UC-C1297

R E G I O N A L   G E O L O G Y

C O N F I R M A T I O N   R E P O R T

NEW SITE GENERATION PROJECT

PHASE I--INVESTIGATIONS

4-3-11 SITE

October 29, 1976

GAK-33

Additions:

January 28, 1977

GEORGE A. KIERSCH

CONSULTING GEOLOGIST

[illegible]

451 062

GEORGE A. KIERSCH
119 WARWICK PLACE
ITHACA, N. Y. 14850

ENVIRONMENTAL /
ENGINEERING GEOLOGY
GEOMECHANICS

607 / 257-0395, HOME
256-5282, CORNELL

October 29, 1976

GAK-34

Mr. M. J. Ray
Licensing Supervisor
New York State Electric & Gas
4500 Vestal Parkway East
Binghamton, New York 13902

Re: Transmittal--
Regional Geology
Confirmation Report
4-3-11 Site

Dear Mr. Ray:

The attached "Regional Geology Confirmation Report, New Site Generation Project Phase I Investigations 4-3-11 Site" at New Haven, N.Y. is submitted as per project plan.

Site 4-3-11 is located in a geological/seismological stable region with minimum potential for unknown geological hazards and adverse features. The site was confirmed by GAK on August 20, 1976 as suitable for follow up Phase II investigations and further licensing efforts for a nuclear power plant.

Respectfully submitted,

George A. Kiersch

George A. Kiersch
Geologic Consultant

Attached:
Report

451 063

R E G I O N A L   G E O L O G Y

C O N F I R M A T I O N   R E P O R T

NEW SITE GENERATION PROJECT

PHASE I--INVESTIGATIONS

4-3-11 SITE

October 29, 1976

GAK-33

Additions:

January 28, 1977

GEORGE A. KIERSCH

CONSULTING GEOLOGIST

119 WARWICK PLACE
ITHACA, N. Y. 14850

451 064

TABLE OF CONTENTS

1.0 SUMMARY AND CONCLUSIONS

2.0 INTRODUCTION

2.1 REGIONAL GEOLOGIC SETTING

2.1.1 Regional Geologic History

2.1.1.1 Precambrian Era

2.1.1.2 Paleozoic Era

2.1.1.3 Post-Paleozoic Eras

2.1.1.4 Regional Stratigraphy

2.2 REGIONAL TECTONIC STRUCTURES

2.2.1 Small-Scale Structural Features

2.3 GLACIAL FEATURES

3.0 INVESTIGATIONS--FIELD/OFFICE

3.1 GENERAL ACTIVITIES

3.2 PERTINENT FEATURES

4.0 SOME FEATURES TO BE INVESTIGATED--PHASE II

4.1 REBOUND AND/OR COMPRESSIONAL SMALL-SCALE FOLD STRUCTURES

4.2 ADIRONDACK UPLIFT AND ASSOCIATED TECTONIC STRUCTURES

4.3 DEFINITION OF TECTONIC PROVINCE

4.4 TECTONIC STRUCTURES OF ST. LAWRENCE VALLEY AND EARTHQUAKE EVIDENCE

5.0 REFERENCES

451 065

FIGURES

1 Generalized Bedrock Geology Map of New York State

2 Physiographic Provinces Map of New York State

3 Regional Geologic Column Central Lowlands/Oswego Area, New York State

4 Sub-Regional Geologic Map Vicinity of Site 4-3-11 (Pocket)

451 067

1.0 SUMMARY AND CONCLUSIONS

The areal and regional geologic setting of site 4-3-11 was investigated during the reconnaissance study of 1975 and the Phase I investigational stage of mid-July to mid-August, 1976. On August 20th at meeting UEC/Boston, GAK confirmed that the site and regional environs are essentially as depicted geologically in the documents utilized as the basis for site selection (GAK, 1975) and further substantiated by the results of the Phase I investigations.

The site and areal surroundings are relatively uniform and consist of the structurally undisturbed and southward dipping Oswego Sandstone and Pulaski Formation (to the northward) which are overlain to varying depths by glacial deposits (Fig. 1). Locally the bedrock surface is somewhat undulating due to the scouring action of glacial processes. No fault(s) are known within the general site area and vicinity, however all of the bedrock surface is concealed by varying depths of glacial overburden. Seven cored borings (B-1 thru B-7) indicated a lack of any significant faulting or folding on the site. Within the regional setting (200 miles), a number of small-and-modest scale faults are known, as shown on Figure 4 and described in Section 2.1. However, none of the faults are considered active and/or significant to the seismo-tectonic history of the region, on the basis of available data. Two seismic zones within 200 miles of the site are associated in a general way with structural features, the Ottawa-Bonnechere graben system and the Clarendon-Linden structural zone. There is no evidence of surficial ground breaking along the Clarendon-Linden structures as a result of seismic activity and furthermore, no tectonic evidence is known that suggests a young date for the fault movement along the structures.

Site 4-3-11 appears to be geologically suitable for further licensing efforts for a nuclear power plant on the basis of Phase I investigations and state-of-knowledge. No additional knowledge of significant features or critical geological conditions have been compiled since the reconnaissance study of 1975.

2.0 INTRODUCTION

The general setting and geological features of site 4-3-11 and the nearby region have been described by Kiersch (1975, p. D-1/-9) and only a brief summary is repeated herein.

The site is within the Erie-Ontario Lowland (Appalachian Plateau/Uplands) with generally flat to gently rolling terrain and a bedrock surface that is of low relief (Fig. 2). The land surface rises gradually southward for some 30 to 40 miles to the Portage Escarpment (an erosional feature) which forms the boundary with the Appalachian Uplands.

The principal rock of the area is the Ordovician Oswego Sandstone, a thin-to-thick-bedded unit, that is over 100 feet thick in vicinity of site. The basal sandstones grade into the underlying Pulaski Formation of shale and sandstone and subsequently into the Whetstone Gulf Formation of shale, sandy dolomites, and calcareous sandstones. The Pulaski and Whetstone

451

Gulf units, comprise the Lorraine Group, in vicinity of site, with a thickness of some 715 feet (see Figure 3).

The Oswego Sandstone consists of gray to greenish-gray, fine-grained, dense, moderately hard thin to thick beds of sandstone with dark gray shale laminations and siltstone interbeds of 2-9 inches thick that increase with depth. The sandstones are commonly cross-bedded. Thin dolomitic zones appear at depth. The rock is a deltaic deposit with some of sandstone fossiliferous. The shale units have undulating surfaces, pinch out, lense and are distorted by soft rock deformation. Near the bottom of formation, sandstone is the dominant rock.

Outcrops of Oswego Sandstone near Nine Mile Point are fractured by two prominent, vertical joint sets of limited vertical extent:

-- Set trends North 25-50 degrees West; and
-- Set trends North 69-80 degrees East.

No significant movement has been reported along the joint surfaces. The upper 20 feet of sandstone at the Nine Mile Point excavation (Unit no. 2, 1976) is fractured both vertically and horizontally. Joints decrease sharply with depth and account for the low water yields. Many have been healed by a carbonate or silica cement. The thin shale laminae partings throughout the sandstone, slake and deteriorate rapidly, upon exposure. Small pop-up structures may be present, although no evidence in core.

The Pulaski Formation consists of blue-gray, medium soft, calcareous and pyritic shale interbedded with reddish to gray, hard, calcareous thin- to medium-bedded sandstone. Parts of the unit are grayish, thin sandy limestones and shaly conglomerate. The rocks weather brownish, but are nowhere near the surface (Fig. 3) in area of site; the formation crops out to the north along the Salmon River around Pulaski, New York (Fig. 4). The Pulaski beds are gradational with the overlying Oswego Sandstone and the underlying Whetstone Gulf Formation. Joints within this unit are widely spaced. The reported ground-water yield is low and of poor quality with hydrogen sulfide common.

2.1 REGIONAL GEOLOGIC SETTING

The sedimentary rock units (Fig. 3) are essentially undeformed along the south shore of Lake Ontario and throughout the sub-region of the site. The Oswego Sandstone and underlying formations dip gently to the south and the southwest with an average regional dip of two degrees or less. No folds or faults of any consequence have been recognized in the nearby region (NMPC, 1972). The rocks are essentially undeformed and progressively younger bedrock is encountered as one proceeds south. A mantle of glacial material effectively covers most of the area.

The younger Paleozoic rocks rest on a Precambrian basement which slopes downward to the south. The combination of a southerly dipping Precambrian basement surface and a northerly dipping land surface produces an increase in thickness of Paleozoic rocks to the south. Deep well data indicate that over 2,000 ft. of Cambrian and Ordovician rocks overlie the Precambrian basement in the vicinity of the site (Kreidler, et al., 1972).

451 068 069

The Precambrian basement crops out in the Adirondack Mountains, east and northeast of the site (Fig. 1). The Adirondacks have persisted as a structural high throughout a great portion of the geologic time and represent an ancient mountain root system which has been periodically uplifted as erosion gradually reduced the super-incumbent load. De Waard (1967) estimated that the crystalline rocks exposed in the Adirondacks have been uplifed as much as 19 to 22 miles. The Paleozoic sedimentary rocks that underlie the site contact the crystalline rocks of the Adirondacks 45 miles to the east-northeast. The Paleozoic rocks thicken in all directions away from the circular outcrop of the Adirondacks. A system of faults radiates from the Precambrian rocks of the Adirondack uplift and can be traced several miles into the onlapping sedimentary rocks.

Paleozoic sedimentary rocks similar to those underlying the site occur under and immediately north of Lake Ontario (Fig. 1). The structural attitude of these rocks is similar to those of the site area with a regional dip to the south and a lack of major faults and folds. The Paleozoic strata in southern Ontario occupy the same structural and stratigraphic position with respect to the Canadian Shield as the Paleozoic rocks to the east of the site hold with respect to the Adirondacks. Liberty (1963) reports minor faulting on the north side of Lake Ontario in the Wellington-Prince Edward Bay area.

The geologic setting of the 4-3-11 site area continues essentially uninterrupted to the west across New York State into southern Ontario. In the vicinity of Toronto and Hamilton, Ontario, several small faults and folds are attributed to differential settlement over Ordovician pinnacle reefs (Karrow, 1963 and Caley, 1940, 1941).

South of the site area the land surfa rises at the Portage escarpment. South of the escarpment is the Appalachian Uplands, a region that includes the Finger Lakes district, the Allegheny Plateau and the Pocono Plateau in Pennsylvania. The Paleozoic sedimentary rocks continue to dip gently to the south; however, younger rock formations (Late Silurian, Devonian and Mississippian) are exposed at the surface. The younger Paleozoic rocks are gently folded and faulted with both the folds and the faults trending east-west, perpendicular to the regional dip. At the base of the folded and faulted sequence is the Salina Formation (Silurian) with several hundred feet of interbedded rock salt and dolomite. Prucha (1968) suggests that the folding and faulting of the younger strata are due to gravity gliding down the regional dip with the Salina Formation acting as a decollement. However, site 4-3-11 lies on rock that is older and stratigraphically below the Salina Formation and thus would not be affected by any movement along the suggested decollement.

The regional gravity map indicates a lack of any major basement derived structures in the area of this study (Revetta, 1970).

2.1.1 Regional Geologic History

The main rock units comprising the Erie-Ontario Lowlands were deposited and their attitude and structural relationships were developed during the Precambrian and Paleozoic Eras. The long period of erosion from the

451 069

Paleozoic to the present resulted in the existing bedrock topography which is blanketed by Pleistocene glacial deposits that form the surface topography of the region.

2.1.1.1 Precambrian Era

Interpretation of the Precambrian sequence is difficult because the rock types and structure relationships are quite complex. The basement rocks of the region are crystalline, igneous and metamorphic rocks similar to those exposed in the southern Canadian Shield and the northwest Adirondack Mountains. The basement surface is a southward sloping nonconformity overlain by over 2,000 feet of lower Paleozoic sedimentary rocks (Kreidler, et al., 1972). The basement surface displays from 100-200 feet of erosional relief in the Frontenac Province of the St. Lawrence region. The slope of the contact averages 45 feet per mile in southern Ontario and steepens to approximately 90 feet per mile in the Finger Lakes region.

Available boring information indicates that the basement rocks in the Erie-Ontario Lowlands are comparable with rocks of the Grenville Series. The Grenville Series, which includes much of the Precambrian rocks of northeastern North America, are a thick series of marbles, paragneisses, metavolcanic and igneous rocks, characterized by a common metamorphic history (last major event 1100 M.Y.A.). Biotite gneisses, pyroxene bearing marbles, orthopyroxenitic amphibolites and "Frontenac-type" monzonites are common Grenville rock types. The Grenville rocks were metamorphosed and severely deformed under conditions of deep burial and high temperatures (600°C) during the Grenville Orogeny, about a billion years ago. Erosion and isostatic uplift raised these deeply buried rocks to the surface by Cambrian time.

2.1.1.2 Paleozoic Era

Erosion continued during the Cambrian Period and reduced the topography of the Precambrian rocks to an almost featureless plain. This ancient surface was gradually submerged by a westward moving sea which formed the Potsdam Sandstone, a ripple-marked beach deposit of eroded and reworked Precambrian rock. As the seas advanced westward, the water deepened in the site area and the sediments formed the sandy dolomites and sandstones of the Theresa Sandstone.

During the Early and Middle Ordovician Period, the region emerged above sea level and erosion removed part of the sedimentary sequence. During the Late Ordovician, the continent was again submergent and a major basin formed between the Taconic orogenic belt and the mid-continent. The Taconic Orogeny affected rocks forming a belt from Newfoundland to Georgia. Uplift of basement rocks in what is now the New England geologic province and the westward movement of nappes, thrust sheets, and gravity-slide blocks from this new highland were major results of the Taconian tectonic processes. Coarse sediments rapidly infilled the newly formed basin from the east, burying shelf carbonates and platform sediments, resulting in the thick sequence of reddish "delta" sediments (including the Queenston Formation and Oswego Sandstone). A long period of carbonate deposition in the region of the site formed the lime shelf deposits of the Black River Formation and Trenton Group. A period of igneous activity occurred during or

immediately after the Taconic Orogeny. This is evidenced by volcanic ash layers in the Black River Formation, dikes and trachyte porphyry intrusion in the Champlain Valley, and mafic intrusions in the Hudson highlands (Broughton, et al., 1966).

During Middle to Late Ordovician time, erosion of the rising mountain range to the east supplied sediment to the sea. Initially, the site area and region was in a deep water depositional environment and received only the muds which formed the Utica Shale and the shales of the Whetstone Gulf. Eventually, the seas began to fill with material and coarser-grained sediments began to reach the area, forming a classic sequence of deposits (Fig. 1). The Whetstone Gulf contains some layers of fine-grained sandstone and the overlying Pulaski contains alternating beds of sandstone and shale. At the time of the deposition of the Oswego Sandstone and the Queenston Formation, the site area was a near-shore or on-shore environment with a large delta stretching across the region. Streams and rivers meandered across the delta forming channel and bank deposits. The finer-grained sediments were carried further to the west and deposited in the deeper waters of western New York. Although overlying Lower Silurian deposits were undoubtedly deposited near the site, they have since been removed by erosion. The Oswego Formation remains as the youngest rock unit at the site.

In the Devonian Period, the Acadian Orogeny produced a new mountain range centered in New England and the Canadian Maritime provinces with associated folding, faulting, metamorphism and igneous intrusions. The southeastern portion of New York State contains rocks that were highly deformed as a result of the Acadian Orogeny (Broughton, et al., 1966).

The slickensides encountered on the shale of Queenston Formation extracted at the Sterling Site west of Oswego, New York, have been dated by potassium-argon isotope dating. This dating test reveals that movement occurred 365 million (± 10 million) years ago during the Acadian Orogeny (D & M, 1974).

Widespread uplift and erosion continued throughout the Paleozoic Era. The Appalachian Orogeny in the Late Paleozoic folded and faulted the rocks in eastern New York and regionally uplifed and tilted the rocks of central and western New York southward into the regional east-west trending homoclinal structure that exists today.

2.1.1.3 Post-Paleozoic Eras

The Appalachian Mountains, which formed near the end of the Paleozoic Era, were largely reduced by erosion during the Mesozoic Era. The removal of this great amount of sediment from the mountain system allowed for further uplift and doming. Additional normal faulting and igneous activity occurred as evidenced by the Triassic fault basins and associated volcanism to the east and southeast in New Jersey (Broughton et al., 1966), and the several Cretaceous ultramafic dikes and diatremes in the Finger Lakes Region.

Continued Cenozoic erosion has produced the existing topography in the region. There is no evidence of any significant igneous activity

451 ~~100~~ 071

(dikes only) or major faulting and folding associated with the Cenozoic Era in central and western New York State (Broughton, et al., 1966).

The Pleistocene Epoch brought continental ice sheets that altered drainage systems, eroded the Oswego bedrock, and left a mantle of glacial debris that forms the topographic features of the site. Several ice sheets passed over the area, but only evidence of the last glacier, the Wisconsin, remains. The Wisconsin ice sheet receded from the site area 10,000-12,000 years ago and left behind outwash deposits and drumlins of glacial till. Pleistocene fluctuations in the level of Lake Ontario resulted in the thin sand, muck, and peat deposits which are encountered at some locations on the site.

The melting of the thick ice sheet resulted in the removal of a considerable load and subsequent isostatic readjustment of the rock. The major portion of the rebound is believed to have occurred in the first 2000 years after unloading (10,000 to 12,000 years ago). The only area still experiencing appreciable glacial rebound is in the Hudson Bay vicinity (Fullerton, 1971). Minor uplift, however, is taking place today throughout the region. This uplift is a reaction to rebound which is currently very active northward in the region of Hudson Bay.

Rebound of the land surface in the region is estimated to range from less than 100 ft. near Lake Erie to more than 500 ft. in the Montreal area. The total rebound due to glacial unloading in the vicinity of the site has been estimated to be from 100 to about 250 ft. (Wolcott, 1972).

2.1.1.4 Regional Stratigraphy

Although the site lies within the outcrop zone of the Oswego Sandstone of Late Ordovician age, the formation is not exposed at the surface within the site or vicinity, but is covered by 10 to 80 feet of Pleistocene deposits. Earlier Paleozoic and Precambrian rocks underlie the Oswego Formation (Fig. 3). The Paleozoic section at the New Haven site consits of approximately 2,000 feet of Cambrian and Ordovician sedimentary rocks. The Oswego Sandstone crops out along the beaches of Lake Ontario a few miles north and northwest of the site (Fig. 1 and 4).

Precambrian crystalline rocks comprise the basement complex of the region and are exposed some 40 miles eastward in the Adirondacks (Fig. 1). Similar rocks occur in the Canadian Shield and Thousand Islands sector of the St. Lawrence Valley. A few deep wells scattered throughout the central New York region have penetrated the basement complex (Kreidler, et al., 1972).

2.2 REGIONAL TECTONIC STRUCTURES

The basement surface and the overlying sedimentary rocks both dip gently to the south throughout most of the Erie-Ontario Lowlands physiographic province. The basement rocks of the region are not exposed anywhere within some 40 miles of the site; however, deep well information and regional associations indicate that the basement rock is composed of Precambrian crystalline rock similar to that which is exposed in the

southern Canadian Shield and Adirondack regions. Available information does not indicate any significant deformation of the Cambrian and Ordovician rocks between the Salina Formation (Silurian Period) to the south and the Precambrian basement to the north. Significant structures in the region surrounding the site are shown on Figure 1. The relevant tectonic structures in the region can be related to geologic conditions that do not enter the site area.

