Vermont Geological Survey
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Vermont Agency of Natural Resources
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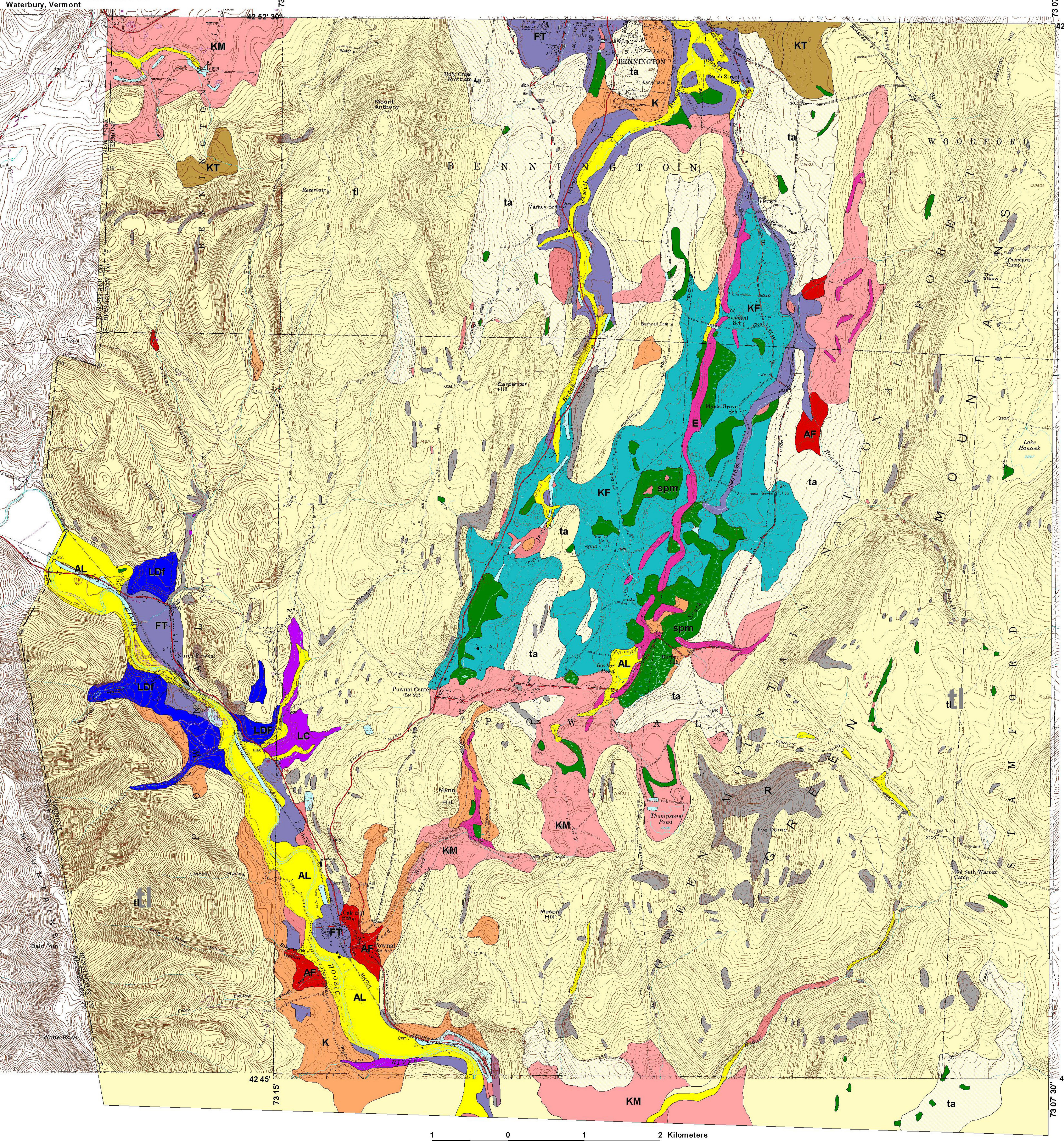

1 0 1 2 Kilometers

Scale - 1:24,000
contour interval = 20'

Surficial Geologic Map of the Pownal-North Pownal, Vermont Area

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HOLOCENE UNITS

- f Fill
- spm Swamp peat and muck
- AF Alluvial fan gravel
- AL River floodplain and tributary alluvium (sand with gravel)

WOODFORDIAN-HOLOCENE UNITS

- AF Alluvial fan gravel
- FT Fluvial terrace sand with gravel

WOODFORDIAN UNITS

- LDf Fan delta gravel with sand
- LC Lake clay and silt
- E Esker gravel with sand

WOODFORDIAN UNITS (Cont'd)

- K Kame gravel and sand, undifferentiated
- KT Kame terrace sand and gravel
- KM Kame moraine gravel, sand and till; minor colluvium on slopes
- KF Kamefield gravel, sand and ablation till with minor colluvium
- ta Ablation till
- tl Lodgement or basal till
- M Moraine till; bouldery with silty-sandy matrix

- R Bedrock outcrop

N
W E
S

Surficial Geology of the Pownal and North Pownal 1:24,000 Quadrangles, Vermont

Final Report: 02 June 1988

David J. DeSimone

David P. Dethier

OPEN-FILE REPORT NO. 1992-2

Contents

Introduction

This final report details the results of our 1:24,000 scale surficial geologic mapping and interpretations of the Pownal, VT, and Vermont portions of the North Pownal, Williamstown, and Berlin quadrangles. Our work builds upon but greatly modifies Shilts' (1966) earlier reconnaissance mapping at 1:62,500 scale and accompanying report.

The report is divided into three major sections. The Physiography and Bedrock Geology section centers on our depth-to-bedrock map and its correlation with bedrock/structural geologic data. The practical aspects of this section lie in the recognition of deep and often buried pre-glacial bedrock valleys. The valley fill may have aquifer potential yet to be realized.

The second section of the report, Environmental Geology, delineates existing and potential gravel resources throughout the project area and provides a forum for consideration of the glacial sediment stratigraphy and groundwater resources along the Hoosic River Valley. The data are largely derived from recent intensive investigation of the aquifers in Williamstown, MA.

The final Glacial Geology section of the report details the important results of our field mapping and revised deglaciation history of the area. The surficial geologic maps should provide a useful data base for local zoning ordinances, landfill siting, aquifer recharge area protection, and commercial/residential development. Appendix A provides a detailed description of the mapping units employed by us. Appendices B and C respectively describe existing exposures of glacial sediment visited by the authors and provide cross-sections outlining the glacial sediment stratigraphy to support the major sections of the report.

It is hoped these data all trickle down to local government authorities by whatever mechanisms currently exist. However, all users of this report must realize that anticipated site specific investigations will still require detailed 1000 feet/inch mapping and other appropriate measures.

Physiography and Bedrock Geology

The mapped area encompasses two distinct upland provinces, the Taconic Mountains and the Green Mountains, and two major valleys, the Vermont Valley and the Hoosic Valley.

The southernmost extension of the Vermont Valley, the major lowland of southwestern Vermont, occupies the central third of the Pownal quadrangle. This broad lowland is subdivided here by a mantled bedrock spur into two smaller valleys. Jewett Brook on the west and South Stream on the east both flow generally northward and merge with the Walloomsac River in Bennington. Both valleys and the bedrock spur trend north to north-northeast. The underlying bedrock consists of interbedded, north-striking marble and quartzite.

The eastern third of the Pownal quadrangle and adjacent portion of the Williamstown quadrangle consists of the Green Mountains, underlain predominantly by the resistant light-colored, Stamford gneiss. The massive Cheshire quartzite is exposed primarily along the steep west-facing mountain front. Structures trend northeast and north.

The western third of the Pownal quadrangle and the mapped portions of the North Pownal and Berlin quadrangles are located in the Taconic Mountains and are underlain by comparatively less resistent black through green, quartz-veined slate and phyllite. The Taconics have a prominent north-south structural grain. The northwest-trending Hoosic Valley cuts diagonally across this structural grain, and the Hoosic River flows northwest from Williamstown, MA, toward Hoosick Falls, NY.

Depth-to-bedrock/overburden thickness map: Depth-to-bedrock data from available water well logs were plotted on a mylar overlay and contoured using a 20 ft. contour interval. The location of some wells is only poorly known and these are designated by the "?" symbol on the map. The accuracy of some depth-to-rock data are similarly questioned.

The zero depth-to-bedrock contour encloses much of the higher elevations of the Green Mountains. Numerous outcrops pock the thin and patchily distributed till cover of the uplands. Insufficient subsurface data and paucity of exposures limited the delineation of any pockets of thick till. However, note that several such areas are indicated with dashed contacts on the surficial geologic maps. These thick till areas were inferred from geomorphological considerations of air photo data but not verified in the field because of inadequate exposures. Generally, these thick till areas are within the ice "shadow" of the Mt. Anthony massif.

The data revealed major pre-Woodfordian (pre-Pleistocene?) bedrock valleys. The pre-glacial Hoosic Valley extends more than 100 ft. below present floodplain elevation. Hoosic River tributaries draining the Taconics and Mt. Anthony generally follow their pre-Woodfordian paths, and these buried valleys apparently deepen near their confluences with the Hoosic Valley. The dramatic valley deepening may simply be an artifact of insufficient data away from the more populated valley confluence area. The pre-glacial Broad Brook Valley incised south-southwestward from The Dome is deeply buried by glacial fill in the Williamstown area.

Well logs indicate a deeply-buried pre-glacial Ladd Valley, incised by the present Ladd Brook along the western edge of the glacial sediment fill. Another buried valley heads at Pownal Center and parallels Rte 7 between Pownal Center and Pownal and trends generally west-southwest to the Hoosic Valley. The Pownal Center data revealed a partially (?) breached divide at the head of this valley.

Two north-flowing pre-glacial valleys separated by a bedrock spur were identified in the Vermont Valley portion of the Pownal quadrangle. Several water wells revealed depths-to-bedrock in excess of 100 ft. in each valley. The narrower Jewett Valley heads at Pownal Center and parallels Mt. Anthony. The broader South Stream Valley heads on the western and northern flanks of The Dome and parallels the Green Mountain massif. Both valleys empty into the Walloomsac in the Bennington area. Jewett Valley diverges around the Park Lawn Cemetery hill in Bennington. The rock spur separating the Jewett and South Stream valleys contains a shallow saddle or trough along its north-south axis.

Rock spurs constrict the Vermont Valley just south of Bennington where the Jewett and South Stream valleys converge. The presence of these spurs have important implications for the deglacial history of the area. The active margin of the retreating ice shifted to the flanks of these spurs, abandoning ice to the south, resulting in an extensive cover of ice stagnation deposits (kame field and undifferentiated kame) over the central portion of the Pownal quadrangle.

Relationship of pre-glacial topography to bedrock geology: Comparison of pre-glacial bedrock valley locations with the Geologic Map of Vermont (1961) suggests some lithologic and structural control on valley development. The northwest-trending Hoosic Valley segment through Pownal and North Pownal follows, in part, a thrust fault. The Jewett and South Stream Valleys developed in the interbedded carbonates and quartzites of the Vermont Valley. The South Stream Valley apparently developed by preferential erosion of the carbonates along the carbonate-quartzite contact at the base of the Green Mountains. The Jewett Valley may have partially developed along the Mt. Anthony thrust fault. Both of these north-south trending valleys parallel the regional strike of the metasedimentary formations. The buried Ladd Valley does not correlate with any recognized structural element but may have developed along an as yet unrecognized fault trace similar to the adjacent valley to the east.

Environmental Geology

Glacial deposits of the Pownal area have been exploited for construction materials for over a century, contain abundant groundwater resources and are used for liquid and solid waste disposal.

