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APPENDIX III

GREAT LAKES SHORELINE DAMAGE SURVEY

MUSKEGON, MANISTEE, SCHOOLCRAFT, CHIPPEWA, ALCONA, AND HURON COUNTIES, MICHIGAN

Prepared for

U.S. Army Corps of Engineers
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By

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This is an appendix to the Summary Report of the Pilot Study Program, Great Lakes Shoreland Damage Study. It identifies erosion and flood damage in the six named counties caused by or directly related to the 1972-1974 high water period on the Great Lakes. Aerial photo mosaics of county shorelands are also included. Part 2, AD-A031 081, contains the photomosaics for the remaining three counties. (the Muskegon, Mainstee, and Schoolcraft)

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Appendix II	Great Lakes Shoreline Damage Survey; Brown, Douglas, and Racine Counties, Wisconsin
Appendix III	Great Lakes Shoreline Damage Survey; Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron Counties, Michigan
Appendix IV	Contract for a Damage Survey of Oswego County, New York
Appendix V	Shoreline Damage Survey: An Appraisal with Recommendations
Appendix VI	Engineering - Economic Analysis of Shore Protection Systems: A Benefit/Cost Model
Appendix VII	Measurement of Coastal Bluff Recession from Aerial Photographs, Muskegon County, Michigan
Appendix VIII	Comparison of Field Data Collection to Date Collected Using Study Instruments in Muskegon and Manistee Counties, Michigan

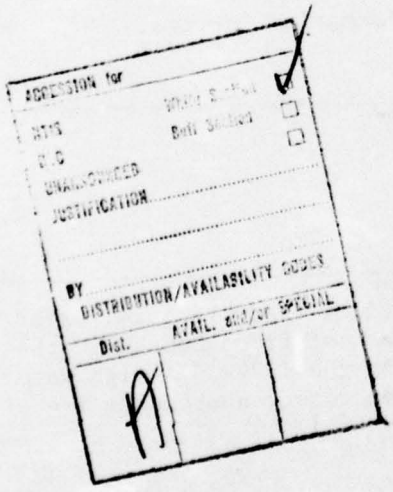


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1.0 INTRODUCTION

1.1 AUTHORITY AND SCOPE

This report is the result of a study undertaken by The University of Michigan Coastal Zone Laboratory, Ann Arbor, Michigan in compliance with Contract No. DAC23-75-C-0027, entered into November 15, 1974 by the United States Government and the Regents of The University of Michigan. This study is accomplished under the survey scope authority for the Great Lakes Water Levels Study.

The contract with the Corps of Engineers has a scope of work designed to evaluate the influence of high water levels on shoreline property located in the Great Lakes region. Specific pilot counties of Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron were selected for the initial study. One of the intents of this first phase of study was to determine the best methods for gathering the data required through actual data gathering efforts. The work and services performed were engineering studies and damage surveys of the Great Lakes shorelands, and included the following tasks:

1. Listing the complete riparian shoreline ownership and preparing maps to indicate land use and description in the six selected Michigan counties.

2. Preparing and distributing to all known riparian residential shoreline owners a self-administered Great Lakes shoreline damage assessment, the results of which were to be compiled and analyzed.

3. Conducting personal interviews of a random sample of residential property owners as a follow-up study to verify the results.

4. Conducting a field damage survey of commercial and industrial properties, public buildings, transportation facilities, and public and private utilities, the results of which were to be compiled and presented.

5. Conducting a study of existing erosion control and flood protection structures to provide general evaluations of their effectiveness, including damage reduction benefits, costs, and condition relationships.

6. Recording, noting, and marking (where possible) the location of all readily discernible high water marks in order to prepare a map showing the estimated extent of flood water damage.

7. Conducting damage surveys of flood plain areas by interviewing flood victims, where applicable.

8. Compiling and presenting newspaper accounts of storm damages, available photographs of damage areas, and other information relating to shore damages.

9. Summarizing the short-term high water recession rate information supplied by the individual property owners. Computing the volumetric contribution of bluff erosion sedimentation to the Great Lakes based on these data and providing bluff and surf zone profiles, all information to be presented on maps and charts.

10. Compiling available information on the effects of high water on recreational opportunities and aesthetic and environmental values.

11. Illustrating the results of the damage survey with maps, charts, and graphs.

12. Preparing a draft and final report and appendices.

The short-term objective of this study is to determine the financial loss in the State of Michigan due to high water-induced effects of flooding and erosion. The long-range goals include such items as development of planning decision tools, coastal zone management programs, and land use studies for reduction of damage or loss resulting from high water levels.

1.2 BACKGROUND

This is a pilot study to identify erosion and/or flooding damages in Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron Counties caused by or directly related to the 1972-74 high water period on the Great Lakes. The study is a cooperative undertaking of the State of Michigan and the Corps of Engineers to develop representative shoreline damage data. This information will be made available to other Federal and state agencies and will provide a base which is needed for the implementation of many Federal and state programs directed at reducing shoreland damages.

A study of damages incurred by shoreline property owners was conducted by the Army Corps of Engineers for the period Spring 1951 - Spring 1952, during a period of high water levels on the Great Lakes. The study indicated that, in general, damages increased due to the increased action of the higher lake levels. The study attempted to bring out the severity of the problems caused to shoreline landowners, especially during periods of high water.

Since then, lake levels have fluctuated, dropping in 1958, experiencing a short rise in 1960, and reaching a record low in 1965. From 1972 and continuing to the present time, the lakes have reached levels comparable to the 1951-1952 study period. In order to obtain the most accurate and complete information about the effects of high water, it is necessary to conduct an updated study during the period when high lake levels occurred. This is normally the time when information is most readily available, since property owners' concern for the problem historically wanes as the lake levels recede. Also, the presence of high lake levels allows the opportunity to empirically study the mechanisms of accelerated erosion and flooding and possible protection schemes, instead of trying to develop data and make decisions after the fact.

1.3 ACKNOWLEDGMENTS

The University of Michigan Coastal Zone Laboratory, designated as the State's Coastal Zone Laboratory by Governor Milliken on January 12, 1973, is thus currently working with the Bureau of Water Management of the Department of Natural Resources and is actively involved in their program to take "action to avert catastrophic consequences" of shoreline erosion, in compliance with Act 14 of the Public Acts of 1973. The results of the damage assessment study will be useful to this and other state and Federal projects.

The University of Michigan Coastal Zone Laboratory would like to gratefully acknowledge and express appreciation to several individuals, agencies, and field offices whose contributions of time, services, and information were of utmost utility in the completion of this study:

The Department of Natural Resources for its assistance in the gathering of information related to the study, and providing input as to the pertinent areas of study.

Specifically, special acknowledgment is given to William Marks and Fred Clinton of the Bureau of Water Management for their invaluable assistance.

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2.0 SHORELAND DESCRIPTION

2.1 OVERVIEW OF COUNTIES' SHORELAND

Muskegon County - Lake Michigan

Muskegon County, located in the Lower Peninsula, is bordered by Oceana County on the north, Ottawa County on the south, and Kent County on the east. Lake Michigan forms this county's western border which stretches for 27 miles. Three major shoretypes are found within this county.

The Muskegon shoretype from the Oceana-Muskegon county line to Duck Lake nine miles southward consists of alternating high sand dune and low, clay bluff. In this area, the beach is 30 to 60 feet wide and sandy. Bluffs are sand over clay, with occasional sandstone outcrops. Dunes range up to 200 feet high and are composed of medium sand.

From Duck Lake to Muskegon State Park the county shoreline along Lake Michigan is sand bluff, in part stabilized by extensive vegetation. The bluff is as much as 120 feet above the lake level, while the beach is ten to 30 feet wide and sandy.

The shoreline from Muskegon State Park to the Muskegon-Ottawa county line consists of gently sloping sand beach, ten to 60 feet wide and backed by sand bluffs 30 feet high and high sand dunes rising to 250 feet above lake level.

There are designated high risk erosion areas located in every reach in Muskegon County.* Table 4 depicts high risk erosion areas in each county.

Muskegon, the major city in this county, is situated in the western half of the county along the shores of Lakes Michigan and Muskegon. The city has a population of approximately 43,000 people, with an additional 19,000 people in nearby Muskegon Heights.

Manistee County - Lake Michigan

Manistee County is located in the western half of the Lower Peninsula on the shores of Lake Michigan. Benzie County lies to the north of this county, while Mason and Wexford Counties are to the south and east, respectively. This county possesses 26 miles of shorelands on Lake Michigan.

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*"High risk erosion areas" are designated by the Water Development Services Division, Michigan Department of Natural Resources.

Generally, the Manistee County shoreline consists of sand beaches with low and high dunes behind them. The shoretype alternates between erodible bluff and glacial lowlands. The morainic bluffs range from 25 to 175 feet high and are composed of coarse sand, clay, and silt. Beaches are sandy with scattered pebbles. Lowlands consist of a bench up to 300 feet wide and approximately eight feet above lake level. The lowland beaches are composed of medium to coarse sand with a gravel belt along the waterline.

Areas in Manistee County experiencing severe erosion include the area at the southern limit of the county, the area immediately south of Portage Lake, and the area immediately south of Arcadia Lake. Every reach in this county contains designated high risk erosion areas (see Table 4).

The major city in this county is Manistee, which has a population of 8,324 and is located around the channel leading into Manistee Lake.

Schoolcraft County - Lake Michigan

Schoolcraft County is located along the northern shore of Lake Michigan in the Upper Peninsula. It is bordered by Alger County to the north, Delta County to the west, and Mackinac County to the east. This county's Lake Michigan shoreline extends for 49 miles.

The shoreline of Schoolcraft County is generally irregular and contains many small bays which are protected by natural breakwaters (jetties) of rocky points reaching out into the lake. Some stretches of shoreline consist of stone or gravel beaches with short stretches of sand beach, especially in the innermost parts of bays.

From the Schoolcraft-Mackinac county line, the shoreline in Schoolcraft County is sheer rock wall for eight miles west to Goodreau's Harbor. From there, six miles to the west along the shoreline are low sand dunes. For the next 24 miles, to Pointe Aux Barques, the shoreline alternates between low plains of cobbles and low sand dunes, except for two areas of limestone outcroppings on either side of Dutch John's Point and between Thompson and Wiggins Point. From Pointe Aux Barques to Little Harbor, a distance of five miles, marshes are sand on top of flat-lying limestone layers. From Little Harbor to the Schoolcraft-Delta county line, the shoreline is characterized by cobbles with an underlayer of bedrock.

This shoreline area on Lake Michgian is not generally subject to critical erosion. Much of the shoreline is protected by outcropping limestone or by gravel and cobble beaches. The only high risk erosion areas in this county are located in Reach 4 (see Table 4).

Manistique, the major city in Schoolcraft County, is built along the shores of the Indian River leading into Lake Michigan, and has a population of 4,875.

Chippewa County - Lake Superior

Chippewa County, located in the Upper Peninsula, is to the east of Luce County and to the north of Mackinac County. Not all of the Chippewa County shoreline is included in the area presently under study. The study was confined to the open water areas of the Lake Superior shoreline in Chippewa County, excluding those portions of the county bounded by the St. Mary's River and Lake Huron. The eastern edge of the study area begins at Brush Point, located six miles west of Sault Ste. Marie, and continues westward for 78 miles along the Lake Superior shoreline.

The Chippewa County shoreline along Lake Superior from the Luce-Chippewa county line to Brush Point alternates between erodible plains and erodible, low bluffs. With the exception of two separate areas of shoreline, the area extending from below Paradise to several miles west of the Naomikong Point is low non-erodible bluff as is a small stretch of shoreline from Salt Point westward to the Pendills Creek outlet.

High risk erosion areas along this shoreline are located both west and south of Whitefish Point. Many homes are endangered in the Paradise area of Whitefish Bay, and scattered high risk erosion areas also exist along the south side of Chippewa County's shoreline.

Brimley, a popular lakeshore resort town, has a population of approximately 500, and is located in Waiska Bay along the banks of the Waiska River.

Alcona County - Lake Huron

Alcona County is bordered by Alpena County to the north, Iosco County to the south, and Oscoda County to the west. Its eastern border, formed by Lake Huron, is 27 miles long.

Generally, the Alcona County shoreline is erodible plain. In a five mile stretch between Greenbush and Harrisville, there are several stretches of high bluffs intermixed with low plains.

From the northern county border (Alpena-Alcona county line) to Harrisville, the shoreland is mainly a stone and boulder shore, with high, bank beaches extending back into the hills. From there to the Alcona-Iosco county line the beaches are mostly sand, usually low, with some high bluffs directly behind. Three areas in Alcona County

are designated as high risk erosion areas, totaling about three miles in length. Most of the county has an erodible shoreline.

The coast along this county consists mainly of resort towns which have a very small year-round resident population. One of the largest of these towns is Harrisville, boasting a population of 487.

Huron County - Lake Huron

Huron County, located in the Lower Peninsula, covers the entire tip of the "thumb" area on Lake Huron. Tuscola County lies to the southwest of Huron County, while Sanilac County is to the southeast. The shoreline along Huron County covers 92 miles of land.

The shoreline in Huron County from the Tuscola-Huron county line up to Sand Point consists of marshy, shallow water inshore without any noticeable bluff. Sand Point is a long, narrow peninsula that juts westward into Saginaw Bay and forms the northern limit of Wildfowl Bay. From Sand Point to a point between Port Austin and Pointe Aux Barques, the shoreline is composed of sand beaches, with generally shallow water inshore, and a bluff of uneven sand ridges, some of which extend to 25 feet above the water. Near Port Austin there are outcroppings of bedrock at the bluff line. Deep water extends closer to shore in the vicinity of Port Austin. The lake bed in this area contains several rocky reefs. From Pointe Aux Barques to a point eastward of Grindstone City, the shoreline is sandstone bluff about ten feet above water. Southeastward to Port Hope, the shore and inshore water areas are boulder strewn, but the bluffs become more pronounced and are principally clay. This condition exists to the Huron-Sanilac county line with few boulders and little sand beach, except in scattered areas.

In Huron County, about 1/3 of the shoreline is classified as non-erodible. Yet, there are some 12 miles of scattered high risk erosion areas in Reaches 2, 3, and 5, as Table 4 documents.

Harbor Beach and Sebewaing are two of the larger coastal cities in Huron County with populations of 2,282 and 2,026, respectively.

2.2 PHYSICAL DESCRIPTIONS OF REACHES

Muskegon County: 5 Reaches

Reach 1 extends from the Muskegon-Ottawa county line for ten miles to a point 1 1/2 miles north of Muskegon Lake outlet. The shoreline along the whole length of this reach consists of high sand dunes, with a steep bluff descending directly almost to the lake. There are low dunes running 200-300 feet back from the lake along some stretches near stream outlets as well as 100-200 foot high dunes rising behind part of the shoreline.

Reach 2 runs from 1 1/2 miles north of Muskegon Lake outlet for six miles northward to one mile south of Duck Lake. The shoreline is erodible low sand bluff, in places stabilized by vegetation, with small dunes 20-40 feet high.

Reach 3 extends from one mile south of Duck Lake for three miles to 1/2 mile south of the outlet of White Lake. The shoreline in Reach 3 consists of high sand dunes ranging up to 200 feet high and is comprised of medium sand, resembling the shoreline type found in Reach 1.

Reach 4 in Muskegon County runs for five miles from 1/2 mile south of White Lake outlet to a point three miles south of the Muskegon-Oceana county line. The high bluff erodible shoreline found in Reach 4 is comprised of silt bluffs rising from the water in the first ten feet of dry beach without cropping sandstone slabs.

Reach 5 makes up the last three miles of Muskegon County to the Muskegon-Oceana county line. This shoreline resembles Reaches 1 and 3 with its high dunes and steep bluff running almost directly into the lake.

See map mosaics for lake bottom profiles.

Manistee County: 8 Reaches

Reach 1 extends from the Manistee-Mason county line northward for four miles. This reach has a high erodible bluff shoreline the entire length. The beach has gravel near the shoreline with sand behind and a variable 25-175 foot bluff of sand with gravel and some clay.

Reach 2 runs for three miles from two miles outh of the Manistee River mouth to one mile north. The entire three mile reach has a low bluff erodible shoreline. This beach as a gravel berm and belt, with a bench up to 300 feet wide. There is some erosion of low bluff by storm waves.

Reach 3 continues northward for the next three miles, from one mile north of the Manistee River mouth to just below the mouth of Bear Lake. The entire reach has a high bluff erodible shoreline similar to Reach 1.

Reach 4 extends from 1/4 mile south of Bear Lake for two miles northward to a point three miles below Portage Point and has a low bluff erodible shoreline similar to Reach 2.

Reach 5 runs for five miles from a point three miles south of Portage Point to two miles north of it. The shoreline from the southern end of the reach for three miles up to Portage Point is high bluff erodible. For two miles north to the end of the reach, the shoreline changes to a low bluff erodible shoretype.

Reach 6 extends for two miles northward from three miles south of Pierport. A high bluff erodible shoreline is found the entire length of this reach.

Reach 7 runs for six miles northward from one mile south of Pierport to just below Arcadia. The entire shoreline in this reach is the low bluff erodible type found in Reaches 2 and 4.

Reach 8 is located in the last mile of Manistee County ending at the Manistee-Benzie county line. This reach's entire shoreline is made up of erodible high bluffs.

Lake bottom profiles are located on the photo mosaics.

Schoolcraft County: 5 Reaches

Reach 1 in Schoolcraft County runs for 13 miles westward from the Schoolcraft-Mackinac county line to 6 1/2 miles east of Dutch John's Point. The first 8 3/4 miles of this reach (moving westward) has a non-erodible low plain shoreline. In the last 4 1/4 miles of the reach the shoreline changes to a low sand dune type area with dunes less than 30 feet.

Extending for ten miles, Reach 2 begins 6 1/2 miles east of Dutch John's Point westward to 1 3/4 miles east of Manistique. The low dune shoretype from Reach 1 extends into Reach 2 for the first 2 1/4 miles (moving westward). The shoreline changes to a low erodible plain just for the next mile, after which it changes back to a low dune shoretype for the next 3/4 mile. From here (1 1/4 miles north of Farnsworth Point) to 3/4 mile from the western limit of the reach, the shoreline changes again to a non-erodible low plain. The last 3/4 mile of Reach 2 has a low dune shoreline.

This low dune shoreline extends into Reach 3 which runs from 1 3/4 miles north of Manistique westward for five miles to Stoney

Point. The first 1 1/2 miles of the reach (moving westward) continues to have a low dune shoreline. From there it changes for one mile to a low erodible shoretype and then changes back to low dune again for another 1/2 mile. The next 1 1/2 miles of the reach have a low erodible plain shoretype and the last half mile of the reach has a low non-erodible shoreline.

Reach 4 runs from Stoney Point westward for ten miles to a point one mile north of Pointe Aux Barques. Starting at Stoney Point moving westward for 2 1/2 miles the shoreline has a low dune shoretype. The next four miles up to Wiggins Point is comprised of a low non-erodible plain. The shoreline changes at Wiggins Point and for the next 1/2 mile becomes a high bluff erodible shoretype. From there the shoreline is a low non-erodible plain for two miles where it changes to a high bluff erodible shoretype for the rest of the reach.

Reach 5 extends from one mile north of Pointe Aux Barques for 11 miles westward to the Schoolcraft-Delta county line. The first mile of the reach moving westward has a low plain non-erodible shoreline followed by wetlands for the next two miles. From there the shoreline become low non-erodible plain for just 1/4 mile followed by 1 3/4 miles of wetlands lasting to just before Cole's Point. From just before Cole's Point for the next two miles there is a non-erodible low plain again that turns into wetlands for 1/2 mile before becoming a non-erodible low plain for the last 3 1/2 miles of the reach.

See map mosaics for lake bottom profiles.

Chippewa County: 7 Reaches

In Chippewa County, Reach 1 extends from the Chippewa-Luce county line for 5 1/2 miles to a point 2 1/2 miles east of Vermilion Point. The shoreline is erodible low plain along the entire extent of this reach.

Reach 2, running from 2 1/2 miles east of Vermilion Point eight miles to Whitefish Point also has an erodible low plain type shoreline for the first 4 1/2 miles moving eastward. From there the shoreline becomes low bluff erodible until the end of the reach.

The low bluff erodible shoreline continues into Reach 3 which runs from Whitefish Point for 25 1/2 miles to an area two miles west of Menekaunee Point. The low bluff shoreline extends from the beginning of Reach 3 at Whitefish Point to three miles north of Paradise, where it changes to a low bluff non-erodible shoreline until the end of Reach 3.

Reach 4, beginning two miles west of Menekaunee Point, has an erodible low plain shoreline, similar to Reach 1 along its 7 1/2 mile length ending 1/2 mile east of Salt Point.

There the shoreline changes again in Reach 5 which begins 1/2 mile east of Salt Point and runs eastward for two miles with a low bluff non-erodible shoreline.

Reach 6 includes three shoreline types in its 26 1/2 mile length from 2 1/2 miles west of Salt Point running eastward to Cedar Point. From the reach's western border for 17 miles eastward to Bay Mills Point the shoreline consists of low erodible bluffs. The shoreline changes here to become a low erodible plain eastward to two miles west of Birch Point. From here until the end of the reach the shoreline again changes to a low erodible bluff.

From Cedar Point 3 1/2 miles to Bush Point, Reach 7 is located with a high erodible bluff shoretype, the only area with high bluffs in the county.

See map mosaics for lake bottom profiles.

Alcona County: 3 Reaches

Reach 1 in Alcona County extends from the Alcona-Iosco county line to 1 1/2 miles north of Sturgeon Point. The shoreline is low erodible plain along the 16 mile reach, consisting of vegetation to the beach edge and no bluff, as well as areas of gravel beach with very low sand bluffs behind.

From 1 1/2 miles north of Sturgeon Point, Reach 2 runs for five miles to two miles south of Black River outlet. Reference material initially designated this shoreline as lowland throughout the entire reach, with gravel and cobble beaches with no bluff. However, field inspections revealed stretches of high bluff shoreline in this area.

Reach 3 shoreline becomes erodible low plain again along the entire six mile length from two miles south of Black River to the Alcona-Alpena county line. The shoreline here has vegetation to the water's edge at most places with no bluff.

See map mosaics for lake bottom profiles.

Huron County: 5 Reaches

Reach 1 in Huron County runs from the Huron-Tuscola county line north 29 miles to the southern edge of Caseville, two miles above Sand Point. The shoreline is wetlands along the entire reach. There are four types of wetlands within this reach. The first area extends from the Huron-Tuscola county line three miles north of Sebewaing and consists of gravelly sand clay beach with vegetation down to the water followed by a beach ridge with a lagoon behind it 100 to 250 feet wide. The next stretch from two miles north of

Sebewaing to the vicinity of Bay Port has a sandy, heavily vegetated beach with no bluff present and an old lakebed upland. Continuing northward along Wildfowl Bay, the shoreline becomes heavily vegetated with vegetation growing in the water for 200 feet out from shore. Aquatic vegetation merges with land vegetation on the clay till beach with sand gravel pebbles. There is no bluff but relic beach bars from the old lakebed are present. From the south side of Sand Point northward to the end of the reach the shoreline becomes sandy with little vegetation.

Beginning at the southern end of Caseville, Reach 2 continues northward for five miles. The shoreline is a low sand bluff susceptible to erosion.

Reach 3 in Huron County extends from three miles north of Caseville to two miles east of Pointe Aux Barques (includes Alaska Bay), a distance of 19 miles, with a generally low dune shore shoreform. From the western reach border to just west of Port Austin (Flat Rock Point), the shoreline consists of a sandy beach and low dunes. From Flat Rock Point to the eastern limit of the reach, the shoreline is comprised of sand and sandstone shingle beaches. The dry beach is slab and sandstone. The bluff is composed of Marshall Sandstone at rocky points, elsewhere there is a low sand bluff.

Reach 4 extends from two miles east of Pointe Aux Barques to 1/2 mile north of White Rock, a distance of 36 miles. The first two miles of the beach's shoreline consists of sandstone bluff. From east of Grindstone City for a distance of about three miles, to Willow River, the shoreline is composed of sand mixed with gravel. There is no bluff in this area. The shoreline from the outlet of Willow River south for three miles has a shoreline with a beach composed of sand, gravel, boulders, and sandstone shingles. The low bluff is sandstone with a clay overlayer and is largely more erodible than the rest of the shoreline within this reach. The shoreline to Falis Creek then becomes a plain with sand and gravel beaches. From Failis Creek to the end of this reach the shoreline is composed of sections of low non-erodible bluffs of sandstone with gravel, rocky beaches and low gravelly plains.

Reach 5 begins 1/2 mile north of While Rock and continues south to the Huron-Sanilac county line, a distance of three miles. The shoreline in this last portion of the county is comprised of erodible clay bluffs. The bluffs reach a height of almost 40 feet. The beach is sand with some gravel mixed in.

See map mosiacs for shore profiles.

2.3 USE, OWNERSHIP, AND VALUE

Muskegon County

Land ownership can be classified as residential, governmental, and commercial/industrial. In Muskegon County, six percent of the total shoreline is owned by commercial and industrial, this being the largest percentage of commercial/industrial land in any of the pilot counties studied. Nugent Sand Company is one of the major industrial users in this county.

Government lands occupy three percent of the shoreline. P. J. Hoffmaster State Park is located in the southern portion of the county. Pioneer County Park and Muskegon State Park are more centrally located in the county, just north of the City of Muskegon. Pere Marquette Park is owned by the City of Muskegon and is situated near the Muskegon Lake Channel. The City of Muskegon is the largest city in Muskegon County and is located on Muskegon Lake. Other lakeshore communities include Muskegon Heights and Norton Shores.

The remaining 91 percent of the lakeshore properties in Muskegon County are privately owned. Of these residential properties, more than half (54 percent) are used only seasonally. The greatest proportion of seasonal properties are located in Reach 5 in the northernmost and least developed section of the county. Another high concentration of seasonal properties occurs in Reach 3 which includes the White Lake and Duck Lake areas. In contrast, the largest proportion of properties which are used as permanent residences occurs north of the City of Muskegon in Reach 2. The average assessed value of these residential properties ranged from $90 per foot in Reach 5 to $240 per foot in Reach 2. Land used primarily on a seasonal basis tends to have the lowest assessed property values, while more permanent residential property is given the highest assessed property value.

Manistee County

The majority (97 percent) of the lakeshore properties in Manistee County are privately owned and can be classified as residential. Only two percent of the identified lakeshore parcels are used either commercially or industrially, and one percent of the properties are government owned. The government-owned land includes Orchard Beach State Park and several road rights-of-way. Industrial holdings in Manistee County are few, the major ones being the Packing Corporation of America and the Amway Corporation. Camp Arcadia, a commercial interest, occupies a large area on the shoreline.

Major cities along the Manistee Countyshoreline include the Cities of Manistee, Arcadia, Pierport, and Williamsport. The City of

Manistee is the most developed city in the county and is located around the channel leading to Manistee Lake. Arcadia is located around Arcadia Lake and Williamsport is located at the inlet to Portage Lake.

Most (64 percent) of the respondents to the Self-Administered Assessment reported seasonal residential land use as opposed to permanent use. Greater seasonal land use was reported in 1/2 of the reaches; while certain reaches, particularly 2, 3, and 8, showed a larger percentage of property occupied year-round. Reaches 2 and 3 are located near the City of Manistee which may account for the greater number of permanent residences.

The assessed values of properties in Manistee County range from $40 per foot of frontage to $175 per foot of frontage. The largest average assessed property value has been reported in Reach 7, which includes Arcadia. The other areas with high reported average assessed values include Reach 4 and 5, but these are not the areas of greatest property development in the county. There does not appear to be a direct correlation between the proportion of permanent residences or the degree of development within various reaches and the average assessed property values per reach in Manistee County.

Schoolcraft County

The shoreline of Schoolcraft County is primarily under private ownership with 96 percent of lakeshore properties classified as residential. Only one percent of the lakeshore parcels have been developed commercially or industrially. Government ownership accounts for three percent of the lakefront.

Manistique River State Forest is the largest area of government-owned land. Other lands owned by governments include Manistique Township Park and various sections of land owned by the State of Michigan in the Parent Bay area.

The primary industrial lands along the shores of Schoolcraft County are owned by Manistique Pulp and Paper near the City of Manistique, and Inland Steel located at Port Inland. The City of Manistique is the only major city located directly on Lake Michigan.

The residential lands in Schoolcraft County are primarily used only seasonally. Of those respondents to the Self-Administered Assessment who classified their property as either seasonal or permanent, 64 percent responded that they make seasonal use of the land. The only area where this is not true is in Reach 3, which includes Manistique, where all the properties were reported as permanent residences.

The average assessed value of the properties in each of the reaches in the county ranged from $5 to $110 per foot of frontage. The most valuable properties were located in Reach 3 and Reach 1 which includes the Gulliver area. The lowest values were reported in Reach 5 which is located in the westernmost portion of the county. This area surrounds Parent Bay and is very sparsely populated. The correlation between assessed property value and degree of development is clear in Schoolcraft County.

Chippewa County

Chippewa has the largest percentage of government-owned land (seven percent of the lakeshore properties) of the six pilot counties studied. A small portion of the county's shoreline, one percent, is commercial or industrial land which includes Escanaba Pulp and Paper Company and Consumer Dock Company. The remaining 92 percent of the county's shoreline studied is residential property.

The government-owned lands in Chippewa County include the Michigan Nature Association and Lake Superior State Forest, located west of Whitefish Point. Tahquamenon Falls State Park occupies approximately three miles of shoreline in Tahquamenon Bay. Hiawatha National Forest is located along much of the shoreline between Pendills Bay and Waiska Bay. Other government-owned lands include Brimley State Park and land owned by the Bay Mills Indians which is situated along the shoreline near Waiska Bay. Munuscong State Forest is located at Brush Point. Chippewa County also contains several other sections of government land which are not named.

There are no large cities in the Lake Superior section of Chippewa County under study. The major communities include Paradise, Emerson, and Brimley. Other smaller towns include Shelldrake, Vermilion, and Bay Mills.

Of the 92 percent of the Chippewa shoreline which is privately owned, residential properties are a large majority; 79 percent are for seasonal use only. None of the reaches reported that more than half of the properties were used as permanent residences. Reach 3, which includes Paradise, Emerson, and Shelldrake, reported 31 percent permanent properties. This is the largest percentage of non-seasonal residences in any reach.

The average assessed property value by reach ranges from $10 to $90 per foot of frontage. Reach 5 is composed entirely of Hiawatha National Forest so there are no assessed property values. The areas with the highest average assessed property values are Reaches 3, 4, and 6, with Reaches 3 and 6 containing the majority of developed areas. Those areas with the lowest assessments have much less development, which indicates a correlation between the degree of development and property worth.

Alcona County

Land that is used for residential purposes accounts for 97 percent of the lakeshore properties in Alcona County. Of the remaining parcels, one percent is used either commercial or industrially and two percent are owned by government. There were no large industries identified in Alcona County. Government owned land includes Harrisville State Park near Harrisville in the southern part of the county and Ne-Wa-Gon State Forest which extends approximately three miles south from the Alcona-Alpena county line. The major lakeshore communities include Harrisville and Greenbush, which are located in the more densely developed southern portion of the county, and Black River, located at the mouth of the Black River in the northern part of the county.

The residential properties in the county as a whole are primarily used on a seasonal basis only. This is true of each reach, as a greater proportion of seasonal rather than permanent residences were reported. This use pattern was particularly evident in the northern portion of the county where 88 percent of the respondents to the Self-Administered Assessment stated that they used their property on a seasonal basis.

The average assessed property values in the assigned reaches ranged from $132 per foot of frontage in Reach 3 to $240 per foot in Reach 1. This difference in property values corresponds well with the greater development of the land and the greater proportion of permanent residences found in Reach 1 in the southern portion of the county, compared to the lesser degree of development and greater percentage of seasonal use found in the northern section of the county.

Huron County

In Huron County two percent of the total properties along the shoreline are owned by commercial and industrial enterprises. Governmental lands occupy one percent of the parcels along the shore; Sleeper State Park and Port Crescent State Park are among these and a number of county and local parks are scattered along the shoreline. The remaining lakeshore properties, 97 percent, are privately owned (residential). In the sample survey it was found that a majority of these residential properties were used seasonally. The assessed values of properties in Huron County range from a low in Reach 4 of $65 per foot of frontage to a high in Reach 3 of $[illegible]75 per foot of frontage.

2.4 SHORE PROTECTION

Muskegon County

Reach 1

There are three identified structures which are classified as permanent. Permanent shore protection structures are designed to function for several periods of high lake levels; whereas expedient structures will function for only short periods of high lake levels. These structures are all protecting public facilities. The first structure is protecting a water intake station. It is a broken concrete revetment between 200 and 500 feet in length with a freeboard (the vertical distance from the still waterline at the time of the 1975 field review to the top of the structure) of four to six feet. The broken concrete pieces are of various sizes and are not staged but randomly placed.

The next structure is a series of steel pile groins and a broken concrete seawall-revetment. The groins are between 50 and 100 feet in length with approximately two feet of freeboard. The revetment is over 1,000 feet in length with a freeboard of six to eight feet. Both structures which form this shore protection work are in moderate condition.

The remaining permanent shore protection work is a broken concrete revetment. The broken concrete sections are not staged but rather randomly placed. The structure is between 100 and 200 feet long with four to six feet of freeboard. This structure is in poor condition. All the remaining shore protection works located in Reach 1 of Muskegon County are classified as expedient. They all appear to be protecting either single or multiple private residential properties. The type of structures identified within this reach are groins, revetments, seawalls, and some combinations of two or more of these.

The groins in this reach are generally 20 to 50 feet in length with a freeboard of up to two feet. The material used for construtution is almost exclusively timber and wood. The seawalls vary between 100 and 200 feet in length with a freeboard of two to four feet. The material used for construction is almost entirely timber. The length of the revetments is, generally, the same as the seawalls, 100 to 200 feet. The height of the revetments varies a great deal with the height of the bluffs. Straw, tires, wood, plastic sheeting, and filled plastic bags constituted the majority of the materials used for construction of the revetments. The general condition of the structures in this reach ranges from moderate to poor.

The structures within this reach have limited effectiveness in reducing erosion. There are several factors which contribute to

this reduction of effectiveness. Many of the seawalls and groins do not have sufficient freeboard to adequately protect the bluffs. They are too easily overtopped by waves and possibly by just storm set-up. Material used for the construction of many seawalls and revetments is of insufficient strength and easily damaged by wave action or floating debris. There is also evidence of scour in front of seawalls which indicates lack of sufficient toe protection. The revetments are usually limited in effectiveness because of the insufficient size or strength of the construction material used. These materials, such as straw or filled plastic bags, cannot withstand the energy of waves if the structure is attacked. The revetments which are of sufficient size and strength material are usually constructed by randomly placing the material and not staging it. This does not prevent waves from jetting through and washing out soil from beneath the revetment.

The shore protective works have little effect on the coastal processes except for some reduction in the amount of material being added to the littoral drift. The locations of the structures are shown on the photo mosaics, numbers 1-1-441 to 1-1-423 and 1-1-401 to 1-1-385.

Reach 2

None of the identified protection works in Muskegon County Reach 2 are classified as permanent. All the structures within this reach are classified as expedient shore protection works for either single or multiple private residential properties. Groins, seawalls, revetments, or some combination thereof constitute the majority of the expedient shore protection works. The general condition of the structures within the reach is moderate.

The groins vary in length from 20 to 50 feet, with freeboard of up to two feet. The construction material used for all the groins is timber. Within this reach the lengths of individual seawalls are difficult to determine. This is because there are stretches where several adjoining land owners have pooled resources to build one large structure. Most, however, have a freeboard of two to four feet, with some extending from four to six feet. The material used for construction of the seawalls is almost exclusively timber, with a few steel piling walls and some sandbag walls. Revetments also vary in length due to multiple property usage. The height of the revetments also varies with bluff size. The revetments are composed of a variety of materials including snow fences, plastic sheeting, and rock.

The general effectiveness of the structures in reducing erosion is limited due to several factors. One of the major reasons is that many of the seawalls and groins have an insufficient freeboard with present high lake levels. Although the freeboard is described as ranging from two to four feet, many of the structures are near the

two-foot limit. This allows the structure to be overtopped, thus reducing effectiveness. The problems of channeling and flanking are accelerated with increased overtopping and many of the structures have inadequate protection for these problems.

These protective structures have little effect on the coastal processes other than helping to reduce the amount of material going into the littoral drift. The location of the structures are shown on the photo mosaics, numbers 1-1-384 to 1-1-368

Reach 3

The only structure within Reach 3 which is classified as a permanent shore protection work is publicly owned and protects a portion of Scenic Drive. The structure is located at Duck Lake Channel. It is a revetment composed of rock, broken concrete, and concrete block. The structure is between 500 and 1,000 feet in length and has a freeboard of six to eight feet. This revetment is in moderate condition. The remaining shore protection works of this reach are classified as expedient. They are all protecting either single or multiple residential property ownership. Groins, seawalls, revetments, and combinations of these three types of structures are the types of shore protection works found in this area.

In general, groins within this reach are 20 to 50 feet in length with a freeboard of up to two feet. The majority of these structures are made of timber. Seawalls are generally constructed across multiple properties; therefore making it difficult to determine an individual length. However, most have a freeboard of up to two feet. Construction material for the majority of the seawalls is timber with a small number using steel piling. Revetments, in this area, are often found on several adjacent properties making individual lengths indistinguishable. Again the height varies with bluff height The few revetments in this reach are composed of rubber tires which are simply placed on the bluff face. The general condition of the protective works can be described as moderate, although some of the newer structures are in excellent condition.

The structures within this reach have limited effectiveness on reducing erosion. This can be attributed to several general reasons. One such reason is shown by the revetment along Scenic Drive. This structure lacks staging of the construction material and is therefore not entirely effective in reducing the loss of soil due to wave action. The seawalls and groins have problems with overtopping due to inadequate freeboard for the present lake levels. Related to this is the need for protection from flanking and channeling. Inadequate size and strength of materials also inhibits structural effectiveness for some seawalls, groins, and revetments.

These structures have a limited effect on coastal processes in that there is only some reduction in material being added to the

littoral drift. The locations of the structures are shown on the photo mosaics, numbers 1-1-367 to 1-1-351.

Reach 4

Within this reach there are no identified shore protection works classified as permanent. All of the identified structures are classified as expedient protective devices. They all appear to be protecting private residential property. The type of structures in this reach are all groins, with the exception of one seawall-groin combination. The length of the groins ranges from 20 to 50 feet with one to three feet of freeboard. The majority of these structures are composed of timber with a few large sandbag groins. The seawall is 50 to 100 feet in length with a freeboard of four to six feet and is of timber construction. The structures are all in moderate condition.

The protective works have limited effectiveness in reducing erosion. This is primarily due to the lack of freeboard which leads to overtopping. The overtopping then leads to the related problems of the need for flanking and channeling protection.

The structures' effect on the coastal process results in some reduction in the amount of material being added to the lake system. The location of the structures is presented on the photo mosaics, numbers 1-1-350 to 1-1-344.

Reach 5

This reach has no identified structures which can be classified as permanent. All structures are identified as expedient and appear to be private residential structures. They are composed of groins, seawalls, or some combination of the two. The groin construction in this area concentrated on timber as the building material, with the exception of one series of large sandbag structures. The average length is 20 to 50 feet with two to four feet of freeboard. The seawalls are composed of timber and generally range from 100 to 200 feet in length with a freeboard of two to four feet. The structures are generally in moderate condition, but there are several new structures in excellent condition.

There are several reasons why these protective works have limited effectiveness in reducing erosion. One reason is that some structures are built with materials of inadequate strength with the resulting physical destruction decreasing effectiveness. Some have insufficient freeboard which allows them to be overtopped and increases the need of flanking protection.

In general, the structures do tend to reduce the amount of material being added to the lake system. The locations of the protective works are shown in the photo mosaics, numbers 1-1-343 to 1-1-333.

Manistee County

Reach 1

Within this reach none of the identified structures are classified as permanent. All of the identified shore protection structures are classified as expedient. There is one structure protecting a public water facility and the rest are located on private residential property. The type of structures found within this reach are groins, seawalls, or a combination of the two.

Groins in this area are generally 20 to 50 feet in length with a freeboard of up to two feet. They are all of timber construction. Seawalls average from 100 to 200 feet in length and have a freeboard of one to three feet. These structures are also made of timber. In general, the privately-owned structures are in moderate condition with several in excellent condition. The structure protecting the public water facility is also in excellent condition.

These protective works have a minor effect on the reduction of erosion. Most structures lack adequate freeboard for the current high water levels, and thus they are easily overtopped. Therefore, many of the structures also need protection from flanking and channeling. A few of the protective works are built with materials of inadequate strength which decreases their effectiveness due to physical damage.

The structures within this reach have little effect on the coastal processes in that there is only a minor reduction in the amount of material being added to the littoral drift. The locations of the protective works are shown on the photo mosaics, numbers 2-1-167 to 2-1-160, plus 2-1-146 to 2-1-142.

Reach 2

There are no permanent or expedient shore protection works identified within this reach.

Reach 3

This reach has not identified shore protection works which are classified as permanent. The two structures identified within this reach are both expedient and are on private residential property.

One is a seawall-revetment combination which is 50 to 100 feet in length with an undetermined freeboard. This structure has a broken concrete revetment with a steel piling seawall and has been virtually destroyed. The other structure is a revetment which is 50 to 100 feet long with an undetermined freeboard. This structure is composed of rock filled gabions and is also in very poor condition.

Neither structure has any effect on reducing shore erosion due to severe structural damage. They also have no effect on the coastal process. The locations of the protective works are shown on the photo mosaics, numbers 2-1-131 to 2-1-123.

Reach 4

This reach contains no identified shore protection works which are classified as permanent. The structures identified are classified as expedient and are either groins, seawalls, revetments, or some combinations of these three types. All appear to be privately owned.

Groins in this area are generally 20 to 50 feet in length with two to four feet of freeboard. They are all constructed of timber. The revetments are generally 100 to 200 feet in length with a freeboard that varies with bluff height. The construction materials for revetments include rock, small sandbags, and plastic sheeting. The condition of the structures within this reach ranges evenly from excellent to poor.

Generally, these protective works have limited effectiveness in reducing erosion. Some of the major problems are inadequate strength of materials, resulting in physical damage to the structures and reduced effectiveness. There is a need for flanking protection for some seawalls. The structures have a minor effect on the coastal processes by limiting the amount of material being added to the lake system. The locations of the shore protection works are shown on the photo mosaics, numbers 2-1-122 to 2-1-117.

Reach 5

There are no identified shore protection works within this reach which are classified as permanent. All structures, either groins, seawalls, or a combination of the two, are expedient and appear to be private homeowner structures.

The groins in this area are generally 20 to 50 feet in length with two to three feet of freeboard. All the groins are made of timber. The seawalls generally range from 100 to 200 feet in length with a freeboard of two to four feet. Most structures are composed of timber or steel piling or a combination of the two materials. One seawall is constructed with large sandbags. The condition of all the structures within the reach ranges fairly evenly from excellent to poor.

The structures tend to have limited effectiveness in reducing the rate of erosion. There is a general need for flanking protection and tiebacks for the seawalls. Some of the construction materials, for both seawalls and groins, are of inadequate size and strength.

Some structures have inadequate freeboard for the current high water levels which increases the frequency of overtopping.

The structures somewhat limit the amount of material which is added to the littoral drift. The locations of the shore protection works are shown on the photo mosaics, numbers 2-1-116 to 2-1-98.

Reach 6

This reach contains no identified protective works which are classified as permanent. There are two identified expedient structures and both appear to be on private residential property. Both structures are seawalls in very good condition.

The two seawalls are approximately 100 to 200 feet in length with about two to four feet of freeboard. One of the structures is constructed of steel piling and the other of timber.

The effectiveness of the seawalls in preventing erosion is limited. There is some problem with overtopping due to inadequate height of the structures. This also leads to the need for increased protection from flanking and channeling.

Both structures do have some effect on the coastal process, because of the minor reduction in material being added to the lake system. The locations of the shore protection works are shown on the photo mosaics, numbers 2-1-98 to 2-1-91.

Reach 7

None of the structures identified within this reach are classified as permanent. All identified protective works are classified as expedient and appear to be privately owned. The types of structures identified include seawalls, groins, a few revetments, and some combinations.

The groins in this area are generally 20 to 50 feet in length with approximately two feet of freeboard. They are all constructed of timber. The seawalls average about 200 feet in length and have two to three feet of freeboard. Most of these structures are constructed of timber, although there are a few constructed of concrete. The revetments located in this reach are also about 200 feet in length, with the freeboard varying with bluff height. Construction materials include broken concrete and rock. All of the structures are generally in moderate condition.

The effectiveness of the structures is limited. For revetments there are some problems with the size or strength of the construction materials used, which prevents complete protection. The groins and seawalls generally have problems with inadequate height which allows more overtopping. This leads to problems with structures having

inadequate protection from flanking and channeling. A few cases showed evidence of inadequate toe protection for seawalls.

The structures within this reach cause some limitation in the amount of material being added to the lake system. The locations of the structures are shown on the photo mosaics, numbers 2-1-91 to 2-1-71.

Reach 8

This reach contains no identified structures which are classified as permanent. The identified shore protection works are classified as expedient, and appear to be privately-owned structures. These protective works consist of groins, seawalls, groin-seawall combinations, and one revetment-groin-seawall combination.

The groins vary in length from 20 to 50 feet with a one- to three-foot freeboard. They are all constructed of timber. Seawalls in this reach are generally 100 to 200 feet in length with two to four feet of freeboard. All of these structures are also made of timber. The revetment is a little over 200 feet in length with a varying height. This structure is composed of randomly placed, borken concrete. The structures are generally in moderate condition with a few structures in poor condition.

Their effectiveness in reducing erosion is limited generally because of two major factors. The inadequate height of the structures leads to increasing overtopping, and the related need for channeling and flanking protection.

The structures have a minor effect on the coastal processes because of the small reduction in the amount of material being added to the lake system. The locations of the structures are shown on the photo mosaics, numbers 2-1-71 to 2-1-67.

Schoolcraft County

Reach 1

There are two identified shore protection works in this reach which are classified as permanent. They are both within 1/2 mile of the eastern county line. Both are revetment-seawalls that appear to be for the protection of commercial property. The structures are approximately 100 feet in length with a height of eight to ten feet above the water level. They are constructed of large rocks that appear to be randomly placed. Both are in very good condition.

The revetment-seawalls have limited effectiveness in reducing erosion due probably to the lack of the rock being staged. This

allows the water to jet through and wash out some of the underlying soil.

They do, however, affect the coastal process by limiting the amount of material being added to the lake system. The locations of the shore protection works are shown on the photo mosaics, numbers 7-12-440 and 7-12-373.

Reach 2

There are no permanent or expedient shore protection works identified within this reach.

Reach 3

None of the structures identified in this reach are classified as permanent. The two identified protection works are classified as expedient. They may be publicly owned. One is a revetment; one is a seawall-revetment combination.

The individual revetment is apprximately 500 feet in length with four to six feet of freeboard. It is constructed of small rock. The seawall-revetment combination is about 50 to 100 feet in length with a freeboard of two to four feet. It is a steel pile seawall with a small rock revetment. Both structures are in moderate condition.

The structures have limited effectiveness in reducing erosion mainly because of the small size of the rock used for construction. They do, however, have a minor effect on the coastal process by the small reduction in material being added to the lake system. The locations of the structures are shown on the photo mosaics, numbers 7-12-326 to 7-12-314.

Reach 4

There are no permanent or expedient shore protection works identified within this reach.

Reach 5

There are no permanent or expedient shore protection works identified within this reach.

Chippewa County

Reach 1

There are no permanent or expedient shore protection works identified within this reach.

Reach 2

There are no protective works identified in this reach which are classified as permanent. There is one expedient structure which is publicly owned and appears to be in moderate condition. This is a groin series, located at Whitefish Point, protecting a Coast Guard Station Lighthouse. The groins in the system average approximately 50 feet in length with two to four feet of freeboard and are of timber construction.

They show limited effectiveness in reducing erosion. This is because there is a need for some flanking protection. There is also the possibility of some problem with scouring or foundation strength of the groins. This is indicated by the fact that some groins are leaning. This groin series affects the coastal process because it limits the amount of material being added to the lake system. The location of the series of groins is shown on the photo mosaics, numbers 8-9-257 to 8-9-291.

Reach 3

This reach contains no identified shore protection structures which are classified as permanent. All identified shore protection works are classified as expedient and appear to be privately owned. The majority of the structures are seawall-groin combinations with a few seawalls, groins, revetments, and revetment-seawall combinations. The structures generally appear to be in moderate condition.

The groins are generally 20 to 50 feet in length. With the large number of structures, there is greatly varying freeboard. The vast majority of the structures are made of timber and wood. The seawalls in this area average 100 to 200 feet in length and also have greatly varying freeboard. The construction material is almost exclusively timber and wood. Revetments are generally 100 to 200 feet in length with the height varying according to bluff height. Construction is also almost exclusively of timber and wood with some small sandbag revetments.

These structures show limited effectiveness in reducing shoreline erosion. This is largely due to the insufficient freeboard, which allows overtopping on many structures and the related problems of channeling and flanking protection. There is also reduced

effectiveness because physical damage to structures which are constructed of materials of insufficient size or strength has occurred.

These structures affect the coastal process by limiting somewhat the amount of material which is being added to the lake system. The locations of the protective works are shown on the photo mosaics, numbers 8-9-290 to 8-9-377.

Reach 4

There are no permanent or expedient shore protection structures identified within this reach.

Reach 5

There are no permanent or expedient shore protection structures identified within this reach.

Reach 6

None of the identified shore protection structures within this reach are classified as permanent. All the identified shore protection structures are classified as expedient protective works. They all appear to be privately owned. Their condition is generally moderate with a few structures in poor condition. The structures within this reach are almost entirely seawalls, with a few revetments or revetment-seawall combinations.

The seawalls are generally 100 to 200 feet in length with two to four feet of freeboard. They are mostly of timber construction with some steel piling and rock and/or concrete block seawalls. The revetments also average 100 to 200 feet in length. The freeboard varies with bluff height. All of the revetments are made of rock.

Due to instances of inadequate height, insufficient size or strength of materials, and the need for flanking protection, the structures have, in general, limited effectiveness in reducing erosion.

The structures' effect on the coastal process limits the amount of material being added to the lake system. The locations of the shore protection structures are shown on the photo mosaics, numbers 8-9-408 to 8-9-470, plus 8-52-0 to 8-52-42.

Reach 7

There are no identified shore structures within this reach which are classified as permanent.

All but one of the structures appear to be on private property. There is one revetment which appears to be protecting a Coast Guard light. The majority of the structures in the reach are seawalls with two revetments. Construction materials vary, but in general are timber, rock, or a combination of the two. There is some use of concrete for seawalls. In general, these structures are in moderate condition.

The structures within this reach have limited effectiveness in reducing erosion. The major reasons for this are that the structures, in general, do not have enough freeboard to prevent overtopping. Also, some of the construction material appear to be of insufficient size or strength to withstand a major wave attack.

The shore protective works have little effect on the coastal processes except for some reduction in the amount of material being added to the littoral drift. The locations of these structures are shown on the photo mosaics, numbers 8-52-35 to 32, and 8-52-64 and 65.

Alcona County

Reach 1

One of the structures identified within this reach is classified as a permanent shore protection work. It appears to be publicly owned and is in moderate condition. This revetment-seawall is located just south of the Harrisville Harbor. It is about 200 feet in length with a height of six to eight feet, and is constructed of large blocks of broken concrete and rock. The material does not appear to be staged, but rather randomly placed.

The remaining identified shore protection structures in this reach are classified as expedient and appear to be privately owned. They are comprised of mostly seawalls with a few revetments, groins, and some combinations of the three types. Groins found in Reach 1 are generally 20 to 50 feet in length with up to two feet of freeboard. They are all constructed from steel piling. Seawalls vary from 100 to 200 feet in length with up to four feet of freeboard. Some are constructed of timber and some of randomly placed concrete blocks or broken concrete. Revetments are approximately 100 to 200 feet in length with varying freeboard. They are composed of broken concrete and rock which does not appear to be staged. The condition of the structures can be generally described as moderate.

The structures have limited effectiveness in reducing erosion. This can generally be attributed to the lack of material staging in the revetments and seawalls. This lack of staging allows jetting action which will remove soil from the bank or bluff. The lack of

adequate height in some seawalls leads to overtopping which will reduce the effectiveness of the structure.

The protective works do affect the coastal process by causing some reduction in the amount of material being added to the lake system. The locations of the shore protection structures are shown on the photo mosaics, numbers 6-26-85 to 6-26-31.

Reach 2

This reach contains no identified permanent shore protection works. There are five identified shore protection structures which are classified as expedient. There is one groin series, two revetments, and two pile systems (driven, individual posts, with tires on them). These appear to be privately owned and are generally in moderate condition, with a few structures in poor condition.

The groins in this series are 20 to 50 feet in length with two to four feet of freeboard. The groins in this system are constructed of timber. Both revetments are approximately 200 feet in length with two to four feet of freeboard. Both are constructed of rock. The two series of piles have various lengths of structure. There is also a great variation in height of the piles. This system is also made of timber.

These structures show limited effectiveness in reducing erosion rates. The revetments' construction materials are not staged, which allows jetting, thus limiting their effectiveness. There are a few problems with inadequate structure height which leads to overtopping. The series of piles have no effect in reducing erosion.

These protective works do affect the coastal process by causing a minor reduction in the amount of material being added to the lake system. The locations of the shore protection structures are shown on the photo mosaics, numbers 6-26-30 to 6-26-18.

Reach 3

None of the identified shore protection works within this reach are classified as permanent. There are three identified shore protection works within this reach which are classified as expedient structures. All appear to be privately owned and are generally in moderate condition. These structures are all revetment-seawalls approximately 200 feet in length with about four feet of freeboard. They are all of stone or rock construction.

The revetment-seawalls exhibit limited effectiveness in reducing erosion. This can largely be attributed to the apparent lack of the

construction materials being staged and to some problem with insufficient size of the rock.

The structures do affect the coastal process by causing some reduction in the amount of material going into the lake system. The locations of the structures are shown on the photo mosaics, numbers 6-26-17, plus 6-25-141 to 6-25-151.

Huron County

The structure review portion of this program utilized field observations. These observations were made from a small research vessel. Severe weather conditions for four days prevented completion of this task in a number of the reaches.

Reach 1

There was no structure review within this reach due to weather conditions.

Reach 2

There was no structure review within this reach due to weather conditions.

Reach 3

The structure review was not entirely completed within this reach due to weather conditions. Approximately, the western three miles of the reach were not covered.

There is one structure within this reach which is classified as permanent. This structure is located just west of the Port Austin Harbor entrance. The structure is a concrete seawall which appears to be protecting private property. The structure is in excellent condition. The seawall is about 100 feet in length and about eight to ten feet in height.

The remaining structures within this reach are classified as expedient. The majority of structures are seawalls, with a few revetment-seawall combinations, and one seawall-groin combination. The condition of the structures ranges from excellent to poor.

The one series of groins has a freeboard of about two feet with a length of about 20 feet. The groins are constructed of timber. The seawalls and seawall-revetment combinations have a wide variety of heights with the general length being around 200 feet. There is also a wide variety of materials used in the cnstruction of the

seawalls and seawall-revetment combinations. These materials include timber, steel piling, concrete block, cast concrete, rock and wire baskets.

The structures within this reach have limited effectiveness in reducing erosion. Some seawalls and revetments have insufficient height to prevent overtopping, while others do not have sufficient protection for channeling or flanking behind the structures. Also, most of the rock revetments are not staged; therefore, they are not entirely effective.

The shore protective works effect the coastal process by somewhat limiting the amount of material which is added to the littoral drift. The locations of the protective works are shown on the photo mosaics, numbers 3-27-320 to 3-27-361.

Reach 4

There is one strucutre within this reach which is classified as permanent. This structure is a rock revetment-seawall. It appears to be protecting a Coast Guard Station and a section of Lighthouse County Park. The structure is about 500 feet in length with about six feet of freeboard. The structure is in moderate condition.

The remaining structures within this reach are classified as expedient. The vast majority of the structures are revetment-seawall combinations with a few seawalls, a few revetments, and one groin series. In general, the condition of the structures is moderate. There is a wide variety of materials used in the construction of the protective structures. The most widely used material is rock, for both the construction of revetments, seawalls, and combinations. Seawalls are also constructed of timber, steel piling, and concrete blocks. The groins are constructed from timber.

The heights of the revetment-seawalls, seawalls, and revetments are widely varied. In general, they range between one and six feet. The lengths of the structures is generally between 100 and 200 feet. The groin series has a freeboard of about one foot and a length of about 50 feet.

In general, the shore protective works within this reach have limited effectiveness in reducing erosion. There are several reasons for this. A large number of the structures lack sufficient height to prevent overtopping. The majority of structures have no protection from channeling and flanking. Also, there are structures which use insufficient sized rock, which can be easily shifted about during a storm. There is also a lack of staging in the construction of many seawall-revetments or revetments

The structures effect the coastal processes by somewhat limiting the amount of material which is being added to the littoral drift.

The locations of the protective works are shown on the photo mosaics, numbers 3-27-362 to 3-27-479.

Reach 5

There are no identified protective works within this reach.

3.0 DAMAGE AREAS

3.1 DAMAGES DUE TO FLOODING

Muskegon County

Muskegon County shoreline consists of 27 miles of high sand dune and erodible clay bluffs. Due to the predominance of high sand dune and clay bluff areas, it was expected that there would be little flooding damage reported. However, flood damages were reported in this county probably due to homeowners improperly interpreting certain damages due to high lake levels as flood damages. Flooding damages and costs of flood protective measures which were undertaken are summarized in Table 1-1. The small area of lake flood plain has been defined for the 100-year flood levels, which are shown on the photo mosiacs, frame 1-1-33 to frame 1-1-441.

Specifically, Reaches 1, 3, 4, and 5 in Muskegon County all have high dune and bluff shorelines which should therefore sustain little or no flooding damages, according to their shoretype. Reach 2, however, has a low erodible bluff shoreline where flooding is more likely to occur. This is most clearly documented by Column 3, Flood Damages to Structure and Contents, in Table 1-1. Reach 2 had the only reported flood damages to Structure and Contents.

Manistee County

The 26-mile shoreline of Manistee County alternates between erodible bluffs and glacial lowlands. Flood damages are more likely where the lowlands are encountered. In contrast, the high bluff areas would characteristically sustain much less flood damage. For reported flood damages and costs of protective actions, see Table 1-2. The high lake levels are shown by the 100-year flood levels as denoted on the photo mosiacs, frame 2-1-67 to frame 2-1-167.

Due to the high bluff shorelines of Reaches 1, 3, 6, 8, and part of Reach 5, little flooding damages were anticipated in this area. This correlates closely to the information reported by property owners in Table 1-2. Two high bluff reaches reported no flooding at all. The most flooding was reported in the low erodible bluff stretches of shoreline found in Reaches 2, 4, 5, and 7, which were more susceptible to flooding due to their shoretypes. Reaches 5 and 7 were the only reaches to list any costs for protective measures undertaken by property owners, see Column 8, Costs of Protective Structures, Table 1-2.

Schoolcraft County

The 49-mile shoreline of Schoolcraft County along Lake Michigan is very irregular, with shoreforms alternating from sheer rock walls to low sand dunes, low plains, and marshes. Since much of the shoreline is naturally protected by gravel and cobble beaches or by outcrops of limestone, minor flooding damages were expected in this county. Reach 4, specifically, has several stretches of high bluffs which should not be affected by flooding at all. This is reflected in the 100-year flood level as shown in the aerial photographs, frame 7-12-190 to frame 7-12-440. Reported flooding damages incurred by property owners are summarized in Table 1-3. As shown in Columns 4, 5, and 6 of this table, only Reaches 1 and 2, with their low dune and plain shoretypes, reported flooding damages. None of the property owners in this county reported taking any protective measures.

