UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# POTENTIAL GEOLOGIC HAZARDS AND CONSTRAINTS FOR BLOCKS IN PROPOSED MID-ATLANTIC OCS OIL AND GAS LEASE SALE 49

R. W. Hall and H. R. Ensminger, Editors

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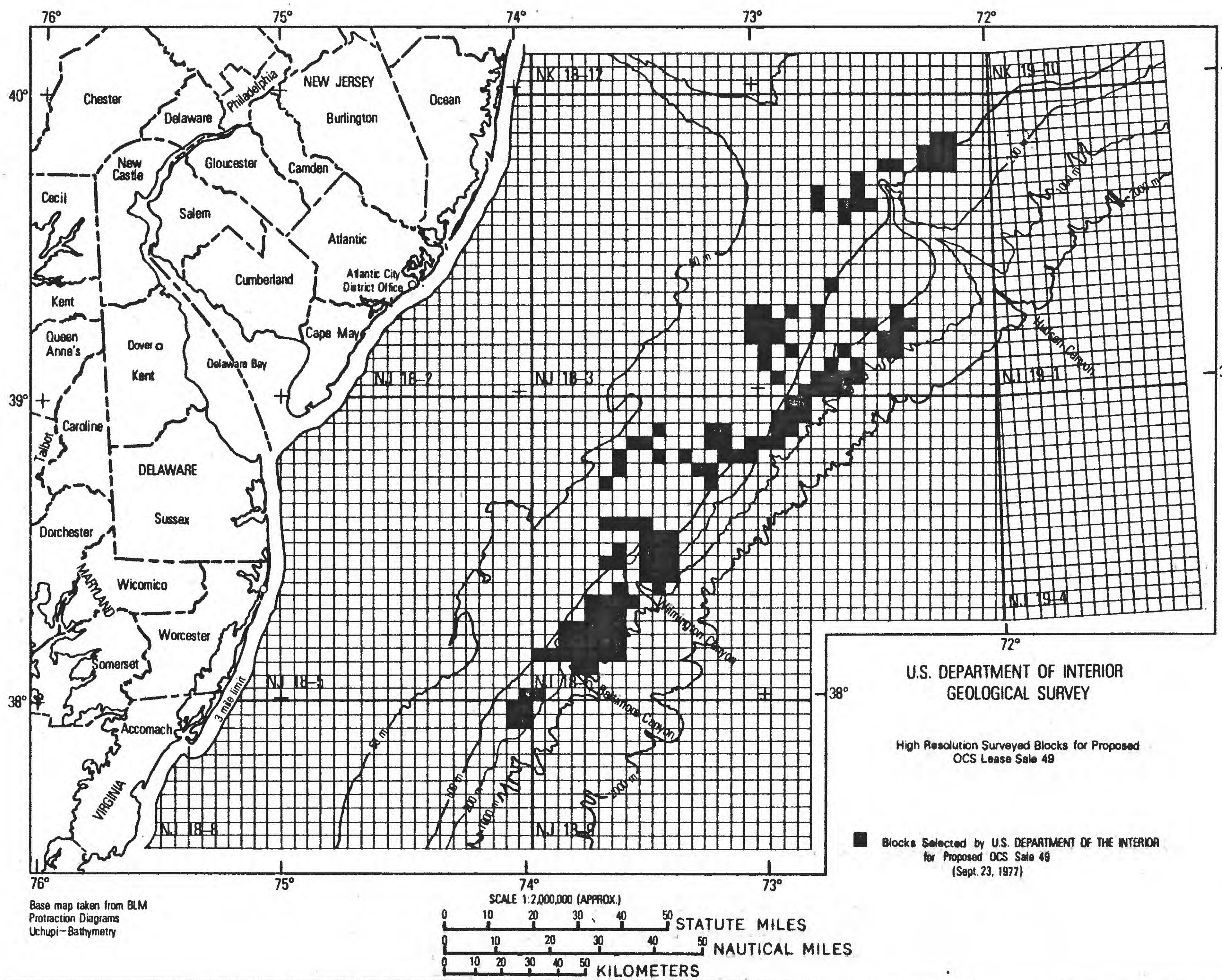

U.S. DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY
High Resolution Surveyed Blocks for Proposed OCS Lease Sale 49
Blocks Selected by U.S. DEPARTMENT OF THE INTERIOR for Proposed OCS Sale 49 (Sept. 23, 1977)
Base map taken from BLM
Protraction Diagrams
Uchupi–Bathymetry
SCALE 1:2,000,000 (APPROX.)
STATUTE MILES
NAUTICAL MILES
KILOMETERS
76°
75°
74°
73°
72°
40°
39°
38°
NEW JERSEY
DELAWARE
MARYLAND
VIRGINIA
Chester
Delaware
Philadelphia
Burlington
Ocean
New Castle
Gloucester
Camden
Cecil
Salem
Atlantic
Cumberland
Atlantic City District Office
Kent
Queen Anne's
Dover
Delaware Bay
Cape May
Caroline
Talbot
Sussex
Dorchester
Wicomico
Worcester
Somerset
Accomach
3 mile limit
NK 18-12
NK 19-10
NJ 18-2
NJ 18-3
NJ 19-1
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NJ 18-5
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NJ 18-8
NJ 18-9
Hudson Canyon
Wilmington Canyon
Baltimore Canyon

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# POTENTIAL GEOLOGIC HAZARDS AND CONSTRAINTS FOR BLOCKS IN PROPOSED MID-ATLANTIC OCS OIL AND GAS LEASE SALE 49

R. W. Hall and H. R. Ensminger, Editors


## ABSTRACT

Analysis of side-scan sonar, subbottom profiler, processed sparker, and fathometer data (approximately 5060 km) from the 136 blocks in the proposed Outer Continental Shelf Lease Sale 49 disclosed features that are potential geologic hazards to oil and gas exploration and development operations. These potential hazards are past mass sediment movement (slumping or sliding) in parts or all of 57 proposed lease sale blocks (27 of which are virtually covered by slumped materials), shallow gas deposits in three proposed lease sale blocks, and recent shallow faulting in one proposed lease sale block.

Other features considered merely to be developmental constraints can be accommodated by existing standard design and engineering technology: erosion and scour, sand waves, filled channels, acoustically turbid zones (gassy sediments), lagoonal sediments, potentially unstable slopes (due to gradient), unidentified bottom objects, and a shipwreck.

## INTRODUCTION

The U.S. Geological Survey has assessed geologic and other natural and manmade hazards and constraints which could adversely affect drilling for oil and gas in the 136 blocks tentatively selected by the Department of the Interior for inclusion in the proposed Federal Outer Continental Shelf (OCS) Lease Sale 49. These blocks are in the Baltimore Canyon Trough area off New Jersey, Delaware, Maryland and Virginia. Water depths within the proposed sale area range from 51 m to 1461 m. Depth to the shelf break ranges from 90 to 200 m in the sale area. The break is generally at shallower depths near canyon heads (90 - 120 m range) and increases in depth in intercanyon areas (120 - 200 m range). The continental shelf extends from the coast to the shelf break; the continental slope begins at the shelf break where gradient increases.

Our judgments concerning potential geologic hazards and constraints are largely based on data collected from high-resolution geophysical (HRG) surveys and certain published documents. Some geologic features and conditions can pose varying degrees of risk to oil exploration and development activities.

In this report, these geologic features and conditions are categorized as hazards or as constraints. Hazards consist of recent shallow faulting, shallow gas deposits, and mass movement (slumping) (Table 1). Constraints consist of sand waves, erosion/scour, filled channels, relict lagoonal deposits, gassy sediments (acoustically turbid zones), potentially unstable slopes, and bottom objects or debris.

### Hazards

Hazards are defined as geologic conditions that have a high inherent risk and may be hazardous to oil and gas exploration and development operations; not identifying, avoiding, or taking proper engineering precautions against them could have dangerous consequences. The difficulties posed by these features are amplified because their failure mode is often unpredictable. In areas where these conditions have been identified, special engineering procedures may be required or the structure may have to be resited.

Locations of these hazards (shallow faults, shallow gas deposits, and mass movement (slumping)) are shown on both the 1:48,000-scale block maps (Appendix) and the 1:250,000-scale Summary hazards and constraints map (Plate 1).

One small shallow fault was observed on our data for Block NJ 18-6-837 in Subarea 5. Published knowledge of shallow faulting in the sale area is limited to the small-scale faults southwest of Hudson Canyon (Sheridan and Knebel, 1976) and the axial fault at the head of Wilmington Canyon

(Kelling and Stanley, 1970). Data acquired in this survey have not verified the existence of the faults shown on either of these investigations. Other than the shallow fault in Subarea 5 we observed no faults in the sale area on our processed sparker or HUNTEC* data except those associated with slumping on the continental slope.

In this report shallow gas deposits refer to confined accumulations of gas with possibly higher than ambient pore pressure. The main evidence for shallow gas deposits is bright spots on processed seismic records. Characteristics of bright spots include phase shifts, amplitude anomalies, velocity pulldowns, and blankouts. Other evidence for shallow gas deposits is water column anomalies or arched reflectors found in association with seismic blankouts.

Although considerable acoustic evidence exists to support the presence of gaseous sediments (acoustically turbid zones) on a large scale within the sale area, only one bright spot was noted. This bright spot was seen only on data collected for the Sale 40 hazards analysis. Amplitude anomalies which might indicate gas accumulation were common on the slope. However, the few anomalies that may indicate high-pressure accumulations were very small (less than a few hundred meters in lateral extent). This type of anomaly was most common on the slope in association with relatively deeply buried slump or slide units.

In Subarea 2, a water column anomaly associated with a seismic blankout is interpreted as a shallow gas deposit (Fig. 1). Also, arched reflectors associated with a seismic blankout (Fig. 2) are also interpreted as a shallow gas deposit.

Large parts of the continental slope show evidence of mass movement or slumping. Hummocky topography, truncated reflectors, slump blocks, and slump scars were observed on the processed sparker records.

An airgun profile (taken during a previous study of the area) shows large slump blocks with thicknesses approaching 600 msec (500 m) in Subareas 2 and 3, Blocks NJ 18-3-946, -947, -990 and -991, and extending farther down the continental slope. (Note: Throughout this report, subsurface depths are calculated using an assumed sound velocity of 1500 m/sec). This thickness is generally greater than the depth of penetration of the sparker data collected for this report, and therefore there may be additional, undetected surfaces of dislocation below the continental slope. The areas are within blocks shown to contain slumping hazards (J. M. Robb, U.S. Geological Survey, written commun., 1978).

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*Use of trade names in this open-file report is for descriptive purposes only and does not constitute an endorsement by the U.S. Geological Survey.

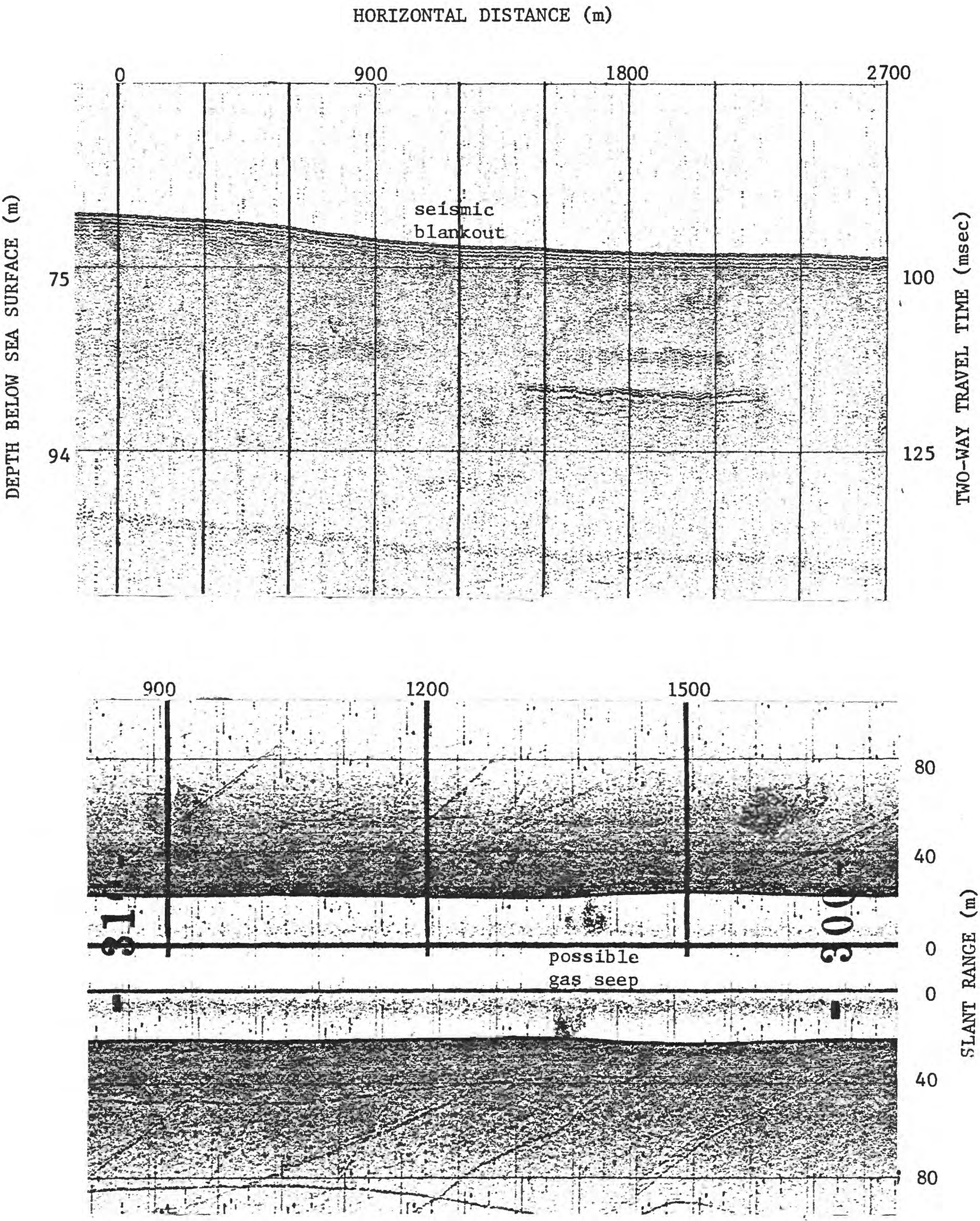



Figure 1- Side-scan sonar and Huntec profile showing a water column anomaly directly above a seismic blankout, indicating a possible gas seep. The longitudinal furrows on the side-scan segment are trawl scars. Vertical exaggeration (Huntec) = 10X. (See Plate 1, Block NJ 18-3-770).

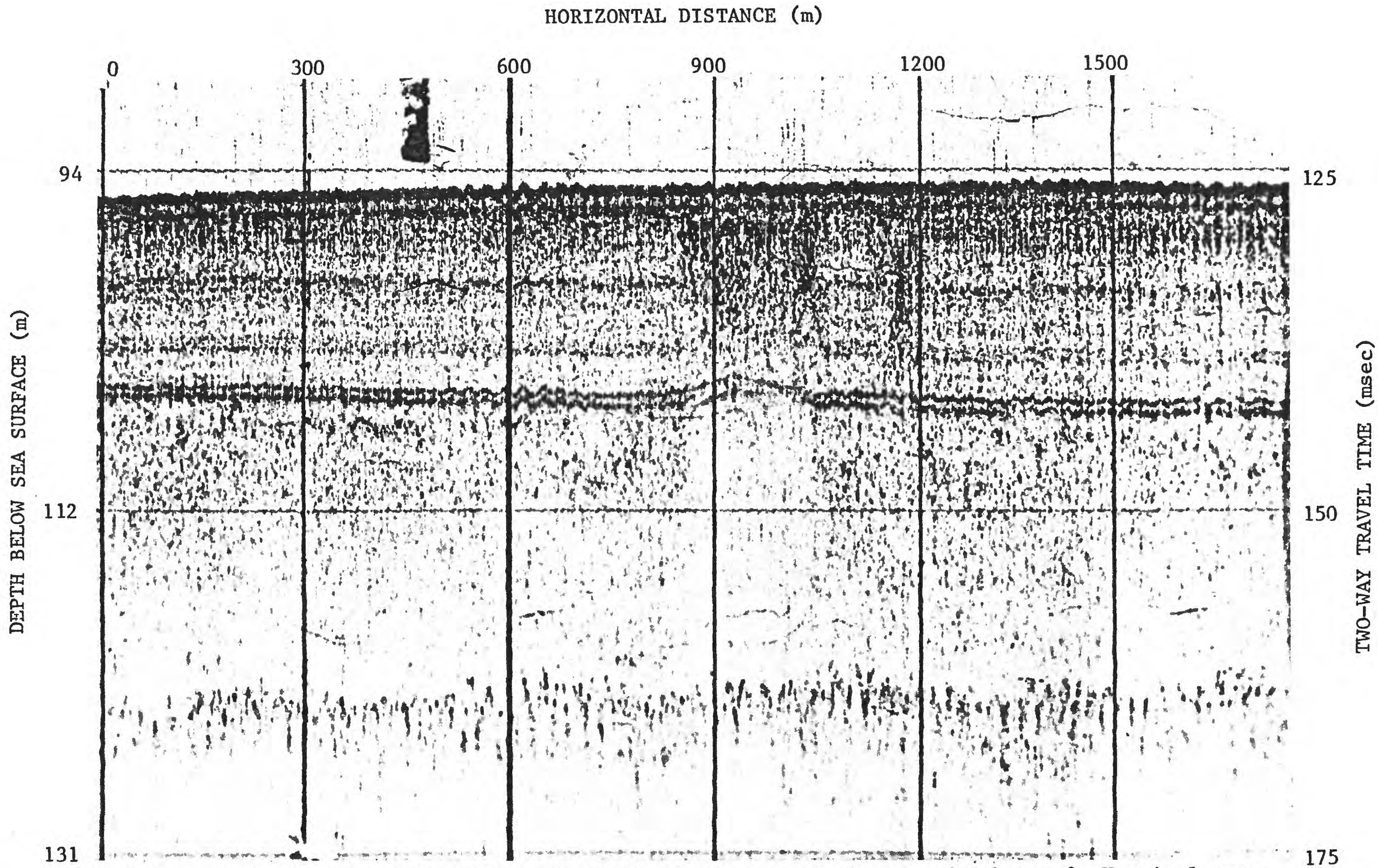



Figure 2- Possible geopressured gas pocket in the west-central part of Subarea 2. Vertical exaggeration = 10X. (See Plate 1, Block NJ 18-3-724).

## Constraints

Other aspects of the Atlantic OCS regional geology have an impact on oil and gas related activities but are considered to be merely developmental constraints because, once identified, their adverse effects can be minimized through the use of existing standard design and engineering technology. These second-order problems include such features and conditions as sand waves, erosion/scour, filled channels, relict lagoonal deposits, gassy sediments (acoustically turbid zones), potentially unstable slopes, and bottom objects or debris. The gassy sediments are shown on the block maps and the Summary hazards and constraints map as acoustically turbid zones. Locations of these constraints are shown on both the 1:48,000 scale block maps (Appendix) and the 1:250,000-scale Summary hazards and constraints map (Plate 1).

The constraints presented by sand waves are related to their mobility. Sand waves are assumed to be migratory while sand ridges are static or nearly so. Only sand waves are considered to be constraints. High-velocity bottom currents, particularly those due to storms, can remobilize sand size particles and result in significant horizontal crest/trough displacements (McKinney and others, 1974). Lateral migration of the crest can "strand" platform supports or wellhead plumbing by eroding away the surrounding support materials. Small scale erosion/scour would have essentially the same effect. Sand waves, ripples and evidence of erosion/scour are widespread in the proposed Sale 49 area and have been indicated on the 1:48,000-scale maps.

Filled channels and relict lagoonal deposits may pose problems in terms of foundation support for large structures. The mechanical properties of channel fill and lagoonal sediments can differ markedly from the regional surface sediments which bound them. This can result in differential settling of structures which straddle the boundary between the two sediment types. In addition, since grain size in channel fill deposits can range from clays to boulders, problems with mud circulation and emplacement of surface casing can occur.

In the context of this report gassy sediments are taken to mean near-surface sediments which contain enough gas, either in the bubble phase or dissolved, to be detectable as acoustically turbid zones or blankouts on high-resolution seismic reflection data. Gassy sediments are not thought to pose significant risk to oil development and are presented as constraints because of the remote possibility of spontaneous, gas-induced sediment liquefaction.

Dissolved interstitial gas appears to be rather common in the near-surface sedimentary section throughout much of the proposed Lease Sale 49 area, particularly in shelf-edge areas ranging from 70 to 200 m in water depth. While gas in foundation zone sediments poses no risk in itself, under certain conditions it can affect load bearing capacity and the stability of those sediments. Given the correct parameters as to gradient, gas concentration, sediment compaction and porosity, gassy sediments can spontaneously liquefy when subjected to cyclic loading. The potential for gas-related sediment liquefaction in the proposed Sale 49 area is not known, but the problem is common in the Mississippi Delta region and has been the subject of a number of studies there (Whelan and others, 1978). It is difficult, however, to draw any inferences from these studies as to the likelihood of gas-induced stability problems on the Atlantic OCS because the regions are geologically dissimilar.

High methane concentrations have been encountered in cores of upper Pleistocene units on the outer shelf (Atlantic Continental Margin Coring Project - Sites 6007 (southwest of the proposed sale area) and 6021; Hathaway and others, 1976) and slope (L. J. Doyle and G. L. Hayward, Univ. of South Florida, oral commun., 1978). If gas (presumed to be primarily biogenic methane) is the cause of these acoustic signatures, cyclic loading could result in bubble coalesence and consequent modification of the geotechnical characteristics of the material (Whelan and others, 1978). Accordingly, where turbid units occur at the margins of steep slopes (e.g., canyon margins) the risk of foundation failure may be significantly higher than in other areas unless proper engineering design is incorporated.

A condition related to shallow gas is that of hydrated gas. Hydrated gas may occur in some of the blocks on the slope. A gas hydrate is an ice-like, crystalline lattice of water molecules in which gas molecules (in this case, hydrocarbons) are physically trapped (Tucholke and others, 1977). We can find nothing definitive in the literature reporting the existence of gas hydrates in any of the proposed Lease Sale 49 blocks, nor do our geophysical data support their existence.

We have delineated a potentially unstable zone between the shelf break and a line on the slope which defines the upslope limit of the occurrence of mass movement-related structures. This upper zone has been identified as posing a constraint rather than a hazard because convincing geophysical evidence of past mass movements is lacking. However, on the basis of gradient and composition of surficial sediments, we believe that creep or slumping may occur.

Problems presented by bottom objects (debris, ordnance, etc.) are relatively straightforward. These features, seen on side-scan sonar records, are not positively identifiable as shipwrecks or non-hazardous features such as trawler scars. Simply repositioning the structure may often afford the best solution.

## DATA COLLECTION AND ANALYSIS

The bulk of the data involved in the block-specific part of this report were collected by Offshore Navigation, Inc. (Contract 14-08-0001-16243) during the winter of 1977-78. The contractor also supplied data reduction services and a preliminary hazards report which was extensively modified and reinterpreted by U.S. Geological Survey personnel. A total of approximately 5060 km (3129 line miles) of side-scan sonar, subbottom profiler, processed sparker, and fathometer data were collected on a 800 X 3200 m grid over all blocks tentatively selected for lease. Navigation services were provided by the contractor using ARGO as the primary navigation system, with satellite navigation as an update. Quoted system accuracy is $\pm$ 50 m. Data acquisition, processing, and interpretation were monitored throughout the contract period by U.S. Geological Survey personnel.

Three vessels were employed (R/V CAPE HENLOPEN, M/V ATLAS II, M/V ANNANDALE) using identical geophysical systems. Bathymetric data were collected using an Edo Western 4034A Sonar Sounding System. Near-surface reflection profiles were displayed on an EPC Model 3200 flat bed recorder using a HUNTEC HYDROSONDE as source/receiver. The HUNTEC system is a heave compensated, subtowed, electromechanical source which operates nearly independently of sea state. Maximum depth of subsurface penetration was approximately 50 msec (38 m). HUNTEC data is depth dependent, with data quality decreasing in water depths greater than 200 m or in areas of steep gradient. The deep reflection profiling equipment consists of a 12 channel hydrophone, 10 kJ sparker source and Quantum Model DAS/IA digitizing unit. The sparker data were machine processed in a conventional ADP format. Side-scan sonar data were recorded on a Klein Model 400 system. Normal operational considerations prevented the collection of useful side-scan sonar data in water depths greater than approximately 200 m.

Data quality was relatively good for all systems used in all subareas, except for HUNTEC and side-scan sonar in Subarea 5 where operational problems and/or surficial geology reduced HUNTEC penetration and decreased side-scan sonar resolution.

Microfilm copies of all side-scan sonar, subbottom profiler, sparker, and bathymetric records, along with contractor interpreted copies of all 1:48,000 scale navigation, potential hazards, bathymetry, shallow structure, and sediment isopach maps are available for purchase from the National Geophysical and Solar-Terrestrial Data Center (NGSDC) in Boulder, Colorado. In correspondence with NGSDC concerning this data, refer to data set AT16243.

The data are also available for public inspection in the U.S. Geological Survey office, 1725 K St. NW, Washington, D.C.

## SUBAREA 1

by G. B. Carpenter

### Surface Morphology and Shallow Structure

The area southwest of Hudson Canyon shows a simple landward morphologic sequence beginning at the shelf break: (1) Prograded wedge of Recent sediments; (2) Featureless, acoustically reflective and generally flat plain; and (3) A series of en echelon sand ridges generally paralleling the shelf break.

The prograded sediment wedge which forms the present-day shelf break shows, on HUNTEC reflection data, considerable internal stratification. Surface sediments on the wedge are finer (35% sand) than those near the northwest edge of Subarea 1 (90% sand) (M. A. Smith, U.S. Geological Survey, oral commun., 1978). The shelf break appears to have migrated roughly 4 km seaward since the deposition of the deepest observed reflector (Pleistocene?). To the northeast of Hudson Canyon progradational thickening begins much farther landward than in the area southwest of the Canyon. The wedge appears to be thicker, is spread over a larger area in the northeast and shows much less internal structure. The differences in acoustic character on the sides of the Hudson Canyon probably are caused by changes in grain size, composition, porosity, or some combination of these and other parameters.

The surface of the featureless, flat area (zone 2) between the prograded wedge and the sand ridge field is highly reflective and produces strong multiple returns on HUNTEC records. Weak subbottom reflectors generally parallel the bottom. These acoustic properties indicate that the surface sediments are mainly coarse-grained material such as sand.

The sand ridges (zone 3) are clearly constructional features which were deposited on a flat or gently undulating surface. The apparent lack of internal stratification precludes a judgment as to whether they are migratory. The features have no fixed amplitude or wavelength and generally are parallel to the shelf break.

### Hazards

No hazards were identified.

### Constraints

Gassy Sediments (Acoustically Turbid Zone)

Numerous opaque, time-transgressive and poorly defined reflectors occur within the wedge and may indicate subsurface interstitial gas. Geochemical analyses in the area show an excellent correlation of high interstitial gas concentrations with the areal limits of the prograded sediment wedge (M. A. Smith, U.S. Geological Survey, oral commun., 1978).

The increased levels of gas in these sediments along with steeper gradients near the shelf break may make these sediments more prone to gas-induced liquefaction or slope failure than those landward of the wedge, but in general these gassy sediments are probably not a serious constraint.

## Potential Slope Instability

The surface of the prograded wedge discussed above is often hummocky, particularly just beyond the shelf break. This hummocky appearance indicates either soil creep or depositional processes. This area, however, has already been mapped as a region of potential slope instability, owing to slope gradient and the composition of surficial sediments.

## Erosion/Scour

Considerable evidence exists for intense and contemporary sea-floor erosion and scour in Subarea 1. With the exception of the prograded sediment wedge and the zone seaward of the shelf break, most of the surface sediments are sand or other coarse-grained material. Erosional channels are common and most show no evidence of recent fill. The erosional surface occurring throughout Subarea 1 shows no evidence of recent sedimentation. The surface morphology of the entire area is apparently a result of dynamic bottom water circulation patterns. Bottom current-related features range in scale from sand ridges of greater than 5 m relief to rippling and subtle textural changes in surface sediments.

Side-scan data taken in the west-central part of Subarea 1 (Block NJ 18-3-289) show a sunken vessel which appears to lie in an excavation about 3 m deep (Fig. 3). This hole is probably a result of scour around the hull which has occurred since the vessel sank. In view of the many features in Subarea 1 related to erosion and/or redeposition of surface sediments, the scour, as noted around the sunken vessel, may not be merely a local occurrence but perhaps is widespread throughout the sale area. Scour will possibly occur around bottom-sited structures and some engineering consideration will be required.

## Lagoonal Sediments

On reflection records through Block NJ 18-3-248 a possible beach/barrier island/lagoon complex shows as a series of flat-lying reflectors deposited within a broad shallow trough (lagoon?) situated landward of a raised, internally structureless ridge (barrier island?). A seismic blankout, interpreted as gassy sediments, is found very near the supposed lagoonal deposits (Fig. 4). Large horizontal variations in load-bearing capacity across the complex might result in foundation problems. If gas is associated with the lagoonal sediments (a not unlikely situation), this would tend to increase the instability problem. Obviously, such beach complexes were once widespread on the shelf but most were destroyed or altered beyond recognition by transgressing post-Pleistocene seas. Why this particular feature escaped the consequence of the transgression is unknown.

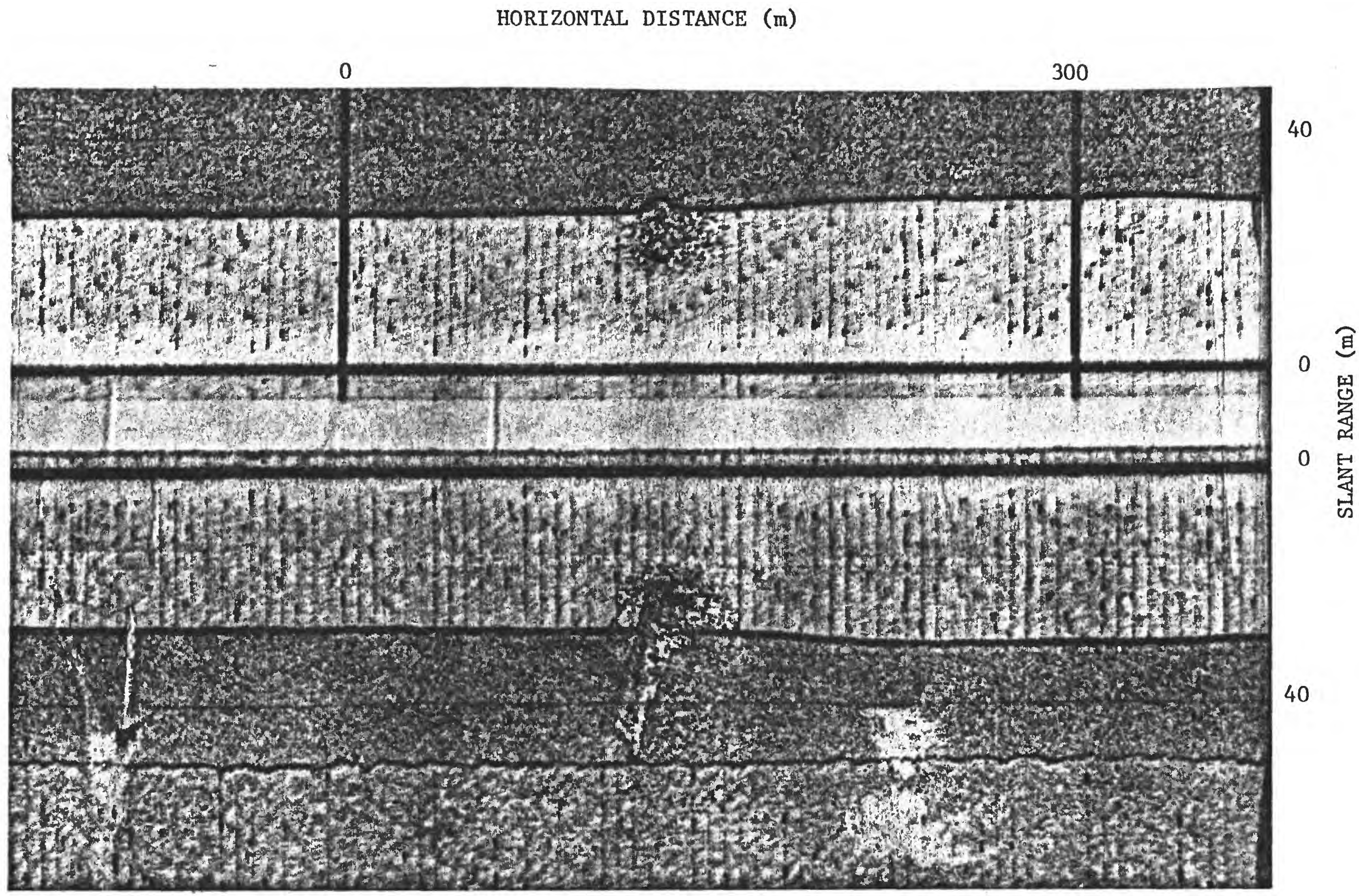



Figure 3- Side-scan sonograph of a sunken vessel in Subarea 1. Note the 3 m excavation around the hull. Reflections in the water column are probably due to fish. (See Plate 1, Block NJ 18-3-289).

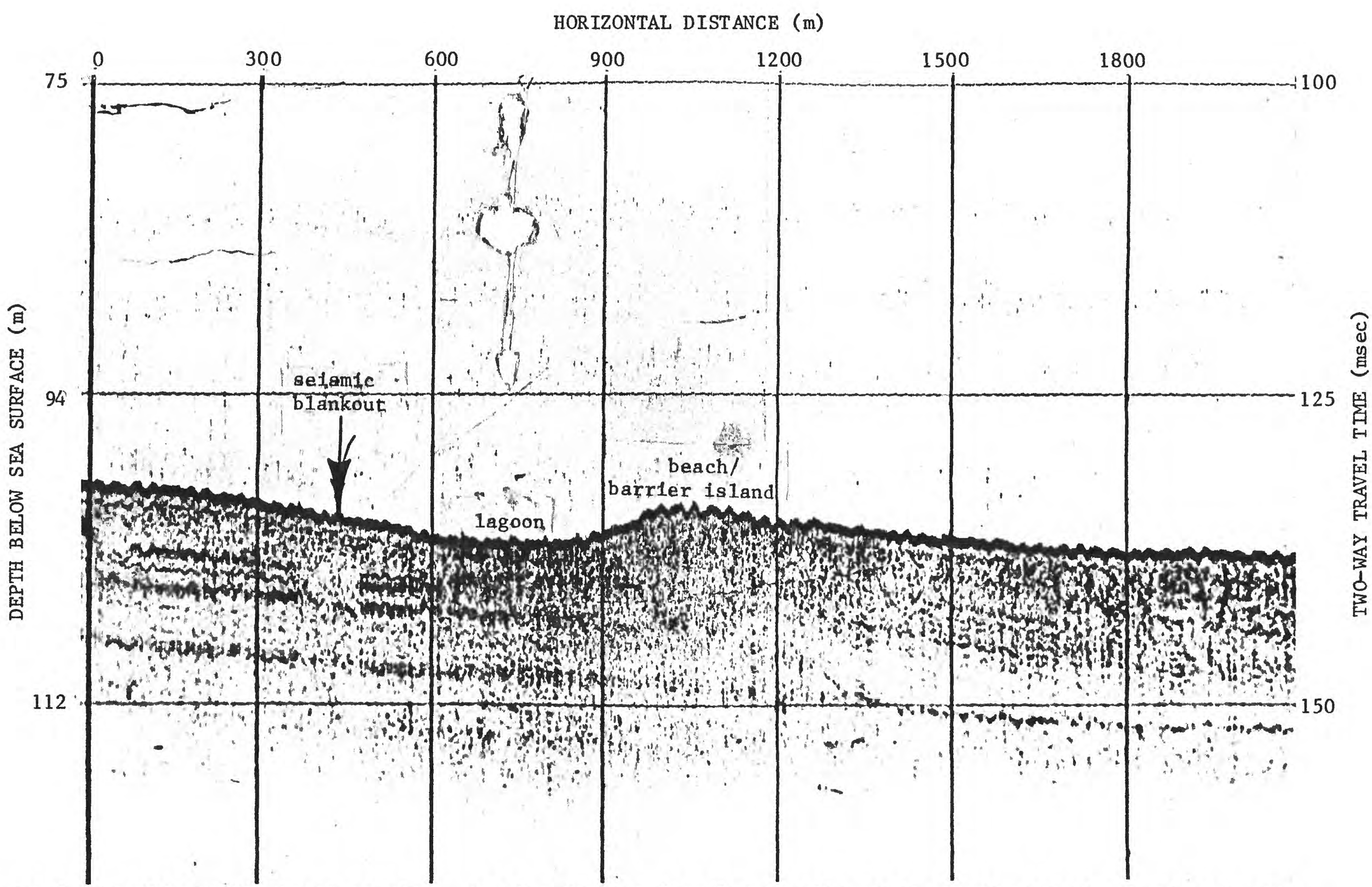



Figure 4- Possible relict beach complex. Beach sediments (sand) laterally grade rapidly into lagoonal sediments (mud/clay) probably resulting in large variations in foundation zone load bearing capacity across the transiton. Vertical exaggeration = 10X. (See Plate 1, Block NJ 18-3-248).

## SUBAREA 2

by G. B. Carpenter

### Surface Morphology and Shallow Structure

The regional slope gradient is about 75 m/km in the northeast, increasing southwestward to about 120 m/km near Toms Canyon (17.5 m/km equals $1^{o}$). Local gradients can be greater than 175 m/km or $10^{o}$.

In general, the shelf sea floor in Subarea 2 shows extensive small-scale roughness and is incised by numerous small, discontinuous erosional channels. The surface is pockmarked by many small (2 m dia.) shallow holes which locally are so numerous that they have coalesced and significantly altered the surface texture. These sonograph signatures may be of biological origin.

A prominent ridge about 10 m high (Fig. 5) is found just landward of the shelf break in the western part of the subarea. The ridge gradually disappears toward the northwest. A narrow band of surface sediment ripples about 300 m wide occurs very near and parallel to the shelf break. The band fades towards the northwest, away from Toms Canyon.

A group of northeast-trending sand ridges is found adjacent to the landward edge of the erosional zone. The ridges have been deposited on a flat-lying subbottom reflector and are clearly constructional features similar to the sand ridge shown in Figure 5. The largest has an amplitude exceeding 10 m and is devoid of internal structure (on our data) which precludes a judgment as to whether they are migratory. These ridges are not considered to be constraints and are not mapped as such.

### Hazards

#### Slumps/Slides

The most significant geological condition affecting resource development in Subarea 2 and the entire sale area is slumping in those blocks on the continental slope.

The slope surface is characterized by a "blocky" texture which becomes more pronounced to the southeast downslope. Thus there may be some merit to the simplistic notion that the risk of slope failure increases with increasing gradient. Unfortunately, our data do not allow a judgment as to whether the blocky texture is a result of sediment failure or an erosional/depositional process. However, all areas with good quality data on that part of the slope seaward of the line describing the first occurrence of mass movement related structures show considerable evidence of past mass movements. The possibility of further slumping cannot be dismissed.

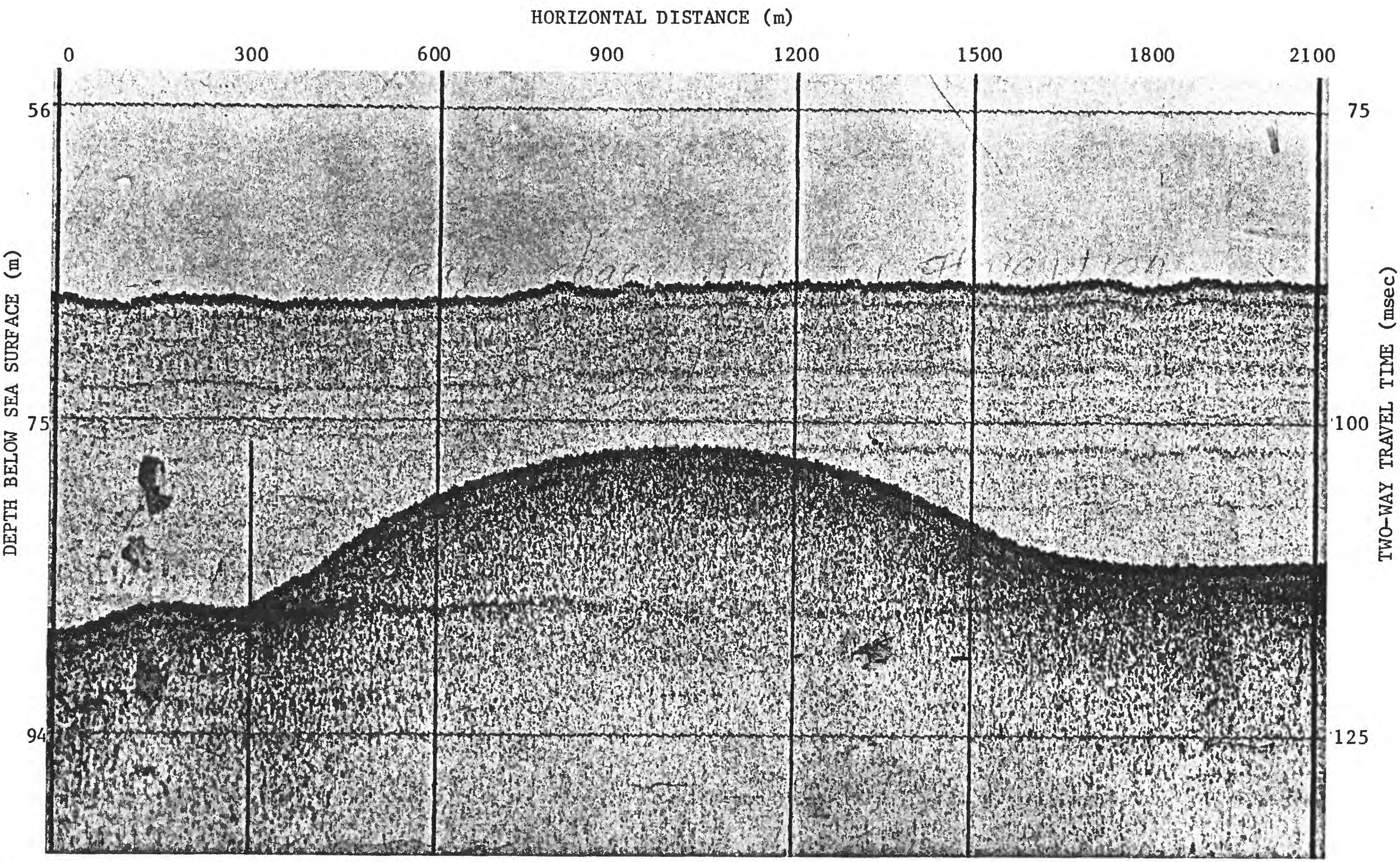



Figure 5- Sand ridge in western part of Subarea 2. Note the flat horizon upon which the ridge has been constructed. The absence of diagnostic internal layering in the ridge precludes a judgment as to whether the feature is static or migratory. The ridge is approximately 10 m high. Vertical exaggeration = 10X. (See Plate 1, Block NJ 18-3-765).

We have mapped the first occurrence of those structural elements downslope of the shelf break which appear to be the result of mass movements of near-surface sediments. When correlated on adjacent profiles, these occurrences define a line approximately at the shelf break. All tracts partially or wholly seaward of this line show faulting, truncation of reflectors, slump blocks and other mass movement related structures. The line drawing of a sparker profile (Fig. 6) typifies the shallow geologic structure of much of the continental slope region.

### Shallow Gas Deposits

One bright spot (Block 18-3-773) was observed on sparker data collected for the OCS Lease Sale 40 hazards analysis. Because the bright spot is small and is located between proposed Sale 49 sparker traverses, it was not seen on these data.

Block NJ 18-3-724 is an isolated tract in the west-central part of Subarea 2. Many of the profiles in this block show evidence of shallow gas. Figure 2 is a shallow subbottom reflection profile across a suspected gas pocket. The dual reflector under the opaque zone is subtly arched upward perhaps indicating high-pressure gas beneath it. This pocket may have been the source for gas in the overlying opaque zone. Alternatively, the arching of the reflector may be the result of a high-velocity zone over it. No indications of seeping gas were detected. The arched reflector, coupled with the opaque zone, however, is sufficient evidence to allow us to interpret this feature as a shallow gas deposit, and it has been shown as such on the block maps and the Summary hazards and constraints map.

Profiles in Blocks NJ 18-3-726 and -770 north of Toms Canyon show evidence of gas in near-surface sediments. Figure 3 is a composite profile showing a seismic "blankout" on the shallow subbottom profiler which correlates with a water column anomaly on a side-scan sonograph. Although the anomaly could be of biological origin, its position over a possible subsurface gas deposit may indicate that it is a gas seep. This combination of acoustic blankout and a water column anomaly found in Block NJ 18-3-770 is interpreted and mapped as a shallow gas deposit. Side-scan data reveal numerous water column anomalies on the shelf which have been interpreted as being fish because of their locations in productive fishing areas (as evidenced by the great number of trawl scars on the bottom). The anomalies do not correlate with other geophysical data and are thus probably unrelated to seeping gas.

### Constraints

A zone of intense and apparently contemporary erosion occurs in the western part of Subarea 2 just landward of the shelf break. Surface sediments in the erosional zone are highly reflective with strong multiples, indicating they are probably sand or other coarse-grained materials. The

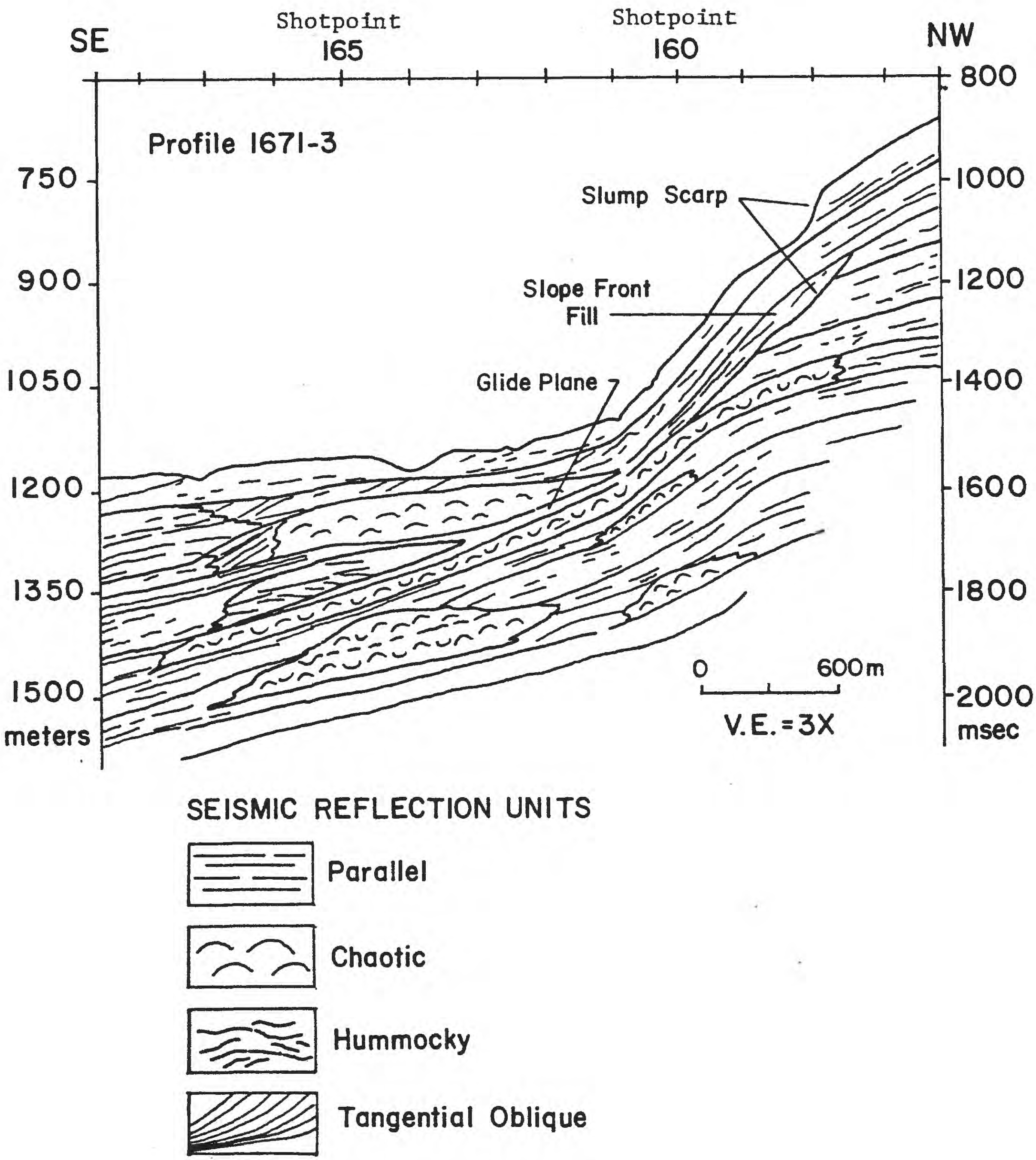



Figure 6– Interpreted sketch of a sparker profile which crosses southwestern margin of the slide/slump complex on the upper slope northeast of Wilmington Canyon. Chaotic units define individual debris slides which are flanked by parallel bedded units. Note the glide plane and possible buried scarp. The reflection character of the shallower units is not apparent on this sparker profile but presumably the upper 50 m includes recent slide debris associated with the 60 m scarp at shot point 158. Vertical exaggeration = 3X. (See Plate 1, Block NJ 18-6-626).

surface is now being intensively eroded and in places resembles subaqueous badlands. The slopes are steep, sharp, and well defined (Fig. 7). A prominent erosional channel more than 10 m deep has been mapped (Blocks NJ 18-3-810, -811 and -854) and other smaller ones are also shown. The largest channel appears to be leveed on its northwest bank. Erosion and scour around the bases of platforms and other bottom-anchored structures are likely to occur in this area.

Block NJ 18-3-639 is an isolated block at the north end of the central section (Plate 1). The sediment surface in Block 639 exhibits evidence of small-scale roughness and channeling, indicating erosion/ scour may be present.

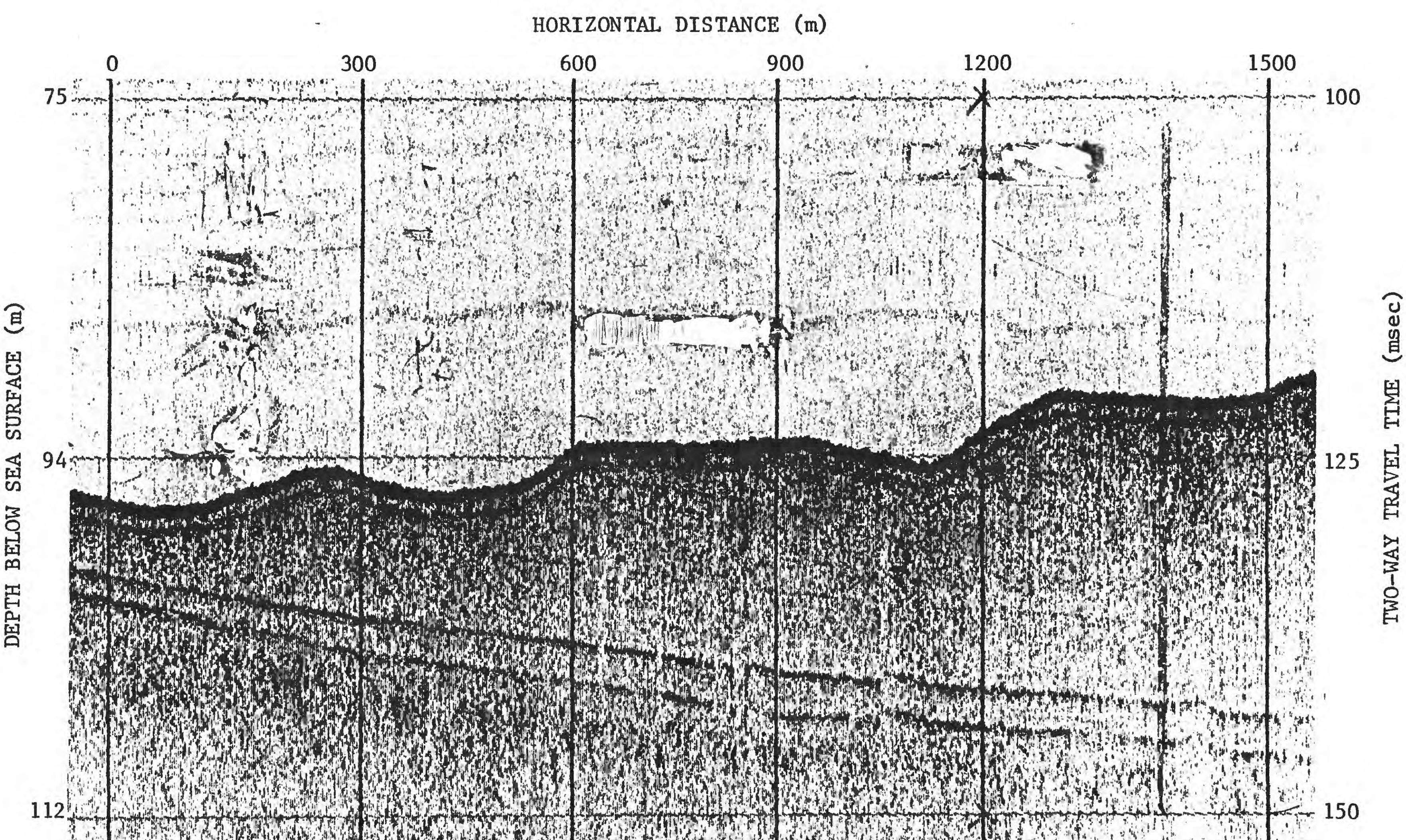



Figure 7- Profile taken in the western part of Subarea 2 just landward of the shelf break, showing evidence of erosion of surface sediments. Vertical exaggeration = 15X. (See Plate 1, Block NJ 18-3-854).

## SUBAREA 3

by C. L. Davis and H. R. Ensminger

### Surface Morphology and Shallow Structure

Subarea 3, which contains 32 blocks, is approximately in the center of the proposed Lease Sale 49 area. Seventeen of the blocks are on the continental shelf proper, seven blocks are on the shelf break, and eight blocks are on the upper continental slope adjacent to the shelf break.

Bathymetric data reveal that the surface relief of the shelf in 17 blocks (NJ 18-6-98, -102, -103, -140, -141, -146, -147, -183, -186, -188, -191, -192, -227, -233, -234, -270 and -278) is gently undulating. The undulate relief is interpreted as having been constructed by waves or currents that piled mobilized sediment into elongate low ridges generally trending northeast. They are 13 to 19 km long, 3 to 5 km wide, and 6 to 8 m high. The exact dimensions of the ridges are difficult to determine because data coverage is discontinuous over adjacent non-lease sale blocks. However, the available bathymetry suggests that there are northeast-trending ridges in this part of the subarea, and that the intervals between the ridges are very flat. One long ridge is located in Blocks NJ 18-6-183, -140, -141 and -98. Two parallel elongate ridges, of undetermined length, are located in Blocks NJ 18-6-102, -103, -146 and -147. These two ridges are approximately 1.5 km apart.

The shelf relief in Blocks NJ 18-6-287, -234, -191 and -192 is less than in the blocks associated with the sediment ridges. The gradient of the shelf surface in the blocks which are located at the shelf edge is greater than the gradient in the blocks located shoreward of the shelf edge. With the exception of the steep gradients found in blocks along Lindenkohl and Carteret Canyons, the gradients in the shelf edge blocks are uniform and smooth and steepen gradually from the flatter shelf to the steeper shelf break.

Sediments within blocks located on the upper continental slope appear to have slumped, and have formed a hummocky slump topography downslope from the shelf break. These deposits often coalesce forming a continuous field of slump deposits.

The unconsolidated shelf sediments in Subarea 3 vary in thickness from 0 to approximately 15 m. The thickest accumulation is in the elongate ridges where the accumulation is 10 to 15 m. The thickness of potentially mobile sediment in the area between the ridges is 0 to 5 m. At the shelf break and on the slope, this unconsolidated layer is not detectable.

### Hazards

#### Slumps/slides

A province of slump deposition on the upper continental slope is illustrated on the block maps. Reflection profiles across the slumps reveal truncation of the acoustic reflectors. The slump blocks occur both individually and in groups, often coalescing.

## Constraints

### Sand Waves

There are three groups of sand waves in Subarea 3. A small group of sand waves is in Block NJ 18-6-186. Their amplitude is no greater than 1 m. A long sinuous field of sand waves is located in Blocks NJ 18-6-191, -192 and -149. The field is approximately 11 km long and 1.5 km wide at the widest point. The waves in this field are en echelon and have a wave height of up to 2 m. The third group of sand waves is located in the northeast corner of Block NJ 18-6-149 and the northwest corner of Block NJ 18-6-150. These sand waves are located in water depths of 75 to 100 m. Seismic reflection profiles of the sand waves provide very little definitive acoustical evidence to judge whether they are active or not, but experience has shown that sand waves can cause problems with leveling base plates and with routing submarine pipelines.

### Gassy Sediments (Acoustically Turbid Zone)

Seismic profiles indicate the possible presence of gassy sediments in a long narrow zone on the outer shelf adjacent to the shelf break. This zone varies in width from 2.5 to 5 km and in Subarea 3 is located in Blocks NJ 18-6-193, -149, -150, -151, -107, -63, -20 and in Block NJ 18-3-989. Usually, gas in the shallow sediments of the outer continental shelf is methane of biogenic origin, reservoir gas that has migrated up from greater depths, or a mixture of both biogenic and heavier reservoir gas.

### Potential Slope Instability

A part of the upper continental slope that has the potential for slope instability lies between the shelf break and the upper slope limit of the designated slump zone. Seismic records depict the sediment surface on this part of the slope as relatively smooth and positioned just upslope of the "blocky" appearing slump zone.

This smooth surface suggests that the upper slope sediments have not slumped, but potentially are a source for future slumping. The potentially unstable slope zone becomes narrower in the immediate vicinity of Lindenkohl and Carteret Canyons and is broadest in the intercanyon areas. The narrowest zone around Lindenkohl Canyon is approximately 500 m wide. On the western side of the head of Lindenkohl Canyon, the potentially unstable zone is approximately 2 km wide. The zone is approximately 4 km wide in the intercanyon area between Lindenkohl and Carteret Canyons. Northeast of Carteret Canyon the potentially unstable sediment zone varies in width from 1 to 2 km.

## SUBAREA 4

by R. S. Clingan and J. C. McCarthy

### Surface Morphology and Shallow Structure

The principal morphologic features are the shelf break and Wilmington Canyon. Depths to the shelf break are 100 to 200 m. Within the canyon, the shallowest depth is coincident with an abrupt erosional break in slope at the canyon head. Within intercanyon areas, the shelf break is a gently rounded depositional surface.

The shelf dips gently to the southeast although local deviations were noted. Typical gradients on the shelf range from less than 1 to 5 m/km while on the upper slope, they range from 30 to 300 m/km. The steepest slopes observed (400 m/km) are associated with the eastern flank of Wilmington Canyon. Relief on the shelf is less than 10 m. The maximum relief is associated with linear sand bodies and superimposed sand waves. Sand wave fields, the principal second-order bathymetric feature on the shelf, tend to be concentrated around the head of Wilmington Canyon. Elsewhere, the shelf is relatively flat except for isolated zones of shallow "pockmarks" which occur principally at or near the shelf break. Topography on the upper slope is very irregular, owing to widespread mass wasting.

### Surficial Sediments and Shallow Stratigraphic Framework

Surficial sand thicknesses of 1 to 20 m in Subarea 4 reflect the fluvial influence of the ancestral Great Egg and Delaware Rivers which probably debouched in this region during periods of lowered sea level (Knebel and Spiker, 1976). At present, the surficial sand sheet is being reworked and sorted, at least to a depth of about 1 m (Twichell, 1978). If this is the limit of potential substrate mobility, the adverse effect on bottom sited structures would be slight.

### Hazards

#### Slumps/Slides

All seismic profiles which were acquired from intercanyon slopes of Subarea 4 show submarine slide or slump complexes seaward of a line varying between the 300 and 500 m isobaths. Typical features are slump scars, hummocky topography, discordant slumped units or chaotic debris flows and well-defined glide planes immediately overlain by amorphous units. These features are exposed or veneered with pelagic and terrigenous sediments suggesting that mass wasting has occurred in geologically recent time.

Figure 6 is a sketch (to scale) of the southwest margin of a slide complex located by McGregor and Bennett (1977). They interpreted this unit as a coherent slump block ranging in thickness from 65 msec (50 m) to 364 msec (300 m).

Our interpretation (Fig. 6) suggests that several episodes of slumping formed a single complex that is discordant with the adjacent parallel bedded slope facies. The complexity of the seismic facies in the unit suggests that geotechnical properties may vary markedly within a specific block. On this particular example the seismic section to the southeast consists almost entirely of parallel reflections, whereas the central part of the section consists of a complex of chaotic, hummocky and parallel reflections to a depth of at least 600 msec (450 m). The parallel bedded facies indicate normal slope sedimentation and thus, presumably, relatively stable foundation conditions.

Bennett and others (1977) described some of the geotechnical measurements made on several cores in different areas of the large slide complex northeast of Wilmington Canyon. A normal marine consolidation profile was implied for surficial units upslope of the slide by shear strength and wet unit weight values. These values increased with depth and decreased with increasing water content. Surficial sediments overlying the slide complex generally exhibited lower shear strength, and the variability of other mass properties was noted to increase with sediment depth in the cores. Upslope of the slide units, creep and apparent foundering of surficial sediment are indicated by contorted bedding and the presence of sand clasts within the silty clays and clayey silts. Included among the areas mapped as potentially unstable are the steep slopes bounding Wilmington Canyon. Direct evidence of slope failure within the canyon was not as common as that noted for intercanyon areas. However, the steep gradients (commonly greater than 350 m/km) and evidence of erosional processes which could lead to oversteepening or removal of support for canyon-wall units suggest the potential for slope failure.

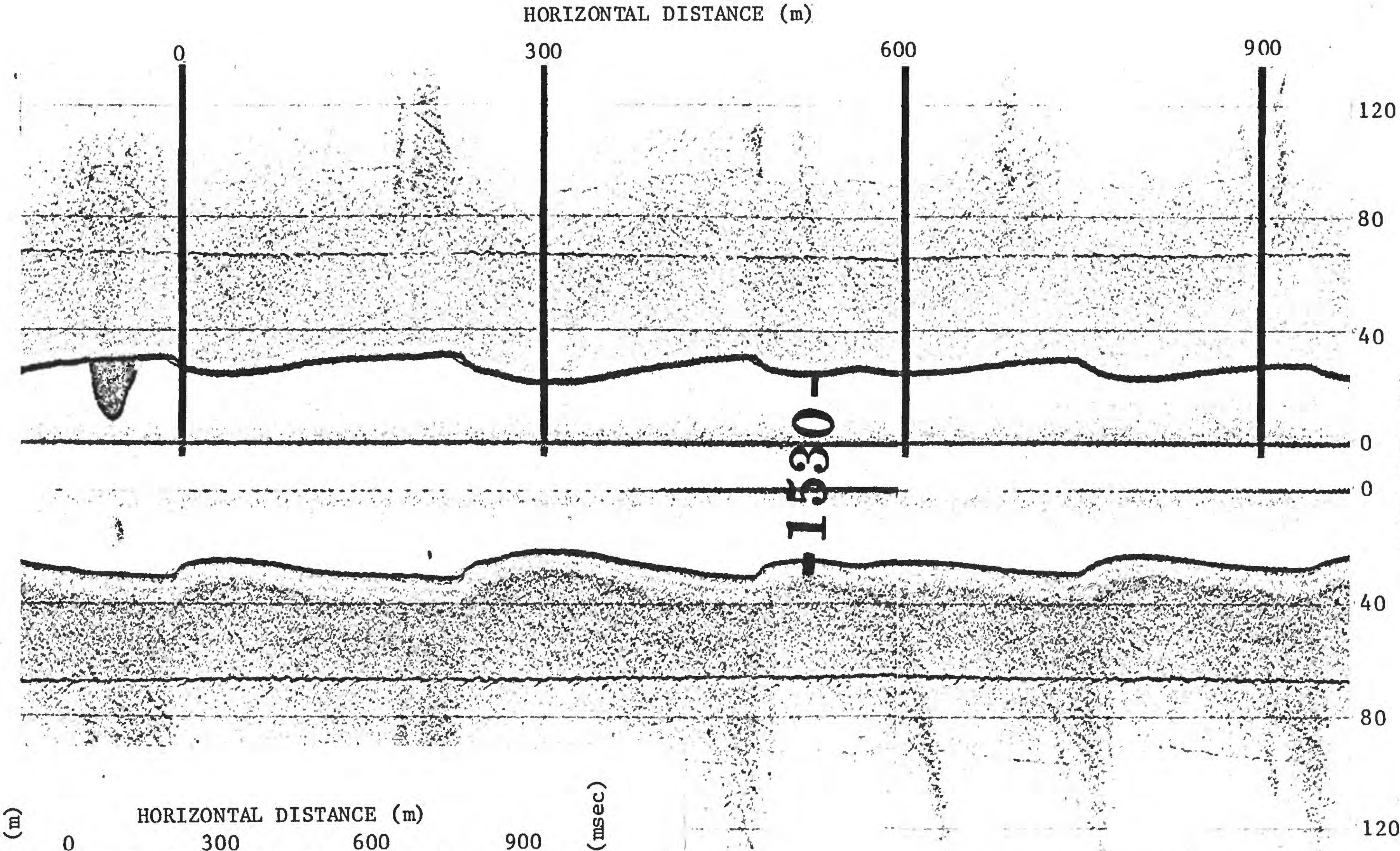
Faulting

No evidence of recent shallow faulting on the shelf was observed within Subarea 4. The only published evidence of faulting within the subarea is Kelling and Stanley's (1970) proposed axial fault which parallels the present shelf break at the head of Wilmington Canyon. They noted up to 60 m displacement (downthrown to the southeast) and hypothesized that this fault is a gravity-controlled feature (slump or glide plane?) resulting from failure of shelf-edge units. They show the fault intersecting the water-seafloor interface in deeper portions of the canyon, but apparently no displacement of upper Pleistocene sediments. This fault was not detected on our data and there is no evidence to suggest recent movement.

## Constraints

Sand Waves

Sand wave fields occur in the vicinity of Wilmington Canyon on substrates of gravelly sand between the 80 and 100 m isobaths (Fig. 8). These features have been previously reported by Knebel and Folger (1976), Knebel and others (1976) and Kelling and Stanley (1970). More recent investigations conducted by the U.S. Geological Survey suggest that



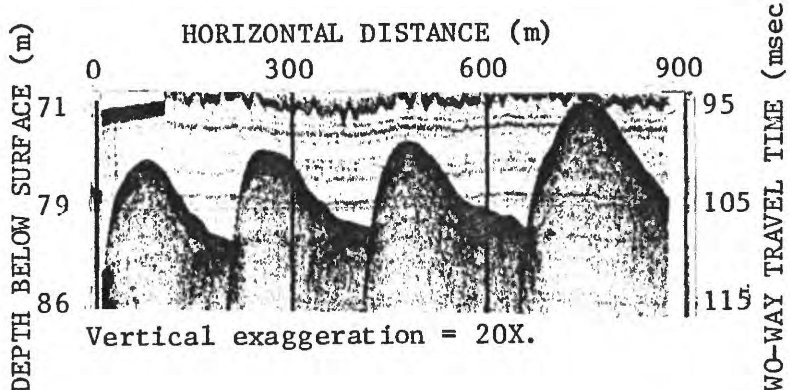




Figure 8- Side-scan sonograph and corresponding shallow subbottom profile (inset) crossing a portion of a sand wave field located northeast of the head of Wilmington Canyon. Straight crested sand waves strike approximately northwest which is typical of other fields in the region. Maximum relief in this example is about 9.5 m with a corresponding ripple index (L/H) of about 30. Note the "fish shoal" on the extreme left of the profile and the trawl marks crossing the sand waves. Water depth is about 95 m. Width exaggeration about 2.4X. (See Plate 1, Block NJ 18-6-449).

these sand waves are relict and not a result of the present hydraulic regime (Twichell, 1978).

### Gassy Sediments (Acoustically Turbid Zone)

Acoustically turbid and/or opaque facies (Schubel, 1974) and fill facies (Mitchum and others, 1977) within the shallow subbottom indicate potentially adverse foundation conditions for long term stability of bottom-mounted structures. Acoustically turbid or opaque seismic facies units recognized on higher frequency reflection profiles are commonly associated with gassy sediment zones (e.g., Schubel, 1974; Antoine and Trabant, 1976; Whelan, 1976). Acoustically turbid sediments are widespread on the outer shelf in the Wilmington Canyon area and occur principally within or near the top of the late Pleistocene unit characterized by oblique and complex cut and fill reflection patterns (Fig. 9). The unit is veneered by a surficial sand sheet on the outer shelf of Subarea 4 (Knebel and Spiker, 1977). Secondary occurrences are commonly associated with channel and canyon fill units.

The principal zone of acoustically turbid facies in Subarea 4 occurs as a laterally continuous trend, 10 to at least 50 km wide, broadening to the southwest, which strikes subparallel to the shelf break. The seaward limit of the facies is usually well defined and remarkably linear; in contrast, the landward boundary tends to be more irregular and diffuse. Southwest of Wilmington Canyon the turbid facies typically contains irregularly distributed high-impedance point sources of uncertain origin (e.g. Fig. 10a, b). These may be the result of cobble or larger size erratics or sand clasts like those noted by Bennett, Lambert, and Hulbert (1977) in box cores from the upper slope in the vicinity. Assuming the turbid character is due to gas in the bubble phase, the high-porosity sand structures would constitute small reservoirs of high-impedance gas within the clayey-silty matrix assumed to be the source of gas generation.

### Fill

Fill facies occur in two basic modes in Subarea 4: (1) very large, relatively deep valley and canyon fill complexes and (2) smaller, shallow channel fills which developed during the most recent period of lower sea level (Fig. 11a, b).

Although the large valley and canyon fill complexes might pose some anomalous drilling conditions due to the unpredictability of the materials they contain, they generally occur well below the foundation zone in Subarea 4. The upper rim of the buried canyon is approximately 75 m below the sea floor, except at the shelf margin where the rim intersects the steep canyon slopes. Although the deeply buried valleys are not indicated on the block maps, blocks containing potential problem areas of the nature described are already designated as areas of potential slope instability on the basis of their gradient and surficial sediment composition.

Small filled channels do occur within the foundation zone, and geotechnical properties can be expected to vary markedly within very short distances. (See Appendix and Plate 1.)

