

43RD ANNUAL REUNION

P. F. KARROW

NORTHEAST FRIENDS of the PLEISTOCENE

LATE WISCONSIN

STRATIGRAPHY
OF THE
UPPER CATTARAUGUS
BASIN

R.G. LA FLEUR

CONTRIBUTORS

P. E. Calkin
E. H. Muller
R. G. La Fleur

R. H. Fakundiny
& NYSGS staff

Scale 500 000

A. F. Hassan, Cartographer

Compiled 1913

1980

GUIDEBOOK

43rd Annual Reunion

NORTHEAST

FRIENDS OF THE PLEISTOCENE

Robert G. LaFleur
Editor

Contributors:

P.E. Calkin & E.H. Muller

R.G. LaFleur

R.H. Fakundiny, R.H. Fickies,
H.H. Bailey, R.H. Dana, Jr. &
S.A. Molello

Technical Editor:

J. J. Sevon

May 1980

Typist:

G.W. Hoffman

Springville, N. Y.

Mirror, mirror on the wall,
Who has the brightest drift of all?
Oh, Lee Ann, is it thou?
Subdued of form, and wond'ring how
Intimate Kent, so full of clout
Can, too, be drab -- we've found him out!

Lavery and Hiram -- now that's a pair,
Slinging mud from here to there.
Not helping much with motley stones
When what we want are wood and bones.
So tell us, mirror on the wall
Who needs the brightest drift of all?

CONTENTS

	<u>Page</u>
 GEOLOGIC SETTING AND GLACIAL OVERVIEW OF THE UPPER CATTARAUGUS BASIN, SOUTHWESTERN NEW YORK	
P.E. Calkin and E.H. Muller.	1
 LATE WISCONSIN STRATIGRAPHY OF THE UPPER CATTARAUGUS BASIN	
R.G. LaFleur	13
Trip log - day one	22
Trip log - day two	26
Stratigraphic sections	28
 GEOLOGIC STUDY OF THE BURIAL MEDIUM AT THE LOW-LEVEL RADIOACTIVE-WASTE BURIAL SITE, WEST VALLEY, NEW YORK	
R.H. Fakundiny, R.H. Fickies, H.H. Bailey, R.H. Dana, Jr., and S.A. Molello	39
 GLACIAL STRATIGRAPHY IN PART OF BUTTERMILK CREEK VALLEY	
.	40
Geologic sections and test borings	52
Reports on geohydrology ,	63



GEOLOGIC SETTING AND GLACIAL OVERVIEW

OF THE UPPER CATTARAUGUS BASIN, SOUTHWESTERN NEW YORK

Parker E. Calkin
Dept. of Geological Sciences
State Univ. of N.Y. at Buffalo
Buffalo, NY 14226

Ernest H. Muller
Dept. of Geology
Syracuse University
Syracuse, NY 13210

The upper Cattaraugus Creek basin lies within the glaciated Southern New York Uplands Section of the Allegheny Plateau, an area characterized by low hills with rounded summits contained within a network of through valleys and breached drainage divides. The underlying bedrock dips southward at about 8 meters per kilometer and consists of interbedded marine shale and siltstone associated with the Upper Devonian Catskill clastic wedge (Tesmer, 1975). Northward, the landscape is furrowed by deep parallel northward trending troughs separated by broad plateau interfluvies. Thick valley fill of the Lake Escarpment Moraine blocks the troughs and comprises the watershed bounding the Cattaraugus drainage basin on the north. Southward from the Cattaraugus basin low hills gradually yield to higher relief and the marks of glaciation become less dominant. A major change in topographic aspect coincides approximately with the Allegheny Valley and marks the northern margin of the unglaciated Salamanca Re-entrant (MacClintock and Apfel, 1944). This high and rugged region, corresponding closely to Allegany State Park, is underlain by sandstone and conglomerate ranging from Upper Devonian to Lower Pennsylvanian (?), and mantled by a thin regolith of frost-shattered, mass-wasted debris. Accordant summits in the Salamanca Re-entrant mark a regional preglacial erosion surface (Cole, 1941). Hypothetical extrapolation of this preglacial surface northward indicates that summit reduction by glacial scour in Cattaraugus County was generally less than 60 m (Muller, 1963). North of Cattaraugus Creek, however, "land forms developed to accomodate glacial flow, virtually eliminating all elements of an earlier fluviially created morphology" (Donahue, 1972, p. 35).

The geomorphic history of the area began with epeirogenic uplift and gentle tilting at the close of Paleozoic sedimentation in the Appalachian geosyncline. Regional erosion has obliterated all evidence of the manner in which initial southward consequent drainage was reversed to a generally northwesterly obsequent system. Broad uplift must have episodically interrupted river cutting, resulting in deep entrenchment of valleys. Among the largest of these valleys in Cattaraugus County was the one cut by the preglacial Cazenovia River (Fairchild, 1932; Calkin et al., 1974) which flowed more than 70 km northward from the present village of Ischua, past Chaffee and East Aurora toward Buffalo. The preglacial Allegheny River

flowed westward along its present course marginal to the Salamanca Re-entrant, thence northward through the Conewango Valley past present Gowanda to Lake Erie approximately following the lower valley of Cattaraugus Creek (Muller, 1977b; Ellis, 1980). Between the preglacial Cazenovia and Allegheny rivers, two other major streams had their headwaters in the upper Cattaraugus basin area. Preglacial Buttermilk River, heading near Ashford, connected West Valley to Springville and followed either the present course of West Branch of Cazenovia Creek to Orchard Park or of Eighteenmile Creek to Hamburg (Hodge, in prep.). The preglacial Connoisarauley River flowed from present Plato via Ashford Hollow to Morton Corners and Eden Valley, following the present South Branch of Eighteenmile Creek (Fairchild, 1932).

Spreading radially southward from the Ontario and Erie basins, ice of the continental ice sheet abutted repeatedly against the high land of the Salamanca Re-entrant. Spotty occurrences of weathered till and gravel around the margins of the re-entrant have been considered of Illinoian age (MacClintock and Apfel, 1944; Bryant, 1955; Muller, 1965, 1975, 1977a), and mark the only pre-Wisconsin glacial exposures in New York. Several lines of evidence, including two of major importance, indicate a long history of pre-Wisconsin glaciation. (1) Glacial impoundment of the Allegheny River and subsequent permanent diversion from its northward course to its present southerly path to the Ohio River resulted in deep incision across the Kinzua Col (Muller, 1975; Philbrick, 1976) in northwestern Pennsylvania. (2) As a result of ice marginal superposition and entrenchment, Cattaraugus Creek cut a westward course transversely across the Tertiary north-trending valley system (Fairchild, 1932; Calkin et al., 1974).

Several major drift sheets are recognized in southwestern New York, reflecting at least two distinct Wisconsin glaciations (Muller, 1963, 1965, 1975, 1977a). As mapped by MacClintock and Apfel (1944), the oldest Wisconsin drift terminates at the Olean Moraine against the northeastern flank of the Salamanca Re-entrant. In this area the Olean Moraine marks the ice border at its Wisconsin maximum. On the basis of stratigraphic, pedologic, morphologic and lithologic differences, MacClintock and Apfel (1944) considered it to be distinctively older than the terminal moraine marginal to the northwest flank of the Re-entrant. Correlation with a Middle Wisconsin invasion is supported by the interval between events represented in the subsurface in southwestern New York (see below) and tied to stratigraphic relations in the vicinity of Titusville, Pennsylvania (Chapman and Craft, 1976; Muller, 1975, 1977a; White et al., 1969). A different correlation is adopted by workers in Pennsylvania who have followed the Wisconsin glacial border from eastern and northern Pennsylvania to the Salamanca Re-entrant and consider the border to be of Late Wisconsin age over the whole distance (Crowl, 1980; see also Dreimanis, 1977a).

Whereas Olean drift is characteristically composed of local materials and is deeply leached with strongly modified morainal topography, the Kent Moraine bordering the Salamanca Re-entrant on the northwest displays sharper relief and brighter, less-weathered deposits. Meltwater channels incised along the margin of the melting ice sheet effected diversion of

impounded northward-draining valleys. The Kent Moraine, traced northeast from Ohio and western Pennsylvania marks the maximum advance during Late Wisconsin time, an event which is now well bracketed by radiocarbon data. The ice margin had not yet crossed the buried Niagara Gorge in its Late Wisconsin advance at 22,800 yr B.P. (Hobson and Terasmae, 1969); nor had it crossed Rush Creek in the Genesee Basin of south-central New York at 25,300 yr B.P. (Muller et al., 1975); yet by 19,000 to 20,000 years ago, the ice sheet had reached its maximum extent throughout the Erie Basin (Dreimanis and Goldthwait, 1973).

Evidence of extensive glaciation followed by a long, cool interstadial preceding the Olean advance as well as a succeeding shorter interstadial before Kent glaciation is well documented by multiple till exposures and subsurface data at the Gowanda Hospital and Otto, New York, organic sites (Muller, 1964; Calkin et al., 1975, in prep.). At Gowanda, a red till derived from the Erie glacial lobe bears a deeply weathered soil profile and is overlain in turn by gravelly organic silt, a basal till which incorporates some of the silt, and gravels bearing a terrestrial mollusc assemblage indicative of cold forest-tundra conditions. The organic silt carries a *Picea*-rich pollen spectrum and wood which has been radiocarbon dated from more than 46,000 to a probably finite 51,000 yr B.P. This lower till, soil, organic, and till sequence matches well with the sequence of till, lower organic unit (63,900 yr B.P.), upper organic and gravel unit (more than 52,000 yr. B.P.) and overlying till in the well-known Otto site (Muller, 1964). Correlation is based on stratigraphic relations as well as similarity in ^{14}C dates and pollen data (Calkin et al., in prep.). Upper tills of this sequence are in turn correlated with the Olean Drift (Muller, 1975) and tentatively the Middle Wisconsin Cherry-tree Stadial of Ontario. The advance in New York may have begun somewhat earlier than indicated by the 44,000 yr B.P. dates presently recognized as maxima for this stadial in southern Ontario (Dreimanis et al., 1966; Dreimanis, 1977b).

The Otto organic units have in the past been loosely correlated with the Early Wisconsin St. Pierre beds of the St. Lawrence Valley on the basis of similarity of dates. The St. Pierre beds have, however, been redated from 65,000 to 74,000 yr B.P. (Stuiver and Yang, 1977; Stuiver et al., 1978) supporting extension of the Wisconsin chronometric scale as suggested earlier (Dreimanis and Raukas, 1975; Terasmae and Dreimanis, 1976). This extension of the Wisconsin implies backdating of the Middle Wisconsin from 50,000 to at least 70,000 yr B.P. Thus, the soil which represents a long interval of weathering as well as the organic units at both Gowanda Hospital and Otto are assigned to the Middle Wisconsin Port Talbot Interstadial as now presently recognized. Furthermore, underlying tills at each site represent one or more Early Wisconsin advances onto the Allegheny Plateau.

Extending eastward along the south side of the Cattaraugus Valley are correlatives of the Lavery Till and the overlying Hiram Till with its associated Defiance Moraine. Correlation is based solely upon eastward tracing and on stratigraphic and lithologic correspondence to units mapped in northwestern Pennsylvania (Muller, 1963; 1975, 1977a, 1977b;

Shepps et al., 1959). Stratigraphic relationships and till constitution seem to record an episode of ice marginal reorganization and short readvance following the Kent maximum. Both the Lavery and Hiram tills are generally thin and the latter, in particular, is rich in clay presumed to have been derived from proglacial lake deposits. These ice-marginal lakes developed in northward-draining troughs during a short retreat tentatively correlated with the Erie Interstadial.

South of Gowanda and extending along the watershed north of Cattaraugus Creek are a series of prominent parallel gravelly ridges, the eastward extension of Leverett's (1902) Lake Escarpment Moraine System. These mark an oscillating stand of the ice margin behind the Defiance Moraine. Referred to as the Ashtabula Moraine in western Pennsylvania and Ohio (Muller, 1963; White et al., 1969), the Lake Escarpment ridges are correlative with the equally massive and similarly complex Valley Heads Morainic System in central New York (Muller, 1965, 1975, 1977a, 1977b).

During Valley Heads Glaciation, pitted outwash trains were built southward into the Cattaraugus Basin over valley fills which are as much as 200 m thick in the northwest trending valleys at Chaffee and Springville. Outwash plains were graded to a series of proglacial lakes that reached out 427 m (1400 ft) in the Cattaraugus Valley east of Springville and in Skinner Hollow near Otto during the Valley Heads maximum. These in turn drained westward along the ice margin into the Conewango Valley and so to the Allegheny River.

Ice marginal retreat from the outermost Lake Escarpment ridges may have begun as early as 15,000 yr B.P., followed by encroaching boreal spruce forest. Peat deposited directly on outwash at a mastodon locality^{a)} along Nichols Brook near Chaffee and therefore considered to shortly post-date an early episode of ice-marginal recession, was dated at 14,900, 13,800 and 12,800 yr B.P. at successively higher levels. Wood of 11,210 yr age (Calkin and Miller, 1977) and 12,020 (Merritt and Muller, 1959) obtained from the middle of this section suggested that the older samples might have been contaminated by recycled carbon. Subsequent pollen correlations with well-dated peat at Winter Gulf near North Collins indicate that the older dates may be correct (Calkin and McAndrews, 1980). This allows correlation of the Lake Escarpment ridges with the Port Bruce Stadial of Ontario and relates the succeeding retreat to the Mackinaw Interstadial of Dreimanis and Karrow (1972).

Ice tongues in the several long valleys trending north from Chaffee, Springville, and Morton Corners gave way to a series of short-lived proglacial lakes. Initially, these lakes drained south across the Valley Heads Moraine into the Cattaraugus Basin. Later they found outlet westward via spillways along the north margin of the plateau, building massive kame delta and lacustrine deposits (Hollands, 1975; Owens et al., 1972; Pryor, 1975) en route to glacial Great Lake Arkona (Calkin and Miller, 1977; Calkin and McAndrews, 1980). The Port Huron readvance of about 13,000 yr B.P. that followed retreat north beyond the Niagara Escarpment (Dreimanis and Goldthwait, 1973) may have reached south to the Hamburg Moraine but did not reach the Gowanda or Norfolk (Erie-Long Point) Moraines in

a) Mastodon or mammoth remains elsewhere in the area (Heubusch, 1959) include a mastodon tooth unearthed in 1971 from a kettle on post-Kent outwash gravels in West Valley (Calkin and Miller, 1977)

the Erie Basin. Retreat from the Hamburg Moraine, followed by lowering of glacial Great Lake Whittlesey had taken place by 12,700 yr B.P. (Calkin and McAndrews, 1980). Recent analysis of the Coleoptera assemblage at Winter Gulf (Schwert and Morgan, 1980; Calkin and McAndrews, 1980) suggests that temperate conditions may have prevailed during glacial oscillations into glacial Great Lake Warren. Final recession of the ice margin into the Ontario Basin, initiation of Early Lake Erie and initial cutting of the present Niagara Gorge must have been under way by at least 12,300 yr B.P. (Calkin and Brett, 1978).

REFERENCES

- Bryant, J.C., 1955, A refinement of the upland glacial drift border in southern Cattaraugus County, New York (M.S. Thesis): Ithaca, New York, Cornell University.
- Calkin, P.E., and Brett, C.E., 1978, Ancestral Niagara River drainage: Stratigraphic and paleontologic setting. Geological Society of America Bulletin, v. 89, p. 1140-1154.
- Calkin, P.E., Hodge, D.S., Champion, D.E., Oaksford, E.T., and Palmer, E.C., 1974, Gravity delineation of the preglacial Cazenovia River Valley, Western New York State, U.S.A.; Zeitschrift für Geomorphologie N.F. Band 18, Heft 3, p. 247-259.
- Calkin, P.E., and McAndrews, 1980, Geology and paleontology of two Late Wisconsin sites in western New York: Geological Society of America Bulletin, v.
- Calkin, P.E., and Miller, K.E., 1977, The Quaternary environment and man in western New York: Annals of the New York Academy of Science, v. 288, p. 297-315.
- Calkin, P.E., Muller, E.H., and Barnes, J.H., 1975, Quaternary stratigraphy of the Gowanda Hospital site, Erie County, New York: Geological Society of America Abstracts with Programs 7(1), p. 36.
- Calkin, P.E., Barnes, J.H., and Muller, E.H., in preparation, The Gowanda Hospital Interstadial site.
- Cole, W.S., 1941, Nomenclature and correlation of Appalachian erosion surfaces: Journal of Geology, v. 49, p. 129-148.
- Cowan, W.R., 1978, The Innerkip Interstadial site: Ontario Geological Survey, unpublished manuscript, 17 p.
- Chapman, W.F. and Craft, J.L., 1976, Glacial aspects of the Oil City area, in Ward, A.N., Chapman, W.F., Lukert, M.T., and Craft, J.L., Bedrock and Glacial Geology of Northwestern Pennsylvania in Crawford, Forest and Venango Counties: 41st Annual Conference of Pennsylvania Geologists, Harrisburg, Pa., Bureau of Topographic and Geologic Survey, p. 1-6.

- Crowl, G.H., 1980, The Woodfordian age of the Wisconsin glacial border in Northeastern Pennsylvania: *Geology*, v. 8, p. 51-55.
- Donahue, J.J., 1972, Drainage intensity in western New York: *Annals of the Association of American Geographers*, v. 62(1), p. 23-36.
- Dreimanis, A., 1977a, Late Wisconsin glacial retreat in the Great Lakes region, North America: *Annals of the New York Academy of Sciences*, v. 288, p. 70-89.
- Dreimanis, A., 1977b, Correlation of Wisconsin glacial events between the eastern Great Lakes and the St. Lawrence Lowlands: *Geogr. Phys. Quat.*, v. XXXI, p. 37-51.
- Dreimanis, A., and Goldthwait, R.P., 1973, Wisconsin glaciation in the Huron, Erie, and Ontario lobes: *Geological Society of America Memoir* 136, p. 71-105.
- Dreimanis, A., and Karrow, P.F., 1972, Glacial history of the Great Lakes - St. Lawrence region, the classification of the Wisconsin(an) stage, and its correlatives 24th International Geological Congress, Section 12, p. 5-15.
- Dreimanis, A., and Raukas, A., 1975, Did Middle Wisconsin, Middle Weichselian, and their equivalents represent an interglacial of an interstadial complex in the northern hemisphere? in *Quaternary Studies*, R.P. Suggate and M.M. Cresswell (eds.), Royal Society New Zealand, Bull. 13, p. 109-120.
- Dreimanis, A., Terasmae, J. and McKenzie, G.D., 1966, The Post Talbot Interstade of the Wisconsin Glaciation: *Canadian Journal of Earth Sciences*, v. 3, p. 305-325.
- Ellis, Lynn Doyle, 1980, Geophysical reconstruction of the Preglacial Allegheny River Valley, western New York: (M.A. Thesis): State University of New York at Buffalo, 83 p.
- Fairchild, H.L., 1932, New York Physiography and glaciology west of the Genesee Valley: *Rochester Academy of Science Proceedings*, v. 7, p. 97-136.
- Heubusch, C.A., 1959, Mastodons and mammoths in western New York: *Science on the March*, Buffalo Society of Natural Sciences, v. 40, p. 3-9.
- Hobson, G.D., and Terasmae, J., 1969, Pleistocene geology of the buried St. Davids gorge, Niagara Falls, Ontario: geophysical and palynological studies: *Geological Survey Canada*, Paper 68-67, 16 p.
- Hodge, D.S., in preparation, A gravity study of the preglacial Buttermilk River valley near Springville, New York.
- Hollands, G.G., 1973, History of deglaciation of southern Erie County, western New York: *Geological Society of America Abstracts with Programs*, v. 5(2), p. 178.

- Karrow, P.E., Cowan, W.R., Dreimanis, A., and Singer, S.N., 1978, Middle Wisconsinan stratigraphy in southern Ontario in Toronto '78 Field Trips Guidebook, A.L. Currie, and W.O. Mackasey (ed), Geological Association of Canada, Toronto, p. 17-27.
- Leverett, F., 1902, Glacial formations and drainage features of Erie and Ohio basins: U.S. Geological Survey Monograph 41.
- MacClintock, P., and Apfel, E.T., 1944, Correlation of the drifts of the Salamanca Re-entrant, New York: Geological Society America Bulletin, v. 55, p. 1143-1164.
- Merritt, R.S., and Muller, E.H., 1959, Depth of leaching in relation to carbonate content of till in central New York soils: American Journal of Science, v. 257, p. 465-480.
- Muller, E.H., 1963, Geology of Chautauqua County New York, part II Pleistocene geology: New York State Museum Bulletin 392, 60 p.
- Muller, E.H., 1964, Quaternary section at Otto, New York: American Journal of Science, v. 262, p. 461-478.
- Muller, E.H., 1965, Quaternary geology of New York, in Wright, H.E., Jr. and Frey, D.G., (eds.), The Quaternary of the United States: Princeton University Press, p. 99-112.
- Muller, E.H., 1975, Physiography and Pleistocene geology, in Geology of Cattaraugus County, New York by I.H. Tesmer, Buffalo Society of Natural Sciences Bulletin 27, p. 10-20.
- Muller, E.H., 1977a, Quaternary geology of New York, Niagara Sheet: New York State Museum and Science Service, Map and Chart Ser. No. 28, scale 1:250,000.
- Muller, E.H., 1977b, Late glacial and early postglacial environments in western New York: Annals of the New York Academy of Science, v. 288, p. 223-233.
- Muller, E.H., Young, R.G., Rhodes, D.D., Willette, Paul, and Wilson, Michael, 1975, Surficial geology of the Genesee Valley, N.Y.: Ms. report, New York Geological Survey.
- Owens, D.W., Daniels, R.B., and Brauen, G.B., 1977, Lacustrine sediments in the Allegheny Plateau of Erie County, New York: Their characteristics of distribution and land use problems: Journal of Soil and Water Conservation, v. 32(2), p. 93-97.
- Philbrick, S.S., 1976, Kinzua Dam and the glacial foreland, in Coates, D. R., ed., Geomorphology and Engineering: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, Inc., p. 175-198.
- Pryor, M., 1975, The glacial history of the Langford, NY 7½' Quadrangle and southern half of the Hamburg 7½' Quadrangle (M.A. Thesis): State University of New York at Buffalo, New York, 58 p.

Schwert, D.P., and Morgan, A.V., 1980, Paleoenvironmental implications of a Late Glacial insect assemblage from northwestern New York: Quaternary Research, v. 13, p. 93-110.

Shepps, V.C., White, G.W., Droste, J.B., and Sitler, R., 1959, Glacial geology of northwestern Pennsylvania: Pennsylvania Geological Survey 4th Series, Bulletin G-32, 59 p.

Stuiver, M., and Yang, I.C., 1977, Early and Mid-Wisconsin Geochronology (40,000 to 75,000 yrs. B.P.) derived from ^{14}C dating: X INQUA Congress Abstracts, p. 443.

Stuiver, M., Heusser, C.J., and Yang, I.C., 1978, North American glacial history extended to 75,000 years ago: Science, v. 200 (4337), p. 17-21.

Terasmae, J., and Dreimanis, A., 1976, Quaternary stratigraphy in southern Ontario in Quaternary stratigraphy of North America, W.C. Mahaney (ed.), Dowden, Hutchinson and Ross Inc., Stroudsburg, Pa., p. 51-63.

Tesmer, I.H., 1975, Geology of Cattaraugus County New York: Buffalo Society of Natural Sciences Bulletin, v. 27, 105 p.

