DEGLACIAL HISTORY AND ENVIRONMENTS OF THE UPPER WALLKILL VALLEY

G. GORDON CONNALLY
12 University Avenue
Buffalo, NY 14214

LES SIRKIN
Department of Earth Sciences
Adelphi University
Garden City, NY 11530

DONALD H. CADWELL
New York State Geological Survey
Room 3140
Albany, NY 12230

INTRODUCTION

The glacial history of the Wallkill Valley of eastern New York first was described by Connally and Sirkin (1967) in the guidebook for the 39th annual meeting of NYSGA. Prior to their interest, the area had received scant attention. It was mentioned peripherally by Woodworth (1905) and discussed in abstract by Connally (1966). The only previous detailed work was a study of proglacial lakes reported by Adams (1934).

Before commencing the joint study, Connally and Sirkin established restrictive criteria for locating the bogs that have become the standard sections: 1) some aspect of the peat bog must be directly linked to some specific geomorphic event, 2) the bog must have a high, unbreached rim with exclusively internal drainage, and 3) a deep section must directly overlie glacial sediments. We refer to this strategy as an integrated approach and contrast it with the grab-sample approach of others.

Following the tenets of the integrated approach, Connally and Sirkin (1970) refined interpretations. They discussed the valley again in the context of the entire Hudson-Champlain Lobe (Connally and Sirkin, 1973) and then Connally (1983) and Connally and Sirkin (1986) discussed regional correlations.

In the summer of 1988, Connally completed a 25-year project, mapping the entire Wallkill Valley at a scale of 1:24,000. The 7½' maps that cover the New York portion are on open file in the New York State Geological Survey in Albany, New York. NYSGS supported the later phases of this project, from 1983 through 1988, under the aegis of Don Cadwell. The maps are part of the data base for the Lower Hudson sheet of the Surficial Geologic Map of New York. During NYSGS sponsorship, new landforms have been recognized, new ideas have been generated in the field of glacial geology, and new interpretations have been applied to the Wallkill Valley

GEOLOGIC SETTING

The Wallkill Valley is a northeast-southwest trending lowland approximately 100 km long and 30 km wide, as shown in Figure 1. It narrows to the south. The western boundary is the scarp of the Shawangunk Mountain cuesta. The eastern boundary, separating the Wallkill Valley from the Hudson River trench, is the Marlboro Mountains. The crystalline rocks of the Hudson Highlands, and appended Schunnemunk Mountain, form the southeastern boundary.

Most of the valley is drained by the northerly flowing Wallkill River and its tributaries. At Sussex, New Jersey the trunk stream bifurcates. Papakating Creek drains the physiographic continuation of the valley for 12 km, from Augusta north to the bifurcation at Sussex. However, the Wallkill River rises almost due south, in a valley that cleaves the crystalline uplands. The southern end of the physiographic Wallkill Valley is approximated by the Culvers Gap Moraine.

The other major drainage system in the Wallkill Valley is Moodna Creek. This stream, and its tributary Otter Creek, flows eastward and empties into the Hudson River between the southern end of the Marlboro Mountains and the Hudson Highlands. Seeley Brook is a small southern tributary to Moodna Creek.

The lowest point in the Wallkill Valley is 140 ft at the confluence with lower Rondout Creek, north of Rosendale, New York. The highest point is 2289 ft at Sam's Point on the crest of the Shawangunks. Though the total relief is more than 2000 ft, most of the valley bottom lies between 200 and 600 ft above sea level, exhibiting low to moderate relief.

Bedrock

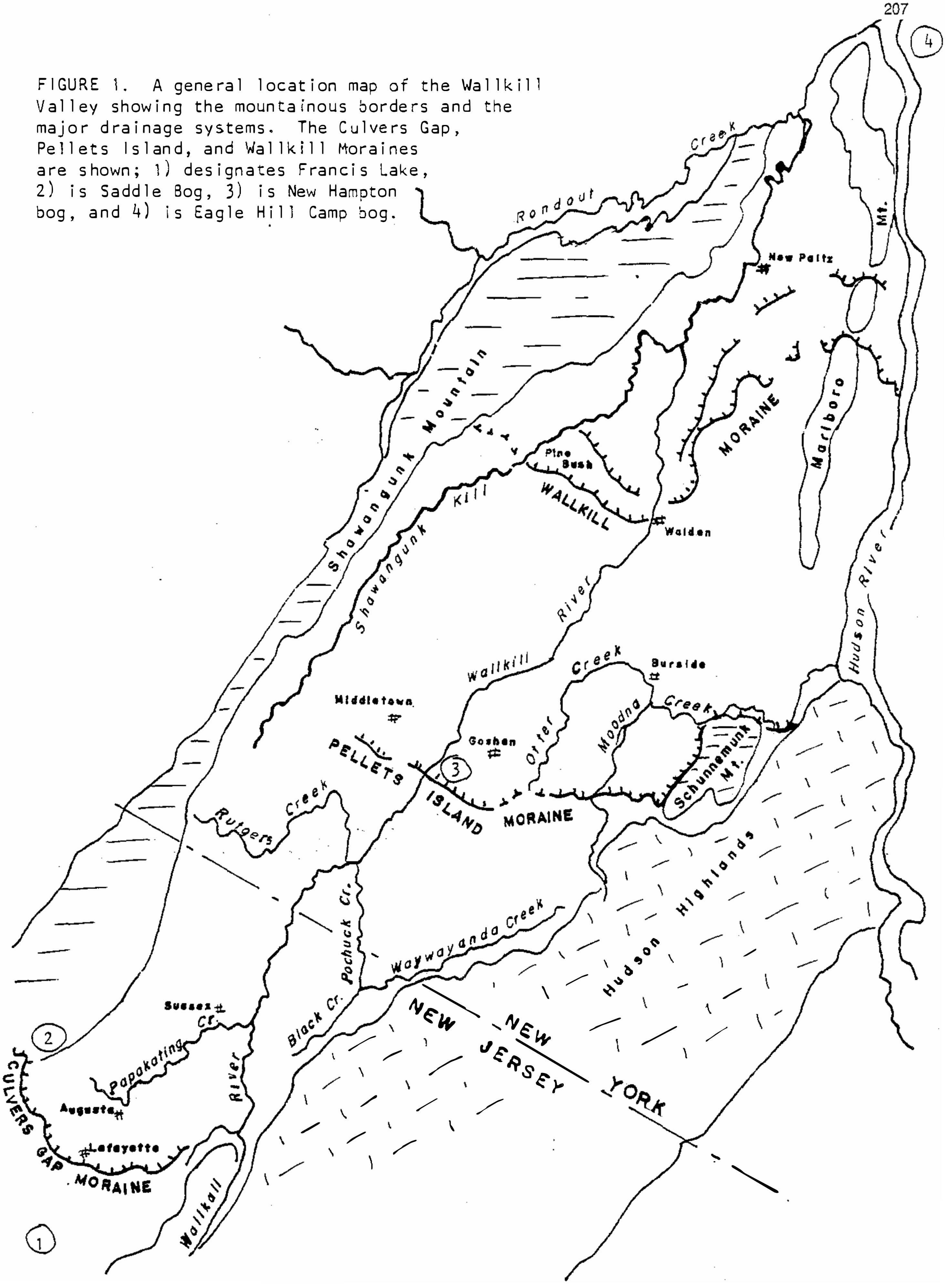
The valley is underlain by rocks of the Ordovician Martinsburg Formation. Resistant sandstone and siltstone beds account for the prominent strike ridges and roches moutonees in the valley bottom. On the east, the Marlboro Mountains result from very coarse and very resistent sandstones in the Quassaic Group. On the west, the softer sedimentary rocks are buttressed by the overlying, very competent, Shawangunk Formation, producing the spectacular Shawangunk escarpment (STOP 5). On the south and east, Schunemunk Mountain is upheld by resistant clastic sedimentary rocks of Devonian age.

Drift

There is an almost continuous blanket of supraglacial meltout till throughout the valley. This till is clogged by clasts and channers of Martinsburg lithologies. It usually occurs as clast-supported diamict. Matrix-supported diamict has been observed only in drumlin cores where sedimentary structures suggest that it has been disturbed or resedimented. Unequivocal subglacial meltout till has not been observed in the valley.

Ice-contact stratified drift is common. It is primarily shale-gravel and sand. However, prominent white sandstone and quartzite clasts derived from the Shawangunk Formation are common in the Wallkill Moraine and immediately adjacent to the Shawangunk Mountains south of that moraine. Lacustrine

FIGURE 1. A general location map of the Wallkill Valley showing the mountainous borders and the major drainage systems. The Culvers Gap, Pellets Island, and Wallkill Moraines are shown; 1) designates Francis Lake, 2) is Saddle Bog, 3) is New Hampton bog, and 4) is Eagle Hill Camp bog.



GLACIAL GEOLOGY

Connally and Sirkin (1967) described 5 ice margin positions, from oldest to youngest, the Ogdensburg-Culvers Gap, Augusta, Pellets Island, New Hampton, and Wallkill Moraines. In 1970, they added a brief discussion of the Rosendale readvance, described by Connally (1968), recognizing it as the youngest deglacial event in the valley. By 1973, they had realized that the "New Hampton Moraine" was only a minor recessional feature closely related to the Pellets Island Moraine and abandoned it as an independent moraine or even as a distinct ice margin position. Also by 1973, Connally had become suspicous that the western Culvers Gap Moraine described by Salisbury (1902) might not correlate with the feature at Ogdensburg and thus Connally and Sirkin (1973) dropped "Ogdensburg" from the previously hyphenated name. Unfortunately, there was no discussion of the reason for that change. Finally, still in 1973, they added the "Sussex Moraine" that was inferred to be recessional to the "Augusta Moraine" in northern New Jersey.

