FINAL REPORT

MISSISSIPPI COASTAL GEOLOGY

AND

REGIONAL MARINE STUDY

1990 - 1994

VOLUME 4

Mississippi Office of Geology / U. S. Geological Survey
Cooperative Agreement No. 14-08-0001-A0827

Submitted to:

U. S. Geological Survey
Center for Coastal Geology and Regional Marine Studies
600 4th Avenue, South
St. Petersburg, Florida 33701

by

Office of Geology
Mississippi Department of Environmental Quality
P. O. Box 20307
Jackson, Mississippi 39289-1307

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MISSISSIPPI MAINLAND SHORELINE

BEACH AND NEARSHORE PROFILES

by

Stephen M. Oivanki

Introduction

Beach profiles provide the best method for measuring short-term shoreline change as well as nearshore bottom changes. They also provide a baseline for evaluating hurricane-related changes along the shore, which is a primary objective of the cooperative USGS/Mississippi Office of Geology study.

The Mississippi mainland shoreline can be broadly divided into three shoreline types: seawalls/artificial beaches, natural marsh, and industrial-commercial docks/harbors. The latter category of commercial harbors and docks is constantly changing as development continues along the Mississippi shoreline. This category is usually located in an urban setting, and the nearshore area is maintained by dredging. The natural marsh category occurs in a generally rural setting at the east and west ends of the state shoreline. Erosion is an ongoing problem there, and the nearshore is dominated by very soft mud and organic debris resulting from destruction of the marsh substrate by wave action. Neither of these two shoreline types can be easily monitored with beach profiles.

The seawalls and artificial beaches in Mississippi make up the bulk of the developed shoreline in the state, and they are located in the central portion of the shore, primarily in Harrison County. The beaches are pumped in front of the seawalls to protect them from hurricane damage and to provide a recreational tourist attraction for the coast. Considerable time and expense is involved on the part of state, county, and local officials to maintain these areas, and this type of shoreline is the focus of the beach profile system developed in this study.

Research Method

The beach profiles are measured with a Wild total station and prism from stations established along the seawall. Accuracy of this instrument is on the order of +/- 0.01 feet. Profiles are located at approximately 1 to 1.5 mile intervals and wherever an unusual shoreline geometry is present which would interrupt the longshore drift of sediment, such as a harbor or groin. The profiles are measured perpendicular to the shoreline from the seawall out into the water to a depth suitable for wading, usually about four feet sub-sea, with a horizontal prism spacing of approximately 10-20 feet, determined at the discretion of the rod holder for the survey and dependent on bottom conditions and the location of bottom features, such as sand bars. All of the profiles are tied to the U.S. Army Corps of Engineers leveling of the seawall, a third-order survey referenced to the 1929 Mean Sea Level Datum. The Corps maintains leveling marks all along the seawall, as does the Mississippi Department of Transportation, and these permanent marks are used whenever possible as profile stations. Where there are no permanent Corps or MDOT marks, a profile station mark is chiseled into the seawall and painted for future recovery. The profiles are resurveyed each year during the summer field season. Descriptions of the station locations are maintained as well as a GPS location for each mark.

Harrison County Profiles

The artificial beach in Harrison County was put in place initially in 1952 after the 1947 hurricane severely damaged the seawall there. It has been renourished several times since then. The seawall is maintained by the county with assistance from the U.S. Army Corps of Engineers. The beach is maintained by the county with a full-time beach maintenance department. Sixteen beach profiles are located in Harrison County at approximately 1 to 1.5 mile intervals along the shoreline (Figure 1). Some profiles are located to measure the effect of shore structures and harbors on beach movement. Beach access is easy, since U.S. Highway 90 parallels the seawall. Historically the beach has experienced erosion along various sections due to wave action and storms; and wind erosion has removed sand from the beach at the rate of about 85,000 cubic yards per year, blowing it over the highway and out of the beach system (Sand Beach Planning Team, 1986). The profiles in place along this beach will, hopefully, provide some insight into

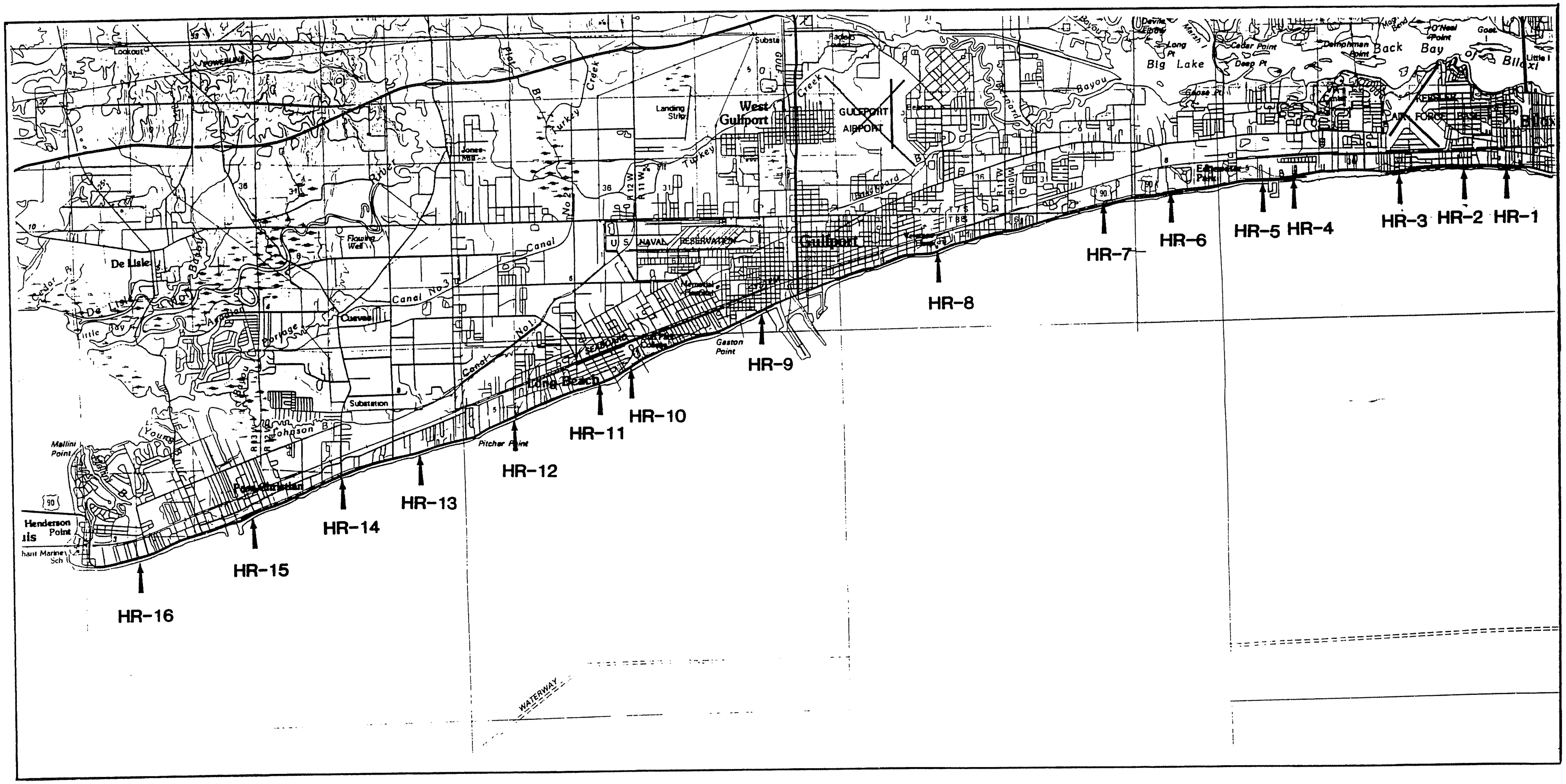


Figure 1. Beach profile locations in Harrison County.

the rates of erosion and the disposition of the sand removed from the beach, particularly in the offshore area.

The profiles were established in the fall of 1991 and summer of 1992, and were measured again during the summers of 1993 and 1994. The composite profiles are shown in the Appendix for this section. All of the profiles with the exception of HR-9 and HR-10 show a small amount of beach retreat. Offshore most of the profiles show a series of sand bars composed of sand eroded from the beach face. These bars show no trend of movement over the two to three year span between the surveys. Profile HR-1 was moved in 1993 due to construction of a county shower/restroom facility at the original location. Profile HR-4 was lost due to casino construction, and a new profile was located and measured in 1994.

Jackson County Profiles

Three profiles were measured in Ocean Springs along the artificial beach there. These profiles are located on Corps of Engineers benchmarks tied to the 1929 Mean Sea Level Datum. The Ocean Springs beach area is more protected than the Harrison County beach since it is located north of Deer Island. The sand here is replenished annually from an upland source trucked to the beach. The profiles show little change over the time period studied, as would be expected for this protected area. The locations of the profiles are shown in Figure 2. The profile charts are included in the Appendix for this section.

The other twelve profiles in Jackson County are located at Belle Fontaine, east of Ocean Springs. These profiles are described in Bulletin 130 which is attached to this report. Their locations are also shown in Figure 2. The Belle Fontaine profiles will be monitored as part of the Gulf of Mexico Program Demonstration Project at Belle Fontaine, scheduled to begin in October, 1994.

Hancock County Profiles

The Hancock County beach profiles are described in the "Hancock County Beach Project" section of this Report. They also make up a part of the storm monitoring system developed for the Mississippi coast.

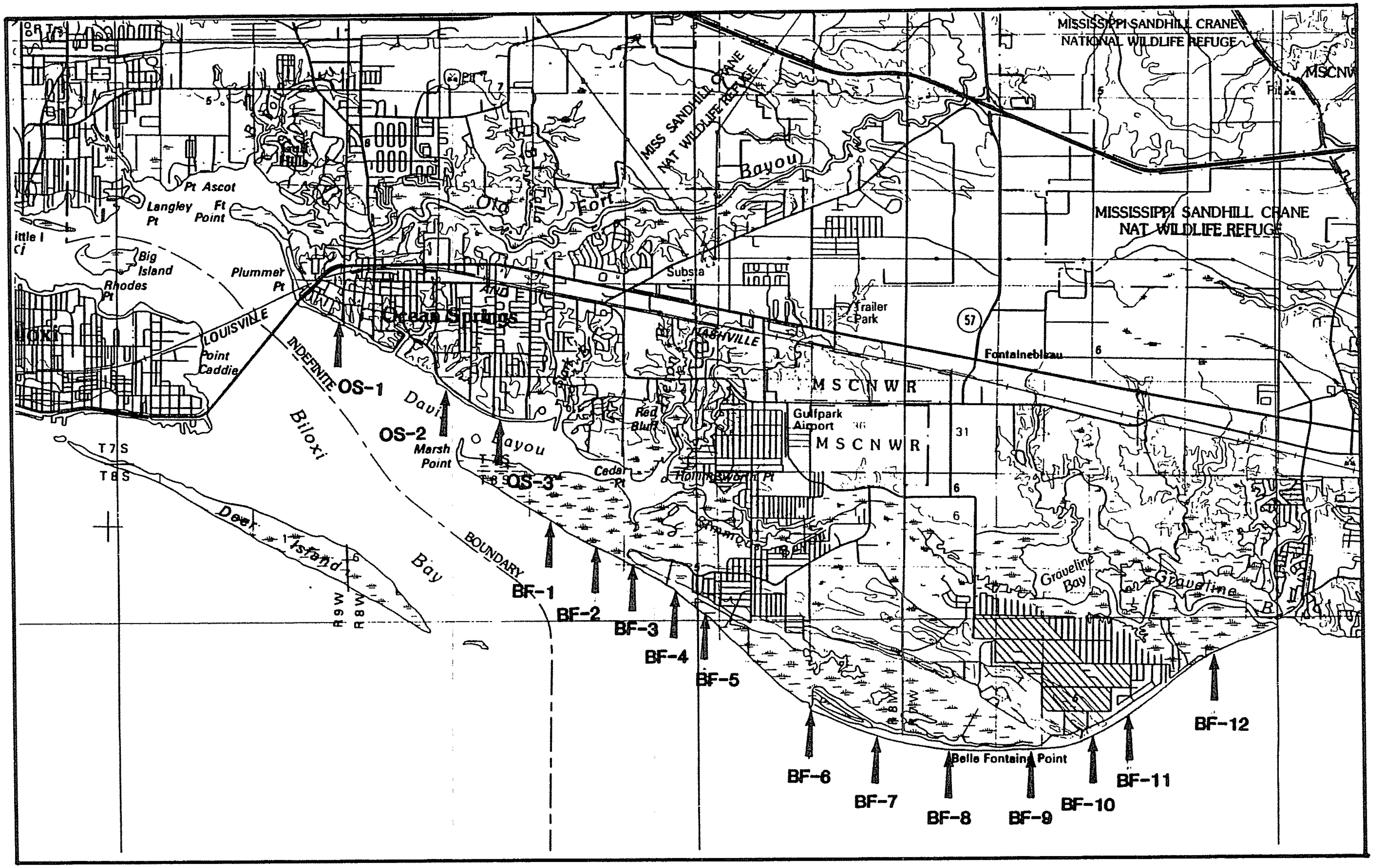


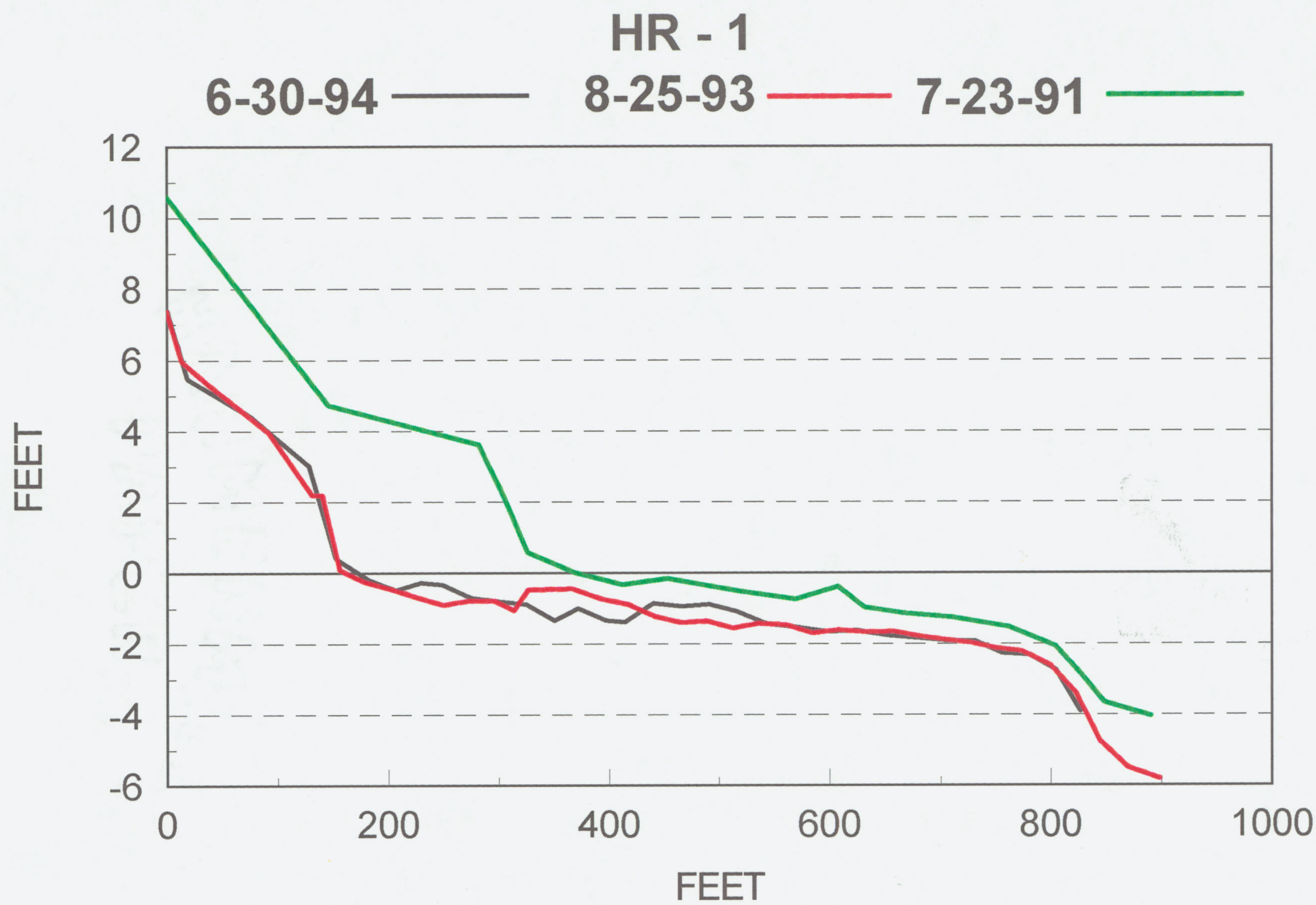
Figure 2. Beach profile locations in Jackson County.

References Cited

Sand Beach Planning Team, 1986, Sand beach master plan; Harrison County, Mississippi: Harrison County Board of Supervisors, Sand Beach Planning Team, Final Report.

A P P E N D I X

Beach and nearshore profiles in Harrison and Jackson Counties



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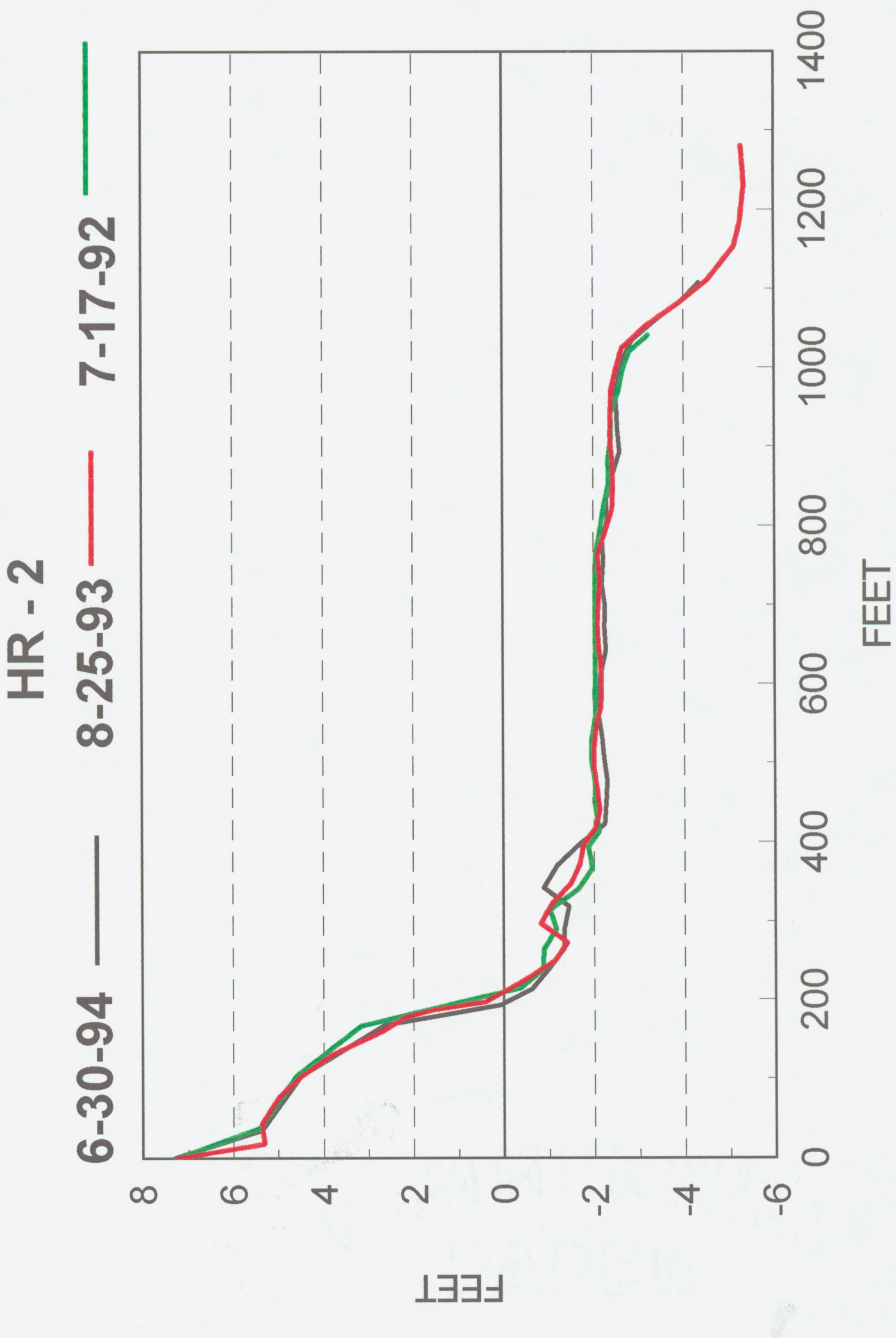
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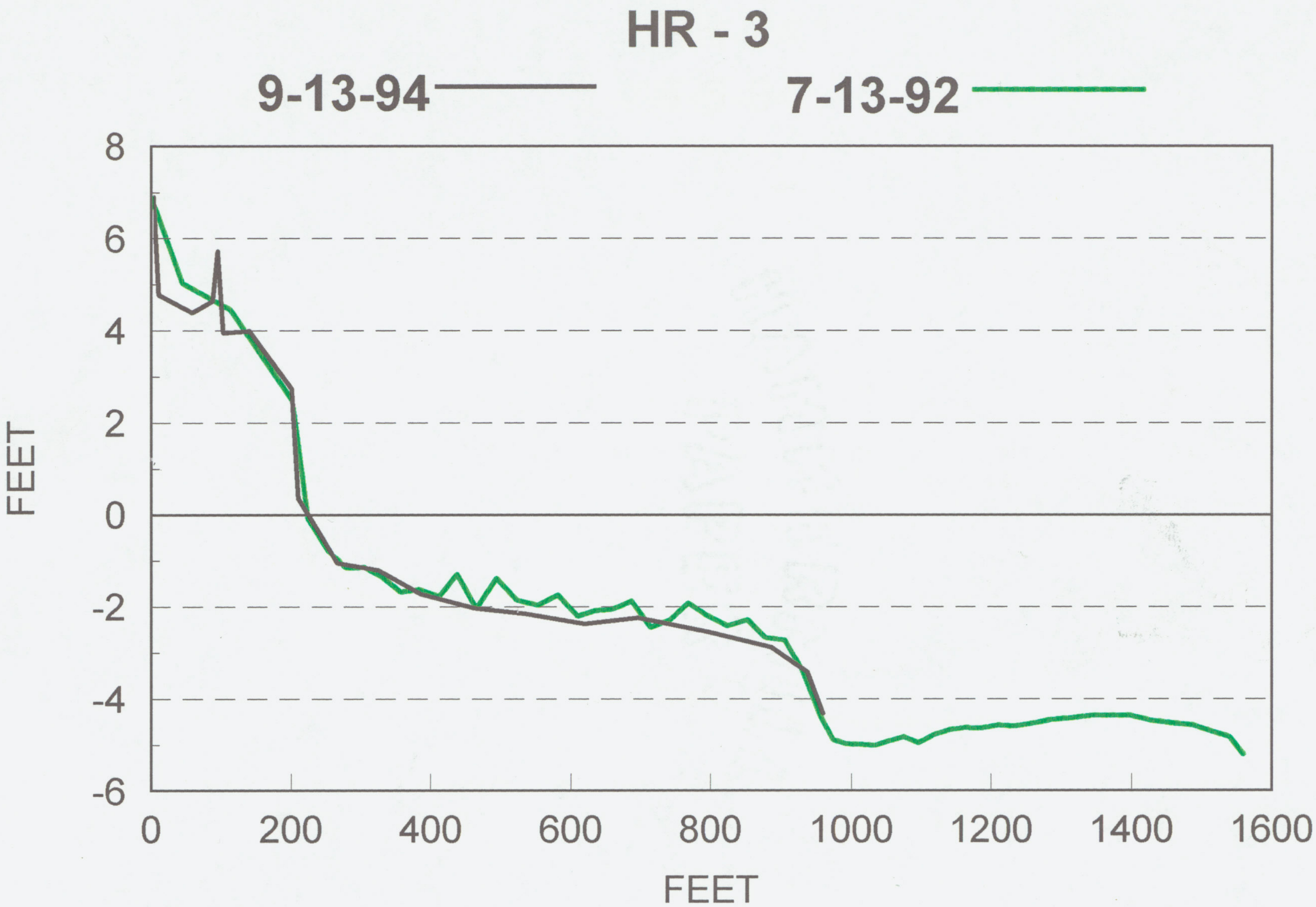

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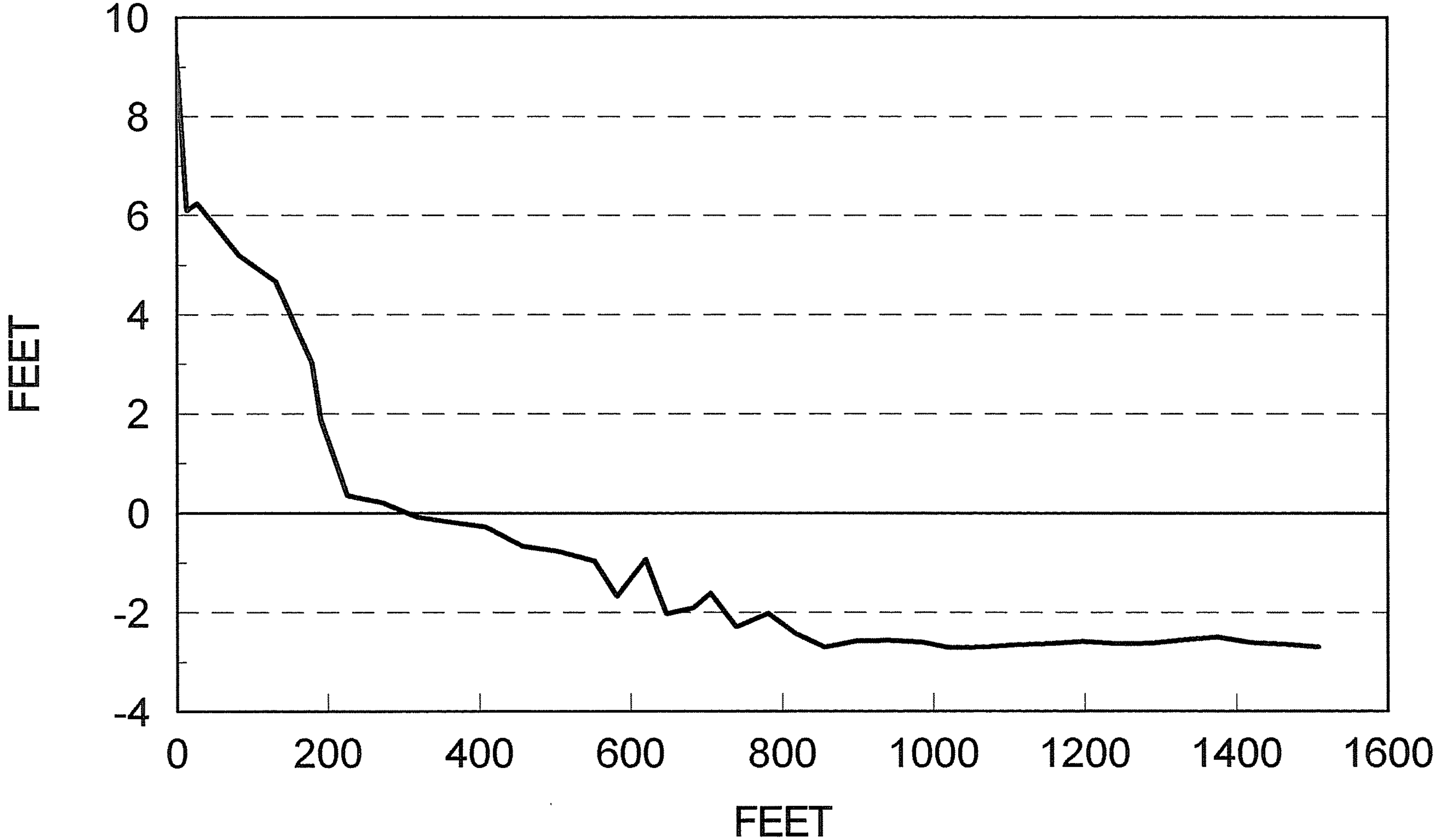

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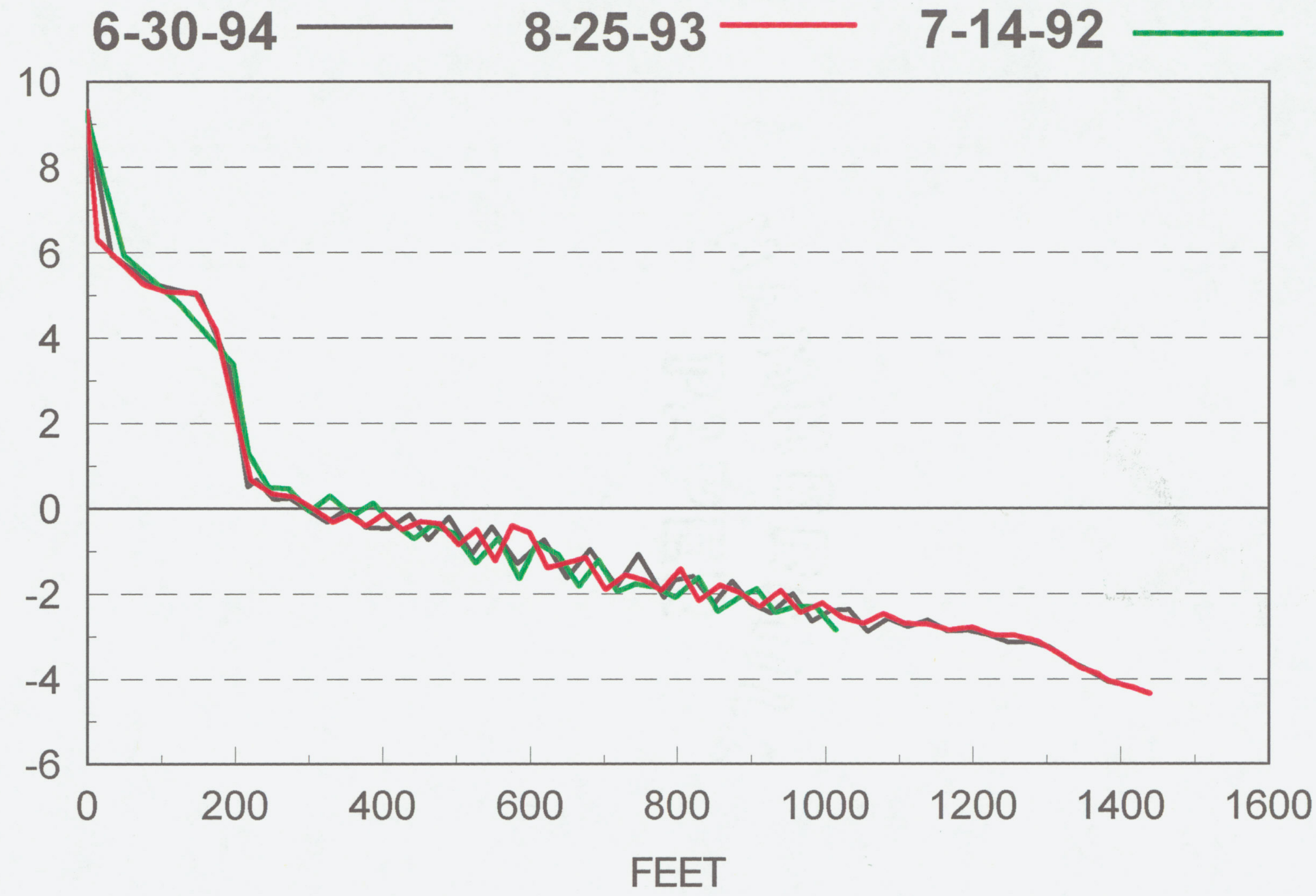

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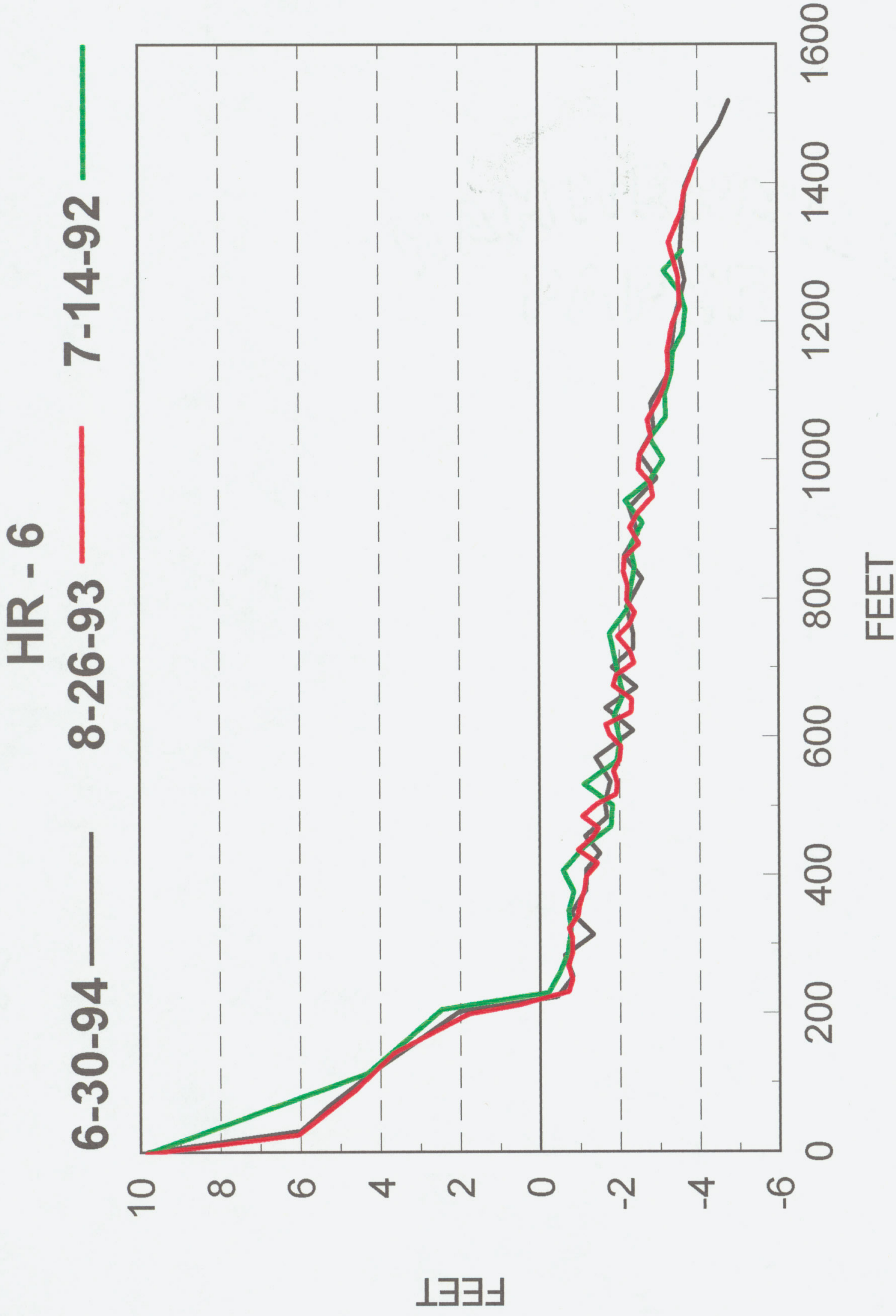
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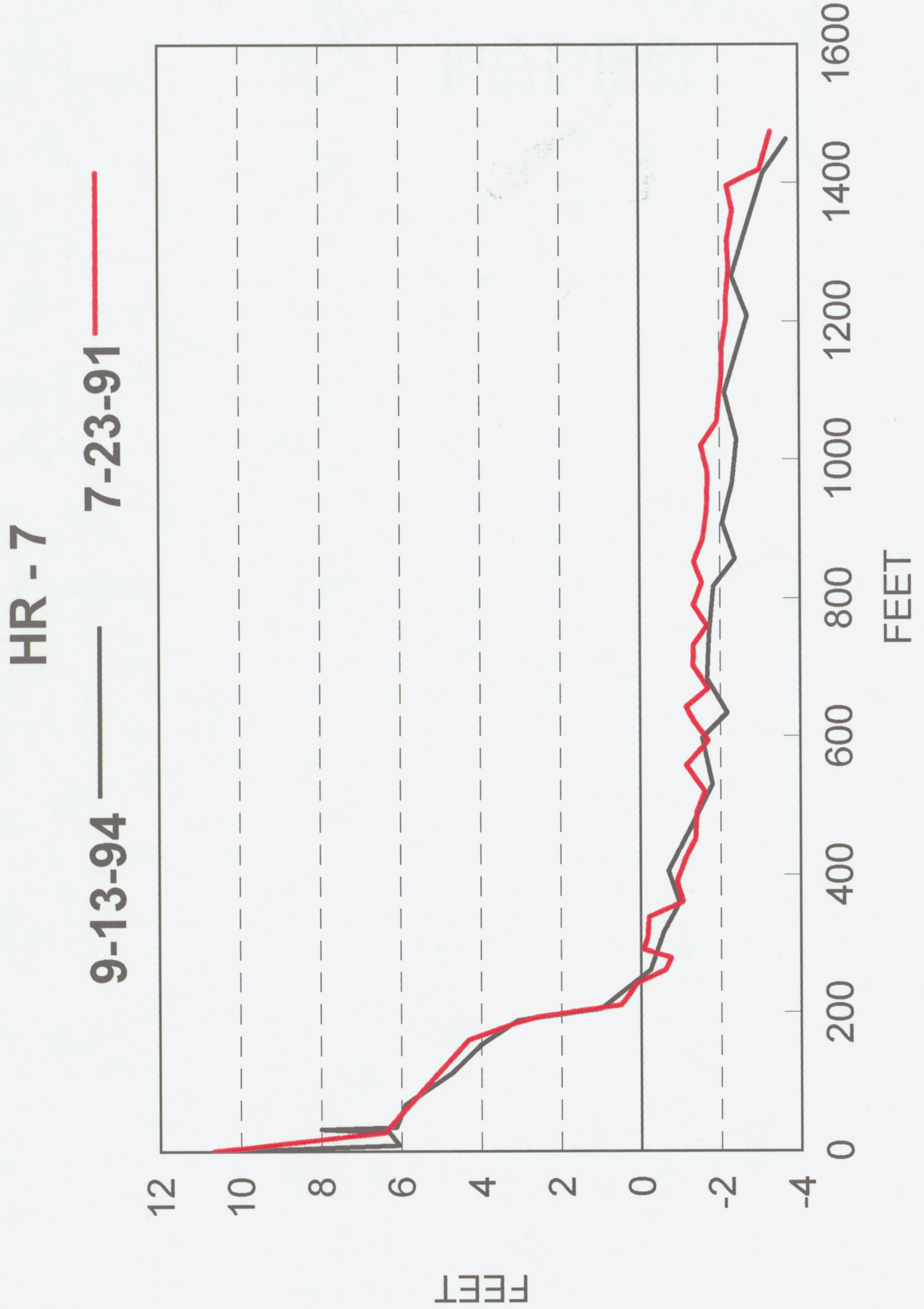
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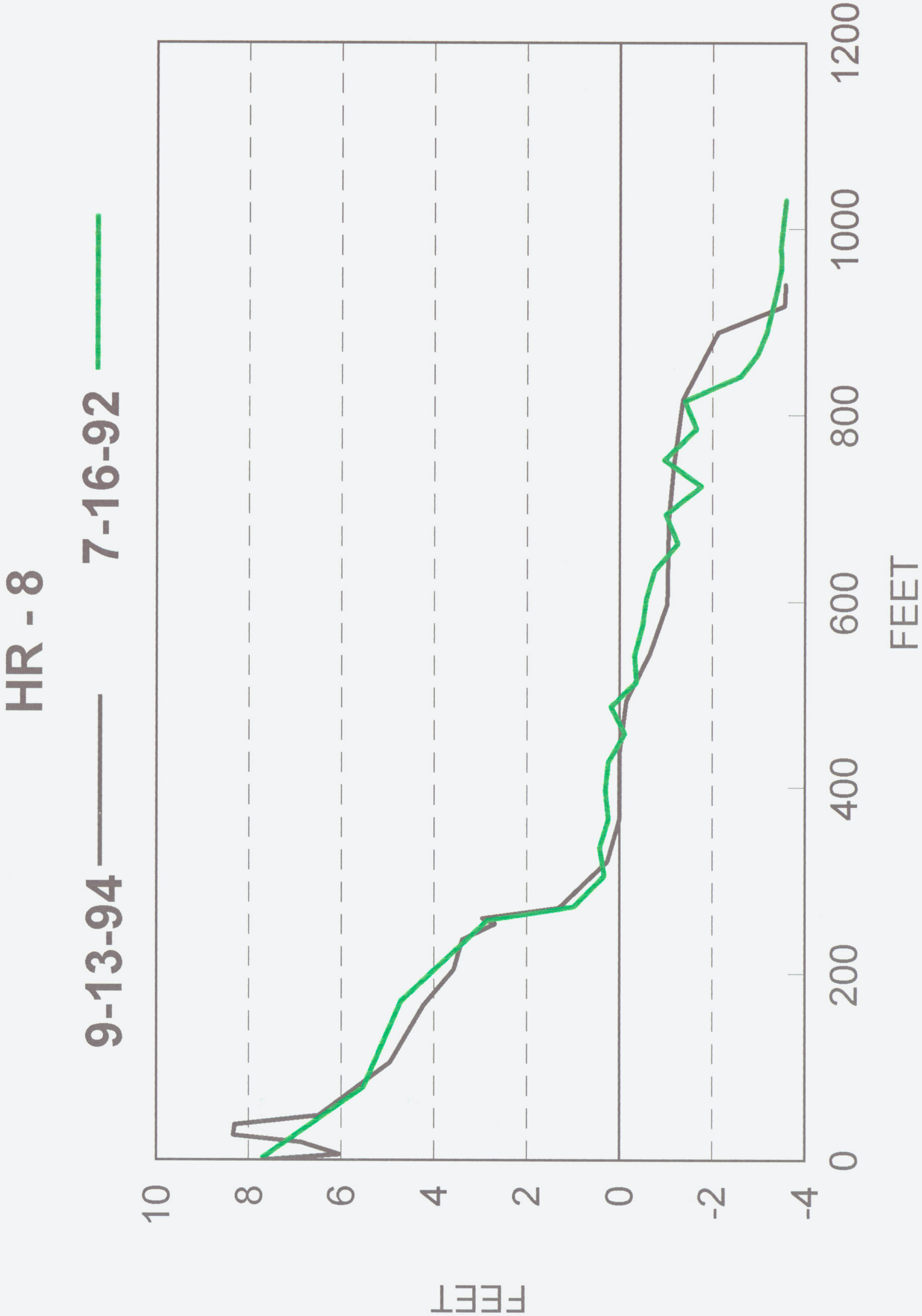
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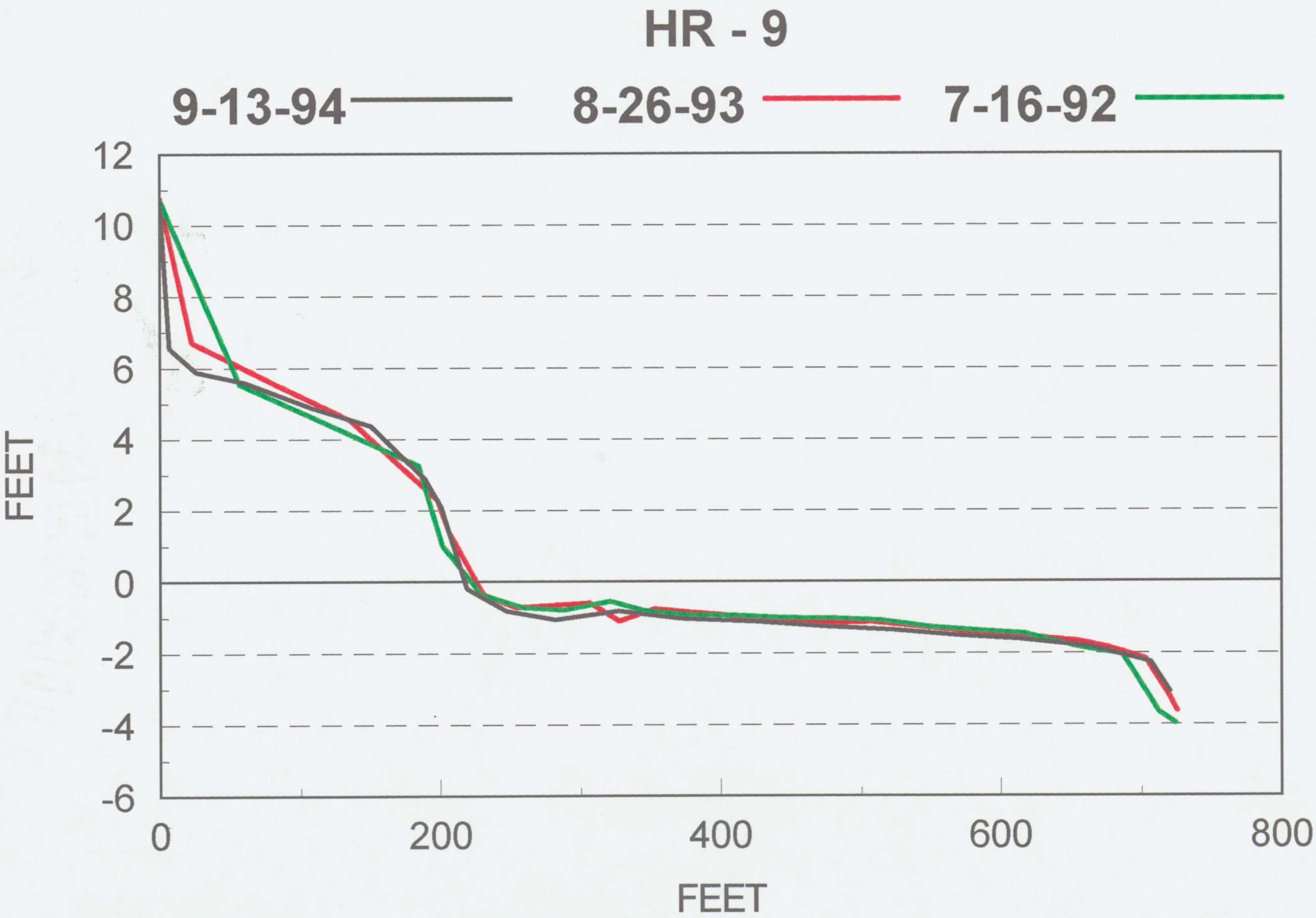
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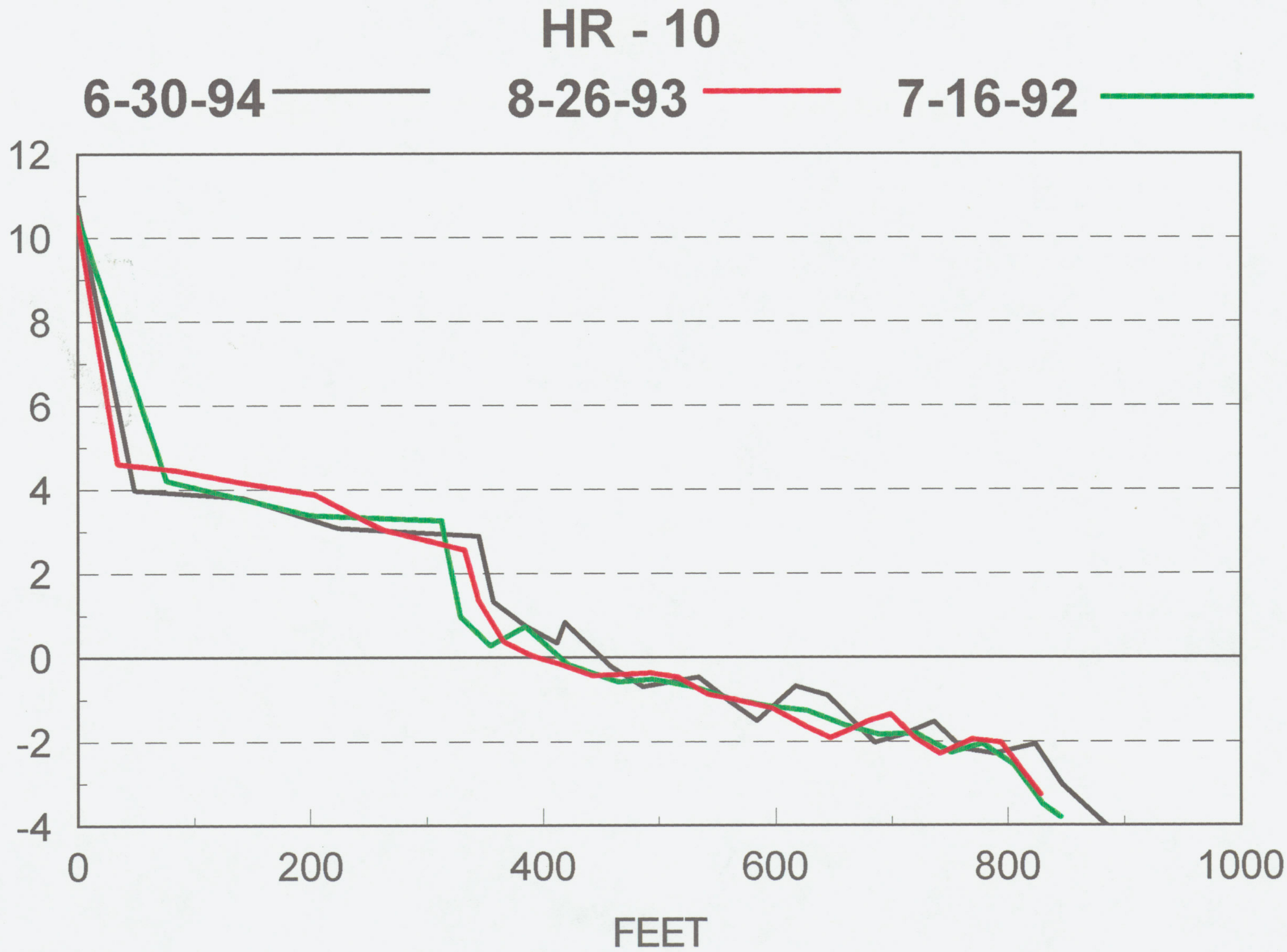

