GRADUATE SCHOOL OF OCEANOGRAPHY

NARRAGANSETT MARINE LABORATORY

UNIVERSITY OF RHODE ISLAND

VOLUME 2

APPENDICES TO

"Environmental Assessment of Fall River Harbor Dredging and Browns Ledge Disposal"

KINGSTON, RHODE ISLAND

APPENDIX

Waves and Associated Bottom Currents

WAVE GENERATED BOTTOM VELOCITIES IN BROWNS LEDGE AREA

INTRODUCTION

The Dobson wave refraction computer program (2) has been combined with first-order linear Airy wave theory (4) to produce maximum bottom horizontal water particle velocities (bottom velocities) for waves moving across the Browns Ledge area. Equally spaced wave rays, simulating a monochromatic wave front, are refracted across planar depth grids towards the proposed Browns Ledge dredge disposal site. Various "deep water" monochromatic wave periods, heights, and directions ranging from the southwest to east (225° to 90°) are advanced in the form of wave orthogonals or wave rays. Groups of these wave rays simulate a wave front, the computer simulation being called wave ray plots or diagrams. At points along these "refracted" wave rays moving across the Browns Ledge area, bottom velocities are calculated. These velocities are then computer contoured and plotted to elucidate bottom regions of high energy (i.e., large bottom velocity regions).

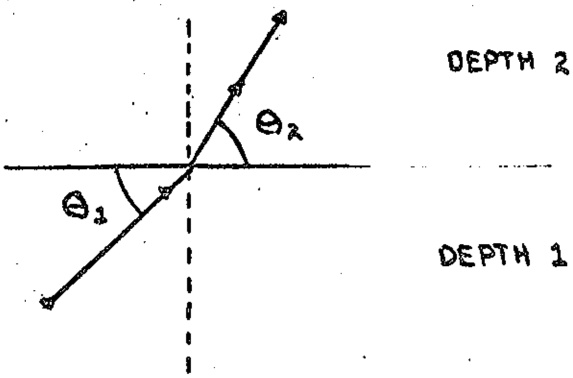
THEORY

In order to study the movements of waves across the continental shelf, the theory of "monochromatic" wave refraction is employed. Monochromatic wave refraction theory attempts to model the movement of wave energy from deep to shallow water for a singular wave period, height, and direction. Computerized wave refraction methods employ wave rays, which are perpendicular to a wave front. The assumptions are made that no energy passes laterally across these orthogonals; that energy losses due to visious dissipation, bottom friction are negligible; no wind stress or currents are present, and that linear wave theory holds (small amplitude waves). As these gravity water waves move from deep water in shallow water they tend to bend or refract with phase velocity according to Snell's Law (4) (Figure 1).

$$[1.1] \quad \frac{\cos\theta_1}{c_1} = \frac{\cos\theta_2}{c_2}$$

c = phase velocity

FIGURE 1.



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where c, the phase velocity is defined as

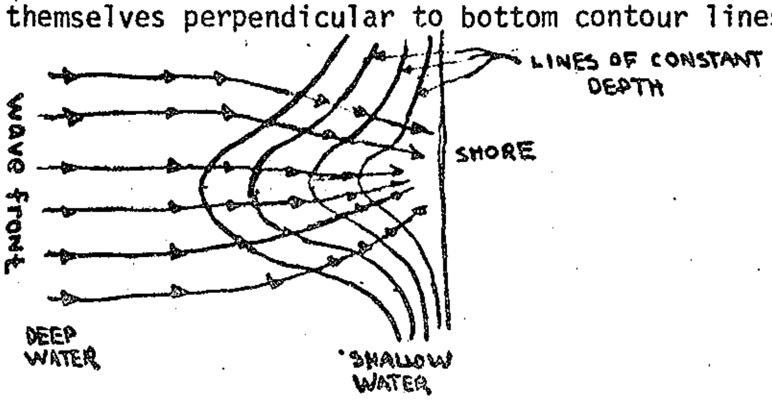
$$[2.1] \quad c = \left(\frac{g}{K}\tanh(Kh)\right)^{1/2}$$

$$[2.2] \quad c = \left(\frac{gT}{2\pi}\right)\tanh\left(\frac{2\pi h}{CT}\right)$$

g = gravititational cnst.
K = wave number = $2\pi/L$
L = wave length
h = water depth
T = wave period

Equation [2.2] illustrates the dependency of linear phase velocity with wave period and depth. Thus the angle of wave ray travel becomes a function of the variation of depth along a wave ray. The wave rays become subject to progressive curving or bending as they progress into shallow water tending to allign themselves perpendicular to bottom contour lines. [FIG.2]

FIGURE 2.



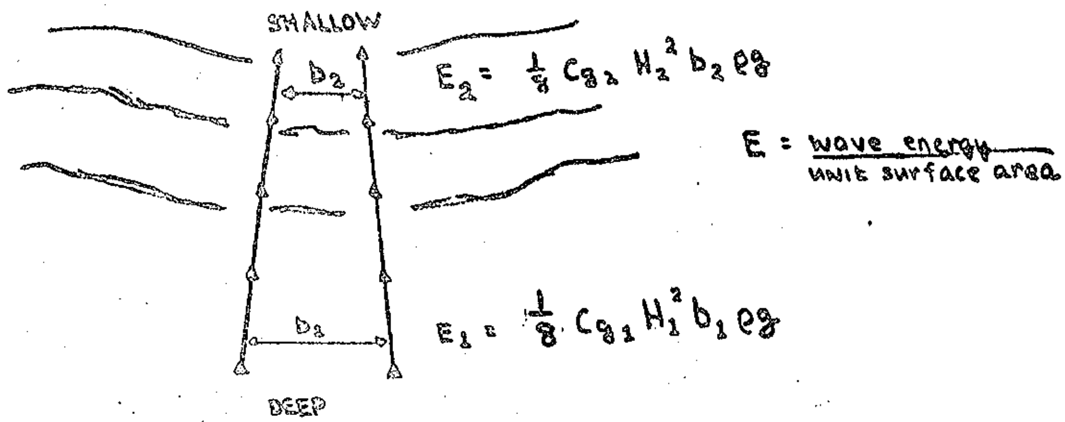


FIGURE 3.

As an illustration, consider two adjacent wave rays representing a wave front propagating into shallow water [Figure 3]. Allow b_1 to be the distance between the orthogonals in deep water and b_2 the distance in shallow water. Assuming wave energy is constant, between rays, equation [3.1] follows

$$[3.1] \quad b_1 H_1{}^2 Cg_1 = b_2 H_2{}^2 Cg_2 \qquad (4)$$

Cg = group velocity

H = wave height

The wave height in shallow water becomes

$$[3.2] \quad H_2 = H_1 \left(\frac{b_1}{b_2}\right)^{1/2} \left(\frac{Cg_1}{Cg_2}\right)^{1/2} = H_1 K_r K_s$$

$$K_r = \frac{b_1}{b_2} = \text{refraction coefficient}$$

$$K_s = \frac{Cg_1}{Cg_2} = \text{shoaling coefficient}$$

where the wave height is a function of a shoaling and refraction coefficient. The mathematics of determining the change of wave ray angle, and refraction coefficient are described in detail by Dobson (2), Rabe (5), Skovgaard <u>et al</u>. (6) and Breeding (1).

Of primary interest in this work are the wave generated bottom velocities. The velocity potential for a small amplitude progressive airy wave travelling in the positive x-direction can be written as (IPPEN)

$$\phi = -\frac{ag}{\sigma}\frac{\cosh k\,(h+Z)}{\cosh kh}\cos(kx - \sigma t) \qquad [4.1]$$

The horizontal velocity component may be obtained by differentiation of [4.1]

$$u = -\frac{\partial\phi}{\partial x} = \frac{agk}{\sigma}\frac{\cosh k\,(h+z)}{\cosh kh}\sin(kx - \sigma t) \qquad [4.2]$$

t = time

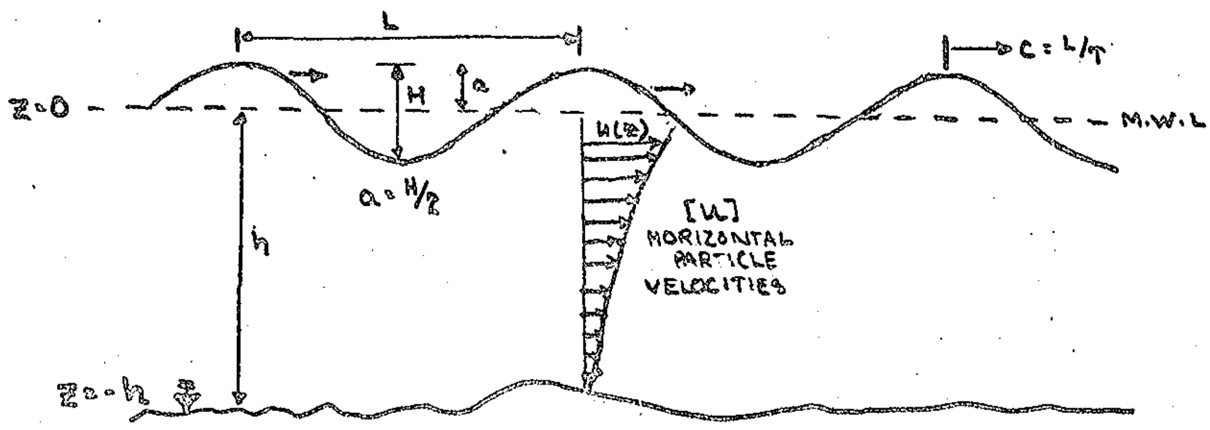
σ = wave frequency = $2\pi/T$

u = horizontal water particle velocity

a = wave amplitide = $H/2$

Equation [4.2] defines the horizontal water particle velocity throughout the water column Z, as a function of time, t, depth, h, wave number, k, and wave amplitude, a [Figure 4].

PROGRESSIVE AIRY WAVE TRAIN



Evaluating [4.2] at $Z = -h$ (at the bottom) and setting $\sin(kx - \sigma t)$ equal to one, equation [4.3] is derived.

[4.3] $$U\ max = \frac{H}{2}\ \frac{g}{c}\ \left(\frac{1}{\cosh}\left[\frac{2\pi h}{CT}\right]\right)$$

$Z = -h$ T = wave period (secs.)

Linear Airy wave theory assumes no net water particle transport with time as evidenced by the cosine term in equation [4.1]. Equation [4.3] illustrates the dependence of wave generated horizontal water particle velocity with wave height, phase speed, and water depth. Wave height, wave ray refraction, and horizontal particle velocities are all a function of water depth, wave period, and initial wave ray direction . (4)

PROCEDURE OF STUDY

The Dobson wave refraction computer program was employed to model the movement of wave rays across the southern Rhode Island continental shelf towards the Browns Ledge area and proposed dredge spoil dump site. The Dobson program requires an array of equally spaced depth values along a two-dimensional x-y depth grid. Seven different depth grids of various scales and grid unit capacities were required for use in this study (Figure 5 and Table 1). Depth values were extracted at equally spaced points from the 1938 and 1967 C & G S Hydrographic mercator map projections (8). The grids were chosen to provide an overlay of depth values for wave refraction, for rays of general southwest to easterly direction. Grid 6 was extended to 40° 15' latitude in order to provide depths for storm waves approaching from the SW to SE range. Grid 3, the general target area for wave rays in this study (longitude range 51°10'-71°01'36" and latitude 41°16'-41°21.6') encompasses the Browns Ledge area and the proposed dump site; range 71°04.8'-71°03.4', 41°17.8'-41°18.8'.

The original computer program was modified to incorporate the seven depth grids, each of varying scale, spatial location and grid unit sizes. Depth values in each depth grid were punched on IBM cards and then stored on

FIGURE 5

DEPTH GRIDS FOR WAVE REFRACTION

ACROSS THE CONTINENTAL SHELF TO BROWNS LEDGE [GRID 3]

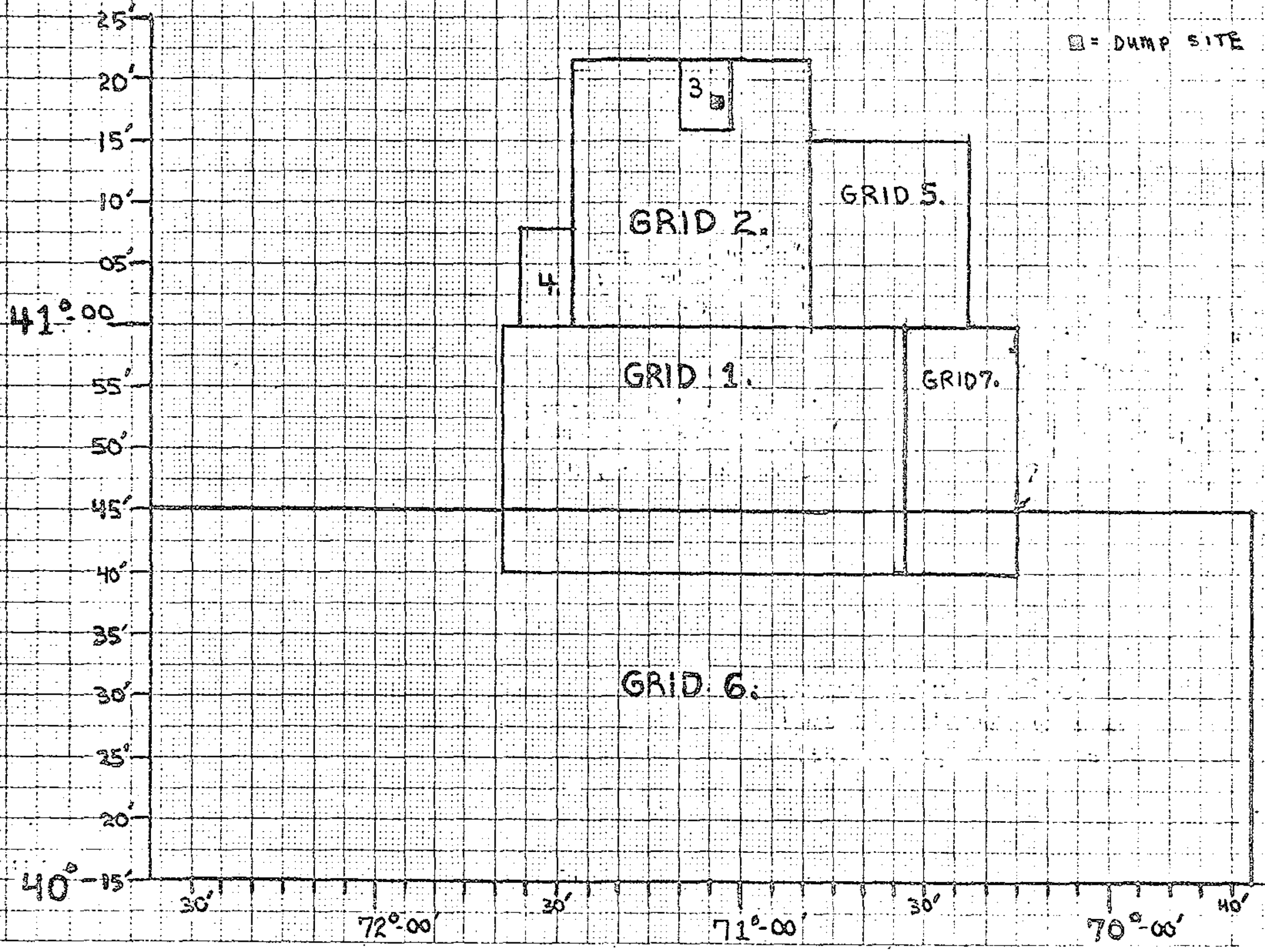


TABLE 1

GRID NUMBER	LATITUDE RANGE	LONGITUDE RANGE	X-Y GRID UNITS	GRID UNIT SIZE (N.M.)	C & GS MAP
1	40°40' 41°00'	71°39'20" 70°33'	79x 32y	0.645	H-6333 H-6447
2	41°00' 41°21'36"	71°26'56" 70°49'	92x 69y	0.318	H-6444 H-6445
3	41°16' 41°21'36"	71°10' 71°01'38"	60x 55y	0.103	H-6445
4	41°00' 41°07'50"	71°26' 71°36'14"	20x 26y	0.318	H-6330
5	41°00' 41°15'	70°49' 70°23'8"	60x 46y	0.340	0808N-51
6	40°15' 40°45'	72°36'48" 69°36'24"	138x 31y	0.818	0808N-52 -54
7	40°40' 41°00'	70°15' 70°36'	17x 21y	0.818	0808N-51

on an IBM 370 disk member for use by the program.

Instabilities in the Beta (ray separation factor) variable in SUBROUTINE HEIGHT (see Dobson [2]) led to refraction coefficients of 5 to 10 giving unbelievable wave heights. This happened whenever a ~~way~~ WAVE ray moved from shallow water into deeper water (i.e., negative $\frac{\partial h}{\partial x}$ and $\frac{\partial h}{\partial y}$'s). This instability was overcome by averaging successive Beta values in the finite difference equation whenever $\frac{\partial h}{\partial x}$ or $\frac{\partial h}{\partial y}$ (PHX or PHY) became negative ('A').

A graphical presentation of wave ray refraction was developed through the use of the URI IBM 370 plotting subroutine packages (3). A subroutine was added to the Dobson program to draw the land boundaries and lines of latitude and longitude on the wave ray plots to provide visual references.

Bottom velocities were calculated in the Dobson program using equation [4.3] for each individual iteration point for wave rays moving inside Grid 3, the Browns Ledge area grid. These x-y co-ordinates and corresponding bottom velocities for each wave ray plot can be stored by the program on a Disk member. A program was written to contour the bottom velocity data for monochromatic wave data at intervals of 5 cm/sec.

An alternate plotting routine was added to the program as a "blow up" to plot wave rays across Grid 3, from deep water.

RESULTS

In order to gain insight into wave conditions in the Southern Rhode Island area, ship observations (SSMO) were used and plotted in Figures 6, 7, 8-A,B,C,D, 9-A&B. These data were taken from Naval Ship Observations (7) within Marsden Square #5 (Figure 9C). It is assumed as standard procedure that wind direction is the same as the wave direction in this data. Figure 6 shows a decrease of 2 to 3 feet in the significant height in the summer

('A') Personal discussion with Dr. Malcolm Spaulding, Dept. of Ocean Eng., University of Rhode Island.

months as compared with the winter and fall months. Figures 8-A, B, C and D illustrate wind direction recorded for the highest third of the waves on a monthly basis. Figures 9-A and B describe a five-year accumulation of all wave height and wind direction data for the highest third of the waves.

Figure 10 illustrates depth contours in 5 foot intervals for Grid 3, the Browns Ledge area. The x and y axes are in Grid 3 units. The proposed one square nautical mile dredge disposal site is marked on the contour map.

Included in the appendix are sections of wave ray-refraction plots and corresponding bottom velocity contour plots for 7.0, 8.0, 9.0, 10.0, 11.0, and 12.0 seconds respectively. (Sections 1 - 6).

For each wave period there are six deep water directional approaches ranging from SW to E; 225^{o}, 202.5^{o}, 180.0^{o}, 157.5^{o}, 135^{o}, and 90^{o} respectively. Upon these "main" refraction plots, the Browns Ledge area (Grid 3) and the disposal site are marked with squares. At given deep water directions, for each period, "blow ups" of the wave rays passing through Grid 3 are given as "sub plots". Following each wave ray subplot are given "monochromatic-linear wave" generated bottom velocity plots at a given deep water wave height for a specific deep water direction and period.

These bottom velocity charts are computer "fitted" contours for the instantaneous maximum horizontal bottom velocity at points along the wave rays passing across Grid 3, the Browns Ledge area. They illustrate regions of instantaneous wave induced bottom energy.

It is interesting to note that the areas of high bottom velocities (30 - 60 cm/sec) for wave periods of 9.0 seconds and greater correspond to areas of shallow depths; in the range of 50 - 80 feet (ledge areas). For 10.0, 11.0, and 12.0, second waves of 3.0 and 4.0 foot initial deep water height, bottom velocities across Browns Ledge range from 15 to 30 cm/sec within the proposed dredge disposal site. For wave periods of 7.0, 8.0, and 9.0 seconds, of initial deep water height, bottom velocities inside the disposal site range from 5 to 20 cm/sec.

CONCLUSIONS:

These wave refraction plots provide a visual experiment in wave movement across the continental shelf towards Browns Ledge. The bottom velocity charts should not be used to infer an overall direction or magnitude of wave induced bottom drift current, as airy wave theory assumes no net particle drift or mass transport. These numbers represent the instantaneous maximum horizontal bottom speed for a monochromatic wave front.

Bottom speeds increase with decreasing depth, increasing wave period and wave height. It is assumed that a wave spectrum in direction and period is not present, and that there are no interactions with the tides, winds or density currents.

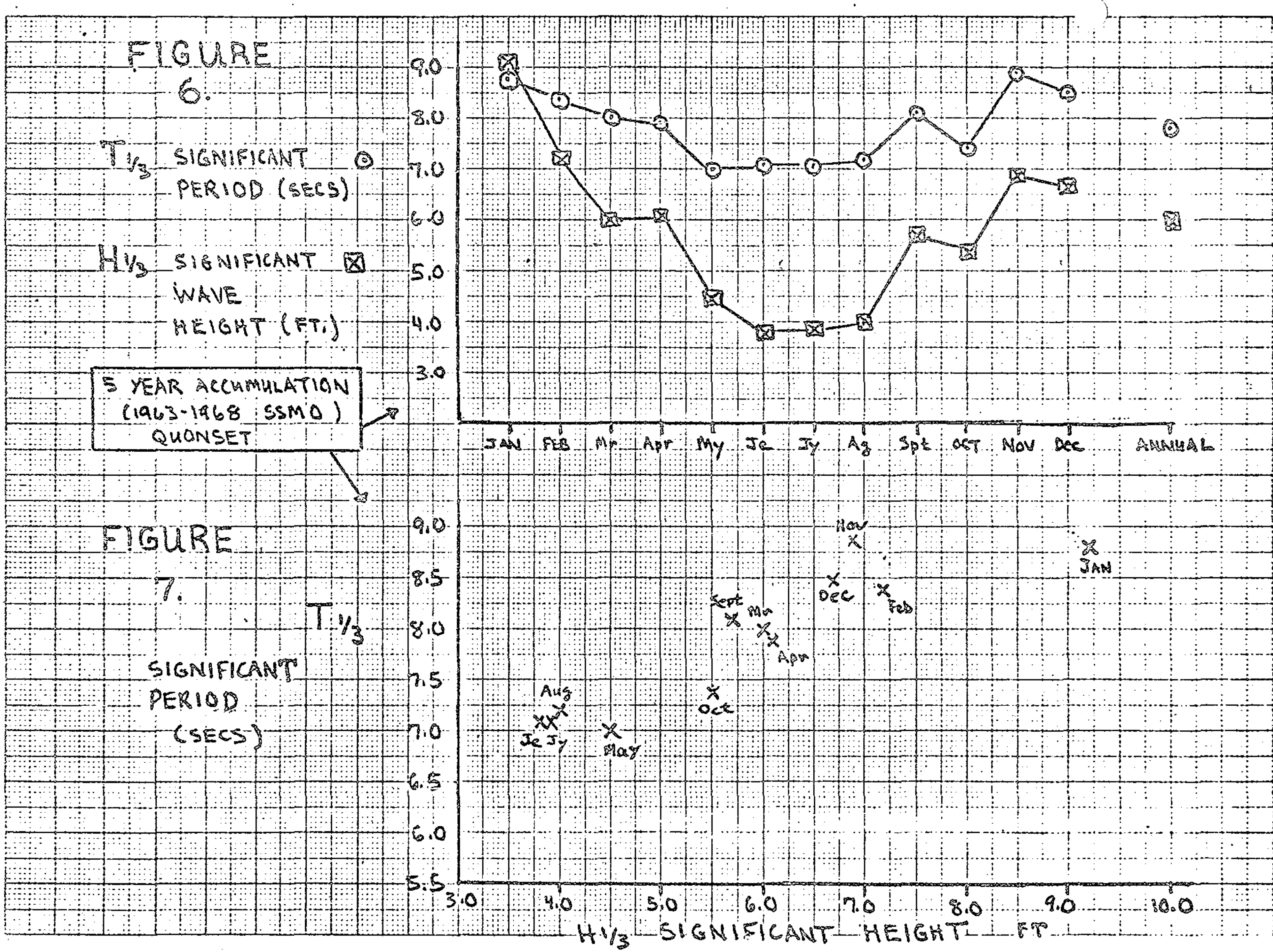


FIGURE 6.
$T_{1/3}$ SIGNIFICANT PERIOD (SECS)
$H_{1/3}$ SIGNIFICANT WAVE HEIGHT (FT.)
5 YEAR ACCUMULATION (1963-1968 SSMO) QUONSET
9.0 8.0 7.0 6.0 5.0 4.0 3.0
JAN FEB Mr Apr My Je Jy Ag Spt OCT Nov Dec ANNUAL
FIGURE 7.
$T_{1/3}$ SIGNIFICANT PERIOD (SECS)
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5
Nov JAN Dec Feb Sept Mr Apr Aug Oct Je Jy May
3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
$H_{1/3}$ SIGNIFICANT HEIGHT FT

FIGURES 8A, B, C, D

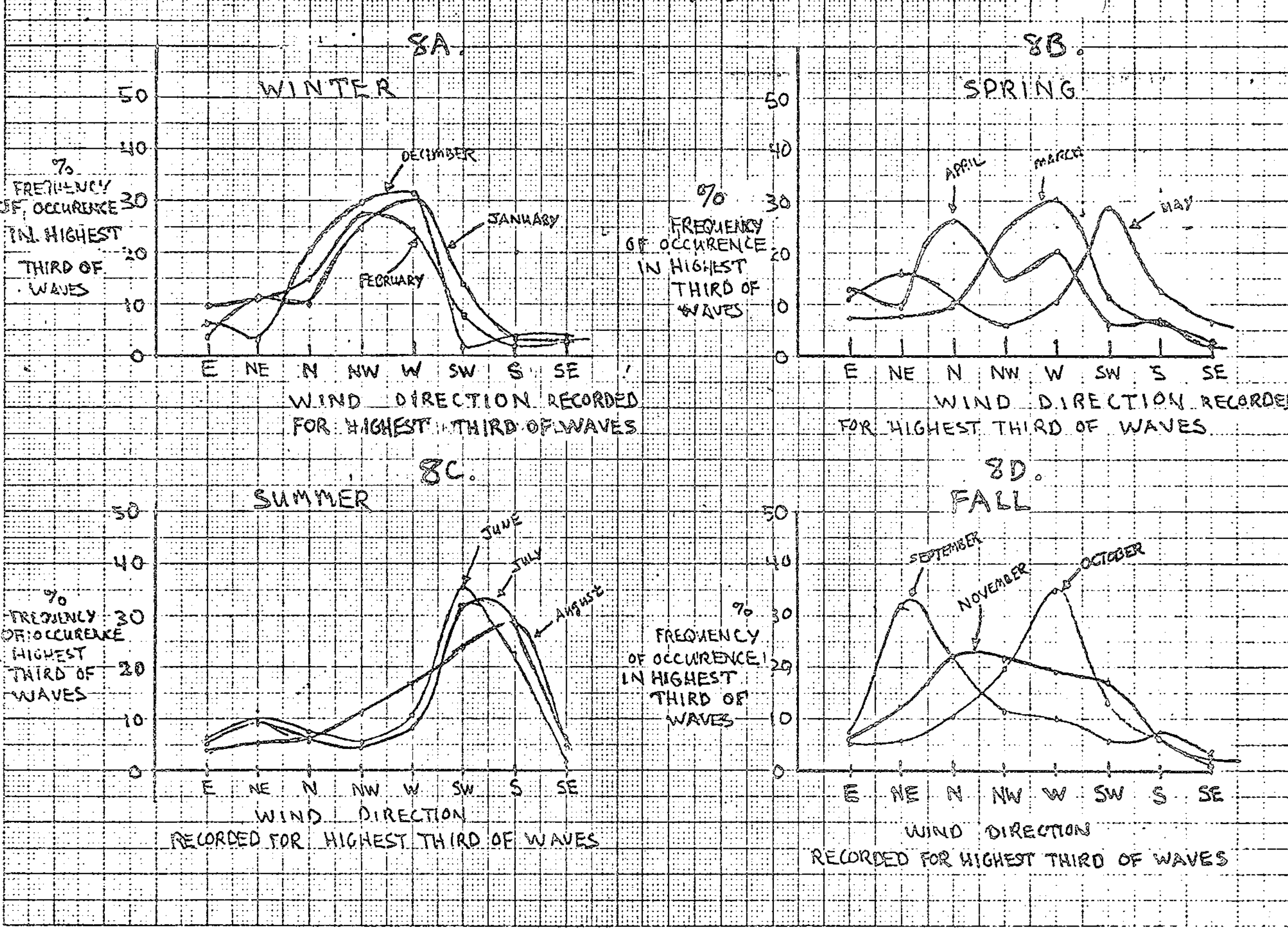


FIGURE 9A.

ANNUAL (1963-1968) SSMO - QUONSET

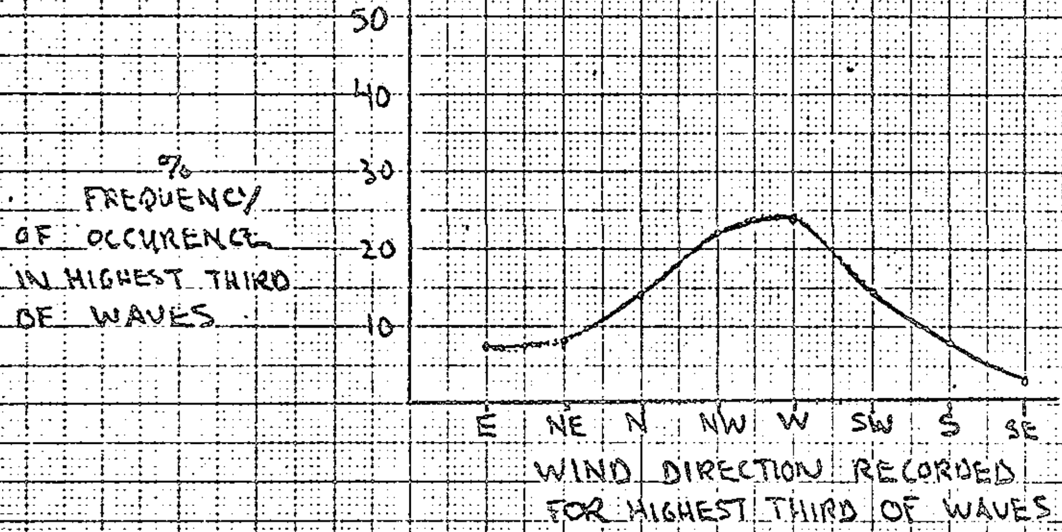


FIGURE 9B.

ANNUAL (1963-1968)

SSMO - QUONSET

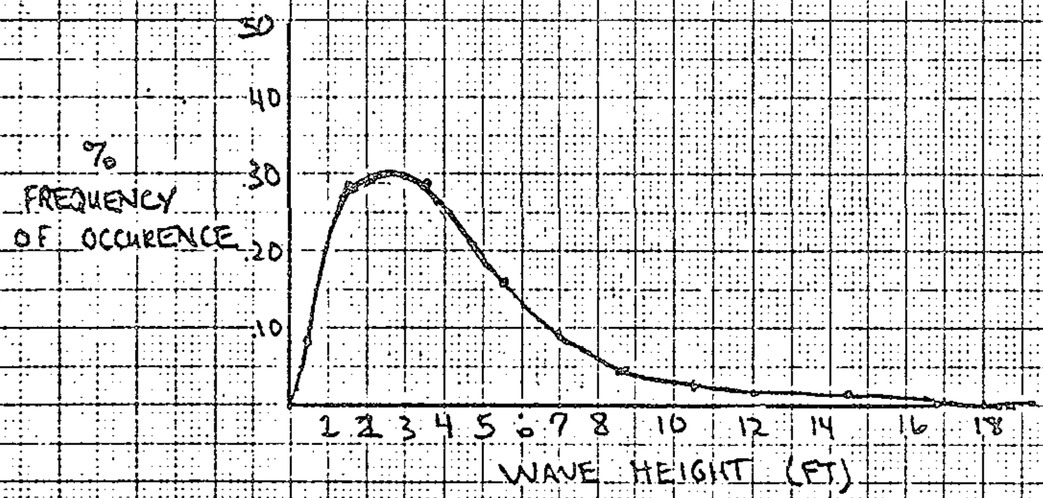


FIGURE 9c

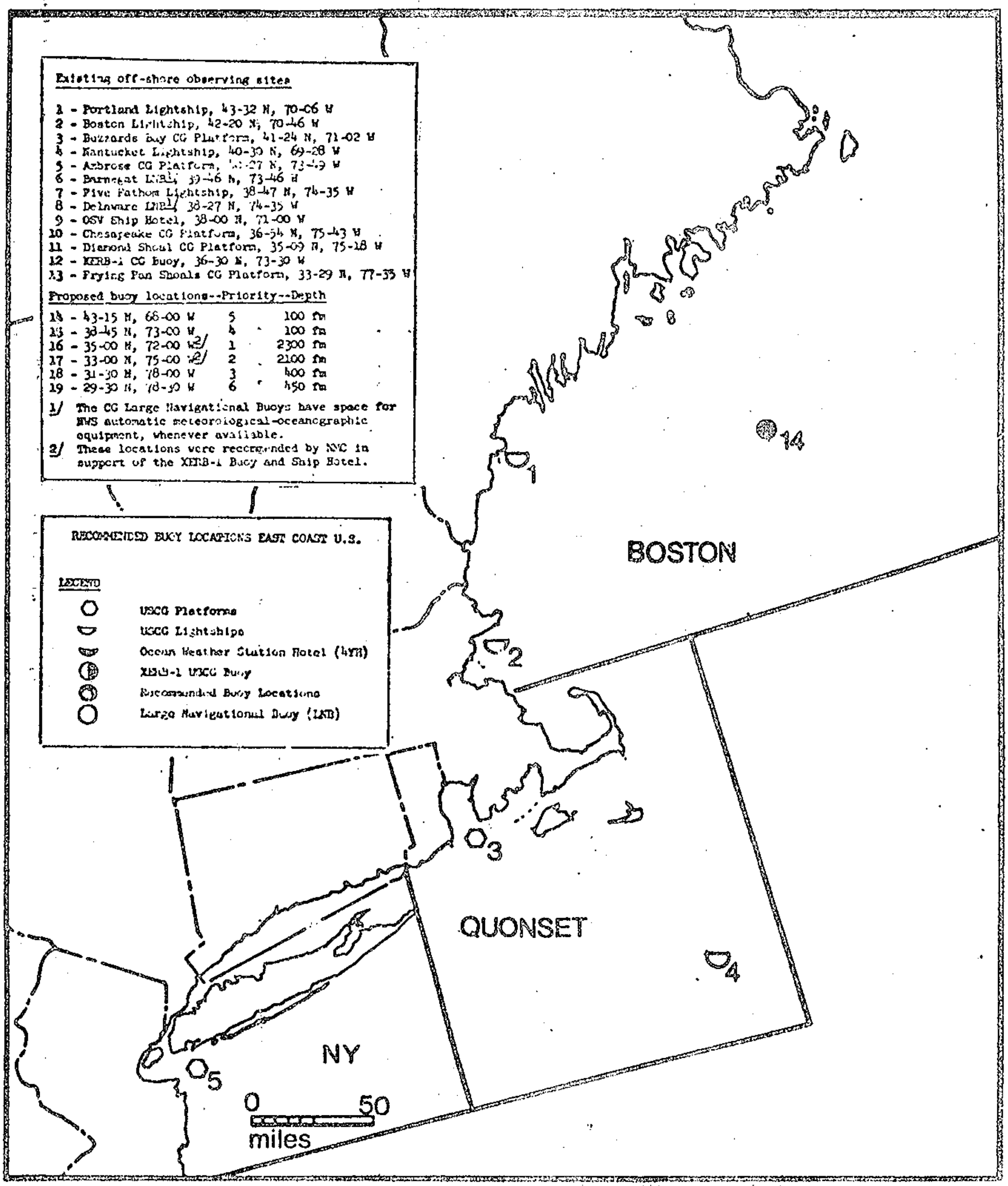
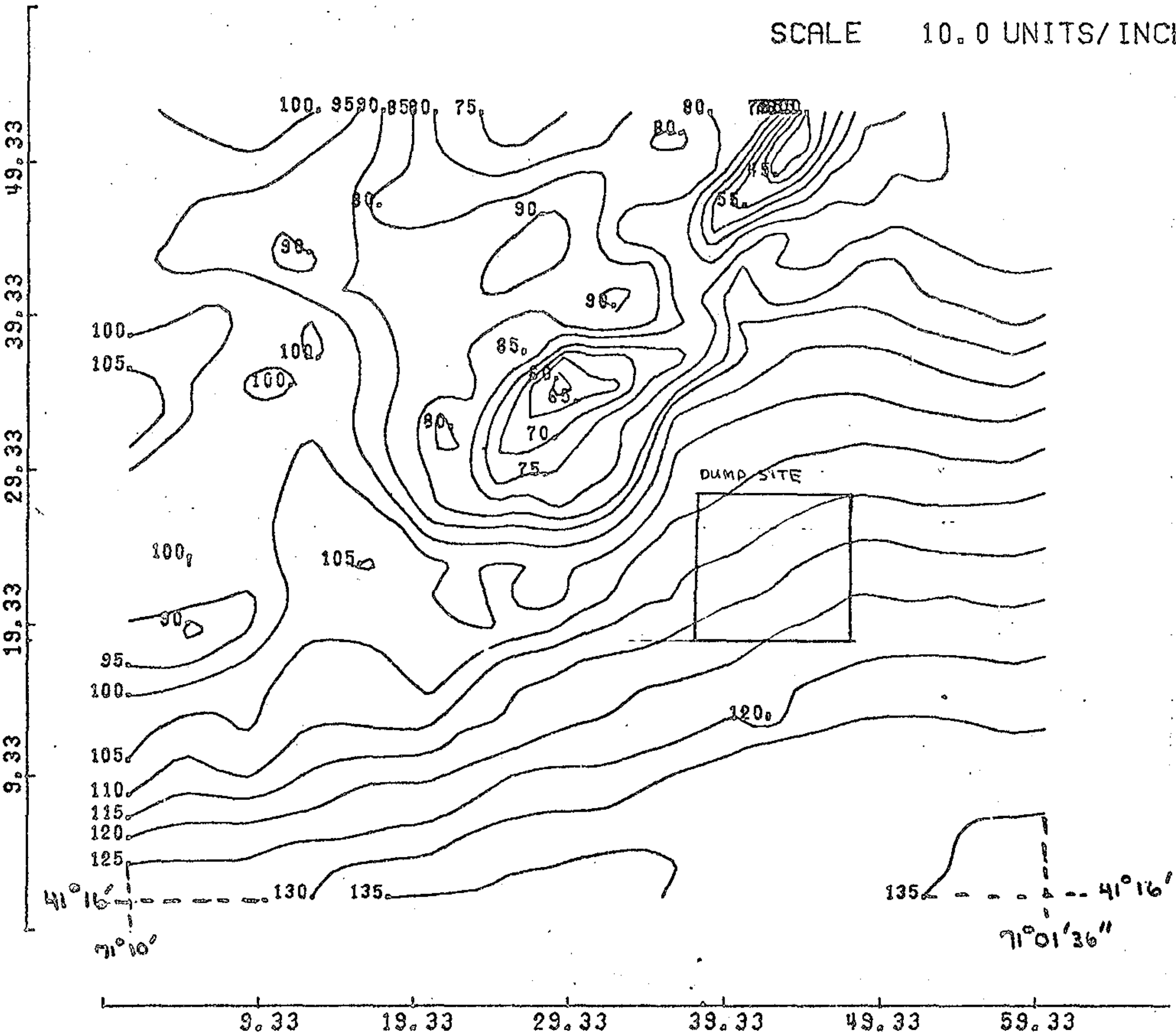

Existing off-shore observing sites
1 - Portland Lightship, 43-32 N, 70-06 W
2 - Boston Lightship, 42-20 N, 70-46 W
3 - Buzzards Bay CG Platform, 41-24 N, 71-02 W
4 - Nantucket Lightship, 40-30 N, 69-28 W
5 - Ambrose CG Platform, 40-27 N, 73-49 W
6 - Barnegat LNB1/, 39-46 N, 73-46 W
7 - Five Fathom Lightship, 38-47 N, 74-35 W
8 - Delaware LNB1/, 38-27 N, 74-35 W
9 - OSV Ship Hotel, 38-00 N, 71-00 W
10 - Chesapeake CG Platform, 36-54 N, 75-43 W
11 - Diamond Shoal CG Platform, 35-09 N, 75-18 W
12 - XERB-1 CG Buoy, 36-30 N, 73-30 W
13 - Frying Pan Shoals CG Platform, 33-29 N, 77-35 W
Proposed buoy locations--Priority--Depth
14 - 43-15 N, 68-00 W 5 100 fm
15 - 38-45 N, 73-00 W 4 100 fm
16 - 35-00 N, 72-00 W2/ 1 2300 fm
17 - 33-00 N, 75-00 W2/ 2 2100 fm
18 - 31-30 N, 78-00 W 3 400 fm
19 - 29-30 N, 78-30 W 6 450 fm
1/ The CG Large Navigational Buoys have space for NWS automatic meteorological-oceanographic equipment, whenever available.
2/ These locations were recommended by NMC in support of the XERB-1 Buoy and Ship Hotel.
RECOMMENDED BUOY LOCATIONS EAST COAST U.S.
LEGEND
USCG Platforms
USCG Lightships
Ocean Weather Station Hotel (4YH)
XERB-1 USCG Buoy
Recommended Buoy Locations
Large Navigational Buoy (LNB)
1
2
3
4
5
14
BOSTON
QUONSET
NY
0
50
miles

FIG. 10



BROWNS LEDGE DEPTH CONTOURS (FT.)

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(2) Dobson, R. S. 1967. Some applications of a digital computer to hydraulic engineering problems. Tech. Rept. 80, Dept. of Civil Engineering, Stanford Univ.

(3) Greenwall, Roger K. 1974. Delta Incremental Plotting System, An Advanced Graphics Manual, 2nd Edition. Univ. of Rhode Island, Computer Laboratory.

(4) Ippen, Arthur T. 1966. Estuary and Coastline Hydrodynamic. McGraw-Hill.

(5) Rabe, K. 1975. An evaluation of available wave refraction models for use on the CDC 3100 computer. Environmental Research Facility, Naval Post Graduate School, Monterey, California.

(6) Skovgaard, Ove, I. G. Jonsson and J. A. Bertelsen. 1975. Computations of wave heights due to refraction and friction. Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE, Vol. 1.

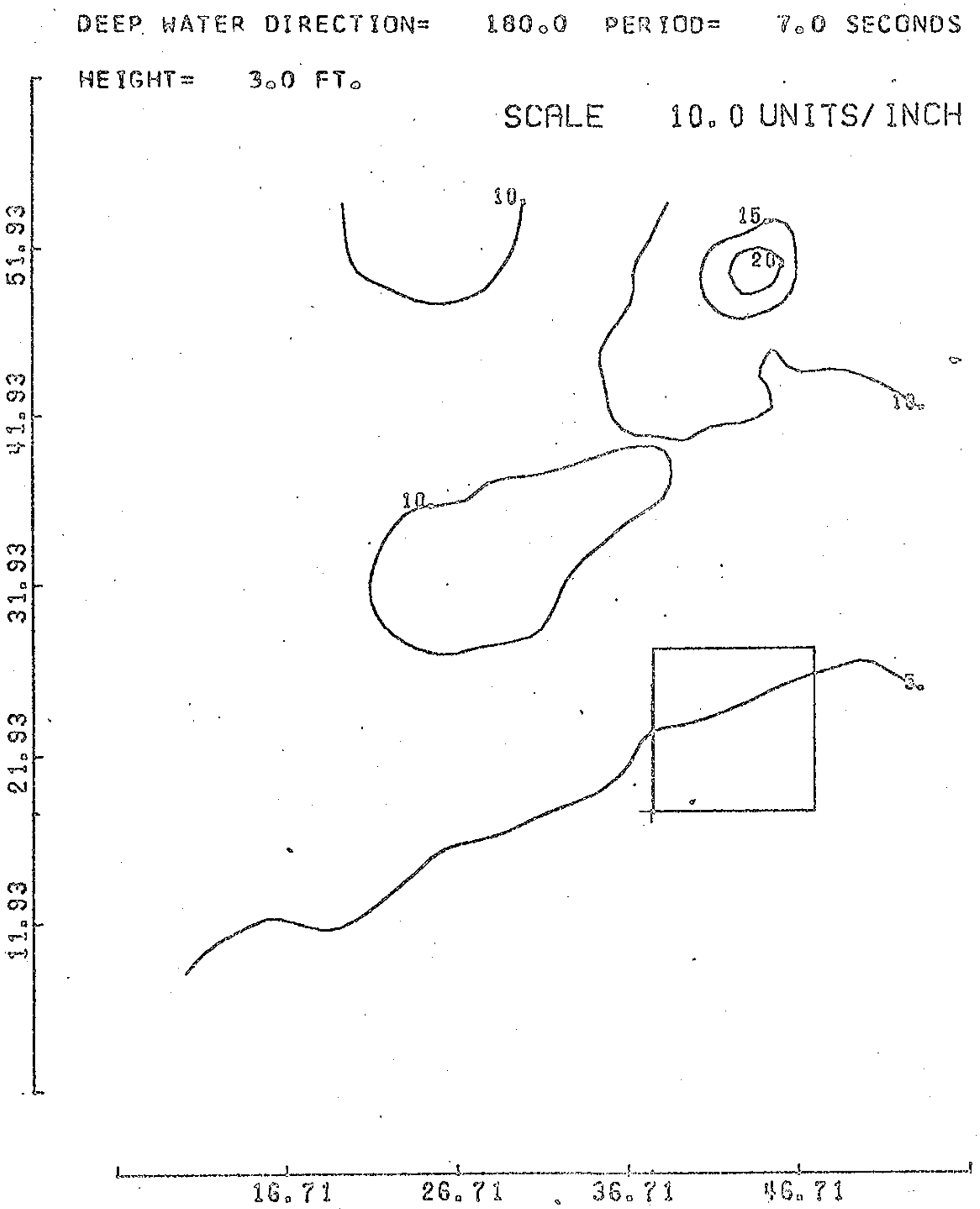
(7) U.S. Naval Weather Service Command. 1970. Summary of synoptic meterological observations (SSMO) for North American coastal marine areas. Vol. II, Areas 4, Boston, 5, Quonset Point, 6, New York, and 7, Atlantic City. NTIS, AD 707 699.

(8) Coastal and Geodetic Survey (C & GS). Bathymetric maps, U.S. Department of Commerce, Environmental Services Administration, Coast and Geodetic Survey, and U.S. Department of the Interior, 1938 and 1967.

SECTION 1

Wave Induced Bottom Currents

(Computer Contoured Bottom Speeds)



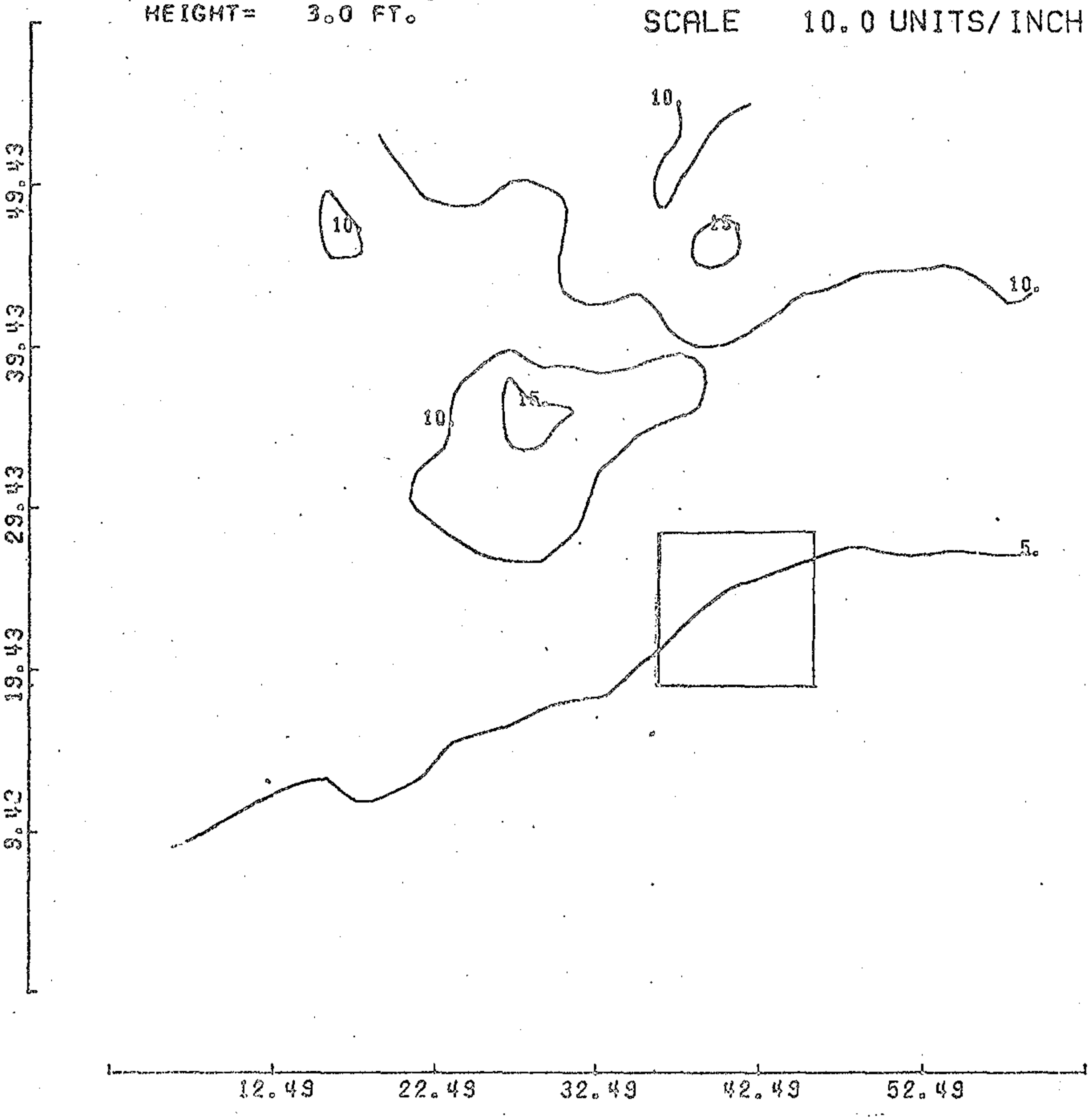
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 7.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

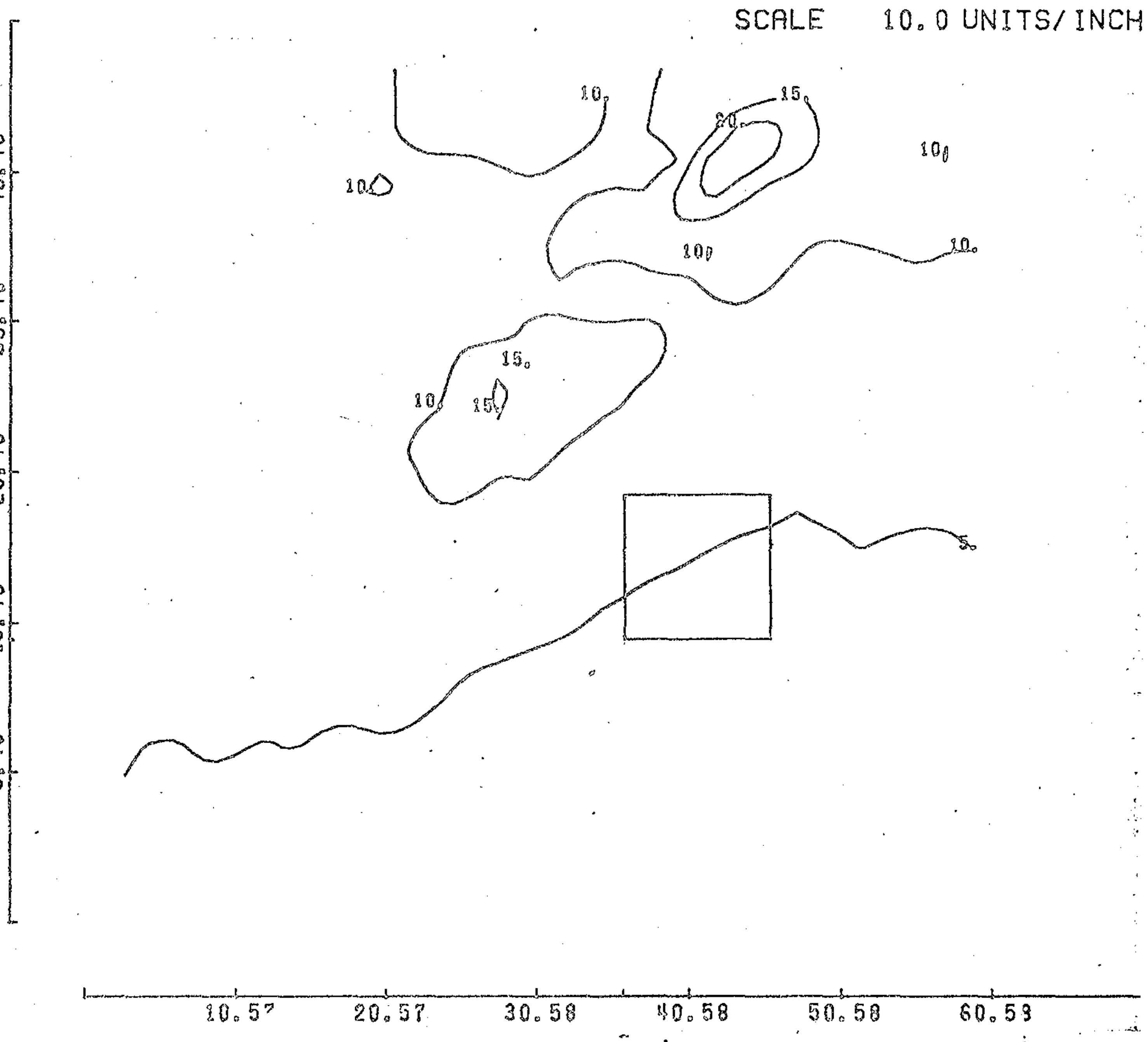


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 7.0 SECONDS

HEIGHT= 3.0 FT.

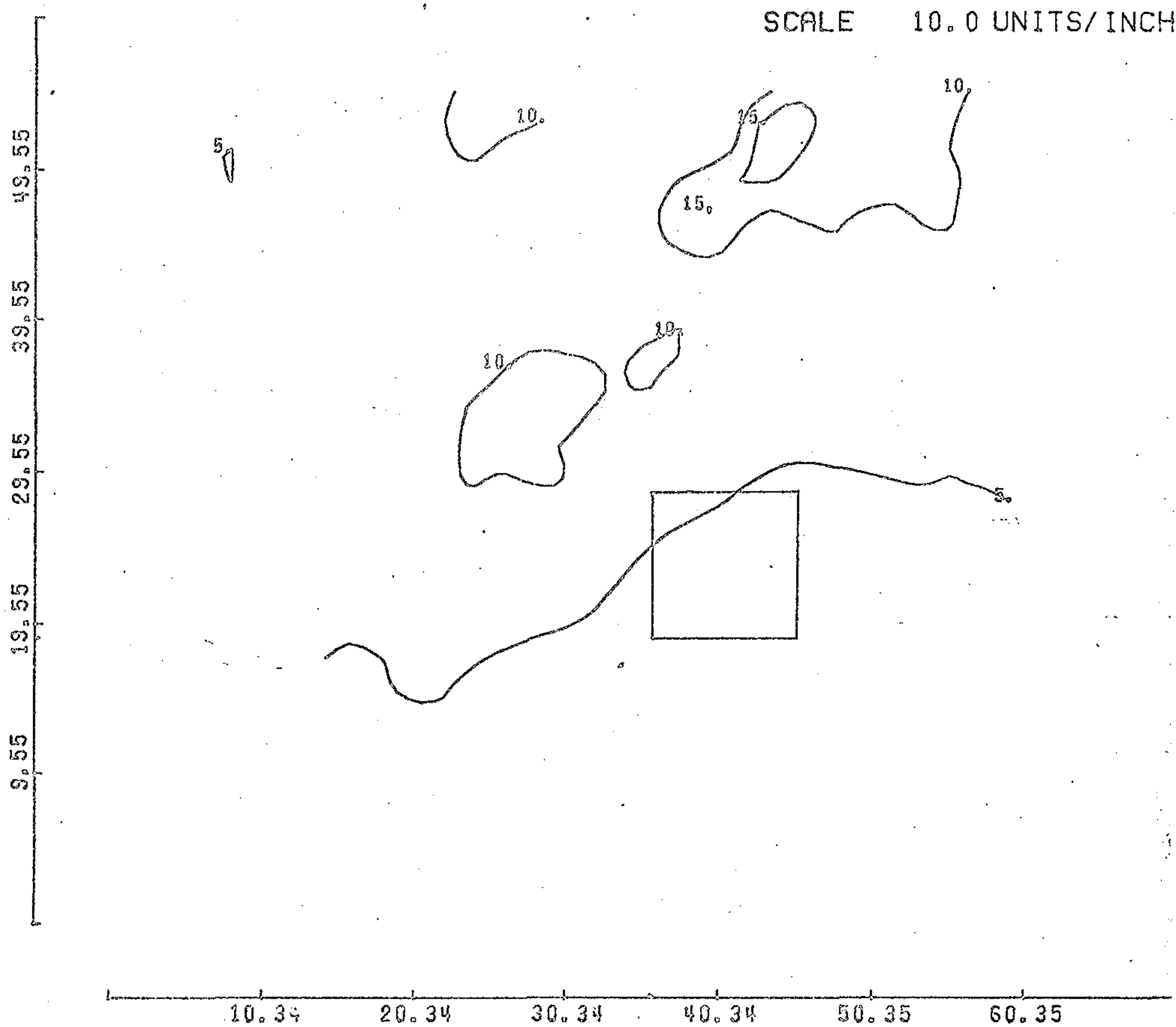


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 7.0 SECONDS

HEIGHT= 3.0 FT.



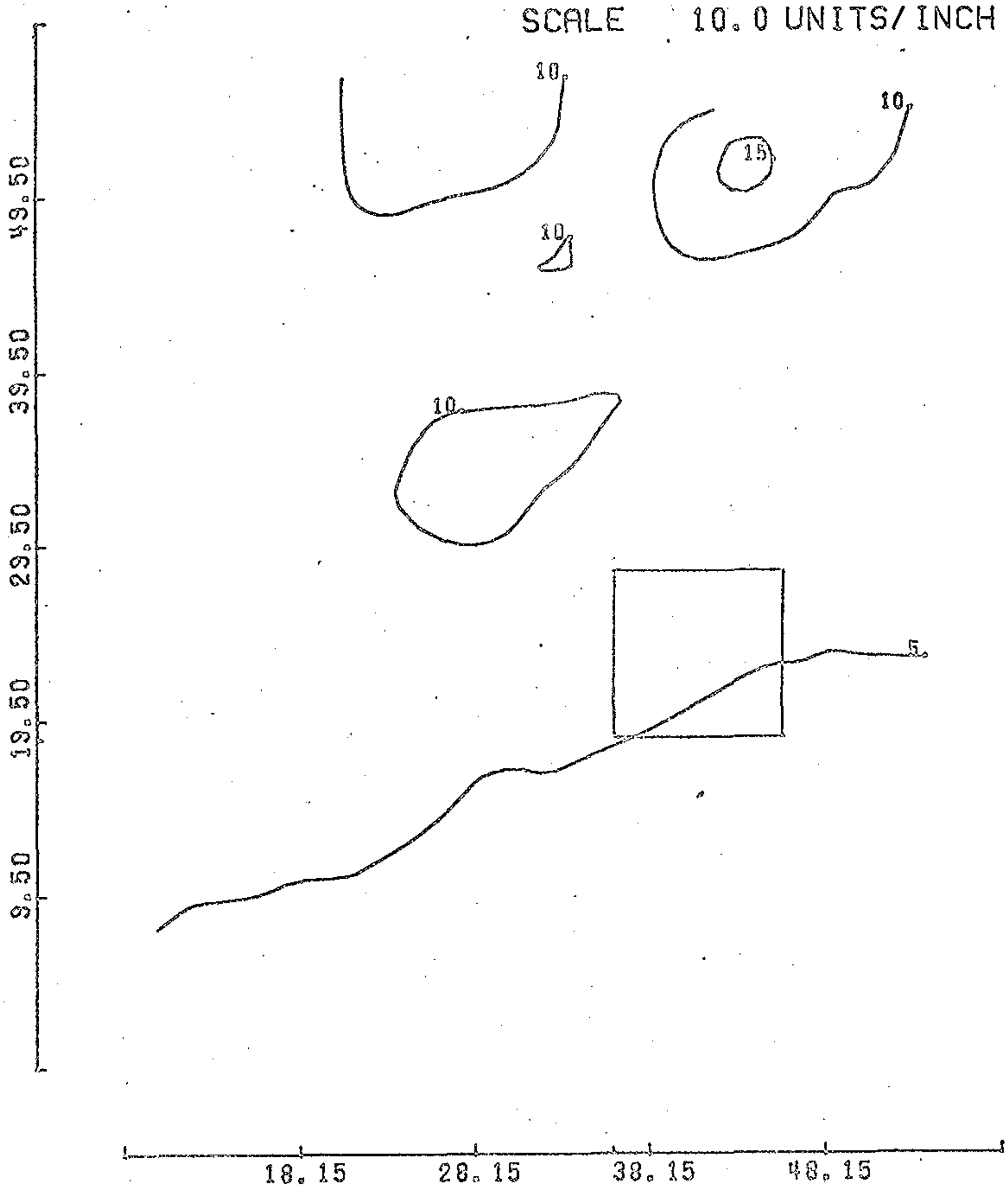
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 8.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH

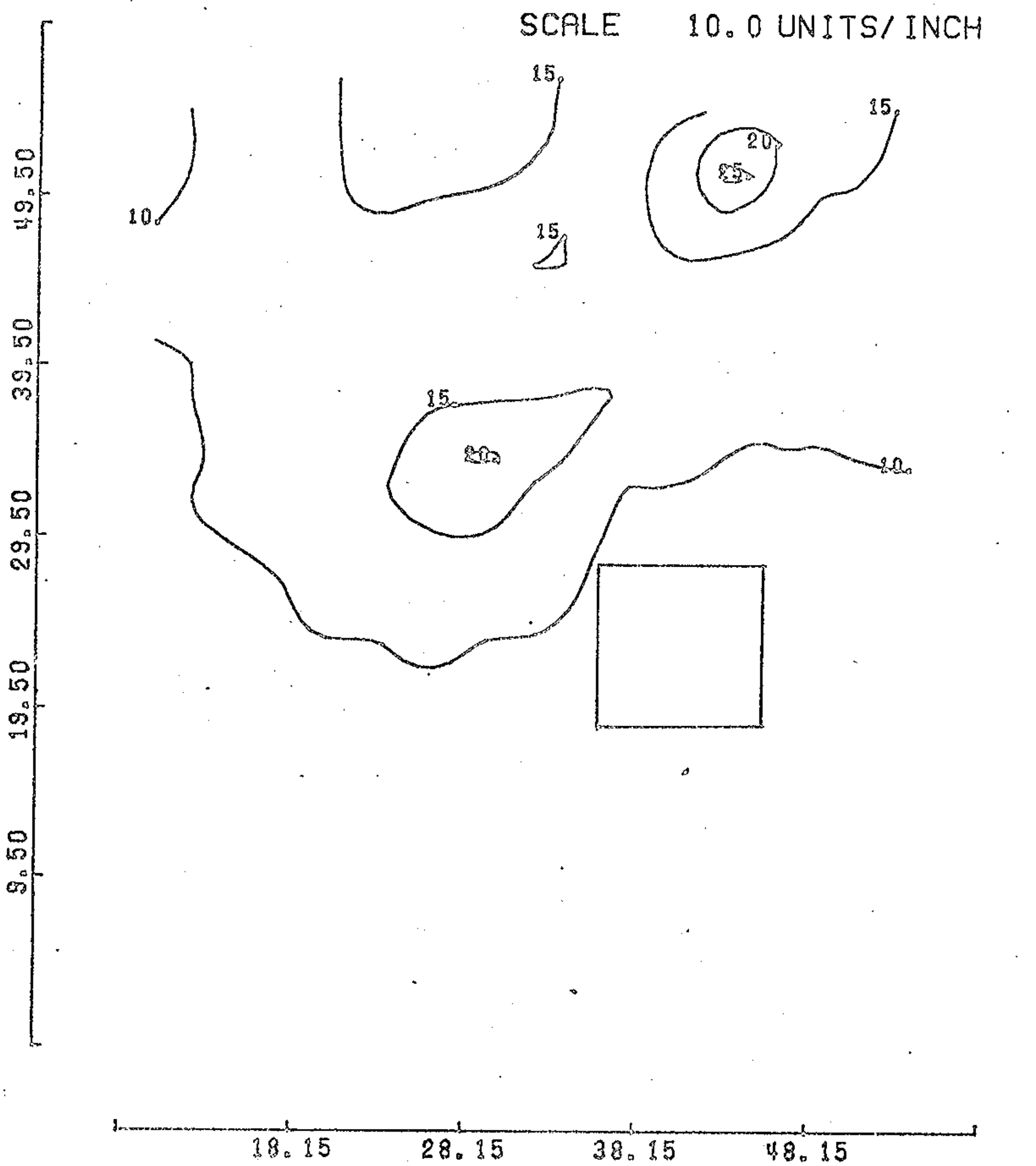


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 8.0 SECONDS

HEIGHT= 3.0 FT.

