

ENVIRONMENTAL GEOLOGY OF THE
LLOYD NUCLEAR POWER PLANT SITE

by

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A History of Site Study

In November 1971 the N.Y. Atomic and Space Development Authority released an anonymous report by Dames and Moore (a consulting engineering firm) entitled: "Consultation and Geologic Evaluation Site Suitability Studies: Hudson River Valley between Albany and Newburgh, New York." The report studied nine sites, two adjacent to the present Lloyd site. Of the nine sites, 5, or more than half, are rated as most favorable for additional study. The Lloyd sites* are described as follows (pp. 12-13):

Based on recent studies (Salkind, personal communication) lithologies within the region in which Areas 5W, 6W, and 7W are located, can be broken down into three separate formations. The youngest, or highest stratigraphically, is the Quassaic Quartzite. This formation crops out in a linear belt from Illinois Mountain (southeast side of Site 5W) north to Connely, New York. This formation forms the core of a normally faulted, recumbent syncline. Underlying the Quassaic Formation is the Austin Glen Graywacke, also a new formation. It was formerly treated as a member of the Normanskill Formation. This formation crops out west of Illinois Mountain and underlies most of Sites 5W and 6W. The regional strike is N25E with all dips to the southeast. This formation is extensively faulted by repetitive high angle reverse faults which have a north-south trend. All of the lowlying swamps occurring between the more resistant outcrops of Austin Glen and Quassaic are thought to be topographic expressions of faults and/or fault zones.

*Site 5W is adjacent to and South of the present Lloyd site.
6W is west and adjacent. Site 7W is not adjacent to the present site.