Because of the new data and new ideas generated during the most recent mapping efforts, we here abandon both the Augusta and Sussex "moraines", no longer recognizing them as ice margin positions, and also modify previous views about the Culvers Gap Moraine. We now recognize the Culvers Gap, Pellets Island, and Wallkill Moraines as the only significant ice margin positions in the Wallkill Valley. However, we continue to recognize the Rosendale readvance, an event lacking a definitive ice margin position, as the youngest event to affect the lower Wallkill Valley. The evolution of terminology, from 1967 to the present, is summarized in Figure 2.

CONNALLY and SIRKIN (1967)	CONNALLY AND SIRKIN (1970)	CONNALLY AND SIRKIN (1973)	CONNALLY-SIRKIN-CADWELL (this Guidebook)
not recognized	ROSENDALE READVANCE	ROSENDALE READVANCE	ROSENDALE READVANCE
WALLKILL MORAINE	WALLKILL MORAINE	WALLKILL MORAINE	WALLKILL MORAINE
NEW HAMPTON MORAINE	NEW HAMPTON MORAINE	*abandoned*	
PELLETS ISLAND MORAINE	PELLETS ISLAND MORAINE	PELLETS ISLAND MORAINE	PELLETS ISLAND MORAINE
not recognized	*not recognized*	SUSSEX MORAINE	*abandoned*
AUGUSTA MORAINE	AUGUSTA MORAINE	AUGUSTA MORAINE	*abandoned*
OGDENSBURG-CULVERS GAP MORAINE	OGDENSBURG-CULVERS GAP MORAINE	CULVERS GAP MORAINE	CULVERS GAP MORAINE

FIGURE 2. Ice margins and events in the Wallkill Valley as they have been interpreted from 1967 to the present.

sands and rhythmically bedded silt and clay are common in bottom lands. Extensive organic deposits are present in the mucklands of southern Orange County. These evidently mark the final phase of sedimentation in once prominent lakes. Organic sediments also are present in many kettle bogs, including New Hampton bog where Sirkin (Connally and Sirkin, 1967) established the pollen stratigraphic standard section for the valley.

Inversion Ridges

Before examining the glacial history of the Wallkill Valley, it is necessary to consider a newly recognized landform that has increased our understanding of events in the valley. This landform is named an inversion ridge. Inversion ridges, and inversion terraces, are quite common flanking the Shawangunk Mountains. Some of these deposits were referred to as inwash and were recognized by Connally and Sirkin in 1967, although they were not fully understood at that time.

The concept of inverted topography certainly is not new to glacial geology (e.g., see Lobeck, 1939, p. 312). It has long been recognized that depressions, or negative areas, on ice sheets collect and concentrate sediment. When the glacier melts, the sediment is let down to form topographic highs, or positive topographic areas. As a corollary, the positive regions on a glacier, comprising mainly unmelted glacier ice, become nagative topographic regions exhibiting a minimum of sediment when the glacier disappears. The definition of the inversion ridge is rooted in this long established concept.

An inversion ridge is a linear accumulation of drift that is located in a depression or valley bottom and is parallel or subparallel to an existing stream channel. It may be prominent or subdued; dissected or intact. It heads at a subareal drainage channel, or at a col or upland valley. It is composed of stratified drift and/or resedimented, clast-supported diamict. Matrix-supported diamict also may occur, but at present it is considered to be a minor constituent. The downslope, or downstream, end of the inversion ridge may merge with another inversion ridge, develop into an inwash or outwash fan (STOP 1), or terminate at what Fleisher (1986) called a dead ice sink. An inversion terrace is similar except that it is banked against a valley wall with the present stream channel on the valley side.

The recognition of inversion ridges as separate landforms restricts the use of the term esker. Inversion ridges represent drainage that was initiated in drainage systems above or beyond stagnant ice masses. Es kers are restricted to former drainage systems that were entirely englacial or subglacial in origin and which therefore may be unrelated to present drainage systems.

Because inversion ridges are so well preserved, and because they often are associated with dead ice sinks, they almost certainly resulted from deposition in or on stagnant ice. They are inferred to document drainage systems that functioned much as they do today after the ice has disappeared. The only difference between modern drainageways and those reconstructed from the inverted topography is that stagnant ice filled the depressions, or valley bottoms, or stream channels and channelized sediments were confined by walls of ice and preserved. Sedimentary structures in rare exposures imply downslope sediment transport, either by water currents or by mass movement.

Culvers Gap Moraine

Salisbury (1902, p. 270) describes

> "... a fairly well defined belt of recessional moraine ... from Ogdensburg, *via* Balesville, to Culver's Gap."

and continues with a more detailed description on pages 350 to 355. In summarizing the glacial history of the Hudson-Champlain Lobe, Connally and Sirkin (1973) inferred that the Culvers Gap Moraine, as illustrated in Figure 3, marked the maximum Woodfordian position. Because of doubts that were expressed in an unpublished manuscript by Connally in the late 1960's, the Ogdensburg portion of Salisbury's Ogdensburg-Culver's Gap Moraine was not included and the name was shortened to "Culvers Gap Moraine".

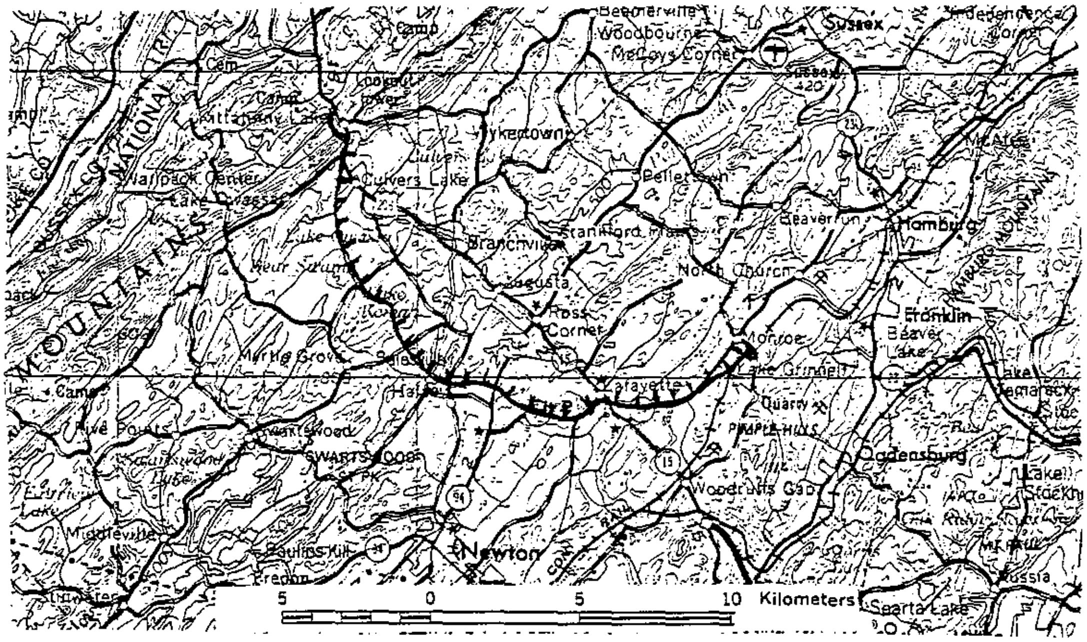


FIGURE 3. The Culvers Gap Moraine from the Kittatiny Mountains on the west to the Pimple Hills on the east. An inversion ridge at Ogdensburg is here considered to be somewhat older than the moraine.

Once Fleisher (1984) introduced the concept of a dead ice sink, later refined by Fleisher (1986), it became obvious that there was a dead ice sink immediately south of the morainal segment southwest of Lafayette, New Jersey. The Lafayette segment exhibits truncated foreset beds that were deposited against, or upon, a stagnant ice mass 3 km long that occupied the Paulins Kill valley from Lafayette south to Newton. If stagnant ice was present as the moraine was being deposited, the moraine hardly could have marked the maximum position of the Hudson-Champlain Lobe. In fact, at least the higher parts of the moraine probably are better interpreted as inversion ridges than as end moraine. Traced westward to the Shawangunk Mountains (Kittatiny Mountain in New Jersey), it appears to be inverted topography formed when drainage from the mountain encountered stagnant ice in the valley.

We still consider the Culvers Gap Moraine to be an end moraine, at least in part. At Lafayette, a large volume of sediment was furnished from a northern "up-ice" source, presumably active ice in the tradition of "the dirt machine" of Koteff (1974). From Lafayette eastward, the ice margin position disappears in the pitted outwash on the west side of Germany Flats (not shown on Fig. 3). The relationship of Germany Flats outwash to the drift at Ogdensburg is problematic.

The Ogdensburg segment probably represents a situation similar to that at Lafayette. The upper Wallkill Valley, southwest of Ogdensburg, probably was a dead ice sink. Drainage from Franklin Creek was channeled southwest onto stagnant ice, ultimately separating a stagnant ice block to the north from another to the south. The detailed mapping by Connally suggests that the outwash at Germany Flats, clearly related to the Culvers Gap Moraine, may be younger than the stagnant ice that remained north of the Ogdensburg inversion ridge. Thus, the drift at Ogdensburg probably is not a moraine segment and may well be older than the Culvers Gap Moraine at Lafayette.

Drift At Augusta

Salisbury (1902, p. 374) first reported the "Augusta Moraine" as follows:

> "A small moraine crosses the valley ... a mile or so north of Augusta. In front of the moraine the surface is strewn with large cobbles, but the gravel decreases notably in size to the southward ... this plain partakes of an overwash plain or a wide valley train.
>
> The southern edge of this plain is continuous with interrupted terraces along Paulinskill,.... The lack of continuity here does not appear to be due altogether to erosion ... the valley was partly occupied with ice when the gravel was deposited. Strongly marked stagnant ice forms are present ..."

