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CLEAR TECHNICAL REPORT NO. 315-D

ASSESSMENT OF THE BREAKWATER STRUCTURES AT CLINTON REEF MARINA, PORT CLINTON, OHIO

By

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Prepared for

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INTRODUCTION

Study Objectives

In 1981, Clinton Reef Marina was issued Department of the Army (DA) permit no. 81-002-1 to contstruct a marina on the north bank of the Portage River approximately one mile upstream of its mouth with Lake Erie. Construction on the marina has now been completed. However, the U. S. Army Corps of Engineers has identified several instances where the marina as constructed deviates from the plan contained in the DA permit. The purpose of this study is to determine the magnitude the difference between the plan and completed structures and to provide an assessment of the environmental consequence of any differences.

The primary deviations noted by the U. S. Army Corps of Engineers, Buffalo District are listed below:

1. Length and width of marina breakwater structures
2. Number and length of boat docks
3. Circulation culverts

This report will concentrate on item no. 1. The circulation problem is discussed in a companion report entitled "Water Circulation study for Clinton Reef Marina, Port Clinton, Ohio" (Herdendorf 1987).

Geographic and Hydrologic Setting

The Portage River has its headwaters in Hancock County (elevation 777 feet) and flows a distance of 60.6 miles to Lake Erie at Port Clinton (elevation 573 feet). The average gradient from head to mouth is 3.3 feet/mile. However, the lower 10-12 miles of this stream functions as an estuary arm of Lake Erie and fluctuates in level in direct response to lake water levels (Langlois 1965). The discharge of river water to Lake Erie averages 400 cubic feet per second (cfs), and ranges between 14,400 cfs (February 1950) and 3 cfs (September 1955). The river has a total drainage area of 581 square miles. Annually the Portage River transports approximately 112,000 tons of sediment from the drainage basin to Lake Erie. The maximum concentrations of suspended sediment can exceed 1,200 mg/l during high flow (Ohio Division of Water 1966). This circumstance results in the turbid nature of the river water throughout much of the year.

Adjacent to the project site, the main channel of the Portage River has a depth of 6-11 feet and a width of 200 feet. Calculated flows in this portion of the river average 0.2 feet per second and range from nil to a maximum of 7.2 feet per second. In response to short-term Lake Erie water level fluctuations, primarily due to wind induced currents, water in the lower reach of the Portage River can flow either downstream of upstream. Water level fluctuations in excess of 8 feet in a 24-hour period have been observed at Port Clinton. Because of the limited fetch, waves in the river at the site rarely exceed 1-2 feet in height.

STUDY METHODS

Profile Sections

Of primary interest in this report are the dimensions of the breakwaters, particularly their underwater configuration. To determine this, baselines were established along the approximate centerlines of the east and west arms of the south breakwater and along the west breakwater. From each basline, two profile lines were established (6 in total) running both toward the river and into the marina (Figure 1). Depth sounds were made with a Raytheon recording fathometer (model DE-119). Horizontal control was obtained with a graduated tag-line and reel mounted aboard an 18-ft outboard motorboat, while vertical control was obtained from periodic (hourly) water level readings at a reference point established near the marina hoist. The results of the underwater sounding and land survey were plotted on graph paper (Figures 4-9) and cross-sectional areas were determined with a Planix digital planimeter (model 6).

The water level during the field survey (16 May 1987, 0800-1400 hrs) showed very little variation and averaged about 4.5 ft above Low Water Datum of 568.6 ft IGLD. Water level elevation was obtained at the beginning of the survey from the guage platform at the Portage River Bridge and confirmed with the water level recordings for Sandusky (Ohio Dept. Nat. Resources, Div. Geological Survey) and Put-in-Bay (Figure 2).

The typical sections described in the permit were plotted on graph paper with a 10:1 vertical exaggeration. Figure 3 shows the configuration for typical section B-B. There appears to be some inconsistency in the permit drawings concerning the overall width of the sections. The drawings label the top of the clay core with a width of 25 ft, then show a 3 ft wide limestone rip-rap cap on both sides of the core. However, the bar scale does not agree with these dimensions. For the purposes of the assessment I have used 25 ft as the width of the core and 31 ft as the overall width of the top of the section, including the rip-rap cap. Typical section B-B is the section authorized for the east and west arms of the south breakwaters (perpendicular segmented piers) and typical section C-C is the section authorized for the west breakwater (west pier).

The results of the underwater soundings and the land surveys were plotted on graph paper (Figures 4-9). Cross-sectional areas were then determined with a Planix digital planimeter (model 6). The appropriate typical section (B-B or C-C) was also overlaid on each measured section for comparison purposes (Figures 4-9).

Habitat Sections

In August 1984, the author conducted an environmental assessment of Harborside, a proposed marina development project immediately downstream of Clinton Reef Marina (Herdendorf 1985). The results of this study can provide a reasonable indication of the biotic nature of sediment and rip-rap habitats at Clinton Reef Marina.

The Harborside collection of benthic macroinvertebrate organisms involved several techniques. First, samples of the bottom sediments were obtained with an Ekman dredge from near the center fo the proposed marina. This material was sieved in the field through a benthos screen (No. 30 mesh) and the organisms retained on the screen were carefully removed and preserved in 10% alcohol. Identification was done using 10-40x magnification and the taxonomic keys given by Clarke (1981), Eddy and Hodson (1961), Edmondson (1959) and Pennak (1978). Other methods included using dip nets in the nearshore waters and visual inspection of Cladophora beds, rip-rap boulders, and beached mollusk shells. SCUBA diving techniques proved to be an effective way to survey the entire bottom of the site and to obtain live mollusks.

Information on the fish utilizing the Harborside site was obtained by three methods: 1) interviews with local fishermen, 2) observation of beached specimens on the shores adjacent to the site, and 3) direct test netting. Both a 10-ft- and 25-ft-long shore seine were used to collect fish samples along the west and north shores of athe proposed marina. Test netting was conducted from the shore out to a depth of five feet. Representative specimens were preserved in 10% alcohol. The identification of fish specimens was confirmed using the taxonomic keys presented in Trautman (1981).

RESULTS OF INVESTIGATION

Breakwater Construction

The permit plan authorizes: (1) "a breakwater about 1400 ft long, parallel to and about 400 ft water from the existing shoreline " and (2) "a jetty about 900 linear feet waterward from the existing shoreline." The shore parallel breakwater, as constructed, is segmented into an east and west arm with a 170 ft entrance opening and is referred to in this report as the "south breakwater." The combined length of these arms is approximately 1450 ft. The jetty at the west side of the marina is referred to in this report as the "west breakwater." This structure has a length of approximately 980 ft. Because the length of the south breakwater is within 3.6% of the plan length, a plan length of

1450 ft has been used for calculation purposes for typical section B-B. The length of the west breakwater exceeds the plan length by 8.9%. Because the Corps of Engineers has questioned this deviation, a plan length of 900 ft has been used for calculation purposes for typical section C-C.

The results of the hydrographic survey at six profile stations (Figure 1) are presented in graphic form in Figures 4-9 and in tabular form in Tables 1-4. The east and west arms of the south breakwater were authorized to be constructed in accordance with typical section B-B (Figure 3) and the west breakwater in accordance with typical section C-C. Considering cross-sectional area the following degree of agreement was obtained between the plan and the actual structure:

	Cross-sectional area		Percent
	Plan	Structure	Difference
South Breakwater			
East arm	915 ft^2	910	-0.5%
West arm	915	1037	+13.3%
West Breakwater	660	783	+18.6%
		MEAN	+10.4%

Thus, on the average the breakwaters as constructed are about 10% larger than the plan. This is the result of two factors: (1) the top surface of the breakwaters is approximately 2.5 to 3.5 ft lower than the plan and (2) the underwater slope is 3:1 in some location as compared to 2:1 in the plan.

