GEOLOGICAL SURVEY

PROCEEDINGS

3RD ANNUAL

LAKE ERIE COASTAL EROSION STUDY WORKSHOP

January 31-February 1, 1995

USGS Center for Coastal Geology

St. Petersburg, FL

Edited by

David W. Folger

Open File Report 95-224

April 1994

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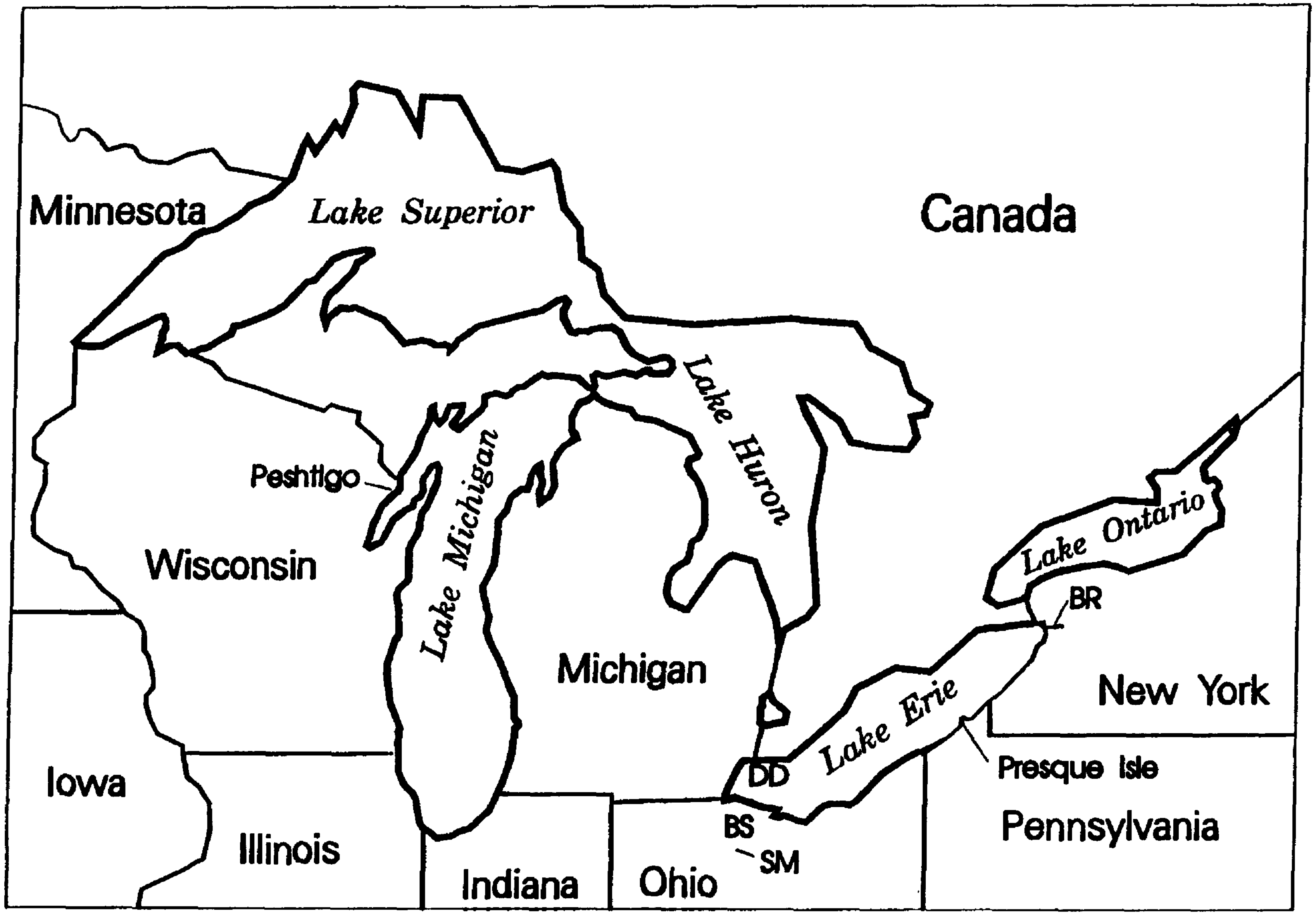