Small thrust faults and broad folds are found south of Syracuse in rocks stratigraphically above the Salina Formation. Normal faults are located in Paleozoic rocks where they meet the Precambrian rocks of the Adirondacks and Canadian Shield (Lowville, New York; Picton, Ontario). Faulting northeast of the site near Massena, New York, and Ottawa, Ontario, is attributed to adjustment of stresses along the Ottawa-Bonnechere graben system and auxiliary faulting (Figs. 1 and 4).

The closest relevant tectonic feature that occurs within the Erie-Ontario Lowlands is the Clarendon-Linden structure (Fig. 1). The structure has been investigated in some detail by Van Tyne (1975). Its closest approach is about 95 miles west of the site. The following summarizes the principal conclusions of Van Tyne who describes the features as a high-angle reverse fault which passes into a monocline near the surface.

a. Evidence was apparent from the two subsurface structural contour maps prepared (Trenton/Medina Formations) that the Clarendon-Linden fault/fold consisted of more than one parallel fault at depth. This was further confirmed by evidence from a third and lower level, partial map constructed on the top of Galway Formation.

b. Throughout the length of the Clarendon-Linden trend, the rocks are folded near the surface and no substantial faulting and offset has been confirmed. A series of small, en-echelon faults and thrusts probably occur along the trend of the main flexure, such as the small fault trending about N 60°E near East Alexander.

c. The occurrence of salt/gypsum beds and soft shales in shallow formations along the Clarendon-Linden trend could serve to absorb the large-scale faulting at depth in the more plastic-flow, shallow rocks and thereby form the near-surface folds and flexures.

d. The initial movement along the main Clarendon-Linden structure occurred as a growth-type fault with normal movement down-to-the-east; this took place during lower and middle Ordovician time.

e. At a much later time; probably during the late Paleozoic Appalachian Orogony, regional compressional forces from the east re-activated the original normal fault zone and caused a reversal of the displacement. This formed the high-angle, reverse fault with the near-surface folding as identified today.

f. Another possible explanation of the fault's origin is an initial occurrence in Pre-Cambrian times as a basement fault with subsequent re-activation and movement in mid to late Paleozoic times.

451 073

An evaluation of available data correlated with further observations on the Clarendon-Linden faults/fold indicate the following limitations and circumstances that must be considered when appraising the earthquake potential:

a. Dating of the movement along the faults/fold has been relative only, as inferred from the subsurface maps and other sources. No surface dislocations associated with the faults have been identified in the overlying Pleistocene and recent deposits that are unequivocally post-glacial in origin (R. Fakunding, 1974-75; Dames and Moore, 1974, 1975). No tectonic evidence is known that suggests a young date for the fault movement along the Clarendon-Linden structure.

b. Earthquake events have been monitored in the vicinity of Attica-Dale, New York since 1971. There is no demonstrated connection to date between the scattered earthquakes and the specific faults, except in a general geographic occurrence. A few events are reported by Fletcher and Sykes (in press) to have occurred at locations that essentially coincide with the faults as plotted by Van Tyne (1975).

c. The earthquakes seem to have the characteristics of a shallow event. The Pre-Cambrian basement is within 2500 ft. of surface in Attica area. Fletcher and Sykes (in press) report that most events recorded are shallow, and apparently originated in the Paleozoic rock column overlying the basement.

d. Gravity and magnetic anomalies suggest the alignment of the main fault, but do not infer the east or west parallel branches shown by Van Tyne (1975).

e. There is no close association of the earthquake events with the postulated igneous intrusives "mapped" in the underlying basement rocks by Revetta (1970).

f. The contemporaneous stress field has been measured at two localities in the region, Somerset northwest of fault zone and Sterling west of Oswego (D & M, 1975). At both, stresses are acting from the north-northwest and south-southeast directions and not in the east-west directions postulated by some (Sbar and Sykes, 1973). The latter circumstance has been proposed, if a young continuing movement was in progress along one or more of the faults.

g. Glacial rebound was primarily active 8,000 to 10,000 years ago immediately after the ice retreated. The phenomenon is weak today and not a likely cause of the main earthquake events.

h. Any tectonic stresses set up by plate movement beneath the upstate New York region is believed to be occurring at depths of around 150 km. If tectonic stresses are a cause of the earthquakes, stronger events would be expected than are characteristic of the region.

Minor faulting has been recognized in Scriba, Ontario Center and Rochester, New York, but these are local features that are old and inactive.

451 074

The term "minor" is used to denote structures that are localized in extent and are not related to major structural systems such as the Ottawa-Bonnechere graben. The extensive mantle of glacial soils restricts detailed investigations of the bedrock. Therefore, similar old and inactive minor faults may occur throughout the region. Correlation between Phase I borings at the New Haven site indicates the lack of any significant faulting or folding on the site.

Post-glacial rebound and pop-up structures are common throughout the area. These features are usually small and difficult to recognize from borings. It is possible that minor pop-up features are located in the bedrock near the site, but they should be minor features and their existence should not affect the siting of a facility at the New Haven site.

The closest zone of significant tectonic deformation to the site is the Ottawa-Bonnechere graben. A linear belt of normal faults trending west-northwest comprises the major part of this structure, which parallels the Ottawa River from Montreal, westward beyond Ottawa. Several faults, including the Gloucester fault, intersect the main zone.

A geologic/tectonic investigation (D & M, 1971) along a 110 mile stretch of the St. Lawrence River Valley from east of Ogdensburg, New York, to Montreal, Quebec, failed to reveal the presence of the rift structures which were postulated to extend along the St. Lawrence River, southwestward from Montreal (Kumarapeli, 1966). Geologic mapping, test borings and geophysical techniques were used to perform this investigation. The study revealed that the Ottawa graben, a major geologic structure, appears to extend from a zone of complex structural deformity near Montreal westward beyond Ottawa.

2.2.1 Small-Scale Structural Features

Two minor geologic features were encountered during excavations made for the James A. FitzPatrick Nuclear Power Plant in Scriba, New York, a few miles north of the site. A compression buckle or teepee fold, striking North 78° West, was encountered in the Oswego Sandstone. The buckle was a near-surface compression failure of limited extent. Its origin predates the last advance of continental ice and there has been no movement on it since the retreat of the ice. Evidence of residual stresses, that would exist if the rock were still undergoing strain, were absent or negligible (D & M, 1968). The second geologic feature encountered was a small normal fault also striking North 78° West. Total displacement on the fault is approximately 17 inches with up to 4 inches of gouge. Conclusions resulting from detailed investigations of this fault are:

a. The fault motion dies out within approximately 1500 feet and resolves itself simply into a set of joints.

b. The absence of montmorillonite or halloysite in the fault gouge and shale adjoining the fault strongly suggest that there has been no hydrothermal alteration as would be expected if the fault were associated with deep-seated tectonic activity.

451

075

c. Secondary calcite deposited in joints immediately along the fault and probably associated with it suggest the fault is relatively old.

The determination of the "relatively old" age for the faulting is based on the undisturbed nature of the secondary calcite. Any movement along the fault subsequent to the calcite deposition would have sheared or crushed this mineralization.

West of the site, faulting with 2 to 15 feet of displacement occurs at Rochester (Zenger, 1965). This normal fault strikes northwest and cuts the Lockport Formation along the Barge Canal at Rochester. The faulting is dated as post-Lockport, or younger than approximately 400 million years old. A second feature, a sharp-crested anticline, with axial plane striking northwest, occurs a few hundred feet south of the fault. This fault is minor and is located 70 miles west of the site. Several faults with displacements of a few feet are exposed in the Genesee River valley near Kodak Park in Rochester. These faults are low-angle and disappear into the bedding planes of the Silurian rock. The depth and length of the Genesee River valley prevents tracing the faults to the surface to examine their relationship with the overlying Pleistocene deposits. Consequently, these faults are known as post-Silurian in age only.

Karrow (1963) has noted several small faults in the Hamilton-Galt area and Caley (1940, 1941) has noted several small folds in the Toronto-Hamilton-Brantford area, 180 miles west of the site. These features occur in the limited exposures of the Dundas-Meadford, Queenston, and Clinton Formations, are steeply dipping or vertical, and vary in strike from east through northwest. Karrow examined the minor faults in outcrop and determined that the displacements on the faults diminish with depth. Karrow believes the faults are non-tectonic in origin and may be related to differential settlement over underlying pinnacle reefs or to differential isostatic adjustment.

A normal fault was identified during geological investigations near Ontario Center, New York and was subsequently exposed in a deep open-cut. The fault extends for some 3,000 ft. in length and has been intersected by several borings; stratigraphic offset is 26 feet in the Queenston Formation. The Pleistocene deposits overlying the Queenston are not offset. This fault near the Ginna power plant has been age dated as very old and inactive (D & M, 1974).

Minor faulting in Ordovician rocks has been reported near Lowville, New York, about 45 miles northeast of the site. Three faults are located northwest of Lowville (Fig. 4). Another fault is located approximately 2 miles southeast. The faults range from 1 to 3 miles in length. All four faults are oriented in a northeast-southwest direction, are roughly parallel to each other, and are downthrown on the southeast side. The extent of displacement is not known and the faults appear to be confined principally to Ordovician strata. This faulting is apparently related to the differential uplift of the Adirondack dome. As the Precambrian core of the Adirondacks were uplifted, the sedimentary rocks draped on the flanks were extended and faults formed. Several faults, sub-perpendicular to the Adirondack outcrop, including ones reported by Kay (1953) in the Utica quadrangle and Miller (1909) in the Remsen quadrangle, are evident around

451 076

the perimeter of the domal uplift. None of the faults can be traced further west than the Tug Hill Plateau, approximately 40 miles west of the site.

Minor faulting is also reported in Ordovician strata in Canada on the north side of Lake Ontario. According to Liberty (1960, 1963), normal faulting occurs along the Salmon River north of the Bay of Quinte and at Picton, Ontario. Both faults strike northeast and are downthrown about 100 feet on the west side. Stratigraphic offset along the Picton fault decreases southward, suggesting a pinching out of the fault in that direction. The Picton and Salmon River faults are sub-perpendicular to the Canadian Shield-Lowlands boundary, suggesting that they are similar in origin to the Lowville faults with rising Precambrian rocks extending and tearing the overlying Paleozoic beds.

A number of small faults in Devonian rocks are exposed near Syracuse. The faults strike North 70° West and exhibit a maximum displacement of about 40 feet. Typical of these faults is a low-angle reverse fault with a stratigraphic displacement of 27 feet which is exposed south of Syracuse in a quarry near Jamesville. Other minor faults have been reported in the area of Jamesville. Thrust faulting in Devonian strata is also recognized about 70 miles south of the site near Ithaca, New York. All of these faults occur in rock units that lie stratigraphically above the Salina Formation and may be related to downdip movement along the Salina decollement. The rock units encountered at the site lie stratigraphically below the Salina Formation.

Faulting in the region surrounding the site can be related to geologic features in areas that are not structurally identical to the geologic setting of the site. Faulting south of Syracuse may be related to movement along the decollement created by the Salina Formation. Faulting to the east along the Adirondacks and to the north along the Canadian Shield can be attributed to the displacement of the Paleozoic sediments as a result of uplift of the Precambrian rocks. Faulting to the northeast near Ottawa is attributed to the Ottawa-Bonnechere graben system. The Clarendon-Linden structure remains as the only relevant structure in the region that is located in a geologic setting that is similar to that of the New Haven site.

Glacial rebound has been active throughout the Lake Ontario region and small-scale relief joints and/or faults are common throughout the zone of relaxation in the near-surface rock column (Fig. 3). A second type of small-scale structural feature common to the region is compressional folds and/or pop-up features within the shallow zone of surface rocks. The features are associated with the rebound phenomenon and/or abnormally high, near-surface horizontal stresses and have been observed at many localities in the Erie-Ontario Lowland (Fig. 2).

2.3 GLACIAL FEATURES

Glacial history starts during the early Pleistocene time -- with several thick ice sheets advancing across region and the last glacial ice retreating some 10-12,000 years ago. The previously existing (ancestral) weathered rock and soil mantle were scoured along with a sizeable thickness of the bedrock formations. The ice-removed debris and rock materials were

451 077

deposited over region in form of glacial till, sands and gravel, outwash, and special glacial features such as drumlins, moraines, eskers and other glacial landforms. All are common in the Erie-Ontario Lowlands (Fig. 2).

During the retreat of the last glacial ice, a large glacial lake, ancestor of present Lake Ontario, was created by the obstruction of natural drainage outlets by ice barriers and/or moraines. Post-glacial erosion and weathering has produced only minor modification of the glacial terrain.

Melting of the thick regional ice sheet several times caused an unloading and consequent rebound adjustment of the ground surface and rock column. For example, near Montreal, Canada the rebound was several hundred feet with progressively less southward into New York State.

Site 4-3-11 lies within the areal sector that has been modified by the recent water level changes and activity of Lake Ontario. Consequently many of the glacial features (deposits) prominent south of the site are masked or modified within the site area.

3.0 INVESTIGATIONS--FIELD/OFFICE

The 'on-site' investigations (described in GAK-28 and GEI-No.37) summarize a minimal boring and seismic investigations of site 4-3-11. The seismic lines and borings were designed to outline any sectors of deep glacial deposits in contrast to the ridge areas which are underlain by the Oswego Sandstone at a somewhat shallow depth. Furthermore, the investigations were designed to establish a general subsurface knowledge of the site and rock conditions on which to base the Phase II investigations.

3.1 GENERAL ACTIVITIES

The Phase I regional geologic investigations included the following activities:

a. A review and general logging of core from the seven borings (B-1 thru B-7) to evaluate the characteristics and properties of the bedrock units and any structural feature(s) exposed in the core.

b. A review and analysis of the subsurface data provided by the three geophysical profiles across the site area for correlation with the overburden and bedrock units and any indication of abnormal structural features.

c. A review and evaluation of the general geology of the site area for correlation with the regional structural trends and distribution of glacial deposits and bedrock units. Later, the site geology mapping or plot data assembled by GEI (May-August, 1976) was made available to GAK for the regional interpretation and analysis in January, 1977.

d. A review, compilation and general evaluation of regional geology data was performed for project purposes, such as seismo-tectonic analysis. No regional geologic mapping was undertaken for Phase I. Rather, data was utilized from the published and unpublished sources and from a general knowledge of the regional/local geologic features gained from

many field examinations over the years extending from Buffalo to Pulaski, throughout the Mohawk valley, and central New York State.

3.2 PERTINENT FEATURES

A description of the regional geologic setting, history and the principal tectonic structures, both large and small, of possible concern to the evaluation of site 4-3-11 are discussed in sections 2.1 and 2.2. A brief explanation of the pertinent features included in the regional geologic review are:

a. Available information indicates that no significant deformation has occurred that involves the Cambrian, Ordovician, Silurian, and Devonian rocks to the north and south of site.

b. Normal faults occur in Paleozoic rocks on flanks of Adirondack uplift and the Canadian Shield. Evidence indicates they are very old and inactive; uplift theory of Isachsen (1975) not documented.

c. Faults and the graben system that extends from Massena, New York to Ottawa, Canada are rifts due to adjustments of stress along the whole system with auxiliary faulting.

d. Monoclinal folding with faulting at depth along the four faults comprising the Clarendon-Linden structure has been dated only relatively. However, no evidence is known that suggests a young date for the fault movement.

e. Small thrust faults and broad folds occur in the Devonian rocks near Syracuse and southward near Ithaca. All faults occur in rocks that overlie the saltbeds of the Salina Formation and may have formed by a large-scale, block-type movement downdip along the salt in early geologic time. The rock units of the site area are older and lie below the Devonian rocks.

f. A small normal fault up to 3,000 feet long occurs in the Queenston rocks (Oswego Formation) near Ontario Center and the Ginna power station located east of Rochester. The fault has been dated as very old and inactive.

g. Small normal faults and/or graben structures have been determined, on the basis of deep well logs, to occur in the Cambrian and Ordovician rocks south of Rochester. These structures are very old and are not evident in the younger, overlying beds.

Pockets of natural gas were encountered in the Oswego Sandstone during cored boring exploration for the Nine Mile Point Nuclear Station (NMPC, 1972). Gas flows largely ceased within 24 to 48 hours after completion of drilling. Similar gas flows are being experienced in the 70-foot deep excavation for unit no. 2. Local gas seeps are released through several ground water-filled sump pits excavated below foundation level. The gas is 93 percent methane and is probably generated in the underlying Pulaski and Trenton Formations (Fig. 3).

4.0 SOME FEATURES TO BE INVESTIGATED- -PHASE II

4.1 REBOUND AND/OR COMPRESSIONAL SMALL-SCALE FOLD STRUCTURES

Locally the Oswego Sandstone may possess high compressional stresses that form modest pop-up features when the rock surface is 'unloaded' by removing the glacial overburden and/or near-surface rock. A regional investigation of this phenomenon (such as occurred at the Fitzpatrick and Nine Mile Point sites has been undertaken. The features, teepee folds and buckles are also common in the Queenston Formation that crops out in the Low Lands province westward along Lake Ontario to Buffalo and beyond into Canada (Fig. 1).

4.2 ADIRONDACK UPLIFT AND ASSOCIATED TECTONIC STRUCTURES

Age of last fault movement and the potential for recurring activity are critical to the regional analysis and seismo-tectonic evaluation. The many ancient or paleo-faults that occur on the flanks and within the Adirondack uplift are generally considered to have formed during the domal uplift and are Pre-Devonian in age (over 350 million years old). However, some investigators have inferred a possible Post-Paleozoic age (over 200 million years), while some inference exists for recurring movement during Mesozoic-Cenozoic time (100 to 10-20 million years). Currently several investigators hypothesize that the Adirondacks are undergoing active doming/uplift and selected tectonic features may have been reactivated (Isachsen, 1975 and Brown, et al., 1976). The latter, young evolution of the Adirondacks, involves a rejuvenation of the ancient uplift by the emplacement of a peridotite plutonic mass at depth--which is causing the progressive uplift reported by some investigators on the basis of re-levelling data (Isachsen, 1975 and Brown, et al., 1976). This process of emplacement is considered by some as a possible source of the low-level seismic energy releases common in parts of the central Adirondacks.

The geologic mechanism that could provide the source energy for the seismic events associated with the Adirondack Mountains is not clearly understood and some broad studies are in progress.

4.3 DEFINITION OF TECTONIC PROVINCE

The actual boundaries of the regional, seismo-tectonic province involving site 4-3-11 are somewhat different, according to the definitions of New York State and Federal agencies. The limits and province designation could modify the seismic analysis somewhat and should be clarified. For example, one possible means is utilizing the in-situ stress patterns of region to delimit boundary between Lowlands province of site and Upland/Highlands province to the east.

