical evidence at Mechanicville as conclusive evidence against a Lake Albany estuary. Stoller was the first to interpreted and name stages in Lake Albany based on deposits in the Schenectady and Saratoga 15" quadrangles (Stoller, 1922). Woodsworth (1905) recognized the Quaker Springs phase of Lake Vermont (Champlain Valley) on the Schuylerville 15" quadrangle, noting the erosive work of a "powerful stream of water" at Quaker Springs as evidence of a lake outlet there. Chadwick (1928) recognized a lowering Lake Albany. He named the Coveville phase of Lake Vermont as he considered its outlet to be at "The Cove" in Coveville. He made no mention of Woodsworth's Quaker Springs phase. LaFleur (1965) rejected the interpretation of Quaker Springs and Coveville outlets. He suggested early phases of Lake Vermont were controlled by later phases of Lake Albany and proposed the renaming of lower Lake Albany phases. Connally and Sirkin (1969) proposed the names "Quaker Springs" and "Coveville" for lower Albany phases. DeSimone (1985) recognized three phases of Lake Fort Ann in the Hudson Valley. DeSimone (1985) and DeSimone and LaFleur (1985) postulated a slightly lower Albany phase, between Lakes Albany and Quaker Springs. The table below shows the current interpretation of Hudson Valley glacial lake level elevations in the study area.

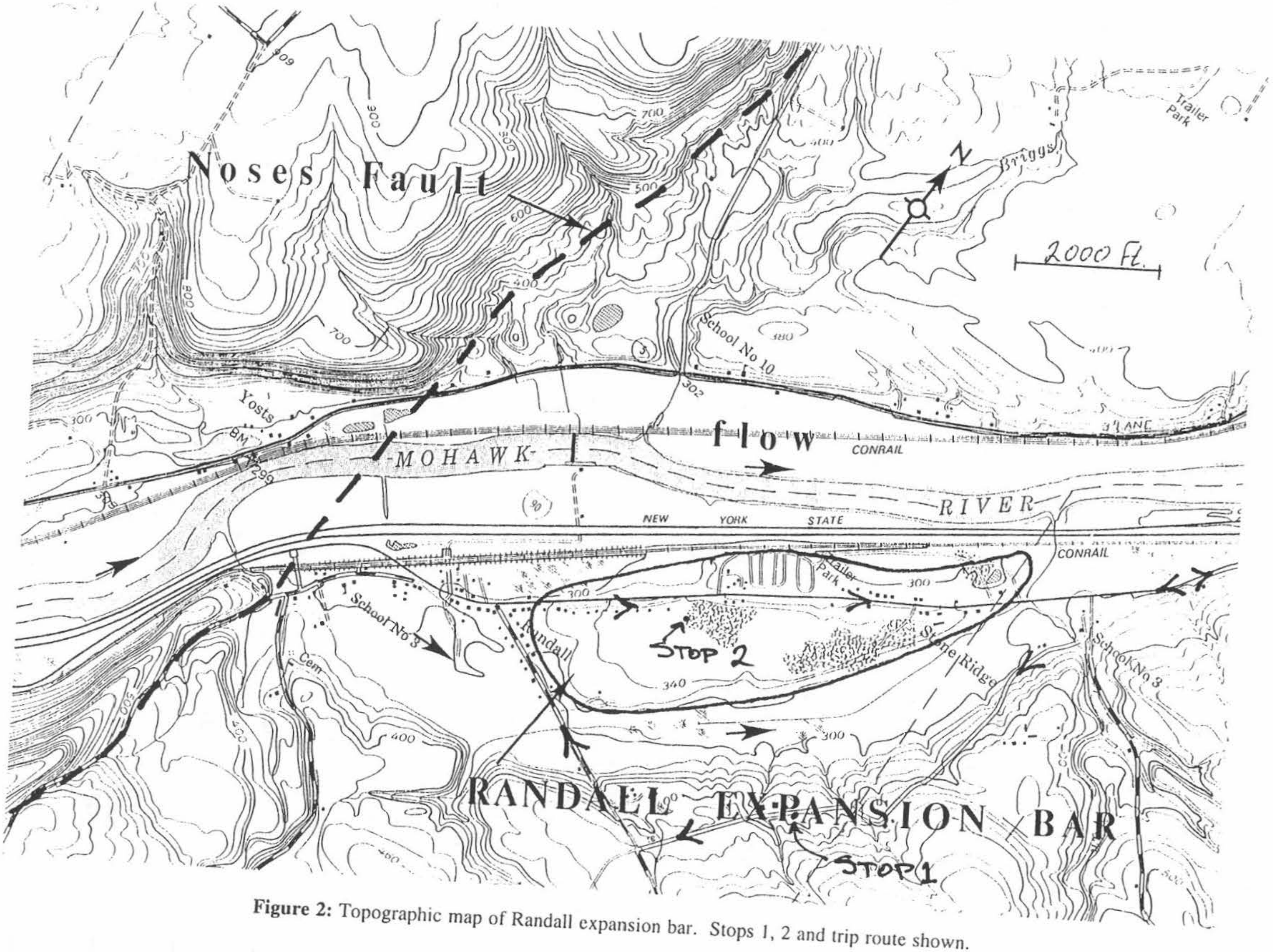


Figure 2: Topographic map of Randall expansion bar. Stops 1, 2 and trip route shown.

HUDSON VALLEY GLACIAL LAKE	SCHUYLERVILLE/ SARATOGA SPRINGS	MECHANICVILLE/ EAST LINE	TROY/ SCHENECTADY
Albany	370 feet	350 feet	340 feet
Albany II	340	330 (1)	~310
Quaker Springs	310	300	~290
Coveville	270-240	240-220	~220
Fort Ann I	200	190	~180
Fort Ann II	160	150	~140
Fort Ann III	130	120	~110

Modified from DeSimone (1985)
(1) This study

Hudson-Mohawk Lowland Paleochannel Development

Stoller's surficial mapping in the Schenectady (Stoller, 1911), Saratoga (Stoller, 1916), and Cohoes (Stoller, 1920) 15' quadrangles was the first detailed examination of the area. Schock (1963), DeSimone (1977) and Dahl (1978) mapped the Troy North, Schuylerville, and north half of the Mechanicville 71/2' quadrangles, respectively. Hanson (1977) mapped the Round Lake, Niskayuna and southern half of the Mechanicville 71/2' quadrangles.

Fairchild recognized the contribution of Great Lakes drainage to the Hudson Valley via the Mohawk Valley (Fairchaild, 1904). He coined the terms "Glaciomohawk" and "Iromohawk" referring to Mohawk Valley drainage before and after the initiation of Lake Iroquois. Stoller (1911) considered the development of, what he terms, "distributary channels north of Schenectady Delta" as due to a lowering of Lake Albany. Fairchild (1917) considered "land uplift ... by a wave movement" as the mechanism responsible for diversion of Iroquois waters into the channels. Stoller (1911) considered distributary channel occupancy to be controlled by undercutting of other distributary channels from overtopping and headward erosion. Remnant ice may have played a part in channel diversion (LaFleur, 1979, 1983) and at least three catastrophic lake outbursts in the western Mohawk Valley and/or Ontario Basin may have been responsible for channel overtopping and initiation of distributary channel incision (LaFleur, 1975, 1979, 1983, and Hanson, 1977). Hanson (1977) rejected simple headward erosion as a mechanism for modern channel occupancy.

Stoller (1911, 1922) advocated fluvial action as the mechanism for removal of sediments from Ballston, Round and Saratoga Lake basins. Fairchild (1917), Cook (1930), Hanson (1977), and LaFleur (1979, 1983) all considered the basins to be kettles. Cushing and Ruedemann (1914) considered Lonely Lake basin a kettle, but Saratoga Lake Basin to be a "less deeply filled" portion of preglacial drainage. Hanson (1977) identified a relatively small kettle at Elnora and called it the Elnora ice block. Woodsworth (1905) and Cook (1909) consider Ballston Channel and the location of Saratoga and Round Lakes as preglacial fluvial channels. Dineen and Hanson (1983) mapped the extent of preglacial drainage in the area, and in particular the Colonie Channel which Woodsworth and Cook first recognized. Cook (1909) traced the preglacial Mohawk gorge between Schenectady and just north of Coeymans (where it joins the Hudson), concluding that the modern river channel east of Rexford is post-glacial.

SCOTIA GRAVEL

The Scotia Gravel is a disjointed fluvial deposit in the eastern Mohawk River Valley at Scotia, Randall, Fort Hunter, and Fultonville(?). The type locale for the deposit is in Scotia, this segment being by far the largest. The Scotia Gravel at Scotia (Figure 3) extends along the valley trough a distance of 8.3 miles in an expanding downvalley "wedge", from Hoffmans to Collins Lake, Scotia. The deposit is about 1 mile across at its widest point where well logs indicate it to be over 100 feet thick (Winslow et al., 1965). The highest part of the wedge is approximately 70 feet above the Mohawk River, with a maximum elevation of 310+ feet near Hoffmans and 290+ feet in Scotia.

In general, the Scotia deposit fines downvalley. Gravel near Hoffmans is typically well-sorted, clean, and clast supported, with individual clasts ranging up to softball size. Farther downvalley, the deposit is sandier and more matrix supported. At Collins Lake, the deposit has no gravel; it is strictly a very well-sorted, coarse-grained sand. Gravel lithology is dominated by quartzite, gneiss, and red quartzitic sandstone of Adirondack provenance along with carbonates minor shale presumably with a western Mohawk provenance.

Much of the deposit, in apparently random locales, is bound by a weak carbonate cement. The origin and precipitational environment of the cement is enigmatic, because it apparently shows signs of both vadose and phreatic conditions (S. Gaffey, personal communication, 1994). The carbonate could come from dissolution of carbonate clasts in the deposit or from carbonate rich Iromohawk waters. The Mohawk Valley contains many potential carbonate sources, making the latter possibility quite reasonable. Carbonate precipitation could have been

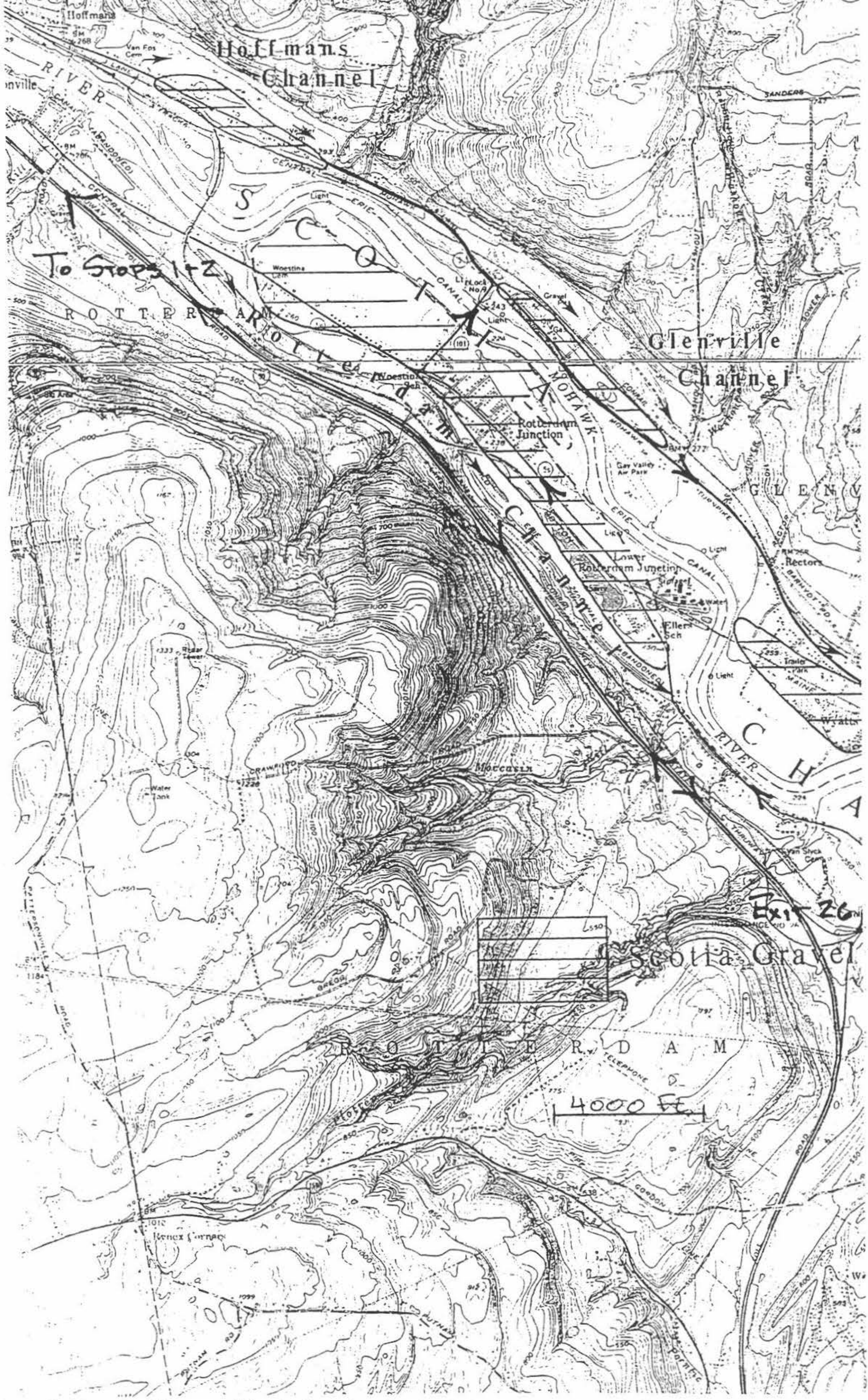


Figure 3: Topographic map of Scotia Gravel at Scotia. Relevant morphologic features, stops 3 and 4, and trip route shown.