Chippewa County

The portion of Chippewa County along Lake Superior included in the study area has erodible plain and bluff shoretypes as well as several stretches of non-erodible bluff shoreline. The predominant shoretypes in this area are much more susceptible to flooding and the resultant damage than the high dune and bluff shoretypes found in several other counties under study. The high lake elevations as denoted by the 100-year flood levels are shown in the aerial photographs, frame 8-9-239 to frame 8-52-65. As Table 1-4 indicates, respondents to the assessment reported the highest dollar damage due to flooding of all the Michigan pilot counties surveyed. It was expected that heavy flooding damages would be incurred by the majority of the reaches in this county. However, large portions of Reach 1 are undeveloped; thus, it would be difficult for the property owner to perceive flooding damages on undeveloped land. Reach 5 is part of a national forest area so there are no residential property owners in this reach. Damages incurred by the national forest will be discussed in Section 4.0, Recreational and Environmental Losses. Reach 7 contains the only high erodible bluffs in the county, where little flooding damage is anticipated. Reaches 3, 4, and 6 were the only areas to report any costs of protective actions against flooding, as demonstrated by Table 1-4, Columns 7-10. However, while Reach 6 reported the largest expenditures for protective measures, it also sustained the highest amount of dollar damages, especially in the areas of Grounds and Improvements and Miscellaneous Damages. Only Reaches 3 and 6 incurred damages to Structures and Contents.

Alcona County

Although Alcona County's prevalent shoretype is erodible plain, there are several stretches of high bluffs located between Greenbush and Harrisville. Extensive flooding due to high lake levels was

expected in areas with low plain shoreforms, as in Reaches 1 and 3, whereas the bluffs in Reach 2 offer more protection. Reported costs of protective measures as well as flooding damages are listed in Table 1-5. The high lake levels as illustrated by the 100-year flood levels are shown in the photo mosaics, frame 6-26-81 to frame 6-26-12 and frame 6-25-151 to frame 6-25-139.

Reach 1 sustained the greatest amount of reported dollar damages due to flooding in the county. The highest amount of damage was accrued to Structures and Contents (see Column 3, Table 1-5). The majority of residential dwellings in this county are located in this reach. In addition, most of these dwellings are found within 50 feet of the bluff.

Huron County

The shoreline of Huron County consists of 92 miles of wetlands and low sand bluffs, also with a very small area of high erodible bluffs. Reports of flooding damage were expected, particularly in the areas of shoreline designated as wetlands, and also for areas of erodible low sand and clay bluff. Reach 1 is basically wetlands and is the area most susceptible to flooding damage. Reaches 2, 3, and 4 are basically low bluff and lowland areas, which are characteristically in danger of flooding during high lake levels. Because of the 40-foot high bluffs existing in Reach 5, it was not expected that much flooding damage would be reported there. Flooding damages and costs of flood protective measures are summarized in Table 1-6. The lake flood plain has been defined for the 100-year flood levels, and these are shown on the photo mosaics, frame 3-27-204 to frame 3-27-489.

The residents of the marshy area of Reach 1 reported the greatest amount of damage due to flooding. Reach 5 residents reported the least damage due to flooding, probably since they suffered fewer damages due to the high bluff nature of their shoreland. This is documented in Column 2, Total Costs, in Table 1-6, which shows dollar costs due to flooding.

Land use density was about equal for all the reaches. Thus, shoretype is the major factor influencing the extent of flood damage reported.

3.2 EROSION DAMAGE

Muskegon County

Due to its high sand dune a d e dib e bluff shoretypes along this exposed shoreline, it was an cipa ed that Muskegon County would suffer severe erosion damage Reaches , 3, and 5, in particular, with their dune shoretypes desce ding a most directly into the lake would be expected to report large erosion damages due to high lake levels, with no beach to protect the bluff from direct wave attack. The shoreline in Reach 2 appears to be less susceptible to erosion as the low erodible sand bluff is stabilized somewhat by extensive vegetation in several places. Reported erosion damages and costs of protective measures are summarized in Table 2-1. Economic losses due to erosion are significantly greater in Muskegon County than in other counties included in the study. Contributing factors to the high economic losses are the erodible exposed shoreforms as well as the large degree of shoreline property development. The majority of residences are reportedly located within 50 feet of the bluff throughout this entire county (see Table 3-1). This could be a major factor behind the large reported amounts of erosion damage to the structures and their contents. This area also reported the largest volume of bluff lost. Reported amounts of beach area and volume of bluff lost are listed in Table 3-1. Designated high risk erosion areas are located in every reach along the county's shoreline.

Manistee County

Manistee County has 26 miles of erodible bluff and glacial lowland shoreforms along Lake Michigan. These shoretypes typically are susceptible to extensive erosion damages in open coast areas characteristic of this county. It was anticipated that a large amount of dollar damages due to erosion would be reported for Reaches 1, 3, 5, 6, and 8 specifically, with their high erodible bluff shoretypes. Property owners incurred large economic losses due to erosion damage as demonstrated by Table 2-2 which summarizes reported erosion damages and costs of protective actions. Table 3-2 depicts the calculated amounts of beach area and bluff eroded during the study period. Reach 2 reported the greatest losses to bluff due to erosion and Reach 7 recorded the most beach area lost, according to Table 3-2. Reach 5 reported the largest amount of dollar damages due to erosion, with damage reported in every category (see Table 2-2). Physical characteristics were essentially the same for all reaches in this county so differences in totals are not easily explained.

Schoolcraft County

Schoolcraft County's 49-mile shoreline is irregular, alternating from sheer rock walls to low sand dunes. Damages due to erosion were expected to be minor. This is due to the abundant natural shoreline protection and the low degree of shoreland property development in this area. Reach 1 and part of Reach 2 may be expected to sustain erosion damages, in particular, due to their low dune shoreforms; however, none of the other reaches would characteristically be affected to any great extent. Reported erosion damages and costs of protective measures which were undertaken are summarized in Table 2-3. As this table indicates, Schoolcraft County reported small amounts of erosion damages as expected based on the factors listed above. The low degree of development is exemplified in that there are only eight dwellings reported within 50 feet of the bluff throughout this entire county (see Table 3-3). The minor erosion damage reported may also be correlated with the minimal amount of calculated bluff material eroded, although the area of beach lost was quite substantial; the second highest of the counties examined. The calculated beach area and volume of bluff eroded are summarized in Table 3-3.

Chippewa County

While there are only two stretches of non-erodible, low bluff shoretype in Chippewa County, most of the shoreline alternates between erodible low plain and erodible low bluff shoretypes. It was expected that these areas would incur substantial erosion damages due to high lake levels. Scattered high risk erosion areas around Whitefish Point, Paradise, and near the southern end of the county are likely to be hardest hit. Damages typically would be minor in Reaches 3 and 5 as they contain the only stretches of non-erodible shoreline. Reported erosion damages and costs of protective measures utilized by property owners are summarized in Table 2-4. The second largest amount of total dollar damages due to erosion in Michigan occurred to shoreline property in this county. The amount of beach area as well as volume of bluff eroded in this area was also substantial, as documented by Table 3-4 which lists the calculated beach and bluff area lost during the study period. The majority of dwellings are located within 50 feet of the bluff edge, and are therefore threatened by substantial erosion damage (see Table 3-4). This is further suggested by the substantial expenditures for protective structures borne by property owners to prevent erosion losses. The only emergency evacuations reported by any of the counties surveyed occurred in Reach 6 in this county, although only minimal costs were involved. Reach 5's entire shoreline is part of the Hiawatha National Forest, and therefore no property owners live in this reach. Information on damages sustained in this forest is in Section 4.

Alcona County

Alcona County's shoreline is generally erodible plain, with short stretches of high bluff in Reach 2. The entire shoreline is susceptible to erosion damages, with high risk erosion areas located in every reach (see Table 4).

Moderate economic losses due to erosion were reported by property owners in Alcona County. This is documented in Table 2-5, which summarizes reported erosion damages and costs of protective measures. Reach 1 sustained the greatest amount of dollar damages as well as reporting the greatest expenditure on protective structures in the county. This is due to the location within this reach of the majority of the residences in the county. There are 99 residences out of the total of 121 dwellings in the county that are located within 50 feet of the bluff in this reach. The calculated volume of bluff eroded and beach area lost during the study period are shown in Table 2-5. The volume of bluff eroded was minimal in comparison with other areas, and the lowest amount of beach lost also occurred in this area.

Huron County

Nearly 1/3 of Huron County's shoreline is classified as non-erodible, particularly in areas of marshy lowlands and non-erodible clay bluffs. However, there are some 12 miles of scattered high risk erosion areas. The greatest risk of erosion occurs specifically in Reaches 2, 3, parts of 4 and 5. This is due to their erodible sand bluff shoretypes. Parts of Reach 4 are also susceptible to erosion damages, although there are stretches of non-erodible bluff evident.

Reported erosion damages and costs of protective measures undertaken by property owners in this county are listed in Table 2-6. Only moderate economic losses were reported as a result of erosion processes, with most of the damages occurring in Reach 4 to Grounds and Improvements (see Table 2-6). Reach 1 reported the greatest expenditures for protective structures in the county. The reported economic losses due to erosion were moderate in this county, but the reported amounts of beach and bluff material eroded were quite substantial.

Huron County lost the greatest amount of beach material and volume of bluff eroded of the six counties studied. This large amount of eroded material may be due to the fact that Huron County is the largest county surveyed consisting of 92 miles of shoreline. Table 3-6 lists the calculated amounts of beach area and bluff volume eroded during the study period. A factor contributing to the moderate economic losses is the limited number of residences located within 50 feet of the bluff (see Table 3-6).

3.3 AREAS OF MAJOR AND MINOR PROBLEMS

The last two sections of the report have dealt specifically with the particular areas in each county where flooding and erosion problems have been encountered. In order to determine the areas of major and minor problems, total damages reported in each reach were examined. This combination of flooding damages, erosion damages, and costs of protection for flooding and erosion is incorporated in this section to provide a gauge for problem areas.

In order to determine those areas which could be identified as having major problems and those areas having minor problems, a "damage ratio" was established. This damage ratio was computed by dividing the average reported damage by the market value of the property, market value being determined as twice the county's assessed value. If the damage ratio in any reach exceeded .50; that is, if more than 50 percent of the market value of the property was accrued in damages, this was considered an area of major problems. If the ratio was less than .10 in any reach, then this region was determined to be a minor problem area. Reaches with damage ratios between .1 and .5 were defined as moderate problem areas. The usefulness in using this kind of determination is that it identifies those areas of prime concern and those areas where little or no problem exists. Table 4 contains the damage ratios calculated for the counties studied. To make the assessment of damages more valid, only those reaches which contained 15 or more respondents have a damage ratio computed. From this table the major problem areas are identified as Reaches 1 and 5 in Muskegon County; Reaches 1, 5, and 7 in Manistee County; and Reach 3 in Chippewa County. No areas of minor problems were found using this method.

Table 4 also shows values of average reported damages per foot of shoreline frontage, which can be used as another indicator of major and minor problem areas. In this case, major problems were determined in those reaches where damages exceeding $75 per foot were reported. Areas of minor problems were those where the average reported damage per foot was less than $10. Reaches reporting damages between $10 and $75 per foot were defined as moderate problem areas. Again only reaches with more than 15 respondents were included in the analysis. When using this determination, Reach 2 in Muskegon County and Reach 1 in Huron County were, in addition to the above reaches, identified as major problem areas. Again no minor problem area was determined.

Additional information was obtained from the Michigan Department of Natural Resources, which studied recession rates on Michigan shorelines and reported high risk erosion areas. Although study on all the Michigan shoreline was not complete at the time this report went to print, areas of high risk erosion had been identified for all the counties under study. The reaches where high risk erosion areas have been identified are noted on Table 4. These areas were defined

by the Water Development Services Division, Michigan Department of Natural Resources. It was found in general that reaches defined as major damage areas contained shoreline classified as high risk erosion.

3.4 COMMERCIAL AND INDUSTRIAL SURVEY RESULTS

In addition to the residential property located on the lakeshore, there are property holdings by commercial and industrial firms and various utilities and governmental agencies. For the most part, land owned by the government is either in undeveloped holdings or developed for recreational purposes. The damages identified in these recreational lands will be covered under Section 4 of this report.

The commercial and industrial concerns that were identified and located were interviewed either by telephone or in person to ascertain what kinds of damages were incurred to their properties, the costs of these damages, and whether any actions were taken to prevent further damage. In addition, other information was collected concerning characteristics of the individual properties, such as length of shoreline, bluff height, and use of the property.

Based on shoreline frontage, the commercial/industrial properties can be categorized into two categories. One is the small tract which contains a commercial enterprise, such as a motel, store, or restaurant. These properties normally have frontages of less than 500 feet. The other category is the large tract, which is usually an industry, where the frontage length can range from 1,000 to 5,000 feet. This category was primarily represented by such industries as steel, pulp and paper, chemical, sand mining, electrical utility, and sugar refining.

Reported bluff heights for the commercial/industrial properties varied widely from county to county, which is verified by looking at the different shoreforms found in each area. Bluff heights in Muskegon and Manistee Counties were reported as ranging from three to 100 and up to 150 feet, respectively. This is characteristic of high bluff formations found in these regions. Schoolcraft and Chippewa Counties identified smaller bluff heights of up to ten and to 18 feet, respectively. The commercial/industrial property in Alcona County reported a bluff height of about three feet. Reported bluff heights in Huron County ranged from one to 30 feet, the relatively low height being typical in this county.

The recession rates reported in the interviews followed the same pattern as the bluff heights. Muskegon and Manistee Counties reported the largest values of bluff recession, with Muskegon reporting up to 300 feet and Manistee indicating up to 100 feet. The values reported for the rest of the counties were substantial, on the order of ten to 30 feet for the study period, but small compared to the values for Muskegon and Manistee Counties. However, one commercial enterprise in Huron County did report up to 200 feet in bluff recession.

In the six counties studied, 178 commercial/industrial properties were identified (see Table 5). Of these, only 43 could be located

and scheduled for an interview. Only three of those interviewed reported any damage due to flooding, and 12 of the 43 reported no damage due to erosion. Erosion damage that was reported was identified in four different categories: structures, grounds, clean-up, and other. Additionally, these commercial/industrial property owners were questioned about costs of protective actions and any business losses incurred as a result of erosion damages. Table 6 shows the total figures for these categories for the six counties.

Chippewa County reported a total of $37,000 in damage, the majority of which resulted from building protective structures in Tahquamenon Falls State Park. The rest of the damages were incurred by resorts and motels. In Schoolcraft County there were only four respondents; three reported no damage and a fourth could not ascertain any dollar value for damages. One industry installed rip-rap in order to slow or stop the erosion problem, but this is the only reported case of any attempt at structural shoreline protection.

In Manistee County a total of more than $120,000 worth of damages were reported; the Manistee County Road Commission reported $30,000 in damages and an additional $17,000 in protective structures alone. Other protective structures were built by resorts and motels which had incurred damages, and a paper company spent $10,000 for a seawall. In Muskegon County, the water filtration plant reported damages of $10,000 and said they spent another $7,500 on protective structures. Another $3,800 in lost employee wages was incurred when lifeguards could no longer be utilized at one site. One sand mining operation reported that since there was a front dune between the sand mining and the lake, no real damages were at present being incurred. Non-residential damages equalling $45,000 were reported in Alcona County. Losses of 9,000 cubic yards of sand were also reported.

Huron County reported $50,000 in erosion damages due primarily to losses on grounds and improvements. The Detroit Edison Company's Harbor Beach Power Plant alone suffered $20,000 damage to roads and storage areas, while another commercial respondent reported a similar amount as a net loss of property resale value. Three of the non-residential property owners interviewed reported flooding damages of the following types:

Structure and Contents	$15,220
Grounds and Improvements	5,100
Protective Structures	250
Relocation Costs	1,500

This was the only Michigan county that experienced non-residential flooding damage.

The question of future erosion problems was posed to the non-residential property owners, and the response indicated that concern for future erosion problems was located in Chippewa, Manistee, and Huron Counties. Thirteen responses in these counties indicated that if the erosion continues, an additional $203,000 would be required to protect the shoreline in the next 25 feet of bluff recession. Twelve respondents reported that there was no problem with future erosion conditions, either because the existing structure was felt to be sufficient or else there was no real problem with erosion to begin with. Only one respondent in Huron County expressed concern about flooding problems in the future, indicating that the low area does not allow for protection against such damage.

4.0 RECREATIONAL AND ENVIRONMENTAL LOSSES

4.1 BEACH RECREATION

The effect of high lake levels on beach recreational opportunities can be broken down into two categories: the effect on public recreation and the effect on private recreation. A study of damages and loss of beach recreational opportunities at Michigan state parks has been used to evaluate the effect on public recreation; however, the information necessary to evaluate the effect on private beach recreation is not available. Therefore, this section of the report discusses the changes that occurred to beach recreational opportunities at the state parks located in the six pilot counties. Seven state parks are located on the lakeshore of five of the counties in this study, with Schoolcraft County having no lakeshore state parks. P. J. Hoffmaster and Muskegon State Parks are located in Muskegon County, Orchard Beach State Park in Manistee County, Harrisville State Park in Alcona County, and Port Crescent and Sleeper State Parks in Huron County.

Much of the information for this report was made available from the biannual reports that various park managers have made to the Michigan Department of Natural Resources. (Copies of these reports are included in Appendix D of this report.) Since the reports made to the DNR were informal, the information presented varied in emphasis and amount of detail. Therefore, phone calls were made to all the parks in order to obtain the same type of information from each location. The following is a summary of the information obtained from the various parks. An attempt has been made to draw some conclusions about the effects of the high lake levels on the recreation opportunities and the changes in the aesthetically valuable features available at these parks.

P. J. Hoffmaster State Park

In the March 15, 1973 erosion report from the P. J. Hoffmaster State Park in Muskegon County to the Department of Natural Resources, severe erosion was anticipated along 2 1/2 miles of beach, with loss of foredunes, trees, and vegetation. The beachstairs were also reported to be in danger. By April 18, 1974, although the beachstairs were closer to the water, they had not yet been damaged. The buildings in both the old and new day use areas were not in danger due to erosion because they were located far enough from the lake. The loss of beach continued during the summer of 1974, at which time a few trees were lost. However, in the October 1974 report, the park manager indicated that overall erosion has had little effect on the park facilities, and that further damage could only be expected if lake levels were to continue to rise.

It would appear that for recreational areas, such as P. J. Hoffmaster State Park, erosion has not greatly affected the quality of recreation available. The beach area that remains is still capable of supporting swimming, picnicking, and hiking, while the adjacent campgrounds are also free of danger. The old day use and campground areas would become less available for recreation if the stairs were lost, because access to the beach area would become more difficult. According to the attendance figures, the high lake levels have not adversely affected the use of this park. In fact, attendance has increased continuously at the campgrounds, as is demonstrated by the following figures:

Year	Campgrounds	Day Use	Total
1970	57,544	151,896	209,440
1971	86,387	170,268	256,655
1972	93,740	138,130	231,870
1973	106,284	166,191	272,475
1974	114,692	180,298	294,990

Even the estimated 7,000 square feet of beach loss has not decreased the recreational use of P. J. Hoffmaster State Park. However, these attendance figures are not truly representative of the effects of high water levels on the recreational use of the park, since 146 additional campsites were put into service in 1973. Thus, the figures must be adjusted to account for this addition. Although the new campsites were completed in 1973, they were closed from July 4, 1973 to the end of the season due to a water supply problem which was completely unrelated to the lake level conditions at that time. These factors make it difficult to draw conclusions from the attendance figures, but it does appear that the trend of increasing attendance indicates that high lake levels may not play a significant role in determining use of the facilities. Since the campgrounds are well away from the lake, their use is not directly affecting the use of the general park area.

In general, it is difficult to assess the effects of high lake levels. Although the loss of beach area has reduced the beauty of the beach, the desire to reach the lake has been strong enough to outweigh this inconvenience.

Tahquamenon Falls State Park

The picnic area of Tahquamenon Falls State Park in Chippewa County has suffered extensive damage. By April 24, 1974 approximately 1/3 of the area between the parking lot and the lake had been lost. At this time, a revetment and groin system was reported to be constructed to reduce the erosion damage. However, by October 1974, the erosion control structures had not yet been completed, and the materials necessary for the project were being stockpiled at the

site. Although no park structures have been endangered by erosion, it would seem that the recreational value of this park has decreased due to erosion and the planned protective structure.

The area available for picnickers is now smaller than before, and the proximity of the parking lot appears to adversely affect the aesthetic value of the area. It would seem that many visitors to the lakeshore areas seek to escape the closeness of the urban environment. Unfortunately, a 42-foot strip between the parking lot and the edge of the lake does not ideally satisfy this desire. Although the construction of the erosion control structures has been considered necessary, they, too, can reduce the aesthetic and recreational desirability of the site. The presence of the stone, gravel, and sand which is stockpiled for revetment construction is temporary in nature, and despite its aesthetic devaluation of the area, it should not affect the future use of the park. Attendance figures were not available for this park so the actual effect on use cannot be evaluated.

Port Crescent State Park

The erosion report from Huron County's Port Crescent State Park that was submitted to the DNR was vague, thus making it difficult to estimate the effect that erosion has had on recreation and aesthetics. The sketch included in the report to the DNR (see Appendix D) indicates that the erosion attributed to the March 17, 1973 storm has left the underground electrical system only five feet from the edge of the bluff. The October 1974 report states that slightly lower lake levels have resulted in a cessation of erosion damages.

It is difficult to conclude what effect the high lake levels have had at Port Crescent. Additional information obtained from the park points out that the primary erosion problem is the loss of trees and the clean-up that this necessitates. Stone and fill have been hauled in as a temporary measure to attempt to decrease erosion.

The facilities at the park have undergone no major damages. The loss of 750 feet of snow fence and 26 poles was valued at $220. The repair of damage to the launch area at the boat launching site required moving the concrete slab and adding fill costing $564. Clean-up operations were handled by the park staff, with labor costs amounting to $365, while the equipment used either belonged to the park or was available at reduced costs. The total cost for use of this clean-up equipment was $126. In addition, gravel was used to replace blacktop which had washed out, costing $200.

In general, it appears that high water levels have not greatly affected the use of the park. Attendance continues to follow an increasing trend, but, again, it is difficult to assess what other factors have influenced attendance, or to determine if the use of the park would have shown a greater increase in the absence of high water.

The following use figures are for the number of permits issued for camping:

Year	Camping Permits
1970	5,765
1971	6,008
1972	6,227
1973	not available
1974	6,283

Since the edge of the water is now closer to the campgrounds, it is possible that users have actually enjoyed the higher lake levels.

Sleeper State Park

In the March 1973 report sent to the DNR, the park manager of Sleeper State Park in Huron County indicated that considerable damage had occurred to a retaining wall and a landing. These structures were damaged earlier by a storm on November 14, 1972, and are still in danger of further damage. As the reports demonstrate, considerable dune and beach loss has occurred, particularly in the area to the west of the park store where the dunes have receded. The area of moving sand is a problem. According to the April 24, 1974 report, an atypically strong north wind affected the location of the edge of the water, leaving no beach area. However, the October 1974 report shows the existence of approximately ten feet of beach at this location. This final report reveals that Sleeper State Park has continued to suffer erosion losses. During the summer of 1974, an additional five feet of bluff as well as "all the remaining cement terrace work and five feet of sidewalk" were lost due to the erosion. Although no other structures are in immediate danger, it is clear from the park manager's report that the shifting dune problem is a nuisance which may be affecting recreational use.

Sleeper State Park exemplifies an area where considerable erosion losses have occurred, although a correlation between this erosion and park use is difficult to make. Here, too, high waters have not caused a significant decline in total attendance. Attendance figures for the past five years are as follows:

Year	Campgrounds	Day Use	Total
1970	93,350	71,308	164,658
1971	83,216	65,514	148,730
1972	80,074	53,409	133,483
1973	87,824	63,521	151,345
1974	97,563	56,860	154,423

The day use and camping figures indicate that the greatest decrease in use occurred in 1972, but that total attendance has not increased to the 1970 levels during the period from 1973 to 1974. The decrease in attendance in 1971 and 1972 cannot be correlated with high lake levels, making it difficult to determine what has caused the attendance changes.

It is difficult to assess the effects of the high lake levels on the use of the recreational area, but it appears that high waters have not significantly reduced its recreational desirability. The steep sand bank caused by the erosion of the dunes, combined with the narrow beach area, do not present a highly desirable area for swimming and/or sunbathing. In addition, the loss of the retaining structure probably caused an unsightly picture over the period of months that it took for the wall to crumble away. Although the inundation of the beach which occurred when the April 24, 1974 survey was made may not be common, it indicates that a strong northerly wind would make the area undesirable for most forms of recreation.

Brimley State Park

Brimley State Park, located in Chippewa County, reported on April 22, 1974 that "a great deal of erosion has taken place." The seawall in the day use area appears to be providing protection to the picnic area, and although there were no reports of erosion behind the seawall, some loss of sand in front of the seawall was reported. Small amounts of sand loss in front of the bluff at the campground were also reported, but it appears that the area as a whole had not been greatly affected. The October 17, 1974 report indicated that the situation has stabilized at least temporarily, and that erosion is not a major problem.

Since erosion damage at Brimley is not severe, the recreational opportunities afforded by the park have not been greatly affected. Although the seawall built in 1973 is certainly not a welcome addition to a recreational area, it appears to be reducing losses effectively, while the 40 feet of beach in front of the wall provide some area for swimming and other activities.

Attendance figures actually increased in 1973 when the stone seawall was being built. Although 1974 attendance figures show a decline from the 1973 peak, the increasing trend established in 1970, 1971, and 1973 seems to be continuing. The attendance figures are:

Year	Camping	Day Use	Total
1970	96,980	41,197	138,177
1971	103,528	43,090	147,618
1972	106,350	35,755	142,105
1973	120,880	53,665	174,545
1974	113,424	45,067	158,491

Again, high water does not appear to have an adverse affect on the recreational use of this park. Although attendance has fluctuated, no direct correlation can be drawn to lake level changes.

Muskegon State Park

Muskegon State Park in Muskegon County has reported more severe erosion problems than the other parks in this study. Considerable damage was reported in the April 1973 report sent to the DNR. A stairs leading from the north campgrounds has been left hanging in the air due to erosion at its base, and could be lost during a storm. Two major areas in immediate danger were the road leading to the south campground and the north parking lot by the bathhouse. High waters and storms could cause a segment of the road to be washed away. No losses had occurred by April 25, 1974, but the endangered structures continued to be threatened. The beach house and the adjacent parking lot were now also in danger. Continued high water at all these locations has accelerated the erosion and perpetuated the threat to the structures. It was noted that the shoreline is so close to the stairway that the steps and landing will eventually be lost. Another facility in the park which is suffering from the high lake levels but not from erosion is the boat launching ramp. Since the ramp is inundated "from time to time," its accessibility as a launch site has been decreased.

The erosion damages incurred by the dunes surrounding the stairway at the north campgrounds has left the entire structure suspended over the beach and has made it necessary to rebuild the stairs (see Photo # 35A, Sheet 1). In October 1974, it was noted that the stairway would soon be unsafe to use. Additional rubble has been placed to reduce the erosion threat to the road (see Photo #17-18, Sheet 2); however, this is expected to be insufficient to reduce further jeopardy to the road. The threat to the parking lot continues, and it has been necessary to periodically place sand fill to save the lot. The shoreline continued to advance during the summer of 1974, and losses to the beach area were noted. Also, the additional erosion brought the edge of the water up to a drinking foundation. Attempts were made to protect the fountain with concrete and sandbags, but these efforts only provided temporary protection. The summer water levels also inundated the boat launching ramp, making it an unusable launch site at various times.

The erosion problems at the park have necessitated a number of repairs. The beach stairs at the north campgrounds have been reconstructed so that they end on the side of the bluff. This work required an estimated $500 in labor costs and $35 in vehicle charges. The materials used in the reconstruction were available at the park, and thus were not included in the cost. The endangered road is a county road, and therefore is not maintained by the park. Costs for the rubble that has been dumped by the county are not available; the

labor costs for park workers dumping dead trees at the site were estimated to be $100. Approximately $150 was spent for the labor used to provide protection to the drinking fountain, with an additional vehicle charge of $10.50. Since a group of Boy Scouts helped in doing the work, an estimated $50 was saved in labor costs.

In 1974, a swing set at the beach area near the bathhouse was inundated. Although this condition poses additional threats to users, park officials have chosen to leave the apparatus in place. This play area is enjoyed by many people, but requires additional supervision by the life guards on duty.

It is clear that Muskegon State Park has reported the most severe losses of the parks considered herein. In addition to the problems with the various structures, the high water has also decreased the aesthetics of the park. The stairs at the north campgrounds no longer lead to the beach, they now lead directly to the water. In fact, virtually no beach now exists where there was formerly a considerable sandy beach. Although it is difficult to assess the effects on hiking and picnicking, it generally appears that the high lake levels have hampered the recreational opportunities in this area. The flooding of the boat launching site combined with various other losses would necessarily have created a situation in which the value of the park for recreational activities has been decreased by the high lake levels. Even if the lake levels receded, reconstruction of the stairs and similar structures would be required to restore the area's pre-high water recreational resources.

The attendance figures for Muskegon State Park do not reflect a drastic reduction in the use of the park's facilities. The following attendance statistics were provided by park officials:

Year	Camping	Day Use	Total
1970	141,197	375,001	516,198
1971		not available	
1972	--	--	465,579
1973	116,501	386,363	502,864
1974	117,543	272,437	389,980

It is of interest to note that these figures do not demonstrate the general increasing trend to be found in other parks. Although the erosion problems may have possibly affected the fluctuating attendance, other factors should also be considered before conclusions are drawn.

Harrisville State Park

A park ranger from Harrisville State Park in Alcona County provided the information presented here since there were no official

reports available. Although the park has experienced some damage due to erosion, any such damage was slight. Overall, the higher water levels have had little or no effect on the use of the park.

Erosion is the primary problem, recently causing the loss of approximately 12 cedar and two to three ash trees. Forty to 50 feet of beach over 1/4 mile stretch of beach have also been lost during the study period for a total of 1 1/3 acres of beach lost. This 1/4 portion of the beach covers about 1/2 of the total shoreline at Harrisville State Park. The area has also experienced some flooding problems. In August 1974, two or three low-lying campsites were attacked by waves which washed up over them during a storm. Despite these damages, public utilization of the park seems to be unaffected. The quality of the beach has actually improved because sand now covers an area which was formerly mostly rocks. A gradually sloping beach exists, so there is no threat to bathers.

The inundation of the beach necessitated the moving of the playground equipment to a different area with labor costs for this move amounting to approximately $64 for 16-man hours of work. No buildings have been endangered as of yet; however, the four-foot square by two-foot deep concrete slab base of the lifeguard tower was lost. The replacement cost of this slab was $50. Aside from these relatively minor expenditures, the park has spent no money to build protective structures or to take any other protective measures.

Since the area of erosion is mainly to the north of the campgrounds, this has had little effect on attendance. The camping and day use figures for Harrisville State Park are presented below:

Year	Camping	Day Use	Total
1970	38,101	82,455	120,556
1971	40,637	83,110	123,747
1972	21,363	81,510	102,873
1973	21,504	83,299	104,803
1974	20,106	100,004	120,110

The drop in park attendance over the past two years is attributed to the implementation of a different counting method by park officials. Previously, all cars which traveled along a county road running through the park were included, while now only those cars in the park's parking lot are counted. Other factors which have affected the attendance figures during the two-year study period include an unusually cool spring in 1973, and a sharp decline in the number of people driving and the number of miles traveled due to the gas shortage in that year. The 1974 figures show a jump in attendance which is correlated with the salmon fishing in the fall.

Attendance figures for the period between June 15 and Labor Day would probably be more useful in determining trends in park utilization

at this locale. However, even the existing figures indicate that despite some minor damages, the overall use of this park has not been reduced to any great extent by the higher lake levels.

Orchard Beach State Park

No erosion reports were made to the DNR for Orchard Beach State Park in Manistee County. The information obtained from this park indicates that it has experienced some damage due to higher lake levels, although park personnel could not assess a specific dollar value to these damages. Higher lake levels have washed all of the sand away from a 400-yard expanse of beach, making it no longer usable for recreational swimming, etc. Rock is all that remains now at the base of the bluff. The bluff has been experiencing recession which, in turn, has damaged the vegetation in the area around the bluff. Park personnel could not specify the exact damages incurred.

No land structures have been damaged at Orchard Beach. This may be due in part to the fact that none of the structures are located close to the edge of the bluff; the closest one being the shelter building which is located 50 feet from the edge. However, no erosion has occurred at this location.

No protective action was taken by park personnel during the two-year period under study. However, actions which were taken four years ago may continue to provide protection even today. At that time (1971), rock baskets were placed to alleviate the problem of sand loss. In addition, drains were placed in the bluff to relieve pressure in the clay. Despite the destruction of vegetation caused by the receding bluff, no clean-up effort has been made to rid the area of the downed trees.

The attendance figures shown below indicate that high lake levels have had a detrimental effect on day use of the park in particular:

Time	Camping	Day Use	Total
1970	87,644	19,390	97,034
1971	91,981	19,719	111,700
1972	72,264	16,010	88,274
1973	69,764	11,576	81,340
1974	73,261	8,861	82,122

The camping facilities at the park have also experienced a decline in public utilization, but this decrease is minor in comparison to the dramatic loss of user days. The attendance figures for day use during the three-year period from 1970 to the end of 1972 show that an average of 18,400 people made use of the beach during that time period. This means that approximately 6,800 user days were lost in

1973, and that by 1974, this figure had jumped to over 9,500 user days lost.

Park attendance had experienced a sharp increase in 1968 because of a salmon boom that occurred in that year. However, this has decreased lately since other parts of the state have been stocking their waters with fish. Other than the aforementioned changes, there have been no radical differences in the facilities during the study period which may have affected use of the park.

4.2 RECREATIONAL BOATING

Fluctuations in water levels can affect recreational boating opportunities by either causing changes in the desirability of docking facilities or by causing changes to navigation structures. Therefore, this section has been divided into two components to discuss these two factors.

Effect of High Water on Docks and Piers

According to a statement issued by the Waterways Division of the Michigan Department of Natural Resources, high water levels on the Great Lakes have not greatly affected boating opportunities in any of the six counties under study. This is attributable to the fact that piers are built at a height 5 1/2 feet above the high lake level (lake elevations based on IGLD, International Great Lakes Datum). To the present time, water levels have not exceeded record height; thus, the additional freeboard at the top of these structures has kept them from being inundated.

The same degree of success may not be found in commercial facilities which have been constructed without prior knowledge of this record high in the lake levels. Thus, these structures may now have been inundated.

There are presently ten facilities operated either by the State of Michigan, or as a joint venture by the state and community participation. It should be noted that many local governments and groups do participate in a community's building of a pier; however, any project which has received state government assistance will have had the benefit of data input of this kind. Therefore, these structures should not have suffered from inundation due to high water levels.

The state has also provided for erosion control structures at these locales. Erosion rates vary from lake to lake, and in Lakes Michigan and Huron, not only are the piers built to a specified height, but also the land in the vicinity of the facility is built up to that same 5 1/2 foot datum level. This is accomplished by constructing a wall out of steel sheet piling—a method whereby sections of steel interlock to create a solid wall. This structure serves not only as a shore erosion control device, but also as a mooring for the boats that utilize the facilities. Another protective measure taken by the state is the placement of fill rock on the slope of land between the dredged ground and the bluff. The location of these structures in areas which are protected either by breakwaters or by the natural protection offered by harbors is part of their design. Such designing further decreases the chances that these facilities will experience destruction or damage.

There appears to be a tradeoff between problems experienced during high water as opposed to low water periods. When lake waters are low, dredging is often called for to make the area usable by boats. However, during high water levels, problems related to ice-jacking are sometimes increased. This is not to say that ice damage does not occur during low water levels, but when the waters are high, the ice may come into direct contact with the piling or its members, thus increasing damage which may be incurred. Many areas have incorporated the use of bubbler systems to keep the lake around the pilings from freezing over. This action has been fairly successful in many areas where it has been tried, but it is expensive.

In general, it appears that the higher lake levels have not had a marked effect on the facilities constructed completely or in part by the State of Michigan, due to the plan of action incorporated by the state in its construction of such facilities. However, the same degree of success should not necessarily be attributed to private or commercial facilities in the same category. Boating in these instances may have been severely hampered by higher water levels which have inundated a pier that was not built to withstand a realistic expected maximum water level. (Private facilities, for the most part, were not included in this study since they were located on connecting inland lakes which were not serviced by this program.)

The Effects of High Water on Navigational Structures

This section of the report will utilize information obtained from various members of the U.S. Army Corps of Engineers. Both telephone and in-person interviews were used to obtain this data. Specifically, navigational structures, such as piers, jetties, breakwaters, marinas, and harbors, which come under the jurisdiction of the Army Corps of Engineers will be examined to determine their effects on the surrounding environment, as well as to indicate what effects the higher lake levels have had on the structures themsleves. This section will incorporate data which was obtained from the Section 111 Study currently being conducted by the Detroit District of the Corps.

The St. Lawrence Seaway, its connecting channels and the Great Lakes form a 2,342 mile waterway which ties the center of North America with the Atlantic Ocean. This vast system is presently responsible for the transport of 220 million tons of commercial traffic annually. The major cargoes being transported are iron ore, coal, limestone, grain, and other general products. Nineteen states are included in the Great Lakes tributary system, which benefits from the abundance of quality natural resources and extensive factory networks located in the area.

The Great Lakes Basin also provides a variety of natural resources which are of great recreational and aesthetic value to its

inhabitants. The area is dotted with beautiful natural harbors, and also many man-made harbors which serve as a refuge to the hundreds of large and small craft that use the waters annually.

Of the six counties under study, only five have harbors which have been examined in the Corps report. Included in the study were Muskegon and White Lake Harbors in Muskegon County; the harbors of Portage Lake, Manistee, and Arcadia in Manistee County; Alcona County's Harrisville Harbor; Whitefish Point Harbor located in Chippewa County; and Harbor Beach, Caseville Harbor, Port Austin Harbor, Bay Port Harbor, and the Sebewaing River to be found in Huron County. Only Schoolcraft County does not have any harbors under study by the Corps of Engineers.

The following summaries examine the nature and amount of damage experienced in the aforementioned harbor areas, especially as caused by navigational structures erected by the U.S. Army Corps of Engineers. The primary goal of the study was to determine what damages have been experienced, and to recommend the mitigation of any such damages in an appropriate manner. It should be noted that specific information on each of the harbors mentioned above is not available as of yet, since many of the projects have not been completed to date.

Muskegon County

Studies were done on Muskegon Harbor and White Lake Harbor. A preliminary report obtained as a result of these studies indicated that the erosion problem could be attributed in part to the navigation structures, as well as to other natural erosion processes. An environmental statement was issued detailing the effects.

At Muskegon Harbor, seven beach nourishment supply sites were established and maintained by the Corps to provide immediate and longer term relief to these damaged shore areas. An unpolluted source of material for the nourishment supply will be provided by the sediment accumulations in the vicinity of the harbor mouth. The White Lake Harbor area will be aided in much the same manner, with the only major difference being that there will be five such sites at this location.

Manistee County

Manistee Harbor has recently been the subject of a study. The field work done there is still not complete, and it has not been analyzed to date. However, during the winter of 1974-75, a major storm was experienced at Manistee Harbor, with damage being reported as a result of this storm activity.

Schoolcraft County

As stated earlier, this county has not undergone any major studies of this nature to date.

Chippewa County

A complete Section 111 Study is not available for this area. However, a negative study was performed at Whitefish Point Harbor. Erosion rates and trends were examined, revealing that the erosion at this harbor was probably not related to the presence of navigational structures in the area.

Alcona County

A preliminary study has been conducted at Harrisville Harbor, but the results obtained thus far do not attribute the erosion to the harbor.

Huron County

A preliminary study was done for Harbor Beach, but this study did not indicate that the harbor had caused any of the erosion in the vicinity.

In general, navigational structures built by the Corps were designed with the high waters in mind. Although many were constructed over 100 years ago, they have not generally needed major revampments since the turn of the century. Some additions may have been made to the structures, such as making a structure longer or higher, but radical design changes have not been necessary.

Commercial navigation harbors were generally built between 1860 and 1890, the earliest such harbor being constructed at St. Joseph in the 1830's. More recently, the trend has been toward the building of recreational harbors, such as the one at Port Austin. In addition, some commercial harbors have also gone into recreational use—White Lake Harbor, for example.

Records are kept by the Corps on the repairs and maintenance of the navigational structures over the years. However, it is difficult, if not impossible, to state with a reasonable degree of certainty, that the maintenance costs paid during a particular period were incurred during that same period. It is even more difficult to ascertain whether repair costs are directly attributable to the higher lake levels experienced during the study period. There is a certain amount of normal wear and tear that each structure is expected to experience. Yet, during the study period of Labor Day 1972 to Labor Day

1974, no work may have been done on a particular structure. However, this does not mean that this structure is not in need of repair, but may merely be that repairs are not made until several years after the damages have occurred. The dollar values of certain repairs may not be representative of the maintenance that may have been necessitated by the gradual deterioration of a structure. It should be noted that the Corps surveys these harbors on a regular basis, and that each harbor experiences maintenance periodically, perhaps once every four to five years.

The structures do not seem to be a limiting factor in the recreational utilization of the area, perhaps because many of them were designed to increase recreational use of the shorelands. However, as noted above, they do occasionally add to the erosion in an area, thereby decreasing the recreational uses of the land and water to some extent.

The very presence of high waters alone do not present any danger to the navigational structures, since they are generally built to withstand water levels which are much higher than usual. The major explanation for damages incurred during a high water period seems to correlate with the amount of storm activity experienced during a given period. Since high waters reduce the amount of beach area and shore depth in general, during storm activity, the force of the storm on the structures is increased because the waves are hitting from a much greater height with greater force. And because of the lag in maintenance, it is impossible to determine now what level of damage might have been done by these storms during the period of investigation. there is no real evidence to indicate that the high waters endanger the structures in any substantive way on their own.

4.3 ENVIRONMENTAL AREAS

Due to the very unique scenic and productive wildlife habitats to be found in the Great Lakes Basin Area, there is a great deal of competition among various user groups for these resources. An increase in the number of lakeside homes being built has resulted in a subsequent decrease in the amount of land available for public use along the shore. The lands which remain are in great demand for both industrial and residential purposes. One area of the shorelands which is experiencing increased demand from the public is the wetlands of the State of Michigan. As an alternative to competing for the dwindling number of properties suitable for development, these two user groups have sought to obtain wetland properties which may be filled in for use as building sites. Conversely, conservationists are actively fighting any such development since it would undoubtedly mean the disruption of a very unique form of natural habitat for the plant and animal communities presently living in the marshes and swamps of Michigan.

At present 15 percent of Michigan's mainland shorelands are covered with wetlands. Natural plant and animal communities perform a vital role in maintaining the delicate balance of nature necessary for the continued welfare of the Basin's residents. The residents, in turn, can greatly affect these natural areas in a variety of ways. In an attempt to preserve some of these areas, federal, state, and local governments, groups and private agencies are becoming involved in setting aside certain portions of land for use as parks, forests, recreation areas, and wildlife reserves. However, there is conflict among these various planning groups as to the degree and nature of development that should take place in these wetlands. The lake level affects the extent and type of wetland available, and subsequently the decision that will have to be made in this regard should reflect this consideration.

The following synopsis attempts to present a county-by-county analysis of the effects of higher lake levels on the natural wildlife habitats to be found in the marsh and swamp lands of the State of Michigan.

Muskegon County

Sand beaches, high bluffs, and dunelands are typical components of the Muskegon County shoreline. In the areas of White and Muskegon Lakes, however, higher lake levels have played an important role on the wildlife located there. These two lake areas are generally called drowned river mouths, and have marshes in the upper ends of the lakes. Higher lake levels make these marsh lands more productive from a wildlife standpoint, especially for any furbearing animals which inhabit the area.

Manistee County

Arcadia and Manistee Lakes both have marshes in the upper ends of the lakes. When water levels rise on the Great Lakes, these marsh areas are made more productive. Again, any such benefits are sometimes offset by waters which become excessively deep, thereby drowning vegetation or forcing certain species of birds and mammals to move to higher ground.

Schoolcraft County

Schoolcraft County is characterized by a rocky shoreline, where wetlands exist minimally, if at all. The gull population of this county has occasionally had to relocate, however, due to the rising waters. Otherwise, the high waters have had no impact on the wildlife species in this area.

Chippewa County

The majority of wetlands in this county are located outside the study area in the St. Mary's River Area from Soo to Detour. However, the Whitefish Bay region is characterized by big stands of bullrush which diving ducks use as an integral part of their living environment. Higher lake levels have had neither a positive nor a negative impact on this element of the wildlife community.

Alcona County

This county does not possess any wetland areas which would be influenced by higher lake levels.

Huron County

The Sebewaing area of western Huron County has experienced higher water levels in the marsh habitat due to higher lake levels in Lake Huron. This has improved the value for waterfowl but has also caused waters in some areas to become too deep to sustain nesting habitats for many species of wildlife. The coastal marsh areas have been enhanced by higher water levels which have moved into the flood plain zone. The only negative impact here has been the destruction of vegetation beds by higher water levels. The impact on upland game has been minimal since these animals generally move to more secure areas when their habitat is threatened by rising waters. Former dry marsh areas are now submerged, enhancing their use as a habitat. However, a negative impact may be experienced if the rising waters cause the vegetation in the area to be covered by sand. Sand covering will keep any such vegetation from growing back, but if the high waters do not

cover the vegetation with sand, the vegetation should return with the return of normal water levels.

5.0 CONCLUSIONS

Muskegon County

Muskegon County, located on Lake Michigan in the Lower Peninsula of the State of Michigan, was divided into five reaches. Three bluff types are found alternating in this county: high sand dune, erodible low bluff, and erodible high bluff. The high sand dune shoreform predominates in this county.

Private land ownership amounts to 91 percent of the properties (mostly seasonal use) on the shoreline. Governmental lands represent three percent of the properties and commercial/industrial lands make up six percent of the properties.

This county has many shore (erosion) protective devices. Of these, only four structures viewed in the field were classified as permanent; the remaining structures were identified as expedient.

The Self-Administered Resident Assessment reported $154,000 in damages due to flooding and $1,651,000 was reported in erosion damages. The expanded* value for damages due to flooding and erosion is $2,254,000, and the expanded value for cost of protective action in this county is $1,346,000. These were the largest damages reported by any county under study. *Reaches 1, 2, and 5 in Muskegon County* reported the greatest damages. Non-residential interviews showed $24,000 of damage due to erosion; no damage was reported for flooding. The area of beach lost in this county during the period of study was calculated to be 14 million square feet, and the amount of bluff material eroded was calculated to be 225 million cubic feet.**

Changes in recreational opportunities due to high water were undetected during this period of study. No effects on navigational structures are discernible at this time in this county, although beach nourishment has been required down drift of some of these structures. In general, it appears that environmental areas have benefited from the higher water levels.

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*The values reported from the Self-Administered Resident Assesment reflect damages from only 60-80 percent of the total population of the various counties. The expanded totals were calculated to indicate the extent of damages incurred over the entire population. The procedure utilized in deriving these calculations is given in Appendix G, Shoreline Damage Survey: An Appraisal with Recommendations.

**See page 80a for procedure used to calculate beach area and volume of bluff lost.

See summary maps and summary tables for further details regarding Muskegon County.

Manistee County

Manistee County is located in the Lower Peninsula of the State of Michigan on Lake Michigan. This county was divided into eight reaches. Erodible high bluff and erodible low bluff make up the county's shoreform in an alternating pattern; erodible low bluff is slightly more predominant.

Commercial/industrial ownership provides two percent of the property usage in this county, governmental properties account for one percent of the properties, and the remaining 97 percent of the properties are in private residential ownership (predominately seasonal usage).

The county, like Muskegon County, has a large number of shore (erosion) protection devices. None of these protective works were identified as permanent during review of these structures; all were classed as expedient.

Flood damages reported on the Residential Self-Administered Assessment amounted to $132,000, and erosion damages reported on the same assessment came to $977,000. The expanded value for damages due to flooding and erosion is $1,470,000, while the expanded value for costs of protective actions in this county is $652,000. Reaches 1, 5, and 7 in this county were classed as major damage areas. The non-residential interviews indicated no damages due to flooding, but revealed $130,000 of damage due to erosion. This was the largest non-residential damage reported by any county. It was calculated that over seven million square feet of beach area was lost during the study period, and the volume of bluff material eroded was calculated to be 99 million cubic feet.

Recreational opportunities seem to have been slightly reduced due to high water in this county. Navigational structures have experienced some damage during this period of high water. Environmental areas have received some benefits by the higher waters but have also experienced some losses.

Schoolcraft County

Schoolcraft County is located in the Upper Peninsula of the State of Michigan on Lake Michigan and has been divided into five reaches. Shoreforms found scattered over this county include non-erodible low plains, wetlands, low sand dune, and erodible low plains; the non-erodible low plain is the predominant shoreform.

Private residential properties make up 96 percent of the ownership in this county and are used primarily seasonally. Only one percent of the properties are commercial/industrial, and three percent of the properties are in governmental ownership.

Very few shore (erosion) protection works are found in this county. Two of these structures were identified as permanent; the remaining structures were classed as expedient.

The Self-Administered Residential Assessment reported only $4,000 in damage due to flooding and only $40,000 in damage due to erosion; this was the smallest of the counties under study. The expanded value for flooding and erosion damages in this county is $115,000 and the expanded value for costs of protective actions is $20,000. The response rate was too small to determine areas of major damage. The non-residential interviews recorded no damages from either flooding or erosion. The area of beach lost in this county during the study period was calculated to be 14 million square feet. The volume of bluff material eroded was calculated to be nearly 11 million cubic feet.

No change in recreational opportunity was detected during this study and no data is available on the effect of navigational structures in the county. The gull population has had to relocate to new breeding grounds, but this was the only impact on environmental areas detected.

Chippewa County

The portion of Chippewa County under study is located in the Upper Peninsula of the State of Michigan along Lake Superior. This county was divided into seven reaches. The shoreforms of this county include erodible low bluff, erodible high bluff, erodible low plain, and non-erodible low plain. The non-erodible low plain and the erodible low bluff make up most of the shoreline.

This county has the largest percentage of government-owned properties, seven percent. A small portion, two percent, of the properties is commercial/industrial. The remaining 91 percent of the properties is predominantly seasonal residential.

No permanent shore (erosion) protection works were found in the county. All the structures reviewed were classed as expedient. This county did not have a large number of shore protection works.

Flood damages totaled $311,000 and erosion damages totaled $1,268,000 as reported on the Self-Administered Residential Assessment. The expanded value for flooding and erosion damages in this county is $1,756,000. The expanded value for costs of protective actions came to $792,000. Only Reach 3 was an area of major damage.

Non-residential interviews detected no damage due to flooding and $27,000 in damage due to erosion. The calculated volume of bluff lost during the study period was 49 million cubic feet and the calculated area of beach lost was ten million square feet.

No apparent change in recreational opportunities can be attributed to high water from the data available. Navigational structures have not been influenced by the high water during this period of study, nor does it appear that these structures have had an adverse effect on the surrounding shore areas. Environmental areas have not gained or lost overall due to the higher water levels.

Alcona County

Alcona County, located on Lake Huron in the Lower Peninsula of the State of Michigan, has been divided into three reaches. Two major shoreforms are identified in this county: erodible low plain, which predominates, and wetlands. Some high bluff was detected in some portions of this county.

Residential use makes up 97 percent of the properties in this county, primarily used on a seasonal basis. The remaining properties are divided into one percent as commercial/industrial and two percent as governmental.

There was not a large number of shore (erosion) protective devices in this county and only one of these was reviewed and classed as permanent; the remaining structures were all classed as expedient.

Damages due to flooding were reported which amount to $110,000 and damages due to erosion were reported in the amount of $397,000. The expanded value for damages due to flooding and erosion in this county is $644,000. The expanded value of costs of protective actions undertaken by property owners is $293,000. None of the reaches in this county were designated areas of major damage. The non-residential interviews revealed no damage due to flooding and $45,000 due to erosion. During the period of study the calculated area of beach lost was only one million square feet and the calculated volume of bluff material lost was 16 million cubic feet.

Changes in recreational opportunities were undetected during this study. No effects to or by navigational structures have been documented during this program. There is no data available to show any change in environmental areas.

Huron County

Huron County consists of five reaches in the Lower Peninsula of the State of Michigan, covering the entire tip of the "thumb" area on

Lake Huron. The shoreforms found in this county include marshy wetlands, low sand and sandstone bluffs and dunes, and high clay bluffs.

Governmental lands occupy one percent of the shoreline properties, while commercial/industrial ownership makes up two percent of the property usage. The remaining 97 percent of lakeshore properties are privately owned, and are primarily for seasonal use.

Of all the shore (erosion) protective structures reviewed in this county, only two were classed as permanent, the remaining structures were identified as expedient. There were a large number of protective structures located in the reaches examined.

Reported damages due to flooding totaled $154,000 while erosion damages were reported as $487,000. The flooding damages reported were among the highest of the counties examined. The expanded value of damages due to flooding and erosion in this county is $3,415,000 and the expanded value for costs of protective structures is $2,060,000.* Reach 1 was the only area sustaining major damages. Non-residential interviews indicated $22,000 in damages due to flooding, and $49,000 in erosion damages. This was the only county to report flooding damages incurred to non-residential properties.

The amount of beach area lost during the period of study was calculated to be 17 million square feet, while the volume of bluff material eroded was calculated to be 230 million cubic feet.

High lake levels do not appear to have significantly reduced recreational opportunities during this period of study, although the parks have suffered extensive beach erosion. No effects on navigational structures are discernible at this time. Environmental areas have received some benefits by the presence of high waters but have also experienced some losses, such as the destruction of vegetation beds.

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*Huron County used a special reduced sampling plan to collect data. The response rate to this sampling plan was about the same as the rate experienced in the other study counties. The sampling plan consisted of mailing the Self-Administered Residential Assessment to a fraction of the population; thus, in total, a smaller percentage of the county's property owners were able to respond. Therefore, the expanded totals are much greater than the reported damages because of the increased multiplication factor. For further reference, see Summary Report.

6.0 LIST OF REPORTED TABLES

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SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - MUSKEGON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	154	P	53	2	91	0	5	0	0	2
Reach 01	19	0	11	P	7	0	0	0	0	0
Reach 02	75	P	24	P	50	0	0	0	0	0
Reach 03	40	0	8	1	30	0	0	0	0	2
Reach 04	0	0	0	0	0	0	0	0	0	0
Reach 05	20	0	10	1	4	0	5	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 1-2

SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - MANISTEE COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	132	7	84	4	11	0	26	0	0	0
Reach 01	8	0	4	1	4	0	0	0	0	0
Reach 02	14	0	14	0	0	0	0	0	0	0
Reach 03	0	0	0	0	0	0	0	0	0	0
Reach 04	16	0	14	3	0	0	0	0	0	0
Reach 05	17	4	2	P	P	0	11	0	0	0
Reach 06	0	0	0	0	0	0	0	0	0	0
Reach 07	72	3	46	P	7	0	15	0	0	0
Reach 08	5	0	5	0	0	0	0	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 1-3

SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - SCHOOLCRAFT COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	4	0	1	1	3	0	0	0	0	0
Reach 01	3	0	1	1	1	0	0	0	0	0
Reach 02	2	0	0	0	2	0	0	0	0	0
Reach 03	0	0	0	0	0	0	0	0	0	0
Reach 04	0	0	0	0	0	0	0	0	0	0
Reach 05	0	0	0	0	0	0	0	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 1-4

SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - CHIPPEWA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	311	29	145	8	75	4	38	0	2	12
Reach 01	0	0	0	0	0	0	0	0	0	0
Reach 02	1	0	1	0	0	0	0	0	0	0
Reach 03	128	20	77	3	18	0	8	0	1	2
Reach 04	7	0	4	P	1	0	2	0	0	0
Reach 05	0	0	0	0	0	0	0	0	0	0
Reach 06	175	9	63	5	56	4	28	0	1	10
Reach 07	0	0	0	0	0	0	0	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 1-5

SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - ALCONA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	110	4	61	1	17	1	25	0	P	1
Reach 01	87	3	48	1	16	0	18	0	P	1
Reach 02	12	0	7	P	P	0	4	0	0	0
Reach 03	11	1	6	0	P	1	3	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 1-6

SUMMARY OF REPORTED RESIDENTIAL PROPERTY FLOOD DAMAGES - HURON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Flood Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	154	4	75	15	33	0	26	0	P	1
Reach 01	71	3	36	3	13	0	15	0	0	1
Reach 02	20	0	15	5	0	0	0	0	0	0
Reach 03	27	0	13	1	13	0	0	0	0	0
Reach 04	33	1	9	6	6	0	11	0	P	0
Reach 05	3	0	2	0	1	0	0	0	P	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 2-1

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - MUSKEGON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	1651	77	671	79	315	52	415	0	10	32
Reach 01	370	10	218	53	34	3	44	0	4	2
Reach 02	784	33	220	19	164	49	269	0	4	25
Reach 03	279	32	156	5	33	0	49	0	2	3
Reach 04	68	0	35	0	14	0	17	0	0	2
Reach 05	150	3	41	1	70	0	36	0	0	0

* Sums may not total in individual columns due to rounding.

TABEL 2-2

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - MANISTEE COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	987	45	360	6	244	24	268	0	1	27
Reach 01	186	0	56	0	71	0	57	0	1	2
Reach 02	31	0	1	0	20	0	10	0	0	0
Reach 03	14	0	9	0	2	0	0	0	0	3
Reach 04	54	0	16	0	0	15	22	0	0	0
Reach 05	299	41	129	2	33	10	82	0	0	3
Reach 06	12	0	3	0	9	0	0	0	0	0
Reach 07	226	0	93	P	110	0	23	0	0	0
Reach 08	165	4	52	5	0	0	84	0	1	19

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 2-3

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - SCHOOLCRAFT COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	40	P	22	10	4	0	4	0	0	0
Reach 01	28	0	18	10	0	0	P	0	0	0
Reach 02	10	P	3	P	4	0	3	0	0	0
Reach 03	1	0	1	0	0	0	0	0	0	0
Reach 04	1	0	P	P	0	0	P	0	0	0
Reach 05	0	0	0	0	0	0	0	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 2-4

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - CHIPPEWA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	1268	31	502	45	242	7	418	P	8	16
Reach 01	5	0	5	0	0	0	0	0	0	0
Reach 02	21	0	16	3	0	2	0	0	P	0
Reach 03	768	19	234	25	136	4	332	0	4	14
Reach 04	44	5	18	2	12	0	7	0	0	0
Reach 05	0	0	0	0	0	0	0	0	0	0
Reach 06	370	7	176	10	92	1	78	P	3	2
Reach 07	61	0	53	5	1	0	1	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 2-5

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - ALCONA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	397	53	195	8	39	2	95	0	2	2
Reach 01	346	52	169	4	37	P	80	0	2	1
Reach 02	28	1	17	2	1	1	5	0	P	1
Reach 03	23	0	9	2	1	1	10	0	0	0

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

TABLE 2-6

SUMMARY OF REPORTED RESIDENTIAL PROPERTY EROSION DAMAGES - HURON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Total Costs ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
County*	487	21	189	13	50	P	208	0	2	5
Reach 01	225	P	70	7	5	0	141	0	0	3
Reach 02	47		19	2	7	0	19	0	0	0
Reach 03	79	P	31	2	19	P	25	0	0	2
Reach 04	129	20	66	2	19	0	20	0	1	0
Reach 05	7		3	0	1	0	2	0	1	P

P = positive value reported, less than $1000.

* Sums may not total in individual columns due to rounding.

For beach area lost, the computation of area lost for each reach was calculated to be:

(Mean of reported beach depth lost) X (5280 ft/mile)

X (Number of miles in reach).

This calculation resulted in the total number of square feet of beach area lost in the reach. Similar calculations were done for each reach in the particular county, and the sum of the values for each reach resulted in the county total.

For volumetric contribution, a formula for calculating the bluff volume lost was set out in the contract. In mathematical terms the formula is:

(Bluff elevation + 12 feet) X (Recession Rate) X (Length of Frontage)

In order to evaluate the number of responses in each reach, mean values of bluff elevation and recession rate were used, so that the formula actually used becomes:

Mean (Bluff height + 12 feet) X Mean (Recession Rate)

X (5280 ft/mile) X (Number of miles in reach)

This is the working formula for evaluating total volumetric contribution for each reach. Again, county values were derived from the sum of the contributions in each reach.

TABLE 3-1: PHYSICAL EROSION LOSSES - MUSKEGON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*		Number of Residences Located Within ____ Feet of Edge of Bluff					
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
County	13700	224510	51	54	31	20	12	9
Reach 01	3700	83600	10	9	5	4	0	1
Reach 02	2700	60000	19	33	17	11	6	1
Reach 03	1700	39400	12	3	6	3	5	2
Reach 04	2900	19600	2	2	2	1	1	2
Reach 05	2700	22000	8	7	1	1	0	3

* See appendix for procedure used for calculating these quantities.