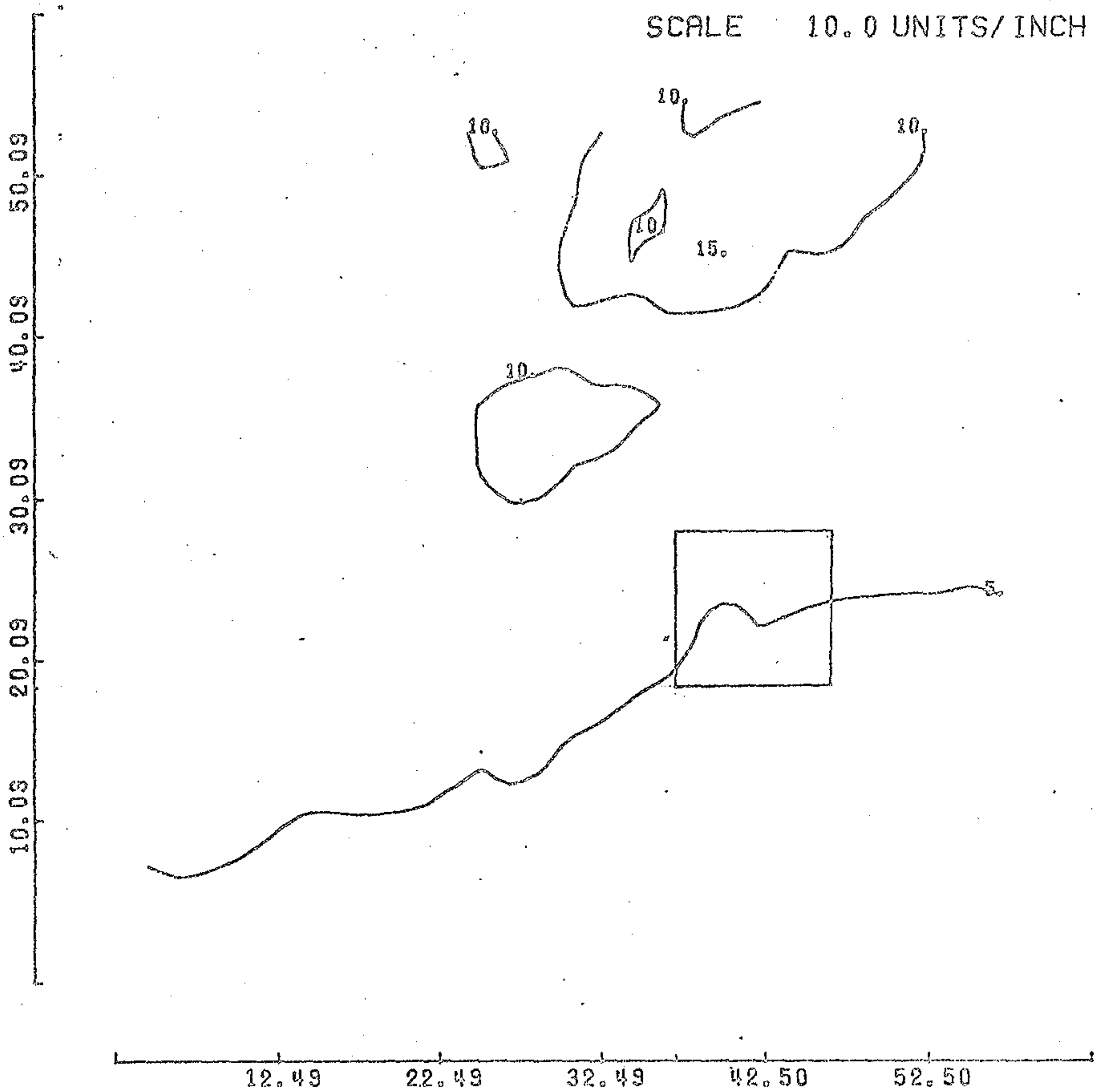


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 8.0 SECONDS

HEIGHT= 2.0 FT.



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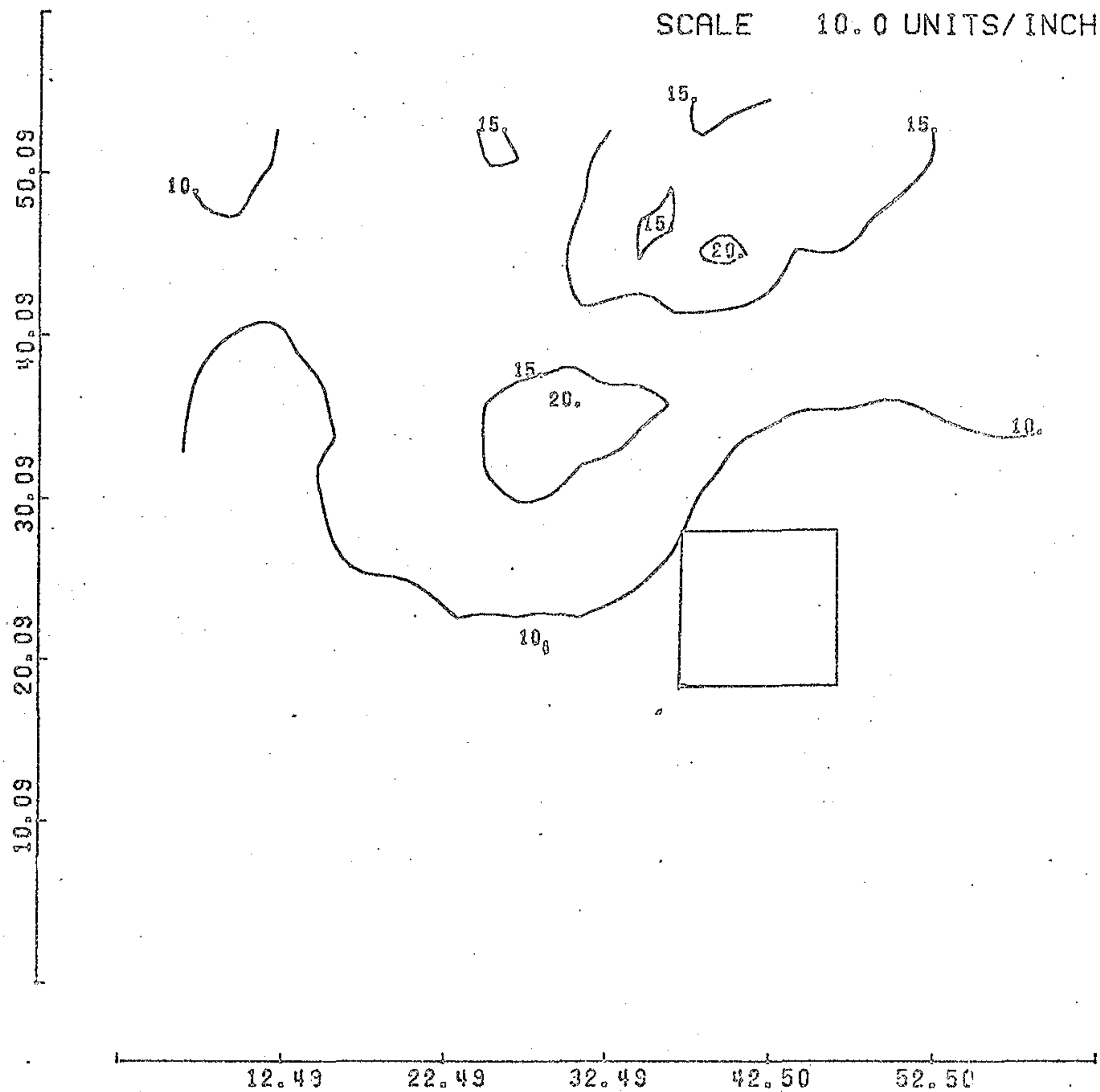

BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

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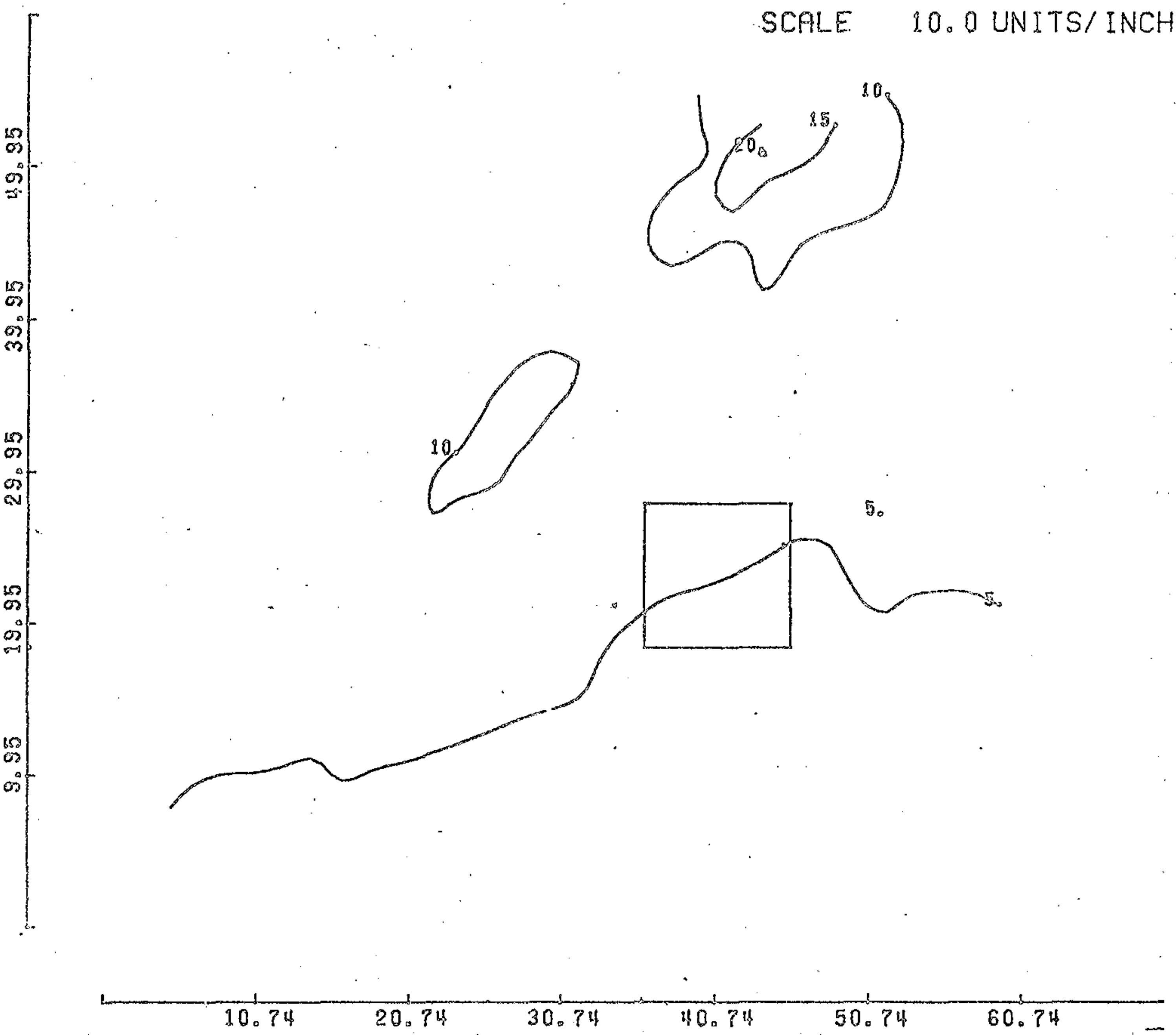
HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH



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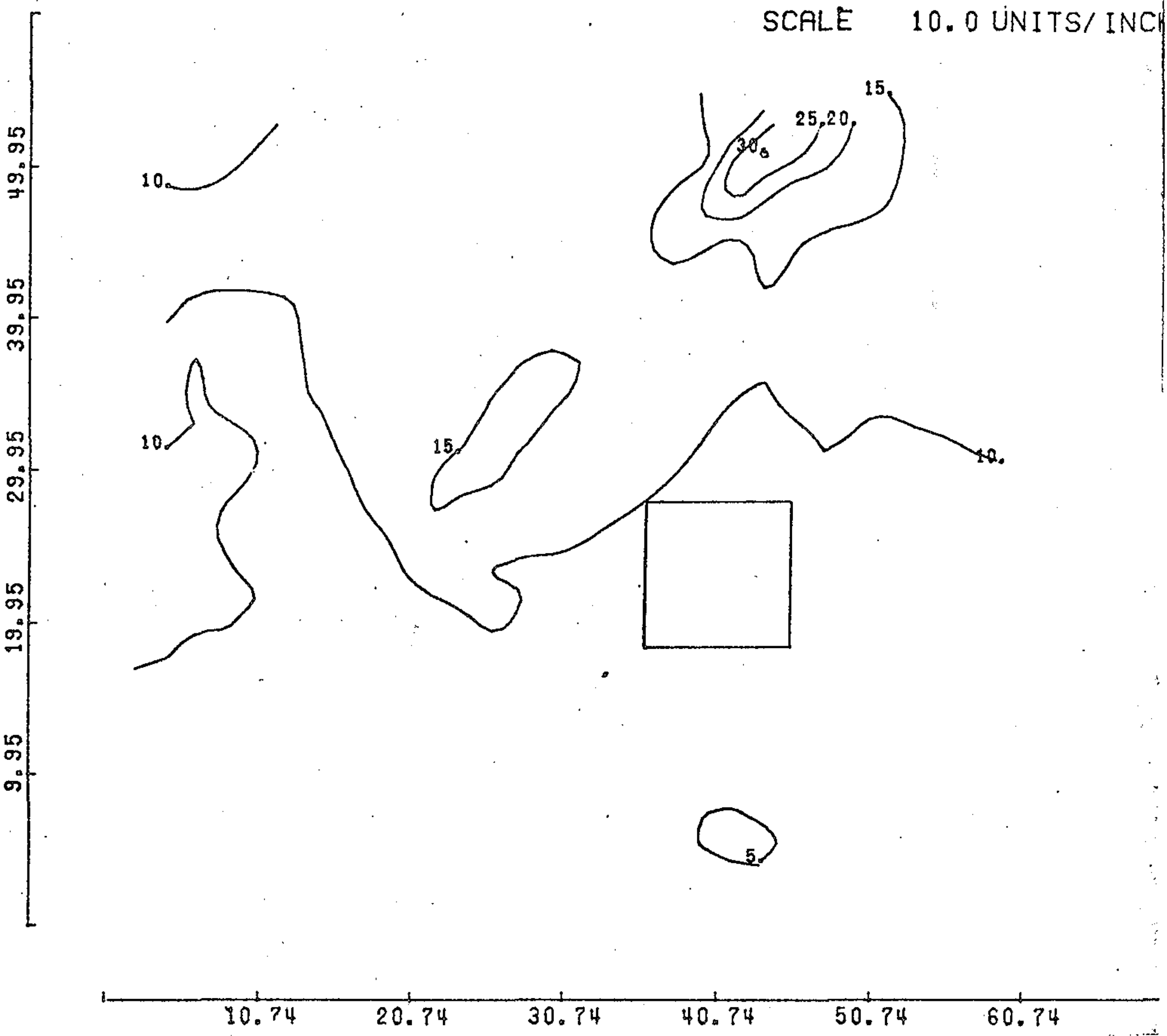

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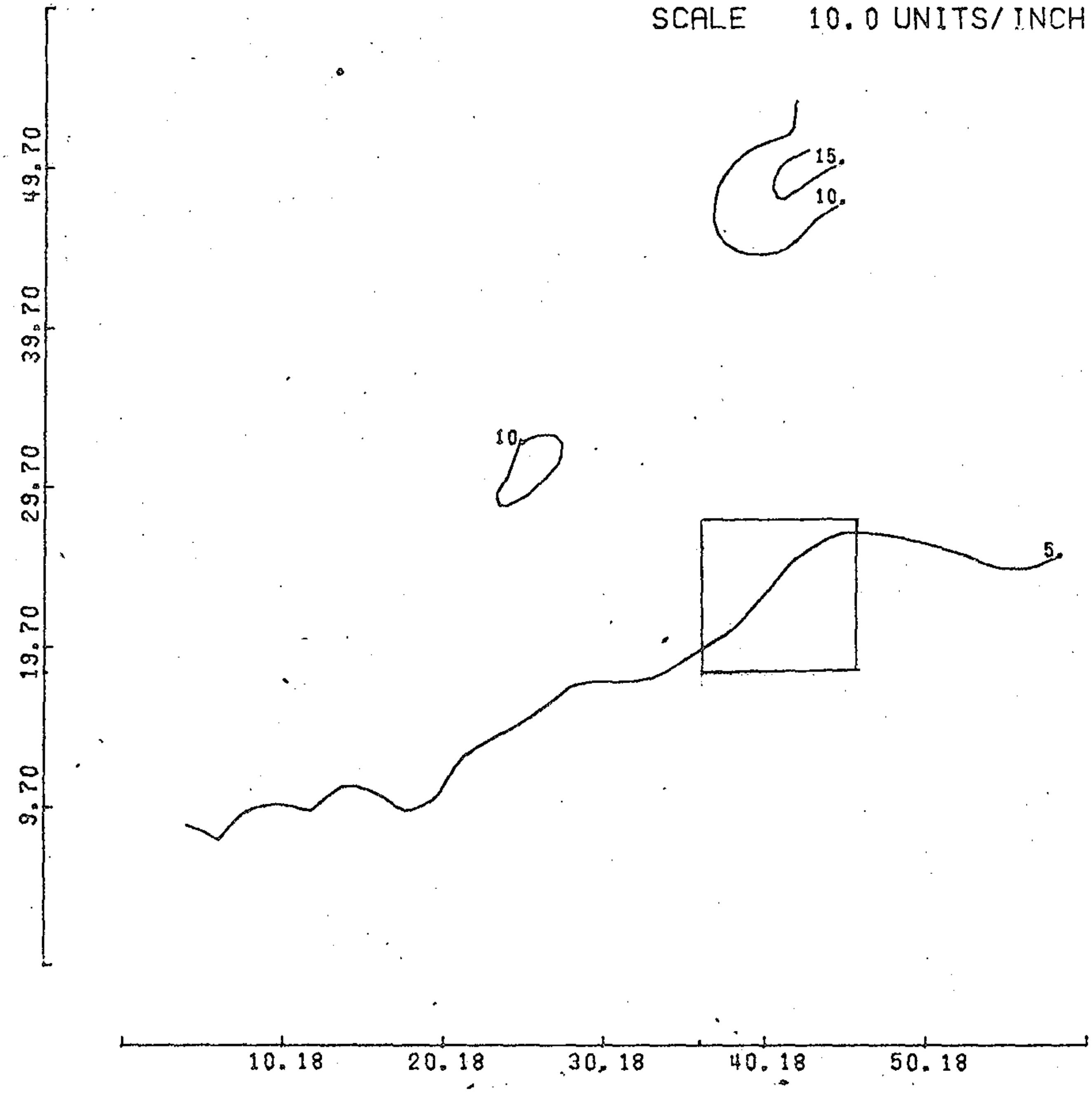
HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH

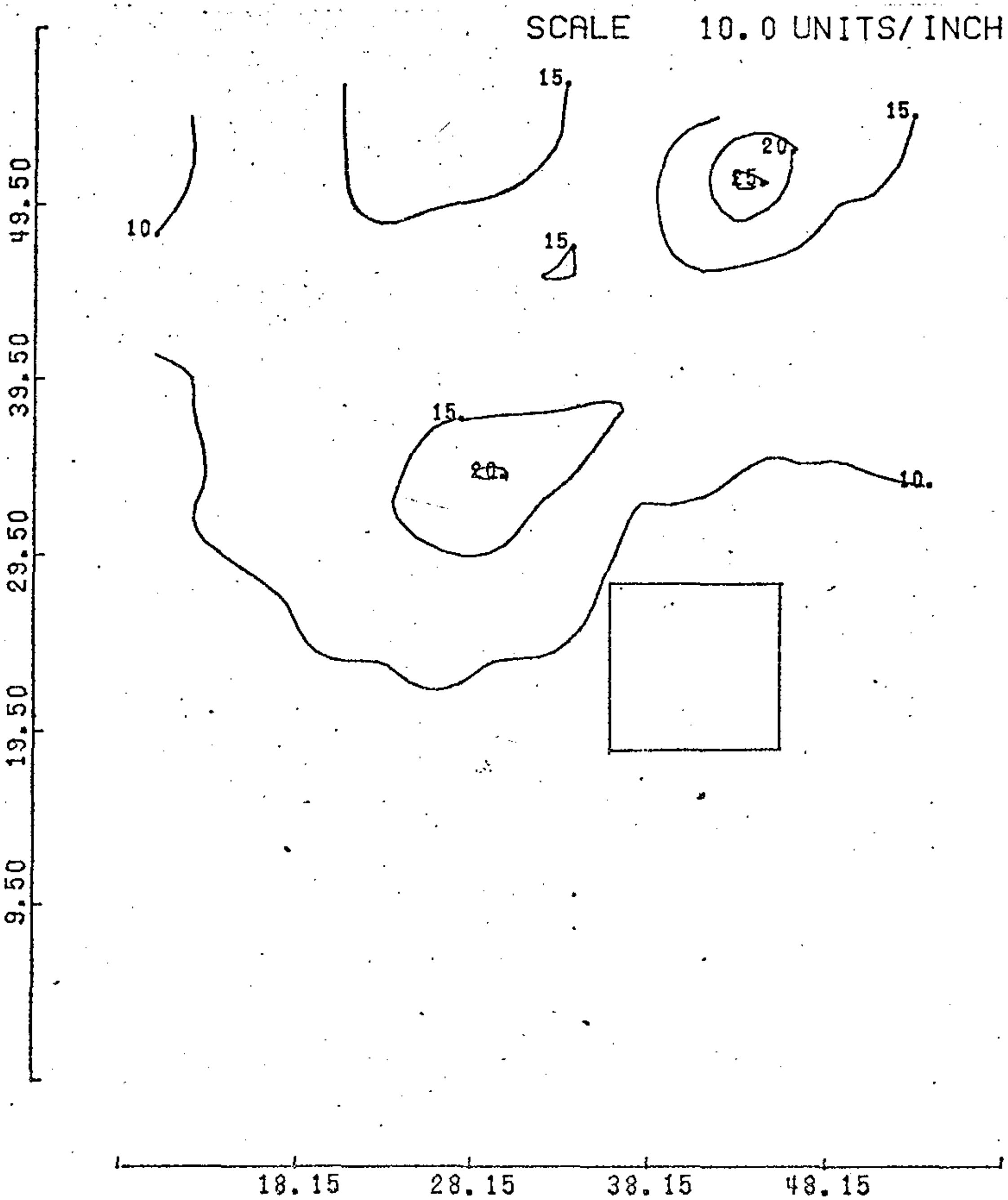


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 8.0 SECONDS

HEIGHT= 3.0 FT.



BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

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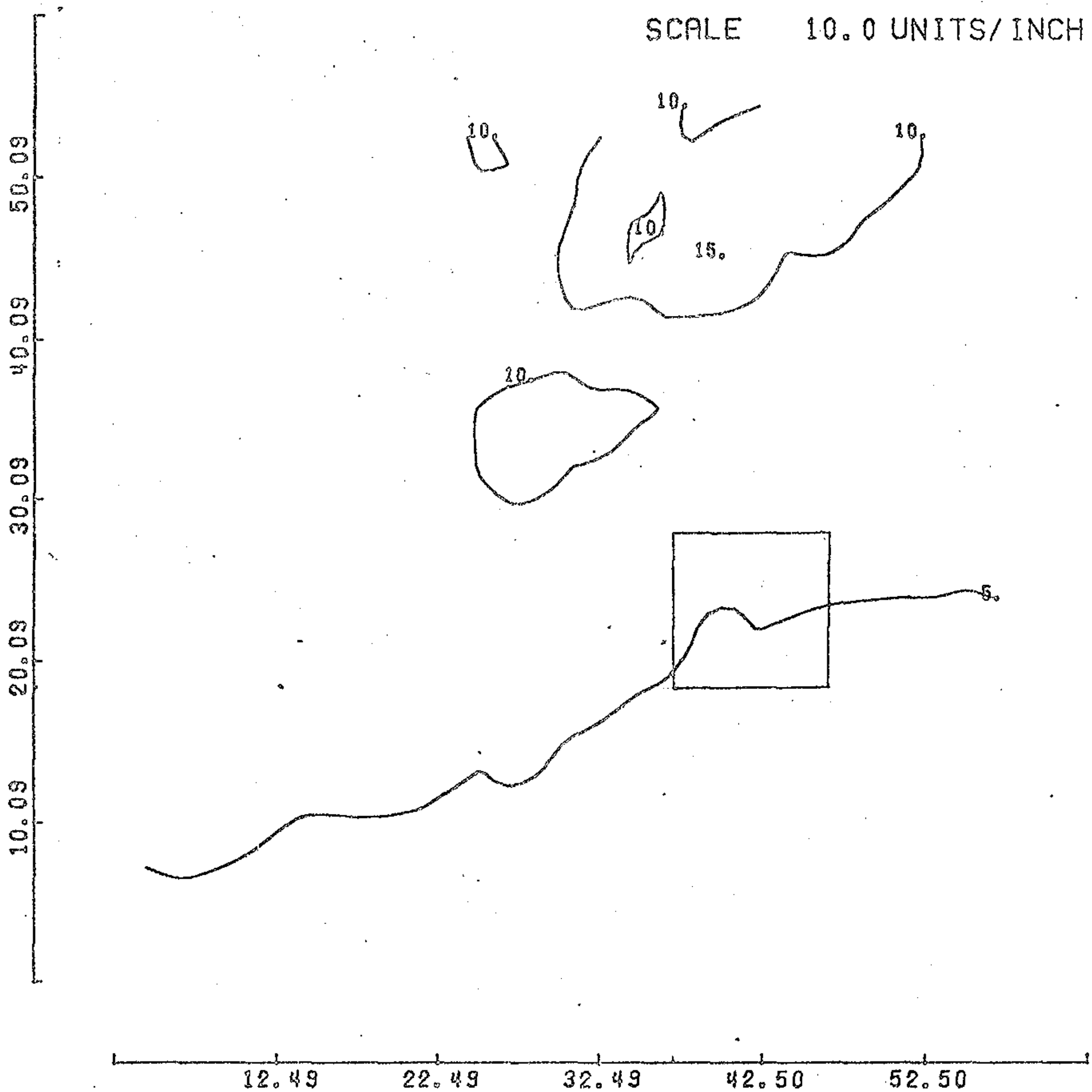

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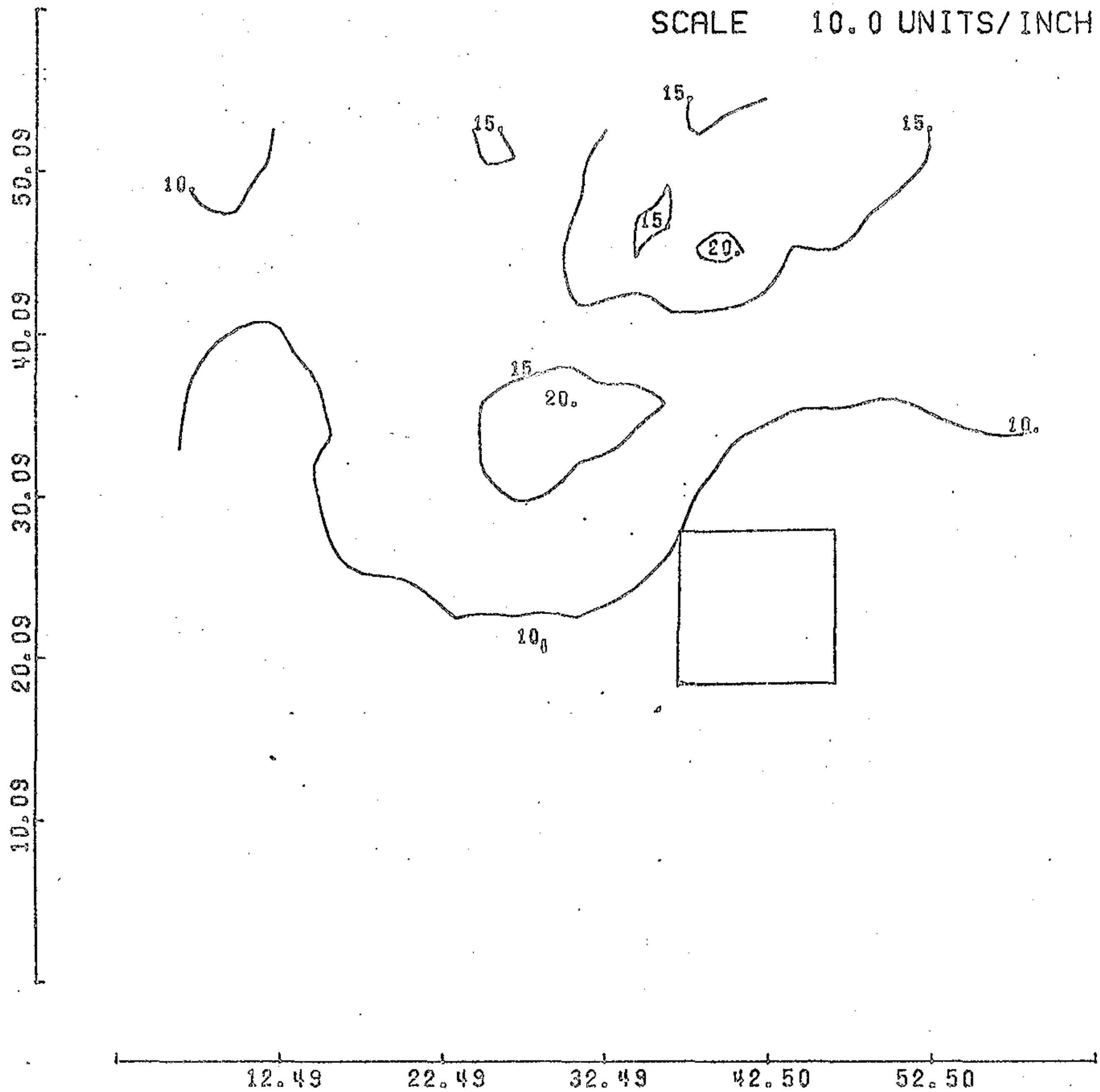

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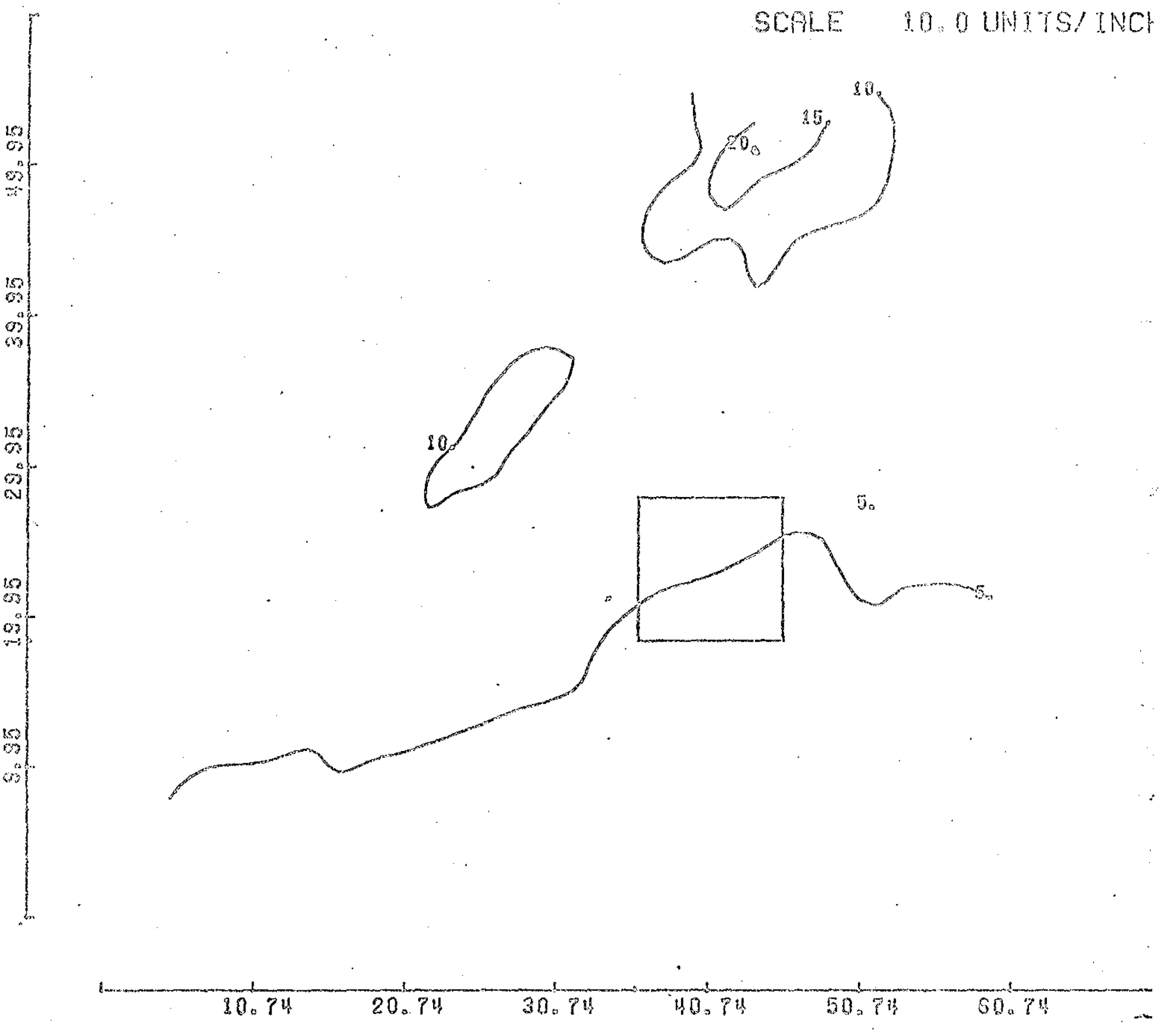


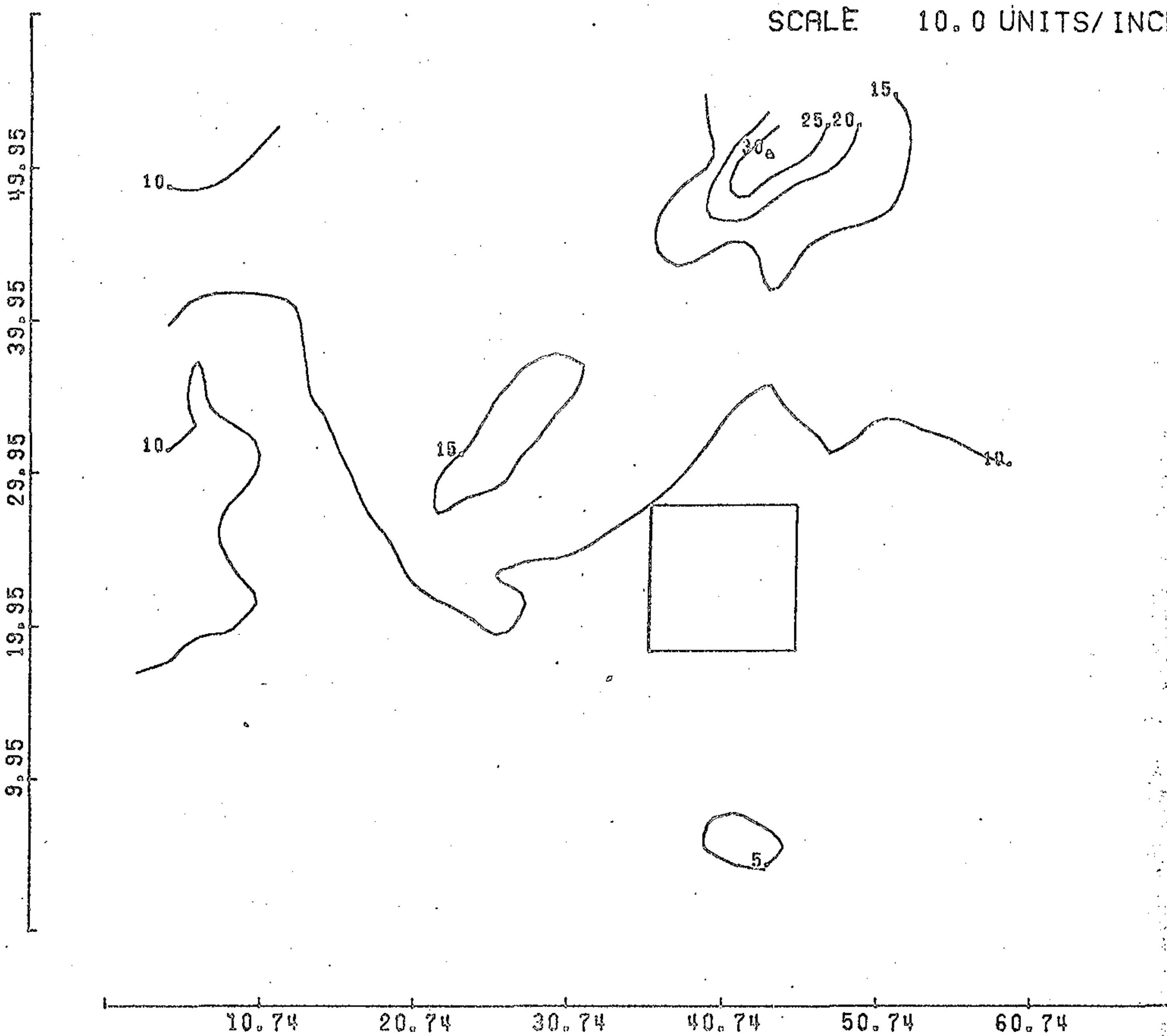
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 8.0 SECONDS

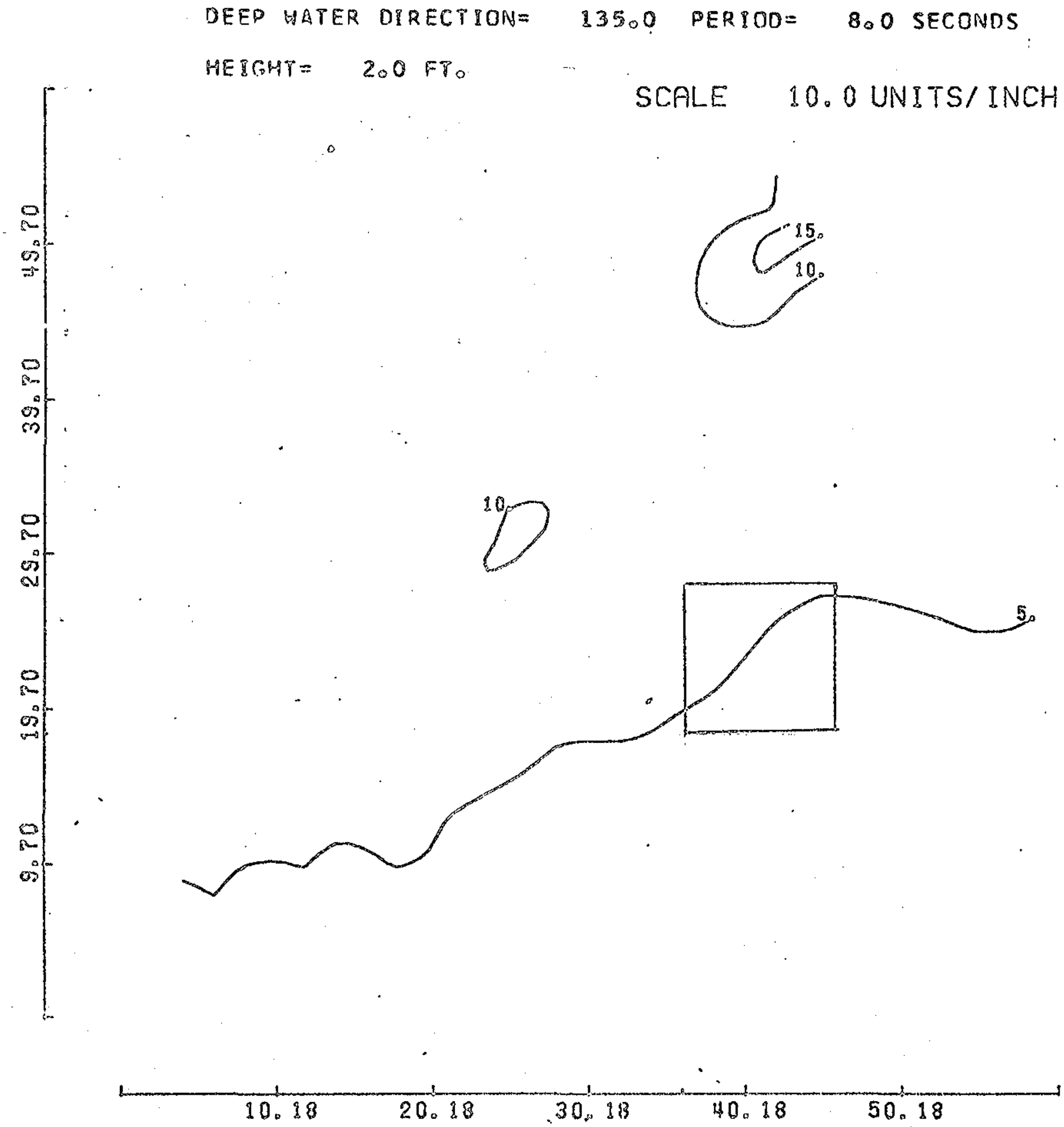
HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INC



BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)



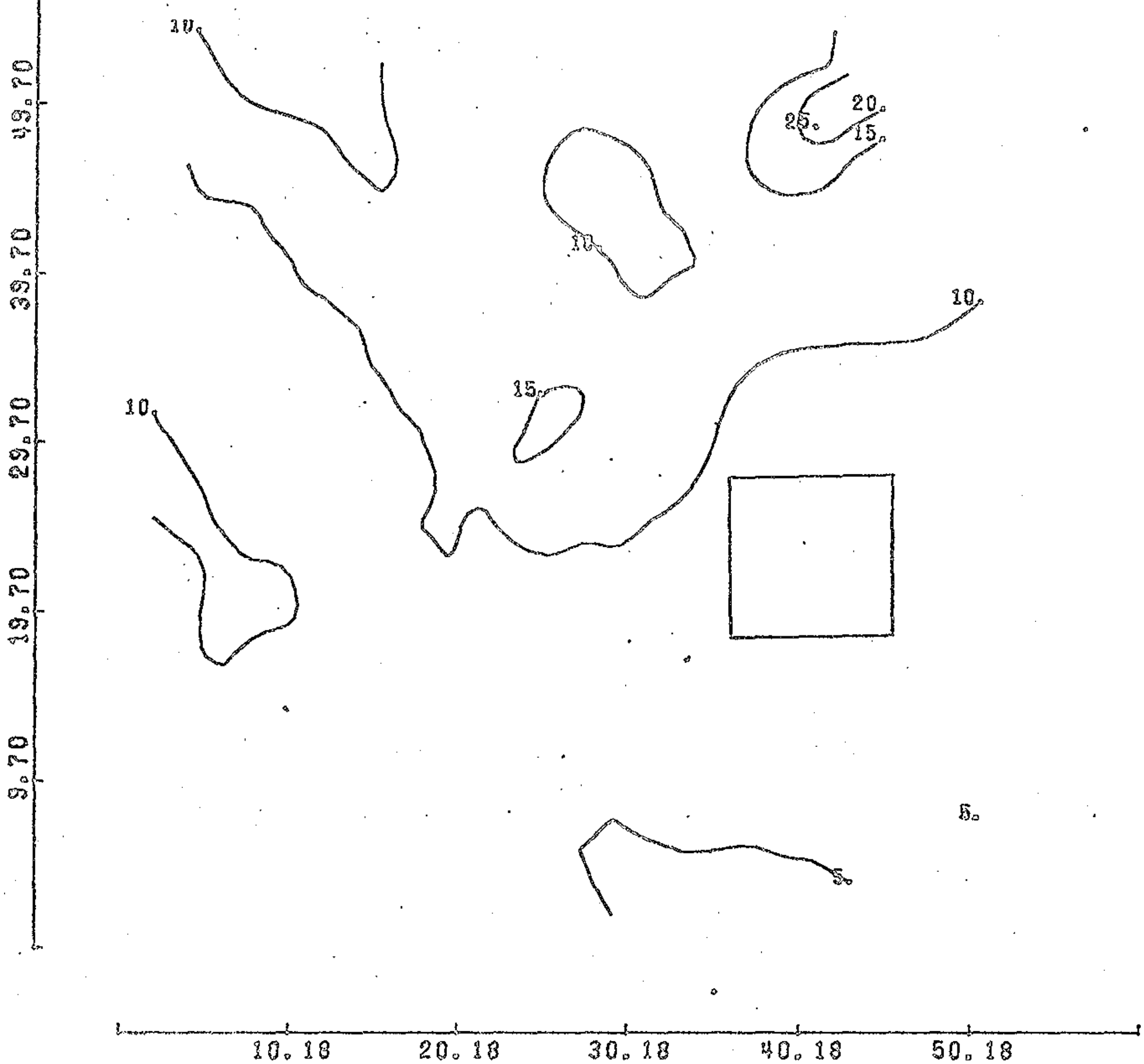
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 ° PERIOD= 8.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

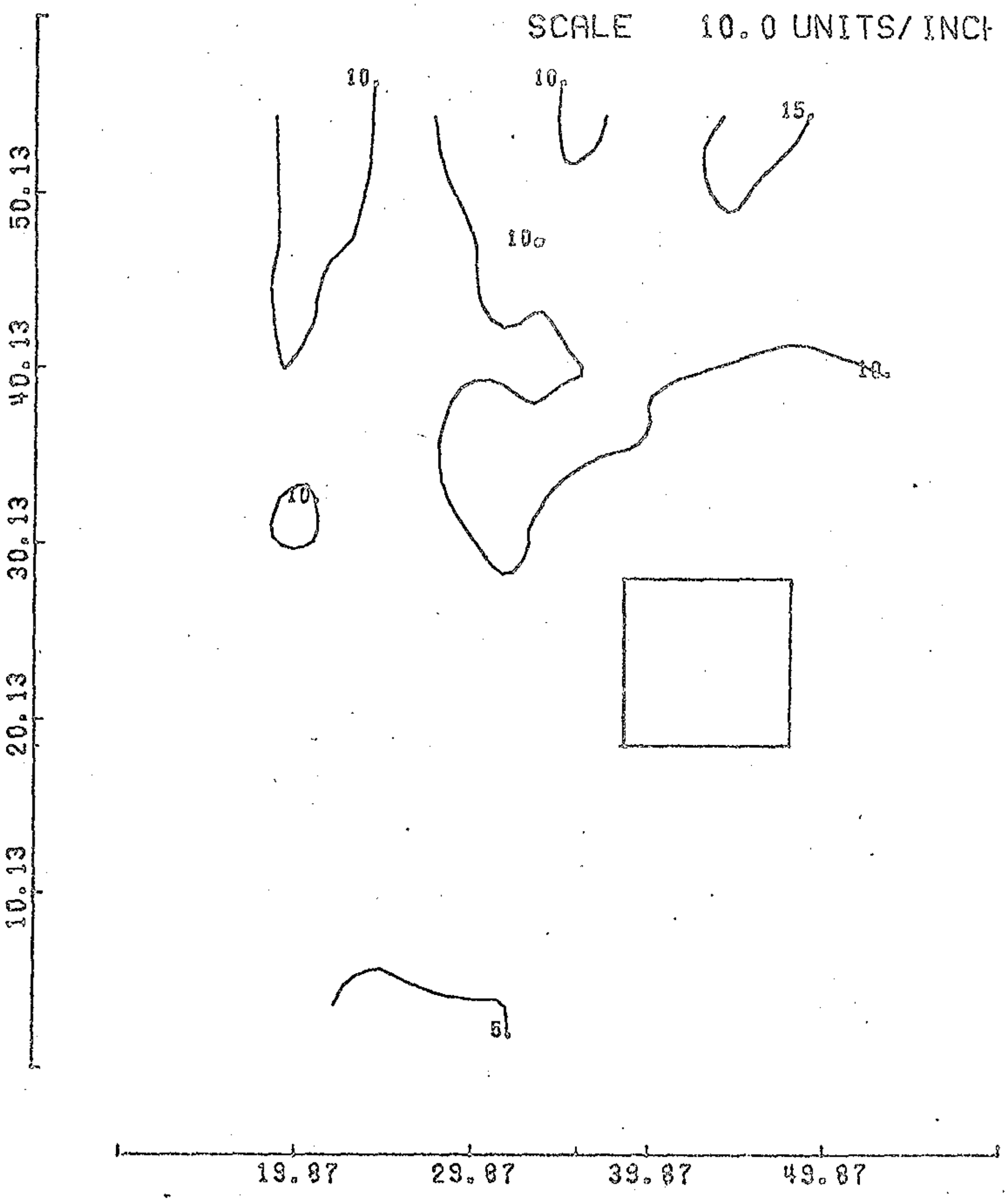


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 9.0 SECONDS

HEIGHT= 2.0 FT.

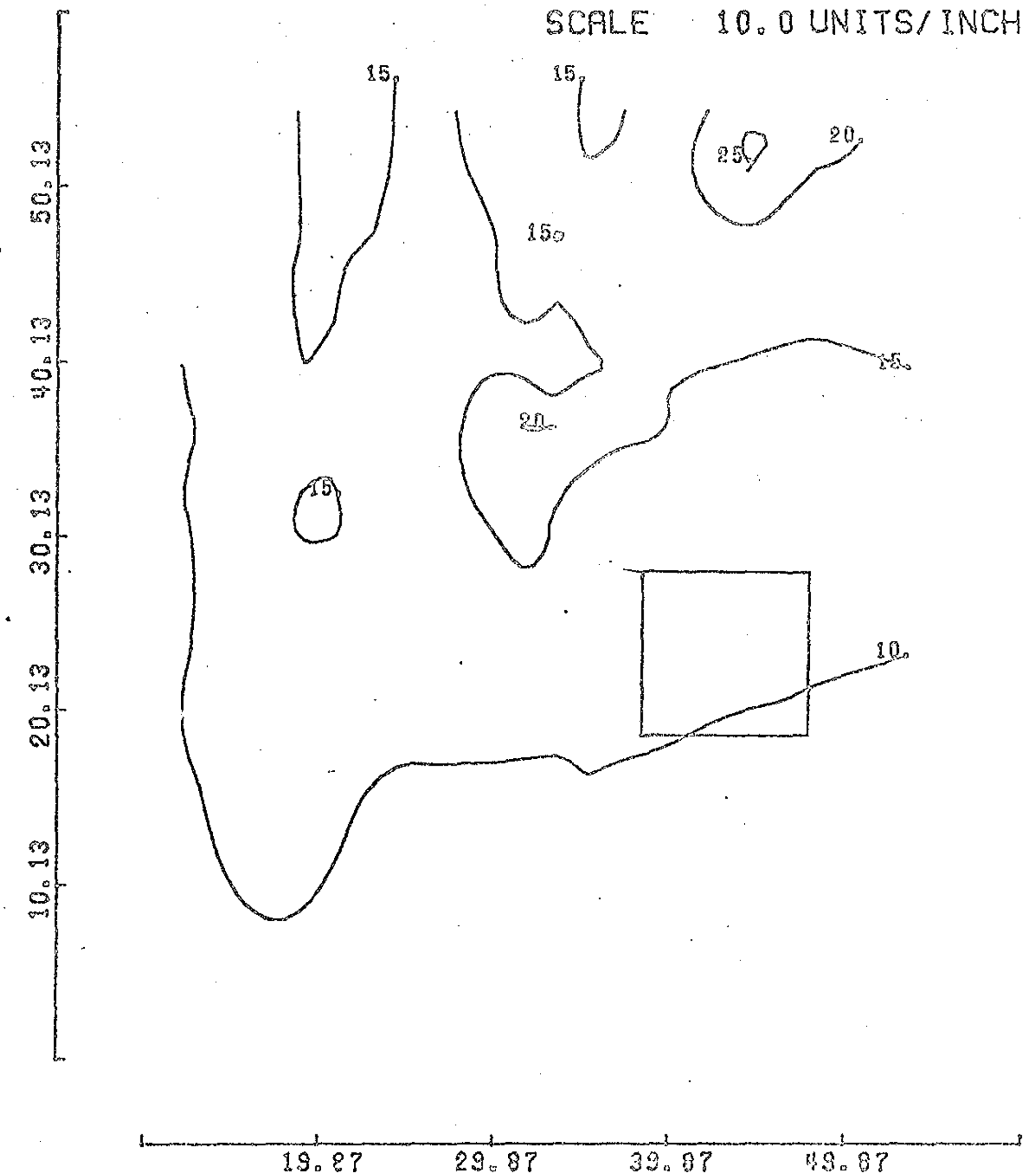


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 9.0 SECONDS

HEIGHT= 3.0 FT.

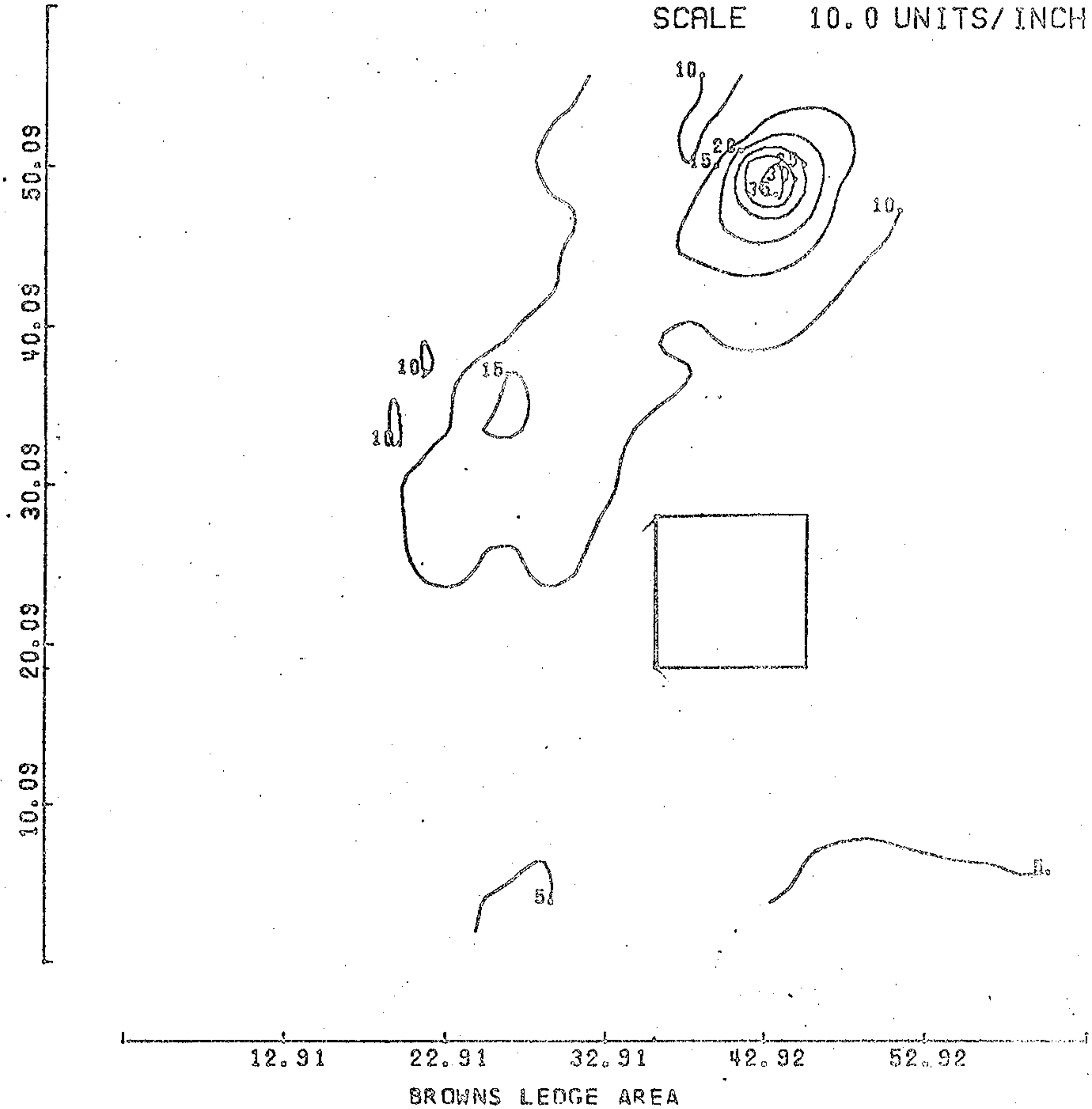


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 9.0 SECONDS

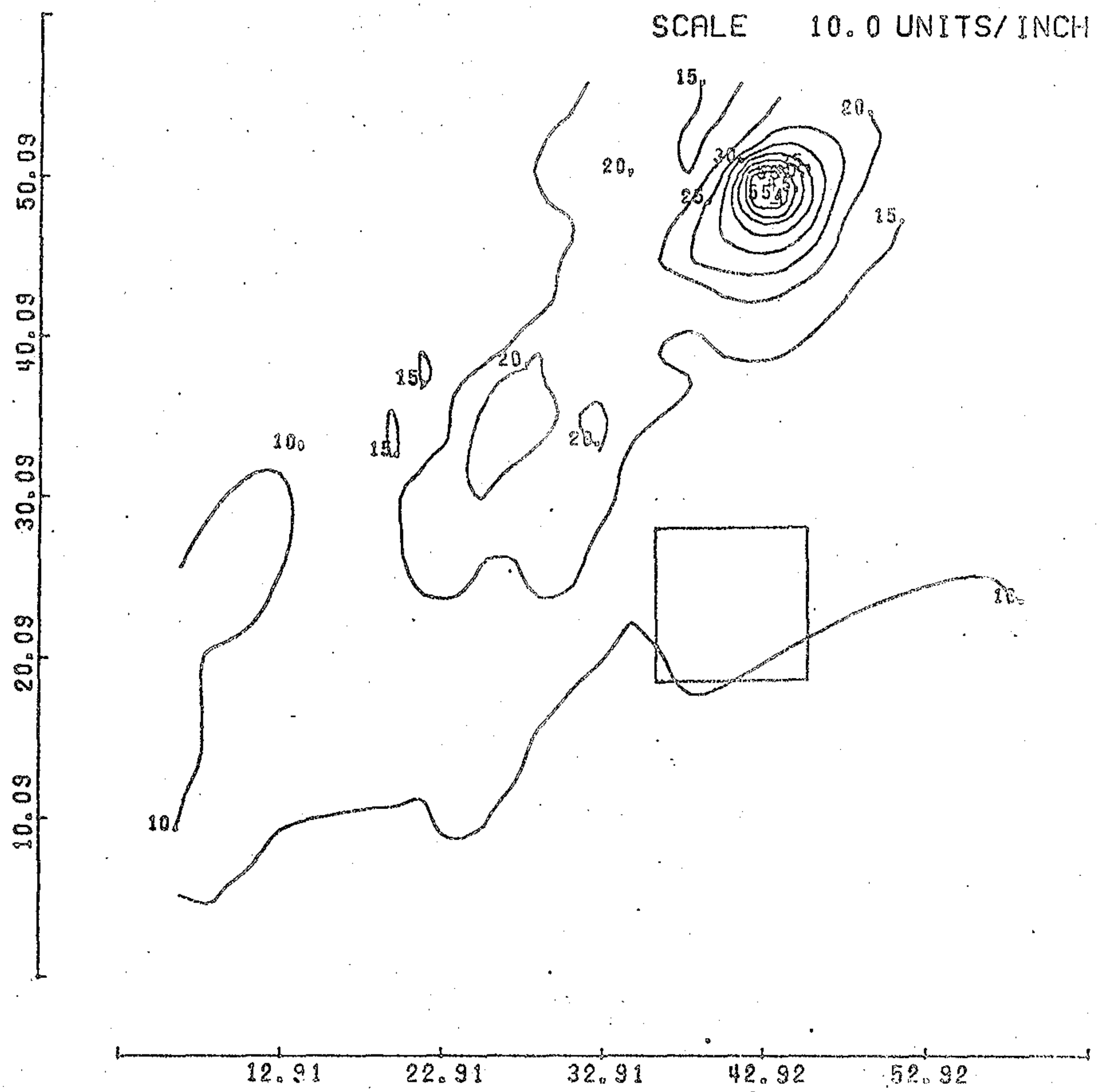
HEIGHT= 2.0 FT.



LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 9.0 SECONDS

HEIGHT= 3.0 FT.

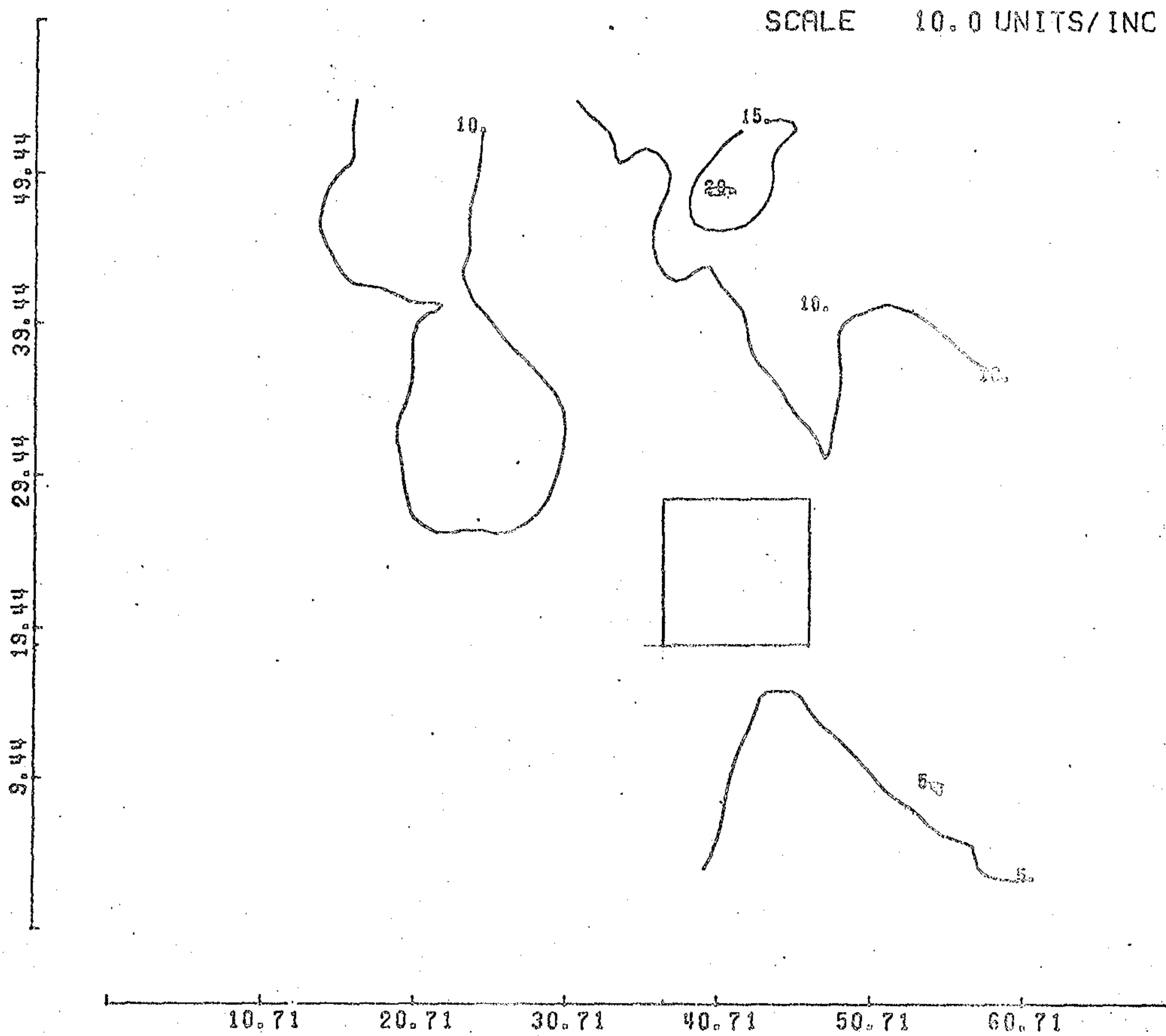


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 9.0 SECONDS

HEIGHT= 2.0 FT.