BS - Black Swamp; SM - Springville Marsh; DD - Detroit Delta; BR - Buffalo River

Fig. 1a

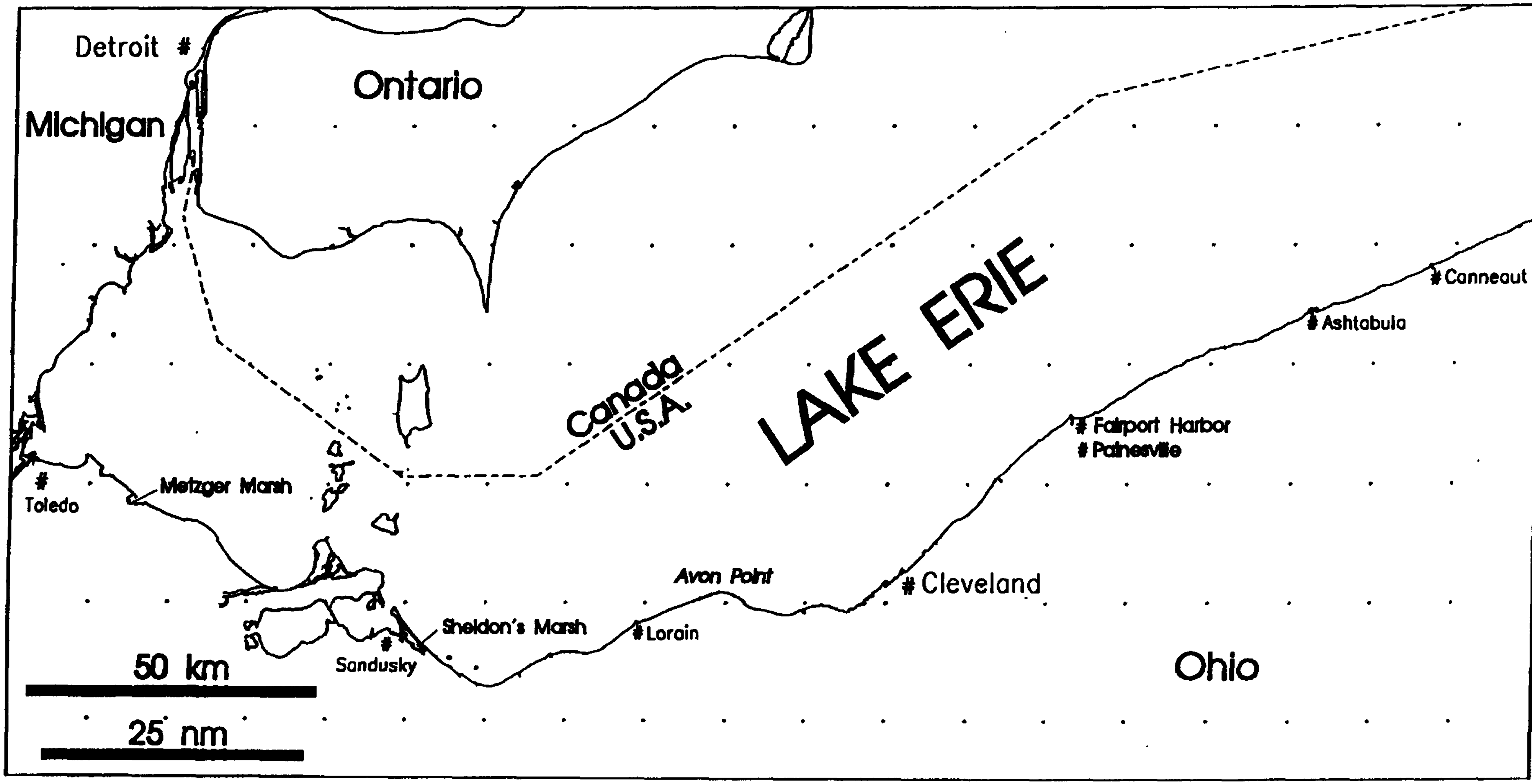
Detroit
Michigan
Ontario
Toledo
Metzger Marsh
Canada
U.S.A.
LAKE ERIE
Canneaut
Ashtabula
Fairport Harbor
Painesville
Avon Point
Cleveland
Sheldon's Marsh
Lorain
Sandusky
Ohio
50 km
25 nm