Sand and gravel resources: Gravel pits are noted on the maps of surficial geology, and areas mapped as ice-contact deposits (K-designation) represent potential gravel resources. The largest active pits are located southeast of Pownal (POW 86-23P), along Military Road 1/2 mile south of Barber Pond (POW 86-1P), in the central part of the Pownal quadrangle near Bushnell School (POW 86-4P), and in North Pownal (NPO 86-2P). Thicknesses at these pits range from 20 to 130', and sediment texture is variable. Areas near South Stream Road, north of Bushnell School, and areas mapped as K near Barber Pond probably are underlain by thick deposits of gravel.

Location POW 86-23P, near the Massachusetts border, consists mainly of well-sorted sand and minor gravel, whereas pits near North Pownal and in the central Pownal quadrangle expose well-sorted to poorly sorted gravel which contains lenses and beds of sand. Clasts in the western part of the project area are rich in phyllitic material, and marble is locally abundant in the central Pownal pits. Other lithologies probably do not pose limitations for use as construction materials or aggregate.

Stratigraphy of valley fill: Drilling in the Hoosic valley two miles south of the project area by Alliance, Inc. (Alliance, Inc., 1987), and older well logs show that most of the valley floor is underlain by thick silt deposits that are capped locally with 8 to 35 feet of Holocene floodplain deposits, mainly sand. Woodfordian deposits of silt, silty sand, and clayey silt range from 20 to more than 90 feet thick, and the total depth to till or bedrock may be as much as 180' locally between Pownal and the Massachusetts border (see Hansen and others, 1973). The Hoosic River flows over bedrock west of Pownal, but in most areas between Williamstown and N. Petersburg thin (<8') Holocene deposits lie above thick deposits of glaciolacustrine material. Near the mouth of Ladd Brook, along the east flank of the Taconic Range, and locally in the flood plain, gravel deposits as thick as 25 feet lie above glaciolacustrine silt. These deposits are interpreted mainly as latest Pleistocene/Holocene fans, and as filled Holocene channels of the Hoosic River.

Ground-water resources: The principal ground-water resources in the project area occur along the axis of the Hoosic River valley, in the central part of the Pownal quadrangle, and in fractured carbonate bedrock beneath glacial deposits. The bedrock aquifer is not considered here. The deep Hoosic valley aquifer by analogy with information from Williamstown (Hansen and others, 1973; Alliance, 1987), is developed in gravel and sand lenses that are found beneath fine-grained deposits at depths of 80 to 150'. At some locations in Williamstown the aquifer is confined, and gage pressures on deep wells are 15 psi. Yields of 20 to over 100 gallons per minute (gpm) are common elsewhere in the deep aquifer. Shallow wells (<30') are developed in the Hoosic valley in gravel that overlies lacustrine silt. Yields of 10 gpm are common from this shallow aquifer. At certain locations these and other shallow wells may dry up during periods of drought, and there is a significant potential for contamination of shallow aquifers where household or municipal wastes are placed in the gravel. Deeper wells in the Pownal upland (see Depth-to-bedrock) are less subject to contamination or dry-period failure.

These wells mainly are developed in ice-contact deposits that overlie till, and yield 5 to 20 gpm.

The deep aquifer in the Hoosic valley is probably supplied by upland recharge areas because the lacustrine deposits prevent local recharge (Alliance, 1987). Recharge areas for aquifers in the Vermont valley have not been investigated, but presumably water infiltrates into bedrock fractures exposed on upland (above 1400') slopes, as well as into areas close to the wells. These latter recharge areas are usually coarse textured deposits that crop out within 500 ft of the wellhead. Recharge areas and shallow aquifers can be polluted by leachate from septic systems that do not function properly, or by unlined sanitary landfills. The area of Pownal between Barber's Pond and the Bennington municipal line contains many areas of coarse deposits (see map). Potential migration of wastes in these coarse deposits should be investigated when town officials consider landfill siting or new subdivisions.

Glacial Geology

The existing reconnaissance map (Shilts 1966, Stewart and MacClintock 1970)) of the area at a scale of 1:62,500 was substantially revised. Our field work and air photo analyses have enabled us to more accurately decipher the glacial-deglacial history, delineate ice margins, and define glaciolacustrine phases.

An overview contrasts two distinct glacial landform morphologies. The upland regions above 1100-1400 ft. exhibit a streamline-molded landscape and expose generally thin sediment cover. Drumlinoid forms predominate and serve as ice flow indicators whose axes vary less than the rock striations. The lower valley slopes and valley bottoms are more thickly mantled with glacial sediment and exhibit a landscape of hummocky ground through which protrude several drumlin/drumlinoid landforms in the Vermont Valley. The surface sediment in the hummocky terrain is often a non-stratified, loosely-compacted diamicton of probable meltout and sediment flow origins. Stratified meltwater sediment generally underlies this diamicton cap and inferred depositional environments include subglacial streams, crevasse fill, deltas, and local impondments. No major glaciolacustrine phase was recognized in the Vermont Valley portion of the Pownal quadrangle.

The Hoosic Valley in the area presents a third suite of landforms. The major features are the low-gradient fluvial terraces and modern floodplain sediment developed on an eroded valley fill of glacial Lake Bascom sediment. Lower valley slopes reveal erosionally isolated fragments of ice-contact meltwater deposits. Late-glacial tributary streams deposited fans or fan-deltas graded to one or another of lower Lake Bascom levels. These latter features have also been dissected by tributary streams, and small Holocene alluvial fans were delineated along some tributary courses.

Woodfordian glaciation and ice flow data: Drumlin/drumlinoid axes and striations indicate that Laurentide ice advanced generally southward to southeastward over the area. Ice flow axes ranged from 340° to 360°. The more southeastward ice flow axes ranging from 300° to 340° are clustered in the southeast quadrant of the Pownal quadrangle and indicate the flow direction of the thickest ice across the Green Mountain massif.

Numerous axes support topographically-constrained ice flow during deglaciation and presumably also during the earliest stage of Woodfordian ice advance when thinner ice first encroached the valleys. Drumlin/drumlinoid axes in the Vermont Valley are valley-parallel and trend to the south and south-southwest. Two axes along the lower western flank of the Green Mountains have a similar trend and indicate topographically-constrained ice of considerable thickness was once active in the Vermont Valley.

The Woodfordian ice abraded and streamlined the topography of southwestern Vermont as it did elsewhere in the Taconic Mountains and Hudson Valley of eastern New York (DeSimone 1985, DeSimone and LaFleur 1985, 1986). Mt. Anthony and the Taconic highlands along the New York border are predominantly underlain by weak phyllite, slate, and shale lithologies and were thoroughly abraded and streamlined into a drumlinoid landscape with pronounced north-south trends. The generally thin mantle of lodgement till is dominated by these local lithologies but is clast-enriched in the more resistent vein quartz, quartzite, and carbonate lithologies. The latter quartzites and carbonates are exposed in the Vermont Valley to the north. Pebble and larger clasts are subrounded to rounded and comprise only 10-25 percent of the observed diamictons. The very compact matrix is a silty-clayey, light to medium dark gray-colored rock flour derived from the local phyllites, slates, and shales. No good exposures of this Taconic-type lodgement till were observed in the study area. NPO86-5 is a poor, gullied, and perhaps graded surface exposure with a gravel lag veneer. However, several good exposures of this till were observed in the Massachusetts portion of the Williamstown quadrangle and on the

Bennington, Hoosick Falls, and Berlin quadrangles. This basal diamicton closely resembles basal till elsewhere in the Taconics and Hudson Valley of eastern New York (DeSimone 1985) where it was observed in contact with a striated bedrock surface.

In contrast, the highly resistant crystalline granitic lithologies of the Green Mountains in the eastern third of the Pownal quadrangle were less effectively streamlined and were abraded into a more bulbously-rounded topography. Drumlinoid axes at hill summits trend to the southeast whereas the structural grain of the rocks trends more north-south. The local till here has a coarser-grained silty-sandy matrix. The more numerous cobble, pebble, and boulder clasts are subrounded to angular (faceted?) and numerous boulders pock the surface. This inferred basal diamicton is difficult to distinguish from interpreted meltout and sediment flow diamictons along the lower flanks of the Green Mountains. Absence of good vertical exposures aggravated the situation. Our field distinction was made on gullying characteristics; the more silty and cohesive lodgement till eroded into steeper-walled gullies than the sandier and less cohesive meltout till as revealed along old logging trails.

<u>Deglacial sediment and history</u>: Thinning ice during the earliest deglaciation of the area exposed The Dome and the southeast portion of the Pownal quadrangle. Meltwater flowed from the heads of drainage divides northeast of The Dome at 2020 ft., west-southwest of The Dome at 1720 ft., and east of Mason Hill (VT) at 1520 ft. Minor underfit streams occupy the latter two valleys and Broad Brook follows the foremost valley. Meltwater flow along these routes contributed to the

extensive ice-contact stratified and non-stratified sediment deposited north of Williamstown. These hummocky deposits extend from approximately 1140 ft. locally down to 800 ft. along the VT-MA border in the Mason Hill Road-Mason Hill area and across Broad Brook to the base of Pine Cobble. A combined kame terrace-kame moraine environment is inferred along a margin of the Hoosic ice tongue in Williamstown. We believe this ice front continued along the western and northern sides of Mason Hill (VT), but no deposits verify this location. Several wells in the Broad Brook area reveal sediment thicknesses to 180 ft. filling the buried pre-glacial Broad Brook Valley.

Continued ice thinning and marginal retreat isolated the Hoosic ice tongue from the Vermont Valley sublobe by initial deglaciation of Mt. Anthony. A Vermont Valley ice margin was reconstructed from extensive kame moraine, esker, delta, and kame plateau sediments deposited east of Pownal Center and generally south of Barber Pond Road. (See cross-sections E-E' and E-E" in Appendix C). Some deposits include the esker gravel east of Mann Hill (POW86-7), the kames at Thompson Pond, and the well-exposed deltaic foreset sands (POW86-1) at the terminus of the Barber Pond esker (POW86-21). Bouldery deposits were observed in an old pit at POW86-11. Additional deposits related to this ice front include POW86-9, POW86-13, POW86-15, POW86-14, POW86-12, and POW86-8. Interpretation of water well data suggests overburden thickness in excess of 100 ft. north of Thompson Pond and in the area of POW86-1 filling the pre-glacial South Stream Valley. Ice marginal sediment and meltout till accumulated along the lower flanks of the Green Mountains at POW86-2P and surrounding area.

The Hoosic ice tongue retreated to its Pownal position northwest of Williamstown where subaqueous sediments accumulated in fan and lacustrine settings adjacent to the ice margin at POW86-23 and POW86-24. The hummocky topography between 600-800 ft. west of Northwest Hill Road suggests a continuation of ice marginal sediments west of the Hoosic ice tongue. A small boulder moraine (WIL86-1P), topographically expressed as a low ridge at approximately 600 ft., was deposited along the lower flank of the eastern valley wall at the edge of the Pownal and Williamstown quadrangles. Glacial Lake Bascom at or near its maximum elevation controlled by the Berkshire spillway (Taylor 1903, 1916, Bierman and Dethier 1986) fronted the retreating Hoosic ice tongue. The fining upwards sequence observed at POW86-23 confirms retreating meltwater sources and gradual predominance of lacustrine sand and minor silt in the lake environment. Meltwater flowed down Ladd Brook to Lake Bascom and may have been a sediment source for POW86-23.