Another perspective is to compare the basal width and area of the structures and the plan:

	Width (ft)		Basal Area (ft^2)	
	Plan	Structure	Plan	Structure
South Breakwater				
East arm	91	134	5.6×10^4	8.3×10^4
West arm	91	155	7.5×10^4	12.7×10^4
West Breakwater	79	110	7.1×10^4	10.8×10^4
		TOTAL	2.0×10^5	3.2×10^5

Due to the more gentle slopes the structure covers approximately 60% more mud, river bottom than called for in the plan. However, because of the gentle slope the surface area of submerged rip-rap habitat has also increased (Figure 10):

	Slope Area of Submerged Rip-Rap (ft^2)		Percent Increase
	Plan	Structure	
South Breakwater			
East arm	2.5×10^4	$4.0 \text{ X } 10^4$	60%
West arm	3.3×10^4	6.6×10^4	100%
West Breakwater	2.8×10^4	4.4×10^4	54%
		MEAN	71%

The total volume of material used to construct the breakwaters is estimated at about 81,200 yd^3. This is 10,000 yd^3 (14.4%) greater than the amount calculated for the plan. This difference is largely due to the gentler slope of the structures and the 80 ft projection of the west breakwater beyond the plan length of "about" 900 ft.

Benthic Habitat

Recent studies at Harborside, the marina adjacent to Clinton Reef Marina, shows that several types of materials are available to the bottom-dwelling invertebrates (or benthos) of this area of the river, including (1) organic mud, (2) silty mud, (3) aquatic plant beds, largely filamentous algae, and (4) limestone rip-rap breakwaters and shore protection. A total of 25 different taxa of benthic invertebrates were identified in field samples collected from all habitat types (Table 5).

The organic bottom muds found in the nothern half of the basin contained a considerable amount of plant debris. These muds were typified by oligochaetes (sludge worms), chironomid (midge) larvae, and spherid (fingernail) clams. The large oligochaete, *Branchura sowerbyi* was one of the most abundant benthic forms and serves as food for some of the bottom invading fish species.

The silty muds occurred in the southern part of the marine basin and contain less organic debris. In addition to the worm and midge populations, large-sized unionid clams were widely scattered in the sediments. The highest numbers, but still very low density, were found by diver-survey in the southwest part of the basin. A small sandy nearshore area yielded few organisms other than beached mollusks.

The *Cladophora* and other aquatic plant beds contained a diverse population of invertebrates, including leeches, snails, fingernail clams, amphipods, crayfish, and beetles. Many of these organisms are in the food web of Portage River fish species. These beds were generally associated with the stone rip-rap shore which also contained a number of interesting invertebrates, including freshwater sponges, bryozoans, Japanese snails, and isopods. Cladophora requires a solid substrate, such as rip-rap, for filament attachment.

No rare, threatened or endangered invertebrate species were found at the project site.

A total of 8 families and 18 species of fish were either collected or observed as beached specimens within the project site (Table 6). Dorosoma cepedianum (gizzard shad), and Notropis hudsonius (spottail shiner) were the most abundant species collected. Ictalurus melas (black bullhead), Ambloplites rupestris (rock bass), Micropterus dolomieui (smallmouth bass), and Perca flavescens (yellow perch) were only observed from beached specimens. Ictalurus punctatus (channel catfish) was taken in the basin by local fishermen. Other species were only occasionally taken in seines.

Trautman (1981) reports that 62 species of fish have been taken in the lower Portage River since the turn of the century. Approximately 30% of these species were observed during a one-day field survey in August 1984 (Table 6). It is likely than an additional 10-20 species utilize the boat basin at various times throughout the year.

No species of important commercial or sport interest, other than several sunfishes, were collected during the field survey.

Beached specimens, such as yellow perch, smallmouth bass, and catfishes, indicate that there is some utilization of the marina by sport and commercial species.

One species of fish, Ichthyomzon unicuspis (silver lamprey), which is on the Ohio list of endangered species has been reported for the lower reach of the Portage River. No specimens of this species were observed during the 1984 survey. However, in 1982, the author collected a specimen in the Catawba Island lagoon which is now being developed as the LeMarin condominium/marina complex (approximately 7 miles northeast of the present study site). This species utilizes Lake Erie tributaries in the spring and it is relatively common in south shore streams at that time of year. The study site is not considered critical to the survival of this species.

CONCLUSIONS

DA permit no. 81-002-1 authorizes the construction of "about" 2300 linear ft of breakwater structures at Clinton Reef Marina. As constructed, the total length of the structure is approximately 2430 ft. Thus, the length of the structures is within 5% of the plan. No individual structure is more than 9% longer than the plan. Because the permit contains the qualification word "about" when referring to structure lengths, small deviations such as these are well within acceptable field construction limits for underwater work.

Hydrographic surveys (Figures 8-9) show that the west breakwater is reasonably close to the profile of typical section C-C in terms of slope. At the water line, this structure is approximately 18 ft wider than shown in the plan. Because of slumping at the toe of this structure, the base is about 31 ft wider than the plan. In terms of cross-sectional area, this structure exceeds the plan by about 19%.

The east arm of the south breakwater (Figures 4-5) has a mean cross-sectional area within 0.5% of the plan. At the water line, this structure is about 14 ft wider than the plan and 43 ft wider at its base. The west arm appears to have suffered more underwater slumping (Figures 6-7), thereby exceeding the plan cross-sectional area by 13%. At the water line, the west arm is also 14 ft wider than the plan, but its base is 64 ft wider.

The total marina project encompasses an area of approximately 47 acres. The 1981 DA permit authorized construction which would cover about 5 acres of Portage River bototm with breakwaters. As constructed, the breakwaters cover about 7 acres of bottom land. In terms of percentages, the DA permit authorized about 10% of the project area covered by breakwater, whereas the actual area covered by these structures is about 15% of the total project area. Thus, the existing structures pre-empt approximately 5% more of the river bottom within the marina site than originally planned.

The permit plan would have resulted in the replacement of 5 acres of silt and organic mud environment with 2 acres of limestone rip-rap habitat. As constructed, the breakwaters replace 7 acres of sediment with over 3 acres of rock bottom. The ecological benefits of increased rock substrate are demonstrated by teh 1984 studies at Harborside Marina (Herdendorf

1985). The sediment bottom of this portion of the Portage River contains a low-density, low-diversity of aquatic invertebrates, whereas the limestone rip-rap provides excellent structure and attachment surfaces for diverse phytobenthos, zoobenthos, and fish. The rubble-mound construction of the breakwaters simulates the productive reefs and Bass Islands shoreline of western lake Erie. Thus, a net benefit to the biological community of the lower Portage River has occurred by virtue of rip-rap breakwater construction in the area.

Deviations from the permit plan are measurable, but not significant when dealing with the uncertainties of underwater construction. The breakwaters at Clinton Reef Marina have now been in place long enough for phyto- and zoo-benthic colonization to have taken place to a significant degree. The underwater slope of the structures, ranging from 2:1 to 3:1, appears now to have stabilized and no further slumping is anticipated. Thus, disturbance fo these structures to change their present configuration would be ill-advised.