4.4 TECTONIC STRUCTURES OF ST. LAWRENCE VALLEY AND EARTHQUAKE EVIDENCE

The possibility that tectonic structural features occur in the St. Lawrence valley and trend southwestward toward Lake Ontario and the site have been suggested by earlier investigators (Kumarapeli, 1966). However, other investigators have concluded that no such tectonic features (D & M, 1971) or potential hazard exists. This possible regional feature, if present, could be significant to the site evaluation and seismo-tectonic analysis. For example, such a feature within the vicinity of the site would increase the seismic hazard potential.

451 080

A recent report by Coates, et al. (1975) suggests that evidence of young earthquake activity is recorded in the Pleistocene glacial sediments of the St. Lawrence valley. Although the indications of seismicity as reported are sketchy and inconclusive, the possible significance to site 4-3-11 warrants a field evaluation and analysis of the evidence.

5.0 REFERENCES

Broughton, J.G., Fisher, D.W., Isachsen, Y.W., and Rickard, L.V., 1966, Geology of New York, a short account: New York State Museum and Science Service, Educ. Leaflet 20, 45 p., 23 figs.

Brown, L.D. and Oliver, J.E., 1976, Vertical crustal movements from levelling data and their relation to geologic structure in eastern United States: reviews of geophysics and space physics, v. 14, no. 1, p. 13-35.

Caley, J.F., 1940, Paleozoic geology of the Toronto-Hamilton area: Geol. Survey Canada memoir 224.

Caley, J.F., 1941, Paleozoic geology of the Brantford area: Geol. Survey Canada memoir 226.

Chute, N.E., 1964, Structural features in the Syracuse area in Prucha, J.J. (ed.) Guidebook to field trips, New York State Geological Association, 36th Annual Meeting, Syracuse, New York, p. 74-77.

Coates, D.R. (ed.), 1975, Identification of late Quaternary sediment deformation and its relation to seismicity in the St. Lawrence Lowland, New York: New York State Energy Research and Development Authority, 267 p.

deWaard, D., 1967, Absolute P-T conditions of the granulite facies metamorphism in the Adirondacks: Koninkl Nederlandse Akad. Wetensch, Proc. v. 40, no. 4, p. 400-410.

D & M, 1968, Preliminary safety analysis report, James A. Fitzpatrick nuclear power plant: New York Power Authority/Dames & Moore, Cranford, N.J.

D & M, 1968a, Preliminary safety analysis report, Nine Mile Point Nuclear Station, Unit 1: Niagara Mohawk Power Corporation/Dames & Moore, Cranford, N.J.

D & M, 1971, Regional geotechnical and tectonic study, St. Lawrence River Valley: New York State Atomic and Space Development Authority report (Dames & Moore).

D & M, 1974, Geological and geophysical investigations of fault near Ginna nuclear power plant: Rochester Gas and Electric Company, N.Y., Dames & Moore, Cranford, N.J.

D & M, 1975, Preliminary safety analysis report, Sterling Nuclear Station (SNUPPS): Rochester Gas and Electric Company, Dames & Moore, Cranford, N.J.

451 081

Fisher, D.W., Rickard, L.V., and Isachsen, Y.W., 1970, Geologic map of New York State: New York State Museum and Science Service, Map and Chart Series No. 15.

Fullerton, D.S., 1971, Indian Castle glacial readvance and its regional implications in the Mohawk Lowland, New York: Ph.D. Thesis, Princeton, N.J.

Isachsen, Y.W., 1975, Possible evidence for contemporary doming in the Adirondack Mountains, New York and suggested implications for regional tectonics and seismicity: Tectonophysics, v. 29, p. 169-181.

Karrow, P.F., 1963, Pleistocene geology of the Hamilton Galt area: Ontario Dept. Mines, Geol. Report no. 16.

Kay, Marshall, 1953, Geology of the Utica quadrangle, New York: New York State Museum Bulletin, No. 347.

Kiersch, G.A., 1975, Geological reconnaissance and evaluation of preferred sites, New York State Electric and Gas Corporation New Site Selection Study: United Engineers, Boston, 150 p., 34 figs. (Dec. 5, 1975).

Kreidler, William L., 1959, Selected deep wells and areas of gas production in eastern and central New York: New York State Museum and Science Service, Bull. 373.

Kreidler, W.L., VanTyne, A.M., Jorgensen, K.M., 1972, Deep wells in New York State: New York State Museum and Science Service. Bull. no. 418A, 335 p.

Kumarapeli, P.S., and Saull, V.A., 1966, The St. Lawrence Valley system: Canadian Journal of Earth Sciences, Vol. 2, p. 639-657.

Liberty, B.A., 1960, Belleville and Wellington, map areas, Ontario: Geol. Survey Canada, Dept. Mines and Tech. Surveys, Paper 60-31.

Liberty, B.A., [illegible], Geology of Tweed, Kaladar and Bannockburn map areas: Ontario Geol. Survey Canada, Ottawa.

Miller, W.J., 1909, Geology of the Remsen quadrangle, New York: New York State Museum Bulletin, No. 126.

NMPC, 1972, Preliminary safety analysis report, Nine Mile Point Nuclear Station Unit 2: Niagara Mohawk Power Corporation, Dames & Moore, Cranford, N.J., v. VIII, (June, 1972).

Prucha, J.J., 1968, Salt deformation and decollement in the Firtree Point anticline of central New York: Tectonophysics, v. 6, no. 4, p. 273-299.

Revetta, F.A., 1970, A regional gravity survey of New York and eastern Pennsylvania: Ph.D. Thesis, Univ. of Rochester, Rochester, N.Y. (unpubl.)

Rickard, L.V., 1973, Stratigraphy and structure of the subsurface Cambrian and Ordovician Carbonates of New York: New York State Museum and Science Service, Map and Chart Series No. 18.

Sbar, M.L., and Sykes, L.R., 1973, Contemporary compressive stress and seismicity in eastern United States: Bull. Geol. Society America, v. 84, p. 1861-1882.

Van Tyne, Arthur M., 1975, Subsurface investigations of the Clarendon-Linden structures, New York State Museum and Science Service, Open-File Report., 12 p., 8 maps.

Wolcott, R.I., 1972, Late quaternary vertical movements in eastern North America; quantitative evidence of glacio-isostatic rebound: Reviews Geophysics and Space Science, v. 10, p. 849-884.

Zenger, D.H., 1965, Stratigraphy of the Lockport formation (Middle Silurian) in New York State: New York State Museum and Science Service Bull., No. 404, 210 p.

451 083

GENERALIZED BEDROCK GEOLOGY OF NEW YORK STATE

COMPILED BY
GEOLOGICAL SURVEY
OF THE
NEW YORK STATE MUSEUM AND SCIENCE SERVICE
1972

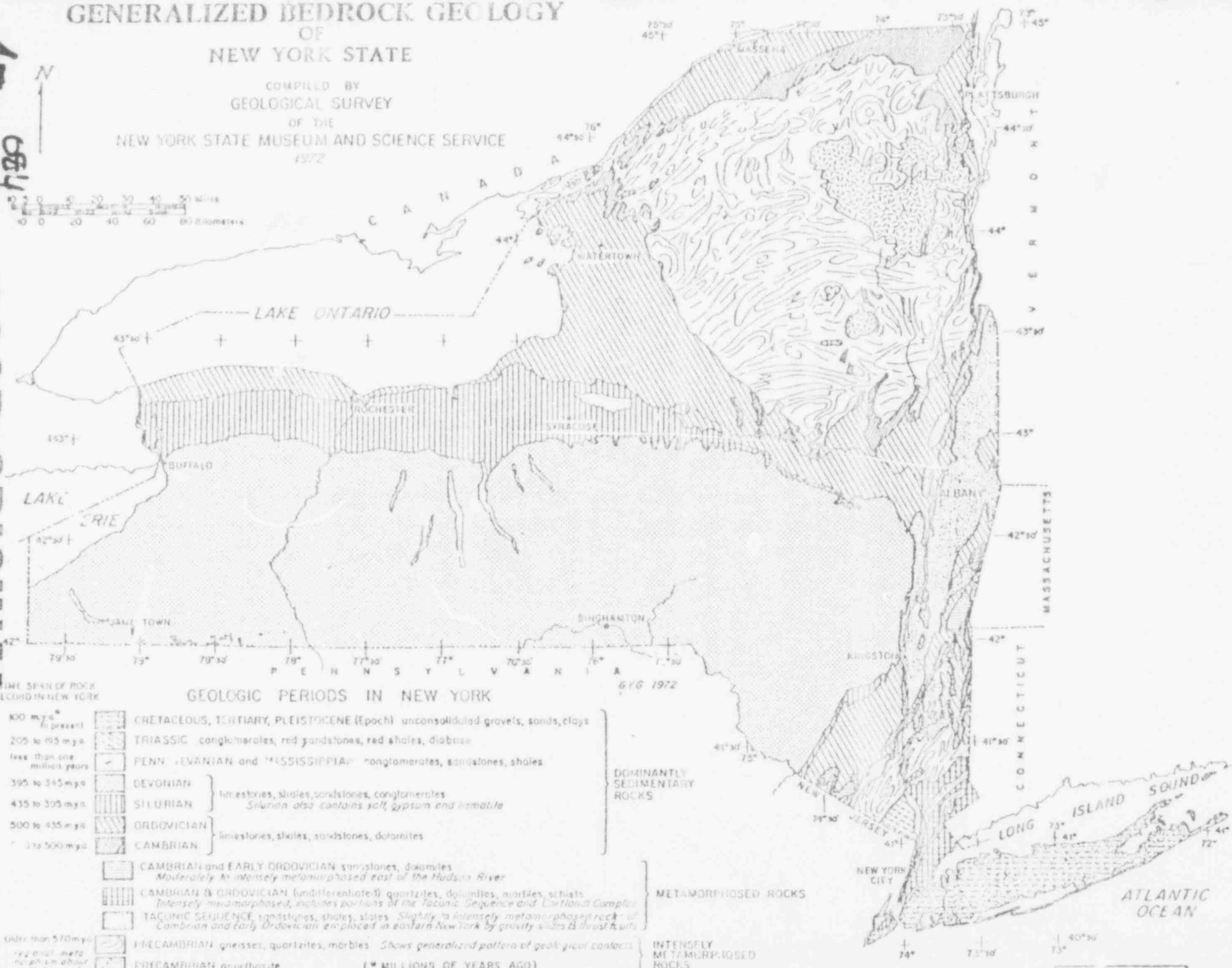
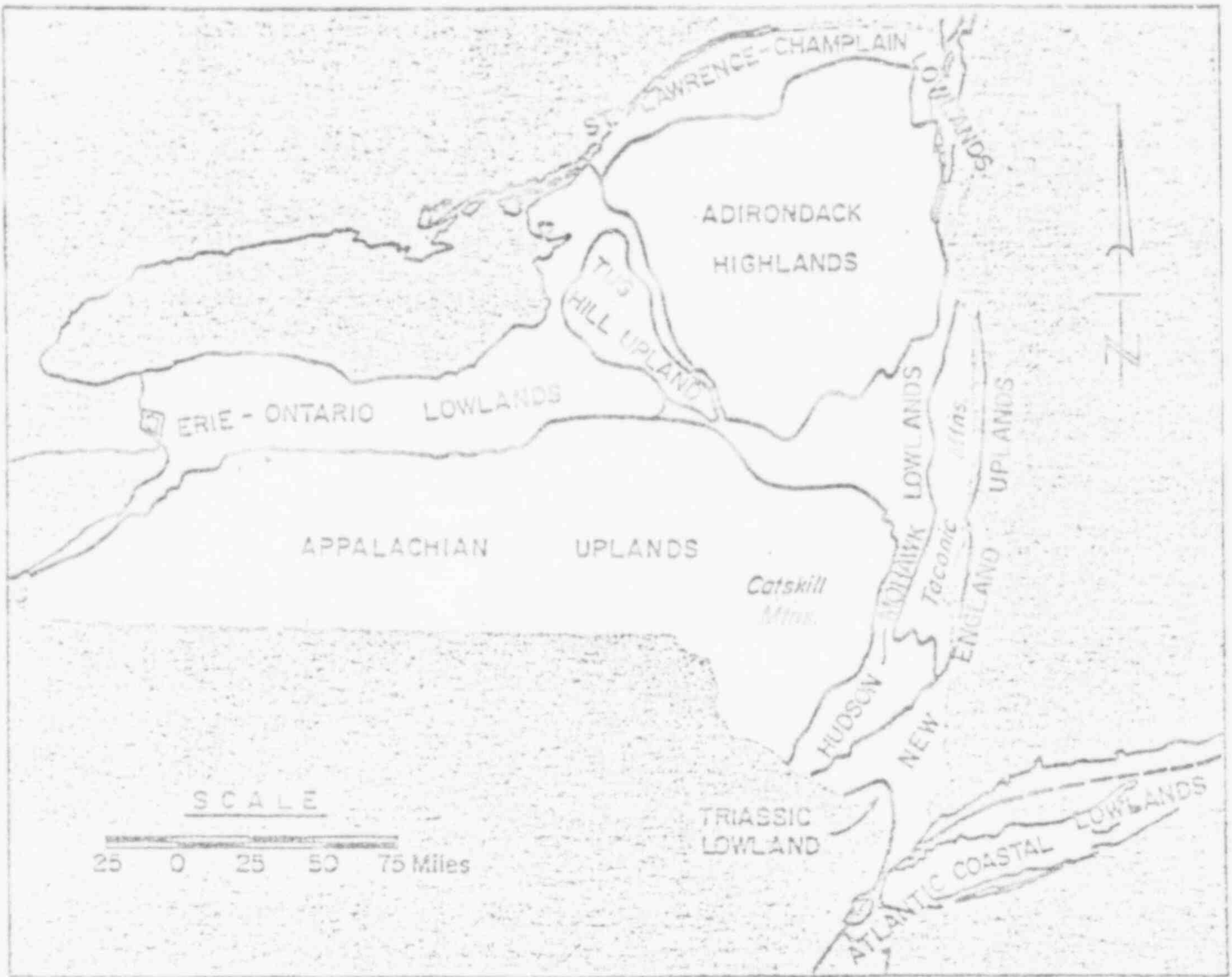


FIGURE 1

POOR ORIGINAL



AFTER BROUGHTON, J.G. ET AL, 1966.

PHYSIOGRAPHIC PROVINCES OF NEW YORK STATE

451 085

POOR ORIGINAL

FIGURE 2

SURFICIAL/OVERBURDEN MATERIALS

SOIL with sandy, silty clays and some angular rock fragments. Thin cover, low permeability.

GLACIAL SANDS: Brownish to grayish, fine-to medium-grained sands and silty clay matrix with some gravels, cobbles and angular rock fragments. Locally moderate permeability, wells common.

GLACIAL TILL: Brown to gray, heterogeneous mixture of fine to coarse sands with gravels and some cobbles and rock fragments in matrix of silt and clay; denser with depth, some silty zones. Low permeability.

Compressional wave velocity, 2000 ft/sec; shear wave velocity 1000 ft/sec (calculated); Poisson's Ratio 0.30 (assumed), unit weight 140 pounds (NMPC, 1972).

451

080

NOT TO SCALE

BEDROCK UNITS

OSWEGO FORMATION/SANDSTONE: Light gray to greenish-gray, fine-grained, dense, moderately hard, thin to thick beds; parts cross-bedded with dark gray shale laminations and siltstone interbeds (2" - 9") increasing with depth, scattered dolomitic zones.

Joints commonly 2-3 feet apart. Small gas pockets locally. Good-quality, modest groundwater yields uppermost few feet of jointed/weathered sandstone.

Thickness near Oswego -- some 150 feet (NMPC, 1972).

PULASKI FORMATION/SHALE & SANDSTONE: Blue-gray, medium-soft, calcareous and pyritic shale interbedded with reddish to gray, hard, calcareous thin-to-medium bedded sandstone; parts grayish, thin sandy limestones and shaly conglomerate. Weathers brownish.

Joints widely spaced. Low yields, poor-quality (hydrogen sulfide) ground water.

Thickness Lorraine Group near Oswego -- Nine Mile Point -- some 715 feet (NMPC, 1972).

WHETSTONE GULF FORMATION: Dark gray, sandy shale with thin interbeds of clayey and pyritic, sandy dolomites and quartz/calcareous sandstones. Shales weather light gray. Gradational contacts bottom and top.

TRENTON GROUP: Series of bluish-gray to gray, fine- to coarse-grained, thin to thick limestones and silty, sandy, limey beds; usually thin distinctive partings. Parts blackish shales. Gradational contacts with intertonguing and wedging of units common.

Yields natural gas many local fields; initial high flow generally decreases rapidly to low flow, many abandoned fields.

Thickness Trenton Group near Oswego -- Nine Mile Point -- some 870 feet (NMPC, 1972).

NOTE:

Generalized full thickness of surficial/overburden materials and/or bedrock units shown may not occur at any site.

GEOLOGIC DATA

Sources given in accompanying Site Reports and Section in Bibliography.

NEW YORK STATE ELECTRIC & GAS CORPORA

NEW SITE SELECTION STUDY

REGIONAL GEOLOGIC COLUMN
CENTRAL LOWLANDS/OSWEGO AR

GEORGE A. KIERSCH
GEOLOGICAL CONSULTANT

PREPARED	DWN CHKD
WEC-GK	DGC

DWG NO GAK-10-013

FIGURE 3

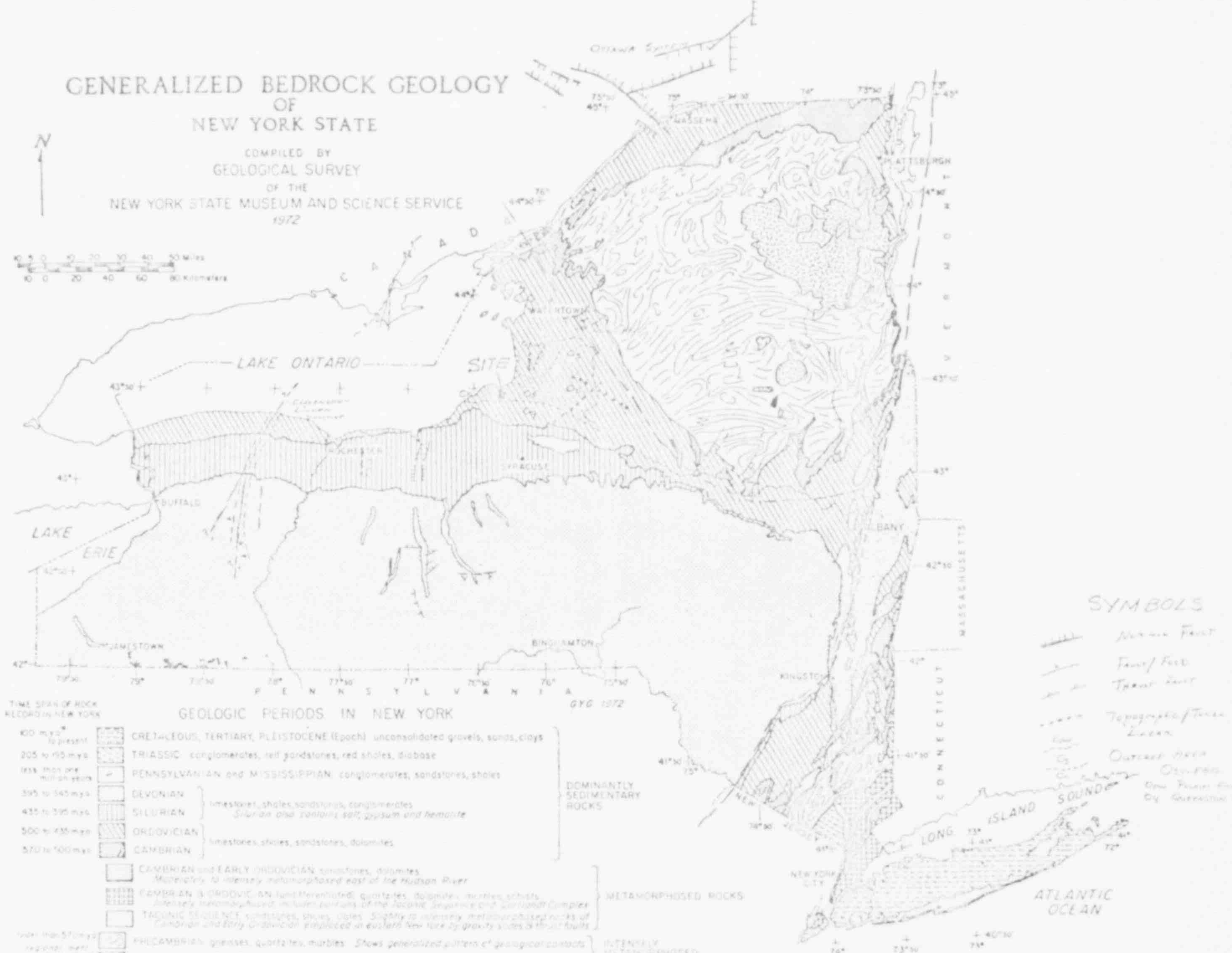


FIG 4

451 087

POOR ORIGINAL

CONFIRMATION STUDY
of SITE 4-3-11

NEW YORK STATE ELECTRIC & GAS CORPORATION
NEW SITE PROJECT

GEOTECHNICAL ENGINEERS INC.

