LANDSLIDE POTENTIAL IN

THE ATLANTIC HIGHLANDS OF NEW JERSEY

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ABSTRACT OF THE THESIS

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the Atlantic Highlands of New Jersey

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A variety of landslides has damaged heavily many
residences in the suburban communities between Atlantic
Highlands and Waterwitch, New Jersey. Factor mapping
provides inexpensive regional analysis of potential
landsliding areas. Three factors, slope, geology
and water, are crudely analogous to variables which
a soil mechanics study considers. Slope, expressed
as a percentage of a given horizontal distance, compares
to engineering considerations of load and slope angle.
Geologic unit roughly labels cohesion and angle of
internal friction values for each formation. Relative
water abundance approximates seepage force and indicates
the position of a water table. Comparison of factors
in landslide case histories with study area factors
determines landslide potential.

Steep slopes of the Atlantic Highlands continue
to have high landslide potential. Slope failure occurs
mainly in the medium-grained sand of the Shrewsbury

Member of the Red Bank Sand Formation. Not only are
the potential landsliding areas susceptible to the
slump-type failure but also to other types of land-
sliding such as slow earthflows, debris slides and
other complex landslide forms.

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INTRODUCTION

The Atlantic Highlands of New Jersey are sand hills on the southern side of Sandy Hook Bay and 32 kilometers south of New York City. (Fig. 1). Recently, houses on an escarpment that faces the bay have been damaged by movements in the escarpment soil and rock. Physical aspects of the landslides have been studied intensively since the last major event in 1972. The studies include engineering slope stability analysis presently in legal litigation and mapping of landslides (Minard 1969, 1974). The method used in this paper is factor mapping. It uses landform and surface measures that Blanc and Cleveland (1968) suggested for a regional study of landslide-prone areas in California. Nilsen and Brabb (1973) demonstrated a factor mapping technique in the San Francisco Bay area of California.

In discovering potential landslide areas, an objective was to provide a cogent investigative approach. This has been accomplished by using a topographic map and a geology map with field identification of landslides based on shape and with field recognition of relative surface water abundances. The data from these exercises has been interpretted by factors of
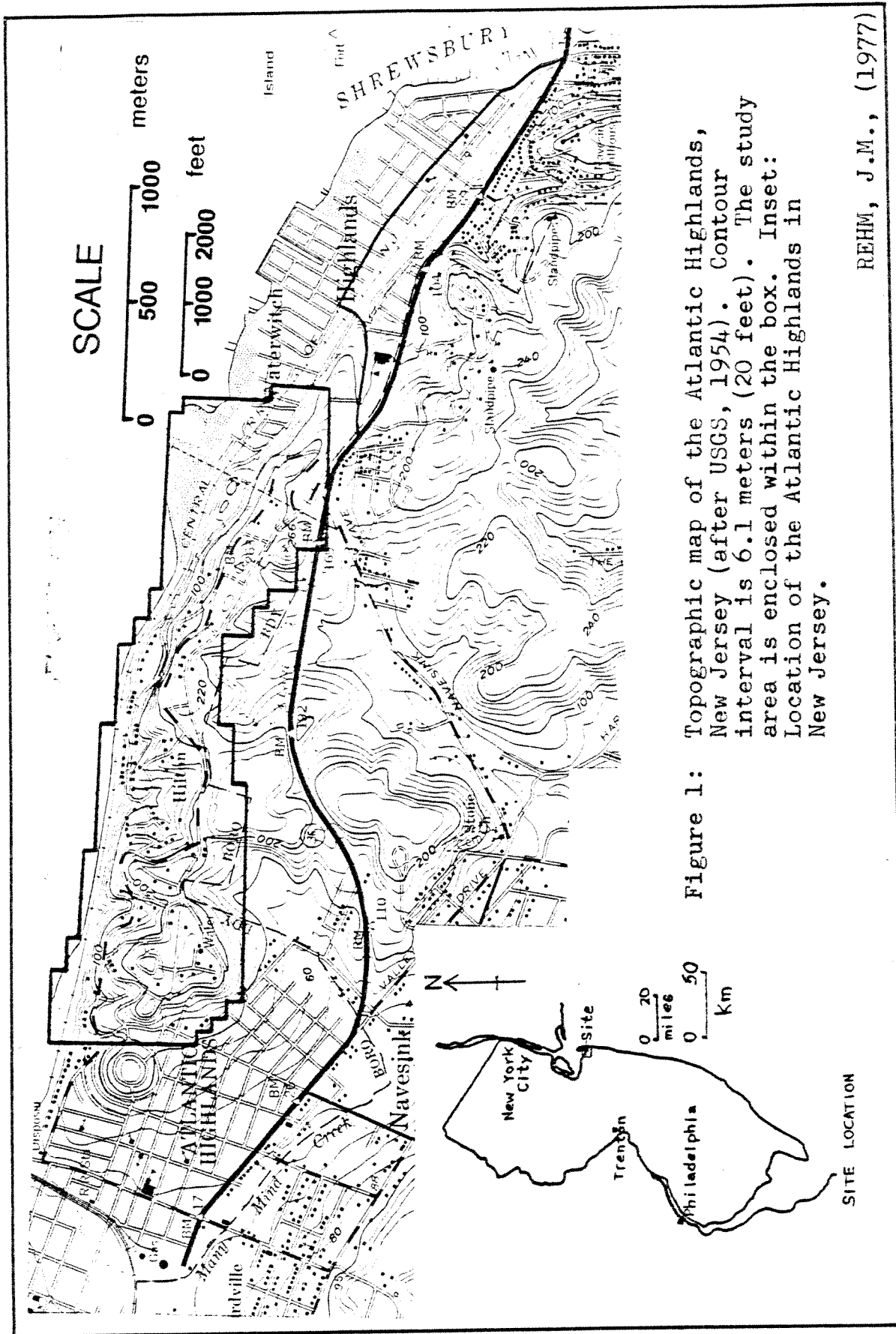
Figure 1: Topographic map of the Atlantic Highlands, New Jersey (after USGS, 1954). Contour interval is 6.1 meters (20 feet). The study area is enclosed within the box. Inset: Location of the Atlantic Highlands in New Jersey.

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landslide case histories.   The result is a
preliminary inexpensive regional tool that directs
more detailed research into the best areas and locates
areas where further development should be approached
with caution.