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TABLES

AND

FIGURES

TABLE 1

CROSS-SECTIONAL AREA (FT^2) OF TYPICAL SECTIONS AS COMPARED TO MEASURED PROFILE SECTIONS

*Typical Section B-B		Profile Sections			
Clay Core	Rip-Rap	Sta.1	Sta.2	Sta.3	Sta.4
825	915	660 (175)	1160 (385)	1025 (295)	1050 (305)

**Typical Section C-C		Profile Section	
Clay Core	Rip-Rap	Sta.5	Sta.6
588	660	810 (220)	755 (170)

Percent Difference Between Area of Typical Sections and Measured Sections:

Station:	1	2	3	4	5	6	MEAN
	-27.9%	+26.8%	+12.0%	+14.8%	+22.7%	+14.4%	+10.4%

*Elevation 564 to 579 IGLD
**Elevation 566 to 578 IGLD

(   ) = cross-sectional area beyond the limits of typical section

TABLE 2

BASAL WIDTH (FT) OF TYPICAL SECTIONS AS COMPARED TO MEASURED PROFILE SECTIONS

*Typical Section B-B		Profile Sections			
Clay Core	Rip-Rap	Sta.1	Sta.2	Sta.3	Sta.4
85	91	115 (24)	153 (62)	147 (56)	164 (73)

**Typical Section C-C		Profile Sections	
Clay Core	Rip-Rap	Sta.5	Sta.6
73	79	120 (41)	101 (22)

Percent Difference Between Width of Typical Sections and Measured Sections:

Station:	1	2	3	4	5	6	MEAN
	+26.4%	+68.1%	+61.5%	+80.27%	+51.97%	+27.87%	+52.7%

*Basal width at elevation 564 IGLD
**Basal width at elevation 566 IGLD

( ) = basal width beyond the limits of typical section

TABLE 3

SURFACE AREA (FT^2) OF SUBMERSED BREAKWATER FOR TYPICAL SECTIONS AS COMPARED TO MEASURED PROFILE SECTIONS

	Area for Typical Section (B-B)*	Area for Typical Section (Sta. 1-4)
South Breakwater		
East arm	24,924	40,052
West arm	33,366	66,068
	(C-C)**	(Sta. 5-6)
West Breakwater	28,260	43,512
TOTAL	86,550 (2.0 acres)	149,632 (3.4 acres)

*Sumberged breakwater defined as elevation 573 to 564 IGLD
**Submerged breakwater defined as elevation 573 to 566 IGLD

TABLE 4

SUMMARY OF BREAKWATER DIMENSIONS FOR CLINTON REEF MARINA

SOUTH BREAKWATER, EAST ARM

Length (ft)	*Mean Top Width (ft)	Mean Basal Width (ft)	Cross-sectional Mean Area (ft^2)
620	69	134	910

Bottom Surface Area (ft^2)	**Slope Surface Area (ft^2)	Volume (ft^3)
83,080	40,052	564,200 (20,896 yd^3)

SOUTH BREAKWATER, WEST ARM

Length (ft)	*Mean Top Width (ft)	Mean Basal Width (ft)	Cross-sectional Mean Area (ft^2)
830	69	155	1,037

Bottom Surface Area (ft^2)	**Slope Surface Area (ft^2)	Volume (ft^3)
128,650	66,068	860,710 (31,878 yd^3)

WEST BREAKWATER

Length (ft)	*Mean Top Width (ft)	Mean Basal Width (ft)	Cross-sectional Mean Area (ft^2)
980	69	110	783

Bottom Surface Area (ft^2)	**Slope Surface Area (ft^2)	Volume (ft^3)
107,800	43,512	767,340 (28,420 yd^3)

TYPICAL SECTION B-B

Length (ft)	*Top Width (ft)	Basal Width (ft)	Cross-sectional Area (ft^2)
1450	55	91	915

Bottom Surface Area (ft^2)	*Slope Surface Area (ft^2)	Volume (ft^3)
131,950	58,290	1,326,750 (49,139 yd^3)

TYPICAL SECTION C-C

Length (ft)	*Top Width (ft)	Basal Width (ft)	Cross-sectional Area (ft^2)
900	51	79	660

Bottom Surface Area (ft^2)	*Slope Surface Area (ft^2)	Volume (ft^3)
71,100	28,260	594,000 (22,000 yd^3)

*Width at lake level (573 ft)
**Surface of slope below lake level (573 ft)

TABLE 5

BENTHIC INVERTEBRATES COLLECTED IN AUGUST 1984 AT HARBORSIDE, A PROPOSED MARINA SITE ON THE PORTAGE RIVER

	Habitat
Phylum Porifera (sponges)	
Class Demospongiae (horny sponges)	
Family Spongillidae (freshwater sponges)	
1. *Spongilla* sp.	rip-rap
Phylum Nematoda (roundworms)	
Class Adenophorea	
Family Tripylidae	
1. *Trilobus* sp.	organic mud
Phylum Bryozoa (moss animals)	
Class Ectoprocta	
Family Plumatellidae	
1. *Plumatella* sp.	rip-rap
Phylum Annelida (segmented worms)	
Class Oligochaeta (aquatic earthworms)	
Family Tubificidae	
1. *Branchiura sowerbyi*	organic mud
2. *Limnodrilus* sp.	organic mud
3. *Peloscolex* sp.	organic mud
Class Hirudinea (leeches)	
Order Pharyngobdellida	
Family Erpobdellidae	
1. *Erpobdella* sp.	*Cladophora* beds
Phylum Mollusca	
Class Gastropoda (snails)	
Subclass Pulmonata (lung-breathing snails)	
Family Physidae	
1. *Physa integra*	*Cladophora* beds
Subclass Prosobranchia (gill-breathing snails)	
Family Viviparidae	
1. *Viviparus* sp. (Japanese snail)	rip-rap
Family Pleuroceridae	
1. *Pleurocera acuta*	beached specimen
Class Pelecypoda (clams)	
Order Eulamellibranchia (naiades)	
Family Unionidae (mussels)	
1. *Amblema costata*	silty mud
2. *Amblema plicata*	beached specimen
3. *Quadrula quadrula*	beached specimen
4. *Anodonta grandis*	silty mud

TABLE 5 (Continued)

BENTHIC INVERTEBRATES COLLECTED IN AUGUST 1984 AT HARBORSIDE, A PROPOSED MARINA SITE ON THE PORTAGE RIVER

Family Unionidae (Continued)	
5. *Actinonaias carinata*	beached specimen
6. *Leptodea fragilis*	beached specimen
Order Heterodonta	
Family Sphaeriidae (fingernail clams)	
1. *Sphaerium* sp.	*Cladophora* beds and organic mud
Phylum Arthropoda	
Class Crustacea	
Order Isopoda (aquatic sowbugs)	
Family Asellidae	
1. *Asellus* sp.	rip-rap
Order Amphipoda (scuds)	
Family Gammaridae	
1. *Gammarus fasciatus*	*Cladophora* beds
Order Decapoda (crayfishes)	
Family Cambaridae	
1. *Orconectes* sp.	*Cladophora* beds; silty mud
Class Insecta (insects)	
Order Ephemeroptera (mayflies)	
Family Ephemeridae (burrowing mayflies)	
1. *Hexagenia* sp.	floating specimen (adult)
Order Coleoptera (beetles)	
Family Gyrinidae (whirligig beetles)	
1. *Gyrinus* sp.	*Cladophora* beds
Order Diptera (flies)	
Family Chironomidae (midges)	
1. *Procladius* sp.	organic mud
2. *Chironomus* sp.	organic mud
3. *Coelotanypus* sp.	organic mud

Data Source: Herdendorf (1984).