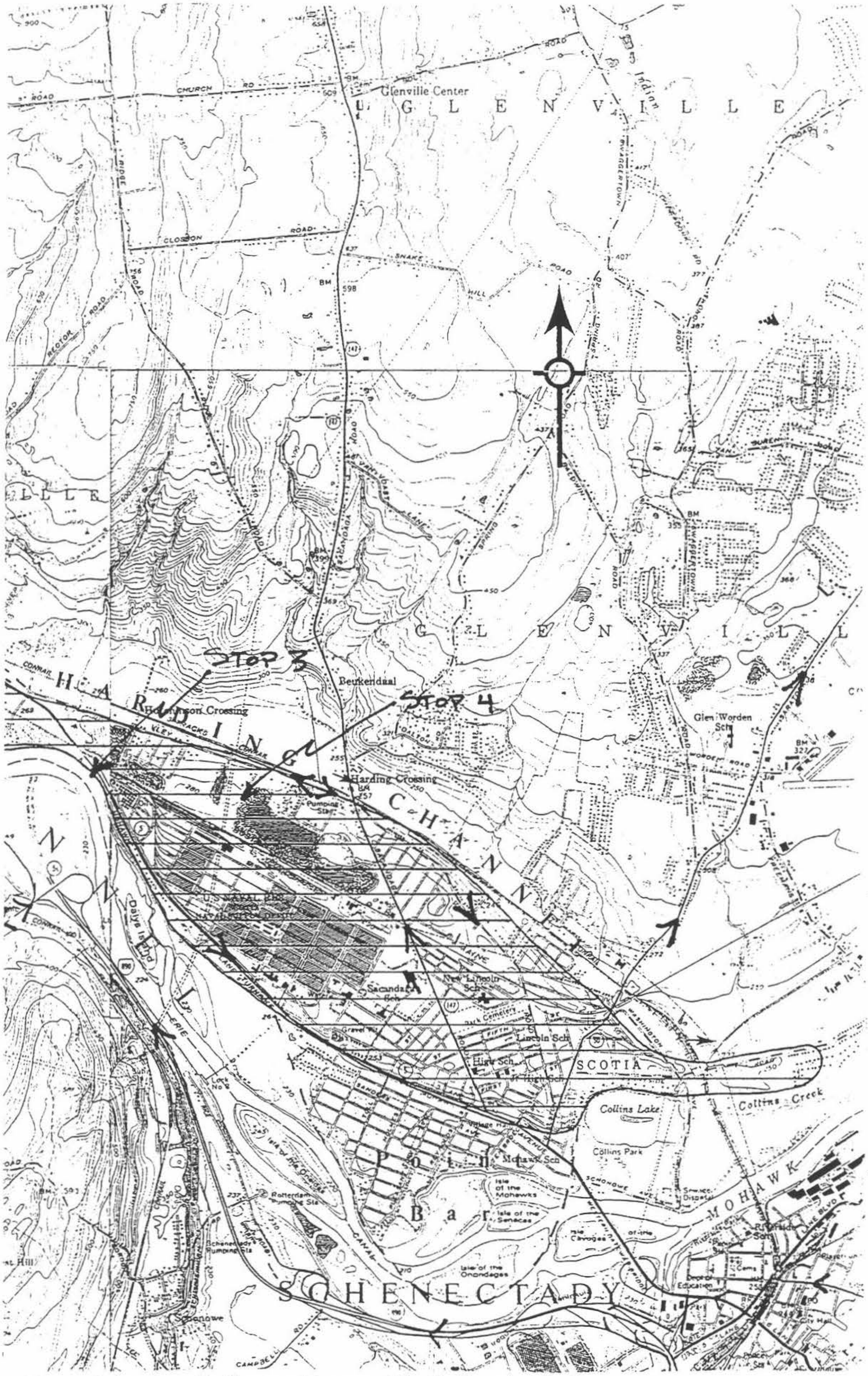


Figure 3 (continued): Topographic map of Scotia Gravel at Scotia.

caused by changing water levels associated with Iromohawk discharge leaving gravel clasts alternately wet and dry, thereby changing carbonate equilibrium conditions enough to cause precipitation. More detailed study of the cement is needed to test this hypothesis.

Exposures of the Scotia deposit reveal little in the way of bedforms, appearing quite massive in many locations. Clast imbrication is evident, but not pervasive in these areas. The only observed exception to the general massive nature of the deposit is east of Wyatts along a precarious exposure bordering the Mohawk River. This exposure is marked by numerous east-dipping graded gravel foreset beds. Dozens of these foresets are visible across the exposure, each grading from cobble to coarse sand and pebble gravel, and measuring approximately 3 feet in thickness (Figure 4). The cyclic nature of the graded foresets is more typical of a long-term rather than catastrophic depositional event; furthermore, the cyclically suggests a seasonal variation in transport energy - essentially gravel varves. If a gravel varve hypothesis is correct, the Scotia deposit records many tens if not hundreds of years of deposition. Baker (1973) describes similar graded features in catastrophic outburst pendant bars in the channeled scablands of Washington State. However, he attributes the graded nature of the deposit to eddies developing behind the channel protuberance associated with the bar. The Scotia deposit is clearly not a pendant bar as no such protuberance is evident.

The gradient and discharge of the modern Mohawk River may be too low to account for the thickness and grain size of Scotia Gravel (LaFleur, 1983). The stratigraphic position of the gravels requires it to be either the last depositional (ignoring modern alluvium) event in the valley or the remnant of an exhumed topography. The exhumed scenario would require the gravel to be at latest Erie Interstade in age (i.e., equivalent to Little Falls Gravel (LFG)). If this is the case, the gravels would have been overridden by glacial ice at least once during the Port Bruce Stade. Exhumation would then need to remove all glacial material because none is found stratigraphically above the gravel. It seems unreasonable that no material would remain, especially erratic boulders that would have been associated with the deposit and unlikely to have been moved during exhumation. Portions of the LFG have been exhumed near Little Falls, but by far the majority of the remaining deposit is buried in glacial and lacustrine sediments. A second problem with exhumation is the erosion of LFG at Little Falls. Clearly, a huge amount of gravel has been eroded from a deposit that likely spanned the entire width of the valley east of Little Falls. If the gravels at Scotia are considered equivalent to LFG, where are the eroded LFGs? Lastly, projecting the modern valley slope from the top of gravel at Scotia, it intersects fairly well with the top of the gravel bar at Randall. Farther projection of this line westward intersects the LFG well below its peak. Explanations of differential uplift or eroded nickpoints could explain this last observation, but taken as a whole it seems probable that the Scotia Gravel is the product of a second fluvial event in the valley, that being the drainage of Lake Iroquois. Lake Iroquois drainage eroded LFG between Little Falls and St. Johnsville and transported it downvalley, redepositing it in Randall, Fultonville(?), Fort Hunter and Scotia.

The locations of Scotia Gravel are directly related to valley morphology. The three deposits of Scotia Gravel are found in valley expansions. The Randall and Scotia deposits are located downvalley of the Noses and Hoffmans faults, respectively. Brigham was apparently the first to make the connection between the faults and the locations of deposits, however he considered the depositional environment as lacustrine rather than fluvial (Brigham, 1929). The locations of the Fultonville and Fort Hunter deposits are related to valley expansions associated with fairly dramatic valley bends.

The width of the modern Mohawk floodplain between Hoffmans and Barge Canal Lock 8 is fairly consistent at about 2,000 feet. Throughout this reach, the Mohawk floodplain north of the river is bounded by a bank of gravel 50 to 70 feet high, peaking in elevation between 290 and 310 feet. The slope of this bank appears too steep to be depositional in origin; however, with the exception of active bank erosion just east of Wyatts, the Mohawk River has apparently done nothing to modify the bank. Observed bedrock(?) just below ground surface, south of the river and east of Wyatts exposure, may have forced the modern Mohawk into the bank. South of the Mohawk River at Rotterdam Junction, the 2,000 foot wide swath is bounded by a low ridge of gravel that parallels the valley trough and crests at 260+ feet elevation. Downvalley of Rotterdam Junction, the Mohawk or its floodplain are in contact with the southern valley wall. Both valley walls throughout the reach are composed of shale covered by a thin veneer of glacial till or diamicton. The floodplain is floored in gravel and covered by a patchy, fairly thin (<10 feet) layer of alluvium.

East of Lock 8 the valley rapidly expands into Schenectady Basin (Figure 3). The southern bedrock wall at Lock 8 swings to the south, following the course of the preglacial Mohawk channel (Winslow et al., 1965), where bedrock gives way to glacial and glaciolacustrine sediments that rim the southern basin wall. Well logs (Winslow et al., 1965) indicate the alluvium covered floor of Schenectady Basin is underlain by a 20 to 50 foot layer of sand and gravel over till. This sand and gravel layer is pervasive across the basin, but absent from stratigraphy in the southern basin wall, indicating that sand and gravel in the basin was deposited following or during erosion of the southern basin wall.

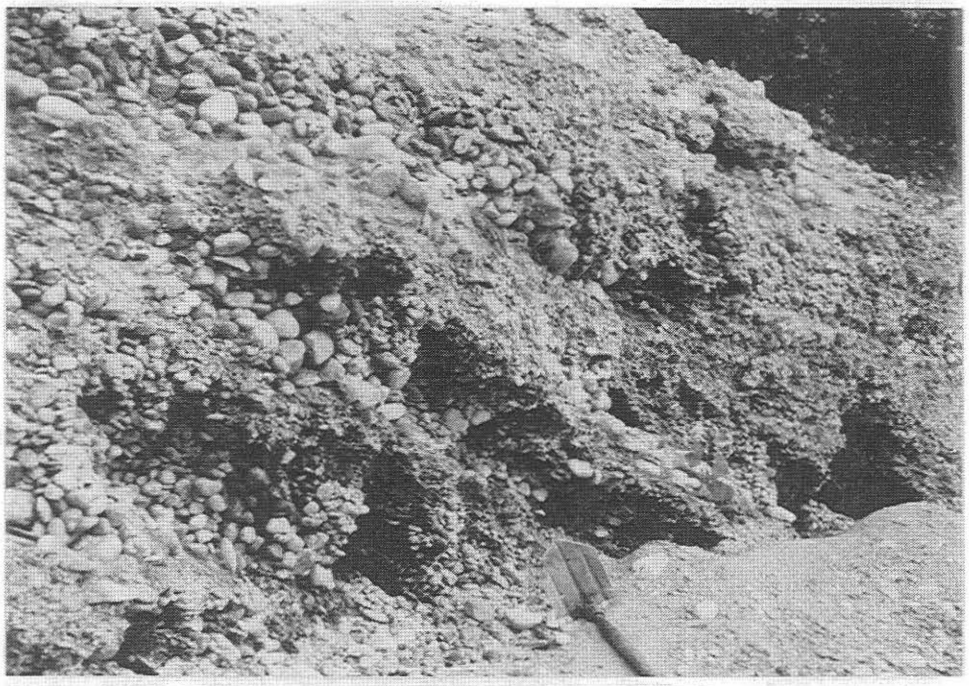


Figure 4: Exposure of graded Scotia Gravel foreset beds near Wyatts.

Figure 5: Internal structure of Randall expansion bar. Downvalley is to the left, frontend loader is approximately 15 feet high.