The Potter Hill outlet was exposed as the Hoosic ice tongue retreated through the North Pownal area and Lake Bascom fell to the 890-900 ft. (273 m) level. Fine-grained sediment accumulated in the lake basin (NPO86-7, NPO86-8) while coarse-grained sediment was contributed by tributary streams as deltaic fans graded to this and lower Bascom levels. Ice-contact stratified sediment was deposited at NPO86-2 as the ice retreated through North Pownal. Contemporaneously, the Vermont Valley sublobe stagnated in the central portion of the Pownal quadrangle (DeSimone and LaFleur 1986). Stagnation is indicated by the widespread hummocky topography composed of numerous kames and kettles, kame plateaus, short esker segments, and one long, nearly continuous esker. The locally-variable stratigraphy revealed in borrow pits generally consists of a non-stratified diamicton or mantle approximately 1-3 m (3-10 ft.) thick overlying stratified glaciofluvial and glaciolacustrine sediment. This diamicton varies from a clast-supported cobble, boulder, and pebble unit with little matrix (POW86-10, POW86-21) to a loose sandy unit with 20-40 percent pebble and cobble clasts (POW86-3, POW86-4P, POW86-13, POW86-14, and others). The lower diamicton contact is undeformed where observed; no evidence of sediment flow was observed. Hence, this unit was interpreted to be a meltout till. POW86-15 revealed a non-stratified diamicton overlain by stratified glaciofluvial sediment, and POW86-4P revealed load deformation (flame and dish) structures at the lower diamicton contact in one portion of the excavation. These two exposures indicate that sediment flow processes played some role in the deposition of the non-stratified diamicton collectively mapped as meltout till.

The active margin of the Vermont Valley sublobe shifted northward to the base of Mt. Anthony and its largely buried eastern spur, across the base of the bedrock spur which subdivides the central portion of the Pownal quadrangle and along the flank of the west-trending rock spur from the Green Mountains. Together, these rock spurs and the isolated rock knob of the Park Lawn Cemetery hill in Bennington represent the flank of the pre-glacial Walloomsac Valley which trends east-west through Bennington, VT. The valley flank is dissected here at the confluence of the pre-glacial South Stream and Jewett Brook Valleys. Thus, the shift and location of the active ice margin in the Vermont Valley was here topographically controlled and resulted in the stranding of ice in the Vermont Valley south of Bennington. Water well logs indicate considerable sediment thickness beneath terraces and morainal deposits southeast of Bennington, filling the pre-glacial South Stream Valley and supporting our ice margin location here. (See cross-sections A-A' and D-D' in Appendix C).

The abundance of sediment deposited in subglacial fluvial and lacustrine environments and the absence of continuous horizontally-bedded lacustrine sand, silt, and clay indicates Lake Bascom did not invade the central portion of the Pownal quadrangle. (See cross-sections B-B' and C-C' in Appendix C). Small local impondments may have existed amid stagnant ice and along the base of the Green Mountains, but there was no large expanse of open lake water.

Ice margin correlations and Lake Bascom levels: Taylor's (1903) northeast-trending ice fronts and overall pattern of ice retreat south of the project area is consistent with our interpreted ice borders. It is possible to attempt correlations with his work and with detailed studies to the northeast (DeSimone 1985, DeSimone and LaFleur 1985, 1986).

Our earliest ice margin through the Williamstown area is coincident with Taylor's (1903) ice margin #15. Lake Bascom in the Hoosic Valley was at or near its maximum (1005-1050 ft.) (305 m-318 m) elevation controlled by the kame moraine and bedrock spillway north of Pittsfield, MA (Taylor 1916, Bierman and Dethier 1986). Isostatic tilting (Bierman and Dethier 1986) has resulted in an approximately 1050-1100 ft. elevation for these lake features in the Williamstown area. Taylor (1903) correlated ice at Berlin, NY, in the Little

Hoosic Valley with ice margin #15. We concur with these ice borders and tentatively correlate them to the Schodack (D) ice margin of the Hudson Lobe (DeSimone and LaFleur 1985, 1986).

Taylor's (1903) last indicated ice border, #16, correlated ice at Petersburg, NY, and Pownal, VT. We extend this correlation to include the Pownal Center-Barber Pond ice margin. These ice borders are correlated with the Meadowdale (C) ice margin of the Hudson Lobe as previously suggested by DeSimone and LaFleur (1985, 1986). Lake Bascom was still controlled by the Berkshire spillway north of Pittsfield and maintained its maximum elevation. The waters of Lake Berlin in the Little Hoosic Valley were still distinct from those of Lake Bascom. Lacustrine conditions did not yet invade the Vermont Valley in the Bennington area as that region was still ice covered.

Thinning and northwestward retreat of the Hoosic ice tongue from its Pownal position opened the Potter Hill outlet at 890-900 ft. (273 m) and Lake Bascom fell to this level. Lake water drained westward from the outlet past Lake Lorraine and Boyntonville, NY, where meltwater channels were identified on the topographic map and passed east and south of Pittstown, NY, where a continuation of these meltwater channels can be traced. The Hudson Lobe, located by ice-marginal deposits, extended from Pittstown to Boyntonville, thence northward and eastward through Southwest Hoosic and Pine Valley to the Hoosic Valley ice tongue.

Evidence in the form of tributary fan-delta deposits and terraces for lower Bascom water levels has been previously noted (Bierman and Dethier 1986). The lower Bascom water levels were stable for some undetermined interval, but appropriate spillways have not yet been identifed. Continued ice retreat from both the Hoosic and Little Hoosic Valleys merged Lakes Berlin and Bascom at the Potter Hill level and brought both ice tongues to the valley junction at North Petersburg. Contemporaneously, the active margin of Vermont Valley sublobe shifted to the Mt. Anthony-Bennington South position. These North Petersburg-Bennington South ice borders were tentatively correlated with the Guilderland (B) ice margin of the Hudson Lobe (DeSimone and LaFleur 1986) and we concur with this correlation.

Continued ice retreat from North Petersburg may have exposed lower meltwater outlets. Map analysis and field observations suggest that a 700 ft. (212 m) Lake Bascom level may have been controlled by the Otter Creek channels which head at Nipmoose Hill on the Eagle Bridge, NY, quadrangle. Lake outflow would have followed the ice margin until reaching the well-defined channel heads at Nipmoose Hill. An intermediate ice margin is suggested trending northeast through East Pittstown, NY, around Nipmoose Hill, northeastward again to the Case Brook Valley and then to the Hoosic Valley. Underfit streams currently follow the bottoms of the Otter Creek channels suggesting some previous incision by meltwater. A minor 700 ft. terrace west of Pownal may be graded to this level.

Continued ice retreat to the Hoosick Falls position along the Niskayuna (A) ice margin of the Hudson Lobe (DeSimone and LaFleur 1986) would have shortly exposed the Case Brook col at 625 ft. (189 m) on the west side of the Hoosic Valley. Lake outflow could have drained through Case Brook Valley to Eagle Bridge, NY, thence along the ice front to Lake Albany in the Hudson Valley. Several tributary fan-deltas in the project area appear graded to this 620-630 ft.

Bascom level and suggest this level must have persisted longer than the 700 ft. level. The well-exposed, coarse-grained, poorly-sorted fluvial gravels (NPO86-2P, -3) of one large coalesced fan-delta complex west of North Pownal have largely buried earlier ice-contact stratified drift. The large sediment volume, small drainage area, abundance of locally-derived clasts, and presence of numerous deeply-weathered pre-Woodfordian clasts suggest rapid "flushing" of drift from these small tributary valleys soon after deglaciation while the ground was unvegetated and easily eroded. The 600 ft. Potter Hollow fan-delta in North Pownal, the 620 ft. Ladd Brook fan-delta in Pownal, and the small 600-620 ft. terraces at Ellis Mine Hollow and Frost Hollow were correlated to this level. In New York, the well-exposed Church Hollow fan-delta at 600 ft. and the unnamed fan 1/4-mile north were correlated to this Bascom level. The small preserved terrace remnant north of Petersburg also appears graded to this level. A major 630 ft. braid delta at the mouth of the Green River in Williamstown, MA, was similarly correlated. The absence of 700 ft. deposits along the same tributaries is somewhat puzzling but may be explained by a short duration of the 700 ft. Bascom level with complete removal of any 700 ft. deposits during aggradation to the 620-630 ft. level. The short distance of ice margin retreat to the 625 ft. Case Brook col is consistent with our view of a short duration 700 ft. level. Lake Bascom simply did not exist long enough at a 700 ft. level for much sediment aggradation.

Further ice retreat from Hoosick Falls to North Hoosick (Waterford (1)) ice margin of the Hudson Lobe after DeSimone and

LaFleur (1986) was accompanied by a drop in Lake Bascom from 620-630 ft. to 520-540 ft. (158-164 m). No outlet seems possible except for meltwater flow along or under the ice margin and down the Hoosic Valley to Lake Albany. This final Bascom level lasted long enough for numerous fan-deltas to accumulate in the Little Hoosic Valley at North Petersburg (540 ft.), Hoosick (520 ft.) and the dissected fan at 520 ft. of the Walloomsac River in Hoosick Junction. Alluvial fans and fluvial terraces at this level along the Hoosic River through the Pownal and North Pownal quadrangles are too close to the modern flood-plain level and insufficiently exposed to determine if they are of Woodfordian or Holocene age. The low level of Lake Bascom prompted dissection of earlier deposits through the project area and elsewhere as tributaries downcut to the lowering base level.

The suggested lower Bascom outlets discussed above are only tentative as no detailed field work has been done in the outlet areas. The reconnaissance level mapping on open file at the New York State Geological Survey, however, does not preclude the possibility that these outlets were used for Lake Bascom drainage. Alternatively, lower Bascom water levels could have been controlled by subglacial drainage beneath the retreating Hoosic ice tongue if the ice was sufficiently thin. Subsequent erosional and depositional events would have obliterated any evidence of former subglacial drainage channels in the Hoosic Valley.

Final drainage of Lake Bascom occurred when the ice margin retreated north of North Hoosick and allowed free drainage of meltwater down the Hoosic Valley depositing outwash terraces at

400-420 ft. and ultimately the early Hoosic Delta at 370 ft. (112 m) into Lake Albany. These events have been correlated to the Willow Glen (2) ice margin of the Hudson Lobe (DeSimone and LaFleur 1986).

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Appendix A: Description of Mapping Units

$_xR$; rock outcrop; subscripts denote lithologies as follows:

- $_{gn}R$ - gneiss
- $_{gr}R$ - granite
- $_{qz}R$ - quartzite
- $_{mb}R$ - marble
- $_{ds}R$ - dolostone
- $_{ls}R$ - limestone
- $_{ph}R$ - phyllite
- $_{sl}R$ - slate
- $_{sc}R$ - schist (Dalton Fm. on Pownal quadrangle)
- R - undifferentiated, often observed only on air photos

Outcrop data for the eastern half of the Pownal quadrangle was provided by Ratcliffe from his preliminary bedrock map.

WOODFORDIAN UNITS:

tt_L; thin (<3 m or 10 ft.) lodgement till, cover moraine veneer; patchy distribution with frequent rock outcrops, areas of fresh rock rubble, and areas of thin weathering mantle. Terrain is streamlined and drumlinoid forms are abundant. See t_L below for sediment description.

t_L; thick (>3 m or 10 ft.) lodgement till, cover moraine blanket; thickness verified in exposures and well logs or inferred from landform analysis (i.e., drumlins). Terrain is characterized by streamline-molded forms. Taconic type and Green Mountain type tills are confined to their respective geographic areas. Lithologies are described below.

Designation of diamictons as lodgement till encompasses sediment deposited directly beneath ice and deposited by meltout of debris-rich basal ice. No distinction between these two processes was observable in exposures. Mass movement and fluvial processes were of limited importance as inferred from exposures.