TABLE 6

FISH SPECIES OBSERVED IN AUGUST 1984 AT HARBORSIDE, A PROPOSED MARINA SITE ON THE PORTAGE RIVER

Class Osteichthyes (bony fish)
- Order Clupeiformes
  - Family Clupeidae (herrings)
    1. *Dorosoma cepedianum* (gizzard shad)
- Order Cypriniformes
  - Family Cyprinidae (carps and minnows)
    1. *Cyprinus carpio* (common carp)
    2. *Notemigonus crysoleucas* (golden shiner)
    3. *Notropis atherinoides* (emeral shiner)
    4. *Notropis hudsonius* (spottail shiner)
    5. *Notropis spilopterus* (spotfin shiner)
    6. *Pimephales notatus* (bluntnose minnow)
- Order Siluriformes
  - Family Ictaluridae (catfishes)
    1. *Ictalurus melas* (black bullhead)
    2. *Ictalurus punctatus* (channel catfish)
- Order Percopsiformes
  - Family Percopsidae (trout-perches)
    1. *Percopsis omiscomaycus* (trout-perch)
- Order Perciformes
  - Family Percichthyidae (temperate basses)
    1. *Morone americana* (white perch)
  - Family Centrarchidae (sunfishes)
    1. *Ambloplites rupestris* (rock bass)
    2. *Lepomis gibbosus* (pumpkinseed)
    3. *Lepomis macrochirus* (bluegill)
    4. *Micropterus dolomieui* (smallmouth bass)
    5. *Pomoxis annularis* (white crappie)
  - Family Percidae (perches)
    1. *Perca flavescens* (yellow perch)
  - Family Sciaenidae (drums)
    1. *Aplodinotus grunniens* (freshwater drum)

Data Source: Herdendorf (1984)

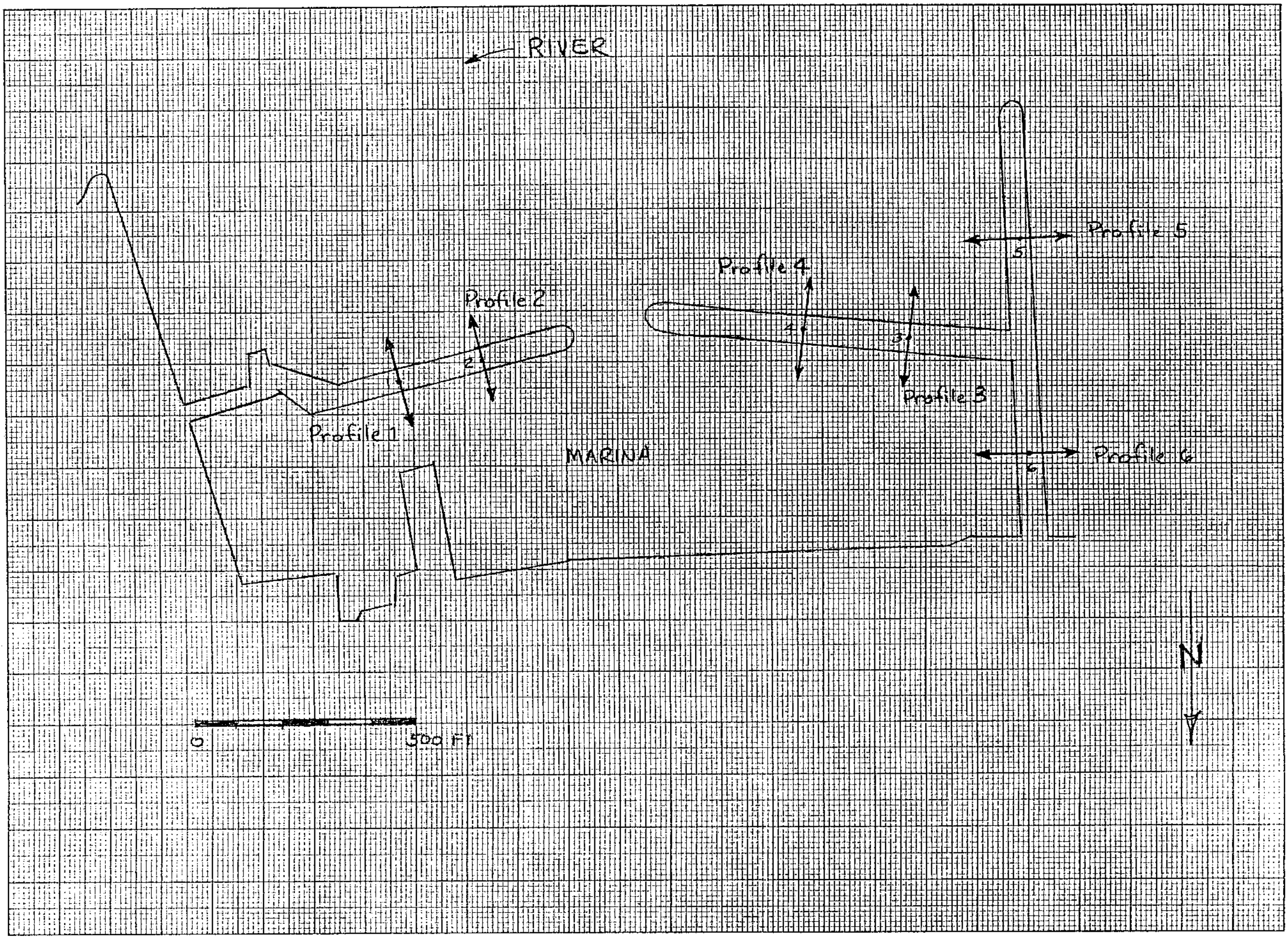

Figure 1. Location Map of Clinton Reef Marina showing placement of profile lines.

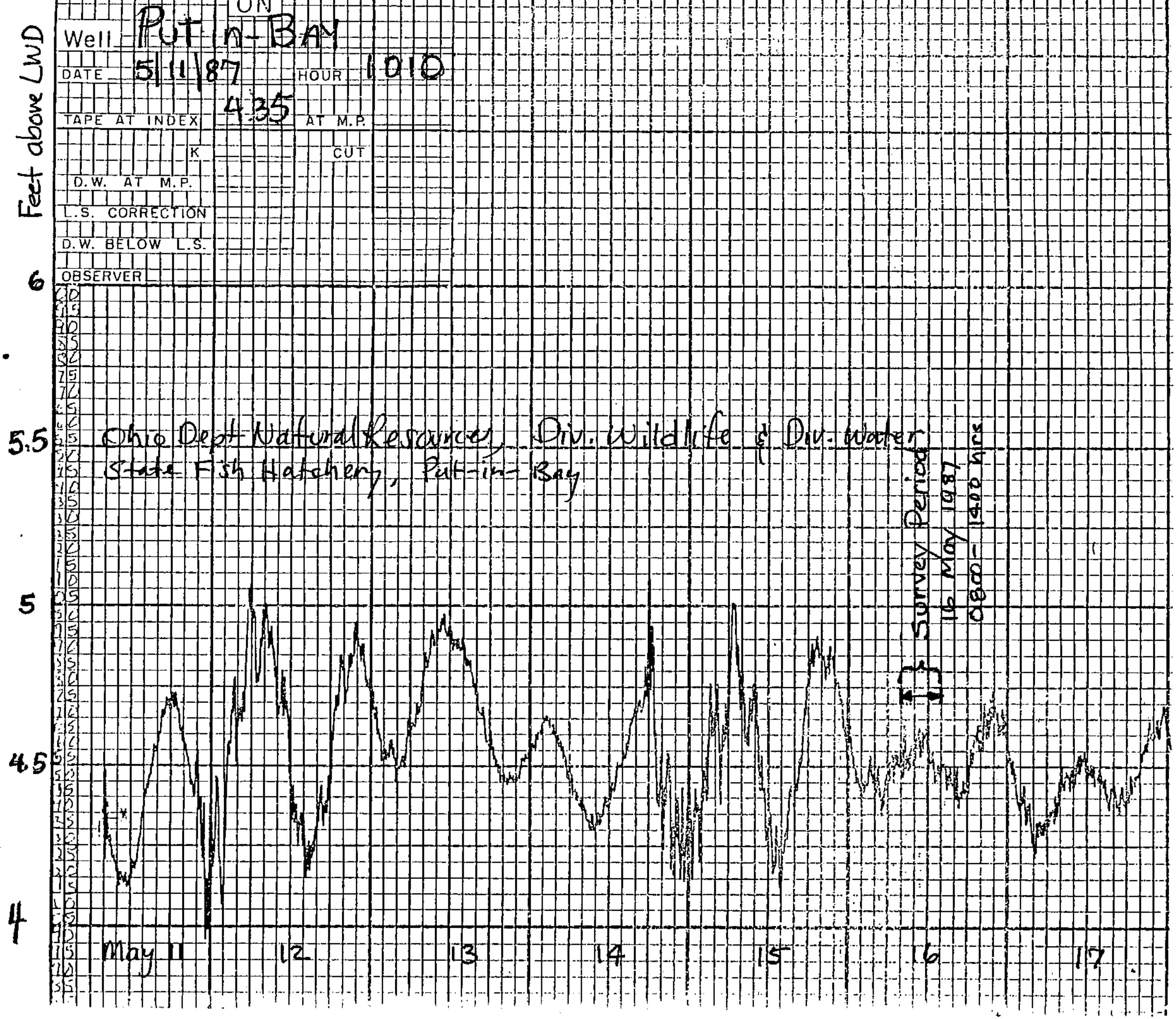

Figure 2. Lake Erie water levels at Put-in-Bay, Ohio for period 11-17 May 1987.