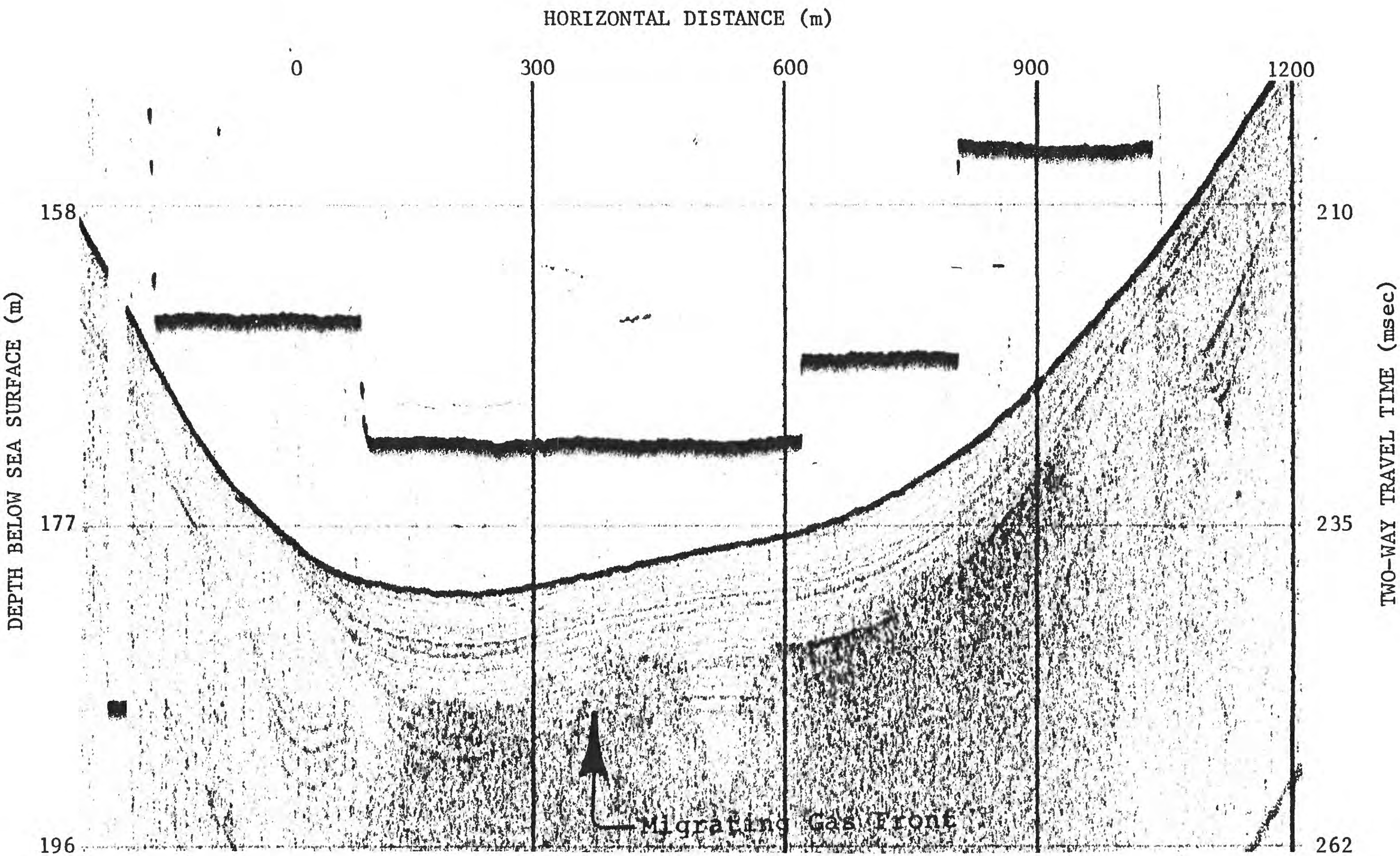
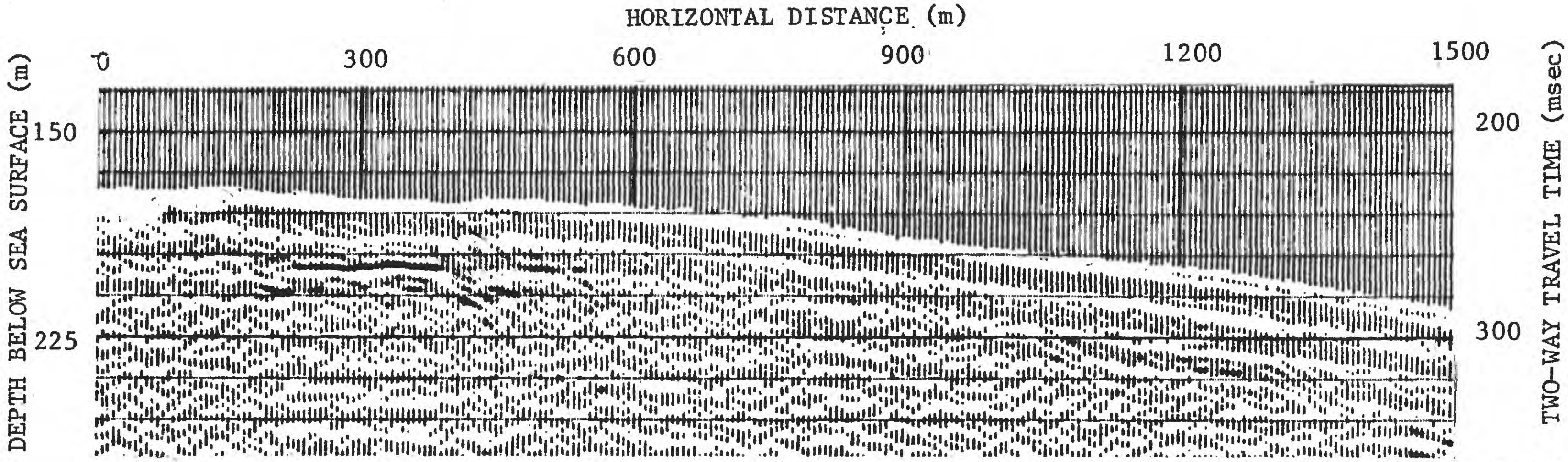



Figure 9- Shallow subbottom profile (Huntec-hydrosonde) showing acoustically turbid fill units at the head of Wilmington Canyon. Migrating gas (?) front is discordant with fill strata. Note the "holiday" in the gas front at about 500 m and the stratigraphic seal between 600 m and 900 m. Depth is approximately 180 m at canyon axis. Vertical exaggeration = 15X. (See Plate 1, Block NJ 18-6-449, -450).



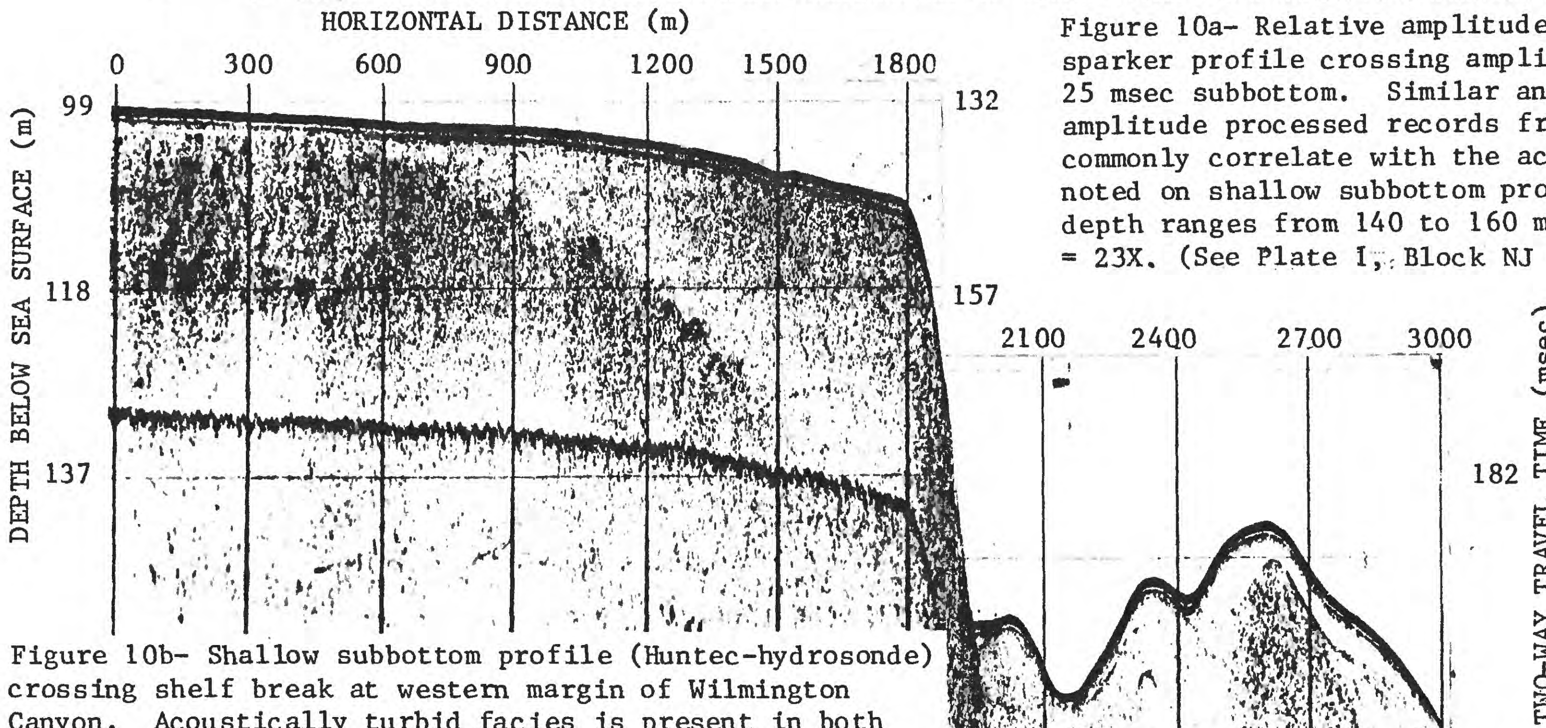




Figure 10a- Relative amplitude processed multichannel sparker profile crossing amplitude anomaly at about 25 msec subbottom. Similar anomalies are present on most amplitude processed records from the outer shelf and they commonly correlate with the acoustically turbid facies noted on shallow subbottom profiles (see below). Water depth ranges from 140 to 160 m. Vertical exaggeration = 23X. (See Plate 1, Block NJ 18-6-666).

Figure 10b- Shallow subbottom profile (Huntec-hydrosonde) crossing shelf break at western margin of Wilmington Canyon. Acoustically turbid facies is present in both shelf and canyon units. Shelf facies contains a number of larger point sources which might be indicative of gas accumulation in higher porosity "microreservoirs". Turbid facies in canyon is similar to deep water signatures attributed to gas hydrates. Water depth at shelf break is 110m. Vertical exaggeration = 10X. (See Plate 1, Block NJ 18-6-535).

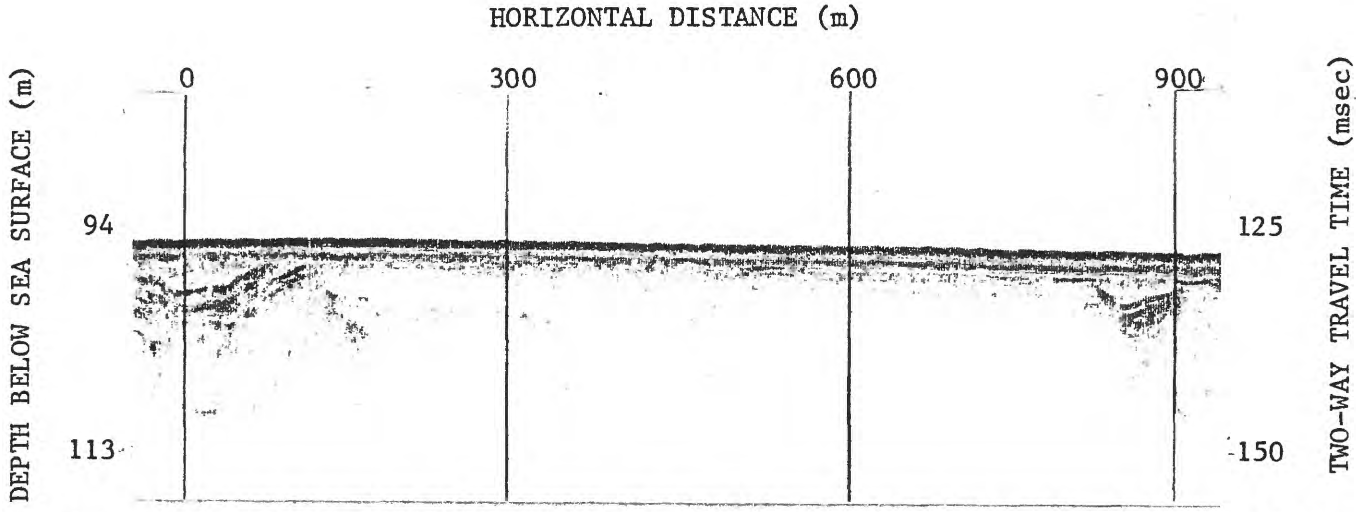



Figure 11a- Shallow subbottom profile (Huntec-hydrosonde) crossing two small buried channels on the shelf northeast of Wilmington Canyon. Fill facies is less than 10 msec thick. Approximately 2 msec of surficial sand overlies channel fill complexes. Vertical exaggeration = 10X. (See Plate 1, Block NJ 18-6-450).

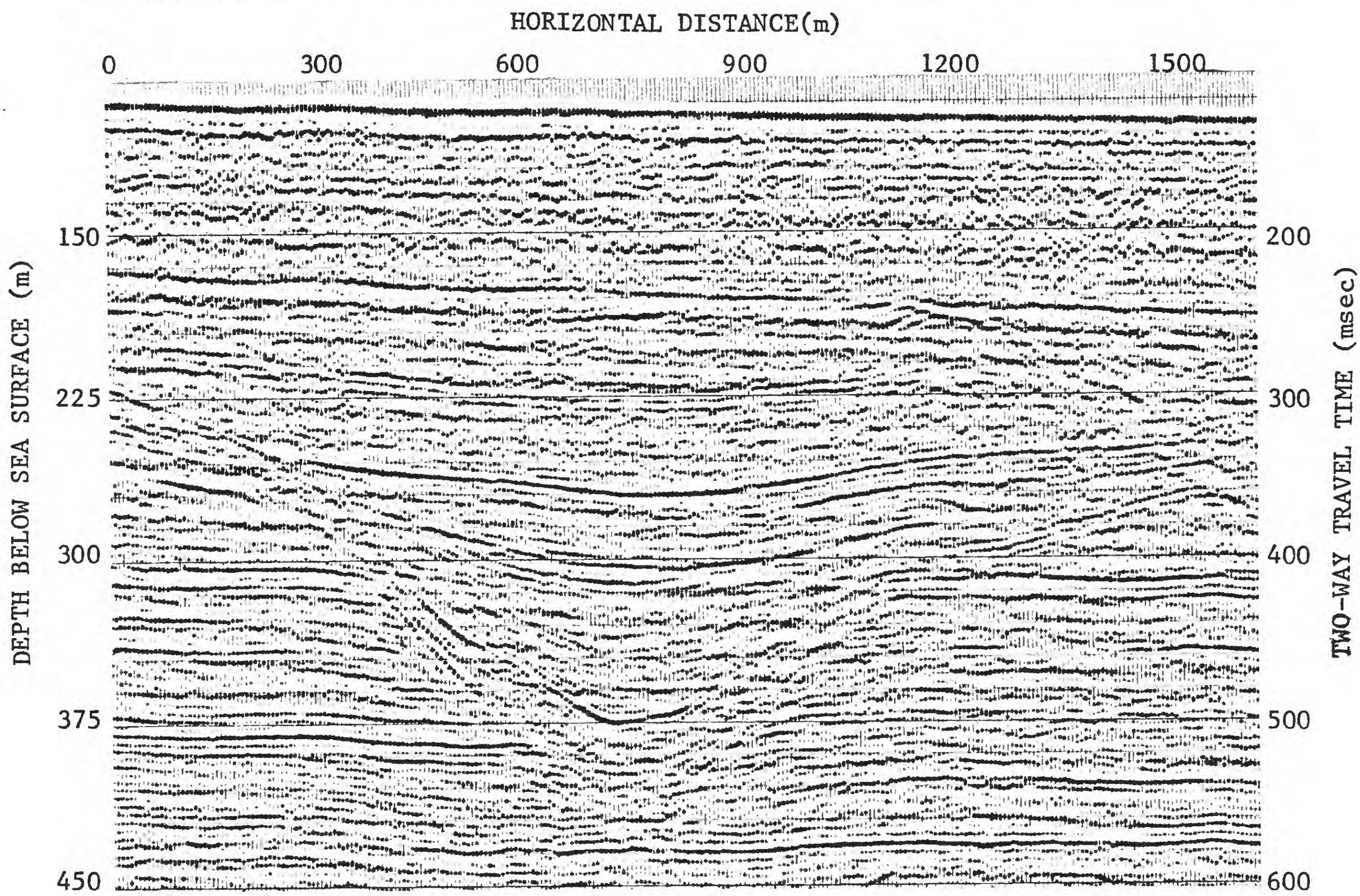



Figure 11b- Processed multichannel sparker profile crossing deeply incised Pleistocene valley near the head of Wilmington Canyon. Fill facies is more than 200 msec thick at the margin of the canyon to the southeast. Sill depth occurs at about 120 msec below late Pleistocene coastal plain and shallow marine sediments. Water depth approximately 80 m. Vertical exaggeration = 3X. (See Plate 1, Block NJ 18-6-491).

## SUBAREA 5

by J. W. Roberts and R. W. Hall

### Surface Morphology and Shallow Structure

Baltimore Canyon is the most prominent physiographic feature in the subarea. The majority of the canyon is not included in the proposed Lease Sale 49 area but several blocks do include parts of the upper walls of the canyon. The canyon head is included in Block NJ 18-6-751 where slopes are nearly 80 m/km. Other canyon wall gradients exceed 400 m/km.

In the immediate vicinity of Baltimore Canyon, extensive canyon cut and fill preceded the present canyon's excavation. Complex deep channeling is evident on the shelf and upper slope southeast of the head of Baltimore Canyon. Fill thickness in this area exceeds 300 msec (225 m) with a rim depth of approximately 100 msec (75 m). Conceivably, canyon fill deposits crop out on the walls of Baltimore Canyon, possibly creating problems related to differential compaction and lost circulation; however, because of steep gradient or obvious slumping, these slopes have been denoted as potentially unstable. Blocks containing evidence of buried canyons include NJ 18-6-795, -796, -837, -838, -839 and -840.

Four Blocks (NJ 18-8-40, -41, -84 and -85) in the southwest corner of the proposed sale area contain a large buried canyon that ranges from 3500 to 7000 m in width, increasing seaward. The rim depth is 100 msec (75 m) and fill thickness approaches 355 msec (280 m). The buried canyon trends normal to the present shelf break.

The outer shelf is flat and featureless, with the minor exception of a sand ridge in several non-lease sale blocks. Water depths range from 115 to 140 m; typical gradients are 1 to 5 m/km to the southeast.

A prograded sediment wedge is present on the entire shelf edge south of the canyon and on a portion north of the canyon, accompanied by a zone of point source reflectors that are possibly boulders. This zone is probably not hazardous but does show evidence of the building-out involved in shelf progradation.

The shelf break generally parallels the 130-140 m isobath; however, in the six southernmost sale blocks the break tends to diverge seaward, following the 160-170 m isobath. In the canyon area, the break is abrupt and well-defined, often accompanied by a deeper secondary scarp primarily on the southern edge of the canyon. In intercanyon areas, the break is less abrupt and tends to become harder to define.

The upper slope to the northeast and southwest of the canyon has a fairly even gradient with minor perturbations for small canyons or delta-like deposits. The southeastward gradient ranges from 40 m/km on the upper slope to 200 m/km farther seaward, with an average of approximately 100 m/km. Water depths range from 140 to 1300 m. The slope surface is irregular due to sediment mass movement or to gullying from turbidity flows during lowered sea level.

## Surficial Sediments

Sediment distribution maps (Stanley and Wear, 1978) show primarily sandy mud and muddy sand in the canyon and on the slope. The upper slope is composed of slightly gravelly muddy sand. The sediment coarsens to slightly gravelly sand and gravelly sand on the shelf. The general decrease in grain size from shelf to slope is typical of most Atlantic margins.

## Hazards

### Fault

A small scarp seen on HUNTEC data in the extreme northwest corner of Block NJ 18-6-837 is probably a sea-floor displacement along a shallow fault. Relief is approximately 2 m. Because most of the fault apparently occurs outside the sale area in non-surveyed blocks, its lateral extent and strike could not be determined.

### Slumps/Slides

In the immediate Baltimore Canyon area, slope instability in the form of slumping or sliding is evident immediately seaward of the shelf break. Away from the canyon area, where slope gradients are generally less steep, slumping occurs approximately 1500 to 3500 m seaward of the shelf break. Individual slumps are generally not traceable on adjacent lines, making it impossible to map them as such. The upper reaches of Baltimore Canyon are characterized by relatively gentle slopes with no evident slumping.

## Constraints

### Potentially Unstable Slopes

The band of potential slope instability, defined as the zone between the shelf break and the first occurrence of slumping or sliding on the slope, widens in the areas of low gradient away from the canyon, where slumping is evident farther downslope. Inner canyon areas, with their higher gradient, have narrow bands of potential slope instability, as slump areas occur almost immediately downslope from the shelf break. Although surficial slumping is not seen in the head of the canyon, the slope gradient makes this area potentially unstable.

## Gassy Sediments

Gassy sediments are common in Subarea 5, underlying much of the shelf and, in some places, a narrow fringe on the upper slope bordering the shelf break. The zone of gassy sediments appears to be more extensive immediately northeast of the canyon areas than southwest of the canyon.

## CONCLUSIONS

The following blocks in proposed Lease Sale 49 show evidence of potential geologic hazards.

1. Slumps and slides (geophysical evidence of mass movement related structures) (Table 1 further categorizes these blocks)
   NJ 18-3-732, -773, -774, -776, -777, -819, -820, -860, -863, -864, -903, -905, -946, -947, -948, -949, -989, -990, -991 and -992
   NJ 18-6-20, -21, -63, -64, -65, -107, -108, -149, -150, -151, -539, -540, -581, -582, -583, -623, -626, -667, -668, -710, -711, -751, -754, -755, -795, -797, -798, -799, -838, -839, -840, -841, -842, -843, -884 and -885
   NJ 18-8-85

2. Shallow gas deposits
   NJ 18-3-724, -770 and -773*

3. Recent shallow faulting
   NJ 18-6-837

This listing of potential hazards is a "best estimate" and is based on an interpretation of high-resolution geophysical data, a literature search, and a small number of core and dredge samples. The three categories of hazards are discussed at length in the text.

*The bright spot (shallow gas deposit) in Block NJ 18-3-773 was seen only in data collected for the Sale 40 hazards analysis.

Table 1. Listing of blocks exhibiting slumped materials, evidence of potential slope instability, and evidence of shallow gas.

Blocks located essentially all within an area of slumped materials:

| | |
|---|---|
| NJ 18-3-776 | NJ18-6-65 |
| -777 | -108 |
| -819 | -540 |
| -820 | -583 |
| -860 | -755 |
| -863 | -798 |
| -864 | -799 |
| -903 | -841 |
| -905 | -842 |
| -947 | -843 |
| -948 | -884 |
| -949 | -885 |
| -990 | |
| -991 | |
| -992 | |

Blocks located within an area of potentially unstable slopes, or in part in an area of potentially unstable slopes with the remaining part showing evidence of slumped materials:

| | |
|---|---|
| NJ18-3-732 | NJ18-6-21 |
| -946 | -64 |
| | -151 |
| | -192 |
| | -193 |
| | -278 |
| | -626 |
| | -668 |
| | -711 |
| | -754 |

Blocks that are, in part, on the relatively stable continental shelf, with the remaining portion located in an area of potentially unstable slopes and, in some cases, areas of slumped materials:

NJ18-3-773
-774
-989

| | |
|---|---|
| NJ18-6-20 | NJ18-6-581 |
| -63 | -582 |
| -107 | -623 |
| -149 | -666 |
| -150 | -667 |
| -191 | -710 |
| -233 | -751 |
| -234 | -753 |
| -449 | -795 |
| -493 | -796 |
| -495 | -797 |
| -535 | -838 |
| -537 | -839 |
| -538 | -840 |
| -539 | -969 |

NJ18-8-84
-85

Blocks showing evidence of shallow gas deposits:

NJ18-3-724
-770
-773

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APPENDIX

Maps showing hazards and constraints for each individual block in the proposed Lease Sale 49 Area, Baltimore Canyon Trough.

# EXPLANATION FOR BLOCK MAPS

**Proposed Lease Sale 49**

## HAZARDS

Shallow Fault

Shallow Gas Deposit

Slump or Slide

## CONSTRAINTS

Erosion/Scour

Sand Wave Field

Filled Channel

Acoustically Turbid Zone
(Gassy sediments)

Lagoonal Sediments

Potentially Unstable Slope

Bottom Object

Cable

Shipwreck

Additional Comments Noted: Inactive Munitions Dumpsite

Undetonated Explosives

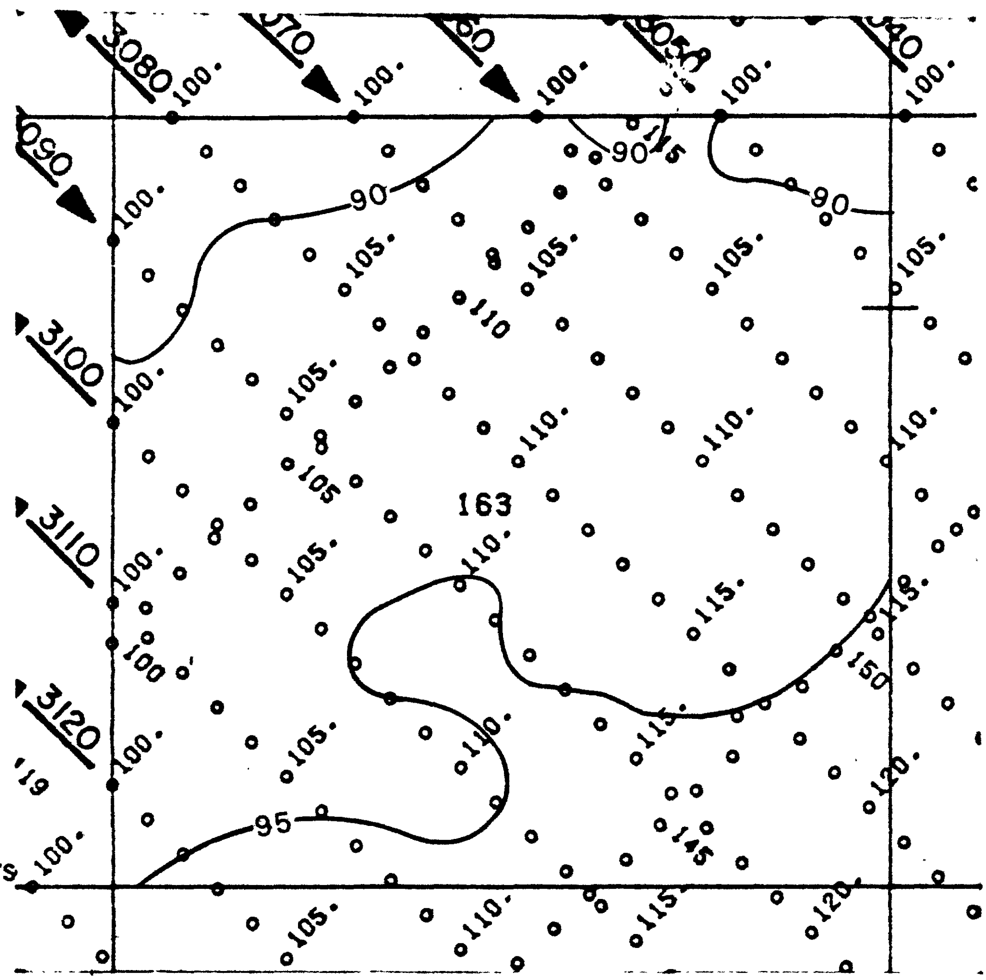
Map Scale 1:48,000

Water Depth Contours in Meters

Proposed
Lease Sale #49

Block No. 163
(NJ 18–3)

Contours in Meters

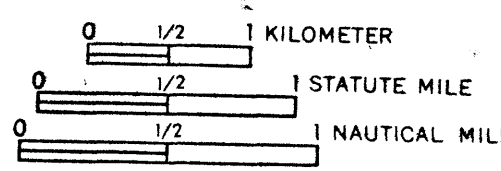



Water Depth: max. 96 m , min. 86 m

Slope Gradient: 1.6 m/km, Direction: SE

Surface Sediment Type: Mud

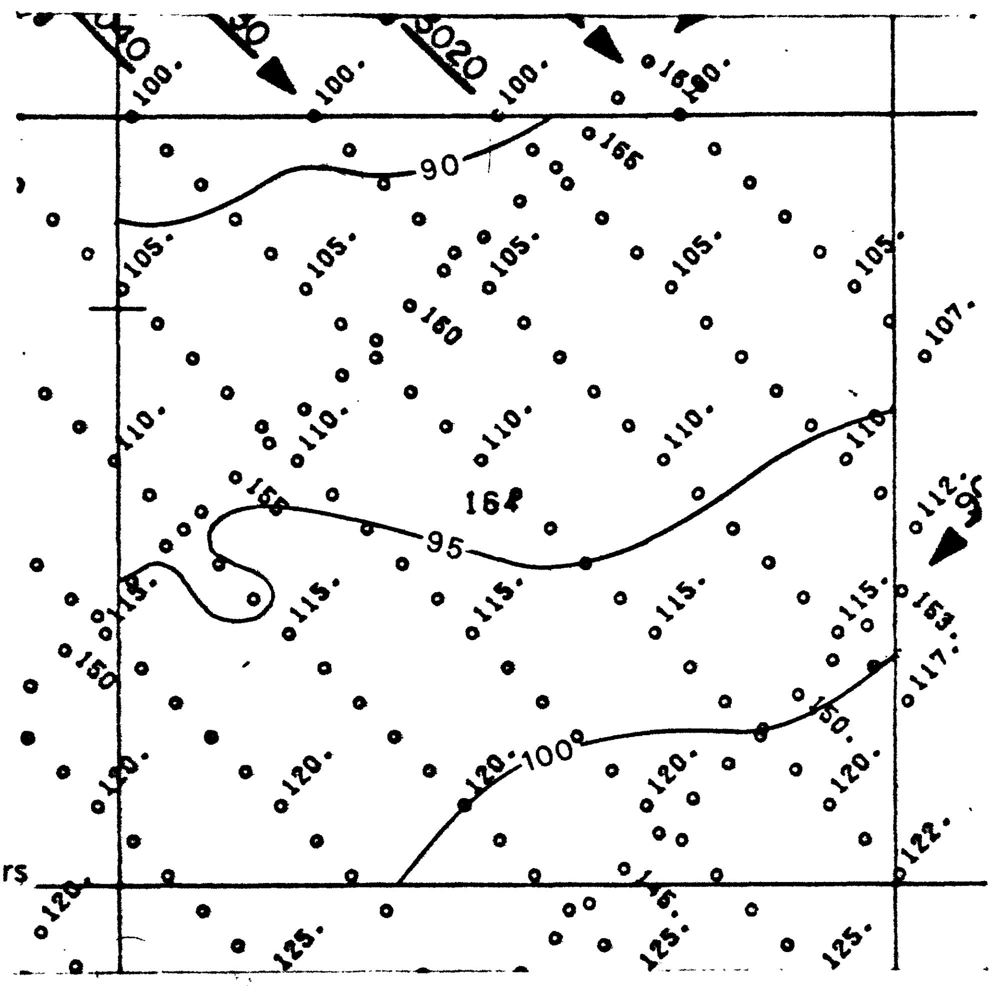
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 164
(NJ 18–3)

Contours in Meters

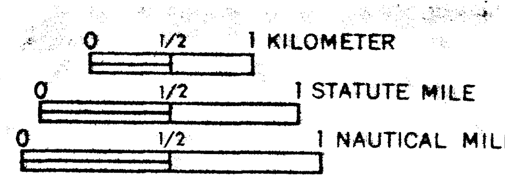



Water Depth: max. 103 m , min. 88 m

Slope Gradient: 4.7 m/km, Direction: SE

Surface Sediment Type: Mud

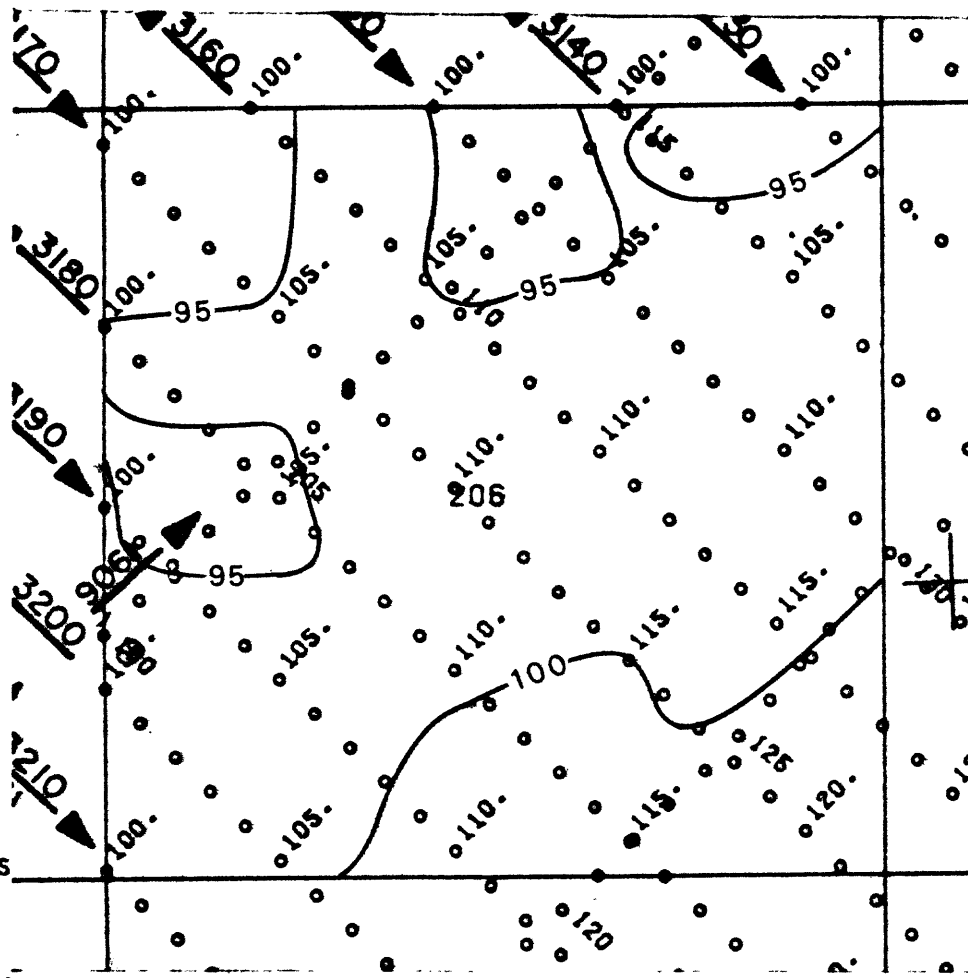
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 206
(NJ 18-3)

Contours in Meters

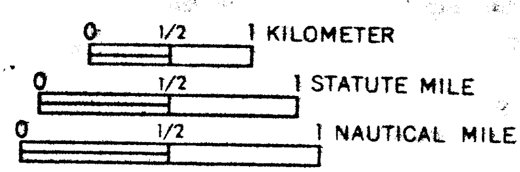



Water Depth: max. 103 m , min. 90 m

Slope Gradient: 3.2 m/km, Direction: SE

Surface Sediment Type: Mud

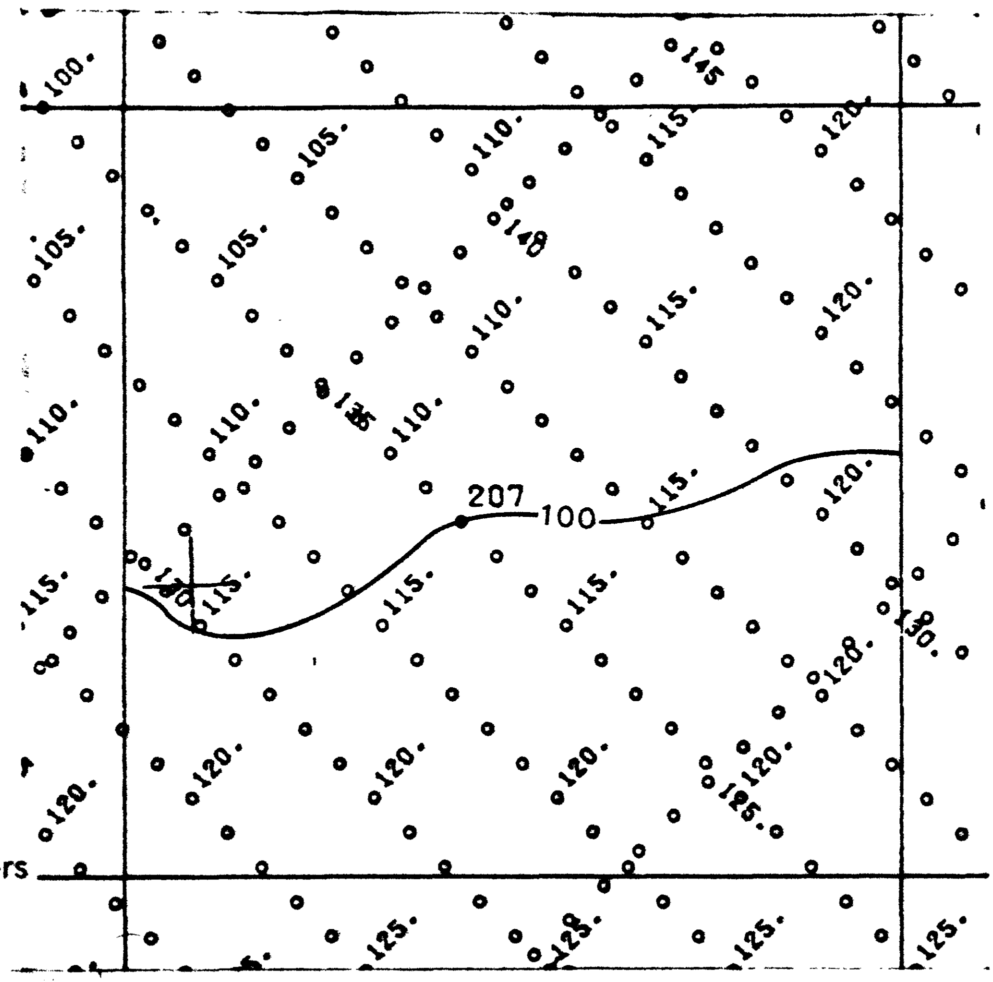
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 207
(NJ 18–3)

Contours in Meters

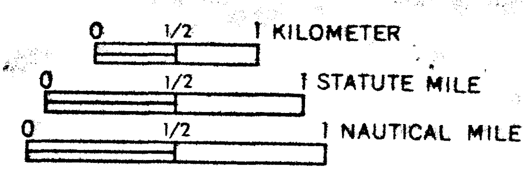



Water Depth: max. 109 m , min. 95 m

Slope Gradient: 3.2 m/km, Direction: SE

Surface Sediment Type: Mud

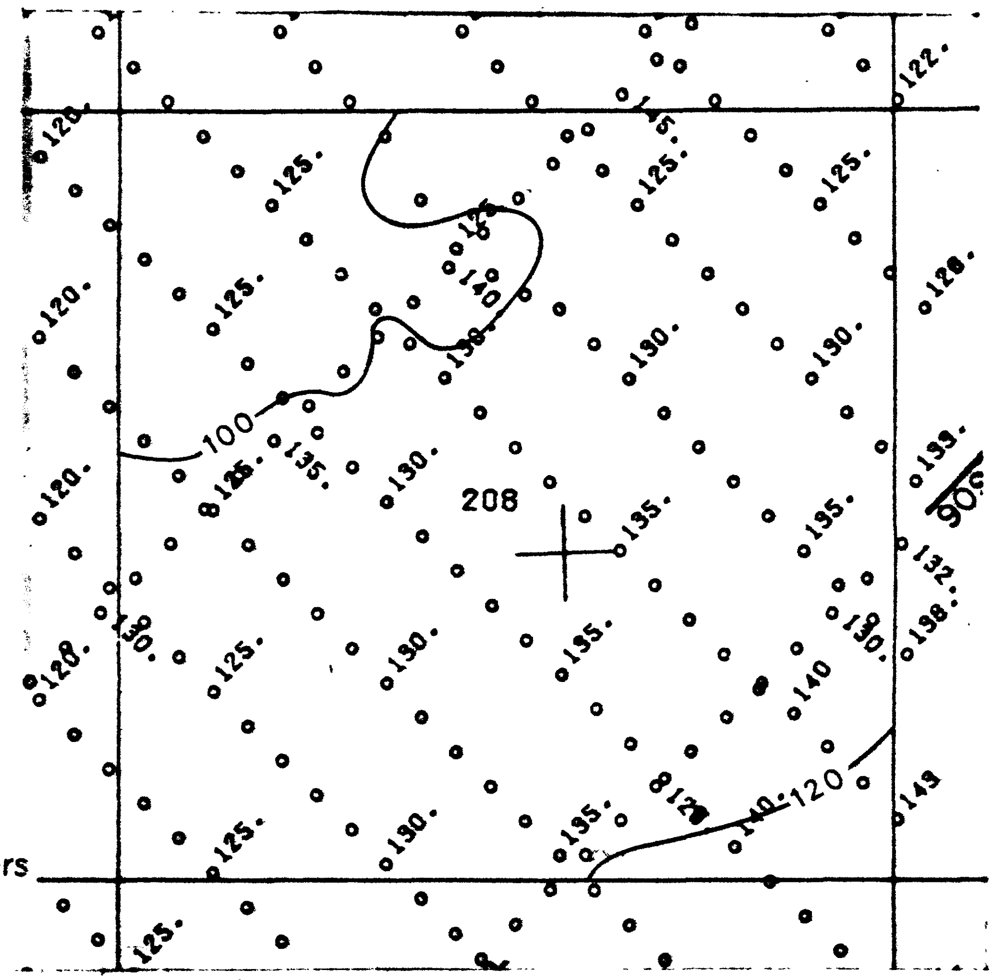
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 208
(NJ 18–3)

Contours in Meters

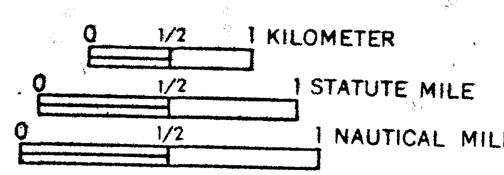



Water Depth: max. 126 m , min. 97 m

Map Scale 1:48,000

Slope Gradient: 5 m/km, Direction: SE

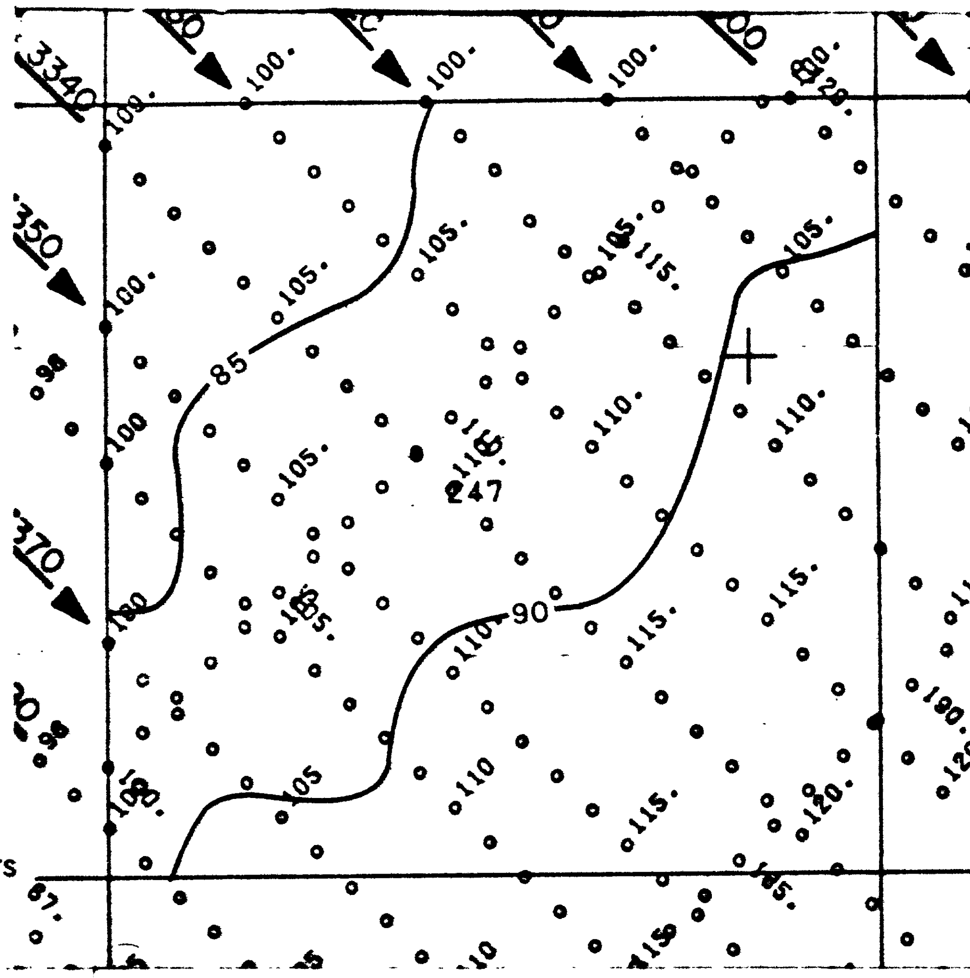
Surface Sediment Type: Mud



Proposed
Lease Sale #49

Block No. 247
(NJ 18–3)

Contours in Meters

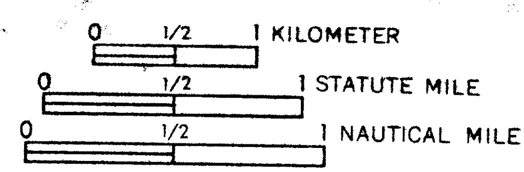



Water Depth: max. 92 m , min. 80 m

Map Scale 1:48,000

Slope Gradient: 2 m/km, Direction: SE

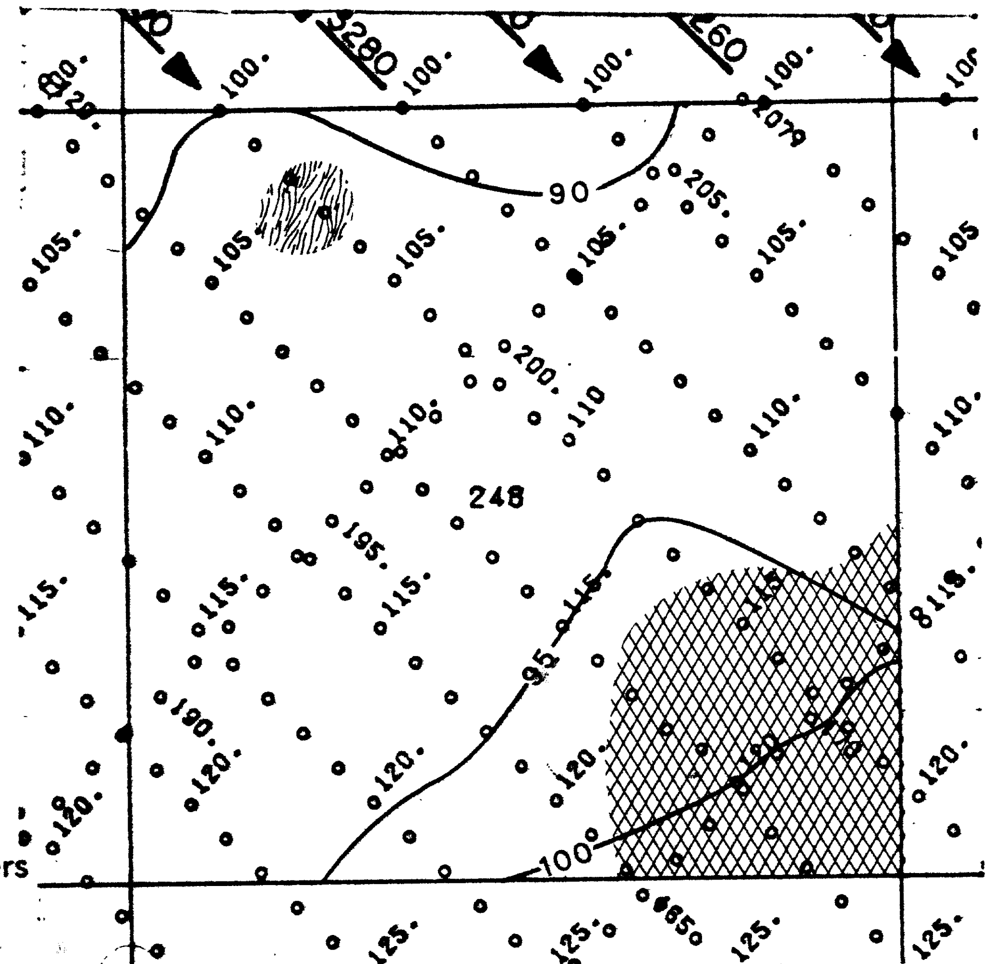
Surface Sediment Type: Sand



Proposed
Lease Sale #49

Block No. 248
(NJ 18–3)

Contours in Meters

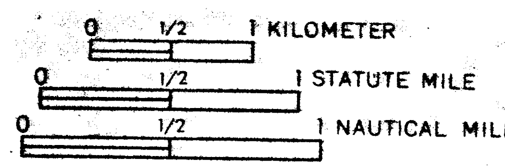



Map Scale 1:48,000

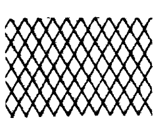
Water Depth: max. 105 m , min. 88 m

Slope Gradient: 2.1 m/km, Direction: SE

Surface Sediment Type: Fine sand




## CONSTRAINTS



Erosion/Scour

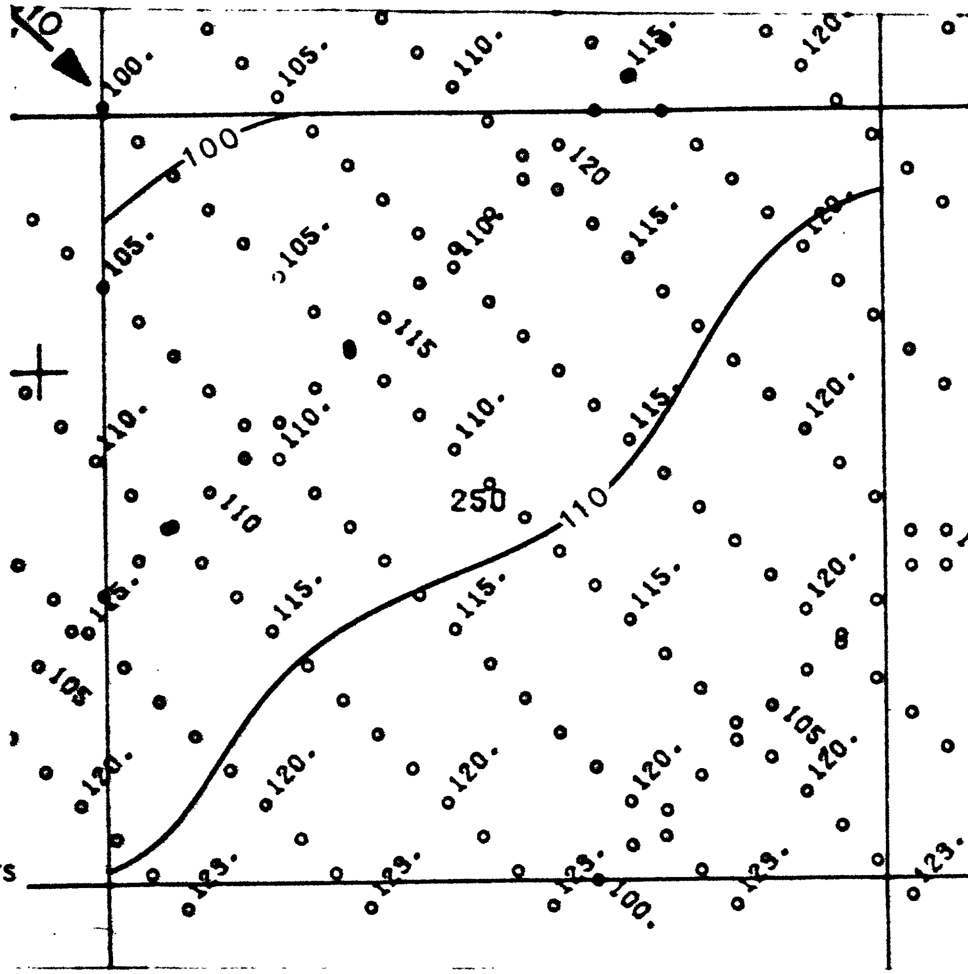
Lagoonal Sediments

Additional Comments: See figure 4

Proposed
Lease Sale #49

Block No. 250
(NJ 18–3)

Contours in Meters




Water Depth: max. 119 m , min. 99 m

Slope Gradient: 3.1 m/km, Direction: SE

Surface Sediment Type: Mud/sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

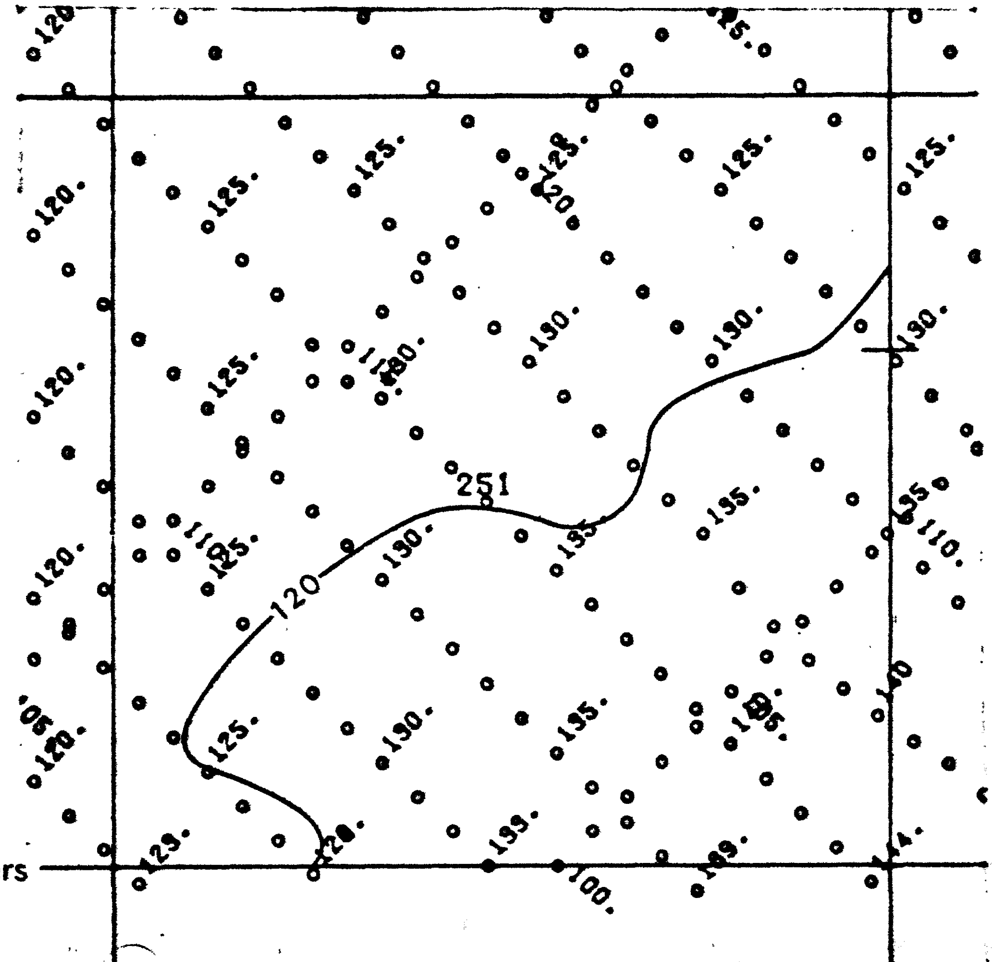
Proposed

Lease Sale #49

Block No. 251

(NJ 18–3)

Contours in Meters

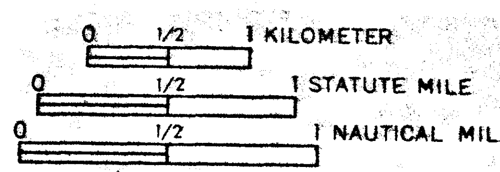



Water Depth: max. 125 m , min. 103 m

Map Scale 1:48,000

Slope Gradient: 2 m/km, Direction: SE

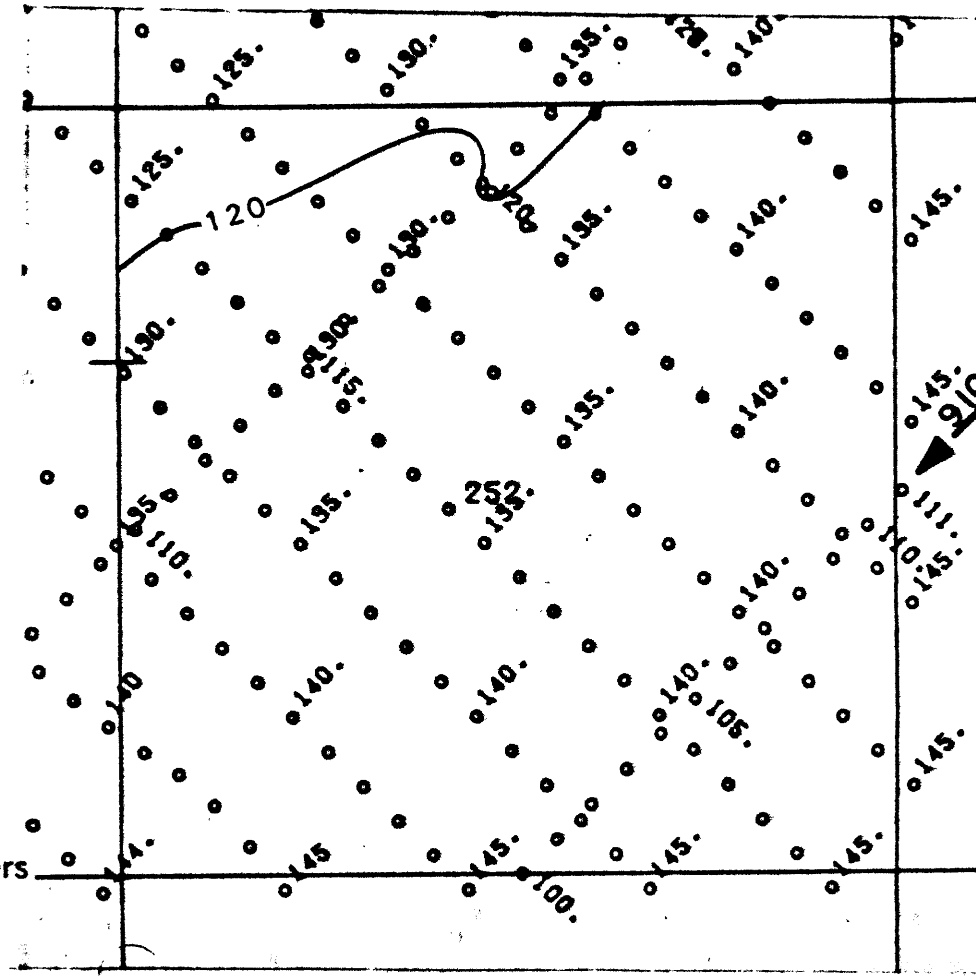
Surface Sediment Type: Mud



Proposed
Lease Sale #49

Block No. 252
(NJ 18–3)

Contours in Meters

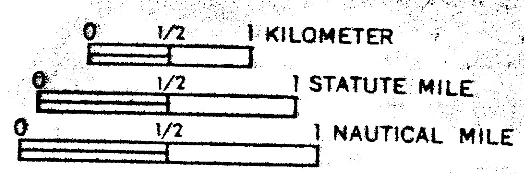



Water Depth: max. 127 m , min. 115 m

Slope Gradient: 2.6 m/km, Direction: SE

Surface Sediment Type: Mud

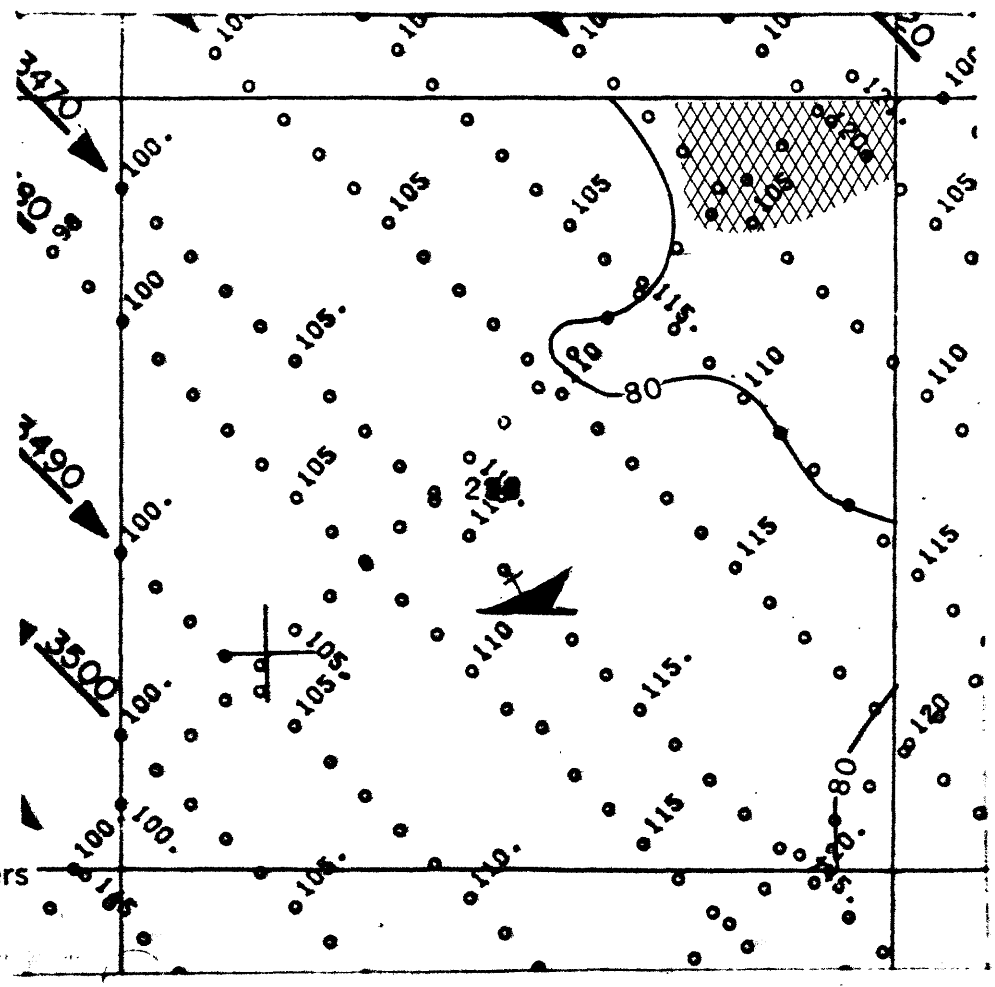
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 289
(NJ 18–3)

Contours in Meters

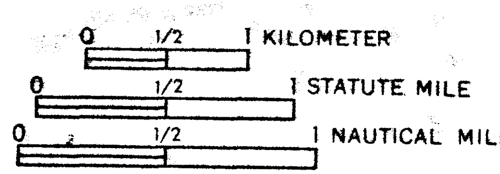



Water Depth: max. 80 m , min. 76 m

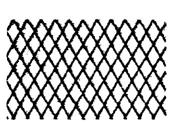
Map Scale 1:48,000

Slope Gradient: 1.8 m/km, Direction: SE

Surface Sediment Type: Sand




## CONSTRAINTS



Erosion/Scour

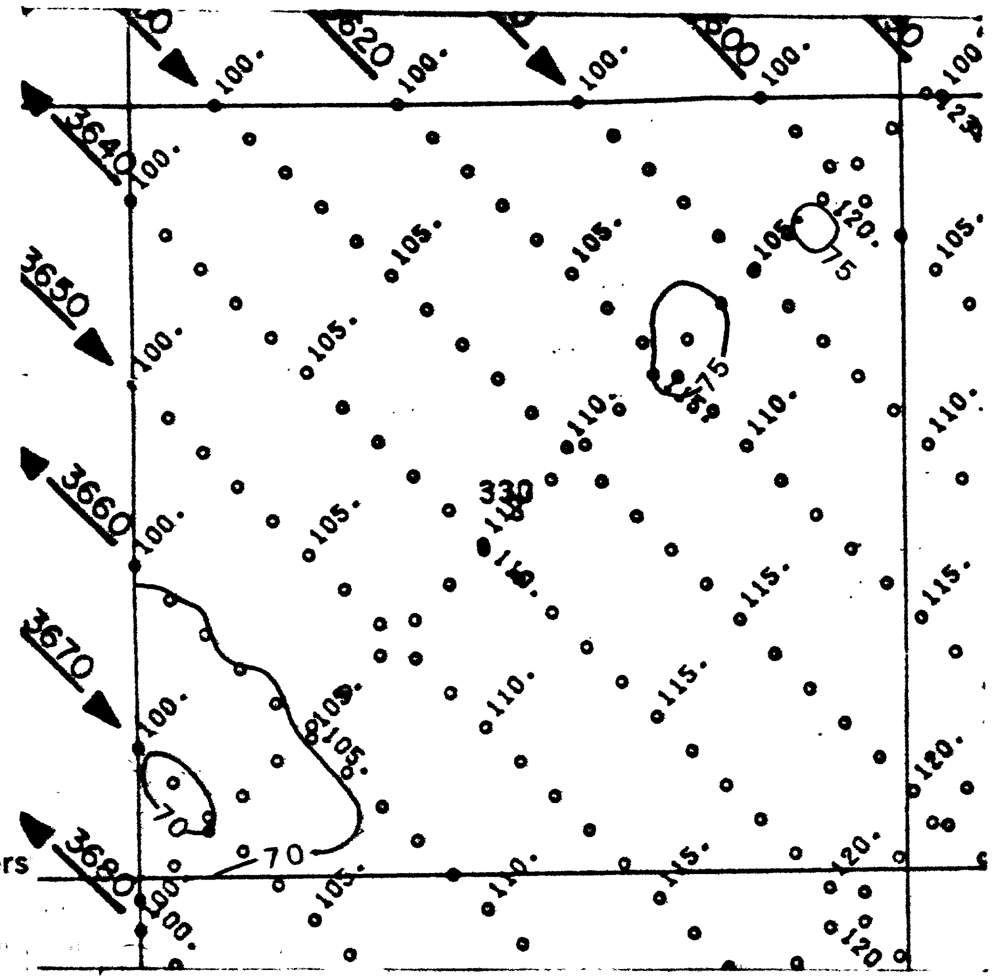
Shipwreck

Additional Comments: See figure 3

Proposed
Lease Sale #49

Block No. 330
(NJ 18–3)

Contours in Meters

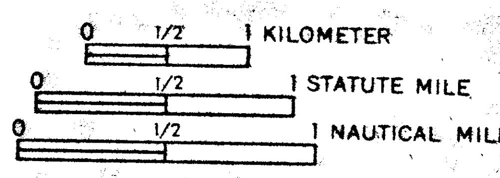



Water Depth: max. 73 m , min. 69 m

Map Scale 1:48,000

Slope Gradient: 1.1 m/km, Direction: NE

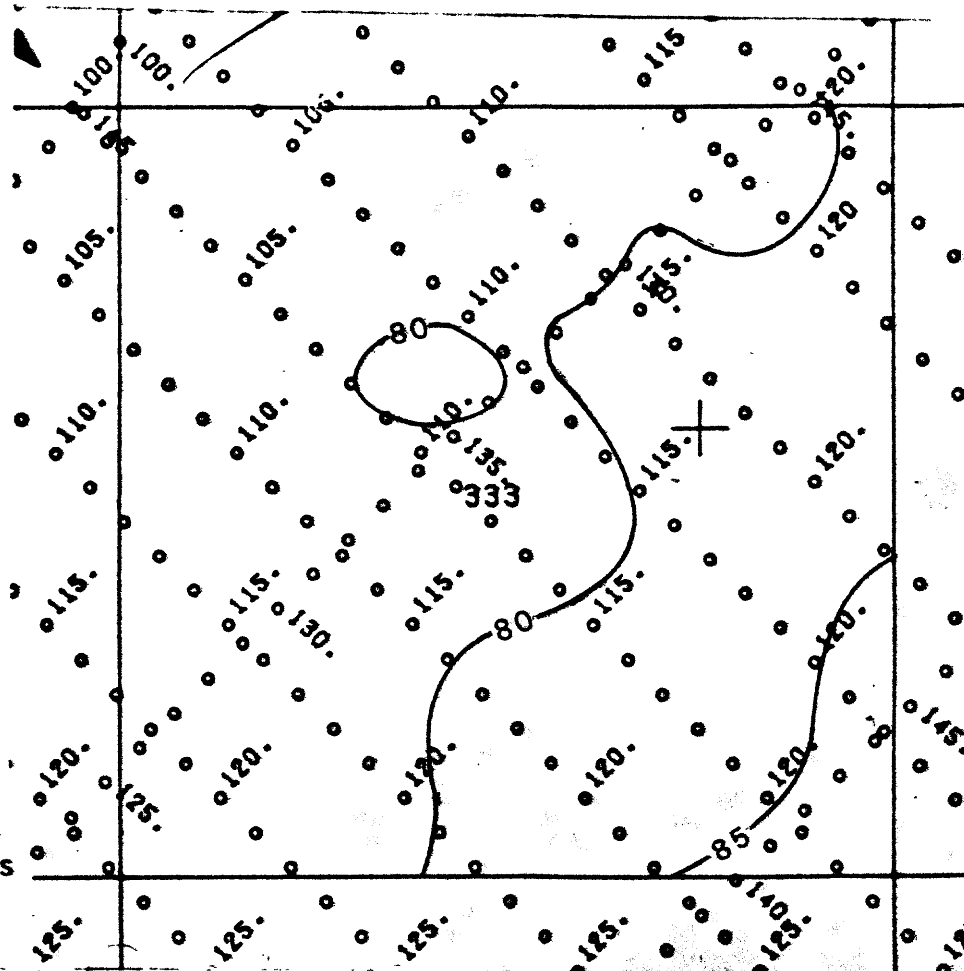
Surface Sediment Type: Fine sand



Proposed
Lease Sale #49

Block No. 333
(NJ 18–3)