Fig. 1b

INTRODUCTION

The Lake Erie Coastal Erosion Study, a cooperative between the Ohio Geological Survey and the U.S. Geological Survey, was initiated in FY 1991 to document the rates of retreat along the Ohio shoreline, map the nearshore geology, and assess some of the processes responsible for the retreat.

Participants have included Scudder Mackey, Donald Guy, Jonathan Fuller, and Richard Pavey of the Ohio Geological Survey and John Haines, Steven Colman, David Folger, David Foster, Robert Oldale, Peter Barnes, Byron Stone, Ronald Circe, and Gerald Shideler of the USGS. Michael Chrzastowski of the Illinois State Geological Survey and Curtis Larsen of the USGS attended this workshop as consultants.

Field work for the study is about 85% complete. The remaining work will be carried out in the summer of 1995. Evaluation and compilation of data already acquired will be completed during 1995.

Work in progress or completed that was discussed at this workshop (see abstracts this volume) includes: 1) Quantity and fate of sediment in the coastal ice along the Ohio Lake Erie Coast (Barnes, Guy, Frederick, and Dunhill); 2) Suggestions for final stages of the USGS/Ohio Geological Survey cooperative Lake Erie coastal erosion study (Chrzastowski); 3) Sedimentary environments in the western basin of Lake Erie (Circe and Fuller); 4) Sidescan sonar survey of Lake Erie in Ohio waters (Foster, Folger, Fuller, and Circe); 5) The geology of the Ohio area of Lake Erie from shallow seismic data (Fuller, Oldale, Circe, Liebenthal, Parolski, and Nichols); 6) The surficial sediments of Ohio's nearer shore area of Lake Erie from sidescan sonar data (Fuller, Liebenthal, Cross, Nichols, and Irwin); 7) Nearshore sediment distribution, Lake County, Ohio (Guy); 8) A preliminary assessment of recession rates at Painsevile on-the-Lake (Guy); 9) Remote video monitoring (Haines & Townsley); 10) Process/predictive models (Haines, Guy, and Mackey); 11) Objectives for 1995-1996 (Haines, and Mackey); 12) Lake Erie sediment budget (Mackey); 13) Lake Erie wetlands-Metzger Marsh restoration project (Mackey); 14) Coastal lithologies of the Perry quadrangle, Lake County, Ohio (Pavey, Stone, Bruno); 15) Marine geologic atlases on CD-ROM-a method of assembling, integrating, and displaying information (Polloni); 16) Surficial materials and erosion in the coastal area of the North Kingsville 7.5' quadrangle, Ashtabula County, Ohio (Stone, Pavey, Bruno); and 17) Glacially-modified bedrock-surface topography and overlying surficial geologic materials in the western Lake Erie coastal area, northwestern Ohio and southeastern Michigan (Stone and Shideler).