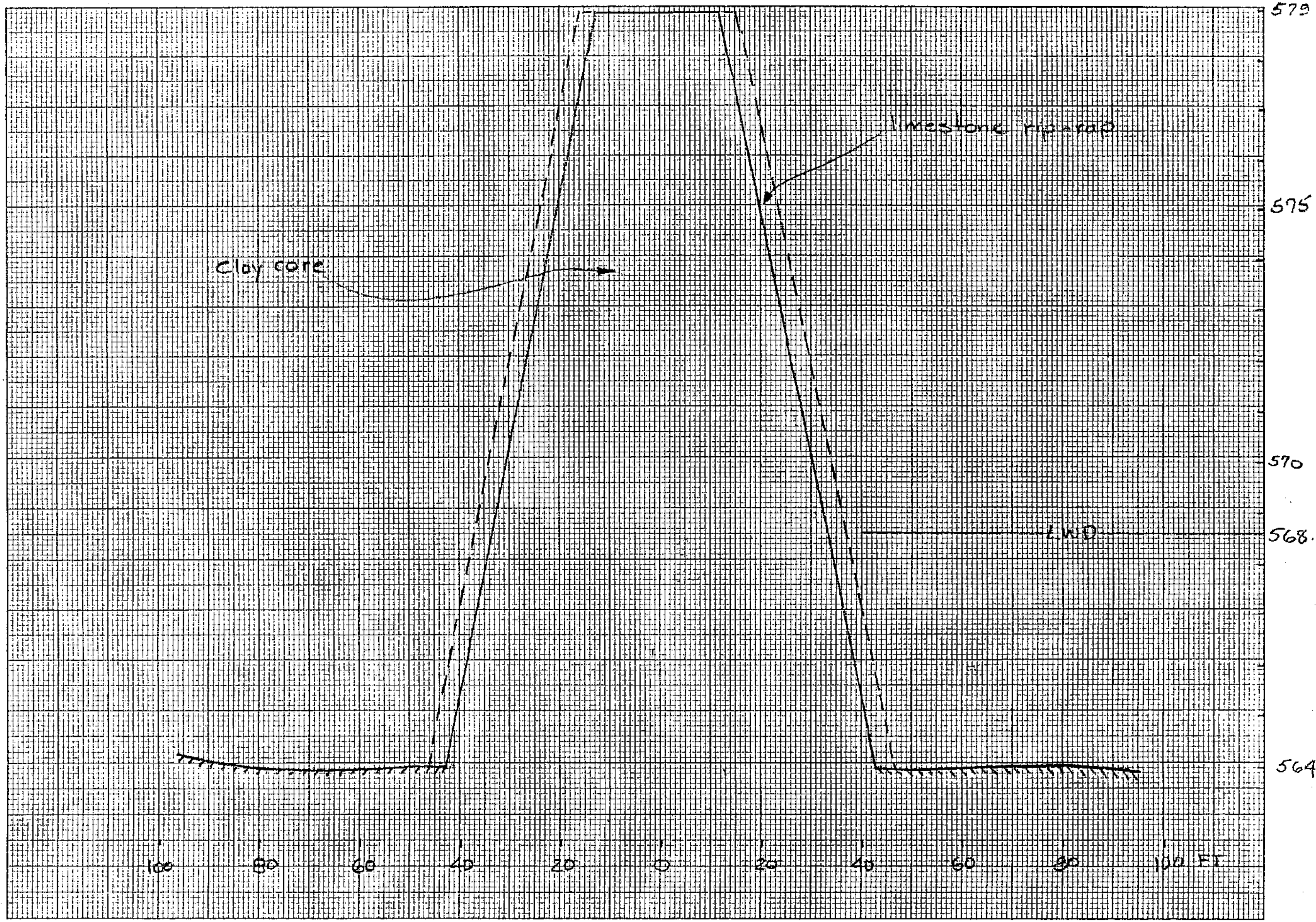

Figure 3. Typical Section B-B (South Breakwater).

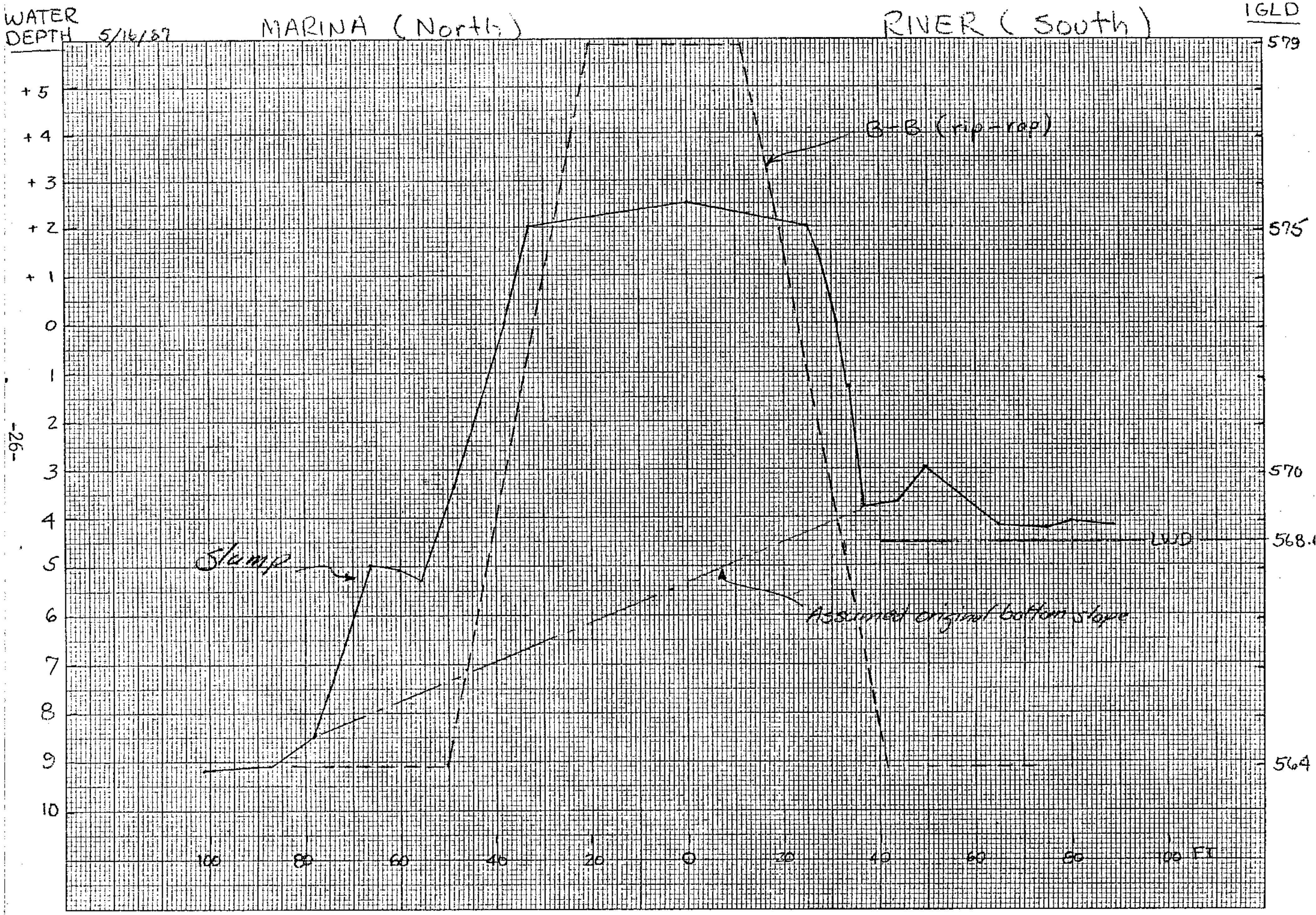

Figure 4. Depth Profile line at Station 1.