Taconic type lodgement till is very well-compacted with an unoxidized light to medium dark gray color (N7-N4) in fresh exposures. The matrix component (75-90%) is silty-clayey and unstratified. The clast component (10-25%) consists of subrounded to rounded cobbles and pebbles with occasional boulders. Clast lithologies are primarily locally-derived phyllite, slate, and shale. Quartzite, vein quartz, and carbonate clasts are locally abundant. Exposures in and surrounding map area are NPO 86-5, BEN 86-1, BER 86-2.

Green Mountain type lodgement till is not well-exposed in the area. Washed surface exposures along abandoned logging trails and oxidized soil cuts <1/2 m deep yielded some information. The till is well-compacted with an unstratified silty-sandy matrix (60-75%) oxidized to a brown color (5YR 4/4-10YR 5/3). Subangular to subrounded clasts (25-35%) are primarily of local quartzite and gneiss. Clast sizes range from pebbles through cobbles to frequent boulders. Numerous boulders are scattered across the thin till surface of the eastern highland.

Vermont Valley drumlinized lodgement till retains its streamlined form despite partial (?) veneer of ablation lag. Plowed fields indicate a till intermediate between Taconic and Green Mountain varieties with a greater proportion of local carbonate and quartzite clasts.

tt_A; thin (<3 m or 10 ft.) ablation till with areas of modern weathering mantle and rock outcrop, hummocky ground moraine veneer. See below for sediment description.

t_A; thick (>3 m or 10 ft.) ablation till, hummocky ground moraine blanket. Diamictons interpreted as meltout till consist of an unstratified sandy to silty-sandy oxidized brown (5YR 4/4-10YR 5/4) colored matrix (60-75%). Subangular to subrounded clasts (25-40%) are of varied lithologies. The sediment is loosely-compacted, locally very cobbly and not well-exposed along the base of the Green Mountains where it is primarily mapped. No clearly discernible landform unit was recognized. The unit is thought to overlie lodgement till or rest directly on bedrock. Areas of similar surface material with a more distinctly kamiform terrain, often with a few kames or short esker segments, are designated KM or SKM or K.

M; moraine till; One exposure (WIL 86-IP) in a small, low ridge along the Hoosic Valley consisted of a clast-supported boulder diamicton. The silty-sandy matrix is fairly well compacted with numerous pebbles. Cobbles and boulders up to 2 m diameter comprise 75-85% of the deposit. Some boulders appear faceted and striations were observed. Clast lithologies include carbonates and quartzite. Minor cobbles and pebbles of schist and phyllite are deeply weathered.

KF; kame field; formerly referred to as kame stagnation moraine or stagnation kame moraine; This unit encompasses much of the sediment in the central portion of the Pownal quadrangle. It is characterized by a surface diamicton facies of unsorted and unstratified to crudely stratified pebble and cobble clasts (40-60%) in a sandy to sandy-silt matrix (40-60%). Larger clasts up to boulder size are frequent. Thickness ranges from approximately 1.5 ft. to 5 ft. (0.5 - 2.0 m) but averages 3 ft. Color is an oxidized moderate brown to dark yellowish brown. The contact with underlying stratified meltwater sediment is usually sharply defined. At one locality (POW 86-4P), flame and dish structures were observed at the contact between stratified sand and the overlying unstratified sandy diamicton. The diamicton facies clearly coarsens upward at this locality.

Overall, multiple origins are inferred for this diamicton. Some of the sediment was deposited as simple meltout till, while other exposures indicate flow processes involving sediment and meltwater derived from stagnant ice.

The underlying stratified meltwater sediment consists of well sorted to moderately sorted sand and pebble/cobble gravel interbeds. Angle-of-repose bedding, tabular cross-stratification, and horizontal bedding are collectively present in the numerous exposures. Ripple cross-lamination and hummocky cross stratification are locally present. Localized sagged bedding and normal faulting indicate nearby ice. The sediment is interpreted to represent subglacial ice-contact sedimentation from meltwater streams with local deltaic sedimentation into subglacial ponds.

The morphology of the KF includes isolated large kames standing above an expansive rolling hummocky landscape of small moulin kames, short esker segments, irregular gravel-sand ridges, and occasional kame plateaus. The kame plateaus are flat-topped sand and gravel forms surrounded by ice-contact slopes.

KM; kame moraine; The unit is a fairly narrow band <2,000 ft. (700 m) wide of ice-contact stratified sediment variably capped with unstratified sandy diamicton and incorporating varied landform elements including eskers, deltas, terraces, and kames within an overall hummocky terrain and deposited along valley ice tongue margins. Clinoform and cross-stratified sands interbedded with clinoform pebble and small cobble gravels predominate, but the sediment is locally variable from a bouldery sandy diamicton (POW 86-11) to faulted kame deltaic sands with minor gravels and diamicton (POW 86-1).

Subaerially-exposed, ponded, and subglacial depositional environments are inferred to have been present along the margin of Vermont Valley ice in the Pownal quadrangle. Meltwater and the Walloomsac River draining the uplands of the Woodford quadrangle are indicated sediment sources.

KT; kame terrace (lateral terrace); Portions of a multiple level (900-920 ft. and 1000 ft.) deposit at the head of kame moraine segments along the lower flank of the Green Mountains and just south of the Roaring Branch Walloomsac River. The sediment is predominantly horizontally-bedded sands and gravels with ripple lamination and turbidity current deposits at BEN 86-2P. Sandy cobbly diamicton along the slumped ice-contact margin was observed.

K; undifferentiated hummocky terrain with insufficient exposure to further define the unit; may include isolated kames, kame field, and/or hummocky ground moraine (tt_A or t_A). Sediment in exposed kames elsewhere consists of stratified meltwater deposits of fluvial and lacustrine origin and unstratified to crudely stratified diamictons varying from sandy to cobbly texture.

E; eskers; higly variable sediment texture with eskerine landform deposited in subglacial tunnel environments. The sediment ranges from well sorted and well stratified sand and gravel observed at most exposures to a poorly sorted and poorly stratified course cobble and boulder diamicton (POW 86-21). The latter clasts are faceted and crescentic-marked quartzites. Accordingly, esker sedimentation was accomplished by meltwater streams and by direct meltout from debris-rich ice. The South Stream esker, a beaded esker, is traceable for approximately 4 1/2 miles. It trends N-S nearly from the large kame (POW 86-18P) near the fish hatchery on South Stream Road to its distal kame delta (POW 86-1) within the Pownal Center kame moraine complex. Sediment texture varies along the esker's length, but paleocurrent directions consistently point to a northerly meltwater source.

A prominent E-W tributary (engorged?) esker approximately 0.5 miles long crosses South Stream Road, and paleocurrent indicators suggest meltwater flowed toward the primary South Stream esker.

Several short esker segments from 1100-1400 ft. (POW 86-2P, POW 86-3) are within the eastern kame moraine complex at the base of the Green Mountains and may have originated as crevasse fillings.

The Ladd Brook esker along Witch Hollow Road is traceable for approximately 1 mile to its distal end where an unexposed 1120-1140 ft. (kame delta?) deposit exists.

OW-OF; outwash (valley train) and outwash fan; Outwash is meltwater-derived gravel and sand with a flat to gently sloping morphology on valley bottoms. Outwash fan gravel with sand is a meltwater-derived deposit with a fan morphology akin to an alluvial fan. Both are very minor units in the project area.

Lc; lake clay and silt; Rhythmically-bedded to massive lacustrine sediment of Glacial Lake Bascom in the Hoosic Valley. The light through medium dark gray to light olive gray sediment contains occasional ice-rafted pebbles. Two exposures (NPO 86-7, NPO 86-8) contrast undeformed versus deformed clays. The latter exposure contains flow-like structures and numerous stones. This stratified clay diamicton is interpreted to represent redeposited lake beds which flowed down the adjacent valley slope and incorporating stones from lodgement till on the slopes.

LD_f; fan-delta gravel and sand; Small meteoric fan-deltas deposited by tributary streams into Lake Bascom at one or more of its lower levels. A generalized stratigraphy can be assembled from exposures both within and outside the mapping area. Approximately 5-15 ft. of horizontally-bedded, poorly sorted, channeled cobble and pebble gravel topset beds truncate and overlie inclined foreset gravel and sand interbeds which may overlie and truncate finer sand and silt interbeds of bottomset lacustrine origin. Boulders and colluvium may be present in the topset facies. Clasts vary from rounded to angular, but most are of local phyllite and vein quartz with some quartzite. The progradational sequence represents an alluvial fan-delta built into a lake. Sediment was derived from erosion of glacial valley-fill till and bedrock along tributaries to the Hoosic. No faulting or other deformation is present to suggest these are inwash-type sediments deposited against an ice margin. These deposits are aquifer recharge areas and may be moderately useful aquifers, but their poor to moderate sorting lowers permeability.

WOODFORDIAN-HOLOCENE UNITS:

FT; fluvial terrace; sand, silt and gravel interbeds, horizontally-stratified, with a terraced morphology and at an elevation near modern floodplain level. Although a terrace elevation may correlate with a lower Bascom water level, it cannot be conclusively determined whether these are late glacial or modern deposits of the Hoosic River. Terraces may be expected to form in the Hoosic Valley as the Hoosic River graded to lower Bascom water levels in late glacial time, graded to lower lake levels in the Hudson Valley during late glacial time, and graded to modern base level. These deposits recharge the upper unconfined Hoosic floodplain aquifer and represent excellent sites for commerical and/or residential development.

AF; alluvial fan; gravel deposits of poorly sorted and poorly stratified character. They may serve to recharge aquifers.

HOLOCENE UNITS:

FP & AL; floodplain sediment along major streams and alluvium along minor streams. Textures vary from finer overbank sediment to coarser point bar and channel deposits. Organics may be present. Generally, the floodplain sediment along the Hoosic River is a sand or silty sand. Alluvium along upland tributaries is highly variable and its texture may reflect the adjacent parent material. The Hoosic River floodplain deposits have moderate aquifer potential.

AF; alluvial fan; Small fans at tributary junctions and along base of steeper slopes. These are not well-exposed, but the sediment is presumably coarse-grained, poorly sorted, and of predominantly angular clasts. Organics may be present. Their localized occurrence and poor sorting result in low aquifer potential.

Spm; swamp peat and muck; Poorly drained upland and lowland areas are underlain by organically-derived sediment overlying either floodplain sediment in the lowlands, kettle-fill, or thin till in the uplands.

f; artificial fill; predominantly along roadbeds and railroad grades.

APPENDIX B: LIST OF EXPOSURES

POW86-1: This is an active pit with approximately 40 vertical feet of total exposure located within the Pownal Center-Barber Pond kame moraine. The basal facies is a well-sorted and well-stratified sand approximately 25 feet thick. The lower sand unit in the western end of the exposure consists of steeply dipping foreset-type sand beds which are strongly faulted on both a large scale and microscale. Elsewhere, the sand facies is predominantly horizontally laminated with ripple laminations and ripple cross laminations, and channel structures. An intermediate gravel facies (3-5 feet) truncates the sand facies and consists of horizontally bedded cobble and pebble gravel with minor sand. The moderately well-sorted gravel of this topset-type facies is dominated by quartzite and lesser phyllite-slate lithologies. The progradational nature of this deltaic sequence at the terminus of the Barber Pond esker indicates deposition in a kame delta environment, probably into a local impondment along the ice margin at the base of the Dome. The local ice marginal pond here at an elevation of 1360 feet spilled over into the Ladd Brook Valley and drained into Lake Bascom.