AGENDA

3rd ANNUAL WORKSHOP

LAKE ERIE COASTAL EROSION STUDY

USGS CENTER FOR COASTAL GEOLOGY

St. Petersburg, FL

January 31-February 1, 1995

Purpose: To review and integrate all aspects of the study and develop plans for publication

TUESDAY

January 31,1995

Introductory Comments

0830	Status of USGS coastal studies	Abby Sallenger
0845	Agenda for the workshop	Dave Folger

Geologic Framework-Work Accomplished

0900	Sidescan Sonar Analysis	Dave Folger

0930	Offshore Seismic Analysis	Jonathan Fuller
1000	Coffee Break/Discussion	
1015	Nearshore Mapping and Profiling -Central Basin	Jonathan Fuller Don Guy
1100	Nearshore Mapping and Profiling -Western Basin	Jerry Shideler Byron Stone
1200	Lunch	
1300	Shoreline/Bluff Geology	Rick Pavey Byron Stone

Processes-Work Accomplished

1400	Rates and Processes of Bluff Retreat	Don Guy Scudder Mackey
1445	Coffee/Discussion	
1500	Shoreline Video Monitoring	John Haines
1600	Discussion	
1700	Adjourn	

WEDNESDAY

February 1, 1995

0900	Framework and Processes -Objectives and Schedule	John Haines
1000	Coffee/Discussion	

Sediment Budget-Work Accomplished

1015	Lake Erie Sediment Budget	Scudder Mackey

Predictive Models-Work Accomplished

1015	Process/Predictive Models	John Haines Don Guy Scudder Mackey
1200	Lunch	
1300	1995 Overall Objectives, Schedule, & Publication Plan	Dave Folger
1330	Discussion	
1400	Impressions and Recommendations	Mike Chrzastowski
1500	Coffee	
1515	Lake Erie CD ROM	Chris Polloni
1615	Discussion	
1700	Adjourn	

ABSTRACTS

QUANTITY AND FATE OF SEDIMENT IN THE COASTAL ICE ALONG THE OHIO LAKE ERIE COAST

BARNES, Peter[1]; GUY, Donald, Jr[2]; FREDERICK, Todd[1]; and DUNHILL, Gita[1]

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[2]Ohio Geological Survey, Sandusky, OH 44870-4132

Studies during the past year have focussed on the seasonal cycle of coastal ice formation and the potential opportunities for the ice to incorporate and transport coastal sediment. Four coastal sites were repetitively photographed by USGS volunteers to determine ice formation and decay patterns from December 1993 through early April 1994. These data were compared with lake front weather data. From west to east, these sites are: Crane Creek, Cedar Point, Heidelberg Beach, and Geneva. Video coverage at Painesville-on-the-Lake supplemented the photographic observations.

Coastal ice was present a month earlier in the winter of the 1993/94 and ice conditions were more severe than during studies conducted the previous year. Ice break-up, however, occurred in late March and early April 1994, the same time as the previous year. The midwinter Lake Erie coastal ice complex was composed of an often poorly defined shoreface ice foot and a well defined ice ridge about 1-3 m in height. The western end of the lake froze in late December, 1993 during quiet conditions. Anchor ice was formed with sediment incorporated within it a few meters offshore. Subsequently, a stable ice sheet formed and little sediment transport by ice rafting could have occurred. Ice did not form at the eastern sites until 5 days later. From Cedar Point eastward, storms with southerly winds, and lingering heat in the lake resulted in destruction, reworking, and partial removal of coastal ice several times before it became stable at the coast in January. Video coverage also documented the episodic progression to a stable ice sheet. Except at Crane Creek, extensive sediment deposits could be seen on the ice at all locations, especially during the ice melting and ice decay periods in late March. Preliminary measurements of sediment content of ice indicate an order of magnitude increase over the previous year. As in previous studies almost all the ice-entrained sediment was sand.

In spring, ice melted or left the coast in a west to east time sequence. The western sites were ice-free in late March while ice was present at Geneva until April 10th. Photographs indicate floating brash ice moving eastward and offshore during break-up. The most dramatic indication of coastal ice mobility and transport occurred at Geneva during a period of above freezing temperatures, where extensive sediment discolored drift ice in early April for as long as a week after the coast was initially free of the stable winter coastal ice. Both video and photographic monitoring indicate that most of the coastal ice only partially melts before being transported offshore and alongshore leading to loss of sediment from the littoral zone.

