50-247

INDIAN POINT NO. 2

ROUTINE MONTHLY THERMAL MONITORING

- REPORT NO. 1 -
- MAY, 1974 -

PREPARED BY

DAMES AND MOORE
AND
CONSOLIDATED EDISON COMPANY
OF NEW YORK, INC.

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I. INTRODUCTION

This report presents the results of the first of a series of routine monthly thermal monitoring surveys of the thermal plume of Consolidated Edison Company of New York, Inc. (Con Edison) Indian Point Nuclear Generation Station, located at Buchanan, New York. There are currently two units in operation; Unit 1, with power level of 275 MWe (gross) and Unit 2, with a power level of 906 MWe (gross). Hudson River water is drawn through separate intakes in front of each unit, passes through the once-through cooling system, and is released downstream of the plant through a common discharge structure (See Figure 1). Units 1 and 2 were operating at 275 MWe (gross) and 800 MWe (gross) respectively during the field operation.

The thermal plume was measured (down to 2°F excess temperature), over five consecutive tidal phases on May 31, 1974 (flood, HWS, Ebb, LWS, flood) from two mobile monitoring platforms. The ambient river temperature and conductivity were obtained at either of two cross sections: an upstream cross section was monitored during ebb while a downstream one was monitored during flood. The intake and discharge temperature and conductivity were measured periodically in the intake forebay and in the discharge canal during the field operation. The field procedure, equipment, and boats used in the survey are described in Section II. The results are presented and discussed in Section III.

II. FIELD EQUIPMENT AND PROCEDURE

On Friday, May 31, 1974 mobile scans of the Indian Point thermal plume were conducted over five consecutive tidal phases (1-1/4 tidal cycles) by the Dames & Moore field team. Each scan consisted of a near field study and a far field study with each scan preceded and/or followed by several vertical profiling transects across the river. On shore, intake and discharge temperatures were monitored periodically throughout the day.

EQUIPMENT

1. Near field:

   The near field study was conducted from a power boat equipped with a Motorola Mini-Ranger for navigation and an Endeco Model 133 thermistor system for monitoring the temperature of the plume. This boat also performed river transects using an Endeco Model 110 Current meter and a Hydrolab Model TC-2 conductivity meter. The river parameters measured (as a function of depth) were temperature and conductivity.

2. Far field:

   The far field data were acquired with a second boat, similarly equipped as the nearfield boat except that the thermistor deck units on this craft were interfaced with the Motorola Mini-Ranger and the data were automatically recorded on magnetic tape cassettes.

A Hydrolab Surveyor was employed to record temperature and conductivity as a function of depth on the ambient transects conducted from this boat.

3. Intake and discharge:

Intake and discharge temperatures were monitored with the Hydrolab Surveyor.

PROCEDURE

1. Near field:

Preceding and following each of the five near field scans, a river transect was performed. This transect consisted of occupying five pre-selected stations and measuring temperature and conductivity at four depths: surface, 1/3 total depth, 2/3 total depth and bottom. The five stations were so distributed as to be representative of the conditions found across the width of the river (Transect BB of Figure 2). After completion of the transect, the boat proceeded to the area of the discharge canal. Thermistors were lowered to depths of 1, 3 and 6 feet and eleven (11) lines were run parallel to the discharge canal. Each successive parallel line was run towards the center of the river such that coverage was usually from 30 feet to 1000 feet out from the discharge. Each line began and ended where the surface temperature was less than 2°F above ambient or when in the judgement of the party chief, the scan was intruding into the far field.

Data collection began when the boat was positioned on a course parallel to the discharge canal while maintaining a speed of 3 mph. Temperature and navigational data were obtained from the digital readouts every 10 seconds during the running of a line.

2. Far field:

Preceding each of the far field scans, a transect was run to determine ambient river conditions. This transect consisted of occupying three to five stations across the river's width and taking temperature and conductivity measurements at various depths. On ebb, the transect was located north of the Indian Point site whereas on flood it was south of the site (Transects AA and YY on Figure 2). Upon completion of the ambient determinations, the boat proceeded to the discharge area to start the thermal scan. The boat began tracing the position of the plume by zig-zagging across the river, turning back towards the opposite shore whenever the surface temperature was less than 2°F above ambient. Boat speed was approximately 5 mph. Thermal data, navigational positions and time were automatically recorded on magnetic tape cassettes. Each scan continued until the plume temperature was less than 2°F above ambient.

3. Intake and discharge:

Intake temperatures were monitored at the northernmost and southernmost intake canals of Unit 2. Temperature and conductivity were monitored at four depths: surface, 1/3 total depth, 2/3 total depth and bottom. One lowering was performed at each intake.

Discharge temperatures were monitored for the same depths at one cross section of the canal. One lowering was performed on the east side of the canal, one on the west side and one in the middle. Both conductivity and temperature (versus depth) were monitored.

4. Plant Performance Data:

As previously mentioned, Units 1 and 2 were operating at an average of 275 MWe (gross) and 800 MWe (gross) during the field operation. The power levels for both units during the day preceeding the survey and the day of the survey are tabulated in Table 1 and illustrated in Figure 3. The flow rates for each unit were constant and are presented in Table 2. The total flow was 1,160,000 gpm. The power levels and temperature rise for both Lovett Units 4 and 5 are presented in Table 3. The condenser cooling water flow rates were 104,300 and 120,000 gpm, respectively. Bowline Units 1 and 2, and Lovett Units 1, 2 and 3 were not operating during this period.

III. RESULTS

1. Summary

Before each near and far field thermal scan, temperature and conductivity profiles were obtained at the transect located at the southern edge of the Indian Point discharge (Transect BB, Figure 2). Ambient temperature and conductivity profiles were taken at either a northern transect at Roa Hook (Transect AA, Figure 2) for ebb, or at a southern transect at Verplanck (Transect YY or Y'Y', Figure 2) for flood. The water was basically fresh, as the conductivity ranged from 175 to 180 umho. The fresh water flows (at Troy Lock) for the period preceding the survey are given in Table 4.

Both near and far field isotherms are presented for each tidal cycle, with the far field isotherms indicated down to approximately the 2°F excess temperature interval (2°F above ambient).

The average area temperature at the Indian Point transect (Transect BB) varied from approximately 17.0°C (62.6°F) at flood, to 17.3°C (63.1°F) during HWS and ebb, with an intermediate value of about 17.2°C (62.8°F) during LWS.

The Lovett plume does not appear to have any influence on the Indian Point Transect. Furthermore, from the far field patterns any influence of the Lovett Plume on the Indian

Point Plume down to the 2°F excess temperature isotherm is not discernable.

The computations for determining compliance with the New York State Thermal Criteria were performed using a different ambient for the surface width and cross sectional area evaluations. This reflects the natural tendency for a water body, when exposed to natural surface heating, to undergo self-thermal stratification; i.e., the surface layer is warmer than the lower layers. (See Table 7). The surface width computations are based on the average temperature of upper layer (upper 5 feet) of the ambient transect. This in itself is a conservative assumption, for the surface temperature is warmer than this upper layer temperature. The cross sectional width computations are based on the area average temperature at the ambient transect. This also is a conservative assumption, for the plume is primarily a surface phenomenon.

With respect to the actual computations, generally if the absolute value of the 4° excess isotherms was, say 66.7°F, calculations were based on the next <u>lowest</u> mapped temperature, 66.5°F, or even 66.0°F. This introduces yet another conservative factor into the final figures. The actual absolute temperatures were mapped and not the excess temperature isotherms; thus avoiding an <u>a priori</u> decision on the value of ambient. Inasmuch as providing 0.1°F isotherm intervals on the maps would have made them impossible to read, a decision was made to plot the 0.5°F isotherm for the far field and the 1.0°F isotherm for the near field.

The maximum lateral extent of the 4°F excess surface temperature isotherm, using the very conservative approach, occurs during LWS. Computations performed on the 3.1°F excess temperature isotherm, yields a percentage width of 46%, well within the 67% limit (for 4°F excess temperature). The corresponding value for the percentage cross sectional area, using the 3.3°F excess temperature isotherm is 19%, also well within the criteria, 50%. Tabulated values for the five phases of the tidal cycle that were examined are presented in Table 6.

2. Discussion

The ambient temperatures were obtained, as previously mentioned, from the northern transect at Roa Hook for the ebb and LWS (slack after ebb) measurements. Similarly, the profiles at Lovett-Verplanck were used to provide ambient temperatures for the flood and HWS (slack after flood) measurements.

As previously indicated, separate ambients were assigned to the surface width and cross-sectional area calculations. Examination of the ambient temperature profiles (Roa Hook at Ebb and HWS, Figures 16 and 21 respectively, and Lovett - Verplanck at first and second flood, Figures 5 and 27 respectively), indicates that the surface temperatures are higher than the bulk of the cross section of the river as a result of surface heating. This condition becomes prevalent with increasing daylight hours. Therefore, inasmuch as the thermal plume (for width calculations) is a surface phenomenon, it is a logical extension to take the upper layer measurements to be representative of its ambient. It should also be noted, that in addition to a natural variation with depth, there is a natural variation laterally (i.e., shore to shore) at all depths. To maintain an element of conservatism, the ambient surface temperature will be determined by assigning surface ambient as the average temperature of the upper 5 feet (approximately) of the river at these ambient transects. This is called ambient "1", likewise, the cross sectional area calculations are based on the area average temperature at the ambient (ambient "2") transects. This is also conservative because it includes temperatures at depths greater than the depth of the plume. Table 7 compares the various values.

Discussion of the apparently higher ambient temperatures measured in the Verplanck area is of interest. As footnoted in Table 7, the second flood ambient transect was taken further south (of the Indian Point station), thus one would expect, that if the plant had an influence on this transect, the temperatures recorded would be lower. This is not the case, however. Bowline was not operating, and therefore is not a factor. Lovett (which was operating at an average of less than 300MWe during the course of the survey) is on the opposite shore and presumably would not affect more than a small portion of the channel. This unexpected behavior (ambient increasing southward and with time) may be attributed to the warming of the water in Haverstraw Bay area.

This bay is quite shallow (depth less than 10 feet), and relatively large in area, and during the day experiences solar heating of its water. The bay water eventually enters and mixes with the main channel flow during flood, and results in an increase in water temperature upstream. This may account for the higher ambient south of the I.P. station and the increase in this ambient during the daylight hours.

A. First Flood (0737)

Ambient at the first flood will be taken from the transect obtained at Verplanck. As previously mentioned, surface widths and area average computations will have different ambients.

The relevant statistics, utilizing Table 7 are:

	Ambient 1	Ambient 2
(1) Ambient	17.03°C(62.65°F)	16.96°C(62.53°F)
(2) 4°Excess Temperature Above Ambient	19.2°C(66.6°F)	19.2°C(66.6°F)
(3) Temperature at which Perform Calculations	18.9°C(66.0°F)	18.9°C(66.0°F)
(4) Excess Temperature: (3)-(1)	3.4°F	3.4°F

For convenience identical excess temperatures will be selected for Ambient 1 and Ambient 2. The surface width of the 66.0°F isotherm (which is of greater extent than the 66.6°F isotherm) can be estimated from the near field mappings (Figure 7.1) as less than 700 feet, which translates into a percentage width (river width approximately 5000 feet) of less than 15%. The maximum depth of the 18.9°C isotherm, as taken from the I.P. transect is less than 10 feet (maximum temperature at the 10 foot depth is 17.1°C). From the 6 foot depth isotherms (near field) the width of the 66°F isotherm is approximately 300 feet. Inasmuch as the cross sectional area is about 160,000 feet^2, the cross-sectional area exceeding 4°F excess temperature (actually 3.4°F excess temperature) is less than 2% (10 X 300 X 100/160,000).

B. High Water Slack (1002)

Ambient for HWS will also be obtained from the transect recorded at Verplanck during the preceding flood. The ambient temperatures for the two computations are listed above, and are identical. The surface width of the 66.0°F isotherm (which is of greater extent than that of 66.6°F isotherm) is estimated as in (A) above. The width of the isotherm is obtained from the 6 foot depth mappings as less than 500 feet (there are actually only isolated pockets of 66°F water); and with a maximum depth of less than 10 feet (see Figure 12.3), the percentage cross sectional area within this excess temperature isotherm is less than 4%. As previously mentioned, these computations were in effect performed with the 3.4°F excess temperature isotherm.

C. Ebb (1334)

Ambient for this tidal phase is obtained from the ebb Roa Hook transect. The relevant statistics, obtained from Table 7 are:

	Ambient 1	Ambient 2
(1) Ambient	16.64°C(61.95°F)	16.55°C(61.79°F)
(2) 4°Excess Temperature Above Ambient	18.8°C(66.0°F)	18.7°C(65.8°F)
(3) Temperature at which Perform Calculations	18.3°C(65.0°F)	18.3°C(65.0°F)
(4) Excess Temperature: (3)-(1)	3.0°F	3.2°F

For convenience the same temperature will be used for computing the percentage width and cross-sectional area required for comparison with the New York State Criteria. The surface width of the 65.0°F isotherm (which is of greater extent than the 66.0°F isotherm) can be estimated from Figure 18.1 as 1200 feet, or less than 25%. The corresponding percentage cross-sectional area, estimated from the 6 foot depth isotherm (width of 900 feet, maximum depth less than 10 feet) is less than 6%.

D. Low Water Slack (1650)

Ambient for this tidal phase will also be obtained from the Roa Hook transect. The pertinent statistics are:

	Ambient 1	Ambient 2
(1) Ambient	16.60°C(61.88°F)	16.47°C(61.65°F)
(2) 4°Excess Temperature Above Ambient	18.8°C(65.9°F)	18.7°C(65.7°F)
(3) Temperature at which Perform Calculations	18.3°C(65.0°F)	18.3°C(65.0°F)
(4) Excess Temperature: (3)-(1)	3.1°F	3.3°F

The surface width of the 65.0°F isotherm (which is of greater extent than the 65.9° or 65.7° isotherm) can be estimated from the far field patterns (Figure 24.1), as approximately 2300 feet, or about 46 percent. The cross-sectional area, estimated as before, is about 19% (30 X 1500 X 100/160,000). As indicated, these computations were performed with the 3.1°F and 3.3°F excess isotherms for surface width and cross-sectional area, respectively.

E. Second Flood (2009)

Ambient temperature for this tidal phase is obtained from the Verplanck transect. The pertinent statistics are:

	Ambient 1	Ambient 2
(1) Ambient	17.47°C(63.45°F)	17.42°C(63.36°F)
(2) 4°Excess Temperature Above Ambient	19.7°C(67.5°F)	19.6°C(67.4°F)
(3) Temperature at which Perform Calculations	19.4°C(67.0°F)	19.4°C(67.0°F)
(4) Excess Temperature: (3)-(1)	3.5°F	3.6°F

For simplicity the ambient methods will be computed using the same excess temperature. The surface width of the 67.0°F isotherm (which is of greater extent than the 67.5°F isotherm) is about 750 feet, or about 15%. The 67°F isotherm is actually not a continuous band of water, but isolated pockets, separated by water where temperature is less than 67°F. Use of the actual width of the 67°F pockets generates a surface width of less than 450 feet, or less than 10% of the width. The cross-sectional area, using either technique, is less than 1%.

TABLE 1

INDIAN POINT POWER LEVELS

DATE	TIME	UNIT 1 MWe (gross)	UNIT 2 MWe (gross)
5/30/74	200	275	400
	400		400
	600		410
	800		420
	1000		630
	1200		630
	1400		800
	1000		810
	1800		830
	2000		810
	2200		790
	2400		790
5/31/74	100		800
	200		800
	300		800
	400		800
	500		800
	600		800
	700		800
	800		820
	900		820
	1000		810
	1100		810

(cont'd)

INDIAN POINT POWER LEVELS

DATE	TIME	UNIT 1 MWe (gross)	UNIT 2 MEe (gross)
5/31/74	1200	275	800
	1300		820
	1400		826
	1500		810
	1600		800
	1700		800
	1800		800
	1900		800
	2000		810
	2100		810
	2200		810

TABLE 2

INDIAN POINT FLOW CHARACTERISTICS

	TOTAL	UNIT 1	UNIT 2
A)	Total		
	Circulating Water		
	No. of Pumps	2	6
	Flow/pump (gpm)	140,000	140,000
	Service Water		
	No. of conventional pumps	2	3
	Flow rate/pump (gpm)	16,000	5,000
	No. of Nuclear pumps	4	3
	Flow rate/pump(gpm)	1,500	5,000
B)	Survey Flows		
	Circulating Flow	280,000	840,000
	Service Flow	20,000	20,000
	Total	300,000	860,000

TABLE 3.

OPERATING CHARACTERISTICS

Lovett

		Unit 4*			Unit 5*		
Date	Time	MWe	Inlet Temp. (^{o}F)	Outlet Temp. (^{o}F)	MWe	Inlet Temp. (^{o}F)	Outlet Temp. (^{o}F)
5/30/74	200	72	63	72	70	64	72
	400	70	63	72	70	62	71
	600	78	63	72	70	63	71
	800	135	63	77	140	63	77
	1000	176	63	82	200	63	80
	1200	175	64	84	200	65	81
	1400	176	64	84	200	65	80
	1600	174	63	82	100	62	78
	1800	150	65	85	200	64	80
	2000	160	64	82	200	64	80
	2200	115	63	77	150	64	76
	2400	97	63	77	72	63	75
5/31/74	200	87	64	75	62	63	72
	400	87	63	74	62	62	71
	600	86	63	74	62	61	71
	700	86	63	74	82	62	73
	800	105	63	74	120	63	76
	900	172	64	84	200	63	82

(cont'd)

OPERATING CHARACTERISTICS

Lovett

Date	Time	MWe	Inlet Temp. (°F)	Outlet Temp. (°F)	MWe	Inlet Temp. (°F)	Outlet Temp. (°F)
6/3/74	1000	161	62	84	190	63	81
	1100	166	62	84	190	63	79
	1200	165	62	84	200	64	80
	1300	167	65	84	200	66	82
	1400	171	65	85	200	67	83
	1500	170	64	85	200	65	81
	1600	150	63	80	155	63	77
	1700	155	63	80	145	63	77
	1800	155	64	81	145	63	77
	1900	150	64	81	146	63	77
	2000	152	64	81	140	63	73
	2100	152	64	81	68	63	73
	2200	151	64	81	66	63	73

* Capacity Unit 4 and Unit 5 185 and 205 MWe, respectively.

TABLE 4

INTAKE AND DISCHARGE TEMPERATURES

5/31/74

DISCHARGE			INTAKE		
Location	Time	Ave. T°C	Location	Time	Ave. T°C
West	0845	24.0	North	0915	17.1
Mid	0852	24.2	South	0920	17.1
East	0858	24.2			
West	1035	24.1	South	1107	17.0
Mid	1040	24.1	North	1120	17.0
Wast	1046	24.1			
West	1545	23.7	North	1515	17.0
Mid	1551	23.8	South	1528	16.9
East	1558	23.9			
Mid	2140	24.3	South	2115	17.5

TABLE 5

RIVER GAUGE FLOW OVER TROY LOCK
INCLUDING THE POWER HOUSE

		CFS			CFS
May	10	21,300	May	28	13,200
	11	26,100		29	13,200
	12	27,200		30	12,800
	13	47,800		31	12,100
	14	50,600			
	15	38,400			
	16	34,400			
	17	30,400			
	18	33,200			
	19	27,700			
	20	23,500			
	21	20,500			
	22	19,700			
	23	17,500			
	24	16,800			
	25	17,700			
	26	16,800			
	27	13,200			

TABLE 6

Percentage Width and Cross Sectional Area

Tidal Phase	Ambient "1" Excess Temperature* (°F)	Ambient "1" Percent Width	Ambient "2" Excess Temperature* (°F)	Ambient "2" Percent Area
First Flood	3.4	15	3.4	2
HWS	3.4	20	3.4	5
Ebb	3.0	25	3.2	6
LWS	3.1	46	3.3	19
Second Flood	3.5	15	3.6	1

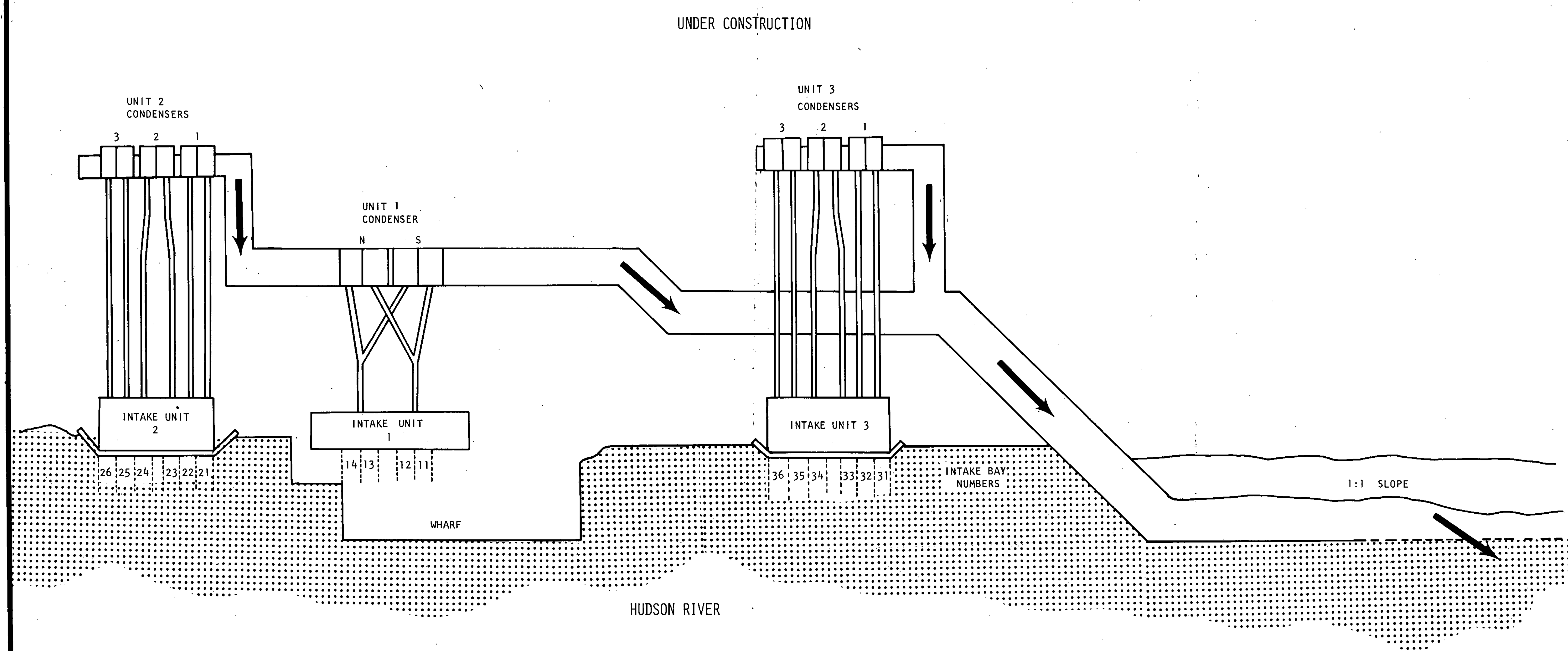
* Temperature above ambient at which evaluate percentage width and cross sectional area.

TABLE 7

Ambient Tabulation

Tidal Phase (and time)	Location	Average Surface Temperature (°C)	Average Upper Layer Temperature (Ambient 1) (°C)	Average Bottom Temperature (°C)	Average Cross Sectional Temperature (Ambient 2) (°C)
First Flood (0737)	Verplanck (1)	17.03	17.03	16.9	16.96
Ebb (1334)	Roa Hook	16.68	16.64	16.50	16.55
LWS (1650)	Roa Hook	16.62	16.60	16.32	16.47
Second Flood (2009)	Verplanck (1)	17.57	17.47	17.35	17.42

(1) It should be noted that the second flood transect was obtained further south than the first, and if the plant had any influence at these transects, it would be less pronounced (i.e., lower) at the southern most one. However, the reverse is the case.