Contours in Meters




Water Depth: max. 88 m , min. 76 m

Map Scale 1:48,000

Slope Gradient: 2.8 m/km, Direction: SE

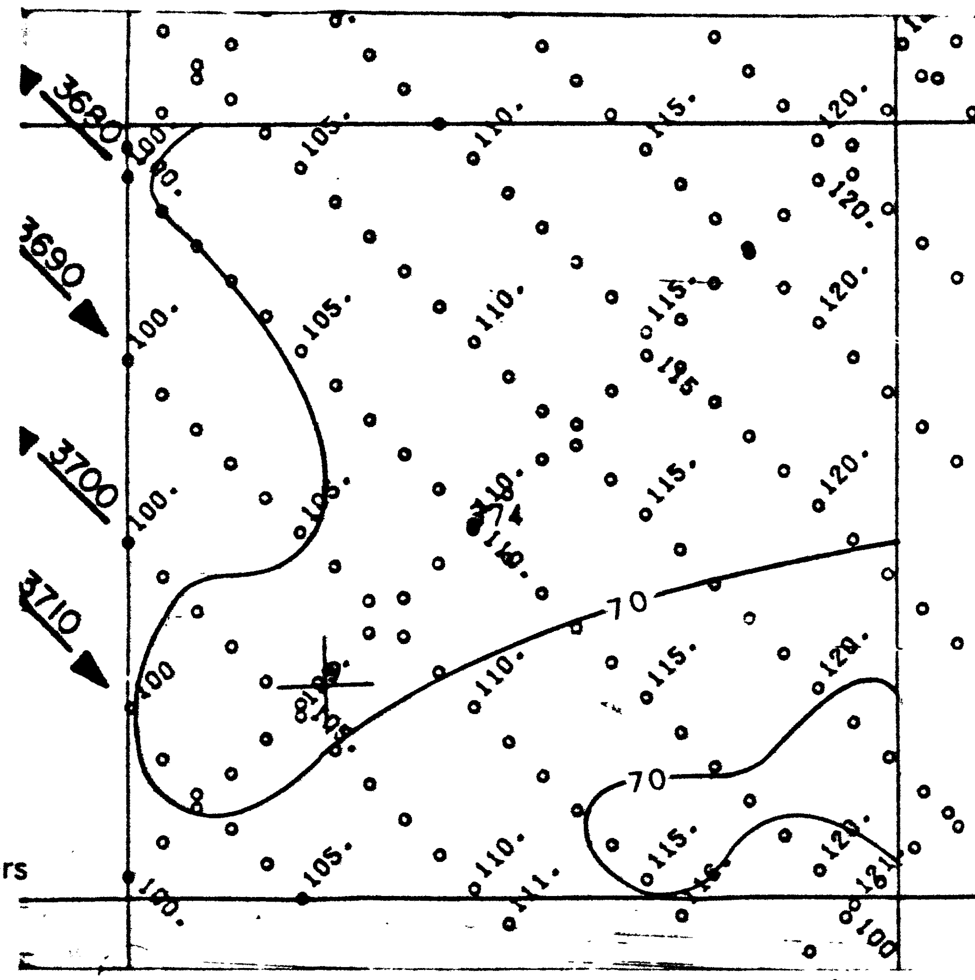
Surface Sediment Type: Fine sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 374
(NJ 18–3)

Contours in Meters

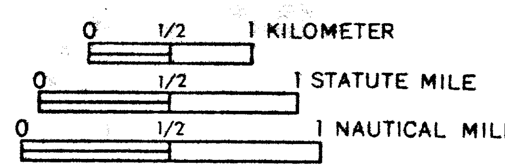



Water Depth: max. 73 m , min. 69 m

Map Scale 1:48,000

Slope Gradient: 0.9 m/km, Direction: SE

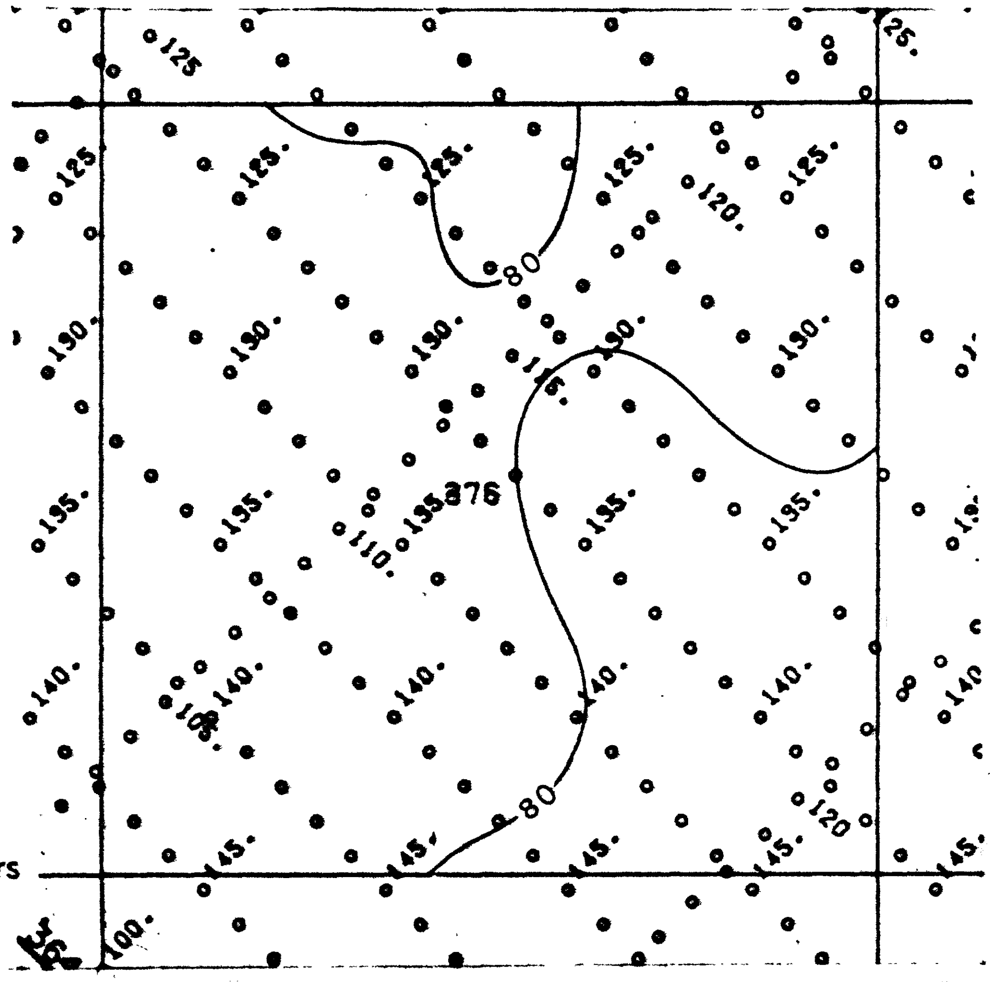
Surface Sediment Type: Fine sand



Proposed
Lease Sale #49

Block No. 376
(NJ 18–3)

Contours in Meters

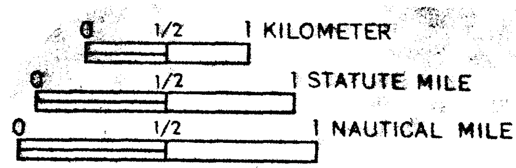



Water Depth: max. 85 m , min. 78 m

Map Scale 1:48,000

Slope Gradient: 2.1 m/km, Direction: SE

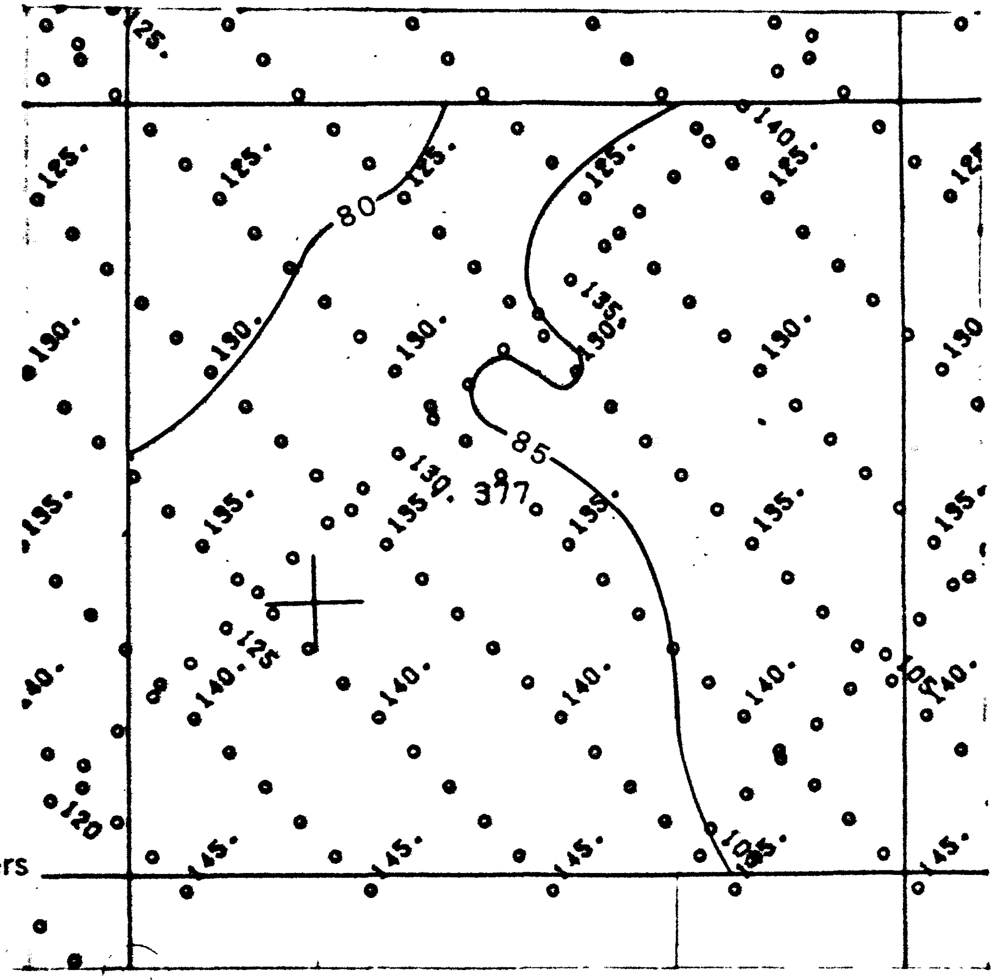
Surface Sediment Type: Fine sand



Proposed
Lease Sale #49

Block No. 377
(NJ 18–3)

Contours in Meters

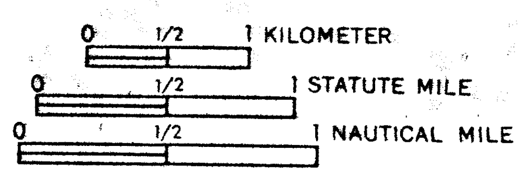


Water Depth: max. 88 m , min. 76 m

Map Scale 1:48,000

Slope Gradient: 2.7 m/km, Direction: SE

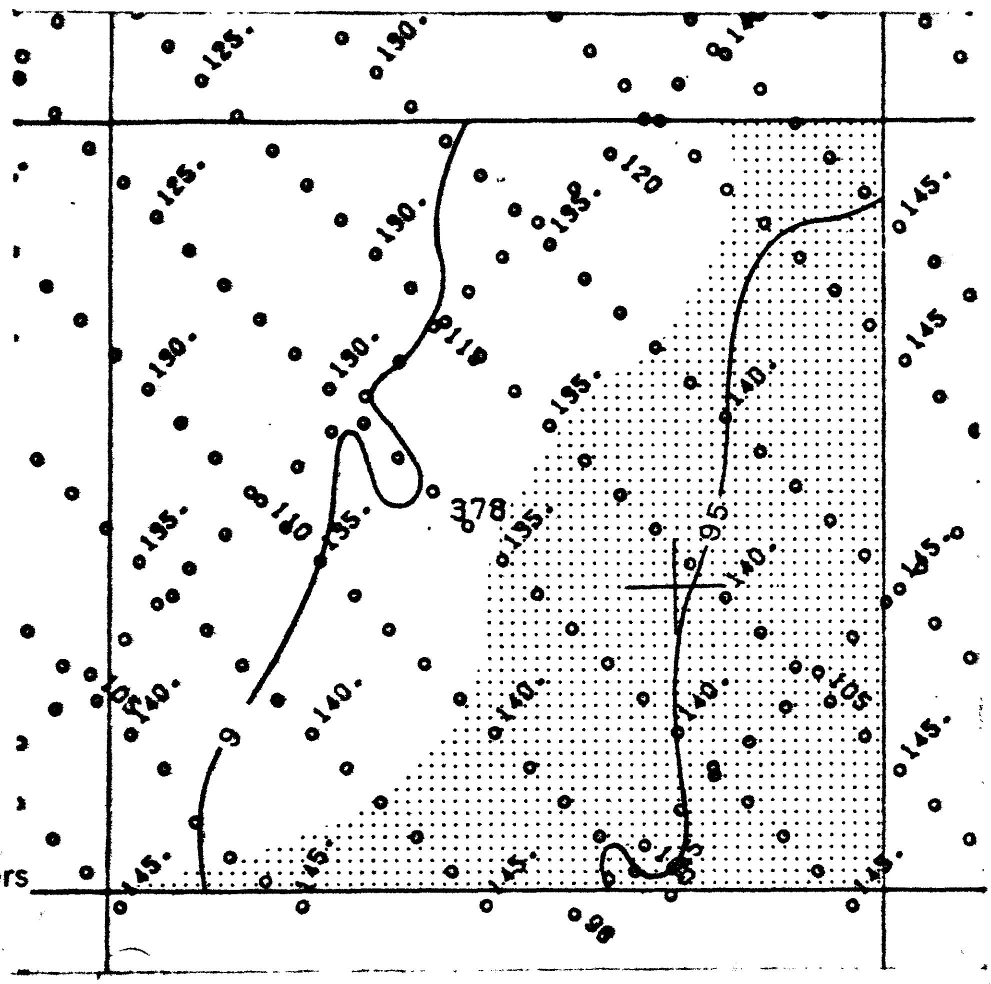
Surface Sediment Type: Sand



Proposed
Lease Sale #49

Block No. 378
(NJ 18–3)

Contours in Meters

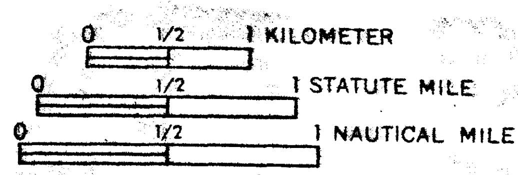



Water Depth: max. 97 m , min. 86 m

Slope Gradient: 2.2 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000



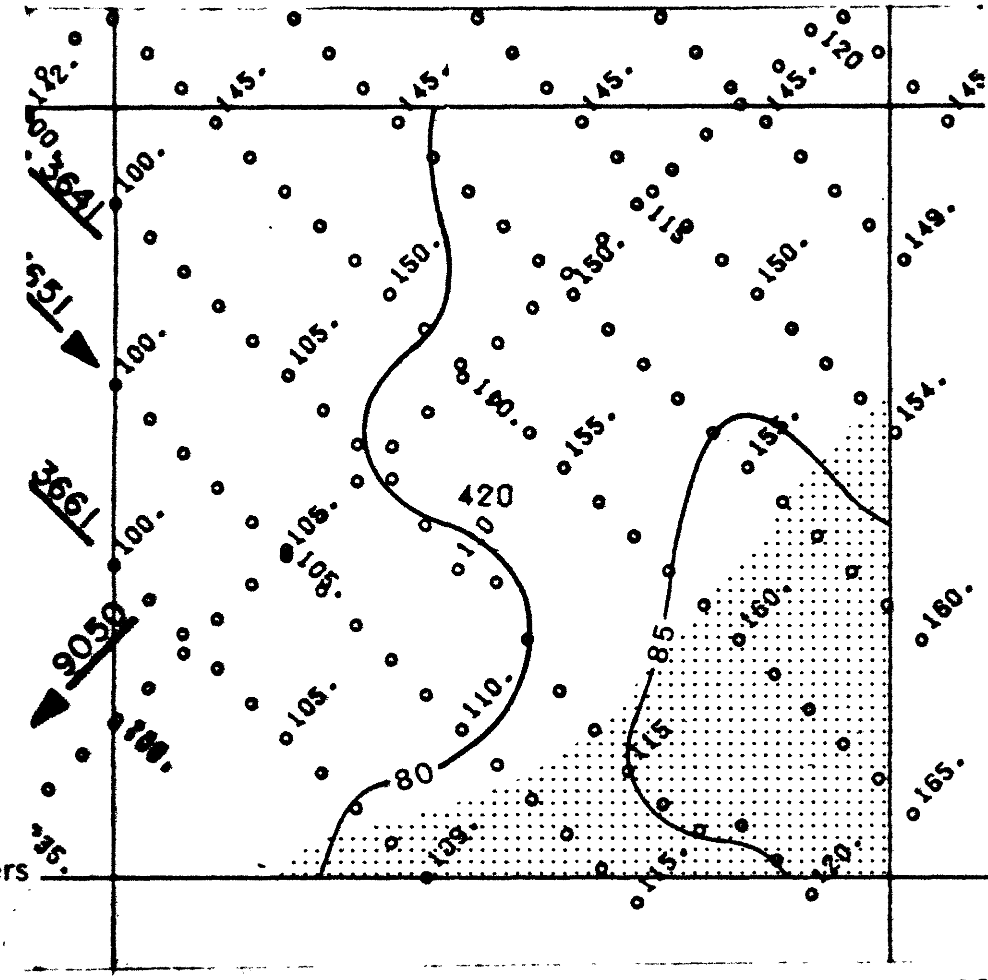

## CONSTRAINTS

Acoustically Turbid Zone

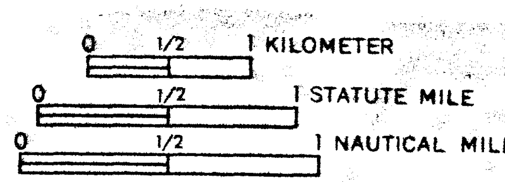
Proposed
Lease Sale #49

Block No. 420
(NJ 18–3)

Contours in Meters




Map Scale 1:48,000




Water Depth: max. 87 m , min. 77 m
Slope Gradient: 2.1 m/km, Direction: SE
Surface Sediment Type: Shelly sand

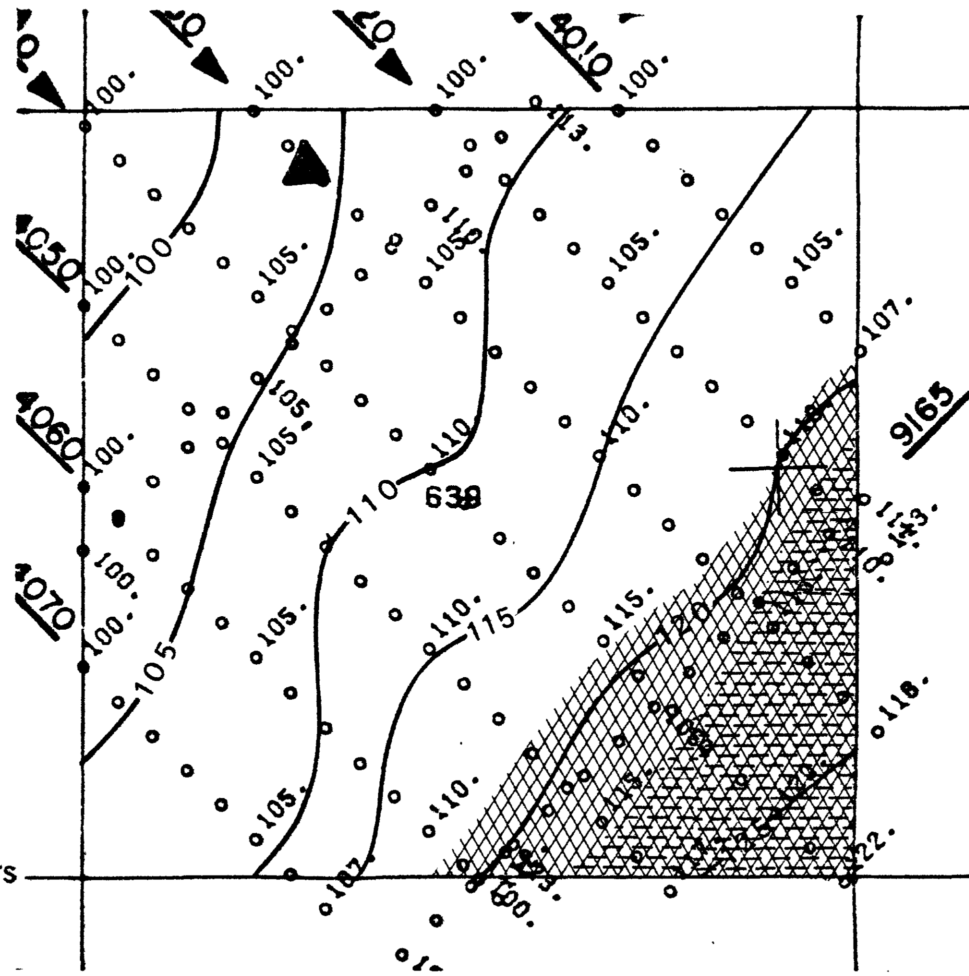
CONSTRAINTS

Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 639
(NJ 18–3)

Contours in Meters

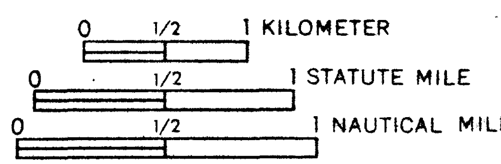



Water Depth: max. 127 m , min. 95 m

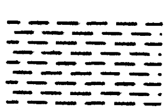
Slope Gradient: 5 m/km, Direction: SE

Surface Sediment Type: Muddy sand

Map Scale 1:48,000

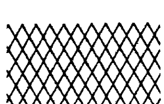



## CONSTRAINTS



Filled Channel

Bottom Object

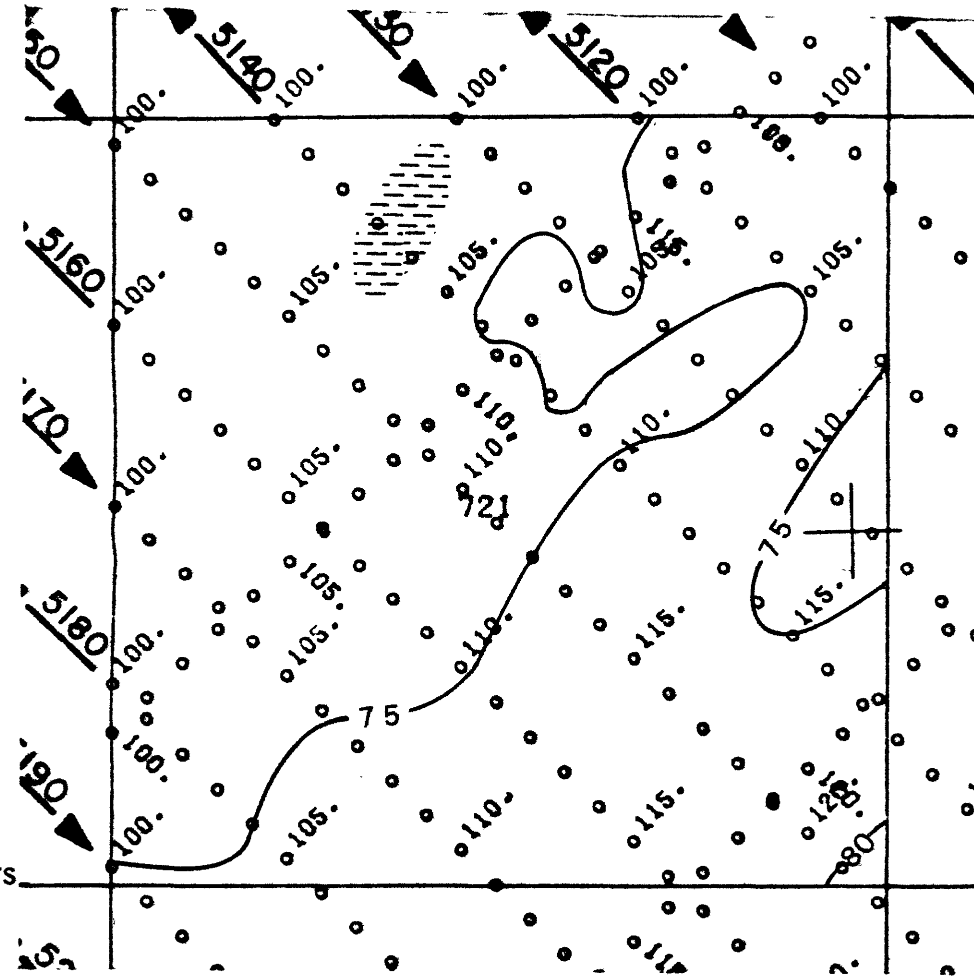


Erosion/Scour

Proposed
Lease Sale #49

Block No. 721
(NJ 18–3)

Contours in Meters

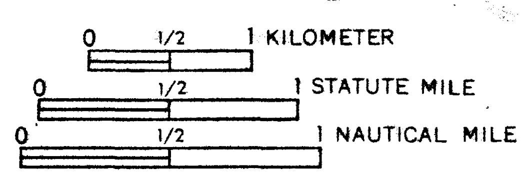



Water Depth: max. 81 m , min. 72 m

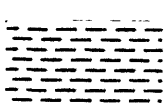
Slope Gradient: 1.2 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000




## CONSTRAINTS

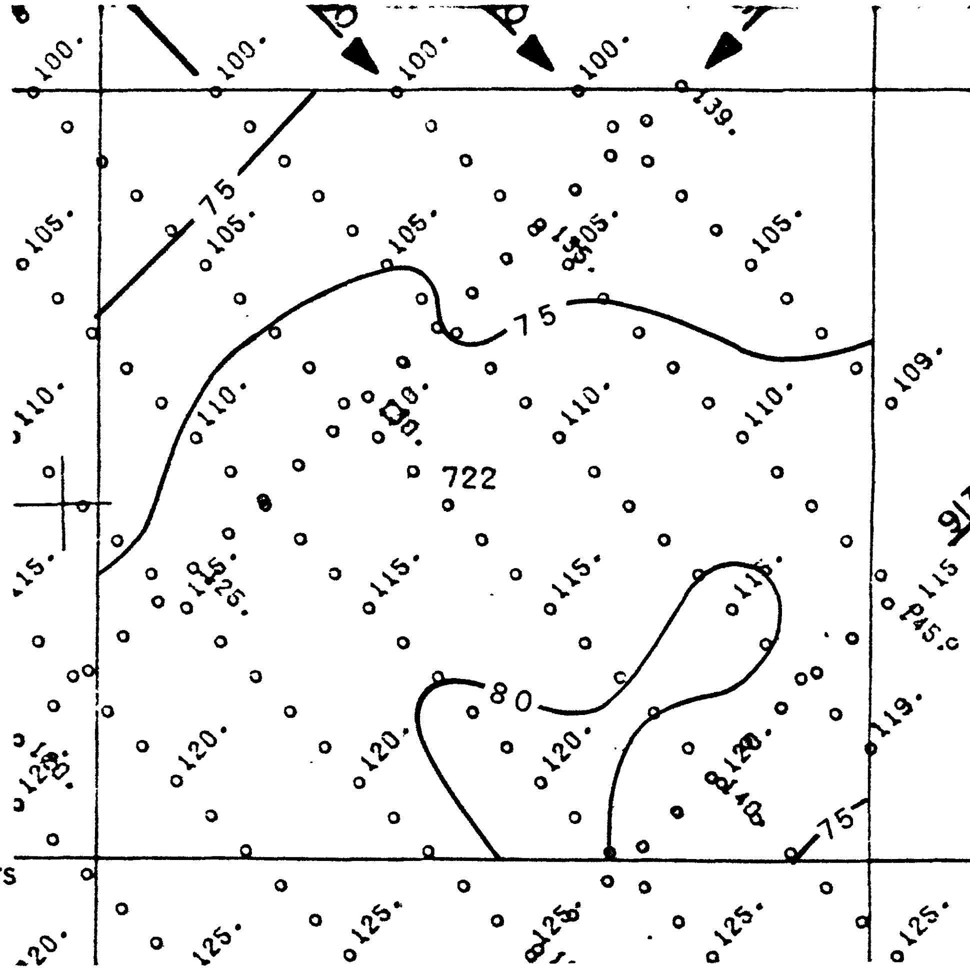


Filled Channel

Proposed
Lease Sale #49

Block No. 722
(NJ 18–3)

Contours in Meters

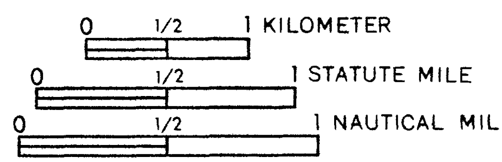



Water Depth: max. 81 m , min. 74 m

Slope Gradient: 1.9 m/km, Direction: SE

Surface Sediment Type: Sand

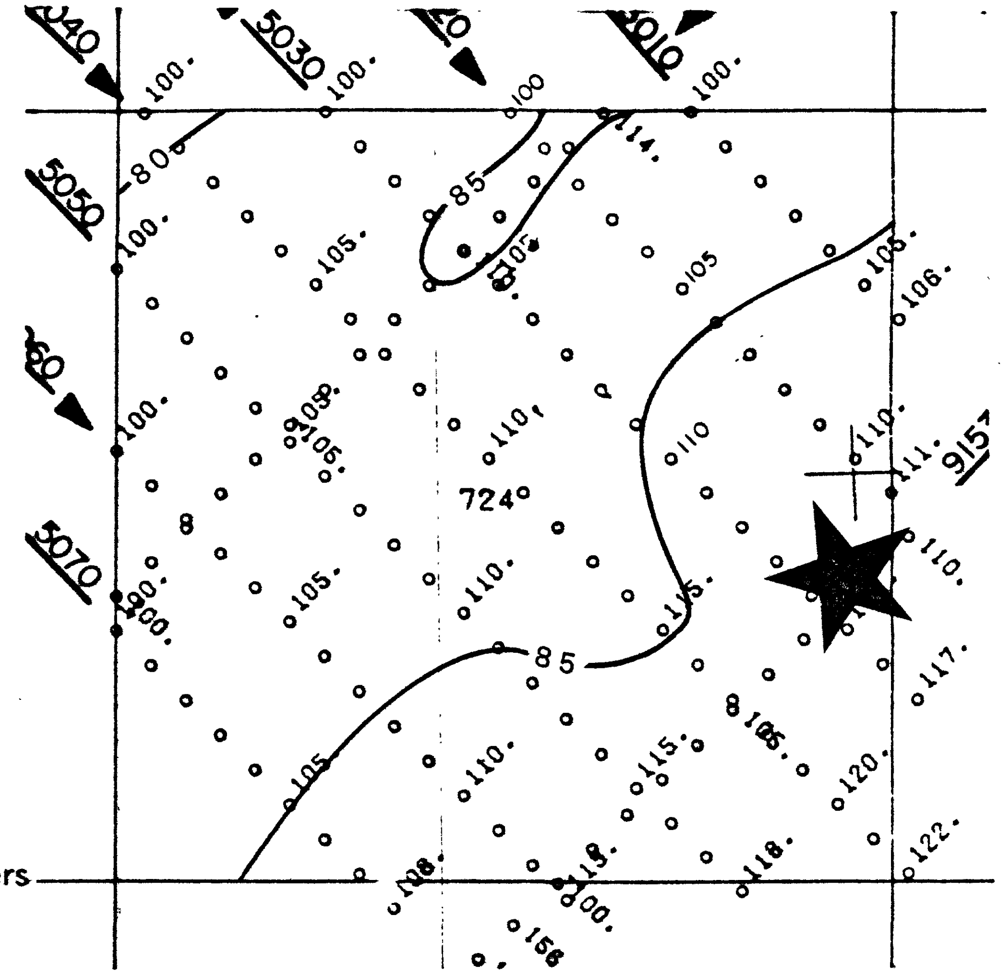
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 724
(NJ 18–3)

Contours in Meters

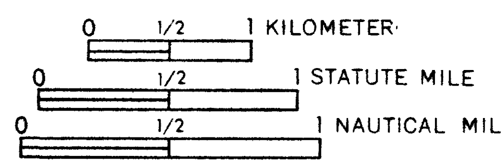



Water Depth: max. 86 m , min. 79 m

Map Scale 1:48,000

Slope Gradient: 2 m/km, Direction: SE

Surface Sediment Type: Sand




## HAZARDS

★ Shallow Gas Deposit

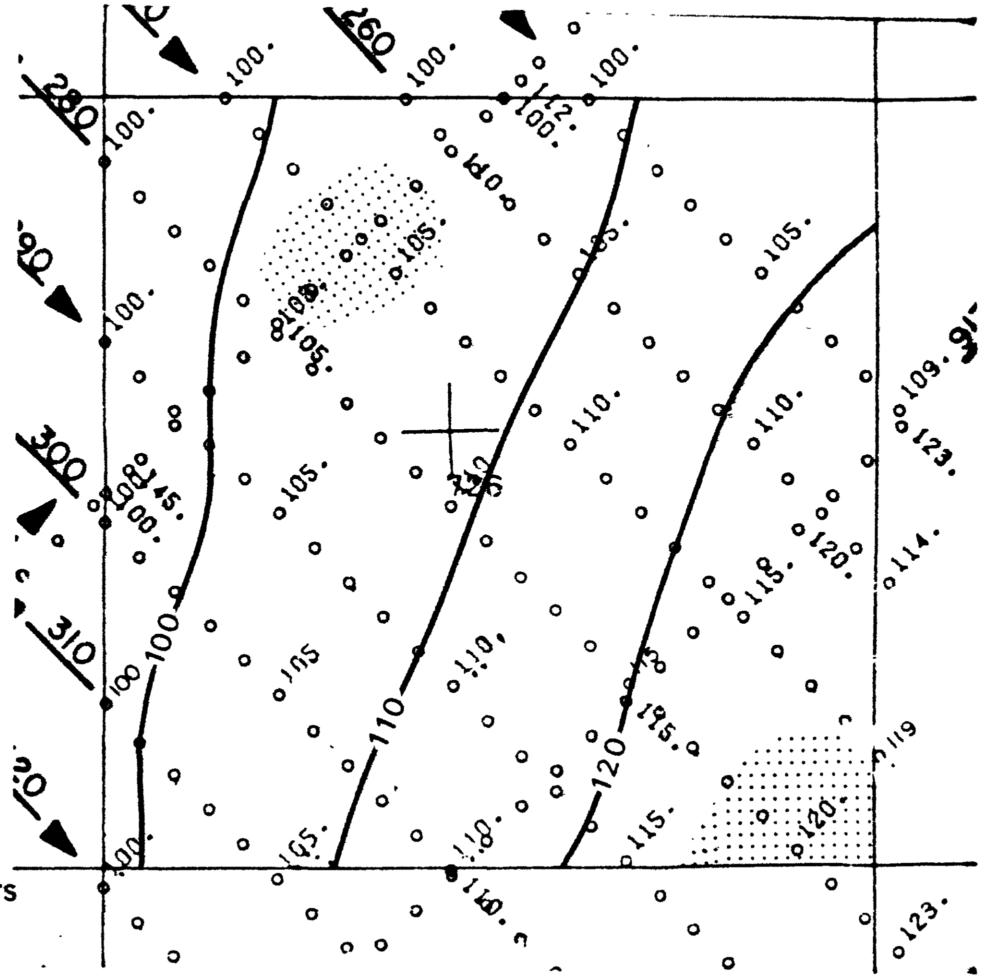
Additional Comments: The shallow gas deposit shown is illustrated in Figure 5 and discussed in the text.

See figure 2

Proposed
Lease Sale #49

Block No. 726
(NJ 18–3)

Contours in Meters

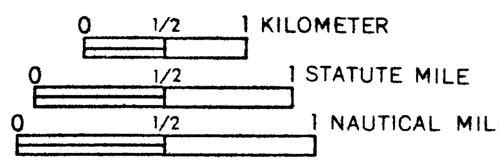



Water Depth: max. 121 m , min. 95 m

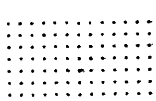
Slope Gradient: 4.5 m/km, Direction: SE

Surface Sediment Type: Mud

Map Scale 1:48,000




## CONSTRAINTS

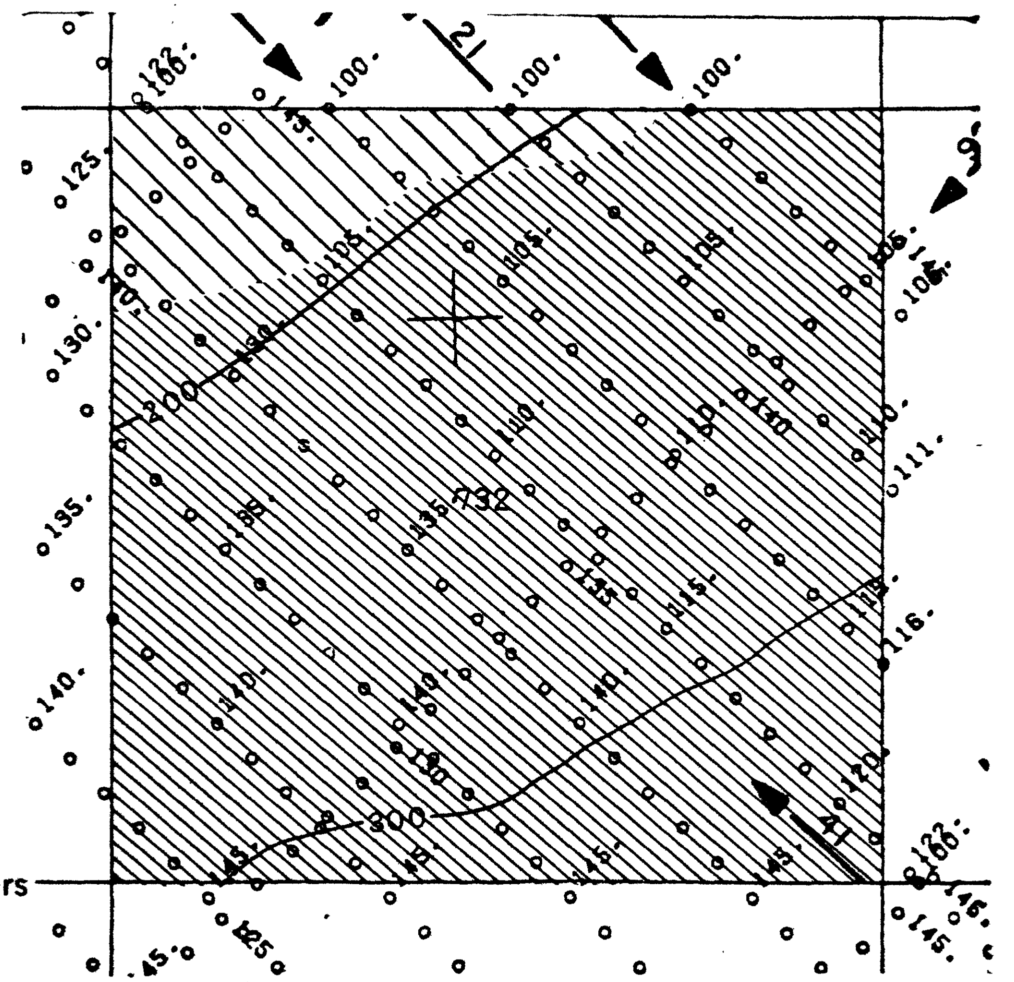


Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 732
(NJ 18–3)

Contours in Meters

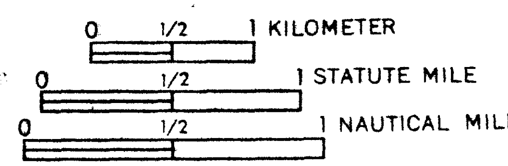



Water Depth: max. 360 m , min. 160 m

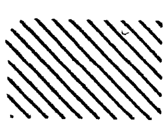
Slope Gradient: 30 m/km, Direction: SE

Surface Sediment Type: Sand/clay

Map Scale 1:48,000

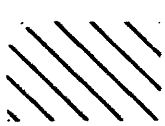



## HAZARDS



Slump or Slide

## CONSTRAINTS

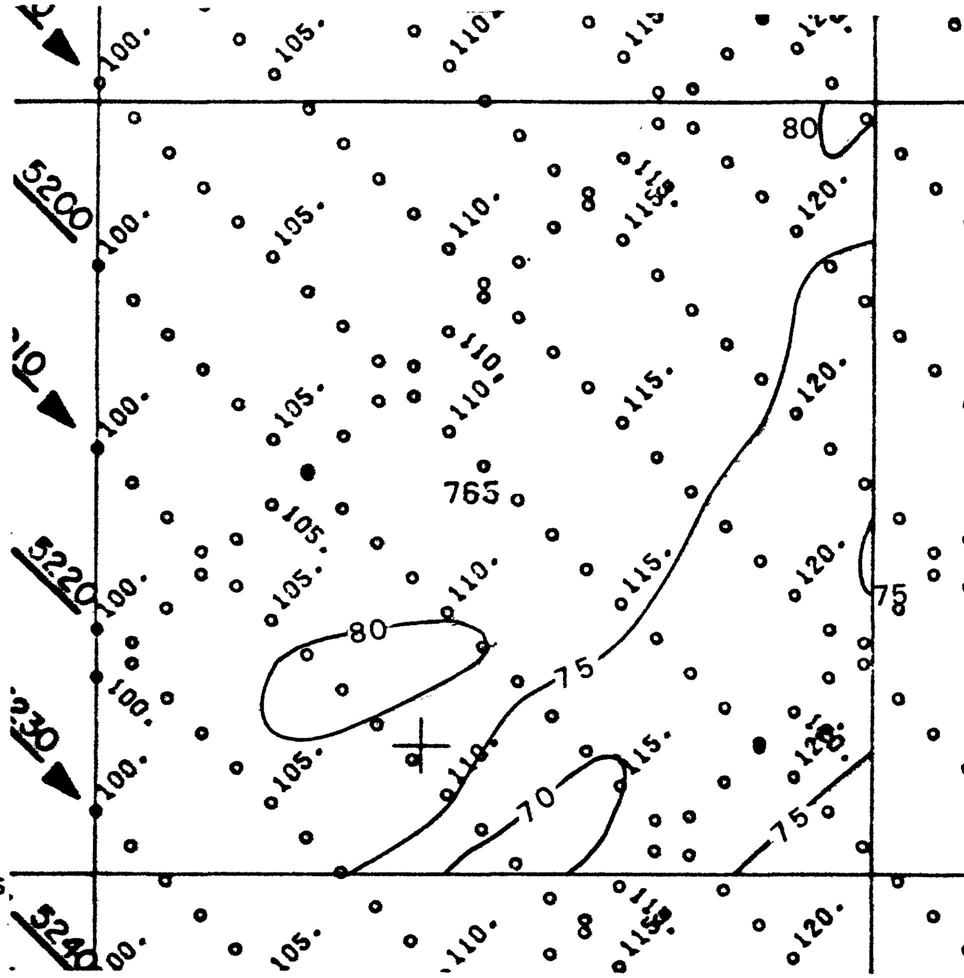


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 765
(NJ 18-3)

Contours in Meters

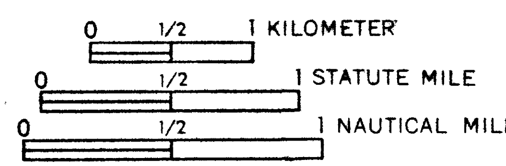



Water Depth: max. 81 m , min. 69 m

Map Scale 1:48,000

Slope Gradient: 1.6 m/km, Direction: SE

Surface Sediment Type: Sand

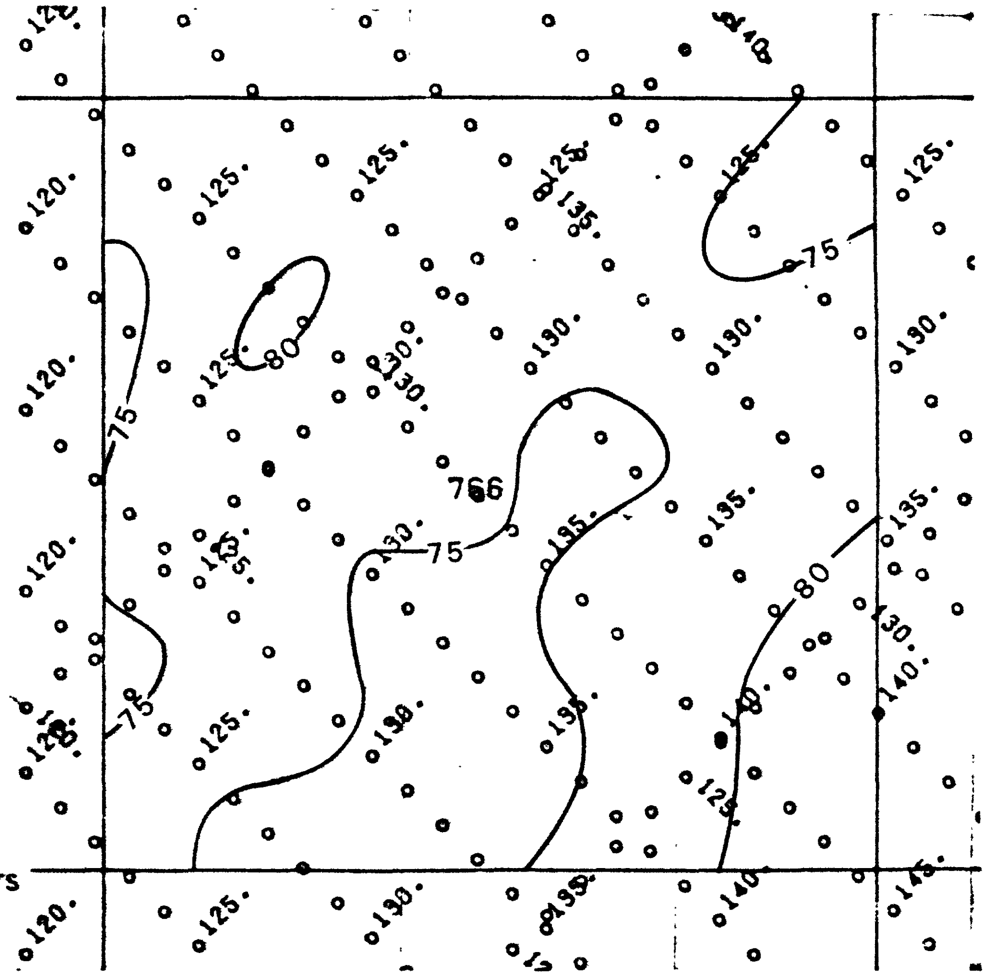



Additional Comments: See figure 5

Proposed
Lease Sale #49

Block No. 766
(NJ 18–3)

Contours in Meters

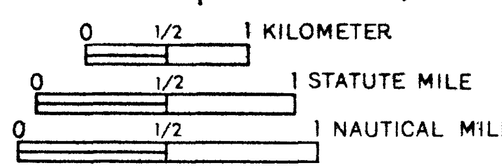



Water Depth: max. 82 m , min. 75 m

Slope Gradient: 3 m/km, Direction: SE

Surface Sediment Type: Silty sand

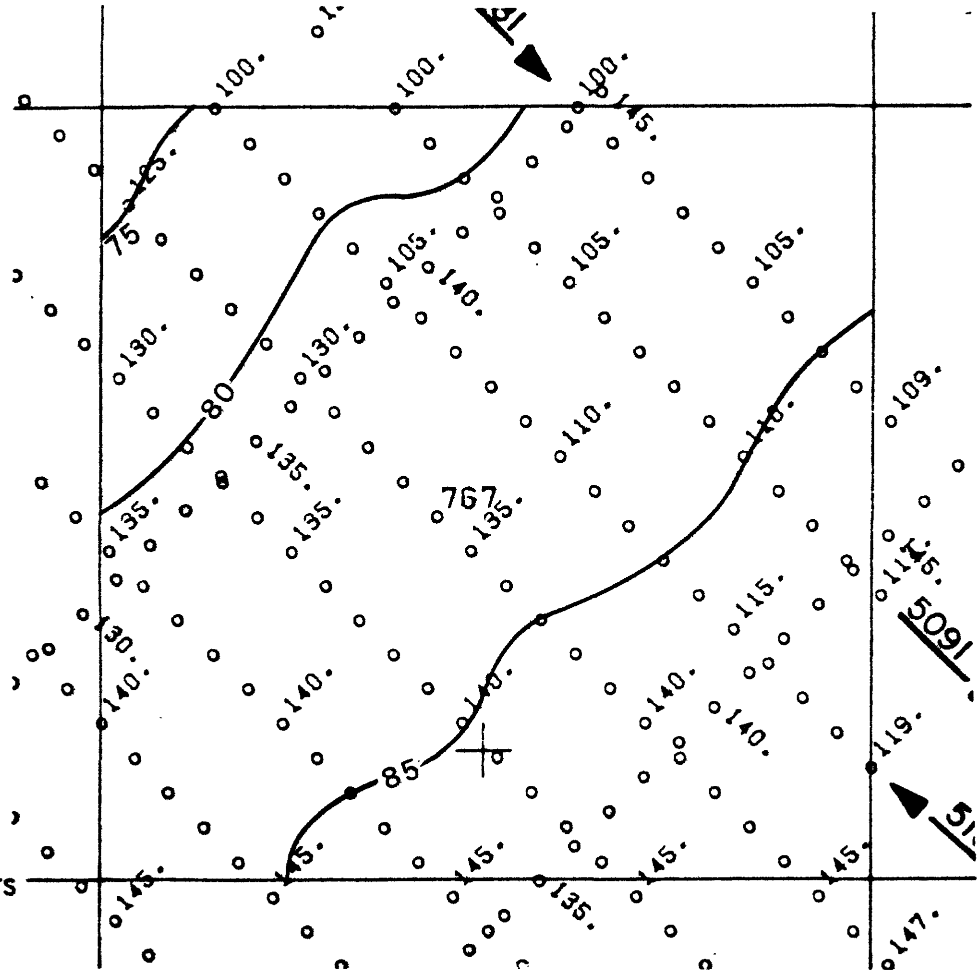
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 767
(NJ 18–3)

Contours in Meters



Water Depth: max. 88 m , min. 75 m

Slope Gradient: 1.3 m/km, Direction: SE

Surface Sediment Type: Sand

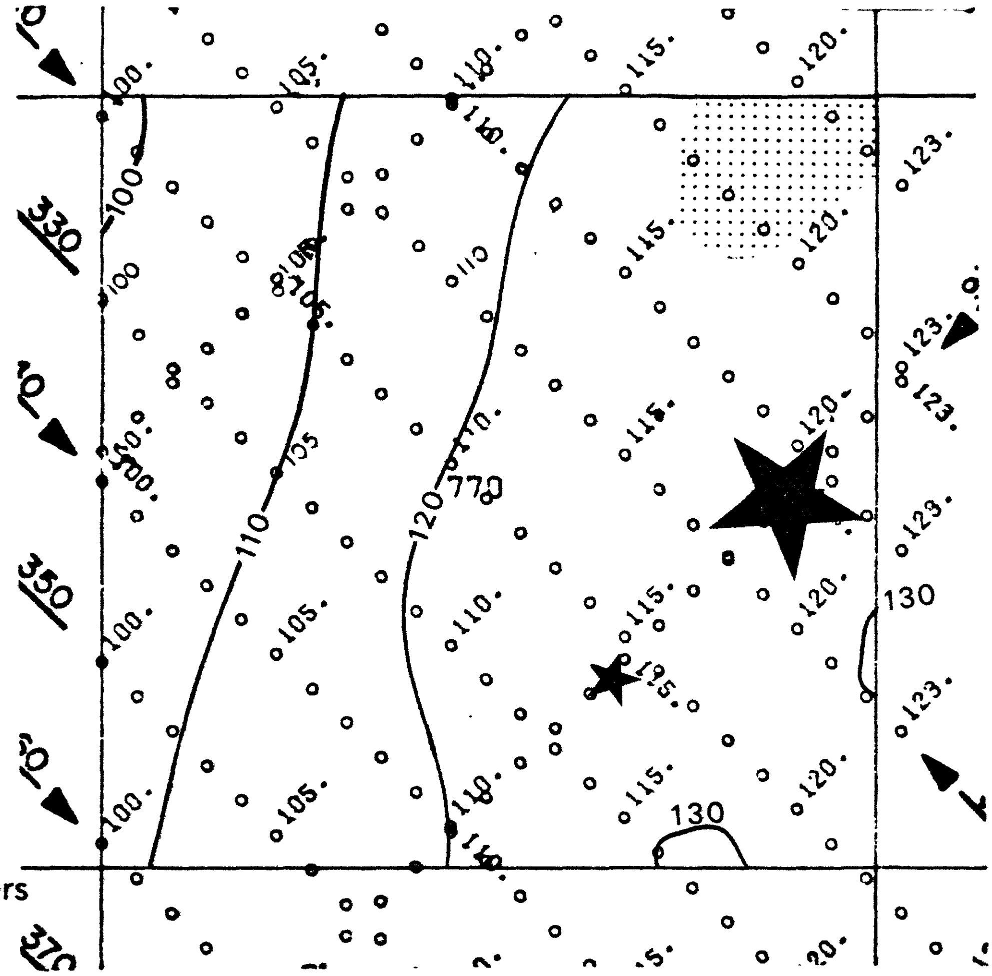
Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 770
(NJ 18-3)

Contours in Meters




Water Depth: max. 130 m , min. 100 m

Slope Gradient: 6 m/km, Direction: SE

Surface Sediment Type: Muddy silt,

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

★ Shallow Gas Deposit

## CONSTRAINTS

Acoustically Turbid Zone

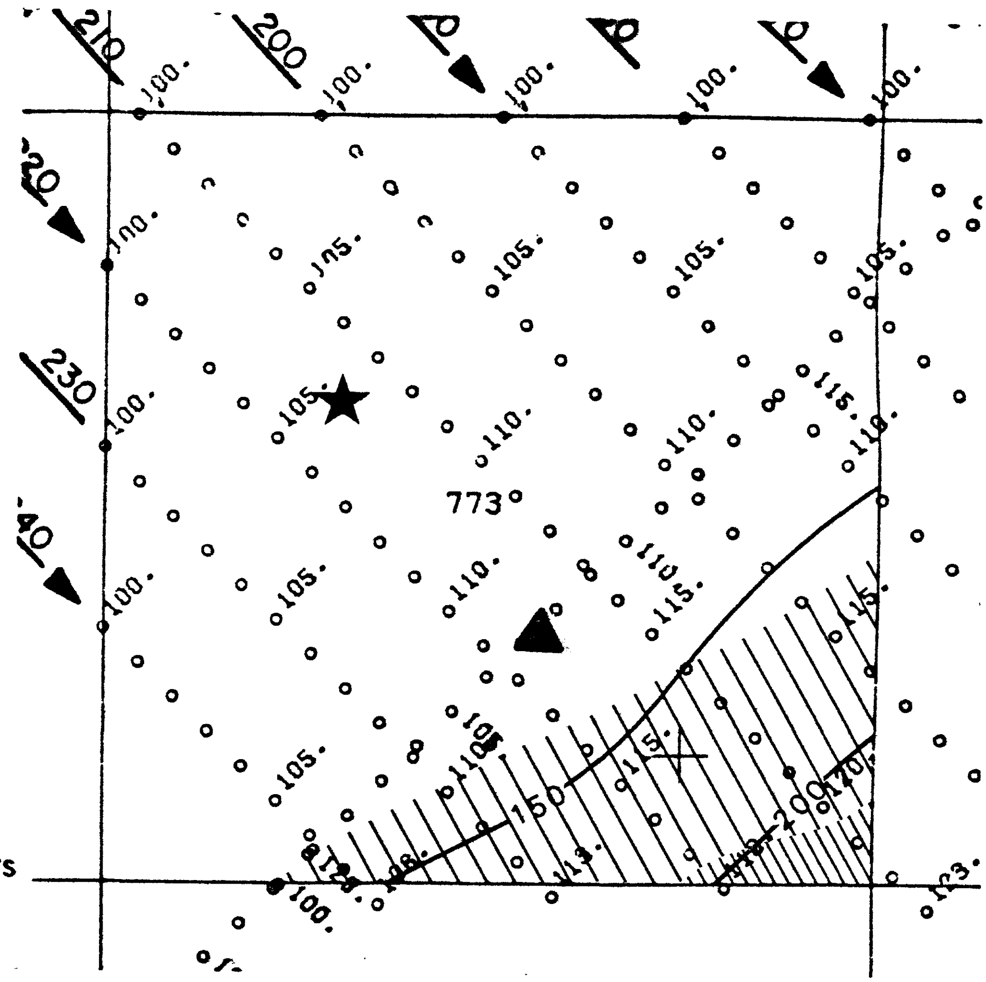
Additional comments: Undetonated explosives- southern 1/3 of block (BLM, Sale 49 EIS, Visual # 1)

See figure 1

Proposed
Lease Sale #49

Block No. 773
(NJ 18–3)

Contours in Meters




Water Depth: max. 230 m , min. 140 m

Slope Gradient: 40 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

Shallow Gas Deposit

## CONSTRAINTS

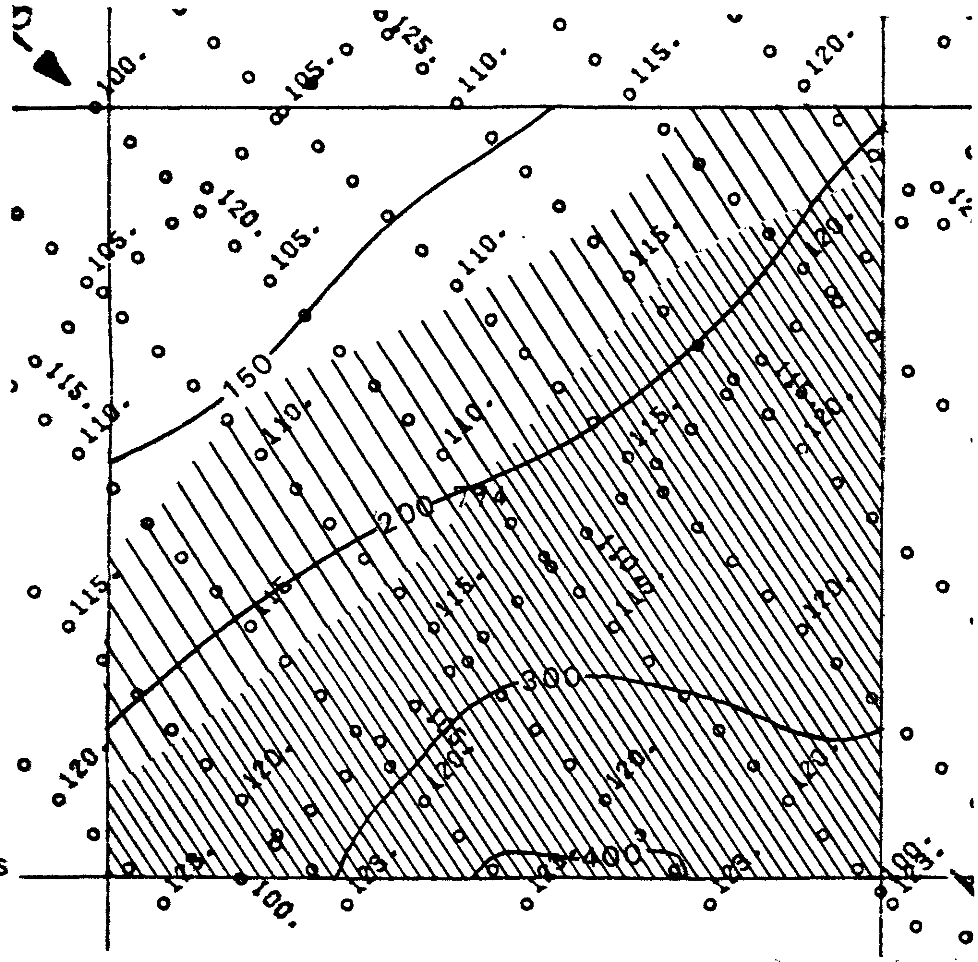
Potentially Unstable Slope

Bottom Object

Proposed
Lease Sale #49

Block No. 774
(NJ 18–3)

Contours in Meters




Water Depth: max. 325 m , min. 140 m

Slope Gradient: 42 m/km, Direction: SE

Surface Sediment Type: Sand

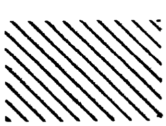
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS



Slump or Slide

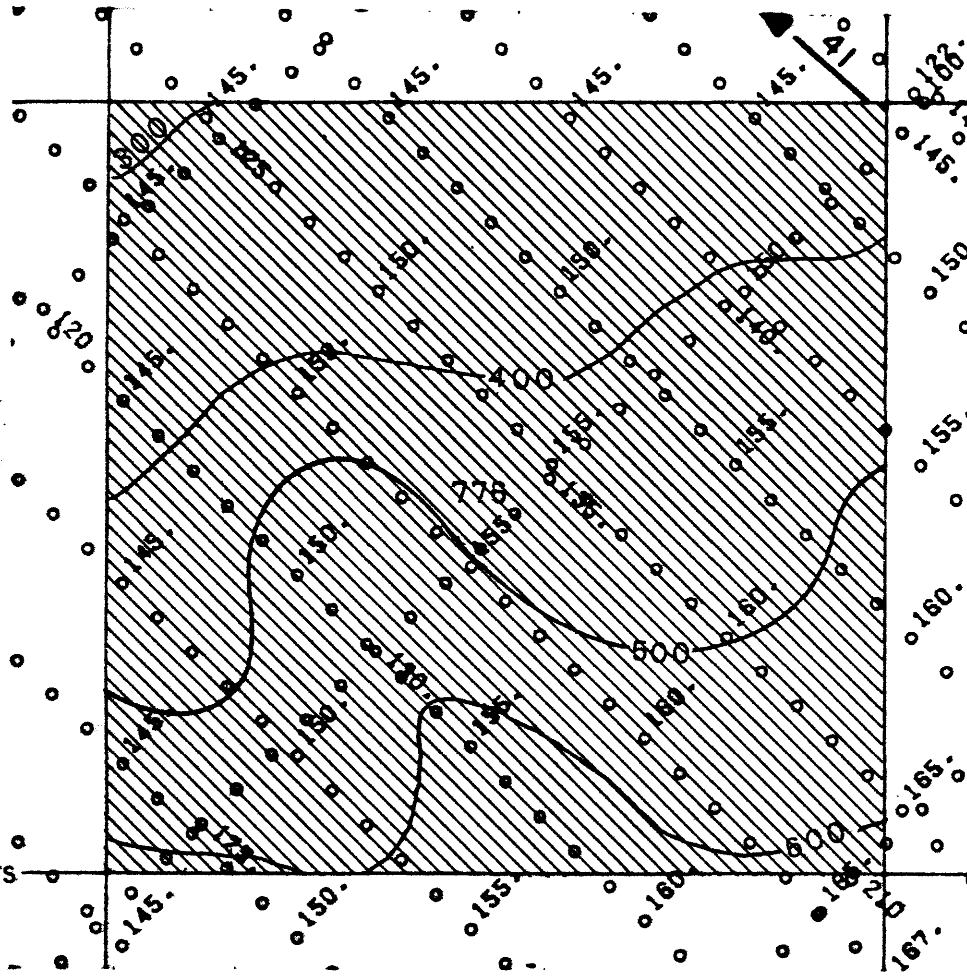
## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 776
(NJ 18–3)

Contours in Meters




Water Depth: max. 650 m , min. 280 m

Slope Gradient: 50 m/km, Direction: SE

Surface Sediment Type: Sandy clay

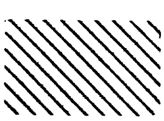
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

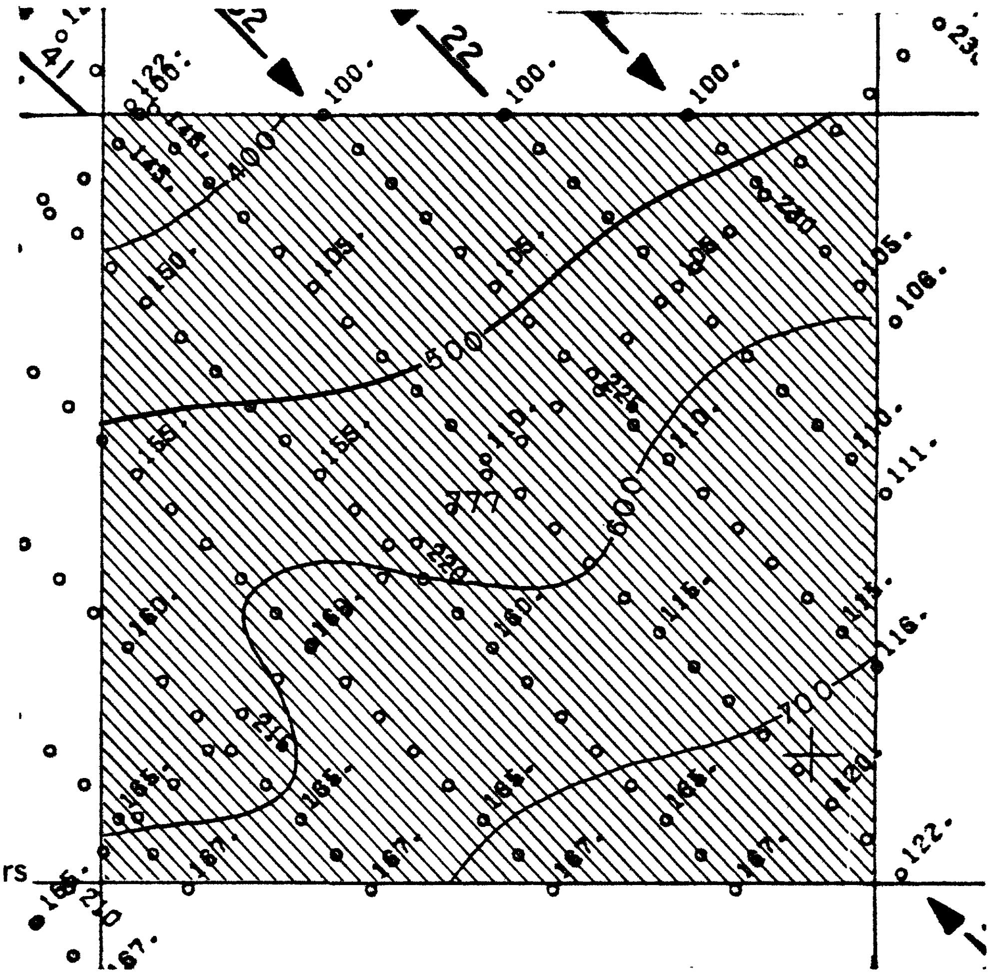


Slump or Slide

Proposed
Lease Sale #49

Block No. 777
(NJ 18–3)

Contours in Meters




Water Depth: max. 765 m , min. 400 m

Slope Gradient: 60 m/km, Direction: SE

Surface Sediment Type: Sandy silt

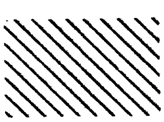
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

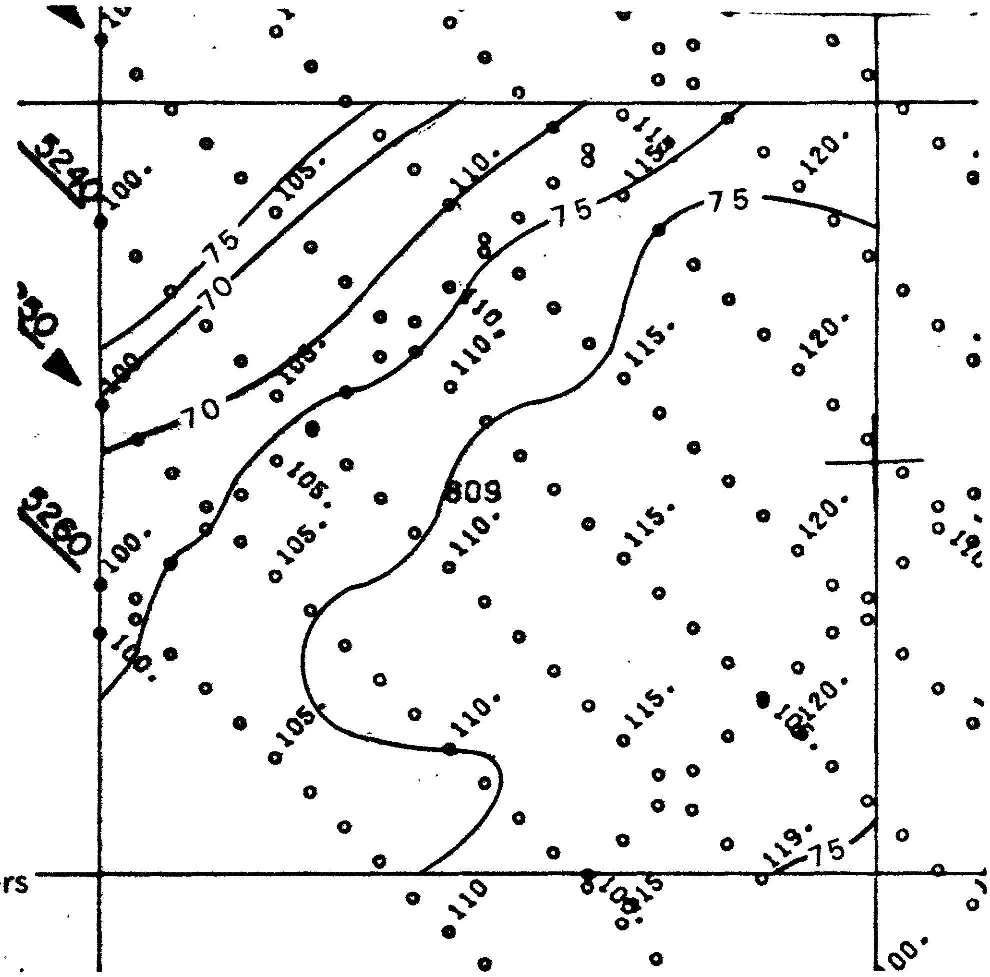


Slump or Slide

Proposed
Lease Sale #49

Block No. 809
(NJ 18–3)

Contours in Meters




Water Depth: max. 76 m , min. 67 m

Slope Gradient: 1.8 m/km, Direction: NW

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

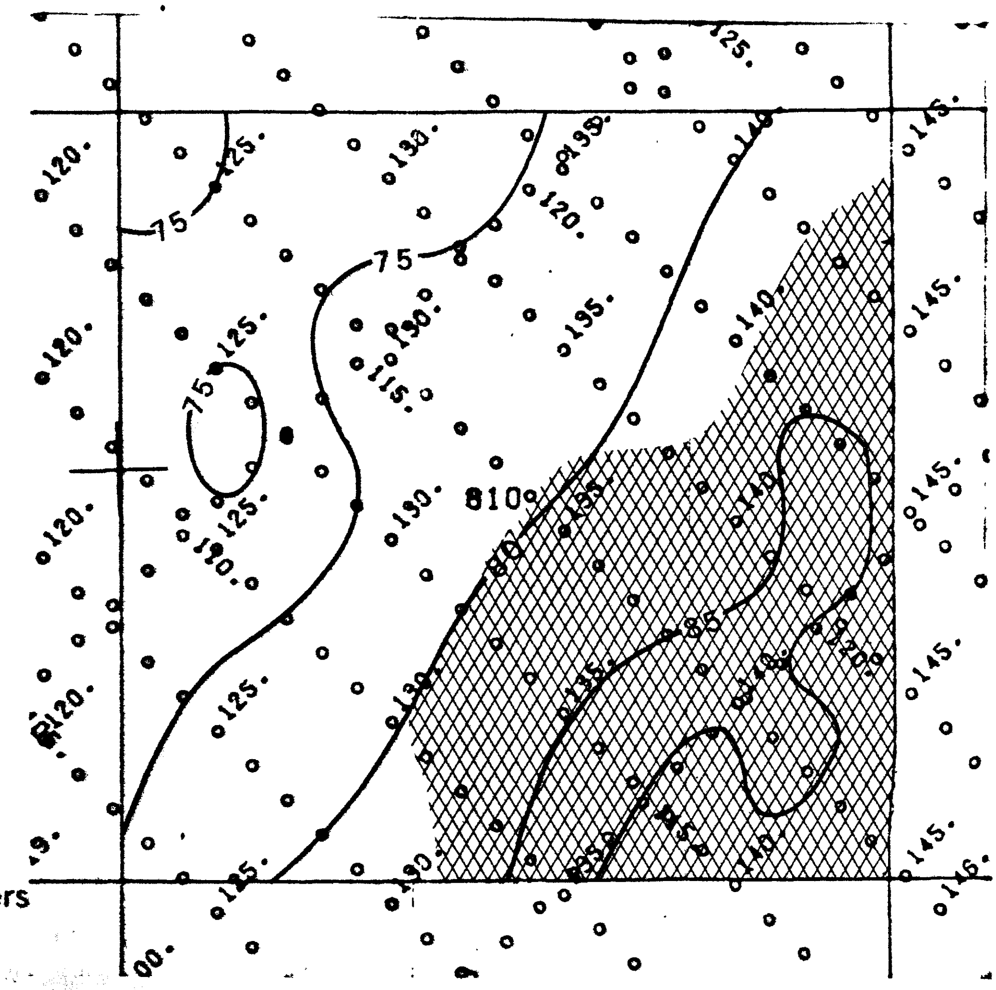
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 810
(NJ 18–3)

Contours in Meters




Water Depth: max. 88 m , min. 72 m

Slope Gradient: 4 m/km, Direction: SE

Surface Sediment Type: Silty sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

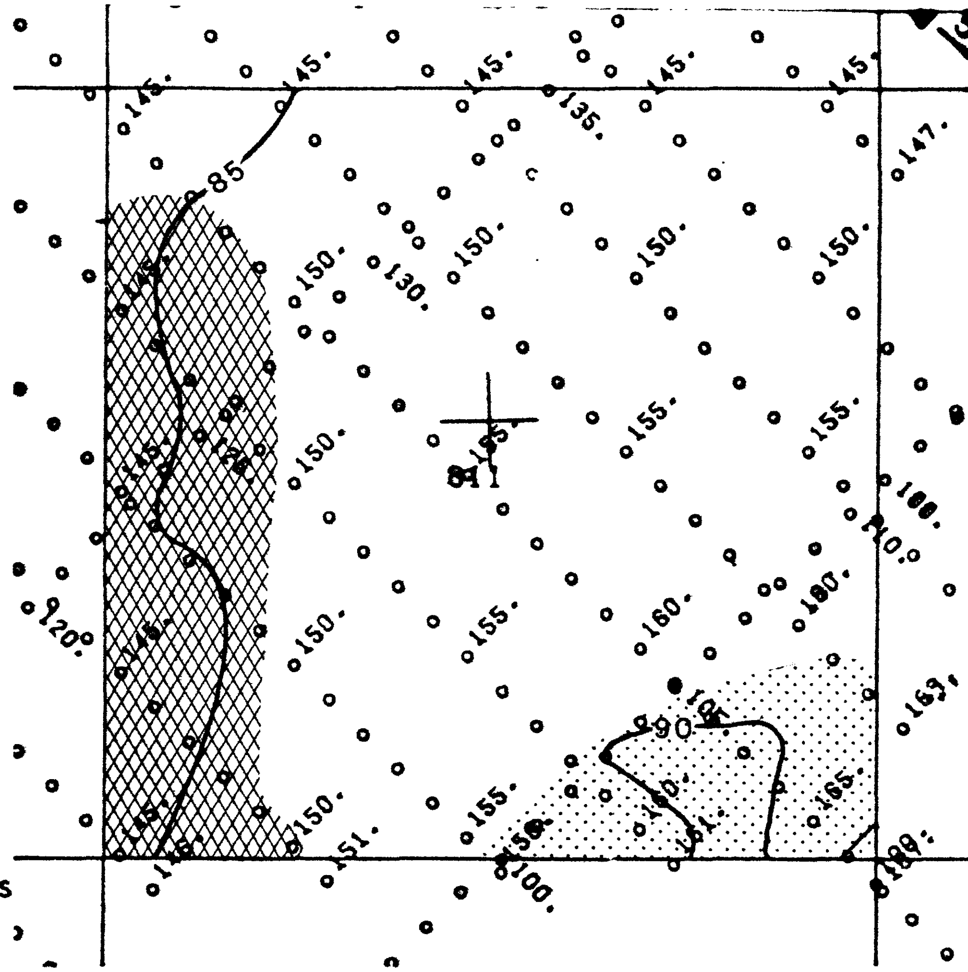
Erosion/Scour

Additional Comments: See figure 7.