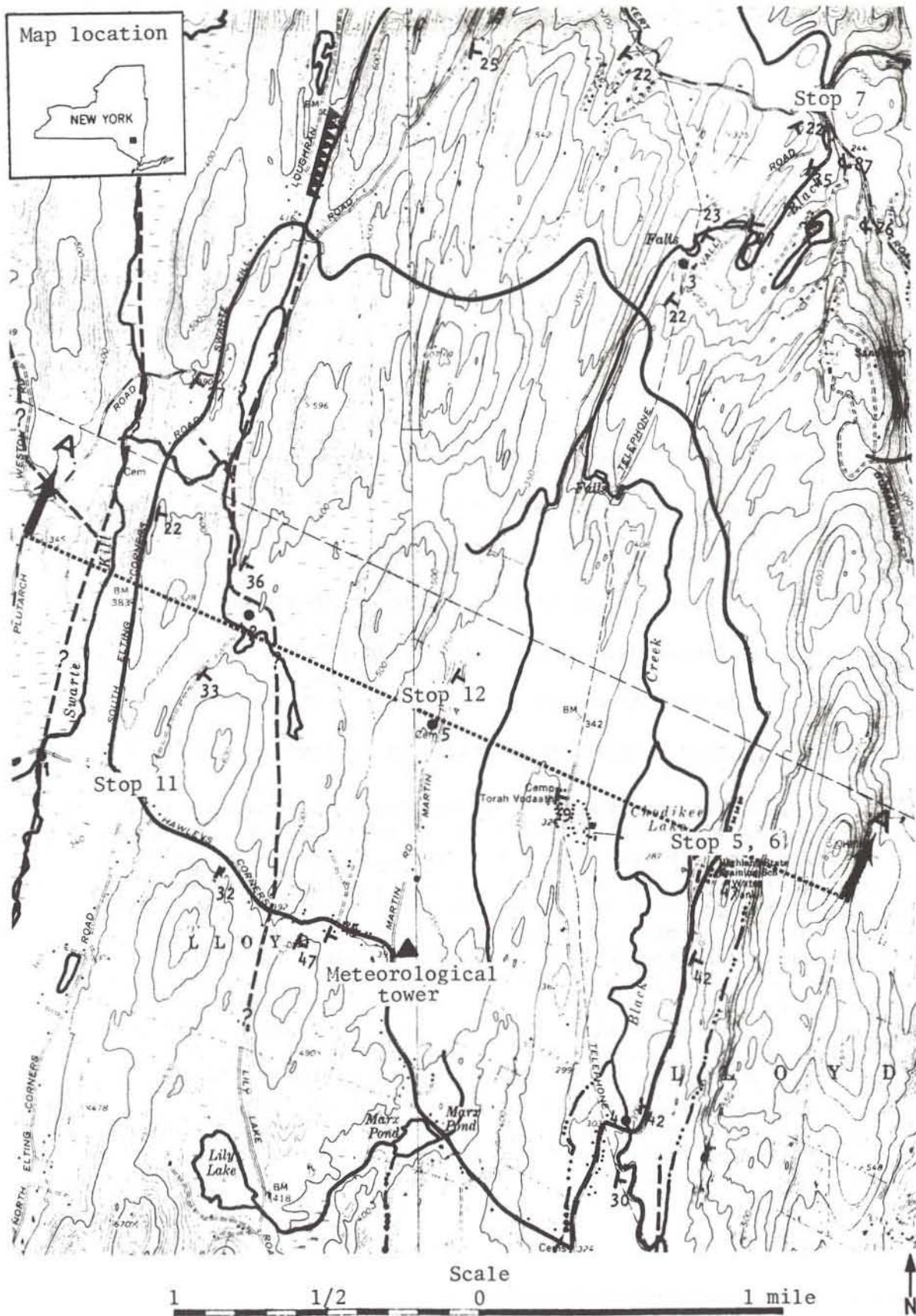


Fig. 1 Modified Dames and Moore 1973 site map. Trimmed to fit page; drainage emphasized; scale reduced; tower, stops and location map added.

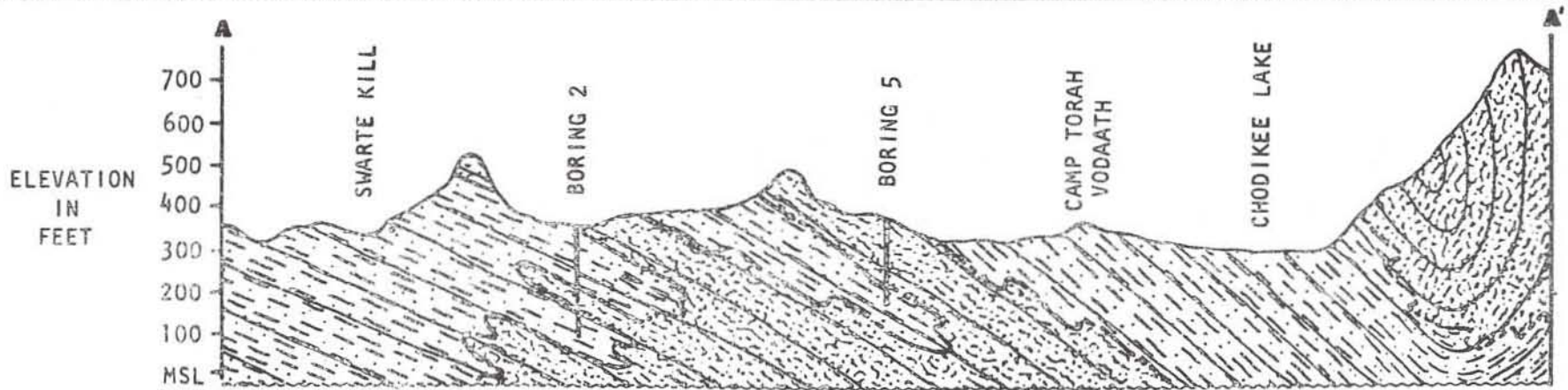
In addition to this information, a 1/250,000 scale Geologic map is provided. The sites are only 1/4 inch in diameter at this scale and thus little detail is shown. This report is at best a preliminary reconnaissance of the entire region. It is so preliminary that the choice of best sites is difficult with the meager information available. At least, the description of the Lloyd site is fairly correct as far as it goes.

In June 1973 another report was released by the N.Y. Atomic and Space Development Authority. This report also was generated by anonymous members of the Dames and Moore staff. The Report was called "Report: Site Suitability Geotechnical Studies; Lloyd, New York."