451 089

CONFIRMATION STUDY
of SITE 4-3-11

NEW YORK STATE ELECTRIC & GAS CORPORATION
NEW SITE PROJECT

Submitted to

UNITED ENGINEERS & CONSTRUCTORS Inc.
100 Summer Street
Boston, Massachusetts

By

GEOTECHNICAL ENGINEERS INC.
1017 Main Street
Winchester, Massachusetts 01890

Project 76265
December 23, 1976
Document No. 72
Revised February 8, 1977

090
451

TABLE OF CONTENTS

	Page
1. INTRODUCTION	
1.1 Purpose	1
1.2 Scope	1
1.3 Authorization	2
2. FIELD INVESTIGATION	
2.1 Boring Program	3
2.2 Surficial Mapping	4
3. GEOLOGY	
3.1 Surficial Geology	5
3.1.1 Brown Till	5
3.1.2 Gray Till	6
3.1.3 Stratified Silts and Fine Sands	6
3.2 Bedrock Geology	6
4. GROUNDWATER CONDITIONS	
4.1 Groundwater	9
4.2 Permeability Tests	9
5. PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS	
5.1 Surficial Geology	11
5.2 Bedrock Geology	11
5.3 Groundwater Conditions	12

TABLE 1 - SUMMARY OF BORING PROGRAM - Site 4-3-11
TABLE 2 - SUMMARY OF OBSERVATION WELL DATA

Fig. 1 - Boring Location Plan
Fig. 2 - Subsurface Profiles, Site 4-3-11
Fig. 3 - Subsurface Profiles, Site 4-3-11

APPENDIX A - BORING LOGS
APPENDIX B - TRENCH LOGS
APPENDIX C - REPORT OF FIELD TRIP TO SITE 4-3-11, May 11-12, 1976

451 091

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to present the results of a preliminary geotechnical investigation conducted at the proposed power plant site (4-3-11) in New Haven, New York. The geotechnical investigation was conducted to (1) determine whether the site is as depicted in available published literature and (2) to confirm the results of the initial site selection study.

1.2 Scope

The subsurface soil and rock conditions were investigated with eight (8) borings which ranged in depth from 20 ft to 260 ft. Soil samples were obtained at approximately 5-ft intervals using a standard 2-in. split spoon sampler, which also provides a record of the standard penetration resistance.

Rock was cored using either a 5-ft NX core barrel with a split inner liner or a 10-ft NX core barrel with a solid inner barrel. Rock was sampled continuously. Approximately 20 ft of rock was sampled in six (6) borings and 200 ft in one boring. One boring was terminated at a depth of 20.7 ft in soil when the casing drive shoe was lost down the hole.

The surficial geology investigation included a limited geological reconnaissance conducted on May 11 and 12, 1976, the results of which are presented in a report dated May 26, 1976 and included in Appendix C to this report. An additional preliminary geologic reconnaissance was conducted simultaneously with the boring program.

All soil and rock samples were described in the field. No laboratory tests were performed on these samples.

The groundwater level in all borings was recorded and observation wells were installed in six (6) borings with one (1) boring left cased open for possible future re-entry.

Four (4) test pits were dug by a backhoe in conjunction with the foundation investigation for the meteorological tower. The test pit logs describing the soil conditions in the test pits are included as Appendix B to this report.

1.3 Authorization

This work was authorized by United Engineers & Constructors Inc., Purchase Order No. 6378.002-49-1.

2. FIELD INVESTIGATION

2.1 Boring Program

Appendix A contains the logs for all borings performed at Site 4-3-11. The logs include field descriptions of split spoon samples and rock cores, information concerning the observation wells installed in six (6) of the borings, and groundwater levels. All borings were located at stakes placed under the direction of United Engineers & Constructors Inc. The location and elevation data presented on the boring logs are approximate and are taken from the New Haven Quadrangle 7.5-minute series USGS Topographic Map dated 1956. Actual elevations and locations will be provided by United Engineers & Constructors Inc. at a later date. Fig. 1 shows the approximate locations of the borings and geophysical lines, Figs. 2 and 3 show cross sections derived from the boring data and preliminary profiles provided by Weston Geophysical Engineers Inc. Table 1 summarizes the data from the boring program.

The borings were advanced using a Joy-12 or a Sprague and Henwood drill rig. On the first boring attempted at the site (B-7), the method of advancing the boring in soil was to drive 4-in. casing with a 300-lb hammer, recording casing blows, and then clean out the casing by roller bitting. This technique was abandoned when it became obvious that the soil was very dense (e.g. 1000 blows for 9 in.) and that driving casing was a very time consuming operation. Thereafter, the boring was advanced in soil by roller bitting ahead of casing and then driving the casing without recording casing blows.

Boring B-7 was advanced to a depth of approximately 20 ft when the driving shoe was lost off the end of the casing. Since retrieval was virtually impossible, the boring was abandoned, relocated approximately 3 ft to the east, and labelled B-7A.

Soil was sampled at approximately 5-ft intervals using a standard 2-in. OD split-spoon sampler driven 18 in. by dropping a 140-lb hammer 30 in. The number of blows required to drive the sampler the three 6-in. increments were recorded. The number of blows required to drive the sampler the last 12 in. is reported as the Standard Penetration Resistance (N) value. In cases where more than 100 blows were required to drive the sampler a 6-in. increment, the sampling was terminated and the N value is reported as the number of blows over the depth of penetration.

451 094

All rock core was NX-size (2-1/8-in. diameter) and rock was sampled continuously over the required depth. In six borings the boring penetrated approximately 20 ft into rock, and core was taken using a 5-ft NX core barrel with a split inner liner. In Boring B-5, 200 ft of rock was sampled. Initially, the 5-ft NX barrel with the split inner liner was used. Since the RQD (rock quality designation) values were very high for the first three samples, the 10-ft NX core barrel with the solid inner barrel was used to expedite the boring program.

In general, all borings encountered basically similar soil profiles. The soils encountered are described in detail in Section 3.1. In all cases 6 in. to 12 in. of topsoil overlies a brown ablation till. The brown till has the characteristic unsorted structure of till and is primarily a non-plastic soil. The brown till is underlain by a gray till which also has an unsorted structure and is primarily a non-plastic soil, although it is slightly plastic in various locations. The gray till is very dense and the split spoon sampler could seldom be driven the full 18 in. In contrast, the sampler could be driven the full 18 in. in the brown till.

In two of the borings (B-3 and B-5) a dense, stratified, gray, silty fine sand was encountered below the gray till. The silty fine sand is similar to the matrix material of the overlying gray till. The deposit lacked gravel-size particles and contained few particles of coarse sand size. The samples were stratified, with 1/32 in. to 1/8 in. layers of non-plastic silts and fine sands and some slightly plastic silt layers.

2.2 Surficial Mapping

The surficial mapping was limited because of the dense vegetation and lack of rock outcrops on the site. Observations were made along public roads and along geophysical survey lines 1, 2, and 3. In addition, traverses were made along the New York Central Railroad tracks to the northeast of the site and along Butterfly Creek. Offsite visits were made to the Salmon River Falls and the excavations at the Nine Mile Point Nuclear Power Plant construction site to view exposures of bedrock. A detailed discussion of the surficial and bedrock geology is included in Section 3.

451 095

3. GEOLOGY

3.1 Surficial Geology

The topography of the site, shown on Fig. 1, is hummocky and characteristic of an area underlain by ground moraine. A prominent drumlinoid feature, which is located near the center of the site and is oriented in a north-south direction, represents a typical feature of the area. The greatest difference in elevation on the site occurs between this drumlinoid feature and the low-lying swampy area on the western edge of the proposed site, with the drumlinoid feature rising approximately 90 ft over a distance of approximately 4000 ft. Several streams intersect the site with their north-south direction controlled by drumlinoid features in the area. Butterfly Creek is the largest of the three streams on the site and intersects the site along the eastern portion. Two unnamed creeks lie on the western portion of the site and meet at a point just north of the low-lying swampy area. The stream resulting from the combination of the above two streams then drains into Catfish Creek. Both Catfish and Butterfly Creeks terminate in Lake Ontario at Mexico Bay.

The surficial mapping of the site included traverses along all three geophysical lines, the New York Central Railroad right-of-way, the transmission line right-of-way and the streams intersecting the site. No outcrops of bedrock were found on the site. The results of the boring program and geophysical program indicate that the bedrock is relatively flat and is overlain with dense soils to a sufficient depth that outcrops would not be expected.

The soil conditions throughout the site were found to be very similar. A detailed description of the soil conditions found in each boring is presented in Appendix A and descriptions of the soil conditions at the meteorological tower site is presented in Appendix B. In general, four soil types were found on the site, one of which is approximately one foot of topsoil which was found in each boring and test pit. The three other soil types are described in detail below.

3.1.1 Brown Till

Beneath the topsoil, brown till was found in all borings and in the test pits. The soil was widely graded (i.e., contains a wide range of grain sizes). In the test pits, boulders up to 12 in. in diameter were found. The

material had an unsorted (homogeneous) structure characteristic of till. The material was non-plastic to slightly plastic depending upon the location. The soil is dense, with N values generally ranging between 50 and 100. The thickness of the deposit ranges from 10 to 20 ft.

3.1.2 Gray Till

Directly below the brown till lies a gray till. The gray till was only encountered in the borings and not in the test pits since the test pits were relatively shallow. The gray till is widely graded and has an unsorted structure. Several small boulders (up to 7 in.) were encountered in the boring operation. The material is non-plastic to slightly plastic depending on the location. The till is very dense and the change from the brown till to the gray till could often be noted merely by the increased difficulty in advancing the boring. An example of the degree of density is that in 33 attempts to drive a split spoon sampler 18 in., only two attempts were successful. The thickness of the deposit ranged from 10 ft to 40 ft in the seven (7) borings which penetrated to bedrock.

3.1.3 Stratified Silts and Fine Sands

In Borings B-3 and B-5 located in the southeast corner and center of the site, respectively, a deposit was located below the gray till which consists of finely stratified (1/32-in. to 1/8-in.-thick) layers of fine silty sands and silts. The sorted nature of the deposit indicates that it is a water-laid deposit. The deposit is dense with N values from 49 to 117. The thickness of the deposit was 11 ft in B-3 and 10 ft in B-5.

3.2 Bedrock Geology

The approximate ground elevation, depth to bedrock elevation of the bedrock surface and depth of rock cored at each boring is shown in Table 1. The total footage of rock core obtained during this investigation was 326.5 ft

All of the borings which were carried into bedrock encountered the Oswego sandstone, which consisted generally of a gray to gray-green, fine-grained, medium hard, non-calcareous sandstone. The sandstone typically graded into an argillaceous sandstone, which was characterized by a slightly darker color. In all the shallow bedrock borings except Boring B-6 and in the upper 30 ft of bedrock in Boring B-5, the argillaceous sandstone comprised approximately

20 pe cent of the rock core. The ratio of argillaceous sandstone to sandstone increases with depth in Boring B-5 such that at about 75 ft below the bedrock surface essentially all of the sandstone is argillaceous.

Simultaneously with the increase in the amount of argillaceous sandstone with depth is an increase in the amount of shale in the bedrock. In all the shallow bedrock borings except Boring B-6 and in the upper 30 ft of rock in Boring B-5, the shale generally occurs as small, irregular and discontinuous pods which comprise less than one percent of the rock core. At depths greater than 30 ft below the bedrock surface in Boring B-5, shale occurs as continuous beds as well as in irregular pods. The percentage of the core which consists of shale increases with depth such that at a depth of about 80 ft below the bedrock surface, approximately half of the core is shale. The percentage of the shale in the uns in the remainder of the boring ranges between approximately 10 to 75 percent.

The bedrock in Boring B-6 was unique in that shale layers exist within 20 ft of the bedrock surface. These sh layers range in thickness from 1/8 in. to 6 in.

The bedding in the sandstone and shale was generally within a few degrees of horizontal throughout the entire thickness of rock that was cored. However, slight variations in the attitude of the bedding did exist on a local scale, i.e., over a length of up to a few inches along the core. In these cases, the bedding would increase typically to a dip of about 10 degrees. On occasion the sandstone would exhibit cross-bedding, with the bedding dips approaching 45 degrees.

With the exception of Boring B-6, essentially all of the rock which was encountered more than 1 or 2 ft below the bedrock surface was fresh and unweathered. The weathering which did exist within a short distance of the bedrock surface consisted primarily of rust staining along joint surfaces with little or no decomposition of the intact rock. In Boring B-6, the rock core contained considerably more shale than the other shallow rock borings and most of the joint surfaces and the shale layers exhibited moderate to severe weathering.

In general, the bedrock is intact with infrequent jointing, which results usually in RQD values greater than 80 percent. Joint spacing generally ranges from a fraction of

an inch to about 2 ft, with the closer spaced joints usually occurring over a short length (typically less than 2 to 3 inches) of the core and almost always associated with the shale layers. The core breaks usually occurred in a portion of the sandstone which contained the irregular shale pods or at shale beds. These joints are noted by the remark "shale parting" on the boring logs in Appendix A.

Because of the unweathered nature of the rock, it was not always possible to tell if the core breaks were the results of the drilling and sampling activities or if they represent joints. When this distinction could not be made, the more conservative designation as a joint was made.

The orientation of the joints were generally within a few degrees of horizontal as a result of their association with bedding planes. The joint surfaces were generally clean and unweathered with an approximate equal distribution of smooth, planar surfaces and rough, irregular surfaces. Infrequently a trace of mica existed on a joint surface.

Evidence indicating that shear displacements had taken place was found in only one location. This was at a depth of about 5 ft below the bedrock surface in Boring B-2, in which a fracture surface in an 8-in.-thick layer of waxy siltstone (or claystone) exhibited a striated and polished surface.

The presence of shale layers within the upper 20 ft of bedrock in Boring B-6 is worthy of note because this was the only boring location in which distinct shale layers were found this close to the bedrock surface. The shale layers within the 20-ft depth into bedrock of Boring B-6 occur between an elevation of approximately 249 and 269 ft. In Boring B5 shale layers were first encountered at an elevation of about 266 ft and again at an approximate elevation of 252 ft. Thus, the bedrock cored in Boring B6 appears to be in the proper relative stratigraphic position with the bedrock cored at the deep boring of the site, Boring B-5.

4. GROUNDWATER CONDITIONS

4.1 Groundwater

Groundwater readings were taken by Geotechnical Engineers Inc. during the boring operation and by United Engineers & Constructors Inc. since the termination of the boring program. All groundwater readings were taken in observation wells installed in borings. Details of the observation well locations within the boring are presented on the boring logs in Appendix A. It should be noted that the groundwater conditions reported only reflect the conditions within the limits of the bentonite seals in each boring and that all observation wells are installed in the lower gray till with the exception of the observation well in Boring B-3, which is located partially in an outwash material.

The groundwater elevations are shown on Figs. 2 and 3. They are based on ground elevations as discussed in Section 3.1. In general, the groundwater elevations are higher along the southern portion of the site in Borings 1, 2, and 3 along geophysical profile line GP3. The elevations range from approximately 385 ft in Boring 2 to 350 ft in Boring 3 along GP3. Borings 4 and 5 are located along line GP1 approximately in the center of the area being investigated and the groundwater elevation in both borings is approximately 320 ft. This elevation corresponds to the elevation of the swampy area situated between the borings as shown on Fig. 3. The groundwater elevations along the northerly portion of the site, GP1, in Borings 6 and 7 is approximately 305 ft.

Based on this limited amount of data, it appears that the elevation of the groundwater table decreases from the south to the north, which also corresponds with the general topography of the site. In the east-west direction, the elevation of the groundwater appears fairly level with possibly a slight decrease in elevation to the east.

4.2 Permeability Tests

In order to determine the permeability of the gray till, falling-head permeability tests were performed in the six (6) observation wells. Details of the observation wells are presented on the boring logs in Appendix A and the results are summarized on Table 2.

The permeability tests were performed only after the groundwater level in the boring had reached equilibrium. The permeability test was conducted by first obtaining the static groundwater elevation in the observation well. The observation well was then filled with water and the water level allowed to fall while readings of the depth to the water surface were taken at regular intervals. Based on the dimensions of the boring and the rate at which the water level fell, the permeability of the soil was calculated.

The results of the six (6) permeability tests indicate that the gray till has a very low permeability ranging between 0.02×10^{-4} to 2.56×10^{-4} cm/sec. The results of the tests are within the range that would be expected for soils with 20 percent to 50 percent fines (less than No. 200 sieve). The observation well installed in B-3 is partially located in a material described as a stratified silty fine sand. The measured permeability is $.09 \times 10^{-4}$ cm/sec.

In the future, permeability tests would be conducted in the brown till and the stratified silty fine sands to provide a more complete understanding of the relative permeabilities of the soil types encountered on the site.

5. PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

5.1 Surficial Geology

The surficial deposits consist primarily of two tills. A brown till overlies a gray till. Both tills are dense, with the gray till the denser of the two. In two (2) borings, a dense stratified silty fine sand deposit with a thickness of approximately 10 to 11 ft, was encountered beneath the tills. Permeability tests conducted in six (6) observation wells indicate that the soil just above bedrock is relatively impermeable with permeability values ranging from 0.02×10^{-4} to 2.56×10^{-4} cm/sec.

The surficial geology is essentially as expected. Based on the results of this preliminary investigation, there do not appear to be any technical questions which could not be answered with a more detailed study or which would adversely affect the licensability of the site.