Proposed
Lease Sale #49

Block No. 811
(NJ 18–3)

Contours in Meters

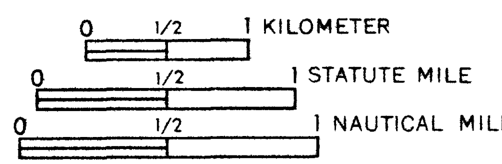



Water Depth: max. 91 m , min. 83 m

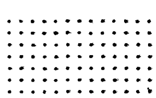
Slope Gradient: 1.8 m/km, Direction: SE

Surface Sediment Type: Silty sand

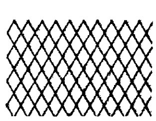
Map Scale 1:48,000




## CONSTRAINTS



Acoustically Turbid Zone

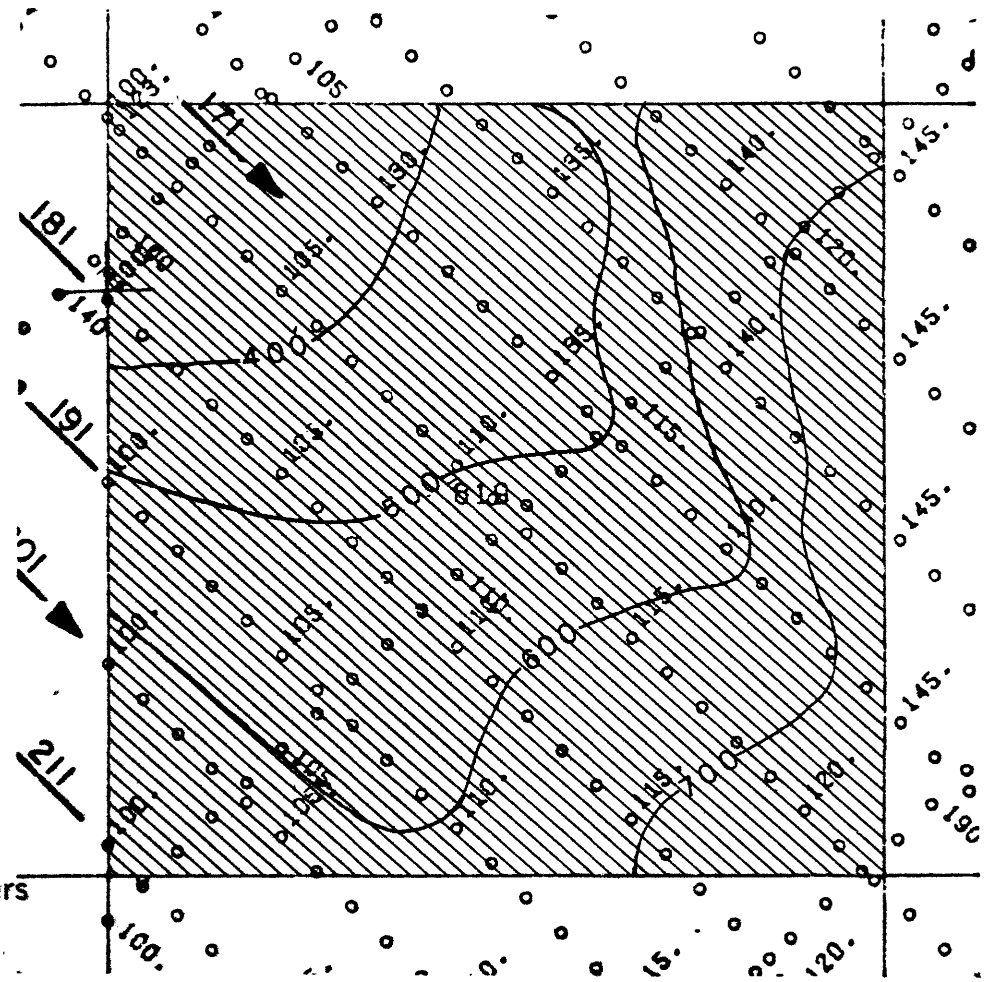


Erosion/Scour

Proposed
Lease Sale #49

Block No. 819
(NJ 18-3)

Contours in Meters




Water Depth: max. 715 m , min. 325 m

Slope Gradient: 80 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

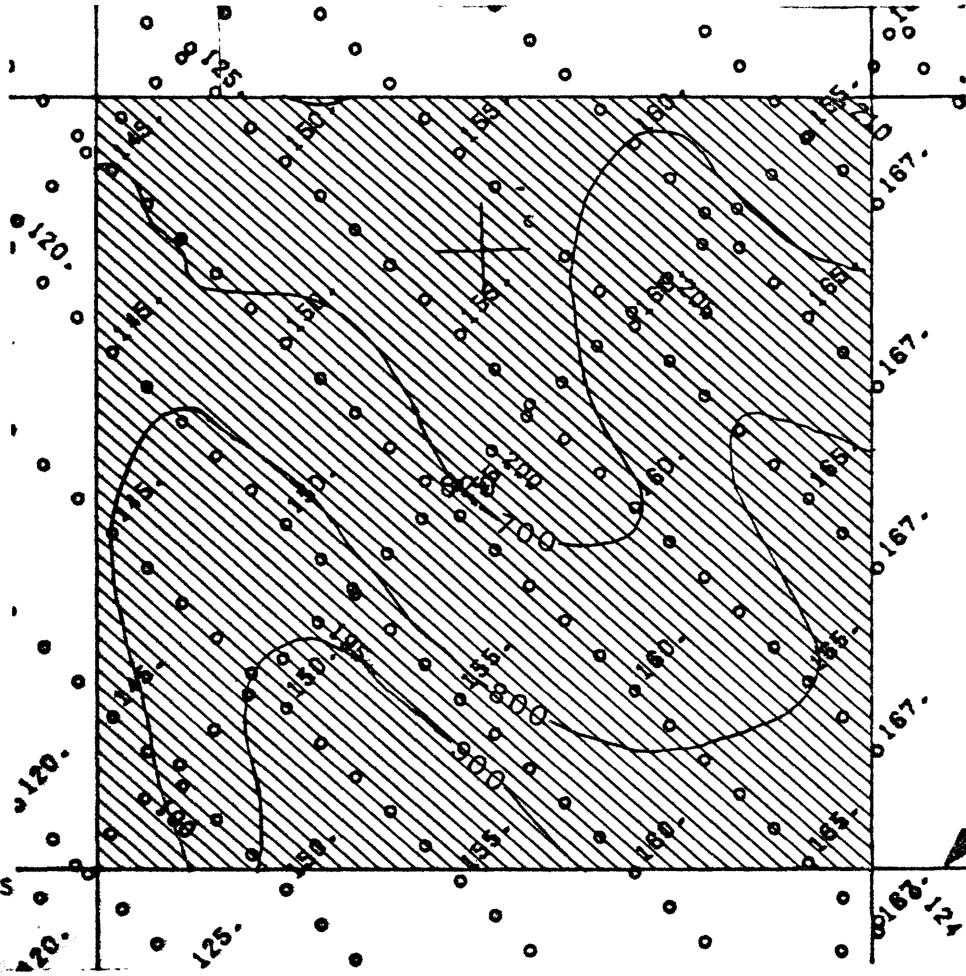
## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 820
(NJ 18–3)

Contours in Meters

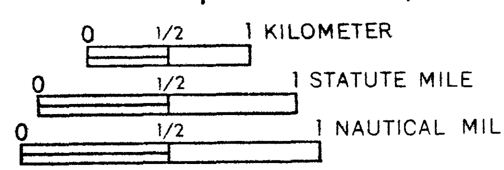



Water Depth: max. 850 m , min. 600 m

Slope Gradient: 45 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000



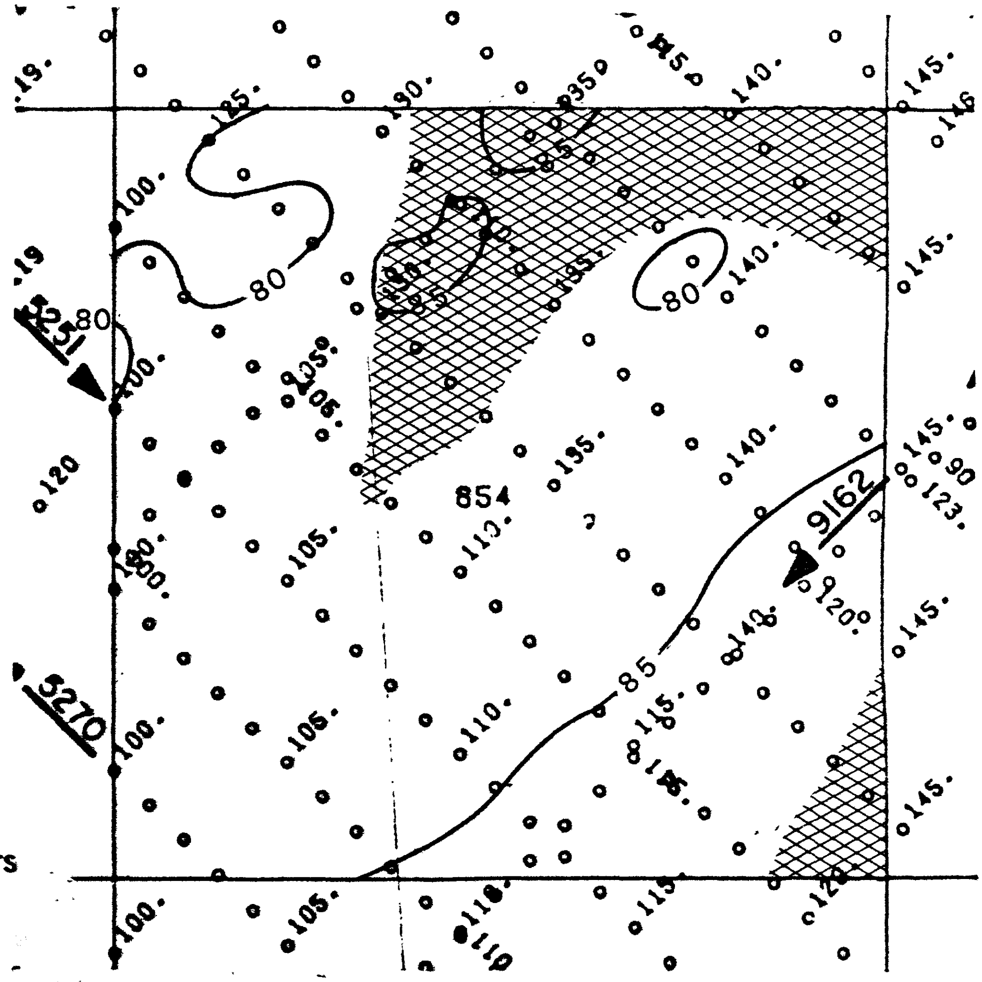

## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 854
(NJ 18–3)

Contours in Meters




Water Depth: max. 92 m , min. 75 m

Slope Gradient: 3 m/km, Direction: SE

Surface Sediment Type: Muddy sand

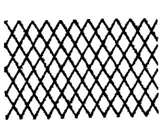
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

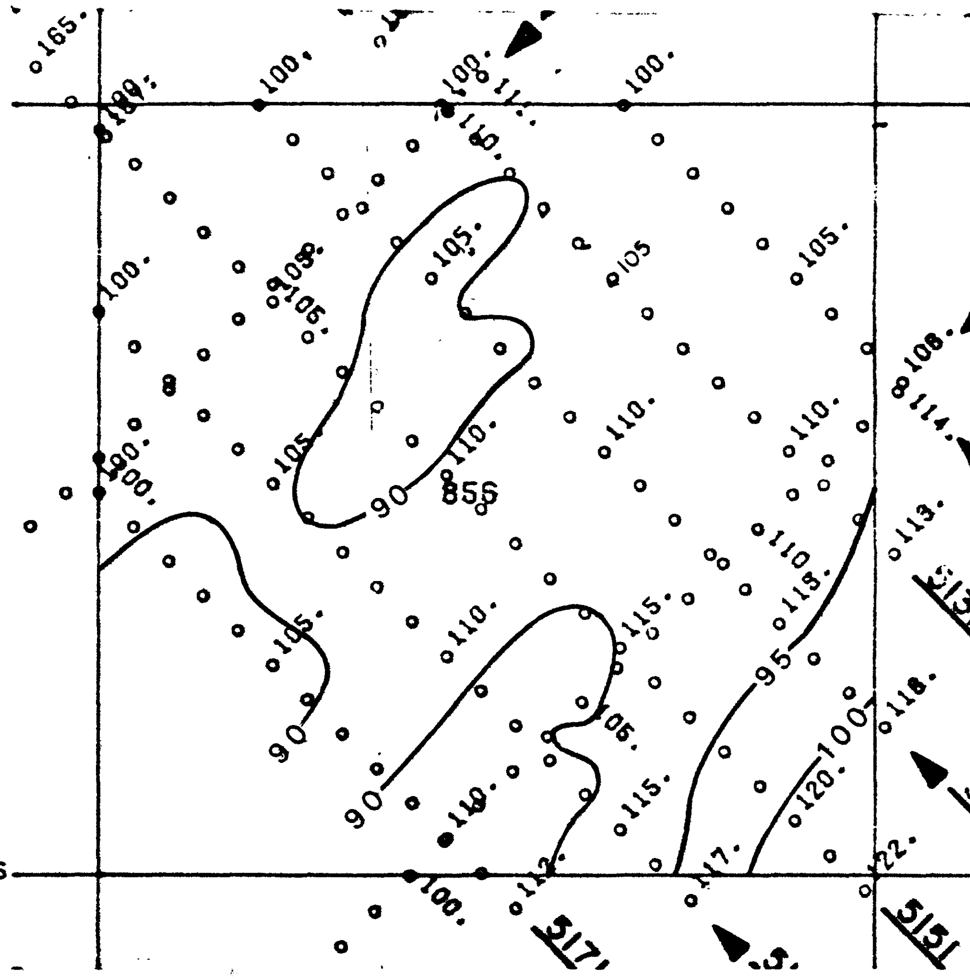


Erosion/Scour

Proposed
Lease Sale #49

Block No. 856
(NJ 18–3)

Contours in Meters




Water Depth: max. 105 m , min. 88 m

Slope Gradient: 2.2 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

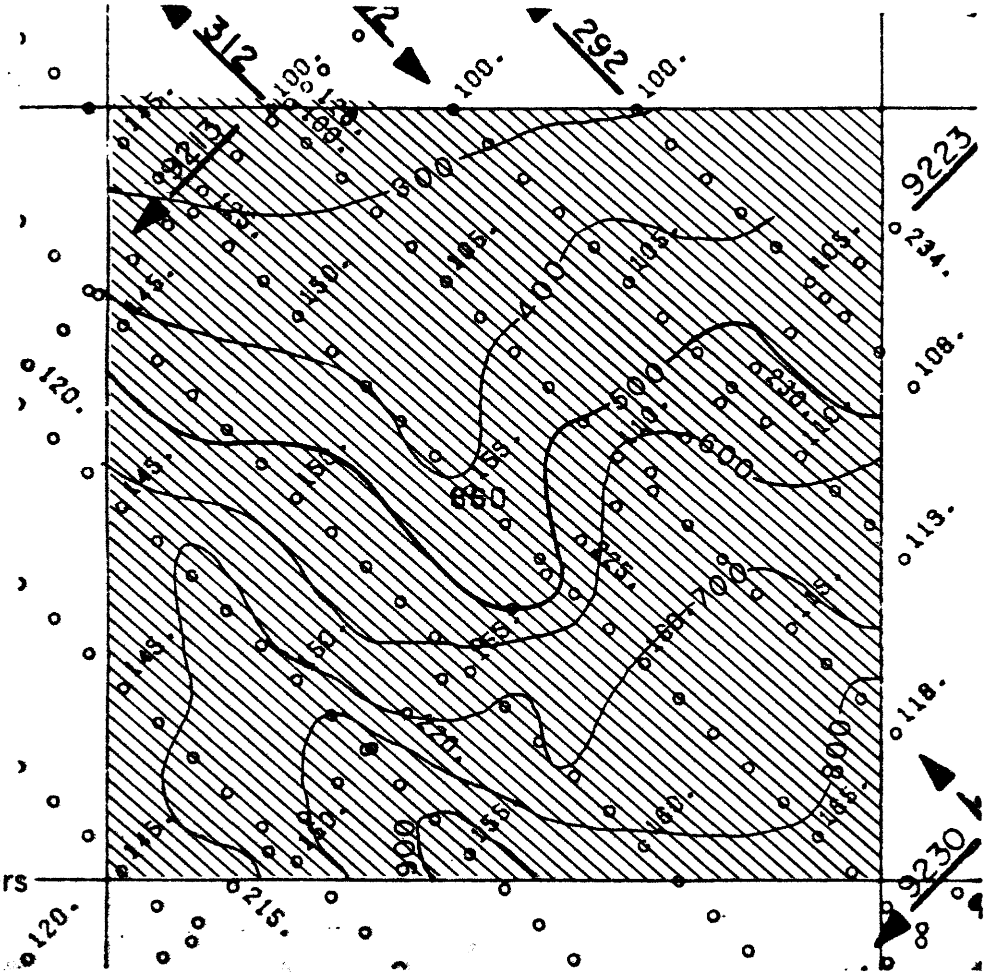
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 860
(NJ 18–3)

Contours in Meters

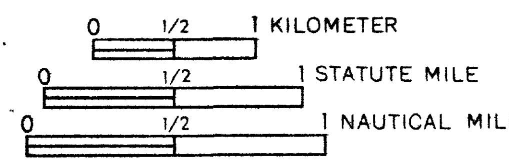



Water Depth: max. 883 m , min. 285 m

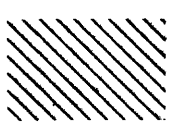
Slope Gradient: 110 m/km, Direction: SE

Surface Sediment Type: Silty clay

Map Scale 1:48,000




## HAZARDS

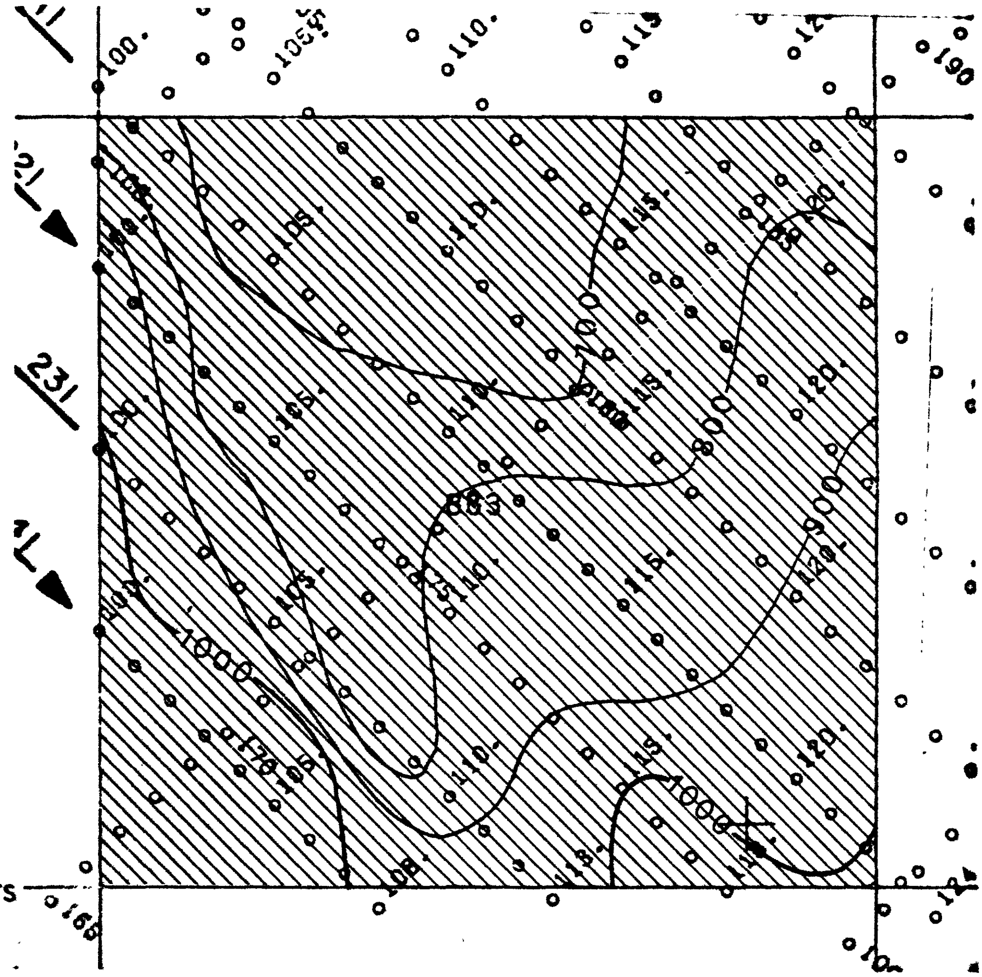


Slump or Slide

Proposed
Lease Sale #49

Block No. 863
(NJ 18–3)

Contours in Meters

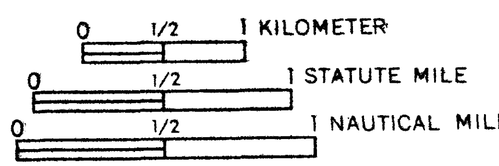



Water Depth: max. 1100 m , min. 615 m

Slope Gradient: 65 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000



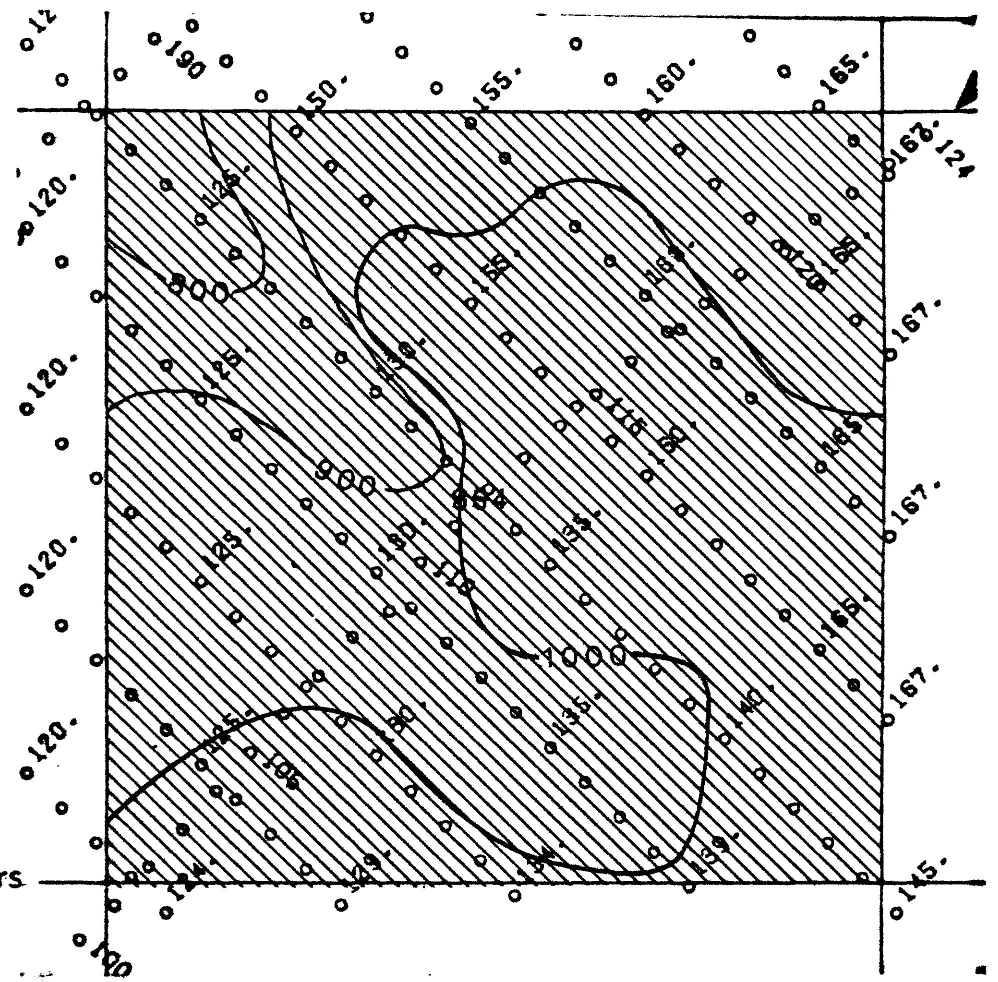

## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 864
(NJ 18–3)

Contours in Meters

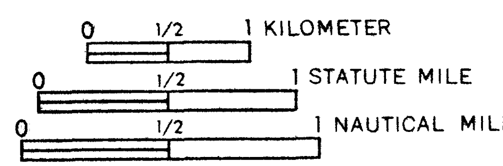



Water Depth: max. 1175 m , min. 740 m

Slope Gradient: 60 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000



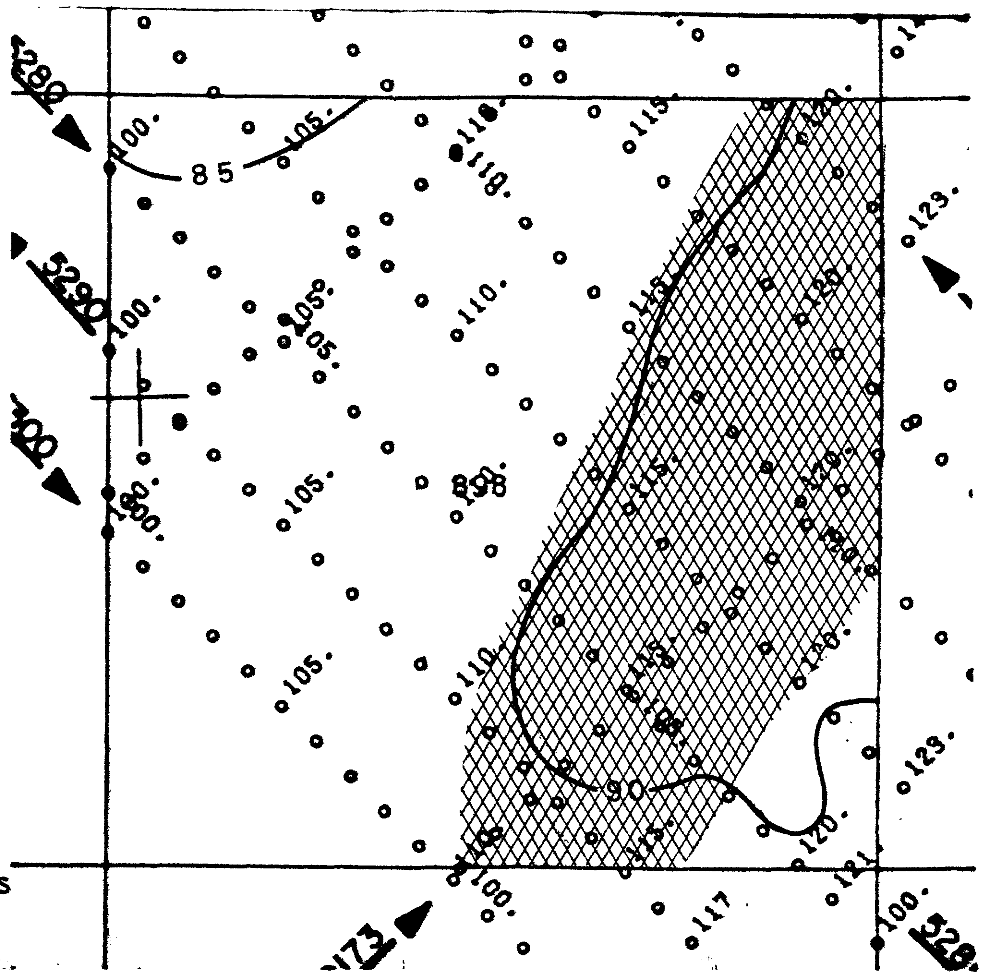

## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 898
(NJ 18–3)

Contours in Meters




Water Depth: max. 95 m , min. 82 m

Slope Gradient: 1.4 m/km, Direction: SE

Surface Sediment Type: Sand

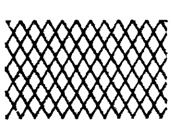
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

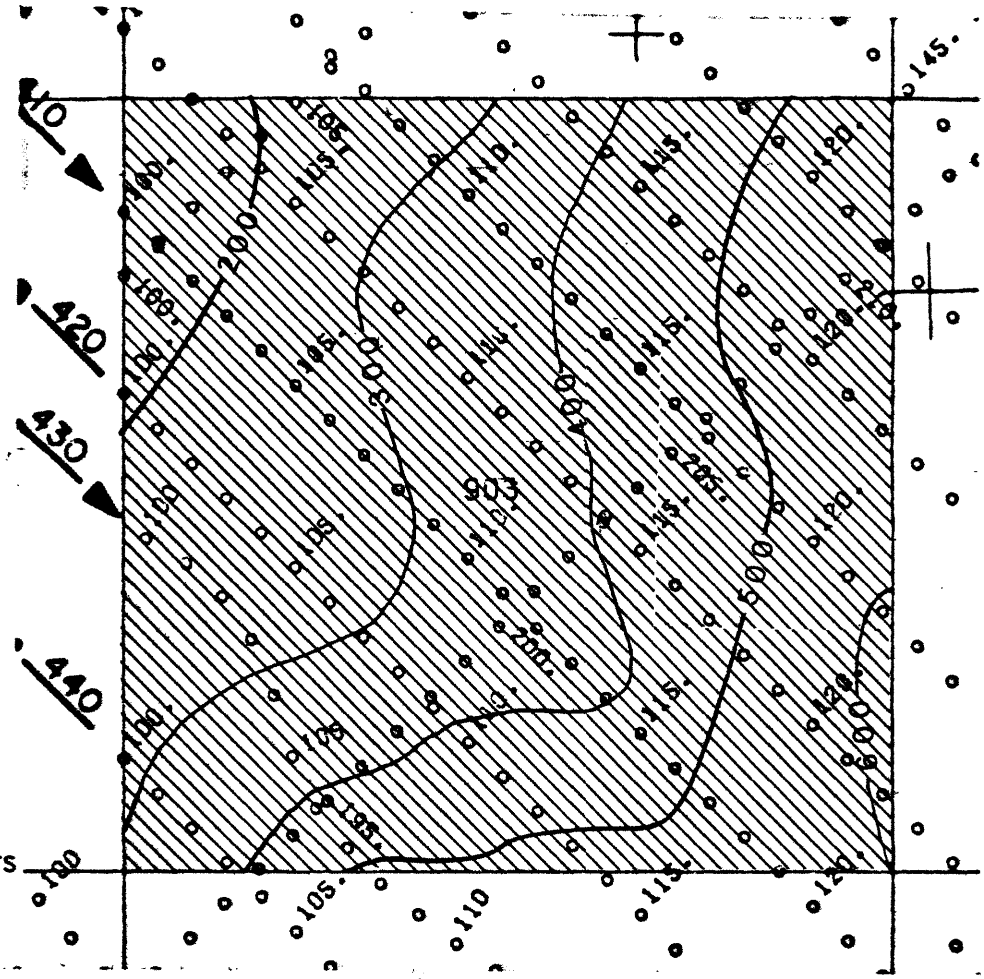


Erosion/Scour

Proposed
Lease Sale #49

Block No. 903
(NJ 18-3)

Contours in Meters




Water Depth: max. 650 m , min. 180 m

Slope Gradient: 60 m/km, Direction: SE

Surface Sediment Type: Sandy clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

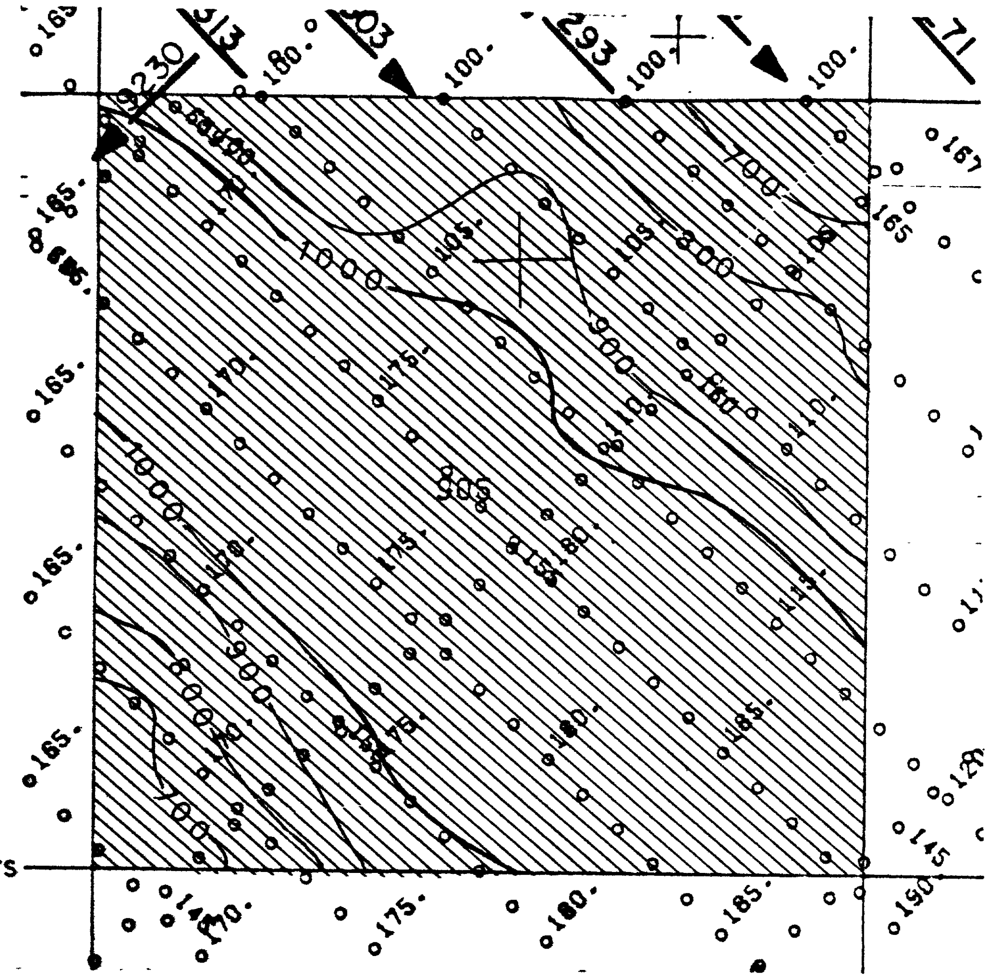
0 1/2 1 NAUTICAL MILE

Slump or Slide

Proposed
Lease Sale #49

Block No. 905
(NJ 18–3)

Contours in Meters



Water Depth: max. 1280 m , min. 630 m

Slope Gradient: 70 m/km, Direction: SE

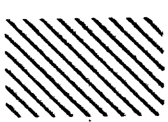
Surface Sediment Type: Clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

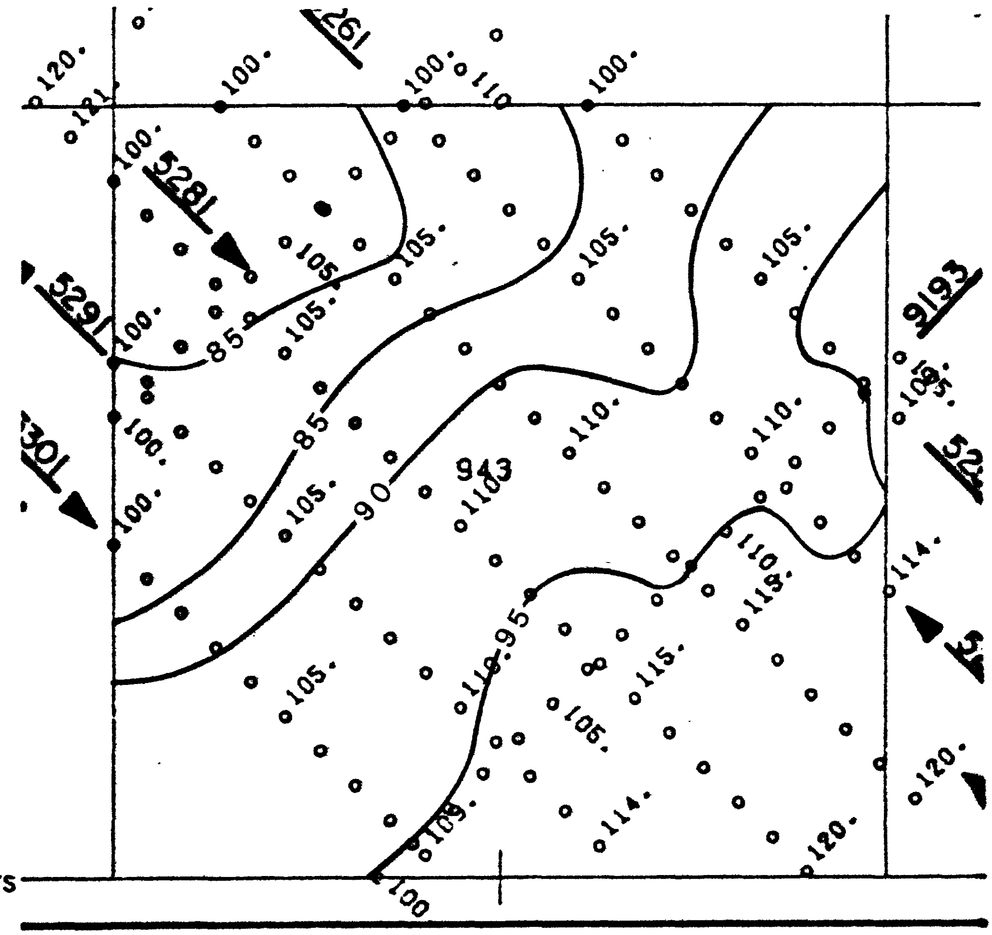
0 1/2 1 NAUTICAL MILE



Slump or Slide

Proposed
Lease Sale #49

Block No. 943
(NJ 18-3)




Contours in Meters

Water Depth: max. 101 m , min. 82 m

Slope Gradient: 5 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

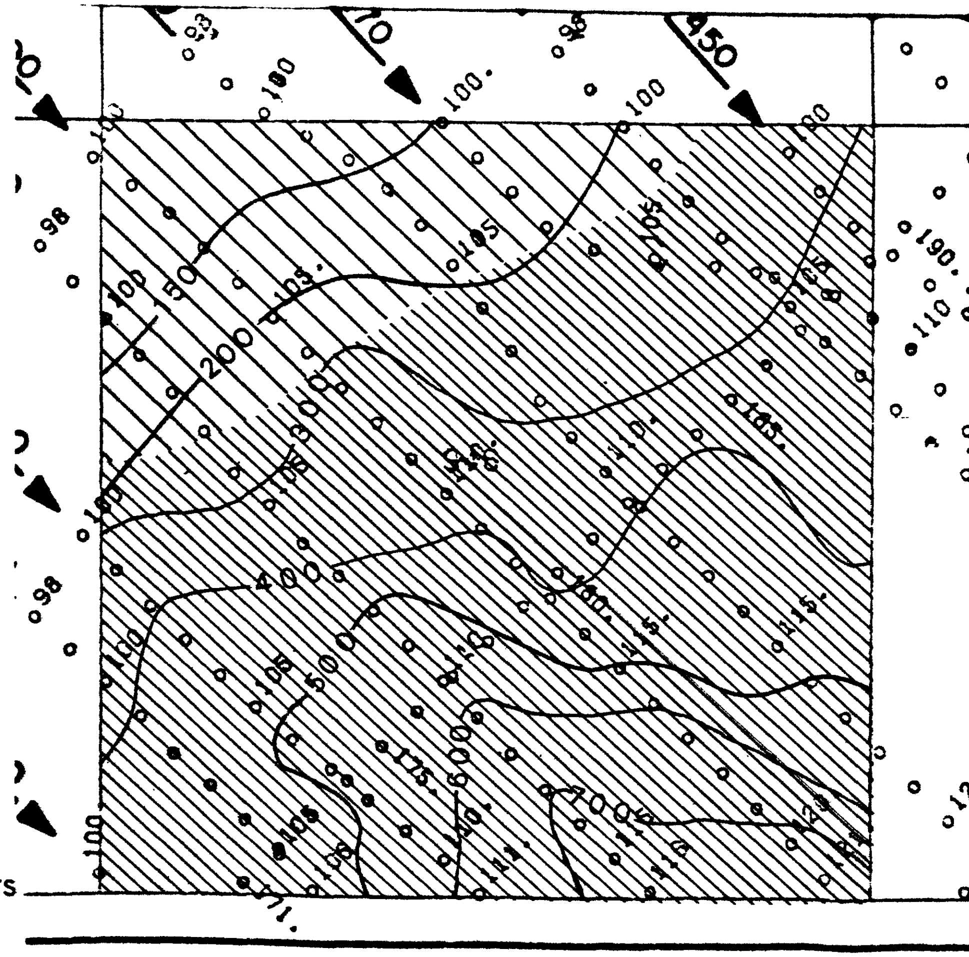
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 946
(NJ 18–3)

Contours in Meters

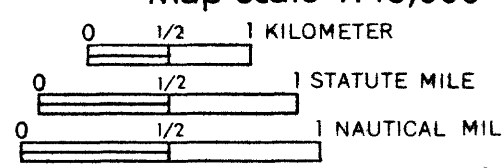



Water Depth: max. 785 m , min. 125 m

Slope Gradient: 110 m/km, Direction: SE

Surface Sediment Type: Sandy clay

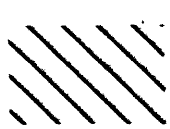
Map Scale 1:48,000




## HAZARDS

Slump or Slide

## CONSTRAINTS

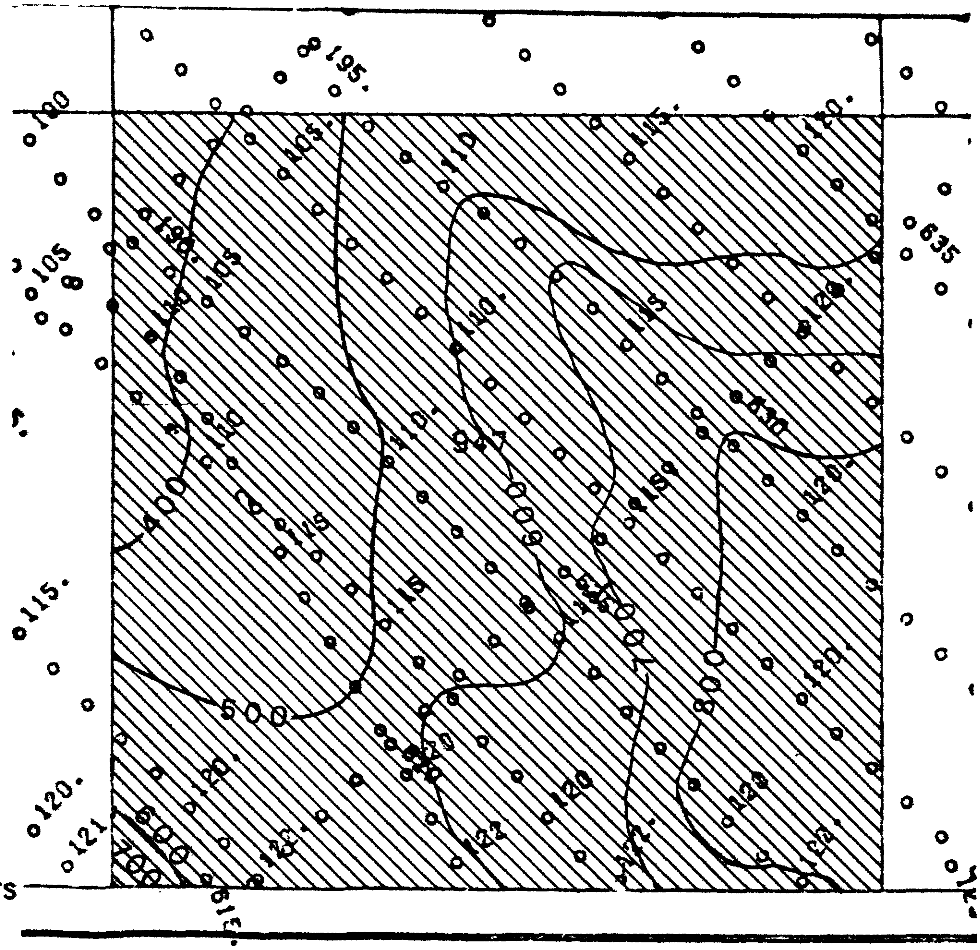


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 947
(NJ 18–3)

Contours in Meters




Water Depth: max. 835 m , min. 355 m

Slope Gradient: 95 m/km, Direction: SE

Surface Sediment Type: Sandy clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

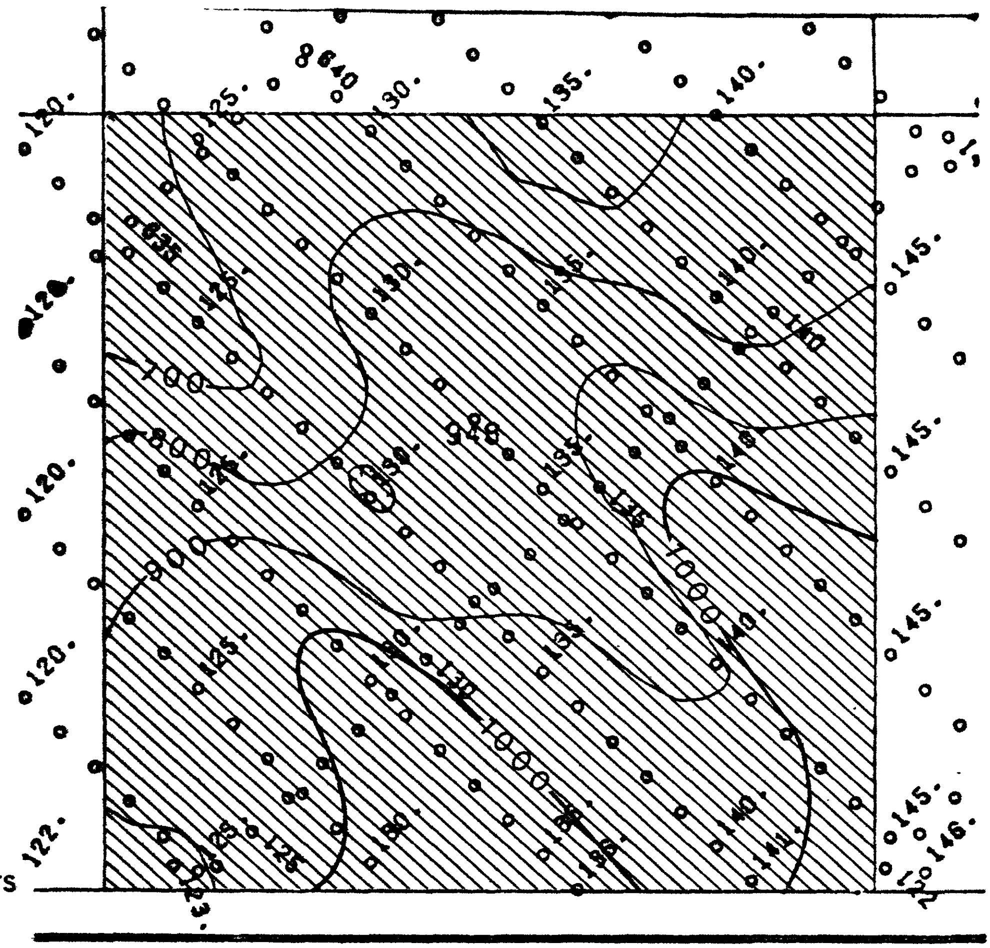
## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 948
(NJ 18–3)

Contours in Meters

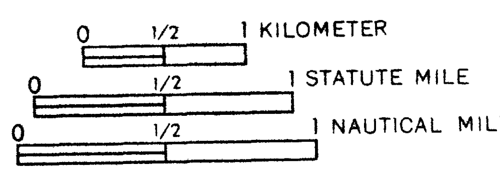



Water Depth: max. 1078 m , min. 700 m

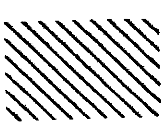
Slope Gradient: 105 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000




## HAZARDS

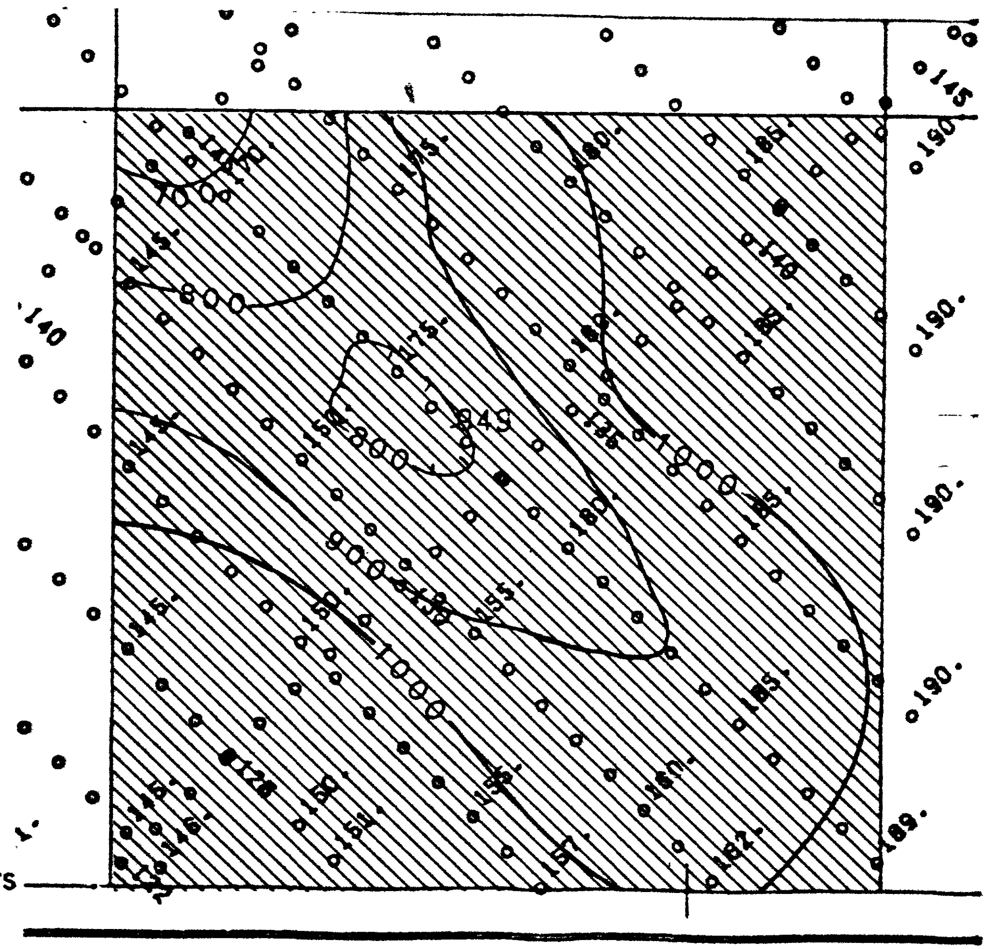


Slump or Slide

Proposed
Lease Sale #49

Block No. 949
(NJ 18–3)

Contours in Meters

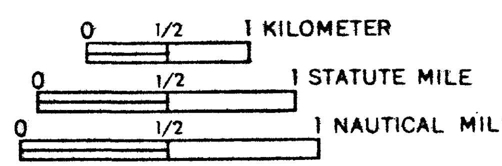



Water Depth: max. 1300 m , min. 699 m

Slope Gradient: 75 m/km, Direction: SE

Surface Sediment Type: Clay

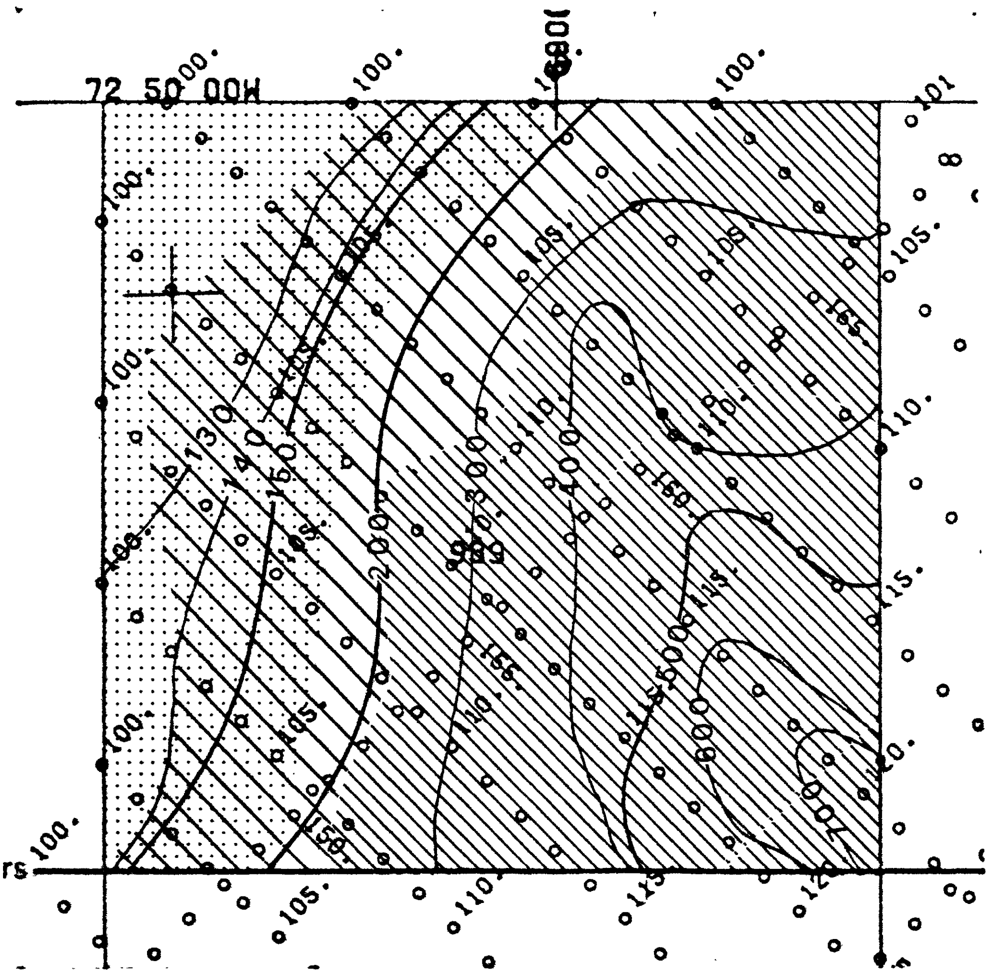
Map Scale 1:48,000




## HAZARDS

Slump or Slide

Proposed
Lease Sale #49




Block No. 989
(NJ 18–3)

Contours in Meters

Water Depth: max. 802 m , min. 122 m
Slope Gradient: 100-150 m/km, Direction: SE
Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

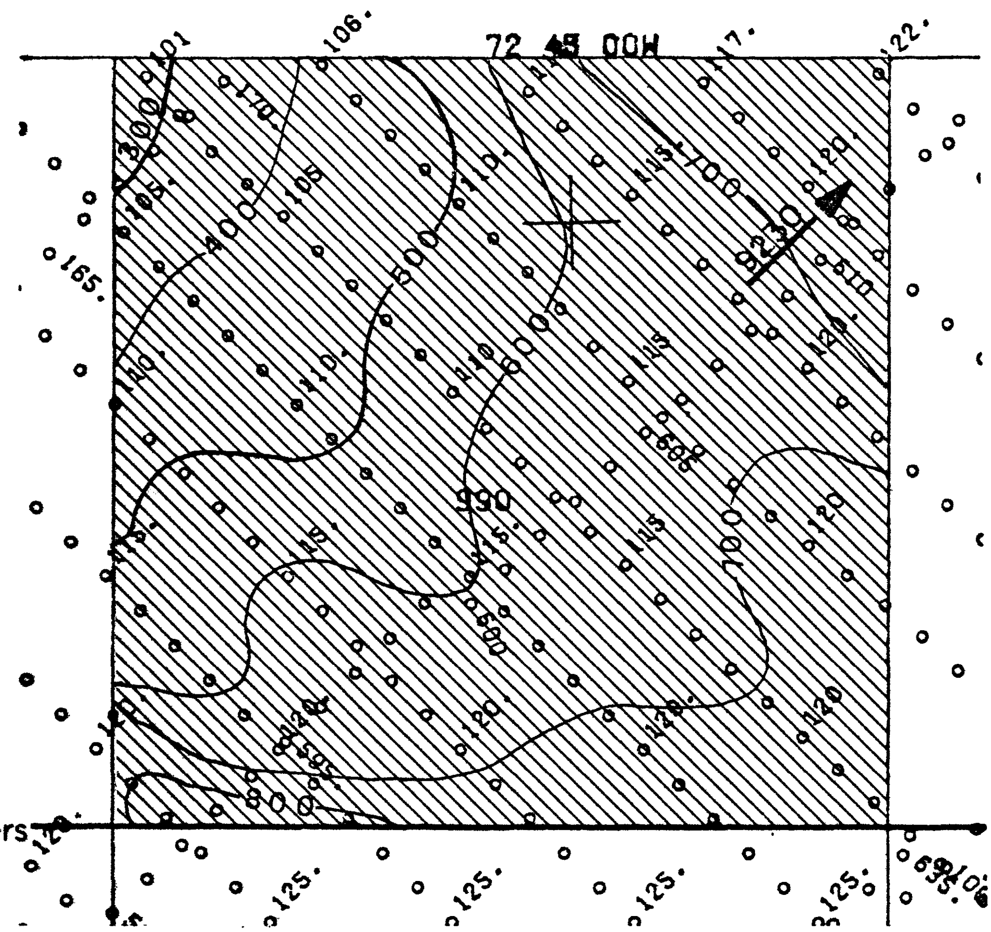
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 990
(NJ 18–3)

Contours in Meters




Water Depth: max. 771 m , min. 281 m

Slope Gradient: 85 m/km, Direction: SE

Surface Sediment Type: Sandy clay

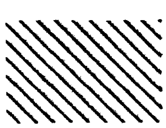
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

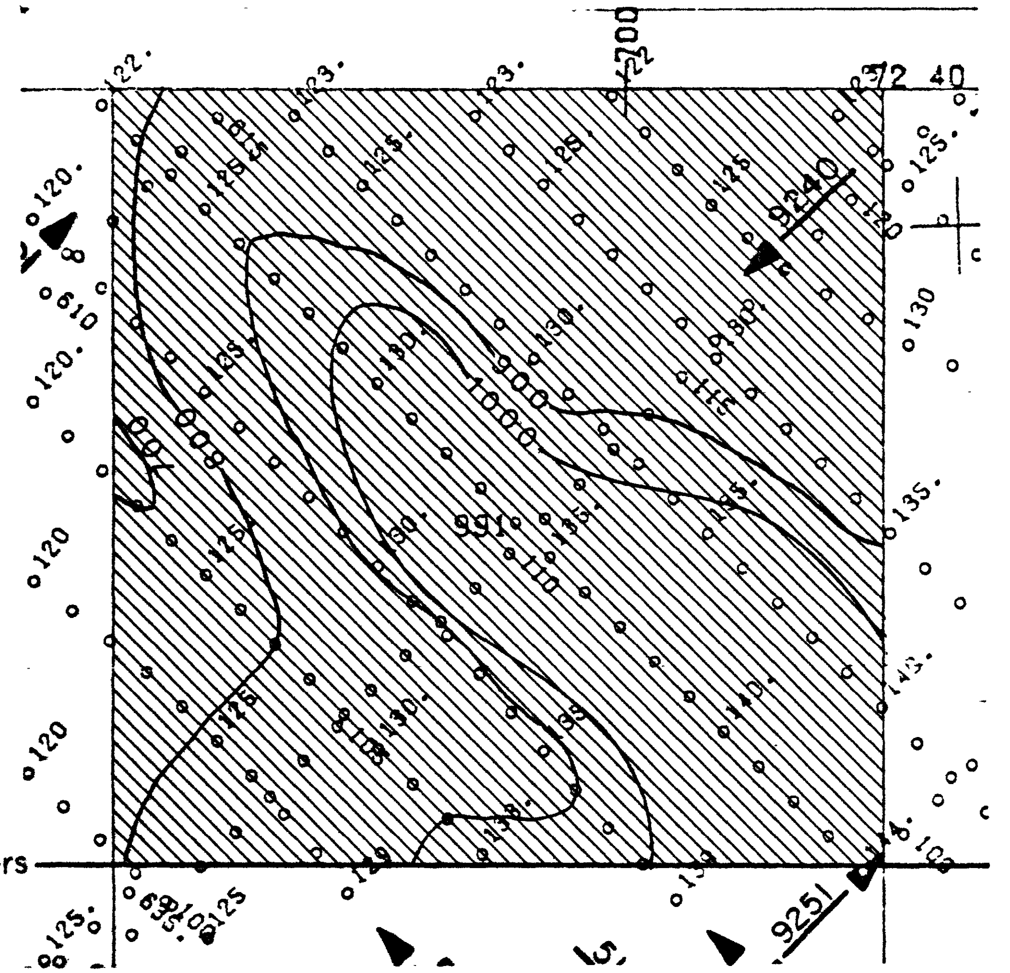
## HAZARDS


Slump or Slide

Proposed
Lease Sale #49

Block No. 991
(NJ 18–3)

Contours in Meters




Water Depth: max. 1111 m , min. 60.9 m

Slope Gradient: 20–30 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

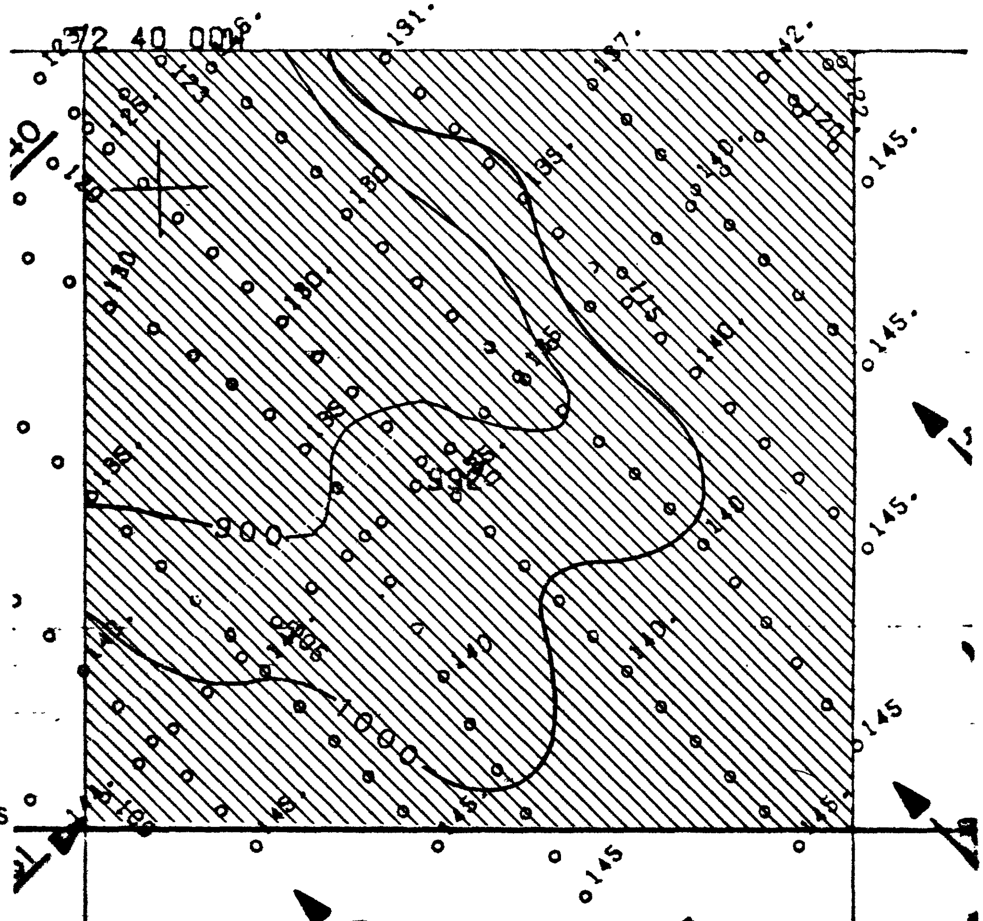
## HAZARDS

Slump or Slide

Proposed
Lease Sale #49

Block No. 992
(NJ 18–3)

Contours in Meters




Map Scale 1:48,000

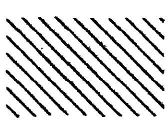
Water Depth: max. 1250 m , min. 707 m

Slope Gradient: 70 m/km, Direction: SE

Surface Sediment Type: Clay

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

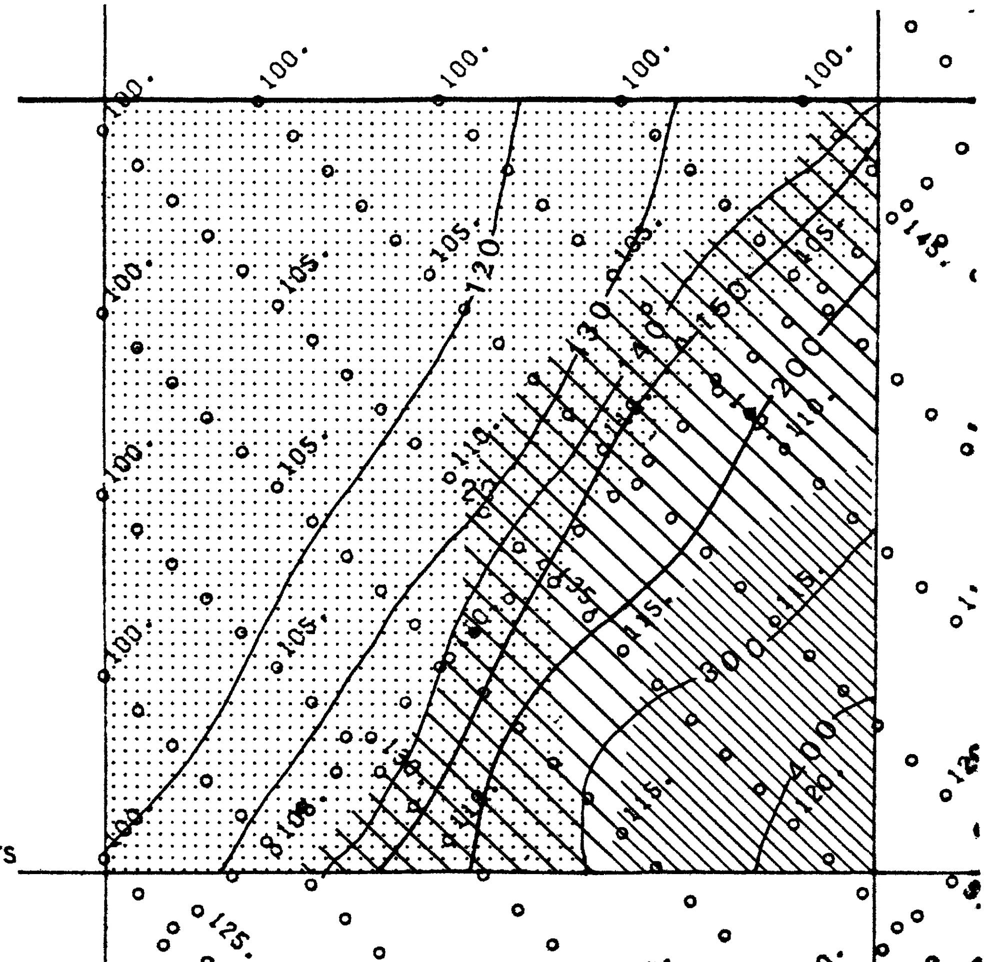


Slump or Slide

Proposed
Lease Sale #49

Block No. 20
(NJ 18–6)