The report is very general. Fig. 1 is a copy of the site geologic map from this report. The cross section A-A' section clearly crosses two faults on the geologic map. However the cross section drawn from the geologic map and reproduced here in Fig. 2 shows no faults. Interestingly, two different vertical exaggerations are claimed for this one cross section. One might seriously question the extremely rapid facies changes shown on the section, for example in one case 500 feet of "quartzite" grades into "Interbedded graywacke/shale" in a horizontal distance of only 2000 ft. There certainly are facies changes in the area but it is doubtful that any are this extreme. Faulting is a more likely explanation.

Dr. Russell Waines and I released to the local press in Oct. 1975 a consistent version of the Dames and Moore cross section. Our modified version is shown in figure 3. The omitted faults are shown and the vertical scale is the same for topography and structure. The facies changes are left as is. In other words we did not at that time change the geologic interpretation we only removed the internal inconsistencies.

There are also problems or questions about interpretation. For



SUBSURFACE SECTION A-A'

VERTICAL EXAGGERATION = 5X
 (NO VERTICAL EXAGGERATION OF STRUCTURE)

HORIZONTAL SCALE: 1:24,000



KEY:


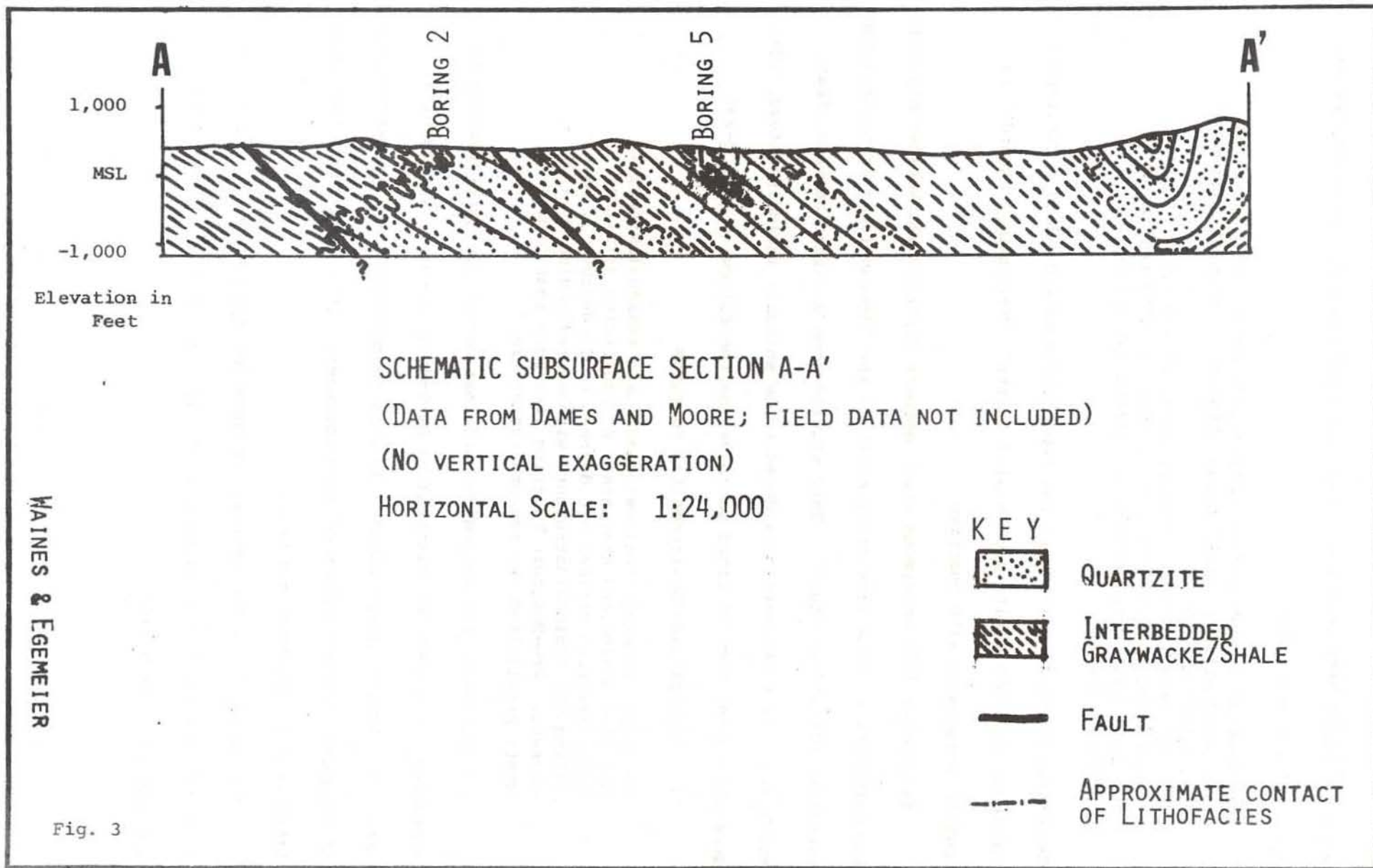
-  APPROXIMATE CONTACT OF LITHOFACIES
-  QUARTZITE
-  INTERBEDDED GRAYWACKE/SHALE