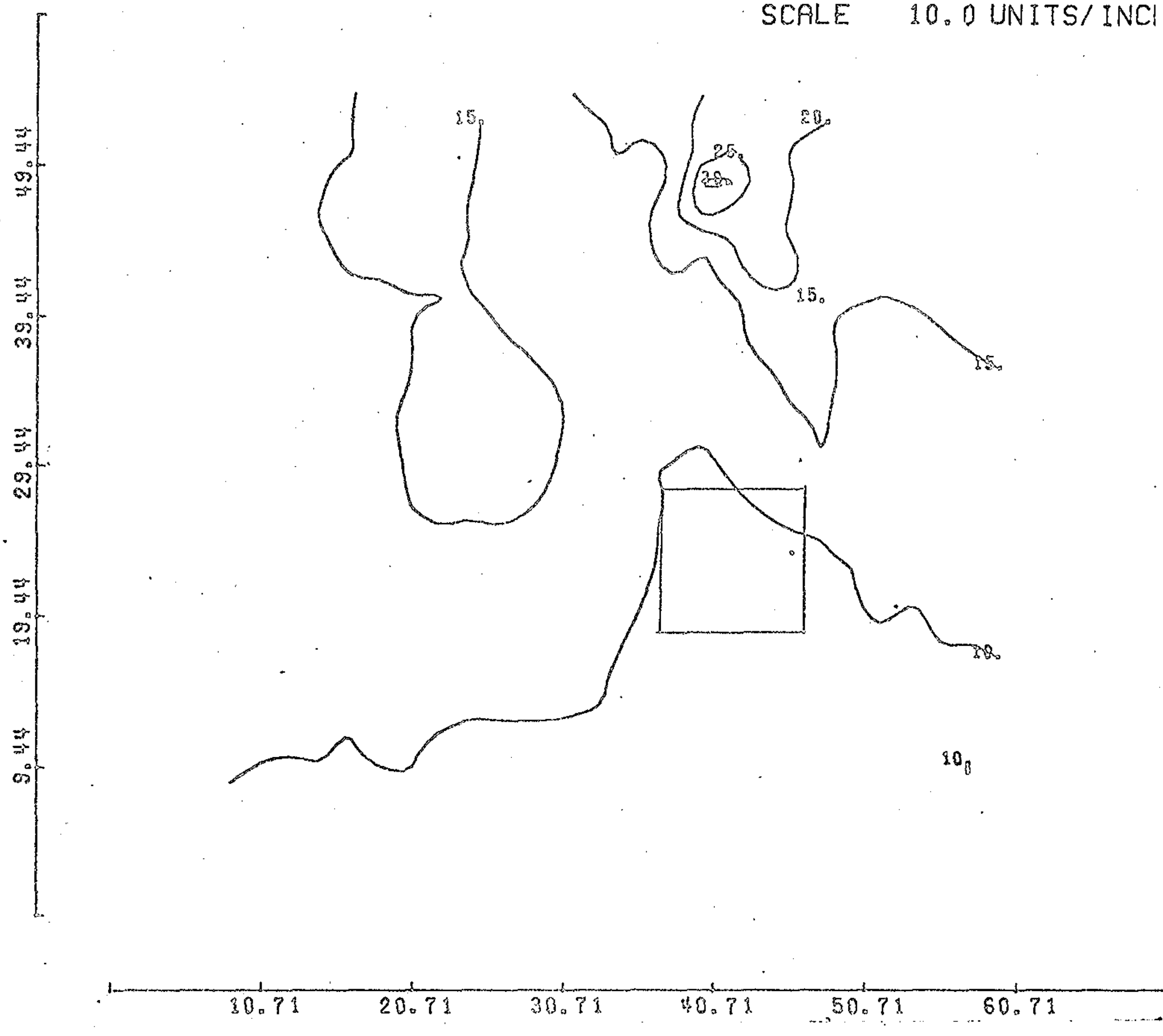
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 9.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

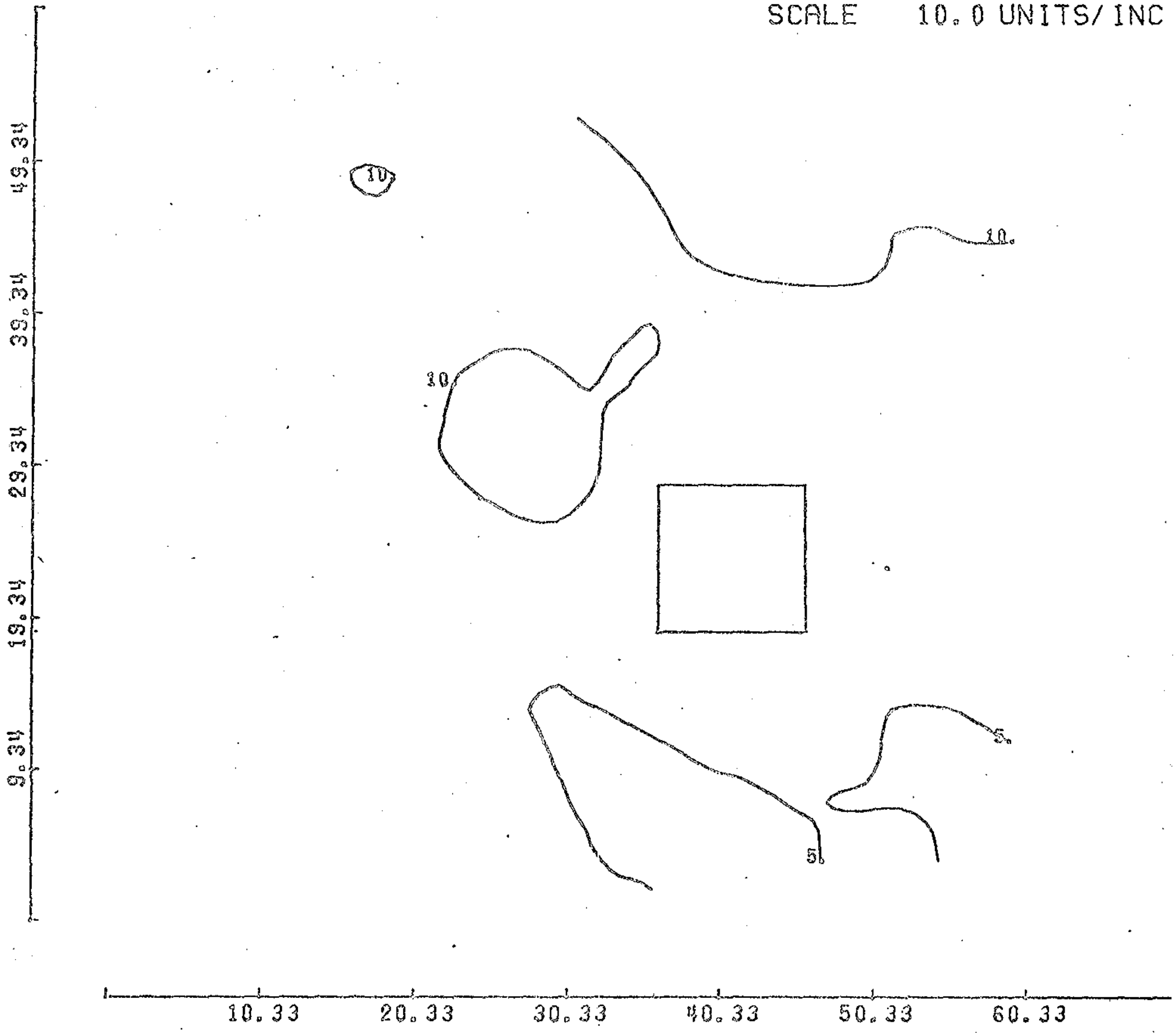


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 9.0 SECONDS

HEIGHT= 2.0 FT.



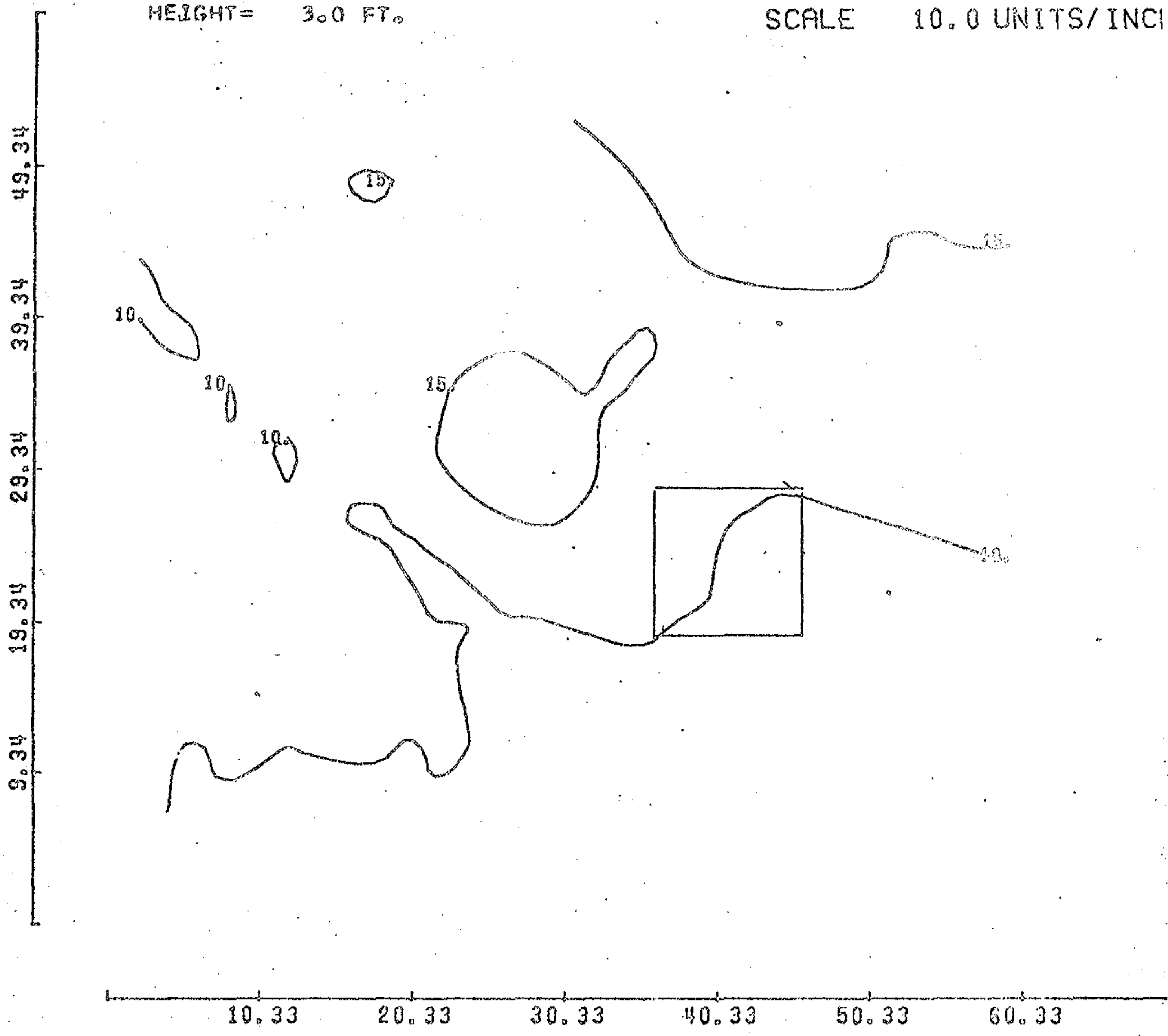
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 9.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH



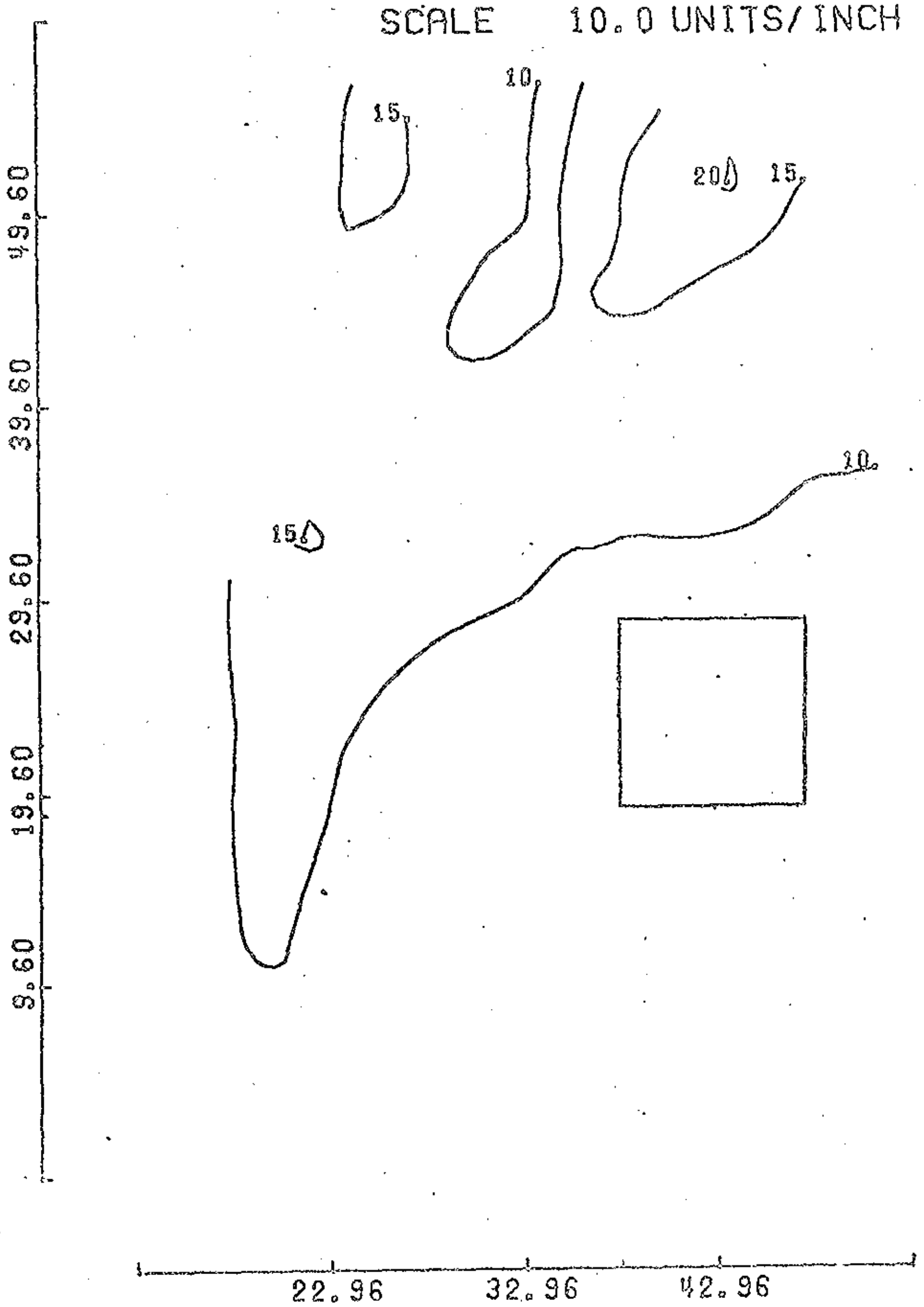
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 10.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH



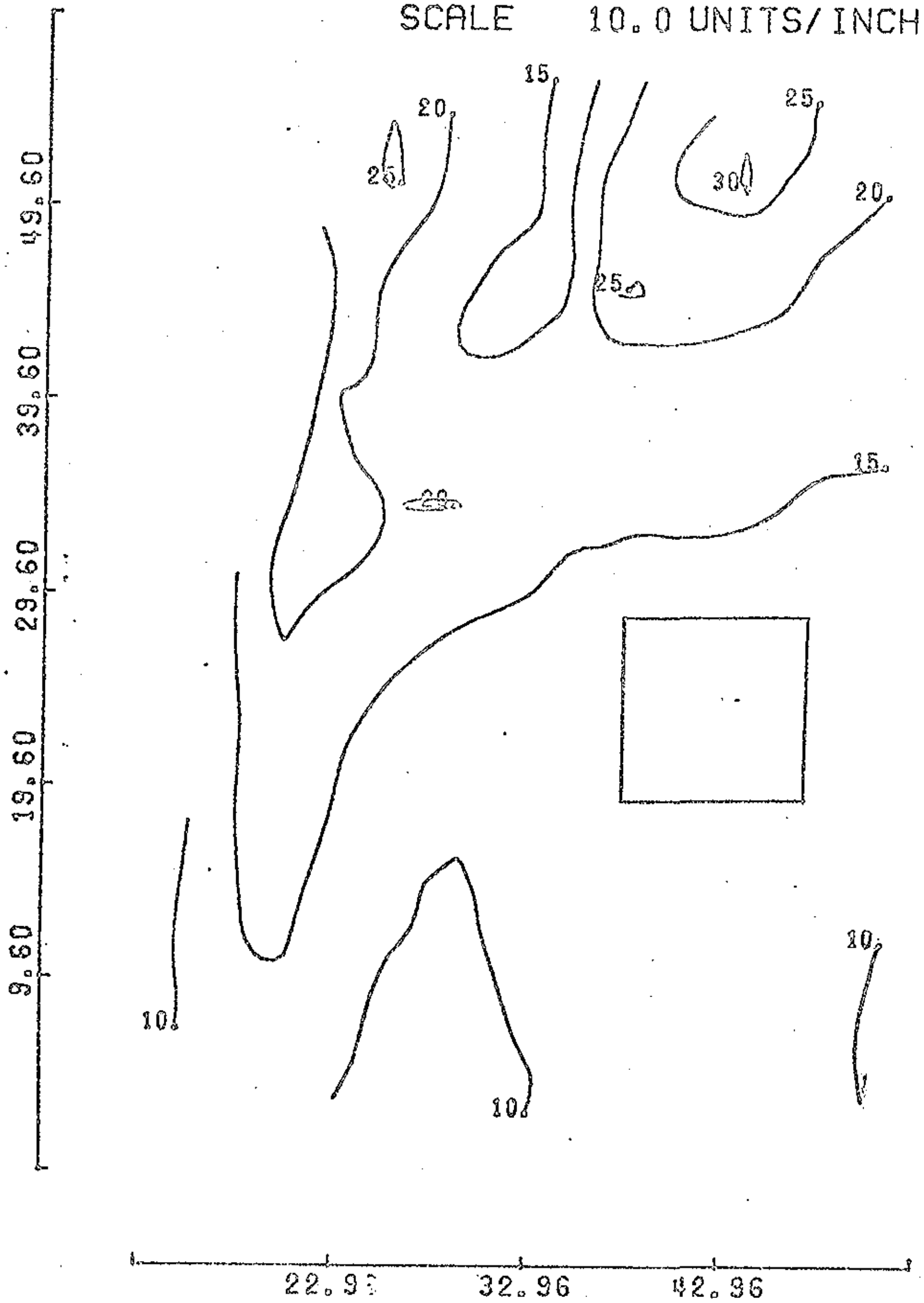
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 10.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

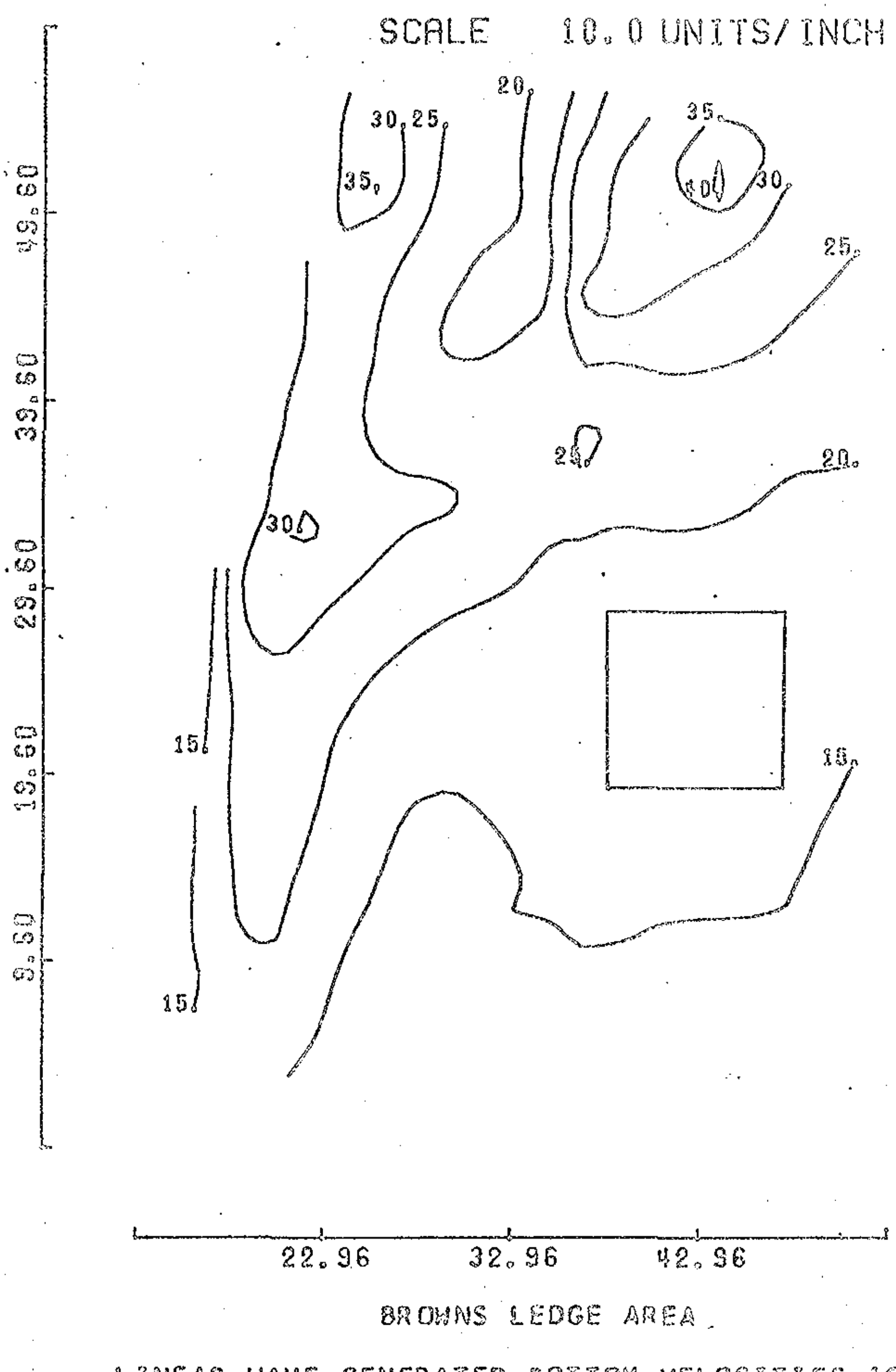


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 10.0 SECONDS

HEIGHT= 4.0 FT.

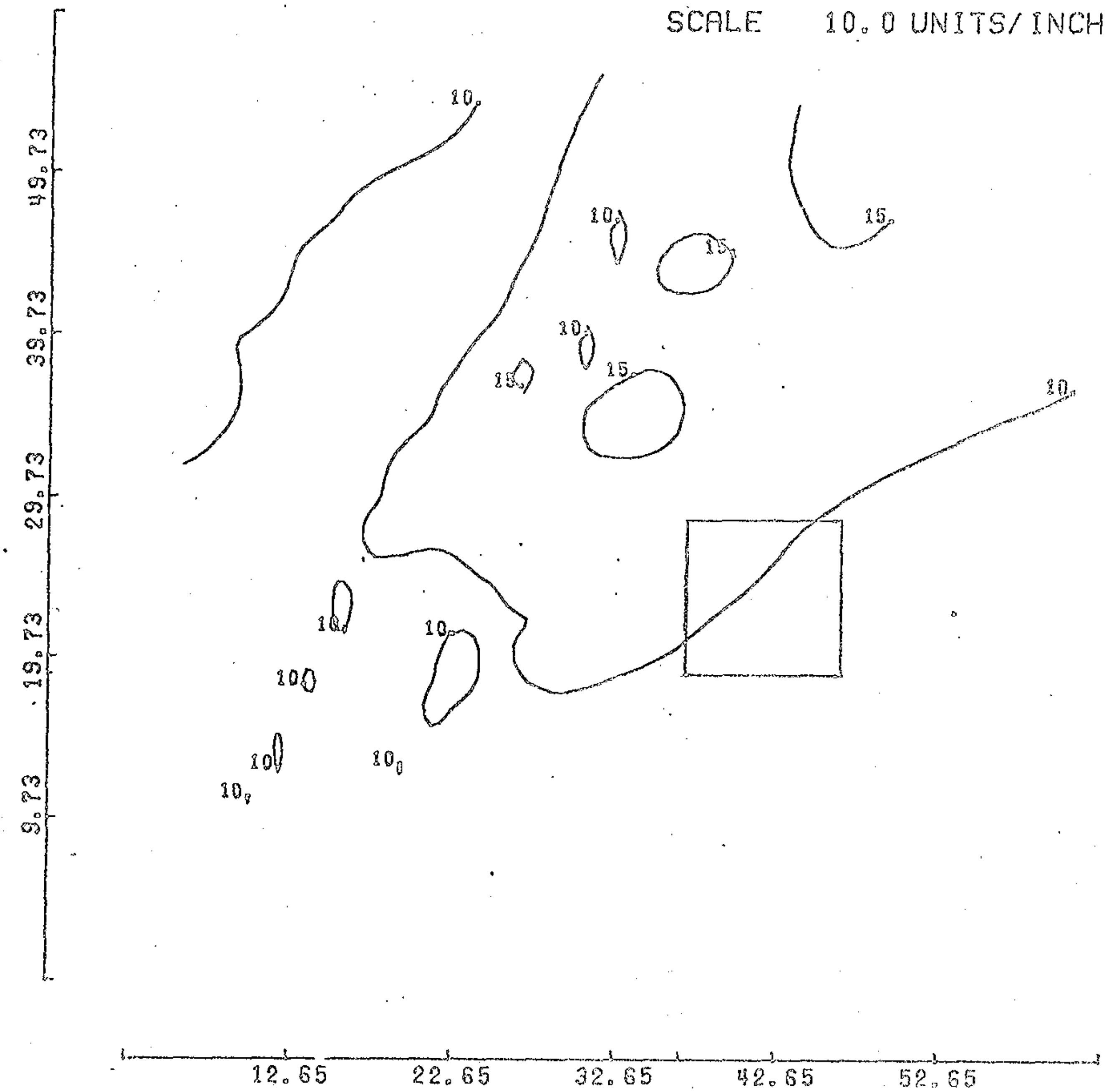


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 10.0 SECONDS

HEIGHT= 2.0 FT.

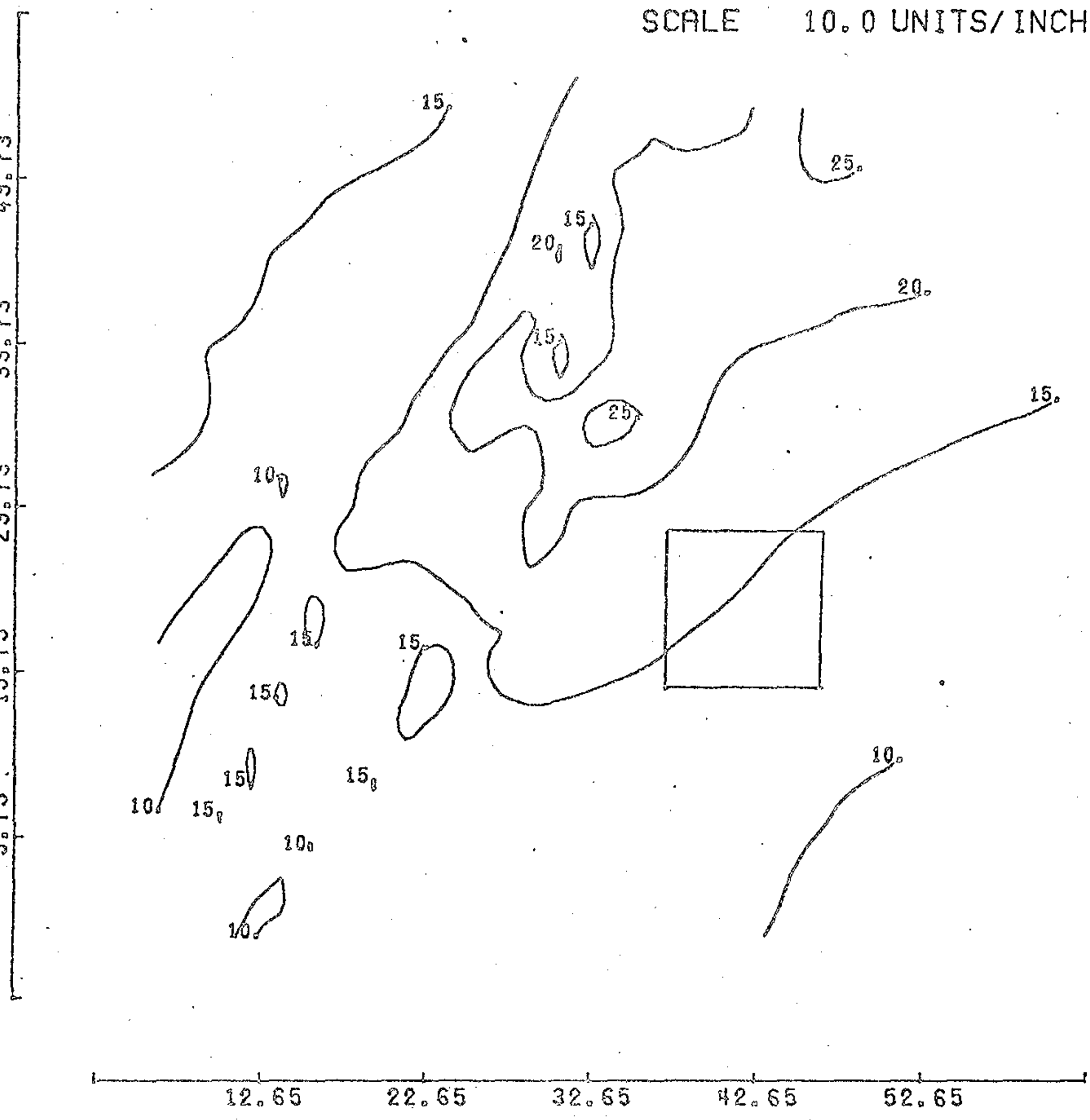


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 10.0 SECONDS

HEIGHT= 3.0 FT.

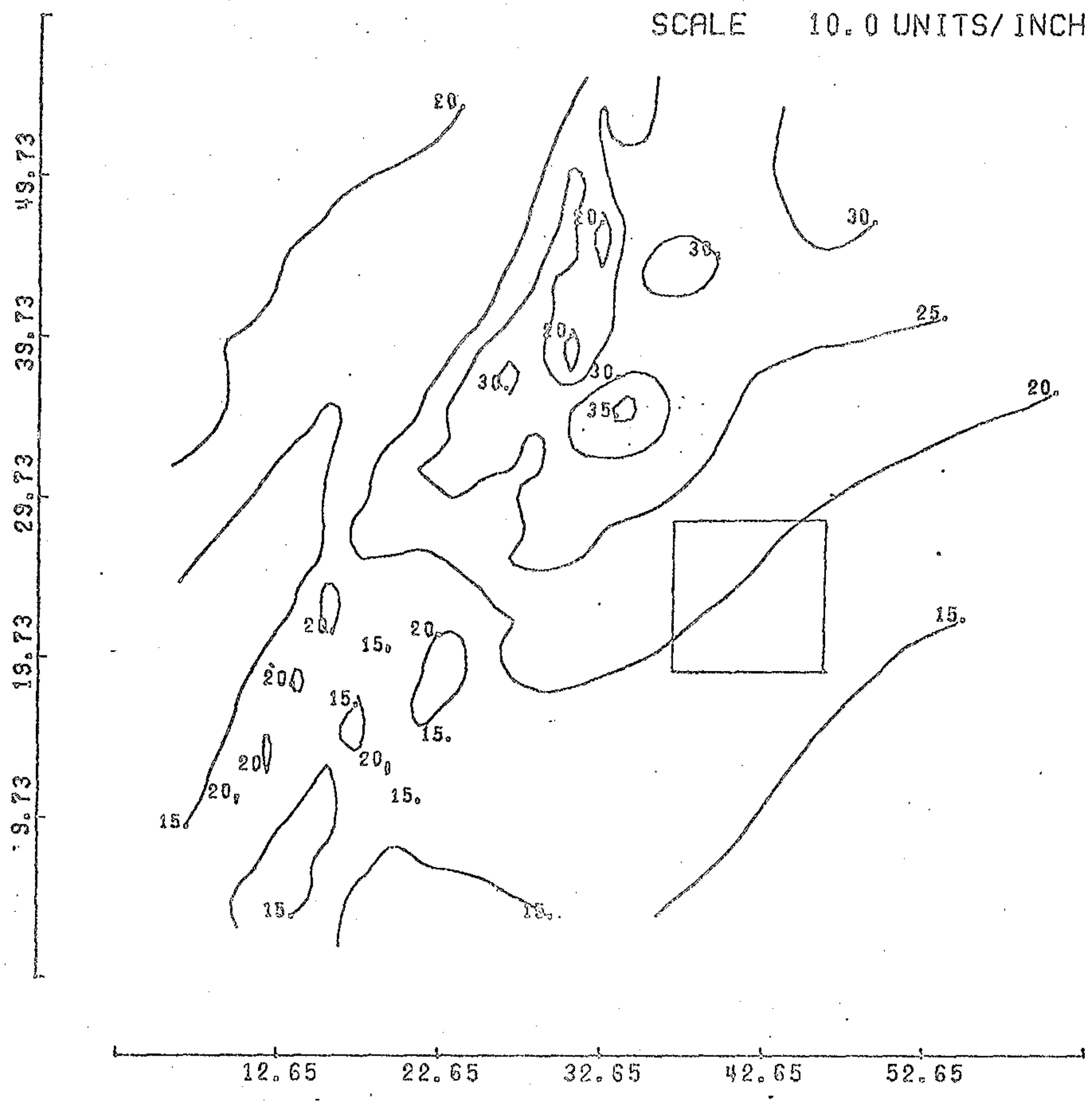


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 10.0 SECONDS

HEIGHT= 4.0 FT.

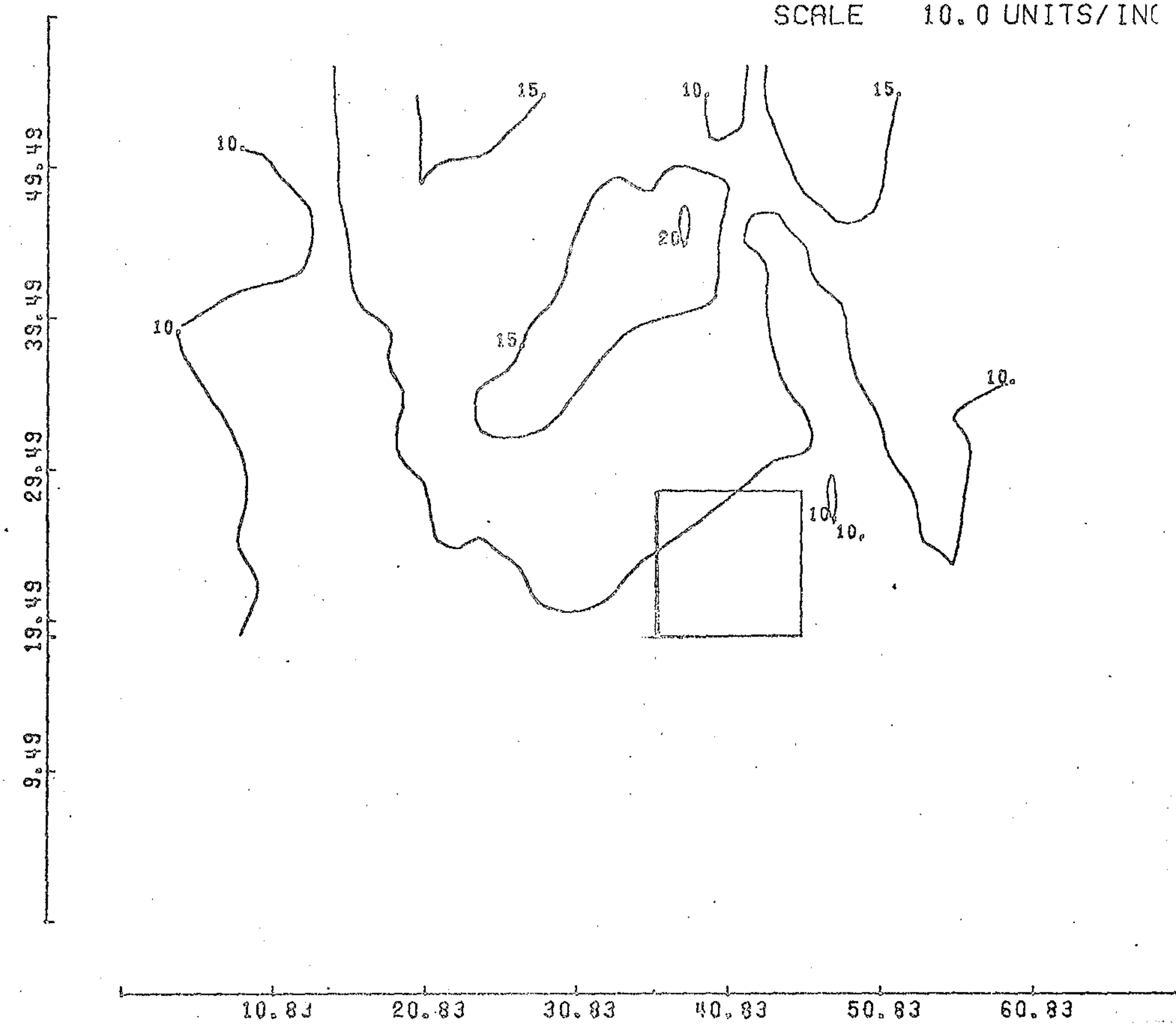


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 10.0 SECONDS

HEIGHT= 2.0 FT.



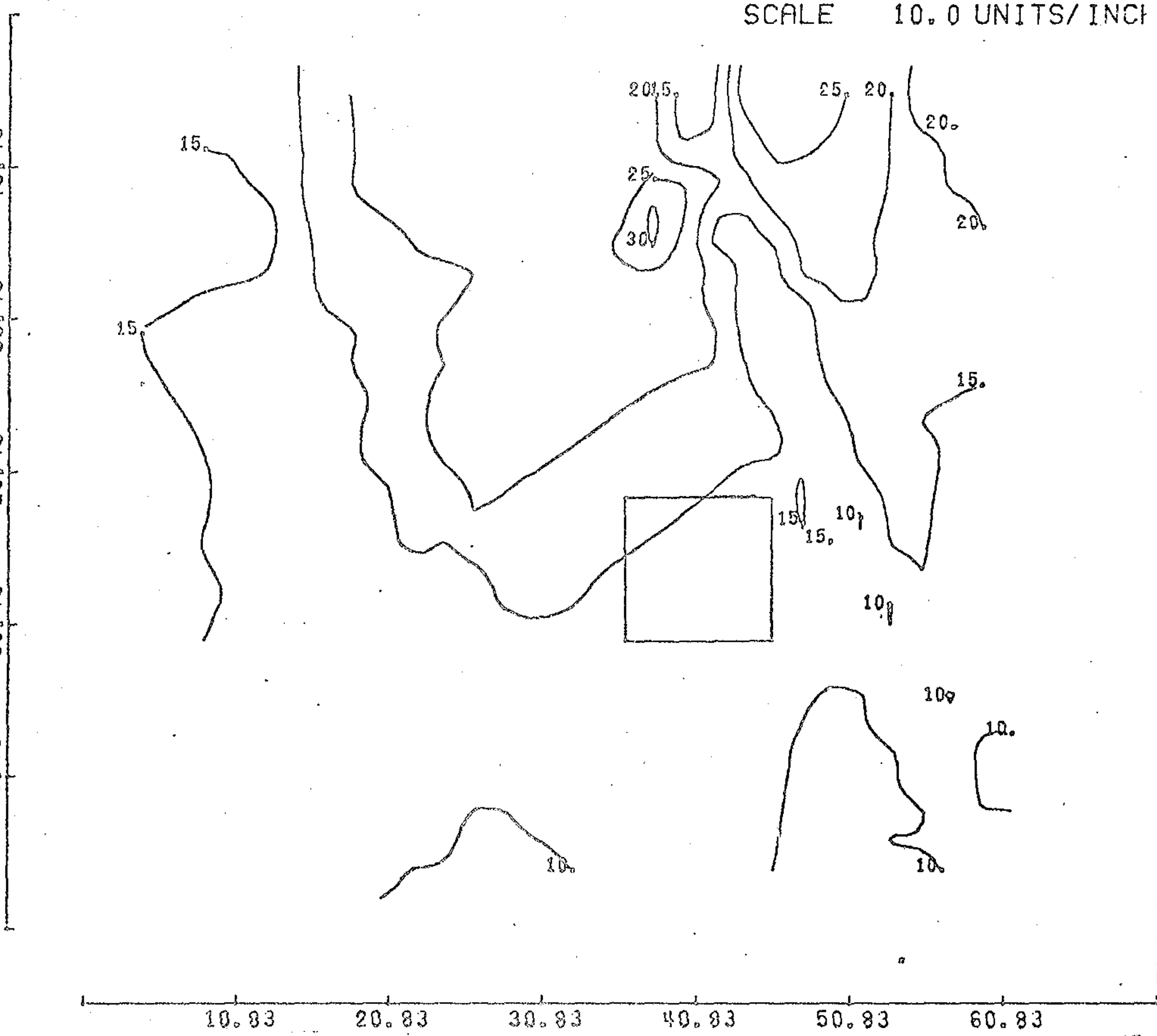
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 10.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

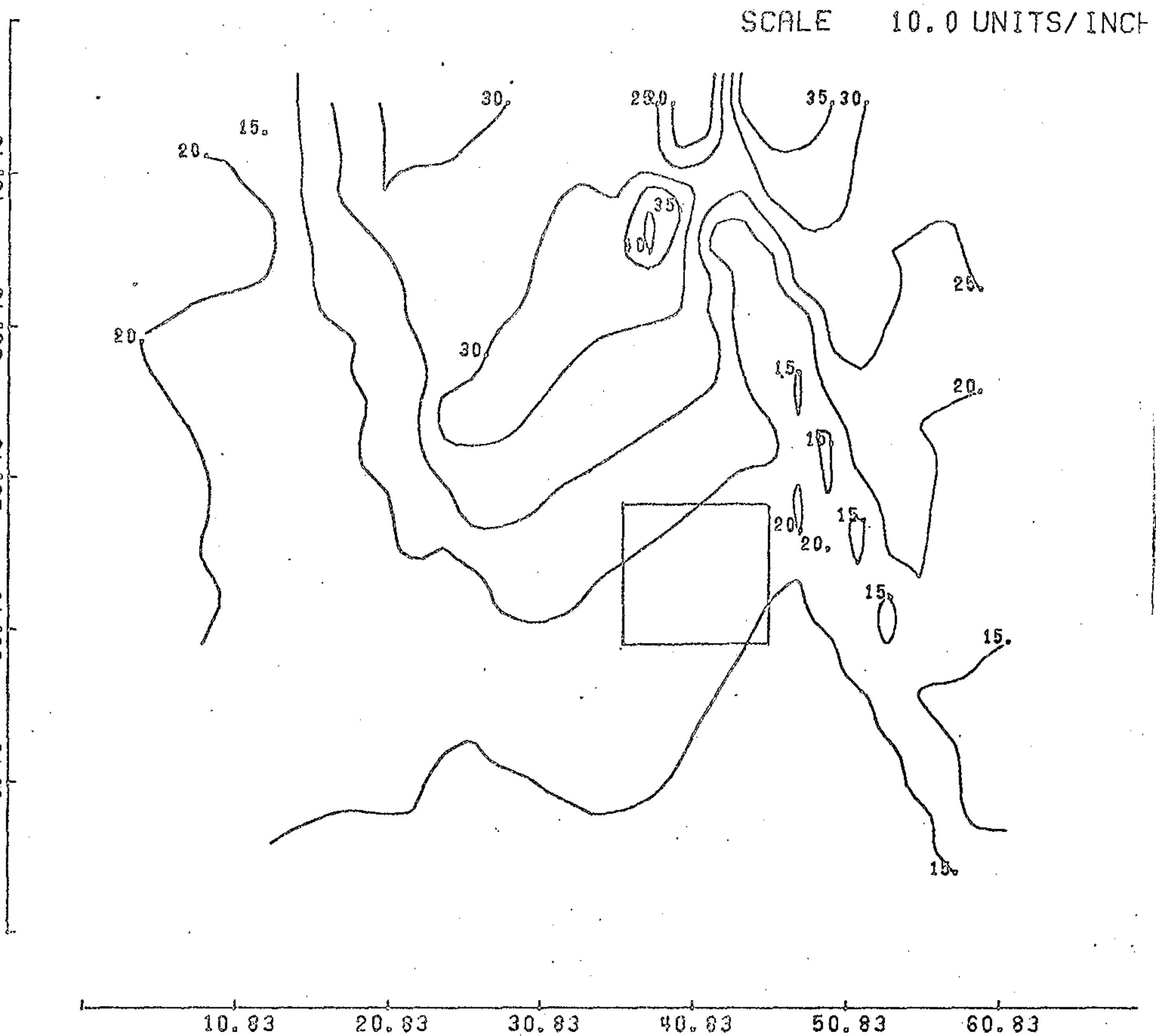


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 10.0 SECONDS

HEIGHT= 4.0 FT.

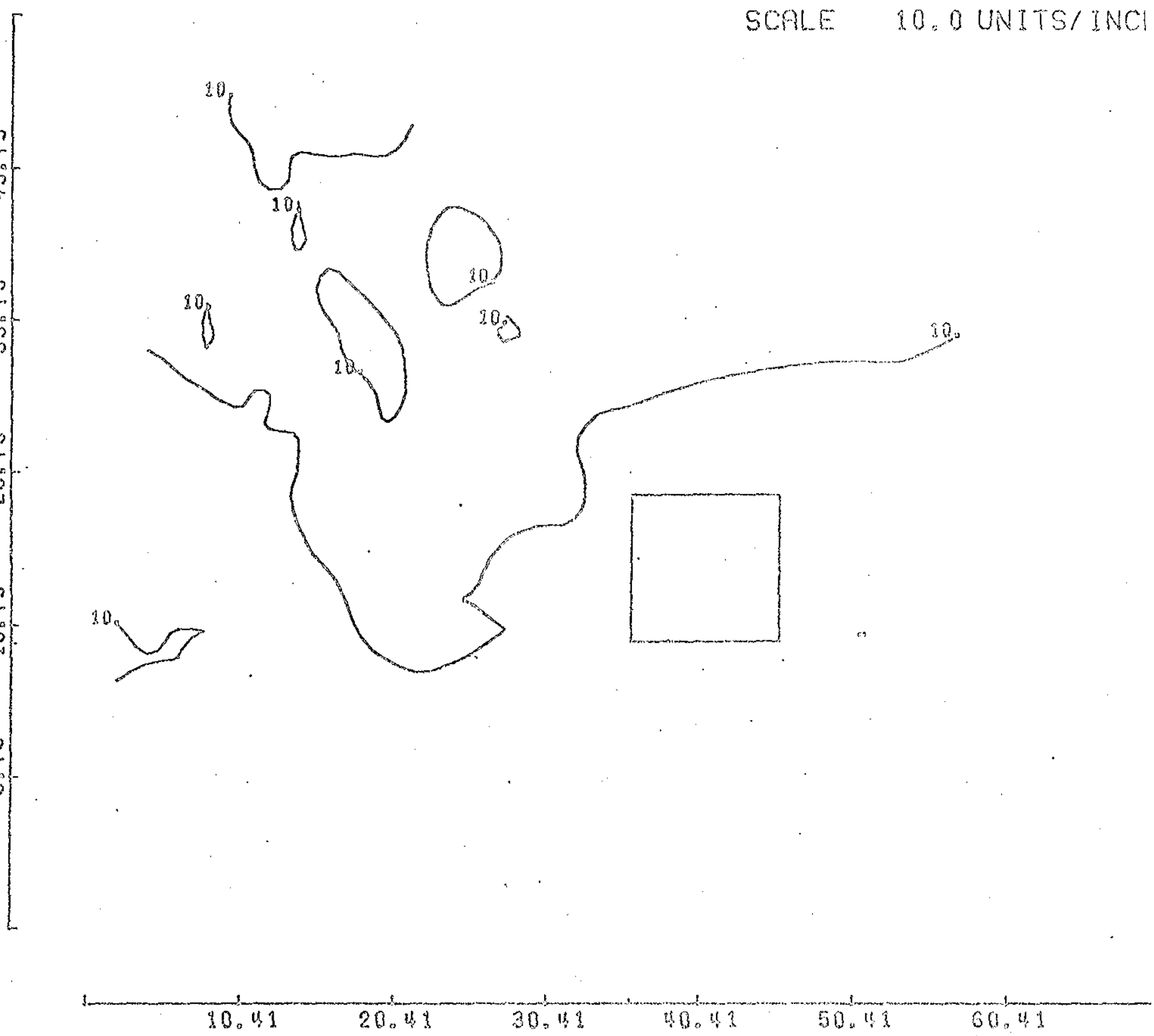


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 10.0 SECONDS

HEIGHT= 2.0 FT.

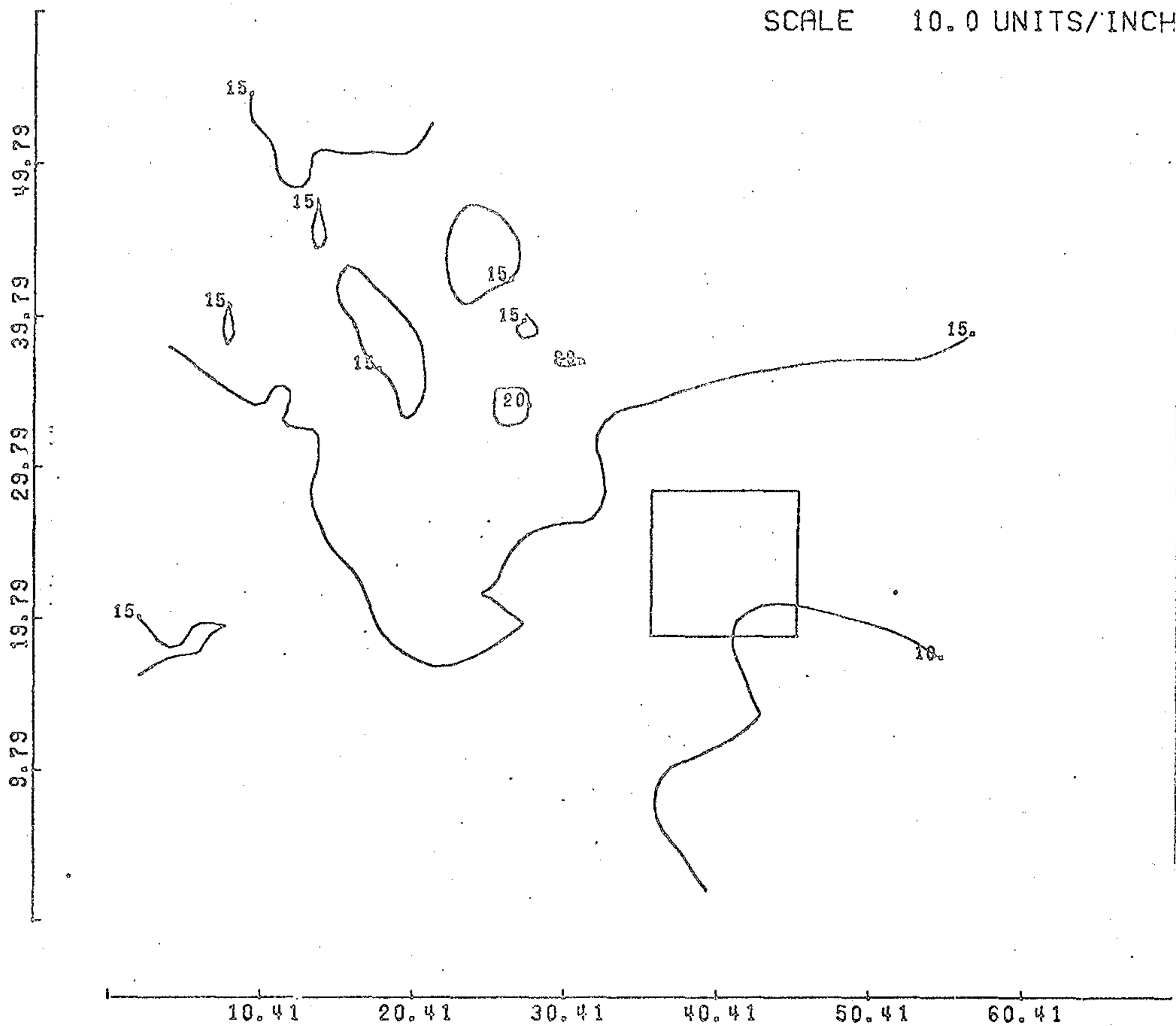


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 10.0 SECONDS

HEIGHT= 3.0 FT.

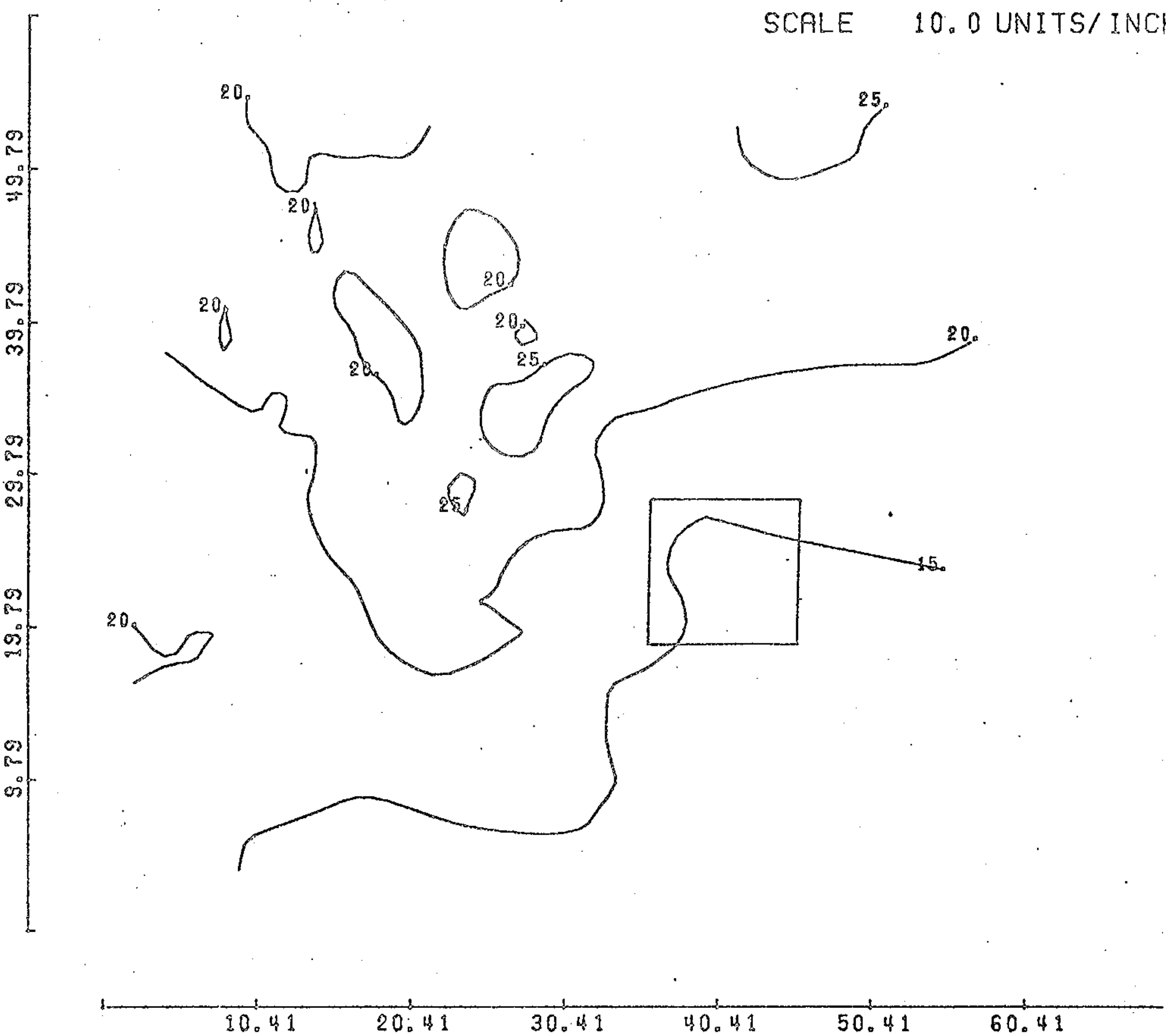


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 10.0 SECONDS

HEIGHT= 4.0 FT.

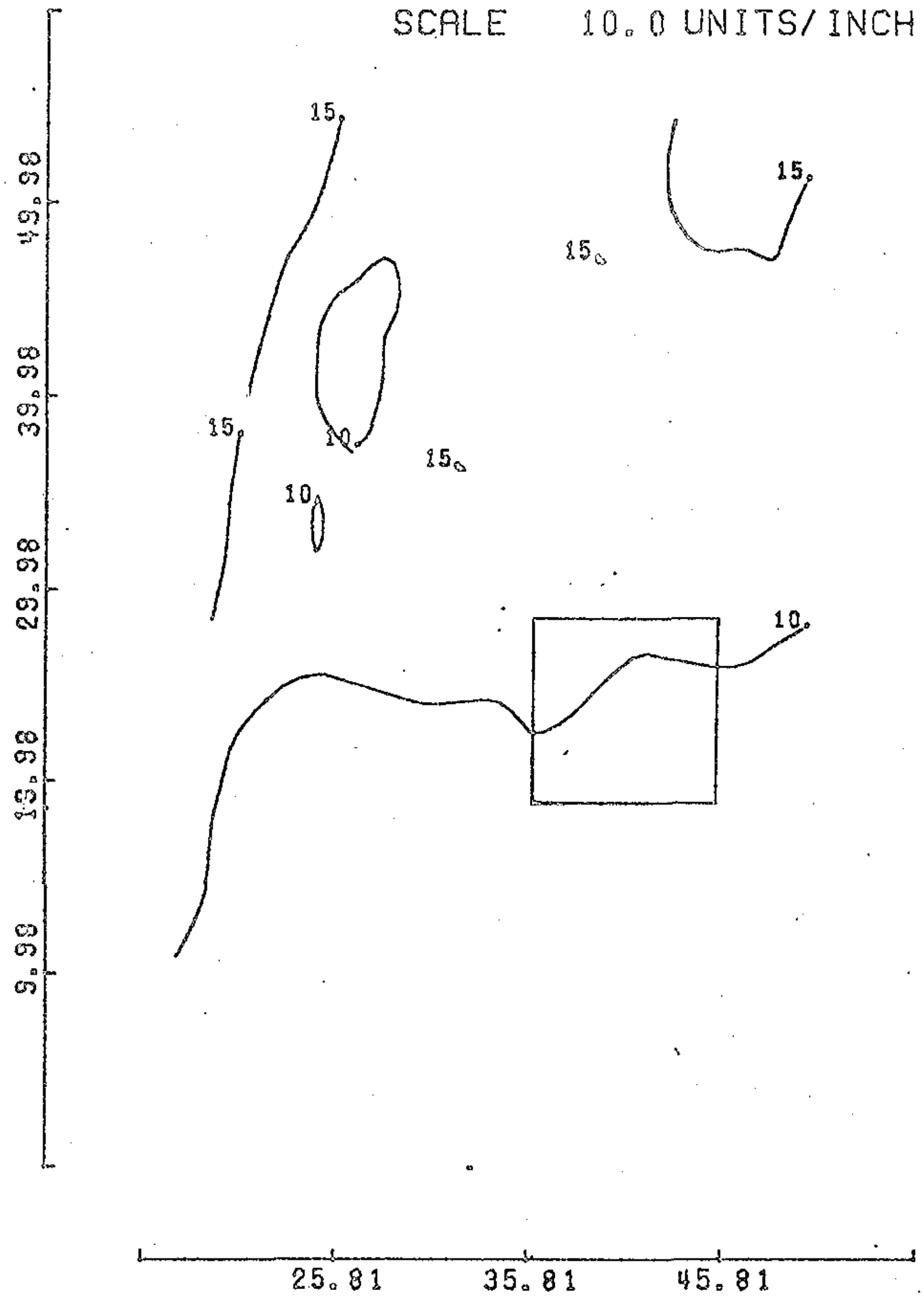


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 11.0 SECONDS .

HEIGHT= 2.0 FT.

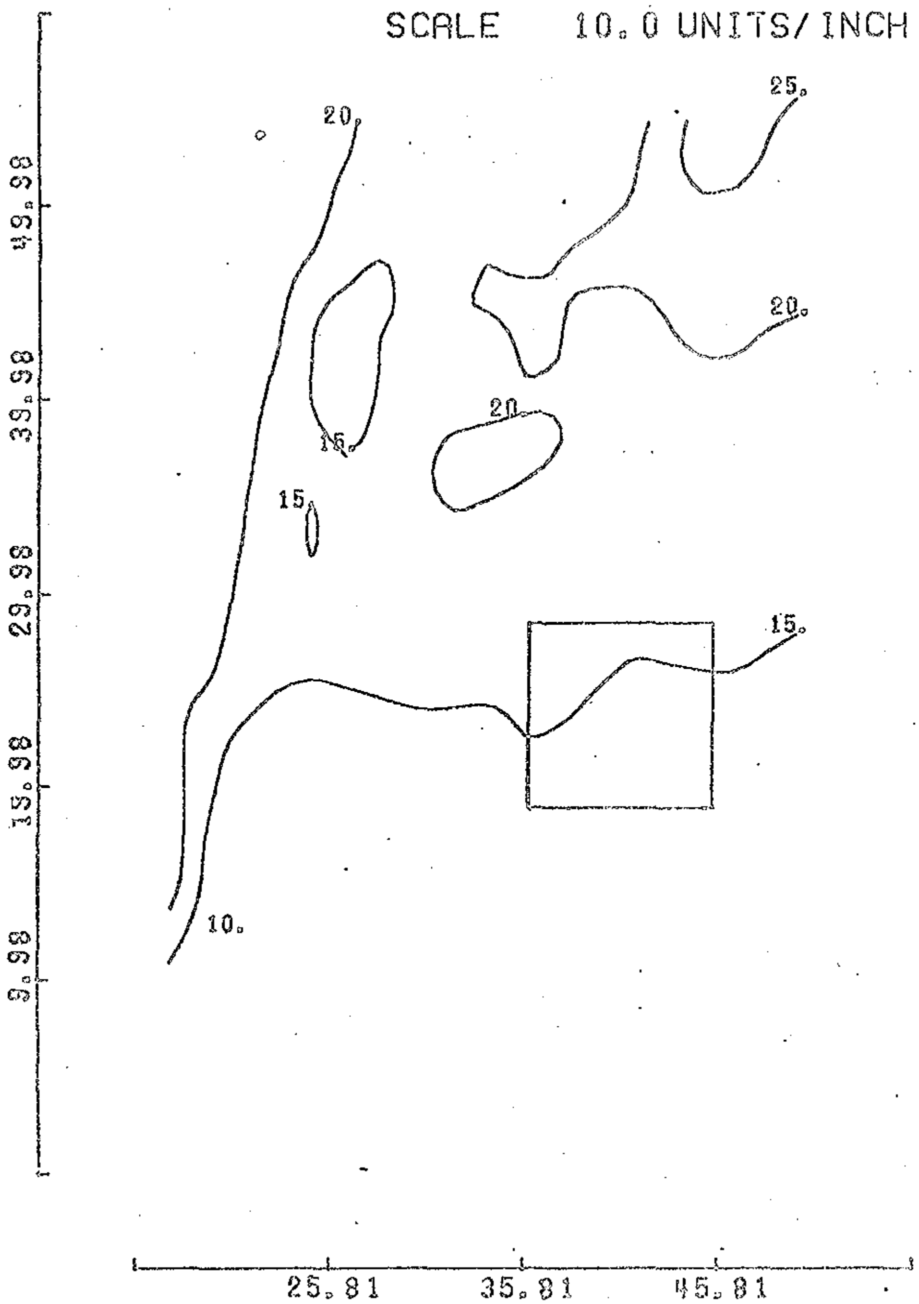


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 11.0 SECONDS

HEIGHT= 3.0 FT.