Our results thus far suggest that coastal ice interaction is most important from Cedar Point eastward due to the longer duration of freeze-up and break-up and the opportunity for vigorous wave activity at those times to entrain and transport both ice and sediment. The marked increase in sediment content of ice over the previous year suggests that ice accounts for a much larger percentage of coastal sediment removal than the 1% reported from those previous observations.

SUGGESTIONS FOR FINAL STAGES OF THE USGS/OHIO GEOLOGICAL SURVEY COOPERATIVE LAKE ERIE COASTAL EROSION STUDY

CHRZASTOWSKI, Michael J.

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From 1987 to 1992, the U.S. Geological Survey (USGS), Illinois State Geological Survey (ISGS), and Indiana Geological Survey (IGS) conducted a cooperative research project focusing on coastal erosion along the Illinois and Indiana coasts of Lake Michigan. This Southern Lake Michigan Coastal Erosion Study examined local and regional coastal gelogic framework, lake-level history, and coastal processes. Of the numerous map and report products resulting from this five-year study, a prime reference is the collection of 13 papers assembled in the 1994 Special Issue of the Journal of Great Lakes Research, v. 20, no. 1.

Since 1991, the USGS and the Ohio Division of Geological Survey have cooperated on a Lake Erie Coastal Erosion Study of the Ohio shore. Although the southern Lake Michigan study and the Lake Erie study differ in many ways, some of the problems addressed during the completion phase of the southern Lake Michigan study may provide beneficial guidelines for the same phase of the Lake Erie study. These include:

1) Product Delivery to Selected Customer/Users: As soon as products are completed, they should be submitted to appropriate repositories, some of which will be libraries in the state. Selected libraries in neighboring states or regional and national repositories for coastal studies may also be appropriate. The libraries at the NOAA Great Lakes Environmental Research Center in Ann Arbor, Michigan, and the U.S. Army Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi are examples of regional and national repositories, respectively. For the most immediate means of making information available, direct mailing of products is suggested to customer/users who can use the information for planning, management, mitigation or remedial action along the coastal zone. These may be offices or agencies in federal,

state, or municipal government. In some cases it may be appropriate to mail products directly to engineering or environmental firms in the private sector.

2) Benefits of Popular-Style Products: In addition to the map and report products prepared for the scientific and technical community, popular-style publications designed for a more general distribution can reach a much larger audience. One of the most widely distributed products of the Southern Lake Michigan Study is a paper that describes the history of building the Chicago lakefront, the processes leading to the deterioration of the lakefront, and the proposals for how the lakefront should be rebuilt (Shore and Beach, 1991, v. 59, no. 2, p. 2-10). For any coast dominated by private residential property, a product that describes coastal erosion or other coastal processes in a non-technical way will provide desired information and education for property owners.

3) Data Archiving: At some future date, various components of data collected in this study will have application to other investigations. Besides published information, there is need for accessibility to raw data sets and any other data that may not have appeared in published form. Because numerous researchers from both state and federal geological surveys have worked on the cooperative project, raw field data commonly resides in several different places. Future researchers will benefit if data can be compiled and assembled in a single, easily accessible source. In the Southern Lake Michigan Study, a CD-ROM proved to be the most effective way of archiving data.

4) Identifying Continuation/Spin-off Projects: Although the Lake Erie study has answered many questions, new questions have arisen and new areas of coastal study have been identified. As the copperative study concludes, the opportunity exists to use it as a foundation for continuation spin-off investigations that could be funded by other federal, state, or municipal agencies. In the Southern Lake Michigan Study, monitoring of coastal changes at North Point Marina and Illinois Beach State Park identified the critical need for further evaluation of erosion trends, and in late 1994 a new four-year project was begun by ISGS with funding through the Illinois Department of Conservation, which is reponsible

for the management of this coastal reach.