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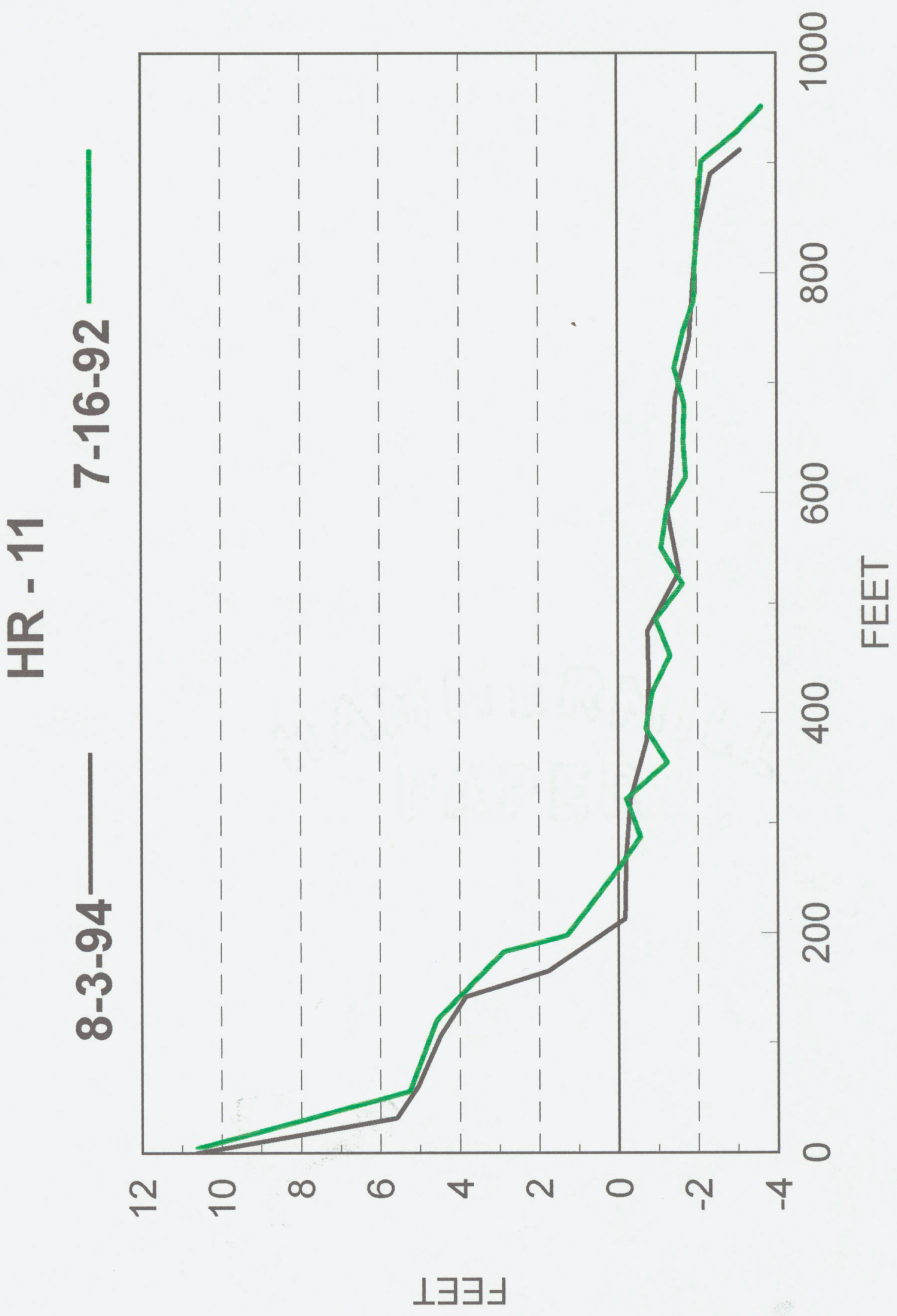
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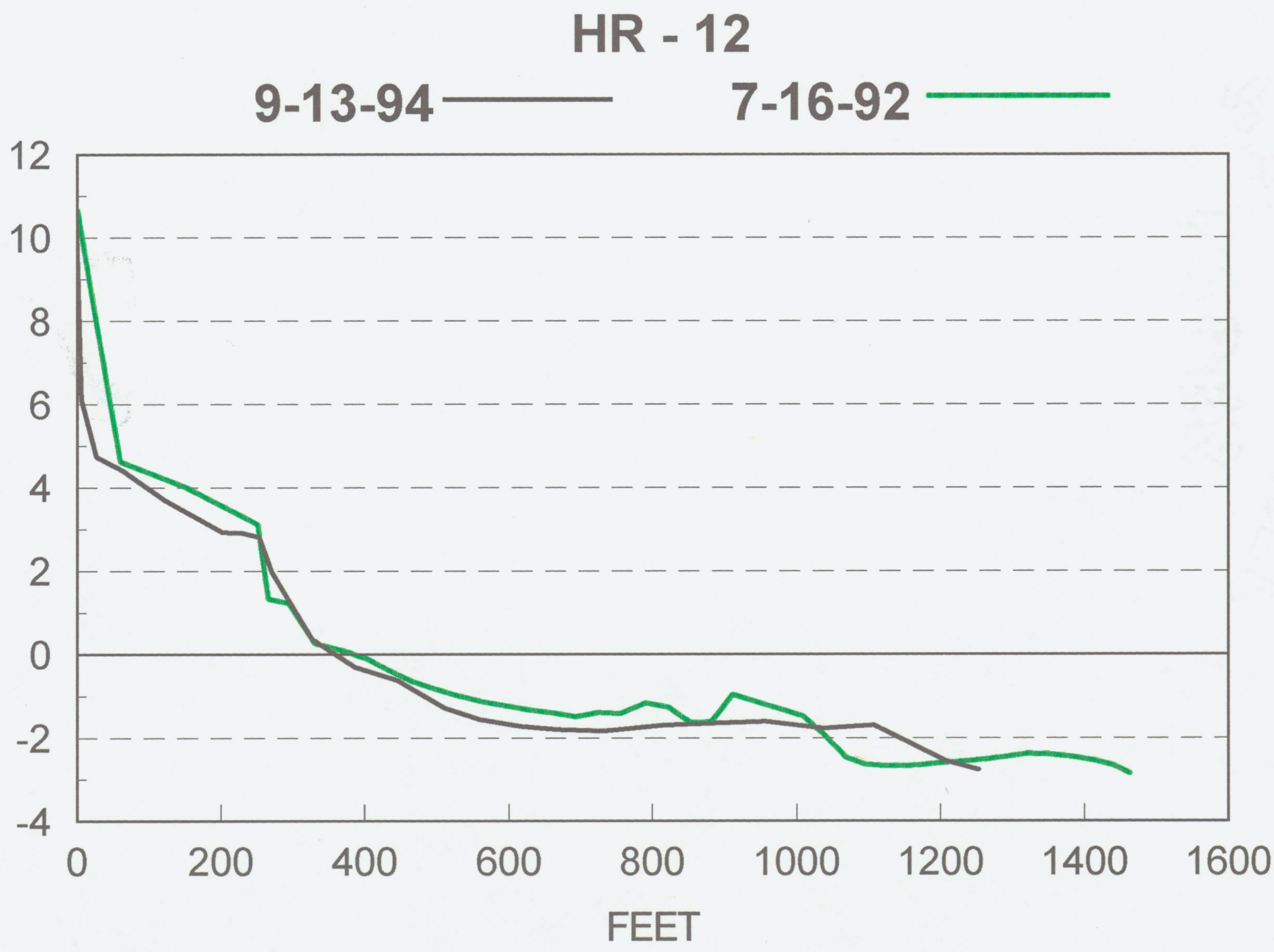
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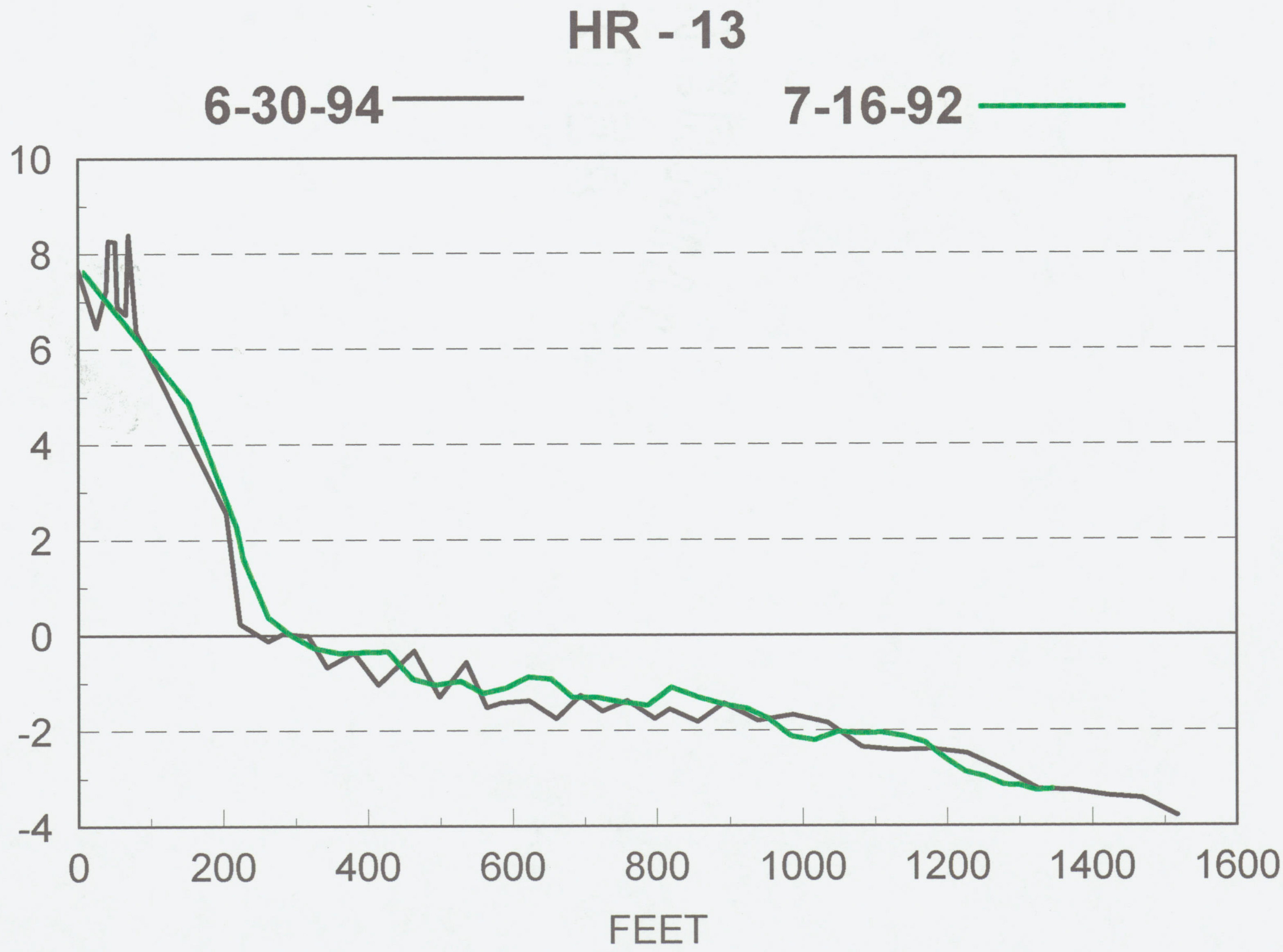
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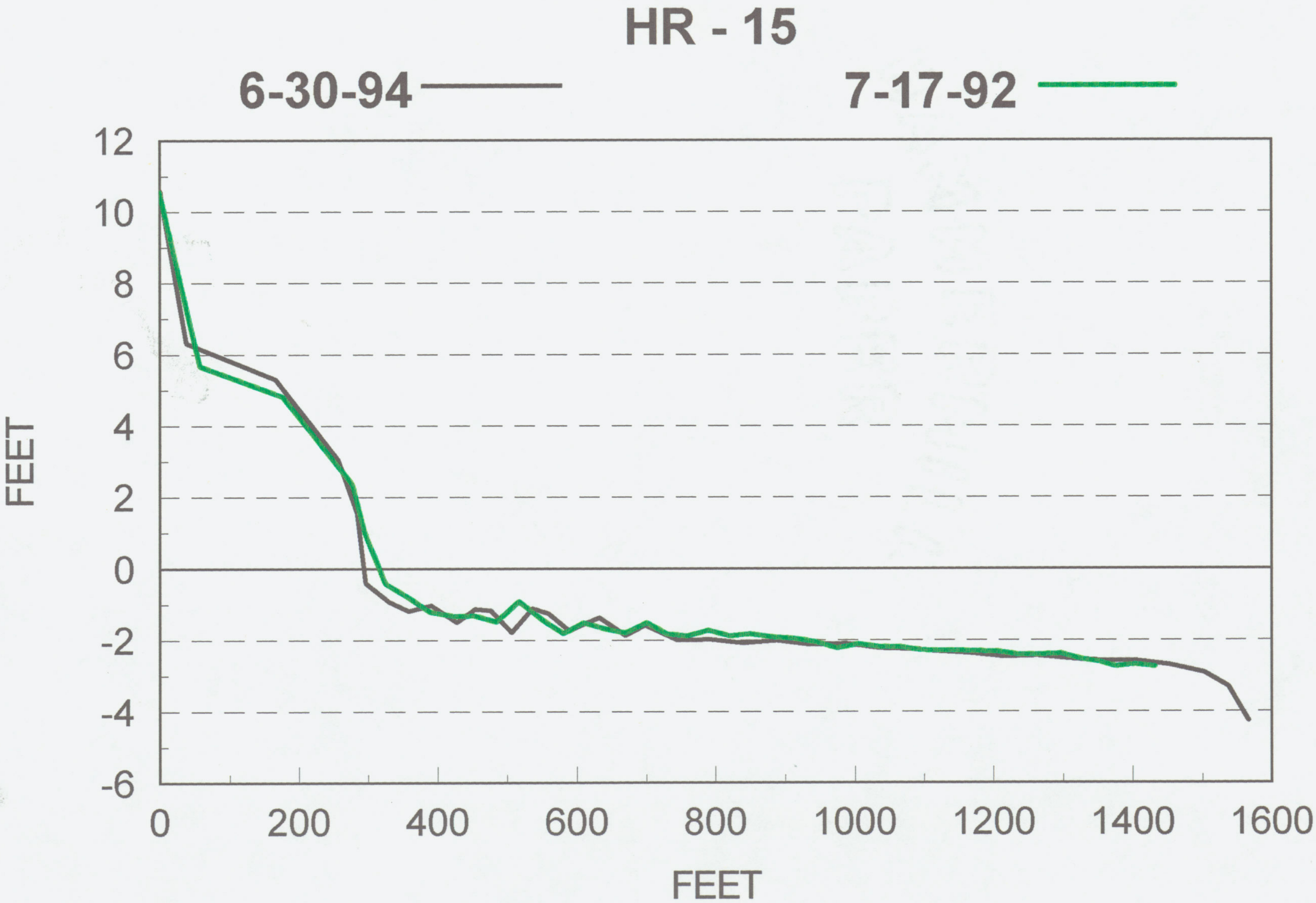
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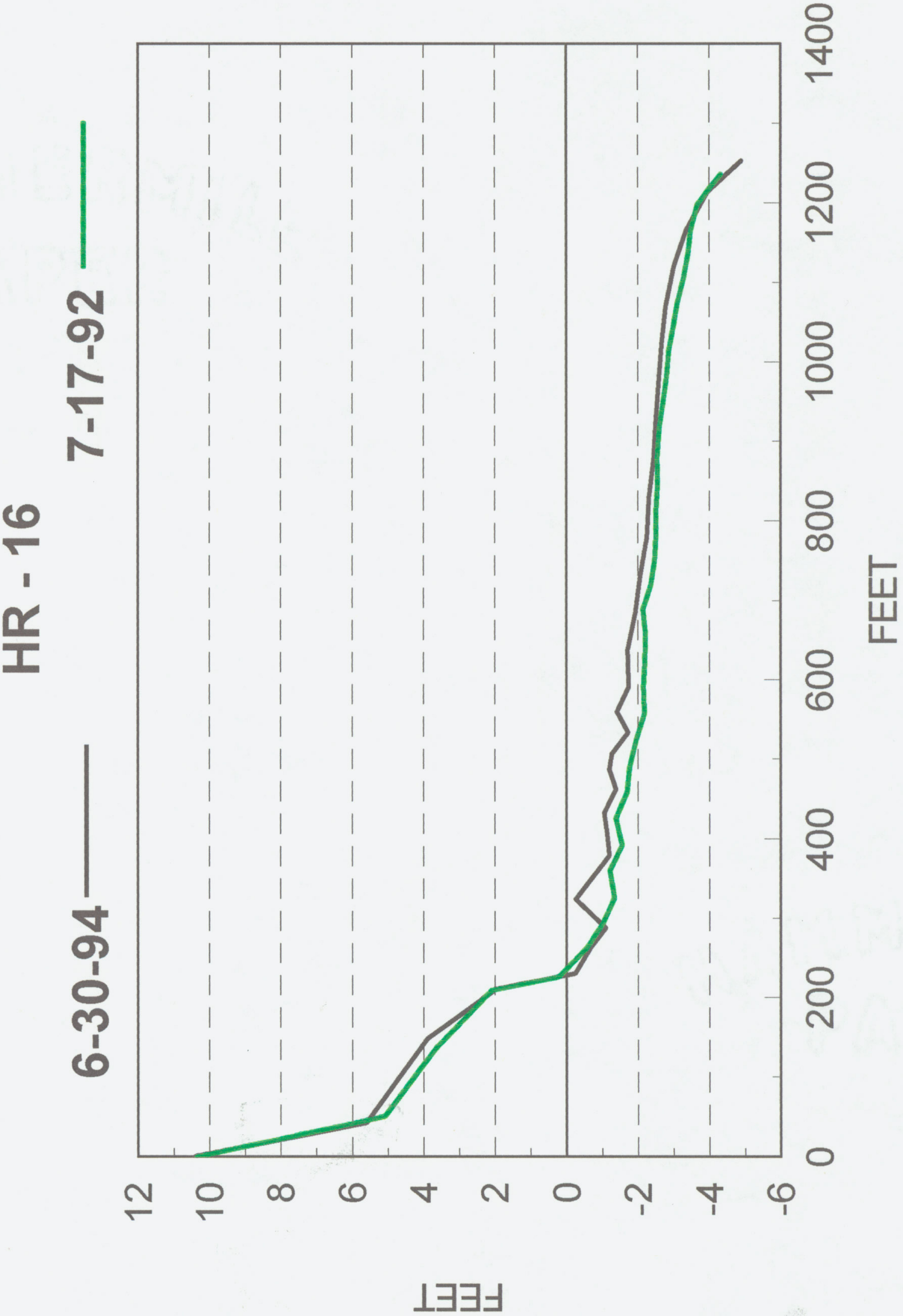

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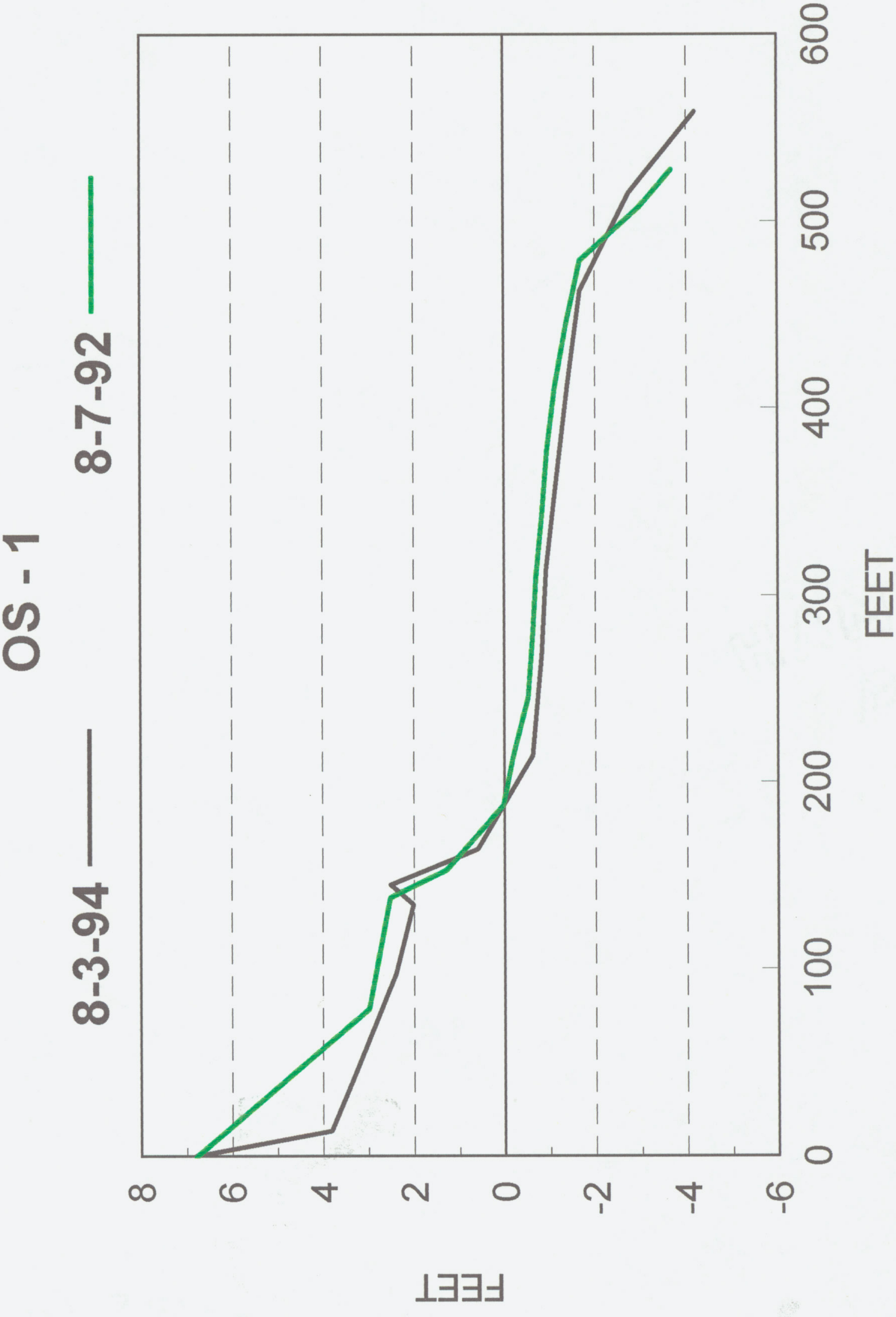

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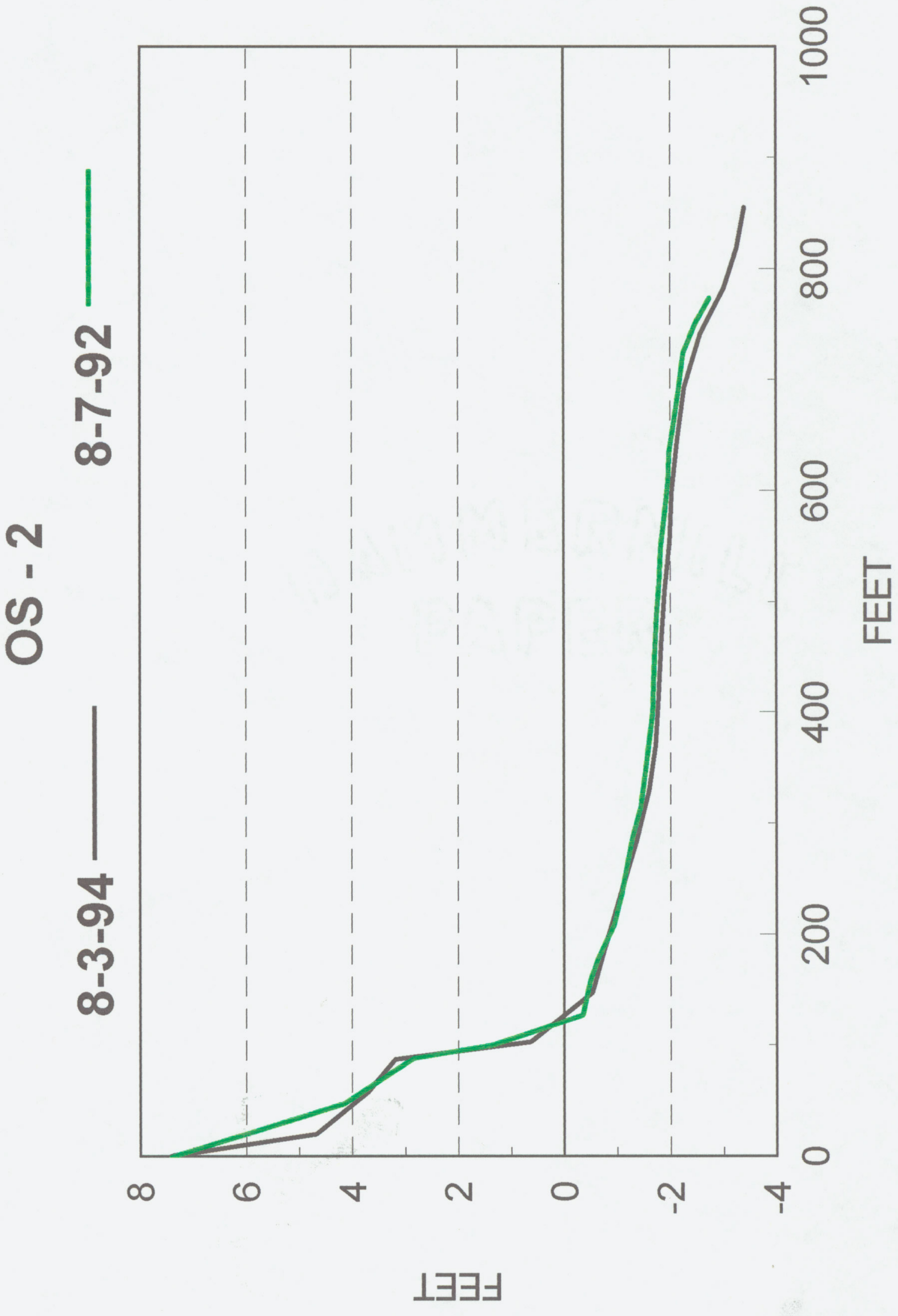

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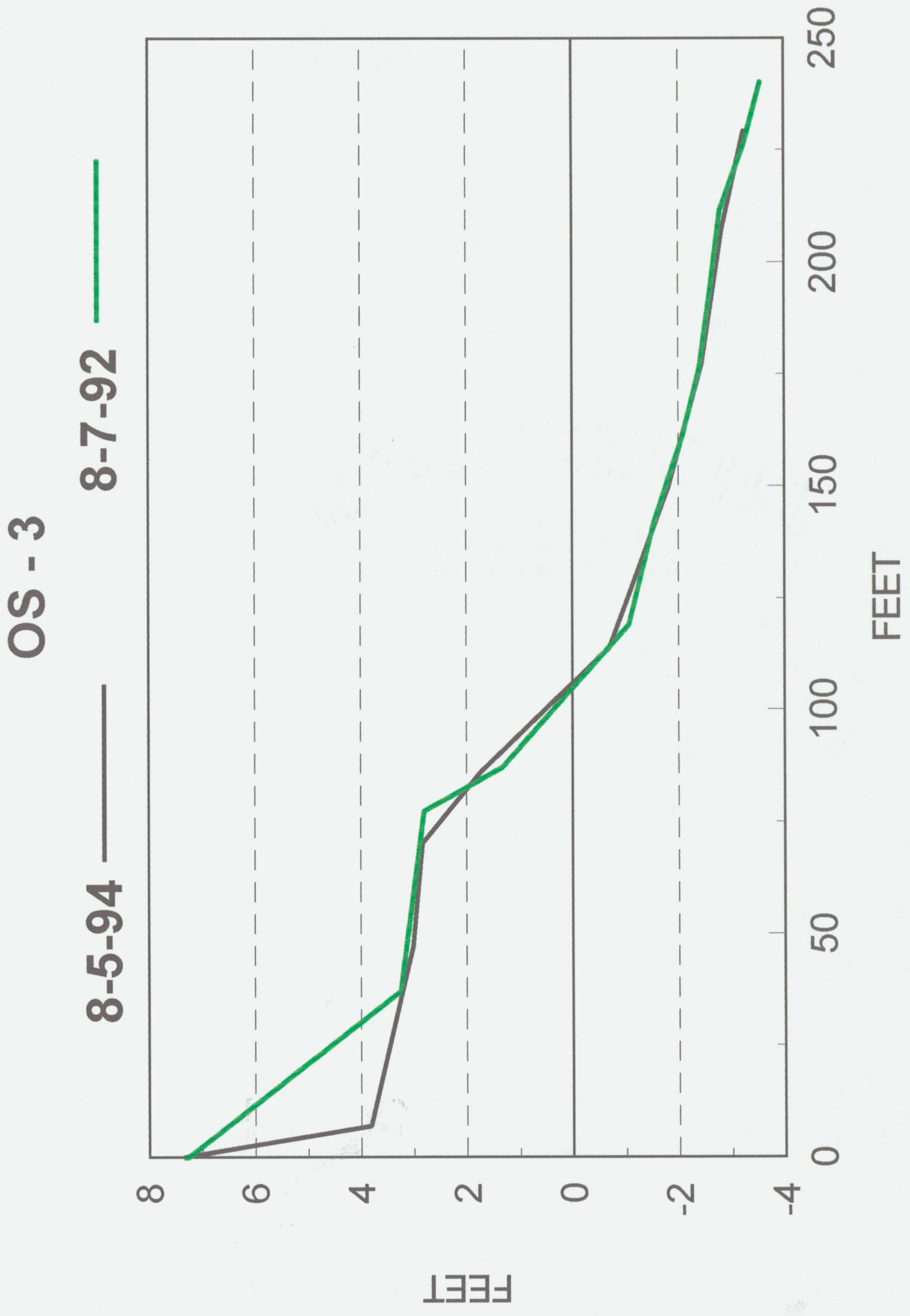
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BEACH AND NEARSHORE SEDIMENT BUDGET OF HARRISON COUNTY, MISSISSIPPI: A HISTORICAL ANALYSIS

by

Klaus J. Meyer-Arendt
Department of Geosciences
Mississippi State University

Introduction: The Problem

The beach and nearshore environment of Harrison County, Mississippi, has been subject to much human modification since the earliest relatively accurate maps of the coast were produced in the early 1850s. Sediment changes in the beach and nearshore environment of Harrison County may be analyzed in terms of gains and losses. Sediment gains are attributed to land fill, dredge-and-fill, shell deposition, and artificial beach nourishment, all of which have effectively extended the mainland shoreline seaward into the nearshore zone. Sediment losses are attributed to offshore, onshore, and longshore sand displacement by waves and winds, especially in conjunction with storm events. However, dredging for channel maintenance and for dredge-and-fill construction also accounts for sediment removal from the natural system for redistribution at other subaqueous and subaerial sites. As no comprehensive attempts at summarizing the history of sediment changes have been made, this study is offered as a preliminary baseline document with particular emphasis upon subaerial fill.

Methodology

To conduct the proposed research an investigation was made of records at various institutions, including: Biloxi Public Library, Gulfport Public Library, Pass Christian Public Library, the U.S. Army Corps of Engineers (Waterways Experiment Station library in Vicksburg and records division of the Mobile District Office), Brown & Mitchell, Inc. (Biloxi), the Mississippi State Port (Gulfport), Harrison County Planning Office, Gulf Regional Planning Commission (Gulfport), the Office of the Secretary of State (tidelands division, Gulfport), the Harrison County Sand Beach

Department (Gulfport), the Mississippi State Highway Department (Jackson), the Mississippi Office of Geology (Jackson), the Mississippi State Archives (Jackson), the Historic New Orleans Collection (New Orleans), and archives at Mississippi State University and Louisiana State University. Data compiled by the author under previous investigations were incorporated into the present project as they were deemed applicable. In preparation of the results of the project, the following tasks were undertaken:

1. Shoreline change maps were evaluated to determine precise locations of significant alteration. This was facilitated by the shoreline change study recently completed for the Mississippi Office of Geology. Also, maps generated by the Secretary of State's office for use in the "tidelands dispute" displayed shorefront reaches in which human encroachment into state water bottoms had taken place since the 1850s maps were produced.

2. From the results of Task 1, the various types of modifications (e.g., seafood, commercial, port, recreational) became apparent, and insights into nearshore sedimentary modifications were gained.

3. The U.S. Army Corps of Engineers was consulted to document (and quantify) sedimentary displacements associated with various navigation, harbor improvement, and shoreline protection projects.

4. Archival and cartographic sources were consulted to compile additional data needed to complete the project. This "literature review" process took the author to the various aforementioned institutions.

5. Because a lack of consistent quantitative data was found to document nearshore fill associated with the seafood industry, the historical record was reconstructed cartographically. Topographic maps, aerial photographs, and detailed land use maps prepared by the Sanborn Insurance Company were overlaid (after rectifying for scale differences) to document the chronology of nearshore land reclamation. Areal expansion was documented on draft maps for each map interval, and areas were measured by digitization. The newest large-scale aerial photographs available for Harrison County at the time of this study (Summer, 1993) dated to January 1992. (Since that date, dockside casino gambling has been legalized in Harrison County, and numerous additional

shorefront modifcations have been made. Unfortunately, this study had no accurate basis for adding these recent modifications.)

6. Hydrographic surveys were consulted to determine the water depths into which fill took place, and subaerial elevations were estimated from maps and also interpolations. Areal measurements were thus converted to volumetric measurements.

7. By summation of the compiled data and analysis thereof, the following historical reconstruction of beach and nearshore sediment changes was prepared.

Results

In terms of sedimentary gain, the types of modifications to the beach and nearshore sediment budget along the mainland shoreline of Harrison County (from Henderson Point in the west to the U.S. Highway 90 bridge approach in the east) include the following:

1. reclamation (expansion of "functional uplands" into the nearshore zone)
    - a. shell disposal and landfilling associated with the seafood industry
    - b. pier and wharf construction and landfilling associated with harbors
        - i. commercial harbors
        - ii. marinas (for commercial fishing boats and recreational vessels)
    - c. landfilling associated with commercial expansion (including in conjunction with the widening of U.S. Hwy 90)
    - d. landfilling associated with U.S. Coast Guard base construction
    - e. landfilling associated with recreational piers
    - f. landfilling associated with recreational urbanization
2. shoreline "improvements" and protection
    - a. Beach Boulevard construction
    - b. seawall construction (to protect Beach Boulevard)
    - c. artificial beach construction (to protect seawall)
        - i. initial sand placement
        - ii. sand renourishment
3. dredge spoil disposal (derived from dredging sediment from the nearshore and offshore zones)

a. derived from harbor dredging
   i. initial construction
   ii. maintenance dredging & harbor improvements
b. derived from channel dredging
   i. initial construction
   ii. maintenance dredging & channel improvements
c. sand dredging to acquire nourishment material
   i. to create (and maintain) artificial beach
   ii. to nourish other critically eroding shoreline segments

The above processes identified as taking place in Harrison County also may be expressed geographically, i.e. shore and nearshore regions can be delineated into various "zones" of sediment gain or loss, where one or more of the processes prevail. Based upon broad divisions of shorefront and nearshore, the following "zones" represent the subsequent format in which this report is organized (Figure 1):

SHOREFRONT

1. Pass Christian Small Craft Harbor
2. Long Beach Small Craft Harbor
3. Gulfport Harbor
4. Courthouse Rd. Pier (Mississippi City)
5. Broadwater Beach Marina
6. Mladinich Recreational Complex (Sea'n'Sirloin/Rodeway Inn)
7. Biloxi Waterfront (CBD)
8. "Casino Row" (Front Beach of Point Cadet Seafood District)
9. Beach Blvd./Seawall/Artificial Beach Complex (entire county)

MISSISSIPPI SOUND

10. Ship Island/Gulfport Ship Channel
11. Deer Island/Biloxi Harbor Navigation Channel

Modifications to the shorefront or nearshore that did not entail the placement or removal of sediment are not included in this report. Such structures, which include piers, wharves,

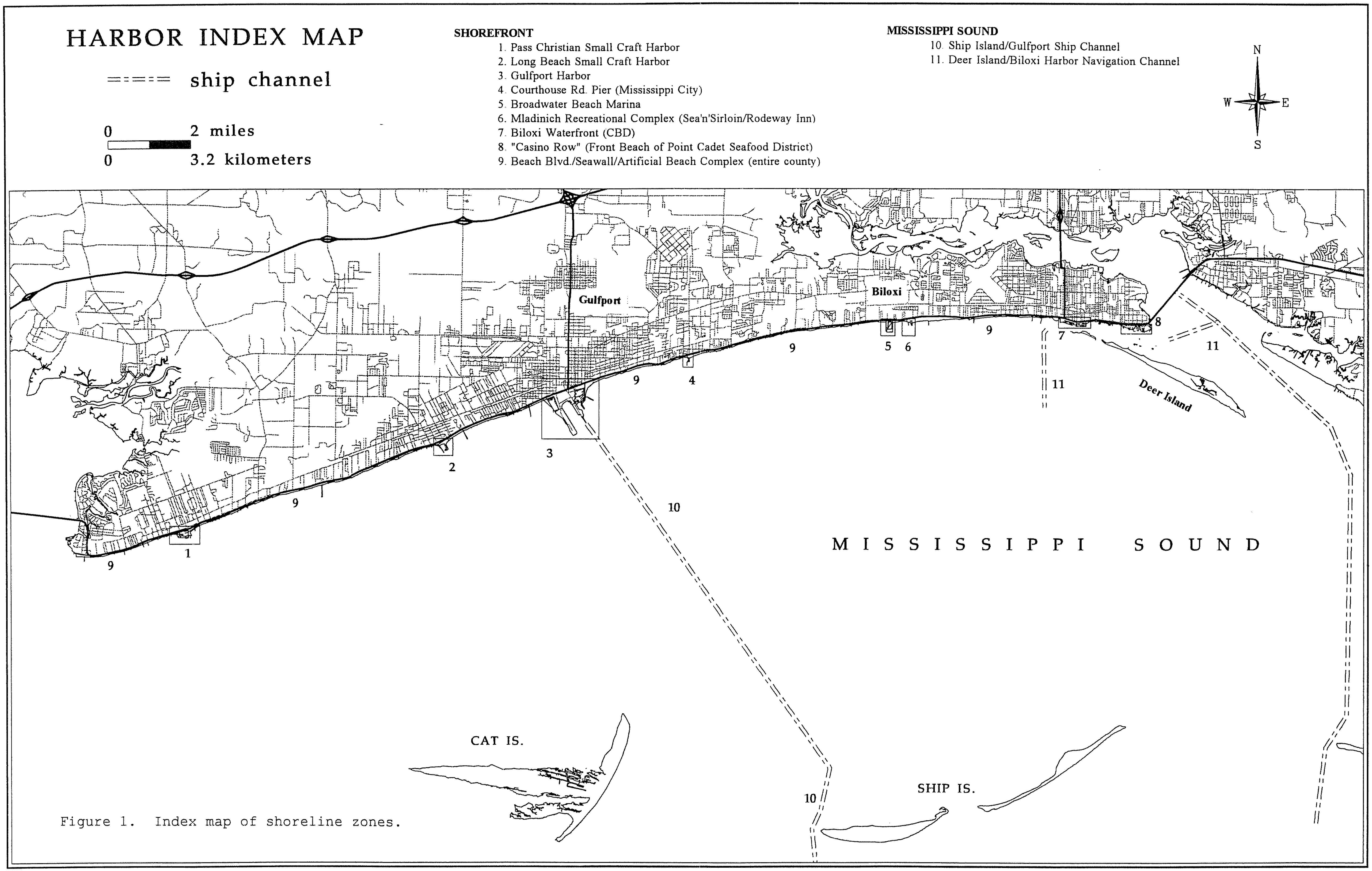


Figure 1. Index map of shoreline zones.

boathouses, seafood platforms/sheds, and occasionally more substantial building, are herein considered ephemeral and not necessarily contributory to significant modifications to the sediment budget.

SHOREFRONT

1. Pass Christian Small Craft Harbor

The present-day Pass Christian Small Craft Harbor owes its origins to the same seafood industry boom that hit Biloxi in the late 1800s and early 1900s. Soon after 1893, the Biloxi-based Dunbar, Lopez, Dukatelo company established Pass Packing Co. on piers jutting into the nearshore at the exact location of the present east side of the harbor (Figure 2). The packing complex, containing oyster-shucking, canning, and ice-making buildings, was located beginning 700 ft seaward of the natural shoreline and extending out to about 1300 ft from shore (or about the 6 ft isobath). The 1904 Sanborn map showed a distinct island (about 1.6 acres in size) underneath the packing company and a plank boardwalk (700 ft in length) connected the oyster-shell island to the mainland. Between the 1909 and 1918 Sanborn maps, two types of sedimentary changes were noted: 1) the island became enlarged and also subaerially connected to the mainland, reflecting continued in situ disposal of oyster shells, and 2) apparent wave-sheltering by the artificial "shell tombolo" led to localized sand accretion to the natural shoreline, mostly to the east of the approach to the seafood cannery. Between 1924 and 1940, two more nearshore changes were evident: 1) the westside jetty, extending seaward 1000 ft, then angled eastward for 600 ft, was constructed to provide a small craft safe harbor, and about 5 acres of sand accreted against the jetty, and 2) about 5 acres of fill was added along the east side of the old packing house shell fill by a combination of natural sand accretion and fill placement. Although no records exist and this work precedes federal involvement, the latter fills most likely represent local harbor-dredging and dredge-disposal activities.

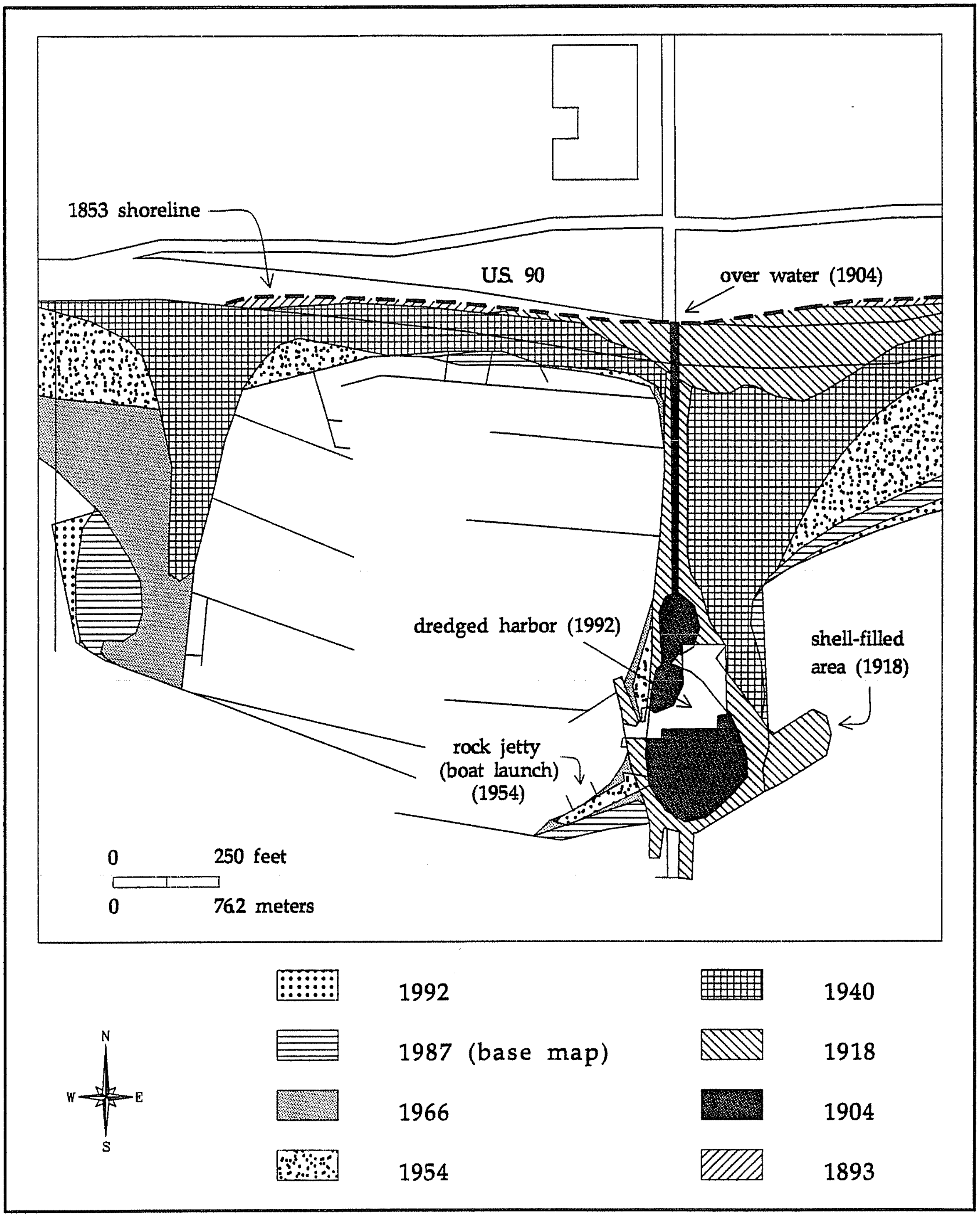


Figure 2. Nearshore changes, Pass Christian.

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume* (cu.yd.)	Cum. (cu.yd.)	Type of fill
1893-1904	1.6	1.6	5	6	28,400	28,400	shell
1909-1918	3.6	5.2	4	6	58,100	86,500	shell
1909-1918	2.9	8.1	0.5	0.5	4,700	91,200	accreted sand
1924-1940	5.1	13.2	3	1	32,900	124,100	accreted sand
1924-1940	4.9	18.1	2	2	31,600	155,700	accreted sand/fill
1940-1954	?	?	?	9	71,200	226,900	dredge spoil
1940-1954	0.5	18.6	2	3	4,000	230,900	dredge spoil
1954-1966	3.6	22.2	3	3	34,800	265,700	riprap/spoil acc. sand
1966-1987	1.1	23.3	4	7	19,500	285,200	dredge spoil
1987-1992	0.3	23.6	4	7	5,300	290,500	dredge spoil

Table 1. Chronology of Nearshore Areal and Volumetric Expansion, Pass Christian Harbor and Vicinity.
[length of shoreline impacted by nearshore reclamation and sand accretion: 2270 ft]
* In this and other tables, volume is calculated as follows: 3 ac. x 43560 $ft^2/ac.$ x (depth+elev.) ÷ 27 ft^3/yd^3...unless volumetric data were available.

In 1945, maintenance of the Pass Christian Harbor fell under the jurisdiction of the federal government (USACE, 1989), and a harbor depth of 7 ft and an entrance channel depth of 7 ft were authorized. By the time of the 1954 T-chart, much land along the "east pier" was above the 10-ft contour, thus apparently reflecting the location of deposited dredge spoil. Assuming an average elevation increase of 9 ft over the 4.9 acres east of east pier, the calculated amount of net placed fill, 71,150 cubic yards (Table 1), roughly equals the removal of 3 ft of sediment from an area measuring 1000 ft by 700 ft, the exact dimensions of the Pass Christian Harbor. Also in the 1940-1954 interval, the artificial sand beach was placed on the flanks of the harbor, but these numbers will be incorporated into Section 9 of this report. Within the harbor, only a small amount of fill was noted at the north end parking area between 1940 and 1954. By 1966, many harbor improvements were made, particularly in the form of reinforcing the west pier with concrete and riprap. Also along the west pier riprap was placed at the pier terminus and sediment accretion (natural or dredge spoil?) was noted. Since the federal harbor-dredging project was officially completed in 1959, it is quite likely that some dredge spoil was placed along the west flank of the west pier. (Mr. Paul Warren of the USACE, Mobile District, stated that some material dredged from the entrance to the harbor was deposited on the beach east of the harbor [in the 1960s?], but the high silt content was deemed undesirable by beachgoers.)

USACE records indicate that 37,000 cubic yards were dredged from the harbor and harbor entrance in June 1974 and apparently deposited to the west of the harbor. Aerial photos of 1987 show a retaining wall west of the west pier enclosing a dredge spoil deposition site, and about one acre of subaerial fill had been placed. An additional 0.3 acre appeared between 1987 and 1992, at which time the fill area had been paved over to create a parking area for the harbor and a new fishing pier.

2. Long Beach Small Craft Harbor

The east pier of the present Long Beach Small Craft Harbor has its origins in a rock rubble groin/pier that was constructed between 1924 and 1940 and was a seaward extension of Cleveland Ave. Extending out about 900 ft, the riprap groin measured about 0.7 ac in area (Figure 3, Table 2). In the 1940s, the "rock jetty" was extended seaward 350 ft, encompassing an areal expansion of 0.5 ac. By the early 1950s, the artificial sand beach had been placed along most of the Harrison County shorefront, and within the limits of what was to become the Long Beach Harbor a total of 4.5 ac of sand (or 40,000 cubic yards according to USACE fill design criteria) was placed. By 1966, the sand beach was still there within the future harbor limits, but a framework for the modern harbor had been laid.

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1924-1940	0.7	0.7	4	6	11,300	11,300	riprap
1940-1954	0.5	1.2	6	6	9,700	21,000	riprap
1940-1954	4.5	5.7		4	40,000	61,000	sand beach
1954-1966	4.6	10.3	4	6	74,200	135,200	riprap fill
1966-1987	1.7	12.0	5	6	30,200	165,400	riprap
1966-1987	1.9	13.9		6	61,500	226,900	dredge spoil
1987-1992	1.5	15.4		3	7,300	234,200	fill

Table 2. Chronology of Nearshore Areal and Volumetric Expansion, Long Beach Harbor and Vicinity
[length of shoreline impacted by nearshore reclamation and sand accretion: 900 ft]

A 500-ft riprap groin was built in 1966 as the beginnings of the west pier, and a right-angle breakwater (about 900 ft total) was built to semi-enclose the harbor. Spoil from harbor dredging was placed along the west side between the groin and the offshore breakwater, but the 1966 map does not indicate any subaerial expression of that spoil. The east pier was expanded by about 3.6 acres with riprap and other fill. (According to Long Beach Harbormaster Danny Kaletsch, no records of any of the harbor improvements exist.) Much of the riprap, especially from the breakwater, was lost to Hurricane Camille in 1969, and the present harbor dates to post-storm construction in the early 1970s. The west pier was substantially expanded and reinforced at this time, and the now enclosed sand beach became filled with spoil dredged from the harbor (thus leading to a seaward shift in position of the shoreline). The only significant change between 1987 and 1992 was that 1.5 ac of the east-flanking sand beaches were converted into an asphalt parking lot.

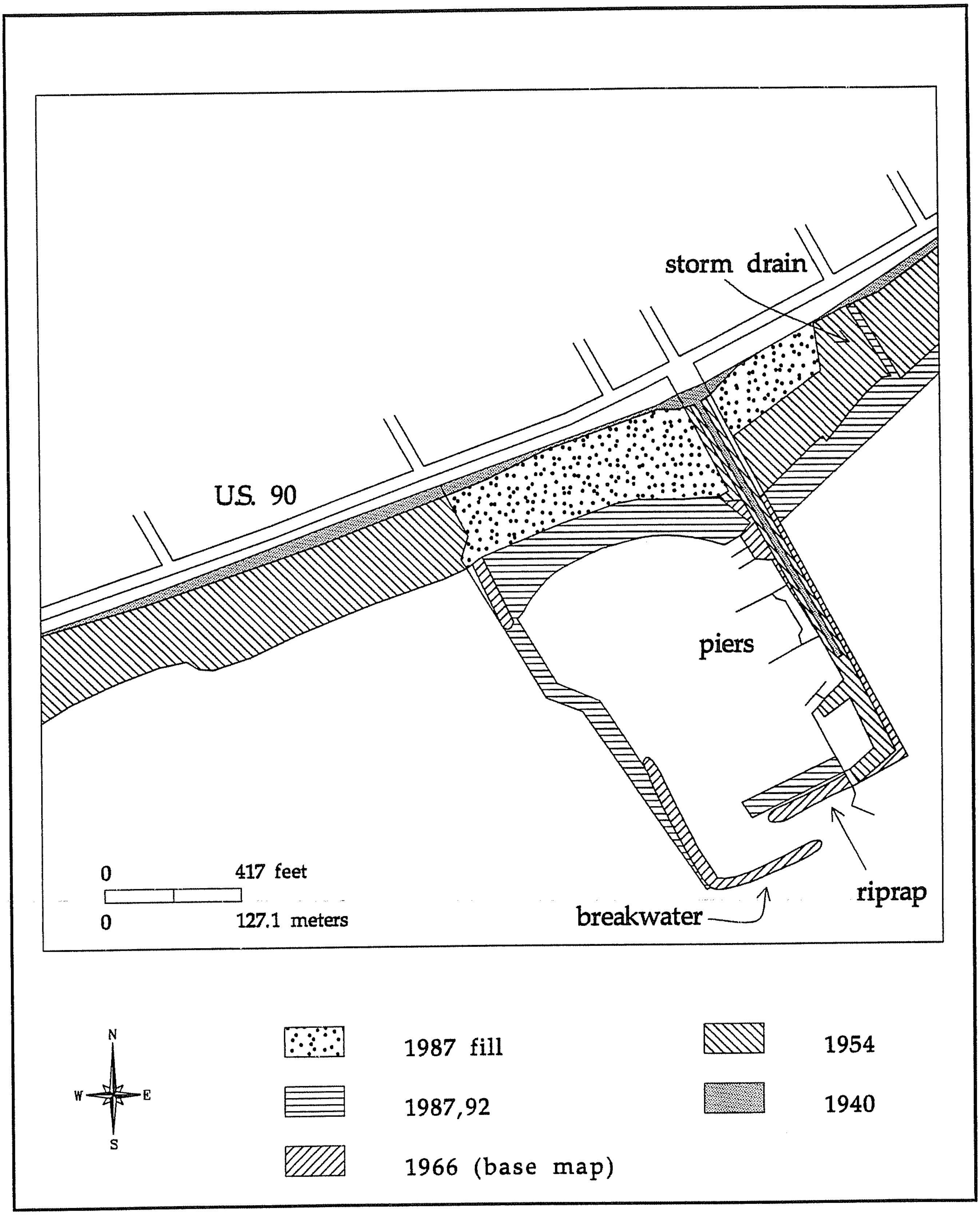


Figure 3. Nearshore changes, Long Beach and vicinity.

3. Gulfport Harbor

The history of the Port of Gulfport is a long and interesting one which has received much attention by historians (Black, 1986; Switzer, 1992). In 1887, a 5000-ac block of land was bought and platted as the town of Gulfport, which was located directly north of the preexisting natural ship anchorage in the lee of Ship Island (in the vicinity of Ft. Massachusetts). To make the new port a success, a direct rail link with the interior of Mississippi was necessary. Although a few problems were encountered, the Gulf and Ship Island Railroad connected Gulfport to Hattiesburg by 1896 (Switzer, 1992). Construction began on a pier at Gulfport (at the site of the present east pier), and exports, mostly lumber, were lightered out to ships in the Ship Island anchorage. Following completion of the 4500-ft-long trestle pier (to about 12 ft water depth), Capt. Joseph Jones (the man responsible for most of the successful early development of the port) foresaw possibilities of a mainland harbor (Switzer, 1992). Although an 1896 federal cost-benefit study of dredging a ship channel out to deep water found that costs greatly outweighed the benefits, a high demand for Mississippi timber the following year led Capt. Jones to initiate channel-dredging himself.