White, G.W., Totten, S.M., and Gross, D.L., 1969, Pleistocene stratigraphy of northwestern Pennsylvania: Pennsylvania Geological Survey, 4th Series, General Geology Report G 55, 88 p.

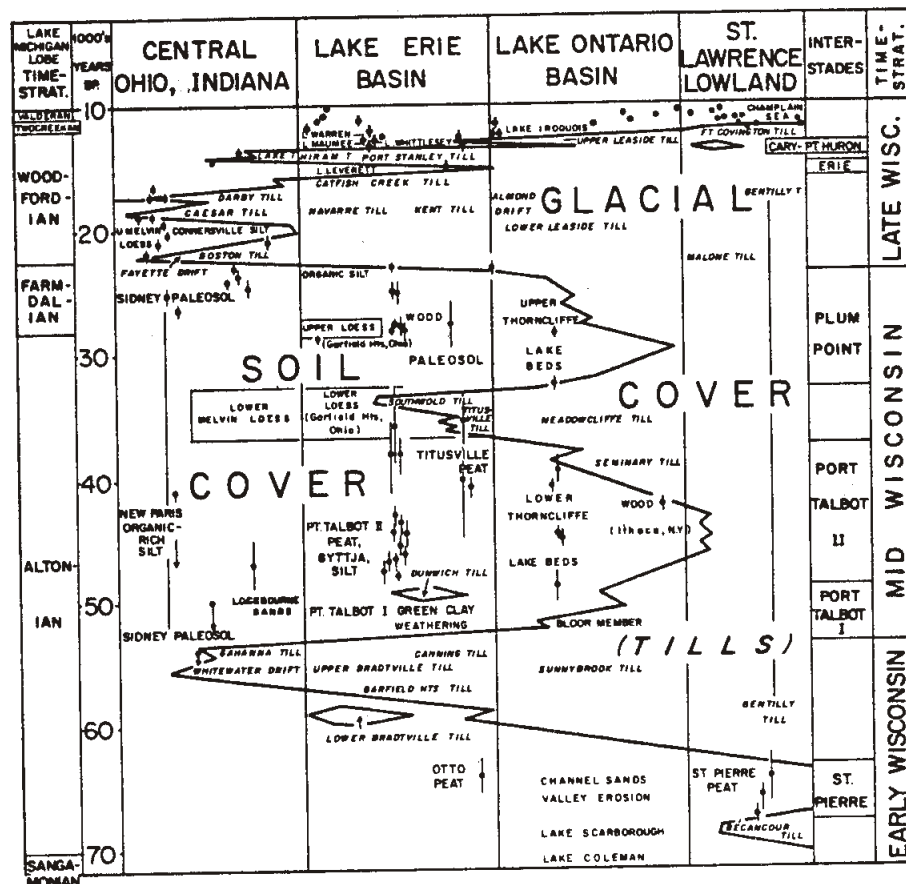


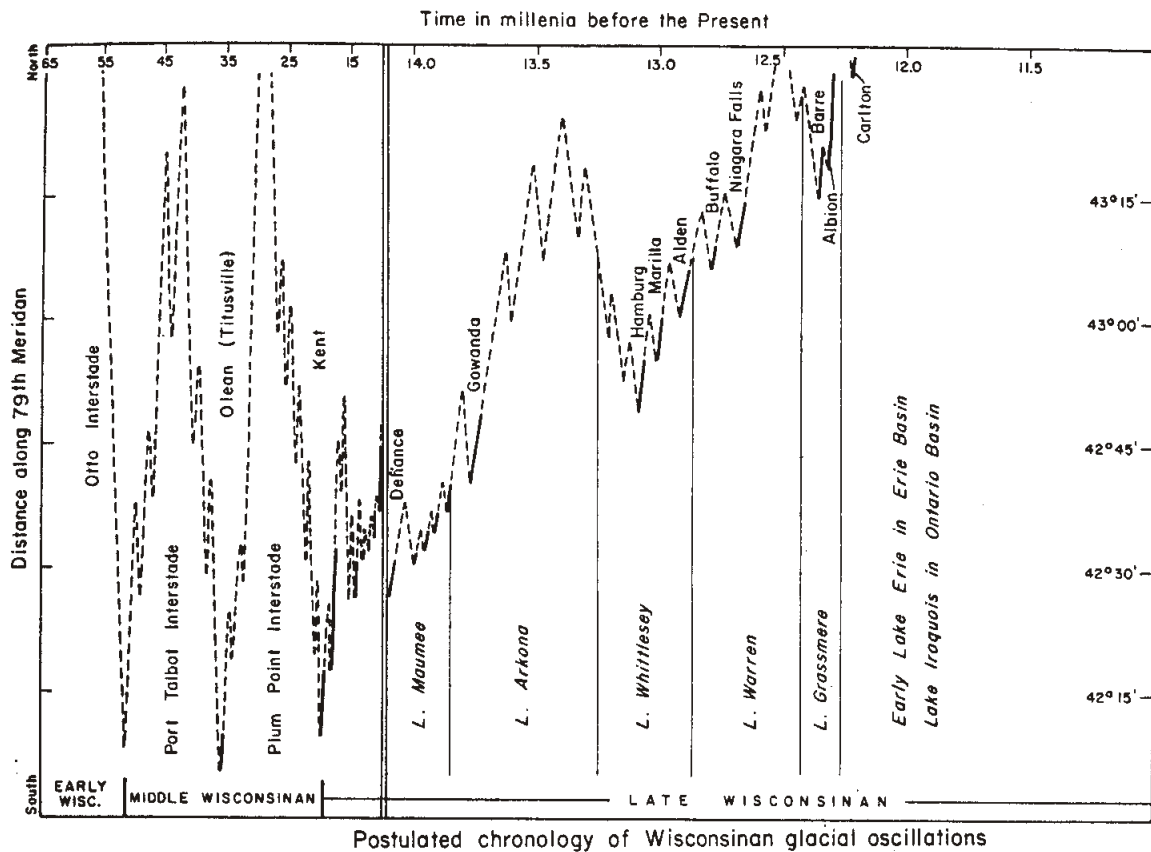
Figure 2. Wisconsin chronology, eastern Great Lakes, from Dreimanis and Goldthwait, 1973.

1000 YRS B.P.	SAGINAW LOBES	HURON LOBES	HURON, GEORG BAY & ERIE LOBES				GEORG B & ERIE LOBES		ONTARIO LOBE	
	DECATUR SUBLOBE	E MICHIGAN SW ONTARIO	WHITE RIVER SUBLOBE	MIAMI SUBLOBE	SCIOTO SUBLOBE	KILBUCK AND GRAND R SBL	SW ONTARIO	TORONTO AREA	S OF LAKE ONTARIO	
12	?	TILLS OF PT HURON MOR SYSTEM	LAKE WHITTLESEY AND WARREN IN HURON AND ERIE BASINS					HALTON T WENTWORTH T	UPPER LEASIDE TILL	POST- VALLEY HDS TILLS
13	CARY - PORT HURON INTERSTADE									?
	LAKE ARKONA IN HURON AND ERIE BASINS									LACUSTR DEP
14	FORMATION SIXTEEN NAMED MORAINES	CARY TILL	LAGRO FM NEW HOLLAND TILL MEMB (H)	CLAYEY TILL (H)	LAKE TILL TYMCHT T HIRAM TILL	ASHTABULA T HIRAM TILL HAYESVILLE T	PT. STANLEY DRIFT (E)	VALLEY HEADS DRIFT		
15		ERIE INTERSTADE						LACUSTR SILT & CLAY, BEACHES, DELTAS	LOWER	
		ALLUV. GRAV					WEATHERING			
16	FORMATION SIXTEEN NAMED MORAINES	"LOWER" SANDY AND SILTY TILLS	TERRACE FALGAR FORMATION	CARTERS- BURG	BLOOMINGTON DRIFT	DARBY TILL	KILB SBL ← GR R SBL	CATFISH	LEASIDE	
17				TILL	FARMERSVILLE MOR	REESVILLE MOR		CREEK		
18				MEMBER	CHAMPAIGN DRIFT	ORGANIC SILT				
19				SHELBYVILLE DRIFT HARTWELL M.	CAESAR TILL	DRIFT				
20				CRAWFORD MORaine	CONNERS- VILLE INTERSTAD SILT					FOREST BED OR SILT
21	WEATHERING SHELBYVILLE MOR SYSTEM	VERTIGO ALP DOUGHT BED	CENTER GR. TILL MEMB SHELBYV MOR	FAYETTE	BOSTON DRIFT	NAVARRE TILL (G + E)	KENT TILL (E + O)	(G + E)	TILL	
22				DRIFT	MT OLIVE MOR	NAVARRE TILL	KENT TILL		KENT TILL	ALMOND DRIFT

TIME STRAT.	1000 YRS B.P.	HURON, GEORGIAN BAY & ERIE LOBES				ONTARIO LOBE		
		MIAMI SUBLOBE	SCIOTO SUBLOBE	KILBUCK & GRAND RIV. SUBLOBES	SW. ONTARIO	TORONTO AREA	S. OF LAKE ONTARIO	
L.W.				VARVED CLAY ORGANIC SILT	CATF. CR. TILL PLUM POINT INTERSTADIAL	LEASIDE TILL		
MID - WISCONSIN	25	SIDNEY		(Cleveland) UPPER LOESS	LACUSTRINE AND LITTORAL DEPOSITS, WOOD	UPPER THORN- CLIFFE BEDS		
	30	INTERSTADIAL						
	35	SOIL, PEAT, WOOD	LOWER MELVIN LOESS	Titusville TILLS (E) LOWER LOESS (Cleveland) PEAT IN ALLUVIAL GRAVELS (Titusville)	SOUTHWOLD DRIFT (G)	MEADOW- CLIFFE TILL	?	
	40				PORT TALBOT II INTERSTADIAL	SEMINARY TILL	VARVED SILT	
	45	NEW PARIS INTERSTAD. ORGANIC SILTS			PEAT, LACUSTRINE, AND ALLUVIAL DEPOSITS	LOWER THORN- CLIFFE BEDS		
	50		LOCKBOURNE SANDS (G)		DUNWICH TILL (G)			
					PT. TALBOT I GREEN CLAY			
EARLY WISCONSIN	55	WHITE- WATER DRIFT (H)	GAHANNA DRIFT (H + G + E)	GARFIELD MTS. TILL, "RED" TILL (E)	U. BRADTVILLE (E) CANNING TILL (O) L. BRADTVILLE TILL (G)	BLOOR MEMBER VARVED CLAY SUNNY- BROOK TILL	OLEAN DRIFT	
	60							
	65	SPRUCE- OAK ZONE (Smith Farm, Unit B - Top)				CHANNEL SANDS VALLEY EROSION	OTTO INTERST. PEAT	
	70	INVOLUTIONS (Smith Farm)				SCARBOROUGH FORMATION LACUSTR. DEP.	STREAM FORMATION GRAVELS (Ottawa, N.Y.)	

NOTE: PROBABLE LOBES INDICATED BY THEIR FIRST LETTER

Figure 3. Wisconsin chronology, eastern Great Lakes, from Dreimanis and Goldthwait, 1973.



Through Wisconsin time glacial advance and retreat, with a timetable approximately as suggested above.

Impounded proglacial lakes with rising and falling levels controlled by lowest available outlets, with chronology like that for the Late Wisconsin illustrated in the Erie Basin at right.

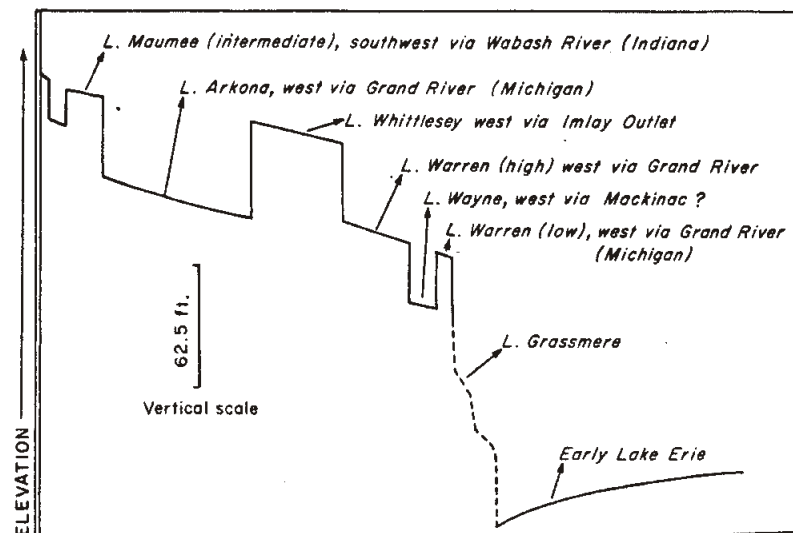


Figure 4. Wisconsin chronology of western New York, from Muller, 1977.

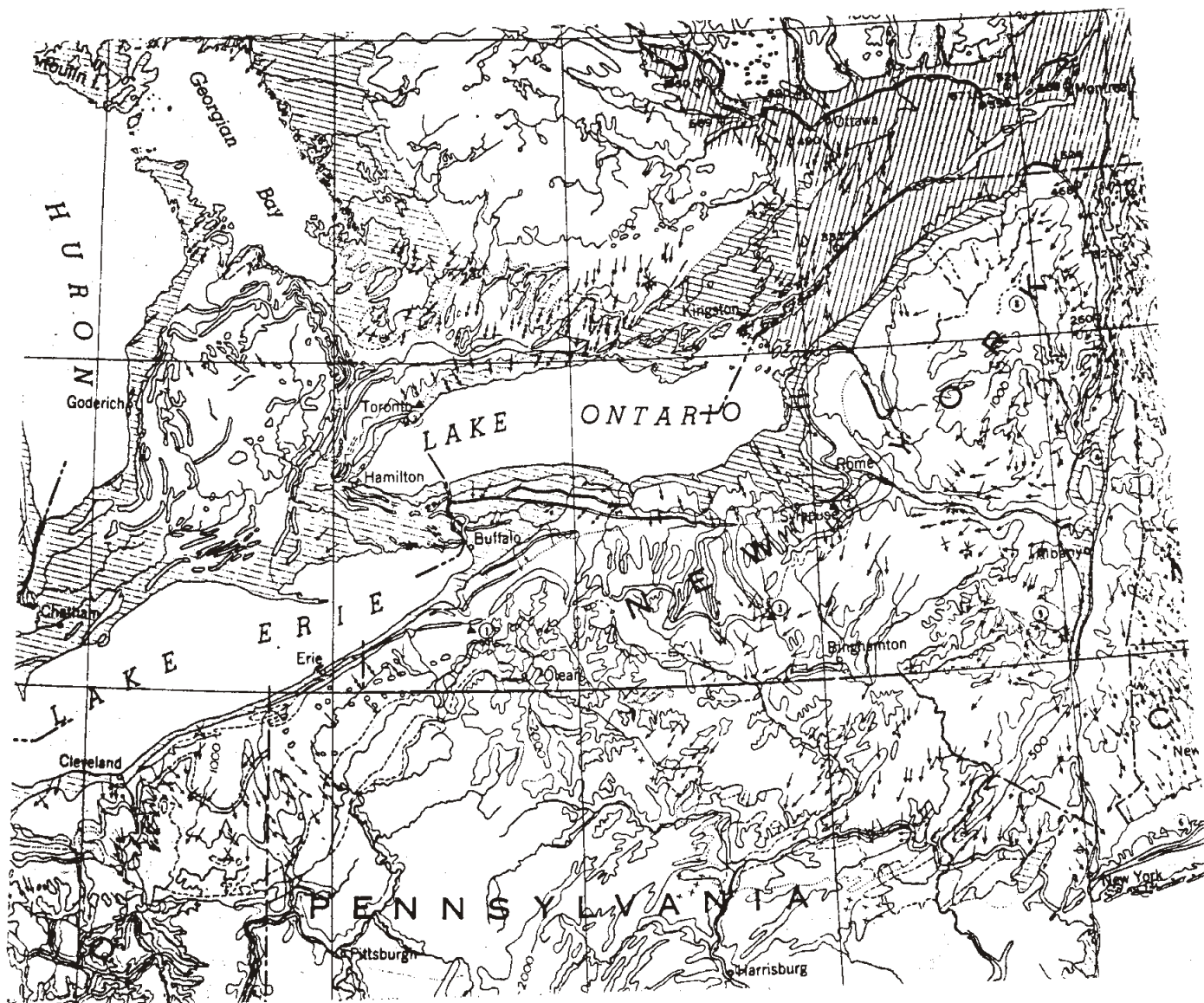


Figure 5. Portion of Glacial Map of North America, GSA, 1945.
Scale: about 72 miles to the inch.

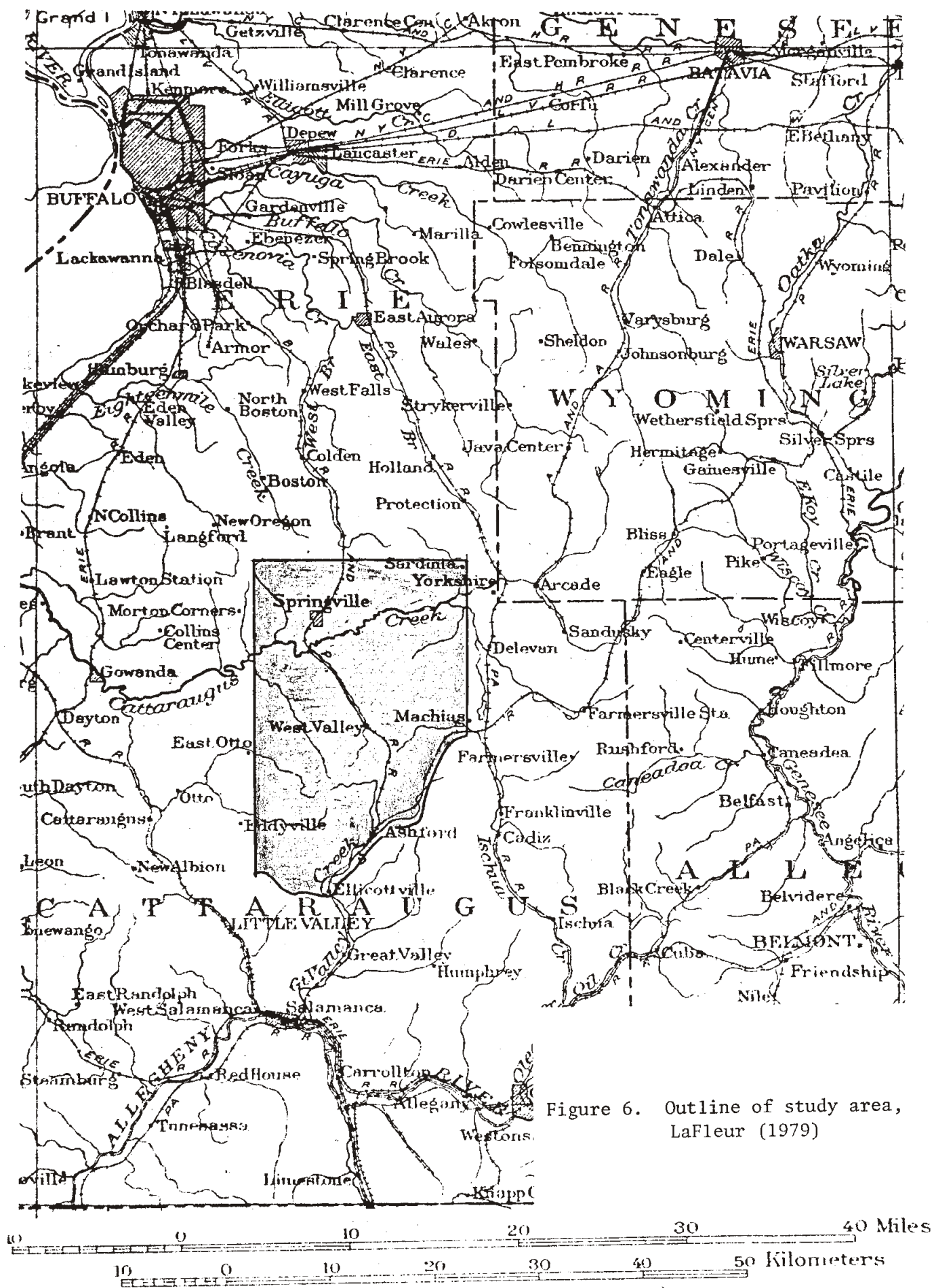


Figure 6. Outline of study area, LaFleur (1979)

LATE WISCONSIN STRATIGRAPHY OF THE UPPER CATTARAUGUS BASIN

Robert G. LaFleur
Department of Geology
Rensselaer Polytechnic Institute
Troy, N.Y. 12181

INTRODUCTION

As part of an investigation of factors controlling subsurface movement of radioisotopes near low-level radioactive-waste burial grounds, the U.S. Geological Survey, in cooperation with the New York State Geological Survey, mapped the surficial geology of the area surrounding the Western New York Nuclear Service Center. A detailed glacial geologic map of the study area, prepared at a scale of 1:24,000, includes the Ashford Hollow and West Valley 7½-minute quadrangles and parts of the Ellicottville, Ashford, Springville, and Sardinia 7½-minute quadrangles (Fig. 6). Several freshly exposed sections within this 165-mi² area were measured and described in detail, and cores from test borings near the low-level burial ground were examined. In addition, a large-scale map of the immediate vicinity of the facilities at the Center was prepared to show distribution of surficial deposits in detail and locations of mass movements. The immediate goal of this work was to define the areal extent, stratigraphic position, lithology, and mode of deposition of the till in which the radioactive-waste burial grounds are located. The results of the investigation, undertaken in 1975-76, are reported in LaFleur (1979). Excerpts from this work that bear on stratigraphic relationships among mapped units are included here.

Our focus for the Friends gathering is on the detailed stratigraphy that was assembled during the intensive study of the Nuclear Service Center environs. Of particular interest is the multiple glacial record exposed along dissected valley floors and the age and character of the Olean drift to the south.

STRATIGRAPHY

Four cycles of glacial advance proposed by Muller (1975) - Olean, Kent, Defiance, and Valley Heads - are evidenced areally and stratigraphically in the Cattaraugus basin. Lobate ice advance through north-draining valleys, particularly Connoisarauley and Buttermilk valleys, was progressively less ambitious with time. The stratigraphic record in the valleys includes proglacial lacustrine silt and clay, lodgment till, ice-recessional and free-drainage gravel and sand, and erosional unconformity, generally arranged in that ascending order. On the interfluvies an interrupted record of tills and minor stratified drift suggests that only Olean and Kent ice covered the summits; Defiance (Hiram) and Valley Heads (Lake Escarpment) ice did not. The products of each glaciation have distinguishing textures, lithologies and colors, which permit working syntheses of glacial and deglacial episodes. The upper Cattaraugus basin may have been accessible to both the Erie and Ontario lobes during Olean and Kent glaciations; but younger Defiance and Lake Escarpment advances involved invasion by only the Erie lobe.

The regional chronology of Dreimanis and Goldthwait (1973) is summarized in Figures 2 and 3, that of Muller (1977), in Fig. 4.

Olean Glaciation

Olean drift described by MacClintock and Apfel (1944) in Cattaraugus County, generally south of the Cattaraugus divide, was correlated by Muller (1977) with the Titusville (middle Wisconsin) glaciation. Crowl (1980) however traced the Woodfordian drift border through Pennsylvania to join the Olean limit in New York. "Drab" Olean drift contains only a small percentage of exotics, is slightly calcareous, and is deeply oxidized. Throughout the Olean landscape, valley walls are commonly colluviated, and morainal deposits are topographically subdued. Muller (1977) used a 20% exotic stone content (carbonates and crystallines) to separate drab Olean from bright Kent tills and ice-contact deposits and a 30% limit to distinguish outwashes.