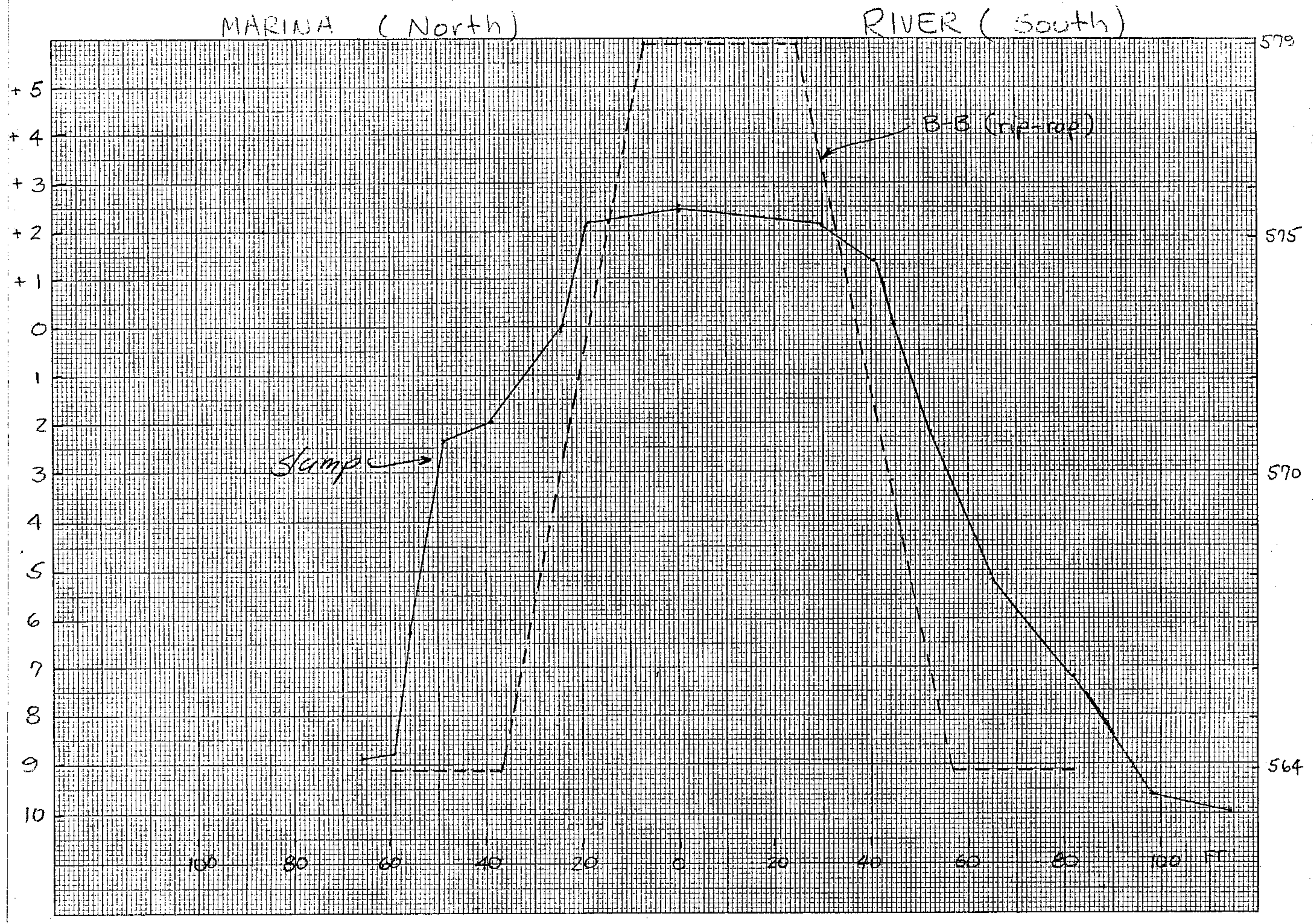

Figure 5. Depth Profile line at Station 2.

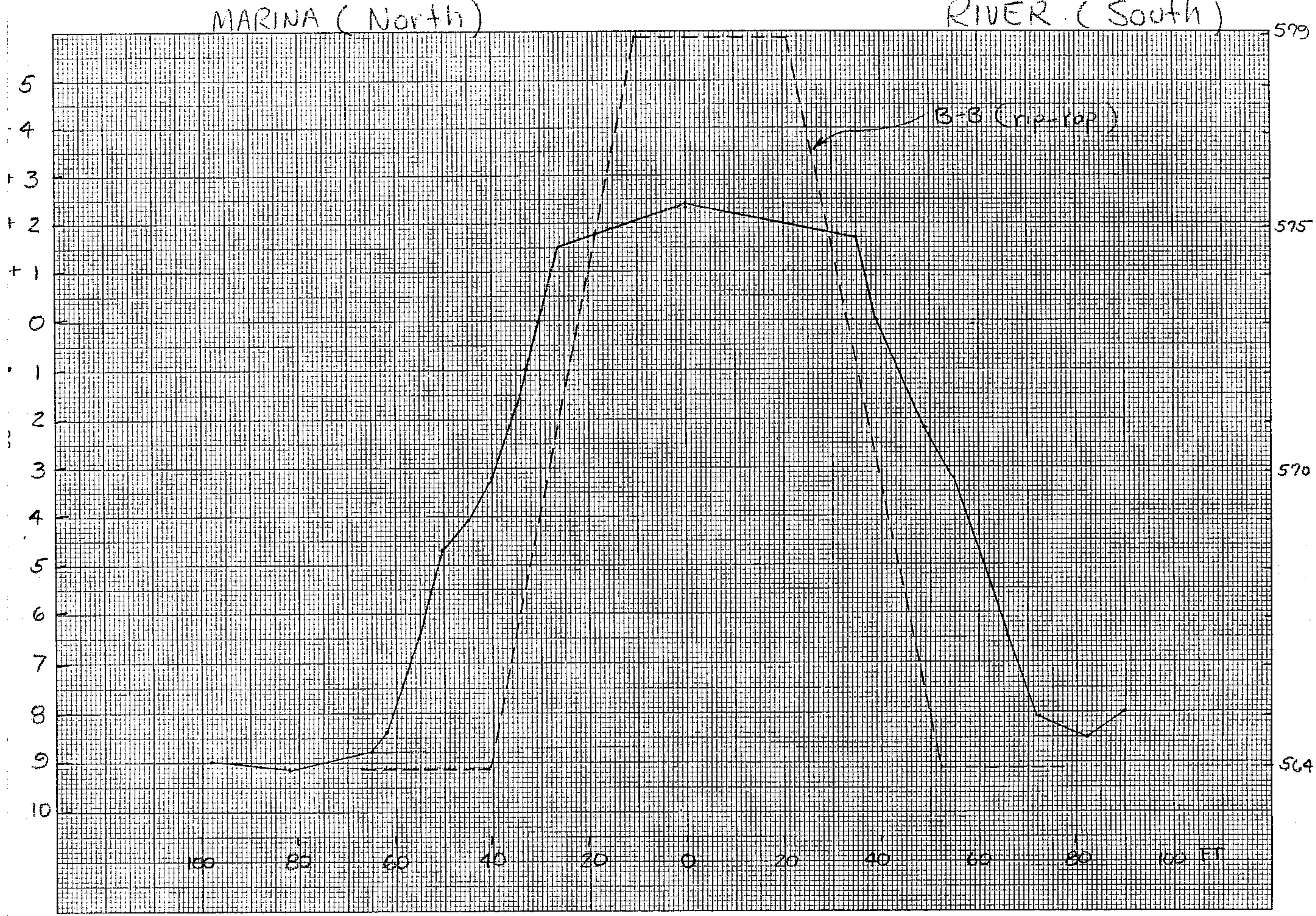

Figure 6. Depth Profile line at Station 3.