Fig. 2. Lloyd Site cross section after Dames and Moore, 1973.

B-9-4

DAMES & MOORE



example, several site bore holes logs hit possible fault zones (Dames and Moore, 1973, plate 2-6a):

"1' Zone showing contorted bedding and several calcite veins with small offsets; slickensides also occur at right angle to dip at 129' and 129.5'.
The zone from 126'-131' clearly shows evidence for at least 3 episodes of deformation, 1) folding, 2) jointing and/or fracturing with vein filling by quartz and calcite, 3) offset of veins."

There is a short discussion in the report of bore hole data. The report concludes that the faults are "healed faults". Presumably "healed" is roughly synonymous with inactive.

In October 1973 anonymous staff members of Stone and Webster Engineering Corporation did a site study entitled the "Metropolitan Transportation Authority Plant Site Study". They studied some 32 sites between Albany and N.Y.C. 21 sites were considered to be suitable including Lloyd. The geologic suitability of Lloyd was based on the following (pp. 2-29).

"(1) Physical and Environmental Features

Geology: Possibly shallow organic and residual material overlies shales and graywackes of Ordovician (sic) Age. This formation strikes N15 degrees to 20 degrees E, paralleling the regional structure with easterly dips of ± 30 degrees. Pre-Mesozoic faulting lies more than 5 miles west, paralleling the regional structure."

The quality of the geological information not just its sparcity is a problem. I accept the misspelling of Ordovician as a typographical error, but the statement about ± 30 dips to the east may represent a lack of adequate geologic review of this document. It's quite clear that very little was known about the site.

The weakness of the geologic information may not be significant as Stone and Webster's conclusions on the site did not use any geologic information. They said:

"The Lloyd site is not recommended for detailed study because the cost of a nuclear power plant at that location exceeded the costs at other sites."

A need for the site is not obvious. The executives of Central Hudson Gas and Electric Corporation, the local utility, have publically stated that they have no interest in the site. No utility has indicated an interest in the site. Even so there is strong local opposition to the site.

The local opposition to the site proved effective enough to influence the state legislature. The legislature abolished ASDA, the state agency that was promoting the site and set up the New York State Energy Research and Development Authority (ERDA). ERDA's authority is to site new energy systems only, and hence it does not have authority to site nuclear power plants. ERDA has, however, finished the Lloyd Site study to complete ASDA's last project.

In November 1975 ERDA released another Dames and Moore report on the site. This anonymously authored report is titled "Report of Investigations Lloyd, N.Y." ERDA has revealed that two participants in the project were Joseph A. Fischer, a Civil Engineer, and Dr. Matthew L. Werner, a geologist.

According to the report, page A-1 field procedures were

"* * * initial field efforts were directed toward developing a quick, but detailed geologic understanding of the area within a five mile radius of the site. This was achieved by 18 circular mapping traverses, evenly distributed over the area, of about 6 miles in length each of which was covered in one man day * * *.