Exposures along Snake Run Road 2 miles north of the Kent Moraine show, in descending order: drab upland moraine gravel, interfingering drab and very bright tills, red clay and black gravel, and drab greenish-gray to light olive-gray till and gravel (probably all Woodfordian) over Connoisarauley and East Otto lobes (Fig. 7), which deposited the upper (Kent) part of the Snake Run section, may have competed for space along the interfluvial separating their valleys. Each lobe contributed a till substrate of very different lithologic composition, determined only by the location in the ice of bright and drab components. An areal facies relationship between drab and bright Kent drift is clearly required by the interfingering till sequence in the upper Snake Run section. Perhaps this facies relationship also includes the drab greenish-gray tills that extend 42 feet below the base of the interfingering bright and drab units. Should further study prove this 42-foot-thick sequence to be Olean, which it resembles, the lithologic similarity of these units to others higher in the Snake Run section may suggest an early Woodfordian age for Olean till. The basal 66 feet of the section contains oxidized, noncalcareous yellowish-gray clean gravel and faulted sand overlying oxidized and leached till that contains abundant slabs of local bedrock. These units, different from any in the section above, may date from the mid-Wisconsin or earlier.

In spite of the lithologic similarities between Kent and Olean (?) suggested at Snake Run, the outwash that emanated from the ice at the time of emplacement of the Kent Moraine seems to have been laid down in completely deglaciated valleys (Fig. 7). If the Olean should prove to be early Woodfordian, a yet unidentified early Woodfordian interstadial interval of some duration prior to formation of the Kent Moraine would be indicated. Such an interval may have been important in the colluviation and oxidation of the Olean drift.

Kent Glaciation

Muller (1977) traced moraines and drift borders eastward from northwestern Pennsylvania and projected the Kent Moraine northeastward through the study area along an irregular border sharply controlled by topography. He equated the moraine with the Woodfordian glacial limit. The Kent Moraine forms the Cattaraugus divide in Buttermilk Valley (Figs. 7 & 13).

Some of the till and recessional deposits associated with the Kent glacier contain high percentages (20-40 percent) of exotic rocks derived from the Niagaran escarpment and the Canadian shield. This bright drift

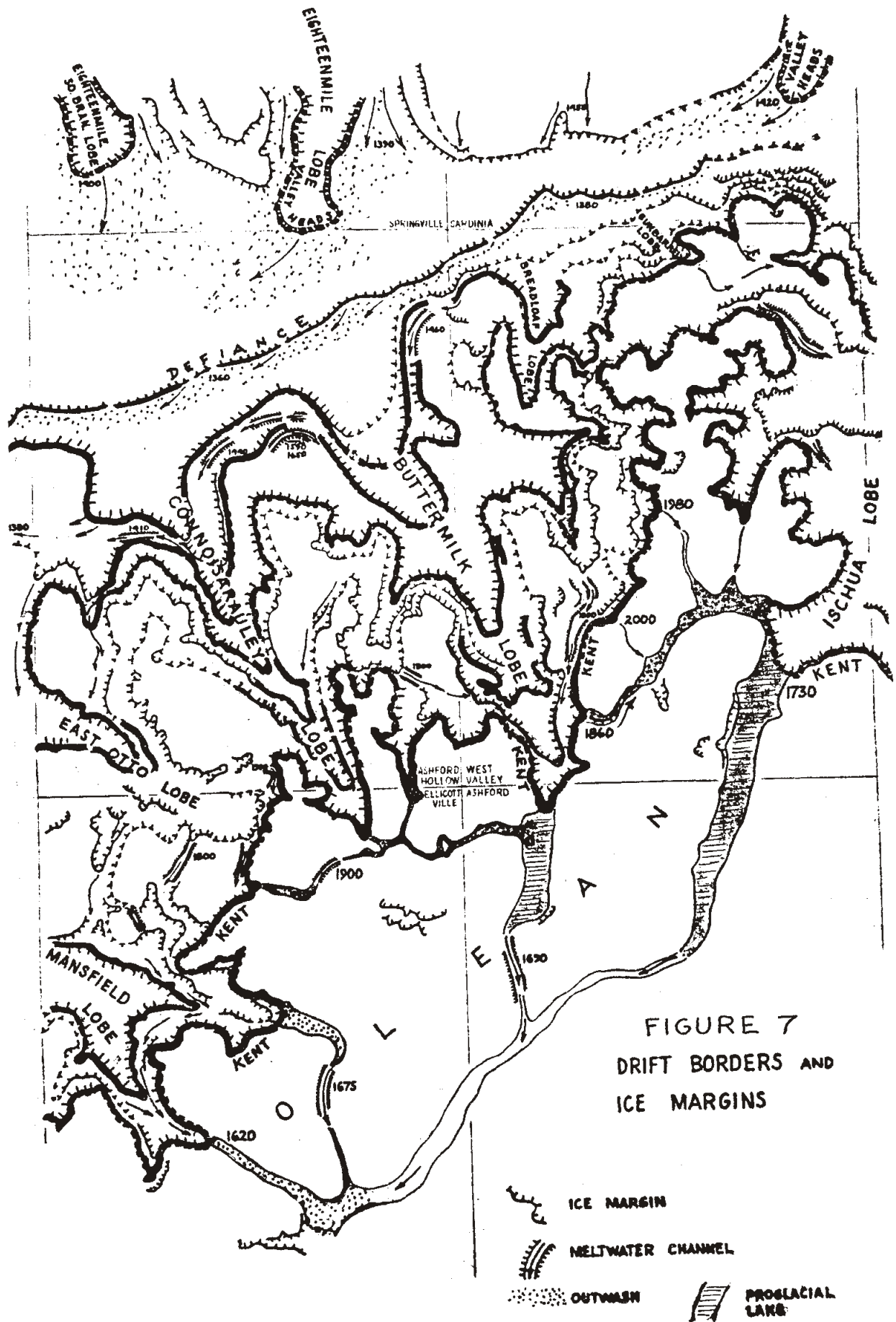


FIGURE 7
DRIFT BORDERS AND
ICE MARGINS

is calcareous, leached to a depth of 1 to 3 feet, and oxidized to a depth of 8 to 10 feet. Morainal topography developed on Kent deposits is fresh and not noticeably colluviated.

North of the Kent Moraine, Muller (1963) recognized in Chautauqua County the Clymer and Findley Lake moraines. These project eastward and may be represented here by recessional moraine loops just inside the Kent Moraine, but tight crowding of these loops precludes accurate correlation (Fig. 7). Dark-gray tills related to active Clymer or Findley Lake ice may be present in the Kent portion of the Connoisarauley Creek section (Fig. 15).

Kent drift is exposed chiefly in the uplands and along the valley sides where it is generally drab (less than 5 percent exotics), weakly calcareous, and greenish gray (5GY5/1)¹ oxidized to grayish orange (10YR7/4); however, some of the Kent till and gravel is highly calcareous, generally pale red (5R6/4), and has a stone content that is 20 to 40 percent exotic (including red and white sandstones, carbonates, and crystalline Canadian Shield lithologies). In the few places where till assigned to the Kent glaciation is exposed along valley floors beneath the Lavery, it is tougher, less clayey, and darker olive-gray (5Y4/1).

Kent Recession - Erie Interstade

After emplacement of the Kent Moraine, the Erie and Ontario lobes withdrew significantly. Pauses in the recession of the Kent ice margin through a proglacial lake in Buttermilk Creek valley permitted accumulation of a more or less continuous series of kame deltas in which topset pebble gravel and clinoform turbidite sand and silt prograded southward over bottomset rhythmic clays. The southernmost delta sequence is exposed at Riceville Station (Fig. 11), and successors are well exposed in bluffs along Buttermilk Creek (Fig. 10).

As deglaciation proceeded, the glacial lake in Buttermilk Valley drained and exposed the kame deltas and lacustrine floor to subaerial erosion during the succeeding Erie Interstade. The upper part of a section near the former stream gage on Buttermilk Creek (Fig. 9) includes an erosion surface overlain by locally derived gravel beds which in turn are overlain by proglacial lacustrine clay and clayey silt till; these deposits record the advance of the ice after subareal Erie Interstade erosion. Two earlier glacial-deglacial episodes, the latest of which is of probable Kent age, are also partly recorded in this section. Similar relationships are shown in exposures along Connoisarauley Creek, which drains the next valley to the west (Fig. 15).

Two major exposures suggest the degree of dissection of the Buttermilk-Cattaraugus Valley after the Kent recession. At Felton Bridge, 2,200 feet southwest of the confluence of Buttermilk and Cattaraugus

¹Colors designated according to Munsell Soil Color Charts, 1954, Baltimore, Md., Munsell Color Company.

creeks, a narrow, steep-walled channel cut in rock is filled with 30 feet of very bright boulder gravel (30-40 percent exotics) that grades upward to pebble gravel and underlies Lavery till. The base of the boulder fill is not exposed and lies below the present low-flow level of Cattaraugus Creek. A northwestward projection of the channel across the modern stream is required to bypass an unbroken shale cliff 130 feet high cut by the post-glacial Cattaraugus.

At a north-bank exposure on the Cattaraugus, 2.2 miles southwest of Sardinia and 7.5 miles upstream from Felton Bridge (Fig. 8), bright ice-contact clinoform gravel beds, dipping westward, are overlain by pro-Lavery deformed rhythmite clay beds that are in turn overlain by Lavery till. The melt-water stream that transported the bright Kent gravel westward from an eastward-receding ice margin followed a profile topographically near that of the present Cattaraugus. Also at this location, deformation sense in the pro-Lavery lacustrine beds indicates dominant southeastward ice flow from the Erie lobe after the Erie Interstade.

Defiance Glaciation Lavery - Hiram

One of several lobes refilled Eighteenmile Creek valley, which is aligned with Buttermilk Creek valley to the north (Fig. 7), then advanced into Buttermilk Creek valley through impounded lake waters and terminated at or near a valley-plugging moraine at West Valley. A Lavery age is assigned to this advance. In Buttermilk Creek valley, the pro-Lavery glacial lake was controlled by the summit of the Kent moraine at 1,710 feet (Fig. 13). The top of the Lavery till now lies at an altitude of about 1,380 feet at the latitude of the waste-burial site, so the Lavery glacier must have been buoyed up by a hydrostatic head approaching 400 feet as it overrode a saturated, thick, muddy substrate. It emplaced a stony, clayey, silt till with minor interbedded silty clay, which now forms the host formation for the waste-burial ground. The overridden Kent kame deltas experienced only minor alteration from the partly bouyant Lavery ice and retained much of their original sedimentary structure and land-form beneath the till.

The Lavery till is concentrated along the valley floor and extends only slightly onto the valley wall. During advance, the glacier sole may have periodically floated free from the substrate and allowed space for rapid accumulation of poorly bedded, pebbly silt and clay. Regrounding of the ice and renewed movement could be responsible for the till deposition as well as its structural deformation. This unit does not appear to be either an overridden, in-place, lacustrine sequence or a flow-till assemblage. Rather, it is a lodgment till complex with minor micro-stratified inclusions that are always torn and deformed.

The thickest Lavery section measured was at the north end of Buttermilk Creek valley, where 130 feet of till is overlain by 6 feet of Defiance (?) outwash gravel. Lavery till averages 80 feet in thickness near the waste-burial site, thins to 16 feet at Riceville Station (Fig. 11), and pinches out near West Valley.

Although the Lavery till has wide areal extent, exposures showing more than a few feet of section are uncommon. Because of its clayey, fine-silty

texture, its thickness of over 100 feet, and its deep postglacial dissection, the till is highly susceptible to slumps and shallow-seated rotational slides. Periodically during mass wasting, sections several feet thick are exposed in slide scars, but are lost by failure within a few weeks. The basal 10 to 15 feet of Lavery till in contact with Kent recessional beds is well exposed along the west wall of Buttermilk Creek and in an east-bank bluff of Connoisarauley Creek 0.6 mile northwest of Connoisarauley Road. Deformed pro-Lavery lacustrine sediments overlying Kent recessional gravel are well exposed in a bluff on Cattaraugus Creek 2.2 miles southwest of Sardinia (Fig. 8).

Lavery till is moderately bright (10 to 15 percent exotics), highly calcareous, and medium olive gray (N5-5Y5/1). In the study area, it is confined to the valley floors. Wherever the Lavery is exposed or clearly shown in test borings, it is an interfingering complex of three subfacies. The most abundant subfacies, which forms about 70 percent of the formation thickness, is a pebble and cobble till, moderately bright with a clayey silt matrix. Stones constitute 10 to 20 percent of the unit in field exposures although cobbles larger than 2.5 inches could not be recovered in the core barrel during drilling. Textural and mineralogical analyses by Whitney (1977) on three till matrix samples from the waste-burial site show nearly uniform percentages of clay (40 percent), silt (48 percent), and sand (12 percent); silt and clay fractions are dominated by quartz, mica (illite), and chlorite. Textural analyses of two core samples by the U.S. Geological Survey (unpublished) showed 55 percent clay, 25 percent silt, and 20 percent sand and gravel.

The second subfacies is texturally similar to the first, except that stone content is less than 5 percent and the matrix contains thin, torn wisps of light-gray (N8) quartz silt. Rarely, the till includes or grades into layered silt and clay; otherwise, there is no indication of varved or other rhythmic bedding in either of these subfacies. Both subfacies interfinger, and although they have a general stratiform relationship, each is internally deformed. Any particular lens of each subfacies is of small areal extent. Unoxidized matrix color is a consistent medium olive gray (N5-5Y5/1). Oxidation extends to a depth of about 8 feet. Altered matrix colors above this depth are olive gray (5Y6/1) or pale yellowish brown (10YR6/2). The matrix is highly calcareous and leached to a depth of less than 1 foot. X-ray analyses show quartz and illite to constitute well over half the material in each of seven samples of the till (Table 1).

The third subfacies, exposed only in excavations on the burial site at depths of 7 to 12 feet, consists of stratified sand and gravel with included torn masses of till (subfacies 1) and rhythmic clay. Lenticular and discontinuous, this subfacies represents ice-frontal deposits over-ridden by a late surge of Lavery ice or perhaps by the slightly younger Hiram glacier.

The Lavery commonly contains small inclusions of Kent till and clay, particularly the pale red. For example, a slide scar on the west side of Rock Springs Road 1,500 feet north of the waste-burial site shows Kent red

Table 1.--Mineral composition of selected core samples from Western New York Nuclear Service Center^{1/}

[All values are in weight percent; locations of test holes are shown in Prudic and Randall, 1977, fig. 1]

Minerals	Test-hole identification symbol; depth interval; ^{2/} and material									
	F	I3	J	N	C2	C2	D	D	G	L
	22.4- 22.9	7.5- 7.9	52.7- 53.2	24.5- 24.9	9.5- 10.0	42.5- 43.0	14.0- 14.5	29.8- 30.3	36.2- 36.7	15.3- 15.8
	Till	Oxidized till	Till	Till	Oxidized till	Till	Till	Lake beds	Lake beds	Lake beds
quartz	24	24	24	22	26	22	27	32	23	33
potassium feldspar	1	<1	<1	1	2	1	1	3	0	3
plagioclase feldspar	7	7	5	4	7	5	5	9	6	10
calcite	11	7	7	8	9	7	9	11	7	9
dolomite	5	3	5	5	7	5	5	9	5	11
chlorite	3	0	4	4	1	12	5	4	6	4
kaolinite	9	9	10	9	7	0	9	6	8	5
illite	24	27	27	21	28	26	30	16	19	15
montmorillonite	0	<1	0	0	0	0	0	0	0	0
mixed-layer clay minerals	4	9	4	6	4	1	<1	4	7	5
Totals	88	86	86	80	91	79	91	94	81	95

^{1/} Mineral composition determined by B. J. Anderson, U.S. Geological Survey, by X-ray diffraction according to method of Schultz (1964). Totals between 90 and 105 percent are considered normal for this semiquantitative method. Low totals in some samples probably indicate a higher iron content; the fluorescent radiation produced by iron causes loss of peak intensity and therefore generally lower percentages (B. J. Anderson, written commun., 1978).

^{2/} Depths are in feet below land surface.

clay and greenish-brown silt 50 yards west and uphill from a Lavery till exposure, which contains torn inclusions and stringers of the same Kent lacustrine sediments. Lavery-recessional lacustrine deposits, of local extent only, north of West Valley, also contain Kent red-clay inclusions (Fig. 12).

Soil tests performed for the New York State Geological Survey on Lavery till recovered from an experimental trench show the till to be somewhat overconsolidated. Also, microfabric study of till thin sections shows two sets of conjugate shears, which support the idea that the last mechanical experience of the till was a loading by ice, unbouyed by draining of Buttermilk Creek valley, prior to final ice melt-out (LaFleur, unpub.). Pondered water dissipated westward, first through outlet channels cut into till and rock on the north-facing Dutch Hill spur. Lacustrine sediments were found between the fluvial gravel blanket and the top of Lavery till at only one locality, along Buttermilk Creek 0.4 mile north of the highway culvert near West Valley (Fig. 12).

Withdrawal of Lavery ice from Buttermilk Creek valley was rapid and accompanied by erosion by upland streams, which deposited as much as 10 feet of channery gravel over small lingering ice masses and on exposed Lavery till in Buttermilk Creek valley. Flow direction indicated by the imbrication of these capping gravels is downstream to the northwest.

As the ice margin receded northward from the Dutch Hill spur to a position coincident with the present south wall of Cattaraugus Valley, a sandy pebble-gravel blanket 15 to 30 feet thick was emplaced directly on Lavery till by melt waters that drained freely to the west. This outwash, kamelike along its north edge, is slightly younger than the fluvial gravel of Buttermilk Creek valley. It was proposed equivalent to the Defiance Moraine (Muller, 1975), which marks the Hiram glacial limit, but may be a recessional feature rather than an end moraine.

Assignment of Lavery age to the burial ground till by LaFleur (1979) was prompted by the following observations: 1) the till extends 6 miles beyond the moraine in the main Cattaraugus Valley correlated by Muller (1975) with the Defiance (Hiram limit), 2) the till is ten times thicker than its predecessors in Buttermilk and Connoisarauley valleys and seems to require an unusually large uptake of lacustrine clay and silt originally foreign to the upper Cattaraugus.

Deposition of Erie Interstade clay and silt locally, rather than in the main Erie basin (suggested by Calkin and Muller, this volume), may be difficult to reconcile with evidence for purging of waters from the Cattaraugus basin during and after the Kent recession. On the other hand, a long transport of lacustrine material by ice out of the Erie basin might be expected to diffuse valley-directed flow paths onto interfluvies more than the observed distribution of Lavery till suggests.

Valley Heads (Lake Escarpment) Glaciation

Extending south through Eighteenmile and Cazenovia valleys, lobate Valley Heads ice barely reached the main Cattaraugus Valley (Figs. 1,7). Ice-contact topography extends to Springville, at about 1,400 feet, where a 30-foot

thick gravel outwash (about 10% bright components) overlies clayey till. The lower part of the outwash was distributed directly southward, probably into a shallow lake. The upper part shows a westward transport direction in response to open drainage through Zoar Valley. Till beneath the outwash may be Hiram. It is not oxidized appreciably.

From Sardinia, on the east (Fig. 1), outwash spread westward toward Springville, nicely adjusted to falling base levels. Through this reach, locally, right-bank tributaries, draining an ice-free interfluvium on the north, contributed channery fan gravel to the Valley Heads system.

REFERENCES CITED

- Dreimanis, A., and Goldthwait, R.P., 1973, Wisconsin glaciation in the Huron, Erie, and Ontario Lobes: Geological Society of America Memoir 136, p. 71-106.
- LaFleur, R.G., 1979, Glacial geology and stratigraphy of western New York Nuclear Service Center and Vicinity, Cattaraugus and Erie Counties, New York: U.S. Geol. Survey Open-file Report 79-989.
- MacClintock, P., and Apfel, E.T., 1944, Correlation of the drifts of the Salamanca re-entrant, New York: Geological Society of America Bulletin, v. 55, p. 1143-1164.
- Muller, E.H., 1963, Geology of Chautauqua County, New York, Part II, Pleistocene geology: New York State Museum and Science Service Bulletin 392, 60 p.
- _____, 1975, Physiography and Pleistocene geology, in Tesmer, I.H., Geology of Cattaraugus County, New York: Buffalo Society of Natural Sciences Bulletin, v. 27, p. 10-20.
- _____, 1977, Quaternary Geology of New York, Niagara Sheet: New York State Museum and Science Service, Map and Chart Series, no. 28.
- Schultz, L.G., 1964, Quantitative interpretation of mineralogical composition from X-ray and chemical data for the Pierre Shale: U.S. Geological Survey Professional Paper 391-C, p. C1-C32.
- Whitney, P.R., 1977, Chemical and mineralogical investigation of surficial materials from the West Valley nuclear waste disposal site: New York State Geological Survey Open-File Report, 15 p.

TRIP LOG

Day One

Log begins at intersection of Routes 34 and 219, at western end of village of Springville.

Mile

- 0.0 Proceed east on Main Street (Rt. 39) through Springville. Road descends from highest Lake Escarpment ice-contact gravel terrace at 1380 feet. Inferior terrace levels inset at 1350 and 1330 feet mark stages in downcutting with more distal distribution of outwash to the southwest through Zoar Valley. Ascend higher terrace, at Chaffee Hospital, on left; leave Springville.
- 2.5 Intersection Rt. 240. Continue east on Rt. 39 along north valley wall of Cattaraugus Creek.
- 3.8 Richmond Gulf. Road descends through about 25 feet of Lake Escarpment outwash into clay-silt Lavery till. Shallow-seated, rotational slumps impart a geomorphic signature to Lavery till throughout the Cattaraugus basin.
- 8.0 STOP 1. Lord Hill. Section along Cattaraugus Creek exposes deformed, overridden pro-Lavery clay rhythmites overlying bright Kent-recessional gravel and clay. See Figure 8. Ferruginous gravel and peat form first terrace, accessible at low-water level. Turn around and proceed west on Rt. 39. Re-enter Springville.
- 14.2 STOP 2. John Benz gravel pit 2000 feet south of Rt. 39. About 25 feet of Lake Escarpment gravel and sand overlies Hiram, or pro-L.E.(?) massive, olive-gray clay with few pebbles. Little evidence here for a deglacial interval prior to outwash deposition. Return to Rt. 39 and proceed east.
- 15.0 Turn south on Rt. 240. Road descends through Lake Escarpment outwash and partial section of Lavery till onto 1340-foot high terrace of Cattaraugus Creek that correlates with late Lake Escarpment outwash to the east.
- 15.9 Elk Street intersection. PICTURE STOP. View to west of slumped Lavery till outcropping beneath 1260-foot fluvial terrace. To south, across Cattaraugus Creek, Lavery till is exposed on proximal side of ice-contact, fine-gravel outwash, previously correlated with the Defiance Moraine.
- 16.1 Bigelow Bridge. Cross Cattaraugus Creek.
- 16.7 Turn west on Bond Road.
- 17.2 OPTIONAL STOP. Pit in 1360-foot gravel outwash, somewhat kamic on north side; about 30 feet thick. Proceed west and south to
- 17.9 Thomas Corners Road. PICTURE STOP. From 1360 feet, gravel surface slopes gently southwest. Proceed west on Thomas Corners Road.

Descend outwash onto 1300-foot terrace, then descend steeply through Lavery till.