Figure 6a: Topographic map of southern half of Hudson/Mohawk Lowland. Relevant morphologic features and trip route shown. Scale: 1"= apx. 1 mile.

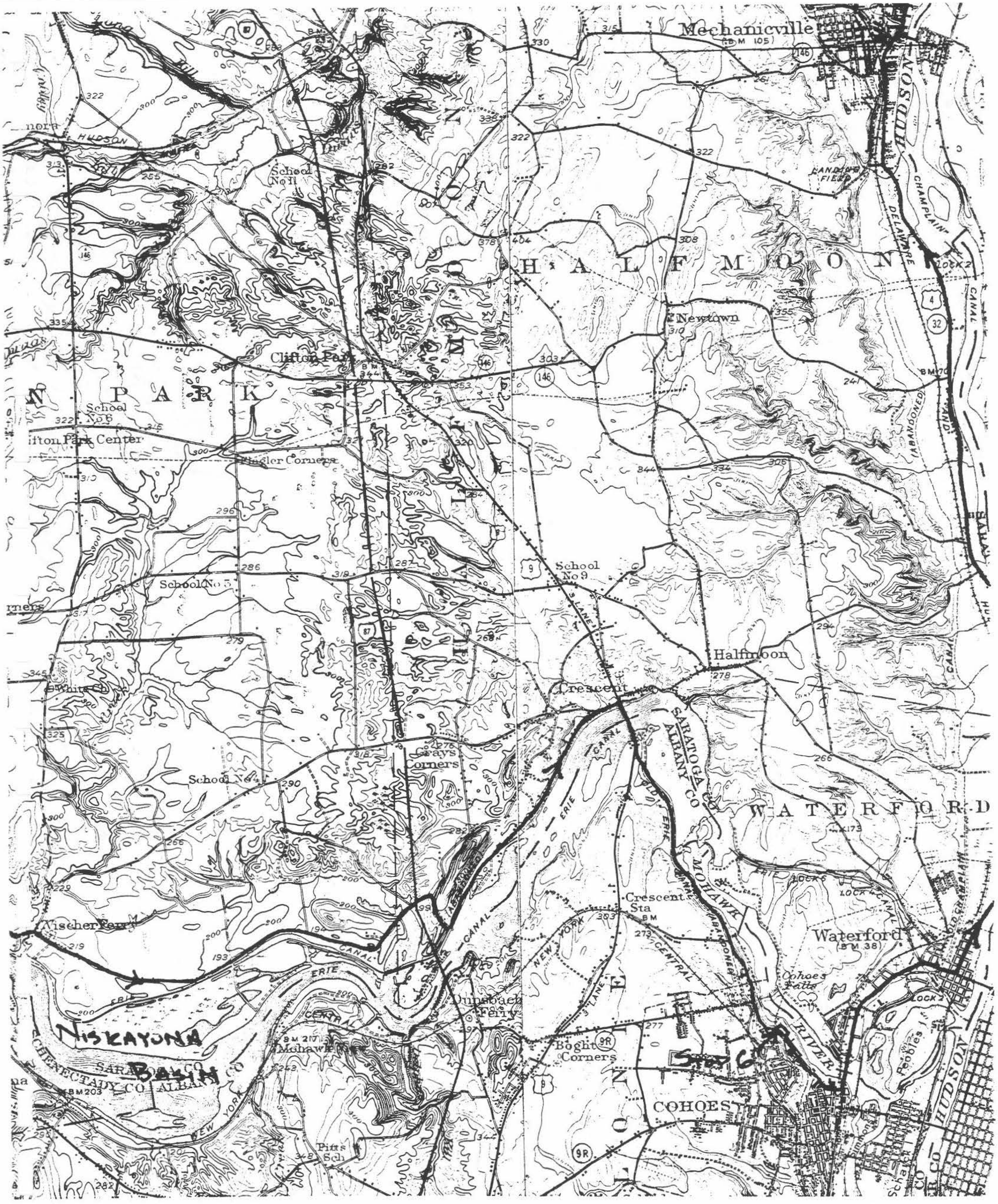
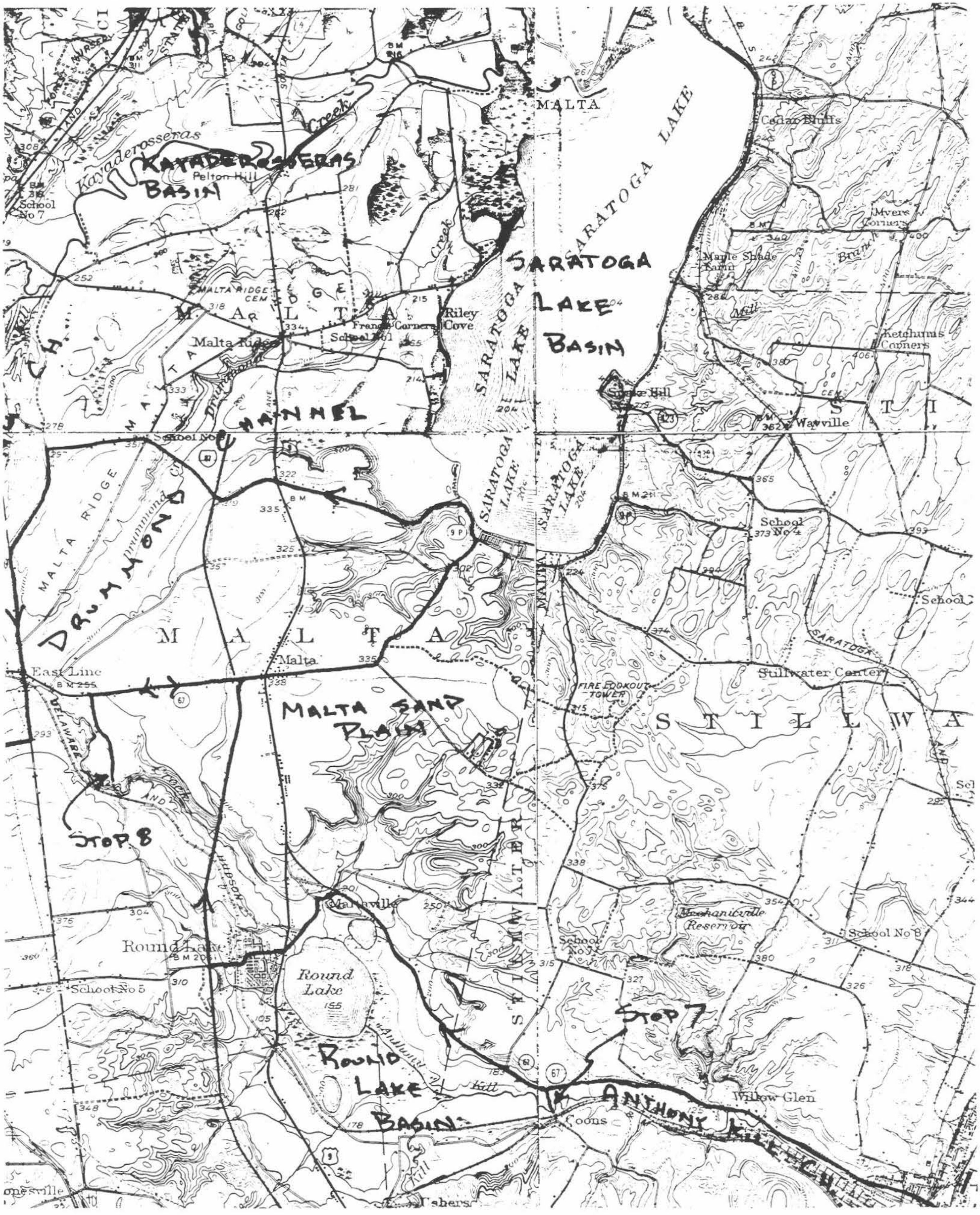


Figure 6a (continued):

Figure 6b: Topographic map of northern half of Hudson/Mohawk Lowland. Relevant morphologic features and trip route shown. Scale: 1"= apx. 1 mile.

Figure 6b (continued):



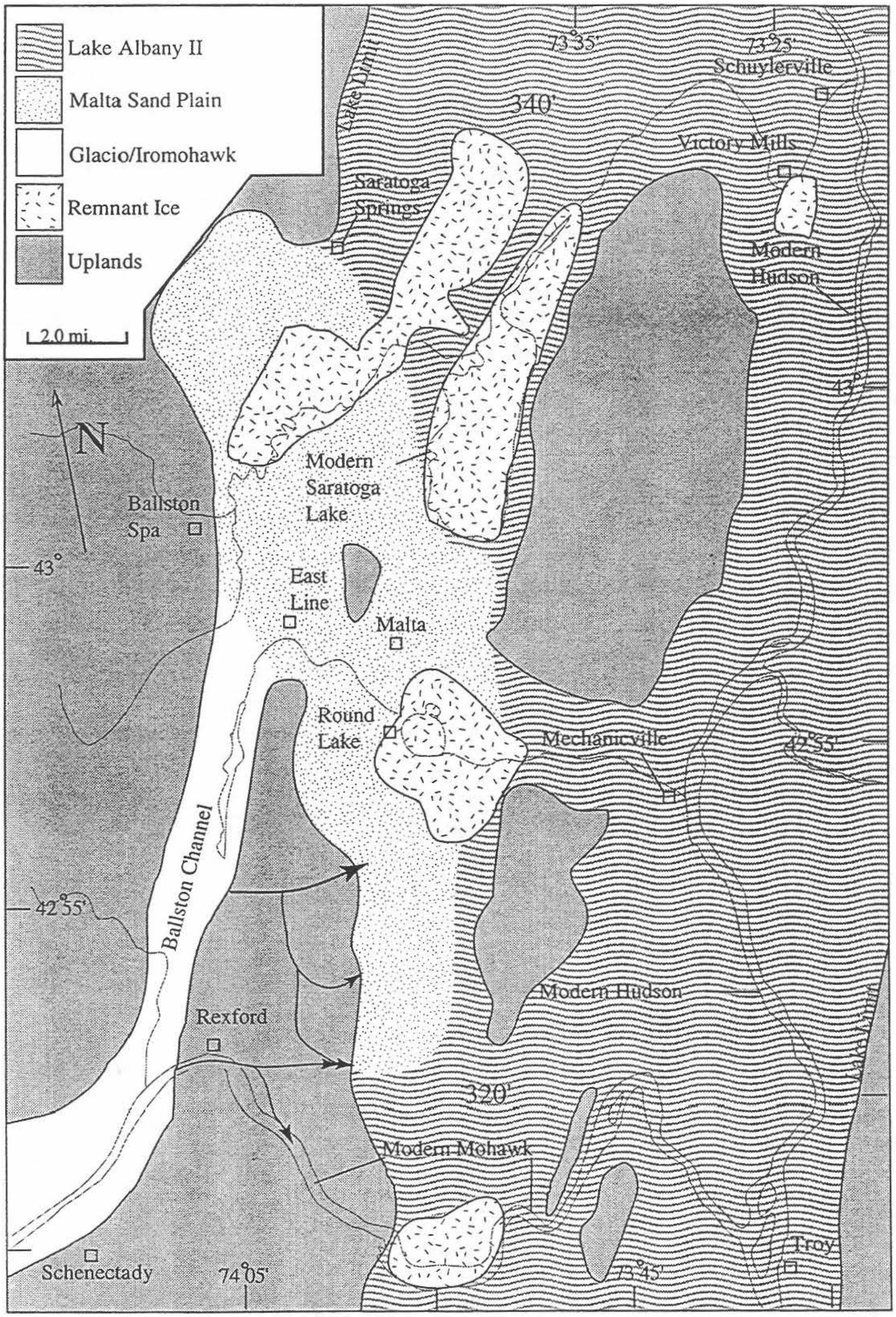


Figure 7: Map of Hudson/Mohawk Lowland during Lake Albany II.

The morphology of the Scotia deposit in Schenectady Basin changes quite dramatically from that immediately upvalley. The abrupt wall of gravel bordering the Mohawk floodplain near lock 8 is modified to a step in Scotia. This step drops from the gravel terrace top of 290+ feet to ~250 feet along Route 5 in Scotia. From Route 5, the gravel gradually slopes to the south toward the Mohawk River at 210 feet. It is reasonable to think this gravel is continuous across the Mohawk where it is overlain by alluvium and visible at ~210 feet in Winslow et al.'s well logs.