In anticipation of a completed dredged channel to Ship Island Pass, expansion of the harbor began. A map made just prior to harbor expansion (no date, but estimated at 1897 or 1898) shows proposed widening and filling of the (east) pier using dredge spoil, construction of a second (west) pier, and several "to be filled" areas (Figure 4). One of these areas, completed in 1899 at the head of the harbor, contained a lake in which logs would be stored in fresh water, safe from the destroying teredo shipworm which thrives in salt water (Miller, 1993). Widening of the east pier (in 1899) was accomplished by outlining a mile-long, 300-ft wide section (centered on the trestle pier) with sheetpile and then filling in with a combination of dredge spoil and oyster shells (Switzer, 1992). A rail line was subsequently laid on top of the now solid east pier, and in 1902 the Port of Gulfport was officially dedicated. Although records of the details of harbor construction are spotty, over the next few years a 5000-ft-long west pier was constructed (in a similar sheetpile/dredge spoil/oyster shell manner, as seen in a photo in Hancock Bank, 1982). Dredging within the harbor and the channel continued steadily, and while it appears that channel dredge spoil was deposited along both flanks of the channel, excess harbor dredge spoil was deposited onto the nearshore to the east of east pier.

The 1916 coast survey map (USCGS, 1916-17), although not very accurate, showed a total of 89 acres of subaerial land seaward of the old natural shoreline, including a 16-acre freshwater holding pond (Figure 5). A more accurate set of engineering plans dated 1927 (Figure 6) shows large acreages of subaerial land which had accreted to both flanks of the harbor as a result of spoil deposition. In 1922 state and federal funding was authorized for channel- and harbor-dredging as well as construction of a creosote breakwater off of the west pier (USACE, 1959). The arrival of Mississippi Power Company led to expansion of the east pier (Switzer, 1992). Further funding in 1930, enhanced by creation of the Gulfport Port Commission and a favorable report by the U.S. Bureau of Engineers, led to renewed dredging and channel-deepening (Switzer, 1992). A 1932 fire on the west pier led to construction of a steel-reinforced concrete dock covering eight acres, upon which six acres of fire-proof warehouses were built (Switzer, 1992; Figure 7). Also, the state waterbottoms east of the port (where much dredge spoil had been deposited and perhaps some longshore-drifting natural beach sands had accumulated) were leased to the city of Gulfport, which constructed the Bert Jones Park and Yacht Basin (see Figure 7). The first accurate map to show the Bert Jones Park, however, was a 1949 U.S. Army Corps of Engineers map (USACE, 1950). The next report on the Port of Gulfport (USACE, 1959) contained a 1957 map which showed an addition of a commercial small craft basin west of the west pier and also a widening of the northern end of the west pier to 1000 ft. Also, the old 16-acre freshwater holding pond was filled in. As in past projects, no records of dredging or fill volumes were kept.

In 1961, the port authority was transferred from the City of Gulfport to the State of Mississippi, and soon several port expansion projects were authorized. The first to be completed was a 1966 extension of the west pier (which was built over a "trailing spit" of riprap). In 1973, there was a further 10-acre extension of the west pier which required 380,000 cubic yards of sand fill dredged from just off the beach at the foot of Hill Place (east of the port). At the same time, East Pier was widened by about 6.5 acres, again using nearshore sands from Hill Place (Mr. C. T. Green, pers. comm.). An 1987 air photo also showed 4 acres of new

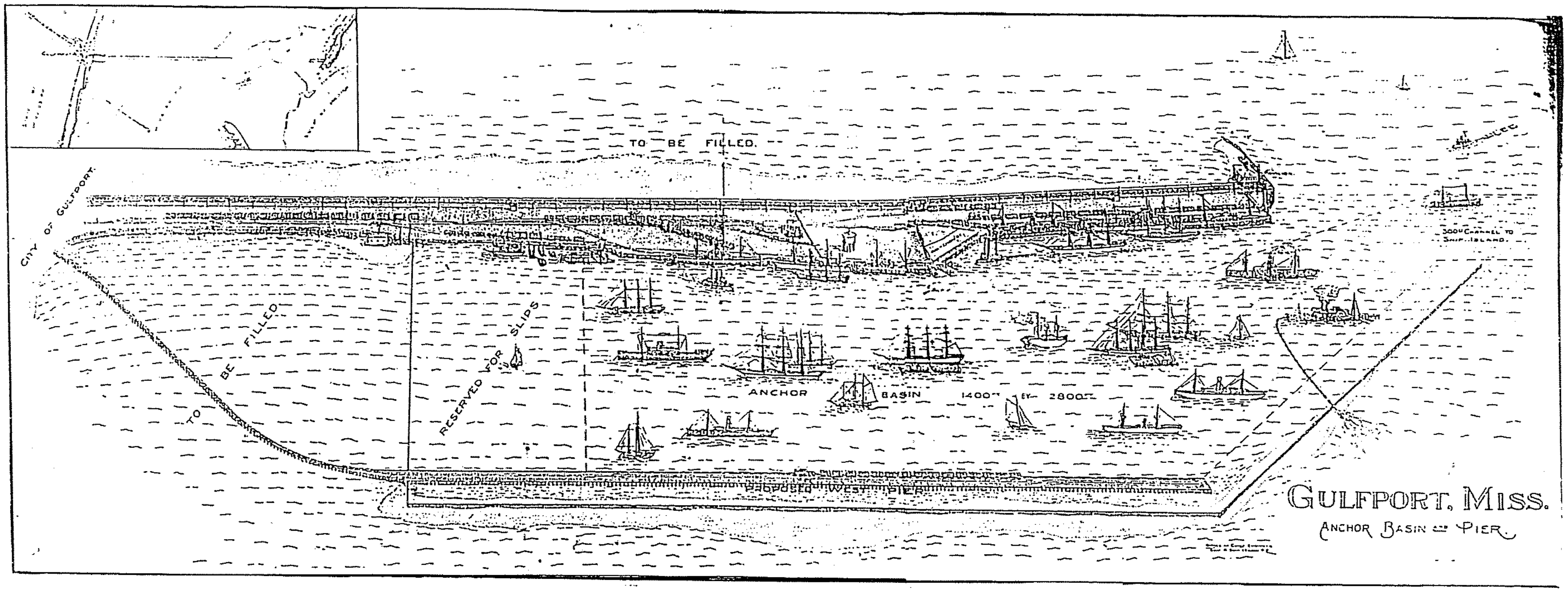


Figure 4. Gulfport Harbor, 1897 or 1898. (courtesy Gulfport Public Library)

land in the port area (riprap, accreted sand?) and about 5 acres of sand accretion along the east side of the Bert Jones Yacht Basin.

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1897-1899	34.4	34.4	6	7	721,500	721,500	sand/shell
1899-1916	38.7	73.1	3	4	437,100	1,158,600	spoil *
1916-1935	35.6	108.7	4	5	516,900	1,675,500	spoil/conc.
1935-1949	49.4	158.1	5	5	797,000	2,472,500	spoil/conc.
1949-1957	16.0	174.1		8	206,500	2,679,000	spoil/fill
1949-1957	27.4	201.5	4	5	397,900	3,076,900	spoil/sand accr.
1966	6.3	207.8	7	11	182,900	3,259,800	spoil/conc. (w. pier)
1973	10.0	217.8	12	11	380,000	3,639,800	spoil/conc. (w. pier)
1973	6.5	224.3	4	7.5	124,000	3,763,800	spoil/conc. (e. pier)
1957-1987	9.0	233.3	2	2	58,100	3,821,900	sand accr.
1993	18.0	251.3	5	11	455,000	4,276,900	spoil/conc. (w. pier)

Table 3. Chronology of Nearshore Areal and Volumetric Expansion, Port of Gulfport and Vicinity
[length of shoreline impacted by nearshore reclamation and sand accretion: 5780 ft]
* these 38.7 acres include: 1) land at head of the port (excluding the 16-acre timber holding pond), 2) the west pier, and 3) dredge spoil/sand accretion along the east side of east pier (no reliable data available)

In 1993, work commenced on both deepening and realigning the Gulfport Ship Channel to a location 1500 ft westward (because of continued shoaling problems in the vicinity of Ship Island). At the same time, expansion of the west pier by 18 acres (to a width of 1000 ft along its entire length) began. (Officially, the 1993

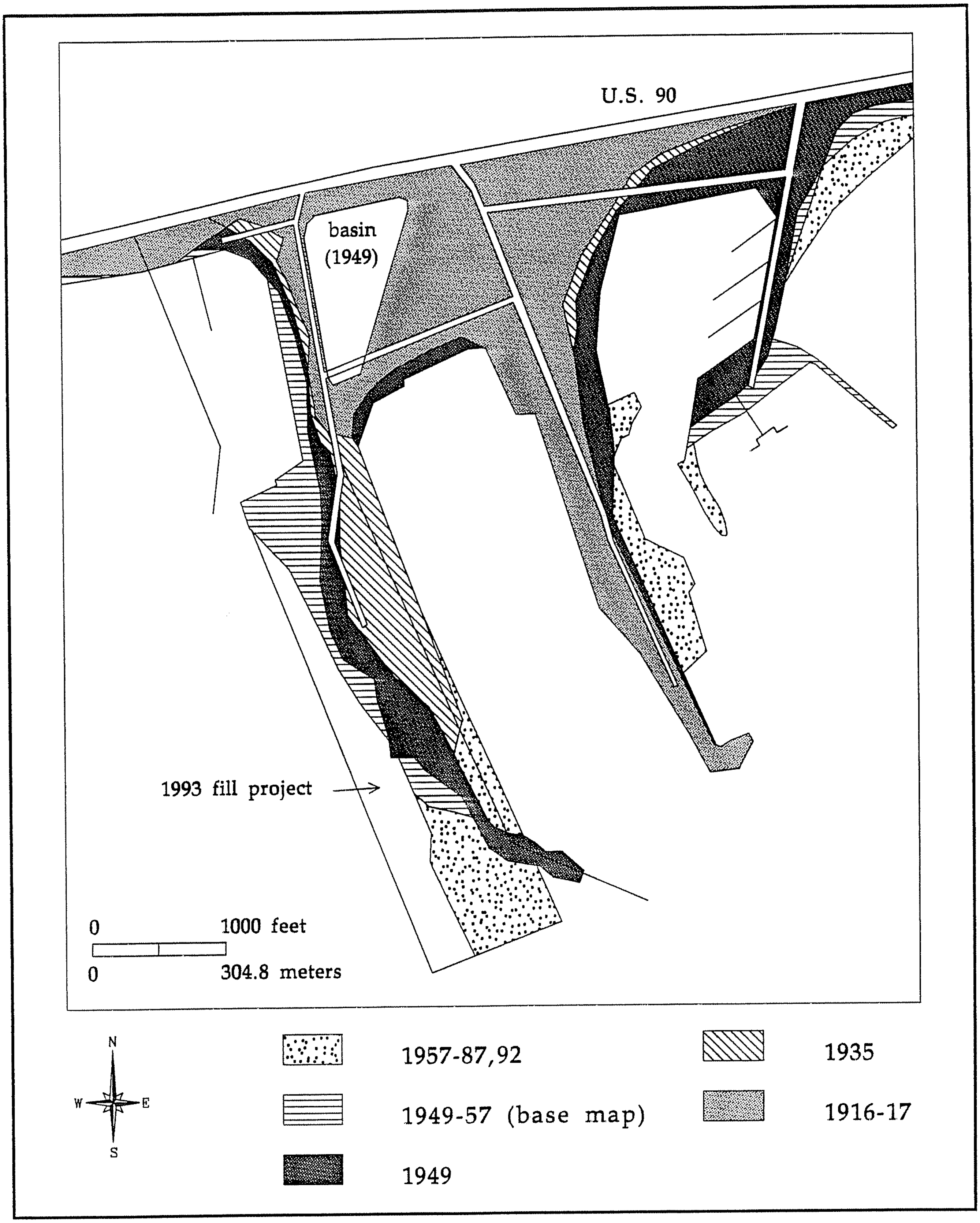


Figure 5. Nearshore changes, Port of Gulfport and vicinity.

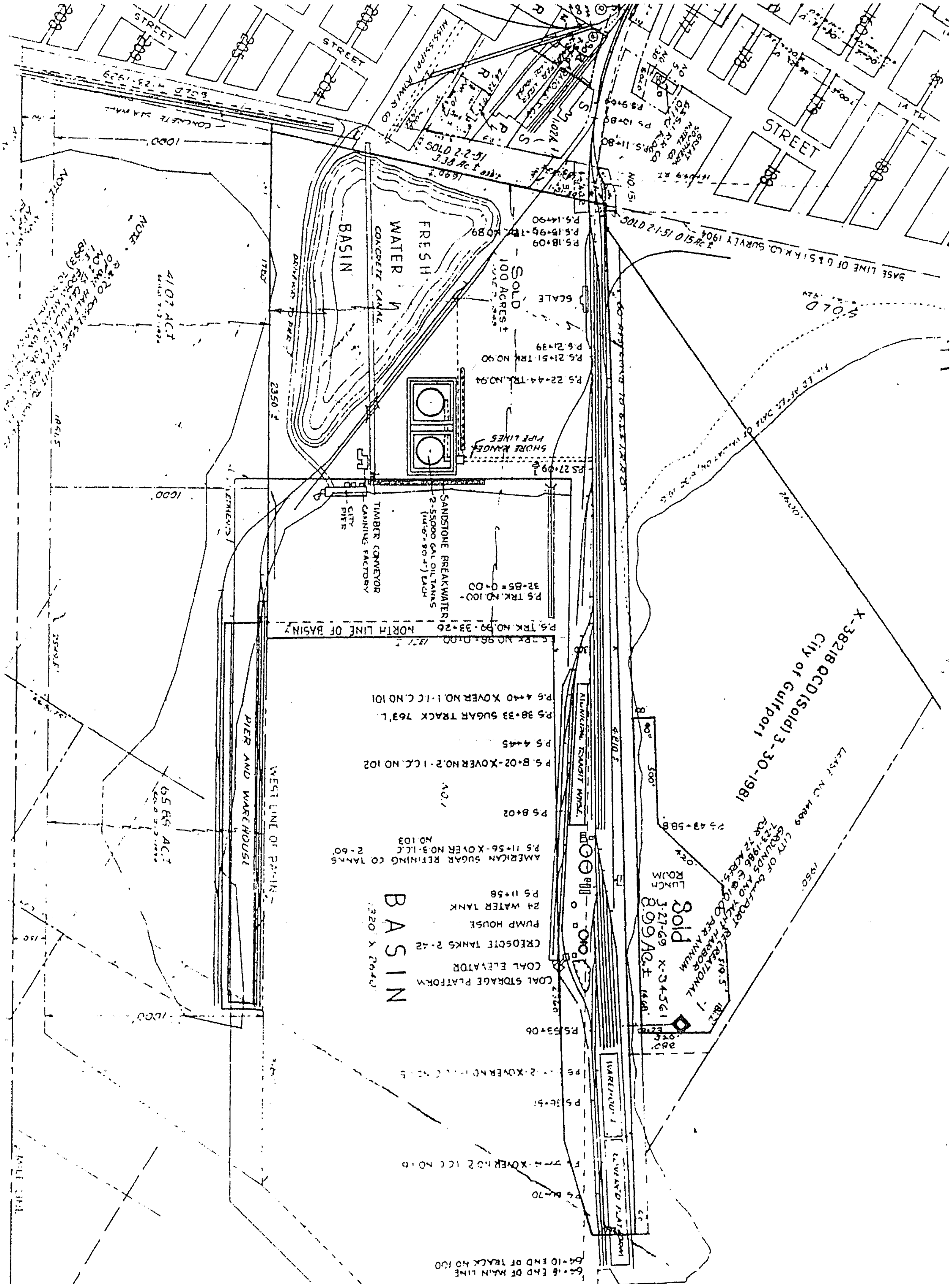


Figure 6. Gulfport Harbor, 1927. (courtesy C. T. Green, MS State Port Commission)

GULFPORT'S NEW PIER (LEFT) IS BIG ENOUGH FOR SIX FOOTBALL FIELDS

Loading thousands of bales of cotton on Japanese ships, unloading sugar from Cuba and asphalt from Trinidad, sacking fertilizer from Chile for southern farms—all are in a day's work at Mississippi's only deep-water harbor. Unlike its venerable neighbors, Gulfport is a new city, conceived when the Gulf and Ship Island Railway, just fifty years ago, chose it for a salt-water terminal, and matured in 1902 when Captain J. T. Jones completed the railway, built a resort hotel, power plant, streetcar line, a creosoting plant, and a bank. A recent water-front improvement is a commodious harbor for small craft.

Figure 7. Port of Gulfport, 1937. (Hildebrand, 1937)

project encompasses 29 acres, but only 18 acres are estimated to replace water.) The estimated 455,000 cubic yards required are dredge spoil derived from the channel-deepening.

4. Courthouse Road Pier (Mississippi City)

At the foot of Gulfport's Courthouse Rd. (formerly within Mississippi City) is a major public parking area, boat launch, restrooms, and fishing pier. This boat launch facility started off as a riprap groin/pier built out 900 ft in the latter 1940s. Apparently fill was overlain upon the landward portion of the pier, but this is somewhat obscured by the recently placed sand beach which appears on the 1954 T-chart (Figure 8). The evidence of fill is seen by the 5-ft contour which juts out about 550 ft from the edge of Beach Blvd. Little change was noted on the 1966 map (except for slight changes in the position of the shoreline), but by 1987 a wooden fishing pier had been extended to the west about 350 ft. By 1992, a second extension (south by 400 ft) had been added, and an area between the pier and a storm drain just west of the facility was filled and converted to a parking lot (~1.4 ac) for a relocated boat launch site (Table 4).

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1940-1954	0.8	0.8	2	6	10,700	10,700	riprap (groin)
1940-1954	0.8	1.6		8	10,700	21,400	dirt fill w/in 5' contour
1954-1992	(pier extensions on pilings only)						
1987-1992	1.4	3.0		6	13,500	24,900	dirt fill parking area

Table 4. Chronology of Nearshore Areal and Volumetric Expansion, Courthouse Rd. Pier
[length of shoreline impacted by nearshore reclamation and sand accretion: 350 ft]

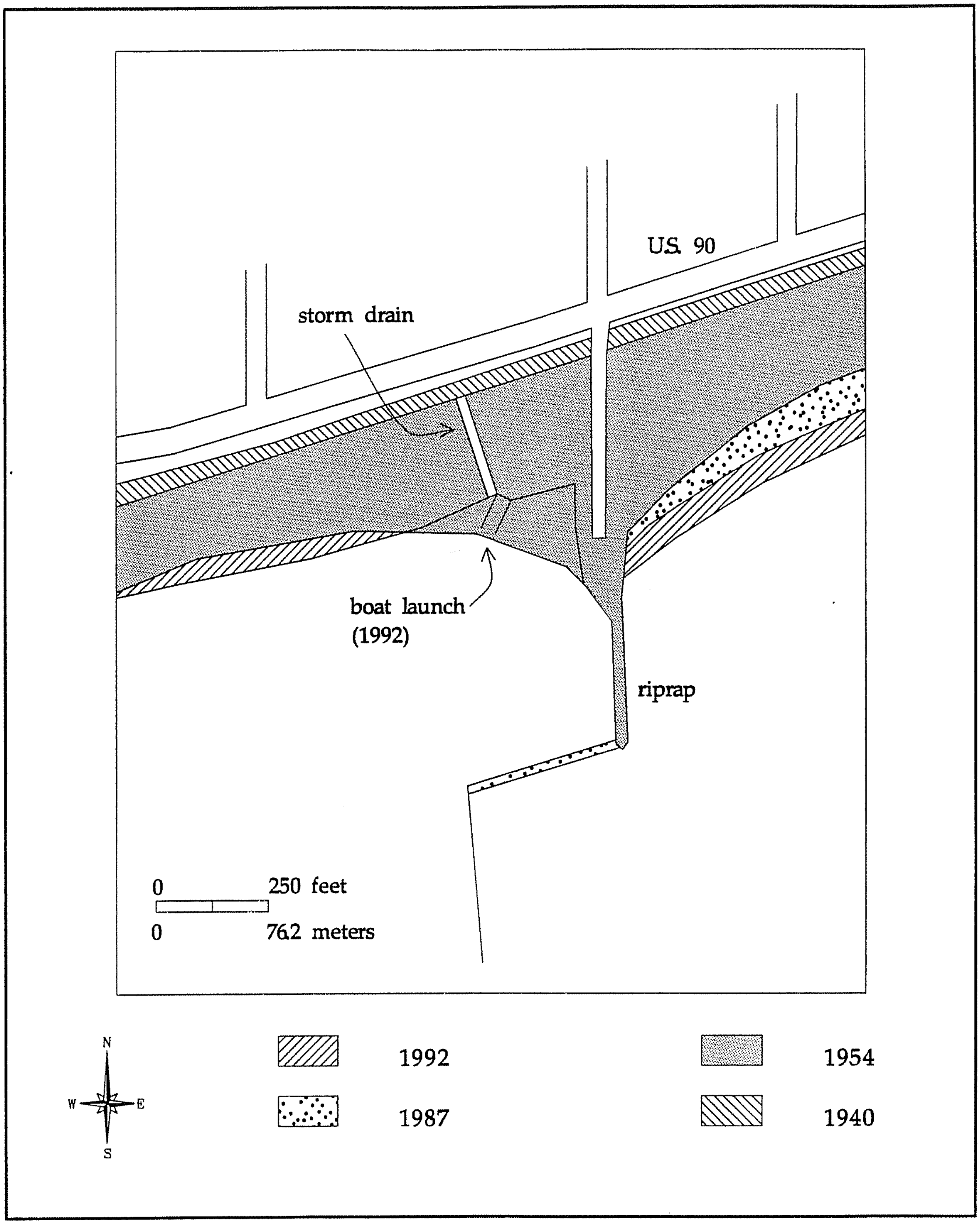


Figure 8. Nearshore changes, Courthouse Road Pier area.

5. **Broadwater Beach Marina**

The Broadwater Hotel was built in 1940 along a stretch of West Beach shorefront that contained only the 1920s seawall and beach highway (Prior, 1947). To enhance its attraction to tourists, the Broadwater built two timber groins, about 200 ft long and spaced about 500-600 ft apart, and pumped sand in between them (Figure 9). (The source of the sand is unknown.) A 400-ft pier on pilings extended to a pavilion.

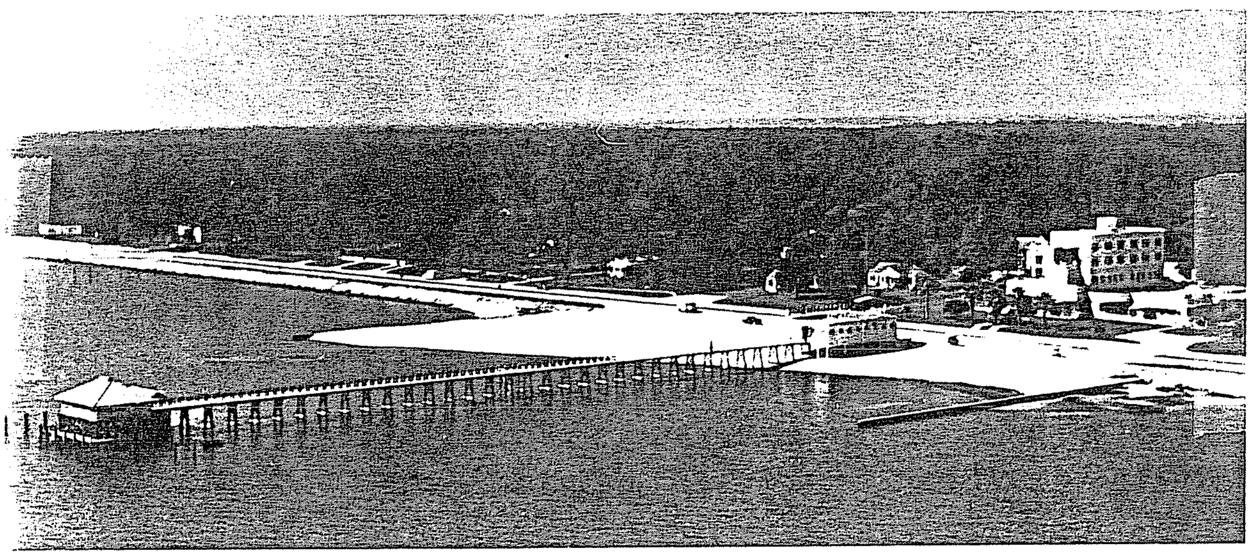


Figure 9. The Broadwater Hotel's sand beach, circa 1948. (photo courtesy of USACE, Mobile District)

The Broadwater's private shorefront engineering efforts (i.e. Broadwater Beach) were soon obliterated by the federal sand beach which was completed in the early 1950s and appears on the 1954 T-chart. During the 1960s, the Broadwater expanded and redesigned the hotel (incorporating the 1940 structure into it) and built a marina in the shorefront (Figure 10; Table 5). The marina, which extends 900 ft along the shorefront and juts out into the nearshore 1550 ft, contains about 21.5 acres of fill and concrete (the material at least partially derived by dredging of the harbor and harbor entrance). Little modification was made to the marina until 1992, when the President Casino was installed there. No areal expansion accompanied the introduction of casino gambling, but some dredging and pile driving was necessary to accommodate the boat, and a grass area was paved over to provide parking spaces.

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1940-1941	2.3	2.3	2	3	18,500	18,500	sand beach
1963-1965	21.5	21.5	4	10	485,600	514,100	dirt/spoil concrete

Table 5. Chronology of Nearshore Areal and Volumetric Expansion, Broadwater Beach Marina
[length of shoreline impacted by nearshore reclamation and sand accretion: 900 ft]

6. Mladinich Recreational Complex

Less then 2000 ft east of the Broadwater Beach Marina is the western terminus of the 6000-ft-long "West Beach strip", Biloxi's post-World War II recreational business district (RBD) that developed just beyond the city's western limits. Because of a low marshy shoreline in this area, it was not only settled later but also the beach highway had to curve inland away from the shoreline to remain on relatively dry land. This early obstacle to development became a later boon to development (following construction of the seawall in the 1920s and especially following completion of the sand beach in the early 1950s) as structures could be squeezed in between the beach and the highway. At the very western end of this recreational strip, near the point where the highway joins up with the beach (see Figure 10), lies the 6th zone of nearshore reclamation, herein referred to, for lack of a better name, the Mladinich Recreational Complex (MRC). Most of the 10.8-acre property (as measured seaward of the seawall, along which the MRC abuts for a length of 840 ft) was owned by Mr. Jake Mladinich, who built Capt. Jake's Sea'n'Sirloin Restaurant, the Fiesta Gift Shop, and an apartment complex (among other businesses). The eastern portion of the property was occupied by the former Sun'n'Sand Motel, now known as the Rodeway Inn.

The 1940 Tobin air photo displayed very little development in the area. The 1920s seawall formed the head of a narrow natural

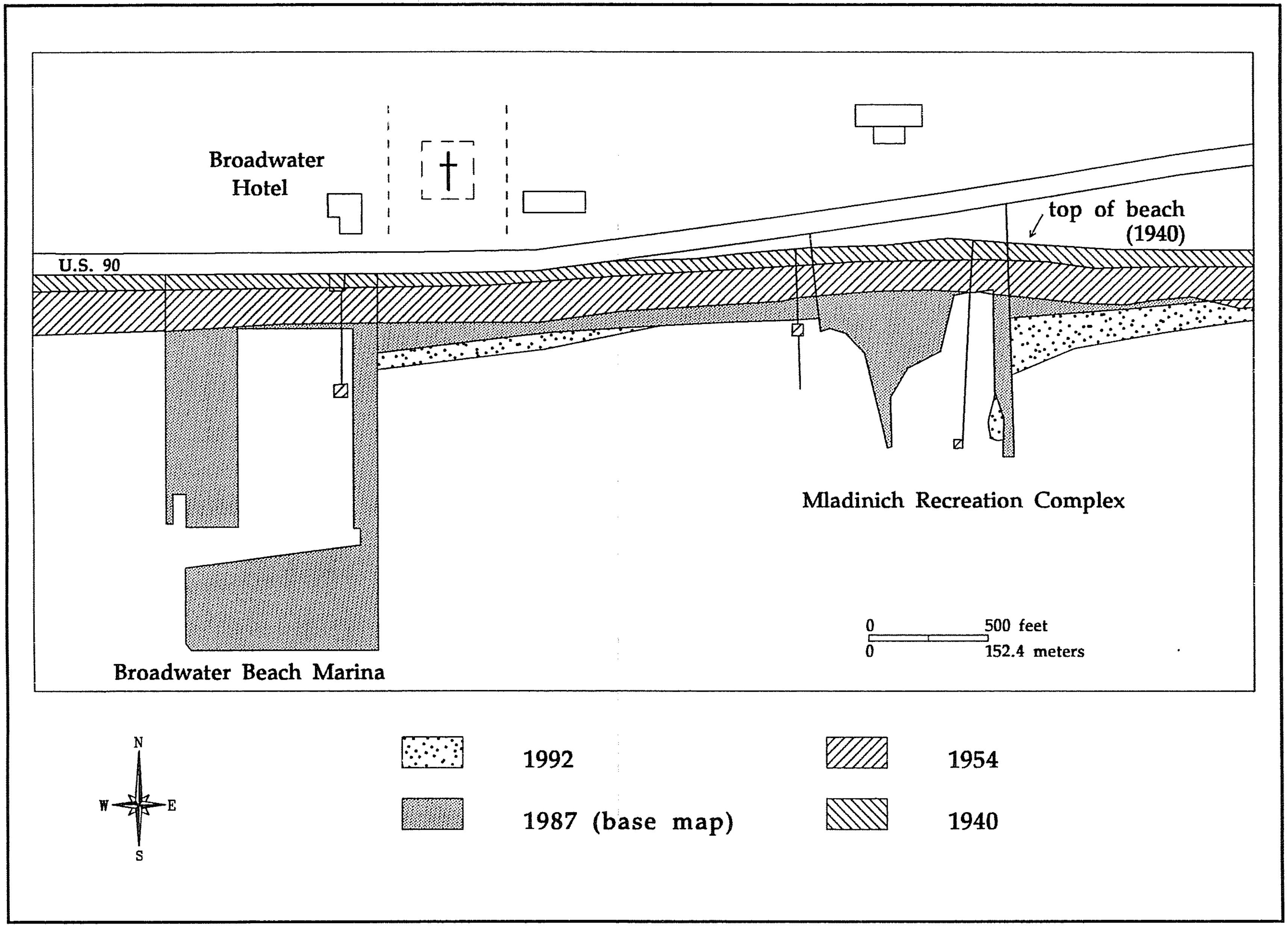


Figure 10. Nearshore changes, Broadwater Beach Marina and Mladinich recreational complex.

beach. The 1954 T-chart showed the new (early 1950s) 200-ft-wide sand beach (the new sand beach actually covered the seawall for about a mile beginning about 1000 ft east of the MRC). A large rectangular structure (the Sun'n'Sand Motel?) was squeezed in between the seawall and the highway, and a pier jutted out 900 ft into the Sound. To the west of this structure, Jake Mladinich began to build his "recreational complex". Beginning with a very narrow piece of property, Mladinich began to fill the beach and nearshore seaward of the seawall. This filling, which took place in the 1960s and 1970s, continued even after it became illegal to do so. Stories abound of night-time dumping of concrete riprap and fill dumped from trucks. Mladinich was able, both "legally" (before enforceable laws were in place) and illegally, to expand his property considerably. The western "prong" of the MRC (Figure 10) consists of concrete rubble illegally dumped. Along the eastern flank of the MRC, a 900-ft-long riprap groin (covered with fill upon which a road was built) was constructed (early 1980s?) as part of a harbor constructed by the Rodeway Inn. For several years, the harbor was home to a paddlewheel cruise ship, which offered dancing and dining cruises around the Sound. This venture did not succeed, in part because of the high costs of maintaining an approach channel into the harbor. The city of Biloxi was asked to take over maintenance of the harbor, but because the riprap groin was private and the benefit-cost ratio not too great, the city declined the offer (pers. comm., Mr. Larry Manuel, Biloxi chief engineer, Nov. 10, 1993). To accurately document the evolution of the MRC is quite difficult (Table 6).

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1954-1987	9.1	9.1	3	7	146,800	146,800	riprap various
early 80s	1.7	10.8	4	7	30,000	176,800	riprap pier

Table 6. Chronology of Nearshore Areal and Volumetric Expansion, Mladinich Recreational Complex
[length of shoreline impacted by nearshore reclamation and sand accretion: 840 ft]

The MRC, in spite of its semi-illegal genesis, in 1992 became a much sought-after property on which to establish casinos. Jake Mladinich sold out his lease (supposedly for $20 million, although there are still some legal complications), and the property is now (1994) the site of the Treasure Bay Casino. Right next door, the Rodeway Inn will soon be the site of the Lone Star Casino. It is obvious that further nearshore modifications are yet to be made.

7. Biloxi Waterfront

The historic City of Biloxi has experienced substantial modification of its shorefront and nearshore environment at two distinct locations: 1) the seafront adjacent to downtown (herein called the Biloxi waterfront), and 2) the distal "front beach" of Point Cadet, which faces Mississippi Sound, rather than Biloxi Bay, and is one of the major sites of the former flourishing seafood industry. (The latter is now the site of intensive casino development, and this has given rise to the now increasingly popular name "Casino Row".) With the exception of the Port of Gulfport, these two locations account for most nearshore reclamation in Harrison County.

The Biloxi waterfront represents the seashore edge of the Biloxi CBD (central business district), and its historical seaward expansion is linked to a combination of industrial (seafood), commercial, and recreational development. The oldest accurate map (1853) displayed considerable human modification in the form of wharf and pier construction and also smoothing of the natural dune scarp. The first Sanborn map (1893) showed a seaward shift of the shoreline (Figure 11), a shift mostly attributed to development of the oyster-canning industry. By 1893, there were several oyster-shucking houses along the Biloxi waterfront, and most of the 4.5-acre reclamation measured is attributed to in situ oyster shell disposal (Table 7). Although there was considerable commercial expansion onto newly reclaimed land into the 1940s, the foundation for this expansion still appears to have been oyster shells. One exception was a 400-ft-long sand beach built in the late 1930s near the present small craft harbor).

In the 1940s, state plans called for the four-laning of Beach Boulevard (US Hwy. 90). Because of the extensive commercial development in place, there was a problem in acquiring sufficient right-of-way to allow for adequate road widening. Furthermore, the

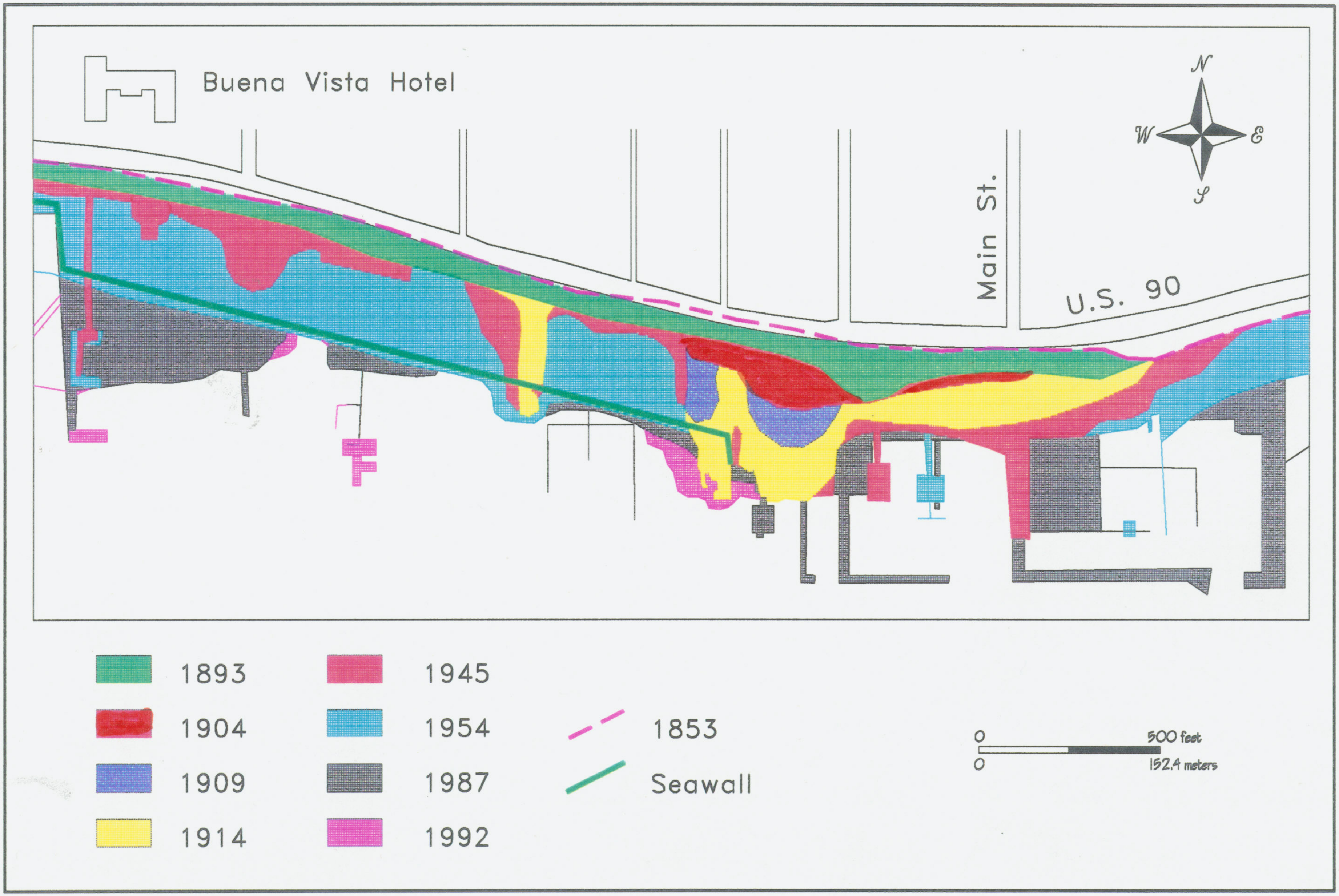


Figure 11. Nearshore changes, Biloxi waterfront.

1947 hurricane caused extensive damage along the narrow western half of the Biloxi waterfront. To solve the right-of-way problem,

Dates	Area (ac)	Cum. (ac)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1853-1893	4.5	4.5	2	2	29,000	29,000	shell
1893-1904	1.1	5.6	2	4	10,600	39,600	shell
1904-1909	0.8	6.4	2	4	7,700	47,300	shell
1909-1914	8.5	14.9	2	4	82,300	129,600	shell
1914-1945	3.7	18.6	3	4	41,800	171,400	shell
1945-1954	8.3	26.9	3	7	150,000	321,400	seawall backfill
1954-1987	6.8	33.7	4	7	120,000	441,400	shell/dirt rubble
1987-1992	0.7	34.4	4	7	12,400	453,800	shell/dirt rubble

Table 7. Chronology of Nearshore Areal and Volumetric Expansion, Biloxi Waterfront
[length of shoreline impacted by nearshore reclamation and sand accretion: 3520 ft]

the state authorized Harrison County to construct a seawall (7 ft above mean sea level), backfill behind the seawall, and grant property rights to the property owners displaced by the highway widening. Although state highway plans show a proposed seawall about 125 ft seaward of the pre-existing 1920s seawall (MS State Highway Dept., 1952), the county eventually constructed the seawall 250 ft south of the old seawall....apparently to balance the 250-ft width previously enclosed by seawall along the eastern half of the Biloxi waterfront. Once backfilled (with dredge spoil?), 8+ acres of new land had been added to the western half. Completed in the early 1950s (just prior to completion of the 4-lane highway in 1955), the new artificial accretion allowed businesses, such as the Buena Vista Motel (now the Biloxi Belle Resort Hotel) and Baricev's Restaurant, to relocate. Furthermore, in the 1950s and 1960s, several property owners reclaimed even more land south of the seawall and built structures (Baricev's) upon it (Figures 12 and

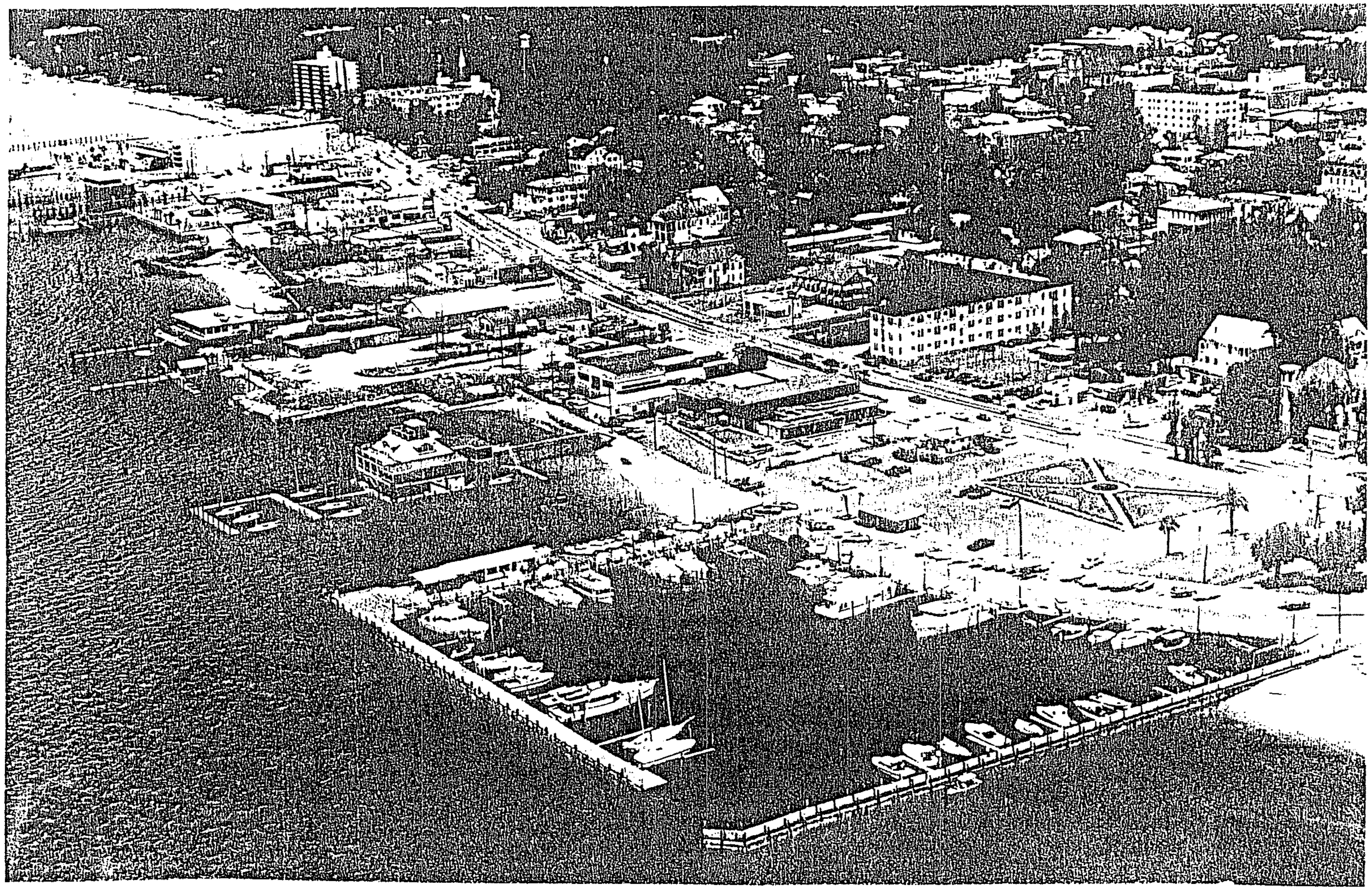


Figure 12. Biloxi waterfront prior to Hurricane Camille, 1969. (USACE, 1970)

13). Again, somewhat ironically, this semi-illegal (or semi-legal) expansion into the nearshore has now, in the early 1990s, provided a legitimate foundation for dockside casino gambling.

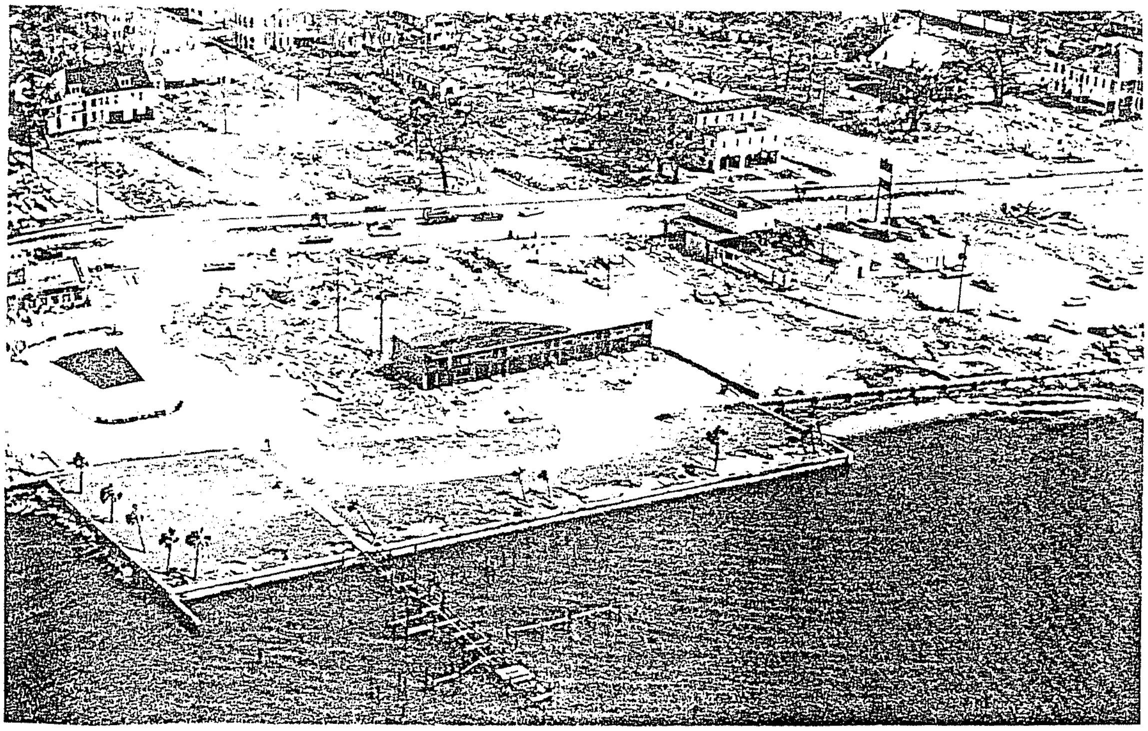


Figure 13. Reclaimed land (post-Camille) south of 1952 seawall, west Biloxi waterfront. (USACE, 1970)

One casino, the Biloxi Belle, bought up many of the businesses that were established on the reclaimed land (including the Buena Vista Motel, Baricev's Restaurant, Pat Peck Honda, and David M's nightclub) and has created a casino resort complex. A second casino, Gold Coast, opened immediately east of the Biloxi Belle in early 1994. Aside from some harbor construction and improvements, there has been relatively little new nearshore reclamation since the major seawall and backfill project of the early 1950s (and subsequent reclamation of land parcels south of the seawall).

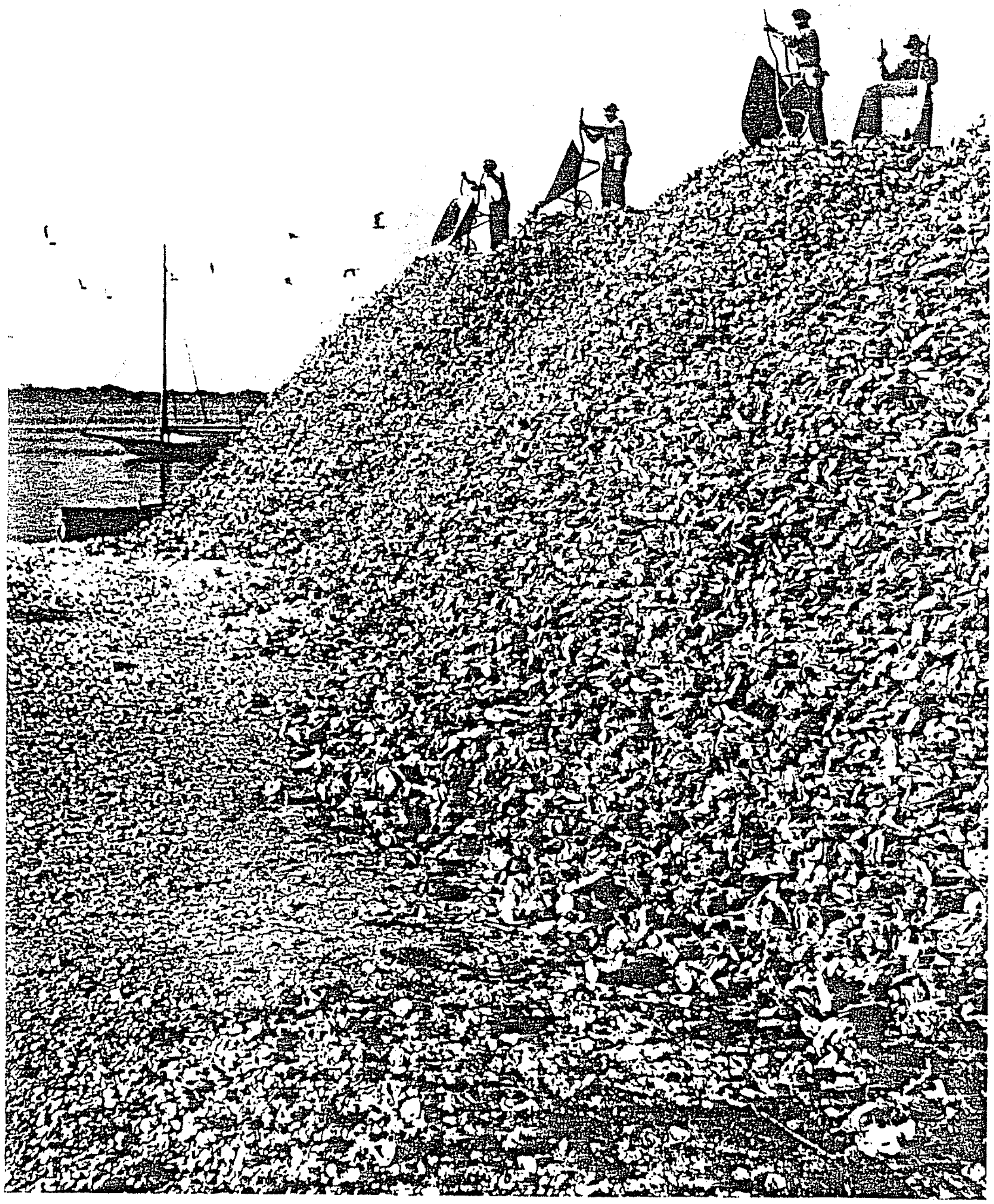
8. "Casino Row" (Front Beach of Point Cadet Seafood District)

At the very eastern end of Biloxi is the region known as Point Cadet. There are several parts to this region, including the point itself, the Back Bay area, and "front beach" (which abuts Biloxi's East Beach). The Point Cadet region, especially Front Beach, became the core of the city's seafood district beginning in 1880.

Once the technology of canning was perfected in the 1870s, it was found that both shrimp and oysters lent themselves well to canning. The first seafood factory, Lopez, Elmer and Company, began operation in 1880. During the off-season for seafood, the cannery kept workers employed by canning figs and other fruits and vegetables (Fountain, 1966). In 1884, a large factory operated by Lopez, Dunbar, & Sons (later known as Lopez-Dukate, and even later as Dunbar-Dukate) was built adjacent to the beach road along Front Beach. Trams on piers extended out to deep water where the fishing boats could unload their catch. Except for the shallow nearshore, Front Beach was ideal because it was sheltered from waves by Deer Island yet it was close to the natural tidal channel which later was dredged to become the Biloxi Ship Channel.

Within a few years, several more seafood factories located in this area, and by 1901, Biloxi ranked second only to Baltimore in terms of seafood production (Biloxi Daily Herald, 1902). That year, Lopez-Dukate Company alone shipped 525 carloads of shrimp and oysters, 26 trainloads of 20 cars each (Fountain, 1966). The bulky and important by-product of all this production was oyster shells, of which many thousands of cubic yards were produced annually. Many of these shells were used as paving material for roads and driveways, both whole and crushed, yet many if not most ended up being deposited in the vicinity of the seafood houses. Later, once fisheries scientists determined that oyster reefs in Mississippi Sound were being depleted, a law was passed by which 50% of harvested oyster shells had to be returned to reefs to insure maintenance of the oyster population (Carter and Ragusin, 1951). In spite of increasing removal of oyster shells in various forms, including poultry grit (ground up shells sold to England as feed), the excess in situ shells formed the foundation of extensive reclamation along Point Cadet's Front Beach (Figures 14 and 15; Table 8).