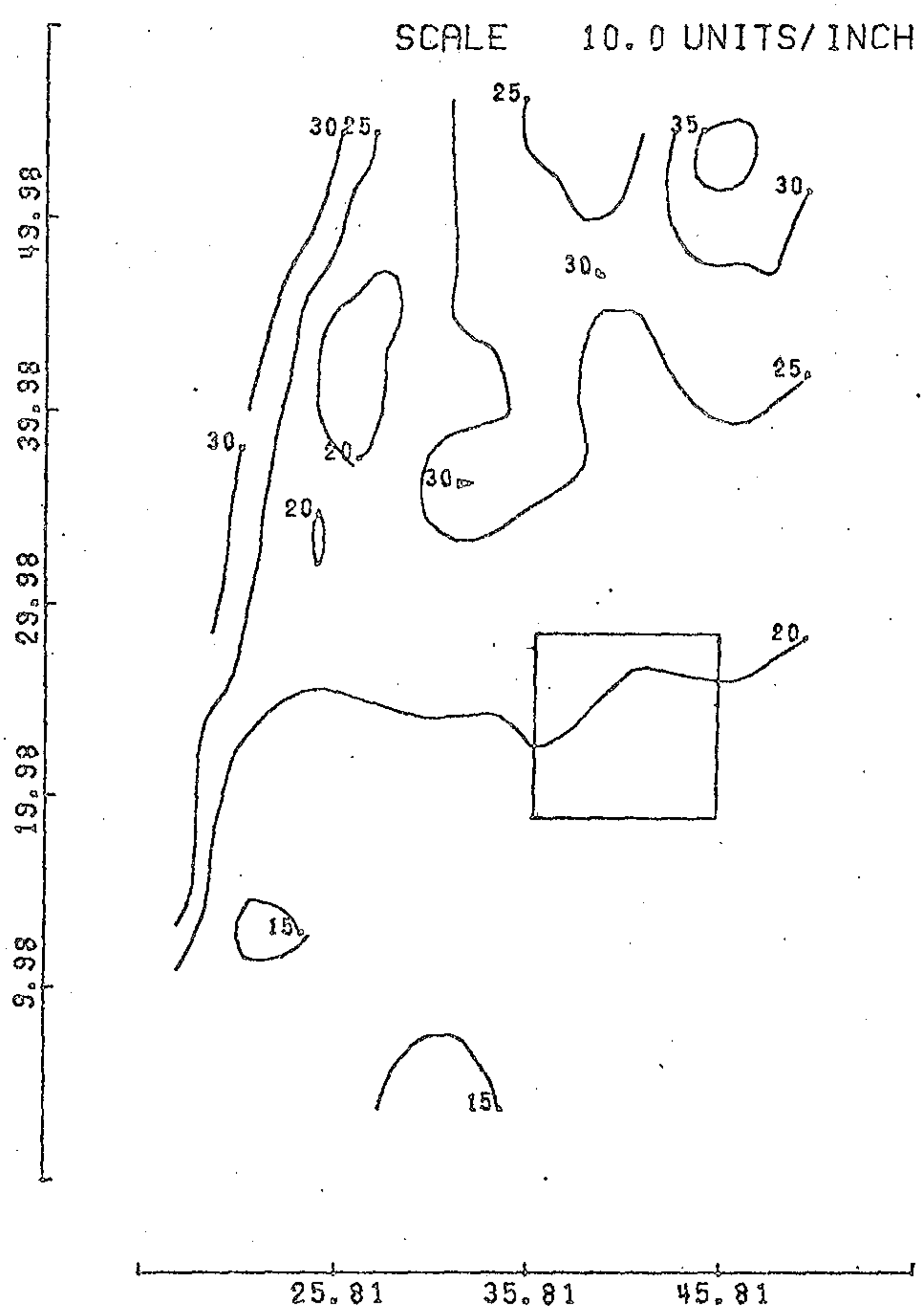


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 180.0 PERIOD= 11.0 SECONDS

HEIGHT= 4.0 FT.

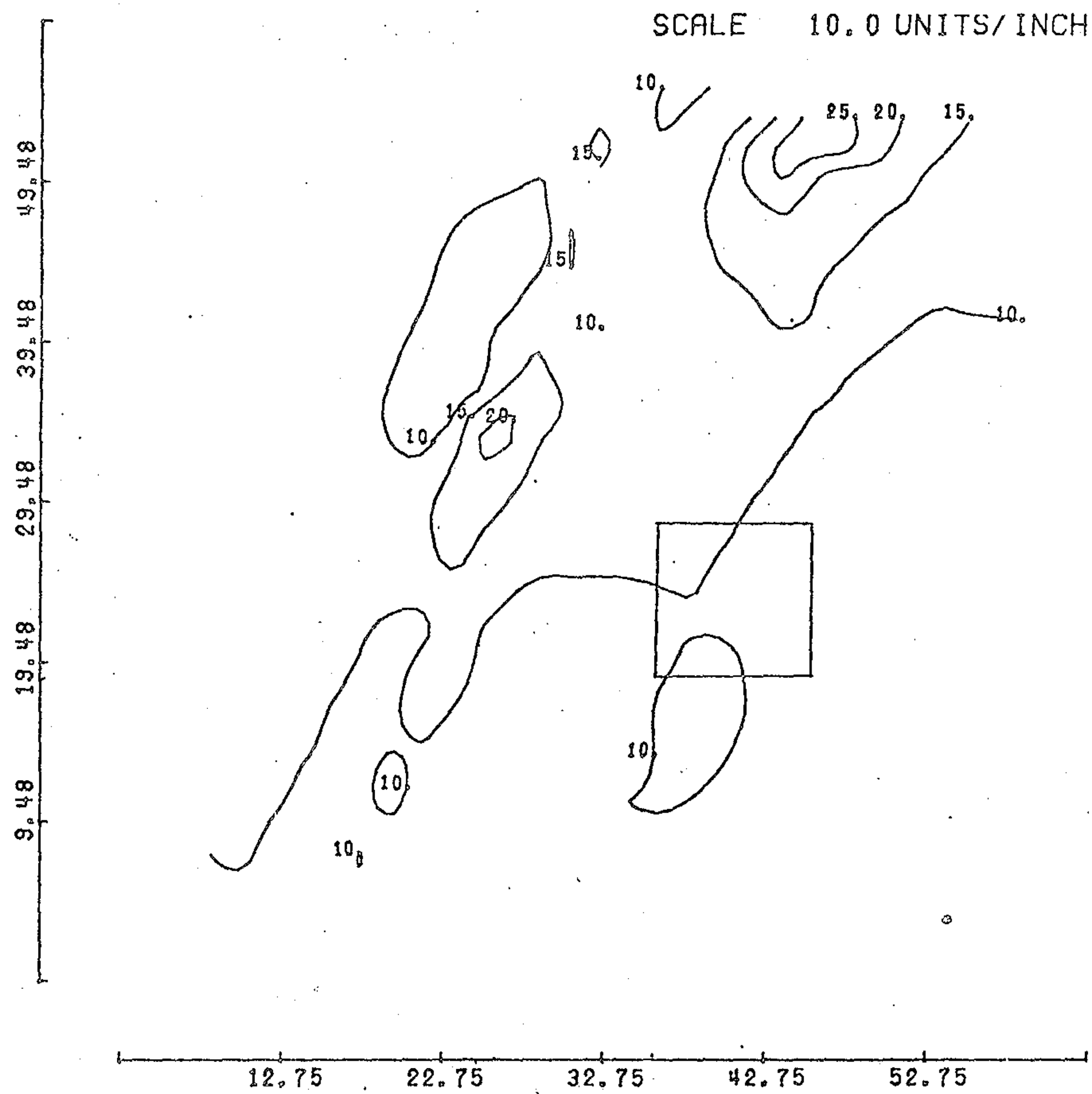


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 11.0 SECONDS

HEIGHT= 2.0 FT.

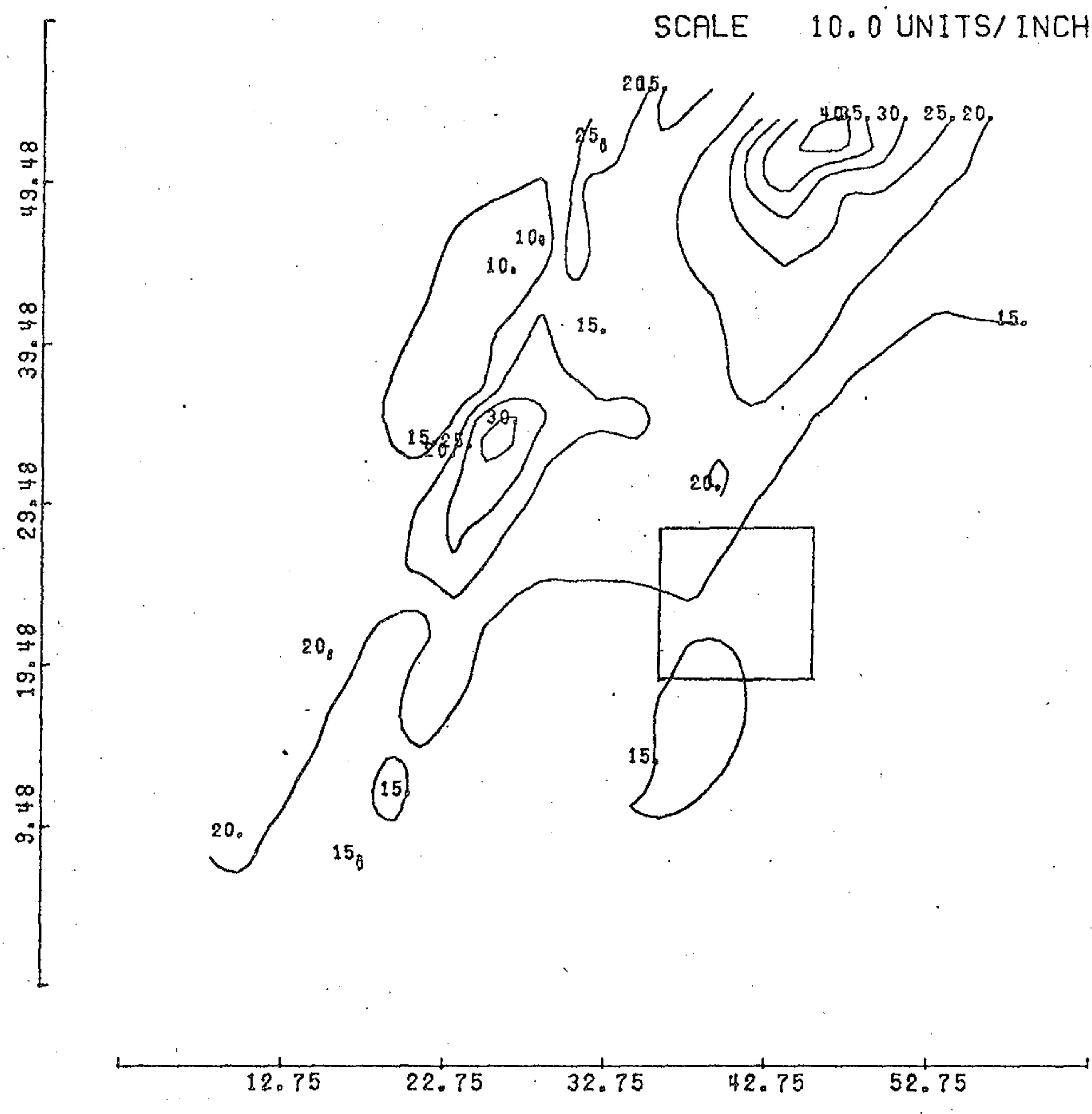


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 11.0 SECONDS

HEIGHT= 3.0 FT.

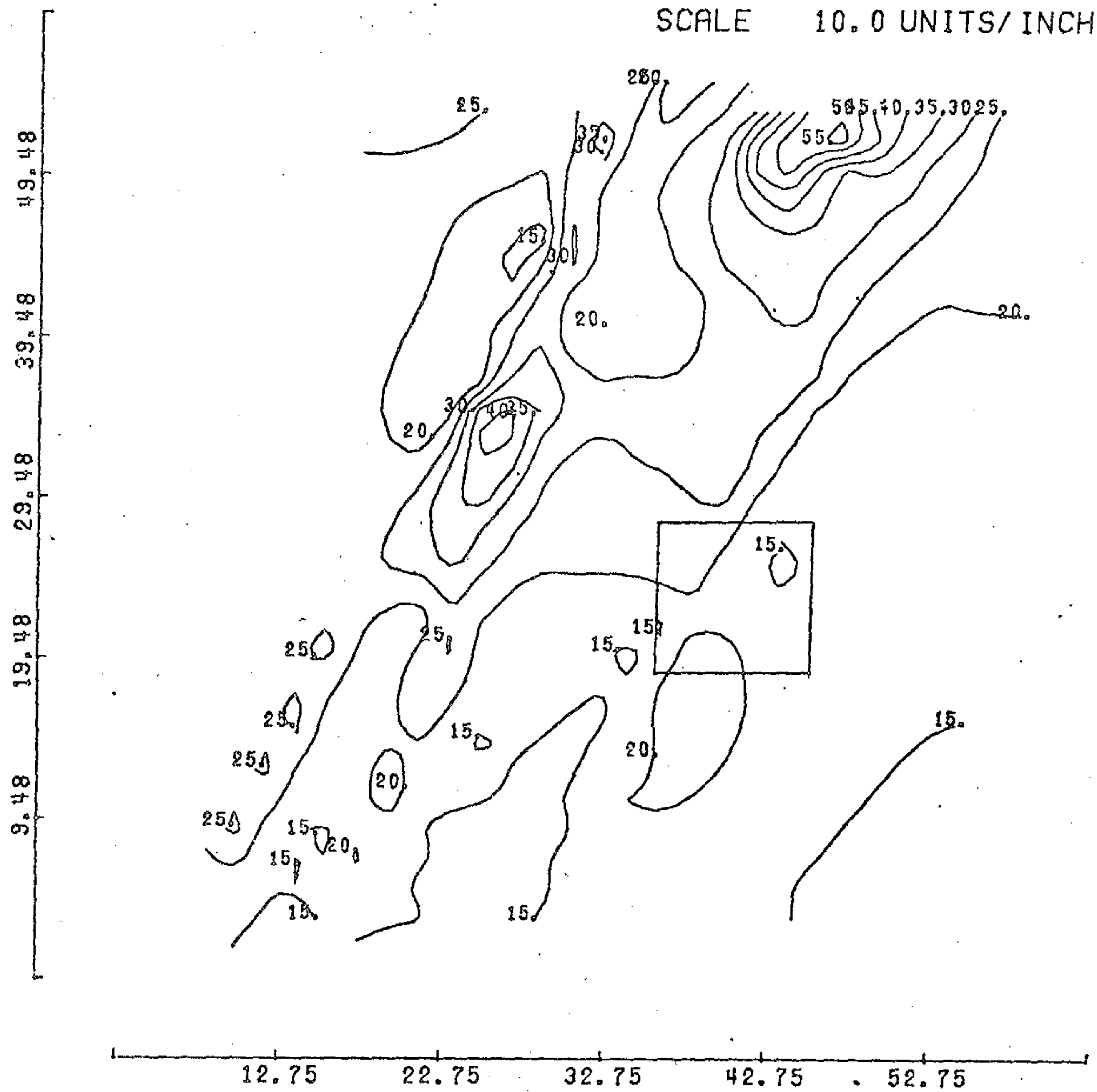


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 11.0 SECONDS

HEIGHT= 4.0 FT.



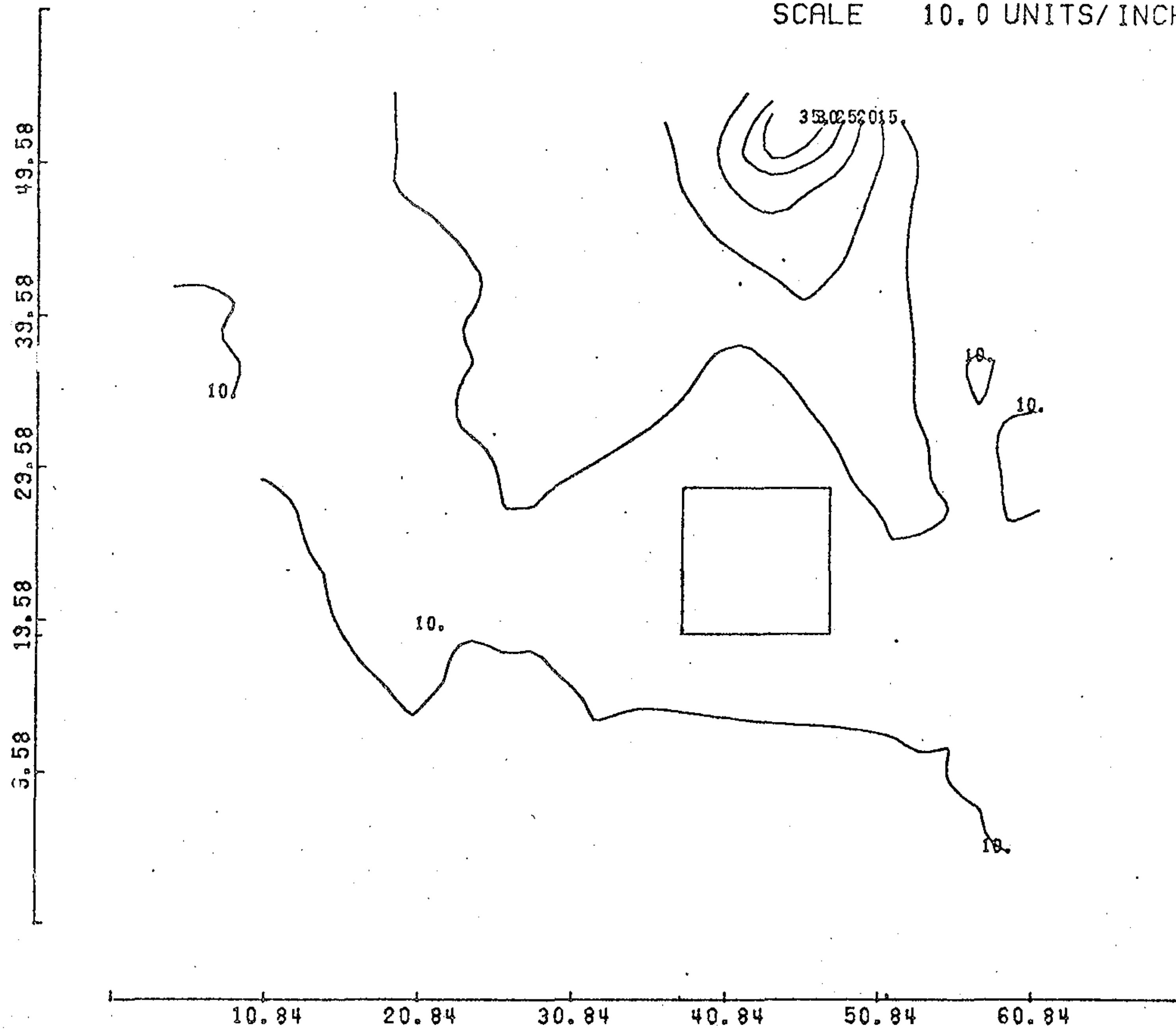
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 11.0 SECONDS

HEIGHT= 2.0 FT.

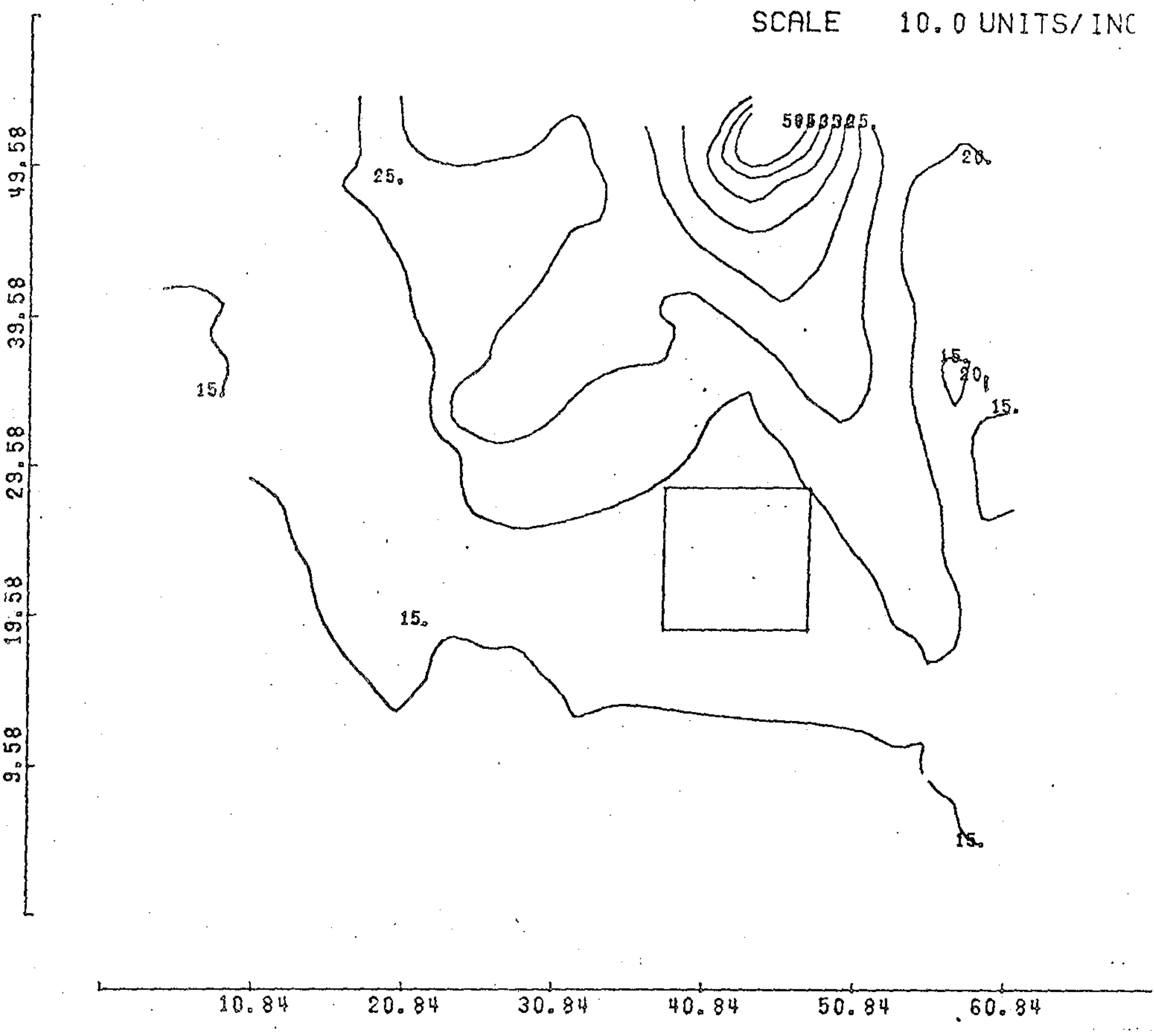
SCALE 10.0 UNITS/INCH



BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 11.0 SECONDS.
HEIGHT= 3.0 FT.

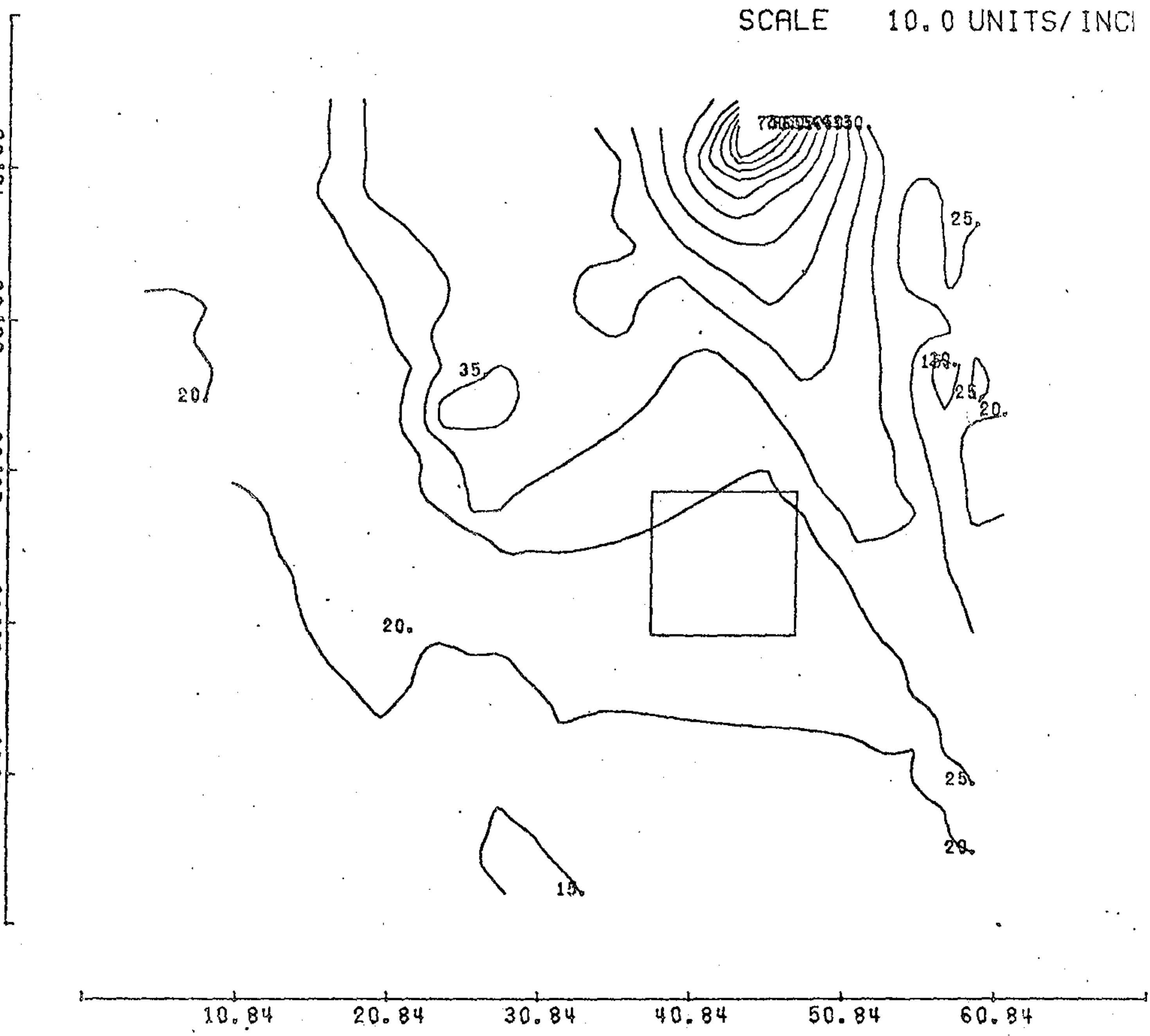


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 11.0 SECONDS

HEIGHT= 4.0 FT.



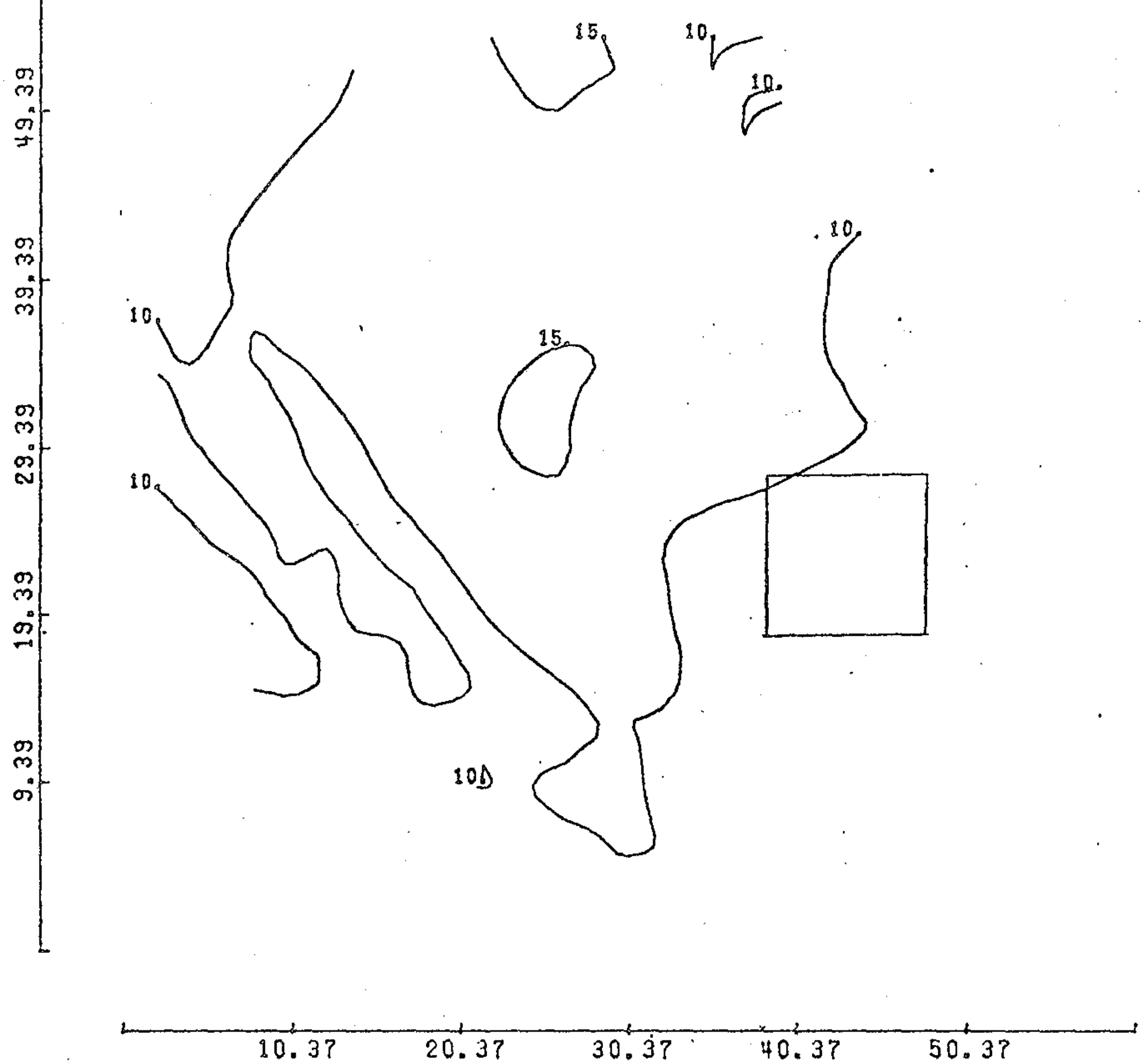
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 135.0 PERIOD= 11.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH



BROWNS LEDGE AREA

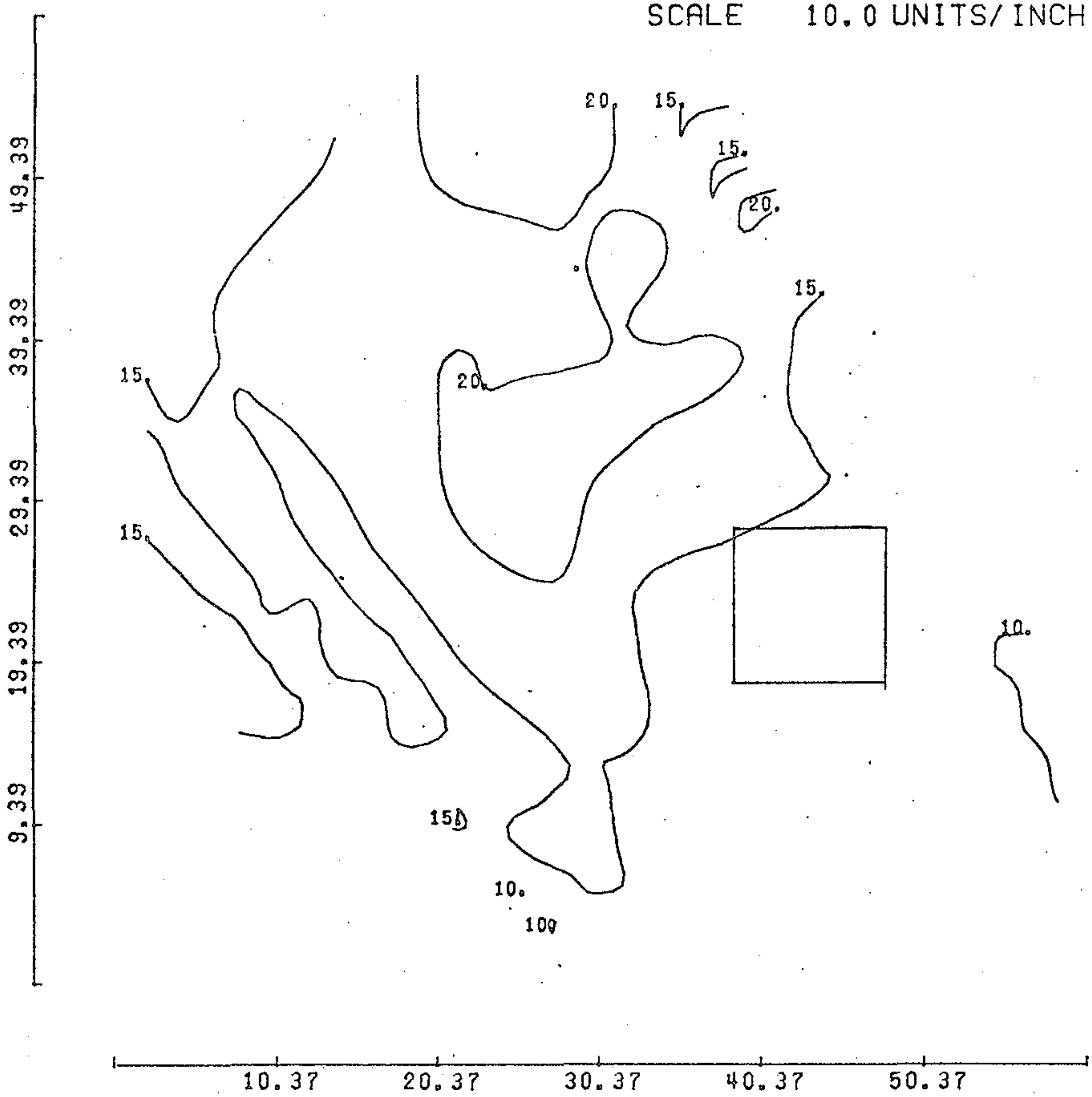
LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

113

DEEP WATER DIRECTION= 135.0 PERIOD= 11.0 SECONDS

HEIGHT= 3.0 FT.

SCALE 10.0 UNITS/INCH

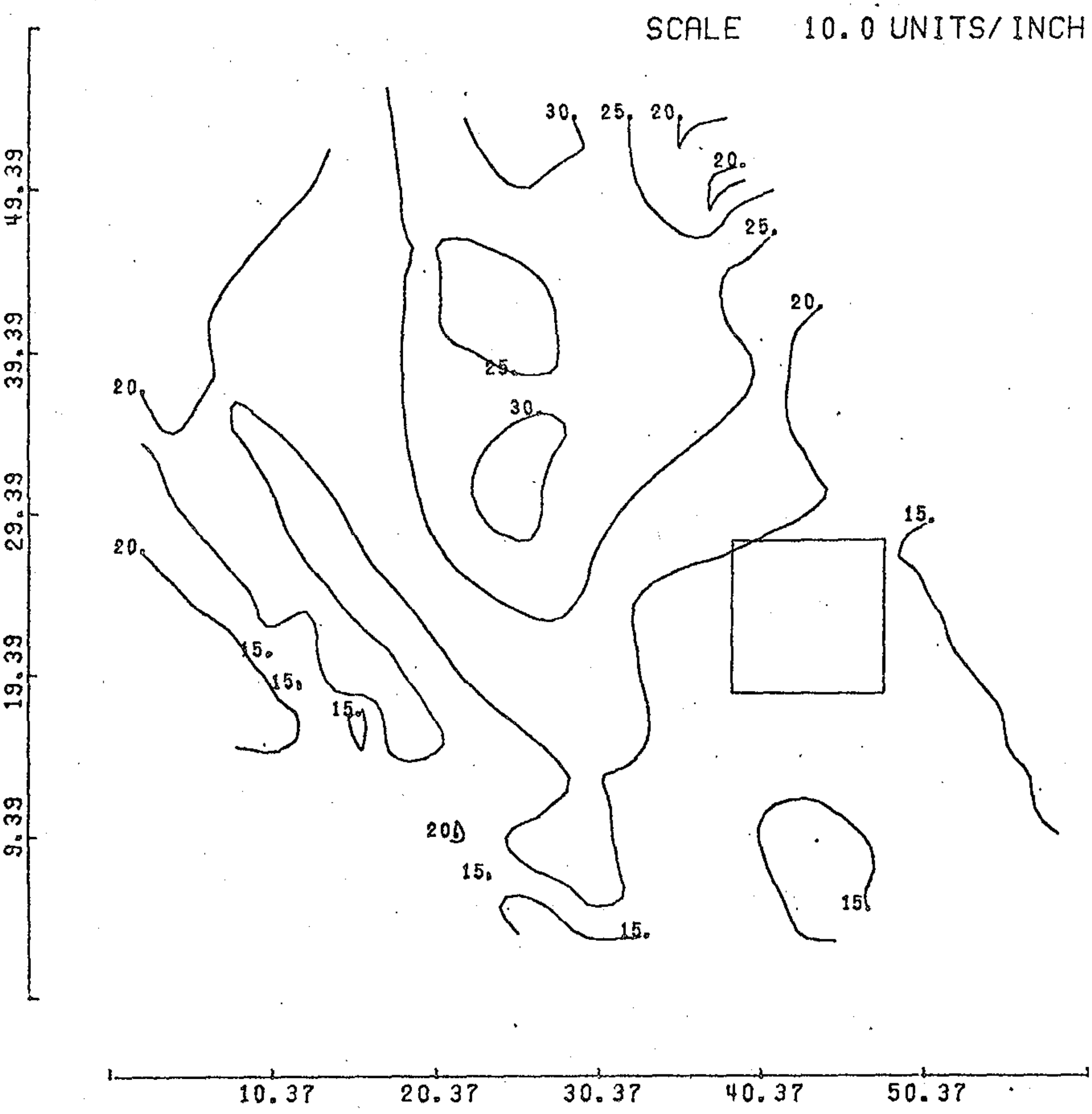


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

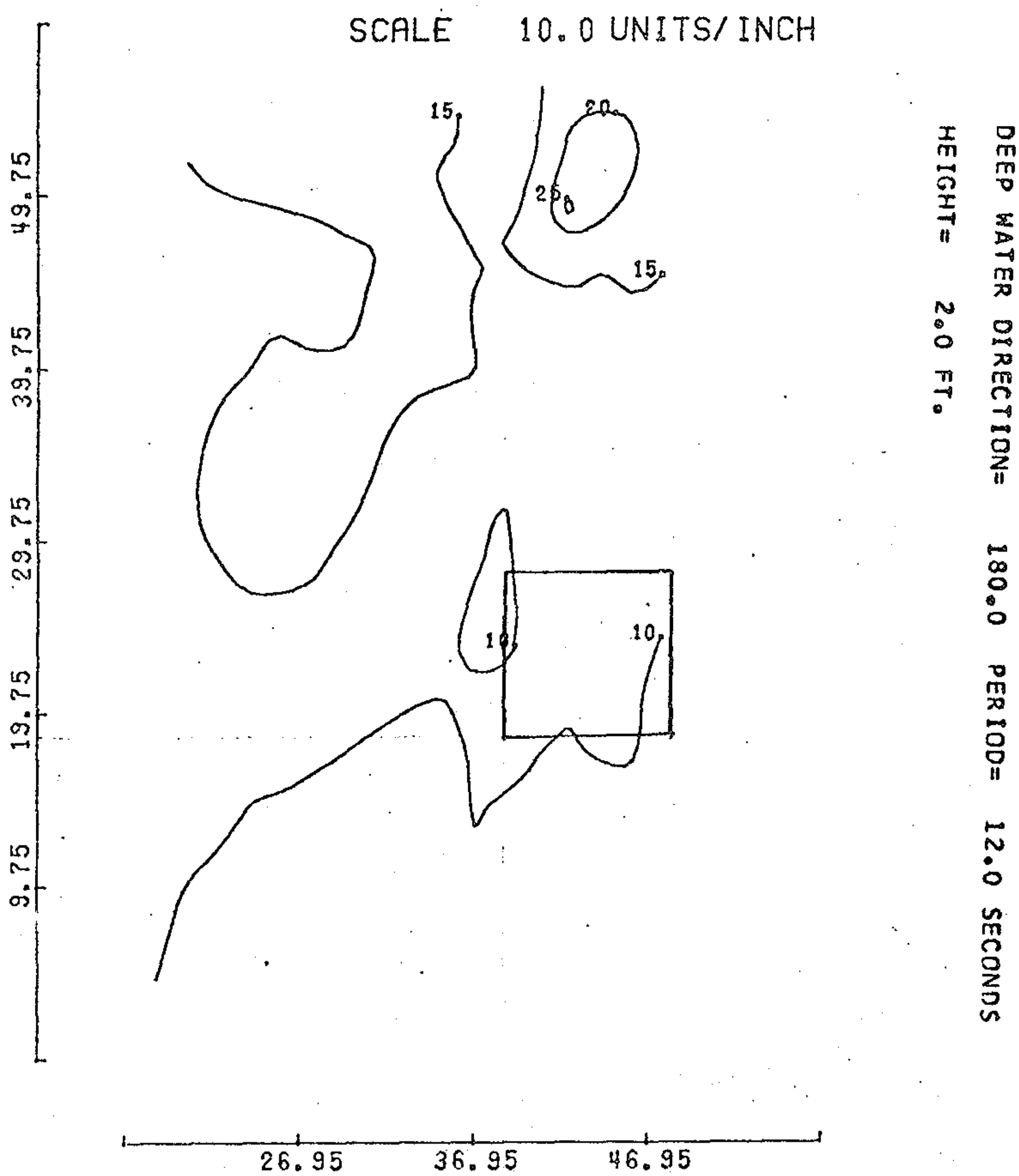
DEEP WATER DIRECTION= 135.0 PERIOD= 11.0 SECONDS

HEIGHT= 4.0 FT.



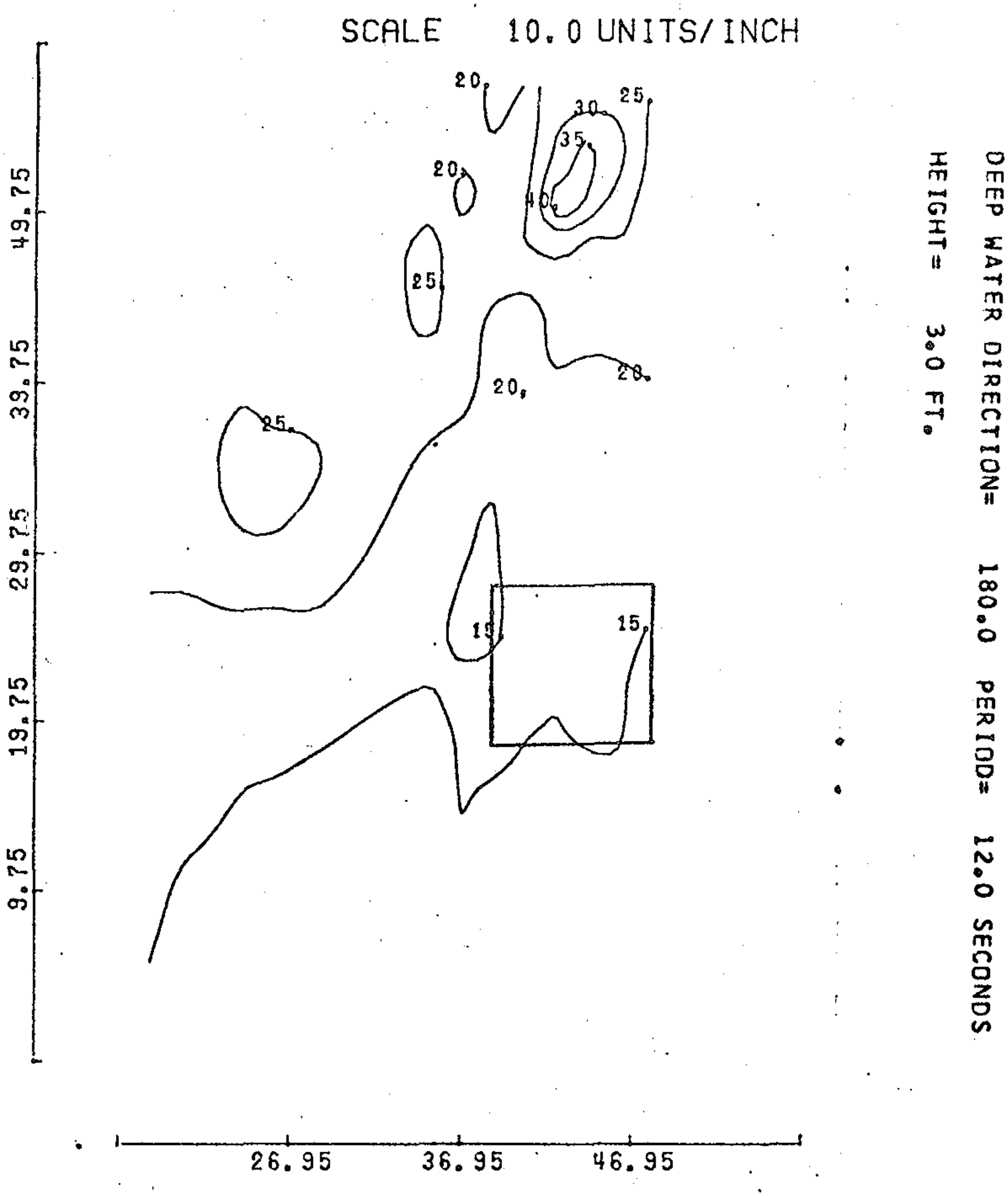
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)



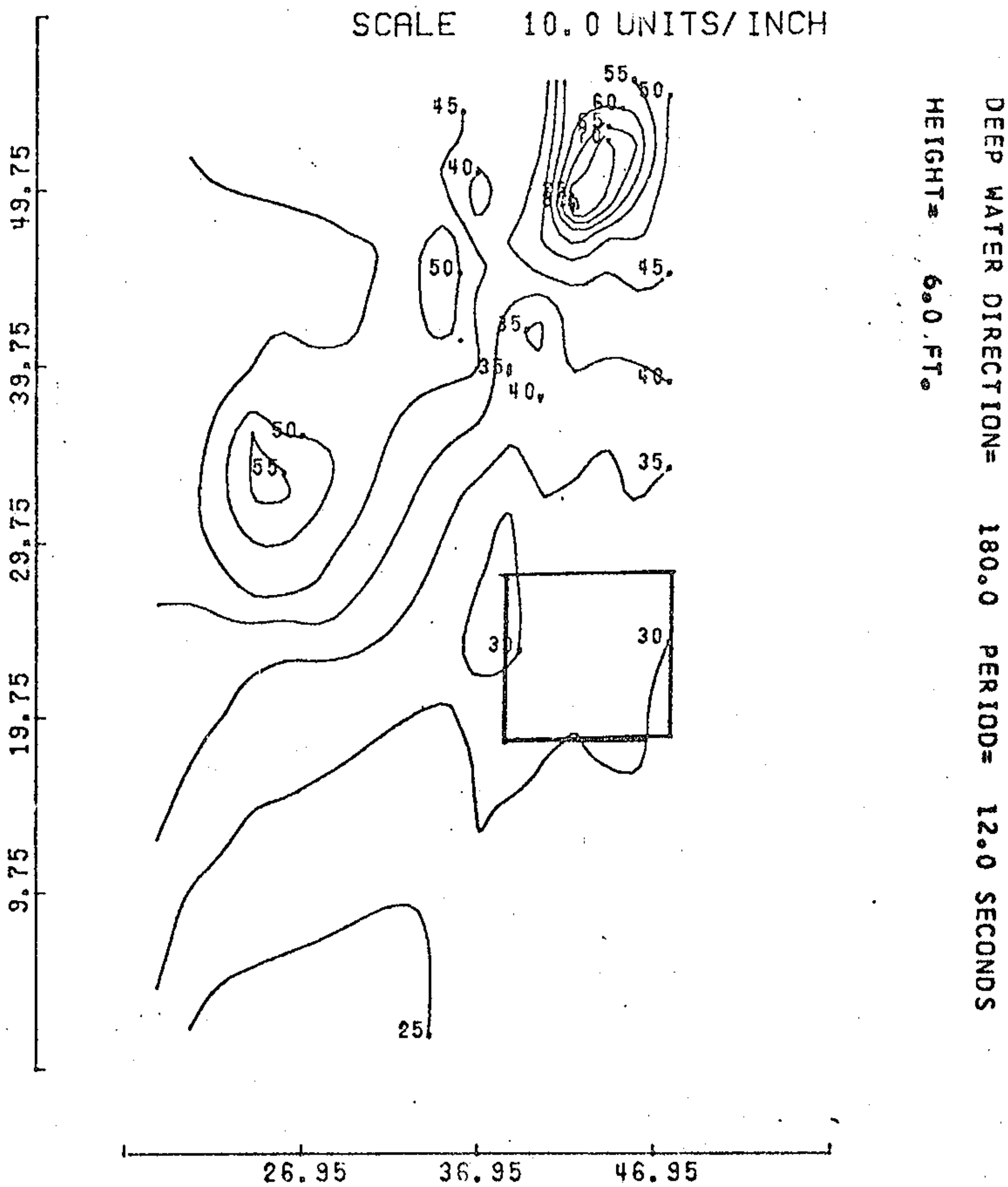
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)



BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)



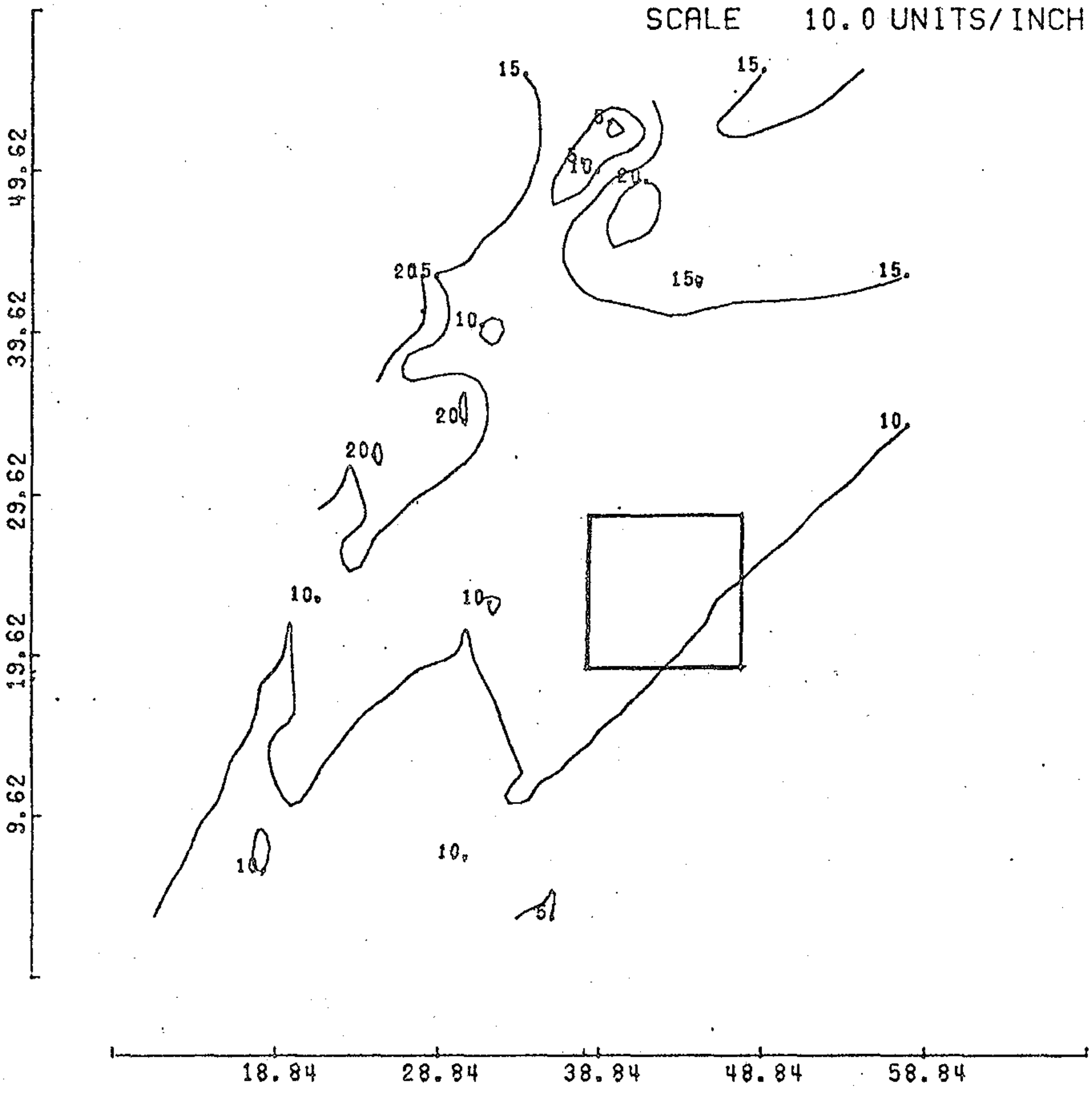
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 12.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH

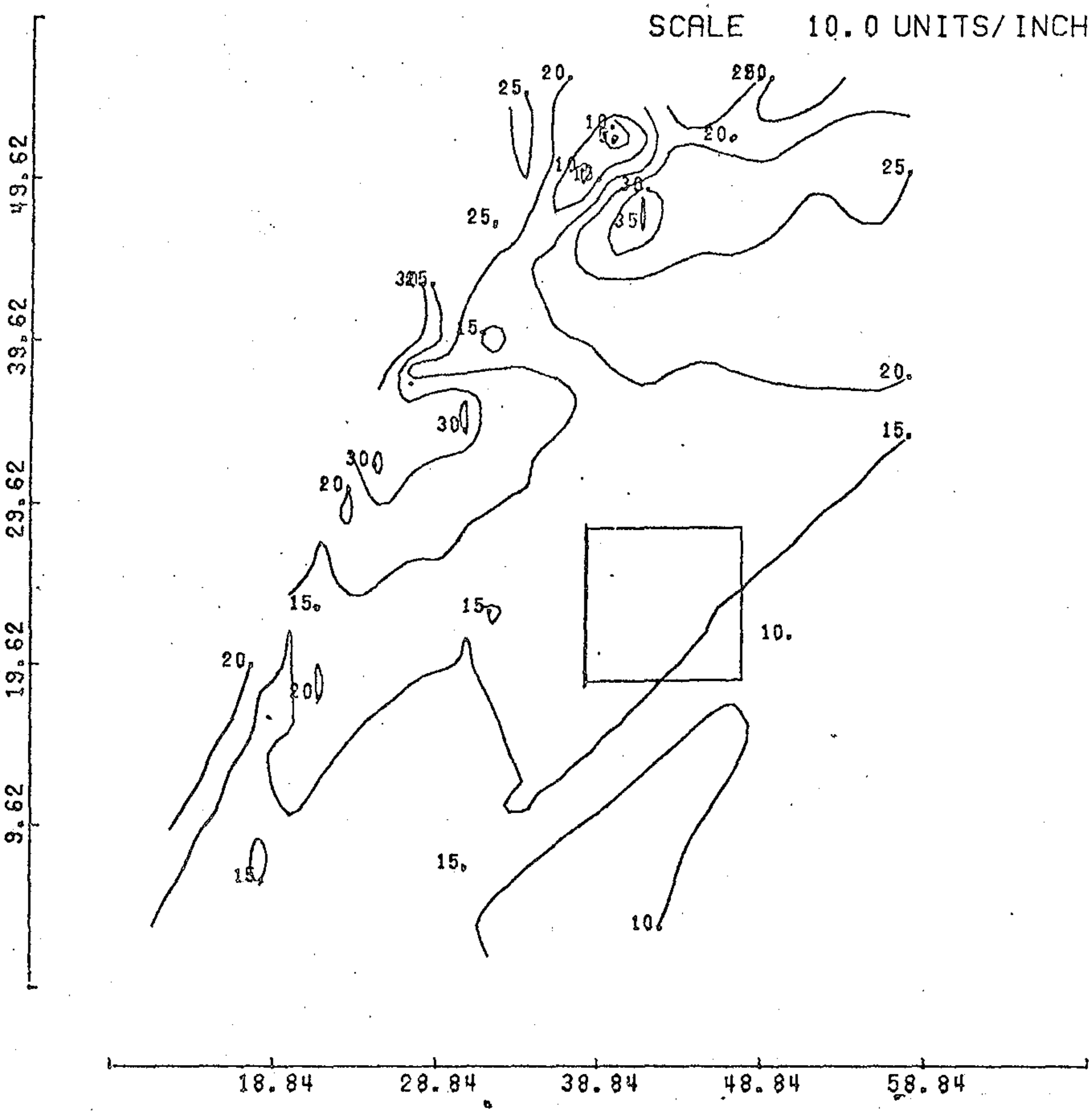


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 12.0 SECONDS

HEIGHT= 3.0 FT.

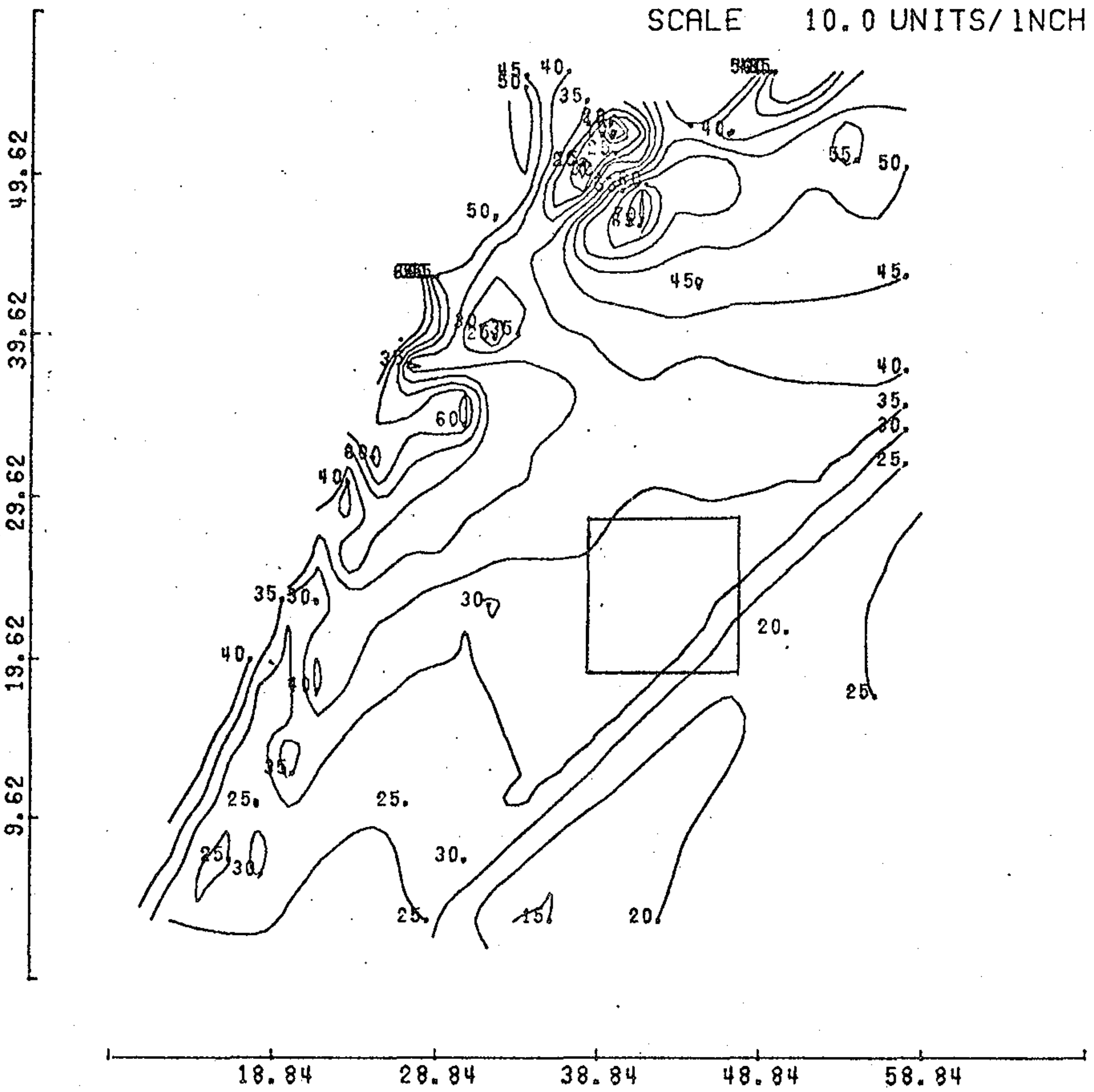


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 202.5 PERIOD= 12.0 SECONDS

HEIGHT= 6.0 FT.