The deposit is inset by four minor channels (Figure 3), three of which hang well above the modern floodplain. Hoffmans Channel has a bottom elevation of 280+ feet, approximately 30 feet above the Mohawk floodplain, with channel dimensions of approximately 5,000 feet in length and 400 feet in width. The channel is bordered to the north by the valley wall and to the south by a ridge of apparently undisturbed gravel peaking at 310+ feet. The downvalley end of the channel is filled by reworked Verf Kill sediment draining from the north valley wall. Some 4,000 feet downvalley, Glenville Channel flanks the northern valley wall in a fashion similar to Hoffmans Channel. The southern channel wall consists of gravel with a peak surface elevation of 300+ feet. The channel is 8,000 feet long and about 500 feet wide with a bottom surface elevation of 280+ feet. The downvalley end of the channel is met by deposits of Washout Creek, with two distinct terrace surfaces of 290+ and 310+ feet.

Harding channel is the largest of the four minor channels. This channel, with dimensions of 20,000 feet in length and approximately 1000 feet in width, flanks the northern valley wall. The upvalley end of the channel is poorly defined, but apparently begins as a shallow trough northwest of Wyatts. The downvalley end of the channel is met by a spit of sand between the channel and Mohawk floodplain northeast of Collins Pond. The spit of sediment extends the channel length an additional 3,000 feet to the east. Channel bottom elevation grades from 250+ near Wyatts to 230-240 feet near Collins Lake. The fourth channel, Rotterdam channel runs along the southern valley wall in Rotterdam Junction. The northern side of the channel is bounded by the previously mentioned 260+ foot elevation ridge of gravel in Rotterdam Junction. The bottom of Rotterdam channel is marginally above the modern floodplain, grading from ~250 feet in the upvalley end at Woestina Cemetery to 230+ feet at Lower Rotterdam Junction. The channel is 12,000 feet long and 600 feet wide.

The modern morphology of the Scotia deposit looks very similar to that of a braided fluvial system. However, the internal structure of the deposit is very regular, similar to a deltaic front rather than a braided bar. Similarly, the deposits' position in a valley expansion suggests a valley delta or expansion bar. The thickness of the deposit (100+ feet) also suggests the deposit was laid down in deep water, also consistent with a delta or expansion bar than a braided fluvial system interpretation.

The most convincing evidence against a braided fluvial system comes from an examination of the Schenectady Basin outlet. As will be illustrated, Iromohawk waters drained through Ballston Channel to Lake Quaker Springs near Saratoga Springs. Adjusting for isostatic rebound, the 310 foot level of Lake Quaker Springs at Saratoga Springs is ~10 feet above the 280 foot elevation of the Ballston Channel divide (the divide is presently in a narrow bedrock "sub-channel" at 270 feet, but erosion to this level did not occur until a lower Hudson Valley base level). Therefore, water level at the modern divide in Ballston Channel was at least 290 feet. Considering the size of Ballston Channel and the volume likely exiting through it (see next section), water depth at the divide must have exceeded 10 feet. Considering the distal end of the Scotia deposit is at 290+ feet, together with the excessive deposit thickness (>100 feet), the Scotia deposit must have been deposited in a water-filled basin. The main body of Scotia gravel continued to be built until the modern channel at Rexford eroded below 290 feet. The size of the deposit and the aforementioned time likely associated with its deposition suggests a considerable amount of time was required for lowering of Rexford sill.

The uneven, channeled, and braided appearance of the deposit between Hoffmans and Schenectady Basin is explained by a transition of the Iromohawk from depositional to erosional flow. This transition could have occurred in one of two ways, or in a combination. First, base level could have lowered, causing initial and secondary outlets from Schenectady Basin to lower. Significant erosion of either outlet below the top of the Scotia deposit (~290 feet) would have initiated erosional flow. Second, the transition could be due to a wane of Iromohawk discharge. According to D. Franzi and D. Pair (personal communication, 1994) the Iroquois transition from Mohawk to St. Lawrence outlets could have been gradual. A waning discharge would tend to channelize across its previous depositional surface, thereby eroding that surface. The second scenario cannot be eliminated, but a response to lowering base level seems reasonable considering Mohawk Gorge (the modern channel/outlet) eroded well below the level of Ballston channel divide and the Scotia deposit.

Following Mohawk Gorge lowering, Harding, Glenville and Hoffmans channels became active, with the majority of flow contained in the 2,000-foot-wide swath referred to as the Scotia Channel (LaFleur and Wall, 1992) (Figure 3). The former bottom of the Scotia Channel exists as the modern floodplain between Hoffmans and Schenectady Basin. Lowering of water level is also recorded in the 20 foot drop of Washout Creek terrace deposits. At Rotterdam Junction, a bend in Scotia channel migrated away from the southern valley wall, leaving either a former channel bottom at 260 feet elevation, or depositing a point bar. Very limited exposures are available,

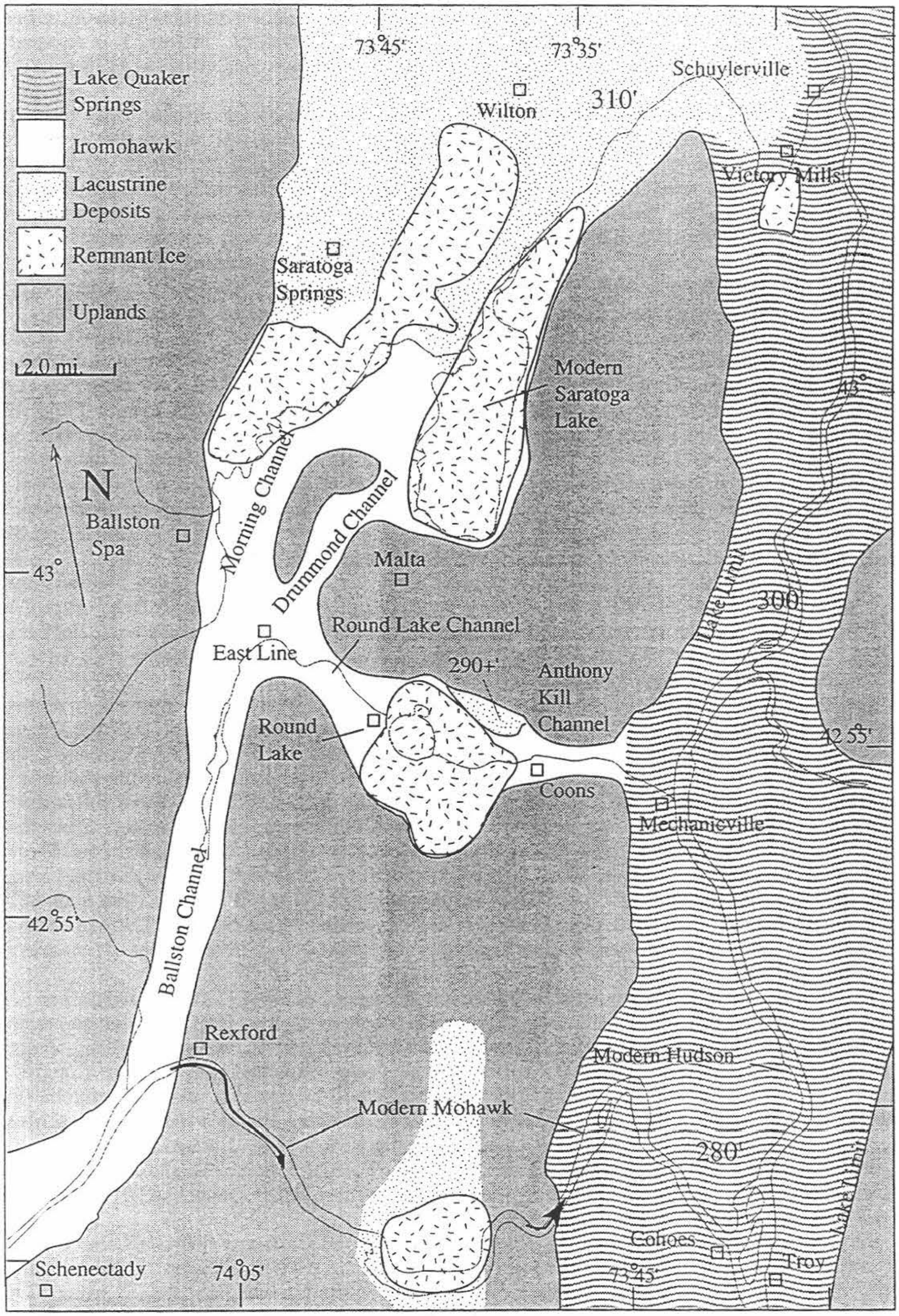


Figure 8: Map of Hudson/Mohawk Lowland during Lake Quaker Springs.

however, to test either hypothesis. At some point, Scotia Channel lowered to where it deactivated Glenville and Hoffmans channels, as they hang well above the modern valley floor. Based on its elevation, Rotterdam channel was the last minor channel to develop, incising the back of the Rotterdam Junction point bar(?) much in the fashion of a chute.

Gravel incision by Scotia Channel was accompanied by channel migration south of Scotia into Schenectady Basin. This migration eroded the southern wall of Schenectady Basin and deposited a point bar against the main body of the deposit south of Route 5 in Scotia. Route 5 in Scotia is built on the top of this point bar and roughly marks a lower limit to the maximum Schenectady Basin water line associated with point bar development. Most, if not all, of the gravel south of Route 5 is reworked from development of the Scotia Channel and redeposited in Schenectady Basin.

The floor of the downvalley end of Harding Channel joins the modern floodplain, suggesting it was active throughout the existence of Scotia Channel, perhaps acting as a chute during periods of high flow. The spit of sand at its downvalley confluence with Scotia channel may be the result of converging Scotia and Harding Channel flows. The morphology of the distal end of the gravel at Collins Lake is enigmatic. It may be either a headward erosional feature developed during the initial transition from depositional to erosional flow regimes, or perhaps an eddy feature developed during the same period.

Based on location, morphology and sedimentary structures, the Randall segment of Scotia Gravel is a classic giant expansion bar (Figure 2), similar to deposits in the channeled scabland of Washington State. The bar measures 7,000 feet in length and 1,800 feet at its maximum width. The 3.8:1 L/W ratio falls within the typical 3 to 4 range of large-scale fluvial landforms (Komar, 1983, 1984). The interior of the deposit is exposed by an active sand and gravel quarry. Large-scale east-dipping (downvalley) cross-bedding is visible throughout the exposed pit (Figure 5), confirming the eastward flow direction inferred from the deposits east-pointing tapered tail. Exposures in contact with the deposit surface show bedding that mimics external morphology. This observation is consistent with an original depositional surface as opposed to an erosional remnant as LaFleur (1979, 1983) infers.

Overall, the Randall deposit is very poorly sorted with individual clasts ranging from small boulders to coarse sand. Thickness of the deposit is approximately 60 feet. One well log from the deposit indicates the bottom of the bar is approximately at the elevation of the modern floodplain (U.S. Geological Survey, Open File) . The height of the bar above the floodplain therefore represents a minimum water depth (60 feet) for bar deposition.

The Fort Hunter deposit is barely perceptible at land surface. The deposit appears as a fluviatile ridge on the Tribes Hill 71/2' quadrangle. No exposures were found in the deposit, but the characteristic Scotia Gravel lithology is evident at the surface. Similar fluviatile ridges in Fultonville are observable on the Randall 71/2' quadrangle, but urban development has made them inaccessible.

PALEOCHANNEL DEVELOPMENT AND USAGE CHRONOLOGY

Introduction

A major problem with previous interpretations of Hudson/Mohawk Lowland distributary channel development and occupation has been the assumption that only one or possibly two channels could have been active at once. Based on this assumption, previous authors (see Historical Review) invoked mechanisms by which flow could be transferred from one channel to the next, in essence shutting off one channel and turning on another. Mechanisms include: an "uplift wave", isostatic rebound, headward erosion, overtopping and overtopping due to catastrophic lake outbursts. Central to the assumption of a progression of channel usage, is a gross underestimation of the quantity of water that developed and occupied these channels. Even the more conservative paleodischarge estimates (Wall, 1995), indicate potentially a tremendous volume of water drained through the Mohawk Valley during this period. It is the author's contention that the Mourning, Drummond, and Round Lake distributary channels (Figures 6a and 6b), as well as the modern channel east of Rexford, *all* accommodated Lake Iroquois outflow throughout the duration of Lake Iroquois. The quantity of water occupying each channel gradually changed, primarily as a function of modern channel incision, but all channels remained active.

The Hudson-Mohawk Lowland north of the Mohawk River is scared by basins and misfit channels, but perhaps most striking is the amount and extent of lacustrine sand between Albany and Gansevoort. Connally and Sirkin (1972) refer to this body of sand as an erg, a sea of sand. Beyond attempting to attribute portions of the erg to different Hudson Valley lacustrine phases, little effort has been made at understanding the source and route by which sediment in these locations was deposited. This section relates deposits and source with misfit channels. In so doing, a relative chronology for the development of deposits and channels emerges.