In spite of economic swings in the seafood industry, factories continued production and the Point Cadet seafood district along Front Beach continued to grow as more and more "beach-heads" were created by oyster shell disposal (Figure 15). In 1933, the easternmost "beach-head" (former site of Barataria Canning Co. and later Biloxi Grit Co.) became selected as a site for a U.S. Coast Guard station. Although no records have been found, it is estimated that about 90,000 cubic yards of fill were added to provide a high foundation for construction of the facility. Much



FROM OFFSHORE OYSTER SHELL MOUNDS LOOK LIKE DUNES ON BILOXI'S BEACH

Formerly this by-product of the oyster fleet was employed for roads, some of which still are in use alon[illegible] the coast. Now shells are returned to replenish reefs and create bottoms to grow more oysters, or ground [illegible] poultry grit, for which England is one of the important customers. Eleven million cans, more than half [illegible] the oysters canned in the United States each year, are packed at Biloxi. From late fall to early spring auxi[illegible] schooners pass through the channel offshore laden down and decks awash with their heavy cargoes (page [illegible]

Figure 14. Excess oyster shells along Point Cadet's Front Beach. (Hildebrand, 1937)

areal expansion took place in the 1925-1940 period, however, and it is difficult to separate the origins of the fill. Based on contours shown on the 1945 map (USCGS, 1949), the 90,000 cubic yard figure was calculated. (The old U.S. Coast Guard property is now the site of the Marine Education Center of the Gulf Coast Research Laboratory, a division of the University of Southern Mississippi.)

Dates	Area (ac.)	Cum. (ac.)	Depth (ft)	Elev. (ft)	Volume (cu.yd.)	Cum. (cu.yd.)	Type of fill
1880-1893	12.8	12.8	2	4	123,900	123,900	shell
1893-1909	8.2	21.0	2	4	79,400	203,300	shell
1909-1914	3.1	24.1	2	4	30,000	233,300	shell
1914-1925	10.6	34.7	3	4	119,800	353,100	shell
1925-1940	18.4	53.1	4	7	326,500	679,600	shell spoil?
1940-1945	2.7	55.8	4	7	34,800	714,400	shell dirt
1945-1954	1.1	56.9	4	4	14,200	728,600	shell dirt
1954-1992	3.6	60.5	5	5	58,100	786,700	shell concrete

Table 8. Chronology of Nearshore Areal and Volumetric Expansion, Casino Row
[length of shoreline impacted by nearshore reclamation and sand accretion: 3420 ft]

Since 1940, there has been relatively little new fill added, although a marina was added at the far east end. Hurricane Camille (1969) destroyed many of the businesses (Figure 17), but the heyday of seafood canning was already over anyway. Much of the seafood industry was inoperative in the 1980s, as facilities moved to Back Bay or (increasingly) overseas to places such as Korea. Beginning in the early 1990s, however, the old seafood district was transformed into prime casino real estate. Being away from public beaches and protected wetlands, the site became sold or optioned to casino operators. In 1992, the first casino opened in the region. By late 1993, two casinos were operating, two were under

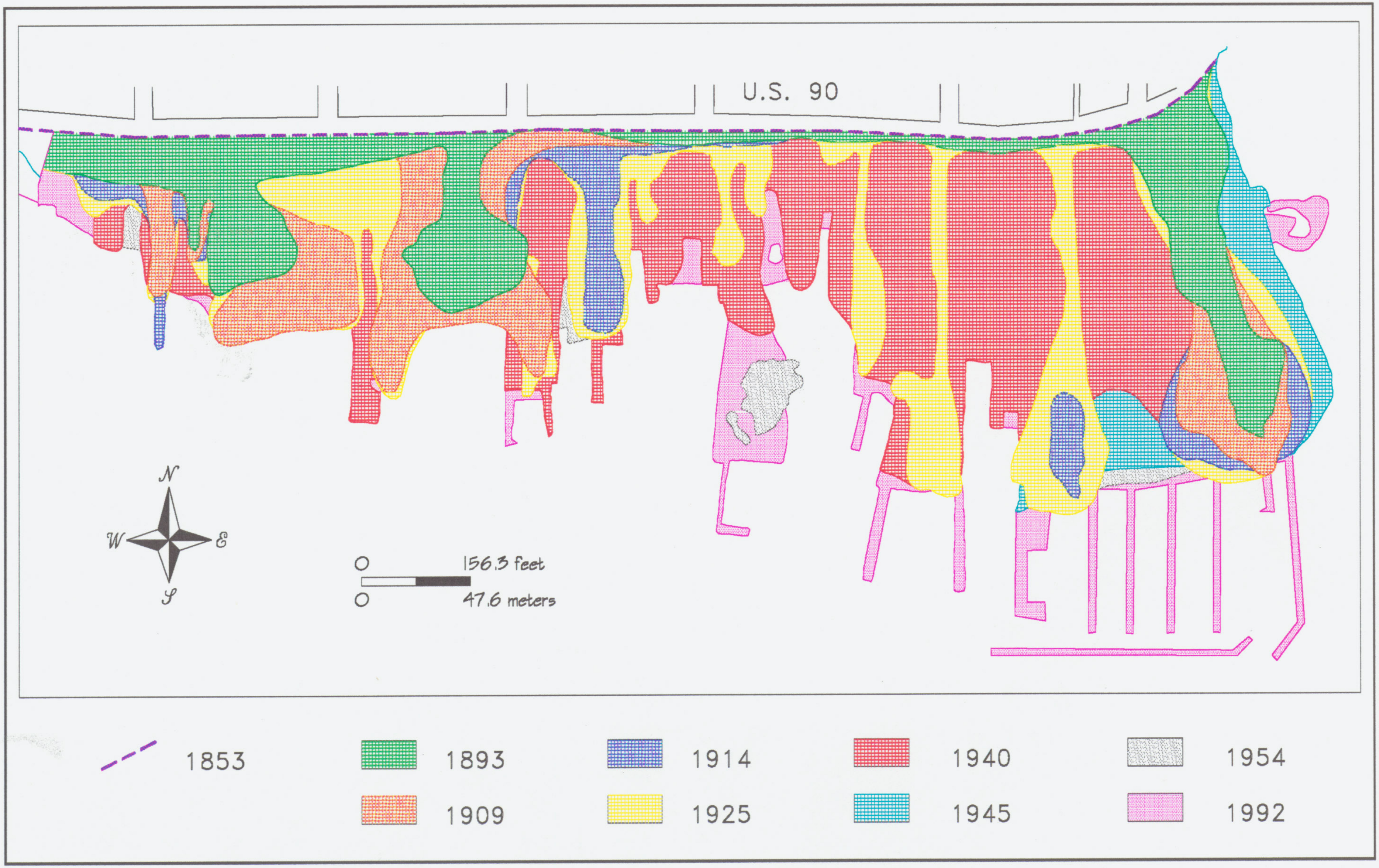


Figure 15. Nearshore reclamation, "Casino Row", Point Cadet.

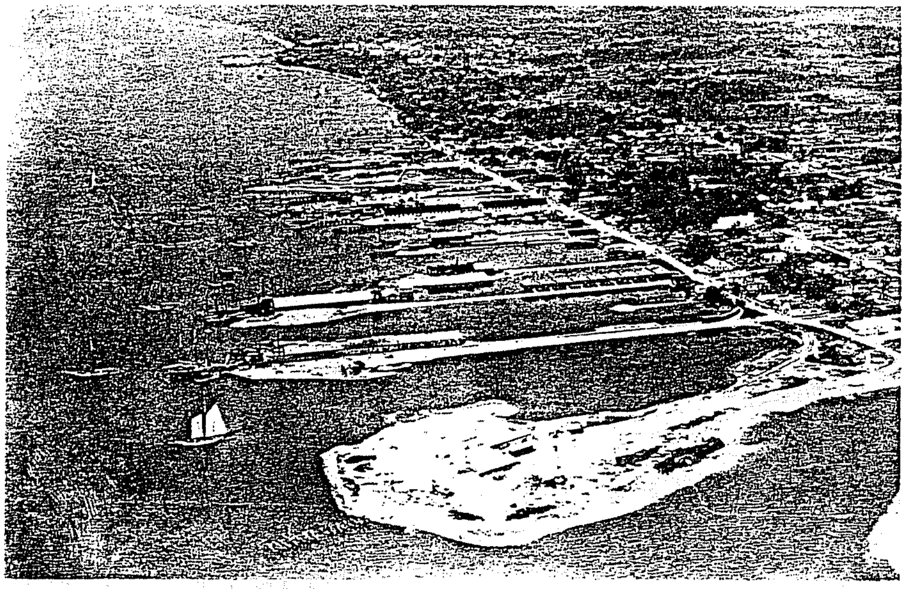


Figure 16. The seafood district, Front Beach of Point Cadet, circa 1930. (Hancock Bank, 1982)

Figure 17. Point Cadet's Front Beach Seafood District following Hurricane Camille, 1969. (USACE, 1970)

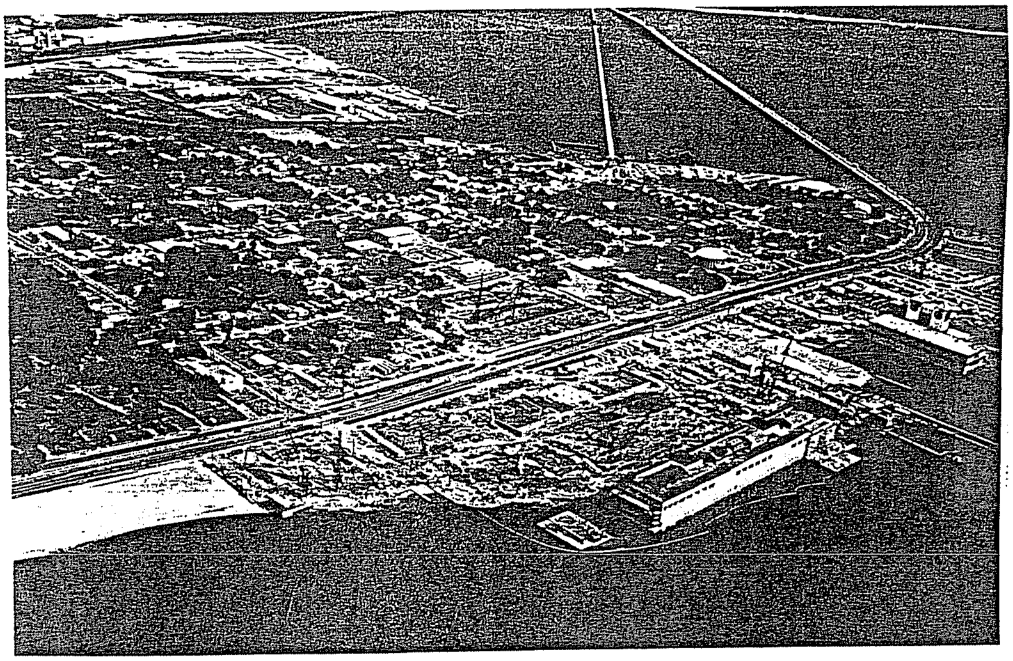


Figure 18. "Casino Row", September, 1993. (photo by author)

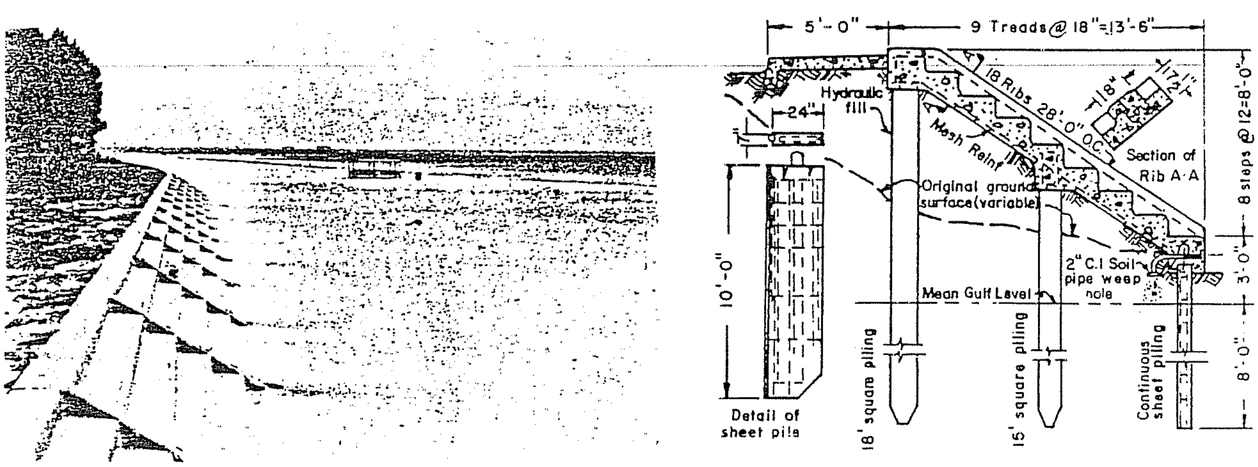


Figure 19. Concrete stepped face seawall, Harrison and Hancock counties, Mississippi.

construction, and three more properties were planned for development (Figure 18)....hence the name "Casino Row". All of the casinos made modifications in the form of grading their property with trucked-in fill, but as this process has not been completed, no research into "casino fill" has been conducted.

9. Beach Blvd./Seawall/Artificial Beach Complex (Harrison County)

Along the mainland shoreline of Harrison County, there has been substantial modification of the beach environment and reclamation of the nearshore environment aside from the eight zones just described. The "zone" in which these additional changes are found may be described as an interrupted "linear zone", which, in turn, may be described as Beach Boulevard, the Harrison County seawall, and the Harrison County sand beach. These three components of this "Beach Blvd./seawall/artificial beach complex" are discussed individually.

Beach Boulevard

As described in an earlier report (Meyer-Arendt, 1992b), the first true modifications to the Harrison County beachfront outside of the urban center can be traced to the creation of what has now become the four-lane Beach Boulevard (US Highway 90). Beginning in the late 1800s, the natural beach, which was up to 80 or 100 ft wide along many reaches, increasingly became used as a road. The main east-west artery was Pass Road, but the beach was popular for excursions, first by horses-and-buggies and later by automobiles, especially in the coastal reaches adjacent to the towns of Pass Christian, Gulfport, and Biloxi. As vehicles became mired in the often waterlogged sands, oyster shells, whole and later crushed, became employed for road fill material (hence the adopted name Shell Drive, or Shell Road) (Black, 1986; Sullivan et al., 1985). In places this shell road was built upon the backshore of the beach, yet in other places the road followed a course amidst the live oaks and above the Pleistocene dune scarp (bluff). In spite of a serious hurricane in 1893 which caused significant damage and shoreline erosion (Sullivan, 1988), the segments of the Shell Drive gradually became extended.

By the turn of the century, the beachfront contained telegraph poles and boardwalks and long reaches of the Shell Drive. Although another hurricane in 1901 caused extensive damage to the beachfront, plans for building a trolley line along the beach were not interrupted (Sullivan, 1988; Sullivan et al., 1985). When a 1909 hurricane caused serious damage to the shell road and new interurban trolley, petitioning for state involvement in erosion control began. A more severe hurricane in 1915 destroyed 50% of the beach roadway which was by then nearly continuous along Harrison County, and in the following year the Mississippi legislature passed a law committing the state to protect the beach "highway" (anon., 1930). Partly to ensure that the state commitment would be honored, the Harrison County communities linked and improved the old Shell Road and in 1918 incorporated it into the "Old Spanish Trail", a coast-to-coast highway development project sponsored by a coalition of local civic boosters. Rights-of-way were obtained, low areas were filled (source of fill unknown, but probably from local source areas, including the lowering of higher portions), and the road was graded and partially paved, a vast improvement over the oyster shells, according to Model T drivers (Bergeron, 1991) (Table 9).

Seawall

The 1915 storm directly stimulated seawall construction along the Mississippi coast. The greatest feat of all was the construction, at a cost of $3.4 million, of the 24-mile-long seawall fronting Harrison County, allegedly the second longest seawall in the world (Davis, 1988; MDWC, 1986). Funded by a state tax on gasoline, the 8-to-11-ft-high, stepped-concrete seawall (only 5 ft in some sections) was built between 1924 and 1930, although 1928 was the year it was officially dedicated (Charlier, 1984; Sullivan et al., 1985). Later, an additional 2 miles of seawall were added, making the total 26 miles (Burdin, n.d.). The seawall was backed by a new state-maintained beach highway. Both the seawall and the highway required backfill sediment which was obtained from dredging 1000 ft offshore (USACE, 1948). Based on a seawall engineering profile, it is estimated that 50 cubic feet of backfill was needed per lineal foot, for a total of 250,000 cubic yards for the seawall alone (Figure 19). Although the seawall proved to effectively protect the highway and coastal property in the absence of several storms, the narrow natural beach quickly disappeared, especially west of the Biloxi lighthouse. The lighthouse, sited on a small "headland", had been subject to erosion since the 19th century and was perhaps the first structure armored with riprap along the Mississippi coast.

Artificial Beach

The seawall performed its job of protecting the beach highway and beachfront infrastructure relatively well until the 1940s, although the natural fronting beach had disappeared. Several local efforts were made to retain a sand beach: in Biloxi groins were built along a 1-mile stretch to retain sand in 1936, and artificial beaches were created at Biloxi's Community House (400 ft long, at present site of the small craft harbor), and the Broadwater Hotel (see earlier section), and planned for west of the lighthouse (900 ft long) and near the White House Hotel. (The source of sand is unknown, but a precedent for beach nourishment in Harrison County was set in Gulfport in 1917, when sands were dredged from 800 ft offshore to create a sloping sand beach west of the harbor [Biloxi Daily Herald, Aug. 24, 1917].) Following a request by county officials in 1942, a 1944 study by the federal Beach Erosion Board pointed out the potential of seawall failure in case of storms and recommended the construction of an artificial beach to protect the seawall (Burdin, n.d.; USACE, 1948; Watts, 1958).

In 1947, a hurricane struck the Mississippi coast (Sullivan, 1988). This hurricane, the first significant storm since 1915, destroyed much of the Biloxi waterfront. Although the Harrison County seawall withstood the onslaught relatively well, several stretches of seawall were greatly damaged, and Harrison County requested that the U.S. Army Corps of Engineers assess the damage. In view of the assessment (USACE, 1948), it was recommended that an artificial beach be created to protect the seawall, with a high amount of federal funding (Wilson, 1951; Watts, 1958). Plans called for 5,700,000 cubic yards to be placed in front of the seawall, thereby creating a beach 265 ft wide and with a berm elevation of 5 ft. In 1950, Harrison County made the requisite repairs to the seawall, and in 1951 the artificial beach was constructed. About 6 million cubic yards of fill material, derived from a shore-parallel borrow area 1500 ft offshore (up to 14 ft deep) was used to create over 700 acres of 265-ft-wide beach along 26.5 miles extending from Henderson Pt. to the Biloxi Lighthouse (Escoffier, 1956b; Escoffier and Dolive, 1954; MacArthur, 1956; Walton and Purpura, 1977; Watts, 1958). (169,000 cubic yards of that total were for backfilling behind newly made seawall repairs [Watts, 1958].) The placement of sand on Biloxi's East Beach, between the Biloxi Waterfront and Casino Row, was an authorized county project undertaken in 1952-53 (1954, according to Burdin, n.d.). Over 500,000 cubic yards of sand was pumped, with the aid of booster pumps, onto East Beach from a source 6000 ft away (anon., 1952). In 1955, the State of Mississippi completed four-laning Beach Boulevard, and a period of rapid tourism development ensued.

Dates	Area/Location	vol. (yd^3)	cum. (yd^3)	type of fill
1880-1915	beach-beach road-shell road	?	?	shell
1915-1918	linking of shell road-paving	?	?	fill/asphalt
1924-1928	construction of seawall/backfill	250,000	250,000	dredged sand
1924-1928	backfill of highway	?	250,000	dredged sand
1951	700 ac. of sand beach, Henderson Pt. to Biloxi	6,000,000	6,250,000	dredged sand
1952-1953	25 ac. of sand beach, East Beach-Biloxi	506,700	6,756,700	dredged sand
1972-1973	beach renourishment	1,923,000	8,679,700	dredged sand
1987-1988	beach renourishment	1,124,000	9,803,700	dredged sand

Table 9. Chronology of Shorefront Fill, Harrison County Beach Blvd./Seawall/Artificial Beach Complex
[length of shoreline impacted: 26.0 miles]

The relative effectiveness of the 1951 beach nourishment project in protecting the seawall became apparent in the 1950s and 1960s as the Mississippi coast was hit by a series of minor and major hurricanes (Sullivan, 1988). There was loss of sand, however, and the beach gradually narrowed. A 1958 study accounted for most of the sand as having moved offshore, and a shoaling of the borrow pit was noted (Watts, 1958). When Hurricane Camille, Force 5 on the Saffir-Simpson scale and among the worst hurricanes ever to strike the U.S. coast, made landfall at Pass Christian in 1969, the Harrison County sand beach and the seawall withstood the storm relatively well (USACE, 1970). Although the beach was due for sand renourishment even before Camille, the hurricane stimulated the call for completing the job. A two million dollar beach renourishment project was undertaken in 1972 and 1973 (Brown & Russell, Inc., 1972; Dixon and Pilkey, 1991). From a borrow area 2000-2500 ft offshore, almost 2 million cubic yards of sediment were pumped onshore, re-creating a 265-ft-wide beach (Field Associates, 1986).

During the 1970s and early 1980s, the sand beach continued to shrink again, and estimates were that 100,000 cubic yards of sand were lost each year, about half to the offshore and the other half onshore because of wind erosion. Since that time, there have been several projects to slow the loss of sand to the wind, projects which included vegetative stabilization and feeder dune construction. In the early 1980s there were calls for another round of beach sand replenishment, optimistically in time for the 1984 World's Fair in New Orleans. The project was delayed for various reasons, and a series of minor-to-medium hurricanes in 1985 (notably Elena) caused extensive wave erosion of beach sands. In 1987-1988, a $3.4 million project renourished the sand beach with 1,124,000 cubic yards of sand dredged from offshore (Brown Engineers, 1987). The source of the fill came from immediately seaward of the 21 borrow areas utilized for the 1972-1973 renourishment project, varying from 2000 to 3000 ft offshore. Also, not the entire sand beach, but only critically eroded segments, was renourished (including Biloxi's East Beach), and once again the Harrison County sand beach was restored to its 1951 condition.

MISSISSIPPI SOUND

10. Ship Island/Gulfport Ship Channel

Many millions of cubic yards of sediment have been dredged in the creation and maintenance of the Gulfport Ship Channel. Accurate records have been kept since the onset of federal involvement in 1960, and these are stored as the U.S. Army Corps of Engineers, Mobile District, field office in Irvington, AL. Although sediments dredged during initial harbor construction were utilized to build up the Port of Gulfport, most sediments dredged from the Gulfport Ship Channel have ended up in waters adjacent to the channel. As the depth of the maintained channel has increased over the decades (from an initial 20 ft to a present 32 ft, and soon to be increased to 36 ft), the volume of sediments has increased accordingly. With the increased minimum channel depth, dredging at the Ship Island bar has increased. Some of these sediments, which were coarser silts and sands, have been used to provide beach nourishment at Ft. Massachusetts (on the west end of Ship Island) (Table 10). Due to the proximity of the Ship Channel to the west tip of the island and prevailing east-to-west longshore-drifting sediment, there have been high recent rates of channel infilling. This has increased the amount of dredging to maintain the channel. In 1993, a channel realignment began, and in the vicinity of the Ship Island bar, the ship channel will be displaced 1500 ft to the west. The impacts of this action upon maintenance of a beach to protect Ft. Massachusetts have yet to be evaluated.

Date	Volume (cu.yd.)	Type of fill
1975	385,000?	dredge spoil
1980	50,000-100,000	dredge spoil
1983	109,600	dredge spoil
1991	58,500	dredge spoil
from dredge records, US Army Corps of Engineers, Mobile District		

Table 10. Chronology of Subaerial Dredge Spoil Placement, Ship Island

11. Deer Island/Biloxi Harbor Navigation Channel

Biloxi has maintained a commercially active harbor since the early 1800s. Federal jurisdiction over the navigation channel leading to Biloxi dates to the 1880s (U.S. Dept. of Army, 1953), and today a 12-ft-deep, 150-ft-wide channel is maintained into Biloxi Harbor from Biloxi Bay in the east (East Approach Channel) and a 10-ft-deep, 150-ft-wide channel is maintained into Biloxi Harbor from Mississippi Sound in the south (West Approach Channel) (Figure 20). The deeper and historically most used approach to Biloxi is from Biloxi Bay because of its sheltered location in the

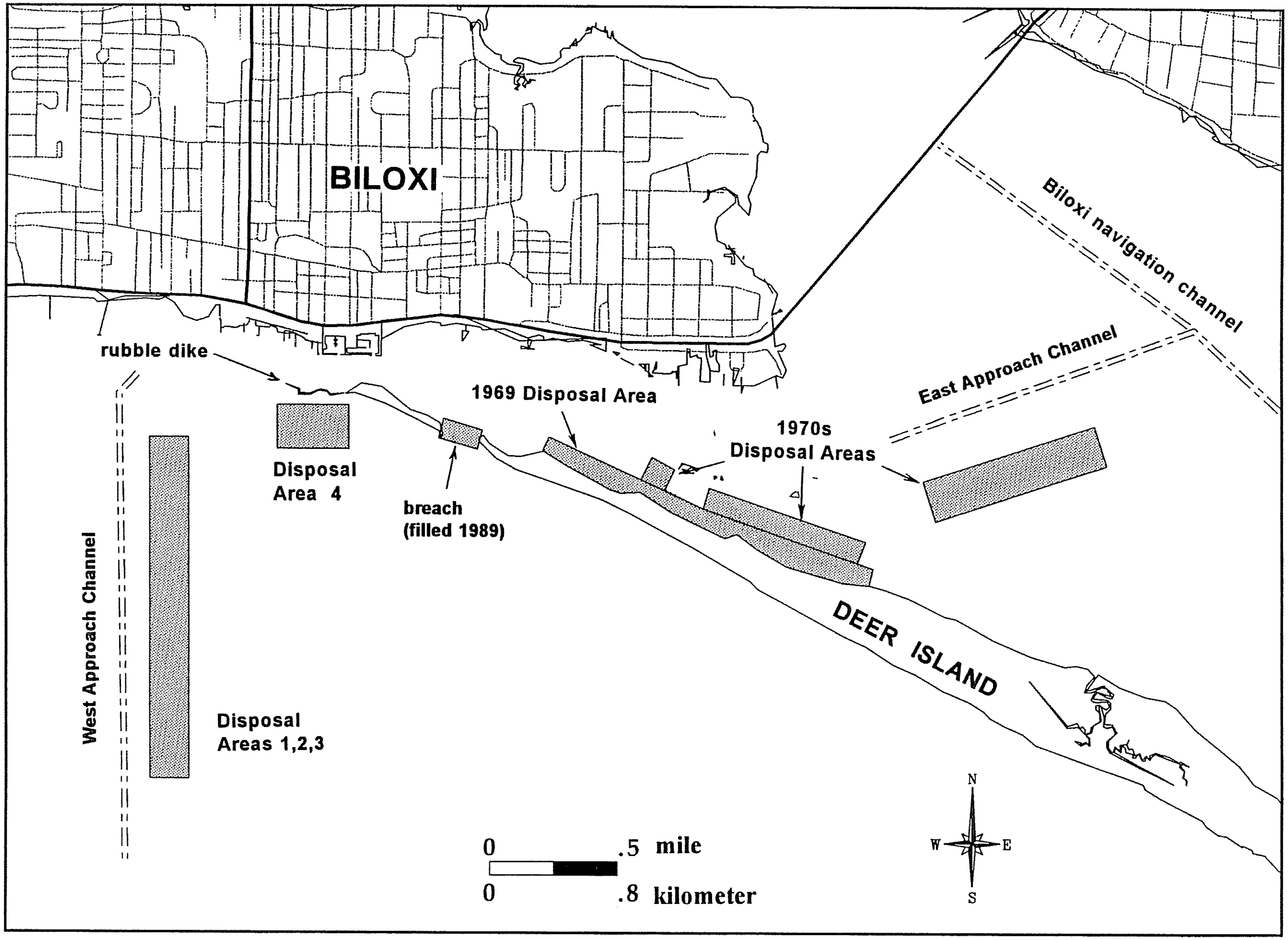


Figure 20. Dredge spoil disposal areas, Biloxi navigation channel and approaches.

lee of Deer Island. This wave sheltering extends also, as noted previously, to the Biloxi Waterfront and to Casino Row.

Although a natural tidal channel occupied (and occupies) the zone where the west tip of Deer Island comes close to the mainland, shoaling was characteristic of both approaches to Biloxi Harbor. Today dredging is important along the entire ship channel. Dredge spoil is normally disposed of adjacent to the channel being dredged, but by the 1950s some of the dredge spoil had become subaerial. Mississippi now has regulations which state that dredge spoil deposited in water bottoms should not come to within 4 ft of the surface, so alternative water bottom sites must periodically be found. Table 11 below lists some of the records of recent maintenance dredging in the Biloxi Ship Channel and approaches that have, directly or indirectly, sub-aerial expression.

A perusal of dredging records on file with the U.S. Army Corps of Engineers in Irvington, AL, indicated that in the late 1960s, the official dredge disposal site was up against the northern edge of Deer Island. When Hurricane Camille breached and also removed part of the very western tip of Deer Island, it was decided to employ some restorative techniques. In 1976, a 1500-ft-long rubble dike was placed at the western tip of the island, and spoil was deposited "behind", or south of, the rubble dike. Also, along the north side of the island, the 1979 dredge disposal sites were relocated northward slightly, apparently because of shoaling. The western tip of the island was again renourished in 1981 (apparently because minor hurricanes in 1979 precluded a natural healing of the island), and as much as 100,000 cubic yards were dumped behind the rubble dike and in the breached area. The backfilled rubble dike seemed to have worked in protecting Biloxi Harbor from high wave energy, but the breach still was not healing as anticipated. In 1989, several years after the 1985 hurricane year (when Elena struck), another nourishment project added spoil behind the rubble dike and to the breach. Today, the breach is still open, but it is so shallow as to effectively dampen high wave energy.

Limitations of study

This project represents a first effort at documenting the sedimentary history of the beach and nearshore environment of Harrison County. Several different categories of sedimentary modifications have been presented. For many of these, such as the oyster shell disposal associated with the seafood industry, detailed records for some types were spotty or absent, and volumetric calculations were made on the basis of areal measurements from historic cartographic sources. For other types of modifications such as dredge spoil removal and disposition, records are fairly good for the last 30 or 35 years. In fact, some of these records are so detailed (before and after bottom profiles, dredge volumes by range line, etc.) that much more work can be done, especially in the vicinity of the Gulfport and Biloxi harbors and their respective approach channels.

Date	Place of fill	Volume (cu.yd.)	Type of fill
1969	in water adjacent to north side of Deer Is.	?	dredge spoil
1976	west tip of Deer Is.	?	riprap rubble
1976	west tip of Deer Is.	56,700	dredge spoil
1979	north of Deer Island, between 1969 site and 3 foot isobath	169,300	dredge spoil
1981	west tip of Deer Is. behind rubble dike	100,000?	dredge spoil
1989	west tip of Deer Is. behind rubble dike	?	dredge spoil
1989	in Deer Is. breach on west spit of island	40,000	dredge spoil
from dredge spoil records, US Army Corps of Engineers, Mobile District (volumes in gross cu. yds.)			

Table 11. Chronology of Subaerial Dredge Spoil Placement, Deer Island

In 1990, the Mississippi Secretary of State's office produced a series of maps and a report (Florida Engineering Services Corp., 1990) on the state's historic tidelands. All of the mainland sites discussed in this report were identified in the 1990 study, and this report should clarify much of the historic basis behind those "zones of nearshore modification and reclamation" along the

Harrison County shoreline. In spite of the many limitations to this study, particularly the lack of accurate data, it represents a "first effort" at better understanding historic human impacts along the Mississippi shores of Mississippi Sound.

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HANCOCK COUNTY BEACH PROJECT

by

Stephen M. Oivanki

INTRODUCTION

Hancock County maintains a seawall along twelve miles of the shoreline. Nine miles of this seawall face wave action from the Mississippi Sound, and this portion of the seawall is experiencing considerable washout behind the sheet pile and some collapse of the roadway adjoining the seawall. A six-mile-long beach was pumped in front of the seawall in 1967 to protect it from further degradation. Hurricanes in 1969 and 1985 eroded most of this beach away, and by 1991 only a few pockets of sand remained. The county decided in 1991 to fund a renourishment of the original beach area with a bond issue supplemented by funding from the seawall tax placed on gasoline sales in the county. The Office of Geology viewed this effort as an opportunity to monitor a new beach from its inception, and possibly gain some insight into the processes involved as the artificial beach becomes acclimated to the natural environment.

Working with the Hancock County Board of Supervisors and engineers for the proposed beach nourishment project, Brown and Mitchell Engineers, the Office of Geology established a shoreline monitoring system with beach profiles along the seawall from Bay St. louis to Bayou Caddy prior to the anticipated start of the nourishment project. The profiles would be used to monitor beach degradation, and the information gained from the monitoring would be transferred to county engineers to aid in the placement of future nourishment efforts.

ACKNOWLEDGMENTS

Many persons helped with the profile surveys discussed in this report. Office of Geology personnel who provided field assistance included Jack Moody, Philip White, Peter Hutchins, Barbara Yassin, Sandra Dowty, Stan Thieling, James McMullin, Michael Fayard, and Steve Champlin. Grain size measurement and statistical analysis of samples was performed by Philip White.

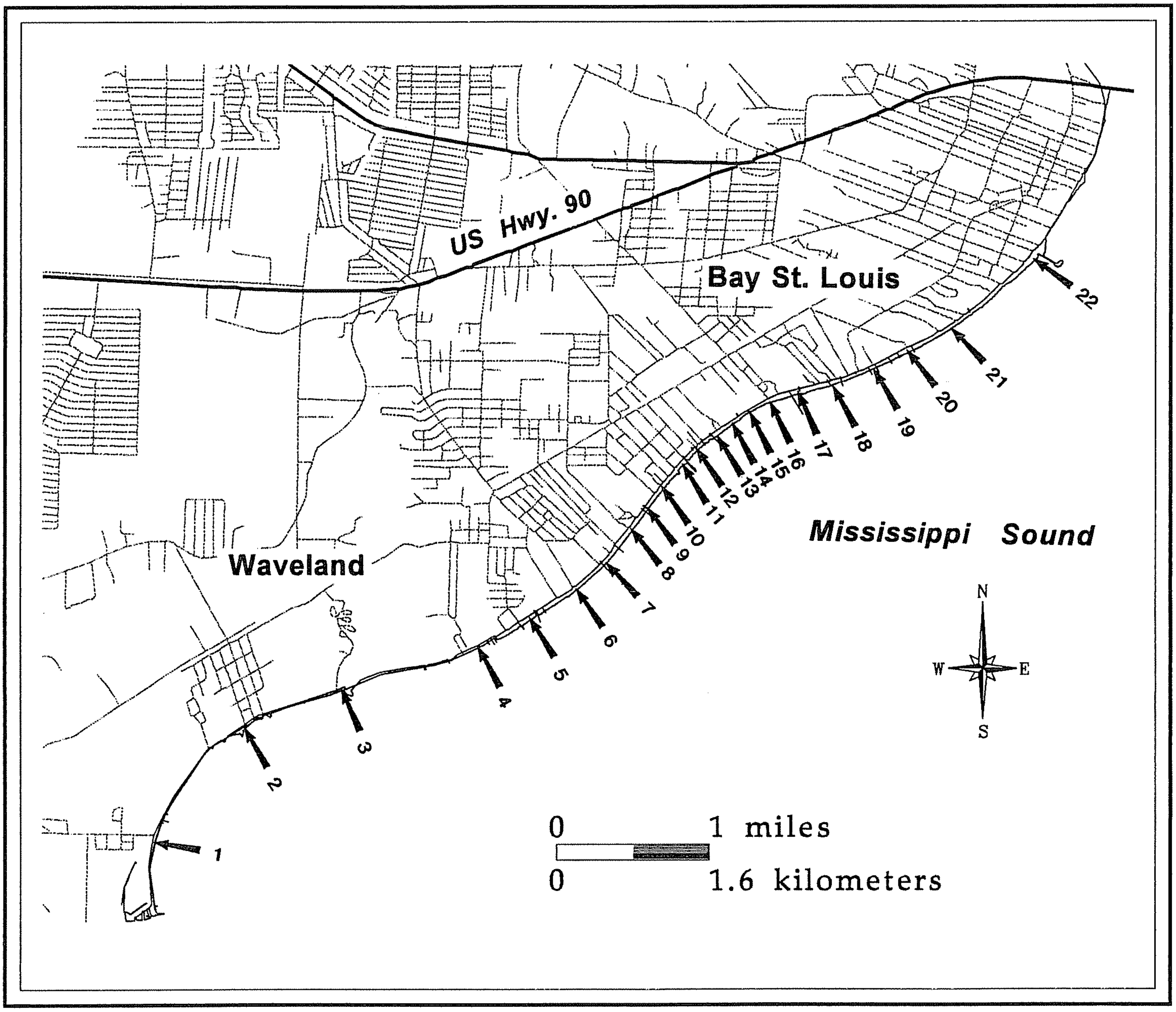


Figure 1. Location map for Hancock County beach profiles.

Figure 2. 1977 aerial photograph of Waveland shoreline showing sand bar pattern offshore.

RESEARCH METHOD

Twenty-two beach and nearshore profiles were established along the Hancock County shoreline in the fall of 1991 at intervals of 1500 to 4000 feet where the new beach was scheduled to be placed the next year. The profiles are tied to the U. S. Army Corps of Engineers mean-sea-level leveling along the seawall, which is a third-order survey based on the 1929 Mean Sea Level Datum. Wherever possible the profile stations are located on permanent Corps benchmarks, and elsewhere a mark is chiseled into the seawall and painted. The profiles are measured using a Wild total station and prism with an accuracy of +/- 0.01 foot. Profiles are oriented perpendicular to the shoreline and measured from the seawall offshore to a depth of approximately -4 feet sub-sea (wading depth), with horizontal prism spacing of approximately 10-20 feet at the discretion of the rod holder for the survey. Profile locations are described and located with GPS positions (Figure 1). Profile data are shown in the Appendix for this section.

Sediment samples were collected along the beach face from Bay St. Louis to Bayou Caddy and along several profiles from the shore out along the profile length to measure grain size sorting of the original beach material. Grain size analysis was performed using half-phi sieve intervals.

PROFILE DATA ANALYSIS

Profile HK-1 is located in an area which has never received any sand nourishment. The profiles surveyed in 1992 and 1994 show the same general cross-section with about a 6-inch reduction in bottom elevation. This indicates probable natural erosion of the bottom in this area over the two years between profile surveys. Profile HK-2, on the other hand, is located at the western terminus of the original 1967 nourishment, and shows an increase in bottom elevation over the same time period indicating sand migration into this area. The offshore bars on profile HK-2 remained in the same general position through the four year period. These offshore bars are composed of sand eroded from the original 1967 beach.

Profiles HK-3 and HK-4 are located in non-beach areas where the original 1967 beach has been completely removed by erosion. They show relatively little change since 1991 with only a slight increase in bottom elevation.

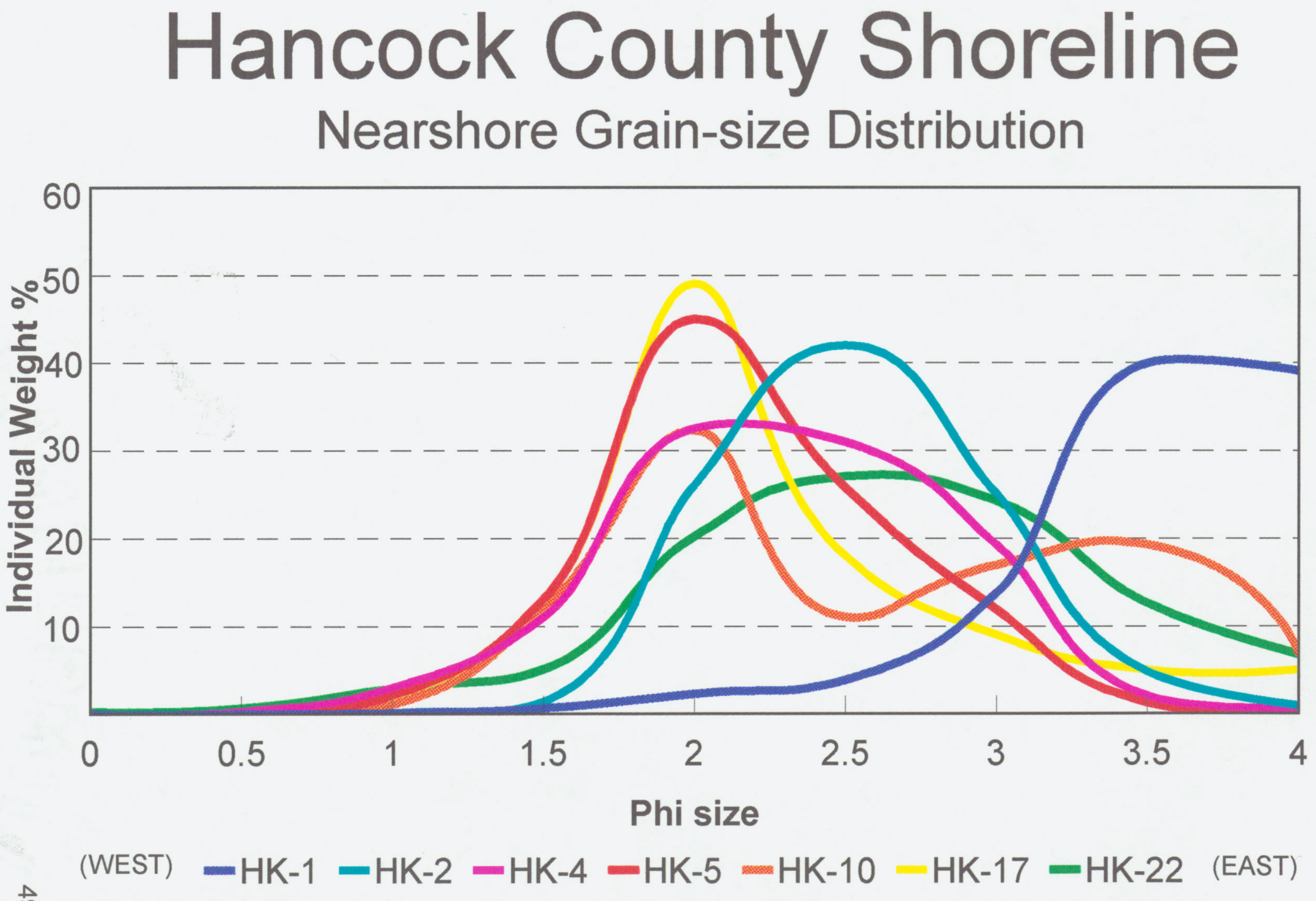
Profiles HK-5 through HK-22 are located along the shoreline nourished by the 1994 project. This area is dominated by offshore bar patterns formed through degradation of the 1967 beach. Aerial photography taken in 1977 (Figure 2) shows almost the exact bar pattern and location offshore that exists today. All of the bars are composed of sand from the original beach. Grain size analysis of sand along the Hancock County shoreline shows a trend of longshore transport and size winnowing from east to west consistent with the predominant wave incidence direction from the south-southeast (Figure 3). There was no noticeable grain-size distribution trend recognized perpendicular to the shore along any of the individual profiles.

1994 BEACH NOURISHMENT

The county was unable to pass the bond issue in 1992, and the beach nourishment was postponed until the fall of 1993. After extensive permit delays, sand pumping was finally begun in June of 1994. The sand source chosen for the nourishment was located about 1000 feet offshore near the eastern terminus of the beach area (see Figure 4). Of the permitted 5.7 miles of beach planned, only 4.2 miles were completed; the remainder was deleted from the project due to possible seagrass habitat damage.

The profiles established and maintained earlier were re-surveyed in 1994 following placement of the new beach. Complete composite profiles are included at the end of this section. The new beach is approximately 200 feet wide and fronts the entire shorefront of the nourished area. Storm water outfall drains were excavated under the beach to minimize surface erosion; however, Beach Blvd., which runs along the entire shoreline, still drains surface runoff directly onto the beach scouring deep runoff channels during heavy rain events.

There has been some concern expressed about the possibility of beach erosion concentrated directly behind the borrow area located near the shore. Previous experience in Louisiana has shown that deep dredge pits near the beach can cause exaggerated wave concentration and erosion. A wave refraction and sediment movement computer model (Shoreline Modeling System) has been obtained from the U.S. Army Corps of Engineers in Vicksburg to try to predict the possible future effects of this pit on the new beach. Additional profiles were established directly behind the new borrow pit, and detailed bathymetry has been surveyed over the pit area. The model will be run as soon as time permits. The Office of Geology Coastal Section will continue to monitor the new beach through the coming years.


Hancock County Shoreline
Nearshore Grain-size Distribution
Individual Weight %
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3
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HK-5
HK-10
HK-17
HK-22
(EAST)

Figure 3

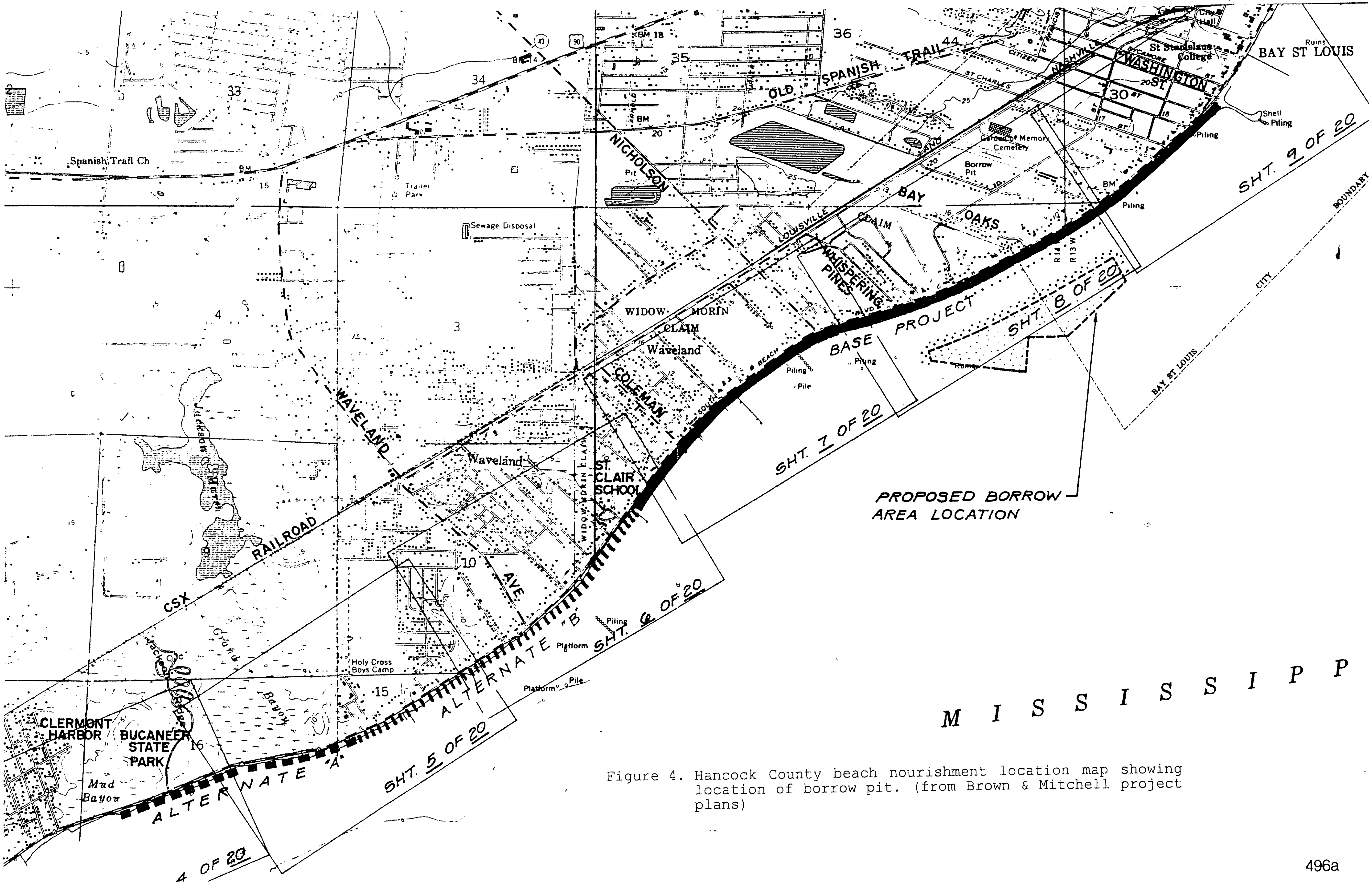
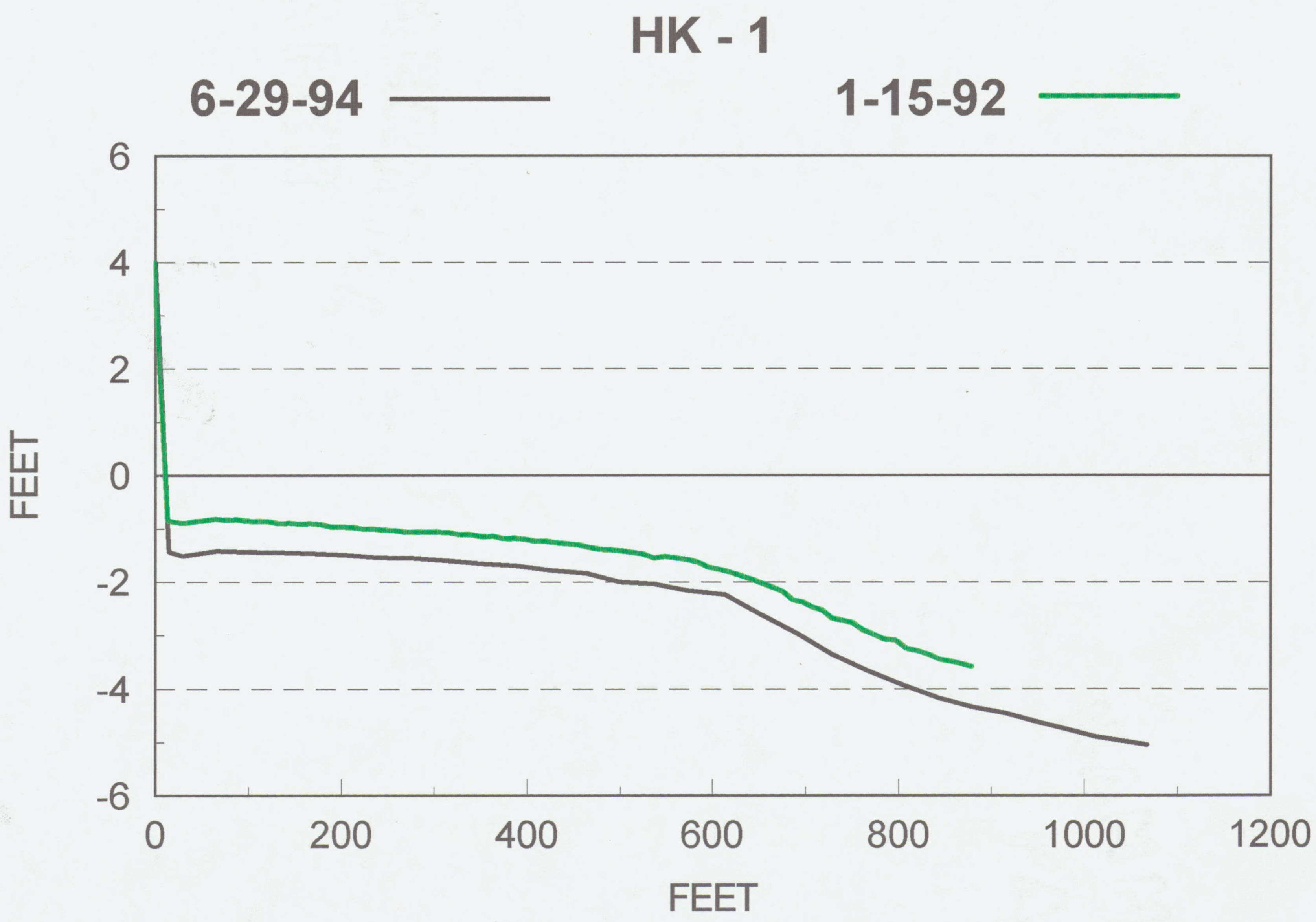


Figure 4. Hancock County beach nourishment location map showing location of borrow pit. (from Brown & Mitchell project plans)