GEOLOGIC SETTING

The Atlantic Highlands area receives its name
from a group of high sandy hills that rise sharply
between Sandy Hook Bay and the Navesink River near
the Atlantic Ocean. The elevation of the broad
summits of the hills commonly is 67 meters with a
maximum elevation near Waterwitch, New Jersey of 81 meters.
These elevations occur within 300 meters of Sandy Hook
Bay forming a steep escarpment. Nearby elevations of
coastal areas that are a similar distance from the
Atlantic Ocean are 33 meters in Red Bank five kilo-
meters to the south and 12 meters in Leonardo three
kilometers to the west.

The Atlantic Highlands are the easternmost exposed
portion of a gently dipping sequence of Late Cretaceous
and Tertiary marine sediments (Minard, 1969). This
sedimentary sequence forms marked relief along the
strike of the Marshalltown Formation in the form of
a cuesta (Widmer, 1964).

Most of the outcropping formations in the escarpment
are composed of non-indurated quartz sand. However,
two formations, the Navesink Formation and the Hornerstown
Formation contain chiefly the dark green mineral,
glauconite. Another formation, the Tinton Formation,
is cemented by the iron oxide mineral, siderite.
Minard (1969) has interpretted the grain sizes and
mineralogy of the Atlantic Highlands in a geologic
map and lithologic table (Fig. 2; Table 1).

PREVIOUS WORK

Much geologic and geographic work in the region
focused on the nearby prominent sand bar, Sandy Hook,
and gave only incidental attention to the Atlantic
Highlands. Landslide occurrences were first mentioned
in the early works by Barker and Howe (1844) who
described a large rapid landslip that was reported
by several witnesses. Cook   (1885), in the Report
of the State Geologist of that year, contributed a
contour map and a cross-section of Sandy Hook Bay.
The cross-section suggested landslide material on the
Atlantic Highlands escarpment. Much geologic work
on the Atlantic Highlands has been published recently
(Minard, 1969; 1974). His first report, on the $7\frac{1}{2}$

Qbs   Beach Sand
Tch   Cohansey Fm.
Tvt   Vincentown Fm.
Tht   Hornerstown Fm.
Kt   Tinton Fm.
Krs   Shrewsbury Member
Krsh   Sandy Hook Member
Kns   Navesink Fm.
Kml   Mount Laurel Fm.
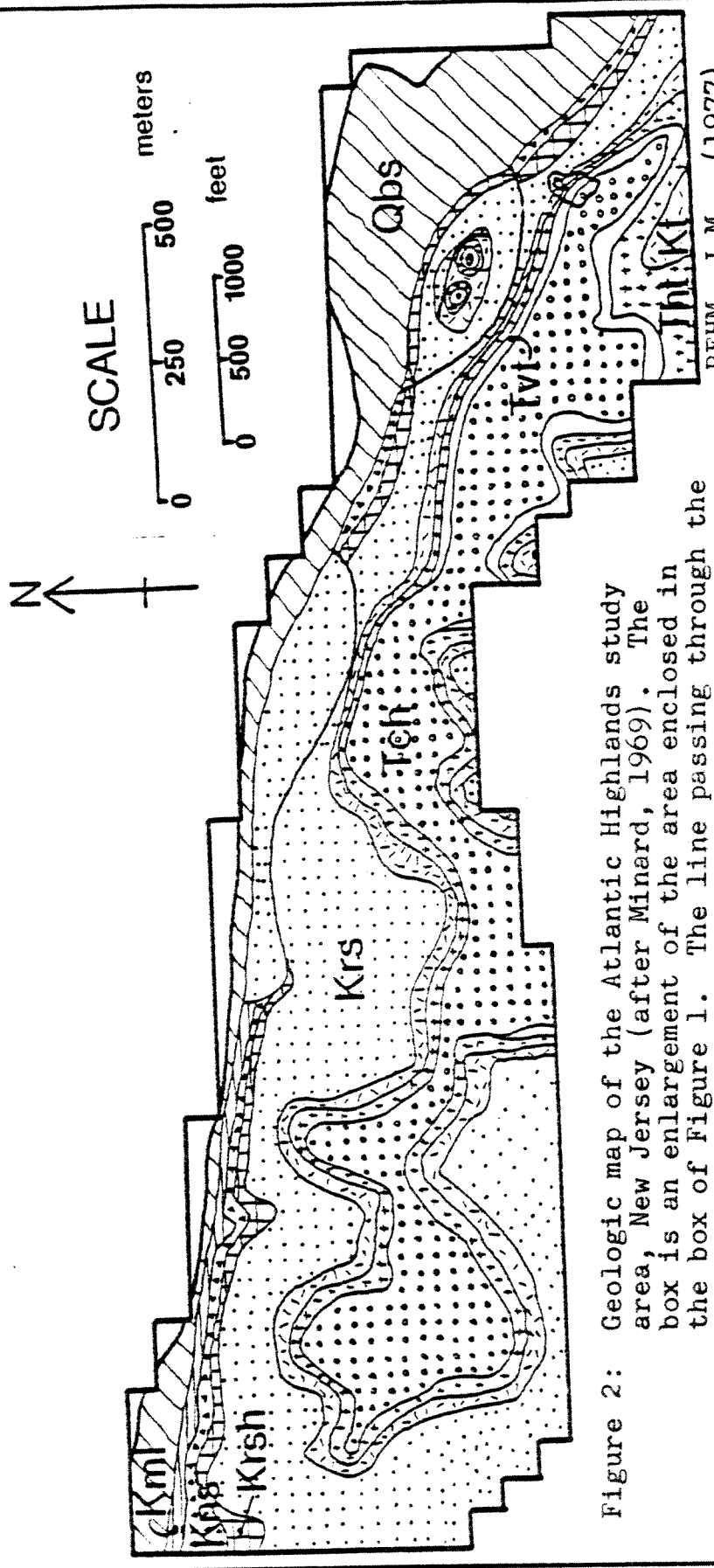
Figure 2: Geologic map of the Atlantic Highlands study area, New Jersey (after Minard, 1969). The box is an enlargement of the area enclosed in the box of Figure 1. The line passing through the box is the Sandy Hook Bay strand line.

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Table 1: Lithology and mineralogy of geologic formations
outcropping in the Atlantic Highlands,
New Jersey.