CIRCULATING WATER SYSTEM

FIGURE 1

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REVISIONS
BY ______ DATE ______
FILE ______
BY ______ DATE ______
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946.7 (REV. 6-61)

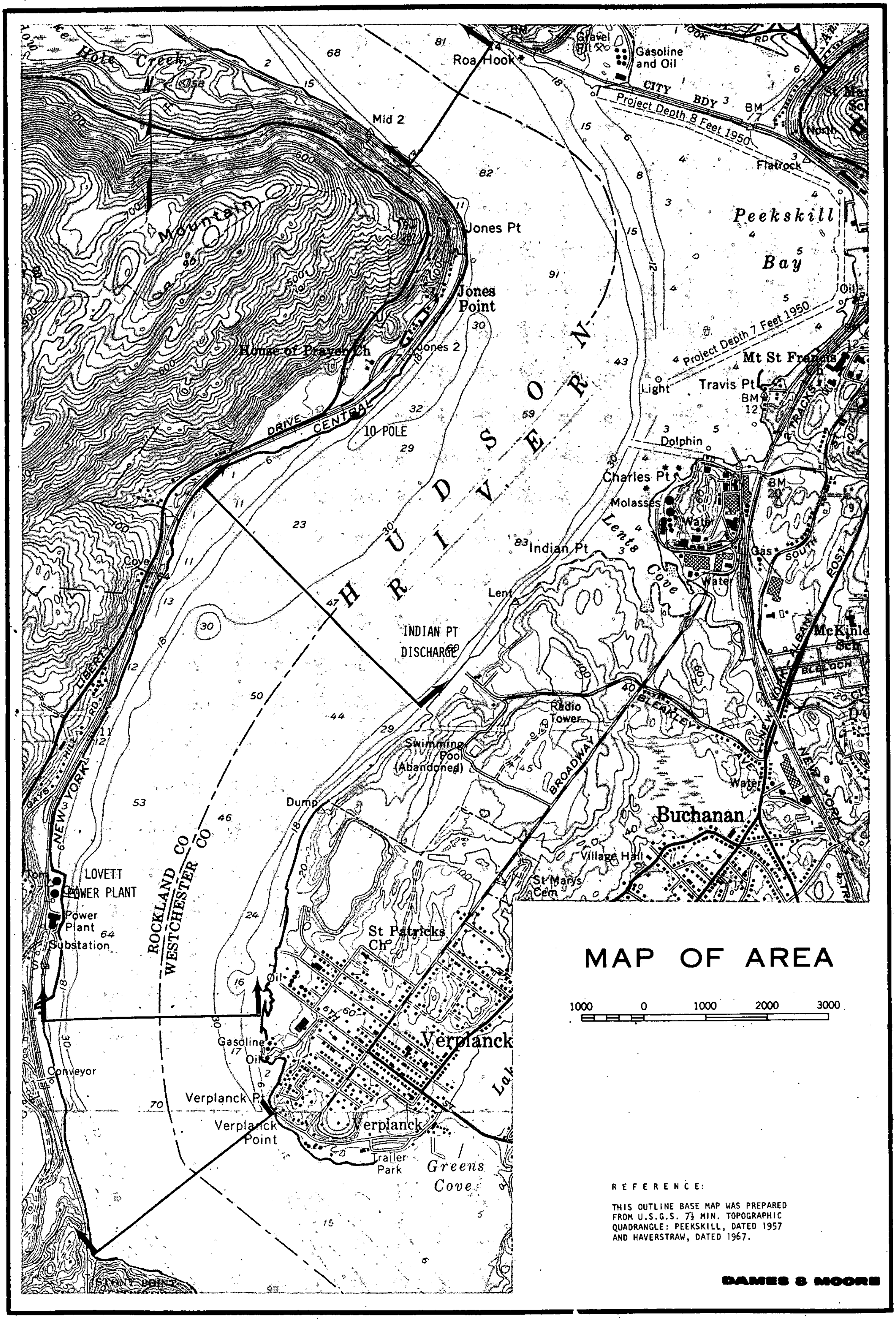
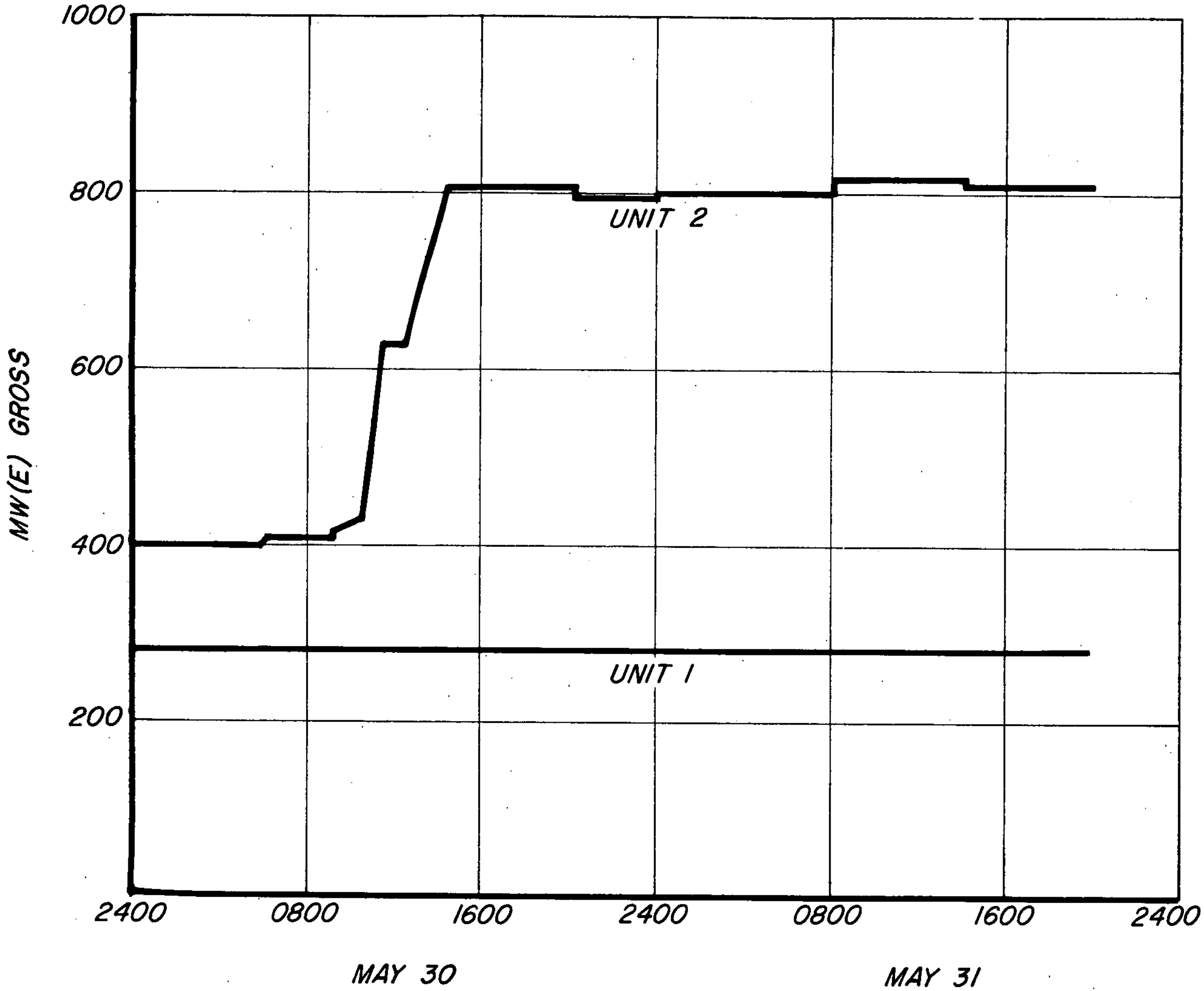


FIGURE 2

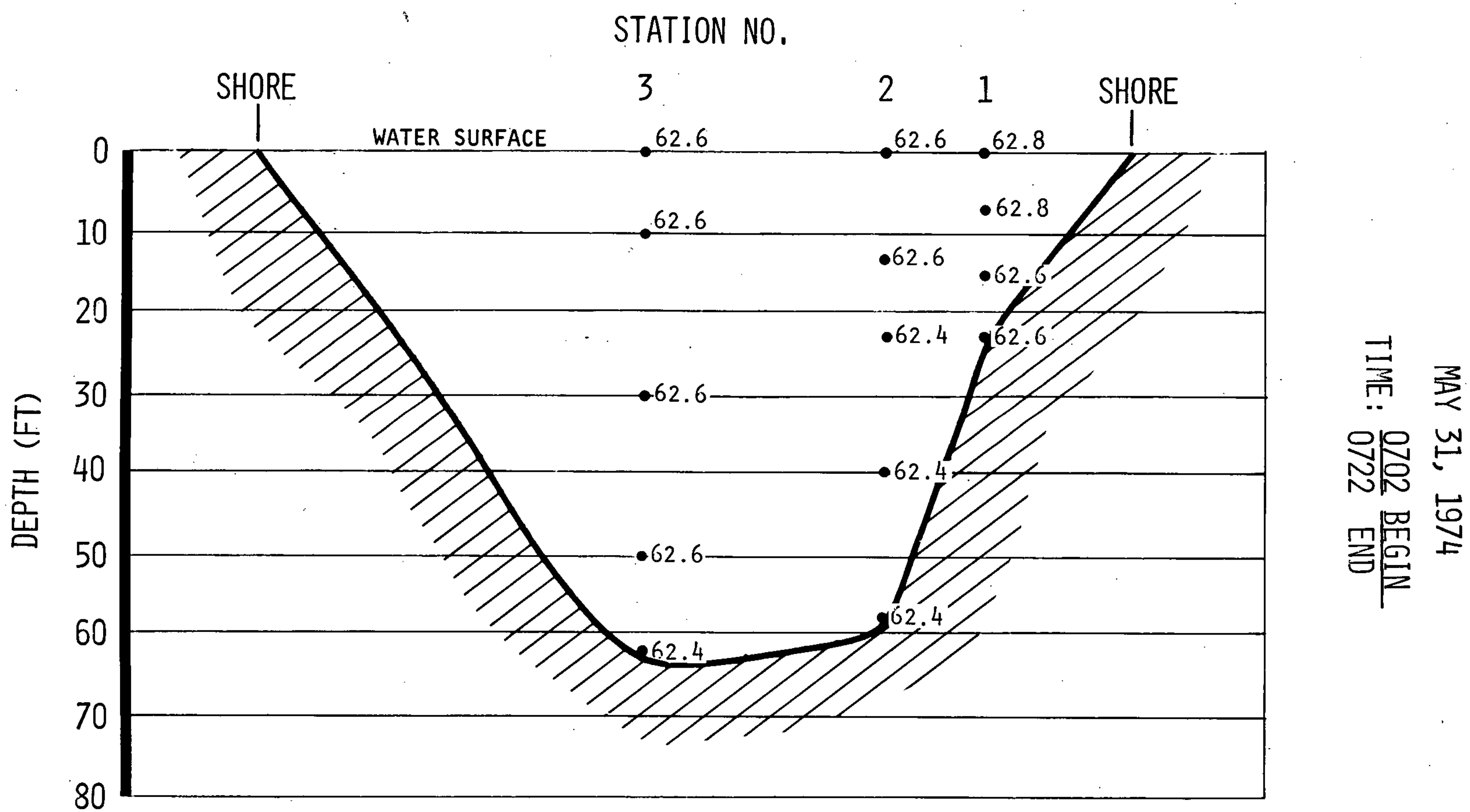


MW(E) GROSS FOR INDIAN POINT 1 & 2,
MAY 30 - 31, 1974

DAMES & MOORE

FIGURE 3

FILE______ BY______ DATE______ REVISIONS BY______ DATE______
CHECKED BY______ DATE______ BY______ DATE______



LOVETT TRANSECT

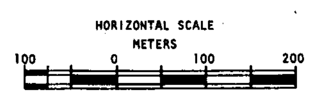


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FIGURE 5

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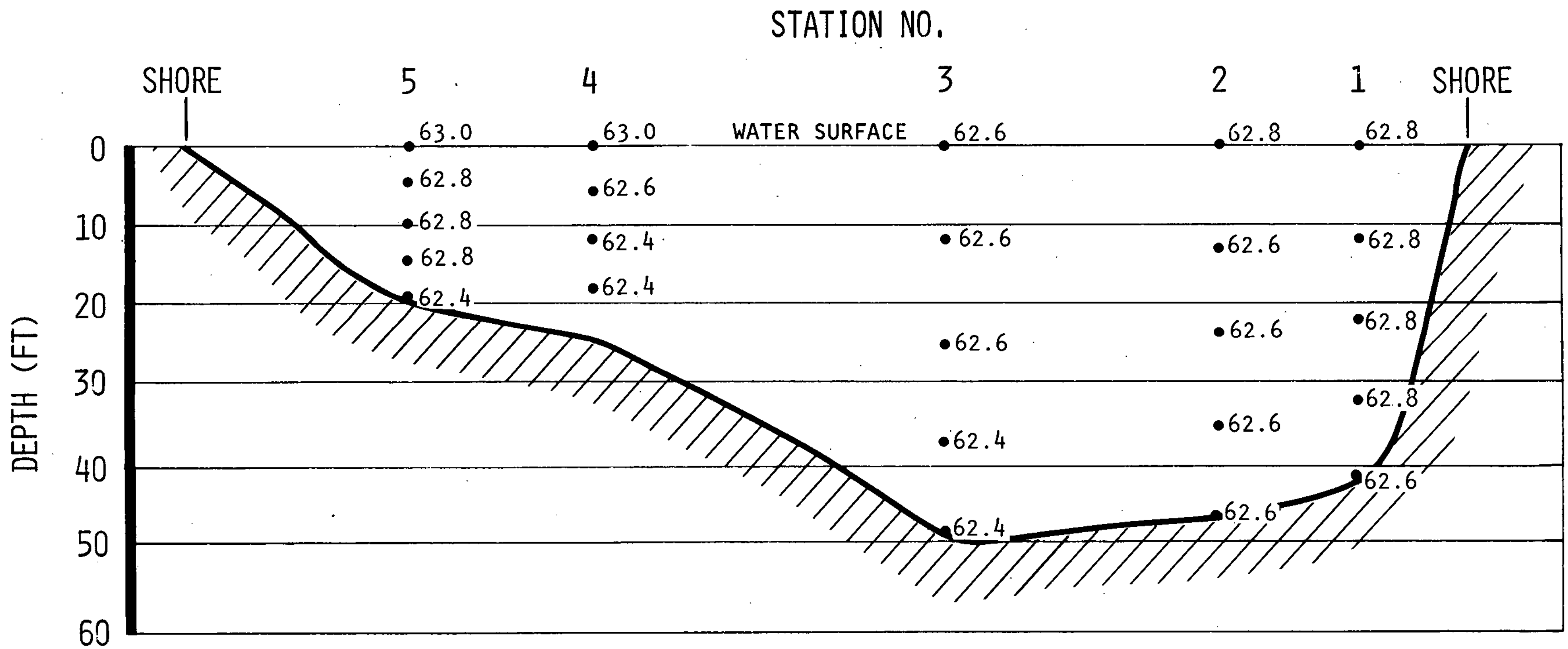

MAY 31, 1974

TIME: 0702 BEGIN / 0732 END

INDIAN POINT TRANSECT

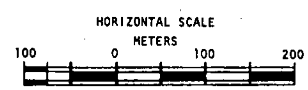

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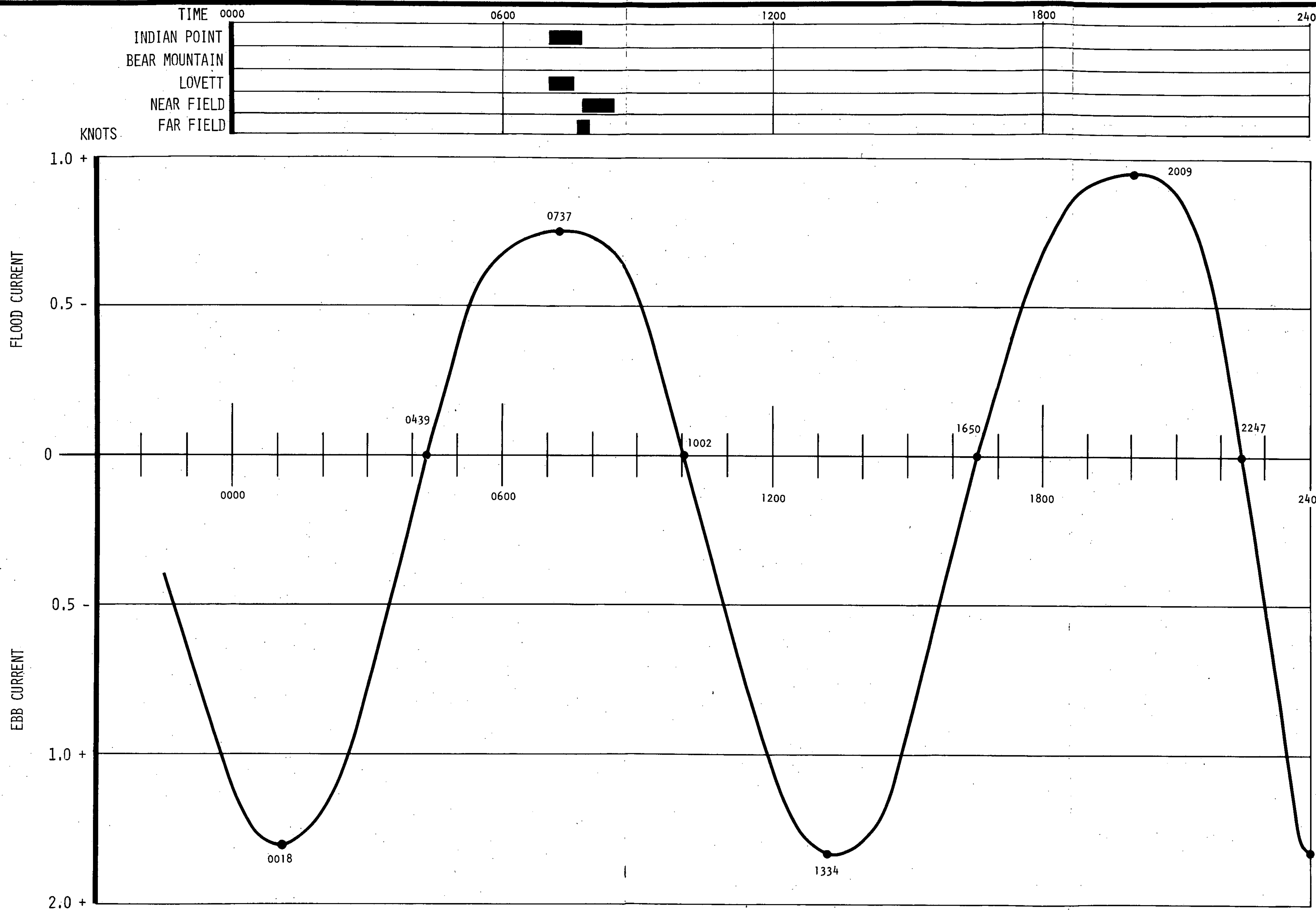
FIGURE 6



TIDAL CURRENT MAY 31, 1974

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FIGURE 4

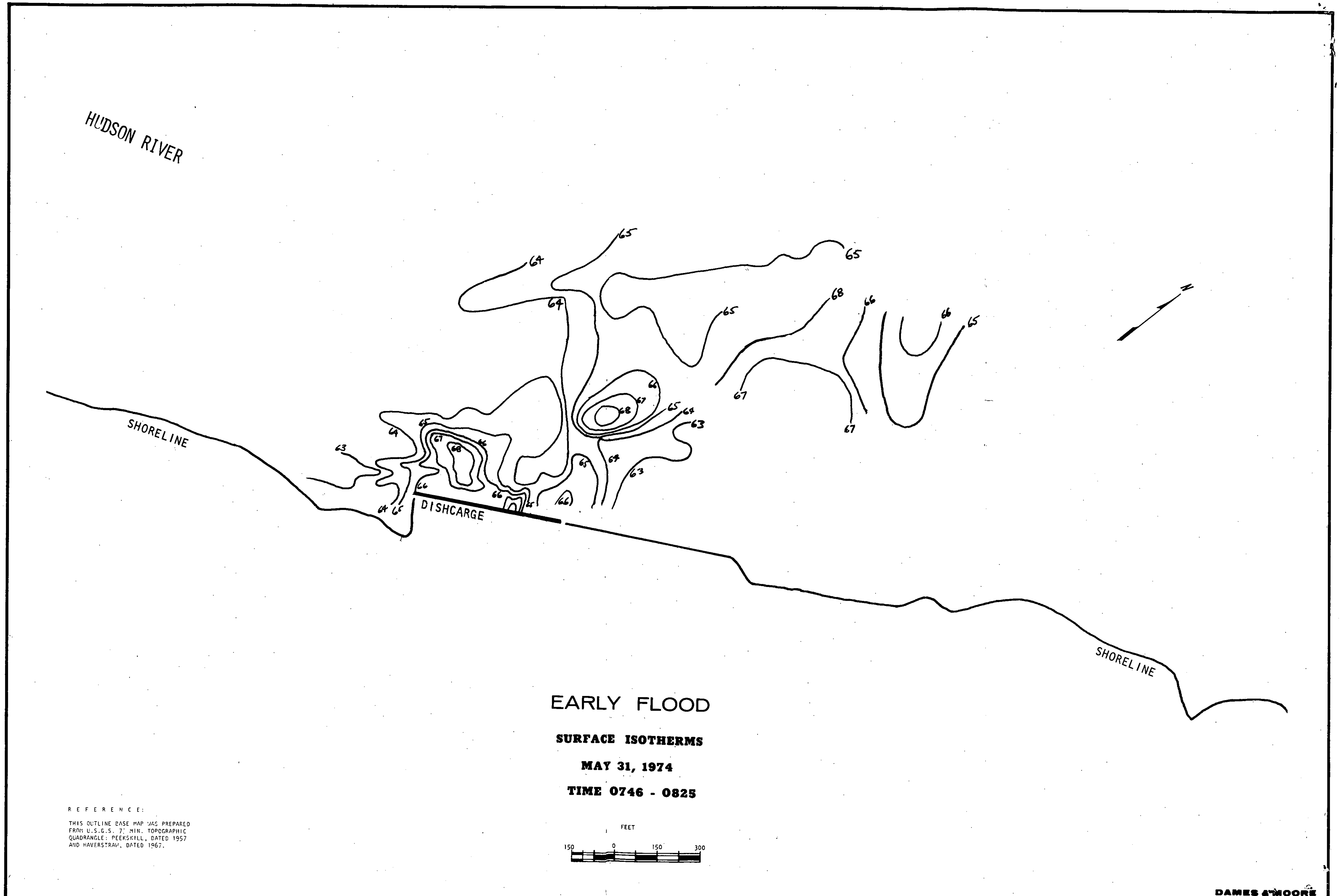
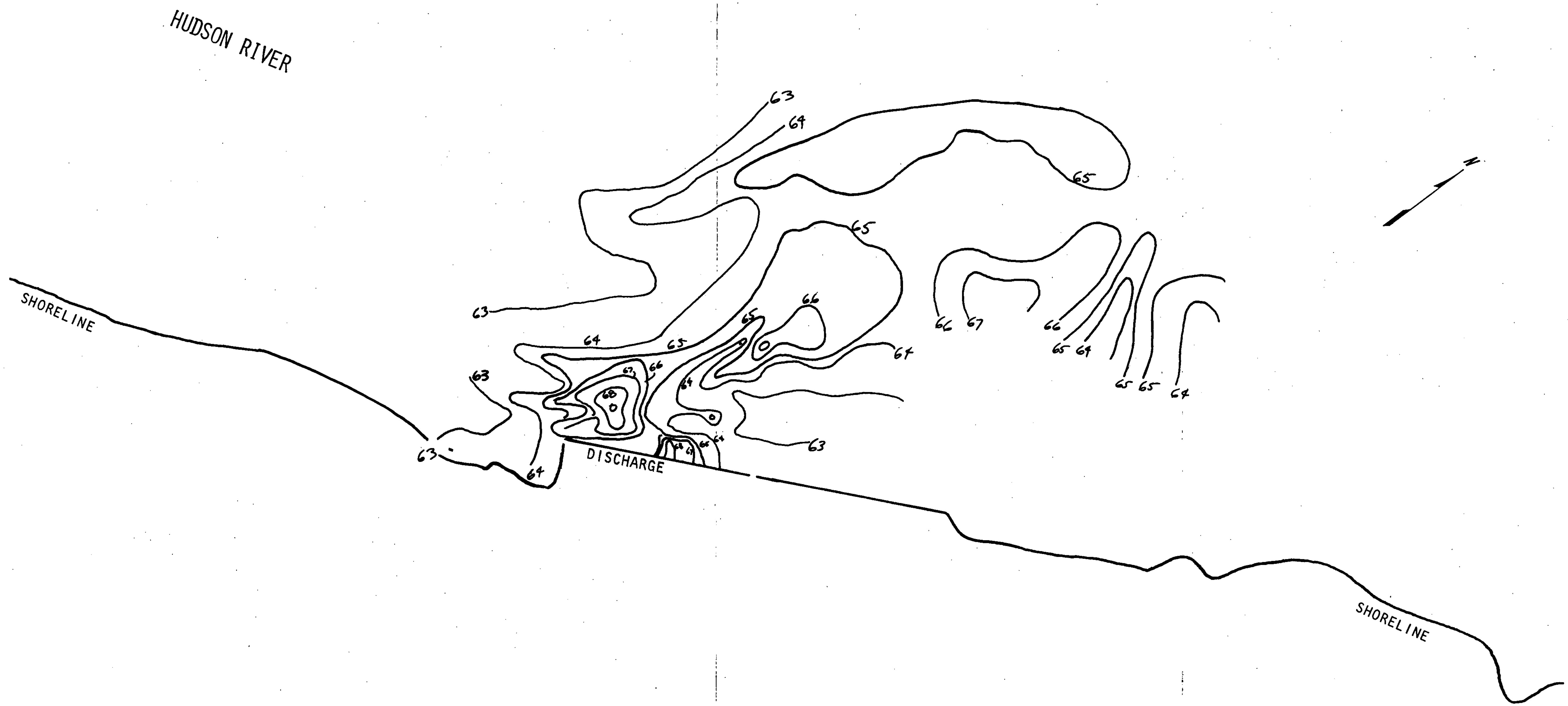