APPENDIX

Beach and Nearshore Profiles in Hancock County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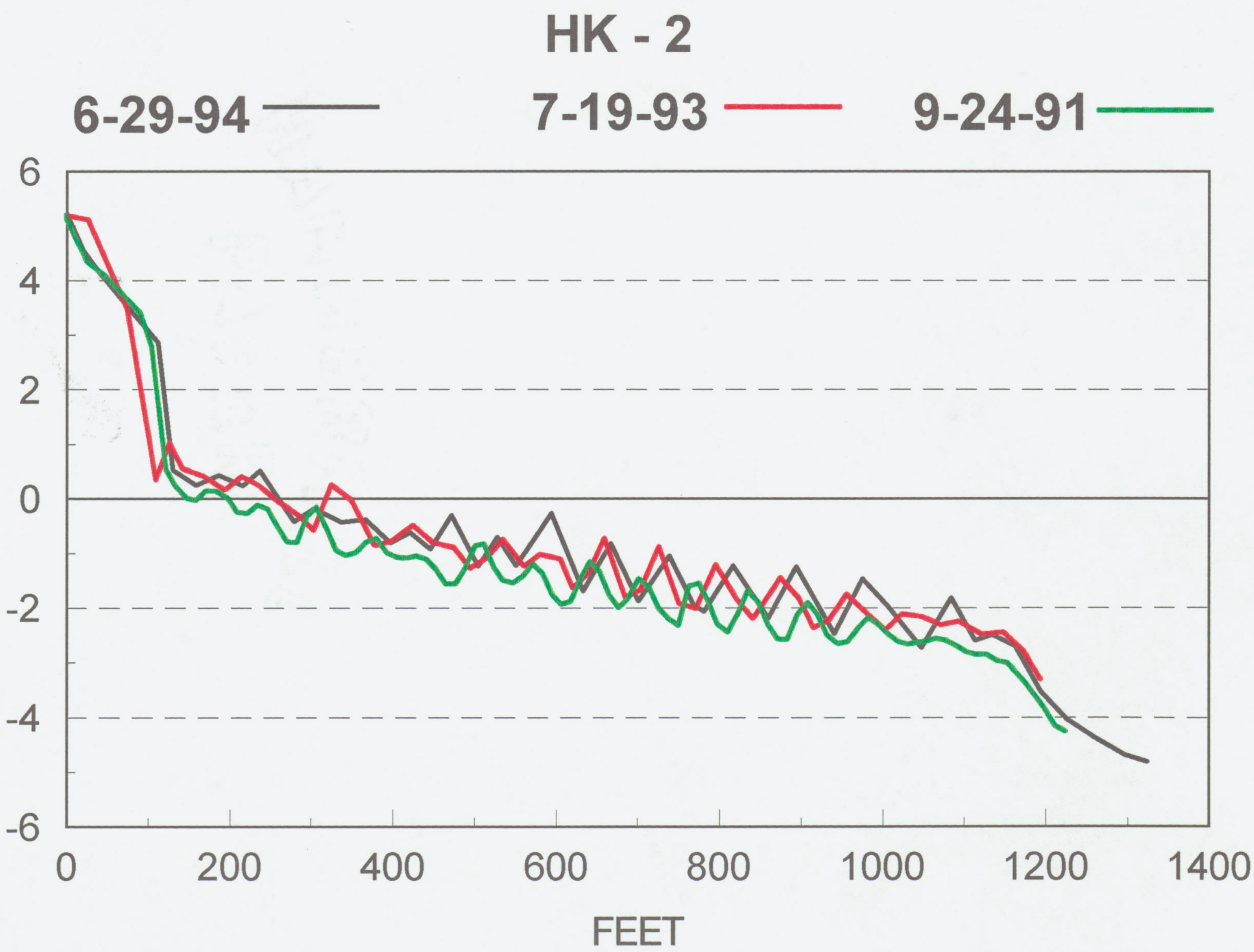
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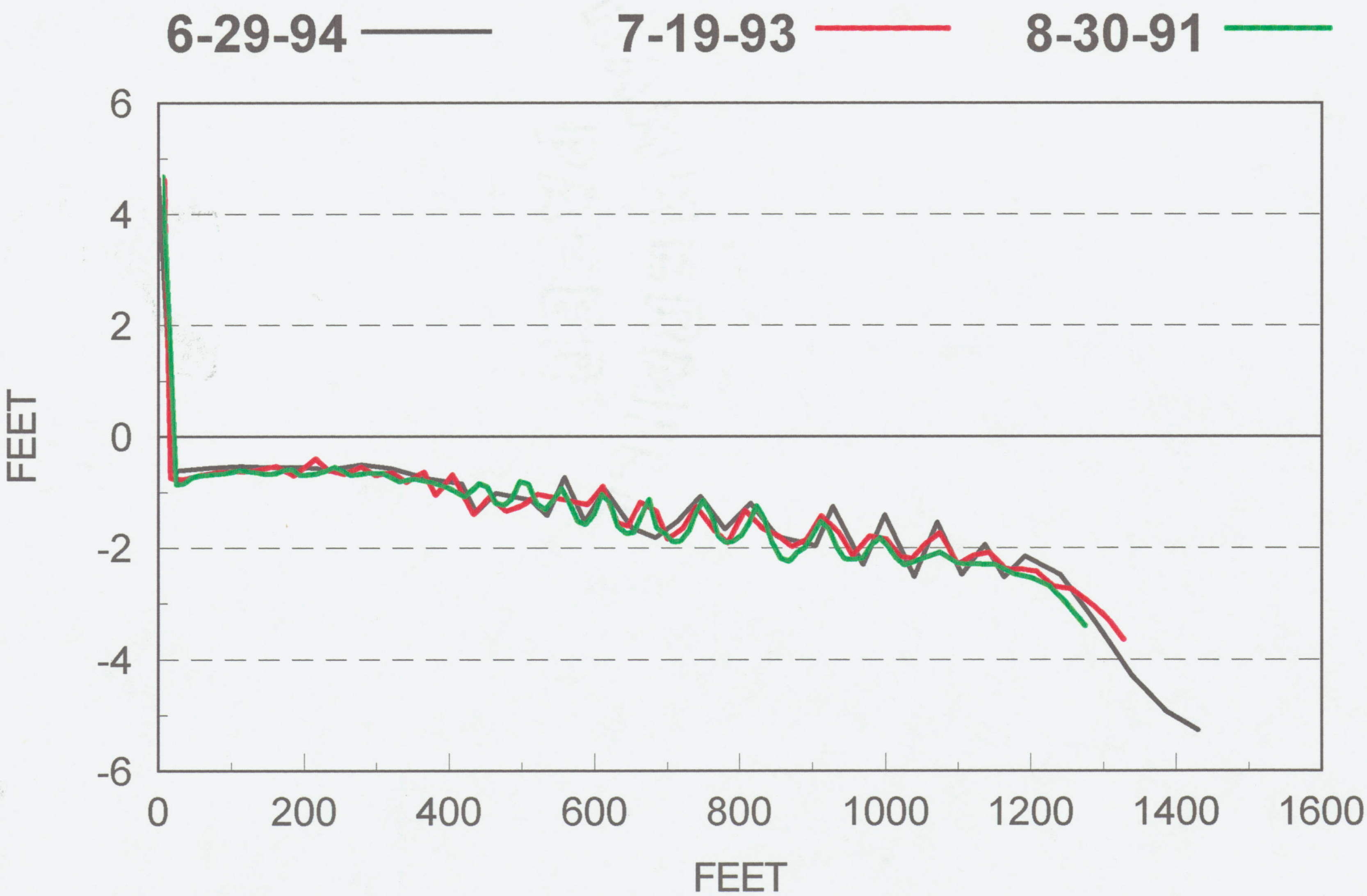

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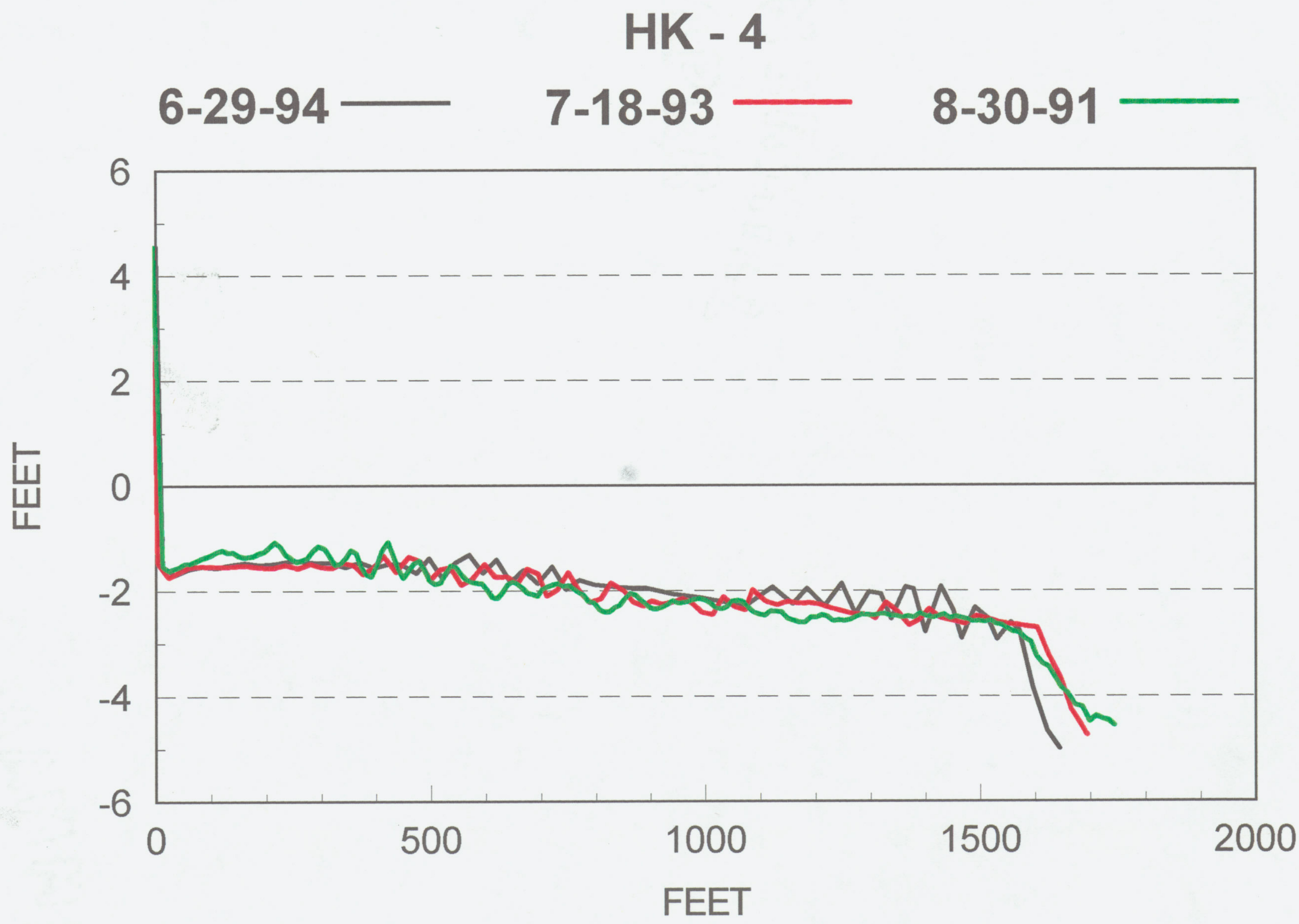

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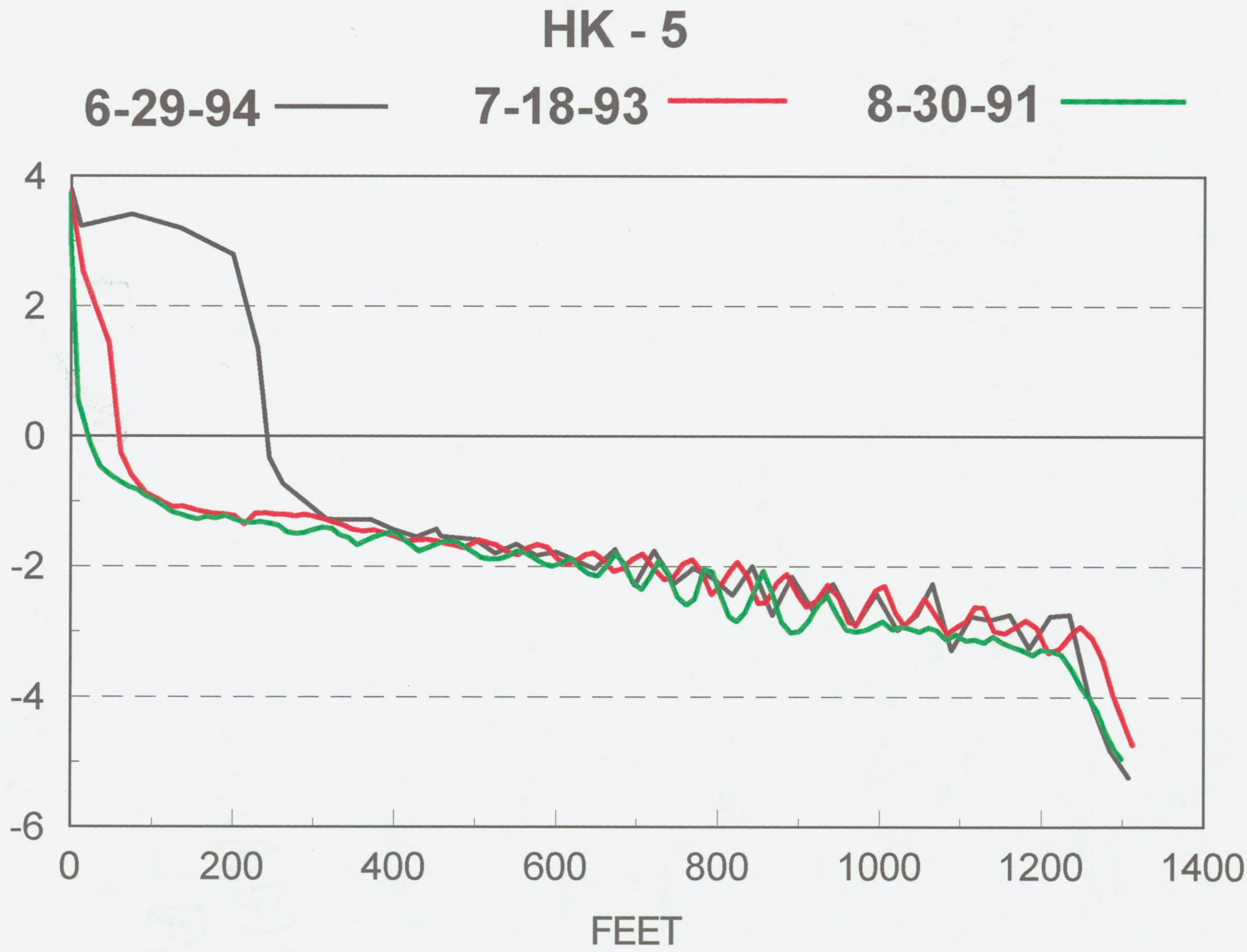
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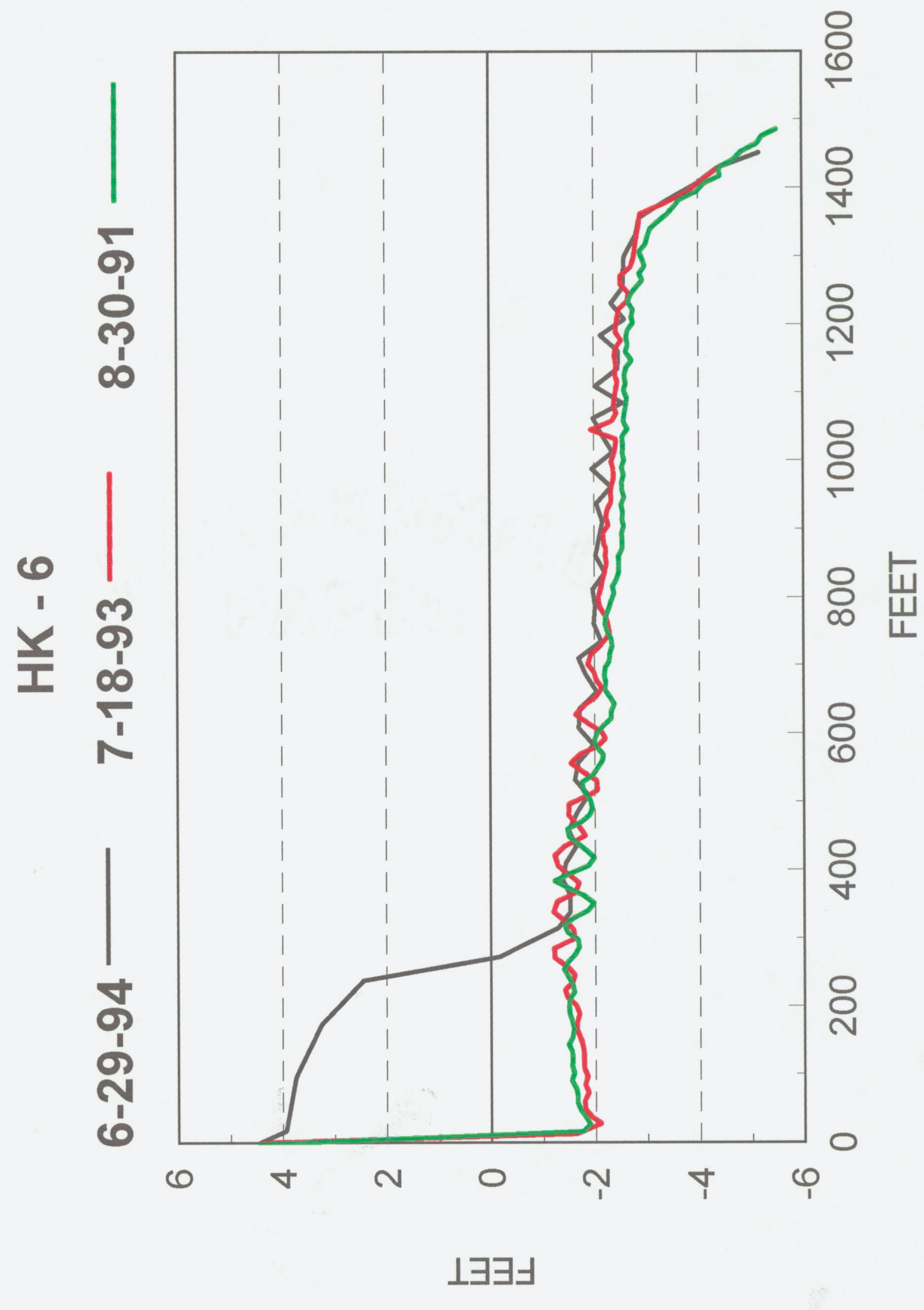

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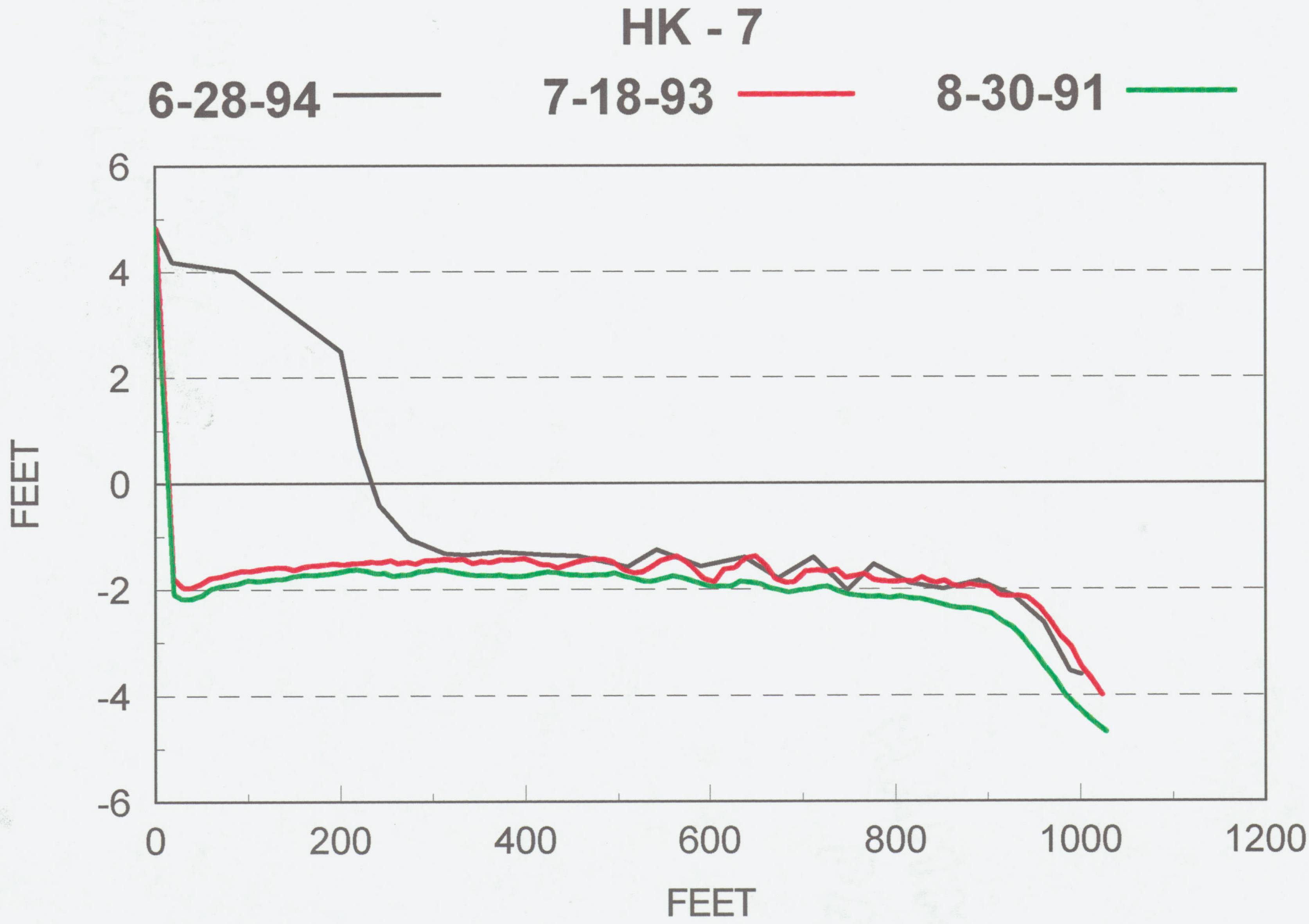

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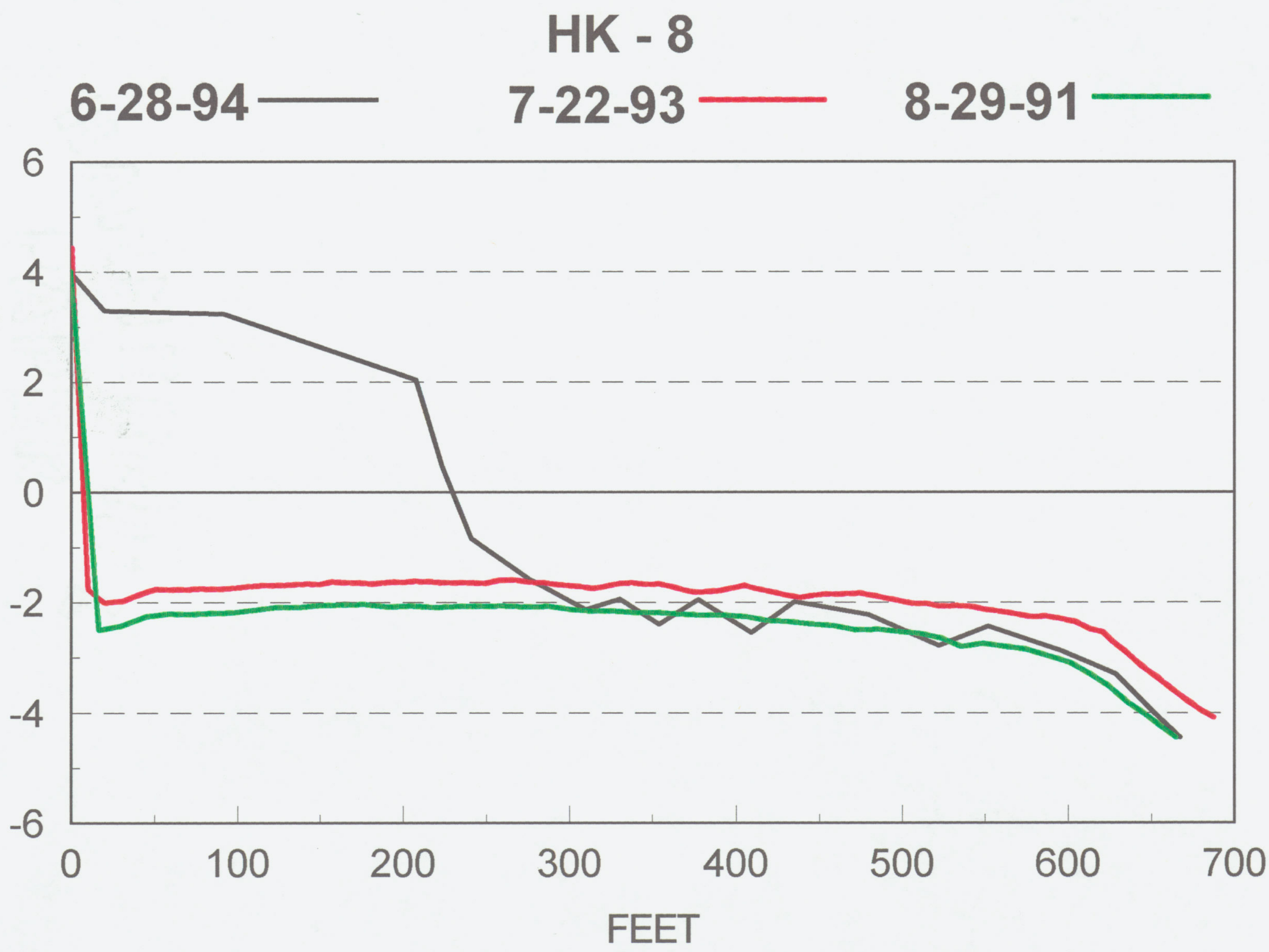

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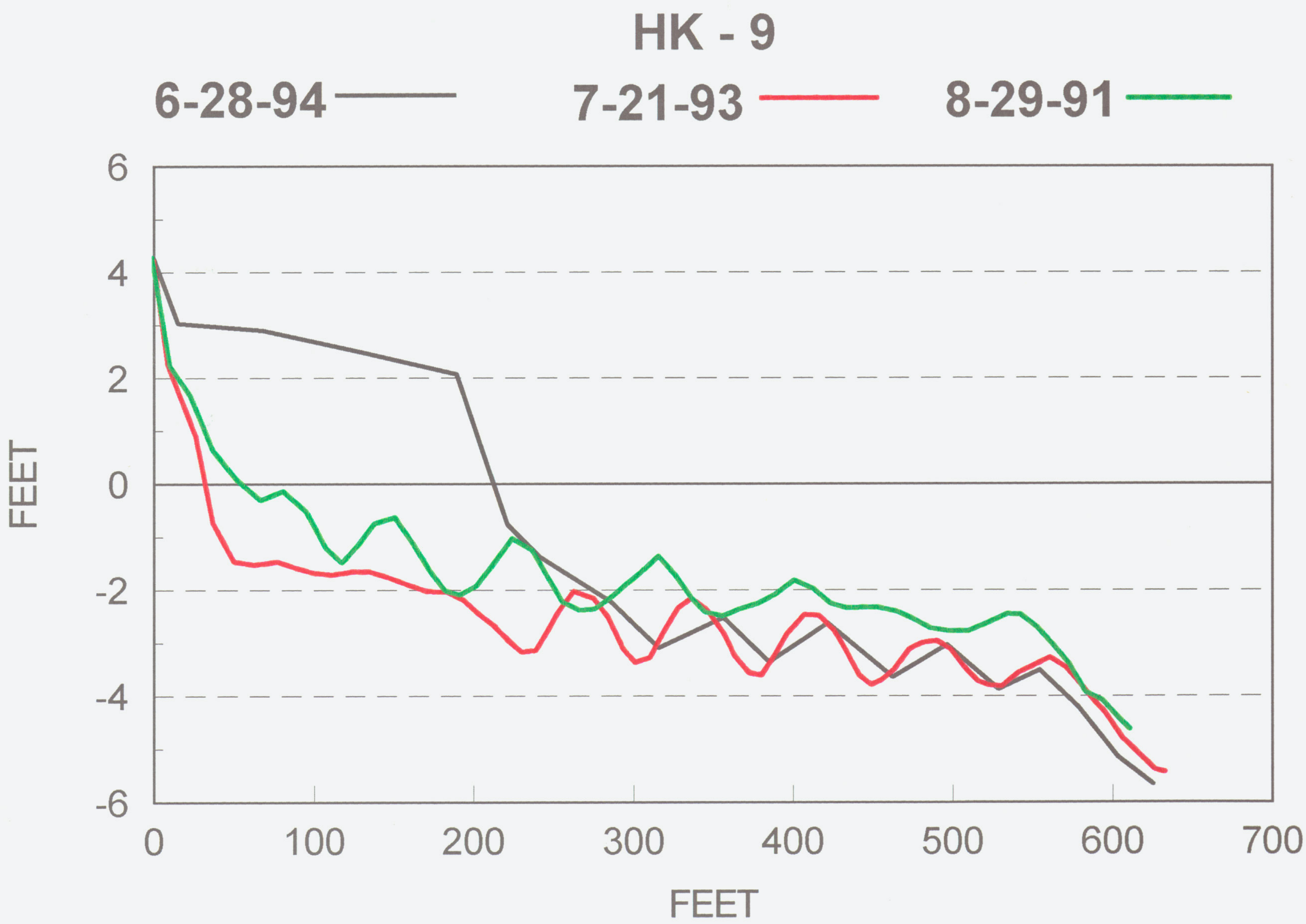
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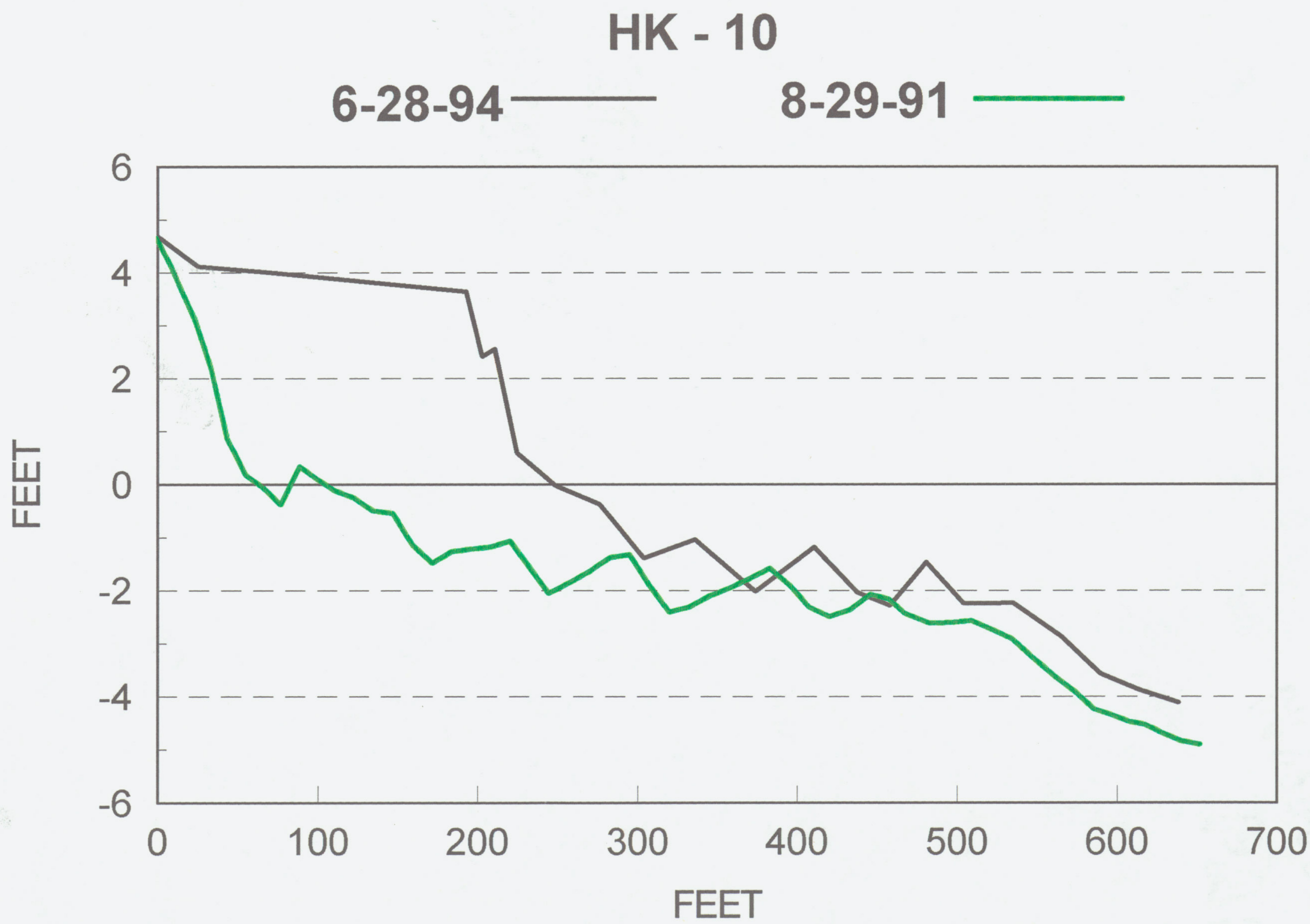
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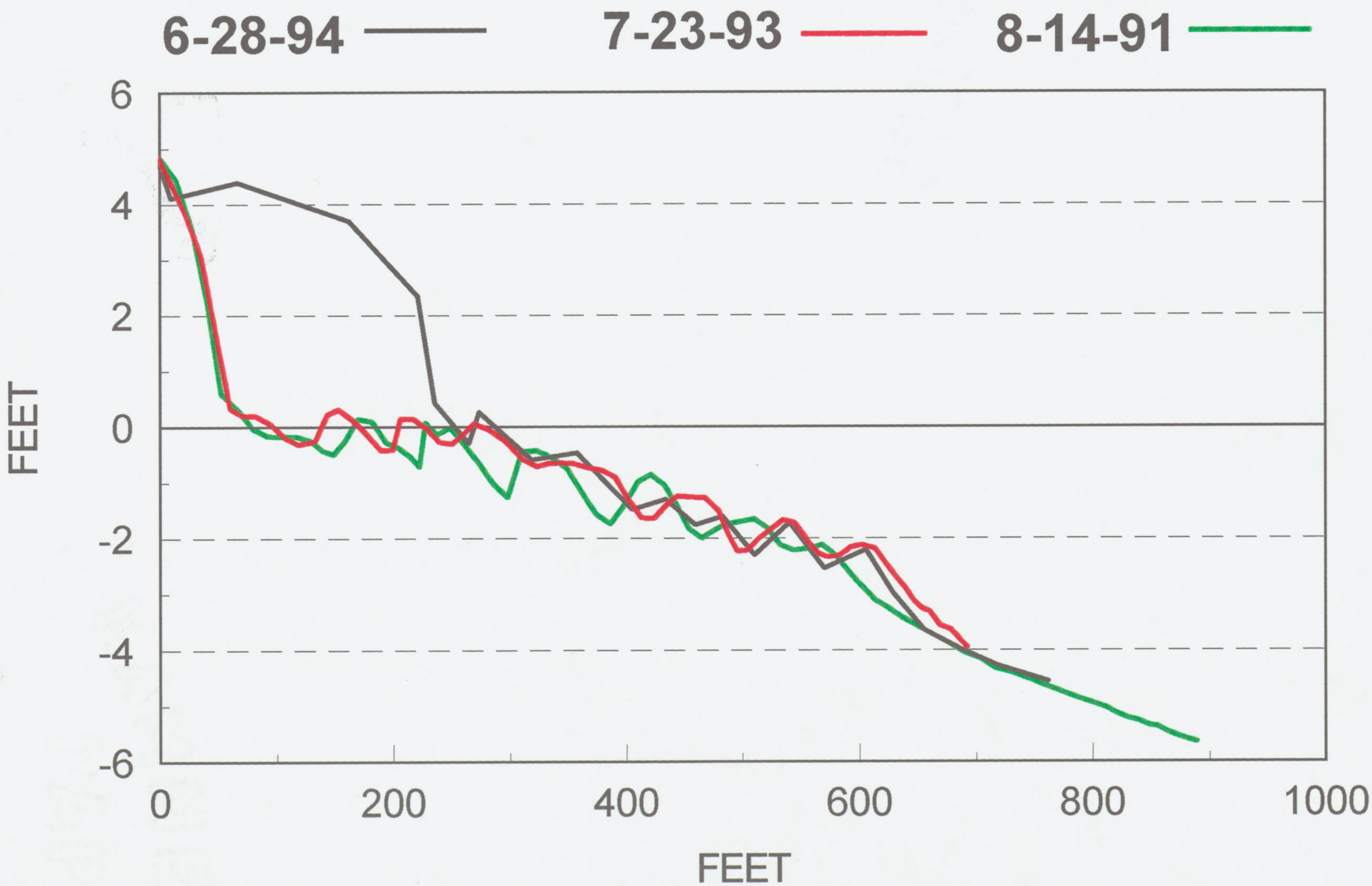

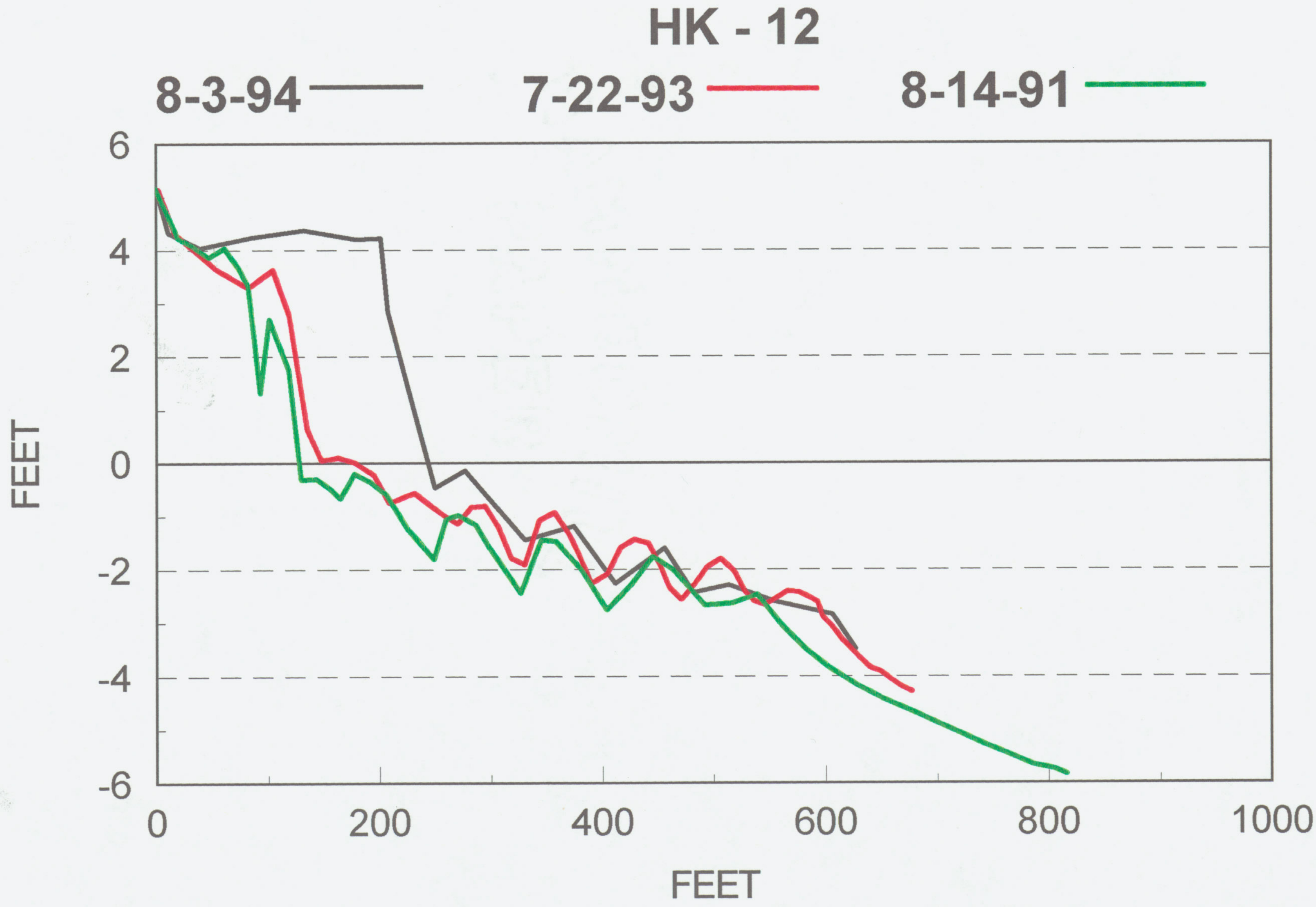
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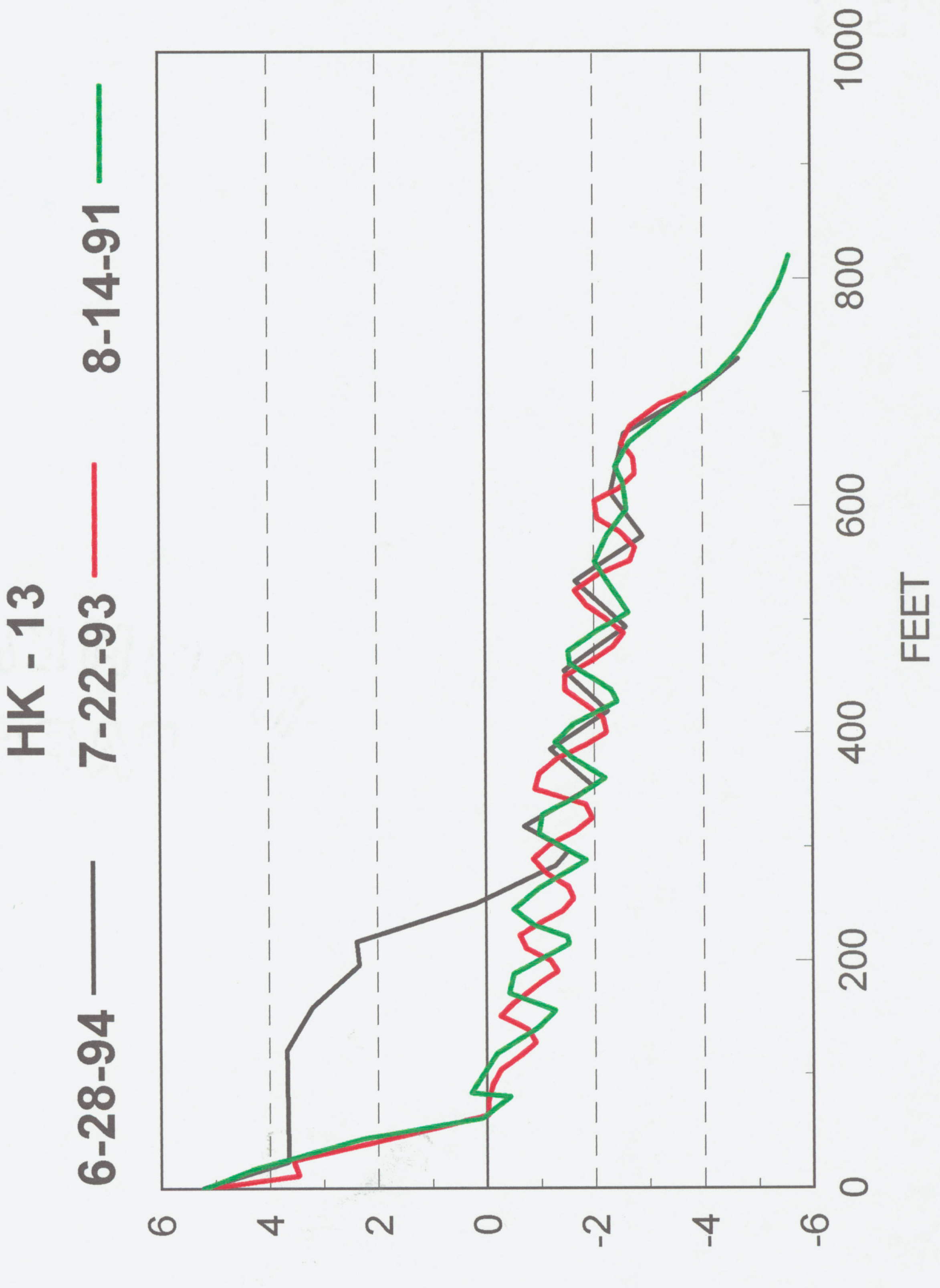
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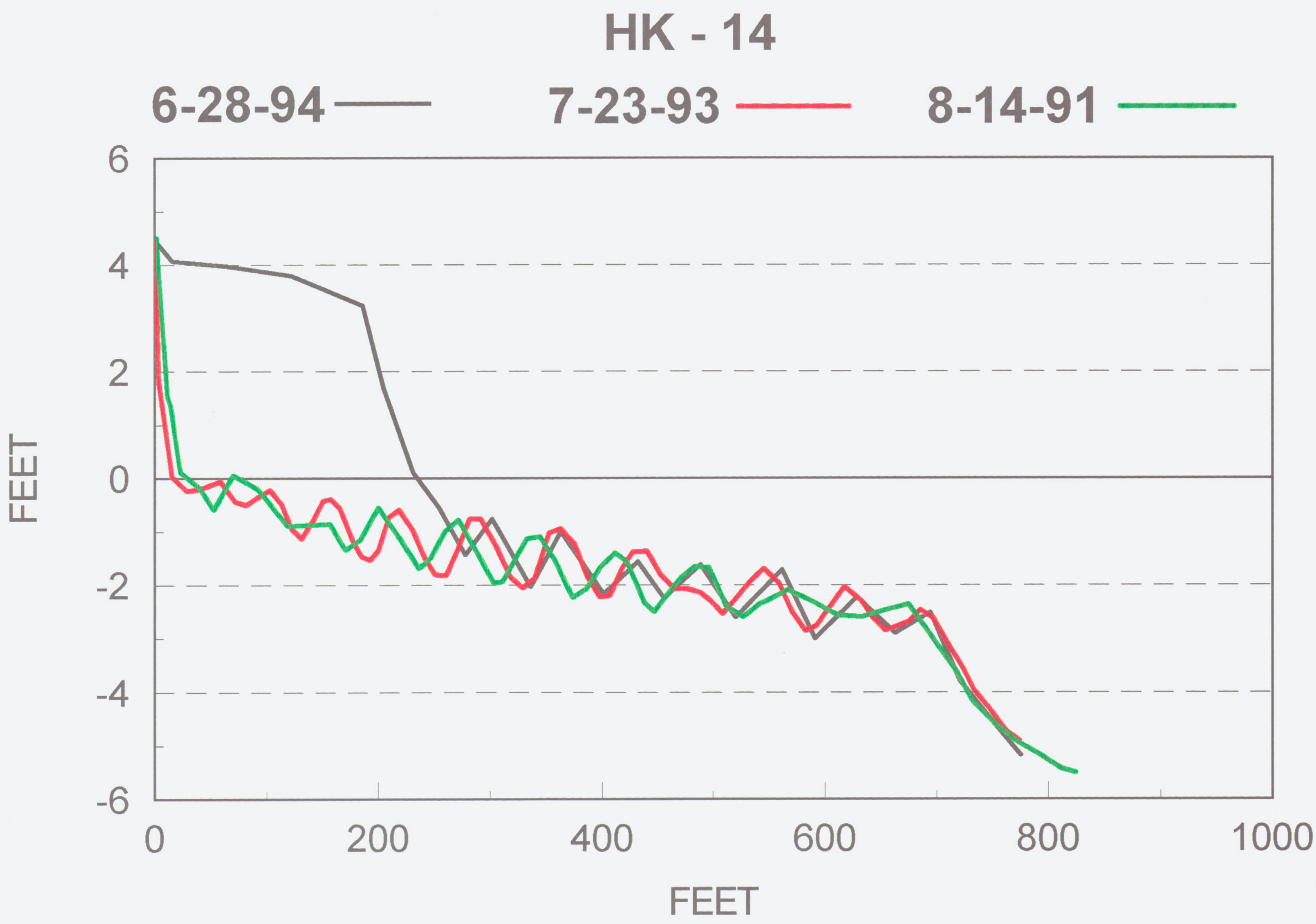

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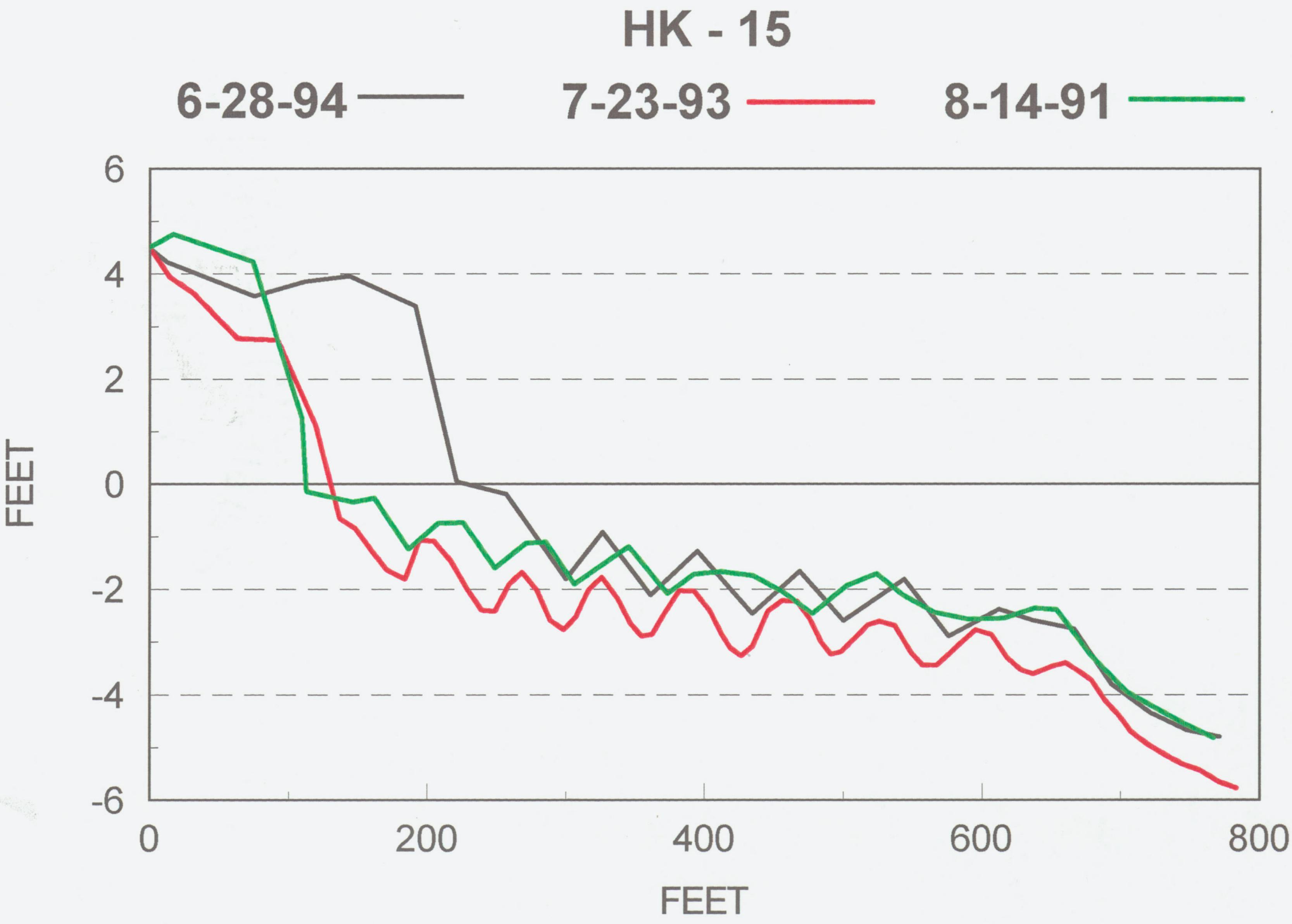