"On each traverse, the mapping geologist was required to establish 5 hard stations at which the following were observed:

lithology and bedform
bedding attitude
fracture cleavage
mineralized veins
faulted surfaces
a sample of 10 fracture attitudes
one oriented sample taken

"In addition, intermediate running stations were established at which all of the above were noted, except fractures and oriented samples. In practice, difficult terrain or cover occasionally made it impractical to establish 5 hard stations per traverse: however, 77 hard stations and 111 running stations were uniformly distributed over the area."

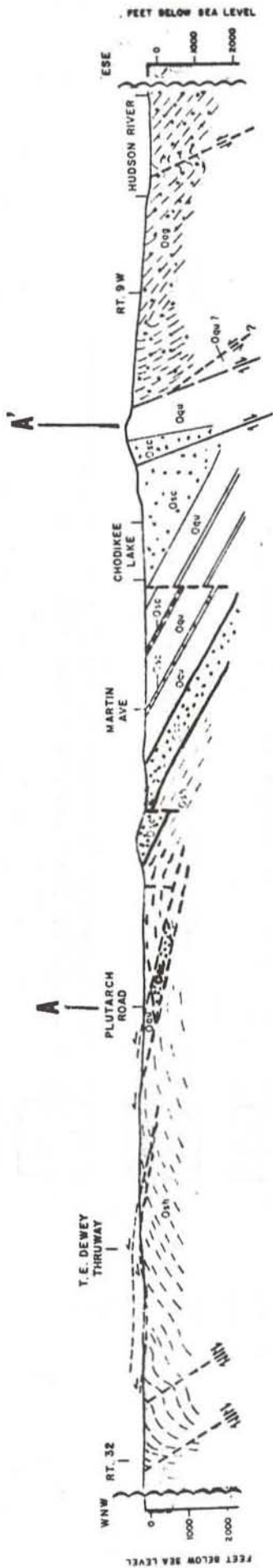
The report also notes that photointerpretation and consultation was used to add to the field data.

The irregular area mapped is 75-80 square miles. Thus one hard station and 1.5 running stations were recorded per square mile. This is one observation per 260 acres. As you see the site you might consider the adequacy of this spacing.

The report included a new cross section which is reproduced in Fig. 4. As this new section is longer, A and A' have been located so this section can be directly compared with all others.

Starting in March 1975, R. Waines and I decided to have a quick look at the regional geology of the site. We started by walking the Dames and Moore cross section and studying all outcrops within a few hundred feet of the trace of the section. Many man days were spent and over 100 observations recorded for the 3 mile section. We then checked critical outcrops mentioned by Dames and Moore and did a general reconnaissance of the area. A broad picture has emerged and is shown in our tentative cross section in Fig. 5.

The aim of this field trip is to show you some of the major points of geologic interest and also show some of the areas of controversy. There is



NOTE:
THIS CROSS SECTION IS BASED ON AVAILABLE
SURFICIAL GEOLOGIC INFORMATION, HOWEVER
SOME SUBSURFACE VARIATION MAY BE EXPECTED

LITHOLOGIES

	AGE	ORDOVICIAN

SCHENECTADY FORMATION: THINLY BEDDED GRAY CALCAREOUS SUBGRAYWACKE, INTERBEDDED WITH DARK GRAY SILTSTONE AND SILT-SHALE(2).

QUASSAIC SANDSTONE: GRAY TO BROWN, CALCAREOUS PROTOQUARTZITE AND SUBGRAYWACKE WITH OCCASIONAL CONGLOMERATIC ZONES OF LIMESTONE, CHERT AND SHALE PEBBLES.

SNAKE HILL FORMATION: DARK GRAY TO BLACK SILT AND CLAY SHALES INTERBEDDED WITH THINLY BEDDED SILTSTONE, CONTAINS FINE SAND TOWARD THE TOP; ABUNDANT FAUNA IN "NESTS".