TABLE 3-2: PHYSICAL EROSION LOSSES - MANISTEE COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*		Number of Residences Located Within ____ Feet of Edge of Bluff					
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
County	7300	99600	37	44	15	8	7	0
Reach 01	1200	15300	3	19	6	4	2	0
Reach 02	1200	36400	0	2	0	1	0	0
Reach 03	400	8800	1	1	0	0	1	0
Reach 04	800	9200	6	2	1	2	1	0
Reach 05	1300	18200	11	11	6	0	2	0
Reach 06	400	200	0	2	0	0	0	0
Reach 07	1400	7400	12	4	1	1	1	0
Reach 08	500	4000	4	3	1	0	0	0

* See appendix for procedure used for calculating these quantities.

TABLE 3-3: PHYSICAL EROSION LOSSES - SCHOOLCRAFT COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*		Number of Residences Located Within ____ Feet of Edge of Bluff					
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
County	14100	10600	4	4	6	7	2	2
Reach 01	3000	5700	2	3	3	3	0	1
Reach 02	2500	2100	1	0	0	3	1	0
Reach 03	500	400	0	0	1	0	0	1
Reach 04	4400	2400	1	1	2	1	1	0
Reach 05	3800	0	0	0	0	0	0	0

* See appendix for procedure used for calculating these quantities.

TABLE 3-4: PHYSICAL EROSION LOSSES - CHIPPEWA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*		Number of Residences Located Within ____ Feet of Edge of Bluff					
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
County	9600	49100	99	122	47	29	14	10
Reach 01	1300	4100	0	0	0	0	0	0
Reach 02	700	30400	0	0	0	0	0	0
Reach 03	4100	1900	45	48	13	11	5	6
Reach 04	900	5900	3	12	4	2	3	0
Reach 05	-	-	-	-	-	-	-	-
Reach 06	2200	4300	51	62	30	14	5	4
Reach 07	400	2500	0	0	0	2	1	0

* See appendix for procedure used for calculating these quantities.

TABLE 3-5: PHYSICAL EROSION LOSSES - ALCONA COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*							
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within ____ Feet of Edge of Bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
County	6400	16200	50	71	32	37	12	9
Reach 01	4000	11800	47	52	25	34	11	9
Reach 02	900	2200	3	14	7	1	1	0
Reach 03	1400	2200		5	0	2	0	0

* See appendix for procedure used for calculating these quantities.

TABLE 3-6: PHYSICAL EROSION LOSSES - HURON COUNTY, MICHIGAN 1972-1974

Reporting Unit	Physical Losses*		Number of Residences Located Within ____ Feet of Edge of Bluff					
	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
County	17100	231000	26	60	28	17	12	6
Reach 01	7300	64600	11	19	4	5	3	3
Reach 02	1100	16600	2	7	6	2	0	0
Reach 03	3500	51000	3	18	9	5	5	3
Reach 04	3700	67100	6	14	9	5	3	0
Reach 05	1500	31700	4	2	0	0	1	0

* See appendix for procedure used for calculating these quantities.

TABLE 4

ASSESSMENT OF DAMAGE AREAS

County	Number of Respondents Indicating Damage[1]	Damage Ratio (Unitless)	Average Reported Damage Per Foot (Dollar)
Muskegon			
Reach 1+	30	.65*	148*
Reach 2+	96	.38	92*
Reach 3+	41	.31	43
Reach 4+	14	-	-
Reach 5+	29	.74*	65
Manistee			
Reach 1+	30	.66*	60
Reach 2+	5	-	-
Reach 3+	2	-	-
Reach 4+	12	-	-
Reach 5+	33	.60*	75*
Reach 6+	3	-	-
Reach 7+	29	.55*	75*
Reach 8+	11	-	-
Schoolcraft			
Reach 1	0	-	-
Reach 2	1	-	-
Reach 3	1	-	-
Reach 4+	7	-	-
Reach 5	9	-	-
Chippewa			
Reach 1	1	-	-
Reach 2+	2	-	-
Reach 3+	136	.57*	44
Reach 4+	17	.30	23
Reach 5	0	-	-
Reach 6+	169	.29	27
Reach 7	4	-	-
Alcona			
Reach 1+	123	.15	37
Reach 2+	23	.13	16
Reach 3+	9	-	-
Huron			
Reach 1	36	.32	90*
Reach 2+	12	-	-
Reach 3+	27	.15	43
Reach 4	27	.23	29
Reach 5+	6	-	-

*Major damage areas

+Reaches containing designated high risk erosion areas by Water Development Services Division, Michigan Department of Natural Resources

[1]Questions B3 and B4, Self-Administered Residential Assessment.

TABLE 5

SUMMARY OF NON-RESIDENTIAL SHORELAND USES

County	Total	Industry	Industrial Land	Government	Government Transportation	Clubs	Taverns	Motels Cabins	Church	Recreation	Land Investment*	Land Development*	Trusts*
Muskegon	14	21	2	14	0	3	0	0	2	1	1	8	13
Manistee	20	1	5	3	2	0	0	1	0	0	1	3	4
Schoolcraft	51	6	4	9	3	0	0	1	0	1	2	23	2
Chippewa	87	1	3	71	0	0	0	6	2	0	0	0	4
Alcona	38	0	3	19	0	1	1	0	0	0	5	6	3
Huron	13	3	0	0	1	1	0	3	1	3	1	0	0

* Although these properties are not privately owned, they essentially fall into the residential category.

TABLE 6

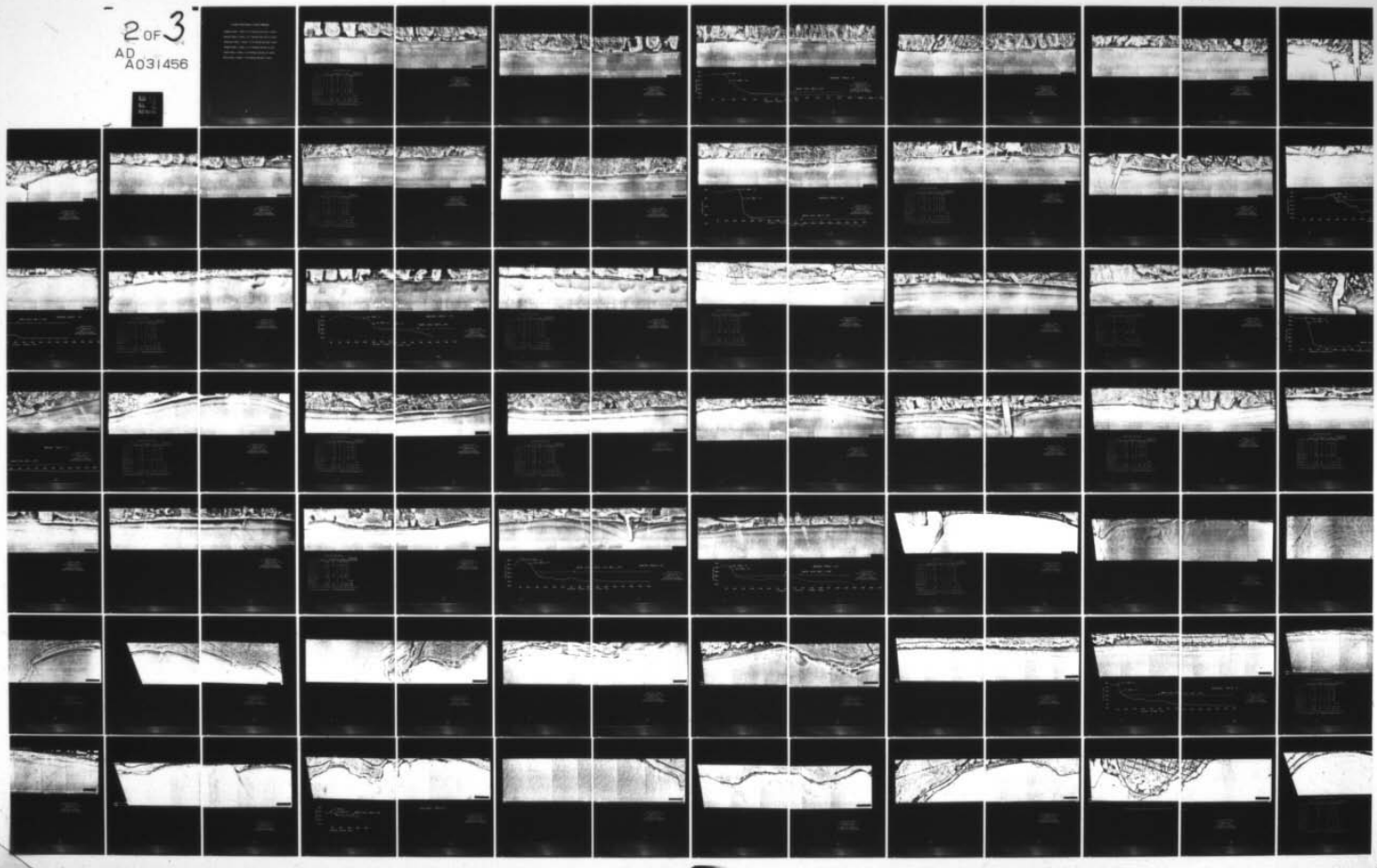
NON-RESIDENTIAL DAMAGE SURVEY

County	Total Costs* ($000)	Erosion Damage by Source				Costs of Protection				Financial Losses
		Structure and Contents ($000)	Grounds and Improvements ($000)	Clean Up ($000)	Other Damages ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Costs of Emergency Evacuation ($000)	Other Costs ($000)	Net Loss of (Rental) Income ($000)
Muskegon	24	3	10	0	0	0	P	0	8	4
Manistee	130	5	85	0	0	0	39	0	1	1
School-craft	0	0	0	0	0	0	0	0	0	0
Chippewa	37	1	7	0	0	0	27	0	1	2
Alcona	45	0	45	0	0	0	0	0	0	0
Huron	48	1	27	0	0	0	0	0	0	20
Total	285	11	174	0	0	0	65	0	9	27

P = positive value reported, less than $1000.
* Sums may not total in individual columns due to rounding.

AD-A031 456 MICHIGAN UNIV ANN ARBOR COASTAL ZONE LAB F/G 13/2
PILOT STUDY PROGRAM, GREAT LAKES SHORELAND DAMAGE STUDY. APENDI--ETC(U)
MAY 76 J M ARMSTONG, M R MCGILL, A M KUBECK DACW23-75-C-0027
UNCLASSIFIED NL

2 OF 3
AD A031456



7.0 AERIAL PHOTO MOSAICS OF COUNTY SHORELANDS

Muskegon County - Plates 1 to 16 (moving from south to north).

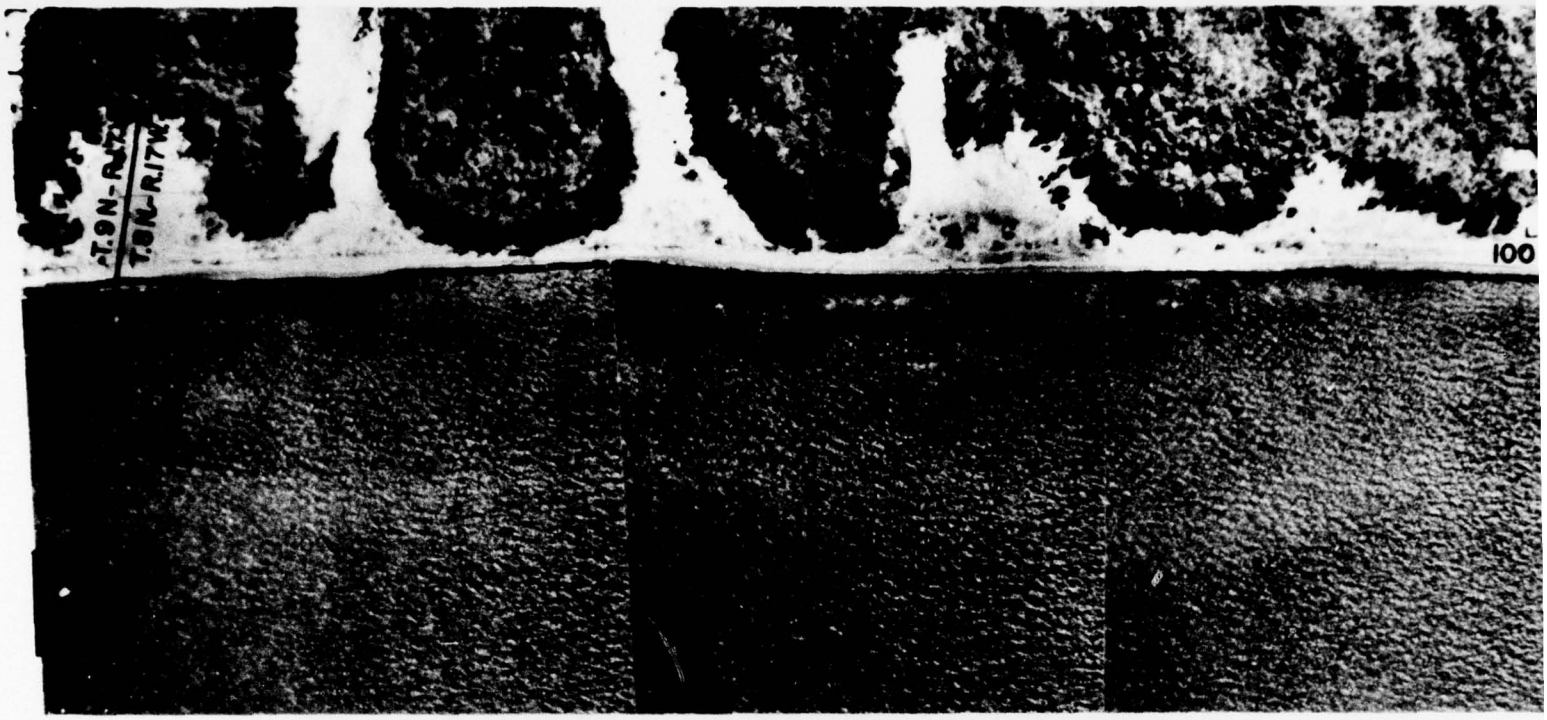
Manistee County - Plates 1 to 15 (moving from south to north).

Schoolcraft County - Plates 1 to 35 (moving from east to west).

Chippewa County - Plates 1 to 53 (moving from west to east).

Alcona County - Plates 1 to 16 (moving from south to north).

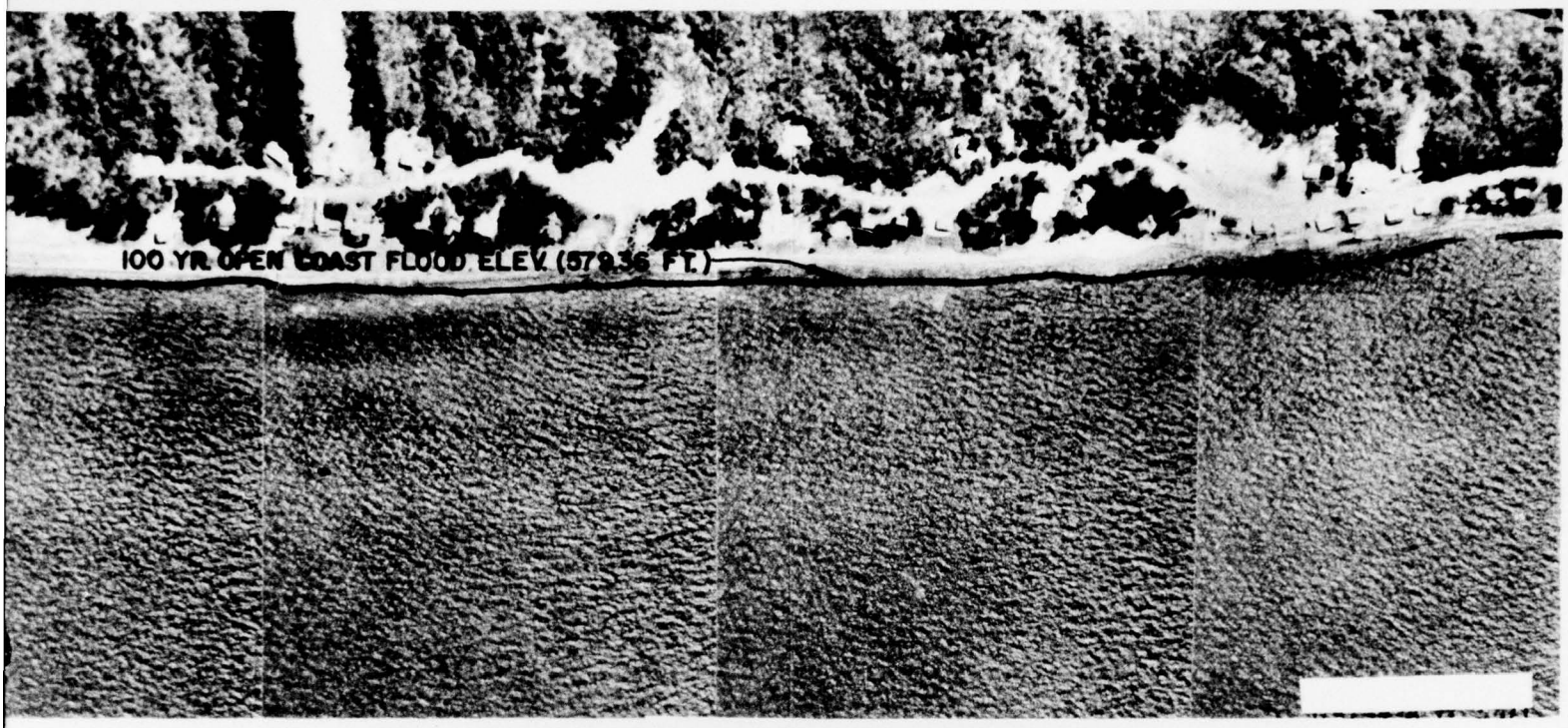
Huron County - Plates 1 to 46 (moving from west to east).



MUSKEGON COUNTY, MICHIGAN REACH #1

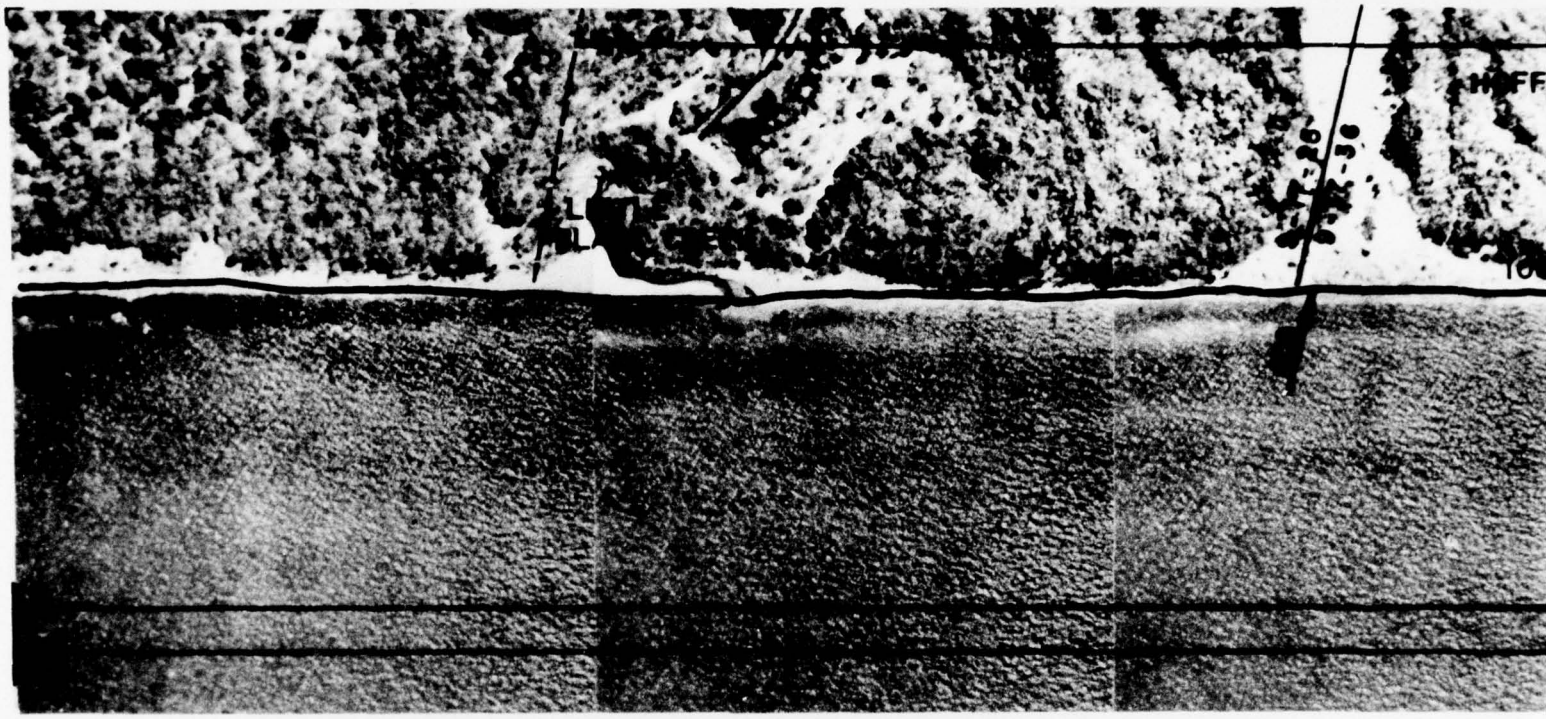
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	43	14200	2200	700	59000	
Reported Market Value ($)	29	51400	12000	500	250000	
Bluff Height (Ft.)	34	67	10	25	300	
Beach Depth (Ft.)	20	38	24	5	500	
Bluff Lost (Ft.)	30	32	4	6	99	
Beach Lost (Ft.)	33	71	12	8	300	
Damages Erosion ($)	24	13250	5000	300	107850	
Damages Flooding ($)	6	3150	1450	500	10000	
Damages - Erosion and Flooding ($)						530,000
Protective Structure Cost ($)	17	7850	4800	100	84000	220,000
Total Damages ($)	30	15700	4850	100	110900	750,000

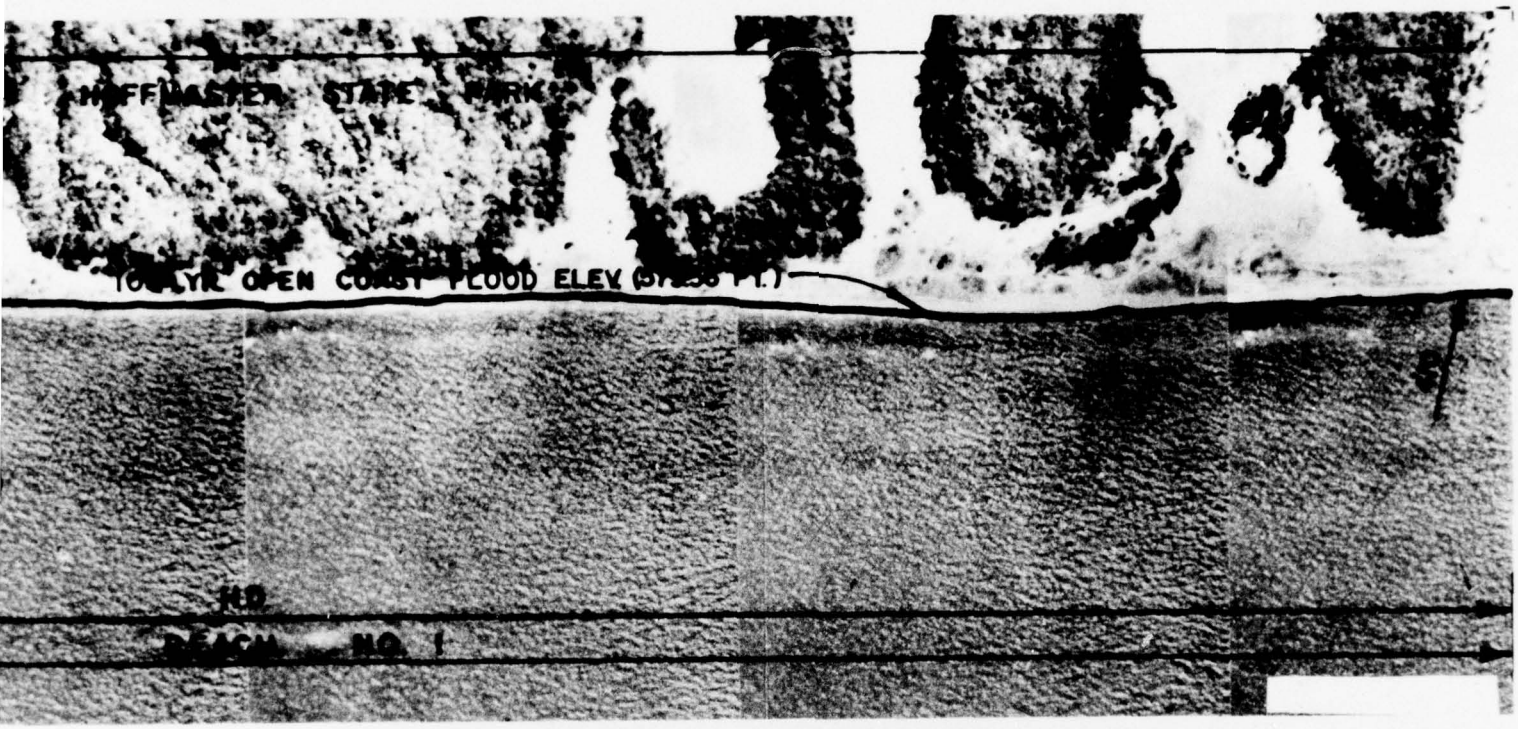
Total Identified Residential Properties: 76 Self-Administered Assessment Respondents: 43



MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 1
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

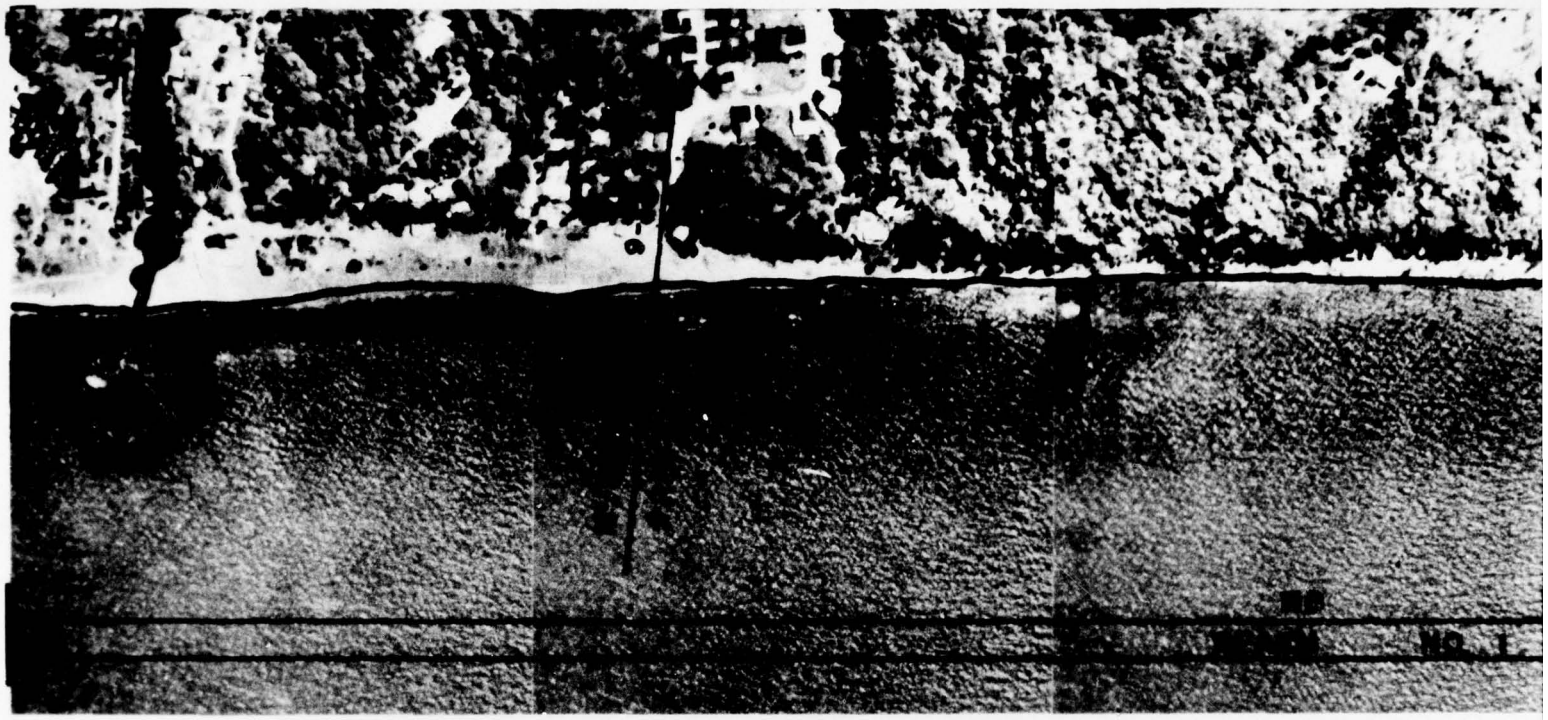


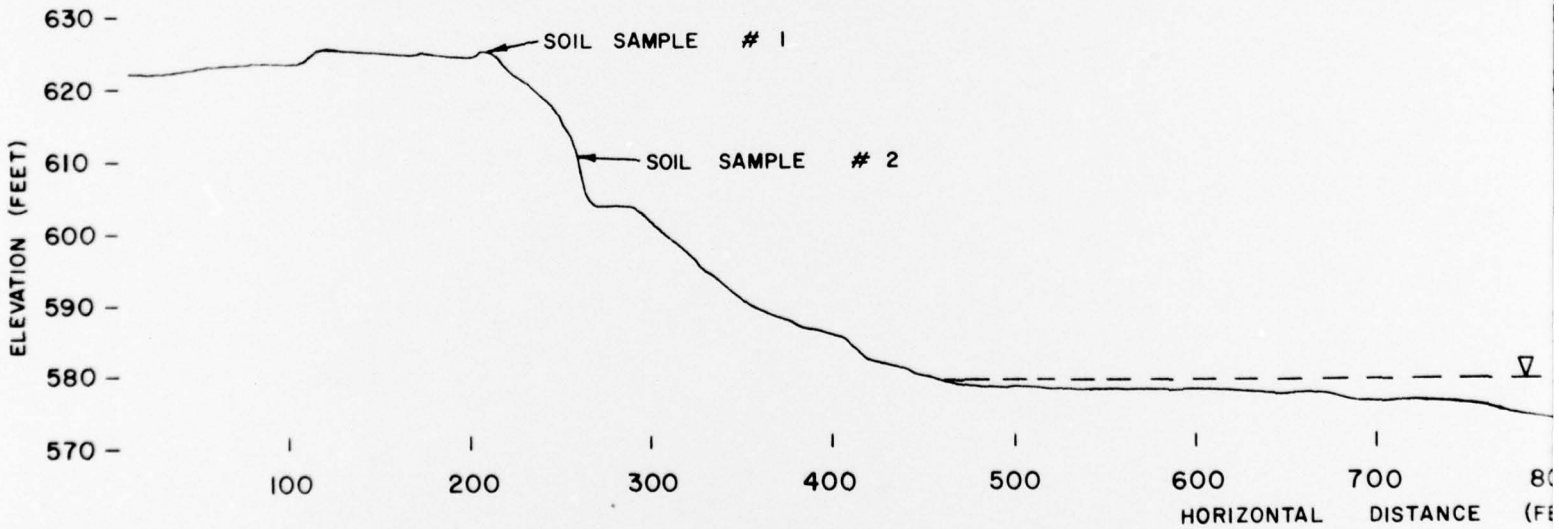


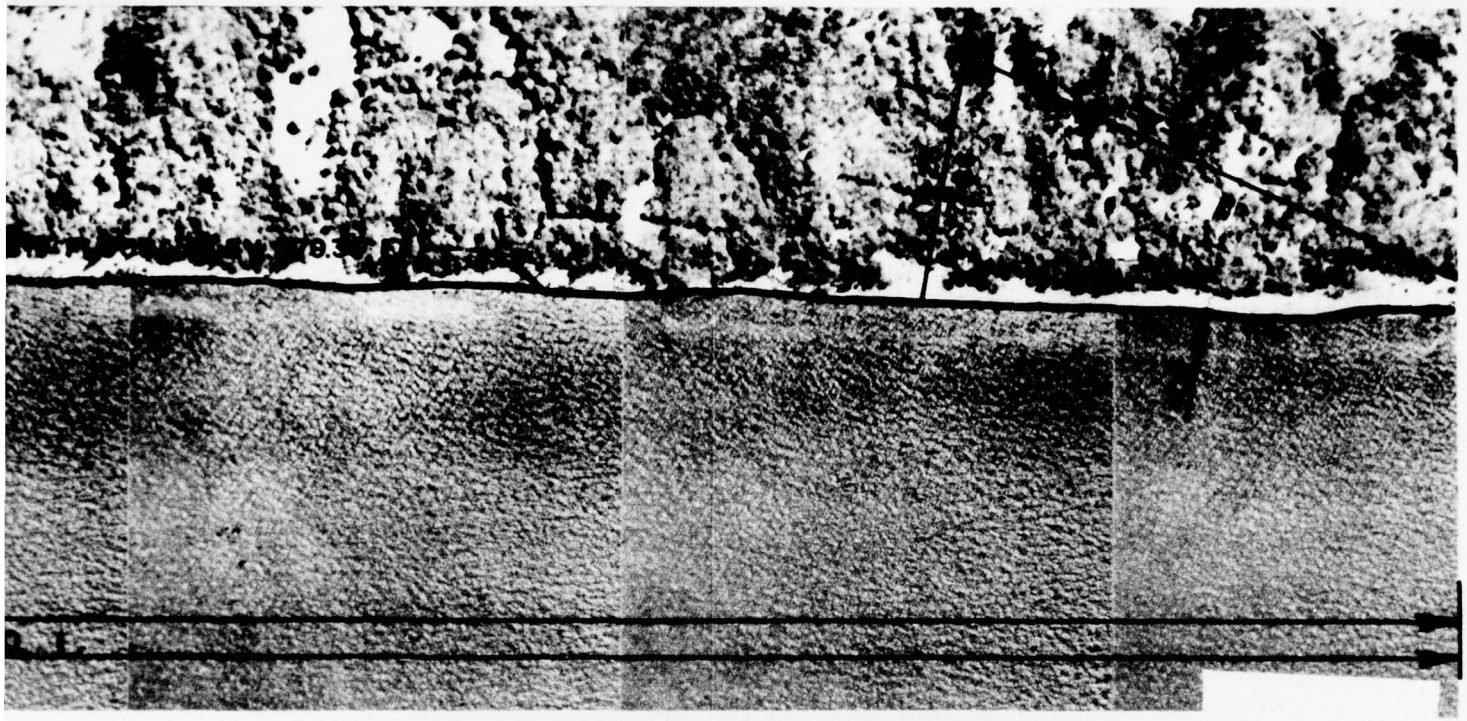
MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 2
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2




630
620
610
600
590
580
570
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
100
200
300
400
500
600
700
HORIZONTAL DISTANCE

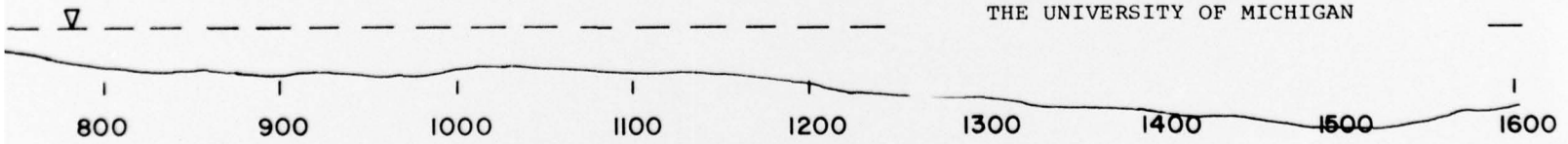


MUSKEGON PROFILE # 1

MUSKEGON COUNTY

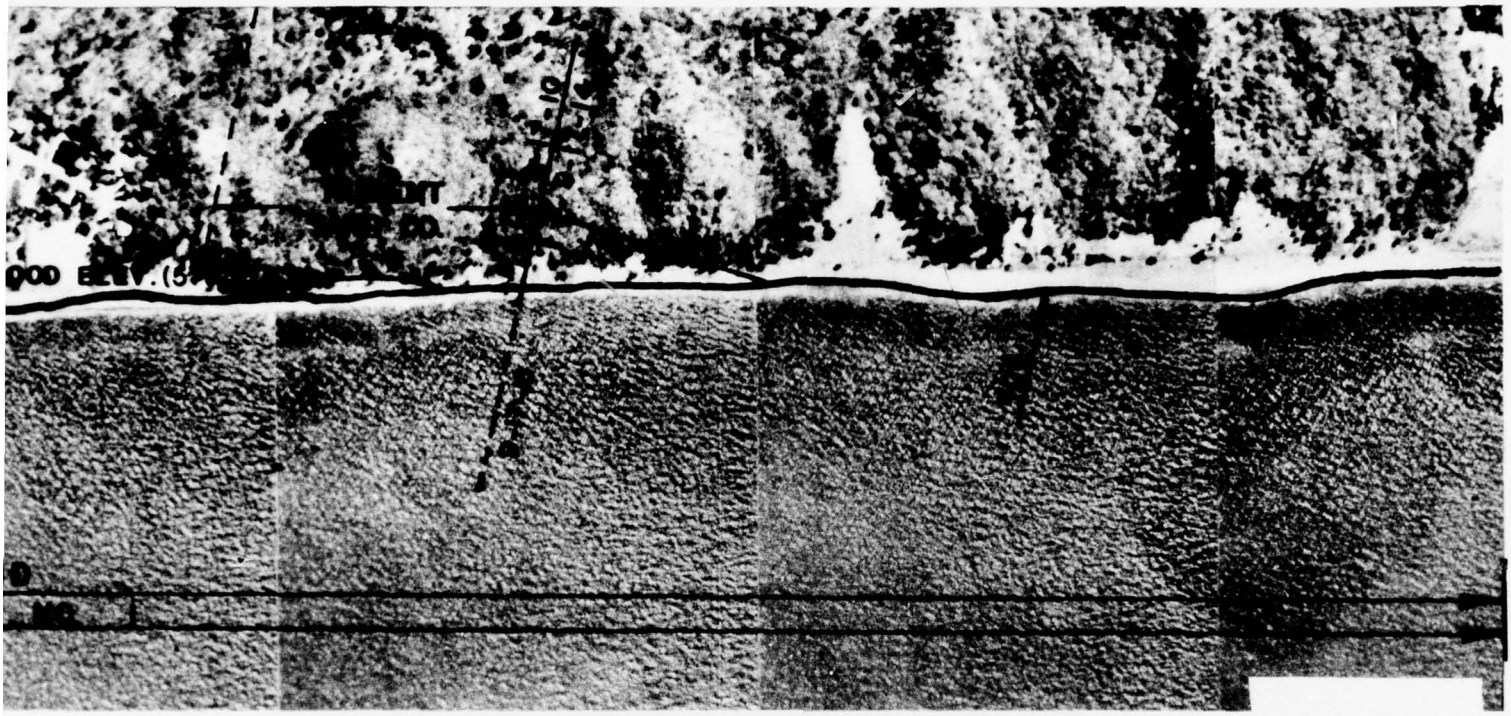
PILOT DAMAGE STUDY, 1975
PLATE NO. 3
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

WATER LEVEL- MAY 3, 1975



2



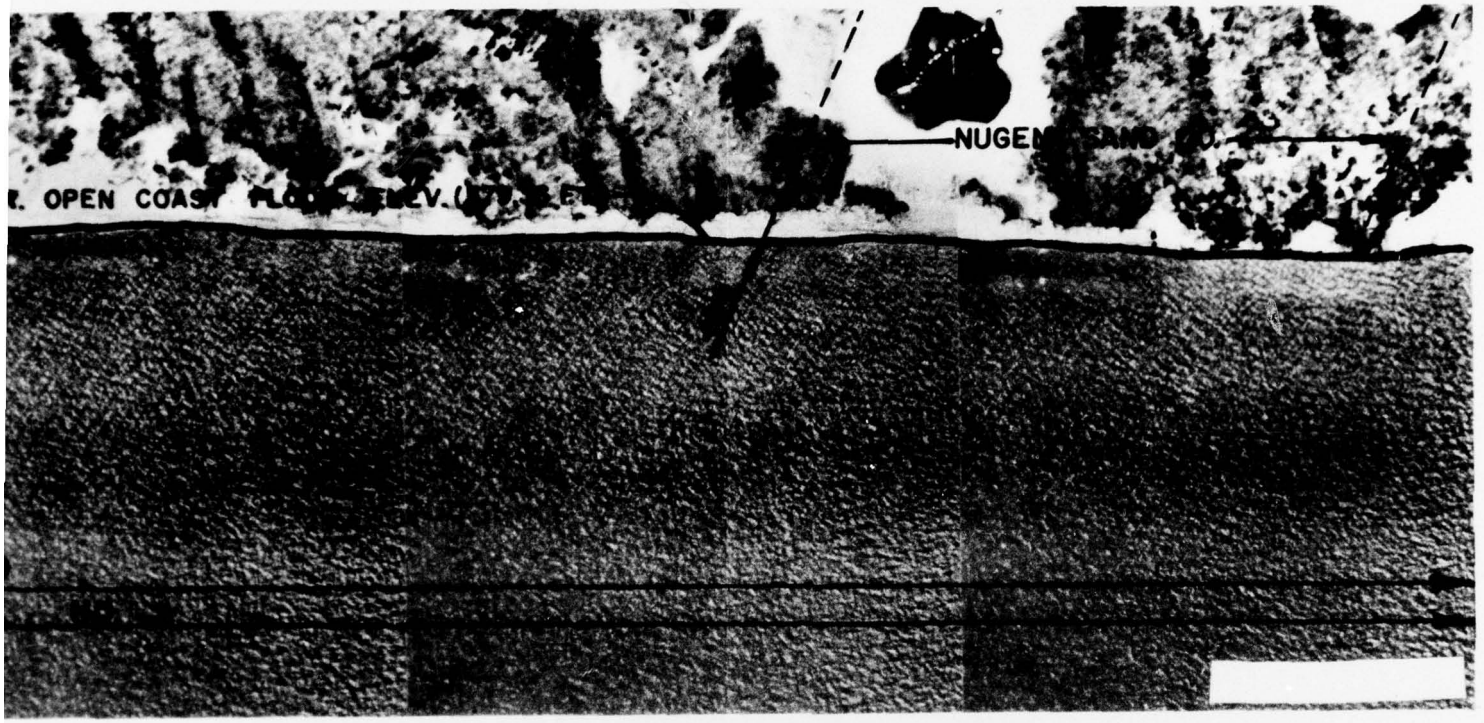


MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 4
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

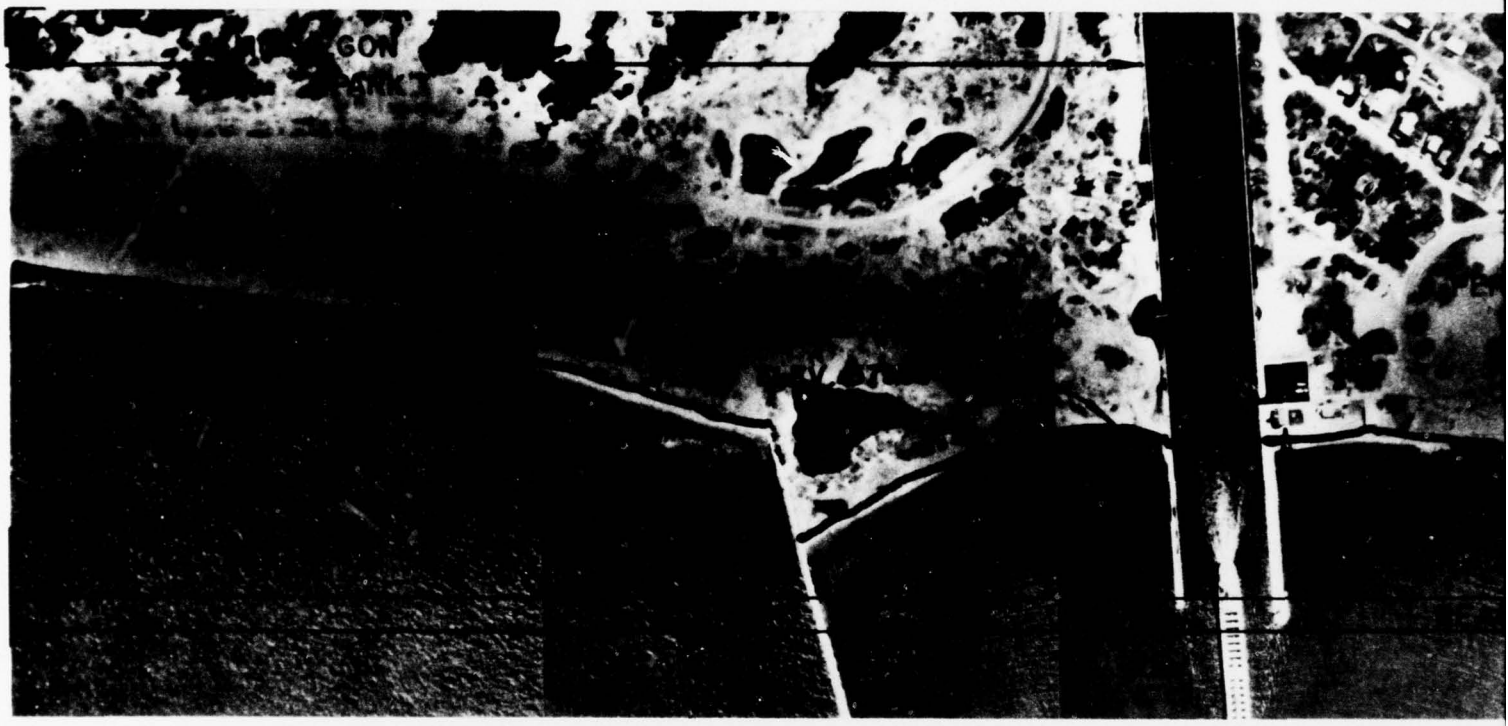
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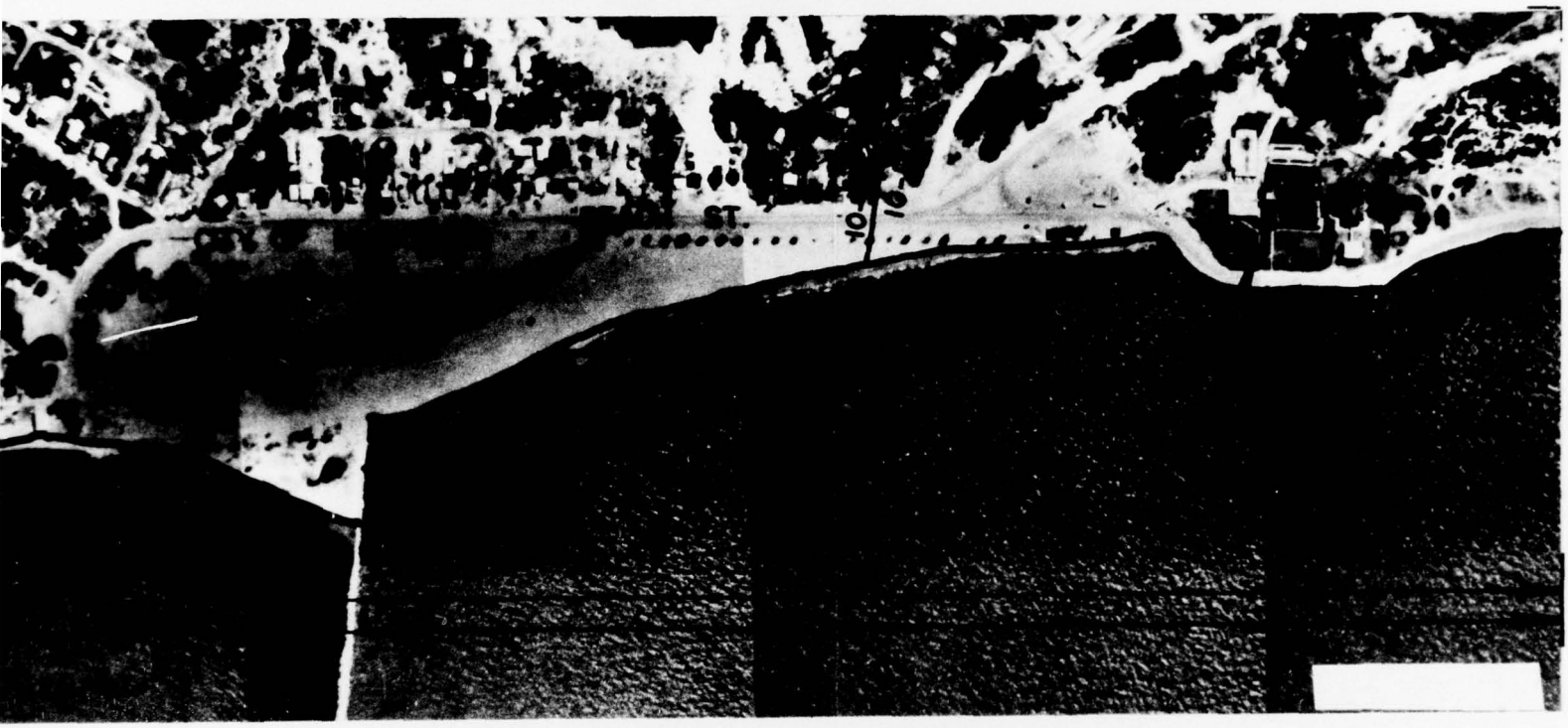

OF
T.S. 117
100 YR. OF



MUSKEGON COUNTY

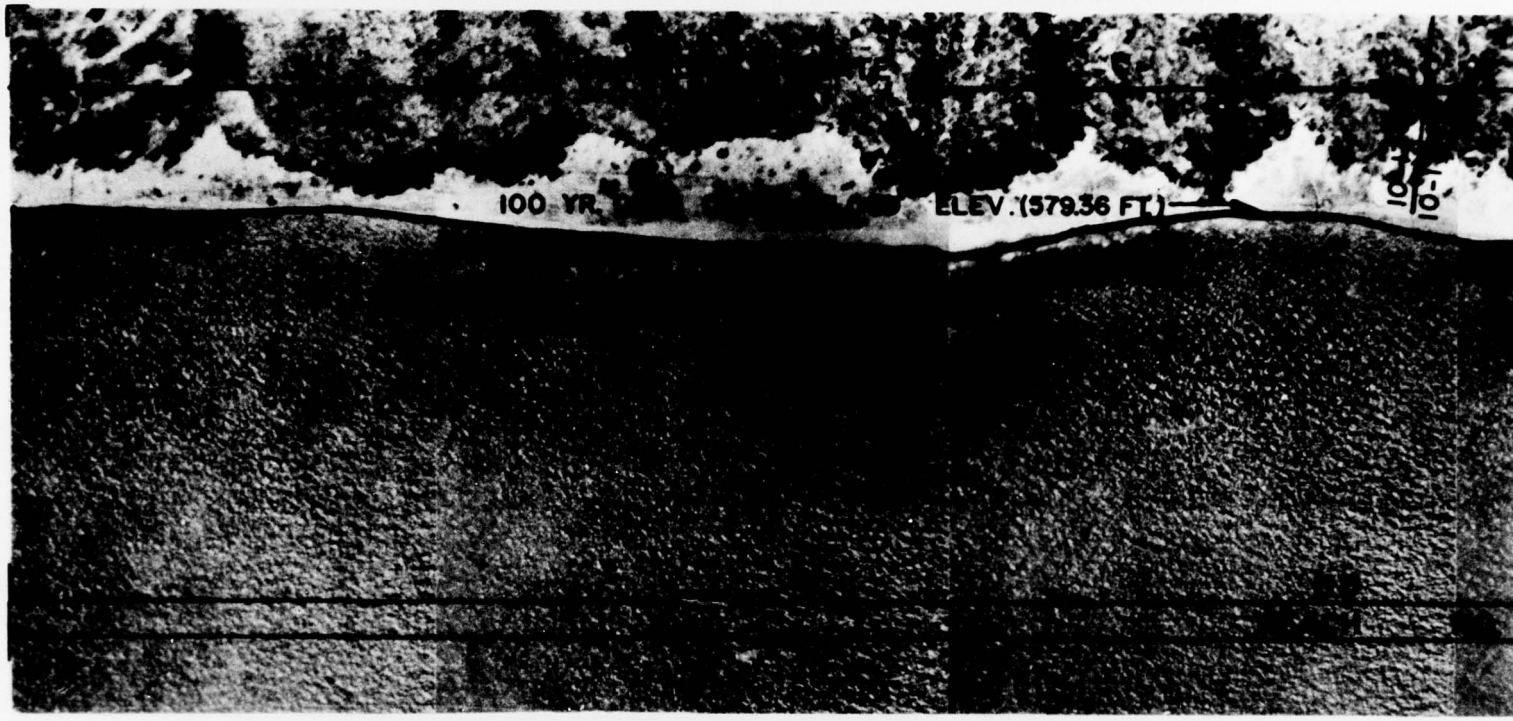
PILOT DAMAGE STUDY, 1975
PLATE NO. 5
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

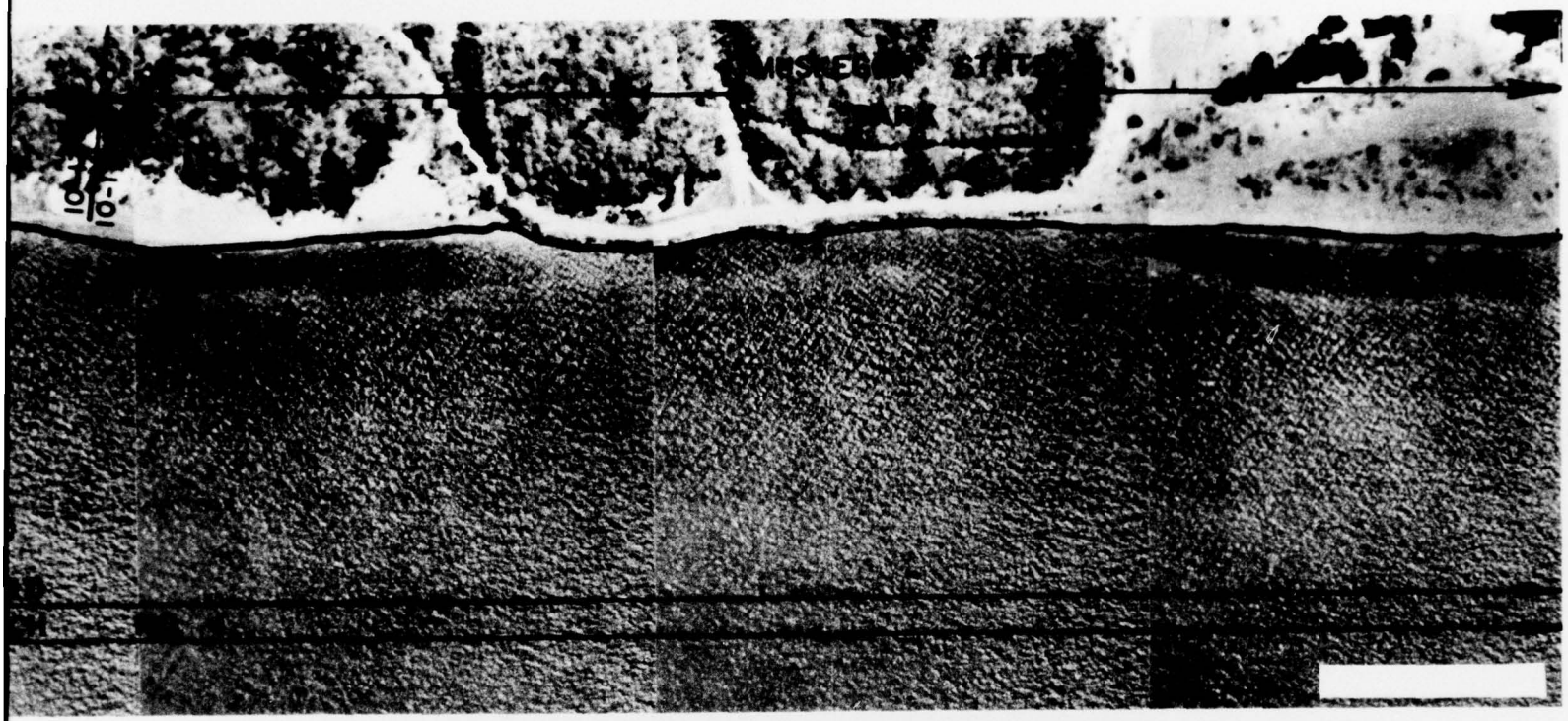




MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 6
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN


100 YR
ELEV. (579.36 FT.)



MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 7
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

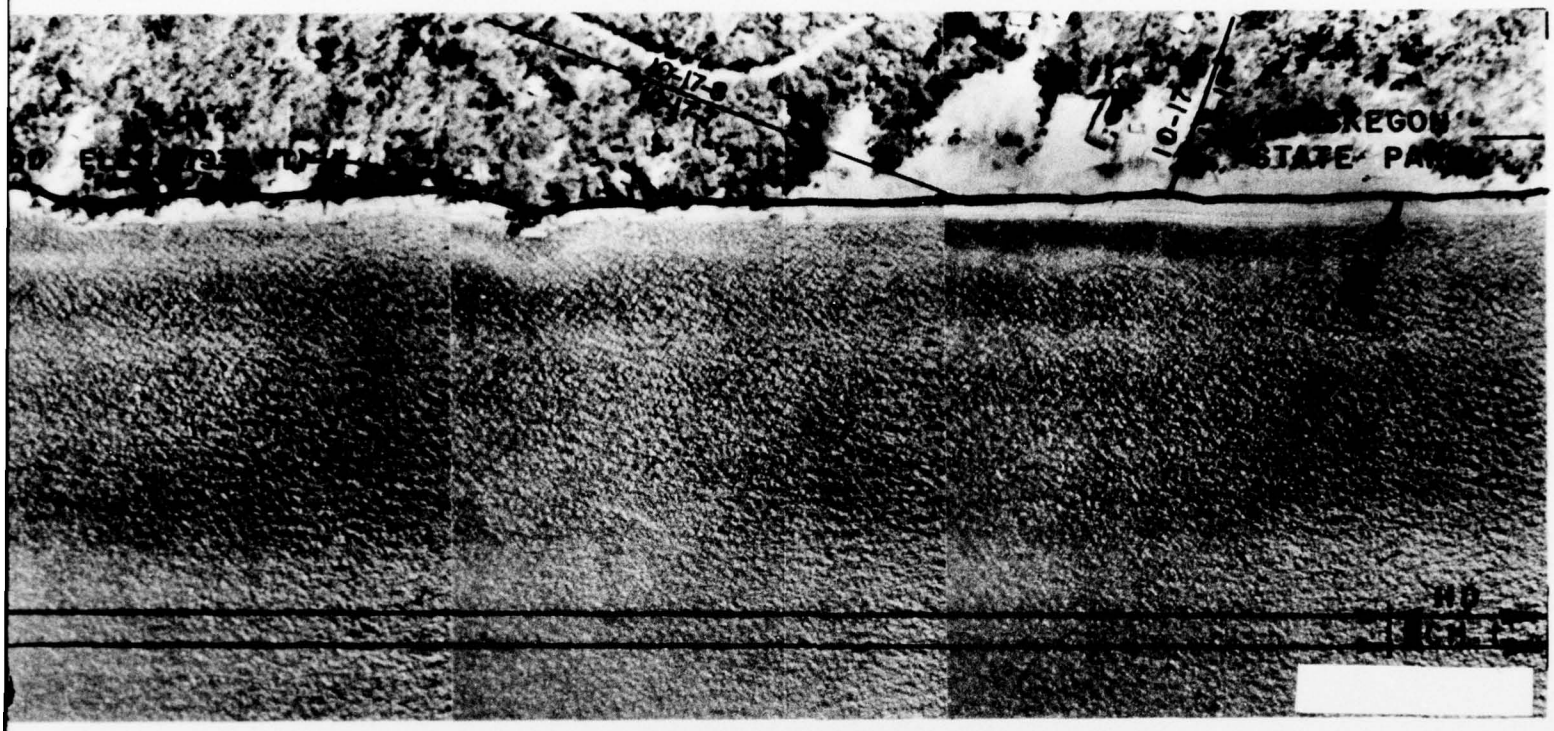
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MUSKEGON COUNTY, MICHIGAN REACH #2