FORMATION NAME	GEOLOGIC AGE	GRAIN SIZE BY WEIGHT PERCENTAGE					MINERALOGY	THICKNESS IN METERS
		GRANULE PEBBLE	VERY COARSE TO COARSE	MEDIUM	FINE TO VERY FINE	SILT TO CLAY		
Cohansey Fm. upper	PALEOCENE	7	48	33	11	1	Quartz	6
Cohansey Fm. lower		14	26	46	13	1	Quartz. Calcarenite cement locally. Clay-Kaolinite, Mica.	6
Vincentown Fm.		0	10	53	23	14	Glauconite Clay-Glauconite	5
Hornerstown Fm.	LATE	0	5	25	27	43	Quartz, Glauconite Siderite cemented.	8
Tinton Fm.	CRETACEOUS	0	12	18	38	32	Quartz, Feldspar	
Shrewsbury Member upper		0	16	52	24	18	Clay-Quartz, Kaolinite	31
Shrewsbury Member lower		0	10	50	30	10	Lessening Glauconite	
Sandy Hook Member upper		0	2	18	53	27	Quartz, Glauconite, Feldspar. Clay-Kaolinite, Smectite, Muscovite, Pyrite Carbonaceous material.	9
Sandy Hook Member lower		0	3	9	52	36	Glauconite. Clay-Kaolinite, Smectite, Chlorite.	8
Navesink Fm. upper		0	35	25	10	30		
Navesink Fm. lower		0	10	32	32	26	Increasing Glauconite	
Mt. Laurel upper		3	2	32	32	31	Quartz, Glauconite, Clay-Quartz, Kaolinite, Lignite	9
Mt. Laurel lower		0	2	4	54	40.		

RED BANK SAND FM.

After Minard, 1969, 1974.

minute Sandy Hook Quadrangle, details geologic formations
on dual bases of lithology and mineralogy and on fossil
assemblages. Using Varnes (1958) classification, he
delineated principle slump blocks. A subsequent
report (Minard, 1974) analyzed these and other features
to determine time relationships and motions within each
block. Pschunder (1977) provided a soil mechanics
method-of-slices solution for slope stability at a part
of the escarpment which overlooks Waterwitch, New Jersey.

METHOD

Landslide Identification and Location

A geologic dictionary defines a landslide as
"the perceptible downward sliding or falling of a
relatively dry mass of earth, rock or mixture of the
two" (American Geological Institute, 1962). It should
be added that landsliding is distinguished from stream
erosion by having a wider uphill portion relative to
the lower portion of an affected slope.

Using a widely accepted landslide classification
(Varnes, 1958), Minard (1969, 1974) recognized slump
landslides in the Atlantic Highlands. This study also uses the
classification. Varnes (1958) basis for the classification
is landslide shape and type of material movement which

is related to landslide factors of slope, mechanical
strength of rock and to water abundance.

Factor Mapping

In natural science, a factor is any entity that
influences a physical or chemical process. A factor
map shows a two-dimensional array of abundances or
other evaluations of the factor. A potential landslide
factor map shows an array of factor measures that may
cause landsliding. Nilsen and Brabb (1973) suggested
measuring of physical factors, slope and geologic
formation in California. The California climate,
however, does not include water as a factor because that
climate is dry. Soil engineering and geological
literature of more temperate climates, much like the
climate of the Atlantic Highlands, includes water as
a third physical factor. A discussion follows on the
importance and possible roles of the three landslide
factors in the Atlantic Highlands.

Slope

Generally, studies of landslide occurrences relate
the event to the steepness of the slope. Steepness
is a proportion of two dimensions, height and horizontal
distance from the bottom to the top of the slope. Terzaghi
(1959) expressed this proportion as the slope angle, B,

which is the angle formed by the slope surface and
a horizontal line at the top of the slope. Landslide
potential was determined by a mathematical relationship
of the slope angle to measures of soil strength. Sharpe
(1938) suggested that landslides occur on steep slopes.
His definition of landslide excluded slower flow forms
such as slow earthflow which also occur on lesser slopes.
Previous factor mapping exercises in California by
Nilsen and Brabb (1973) and by Wilson et. al. (1976)
examine slope as a percentage of vertical distance
over horizontal distance. Nilsen and Brabb (1973)
used a computerized analysis of special aerial photographs
to produce slope percentage.

In the Atlantic Highlands, other workers have related
slope steepness to landsliding. Minard (1974) speculated
that ocean wave action had steepened portions of the
escarpment enough to cause the first ancient landslides.
Pschunder (1977) included a measure of slope steepness
into slope stability calculations of his research in the
escarpment.

In this study, standard sized square grids measuring
61 meters (200 feet) on a side facilitate slope per-
centage measurement. Slope factor values are obtained
by overlaying a grid transparency on a $7\frac{1}{2}$ minute topographic
contour map (1954). By fixing a standard horizontal

distance, this type of measure of slope percentage considers height and therefore load as well as steepness. The grid method also compensates for not having the sophisticated machinery used by Nilsen and Brabb (1973) to analyze slope. Under this evaluation system, higher slope factors indicate a greater landslide potential due to greater steepness.

Water

Water is another factor that causes landslides. It may act in three places; within rock joints, soil pores or as an external erosion agent. Water has been included in many studies of landslides. Its roles depend on climate. Water action in landslides has been studied both in general terms and in specific case histories. Taylor (1948) studied seepage force of water in slopes formed in non-indurated sediments.

In the Atlantic Highlands, Minard (1974) suggested water as a cause of landsliding after reviewing lithology and permeability of the geologic formations. A soil mechanics engineering model of a site in the Atlantic Highlands by Pschunder (1977) made a similar conclusion about water.

Factor mapping in this study also considers water to be an important contributing factor to instability.

Review of a classic work (Terzaghi, 1950) on the potential
roles of water in landsliding shows that Atlantic Highlands
conditions allow water to destabilize the slopes. The
conditions are presence of a fluctuating water table
near the escarpment base, high porosities and great slope
steepness. The associated destabilizing effects are
additional load, seepage force, pressures which push
the rock grains apart and lubrication of slip surfaces.
Water has often been measured as a volume that is assumed
to occupy all soil pores below a water table. This
procedure cannot be used in the Atlantic Highlands because
of local ordinances which ban digging in the hillsides.
Abundances of water instead have been determined by the
occurrence of surface sources, such as springs, pools
and other surface forms.

Geology

Many landslide observers have studied geologic
parameters. In areas primarily of cemented rock outcrop,
structure and mechanical strength are deciding factors
(Jahns and Vonder Linden, 1973). In areas of non-indurated
rock, mineralogy, grain size distribution and grain
arrangement are important (Sharpe, 1938). Different
physical aspects are studied in geological units. Lambe
and Whitman (1969) discuss friction between soil particles.
Terzaghi and Peck (1967) also discuss a frictional variable.

RESULTS

Landslide Identification and Location

Four other kinds of landslides besides the slumps documented by Minard (1974) have been recognized in this research (Table 2). These landslides are found in 11 additional locations to the landslide locations of Minard (1974) (Fig. 3). Generally, these additional landslide locations are smaller but do not appear to have begun recently.