Lake Iroquois Outflow and Lake Albany II

Clear evidence of high-volume discharge in the Mohawk Valley is the transport and deposition of Scotia Gravel. The deposit, as described previously, was made in a relatively low-energy, water-filled basin, which had a surface elevation at Scotia of ~300 feet. The Lake Albany Schenectady Delta stands at 340+ feet elevation just to

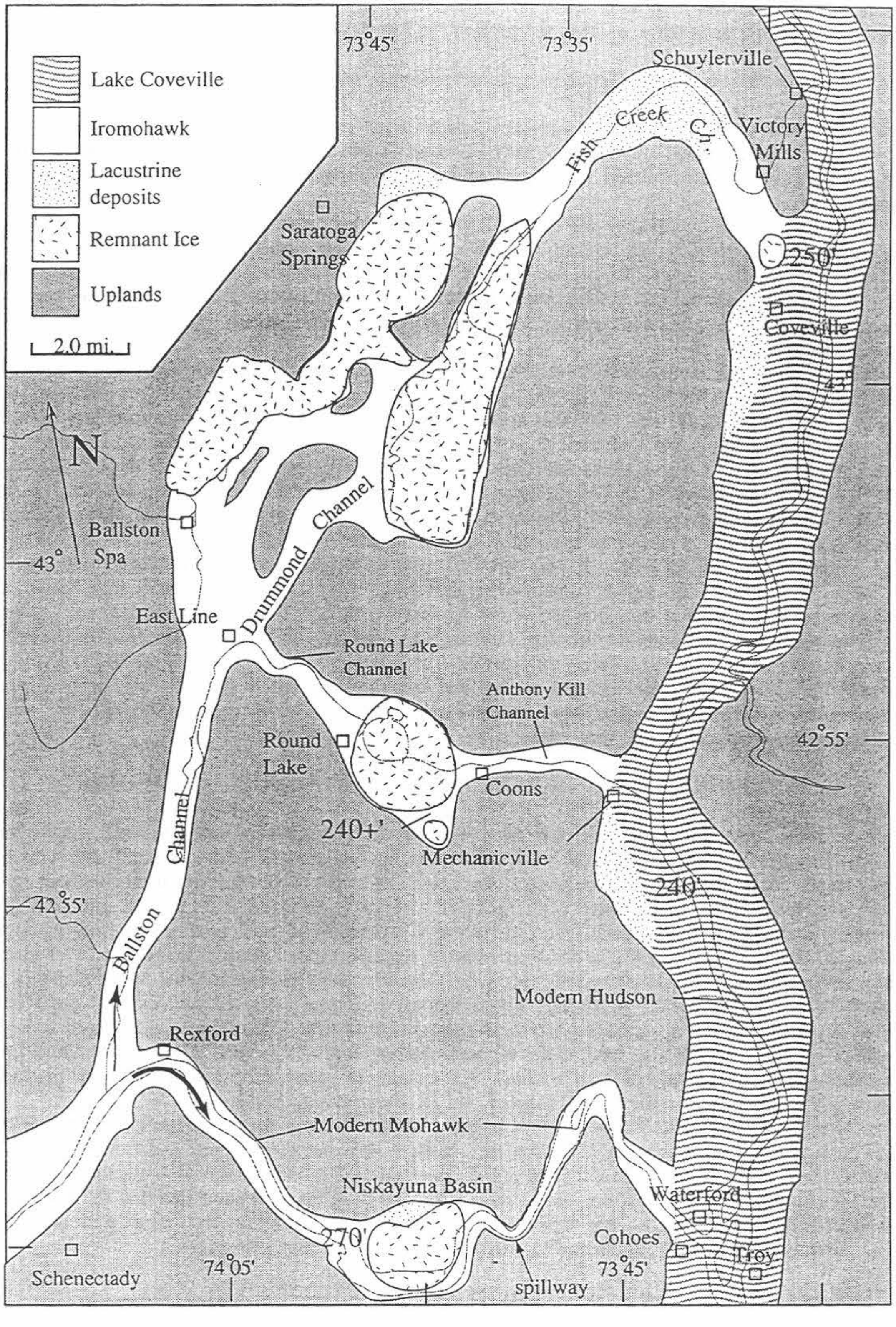


Figure 9: Map of Hudson/Mohawk Lowland during Lake Coveville.

the south of Scotia. Based on the difference in elevation between depositional surfaces and the water levels they represent, the Scotia Gravel was deposited sometime after Lake Albany. This alone does not preclude Lake Albany from receiving high volume discharge; however, it's difficult to envision high-volume discharge making the dramatic ~90° bend at what is now Schenectady Basin unless Schenectady Delta was already inset and cut off.

Cutting off a delta or delta lobe can occur by one or a combination of two processes. First, the feeder channel to the delta becomes choked with sediment, forcing the channel to find an easier path to base level, and second, a change in base level occurs. The presence of the Malta Sand Plain at 330+ feet elevation presents the possibility that a change in base level caused the Mohawk to cut off Schenectady Delta.

The Malta Sand Plain is an extensive sand body requiring a significant sediment source. Considering Ballston Channel provides a direct link between the Mohawk Valley and the sand plain, the Mohawk has to be considered the sediment source. Correcting for isostatic adjustment (DeSimone, 1985), the Malta Sand Plain lies nearly 40 feet below Schenectady Delta, and 30 feet above Lake Quaker Springs deposits both having experienced approximately equal uplift at the Hoosic River mouth. Although no topset-foreset contacts were found in the Malta Sand Plain, it seems unlikely that it was deposited in 40 feet of water 11 miles north of Schenectady Delta. Therefore, an intermediate lake level between Albany and Quaker Springs, as first suggested by DeSimone (1985) and DeSimone and LaFleur (1985), seems likely (Figure 7). Although DeSimone (1985) uses only a small number of features to develop a "lowered Albany" water plane curve, the Malta Sand Plain falls on his curve quite well. The outlet of this lake is debatable, so a naming of this level based on an outlet is not advisable. A temporary and uninspiring name of Albany II, therefore is assigned to this phase. Lake Albany II is equivalent to Stoller's (1922) Malta Delta Stage of Lake Albany.

Considering the extreme ~90° channel bend at Schenectady Basin and initial flow through Ballston Channel was to a base level other than Lake Albany, high discharge is excluded from entering Lake Albany. This implies that at least initially, Lake Albany II did not receive high discharge.

Distributary Channels

A lack of Albany II deltas or sand plains associated with Mourning, Drummond, and Round Lake channels and a massive Quaker Springs sand plain associated with Drummond and Mourning Channels, indicates channel development was due to a lowering lake level and not channel infilling and progradation. Initial development, therefore, of Mourning, Drummond, and Round Lake channels occurred following Lake Albany II. All three channels have erosional surfaces below and adjacent to the Malta Sand Plain. Channel erosional surfaces are between 300 and 310 feet elevation and characterized by a surface of washed till in Round Lake Channel and an exhumed clay surface northeast of East Line between Drummond and Mourning Channels. Drummond channel exhibits an exposure of coarse sand and gravel at its bend southwest of Rt. 9. This sand and gravel is at the top of the stratigraphic section between 290 and 300 feet. Its stratigraphic position and location along the inner channel bend suggest it is a remnant point bar, now hanging 40-50 feet above the channel floor. The development of equal-elevation erosional surfaces in each channel indicates their development was contemporaneous and their nature truly distributary, rather than a series of channels used in some sequential manner. Distributary channels form when a main channel can no longer accommodate flow volume. Considering: (1) the size of these channels; (2) their distributary nature; (3) the coarse-grained point bar in Drummond Channel; and (4) the gigantic Saratoga-Wilton sand plain adjacent to Mourning and Drummond channels, high volume discharge (i.e., Lake Iroquois outflow) must have occurred no earlier than the Lake Albany II - Quaker Springs transition. Such a dramatic flood pulse into the Hudson Valley could have triggered the lake outlet failure (LaFleur, 1979; Stanford and Harper, 1991). DeSimone (1985) considered the Albany-lowered Albany (Albany II) transition to have been gradual. If this was the case, the lake outlet may have been weakened and perhaps all the more susceptible to failing from Iroquois outflow. If it is shown that some other mechanism is responsible for the Albany II-Quaker Springs transition, Iroquois outflow must have occurred some time during Lake Quaker Springs time.

Ice Block Basins

As previous authors have proposed (see Historical Review), the Lake Lonely, Saratoga, Victory Mills, Kayaderosseras, Round Lake, Elnora and Niskayuna basins (Figures 6a and 6b) are considered locations of remnant glacial ice. The argument presented by these authors, and supported here, is that basin morphology is such that fluvial erosion of material is simply not a reasonable explanation of these features. From a sediment budget perspective, the amount of sediment that would have to be removed from the basins by fluvial action is not easily accounted for in the Hudson Valley. Further evidence for the Saratoga ice block can be inferred by ice marginal channels north of Malta Ridge.

Ballston Channel has also been considered by many (see Historical Review) as the former location of remnant ice. It has been argued that the extreme depth at the southern end of Ballston Lake requires an ice block to prohibit infilling by flow through Ballston Channel. This explanation is not considered satisfactory for the following reasons. The southern end of Ballston Lake is at the base of a fairly steep drop in the Ballston Channel bed past its modern divide. Considering this gradient, the discharge, and the size of the channel, flow velocities through this reach must have been substantial. Therefore, the possibility of erosion in this deep part of the lake cannot be easily dismissed. Furthermore, the coarse bedload that might have filled this channel depression would have been deposited along with Scotia Gravel in Schenectady Basin. Sand-sized material could have been easily transported through this reach if it were ice free, considering it would have been transported through a much larger basin at Schenectady. The only available coarse bedload between Schenectady Basin and Ballston Lake is in the southern portion of Ballston Channel. The 4+ foot thick deposit along the western side of the lake of shale rich sand and gravel likely has its provenance in this channel reach. It is not known if this deposit is present on the floor of Ballston Lake, but the availability of such material is limited and perhaps not sufficient to fill the depression. If this scenario is realistic, the northward shallowing of Ballston Lake is a reflection of an Iromohawk competence-loss associated with the observed channel widening midway along its length.

Quaker Springs Base Level

Lake Iroquois discharge into Lake Quaker Springs deposited the Saratoga-Wilton sand plain (Figure 8). Chadwick (1928) was the only person to suggest this sand plain was an Iromohawk deposit (in Lake Albany). He left room for the possibility, however, that the sand plain was a Snook Kill delta, because the Mourning and Drummond Channels did not clearly intersect it. Chadwick failed to recognize the role of remnant ice between the channels and sand plain. Iromohawk drainage through Mourning and Drummond channels drained across, between, and around the Saratoga, Kayaderosseras, and Lake Lonely ice blocks, reaching the southern (proximal) end of the sand plain at, and northeast of, Saratoga Springs. The Albany II sand cap (320-330 feet elevation) on Malta Ridge stands as an erosional remnant to flow through Drummond and Mourning channels. This sand cap likely extended to the west and originally bordered Kayaderosseras Basin remnant ice.

Sand plains west, north, and south of Niskayuna Basin are at an elevation correlative with Lake Quaker Springs. The Elnora Channel was not likely active during Lake Quaker Springs because deltaform features bordering Colonie Channel at the end of Dwass Kill and Grooms Corners Channel are not incised by drainage to this base level. Therefore, the source of sands infilling Colonie Channel to the level of Lake Quaker Springs must have been along the course of the modern Mohawk River. Quaker Springs sands just south of Albany County International Airport are below and adjacent to Lake Albany Schenectady Delta sands. As Quaker Springs age deposits are absent from Niskayuna Basin itself, remnant ice must have still occupied the basin. The highest bedrock terrace along the southern wall of Mohawk Gorge began to develop as Iroquois waters drained across the Rexford sill and toward Niskayuna.

Coveville Base Level

Erosional surfaces at 260-270 feet elevation in Mourning, Drummond, and Round Lake channels indicate the channels continued to serve as distributary channels after Lake Quaker Springs (Figure 9). Clear erosional scarps in Mourning and Round Lake channels between this and the 300-310 Quaker Springs erosional surface distinguish this surface from Quaker Springs drainage.