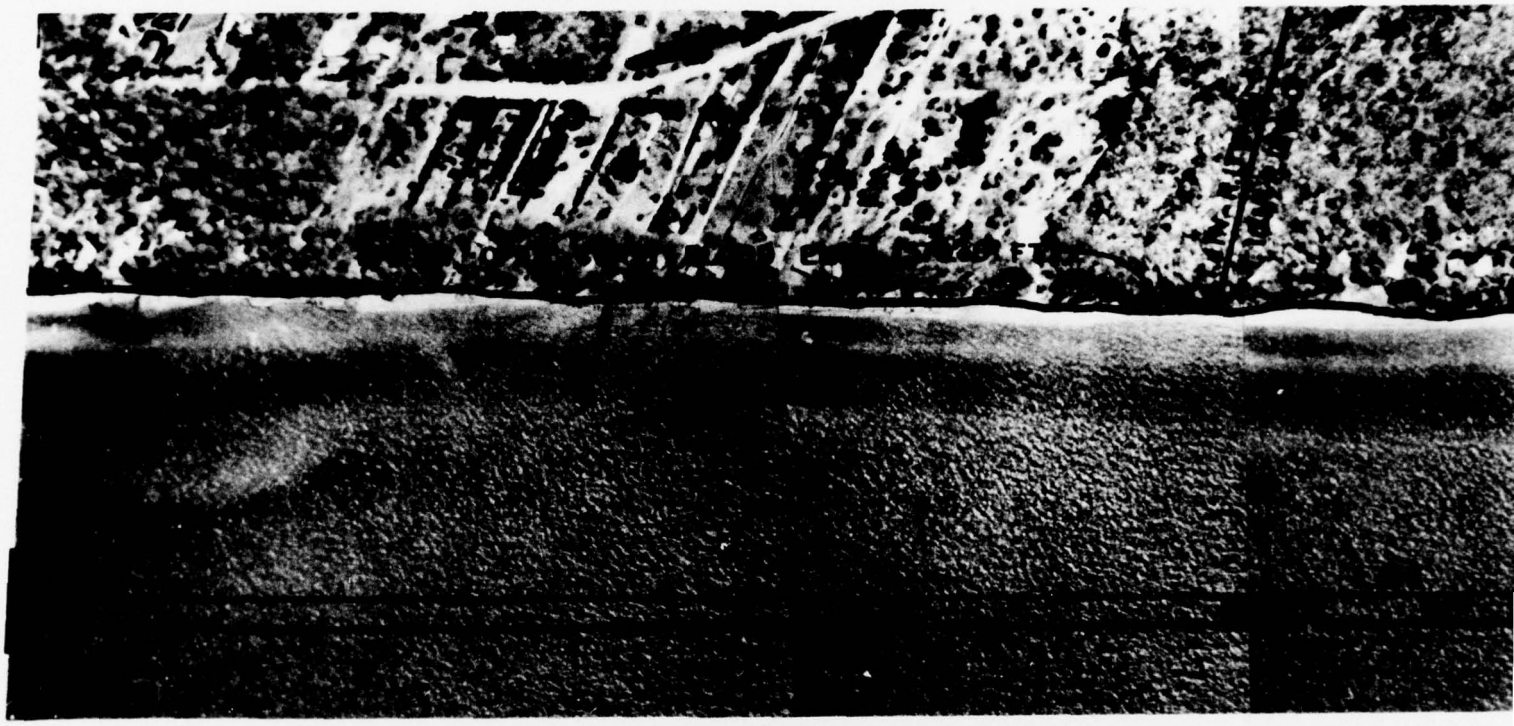
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	111	13200	700	1600	42000	
Reported Market Value ($)	95	34800	1900	1600	95000	
Bluff Height (Ft.)	102	82	13	15	900	
Beach Depth (Ft.)	62	36	10	3	500	
Bluff Lost (Ft.)	86	34	3	5	99	
Beach Lost (Ft.)	89	86	11	5	750	
Damages Erosion ($)	77	6000	700	50	22000	
Damages Flooding ($)	14	5350	1950	250	25800	
Damages - Erosion and Flooding ($)						900,000
Protective Structure Cost ($)	50	8900	1950	100	74200	800,000
Total Damages ($)	96	10250	1400	50	75650	1,700,000

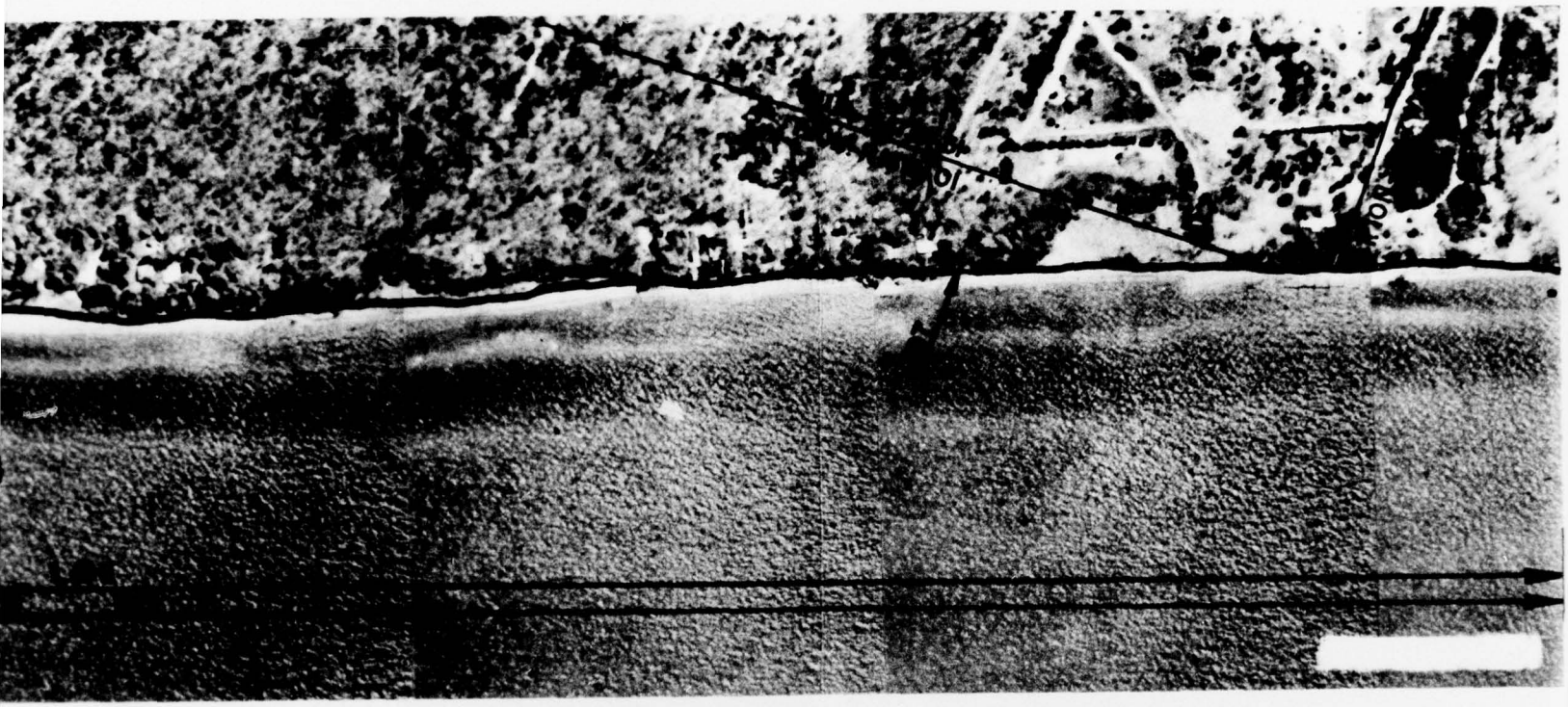
Total Identified Residential Properties: 166 Self-Administered Assessment Respondents: 111



MUSKEGON COUNTY

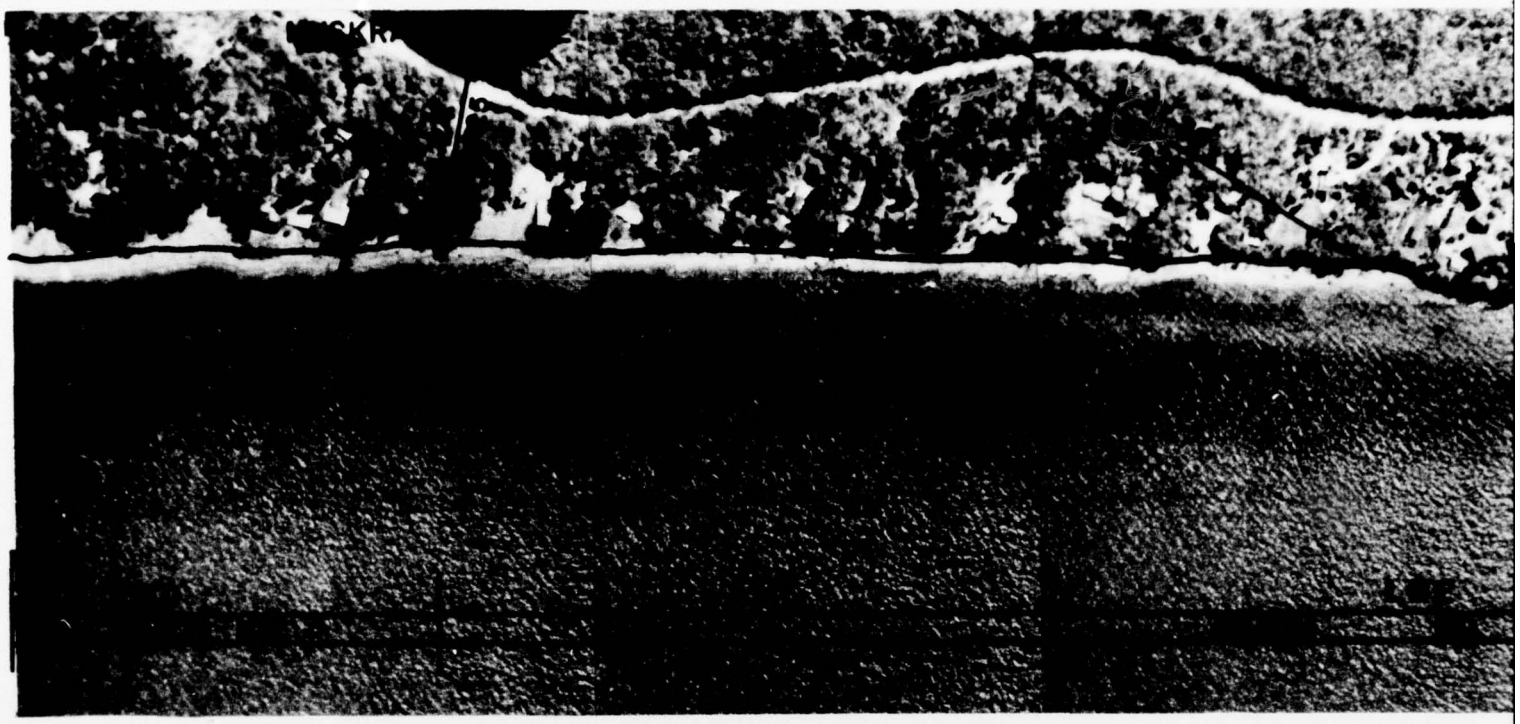
PILOT DAMAGE STUDY, 1975
PLATE NO. 8
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

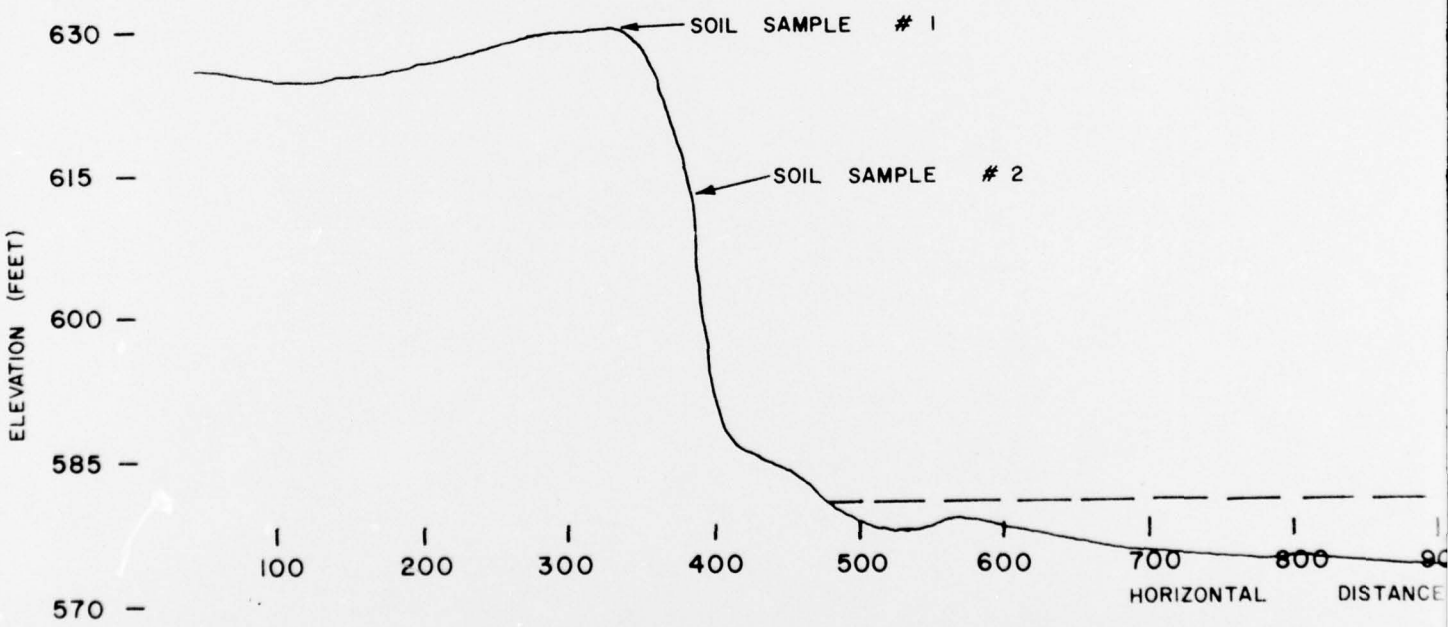


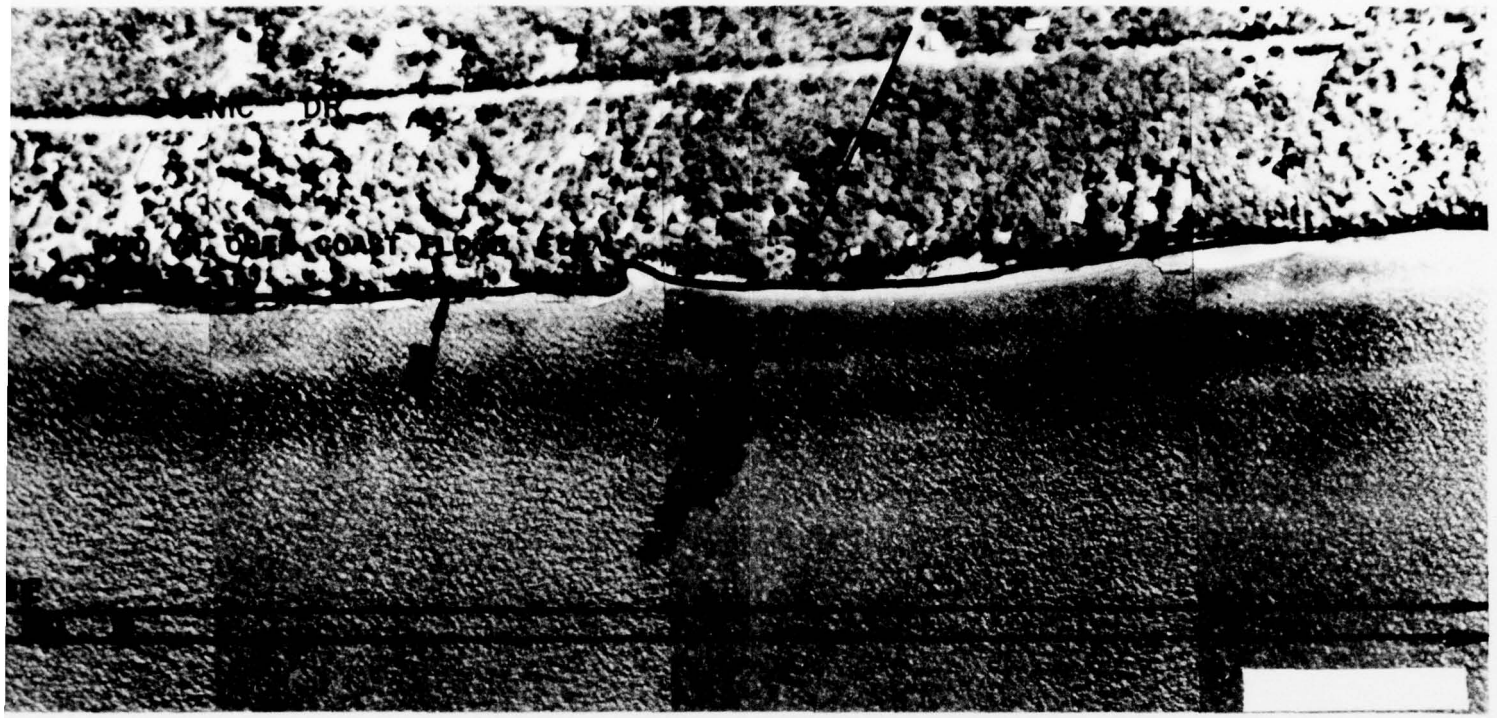


MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 9
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERISTY OF MICHIGAN



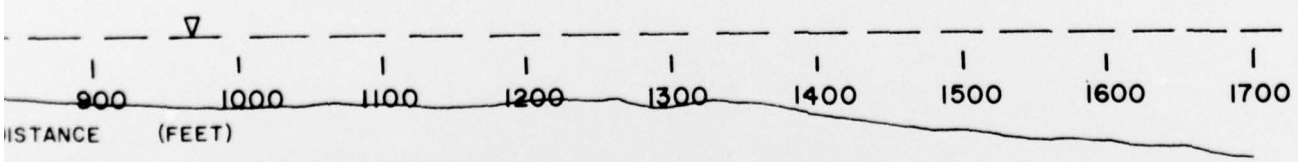

630
615
600
585
570
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
100
200
300
400
500
600
700
800
HORIZONTAL DISTANCE



MUSKEGON PROFILE #2

MUSKEGON COUNTY
PILOT DAMAGE STUDY, 1975
PLATE NO. 10
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

WATER LEVEL – MAY 5, 1975



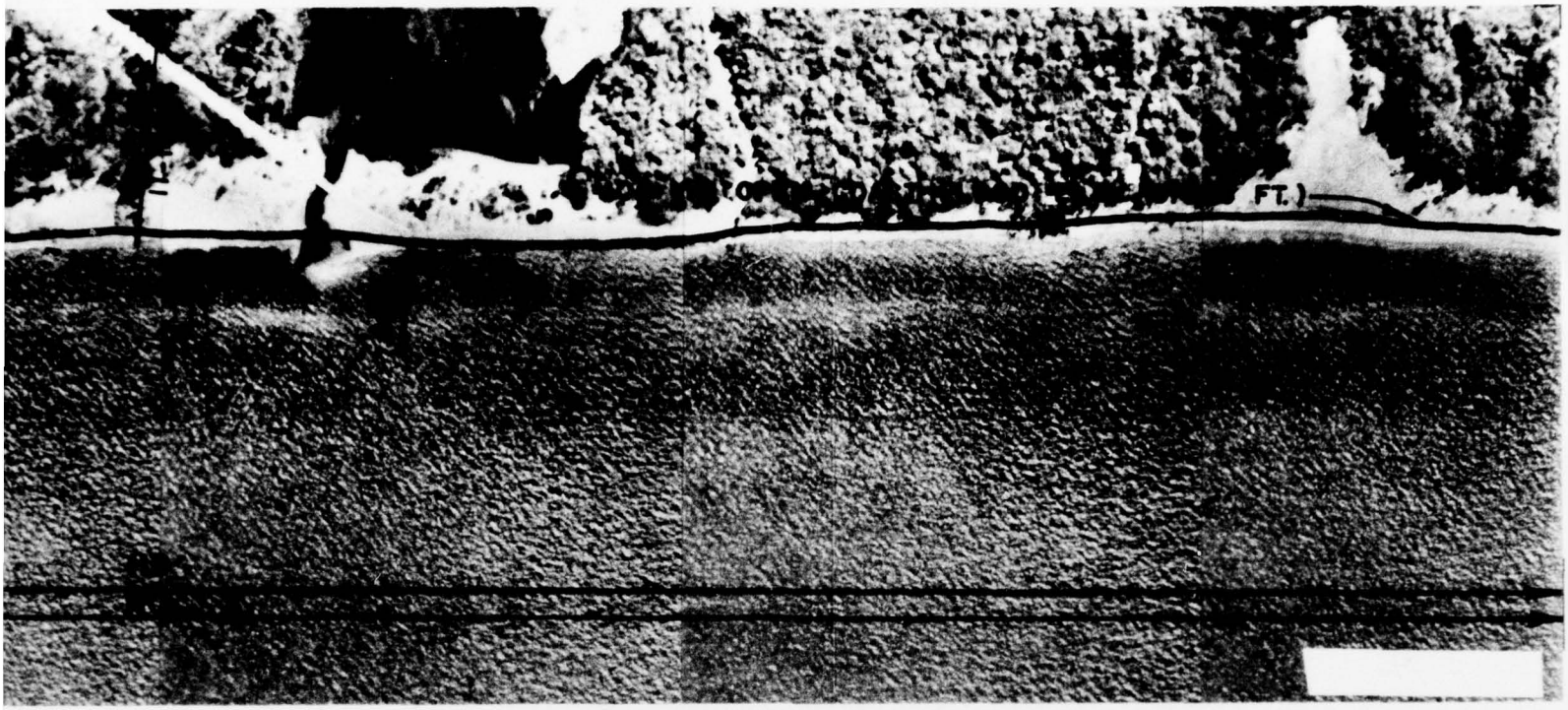
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MUSKEGON COUNTY, MICHIGAN REACH #3

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	57	9700	1200	670	57600	
Reported Market Value ($)	44	35100	4400	7000	150000	
Bluff Height (Ft.)	44	127	30	4	800	
Beach Depth (Ft.)	32	53	27	3	800	
Bluff Lost (Ft.)	40	25	3	4	75	
Beach Lost (Ft.)	43	109	20	18	600	
Damages Erosion ($)	32	7150	1850	100	53000	
Damages Flooding ($)	8	5000	1800	500	14700	
Damages - Erosion and Flooding ($)						470,000
Protective Structure Cost ($)	13	4800	1550	100	18000	110,000
Total Damages ($)	41	8050	1950	100	58400	580,000

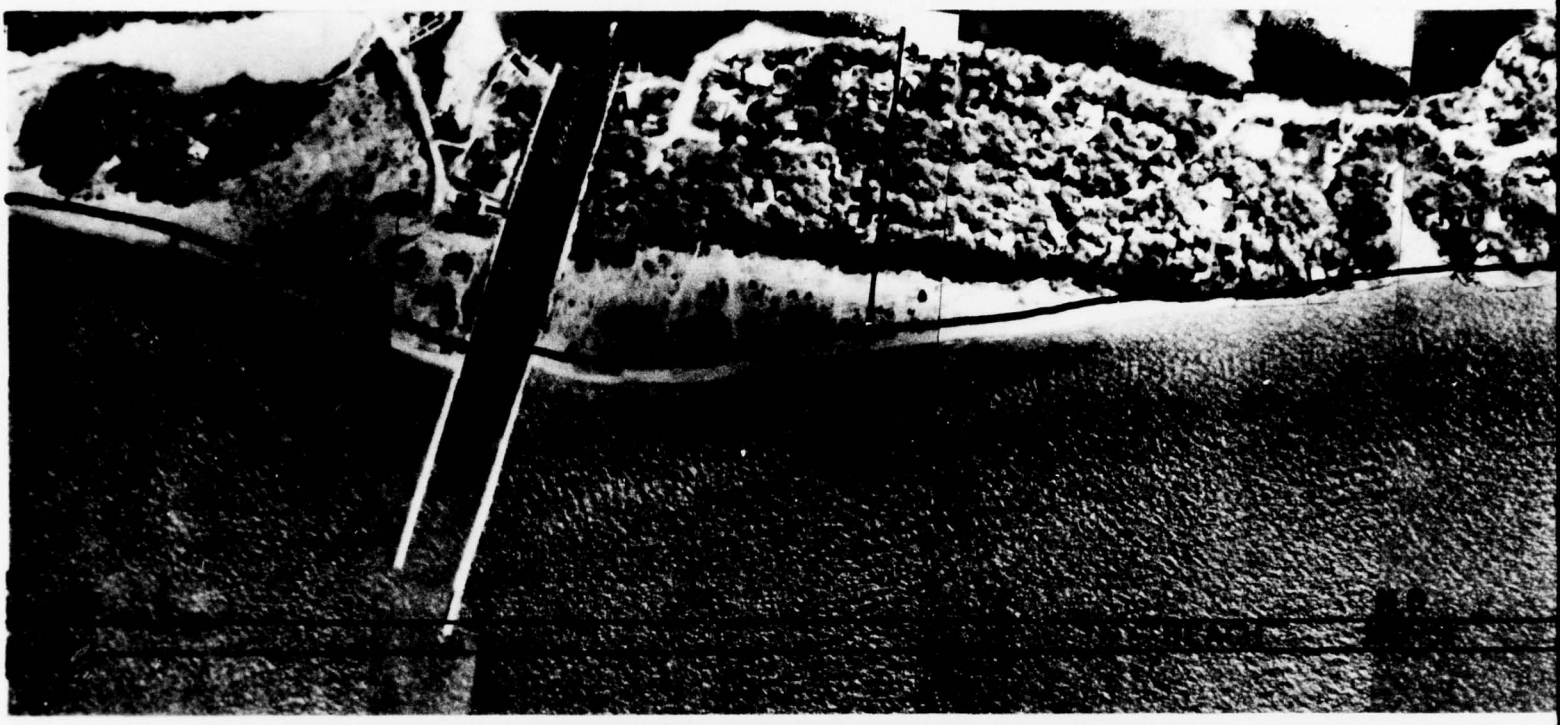
Total Identified Residential Properties: 100 Self-Administered Assessment Respondents: 57

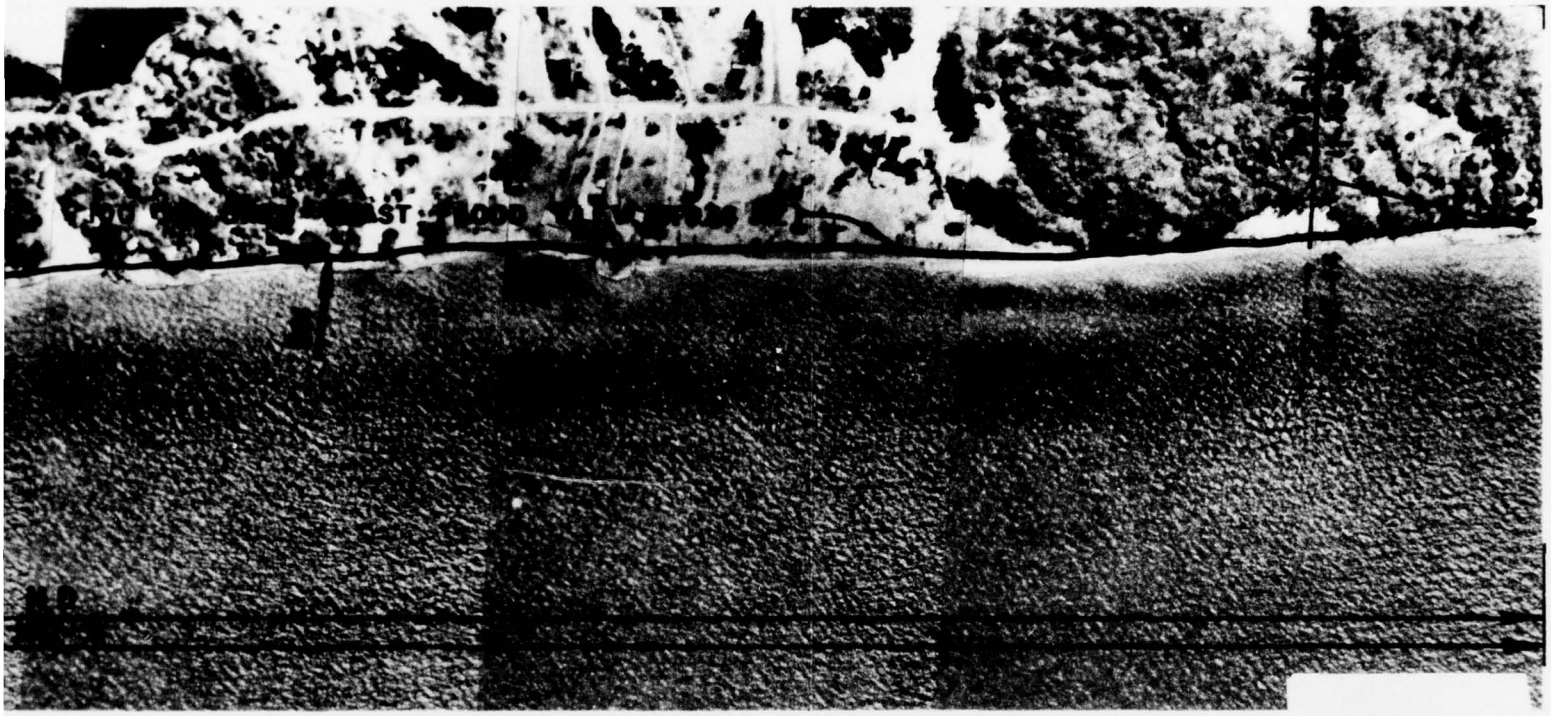


MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 11
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



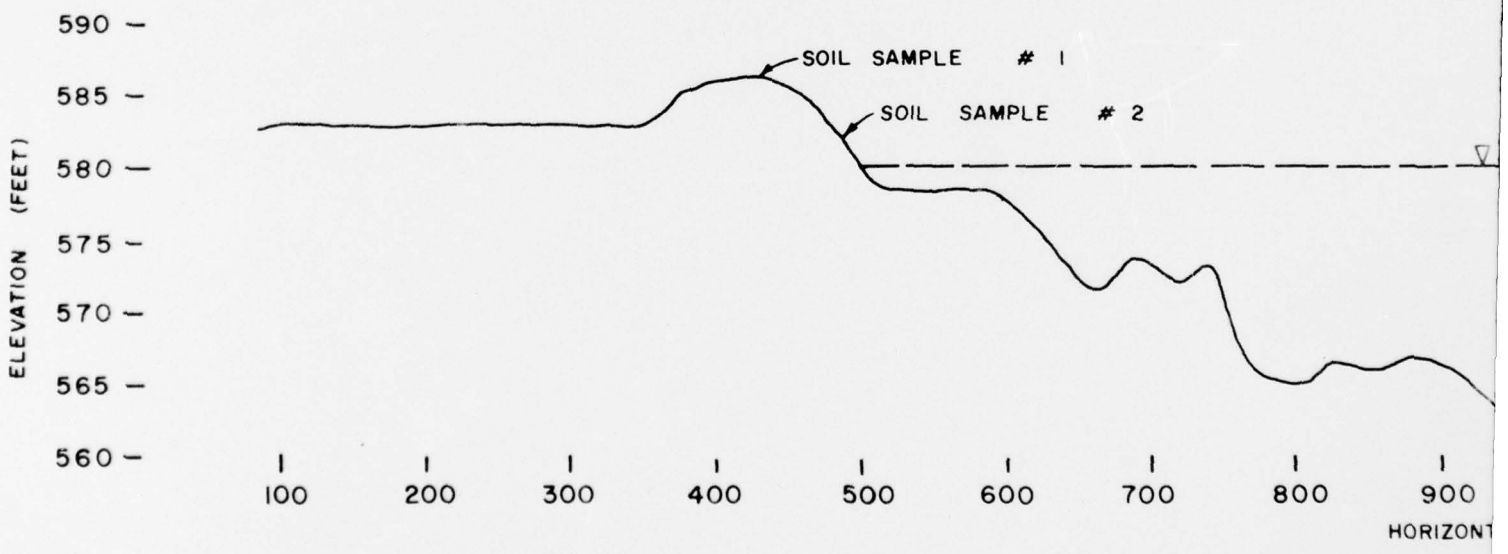


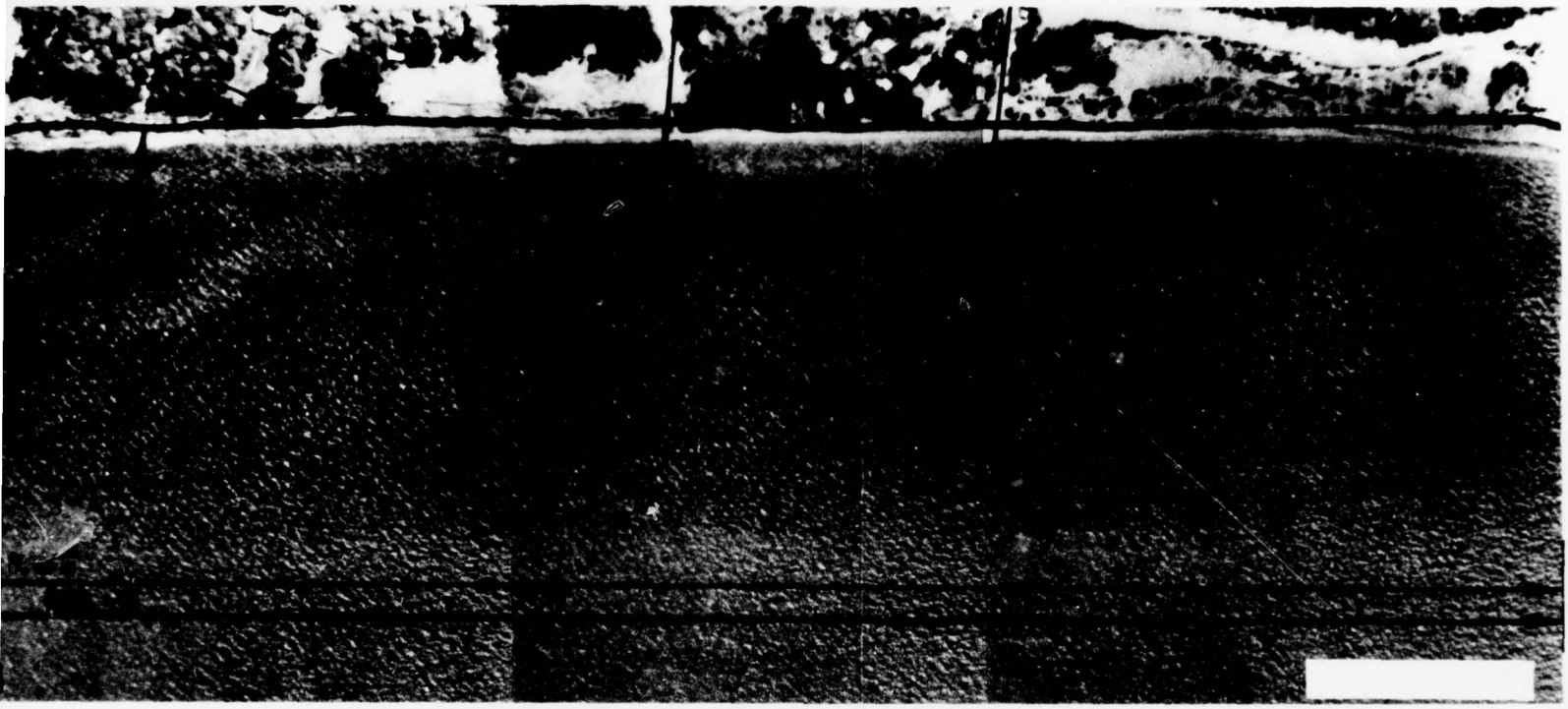
MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 12
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

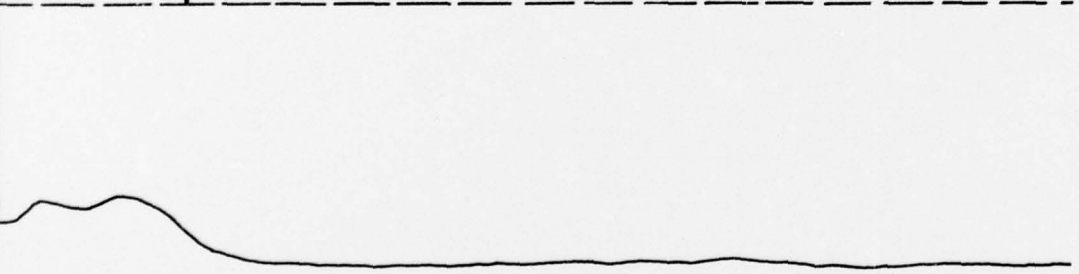

OD ELE


590
585
580
575
570
565
560
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
100
200
300
400
500
600
700
800
900
HORIZONT



MUSKEGON PROFILE # 3

WATER LEVEL - MAY 4, 1975



MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 13
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

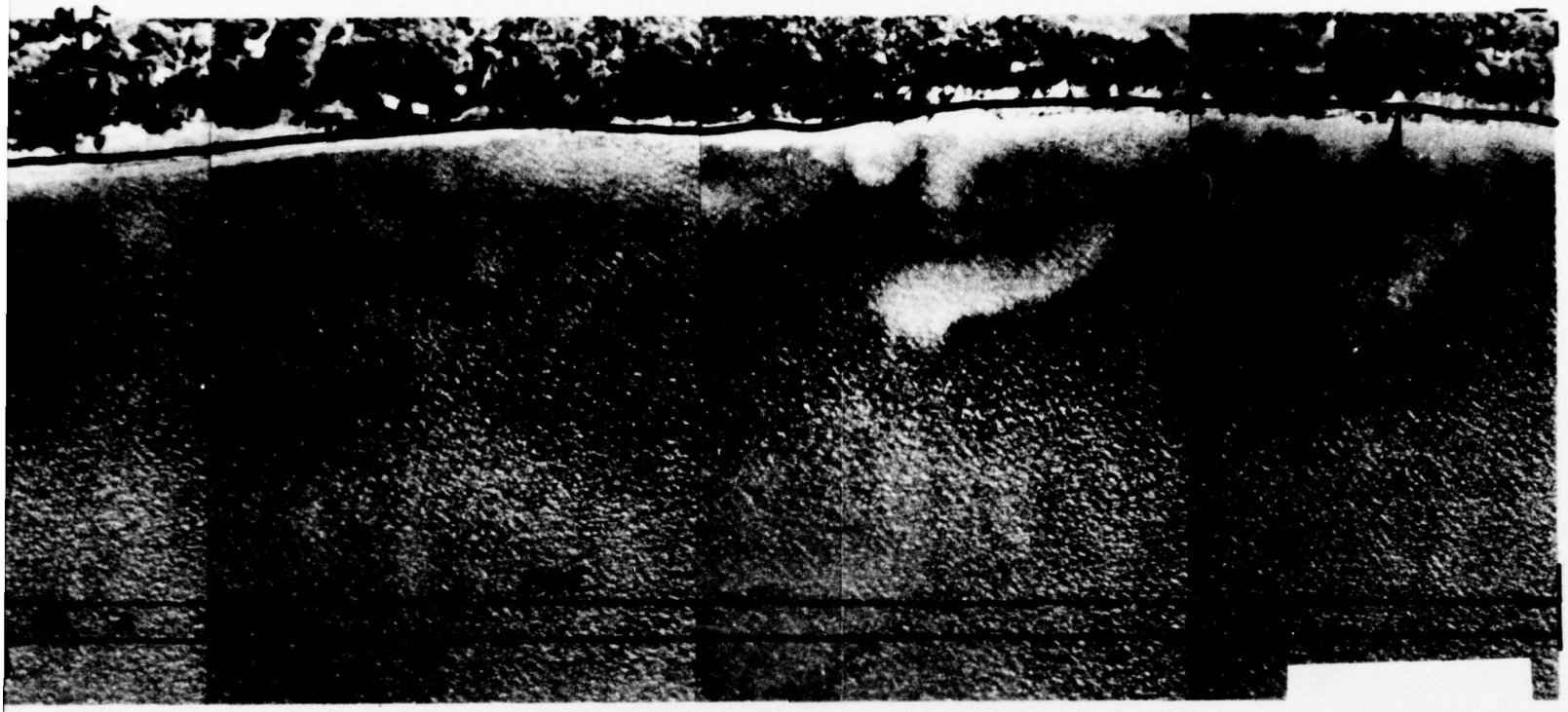
2



MUSKEGON COUNTY, MICHIGAN REACH #4

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	25	7400	1200	890	23310	
Reported Market Value ($)	21	25000	4000	1000	75000	
Bluff Height (Ft.)	15	84	38	12	600	
Beach Depth (Ft.)	15	47	13	1	200	
Bluff Lost (Ft.)	9	55	7	30	99	
Beach Lost (Ft.)	14	108	33	20	500	
Damages Erosion ($)	12	4250	950	250	10200	
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						74,000
Protective Structure Cost ($)	5	3400	650	2100	5500	26,000
Total Damages ($)	14	4850	1100	1000	15500	100,000

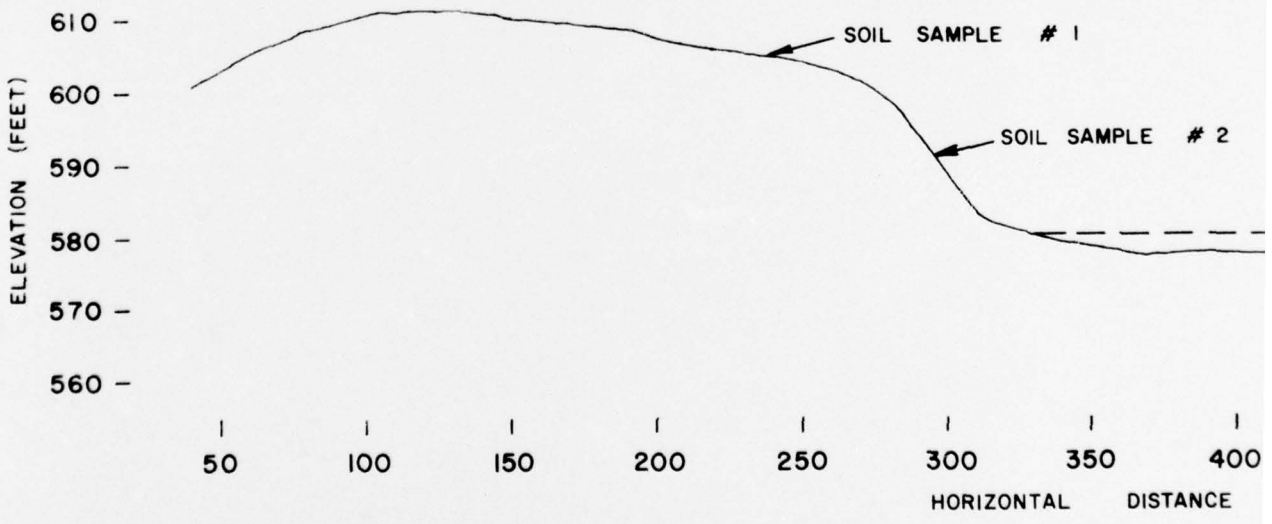
Total Identified Residential Properties: 39 Self-Administered Assessment Respondents: 25

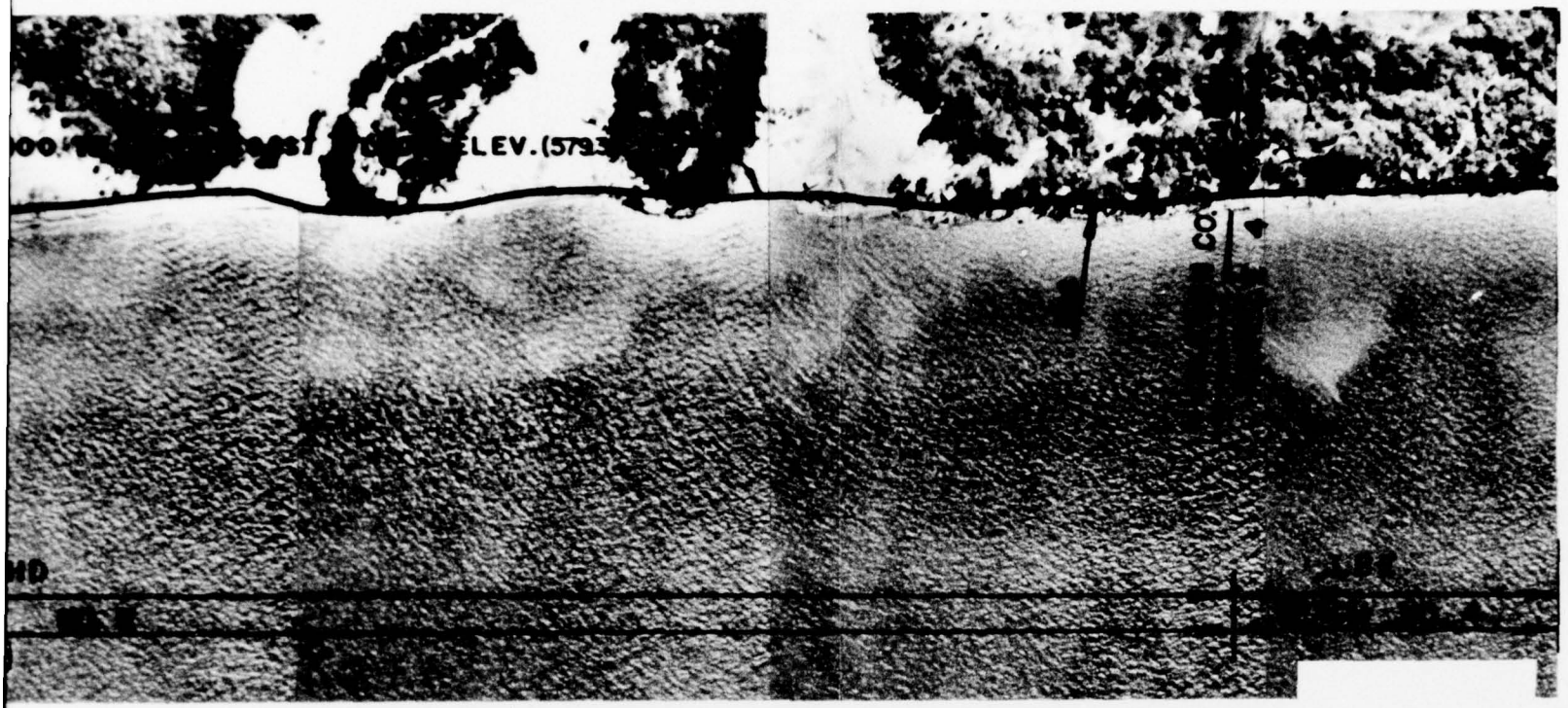


MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 14
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



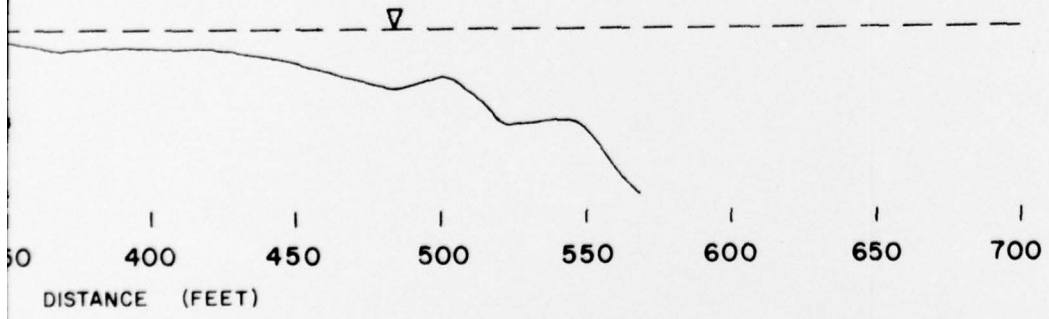

610
600
590
580
570
560
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
50
100
150
200
250
300
350
400
HORIZONTAL DISTANCE



MUSKEGON PROFILE # 4

MPLE # 2

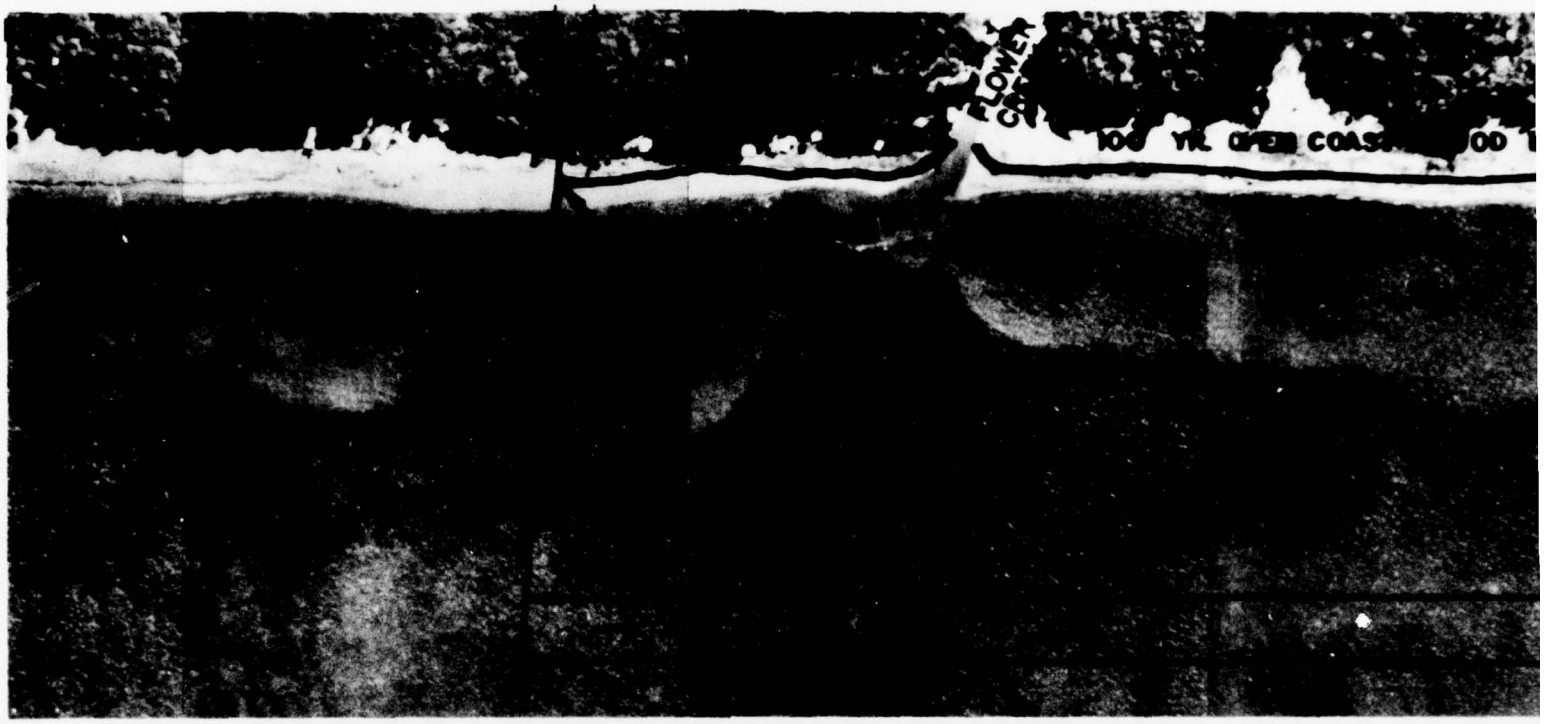
WATER LEVEL - MAY 5, 1975



MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 15
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

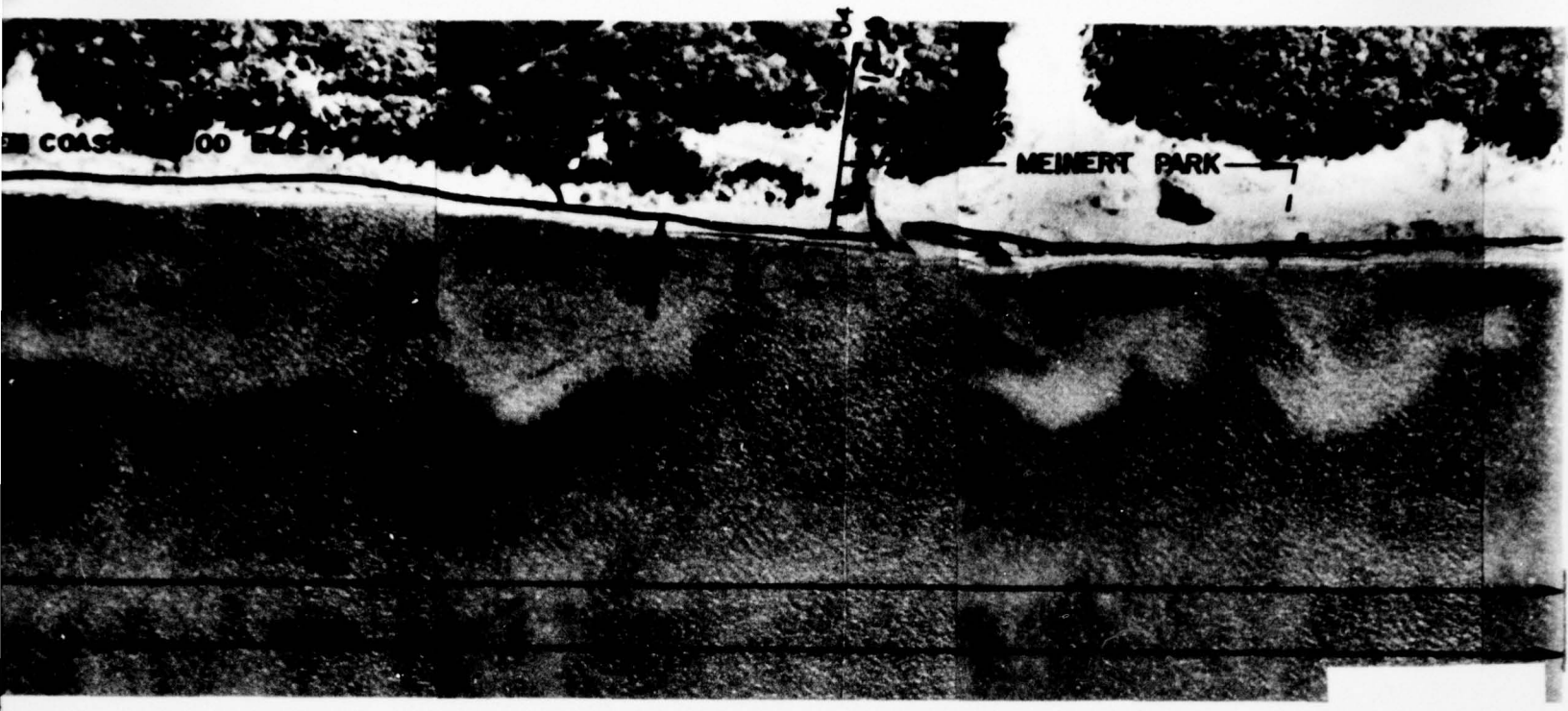
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MUSKEGON COUNTY, MICHIGAN REACH #5

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	49	5700	600	1110	20000	
Reported Market Value ($)	43	25100	2400	6000	75000	
Bluff Height (Ft.)	30	69	16	12	450	
Beach Depth (Ft.)	21	90	26	5	500	
Bluff Lost (Ft.)	26	36	6	4	99	
Beach Lost (Ft.)	26	169	45	15	750	
Damages Erosion ($)	25	4550	850	450	17500	
Damages Flooding ($)	4	3800	2050	100	9000	
Damages - Erosion and Flooding ($)						280,000
Protective Structure Cost ($)	11	7800	2800	1300	31900	190,000
Total Damages ($)	29	7400	1500	100	34900	470,000

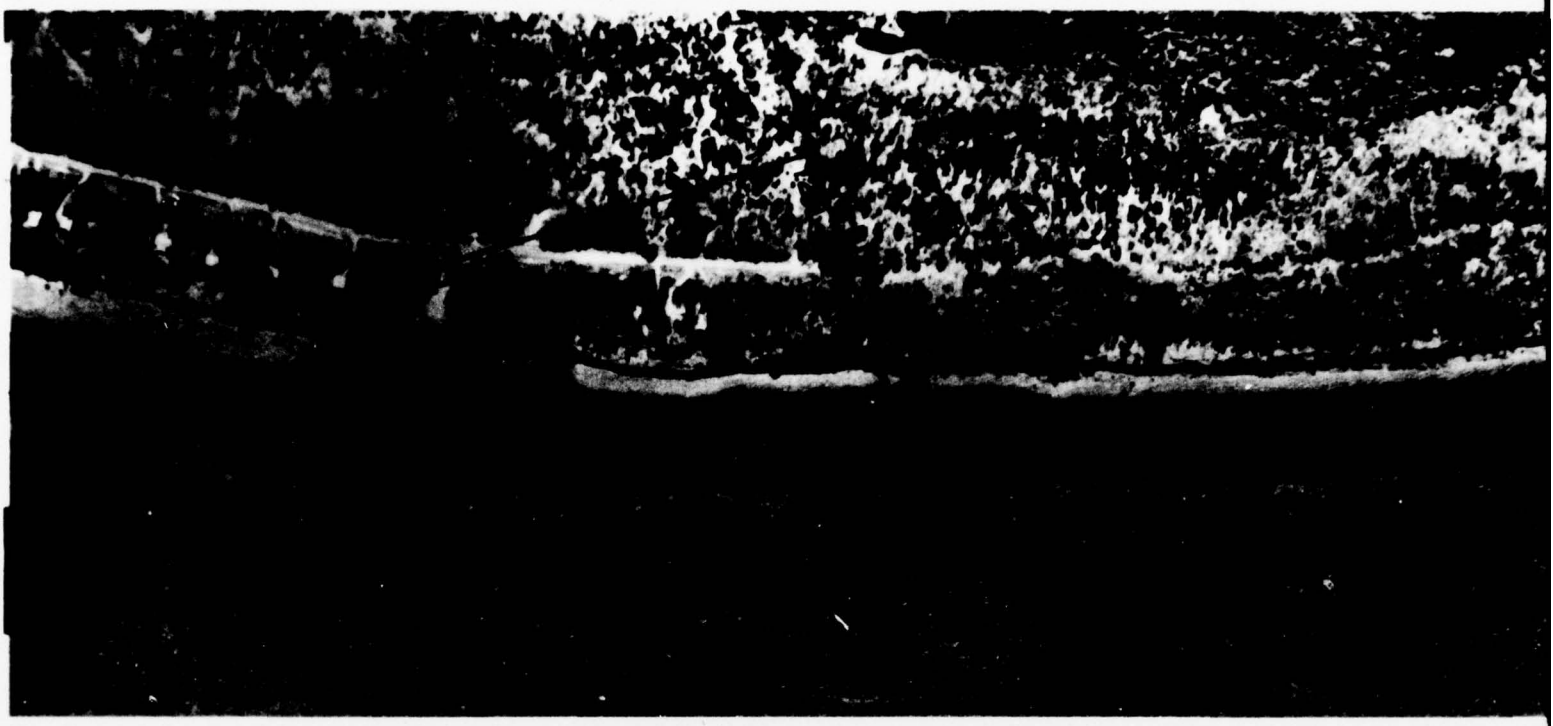
Total Identified Residential Properties: 77 Self-Administered Assessment Respondents: 49



MUSKEGON COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 16
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