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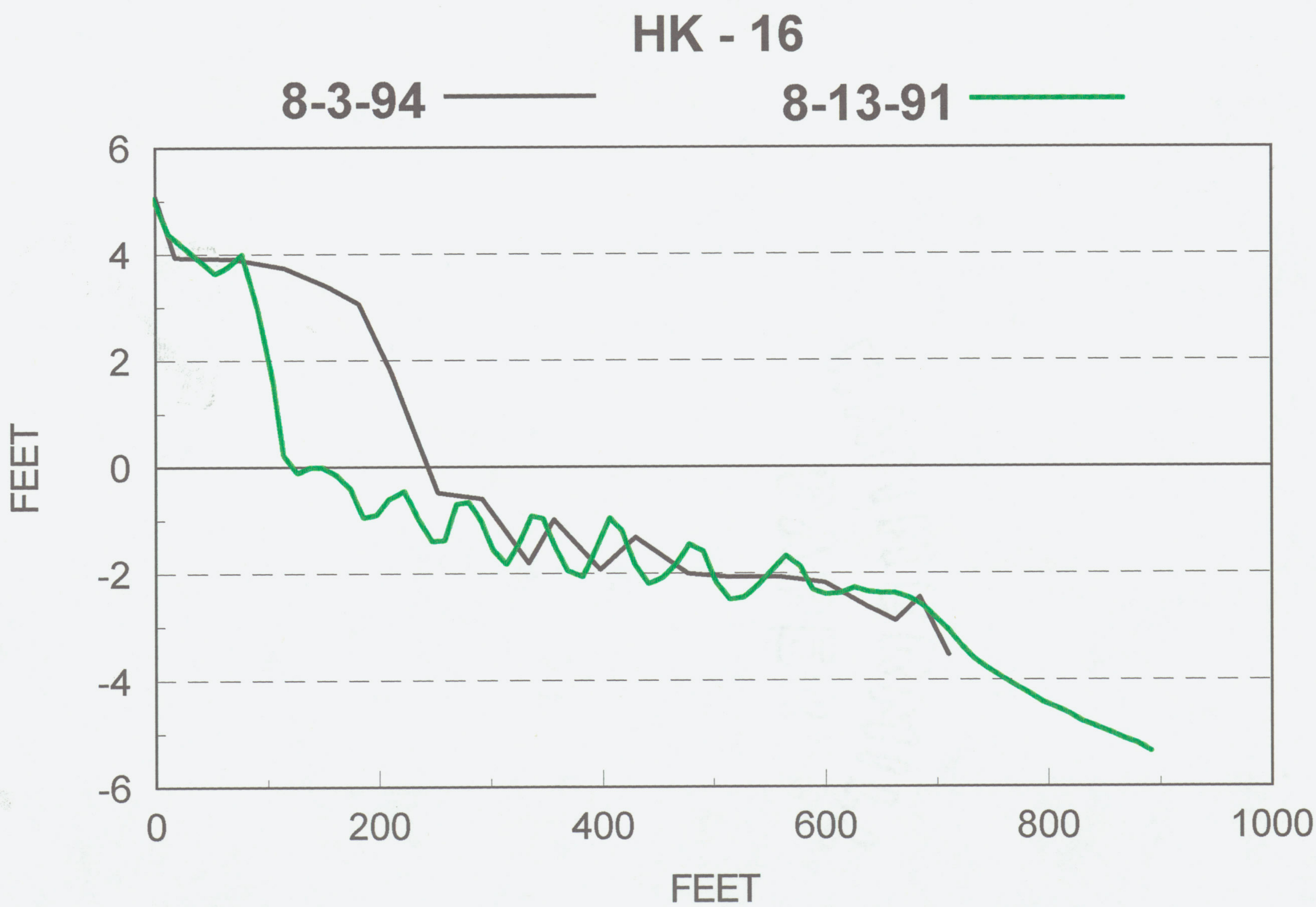

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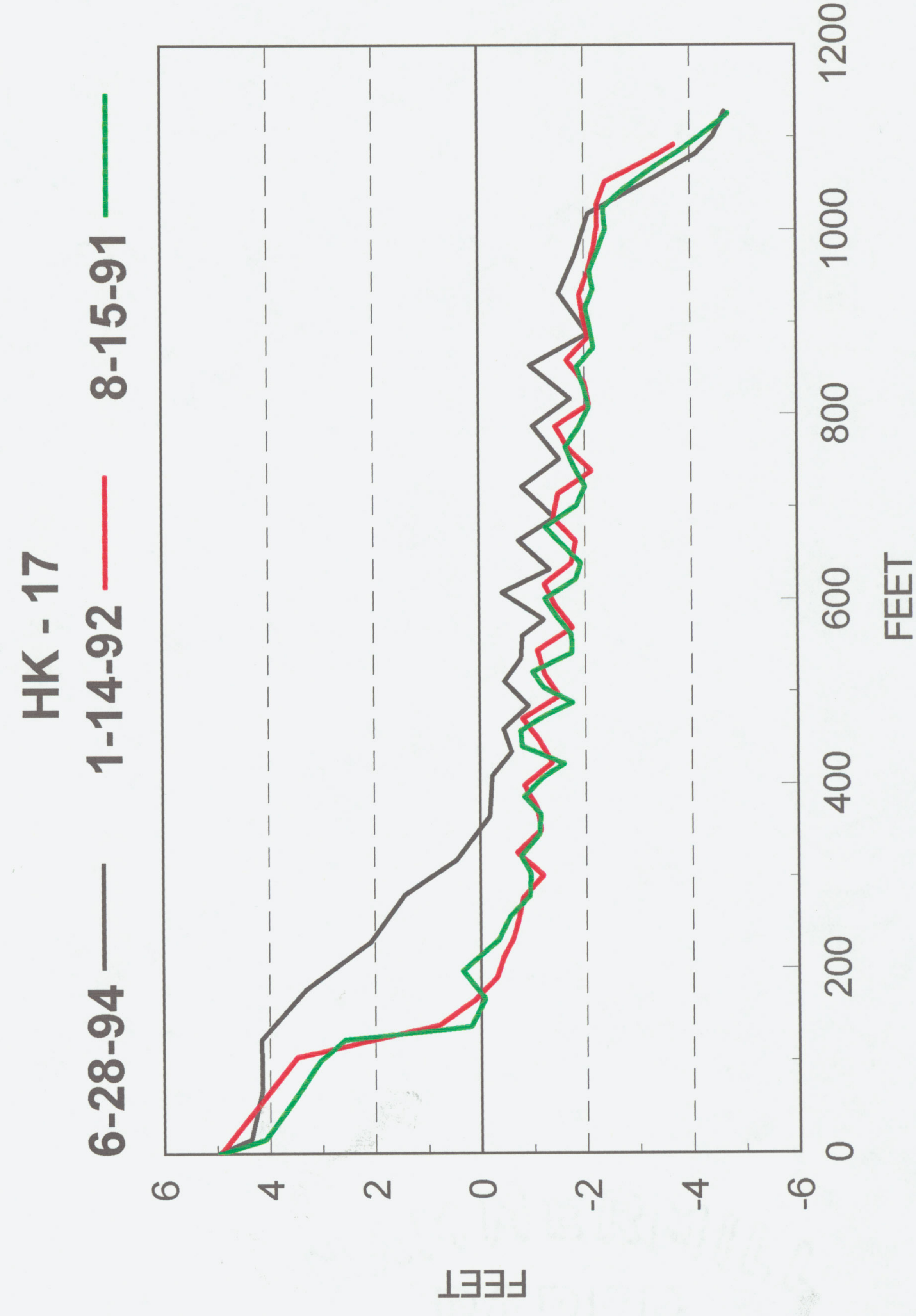

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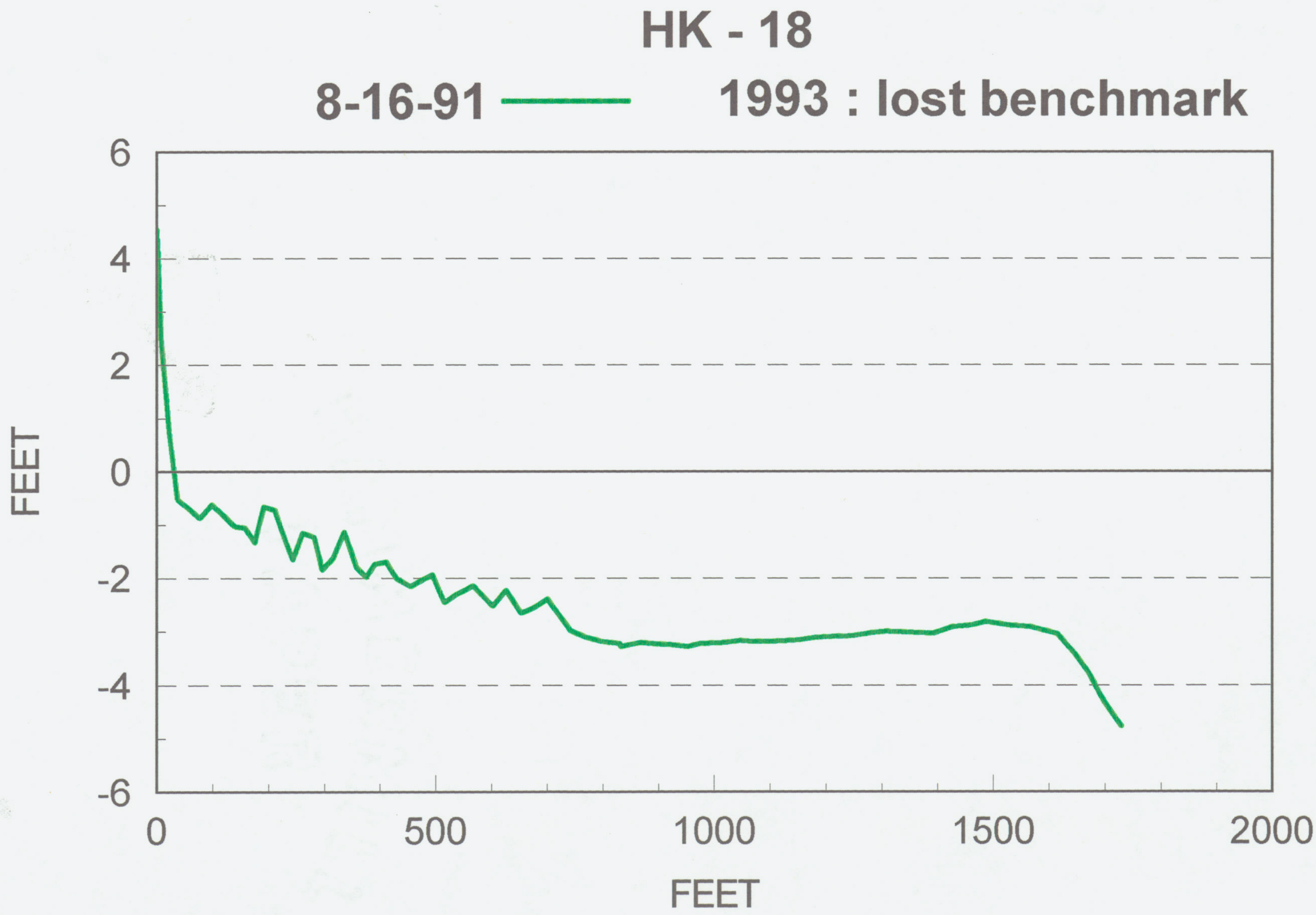
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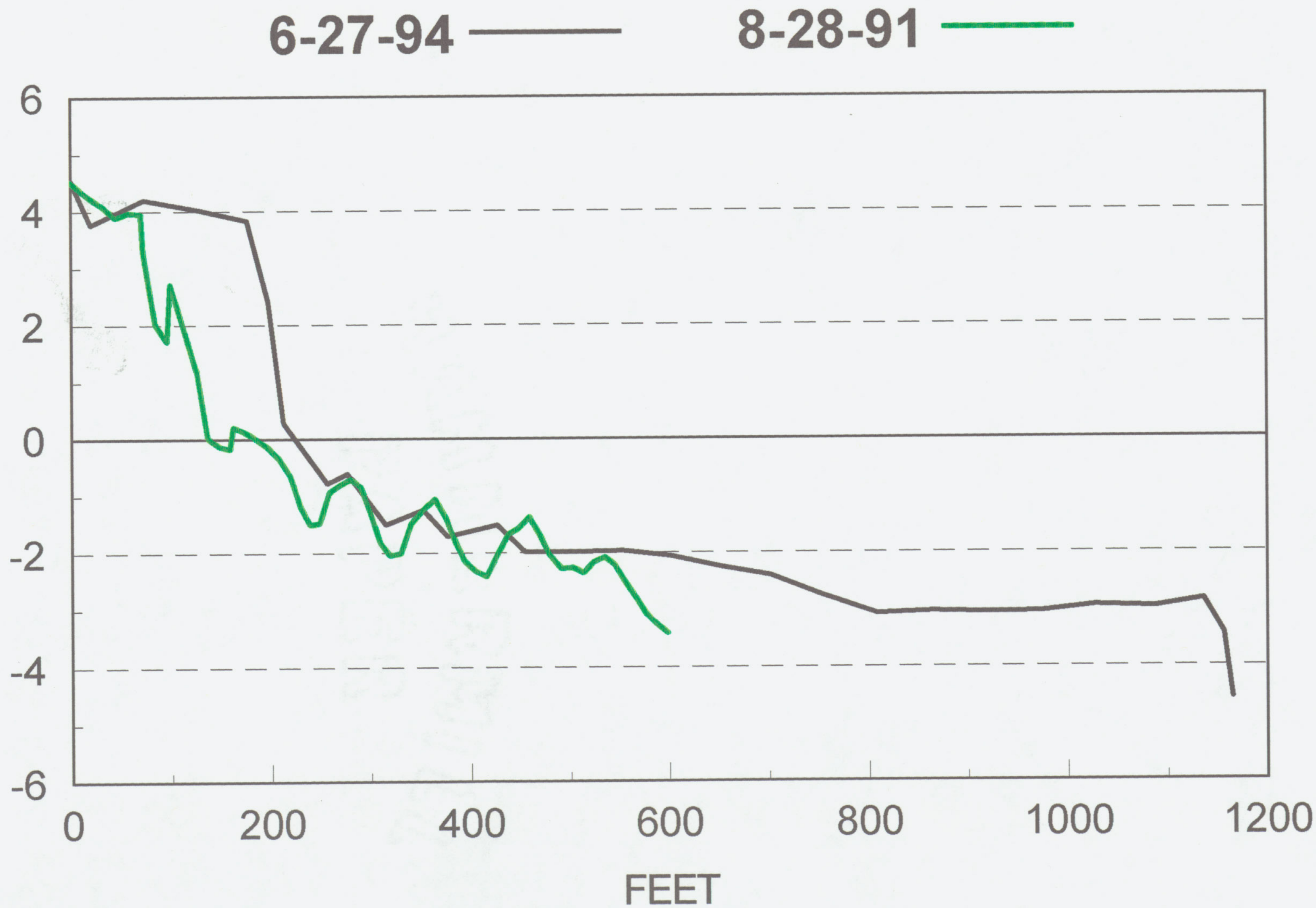

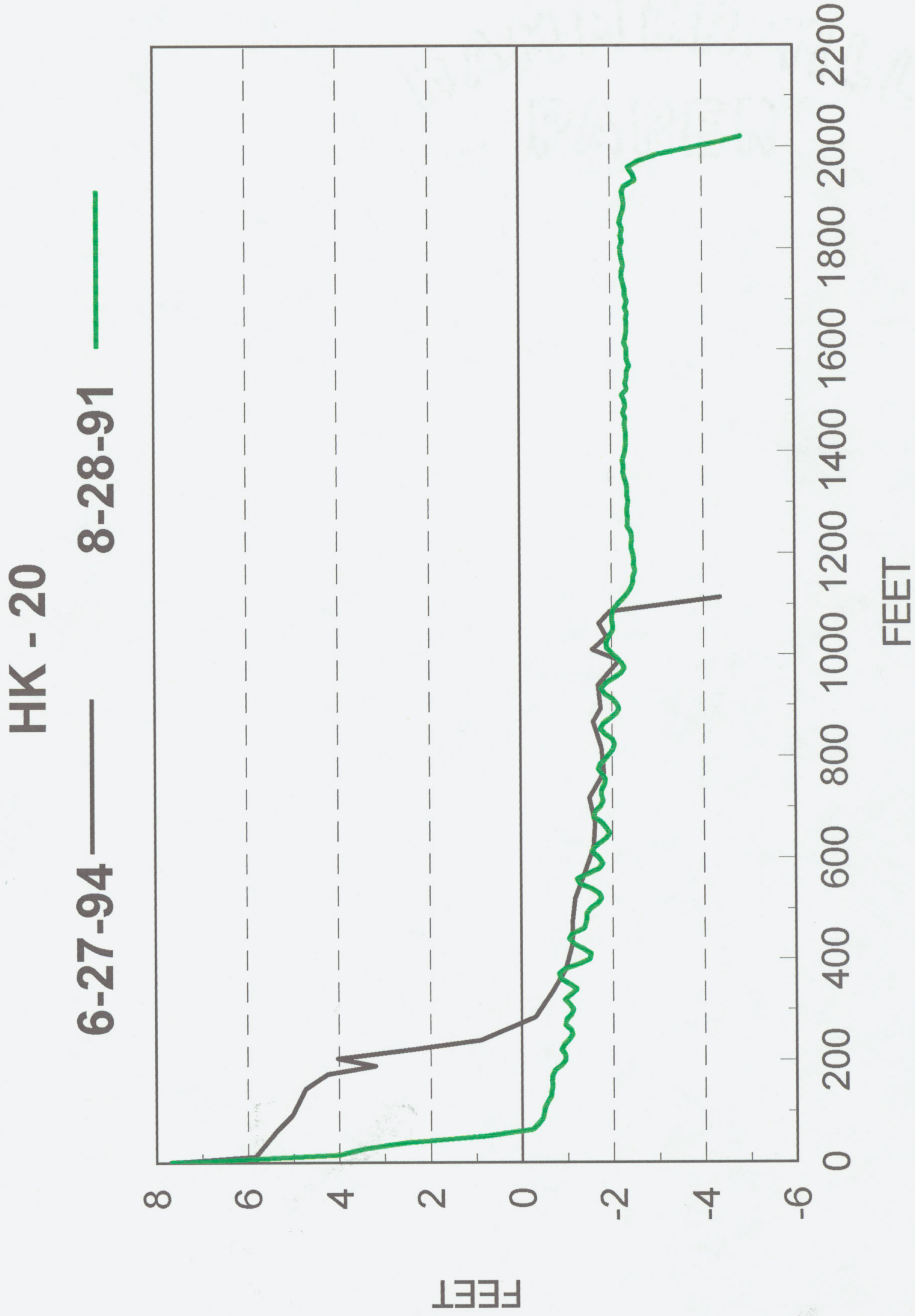

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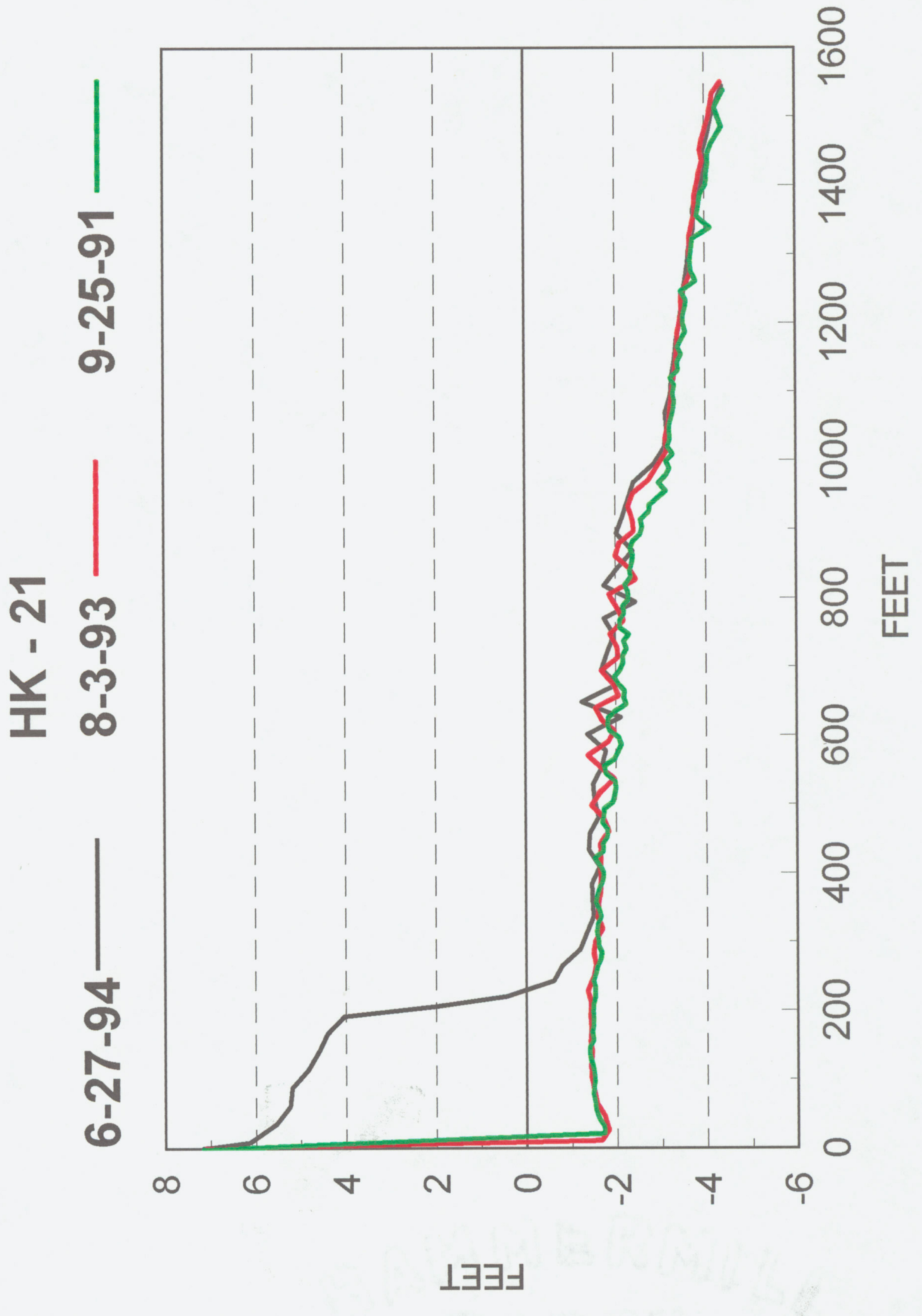
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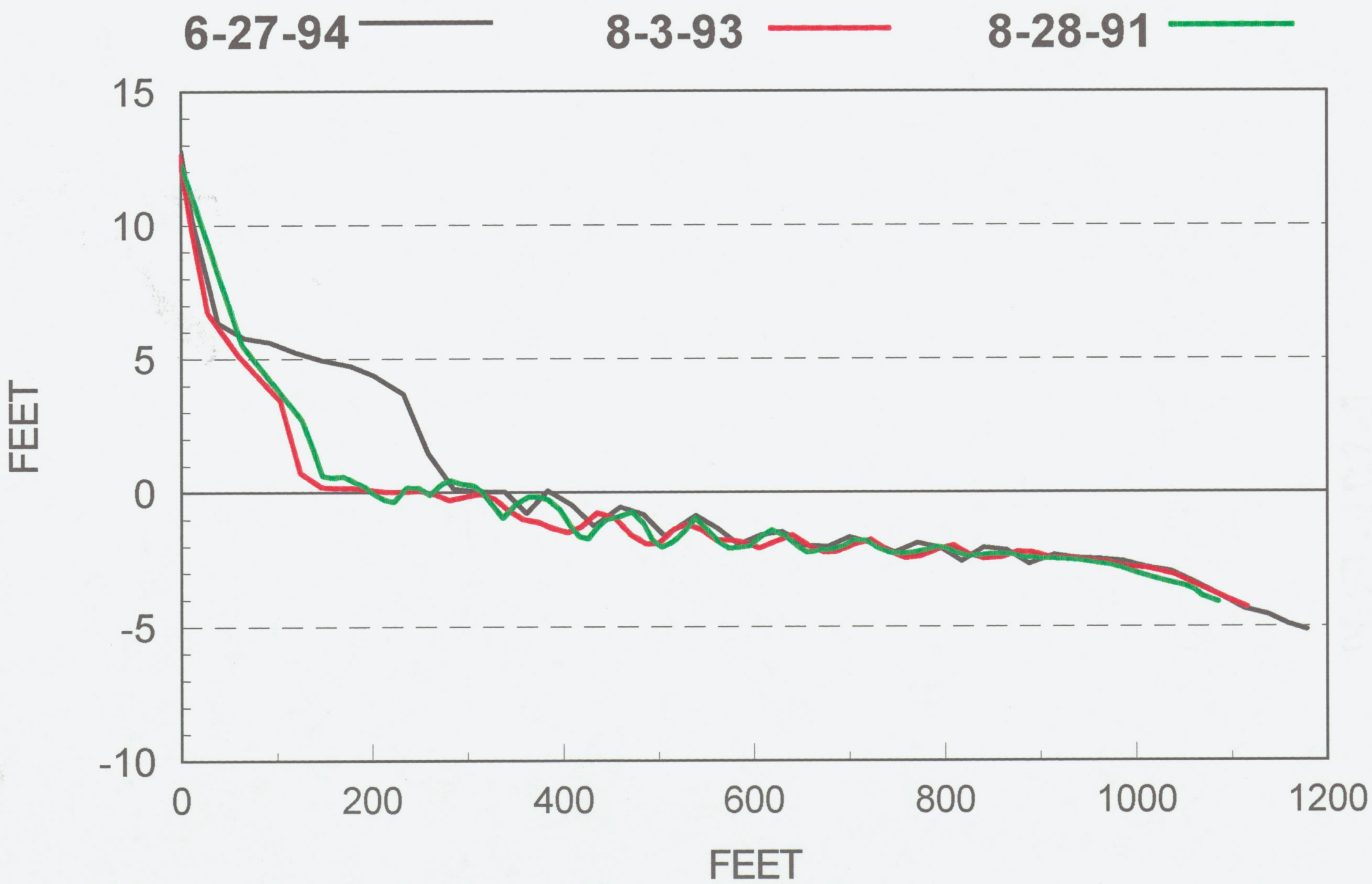
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ROUND ISLAND PROJECT

by

Stephen M. Oivanki

Introduction

Round Island is located about 3 miles offshore of Pascagoula in the Mississippi Sound (Figure 1). It is a small island, only 47.5 acres, and erosion has claimed 84 acres of the island since the 1850s. The Round Island Lighthouse is located at the southernmost point of the island, and is listed on the National Historic Register. The lighthouse and about half of the island are owned by the City of Pascagoula, having been deeded to the city in 1986 after the lighthouse was de-commissioned and declared excess government property.

Erosion of the island by 1986 had left the lighthouse almost entirely surrounded by water and in danger of destruction by the waves (Figure 2). A riprap revetment filled with sand was placed around the lighthouse in 1990 to protect it, but wave action has already severely eroded that structure. The Office of Geology, as part of the cooperative study, decided to investigate the possibility of rebuilding the eroded portion of the island with sand nourishment.

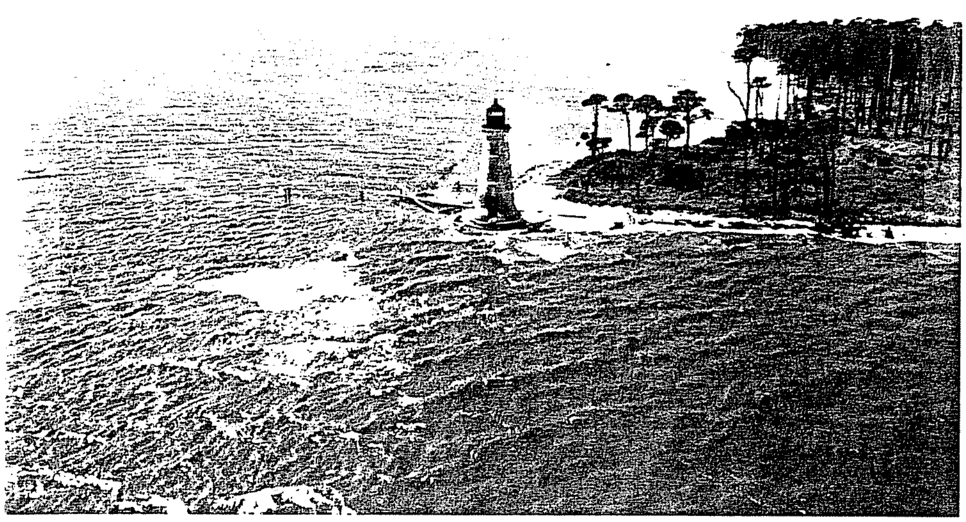

Figure 2. Round Island lighthouse, 1989.

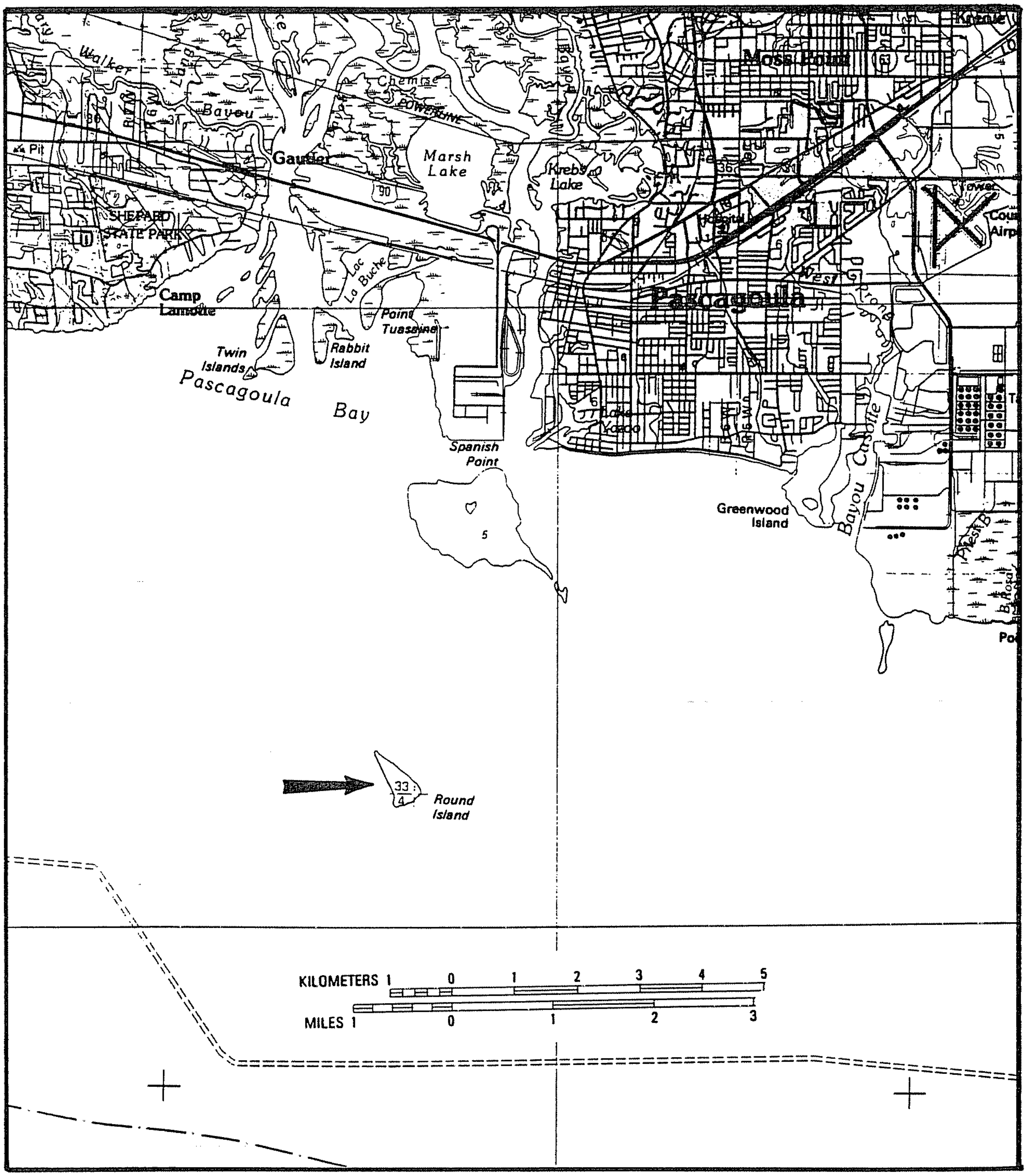

Figure 1. Round Island location reference map.

Method of Investigation

The island has been surveyed in 1993 and 1994 with GPS to establish a short-term rate of erosion. Four acres were eroded from the island between February 1993 and January 1994, however this is within the margin of error for the GPS method used. Twenty-one vibracores were recovered around the island in an effort to find sufficient sand resources near the island for an economical nourishment project. Sand intervals in the cores were analyzed for grain-size distribution. The cores were located with GPS and positioned on all sides of the island (Figure 3) to best explore for sand resources. The island itself is composed of a core of Pleistocene Gulfport Formation sand covered with a veneer of Recent reworked sand.

Seismic data were collected around the island in Year 3 of the cooperative study to try to delineate more accurately the sand resources discovered in the vibracores (Figure 3).

Core Interpretations and Sand Resources

The vibracores recovered around Round Island showed varying amounts of sand content. The top of the Pleistocene was reached in most of the cores, and is recognized by the oxidized orange-yellow color of the exposure surface or the presence of humic acid staining. Where the orange color or humate cement was not obvious, the Pleistocene was picked at the best exposure surface indicated by roots, borings, or extensive oyster reef development. A map of that horizon is shown in Figure 4. Top of Pleistocene was indicated below the total depth in several cores and those depths are shown in parentheses on the map.

Maximum sand thickness is found northwest of the island near the spit at the northwest end of the island formed by migrating sand eroding from the southern shore. Sand measured for the sand isopach map includes only that sand near the surface which could be feasibly dredged for renourishment of the island. Sand layers with substantial mud content and sands below significant mud layers were not counted. Sand deposits up to 15 feet thick are found near the tail of the spit (Figure 5). Relatively thick sands are also found south and southeast of the island. The south side of the island, however, is not considered desirable as a sand source due to the increased wave activity which would be caused by a dredge pit on that side. The sand found on the south side of the island is primarily Pleistocene Gulfport Formation sand, which is highly stained with humate cement similar to the sand found at Belle Fontaine on the mainland. Indurated, humate-cemented hardbottoms occur to the east and northeast of the island.

The seismic data collected around the island proved inconclusive in identifying shallow sand resources. The data in that zone were masked by noise related to the seismic source and nearby ship traffic.

The sand resource at the northwest end of the island is estimated to contain over 1 million cubic yards of medium-grain sand suitable for rebuilding the east end of the island. Dredging of this sand resource would not be detrimental to the island since it is on the lee side of the predominant southeast winds; and the dredge pit would eventually fill up with migrating sand as the rebuilt part of the island gradually eroded back again.

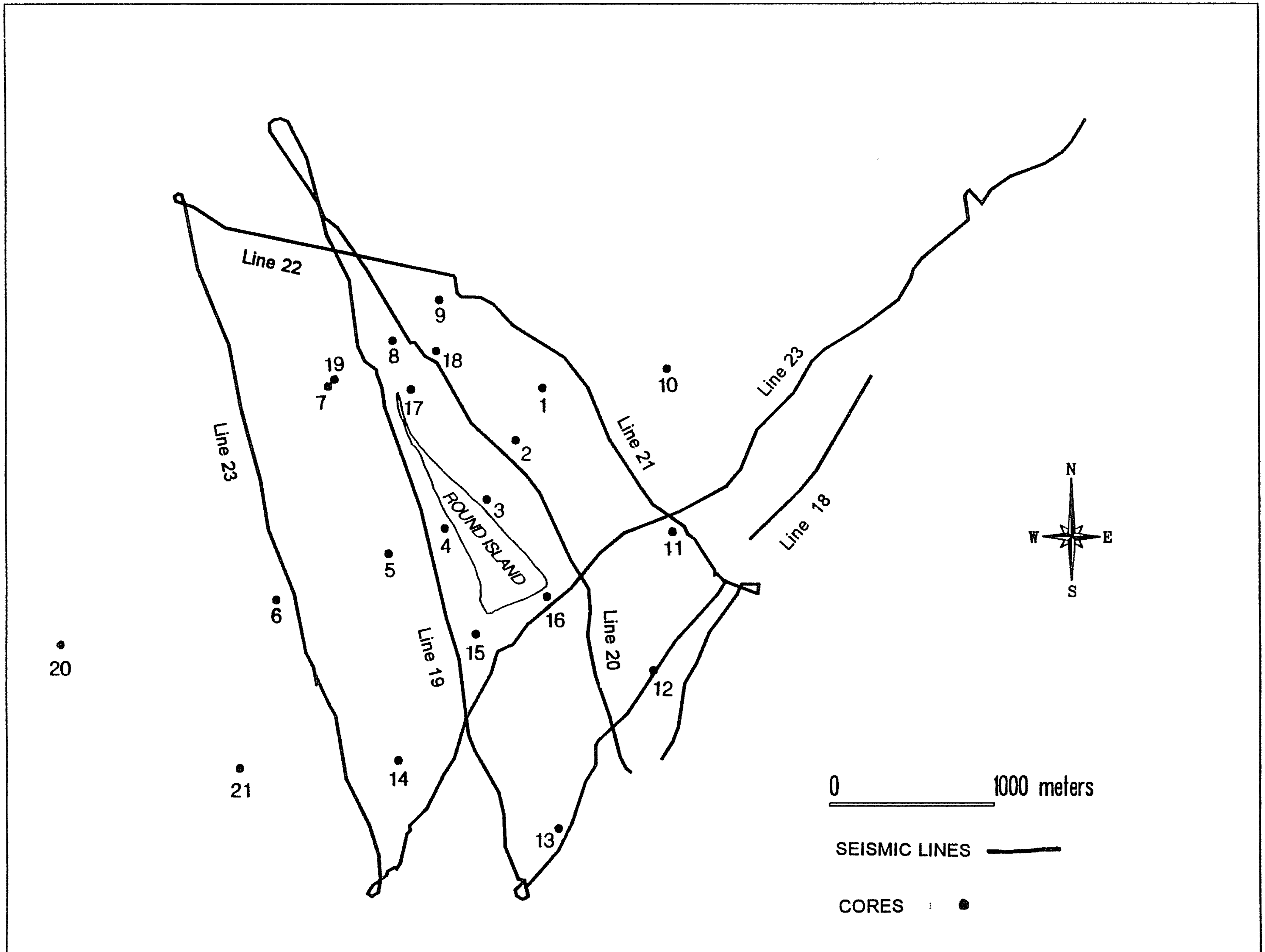

Figure 3. Location reference map for Round Island cores and seismic lines.

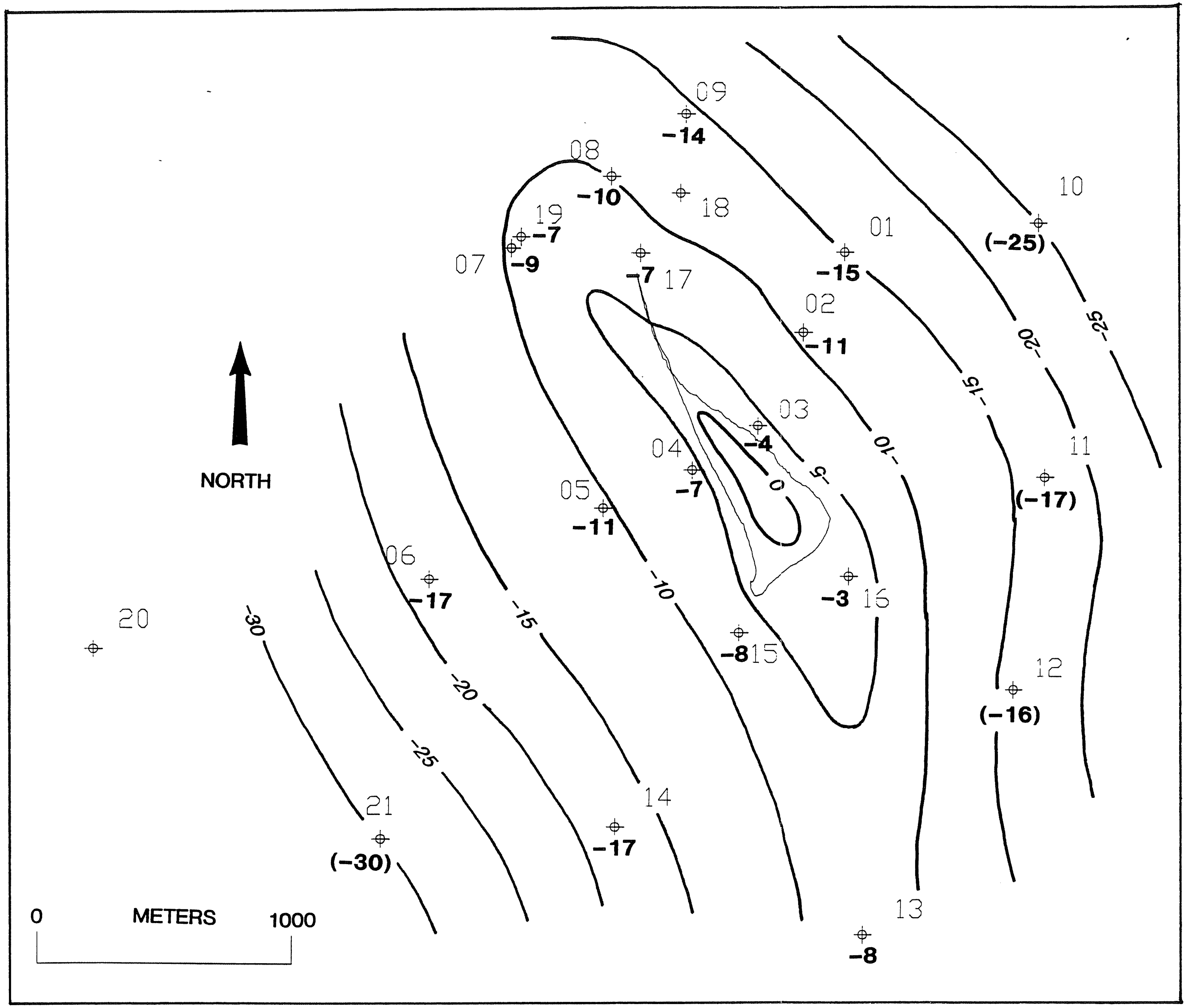

Figure 4. Top of Pleistocene around Round Island from core data, elevations are in feet relative to mean sea level.

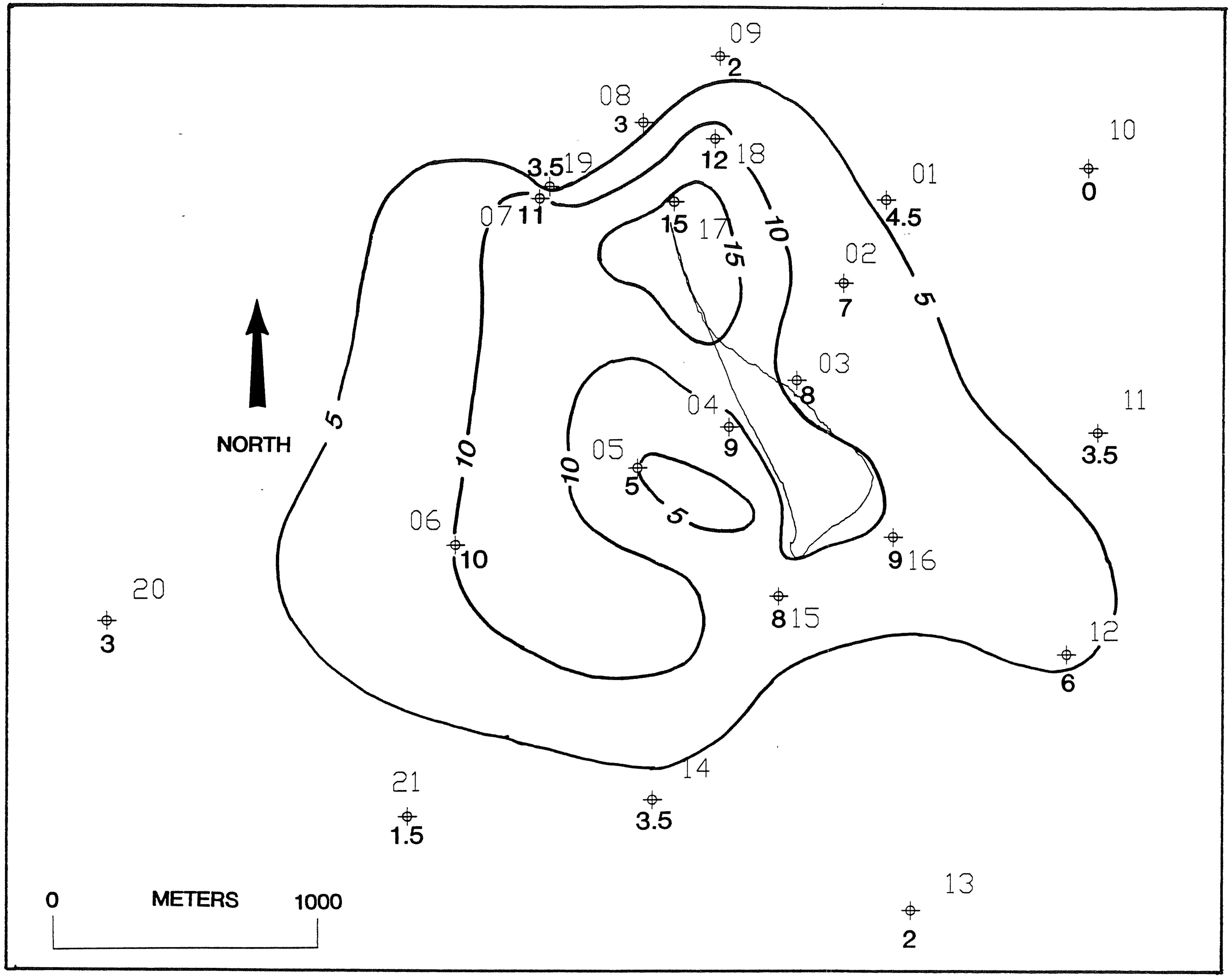

Figure 5. Sand isopach map from cores around Round Island, measured in feet. (sand thickness shown includes only that sand near the surface with minimal mud content)

Round Island Core Descriptions

Round Island Core No. 1
Location: 30° 18' 14.69" N   88° 34' 59.81" W
Water Depth: 8 feet

Depth	Description
0 ft.	White to gray medium sand, burrowed, muddy in spots, becoming dark gray mud with sand-filled burrows at bottom.
3.8 ft.	White to light yellow medium sand.
4.4 ft.	Dark gray mud, few small sandy burrows.
6 ft.	Black organic mud, stiff, light gray mud burrows.
7.5 ft.	Light gray mud, silty, streaked yellow and orange.
11.3 ft	Total depth.

Round Island Core No. 2
Location: 30° 18' 4.38" N   88° 35' 5.71" W
Water depth: 3.25 feet

Depth	Description
0 ft.	Light yellow to gray medium sand, mottled brown spots.
2 ft.	Dark gray mud.
2.1 ft.	Light yellow to gray medium sand, mottled, burrowed, becoming dark brown at 6.5 ft., then lighter to TD, some yellow staining at TD, scattered wood fragments.
7.8 ft.	Total depth, top of Pleistocene.

Round Island Core No. 3
Location: 30° 17' 52.36" N   88° 35' 12.21" W
Water Depth: 2 feet

Depth	Description
0 ft.	Clean white medium sand.
2.1 ft.	Top of Pleistocene, light brown medium sand, streaked darker brown, burrowed.
7 ft.	Dark brown, humate-stained, medium to fine sand, wood fragments, streaked lighter brown.
8.3 ft.	Total depth.

Round Island Core No. 4
Location: 30° 17' 46.51" N   88° 35' 21.71" W
Water Depth: 2.5 feet

Depth	Description
0 ft.	Light brown to white medium sand.
2 ft.	Medium sand as above grading down to dark brown humate-stained sand.
5.0 ft.	Top of Pleistocene, humate-stained medium sand.
7.5 ft.	Clean white medium sand.
8.2 ft.	Dark brown humate-stained medium sand.
8.8 ft.	Total depth.

Round Island Core No. 5
Location: 30° 17' 41.37" N   88° 35' 34.47" W
Water Depth: 7.75 feet

Depth	Description
0 ft.	Dark gray clay, sandy, burrowed.

2.1 ft.	Gray medium sand, burrowed, becoming brown humate-stained at base.
3.4 ft.	Top of Pleistocene, white to yellow medium sand, bright yellow streaks, some brown streaks, becoming darker brown at base.
6.9 ft.	Total depth.

Round Island Core No. 6
Location: 30° 17' 31.87" N   88° 36' 00.03" W
Water Depth: 10 feet

Depth	Description
0 ft.	Dark gray sandy mud and muddy sand, light gray sand filled burrows, becoming more sandy and light orange color at base.
7.6 ft.	Top of Pleistocene, yellow to orange mottled medium to coarse sand, burrowed, becoming bright orange at base, light gray to orange clay layer at TD.
16.8 ft.	Total depth.

Round Island Core No. 7
Location: 30° 18' 14.34" N   88° 35' 48.77" W
Water Depth: 4.25 feet

Depth	Description
0 ft.	Mottled gray and brown medium sand, burrowed.
3.9 ft.	Dark gray mud, gray sand-filled burrows, orange mottling in the sand burrows.
5.2 ft.	Top of Pleistocene.
10.6 ft.	Dark gray to light gray medium sand, muddy, burrowed, orange streaks.
17.3 ft.	Total depth.

Round Island Core No. 8
Location: 30° 18' 23.70" N   88° 35' 34.21" W
Water Depth: 5.5 feet

Depth	Description
0 ft.	Light brown and dark brown mottled medium sand, burrowed.
2.8 ft.	Dark gray to brown mud and brown sand, highly burrowed, oxidized at 4.7 ft (top of Pleistocene).
5 ft.	Concentrated oyster shells (*Crassostrea virginica*).
5.6 ft.	Dark gray clay, sandy, burrowed, scattered small shells, banded clay layer at base.
11.1 ft	Black organic medium to coarse sand, quartz sand stained black.
11.7 ft.	Black to brown humate-stained medium sand.
12.6 ft.	Total depth.

Round Island Core No. 9
Location: 30° 18' 31.89" N   88° 35' 23.61" W
Water Depth: 9 feet

Depth	Description
0 ft.	Dark gray mud, silty and sandy, sand-filled burrows.
1.9 ft.	Gray sand and dark gray mud, burrowed, oxidized orange in spots, scattered wood fragments and sand-filled burrows.
5.1 ft.	Top of Pleistocene.
8.3 ft.	Dark gray mud, white sand-filled burrows, TD in black, banded, very hard mud.
13.3 ft.	Total depth.

Round Island Core No. 10
Location: 30° 18' 18.95" N   88° 34' 31.44" W
Water Depth: 9 feet

Depth	Description
0 ft.	Dark gray mud, gray sand-filled burrows, abundant shells (*Anadara* sp.).
7.9 ft.	Black organic mud, sulphurous, burrowed.
10 ft.	Total depth.

Round Island Core No. 11
Location: 30° 17' 46.51" N   88° 34' 29.72" W
Water Depth: 4.5 feet

Depth	Description
0 ft.	White to gray medium sand, becomes mottled gray from 2.5 ft. to base, burrowed.
3.4 ft.	Dark gray sandy mud, burrowed.
5.2 ft.	Dark gray mud, burrowed, sulphurous, orange streaks at base.
7 ft.	Black organic mud, burrowed.
10.4 ft.	Light gray mud, silty, sulphurous yellow streaks at base.
12.6 ft.	Total depth, probable top of Pleistocene.

Round Island Core No. 12
Location: 30° 17' 19.24" N   88° 34' 33.71" W
Water Depth: 7.5 feet

Depth	Description
0 ft.	Mottled dark gray to light gray medium sand, muddy streaks.

3.5 ft.	Clean white medium to coarse sand, burrowed.
5.5 ft.	Total depth.

Round Island Core No. 13
Location: 30° 16' 47.46" N   88° 34' 54.91" W
Water Depth: 8 feet

Depth	Description
0 ft.	Top of Pleistocene, brown to dark brown mottled medium sand, burrowed.
2 ft.	Dark brown to dark gray sandy mud, gray sand-filled burrows, iron oxide nodules at 5.9 ft.
6.2 ft.	Light gray sandy mud, grades down to light gray medium sand, burrowed.
8 ft.	Total depth.

Round Island Core No. 14
Location: 30° 17' 00.64" N   88° 35' 31.70" W
Water Depth: 8 feet

Depth	Description
0 ft.	Brown to dark gray muddy medium sand, burrowed.
3 ft.	Dark gray sandy mud and muddy sand, burrowed, scattered shell fragments, becoming yellow-streaked at base.
9.2 ft.	Top of Pleistocene, bright orange to red muddy fine sand.
9.5 ft.	Light gray sandy mud, dark gray sand-filled burrows, gray sand at base with orange streaks.
11.4 ft.	Total depth.

Round Island Core No. 15
Location: 30° 17' 25.81" N   88° 35' 14.37" W
Water Depth: 5 feet

Depth	Description
0 ft.	White to light brown medium sand, spots of mud.
1.4 ft.	Sand as above becoming muddier, burrowed, becoming dark brown humate-stained at base.
3.5 ft.	Top of Pleistocene, clean white fine to medium sand, streaks of dark gray sand, orange at top contact, becoming light brown at base.
7.9 ft.	Total depth.

Round Island Core No. 16
Location: 30° 17' 33.34" N   88° 34' 58.24" W
Water Depth: 3.5 feet

Depth	Description
0 ft.	Top of Pleistocene, medium brown medium sand, humate-stained.
2.4 ft.	Dark brown medium sand, humate-cemented, scattered burrows filled with darker sand.
6 ft.	Light brown to gray medium sand, burrowed at base.
9 ft.	Total depth.

Round Island Core No. 17
Location: 30° 18' 14.03" N   88° 35' 29.84" W
Water Depth: 3.5 feet

Depth	Description
0 ft.	Gray top white medium sand, slight yellow tint, streaked with muddy sand, burrowed.

3 ft. Top of Pleistocene, gray and orange mottled medium sand, burrowed, scattered muddy streaks, becomes cleaner at base.

6.4 ft. Clean white medium sand, streaks of dark gray medium sand.

9.4 ft. Dark brown humate-stained medium to coarse sand.

9.7 ft. Light brown mottled coarse sand.

12 ft. White medium sand, burrows filled with light gray mud and fine sand.

14.8 ft. Total depth.

Round Island Core No. 18
Location: 30° 18' 21.79" N 88° 35' 24.20" W
Water Depth: 6.25 feet

Depth Description

0 ft. White to gray medium sand.