- 18.9 Buttermilk Creek. 8-ton bridge. DISEMBARK. Walk across bridge. Exposures of slumped Lavery till along road.
- 19.2 Dutch Hill Road. Turn north.
- 19.4 Felton Bridge, Re-cross Cattaraugus Creek.
STOP 3. Exhumed boulder gravel channel filling. About 25 feet of bright Kent recessional(?) boulder gravel, fining upward to pebble gravel, fills a steep-walled rock cut. Deposit is apparently overlain by Lavery till. Two-mile long gorge, postglacially cut in shale, extends west into Zoar Valley.

LUNCH

Proceed south on Dutch Hill Road.

- 19.9 6-ton bridge over railroad. DISEMBARK. Road ascends proximal side of outwash onto 1360-foot summit, same surface as seen at PICTURE STOP.
- 20.4 Schwartz Road. Turn west. Gullied Lavery till to south of road.
- 21.6 STOP 4. Lavery till exposure, overlain by pebble gravel of 1360-foot outwash. Small pit in gravel north of road.
- 21.7 Route 219. Turn south.
- 22.0 Enter Connoisarauley Creek drainage basin.
- 23.3 Turn east. Road follows lowest (at 1460') of three outlet channels that cut across Dutch Hill spur and connected ice-choked Buttermilk and Connoisarauley valleys during Lavery (and older?) deglacial episodes.
- 24.1 Turn southeast on Cross Road.
- 24.6 Road crosses middle, 1590-foot channel.
- 24.7 Dutch Hill Road. Turn north. Highest, 1640-foot channel approaches from east, at road intersection.
- 24.8 1590-foot channel, here ice defended on north side.
- 25.2 Cross lowest, 1460-foot channel. Drainage flow sense appears to be east to west. Significance of channels in Lavery ice recession from Buttermilk Valley will be discussed at next stop.
- 25.9 Schwartz Road. Turn east.

- 26.2 (Access dirt road to Buttermilk Creek section. See Fig. 9. Permission from Nuclear Fuel Services is necessary to examine)

New road enters Buttermilk Valley along west wall. Lavery till, about 100 feet thick, floors valley to east.

- 27.2 Along road to the west are outcrops of red clay and reddish-brown cobble gravel. The red beds, probably derived from Kent-recessional deposits, interfinger with Lavery olive-gray till 50 yards to the east.

- 27.8 STOP 5. Western New York Nuclear Service Center. Fuel rod reprocessing plant and radioactive-waste burial ground, previously operated by Nuclear Fuel Services, Inc., is now shut down. Immediately east of burial ground is the Buttermilk Creek slide section, described in Fig. 10. A.D. Randall, and D.E. Prudic will discuss stratigraphic and hydrologic investigations in Buttermilk Valley as they relate to the burial ground.

Proceed to Fox Valley Road on new road.

- 29.7 Turn northeast.

- 30.1 Cross Buttermilk Creek. Park at Town of Ashford Garage.

STOP 6. Riceville Station section. See Fig. 11. Section exposes clinoform turbidites, sand, and bright gravel, probably Kent recessional, overlain by pro-Lavery clay, Lavery till, and east of the Highway Garage, by Lavery-recessional gravel. Proceed southwest on Fox Valley Road to intersection.

- 30.4 Turn southeast.

- 31.8 PICTURE STOP. Culvert under West Valley Rd. Section along creek 2,000 feet downstream shows Lavery-recessional lake clay and ice-contact gravel, absent in Buttermilk Creek valley farther north. See Fig. 12.

- 32.0 Route 240. Turn south. Enter hamlet of West Valley.

- 32.8 Leave West Valley. Southernmost exposure of Lavery till in creek west of road.

- 33.8 Rosick Hill Road. Turn east. St. Johns Cemetery.

- 34.1 STOP 6. Gravel moraine at 1700 feet plugs Buttermilk Valley one mile south of Lavery till limit. See Fig. 13. Pit 1/4 mile north on proximal side exposes about 20 feet of lobate pebble gravel and sand, about 10% bright, with deformed masses of blue-gray coarse silt (Kent?). This moraine may represent a Kent recessional stand, perhaps Clymer, or a Lavery terminus.

- 34.3 Turn around at railroad crossing. Tracks occupy small outlet channel at 1690 feet, which drained Lavery melt water south through dissected Kent Moraine.
- 34.9 Return to Rt. 240. Turn south.
- 35.9 Canada Hill Road. Turn east.
- 36.2 STOP 7. Gravel pit in Kent Moraine. Boulder lithologies are like those of Felton Bridge channel filling (STOP 3). Swamp to south is southward continuation of Lavery drainage through breached Kent Moraine. Refer to Fig. 13. Return to Route 240.
- 36.6 Turn south.
- 37.3 Beaver Meadows Road. Turn west.
- 37.7 Colluviated slope and thin Olean till to south of Beaver Meadows Creek. Road continues west through dissected Olean gravel moraine, following outlet channel complex that drained Kent glacier.
- 40.1 Route 219. Turn north into Connoisarauley basin.
- 50.9 Intersection of Route 39, Springville. End trip log for day one.

Day Two

- 0.0 Log begins at intersection of Routes 39 and 219, Springville. Proceed south on 219 toward Ashford Hollow.
- 7.2 Snake Run Road. Turn west.
Road ascends through Kent ground moraine, including red, calcareous till and clay, exposed in scattered outcrops south of road.
- 9.2 STOP 1. Snake Run Road section. See Figure 14. Roadcuts expose interbedded bright and drab tills and stratified units over drab till and gravel. Comparison will be made between these units and till exposures that lie beyond the Kent limit.
- Proceed south on Snake Run Rd.
- 9.8 East Flats Road. Turn east, then south.
- 10.3 Intersection Meyer Hill Road. Turn east, then southeast.
- 10.9 Bailey Hill Road. Turn south. Climb, then descend Bailey Hill, onto Kent recessional moraine.
- 12.3 STOP 2. Till exposure along west side of road. Position is such that Kent ice might have barely covered this locality. Compare with the tills of Snake Run.
- 13.1 Crumb Hill Rd. Proceed south.
- 13.6 Plato Road, turn east.
- 15.3 Rainbow Lake. Kent Moraine.
- 15.8 Mason Hill Road. Bear east. Timber Lake on south.
- 16.5 Rohr Hill Road. Bear right. Kent end moraine immediately to north.
- 16.8 Plato. Continue across 1900-foot outlet channel that drained east. Continue southeast on Jackman Hill Road.
- 17.8 STOP 3. Till exposure on west side of road. This position is 1.5 miles beyond the Kent limit. Compare with tills at Snake Run and last stop.
- 18.4 Turn around at Route 219.
- Proceed north on Jackman Hill Road.
- 19.3 Through Plato.
- 19.7 North on Rohr Hill Road.
- 19.8 STOP 4. Pit east of road. Kent end moraine. See Fig. 15.
- Continue north on Rohr Hill Road,

- 20.9 Kent Moraine
- 21.4 1900-foot outlet channel to west, connecting two Kent-recessional moraine segments
- 22.0 LUNCH. Sculpture Park.
- 22.6 Ahrens Rd. Proceed north.
- 23.1 Ashford Hollow. Route 219. Bear north on 219.
- 26.1 Connoisarauley Road. Turn west.
- 26.6 Walk about 1000 feet north on dirt road.

STOP 5. Radiocarbon-dated, wood-bearing alluvial terrace forms east bank of Connoisarauley Creek. See Fig. 16.

(Fig. 17 shows the section 2000 feet farther downstream on the west side, well exposed in 1975-76 but now totally lost to large mass movements. This section shows the most complete Kent-Lavery succession in the upper Cattaraugus. Those able to visit this locality on occasion might check its future accessibility.)

- 27.1 Return to Rt. 219. Turn north.
- 31.8 Routes 39 and 219, Springville. End of log.

FIGURE 8 LORD HILL SECTION

North bank Cattaraugus Creek,
4700' ENE of Johnson Rd. & NY. 39
Sardinia Quad.

WEST

EAST

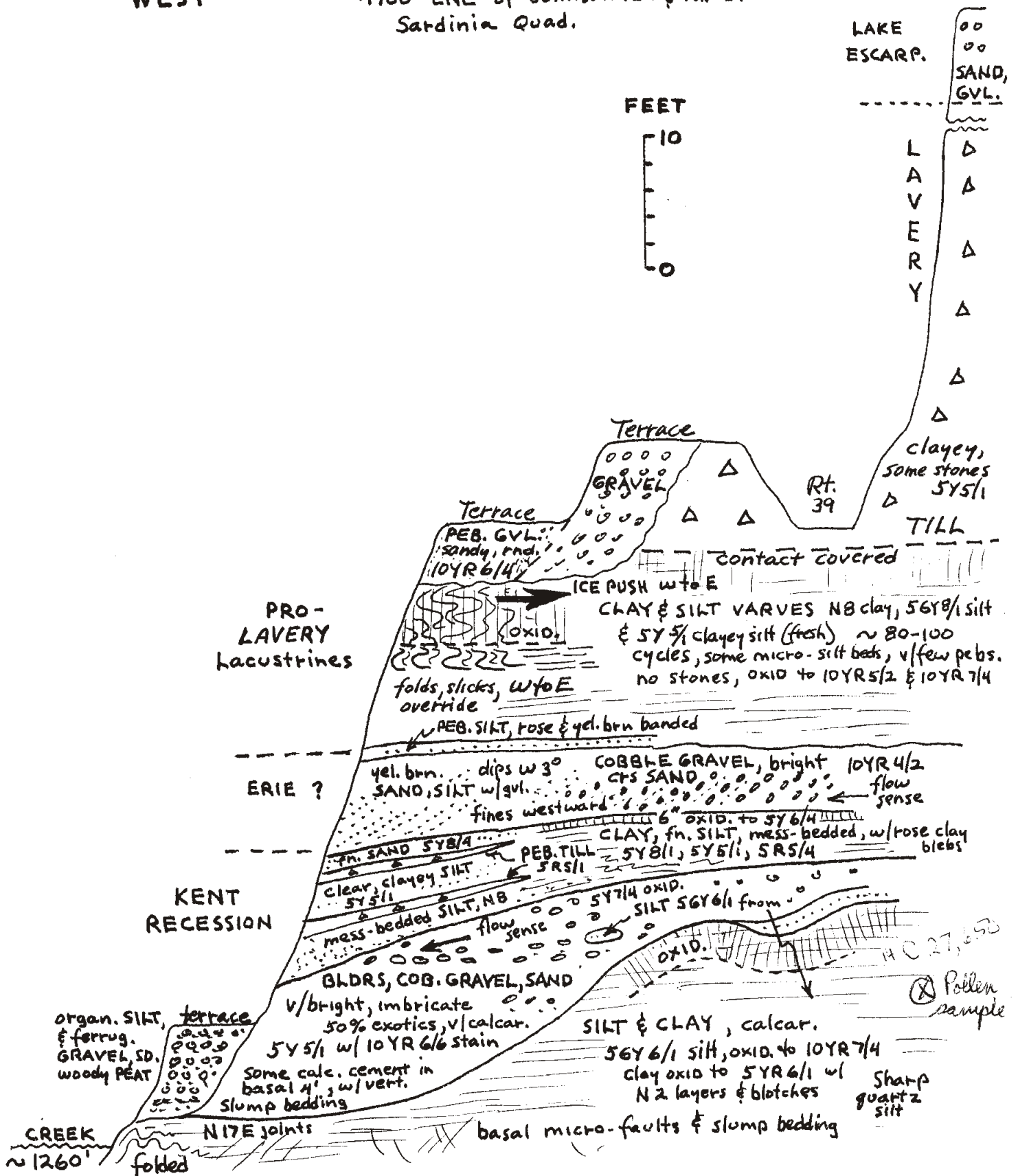


FIGURE 9

BUTTERMILK CREEK GAGE SECTION
East bank, 3600 feet southeast of Thomas Corners bridge
Ashford Hollow Quad.

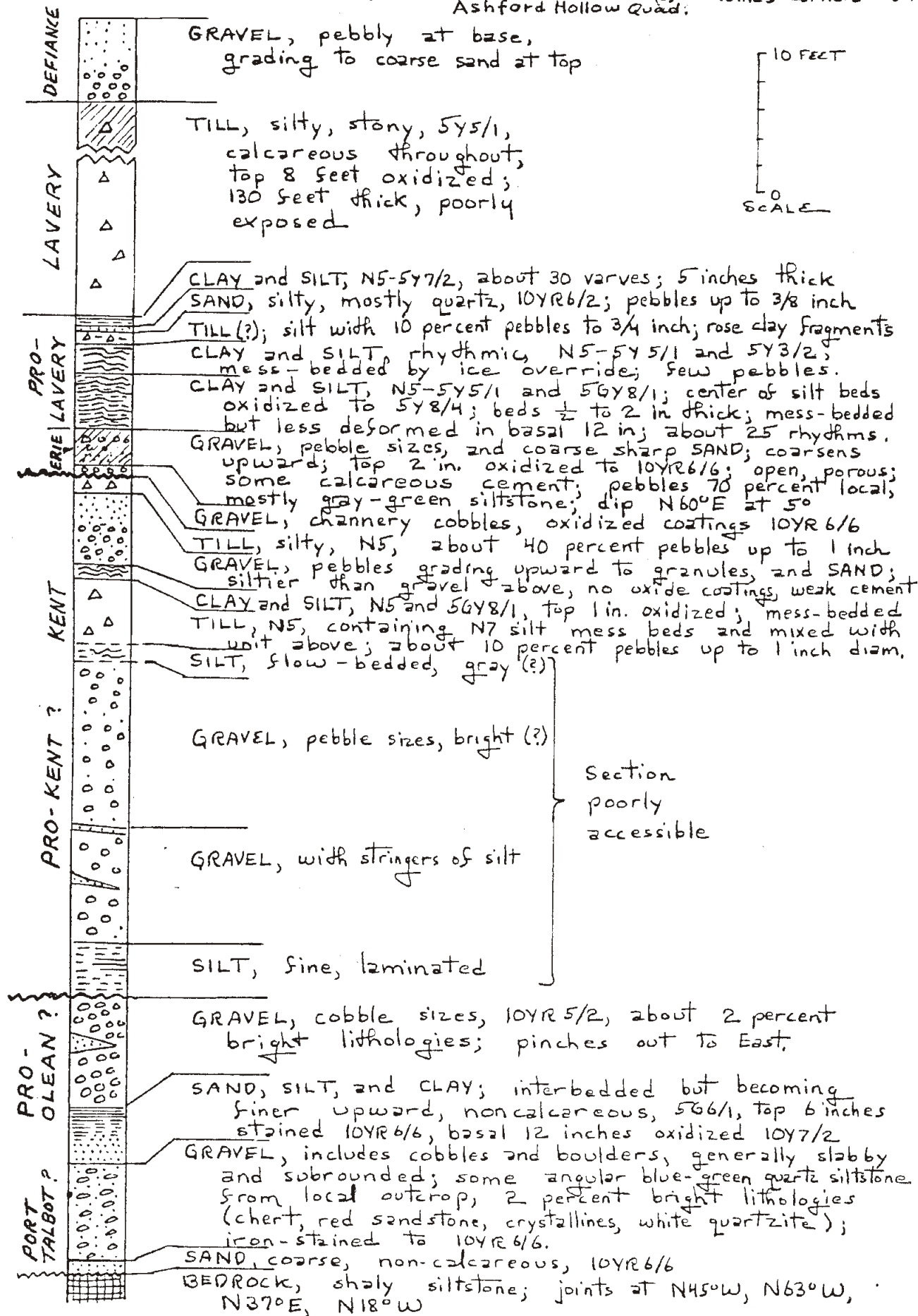


FIGURE 10

SLIDE SECTION

West bank Buttermilk Creek within
Western New York Nuclear Service Center
Section strikes N60°W, beds dip 2-10°SW
Ashford Hollow Quad.

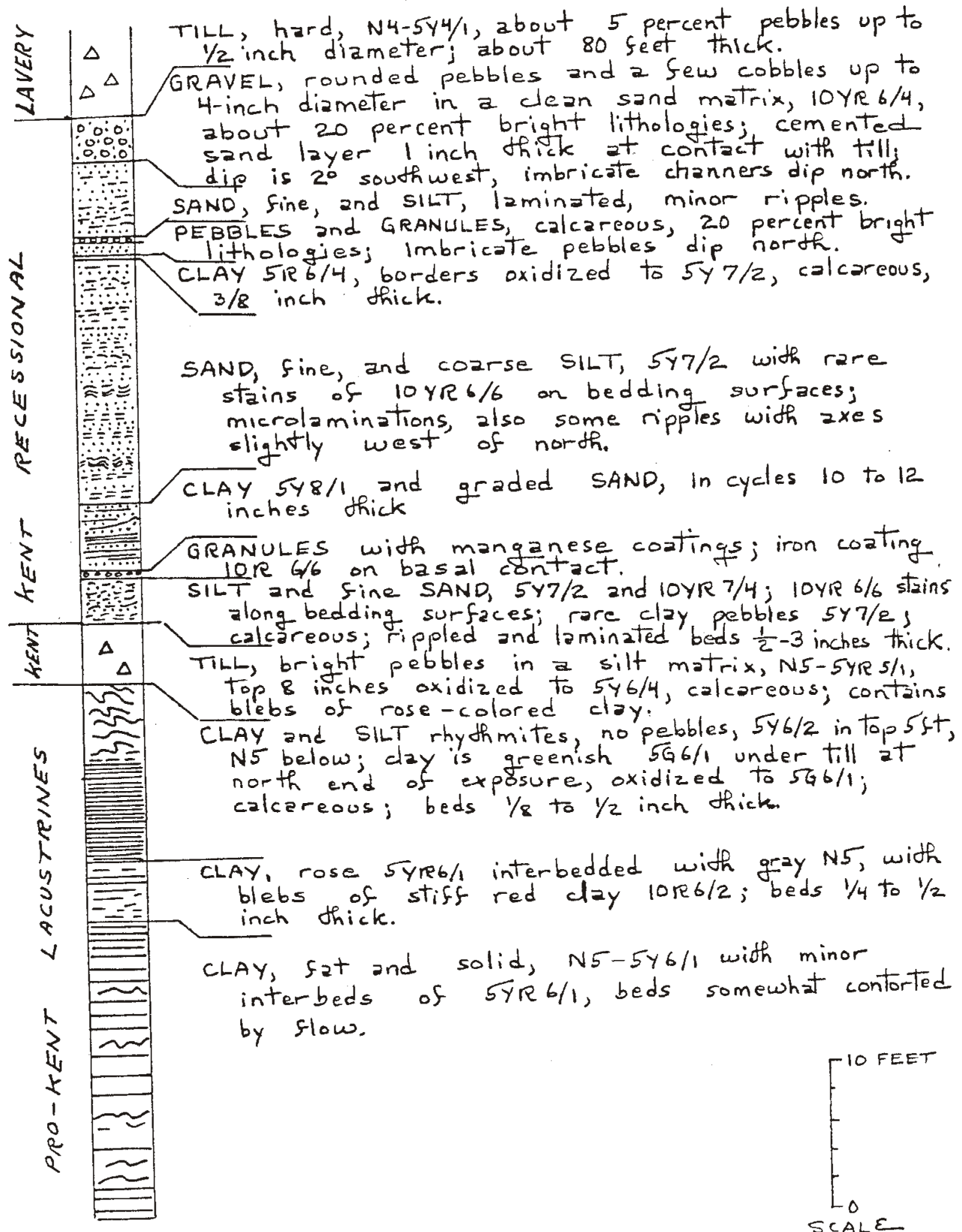
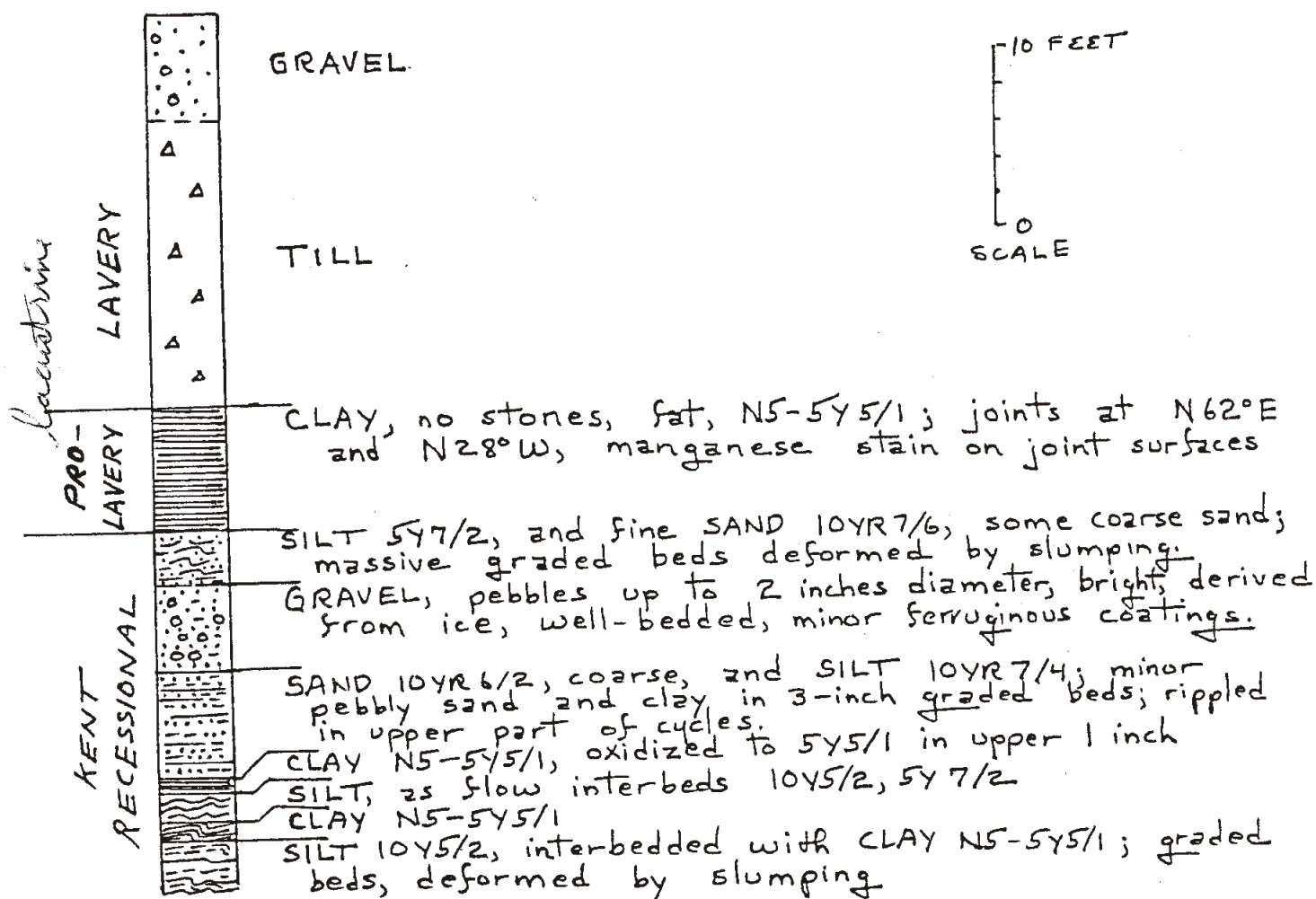