5.2 Bedrock Geology

The bedrock underlying the site is a sandstone of the Oswego Formation. The bedrock is a gray to gray-green, medium hard to hard, non-calcareous sandstone. Bedding was generally horizontal, with cross bedding present. In Boring B-5, the only deep boring on the site, the sandstone became argillaceous at about 75 ft below the bedrock surface. Irregular and discontinuous pods of shale were present in bedrock within 20 to 30 ft of the bedrock surface. In Boring B-5, at depths greater than 30 ft, the shale occurs as continuous beds as well as pods. At approximately 80 ft below the bedrock surface, the Oswego sandstone grades into the underlying Pulaski Shale Fm. as determined by a marked increase in the abundance and thickness of shale beds. The approximate contact between the Oswego Fm. and the underlying Pulaski Fm. has been placed at the depth where sandstone and shale percentages are nearly equal (Kiersch, 1976, personal communication). RQD values generally range from 70 to 100 with the exception of Boring B-6 in the northeast corner of the site where the RQD values were lower. Bedrock is shallowest, 20 ft to 40 ft, in the west-northwest portion of the site and deepest, 70 ft, in the southeast corner and below the drumlinoid feature in the center of the site.

The bedrock geology is essentially as expected. The rock is competent and should provide adequate bearing for any large structure. Based on the results of this preliminary investigation, it is believed that no structural features exist which would preclude the licensing of this site for a nuclear or fossil fuel plant.

5.3 Groundwater Conditions

The groundwater flows from south to the north in the general direction of Lake Ontario. Permeability tests in the gray till indicate that the till has a low permeability. Based on the high RQD values and the general description of the rock, it is believed that the rock should also have a very low permeability.

TABLE 1 - SUMMARY OF BORING PROGRAM - Site 4-3-11
PHASE I - SITE CONFIRMATION STUDIES
NYSE&G NEW SITE PROJECT

Boring No.	Depth of Overburden ft	Depth of Rock Cored ft	Total Depth ft	Ground Surface Elevation (1) ft	Groundwater Elevation (1) ft	Bedrock Elevation (1) ft	Date Started	Date Completed	Date Ob. Well Installed
1	32	20	52	380	364	348	Aug 5, 1976	Aug 9, 1976	Aug 10, 1976
2	44.5	20	64.5	405	392	360.5	Aug 10,1976	Aug 13,1976	Aug 14, 1976
3	69	20	89	355	344	286	July 29,1976	Aug 3, 1976	Aug 4, 1976
4	40.3	20.5	60.8	340	323	299.7	Aug 17,1976	Aug 18,1976	Aug 19, 1976
5	60	200.1	260.1	345	315.9	285	July 27,1976	Aug 6, 1976	-
6	31.5	23.5	55	300	283.9	268.5	Aug 10,1976	Aug. 12,1976	Aug. 13, 1976
7	20.7 (2)	Abandoned For Boring 7A					July 21,1976	July 23,1976	-
7A	34	23	57	325	312.3	291	July 23,1976	July 27,1976	July 28, 1976

NOTE (1) All elevations are approximate and are based on the New Haven Quadrangle 7.5 minute series USGS topographic map. Final elevations will be provided by United Engineers & Constructors Inc. at a later date.

(2) Boring B-7 was abandoned at a depth of 20.7 ft when the casing drive shoe was lost down the hole. The boring was relocated approximately 3 ft east and labelled B-7A.

Geotechnical Engineers Inc.

Project 76265
September 9, 1976
Revised September 16, 1976

104

TABLE 2 - SUMMARY OF OBSERVATION WELL DATA
PHASE I - SITE CONFIRMATION STUDIES
NYSE&G NEW SITE PROJECT

Boring No.	Ground Surface Elevation (1) ft	Bedrock Elevation (1) ft	Depth of Overburden ft	Groundwater Elevation (1) ft	Elevation (1) of Top Seal ft	Elevation (1) of Bottom Seal ft	Permeability k 10^{-4} cm/sec.	Soil Conditions
1	380	348	32	364	356.5	350.2	.02	Gray Till
2	405	360.5	44.5	392	376.2	365.7	.22	Gray Till
3	355	286	69	344	299.4	290.7	.09	Gray Till-Outwash
4	340	299.7	40.3	323	308.4	301.0	.40	Gray Till
6	300	268.5	31.5	283.9	280.0	270.9	2.56	Gray Till
7A	325	291	34	312.3	298.0	292.0	.95	Gray Till

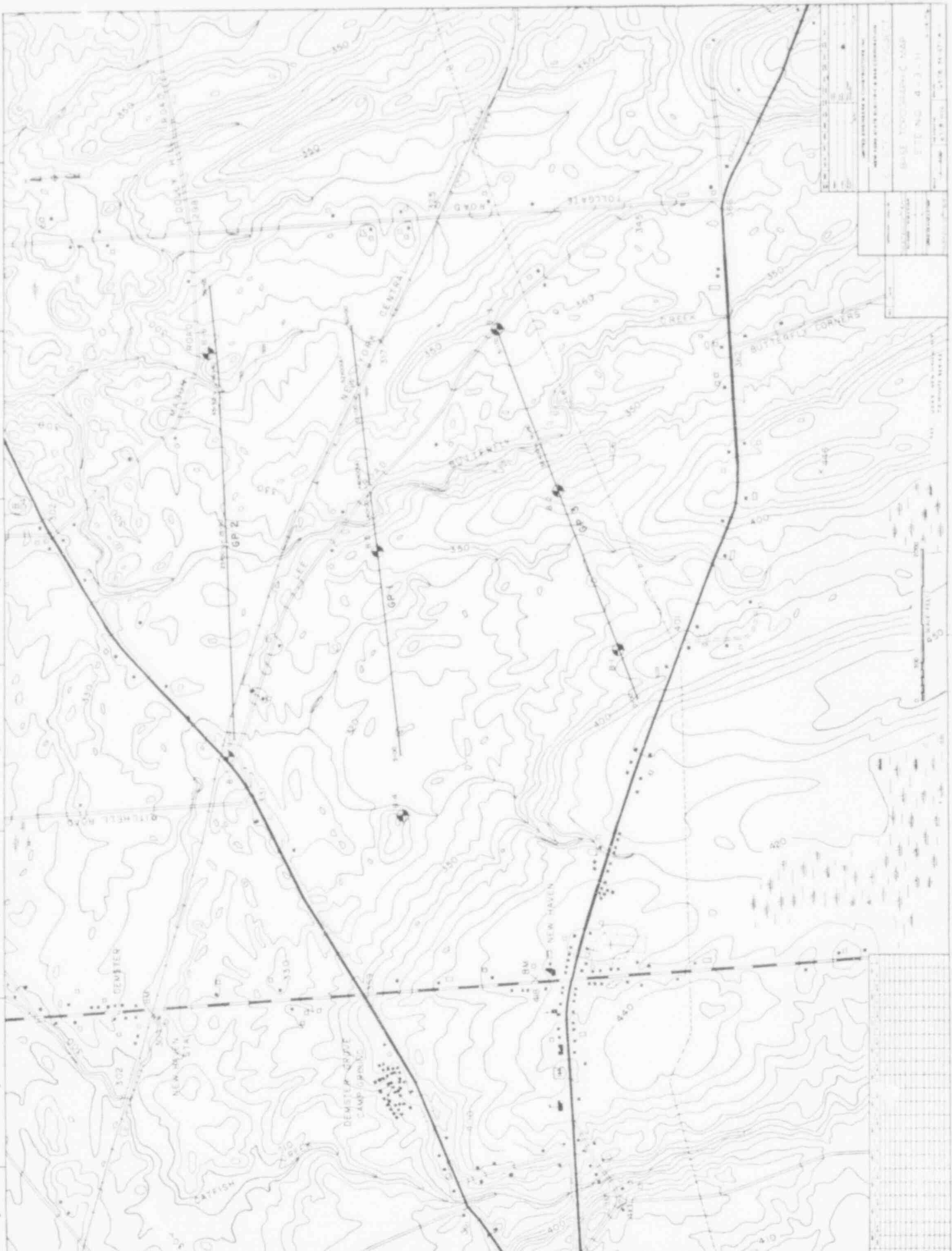
Note: (1) All elevations are approximate and are based on the New Haven Quadrangle 7.5 minute series USGS Topographic Map. Final elevations will be provided by United Engineers & Constructors Inc. at a later date.

Geotechnical Engineers Inc.

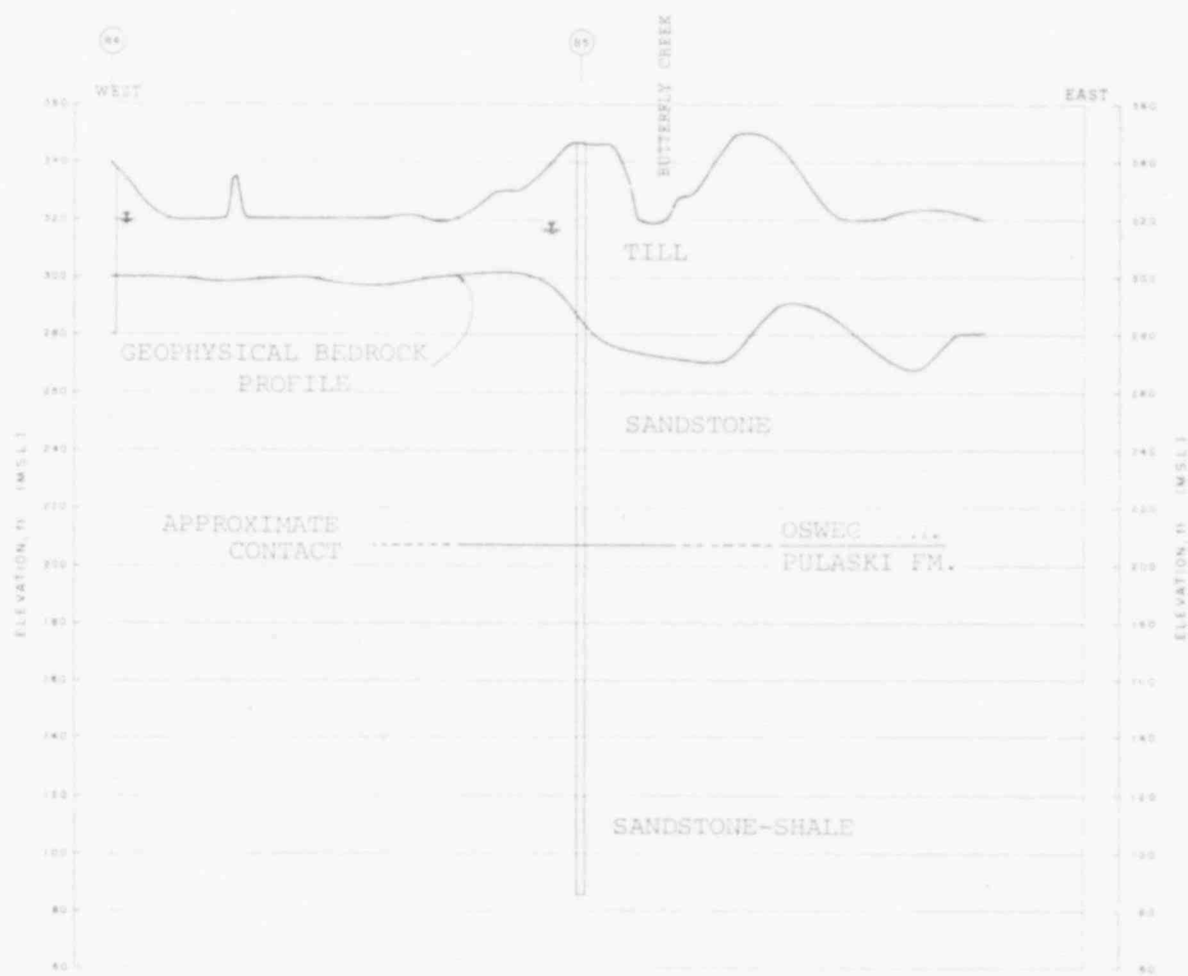
Project 76265
September 10, 1976
Revised September 16, 1976

451

105
~~074~~


NEW YORK CENTRAL
GP 1
GP 2
GP 3
BUTTERFLY CORNERS
CREEK
NEW HAVEN
NEW HAVEN STA
DEMSTER
CATFISH
350
400
420
440

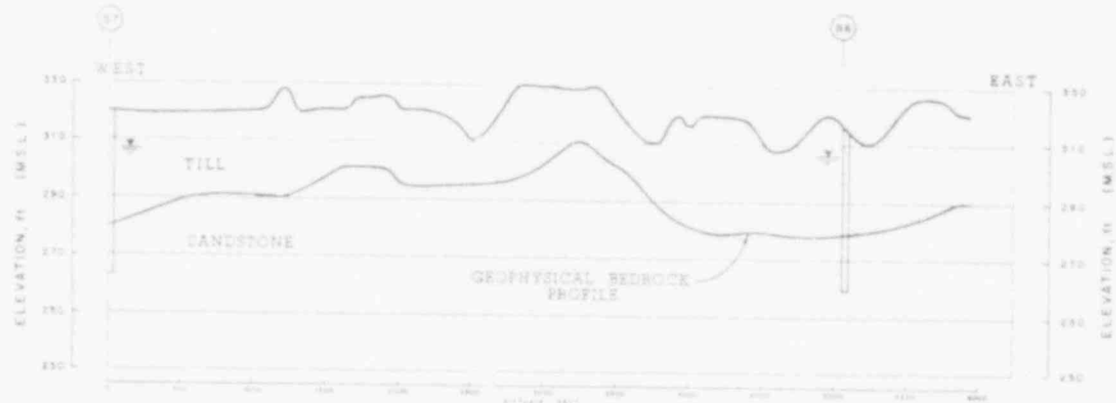
431 ~~075~~ 106



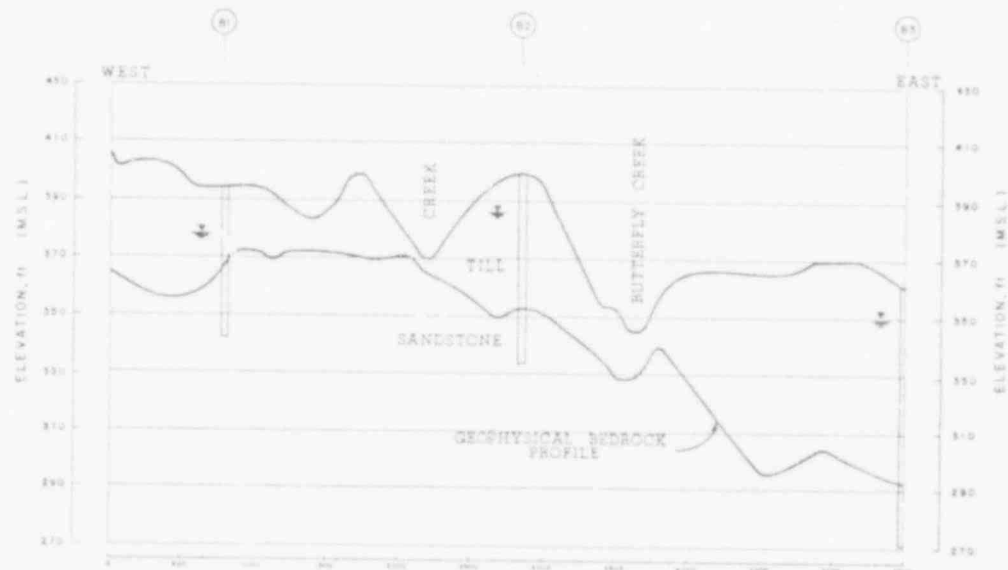
SUBSURFACE PROFILE LINE GP#1

POOR ORIGINAL

451 107 ~~076~~



SUBSURFACE PROFILE LINE GP#2



SUBSURFACE PROFILE LINE GP#3

UNITED ENGINEERS & CONSTRUCTORS INC. BOSTON, MASSACHUSETTS	NEW YORK STATE ELECTRIC & GAS CORP. NEW SITE GENERATION PROJECT	SUBSURFACE PROFILES
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS		

451 ~~077~~ 108

B - 1

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible]

INCLINATION [illegible] BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER DEPTH [illegible] DATE [illegible] LOGGED BY [illegible]

EL MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N REC	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES CORE BREAKS TYPE AND DIP	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487 AND D2488) ROCK DESCRIPTIONS
		S1										[illegible]
		S2										[illegible] Fill
10		S3										[illegible] Fill
		S4										[illegible] plastic fines. Fill
20												Boulder at [illegible]
												[illegible] Fill
												[illegible] similar to S5.
		[illegible]										[illegible]
30		[illegible]										[illegible]
		[illegible]										[illegible]
		[illegible]										[illegible]

BOTTOM OF BORING [illegible]

LEGEND

N STANDARD PENETRATION RESISTANCE
REC LENGTH RECOVERED/LENGTH CORED, %
RQD LENGTH OF SOUND CORE > 4 IN/LENGTH CORED, %
S SPLIT SPOON SAMPLE
U UNDISTURBED SAMPLES
UD SHELBY TUBE UD DENISON
UF FIXED PISTON UP PITCHER
UO OSTERBERG US [illegible]
▽ GROUNDWATER K COEFFICIENT OF PERMEABILITY

DRILL BIT USE: N NEW, R RESET, U USED
DRILL WATER RETURN: C COMPLETE, P PARTIAL, N NONE

PLANAR FEATURES: C CONTACT, F FOLIATION, B BEDDING, X CROSS BEDDING

CORE BREAKS: JOINT, FOLIATION, CONTACT, SHEAR ZONE, DRILLING BREAK, RUBBLE

NOTES

1. [illegible]
2. [illegible]
3. [illegible]

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers [illegible]

PAGE [illegible] OF [illegible] LOG OF BORING [illegible]

POOR ORIGINAL

451 ~~078~~ 109

B - 2

BORING LOCATION ________ GROUND ELEVATION (MSL) ________ DATE START/FINISH ________

INCLINATION ________ BEARING ________ TOTAL DEPTH (FT) ________ DRILLED BY ________

CASING TO ________ CORE SIZE ________ GROUNDWATER ________ DATE ________ LOGGED BY ________

EL. MSL FT	SAMPLE: DEPTH FT	SAMPLE: TYPE AND NO.	SAMPLE: % REC	WATER CONTENT %	GRAPHIC	RATE OF ADV. / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES	SURFACE OF CORE BREAKS		SOIL DESCRIPTIONS (ASTM D2487 AND D2488) ROCK DESCRIPTIONS
												Topsoil
												Till
												LIGHT GRAY, GRAVELLY SILTY FINE SAND, widely graded, nonplastic fines. Till
												LIGHT GRAY GRAVELLY SILTY FINE SAND. Similar to S3.
												LIGHT GRAY, GRAVELLY SILTY FINE SAND. Similar to S3.
												LIGHT GRAY, GRAVELLY SILTY FINE SAND. Similar to S3.
												No recovery.
												LIGHT GRAY, GRAVELLY FINE SANDY SILT, widely graded, slightly plastic fines; homogeneous blocky structure. Till
												LIGHT GRAY, GRAVELLY FINE SANDY SILT. Similar to S8, but with rock fragments. Till

POOR ORIGINAL

LEGEND

N STANDARD PENETRATION RESISTANCE
REC LENGTH RECOVERED/LENGTH CORED, %
RQD LENGTH OF SOUND CORE ≥4 IN./LENGTH CORED, %
S SPLIT SPOON SAMPLE
U UNDISTURBED SAMPLES
UD SHELBY TUBE UN DENISON
UF FIXED PISTON UP PITCHER
UO OSTERBERG
▽ GROUNDWATER k COEFFICIENT OF PERMEABILITY

DRILL BIT USE: N NEW, R RESET, U USED
DRILL WATER RETURN: C COMPLETE, P PARTIAL, N NONE

NOTES

NEW YORK STATE ELECTRIC & GAS CORP.