MANISTEE COUNTY, MICHIGAN REACH #1

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	51	6900	1100	1500	45000	
Reported Market Value ($)	43	47100	12500	5000	500000	
Bluff Height (Ft.)	38	53	5	6	110	
Beach Depth (Ft.)	35	28	6	2	200	
Bluff Lost (Ft.)	28	28	4	5	99	
Beach Lost (Ft.)	35	55	9	5	200	
Damages Erosion ($)	26	4950	1250	150	31250	
Damages Flooding ($)	2	4150	1650	2500	5850	
Damages - Erosion and Flooding ($)						247,000
Protective Structure Cost ($)	19	3550	1200	400	24700	118,000
Total Damages ($)	30	6800	1350	150	32450	365,000

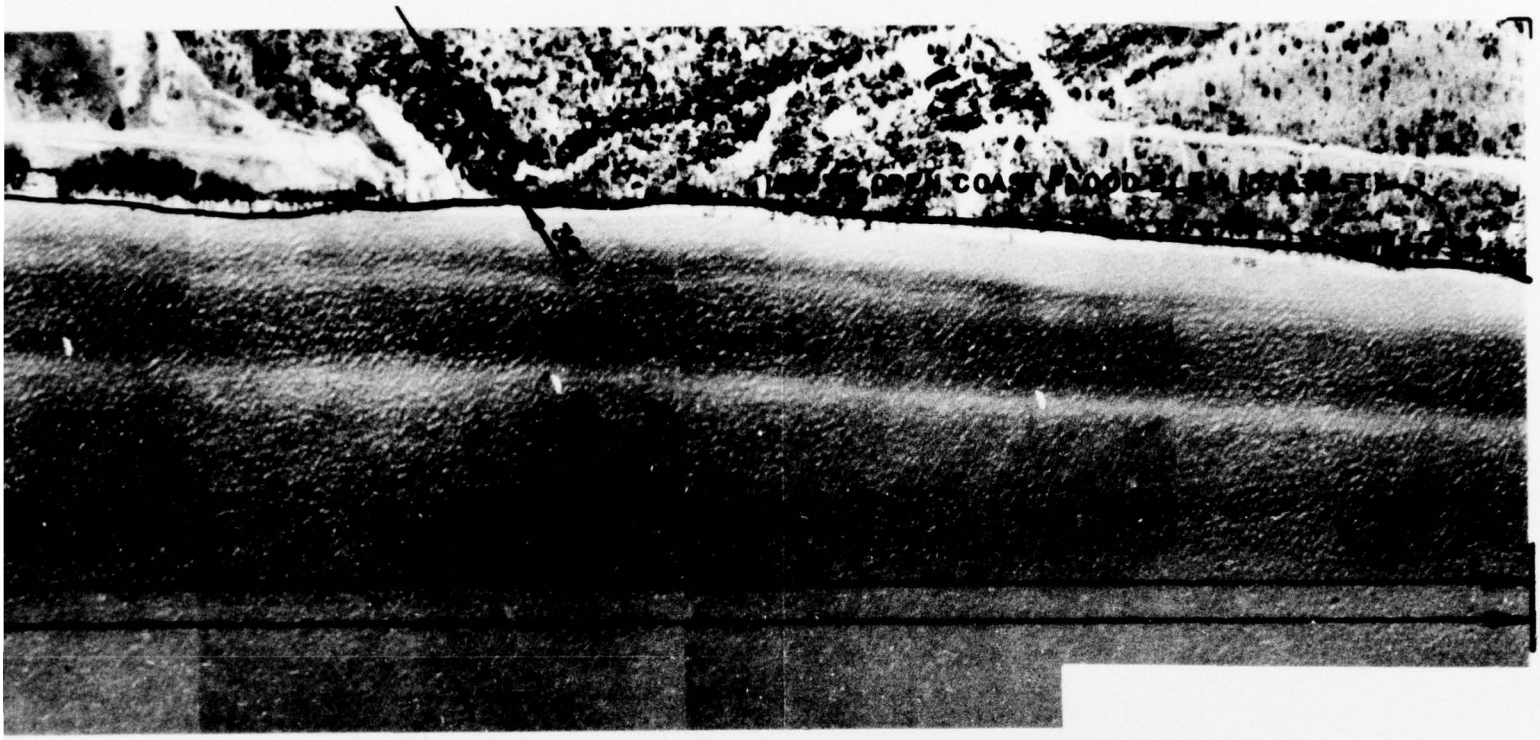
Total Identified Residential Properties: 86 Self-Administered Assessment Respondents: 51

MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 1
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

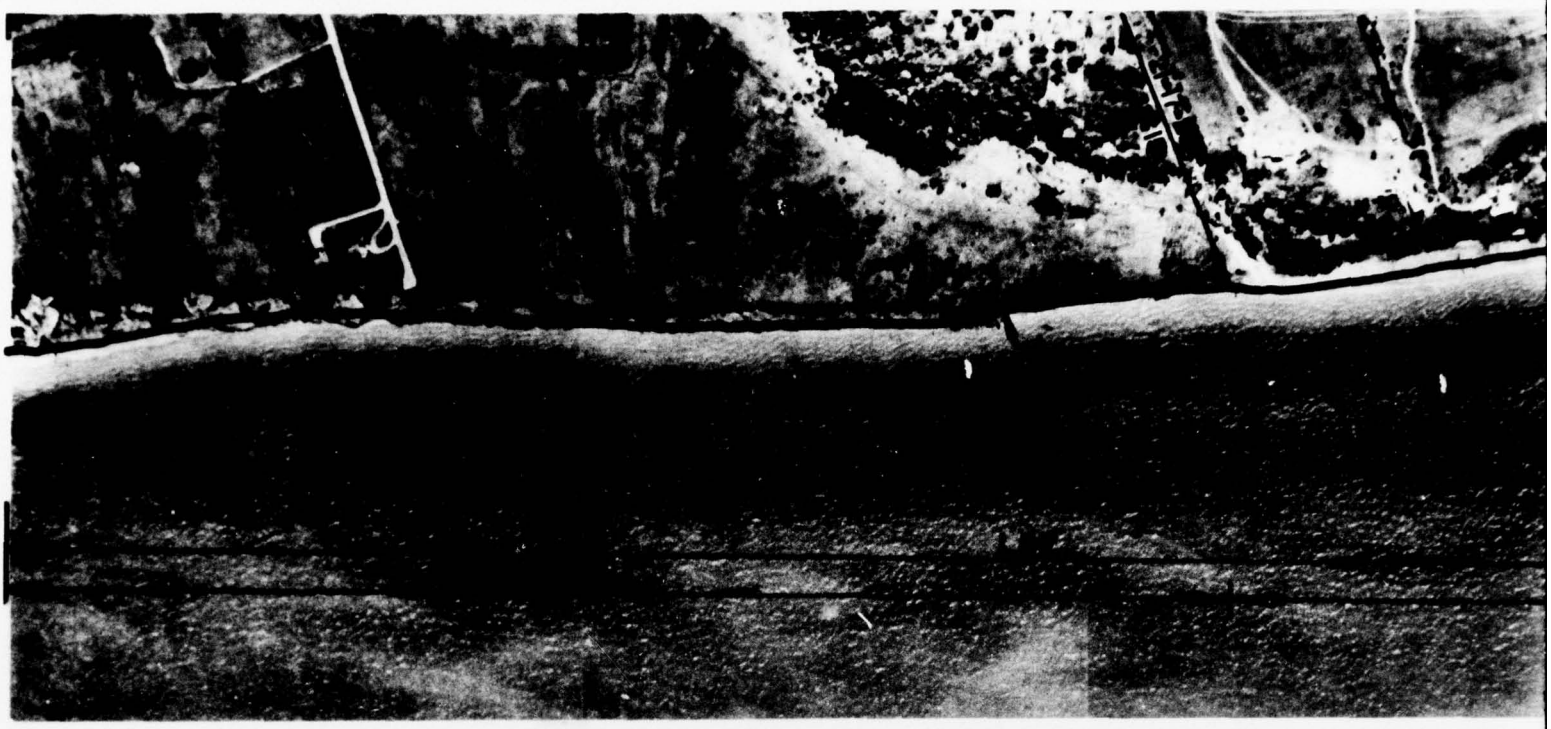
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MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 2
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

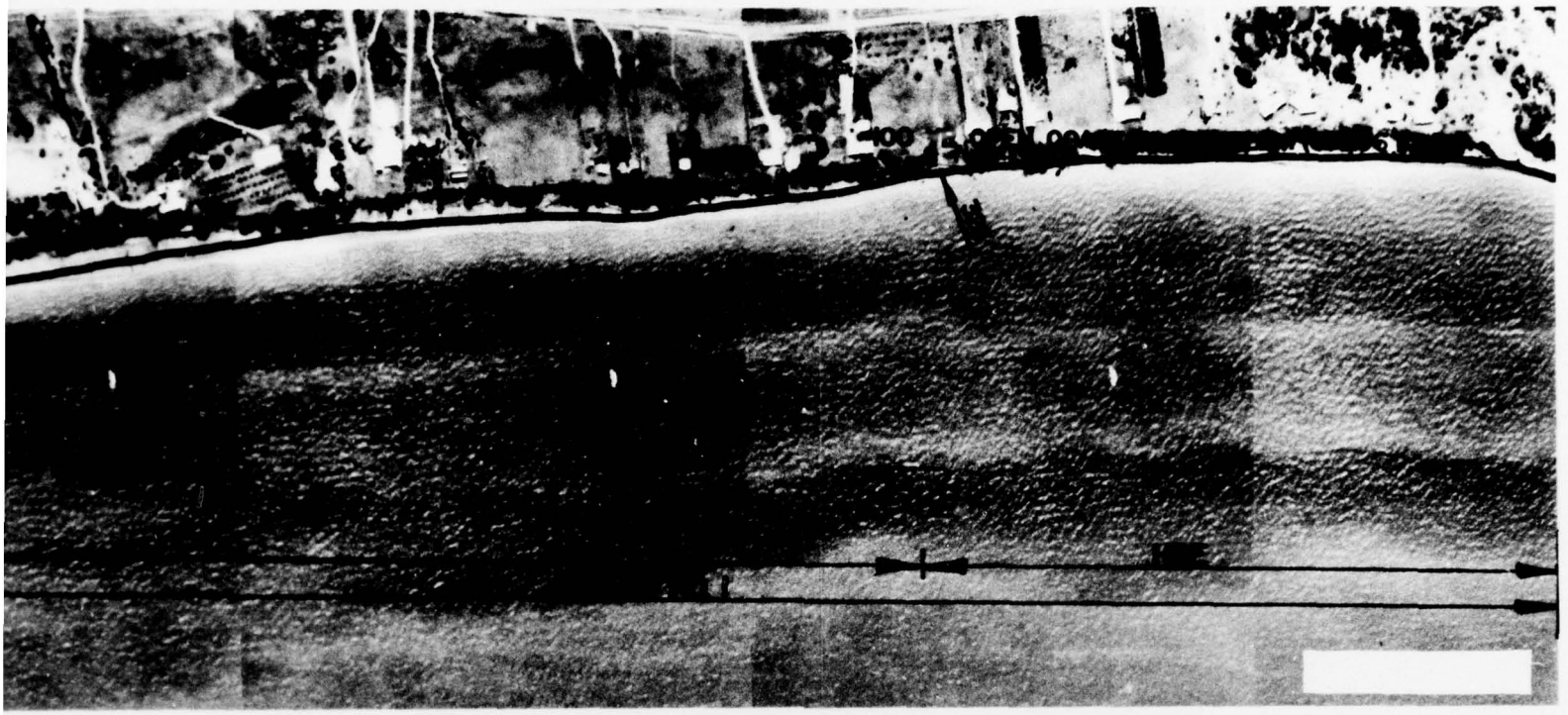
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MANISTEE COUNTY, MICHIGAN REACH #2

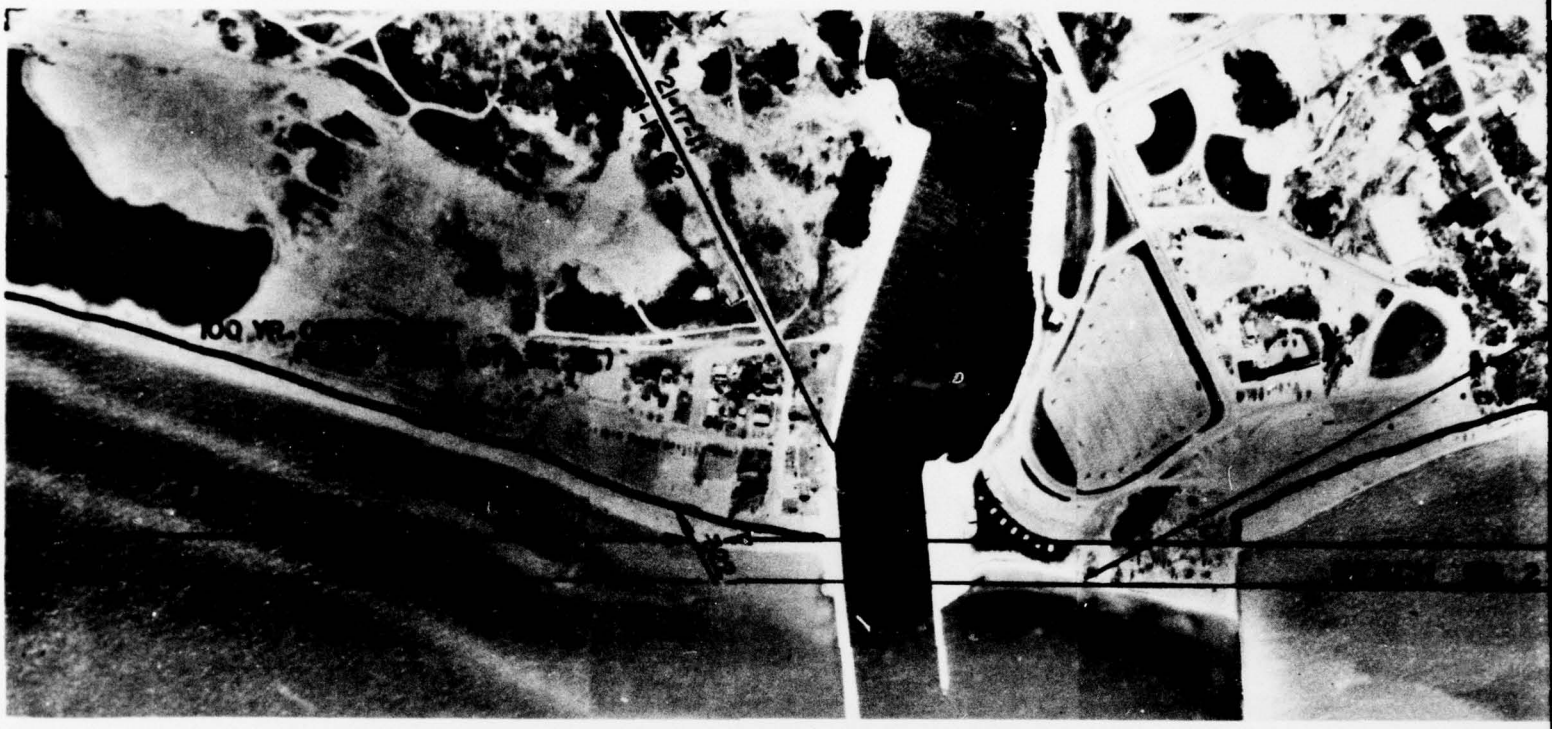
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	6	5500	1100	1800	10000	
Reported Market Value ($)	4	26000	2300	20000	30000	
Bluff Height (Ft.)	5	72	10	40	90	
Beach Depth (Ft.)	3	10	2	7	13	
Bluff Lost (Ft.)	4	60	14	30	99	
Beach Lost (Ft.)	4	72	13	50	100	
Damages Erosion ($)	4	5200	3400	500	51000	
Damages Flooding ($)	1	13800		13800	13800	
Damages - Erosion and Flooding ($)						132,000
Protective Structure Cost ($)	1	1000		1000	1000	15,000
Total Damages ($)	5	7200	3100	500	15000	147,000

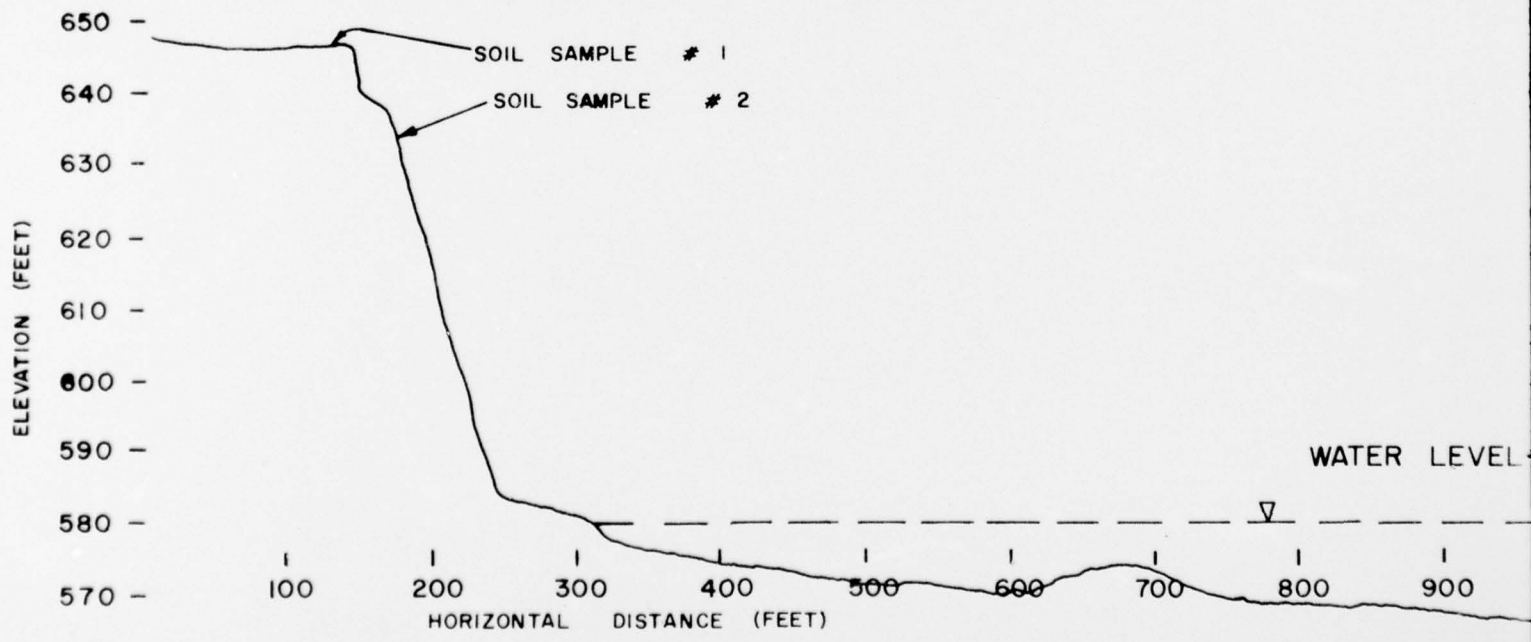
Total Identified Residential Properties: 28 *Self-Administered Assessment Respondents:* 6

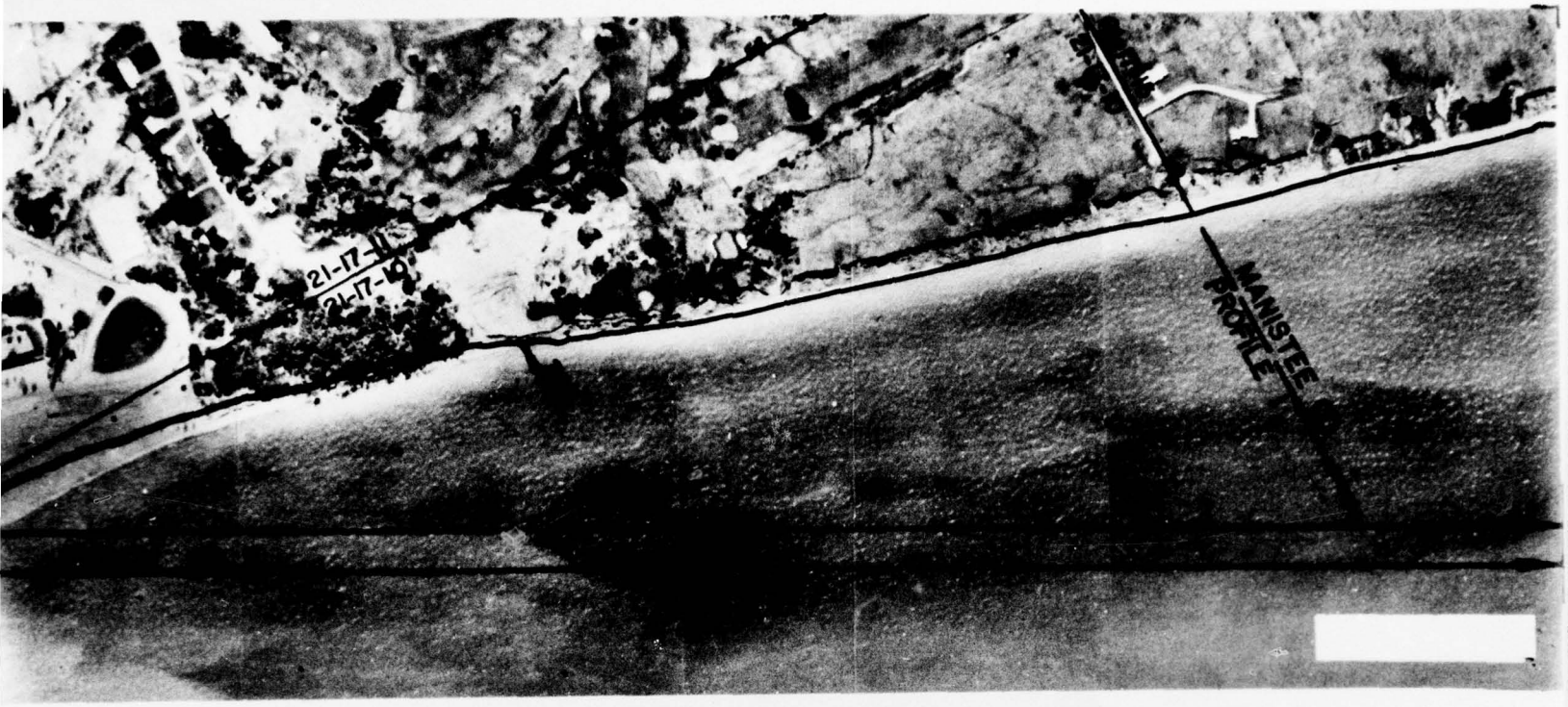


MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 3
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



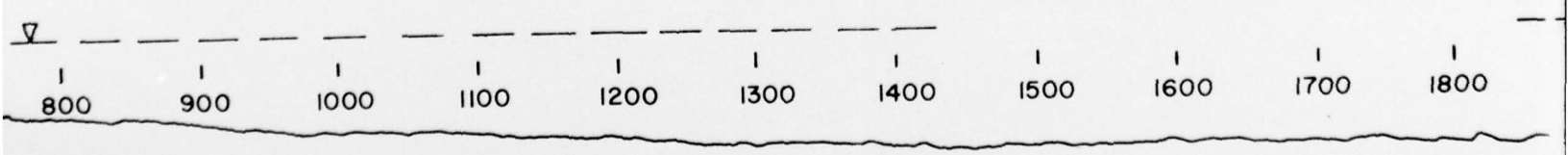

650
640
630
620
610
600
590
580
570
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
WATER LEVEL
100
200
300
400
500
600
700
800
900
HORIZONTAL DISTANCE (FEET)

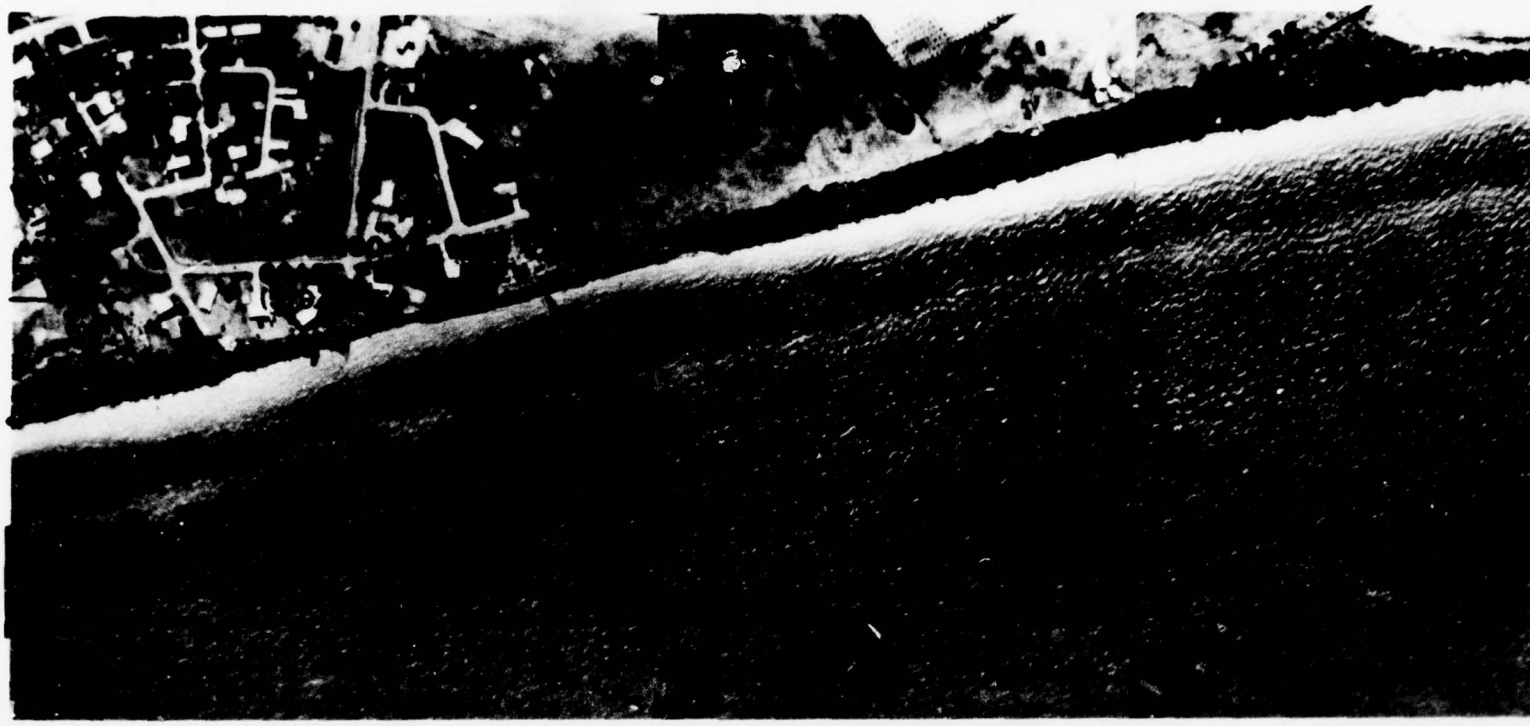


MANISTEE PROFILE # 1

MANISTEE COUNTY
PILOT DAMAGE STUDY, 1975
PLATE NO. 4
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

WATER LEVEL- MAY 11, 1975





MANISTEE COUNTY, MICHIGAN REACH #3

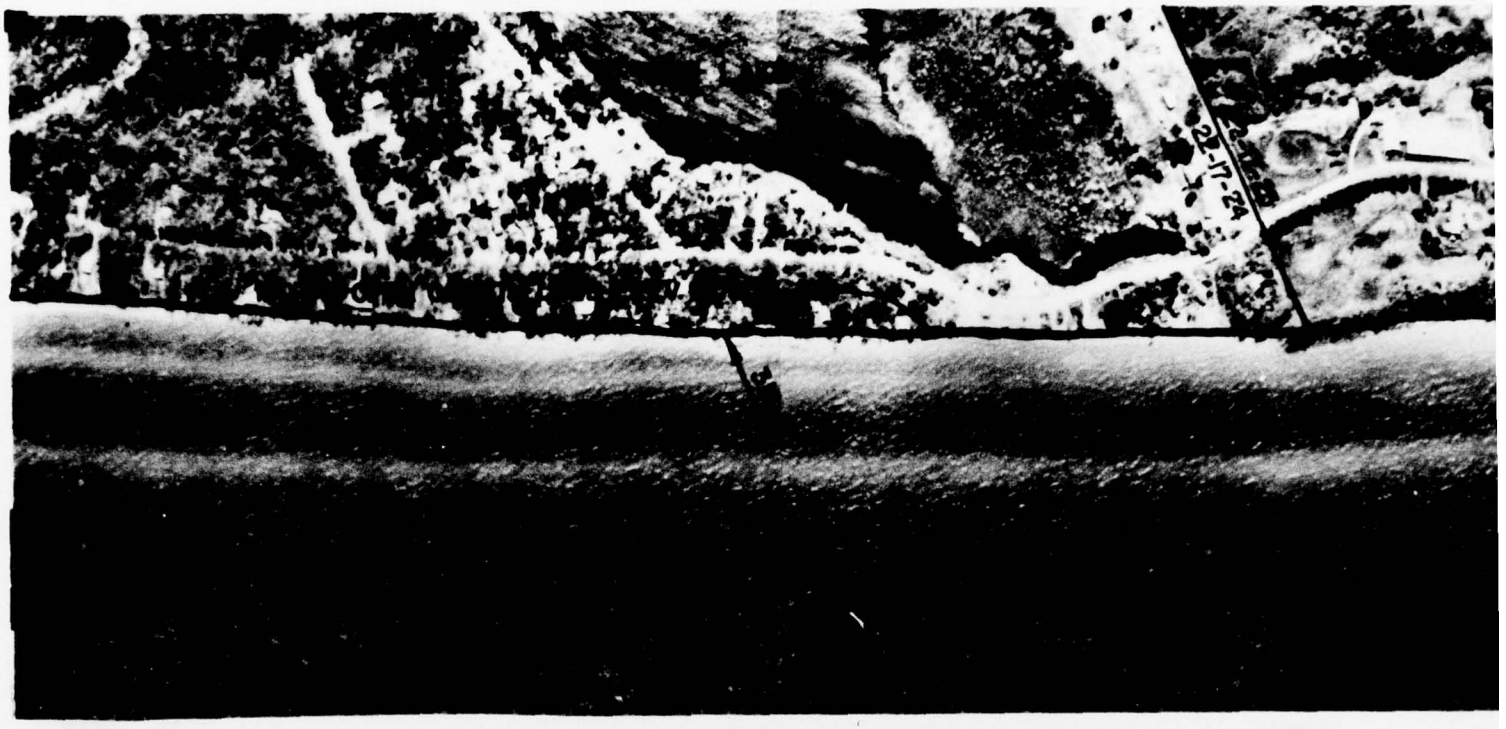
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	11	6500	1800	760	18200	
Reported Market Value ($)	4	30500	3600	20000	35000	
Bluff Height (Ft.)	8	84	3	80	100	
Beach Depth (Ft.)	5	9	1	8	10	
Bluff Lost (Ft.)	3	33	25	8	83	
Beach Lost (Ft.)	6	27	7	5	50	
Damages Erosion ($)	2	6750	4750	2000	11500	
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						26,000
Protective Structure Cost ($)	0					7,000
Total Damages ($)	2	6750	4750	2000	11500	33,000

Total Identified Residential Properties: 14 Self-Administered Assessment Respondents: 10



MANISTEE COUNTY

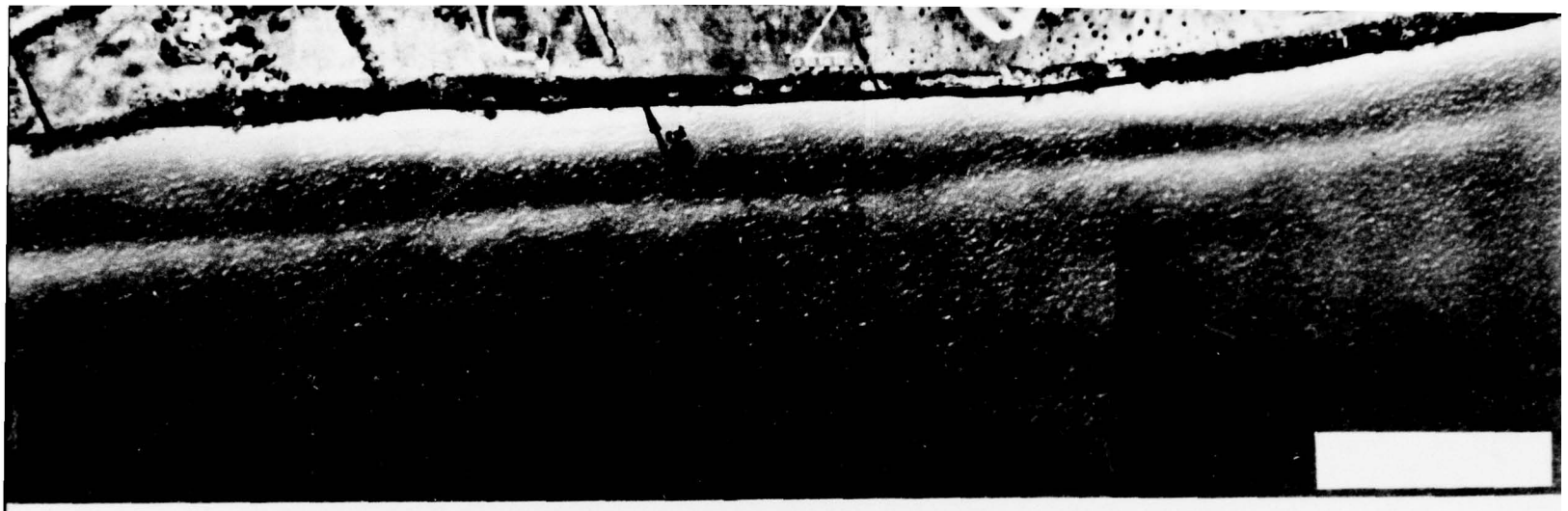
PILOT DAMAGE STUDY, 1975
PLATE NO. 5
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



MANISTEE COUNTY, MICHIGAN REACH #4

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	19	7300	1300	500	22800	
Reported Market Value ($)	13	35100	8900	3000	120000	
Bluff Height (Ft.)	13	33	6	8	68	
Beach Depth (Ft.)	12	15	4	2	40	
Bluff Lost (Ft.)	13	33	8	6	99	
Beach Lost (Ft.)	13	73	13	23	175	
Damages Erosion ($)	9	1800	500	200	5000	
Damages Flooding ($)	3	5500	5050	200	150	
Damages - Erosion and Flooding ($)						61,000
Protective Structure Cost ($)	7	5350	2650	200	16050	52,000
Total Damages ($)	12	5850	2650	400	31650	113,000

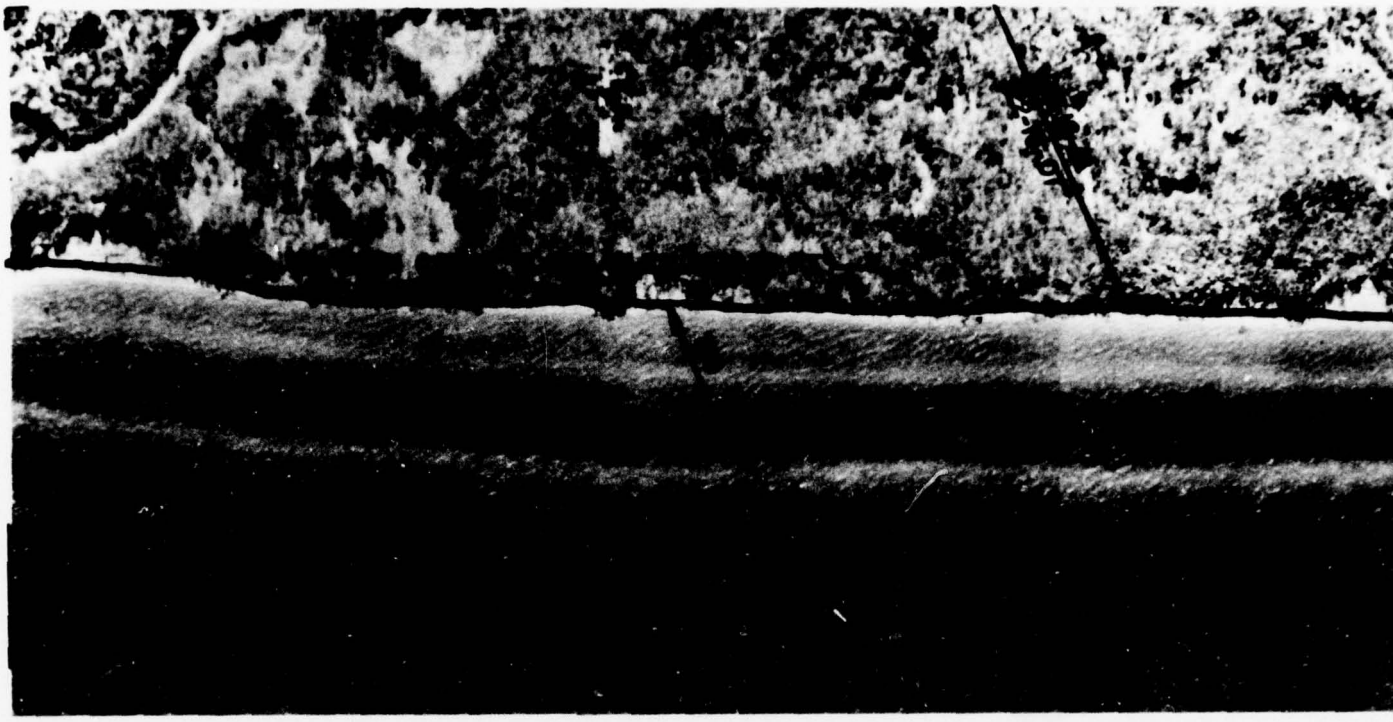
Total Identified Residential Properties: 27 Self-Administered Assessment Respondents: 19



MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 6
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



MANISTEE COUNTY, MICHIGAN REACH #5

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	48	7900	800	1030	24100	
Reported Market Value ($)	34	31900	4200	5000	110000	
Bluff Height (Ft.)	36	30	7	1	225	
Beach Depth (Ft.)	27	20	4	2	100	
Bluff Lost (Ft.)	34	30	4	2	99	
Beach Lost (Ft.)	30	49	6	6	163	
Damages Erosion ($)	32	6500	1300	200	25150	
Damages Flooding ($)	3	2000	1450	450	4900	
Damages - Erosion and Flooding ($)						321,000
Protective Structure Cost ($)	15	6150	2150	250	33600	140,000
Total Damages ($)	33	9300	1700	200	37100	461,000

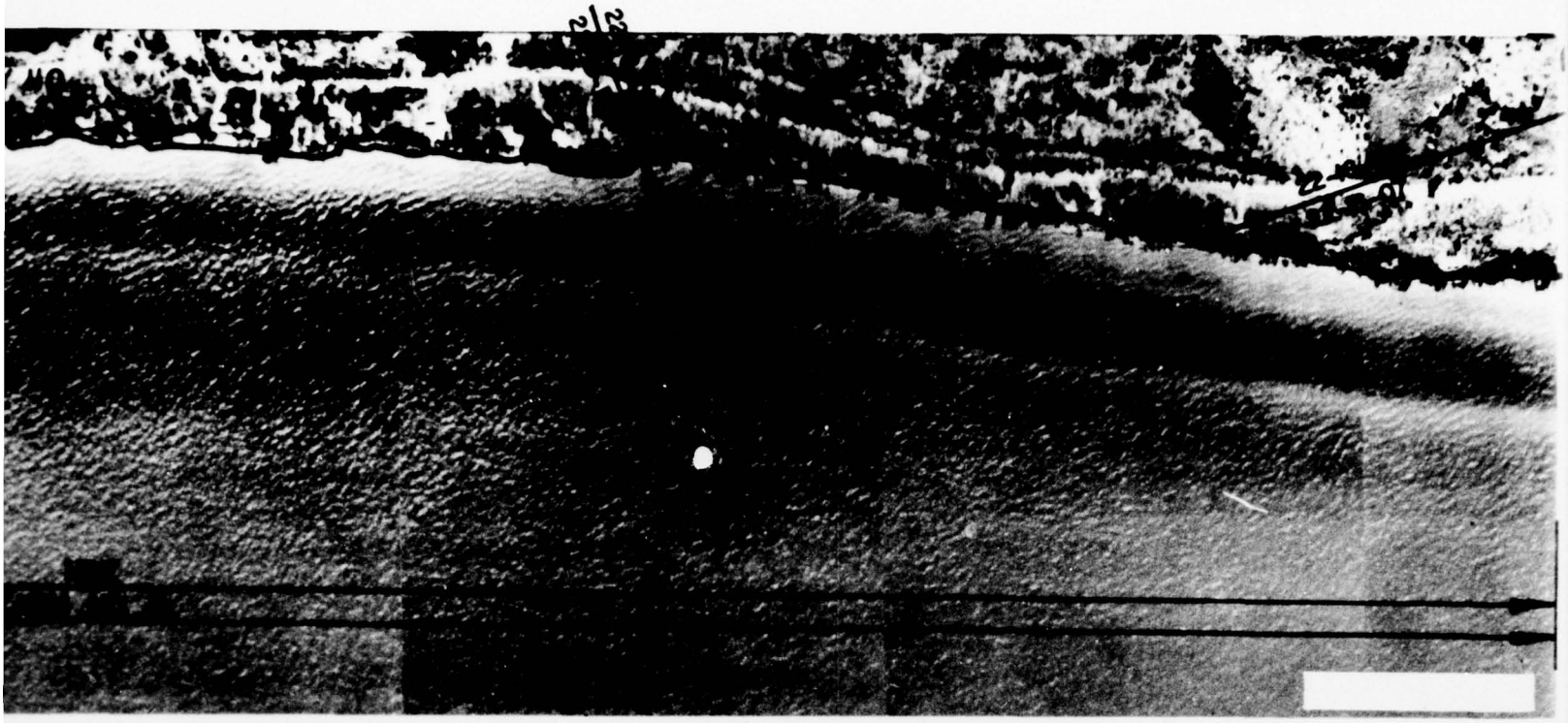
Total Identified Residential Properties: 78 Self-Administered Assessment Respondents: 48

MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 7
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

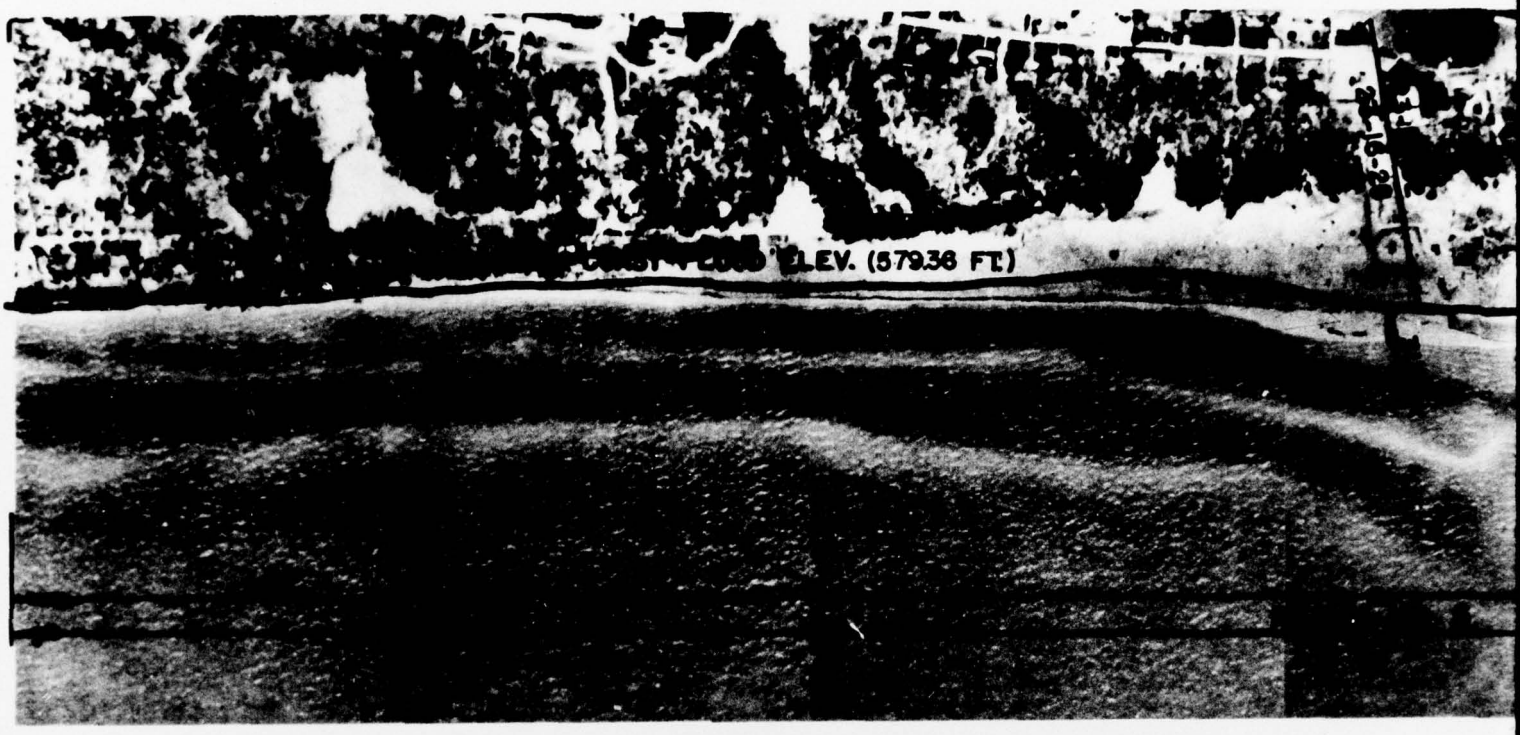
HWY 40



MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 8
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2


ELEV. (5793.6 FT.)



MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 9
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

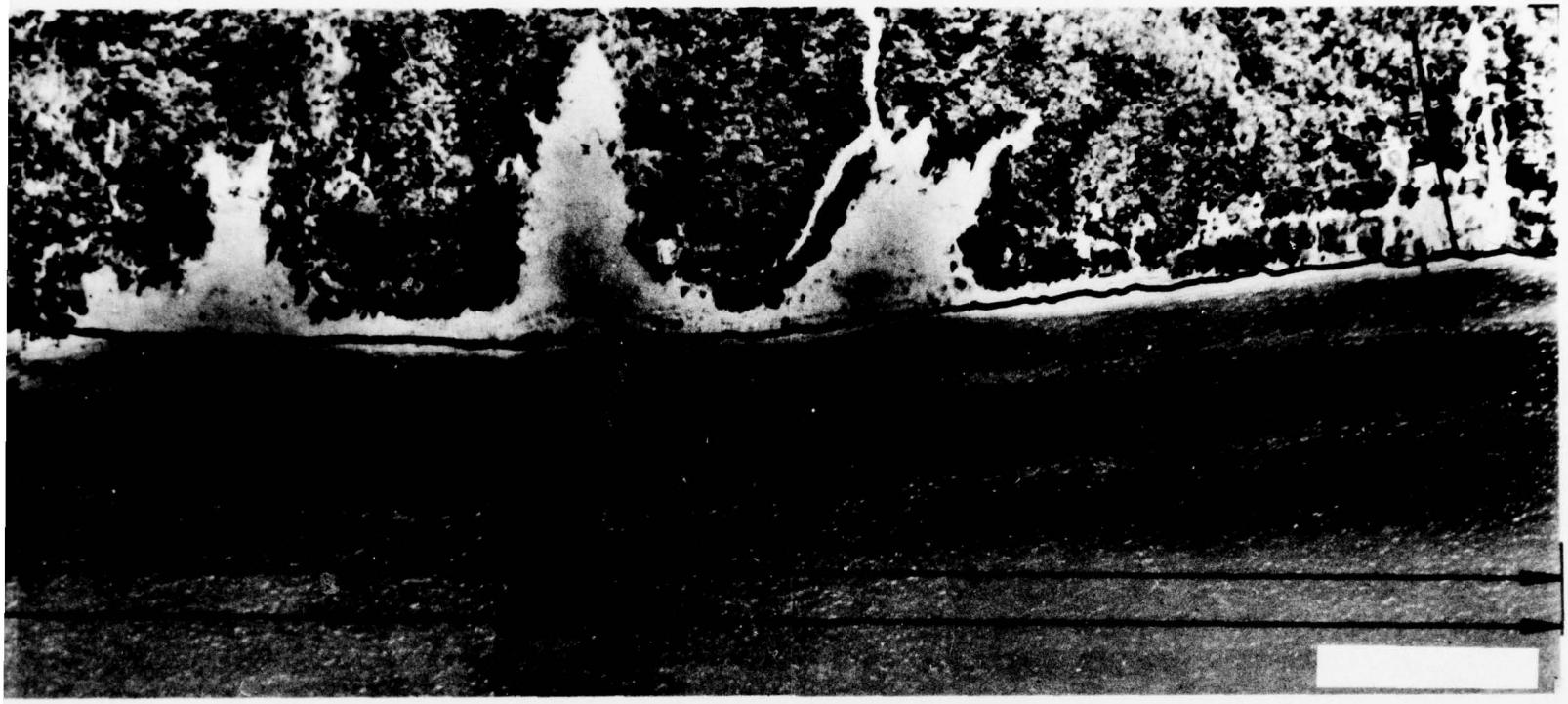




MANISTEE COUNTY, MICHIGAN REACH #6

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	8	6500	800	2600	10400	
Reported Market Value ($)	5	50600	21000	16000	132000	
Bluff Height (Ft.)	2	12		12	12	
Beach Depth (Ft.)	2	5		5	5	
Bluff Lost (Ft.)	2	8	2	6	10	
Beach Lost (Ft.)	2	38	3	35	40	
Damages Erosion ($)	3	3850	750	2500	5000	
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						49,000
Protective Structure Cost ($)	1	5000		5000	5000	22,000
Total Damages ($)	3	5500	1050	4000	7500	71,000

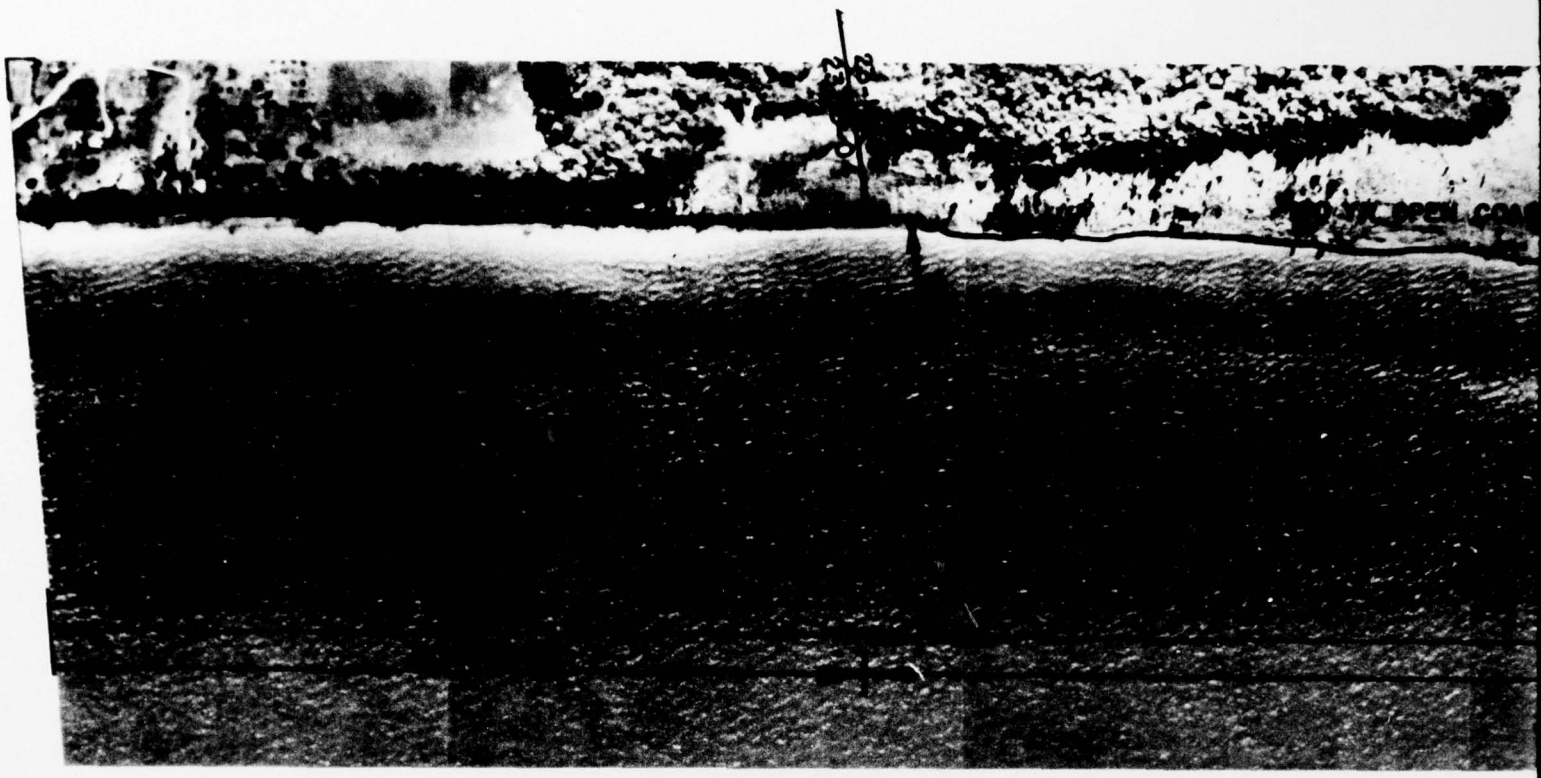
Total Identified Residential Properties: 24 Self-Administered Assessment Respondents: 8



MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 10
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



MANISTEE COUNTY, MICHIGAN REACH #7

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	39	9100	900	1770	25400	
Reported Market Value ($)	29	3700	7000	10000	200000	
Bluff Height (Ft.)	27	33	7	3	140	
Beach Depth (Ft.)	21	23	5	2	100	
Bluff Lost (Ft.)	19	14	2	1	52	
Beach Lost (Ft.)	25	45	7	5	150	
Damages Erosion ($)	23	8800	2550	50	50000	
Damages Flooding ($)	6	9400	5250	1000	35000	
Damages - Erosion and Flooding ($)						438,000
Protective Structure Cost ($)	18	3600	1050	50	19050	123,000
Total Damages ($)	29	11150	2800	50	70000	561,000

Total Identified Residential Properties: 75 Self-Administered Assessment Respondents: 39



MANISTEE COUNTY

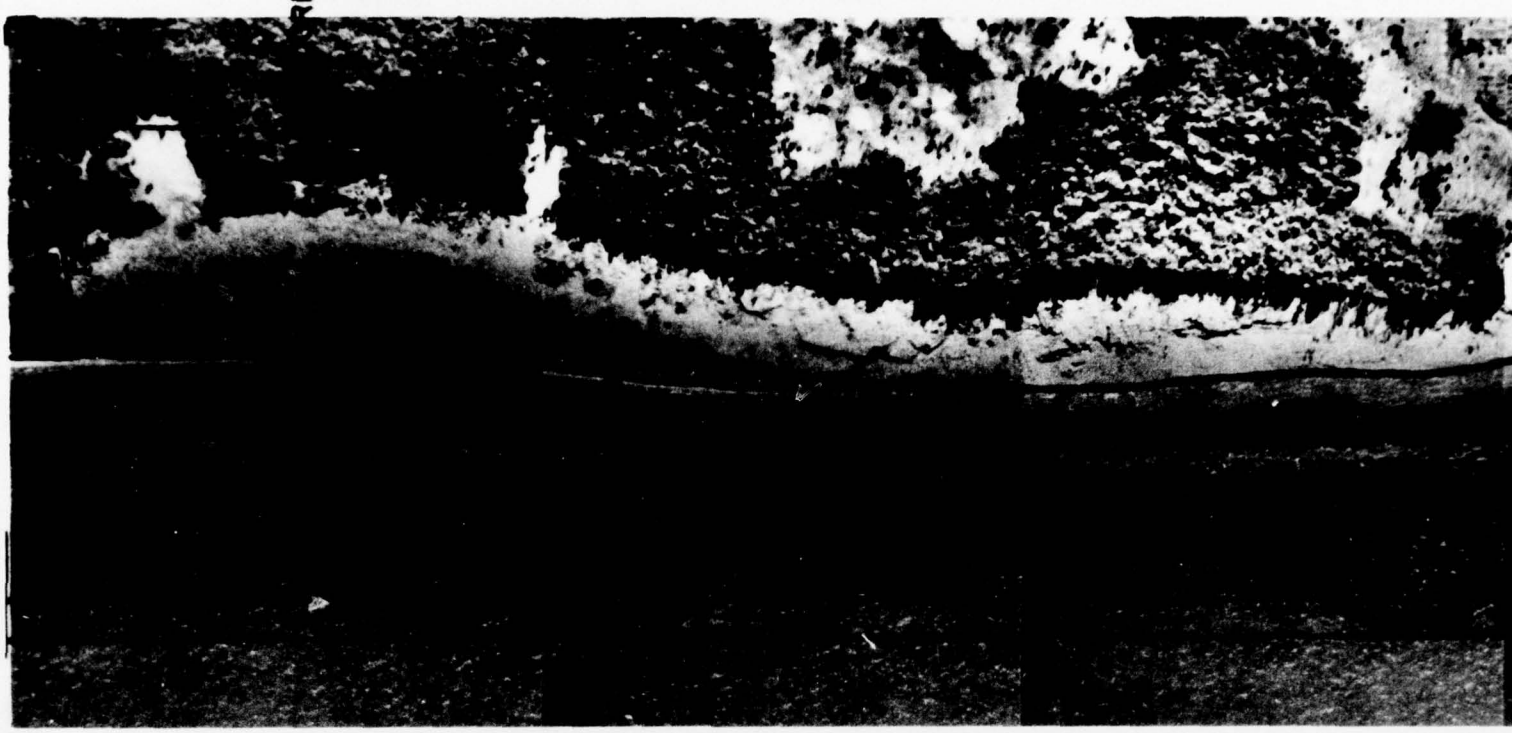
PILOT DAMAGE STUDY, 1975
PLATE NO. 11
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



MANISTEE COUNTY

PLOT DAMAGE STUDY, 1975
PLATE NO. 12
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



MANISTEE COUNTY, MICHIGAN REACH #8

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	11	6000	1400	1800	15300	
Reported Market Value ($)	5	31800	12300	3000	70000	
Bluff Height (Ft.)	10	26	4	10	40	
Beach Depth (Ft.)	8	23	7	6	60	
Bluff Lost (Ft.)	10	31	7	5	75	
Beach Lost (Ft.)	8	96	33	10	300	
Damages Erosion ($)	9	8950	2900	100	27300	
Damages Flooding ($)	1	4500		4500	4500	
Damages - Erosion and Flooding ($)						194,000
Protective Structure Cost ($)	7	12050	4450	200	32600	175,000
Total Damages ($)	11	15400	4400	600	47900	369,000