The deposits described by Salisbury now are interpreted as an inversion ridge formed when Papakating Creek flowed out onto stagnant ice in the main valley. Initial drainage probably was graded to ±520 ft, though the graded plain referred to by Salisbury clearly is graded to ±500 ft. More stagnant ice topography, also previously mentioned by Salisbury, is present between Augusta and Sussex. Most deposits crest at ±520 ft, suggesting initial presence of a threshold to the south that impounded waters at that elevation.

The "Augusta Moraine" is here abandoned both as a moraine and as an ice margin position.

Drift At Sussex

Salisbury (1902, p. 423) described "The Sussex Delta" as follows:

> "A little east of Sussex is an elevated sand and gravel plain ... Its elevation about 535 feet ... it rises by a steep slope eighty to 100 feet above the low land at its border ... On the top, the delta form is less distinct. Instead of being flat or gently sloping, it is pitted by sinks, twenty-five to forty feet deep, and one knoll rises ten feet above the general level ... no exposures reveal the structure ..."

Connally and Sirkin (1973) reinterpreted this feature, located on the west side of the Wallkill Valley, as an end moraine and renamed it the "Sussex Moraine". It was inferred to be recessional to the "moraine" at Augusta. This feature (STOP 1) now is considered to be an inversion ridge deposited by Clove Brook drainage flowing out onto stagnant ice in the valley. It clearly is not graded to either the 520 ft or 500 ft water levels that existed to the south during deglaciation. This inversion ridge must have preceded the ice margin that impounded the lakes to the south. Younger deposits on the east side of the Wallkill River are graded to ±520 ft, with an erosional terrace at ±500 ft. The eastern deposits (STOP 1) are in an inversion ridge from an upland drainage basin and evidently formed after the western inversion ridge, as the stagnant ice surface lowered to the water planes.

The "Sussex Moraine" is here abandoned, both as a moraine and as an ice margin position.

Though there are no true recessional moraines between the Culvers Gap Moraine and the Pellets Island Moraine 42 km to the northeast, there are three prominent stagnant ice complexes, one west and two east of the mucklands surrounding the Wallkill River. To the west, in the valley of Rutgers Creek, ice-contact stratified drift and inversion ridges south of Westtown document a dead ice sink. As the ice retreated, or melted, water was impounded first at ±540 ft and later at ±500 ft. To the east, adjacent to the valley of Pochuck Creek, there is massive ice-contact drift just north of the New Jersey border. Northeast of Warwick, New York, there is a huge dead ice sink of about 20 km^2 that is almost completely collared with outwash and/or inwash gravel. The valley bottom is above 520 ft, precluding evidence of a 500 ft lake level. However, there is abundant evidence that as the stagnant ice melted it was replaced by a lake with a level of ±530 ft in the south and ±580 ft at the Pellets Island Moraine. The only distinctive deposits in the main Wallkill Valley are in a remnant esker system at Breeze Hill, 4 km south of Pellets Island and adjacent to the mucklands.

Pellets Island Moraine

The Pellets Island Moraine, illustrated in Figure 4, was described originally by Connally and Sirkin (1967) as a massive ridge of till and stratified drift. It was named for exposures of sand and gravel in a gravel pit at Pellets Island. The type locality is badly slumped but several newer exposures are present (STOP 2) about 3 km southwest of Goshen. The moraine is traced continuously eastward at the head of the mucklands to the massive esker-fed moraine at Chester; then to the western flank of Schunnemunk Mountain; and thence northeast to the Hudson Highlands west of the Hudson River. Connally and Sirkin (1986) correlated the Pellets Island Moraine with the Shenandoah Moraine, banked against the Hudson Highlands east of the Hudson River.

The Pellets Island Moraine cannot be traced west of the Wallkill River channel. There are esker-fed morainal remnants about 3 km northwest of Pellets Island, in the valley of Catlin Creek, that are undoubted equivalents. However, there is little ice-contact material present between Catlin Creek and the Shawangunk Mountains. Does this suggest a general absence of meltwater in the vicinity of the Shawangunks during deglaciation? Perhaps the meltwater, largely sediment-free, was channeled east to the Wallkill River eskers via englacial drainage.

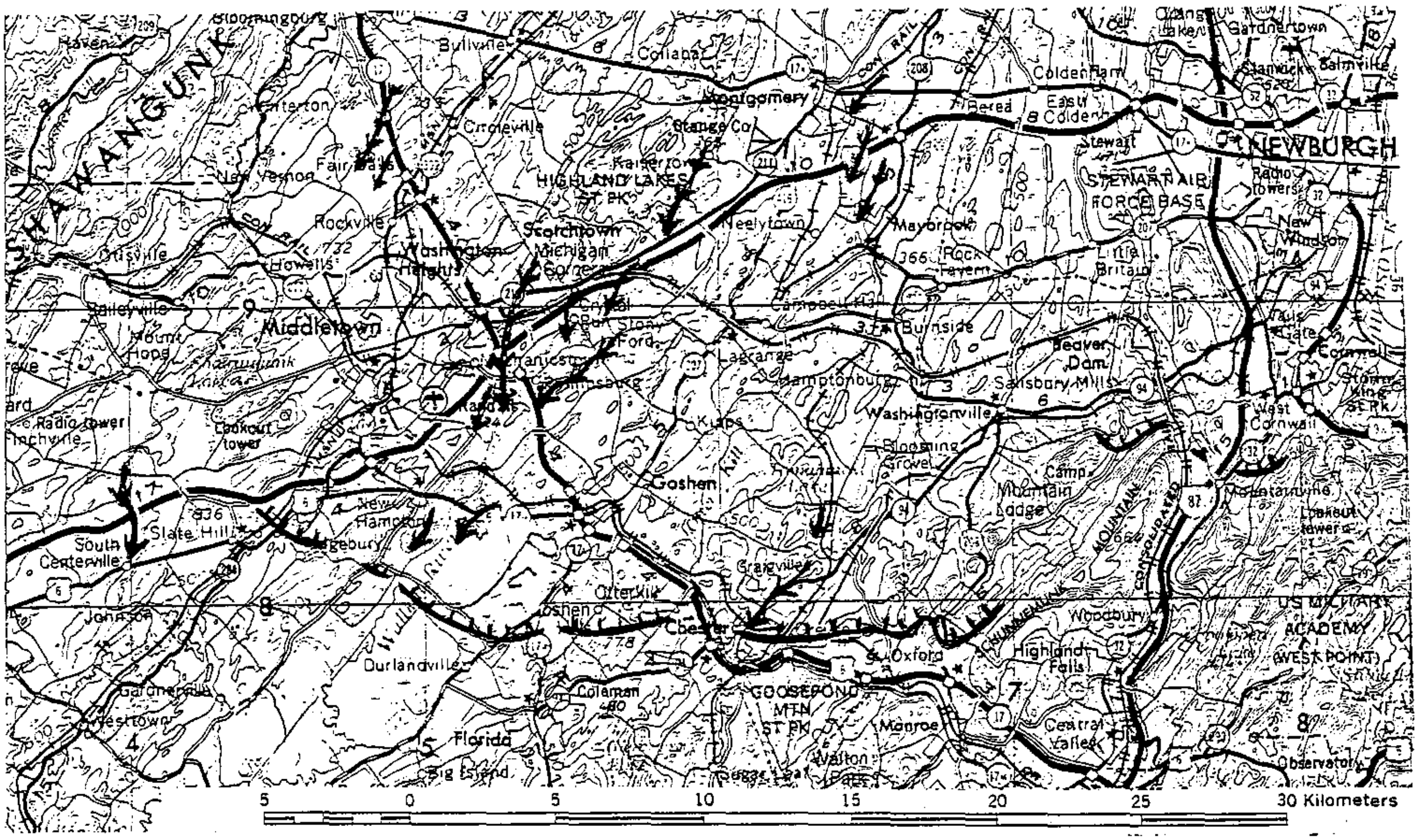


FIGURE 4. The Pellets Island Moraine from Rutgers Creek, southwest of Middletown, to Mountainville in the Hudson Highlands. Arrows indicate the major esker systems that fed sediment to the ice margin.

For 22 km northeast of the Pellets Island Moraine, the Wallkill Valley is congested with esker remnants (STOP 3) and attendant ice-contact deposits. It appears that most sediment was fed to the ice margin by subglacial drainage that funneled into the Wallkill River channels. Outwash and lacustrine deposits flank the ice-contact drift, attesting to a northward-expanding proglacial lake in the lowlands that followed the receding ice margin back to the Wallkill Moraine.

Glacial Lake Fairchild

When the Woodfordian ice margin began to retreat from the Lafayette segment of the Culvers Gap Moraine, meltwater was impounded between the ice margin and the moraine. Evidence between Augusta and Sussex suggests that the initial impoundment was at ±520 ft, but later lowered to ±500 ft. The outlet for these waters was westward to Paulins Kill, either through a channel at Augusta or through an alternate channel 1 km south. Because the southern channel lacks erosional features and is filled with sediment that is smoothly graded to the 500 ft level, we infer that it handled the initial effluent at ±520 ft. Then, much later, the northerly channel at Augusta became the master outlet, the lake level droped to ±500 ft, and the southern channel aggraded.

At first, the impoundment was confined to the lower Papakating Creek valley. Then, when the ice margin retreated north of the bifurcation at Sussex, one of two things happened. Either the waters at ±520 ft expanded southward sown the Wallkill River channel, or a local lake at a superior elevation lowered and merged with the expanding 520 ft lake. Similarly, when the ice margin later retreated north of Pochuck Mountain (Fig. 1), the 520 ft lake expanded east and south, up the Pochuck Creek valley to the vicinity of Sand Hills in the tributary Black Creek valley.