FIGURE 11

Riceville Station Section
 East bank Buttermilk Creek
 near railroad crossing on Fox Rd.
 Ashford Hollow Quad.



~~~~~ CREEK, ~ 1320'



## FIGURE 12

BUTTERMILK CREEK SECTION  
 2000' north of culvert under  
 West Valley Rd. West Valley Quad.

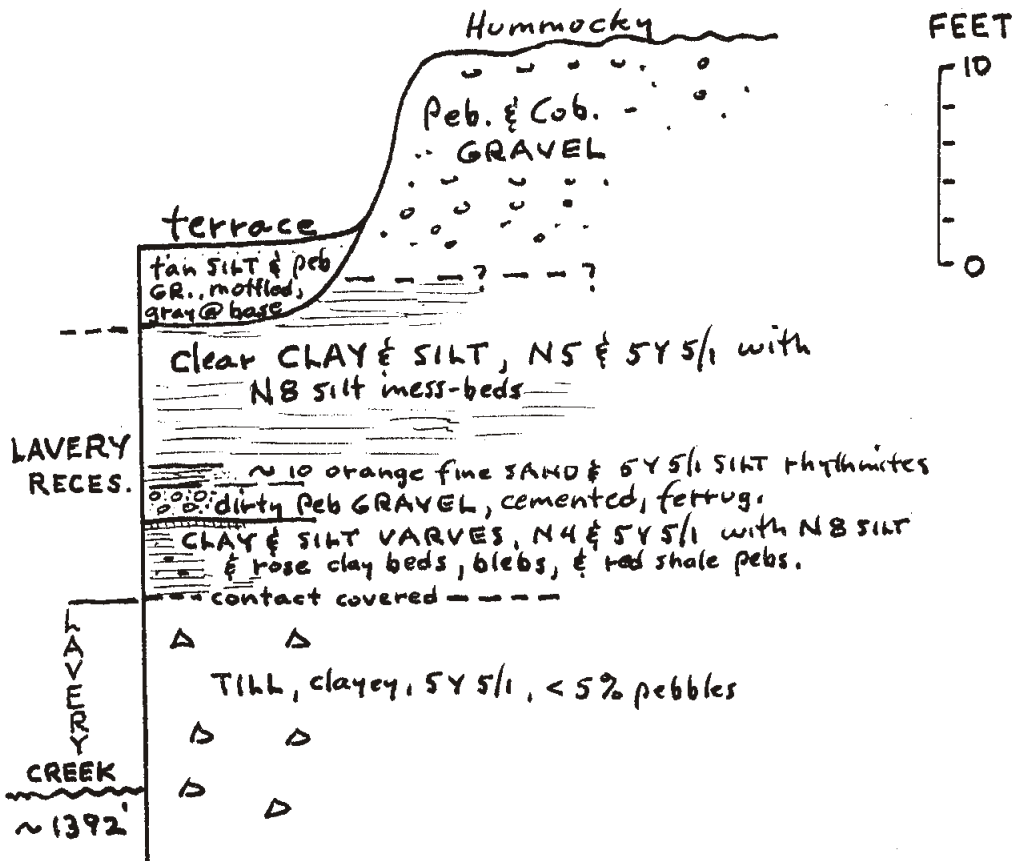
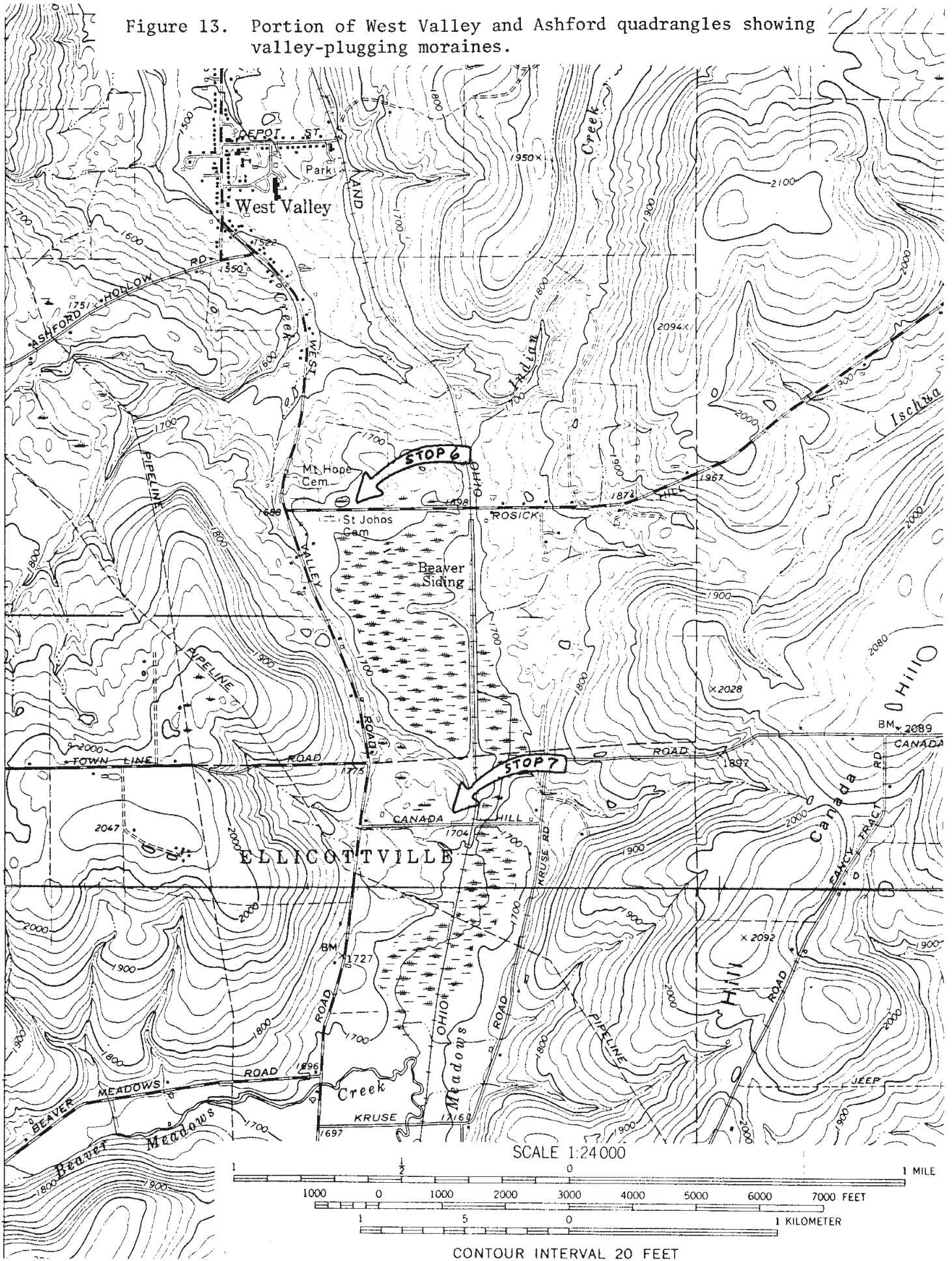
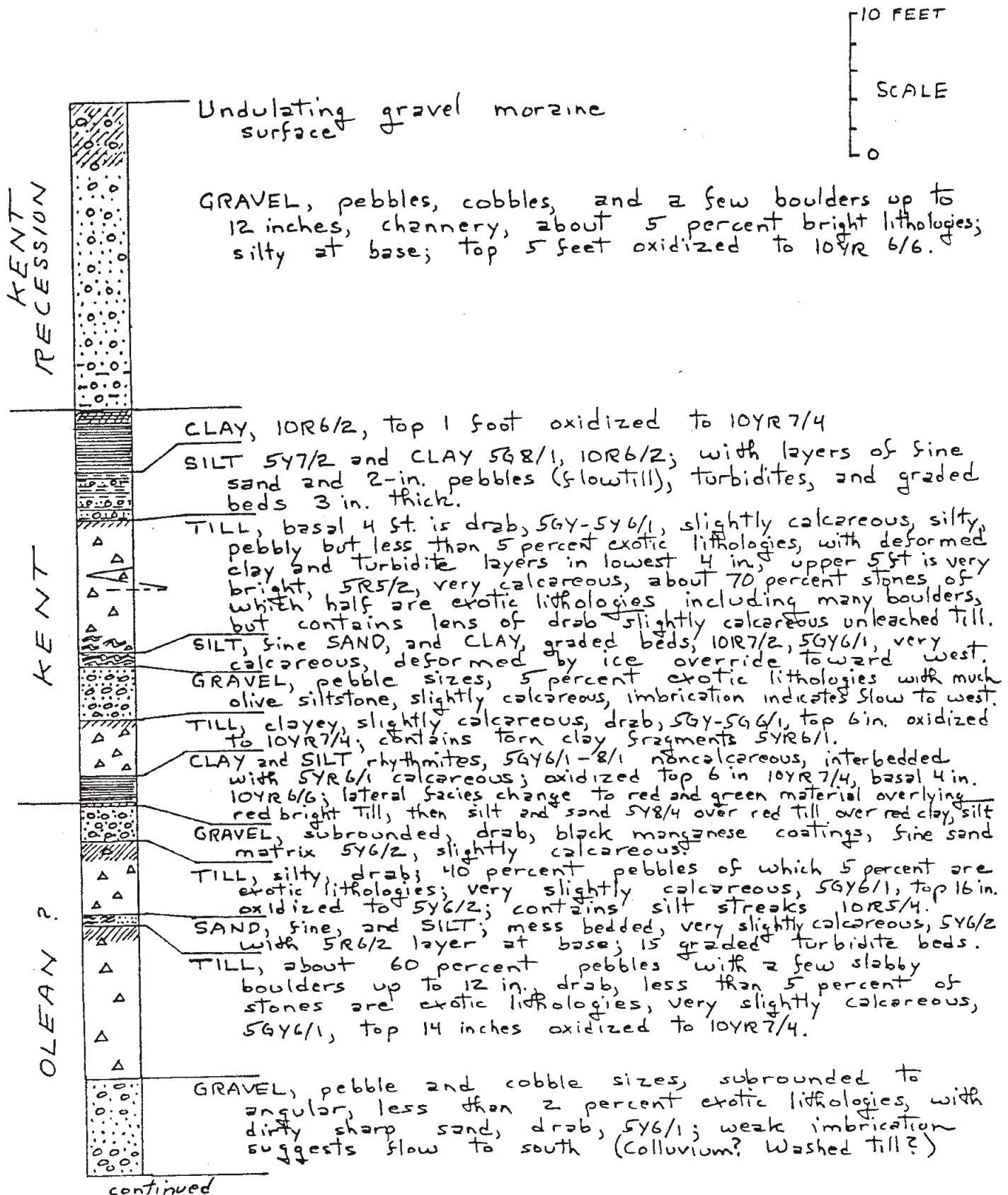


Figure 13. Portion of West Valley and Ashford quadrangles showing valley-plugging moraines.

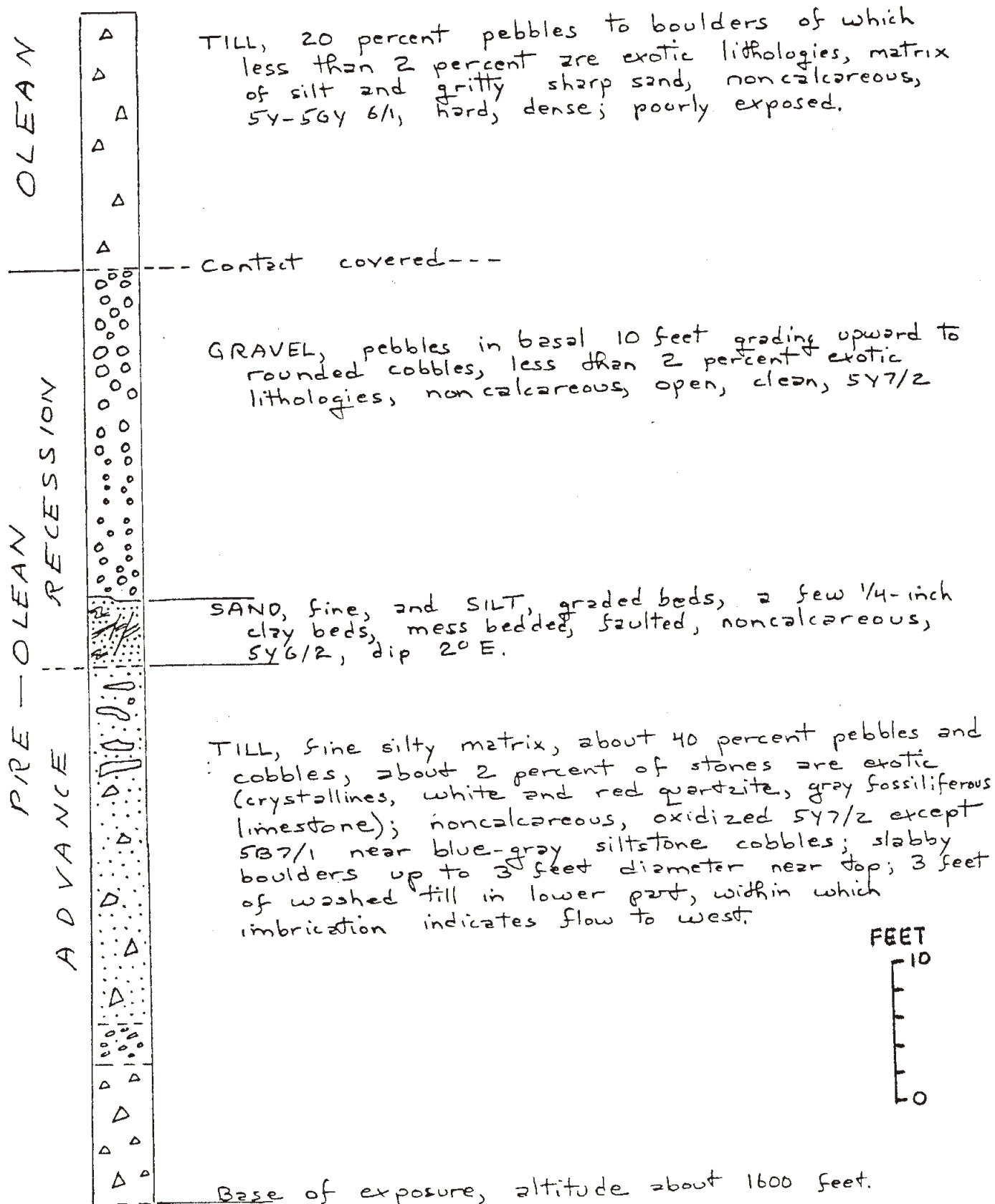


## FIGURE 14

SNAKE RUN ROAD SECTION  
Roadcut section along east side of Snake Run Road,  
1.8 miles southwest of Ashford Hollow  
Ashford Hollow Quad.



## SNAKE RUN ROAD SECTION (contd.)





# FIGURE 15 TIMBER LAKE SECTION

X on road north of lake,  
Ellicottville Quad.

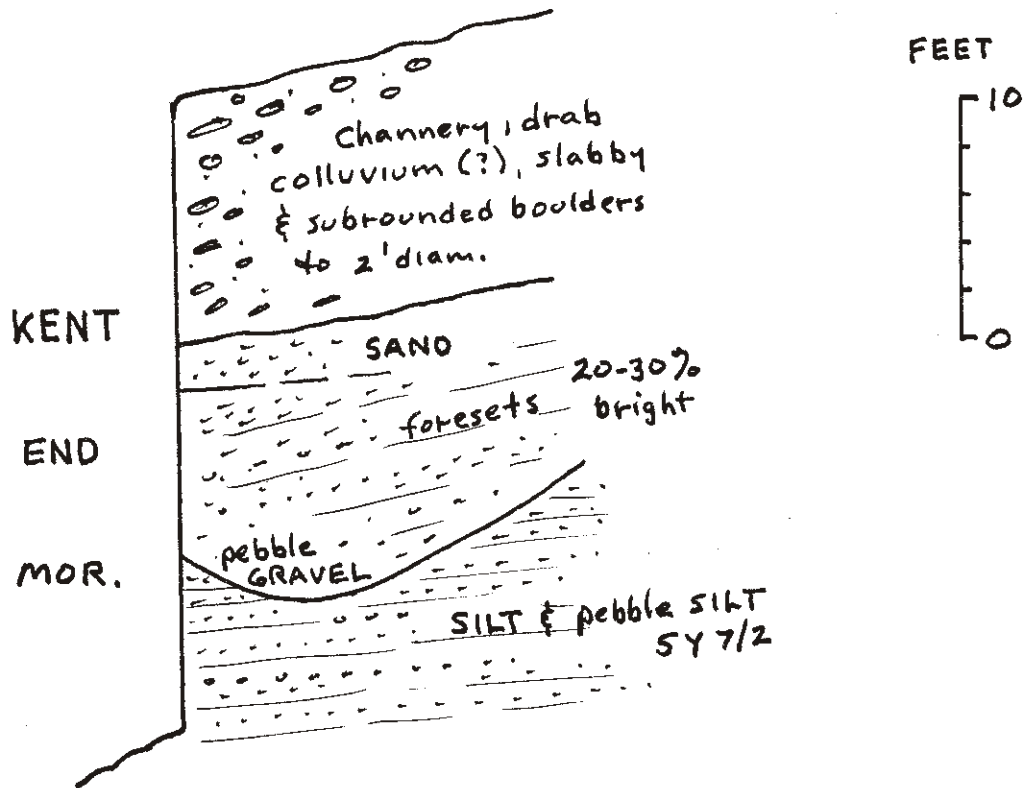


FIGURE 16

## CONNOISARAULEY CREEK

DATED WOOD-BEARING  
ALLUVIAL TERRACE

east bank, 1000 feet north of  
Connoisarauley Rd.  
Ashford Hollow Quad.

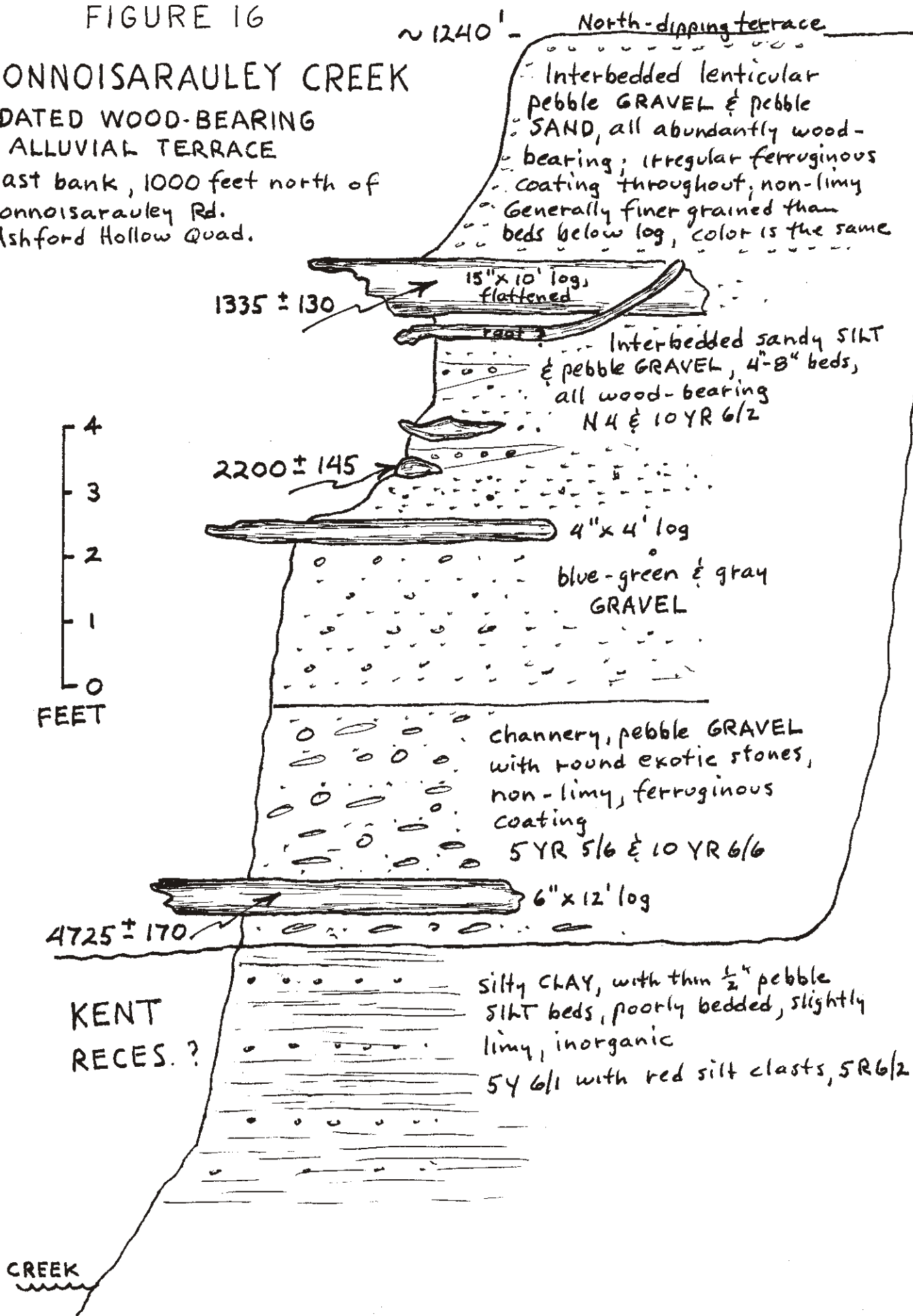
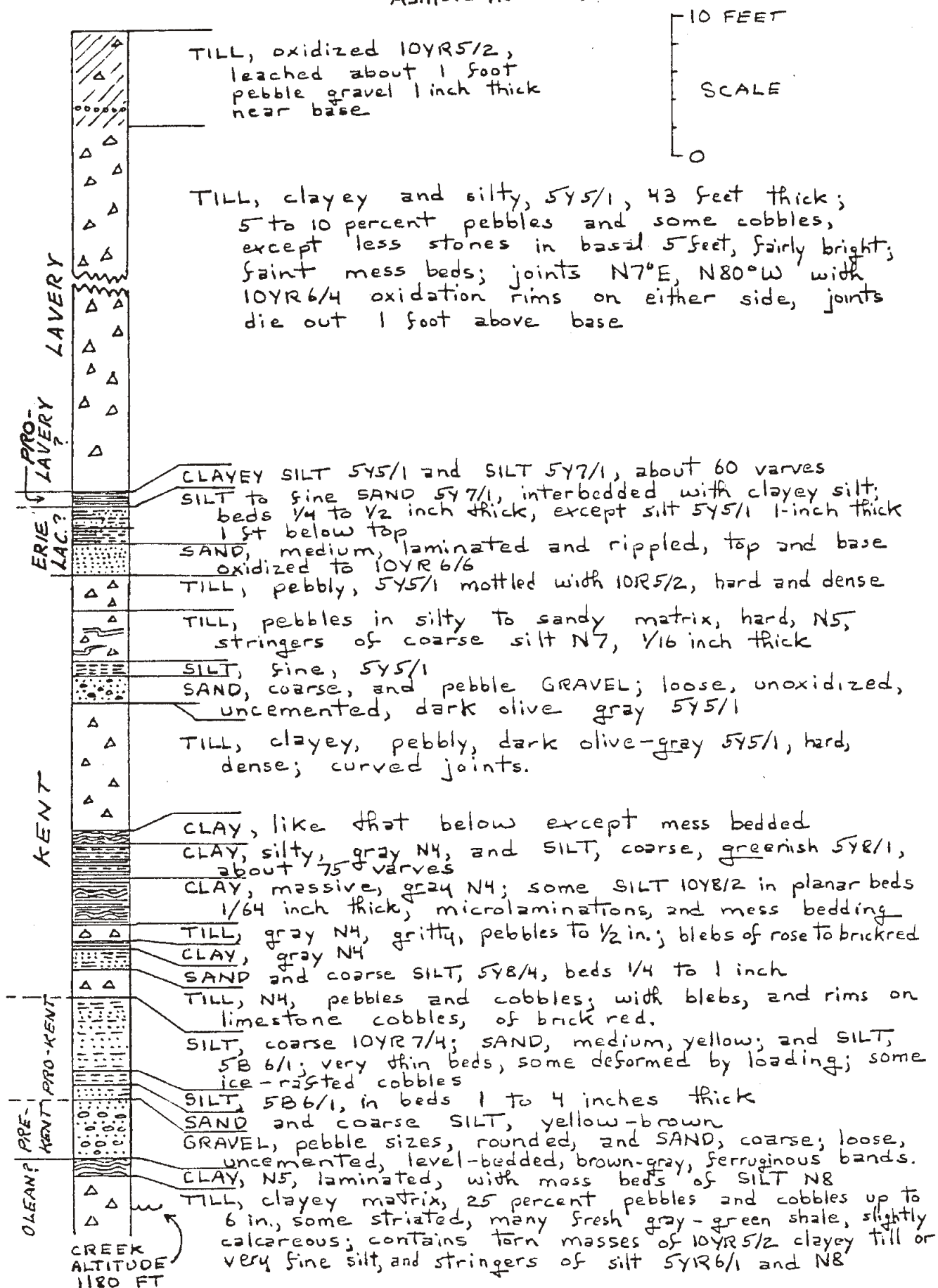


FIGURE 17

# CONNOISARAULEY CREEK SECTION

West bank, 3000 feet west-northwest  
of Connoisarauley Road bridge  
Ashford Hollow Quad.



# GEOLOGIC STUDY OF THE BURIAL MEDIUM AT THE LOW-LEVEL RADIOACTIVE-WASTE BURIAL SITE, WEST VALLEY, NEW YORK

R.H. Fakundiny, R.H. Fickies, H.H. Bailey  
R.H. Dana, Jr., and S.A. Molello<sup>1</sup>

The West Valley low-level radioactive-waste burial site is located in Cattaraugus County, approximately 50 km (30 miles) south of Buffalo, New York. Average elevation is 450 m (1400 feet) above sea level and 260 m (800 feet) above Lake Erie.

The burial site is an area of 4.5 hectares (11 acres) within the 1 km<sup>2</sup> (225 acres) fenced security area of the Western New York Nuclear Service Center. This security area also encompasses a nuclear fuel reprocessing plant with 4 interim high-level waste storage tanks and a second burial area for spent fuel hardware (hulls and ends) and other waste from the reprocessing operations.

Because so many new geological features, such as sand lenses, newly formed erosion scars, and landslides, had been discovered in the area since the original site investigations, it was decided jointly by the NYSGS and the USGS that new geologic mapping of the site and the region around the site was required to determine the geological framework for groundwater movement in the burial area. This work was performed by Robert G. LaFleur. Further work by Allan Randall and David Prudic of the USGS and by Jeffrey Pifer and Wendy Goldschmidt of the NYSGS has refined the work of LaFleur at the site and is reported below. Jon Boothroyd and Barry Timson have been continuing the study by evaluating the geomorphic processes acting in the Buttermilk Creek drainage basin.

The trenches, which contain the low-level radioactive waste, at West Valley, New York, are emplaced in surficial glacial deposits (Lavery, Late Wisconsinan) consisting of a clayey silt till approximately 30 m thick. These deposits overlie lacustrine deposits and till (Kent, Late Wisconsinan) which in turn are inferred to overlie tills and lacustrine deposits (Olean, Late (?) Wisconsinan) which are not exposed in the area of the site. The burial till contains discontinuous, randomly distributed, distorted, silt, sand and gravel pods and lenses. Because of the discontinuous lateral and vertical distribution of these features within the enclosing very low-permeability clayey silt, they do not appear to form preferential permeability systems for ground-water movement.

The burial till has a very low permeability with vertical permeabilities ranging from  $1.25 \times 10^{-8}$  cm/sec to  $4.33 \times 10^{-8}$  cm/sec and horizontal permeabilities of  $3.72 \times 10^{-7}$  and  $7.46 \times 10^{-7}$  cm/sec. Landslide and slope failures exist in the general area and small-scale slope movements occur in man-made ground on the margins of the site.

<sup>1</sup>New York State Geological Survey, Cultural Education Center, Albany, N.Y. 12230

## GLACIAL STRATIGRAPHY IN PART OF BUTTERMILK CREEK VALLEY

BY

ALLAN D. RANDALL

U.S. GEOLOGICAL SURVEY, ALBANY, N.Y.

The U.S. Geological Survey is investigating the sources and movement of ground water near several low-level radioactive-waste burial grounds across the nation, including one at West Valley in the town of Ashford, Cattaraugus County, New York. The objective of this study is to develop geohydrologic guidelines for the siting of radioactive-waste burial grounds. Part of the work at West Valley has been done in cooperation with the New York Geological Survey, the lead agency responsible for a separate, comprehensive evaluation of this particular burial ground. A list of reports released to date on various aspects of hydrology and geology near the West Valley site is included in this guidebook.

Glacial stratigraphy in and around the town of Ashford has been described by La Fleur (1979), largely on the basis of a few well-exposed but widely separated geologic sections. Because of the need to define groundwater flow paths and rates near the burial ground more closely than is usual in water-resources investigations, it was important to determine rather precisely the stratigraphy and geometry of the glacial drift nearby. Therefore, numerous closely spaced sections were measured in the bluffs along Buttermilk Creek and its tributaries from Riceville Station to the mouth of Franks Creek (Fig. 1), and were compared to the logs of test holes drilled nearby. The first interpretation of these results is included in plates 7-8 of La Fleur (1979); some revision and additional detail are presented in this paper. Further refinement is expected in the final report on the U.S. Geological Survey study.

The steep walls of the inner valley of Buttermilk Creek provide abundant evidence of mass movements -- tilted trees, rotated reverse-sloping slide blocks, and amorphous mudslides that encroach upon stream channels. At first, it was expected that shallow excavations on these slopes might be a useless and potentially misleading venture in repeated reexamination of the same material on its way from the top to the bottom of the slope. In many localities, however, a valid geologic section can be pieced together from a stepwise succession of auger holes 5 to 20 feet deep, perhaps interspersed with shovel excavations on small, steeper scarps or recent slide scars. Nearly everywhere, the uppermost 1 to 3 feet consists of colluvium, which is easily recognized by its soft texture, high water content, and embedded leaves. Evidence that the underlying materials were in place was provided by similar sequence and altitude of units in nearby sections, in some sections by similar results from overlapping auger holes started at different altitudes, and by lack of obvious colluvial or mixed materials except for the uppermost 1 to 3 feet.

Lithostratigraphic units identified within the glacial drift of Buttermilk Creek valley from Riceville Station to the mouth of Franks Creek are described in Table 1. Their inferred geometry is illustrated in three cross sections (Figs. 2-4). The location of the cross section



lines, and of the geologic sections, test borings, and wells on which the table and cross sections are based, are shown in Figure 1. The descriptions that follow are based in part on those of La Fleur (1979) and in part on independent observations. Several of the individual geologic sections and well logs prepared during the current study are included at the end of this paper. Geologic names in this paper are those of La Fleur (1979).

The striking difference in lithology between the drift above and below unit 7 is a difference of degree more than of kind. Essentially, units 5 and 6 together (Lavery drift of La Fleur, 1979) consist predominantly of silt-clay till with subordinate, commonly displaced small fragments of lacustrine deposits. By contrast, units 8-11 (Kent drift of La Fleur, 1979) consist predominantly of in-place lacustrine clay, silt, and locally fine sand, with subordinate till and other evidence of the periodic brief presence of floating or readvancing ice. For example, large folds were observed at sections 1J and 1C; zones replete with pebbles, sandy silt blebs and till chunks were recognized in many test holes and geologic sections. Each ice advance into north-draining Buttermilk Creek valley presumably created a similar potential for ponding; why the difference in response? Did reduced water depth due to accumulation of drift reduce buoyancy of the ice? It probably did, but not abruptly. The deeper northern part of unit 5 is lower in altitude than much of units 8-10 (Fig. 3). Did erosion progressively lower the spillway(s) into Allegheny basin south of West Valley? Mapping by La Fleur (1979) shows no evidence of appreciable spillway erosion during or after deposition of these units. Could a change in regional ice-front alignment have permitted frequent westward drainage through a spillway on the north flank of Dutch Hill (Fig. 1) during deposition of unit 5, thereby lowering lake levels below 1,500 feet and grounding the ice much of the time, whereas during deposition of units 8-11 the lake remained generally at the 1,700-foot level and was not completely drained even when the ice retreated briefly?

The widespread presence of gravel (unit 7) between the near-surface till and the predominantly lacustrine sequence beneath supports La Fleur's (1979) interpretation of a significant interruption in glaciation, which he referred to the Erie Interstade. The gravel is probably absent below the burial ground (Fig. 2) owing to glacial erosion although a layer only a foot or so thick might have been missed in some test holes. La Fleur interpreted the gravel in Sections A, F, and 1E (Fig. 3) as kame-delta topsets and predicted (1979, p. 13) the presence elsewhere at this horizon of channel gravels deposited by subaerial drainage during the Erie Interstade. The widespread thin gravel (unit 7) of consistent elevation inferred in Figure 3 suggests a fluvial blanket comparable to unit 4 but thinner, rather than alluvium along distinct incised channels. The fine sand and silt (unit 8) underlying the gravel near section A is probably deltaic; the northward coarsening inferred in Figure 3 suggests a kame delta deposited by meltwater at the ice front. On the other hand, the low altitude and the northward and westward flow sense in the sand and silt at section A suggest sediment derived from local streams deposited in a persistent late-glacial lake.

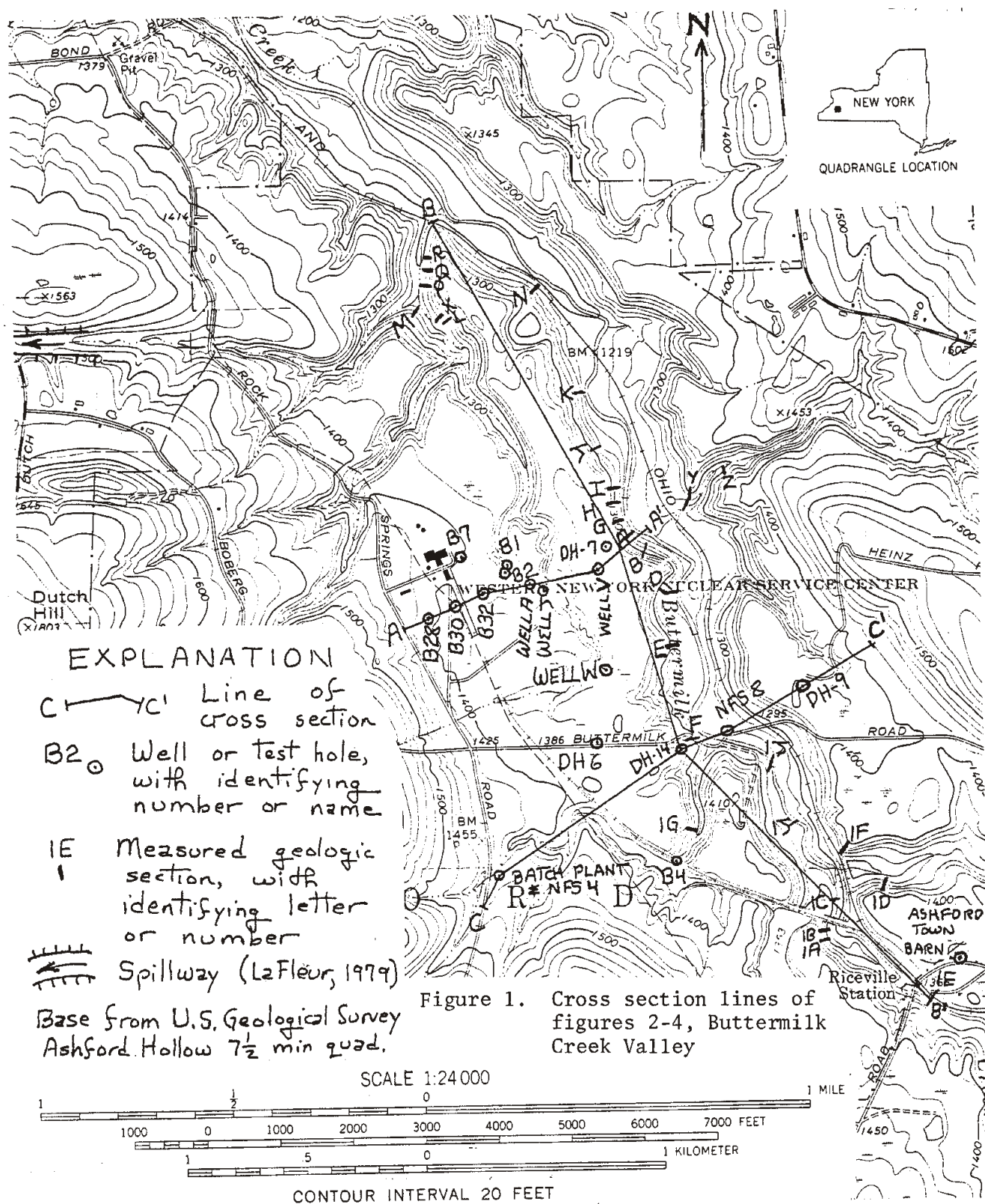
The correlations in Figures 2-4 are based on simple principles analagous

to walking out a contact -- one obtains sections close enough together that the contact between any two units of interest is at nearly the same altitude in successive sections and thus it can be drawn between them with confidence. No unique mineralogical or textural properties of particular units have been identified; thus, it is possible that some miscorrelations have been made. For example, the sequence of till/thin proglacial lacustrines/gravel/fine sand/silt and clay in sections 1B and 1C (north of Riceville Station) is quite similar to that of units 5 to 9 in sections F, B, and A farther north. Therefore, correlation of these units with section 1B was considered, which would require that unit 5 (Lavery till of La Fleur, 1979) be split into two tongues in this locality. This choice was rejected only because of the apparent continuity of other gravel and lacustrine beds above section 1B. Extension of some sections and interpolation of additional sections is planned and should eliminate most questions, but in the absence of unique marker beds some uncertainty may remain.

Figure 4, based entirely on test holes and sections drilled and described by others prior to the current study, illustrates some problems in correlation of the deeper deposits. Units 4, 5, and 7 can be recognized all across the valley at about the same altitudes found elsewhere. At greater depth, however, test-hole logs seem mutually inconsistent. Samples from DH-6, DH-9, and DH-14 were examined in 1962 by geologist H.G. Stewart (writ. comm., 1962). DH-9, sampled only at 20-ft intervals, apparently penetrated a thick section of lacustrine sediment below unit 7; no till equivalent in altitude to unit 10 was recognized. At DH-6, by contrast, till or possible till was reported in much of the interval occupied by the lacustrine deposits of unit 9 in nearby sections and holes. La Fleur (1979, plate 8) correlated the deeper deposits penetrated by DH-6 with a succession of Wisconsin ice advances, presumably reasoning that each gravel layer could represent an interglacial interval of subaerial drainage. This correlation implies that post-Illinoian ice advances caused little erosion in Buttermilk Creek valley and made no contribution to scouring the bedrock valley, the shape of which is inferred in Figure 5. A different interpretation, sketched in Figure 4, implies either that a) stratified silt and clay with ice-rafted pebbles and grit found in cores from DH-6 was misinterpreted as till, or b) readvancing ice tongues were grounded near DH-6 and deposited till, but at the same time they were afloat elsewhere and produced disturbed pebbly zones in unit 9. Conceivably the ice could have been grounded near DH-6 but not elsewhere if remnants of older drift were present on the valley floor only in this locality. In either case, this correlation implies an active ice margin locally at the time of unit 9 (Kent drift of La Fleur, 1979).

#### REFERENCES CITED

- La Fleur, R.G., 1979, Glacial geology and stratigraphy of Western New York Nuclear Service Center and vicinity, Cattaraugus and Erie Counties, New York: U.S. Geol. Survey Open-File Rept 79-989, 17 p.
- Nuclear Fuels Services, 1962, Safety analysis, spent fuel reprocessing plant: Part B of license application to the U.S. Atomic Energy Comm., vol. 1.



## EXPLANATION, Figures 2-4

Site identification (written vertically, above land surface)

A, B, C, 1A, 1B, etc. Measured geologic section (F by H.G. Stewart, 1E by R. La Fleur, remainder by A.D. Randall and/or D.E. Prudic: all written comm.)

Well J, Well V, etc. Test hole drilled for the current study

DH6, DH14, etc. Engineering test boring drilled in 1962 as part of site evaluation; drive-spoon samples examined by geologist

B1, B7 etc. Engineering test boring drilled for engineering design of proposed structures; log by Empire Soils Investigations

Other names: Wells or test wells drilled for private owners.

Materials identification (written horizontally beside each well or section)

T till, silty clay matrix  
t till, stony silty clay

G gravel

S fine to coarse sand


F fine to very fine sand


L silt

Y clay

P pebbly

\* Zone with abundant pebbles and/or sandy silt or till blebs and/or distorted bedding

 Macro-scale folding (1 ft amplitude)

 Top of bedrock

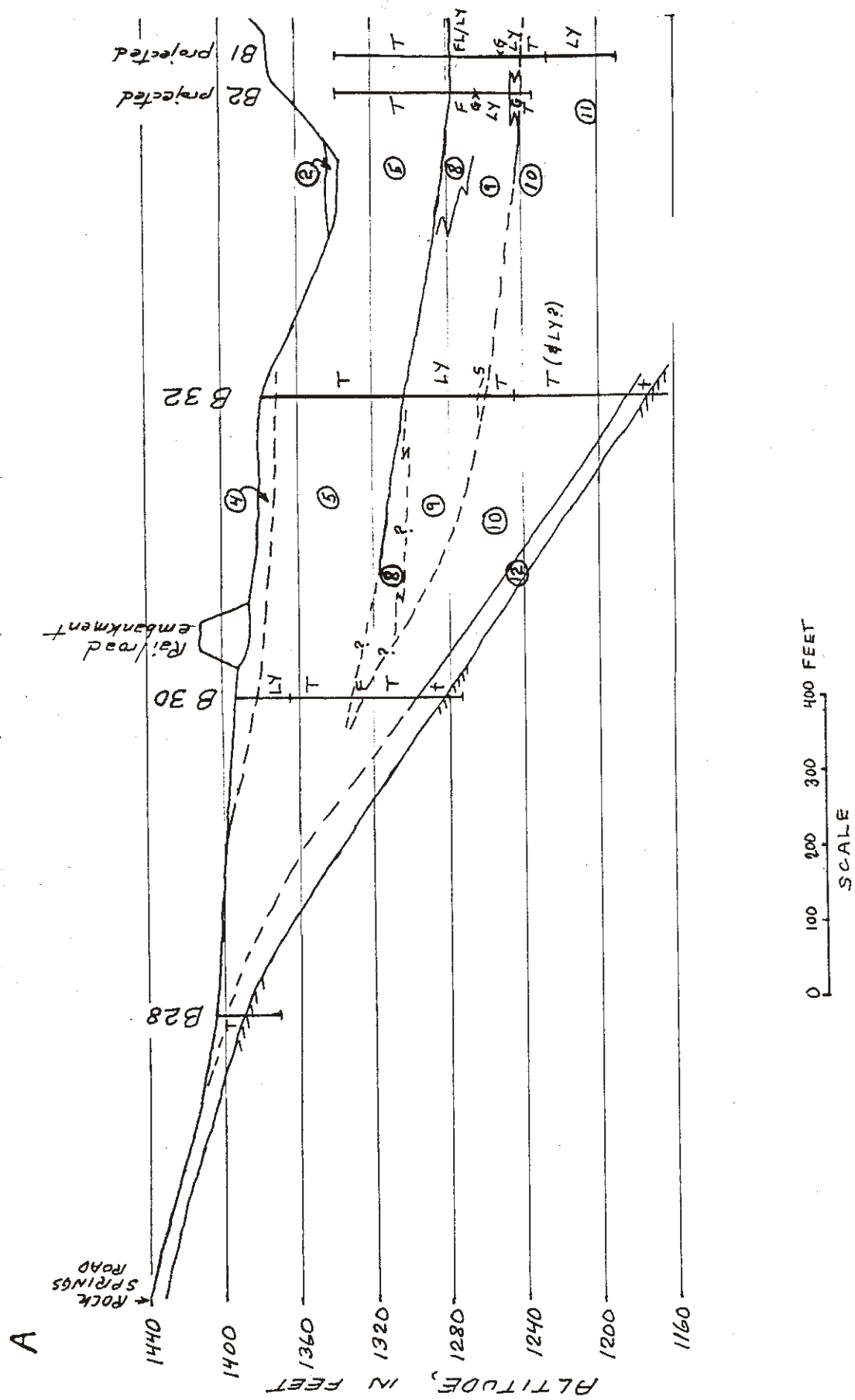
Correlation

① ② etc. Lithostratigraphic units, described in table.



| Unit Number                                                           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (youngest)<br>(1) (2) (3)                                             | Postglacial colluvium, alluvium, terrace alluvium (not shown in some cross sections).                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| (4)                                                                   | Gravel and sand, deposited by local streams draining northward in low areas, perhaps around lingering ice, on a freshly exposed till plain.                                                                                                                                                                                                                                                                                                                                                                                                                        |