Factor Maps

More than 500 observation grids, each measuring 61 meters on-a-side, cover three factors of slope, geology and water in the study area. Figure 4 shows how the slope factors have been evaluated in the Atlantic Highlands and shows their distribution. Figure 5 shows how the geologic formations in the study area have been identified in the observation grids and shows their distribution. Figure 6 shows how the water factors have been evaluated in the Atlantic Highlands and shows their distribution. Slope factors in the study area range from 0, indicating flat areas to 9 indicating a vertical distance that is 90 per cent of the grid side.

Table 2: Landslide types in the Atlantic Highlands according to a landslide classification by Varnes (1958).

TYPE OF MOVEMENT	LANDSLIDE CLASSIFICATION	FAILURE MOTION	ASSOCIATED LANDSLIDES	ACTIVITY AND SIZE IN THE ATLANTIC HIGHLANDS	RATE	CONTRAST TO VARNES (1958)
Slide: Massive Blocks. Failure along planes of weakness	bench slump	Rotation of bottom of slide down and out along a wide area of a slope. Width exceeds length. Failure surface curved up.	earthflow at the bottom.	1972, 300 meters through shoreside residential area	1 minute to 1 day	
	"spoon-shaped" slump	Same motion as bench slump. Length exceeds width.	earthflow at the bottom.	1972, 15 meters wide scarp, 46 meters length	1 minute to 1 day	
	debris slide	Straight breakaway along a planar slightly curved surface. More broken-up material than in slump.	debris flow at bottom.	On going. Shown on 1943 Topographic map. 31 meters wide scarps and slope length. Shallow- affects soil and 3 meters into slope	Minutes to imperceptible	Slow- not sudden failure. Springs at bottom
Flow: Broken-up mass. Failure between all particles in the landslide	sand run	Flow of particles as small stream.	-----	Small areas affected.	Continuous	Grain by grain movement in other landslide scarps.
	slow earthflow	Debris moves like porridge through a small lower opening from a curved surface.	slump sometimes above.	Slope walkways and retaining walls destroyed. Many damaged structures rotting and unused. Structures being pushed downhill. Damage of this kind also being done by creep.	Continuous Imperceptible	Some features immobile
	complex slides	Scarp like debris slide and earthflow	-----	Near other slides. In western area.	-----	Empty Scarp. Some material eroded.

(bench slump)   7, 8, 9, 14, 15
"spoon shaped" slump   3, 6
debris slide   2, 5, 11, 12, 13, 16
sand run   11
slow earthflows   5, 6, 10, 13, 17, 18
complex slides   2, 4
(lineaments)   A
arête   B

SCALE

N

meters
0   250   500

feet
0   500   1000
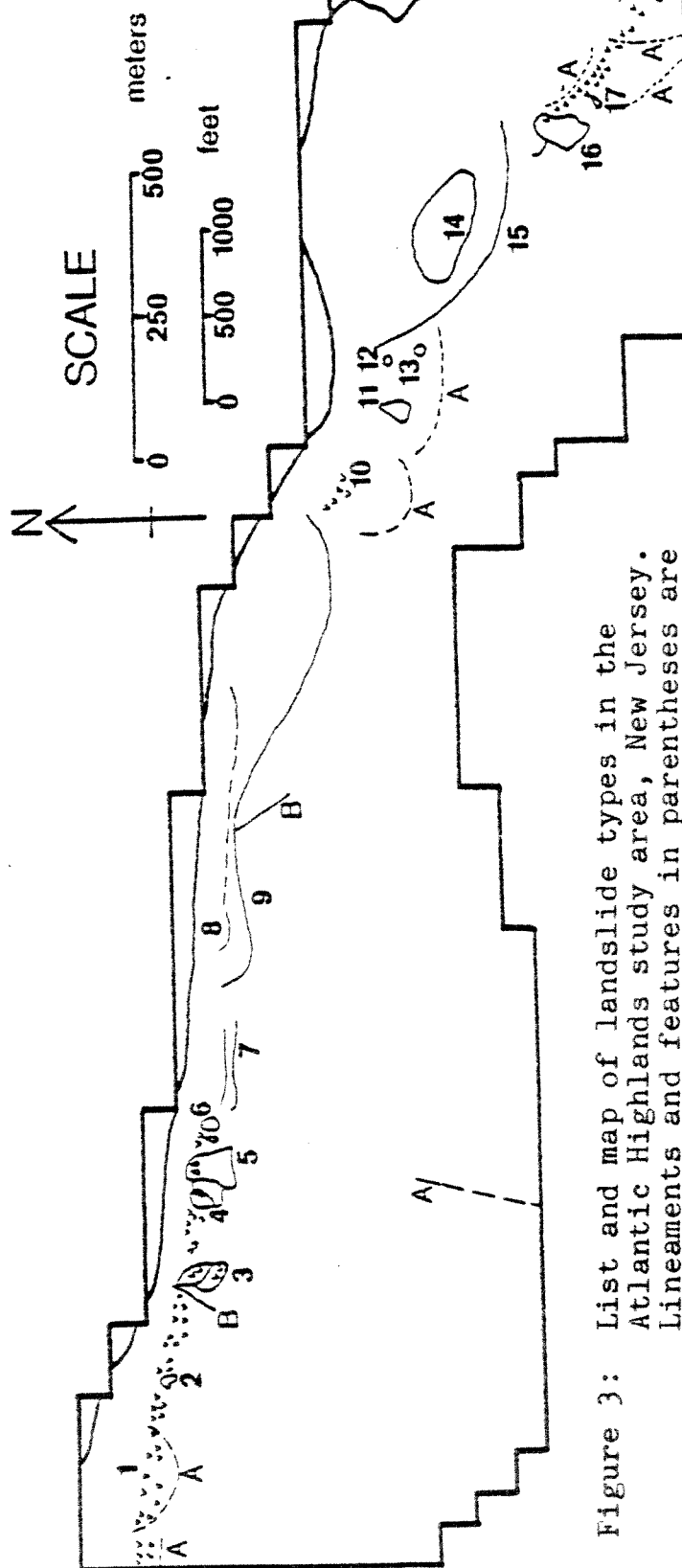
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Figure 3 :   List and map of landslide types in the Atlantic Highlands study area, New Jersey. Lineaments and features in parentheses are after Minard (1974).

Figure 5: Map of geology factor values in the Atlantic Highlands study area, New Jersey. Numbers identify the geologic formation that outcrops in each observation grid.

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No visible water 0
Seasonal stream 1
Wet Ground, Marsh 2
Spring, Small stream 3
2 springs within 31 meters 4
Waterpool, Several springs 5
Rivulet discharge 6

SCALE

N

0   250   500   meters
0   500   1000   feet

Figure 6:   Map of water factor values in the Atlantic Highlands study area, New Jersey. Higher values indicate greater abundances of water coming out of the slope.