In Mourning Channel, the 260-270 foot elevation erosional surface expands north of East Line, bifurcating around the fluviatile rise northwest of Malta Ridge. Because there is nothing bounding this surface to the west and no headward-erosional features along the Kayaderosseras basin wall, flow to the west of the rise would have been bounded by Kayaderosseras Basin remnant ice. The apparent eastward redirection of the surface north of Malta Ridge possibly reflects flow around and not over remnant ice, but the flat-topped drumlinoid features in Kayaderosseras Basin at roughly an equivalent elevation might have been planed by flow across decaying ice. Upon encountering Saratoga Lake Basin, the surface was again redirected by remnant ice to develop the ice marginal channels north of Malta Ridge. All of these channels join Saratoga Basin without any headward erosional features along the basin wall, again indicating water drained across ice.

Although these Mourning Channel erosional surfaces are at approximately the same elevation, they decrease substantially in width to the north. Furthermore, the erosional surface west of Malta Ridge and bordering Kayaderosseras Basin truncates the slightly higher erosional surface bordering Malta Ridge. These features are interpreted as recording diminished flow through Mourning Channel during Lake Coveville time.

The sand capped ridge, at 270+ feet, between Saratoga and Lake Lonely basins was deposited as water drained across and between Saratoga and Lake Lonely ice blocks from erosional surfaces north of Malta Ridge. Sandy terraces along the south side of Fish Creek channel and the western side of the Hudson Valley southwest of Coveville at 270+ feet elevation record the high stand of Lake Coveville. Sands at 260+ feet north of Lonely Lake Basin and partially occupied today by Meadow Brook can be attributed to this Lake Coveville level as well. The Meadow Brook area was occupied by Lake Lonely ice during Lake Quaker Springs, and thereby prevented deposition of Iromohawk-Quaker Springs sand. Meltback of Lake Lonely ice to the modern Lake Lonely Basin margin occurred following Lake Quaker Springs and during Lake Coveville.

A lowering of Lake Coveville to its stable 240 foot level (at Schuylerville) backed the lake out of Fish Creek channel at least as far as Grangerville. Clay flow shadows preserved downchannel of drumlins in the eastern part of Fish Creek Channel (DeSimone, 1977) developed during this lower Coveville phase. Sands at 240 feet elevation southwest of Coveville likely found their source from Fish Creek Channel and record continued use of the channel throughout Lake Coveville. The Victory Mills ice block must have remained throughout Lake Coveville, blocking deposition.

Drummond Channel records Coveville-Iromohawk channel bottoms at 270 foot elevation northeast of East Line, and at a 260+ foot elevation bedrock terrace at the outer Drummond Channel bend. Beyond the junction of Drummond Channel with Saratoga Basin, there is limited evidence of the course of Drummond Channel waters. Sand and gravel capping the largest of three mounds along the western margin of Saratoga Lake is similar to the club-shaped ridge between Lake Lonely and Saratoga Basins. This cap possibly represents deposition in a hole or crack in Saratoga Basin ice. It seems likely flow from Drummond Channel joined Mourning channel waters at the club-shaped ridge, but direct evidence of this has melted away with the Saratoga ice block.

In Round Lake Channel, Iromohawk drainage to Lake Coveville is recorded in two erosional terraces at 270+ feet and 260 feet elevation. The down-channel edge of these terraces has been truncated by drainage to lower base levels, so it is not clear how far the channel extended to the east. A lack of erosional features along the basin margin, indicates drainage was likely across Round Lake Basin ice. The south-central portion of the basin is a likely candidate for the position of an 'ice channel'. This position is suggested by the mound in the central portion of the basin, possibly the product of glacial debris filling a ice hole or crack.

The 290+ foot elevation sand plain in the northeastern portion of the basin may have been active as late as Lake Coveville, recording a slightly higher base level in Round Lake Basin during Lake Coveville than that in the Hudson Valley at Mechanicville. It seems possible that this sand plain was active no later than the high stand of Lake Coveville, as the gradient from a 290+ foot Round Lake Basin base level to 220 foot Mechanicville level seems too steep considering the discharge and composition of Anthony Kill Channel. In any case, the sand plain does not appear disturbed or affected by drainage through the basin, furthering the idea that flow was through the southern portion of the basin.

Sands at ~240 feet elevation between Round Lake Basin and Elnora ice possibly record the lower Coveville phase in the basin, as it is significantly lower than the northern 290+ foot elevation sand plain. Infilling to this level between ice blocks may indicate the blocks were originally connected, which prevented deposition of Albany II sands continuous with the Malta Sand Plain.

A thin layer of coarse sand and gravel east of Coons, hanging ~60 feet above the floor of Anthony Kill Channel, records drainage across Round Lake ice to Anthony Kill Channel. The coarse-grained poorly-sorted nature of the deposit suggests it may have been channel lag and therefore represents the Anthony Kill channel bottom during Lake Coveville time. Anthony Kill Channel developed in response to lowering Hudson Valley base levels and connected water adjacent to Round Lake Basin ice to the Hudson Valley. Sands at 240+ feet elevation south of Mechanicville record usage of Anthony Kill Channel during Lake Coveville time.

East of Niskayuna Basin, the modern channel began to develop toward Coveville base level. The elevation of the bedrock ridge at the Twin Bridges (I-87, the Northway) prior to downcutting by the modern Mohawk is not known. However, the approximate top of rock on the southern valley wall and peculiar break in slope along the bedrock ridge comprising the northern valley wall, both at 270 feet elevation, suggests this ridge of bedrock extended across the Niskayuna Basin outlet. The ridge would have dammed basin water and formed a waterfall between Niskayuna Basin and Lake Coveville. The cutback nature of the southern valley wall at Dunsbach Ferry resembles that of a former plunge basin and supports this position. This waterfall was perhaps 90 feet above the modern Mohawk (dammed) water level and 30 feet above Lake Coveville base level. This spillway/waterfall at the eastern edge of Niskayuna Basin would have allowed continued deposition of sands north and south of Niskayuna Basin above the Hudson Valley Coveville base level. Initial erosion of glacial and lacustrine sediment between Niskayuna Basin and Waterford was initiated during Lake Coveville time.

Modern Channel Development

A dramatic contrast exists between Iromohawk erosional and depositional features associated with Coveville and Quaker Springs base levels. The extent of deposits associated with Drummond and Mourning channels during Lake Quaker Springs time greatly outweighs those of Lake Coveville. Coveville erosional surfaces appear quite substantial in the channels themselves, but the diversion of flow by remnant ice in Kayaderosseras and Saratoga Basins and the closeness in elevations between Coveville erosional and depositional surfaces in Mourning and Drummond channels suggest flow was fairly slow and shallow. Conversely, erosional features in Mohawk Gorge

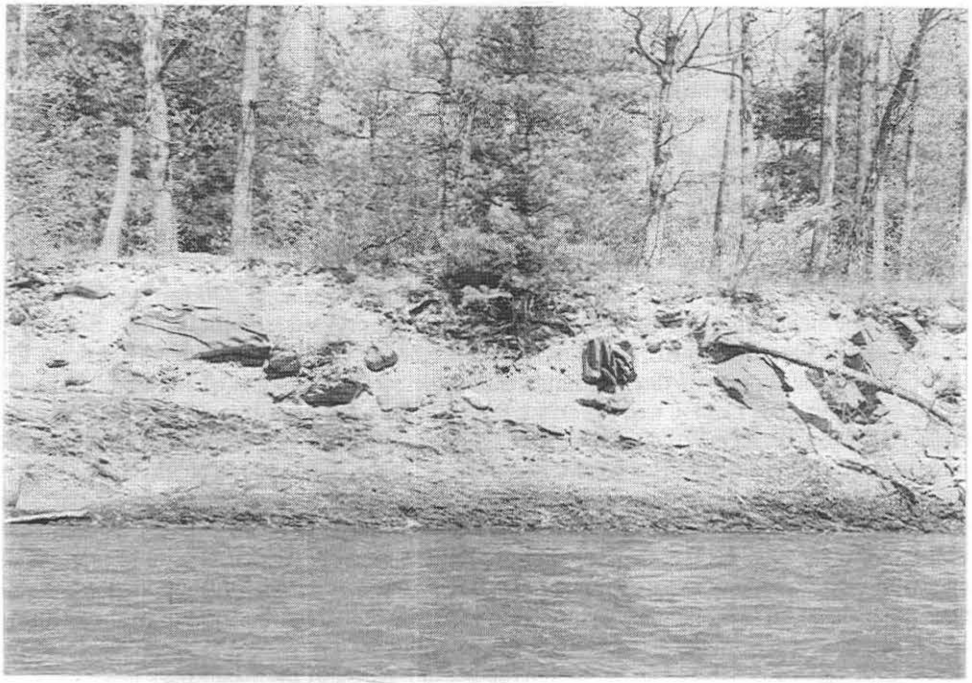


Figure 10: Iromohawk deposit in Mohawk Gorge overlying Schenectady Formation

appear to increase in energy from Albany II to Lake Coveville time. This shift in energy from distributary to modern channels is directly related to the lowering of the bedrock sill at Rexford.

Goat Island, at the downchannel end of Mohawk Gorge, and a 220+ foot elevation gravel-boulder terrace along the northern side of the gorge, are clear evidence that high discharge developed Mohawk Gorge. A bedrock island in a bedrock channel does not form under normal flow conditions. Such islands require simultaneous incision on both sides, normal flow would tend to develop one side preferentially. The position of the gravel-boulder terrace in the gorge requires it to be of fluvial origin. The deposit (Figure 10) lies on a bedrock surface that was exposed by postglacial erosion and is far enough away from the gorge walls to eliminate the incorporation of boulder clasts by mass wasting. The only agent capable and available to move boulder size material found in the deposit is fluvial. It is doubtful that the modern Mohawk is capable of transporting this size material, and furthermore, the modern Mohawk is erosive in this portion of the gorge today, indicating some change in flow conditions since the deposit was made. It seems reasonable that this change is the result of the modern Mohawk flowing across and incising the Iromohawk channel bottom, leaving it as a terrace. If this is the case, the modern Mohawk has cut through ~8 feet of Iromohawk channel lag and 20-25 feet of bedrock.

The 260+ foot elevation bedrock bench at Rexford is slightly lower than the isostaticly corrected (DeSimone, 1985) Ballston Channel divide. Because the bench is lower, it can be inferred that the majority of Iromohawk water, following bench formation, drained through Mohawk Gorge. Bench development is interpreted as an indication of a fairly stable base level of significant duration. The Niskayuna Basin spillway maintained a basin base level very near that of Lake Quaker Springs during Lake Coveville time. This interpretation taken with the observed Quaker Springs-Coveville transition of distributary channels features, indicates the majority of Iromohawk flow was contained in the modern channel during Lake Coveville time.

Lowering of Mohawk Gorge to the 230+ foot elevation Rexford bench occurred only after the Niskayuna Basin spillway eroded, thereby lowering Niskayuna Basin base level and reactivating Mohawk Gorge erosion. Continued lowering of Mohawk Gorge allowed the transition from depositional to erosional environments in Schenectady Basin. The Scotia Gravel was incised, developing Scotia Channel and associated minor channels.

The symmetry of the small delta along the western flank of Ballston Lake indicates its development was unaffected by flow in the channel. The flow through Ballston Channel necessary to develop distributary channel features correlated with Lake Quaker Springs, suggests a post-Lake Quaker Springs age for delta formation. Its elevation above the modern channel divide indicates it pre-dates modern drainage. Furthermore, if the divide 'subchannel' formed because of waning flow through Ballston Channel during Lake Fort Ann time, and the 'subchannel' contained all of this flow, the delta elevation above the top of the 'subchannel' indicates its age can be further constrained to Lake Coveville. This last point is purely conjecture, but internally consistent with the idea that Iromohawk discharge through Ballston Channel to Lake Coveville was clearly diminished relative to Lake Quaker Springs.

Fort Ann Base Level

Flow through Drummond Channel to Lake Fort Ann abandoned the bedrock terrace at the major channel bend as an erosional remnant. Based on the course of Drummond Creek today, it appears that remnant ice continued to force flow north along the western Saratoga ice margin (Figures 11 and 12). This northward flow direction might have been compounded by sediment deposition at the mouth of Drummond channel and adjacent to Saratoga Lake Basin ice.

Base level between East Line and Schuylerville was controlled by a bedrock spillway at ~210 feet elevation west of Coveville. Correcting for isostatic adjustment (DeSimone, 1985), this spillway would have caused an apparent base level at about the present day Saratoga Lake level. Drainage across the spillway developed "The Cove" at Coveville. The size of this feature has caused speculation that Iromohawk flow was necessary to develop it; however, sedimentation at ~210 feet in Fish Creek Channel and the poorly defined nature of the channel indicates this was not the case. Drainage of Saratoga Lake Basin waters across the spillway may have continued well into the Holocene before the lower Schuylerville outlet opened.

