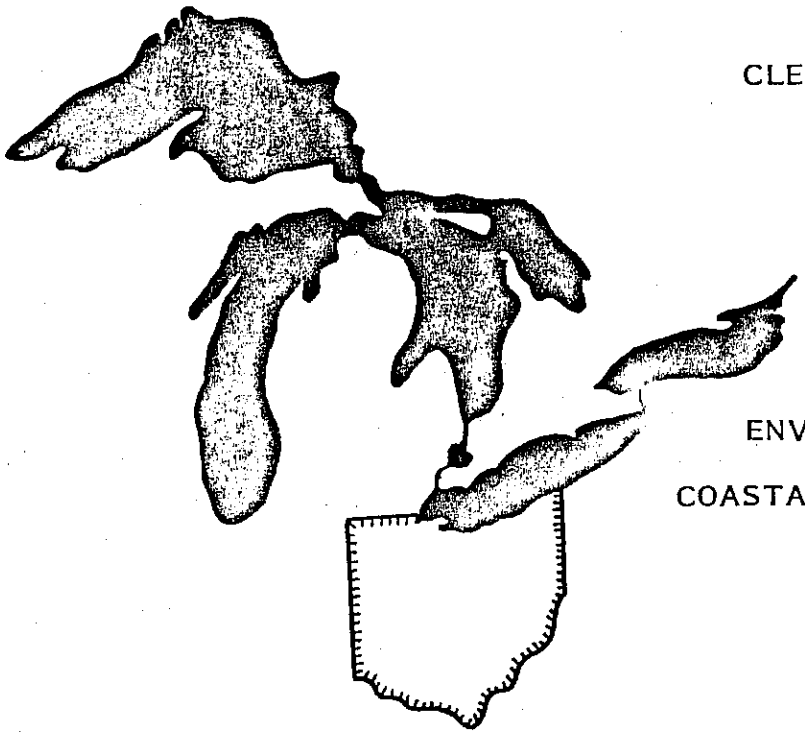

CLEAR TECHNICAL REPORT NO. 281

ENVIRONMENTAL SENSITIVITY INDEX FOR THE COASTAL AREAS OF THE LAKE ERIE SYSTEM

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INTRODUCTION

A classification scheme has been developed to segment the coastal areas of the Lake Erie system into 10 categories based on sensitivity to oil spills and discharges of other hazardous materials. As used here, the Lake Erie system includes that part of the Great Lakes, within the United States, from the head of the St. Clair River at Lake Huron to the mouth of the Niagara River at Lake Ontario. Lake St. Clair, the Detroit River and the navigible portions of the major tributaries are included as part of this system.

CLASSIFICATION OF LAKE ERIE SYSTEM COASTAL AREAS

The classification scheme is based on the sensitivity of coastal areas to oil spills and discharges of other hazardous materials. Ten (10) sensitivity categories have been established:

1. Exposed Bedrock Bluffs
2. Exposed Unconsolidated Sediment Bluffs
3. Shelving Bedrock Shores
4. Sand Shores
5. Mixed Sand and Gravel Shores
6. Gravel Shores
7. Rip-Rap and Harbor Structures
8. Sheltered Bluffs
9. Low Banks
10. Coastal Wetlands

The categories range from least sensitive (Category 1, Exposed Bedrock Bluffs) to the most sensitive (Category 10, Coastal Wetlands). Descriptions of these classifications are presented below:

1. Exposed Bedrock Bluffs

This classification includes vertical or near vertical bedrock bluffs from 10 to 200 feet in height. In the Lake Erie system this includes gray limestone and dolomite cliffs in the islands region of the western basin, black and gray shale bluffs in the central basin from Vermillion to Cleveland, a brown sandstone cliff at Vermillion-on-the-Lake, gray and black shale in the eastern basin between Erie and Buffalo, gray

dolomite and black shale cataracts and cliffs between Niagara Falls and the Niagara Escarpment, and red shale cliffs along the lower Niagara River. The bedrock shores are generally resistant to erosion and contribute little in the way of beach-building material. Landside access to the base of these bluffs is difficult at most locations. Beaches rarely occur in front of the bedrock cliffs, except where streams have cut small ravines or in coves between two headlands.

2. Exposed Unconsolidated Sediment Bluffs

This classification includes vertical or steeply sloping bluffs of unconsolidated material ranging in height from 10 to 150 feet. In the Lake Erie system this includes glacial till and lacustrine sediments. The till is generally the lower unit when the two occur together and its bluffs are often more nearly vertical. It is a gray mixture of compact silt, clay, sand and gravel with the finer particles predominating. Lacustrine bluffs are composed of brown, lake-deposited silt and fine sand. This material is not as compact and is permeable to ground-water; it erodes more easily. The shoreline of the central basin from Cleveland to Erie is dominated by a combination of these two bluff types. Because of their unconsolidated nature, till and lake deposit bluffs are among the most readily eroded shorelines on Lake Erie. Approximately 20% of the material eroded contributes sand and gravel to the littoral beaches. Like the bedrock areas, landside access to the base of these bluffs is difficult at most locations. Deep, "V" shaped ravines have been cut into these cliffs every few miles which afford some access routes. Beaches are normally narrow (<50 feet) and in many areas absent in front of till or lake sediment bluffs, except at stream mouths where widths approach 100 feet.

3. Shelving Bedrock Shores

This classification includes gently sloping bedrock surfaces that extend from the nearshore lake bottom to heights of up to 10 feet above lake level. In the Lake

Erie system this includes the gray limestone and dolomites on the east shores of most of the western basin islands and the Marblehead Peninsula and black or gray shale in the central and eastern basins. In the islands region this exposure is normally a "dip-slope" of the bedrock and commonly contains glacial grooves. The width of these shores range from less than 10 feet to over 100 feet. During the months of May through October dense mats of the filamentous green alga, Cladophora glomerata grow on the rock surfaces from the water down to a depth of approximately 10 feet. Because of the gentle slope and hard surface of this type of shore, access is usually good. Beaches rarely occur in front of the bedrock except in small coves where beach material is generally gravel.

4. Sand Shores

This classification includes granular shores ranging in size from very fine sand to very coarse sand (0.1 to 2.0 mm in diameter). In the Lake Erie system sand beaches are generally narrow to moderate in width (50-100 feet), except at deltas, sand spits and on the updrift sides of large shore structure where wide beaches are found. Notable accumulations of sand occur at the delta of the St. Clair River, north of Monroe harbor at Sterling State Park, Woodtick Peninsula spit on the northwest side of Maumee Bay, Cedar Point and Bay Point spits at the entrance to Sandusky Bay, Headlands State Park west of Fairport Harbor, Walnut Beach west of Ashtabula harbor, Presque Isle spit surrounding Erie harbor and the beaches of Hanford, Sunset, Lotus, Grandview, and Evans bays between Dunkirk and Buffalo. Elsewhere, beaches are generally absent fronting bedrock areas, except at stream mouths and in small cover, or are relatively narrow at the base of unconsolidated bluffs. Because of the gentle slope of most of the larger beaches, small changes in water level can result in major changes in beach width; the narrower beaches are normally steeper and therefore show less change with water level fluctuations. Access to the large

accumulations are generally good, however landside approaches to the small beaches fronting high bluffs are difficult.

5. Mixed Sand and Gravel Shores

This classification includes shorelines composed of sand, gravel and shell mixtures which normally form narrow -- (<50 feet) to moderate -- (<100 feet) width beaches. The slope of the shorelines is generally greater than that for sand beaches but not as steep as that for gravel. These beaches are not wide spread, but they often occur at the high, wave-energy end of sandy shores or in coves between headlands. Access to these beaches is normally good for those associated with larger sandy beaches and poor for those in isolated coves.

6. Gravel Shores

This classification includes granular shores ranging in size from pebbles to boulders (2 to 4000 mm in diameter). In the Lake Erie system gravel beaches are generally narrow (< 50 feet) and are usually associated with bedrock exposures. The most notable gravel beaches occur on Marblehead peninsula and the islands of the western basin. The most common component is pebble to cobble-sized gravel derived from the limestone and dolomite cliffs. Isolated gravel beaches also occur in the central and eastern basins at the base of shale and glacial till cliffs, particularly in small coves. These beaches are typically composed of shale "shingle" and crystalline erratics from the glacial deposits. Landside access to gravel beaches is generally difficult because of the high, steep nature of the surrounding bluffs. In areas of shelving bedrock, access is normally good.

7. Rip-rap and Harbor Structures

This classification includes several types of man-placed material for shore protection and navigation. The variety of material used includes steel sheeting, large concrete blocks, wood, extraneous metallic and concrete debris and tires. A large

portion of the St. Clair, Detroit and Niagara Rivers are reinforced by some type of added structure. The bluff areas between Cleveland and Erie are subject to intensive erosion and these areas have been covered by rip-rap materials.

Other types of man-made structures along the lake are dredge disposal areas (a combination of both steel sheeting and concrete block) and wetlands maintained by earthen and rock covered dikes (i.e. Sandusky Bay).

The fauna and flora associated with this classification is also variable depending on the type of material utilized in the structure and the accessibility to the splash zone. Some of the structures provide fishery habitat and bird nesting sites. Harbor structures create a sheltered effect causing debris and oil to accumulate in slack water areas.

8. Sheltered Bluffs

This classification includes vertical or steeply sloping bluffs of bedrock or unconsolidate deposits which are not exposed to open lake conditions or torrent stream flow. These bluffs can range in height from 5 to 150 feet and are often dissected by tributary ravines. In the Lake Erie systems sheltered bluffs occur along the St. Clair River, Anchor Bay of Lake St. Clair, Detroit River, Maumee Bay, Sandusky Bay, Presque Isle Bay, upper Niagara River, and the navigable portions of the major tributaries. Narrow sand and/or gravel beaches and wetlands are often associated with the edge of these bluffs. These shores are commonly developed for residential and commercial use. Because of this development, landside access is normally good. Natural areas are less accessible.

9. Low Banks

This classification includes low banks (< 5 feet) of unconsolidated sediments (i.e. glacial till, lacustrine deposits, and stream alluvium) which are subject to frequent lake or stream flooding. Because of the longitudinal seiche activity which is

typical of Lake Erie, areas subject to flooding are concentrated at the western and eastern extremities of the lake. Also, the lower reaches of most tributaries have a "drowned month" forming estuarine conditions where flooding from either the lake or the tributary can occur. These low shorelines are also associated with mud flats, sand bars, and wetlands. Because of the low nature of this type of shoreline, landside access is normally good but can be hampered by the soft or marshy nature of the shore material. Shore erosion in these areas can be extreme during high water storms.

10. Coastal Wetlands

This classification includes shore areas with dense growths of primarily emergent or floating aquatic vegetation. The types of wetlands found in the Lake Erie system include the delta wetlands of the St. Clair River mouth, fringing wetlands which require sheltered shorelines such as those of Lake St. Clair and Buckhorn and Strawberry Islands in the upper Niagara River, coastal lagoon wetlandss typified by those associated with Woodtick Peninsula and Presque Isle spits, diked wetlands of the Ohio and Michigan shores of the western basin and the upper reaches of Sandusky Bay, and estuarine wetlands which are prominant in the lower courses of several tributaries such as the Maumee River, Old Woman Creek, Mentor Marsh, and Arcola Creek. Coastal wetlands can vary from a few acre plot in sheltered backwater areas within harbors to over 8000 acres for the St. Clair River delta. Landside access to coastal wetlands is normally good for inshore portions however offshore growths can be difficult to reach because of the lack of suitable foundation for the movement of heavy equipment.

ILLUSTRATIONS OF LAKE ERIE SYSTEM COASTAL AREAS

The following set of 36 photographs is intended to illustrate the major features of the 10 sensitivity categories and show some of the variability that can occur within each category. The photographs are generally arranged in a west to east direction for each type of shoreline.