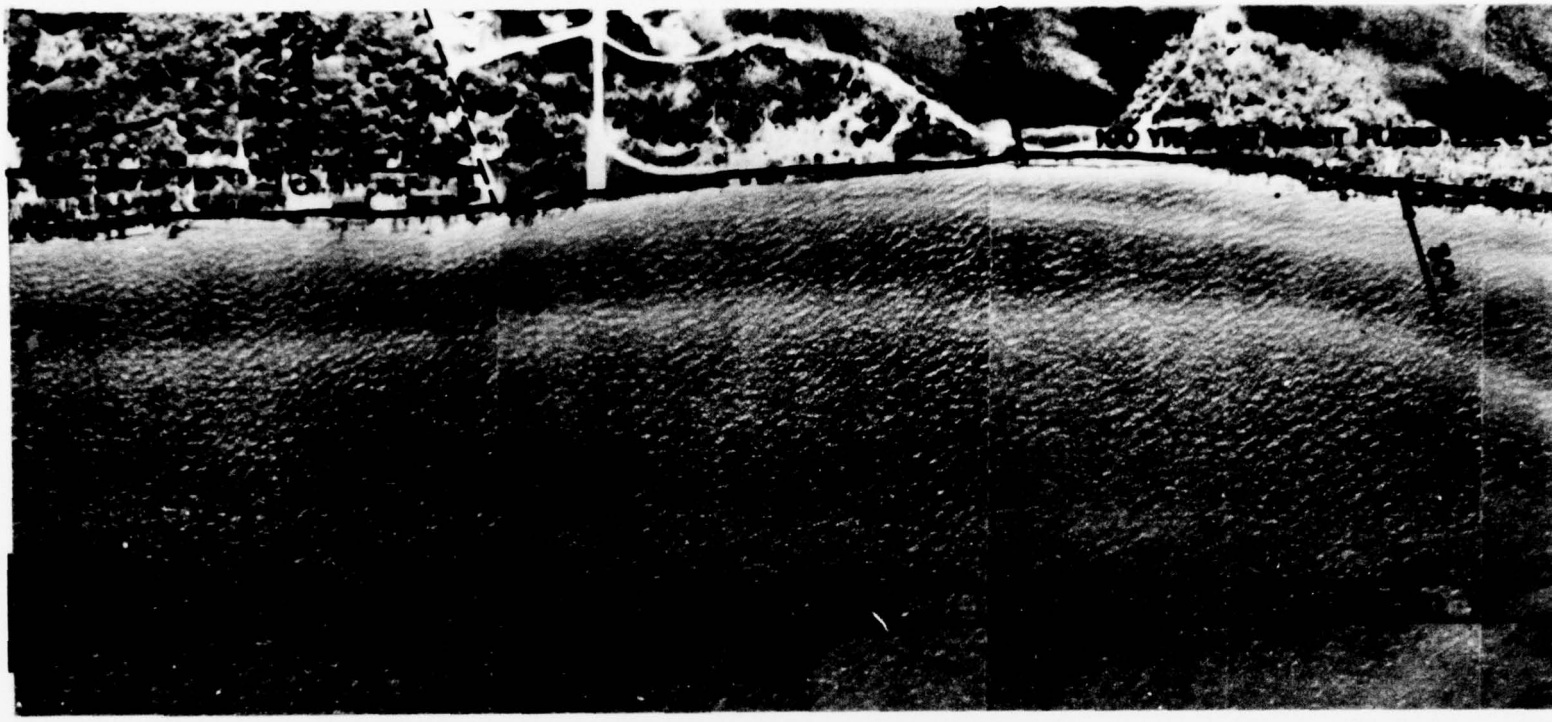
Total Identified Residential Properties: 33 Self-Administered Assessment Respondents: 11

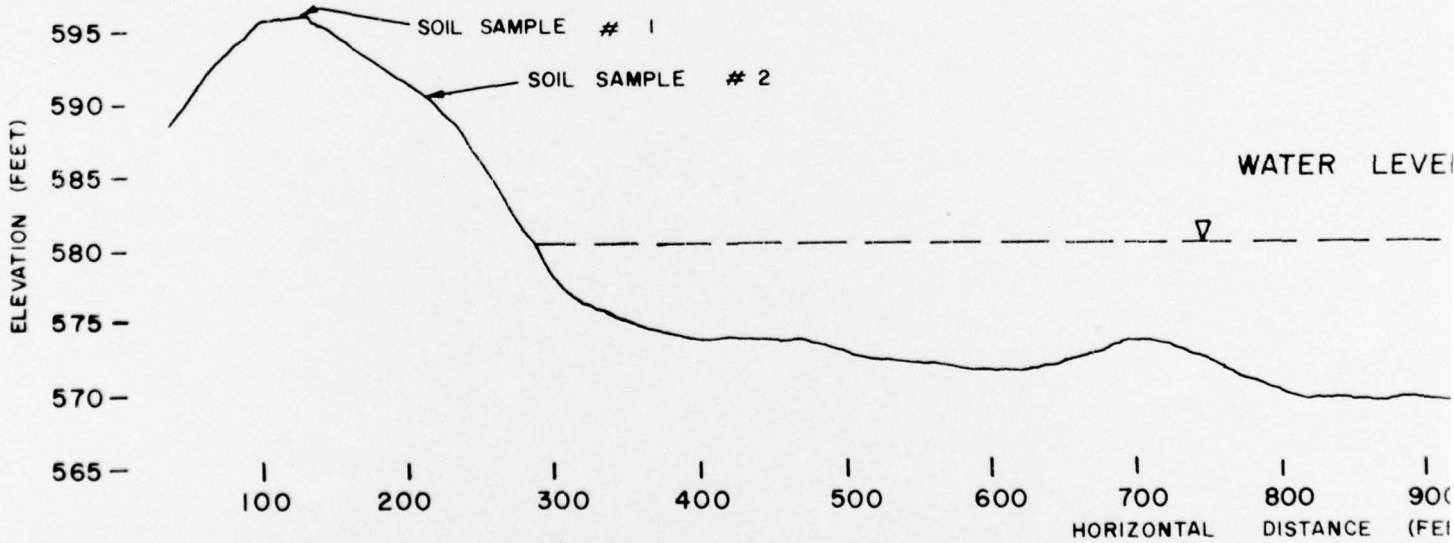


MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 13
SCALE: 1" = 5'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

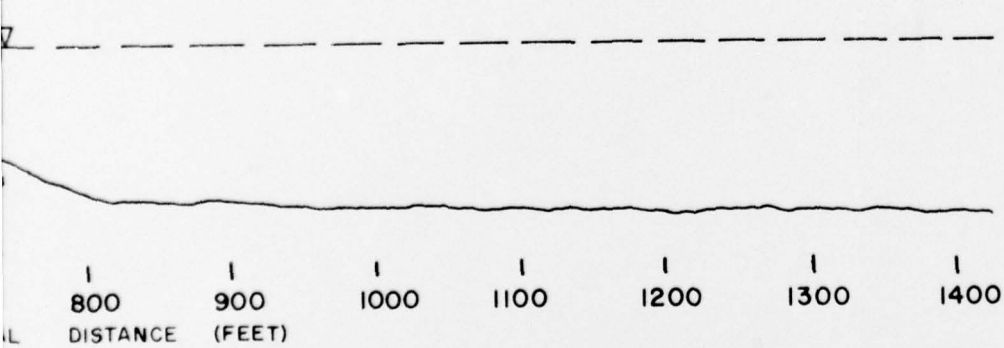



595
590
585
580
575
570
565
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
WATER LEVE
100
200
300
400
500
600
700
800
HORIZONTAL
DISTANCE



MANISTEE PROFILE # 2

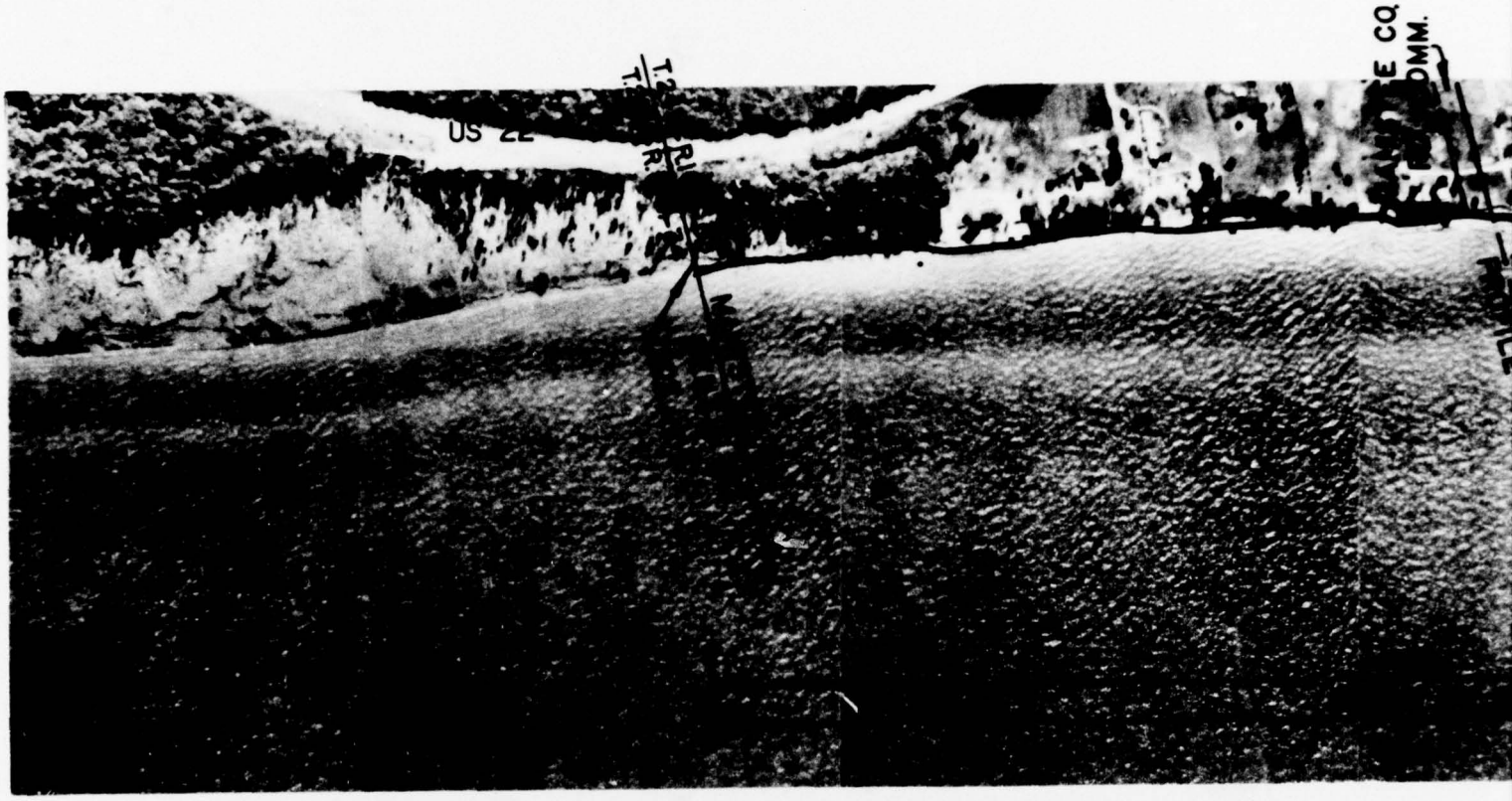
WATER LEVEL - MAY 11, 1975

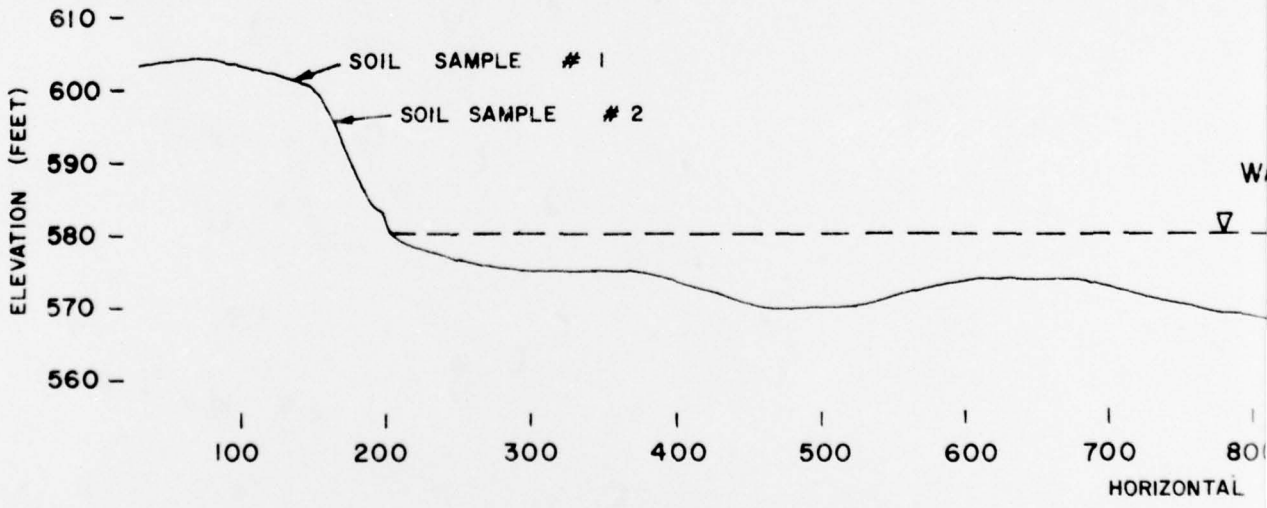


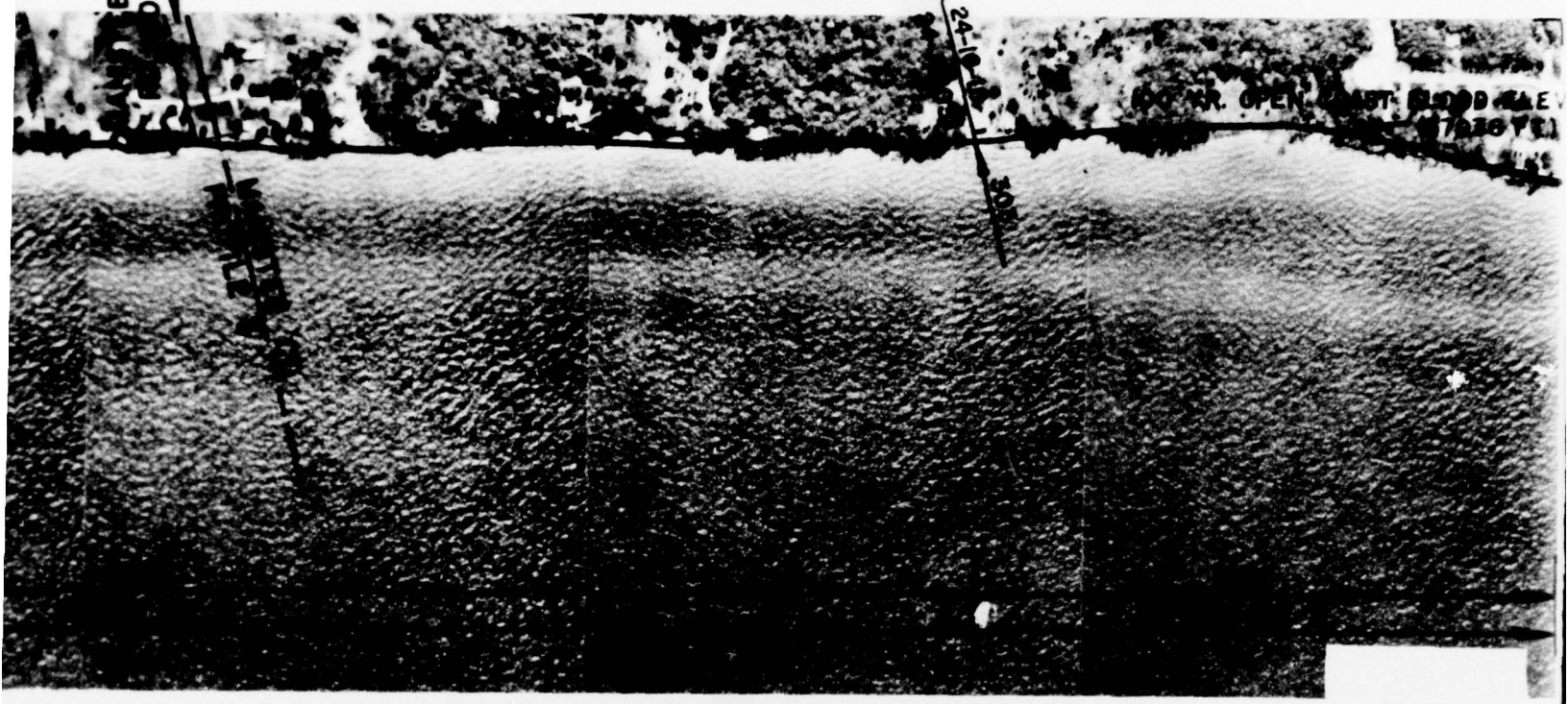
MANISTEE COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 14
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

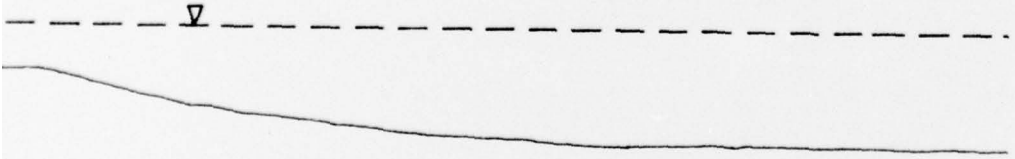

US 22


610
600
590
580
570
560
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
100
200
300
400
500
600
700
HORIZONTAL



MANISTEE PROFILE # 3

WATER LEVEL – MAY 11, 1975

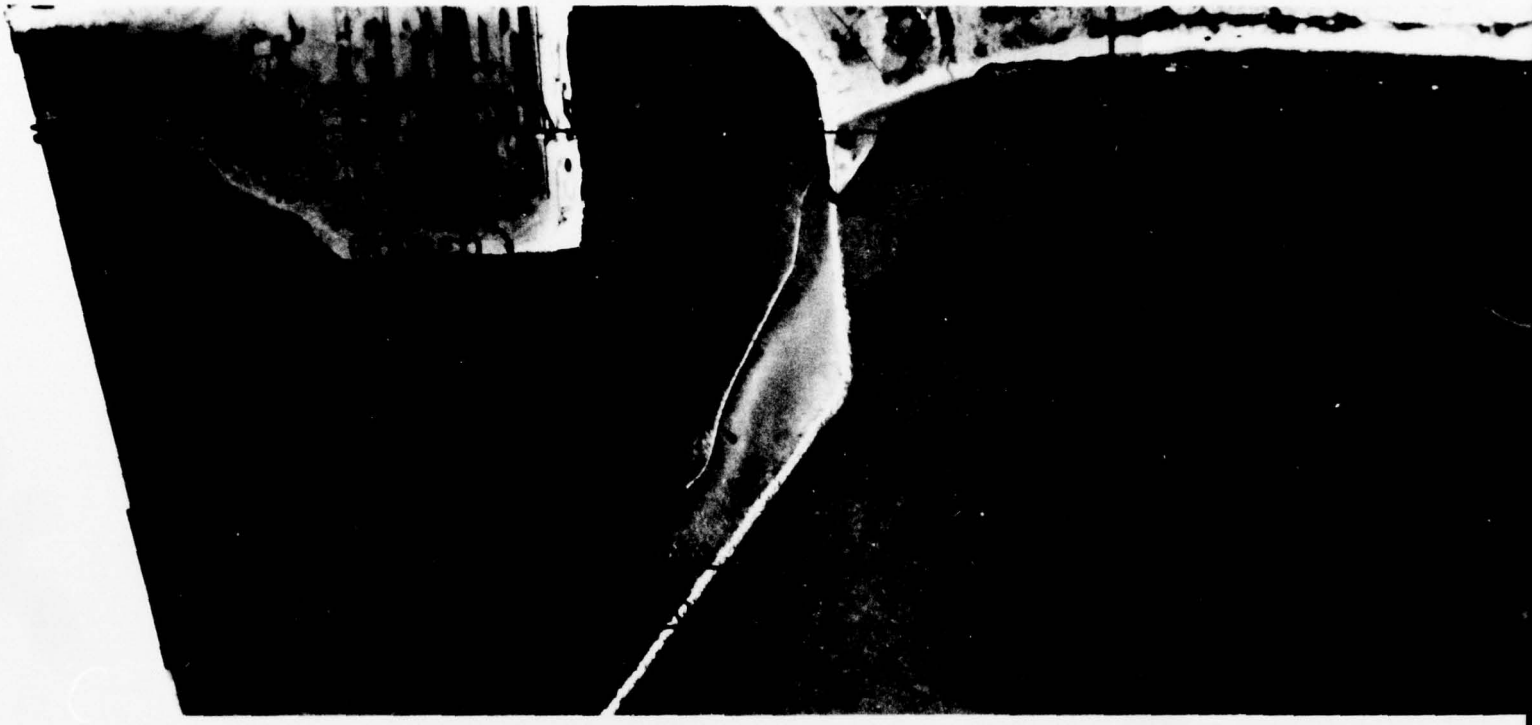


700 800 900 1000 1100 1200 1300 1400 1500 1600 1700

HORIZONTAL DISTANCE (FEET)

MANISTEE COUNTY

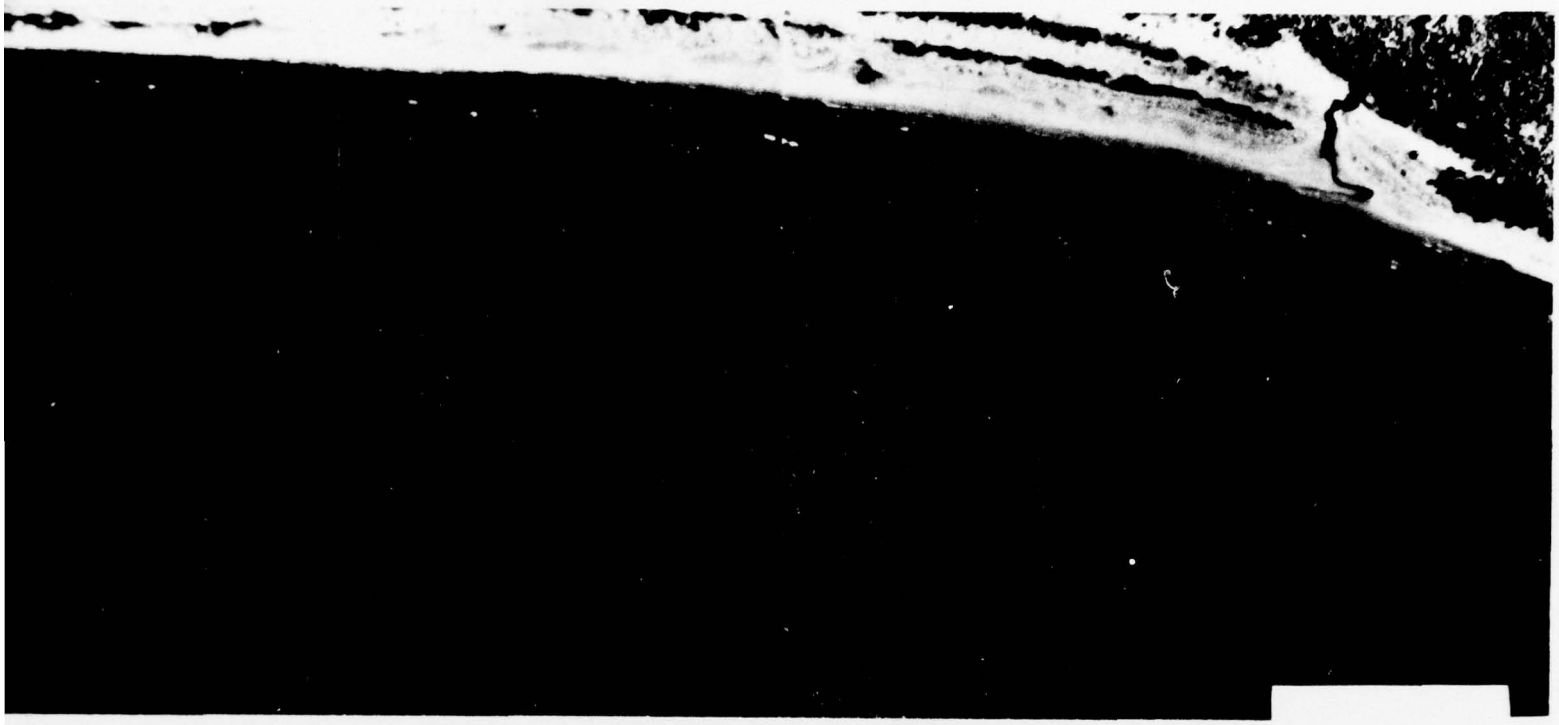
PILOT DAMAGE STUDY, 1975
PLATE NO. 15
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



SCHOOLCRAFT COUNTY, MICHIGAN REACH #1

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	49	8300	2300	250	116500	
Reported Market Value ($)	22	19700	3000	1000	60000	
Bluff Height (Ft.)	17	10	2	1	20	
Beach Depth (Ft.)	8	14	3	8	25	
Bluff Lost (Ft.)	10	31	13	1	99	
Beach Lost (Ft.)	13	51	14	2	130	
Damages Erosion ($)	7	4000	1650	100	10000	
Damages Flooding ($)	4	650	100	400	1000	
Damages - Erosion and Flooding ($)						67,000
Protective Structure Cost ($)	4	800	450	100	2100	8,000
Total Damages ($)	10	3400	1200	200	10000	75,000

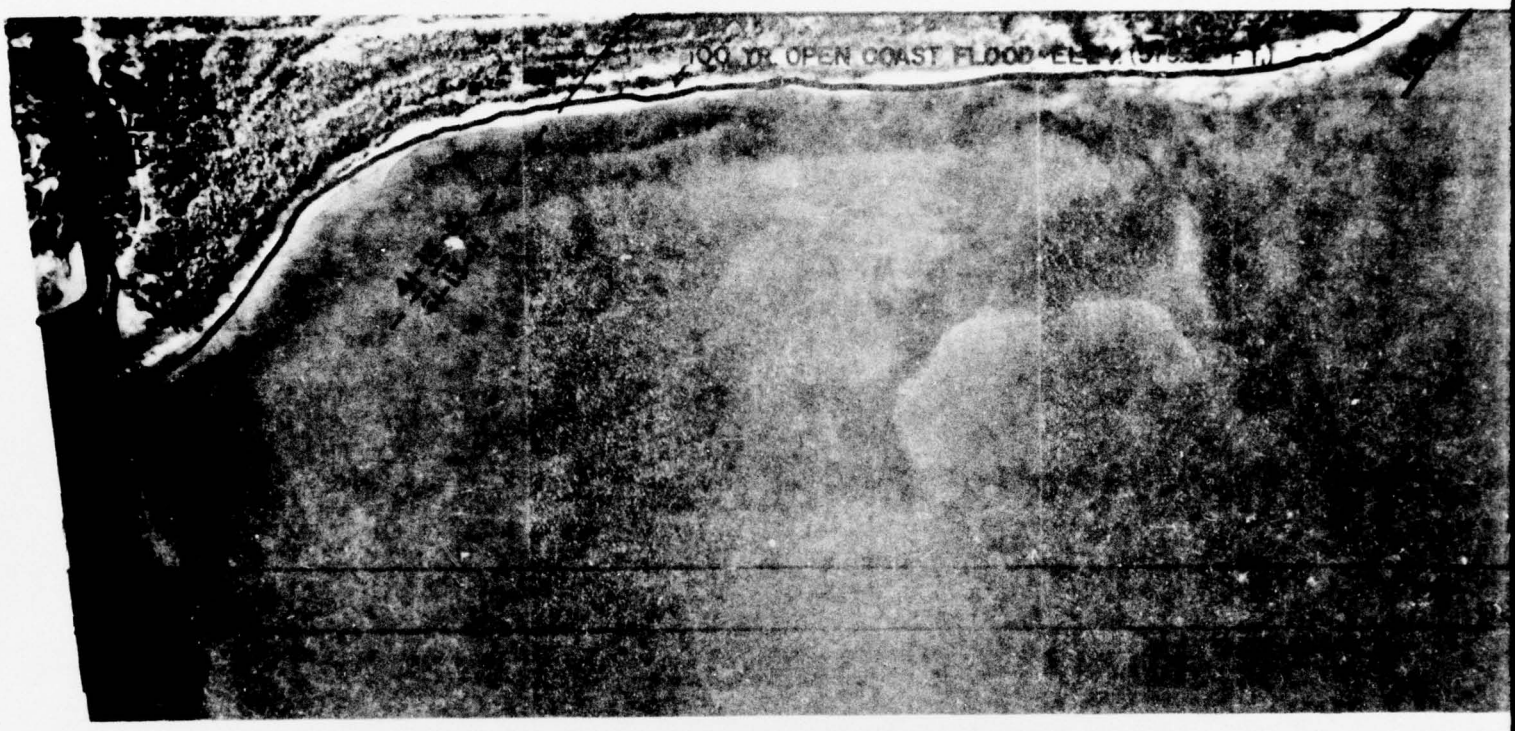
Total Identified Residential Properties: 123 Self-Administered Assessment Respondents: 47

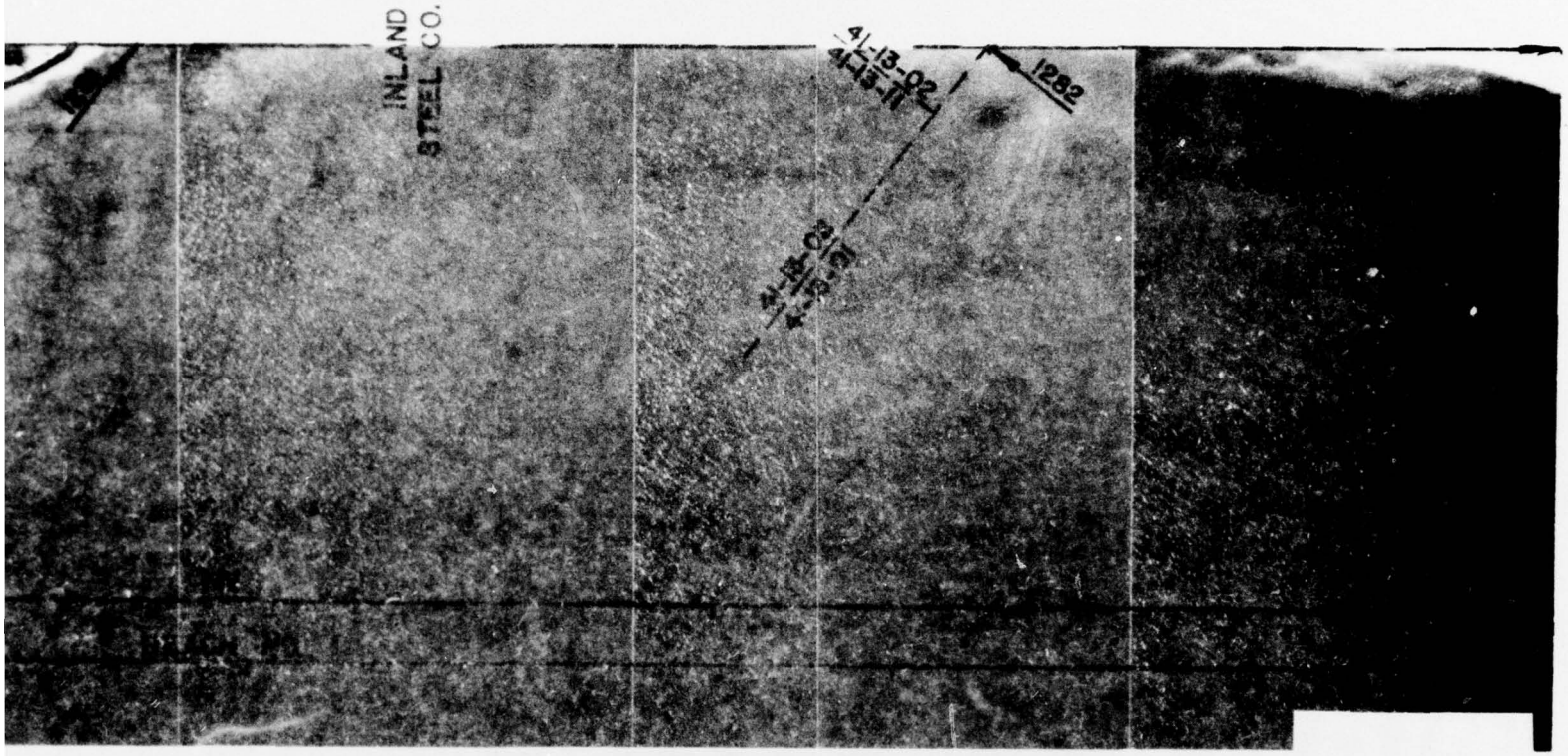


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 1
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2

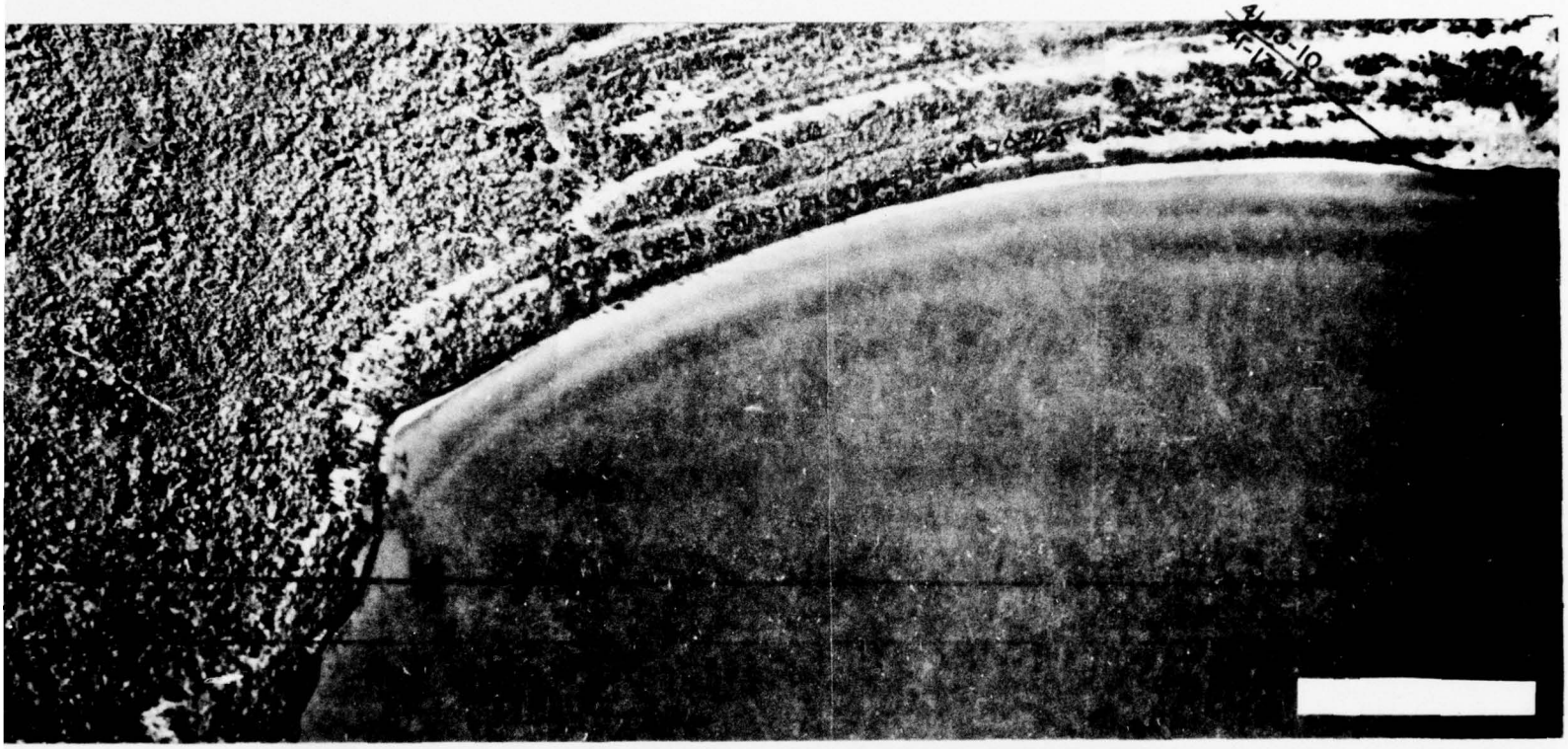

100 YR OPEN COAST FLOOD



SCHOOLCRAFT COUNTY

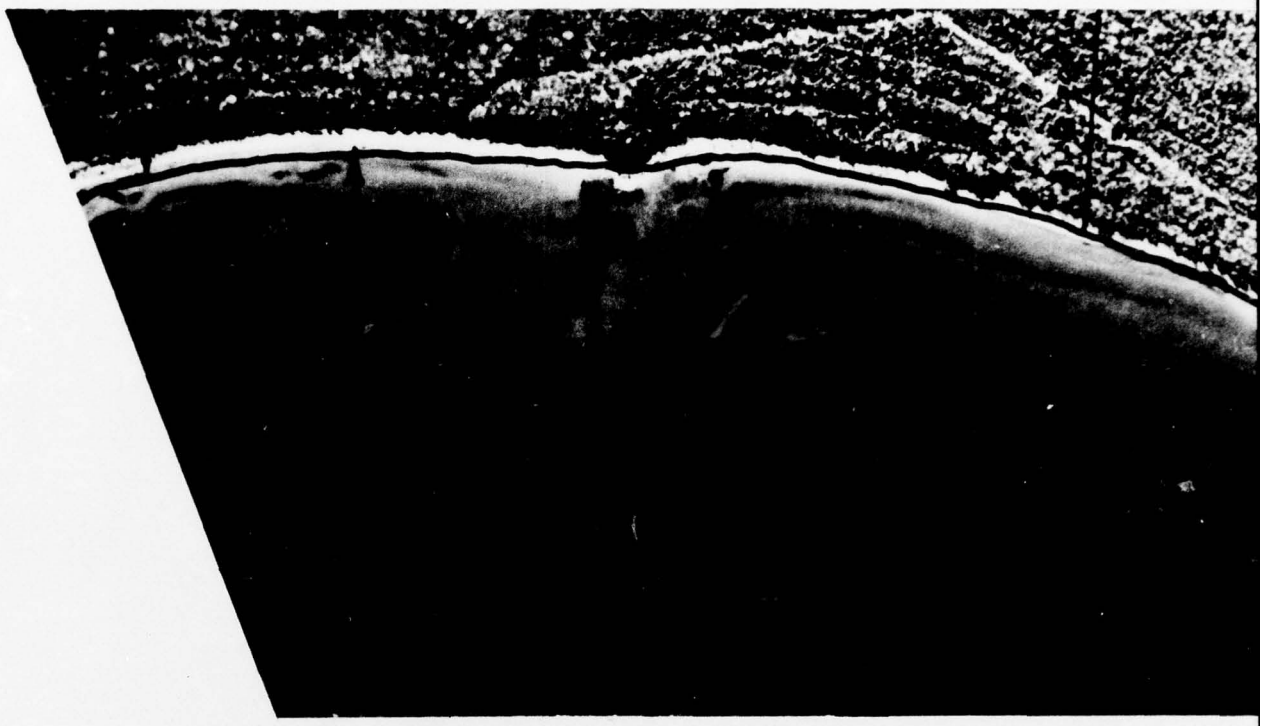
PILOT DAMAGE STUDY, 1975
PLATE NO. 2
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

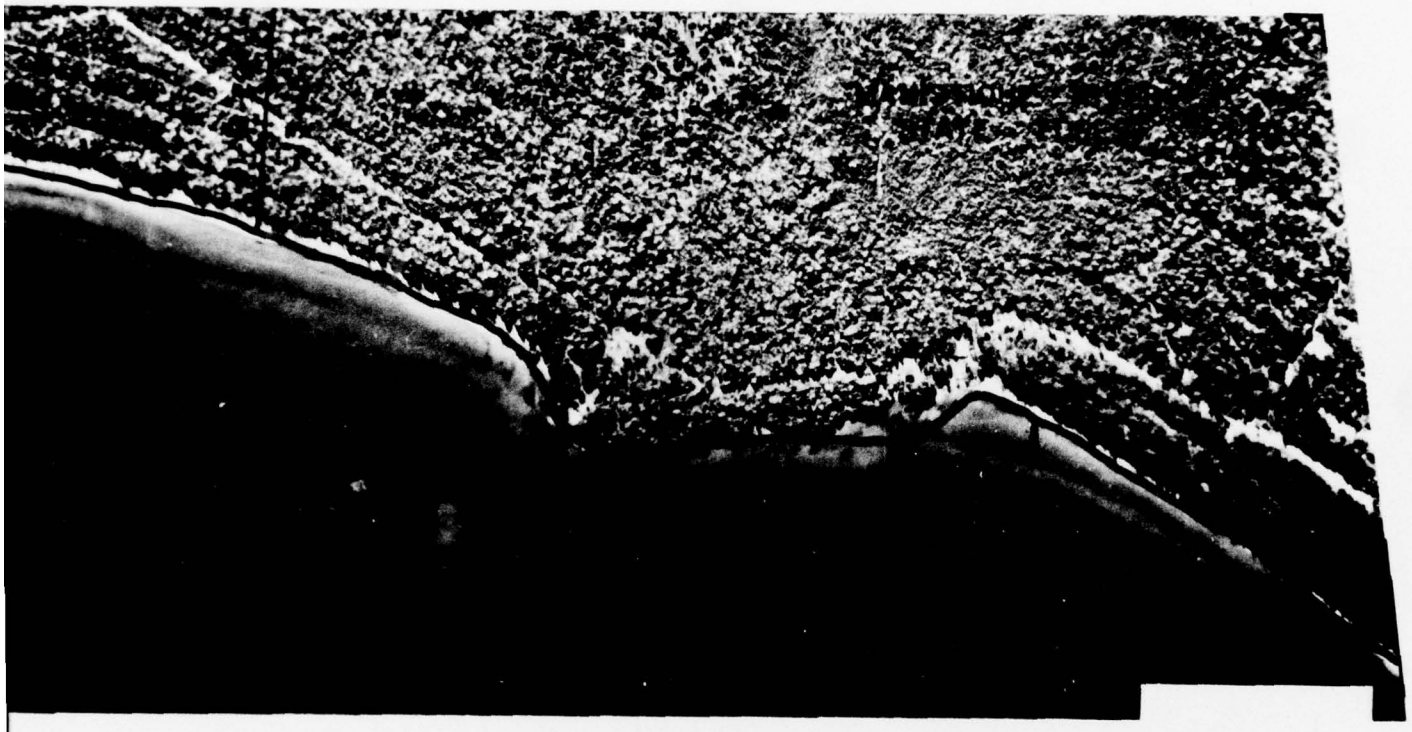




SCHOOLCRAFT COUNTY

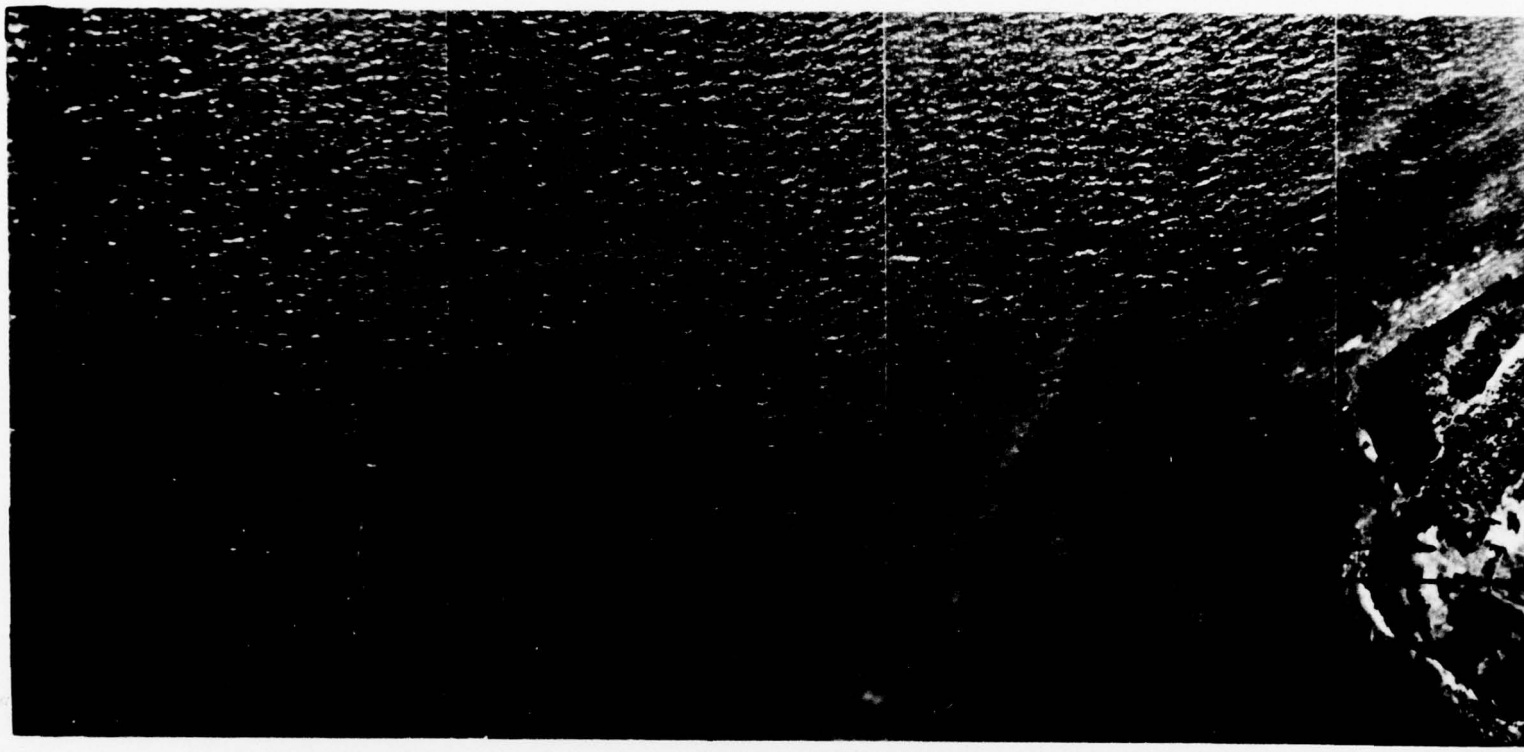
PILOT DAMAGE STUDY, 1975
PLATE NO. 3
SCALE: 1" = 5'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN





SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 4
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

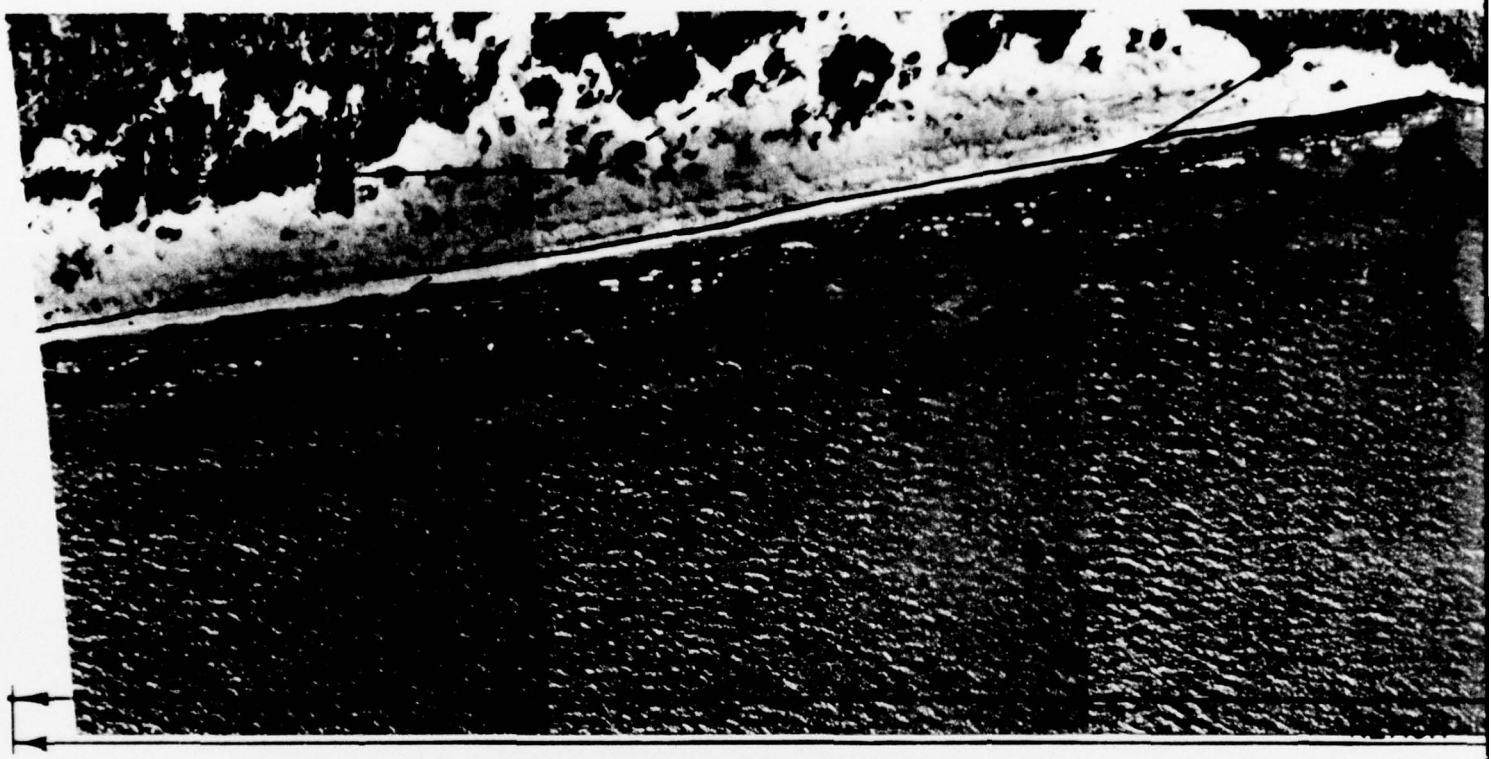


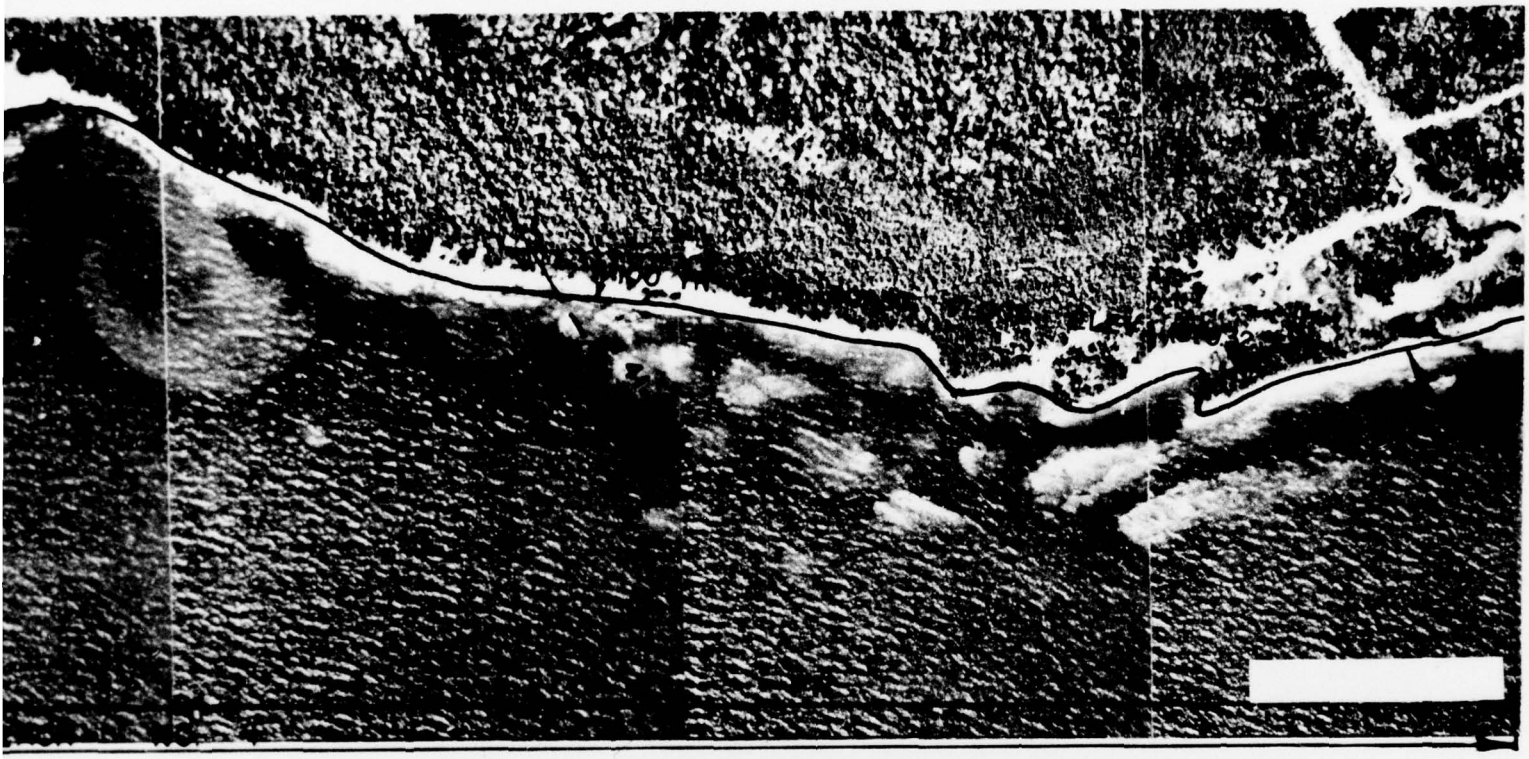


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 5
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

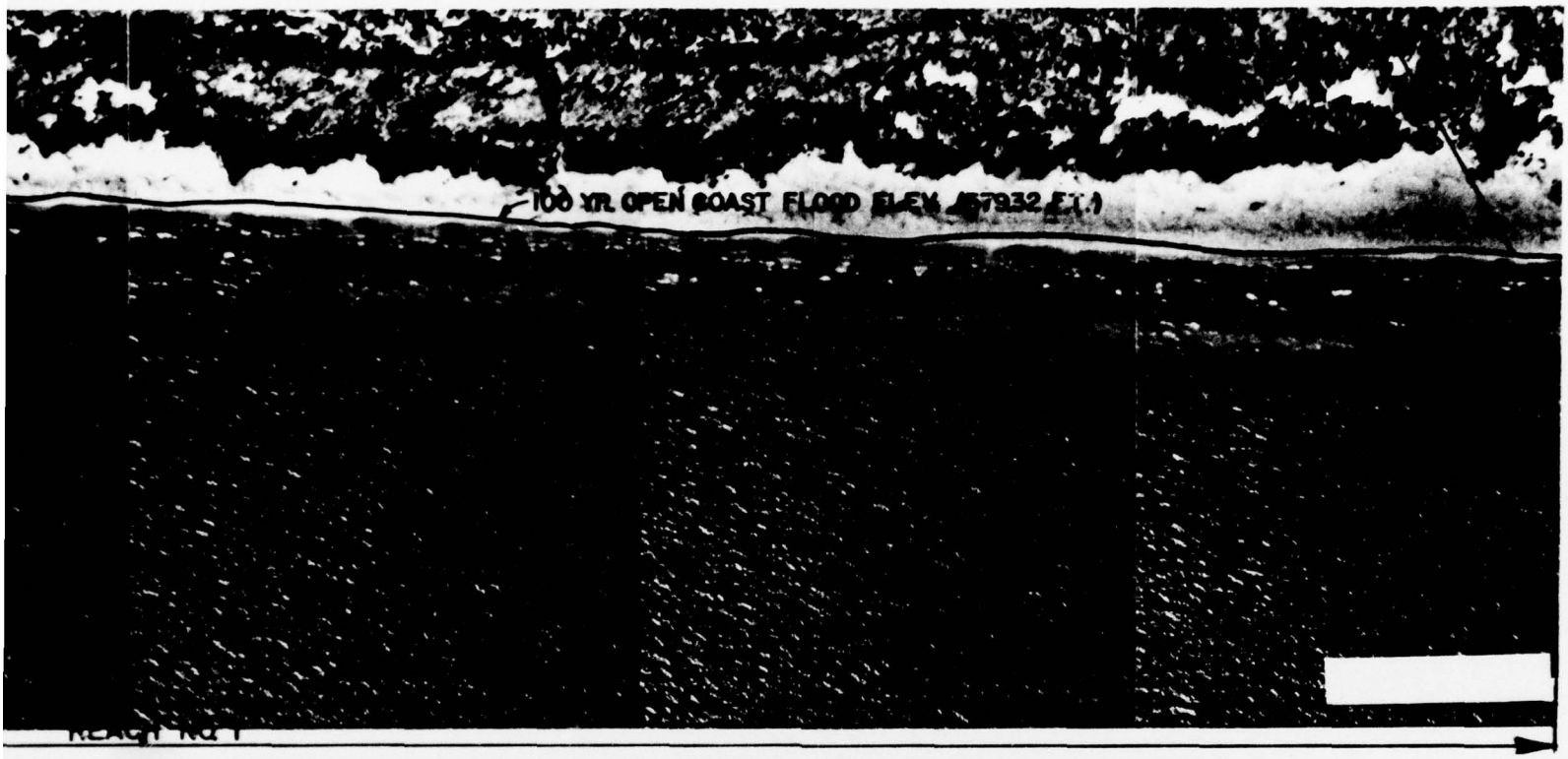






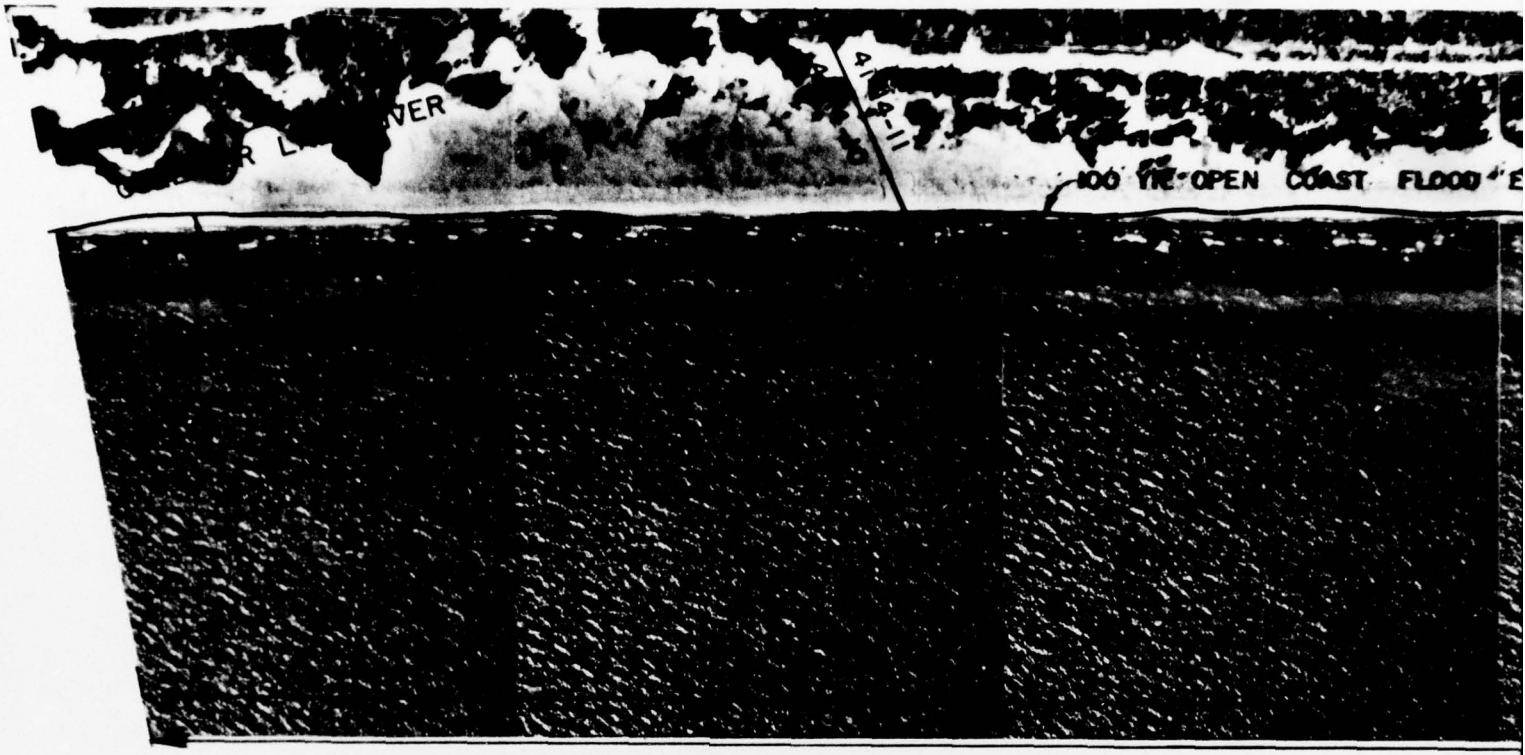
SCHOOLCRAFT COUNTY

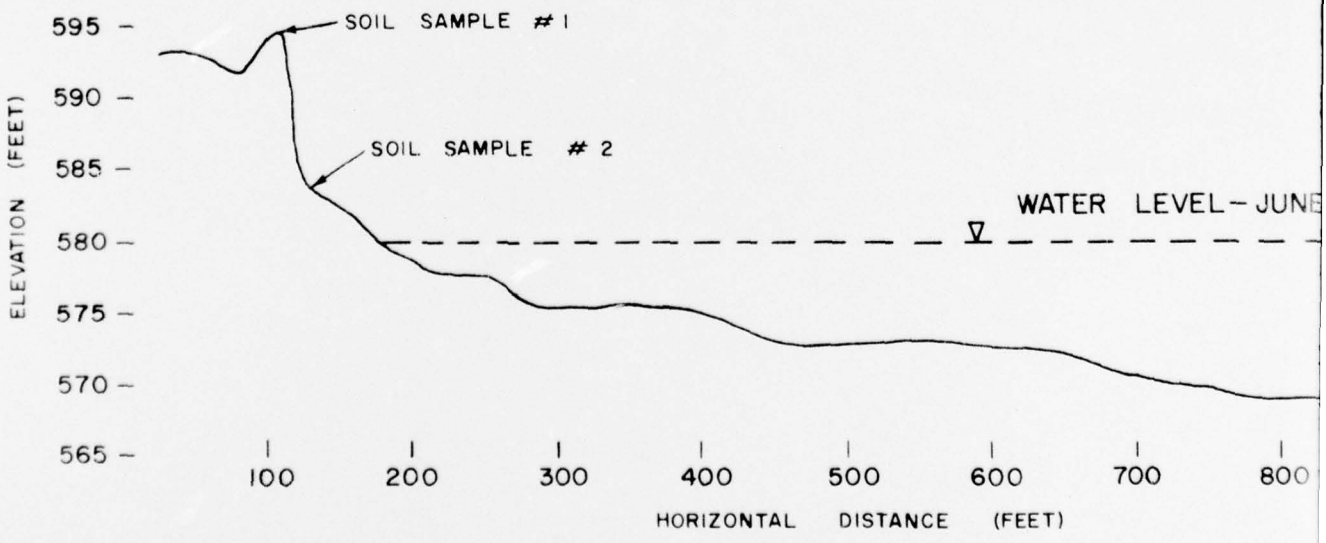
PILOT DAMAGE STUDY, 1975
PLATE NO. 7
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