Headward erosional features in the Coveville channel bottom join the bottom of Mourning Channel at 220+ feet elevation and evidence drainage to a post-Coveville Kayaderosseras Basin base level. The narrow subchannel, now occupied by the Mourning Kill, developed as a result of this base level. The Mourning Kill is clearly misfit in this subchannel suggesting that it became misfit as Iromohawk flow diminished.

Two post-Coveville water levels are recorded in Round Lake Basin at 200 and 170-180 feet elevation. This level is further recorded around nearly the entire basin margin in the form of small deltas and sand plains. Significant basin infilling north of Little Round Lake and along the southern basin margin occurred during this base level, indicating significant remnant ice meltback during or prior to this base level. This 200 foot Round Lake Basin base level is correlated with the 180 foot elevation level of Lake Fort Ann at Mechanicville.

The lowest erosional surface in Round Lake Channel terminates in a small delta at the modern lake margin. This delta is composed almost entirely of shale clasts derived from Round Lake Channel. Creation of the 170-180 foot elevation sand plains in the southern and eastern portions of Round Lake Basin indicate further and perhaps accelerated meltback of Round Lake Basin ice during later Lake Fort Ann levels.

The extent of erosional and depositional features between East Line and Mechanicville, together with the diminished features north of East Line, suggest Round Lake Channel was the dominant distributary channel during Lake Fort Ann time. The shorter route (and steeper gradient) to Hudson Valley base levels allowed Round Lake Channel to undercut and pirate Drummond and Mourning Channels.

Drainage through Anthony Kill Channel lowered the channel floor below the Coons-Coveville age channel bottom. Flow through Anthony Kill Channel deposited a delta south and west of Mechanicville in the 180 foot Lake Fort Ann base level. The sedimentology of the deposit (Wall, 1995) suggests that material was locally derived and likely reworked from tills in the developing Anthony Kill Channel. The graded nature of the deposit suggests Iromohawk discharge was long-term and cyclic, not catastrophic.

Approximately 80 feet of downcutting in Anthony Kill Channel occurred following Mechanicville delta formation. The cutback feature in the northern channel wall at Willow Glen is a likely eddy feature associated with channel widening downchannel of the narrowest channel reach. The Anthony Kill Channel bottom is at the same elevation as an erosional surface just west of Reynolds on the eastern side of the Hudson River. The valley wall adjacent to this surface is concave suggesting modification during Anthony Kill Channel outflow. This, plus the misfit nature of the modern Anthony Kill, indicate a significant amount of drainage occupied the channel during later stages of Lake Fort Ann. Contrary to previous investigations, it is not necessary to flush the entire volume of Iromohawk water through the Anthony Kill Channel to develop these features. Because the channel bottom gradient today is 0.003, it seems quite reasonable that discharge on the order of the modern Mohawk could have developed these features. That is to say, only a portion of Iromohawk flow would be necessary.

The floor of the Elnora Basin is between 210 and 220 feet. This level is very close to the Fort Ann water level in Round Lake Basin, suggesting Elnora Basin may have filled with sediment from surrounding tributaries during Lake Fort Ann time. If this inference is correct, it indicates Elnora ice melted prior to or during Lake Fort Ann time.

Sometime following or in the latter stages of Lake Coveville, the Niskayuna Basin spillway lowered. This lowering allowed a reactivation of erosion in Mohawk Gorge and Schenectady Basin, the development of the 230+ foot elevation Rexford bench, erosion of Goat Island, and deposition of boulder gravel channel lag in Mohawk Gorge, which includes reworked Scotia Gravel.

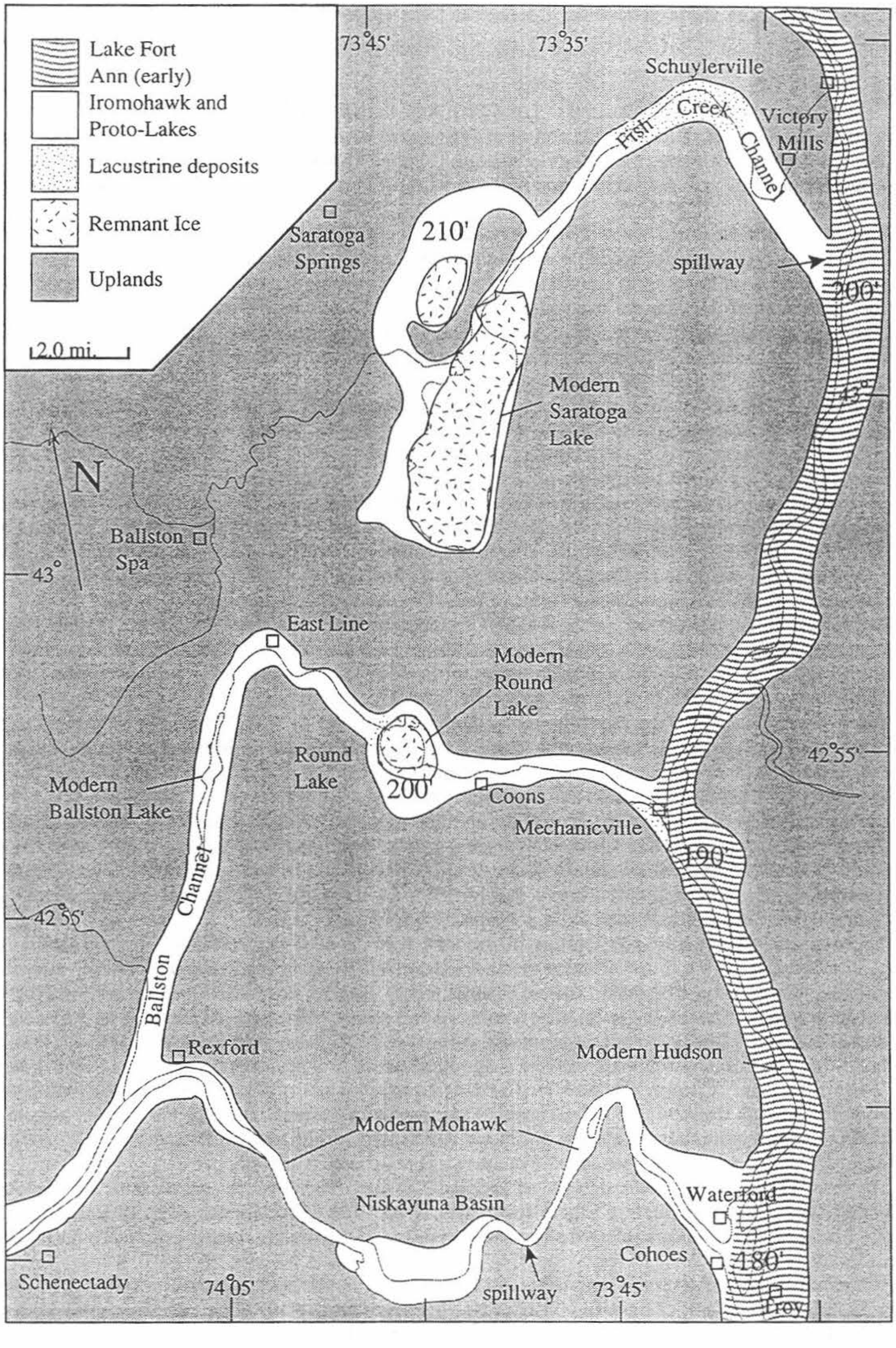


Figure 11: Map of Hudson/Mohawk Lowland during early stages of Lake Fort Ann.

The position of remnant ice in Niskayuna Basin during this period is not clear, but if it lingered during Lake Fort Ann time, it likely resided in the southern portion of the basin where the river flows today. Vischers Ferry sands at 200-210 feet elevation, are slightly higher than modern basin water level. It is not clear if this level is correlative with Lake Fort Ann or a localized base level associated with a lowered Niskayuna Basin spillway. It is also not clear if Stony Creek, the Mohawk or both are the source of these terrace sands, as ample sediment was likely available from both sources. The cutback feature west of Niska Isle is likely due to eddying flow emerging from Mohawk Gorge. The scale of the feature suggests it was developed by high discharge.

Iromohawk drainage stripped glacial and lacustrine material from the Taconic-age thrust slice west of Waterford (see Kidd et al., this volume). It is not clear if the north-south trending ridges and troughs in this area were gullied by fluvial action or reflect the structural geology, but in either case, these troughs likely focused flow to the south, developing the trench the modern river flows through. The pond in Waterford adjacent to the eastern edge of the slice is an artifact of a former plunge basin. The large headward erosional feature occupied by the 'Waterford flight' formed as water drained along the thrust slice margin, eroding the thick sequence of lacustrine sediments directly to the east.

The same argument for high discharge needed to develop Goat Island applies for islands at the modern Mohawk and Hudson River confluence. As some inter-island channels are ~30 feet deep, however, and the highest island is some 20 feet below the lowest level of Lake Fort Ann at Troy (~110'; DeSimone, 1985), it is difficult to envision bedrock erosion in ~50 feet of relatively quietstanding water as far as a mile away from where this discharge would enter Lake Fort Ann III. This observation raises the possibility that a high-discharge Mohawk drained to a Hudson Valley base level closely resembling that of the modern Hudson and clearly below the level of Lake Fort Ann III.

If evidence of high-flow discharge observed in the Anthony Kill and modern channels is attributable to the Iromohawk, and the Fort Ann water plane curves of DeSimone (1985) are accurate, than all Hudson Valley Fort Ann phases must have occurred prior to the Iroquois-Frontenac transition and are therefore correlative with Denny's (1974) Lake Fort Ann I in the Champlain Lowland. Clark and Karrow (1984) correlate a post-Frontenac Ontario Basin level with Lake Fort Ann II in the Champlain Lowland; therefore, if their correlation is correct, Iromohawk drainage had ceased well before Lake Fort Ann II in the Champlain Lowland. Because Lake Fort Ann II (Champlain Lowland) drained through the Hudson Valley, and the Iromohawk drained to a level below Lake Fort Ann III but chronologically before Lake Fort Ann II (Champlain Lowland) outflow, at least one base level is suggested between Lake Fort Ann III and the modern Hudson.

Alternatively, significant inputs from melting ice in the Catskills and Adirondacks could have increased post-Iromohawk discharge to a post-Fort Ann III base level, thereby developing the observed features at the Hudson-Mohawk confluence. Although this alternative is less attractive, both scenarios raise the possibility that Cohoes Falls underwent significant headward erosion prior to modern Mohawk drainage.

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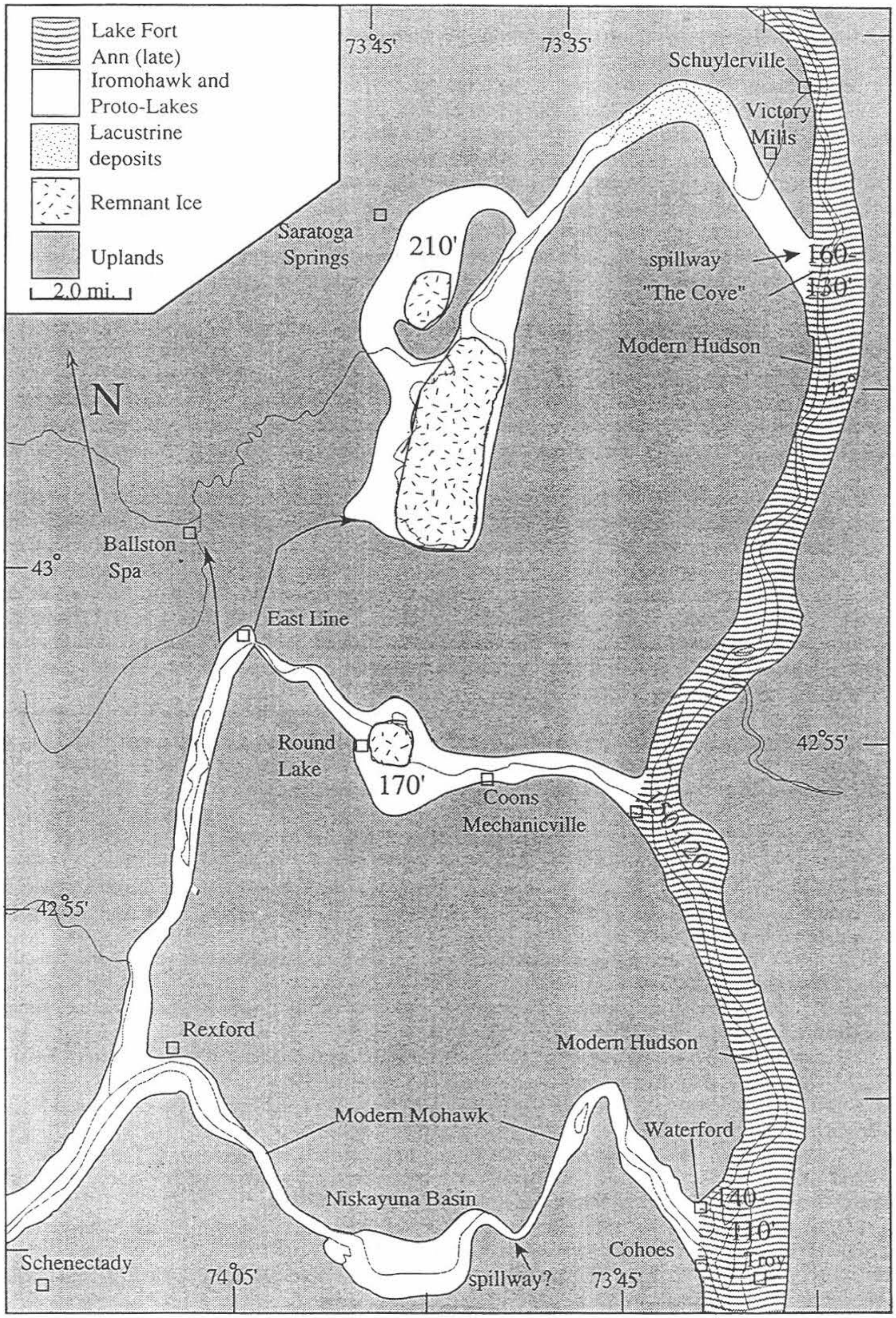

Figure 12: Map of Hudson/Mohawk Lowland during late stages of Lake Fort Ann.