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High values of slope steepness which are greater than
3 are concentrated along the coast of Sandy Hook Bay
and trend to the Southeast in the eastern portion of
the study area. Moderately high slope factor values,
which range in the 3 to 4 category are located in other
isolated places in the study area. The most prevalent
geologic unit in the study area is the Shrewsbury
Member of the Red Bank Sand Formation. Outcrop diminishes
at inland places where the Cohansey and Tinton formations
outcrop. Water factors range from no trace to small
rivulet discharges coming out of a slope. The factors
are higher at the escarpment bottom near to but several
meters in elevation above mean high tide of Sandy Hook
Bay and follow a southeastward trend in the eastern part
of the study area. Water is absent on the surface
further inland except in the western portion of the
study area.

DISCUSSION

This study interprets landslide potential from
3 physical factors, unlike California factor mapping
studies which interpret 2 factors (Blanc and Cleveland,
(1968); Nilsen and Brabb, (1973)). Nilsen and Brabb
(1973) determined the effect of a geologic unit upon
slope by finding the lowest slope angle at which failure

occurred in that given unit. With three factors,
determining landslide potential cannot be achieved by
making one adjustment, as was possible in California.
The third factor in the Atlantic Highlands, water,
sometimes causes landslides on more gentle slopes than
on slopes where it is absent. Orderly interpretation
of landslide potential from the factors is possible
by adjusting expected factor ranges from landslide case
histories to fit observed factor ranges of the study
area landslides. Potential landslide areas have the
same factor ranges as the areas in which landslides
have already occurred.

Thirty-eight of the grids that were assigned to
the study area contain landslides (Fig. 7). The factors
of each grid fall into one of four groups of factor
ranges which correspond to four groups of landslide
case histories. The first case history group (Group I)
states that landslides occur wherever there is a
steep slope, susceptible geology and much water (Table 3).
Abundance of all three factors ultimately causes the
slope to fail. Lambe and Whitman (1969) document several
case histories of this group that are "progressive
failures" in overconsolidated clay. Terzaghi (1950)
describes a similar rock landslide near Frank, Alberta.
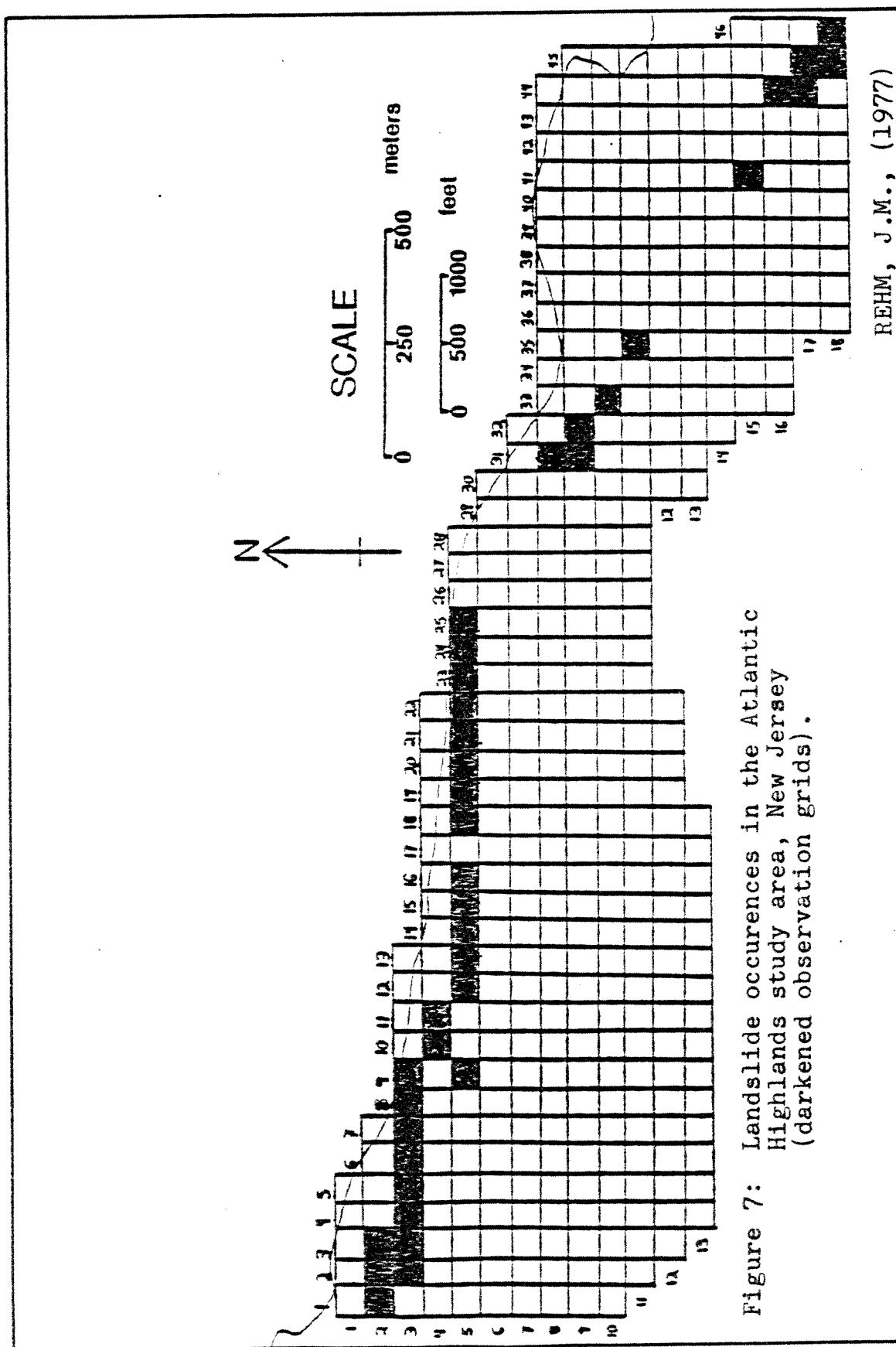The Alberta slide occurred after a long period of mining

Figure 7: Landslide occurences in the Atlantic Highlands study area, New Jersey (darkened observation grids).

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landslides. The potential landslide areas lie topograph-
ically above the present landslide areas on the escarpment
(Fig. 8). Eight grids are scattered outside and on the
other side of the Atlantic Highlands from the escarpment.