Contours in Meters




Water Depth: max. 487 m , min. 115 m

Slope Gradient: 7-143 m/km, Direction: SE

Surface Sediment Type: Sand

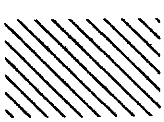
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

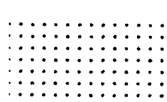
0 1/2 1 NAUTICAL MILE

## HAZARDS



Slump or Slide

## CONSTRAINTS



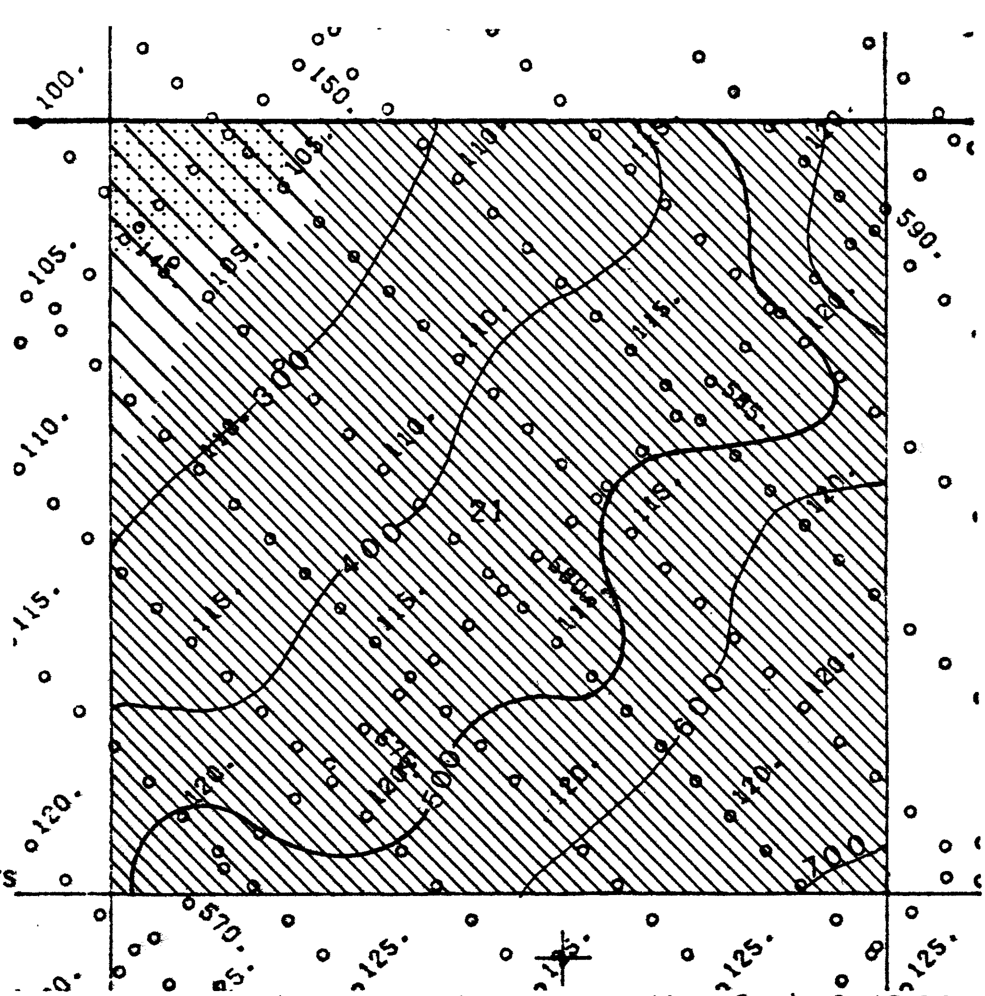
Acoustically Turbid Zone

Potentially Unstable Slope

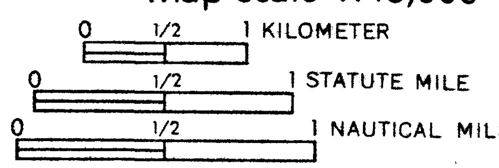
Proposed
Lease Sale #49

Block No. 21
(NJ 18–6)

Contours in Meters




Map Scale 1:48,000

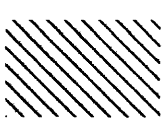



Water Depth: max. 733 m , min. 150 m

Slope Gradient: 100 m/km, Direction: SE

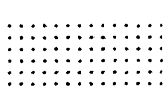
Surface Sediment Type: Sandy clay

## HAZARDS

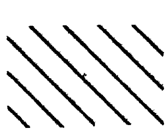


Slump or Slide

## CONSTRAINTS



Acoustically Turbid Zone

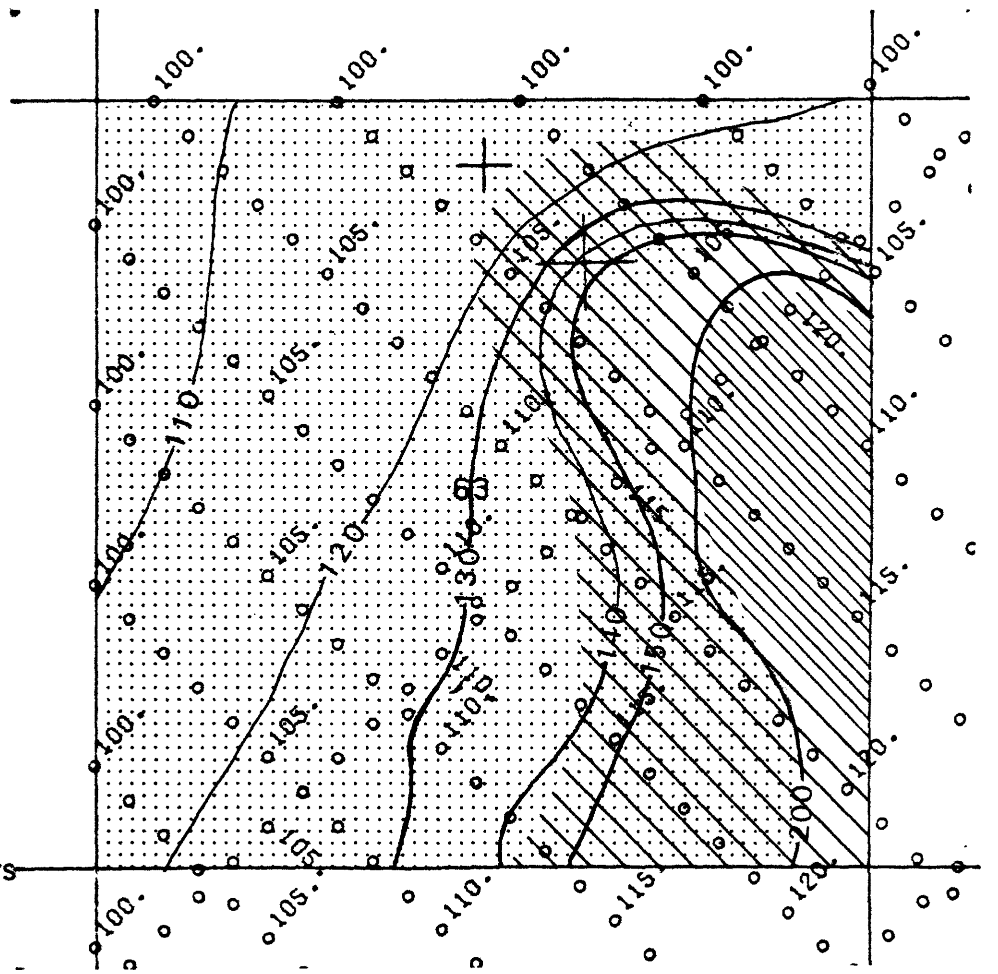


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 63
(NJ 18–6)

Contours in Meters




Water Depth: max. 314 m , min. 106 m

Slope Gradient: 8–28 m/km, Direction: SE

Surface Sediment Type: Sand

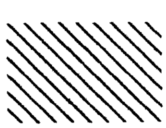
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

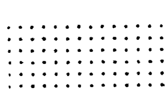
0 1/2 1 NAUTICAL MILE

## HAZARDS



Slump or Slide

## CONSTRAINTS



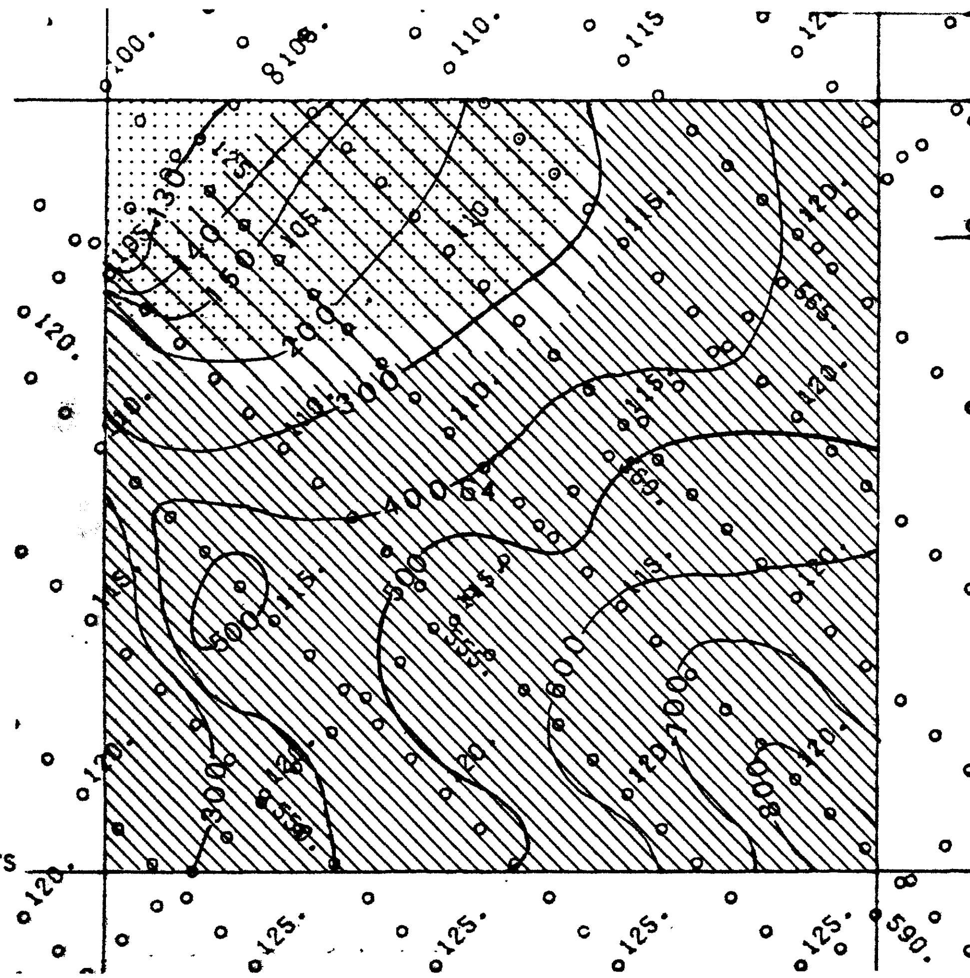
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 64
(NJ 18–6)

Contours in Meters



Water Depth: max. 816 m , min. 130 m

Slope Gradient: 83 m/km, Direction: SE

Surface Sediment Type: Sandy clay

Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

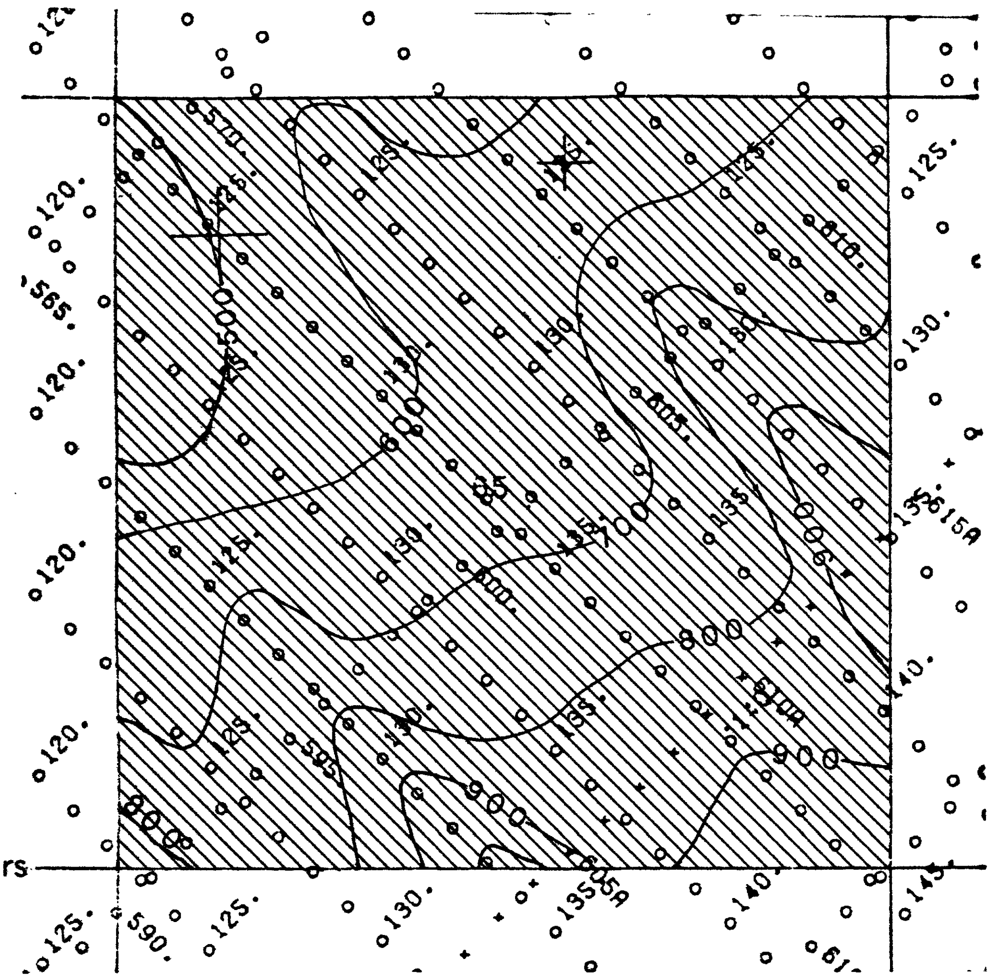
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 65
(NJ 18–6)

Contours in Meters



Water Depth: max. 979 m , min. 448 m

Slope Gradient: 90 m/km, Direction: SE

Surface Sediment Type: Clay

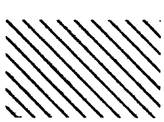
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

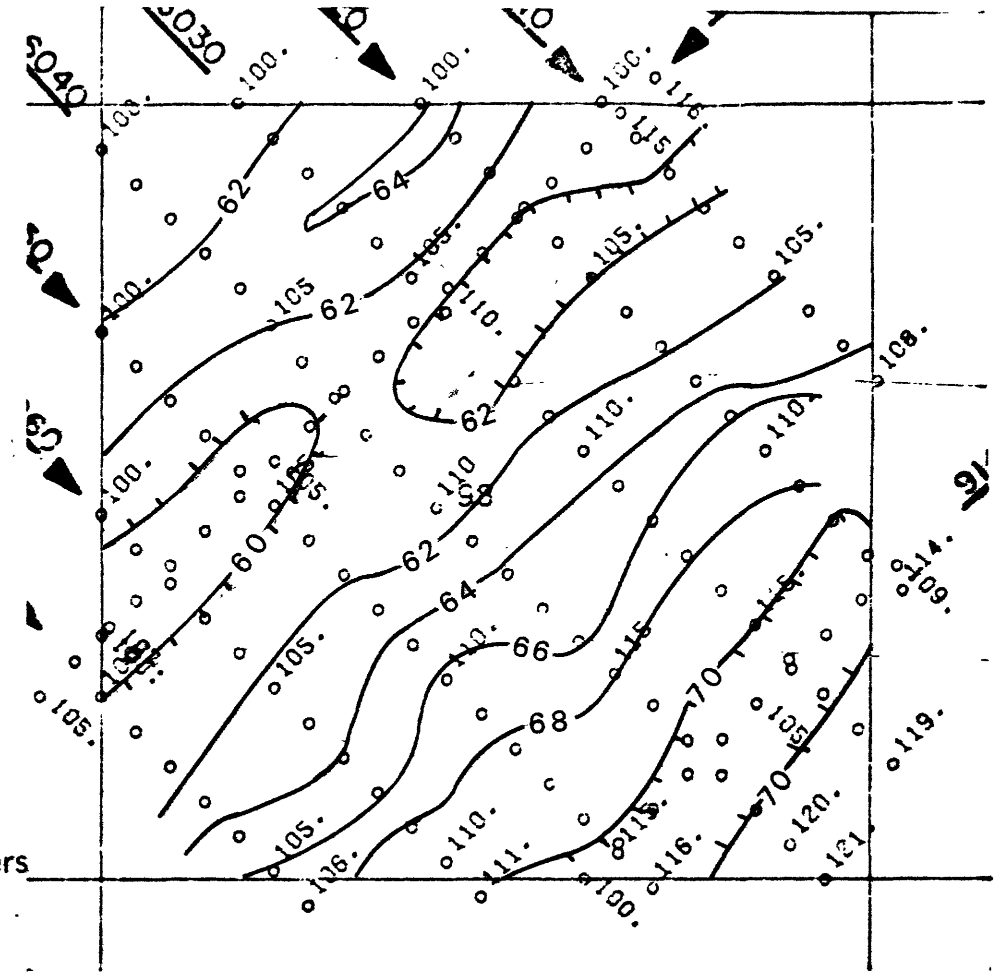


Slump or Slide

Proposed
Lease Sale #49

Block No. 98
(NJ 18–6)

Contours in Meters

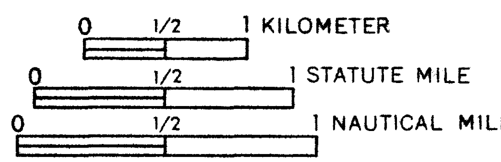



Water Depth: max. 71 m , min. 57 m

Slope Gradient: 3 m/km, Direction: SE

Surface Sediment Type: Sand

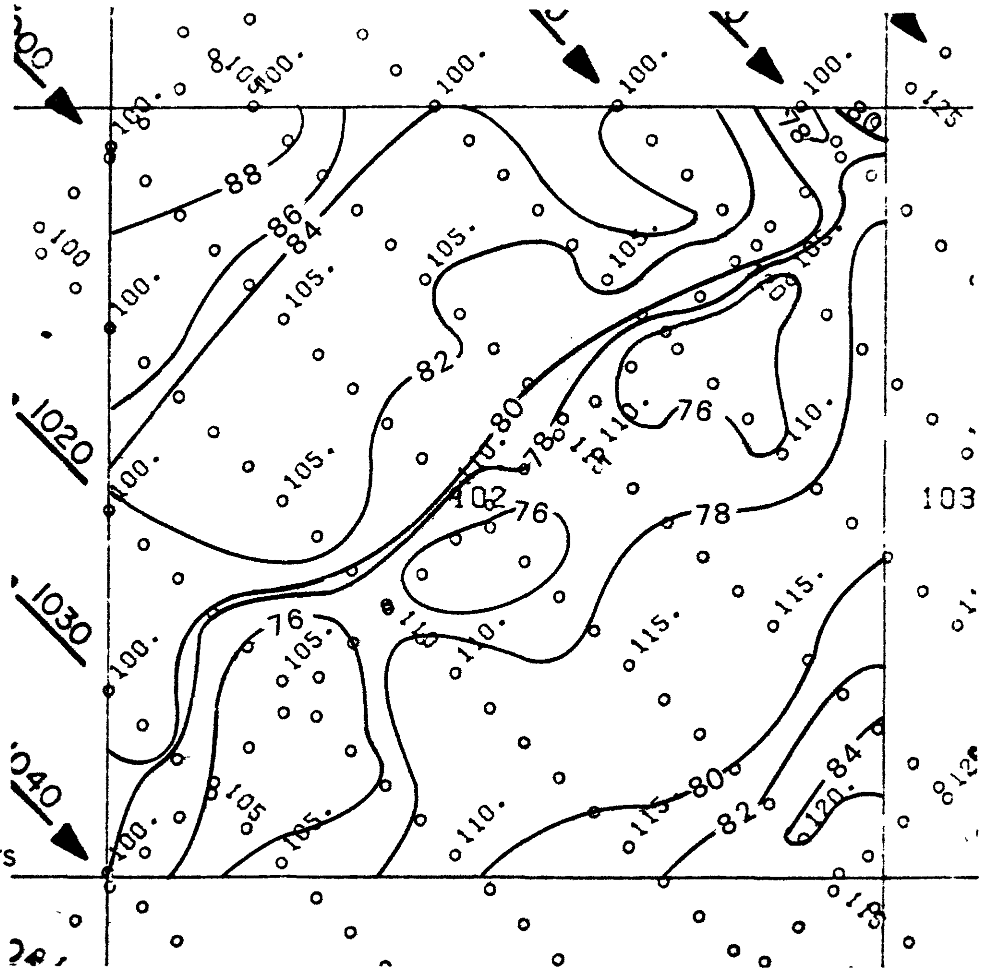
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 102
(NJ 18-6)

Contours in Meters

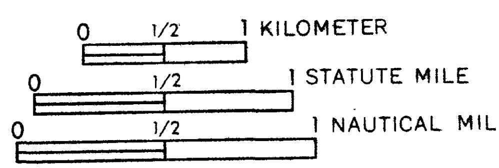



Water Depth: max. 84 m , min. 75 m.

Slope Gradient: 3 m/km, Direction: NW

Surface Sediment Type: Sand

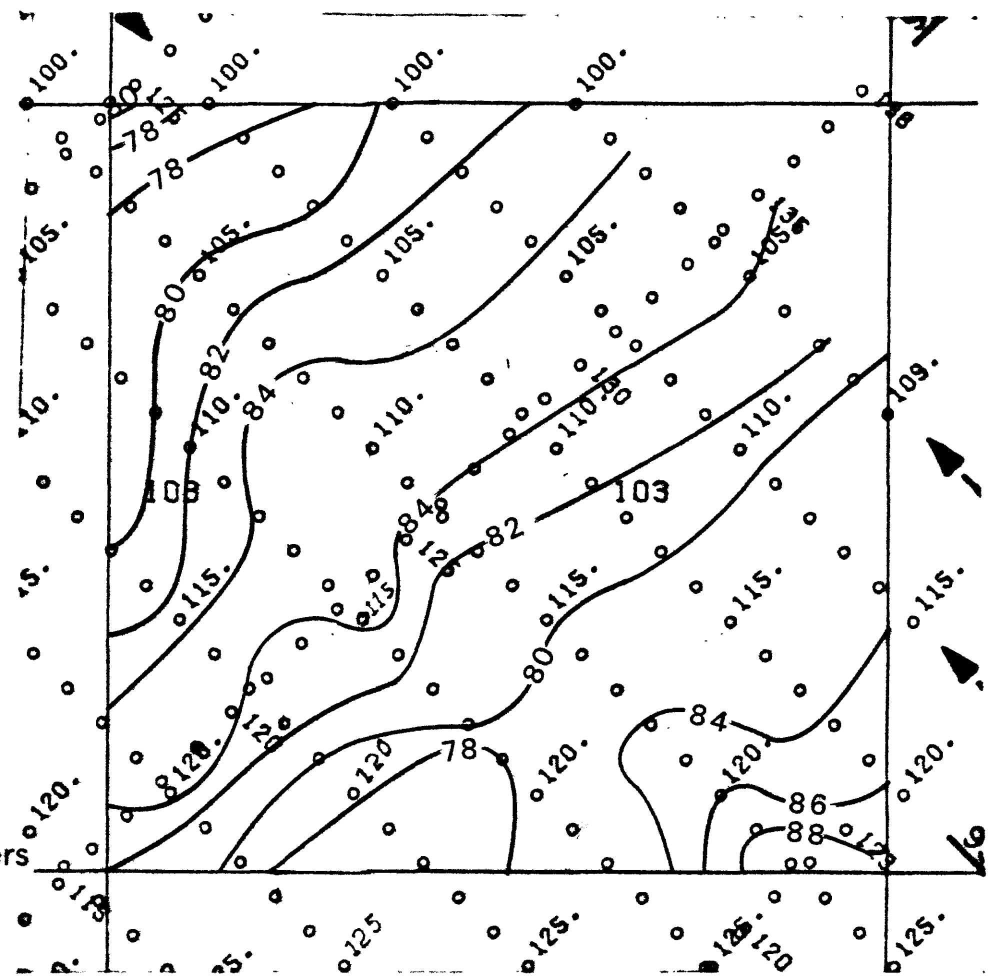
Map Scale 1:48,000



Proposed
Lease Sale #49

Block No. 103
(NJ 18–6)

Contours in Meters




Water Depth: max. 86 m , min. 78 m

Slope Gradient: 2 m/km, Direction: NW–SE

Surface Sediment Type: Sand

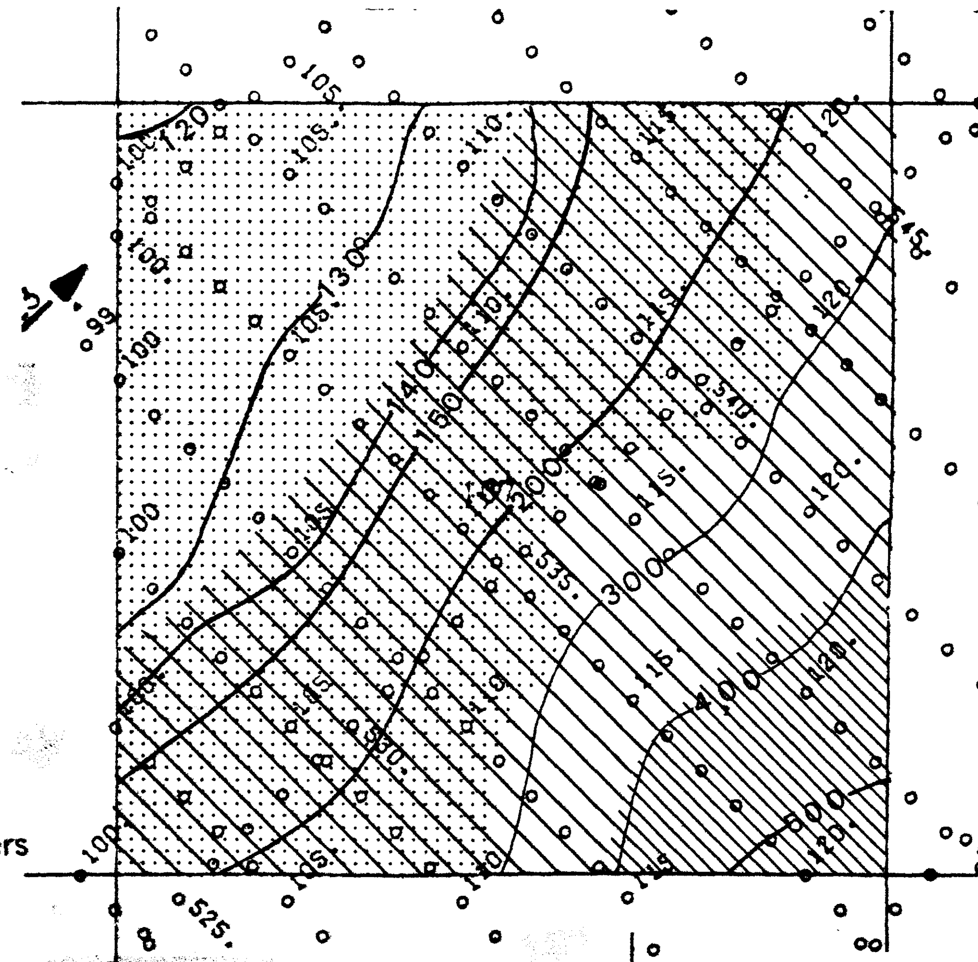
Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

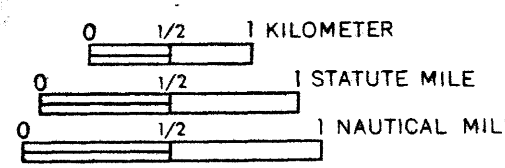
Block No. 107
(NJ 18–6)

Contours in Meters

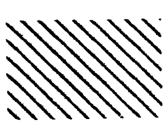


Water Depth: max. 521 m , min. 121 m
Slope Gradient: 75 m/km, Direction: SE
Surface Sediment Type: Sandy clay

Map Scale 1:48,000

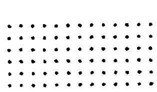



## HAZARDS



Slump or Slide

## CONSTRAINTS



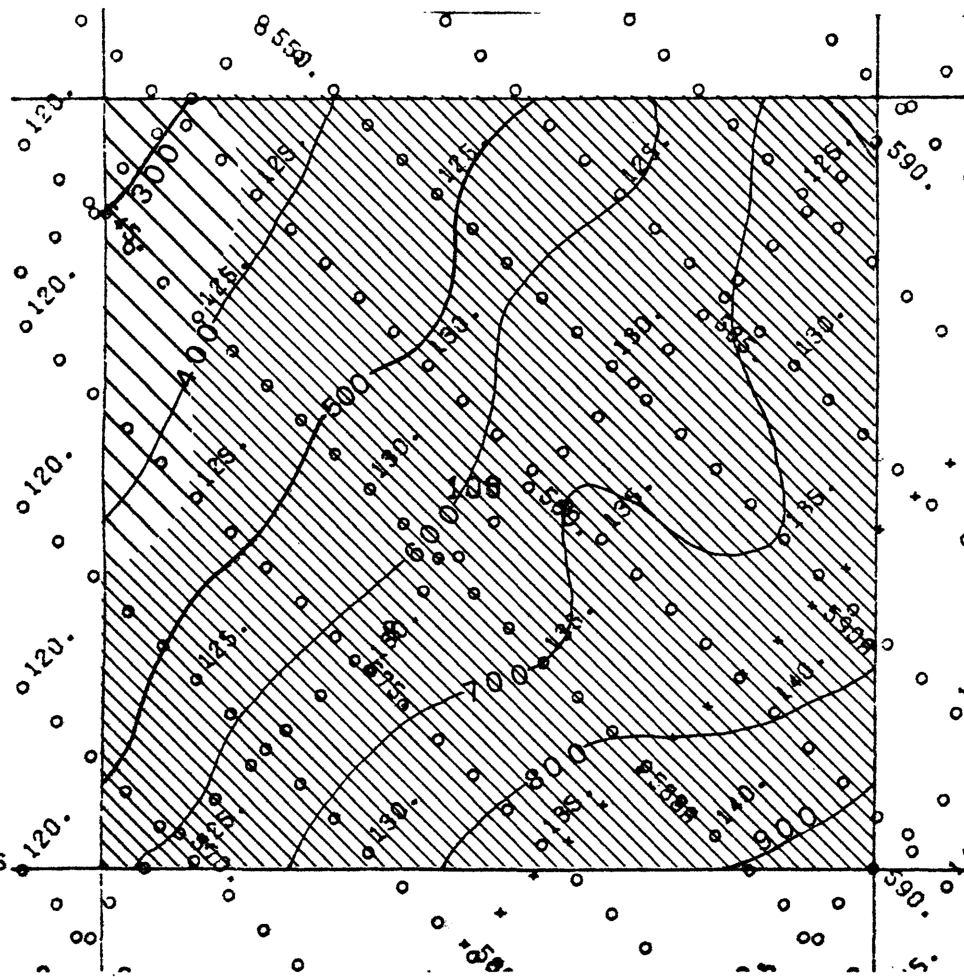
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 108
(NJ 18–6)

Contours in Meters




Water Depth: max. 929 m , min. 279 m

Slope Gradient: 110 m/km, Direction: SE

Surface Sediment Type: Clay

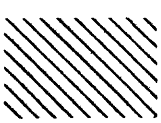
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS



Slump or Slide

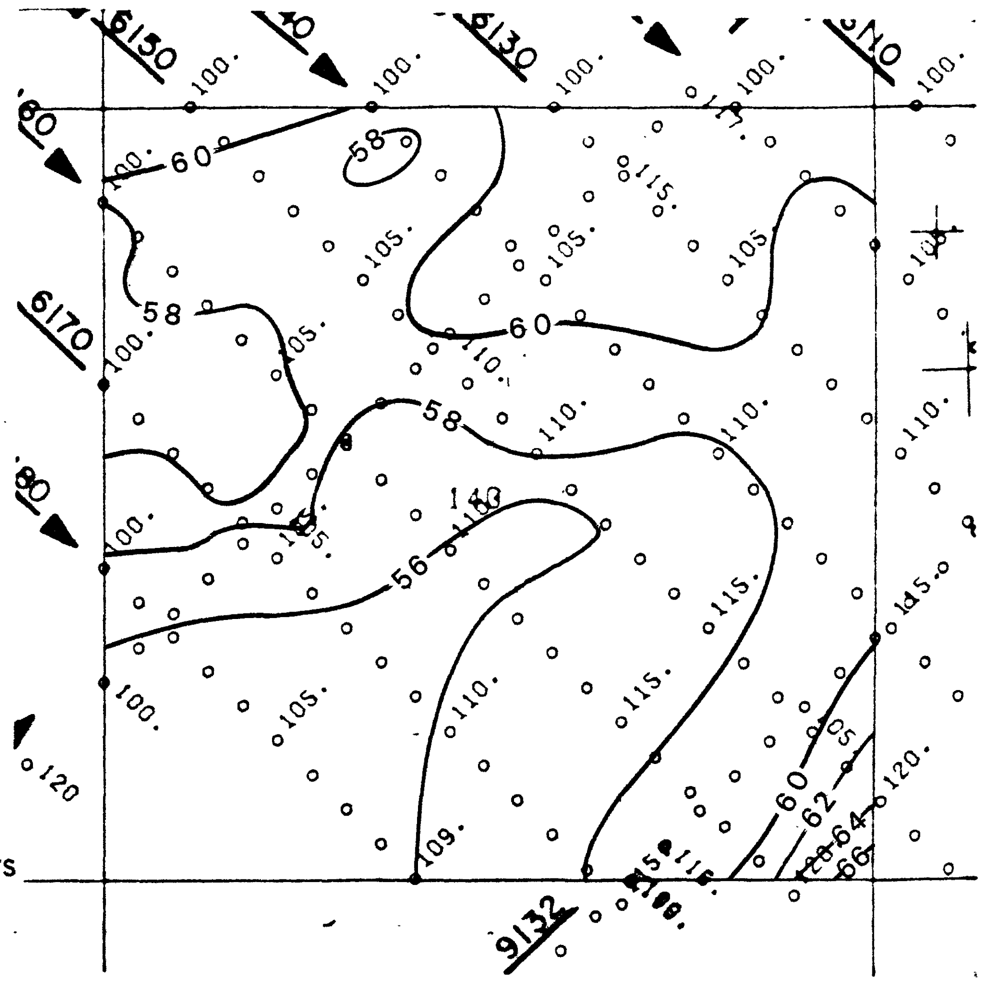
## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 140
(NJ 18-6)

Contours in Meters



Water Depth: max. 64 m , min. 55 m

Slope Gradient: 1.5 m/km, Direction: NW-SE

Surface Sediment Type: Sand

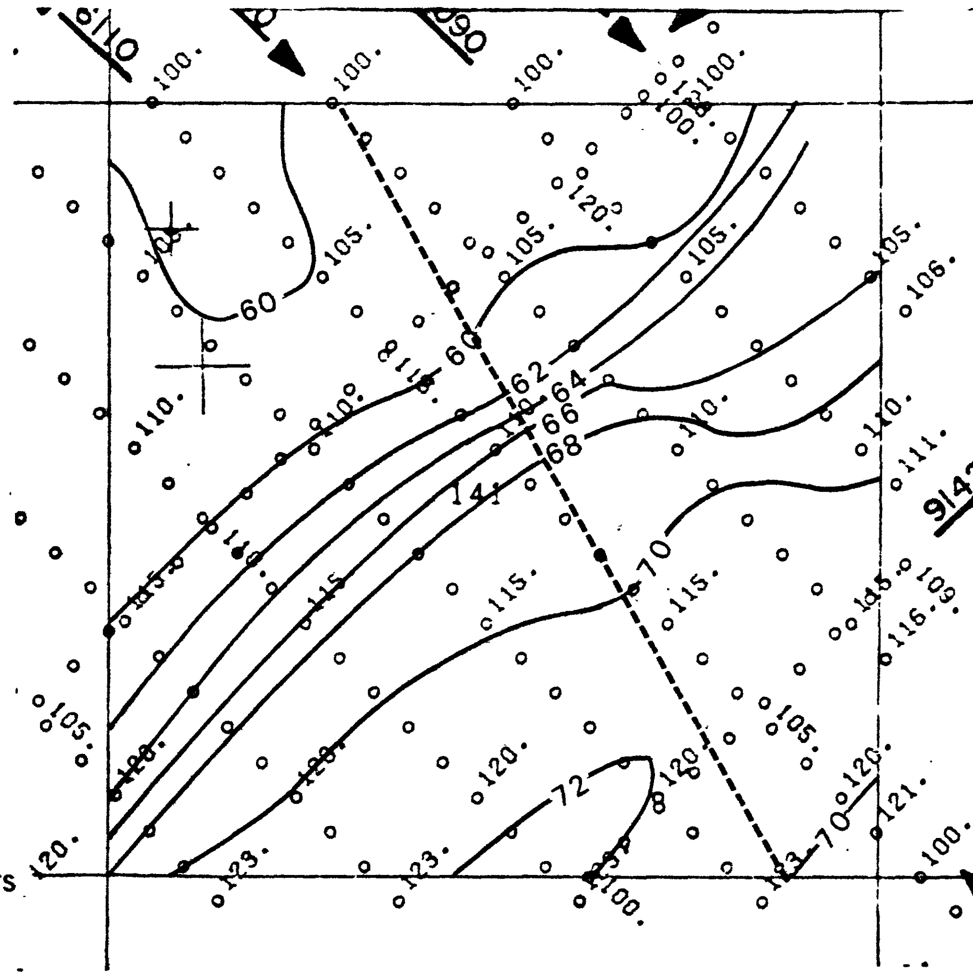
Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 141
(NJ 18–6)

Contours in Meters




Water Depth: max. 72 m , min. 56 m

Slope Gradient: 4 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

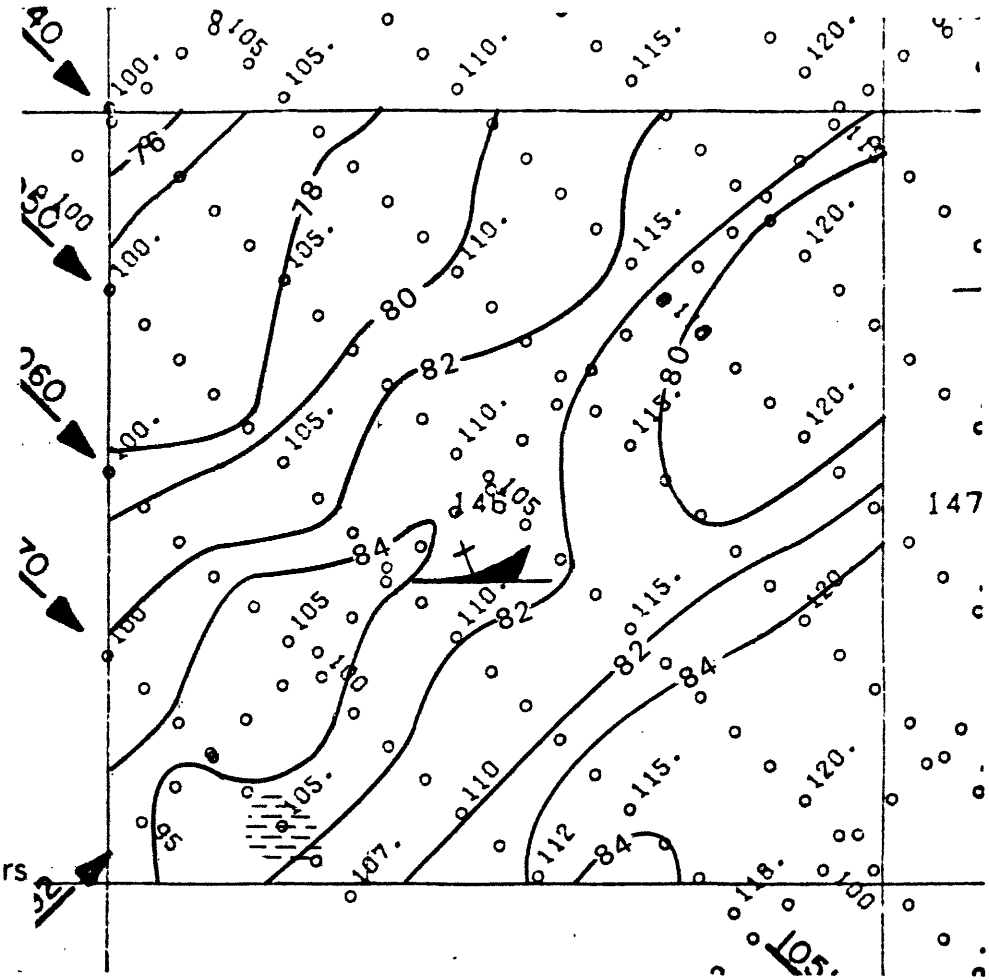
CONSTRAINTS

-------- Cable

Proposed
Lease Sale #49

Block No. 146
(NJ 18–6)

Contours in Meters

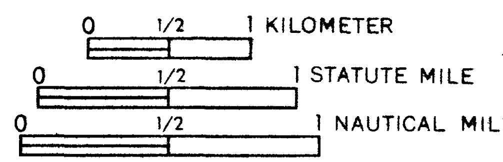



Water Depth: max. 87 m , min. 76 m

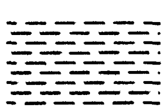
Slope Gradient: 1.5 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000




## CONSTRAINTS

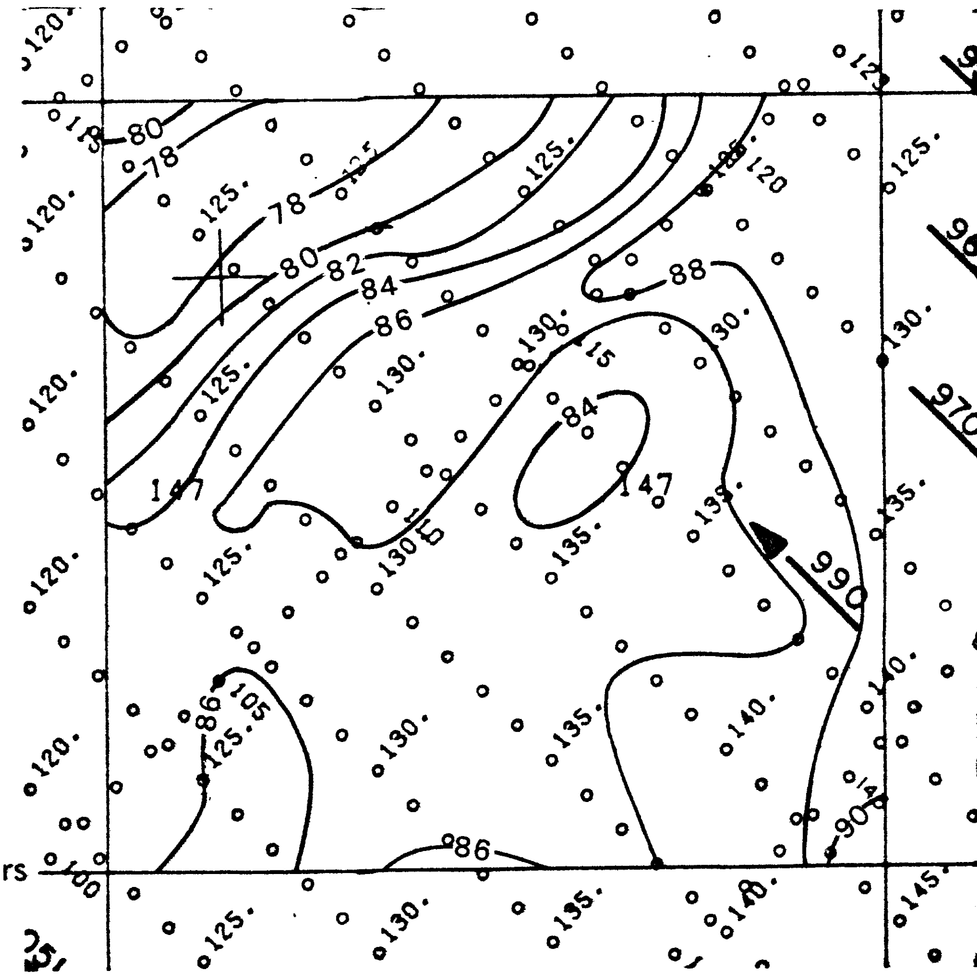

Filled Channel


Shipwreck (from BLM, Draft Environmental Impact Statement, Sale #49, Visual #1)

Proposed
Lease Sale #49

Block No. 147
(NJ 18–6)

Contours in Meters




Water Depth: max. 88 m , min. 75 m

Slope Gradient: 2 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

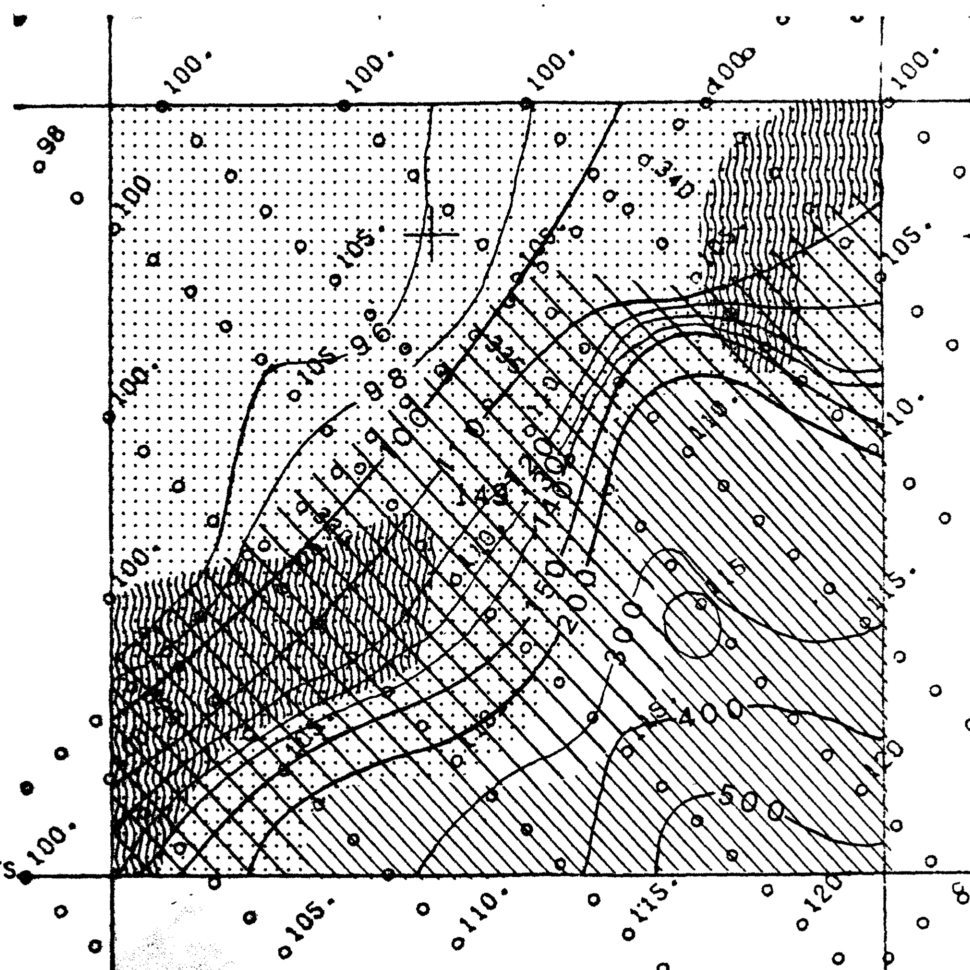
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

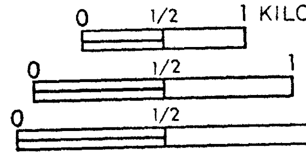
Proposed
Lease Sale #49

Block No. 149
(NJ 18–6)

Contours in Meters

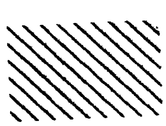



Map Scale 1:48,000



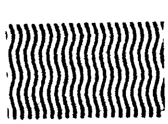

Water Depth: max. 536 m , min. 94 m
Slope Gradient: 2-133 m/km, Direction: SE
Surface Sediment Type: Sand

## HAZARDS

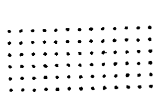


Slump or Slide

## CONSTRAINTS



Sand Wave Field



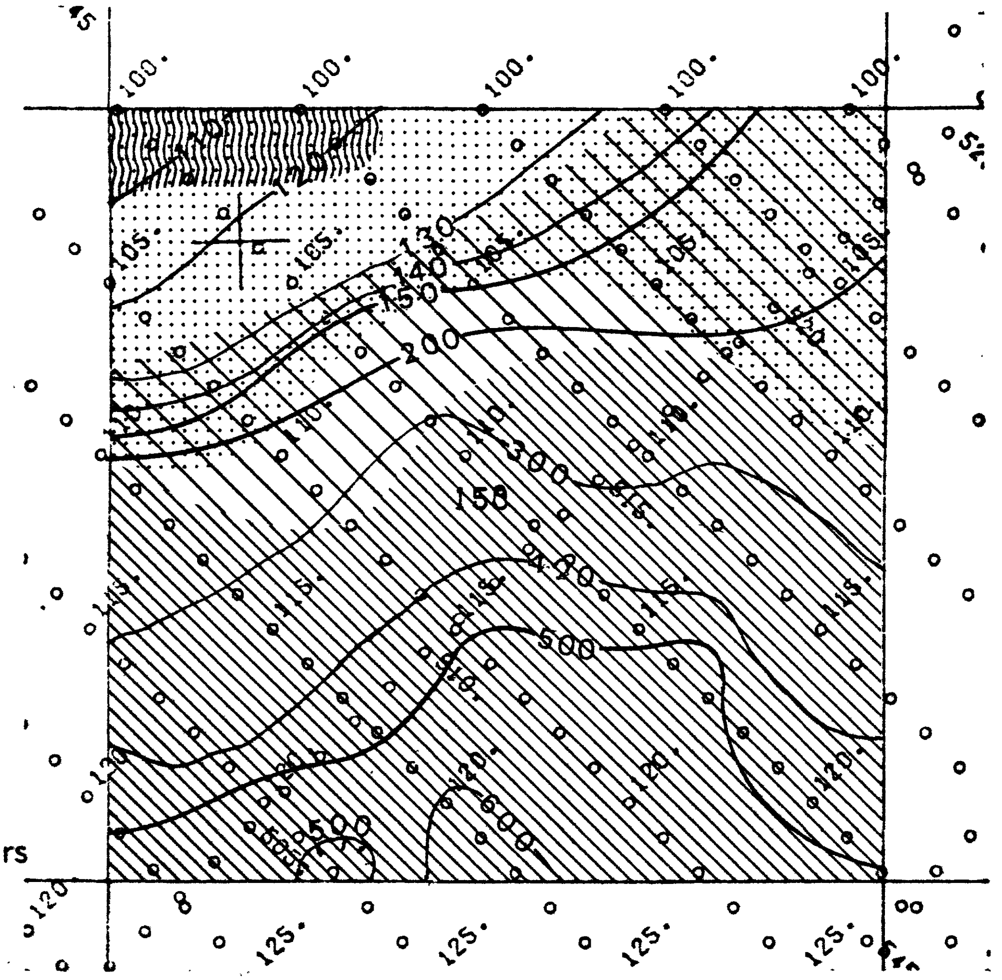
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 150
(NJ 18–6)

Contours in Meters

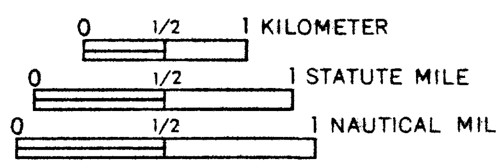



Water Depth: max. 723 m , min. 108 m

Slope Gradient: 120 m/km, Direction: S

Surface Sediment Type: Sandy clay

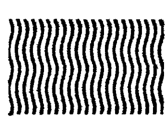
Map Scale 1:48,000



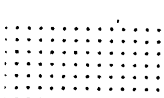

## HAZARDS

Slump or Slide

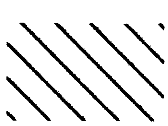
## CONSTRAINTS



Sand Wave Field



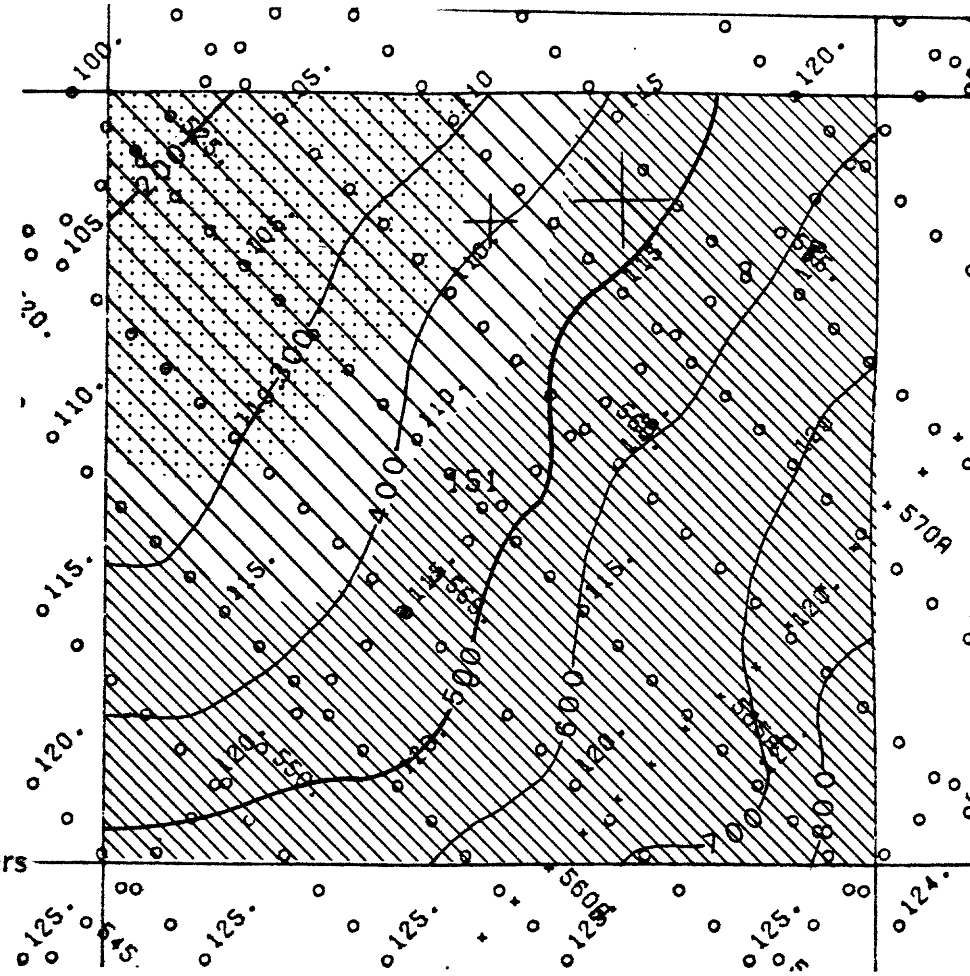
Acoustically Turbid Zone



Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 151
(NJ 18–6)




Contours in Meters

Water Depth: max. 816 m , min. 178 m

Slope Gradient: 125 m/km, Direction: SE

Surface Sediment Type: Clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

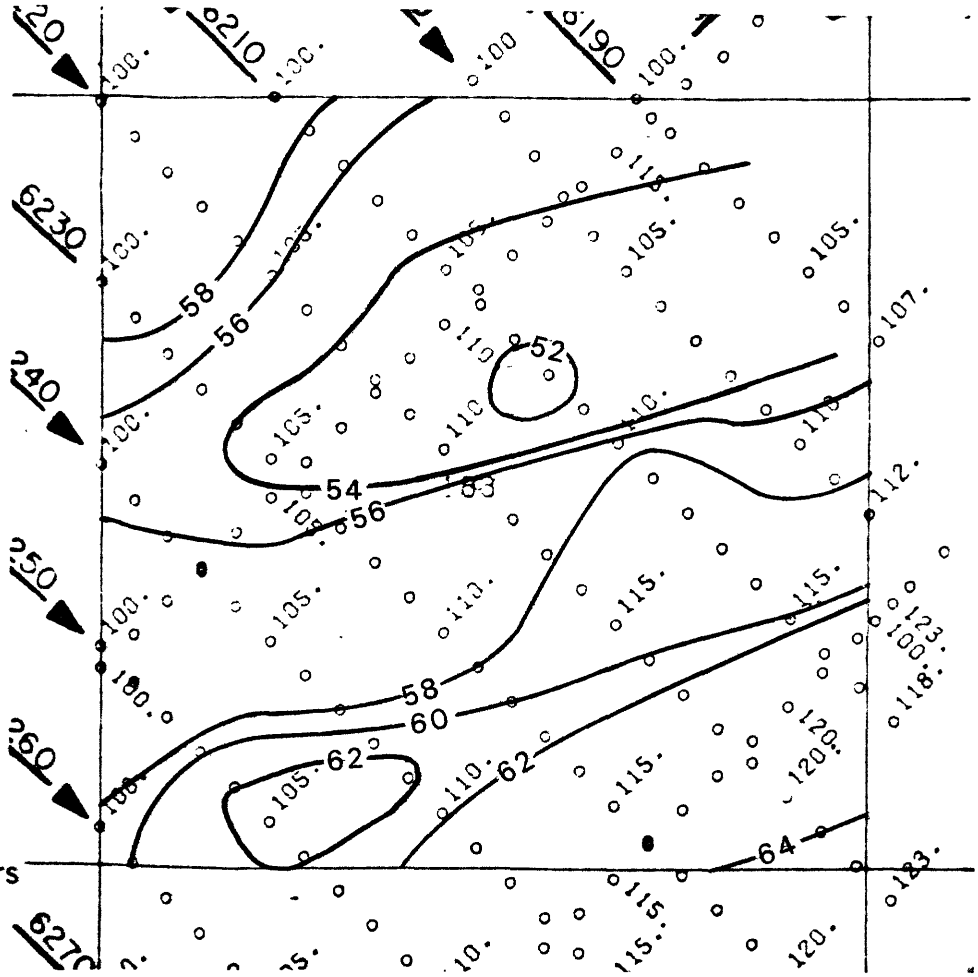
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 183
(NJ 18-6)

Contours in Meters




Water Depth: max. 65 m , min. 51 m

Slope Gradient: 3 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

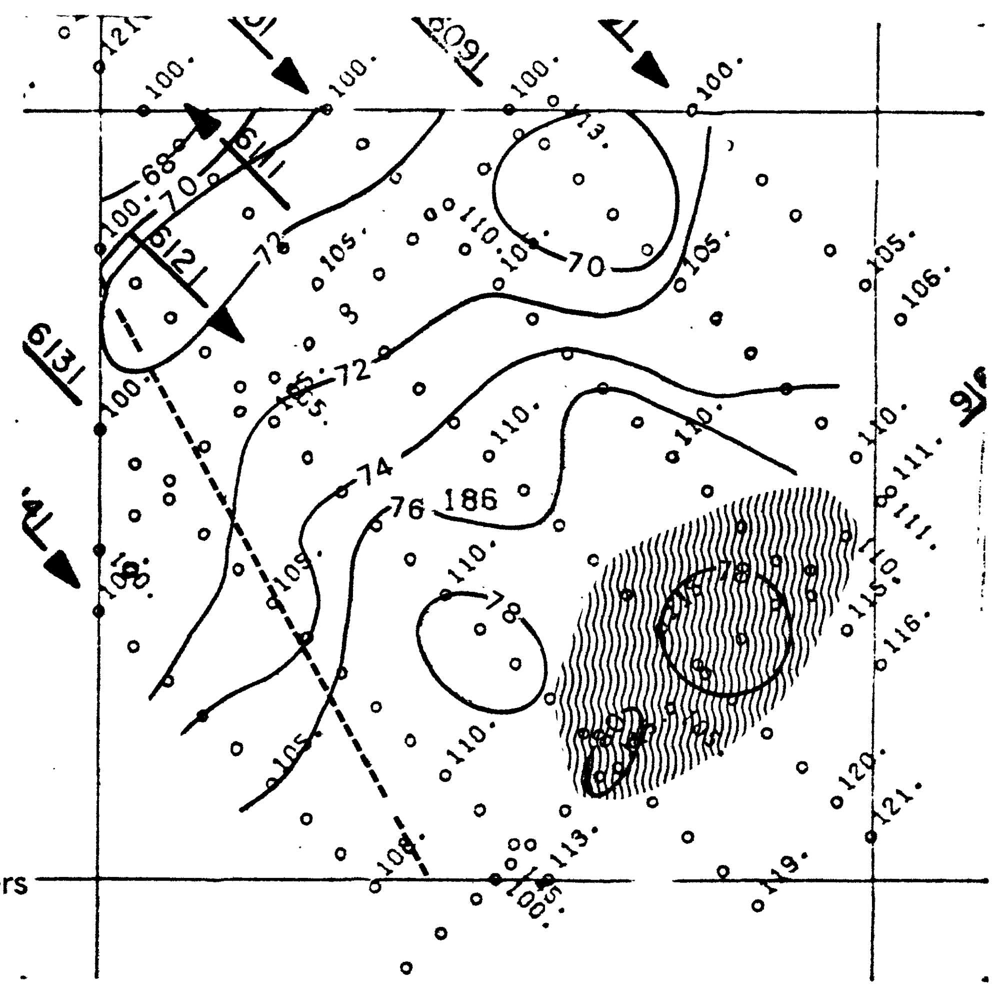
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 186
(NJ 18–6)

Contours in Meters




Water Depth: max. 80 m , min. 67 m

Slope Gradient: 2 m/km, Direction: SE

Surface Sediment Type: Sand

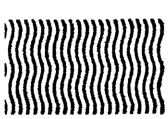
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## CONSTRAINTS



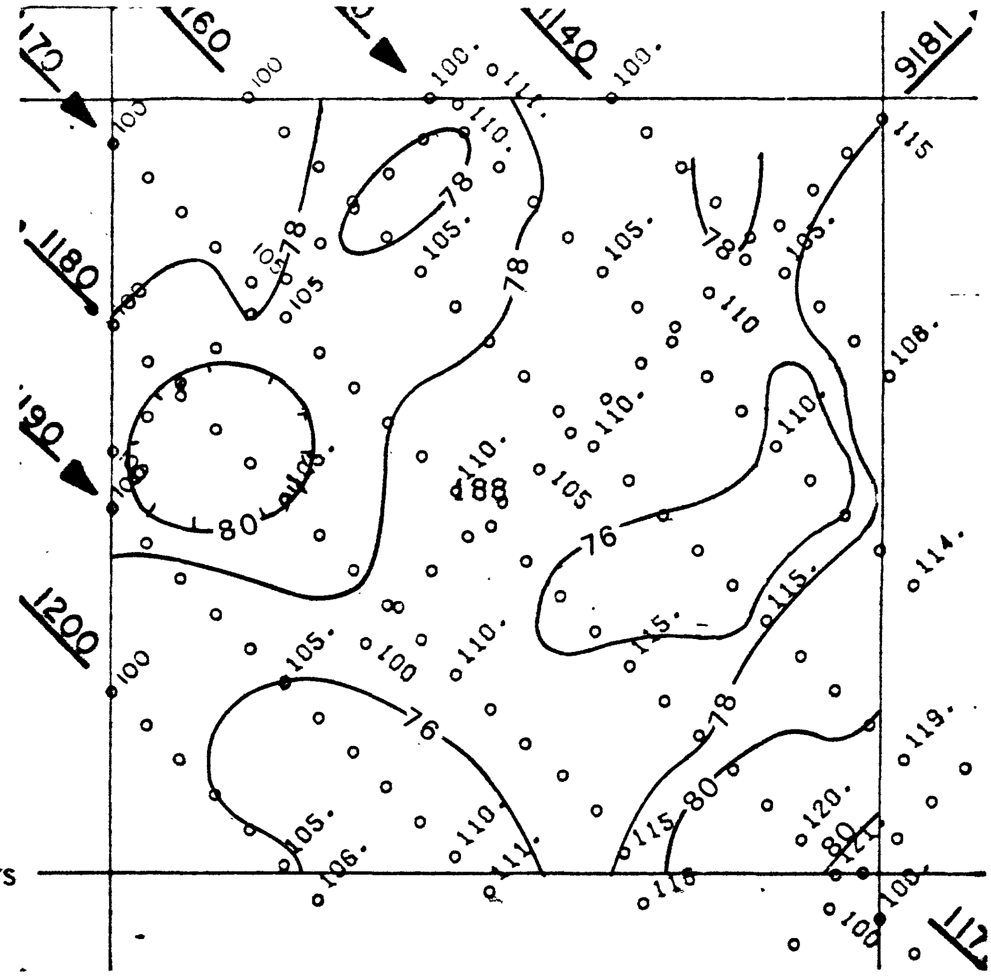
Sand Wave Field

-------- Cable

Proposed
Lease Sale #49

Block No. 188
(NJ 18–6)

Contours in Meters



Water Depth: max. 81 m , min. 74 m

Slope Gradient: 1 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

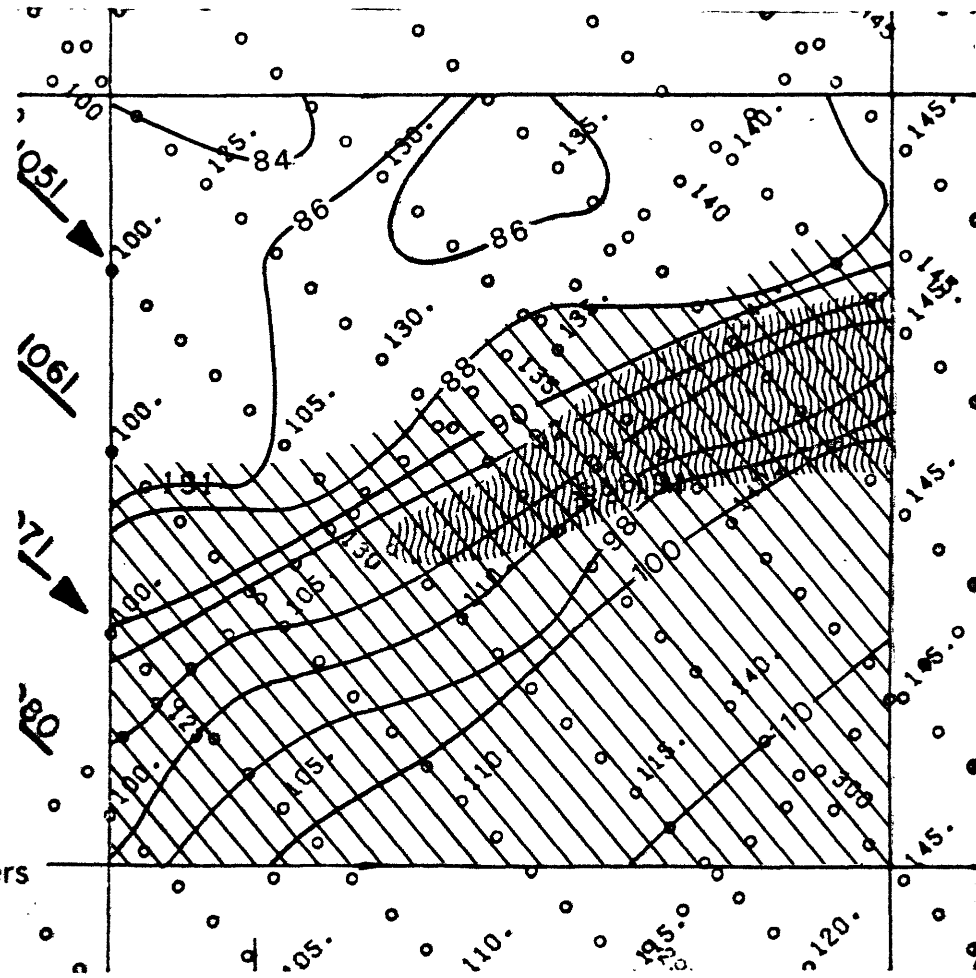
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 191
(NJ 18–6)

Contours in Meters



Water Depth: max. 118 m , min. 84 m

Slope Gradient: 6 m/km, Direction: SE

Surface Sediment Type: Sand

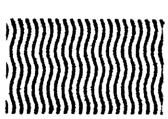
Map Scale 1:48,000

0 1/2 1 KILOMETER

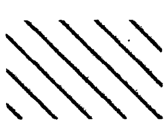
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## CONSTRAINTS



Sand Wave Field

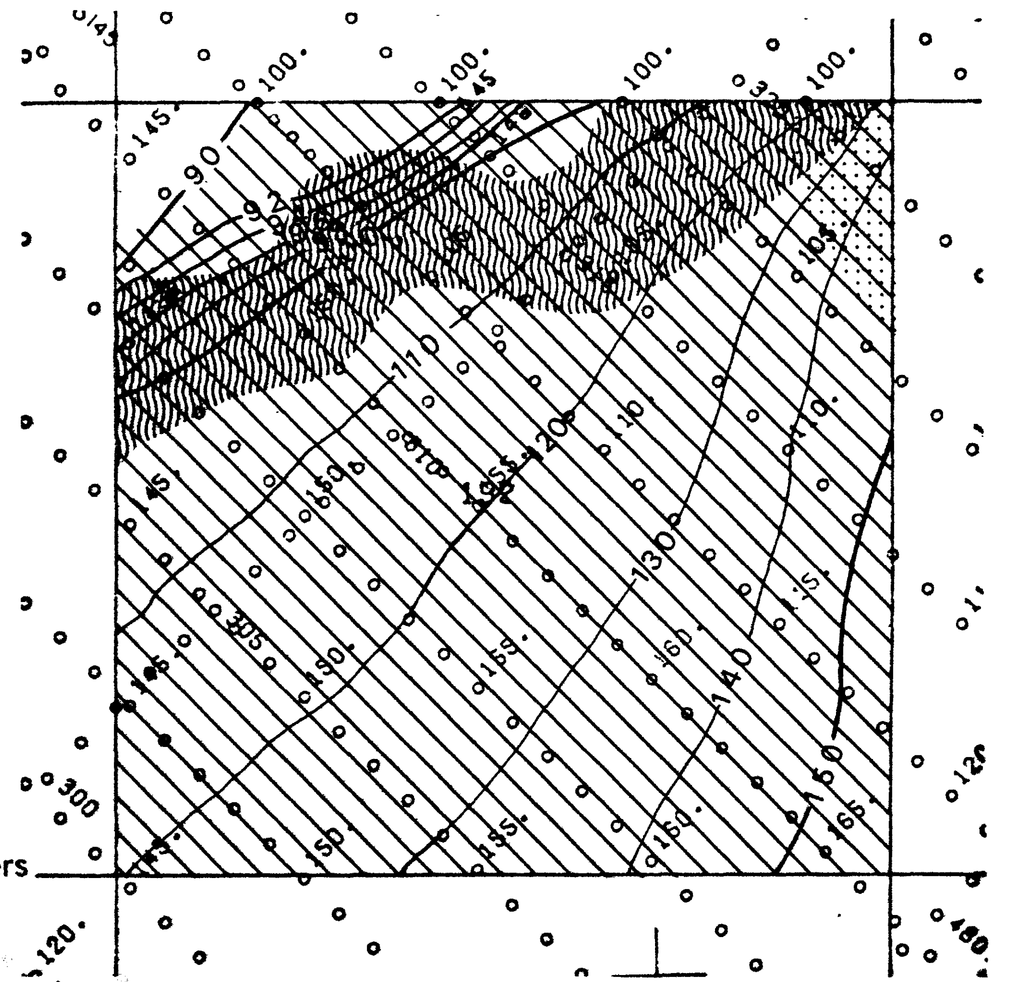


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 192
(NJ 18–6)