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THE PALEOFLUVIAL RECORD OF GLACIAL LAKE IROQUOIS IN THE EASTERN MOHAWK VALLEY, NEW YORK

ROADLOG

Miles	Log
	From Butterfield Hall parking lot, turn right onto Union Ave.
0.0	At 1st traffic light set trip odometer and bear right onto Union St.
0.5	Left at 1st traffic light past railroad underpass.
0.7	Right at 2nd traffic light onto Rt. 5 west.
1.0	Left at 2nd traffic light to 890 west.
4.0	Mohawk River and Barge Canal Lock 8 on right.
4.7	Right on I-90 onramp. Past toll plaza, bear right onto I-90 west.
7.6	Mohawk Valley and Rotterdam Jct. on left.
21.2	*Schoharie Bridge - The original Thruway crossing of Schoharie Creek catastrophically failed in 1987 due to Schoharie Creek high flow and scour of bridge supports.*
23.4	*Mohawk River floodplain and approximate Iromohawk River channel bottom.* *Iromohawk depth in this location was approximately 50 feet.*
25.3	Leave Thruway - Exit 28, Fultonville Fonda - Toll $0.65. Left turn after toll plaza. Mohawk River and Barge Canal on right.
26.3	Left at 1st traffic light onto Rt. 30A south.
26.6	Right on 5S west.
27.2	*Middle Ordovician Canajoharie Shale exposed on left.*
29.6	Left on Borden Rd.
29.7	Right on Dillenbeck Rd. and bear right past red house.
30.4	**Stop 1** - Randall Expansion Bar overview. *Uplifted land associated with the Noses fault (Figure RL1) is visible to the west. At the base of the hill is the Iromohawk channel bottom, and beyond that the Randall expansion bar. The bar measures 7,000 feet in length and 1,800 feet at its maximum width. Thickness of the deposit is approximately 60 feet. One well log from the deposit indicates the bottom of the bar is approximately at the elevation of the modern floodplain (U.S. Geological Survey, Open File). The height of the bar above the floodplain therefore represents a minimum water depth (60 feet) for bar deposition.*
	Continue on road.
31.2	Right at stop sign. *Road descends to Iromohawk channel bottom. Randall bar is straight ahead and to the right.*
31.9	Right at stop sign onto 5S west. *Road climbs along Randall bar long axis.*
32.5	**Stop 2** - Randall Expansion Bar. Pit owned by Santos Construction Company (SCC) - our access to the pit is under consideration by SCC. Contact: Dave Santos (owner) (518) 842-6201 *Large-scale east--dipping (downvalley) cross-bedding is visible throughout the exposed pit, confirming the eastward flow direction inferred from the deposits east-pointing tapered tail. Exposures in contact with the deposit surface show bedding that mimics external morphology. Overall, the Randall deposit is very poorly sorted with individual clasts ranging from small boulders to coarse sand.*
	Continue on Rt. 5S east. *Road descends along eastern tail of Randall bar.*
36.5	Left on 30A north.
36.8	Right at 1st traffic light.
37.3	Right at Thruway (I-90) entrance. I-90 east after toll plaza.
57.4	Leave Thruway - Exit 26, Rts. I-890 and 5S - Toll $0.65.
58.3	Stay left past toll plaza - Rt. 5S Pattersonville.
61.0	*Road crosses top of Rotterdam Jct. portion of Scotia Gravel*
62.1	Right on Rt. 103
62.4	Cross Mohawk River and Barge Canal Lock 9

62.6 Right on Rt. 5 east

62.8 *Glenville Channel visible on left - one of four minor channels to incise the Scotia deposit of Scotia Gravel.*

63.1 *Partially cemented blocks of Scotia Gravel visible in old pit on left.*

65.5 **Stop 3** - Scotia Gravel and Mohawk River overlook.

If water level is low and interest high, hike from here to exposure of graded gravel foresets.

*This exposure is marked by numerous east dipping graded gravel foreset beds. Dozens of these foresets are visible across the exposure, each grading from cobble to coarse sand and pebble gravel, and measuring approximately 3 feet in thickness (**Figures** 3and 3.*

The cyclic nature of the graded foresets is more typical of a long term rather than catastrophic depositional event; furthermore, the cyclically suggests a seasonal variation

in transport energy, essentially gravel varves.

65.6 *Top of Scotia Gravel (~300' asl). Deposit continues to the northern (left) valley wall (3000+ feet)*

67.3 *This stretch of Rt. 5 runs along the top of a giant point bar extending to the south (right) into Schenectady Basin.*

67.9 Left at light onto Rt. 147 - *Road climbs to top of Scotia Gravel.*

69.3 Right on Vley Rd. and left at stop sign.

69.9 Left on Viele Rd.

70.1 **Stop 4** - Scotia Gravel overlook and paleodischarge discussion.

Another Scotia Gravel overlook, this one into a semi-active gravel pit.

Turn around and turn right back onto main road. *Road parallels Harding Channel on left.*

71.7 Bear left at yellow flashing light <<CAUTION - dangerous intersection>>

72.1 Left at light onto N. Ballston Ave. (Rt. 50 north)

73.3 Schenectady County Airport on right.

The airport sits atop a sand plain deposited in Lake Albany by the Glaciomohawk (pre-Iromohawk) and/or Alplaus Kill.

74.9 Right on Glenridge Rd.

75.5 *Road descends into Ballston Channel.*

76.4 Straight at light under railroad bridge. *Bottom of Ballston Channel.*

76.8 *Road climbs out of channel.*

77.2 Right on Rt. 146 south.

77.9 Left at light onto Riverview Rd.

78.5 First left onto Nott Rd. **Stop 5** - Mohawk Gorge

Directly across the gorge, a 1,200 foot wide bedrock bench stands at ~270 feet elevation. This bench descends and narrows to 260+ feet elevation some 6,000 feet downvalley where it pinches out at the narrowest gorge reach. A lower bedrock bench stands at 220+ feet.

Turn around and continue on Riverview Rd.

79.2 Stay right at fork.

83.5 Bear right at fork (stay on Riverview Rd.). *Village of Vischers Ferry is built on the floor of Niskayuna Basin, the southernmost of three giant kettles in the Hudson Mohawk Lowland. Niskayuna Basin is roughly 4 miles (E-W) by 2 miles (N-S). All three basins lie along the N-S trending preglacial Colonie Channel.*

85.0 *Original Erie Canal visible on right.*

87.2 Cross Northway (I-87).

87.3 Right turn at fork. *Road leaves Niskayuna Basin*

87.6 Left at end of road.

88.5 *Mohawk River on right.*

89.9 Right at stop sign.

90.0 Right at light onto Rt. 9 south.

90.2 Left onto Cohoes-Crescent Rd.

93.3 Left onto Front St. (just past old row houses).

93.4 Left onto Cataract St.

93.5 **Stop 6** - Cohoes Falls

The falls are dry throughout most of the year due to a diversion of flow for the Barge Canal and the hydroelectric plant immediately to the west.

Cohoes Falls has eroded back some 2000+ feet in post-glacial time. Inferences from bedrock islands at the Hudson -Mohawk confluence immediately downvalley suggest much of this erosion may have occurred during Iromohawk drainage. Iromohawk flow exposed and eroded the top of bedrock on both sides of the gorge.

Continue on Cataract St. and turn left on Cohoes-Crescent Rd.

94.3 Left at light onto Rt. 32 north.

94.5 *Cross Mohawk River - Bedrock islands visible to right.*

95.7 *Barge Canal locks 2 and 3 visible to right and left respectively.*

96.0 Left on Rt. 4 north.

104.9 Left at light onto Rt. 67 west.

105.5 *Enter Anthony Kill Channel - this channel developed as Round Lake Basin waters drained toward falling Hudson Valley glacial lake levels.*

106.8 *Willow Glen channel expansion (on right).*

Anthony Kill Channel dramatically expands to the north. This feature was likely carved out by eddying flow through Anthony Kill Channel, eroding the less resistant Willow Glen kame delta (the majority of the channel walls are composed of till and bedrock).

108.3 Turn left on unnamed road

108.5 Stop just past bridge to pull off on right. **Stop 7** - Anthony Kill Channel.

A classic example of a misfit stream.

Turn around and continue on Rt. 67 west.

109.0 *Enter Round Lake Basin, the middle of three giant kettles aligned with the preglacial Colonie Channel . Round Lake Basin is nearly circular with a diameter of apx. 2.5 miles*

111.2 Left onto County Rt. 80

111.5 *Road crosses top of small delta at mouth of Round Lake Channel.*

111.9 Cross Rt. 9 at light.

112.7 Right onto Interstate 87 north.

113.1 *Cross Round Lake Channel. Flow was from left to right into Round Lake Basin.*

114.2 Exit 12 off I-87, left at light at end of off-ramp.

115.4 Left on Rhule Rd. No.

116.0 At end of road pull off to right. **Stop 8** - Round Lake Channel

Visible in this portion of Round Lake Channel are two bedrock erosional surfaces which grade to Round Lake Basin water levels correlative with lakes Coveville and Fort Ann in the Hudson Valley. The upper Coveville surface is distinguished from the lower Fort Ann by the bedrock channel wall flanking Rhule Rd. No. The opposite channel wall is visible below the power lines crossing the channel.

Turn around and double back on Rt. 67 east.

117.6 Crossover I-87.

118.1 Cross Rt. 9. - *Road runs across the Malta Sand Plain, a Glaciomohawk deposit into Lake Albany II.*

119.9 *Road descends into Saratoga Lake Basin, the northernmost of three giant kettles aligned with the preglacial Colonie Channel. Saratoga Lake Basin has approximate dimensions of 2 miles (E-W) by 6 miles (N-S).*

120.4 Left at 'T' onto Rt. 9P. *Saratoga Lake is visible straight ahead.*

120.9 *Ascend back onto Malta Sand Plain.*

122.3 Cross Rt. 9

122.9 *Road descends into Ballston Channel. Ballston Channel is the middle of three distributary channels branching from the northern end of Ballston Channel at East Line. Drummond Channel connects with Saratoga Lake Basin to the northeast (right).*

123.1 Cross over I-87.

123.4 *Road ascends out of channel onto Malta Ridge, an erosional remnant between distributary channels (Drummond and Mourning) equivalent with the Malta Sand Plain.*

123.6 Straight at 4-way stop.

124.3 Left onto East Line Rd. *Road parallels Mourning Channel (to right).*

126.3 Straight at traffic light. *East Line - Point at which Ballston Channel splits into the distributary Mourning, Drummond, and Round Lake Channels.*

126.8 Right onto Lake Rd. *Road descends into Ballston Channel.*

127.9 Right onto Outlet Rd.

128.2 **Stop 9** - Northern end of Ballston Lake in Ballston Channel.