An upper diamicton facies (8-15 feet) conformably (?) caps the gravel along the eastern side of the pit at the pit entrance. The unit is unstratified, matrix-supported, and consists of pebble and cobble gravel in a sandy-silty matrix. Presumably this is a meltout till deposited by ablation processes in the ice marginal environment. It may record debris flow onto the kame delta from surrounding ice. Alternatively, the kame delta may have accumulated, at least in part, subglacially beneath an ice shelf along the ice margin. The top of the deposit at 1280 feet+ is well below that of the spillway along Ladd Brook at 1360 feet for meltwater in this pond. Hence, all of the sediment may well be subaqueous gravels and sands prograded into the pond by the subglacial meltwater source represented by the Barber Pond esker. This makes a debris flow origin for the upper diamicton more likely.

POW86-2P: There is no vertical sediment exposure here, but an easily traceable and previously unrecognized esker is observed crossing the powerline along the flank of the Green Mountains. Pebble and small cobble gravel augered up for placement of the powerline support records here the fluvial nature of the eskerine sediment. The esker trends parallel to the flank of the Greens and nearly connects with the east-west spur of the Barber Pond esker which crosses South Stream Road.

POW86-3: Approximately 15 feet of exposure reveals poorly-sorted, crudely stratified pebble and cobble gravel with fairly coarse sand capped by a thin cobbly and pebbly diamicton with no stratification. The thin diamicton represents a meltout till and is characteristic along the lower flank of the Green Mountains where this stagnation blanket presumably drapes stratified fluvial sediment, unstratified lodgement till, and bedrock. The crudely stratified gravel represents esker or crevasse fill sediment.

POW86-4P: The Bushnell School kame is an active borrow pit with interbedded gravel and sand. Well-sorted sand beds alternate with moderately well-sorted to well-sorted gravel beds. Cross stratification, horizontal bedding, graded bedding, and ripple cross laminations are present as are faults and sag deformation due to ice melting. A debris flow deposit which caps part of the kame consists of a sandy, matrix-supported, pebble-cobble, unstratified diamicton. The contact with the underlying stratified sand and gravel is deformed with several tear-ups and flames evident indicating rapid deposition of the flow deposit. Elsewhere the fluvial sediment is capped by a similarly-textured diamicton which forms a thin blanket over the deposit and presumably represents meltout till (subsequently modified by soil and slope processes). The Bushnell School kame interrupts the Barber Pond esker and may well represent a former moulin which brought meltwater into the subglacial tunnel drainage system.

POW86-5: No exposure is present along this small esker segment off Old Sawmill Road. The surface material is a cobbly and pebbly diamicton (?) with numerous boulders scattered along its length. The feature, discovered by a field assistant, is now referred to as the "bees esker" because the same assistant stepped into a hive at the time of his discovery!

POW86-6: This shallow cut in a high terrace remnant along the Hoosic River at 540 feet reveals horizontally bedded and variably sorted pebble gravel and sand. This and similar terraces are correlated to a low level of glacial Lake Bascom in the Hoosic Valley and record the grading of the late glacial Hoosic River to the lower lake levels. The deposit is well above the modern floodplain and, hence, a Holocene origin seems unlikely. No organic matter was observed in the exposure.

POW86-7: This slumped exposure of sand and gravel occurs in the Mann Hill esker which parallels Witch Hollow Road (Hidden Valley Road) for 3/4 mile. The extensive slumping here precludes determination of stratification, if any, within the esker sediment.

POW86-8: This old exposure along Barber Pond Road reveals a pebbly, cobbly, sandy diamicton which may cap stratified meltwater sediment and occurs within the Pownal Center kame moraine complex.

POW86-9: A slumped exposure of loosely-compacted, pebbly, cobbly, sandy diamicton of meltout origin which may rest on bedrock directly as several bedrock exposures nearby suggest. The exposure is at the head of the Ladd Brook spillway for the small ice marginal pond described in association with POW86-1.

POW86-10: The kames exposed here consist of a very coarse-grained cobble diamicton with boulders, in a matrix of pebbles and sand with no fines. Clast-supported and matrix-supported facies are present in this unstratified deposit. The texture, sorting, and absence of stratification again indicate meltout processes primarily responsible for deposition of the ablation lag. No structures were observed to suggest debris flow mechanisms, but their role is as equally likely here as where verified at other sites.

POW86-11: A few apparently in situ boulders and several piled boulders are most obvious in this long abandoned excavation within the Pownal Center kame moraine complex. The colluviated slopes reveal that the boulders were emplaced in a cobble, pebble, and sand deposit which is apparently unsorted and unstratified suggesting an ablation moraine origin at this site. Boulder lithologies are quartzite, carbonate, and phyllite.

POW86-12: This temporary 6-foot deep trench exposed an unstratified cobble, pebble, and sand diamicton of meltout origin.

POW86-13: The site is an old, partially vegetated excavation with approximately five feet of slumped sediment exposed. The fine to medium sand and pebble gravel is stratified and well-sorted. A typical diamicton of meltout origin caps the 100-foot long esker segment or elongated kamiform feature.

POW86-14: A fairly fresh, bulldozed exposure along a new road north from Barber Pond Road reveals a coarse-grained bouldery diamicton with cobbles, pebbles, and coarse-to medium-grained sand. The carbonate and quartzite boulders range from 8-10 feet across, are subrounded, and are heavily striated. Silt through clay particles are not abundant, presumably washed by meltwater from this stagnation moraine. The diamicton is interpreted to be a meltout till of ablation origin. In most of these numerous exposures of meltout till throughout the Pownal quadrangle, it cannot be confirmed whether the sediment is primarily from a subglacial, englacial, or supraglacial environment.

The more rounded, subrounded, and subangular shapes of cobbles and pebbles and the general absence of freshly broken or frost-heaved clasts indicates a very minor contribution of supraglacial debris to these deposits. The large clast sizes and striated nature of numerous boulders here suggest a subglacial or lower englacial origin for the deposit. Its loosely-compacted texture reflects the absence of fines and may also be partly due to an englacial origin as opposed to a strictly subglacial setting for the diamicton.

POW86-15: This site in hummocky terrain is near POW86-14, and approximately 10 feet of sediment is exposed. The lower facies is an unstratified silty, cobbly, sandy diamicton 3-4 feet thick and loosely-compacted. Laterally adjacent to but separated from this diamicton by slumped and bulldozed sediment is a correlative diamicton with two large (10 feet across) striated carbonate boulders. Similarly to POW86-14, this diamicton is interpreted to represent a basal meltout till within this kame stagnation moraine. The upper facies (6 feet thick) consists of moderately well-sorted to well-sorted pebble, cobble and sand interbeds which dip to the south and west reflecting the local direction of subglacial meltwater flow. In contrast to the facies relationships at most other sites, the fluvial meltwater facies at POW86-15 overlies a meltout or basal meltout diamicton. The silty diamicton component indicates the diamicton is less of an ablation lag than those previously described.

POW86-16: Approximately 40 vertical feet of sediment is exposed in this deposit associated with the Barber Pond esker. The lower facies (20 feet) consists of gravel and sand which fines upward to a fairly clean upper sand facies (20 feet). Some crossbedding is preserved, but no ice contact deformation is evident. The fining upwards sequence and its association-physical connection and lobate morphology-with the major esker in the valley suggest an origin as a subaqueous fan deposited either in a subglacial environment or in a small ice-bound impondment isolated during stagnation of the Vermont Valley sublobe in the Pownal Center area. This indicates the sediment within the Barber Pond esker is progressively younger to the north and accounts for the great variability in sediment textures exposed along the esker's length. The filling of the distal southern portion of the esker tunnel and related esker segments of the subglacial "drainage network" date from the time when thicker, more active ice filled the valley. The Pownal Center kame moraine-kame stagnation moraine and the deltaic or subaqueous fan at the esker's terminus are coeval. Thinning and stagnation of the valley ice resulted in "backfilling" of the subglacial meltwater drainage pathways as the active ice margin shifted to the north. Subaqueous fans could be built into subglacial or open ponds associated with the stagnation zone. An analogy with the subglacial meltwater drainage and sedimentation at the margin of the Malaspina Glacier in Alaska is apparent.

POW86-17: This abandoned, soil-covered excavation contains sandy parent material and possesses a kamic topography.

POW86-18: The site is an active gravel pit with approximately 35-40 feet of exposed kamic sediment. This sediment consists of well-sorted sand and pebble gravel interbeds which dip to the west and south into the hillside. Color ranges from tan through dark gray to black. Clast lithologies are dominant quartzite with lesser black slate/ phyllite/shale and a little gneiss. Hand sample matrix analysis of the coarse sand layers reveals approximately 70% rounded quartz/ quartzite grains with tan and white hues, 20% rounded and flattened black slate/phyllite/shale grains, 5% green slate/phyllite shale grains of similar shape, and lesser gneiss and carbonate (?). The black color and relative abundance of black slate and grains and pebbles is unique to this site. Cobbles, pebbles, and coarse sand of a weak lithology like slate are unexpected as abrasion by ice would reduce these clasts to a considerably finer matrix within a few miles of their source outcrops. Accordingly, the abundance of black slate clasts indicates a nearby active ice margin during deposition of this kame. The hypothesis is supported by the morphology of the surrounding terrain and depth-to-bedrock data which indicates a thickening of glacial sediment fill. Thus, we have morphologic, stratigraphic, and provenance data to support our cited ice margin through this area.

Observed faults in the sand which locally pass downward into folds in the lower pebble gravels demonstrate the ice contact origin of the deposit.

The stratified sediment is capped with 2-4 feet (1 m) of unstratified, cobbly, pebbly, sandy diamicton with a loosely-compacted texture and oxidized brown color. This diamicton is again interpreted to be a meltout till mantling the kamic deposit. Less careful observers might suggest this diamicton to be simply part of the soil profile. However, the particle sizes, degree of roundness, and sorting differ from the underlying stratified and sorted glaciofluvial sediment. The contact between the units is variably sharp to somewhat gradational at this and other sites. Hence, this is indeed a different facies and not soil derived from underlying sediment.

POW86-19: This colluviated and overgrown exposure in kamic terrain seems to contain a diamicton cap over stratified glaciofluvial gravel and sand. The landform is linked to a short esker segment opposite the old rail grade.

POW86-20P: This is the active town landfill within the Barber Pond esker complex. The esker morphology is less well-defined and broader patch a hummocky terrain here suggests a breakdown in the confined tunnel depositional environment. The sediment consists of west-dipping, foreset-type gravel and sand interbeds. The poorly- to moderately-sorted pebble and small cobble gravels predominate in the eastern end of the exposure and give way to well-sorted, laminated, cross-laminated, ripple laminated, graded, and occasionally disturbed sands in the western or distal end of the exposure.

Four-inch thick, undulatory, fine sand layers are truncated and thinned into discontinuous lenses by an overlying, graded, medium sand unit which is locally cross-laminated. This unit, in turn, is truncated in a similar fashion. The pattern repeats itself throughout the sand facies, and channel structures were also noted.

The interpretation suggests an environment where high discharge glaciofluvial gravels, perhaps deposited subaqueously in a local subglacial impondment, grade distally to the west into fluvial-lacustrine sands with density flows of sand.

POW86-21: This is the roadside exposure within the Barber Pond esker at the northeastern end of Barber Pond. The sediment here is a very coarse-grained cobble, boulder, and pebble clast-supported diamicton with minor sand. No evidence of clear stratifiction exists. Rather, the deposit represents a lag of coarse debris, perhaps including non-fluvially transported fallout from the surrounding ice. The boulders and cobbles are striated and crescentic-marked, primarily subangular to subrounded, and thus indicate only a short transport history in a fluvial system. Sediment to both the north and south within the esker is notably finer-grained and stratified. A favored environmental interpretation here suggests an accumulation of coarse bedload, combined with fallout of coarse englacial debris, at a location within the subglacial drainage system where the meltwater stream was forced upward from the glacier bed, perhaps initiated by a fallout of englacial debris or an accumulation of subglacial debris by active ice. Flowing upward under hydrostatic pressure, the meltwater stream possessed a lower capacity for coarser clasts and left them behind.