Contours in Meters



Water Depth: max. 154 m , min. 89 m
Slope Gradient: 12 m/km, Direction: ESE
Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

Sand Wave Field

Acoustically Turbid Zone

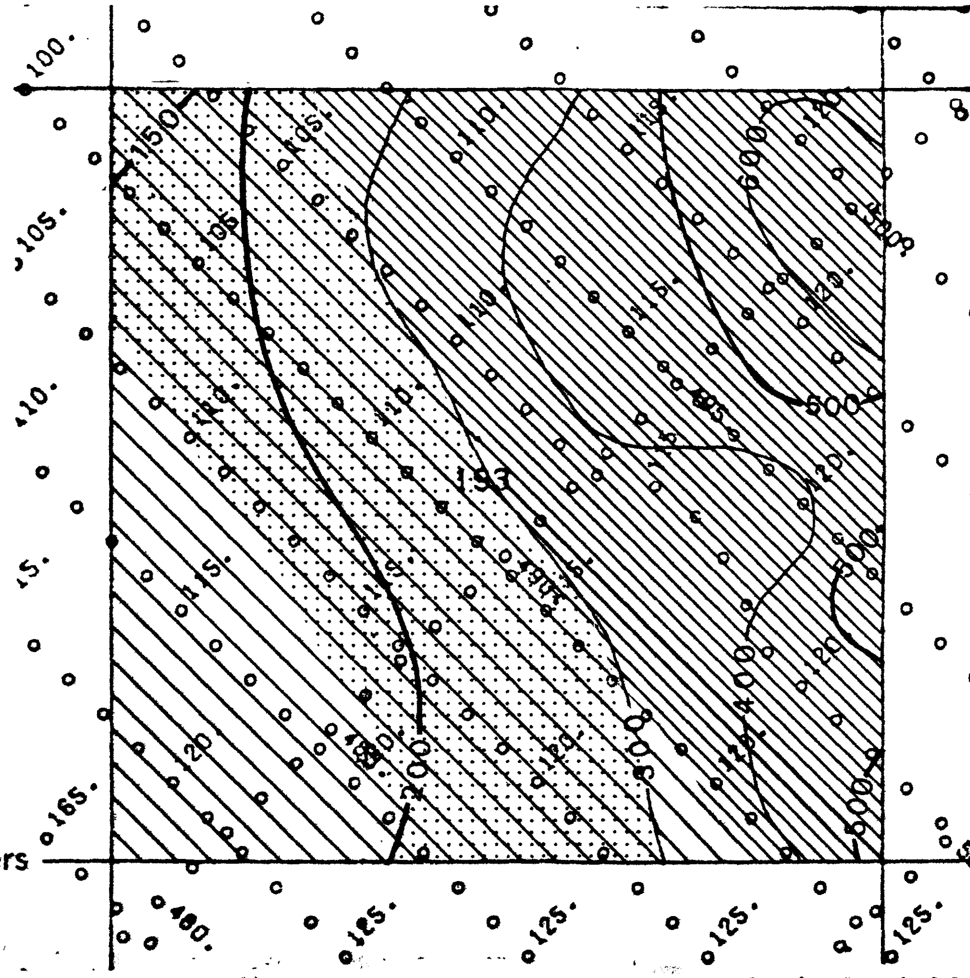
Potentially Unstable Slope

Proposed

Lease Sale #49

Block No. 193
(NJ 18–6)

Contours in Meters




Water Depth: max. 681 m , min. 154 m

Slope Gradient: 88 m/km, Direction: E

Surface Sediment Type: Sandy clay

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

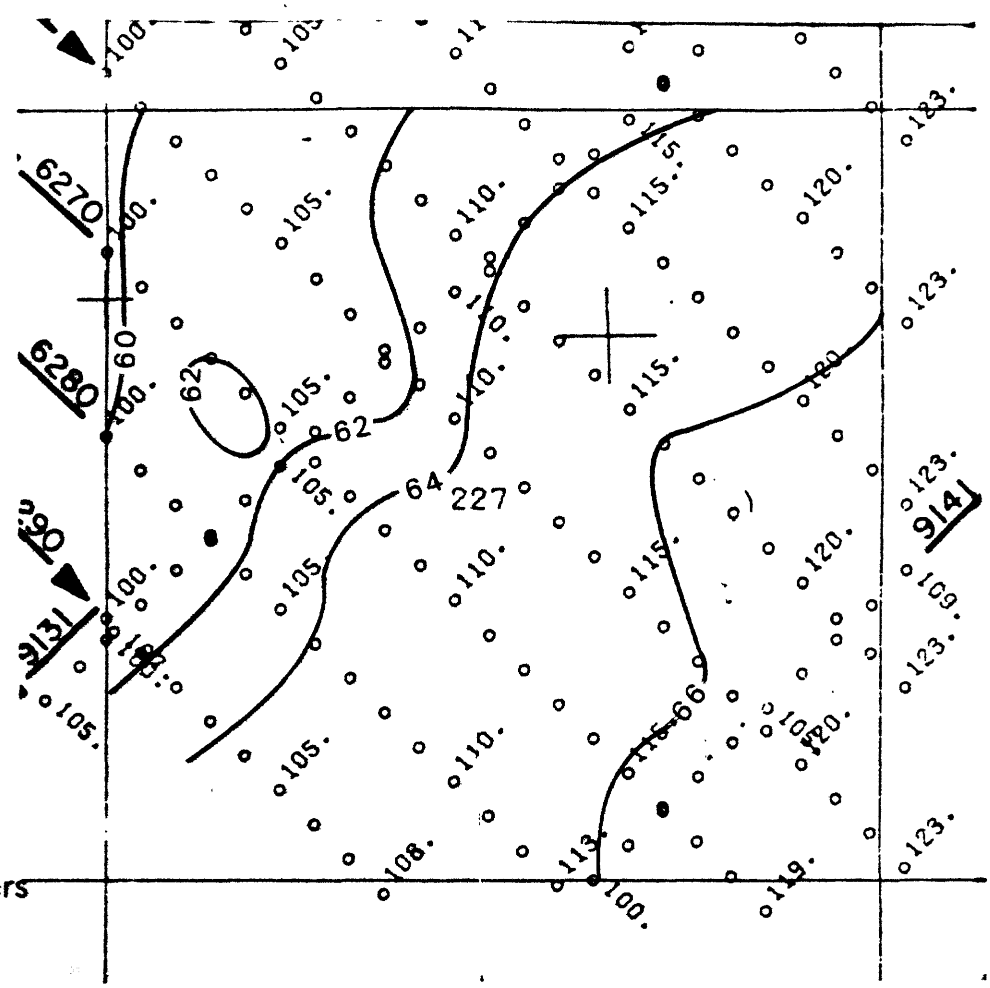
Slump or Slide

## CONSTRAINTS

Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49




Block No. 227
(NJ 18–6)

Contours in Meters

Water Depth: max. 67 m , min. 59 m

Slope Gradient: .2 m/km, Direction: SSE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

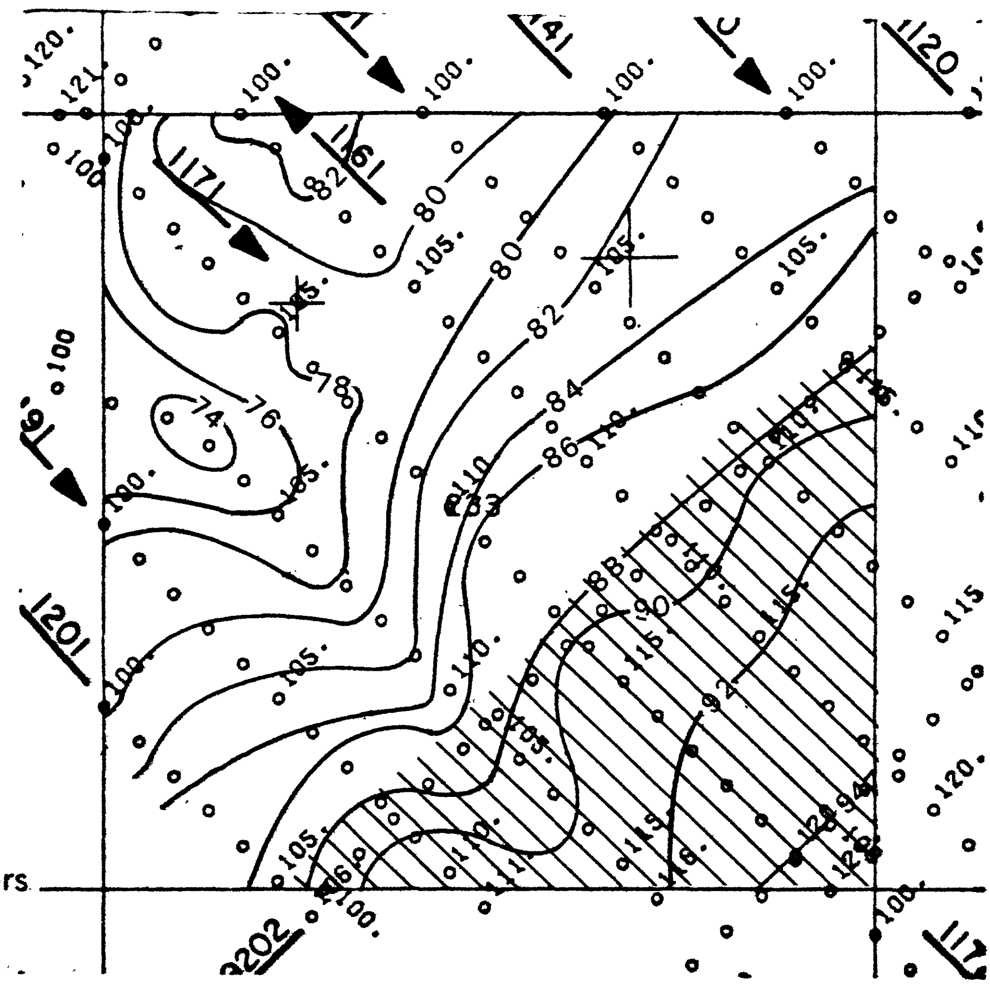
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 233
(NJ 18–6)

Contours in Meters




Water Depth: max. 95 m , min. 73 m

Slope Gradient: 4 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

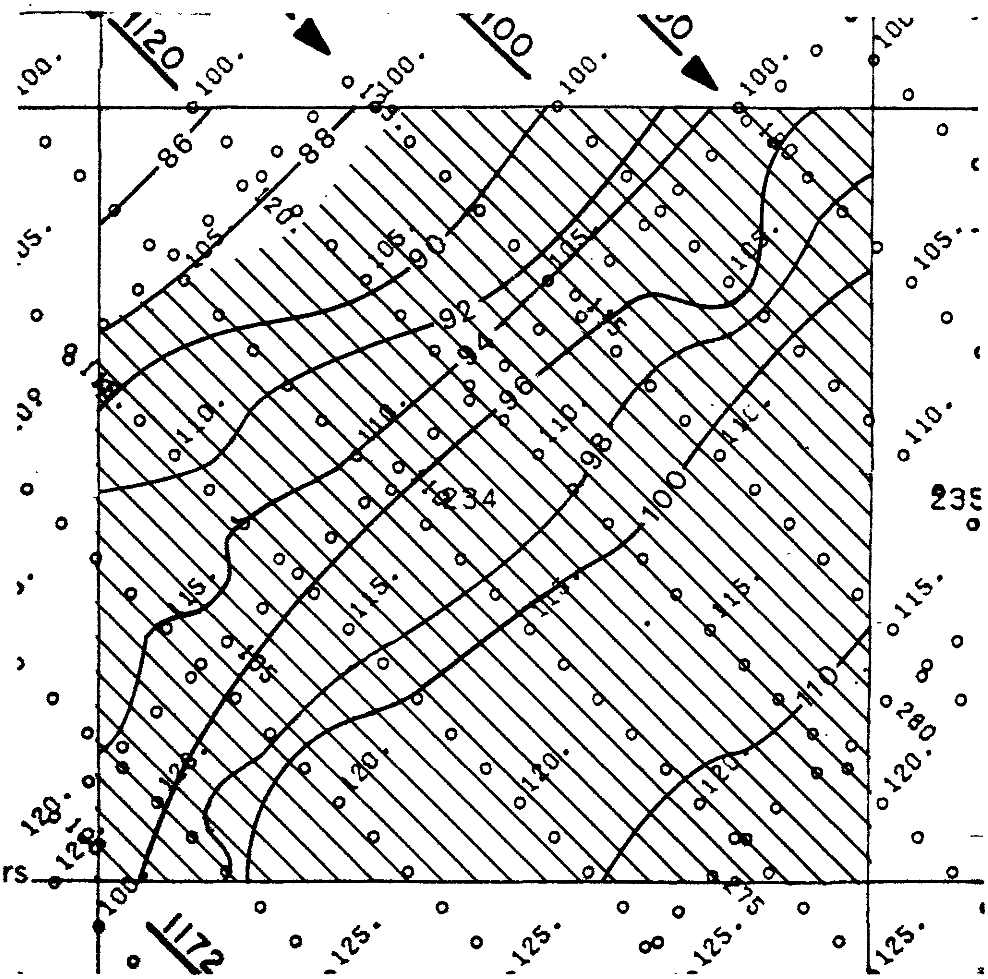
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

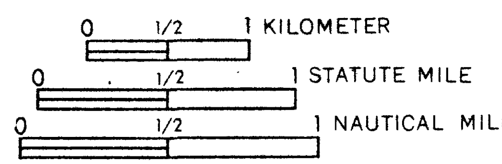



Block No. 234
(NJ 18–6)

Contours in Meters

Water Depth: max. 117 m , min. 85 m
Slope Gradient: 5 m/km, Direction: SE
Surface Sediment Type: Sand

Map Scale 1:48,000



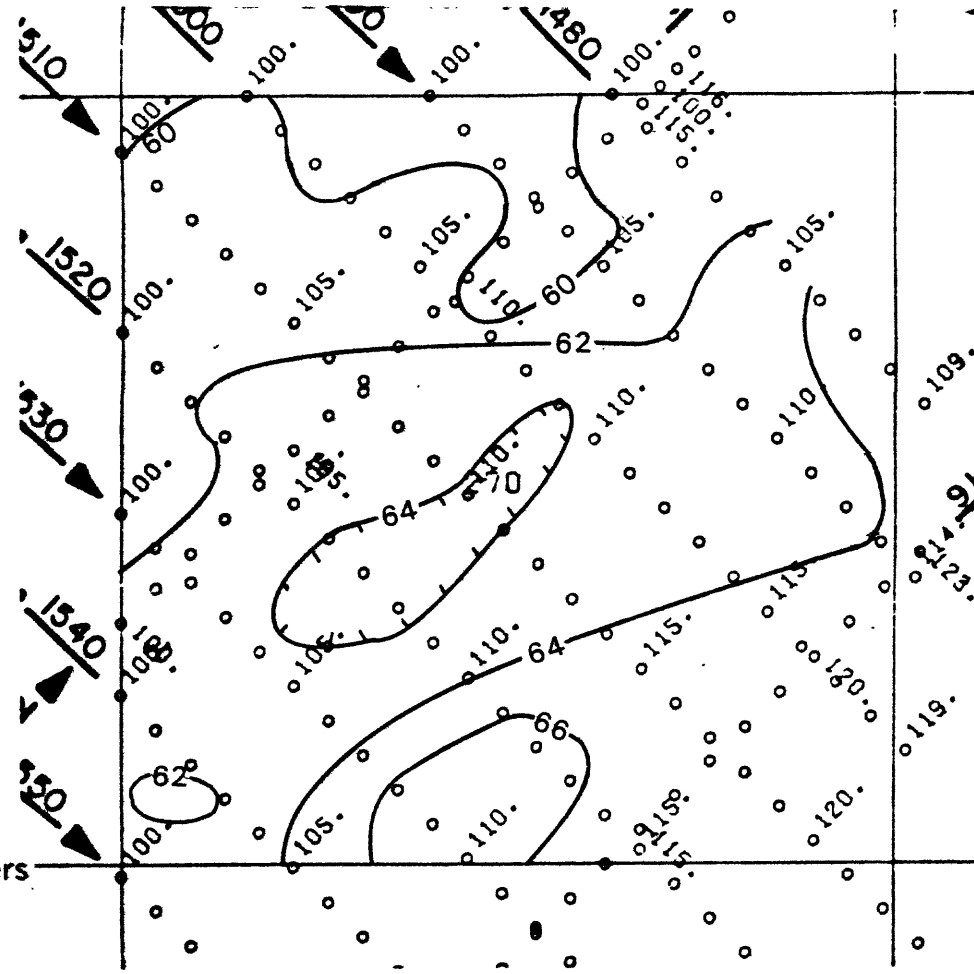

## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 270
(NJ 18–6)

Contours in Meters




Water Depth: max. 67 m , min. 60 m

Slope Gradient: 2 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

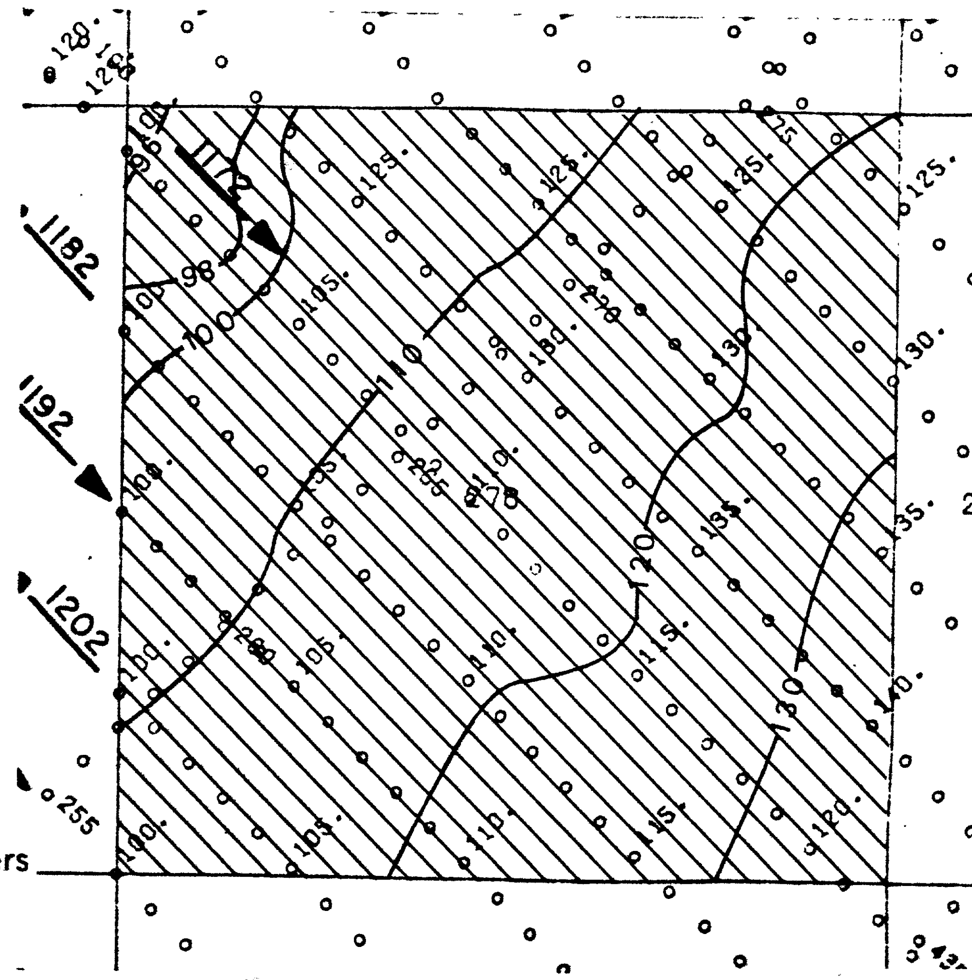
0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

Proposed
Lease Sale #49

Block No. 278
(NJ 18–6)

Contours in Meters




Water Depth: max. 136 m , min. 95 m

Slope Gradient: 7 m/km, Direction: SE

Surface Sediment Type: Sand

Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

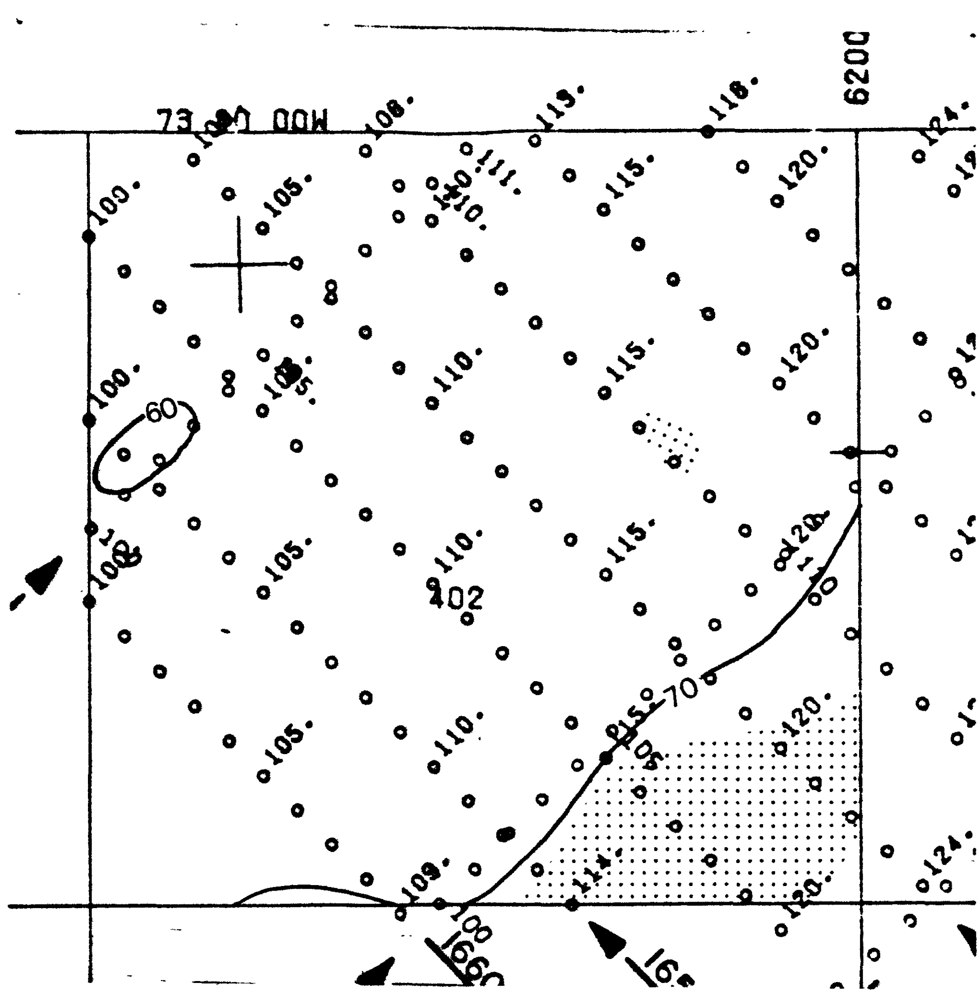
## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

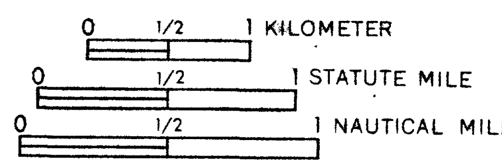
Block No. 402
(NJ 18–6)

Contours in Meters




Water Depth: max. 77 m , min. 59 m

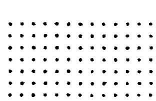
Map Scale 1:48,000




Slope Gradient: 0-5 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly, medium to fine sand

## CONSTRAINTS

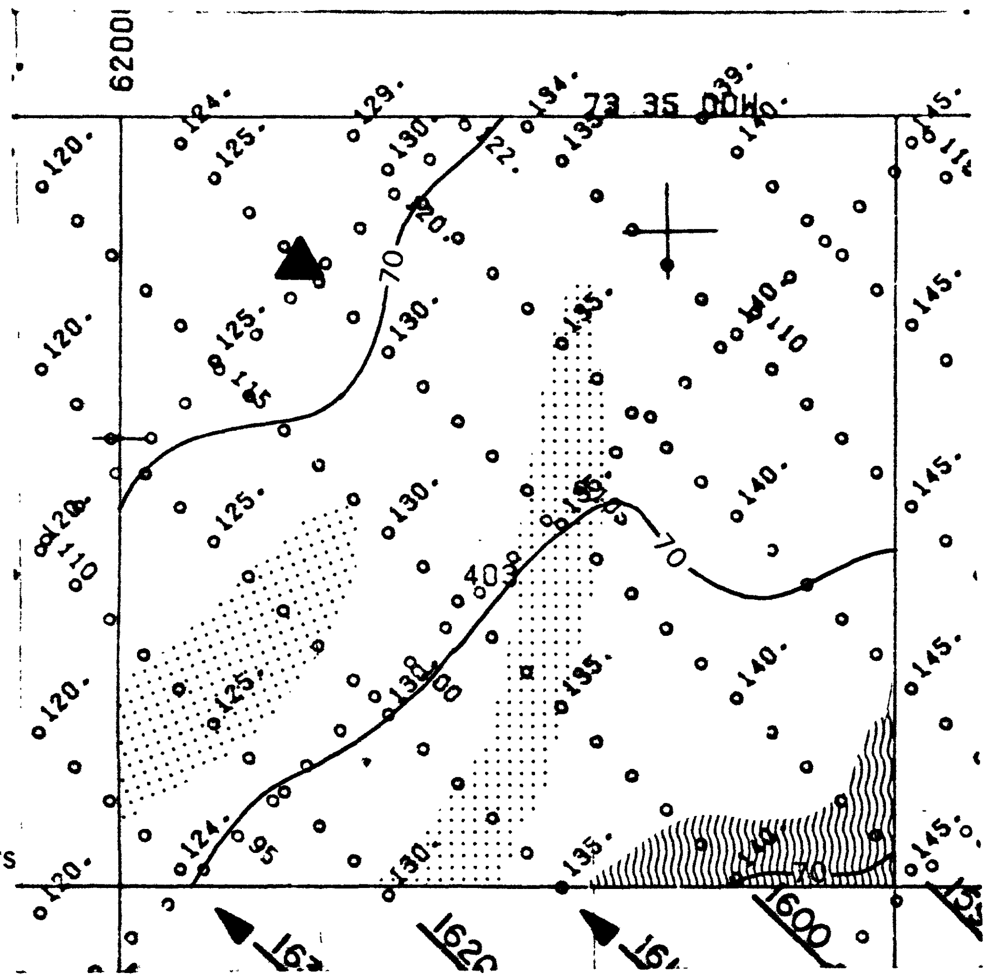

Acoustically Turbid Zone

Additional Comments: Southern portion of the block is underlain by deep, filled valley complex below the foundation zone.

Proposed
Lease Sale #49

Block No. 403
(NJ 18–6)

Contours in Meters

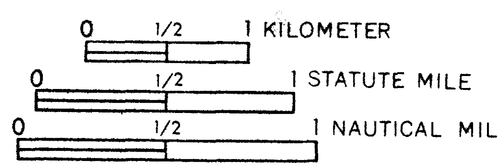



Water Depth: max. 76 m , min. 62 m

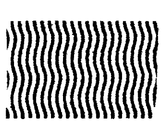
Map Scale 1:48,000

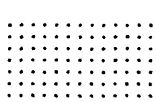
Slope Gradient: 1-8 m/km, Direction: Variable

Surface Sediment Type: Slightly gravelly to gravelly sand




## CONSTRAINTS


Sand Wave Field


Acoustically Turbid Zone

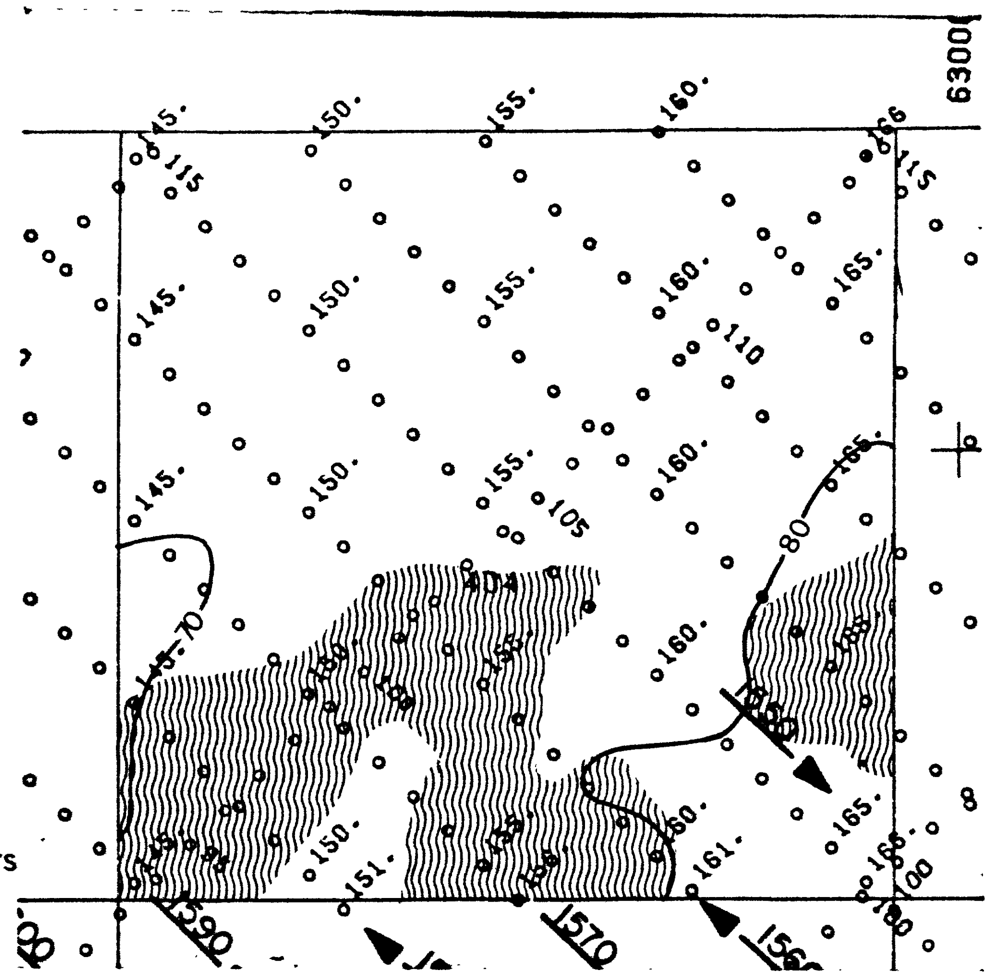

Bottom Object

Additional comments: Southeastern 2/3 of the block is underlain by deep, filled valley complexes below the foundation zone.

Proposed
Lease Sale #49

Block No. 404
(NJ 18–6)

Contours in Meters

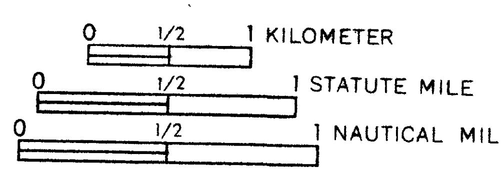


Water Depth: max. 84 m , min. 70 m

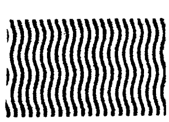
Map Scale 1:48,000

Slope Gradient: 2–5 m/km, Direction: SE

Surface Sediment Type: Gravelly sand




## CONSTRAINTS



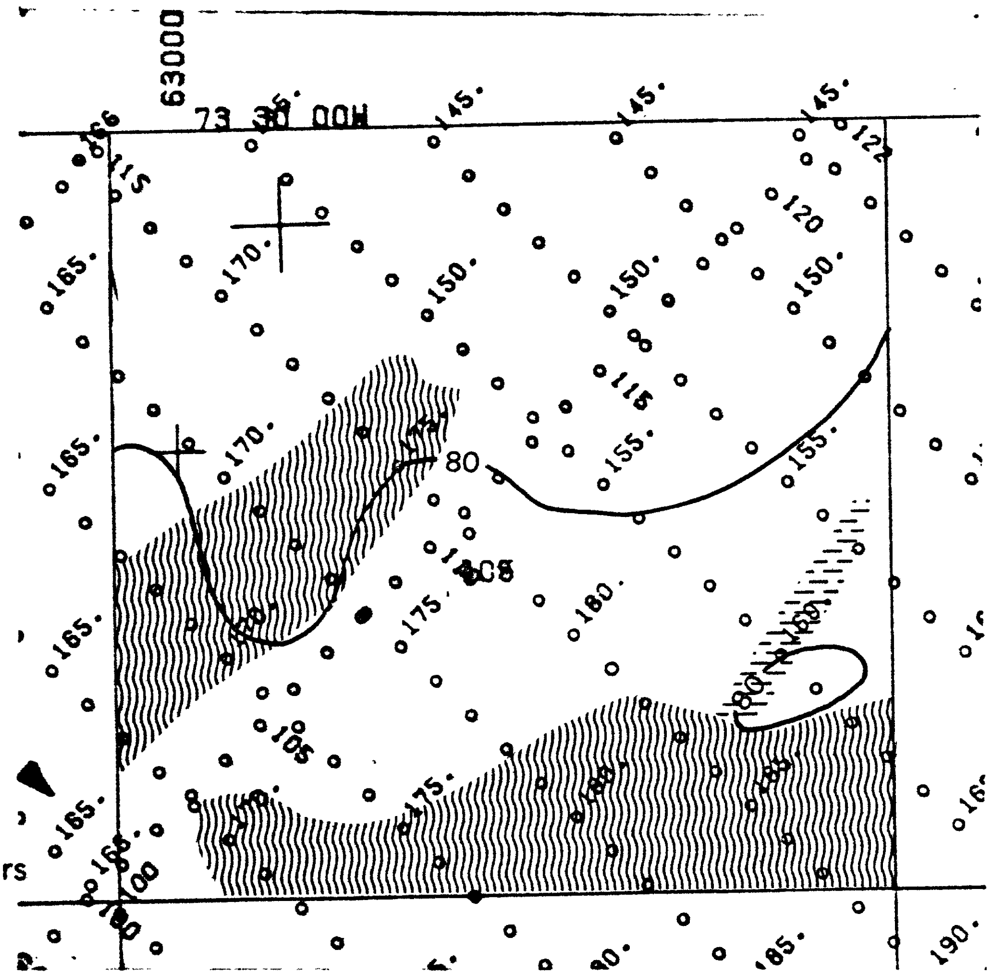
Sand Wave Field

Additional comments; Northwestern 1/4 of the block is underlain by deep, filled valley complex below the foundation zone.

Proposed
Lease Sale #49

Block No. 405
(NJ 18–6)

Contours in Meters




Water Depth: max. 87 m , min. 72 m

Map Scale 1:48,000

Slope Gradient: 1-5 m/km, Direction: Variable

Surface Sediment Type: Slightly gravelly sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

CONSTRAINTS

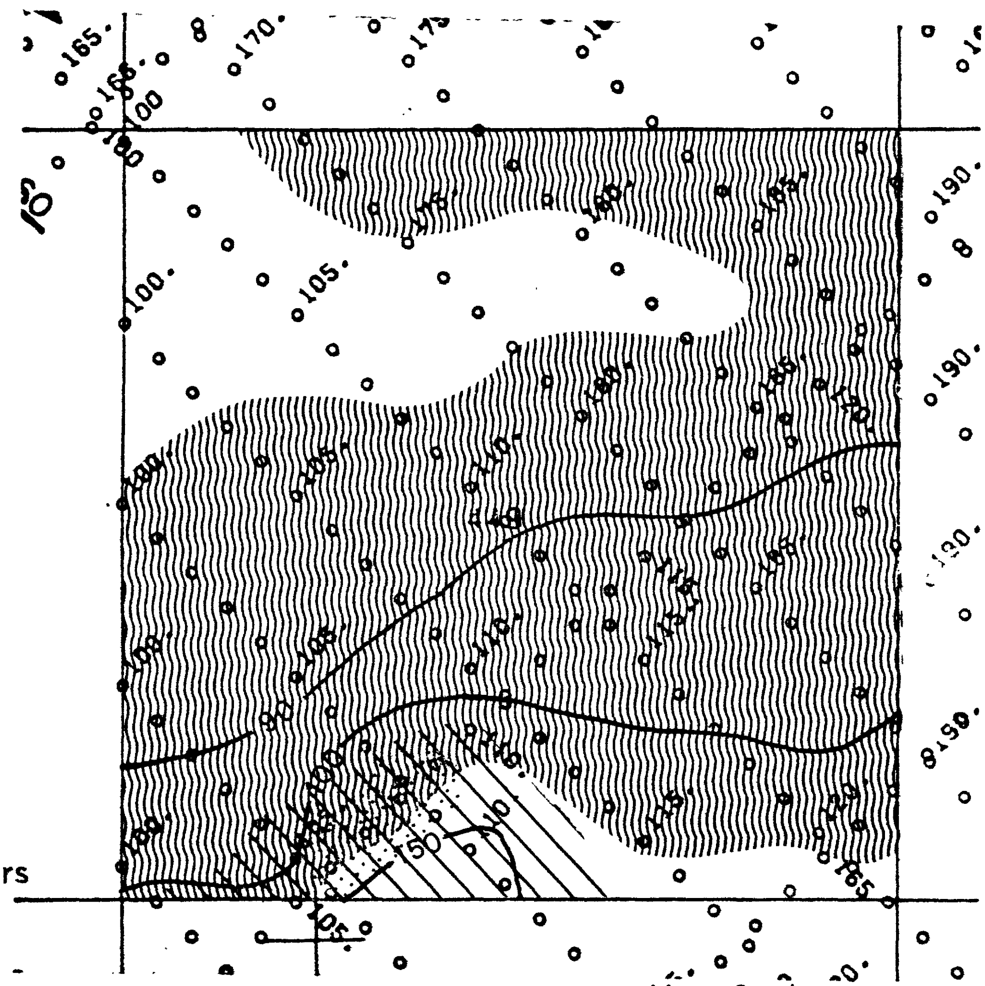
Sand Wave Field

Filled Channel (within foundation zone)

Proposed
Lease Sale #49

Block No. 449
(NJ 18–6)

Contours in Meters



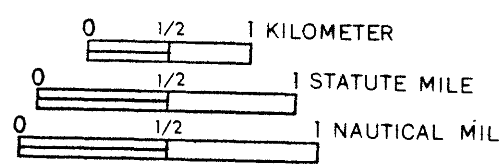
Water Depth: max. ≈180 m , min. 81 m

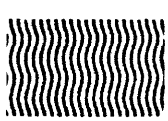
Map Scale 1:48,000

Slope Gradient: min. 1 m/km SE (shelf); max. > 80 m/km SW (canyon head)

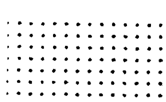
Surface Sediment Type: Gravelly to slightly gravelly sand (shelf);
muddy sand (canyon)

## CONSTRAINTS



Sand Wave Field



Acoustically Turbid Zone

Potentially Unstable Slope

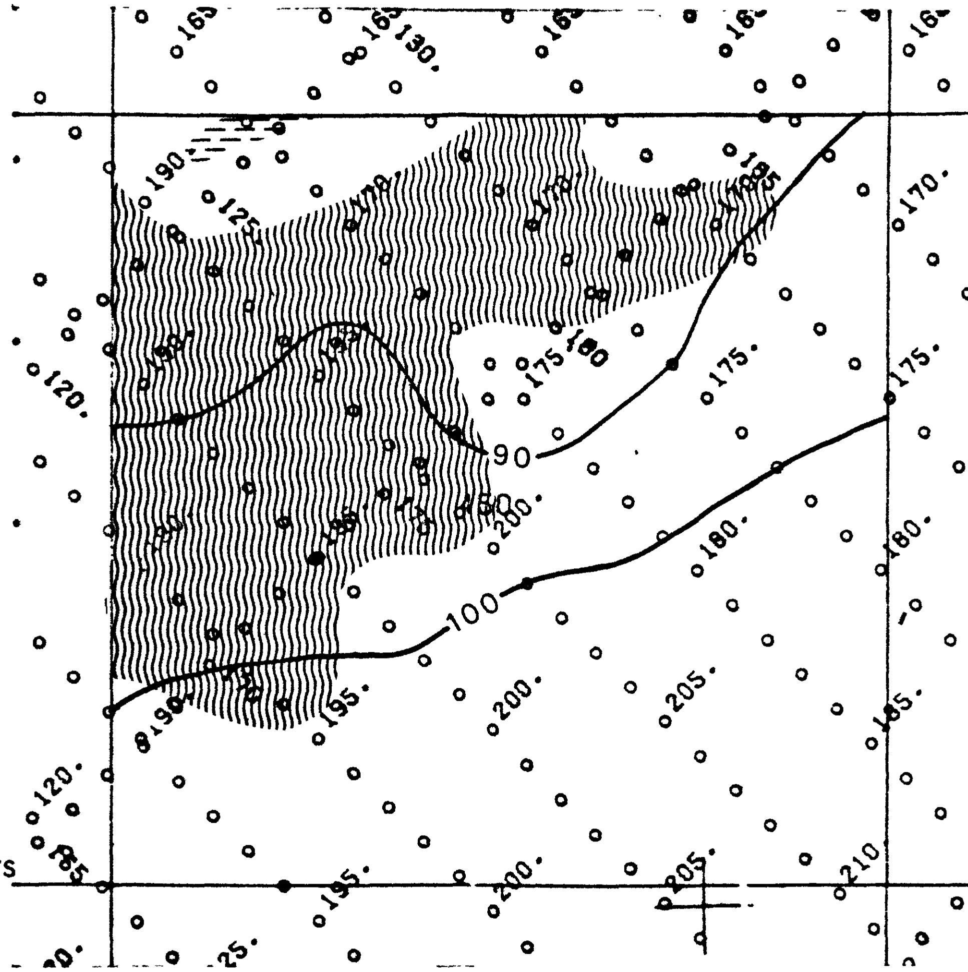
Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep canyon slopes in southern portion of block.

See figures 8, 9

Proposed
Lease Sale #49

Block No. 450
(NJ 18–6)

Contours in Meters




Water Depth: max. 109 m , min. 81 m

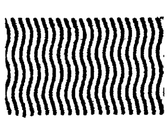
Map Scale 1:48,000

Slope Gradient: 3–4 m/km, Direction: SE

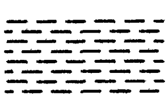
Surface Sediment Type: Gravelly to slightly gravelly sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS



Sand Wave Field



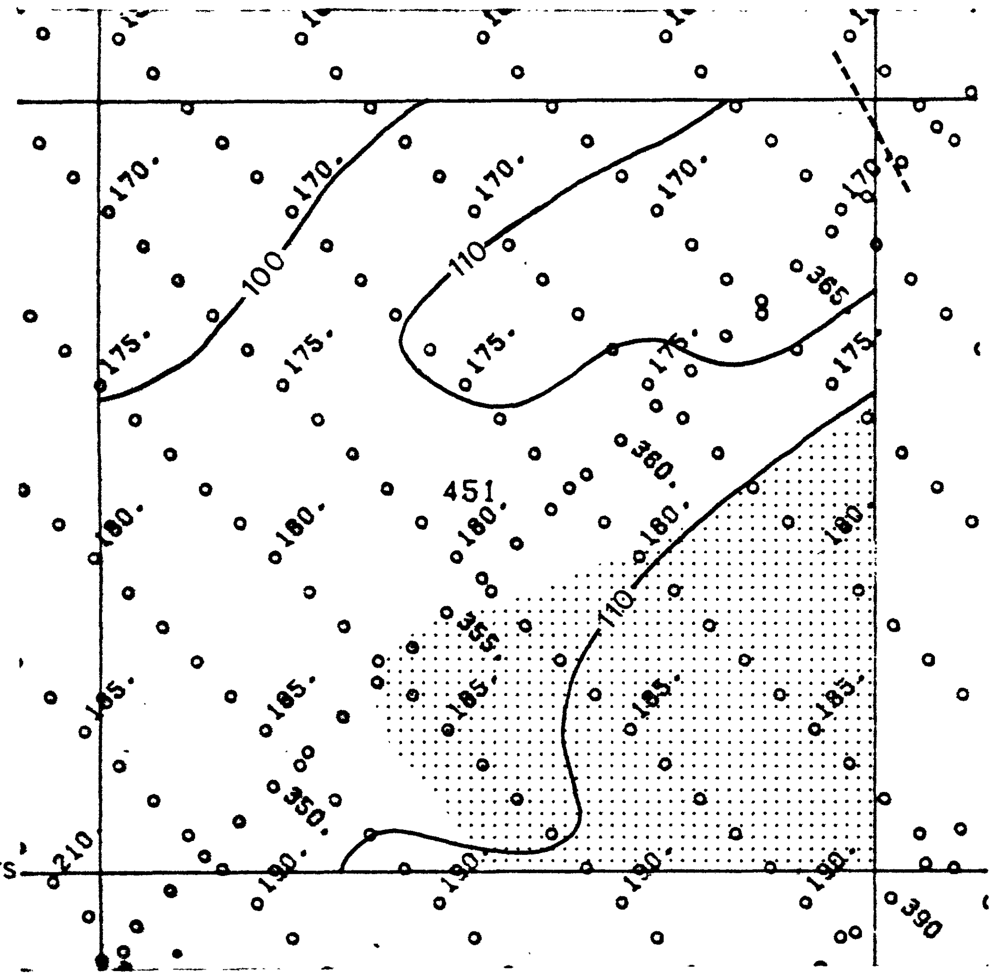
Filled Channel (within foundation zone)

Additional Comments: See figure 11a.

Proposed
Lease Sale #49

Block No. 451
(NJ 18–6)

Contours in Meters

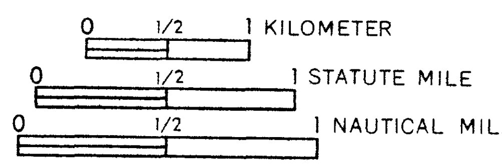



Water Depth: max. 122 m , min. 92 m

Map Scale 1:48,000

Slope Gradient: 4-5 m/km, Direction: SE

Surface Sediment Type: Gravelly to slightly gravelly sand




## CONSTRAINTS

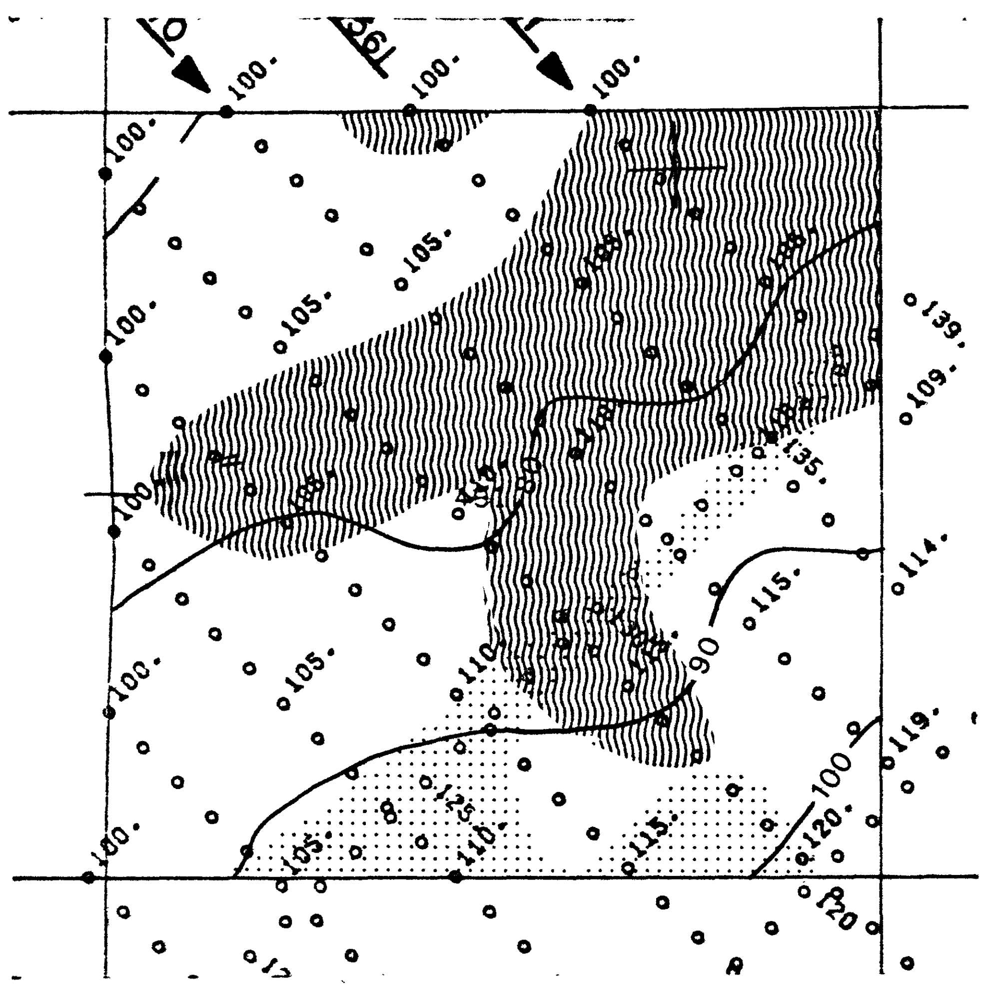
Acoustically Turbid Zone

Cable

Proposed
Lease Sale #49

Block No. 491
(NJ 18-6)

Contours in Meters



Water Depth: max. 105 m , min. 69 m

Map Scale 1:48,000

Slope Gradient: 2-10 m/km, Direction: SE

Surface Sediment Type: Gravelly to slightly gravelly sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

CONSTRAINTS

Sand Wave Field

Acoustically Turbid Zone

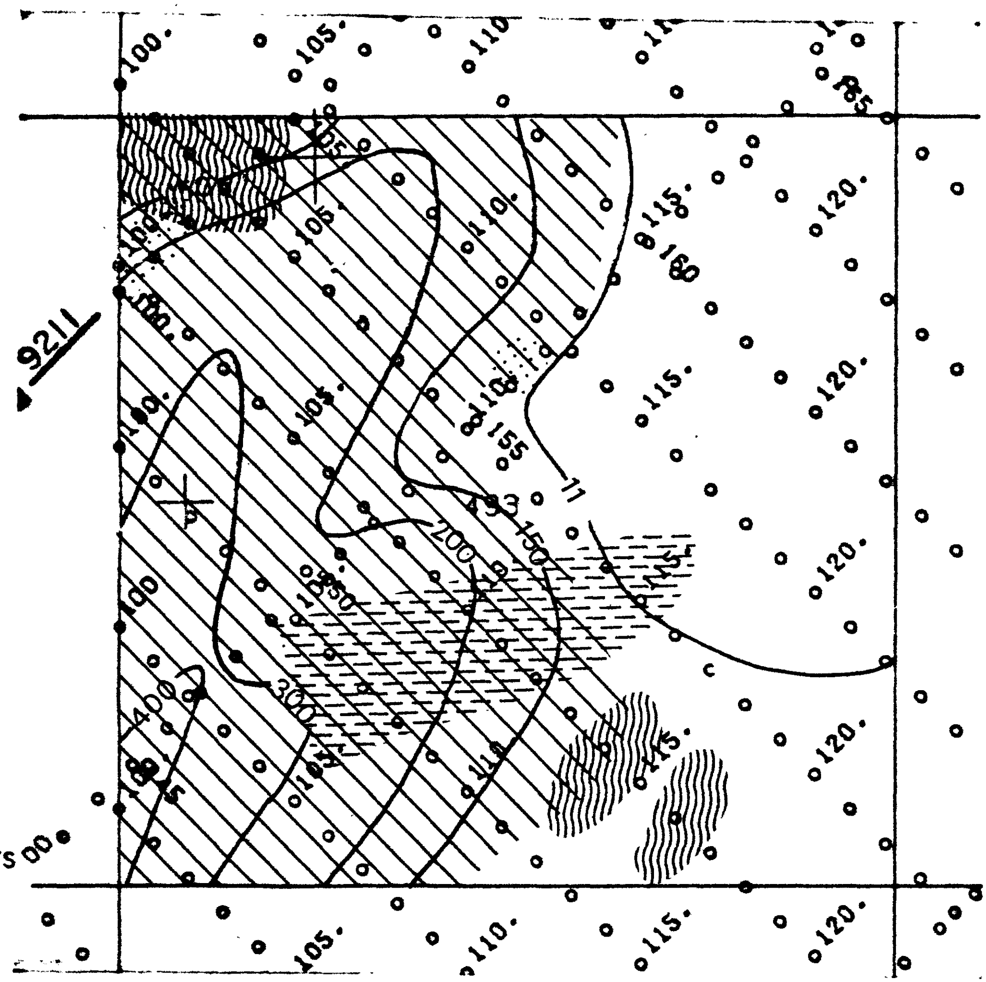
Additional Comments: Most of the block is underlain by deep, filled valley complexes below the foundation zone.

See figure 11b.

Proposed
Lease Sale #49

Block No. 493
(NJ 18–6)

Contours in Meters




Water Depth: max. >409 m , min. 106 m

Map Scale 1:48,000

Slope Gradient: min. > 1 m/km SE (shelf); max. > 200 m/km W (canyon head)

Surface Sediment Type: Slightly gravelly sandy muds to gravelly sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

Sand Wave Field (and zone of megaripples)

Filled Channel (within foundation zone)

Acoustically Turbid Zone

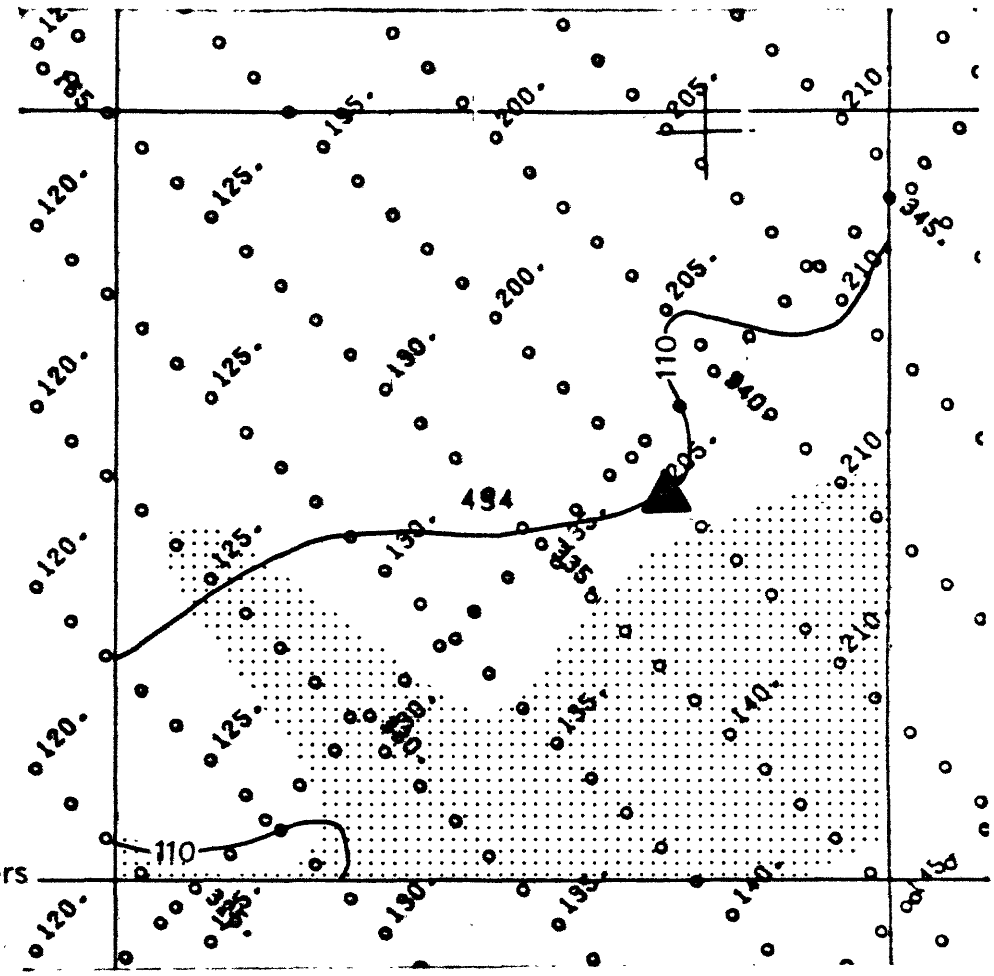
Potentially Unstable Slope

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep canyon slopes at canyon head.

Proposed
Lease Sale #49

Block No. 494
(NJ 18–6)

Contours in Meters

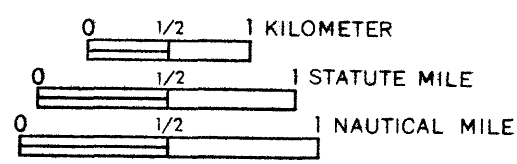



Water Depth: max. 120 m , min. 106 m

Map Scale 1:48,000

Slope Gradient: 3–5 m/km, Direction: SE

Surface Sediment Type: Gravelly sand




## CONSTRAINTS

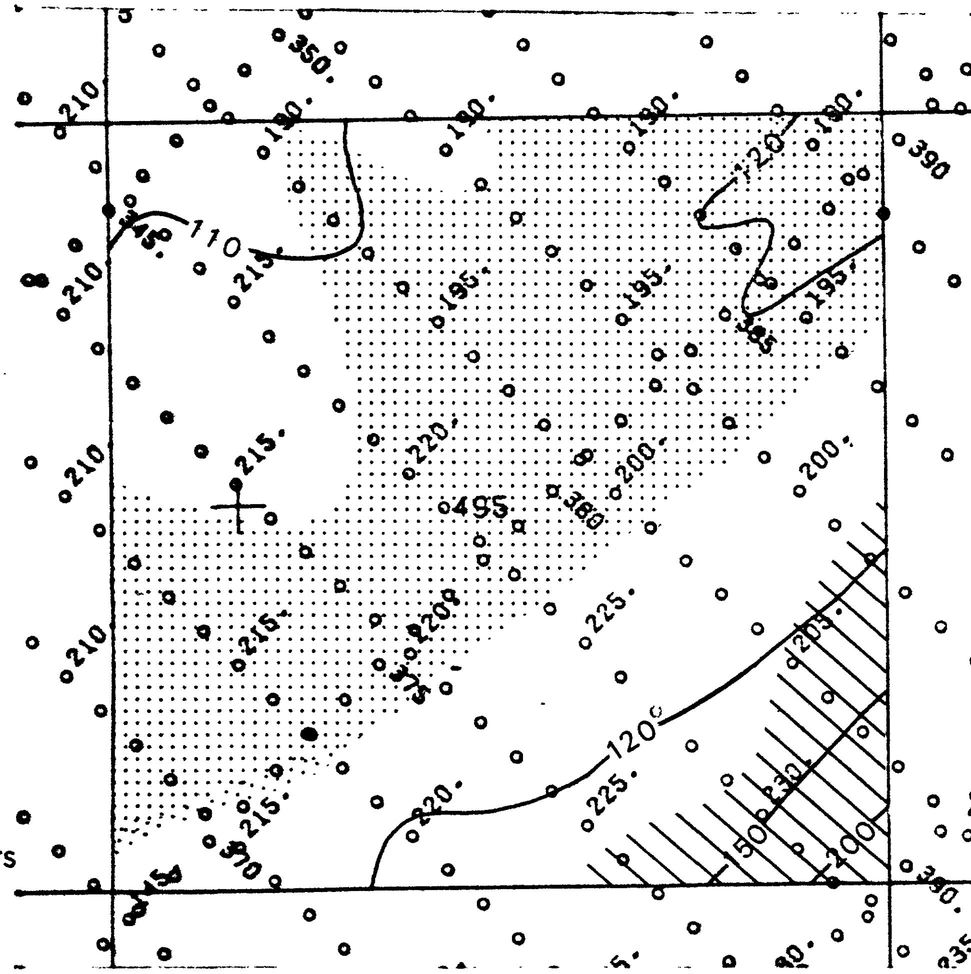
Acoustically Turbid Zone

Bottom Object

Proposed
Lease Sale #49

Block No. 495
(NJ 18–6)

Contours in Meters




Water Depth: max. >250 m , min. 108 m

Map Scale 1:48,000

Slope Gradient: min. 3-4 m/km SE (shelf); max. > 80 m/km SE (slope)

Surface Sediment Type: Gravelly to slightly gravelly muddy sands

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

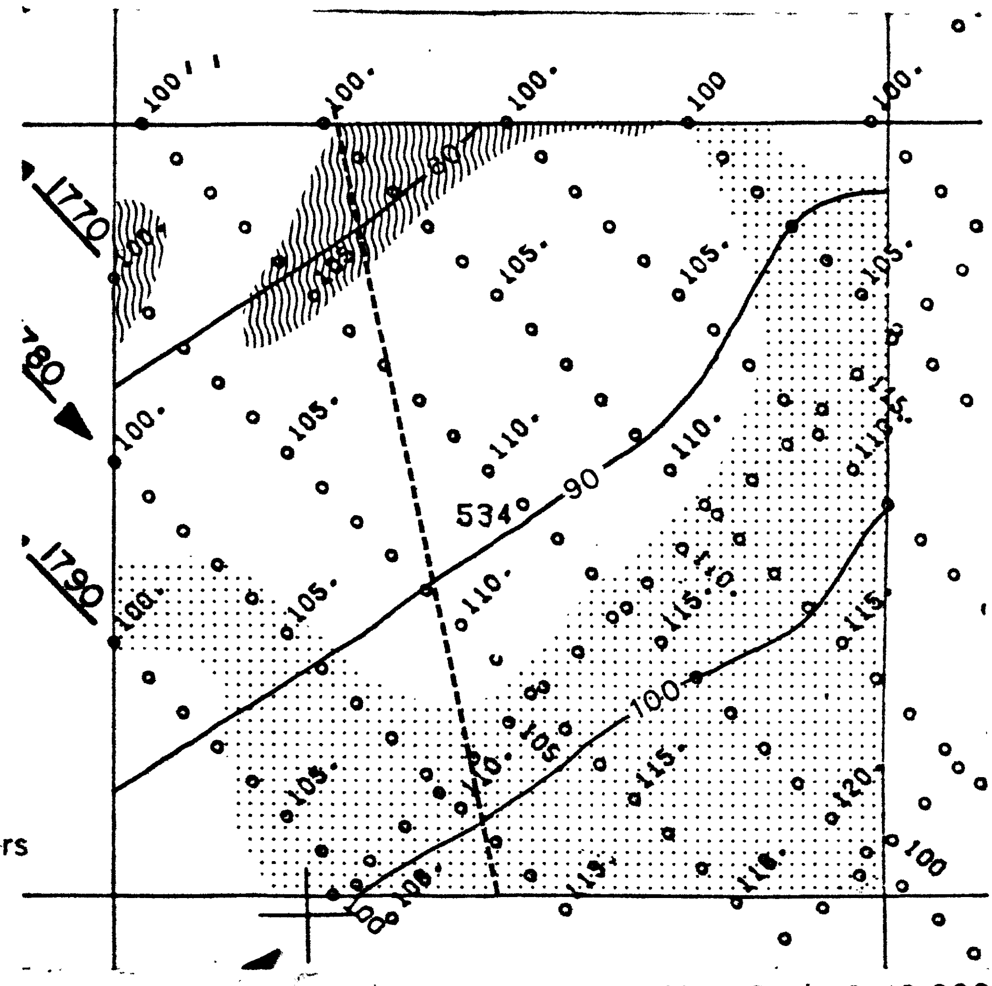
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 534
(NJ 18–6)

Contours in Meters




Water Depth: max. 110 m , min. 73 m

Map Scale 1:48,000

Slope Gradient: 5 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly muddy sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS

Sand Wave Field

Acoustically Turbid Zone

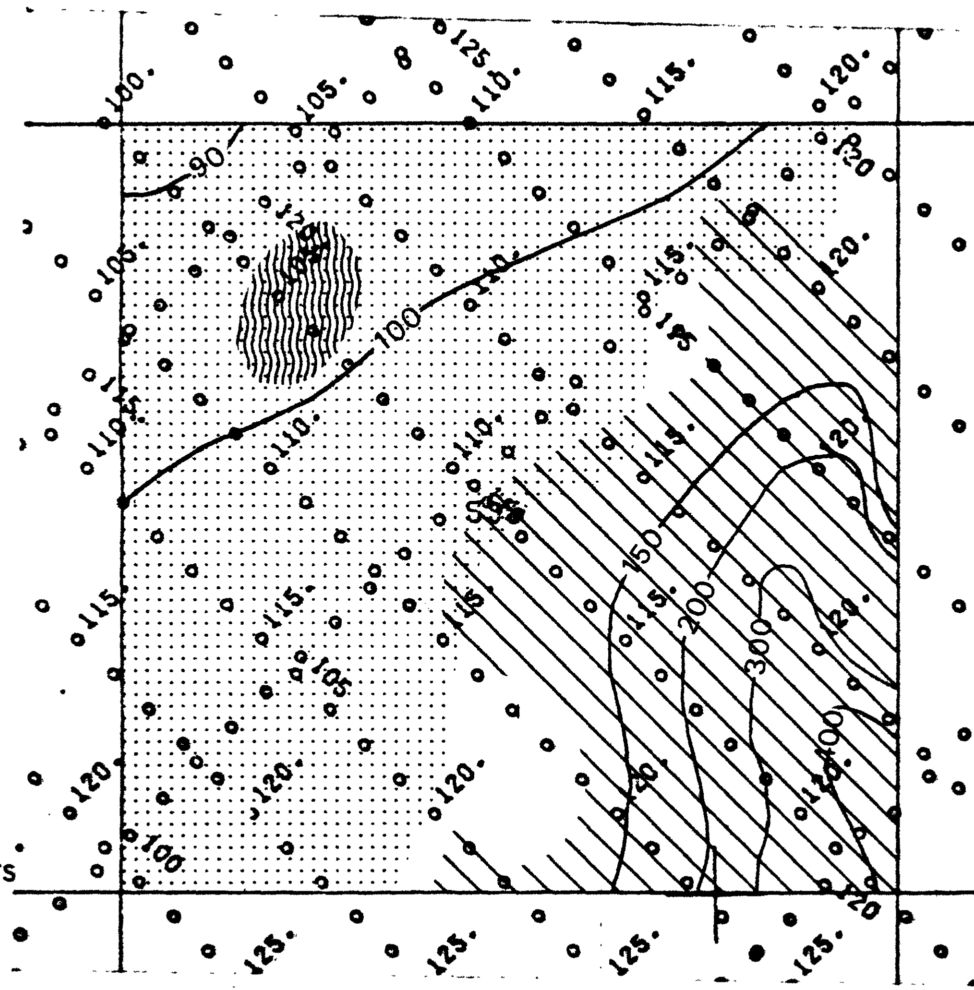
Cable

Additional Comments: Central and northwestern portions of the block are underlain by deep filled valley complex below the foundation zone

Proposed
Lease Sale #49

Block No. 535
(NJ 18–6)

Contours in Meters




Water Depth: max. >430 m , min. 88 m

Map Scale 1:48,000

Slope Gradient: min. 5–6 m/km SE (shelf); max. > 250 m/km E (canyon)

Surface Sediment Type: Gravelly to slightly gravelly sands and muddy sands

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS.

Sand Wave Field (and zones of megaripples)

Acoustically Turbid Zone

Potentially Unstable Slope

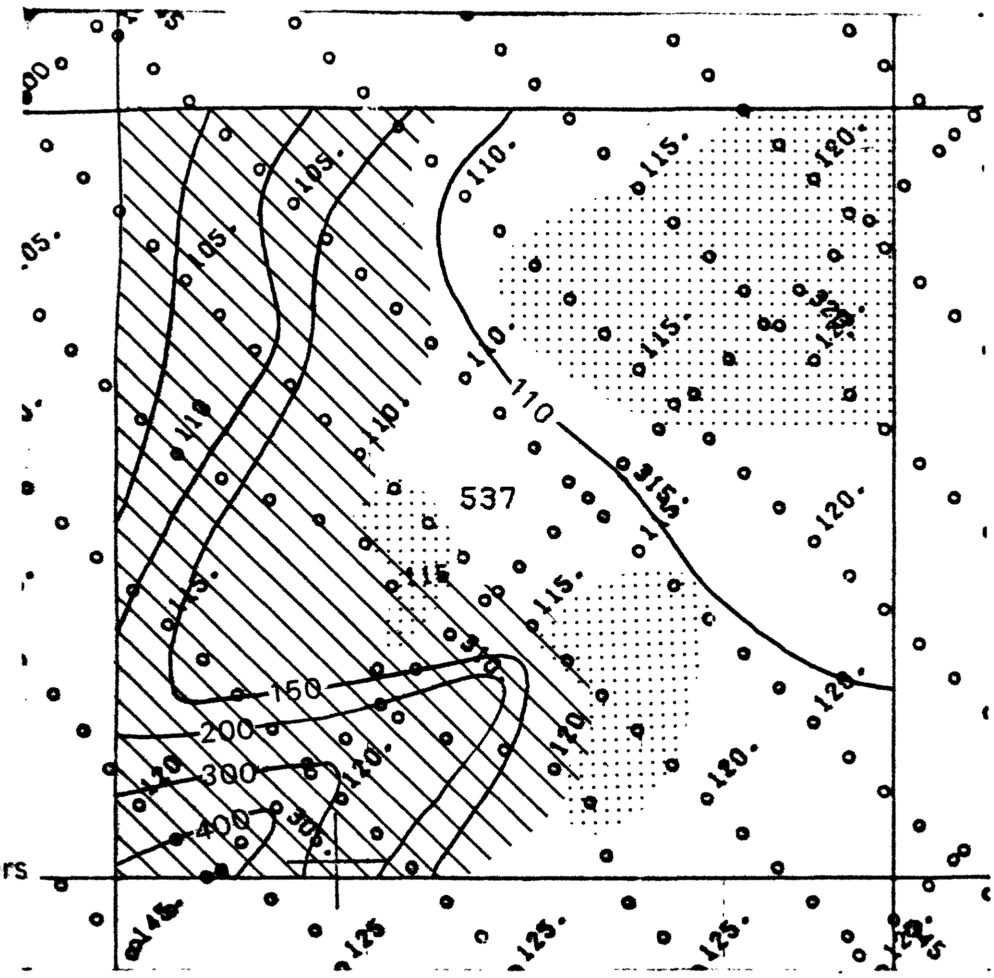
Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with deep slope-front fill and valley-fill on steep slopes of the canyon.
Eastern 2/3 of the block is composed of valley and slope-front-fill complexes.

See figure 10b.