| (5)<br>16 ft (Piceville Station) to<br>130 ft (mouth of Franks Creek) | Till; silty clay matrix with about 25 percent sand and stones; grades or interfingers randomly into similar till containing torn, deformed wisps and blebs of light-gray silt; incorporates randomly oriented pods or masses of stratified sand, gravel, silt, and rhythmic clay-silt which have lateral dimensions of a few meters or less and seem to be more abundant in the interval from 1,350 to 1,370 feet altitude.                                                                                                                                        |
| (6)<br>0-8 ft                                                         | Clay or clay-silt rhythmites: commonly grades up into layered clay with scattered pebbles, then into the overlying till; proglacial. Widespread but commonly less than 2 ft thick and easily overlooked. Bottom 1-2 cm commonly lime cemented.                                                                                                                                                                                                                                                                                                                     |
| (7)<br>0-15 ft<br>0-25 ft(?)                                          | Gravel: pebbles and small cobbles in fine to coarse sand, clean to moderately silty; where thick, may contain interbedded sand or clay layers or grade down into pebbly sand. Recognized in all sections and test holes near Buttermilk Creek and in some to the west (including E7, DH6, and well V on fig. 1).                                                                                                                                                                                                                                                   |
| (8)<br>0-28 ft                                                        | Sand, chiefly fine to very fine, interbedded with silt that becomes predominant with depth; grades into underlying unit. Thickest east and west of the burial ground; may be gradationally present at top of the lacustrine section further south.                                                                                                                                                                                                                                                                                                                 |
| (9)<br>20-50 ft                                                       | Interbedded coarse silt, fine silt, and clay, generally in rhythmic partings and layers up to several millimeters thick; some thick fine silt layers, but close inspection commonly reveals regular partings of coarse silt; some layers with internal deformation; olive gray, except some clay layers pale grayish red. Most sections include one or more intervals containing scattered pebbles, blebs or streaks of reddish-brown or greenish-gray sandy silt, rare masses of olive-gray till a few centimeters to a foot thick, and disturbed stratification. |
| (10)<br>10-25 ft                                                      | Till, similar to unit 5, perhaps darker and less clayey; locally includes deformed silt wisps, crude stratification, and rare inclusions of grayish-red till. Currently inferred distribution (fig. 3) suggests a pulsating readvance.                                                                                                                                                                                                                                                                                                                             |
| (11)                                                                  | Clay and silt, locally deformed in folds with amplitude of a few feet; exposed only south of Buttermilk Hill Road. As much as 350 ft of glacial drift lies below Buttermilk Creek grade along the axis of the bedrock valley; a few deep wells and test holes report predominantly lacustrine clay-silt and (or) till. Two wells (NFS #8, Ashford Town Barn; fig. 1) penetrated gravel of modest permeability just above bedrock at depths close to 300 ft.                                                                                                        |
| (12)<br>(oldest)                                                      | Till, much more sandy and stony than units 5 and 10, exposed and reported in test holes near the west side of the valley, atop or near bedrock.                                                                                                                                                                                                                                                                                                                                                                                                                    |





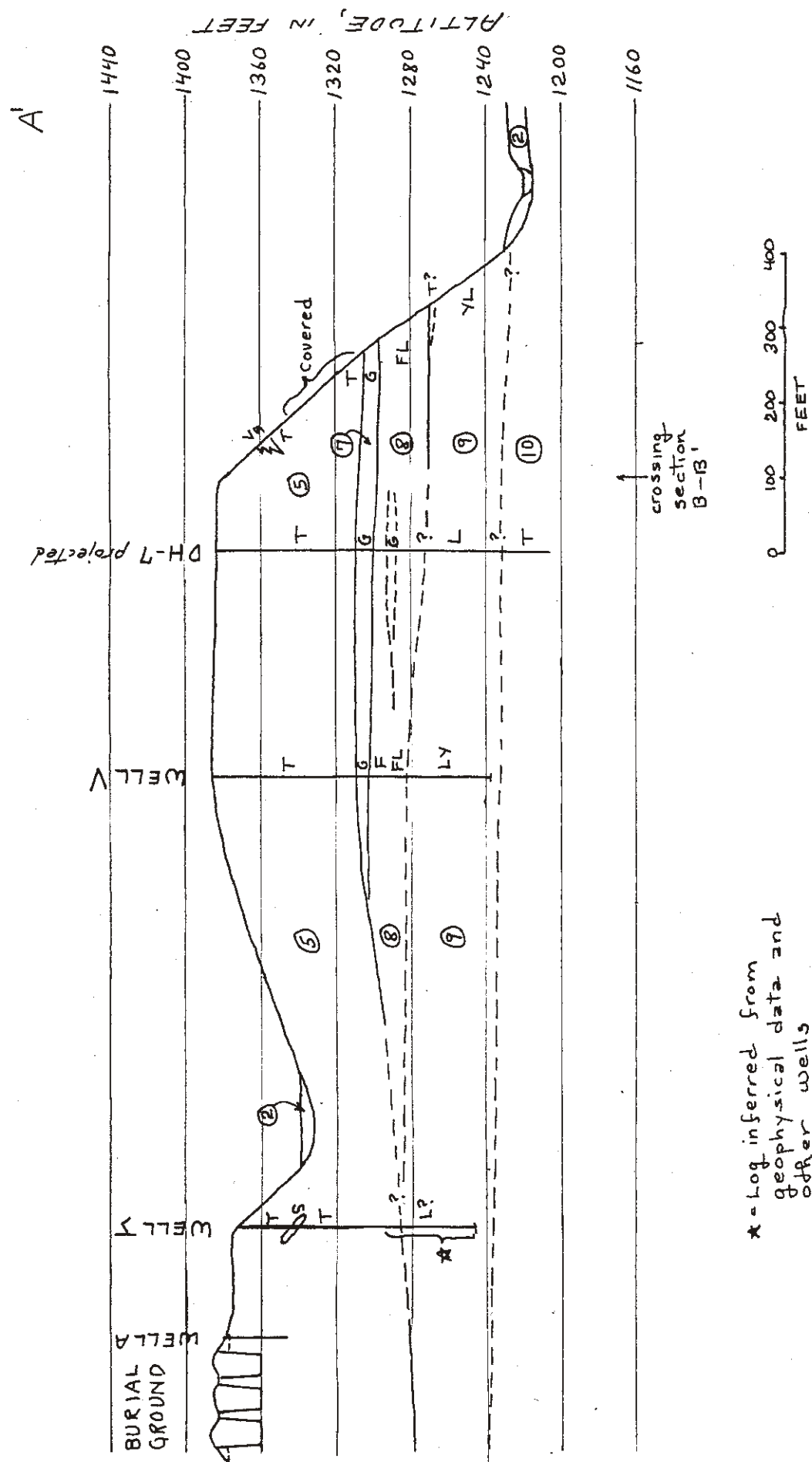
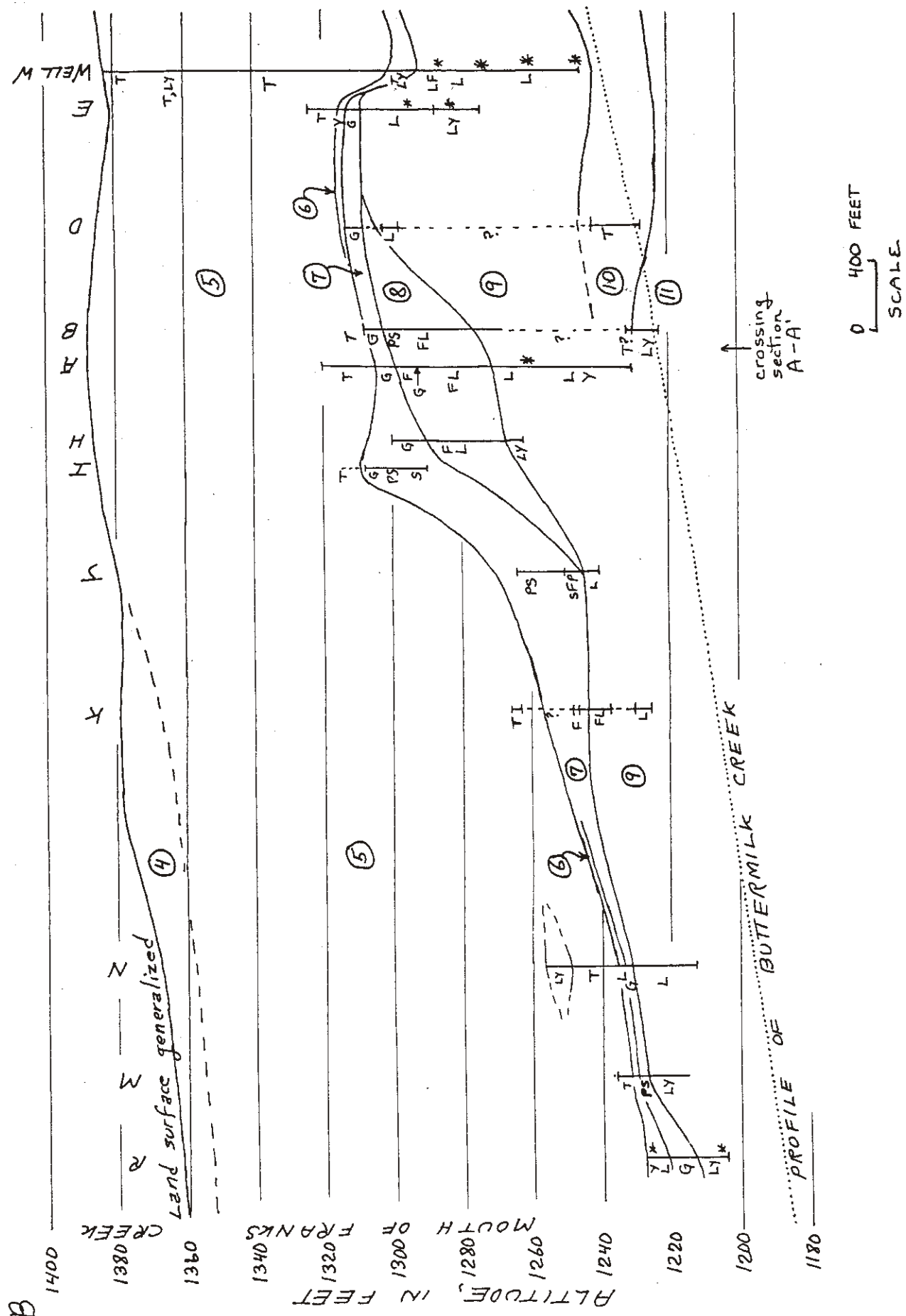


FIGURE 2



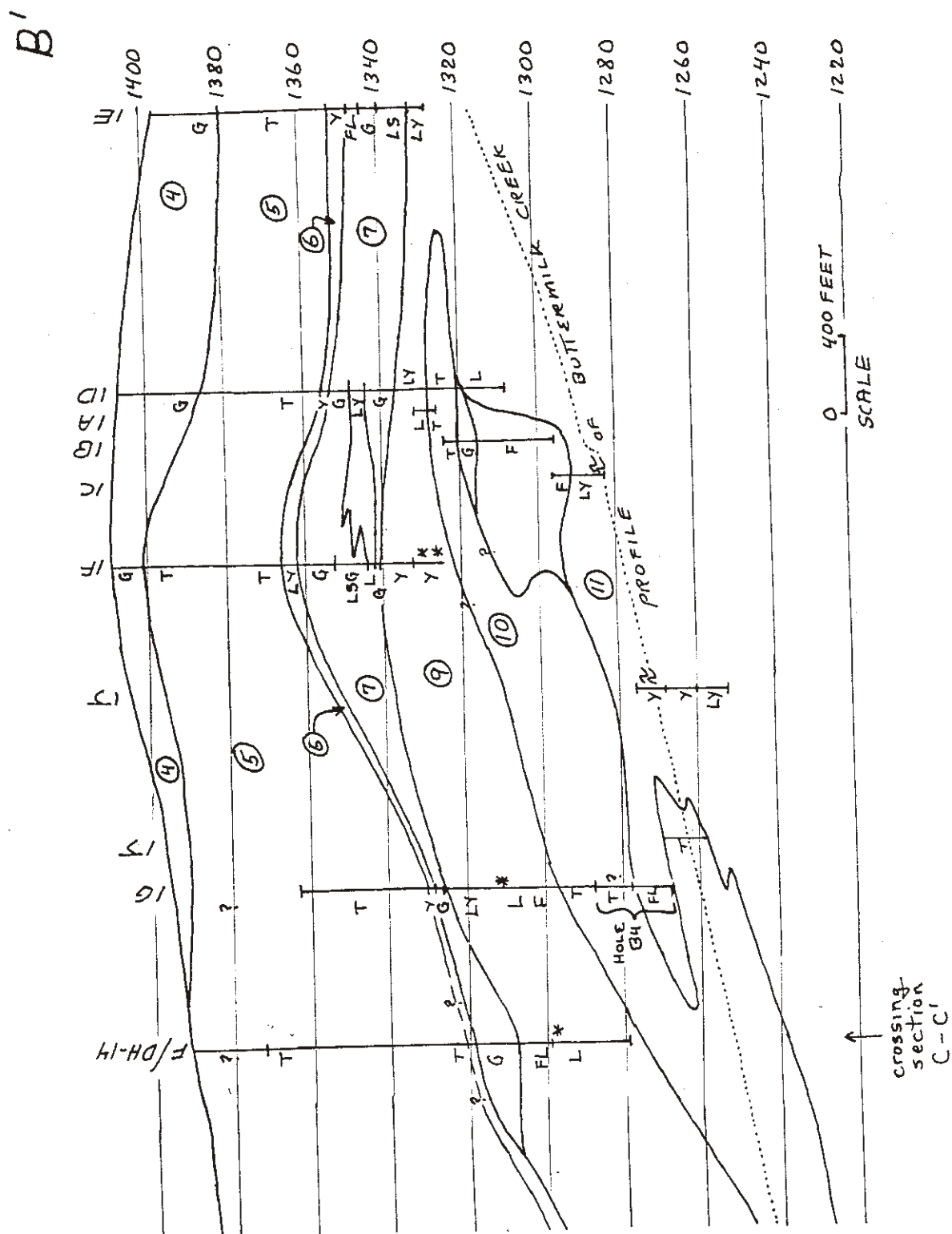


FIGURE 3

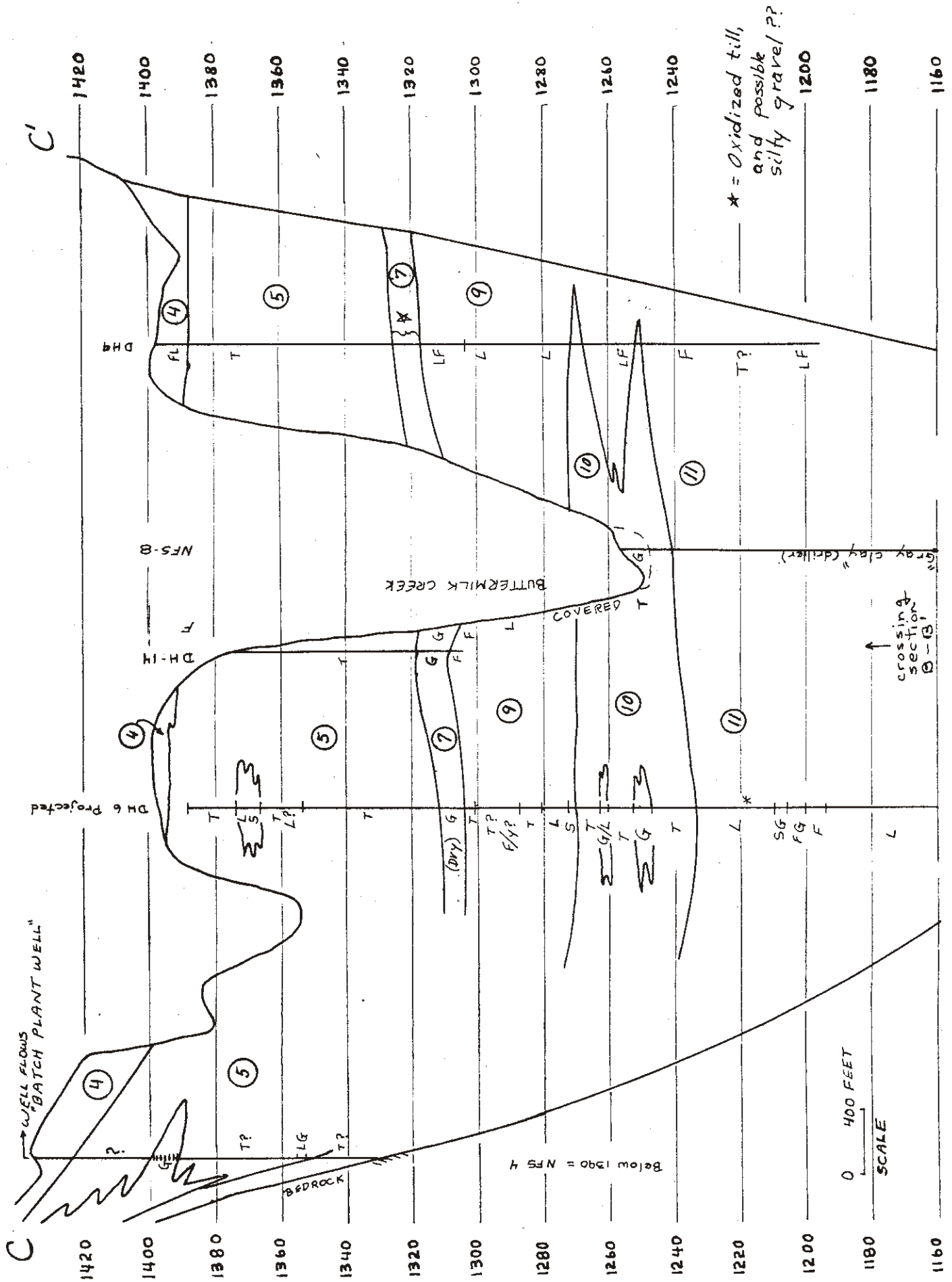
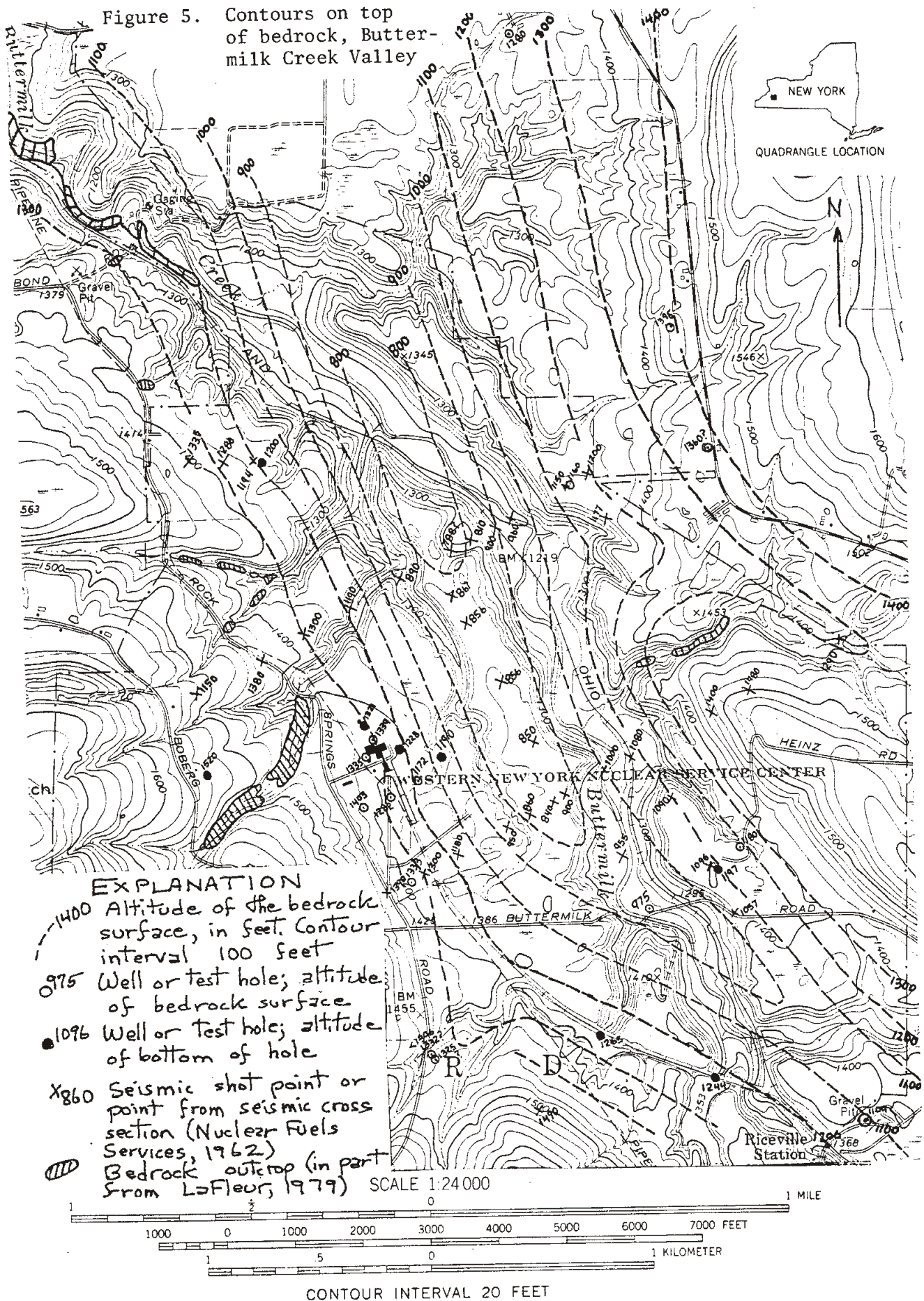


FIGURE 4



Figure 5. Contours on top of bedrock, Butter-milk Creek Valley



## GEOLOGIC SECTIONS AND TEST BORINGS

Logs of 8 geologic sections on the bluffs along Buttermilk Creek and tributaries, and 2 test wells, are given on the following pages. Sections were based on multiple auger holes and small exposures examined by A.D. Randall and/or D.E. Prudic 1976-79; altitudes were determined by hand-levelling up from creek grade whose altitude was estimated from a topographic map of the Western New York Nuclear Service Center (5-foot contours, 1 inch = 400 feet) by Lockwood, Kessler, and Bartlett. Well logs were based on examination of cable-tool drill cuttings supplemented by split-spoon cores, the latter collected at 5 to 10-foot intervals below an altitude of 1325 feet; altitudes were determined by spirit levelling from nearby benchmarks. Locations of wells and sections are shown in Figure 1.

|               |                                                                                                                                                                                                                                                                            |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Site E</u> | West bluff of Buttermilk Creek<br>along nose immediately north of powerline<br>about 1500 ft north of Buttermilk Road                                                                                                                                                      |
| 1380          | Terrace Surface                                                                                                                                                                                                                                                            |
| 1380-1324     | Not examined                                                                                                                                                                                                                                                               |
| 1324-1315     | Till, predominantly silt and clay with 5-15 percent stones and coarse sand; oxidized top 3 ft, unoxidized with oxidized mottling and/or oxidized fractures 3-9 ft; pebbly at base.                                                                                         |
| 1315-1313     | Clay or silty clay, with deformed partings and thin layers of silt; many layers nearly free of pebbles and coarse sand, others have abundant pebbles; many layers have reddish-gray silt blebs; mainly unoxidized, but strongly oxidized yellowish brown 0.5 feet at base. |
| 1313-1309?    | Gravel, pebbles with a few small cobbles, slightly silty; layers of pebbly sand; thickness at least 2 ft, base not examined; oxidized.                                                                                                                                     |
| 1309?-1287    | Silt, well layered, with a few partings or thin layers of clay and rare thin layers of silty very fine sand; oxidized at top, variably oxidized below 1394 ft; numerous irregular masses as large as 10 x 20 mm of grayish-red silt with a few granules at about 1294 ft.  |
| 1287-1274     | Clay and clayey silt, with some thin silts, generally in regular rhythmic layers; clays are reddish or purplish gray; some blebs and thin lenses of brighter grayish-red silt, a few layers with scattered pebbles; a few layers show internal deformation.                |
| 1242          | Buttermilk Creek grade                                                                                                                                                                                                                                                     |

Site M                      Left bank of Franks Creek and Right bank of tributary,  
at junction 1200 feet upstream from railroad

| <u>Altitude (feet)</u> | <u>Materials</u>                                                                                                                                                            |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1246                   | Top of sharp interstream ridge                                                                                                                                              |
| 1246-1242              | Covered; in part oxidized till interbedded with wisps of sand. Possibly colluvium.                                                                                          |
| 1242-1237              | Pebble gravel, poorly exposed; overlying coarse to very coarse sand with small pebbles; dark yellowish brown 10YR4/2. Possibly a remnant of older alluvium of Franks Creek. |
| 1237-1230½             | Till: silty clay with subordinate sand and pebbles, un-oxidized olive-gray 5Y5/1; 0.2 feet of layered clay and silt locally present at base.                                |
| 1230½-1228             | Sand, coarse to very fine, and fine pebble gravel, layered, oxidized moderate yellowish brown 10YR5/4.                                                                      |
| 1228-1217              | Silt and clay, interbedded in horizontal layers, light olivine gray.                                                                                                        |
| 1217-1214              | Covered.                                                                                                                                                                    |
| 1214                   | Junction of tributary with Franks Creek.                                                                                                                                    |

Site N                      Bluff along RR 1650 feet south of Franks Creek,  
1300 feet north of RR bridge over Buttermilk Creek

| <u>Altitude (feet)</u> | <u>Materials</u>                                                                                                                                                           |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1257-1249              | Clay and silt; dry and oxidized 1257-1252 feet, gray with subordinate oxidation below; a few pebbles 1255-1254 ft, otherwise none; no bedding recognized.                  |
| 1249-1235              | Till, unoxidized, sparse pebble content below top 1 foot (estimated < 5%), grades to pebble-free silty clay at 1237 feet.                                                  |
| 1235-1234.2            | Distorted thin layers of gray clay and white coarse silt, with rare blebs of rust-colored silt.                                                                            |
| 1234.2-1233.5          | Silt, with partings and layers < 3 mm thick of clay.                                                                                                                       |
| 1233.5-1232.8          | Pebble gravel and coarse sand, clean.                                                                                                                                      |
| 1232.8-1213            | Silt, in layers commonly 2 to 10 mm thick with subordinate clay partings and layers 1 to 3 mm thick; rare thin layers of silty, very fine sand; saturated below 1225 feet. |
| 1213-1196              | Not augered.                                                                                                                                                               |
| 1196                   | Buttermilk Creek grade.                                                                                                                                                    |

Site Z                      South bluff, Tributary to Buttermilk Creek North  
of Heinz Road, above bedrock in channel 1000 feet  
east of RR

| <u>Altitude (feet)</u> | <u>Material</u>                                                                                                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1310-1307              | Till: stony silt, unoxidized.                                                                                                                                                   |
| 1307-1304              | Not examined.                                                                                                                                                                   |
| 1304-1303½             | Silt and very fine sand, oxidized.                                                                                                                                              |
| 1303½-1296             | Sand, fine to coarse, with granules and pebbles, loose,<br>clean; grading to pebble gravel; layer of layered oxidized<br>clay 0.3 ft thick, also layers of medium to fine sand. |
| 1296-1291½             | Silt, with layers of silty very fine sand, oxidized; thin<br>clay layers near base.                                                                                             |
| 1291½-1289             | Silt to clayey silt, unoxidized, gray; layer silty fine<br>sand 0.1 ft thick; layer of till-like pebbly clayey silt<br>0.2 ft thick.                                            |
| 1289                   | Refusal,                                                                                                                                                                        |
| 1272                   | Bedrock exposed in creek bed.                                                                                                                                                   |



| Site 1D    | Left Bank Gooseneck Creek 600 ft upstream from RR                                                                                                                                                                                                                                                                                            |                          |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 1408       | Top of slope, level surface.                                                                                                                                                                                                                                                                                                                 |                          |
| 1408-1390  | Not examined, probably gravel.                                                                                                                                                                                                                                                                                                               |                          |
| 1390-1386  | Gravel, pebbles and small cobbles with clean coarse sand.                                                                                                                                                                                                                                                                                    |                          |