One form of landsliding, slumping, especially
concerns residents (Fig. 9) and landslide observers
in the Atlantic Highlands. There are two types of
slumps in the study area according to the classification
by Varnes (1958). These types, bench-shaped slumps
and spoon-shaped slumps, occur mainly under landslide
case history groups I and II. The principles have steep
slope as a common characteristic. Eighty-one grids locate
potential slumping areas (Fig. 10). The grid distribution
is similar to potential for all landslides (Fig. 8)
with an exception that there are fewer potential slumping
areas in the western portion of the study area. Only
grids 5,19 to 5,25 are not included in groups I and
II because slumps in those grids uniquely occurred in
older landslide material. Continued landsliding potential
of the landslide material is consistent with Blanc and
Cleveland's (1968) expectation of landslides in old
landslide material in California because of weakening
by past movement. Twenty-four of the eighty-one
potential slumping areas have had landslides. Only
seven of these twenty-four grids have had slumps. This
result contradicts Sharpe's (1938) contention that slump

ROADS:

1. Ocean Boulevard
2. East Highland Avenue
3. Bay side Drive
4. East Mount Avenue
5. Hooper Road
6. Hill Road
7. Cameron Circle
8. Hilton Road
9. Prospect Road
10. Belvidere Road

11. Cedar Place
12. Beverout Place
13. Hillside Road
14. Laurel Drive
15. Shore Drive
16. Summit Avenue
17. Observatory Place
18. Lawrie Road
19. Upper Prospect Road
20. E. Washington Avenue

21. Grand Avenue
22. Chapin Avenue
23. King Street
24. Route 36
25. Sears Landing Road
26. Hook Harbor Road
27. Eighth Avenue
28. Cross Avenue
29. Matthew Street

SCALE

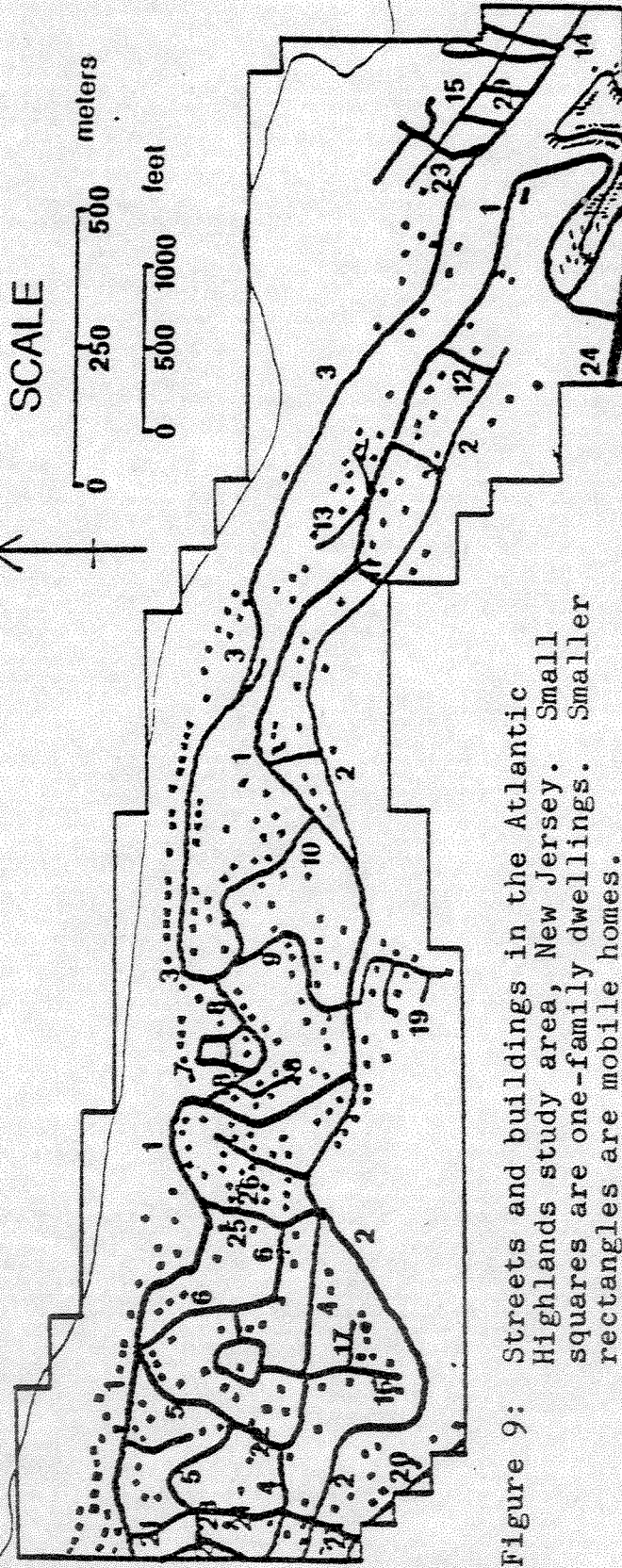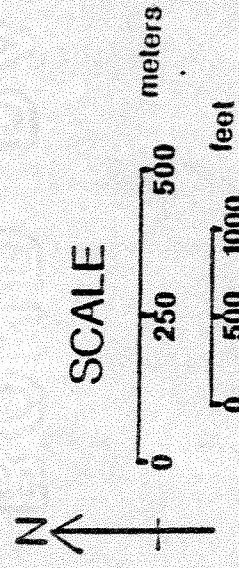Figure 9: Streets and buildings in the Atlantic Highlands study area, New Jersey. Small squares are one-family dwellings. Smaller rectangles are mobile homes.