Proposed Lease Sale #49

Block No. 537
(NJ 18–6)

Contours in Meters

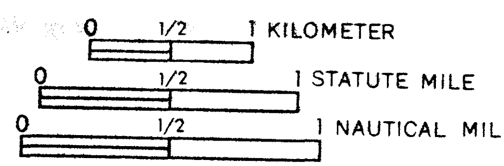



Water Depth: max. >500 m , min. 105 m

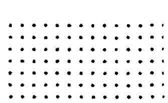
Map Scale 1:48,000

Slope Gradient: min. 2-3 m/km SE (shelf); max. 300 m/km S (into canyon)

Surface Sediment Type: Muddy to gravelly sands (shelf); sandy mud (canyon)




## CONSTRAINTS



Acoustically Turbid Zone

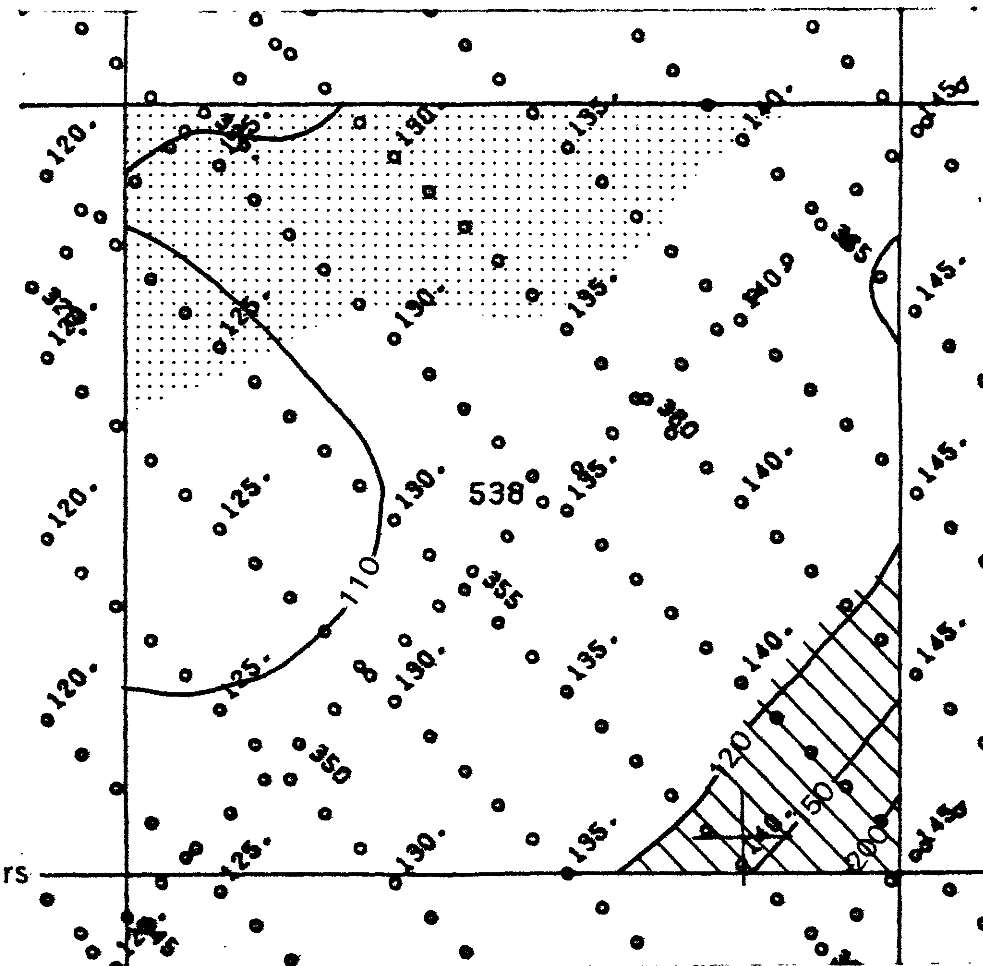
Potentially Unstable Slope

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep canyon walls.

Proposed
Lease Sale #49

Block No. 538
(NJ 18-6)

Contours in Meters

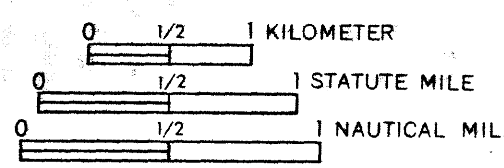



Map Scale 1:48,000

Water Depth: max. >220 m, min. 107 m

Slope Gradient: min. 1-2 m/km SE (shelf); max. >200 m/km SE (slope)

Surface Sediment Type: Gravelly sand




## CONSTRAINTS

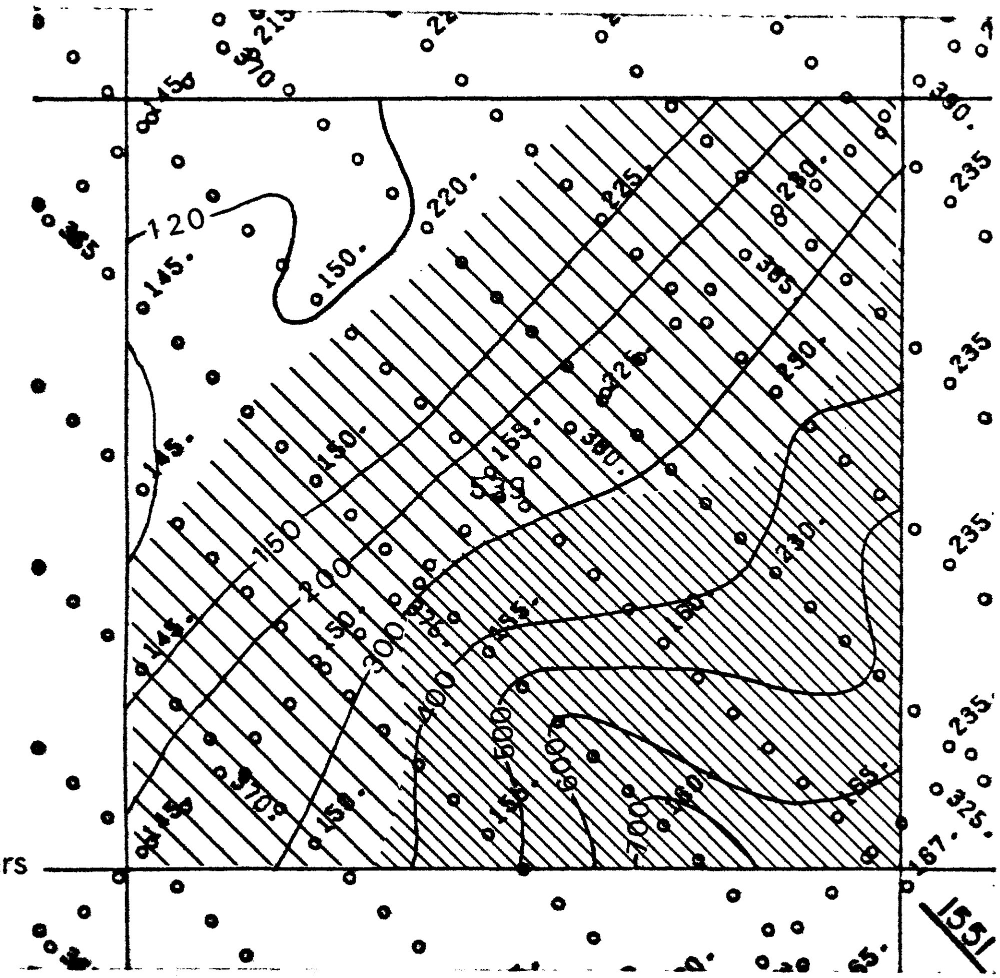
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 539
(NJ 18–6)

Contours in Meters

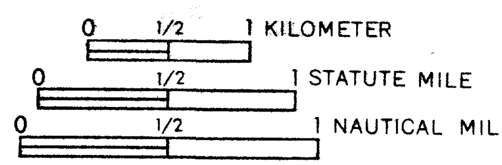



Water Depth: max. >700 m , min. 113 m

Map Scale 1:48,000

Slope Gradient: min. 4–5 m/km SE (shelf); max. > 250 m/km E (slope)

Surface Sediment Type: Slightly gravelly sand to mud




## HAZARDS

Slump or Slide

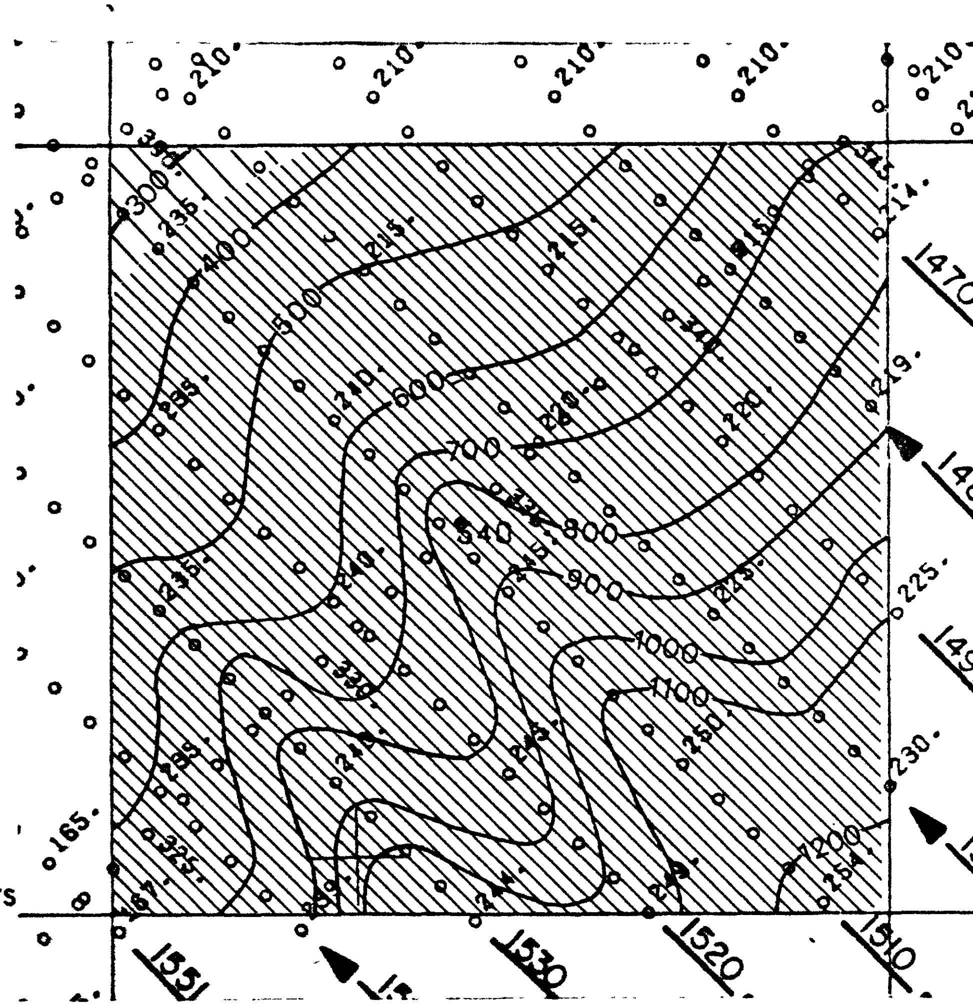
## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 540
(NJ 18-6)

Contours in Meters

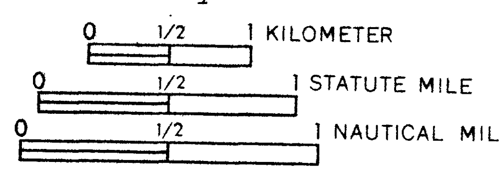



Water Depth: max. >1250 m, min. > 300 m

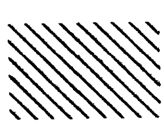
Map Scale 1:48,000

Slope Gradient: min. 150 m/km SE; max. > 350 m/km ESE

Surface Sediment Type: Slightly gravelly sandy mud to sandy mud

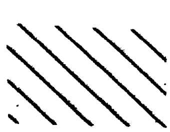



## HAZARDS



Slump or Slide

## CONSTRAINTS

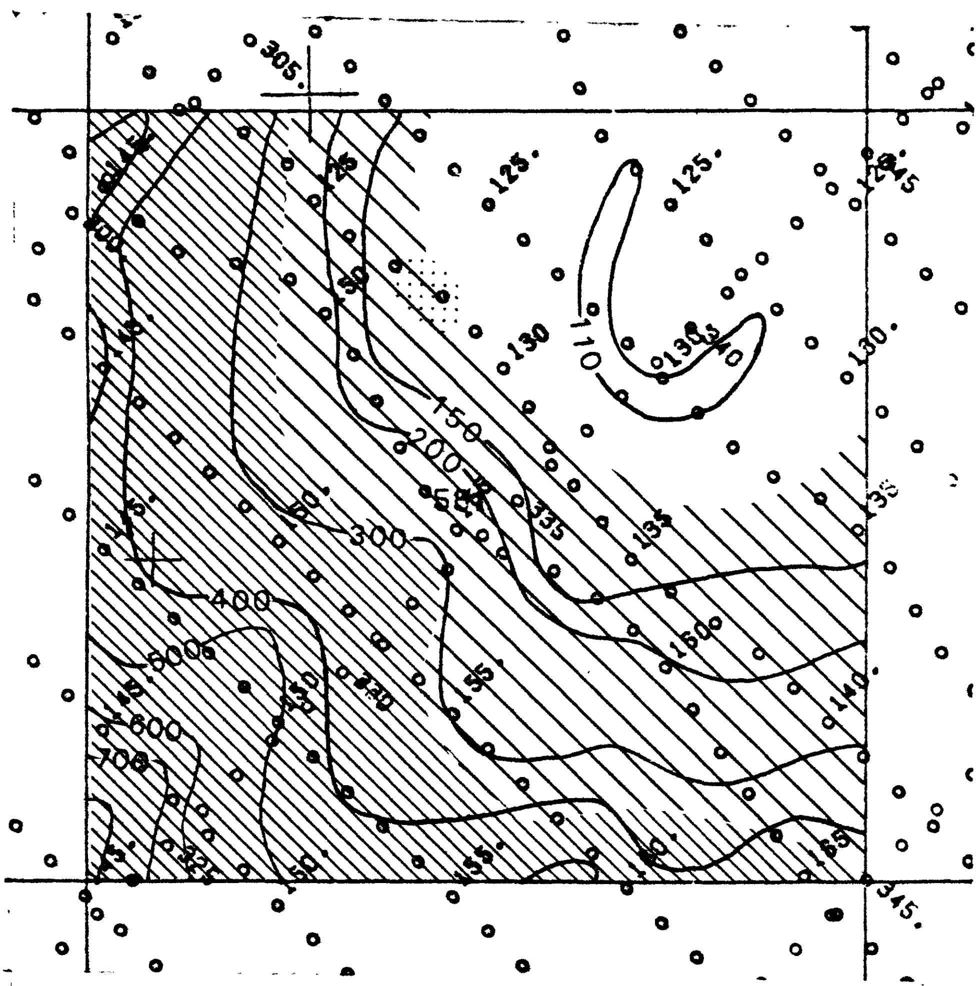


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 581
(NJ 18–6)

Contours in Meters




Water Depth: max. > 800 m , min. 110 m

Map Scale 1:48,000

Slope Gradient: min. 1-2 m/km SW (shelf); max. > 400 m/km W (canyon)

Surface Sediment Type: Slightly gravelly muddy sand to gravelly sand (shelf); sandy mud (canyon)

## HAZARDS

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Slump or Slide

## CONSTRAINTS

Potentially Unstable Slope

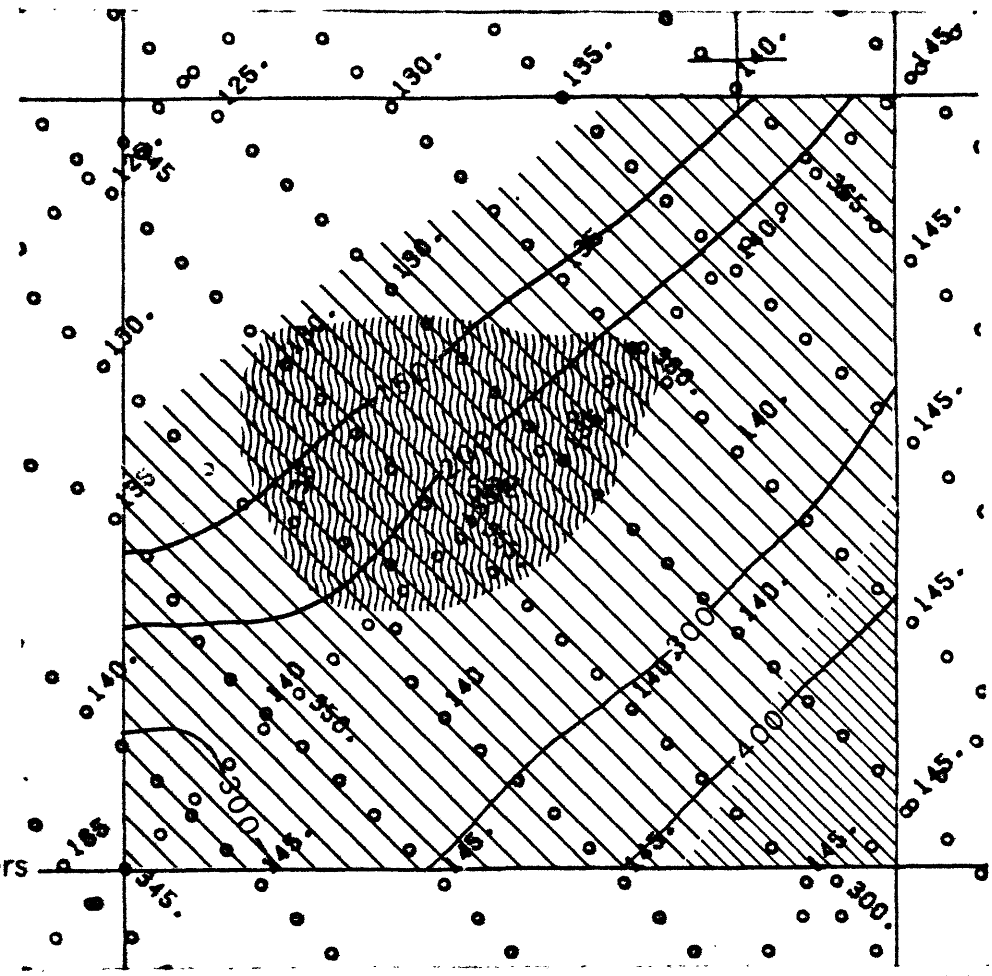
Acoustically Turbid Zone

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep canyon walls.

Proposed
Lease Sale #49

Block No. 582
(NJ 18–6)

Contours in Meters




Water Depth: max. >600 m , min. 111 m

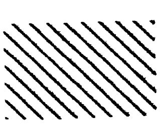
Map Scale 1:48,000

Slope Gradient: min. 1-2 m/km SE (shelf); max. > 200 m/km SE (slope)

Surface Sediment Type: Gravelly sand to slightly gravelly muddy sand (shelf); slightly gravelly sandy mud to sandy mud (upper slope)

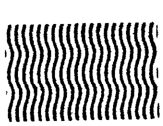
## HAZARDS

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE



Slump or Slide

## CONSTRAINTS



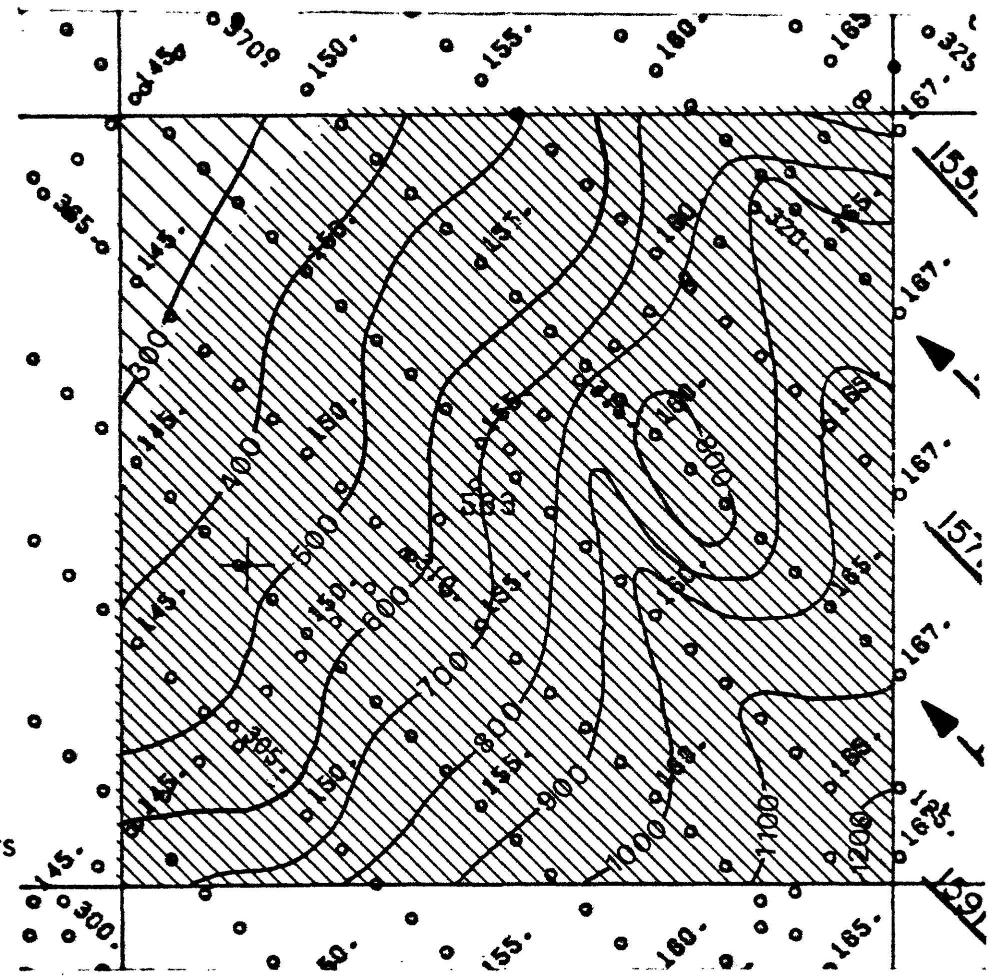
Sand Wave Field (and zones of megaripples)

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 583
(NJ 18–6)

Contours in Meters




Water Depth: max $>$ 1200 m, min. $\approx$230 m

Map Scale 1:48,000

Slope Gradient: min. $<$ 100 m/km SE; max. $>$ 300 m/km E

Surface Sediment Type: Slightly gravelly muddy sands to sandy muds

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

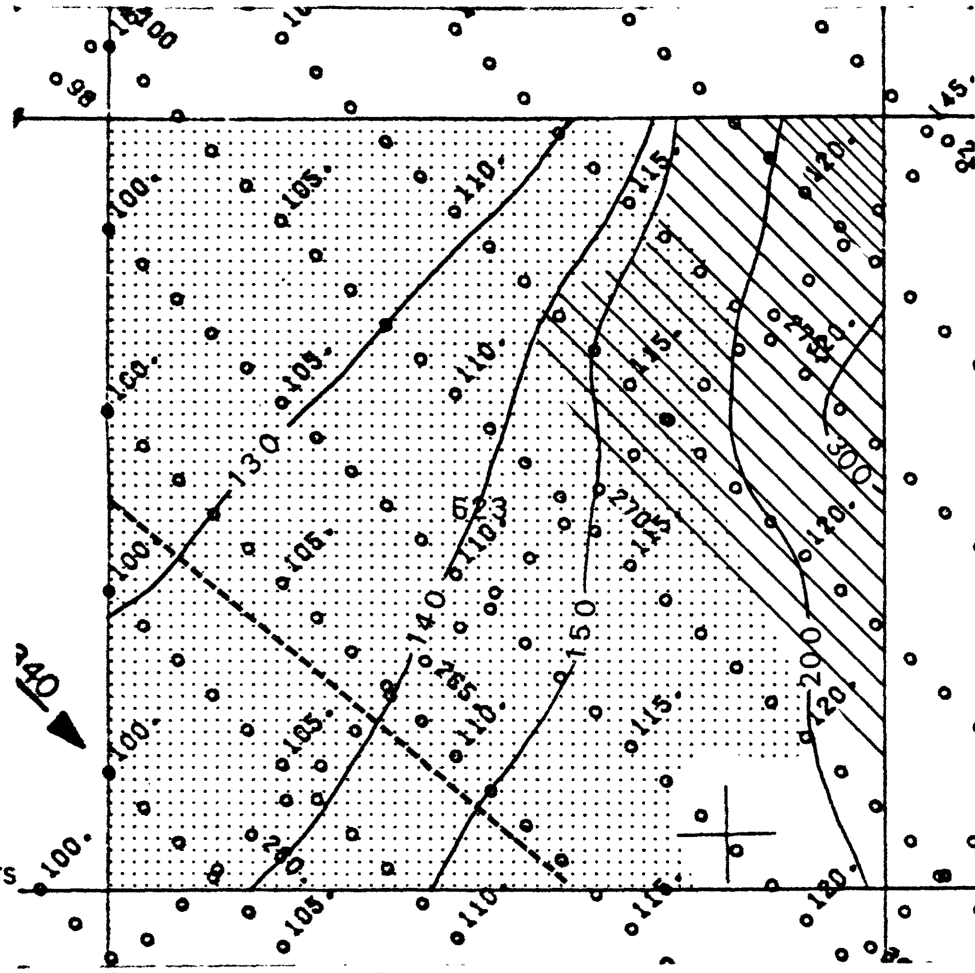
## CONSTRAINTS

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 623
(NJ 18–6)

Contours in Meters




Water Depth: max.≈350 m , min. 124 m

Map Scale 1:48,000

Slope Gradient: min. < 3 m/km SE (shelf); max. 150 m/km E (canyon)

Surface Sediment Type: Gravelly to gravelly muddy sands (shelf); muddy sand (canyon)

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

Acoustically Turbid Zone

Potentially Unstable Slope

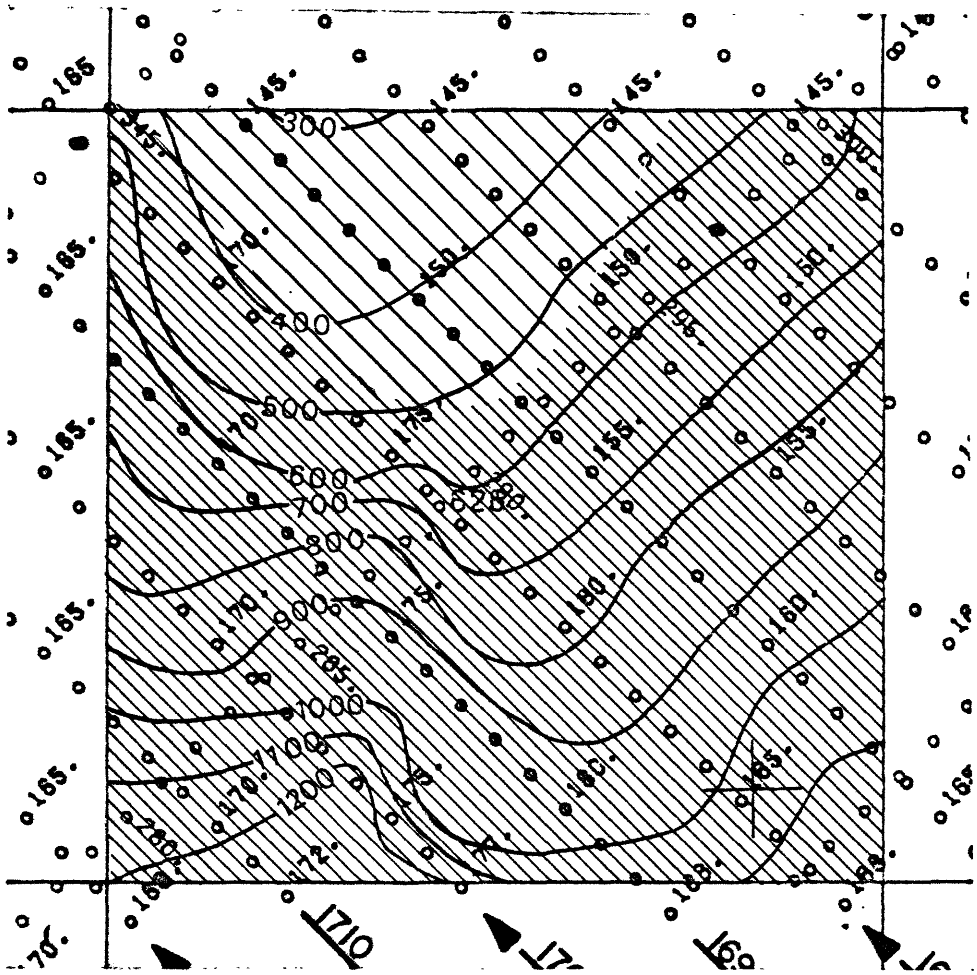
----- -- Cable

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep canyon slopes in the eastern portion of the block. Northeastern 1/4 of the block is underlain by deeply buried slope-front fill and channel fill complex.

Proposed
Lease Sale #49

Block No. 626
(NJ 18–6)

Contours in Meters

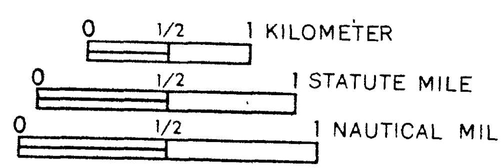



Water Depth: max≈1300 m, min. 290 m

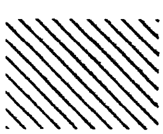
Map Scale 1:48,000

Slope Gradient: min. 100 m/km S; max. > 300 m/km S and W

Surface Sediment Type: Slightly gravelly muddy sand (above slide zone); sandy mud (within slide zone)

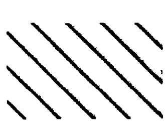



## HAZARDS



Slump or Slide

## CONSTRAINTS



Potentially Unstable Slope

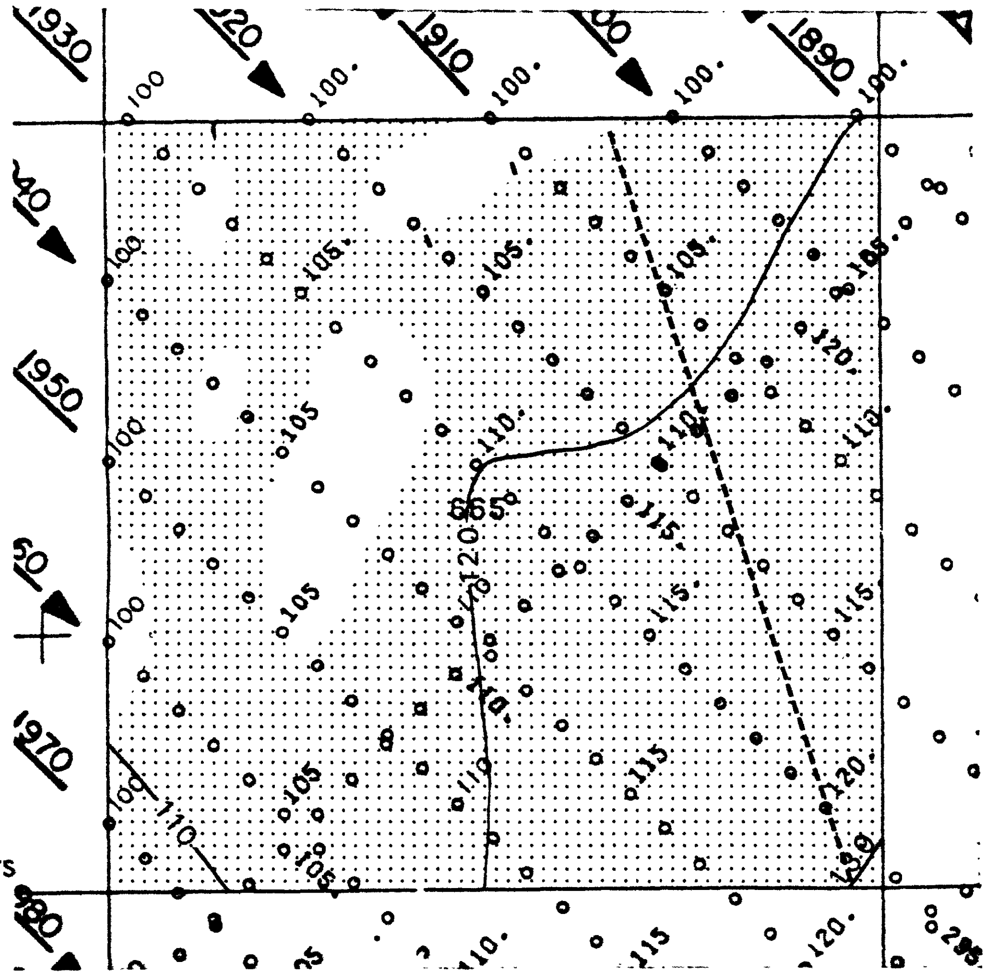
Additional Comments: Inactive munitions dumpsite in extreme lower portion of the block (BLM, EIS Sale 49, Visual #1)

See figure 6

Proposed
Lease Sale #49

Block No. 665
(NJ 18–6)

Contours in Meters

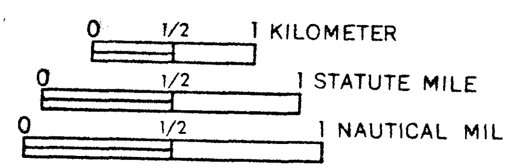



Water Depth: max. 130 m , min. 113 m

Map Scale 1:48,000

Slope Gradient: min. 1-3 m/km SE (shelf); max. 5 m/km SE (shelf)

Surface Sediment Type: Gravelly to gravelly muddy sands




## CONSTRAINTS

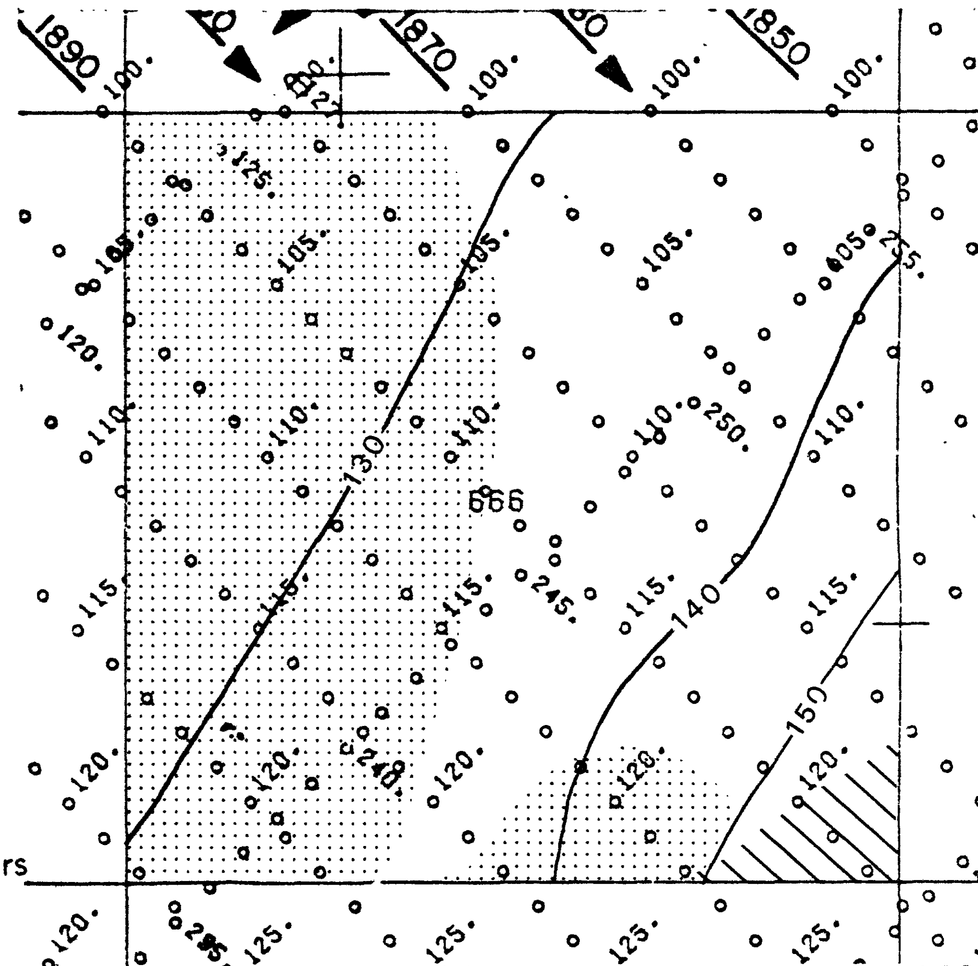
Acoustically Turbid Zone

Cable

Proposed
Lease Sale #49

Block No. 666
(NJ 18–6)

Contours in Meters




Map Scale 1:48,000

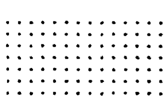
Water Depth: max. > 180 m , min. 121 m

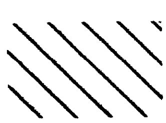
Slope Gradient: min. 4-5 m/km SE (shelf); max. 50 m/km SE (slope)

Surface Sediment Type: Gravelly to gravelly muddy sands

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## CONSTRAINTS


Acoustically Turbid Zone


Potentially Unstable Slope

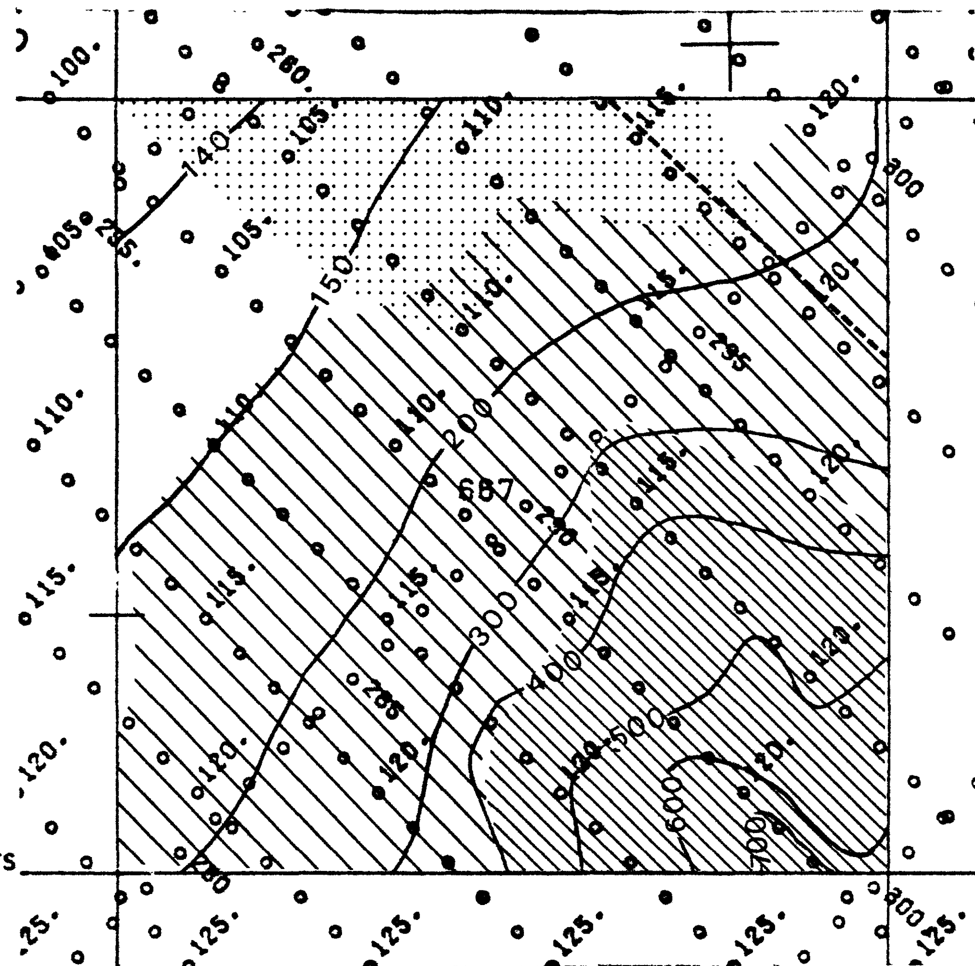
Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep slopes at the shelf break in the southeast corner of the block.

See figure 10a.

Proposed
Lease Sale #49

Block No. 667
(NJ 18–6)

Contours in Meters

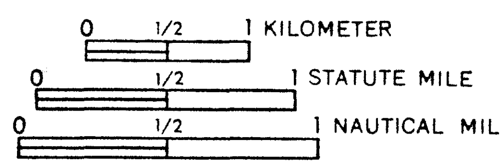



Map Scale 1:48,000

Water Depth: max. >770 m , min. 134 m

Slope Gradient: min. 6 m/km SE (shelf); max. > 200 m/km E (slope)

Surface Sediment Type: Gravelly to gravelly muddy sands (shelf); slightly gravelly muddy sand to sandy mud (slope)




## HAZARDS

Slump or Slide

## CONSTRAINTS

Potentially Unstable Slope

Acoustically Turbid Zone

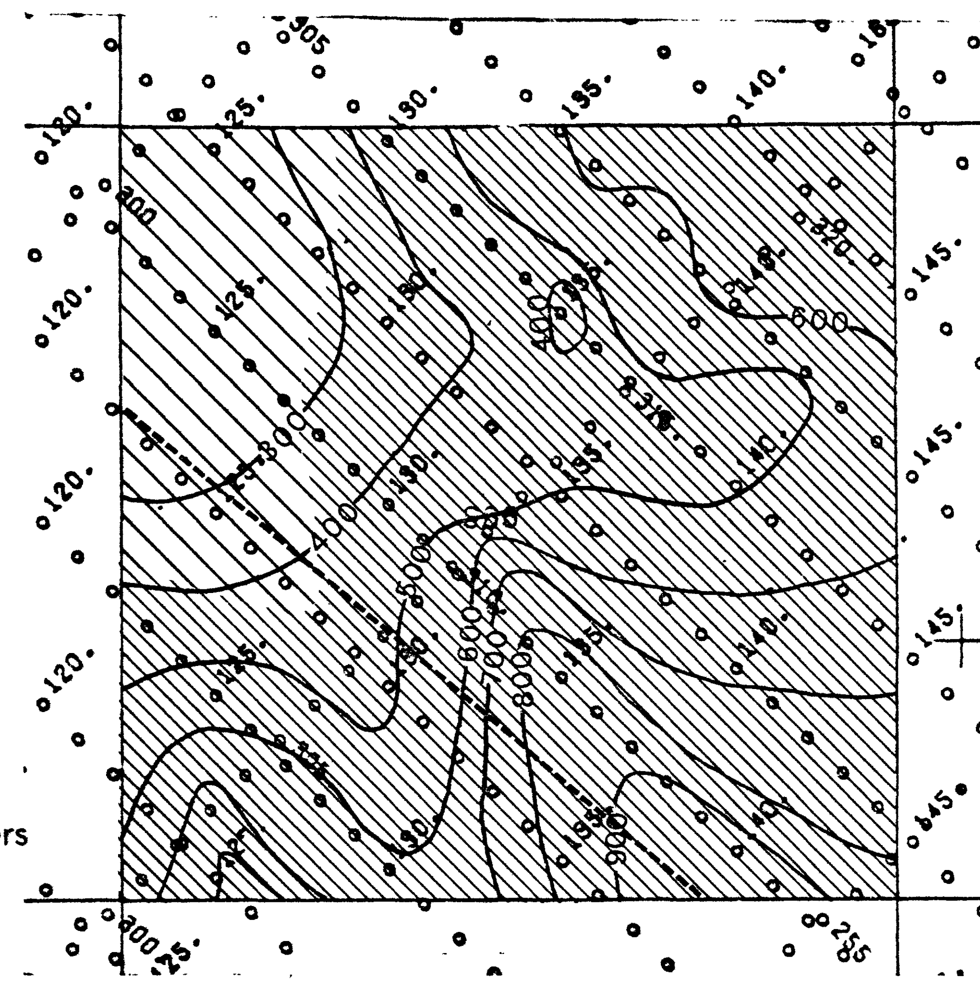
- - - - Cable

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep slopes at the shelf margin.

Proposed
Lease Sale #49

Block No. 668
(NJ 18–6)

Contours in Meters

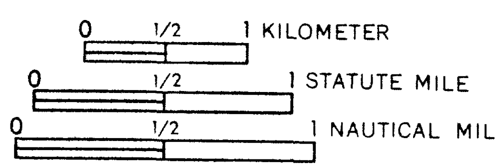



Water Depth: max. >950 m , min. 210 m

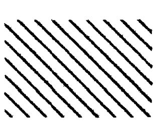
Map Scale 1:48,000

Slope Gradient: min. 30-40 m/km SE; max. > 350 m/km variable

Surface Sediment Type: Sandy mud




## HAZARDS



Slump or Slide

## CONSTRAINTS

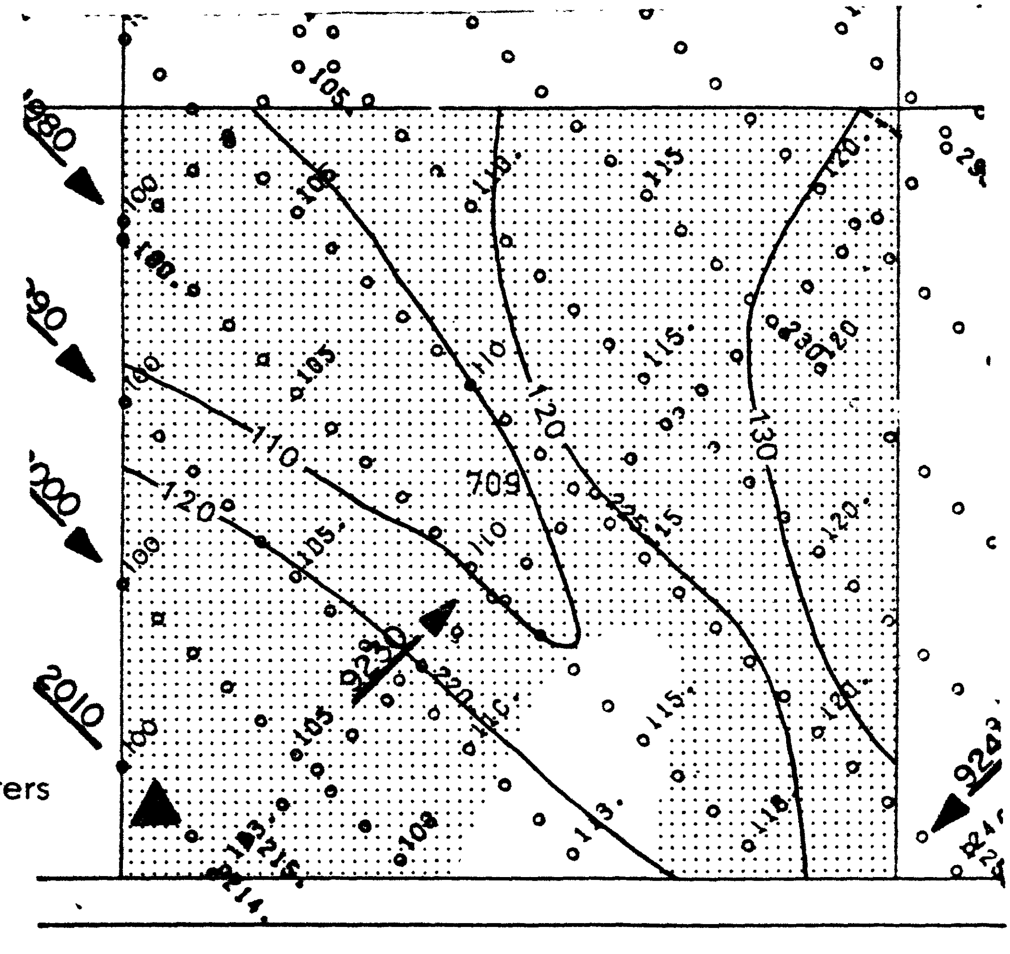
Potentially Unstable Slope

------- Cable

Proposed
Lease Sale #49

Block No. 709
(NJ 18-6)

Contours in Meters

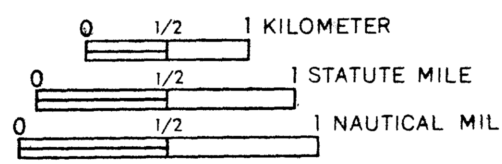



Water Depth: max. 136 m , min. 103 m

Map Scale 1:48,000

Slope Gradient: min. 2-3 m/km SE; max. > 20 m/km E

Surface Sediment Type: Gravelly to slightly gravelly sands




## CONSTRAINTS

Acoustically Turbid Zone

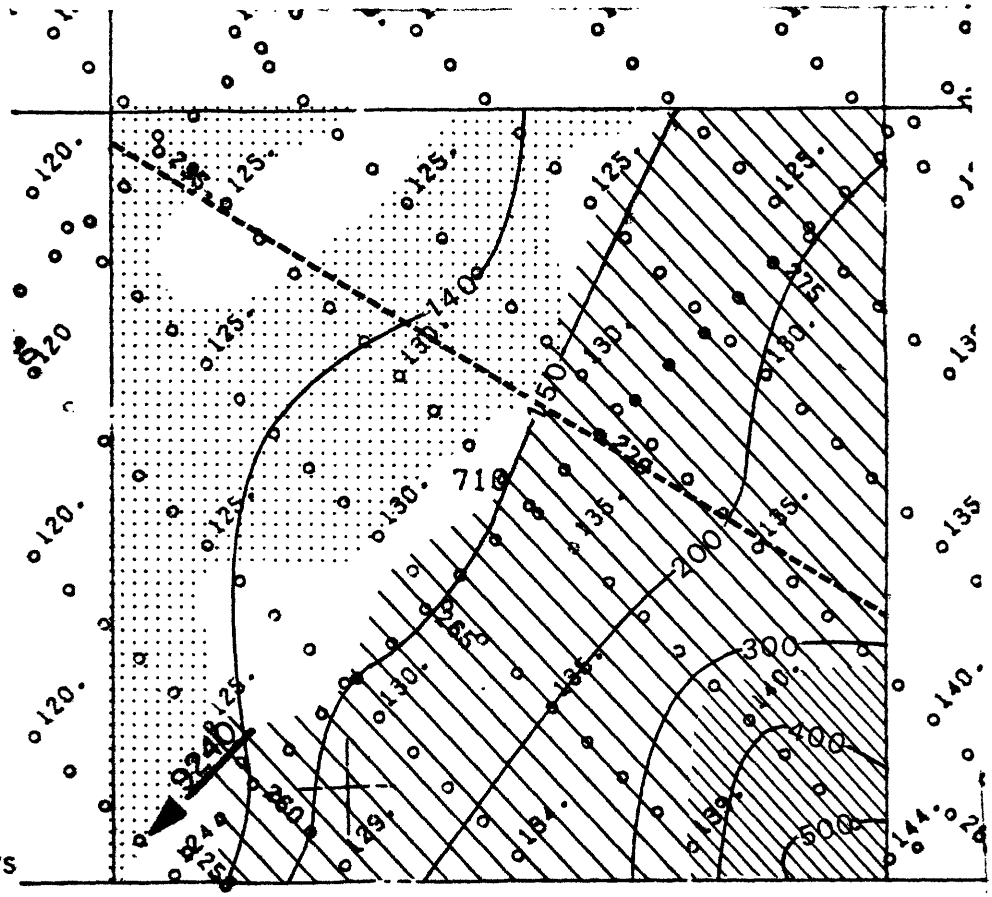
Cable

Bottom Object

Proposed
Lease Sale #49

Block No. 710
(NJ 18–6)

Contours in Meters




Map Scale 1:48,000

Water Depth: max. >590 m , min. 131 m

Slope Gradient: min. 3 m/km SE (shelf); max. 200 m/km S (slope)

Surface Sediment Type: Slightly gravelly sands and muddy sands (shelf); muddy sands to sandy muds (slope)

## HAZARDS

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Slump or Slide

## CONSTRAINTS

Potentially Unstable Slope

Acoustically Turbid Zone

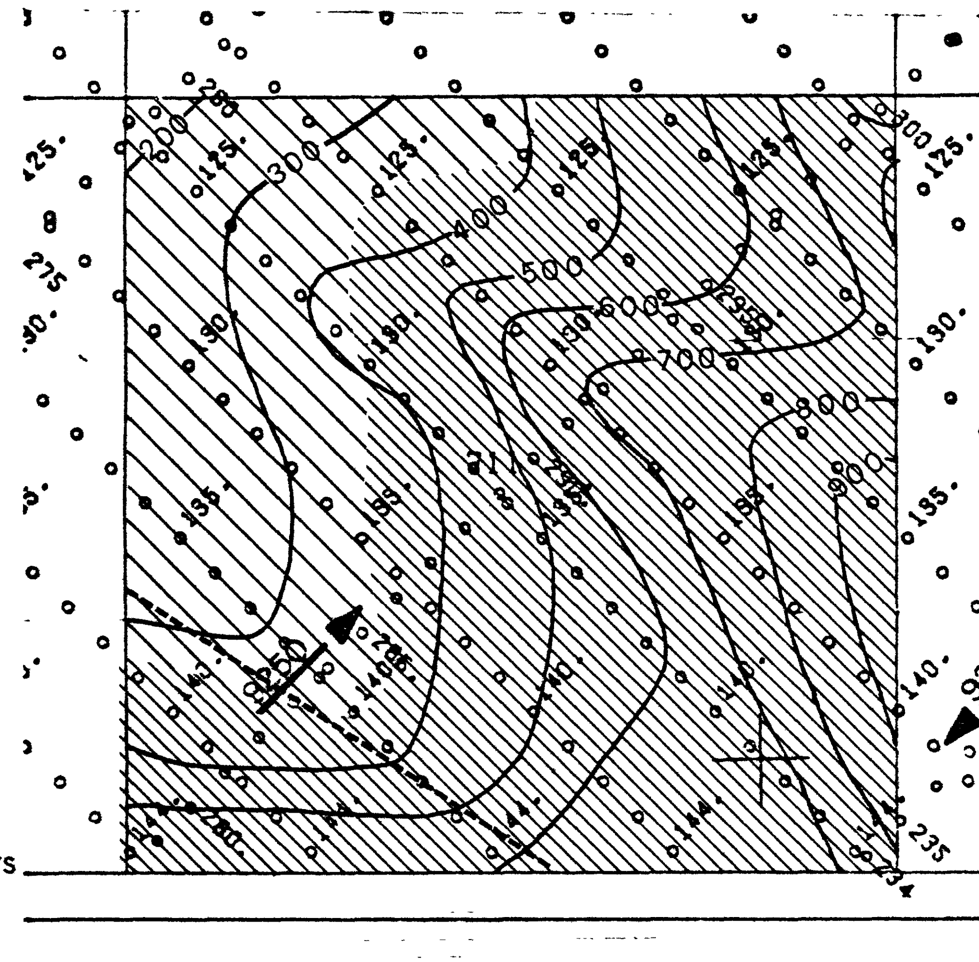
------- Cable

Additional Comments: Poor foundation conditions may be present where acoustically turbid facies occurs in conjunction with steep slopes at the shelf margin.

Proposed
Lease Sale #49

Block No. 711
(NJ 18–6)

Contours in Meters




Water Depth: max. >950 m , min. <190 m

Map Scale 1:48,000

Slope Gradient: min. 50 m/km SE; max. >250 m/km E

Surface Sediment Type: Sandy muds

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

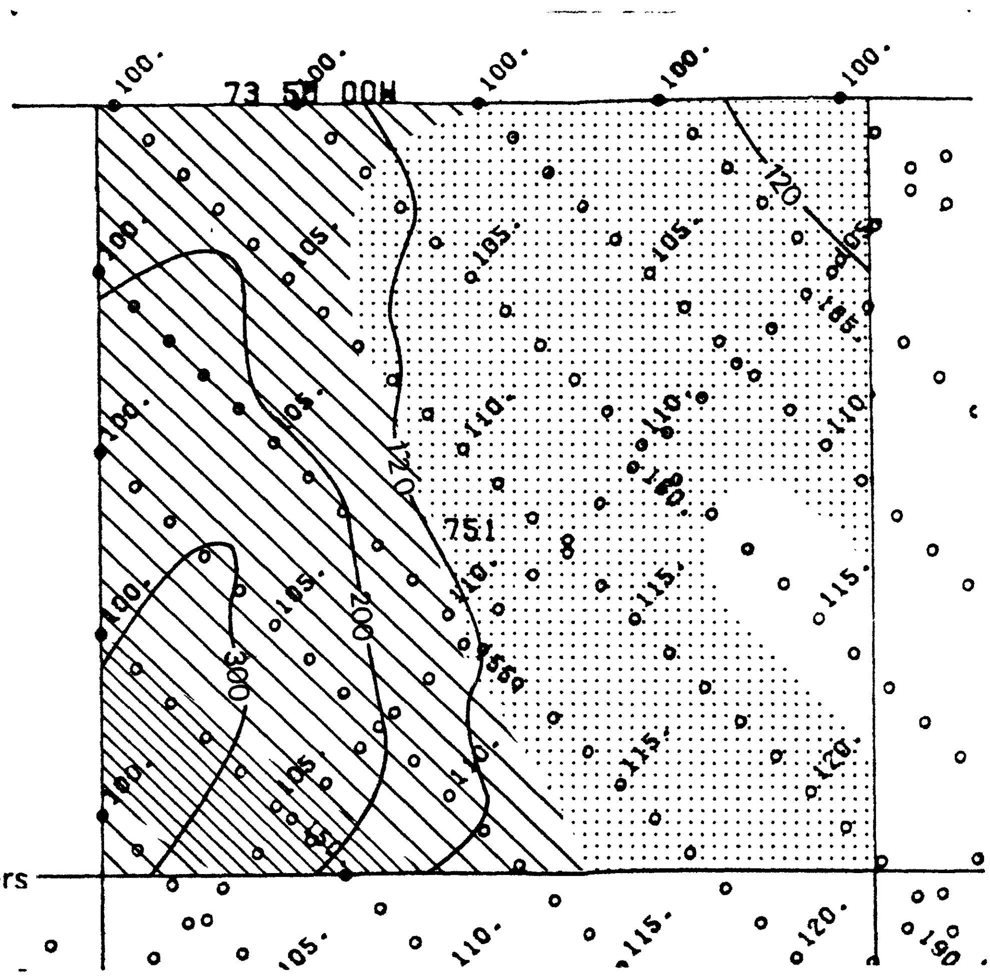
Potentially Unstable Slope

Cable

Proposed
Lease Sale #49

Block No. 751
(NJ 18–6)

Contours in Meters

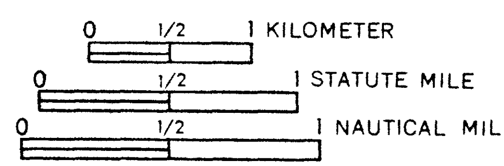



Water Depth: max. 359 m , min. 110 m

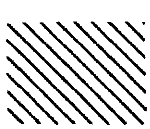
Map Scale 1:48,000

Slope Gradient: min. 1 m/km SW (shelf); max. > 70 m/km SW (canyon)

Surface Sediment Type: Gravelly sand (shelf), slightly gravelly muddy sand (canyon head)

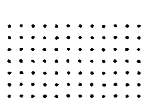



## HAZARDS

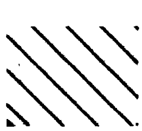


Slump or Slide

## CONSTRAINTS



Acoustically Turbid Zone

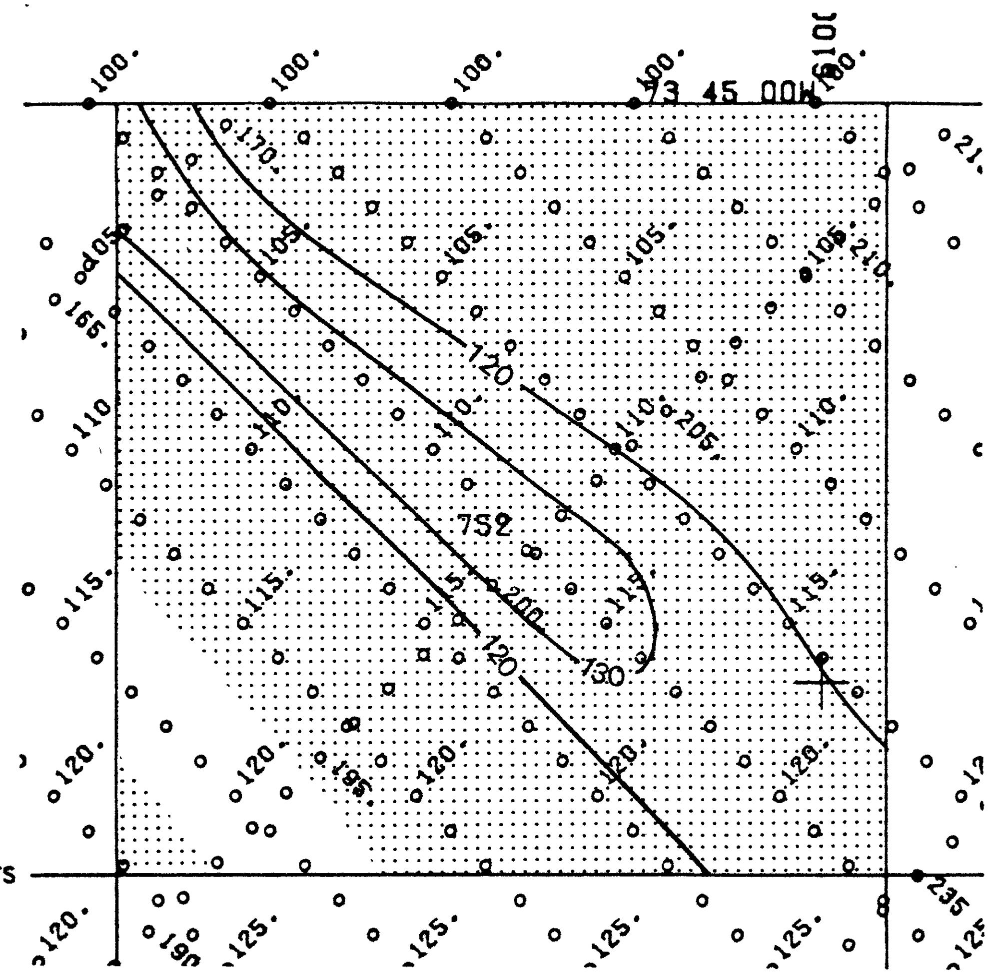


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 752
(NJ 18–6)

Contours in Meters

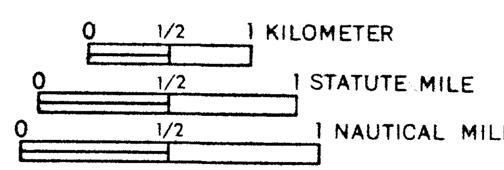



Water Depth: max. 140 m , min. 107 m.