NEW SITE GENERATION PROJECT

united engineers

PAGE ___ OF ___ LOG OF BORING ___

451 ~~879~~ 110

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible]

B - 3

INCLINATION [illegible] BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY [illegible]

EL. MSL FT	SAMPLE DEPTH FT	SAMPLE TYPE AND NO.	N OR REC	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV. / DRILL BIT USE	PIEZOMETER	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS	SURFACE OF CORE BREAKS	GRAPHIC LOG	SOIL DESCRIPTIONS / ROCK DESCRIPTIONS
		S1	[illegible]									[illegible] silty fine sand, uniform gradation, maximum particle approx. [illegible] homogeneous structure, non-plastic fines.
		S2	[illegible]									Light brown, gravelly silty sand, widely graded, maximum particle approx. [illegible] homogeneous structure, non-plastic fines. Fill.
		S3	[illegible]									Light gray, gravelly silty sand, widely graded, maximum particle approx. [illegible] homogeneous structure. [illegible]
		S4	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S5	[illegible]									Light gray, gravelly silty sand, similar to S3.
		SA1	[illegible] Boulder									[illegible] boulder at [illegible]
		S6	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S7	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S8	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S9	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S10	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S11	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S12	[illegible]									Light gray, gravelly silty sand, similar to S3.
		S13	[illegible]									[illegible]
		SA2	[illegible]									
		S14	[illegible]									[illegible]
		NX1	[illegible]									[illegible]

POOR ORIGINAL

LEGEND: N STANDARD PENETRATION RESISTANCE; REC LENGTH RECOVERED/LENGTH CORED %; RQD [illegible]; S SPLIT SPOON SAMPLE; U UNDISTURBED SAMPLE; ∇ GROUNDWATER; DRILL BIT USE; DRILL WATER RETURN [illegible]

PLANAR FEATURES [illegible]

NOTES [illegible]

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers

PAGE [illegible] OF [illegible] LOG OF BORING [illegible]

451 [illegible]

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible] **B - 3**

INCLINATION [illegible] BEARING [illegible] TOTAL DEPTH (FT.) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY [illegible]

EL. MSL FT | SAMPLE (DEPTH FT, TYPE NO, N REC) | WATER CONTENT (%, GRAPHIC) | RQD | RATE OF ADV / DRILL BIT USE | PIEZOMETER TEST | DRILL WATER RETURN | PLANAR FEATURES CORE BREAKS TYPE AND DIP | SURFACE OF CORE BREAKS | GRAPHIC ROCK LOG | SOIL DESCRIPTIONS (ASTM D2487 69 AND D2488 69) ROCK DESCRIPTIONS

[illegible]

BOTTOM OF BORING [illegible]

POOR ORIGINAL

LEGEND

N - STANDARD PENETRATION RESISTANCE
REC - LENGTH RECOVERED / LENGTH CORED, %
RQD - LENGTH OF SOUND CORE / LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES
US - SHELBY TUBE DN - DENISON
UF - FIXED PISTON UP - PITCHER
UO - OSTERBERG

GROUNDWATER

DRILL BIT USE: N - NEW, R - RESET, U - USED

DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES

CORE BREAKS

NOTES

[illegible]

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers

PAGE [illegible] OF [illegible] LOG OF BORING [illegible]

451 081 112

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH Aug. 16, 1976 / Aug. [illegible], 1976 **B4**

INCLINATION Vertical BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible] Drilling Co. - [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE Aug. [illegible], 1976 LOGGED BY [illegible] - R. A. Brown [illegible] - [illegible]

EL. MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N or REC	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS TYPE AND DIP	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487-69 AND D2488-69) ROCK DESCRIPTIONS
		S1	[illegible]					Top of Brown Till				BROWN GRAVELLY FINE SANDY SILT. Topsoil
		S2	[illegible]				PVC pipe perforated with [illegible] slots; [illegible] casing cemented into the ground.					GRAYISH BROWN, GRAVELLY SILTY SAND. Gravel particles are angular with a maximum size of [illegible]; fines are non-plastic. Till
25		S3	[illegible]									No Recovery (Boulder?)
		S4	[illegible]									GRAYISH BROWN, GRAVELLY SILTY SAND. Similar to S2.
		S5	[illegible]									GRAYISH BROWN, GRAVELLY SILTY SAND. Similar to S2.
		S6	[illegible]					Top of Gray Till				
30		S7	[illegible]				Bentonite					LIGHT GRAY, GRAVELLY SILTY SAND. Gravel particles are angular with a maximum size of [illegible]; slightly plastic fines, homogeneous structure. Till
		S8	[illegible]				[illegible] Ottawa Sand					LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S7.
40		S9	[illegible]				Top of Bedrock; Bentonite					LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S7.
		NX1	100					C	Shale part			SANDSTONE, gray, fine-grained, medium-hard, [illegible] grading to argillaceous sandstone. Contains small, irregular, discontinuous pods of shale at 41'[illegible]" ([illegible] 1/16" thick) and at [illegible] ([illegible] 1/8" thick). Bedding generally horizontal but dips increase locally to [illegible]. Joint spacing ranges from [illegible] to [illegible]. SANDSTONE, similar to NX1. Shale-rich zones, with shale pods up to [illegible] thick occur at [illegible] thick) and at [illegible] thick). In the former shale beds are continuous [illegible]; in the latter the shale occurs as irregular, discontinuous pieces.
		NX2	100					C	Shale part			
50		NX3	[illegible]						Shale part			SANDSTONE, similar to NX2. Shale layers occur at [illegible] ([illegible] of run) and at [illegible] thick. The shale occurs as irregular and discontinuous pods which range in thickness up to 1/2". Joint spacing ranges from 1/2' to [illegible].
		NX4	100					C				SANDSTONE, similar to NX3 but no shale-rich zones occur in this run. Some irregular, discontinuous shale pods occur at [illegible]. The maximum thickness of these pods is about 1/8".

BOTTOM OF BORING AT [illegible] FT

451 ~~[illegible]~~ 113

POOR ORIGINAL

LEGEND

N - STANDARD PENETRATION RESISTANCE
REC - LENGTH RECOVERED/LENGTH CORED %
RQD - LENGTH OF SOUND CORE 4 IN./LENGTH CORED %
S - SPLIT SPOON SAMPLE
UNDISTURBED SAMPLES
US - SHELBY TUBE / DN - DENISON
UF - FIXED PISTON / UP - PITCHER
UO - OSTERBERG / [illegible]
GROUNDWATER / k - COEFFICIENT OF PERMEABILITY
DRILL BIT USE: N - NEW, R - RESET, U - USED
DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES: C - CONTACT, F - FOLIATION, B - BEDDING, X - CROSS BEDDING

CORE BREAKS: JOINT, FOLIATION, CONTACT, CHURN JOINT / CORE CAVITY, DRILLING BREAK, SLIPPERS

NOTES

1. Boring location is approximate; coordinates are taken from [illegible].
2. Ground elevation is approximate and is taken from United Engineers drawing no. [illegible].
3. The type of drill rig used was a [illegible]. Borings were advanced for the soil by [illegible] ahead of casing and then driving casing. The core barrel used to sample rock was a 5-ft [illegible] NX split barrel.

NEW YORK STATE ELECTRIC & GAS CORP.

NEW SITE GENERATION PROJECT

united engineers & constructors inc.

[illegible] GEOTECHNICAL ENGINEERING

SITE [illegible] PROJECT [illegible]

PAGE [illegible] OF [illegible] LOG OF BORING B4

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH July [illegible], 1978 / Aug. [illegible], 1978

B - 5

INCLINATION Vertical BEARING NA TOTAL DEPTH (FT) [illegible] DRILLED BY Penn Drilling Co. [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER Depth [illegible] DATE Aug. [illegible] LOGGED BY [illegible]

EL. MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N or REC	WATER CONTENT %	RQD	RATE OF ADV. MIN/FT / DRILL BIT USE	PERMEABILITY TEST	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS TYPE AND DIP	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487 69 AND D2488 69) / ROCK DESCRIPTIONS
		S1	15					TOP OF BROWN TILL				BROWN SILTY FINE SAND, trace of root matter, particles of sandstone to 1-1/2", organic.
		S2	67									BROWN, GRAVELLY SILTY FINE SAND. Widely graded, particles are subangular to angular, non-plastic fines. Till
		S3	100					TOP OF GRAY TILL				BROWN, GRAVELLY SILTY FINE SAND. Similar to S2.
		S4	100									LIGHT GRAY, GRAVELLY SILTY SAND. Widely graded, particles of angular sandstone to 1/2", non-plastic fines, homogeneous structure. Till
		S5	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S6	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S7	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S8	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S9	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S10	100									LIGHT GRAY, GRAVELLY SILTY SAND. Similar to S4.
		S11	117									GRAY SILTY FINE SAND. Contains few particles to coarse sand size, [illegible] subangular, non-plastic fines, stratification with uniform silt and fine sand layers to 1/8"
		S12	117									GRAY SILTY FINE SAND. Similar to S11.
		S13						TOP OF BEDROCK				No penetration, [illegible]
		NX1										SANDSTONE. Gray to gray-green, fine-grained, hard, [illegible] [illegible] with variable shale content. [illegible] darker where sandstone is more argillaceous. Unweathered. [illegible] of argillaceous sandstone [illegible] about [illegible] of the run and occur at [illegible], [illegible] and [illegible]. [illegible]
		NX2	100									SANDSTONE. Similar to NX1. [illegible] of argillaceous sandstone [illegible] at [illegible] and [illegible] and comprise approx. [illegible] of [illegible] thick zone of [illegible] shale [illegible] [illegible]. A joint occurs at [illegible] which dips at [illegible]. The surface of this joint is coated with silt or clay [illegible]
		NX3										SANDSTONE. Similar to NX2.

451 ~~083~~ 114

POOR ORIGINAL

LEGEND

N - STANDARD PENETRATION RESISTANCE
REC - LENGTH RECOVERED/LENGTH CORED, %
RQD - LENGTH OF SOUND CORE 4 IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES
US - SHELBY TUBE UN - DENISON
UF - FIXED PISTON UP - PITCHER
UO - OSTERBERG UG - [illegible]
GROUNDWATER k - COEFFICIENT OF PERMEABILITY
DRILL BIT USE: N - NEW, R - RESET, U - USED
DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES: C - CONTACT, F - FOLIATION, B - BEDDING, X - CROSS BEDDING

CORE BREAKS: SMOOTH / ROUGH — JOINT, FOLIATION, CONTACT; ZONE, LOSS, CORE CAVITY; DRILLING BREAK OR SLAKING

NOTES

1. Boring location is approximate. Coordinates are taken from [illegible].
2. Ground elevation is approximate and is taken from United Engineers drawing no. [illegible]
3. The type of drill rig used was a [illegible]. Borings were advanced [illegible] by roller bitting ahead of casing and then driving casing. The core barrel used to sample rock was a [illegible] NX [illegible] [illegible] barrel.

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers & constructors inc

[illegible]

PAGE 1 OF 4 LOG OF BORING [illegible]

B - 5

BORING LOCATION [illegible] GROUND ELEVATION (M [illegible]) [illegible] DATE START/FINISH July 27, 1976 / Aug. 6, 1976

INCLINATION Vertical BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible] Drilling Co. - P. [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY [illegible]

EL. MSL FT. | SAMPLE (DEPTH FT., TYPE AND NO., N OR REC) | WATER CONTENT % / RQD (GRAPHIC) | RATE OF ADV. MIN/FT / DRILL BIT USE | PRESSURE TEST | DRILL WATER RETURN | PLANAR FEATURES / CORE BREAKS / TYPE AND DIP | SURFACE OF CORE BREAKS | GRAPHIC ROCK LOG | SOIL DESCRIPTIONS (ASTM D2487-69 AND D2488-69) / ROCK DESCRIPTIONS

SANDSTONE, similar to NX3, grading locally to argillaceous sandstone. Zones at 74' (2" thick) and at 80'6" (5" thick) contain irregular shale pods. A 5"-thick zone at 79' contains shale layers which range from 1/32" to 1-1/4" thick. Horizontal jointing is prevalent, frequently with spacing ranging from 1" to 4".

SANDSTONE, similar to NX4. Argillaceous sandstone zones comprise approx. 25% of run. Horizontal jointing prevalent with spacing ranging from 1/2" to [illegible]. Jointing more developed in the argillaceous zones with spacing as small as 1/4". The dip of the bedding at 87' increases locally to 10°. Zones containing irregular pods of shale occur at 86' (5" thick), 86.5' (2" thick) and 90' (2" thick).

SANDSTONE, similar to NX5, grading locally to argillaceous sandstone. Contains a few zones of [illegible] shale at 92' ([illegible] thick), 96' (2" thick) and 96'6" ([illegible]). Also contains small zones of shale pods at 93' (2" thick) and at 95'6" (1-1/2" thick). Joint spacing ranges from 1/8" to 3" with closer spacings generally in the zones of argillaceous sandstone and shale.

SANDSTONE, similar to NX6. Contains zones of sandy shale at 101'3" (1-1/2" thick), 103'6" (4" thick) and 110' (1/2" thick). Zones containing irregular pods of shale occur at 112' (1" thick) and 111'6" (1" thick). At 105'6" a lenticular pod (1/2" thick) of claystone exists which appears waxy. At 105'6" to 110' the sandstone contains spherical calcite concretions (1/32" to 1/2" thick) and the sandstone is slightly calcareous. The dip of the bedding increases locally at 110' to 15°.

SANDSTONE, similar to NX7, grading to argillaceous sandstone. The zone from 112'6" to 116' consists of sandstone interbedded with shale lenses and layers which range from 1/32" to 3" in thickness. Zones of shale pods occur at 117' (1" thick) and 117'6" (1" thick). A 2"-thick layer of shale occurs at 119'. Joint spacing ranges from 1/2" to 3" with closer spacing occurring in the zones of argillaceous sandstone and shale. All core breaks occur along shale partings.

SANDSTONE, similar to NX8, grading to argillaceous sandstone. Well-developed horizontal bedding. The contacts between the sandstone and the argillaceous sandstone are both gradational and sharp. [illegible] continuous shale layers occur at 126' ([illegible] thick) and at 128' ([illegible] thick). A [illegible]-thick zone containing shale pods occurs at 127'6". Some portions of argillaceous sandstone contain irregular zones of the sandstone. Joint spacing ranges from 1/2" to 3".

SANDSTONE, similar to NX9, but predominantly argillaceous sandstone with minor amounts of the argillaceous sandstone. Several shale layers, which range in thickness from 1/2" to 2-1/4", occur throughout the [illegible]. [illegible] generally [illegible] with dip [illegible] to [illegible]. Portions of the argillaceous sandstone contain irregular patches of the [illegible] argillaceous sandstone. Joint spacing ranges [illegible] [illegible] core breaks readily upon handling at [illegible] to 141'.

451 ~~004~~ 115

POOR ORIGINAL

NOTES

LEGEND

NEW YORK STATE ELECTRIC & GAS CORP.

NEW SITE GENERATION PROJECT

united engineers

PAGE [illegible] OF [illegible] LOG OF BORING [illegible]

B - 5

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible]

INCLINATION [illegible] BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY [illegible]

EL. MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N — REC	WATER CONTENT %	GRAPHIC	RATE / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487 OR AND D2488 83) ROCK DESCRIPTIONS
		NX11										SANDSTONE, similar to [illegible] interbedded with SHALE. [illegible] shale layers [illegible]. Approximately [illegible] of the run consists of argillaceous and non-argillaceous sandstone, with the remainder consisting of shale and sandy shale.
		NX12										SANDSTONE and SHALE, similar to NX11. Approximately [illegible] sandstone and [illegible] shale. The shale layers range in thickness from [illegible]. [illegible] More frequent than in previous run.
		NX13										SANDSTONE and SHALE, similar to NX 12. Approximately [illegible] sandstone, [illegible] shale. [illegible] Sandstone layers are medium hard. Joint spacing ranges from 1/8" to 1'.
		NX14										SANDSTONE and SHALE, similar to NX-13. Sandstone [illegible] layers of sandy shale. [illegible] horizontal jointing with joint spacing ranging from [illegible]. Bedding generally horizontal.
		NX15										SANDSTONE and SHALE, similar to NX-14. [illegible] joints are generally horizontal. Jointing is infrequent with spacing ranging from [illegible].
		NX16										SANDSTONE and SHALE, similar to NX 15. [illegible] sandstone [illegible] generally [illegible] horizontal [illegible] joint spacing ranges from [illegible]. Bedding is generally horizontal [illegible].
		NX17										SANDSTONE and SHALE, similar to NX-16. [illegible] The shale comprises about [illegible] of the core [illegible] sandstone. [illegible] generally [illegible]
		NX18										

451 ~~005~~ 116

POOR ORIGINAL

LEGEND: N — STANDARD PENETRATION RESISTANCE; REC — LENGTH RECOVERED / LENGTH CORED, %; RQD — LENGTH OF SOUND CORE / LENGTH CORED, %; [illegible] SPLIT SPOON SAMPLE; UNDISTURBED SAMPLE; ST — SHELBY TUBE; FP — FIXED PISTON; [illegible]; ▽ GROUNDWATER; k — COEFFICIENT OF PERMEABILITY; DRILL BIT USE: N — NEW, R — RESET, [illegible]; DRILL WATER RETURN: C — COMPLETE, P — PARTIAL, N — NONE

PLANAR FEATURES: [illegible] CONTACT, FOLIATION, BEDDING, CROSS BEDDING; CORE BREAKS: JOINT, FOLIATION, CONTACT, [illegible], DRILLING BREAK, SLIPPERY

NOTES: [illegible]

NEW Y[illegible]RK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers

PAGE [illegible] OF [illegible] LOG OF BORING [illegible]

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH July [illegible], 1976 / Aug. [illegible], 1976

B - 5

INCLINATION Vertical BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible] Drilling Co. [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER DEPTH [illegible] DATE [illegible] LOGGED BY [illegible]

EL MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N or REC	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV. / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487-69 AND D2488-69) ROCK DESCRIPTIONS
		NX19	95	57					shale part.			SANDSTONE and SHALE, similar to NX-18. Argillaceous sandstone with a few layers of shale which range in thickness from 2" to 9". The core consists of about 15% shale and 85% argillaceous sandstone. The sandstone portions are massive and intact. Joints are infrequent and are usually associated with shale layers. Bedding is horizontal.
		NX20	100	90					shale part.; contact; shale part.			SANDSTONE and SHALE, similar to NX-19. Argillaceous sandstone interbedded with layers of sandy shale. The shale layers exhibit distinct upper contacts and grade into the argillaceous sandstone. The core from [illegible] to [illegible] consists of irregular and discontinuous rods of shale (up to 1/4" in thickness) in a matrix of sandstone. Bedding is generally horizontal but varies locally.
230		NX21	99	[illegible]					contact; shale part.			SANDSTONE and SHALE, similar to NX-20. Argillaceous sandstone interbedded with occasional shale layers up to 3" thick. The shale layers comprise less than 10% of the core. Joints are infrequent with spacing ranging from 1' to about 2.5' and are usually associated with shale layers. The bedding is less distinct than in previous zone.
240		NX22	95	[illegible]					contact; shale part.; shale part.			SANDSTONE and SHALE, similar to NX-21. Argillaceous sandstone interbedded with sandy shale. The core consists of about equal amounts of shale and sandstone. The sandy shale zones range up to approximately 2.1' thickness and exhibit distinct upper contacts and gradational lower contacts. The rock is generally massive and intact with only infrequent joints. The bedding is less distinct than in previous zone.
250		NX23	100	93					contact; contact			SANDSTONE and SHALE, similar to NX-22. Argillaceous sandstone interbedded with shale. The shale zones range in thickness to 2.5' and comprise approximately 30% of the run. The shale layers exhibit sharp upper contacts and grade into the argillaceous sandstone. Joints occur within the shale zones and at the sharp contacts between the argillaceous sandstone and the shale.
260												

BOTTOM OF BORING AT 263.2 FT

451 ~~[illegible]~~ 117

POOR ORIGINAL

LEGEND

N - STANDARD PENETRATION RESISTANCE
REC - LENGTH RECOVERED / LENGTH CORED, %
RQD - LENGTH OF SOUND CORE > 4 IN / LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES:
US - SHELBY TUBE, UD - DENISON
UP - FIXED PISTON, UP - PITCHER
UO - OSTERBERG, UG - GEL
GROUNDWATER; k - COEFFICIENT OF PERMEABILITY
DRILL BIT USE: N - NEW, R - RESET, U - USED
DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES: C - CONTACT, F - FOLIATION, B - BEDDING, X - CROSS BEDDING

CORE BREAKS (SMOOTH / ROUGH): JOINT, FOLIATION, CONTACT; CORE LOST / CORE SAMPLE; DRILLING BREAK; SLIPPERY

NOTES

1. Boring location is approximate. Coordinates are taken from field maps.
2. Ground elevation is approximate and is taken from United Engineers Drawing No. [illegible]
3. The type of drill rig used was a Sprague & Henwood. Borings were advanced through soil by rolling bitting ahead of casing and then driving casing. The core barrel used to sample rock was a 10-ft NX double tube barrel.