POW86-22: Just north of the landfill, 40 vertical feet of exposed sediment contains poorly sorted to moderately sorted cobble and pebble gravel which grades distally eastward to foreset-type sands. The sediment is generally coarser-grained than at the landfill. The alternating shift of laterally distal sediment from the east to the west from here to the landfill illustrates the splaying out of sediment derived from the primary esker source into broader subglacial depositonal environments adjacent to the primary tunnel.

POW86-23: This is the long-active excavation along Rte 7 operated by the Hart Bros. outfit. The exposure reveals a generally fining upwards lower facies grading from interbedded gravel and sand deposited at angle of repose to an intermediate facies composed of level bedded and tabular x-stratified sand with minor pebble gravel. An upper facies conformably overlies the two conformable lower facies and consists of horizontally-laminated fine sand and silt with occasional thin clay laminae.

The deposit is interpreted to record subaqueous fluvial-lacustrine sedimentation into glacial Lake Bascom. Directional indicators point to northerly and northwesterly sediment sources, consistent with meltwater issuing from the base of the retreating Hoosic ice tongue which defended Lake Bascom. Northerly sediment sources and the terrace-like morphology of the deposit which slopes gently toward the valley axis suggests a supply of meltwater from the Pownal Center region at the distal end of the Vermont Valley and perhaps flowing down Ladd Brook valley from that ice margin which was contemporaneous with the inferred location of the Hoosic ice tongue during deposition of POW86-23.

POW86-24: Abandoned and badly colluviated excavation along Rte 7 southeast of POW86-23 and visible behind the gas station. The occasional fresh exposure reveals level bedded sand with very minor fine pebble gravel and silt (?). The presumed landform of the deposit suggested by the exposure and map contours is that of a subaqueous fan with its apex on the north valley wall and spreading into the narrow valley, perhaps confined by an ice tongue at the time of deposition.

NPO86-1: This exposure on the north side of Rte 346 is just across the state line in New York and totals approximately 20 feet of colluviated sediment. Clearing of the lower portion revealed interbedded and interfingering sand, silt, and clay laminae of lacustrine or subaqueous fan origin. Stones and deformed beds were observed in the clay. We estimate 5-6 feet of disturbed beds at the base of the exposure. This is overlain by approximately 4-5 feet of clean, well-sorted sand, again of probable lacustrine or subaqueous fan origin. The upper portions of the exposed hillslope reveals approximately 8 feet of dirty, poorly stratified phyllitic gravel derived from local bedrock and lodgement till. The gravel is interpretated to represent an alluvial fan facies prograded over and truncating earlier distal subaqueous fan sands. The basal deformed sand-silt-clay interbeds are interpreted to represent sediment remobilized by slope failure beneath Lake Bascom waters. The contact at the top of the deformed beds was not observed and hence, we cannot rule out the possibility of ice override as a mechanism for sediment deformation, but all observations to date argue strongly against any readvance in the Hoosic Valley.

NPO86-2: This is the More excavation west of the Hoosic River in North Pownal. Small exposures northwest of the main excavation reveal laminated and ripple x-laminated sand, which is well-sorted, capped by 1-3 feet of fine pebble gravel. The morphology of the deposits indicate an ice-contact origin as small kames and a short esker segment largely buried by later sediments exposed in the main excavation.

A basal facies in the main exposure was revealed in a single test pit and consists of interbedded sand and silt of probable lacustrine origin truncated by the overlying progradational gravel facies. These 10-15 feet of poorly sorted, horizontally, stratified to unstratified cobble and pebble gravels contain several small boulders and consists predominantly of local phyllite clasts and vein quartzite with lesser amounts of Cheshire (?) quartzite. One percent or less of the clasts as estimated in the field consists of poorly cemented to friable, deeply weathered pre-Woodfordian regolith. These clasts are moderate to dark red and reddish brown, variable to a light to moderate brown oxidized color.

The main gravel facies is interpreted as alluvial fan gravels graded to a 600 foot+ level of Lake Bascom. This fan delta of Halifax Hollow coalesces with the fan delta of adjacent Reservoir Hollow and has largely truncated and buried earlier ice contact sands and gravels deposited along the valley wall. The sediment for these fan deltas was derived from rapid flushing of the lodgement till valley fill with lesser contributions from eroding bedrock and pre-Woodfordian regolith.

NPO86-3: This is a steep, colluviated slope along Reservoir Hollow and is part of the same fan delta complex exposed in the More excavation (NPO86-2).

NPO86-4: A small exposure of stratified gravel at an elevation of 1080 feet along Potter Hollow consists of pebble gravel and sand with minor cobbles. The horizontally bedded sediments are not well sorted.

Phyllite, carbonate, slate, and quartzite are the dominant clast lithologies. The deposit is a small alluvial fan near the head of Potter Hollow where several tributaries join and the stream gradients lessen markedly.

NPO86-5: This is a small surface exposure of lodgement till, partly vegetated, with a cobble lag of phyllite, slate, and quartzite clasts.

NPO86-6: Church Hollow 600 feet fan delta along Rte 22 in New York.

NPO86-7: This is the northernmost of two exposures along the Potter Hollow streambank approximately 0.6 miles north of Rte 346. Total vertical exposure varies from 2-4 feet. The upper unit consists of 2 feet of poorly sorted, poorly stratified gravel and sand with silt and organics. The unit is stable as a soil profile has developed on these Holocene terrace gravels.

The lower unit consists of rhythmically bedded lacustrine clay, gray colored, with occasional stones. The contact with the overlying terrace gravels is a sharp truncation surface. The stones within the Bascom clay unit here may be ice-rifted, but we prefer an alternative explanation. Perhaps the occasional stones here were derived from adjacent lodgement till-covered slopes and were mobilized and redeposited in the soft clay bottom.

NPO86-8: This is the southern exposure of the two mentioned in NPO86-7. The upper terrace gravel is as described previously. The lower clay beds here are deformed, and the disturbed beds suggest flow structures. Stones are more numerous here as well. This stratified clay diamicton was probably redeposited after mobilization upslope as a slump or sediment flow in Lake Bascom. A thin clay cover on the adjacent slopes above the valley bottom might easily have been redistributed, incorporating stones from the underlying till mantle as the flow advanced along the lake bottom.

NPO86-9: This is the well-known clay over lodgement till exposure along Rte 22 north of the Rte 7 junction in New York. The clay rhythmites are probably true varves here in this superb exposure, but as it is several miles within New York, we will not fully describe it here.

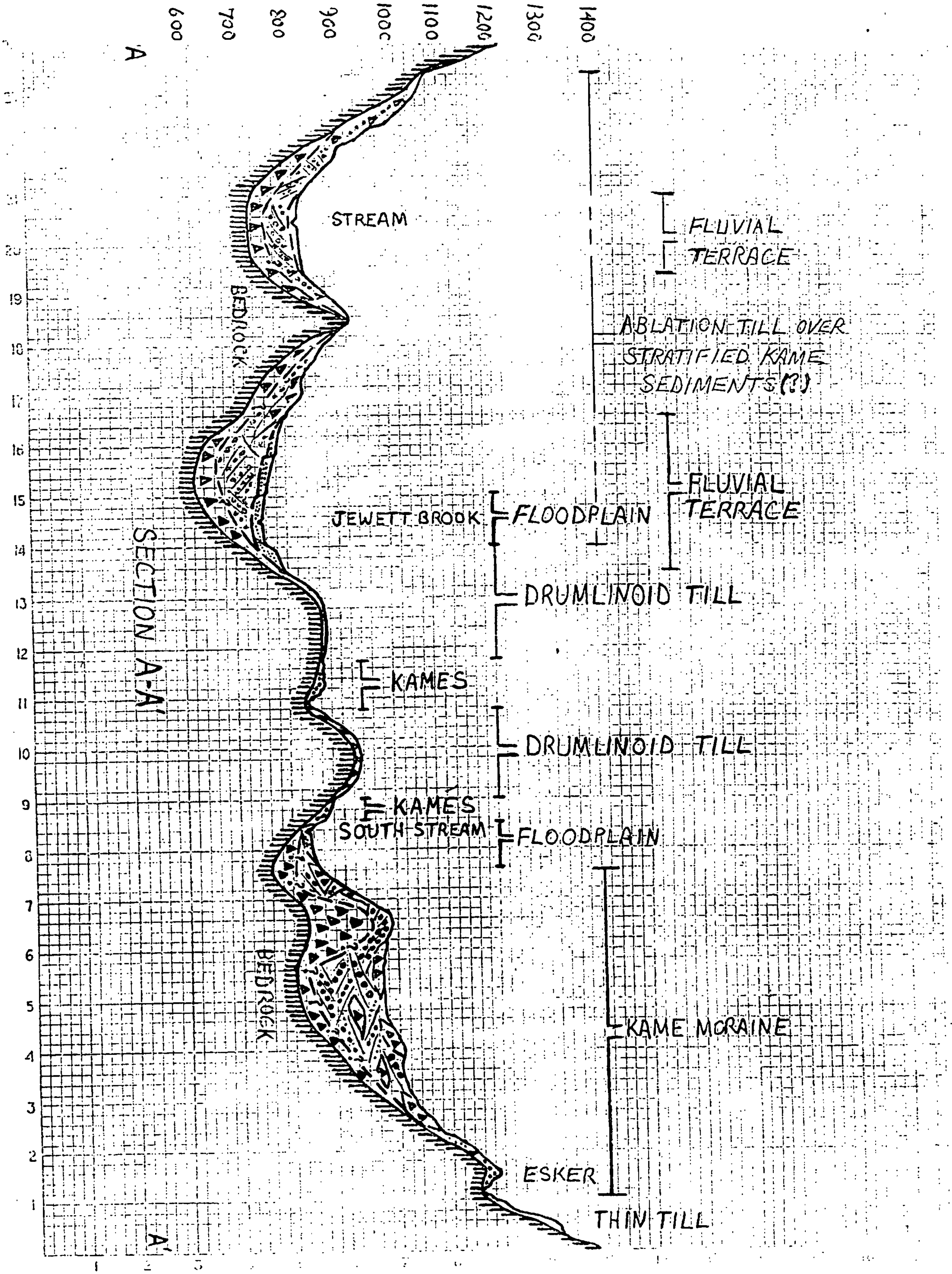
NPO86-10: This is a minor colluviated exposure of pebble and cobble gravel with sand at an elevation of approximately 1120 feet. The morphology of the feature suggests a small isolated kame.