The Lake Erie study will result in yet another contribution to our growing understanding of coastal geology in the Great Lakes region. Possibly, the most significant new understanding that may result from this study is a sediment budget for the littoral sand resources along the Ohio coast. One of the major problems occurring along the more developed coastlines, such as in Ohio, is that coastal construction and shore-defense structures have trapped littoral sediment and shore-defense structures have decreased sand supply from bluff erosion. The result is a diminishing coastal sand resource. A sediment budget was developed for the Southern Lake Michigan project, but it took a regional perspective that could not adequately address individual coastal reaches. Data collected in the Lake Erie study potentially will allow development of sediment budgets on a more local scale that focuses on individual primary and secondary littoral cells.

SEDIMENTARY ENVIRONMENTS IN THE WESTERN BASIN OF LAKE ERIE

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[2] Ohio Geological Survey, Sandusky, OH 44870-4132

The western basin of Lake Erie can be defined from the tip of Point Pelee, Ontario, Canada to Cedar Point, Ohio and westward to the Ohio-Michigan state lines. While the average depth of the entire lake is 17 m, the western basin is only 7-10 m deep. The major physiographic features in the western basin are the numerous bedrock islands and shoals at the eastern end which serve as a demarcation between the western and central basins of the lake.

In September, 1992, a geophysical survey was conducted covering 317 km of tracklines in the western basin. Sidescan sonar data were collected with a 100 kHz towfish and recorded digitally using a Q-MIPS system. A PC-based LORAN-C system was used for navigation. Tracklines were designed to overlay existing ground-truth data (core locations, well holes, and grab samples.)

Interpretation of the sidescan sonar records and existing surficial sediment data taken from data compiled by the Ohio Geological Survey define several sedimentological environments within the western basin: 1) bedrock, 2) gravel, 3) sandy gravel, 4) gravelly sand, 5) sand, 6) sandy mud, 7) mud, and 8) clay. Mud covers the largest portion of the basin. Deposits of sandy gravel and sand are concentrated in two areas of the basin; along the southern shoreline, and extending from the Michigan shoreline well into Ohio waters of the western basin, respectively. Gravel deposits occur in scattered pockets with areas of mud, sand, and sandy gravel. Clay is most predominant along a narrow band of the Ohio shoreline. Sidescan sonar also reveals evidence of scour marks in most of the sedimentary environments. These scours, probably caused by ice during spring thaw, appear as dark bands on the sidescan records.

SIDESCAN SONAR SURVEY OF LAKE ERIE IN OHIO WATERS

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[2]Ohio Geological Survey, Sandusky, OH 44870-4132
[3]U. S. Geological Survey, Reston, VA 22092

Based on 1300 line-km of 100 kHz sidescan sonar data collected by the Ohio Geological Survey and the U.S. Geological Survey during 1991, 1992, and 1993, we mapped the acoustic backscatter characteristics of the lake floor. Acoustic backscatter was divided into 6 categories: low backscatter, intermediate backscatter, high backscatter, high backscatter-ripple fields, high backscatter-bedrock, and high backscatter-dumping grounds. We correlated these categories with previously published surficial sediment maps. Low backscatter correlates with mud and mixed mud and sand; intermediate backscatter with sand and with mixed mud and sand ; high backscatter with mixed sand and gravel and mixed sand, gravel, and mud; high backscatter-ripple fields with sand; and high backscatter-bedrock with shale and carbonate rock. Conflicting correlations exist, particularly close to shore where transitions between bottom types occur more often. Some differences may be due to actual changes in bottom sediment distribution in the last 20-30 years, or may, in part, be due to differences in navigation used in our survey and earlier sediment sampling studies.