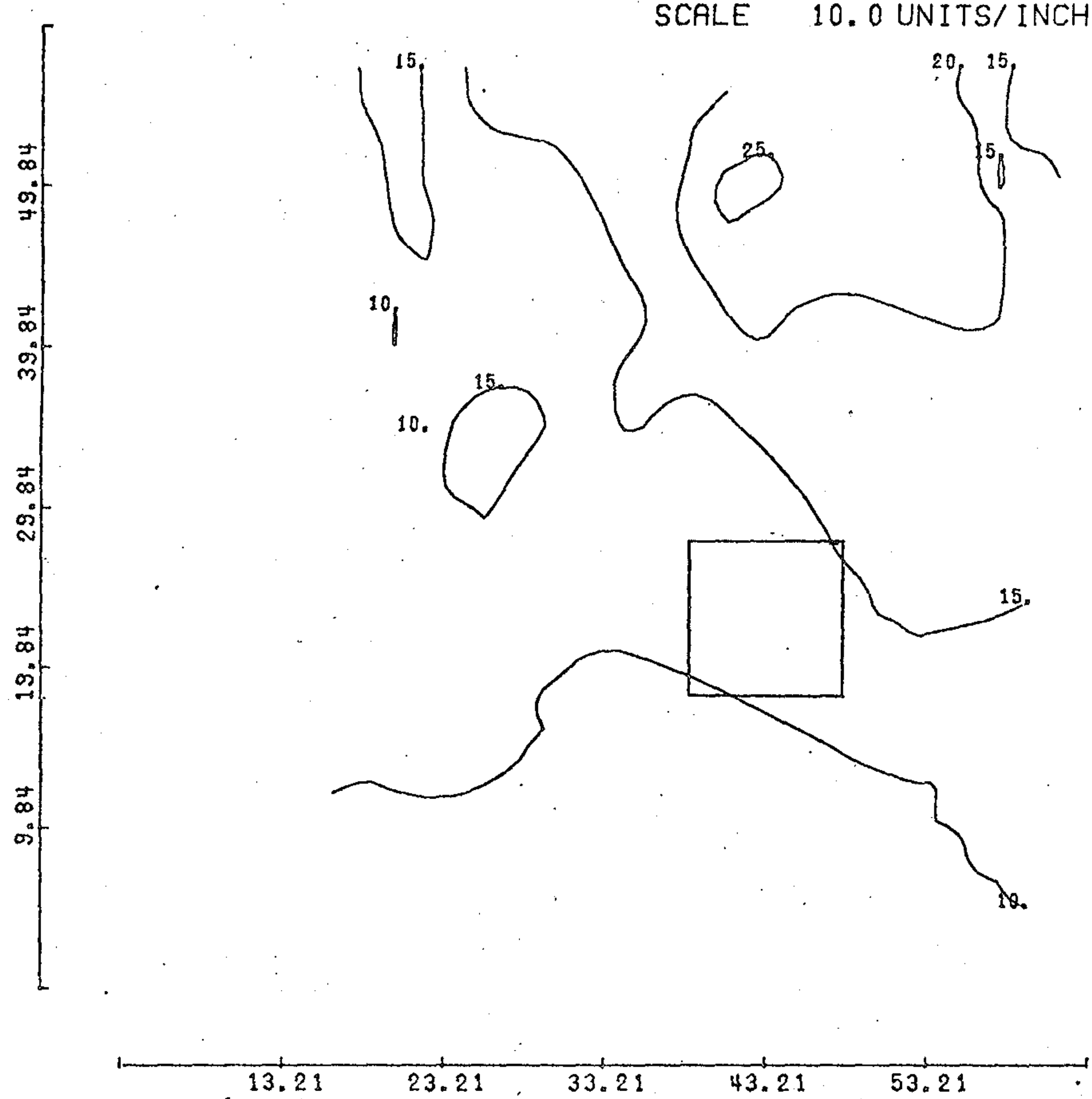
BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 12.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH

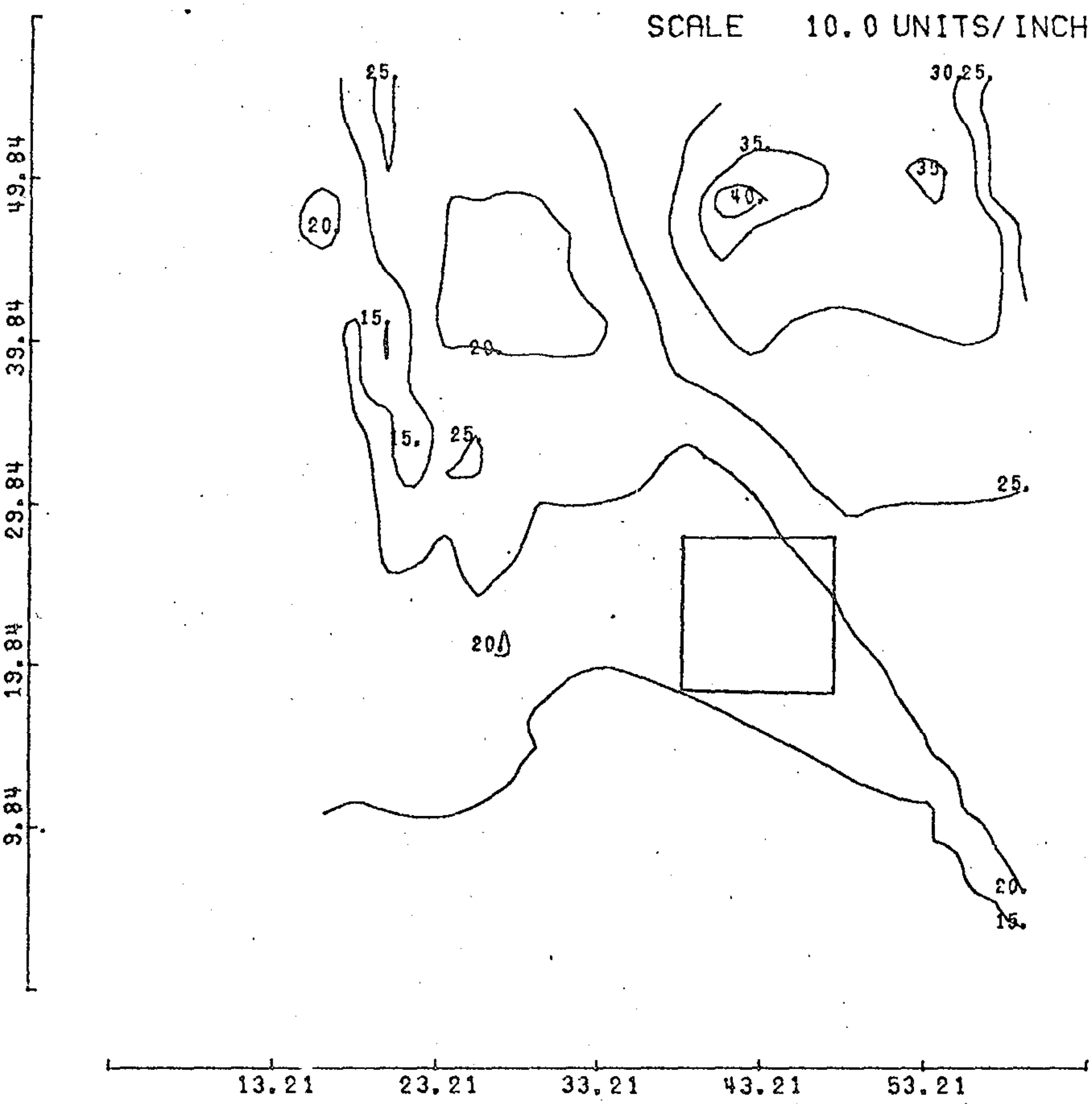


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 12.0 SECONDS

HEIGHT= 3.0 FT.

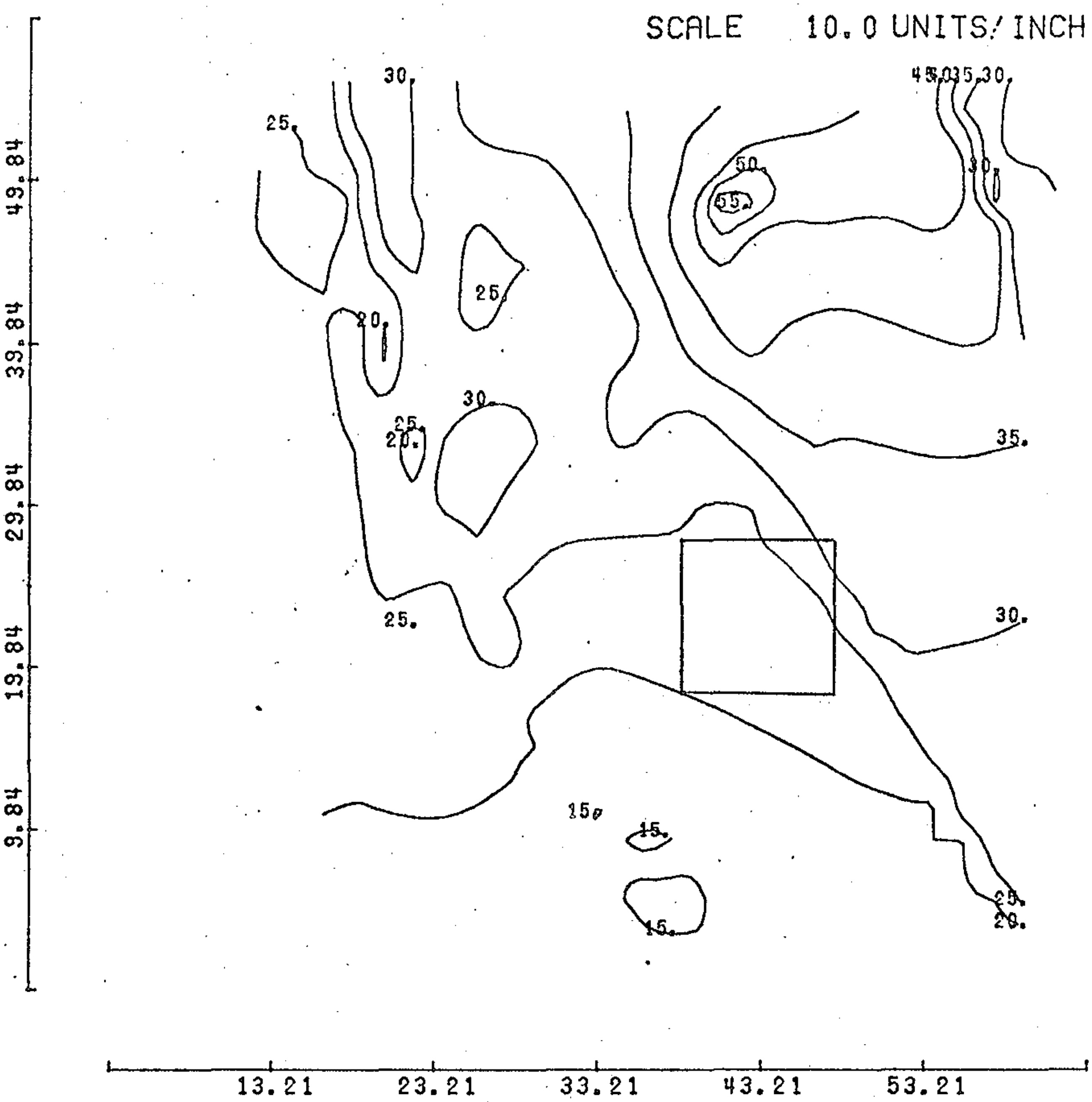


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 12.0 SECONDS

HEIGHT= 4.0 FT.

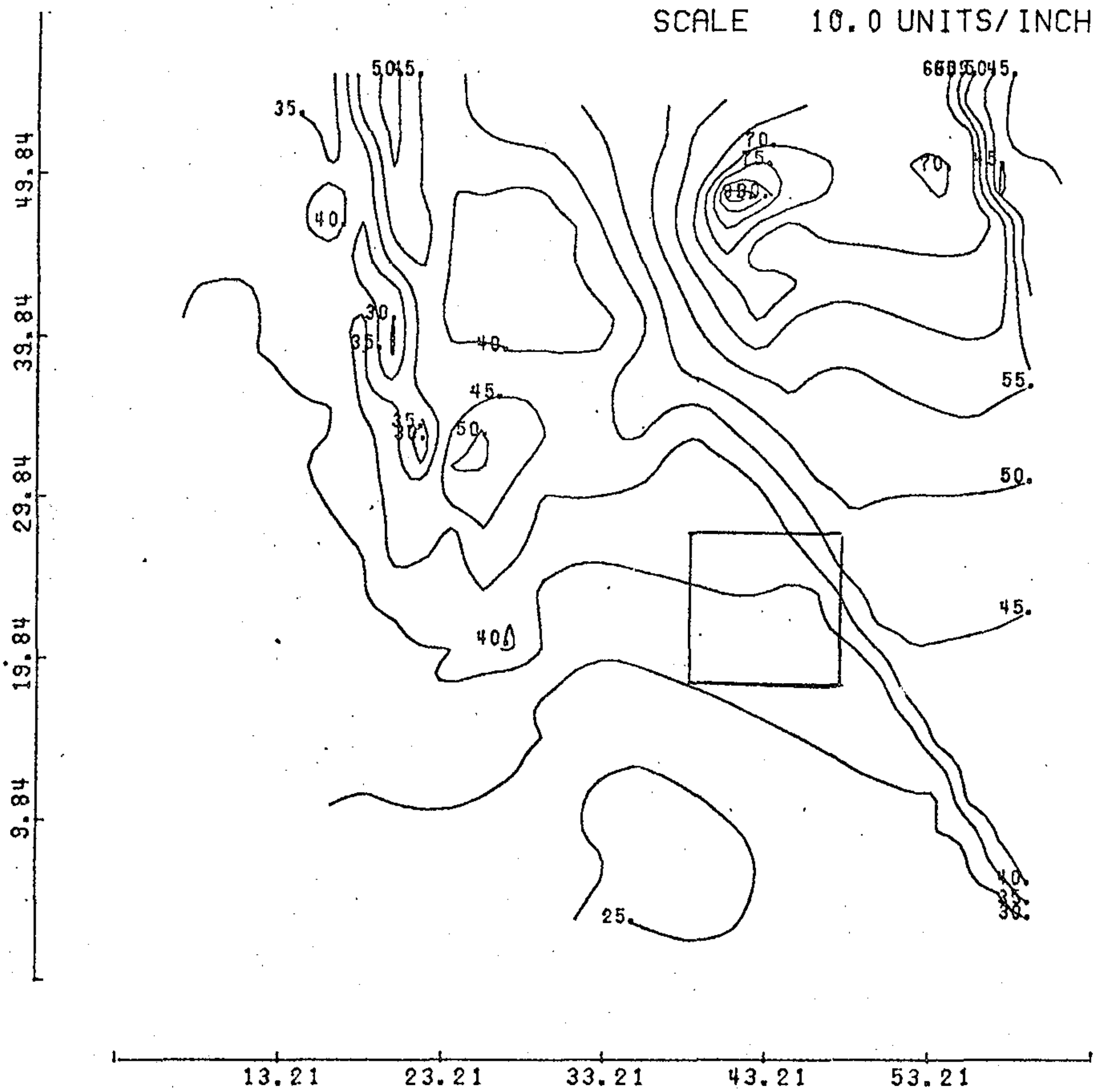


BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

DEEP WATER DIRECTION= 157.5 PERIOD= 12.0 SECONDS

HEIGHT= 6.0 FT.



BROWNS LEDGE AREA

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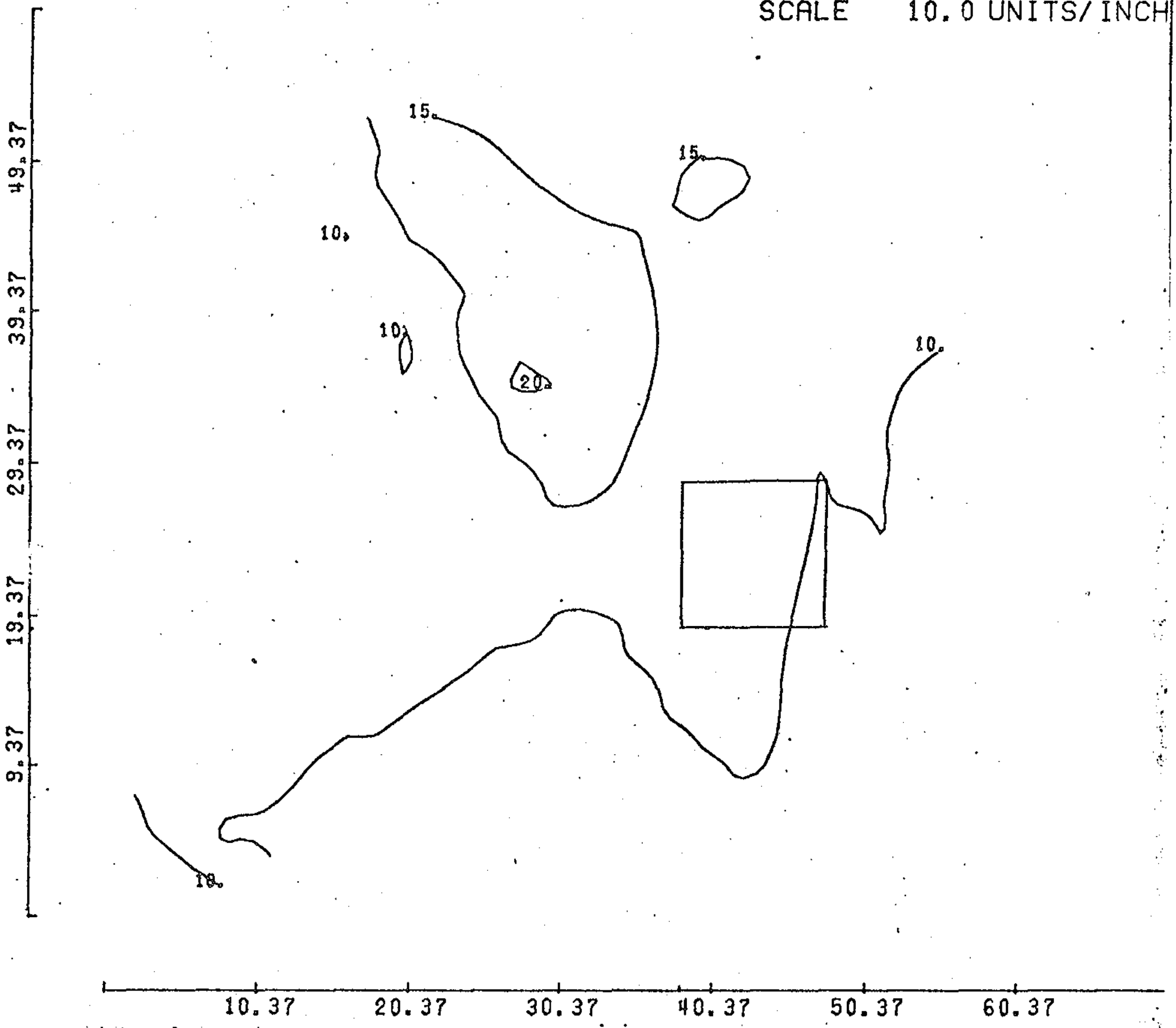
DEEP WATER DIRECTION= 135.0 PERIOD= 12.0 SECONDS

HEIGHT= 2.0 FT.

SCALE 10.0 UNITS/INCH



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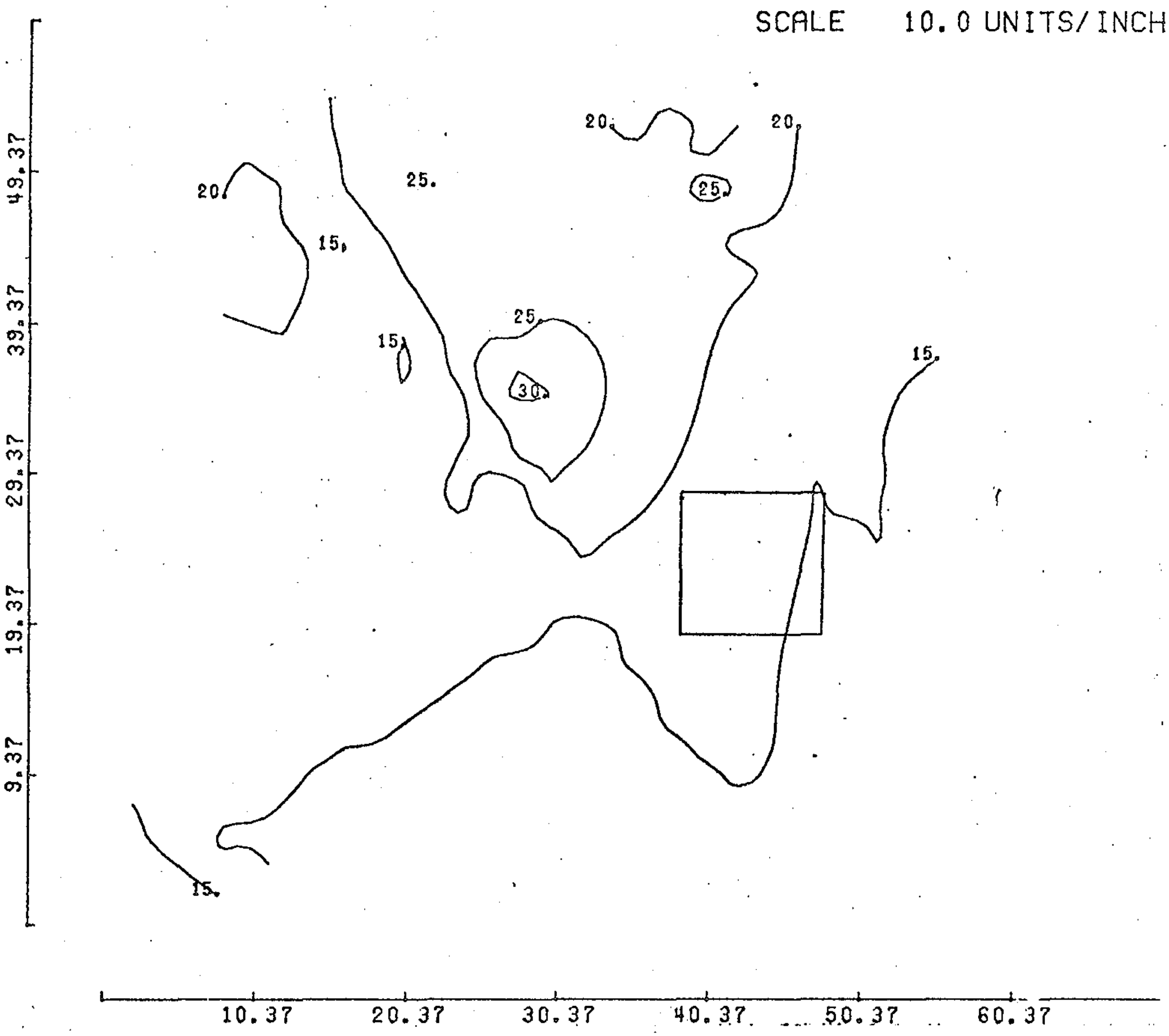
HEIGHT= 3.0 FT.



BROWNS LEDGE AREA

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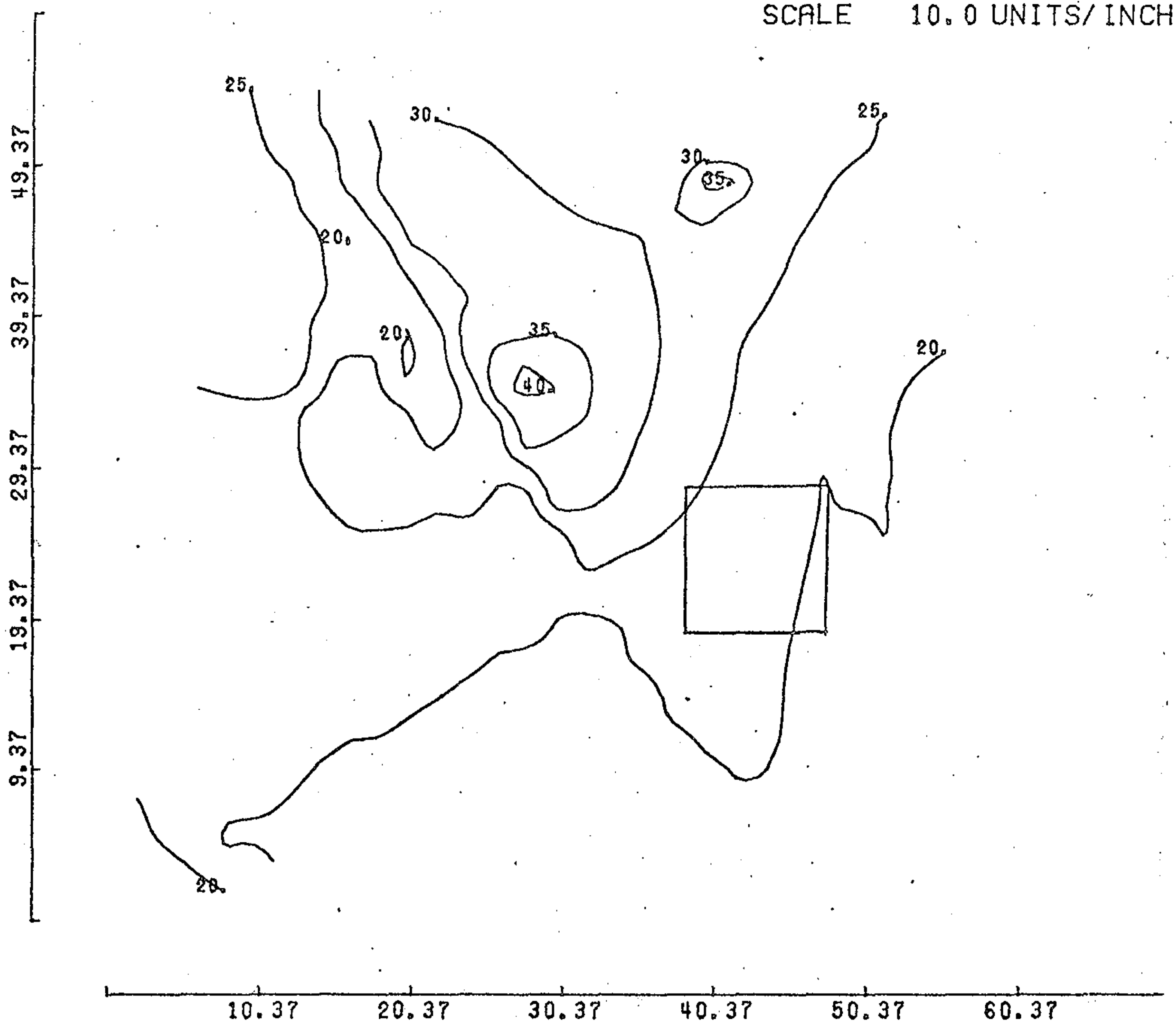
DEEP WATER DIRECTION= 135.0 PERIOD= 12.0 SECONDS

HEIGHT= 4.0 FT.

SCALE 10.0 UNITS/INCH



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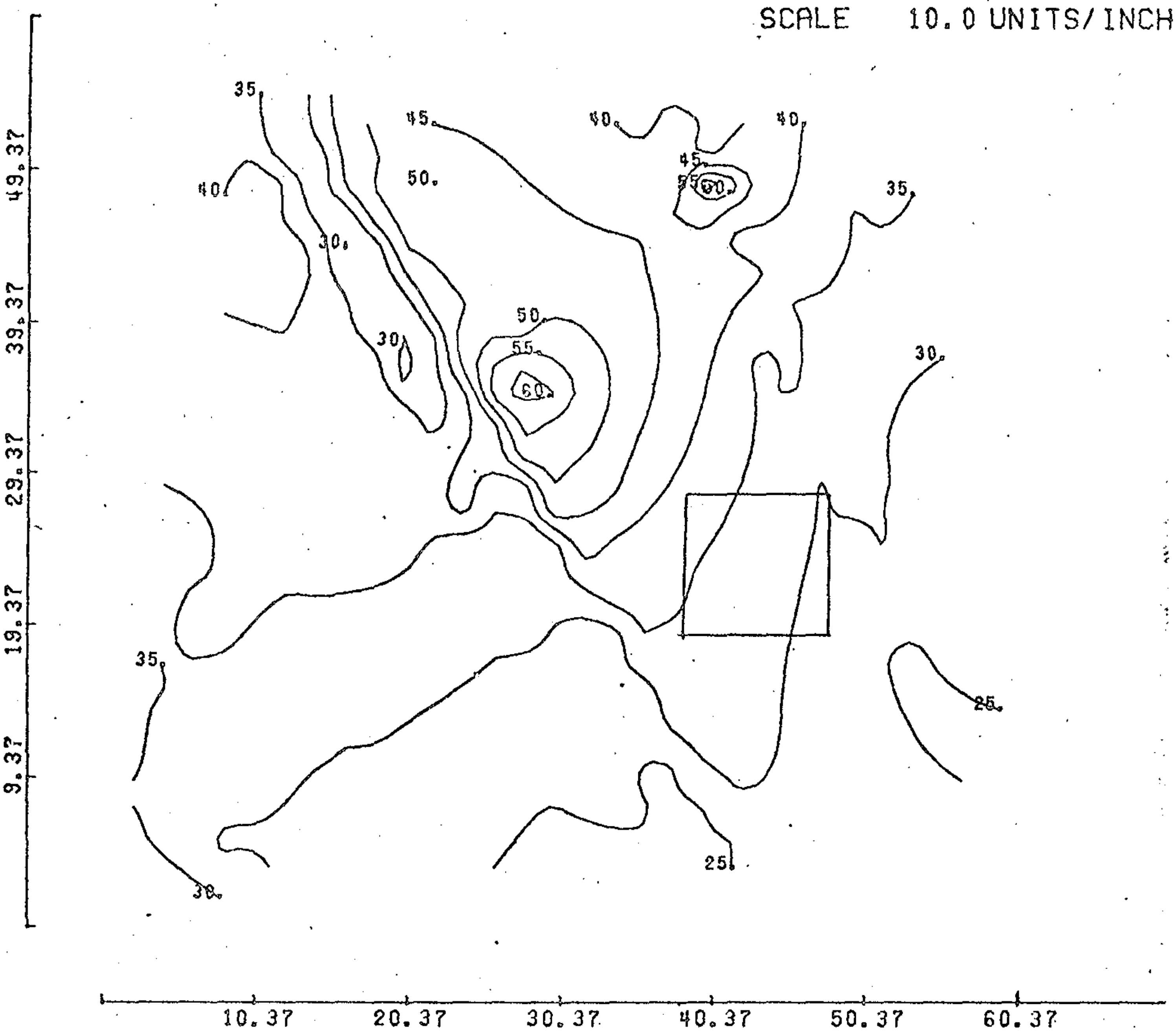
DEEP WATER DIRECTION= 135.0 PERIOD= 12.0 SECONDS

HEIGHT= 6.0 FT.

SCALE 10.0 UNITS/INCH



BROWNS LEDGE AREA

LINEAR WAVE GENERATED BOTTOM VELOCITIES (CM/SEC)

SECTION 2

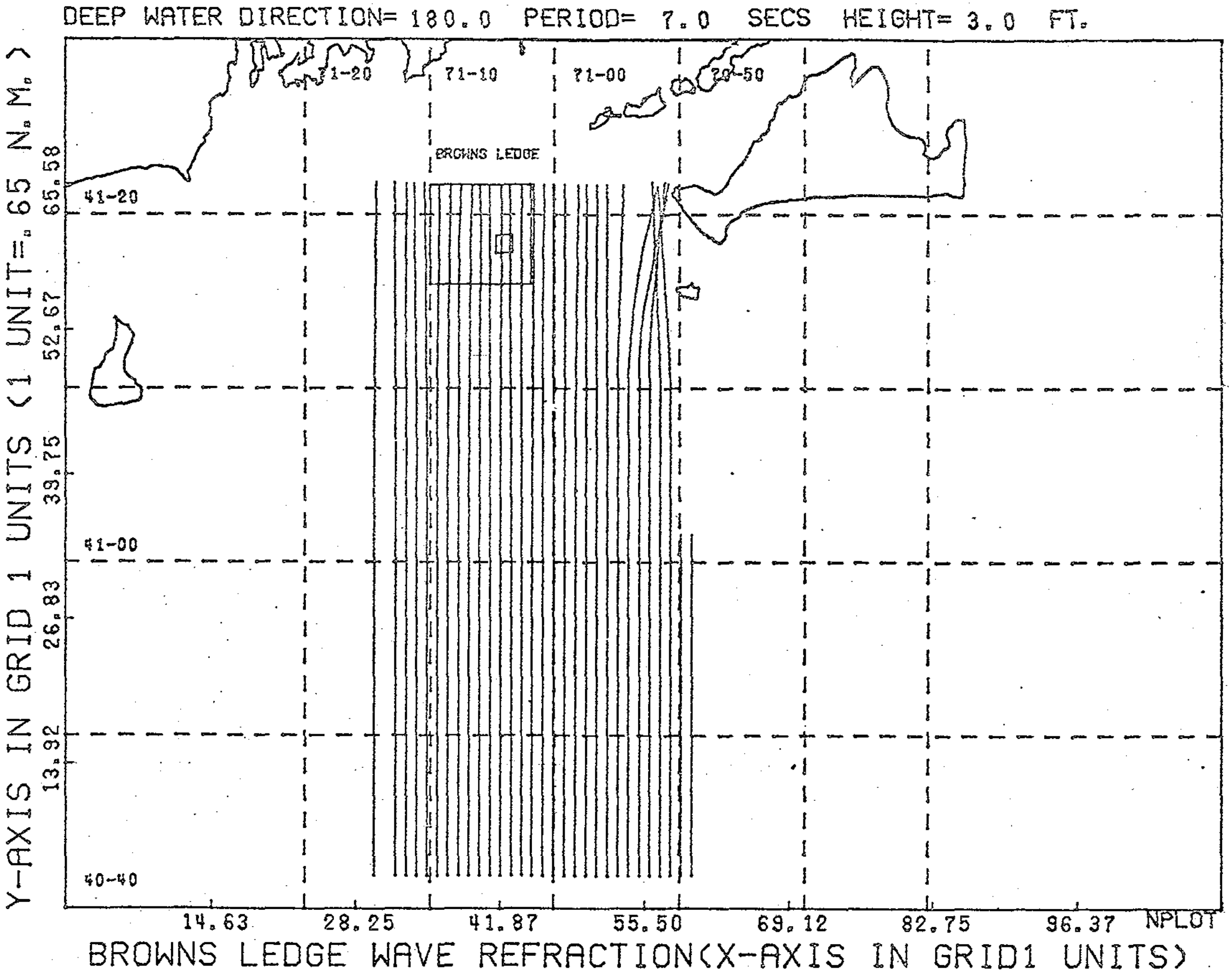
Wave Refraction Diagram

(Computer Plotted Wave Rays)

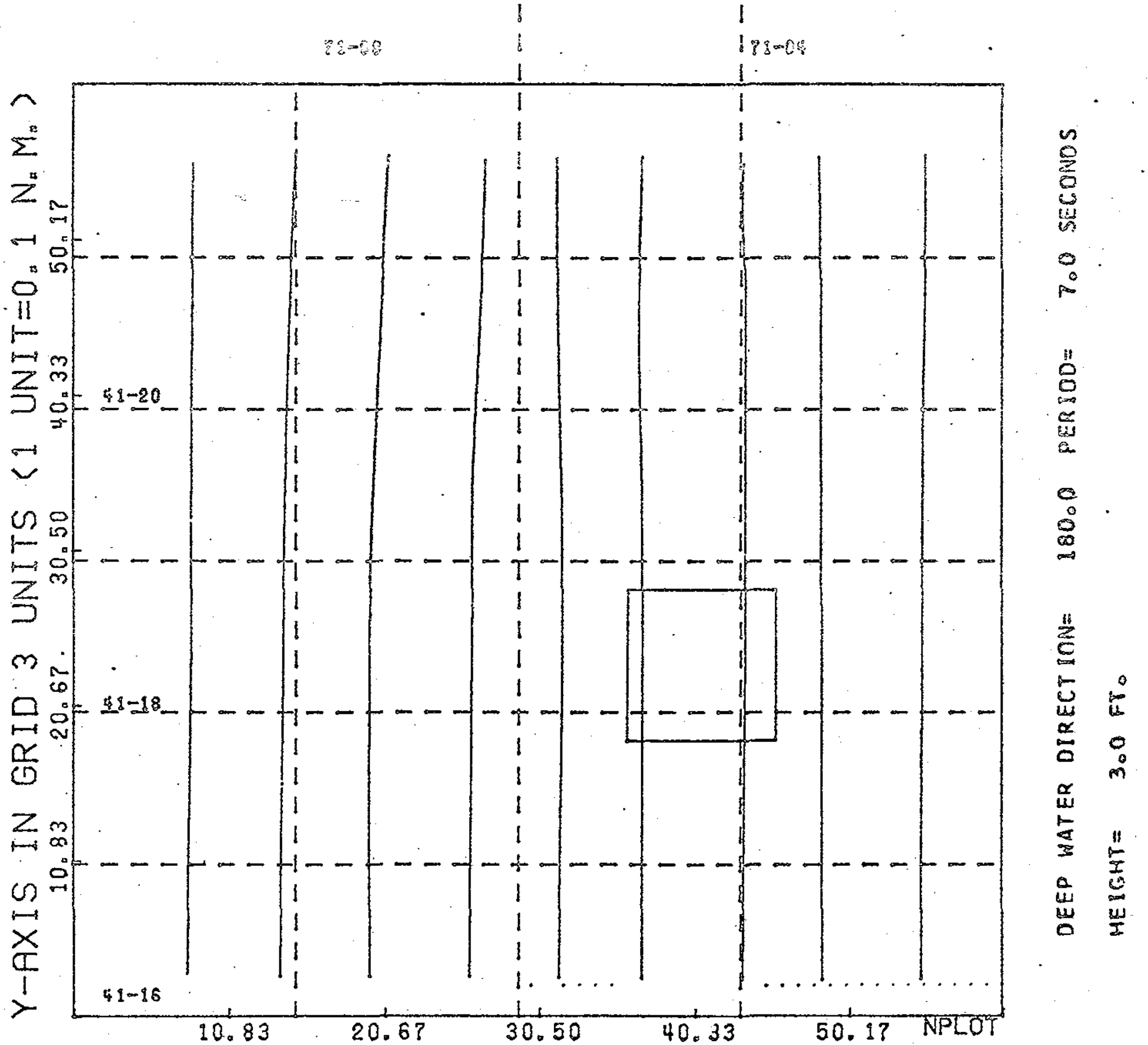
WAVE PLOTS

FOR 7.0 SECOND WAVE PERIODS

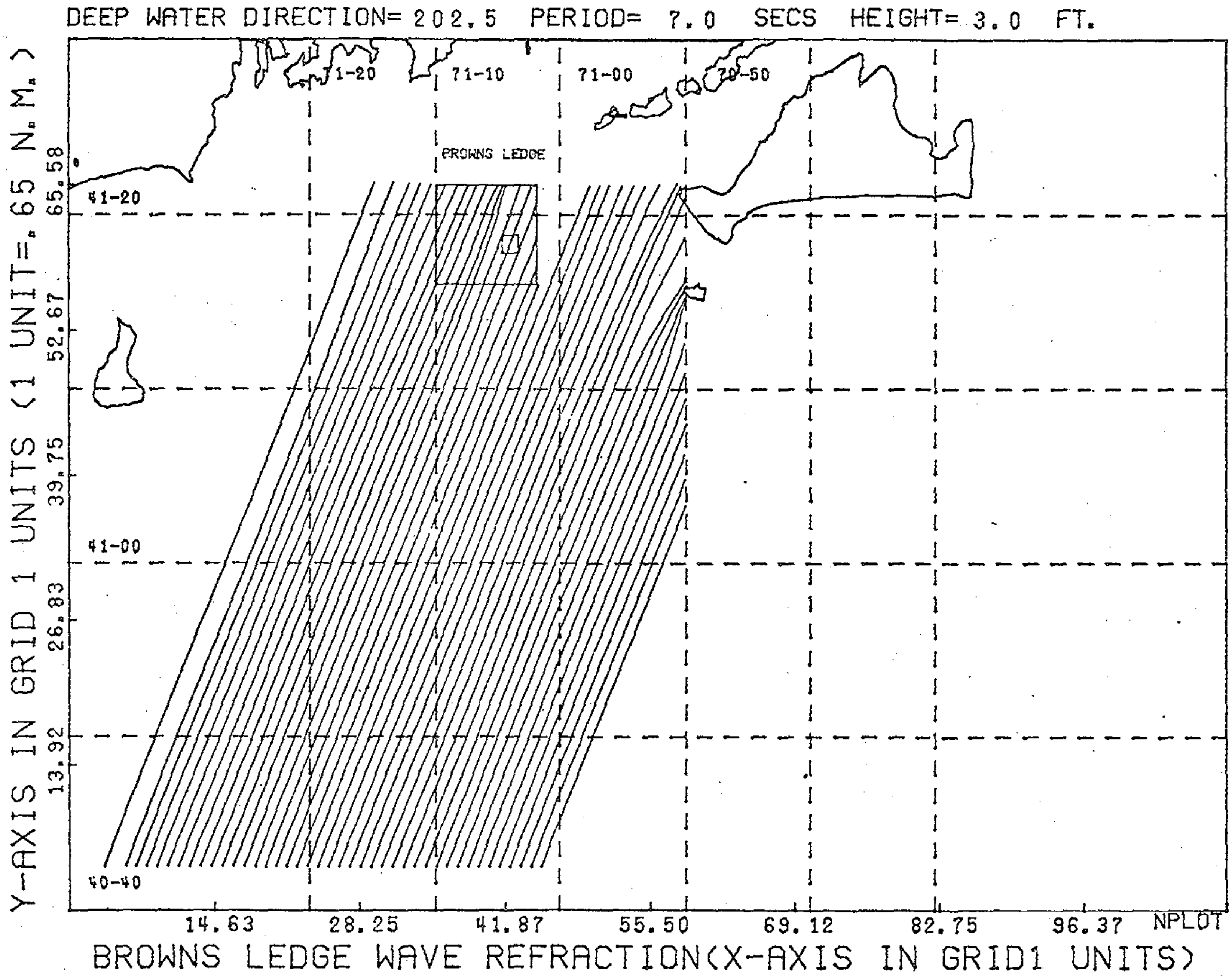
						Deep Water Wave Heights
1.) Direction = 180°						
	Main	-	Sub	-	Contours	- 3.0 Ft.
2.) Direction = 202.5°						
	Main	-	Sub	-	Contours	- 3.0 Ft.
3.) Direction = 225° - Main						
4.) Direction = 157.5°						
	Main	-	Sub	-	Contours	- 3.0 Ft.
5.) Direction = 135°						
	Main	-	Sub	-	Contours	- 3.0 Ft.
6.) Direction = 90° - Main						

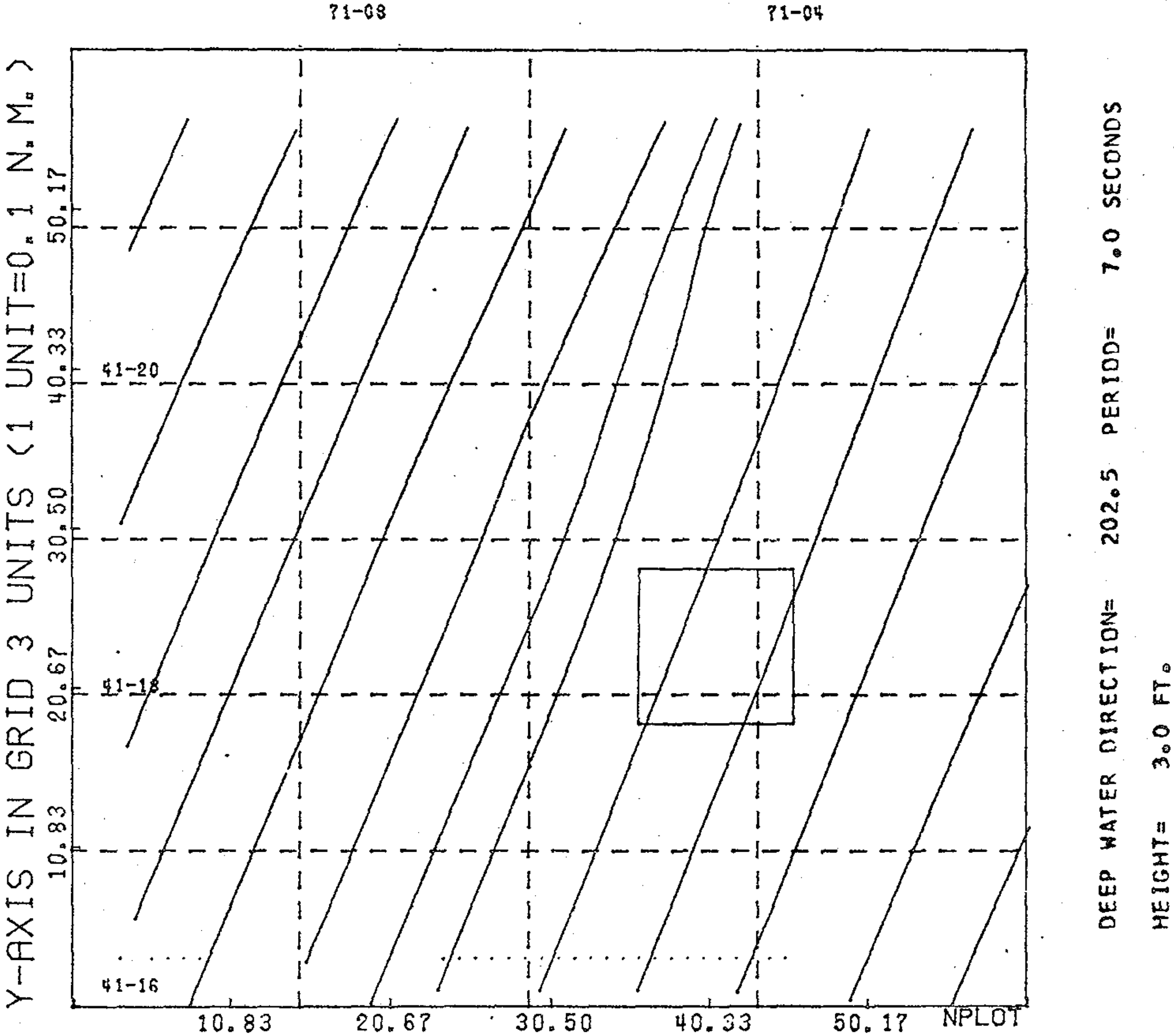

DEEP WATER DIRECTION= 180.0 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-3



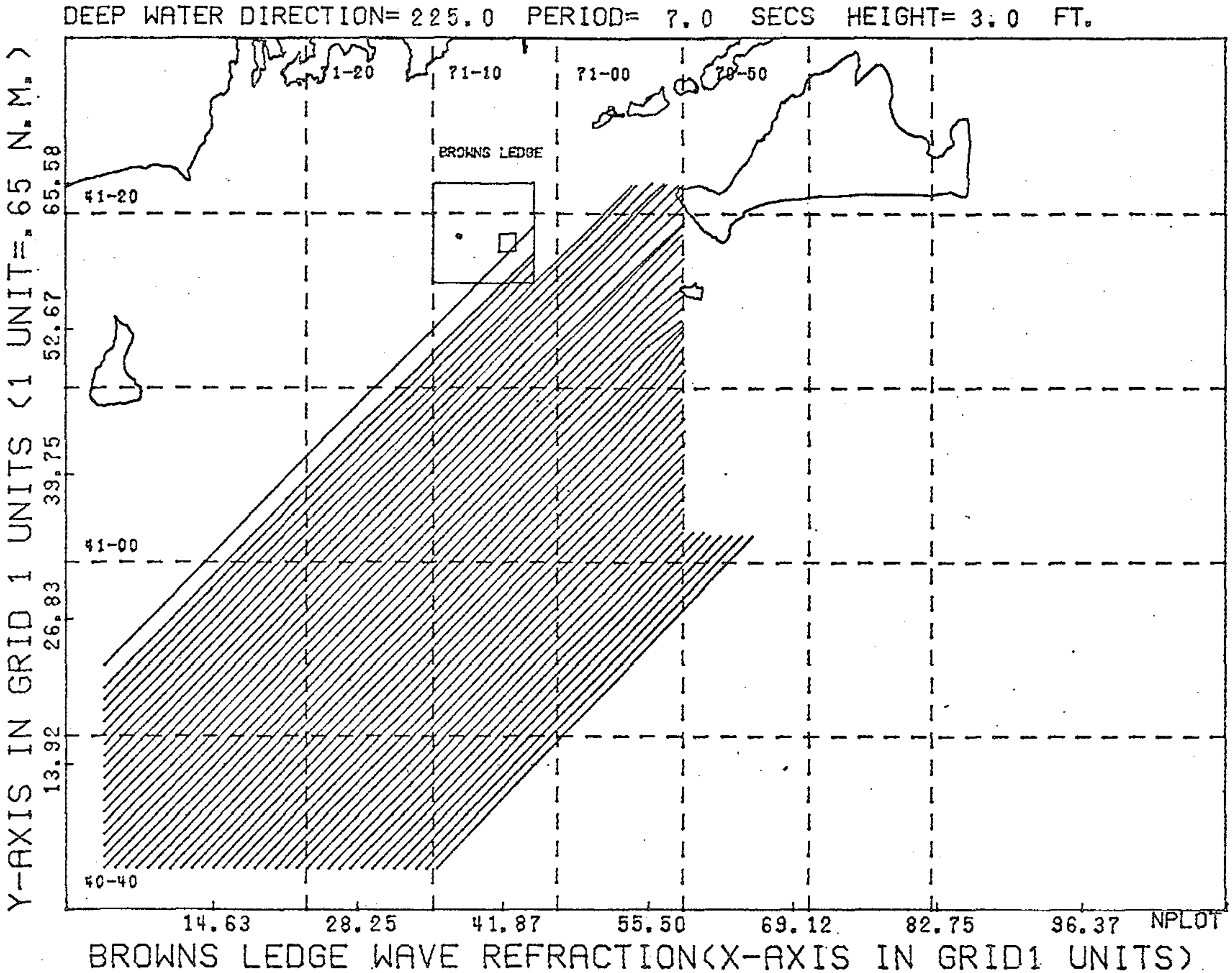
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

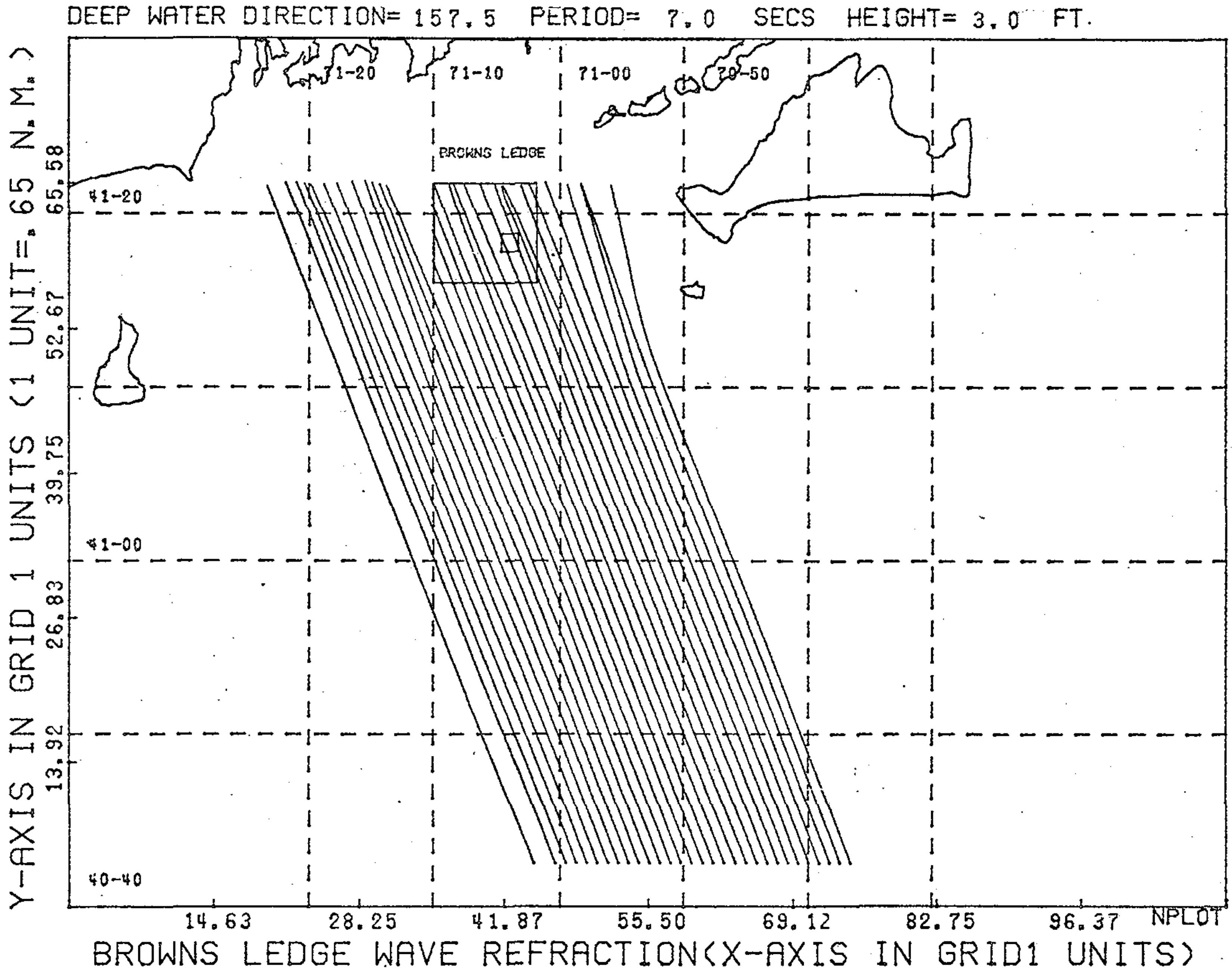

DEEP WATER DIRECTION= 202.5 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

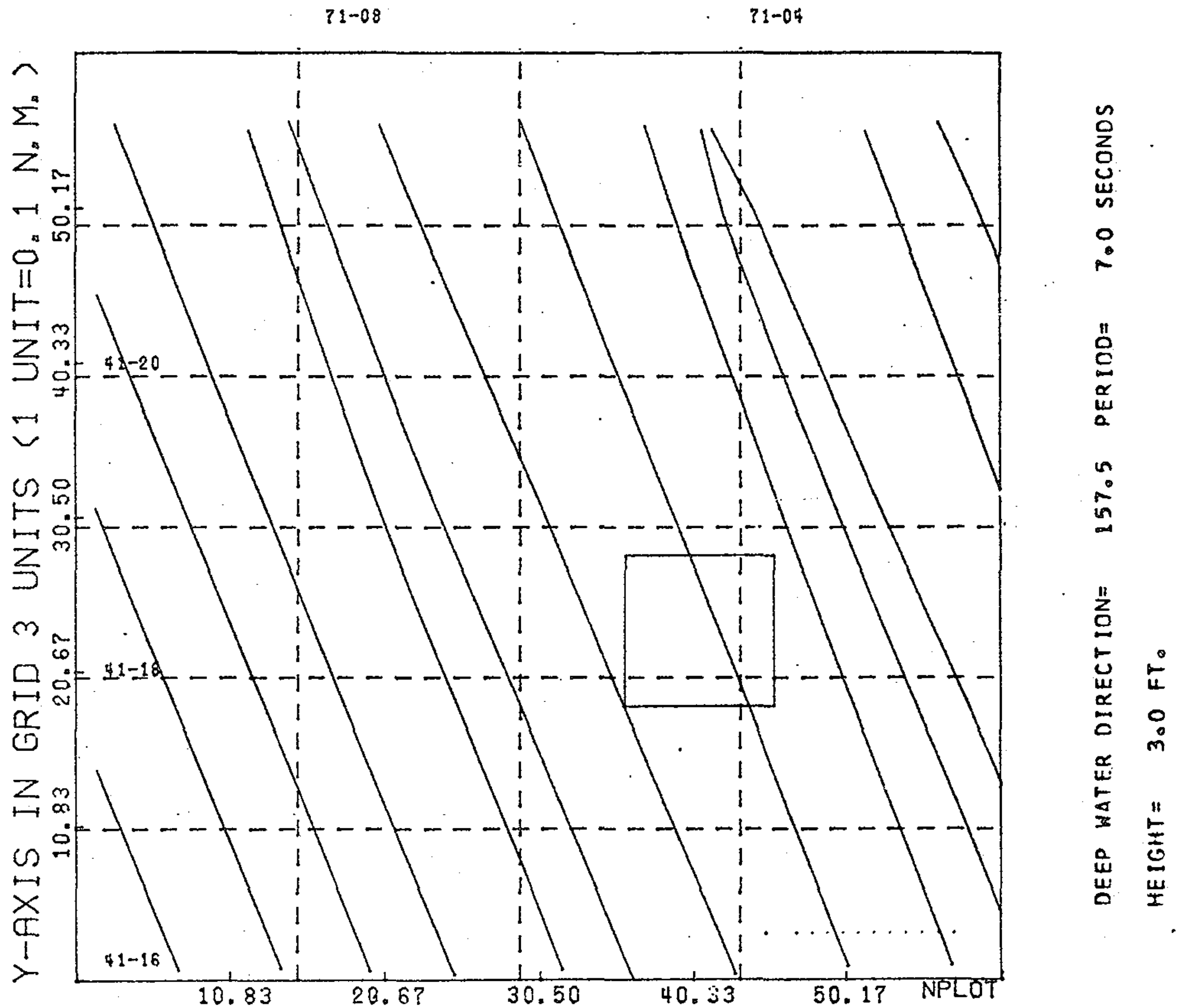


BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-6

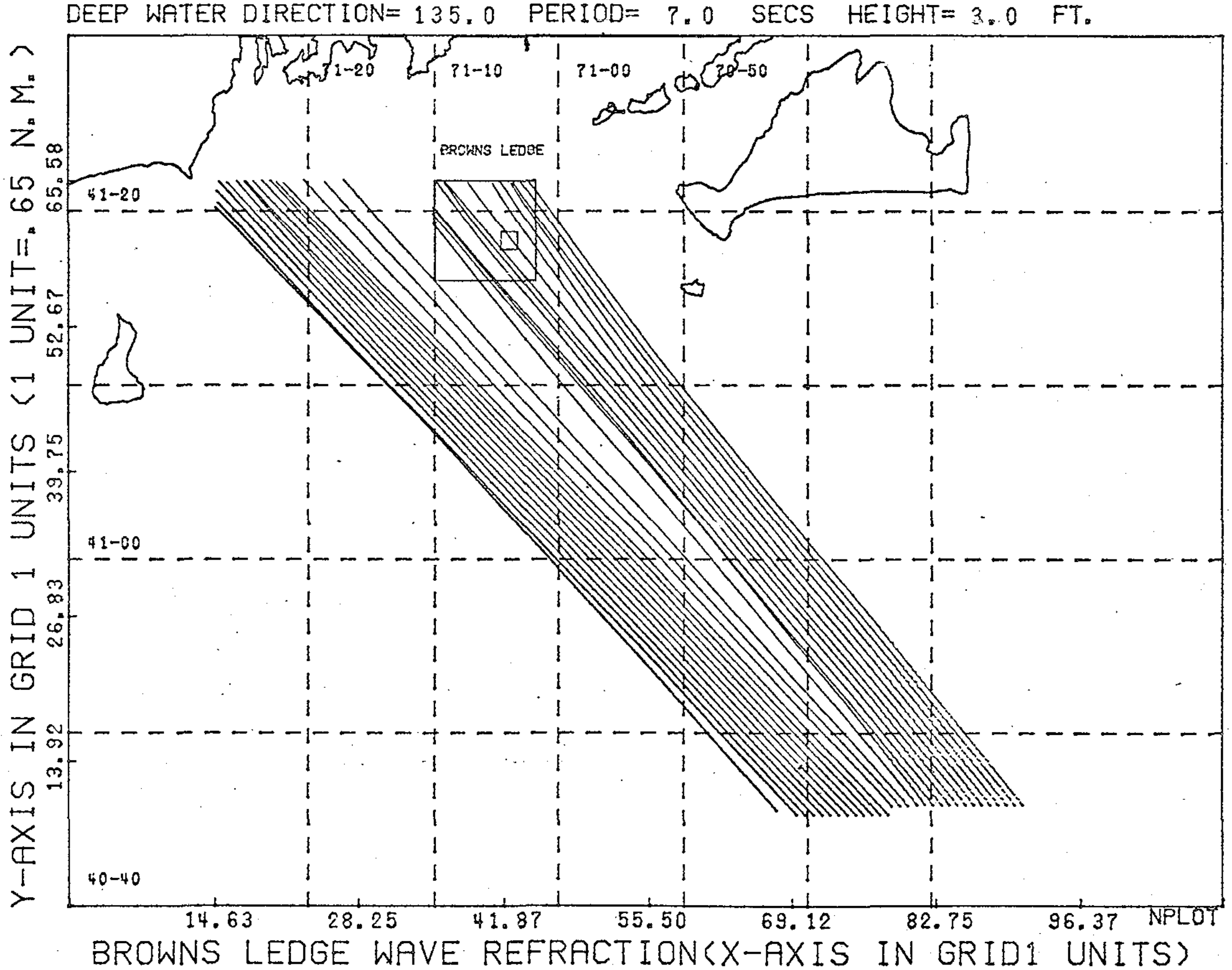

DEEP WATER DIRECTION= 225.0 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)


DEEP WATER DIRECTION= 157.5 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



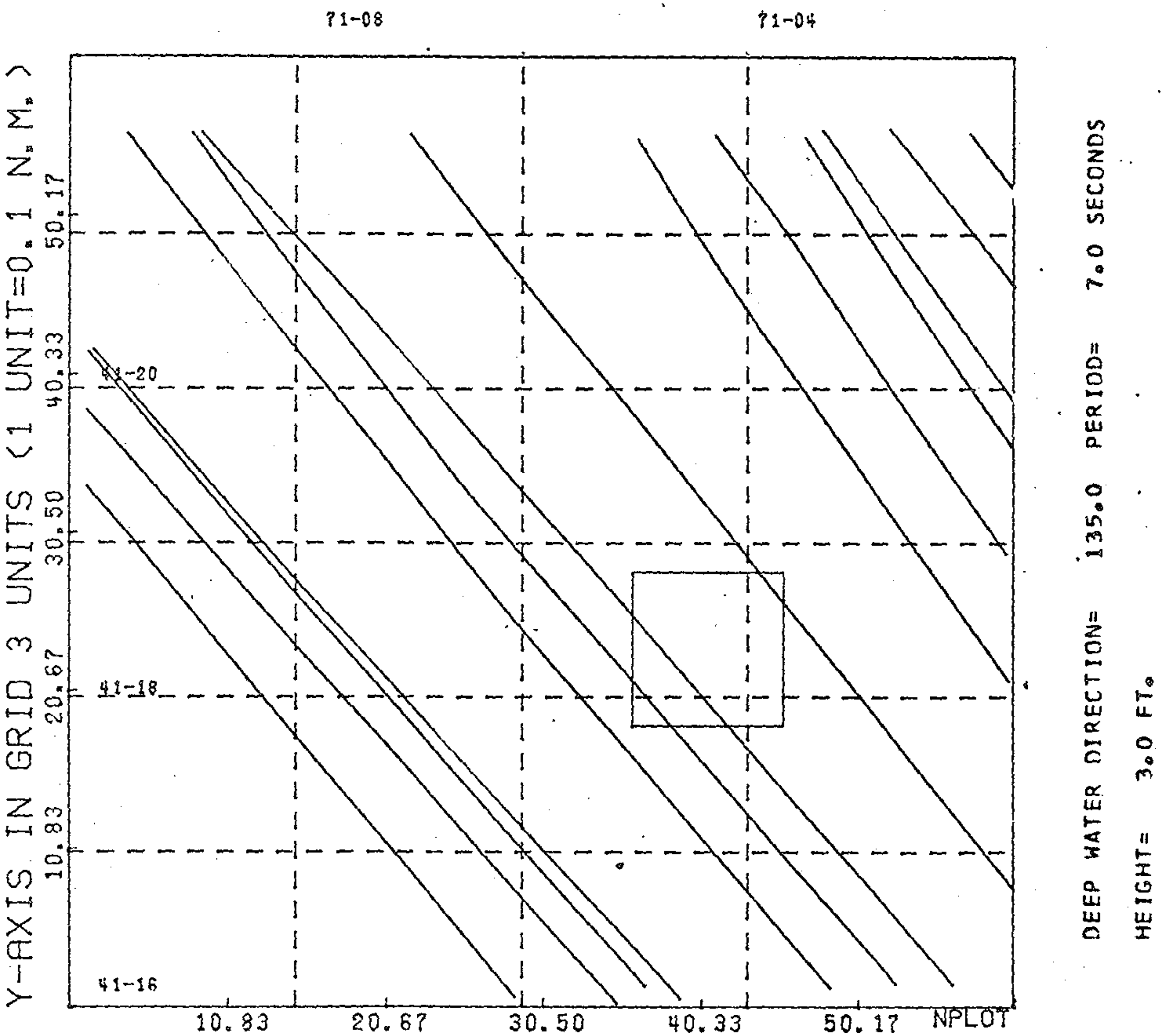
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-9