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SCALE
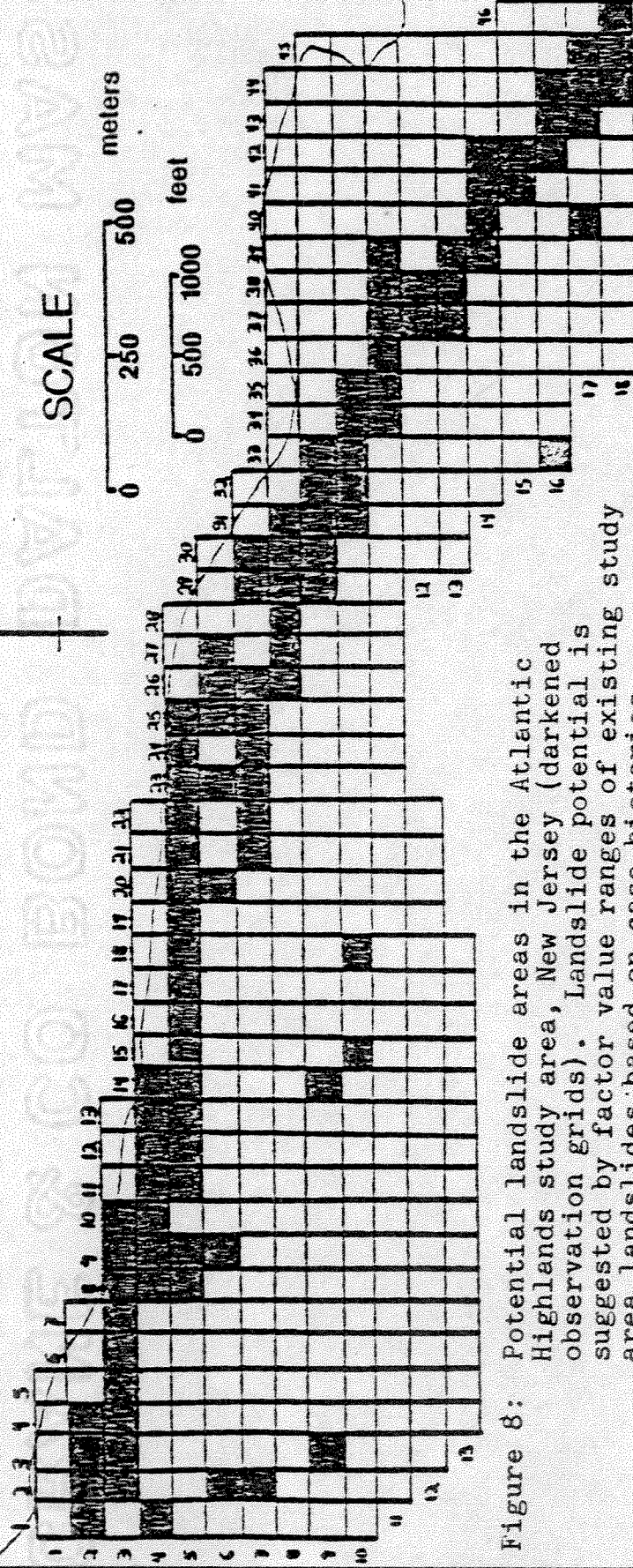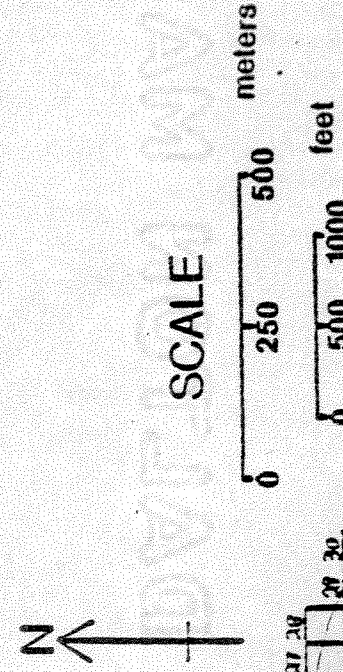
Figure 8: Potential landslide areas in the Atlantic Highlands study area, New Jersey (darkened observation grids). Landslide potential is suggested by factor value ranges of existing study area landslides based on case histories.

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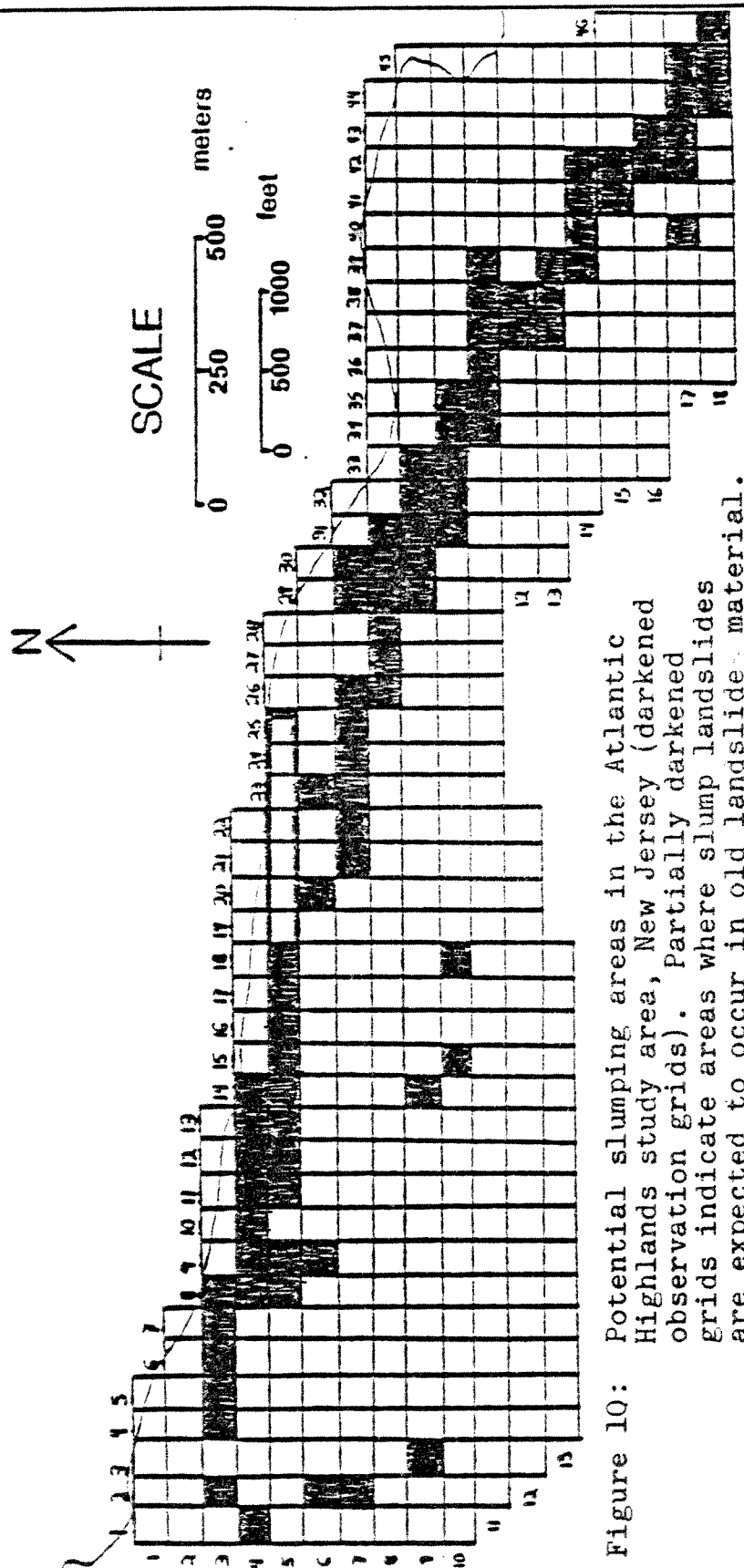
Figure 10: Potential slumping areas in the Atlantic Highlands study area, New Jersey (darkened observation grids). Partially darkened grids indicate areas where slump landslides are expected to occur in old landslide material.