HUDSON RIVER
SHORELINE
DISHCARGE
SHORELINE
63
64
65
66
67
68
EARLY FLOOD
SURFACE ISOTHERMS
MAY 31, 1974
TIME 0746 - 0825
REFERENCE:
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.
FEET
150
0
150
300
DAMES & MOORE

FIGURE 7.1



EARLY FLOOD

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0746 - 0825

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

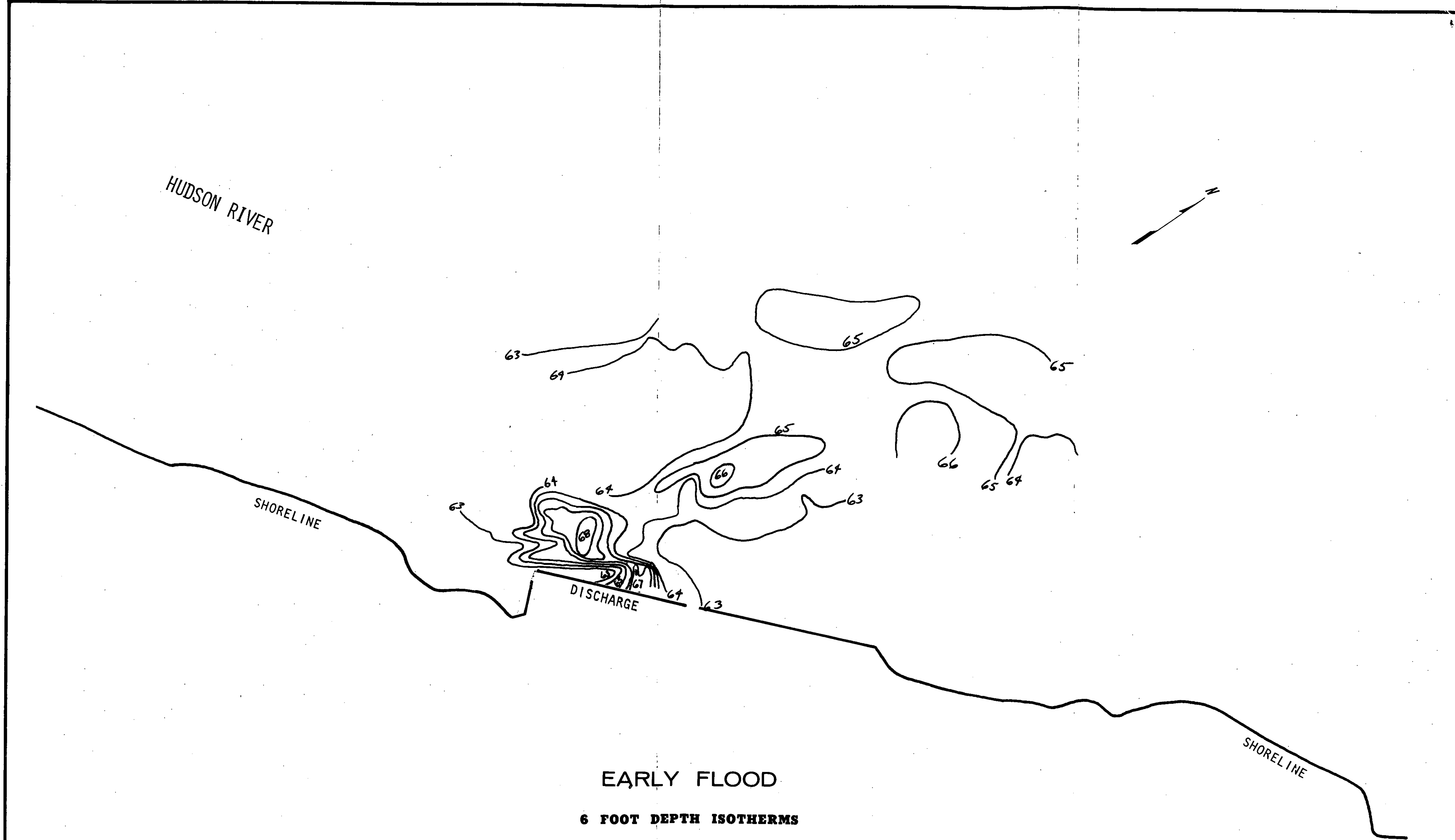
FEET

150 0 150 300

DAMES & MOORE

FIGURE 7.2

466.12 (4-64)



EARLY FLOOD

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0746 - 0825

FEET

150 0 150 300

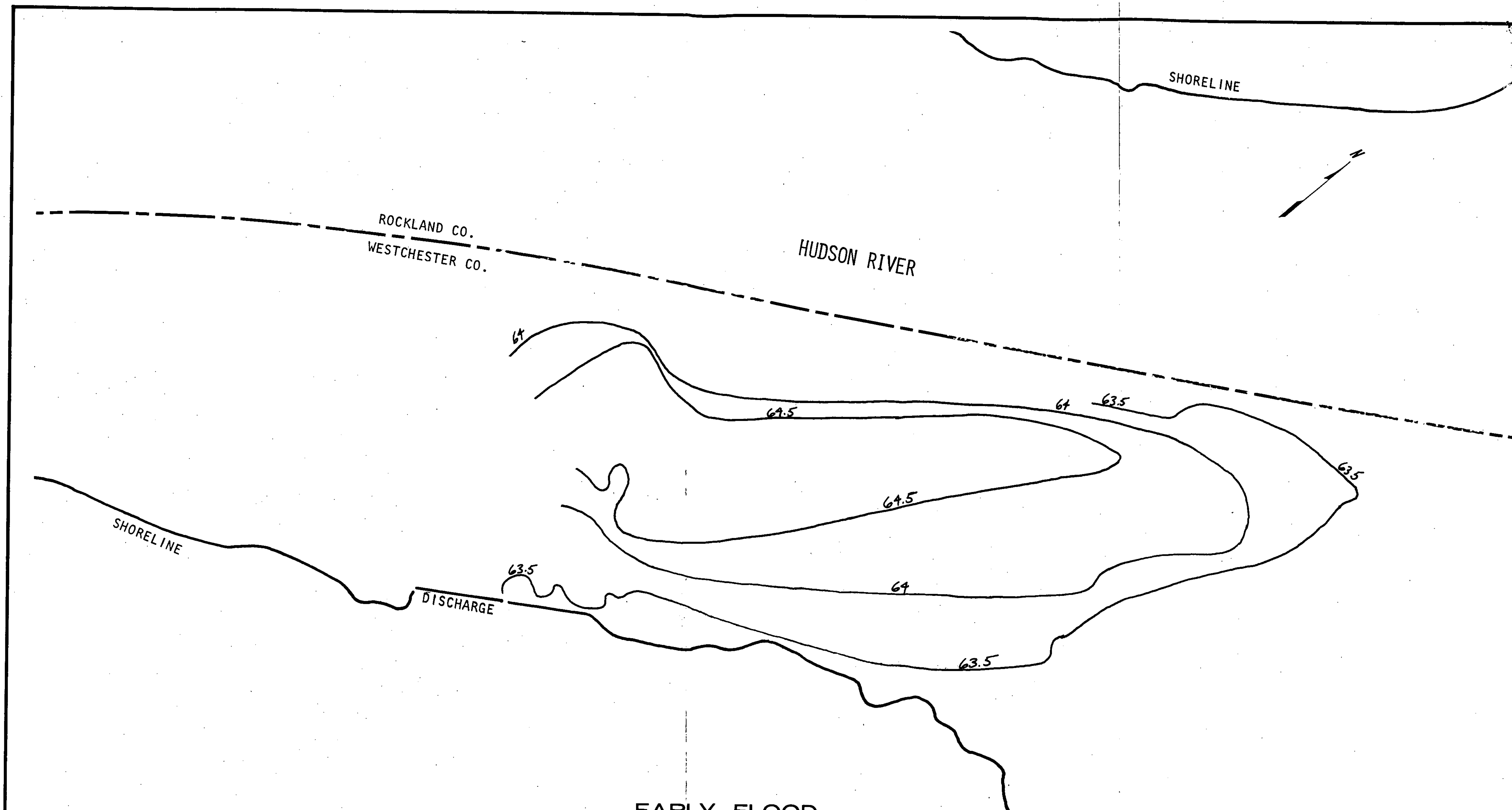
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 7.3



EARLY FLOOD

SURFACE ISOTHERMS

MAY 31, 1974

TIME 0722 - 0739

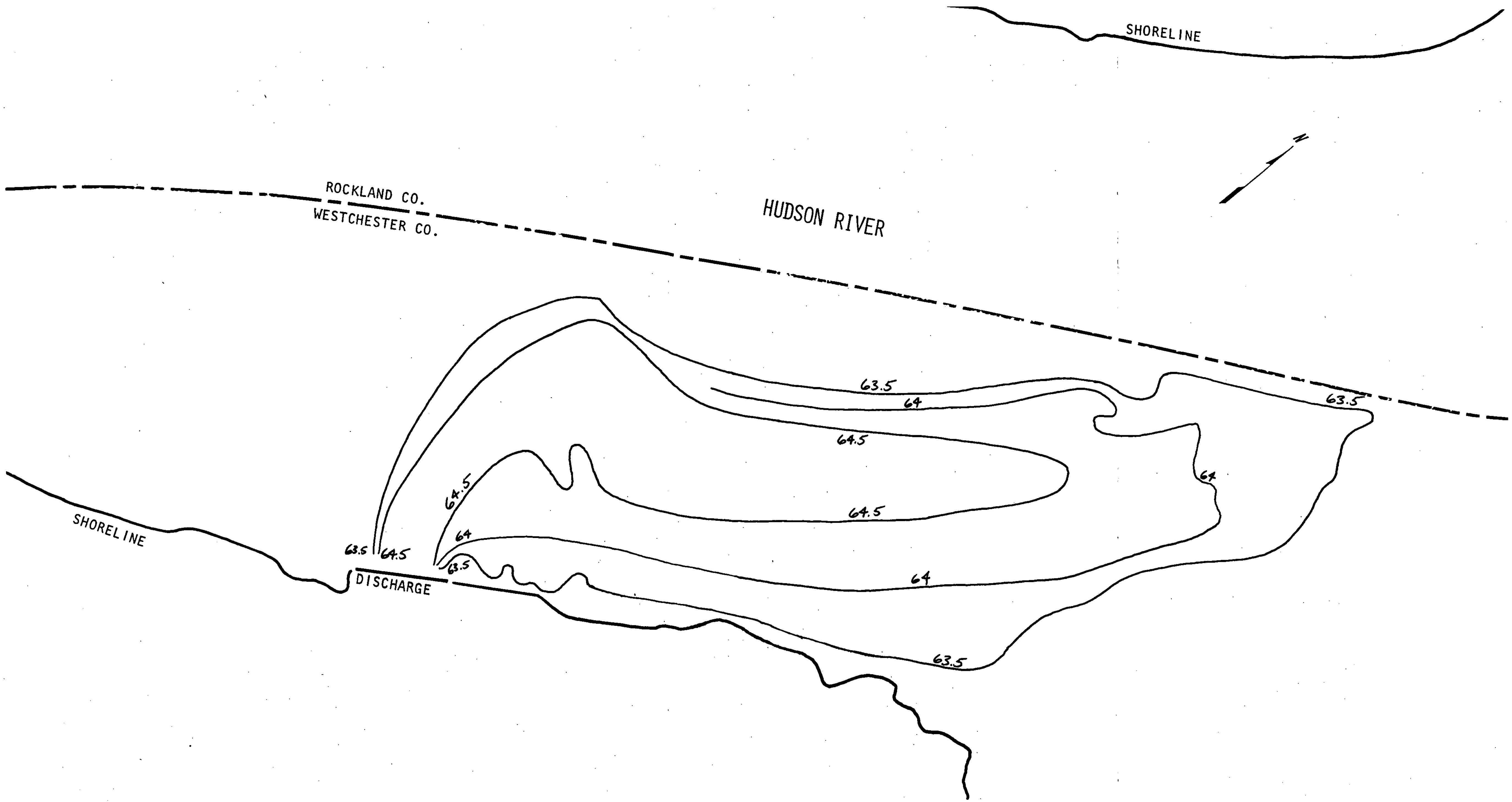
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 8.1



EARLY FLOOD

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0722 - 0739

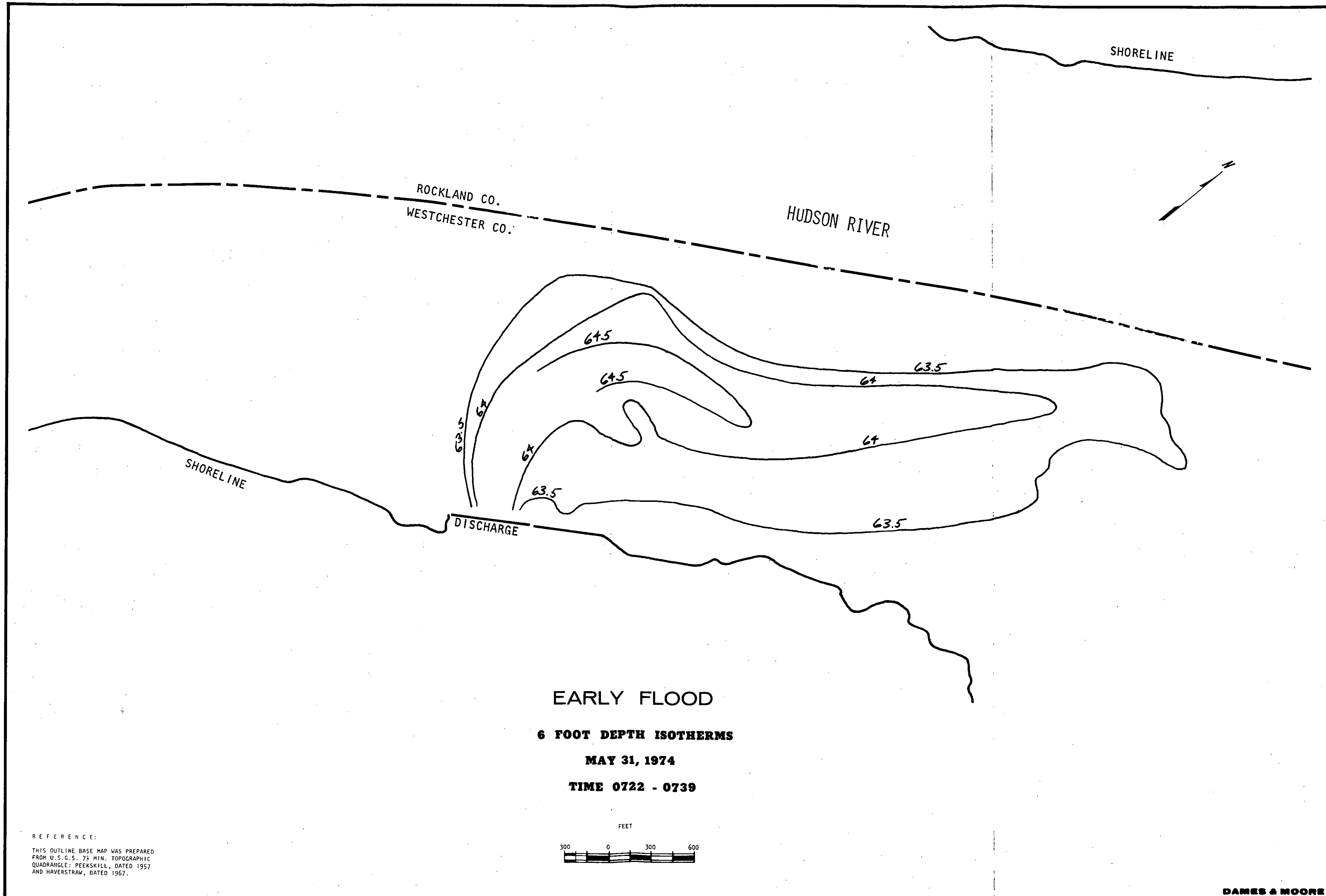
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 8.2



EARLY FLOOD

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0722 - 0739

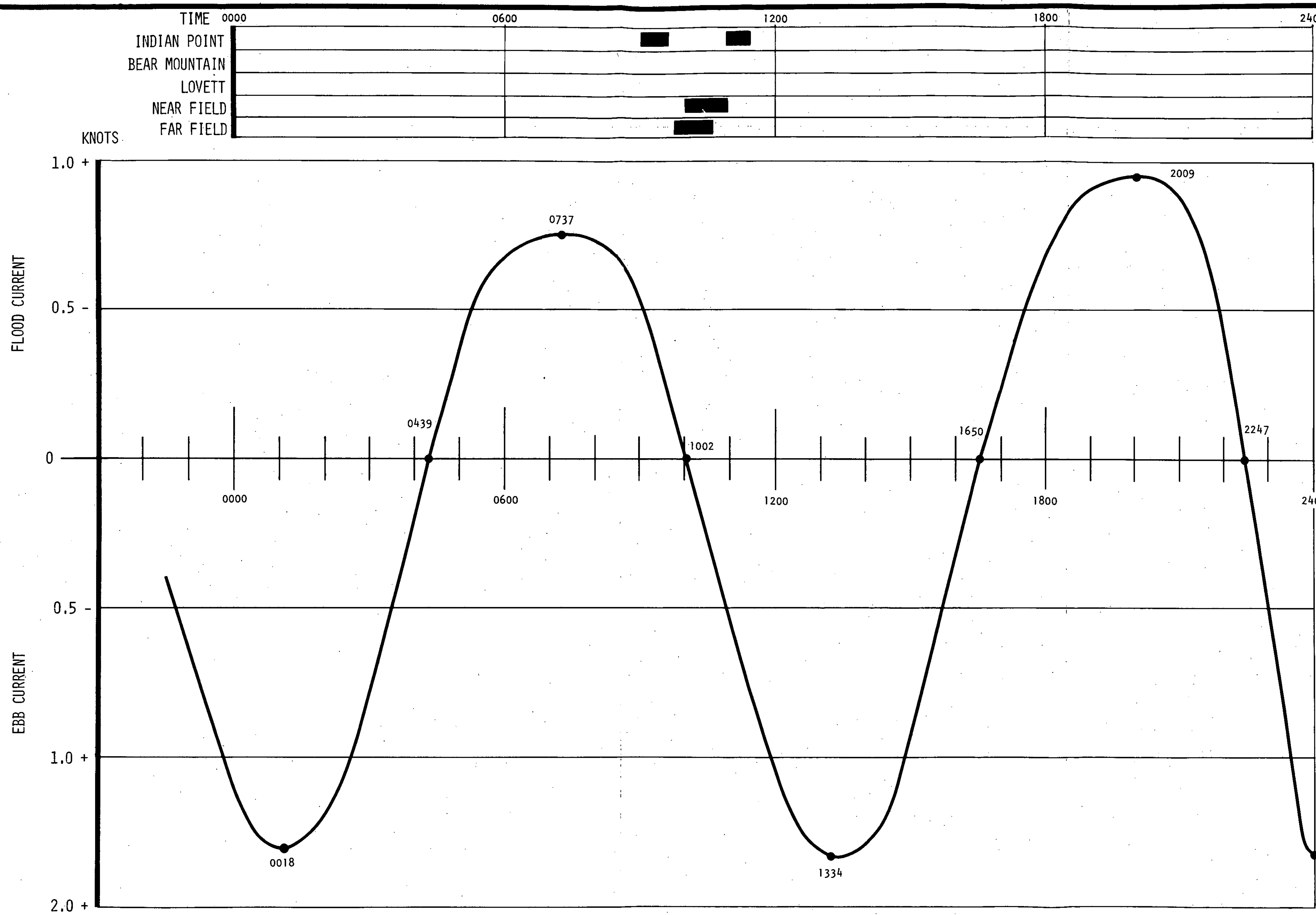
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 8.3

466.12 (4-64)



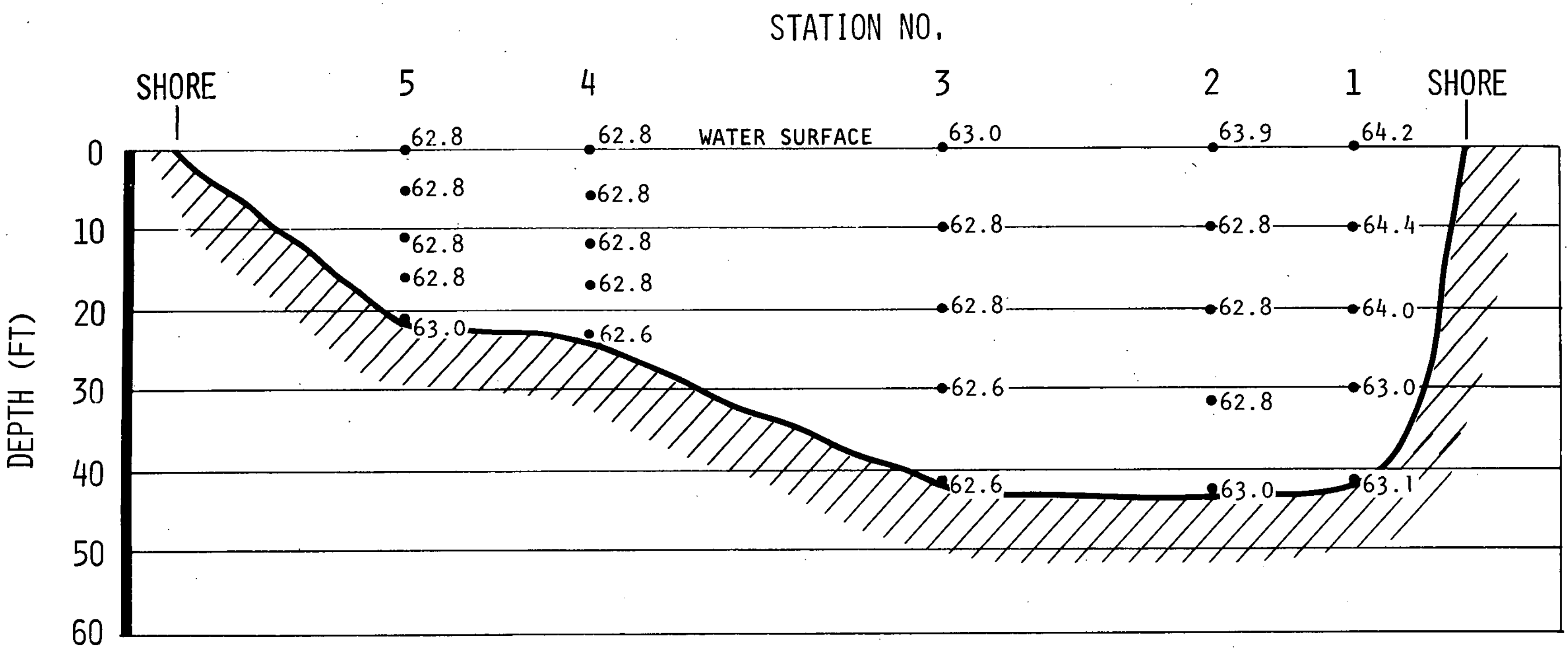
TIDAL CURRENT MAY 31, 1974

FIGURE 9

DAMES & MOORE

FILE________________ BY________________ DATE________________ CHECKED BY________________ DATE________________

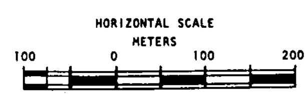
REVISIONS BY________________ DATE________________ BY________________ DATE________________



MAY 31, 1974

TIME: 0853 BEGIN / 0930 END

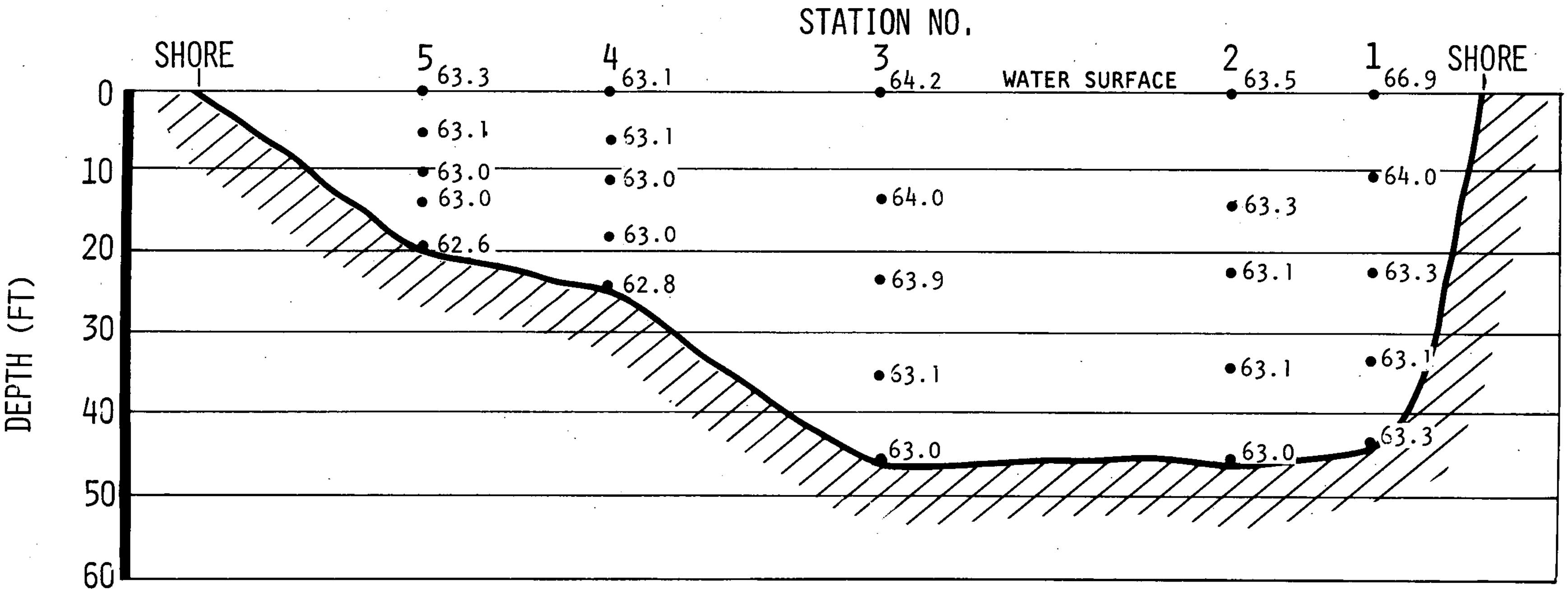
INDIAN POINT TRANSECT



DAMES & MOORE

FIGURE 10

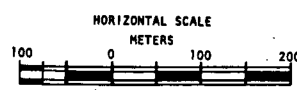
FILE ______ BY ______ DATE ______ REVISIONS BY ______ DATE ______
CHECKED BY ______ DATE ______ BY ______ DATE ______