| 1386-1364  | Till; chiefly clay and silt with 10 to 15 percent gravel and coarse sand; olive gray, top 0.7 foot oxidized. Examined only at top and base; remainder covered.                                                                                                                                                                               |                          |
| 1364-1355  | Not examined, probably mostly till.                                                                                                                                                                                                                                                                                                          |                          |
| 1355-1354  | Clay, massive and very fat, unoxid., gray with faint red tinge, soft.                                                                                                                                                                                                                                                                        |                          |
| 1354-1353½ | Clay and silty clay, layers 5-10 mm thick, with scattered small pebbles; oxid., very firm.                                                                                                                                                                                                                                                   |                          |
| 1353½-1348 | Gravel; pebbles and small cobbles with clean coarse sand at top, fine gravel at base.                                                                                                                                                                                                                                                        |                          |
| 1348-1346½ | Clay, gray to pinkish gray; and silt, gray to yellow-brown, in thin discontinuous and somewhat flow-distorted layers; a few thin layers of very fine sand.                                                                                                                                                                                   |                          |
| 1346½-1344 | Clay, gray to pinkish gray, and silt, gray to brownish gray, in thin regular horizontal layers; a few thin layers of very fine sand, oxidized; calcite-cemented layer 5 mm thick at base.                                                                                                                                                    |                          |
| 1344-1336  | Gravel, small pebbles with abundant coarse sand, silty near top.                                                                                                                                                                                                                                                                             |                          |
| 1336-1329  | Clay, reddish gray, alternating with silt, olive gray, in layers generally 0.02 to 0.07 ft thick, although the clay layers include additional silt partings; grades into nearly massive silty clay that contains rare to abundant blebs of light reddish-gray clay and silt, rare wisps of silt, rare faint layering, and very rare pebbles. |                          |
| 1329-1328½ | Silt, massive, light gray, saturated; no clay or pebbles.                                                                                                                                                                                                                                                                                    |                          |
| 1328-1320  | Till, predominantly clay and silt, about 10% pebbles and coarse sand, unoxid.; a few deformed silt wisps.                                                                                                                                                                                                                                    |                          |
| 1320-1314  | Silt, interlayered with silty very fine sand, fine sand, and clay; sandy units oxid., silts variably oxid. (oxidation may be a surface phenomenon)                                                                                                                                                                                           |                          |
| 1314-1308½ | Silt to fine sand                                                                                                                                                                                                                                                                                                                            | may be slumped material. |
| 1308½-1308 | Till, oxidized.                                                                                                                                                                                                                                                                                                                              |                          |
| 1308-1300  | Not examined.                                                                                                                                                                                                                                                                                                                                |                          |
| 1300       | Gooseneck Creek.                                                                                                                                                                                                                                                                                                                             |                          |

|                |                                                                                                                                                                                                                                                                                           |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Site 1F</u> | Bluff above B&O RR immediately north of Gooseneck Creek                                                                                                                                                                                                                                   |
| 1410           | Top of Slope                                                                                                                                                                                                                                                                              |
| 1410-1402      | Gravel, pebbles and cobbles to 5 inches maximum with clean coarse sand.                                                                                                                                                                                                                   |
| 1402-1366      | Till, predominantly silt and clay with 10-15 percent stones and coarse sand; some surficial oxidation. Examined at several points, not continuously.                                                                                                                                      |
| 1366-1362      | Clay with deformed thin layers of silt increasing in abundance downward; also a few scattered pebbles; gray, except strongly oxidized dark yellowish orange and yellowish brown bottom 0.5 to 1 ft. Pinches out or grades into till laterally. Calcite-cemented layer 5 mm thick at base. |
| 1362-1354      | Gravel; variable at top, ranging from sandy moderately silty pebble gravel to openwork fine-pebble gravel; subrounded to subangular pebbles and cobbles in silty sand matrix at base; examined only at top and base of this interval.                                                     |
| 1354-1350      | Not examined.                                                                                                                                                                                                                                                                             |
| 1350-1344      | Layers of bedded silt, silt with embedded pebbles, a silty very fine sand, clean fine to coarse sand, and clean sandy pebble gravel; oxidized.                                                                                                                                            |
| 1344-1342½     | Silt, oxidized.                                                                                                                                                                                                                                                                           |
| 1342-1341½     | Gravel and coarse sand, clean, saturated.                                                                                                                                                                                                                                                 |
| 1341½-1332     | Layered clay, clayey silt, clay with silt partings; unoxidized gray and pale reddish gray; no pebbles.                                                                                                                                                                                    |
| 1332-1324      | Clay or silty clay, faint layering and silt partings, scattered pebbles; plastic; unoxidized.                                                                                                                                                                                             |
| 1330           | RR Grade                                                                                                                                                                                                                                                                                  |

Site 1G

Left Bank of tributary to Buttermilk Creek,  
450 feet downstream from dam for western NFS water-  
supply lake

|               |                                                                                                                                                                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1400          | Top of slope, level surface                                                                                                                                                                                                                                     |
| 1400-1363     | Not examined.                                                                                                                                                                                                                                                   |
| 1361-1331     | Till; silty clay with pebbles; fully oxidized 0-3 ft, oxidation along root tubes, fractures and mottled areas 3-6 ft, un-oxidized and plastic below (oxidized zone descends along slope); scattered deformed silt and clay beds 1340-1339, 1331-1330.           |
| 1330-1328     | Clay, gray, with subordinate thin layers of oxidized light yellowish brown silt; two layers of pebbly clay with disturbed bedding 0.1 and 0.2 ft thick.                                                                                                         |
| 1328-1326     | Gravel, sandy, clean (top) to silty (base); strong oxidation at base.                                                                                                                                                                                           |
| 1326-1324     | Clay, top 0.5 ft oxidized, remainder gray; subordinate thin silt layers or partings, commonly oxidized;                                                                                                                                                         |
| 1324-1320     | Not examined.                                                                                                                                                                                                                                                   |
| 1320-1318     | Silty clay and silt, layered.                                                                                                                                                                                                                                   |
| 1318-1314.5   | Clay, gray, plastic; a few pebbles near base.                                                                                                                                                                                                                   |
| 1314.5-1312.5 | Silty clay, friable.                                                                                                                                                                                                                                            |
| 1312.5-1311.5 | Clayey silt with clay partings, scattered pebbles, and probably disturbed bedding.                                                                                                                                                                              |
| 1311.5-1310   | Till, sparsely pebbly at top, traces of deformed coarse silt layers at base.                                                                                                                                                                                    |
| 1310-1308     | Silt, gray.                                                                                                                                                                                                                                                     |
| 1308-1304     | Not examined.                                                                                                                                                                                                                                                   |
| 1304-1297     | Sand; chiefly fine or medium to very fine sand and silty very fine sand; lenticular parallel bedding, oxidized, included irregular masses of unoxidized gray silt with flow boundaries; slumping or flow of silt is original, not recent slumping on the slope. |
| 1297-         | (Stream grade)                                                                                                                                                                                                                                                  |
| 1297-1287     | Till, clayey, tough and dense; traces of deformed silt layers at top; upper surface is 2 ft higher a few feet away.                                                                                                                                             |

Site 1J      Exposures and auger hole along Buttermilk Creek  
from Buttermilk Road South to Gooseneck Creek

- A. Nearby continuous exposure 2 ft high along right bank 500 to 700 south of Buttermilk Hill Road, and 5 to locally 12 ft high 800 to 900 feet south of road.

| <u>Altitude (feet)</u>                                                                                                                            | <u>Materials</u>                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1271-1265                                                                                                                                         | Till (?) probably as below, poorly exposed.                                                                                                                                                                                                                                                                                      |