Areas of low backscatter are most common in both the western and central basins due to the extensive deposits of mud and mixed mud and sand. Intermediate and high backscatter areas are most common closer to shore, including the islands between the western and central basins. These are related to deposits of sand and gravel and exposure of bedrock in shallower water. Exceptions occur in the central basin between Conneaut and Ashtabula, Cleveland to Fairport Harbor, and in an area between Lorain and Point Pelee. In the western basin, intermediate backscatter areas are common offshore from Locust Point, and to a lesser extent in the western part of the basin. These areas, except for the region between Astabula and

Conneaut, are where Holocene deposits are thin or absent and glacial sediments are exposed at the lake floor. High backscatter associated with shale is restricted to the central basin within 5 km of the coast. In the western basin, high backscatter from carbonate rock is restricted to the Marblehead Peninsula and Islands to the north as well as in the area off Locust Point. High backscatter also occurs in dumping areas shown on nautical charts. On sidescan records, dumped material commonly appears as distinct ring-shaped features.

THE GEOLOGY OF THE OHIO AREA OF LAKE ERIE FROM SHALLOW SEISMIC DATA

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[3]U.S. Geological Survey, Reston, VA 22092

The USGS Coastal Research Program began a cooperative study with the Ohio Geological Survey in September of 1991. There were many goals within this 5-year program, one of which was the completion of this offshore geologic framework study of Ohio's part of Lake Erie. This study was designed to provide subsurface information for Ohio's lake area and to construct geologic maps to be used as framework for other parts of the study.

Field work included about 1300 km of tracklines that were laid out on a 15 X 25 km grid. Where tracklines crossed areas with previously collected data, such as grab samples and cores, the seismic data could be correlated with sediment type or texture.

All of the cruises were carried out aboard the Ohio Geological Survey's research vessel, the R/V GS-1. This 15-m steel-hulled vessel was built for the Ohio Survey in 1953. It provides an excellent work platform for seismic work because of its stability and acoustically quiet hull design. Most electronic recording equipment on board was provided by the USGS. Loran-C provided navigational control and water gauges along the Ohio shore of Lake Erie provided vertical control.

The primary data on which the maps were based were the seismic records from the pinger and boomer systems (both designed as high-resolution, shallow penetration seismic systems) supplemented with previously collected sedimentologic data.

Two acoustic interfaces were sufficiently coherent to be mapped throughout the area. These were interpreted to be the surface of the bedrock and the surface of the glacially-related sediments. The glacially-related surface is difficult to decipher because of the complex late-glacial and post-glacial lake level history. It marks the change from proglacial deep-water deposition to post-glacial erosion (or shallow-water deposition in the basin centers). Throughout most of the area, the surface is a transgressional unconformity made up of till, glacial lacustrine clays, or a massive clay depending on the location within the basin, and the amount of down-cutting following retreat of the glacial ice. Within 3 km of shore, most of the seismic records show both glacial and postglacial deposits pinching out against the rising bedrock surface. Offshore from most major rivers, the glacial deposits and/or bedrock surface appear to have been eroded, presumably by the river flow when lake levels were lower. Lakeward from shore, the bedrock surface and overlying sediments dip toward the centers of the western and central basins.

Features of note on the Bedrock Surface map are as follows:

1. A deep channel offshore from Conneaut with a second channel just inshore of a 100-m deep platform.

2. Incised channels both nearshore and offshore of Cleveland.

3. Change of contour pattern in the island area representing the change from underlying shale in the central and eastern basins to carbonates in the western basin.

Features of note on the Glacially-Related Surface map:

1. Three cross-lake moraines all cut by channels near the Ohio shore. The easternmost is the Norfolk moraine, the westernmost is the Pelee-Lorain moraine, and, between them, the Erieue moraine which has been postulated but not well documented.

2. A small glacial ridge just east of Kelley's Island that may be

another unnamed cross-lake moraine.

3. A closed depression offshore from Fairport Harbor. The glacially-related sediments appear to be filling a low in the bedrock surface.

4. Possible river channels off Cleveland, Lorain, and Toledo, associated with extreme low lake levels.

The two isopach maps that were produced show the variability of thickness of the glacially related sediment unit and the recent sediments. Both are thickest in the bedrock low off Fairport Harbor and in channels such as off Conneaut. Both are thin in the western basin.