Map Scale 1:48,000

Slope Gradient: 1–5 m/km, Direction: Toward center of block

Surface Sediment Type: Gravelly sand



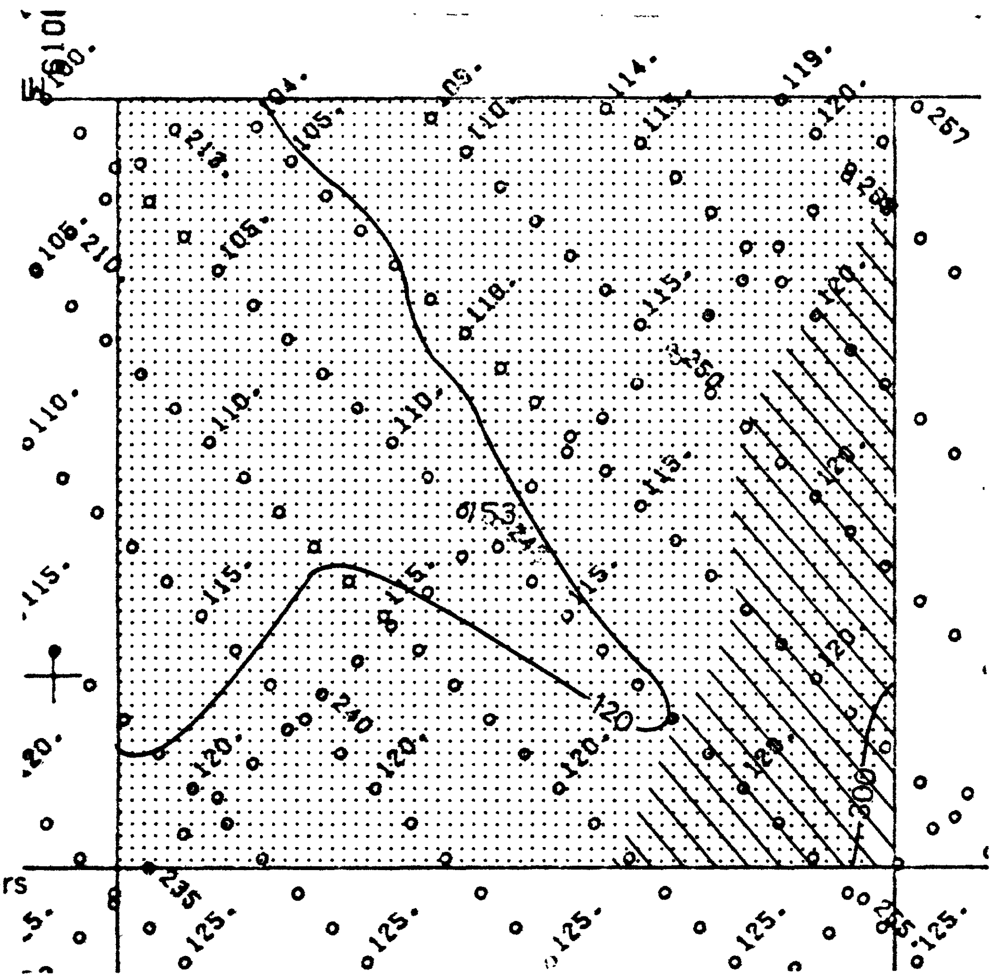

CONSTRAINTS

Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 753
(NJ 18–6)

Contours in Meters

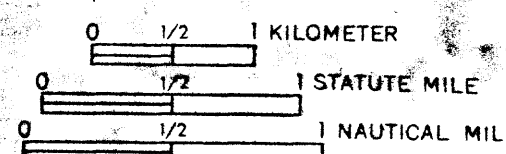



Water Depth: max. 274 m , min. 107 m

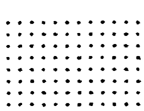
Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SE (shelf); max. ≈ 40 m/km SE (slope)

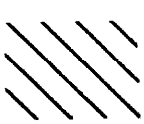
Surface Sediment Type: Slightly gravelly sand




## CONSTRAINTS



Acoustically Turbid Zone

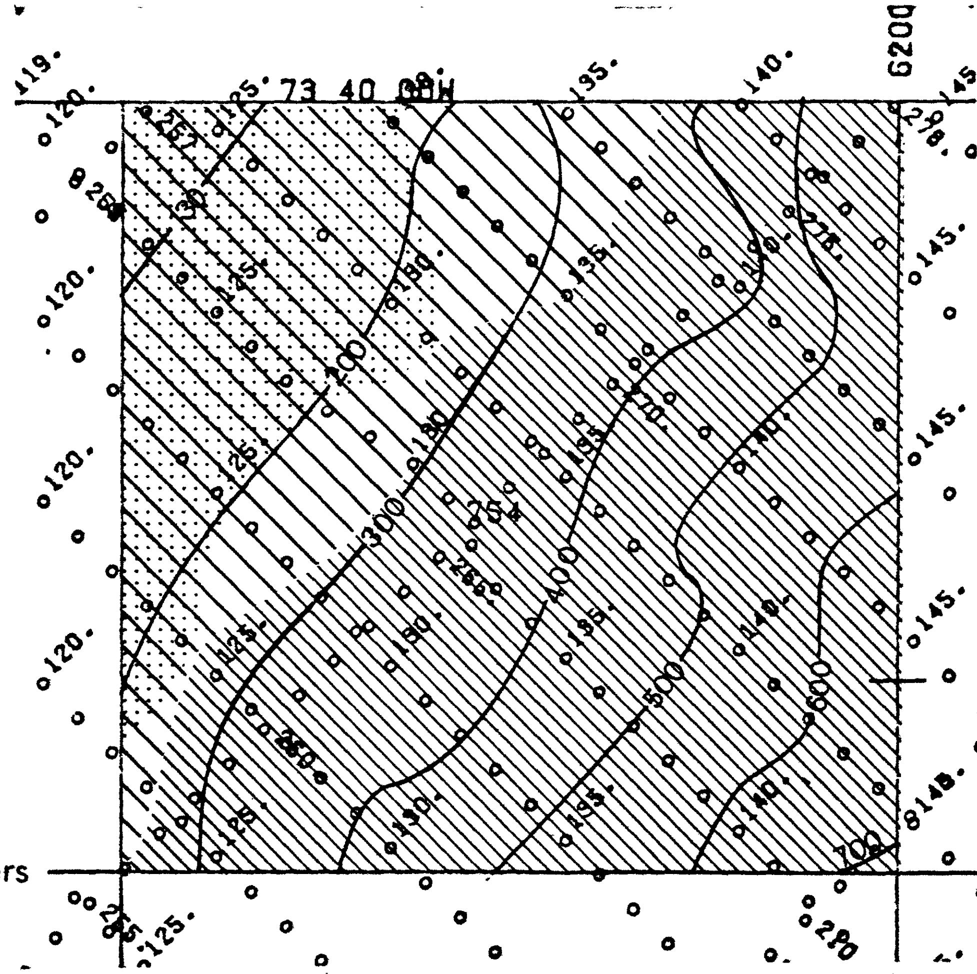


Potentially Unstable Slope

Proposed
Lease Sale #49

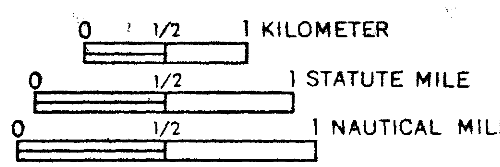
Block No. 754
(NJ 18–6)

Contours in Meters




Water Depth: max. 700 m , min. 125 m

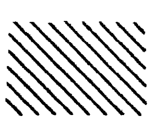
Map Scale 1:48,000




Slope Gradient: 60–100 m/km, Direction: SE

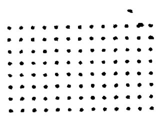
Surface Sediment Type: Muddy sand

## HAZARDS



Slump or Slide

## CONSTRAINTS



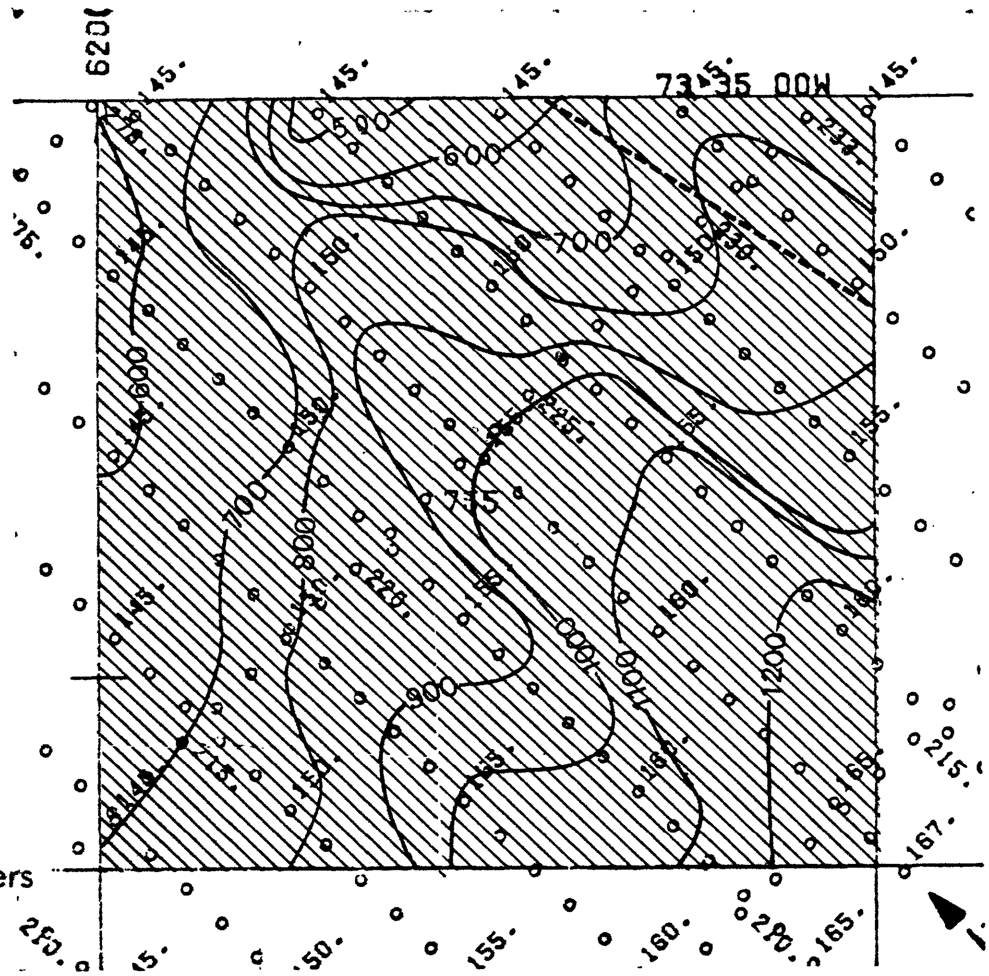
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 755
(NJ 18–6)

Contours in Meters




Water Depth: max. 1278 m , min. 489 m

Slope Gradient: 100-300 m/km, Direction: SE

Surface Sediment Type: Sandy mud

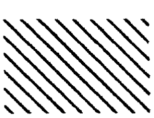
Map Scale 1:48,000

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

## HAZARDS



Slump or Slide

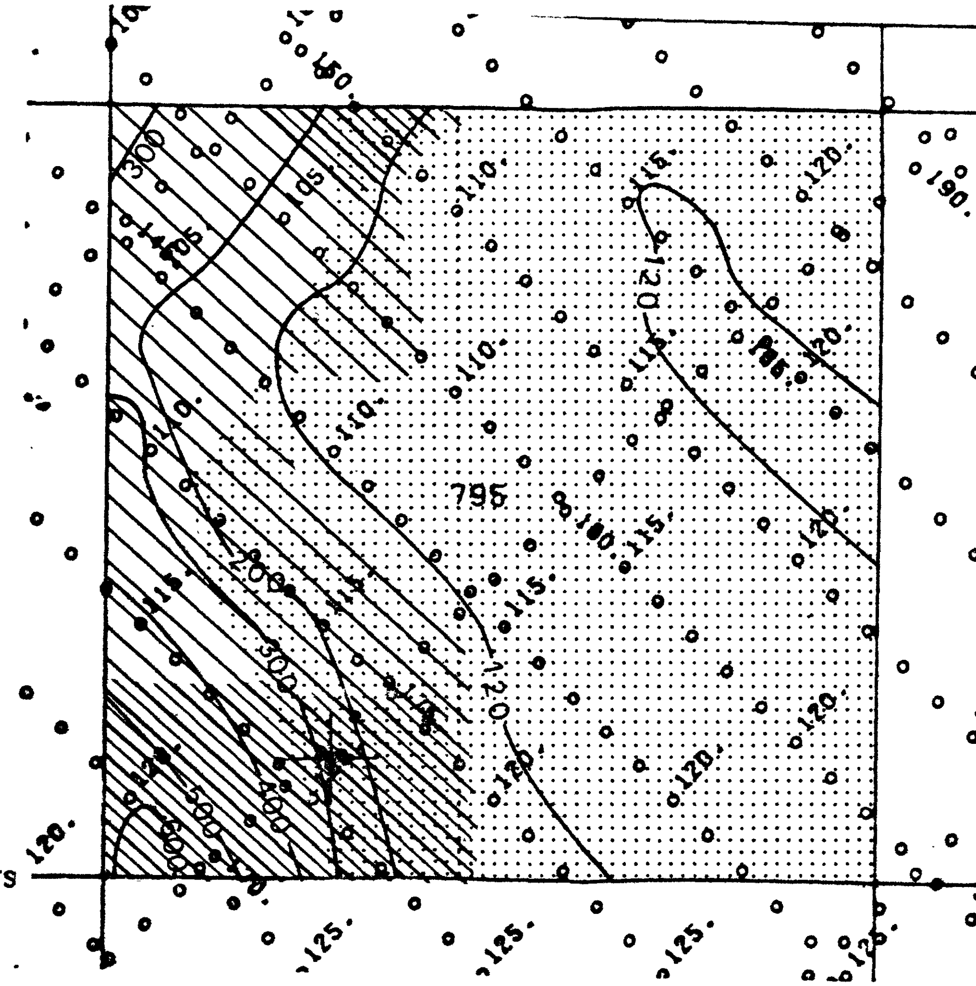
## CONSTRAINTS

-------- Cable

Proposed
Lease Sale #49

Block No. 795
(NJ 18–6)

Contours in Meters




Water Depth: max. 618 m , min. 113 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SW (shelf); max. 80-200 m/km SW (canyon)

Surface Sediment Type: Slightly gravelly sandy mud

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

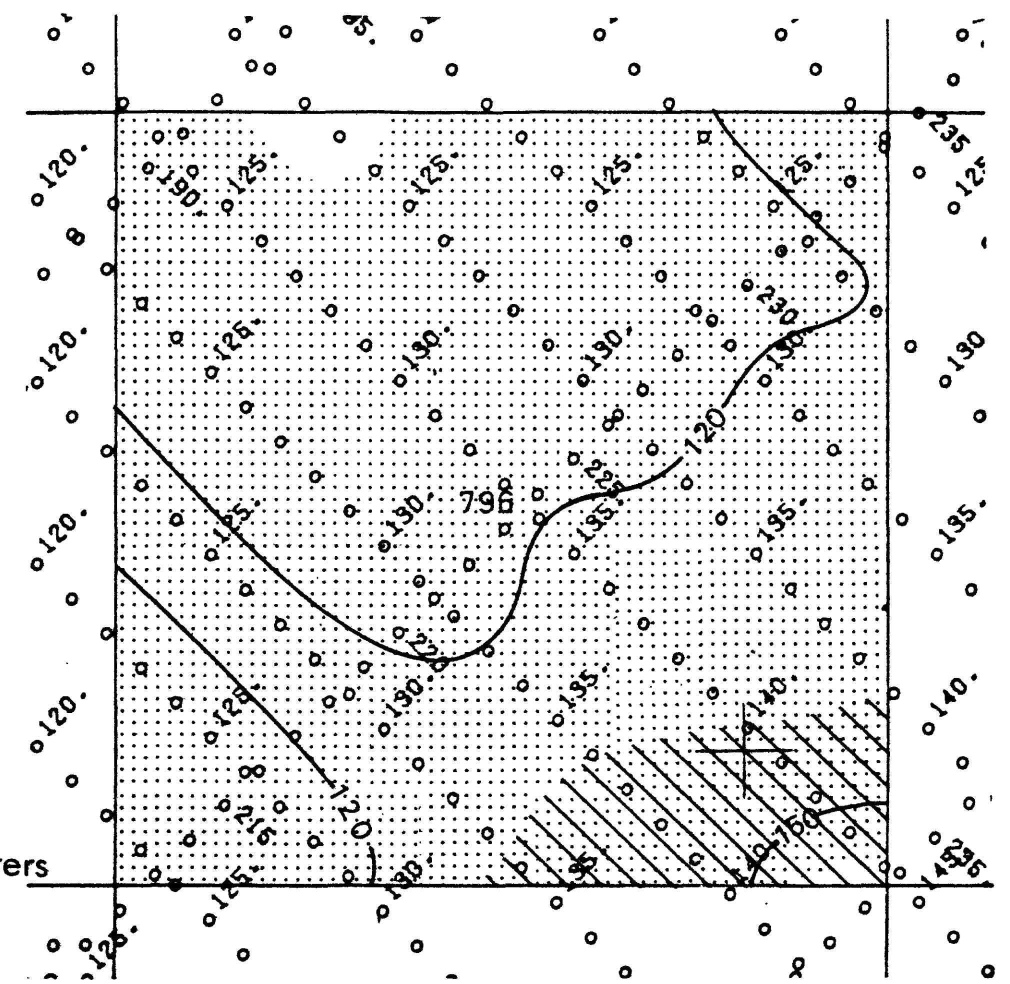
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 796
(NJ 18–6)

Contours in Meters

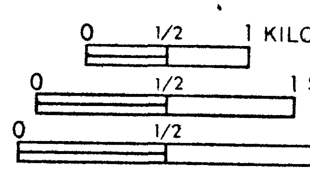



Water Depth: max. 170 m , min. 113 m

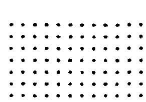
Map Scale 1:48,000

Slope Gradient: min. 1–5 m/km SE (shelf); max. > 50 m/km SE (slope)

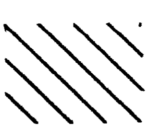
Surface Sediment Type: Medium to fine sand with mollusk fragments




## CONSTRAINTS



Acoustically Turbid Zone

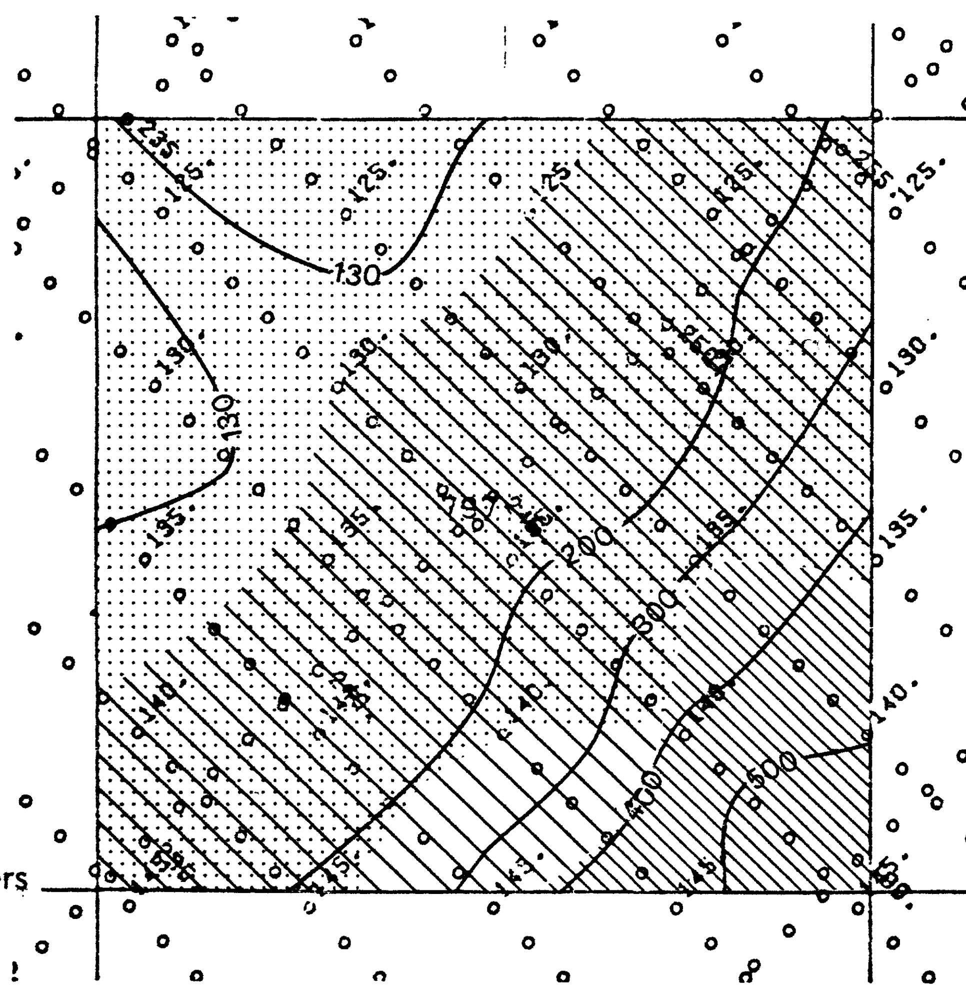


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 797
(NJ 18–6)

Contours in Meters

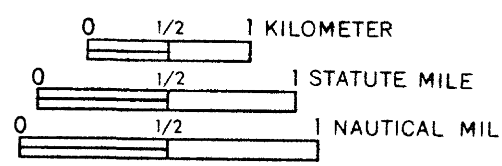



Water Depth: max. 600 m , min. 122 m

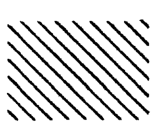
Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SE (shelf); max. 35-200 m/km SE (slope)

Surface Sediment Type: Slightly gravelly sand

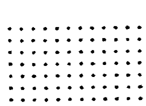



## HAZARDS

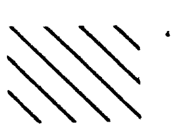


Slump or Slide

## CONSTRAINTS



Acoustically Turbid Zone

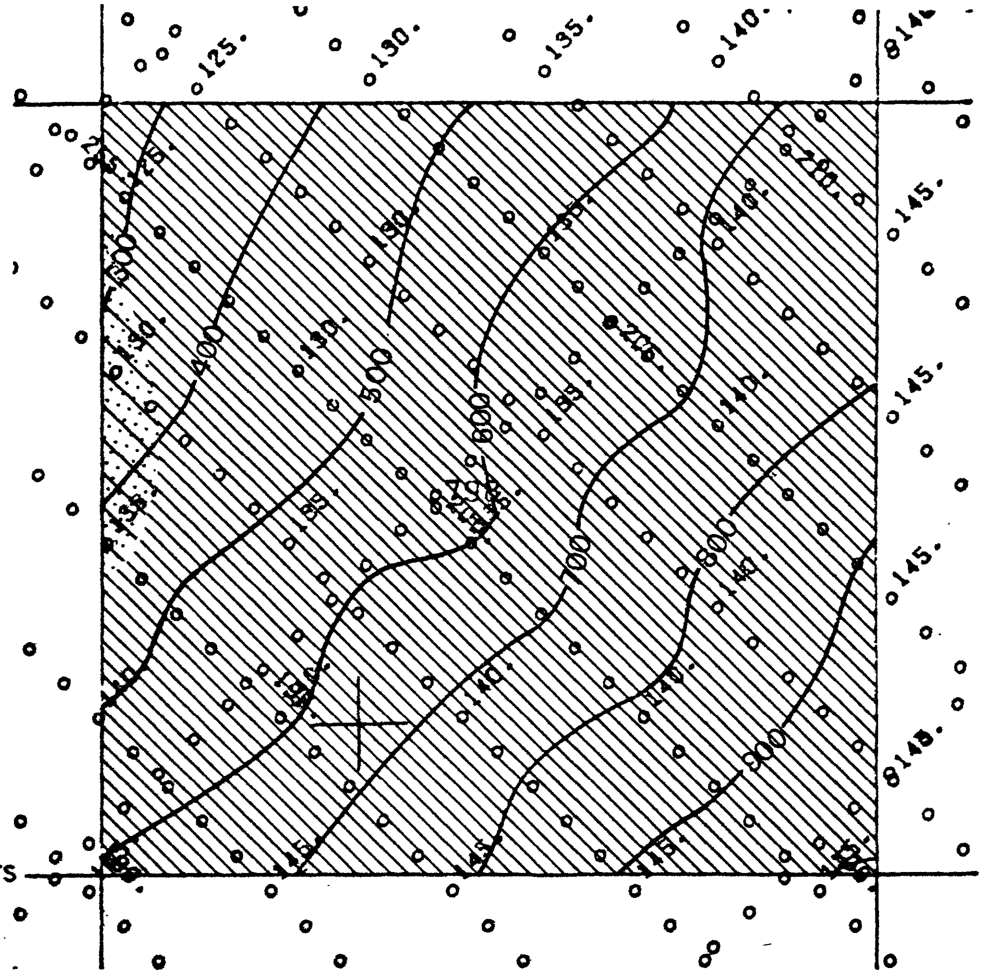


Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 798
(NJ 18–6)

Contours in Meters

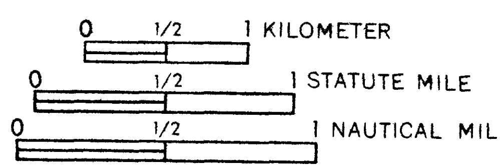


Water Depth: max. 1000 m , min. 280 m

Map Scale 1:48,000

Slope Gradient: 100-125 m/km, Direction: SE

Surface Sediment Type: Muddy sand




## HAZARDS

Slump or Slide

## CONSTRAINTS

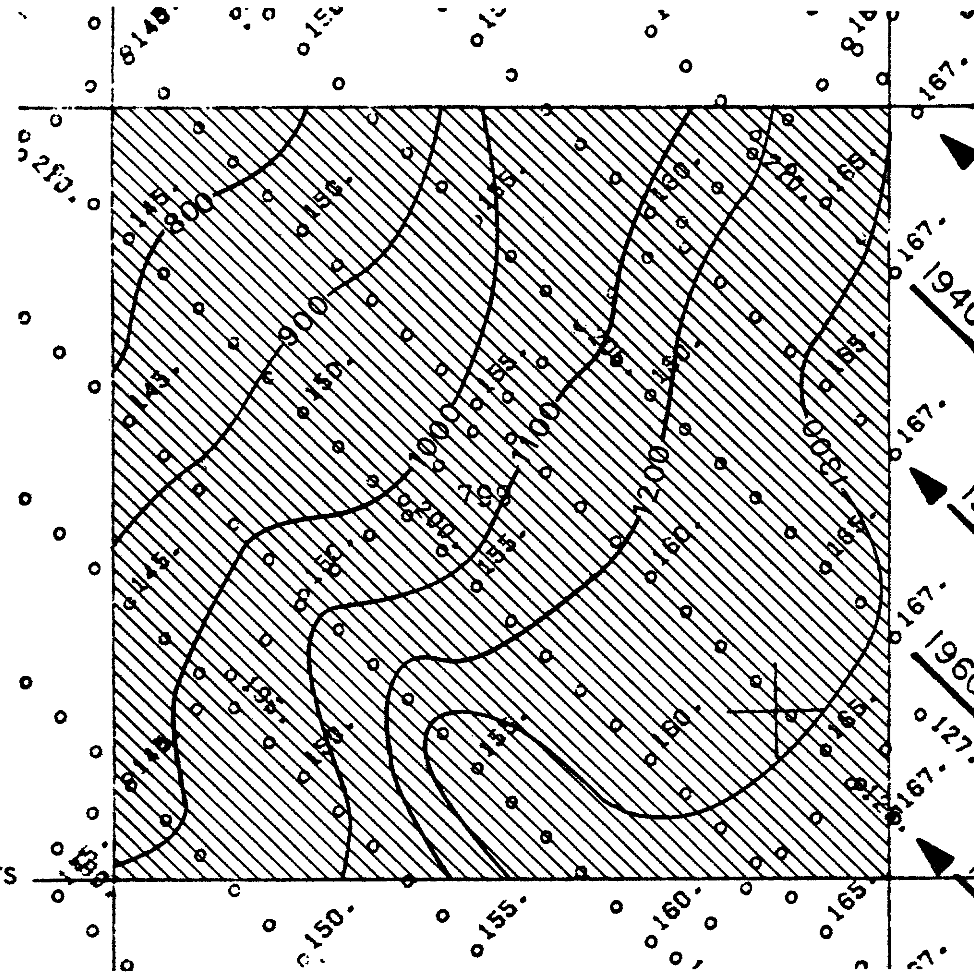
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 799
(NJ 18–6)

Contours in Meters

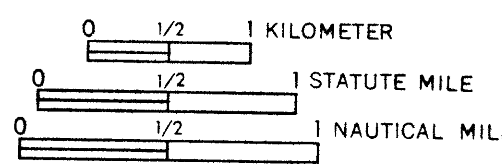



Water Depth: max. 1370 m , min. 735 m

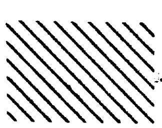
Slope Gradient: 100-200 m/km, Direction: SE

Surface Sediment Type: Sandy mud

Map Scale 1:48,000




## HAZARDS

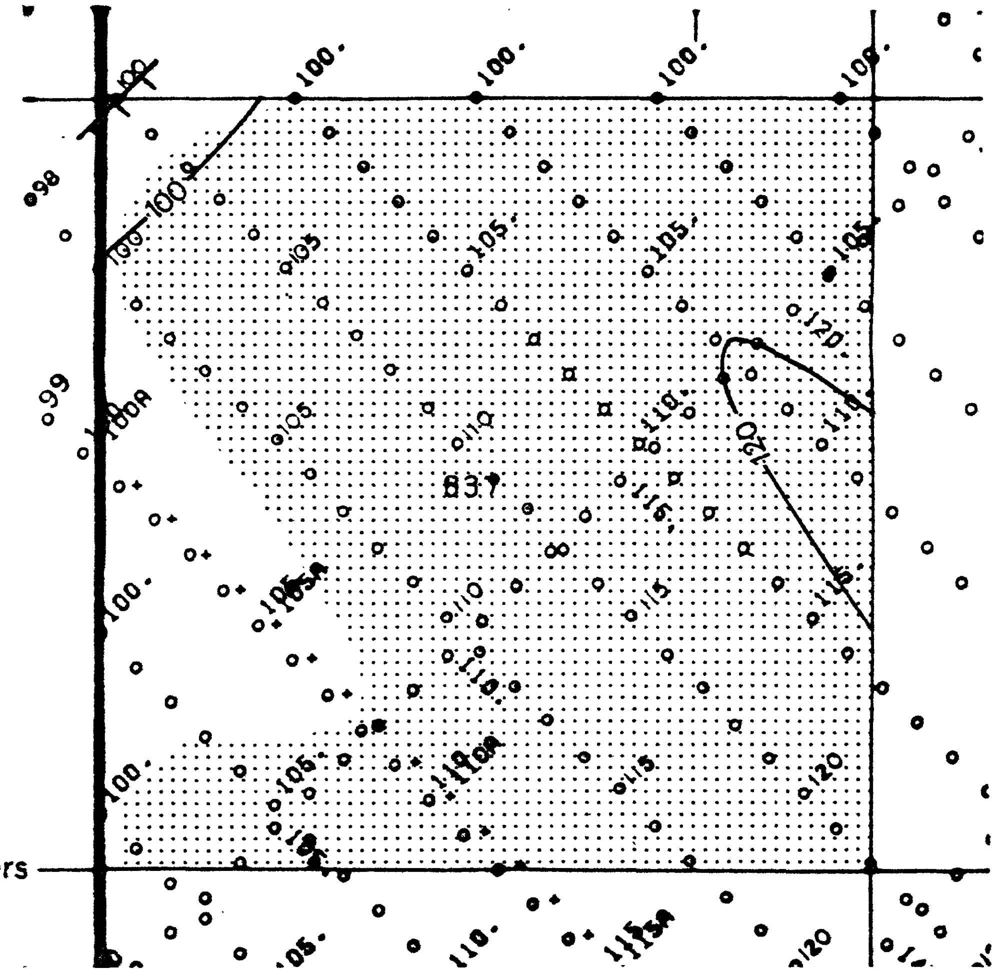


Slump or Slide

Proposed
Lease Sale #49

Block No. 837
(NJ 18–6)

Contours in Meters




Water Depth: max. 124 m , min. 91 m

Map Scale 1:48,000

Slope Gradient: 1-2 m/km, Direction: E

Surface Sediment Type: Slightly gravelly muddy sand

## HAZARDS

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

Shallow Fault

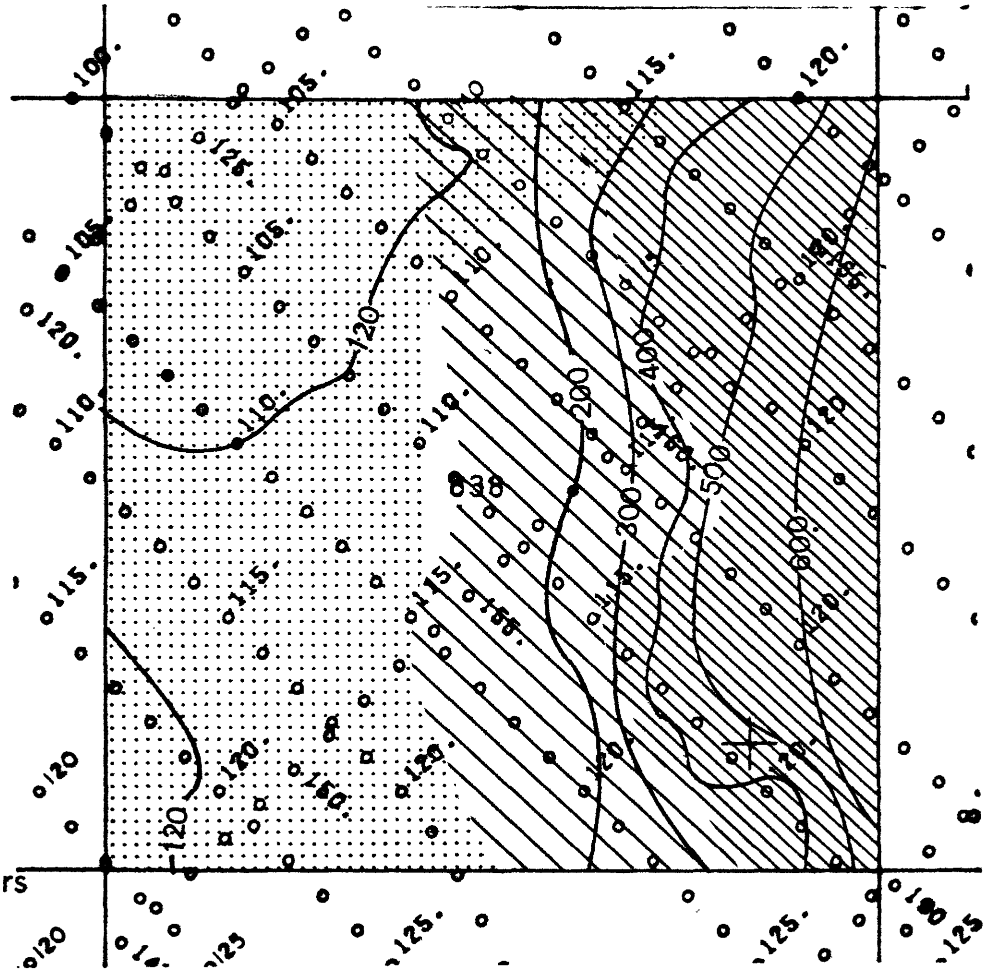
## CONSTRAINTS

Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 838
(NJ 18–6)

Contours in Meters




Water Depth: max. 715 m , min. 114 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km E (shelf); max. > 300 m/km E (canyon)

Surface Sediment Type: Slightly gravelly muddy sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

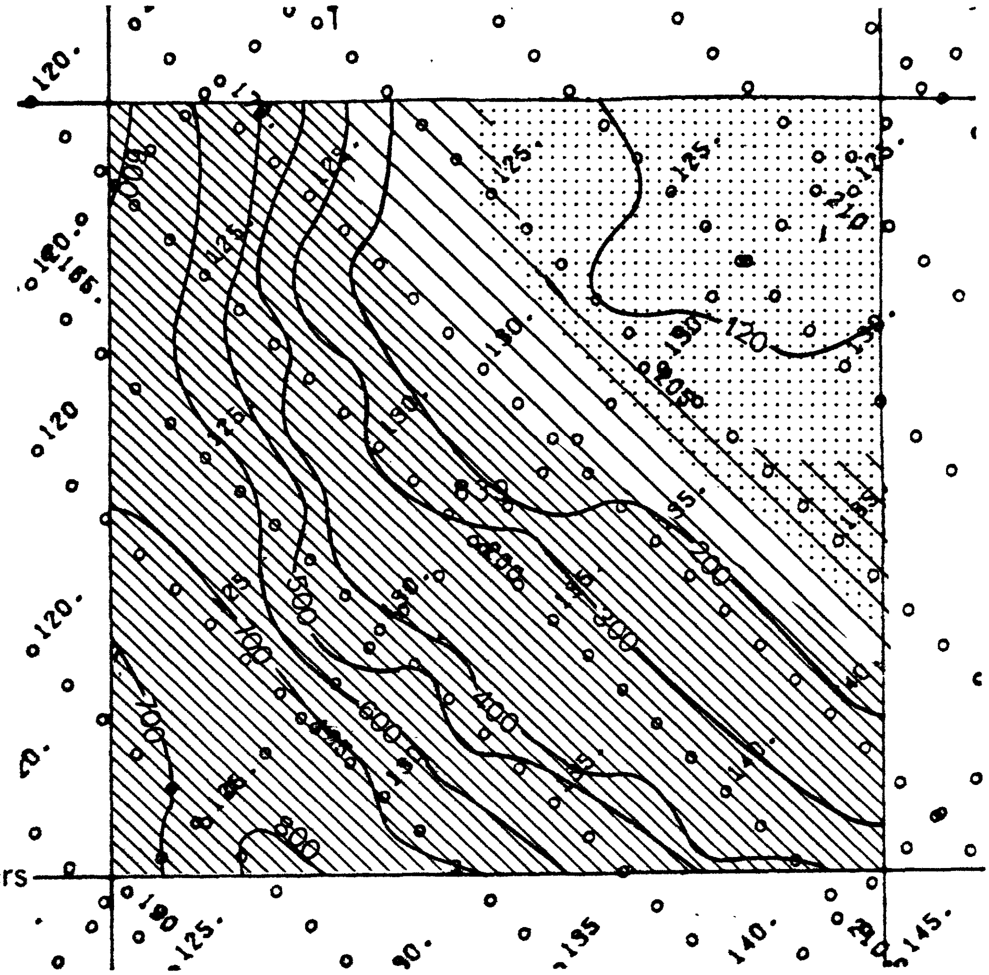
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 839
(NJ 18–6)

Contours in Meters



Water Depth: max. 800 m , min. 115 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SW (shelf); max. > 300 m/km SW (canyon)

Surface Sediment Type: Slightly gravelly sand (shelf), sandy mud (canyon)

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

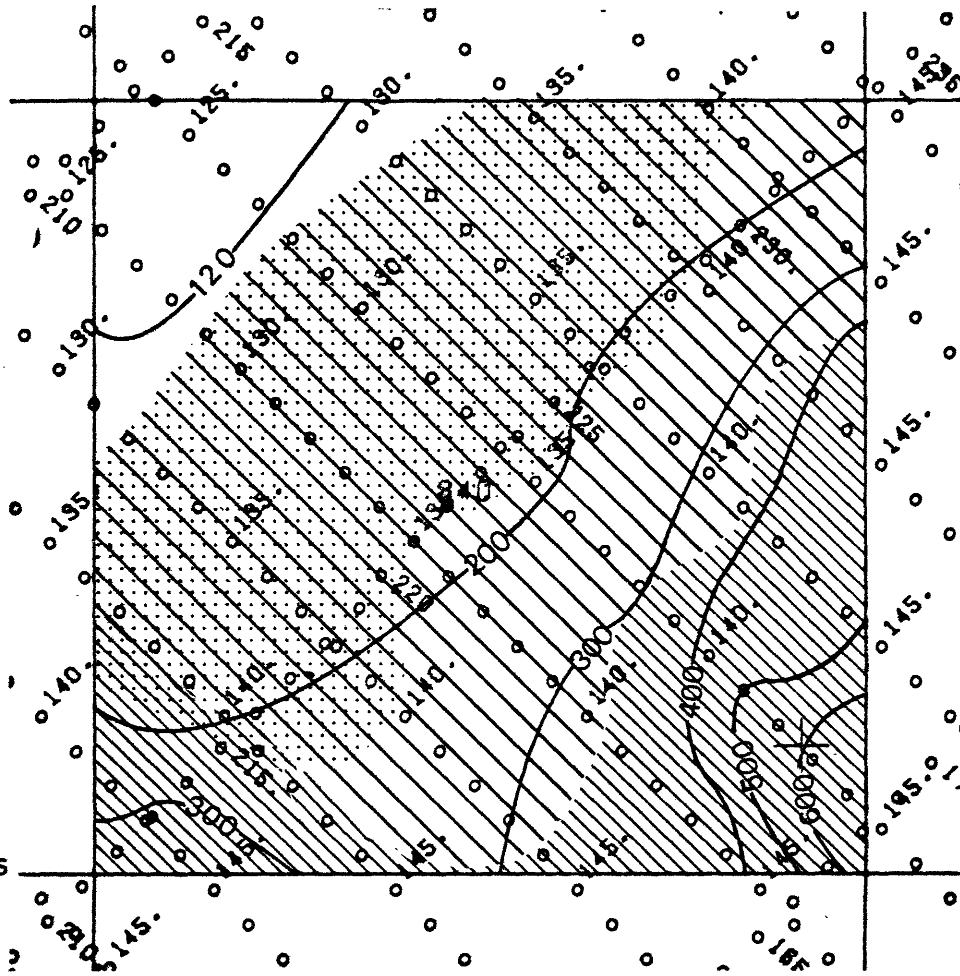
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 840
(NJ 18–6)

Contours in Meters

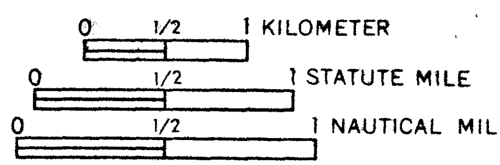



Water Depth: max. 622 m , min. 117 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SE (shelf); max. >160 m/km SE (slope)

Surface Sediment Type: Slightly gravelly sand




## HAZARDS

Slump or Slide

## CONSTRAINTS

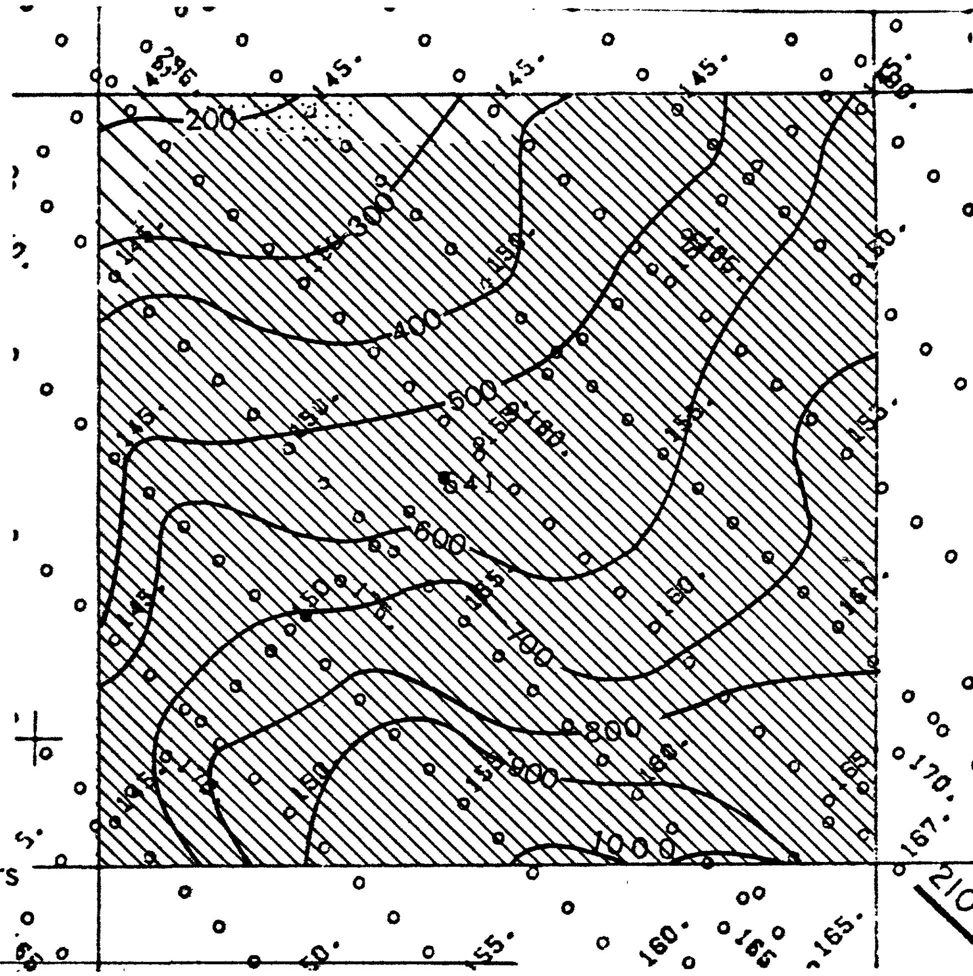
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 841
(NJ 18–6)

Contours in Meters




Water Depth: max. 1034 m , min. 180 m

Map Scale 1:48,000

Slope Gradient: 100-160 m/km, Direction: SE

Surface Sediment Type: Muddy sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

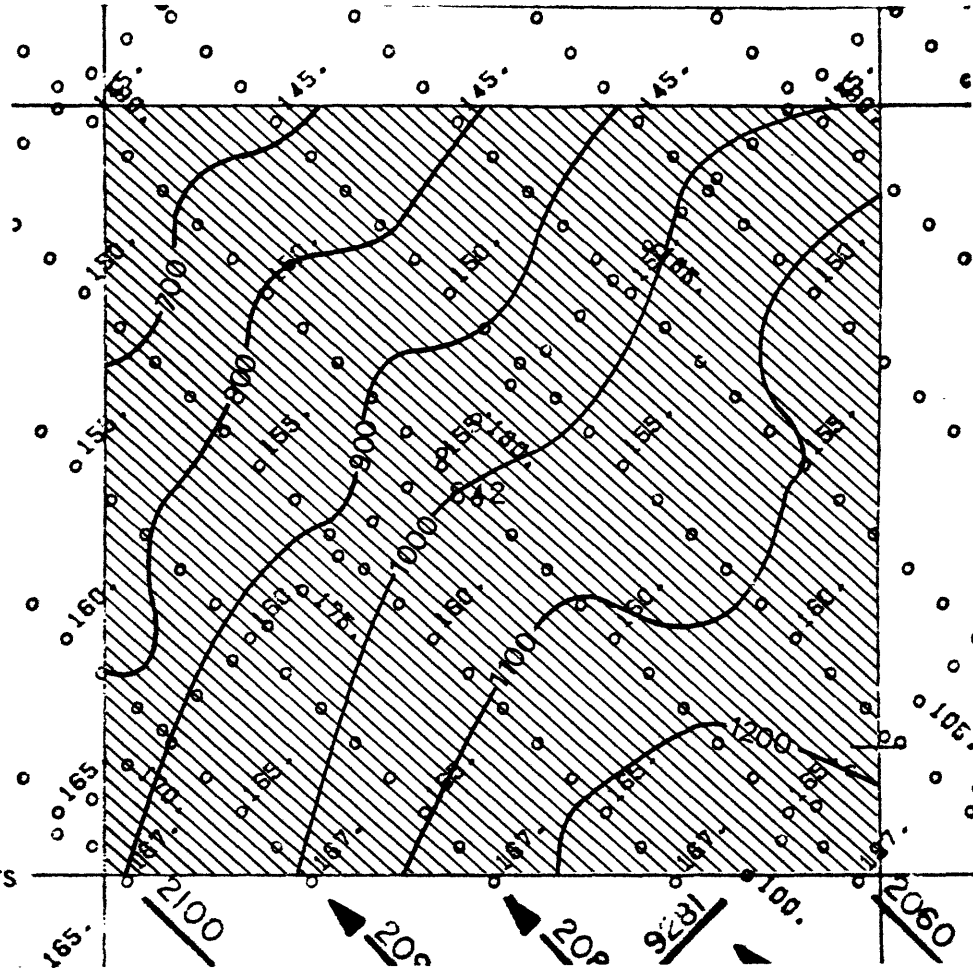
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 842
(NJ 18–6)

Contours in Meters

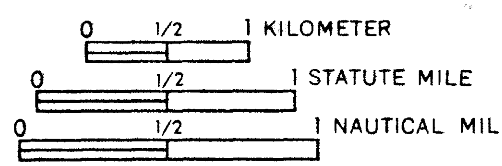



Water Depth: max. 1284 m , min. 640 m

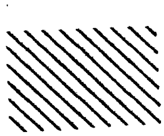
Map Scale 1:48,000

Slope Gradient: 100–150 m/km, Direction: SE

Surface Sediment Type: Sandy mud




## HAZARDS

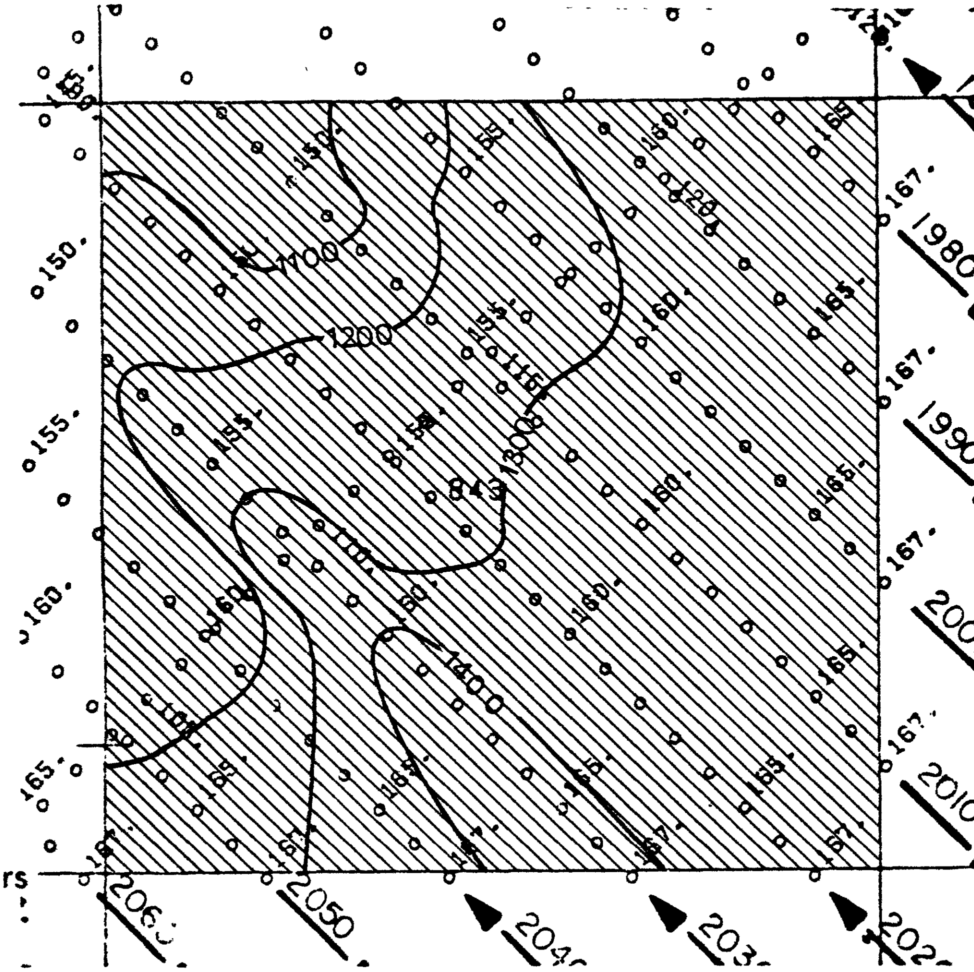


Slump or Slide

Proposed
Lease Sale #49

Block No. 843
(NJ 18–6)

Contours in Meters




Water Depth: max. 1461 m , min. 1045 m

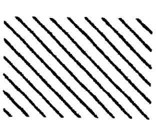
Map Scale 1:48,000

Slope Gradient: 80-200 m/km, Direction: SE

Surface Sediment Type: Sandy mud

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

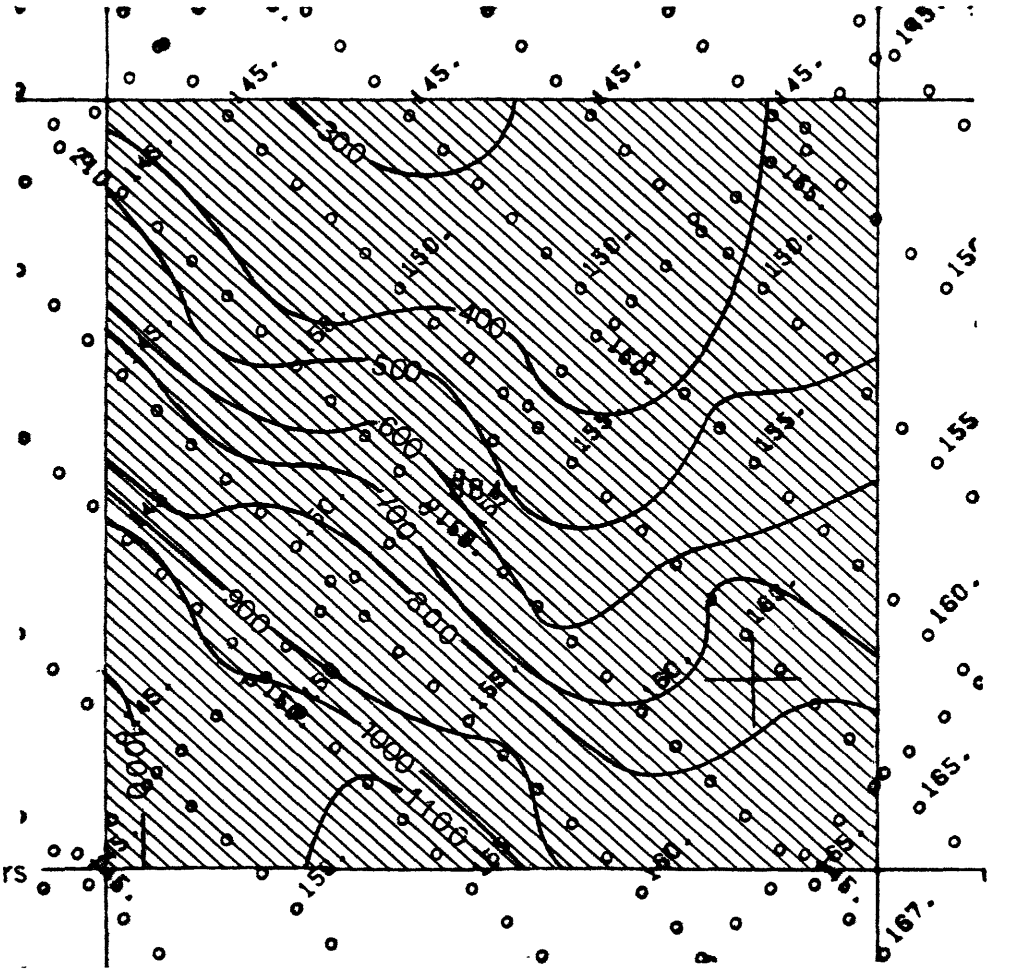


Slump or Slide

Proposed
Lease Sale #49

Block No. 884
(NJ 18–6)

Contours in Meters




Map Scale 1:48,000

Water Depth: max. 1123 m , min. 265 m

Slope Gradient: 100–400 m/km, Direction: S

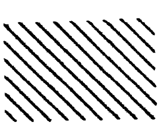
Surface Sediment Type: Sandy mud

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

HAZARDS

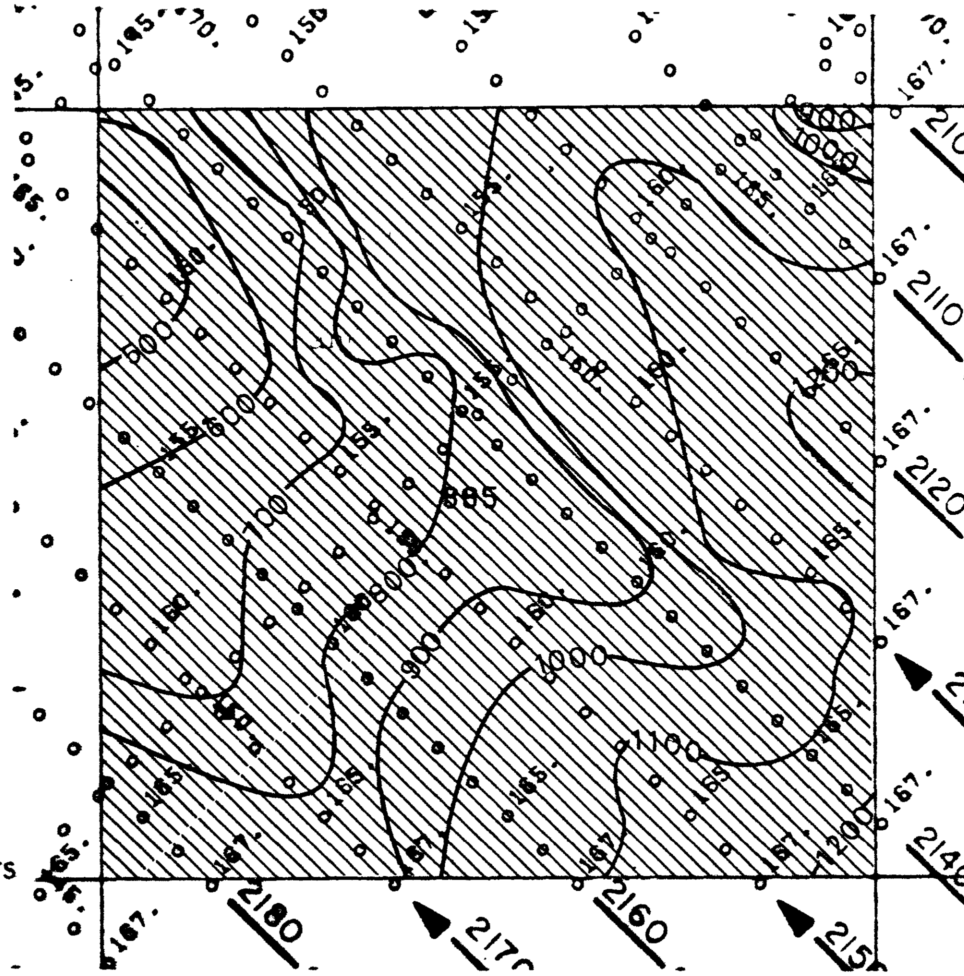


Slump or Slide

Proposed
Lease Sale #49

Block No. 885
(NJ 18–6)

Contours in Meters




Water Depth: max. 1245 m , min. 455 m

Map Scale 1:48,000

Slope Gradient: 100–200 m/km, Direction: SE

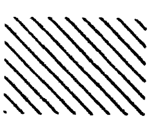
Surface Sediment Type: Sandy mud

0 1/2 1 KILOMETER

0 1/2 1 STATUTE MILE

0 1/2 1 NAUTICAL MILE

HAZARDS

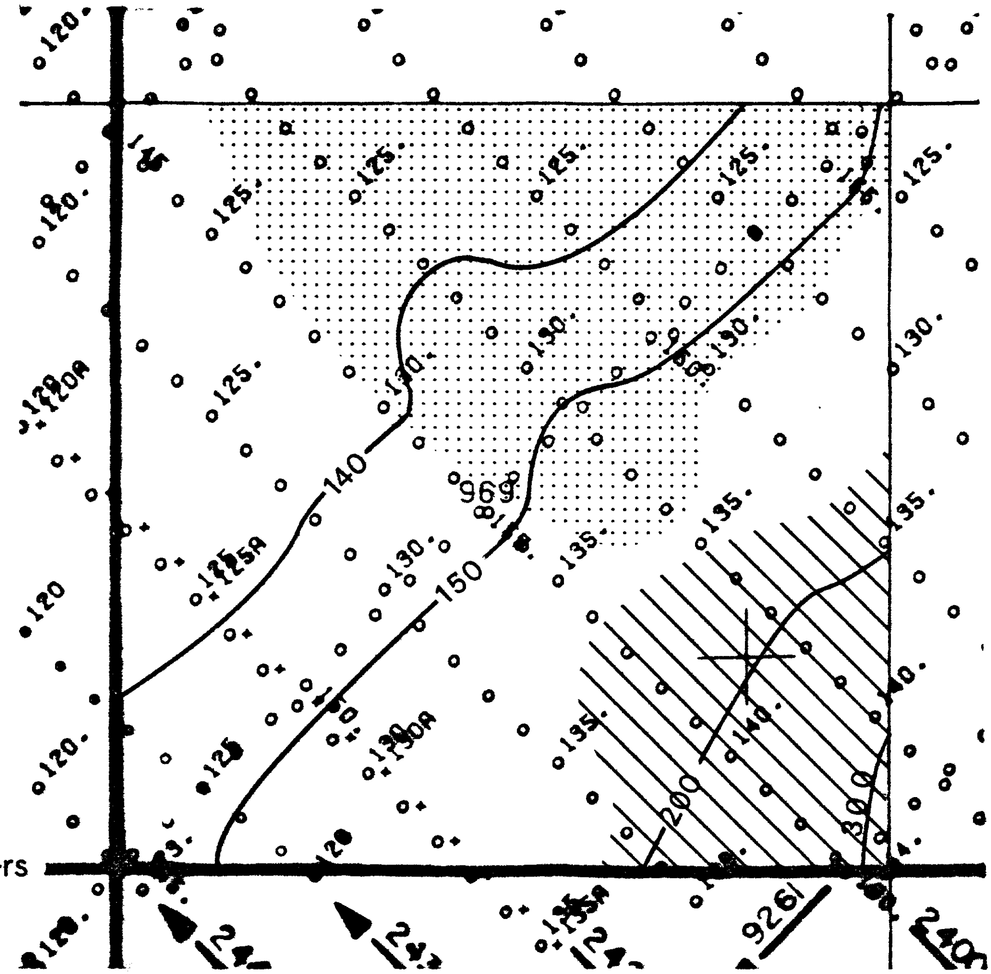


Slump or Slide

Proposed
Lease Sale #49

Block No. 969
(NJ 18–6)

Contours in Meters

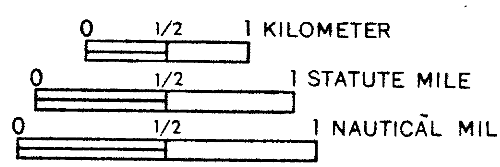



Water Depth: max. 300 m , min. 131 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SE (shelf); max. 10-100 m/km SE (slope)

Surface Sediment Type: Slightly gravelly sand




## CONSTRAINTS

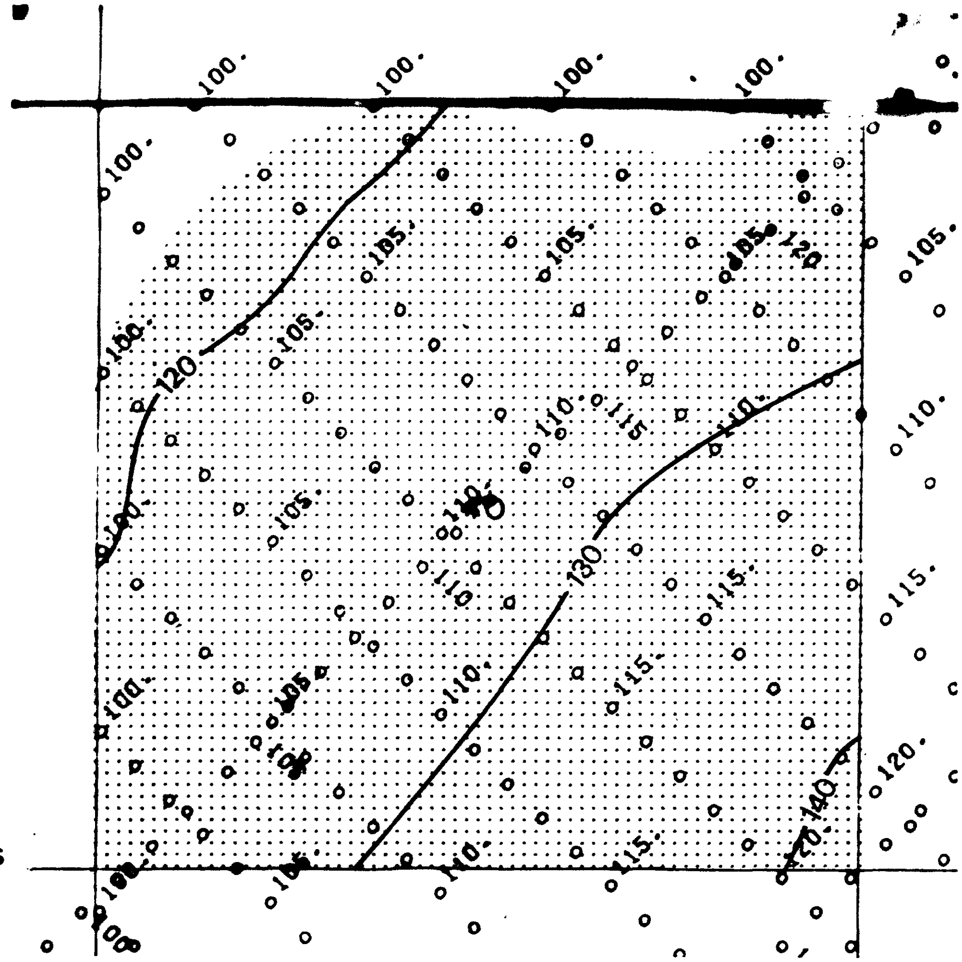
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 40
(NJ 18–8)

Contours in Meters

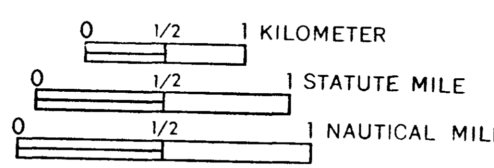



Water Depth: max. 140 m , min. 100 m

Map Scale 1:48,000

Slope Gradient: 5 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly sand



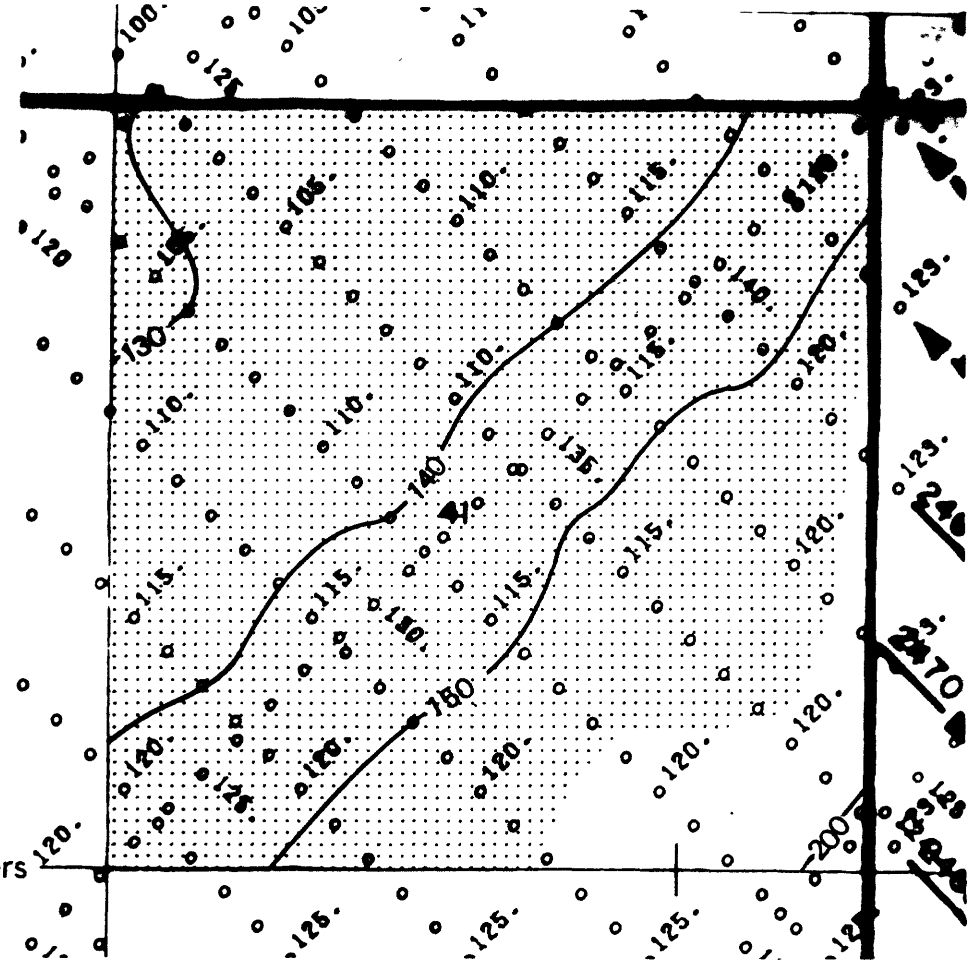

## CONSTRAINTS

Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 41
(NJ 18-8)

Contours in Meters

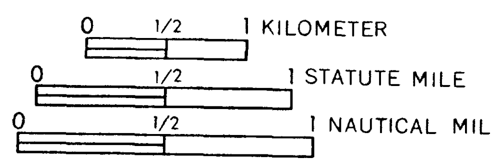


Water Depth: max. 204 m , min. 129 m

Map Scale 1:48,000

Slope Gradient: min. 1-5 m/km SE (shelf); max. 10-25 m/km SE (slope)

Surface Sediment Type: Slightly gravelly sand



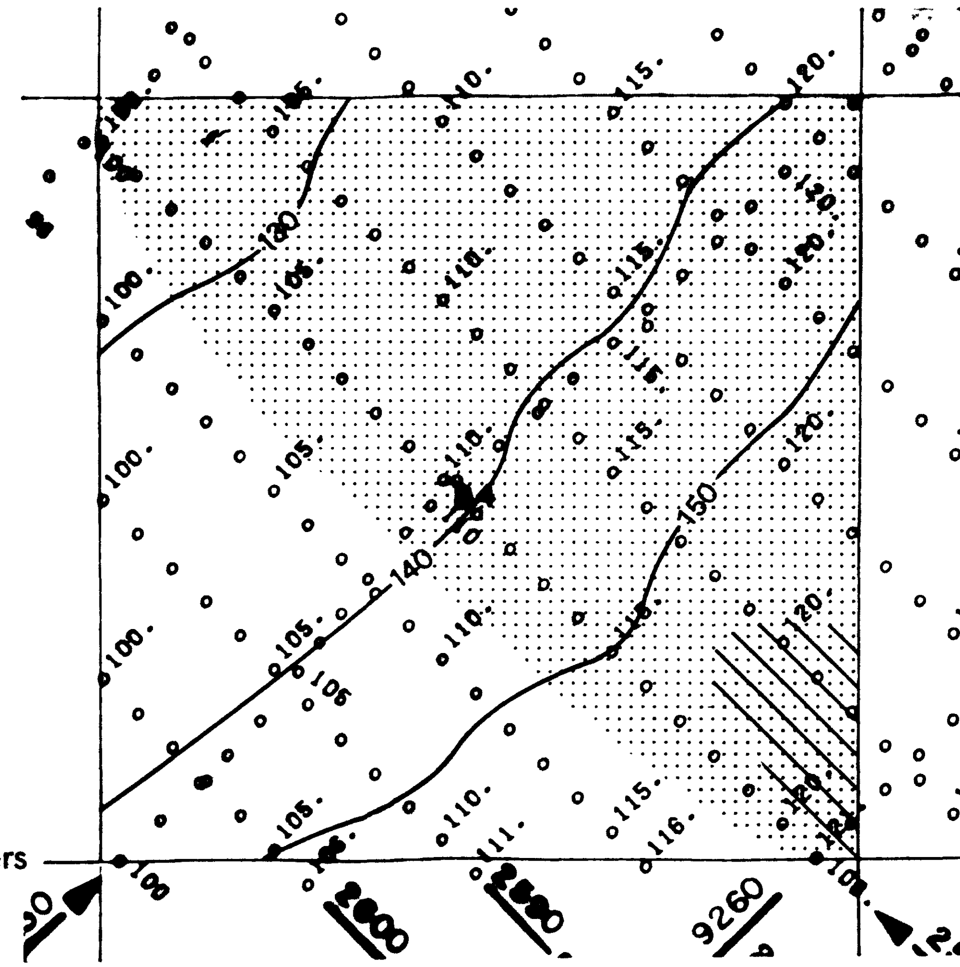

CONSTRAINTS

Acoustically Turbid Zone

Proposed
Lease Sale #49

Block No. 84
(NJ 18–8)

Contours in Meters

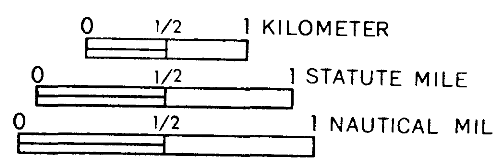



Water Depth: max. 182 m , min. 126 m

Map Scale 1:48,000

Slope Gradient: 5-25 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly sand




## CONSTRAINTS

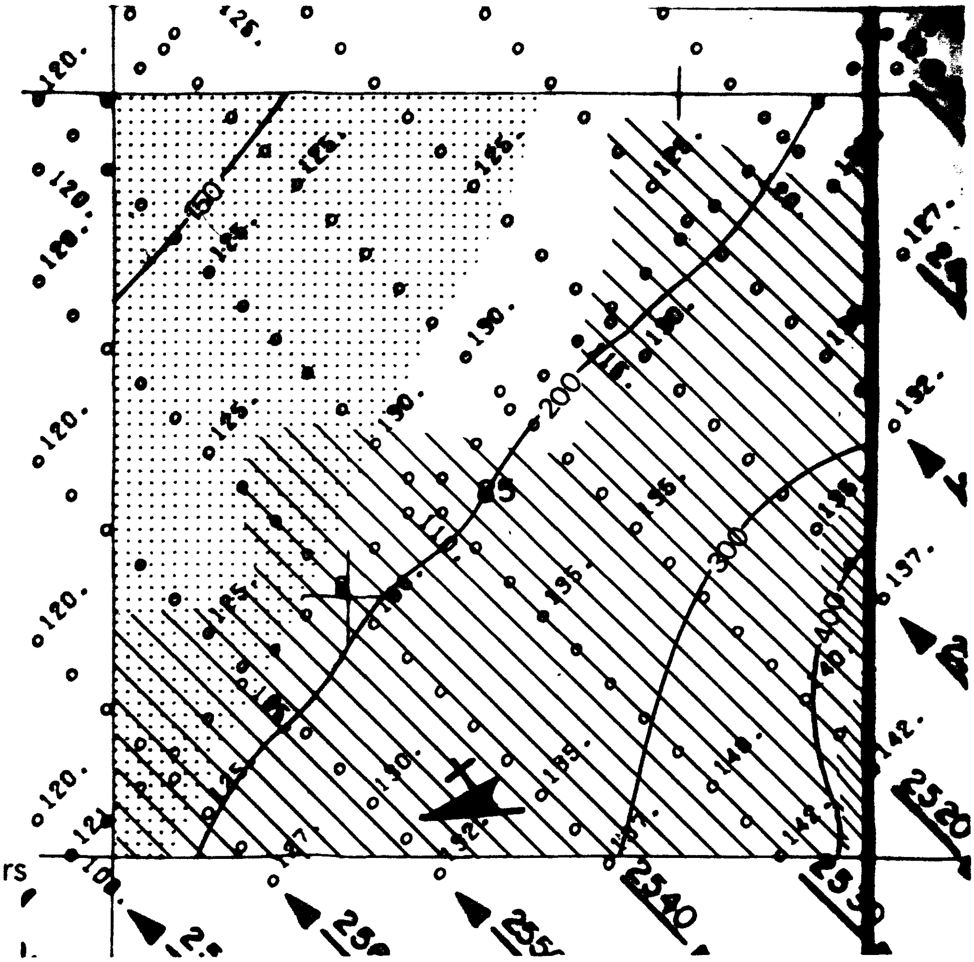
Acoustically Turbid Zone

Potentially Unstable Slope

Proposed
Lease Sale #49

Block No. 85
(NJ 18–8)

Contours in Meters




Water Depth: max. 487 m , min. 145 m

Map Scale 1:48,000

Slope Gradient: 25-75 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly muddy sand

0 1/2 1 KILOMETER
0 1/2 1 STATUTE MILE
0 1/2 1 NAUTICAL MILE

## HAZARDS

Slump or Slide

## CONSTRAINTS

Acoustically Turbid Zone

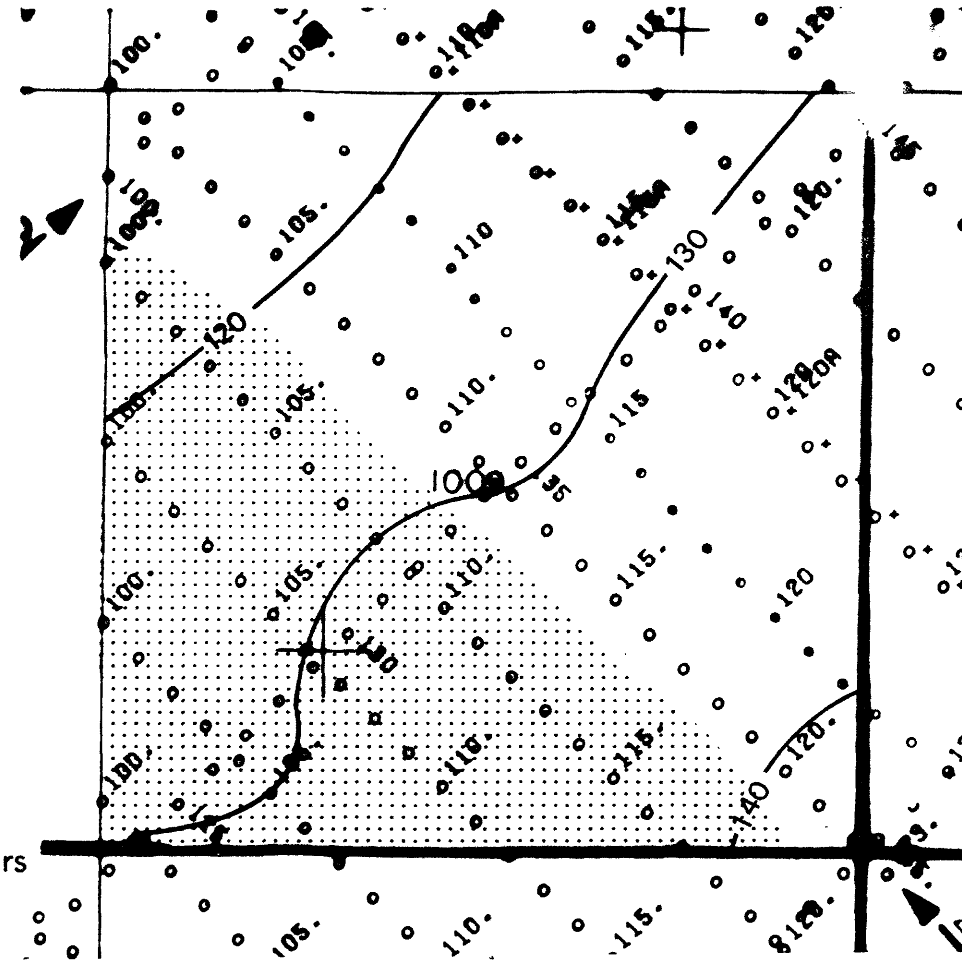
Potentially Unstable Slope

Shipwreck (from BLM, Draft Environmental Impact Statement, Sale #49, Visual #1)

Proposed
Lease Sale #49

Block No. 1009
(NJ 18–5)

Contours in Meters

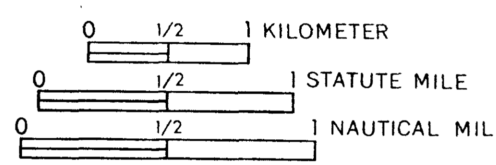



Water Depth: max. 141 m , min. 112 m

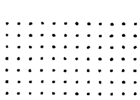
Map Scale 1:48,000

Slope Gradient: 5 m/km, Direction: SE

Surface Sediment Type: Slightly gravelly sand




## CONSTRAINTS



Acoustically Turbid Zone