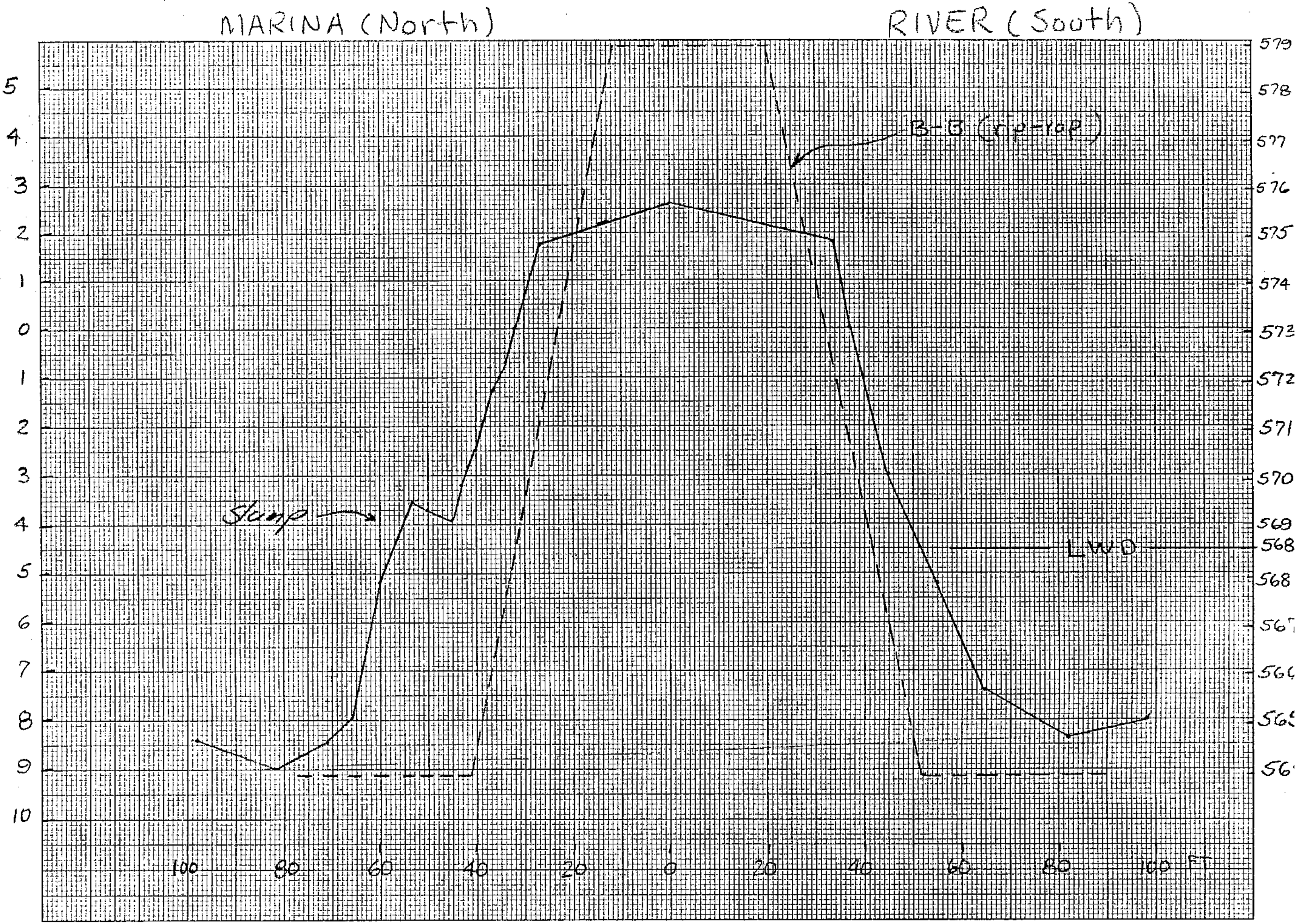

Figure 7. Depth Profile line at Station 4.

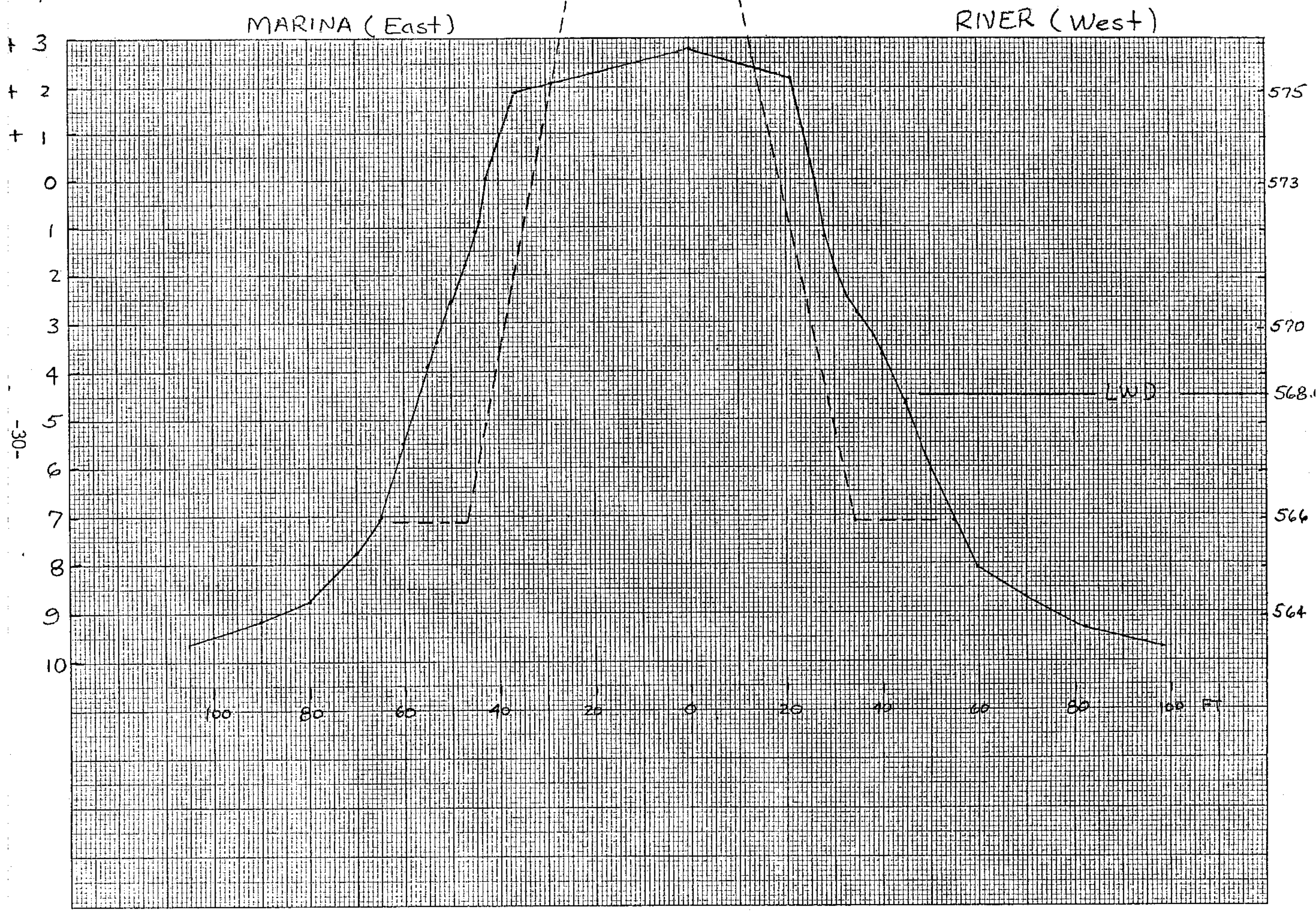

Figure 8. Depth Profile line at Station 5.