When the Woodfordian glacier stood at the Pellets Island Moraine, the lake filled the entire Wallkill Valley, including lower Papakating Creek and Pochuck Creek, at an elevation of ±520 ft. It filled the valley of Rutgers Creek-Catlin Creek southwest of Middletown at an elevation of ±540 ft. The lake extended eastward along the moraine to Chester, where it was blocked at first by the crystalline highlands. In the center of the Wallkill Valley, foreset beds from the moraine document initial deposition at ±580 ft. To the east and west, along the moraine, the elevation was ±560 ft. The lake expanded south from Chester to occupy the dead ice sink at Warwick at ±540 ft. The relationship of this lake and the Pellets Island Moraine is shown in Figure 5.

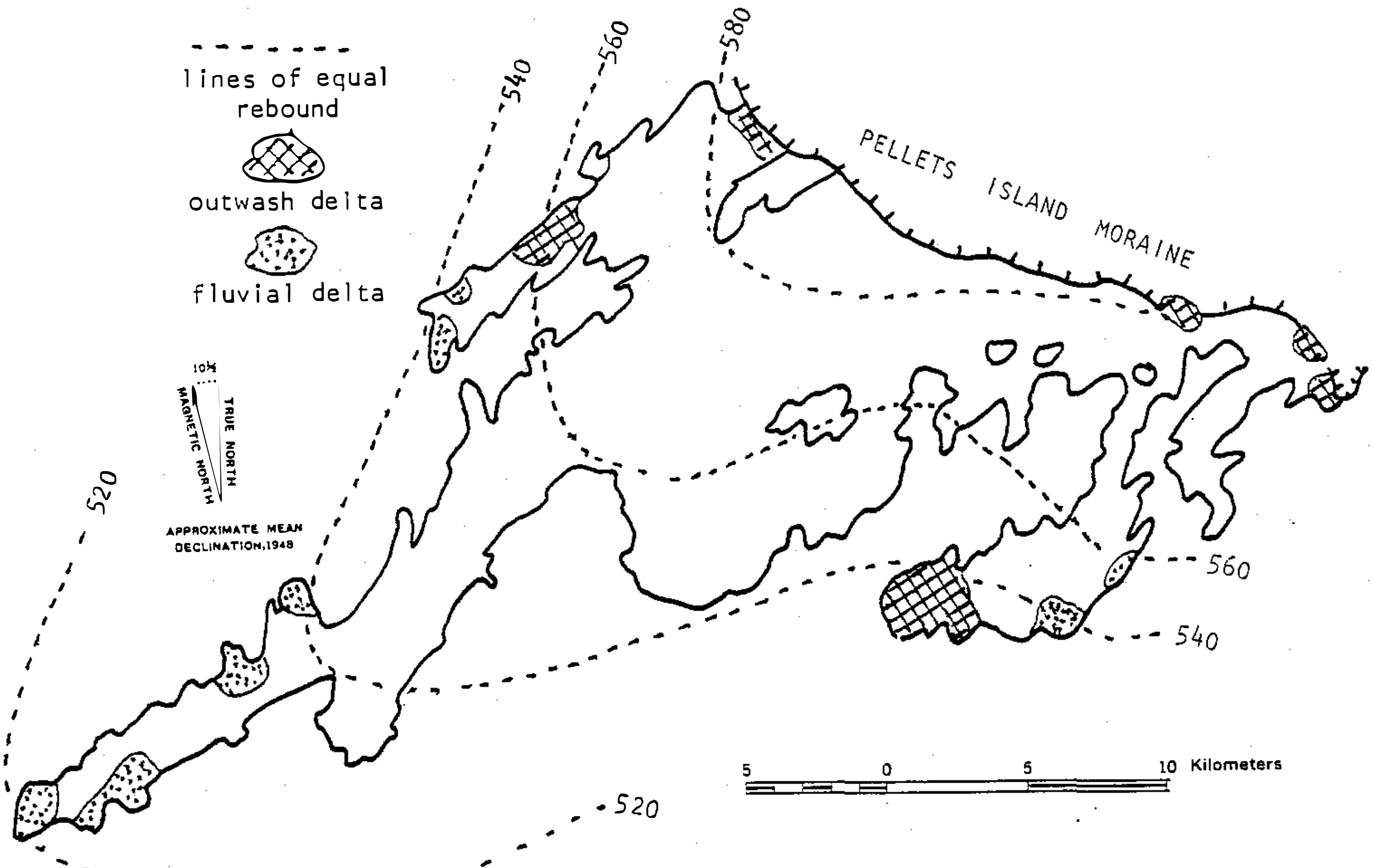


FIGURE 5. Glacial Lake Fairchild when dammed by the ice margin at the Pellets Island Moraine. Outwash deltas and fluvial deltas that were marginal to the lake are illustrated. Isobases suggest lines of equal rebound. An overhead projector transparency of this figure makes an excellent overlay for a 1:250,000 map.

In 1970, Connally submitted a manuscript report to NYSGS and requested that it be considered for publication in expanded form. Since he has had no subsequent word, evidently it still is under consideration. In that manuscript, he proposed the name Lake Fairchild in honor of the late Herman LeRoy Fairchild, pioneering glacial geologist in New York and former chair of the Department of Geology at the University of Rochester. Although the name has been used on an informal basis since that time, we here propose the name Glacial Lake Fairchild for the lake impounded by the Woodfordian glacier as it stood at the Pellets Island Moraine and is illustrated in Figure 5 and described below.

Glacial Lake Fairchild filled parts of four parallel, southwest-trending valleys. The major portion occupied the Wallkill/Papakating valley with a southern outlet to New Jersey's Kittatiny Valley. It occupied the Rutgers Creek valley to the northwest, the upper Waywayanda Creek valley between Chester and Warwick, and the Seeley Brook valley on the east.

The 520 ft Frankford Plains delta near Augusta and the alluvial plain from Armstrong to Pelletstown, on the east side of the Papakating valley, mark the southern end of Lake Fairchild. Another delta 8 km north at McCoys Corners also crests at ±520 ft. West of Sussex, two ice-contact deltas crest at ±540 ft in the tributary valley of Clove Creek, and two more, farther north at Owens and Quarryville, are similar. The only delta north of Sussex is at ±560 ft southwest of Florida, New York, though a ±500 ft delta north of Florida probably represents the lowered, post-rebound, 500 ft phase.

In the Rutgers Creek valley, many lacustrine features are present. Deltas at ±540 ft at Waterloo Mills, ±560 ft and ±500 ft at Westtown; inwash at ±570 ft and a delta at ±500 ft at Millsburg; a spit(?) at ±560 ft west of Slate Hill; and flat-topped outwash at ±580 ft at the Pellets Island Moraine suggest a northerly rebound of 40 ft in 16 km. A similar gradient is evident between Chester and Warwick. South of Warwick, at New Milford, deltaic deposits developed within stagnant ice topography at ±530 ft; north of Warwick several summits are graded to ±560 ft; south of Durland Hill, and at Smith's Clove on the moraine, there are 580 ft deltas. However, the straight connecting the dead ice sink at Warwick with the main lake must have been quite narrow.

As the Woodfordian ice margin retreated north, down the Wallkill Valley, outwash graded to ±580 ft was deposited east and west of New Hampton and farther north at Phillipsburg. Thus, Lake Fairchild continued to expand northward during deglaciation. Following deposition of the Phillipsburg outwash, the new master channel at Augusta appears to have lowered the lake level to a uniform(?) ±500 ft. Because 500 ft features are ubiquitous, local rebound must have followed very closely the removal of ice and the draining of several million litres of proglacial meltwater. Figure 5 shows suggested isolines of equal rebound (isobases) following draining of Lake Fairchild.

Glacial Lake Woodworth

Shawangunk Kill is a mid-elevation tributary of the Wallkill River. It drains the western Wallkill Valley at the base of the Shawangunk Mountains. South of the Wallkill Moraine, the Wallkill River and Shawangunk Kill channels are separated by a high bedrock strike ridge. As the glacier was retreating from the Pellets Island Moraine to the Wallkill Moraine, it impounded water in the valley of Shawangunk Kill at ±600 ft. That lake, confined to the valley of Shawangunk Kill by the glacier and the bedrock ridge, is here named Glacial Lake Woodworth in honor of the late John Brainard Woodworth, the first glacial geologist to report on the Hudson Valley region.

At its maximum extent, Lake Woodworth was just 14 km long, from Winterton to the southwest to near Ulsterville on the northeast. As the ice margin retreated down valley, the level appears to have lowered first to ±520 ft, then to ±440 ft, and finally to the regional level of ±400 ft. The lake probably was penecontemporaneous with Lake Dyson, described on following pages, and is illustrated with that lake in Figure 7.

Wallkill Moraine

The Wallkill Moraine was named and described by Connally and Sirkin (1967). However, detailed mapping has confirmed neither the original description nor the original tracing of the ice margins. Only two ice margins are recognized and illustrated in Figure 6, rather than the three that were proposed in 1967. The outer moraine crosses the Wallkill River at the village of Walden. It was traced westward to Pine Bush as a series of closely spaced ice-contact deposits, outwash deltas, or outwash fans, most fed by eskers. The moraine does not extend south to Bloomingburg as originally suggested. Rather, outwash fans suggest a margin near Walker Valley at the base of the Shawangunk Mountains, 8 km north of Bloomingburg. A recessional position exists 2 to 3 km northeast of the outer margin, tracable from Allards Corners to Red Mills. The outer position is traced east and north from Walden to Modena using outwash aprons. From Modena, the margin turns eastward to Baileys Gap, a col in the Marlboro Mountains, and then southeast to the Milton delta of Lake Albany at the Hudson River trench. The recessional position is traced northward to Clintondale Station, then to Lloyd, and then to a notch at the north end of Illinois Mountain. The recessional margin appears to correlate with the Poughkeepsie Moraine east of the Hudson, as proposed by Connally and Sirkin (1986). However, the outer Wallkill Moraine at Milton may predate the Poughkeepsie ice margin by a short span of time.