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variable. Blanc and Cleveland (1968) cite structure
and location within a geological unit. Jahns and Vonder
Linden (1973) mapped gologic units as contributing
factors to landslides in California.

In the Atlantic Highlands, Minard (1974) speculated
that a chemical reaction between weathering products
of the mineral, glauconite, and calcium minerals caused
weakening of rock structure. This weakening in the
Navesink Formation was supposed to precede slump-type
landslides. No chemical data is available from the
Atlantic Highlands to confirm this model of landsliding.

In the present study, geologic formations are
based on the map by Minard (1969) and are basic units of the
geology factor. To record geologic formations in the
observation grids, the geology map was enlarged to
twice its published size and then was overlaid with an
observation grid transparency. The lowermost geologic
unit occupying at least one-third of any observation
grid is the identified unit for each grid. Treating
geologic formations as distinct units is possible because
Minard's (1969) geologic formations are based on mineralogy,
grain size and on cementation instead of on fossil
assemblages, although fossil assemblages are coincident.
As such, the geologic formations are distinct from one

another. The Mount Laurel Formation is fine quartz
sand with glauconite and clay. The Navesink Formation
is medium and fine glauconite sand. The Sandy Hook
Member of the Red Bank Sand Formation is a fine micaceous
quartz and glauconite sand with clay. It also has
abundant calcareous fossils and contains a water table
that is apparent along the escarpment by numerous seeps.
The Shrewsbury Member of the Red Bank Sand Formation is
a loose medium quartz sand. The Tinton Formation is
a fine iron oxide cemented quartz sand. The Hornerstown
Formation is a weathered fine glauconite sand with clay.
The Vincentown Formation is medium quartz sand. The
Cohansey Formation is a cross-bedded pebbly medium and
coarse quartz sand.

Soil mechanics data could probably distinguish
the landslide potential of each geologic formation but,
in the absence of such data, assigning stability values
to each formation is difficult. Terzaghi and Peck (1967)
do not compare stability calculations of sand and of
clays to each other. It is probably correct to say
only that the iron oxide cemented Tinton Formation is
less likely to landslide than the non-indurated formations.
Therefore, with all available data considered, identifying
numbers label the formations.

activity and rainfall. In the study area 10 observation grids have factors that fit into this group of landsliding (Table 3).

Table 3: Observed factor ranges of landslide case history group I in the Atlantic Highlands, New Jersey.

Factors	Atlantic Highlands Factor Ranges
Steep Slope	≥ 4
Weak Geology	4, 5, 8
Much Water	≥ 4

The second case history group (Group II) states that susceptible terrain has steep slope, a high load, and little water (Sharpe, 1938). In the study area, 18 observation grids have factors that fit into this group (Table 4).

Table 4: Observed factor ranges of landslide case history group II in the Atlantic Highlands, New Jersey.

Factors	Atlantic Highlands Factor Ranges	
Steep slope High Load	≥ 4	≥ 3
Moderately Strong Geology	2, 4 5, 8	1, 4
Little Water	≤ 3	≤ 3

A third case history group states that landslides occur where there is a gentle slope, weak geology and much water (Varnes, 1958). In the study area, 4 observation grids have factors that fit into this group (Table 5).

Table 5: Observed factor ranges of landslide case history group III in the Atlantic Highlands, New Jersey.

Factors	Atlantic Highlands Factor Ranges
Gentle slope	2 - 3
Weak geology	3, 5
Much water	> 3

A fourth case history group and several grids, which are exceptions in this method, are grouped together. The case history group states that landslides will continue in former landslide material (Jahns and Vonder Linden, 1973). Generally, the slope on the fallen landslide material is much less than its original slope. The original geologic material has been broken up and therefore has been considerably weakened and the potential for water action in future landsliding is enhanced. The grids that are exceptions to this method do not fully account for the flow type landslides in their area because their positioning does not cover the entire 25 meter

slope height and because their standard 61 meter to-a-side
dimension is insensitive to the steep slopes which are
locally 50 to 60 per cent of the horizontal distance.
If it were not for their smaller scale, these slopes
would be included in Group II landslides (Table 4).
Both the exceptions and the old landslide material of
the fourth case history group share the same factor
ranges (Table 6).

Table 6:   Observed factor ranges of landslide case history
           group IV and of former landslide sites in the
           Atlantic Highlands, New Jersey.

Description	Factor	Atlantic Highlands Factor Ranges
Old landslide material	Slope	2
	Geology	5
	Water	0
Small Scale Type II Exceptions	Slope	2
	Geology	5, 1
	Water	0

One-hundred-and-two grids locate potential landslide
areas based on the four landslide case history types.
The general distribution of grids showing potential
landslides is similar to distribution showing present

landslides occur on slopes whose factors are measureably greater than factors of slopes which contain types of landslides such as slow earthflows. Atlantic Highlands data suggest, however, that slow earthflows, debris slides and small complex landslides share the same ranges of factor values as slumps (Table 7).

CONCLUSIONS

Field mapping indicates 11 newly documented landslide sites in addition to the slump sites already documented. Four landslide types besides slumps are debris slide, slow earthflow, sand run and a small complex landslide.

Like previous landslide work in the Atlantic Highlands,this research concludes that future landslides are likely along the entire escarpment. Comparison of study area factors with slope, geology and water factors of landslide case histories shows that the landslides may occur in or inland and upslope of existing landslides. Landslides are likely to occur on the side of the Atlantic Highlands summits away from the Sandy Hook Bay although there are no landslides on that side presently. High factors of slope and water are always in the potential landslide areas. The Shrewsbury Member of the Red Bank Sand Formation is probably the least stable geologic formation.

Table 7: Distribution of factors within landslide types according to case history groups in the Atlantic Highlands, New Jersey.+.

| Landslide Type | Group | | | | Number of |
	I	II	III	IV	Grids
Bench and Spoon-shaped Slumps	4	3			7
Slumps in Old Landslide material	1	1	3	3	8
Debris Slides		2			2
Complex Slides		2			2
Slow Earthflows	7	8	1	3	19
					38

+ For factor ranges of case history groups see Tables 3-6.

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Study of landslide types and case history groups shows that other types of landslides have equal likelihood of occuring where slumps are possible. The slow earthflow in particular occurs in a large variety of terrains.

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