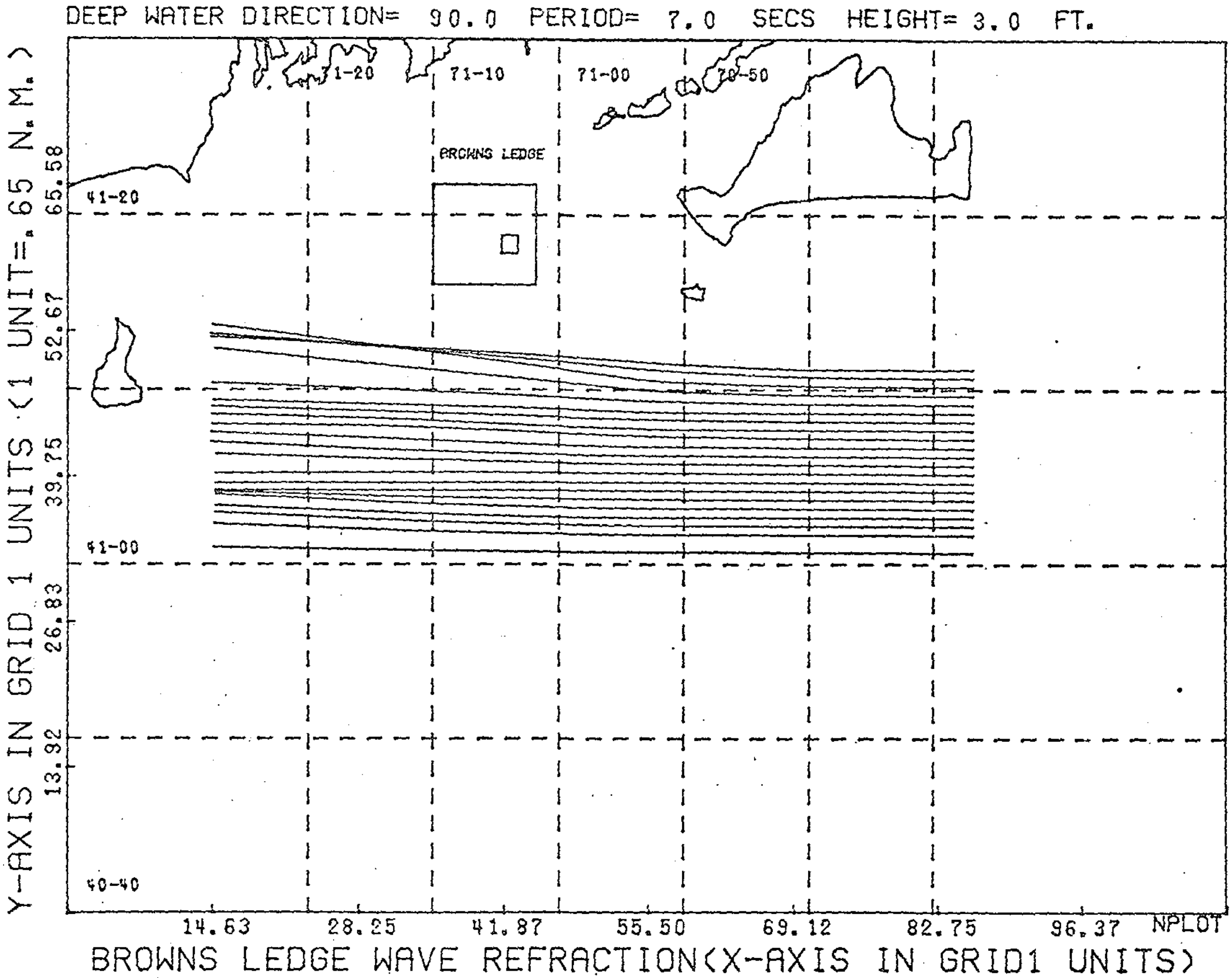


DEEP WATER DIRECTION= 135.0 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-10



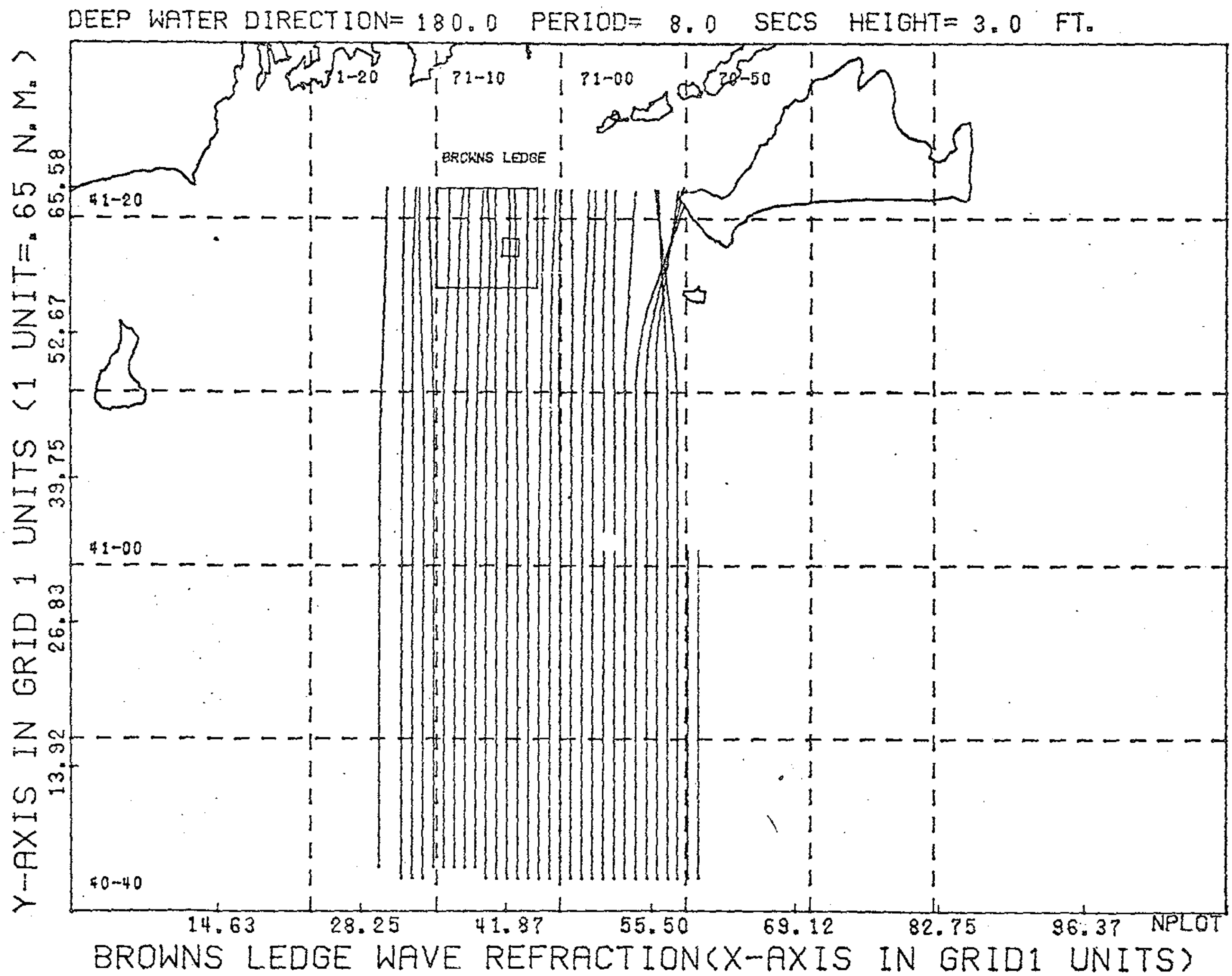
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

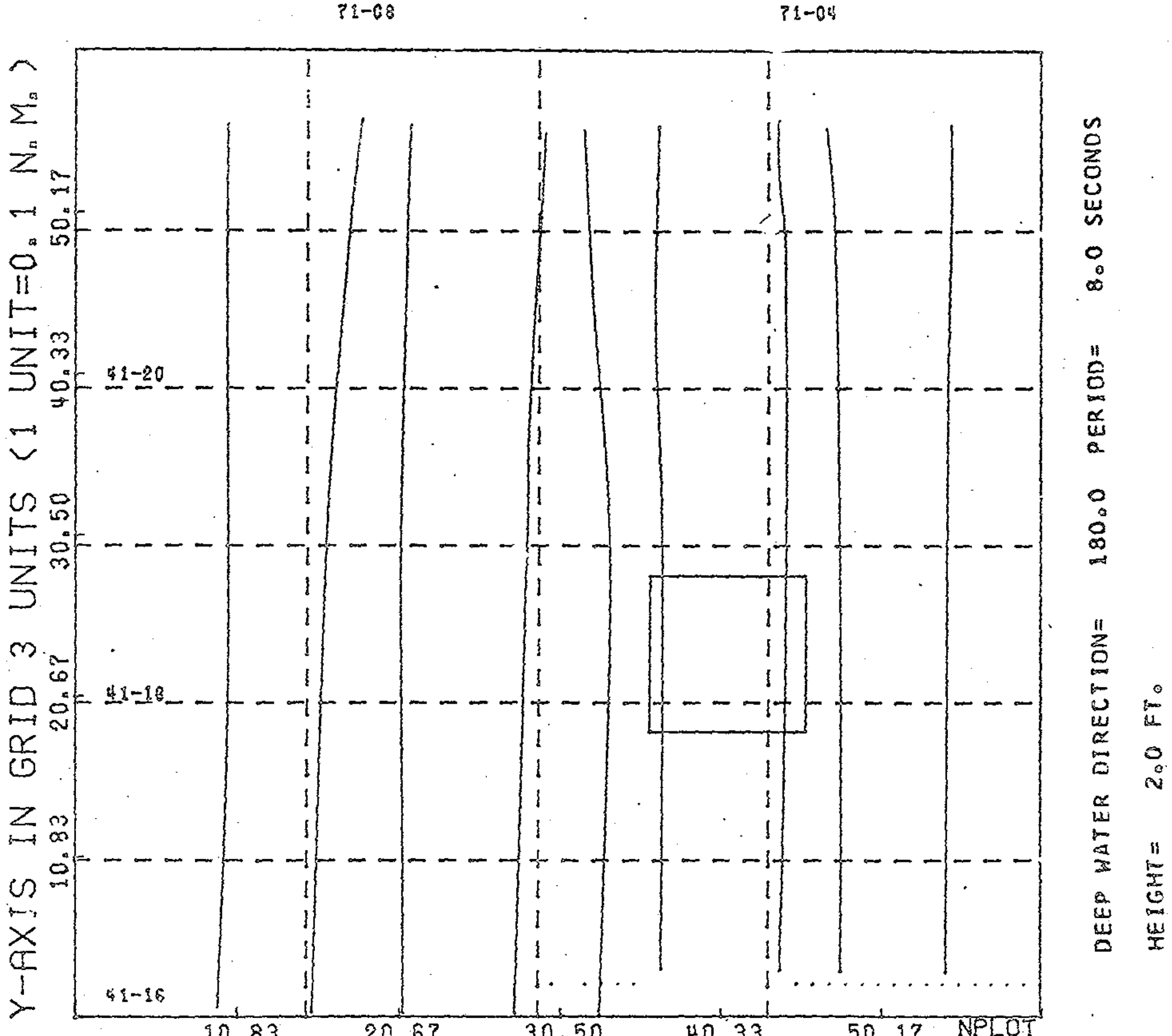

DEEP WATER DIRECTION= 90.0 PERIOD= 7.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

WAVE PLOTS

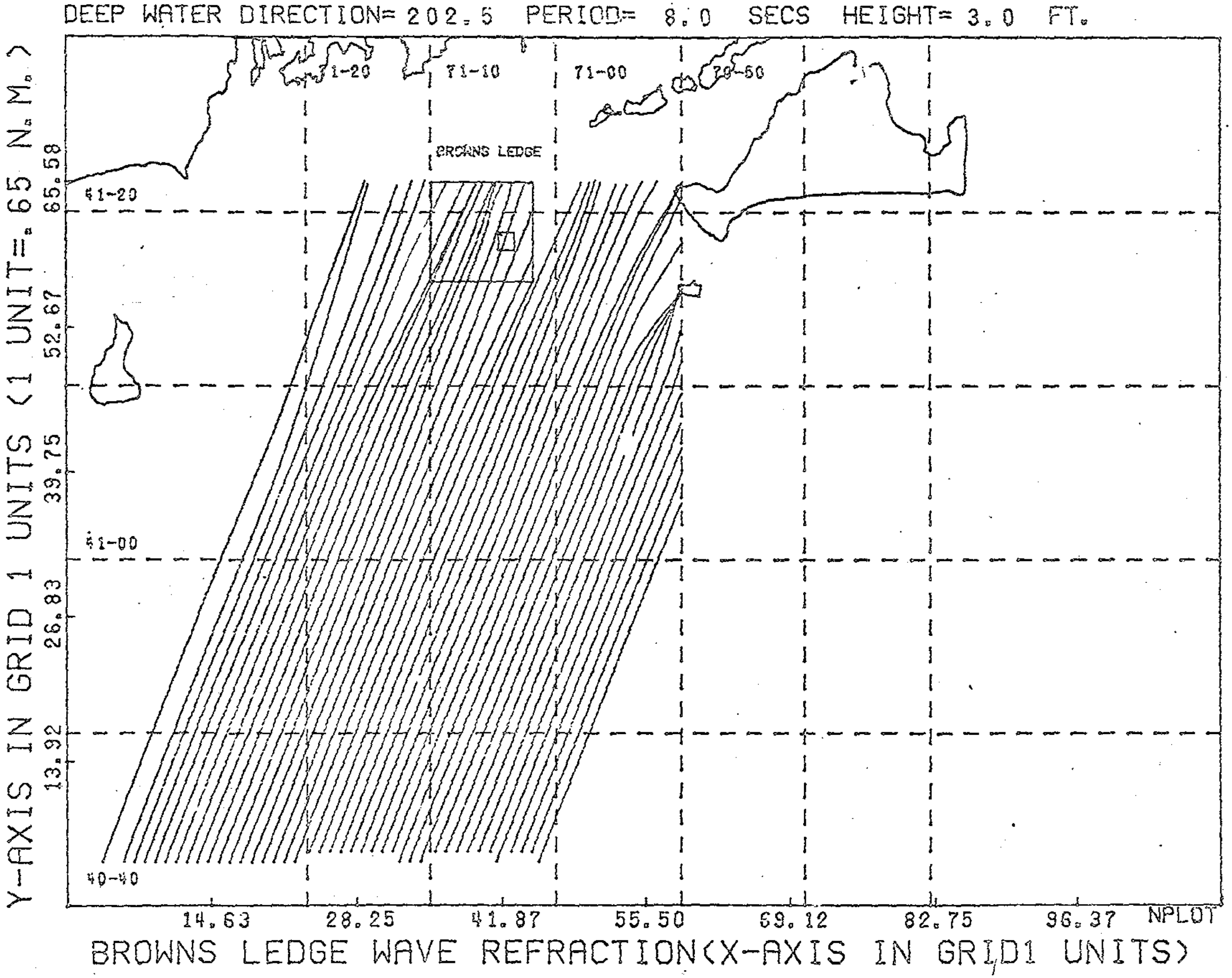
FOR 8.0 SECOND WAVE PERIODS

							Deep Water Wave Heights
1.)	Direction	=	180°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
2.)	Direction	=	202.5°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
3.)	Direction	=	157.5°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
4.)	Direction	=	225°	-	Main		
5.)	Direction	=	135°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
6.)	Direction	=	112.5°	-	Main		
7.)	Direction	=	90°	-	Main		

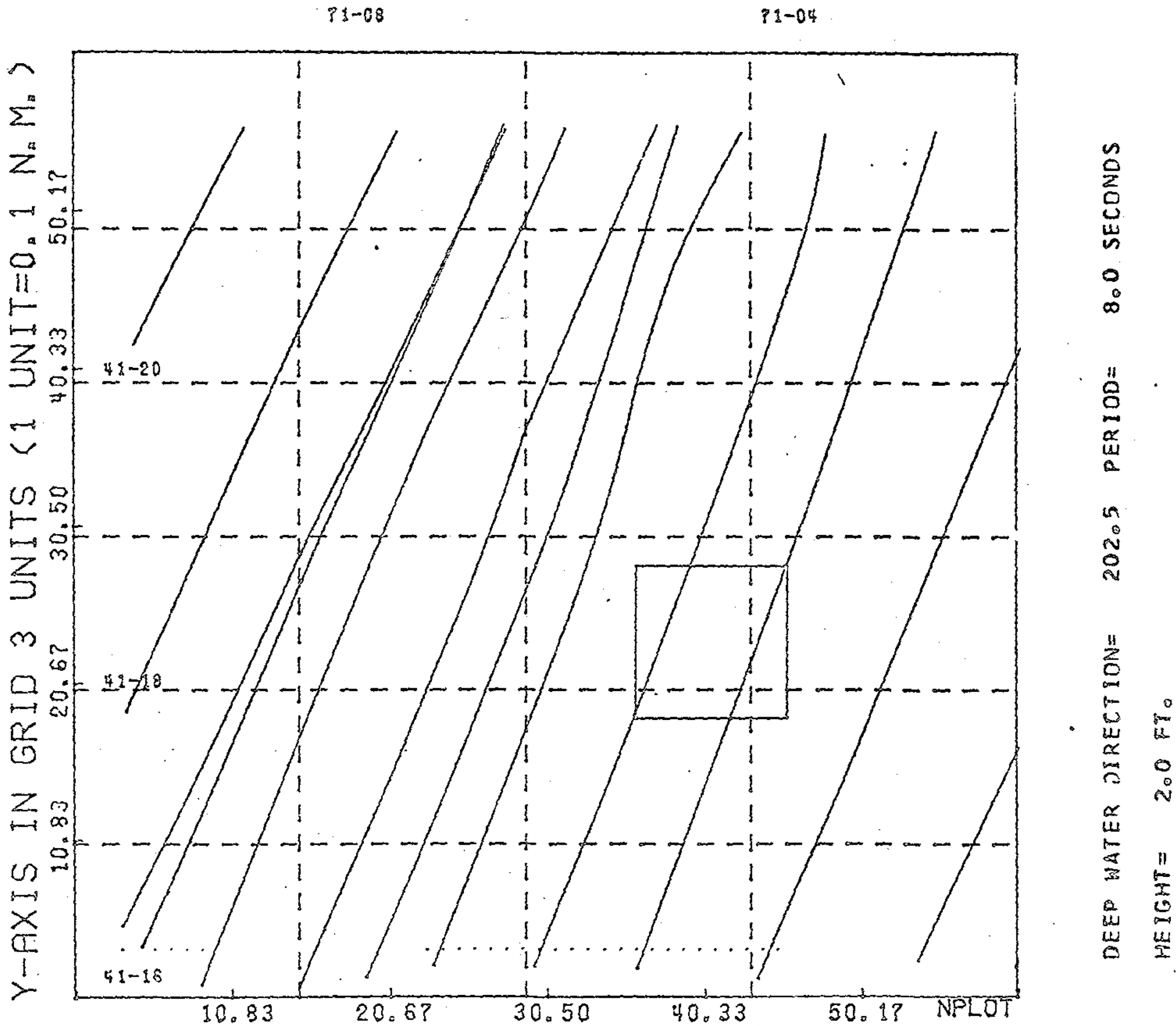

DEEP WATER DIRECTION= 180.0 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



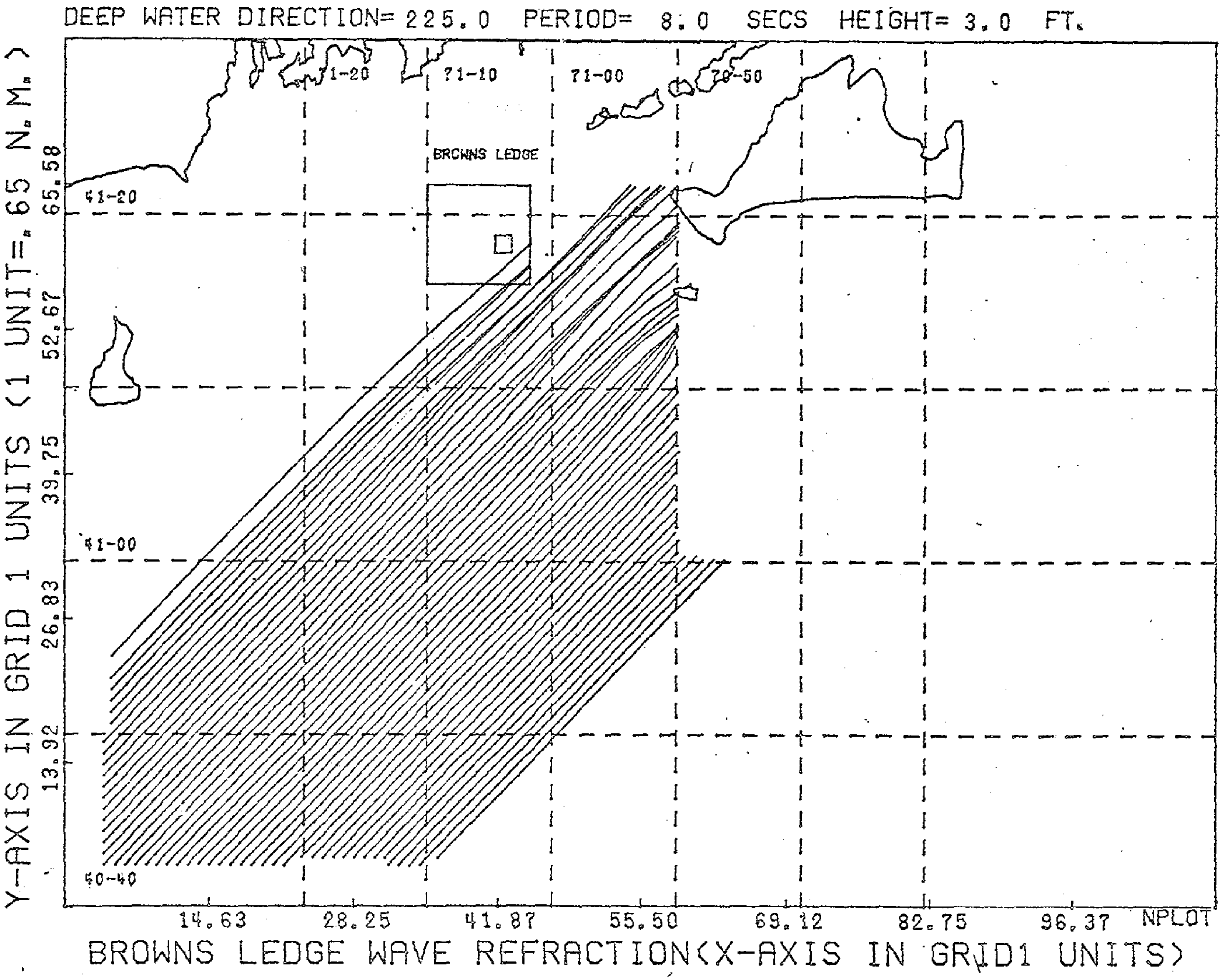
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)



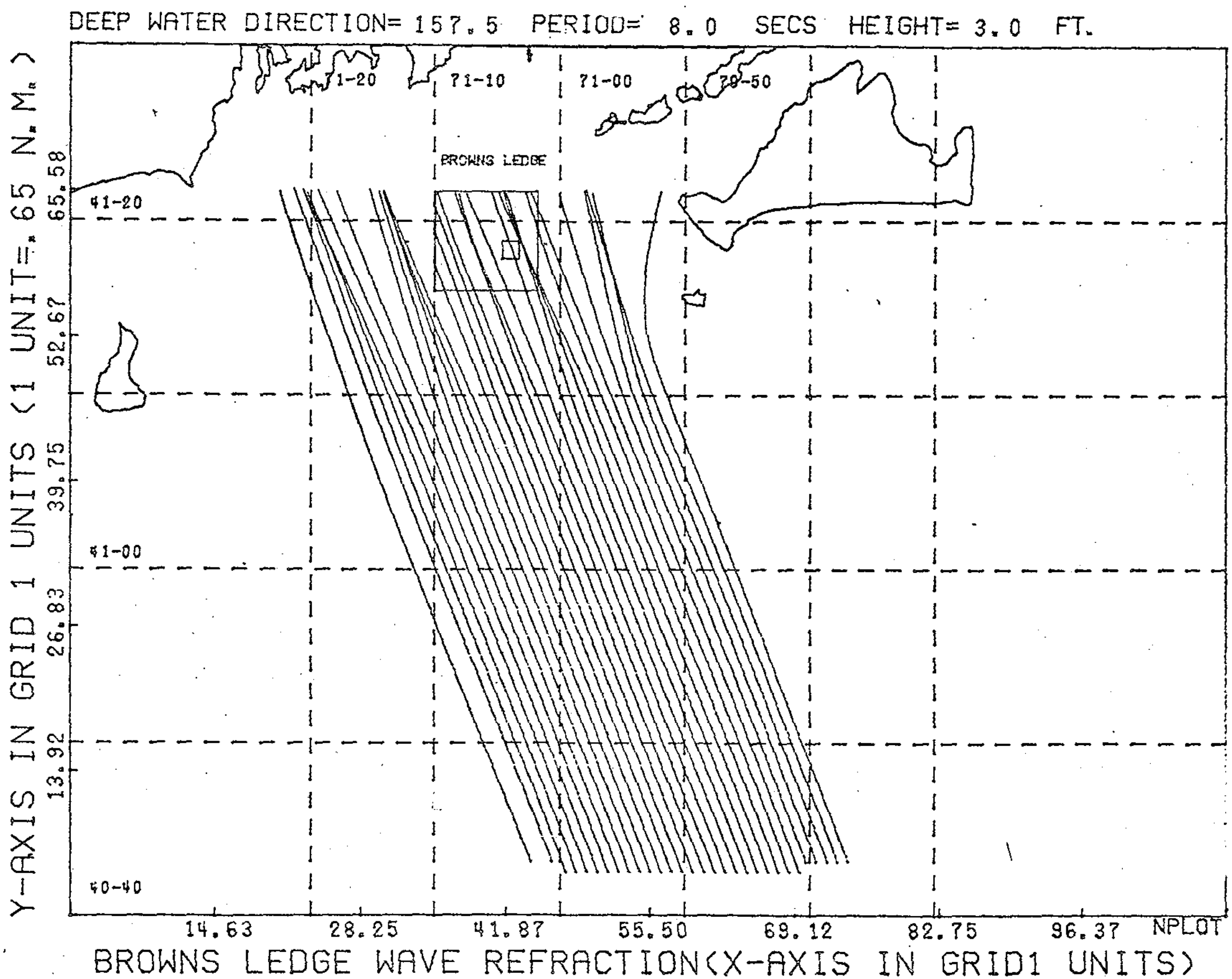
DEEP WATER DIRECTION= 202.5 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

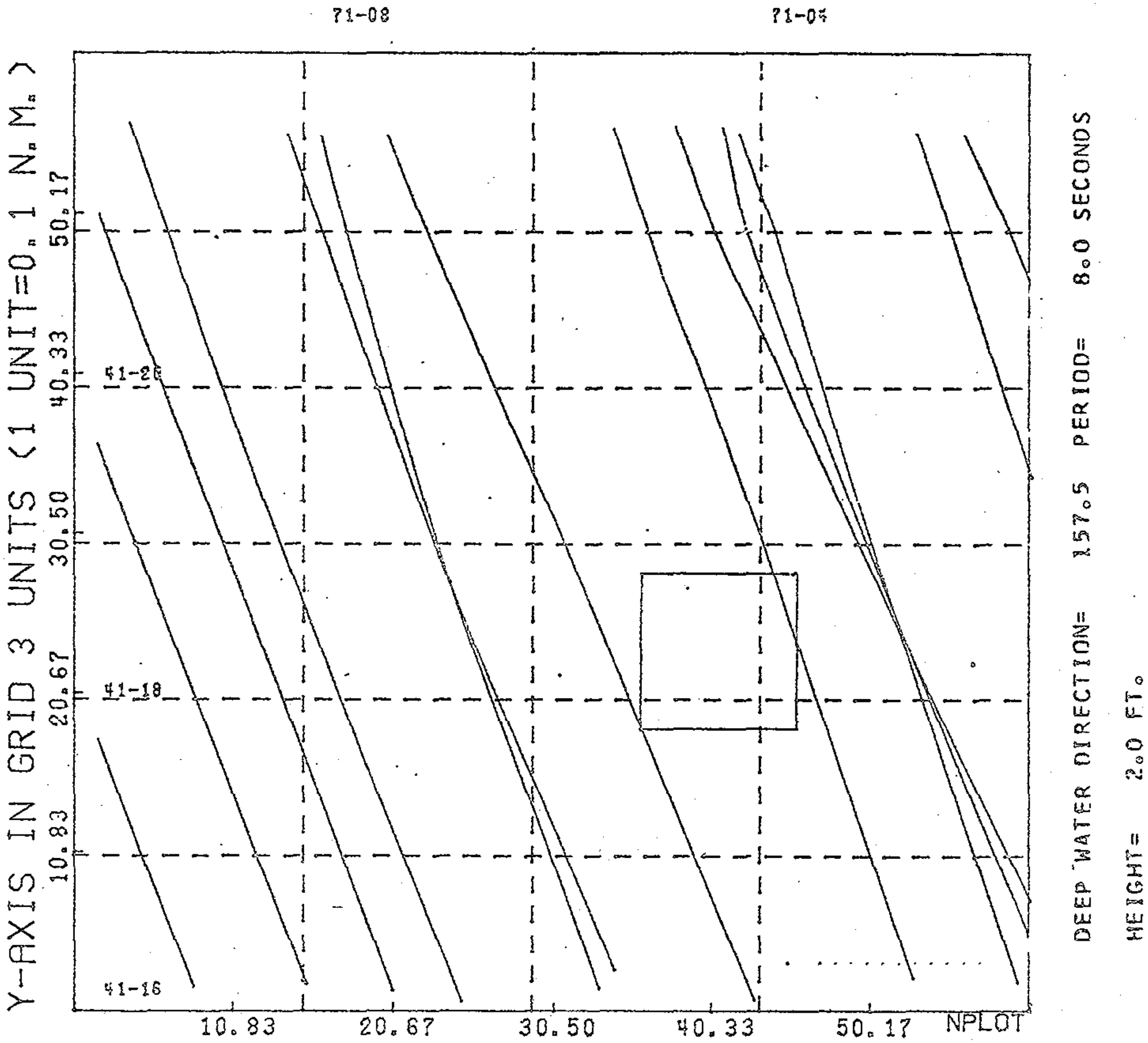

DEEP WATER DIRECTION= 225.0 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-18

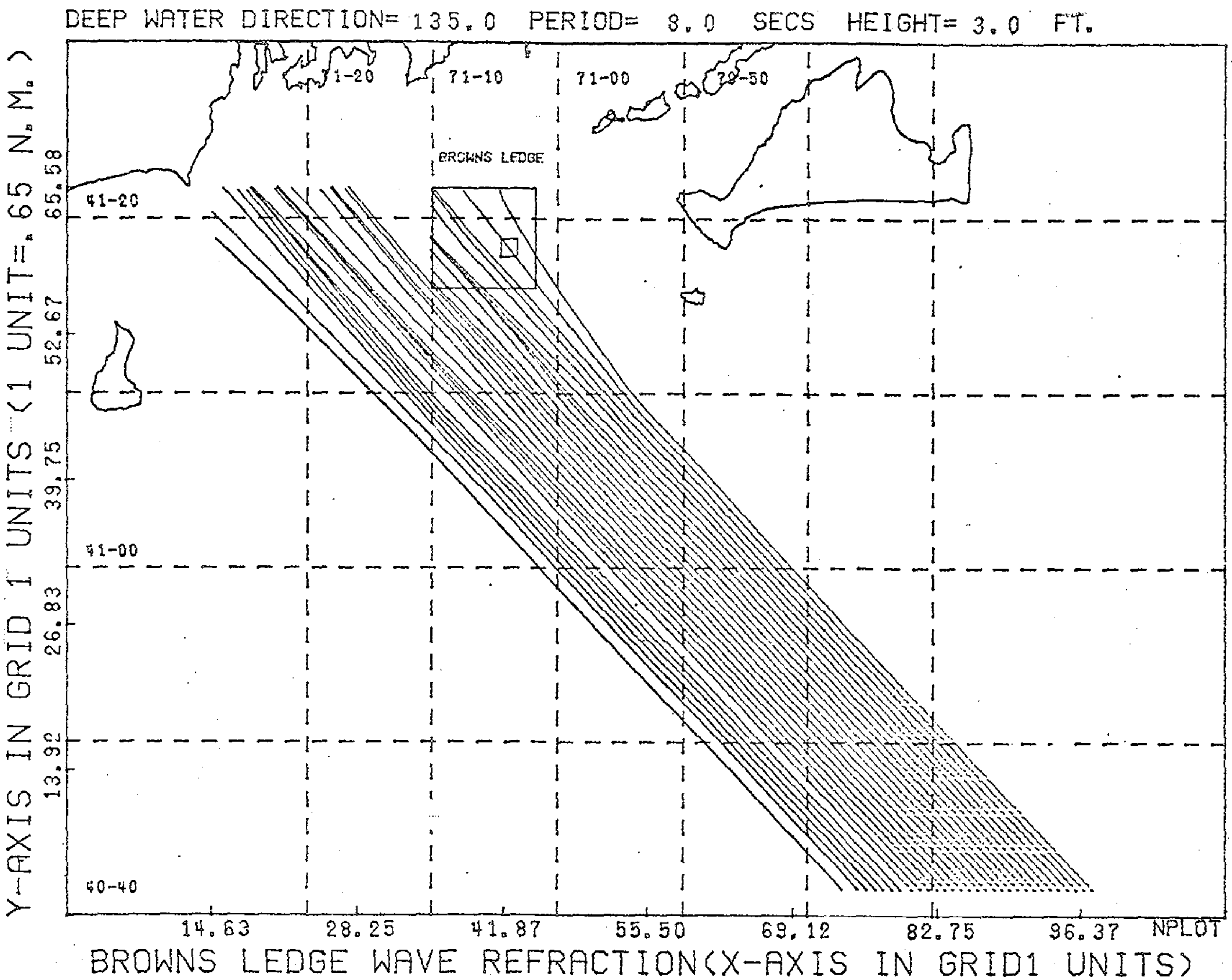


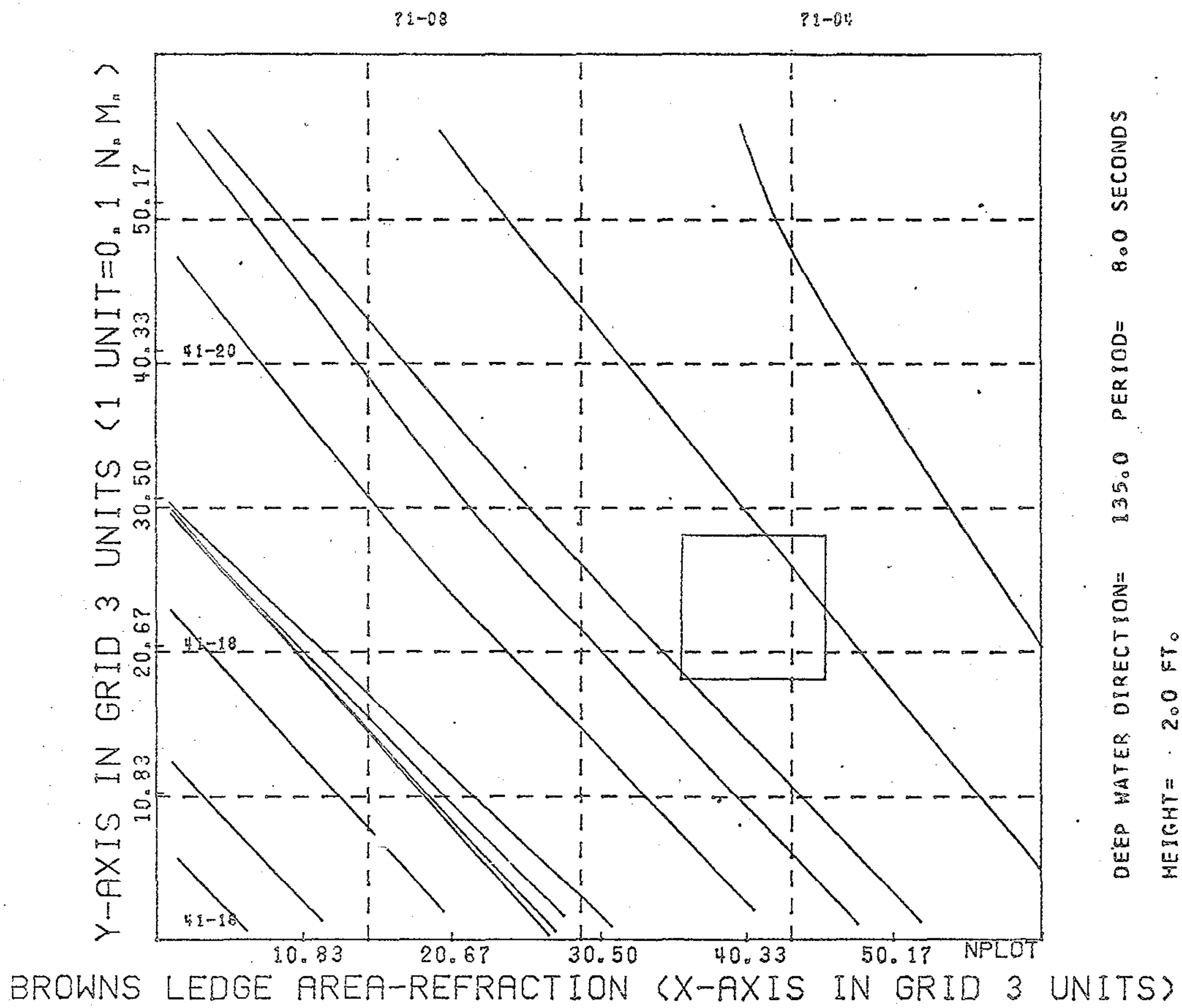
DEEP WATER DIRECTION= 157.5 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
13.92
26.83
39.75
52.67
65.58
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-19

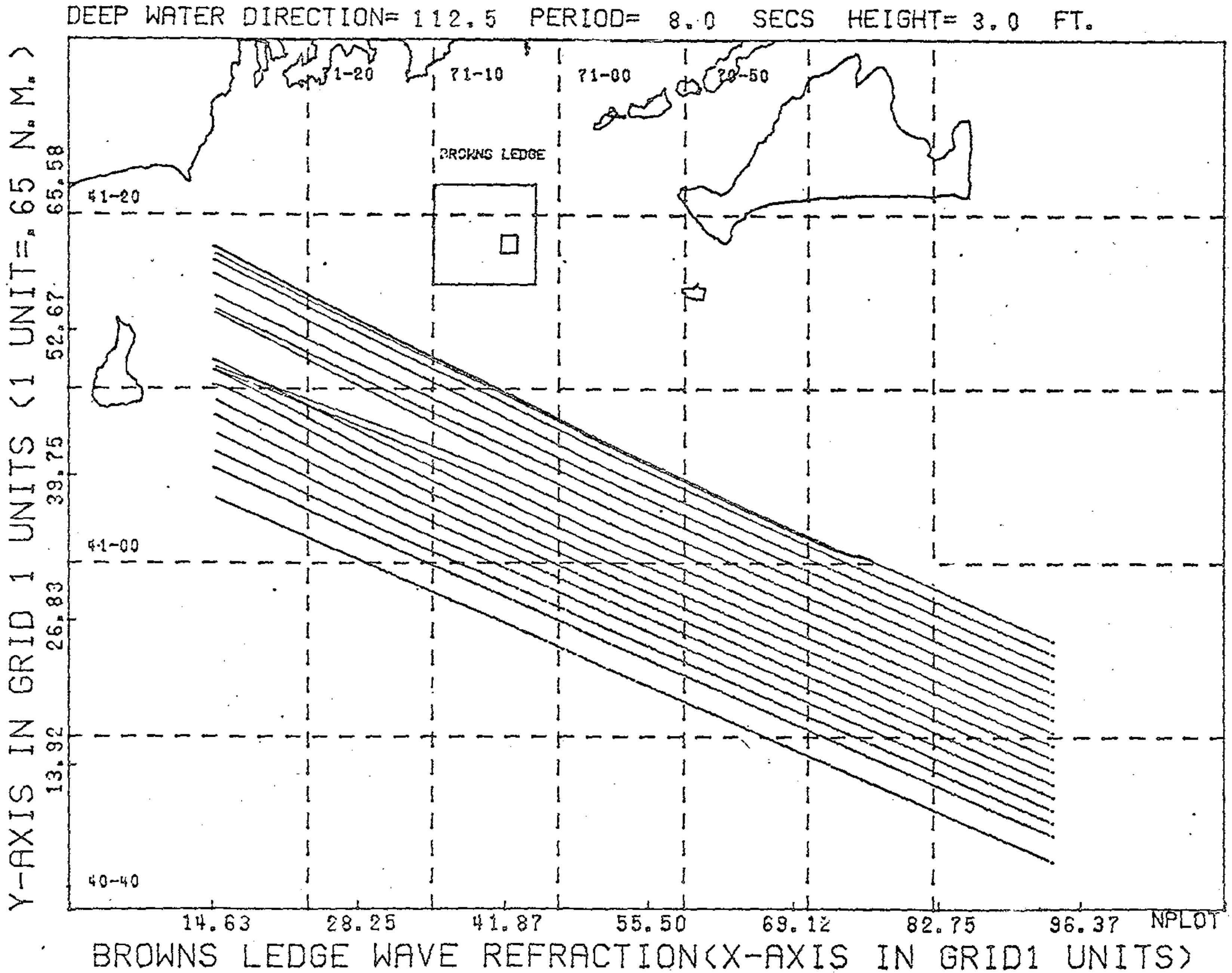


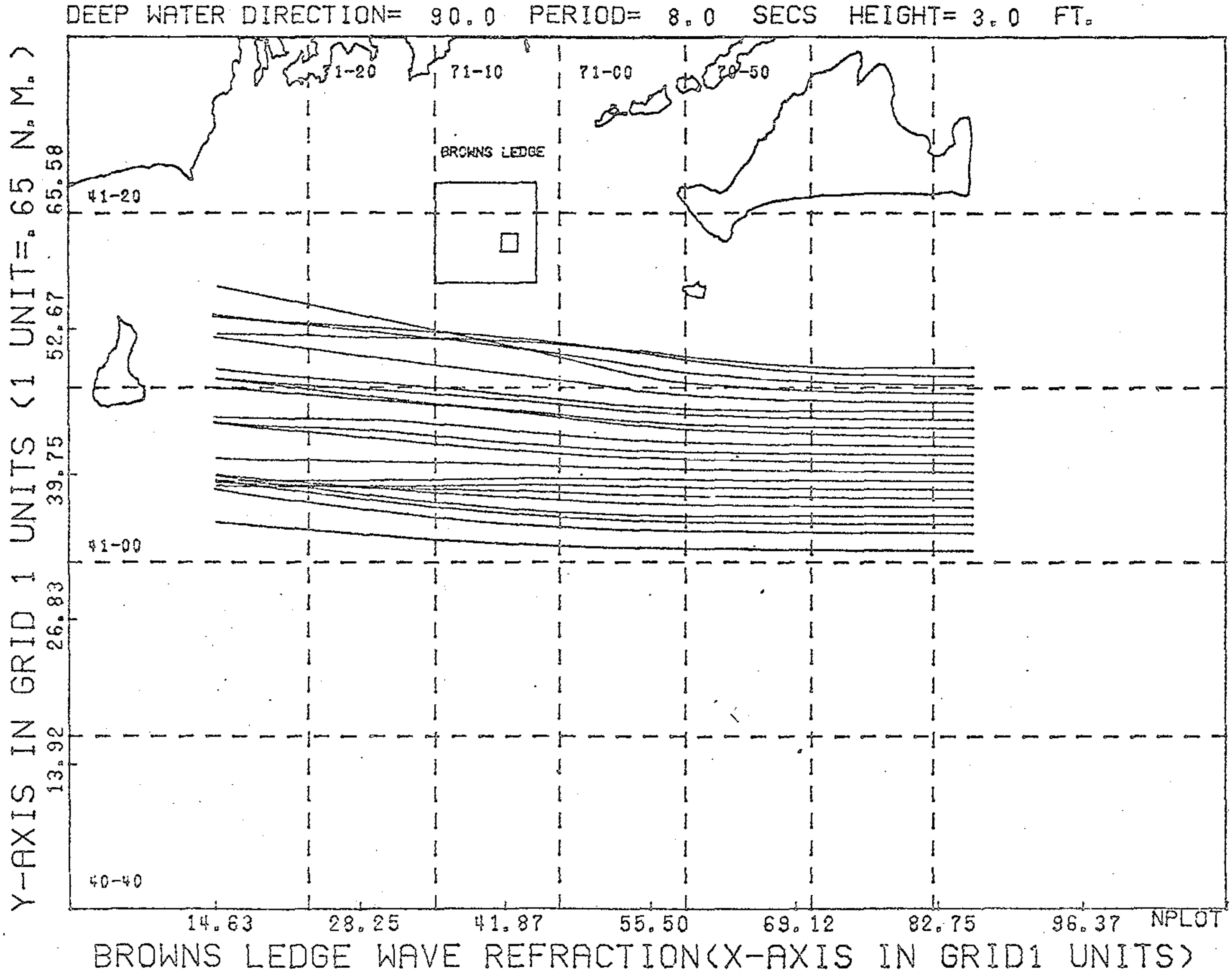
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)


DEEP WATER DIRECTION= 135.0 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



2-21
71-08
71-04
41-20
41-18
41-16
Y-AXIS IN GRID 3 UNITS (1 UNIT=0.1 N.M.)
10.83
20.67
30.50
40.33
50.17
NPLOT
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)
DEEP WATER DIRECTION= 135.0 PERIOD= 8.0 SECONDS
HEIGHT= 2.0 FT.

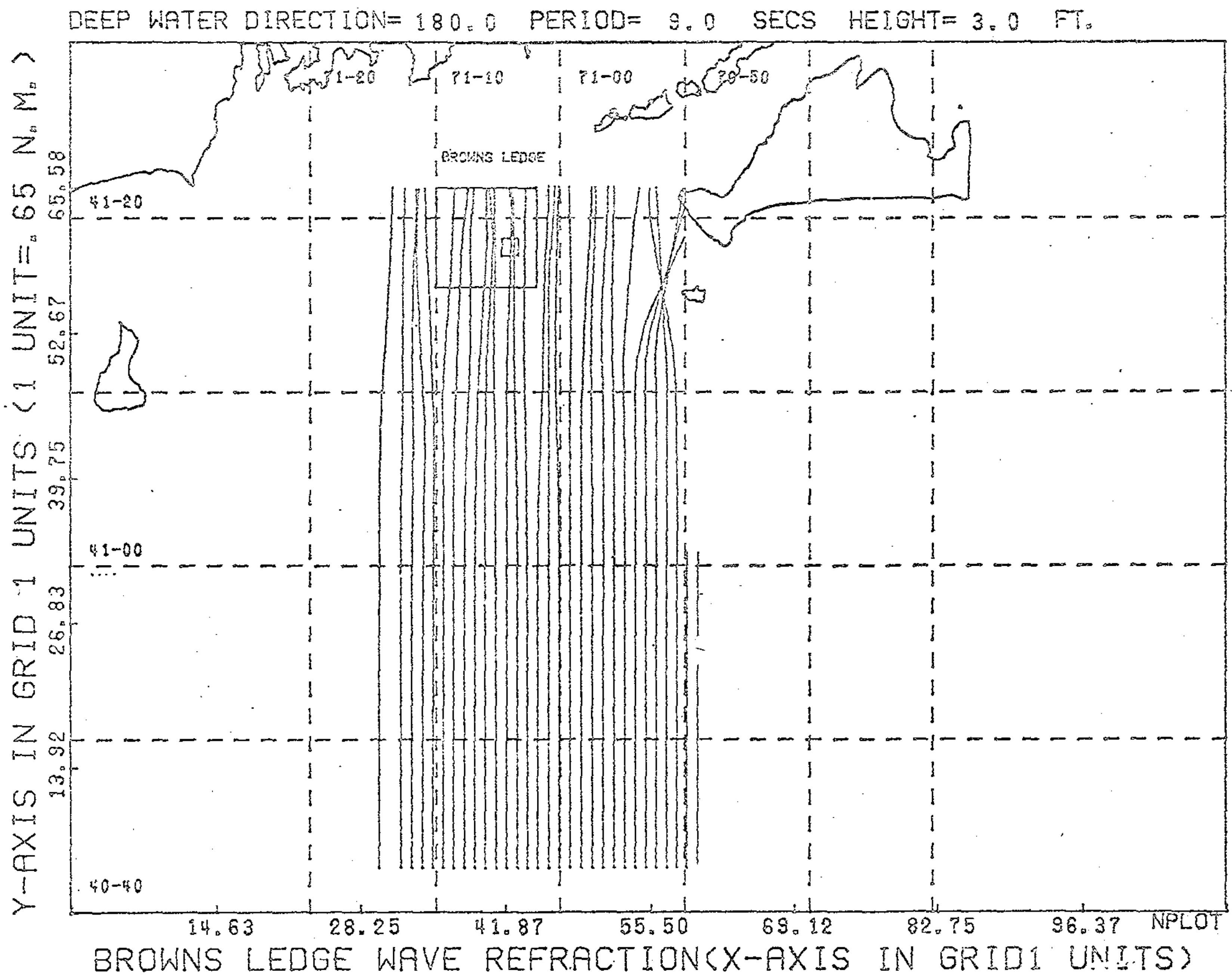

DEEP WATER DIRECTION= 112.5 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

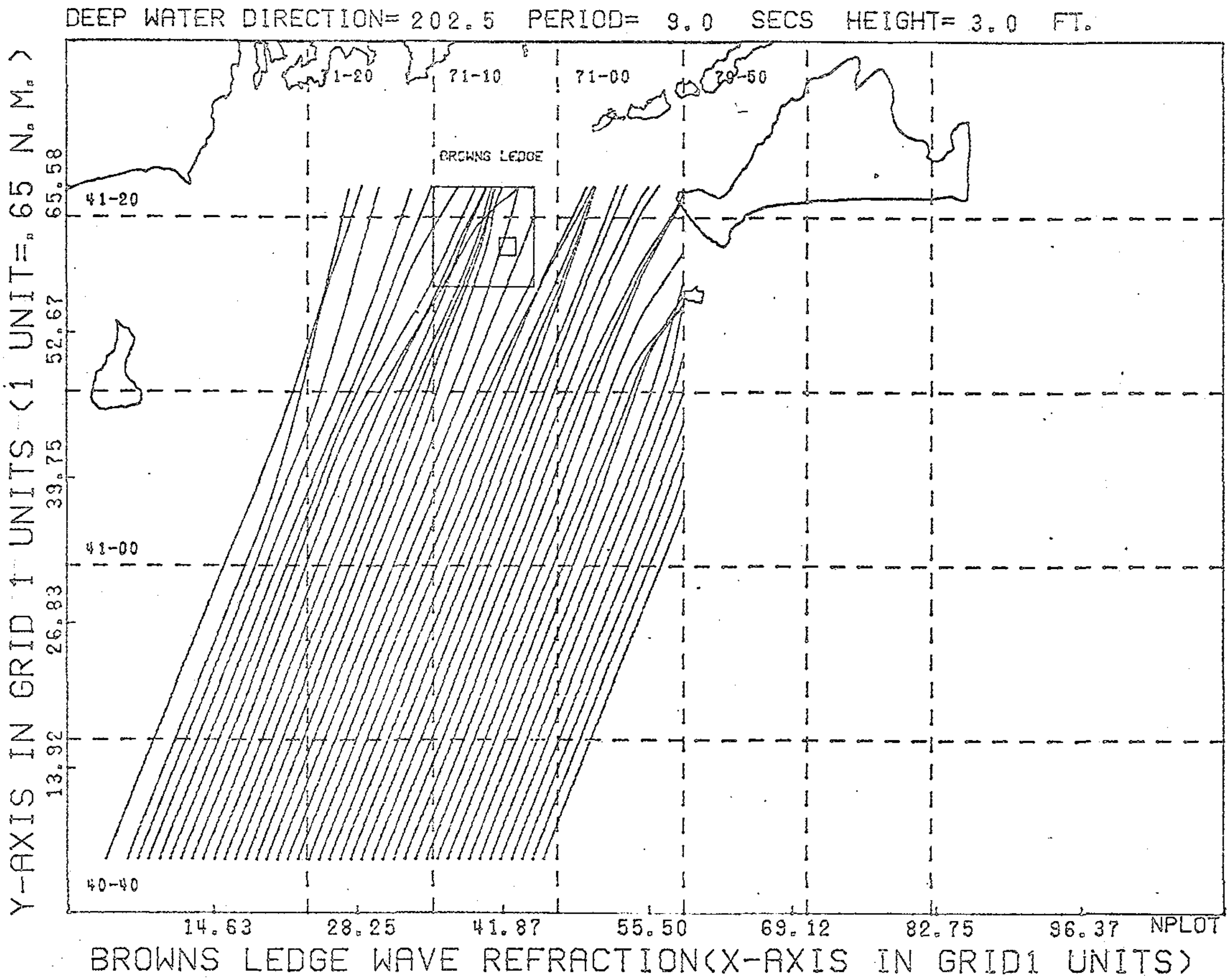

DEEP WATER DIRECTION= 90.0 PERIOD= 8.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

WAVE PLOTS

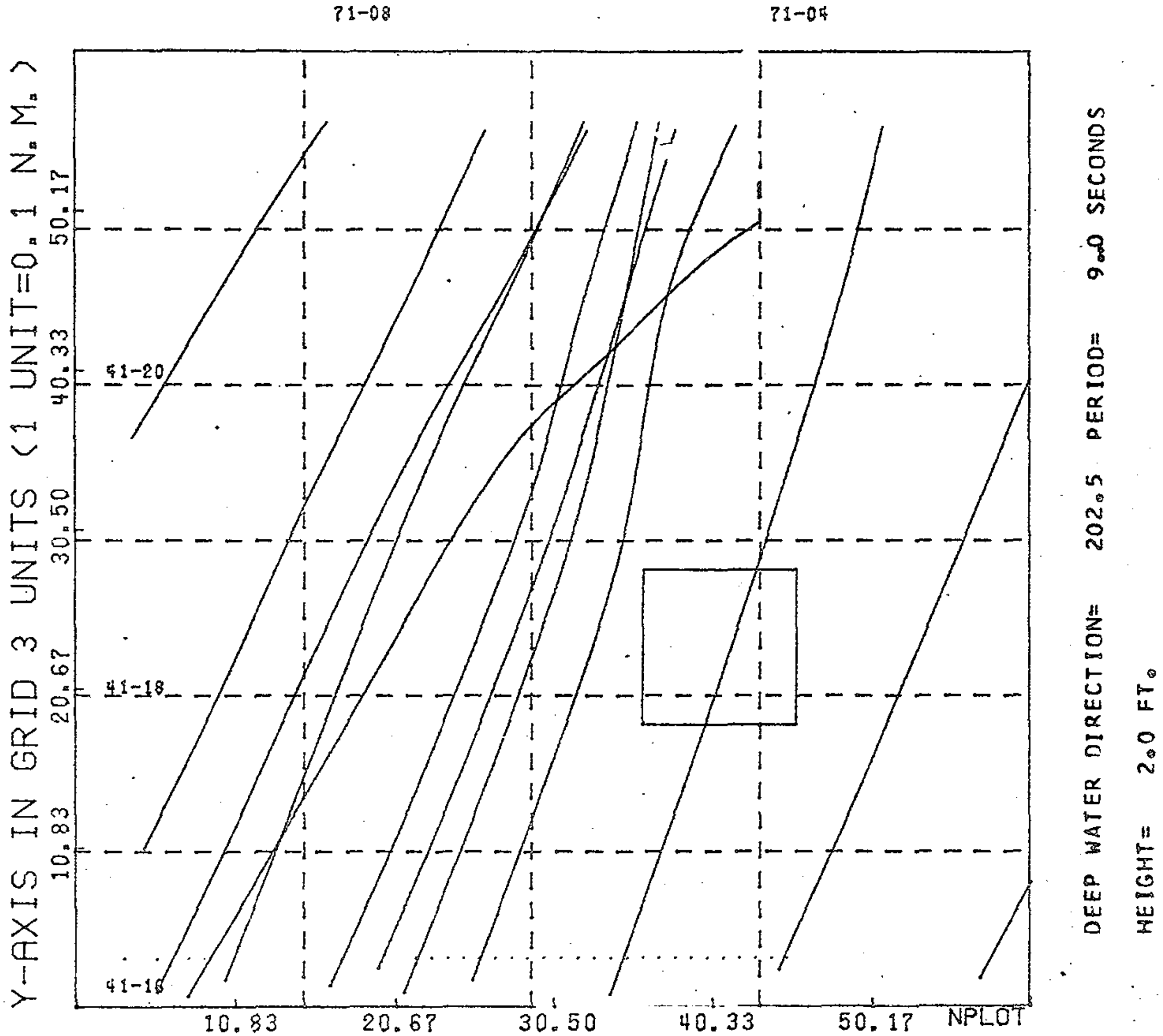
FOR 9.0 SECOND WAVES

							Deep Water Wave Heights
1.)	Direction	=	180.0°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
2.)	Direction	=	202.5°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
3.)	Direction	=	225°	-	Main		
4.)	Direction	=	157.5°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
5.)	Direction	=	135°				
	Main	-	Sub	-	Contours	-	2.0, 3.0 Ft.
6.)	Direction	=	112.5°	-	Main		
7.)	Direction	=	90°	-	Main		


DEEP WATER DIRECTION= 180.0 PERIOD= 9.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT= .65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

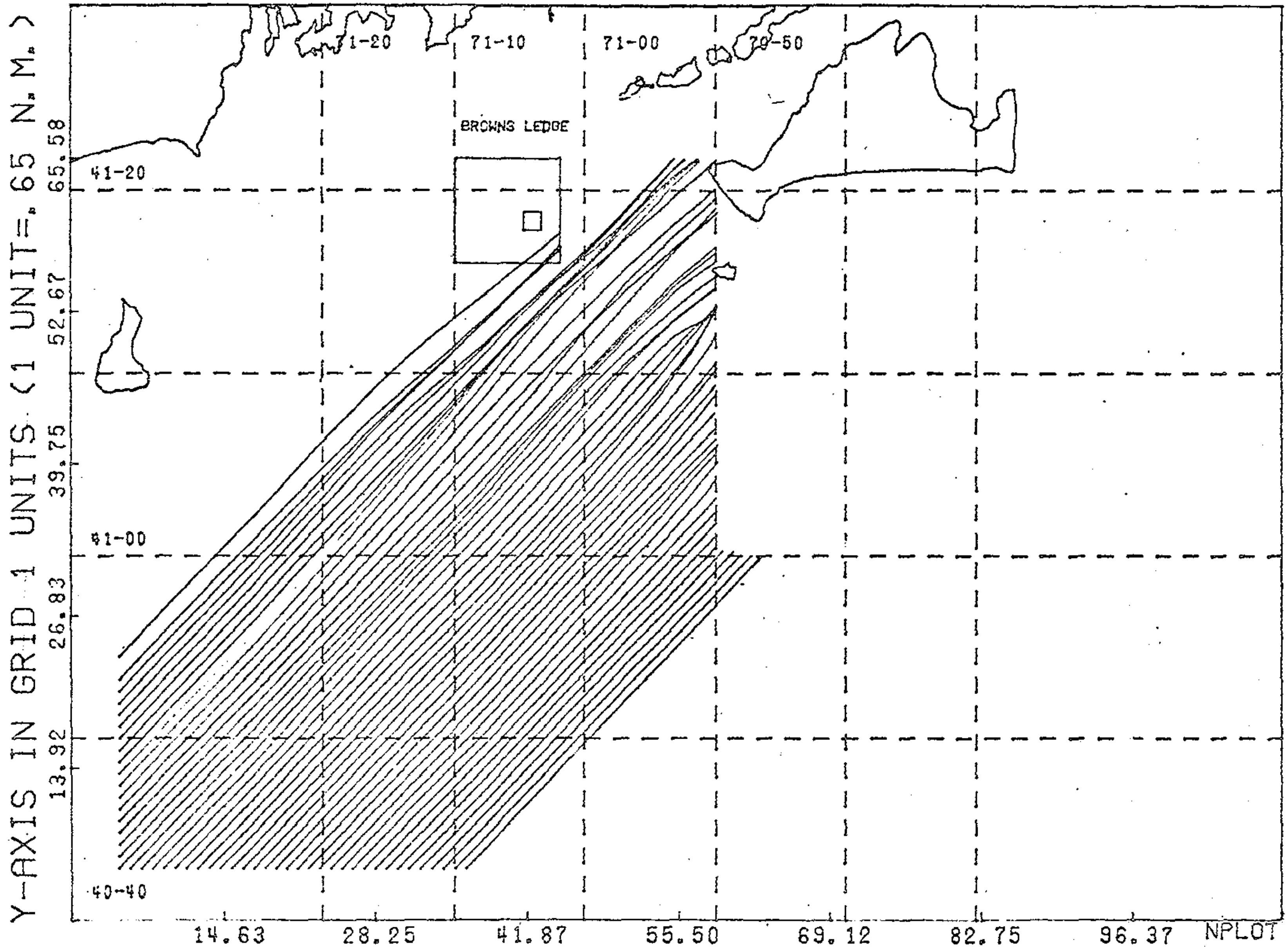

DEEP WATER DIRECTION= 202.5 PERIOD= 9.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-28



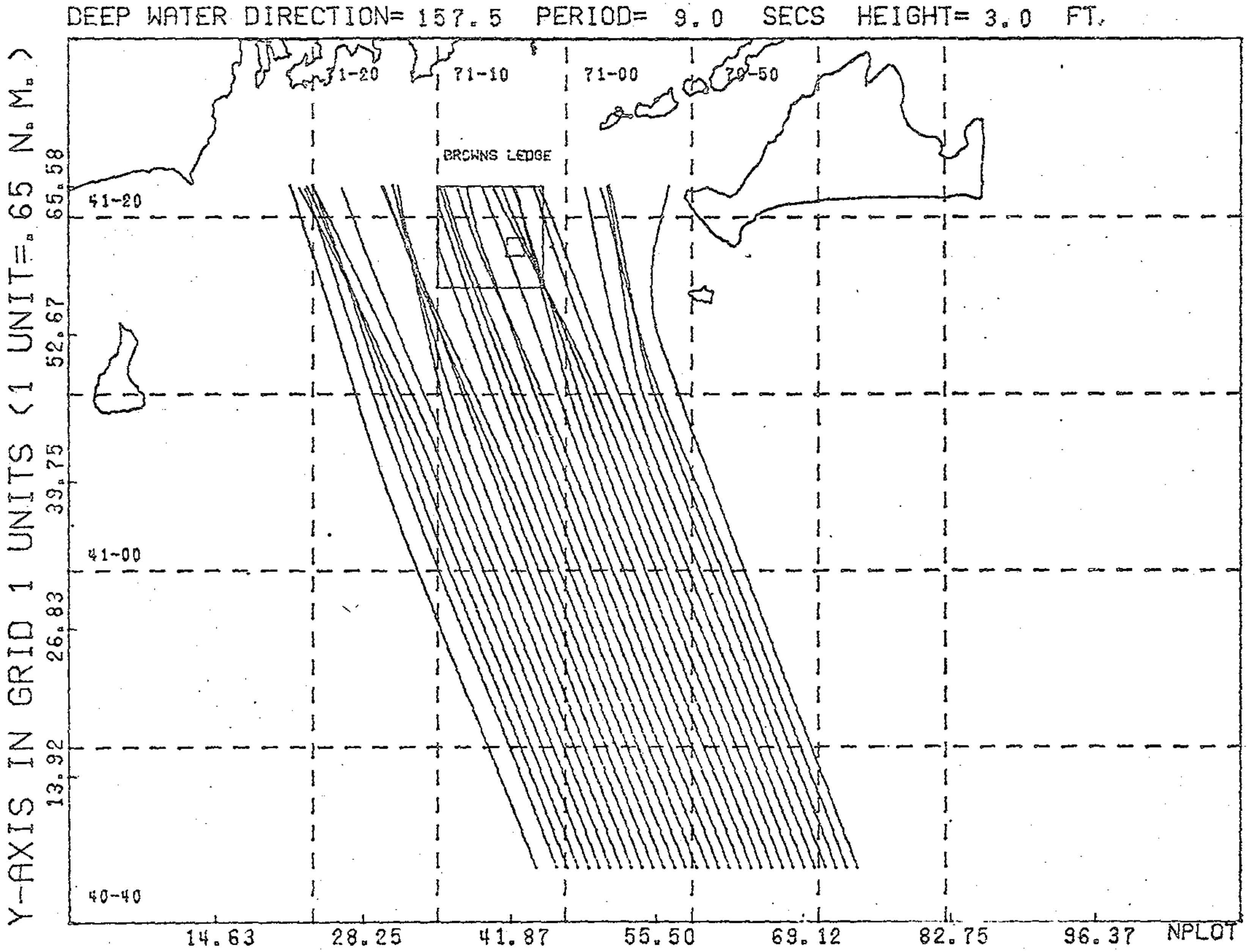
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

DEEP WATER DIRECTION= 225.0 PERIOD= 9.0 SECS HEIGHT= 3.0 FT.