The Wallkill Moraine, like the Pellets Island Moraine, seems to have derived its sediment from an esker system along the Wallkill River channel (STOP 5). Swarms of feeder eskers head at or near the base of the spectacular Shawangunk climbing cliffs. It is probable that the fresh rock face of the northern Shawangunks was created by hydraulic plucking in a bergschrund-like situation that developed between the Woodfordian glacier and the mountain, as it stood at the Wallkill Moraine. Many of these feeder eskers were constructed of huge blocks of Shawangunk conglomerate that were frozen in time as they were moving down the mountain side (STOP 6).

Glacial Lake Dyson

As the ice margin retreated from the Pellets Island Moraine, Lake Fairchild expanded northward in contact with the glacier at ±580 ft. After the glacier had retreated north of Phillipsburg in the main valley, the level of Lake Fairchild lowered to ±500 ft. When the ice margin retreated north of the

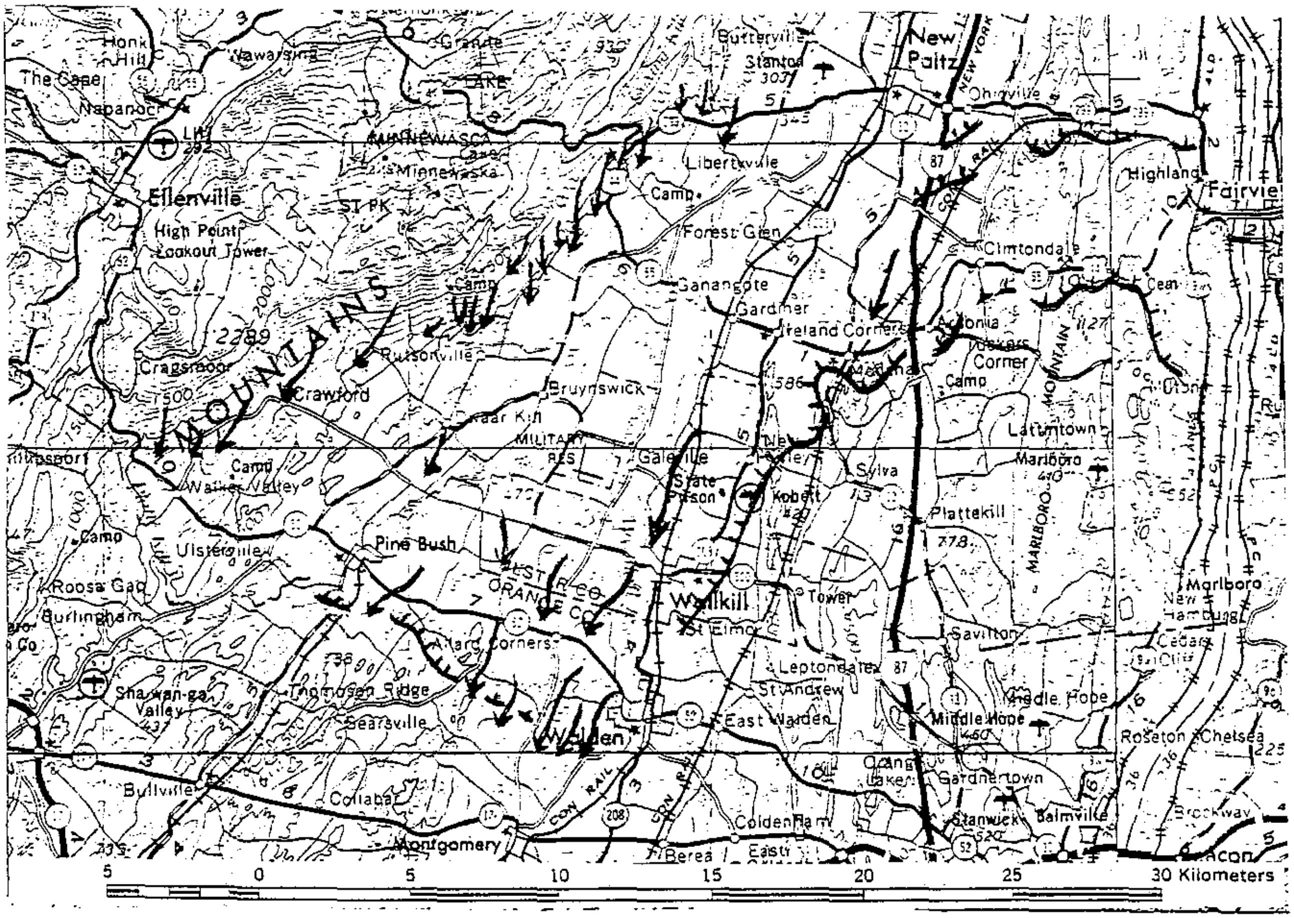


FIGURE 6. The Wallkill Moraine from Pine Bush on the west to the Milton delta of Lake Albany on the east. Arrows indicate eskers that fed sediment to both the outer ice margin and also the recessional position.

Otter Creek channel (Fig. 1), it opened a new eastward drainageway into Lake Albany in the Hudson River trench, via Moodna Creek. A new lake level of ±400 ft was established. The threshold must have been controlled by the drumlinized topography 3 km west of the village of Burnside. Both upstream and downstream of Burnside, there are extensive fluvial remnants aggraded to ±360 ft, thus precluding the obvious bedrock threshold at Burnside as a spillway for the higher 400 ft lake.

Sediments that have been interpreted as deltas and aggraded alluvial plains are present at ±400 ft from Sussex, New Jersey to the Pellets Island Moraine in the main Wallkill Valley. At the Wallkill Moraine, the lake spread westward into Shawangunk Kill and eastward into the headwaters of Otter Creek (Fig. 1). Outwash graded to ±400 ft comprises a large portion of the Wallkill Moraine. Extensive outwash aprons developed between the glacier and the eastern side of the Wallkill River valley (STOP 4) as far north as Clintonville Station and Ohioville. At its maximum extent, the lake was 70 km long, though it might be interpreted as a 40 km long southern lake and a 30 km long northern lake separated by a narrow straight at the Pellets Island Moraine, as shown in Figure 7.

In the unpublished 1970 manuscript report, Connally proposed the name Lake Dyson for this lake. We here propose formally the name Glacial Lake Dyson in honor of the late James Lindsey Dyson, eminent glacial geologist and chair of the Department of Geology at Lafayette College, for the proglacial lake impounded by the Woodfordian glacier as it stood at the Wallkill Moraine, as illustrated in Figure 7.

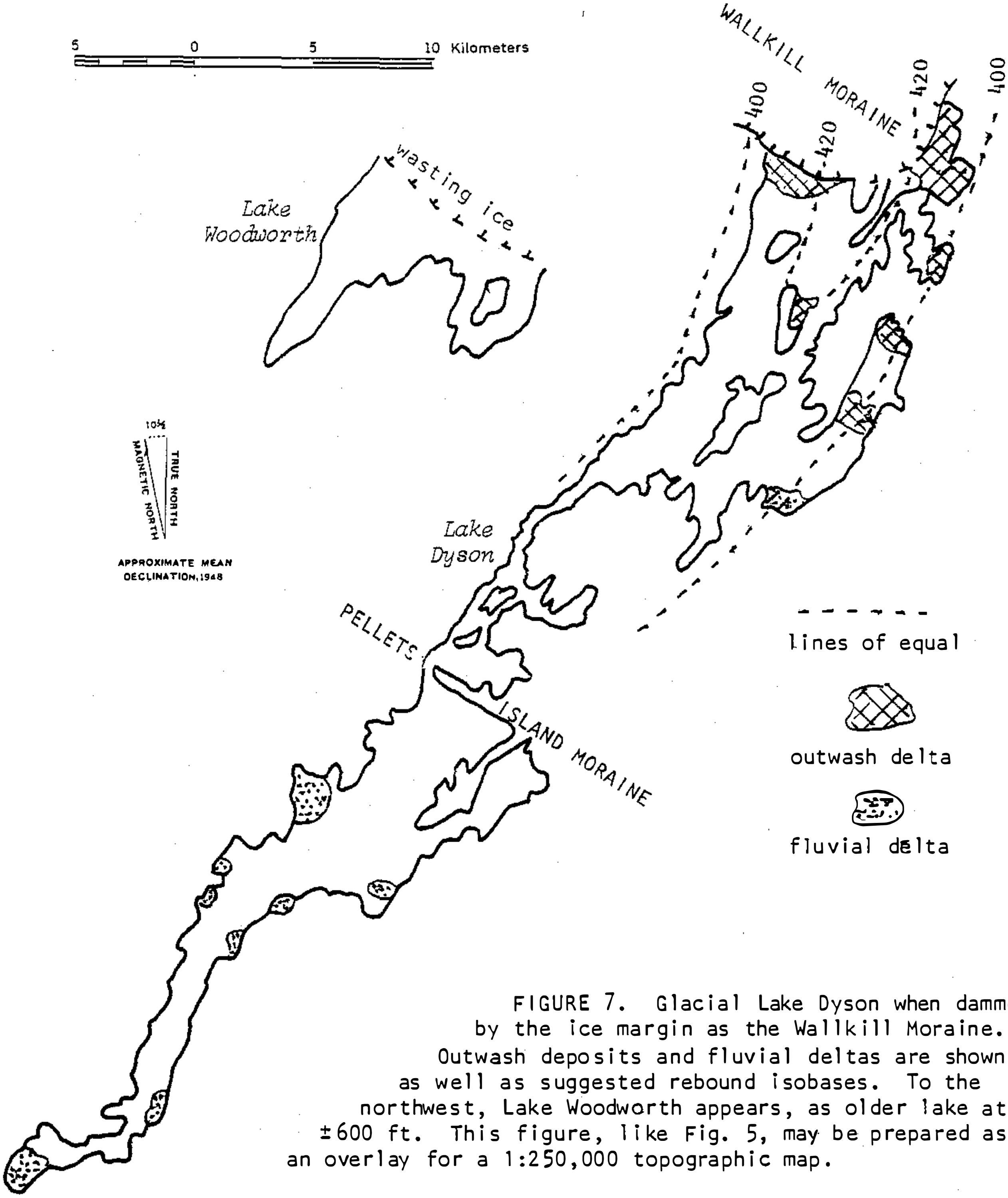


FIGURE 7. Glacial Lake Dyson when dammed by the ice margin as the Wallkill Moraine. Outwash deposits and fluvial deltas are shown, as well as suggested rebound isobases. To the northwest, Lake Woodworth appears, as older lake at ±600 ft. This figure, like Fig. 5, may be prepared as an overlay for a 1:250,000 topographic map.