MAY 31, 1974

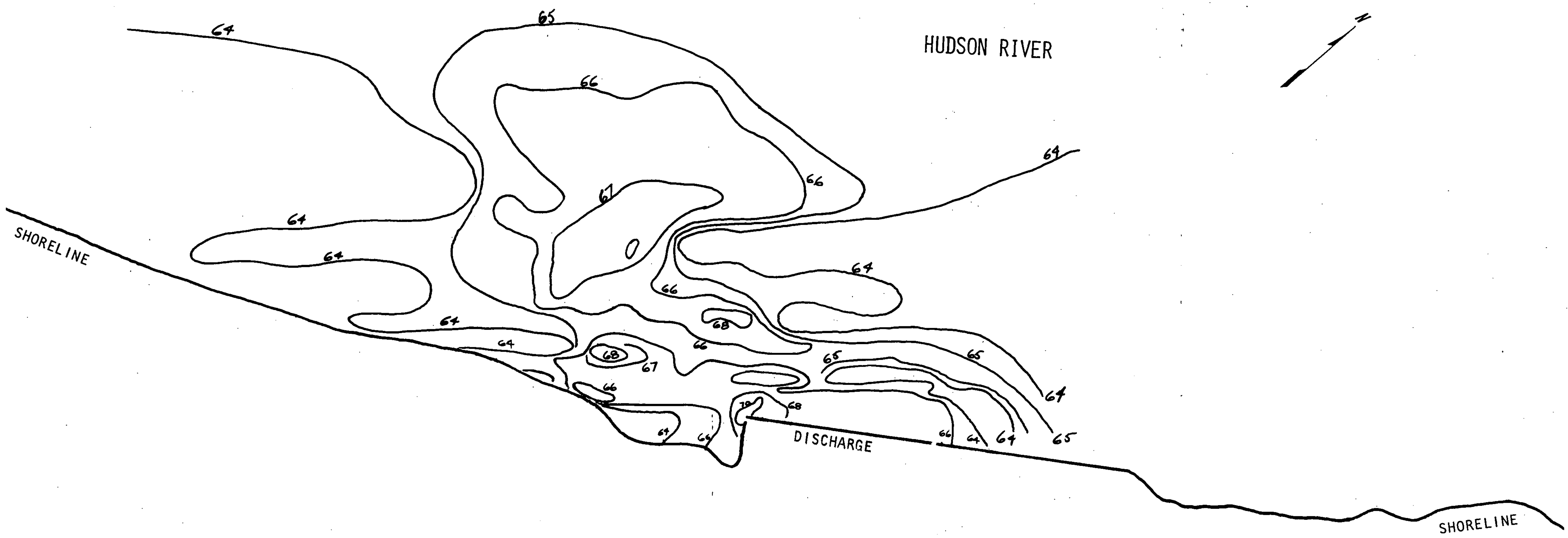
TIME: 1056 BEGIN / 1125 END

INDIAN POINT TRANSECT



DAMES & MOORE

FIGURE 11



HWS

SURFACE ISOTHERMS

MAY 31, 1974

TIME 0952 - 1051

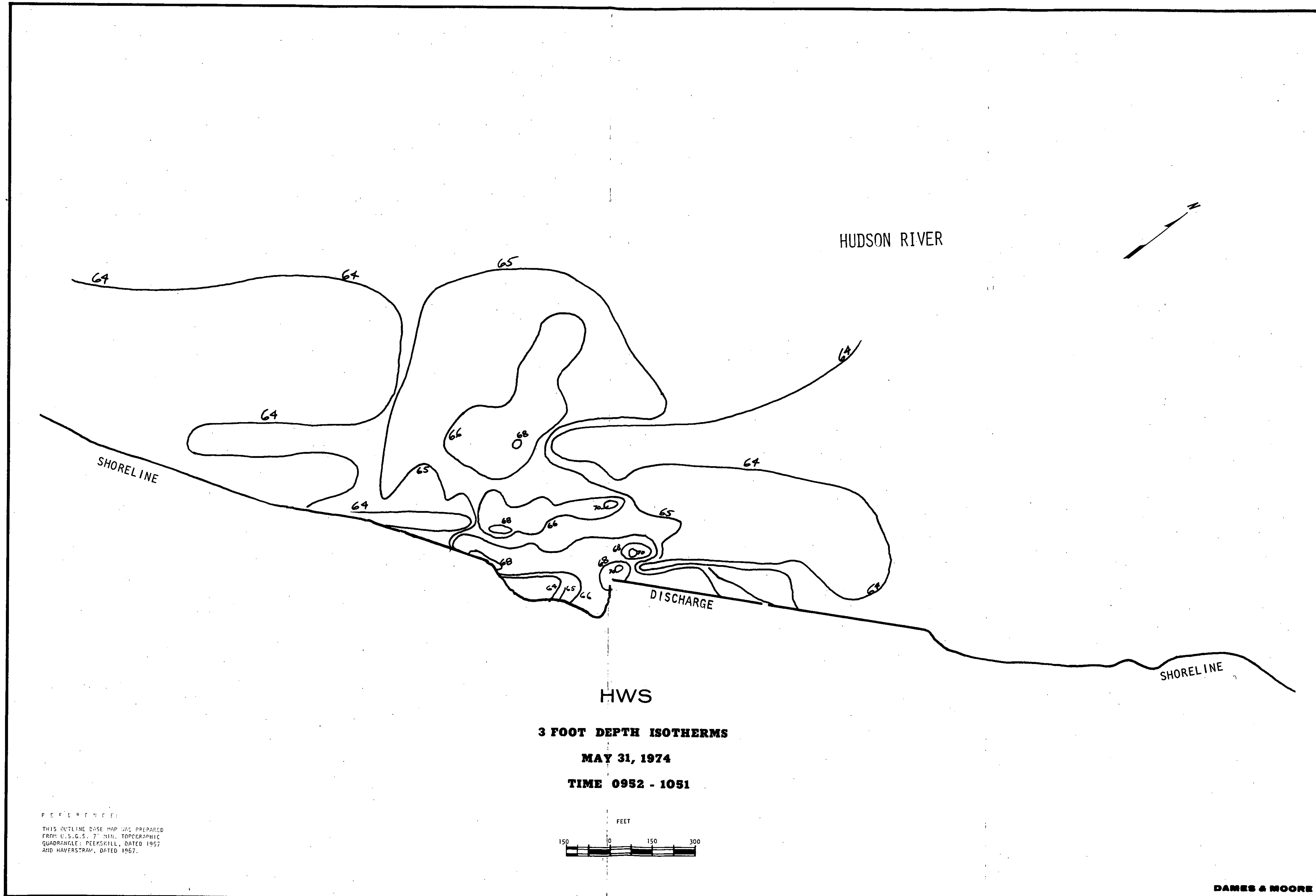
FEET

150 0 150 300

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

FIGURE 12.1



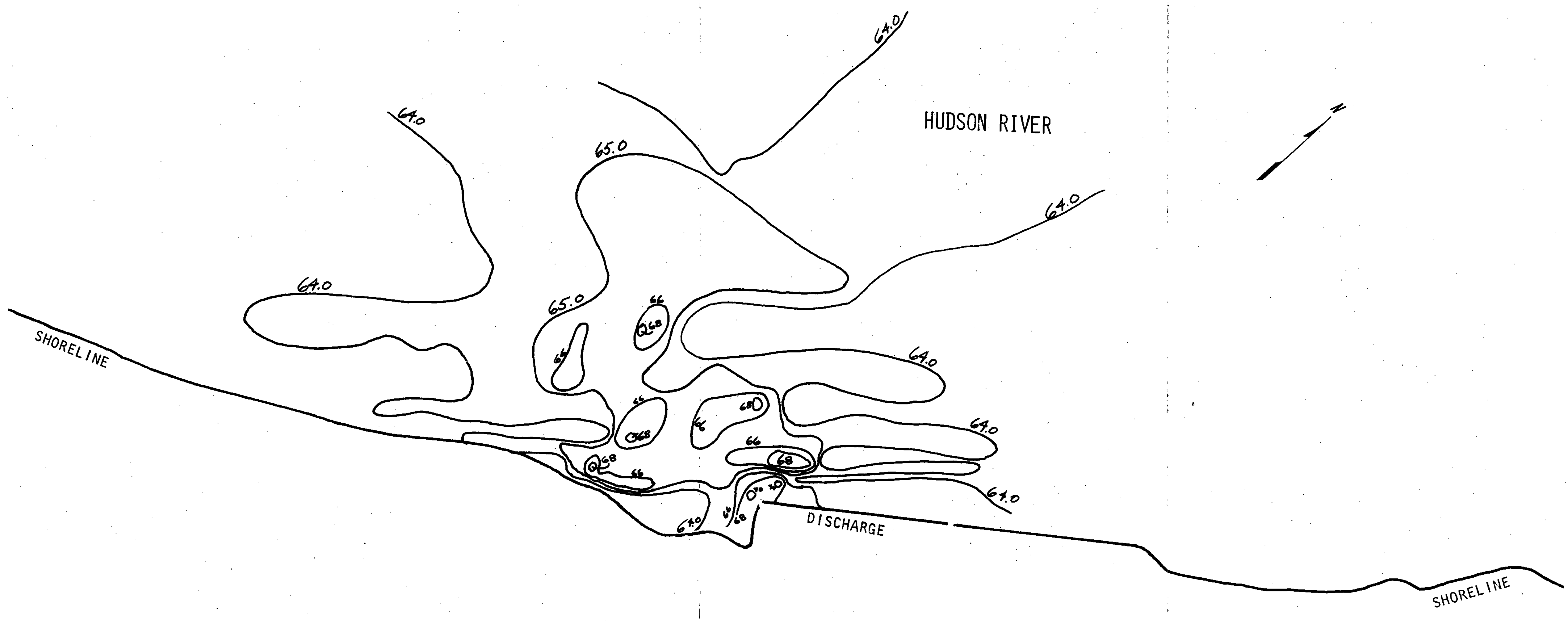
HWS

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0952 - 1051

FIGURE 12.2



HWS

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0952 - 1051

FEET

150 0 150 300

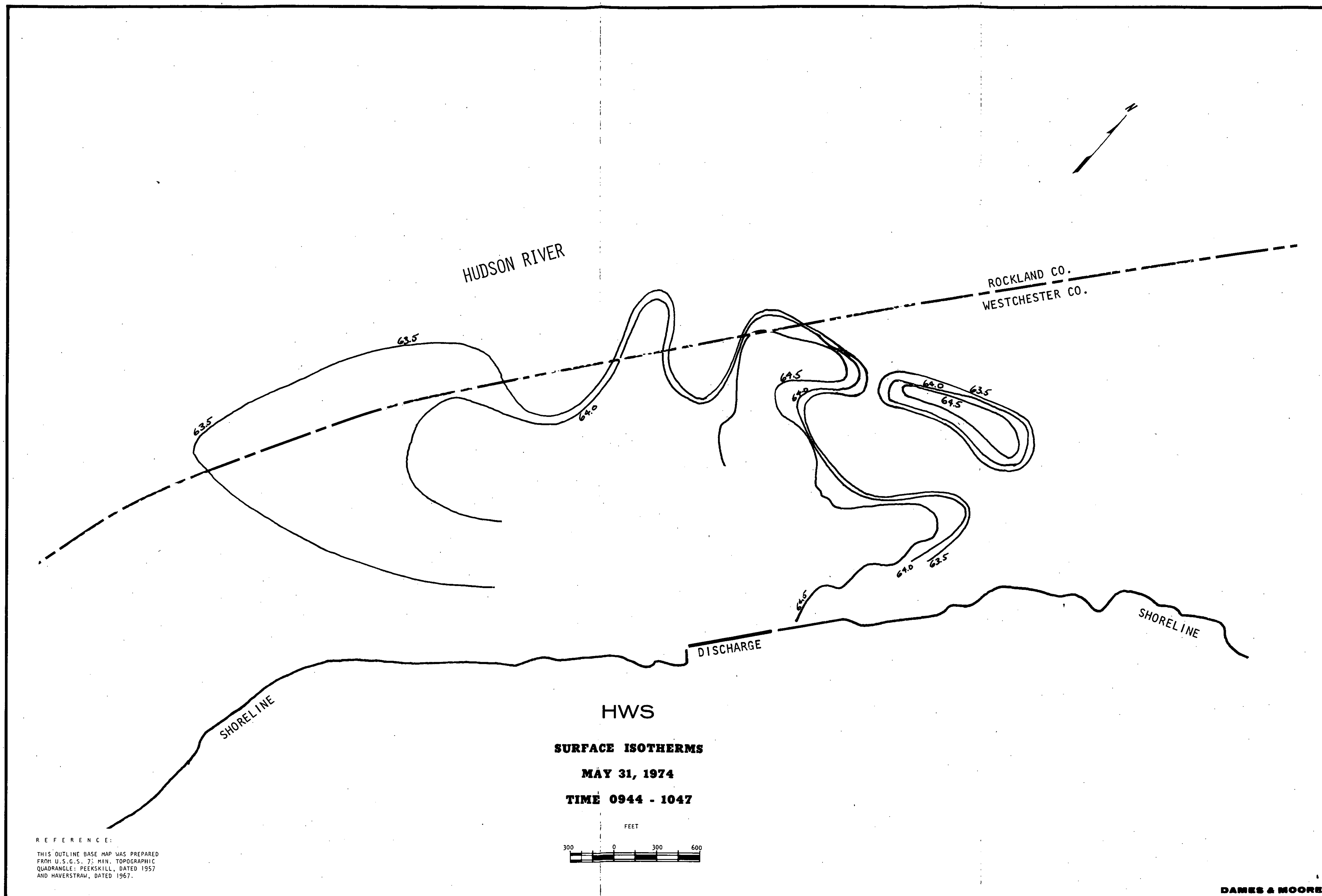
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 12.3



HWS

SURFACE ISOTHERMS

MAY 31, 1974

TIME 0944 - 1047

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

FIGURE 13.1

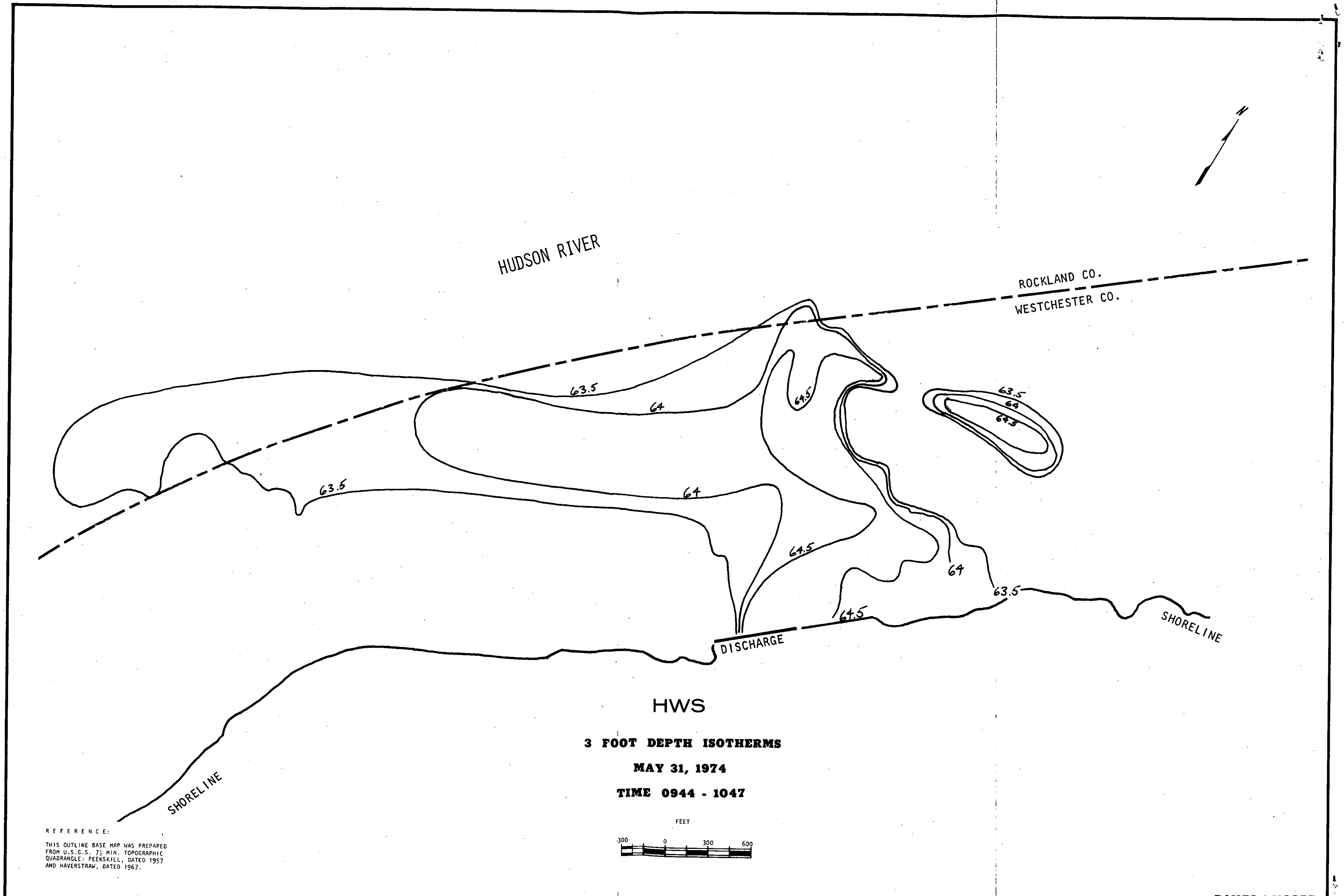
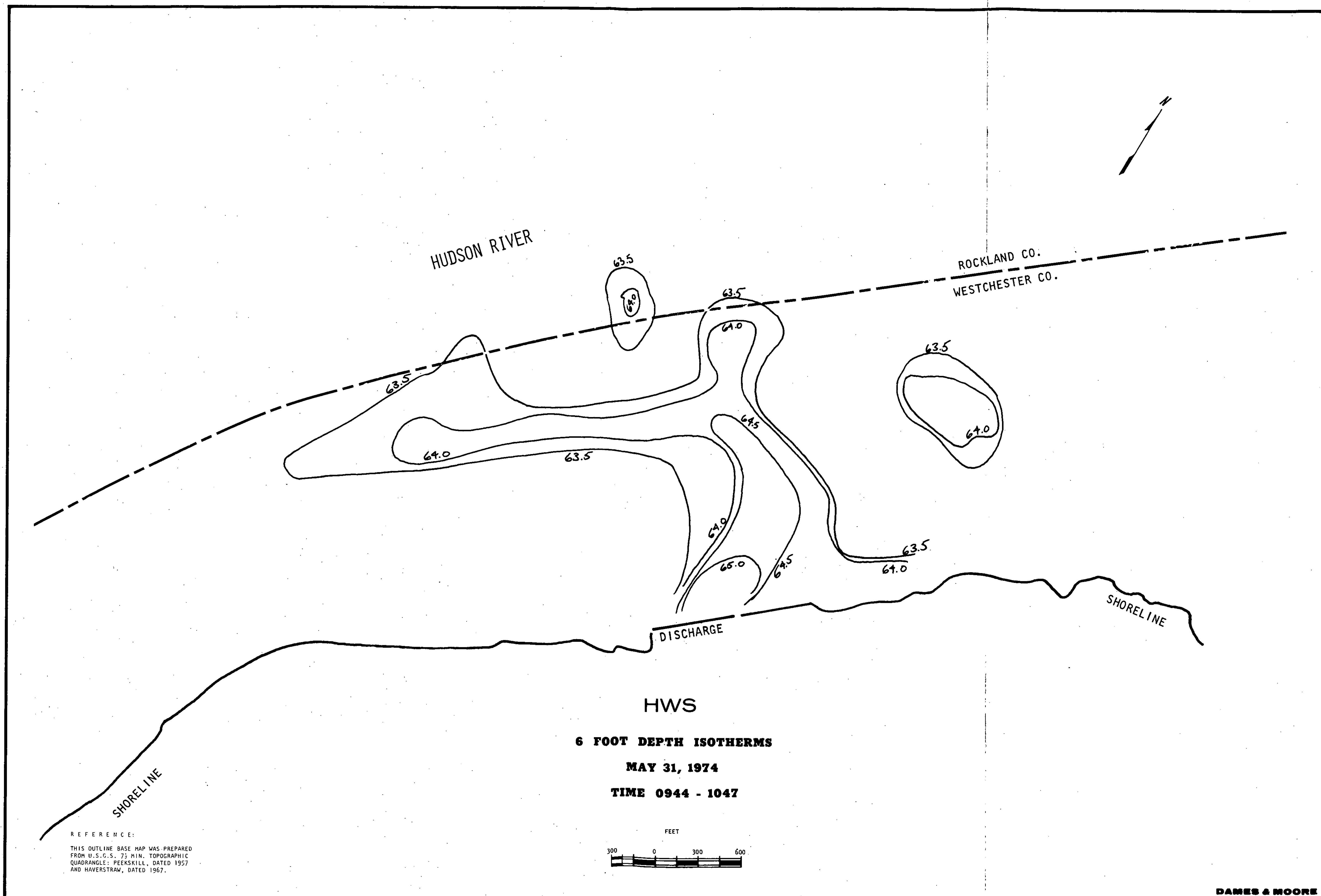


FIGURE 13.2

466.12 (4-64)



HWS

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 0944 - 1047

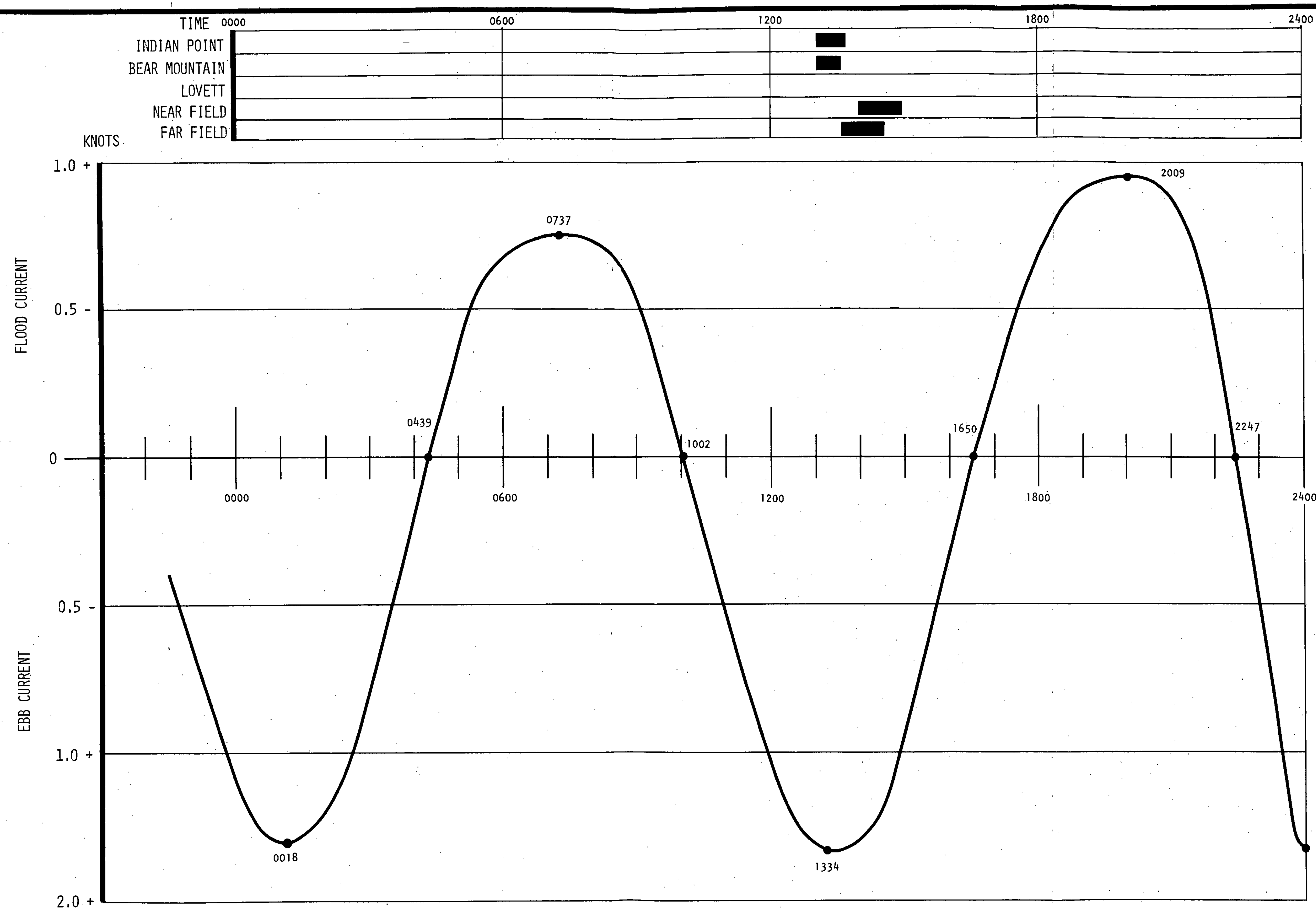
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 13.3