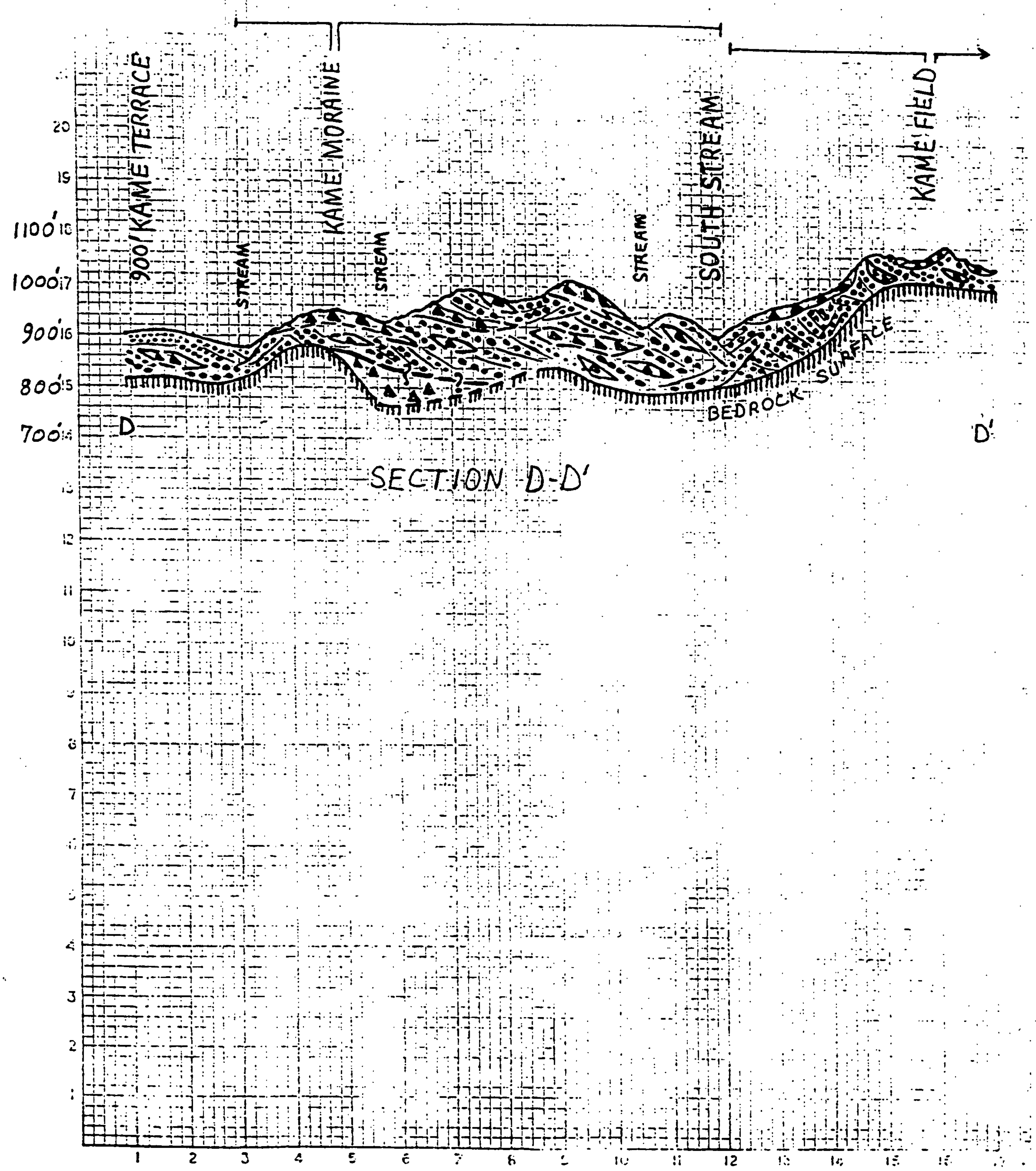
WIL86-1P: This unstratified diamicton consists of faceted and striated boulders up to 5 feet in diameter in a clast-supported deposit with a dense, compacted cobbly, pebbly, and sandy matrix. Clast lithologies include the local carbonates with some Cheshire quartzite and minor deeply weathered gneissic-schistose rock of undetermined source. The occurrence of faceted and striated boulders, the dense packing of clasts and matrix, the lithologic variability of the deposit, its localized geographic extent, and its morphologic expression as a low ridge along the lower valley side indicate a glacial origin as a recessional till moraine deposited along the edge of the Hoosic ice tongue. The ice tongue margin lay in the constricted portion of the valley just north of the MA-VT line and depended glacial Lake Bascom. Subaqueous deposition allowed the fines to settle away leaving a single ridge of clast-rich till moraine. The presence of the boulder diamicton supports the notion that the retreating ice in the area was active with only localized stagnation zones in geographically (topographically) controlled situations.

WIL86-2: This small abandoned exposure along Mason Hill Road across from the reservoir consists of a poorly sorted, poorly stratified, gravelly and sandy diamicton. The short eskerine landform is part of a larger complex of ice-contact sediments at 1100 feet in the Mason Hill-Broad Brook area identified as an ice margin by F. B. Taylor (1903) and confirmed by our mapping.

APPENDIX C: SELECTED CROSS-SECTIONS

Lines of the following sections are indicated on the depth-to-bedrock overlay.


1400
1300
1200
1100
1000
900
800
700
600
A
STREAM
FLUVIAL
TERRACE
BEDROCK
ABLATION TILL OVER
STRATIFIED KAME
SEDIMENTS (?)
FLUVIAL
TERRACE
JEWETT BROOK
FLOODPLAIN
SECTION A-A'
DRUMLINOID TILL
KAMES
DRUMLINOID TILL
KAMES
SOUTH STREAM
FLOODPLAIN
BEDROCK
KAME MORAINE
ESKER
THIN TILL
A'


900' KAME TERRACE
STREAM
KAME MORAINE
STREAM
STREAM
SOUTH STREAM
KAME FIELD
1100'
1000'
900'
800'
700'
D
D'
BEDROCK SURFACE
SECTION D-D'

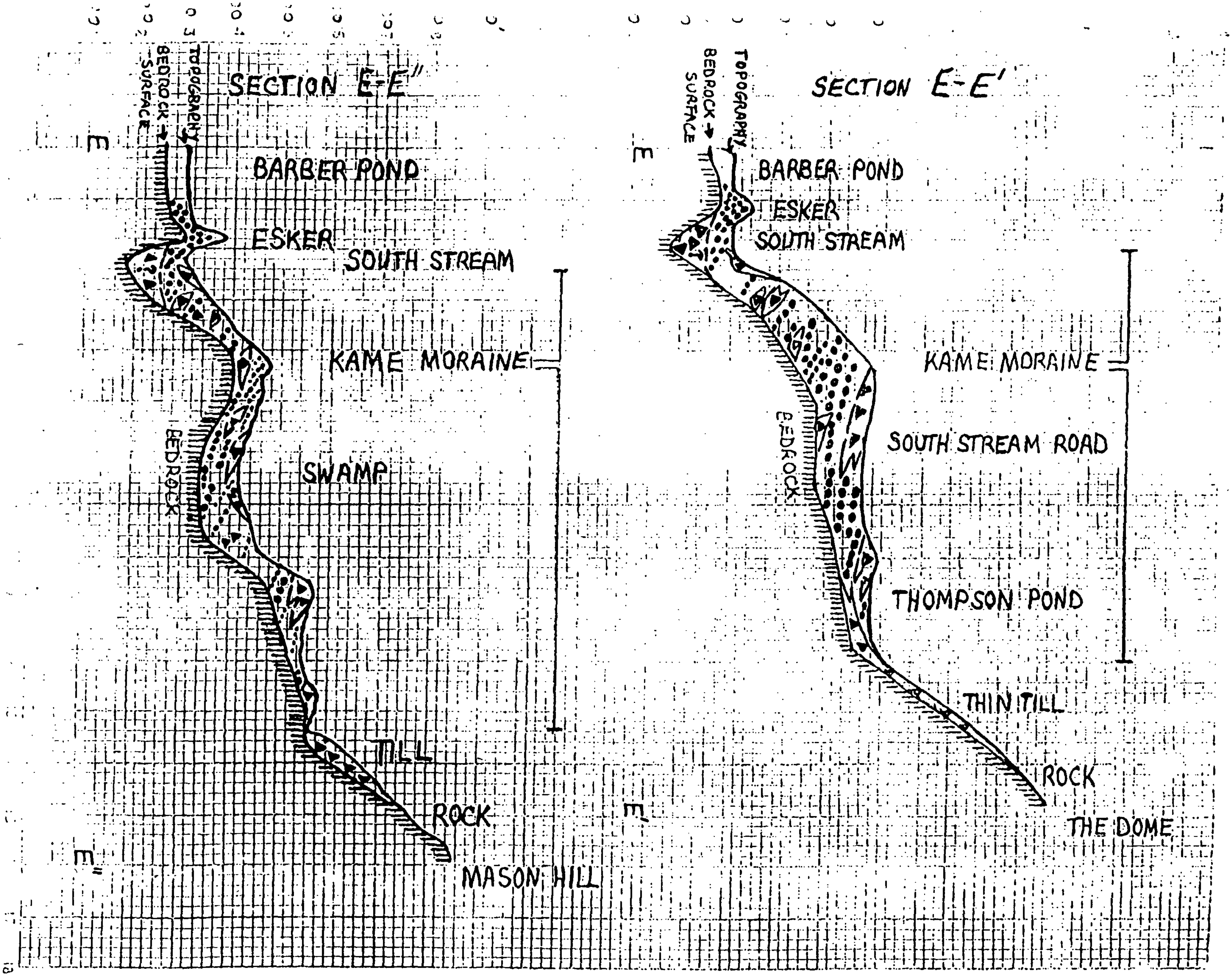

SECTION E-E''
TOPOGRAPHY
BEDROCK SURFACE
E
BARBER POND
ESKER
SOUTH STREAM
KAME MORAINE
SWAMP
BEDROCK
TILL
ROCK
E''
MASON HILL
SECTION E-E'
TOPOGRAPHY
BEDROCK SURFACE
E
BARBER POND
ESKER
SOUTH STREAM
KAME MORAINE
BEDROCK
SOUTH STREAM ROAD
THOMPSON POND
THIN TILL
ROCK
E'
THE DOME

PLATE 2

EXPLANATION

HOLOCENE UNITS

- f — Fill
- Spm — Swamp peat and muck
- AF — Alluvial fan gravel
- FP, AL — River floodplain and tributary alluvium (sand with gravel)

WOODFORDIAN–HOLOCENE UNITS

- AF — Alluvial fan gravel
- FT — Fluvial terrace sand with gravel

WOODFORDIAN UNITS

- LDf — Fan-delta gravel with sand
- Lc — Lake clay and silt
- OW/OF — Outwash/outwash fan sand and gravel
- E — Esker gravel with sand
- K — Kame gravel and sand, undifferentiated
- KT — Kame terrace sand and gravel
- KM — Kame moraine gravel, sand and till; minor colluvium on slopes
- KF — Kamefield gravel, sand and ablation till with minor colluvium
- ta — Ablation till, thick (3m or 10')
- tta — Ablation till, thin (3m or 10') with rock outcrop (colluviated on slopes)
- tl — Lodgement or basal till, thick (3m or 10')
- ttl — Lodgement or basal till, thin (3m or 10') with outcrop (colluviated on slopes)
- M — Moraine till: bouldery with silty-sandy matrix

BEDROCK UNITS

- R — Rock outcrop, undifferentiated
- Rgn — Gneiss
- Rgr — Granite
- Rqz — Quartzite
- Rmb — Marble
- Rds — Dolostone
- Rls — Limestone
- Rph — Phyllite
- Rsl — Slate
- Rsc — Schist