Except for outwash at Montgomery, Campbell Hall, and Coldenham that is graded to ±420 ft, all peripheral features appear to be graded to elevations between 400 and 407 ft. These central features suggest a slight local rebound in the center of the Wallkill Valley following the demise of Lake Dyson. A south-to-north gradient of less than 20 ft can be inferred for the 70 km between Sussex and Clintonville Station.

There are three possibilities that might account for the consistent 400 ft elevation over a distance of 70 km. Perhaps most rebound, local and regional, had taken place prior to deposition of the Wallkill Moraine and only the very center of the valley remained out of adjustment. In this case, rebound in the Wallkill Valley was independent of that in the Hudson Valley to the east. Perhaps regional rebound had an east-to-west gradient and Lake Dyson developed parallel to the iso-adjustment lines. Both of the first two possibilities are consistent with the model developed for Lake Fairchild. The third possibility is that there was little or no rebound in the Wallkill Valley and that the deposits and elevations assigned to Lake Fairchild are misinterpreted.

Once the glacier retreated from the inner Wallkill Moraine, Lake Dyson evidently drained northward through decaying ice. An esker-fed outwash apron at ±340 ft, 1 km west of Libertyville, might represent a lowering lake level, but it is isolated and may just as well be attributed to subglacial deposition. We suggest that Lake Dyson drained quickly and completely, leaving the landscape clear for the Rosendale readvance and related events in the lower Wallkill Valley.

LATE-GLACIAL AND POSTGLACIAL ENVIRONMENTS

In 1964, Connally and Sirkin commenced a cooperative study that eventually encompassed all of the Hudson and Champlain Valleys, as well as adjacent portions of New Jersey and eastern Pennsylvania. They employed the integrated stratigraphic and geomorphic approach that had proven successful in local areas. The research plan was based on the pollen-stratigraphic work of Sirkin, ultimately published as Sirkin (1967a, 1967b, and 1971). Cadwell began working in New Jersey in 1974 and joined the lower Hudson Valley work in 1983.

Research Strategy

Connally and Sirkin chose to study and report only on closed peat bogs. Using the criteria mentioned earlier, they restricted their studies to produce a set of strictly controlled, radiocarbon dated, stratigraphic standard sections throughout the length of the Hudson and Champlain lowlands. The three restrictive criteria assured them *a priori* of the most complete, reliable stratigraphic records possible as standard sections. In each case, the stratigraphic record commenced very shortly after deglaciation. Two bog sites in the Wallkill Valley (New Hampton, Saddle), one adjacent to the Delaware River valley (Wigwam Run), and two in the Hudson Valley (Pine Log Camp, Eagle Hill Camp) all contribute to our understanding of the upper Wallkill Valley.

After preliminary probing to locate the thickest section of pollen-bearing sediment, each bog was sampled with sequential core segments (STOP 4) until coarse clastic sediment was encountered at the base. Each section consisted of an upper, dominantly organic (organic-rich) portion and a lower, dominantly inorganic (suborganic) portion.

The terms organic-rich and suborganic are applied to bog and lacustrine deposits ranging from pure peat to fine-grained clastics that incorporate varying amounts of organic material. Organic-rich deposits range from 90 percent organic matter in peat, to 10 percent for gradational sediments such as clay gyttja. Suborganic deposits generally contain ±5 percent organic matter as shown by ignition studies.

Dating

After completing sequential coring for each section, we retrieved between 5 and 12 additional core segments from the deepest organic-rich sediments. These samples were pooled and submitted to a laboratory for radiocarbon dating. They yielded absolute dates for specific depths at or near the base of each organic-rich portion. The dates are listed in Figure 8.

Using lithologic relationships in each core, we established correlations with specific geomorphic events near each site. We assigned ages to the herb (T), spruce (A), pine (B), and oak (C) pollen zones based on pollen zone correlations with established, dated sections. The radiocarbon date from the base of each organic-rich portion provided a basis for absolute age assignment.

To estimate the age of the base of each section, it is necessary to have a calculated sedimentation rate for suborganic sediments. Davis and Deevey (1964, p. 1293) calculated an average accumulation rate of .036 cm/yr for the basal 2 m of suborganic sediment from the south basin of Rogers Lake in south-central Connecticut. Connally and Sirkin (1986, p. 68) established an independent rate for Pine Log Camp bog near Glens Falls, New York. In 1968, they obtained a date of 12,400 yrs BP from the spruce zone between -8.00 and -7.85 m. In 1970, they obtained a date of 13,150 yrs BP from the base of the herb zone between -8.07 and -8.10 m. Thus, it took 750 years to accumulate the lowest 25 cm of suborganic herb zone sediment at Pine Log Camp bog. This yields an accumulation rate of .033 cm/yr. In estimating the basal age of each section, we now use .036 cm/yr to estimate the minimum time necessary to accumulate suborganic sediment and .033 cm/yr to estimate the maximum.

BOG SECTION	RADIOCARBON DATE in yrs BP	LAB NO.	DEPTH in m	POLLEN ZONE	AGE AT BASE in yrs BP
Pine Log Camp	12,400 ± 200	I-3199	7.85	A_{1-2}	
	13,150 ± 200	I-4986	8.10	T	13,150
Eagle Hill Camp	13,670 ± 170	SI-4082	10.25	T	16,020
New Hampton	12,850 ± 250	L-1157A	7.00	A_3	17,210
Wigwam Run	11,430 ± 300	W-2893	5.25	A_4	17,675
Saddle Bog	12,300 ± 300	W-2562	5.65	A_4	18,360

FIGURE 8. Dates and calculated ages for pollen-stratigraphic standard sections.

Pollen-Stratigraphic Standard Sections

Following is a brief description of each of the bog sections that has been used to help understand late-glacial and postglacial environments in the Wallkill Valley. The data was summarized in Figure 8.

New Hampton Bog. The standard section for the Wallkill Valley is New Hampton bog No. 1 (Connally and Sirkin, 1970, p. 3300-3303). Accumulation began when the Woodfordian glacier retreated north of Phillipsburg, Lake Fairchild drained, and the Lake Dyson level was established below the rim of the bog. The Wallkill Moraine is slightly younger.

The suborganic portion, from -8.50 to -7.00 m comprises the herb zone and the base of the spruce zone. The organic-rich portion, from -7.00 m to the top, comprises the upper spruce zone through the oak zone. The radiocarbon date at the base of the organic-rich portion is 12,850 yrs BP. We estimate a minimum age of 17,020 and a maximum of 17,400 yrs BP for the base of the suborganic portion. We posit an average age of 17,210 yrs BP for the establishment of the Wallkill Moraine and Glacial Lake Dyson.

Saddle Bog. In 1971, we extended our stratigraphic studies westward to Saddle Bog (Sirkin and Minard, 1972, p. D53). This is an upland bog on the side of Kittatiny Mountain, about 400 ft above the Wallkill Valley. It is bordered by a ridge that represents either a minor readvance or the first signs of upland drainage onto newly stagnating ice. Accumulation began after the glacier had receded from the Culvers Gap Moraine, or had begun downwasting there.

The suborganic portion, from -7.65 to -5.65 m, comprises the undifferentiated herb zone and the base of the spruce zone. The organic-rich portion, from -5.65 m to the top, comprises the upper spruce zone through the oak zone. The radiocarbon date at the base of the organic-rich portion is 12,300 yrs BP. We estimate a minimum age of 17,860 and a maximum of 18,360 yrs BP for the base of the suborganic portion. Because of the high quantity of non-arboreal pollen (NAP) throughout the core, and the corresponding lack of forest pollen (AP), during accumulation of the suborganic portion, we posit an age near the maximum 18,360 yrs BP for recession from the Culvers Gap Moraine.

Wigwam Run Bog. In 1974, the three of us extended our studies farther west to Wigwam Run bog (Sirkin, 1977, p. 210-212). The bog is in a kettle that is isolated by an inversion ridge west of the Delaware River and north of the Pennsylvania equivalent of Kittatiny Mountain. Accumulation began when the ice had receded from the terminal position of the Delaware-Minisink Lobe. Connally and others (1979) suggested that this was a post-Culvers Gap, but pre-Pellets Island, deposit.

The suborganic portion, from -7.40 to -5.25 m, comprises the herb zone and most of the spruce zone. The organic-rich portion, from -5.25 m to the top, comprises the top of the spruce zone through the oak zone. The radiocarbon date at the base of the organic-rich portion is 11,430 yrs BP. We estimate a minimum age of 17,400 and a maximum of 17,950 yrs BP for the base of the suborganic portion. We posit an average age of 17,675 yrs BP for deglaciation.