NEW YORK STATE ELECTRIC & GAS CORP
NEW SITE GENERATION PROJECT
united engineers
[illegible]
GEOTECHNICAL ENGINEERING
Site [illegible]
PROJECT [illegible]

PAGE 4 OF 4 LOG OF BORING [illegible]

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible] / [illegible]

B - 6

INCLINATION [illegible] BEARING [illegible] TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY [illegible]

EL MSL FT.	SAMPLE DEPTH FT.	TYPE AND NO.	N or REC	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS	CORE BREAKS REMARKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487 69 AND D2488 69) / ROCK DESCRIPTIONS
		[illegible]										YELLOW BROWN, [illegible] FINE SAND, TOPSOIL
		[illegible]										BROWN, SILTY CLAY. Little to no reaction to shaking test, plastic fines, contains some angular particles of sandstone.
		[illegible]										BROWN AND GRAY, SILTY SANDY GRAVEL. Widely graded, maximum particle to 1-3/4 in., particles are angular, exhibits weak stratification in the form of silty fine to medium sand layers up to 1 in. thick. Till
		[illegible]										BROWN, GRAVELLY SILTY FINE SAND. Angular pieces of gravel to 1-3/8 in., homogeneous structure. Till
		[illegible]										GRAY, SILTY SANDY GRAVEL. Widely graded, contains angular fragments of shale and sandstone to 1-3/4 in. Till
		[illegible]										GRAY, SILTY SANDY GRAVEL. Similar to S5.
		[illegible]										No recovery
		NX1										SANDSTONE, gray, fine-grained, [illegible], hard to hard, [illegible], grading to argillaceous sandstone. [illegible] fractured and slightly weathered. [illegible] surfaces are coated with gray clay or silt. [illegible] SANDSTONE, similar to NX-1, with occasional shale layers [illegible] range in thickness from 1/8" to 1-1/2" thick. The [illegible] slightly weathered rock with [illegible] zones of sandstone.
		NX3										[illegible], similar to NX2. Sandstone grading to argillaceous sandstone with occasional [illegible] shale layers up to [illegible] thick. Generally more massive and intact than [illegible]. Shale layers are moderately weathered.
		NX4										SANDSTONE, similar to NX-3. Sandstone locally grading to argillaceous sandstone. Generally massive and intact with [illegible] jointing. Joints exhibit moderate to severely weathered surfaces.
		NX5										SANDSTONE, similar to NX-4. Sandstone grading to argillaceous sandstone, interbedded with [illegible] and layers of [illegible] to [illegible] thick. Shale layers are moderately to [illegible] weathered.

BOTTOM OF BORING 55.0 FT

451 118

POOR ORIGINAL

LEGEND: N - STANDARD PENETRATION RESISTANCE; REC - LENGTH RECOVERED/LENGTH CORED %; RQD - LENGTH OF SOUND CORE [illegible] / LENGTH CORED %; S - SPLIT SPOON SAMPLE; U - UNDISTURBED SAMPLES: US - SHELBY TUBE, UN - DENISON, UF - FIXED PISTON, UP - PITCHER, UO - OSTERBERG, [illegible]; GROUNDWATER; K - COEFFICIENT OF PERMEABILITY

DRILL BIT USE: N - NEW, R - RESET, U - USED. DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES: [illegible]

NOTES
1. Boring location is approximate. [illegible]
2. Ground elevation is approximate and is taken from [illegible]
3. The type of drill rig used was [illegible]. Borings were advanced [illegible] and then driving casing. [illegible] core barrel used to sample rock was a 5-ft N series, NX split barrel.

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers

PAGE 1 OF 1 LOG OF BORING [illegible]

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH July 21, 1976 / July 23, 1976

B - 7

INCLINATION Vertical BEARING [illegible] TOTAL DEPTH (T.) [illegible] DRILLED BY [illegible] Drilling Co. - K. [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER [illegible] DATE [illegible] LOGGED BY Soil - M. E. [illegible] Rock - M. E. [illegible]

EL MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N or REC	WATER CONTENT %	RQD	RATE OF ADV. / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES CORE BREAKS TYPE AND DIP	SURFACE OF CORE BREAKS	GRAPHIC ROCK LOG	SOIL DESCRIPTIONS (ASTM D2487-69 AND D2488-69) ROCK DESCRIPTIONS
		S1	45									BROWN SILTY SAND. Widely graded, maximum particle 1-1/4", gravel is subangular to angular and predominantly light gray, fine-grained sandstone, some rusty zones, medium reaction to shaking test, fines are non-plastic. Till
		S2	100/5"									LIGHT BROWN, FINE TO COARSE GRAVEL. Note: Penetration stopped on boulder, rolled bit through boulder.
		S3	32									BROWN, GRAVELLY SANDY CLAYEY SILT TO GRAVELLY SILTY SAND. Widely graded, maximum particle 2", gravel is angular to subangular fine-grained sandstone with some dark gray to black shale fragments, slow reaction to shaking test, slightly plastic fines. Till
10		S4	52									LIGHT BROWN, GRAVELLY SILTY SAND. Widely graded, maximum particle 1-2", gravel is predominantly sandstone and subrounded to angular, some irregular inclusions of dark brown fine sandy silt, medium to fast reaction to shaking test, non-plastic fines. Till
		S5	123									LIGHT BROWN, GRAVELLY SILTY SAND. Similar to S4
20		S6	100/2"					Top of [illegible] Till				LIGHT GRAY, [illegible] GRAVELLY SANDY SILT TO CLAYEY GRAVELLY SILTY SAND. Widely graded, medium to slow reaction to shaking test, slightly plastic fines. Till

BOTTOM OF BORING AT 20 ft 8 in.

NOTE: Boring abandoned when casing shoe was lost in hole. See Log of Boring 7A for continuation.

POOR ORIGINAL

451

119

LEGEND

N - STANDARD PENETRATION RESISTANCE
REC LENGTH RECOVERED/LENGTH CORED, %
RQD LENGTH OF SOUND CORE ≥ 4 IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
UNDISTURBED SAMPLES
US - SHELBY TUBE / UD - DENISON
UP - FIXED PISTON / UP - PITCHER
UO - OSTERBERG / U - [illegible]
GROUNDWATER / K - COEFFICIENT OF PERMEABILITY

DRILL BIT USE: N - NEW, R - RESET, U - USED
DRILL WATER RETURN: C - COMPLETE, P - PARTIAL, N - NONE

PLANAR FEATURES: C - CONTACT, F - FOLIATION, B - BEDDING, X - CROSS BEDDING

CORE BREAKS: SMOOTH / ROUGH; JOINT; FOLIATION; CONTACT; CHIPS, LOST CORE, CAVITY; DRILLING BREAK; SLIPPERY

NOTES

1. Boring location is approximate. Coordinates are taken from [illegible] maps.
2. Ground elevation is approximate and is taken from United Engineers drawing no. [illegible]
3. The type of drill rig used was a [illegible]. Borings were advanced through soil by rolling bottom ahead of casing and then driving casing.

NEW YORK STATE ELECTRIC & GAS CORP

NEW SITE GENERATION PROJECT

united engineers [illegible]

PAGE 1 OF 1 LOG OF BORING B-7

B-7A

BORING LOCATION [illegible] GROUND ELEVATION (MSL) [illegible] DATE START/FINISH [illegible]

INCLINATION Vertical BEARING NA TOTAL DEPTH (FT) [illegible] DRILLED BY [illegible]

CASING I.D. [illegible] CORE SIZE [illegible] GROUNDWATER DEPTH [illegible] DATE [illegible] LOGGED BY [illegible]

EL. MSL FT	SAMPLE DEPTH FT	TYPE AND NO.	N or REC.	WATER CONTENT %	RQD GRAPHIC	RATE OF ADV / DRILL BIT USE	PIEZOMETER TEST	DRILL WATER RETURN	PLANAR FEATURES / CORE BREAKS	SURFACE OF CORE BREAKS / REMARKS	GRAPHIC LOG	SOIL DESCRIPTIONS (ASTM D2487 69 AND D2488 69) ROCK DESCRIPTIONS
							PVC pipe protected with 5-ft section of 4 in. steel casing cemented into the ground.					NOTE: Auger hole to Sample 1. For soil conditions above 31', see log of Boring 7
	31	S1					Bentonite					LIGHT GRAY, GRAVELLY SILTY SAND TO GRAVELLY SANDY SILT. Widely graded, maximum particle 1-1/4", grains are angular to subrounded, [illegible] reaction to HCl, rapid reaction to shaking test, non-plastic fines, homogeneous structure. [illegible]
		S2					.95					LIGHT GRAY, GRAVELLY SILTY SAND TO GRAVELLY SANDY SILT. Similar to S1.
34		NX1	100				Bentonite	C				SANDSTONE [illegible] with variable shale content. [illegible] more argillaceous. [illegible]
		NX2	75			4		C				SANDSTONE, similar to NX1. A fractured zone extends from 36' to 38' which contains chips of sandstone and shale and a [illegible] thick clay fill zone. Rock is moderately weathered.
40		NX3				3		N				SANDSTONE, similar to NX1. The upper [illegible] of the core [illegible] irregular and discontinuous zones of dark gray-green claystone or shale, some of which appear waxy. A similar shaly zone occurs between 41'2" and 41'4".
		NX4	90					P		Shale part / Shale part / Shale part / Shale part		SANDSTONE, similar to NX1. Core break at 44' occurs at [illegible] thick shale layer. At 44'8" is a [illegible] thick zone of irregular and discontinuous shale [illegible] in the sandstone. Chips of sandstone at 45'10" are darker in color than normal for the sandstone and appear argillaceous.
50		NX5	100					N				SANDSTONE, similar to NX4. Core less broken in this run than previously.
		NX6	98					N		Shale part / Shale part / Shale part / Shale part		SANDSTONE, similar to [illegible] but more argillaceous and slightly [illegible]. [illegible]

BOTTOM OF BORING at 57'

451

~~009~~

120

POOR ORIGINAL

N - STANDARD PENETRATION RESISTANCE
REC - LENGTH RECOVERED/LENGTH CORED, %
RQD - LENGTH OF SOUND CORE 4 IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES
US - SHELBY TUBE; UF - FIXED PISTON; UO - OSTERBERG; UD - DENISON; UP - PITCHER; UG - GEL
▽ GROUNDWATER; k - COEFFICIENT OF PERMEABILITY
DRILL BIT USE: N - NEW; R - RESET; U - USED
DRILL WATER RETURN: C - COMPLETE; P - PARTIAL; N - NONE

PLANAR FEATURES: C - CONTACT; F - FOLIATION; B - BEDDING; X - CROSS BEDDING
CORE BREAKS: JOINT; FOLIATION; CONTACT; CHIPS, LOST CORE, CAVE; DRILLING BREAK; SLIPPERY

NOTES
1. Boring location is approximate; coordinates are taken from [illegible]
2. Ground elevation is approximate and is taken from United Engineers drawing no. [illegible]
3. The type of drill rig used was a [illegible]. Borings were advanced through soil by [illegible] ahead of casing and then [illegible] casing. The core barrel used to sample rock was a [illegible] NX [illegible], or split barrel.

NEW YORK STATE ELECTRIC & GAS CORP.
NEW SITE GENERATION PROJECT
United Engineers & Constructors Inc.
PAGE [illegible] LOG OF BORING [illegible]

FIELD EXPLORATORY TEST PIT LOG

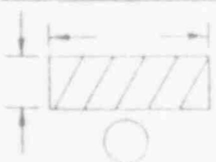
PROJECT: NYSE&G New Site Project
LOCATION: 4-3-11, Met Tower
CLIENT: UE&C
CONTRACTOR: ____ OPERATOR: Carl Farewell
EQUIPMENT: Backhoe
CAPACITY/REACH: ____ / approx. 12 ft
WEATHER: 70° Cool
PERFORMED BY: P. C. Lucia DATE: 7/12/76
CHECKED BY: ____ DATE: ____

PAGE 1 OF 1
TEST PIT NO. 1
LOCATION: South of Center of Met Tower
GROUND EL.: Unknown
DATUM: -
PROJECT NO. 76265
TIME STARTED: 0930
TIME COMPLETED: 1000

DEPTH OF STRATA CHANGE ft.	SAMPLE No. & TYPE	SAMPLE DEPTH ft.	SOIL DESCRIPTION	EXCAV. EFFORT	BOULDER COUNT		REMARK No.
					QTY	CLASS	
0.5			Topsoil	E	0	0	-
3.0			Light brown, silty sand to gravelly silty sand, particles to about 3 in., subangular to subrounded grains, non-plastic fines, uniform structure, possibly till, SW-SM. Possibly some oxidation.	M	0	0	
9.0			Brown gravelly, silty sand. Boulders to 12", particles are subrounded, non-plastic fines, uniform structure, no cementation. Till. SW-SM	D			1
			Bottom of Pit 451 ~~120~~ 121				

REMARKS: 1) Very difficult to excavate, dense. 2) Groundwater not encountered. At 1105 - water observed coming into excavation below depth of about 5 ft. 3) Descriptions made on soil removed from excavation.

TEST PIT PLAN



VOLUME = ____ C.Y.

LEGEND:

BOULDER COUNT

SIZE RANGE CLASSIFICATION	LETTER DESIGNATION
6" - 18"	A
18" - 36"	B
36" AND LARGER	C

EXCAVATION EFFORT

EASY — E
MODERATE — M
DIFFICULT — D

GROUNDWATER

ELAPSED TIME TO READING (HRS) — G.W.L.

TEST PIT No. 1
DEPTH 9.0'
JAR SAMPLES -
BAG SAMPLES -
GROUNDWATER (3)

Lab. 16-2 rev. 0 1 Oct 74

FIELD EXPLORATORY TEST PIT LOG

PROJECT NYSE&G New Site Project
LOCATION 4-3-11, Met Tower SW Guy
CLIENT UE&C
CONTRACTOR ______ OPERATOR Carl Farewell
EQUIPMENT Backhoe
CAPACITY/REACH / 10-12 ft
WEATHER 70°
PERFORMED BY P. C. Lucia DATE 7/22/76
CHECKED BY ______ DATE ______

PAGE 1 OF 1
TEST PIT NO. 2
LOCATION SW Line
GROUND EL. -
DATUM -
PROJECT NO. 76265
TIME STARTED 1010
TIME COMPLETED 1030

DEPTH OF STRATA CHANGE ft.	SAMPLE No. & TYPE	SAMPLE DEPTH ft.	SOIL DESCRIPTION	EXCAV. EFFORT	BOULDER COUNT QTY	BOULDER COUNT CLASS	REMARK No.
			Topsoil.	E			
0.5			Dark brown, fine, silty sand, few coarse particles, non-plastic fines, uniform structures, no cementation. SM	M			
3.5			Tan, clayey, silt. Slight plasticity, some "joints" that are stained, slightly blocky structure, some layering with slightly more clayey layers. ML	M			
5.0			Brown clayey, gravelly, silty sand. Boulders to 12 in., particles are subrounded, slightly plastic fines, no cementation, till. SM	D		A	1
6.0			Bottom of pit				
			451 ~~~~ 122				

REMARKS: 1) Hard to excavate, encountering numerous boulders. 2) Did not encounter groundwater although soil at bottom of excavation appeared saturated. At 1108 water observed ponding in center of excavation at depth of 5 ft.

TEST PIT PLAN

VOLUME = ______ C.Y.

LEGEND:

BOULDER COUNT

SIZE RANGE CLASSIFICATION	LETTER DESIGNATION
6"-18"	A
18"-36"	B
36" AND LARGER	C

EXCAVATION EFFORT

EASY — E
MODERATE — M
DIFFICULT — D

GROUNDWATER

ELAPSED TIME TO READING (HRS)	GWL

TEST PIT No. 2
DEPTH 6.0 ft
JAR SAMPLES -
BAG SAMPLES -
GROUNDWATER (2)

Lab. 16-2 rev. 0 4 Oct 74

FIELD EXPLORATORY TEST PIT LOG

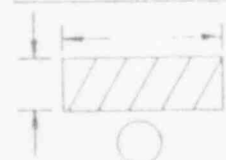
PROJECT NYSE&G New Site Project	PAGE 1 OF 1
LOCATION 4-3-11, Met Tower, SE Guy	TEST PIT NO. 3
CLIENT UE&C	LOCATION SE Line
CONTRACTOR ______ OPERATOR Carl Farewell	
EQUIPMENT Backhoe	GROUND EL. -
CAPACITY/REACH ______ / 10-12 ft	DATUM -
WEATHER 75° Clear	PROJECT NO. 76265
PERFORMED BY P. C. Lucia DATE 7/22/76	TIME STARTED 1035
CHECKED BY ______ DATE ______	TIME COMPLETED 1050

DEPTH OF STRATA CHANGE ft.	SAMPLE No. & TYPE	SAMPLE DEPTH ft.	SOIL DESCRIPTION	EXCAV. EFFORT	BOULDER COUNT QTY	BOULDER COUNT CLASS	REMARK No.
			Topsoil	E			
0.5			Light brown, fine, silty sand. Uniform, non-plastic fines. SM	M			
2.0			Brown, gravelly, silty sand, widely graded. Numerous boulders up to 12", subrounded, non-plastic fines, very difficult to excavate. Uniform structure. Till. SW	D			
4.0			Bottom of Pit				

451 123 ~~122~~

REMARKS: Groundwater not encountered. @ 1110 still no groundwater.