| 1265-1259                                                                                                                                         | Till: unoxidized silty clay with uniformly scattered sand, pebbles, and very rare cobbles; partings and slivers of coarse white silt 1 to 3 mm thick and a few centimeters long are common, generally occurring in clusters or lenses as much as 0.4 ft thick, deformed but crudely horizontal; no gross stratification visible. |
| 1259-1256                                                                                                                                         | Till (?): unoxidized gray silty clay with sparse scattered sand and small pebbles, also abundant wisps of coarse silt and blebs of rose silt; crude stratification visible, including some folds.                                                                                                                                |
| B. Auger hole and continuous exposures 1100 to 2000 feet south of Buttermilk Hill Road; last exposure 350 feet north of mouth of Gooseneck Creek. |                                                                                                                                                                                                                                                                                                                                  |
| 1275-1268                                                                                                                                         | Clay, with partings of silt etched by stream erosion; deformed in broad folds 1 to 2 feet or more in amplitude, some limbs nearly vertical; locally abundant silt wisps; no stones or sand.                                                                                                                                      |
| 1268-1259.5                                                                                                                                       | Clay, gray, unoxidized, plastic, very infrequent silt partings, no stones or sand. No folding visible 1268-1263, auger hole below.                                                                                                                                                                                               |
| 1259.5-1259.5                                                                                                                                     | Clay, plastic, with abundant silt in partings, deformed streaks, and regular layers as thick as 0.1 ft; blebs of rose silt at 1258; very rare scattered pebbles and no sand.                                                                                                                                                     |

Comment: Perhaps the exposure at A marked the advance of a floating ice tongue into a lake, dropping grit and stones into lacustrine deposits similar to those to the south. If ice advance caused the folding at the top of the section at B and nearby, some time must have elapsed before it crossed the area.

## Well V

Altitude of land surface: 1385.9

Altitude of top of 6-inch casing: 1389.5

| <u>Depth (feet)</u> | <u>Materials</u>                                                                                                                                                                                                                                                                                                                                       |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0-44                | <u>Till</u> : predominantly silt and clay, with a little randomly distributed coarse sand to pebbles (est. 10-15% 0-15 ft, 5% or less 15-35 ft, 10-15% 35-43 ft); oxidized 0-9 ft, grading 9-16 ft to unoxidized; relatively clayey 40-44 ft with minor wisps or partings of coarse silt.                                                              |
| 44-49               | <u>Lacustrine</u> : layers of coarse silt, clay with rare silt partings and pebbles, rhythmic-laminated dark gray clay and light gray silt, and probably fine to coarse sand.                                                                                                                                                                          |
| 49-69               | <u>Till</u> : relatively clayey; includes occasional lenses of rhythmic clay and silt, and silt partings; coarse sand to pebbles estimated about 5 percent 49-53 ft, generally greater below.                                                                                                                                                          |
| 69-83               | <u>Till</u> : predominantly silt and clay; randomly distributed coarse sand to pebbles generally about 10 percent, but some relatively pebbly till may be present 75-78 feet; unoxidized; possibly unsaturated 81.5-83 feet.                                                                                                                           |
| 83-94               | <u>Gravel</u> : probably mostly small pebbles and granules, with very coarse to very fine sand, traces of silt; poorly sorted; oxidized; unsaturated; pebble counts at 85 and 90 feet show 18 and 21 percent exotic lithologies respectively, among broken or rounded stones 1-3 cm diameter.                                                          |
| 94-99               | <u>Sand</u> : fine to very fine, with 20 to 50 percent medium to very coarse; traces of silt; rare granules; rare thin layers of grayish red clay with embedded very coarse sand; oxidized, unsaturated.                                                                                                                                               |
| 99-99½              | <u>Gravel</u> : fine pebbles and granules.                                                                                                                                                                                                                                                                                                             |
| 99½-103½            | <u>Sand</u> : very fine to fine, layered; a few thin layers and partings of silt; oxidized, unsaturated; small gray concretions.                                                                                                                                                                                                                       |
| 103½-107            | <u>Lacustrine</u> : upper part mostly silt and(or) clay, no samples; lower part dark clay with numerous partings of unoxidized silt, a few layers of oxidized very fine sand to silt, and occasional round blebs or augen as large as 5 mm of grayish red silty sand and rarely of gray silt or silty sand; unoxidized except very fine sand as noted. |



- 107-118      Lacustrine: silt; chiefly as rhythmic layers of coarse silt  $\frac{1}{2}$  to 3 mm thick alternating with generally thinner layers or partings of dark gray, fine, clayey silt; some thicker layers of coarse silt; one layer of very fine sand 116.6-.7; silt and sand weakly oxidized, generally pale yellowish brown 10YR-5Y 6/2; unsaturated; a few layers with complex internal soft deformation; a few partings of red clay near base.
- 118-129      Disturbed lacustrine: Fine or clayey silt, gray to olive gray, regular fine beds < 1 to 3 mm thick, with a few beds of brownish-gray clay 5YR 5/1 as much as 5 mm thick, and a few partings or very thin beds of coarse silt, which together constitute 50 percent or more of interval; interbedded with layers of disturbed material ranging from severely contorted rhythmic thin layers to irregular mottled blebs of fine to coarse silt, commonly with scattered grains of coarse sand to granules and with scattered blebs or aligned blebs of grayish red 10R 4/2 to light brown 5YR 5/5 silt to sandy silt and one bleb of brown layered clay and silt; at 124 ft, disturbed material includes three layers each 2 to 3 cm thick of structureless clayey silt with randomly distributed pebbles to coarse sand, gray (N5-5GY 6/1) mottled with dark gray (N4), grayish red (10R 4/2), and/or pale yellowish brown, more stony than the till above 83 ft.
- 129-150      Lacustrine: silt, medium to fine, generally in regular beds < 1 to 20 mm thick with slight contrast in grain size between beds, but with partings of coarse silt below 138 ft and beds of coarse silt 1-6 cm thick below 149 ft; olive gray, barely plastic; graded silt beds at 134 ft; a few zones of folded, disturbed beds; rare clay beds up to 7 mm thick; rare scattered coarse sand grains and pebbles 146-149 ft; beds above 135 ft have zero or negative (unsaturated) pressure head.

## Well W

Land surface altitude = about 1383 feet  
 MP is top of 6-inch casing, altitude = 1386.30

| <u>Depth (feet)</u> | <u>Materials</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0-91                | Till, predominantly clay and silt, generally less than 15% coarse sand and fine gravel; includes some very thin rhythmic beds of clay and clayey silt 12-32 ft, which become abundant but contain embedded fine pebbles 30-32 ft; unusually stony 71-84 ft; includes scattered thin layers of silt or clayey silt 81-91 ft. Oxidized 0-8 or more, oxidized fractures or root tubes to 10½ ft or more.                                                                                                                                                                                                                        |
| 91-108              | Silt, with subordinate very fine sand and clay, oxidized and largely unsaturated, some layers with scattered pebbles. Individual layers recognized include very fine sand (only between depths of 93 and 95 feet), very fine sandy silt with traces up to 25% scattered coarse sand to fine pebbles, and coarse to fine silt (all these buff colored); also dark brownish-gray clay with rhythmic silt partings, and one layer of dark brownish gray silty clay with coarse silt partings and large embedded pebbles 107-108 ft. Pebbly layers subordinate, but pebbles as large as 2-inch diameter recovered.               |
| 108-136             | Predominantly silt: layers < 1 to 5 mm thick of fine silt (olive gray) with thinner layers or partings of darker, clayey silt and equally thin layers or partings of coarse silt (light gray to light olive gray), unoxidized and probably saturated. Rare embedded coarse sand to fine pebbles 108-112, 126-127, and 135-136 ft. A few partings and layers of clay (brownish-olive gray) up to 20 mm thick. Many layers appear parallel and subhorizontal, but some sets show severe internal deformation, being folded, squeezed, and(or) discontinuous. Rare blebs of rose-colored coarse sandy silt < 2 mm 126-127.5 ft. |
| 136-138             | Silt, coarse; in part interbedded with fine silt in layers generally 3-10 mm thick; highly disturbed, with predominant steep to vertical dips and with small-scale-plastic deformation, discontinuities, and convoluted fine layers around flowed masses of coarse silt.                                                                                                                                                                                                                                                                                                                                                     |

## REPORTS ON GEOHYDROLOGY

Following is a list of recent published reports concerned with the geohydrology and radiochemistry of the low-level radioactive-waste burial ground at West Valley. Other reports are in press and in preparation. U.S. Geological Survey open-file reports were printed in small editions; copies may be available on loan from the USGS, P.O. Box 1350, Albany, N.Y. or reproductions may be purchased from Open-File Services Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225.

Boothroyd, J. C., Timson, B. S., and Dana, R. H., Jr., 1979, Geomorphic and Erosion Studies at the Western New York Nuclear Service Center, West Valley, New York: Albany, N.Y., New York State Geological Survey, NUREG/CR-0795, 66 p.

Carter, M. W., Moghissi, A. A., and Kahn, Bernd, eds., 1979, Management of low-level radioactive waste: New York, Pergamon Press, 2 volumes.

Includes the following articles:

Husain, Liaquat, Matuszek, J. M., Hutchinson, J. A., and Wahlen, Martin, Chemical and radiochemical character of low-level radioactive waste, v. 2, p. 883-900.

Kelleher, W. J., Water problems at the West Valley site, v. 2, p. 843-851.

Matuszek, J. M., Husain, Liaquat, Lu, A. H., Davis, J. F., Fakundiny, R. H., Pferd, J. W., Application of radionuclide pathways studies to management of shallow, low-level radioactive waste burial facilities, v. 2, p. 901-916.

Prudic, D. E., and Randall, A. D., Ground-water hydrology and subsurface migration of radioisotopes at a low-level, solid radioactive-waste disposal site, West Valley, New York, v. 2, p. 853-882.  
(Identical to USGS Open-file report 77-566.)

Colombo, Peter, Weiss, A. J., and Francis, A. J., 1978, Evaluation of isotope migration-land burial, water chemistry at commercially operated low-level radioactive-waste disposal sites: Upton, N.Y., Brookhaven National Laboratory, Department of Nuclear Energy, Progress Report 7, BNL-NUREG/50861, 26 p.

Colombo, Peter, and Weiss, A. J., 1979, Evaluation of isotope migration-land burial, water chemistry at commercially operated low-level radioactive waste disposal sites: Upton, N.Y., Brookhaven National Laboratory, Department of Nuclear Energy, Progress Report 9, BNL-NUREG-50965, 29 p.

Dana, R. H., Jr., Mollello, S. A., Fickies, R. H., and Fakundiny, R. H., 1979, General investigation of radionuclide retention in migration pathways at the West Valley, New York, low-level burial site: Albany, N.Y., New York State Geological Survey, NUREG/CR-0794, 99 p.

Fickies, R. H., Fakundiny, R. H., and Mosely, E. T., 1979, Geotechnical analysis of soil samples from test trench at Western New York Nuclear Service Center, West Valley, New York: Albany, N.Y., New York State Geological Survey, NUREG/CR-0644, 21 p.

Giardina, P. A., De Bonis, M. F., Eng, Jeanette, and Meyer, G. L., 1977, Summary report on the low-level radioactive waste burial site, West Valley, New York (1963-1975): U.S. Environmental Protection Agency, Report 902/4-77-010, 122 p.

- La Fleur, R. G., 1979, Glacial geology and stratigraphy of Western New York Nuclear Service Center and vicinity, Cattaraugus and Erie Counties, New York, U.S. Geological Survey Open-File Report 79-789, 17 p., 6 pls.
- Lu, A. H., 1978, Modeling of radioactive migration from a low-level radioactive waste burial site: Health Physics, v. 34, p. 39-44.
- Lu, A. H., and Matuszek, J. M., 1978, Transport through a trench cover of gaseous tritiated compounds from buried radioactive wastes: International Symposium on the Behaviour of Tritium in the Environment: San Francisco, Calif., International Atomic Energy Agency, IAEA-SM-232160, 22 p.
- Matuszek, J. M., Strnisa, F. U., and Baxter, C. F., 1976, Radionuclide dynamic and health implications for the New York Nuclear Service Center's radioactive waste burial sites: Vienna, Austria, International Atomic Energy Agency, IAEA-SM-207/59, p. 359-372.
- Prudic, D. E., and Randall, A. D., 1977, Ground-water hydrology and subsurface migration of radioisotopes at a low-level, solid radioactive-waste disposal site, West Valley, New York: U.S. Geological Survey Open-File Report 77-566, 28 p. (Identical to article in Management of Low Level Radioactive Waste.)
- Prudic, D. E., 1978, Installation of water- and gas-sampling wells in low-level radioactive waste burial trenches, West Valley, New York: U.S. Geological Survey Open-File Report 78-718, 70 p.
- Prudic, D. E., 1979, Recharge to low-level radioactive-waste burial trenches 11 through 14, West Valley, New York: U.S. Geological Survey Open-File Report 79-990, 5 p.
- Prudic, D. E., 1979, Core sampling beneath low-level radioactive waste burial trenches, West Valley, Cattaraugus County, New York: U.S. Geological Survey Open-File Report 79-1532, 55 p.