Eagle Hill Camp Bog. The standard section for the mid-Hudson Valley is Eagle Hill Camp bog (Connally and Sirkin, 1986, p. 64-69). Accumulation began when the Woodfordian glacier receded from the Red Hook Moraine that was emplaced east of the Hudson River during the Rosendale readvance.

The suborganic portion, from -11.15 to -10.40 m, comprises only the herb zone. The organic-rich portion, from -10.40 to -1.00 m comprises the herb through oak zones. The upper 1.00 m was too wet to sample. The radiocarbon date at -10.25 m is 13,670 yrs BP. We estimate an age of 13,890 yrs BP for the base of the organic-rich portion. We estimate a minimum age of 15,670 and a maximum of 16,070 yrs BP for the base of the suborganic portion. We posit an average age of 16,020 yrs BP for recession from the Rosendale readvance.

Pine Log Camp Bog. The standard section for the upper Hudson Valley is Pine Log Camp bog (Connally and Sirkin, 1971, p. 998-1003). Accumulation began when kettle ice in outwash from the Luzerne readvance had melted.

The suborganic portion, from -8.10 to -7.85 m, comprises the undifferentiated herb zone. The organic-rich portion, from -7.85 m to the top, comprises the spruce through oak zones. The radiocarbon date at the base of the organic-rich portion is 12,400 yrs BP. The radiocarbon date at the base of the suborganic portion is 13,150 yrs BP, closely approximating deglaciation in the upper Hudson Valley.

Other Radiocarbon Dates In The region

According to Sirkin (1977), the Woodfordian glacier reached a maximum stand on Long Island about 21,750 yrs BP and had begun receding north, up the Hudson Valley, by 21,200 yrs BP. However, the oldest finite radiocarbon dates for pollen stratigraphy are reported by Cotter (1983) for Francis Lake. The lake, while not conforming to our restrictive criteria, is located in northwestern New Jersey, about 20 km south of the Culvers Gap Moraine. Its relationship with the moraine is problematic because it is located between valley trains in Paulins Kill to the west and the Pequest River to the east, but clearly related to neither. Accumulation began following deposition of outwash that probably predates the Culvers Gap outwash in the other valleys by one "event". Dates of 18,570 and 18,390 yrs BP document the oldest herb pollen-bearing sediments in the northeastern U.S. and confirm the presence of tundra vegetation during Woodfordian deglaciation. The herb pollen zone is dated between 18,570 and 14,250 yrs BP and the spruce pollen zone between 14,250 and 11,250 yrs BP (Cotter and others, 1986, p. 42-47).

Cadwell obtained a date in the 19,000 year range from the base of a peat bog on Jenny Jump Mountain, near The Terminal Moraine, in north-central New Jersey. However, the pollen stratigraphy was not consistent with the 19,000 year age and the deposit remains under investigation. An early late-glacial date of 17,950 yrs BP was reported by Weiss (1971, Table 4). The dated sample was from "varved" silt and clay in the lower Hudson River channel, though the sediments are described as pollen-free.

SUMMARY

During late Wisconsinan time, the Woodfordian glacier reached a maximum stand on Long Island about 21,750 yrs BP. Recession was underway by

21,000 yrs BP. In the Wallkill Valley, the glacier advance farther south than Newton, New Jersey, and perhaps as far south as The Terminal Moraine. By 18,570 yrs BP the glacier had established a position south of Newton, shedding outwash past Francis Lake. Subsequently, the Culvers Gap Moraine was deposited. By 18,360 yrs BP, the ice of Kittatiny Mountain had retreated or downwasted and sediment began to accumulate in Saddle Bog. Thus, the age of the Culvers Gap Moraine probably is close to 18,500 yrs BP. By 18,360 yrs BP, tundra vegetation was established in the valley bottom and on the uplands.

As the Woodfordian glacier retreated northward, down the Wallkill Valley, Glacial Lake Fairchild was impounded between the Culvers Gap Moraine and the retreating ice margin, with an outlet at ±520 ft. By 17,675 yrs BP, the ice margin was well north of the Culvers Gap Moraine and by about 17,500 yrs BP, the Pellets Island Moraine was deposited. By 17,210 yrs BP, the glacier had retreated north of the Pellets Island Moraine, an eastward outlet drained the valley, and Glacial Lake Dyson was established at ±400 ft. Shortly thereafter, perhaps about 17,200 yrs BP, the Wallkill Moraine was deposited. When the ice margin resumed northward recession, Lake Dyson drained north into the wasting ice, leaving a large undrained depression to the south that filled with organic-rich sediment to become the Orange County mucklands.

The final event to affect the Wallkill Valley was the Rosendale readvance. That event was completed prior to 16,020 yrs BP and the entire valley was ice-free. Tundra vegetation occupied the valley throughout this interval. Spruce trees began to encroach in northern New Jersey by 14,250 yrs BP. The spruce forest migrated to the Pellets Island Moraine perhaps 13,700 years ago, to the mid-Hudson Valley about 13,000 years ago, and to the upper Hudson Valley by 12,400 yrs BP. Interestingly, pollen stratigraphy from Saddle Bog and Wigwam Run bog indicate that tundra vegetation still dominated the uplands until about 12,500 years ago, long after the spruce forest had migrated up the valley bottom. These relationships are summarized in Figure 9, below.

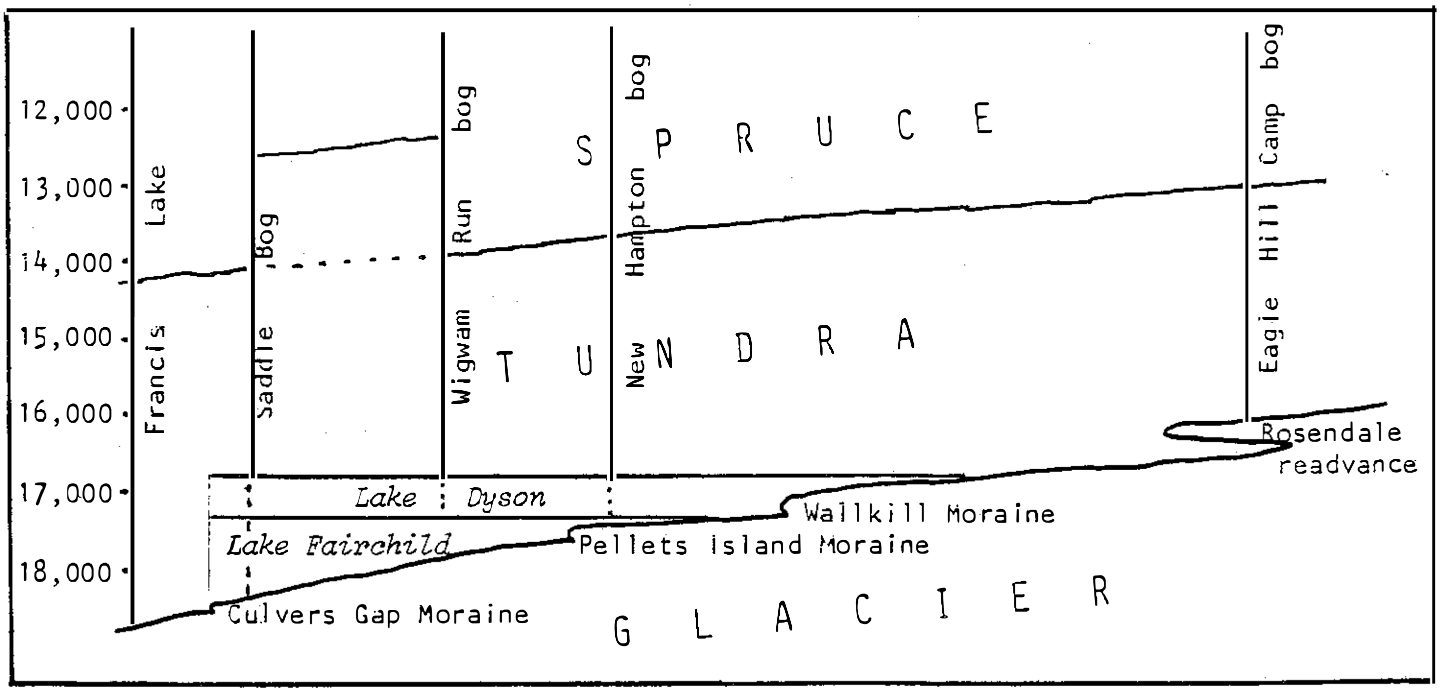


FIGURE 9. A space/time diagram showing the relationship between deglacial events and the migration of vegetation.

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ROAD LOG FOR DEGLACIAL HISTORY AND ENVIRONMENTS OF THE UPPER WALLKILL VALLEY

CUMULATIVE MILAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
		Begin trip, OCCC Parking Lot
0.0	0.0	Turn left (west onto Grandview Road)
0.1	0.1	STOP SIGN, Turn left (south onto Waywayanda Avenue)
1.1	1.0	Turn left (east onto Co. Route 78)
1.8	0.7	TRAFFIC LIGHT, Turn right (south onto Route 17M)
2.1	0.3	TRAFFIC LIGHT, Turn right (west onto Route 6)
3.9	1.8	Esker complex on left marking the Pellets Island Moraine in the Rutgers Creek valley
5.7	1.8	Turn left (south onto Route 284)
9.9	4.2	Dead ice sink on right; inwash is mined for sand and gravel
11.1	1.2	Village of Westtown
14.2	3.1	Continue left on Route 284; Village of Unionville
14.8	0.6	New Jersey State line
15.9	1.1	Lake Fairchild/Lake Dyson lake bottom at left, now the Wallkill River floodplain
20.6	4.7	The inversion ridge formerly identified as the "Sussex Moraine" is visible at 11:00 o'clock

22.0	1.4	TRAFFIC LIGHT, Turn left (east onto Route 23)
22.6	0.6	Bridge across Papakating Creek
23.4	0.8	TRAFFIC LIGHT, Turn left (north onto NJ Route 565)
24.1	0.7	Bridge across upper Wallkill River
24.9	0.8	Stay left (north on NJ Route 565)
25.4	0.5	STOP 1 at Landrud Road, RAIA Industries pit

STOP 1. INTERNAL STRUCTURE OF AN INVERSION RIDGE

NOTE! Permission to enter this property has been obtained for this trip ONLY! RAIA Industries, in Hamburg, New Jersey, probably will NOT grant permission to individuals.