0.4 ft. Dark brown to dark gray very muddy sand and sandy mud, gray sand-filled burrows, black clay balls at base.

3 ft. Top of Pleistocene, dark gray mud, sulphurous, gray sand-filled burrows, slightly oxidized.

6.3 ft. Gray medium sand, mottled dark gray, mud streaks.

11.7 ft. Clean white medium to coarse sand, brown streaks.

15.8 ft. Total depth.

Round Island Core No. 19
Location: 30° 18' 15.72" N   88° 35' 47.36" W
Water Depth: 3.25 feet

Depth	Description
0 ft.	Gray medium to coarse sand, mottled, gray clay-filled burrows at base.
2.1 ft.	Dark gray sandy mud.
2.5 ft.	Gray sand as above.
3.1 ft.	Laminated dark gray mud and orange medium sand.
3.6 ft.	White to gray medium sand, yellowish tint becoming orange at base (top of Pleistocene), gray clay-filled burrows.
4.8 ft.	Gray sandy clay, mottled orange, sand-filled burrows.
6 ft.	Dark gray mud, yellow mottling in sand-filled burrows.
8.2 ft.	Gray muddy medium sand, cleaner sand-filled burrows, mottled.
16.3 ft.	Total depth.

Round Island Core No. 20
Location: 30° 17' 22.27" N   88° 36' 49.26" W
Water Depth: 12 feet

Depth	Description
0 ft.	Dark gray mud, sand-filled burrows, oxidized shale and wood fragments, becoming more sandy at base.
15 ft.	Gray medium sand. mottled and streaked dark gray, white sand-filled burrows, TD in solid sulphur-coated wood log.
18 ft.	Total depth.

Round Island Core No. 21
Location: 30° 16' 58.51" N   88° 36' 06.42" W
Water Depth: 9.5 feet

Depth	Description
0 ft.	Gray to white medium sand, muddy at top becoming very muddy at base.
1.7 ft.	Muddy medium sand and gray mud.
1.9 ft.	Gray mud, white sand-filled burrows, scattered broken shells.
7.5 ft.	Single large oyster shell (*Crassostrea virginica*).
7.5 ft.	Dark gray mud, scattered sand-filled burrows.
8.8 ft.	Gray mud, hard, scattered burrows, mottled.
14.6 ft.	Total depth.

BELLE FONTAINE PROJECT

by

Stephen M. Oivanki

PROJECT SUMMARY

The Belle Fontaine Project was initiated in Year 2 of the cooperative agreement after a meeting with personnel at the Mississippi Bureau of Marine Resources. It is a joint multi-state and multi-federal agency cooperative project designed to aid the understanding of erosion processes in Mississippi and assist coastal managers in the state to address erosion mitigation. The site chosen for the project, Belle Fontaine (Figure 1), contains the only natural beach area left on the Mississippi mainland coast (Figure 2). There has been considerable outcry from residents of the area concerning erosion of their property and potential damage to homes and roads (Figure 3). Numerous piecemeal erosion control structures have been erected by landowners in the past without effective results (Figure 4).

The project was jointly funded by a coastal management grant from the Environmental Protection Agency to the Bureau of Marine Resources and the cooperative agreement funding to the Office of Geology by the USGS. Matching funding was supplied by the Office of Geology and the Gulf Coast Research Laboratory in the form of field work and personnel, and publication funding from the Office of Geology for printing of the final report. The project was designed to address the technical erosion management issues involved as well as to inform the general public of the erosion problems at Belle Fontaine and potential solutions to those problems.

The general history of the area, from its discovery by early French explorers to the present time, was researched by Dr. Klaus J. Meyer-Arendt with the Department of Geosciences at Mississippi State University funded by the USGS agreement. The geologic framework and historical erosion rates for the area were studied by Stephen Oivanki with the Office of Geology and Dr. Ervin Otvos with the Gulf Coast Research Laboratory who contributed his expertise and resources as matching funding. Dr. Joseph Suhayda, with the Civil Engineering Department at Louisiana State University,

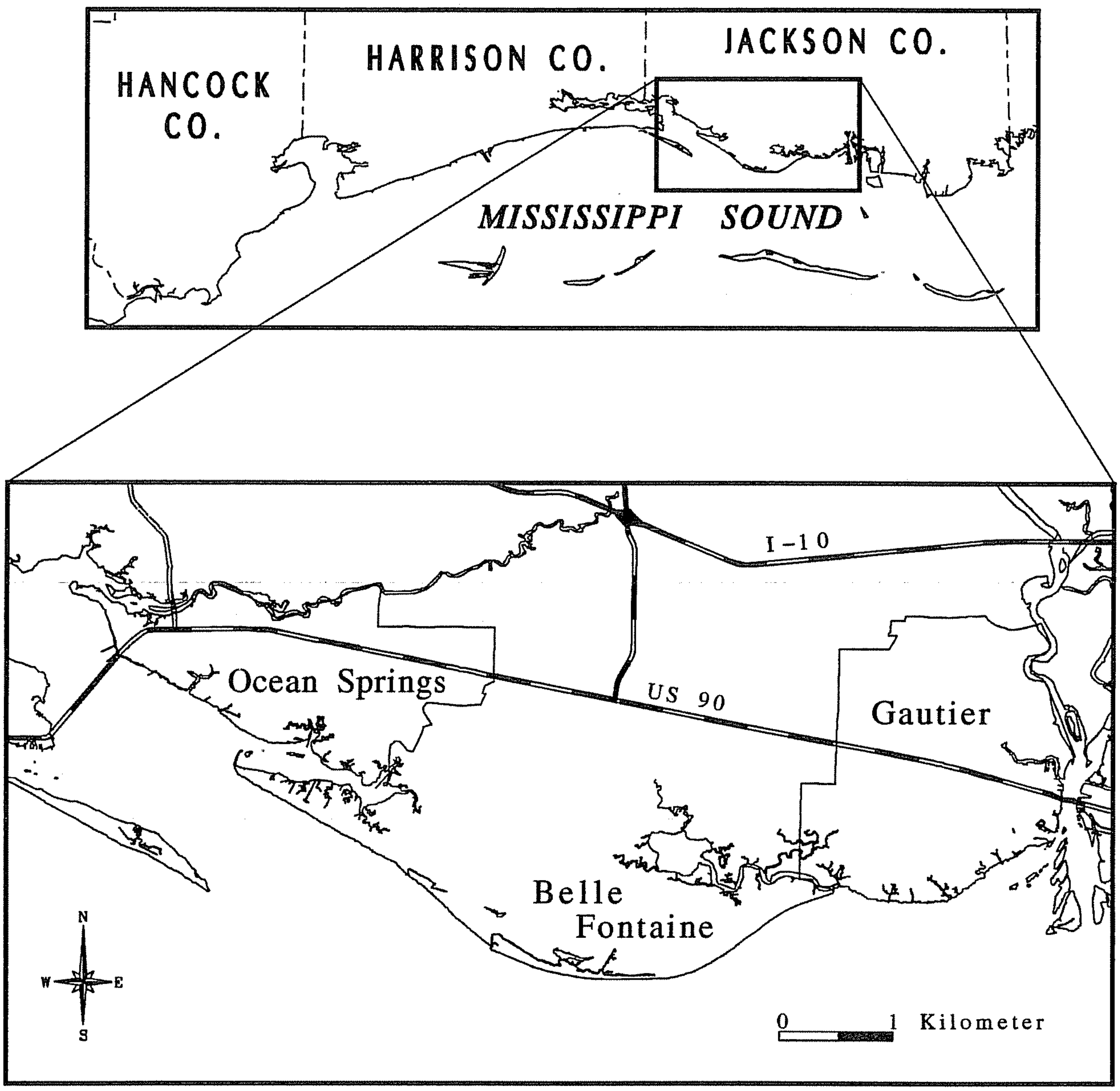

Figure 1. Index map of the Belle Fontaine Project area.

Figure 2. Belle Fontaine Beach, Jackson County, Mississippi.

Figure 3. Belle Fontaine Beach erosion.

Figure 4. Isolated bulkhead/riprap at Belle Fontaine.

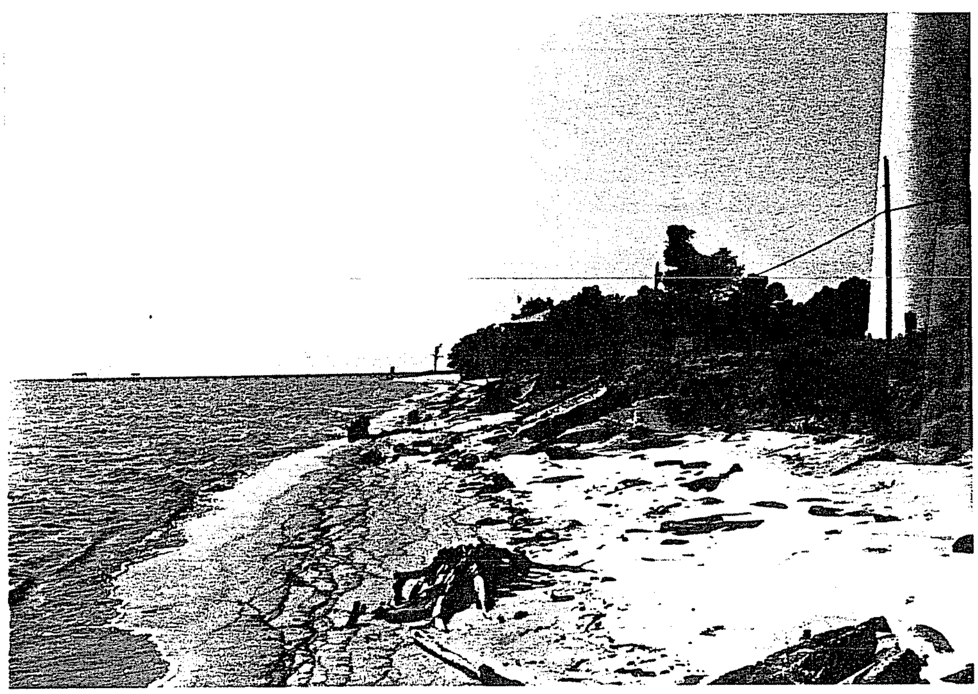

Figure 5. Gulf of Mexico Program demonstration project sand nourishment site.

deployed wave meter equipment and developed a Shoreline Evolution Model to predict future erosion rates and evaluate potential erosion control measures. His portion of the project was funded by the EPA. Cathy Hollomon, with the Bureau of Marine Resources, documented the regulatory history of coastal erosion control in Mississippi.

The results of the project are presented in "Belle Fontaine, Jackson County Mississippi: Human History, Geology, and Shoreline Erosion", Mississippi Office of Geology Bulletin 130, which is included as an attachment to this report. The success of this project demonstrates the benefits of resource and cost sharing between federal and state agencies to accomplish results which could not be attained by any single agency.

GULF OF MEXICO PROGRAM DEMONSTRATION PROJECT

In order to test the Shoreline Evolution Model developed in the Belle Fontaine Project, a grant request was made to the Gulf of Mexico Program to fund sand nourishment on Belle Fontaine beach. Sand would be placed at locations suggested as optimal by the model (Figure 5), and the movement of the sand in response to the natural wave climate over the next several years would be monitored and compared with the movement predicted by the model. Any variation from predicted results would be incorporated into the model to improve its predictive capabilities.

The Gulf of Mexico Program awarded a grant to Jackson County to place 30,000 cubic yards of sand from an upland source on the beach at Belle Fontaine. Matching funding will be in the form of county equipment and personnel to transport and spread the sand, and Office of Geology personnel to monitor sand movement. Placement of the sand is scheduled to begin in October, 1994. The Office of Geology Coastal Section will monitor the sand movement utilizing profiles established along the shoreline. Unusual weather conditions, including wave height and direction, will be monitored by volunteer homeowners along the Belle Fontaine shoreline. Video records of the project and the monitoring results will be compiled by the Office of Geology. A presentation on the development and progress of this project will be made by Stephen Oivanki at the Gulf of Mexico Symposium in 1995.

SUMMARY AND CONCLUSIONS

by

Stephen M. Oivanki

OVERVIEW

At the end of the four-year cooperative "Coastal Geology and Regional Marine Study" research effort with the U. S. Geological Survey the Mississippi Office of Geology Coastal Section is fully equipped and staffed to continue the coastal research and monitoring begun during the cooperative effort. We are grateful to the USGS for their assistance and guidance in establishing this expansion of our research capabilities. The expertise and equipment acquired during this study are a valuable asset to the Office of Geology and the State of Mississippi.

Because the Mississippi coast is so highly developed, and provides such a large portion of our state's economic base, the research emphasis during this study was placed on areas of economic concern to the state and local agencies we made contact with on the coast. Much of the work begun in this cooperative effort is ongoing, and will be continued and expanded in the future. We will continue to address the concerns of local agencies as they are expressed whenever they fit into our research strategies and capabilities.

ATTAINMENT OF ORIGINAL COOPERATIVE AGREEMENT OBJECTIVES

The scope of work and objectives set forth in the original cooperative agreement with the USGS included the following research goals:

(1) to define and document the regional geologic framework within which natural resources processes take place;

(2) to quantify current rates and causes for shoreline erosion/accretion and wetland loss/gain, and sealevel fall/rise and, document the history of these topics;

(3) to identify the processes of sediment transport and describe sediment and the composition of bottom sediments;

(4) to recognize, interpret, and document storm events (hurricanes, tropical depressions, etc.) and determine the effects of storms on shoreline erosion/accretion, wetland loss/gain, and natural resource monitoring; and,

(5) to transfer the products of the study to decision-making agencies for application of the results.

The research effort by the Office of Geology was designed to meet these objectives over a planned five-year cooperative study period.

Despite the abbreviated four-year span of the cooperative agreement, each of these goals were addressed as follows:

(1) Regional Geologic Framework

To begin an interpretation of the geologic framework of the Mississippi coast, a compilation of previous works on the subject was completed, resulting in publication of the "Bibliography of Mississippi Gulf Coast Geology and Related Topics" by the Office of Geology.

All previous cores and drill holes in the Mississippi coastal zone were identified, and all available records and descriptions of those cores and drillholes were acquired by the Office of Geology. These data were then put in a standard digital format for use in later interpretation of the regional geologic framework on the Mississippi coast. Due to the chaotic nature of the core and drillhole data, this process has taken longer than anticipated and is still ongoing.

As originally planned, the regional Holocene/Pleistocene geologic framework of coastal Mississippi and the Mississippi Sound would be reconstructed from an integration of seismic data acquired jointly with the USGS in a series of cruises in the Mississippi Sound coupled with core information acquired from previous drilling and utilization of vibracore capabilities within the Office of Geology. Because Dr. Ervin Otvos with the Gulf Coast research Laboratory is the most knowledgeable geologist in the state with regard to Mississippi coastal geology, he was contracted in Year 3 to begin the process of incorporating the available core information with an interpretation of seismic records in Harrison County, where the most data was available. Had the program extended to five years as originally planned, the geologic interpretation of Hancock and Jackson counties would have been scheduled for completion in Year 4.

The quality of the seismic data was insufficient to do an interpretation of the Holocene/Pleistocene interface as planned in the beginning of the project. Dr. Otvos was unable to produce an integrated core and seismic map of Harrison County. Instead, a map of the prominent Neogene channels was produced at the Office of Geology with some interpretation of possible Neogene depositional environments. Holocene sediment thickness can be generalized from core information, however, there is insufficient core data to make a reasonable map on the top of the Pleistocene.

Additional geologic framework interpretation was done in the Belle Fontaine area as part of the Belle Fontaine Shoreline Erosion Project utilizing previous core information as well as new vibracores acquired during the project. This work was also done with the assistance of Dr. Otvos.

A joint geologic framework project was begun with the Alabama Geological Survey in the Grande Batture area which spans the border between Mississippi and Alabama. Seismic data was acquired by the Office of Geology and 27 vibracores were taken in the Grand Bay area in Alabama and delivered to the Alabama Geological Survey for analysis. This joint project has not been pursued further due to a lack of interest on the part of the Alabama survey personnel.

(2) Erosion/Accretion Rates and Causes

Documentation of historical erosion rates and shoreline changes on the Mississippi coast was begun in Year 1 of the cooperative study. Digitization of historical shorelines by the Louisiana Geological Survey and interpretation of 1986 aerial photos allowed a comprehensive analysis by the Office of Geology of shoreline change in Mississippi from the 1850s to the present. Despite the relatively large margin of error in some of the data, definite trends were established and reliable quantitative figures were derived for relative historical shoreline erosion in the state.

The development of Global Positioning System (GPS) capabilities by the Office of Geology has enabled us to very accurately measure shoreline positions on an annual basis to record short-term erosion/accretion trends, and verify the long-term historical trends identified by other methods.

The Belle Fontaine Project in Jackson County was designed to address shoreline erosion in a specific area with an end result being a computer model of the shoreline which could be used to predict future erosion and evaluate possible erosion control alternatives. The Shoreline Evolution Model resulting from this project is now complete, and formed the basis for an additional ongoing project with the Gulf of Mexico Program to test the model with actual shoreline sand nourishment at Belle Fontaine.

The highly developed nature of the Mississippi mainland shoreline was historically documented by Dr. Klaus Meyer-Arendt with Mississippi State University in two study projects. The first study in Year 1 researched the effects of human intervention on the Mississippi coast. The second study in Year 3 documented the expansion of the Harrison County shoreline by the addition of construction, fill, and sand nourishment with volumetric and geographic data from archival sources.

The Mississippi mainland shoreline has lost about 3148 acres to erosion since the 1850s. Accretion, primarily by human intervention, has reclaimed about 1725 acres over the same time period. Erosion, at least along the inhabited portion of the mainland shoreline, has been effectively halted in Mississippi. Where erosion does occur, it is usually along the artificial beaches, and these beaches are restored periodically by re-nourishment. Erosion along the marsh shorelines in the uninhabited portions of the coast is continuing, however. These shorelines have historically had the highest erosion rates in the state (2 meters per year) and this trend is continuing today.

The Mississippi barrier islands have lost over 2600 acres to erosion since the 1850s. Erosion and accretion on the islands were more or less quantitatively equal until the maintenance of dredged channels began between the islands after the turn of this century. Since that time erosion has out-paced accretion by a margin of three-to-one. Alteration of channel maintenance practices is necessary to reverse this recent trend and save the islands from their demise at the hands of the channel dredges.

(2) Wetland Loss/Gain

Wetland changes in the Mississippi coastal zone have been addressed in a study by Dr. Klaus Meyer-Arendt in Year 2. Previous wetlands distribution maps in the state were acquired from the U. S. Fish and Wildlife Service and compared with a new wetlands and land use interpretation of aerial photo coverage of the coastal zone. The results of this study were analyzed and compiled in Year 4, and will be published next year. This study will serve as a valuable first look at wetlands change trends and development trends along the coast for coastal managers in other state and federal agencies.

(3) Processes of Sediment Transport and Sediment Description

Sediment transport into the Mississippi Sound by rivers was addressed in a study by Dr. Scott Dinnel with the University of Southern Mississippi in Year 2. Satellite reflectance value changes for sediment-laden river plumes were correlated with actual field measurements of sediment load values. The intent of the study was to facilitate more accurate determination of river plume sediment loads in the future by using satellite data only. The data obtained were inconclusive, and there has been no follow-up to this study by Dr. Dinnel.

In order to identify a possible future sand source for nourishment of Round Island in the Jackson County portion of the Mississippi Sound, 21 vibracores were recovered around the island and analyzed for sand resource content. Several seismic lines were recorded near the island for the same purpose. The result was delineation of extensive sand resources at the northwest end of the island suitable for restoration and mitigation of the over 80 acres of erosion on the island since the 1850s.

The new beach nourishment in Hancock County in 1994 will be monitored by the Office of Geology to document changes and sand transport patterns as the new beach becomes acclimated to the wave environment there. These data will prove valuable to improve the efficiency and placement of future beach nourishment efforts.

(4) Recognition and Documentation of Storm Changes

Several storm/hurricane change monitoring measures were established along the coast of Mississippi. The annual GPS shoreline surveys of the coast will provide an accurate benchmark from which to measure shoreline erosion after a major storm impact. The Mississippi Shoreline Geomorphology System provides a comprehensive geomorphic inventory of the coast for identification of geomorphologic changes as a result of storm impact. Analysis of current geomorphologic data revealed numerous previous storm impact features, particularly on the barrier islands, which are in various stages of recovery. The beach profiles established along the mainland shoreline will provide a basis for measuring shoreline and nearshore changes as a result of storm impact, as well as normal changes due to seasonal activity. The bathymetric survey of the Mississippi Sound will provide accurate baseline data for measurement of changes resulting from storm surge scouring of the bottom sediments.

(5) Transfer of Products and Application of Results

The Office of Geology is in contact with all of the management and decision-making agencies on the Mississippi coast. The data acquired in the course of this cooperative study are made available to any and all interested parties. The GPS shorelines measured each year are transferred to the Gulf Regional Planning Office for inclusion in their GIS. Similar plans are underway for a transfer to the Department of Marine Resources when their GIS is installed. The wetlands data will also be available digitally in GIS format for use in coastal planning efforts by state and local agencies on the coast.

A mounted display of shoreline changes on the Mississippi barrier islands was delivered to the National Park Service for permanent display at the Gulf Islands National Seashore Visitors Center in Ocean Springs. GPS equipment and expertise was also provided to the Park Service for several research projects in the park.

Beach and nearshore profiles were surveyed at Greenwood Island in Jackson County in support of a proposed jetty construction project by the Pascagoula Port Authority to protect a local harbor entrance from continued siltation.

The aerial photo flyover of the barrier islands conducted in Year 2 was used by the Mapping Division of the USGS to update topographic quadrangle coverage of the Mississippi coast. The Office of Geology also provided logistic support and boat transportation for field personnel involved with the topographic map revision project on the Mississippi coast. Boat transportation, bottom sediment identification, and bathymetric surveys were provided to the office of Congressman Gene Taylor to aid in identification of potential artificial fishing reef sites along the mainland coast of Mississippi.

The Office of Geology hosted the 1994 USGS Eastern Region Cluster Meeting in Biloxi, and conducted a field trip to the Belle Fontaine Project area for meeting participants.

Research results and data have been distributed to numerous scientific organizations and personnel via 19 professional presentations and 7 published reports and publications. Several interviews by local Mississippi coast television stations and newspapers have provided research results to the general public. The Office of Geology Coastal Section will continue to provide data to the public and the scientific community in the future. At least five presentations and two new publications are planned for the coming year.

UTILIZATION OF RESEARCH CAPABILITIES BY OTHER AGENCIES

In addition to the research, data acquisition, and reports generated in conjunction with this cooperative study, the Office of Geology Coastal Section has developed expertise which is proving valuable to other agencies both in coastal-related activities as well as other regulatory and research needs.

The Geographic Information System (GIS) which has been established at the Office of Geology during this cooperative study is already being used for other research and practical applications. The regional planning agencies on the coast will use the GPS shoreline measured each year by the Coastal Section staff to update their GIS base map, which is used by numerous local and county agencies. The land use/land cover study, scheduled for publication next year, will be used by several agencies as a planning tool to alert potential developers about possible wetland areas and development trends along the coast.

The Mississippi Department of Environmental Quality Emergency Services Division, which is responsible for hazardous materials and oil spill cleanup in the state, has requested that our GIS incorporate planning and response information necessary for their operations. Data input will include the latest GPS shorelines, transportation routes, population data, bathymetry, and shoreline sensitivity index. The new oil spill sensitivity index for Mississippi will be created with support from NOAA and the Minerals Management Service using the Mississippi Shoreline Geomorphology System developed as a part of the cooperative USGS study, and the data will be maintained and updated in the Office of Geology GIS.

The GPS base station network established and maintained by the Office of Geology is being used extensively by state, local, and federal agencies, as well as private contractors, in Mississippi and the surrounding states.

The vibracoring rig built during the cooperative study has been used by the Office of Pollution Control to gather evidence in enforcement actions taken against surface water runoff regulations violators in the state. The video equipment purchased during the cooperative study has also been used to gather evidence in several pollution violations cases. The pontoon work boat and vibracore rig were recently used to collect cores in the lower Pearl River in support of an Office of Land and Water Resources effort to repair cut-outs in the river bank meanders and relieve bottom siltation and flooding in that area.

The Mississippi coast is overdue for a major storm or hurricane impact. The profiles, geomorphology, and bathymetry gathered during the cooperative study will be maintained and used to measure coastal changes resulting from such a storm impact. Documentation of these changes will be valuable to coastal planning and emergency response agencies as an aid in developing better storm survival and recovery techniques. As more annual measurements are made, some relatively short-term shoreline change trends might also be recognized which will aid coastal planning efforts in Mississippi.

FUTURE RESEARCH PLANS

As a continuation of the work started during this cooperative study, the Office of Geology plans to complete the bathymetric survey of the Mississippi Sound during the coming field season and deliver a completed map and data set to the USGS. This will be completed as soon as calm-water conditions will permit. The geologic interpretation of cores and seismic in the Mississippi Sound will be expanded to include Hancock and Jackson counties as time permits.

The new Hancock County beach will be monitored for the foreseeable future to document changes resulting from seasonal weather events. As soon as a change trend can be established from the monitoring data, a report will be issued which will hopefully aid in the design and implementation of future beach nourishment projects in the state. The wave refraction model acquired from the U. S. Army Corps of Engineers will be used to evaluate the effects of the nearshore borrow pit on the new beach.

The Belle Fontaine area will be monitored to document changes resulting from the nourishment project funded by the Gulf of Mexico Program. The Shoreline Evolution Model developed there will be refined as new data are acquired, and hopefully the model can be applied to other sections of shoreline in the state.

The beach profiles established during the cooperative study will be measured each year, and a report will be issued as soon as sufficient data are acquired. These profiles are the most accurate effort to date to document the detailed movement of the artificial beach in Harrison County both onshore and offshore. Trends established by the profiles will aid the county Sand Beach Department in maintaining the beach more efficiently.

The bathymetric survey system developed by the Office of Geology Coastal Section will be used to survey inland lakes and rivers to document sedimentation rates and bottom changes.

The geomorphology of the mainland and the barrier islands will be re-examined in future aerial video flights to establish change trends and keep the database up-to-date in the event of a major storm or hurricane.

The "Bibliography of Mississippi Gulf Coast Geology and Related Topics" will be maintained digitally, and updated as new topics and new published material are added to the literature. Likewise, the core data collection established during the cooperative study will be updated digitally as new cores are recovered, and the data will be made available to other researchers upon request.

Future publications planned from this cooperative study will include a report on the Land Cover/Land Use Changes section of this report and a report on the Beach and Nearshore Sediment Budget of Harrison County. Both of these will be published by the Office of Geology.

The Office of Geology Coastal Section will also continue to assist other state agencies and departments by providing unique, specialized research and data collection techniques which would not otherwise be available.

APPENDIX A

MISSISSIPPI GPS BASE STATION NETWORK

by
Stephen Oivanki

INTRODUCTION

Early in the course of the Cooperative Coastal Geology and Regional Marine Study with the USGS, there was a recognized need for some means of autonomous position calculation in the field. Accurate placement of cores and samples in their correct geographic position where there were no map references was all but impossible. The Global Positioning System (GPS), a military satellite navigation system, was already accepted by most of the scientific community as the best and most accurate means of achieving the desired results in the field. The Office of Geology as well as the Offices of Land and Water and Pollution Control within the Department of Environmental Quality had similar locational needs, so it was decided within DEQ to pursue the acquisition of GPS capability within the department.

MARIS GPS COMMITTEE

The Mississippi Automated Resource Information System (MARIS) is a state organization whose function is the coordination and development of Geographic Information Systems (GIS) in the State of Mississippi to insure that minimum standards are met in each system, that each system is compatible with each other system, and to locate and inventory vital data required for state and local government operations in GIS. All state agencies and many local and federal government agencies in Mississippi are represented as members of the MARIS steering committee.

The subject of GPS capability within Mississippi was presented to the MARIS community, and it was decided to set up a GPS subcommittee to explore the possible alternative methods of setting up a system which would benefit the most users at a minimum cost. Stephen Oivanki acted as the head of this committee. Presentations by several GPS equipment manufacturers were conducted, and independent research was done to determine the best type of GPS equipment to purchase. A survey questionnaire was sent out to all of the MARIS members, as well as other interested local and federal agencies and the private sector, to query their needs as to positional accuracy, current or future GPS use, as well as possible funding for acquisition of a state-wide system. The results of the questionnaire revealed that most current and potential users required position accuracies on the order of 1-5 meters for field positions. Only the Mississippi Department of Transportation had requirements for accuracies in the 0.01 to 0.1 meter range, and they already had plans to acquire their own GPS survey equipment.

None of the agencies responding to the GPS questionnaire had extra funding to contribute to a state-wide system. Such a system would require several base stations in order to differentially correct field positions to overcome the military Selective Availability which was causing errors on the order of 100 meters. Due to the immediate need of the agencies at DEQ, it was decided to pursue a system within DEQ which would then be made accessible to the rest of the state.

EPA SEDM GRANT

An application was made to the U. S. Environmental Protection Agency, Region Four, for a grant to purchase GPS base station equipment and necessary computer hardware and software to set up a differential GPS base station network within Mississippi to serve state users. EPA had already set down their requirements with regard to point-source pollution locations and water system parameters reported to EPA within existing programs at DEQ, and these requirements could only be met with GPS positions. In October, 1992 EPA awarded a grant to DEQ in the amount of $34,500 to acquire two GPS base stations, four computers, one GPS field unit, a Bernoulli drive, and misc. hardware and software to begin setting up the system. The three offices at DEQ all agreed to contribute the remaining equipment and personnel time as a match to the grant.

THE BASE STATION NETWORK

The Office of Geology Coastal Section agreed to do the actual fabrication and placement of the equipment and act as operator for the system. Trimble Navigation was selected as the best preferred equipment manufacturer after questioning several current GPS users, who recommended Trimble for reliability and customer support. Trimble agreed to provide the necessary equipment at a reduced package price, as well as training for all interested DEQ and state personnel. Additional training was provided to state personnel by Stephen Oivanki and Peter Hutchins after the network was declared operational.

The base station sites were selected to provide complete coverage for the state with redundant capability in case of failure of any individual station. Sites selected were: the Chemistry Building on the campus of the University of Mississippi in Oxford, the Institutions of Higher Learning Center in Jackson (MARIS), and the Marine Education Center at Gulf Coast Research Laboratory in Biloxi. Secure office space was donated inside each location to house the computer and peripheral equipment for each station. The three remote base stations are connected by telephone modem to a central computer at the Office of Geology in Jackson. Each base station is equiped with a Trimble 12-channel Community Base station which records correction files during daylight hours each day and stores the files on the site computer. Each night the files are copied to the central computer in Jackson by modem and placed on a bulletin board for access by users. Phone lines are donated for this purpose by agencies at the remote sites. All of the software installation and programming required to set up the automated system was performed by Peter Hutchins.

The locations of the base station antennas were surveyed to precise coordinates courtesy of personnel from Trimble and the USGS Mapping Division using geodetic-quality GPS equipment. Lightning surge protection equipment and power line quality maintenance is installed at all of the remote sites.

NGS HARN IN MISSISSIPPI

The National Geodetic Survey, in 1993, conducted a realignment of the horizontal control points in Mississippi to correspond to the accuracy available with GPS survey methods. This High Accuracy Reference Network (HARN) is being established throughout the country to provide very accurate (1:1,000,000 and 1:10,000,000 baseline accuracy) GPS reference stations tied to control networks across the nation. DEQ participated in this effort with personnel and equipment, and NGS reciprocated by tying the Mississippi Base

Station positions into the HARN free of charge. The station locations are now accurate to better than First Order (1:1,000,000).

NETWORK ACCURACY AND USE

Each of the base stations has been tested for accuracy of their corrected output by correcting averaged field points over existing NGS horizontal control points. Each station has yielded a corrected field position within 1/2 meter of the published control location using Pathfinder C/A code receivers collecting 10-minute averaged positions at 5-second epochs. When field data are collected, a known point is checked during the field session to verify that this accuracy is being maintained.

Since the system was first set up in October of 1993, a total of 51 users have downloaded over 1000 files from the bulletin board to correct field data. Within DEQ the GPS equipment in house now includes 11 Trimble Pathfinder field units and two Navtrac marine navigation units. Recent GPS surveys by personnel in DEQ have included: shoreline measurements along the coast, core and bathymetry profile locations, and seismic track lines by the Coastal Section, Office of Geology; surface pit mine perimeter surveys by the Mining Section, Office of Geology; water well locations by the Office of Land and Water; and point-source pollution locations by the Office of Pollution Control. Some other users include: the State Health Department, State Oil and Gas Board, U. S. Army Corps of Engineers, NASA, National Park Service, Soil Conservation Service, U. S. Forest Service, several county agencies and local municipalities, and several state agencies from surrounding states.

The GPS Base Station System operates for 14 hours each day and the data are accessible by modem through the bulletin board 24 hours a day by anyone free of charge. Access is restricted to 9600 baud or faster modems due to the time required to download the normally large files. The files are automatically recorded each hour in the standard Trimble format referenced to GPS time (Greenwich Meridian Time). The files are self-extracting ZIP files, and are provided in the Trimble *.ssf* format as well as the international RINEX format. The number for the DEQ GPS Bulletin Board is 601-961-5290.

APPENDIX B

MISSISSIPPI COASTAL CORE DATA SET

by

Peter Hutchins

and

Stephen M. Oivanki

Introduction

Over one hundred core hole and drill hole descriptions with foram counts and grain-size analysis results have been delivered to the Office of Geology by Dr. Ervin Otvos as part of his contract during Year 2 of the cooperative study. These cores are from the Mississippi Sound and immediate adjacent areas. Though many are incomplete, each log package should have included the following:

1. A strip log of the hole with descriptions.
2. Foram count of selected samples throughout the core.
3. Grain analyses of selected samples throughout the core.

The logs are divided into sub-groups based on location. These groups include:

Jackson county (JK)
Harrison county (HR)
Hancock county (HK)
Mississippi Sound (MS)
Mississippi Sound Vibracores (MSV)
Major Bays (MB)
Mississippi Barrier Islands (MBI)
Gulf Inner Shelf (IS)

The final delivered collection is incomplete and is in such a cluttered mess that serious thought and much time is needed to retrieve the data for entry into the Office of Geology database. There exist many duplicates of the same logs, and though they should be identical, they are not. Similar strip logs exist for the same interval, yet one will have marks and descriptions different from the other one with an identical heading. Foram sample logs may be duplicated on the back of another log, or photocopied in miniature. Logs with no name or location, haphazard datum and depth descriptions, and various other problems throughout the collection leaves a lot to be desired.

The logs are in the process of being cleaned up, sorted, and then digitized so that the data can be retrieved in a useful, orderly manner. The core database presented here is a best effort to organize this collection into a useful data set which can be queried and searched for use in future geologic investigations in coastal Mississippi.

Data Storage and Retrieval System

The task of digitizing the Otvos core collection into a useful data storage and retrieval system was done using primarily the following software tools:

1. Microsoft Visual Basic
2. Microsoft Access

A relational database is used that will contain four tables: 1. Source 2. Forams 3. Grain 4. Strip.

Source: Contains information about the source of the data entered into the database, i.e., the location, date, length of the core, and the elevation at the top of the hole. Also stored in this table are geographic information on the position of the hole, the units used, datum, coordinate system, and projection of the data. This information can be used for conversions to other coordinate systems.

All data entered into this database must have a related entry in the Source table. All records in all tables will have a field that references back to a record in the Source table.

Forams: Each record in this table contains the name of a specified foram, the log in which it came from, the number found (quantity) and the depth interval that it was sampled from.

Grain: Each record in this table contains the results of a grain size analysis, the interval that was sampled, percent of sand, silt, clay and gravel, GMean(phi), Median(mm), standard deviation, skewness, kurtosis, and a size description of the sample.

Strip: This table contains the strip log descriptions. Each record will refer to a depth interval. The lithologic type and a description for the interval will be stored in this record

MOGCORES.EXE: Using the Program

MOGCORES.EXE is the name of the Microsoft Windows program that was written to store, manipulate, retrieve and display the data. The program was written using Microsoft Visual Basic, and the database is stored in a Microsoft Access format. The program consists of modules to perform various tasks such as data retrieval and data display. All data can be printed as text or displayed in a table format.

A strip log can be created using AutoCAD Release 12. This method sends the data to AutoCad for Windows for automatic creation of a strip log. The log can then be saved in a DXF or DWG format for transferring, viewing, or storage. Another method for strip log creation is being created within MOGCORES. Using that method the chosen log can be viewed or printed, and selected information from other tables can also be presented. If MOGCORES does not perform some function needed, then MS Access can be used to work with the data, including data entry.

The program can be divided into four main functions:
1. Data Viewing
2. Data Editing
3. Data Entry
4. Data Printing

From the Data drop-down menu within the program you can choose the type of data to work with. Currently there are only 4 types of data, so you would choose Source, Foram, Strip, or Grain data. When one is chosen, a window will be displayed showing the data of your choice. This data window serves most of the data manipulation functions. There will be three "radio buttons" labeled Entry, Edit and View. The button that is pushed will determine the type of action that can take place. The View option will be the default choice. In this mode the data cannot be changed. Simply scroll through the display window for the data of your choice. To edit a record, click on it, and hit the Edit button. The record will then be presented, ready to edit. You will be given the choice of deleting or changing the record. If editing, once you have finished, click the Update button. If the data is acceptable, the record will be updated to reflect the change. The last choice is an option to add new records. When the Entry button is pushed, the program sets up for new data. Enter the data and push Add. When finished, press the View button to return to view mode. When finished with the data window, press Exit. When finished with MOGCORES, choose Exit from the top menu bar.

Data Entry

In general, data is entered into a form created for each of the four data types. This allows for fill-in-the-blank data entry. The one common field in all forms is the Source ID number. This number links the data to a particular core hole.

Source: When entering data from a core, you must first register the core into the Source Database table. As mentioned above, this is where you enter the general information about the core hole. Such information would include name, location(x,y,z), length, etc..

Foram: A data record for forams includes the depth interval, top and bottom. The top refers to the distance from the top of the hole to the top of the interval that was sampled. The bottom refers to the distance from the top of the hole to the bottom of the sampled interval. The other two pieces of data entered are species and quantity of the species found within the sampled interval. To find a particular species name, you only have to type in the appropriate box the name of the foram. As you type, the program will search for the closest entry to match your spelling.

Once you see the foram you are looking for in the display window, simply click on it and enter the quantity found. When you are satisfied all the entries are correct, click the ADD button. The program will then check the data, and if it passes inspection, the data will be entered into the database and the screen is prepared for another entry.

Grain: A grain record consists of 16 fields to be entered. The Source ID and depth interval are the same as mentioned before. There are five fields that refer to the size classification found for a particular interval. Four of these fields are measured in percentages of Grain, Sand, Silt, and Gravel found in each sample. In these data sheets, there exist many entries where silt and clay percentages were summed together. When this is the case a checkbox on the form is checked, and the two fields will show the same value. This check is also stored in the database. The next four fields are associated with statistical parameters of grain size. These are the Median(M_d) and Graphic Mean(M_z) measurements. They were given in phi and/or millimeters(mm). There is an entry place for all measurements, but none are required. Following this there are entries for Inclusive Graphic Standard Deviation, Inclusive Graphic Skewness, Graphic Kurtosis, and a size term description. The only fields that require an entry are Source ID, depth intervals, and percentage measurements.

Stratigraphic Descriptions: A record of this type includes, as before, a required Source ID and depth interval. A lithologic description is then entered, where the first word in the description is a keyword that defines the graphic pattern that will be drawn to represent this particular interval on the strip log. There exist only a few keywords: Sand, Silt, Clay, Mud and Gravel. These keywords describe the main lithologic constituent of the interval. The description is deciphered by the program in the following way: The main keyword is the first character in the description up to the first comma or period found. Everything before the period belongs to the main keyword. Everything after the period is stored and displayed along with the keyword. The keyword can be followed by a comma and a descriptive term of the main keyword. An example would be "Sand, Very Fine. Muddy.". A sand pattern (dots) would be shown for the particular section and the pattern density would reflect "Very Fine". Though not implemented as of yet, a secondary symbol, such as "Muddy" or "Granular", will also be displayed.

Viewing Data

As mentioned before, viewing data is as simple as scrolling through the table of data and/or clicking on the particular record. Data is protected from change while in view mode.

Printing Data

Two types of print-outs are supported: graphic and text. The grain and foram data will be available as tabular prints. The stratigraphic data is available as a tabular printout or graphic log printout via AutoCAD. The two methods under development currently are (1)sending the data to AutoCad Release 12 for Windows, and (2)allowing MOGCORES to create and print a log itself. The method used for AutoCad is believed to be changed radically, and for the best, with the release of AutoCad Release 13. This new release is due by the beginning of December, 1994. Once this version is acquired, log creation can be adapted for it. The AutoCAD method is capable of printing in color or black-and-white. You are able to choose a core, then choose the interval you want printed. Other options will include the use of headers, colors, size, and scale. Grain and Foram data can also be represented in a limited fashion on this log.

Print-outs of Log Data

Printed strip logs of the cores currently entered into the database are included as an attachment to this final report. The database and program MOGCORES is also included as a digital attachment to this report.

APPENDIX C

BIBLIOGRAPHY OF MISSISSIPPI GULF COAST GEOLOGY AND RELATED TOPICS

Description of Digital Data

The "Bibliography of Mississippi Gulf Coast Geology and Related Topics" was published as Mississippi Office of Geology Circular 5 in 1993. Due to the timely nature and need for an updated listing of new publications on this subject, the Office of Geology maintains a digital copy of this Circular which is updated each time new publications are released. The data are maintained in WordPerfect for Windows 5.2. An updated copy of this Circular is enclosed on 3.5" diskette as a supplement to the hard copy attached to this report. An insert containing recent additions to the bibliography is included with the attached Circular 5. Data have been updated as of January 1, 1995.

APPENDIX D

Mississippi Office of Geology
Coastal Section

LIST OF PUBLISHED REPORTS

Meyer-Arendt, K. J., 1991, Human impacts on coastal and estuarine environments in Mississippi: GCSSEPM Foundation, 12th Annual Conference, Program and Abstracts, p. 43-55.

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Oivanki, S. M., M. B. E. Bograd, and E. G. Otvos, 1993, Bibliography of Mississippi Gulf Coast geology and related topics: Mississippi Office of Geology, Circular 5, 34 p.

Oivanki, S. M., ed., 1994, Belle Fontaine, Jackson County, Mississippi, human history, geology, and shoreline erosion: Mississippi Office of Geology, Bulletin 130, 136 p.

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APPENDIX E

Mississippi Office of Geology
Coastal Section

LIST OF PUBLISHED ABSTRACTS

1991

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Yassin, B. E., and J. S. Moody, 1993, GIS applications in the study of historic shoreline change, coastal Mississippi: Journal of the Mississippi Academy of Sciences, v. 38, no. 1, p. 40.

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Geology and Geography

NEW EARLY EOCENE LAND MAMMAL FAUNAS FROM THE TUSCAHOMA AND BASHI FORMATIONS IN MISSISSIPPI. D. T. Dockery III, Mississippi Office of Geology, P. O. Box 5348, Jackson, MS 39296, K. C. Beard, A. R. Tabrum, The Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213, and G. R. Case, P. O. Box 689, Ridgefield Park, NJ 07660.

The first Early Eocene land mammal faunas from the North American coastal plains are reported here from the Tuscahoma and Bashi formations of Meridian, Mississippi. The Tuscahoma contains vertebrates above a diastem (discovered by Case) that marks the Paleocene-Eocene boundary as indicated by dinoflagellates and pollen of underlying and overlying clay beds (Lucy Edwards and Norm Frederiksen, U.S. Geological Survey, personal communication). This fauna rests ten feet below the Tuscahoma-Bashi contact and consists largely of shark and teleost fish teeth but also contains snake vertebrae and mammal teeth. The overlying Early Eocene Bashi Formation also has a rich vertebrate fauna that contains mammal remains. To date, land mammal taxa identified from these units include ten species of either Clarkforkian or Wastchian Land Mammal Age (Tuscahoma Formation) and one species that is definitely Wasatchian in age (Bashi Formation). These taxa provide the first opportunity to correlate the Early Eocene marine section of the Gulf Coastal Plain with land mammal ages of the Western Interior.

A HISTORY OF PUBLICATION ON MISSISSIPPI VERTEBRATE FOSSILS. Eleanor Daly Mississippi Museum of Natural Science, 111 N. Jefferson St., Jackson MS 39201

The bibliographic record for Mississippi fossil vertebrates falls into four discernible periods, beginning with the Natchez period and ending with the modern active period. During the 28 years (1842-1870) of the Natchez period, about 40 publications appeared, of which 22 dealt, in whole or in part, with the Pleistocene mammalian megafauna found in the Natchez area. There followed a period of almost 90 years in which works concerning Mississippi vertebrates dwindled and stayed below one a year. From 1870 to 1913, the decline period, 30 papers appeared. 13 of them mention Natchez, but 6 of those were by anthropologists discussing the human pelvis found with the mammals. The time from 1915 to 1961 might be thought of as the Geological Survey period; of the 32 pubs of that time, 14 are G. S. bulletins mentioning vertebrate remains encountered during field investigations. Since 1961 the rate of publication on Mississippi material has gone up to nearly two a year. Some of the authors are actually based in the state. Mississippi is becoming a place where one goes to collect study material, rather than where fossil collections are from. Dissertations and theses by southern authors have begun to appear, dealing at least partly with Mississippi vertebrates collected especially for the project. During the last decade, Mississippi Geology has emerged as an important vehicle for publication on Mississippi vertebrate fossils.

HOLOCENE HISTORY AND EVOLUTION OF HORN ISLAND, MISSISSIPPI SOUND. James B. Rucker Center for Research in Ocean and Space Sciences, University of New Orleans, New Orleans, LA 70148

Horn Island, the longest of the Mississippi barrier islands overlies the buried Pleistocene channel of the Pascagoula River. Stumps and remnants of the forested ridges of eastern Horn Island which are found in the shallow waters of Horn Island Pass provide evidence of the westward migration of the island. Along the length of Horn Island there are a series of three sets of distinctive lineations recurved toward the Mississippi Sound side of the island. At the locations of the recurved lineations, the shoreline on the sound side of the island exhibits slight offsets. The western set of recurved ridges coincides with the 1854 shoreline position. Since then island has migrated 2.8 miles to the west. Based on an examination of the patterns of ridges on areal photos and field reconnaissance it appears that these offsets correspond to positions where the island paused for a period in the course of its general migration to the west. It is likely that the entire island has been reworked by island and pass migration during the last 1,000 years.

QUATERNARY SEA LEVEL CHANGES, RECENT AND FUTURE SHORE EROSION TRENDS, MISSISSIPPI-ALABAMA COAST Ervin G. Otvos, and Wade Howat, Gulf Coast Research Laboratory, Ocean Springs, MS 39564-7000.

The elevated ground that backs the mainland shoreline is composed mostly of Sangamonian interglacial highstand deposits: those of the Gulfport barrier complex and the alluvial Prairie Formation (Otvos, 1991). Late Holocene coastal plain development, by strandplain and wetland progradation, created the Morgan Peninsula, south Hancock and Bellefontaine beach ridge plains- marshlands, the Pearl, Pascagoula, Escatawpa and other deltas. These were also associated with eustatic sea level rise. Current shore erosion is believed to have locally been influenced by compaction of thick, muddy Holocene sediment sequences (e.g., Morgan Peninsula, Cat Island) and tectonic subsidence (primarily in the southwestern, delta-flank zone). Erosion of the relict Escatawpa delta and its since extinguished sand spits was least influenced by sea level rise, more by storm cycles. Between 1848-1989 shore retreat at Grand Batture exceeded 0.8 km. Relative sea level rise at Biloxi may not have exceeded 15-23 cm/century. Preliminary geodetic data suggest that the land along the shoreline may not be stable as thought earlier but is experiencing a subsidence of 16-33 cm/century, while rising as much as 40 cm/century inland. Ongoing global warming, due to man-made and natural causes could seriously impact the mainland shore. Concentrations of carbon dioxide, an essential "greenhouse gas", between 1958-1990 over Hawaii increased from 315 ppm to 355 ppm. Significant further increases are expected. Continued sea level rise would have a relatively minor effect on barrier islands east of Cat Island in the next generations. Current projections of future eustatic sea level rise, generally highly speculative, range between c. 10-83 cm/century.

★ HUMAN RESPONSE TO COASTAL EROSION: MODIFICATION OF THE MISSISSIPPI SHORELINE, by Klaus J. Meyer-Arendt, Department of Geology and Geography, Mississippi State University, MS 39762.

Transgression and shoreline erosion have been characteristic processes along the northern Gulf Coast for several thousand years, but not until coastal environments became recreationally popular in the 1800s did erosion become perceived negatively. Because of human desires to maintain beachfront summer homes and fixed property lines, shoreline retreat became a problem to combat. Over the last century, human efforts to offset the three dominant types of shoreline retreat--normal, storm-induced, and human-induced--have included a variety of structural and non-structural methods.

The Mississippi Coast, the oldest recreationally developed shoreline along the Gulf Coast, has been greatly modified by humans. Narrow natural beaches of Harrison County have become replaced by seawalls and "the longest man-made beach in the world", and adjacent coasts of Hancock and Jackson Counties--including Pascagoula--have been similarly modified. More recent loci of shorefront urbanization such as the Gautier and Bellefontaine headlands contain groins and jetties which have been mostly ineffectual. In view of recent hurricanes and sea level rise predictions, policies of construction setbacks and beachfront retreat may be more rational.

UPDATED LIST OF MISSISSIPPI EARTHQUAKES. Michael B.E. Bograd, Miss. Office of Geology, Jackson, MS 39296

Although the greatest earthquake risk to Mississippi is from a strong event in the New Madrid seismic zone, earthquakes have occurred throughout the state. Of the 31 known earthquakes with epicenters in Mississippi, 19 were felt and the others were detected only by instruments. The earliest was felt in Biloxi in 1853. The strongest earthquake with its epicenter in the state was near Batesville in 1931; this temblor was felt over 65,000 square miles with a maximum intensity of VI-VII. The second strongest occurred near Greenville on June 4, 1967, and was felt over 25,000 square miles; an aftershock on June 29 was felt in 3 counties. The most recent events were 5 minor tremors reported by the public in Pachuta, Clarke County, in August and November of 1989. Uncertainties about epicentral locations and depths make difficult any correlation of these earthquakes with specific structural features. The most obvious cluster of activity is the 10 events in Clarke County; possible sources could be the Pickens-Gilbertown fault zone, the buried Appalachians, salt structures, or oil and gas activity. Nearly one-third of the earthquakes, including the 2 strongest, were in the northwest quadrant of the state, closest to the New Madrid seismic zone. The other events were located in northeastern, central, and coastal Mississippi.

DEVELOPMENT OF COALBED METHANE IN MISSISSIPPI WARRIOR BASIN.
Rudy E. Rogers*, Karl Carlson. Dept. Petrol. Eng., Mississippi State, MS 39762. (MMRI Grant #91-7F)

Since 1980, over 3863 coalbed methane wells have been drilled in the Warrior basin of northwest Alabama at a drilling cost of $1.138 billion. Production of 119 billion cubic feet of gas has been sold. An infrastructure of a booming industry is in place in Alabama. The basin extends across northern Mississippi, but industry activity has not materialized in the state. To determine the potential of coalbed methane in the Mississippi Warrior basin, forty-eight old logs of conventional gas wells in Monroe, Clay, Oktibbeha, Lowndes, and Noxubee Counties were evaluated; such logs have limitations, but they can provide a valid first estimate of the potential of an area. Based on density, compensated neutron, caliper, and gamma ray logs, probable coalbeds were indicated across northeastern Monroe County. The logs showed the coal to often be close to conventional gas reservoirs in sandstone, indicating a probable equilibrium gas content of the adjacent coals. The prevalent depth of the coal seams in Monroe County was 1600 - 1800 ft. Cumulative thickness of all coal in a single well was a maximum of 30 ft in the 1000 ft to 2000 ft interval usually logged. Depths, individual seam thickness, and cumulative thicknesses appear to compare favorably to those seams producing profitably in Alabama. Coreholes should be drilled and cores analyzed to further and more fully characterize the seams.

COMMERCIAL APPLICATIONS OF SHALLOW PIERCEMENT SALT DOMES OF MISSISSIPPI.
A. John Warner and Jack S. Moody, Miss. Office of Geology, Jackson MS 39289

There are 52 recognized shallow piercement domes in the Mississippi Interior Salt Basin. These domes have been evaluated by a variety of industry and government sectors. Initially, the oil and gas industry began to explore some of the domes' caprock and overlying Tertiary sediments in the late 1930's and 1940's. This initial phase of exploration yielded only small amounts of production. During this same period, the sulfur industry evaluated the caprock of 17 domes for elemental sulfur without establishing commercial production. The petroleum industry later utilized two domes for the storage of liquid and gaseous hydrocarbons. Recently, the petroleum industry has renewed its interest in the domes. Deeper drilling has found production on the flanks of the domes. In 1985, Enserch Corp. discovered its West Raymond Field on the flanks of Oakley Dome in Hinds County. Field development has resulted in 13 producing wells and three dry holes. Production is from the Lower Cretaceous Mooringsport, Rodessa, Sligo, and Paluxy formations. As of January 1, 1991, the field has produced 1,540,526 BO and 671,725 MCFG. Several additional flank fields have been discovered to date.