466.12 (4-64)



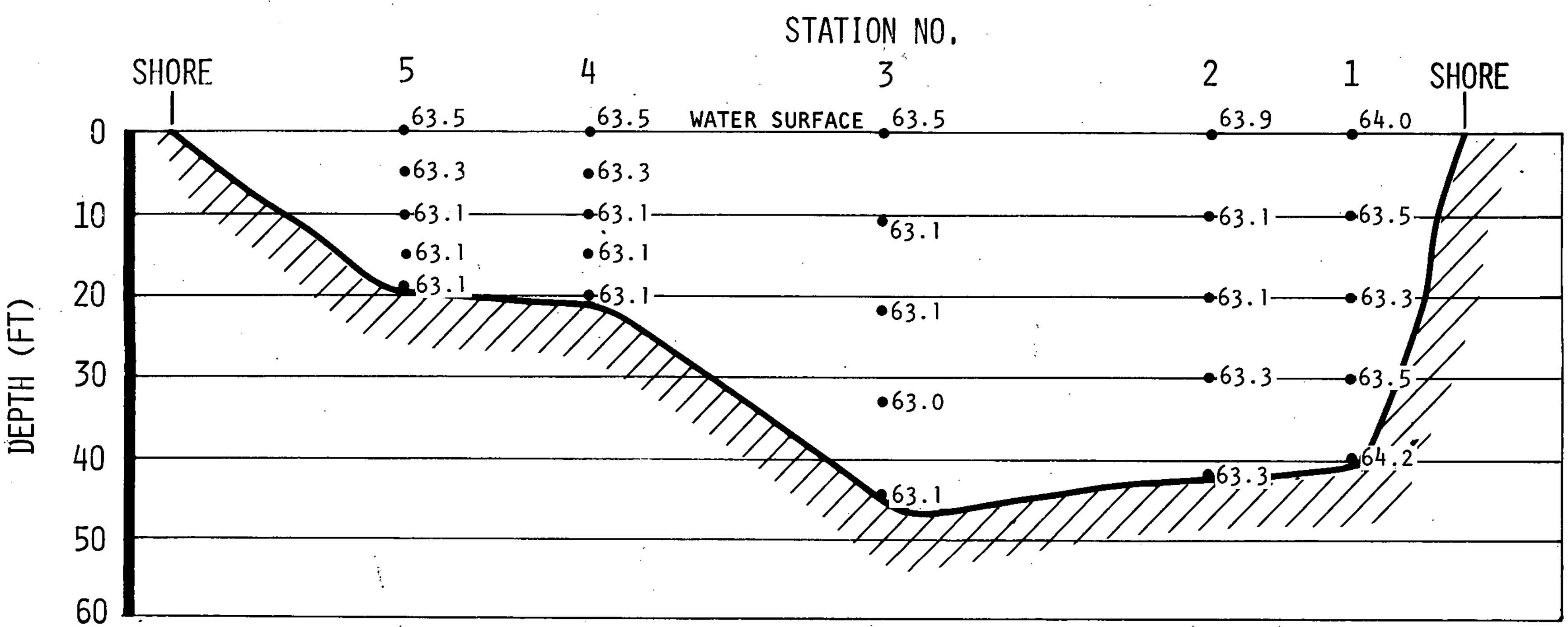
TIDAL CURRENT MAY 31, 1974

DAMES & MOORE

FIGURE 14

FILE ____ BY ____ DATE ____ REVISIONS BY ____ DATE ____

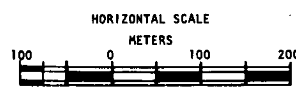
CHECKED BY ____ DATE ____ BY ____ DATE ____



MAY 31, 1974

TIME: $\frac{1306}{1336}$ $\frac{\text{BEGIN}}{\text{END}}$

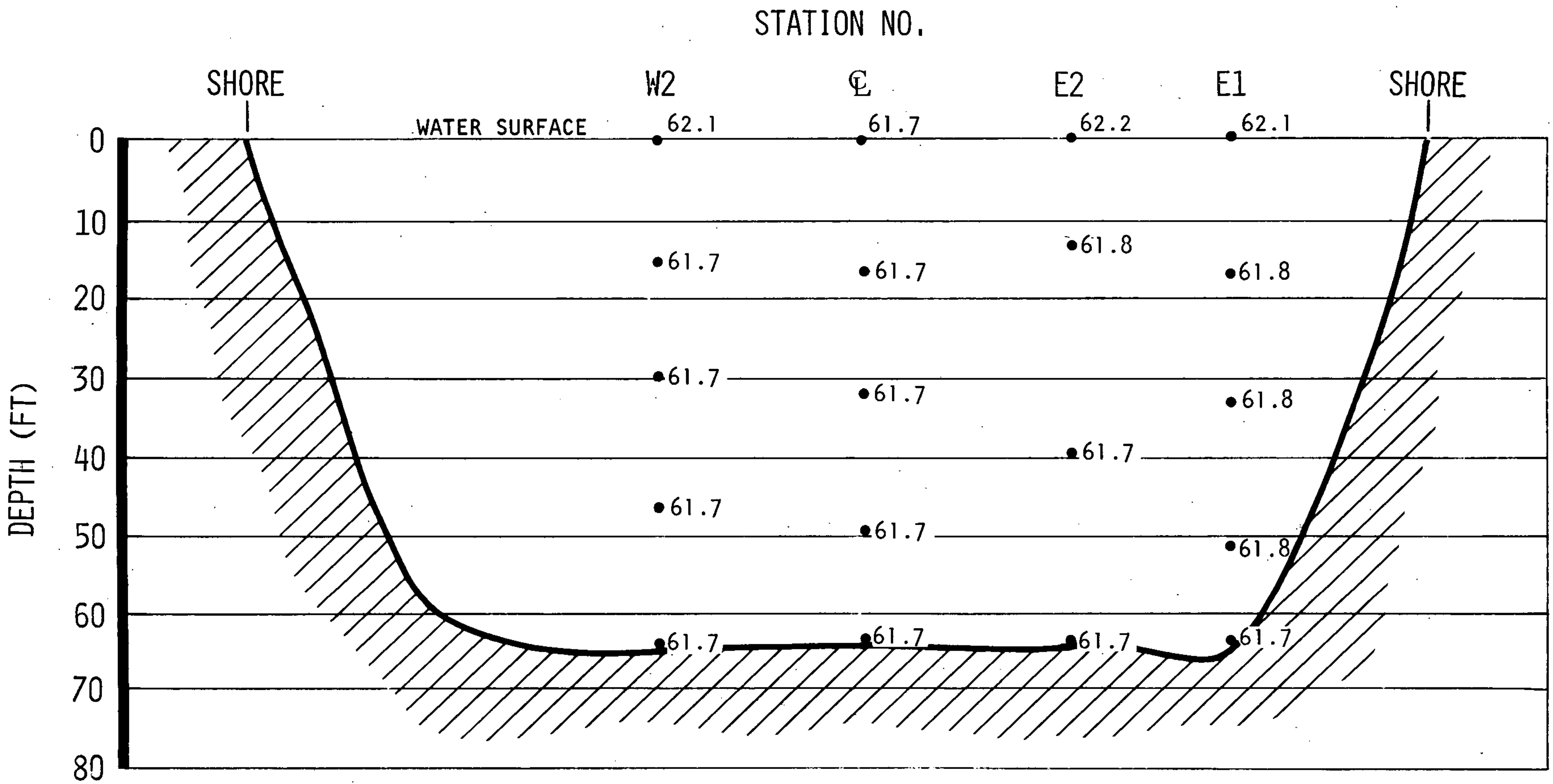
INDIAN POINT TRANSECT



DAMES & MOORE

FIGURE 15

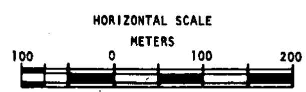
FILE
BY DATE
CHECKED BY DATE
REVISIONS BY DATE
BY DATE



MAY 31, 1974

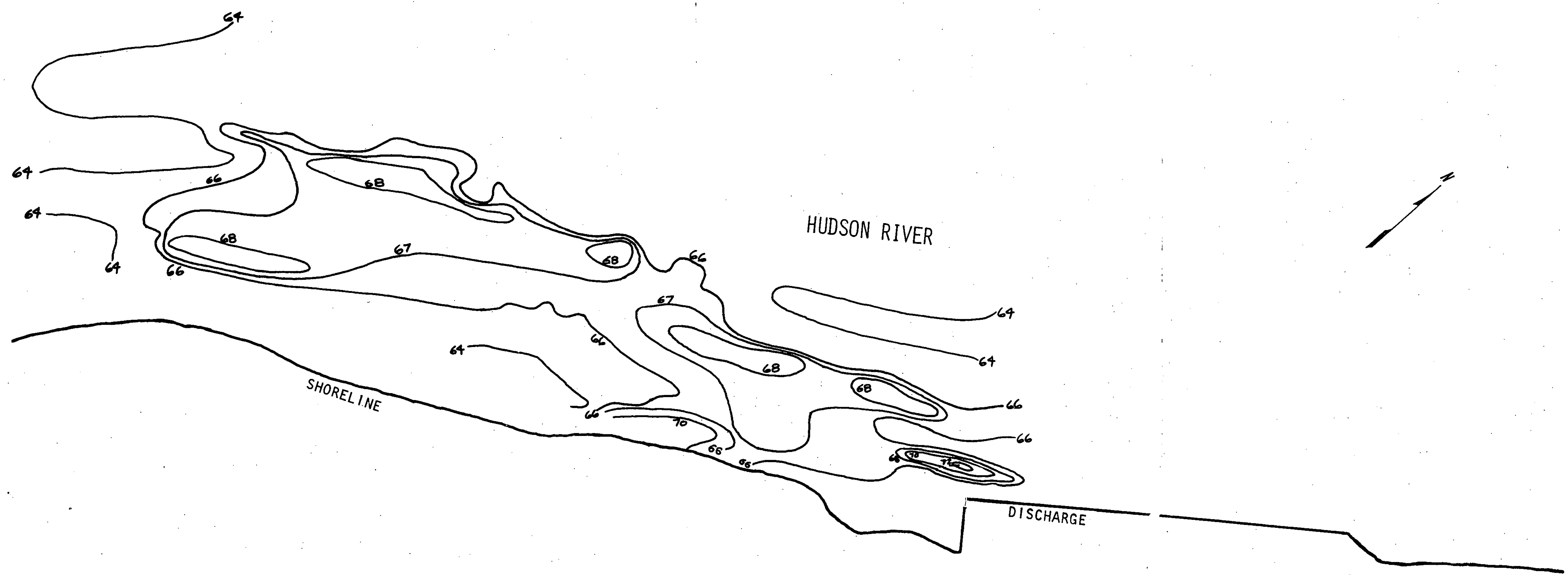
TIME: 1304 BEGIN / 1318 END

ROA HOOK TRANSECT



DAMES & MOORE

FIGURE 16



EBB

SURFACE ISOTHERMS

MAY 31, 1974

TIME 1341 - 1452

FEET
150 0 150 300

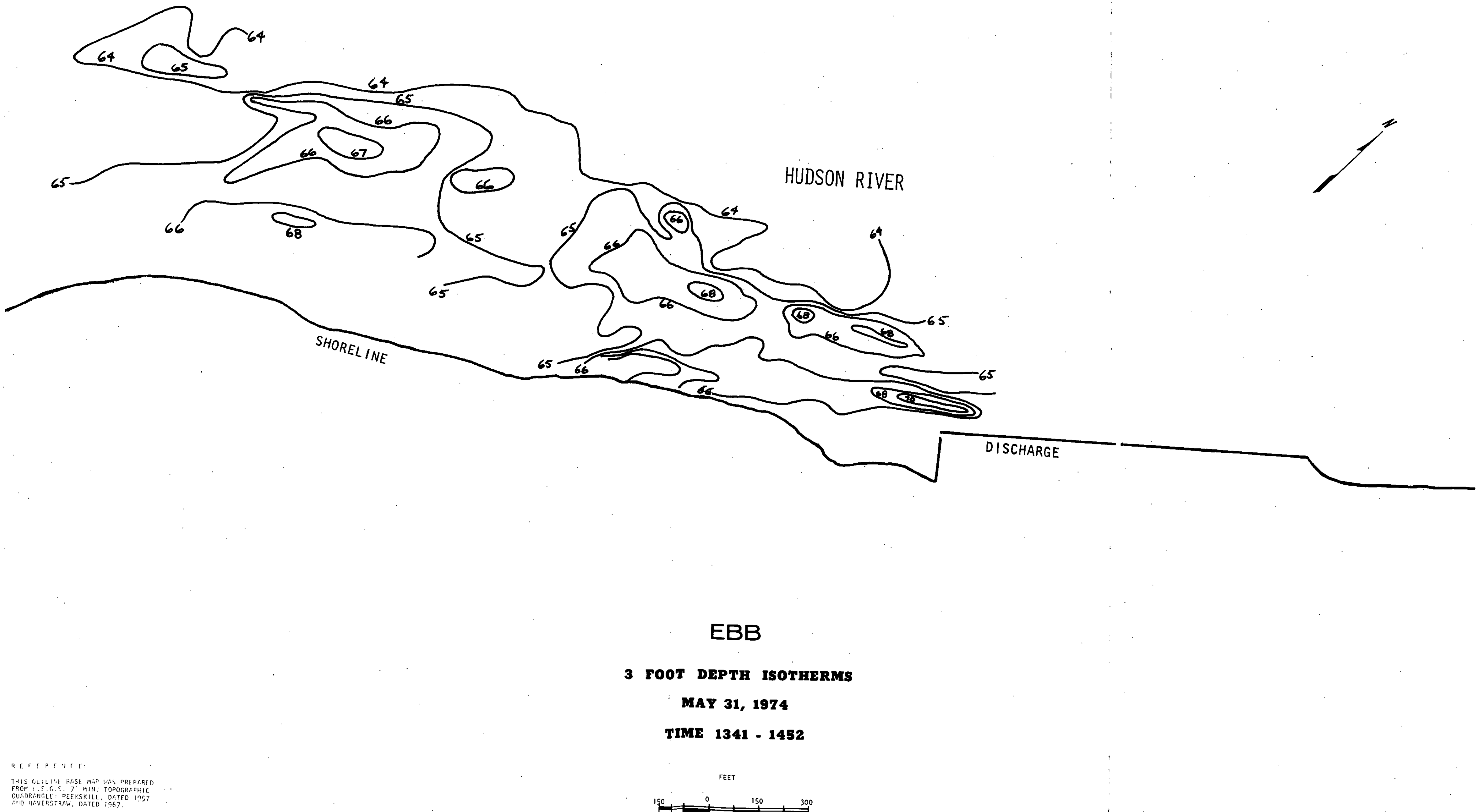
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 17.1



EBB

3 FOOT DEPTH ISOTHERMS

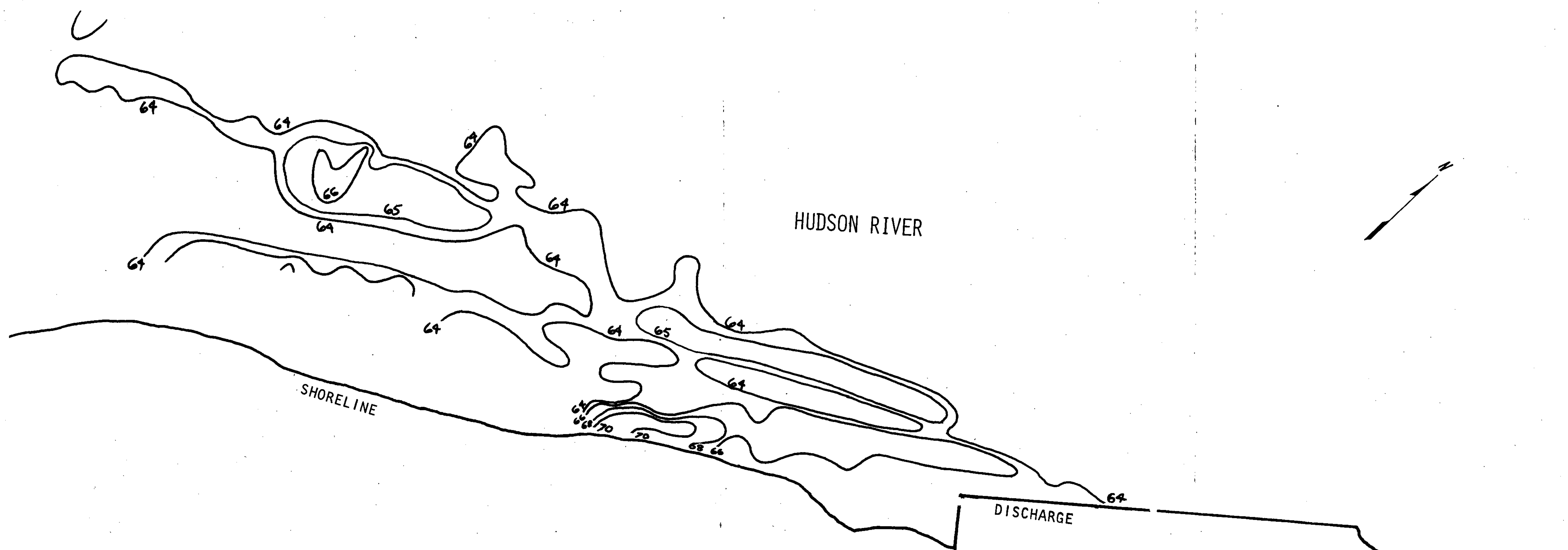
MAY 31, 1974

TIME 1341 - 1452

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

FIGURE 17.2



EBB

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 1341 - 1452

FEET

150 0 150 300

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 17.3

466.12 (4-64)

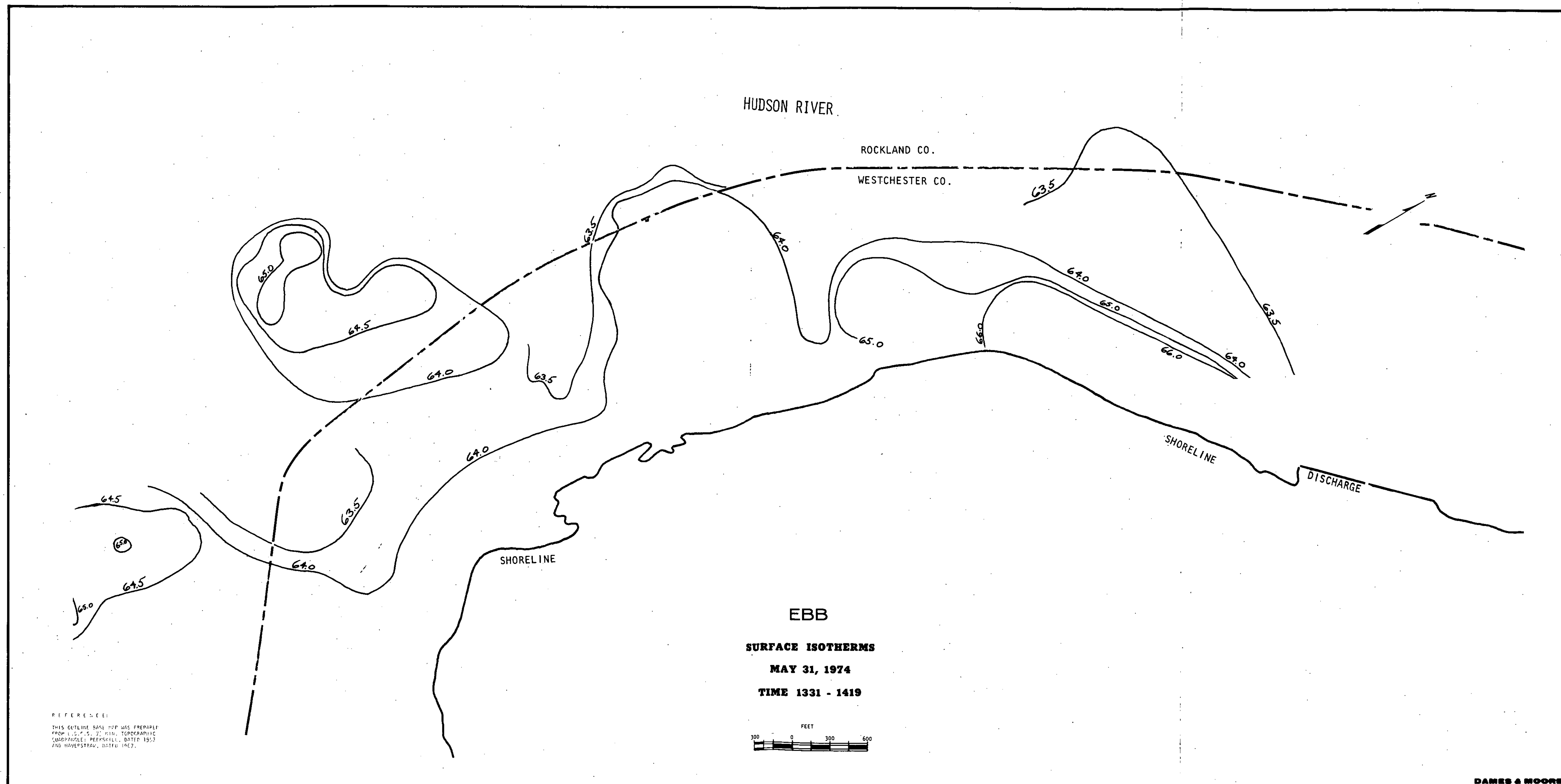

HUDSON RIVER
ROCKLAND CO.
WESTCHESTER CO.
N
65.0
64.5
64.0
63.5
64.0
65.0
66.0
SHORELINE
DISCHARGE
EBB
SURFACE ISOTHERMS
MAY 31, 1974
TIME 1331 - 1419
FEET
300
0
300
600
REFERENCE:
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.
DAMES & MOORE