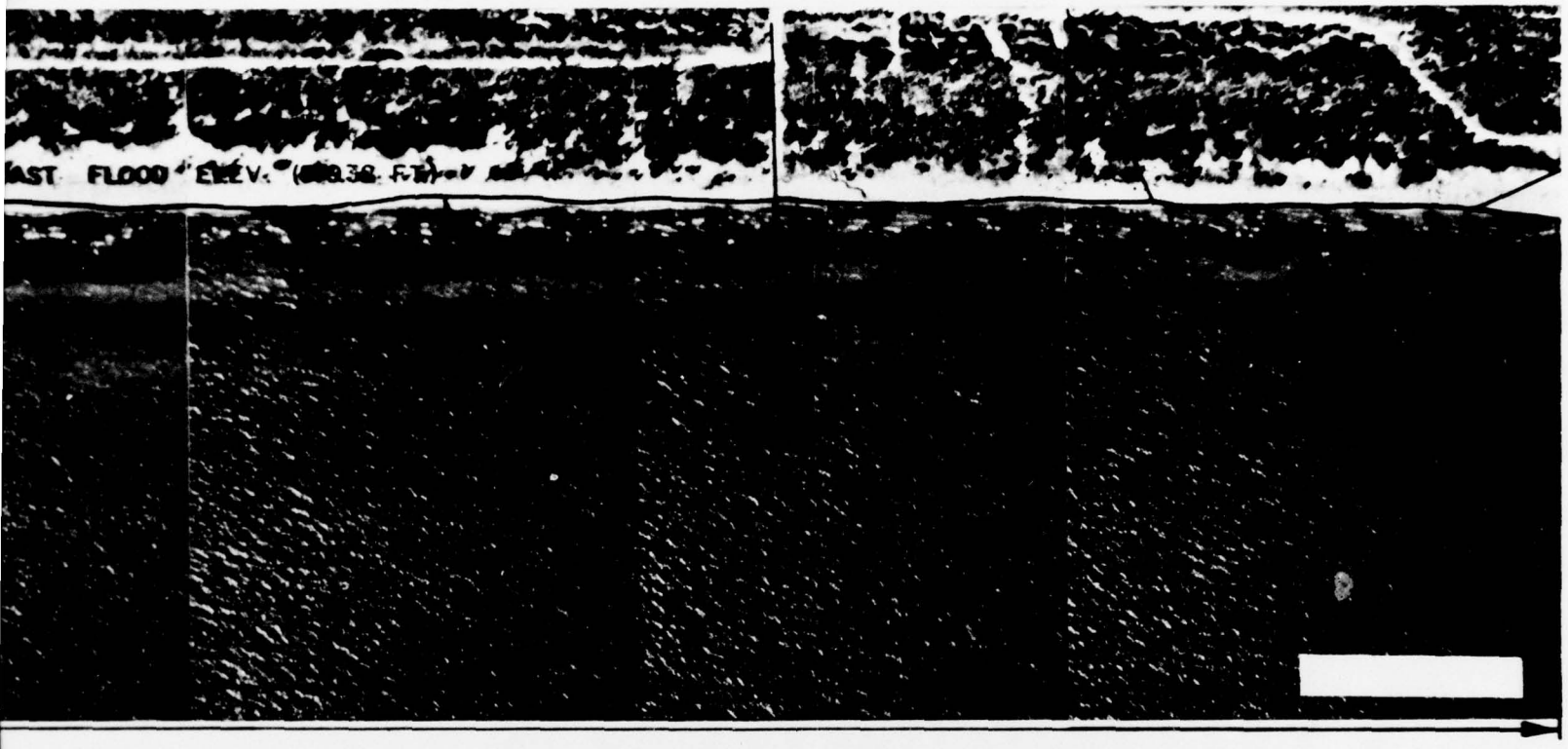


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 8
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

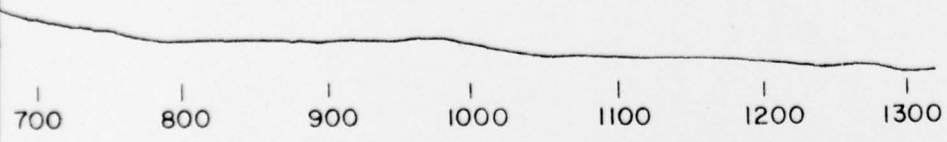

100 YR. OPEN COAST FLOOD


595
590
585
580
575
570
565
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
WATER LEVEL – JUNE
100
200
300
400
500
600
700
800
HORIZONTAL DISTANCE (FEET)



SCHOOLCRAFT PROFILE # 1

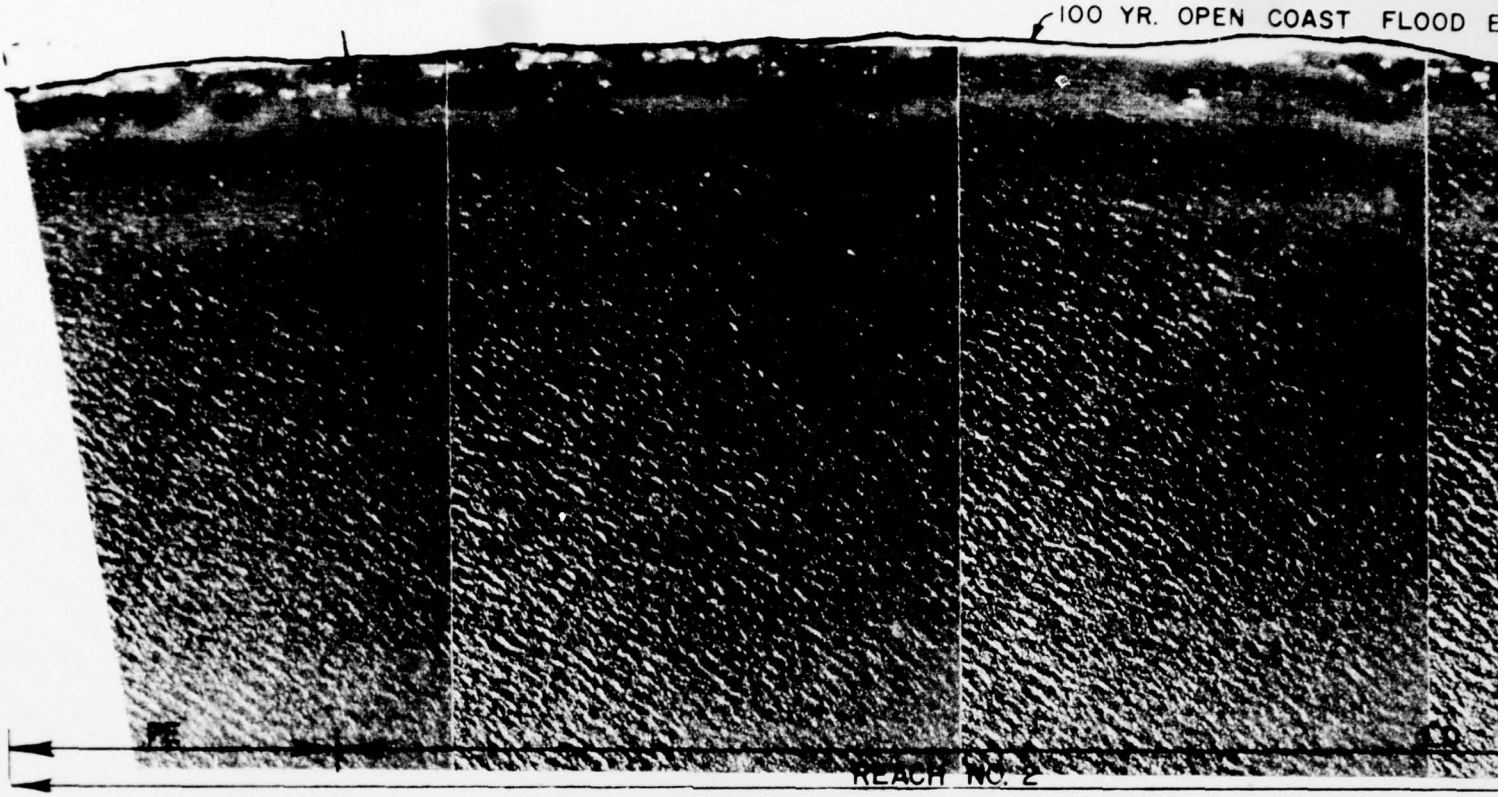
LEVEL - JUNE 11, 1975



SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 9
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

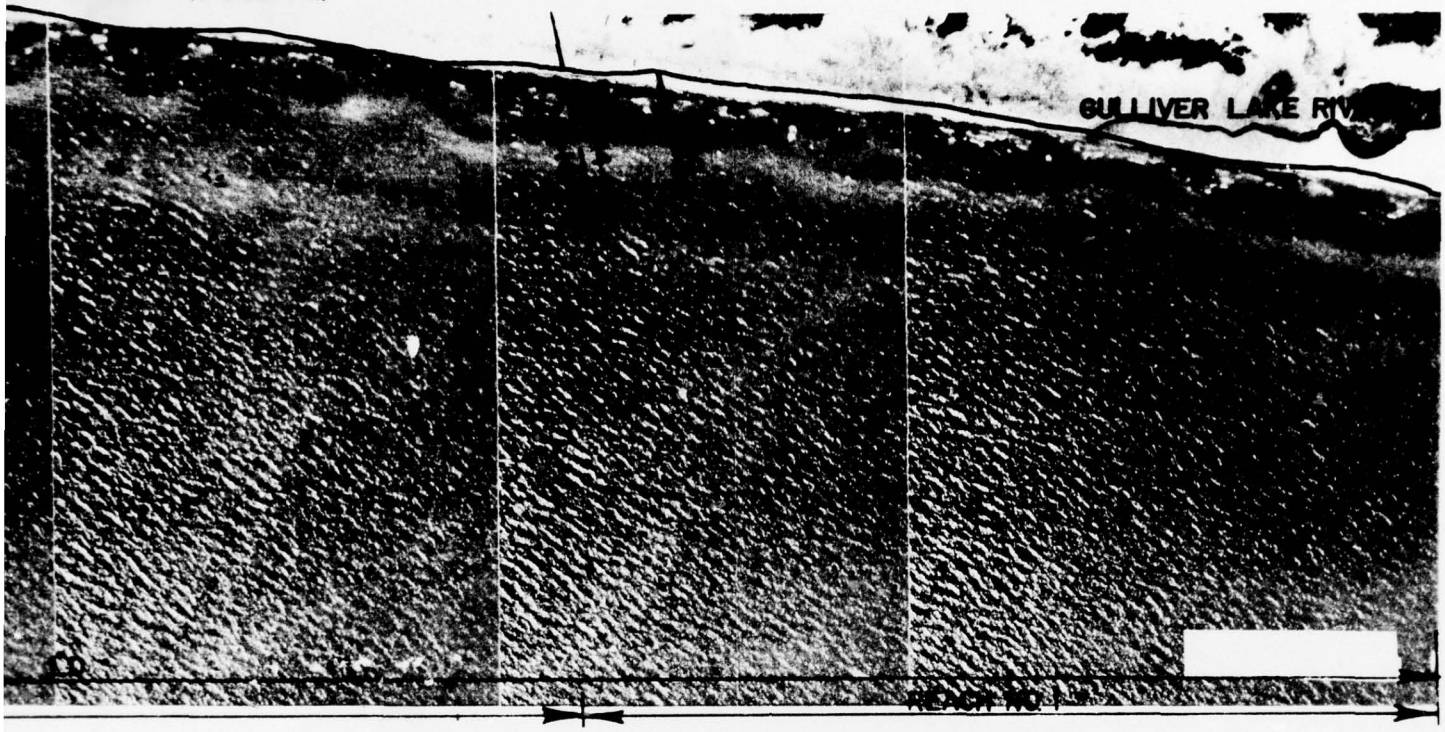
2



SCHOOLCRAFT COUNTY, MICHIGAN REACH #2

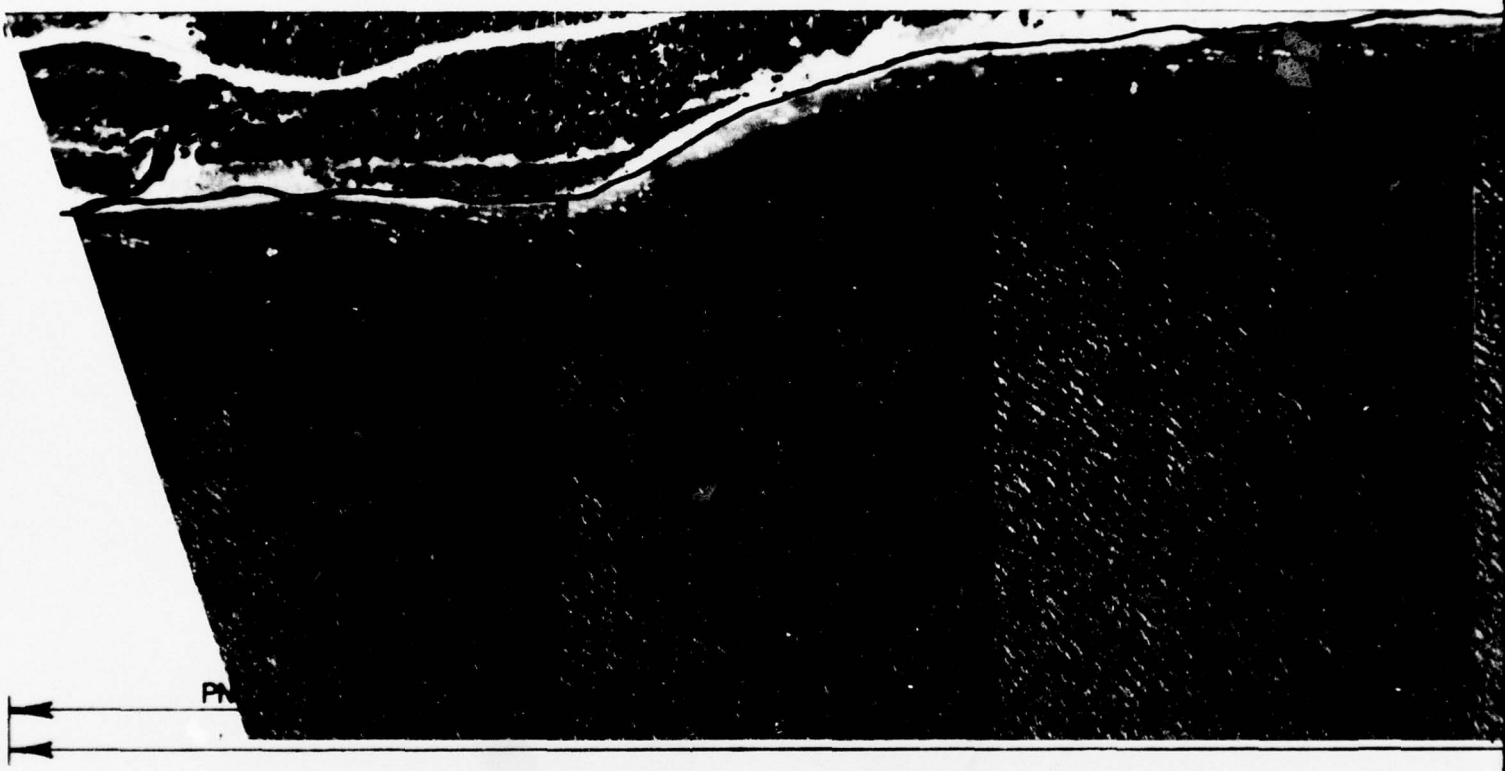
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	46	6000	3400	1000	157500	
Reported Market Value ($)	38	17700	5600	1400	220000	
Bluff Height (Ft.)	11	14	4	5	50	
Beach Depth (Ft.)	9	22	5	5	50	
Bluff Lost (Ft.)	7	17	8	5	63	
Beach Lost (Ft.)	10	47	8	15	88	
Damages Erosion ($)	5	1350	500	250	3000	
Damages Flooding ($)	2	850	150	700	1000	
Damages - Erosion and Flooding ($)						40,000
Protective Structure Cost ($)	2	1500	1250	250	2700	11,000
Total Damages ($)	7	1650	700	250	5700	51,000

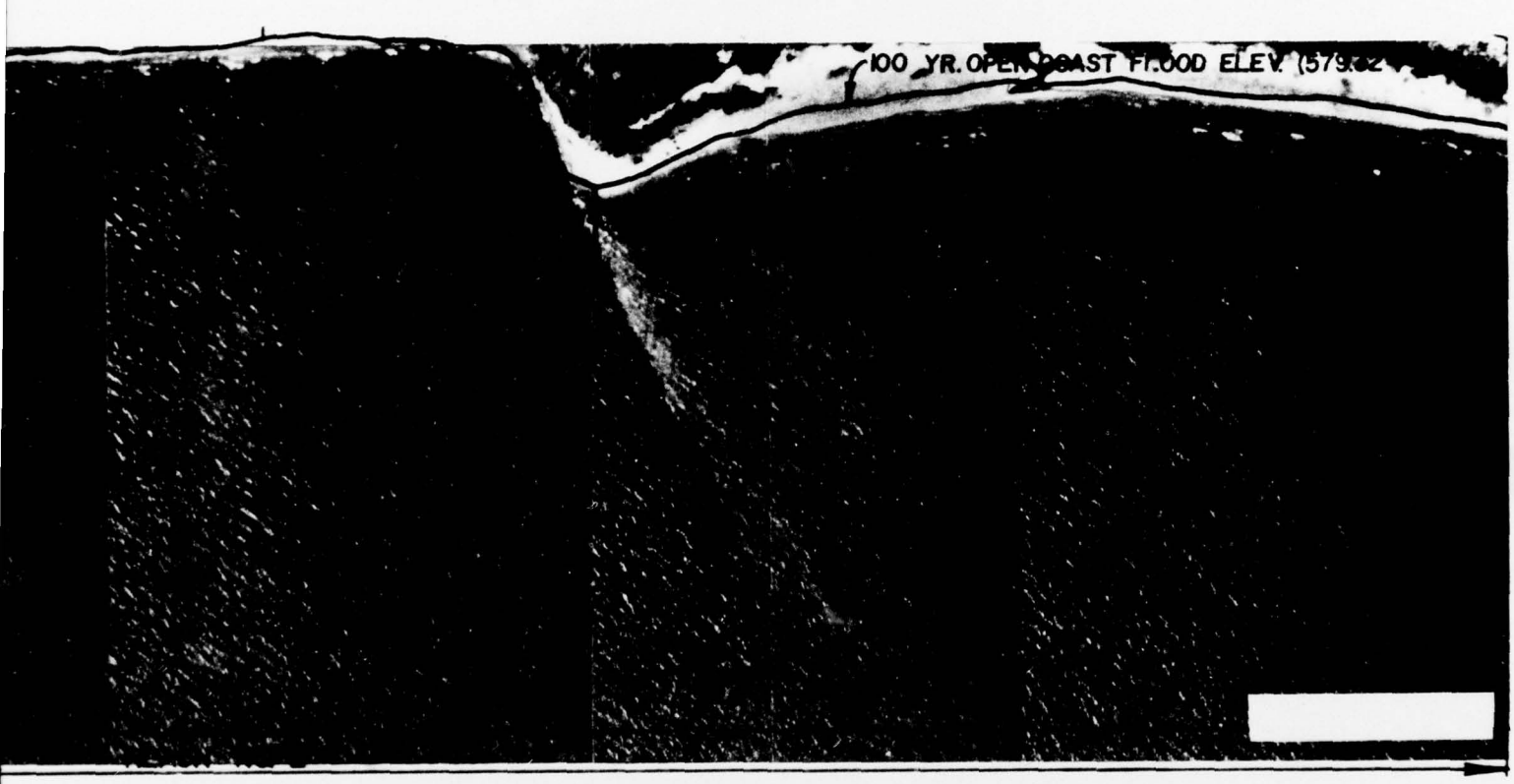
Total Identified Residential Properties: 186 Self-Administered Assessment Respondents: 46



SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 10
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

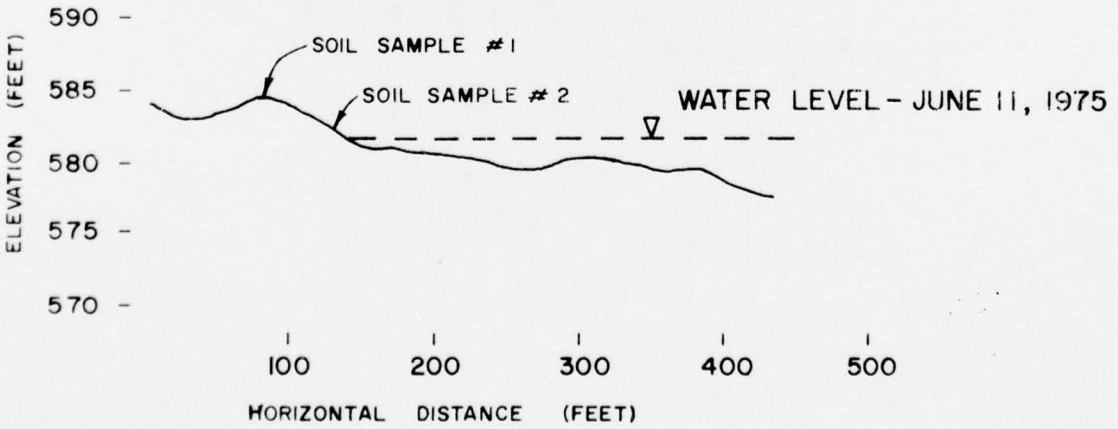

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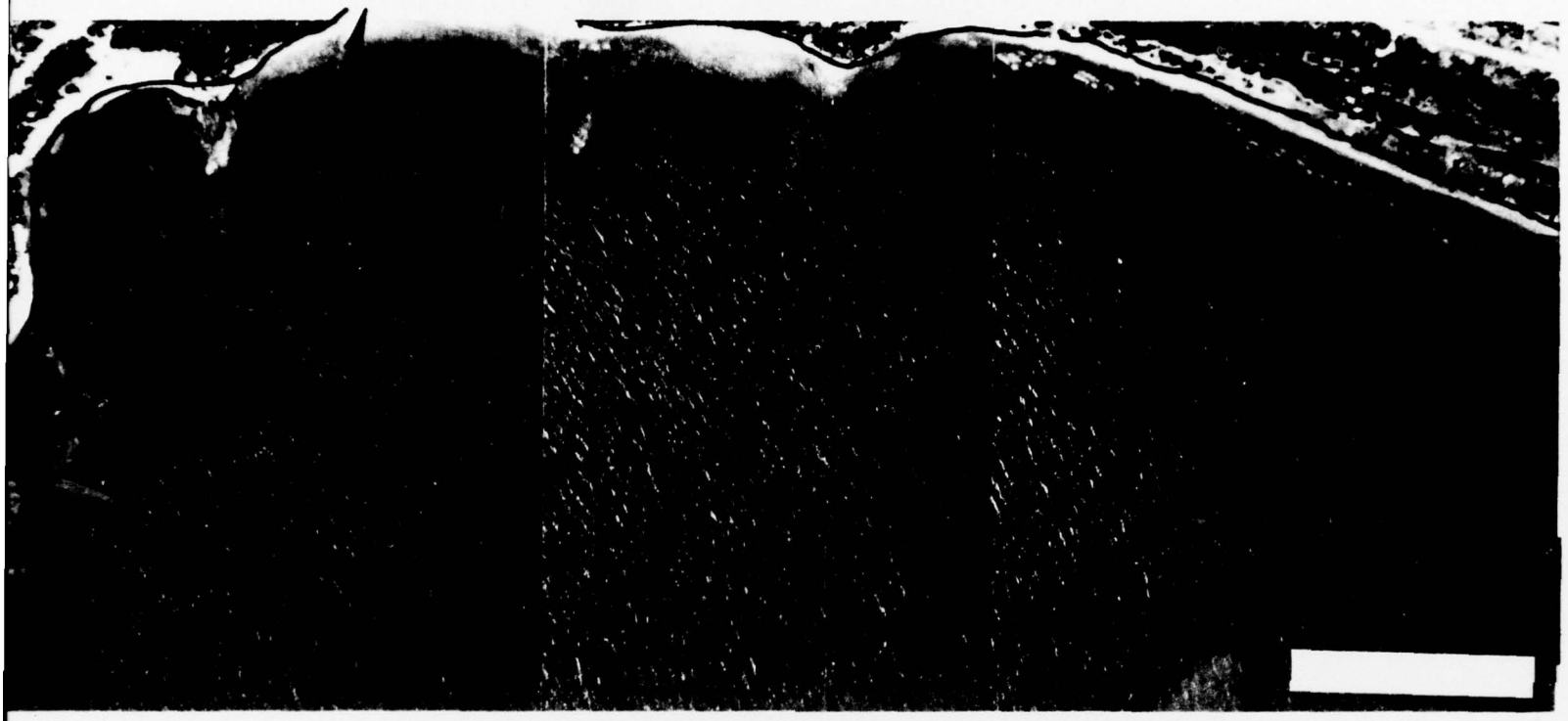


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 11
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



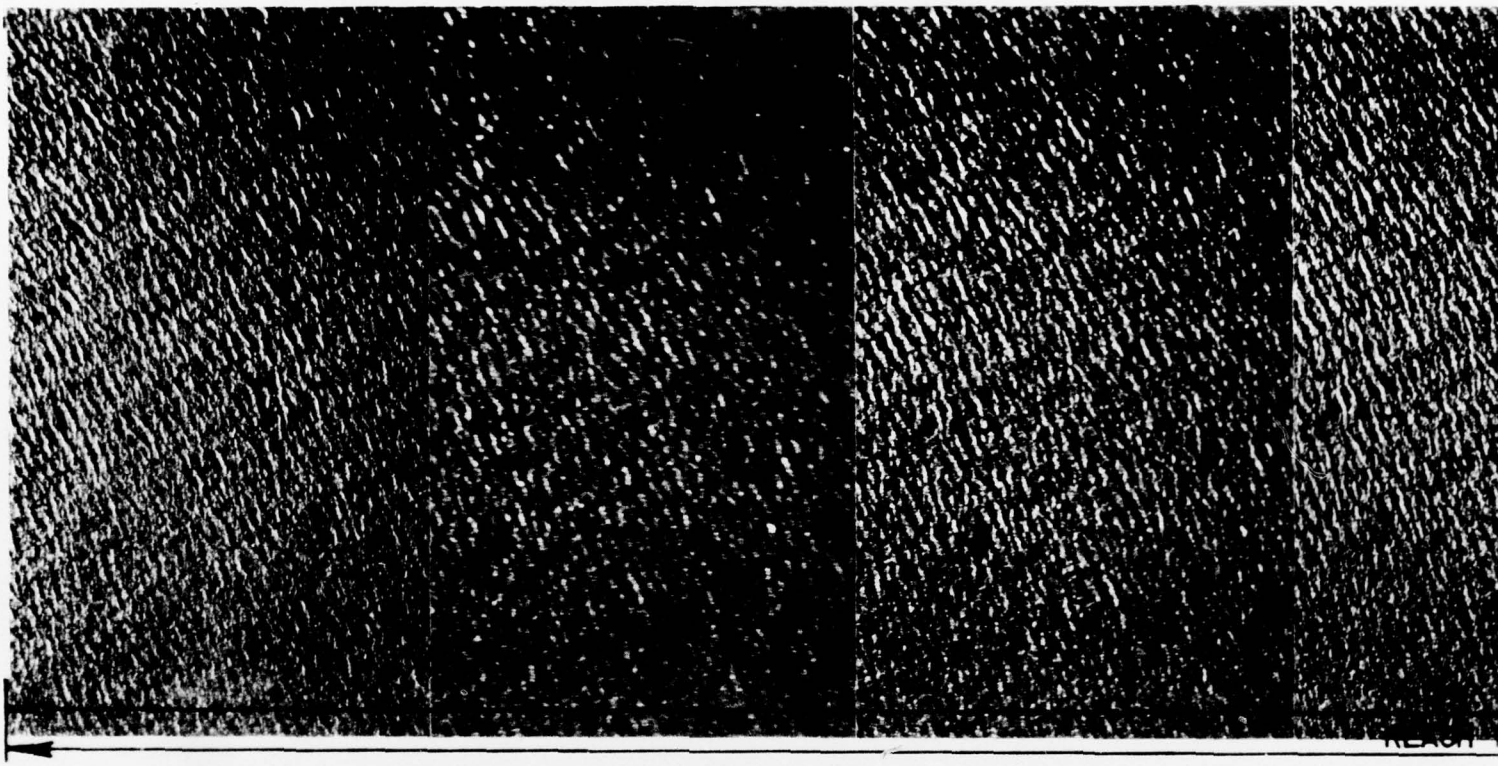

590
585
580
575
570
ELEVATION (FEET)
SOIL SAMPLE # 1
SOIL SAMPLE # 2
WATER LEVEL - JUNE 11, 1975
100
200
300
400
500
HORIZONTAL DISTANCE (FEET)

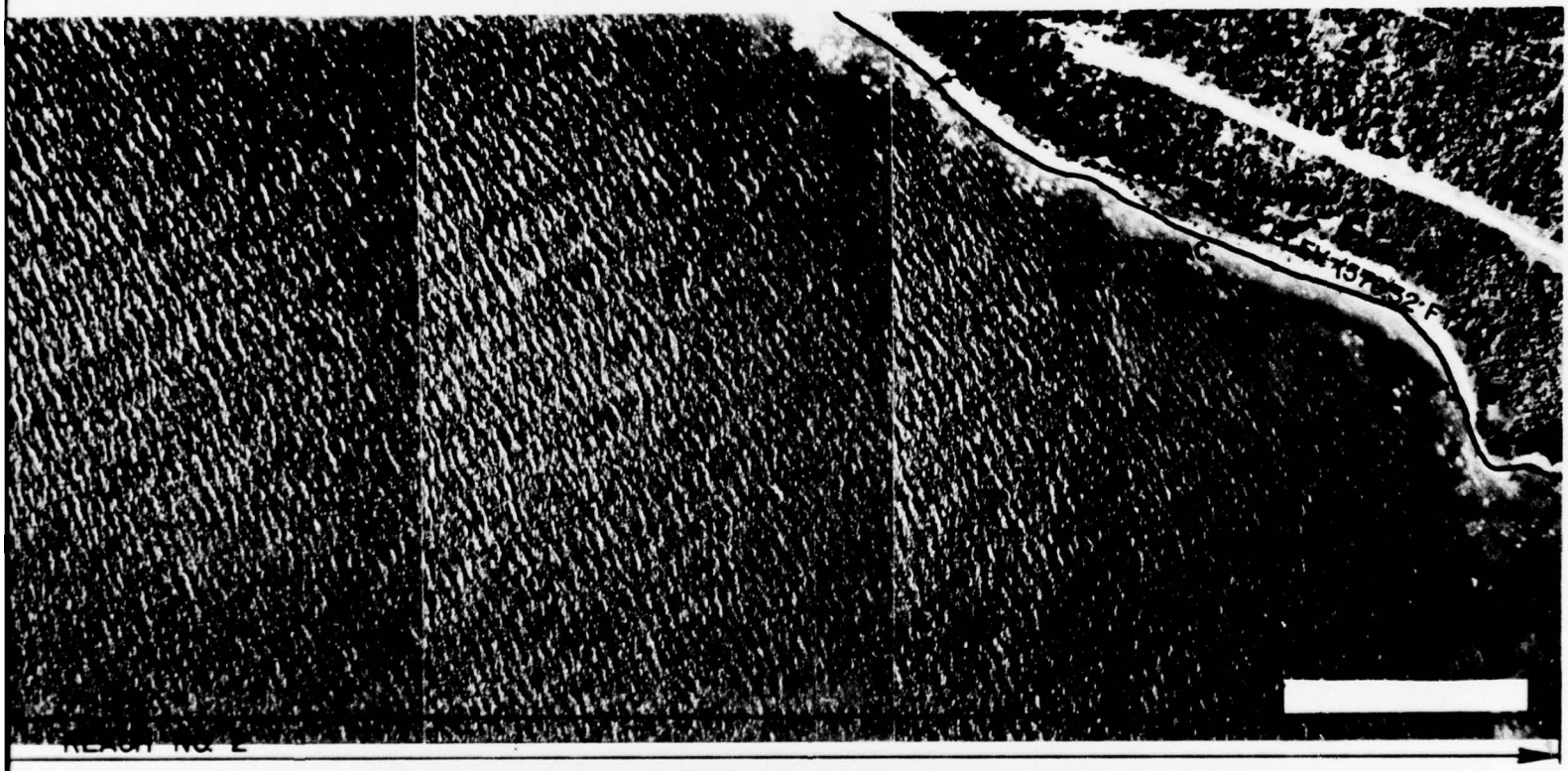


SCHOOLCRAFT PROFILE # 2

SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 12
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

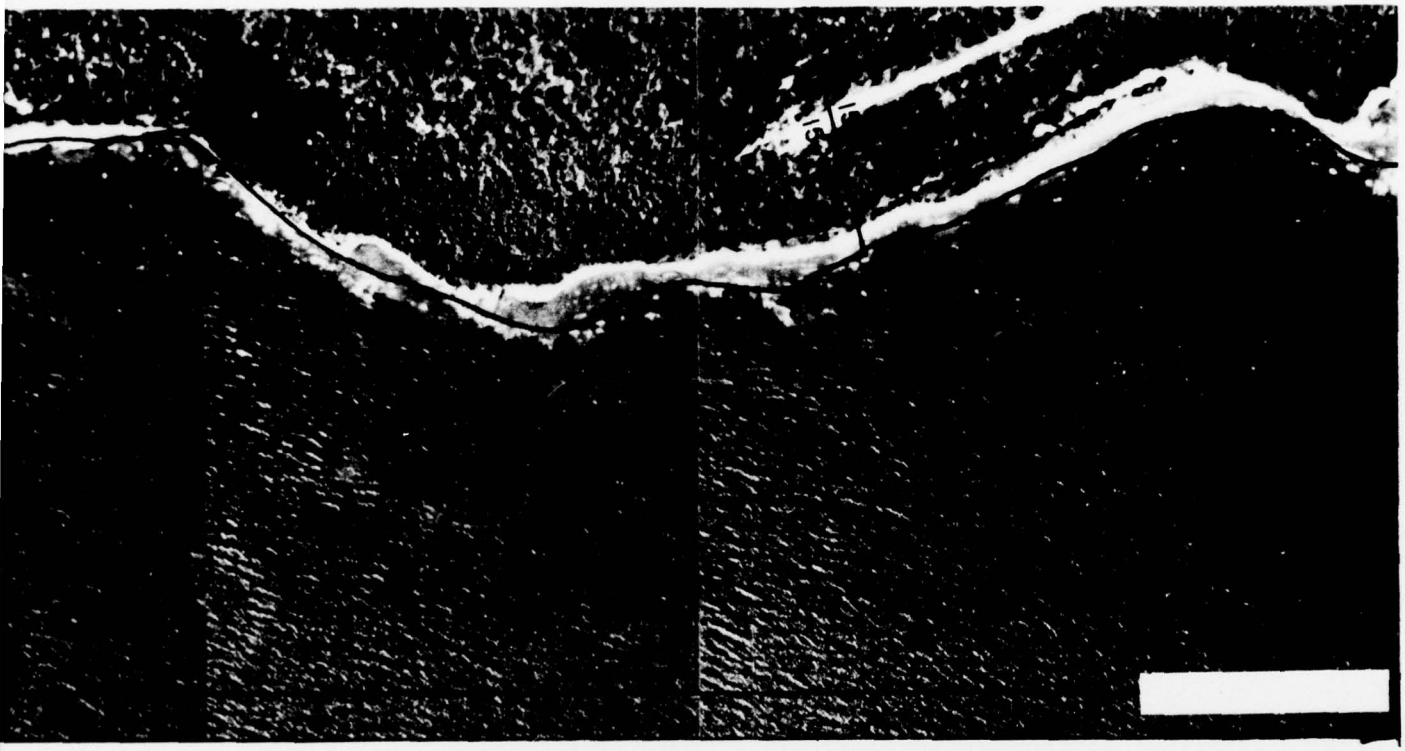

REACH



SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 13
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

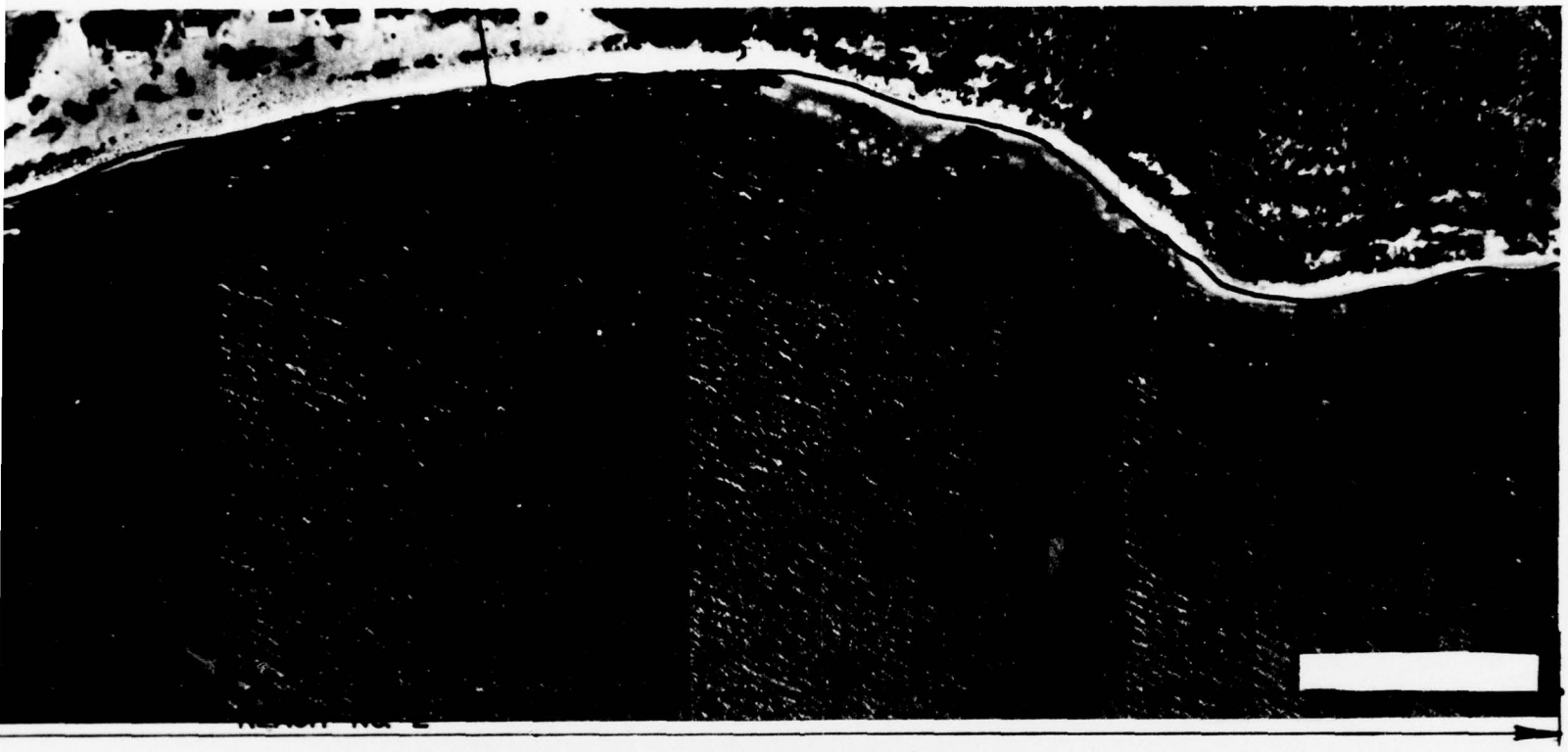




SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 14
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

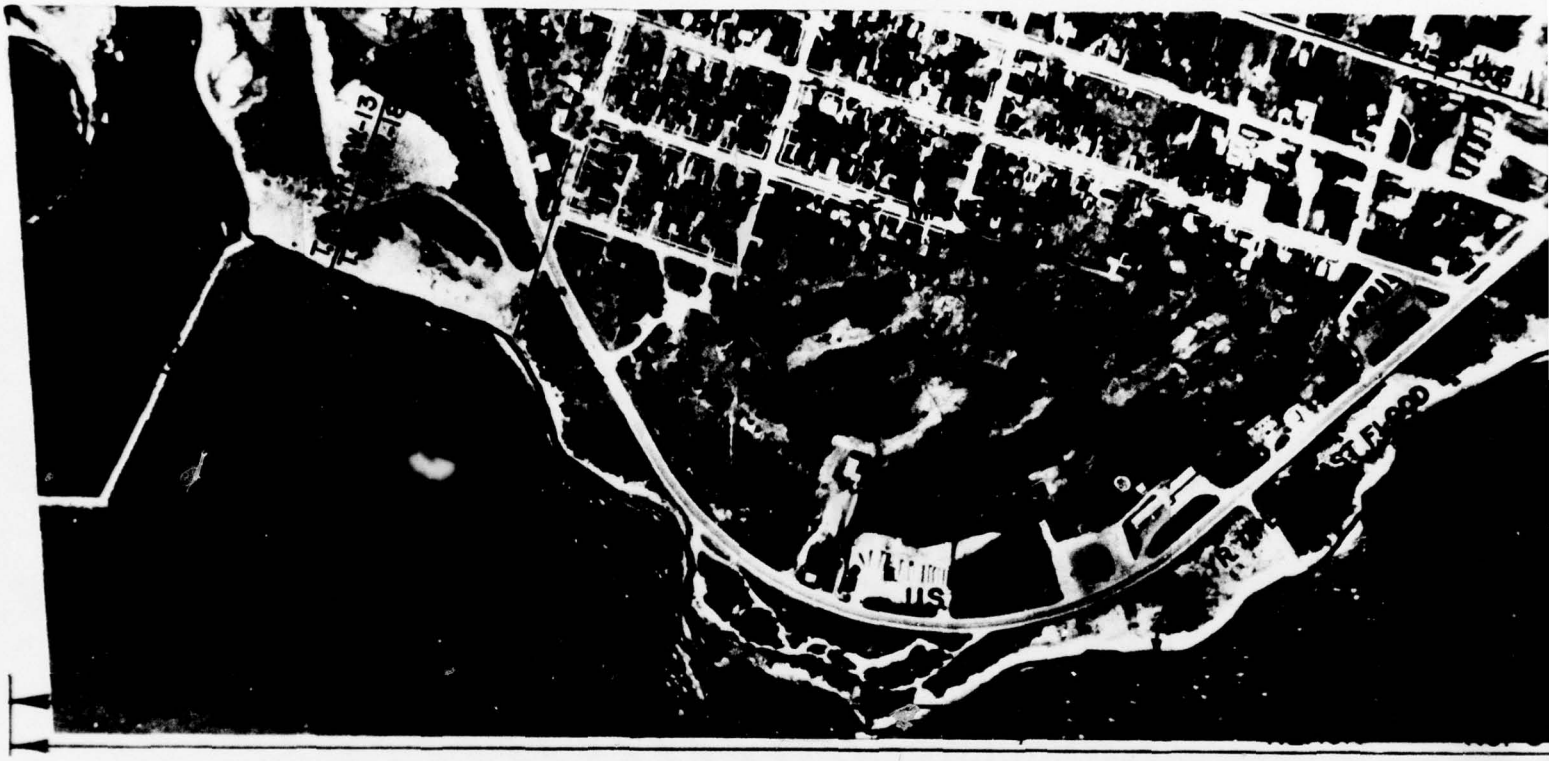

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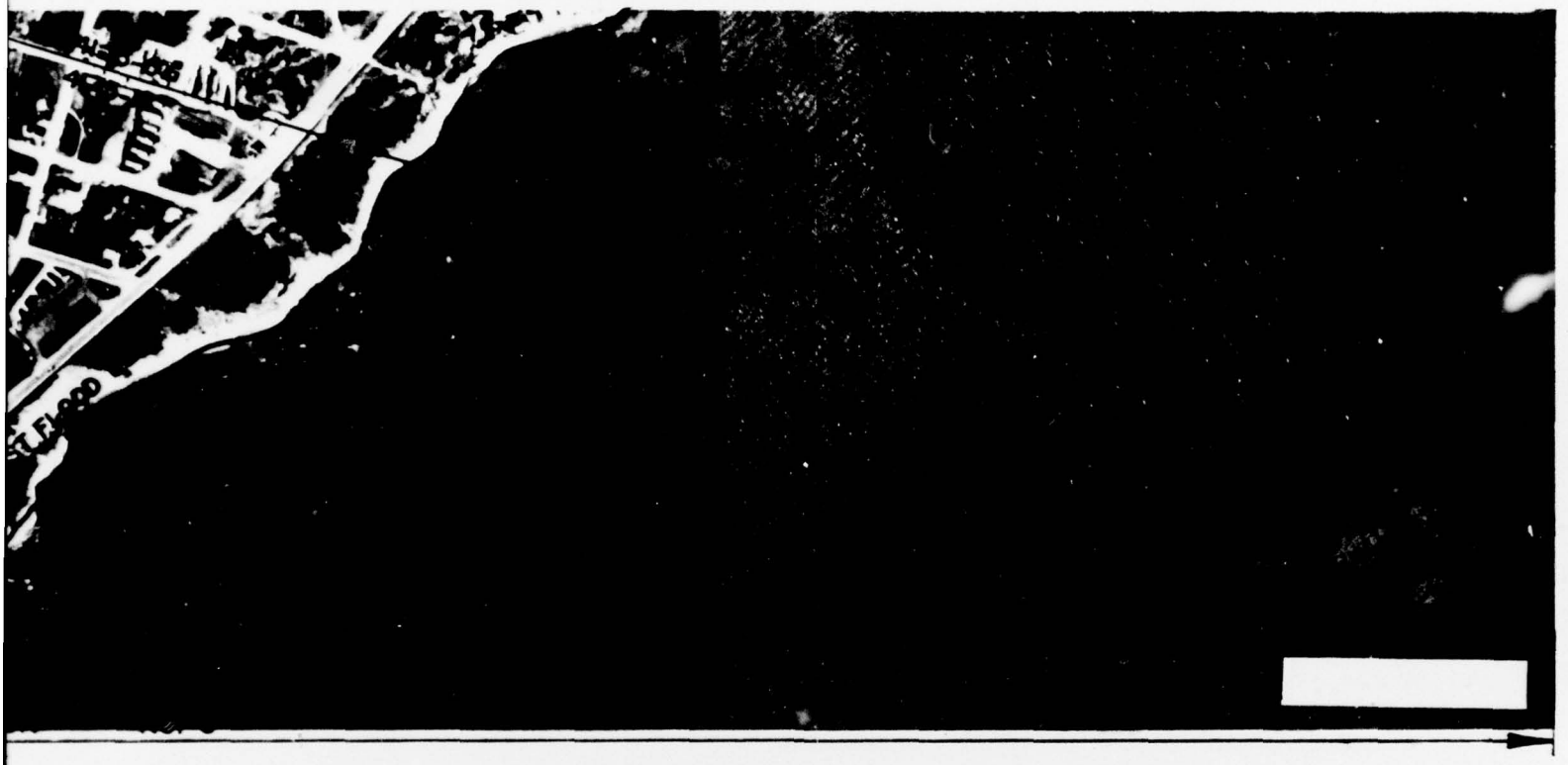
SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 15
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



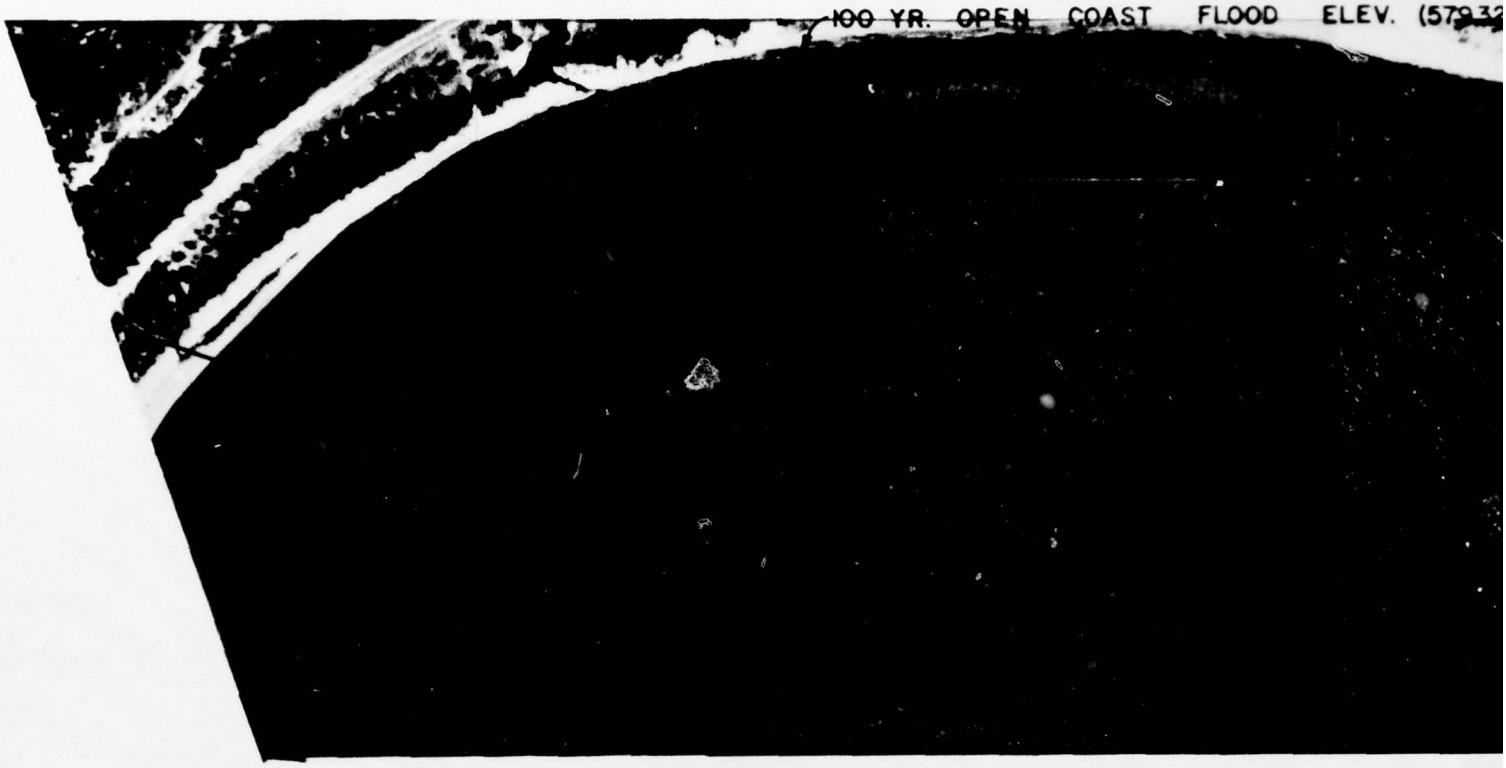
The survey work on this profile has not been completed at this time.