Walk down the inversion ridge to the exposures in the active sand and gravel pit. This feature formerly was described as the "Sussex Moraine". What type of depositional environment can you infer from the sedimentary structures? What and where was the source for this sediment? Where was the glacier? In what condition was the ice?

As you travel to Stop 2, you will cross the upland drainage system that fed onto the ice to form this feature. Keep your eye peeled for this at mile 26.1.

	0.0	Continue north on NJ Route 565
26.0	0.6	Bear left (north onto NJ Route 667)
26.1	0.1	The head of the inversion ridge drainage channel; upland drainage system strewn with boulders to the right, dead ice and inversion ridges (then, stream channels in the ice) to the left.
27.7	1.6	Lake Fairchild/Lake Dyson lake bottom ahead, on left.
28.1	0.4	Stay left
29.2	1.1	Stay left
30.2	1.0	Continue straight ahead
30.5	0.3	Continue straight ahead
31.2	0.7	New York State line (Phew!)
33.7	2.5	Pochuck Creek valley to right at 2:00 o'clock
33.9	0.2	INTERSECTION, continue straight
34.2	0.3	Bridge across Pochuck Creek
34.7	0.5	Turn left (north onto C. Route 6); Village of Pine Island
		Orange County mucklands on both sides of the road for next 5 mi. This is the last remnant of Glacial Lakes Fairchild and Dyson.
38.7	4.0	A cluster of 5 drumlins forms "Big Island".
39.6	0.9	The Pellets Island Moraine crosses the Orange County mucklands.
41.2	1.6	Turn left (west onto Co. Route 42, "Cross Road")

41.7	0.5	Drive up the distal slope of the Pellets Island Moraine
42.4	0.7	Turn left (west onto Co. Route 37, "Maple Road")
42.6	0.2	Stop 2 at Cedar Swamp Road, Gurda Gardens pit

STOP 2. INTERNAL STRUCTURE OF THE PELLETS ISLAND MORAINE

NOTE! You must obtain permission from Gurda Gardens, Ltd. to enter this sand and gravel pit.

Walk into the sand pit on the west side of Cedar Swamp Road. This pit is about 5 km east of the type locality for the Pellets Island Moraine at Pellets Island. The old pit, visitied in 1967, is badly slumped today. What type of depositional environment can you infer from the sedimentary structures? What and where was the source for the sediment? Where was the glacier? In what condition was the ice? How does this deposit contrast with that at Stop 1?

	0.0	Return east on Co. Route 37
45.3	2.7	Bear right onto Maple Avenue Extension
46.0	0.7	Turn right (east onto Route 17)
46.5	0.5	EXIT 124B (north onto Route 207)
46.8	0.3	Turn right (continue north on Route 207)
47.6	0.8	TRAFFIC LIGHT (continue north on Route 207);Village of Goshen
50.0	2.4	Turn left (west onto Everett Road
51.3	1.3	STOP SIGN, Turn left (south onto Hill Road)
51.4	0.1	STOP SIGN, Turn right (west onto Scotchtown Road)
52.3	0.9	Bridge across Wallkill River
52.9	0.6	Turn right (north onto Stony Ford Road)
53.4	0.5	Bear right on Stony Ford Road
53.7	0.4	Turn left (west onto Stage Road)
54.3	0.6	STOP 3 at the Smiley Farm, dirt farm lane

STOP 3. SMILEY FARM ESKER(?)

NOTE! DO NOT EVEN ASK! This popular stop was included on the 1967 trip. Since then, the Smilev's have been deluged with visitors - most of whom have not even esked permission. For many reasons, the Smiley's DO NOT WANT PEOPLE VISITING THEIR WORKING FARM. DO NOT EVEN BOTHER TO ASK PERMISSION! We have obtained permission for this trip only -- and only because of our long association with the Smileys and with this stop.

Climb the hill on the east side of the dirt access road. Gather at the top of the hill, that is located about midway between the Pellets Island and Wallkill Moraines. See if you can come up with an explanation better than 1967's when the term "moulin kame" was bandied about.

	0.0	Return on Stage Road
54.9	0.6	Turn left (north onto Stony Ford Road
56.0	1.1	Turn right (following Stony Ford Road east)
56.3	0.3	Bridge across Wallkill River

57.3	1.0	STOP SIGN, Turn left (north onto Route 207)
58.0	0.7	Bear left immediately after underpass (north onto Route 416)
59.4	1.4	LUNCH STOP at Orange County Picnic Area.

LUNCH STOP. THOMAS BULL MEMORIAL PARK

This is the same lunch stop used in 1967. In May of 1967 it was so cold (it snowed in the Catskills) that Orange County thought we would cancel lunch and didn't even have the restrooms open for us. They are up the hill, on the left. If the weather is bad, we have reserved the picnic pavillion.

	0.0	Continue north on Route 416
62.3	2.9	Bear right (north onto Route 211)
63.7	1.4	STOP SIGN, Turn right (east onto Route 17K); Village of Montgomery
65.6	1.9	TRAFFIC LIGHT, Turn left (north onto Route 208)
68.3	2.7	STOP SIGN, (continue north on Route 208); Village of Walden
68.4	0.1	TRAFFIC LIGHT, Turn right (north with Route 208)
71.8	3.4	YIELD SIGN, Bear right (north with Route 208); Village of Waldkill
72.1	0.3	Wallkill Moraine visible on right from 1:00 o'clock to 4:00 o'clock.
72.7	0.6	Turn right (east onto Route 300); continue up the proximal slope of the Wallkill Moraine
73.6	0.9	Wallkill Moraine outwash apron deposited at the edge of Glacial Lake Dyson at ±400 ft.
73.9	0.3	STOP 4 at boggy area on the right side of the road

STOP 4. A ROADSIDE BOG

At this stop we will demonstrate the technique used in retrieving a core from a subsurface organic deposit. Although this site does not meet the restrictive criteria established by Connally and Sirkin, it is conveniently close to the road as a demonstration site. First we will probe the depth of the organic sediment and then retrieve a sequential core using a Davis Piston Corer. We also will discuss surface vegetation and the subsurface pollen stratigraphy of the Wallkill Valley.

	0.0	Continue east on Route 300
74.0	0.1	Turn left (north onto St. Andrews Road)
74.7	0.7	Turn left (west onto Reservoir Road)
75.3	0.6	Climb the distal slope of the Wallkill Moraine
75.5	0.2	STOP SIGN, Turn right (north onto Route 208)
75.9	0.4	Turn left (west onto Birch Road); the road climbs the distal slope of the "inner" Wallkill Moraine
77.0	1.1	Straght ahead onto paved road
77.3	0.3	Stay right at fork
77.7	0.4	STOP 5 at abandoned sand and gravel pit

STOP 5. ESKER FEEDER FOR THE WALLKILL MORAINE

CAUTION! You are on the property of the Wallkill State Prison. If you do not obtain permission before visiting this pit you may expect a visit from one or more armed officers.

There is little exposure left at this site that is about 4 km north of the inner Wallkill Moraine. Look about for clasts that you can identify as white Shawangunk conglomerate or orthoquartzite sandstone. Take in the splendid view of the bare rock cliffs of Shawangunk conglomerate -- these are made fameous by mountain climbers from all over the northeast. Why are these cliffs so fresh? Why is the escarpment to the south covered by a blanket of talus? What is the source of the sediment for this huge esker that flanks the bottom land channel of the Wallkill River?

Look for evidence of Shawangunk conglomerate as you travel to Stop 6.

	0.0	Turn right (north onto Sand Hill Road)
81.6	3.9	STOP SIGN, Village of Gardner; take a FULL left turn (west onto Main Street; Routes 44 & 55)
82.7	1.1	Bridge across Wallkill River
84.4	1.7	Continue straight (west on Routes 44 & 55)
85.4	1.0	The foot of a feeder esker appears on the left; the road parallels this esker up the hill to the base of the Shawangunk cliffs
86.5	1.1	STOP 6 parking lot of restauratnt

STOP 6. HEAD OF FEEDER ESKER AND VIEW OF SHAWANGUNK CLIFFS

This stop enables you to view the huge, block-sized clasts of Shawangunk conglomerate that were frozen in time as they were moving down into or onto the Woodfordian glacier. Evidently the hydraulic situation along the cliff was similar to a bergschrund on a cirque headwall. The plucking of these huge blocks resulted in a cleanly exposed rock face (or free face) once the glacier receded. Why don't you see these large blocks down in the valley? Why are these cliffs not covered with talus as are those to the south?

As you drive down into the valley, you will pass a second massive esker on your left. Look at the change in the size of the Shawangunk conglomerate lasts as you continue down to the valley floor.

	0.0	Turn right (east onto Route 299)
92.4	5.9	Bridge across Wallkill River
92.6	0.2	TRAFFIC LIGHT (contue straight up hill on Route 299; Route 208 joins from the right); Village of New Paltz
93.1	0.5	TRAFFIC LIGHT (continue east of Route 299; Route 32 leaves to right)
93.9	0.8	Overpass over NYS Thruway
94.0	0.1	New York State Thruway, New Paltz Interchange

END OF TRIP

NOTES