FIGURE 18.1

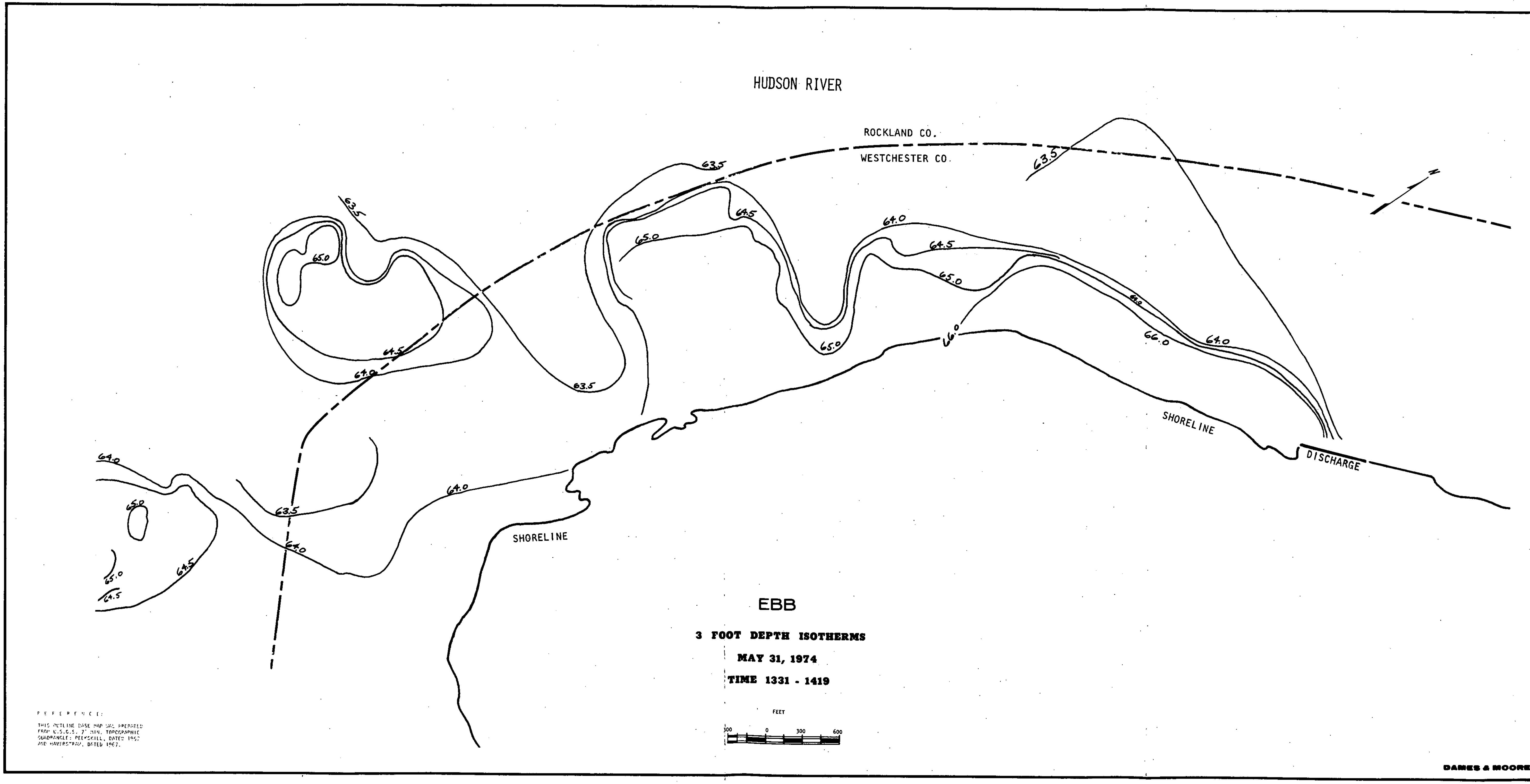
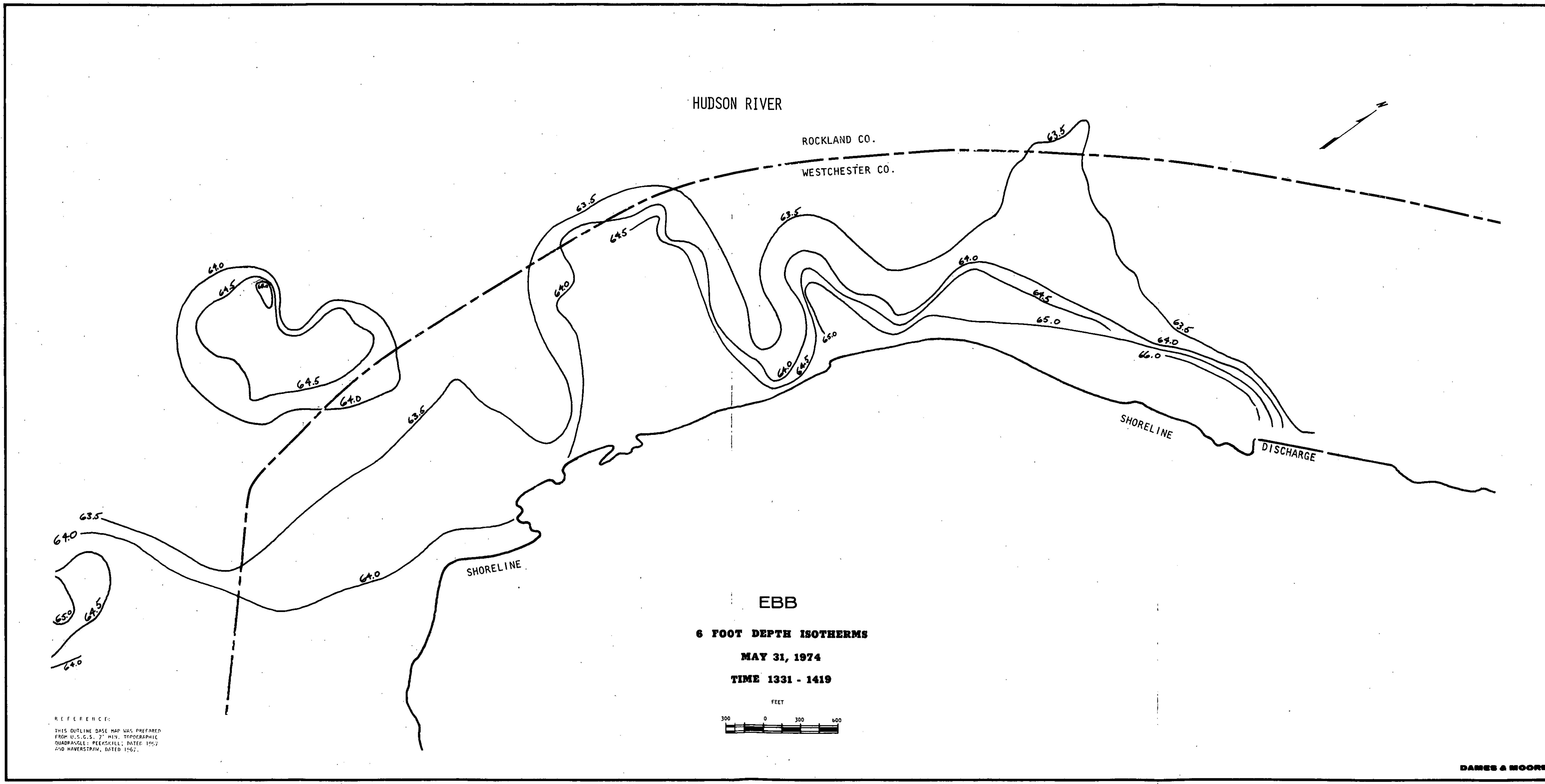
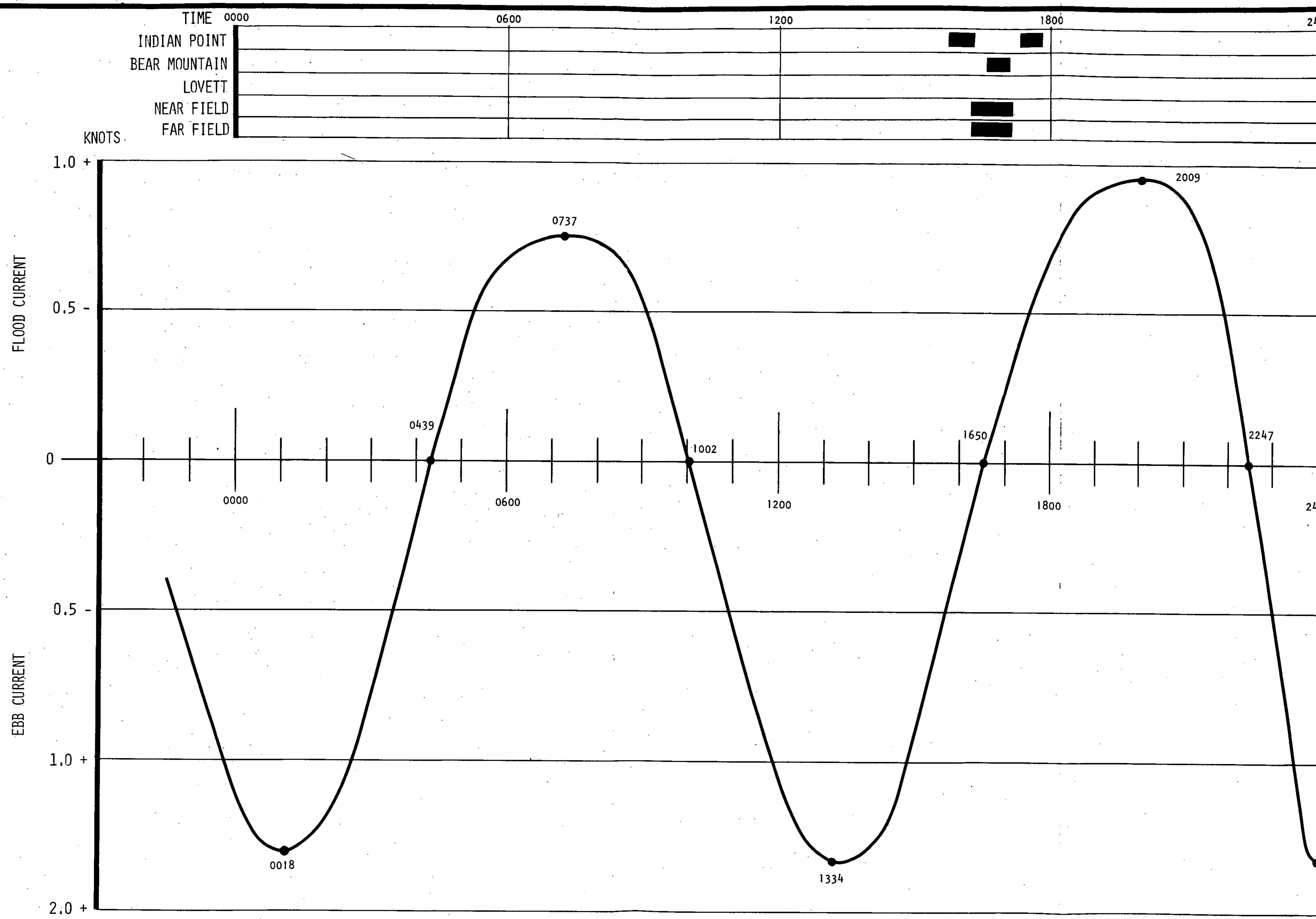

HUDSON RIVER
ROCKLAND CO.
WESTCHESTER CO.
63.5
64.0
64.5
65.0
66.0
SHORELINE
DISCHARGE
EBB
3 FOOT DEPTH ISOTHERMS
MAY 31, 1974
TIME 1331 - 1419
FEET
300
0
300
600
REFERENCE:
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7' MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.
DAMES & MOORE

FIGURE 18.2



HUDSON RIVER
ROCKLAND CO.
WESTCHESTER CO.
63.5
64.0
64.5
65.0
66.0
SHORELINE
SHORELINE
DISCHARGE
EBB
6 FOOT DEPTH ISOTHERMS
MAY 31, 1974
TIME 1331 - 1419
FEET
300 0 300 600
REFERENCE:
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7' MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL; DATED 1957 AND HAVERSTRAW, DATED 1967.
DAMES & MOORE

FIGURE 18.3



TIDAL CURRENT MAY 31, 1974

DAMES & MOORE

FIGURE 19

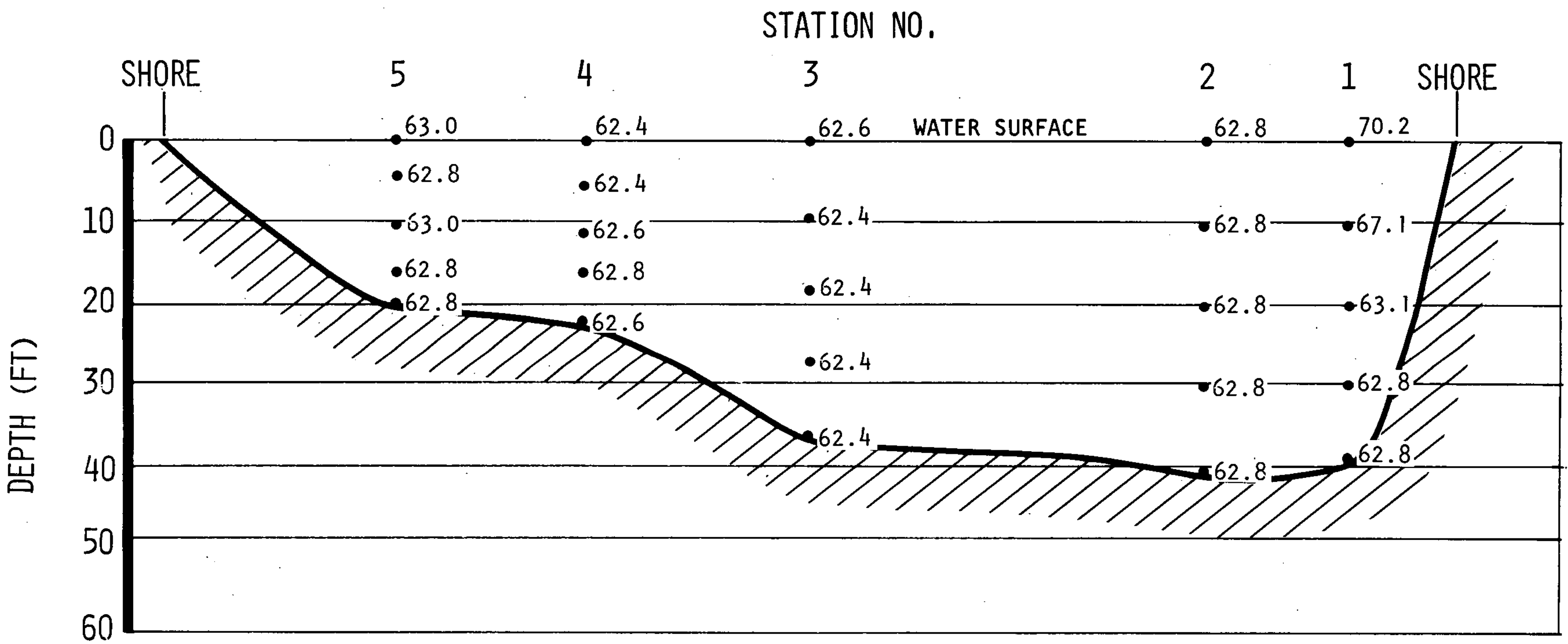
FILE

BY DATE

CHECKED BY DATE

REVISIONS BY DATE

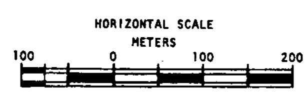
BY DATE



MAY 31, 1974

TIME: 1540 / 1621 BEGIN / END

INDIAN POINT TRANSECT

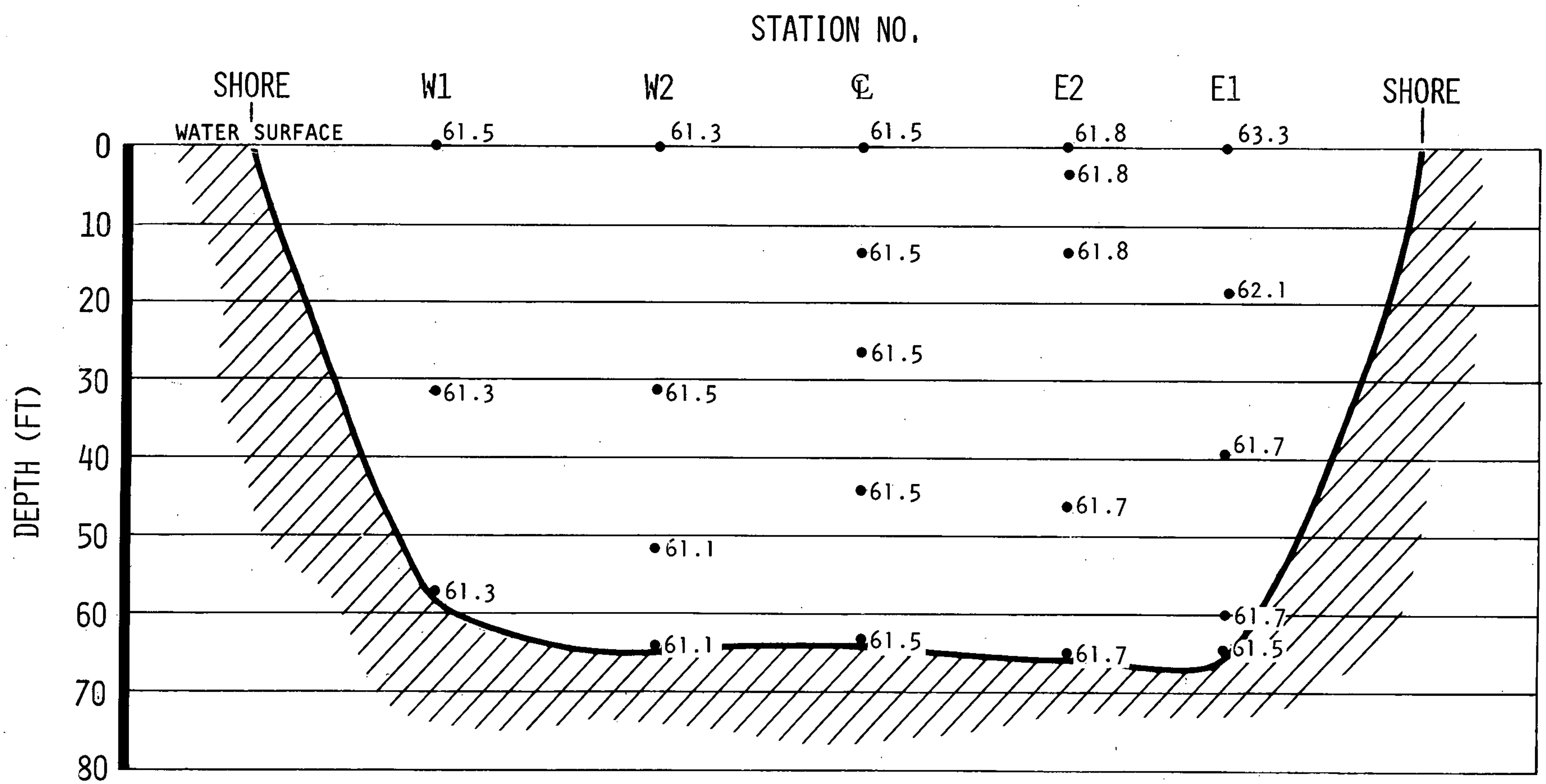


DAMES & MOORE

FIGURE 20

FILE______ BY______ DATE______ CHECKED BY______ DATE______

REVISIONS BY______ DATE______ BY______ DATE______



MAY 31, 1974

TIME: 1650 BEGIN / 1706 END

ROA HOOK TRANSECT

HORIZONTAL SCALE
METERS
100 0 100 200

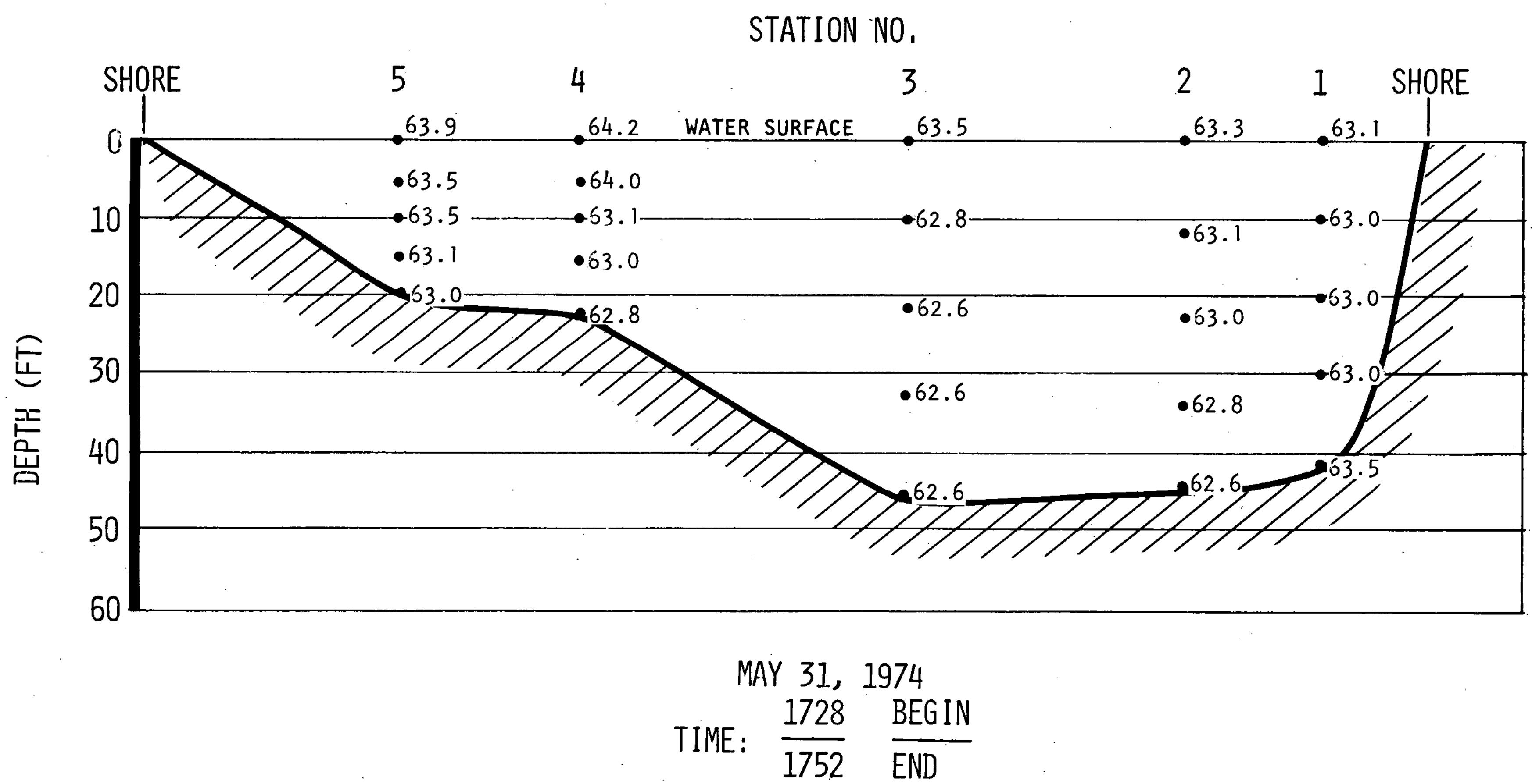
DAMES & MOORE

FIGURE 21

FILE

BY DATE REVISIONS BY DATE

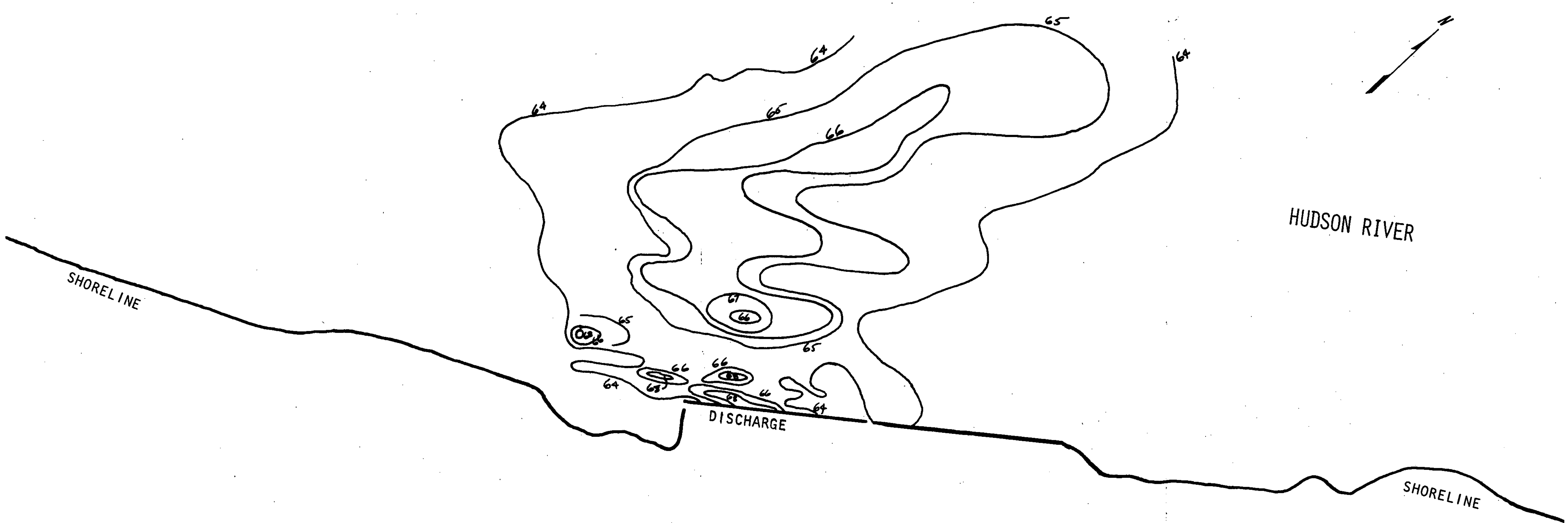
CHECKED BY DATE BY DATE



INDIAN POINT TRANSECT

DAMES & MOORE

FIGURE 22

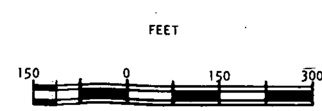


LWS

SURFACE ISOTHERMS

MAY 31, 1974

TIME 1642 - 1721



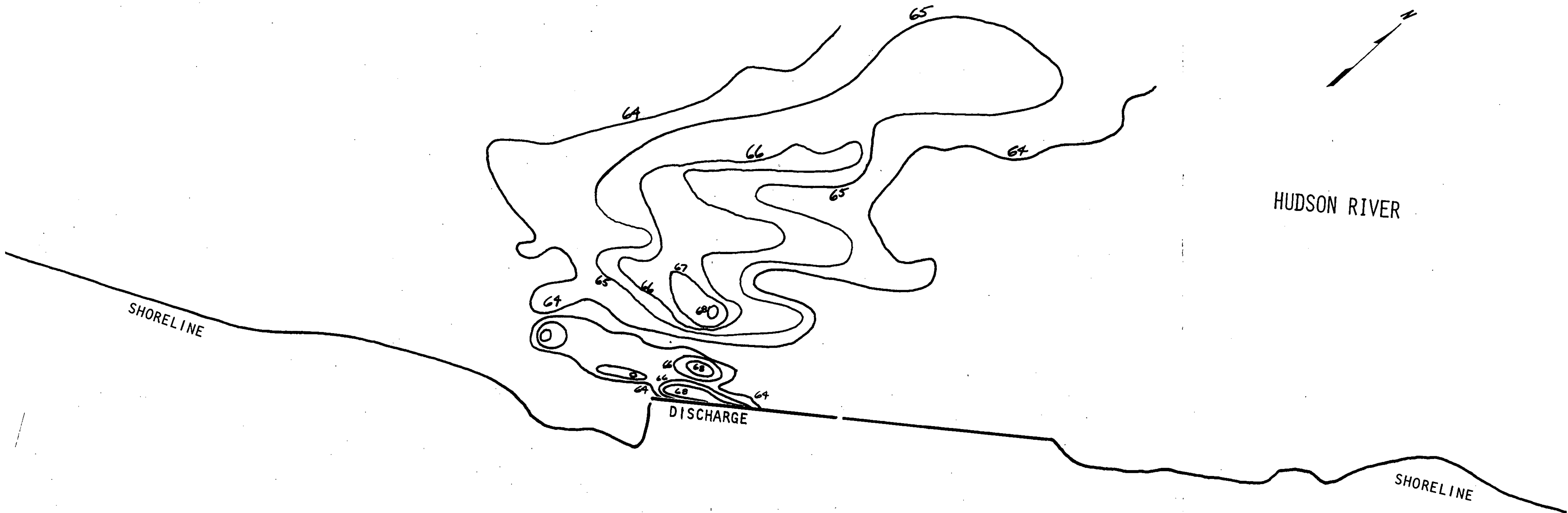
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED
FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC
QUADRANGLE: PEEKSKILL, DATED 1957
AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