EPHRAIM N. LOWE AND THE MISSISSIPPI GEOLOGICAL SURVEY.
Michael B. E. Bograd, Miss. Office of Geology, Jackson, MS 39289

Ephraim Noble Lowe (1864-1933) was State Geologist of Mississippi for 24 years. Under his directorship, the Miss. Geological Survey was essentially a natural history survey. Reports authored by Dr. Lowe included such topics as soils of Miss., iron ores, oil and gas prospecting, road-making materials, plants, and a history of the agency. He enlisted the talents of Calvin S. Brown of Ole Miss (Archeology of Miss.), William N. Logan of Miss. A. & M. College (pottery clays, structural materials, and limestone), and Ralph E. Grim (bentonite). The Survey also cooperated extensively with federal agencies during Lowe's tenure. Bulletins on forestry were published in cooperation with the U. S. Forest Service. The Survey worked with the U. S. Geological Survey on water resources, topographic mapping, and an ambitious Coastal Plain Stratigraphy of Miss. project with L. W. Stephenson and C. W. Cooke. It cooperated with the U. S. Bureau of Soils in the preparation of 40 county soil surveys. Dr. Lowe was able to accomplish this work through great skill as a manager, contending always with a very small staff and budget. He clearly put to good use his training in geology and biology from Ole Miss and the University of Chicago and in the School of Medicine at Tulane University (M.D., 1892).

PALEOBOTANIC PORTRAYAL OF THE PEARL RIVER, LEAKE AND MADISON COUNTIES, MISSISSIPPI DURING THE QUATERNARY PERIOD.
Paul E.Albertson and Joseph B. Dunbar
US Army Engineer Waterway Experiment Station, Vicksburg, MS 39180-6199 601-634-3148

Geomorphic reconnaissance of the Pearl River utilized paleobotanic techniques for Quaternary paleoecology reconstructions. A total of four borings were examined and analyzed for pollen and plant-macrofossils. The chronology of the sediment core was independently tested using radiocarbon dating. This offers an opportunity to visualize the vegetation of the Pearl River Basin in context to the late Quaternary climate and botanic responses in the southeastern U.S.A. (Delcourt and Delcourt, 1985). Our purpose is to portray the paleoecology dynamics of The Pearl. The data suggest the following scenario: starting from 9300 yr BP, the *Picea* spruce boreal forest was replaced by *Quercus* oaks, *Juglandaceae* hickory and *Nyssa* gum of a mesic to hydric habitat; lateral reworking of the river erased the record of regional change at 6500 yr BP of increased pine in the uplands and cypress-gum in the bottoms; record of riparian vegetation renews at 1200 yr BP and continues to the present. The addition of European assemblages such as *Ambrosia* ragweed and *Hypericum* St. John wort are present in sediment of less than 490 yr BP or after 1698 AD.

FOSSIL TELEOSTEAN OTOLITHS FROM THE BOWDEN FORMATION OF JAMAICA.
Gary L. Stringer, Dept. of Geology, Univ. of Southern Miss., Hattiesburg, MS 39406

Pliocene teleostean otoliths from the Bowden Formation of Jamaica represent the first otolith assemblage to be formally described from Jamaica and only the second Pliocene otolith assemblage to be studied from the Caribbean. Approximately 1400 otoliths were identified from the classic Bowden shell bed and represent at least 55 taxa of teleosts. The most abundant taxa of the assemblage include Gobiidae ind., Diaphus schwarzhani, Bregmaceros sp., Diaphus aff. D. brachycephalus, Otophidium robinsi, and Lonchopisthus micrognathus. Comparison of the fossil taxa to the bathymetric distributions of closely related Recent forms reveals an association with shallow-water marine forms (including euryhaline species), neritic species, and middle to outer shelf forms with some upper slope and pelagic elements. Indications of reefal elements also exist in the fossil assemblage. The fossil otolith assemblage is quite similar to the Recent Caribbean ichthyological fauna with a few exceptions.

ORIGINS OF MISSISSIPPI'S MIOCENE STRATIGRAPHIC PROBLEMS.
Ervin G. Otvos* and Wade E. Howat, Geology Section, Gulf Coast Research Laboratory, Ocean Springs, MS 39564-7000

Several problems involved in Mississippi's present Miocene stratigraphic nomenclature go back a century, to the field work and publications (1888-1893) of Laurence C. Johnson, an able US Geological Survey, later Alabama Geological Survey geologist. He was the one who named the "Hattiesburg" and the "Pascagoula formations" in stream banks. Johnson distinguished the Pascagoula from E. W. Hilgard's now-obsolete "Grand-Gulf formation" (later, Group) and characterized it with a newly described brackish water oyster (Ostrea westi) and a "Gnathodon" species (Rangia johnsoni). Definition of "formation" boundaries between the two units, as well toward the Early Miocene Catahoula Formation and the overlying "Pliocene Graham Ferry Formation" (Brown and others, 1944) has never been attempted. Nevertheless, the formation names remained in local use. These deposits are of fairly nondescript, sandy-muddy, siliciclastic lithology, with various grayish, bluish and greenish hues. The sediments formed in continental and brackish environments. Downdip, broadly correlatable marine sediments have been previously associated only with the Hattiesburg (Amphistegina zone: Gravell and Hanna, 1938; Dockery, 1981). Work in progress at GCRL indicated the presence of fossil-dated Lower-, Middle- and Upper Miocene marine units at coastal and nearshore localities. Marine Miocene units (Amos and Escambia Members of the Middle-Upper Miocene "Pensacola Clay") of NW Florida- S Alabama were correlated with units, found in SE Mississippi. Correlation between datable marine and updip continental-brackish deposits, especially on the long range, is not feasible. The use of the terms, "undifferentiated Neogene/ or Miocene deposits" is recommended instead for the brackish and alluvial units (Otvos, 1991, Table 1).

THE FRANKSTOWN LATE CRETACEOUS VERTEBRATE HORIZON, A TRANSGRESSIVE LAG AT THE BASE OF THE DEMOPOLIS FORMATION IN PRENTISS AND LEE COUNTIES, MISSISSIPPI.
David T. Dockery III, Miss. Office of Geology, Jackson, MS 39289 and Earl M. Manning, Baton Rouge, LA.

A roadcut made in 1990 for Highway 45 through the south valley wall of Twenty Mile Creek just NNW of Frankstown, Mississippi, exposed a section of the Demopolis and underlying Coffee formations and an abundance of shark teeth and other vertebrate remains. Material from this cut was used as fill for the highway across the Twenty Mile Creek flood plain. The abundance of vertebrate fossils in the highway cut and exposed in the fill along a one-mile stretch of roadbed attracted national attention. These fossils include a diversity of late Campanian shark, ray, bony fish, and reptile remains, including rare dinosaur teeth. Where in place, they are concentrated as a lag deposit above the Coffee-Demopolis unconformity in a 1.7 foot-thick, well sorted, fine-grained sand here informally referred to as the Frankstown sand. Overlying this sand is a one foot-thick oyster biostrome, consisting largely of Pycnodonte convexa (Say), in a sandstone matrix. This ledge-forming bed is a continuation of the transgressive Frankstown sand and can be mapped over a large area of NE Mississippi.

★ BARRIER ISLANDS, MISSISSIPPI GULF COAST: CLASSIFICATION OF GEOMORPHIC FEATURES.
Mario V. Caputo*, Dept. Geol. and Geog., P. O. 5167, Miss. State Univ., and Stephen Olvanki, Miss. Office of Geology., Jackson, MS

The trial classification presented herein characterizes the sedimentary-geomorphic setting of the five barrier islands (Petit Bois, Horn, East Ship, West Ship, and Cat) protecting the Mississippi Gulf coast. Four categories form the basis of the classification: 1) barrier framework, 2) morpho-sedimentary zones, 3) coastal processes, and 4) geomorphic features. A framework of submerged platform (shelf), subaerial margin (beach), and interior (eolian-washover-marsh complex) is influenced by specific processes. The shelf is either non-barred or barred with ridge and runnel topography. Mean low-tide marks the shelf-beach boundary. Beaches are grouped as: 1) either Sound-facing, Gulf-facing, or adjacent to tidal passes, and 2) either erosional or depositional. Erosional beaches reflect barrier migration, diminishing sediment supply, and sediment removal. They are recognized by drowned maritime flora, exhumed marsh, and erosional scarps of elevated eolian, washover, beach, and marsh platforms. Depositional beaches express the accretion of barrier margins through spit growth and wind-washover sedimentation. Above the level of mean spring tide is a complex of washover corridor/splay, wind flat, dune, beach ridge, maritime forest, and pond/marsh of the island interior.

★ LOW-ORDER, MORPHO-SEDIMENTARY CHANGES ON BARRIER ISLANDS, MISSISSIPPI GULF COAST.
Mario V. Caputo*, Dept. Geol. and Geog., P. O. 5167, Miss. State Univ., and Stephen Oivanki, Miss. Office of Geology, Jackson, MS
Morpho-sedimentary features observed in aerial photography serve as reference data for monitoring local changes in the barrier island system of the Mississippi Gulf Coast. Drowned maritime flora, exhumed marsh, scarps, spits, washover flats/splays, eolian flats/dunes, dune-beach ridges, pond/marsh, and maritime forest are semi-permanent features which evolved over different time spans at different rates. They are low- and medium-order responses to coastal processes. A comparison between aerial videodata collected in July, 1989 and in July, 1991 indicates the persistence of low-order geomorphic modification. Several washover splays were deposited near the east end of West Ship Island; a recurved spit became attached to the island and formed a partially enclosed lagoon. Washover corridors on East Ship Island were reoccupied and buried with dark sediment. Near West Point of Cat Island, barred topography incised with channels formed on the nearshore shelf and spits were built across mouths of some tidal creeks. An interdune pond/marsh on Horn Island diminished in size due to the encroachment of washover and eolian sediment. The cummulative effect of small-scale, low-order geomorphic changes, over time, contributes to high-order changes at the scale of the total barrier island.

★ A PROFILE ANALYSIS OF THE BEACH AND NEARSHORE, HANCOCK COUNTY, MISSISSIPPI.
Stephen M. Oivanki* and Jack S. Moody, Miss. Office of Geology, Jackson, MS 39289
Prior to an anticipated beach nourishment project scheduled for Winter 1991-92, profiles were established along a 7 mile section of Hancock County shoreline between Bay St. Louis and Bayou Caddy from the seawall to subsea depth of approximately 5 feet. Profile lengths ranging from 600 to 2000 feet were measured using a Wild total station and prism pole. Bottom samples were collected on selected profiles. The nearshore zone varies from 400 to 1500 feet wide with from 5 to 12 offshore bars sub-parallel to the shore having elevations of approximately one foot above the bottom slope. The bars are more numerous offshore from remnant beach areas and are absent near Bayou Caddy. Sediment grain size consists of fine sand on the beach and nearshore with an abrupt change to silt and mud at -3 1/2 feet subsea coincident with an abrupt increase in slope. Overall grain size decreases to the southwest toward Bayou Caddy. All of the sand present in the study area is believed to be the result of previous beach nourishments in 1967 and 1972.

SHORELINE CHANGES AT OCEAN SPRINGS, MISSISSIPPI, 1900-1992.
Klaus J. Meyer-Arendt, Pete A. Kohn, Walter E. Kelley, Dept. Geology and Geography, Miss. St. Univ., Mississippi State, MS 39762.

The Biloxi Bay shorefront of Ocean Springs, Mississippi has undergone many changes since seaside tourism first became popular there a century ago. Discontinuous Pleistocene dune bluffs, interspersed with wetland-fringed bayous, were formerly fronted by muddy tidal flats containing varying amounts of shell material. As along the shorefronts of Hancock and Harrison Counties, seawalls were built fronting the developed sections of Ocean Springs in the late 1920s. Two decades later, beach nourishment projects created sand beaches in front of the two seawall segments, and the modern shoreline reaches of Front Beach and East Beach became named. Front Beach, more exposed to wave and tidal forces, experienced greater levels of erosion, and renourishment with dredged material was conducted in the 1970s. At wave-sheltered East Beach, marsh vegetation colonized the beachfront intertidal zone and thus assisted in the stabilization of the shoreline. These new wetlands became modified by routine 'beach maintenance' activity in the 1980s, and shoreline retreat appears to have become more pronounced by the early 1990s. Present research, including beach profiling, is now investigating recent changes at Ocean Springs' East Beach.

★ HISTORICAL SHORELINE ANALYSIS OF THE MISSISSIPPI COASTLINE.
Jack S. Moody* and Stephen M. Oivanki, Miss. Office of Geology, Jackson, MS 39289
As a part of a cooperative study between the Mississippi Office of Geology, the USGS, and Louisiana Geological Survey, the mainland shorelines of 1847, 1917, 1932, and 1951 were digitized. In addition, two aerial photo surveys, 1978 and 1986, were interpreted and the subsequent maps were digitized and stored on a GIS system. Several studies in the past documented the changes through the above time periods for the offshore islands but this is the first such study for the entire mainland coast. It is now possible for investigators to identify those parts of the Mississippi coastline which exhibit historical trends of erosion or accretion and establish their respective rates of change. This information will be used by the scientific community to study the evolution of Mississippi's microtidal storm-dominated coastline as it is subjected to worldwide sea level rise, low sediment input, human induced modifications of the coast, and frequent storm activity. This same information will prove helpful to coastal officials and planners as it identifies and quantifies areas of erosion and accretion.

EFFECTS OF A SMALL-SCALE OIL SPILL ON THE NEAR-SHORE MACROINVERTEBRATE COMMUNITIES OF HORN ISLAND, MISSISSIPPI.
Jerry A. McLelland*, Richard W. Heard, and S. Dawne Hard. Invertebrate Zoology Section, Gulf Coast Research Laboratory, P.O. Box 7000, Ocean Springs, MS 39564.
Sand beach and near-shore benthic habitats along the north shore of Horn Island were impacted by a small-scale oil spill resulting from a ruptured pipeline in Mississippi Sound on September 18, 1989. A 14-month study was undertaken to assess the effects of the oil spill and ensuing cleanup operations on macroinvertebrate communities at a site within the hardest hit area, a 1.2 km stretch of beach adjacent to Big Lagoon, near the center of the island. This site was compared to an ecologically similar but unaffected "control" site on Ship Island. Populations at both sites were monitored at six-week intervals for nine sampling periods as a means of estimating recovery. Three habitat zones were studied: supratidal, intertidal, and near-shore subtidal. Of these, the supratidal fauna exhibited the most severe impact from oil smothering and beach cleanup, as indicated by disappearance of the crustaceans, *Scyphacella arenicola*, *Americorchestia salomani*, and *Ocypode quadrata*. By the following summer, these animals had recolonized the affected area. In the other zones where oil impact was less severe, recovery was indicated by gradual recruitment of the intertidal amphipod, *Haustorius jayneae*, and by an increase in species richness and diversity in the subtidal zone.

AN EXAMPLE OF SLUMP BLOCK CONSTRUCTION OF THE CONTINENTAL RISE.
C. A. Brunner *, Center for Marine Science, University of Southern Mississippi, Stennis Space Center, MS 39529 and S. J. Culver, Department of Geological Sciences, Old Dominion University, Norfolk, VA 23529-0496
The age, origin, and geologic development of outcropping sedimentary units on the continental slope and rise of the Wilmington Canyon region are assessed from analysis of foraminifera. DSRV *Alvin* was used to core outcrops and subcrops of strata in the walls and floors of Wilmington, South Wilmington, and North Heyes Canyons. Benthonic foraminifera from 34 samples were identified, counted, and analyzed using cluster analysis to determine water depth of units at the time of original deposition.
Sedimentary units exposed by canyon incision into the slope appear in place based on benthonic foraminiferal paleodepth estimates. In contrast, units exposed in the walls and floor of South Wilmington Canyon on the upper continental rise clearly consist of blocks displaced from shallower depth. The base of the sequence consists of strata derived from inner and middle neritic depths and is overlain by a unit either slumped from nearby or deposited *in situ* at lower bathyal to abyssal depths. This unit is overlain by strata derived from middle to outer neritic depths and is overlain, in turn, by a unit displaced from upper bathyal depth. The Pleistocene strata of the canyon floor and north wall are capped by a thin dusting of Holocene contourite. South Wilmington Canyon was incised into the upper rise during the Pleistocene after emplacement of the last slumped block.

FLUX AND ABUNDANCE OF MARINE SNOW AGGREGATES AT A STATION IN THE EASTERN CENTRAL PACIFIC
Arne - R. Diercks* and Vernon L. Asper, Center for Marine Science, TRL 242, University of Southern Mississippi, Stennis Space Center, MS 39529; Meredith Sessions, Scripps Institute of Oceanography, University of California, San Diego, La Jolla, CA 92093-0222 and Dave Jones, Rutgers Shellfish Laboratory, P.O. Box 687, Port Norris, NJ 08349
Marine Snow data were obtained as part of a U.S.-Soviet research expedition aboard the R/V Yuzhmorgeologiya (Ministry of Geology, USSR) in the eastern central Pacific. A total of nearly 3000 images were achieved from a survey camera and from a sediment trap camera system. About 1400 images were analyzed using a digital image analysis system. The abundances of aggregates observed were relatively low, ranging from 0 to 0.05 aggregates ltr^{-1} throughout most of the water column and up to 0.6 ltr^{-1} at the surface. The flux of aggregates showed a break after roughly 12 hours. Fluxes before and after this break are 7,329 and 2,225 aggregates $m^{-2}\ d^{-1}$ respectively. The reason for the sudden reduction in aggregate flux is unknown, but could be related to resuspension of aggregates from the seafloor by the arrival of the mooring anchor or to other research activities carried on in the area. Sinking speeds calculated from flux/abundance were 146 m d^{-1} and 45 m d^{-1} respectively. The total mass flux determined by weighing the filtered sample, was 122 mg $m^{-2}\ d^{-1}$. Movement of particles lying inside the sediment trap could also be seen. Visitation by planktonic or nektonic swimmers is one likely explanation because no preservatives were used.

NAVY OCEAN MODELING AND PREDICTION AT NRL.
J.W. McCaffrey, Jr., Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS 39529-5004
In 1986 the then Oceanographer of the Navy, RADM J.R. Seesholtz, outlined his goal for the establishment of a global ocean forecasting capability by the mid-90's. Ocean modeling and prediction within the Navy is now on the threshold of substantial advances. Over the next several years the scope and accuracy of ocean forecasts will be revolutionized through the newly emerging computer and satellite technology and through advances in numerical ocean models, data assimilation, numerical atmospheric forecasts, and computer graphics and data management. Ocean circulation forecast systems have been developed and transitioned to the operational community which show skill relative to persistence for several weeks. An eight processor, 128 million word CRAY Y/MP has been installed at the Naval Oceanographic Office for ocean model research, development and operation. A schedule has been adapted for research, development and operational implementation of a Navy Ocean Modeling and Prediction which maximizes the opportunities provided by present and future computer and satellite systems.

MISSISSIPPI AGRICHEMICAL GROUNDWATER MONITORING PROGRAM STATUS REPORT

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The objective of this program is to determine the impact of Agricultural Chemicals on Mississippi's groundwater resources. The goal of the Groundwater Monitoring Program is sample collection from a minimum of three shallow drinking water wells in each county. Initial sampling has focused on areas of heaviest agrichemical usage. In addition to groundwater monitoring, this program is involved in the prevention of possible groundwater contamination through current projects such as developing methods of recycling plastic pesticide containers and disposal of un-used chemicals. Through October, 1991, wells in 53 counties have been sampled and analyzed for 76 Pesticides, 21 Metabolites, 48 Volatile Organics, and 27 inorganics. Sampling in the remaining counties is in progress along with re-sampling of any suspect wells. Results summarized to date show that thirteen chemical residues were detected, but at concentrations slightly above the lower level of detection. These preliminary results indicate agricultural chemicals are not impacting groundwater quality in the State of Mississippi.

DELINEATION OF FLUVIAL SAND BODIES USING GEOLOGICALLY BASED CALCULATIONS.

Darrel W. Schmitz, Department of Geology and Geography, Mississippi State University, Mississippi State, MS 39762

A model was developed which uses geologically based calculations to follow a fluvial sand body into and through a site. The model accomplishes this by establishing the environment of deposition from stratigraphic information and by assuming the sand body width is the same as the meander belt width. The meander belt width is calculated from sand thickness, once the sand body has been encountered, such as by a subsurface boring. Spacing for additional data locations, away from the initial one intercepting the sand, is determined from the sand body width and the probability of a second location intersecting the sand body. The sand thickness is estimated for a site by kriging (a geostatistical technique which estimates the value of a variable away from known points). Kriging gives the errors for the estimated sand thickness. These errors are then used, in combination with the spacing determined from the probability of another data location intersecting the sand body, to select a new location. The new data location(s) are selected in areas with the most error at the determined spacing. By following this model, fluvial sand bodies are delineated with a fewer number of data locations than necessary using conventional methods.

PROCESS-RESPONSE OF THE YAZOO RIVER, NORTHWESTERN MISSISSIPPI.

Danny W. Harrelson, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

As part of the investigation for the Upper Yazoo Projects, some forty-five borings were drilled along the Yazoo River. The Yazoo, beginning at Greenwood, MS, with the confluence of the Yalobusha and Tallahatchie Rivers flows south 188 miles until it empties into the Mississippi River just north of Vicksburg, MS. The course of the river flows near the eastern alluvial valley wall along its entire length forming the classic "Yazoo Type" tributary that parallels a major trunk stream for a considerable distance before flowing into it. Channel width for the river varies from 300 to 500 feet and in the main channel slopes are approximately 0.2 to 0.3 ft per mile. Base flow for the Yazoo maintained at approximately 10,000 c.f.s. is controlled by releases from the four USACE lakes. The geologic and hydrologic data obtained during this investigation has revealed some geomorphic features of the Yazoo River that include: 1) an underfit nature indicating discharges that were once much larger than current levels, 2) underfit conditions that result in the current Yazoo River being captured for more than 100 miles in an abandoned course of the ancient Yazoo, 3) a lack of Terrace deposits, and 4) a stable channel with no chute or neck cutoffs occurring during the last 50 years of surveys. In conclusion, current conditions observed on the Yazoo River are the results of its response to climatic variations and historic engineering activities.

MERIDIAN SAND PALEOCHANNEL AT MERIDIAN, MISSISSIPPI

Stephen L. Ingram, Miss. Office of Geology, Jackson, Ms 39289

The Tallahatta Formation and Meridian Sand comprise the TE2.1 Sequence of Baum and Vail's coastal onlap cycle chart (1990). These deposits are recognized as late Lower Eocene through early Middle Eocene in age, and are assigned to the Claiborne Group. The Meridian Sand is identified as the lowstand deposits of the TE2.1 Sequence Event, and overlies a deeply channelled Type 1 sequence boundary above the underlying Hatchetigbee Formation. The Tallahatta Formation represents the transgressive surface and highstand deposits of the TE2.1 Sequence. In the Covert Sand Pit located in the Sowashee Creek flood plain on the south side of I-20, Meridian, Mississippi, the Meridian Sand section is expanded at the expense of the Hatchetigbee below. Thick clayball conglomerates with boulder-sized clasts and massive sections of sand fill a paleochannel that flanks the eastern side of Sowashee Creek.

OYSTER REEF DEVELOPMENT AND MANAGEMENT IN THE MISSISSIPPI SOUND USING A GEOGRAPHIC INFORMATION SYSTEM.

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Oyster reefs in the Mississippi Sound have undergone significant stress in recent years resulting in reduced harvest capacities and higher market prices. Several factors account for this stress including reduced salinity content of the water due to an overabundance of freshwater storm discharge, high fecal and coliform levels, water depth, poor harvesting practices, and availability of food resources for the oyster's consumption. This paper explores these factors as individual coverages for implementing a geographic information system to assist in developing new reef locations and managing existing reefs.

★GIS APPLICATIONS IN THE STUDY OF COASTAL PROCESSES.

Barbara E. Yassin, Stephen M. Oivanki, and Jack S. Moody, Miss. Office of Geology, Jackson, MS 39289

GIS (Geographic Information System) a system for storing and manipulating spatial information in a computer, provides an unlimited format for the accumulation and study of data required to predict changes in the dynamic coastal environment. Using ARC/INFO, a GIS software, the Office of Geology is developing a database of historical shoreline maps, seismic profiles, core information, beach profiles, public land survey, hydrographic data, and geomorphic data. This extensive database will be layered to study the interrelationships of the various coastal processes. Historical trends can be easily recognized and used to focus research efforts on critical areas. Short term and seasonal change patterns can also be identified by updating the database with current research information. Previously these data were only available from numerous separate sources. GIS provides a method of incorporating all sources of geographic information into a readily accessible and easily manipulated form. Digital data can be rapidly transferred to appropriate federal and state agencies, municipalities, consulting groups, and individuals for application of the results.

THE USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN WATER RESOURCE MANAGEMENT. WITH PARTICULAR REFERENCE TO SURFACE WATER.

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This paper will outline why and how geographic information systems are useful to those that manage our water resources. Surface water examples will be cited to illustrate the application of these techniques toward the problem of flood management.

THE WORK OF MISSISSIPPI'S STATE MAPPING ADVISORY COMMITTEE.

Michael B. E. Bograd, Miss. Office of Geology, Jackson, MS 39289 and Paul E. Davis, Technical Director, MARIS, Jackson, MS 39211

Mississippi's State Mapping Advisory Committee (SMAC) was organized in 1983, reorganized in 1988, and operates under an Executive Order. In accordance with guidelines from the U.S. Geological Survey's National Mapping Division, it is made up of representatives of state agencies, private organizations, and institutions with statewide interests. The essential functions of SMAC are to coordinate mapping needs within the state and to communicate these needs to the USGS through the annual A-16 process. In addition to these functions, SMAC has addressed aspects of the state coordinate system and the National Aerial Photography Program. As the role of SMAC expands, additional map-related topics may be considered. These might include geographic names, digital cartographic data, serving as a clearinghouse for information, and map accuracy standards. SMACs in other states perform these types of functions. The Mississippi SMAC is receptive at any time to suggestions about needed map products.

★ HISTORICAL HUMAN IMPACTS UPON THE BELLEFONTAINE COAST, MS.

Klaus J. Meyer-Arendt, Dept. Geology and Geography, Miss. St. Univ., Mississippi State, MS 39762.

As part of a broader study conducted by the MS Office of Geology and the Bureau of Marine Resources in 1992, historical settlement patterns and landuse impacts on Mississippi's Bellefontaine headland were investigated. By means of archival research, interviews, and field surveys, it was found that human interference with coastal processes is relatively recent. In spite of archeological evidence of aboriginal usage, Indians occupied the region only temporarily during oyster- and shellfish-gathering periods. Similarly, the eighteenth-century French settlers--notably J.B. Baudreaux and his descendants, who acquired title to the property--resided on the coast only seasonally. The first permanent coastal inhabitants arrived in the nineteenth century, but settlement directly upon the storm-prone shorefront remained sparse until the 1950s. In spite of the 1947 hurricane which destroyed the few existing beachfront homes, a "beach subdivision era" began in the late 1950s. This coastal urbanization, mostly along what is now called Bellefontaine Beach, was accompanied by increased structural modification of the beach environment. A jetty/terminal groin was built at the west end of the Bellefontaine Beach Subdivision, and following Hurricane Camille in 1969 sand-trapping groins became more numerous. Field surveys in May 1992 identified 35 piers, 25 groins, and 35 bulkheads along the Bellefontaine headland (excluding the riprap bulkhead at the public fishing pier near Pointe aux Chênes). Preliminary evidence indicates that these structures have not effectively halted shoreline erosion but have assisted in further degrading a naturally erosive shoreline.

ESTABLISHED MISCONCEPTIONS ABOUT GULF COASTAL PLAIN PLEISTOCENE STRATIGRAPHY AND GEOMORPHOLOGY

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The use of outdated glacial chronostratigraphy has been a general feature of publications on the northern Gulf. A decade after the Wisconsinan interglacial was disproven, Fisk claimed that the youngest of four Louisiana coastwise terraces, the Prairie, formed during a mid-Wisconsinan marine highstand. The classic, universal four-glacial-three interglacial scheme, developed at the turn of the century in the Alps by Penck and Brueckner is now known to be invalid. Despite the revisions, rejected terms (Nebraskan and Kansan Glacial; Yarmouthian Interglacial) are still in use. Long after the c. 135-80 ka Sangamonian Interglacial was firmly established, several tables place c. 200 ka older than its radiometric age. They replace the Sangamonian with the Farmdalian "Interstade"; a brief, locally developed, not full-glacial interval of 28-25 ka BP - unrelated to major transgression and highstand. In recent publications, including Survey and GSA maps, the age of the Sangamonian Ingleside barrier and the Prairie coastwise alluvial surface with underlying deposits is given as Mid-Wisconsinan. This assumption led to mapping of a "Prairie Complex" in Louisiana maps, consisting of a sundry assortment of ill-defined sedimentary units. The approach repeats Fisk's failure to vertically delineate his "Prairie Formation" beneath the Prairie surface. Substantial alluvial aggradation and barrier formation could not have been accomplished with low coastal base levels during glacial marine lowstands. This fact is being disregarded. Evidence for the Mid-Wisconsinan age of the "upper" Prairie sequence in Louisiana and Texas, including paleosol and loess stratigraphy, is inconclusive. Despite general opinion to the contrary, the Gulfport-Ingleside barriers were not barrier islands but mainland strandplains.

HILGARD AND SMITH AT THE MISSISSIPPI GEOLOGICAL SURVEY

Michael B. E. Bograd, Mississippi Office of Geology, Jackson, MS 39289

Eugene Woldemar Hilgard and Eugene Allen Smith had much in common (besides their first names), including Ph.D. degrees from Heidelberg University completed in their twenties (Hilgard in 1853 and Smith in 1868), college professorships, positions as State Geologists (Hilgard in Mississippi and Smith in Alabama), distinguished careers through the second half of the 19th century and into the 20th, and both died in their eighties. Also, both men began their professional careers at the Mississippi Geological Survey, working together from 1868 to 1871. In 1871 Smith moved to the University of Alabama as Professor of Geology; he served as State Geologist of Alabama from 1873 to 1927. At the same time, Hilgard served as State Geologist of Mississippi and on the faculty of the University of Mississippi; he moved to Michigan in 1873 and to California in 1875. At the University of California at Berkeley, Hilgard gained an international reputation as a soil scientist and the Father of Agricultural Geology. The Survey appropriation was withheld in 1872 and the agency entered a period of inactivity. It is interesting to speculate about advances that may have been made in Mississippi if we had not lost Hilgard and Smith at this time.

★ GLOBAL POSITIONING SYSTEM (GPS) IN MISSISSIPPI, A STATUS REPORT

Stephen M. Oivanki, Miss. Office of Geology, Jackson, MS 39289

The Global Positioning System is a satellite navigation and location system operated by the U. S. military. Satellites orbiting the earth transmit radio ranging signals to receivers on the ground to give ground positions with an accuracy previously unattainable by any other means. Civilian use of this system has revolutionized GIS applications allowing direct digitization in the field of accurate position and attribute information. In order to achieve maximum accuracy from GPS, reference base stations are needed to correct normal errors in the radio wave transmissions. The Miss. Dept. of Environmental Quality has established a network of three recording base stations in Jackson, Oxford, and Biloxi for this purpose. The base stations record GPS data files for distribution by modem to users around the state, and support differential solutions for mapping-grade GPS units with accuracies of 1 to 3 meters horizontal. Specific hardware and software are required to use this system. The base stations are part of the High Accuracy Reference Network (HARN) being established this year in Mississippi by the National Geodetic Survey.

THE MISSISSIPPI HYDROLOGIC INFORMATION SYSTEM HARDWARE AND SOFTWARE IMPLEMENTATION.

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It was recognized that the Department of Environmental Quality, Office of Land and Water Resources (OLWR), needed to implement a Geographic Information System (GIS) in order to better manage the hydrologic data of the state of Mississippi. After determining the appropriate software and computer configuration, the Office of Land and Water Resources has acquired major portions of the hardware and software necessary to answer questions concerning the hydrologic cycle and some of the water use practices of the State. Human resource development is also a very important factor of GIS implementation and the changes made in the staff and cross training was essential to the development of the Mississippi Hydrologic Information System (MHIS). The digital data the OLWR is using for the basemap along with the problems we anticipate in the conversion of hard copy media into digital data is also presented. Implications for further growth are indicated by the projected size of the data base along with the equipment necessary to fully implement a digital cartographic mapping workstation with full GIS capabilities.

★ GIS APPLICATIONS IN THE STUDY OF HISTORIC SHORELINE CHANGE, COASTAL MISSISSIPPI

Barbara E. Yassin*, and Jack S. Moody, Mississippi Office of Geology, Jackson, MS 39289

GIS (Geographic Information System) is a computer-based system designed to support the capture, management, analysis, and display of spatial data. It was used to find the total acreage of erosion and accretion in predefined areas of interest. Using digitized shorelines (1850, 1917, 1950's, 1986) and ARC/INFO, a GIS software, we determined the environments that are actively changing on the Mississippi coast and islands. The shorelines were edited to remove extraneous data, then unioned together, attributed with the status of land or water, and finally the frequency and total acreage were determined for land changed to water and water changed to land. The same acreage for different environments can be consistently and reliably computed using GIS. The numbers can be interpreted by scientists to evaluate the effectiveness of a seawall or the vulnerability of a natural shoreline.

MAN-MADE AND NATURAL CHANGES ON THE MISSISSIPPI GULF COAST

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ABSTRACT

The Mississippi Gulf Coast exhibits a dynamic interaction between man and the coastal environment. Changes brought about by natural processes are contrasted with those changes resulting from the direct or indirect intervention of man and the development of the Mississippi shoreline. Historical shorelines for the Mississippi mainland coast and the barrier islands were digitized from USGS T-sheets for 1850, 1917, and the 1950's and from air photo interpretation for 1986. Data were manipulated in ARC/INFO for analysis and display, and changes were quantified for various shoreline types. Erosion and accretion trends recognized were related to known activities and events, and classified as either man-made or natural. Major man-made changes include the Harrison County seawall and artificial beach, Gulfport and Biloxi harbor development, Port of Pascagoula and Ingalls Shipyard, dredging and spoil disposal in harbors and access channels, and individual bulkheads and groins placed for property protection. Notable natural changes include the westward migration of the barrier islands, erosion of marsh shorelines in Hancock and Jackson Counties, and erosion of the Belle Fontaine headland in Jackson County. Natural processes acting on the mainland shoreline have resulted in an average net land loss of 2968 acres between 1850 and 1086, while man-made changes resulted in a net gain of 1616 acres during the same period. Maximum erosion rates occurred in the west Hancock County and east Jackson County areas as a result of natural processes. Maximum accretion occurred as a result of dredge spoil disposal and beach nourishment in Jackson and Harrison Counties.

COREHOLES IN LAUDERDALE AND KEMPER COUNTIES, MISS., HELP TO REDEFINE THE TUSCAHOMA-NANAFALIA BOUNDARY OF THE WILCOX GROUP

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Two coreholes, PT3 in northwestern Lauderdale County and PT5 in southern Kemper County, recovered specific lithologies which indicate a Nanafalia-Tuscahoma formational boundary lower than previously thought. Both coreholes encountered previously unseen fossiliferous, marine units. These marls lie within a laminated, very fine-grained sand, silt, and lignitic unit and are above a distinctive blocky, silty clay unit (Grampian Hills equivalent). Subsequent paleontological support (benthic Foraminifera - Fluegeman, personal communication) suggests the marls to be of Tuscahoma age rather than Ostrea thirsae bed (Nanafalia) equivalents. The Grampian Hills clay grades below into a slightly marine, fine- to medium-grained sand. This sand contains rare planktic Foraminifera that indicate a Nanafalia age. Coreholes PT3 and PT5 were drilled in support of geologic mapping along the Wilcox outcrop belt.

TAXONOMIC QUESTIONS ARISING FROM THE DISCOVERY OF A MOODYS BRANCH ZYGORHIZA (CETACEA, ARCHAEOCETI)

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The Mississippi Museum's mounted *Zygorhiza* is one of the best ever found, and also the oldest good specimen of its kind. It was collected from the upper Moodys Branch Formation, while all other significant basilosaurid specimens from the southeastern U. S. are from the Yazoo Clay and age equivalents. Fossil species do not usually persist from one formation to the next, a consideration that led to comparative studies with the few other good specimens in museum collections. This project revealed much individual variation in the characters examined. The Moodys Branch *Zygorhiza* differs in the shape of its narial fossa, in the size of its thoracic region and in that the first pair of ribs is not clubbed. However, a new species should not be proposed on one individual, in view of the observed variablity of known specimens. The genus *Zygorhiza* may be a junior synonym of *Dorudon*, a similar and contemporary basilosaurid. Kellogg's (1932) diagnosis, based on details of the cheek teeth, is not adequate to separate them. *Zygorhiza* may be distinguishable from *Dorudon* through its often crenulated cingula, a slightly slimmer skull and large upper second incisors.

MISSISSIPPI'S MARINE MIOCENE - BRIDGING THE GAP.

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Until very recently, the Mississippi geological literature only listed four, rather vaguely delineated Neogene formations of fresh-water and paralic depositional facies (Catahoula, Hattiesburg, Pascagoula and Graham Ferry). They succeeded a marine interval, earlier believed to be the youngest exactly datable in the coastal and offshore Mississippi Neogene; the Late Oligocene(?)- lowermost Miocene *Heterostegina* "horizon". Extensive drill sample work underway is proving the presence of a Lower Miocene, Tampa Formation-correlative shelf unit (including *Globorotalia kugleri*, *Globigerinoides primordeus*, etc. planktonic foram species), a Middle Miocene (*Globorotalia mayeri*, *G. siakiensis*, *Cassigennella chipolensis*) and an Upper Miocene, (*Neogloboquadrina acostaensis*, *Globigerina nepenthes*) sequence, found in at least four coastal counties. Lower and Middle Miocene limestone beds have been recognized for the first time. The Catahoula and Hattiesburg designations may not apply in these areas. Because of the scarcity of appropriate age-diagnostic planktonic foraminifers, the ability of age determination within sufficiently narrow limits depends largely on the abundance of available drill sample material.

PETROLEUM POTENTIAL OF THE MIOCENE IN THE COASTAL COUNTIES AND THE OFFSHORE WATERS OF MISSISSIPPI.

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Oil and gas have been produced in large quantities for many years from the Miocene sediments of the Louisiana-Texas coastal areas and offshore waters, and since 1979, shallow gas from the Miocene in the Alabama coastal and offshore areas. Mississippi's coastal and offshore areas lack Miocene production, but this may not be for long. Sediments comprising the stratigraphic units of the Miocene in southwestern Alabama extend into and can be traced over large portions of coastal and offshore Mississippi. Paleontological information indicates that the marine and transitional marine environments of deposition present during the Miocene in southwestern Alabama extended into at least the eastern portion of coastal and offshore Mississippi. Fields which have produced or are currently producing gas from shallow Miocene sediments are located only a few miles from the Mississippi state borders in Louisiana, Alabama, and the Federal OCS waters offshore (Mobile Area). Because of stratigraphic and paleontological similarities between the Miocene sediments of these areas and the Mississippi coastal and offshore areas, it is likely that the shallow Miocene sediments of coastal and offshore Mississippi may contain significant gas reserves.

SEARCH FOR INTERGLACIAL EVENTS DURING THE LAST 780,000 YEARS IN THE SUBPOLAR NORTHEAST PACIFIC OCEAN.

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The ultimate objective of this study is to define a planktonic foraminiferal biostratigraphy for the Brunhes Chron (0-780 kyBP) in the subpolar Pacific Ocean. The main hypothesis is that a transitional fauna replaced the subpolar fauna during the six strongest interglacial periods of the Brunhes Chron, as with the penultimate interglaciation (125 kyBP) in ODP Hole 856A. In this preliminary work, location of transitional faunas is attempted in core Y70-5-64 using carbonate and $\delta^{18}O$ stratigraphies. Interglacial periods are generally characterized by poor carbonate preservation and $\delta^{18}O$ minima. Two intervals of low calcium carbonate and inferred interglacial isotope stages were selected for a census of planktonic foraminifers in core Y70-5-64. A transitional fauna was not found, but rather a subpolar dissolution fauna was dominant. The subpolar dissolution fauna correlated with intervals of low carbonate probably indicating high stands of the carbonate compensation depth. Further explorations for interglacial events in selected intervals for core Y70-5-64 and other cores from the subpolar northeast Pacific Ocean are in progress.

PAST AND FUTURE EROSION TRENDS AT BELLE FONTAINE, JACKSON COUNTY, MISSISSIPPI

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The Belle Fontaine headland is the site of the only remaining natural beach on the Mississippi mainland coast. The beach is formed by longshore current distribution of sand eroded from the Pleistocene bluffs located in the central portion of the area. Historical erosion rates determined from comparison of digitized USGS T-sheets and aerial photographs from the 1850's through 1986 show a loss of 473 acres during that time period. Armoring of the bluffs by residents to protect their homes has deprived the longshore drift system of its natural sand source. As a result the erosion rate along the beach areas east and west of the bluffs has increased in recent years. A computer shoreline erosion model was developed for the area to predict future shoreline trends and to design shoreline protection methods. Wave data were collected with a wave meter during a three-month winter storm period, detailed offshore bathymetry was acquired, nearshore bottom profiles were measured, and sand grain size distribution was measured for inclusion in the model. A breakwater is indicated by the model to protect the bluffs from erosion by high waves, and selective sand nourishment is recommended along those sections of the beach where sand deficiency results from the breakwater placement. The model predictions will be tested this winter with a limited beach nourishment project by Jackson County and the EPA Gulf of Mexico Program. Sand will be placed at locations indicated by the model, and subsequent movement of the sand will be monitored by the Office of Geology. Variations from predicted results will be noted and the model will be refined to reflect observed field conditions.

A COMPARISON OF SHORELINE MEASUREMENT TECHNIQUES: GPS SURVEY, AIR PHOTO INTERPRETATION, AND TOTAL STATION SURVEY.

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Several methods of shoreline position measurement were evaluated for relative accuracy, time efficiency, and ease of measurement. Air photos taken of Round Island in February, 1993 at a scale of 1:10,000 were interpreted for the high-tide water line and digitized. The island shoreline was surveyed with a total station and prism in August, 1993, and at the same time the shoreline was surveyed with a mapping-grade GPS unit. A survey-grade GPS unit was used to measure the same shoreline in October, 1993. All GPS measurements were differentially corrected. Control points were placed at visible marks on the air photos using averaged GPS positions, and the same control points were used to correctly orient each surveyed data set in AutoCAD. A comparison of total island area and shoreline position found with each method is made by overlaying each data set corrected to the same control points. GPS measurement is by far the fastest method, requiring only a walk-around of the shoreline with a unit and antenna. Accuracy of position measurements with mapping-grade units is on the order of 2-5 meters. Survey-grade GPS units decrease the error to about 0.5-2 meters, but at a significant increase in unit cost. Total station measurement is the most accurate, but instrument cost is high and the time and man-power required are also high. Air photo interpretation and digitization is the least accurate, about plus or minus 10 meters, but the relative cost and time involved are the lowest.

SHOREFRONT CHANGES IN BILOXI, MISSISIIPPI, 1853-1992: GEOLOGIC AND GEOGRAPHIC FOUNDATIONS OF "CASINO ROW".

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Located in the lee of Deer Island, a Pleistocene beach ridge that became separated from the mainland following Holocene sea level rise, the wave-sheltered shorefront of Biloxi has been subjected to extensive historic human modifications. Whereas Deer Island has decreased in area by about 274 acres since the 1850s (largely due to natural processes), about 120 acres of land have been "artificially accreted" to the Biloxi shorefront--35 acres at the downtown waterfront, 60 acres along front beach of Point Cadet (from Oak St. to Cadet St.), and 25 acres of sand fill on East Beach. The earliest nearshore reclamation was in the natural harbor fronting downtown Biloxi, where commercial and industrial development led to an accretion of 19 acres (170,000 cu. yds.) by 1945. Postwar development, especially in conjunction with the 1950s widening of Highway 90, added 16 acres (280,000 cu. yds.) The seafood industry accounted for most of the changes along Point Cadet's front beach where, since 1880, many seafood processing operations located along the beach or on piers extending into the shallow nearshore waters. By 1940 almost 600,000 cu. yds. of oyster shells had been deposited, and over 53 acres of land were created. In 1933, at least 90,000 cu. yds. of grade-raising fill were added at the east end to provide a site for a U.S. Coast Guard base (the present site of the GCRL Marine Education Center). These sites of historic nearshore reclamation now provide a foundation for a new economic boom in Harrison County--dockside casino gambling. As shorefront casino sites are restricted to areas of non-sand beach, both the Biloxi waterfront and Point Cadet's front beach have become transformed, the latter into what is now referred to as "Casino Row". The inauguration of casino gambling has initiated yet another phase in the history of human modification of Mississippi's historic tidelands.

GEOLOGY OF THE MERIDIAN SOUTH 7.5 MINUTE QUADRANGLE MAP

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The Meridian South 7.5 Minute Quadrangle, Lauderdale County, Mississippi, is located within the outcrop belts of the Wilcox and Claiborne groups. Formations mapped within this quadrangle include the Tuscahoma, Bashi, and Hatchetigbee formations of the Wilcox Group, and the Tallahatta and Winona formations of the Claiborne Group. The stratigraphy is comprised of interbedded sands, silts, and clays, with subordinate lignite. A geologic cross-section perpendicular to the outcrop belt shows dip rates of up to 100 feet per mile. A structure map on the top of the Bashi Formation reveals that the city of Meridian is situated on the nose of a structural ridge. This surface geologic mapping project is part of the Office of Geology work to differentiate the Wilcox Group and revise the state geologic map.

TEACHING INVERTEBRATE TAXONOMY IN THE PALEO LABORATORY USING A TAXONOMIC DATABASE ON A LAPTOP COMPUTER.

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One of the most difficult aspects for students of Invertebrate Paleontology is the need to retain the terminology used to classify fossils. Latin taxonomic terms may be confusing to students, and difficult to retain. After compilation of a database listing all fossil specimens in the teaching collection, using Borland software's Paradox® v3.5 database, we provided lab students access to this database on a lap-top computer. Students are able to generate lists of all specimens arranged by taxonomic groupings, and lists of all specimens in a particular laboratory cabinet and drawer. Similarly, advanced students may view lists of fossils in the collection, arranged by geologic time interval.

Use of the computer database also facilitates the problem of specimen curation and collection maintenance, and minimizes problems in rearranging specimens. It is possible to immediately locate the appropriate placement (cabinet-drawer number) of all specimens in the teaching collection by accessing the individual record by specimen number. This makes it possible to easily replace any removed specimen in its appropriate location after use and examination. Record-keeping is also easier with the computer database, as newly-acquired specimens can be cataloged and added to the collection using Paradox for data entry.

GEOGRAPHIC INFORMATION SYSTEM (GIS) APPLICATIONS IN PETROLEUM EXPLORATION.

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Wildsville field, discovered in 1953, is located in section 12, T7N-R6E, and in sections 7 and 37, T7N-R7E of Concordia Parish, Louisiana. The field is productive from the Wilcox trend, a prolific play in Mississippi and Louisiana. Geological data from this 9 well field was utilized to construct a "test-bed" for subsurface modeling using GIS applications. The top of the Wilds sand (Wilcox formation) was used as the basis for a digital elevation model to depict oil migration. The well locations, along with political and ownership boundaries, are stored in relational databases which can be updated for temporal change delineation. These delineations can be shown in choropleth maps capable of predicting oil accumulations. The points of concentration can be used to spot future wells and determine if potential locations have sufficient merit to justify additional exploration. This technology is also applicable to field exploration in the Mississippi portion of the Wilcox trend.

APPLICATION OF GIS IN INTEGRATING CLAY DATA BASES OF NORTH MISSISSIPPI

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A geographic Information System (GIS) has been used to integrate data regarding clay deposits of Tippah, Union, and Benton counties, Mississippi. The objective was to develop a GIS data base to study the economic potential of clay deposits in this region. PC Arc/Info and dBase software have been used in this project. The data sources included a data base constructed by the Mississippi Office of Geology (MOOG), and several published and unpublished reports and maps regarding the clay deposits. An Arc/Info internal identification number was used as a common element to attach other attributes and to directly transfer the MOOG dBase file. Additional attributes, such as overburden and elevation, were added to make the GIS database more useful. The database consists of 108 wells, 158 samples with 51 attributes attached to each sample entry. TIGER files were used to overlay the stream and transportation networks on the study area. Networking and routing capabilities of the GIS were used to find the optimal hauling route of the clay. Most of the clays are kaolinitic or associated types. This data base can now be used by industry or the private sector for economic evaluation of these mineral resources.

★ GEOMORPHIC ANALYSIS AND INVENTORY OF THE MISSISSIPPI MAINLAND COAST.

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A geomorphic classification and inventory of the mainland Mississippi coast was compiled from features visible on oblique aerial video photography shot from a helicopter in 1991 by the Louisiana Geological Survey. The shoreline is subdivided into three shore-parallel sets composed of the main shoreline feature, backshore modifier, and foreshore modifier. All features less than 30 meters in linear extent are designated point features in the classification. A program developed in ARC/Info by the Miss. Automated Resource Information System (MARIS) allows display of the data and statistical calculations. Comparison of data sets from subsequent biannual flyovers using this method will aid in quantifying shoreline changes on the mainland coast as development of the shoreline continues. Classification categories are basically divided into man-made and natural features. Man-made features include dredge spoil, artificial beach, seawall/bulkhead, riprap, and harbor/dock. Point features include groins, jetties, piers, outfalls, and canals. Predominant natural features include marsh, tidal channels, perched beach, washover flat, and irregular dunes. Less than half of the Mississippi mainland shoreline remains in its natural state, predominantly natural marsh near both borders and beach in the Belle Fontaine area. Most of the Mississippi coast is occupied by seawalls, artificial beaches, dredge spoil and harbors or docks. Continued development of the shoreline, particularly the influx of floating casinos, is changing both the natural and man-made portions of the coast.

★ WETLAND LOSS AND HABITAT DISTRIBUTION IN THE GAUTIER SOUTH QUADRANGLE, A GIS APPLICATION.

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As part of an ongoing cooperative study with the U. S. Geological Survey, the Office of Geology is investigating historical wetlands change and habitat conversion along the Mississippi coast. The Gautier South Quadrangle is an example of the methods and results obtained thus far. U. S. Fish and Wildlife Service digital habitat data for the years 1956 and 1978 were obtained for land below the 15-foot contour (the coastal zone) for all USGS coastal quadrangles. Color infrared imagery from 1991/1992 was interpreted and digitized for a current data set. The over 200 Cowardin habitats used in the USFWS classification were simplified into eight categories for ease of interpretation. The eight categories (water, marsh, forest, beach, agriculture, developed, dredge spoil, and non-coastal) are compatible with both the Cowardin and Louisiana Geological Survey classification systems. Digital data were compared and analyzed in ARC/Info for GIS display. By comparing habitat polygons for the three data years, it was found that 6.4% of the marsh wetlands in the Gautier South Quadrangle had converted to water, and the total number of acres of marsh had decreased by 13.6%. The majority of changing marsh habitat was converted to forest. Between 1956 and 1992, more agriculture habitat changed to marsh than vice versa, and urban development of forest habitat was twice as common as urban development of agricultural land.

ANALYSIS OF SUSPECTED LINEAMENTS IN WESTERN WARREN AND EASTERN HINDS COUNTIES.

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MSS satellite imagery has been utilized in helping to identify suspected lineaments in western Warren and eastern Hinds counties. The imagery was manipulated using the AGIS software package. A sequence of steps were taken to extract the lineaments including: image stretching, low pass filtering, directional filtering, and density slicing. The manipulated image was then combined with the original image into a single channel data file. SAR imagery was used to verify the location of the lineaments as identified by the AGIS package. Two major lineaments have been identified through the utilization of these procedures. The fluvial geomorphology of the area supports these findings. Preliminary work suggests these lineaments may represent structural features such as those associated with diaperic salt structures.

THE PAINT FILTER TEST WITH OBSERVATIONS OF A PARTICULAR SORBENT AND ITS DEGREE OF SUCCESS IN PREVENTING THE RELEASE OF DIESEL FUEL OR LIGHT CRUDE OIL DURING THE PROCESS OF SORPTION.

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Three methods were used and are as follows: 1) Fill fine or coarse mesh filters full with sorbent and either add 100 grams of hydrocarbon into center of a sorbent or mix 100 g of hydrocarbon and sorbent and pour into filter; 2) Take 100 g of each sorbent and add 10 g, 25 g, and 75 g of hydrocarbon; 3) Put 50-150 g of sorbent in 100-150 mL of sorbate and let stand in a hood for 24 hours to observe structural integrity. As a general rule, if no hydrocarbon is released in a one, three, or five minute period then the sorbent passes the Paint Filter Test, but if hydrocarbon is released in a five minute period then the sorbent fails. I have observed that Sphag Sorb, one of the sorbents, passes every possible test and is only saturated half its capacity! All sorbents pass the mixing procedure because the entire contents contains hydrocarbon rather than only the center. I must conclude that the test is not valid due to the five minute limitation in 1-2. Hydrocarbons exist for a long time so a "pass" may "fail".