TEST PIT PLAN



NORTH

VOLUME = ______ C.Y.

LEGEND:

BOULDER COUNT

SIZE RANGE CLASSIFICATION	LETTER DESIGNATION
6" - 18"	A
18" - 36"	B
36" AND LARGER	C

EXCAVATION EFFORT

EASY — E
MODERATE — M
DIFFICULT — D

GROUNDWATER

ELAPSED TIME TO READING (HRS) | GWL

TEST PIT No. 3
DEPTH 4.0
JAR SAMPLES -
BAG SAMPLES -
GROUNDWATER (1)

Lab. 16-2 rev. 0 4 Oct 71

REPORT OF FIELD TRIP

TO SITE 4-3-11

CONDUCTED MAY 11-12, 1976

NEW YORK STATE ELECTRIC & GAS CORPORATION
NEW SITE PROJECT

Submitted to

UNITED ENGINEERS & CONSTRUCTORS INC.
100 Summer Street
Boston, Massachusetts

By

GEOTECHNICAL ENGINEERS INC.
1017 Main Street
Winchester, Massachusetts 01890

Project 76265
May 26, 1976
Document No. 26

451 124

TABLE OF CONTENTS

	Page
1. INTRODUCTION	
1.1 Objective	1
1.2 Scope	1
2. SUMMARY OF WATER WELL DATA IN VICINITY OF SITE 4-3-11	2
3. SUMMARY OF GEOLOGICAL FIELD RECONNAISSANCE OF SITE 4-3-11	3
4. PRELIMINARY CONCLUSIONS RELATIVE TO SITE 4-3-11	5

TABLE 1 - SUMMARY OF WATER WELL DATA, VICINITY OF SITE 4-3-11, NYSE&G NEW SITE STUDY

TABLE 2 - SUMMARY OF OBSERVATIONS MADE DURING THE GEOLOGICAL FIELD RECONNAISSANCE OF SITE 4-3-11 NYSE&G NEW SITE STUDY

FIG. 1 - Location Map, Geological Reconnaissance, Site 4-3-11

451 125

1. INTRODUCTION

1.1 Objective

This report presents the results of a preliminary geological reconnaissance of Site 4-3-11 which was conducted by GEI on May 11 and 12, 1976. There were two objectives for this study. The primary objective was to obtain information on the depths of the overburden in the area within and to the east of Site 4-3-11 so that recommendations could be made regarding the possible relocation of the site. The second objective was to obtain a general overview of Site 4-3-11 to assist in formulating a site confirmation plan.

1.2 Scope

The scope of the geological reconnaissance included the acquisition of water well data in the vicinity of Site 4-3-11, a limited on-site field geological reconnaissance and an examination of the off-site geology from the public roadways.

2. SUMMARY OF WATER WELL DATA IN VICINITY OF SITE 4-3-11

Water well data were obtained at several locations along Lee Road, County Route 6, Route 104 and Route 104B. The approximate locations of these wells are shown in Fig. 1. The data, which consist of the name of the present homeowner, the depth of the well, the type of soil, and depth to bedrock (if known) are presented in Table 1. In all cases the data were obtained without the benefit of boring records, and, therefore, the accuracy of the data is uncertain. (The water wells for which data are presented in this report are in addition to those described by G. A. Kiersch in his report "Geological Reconnaissance and Evaluation of Preferred Sites, NYSE&G, New Site Selection Study," dated December 5, 1975.)

Based upon the well data, the overburden materials which exist in the area of Site 4-3-11 consist of glacial till and clay. Till was encountered in at least 14 of the 18 wells for which subsurface data were obtained and appears to exist around the entire perimeter of the site. The thickness of the glacial till, as encountered in the wells, ranges up to 100 ft (as reported for well W-2). The clay on the other hand, was reported as encountered in only four wells. These four wells are W-1, W-2, W-14 and W-16 and are located along the southern boundary of the site. The thickness of the clay ranges up to a maximum of 10 ft (as reported for well W-1).

There is a notable difference in the thickness of the overburden along the northern and southern boundaries of the site: Along the northern boundary of the site most of the wells are shallow, with the water derived from the glacial till at depths of 9 to 28 ft. Bedrock was encountered in wells W-7, W-9, and W-13, at depths of 28, 10 and 21 ft, respectively. Along the southern side of the site, the thickness of the overburden, as encountered in wells W-1, W-2, W-3 and W-16, ranges from 65 ft to over 100 ft.

A high frequency of boulders was encountered during the drilling of the wells adjacent to the site. At the location of well W-4, extremely bouldery till was encountered during the drilling of the entire well to a depth of 92 ft.

451 127

3. SUMMARY OF GEOLOGICAL FIELD RECONNAISSANCE OF SITE 4-3-11

This investigation included an off-site reconnaissance which was limited to observations from the public roads and an on-site reconnaissance which consisted primarily of traverses along creeks and the right-of-way of a high-voltage transmission line.

The topography throughout the area is hummocky and characteristic of an area underlain by ground moraine glacial till. Additional evidence of the presence of glacial till is provided by the numerous stone walls which exist in the area. Drumlins and drumlinoid-type features are very prominent south and east of the site area and swampy areas occur between these hills. The Soil Conservation Service in Oswego has indicated that these swamps are underlain by lacustrine clay deposits. No bedrock outcrops were observed in the area during the off-site reconnaissance.

The on-site field reconnaissance consisted of traverses made along the transmission line right-of-way, Butterfly Creek, an unnamed creek approximately 1500 ft west of Butterfly Creek, and the ridge parallel to Butterfly Creek, and observations made along the public roads bounding the site. The locations of these traverses are shown in Fig. 1 and the observations made during these traverses are presented in Table 2.

The transmission line right-of-way passes through cultivated fields with the exception that at the higher elevations on the ridge near Butterfly Creek the right-of-way is covered with brush and small trees. The traverse along the unnamed creek (Traverse HJ) was in an area of open fields. The traverse along Butterfly Creek (Traverse CBE) was in an area covered with thick brush and the traverse along the ridge (Traverse FG) was in an area of brush and mature hardwoods.

No bedrock was found during the on-site reconnaissance except in the basement of a house near the location of well W-9. At this location, sandstone occurs at a depth of about 4 ft below the ground surface. Glacial till, overlying the bedrock, is also exposed in the basement of this house. The glacial till is a very dense, brown, silty sand and gravel with numerous cobbles and boulders.

451 128

A glacial till consisting of a silt and clay matrix containing gravel and boulders was encountered at the lower elevations of the site along Butterfly Creek and the creek which exists some 1500 ft west of Butterfly Creek. The location of these exposures are noted as Nos. 1 and 4 in Fig. 1. Although exposures of till were not found at the higher elevations, the presence of numerous boulders on the surface of the ground suggested that the majority of the area is underlain by glacial till.

The boulders in the till are large. For example, a slab of sandstone with a maximum dimension of about 10 ft was observed at location No. 3 in Fig. 1.

Kame features were observed in the vicinity of Butterfly Creek at the locations noted in Fig. 1. The surficial material associated with these features consists of silty sand and gravel.

451 129

4. PRELIMINARY CONCLUSIONS RELATIVE TO SITE 4-3-11

Evidence exists which suggests that the thickness of the overburden is greater along the southern and western boundaries of Site 4-3-11 than at locations along the northern and eastern boundaries. This evidence consists of the following:

(1) Reported overburden thickness in excess of 65 ft along Route 104 and County Route 6 at Wells W-1, W-2, W-3, W-4, and W-16.

(2) Depths to bedrock of between 10 ft and 28 ft at wells W-7, W-9, and W-13 which are located along Route 104B and Lee Road.

(3) Shallow bedrock was observed at a depth of about 4 ft in the basement of the home located near well W-9.

There is evidence that two glacial tills exist at the site: an upper till which is permeable, bouldery, and granular in which many wells in the area have been dug and which exists at the higher elevations of the site, and a lower till which consists of a silt and clay matrix with gravel and boulders. This latter till is found in the lower elevations of the site. The evidence for two tills is as follows:

(1) The wells located along the roads which form the perimeter of the site encountered a granular, bouldery, permeable till from which water is produced.

(2) A granular till with boulders was found in the basement of the home located near well W-9.

(3) A silt and clay till was examined in exposures along Butterfly Creek and the creek approximately 1500 ft west of Butterfly Creek.

(4) A telephone conversation with Dr. Maurer of the Department of Earth Sciences of the State College of New York at Oswego indicates that two tills have been mapped in the area.

(5) Personal communication with the Soil Conservation Service in Oswego indicates that they have identified two tills in the site area.

Until additional investigations, including test borings and refraction seismic surveys, define the subsurface conditions, no definite conclusion can be reached regarding the thickness of the overburden at the site. It is recommended that additional subsurface data be obtained prior to relocating the site to the ridge centered along Traverse FG. Although the presence of large sandstone blocks along the ridge might suggest shallow bedrock, the possibility exists that a thick deposit of till underlies the ridge.

451 131

TABLE 1 - SUMMARY OF WATER WELL DATA
VICINITY OF SITE 4-3-11
NYSEW NEW SITE STUDY

Well	Owner	Well Depth ft	Surface Conditions
W-1	T. Bond	80	0-30 ft Glacial till 30-40 ft Clay 40-80 ft Glacial till 80 ft Bedrock
W-2	T. Bond, Jr.	142	0-100 ft Glacial till 100 ft-? Clay Bedrock depth unknown.
W-3	R. Yager	65	Glacial till, no bedrock encountered.
W-4	R. G. Alfred	92	Very bouldery till. No bedrock encountered.
W-4A	R. G. Alfred	32	(No information)
W-5	T. Benz	1000±	Bedrock depth unknown
W-6	D. Whaley	9	Glacial till.
W-7	K. Earnshaw	28	0-28 ft Clayey till 28 ft Bedrock
W-8	W. Adams	15	Glacial till
W-9	S. Miller	75-80	0-10 ft Glacial till 10 ft Sandstone
W-10	Lee Auto Sales	13	Glacial till
W-10A	Lee Auto Sales	13-15	Glacial till
W-11	J. Shumway	90	(No information)
W-12	[illegible]	9	Glacial till

NOTE: The locations of these wells are shown in Fig. 1.

POOR ORIGINAL

451 132

TABLE 1 - SUMMARY OF WATER WELL DATA
VICINITY OF SITE 4-3.11
NYSE&G NEW SITE STUDY

Well	Owner	Well Depth ft	Surface Conditions
W-13	D. Vroman	97	Bedrock at 21 ft.
W-14	F. Shepard	20	0-18 ft Cemented till with boulders 18-20 ft Blue clay
W-15	C. Bickford	12	Glacial till.
W-16	R. Thomas	90	Glacial till with clay

NOTE: The locations of these wells are shown in Fig. 1.

Geotechnical Engineers Inc.

Project 76265
May 26, 1976

451 133

POOR ORIGINAL

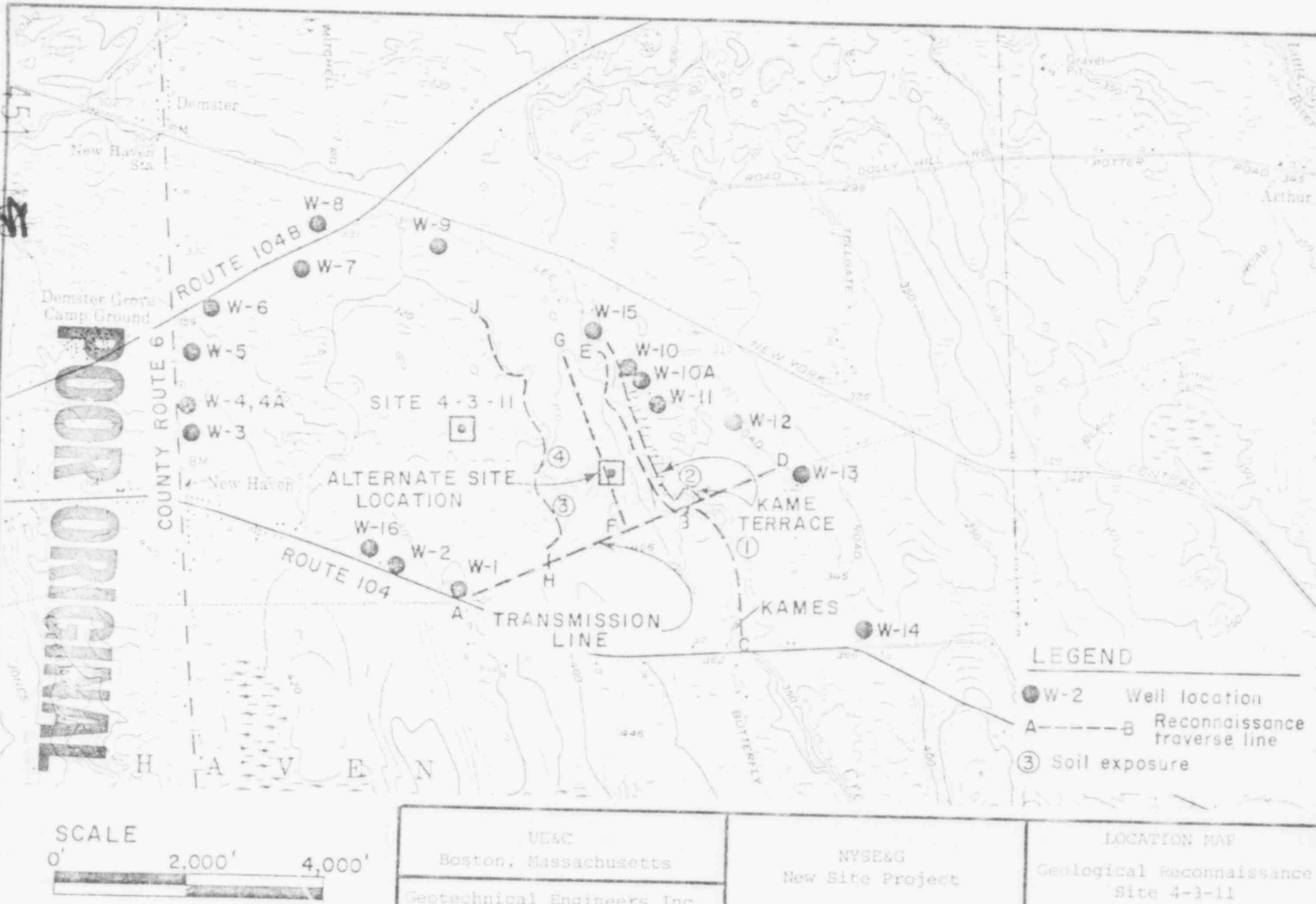
TABLE 2 - SUMMARY OF OBSERVATIONS MADE DURING THE GEOLOGICAL FIELD RECONNAISSANCE OF SITE 4-3-11 NYSE&G NEW SITE STUDY

Traverse	Description
Traverse A-B-C	This traverse was made along the transmission line right-of-way to Butterfly Creek and then to Route 104. Numerous stone walls were observed. The top of the knoll on the ridge (El. 406) contains numerous surface boulders. No soil or rock exposures along the transmission line were observed. Numerous boulders around the transmission poles indicate bouldery till. Ice contact features consisting of a kame terrace deposit were noted near Butterfly Creek. Glacial till was found exposed in a cut bank 4 to 5 ft high along Butterfly Creek. The exposure, designated as No. 1, is shown on Fig. 1. This till is a mottled yellow-brown to red-brown clayey silt with gravel. Kame-like features were noted where Butterfly Creek crosses Route 104.
Traverse D-B-E	A traverse was made from Lee Road along the transmission line right-of-way to Butterfly Creek and then along both banks of the creek. Two prominent knobs (approximate El. 370) which may represent kames or shallow bedrock were observed along the power line. Many surface boulders and fragments of sandstone were evident where the fields had recently been plowed. The boulders and fragments were more numerous on the knolls. At the creek near the transmission line, a small exposure, designated as No. 2 on Fig. 1, was noted. The exposure consisted of brown silty sand and gravel. The traverse made along both sides of Butterfly Creek to Lee Road revealed no soil or rock exposures. Ice contact features consisting of a kame terrace deposit were observed along the east bank of the creek about 500 ft north of Location No. 2. Digging into the bank exposed the same brown, silty sand and gravel as at Location No. 2.

451 134

TABLE 2 - SUMMARY OF OBSERVATIONS MADE DURING THE GEOLOGICAL FIELD RECONNAISSANCE OF SITE 4-3-11 NYSE&G NEW SITE STUDY

Traverse	Description
Traverse B-F-G	A traverse was made along the prominent ridge found along the easterly portion of the site. This ridge has a drumlin-like appearance and represents the topographic high for the site. Most of the ridge is covered by thick woods. No bedrock outcrops or soil exposures were noted along the ridge. Many surface boulders exist along the slopes of the ridge. In places along the slopes stockpiles of boulders exist.
Traverse H-J	The creek located about 1500 ft west of Butterfly Creek was examined for soil and bedrock exposures. This tributary follows the westerly slope of the drumlin-like ridge. No bedrock outcrops were observed along this traverse. A large sandstone slab was exposed in the slope along the creek at the location designated as No. 3 in Fig. 1. The size of the slab is 10 ft long by 3 ft high. This slab had the appearance of an outcrop but closer examination indicated it to be a boulder. The bedding attitude was measured and found to be striking N40E and dipping 19° SE. This attitude is inconsistent with the bedding attitude of the bedrock of the area which is essentially horizontal. Soil was also exposed below this slab which also indicated the likelihood of it being a boulder. Many boulders of gneiss and sandstone were noted along the traversed stream route. The boulders ranged in size up to a maximum dimension of 5 ft. Several stockpiles of boulders were noted along the creek. An examination was made of the low area which is shown by Kiersch (1975) as the center of the site. The area is low and wet and consists of farmland. No evidence of a thick deposit or organic material was found. An exposure, No. 4 on Fig. 1, was examined in a 3-ft-high stream cut. This exposure showed approximately 1 ft of gray silty fine sand alluvium overlying a mottled gray to yellow-brown slightly plastic silt and clayey silt with gravel.



UE&C
Boston, Massachusetts

Geotechnical Engineers Inc.
Winchester, Massachusetts

NYSE&G
New Site Project

Project 76265

LOCATION MAP
Geological Reconnaissance
Site 4-3-11

May 1976 Fig. 1

POOR ORIGINAL