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SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 16
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



SCHOOLCRAFT COUNTY, MICHIGAN REACH #3

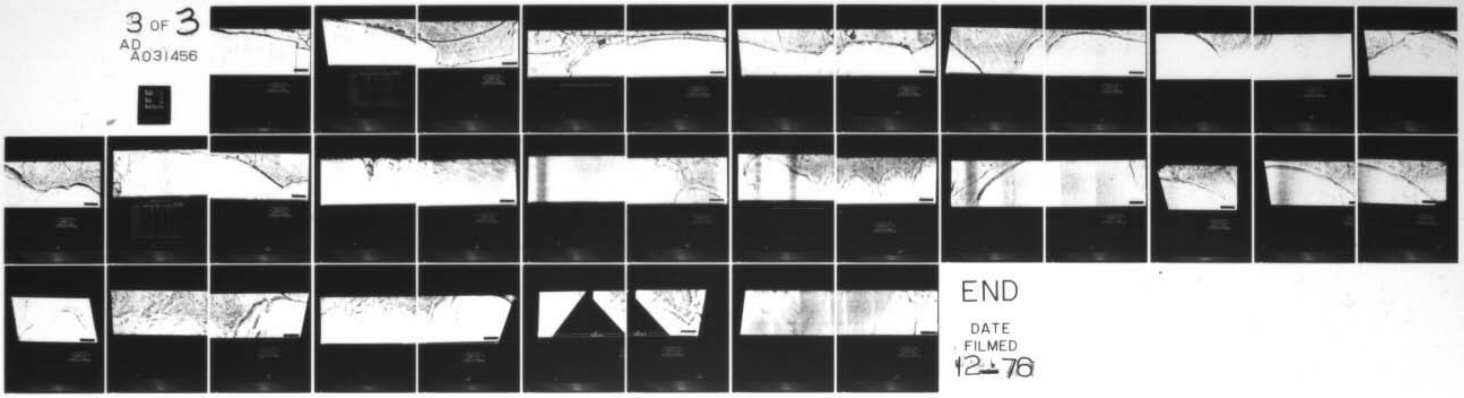
Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	9	7000	1900	900	19000	
Reported Market Value ($)	3	60800	39000	10000	137500	
Bluff Height (Ft.)	2	6	2	4	8	
Beach Depth (Ft.)	2	105	15	90	120	
Bluff Lost (Ft.)	1	10		10	10	
Beach Lost (Ft.)	2	18	3	15	20	
Damages Erosion ($)	1	1000		1000	1000	
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						3,000
Protective Structure Cost ($)	0					0
Total Damages ($)	1	1000		1000	1000	3,000

Total Identified Residential Properties: 19 Self-Administered Assessment Respondents: 8

AD-A031 456 MICHIGAN UNIV ANN ARBOR COASTAL ZONE LAB F/G 13/2
PILOT STUDY PROGRAM, GREAT LAKES SHORELAND DAMAGE STUDY. APENDI--ETC(U)
MAY 76 J M ARMSTONG, M R MCGILL, A M KUBECK DACW23-75-C-0027

UNCLASSIFIED NL

3 OF 3
AD
A031456



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12-76

SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 17
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



SCHOOLCRAFT COUNTY, MICHIGAN REACH #4

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	22	4800	800	200	11700	
Reported Market Value ($)	8	21800	10000	1000	88000	
Bluff Height (Ft.)	8	12	5	3	35	
Beach Depth (Ft.)	7	13	6	2	40	
Bluff Lost (Ft.)	5	13	7	2	40	
Beach Lost (Ft.)	8	83	60	9	500	
Damages Erosion ($)	1	400		400	400	
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						4,000
Protective Structure Cost ($)	1	350		350	350	1,000
Total Damages ($)	1	750		750	750	5,000

Total Identified Residential Properties: 47 Self-Administered Assessment Respondents: 22



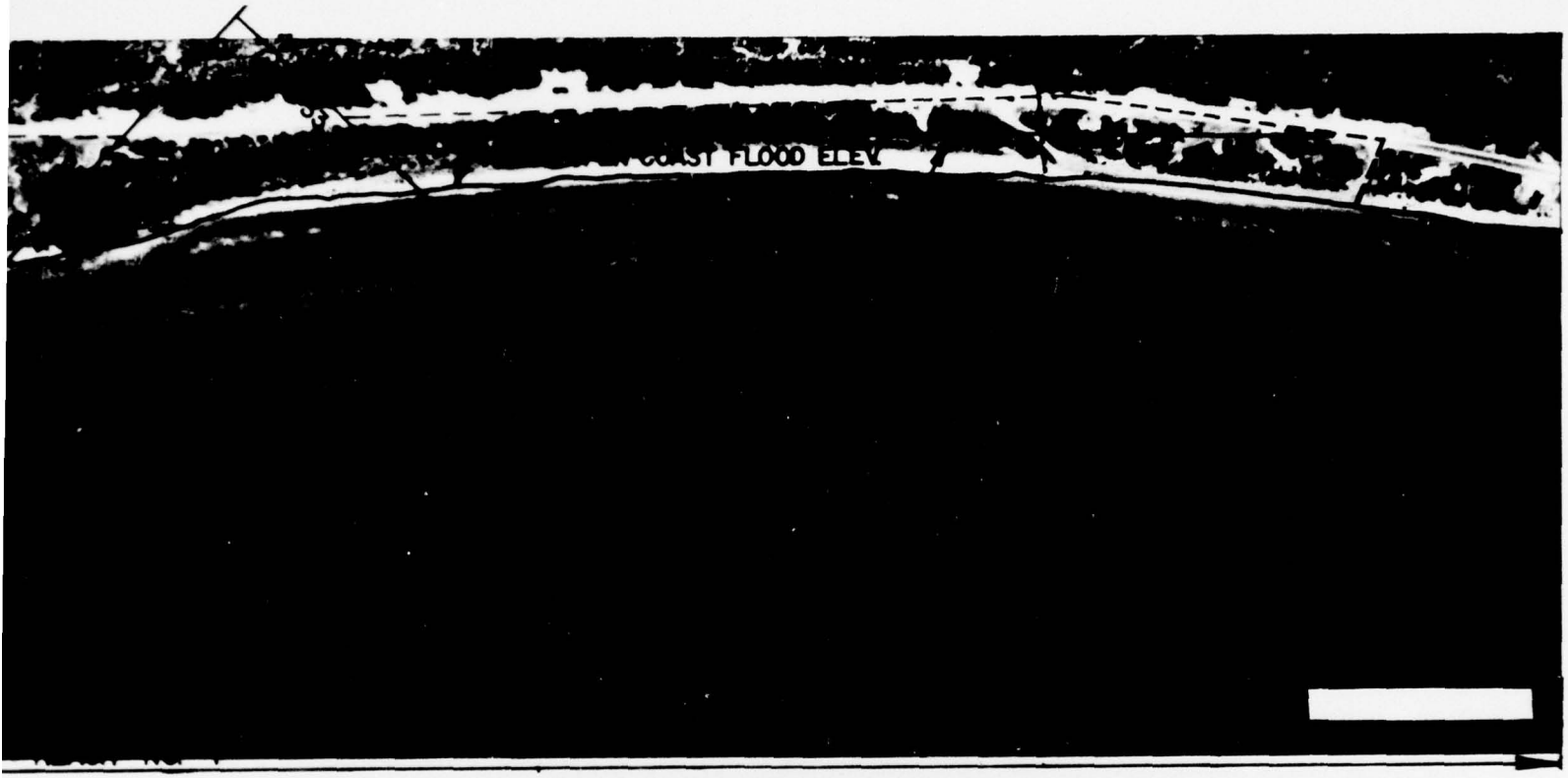
SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 18
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



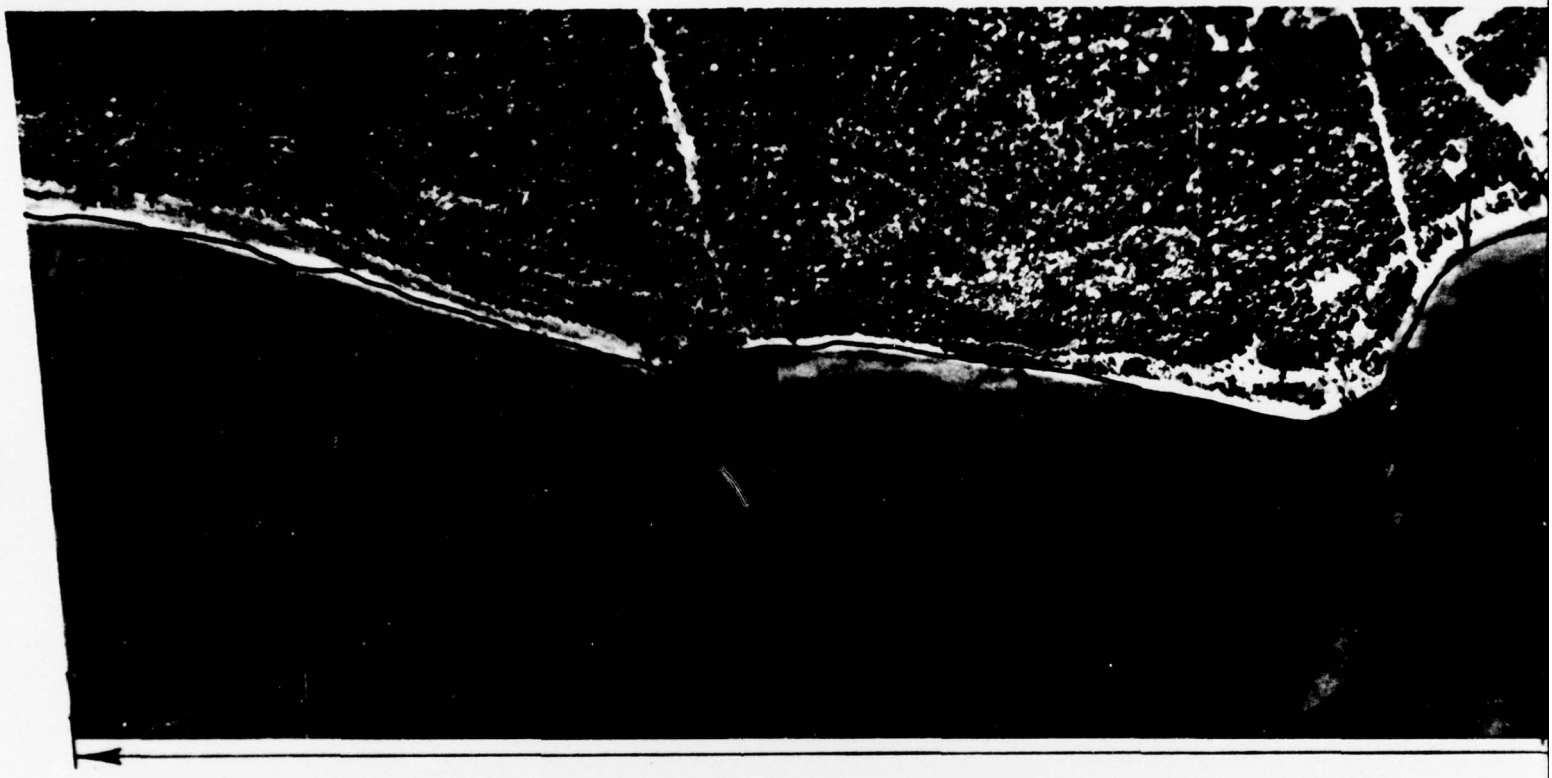
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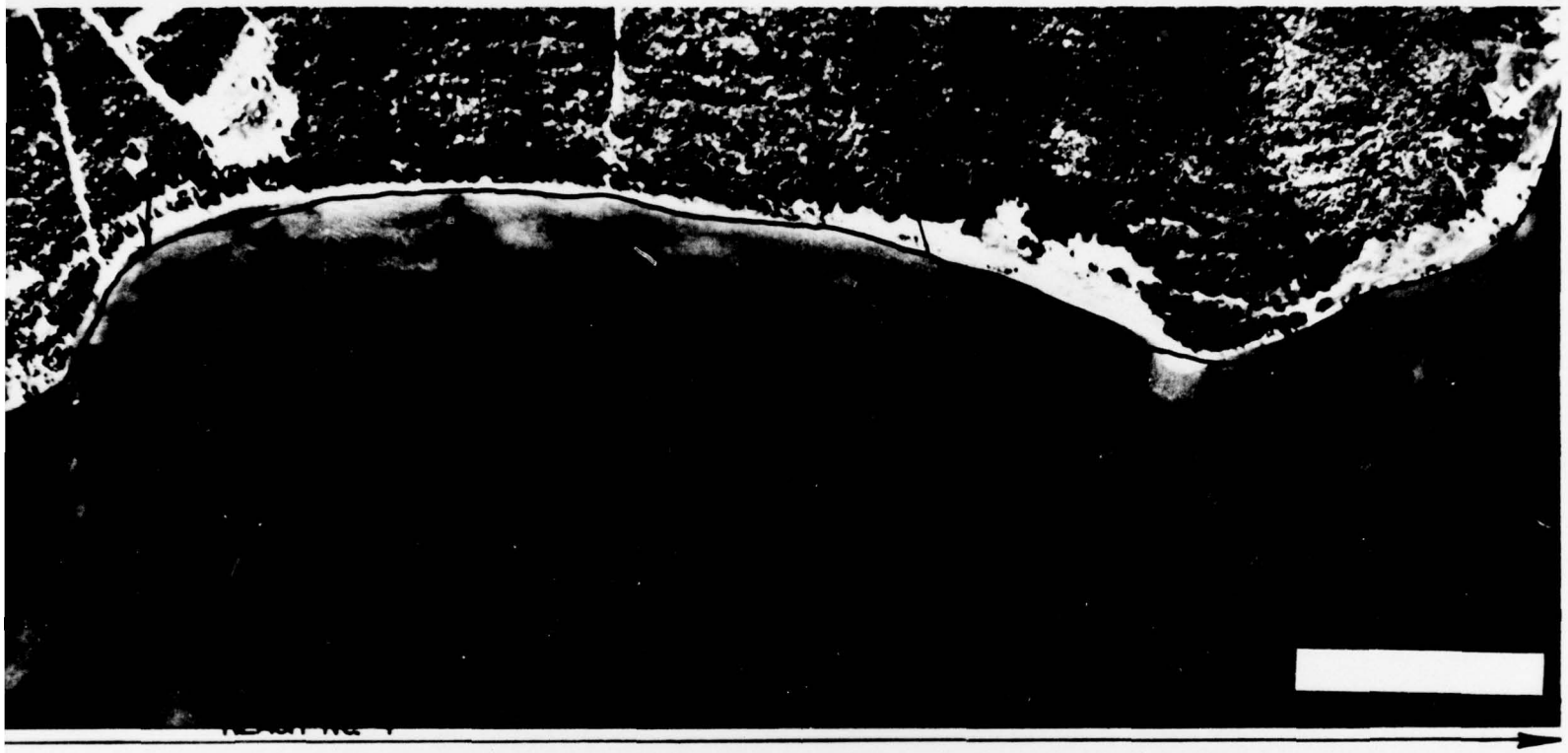


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SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 19
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

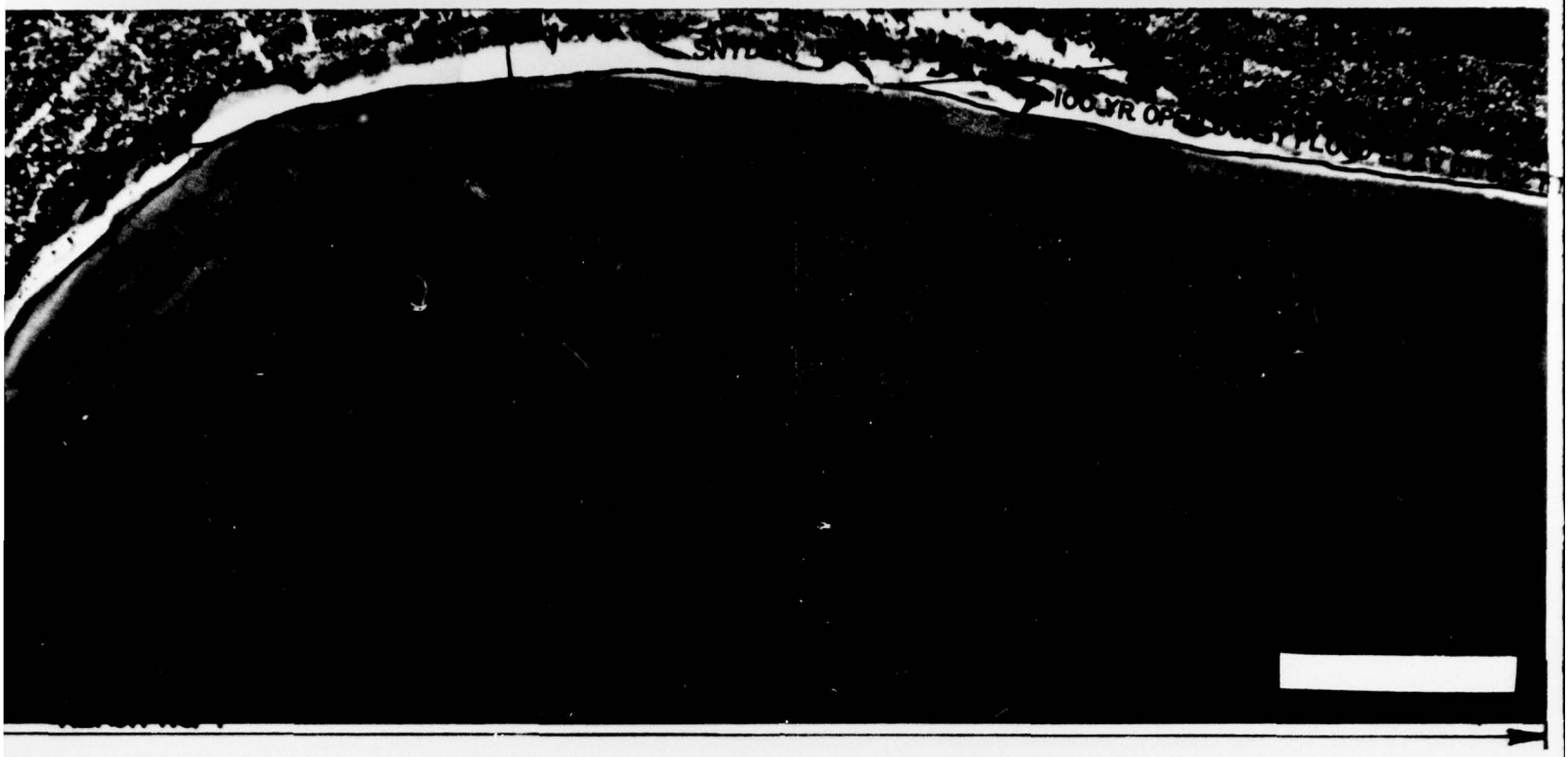




SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 20
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

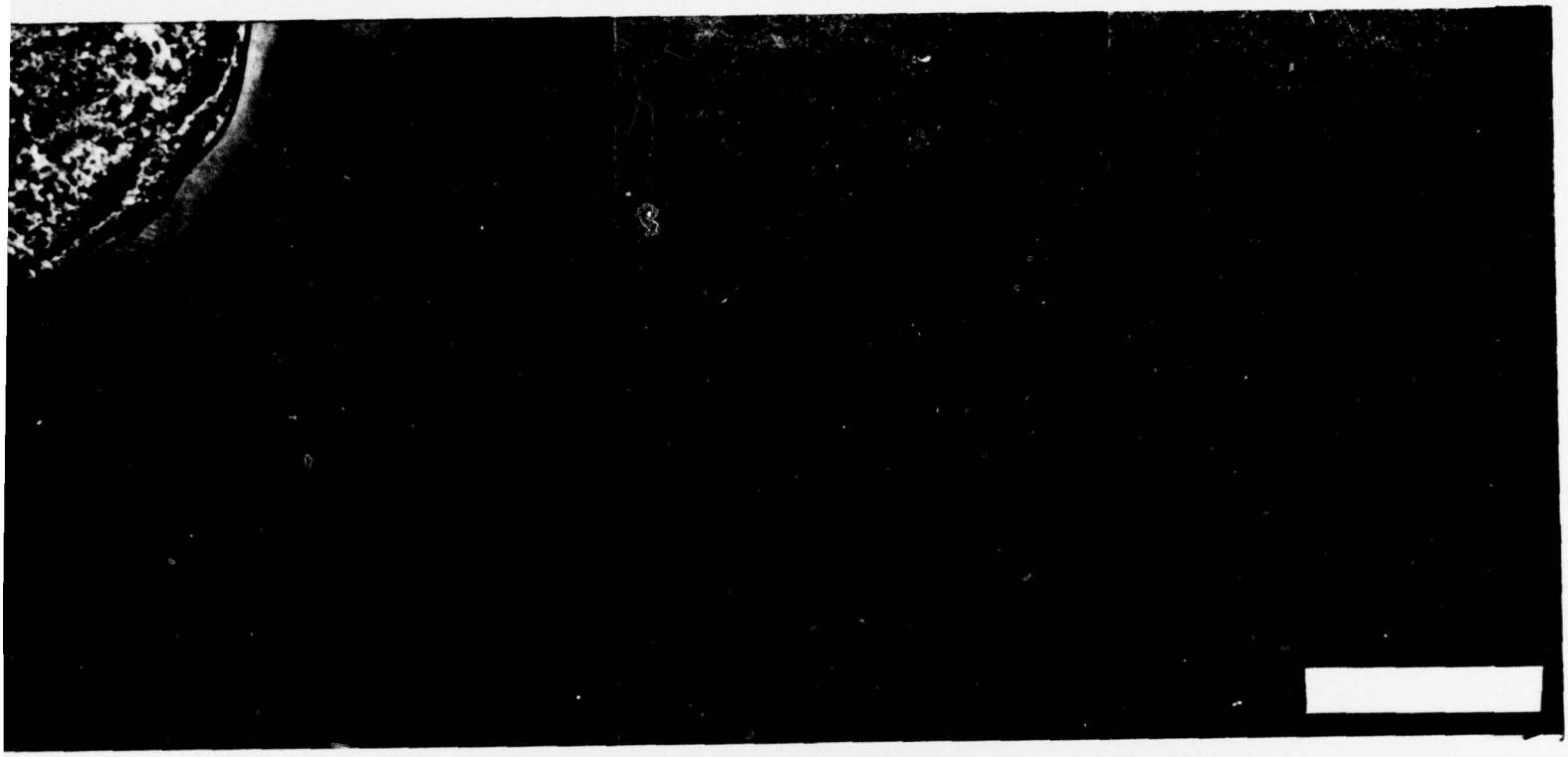




SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 21
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

2



SCHOOLCRAFT COUNTY

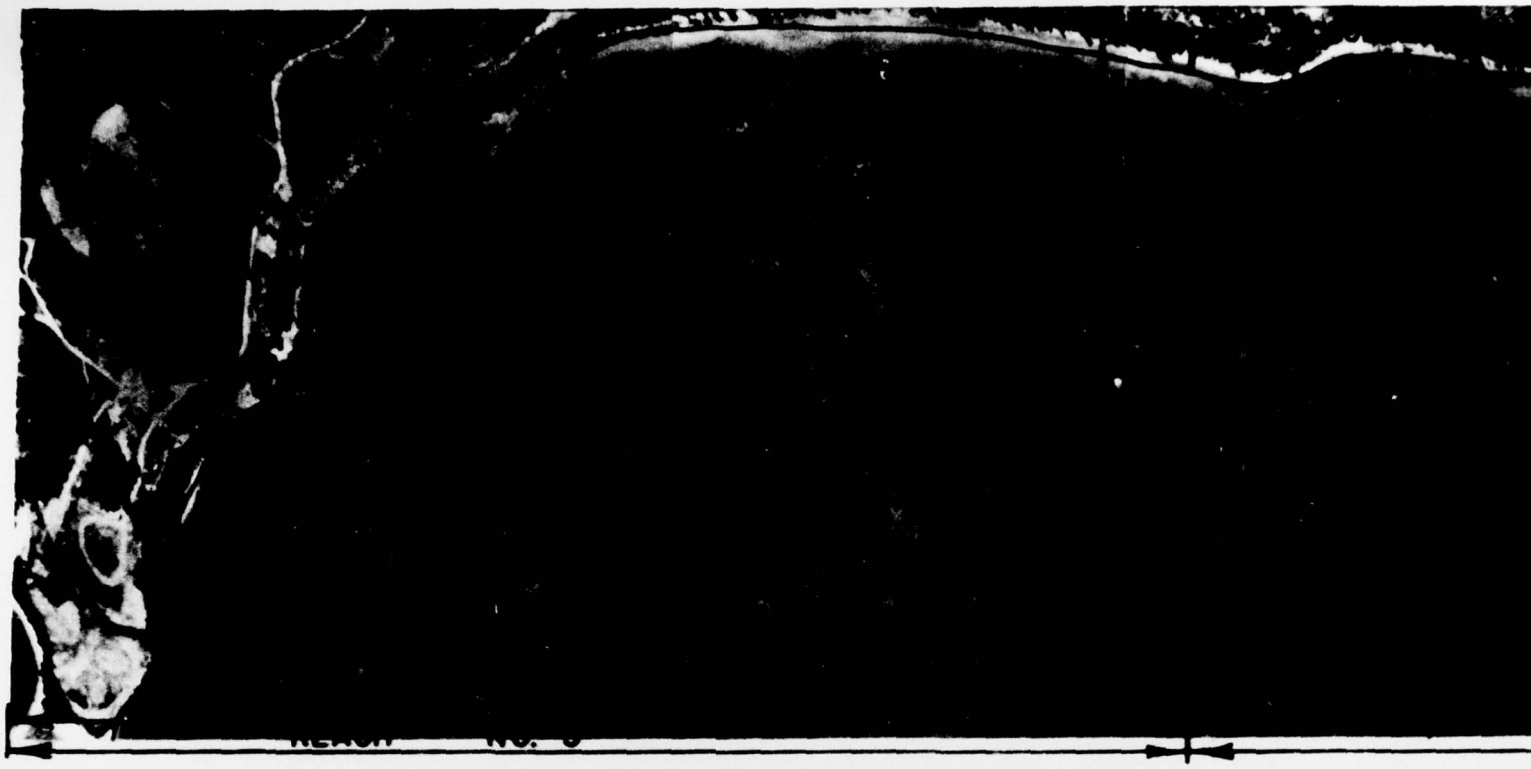
PILOT DAMAGE STUDY, 1975
PLATE NO. 22
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN


COAST FLOOD ELEV.
(579.52 FT.)
100-YR.
100-YR.



SCHOOLCRAFT COUNTY

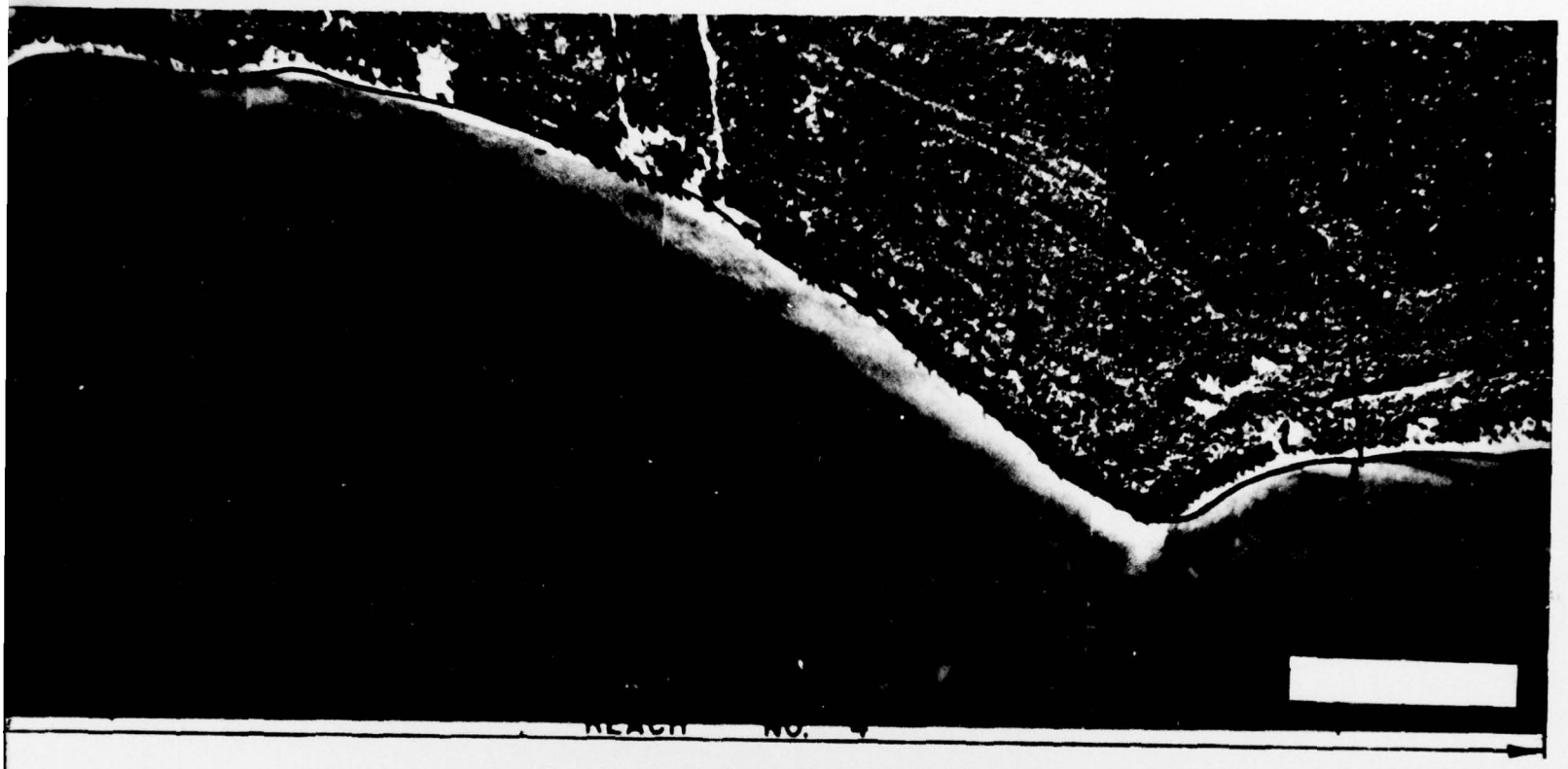
PILOT DAMAGE STUDY, 1975
PLATE NO. 23
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



SCHOOLCRAFT COUNTY, MICHIGAN REACH #5

Variable	No. of Responses	Mean	Standard Error of Mean	Range Minimum	Range Maximum	Adjusted Expanded Total for All Property Listings
Assessed Value ($)	2	3600	300	3300	4000	
Reported Market Value ($)	2	9400	300	9100	9800	
Bluff Height (Ft.)	0					
Beach Depth (Ft.)	0					
Bluff Lost (Ft.)	0					
Beach Lost (Ft.)	0					
Damages Erosion ($)	0					
Damages Flooding ($)	0					
Damages - Erosion and Flooding ($)						700
Protective Structure Cost ($)	0					100
Total Damages ($)	0					800

Total Identified Residential Properties: 9 Self-Administered Assessment Respondents: 2



SCHOOLCRAFT COUNTY

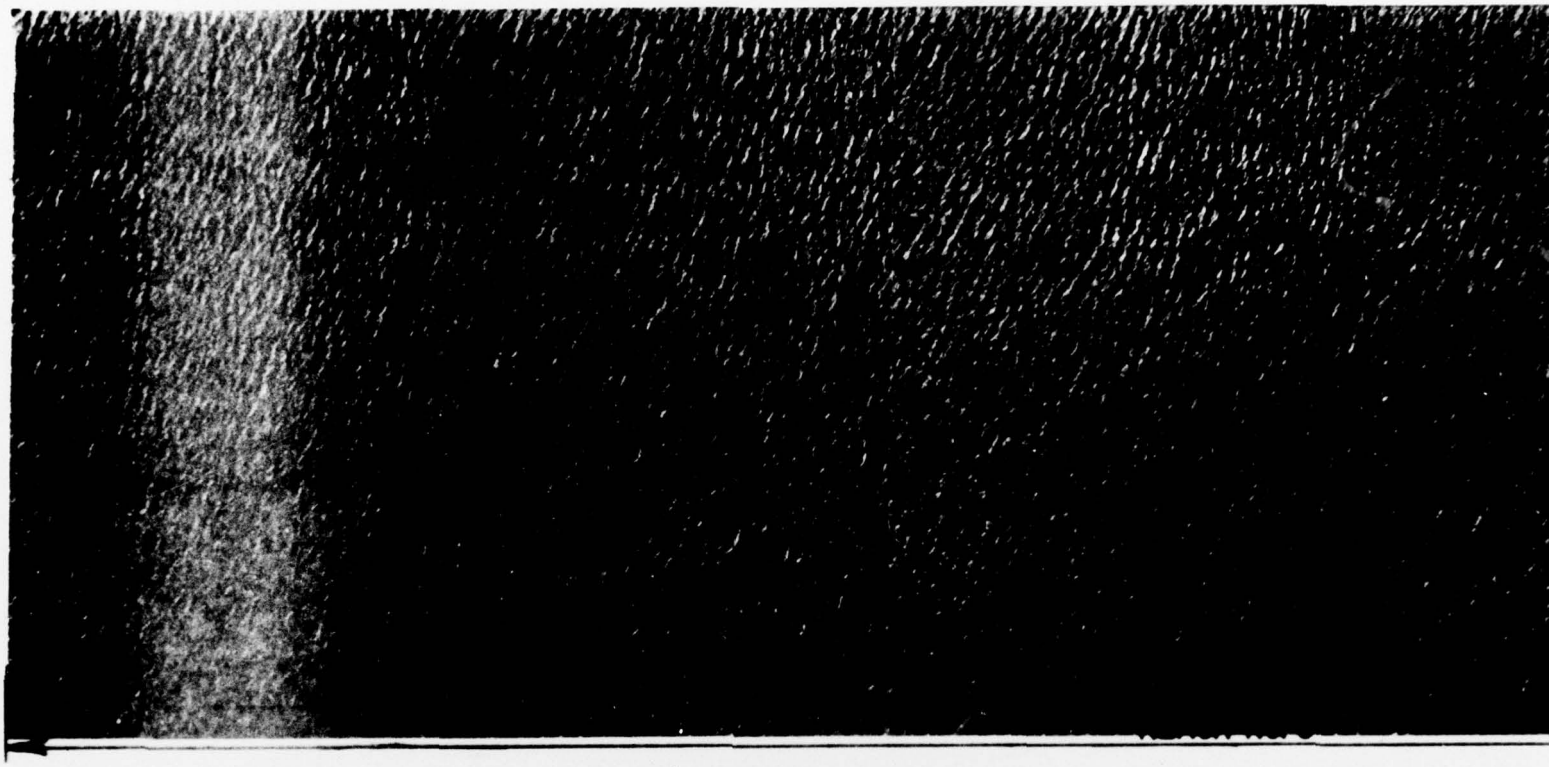
PILOT DAMAGE STUDY, 1975
PLATE NO. 24
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN





SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 25
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN





SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 26
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



The survey work on this profile has not been completed at this time.

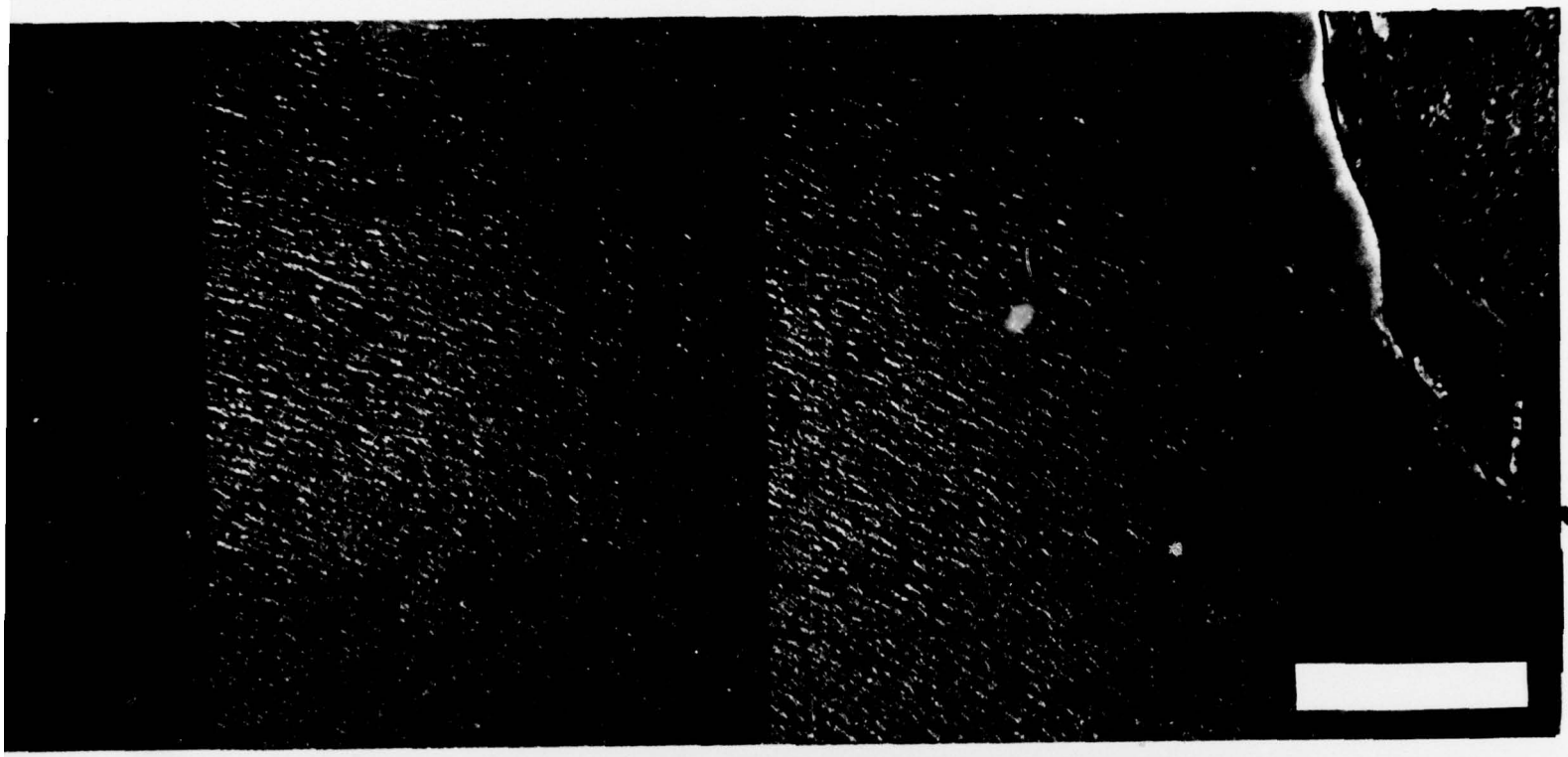


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SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 27
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN


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SCHOOLCRAFT COUNTY

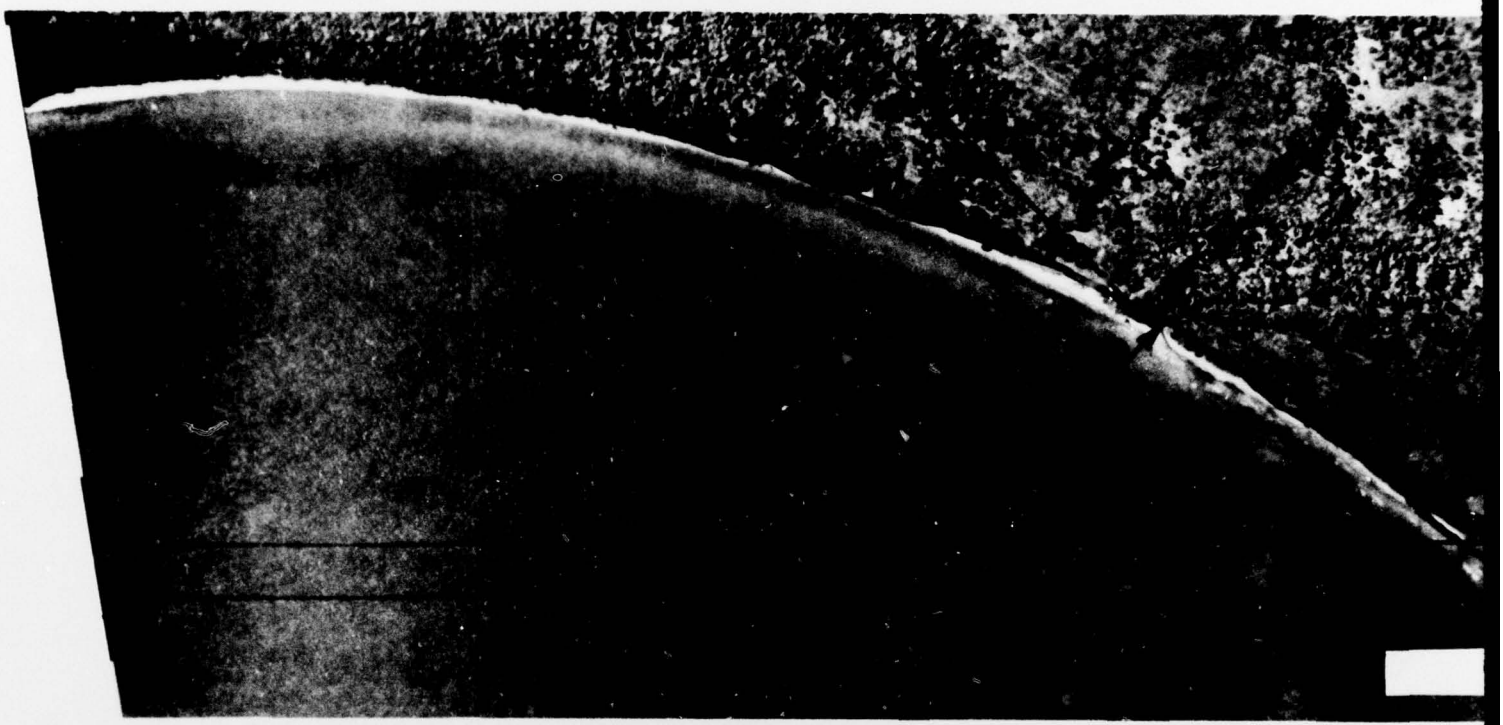
PILOT DAMAGE STUDY, 1975
PLATE NO. 28
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

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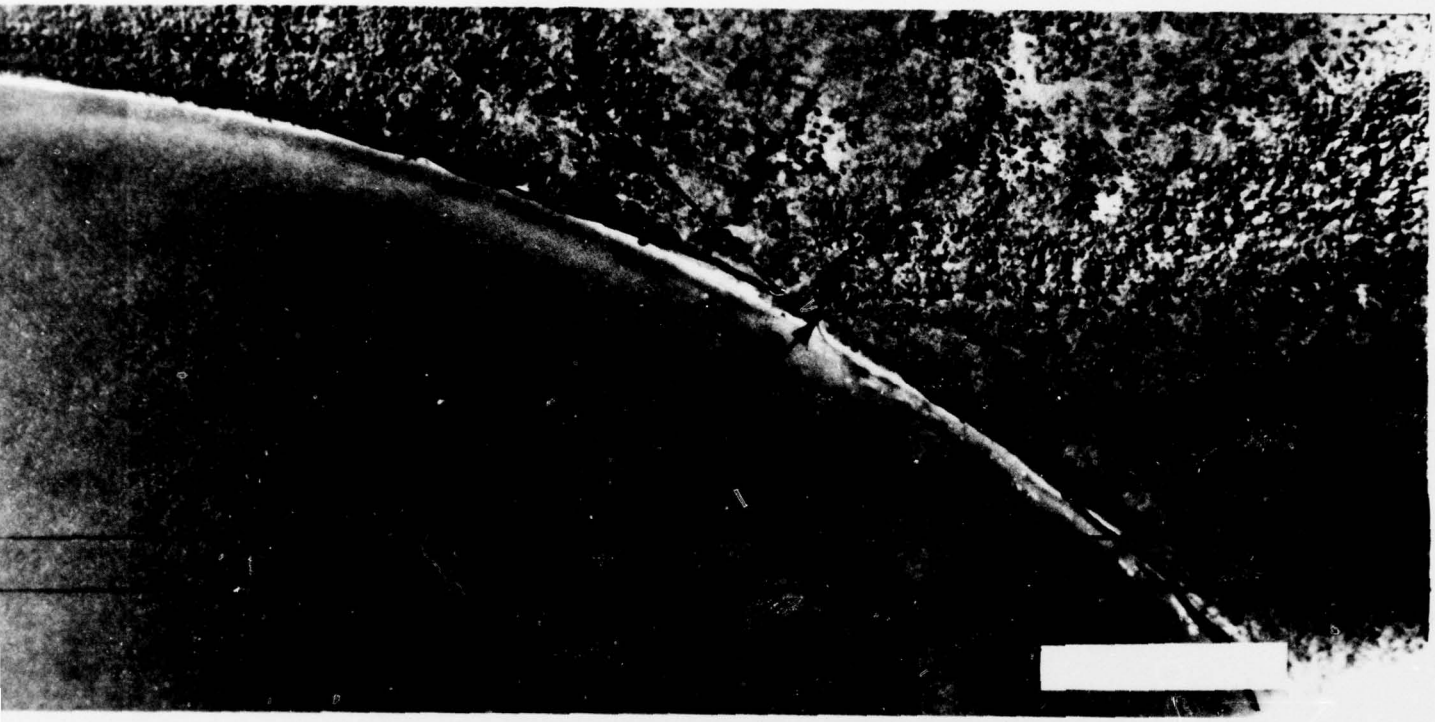
SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 29
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



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PILOT DAMAGE
PLATE N
SCALE: 1"
COASTAL ZONE
THE UNIVERSITY



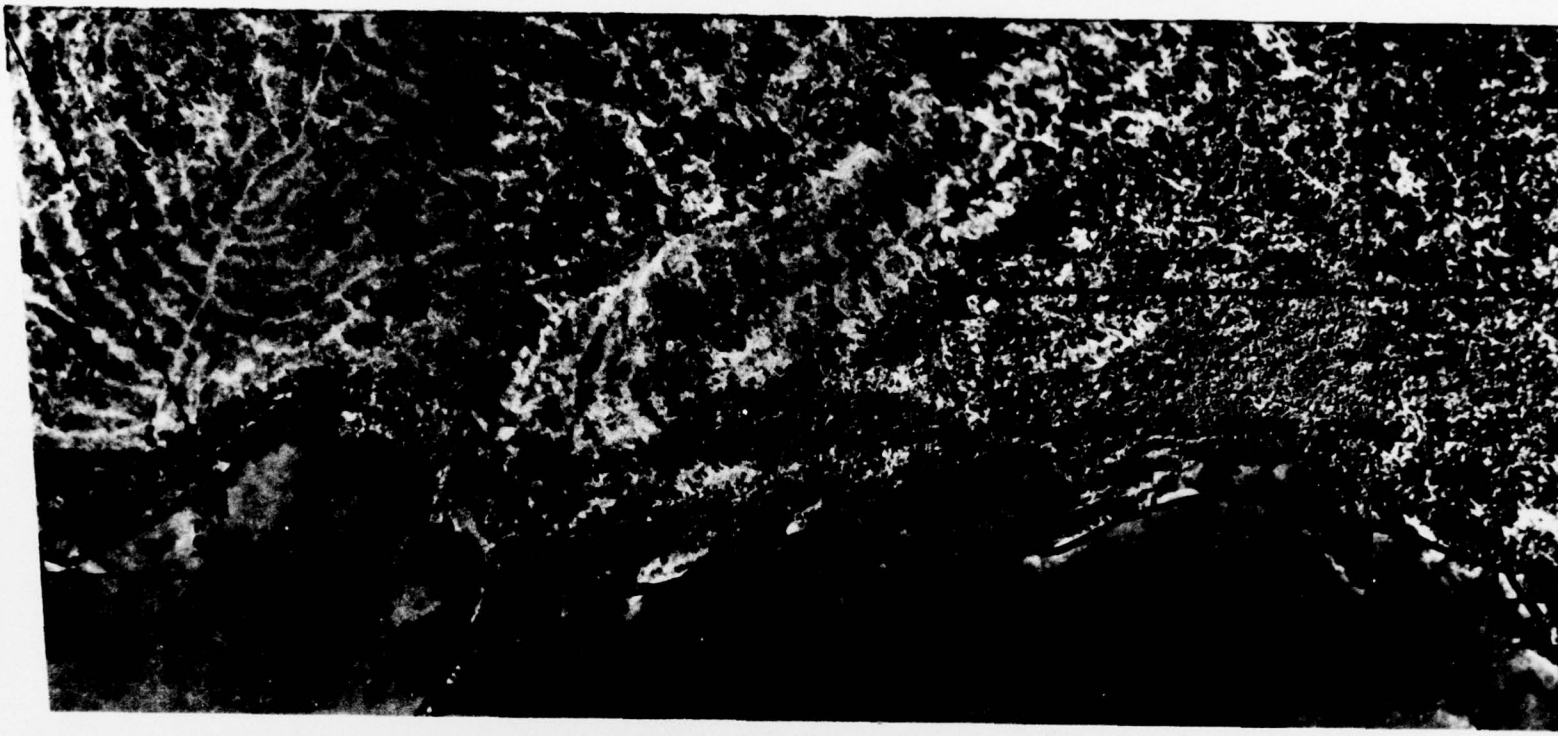
SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 30
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 31
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

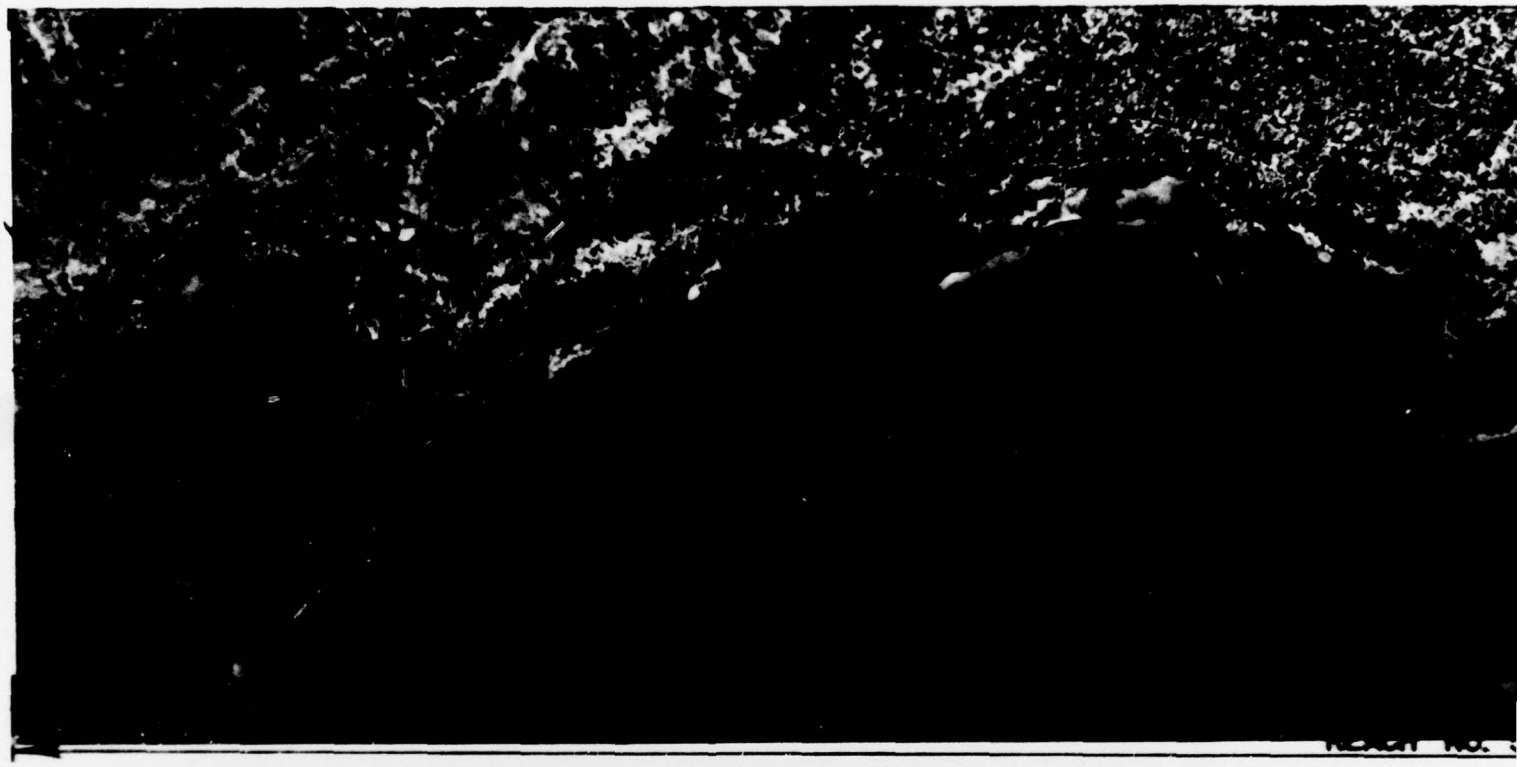


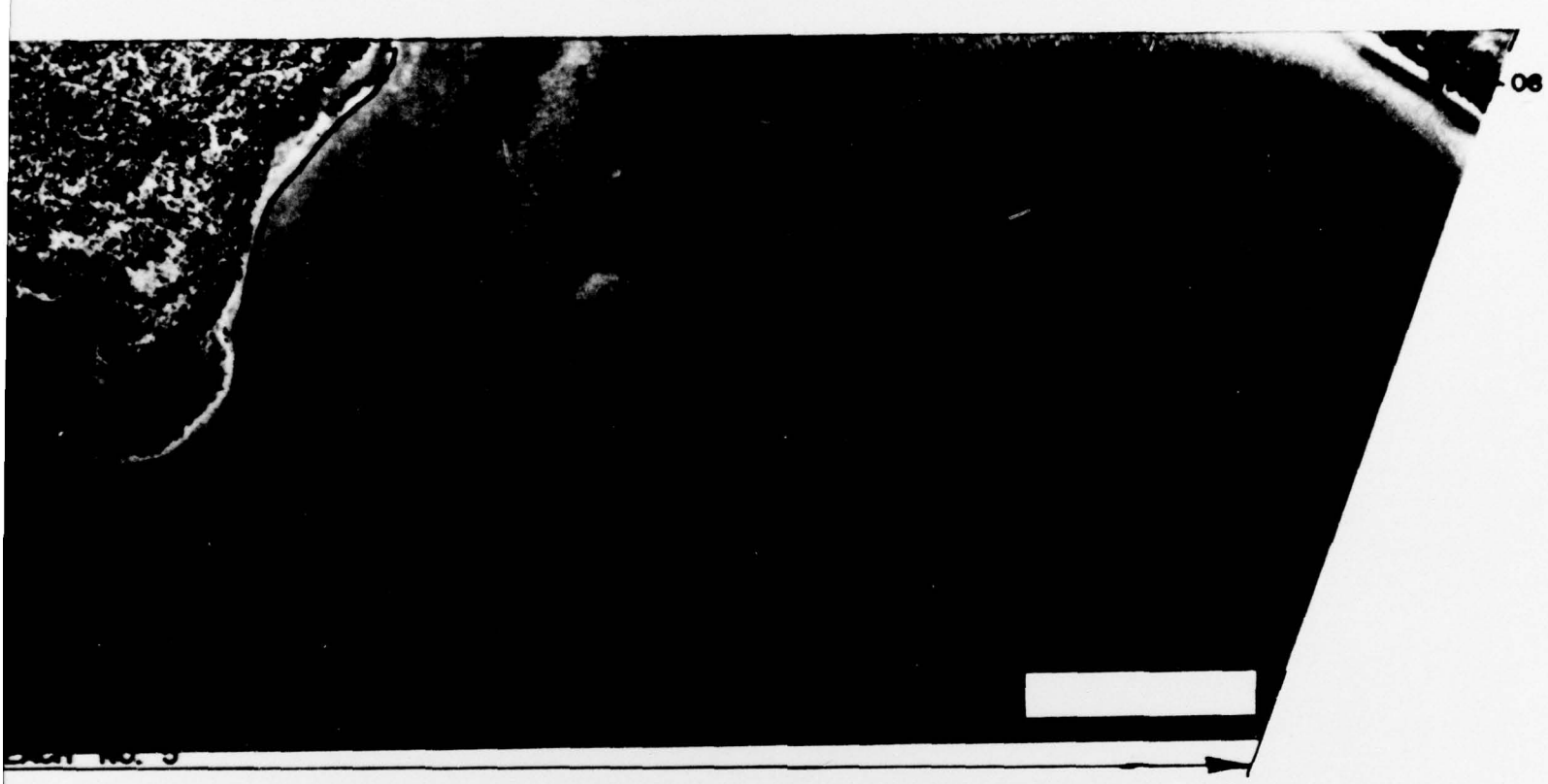


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 32
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

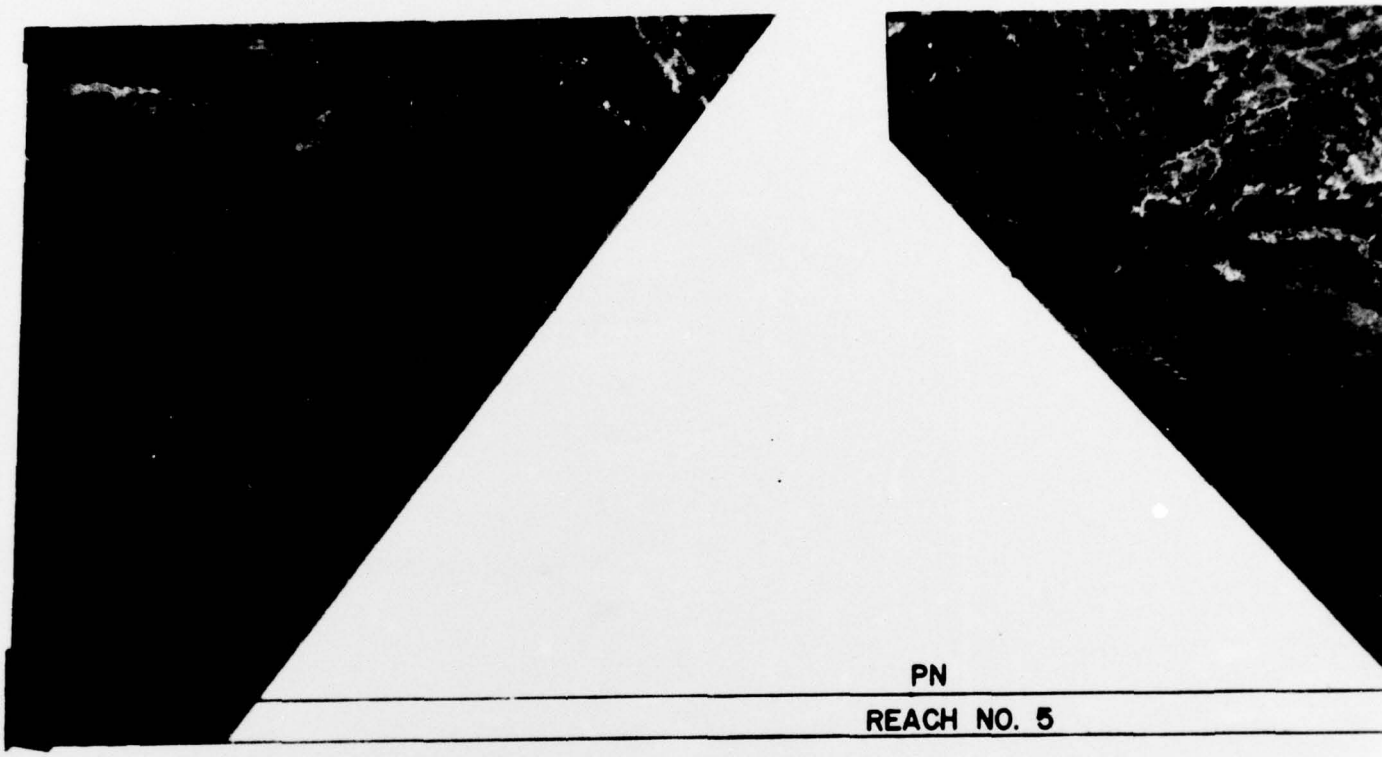
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SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 33
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN



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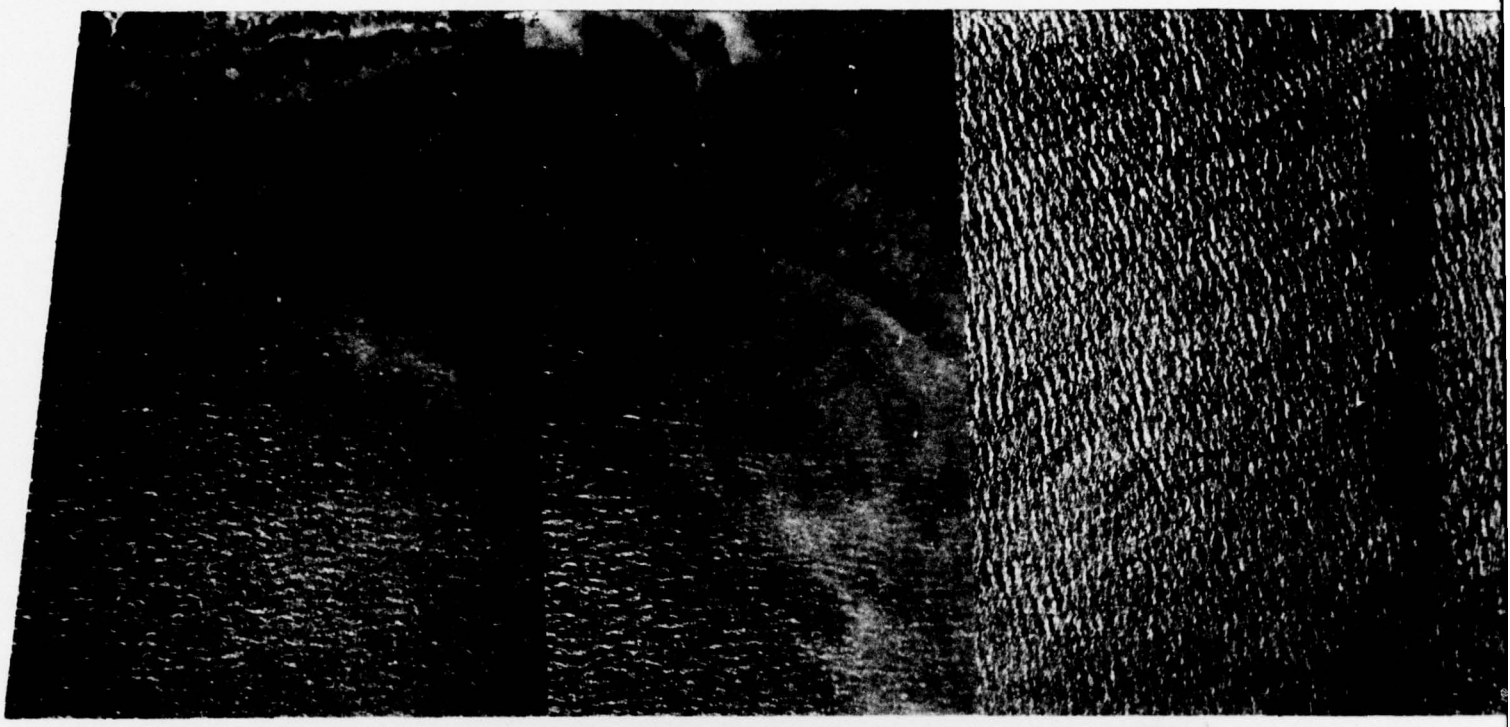
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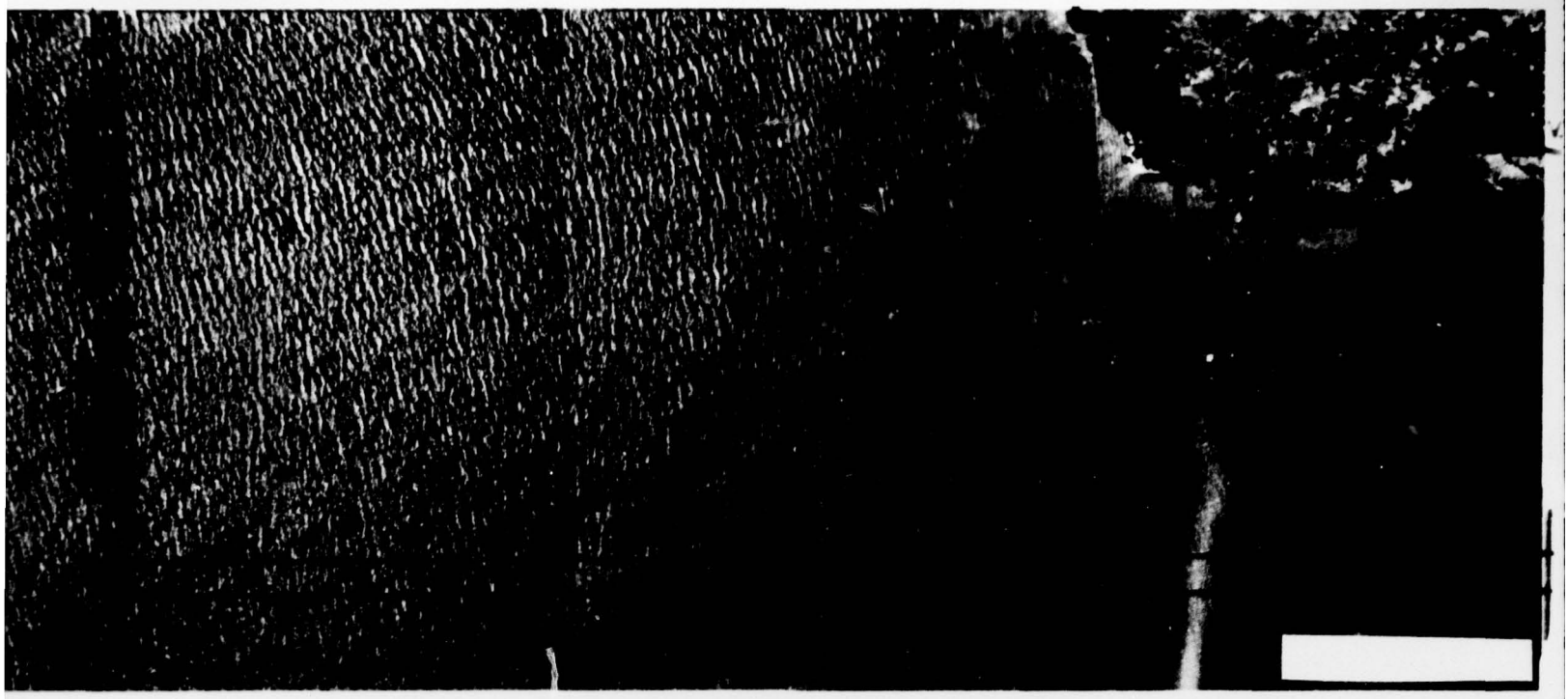


SCHOOLCRAFT COUNTY

PILOT DAMAGE STUDY, 1975
PLATE NO. 34
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
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PILOT DAMAGE STUDY, 1975
PLATE NO. 35
SCALE: 1" = 500'
COASTAL ZONE LABORATORY
THE UNIVERSITY OF MICHIGAN

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