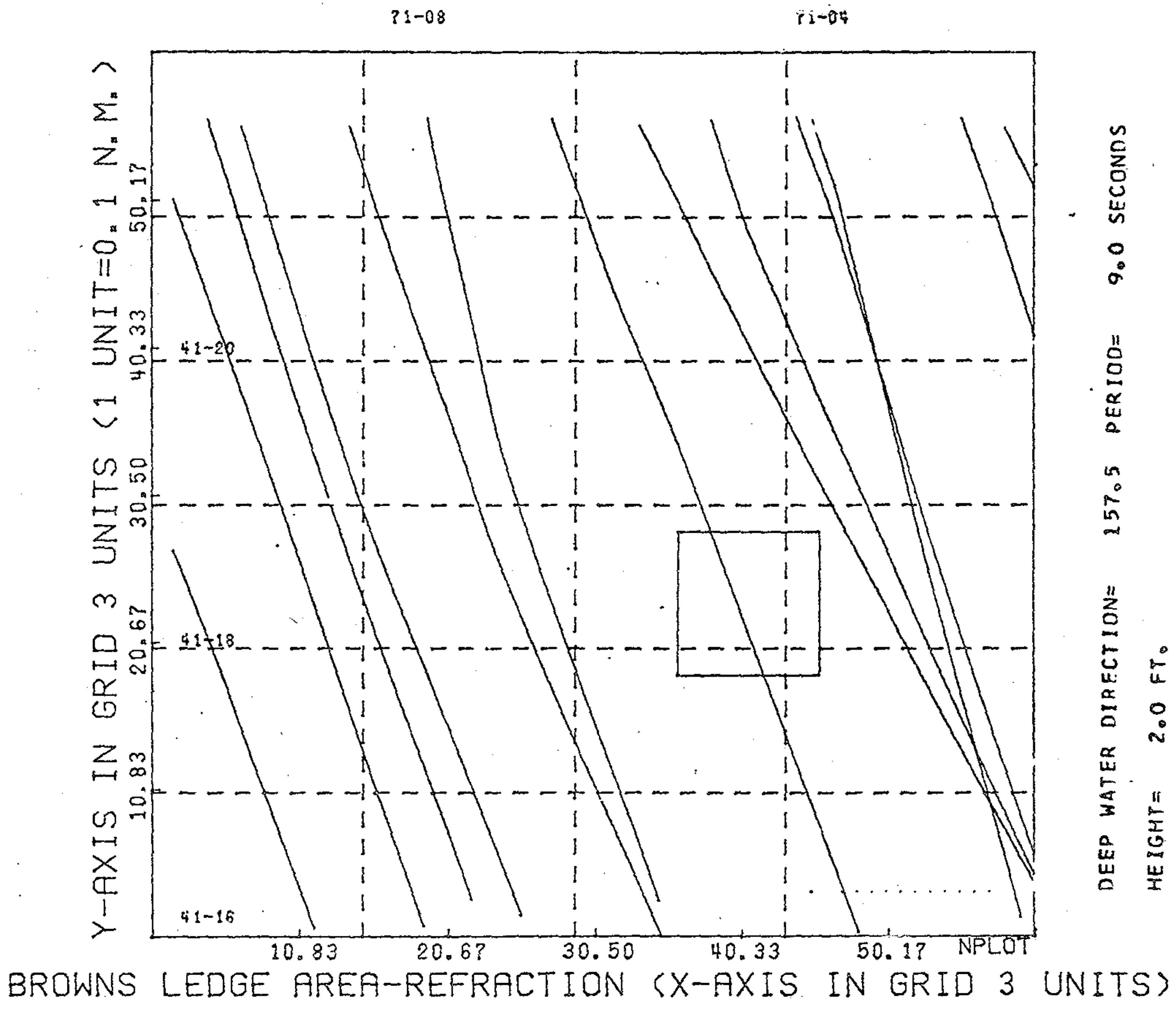


BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-30

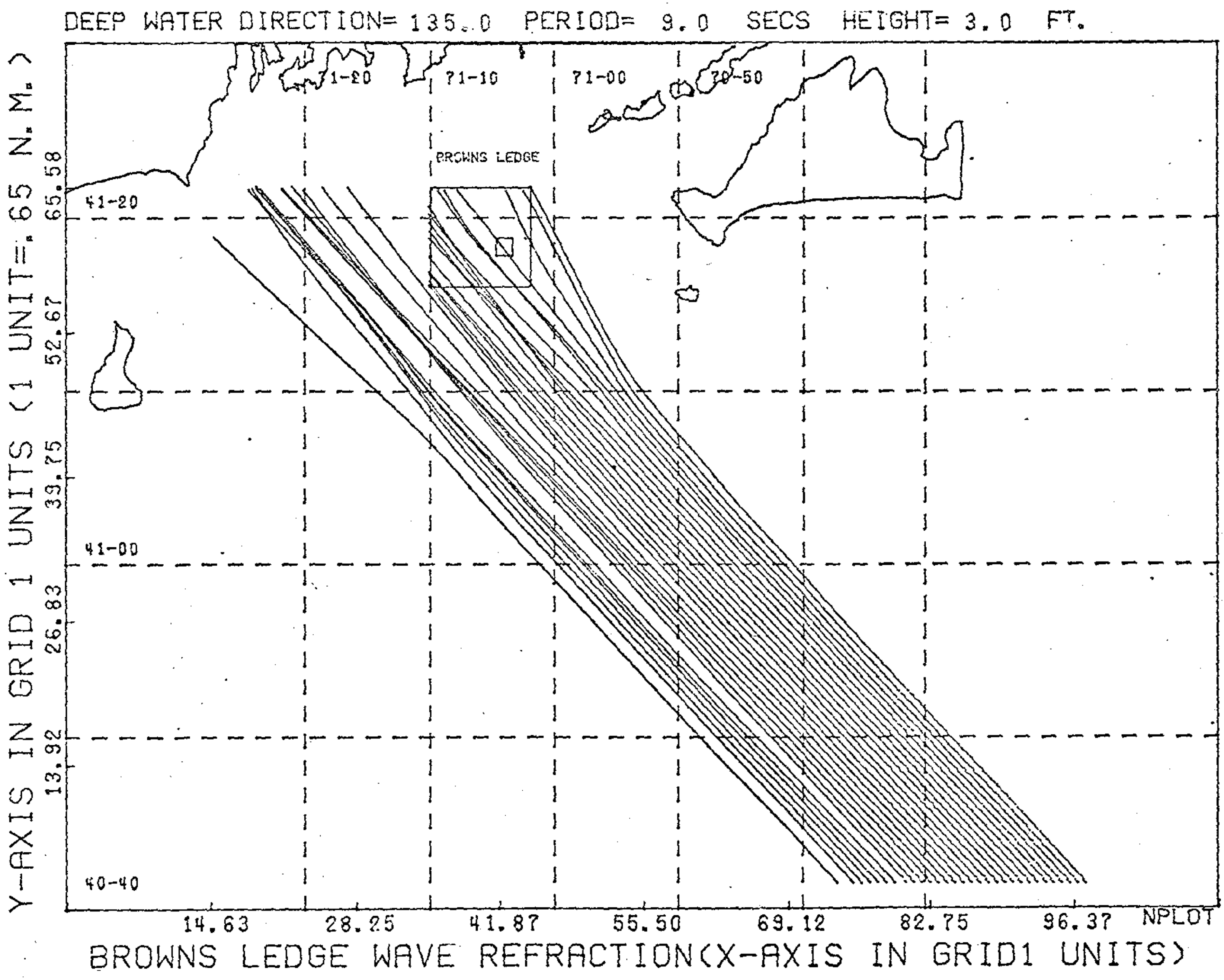


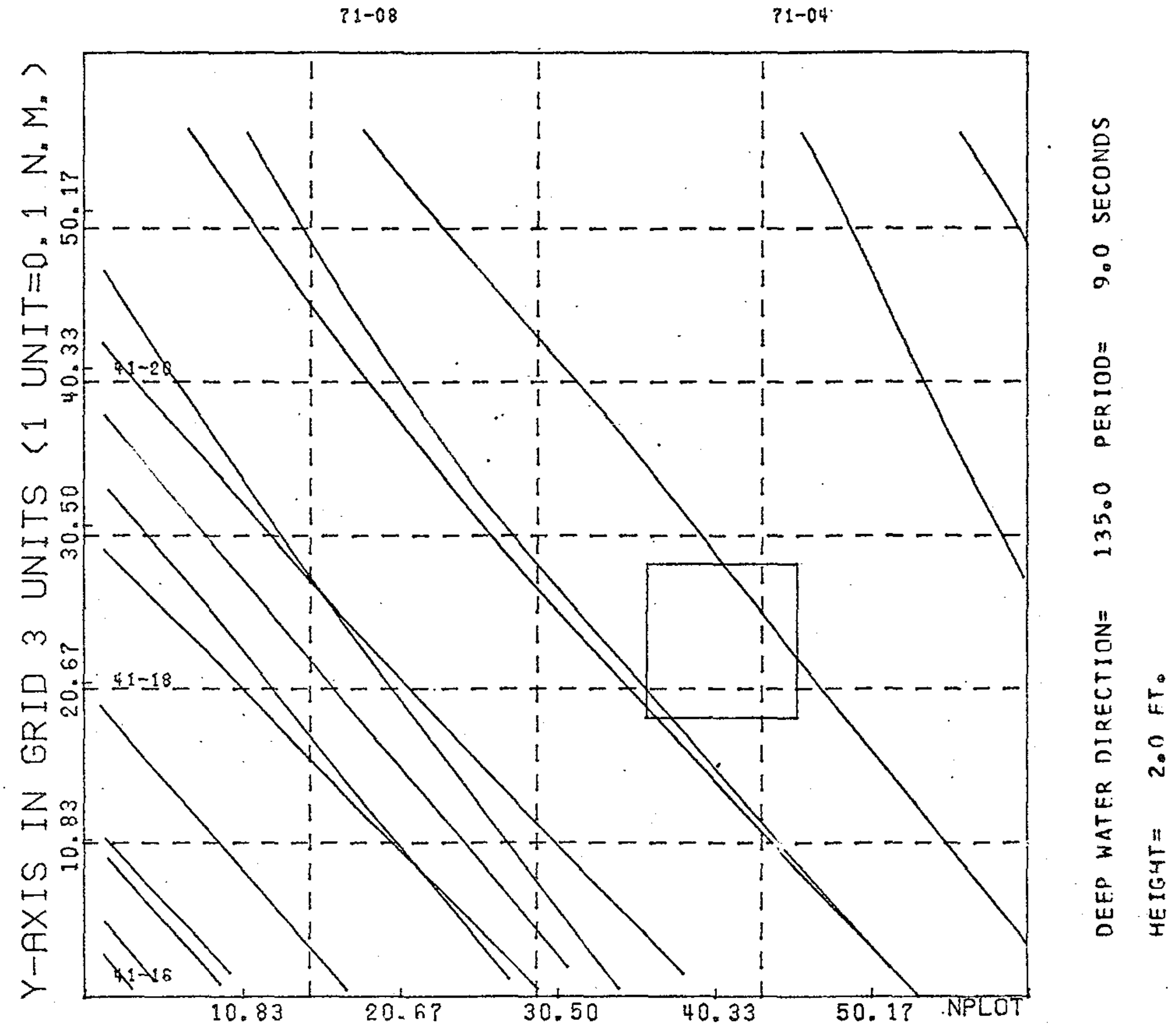
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



71-08
71-04
41-20
41-18
41-16
10.83
20.67
30.50
40.33
50.17
NPLOT
Y-AXIS IN GRID 3 UNITS (1 UNIT=0.1 N.M.)
DEEP WATER DIRECTION= 157.5 PERIOD= 9.0 SECONDS
HEIGHT= 2.0 FT.
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

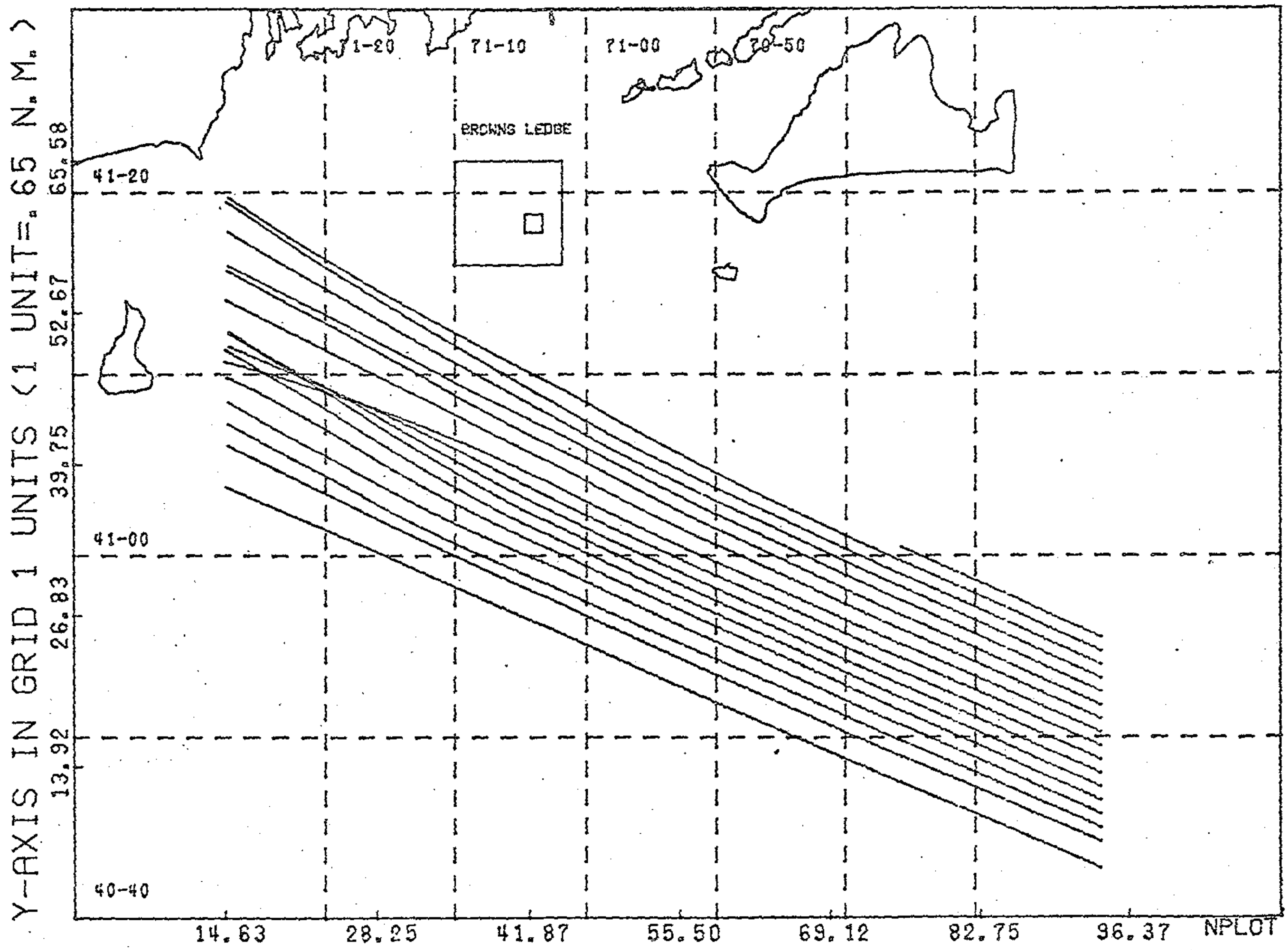
2-32


DEEP WATER DIRECTION= 135.0 PERIOD= 9.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

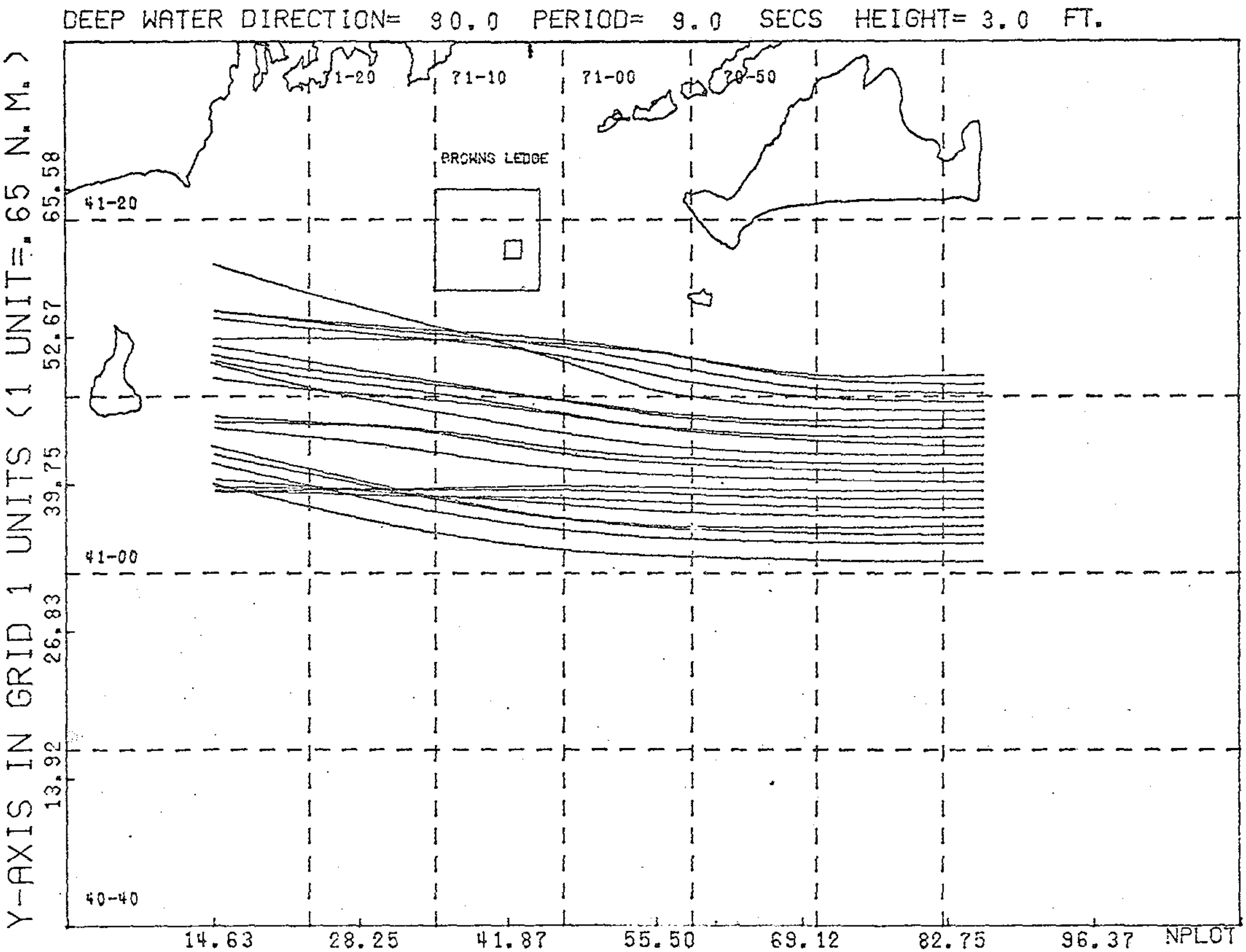


BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

DEEP WATER DIRECTION= 112.5 PERIOD= 9.0 SECS HEIGHT= 3.0 FT.



BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



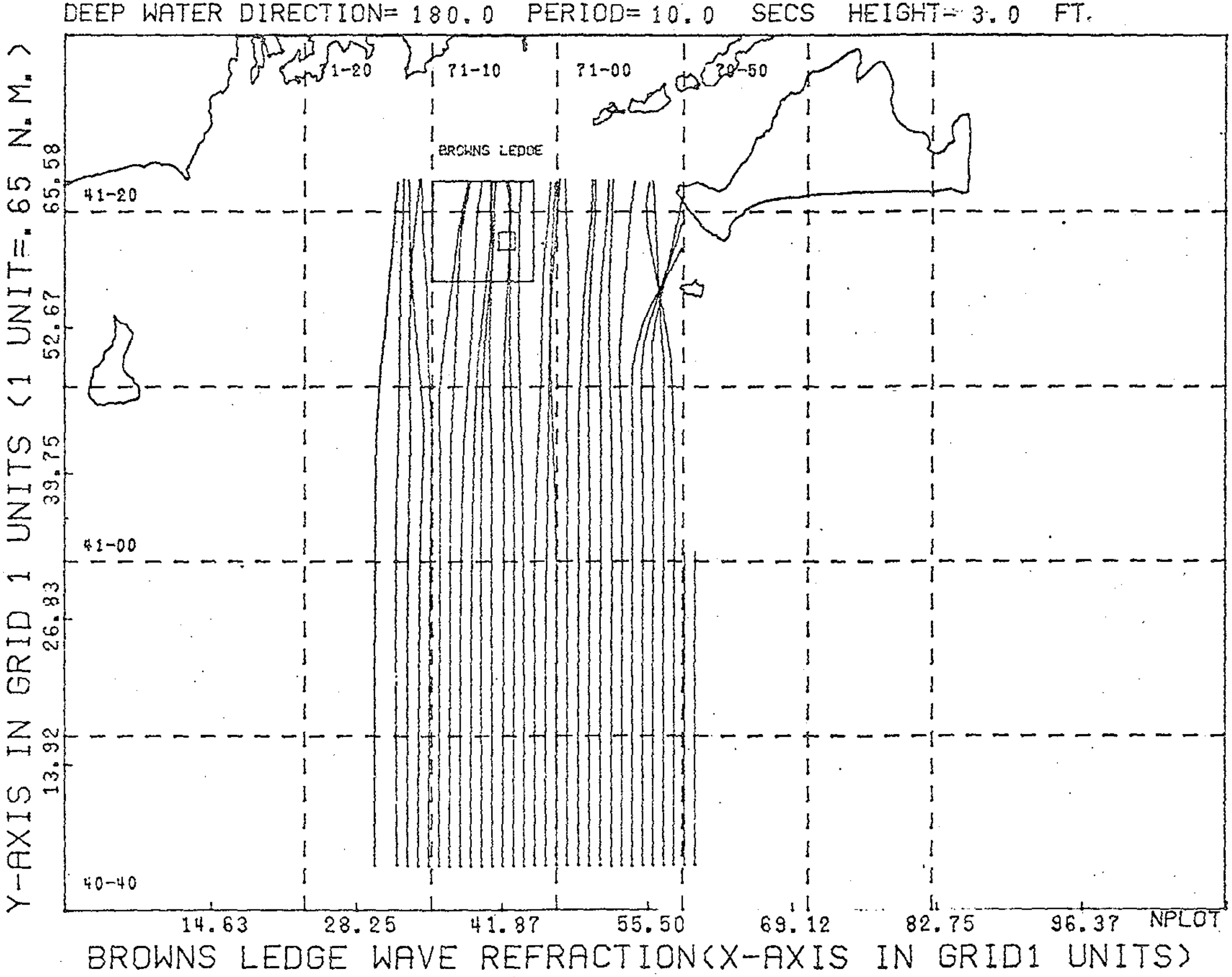
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

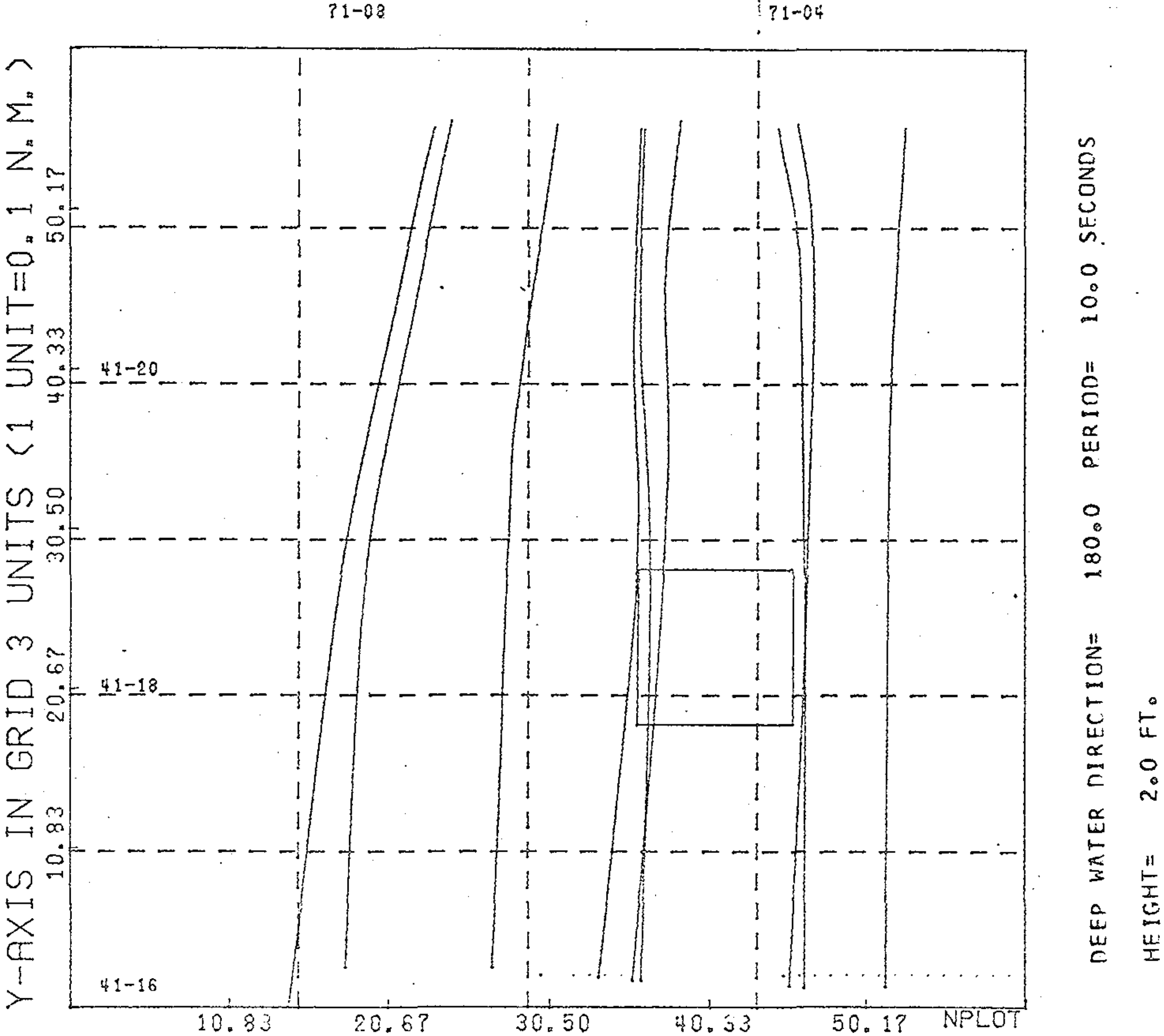
WAVE PLOTS FOR

10 SECONDS

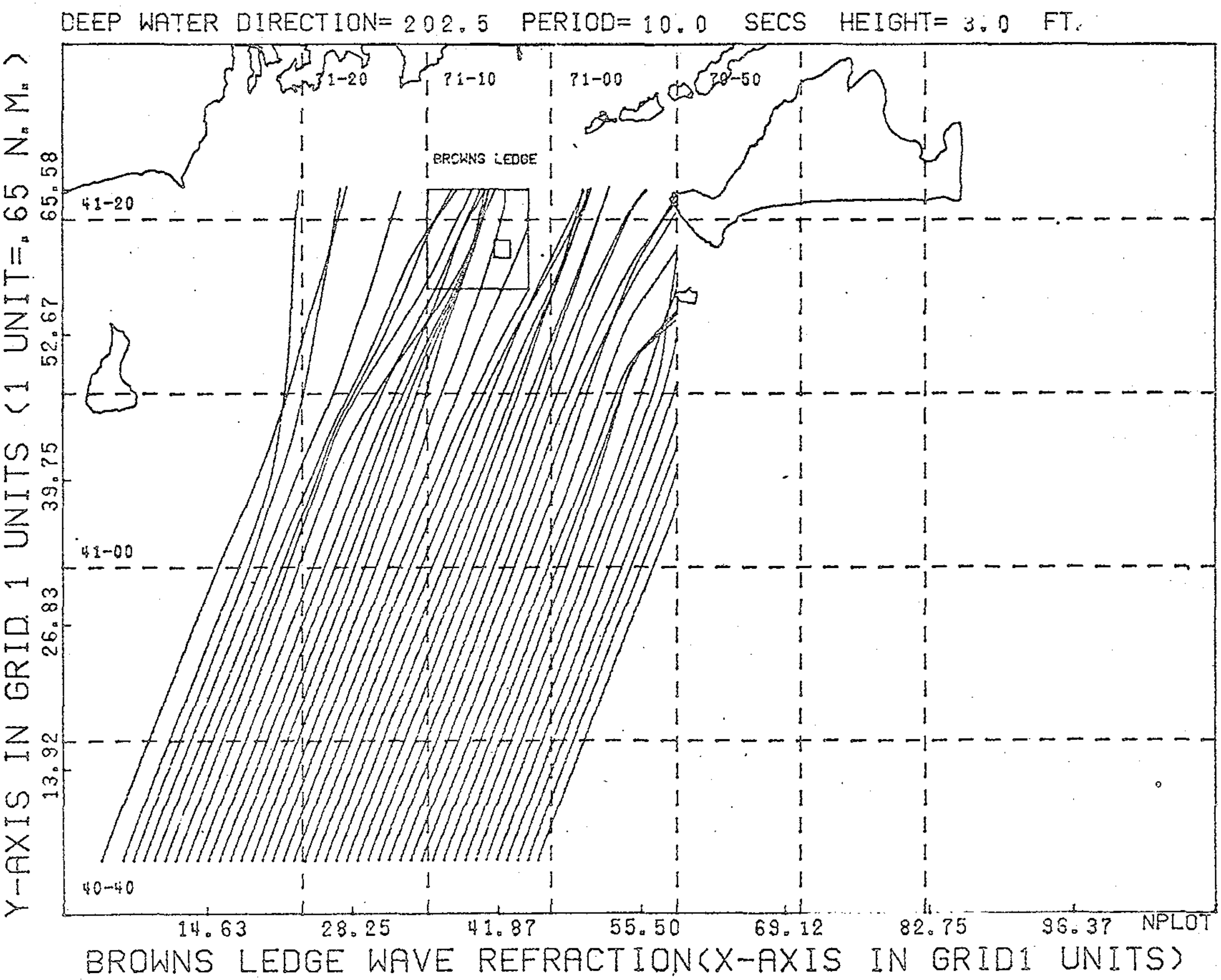
MAIN 3.0 Ft. 10.0 SECONDS

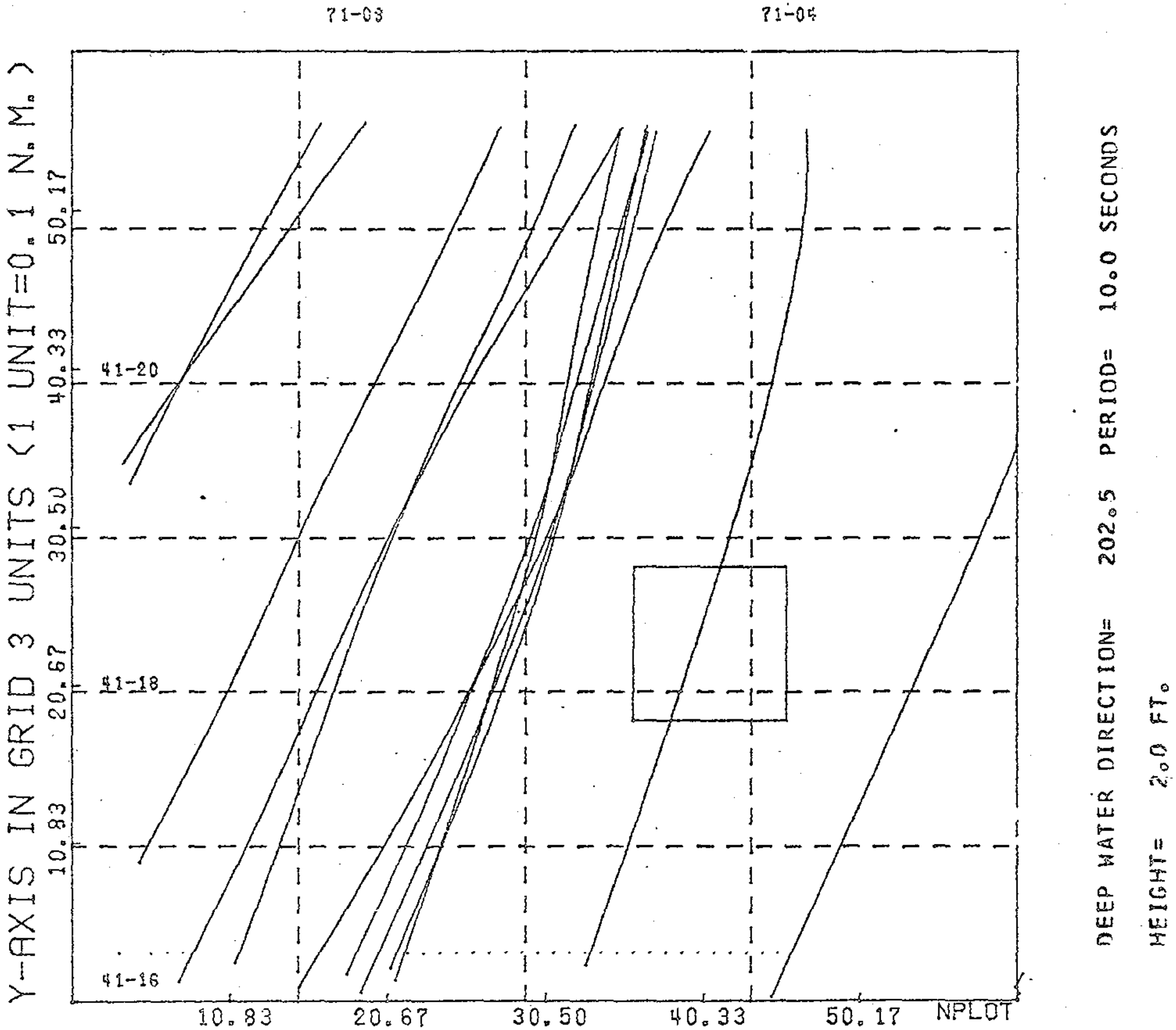
								Deep Water Wave Heights
1.)	Direction		=	180.0°				
		Main	-	Sub	-	Contours	-	2.0, 3.0, 4.0 Ft.
2.)	Direction		=	202.5°				
		Main	-	Sub	-	Contours	-	2.0, 3.0, 4.0 Ft.
3.)	Direction		=	225°	-	Main		
4.)	Direction		=	157.5°				
		Main	-	Sub	-	Contours	-	2.0, 3.0, 4.0 Ft.
5.)	Direction		=	135.0				
		Main	-	Sub	-	Contours	-	2.0, 3.0, 4.0 Ft.


DEEP WATER DIRECTION= 180.0 PERIOD= 10.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



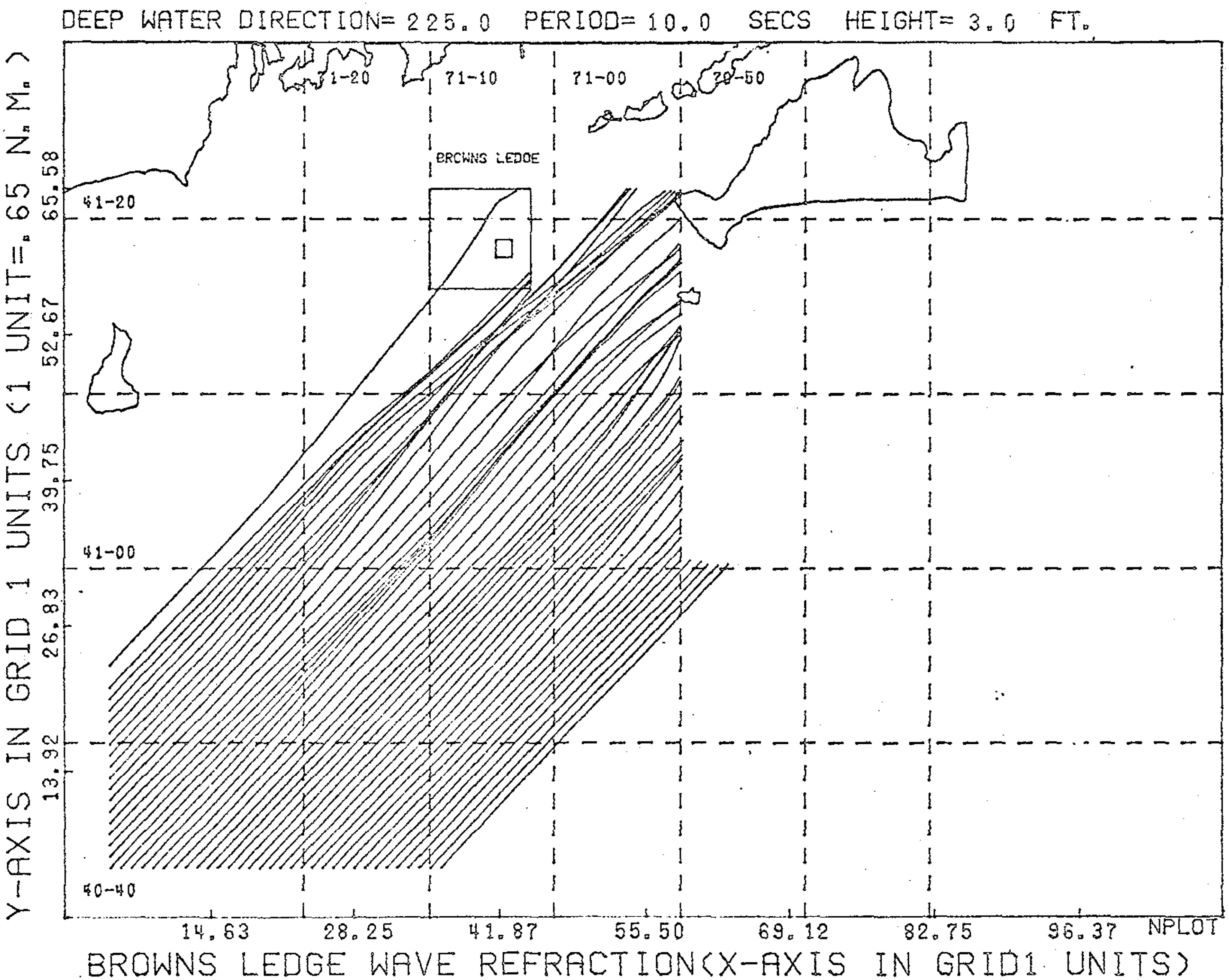
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

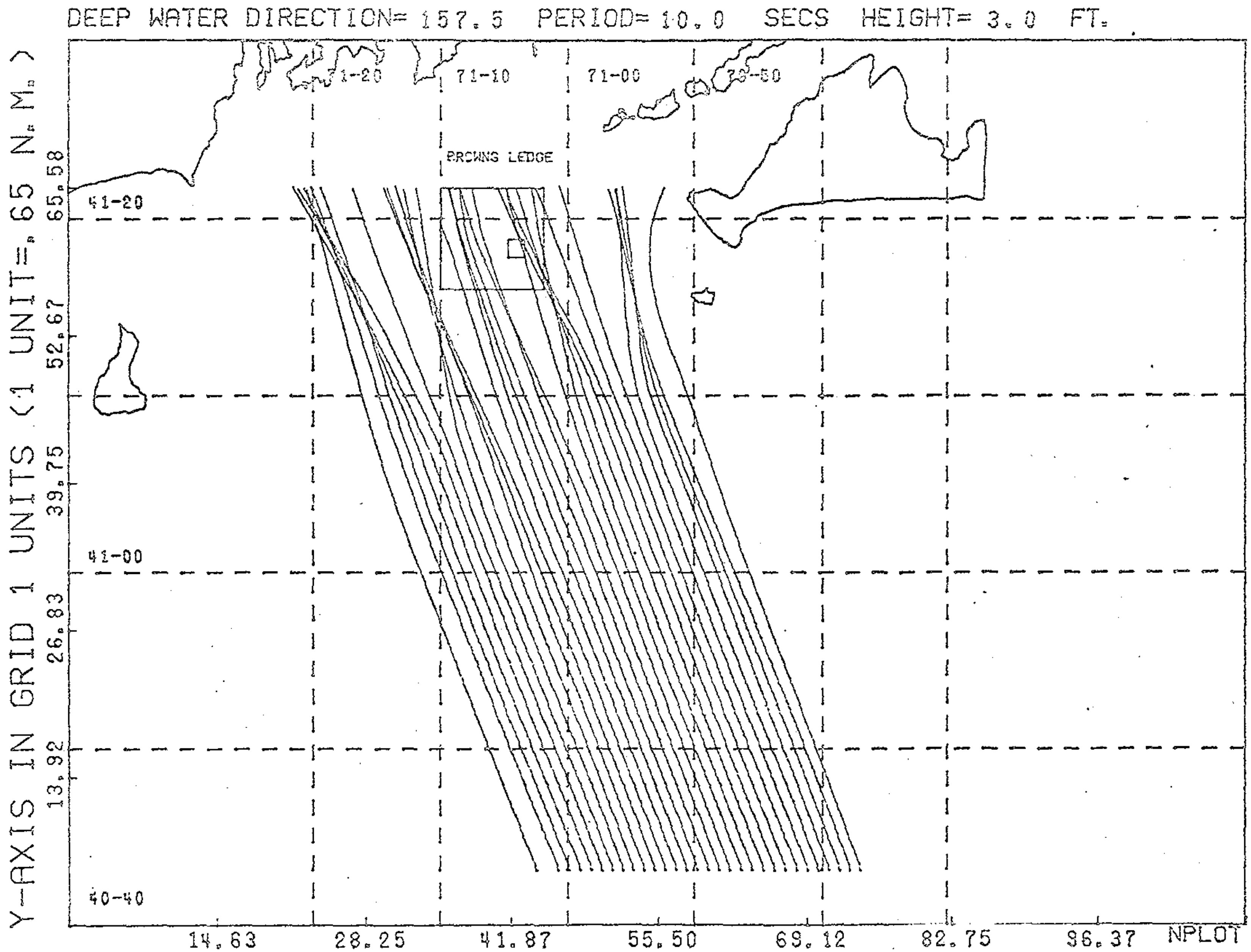

DEEP WATER DIRECTION= 202.5 PERIOD= 10.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



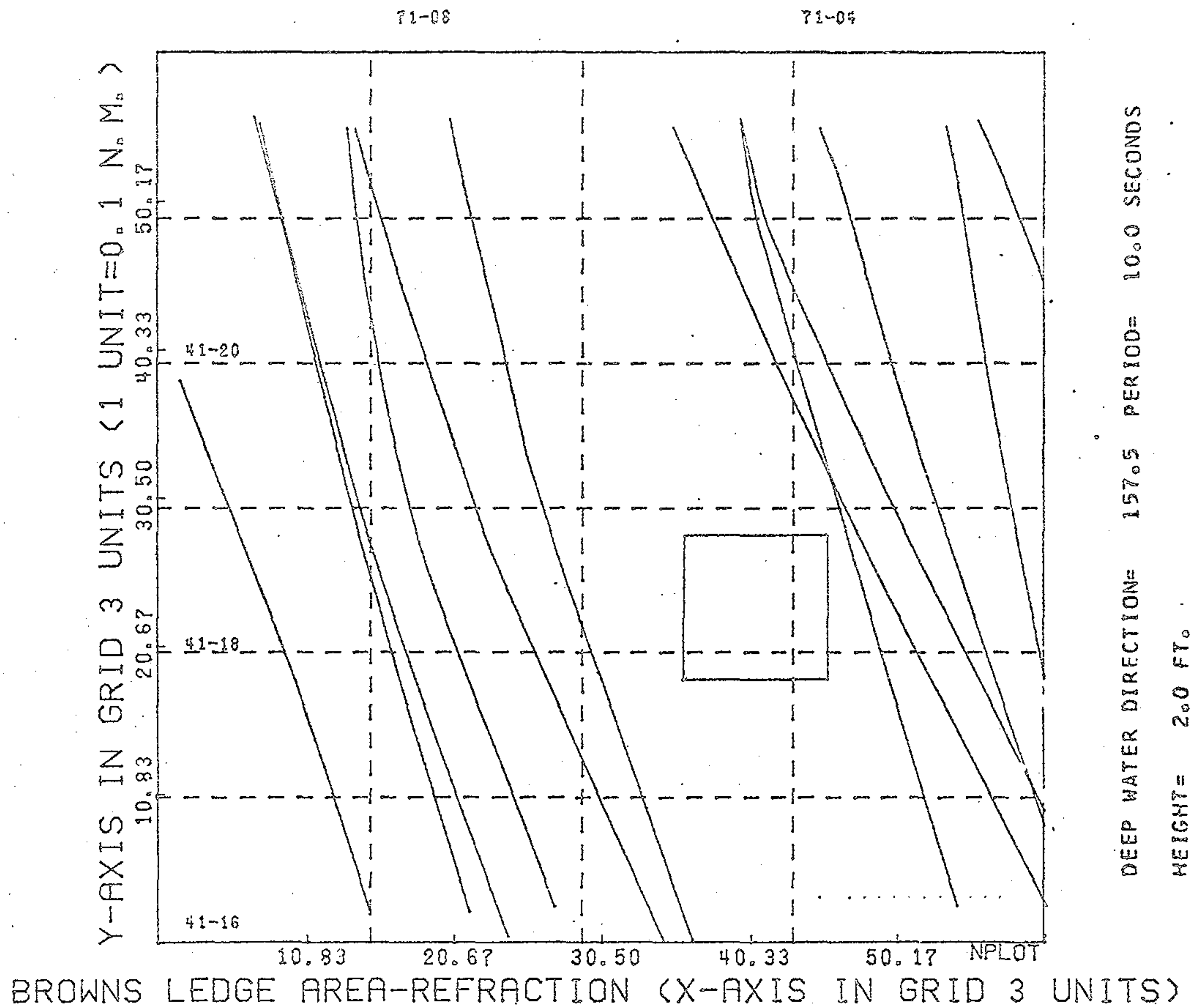
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-41

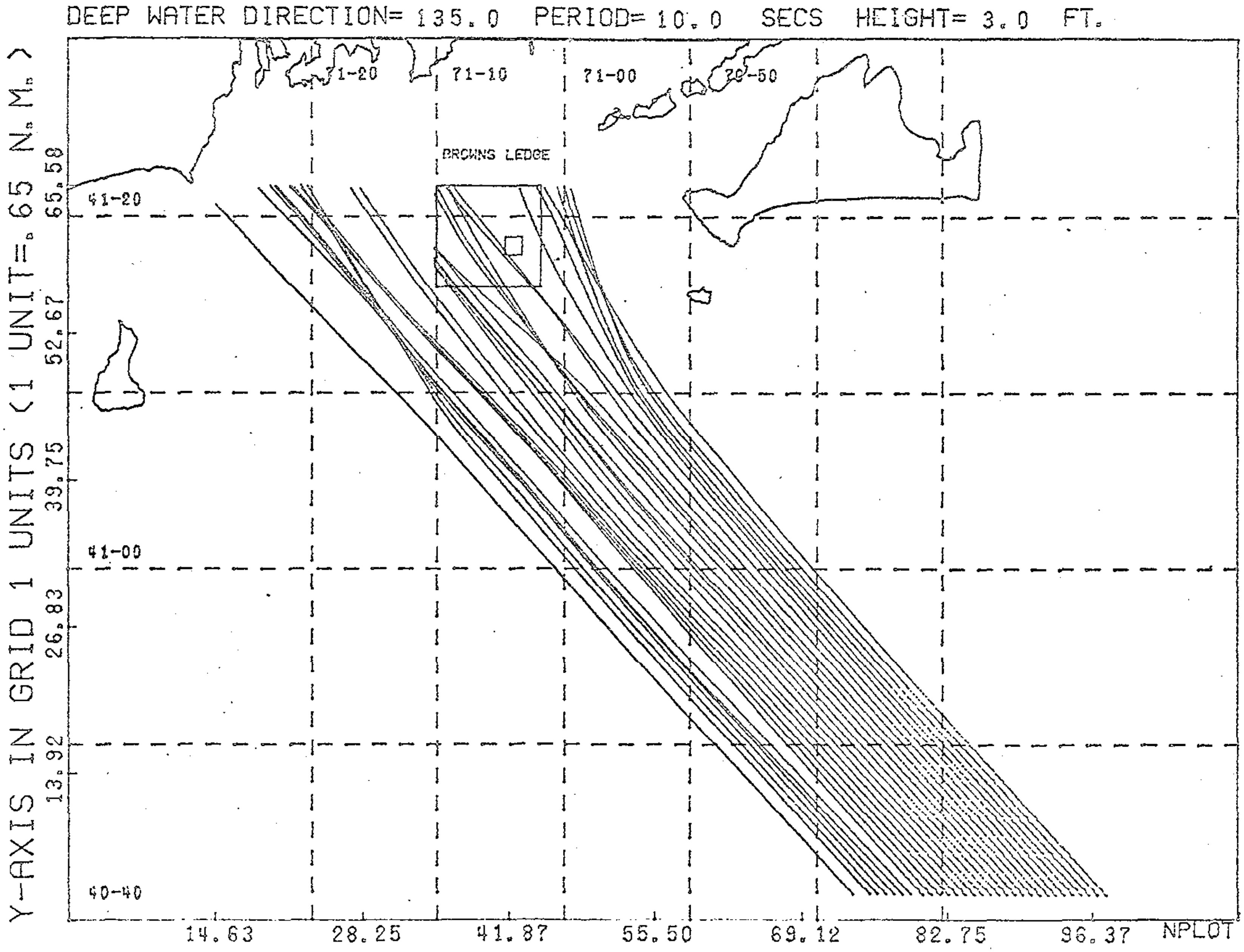

DEEP WATER DIRECTION= 225.0 PERIOD= 10.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT= .65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

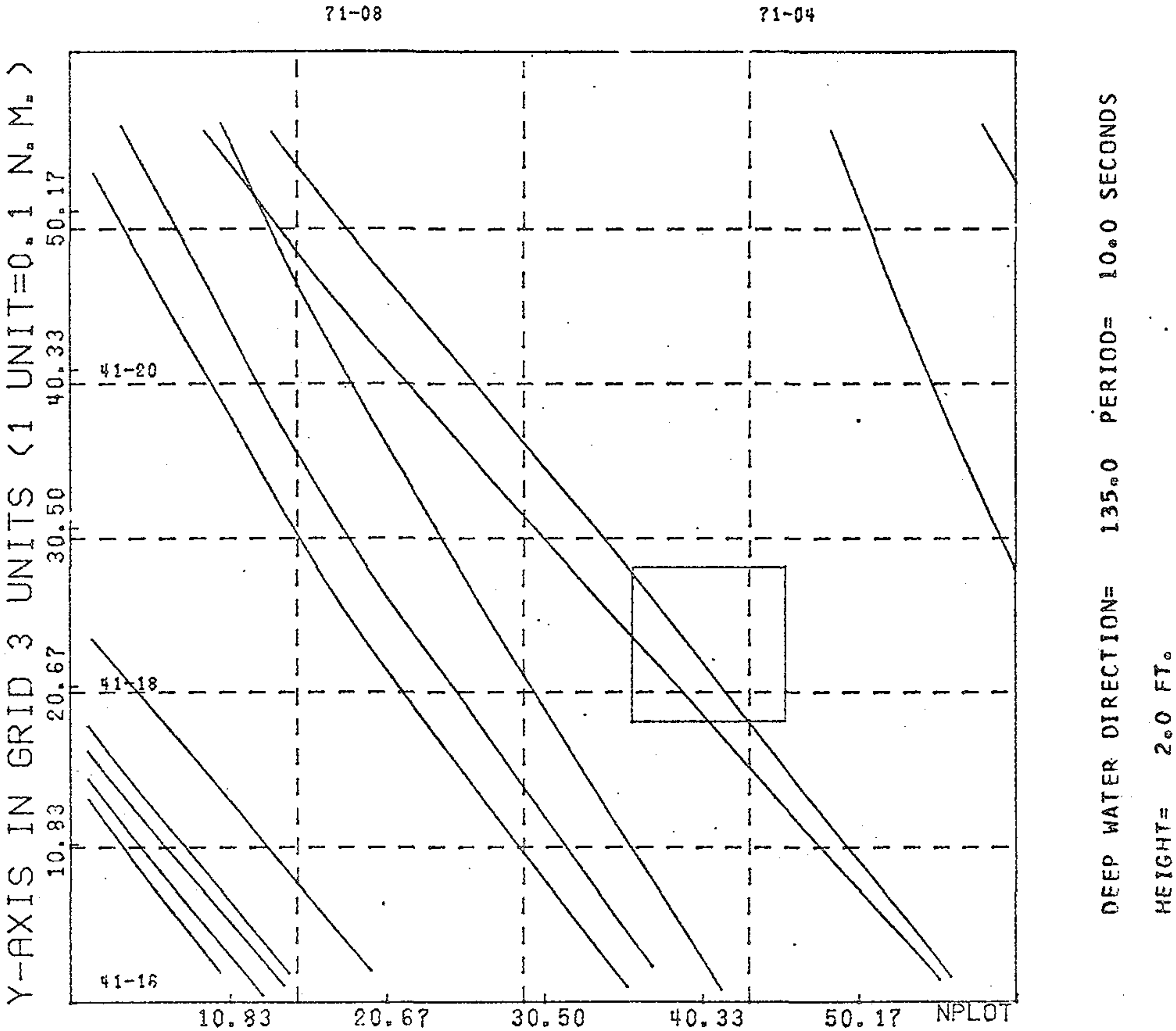


71-08
71-04
Y-AXIS IN GRID 3 UNITS (1 UNIT=0.1 N.M.)
50.17
40.33
30.50
20.67
10.83
41-20
41-18
41-16
10.83
20.67
30.50
40.33
50.17
NPLOT
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)
DEEP WATER DIRECTION= 157.5 PERIOD= 10.0 SECONDS
HEIGHT= 2.0 FT.



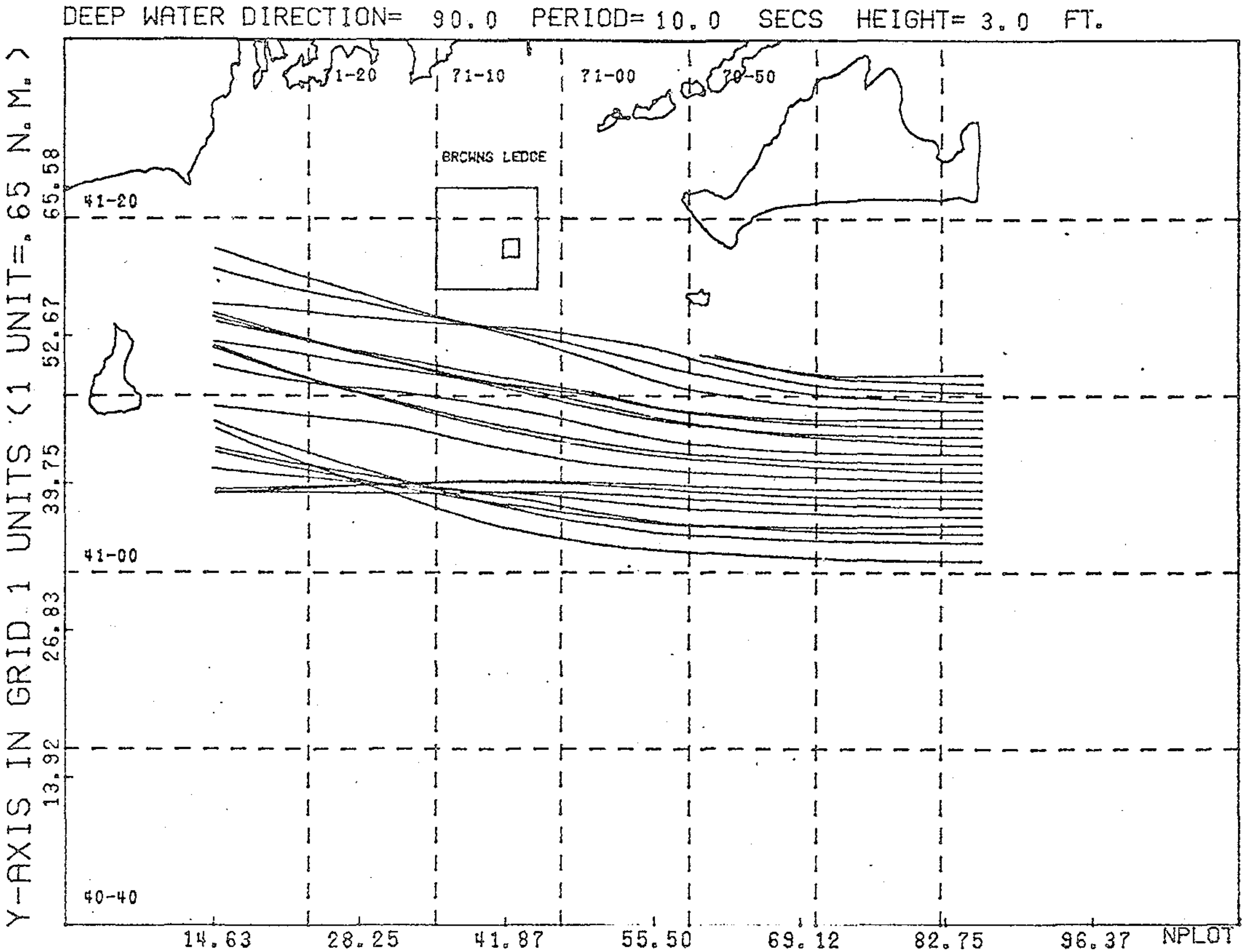
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-45



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-46



BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

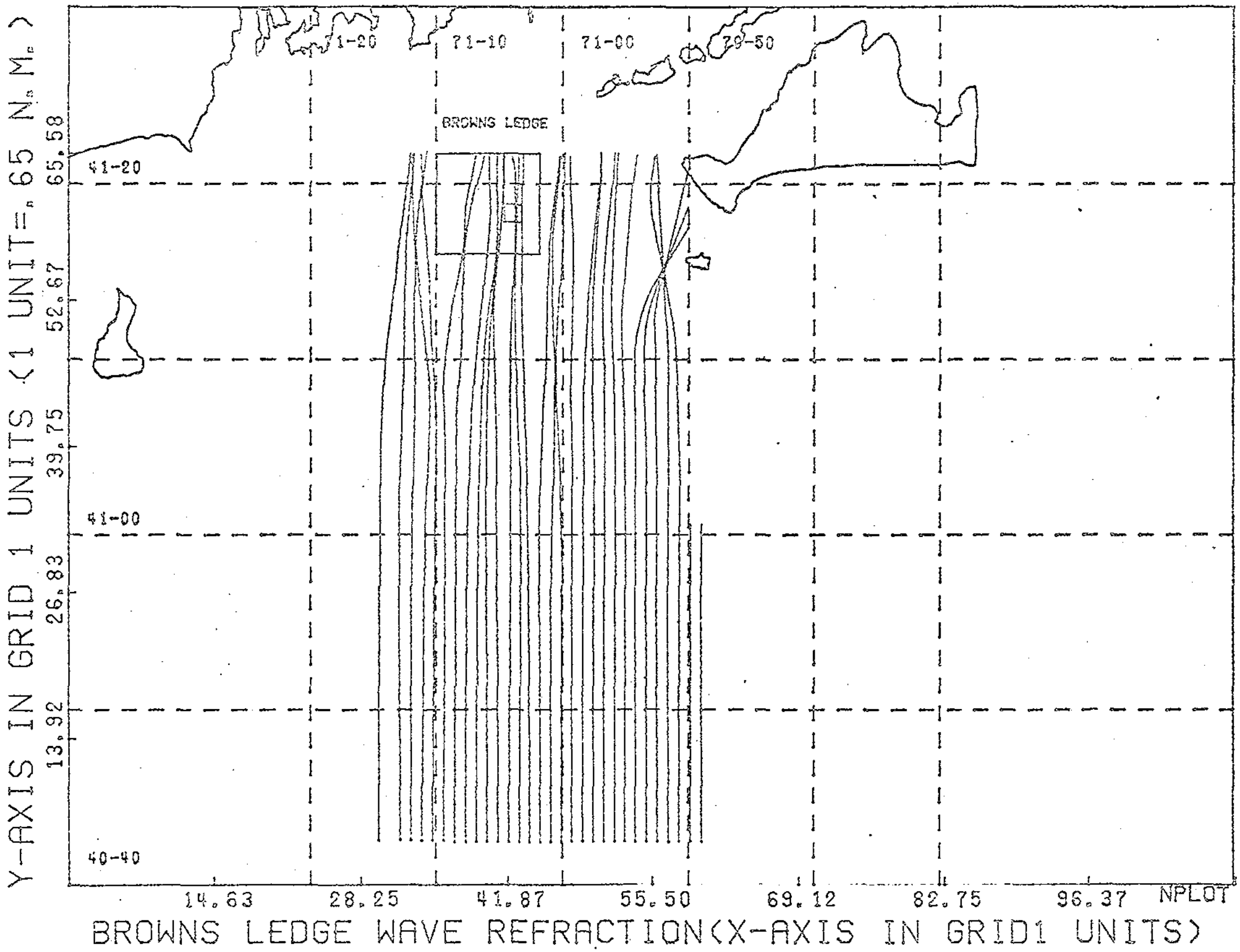
WAVE PLOTS FOR

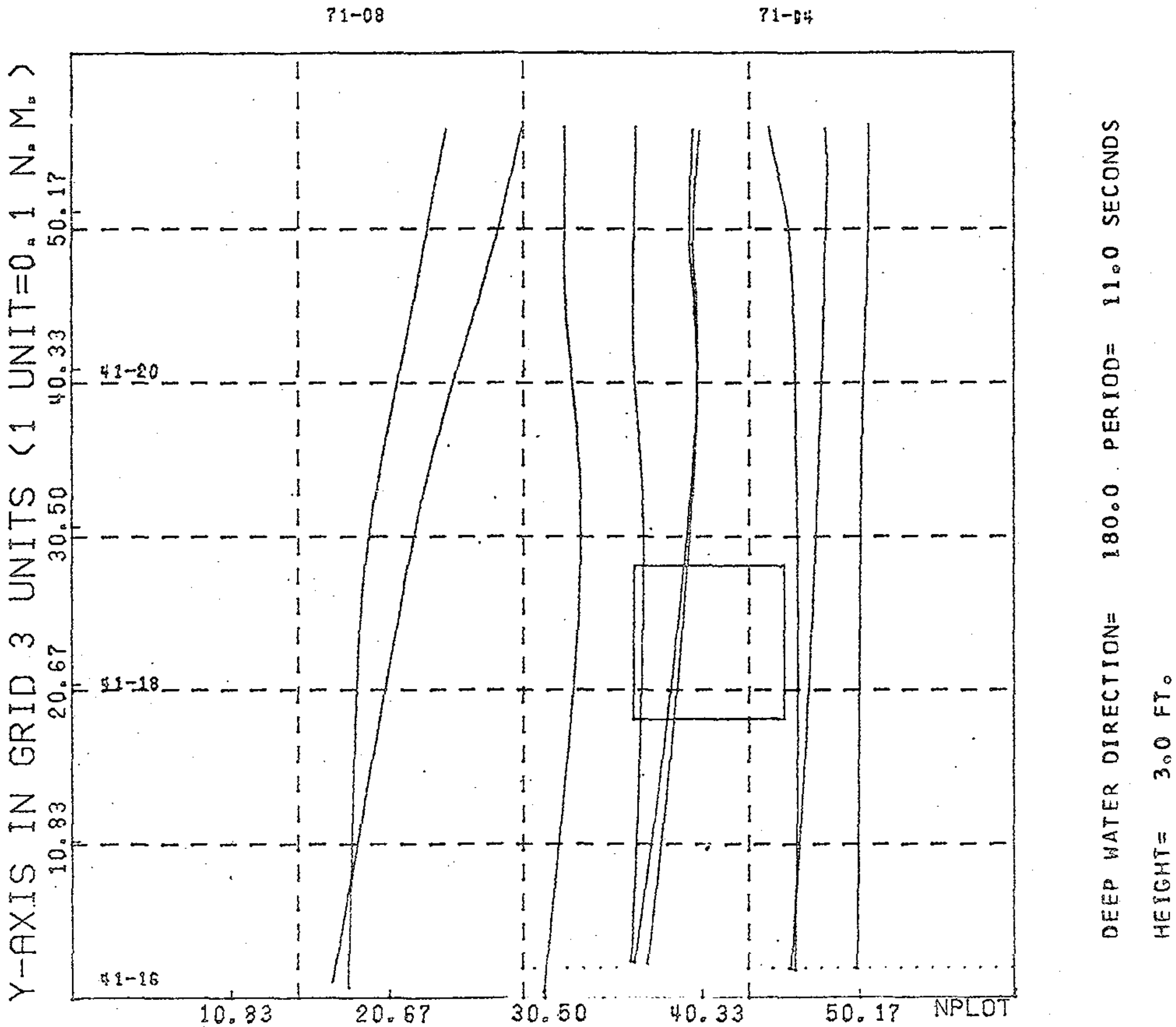
11 SECONDS

MAIN 3.0 Ft., 11.0 SECONDS

						Deep Water Wave Heights
1.)	Direction	=	189.0°			
	Main	-	Sub	-	Contours	- 2.0, 3.0, 4.0 Ft.
2.)	Direction	=	202.5°			
	Main	-	Sub	-	Contours	- 2.0, 3.0, 4.0 Ft.
3.)	Direction	=	225.0°-	Main		
4.)	Direction	=	157.5°			
	Main	-	Sub	-	Contours	- 2.0, 3.0, 4.0 Ft.
5.)	Direction	=	135.0°			
	Main	-	Sub	-	Contours	- 2.0, 3.0, 4.0 Ft.
6.)	Direction	=	90.0°			

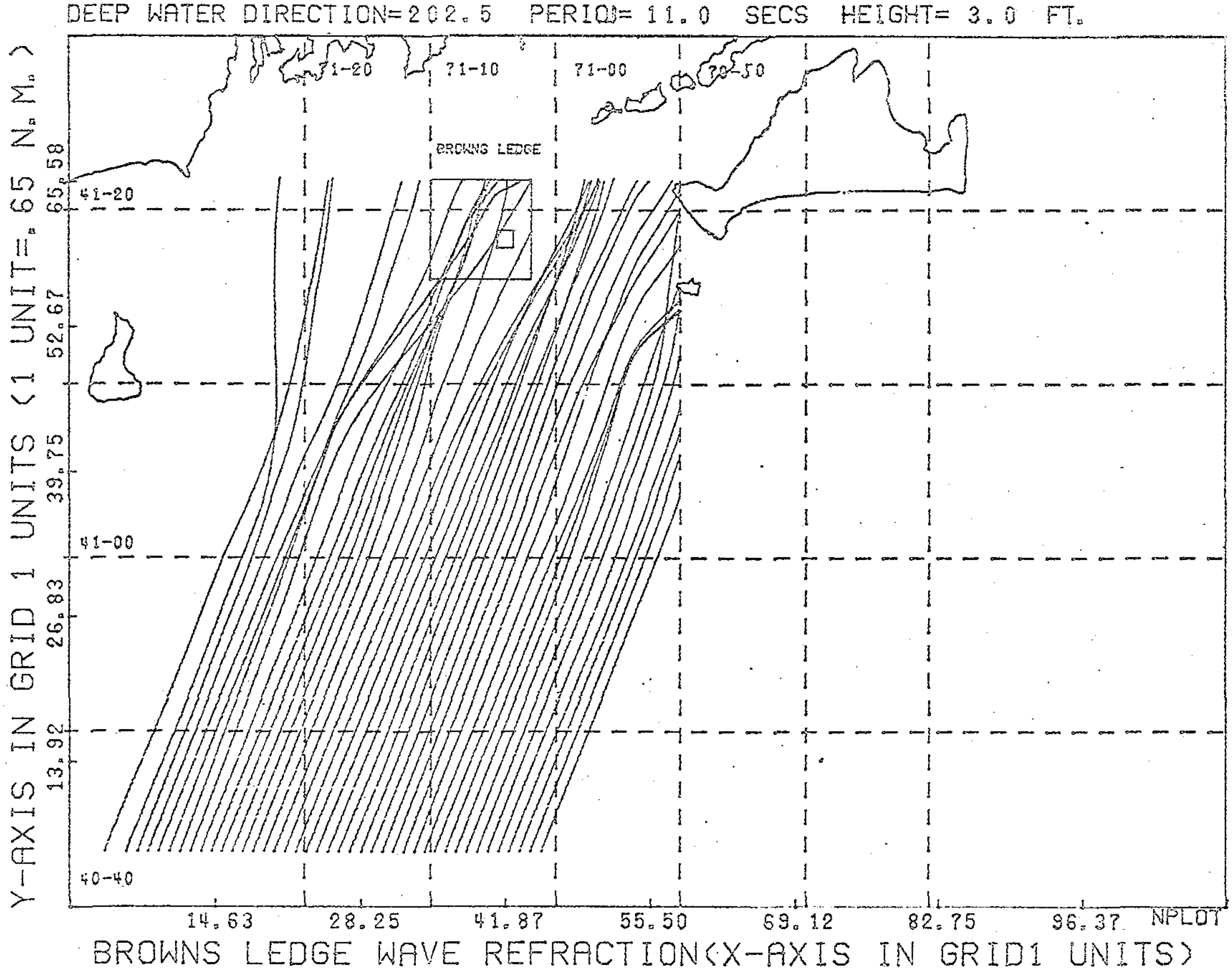
DEEP WATER DIRECTION= 180.0 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.