D.J. DeSimone 1987
D.P.Dethier

SURFICIAL GEOLOGIC MAP OF THE POWNAL-NORTH POWNAL, VERMONT AREA

19B

DEPTH TO BEDROCK IN THE POWNAL AND NORTH POWNAL VERMONT AREA

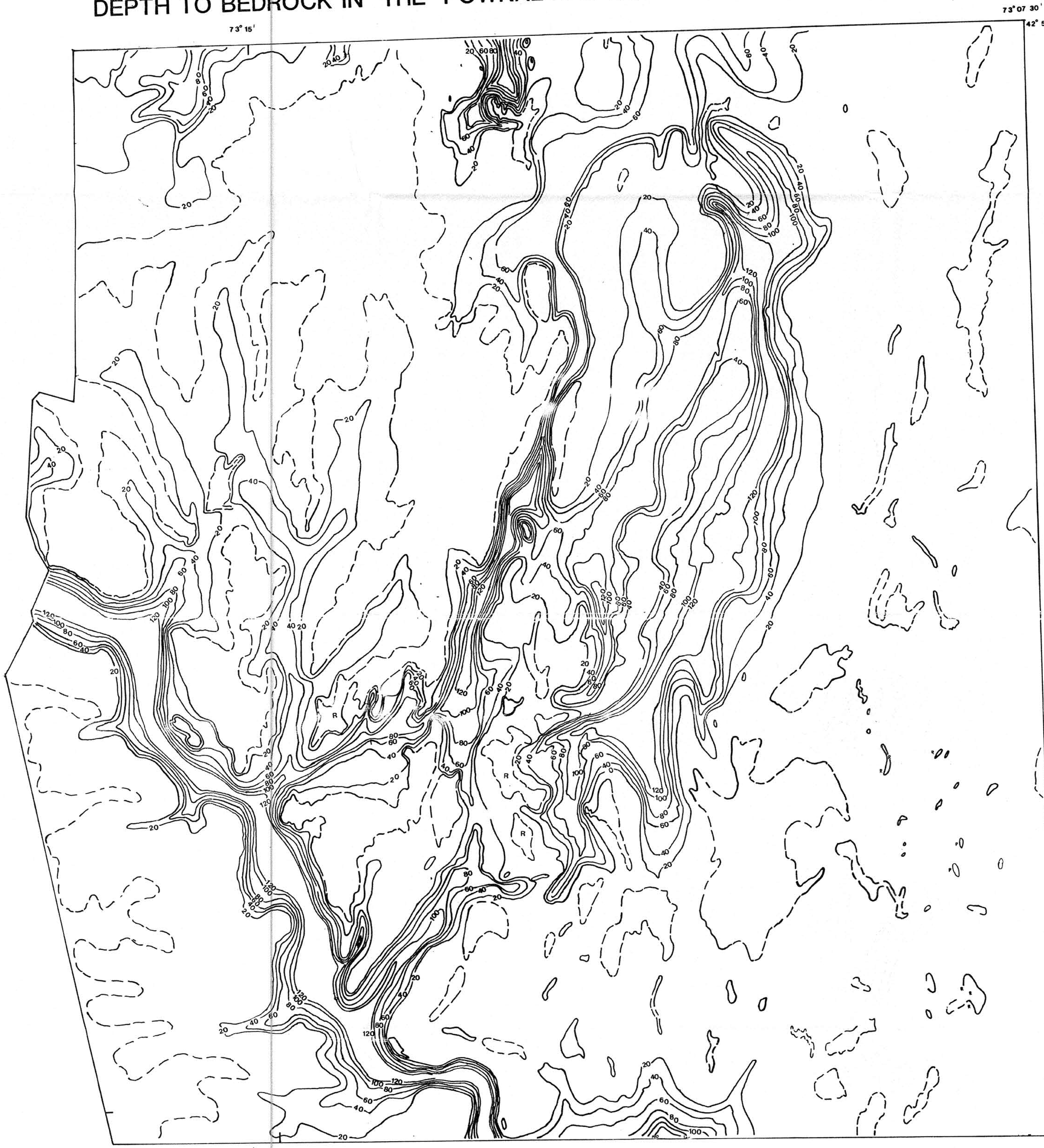


PLATE 1

EXPLANATION

Contour Interval 20 ft.

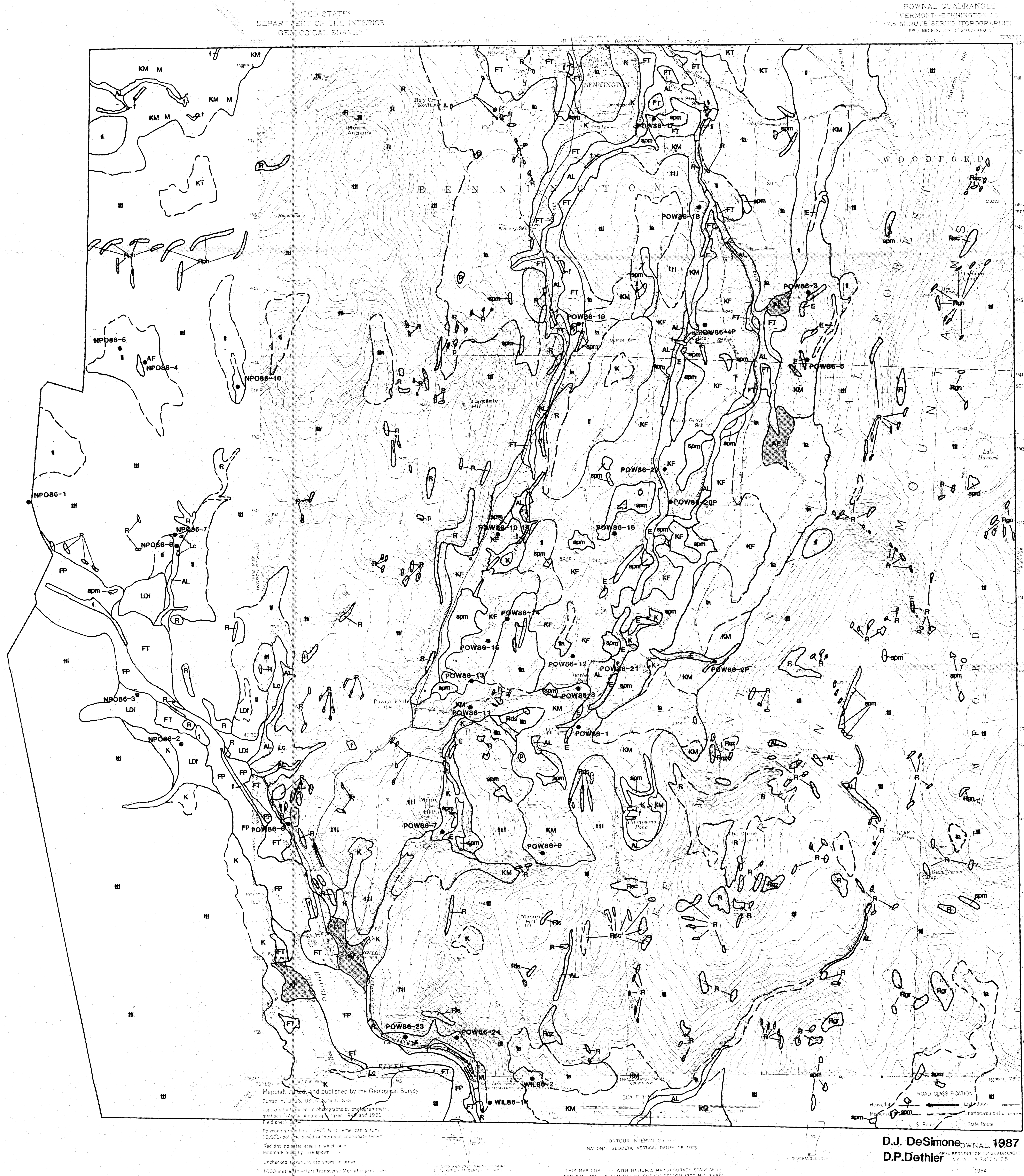
-20- Depth to rock contour

(R) Area of predominantly rock outcrop

Contact State of Vermont or authors for well data

D.J. De Simone 1987
D.P. Dethier

PLATE 2



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SURFICIAL GEOLOGIC MAP OF THE POWNAL-NORTH POWNAL,VERMONT AREA

19B

DEPTH TO BEDROCK IN THE POWNAL AND NORTH POWNAL VERMONT AREA

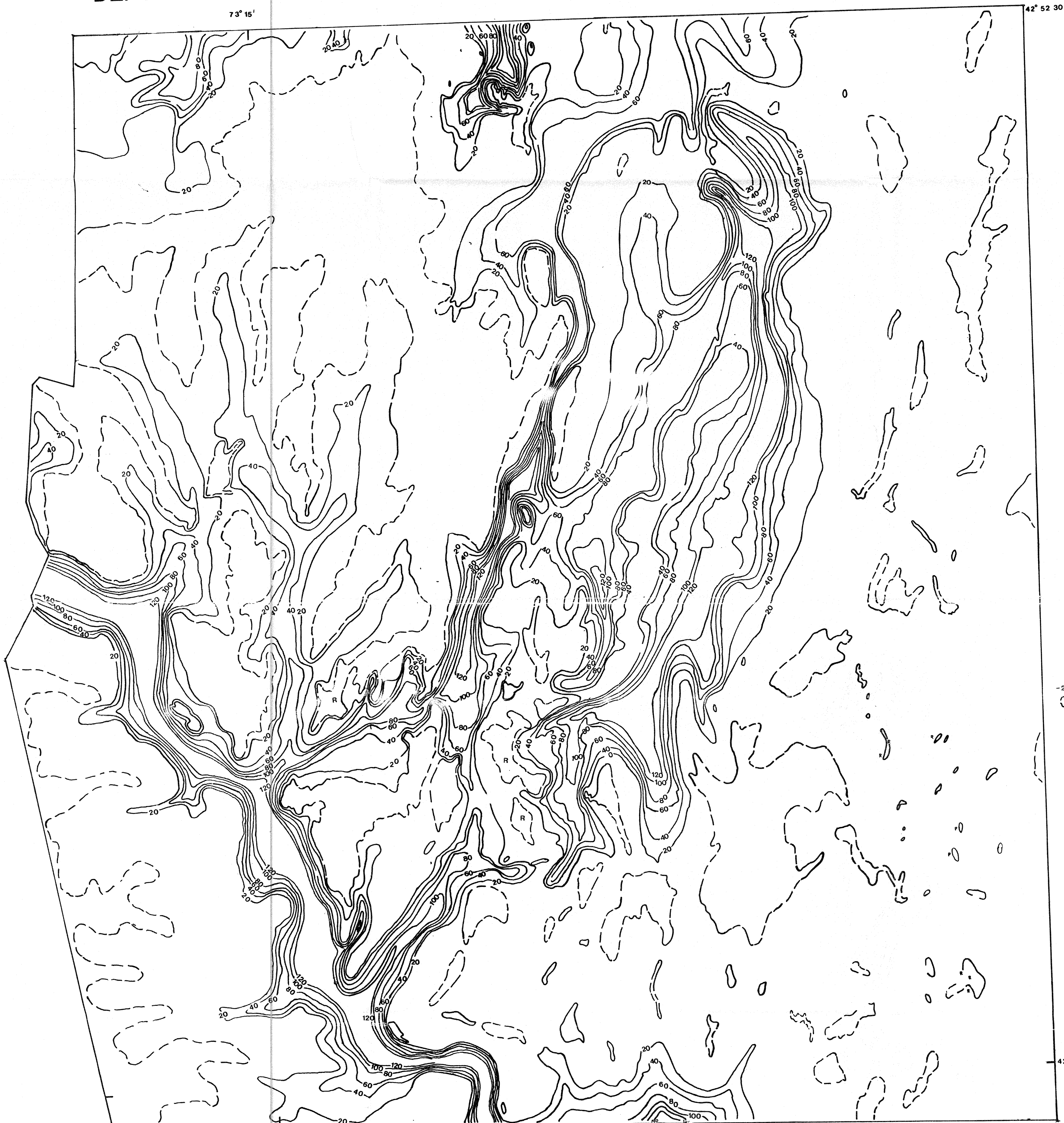

PLATE 1

EXPLANATION

Contour Interval 20 ft.

-20- Depth to rock contour

(R) Area of predominantly rock outcrop

Contact State of Vermont or authors for well data

D.J. De Simone 1987
D.P. Dethier