AUSTIN GLEN MEMBER (NORMANSKILL FM.): THICKLY BEDDED GRAYWACKE TO SUBGRAYWACKE INTERBEDDED WITH DARK GRAY SHALES.

UNDIFFERENTIATED TACONIC ALLOCHTHON CONSISTING OF STUYVESANT FALLS FM. AND MT. MERINO AND INDIAN RIVER MEMBERS OF NORMANSKILL FM.

MT. MERINO: WHITE-WEATHERING BLACK AND GREEN CHERT AND DARK GRAY SHALE.

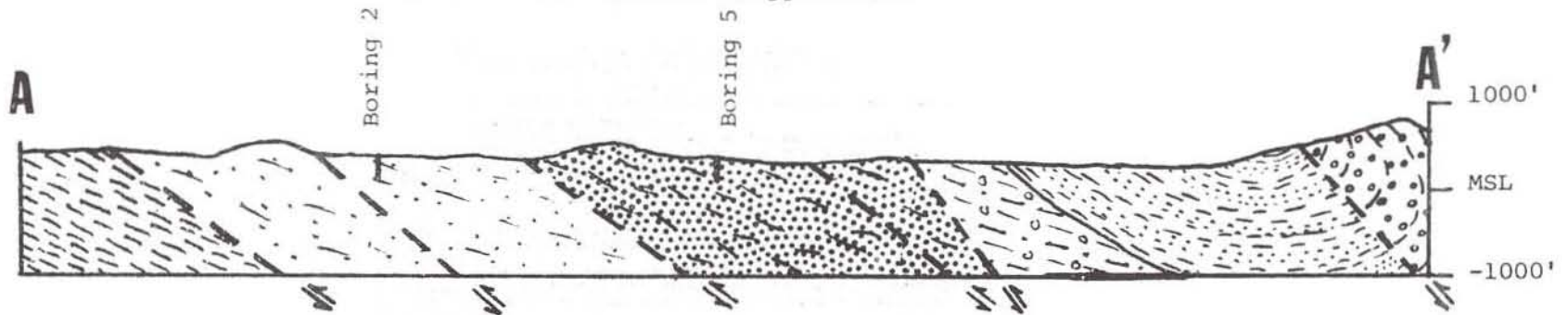
INDIAN RIVER: RED AND GREEN SHALE AND CHERT.

STUYVESANT FALLS FM: SHALE AND SILTSTONE





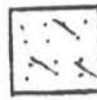

Fig. 4. Cross section from Dames and Moore 1975 geologic map. Section trimmed along wavey lines at ends to fit page. Color on original section not reproduced.

TENTATIVE SUBSURFACE SECTION A-A'

Actual dip of faults uncertain. Numerous minor faults omitted.
Scale 1:24,000. No vertical exaggeration.



KEY ——— Stratigraphic Contact - - - - - Fault

- | | | |
|---|---|---|
| A |  | Graywacke laminated, massive weathering, rare chert pebbles; most graywacke beds 1-10 ft. thick. A may correlate with 2. |
| 1 |  | Shales-graywackes interbedded about 50-50. Graywacke beds often a foot or more in thickness. |
| 2 |  | Graywacke, laminated, occasional large chert pebbles. Generally beds one to several feet thick. |
| 3 |  | Graywacke, laminated, occasional small chert pebbles or no chert pebbles. Generally beds one to several feet thick. Fifty foot shale marker? near base of unit. |
| 4 |  | Shales-graywackes interbedded, more shale than graywackes. Most graywacke beds less than one foot thick. |
| 5 |  | Shale, occasional siltstone. Siltstone beds generally half foot or less in thickness. |

ORDOVICIAN

Fig. 5.

ample room for supposition and argument until adequate study is completed.

The site geology is difficult to determine due to a lack of good marker beds, a lack of diagnostic fossils, and lack of continuous outcrop. Recently, many people have started working out the geology, however, a considerable effort will be required to gain a detailed understanding of the site geology. There is still a lot to be done, for example, as yet there is no published detailed stratigraphic column of the site area. Up until now there had been no economic reason to study this area.

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