466.12 (4-64)

FIGURE 23.71



LWS

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 1642 - 1721

REFERENCE:

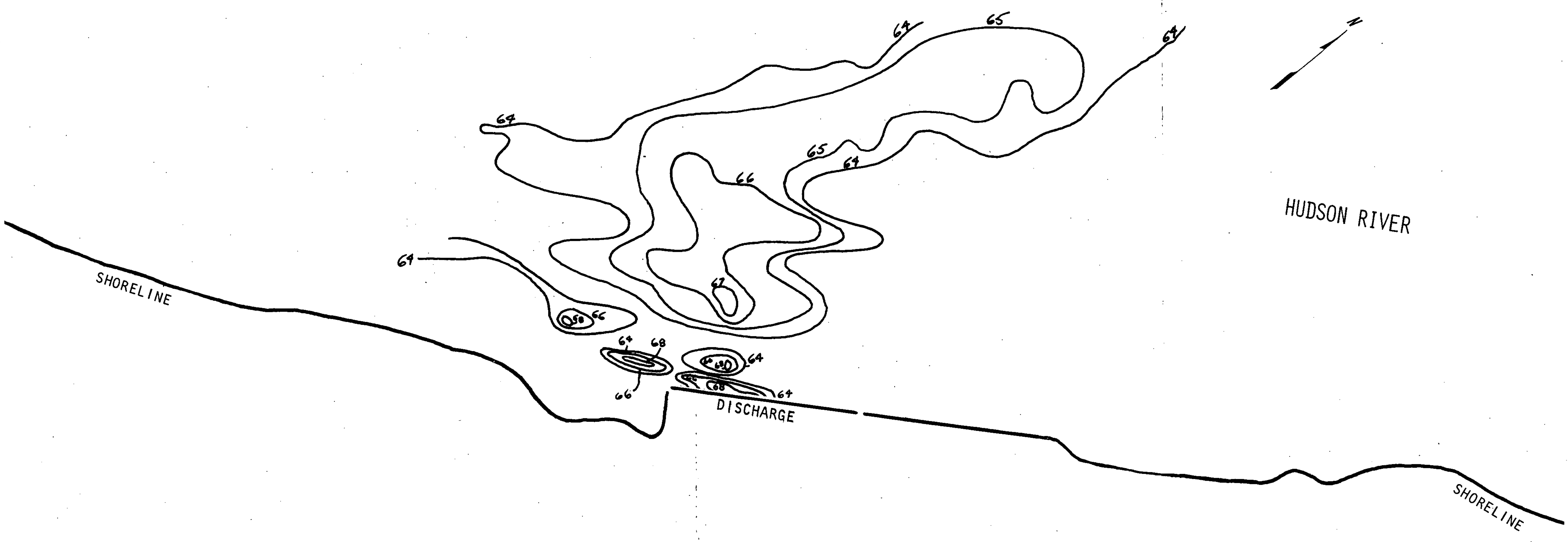
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

FEET 150 0 150 300

DAMES & MOORE

FIGURE 23.2

466.12 (4-64)



LWS

6 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 1642 - 1721

FEET

150 0 150 300

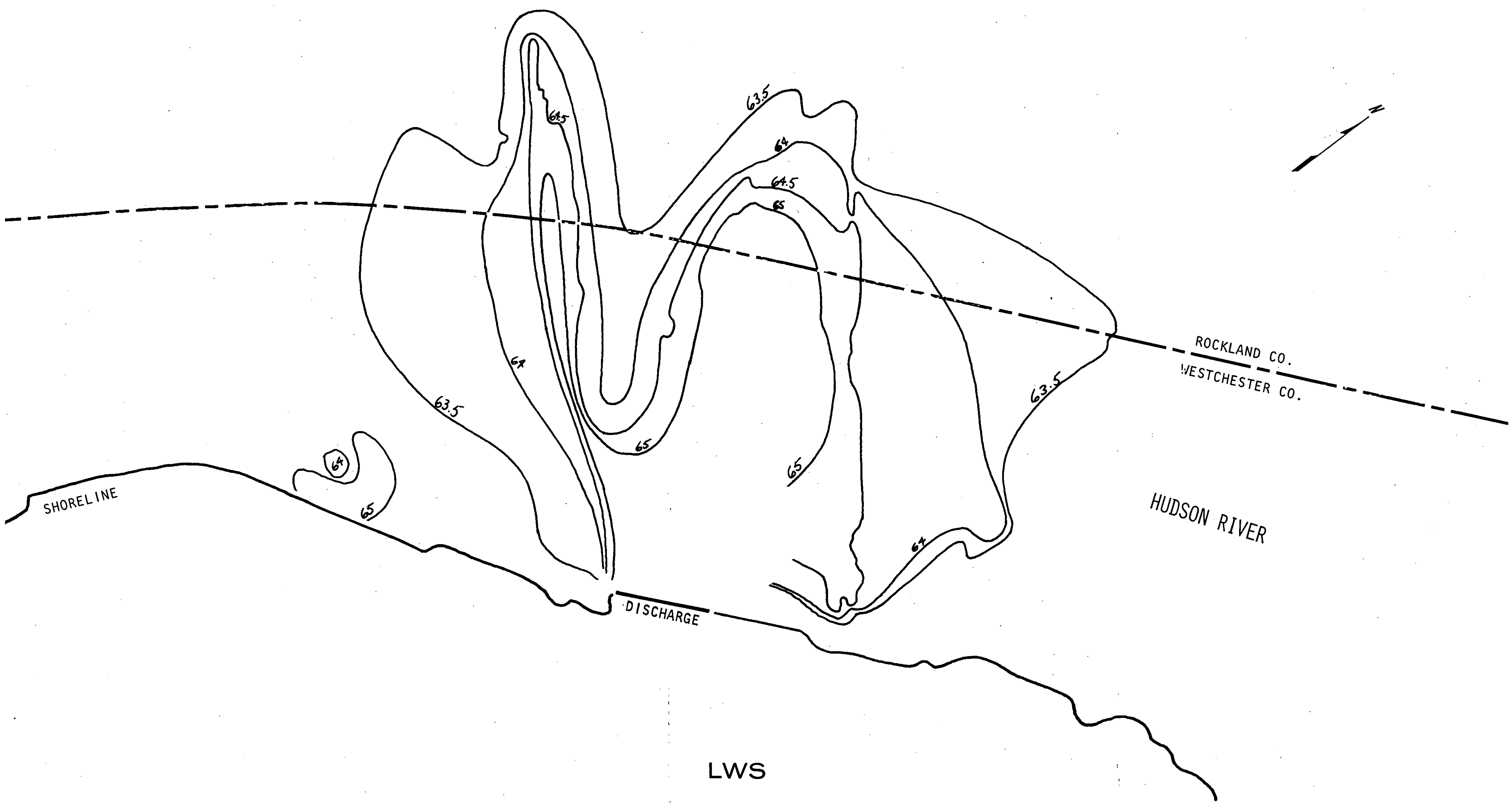
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 23.3

466.12 (4-64)



LWS

SURFACE ISOTHERMS

MAY 31, 1974

TIME 1641 - 1719

FEET

300 0 300 600

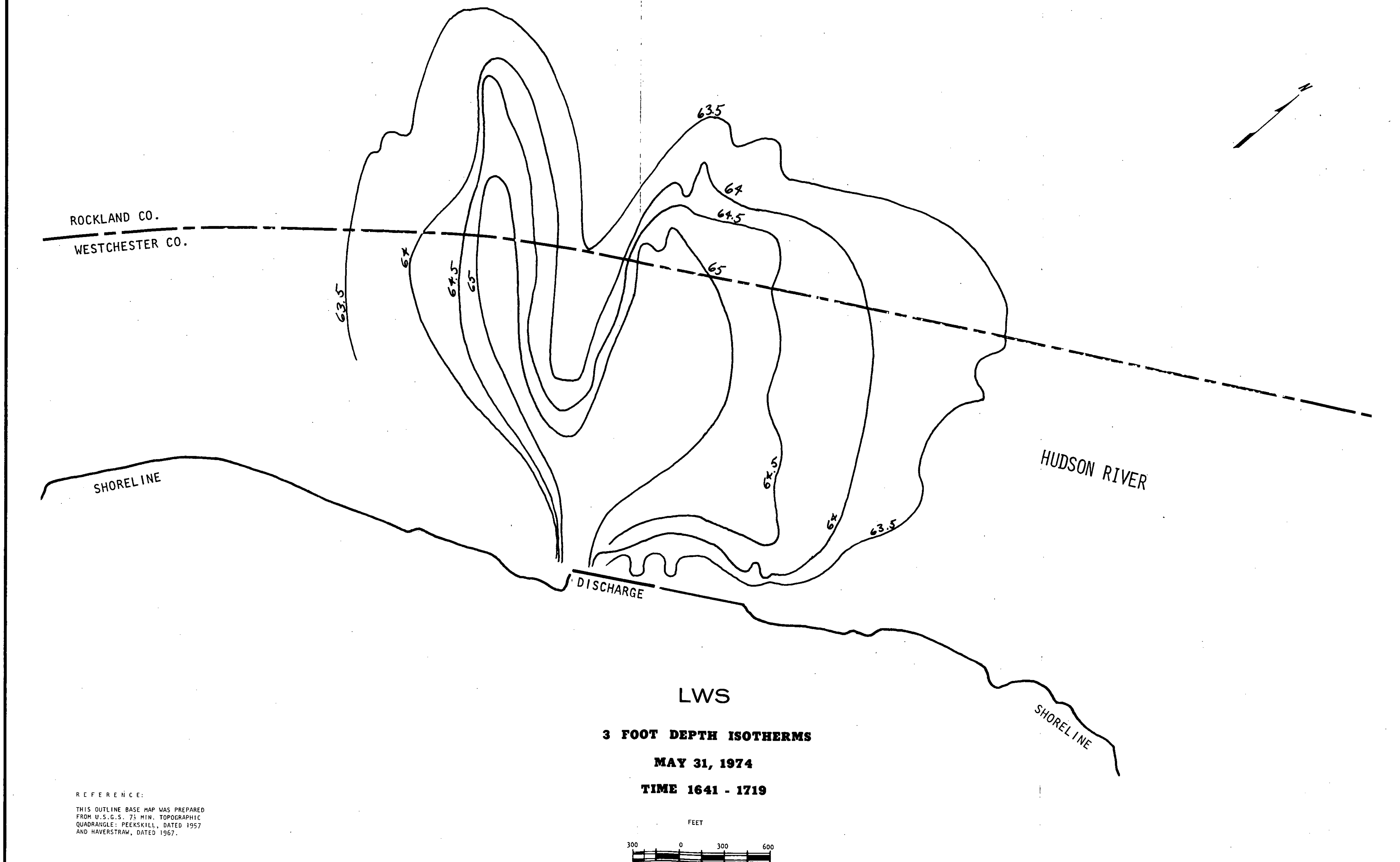
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 24.1

466.12 (4-64)



REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

LWS

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 1641 - 1719

DAMES & MOORE

FIGURE 24.2

466.12 (4-64)

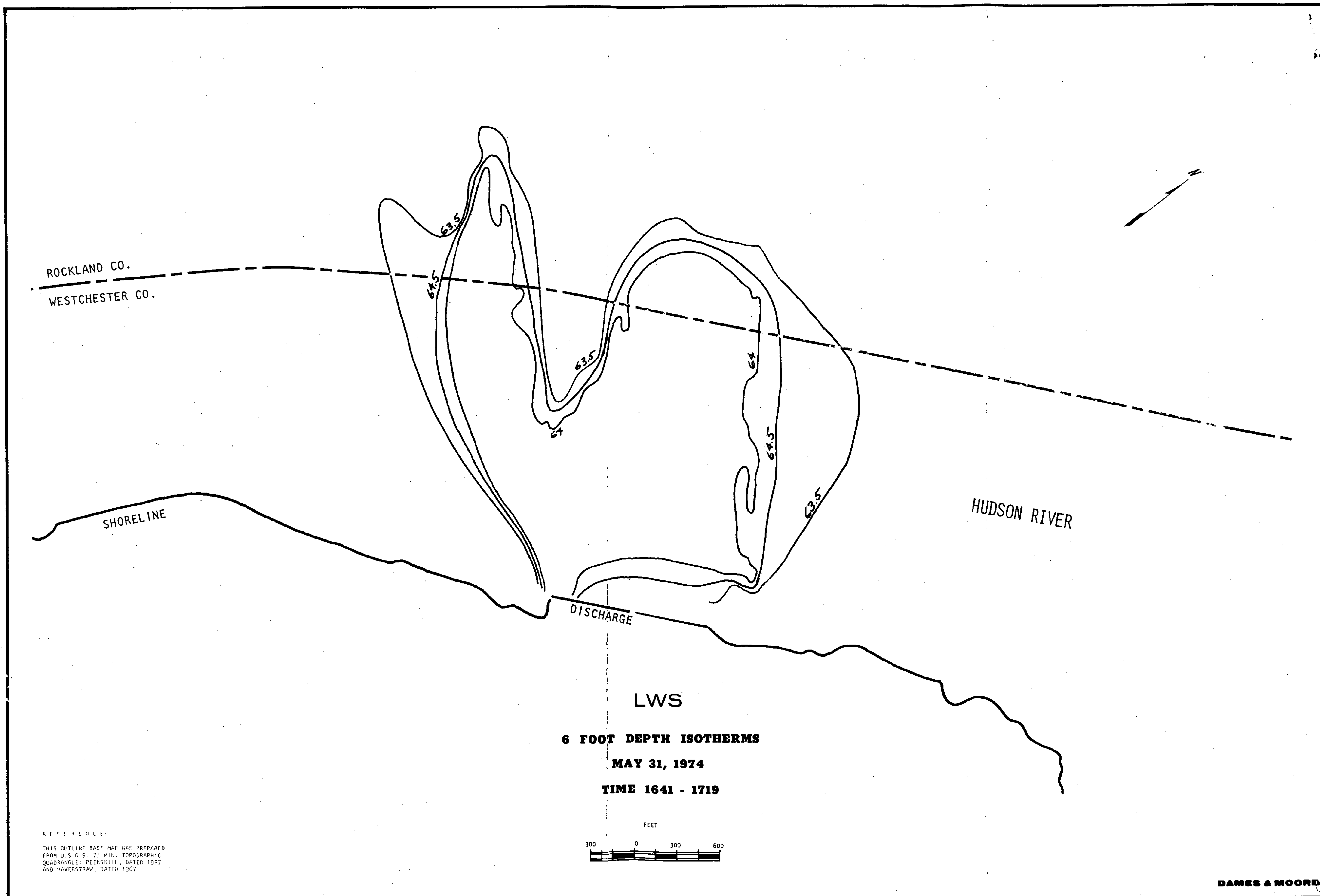
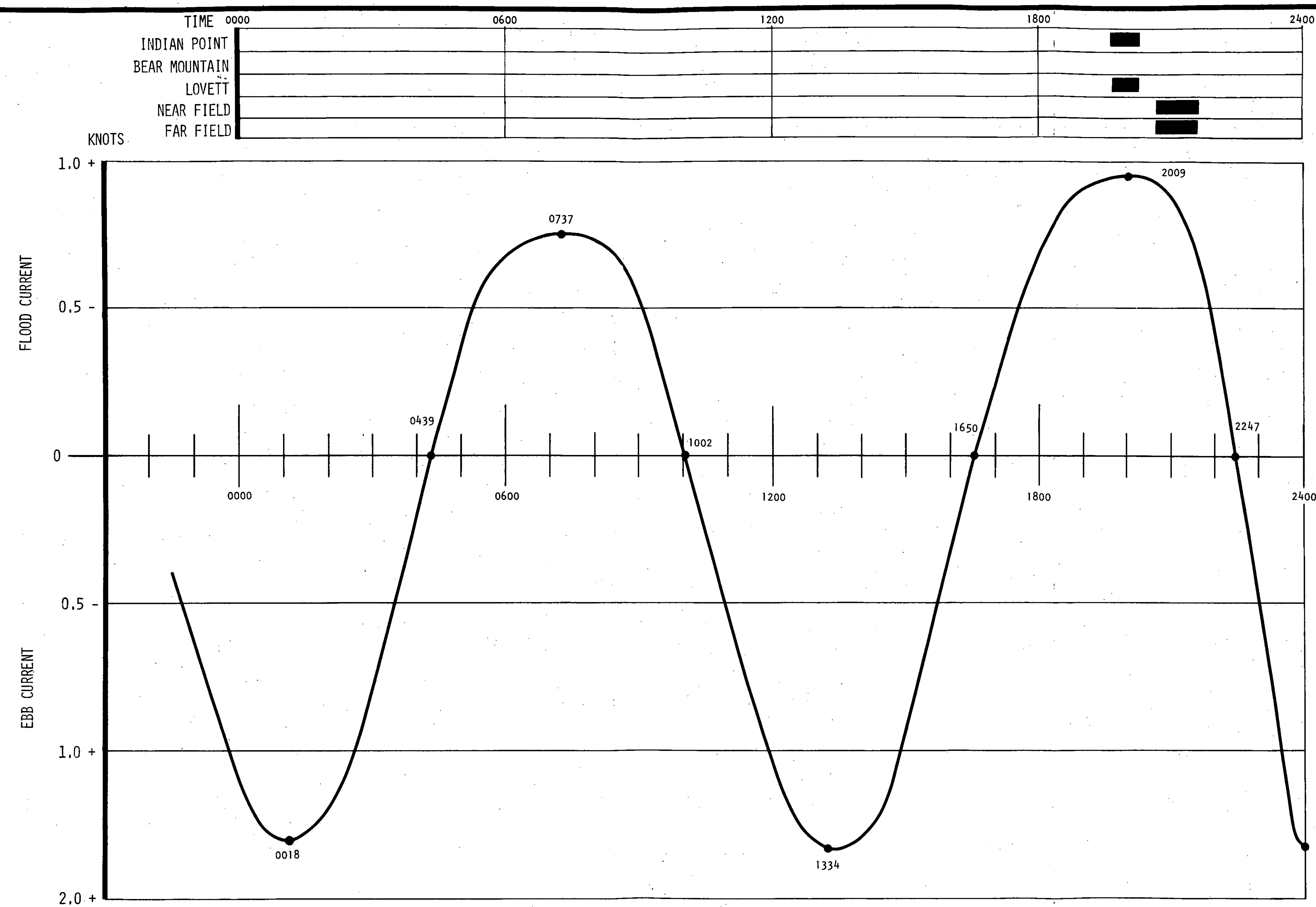


FIGURE 24.3

466.12 (4-64)