TYPE 1
EXPOSED BEDROCK BLUFFS

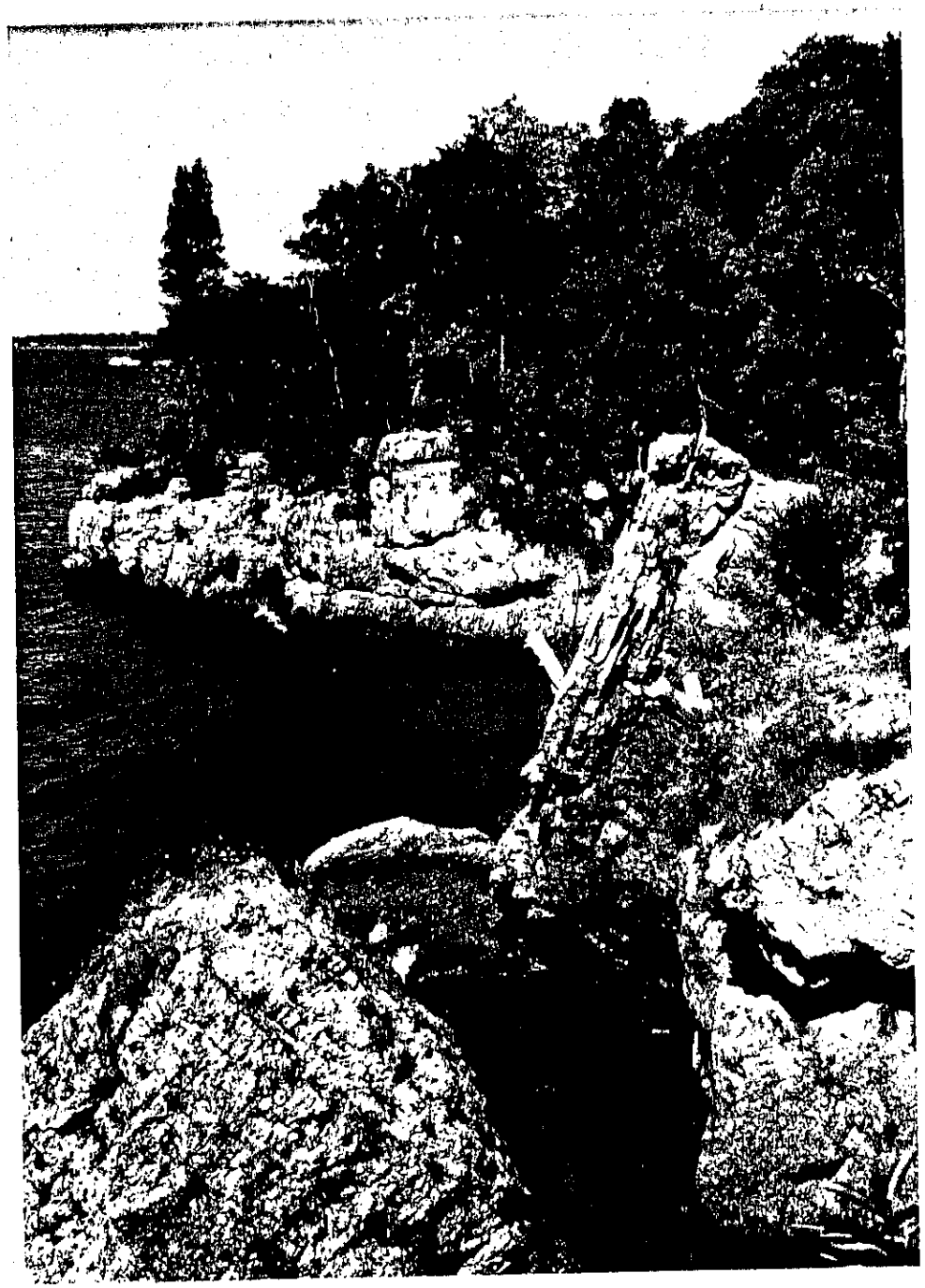

Figure 1-A Bedrock bluff (Put-in-Bay Dolomite, Silurian) on the west shore of South Bass Island, Ottawa County, Ohio; note absence of beach.

TYPE 1
EXPOSED BEDROCK BLUFFS

Figure 1-B Aerial view of bedrock bluffs (Conewango Shale--Devonian) near Dunkirk, Chatauqua County, New York; note sand and gravel beaches (Type 5) in coves between bedrock headlands.

TYPE 1
EXPOSED BEDROCK BLUFFS

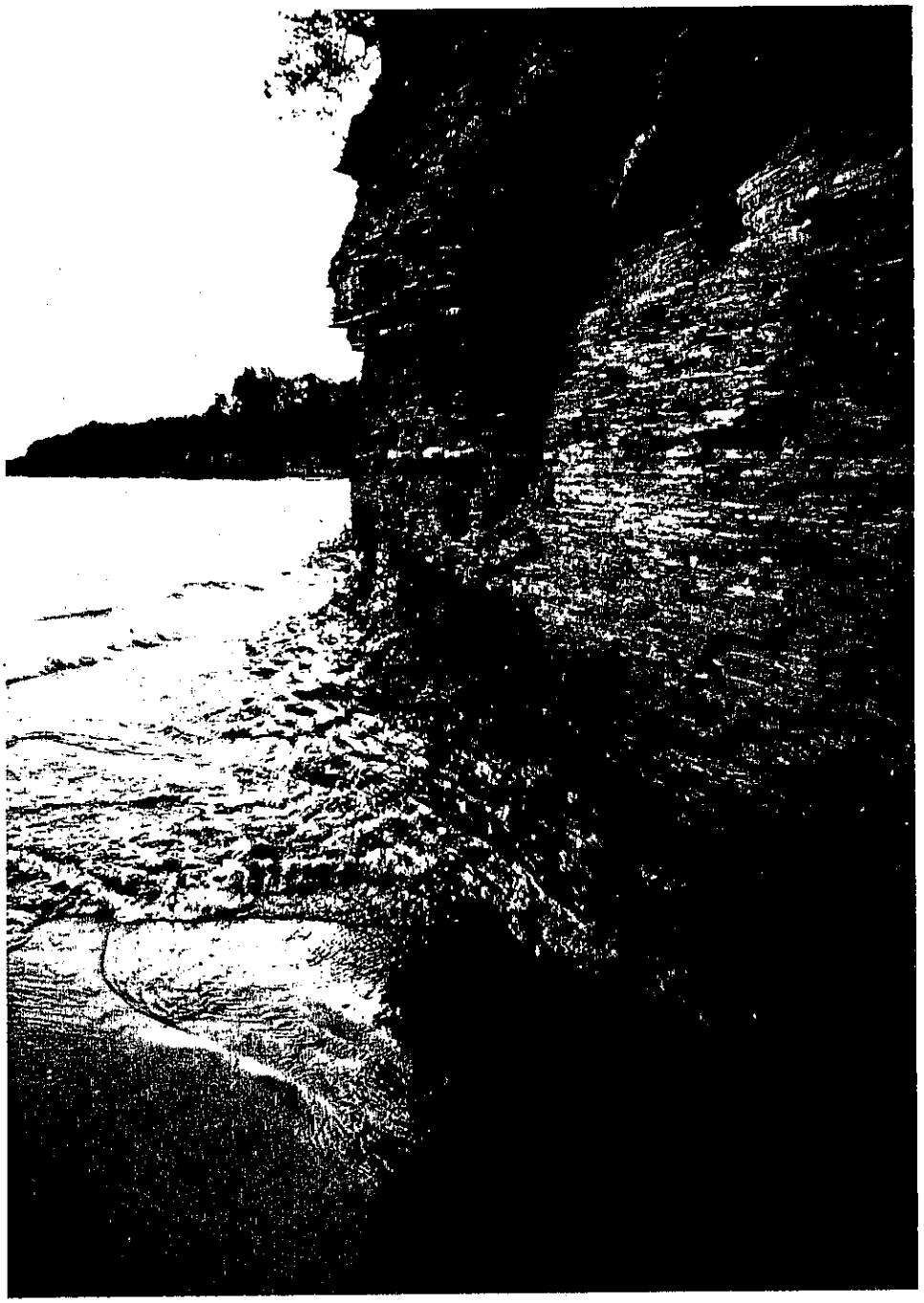

Figure I-C Bedrock bluff (Conewago shale--Devonian) at Sturgeon Point, Erie County New York; note vertical cliff and absence of beach at headlands.

TYPE 1
EXPOSED BEDROCK BLUFFS

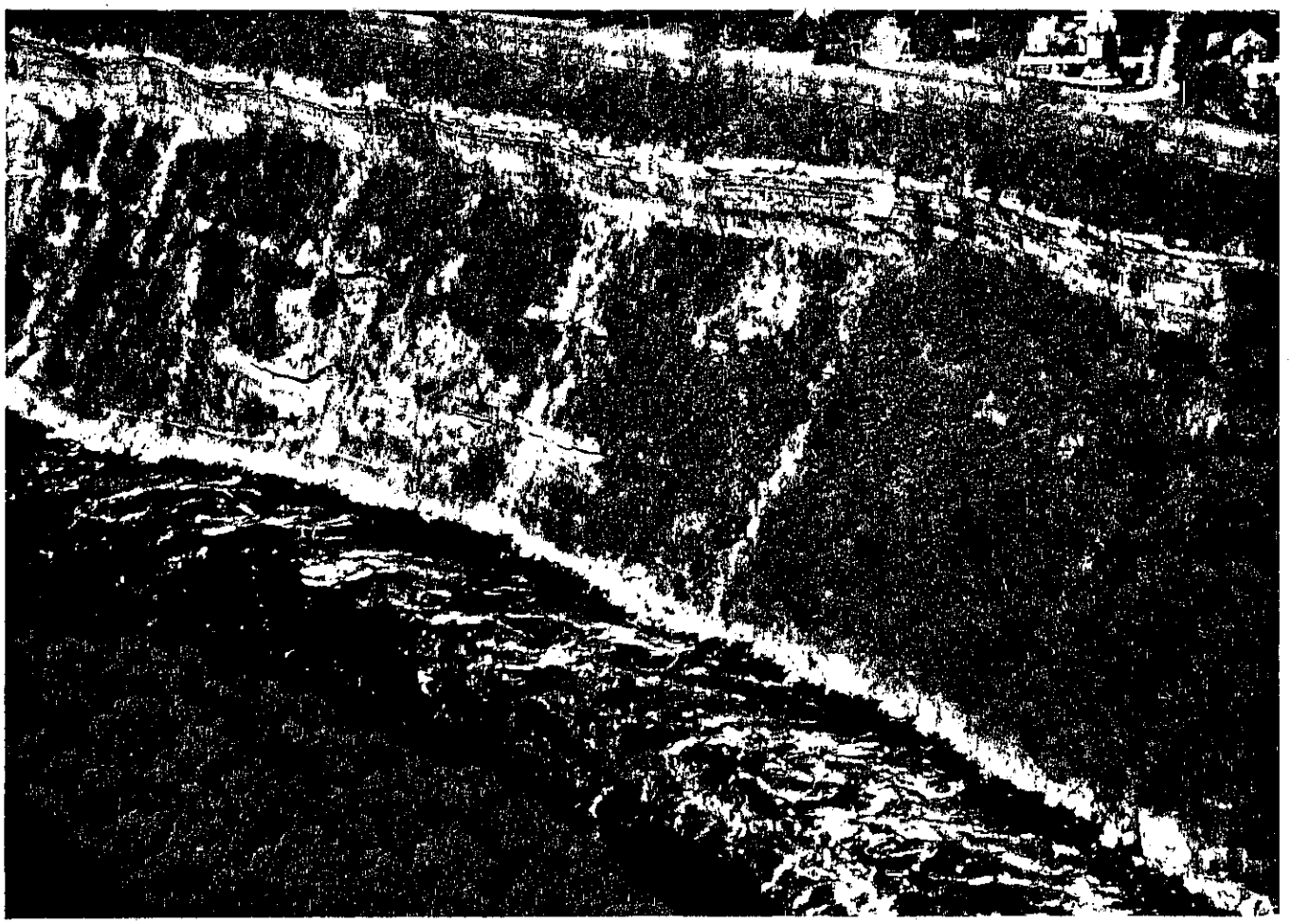

Figure I-D Aerial view of bedrock bluff (lower unit, Rochester Shale and upper unit, Lockport Dolomite--Silurian) along the Niagara River Gorge between the Falls and the Escarpment, Niagara County, New York; note boulder shore at base of cliff (Type 6).