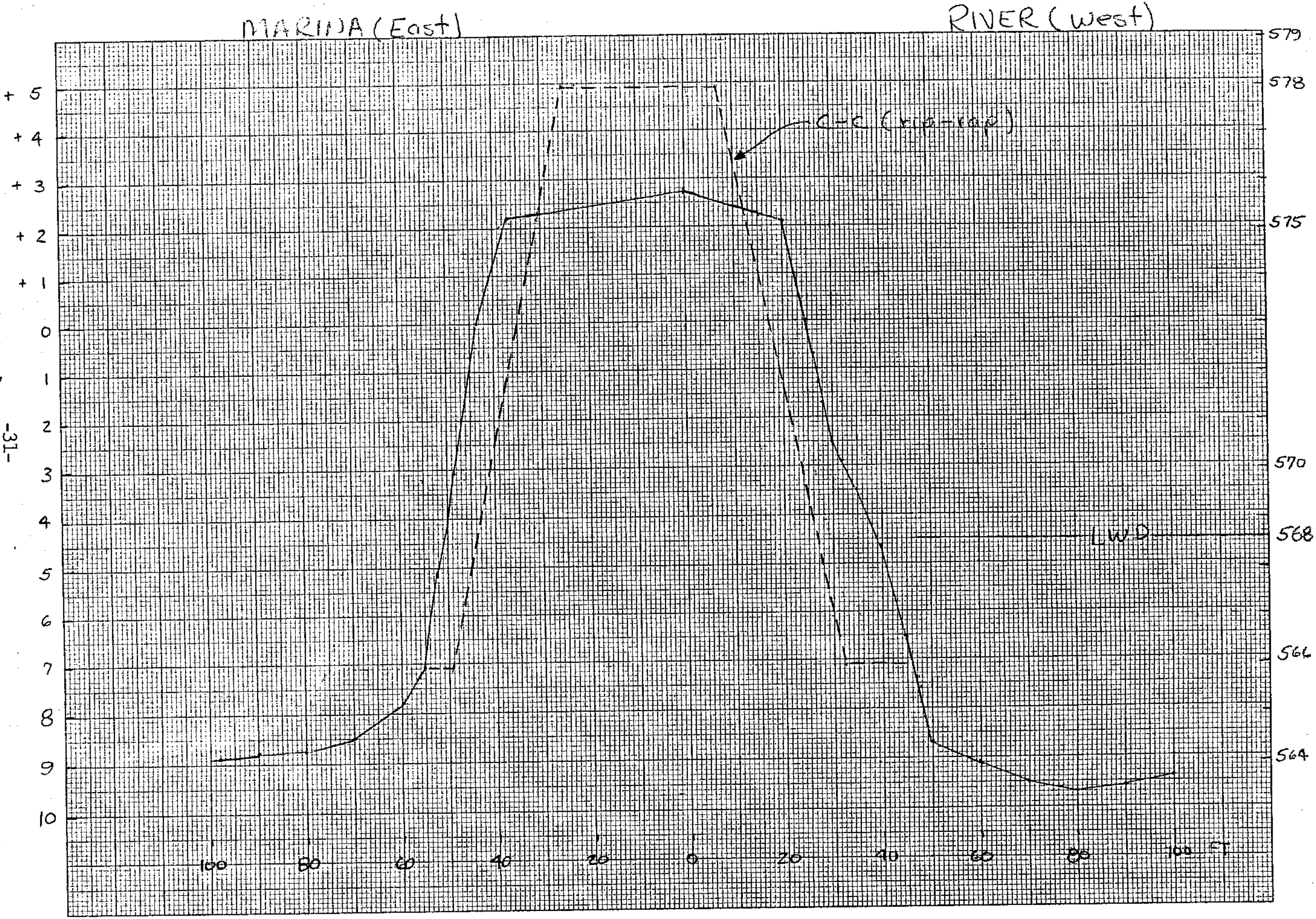

Figure 9. Depth Profile line at Station 6.

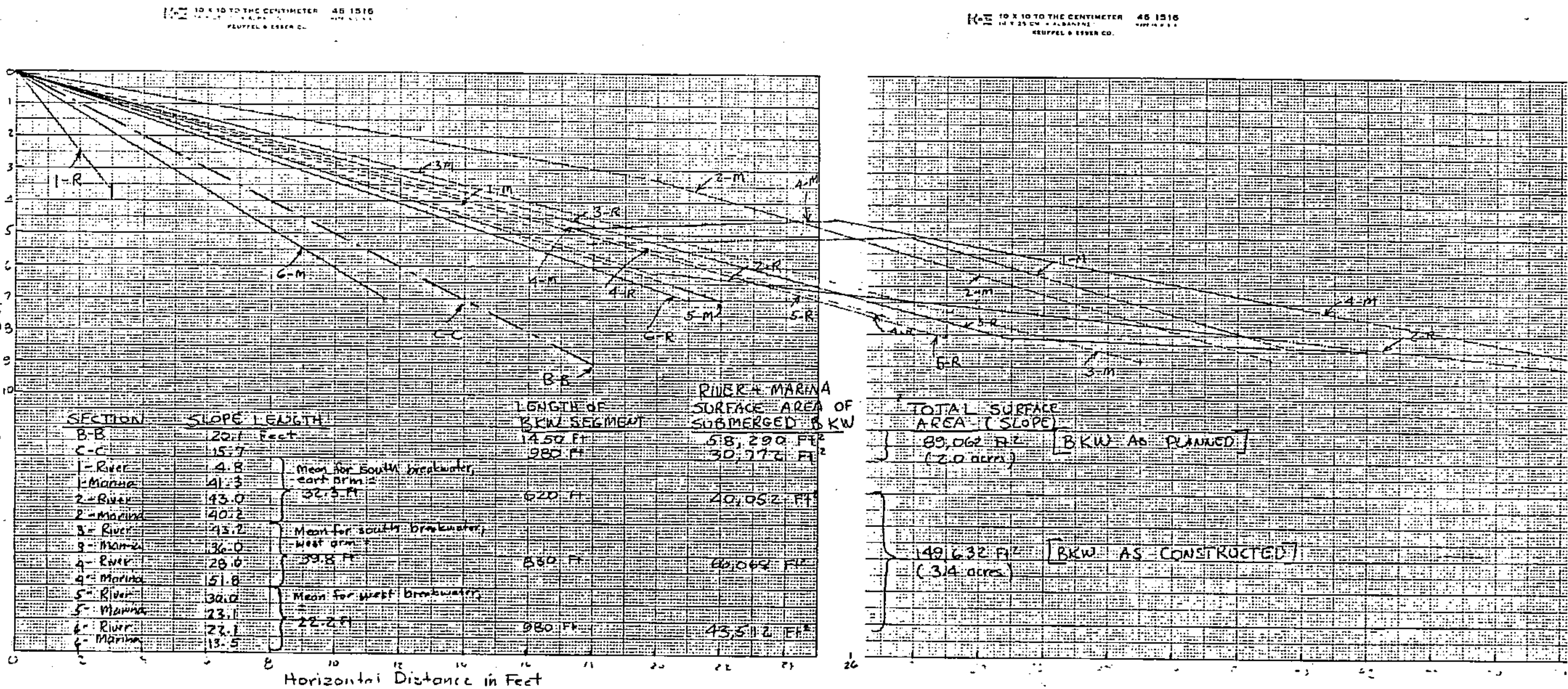

Figure 10. Comparison of slope distance and area between planned and constructed breakwaters at Clinton Reef Marina.