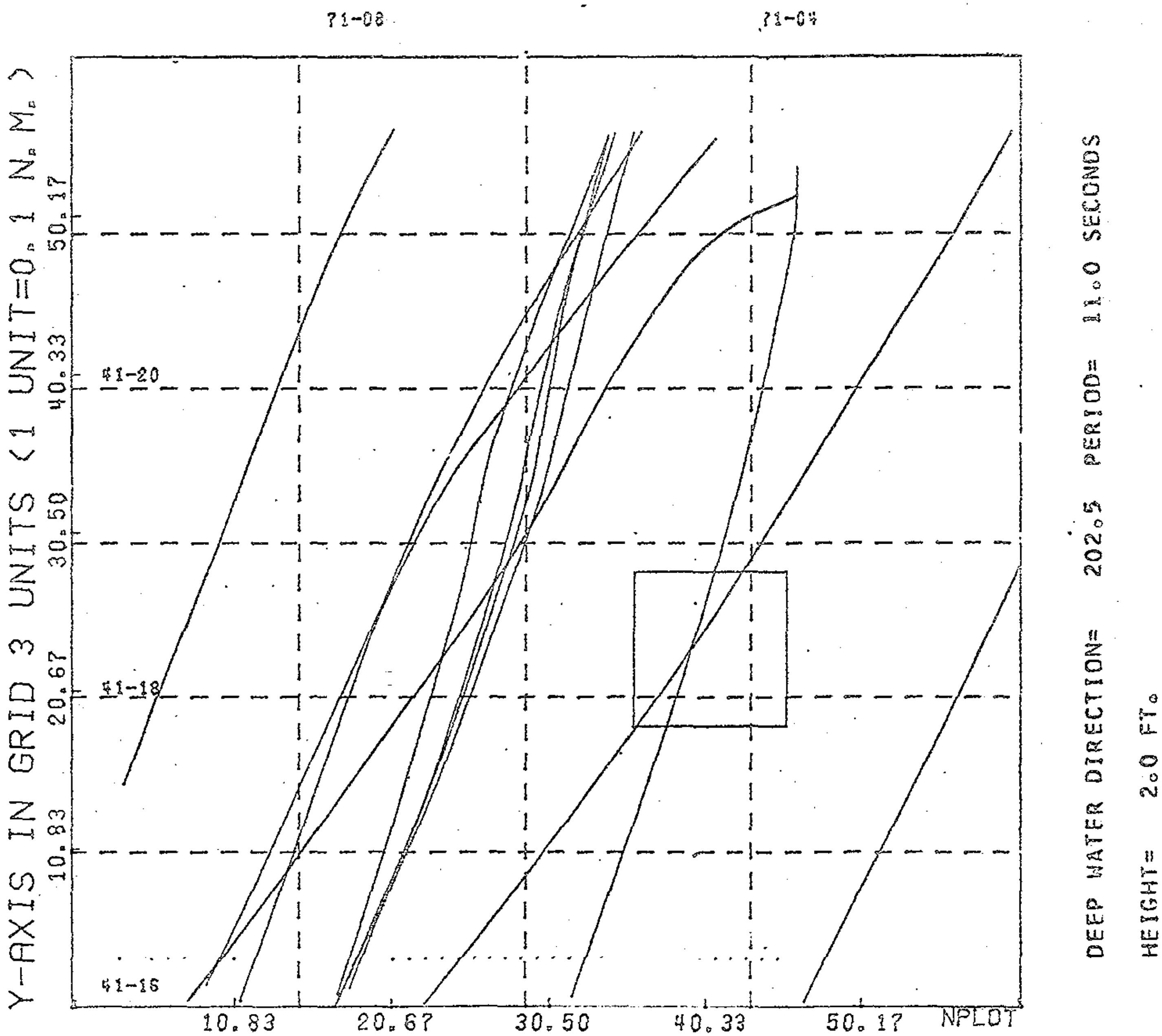


BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

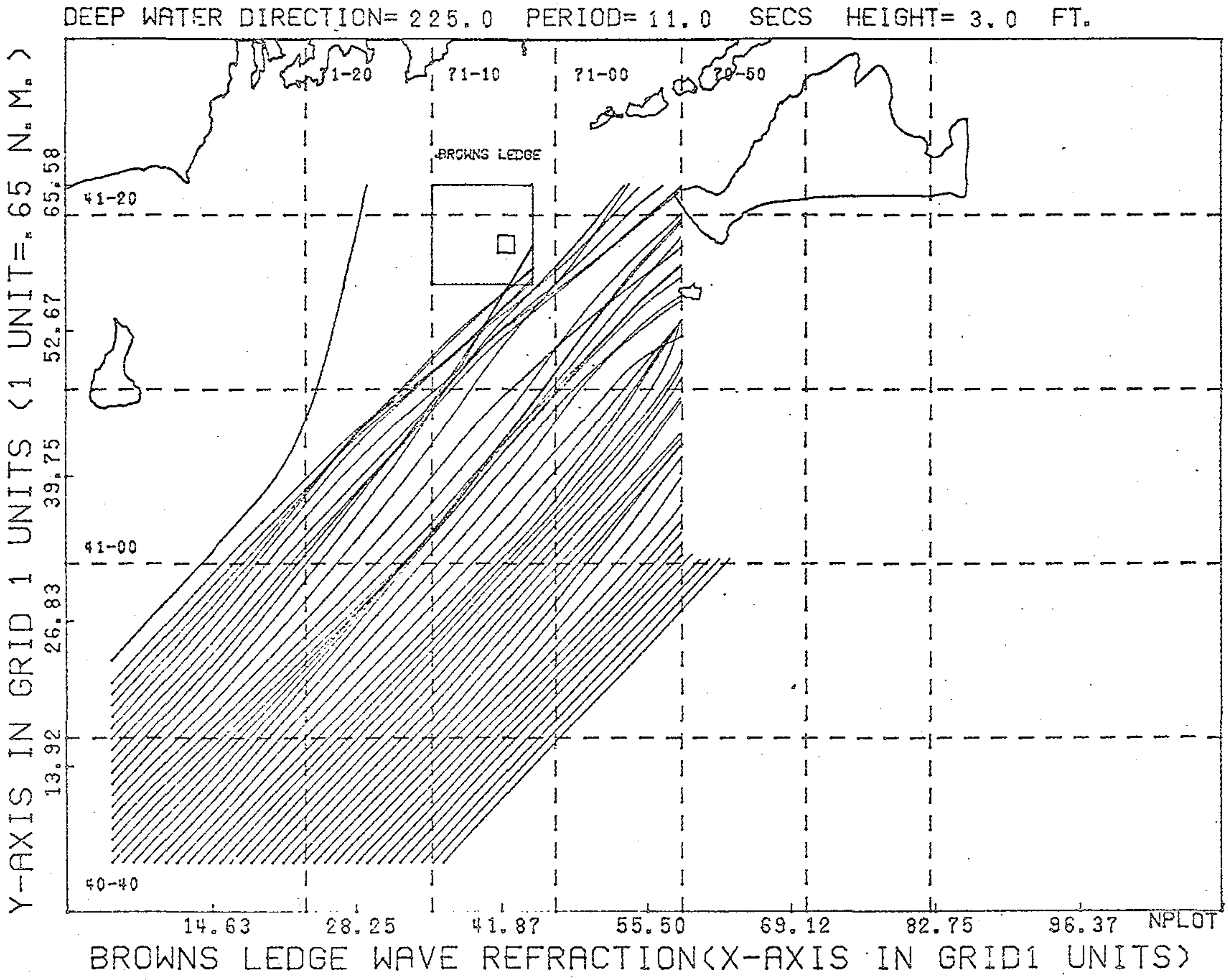
2-5D


DEEP WATER DIRECTION=202.5 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

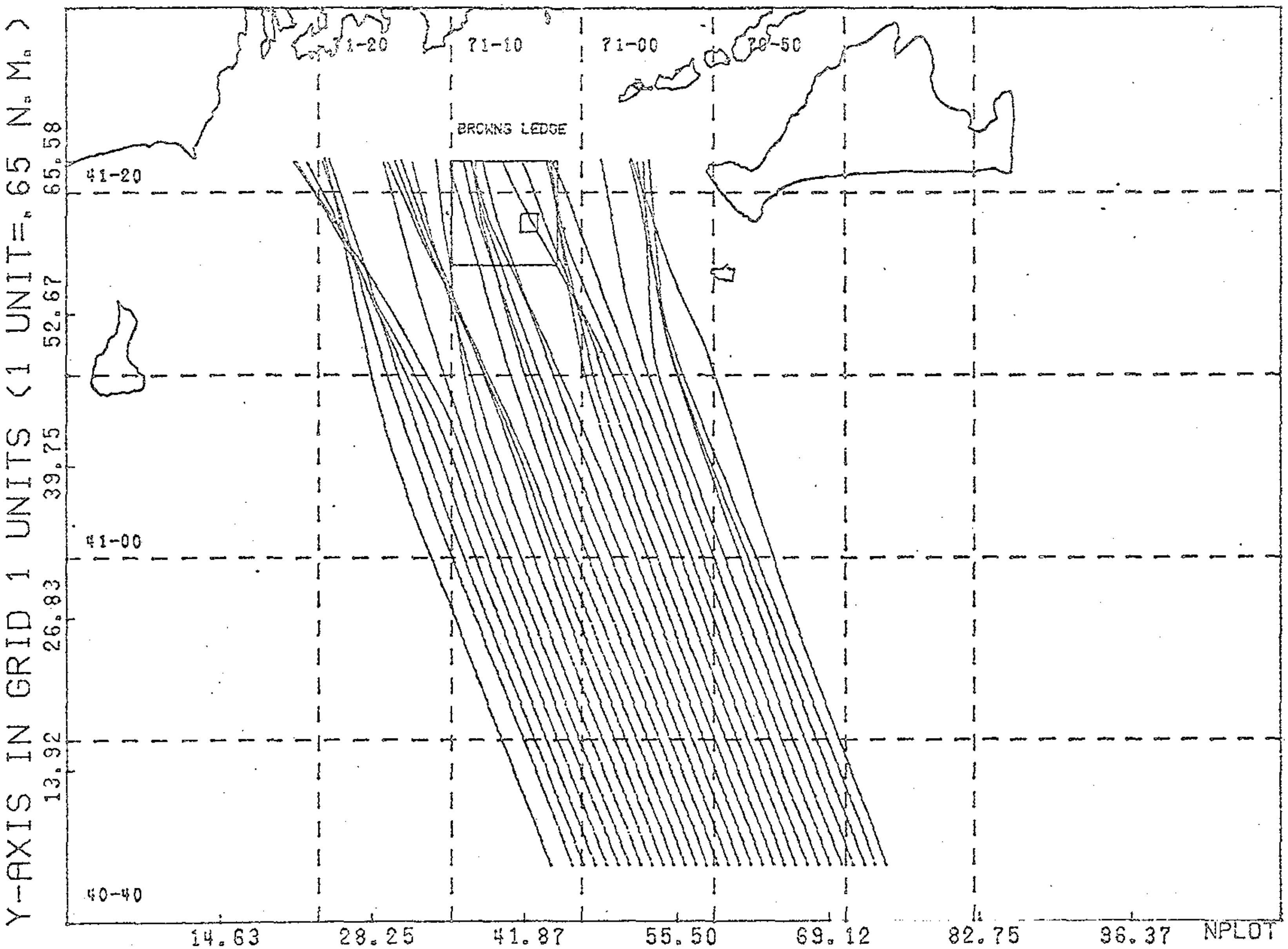
2-51



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

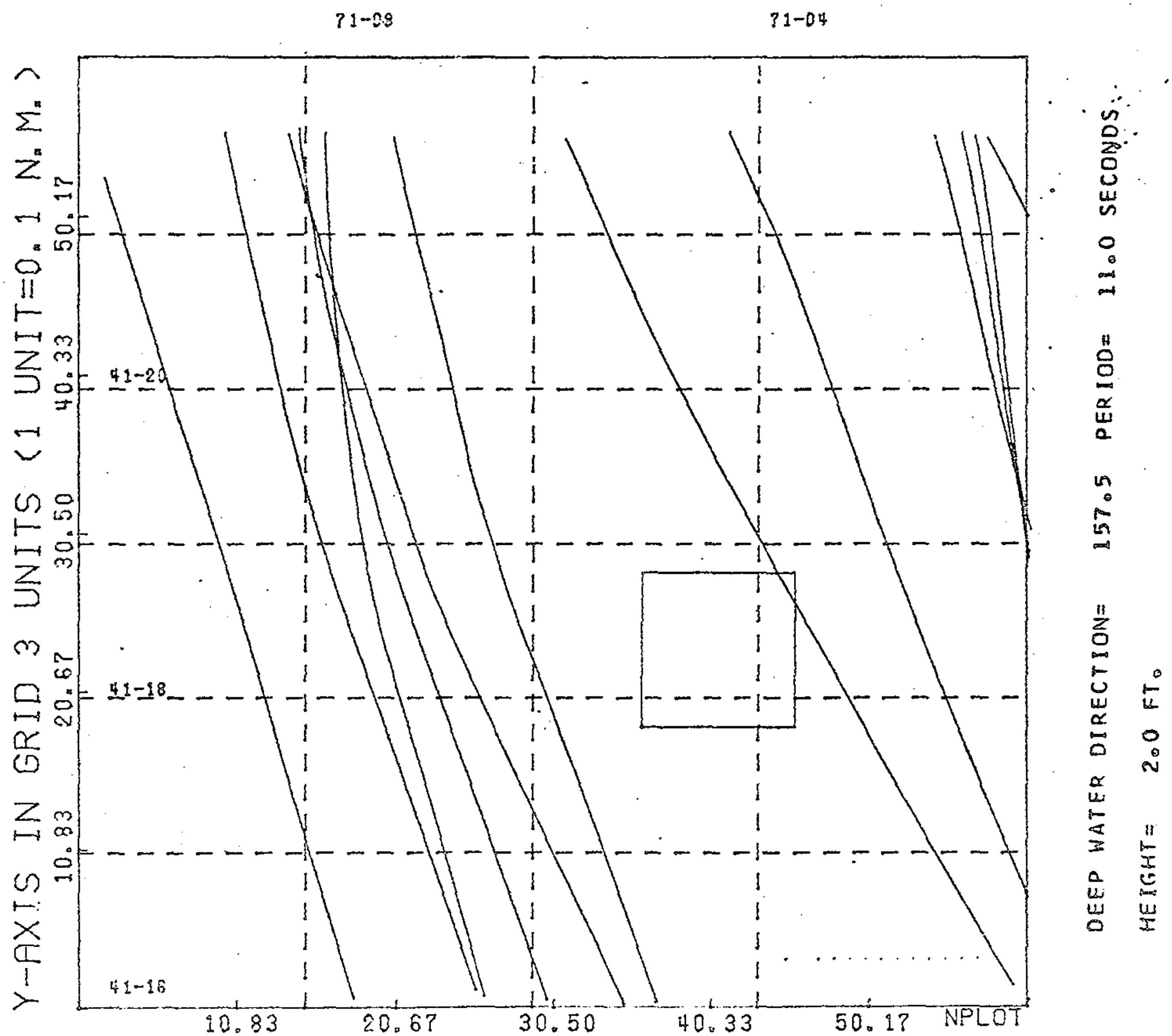

DEEP WATER DIRECTION= 225.0 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
Y-AXIS IN GRID 1 UNITS (1 UNIT= .65 N.M.)
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

DEEP WATER DIRECTION= 157.5 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.



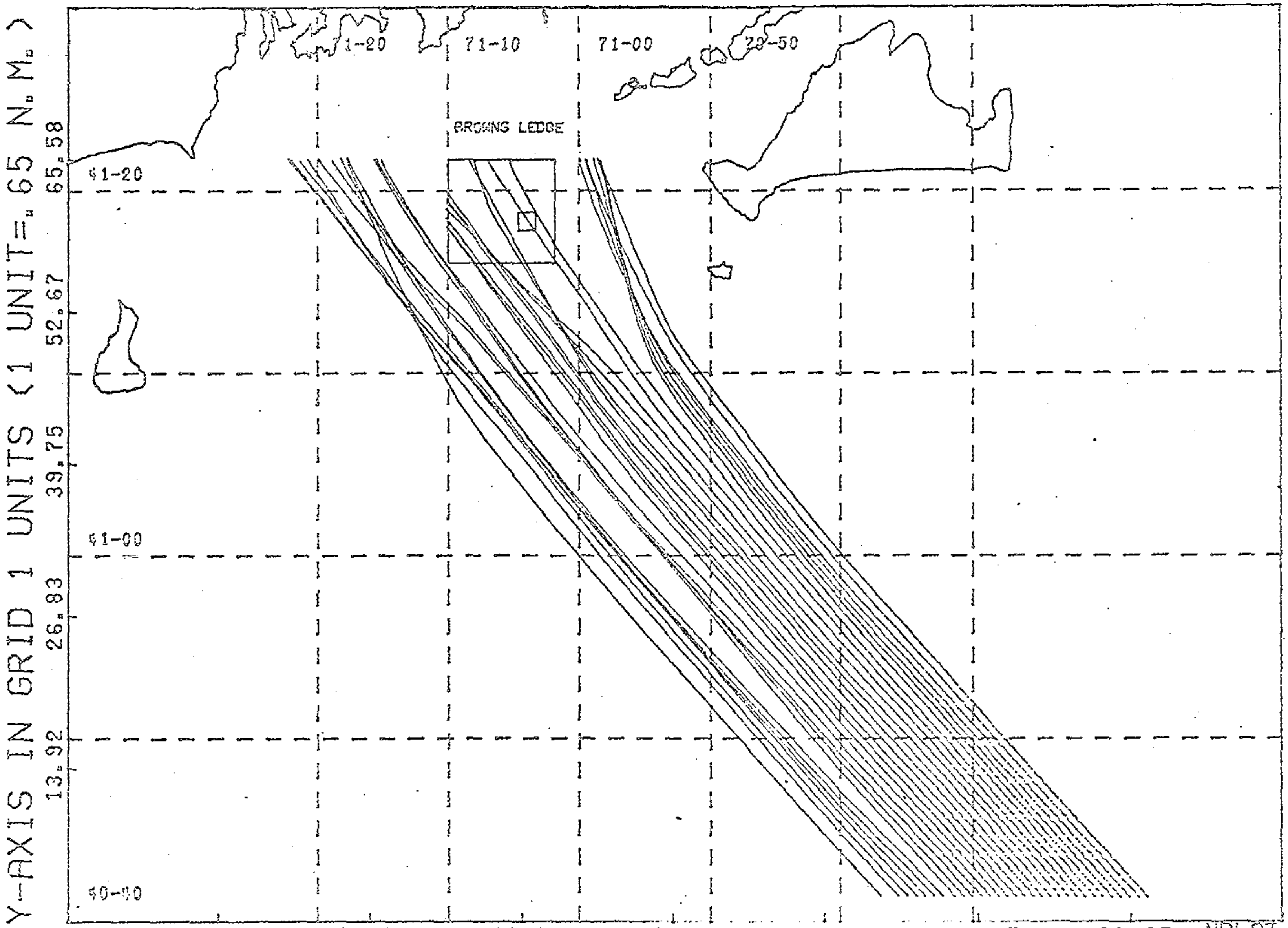
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-54



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

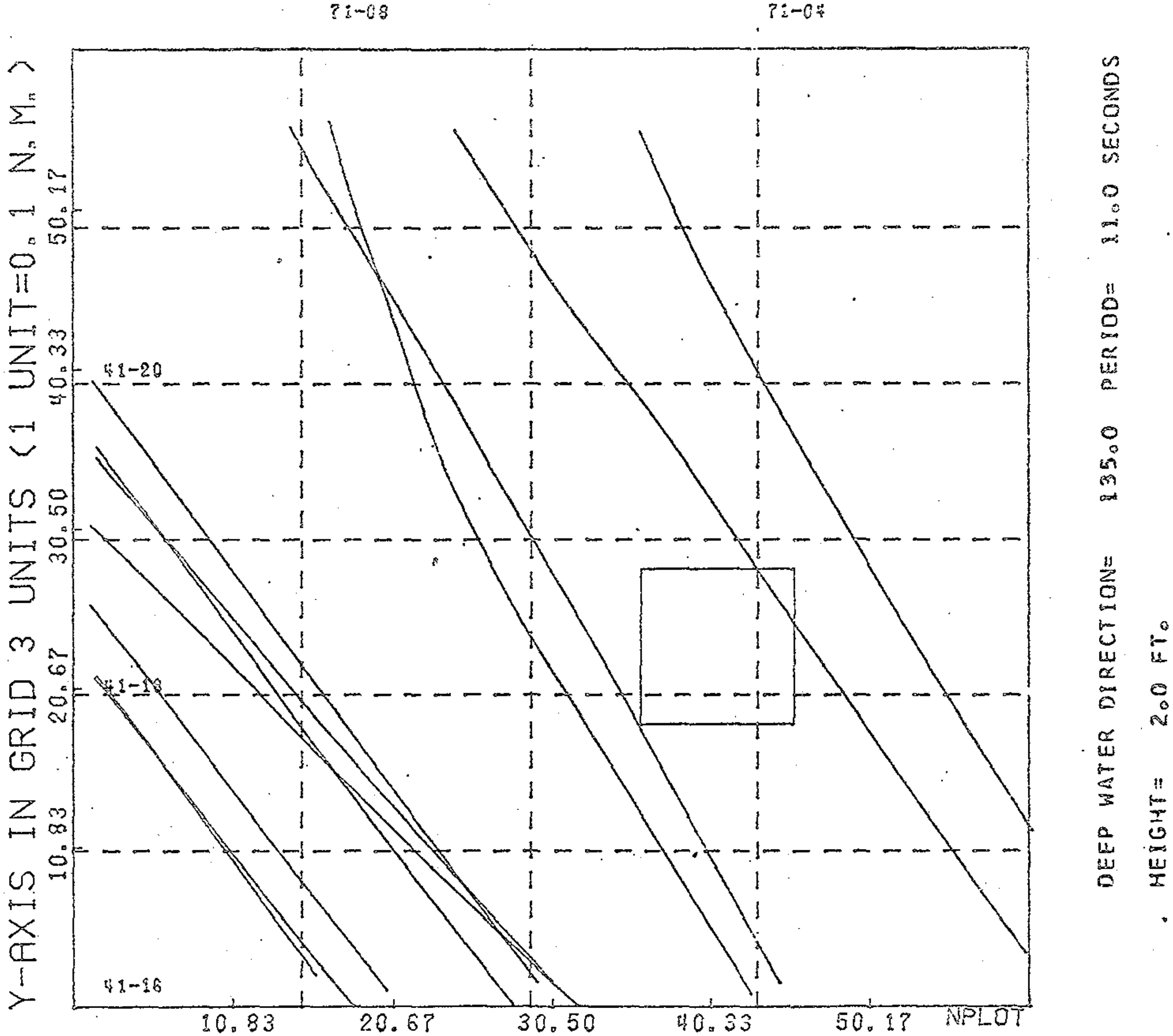
DEEP WATER DIRECTION= 135.0 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.



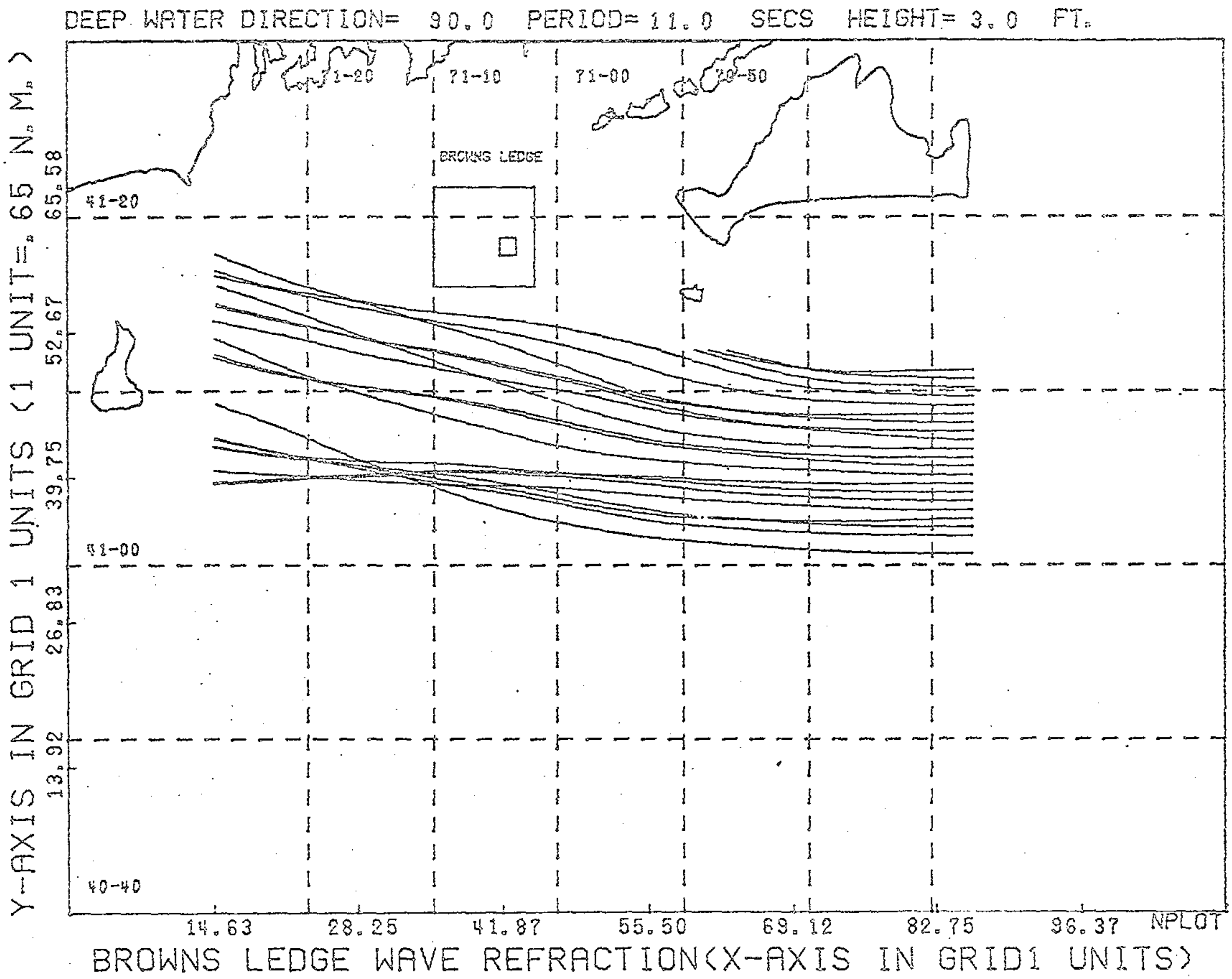
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

2-55

2-56



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)



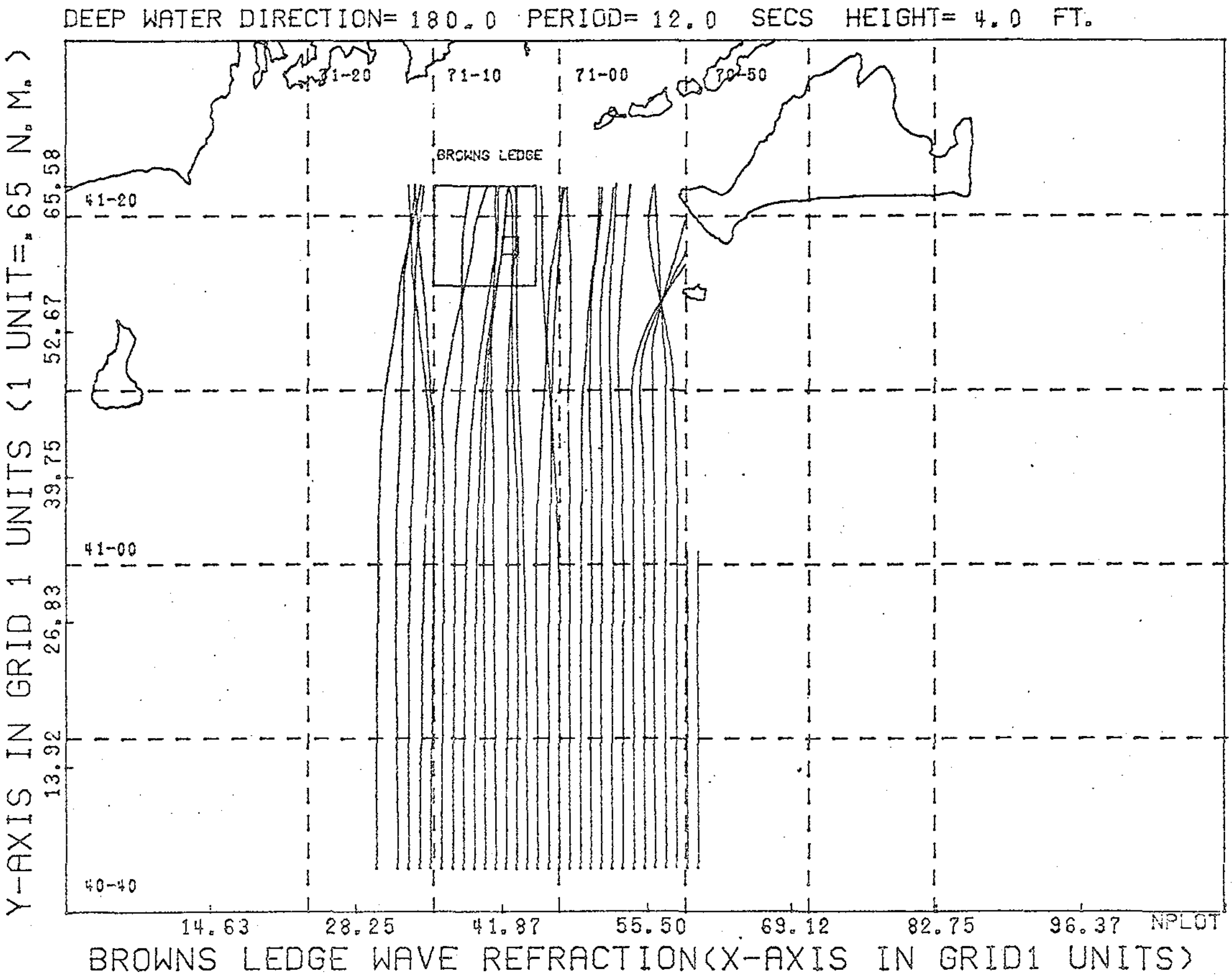
DEEP WATER DIRECTION= 90.0 PERIOD= 11.0 SECS HEIGHT= 3.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)

WAVE PLOTS

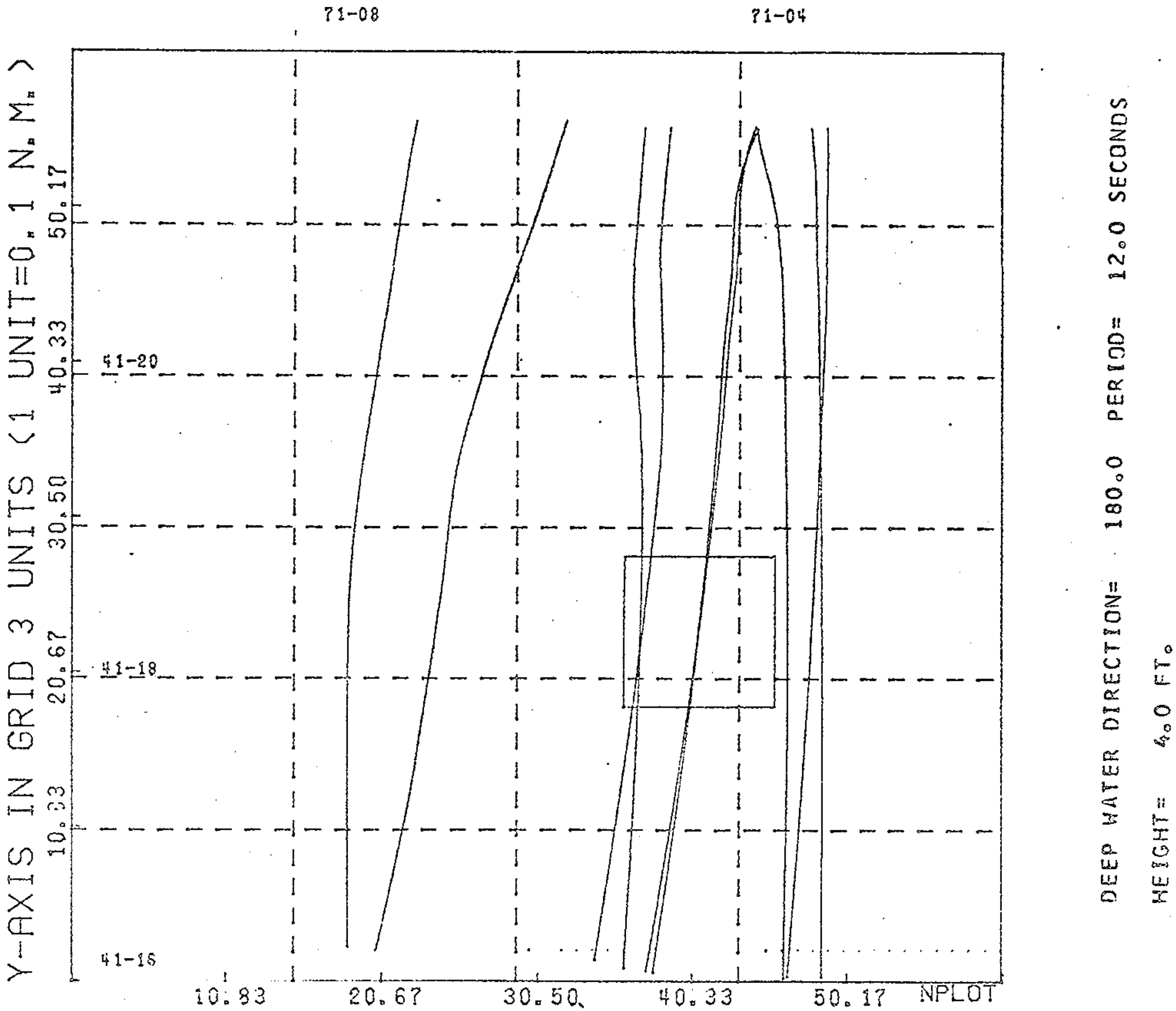
FOR 12 SECONDS

							Deep Water Wave Heights
1.)	Direction	=	180.0°				
	Main	-	Sub	-	Contours	-	1.0 Ft., 3.0 Ft., 6.0 Ft.
2.)	Direction	=	202.5°				
	Main	-	Sub	-	Contours	-	2.0 Ft., 3.0 Ft., 6.0 Ft.
3.)	Direction	=	225.0° -		Main		
4.)	Direction	=	157.5°				
	Main	-	Sub	-	Contours	-	2.0 Ft., 3.0 Ft., 4.0 Ft., 6.0 Ft.
5.)	Direction	=	135.0°				
	Main		-		Contours		2.0 Ft., 3.0 Ft., 4.0 Ft., 6.0 Ft.

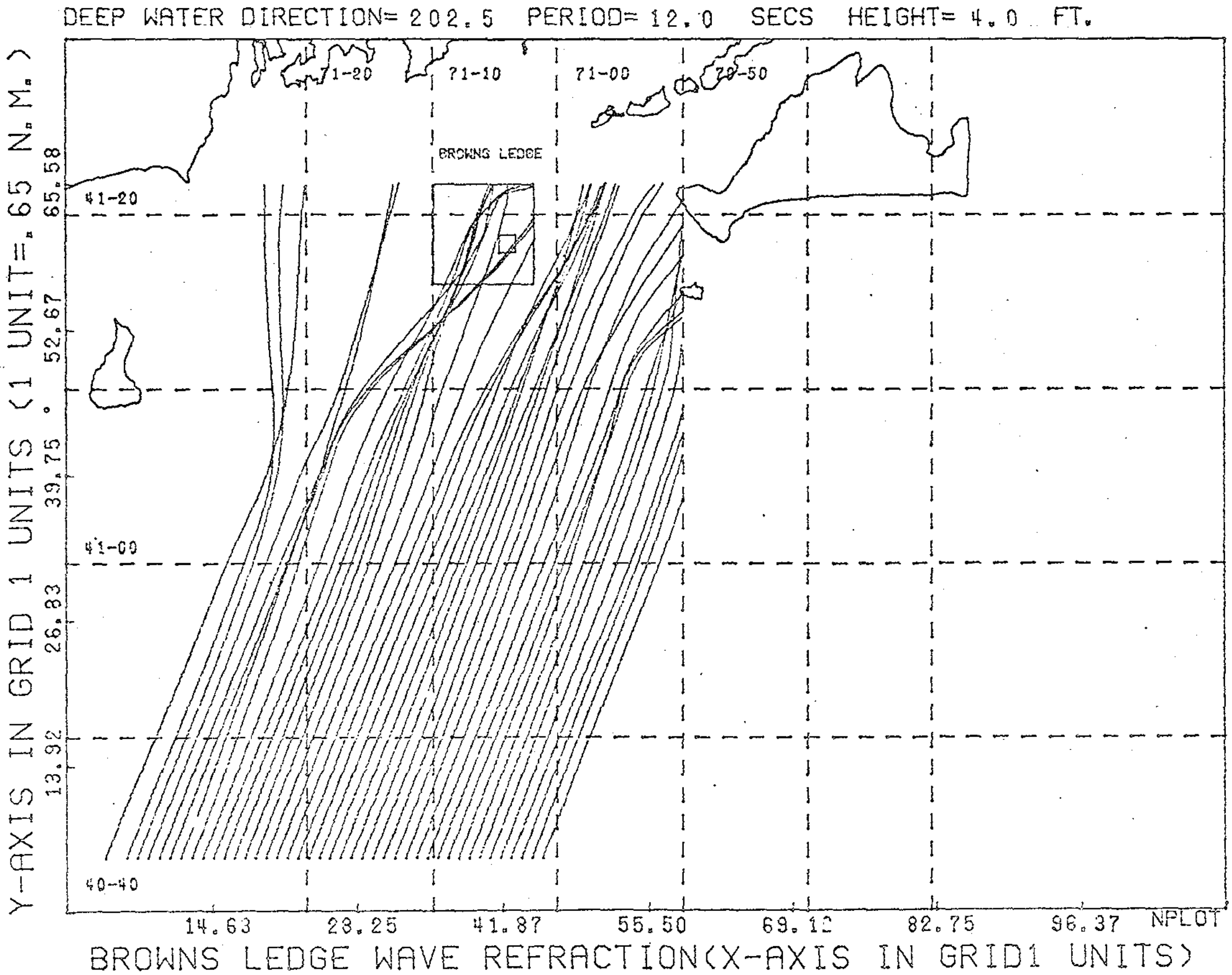
2-59

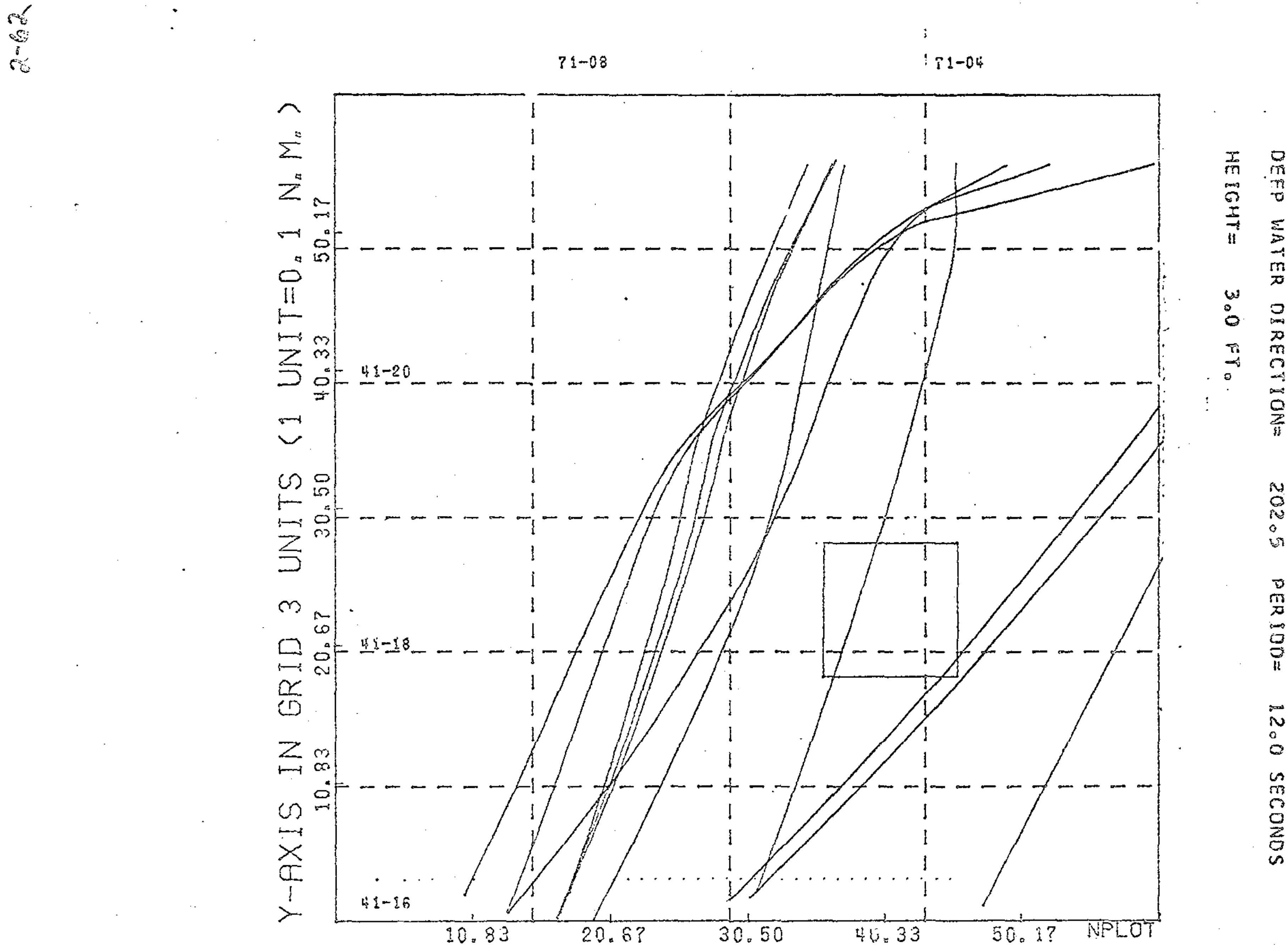


DEEP WATER DIRECTION= 180.0 PERIOD= 12.0 SECS HEIGHT= 4.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT= .65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



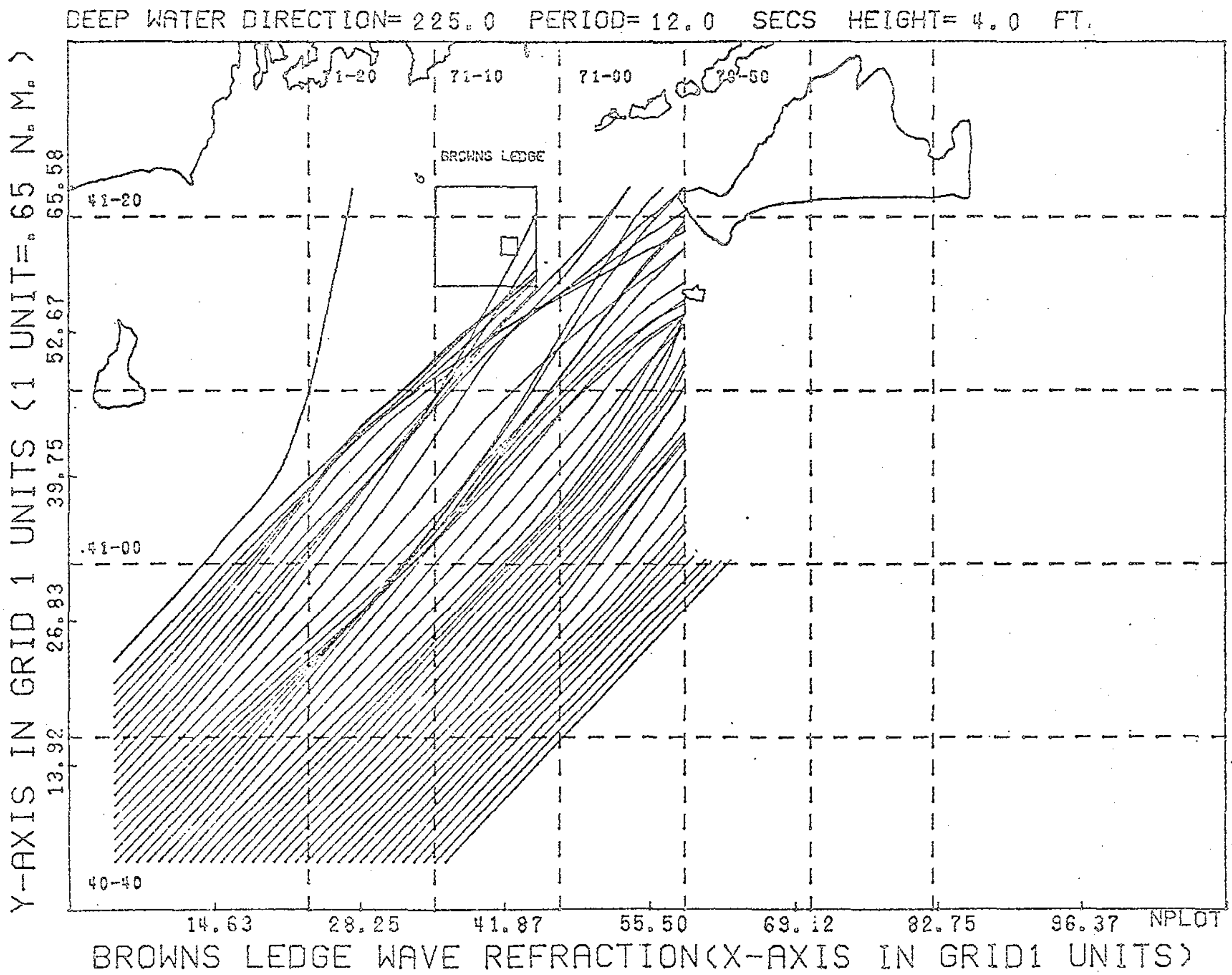
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

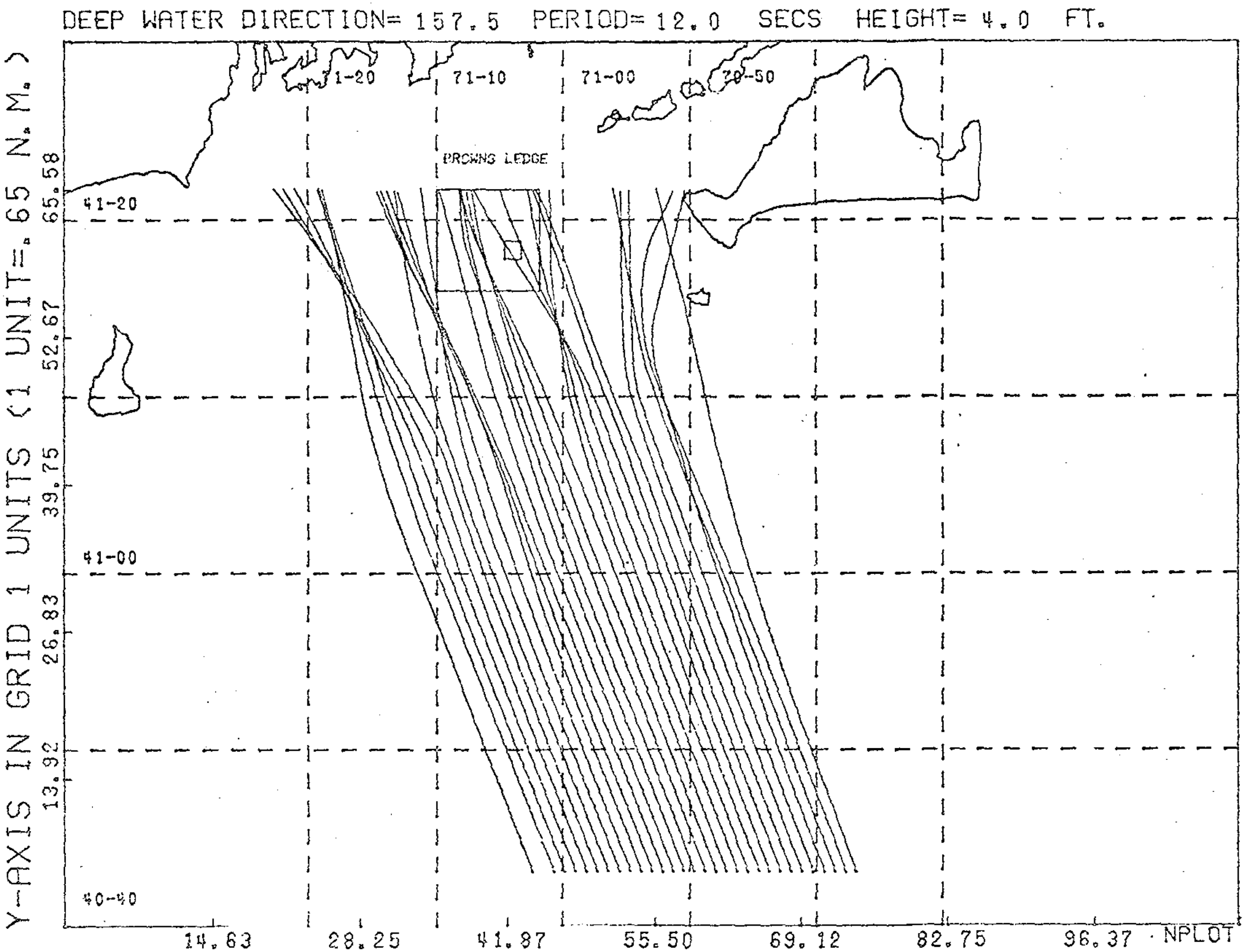

DEEP WATER DIRECTION= 202.5 PERIOD= 12.0 SECS HEIGHT= 4.0 FT.
71-20
71-10
71-00
70-50
BROWNS LEDGE
41-20
41-00
40-40
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



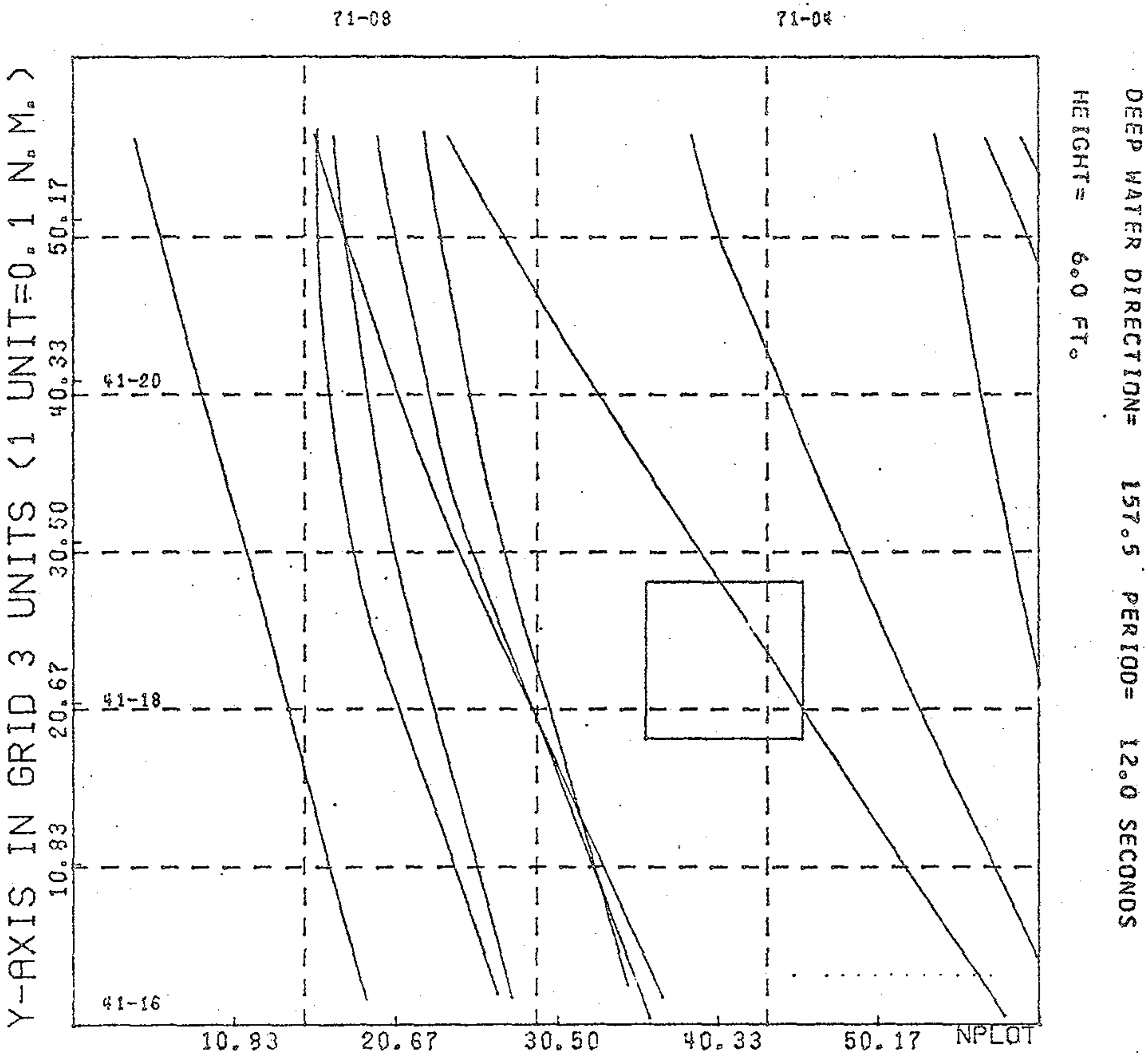
BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-63


DEEP WATER DIRECTION= 225.0 PERIOD= 12.0 SECS HEIGHT= 4.0 FT.
Y-AXIS IN GRID 1 UNITS (1 UNIT=.65 N.M.)
BROWNS LEDGE
71-20
71-10
71-00
70-50
41-20
41-00
40-40
65.58
52.67
39.75
26.83
13.92
14.63
28.25
41.87
55.50
69.12
82.75
96.37
NPLOT
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



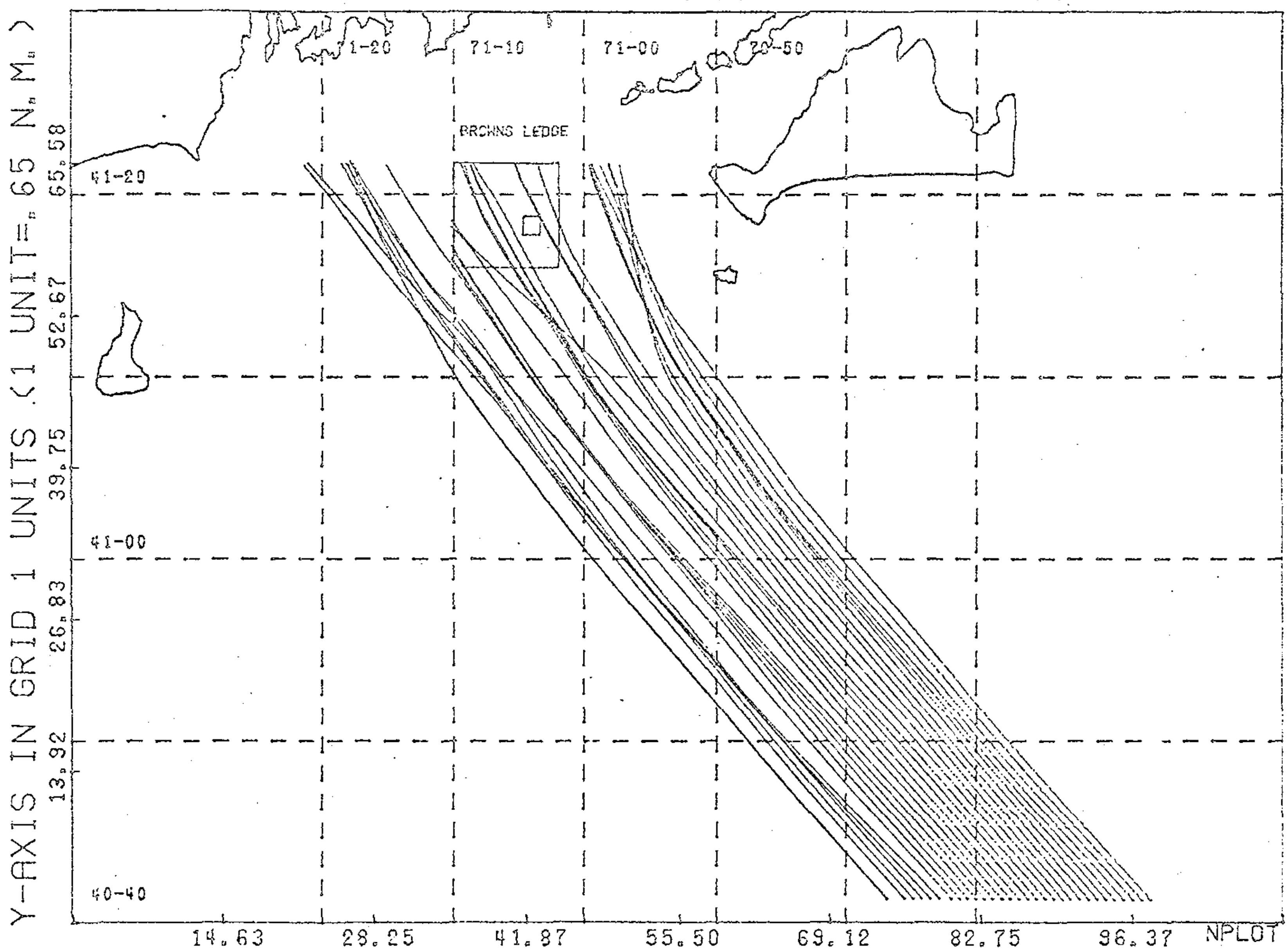
BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)



BROWNS LEDGE AREA-REFRACTION (X-AXIS IN GRID 3 UNITS)

2-66

DEEP WATER DIRECTION= 135.0 PERIOD= 12.0 SECS HEIGHT= 4.0 FT.



BROWNS LEDGE WAVE REFRACTION(X-AXIS IN GRID1 UNITS)