TYPE 2
EXPOSED UNCONSOLIDATED SEDIMENT BLUFFS

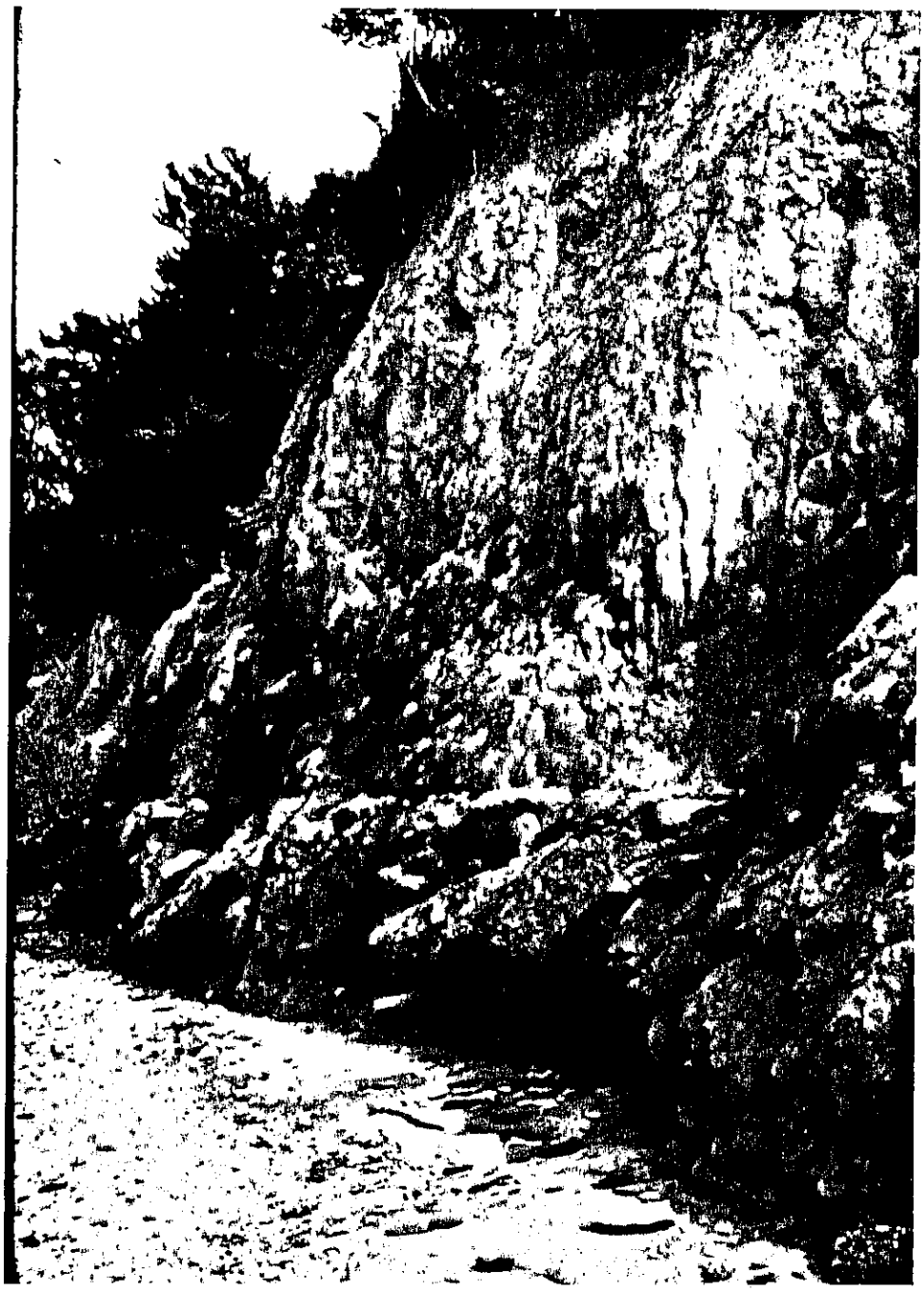

Figure 2-A Unconsolidated sediments bluff (lower unit, gray glacial till; upper unit, brown lacustrine deposits) east of Vermillion, Lorain County, Ohio; note mixed sand and gravel beach.

TYPE 2
EXPOSED UNCONSOLIDATED SEDIMENT BLUFFS

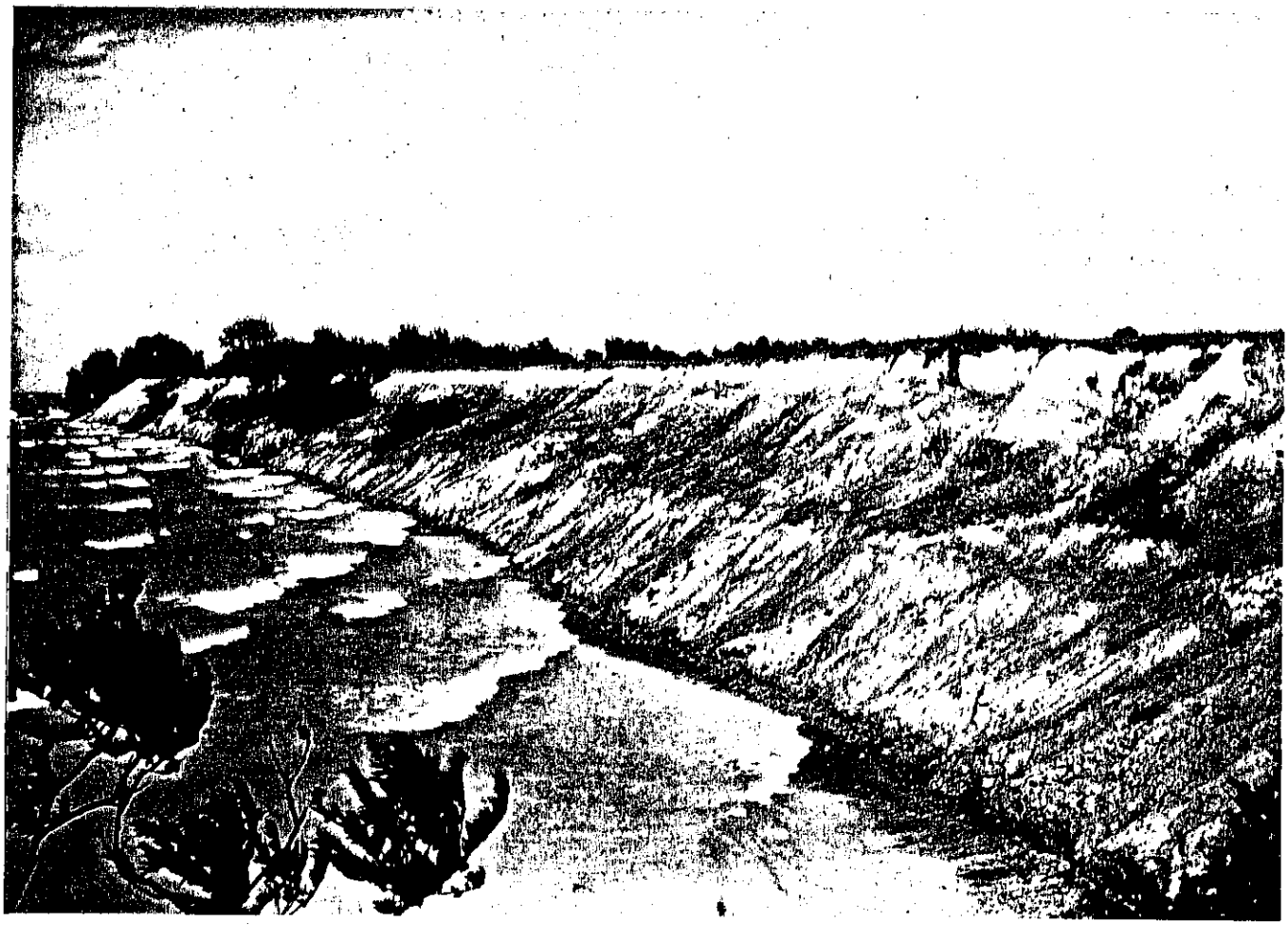

Figure 2-B Unconsolidated sediment bluffs (lower unit, gray glacial till; upper unit, brown lacustrine deposits) North Kingsville, Ashtabula County, Ohio; note springs between the two units and wave attack at the base of the till.

TYPE 2
EXPOSED UNCONSOLIDATED SEDIMENT BLUFFS

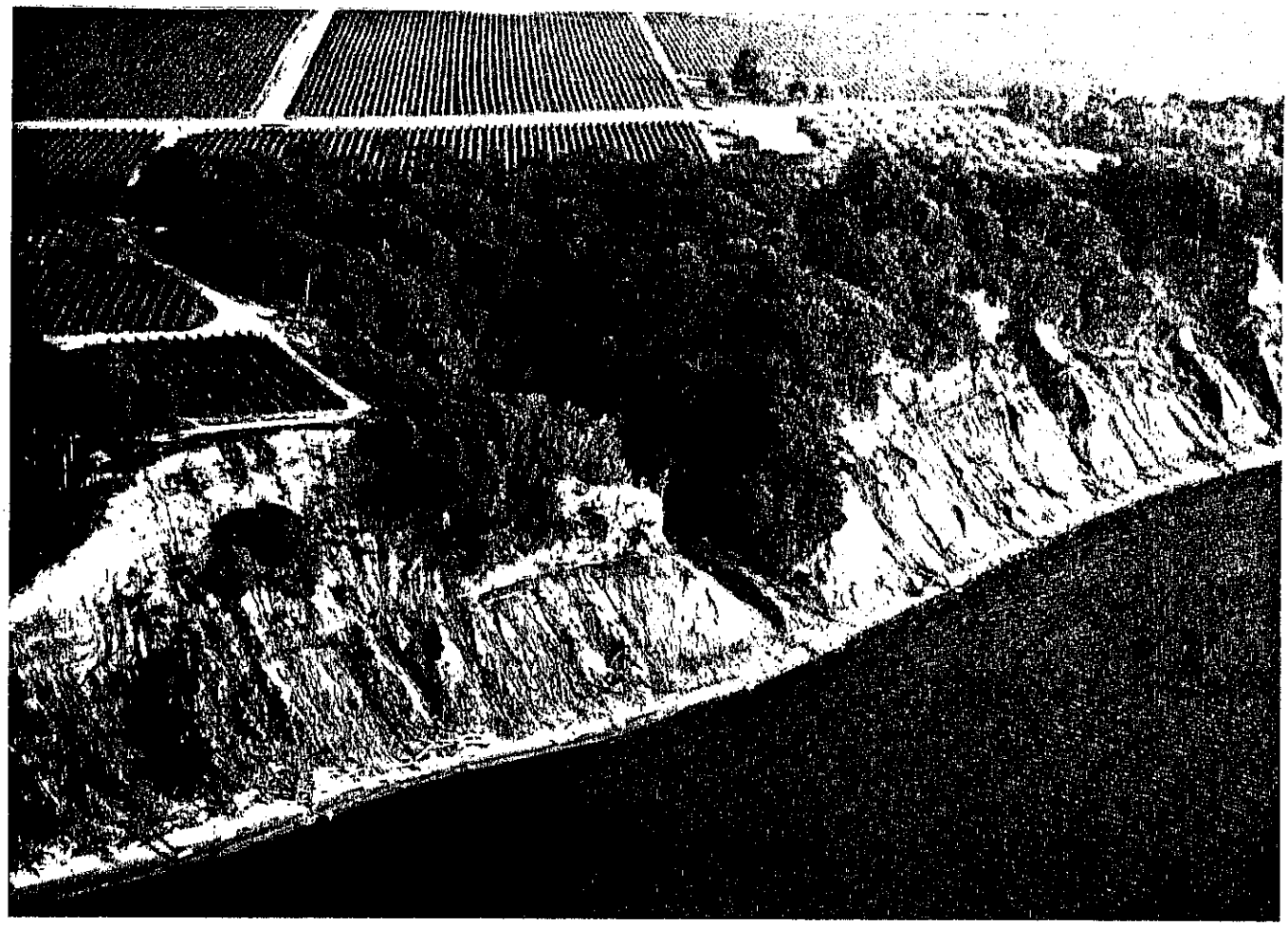

Figure 2-C Aerial view of unconsolidated bluffs (lower unit gray glacial till; upper unit, brown lacustrine deposits) near North East, Erie County, Pennsylvania; note deep ravine.