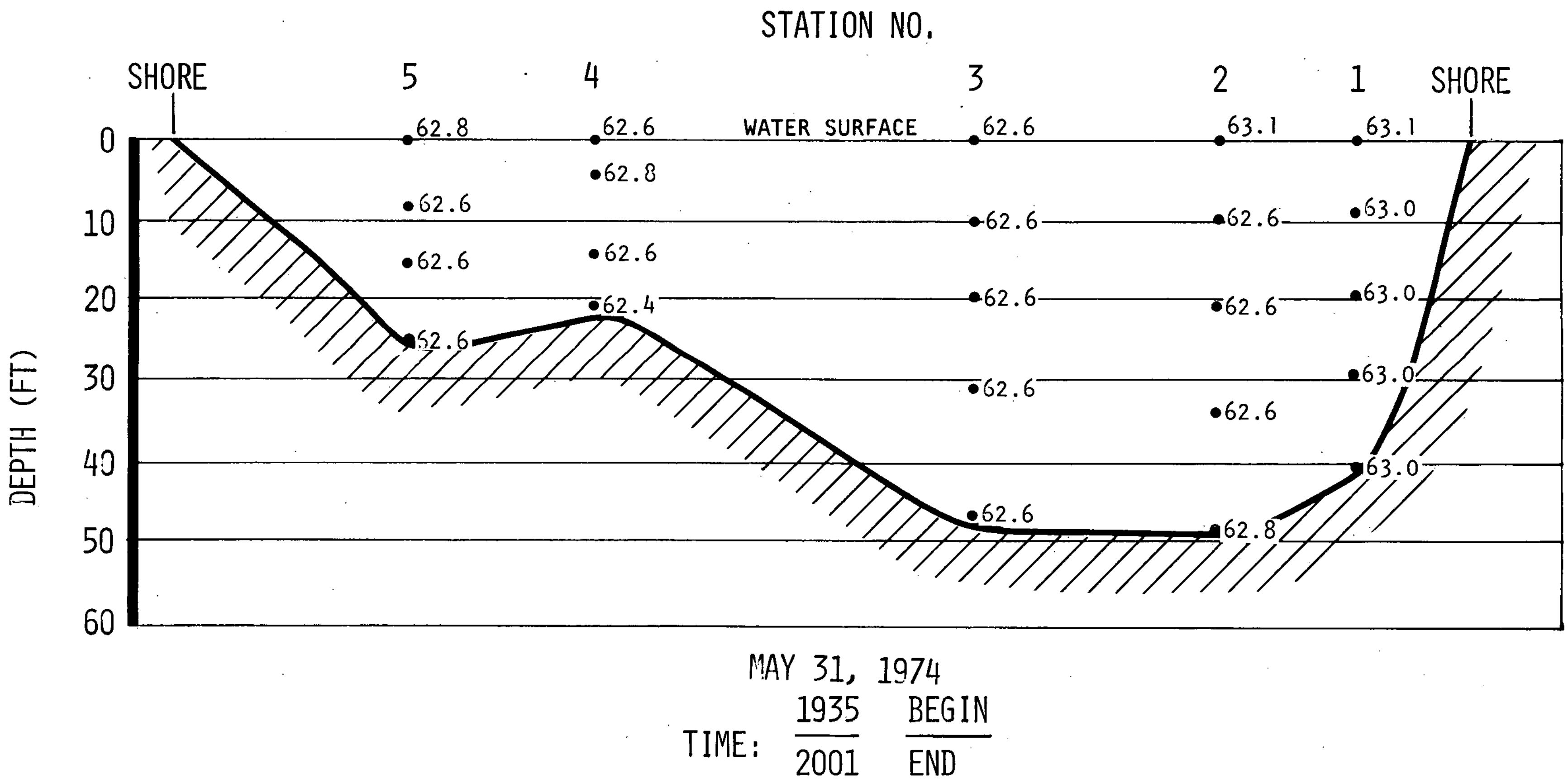
TIDAL CURRENT MAY 31, 1974

FIGURE 25

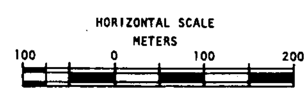
DAMES & MOORE

BY______ DATE______ REVISIONS BY______ DATE______

FILE______ CHECKED BY______ DATE______ BY______ DATE______



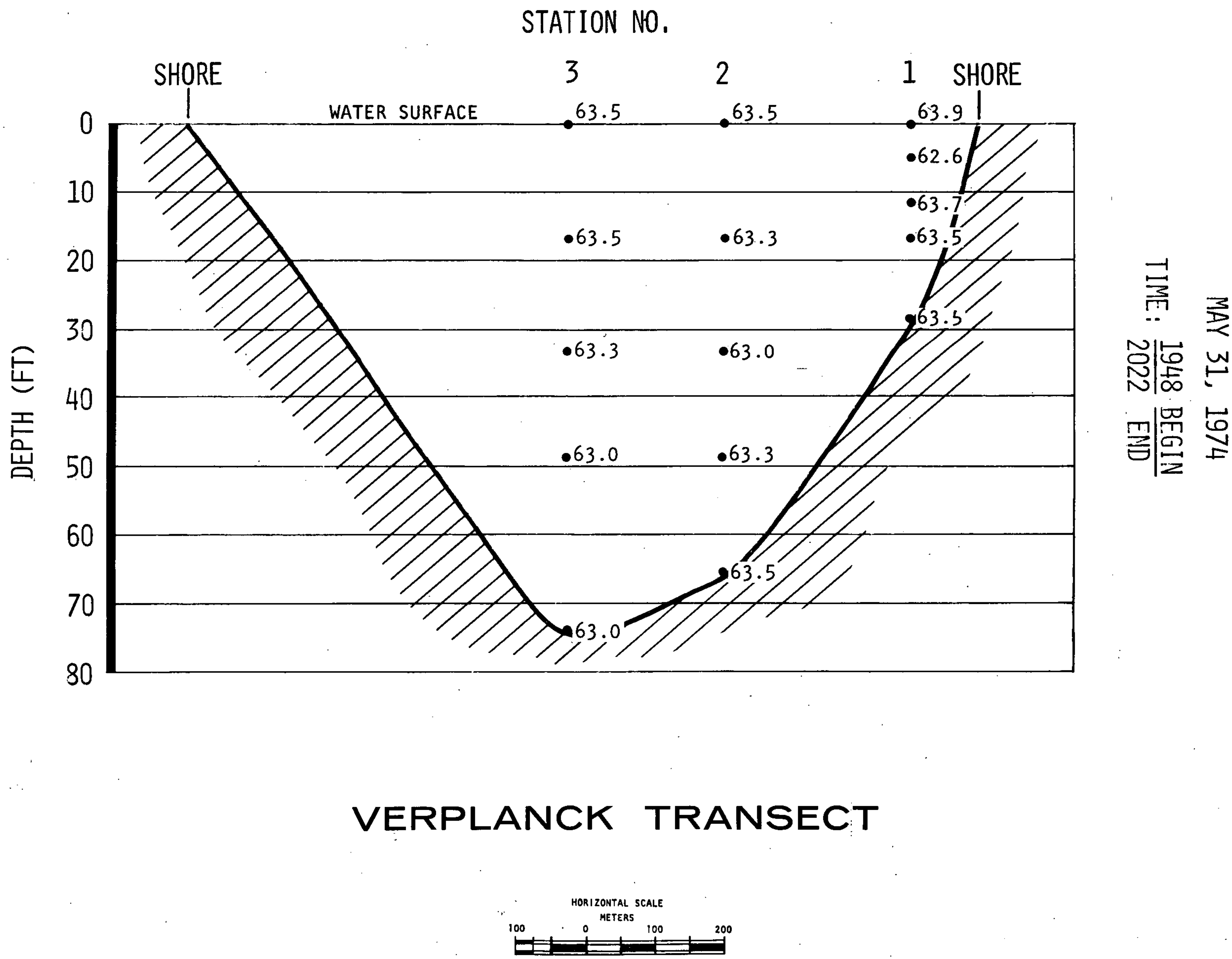
INDIAN POINT TRANSECT



DAMES & MOORE

FIGURE 26

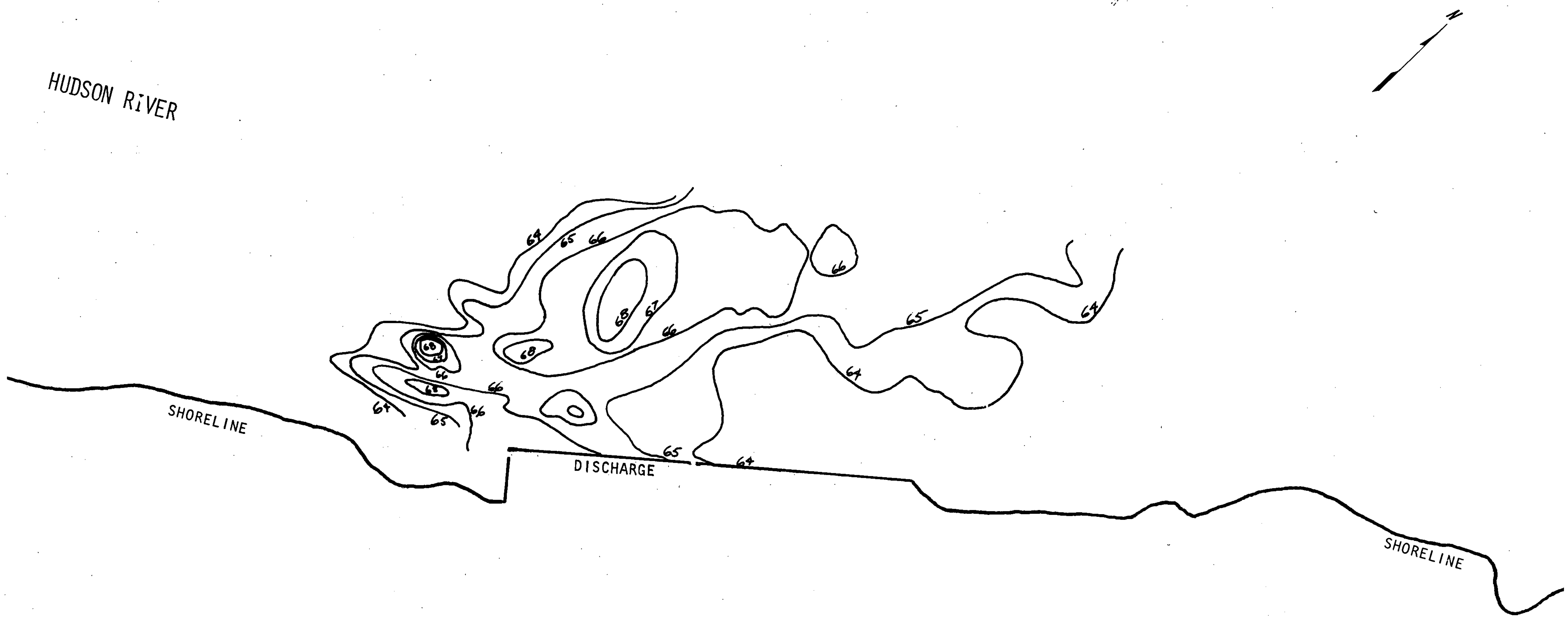
FILE	BY	DATE	REVISIONS	BY	DATE
	CHECKED BY	DATE		BY	DATE



VERPLANCK TRANSECT

DAMES & MOORE

FIGURE 27



LATE FLOOD

SURFACE ISOTHERMS

MAY 31, 1974

TIME 2009 - 2056

FEET

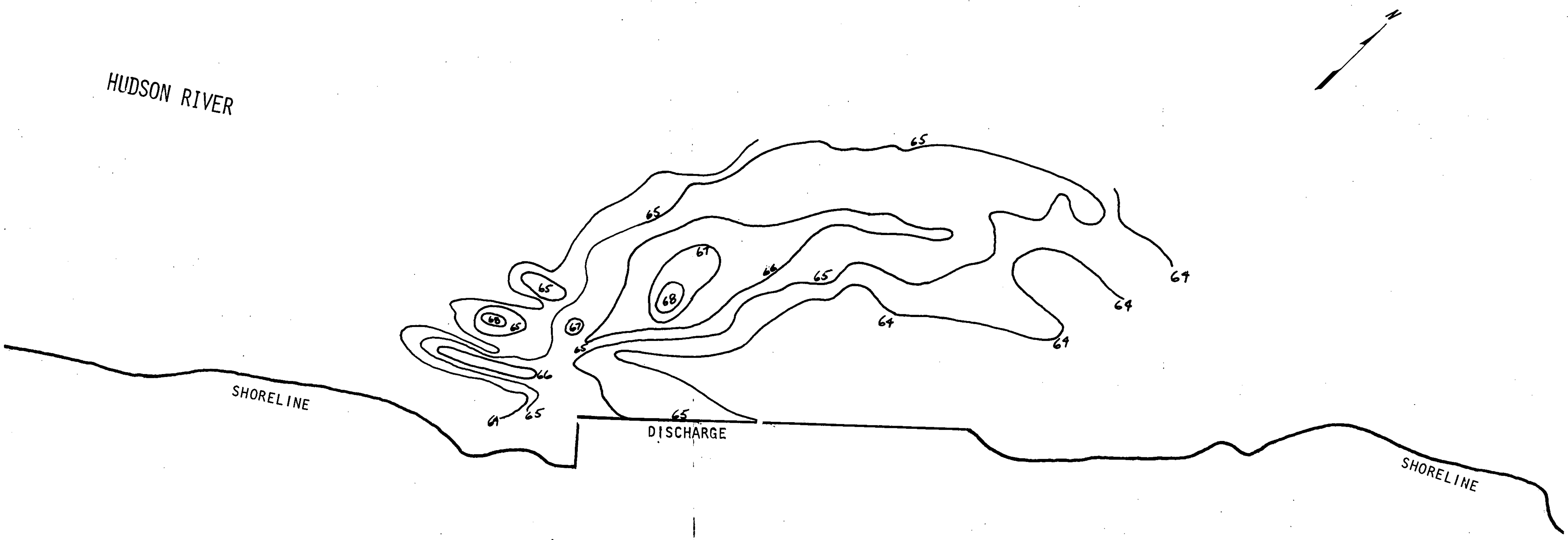
150 0 150 300

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 28.1



LATE FLOOD

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 2009 - 2056

FEET

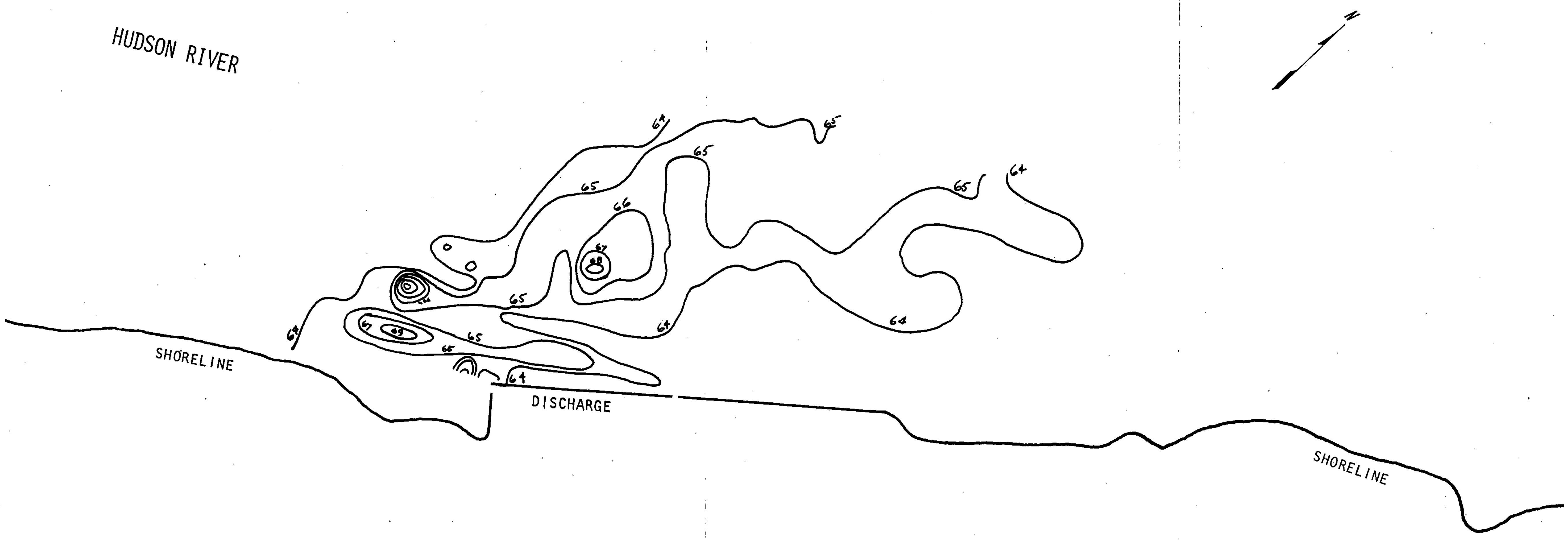
150 0 150 300

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 28.2



LATE FLOOD

6 FOOT DEPTH ISOTHERMS

MAY 31,1974

TIME 2009 - 2056

FEET

150 0 150 300

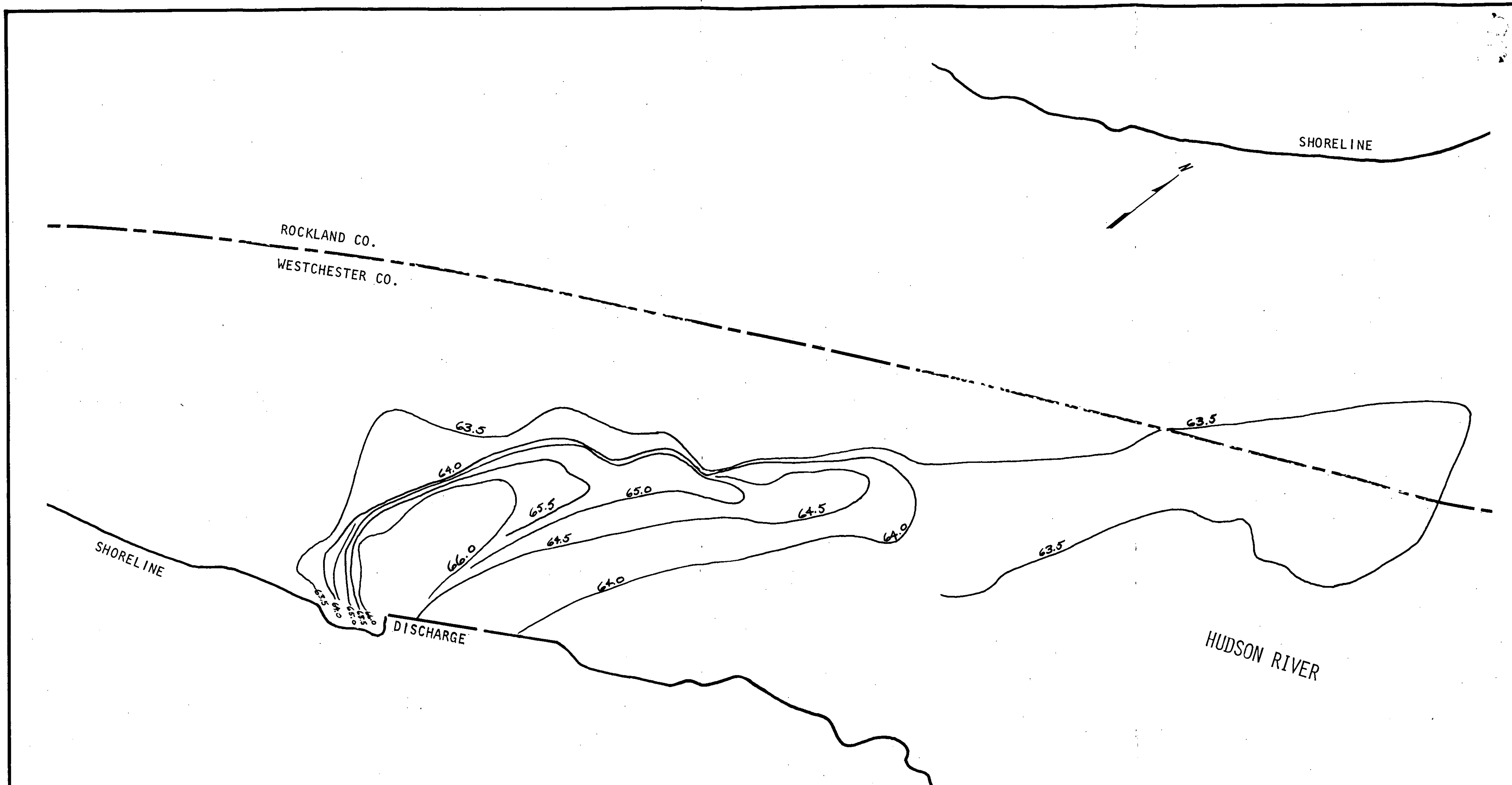
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 28.[illegible]3

466.12 (4-64)



LATE FLOOD

SURFACE ISOTHERMS

MAY 31, 1974

TIME 2012 - 2053

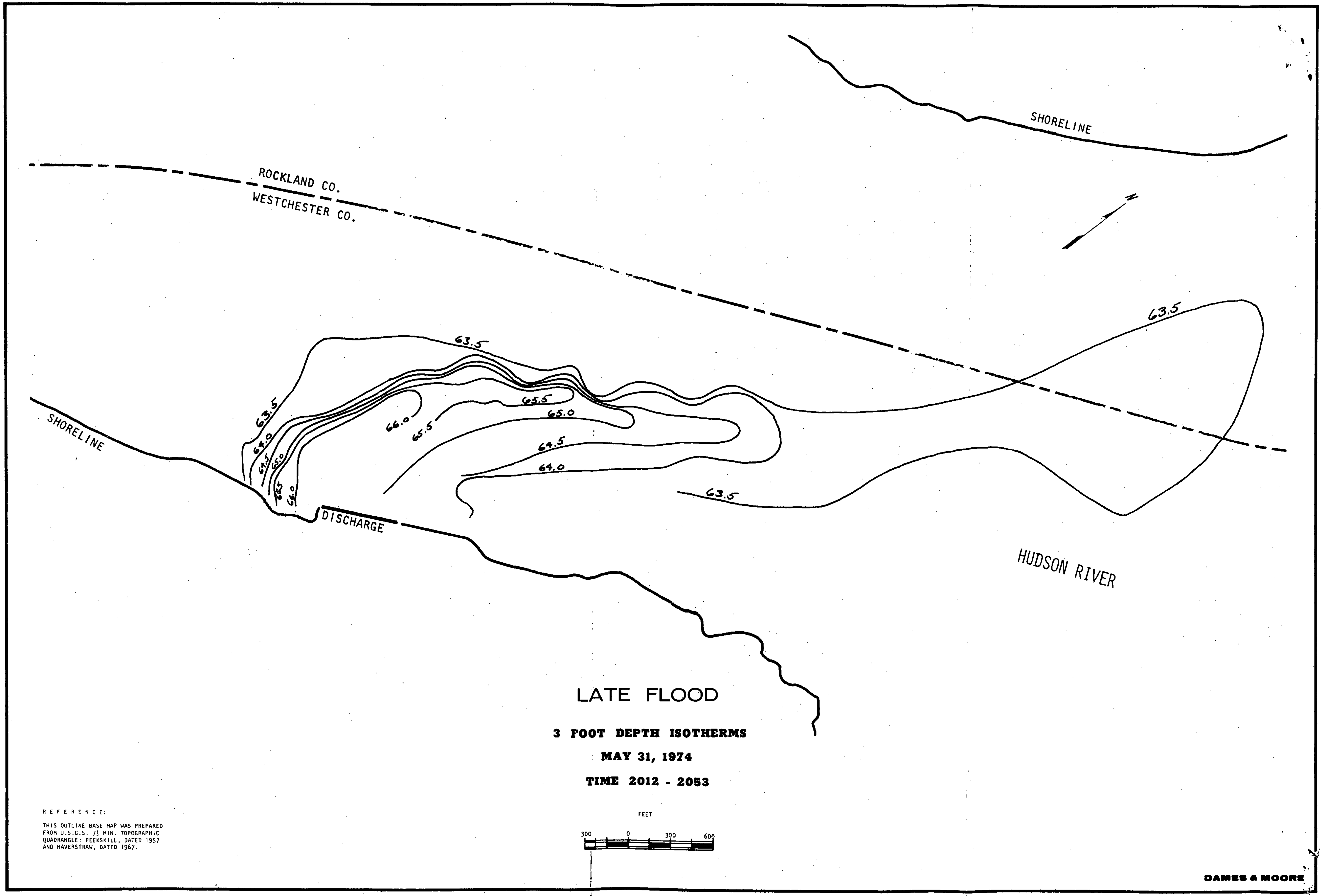
REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

DAMES & MOORE

FIGURE 29

466.12 (4-64)



LATE FLOOD

3 FOOT DEPTH ISOTHERMS

MAY 31, 1974

TIME 2012 - 2053

REFERENCE:

THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.

FIGURE 29.2

466.12 (4-64)

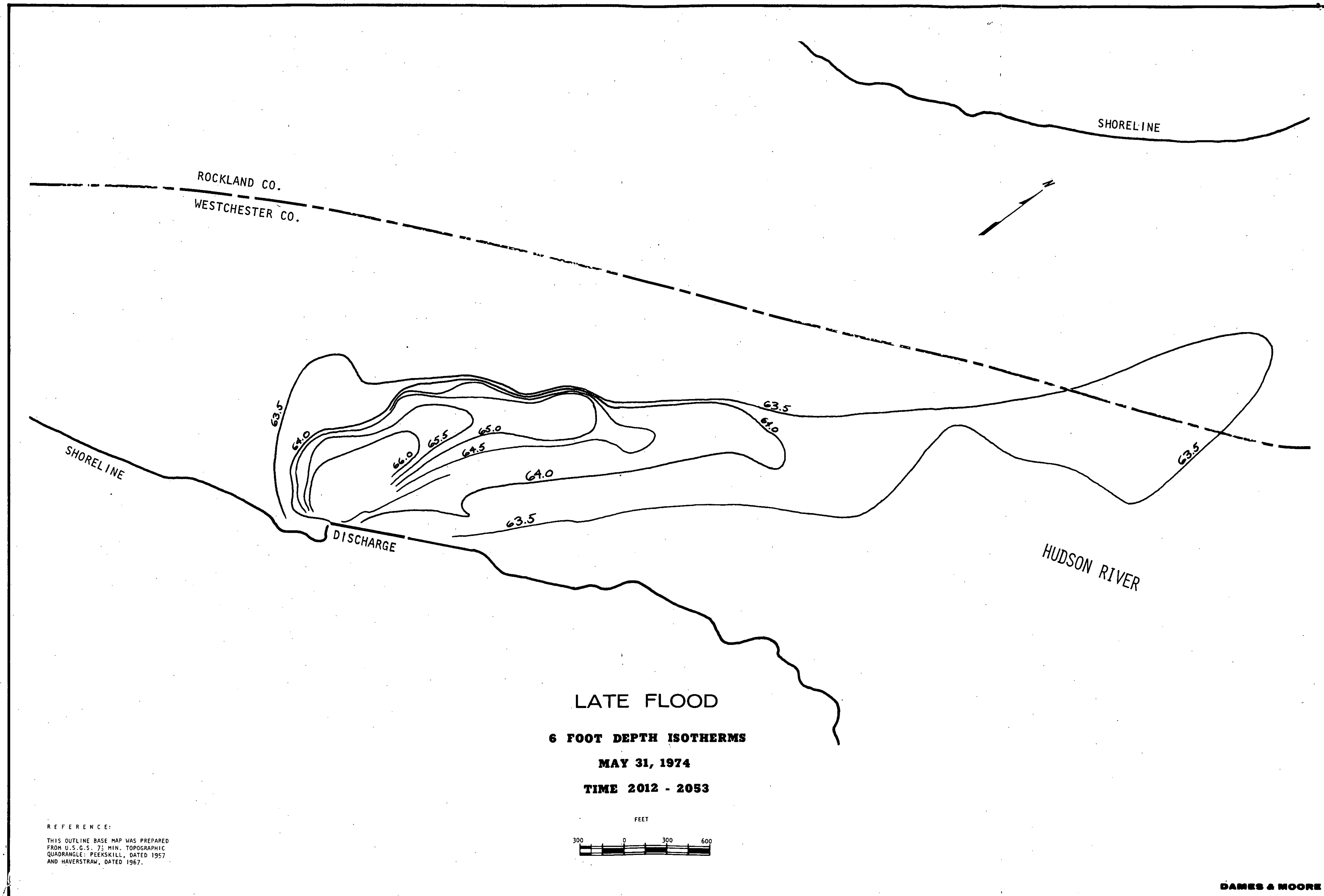

SHORELINE
ROCKLAND CO.
WESTCHESTER CO.
N
63.5
64.0
65.5
66.0
65.0
64.5
64.0
63.5
63.5
64.0
63.5
SHORELINE
DISCHARGE
HUDSON RIVER
LATE FLOOD
6 FOOT DEPTH ISOTHERMS
MAY 31, 1974
TIME 2012 - 2053
FEET
300 0 300 600
REFERENCE:
THIS OUTLINE BASE MAP WAS PREPARED FROM U.S.G.S. 7½ MIN. TOPOGRAPHIC QUADRANGLE: PEEKSKILL, DATED 1957 AND HAVERSTRAW, DATED 1967.
DAMES & MOORE

FIGURE 29.3

17-7A