TYPE 3
SHELVING BEDROCK SHORES

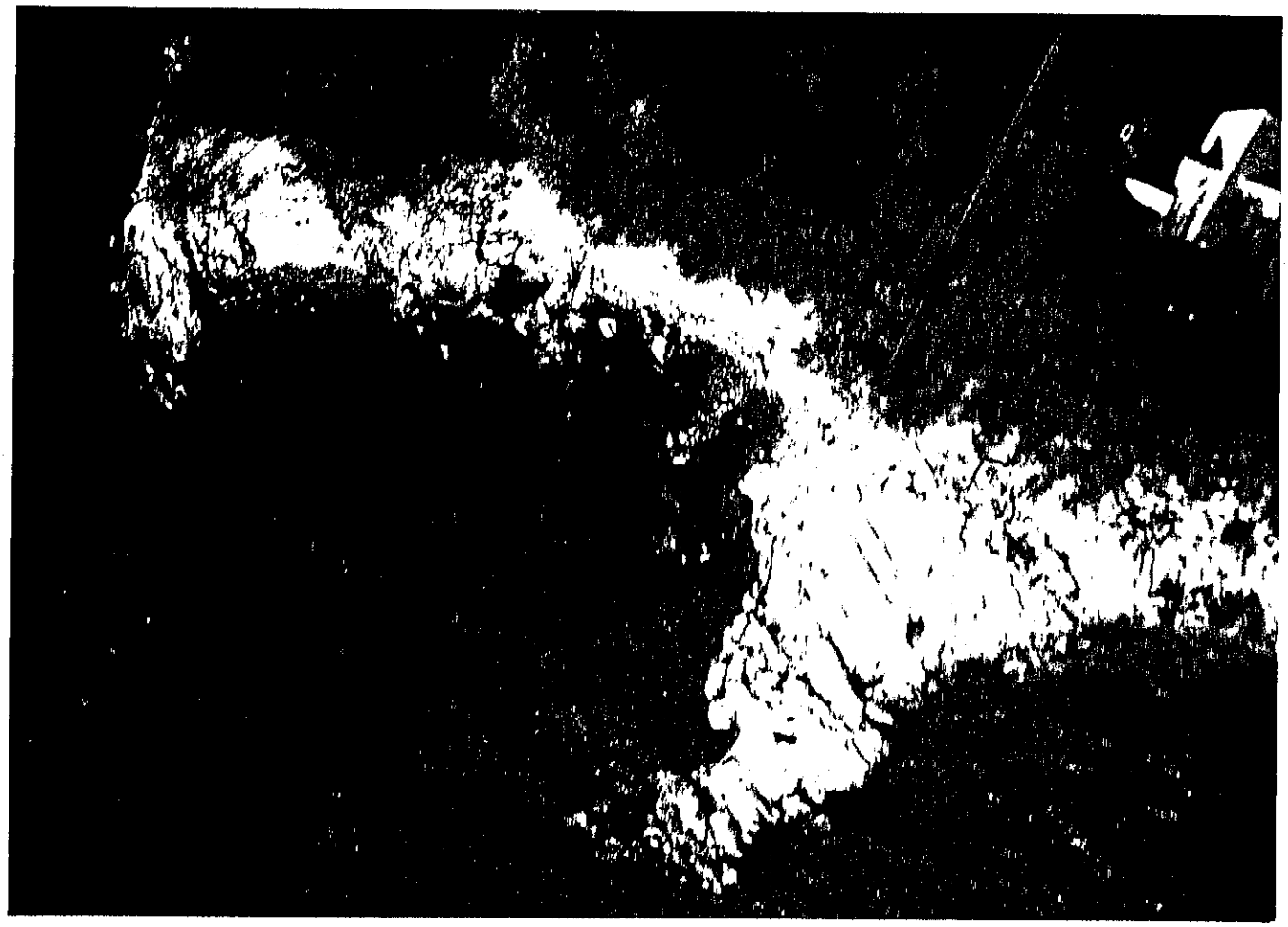

Figure 3-A Aerial view of shelving bedrock (Put-in-Bay Dolomite--Silurian) on the east shore of South Bass Island, Ottawa County, Ohio; note glacial grooves.

TYPE 3
SHELVING BEDROCK SHORES

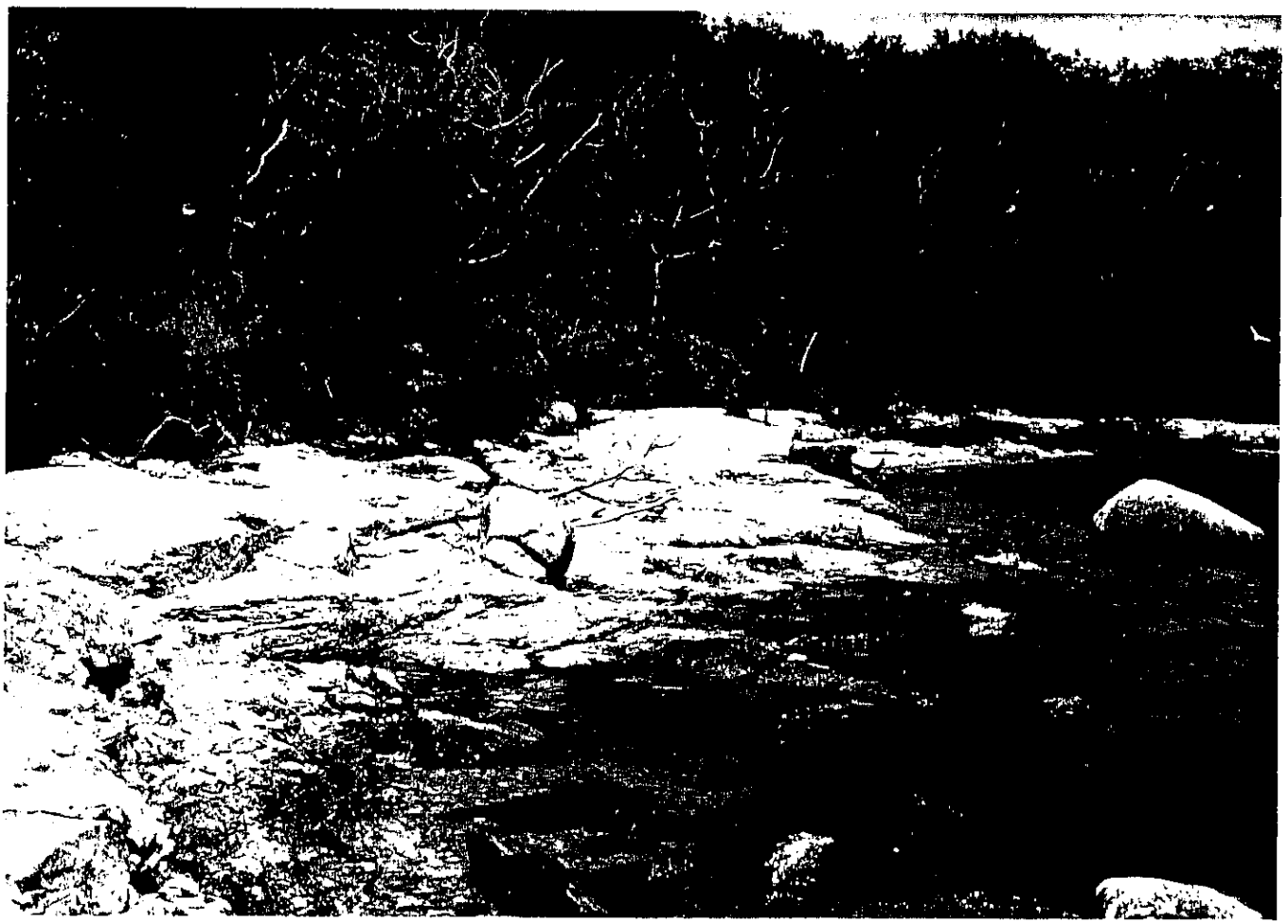

Figure 3-B Shelving bedrock (Raisin River Dolomite--Silurian) on the east shore of Middle Sister Island, Essex County, Ontario; note Cladophora glomerata growth.

TYPE 3
SHELVING BEDROCK SHORES

Figure 3-C Shelving bedrock (Ohio Shale--Devonian) at Vermillion, Erie County, Ohio; note lacustrine deposits forming low bluff on top of bedrock shelf.

TYPE 4
SAND SHORES

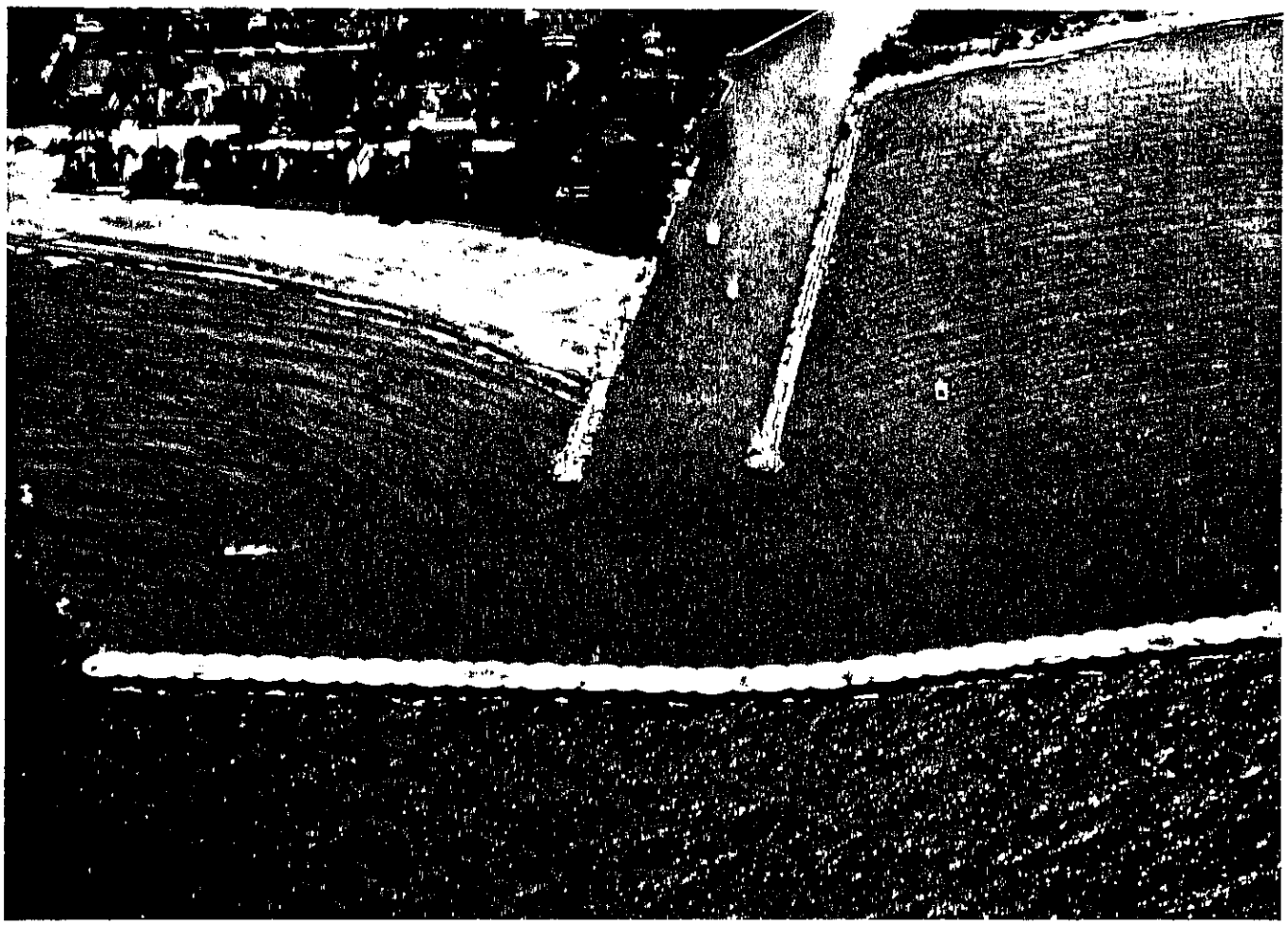

Figure 4-A Aerial view of sand beach accumulated on the updrift (east) side of Vermillion harbor jetties, Erie County, Ohio; note sand starvation on the downdrift shore.

TYPE 4
SAND SHORES

Figure 4-B Aerial view of sand spit (Bay Point) deposited at the entrance to Sandusky Bay, Ottawa County, Ohio; note wetlands formed on bay-side (left) of spit.

TYPE 4
SAND SHORES

Figure 4-C Sand spit in the process of forming a coastal lagoon at the distal end of Presque Isle, Erie County, Pennsylvania; note the fine nature of the sand.

TYPE 5
MIXED SAND AND GRAVEL SHORES

Figure 5-A Mixed sand, gravel and shell beach at Locust Point, Ottawa County, Ohio; note abnormally high percentage of shell material.

TYPE 5
MIXED SAND AND GRAVEL SHORES

Figure 5-B Mixed sand and gravel beach accumulated on the updrift (east) side of a steel, sheet-piling groin at Crane Creek State Park, Ottawa County, Ohio; note coarse nature of beach material at crest of berm.

TYPE 5
MIXED SAND AND GRAVEL SHORES

Figure 5-C Mixed gravel and sand beach at the base of a glacial till bluff in Sheffield Lake, Lorain County, Ohio; note narrow nature of this beach.

TYPE 6
GRAVEL SHORES

Figure 6-A Pebble and cobble beach fronting shelving bedrock on the northeast shore of Middle Island, Essex County, Ontario; note the rounded nature of the dolomite gravel, steepness of the beach slope and successive storm ridges.

TYPE 6
GRAVEL SHORES

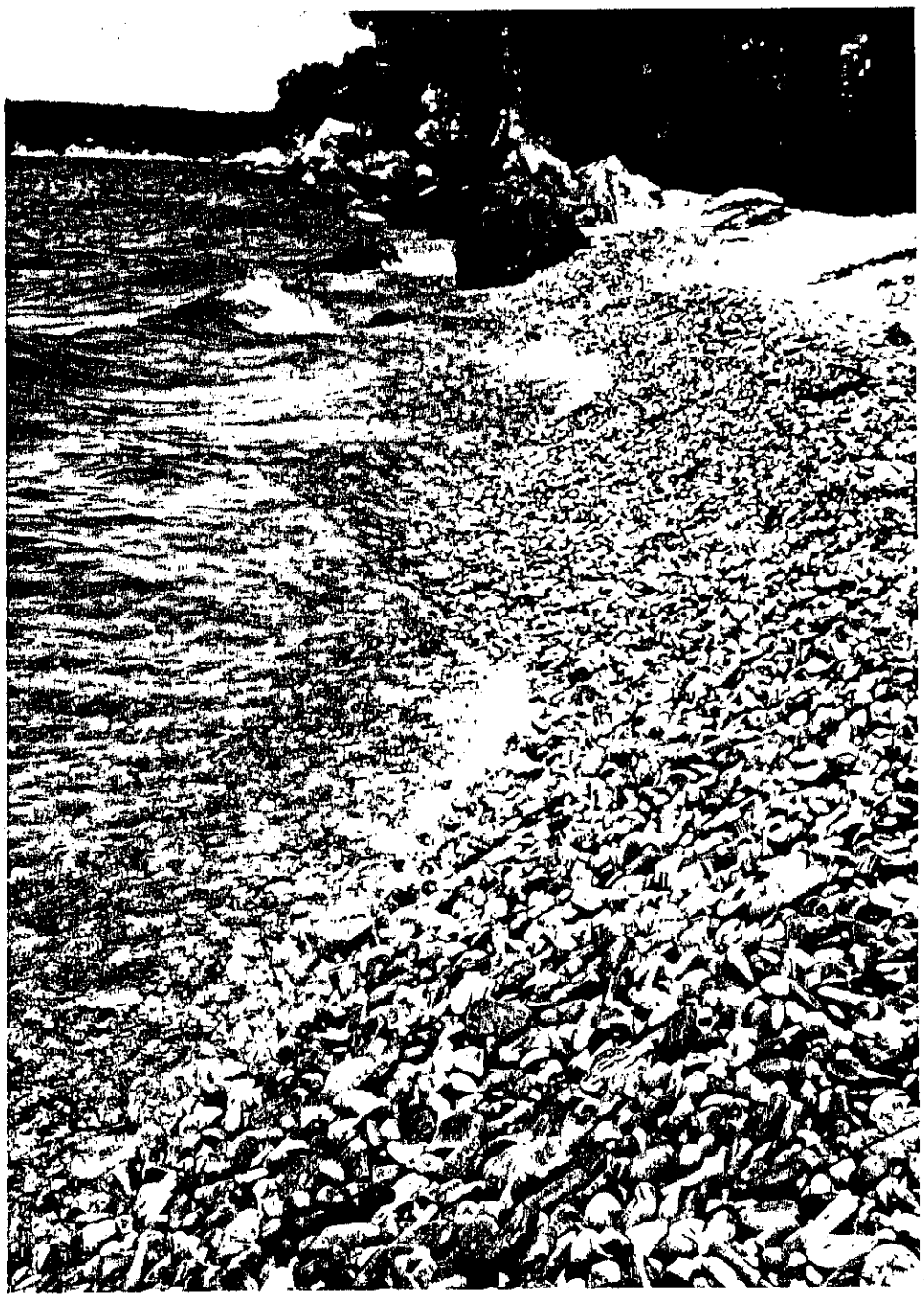

Figure 6-B Cobble beach fronting, a dolomite cliff on the southwest shore of South Bass Island, Ottawa County, Ohio; note the narrowness and steep nature of the beach.

TYPE 6
GRAVEL SHORES

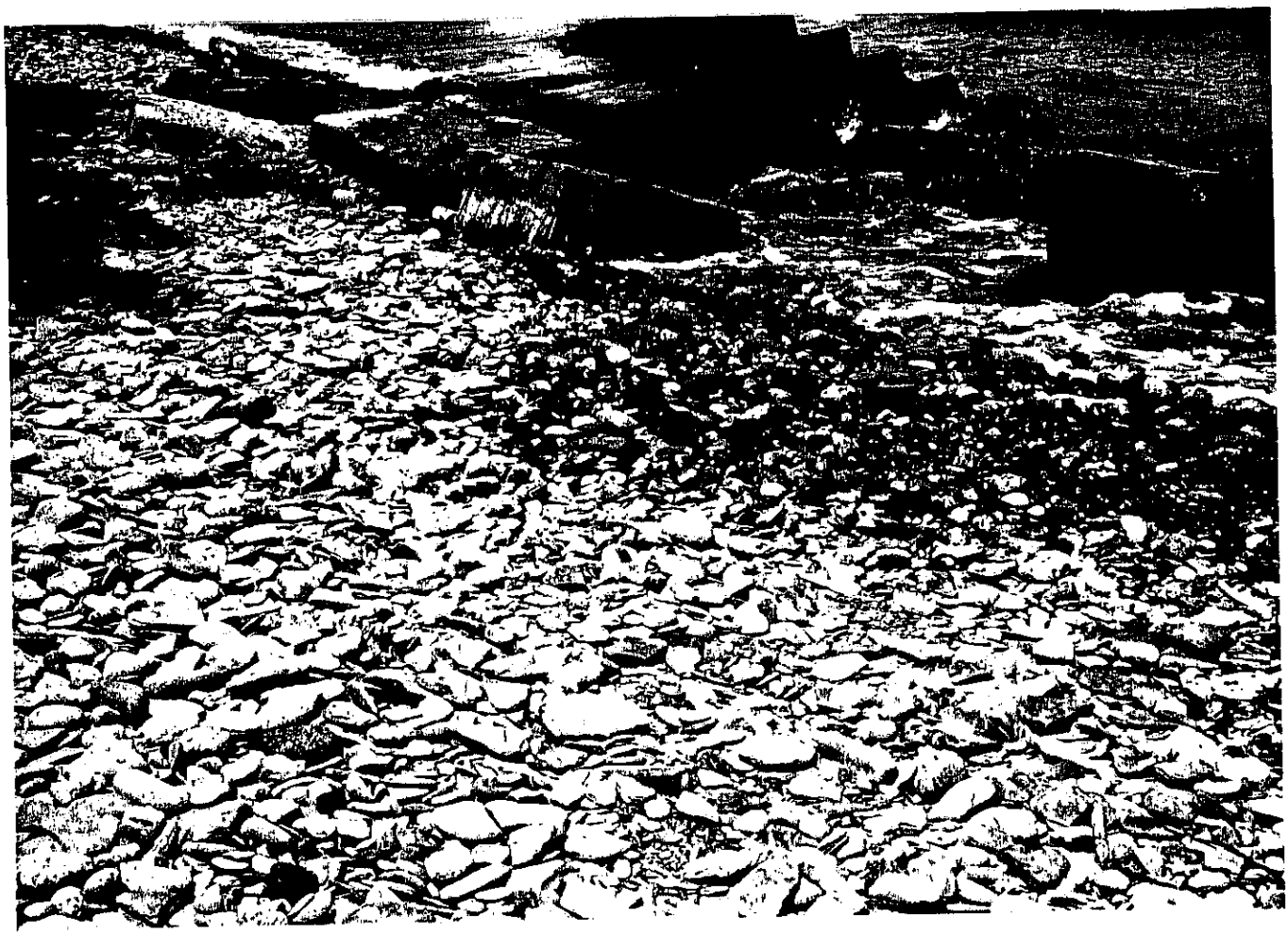

Figure 6-C Shingle beach composed of shale slabs weathered from bedrock at Sheffield Lorain County, Ohio; note overlapping nature of the beach material.

TYPE 6
GRAVEL SHORES

Figure 6-D Cobble and boulder beach composed of igneous and metamorphic rocks weathered from glacial till near Sturgeon Point, Erie County, New York; note the coarse but poorly sorted nature of the beach materials.

TYPE 7
RIP-RAP AND HARBOR STRUCTURES

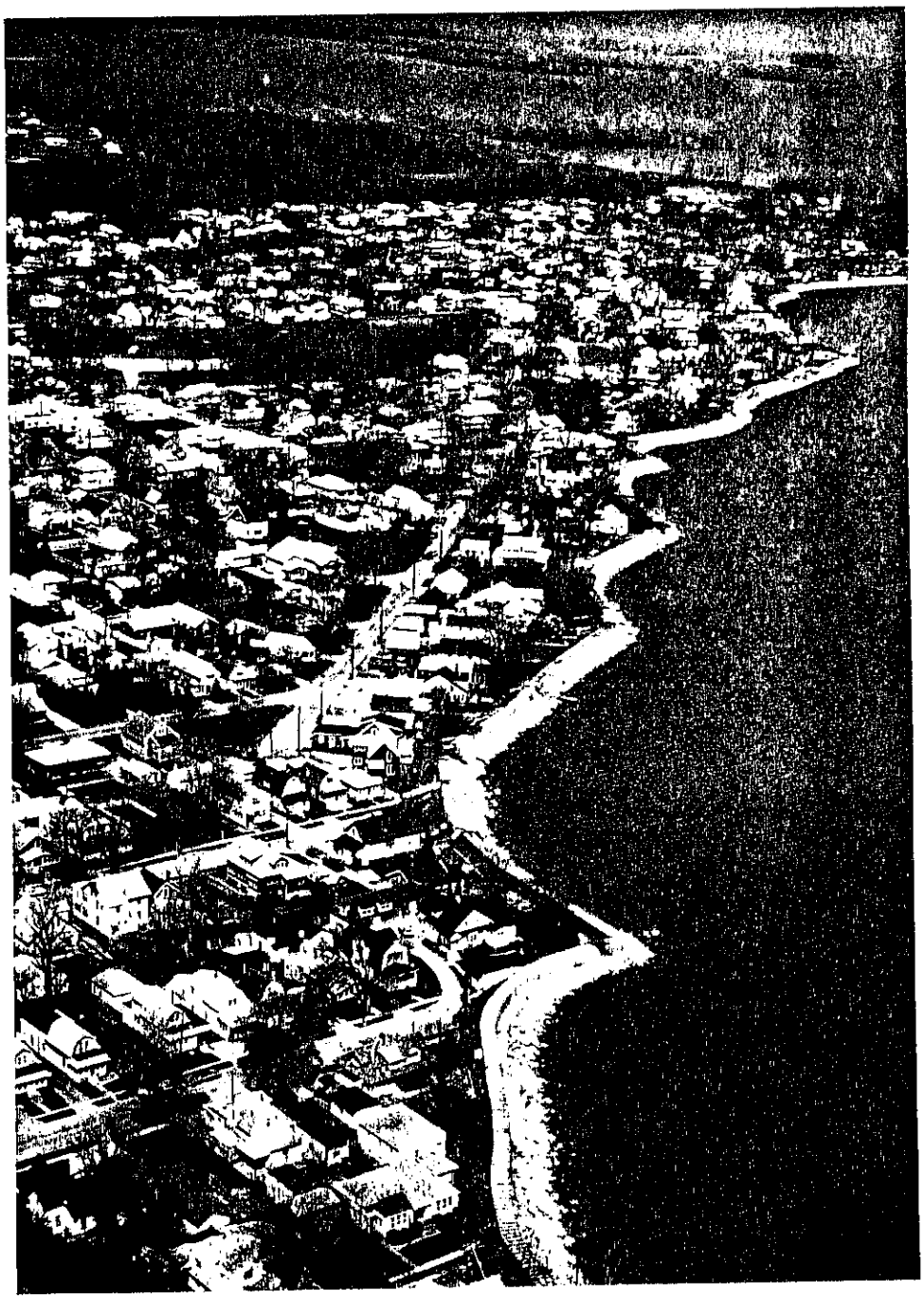

Figure 7-A Aerial view of rip-rap protection on the Maumee Bay shore of Point Place, Lucas County, Ohio; note lack of beaches.

TYPE 7
RIP-RAP AND HARBOR STRUCTURES

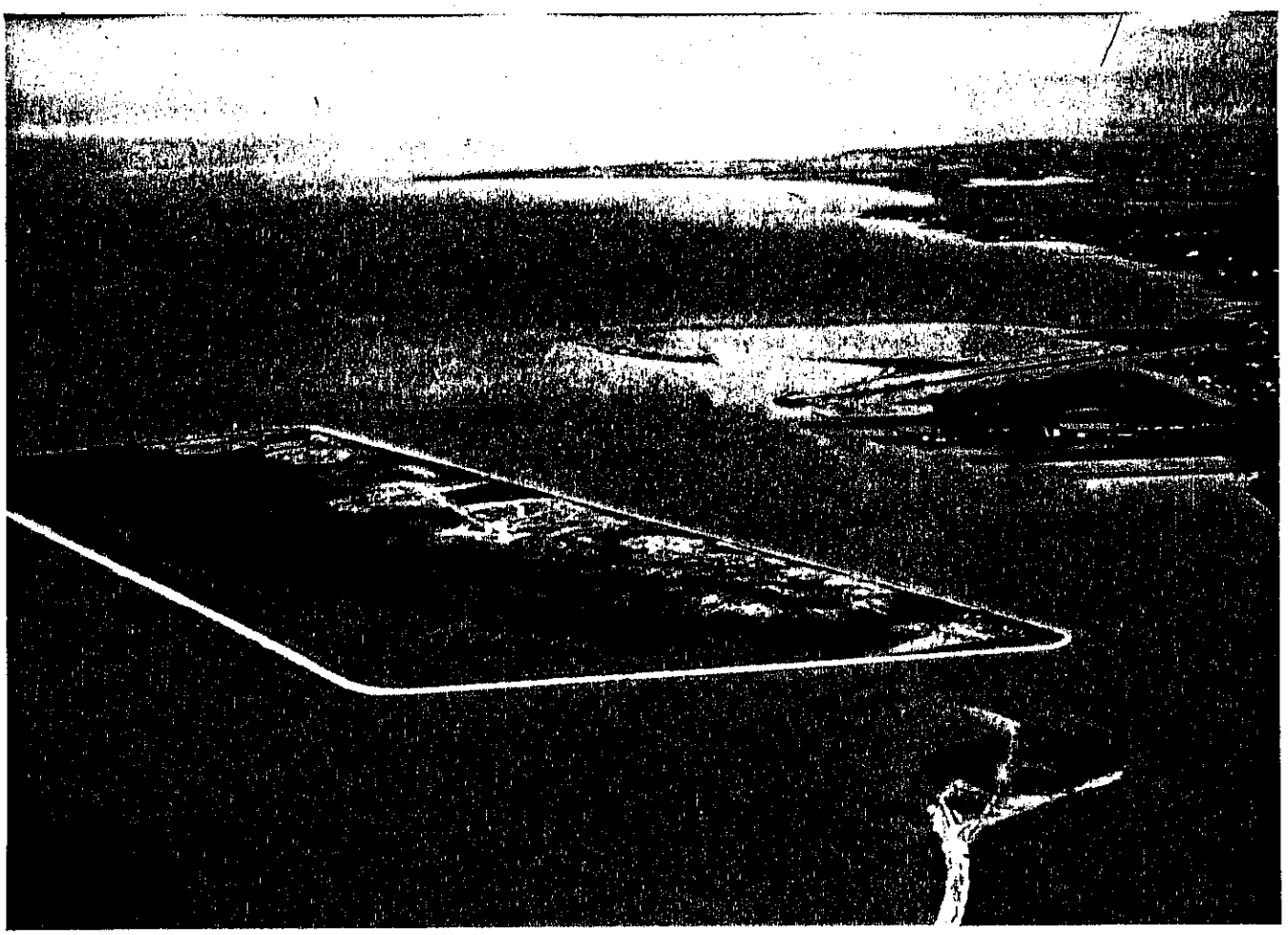

Figure 7-B Aerial view of confined, dredged material disposal island constructed of coarse rip-rap in Toledo harbor, Lucas County, Ohio; note wetlands (Type 10) formed inside diked area.

TYPE 7
RIP-RAP AND HARBOR STRUCTURES

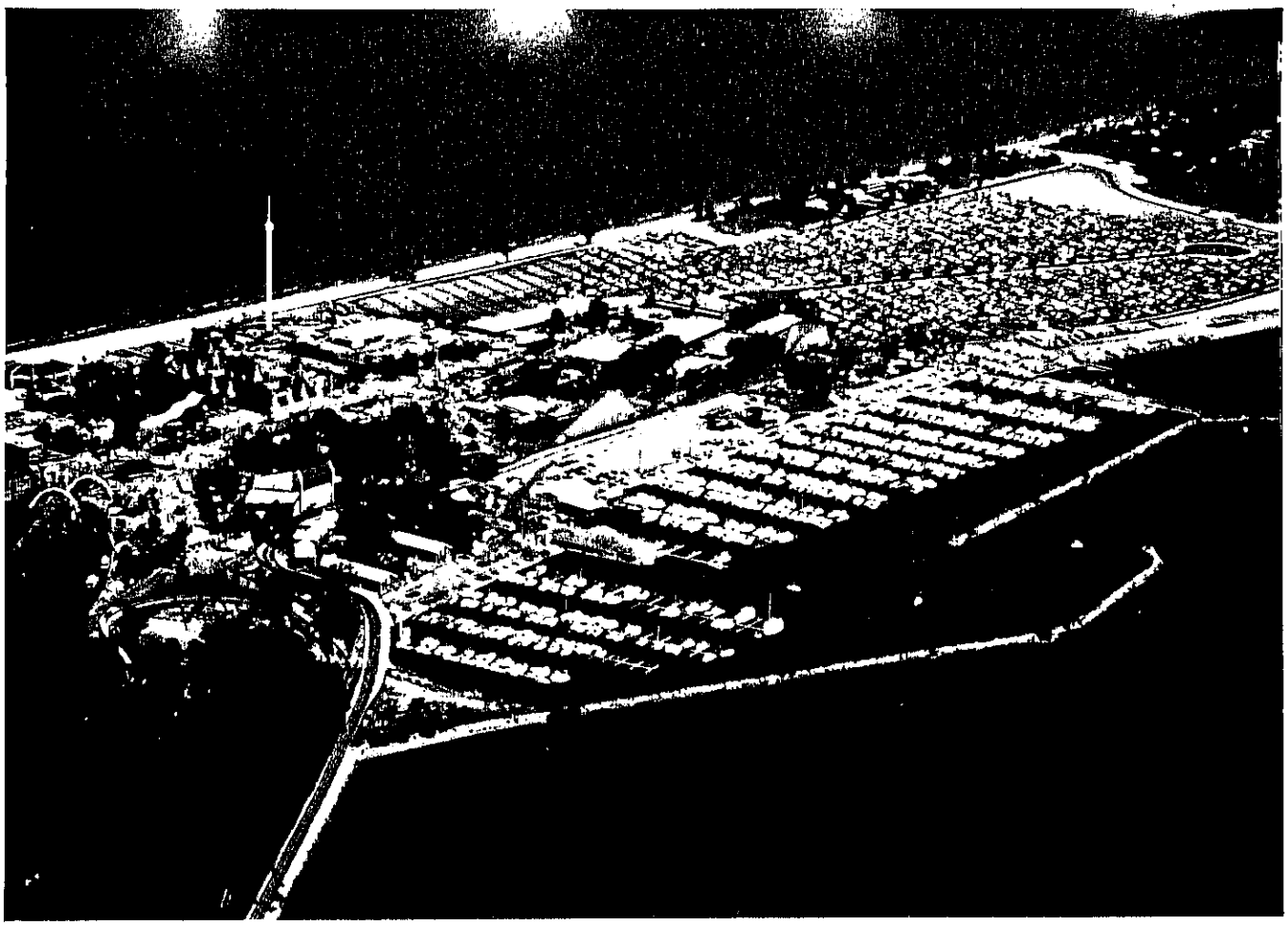

Figure 7-C Aerial view of small boat harbor constructed of rip-rap on the Sandusky Bay side of Cedar Point, Erie County, Ohio; note sand beach (Type 4) fronting the lake side of the spit.

TYPE 8
SHELTERED BLUFFS

Figure 8-A Sheltered lacustrine bluffs of upper Sandusky Bay, Sandusky County, Ohio; note the debris which has accumulated along the shore.

TYPE 8
SHELTERED BLUFFS

Figure 8-B Aerial view of sheltered bluffs within a freshwater estuary at the mouth of Old Woman Creek, Erie County, Ohio; note the barrier beach (Type 4) fronting the mouth and the wetlands vegetation (Type 10) near the island.

TYPE 8
SHELTERED BLUFFS

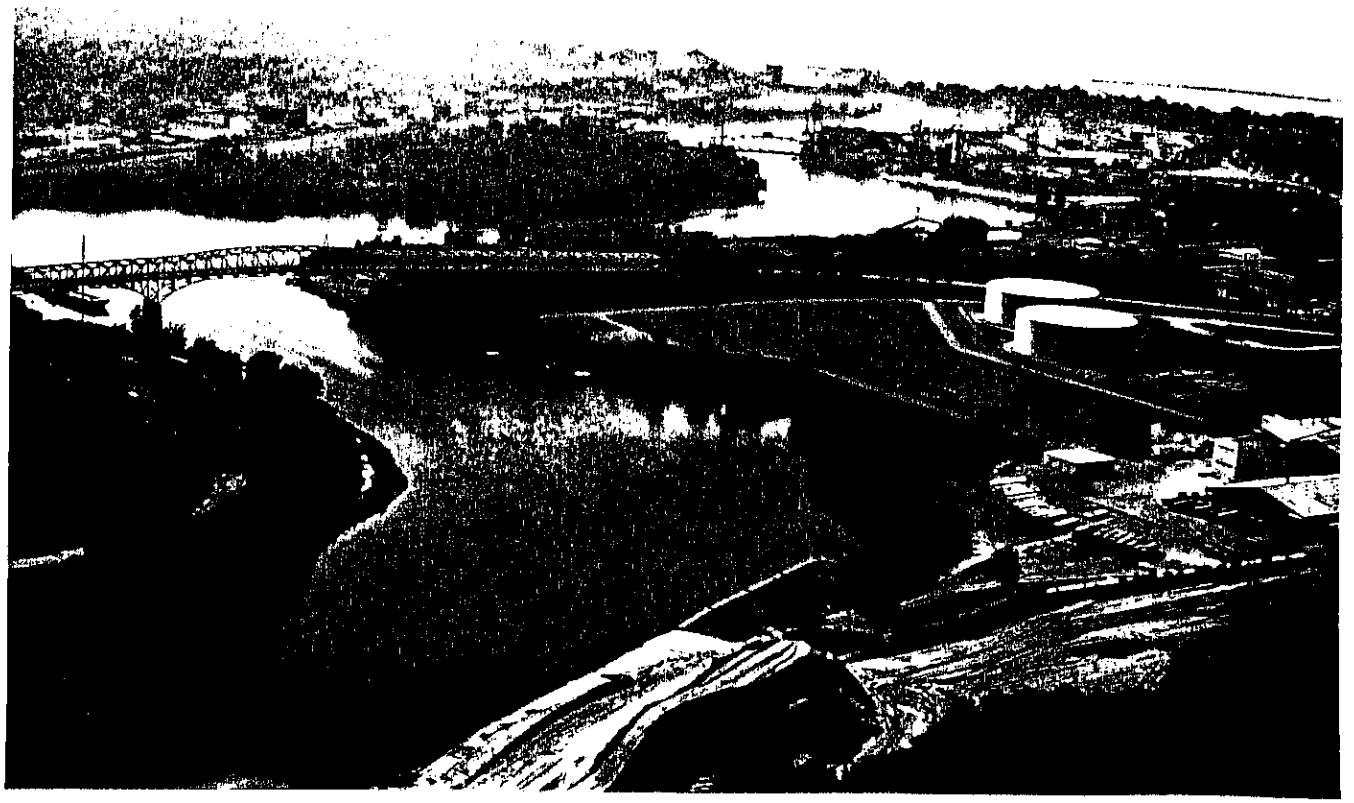

Figure 8-C Aerial view of sheltered bluffs along the Black River at Lorain, Lorain County, Ohio; note the harbor structures at the mouth of the river.

TYPE 8
SHELTERED BLUFFS

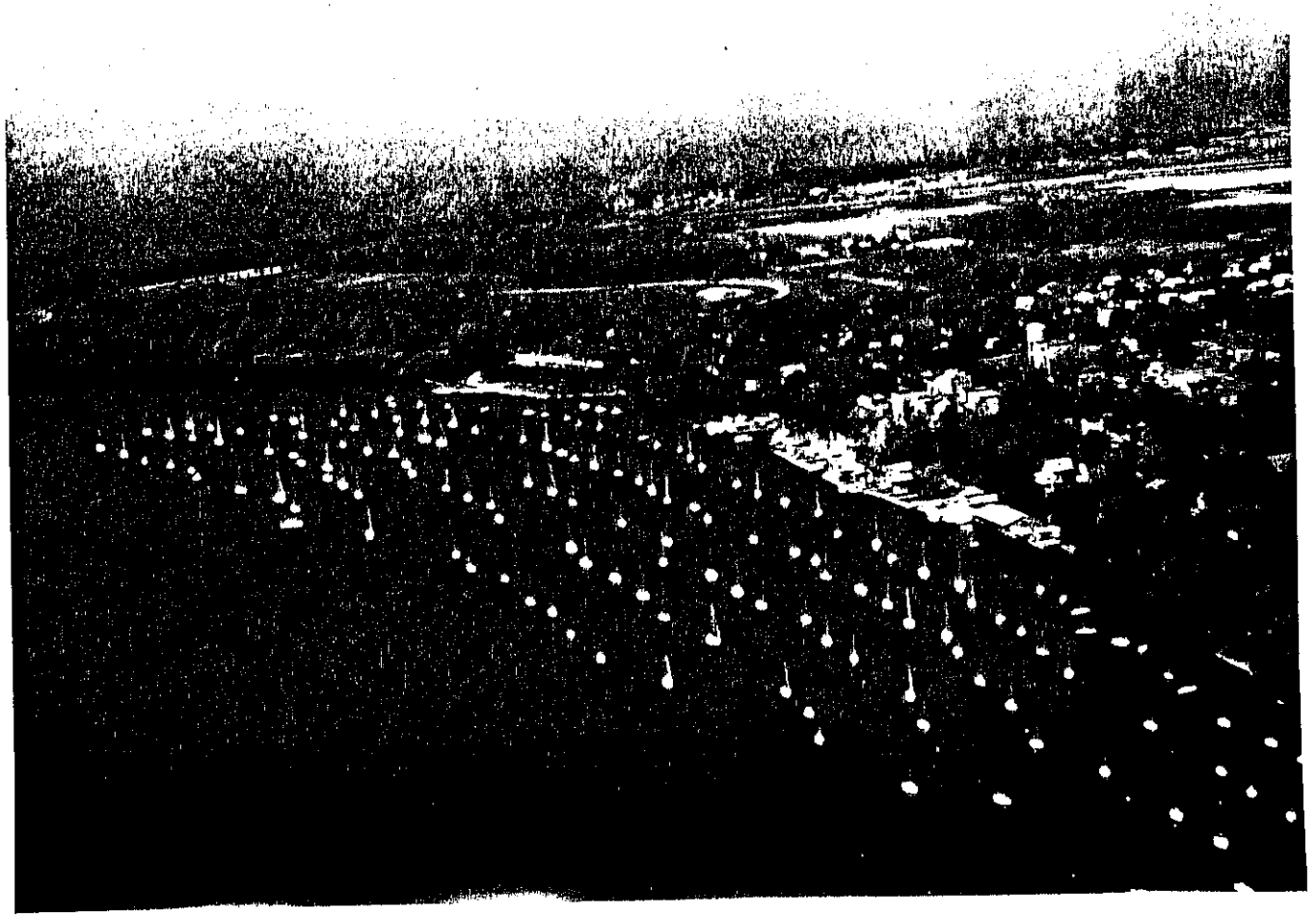

Figure 8-D Aerial view of sheltered bluffs near the mouth of the Niagara River at Youngstown, Niagara County, New York; note large sailboat anchorage in this protected area.

TYPE 9
LOW BANKS

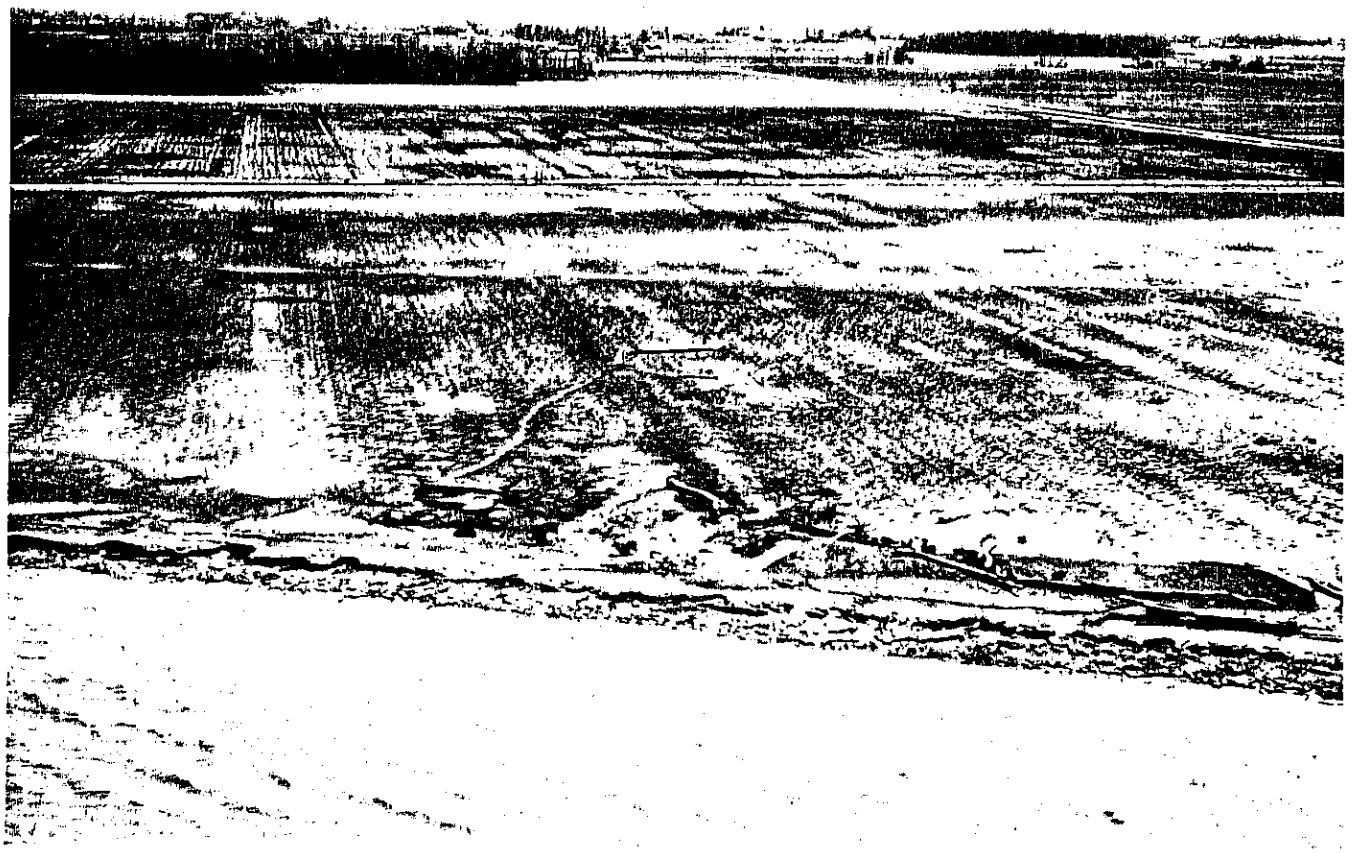

Figure 9-A Aerial view of low banks of lacustrine sediments along the south shore of Maumee Bay near Oregon, Lucas County, Ohio; note evidence of recent lake flooding.

TYPE 9
LOW BANKS

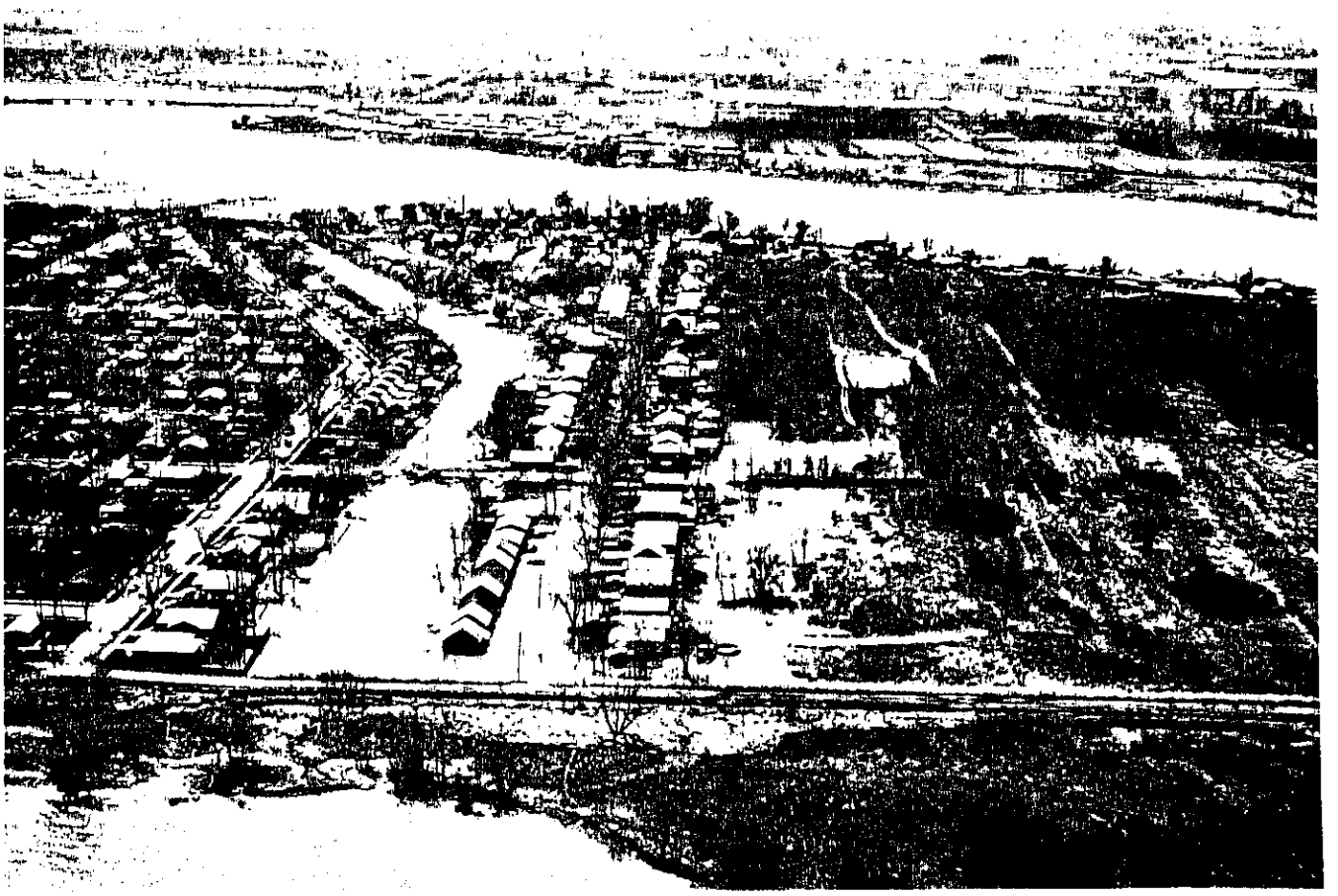

Figure 9-B Aerial view of flooding over the low banks of Maumee Bay (foreground) and the Ottawa River (background) at Point Place, Lucas County, Ohio; note low nature of terrain.

TYPE 10
COASTAL WETLANDS

Figure 10-A Aerial view of delta wetlands and residential lagoons at the mouth of the St. Clair River, St. Clair County, Michigan; note emergent aquatic vegetation in foreground.

TYPE 10
COASTAL WETLANDS

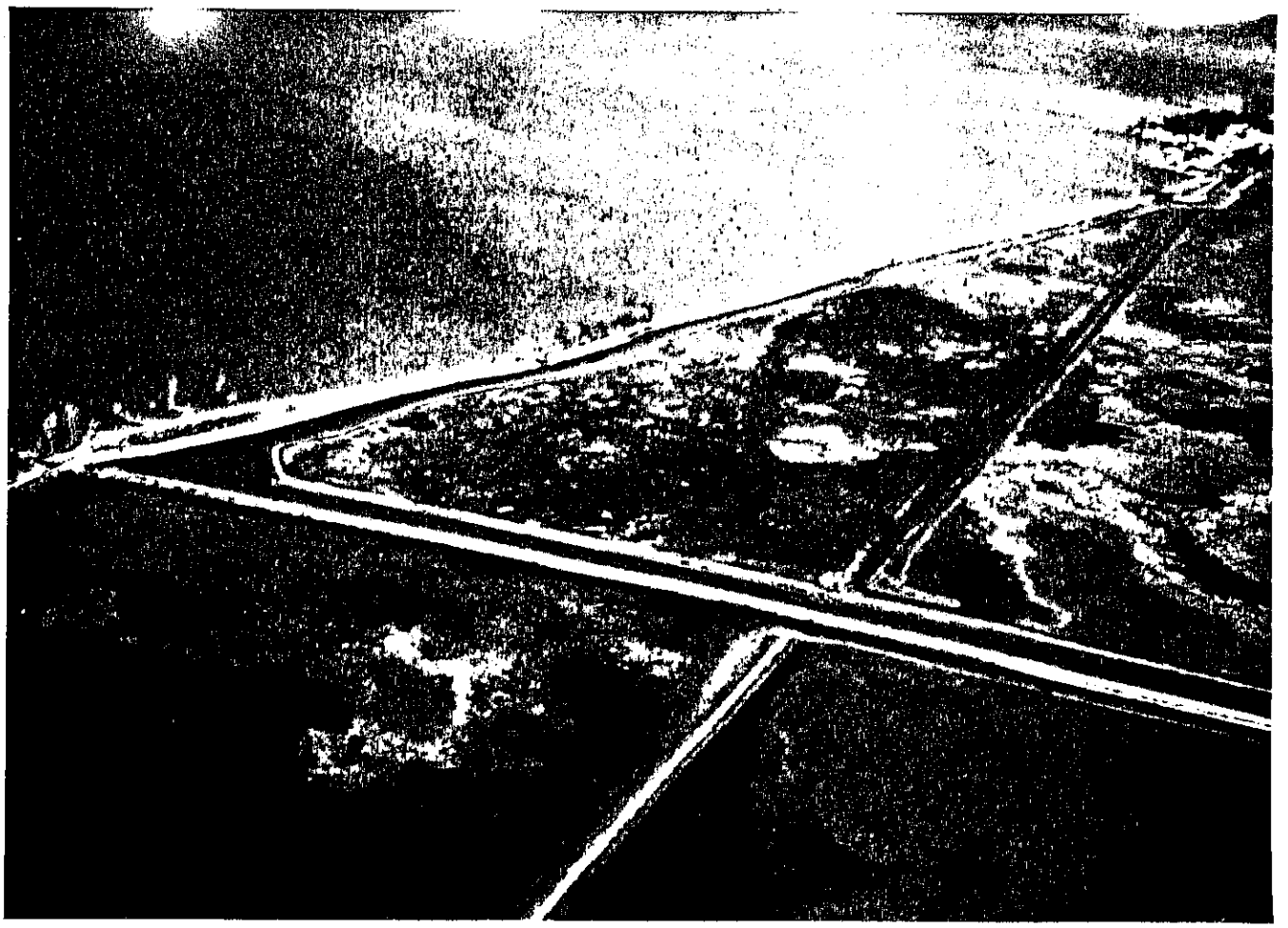

Figure 10-B Aerial view of diked wetlands at Ottawa National Wildlife Refuge, Ottawa County, Ohio; note rip-rap (Type 7) construction of dike.

TYPE 10
COASTAL WETLANDS

Figure 10-C Surface view of rip-rap dike (Type 7) at Darby Marsh, Ottawa County, Ohio; note wetland vegetation being protected by dike.

TYPE 10
COASTAL WETLANDS

Figure 10-D Aerial view of wetlands formed behind Cedar Point spit, Erie County, Ohio; note that the sand spit (Type 4) has broken away from the rip-rap (Type 7) protected portion of the spit.

TYPE 10
COASTAL WETLANDS

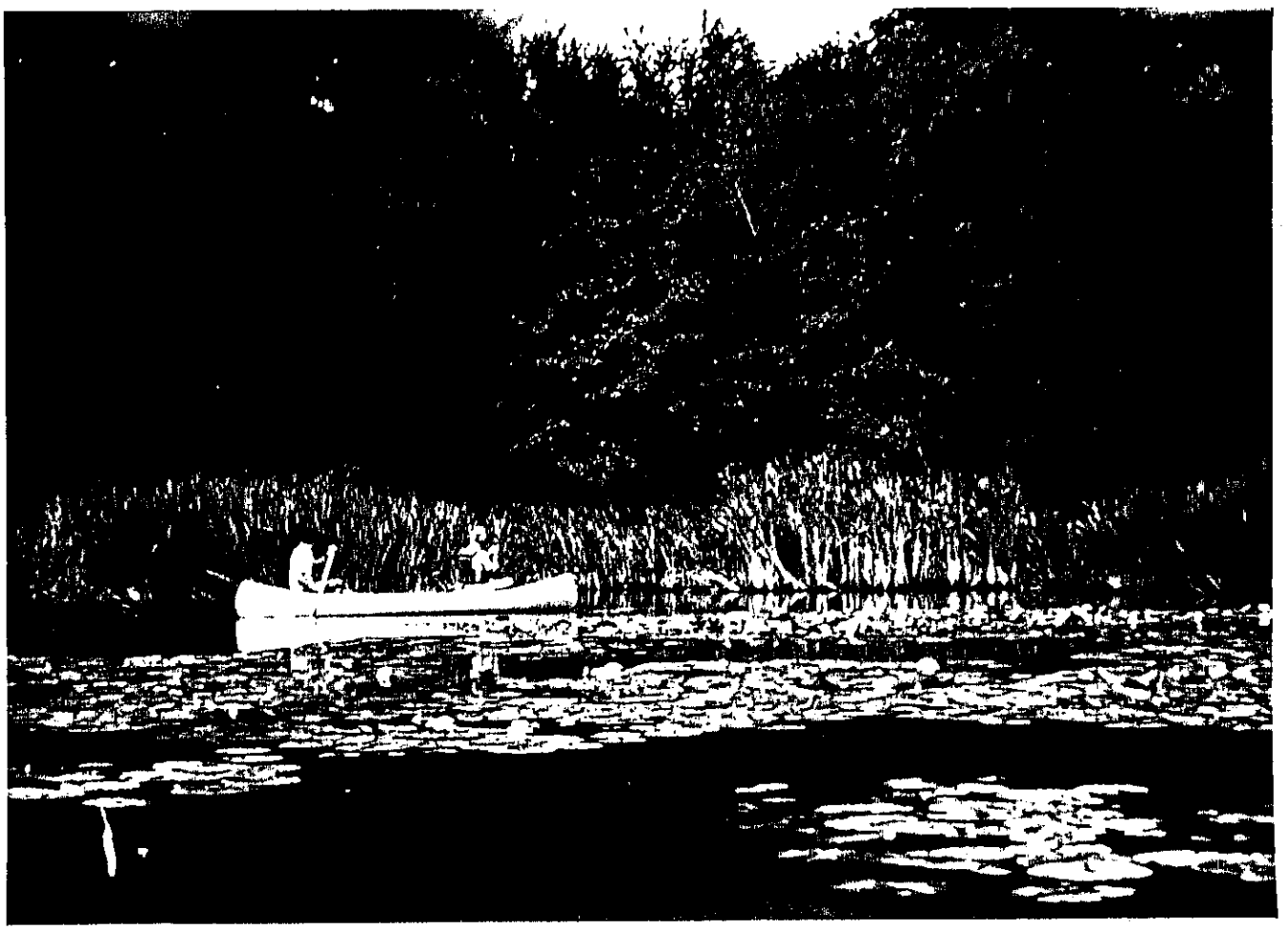

Figure 10-E Wetlands developed within a freshwater estuary at the mouth of Old Woman Creek, Erie County, Ohio; note floating and emergent aquatic vegetation.

TYPE 10
COASTAL WETLANDS

Figure 10-F Wetlands developed within a coastal lagoon formed by sand spit growth on Presque Isle, Erie County, Pennsylvania; note emergent and submergent aquatic vegetation.

TYPE 10
COASTAL WETLANDS

Figure 10-G Fringing coastal wetland formed on the sandy shore (Type 4) of Strawberry Island and shallow bottom of the Niagara River, Erie County, New York; note sheltered nature (Type 8) of shoreline in the background.