The maps developed in this study agree well with the trends on most of the previously published maps covering parts of the Ohio lake floor.

THE SURFICIAL SEDIMENT DISTRIBUTION NEAR THE OHIO SHORE OF LAKE ERIE DETERMINED WITH SIDESCAN SONAR

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In September of 1991, the Ohio Geological Survey began field work for a cooperative study with the U.S. Geological Survey's Coastal Research Program. There are many goals within this 5-year program, one of which, addressed in this report, is to tie the offshore framework seismic data to the nearshore profiles which extend about 600 m offshore.

Field work included about 840 line-km of shallow seismic and sidescan sonar data laid out in three shore parallel tracklines 600 m, 1.4 km, and 2.1 km from shore. The 600 m trackline connected the ends of profiles normal to the shore that have been surveyed repeatedly by the Ohio Geological Survey along the entire Ohio coast (see Guy, this volume).

All the data were collected aboard the Ohio Geological Survey's 15-m steel-hulled research vessel, GS-1, which provides a stable and acoustically quiet platform. Electronic recording equipment on board was largely provided by the U. S. Geological Survey.
The principal source of data used for these preliminary maps was the sidescan sonar records supplemented with seismic (3.5 kHz) records. More complete analyses of the 3.5 kHz seismic and Boomer seismic records (both high-resolution, shallow penetration seismic systems) will be provided following more complete analysis. Most navigation was with a Loran-C system. On the final leg of the cruise GPS and differential GPS were used to evaluate the distortion problems with Loran nearshore. All Loran-C data will be corrected with radar fixes, triangulation, and GPS positions. Vertical control was based on water level data from gauges along the Ohio shore of Lake Erie.

Preliminary interpretation of the sidescan records reveals that four basic classes of acoustic backscatter are related to predominant bottom sediments. These include mud, sand/silt, glacially-related sediments (till, boulders, gravel), and bedrock. Bedrock is widespread in the nearshore area from the Pennsylvania border to about Ceylon, except near harbors where a filet of sand is typically associated with structures such as breakwaters, and from Fairport Harbor to Lakewood where glacial sediments are common. An exception between Fairport and Lakewood is between Eastlake and Euclid where both rock (inshore) and glacial deposits (offshore) are exposed in about equal areas. Throughout the whole map area the interface between rock and overlying material is complex. Close to the shoreline from Ceylon to Catawba, recent sediments are most common with only small areas of glacial deposits or bedrock. The reach from Catawba to Little Cedar Point (near Toledo) is dominated by glacial deposits. Small sand deposits are associated with the mouths of some small tributaries. Other sand deposits are present along the lakeward edge of the study area well offshore from the stream mouths. This sand may be remanent deposits that accumulated prior to the rise in lake level, the inshore parts of which were subsequently removed by erosion. These interpretations correlate well with previously published and unpublished data and add considerable detail to existing maps.

DISTRIBUTION OF NEARSHORE SEDIMENT AND NEARSHORE BARS, LAKE COUNTY, OHIO

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Distribution of nearshore sediment and nearshore bars along 50 km of the Ohio lakeshore was mapped using data from 32 shore-normal bathymetric profiles run in September and October, 1994. The profiles are 1-2 km apart and extend 1 km offshore to a water depth of 7-10 m. All of the profiles are tied to bench marks established and used by the U. S. Lake Survey for profiling in the late 1940's. Horizontal and vertical control for the surveys was maintained with a geodimeter and bathymetric data were collected with a recording echosounder operated from a small boat. Temporal changes in distribution of sediment and nearshore bars were mapped by comparing 1994 data with data collected along the same profiles run in 1970 (see Carter, 1976).

Three principal map units, --sand and gravel, till, and shale--, have been identified on the bathymetric records based on differences in acoustic reflectance. In some areas, thin deposits of sand overlie shale or till, but these could not always be differentiated as mappable units. Jetted holes and surface samples collected for an earlier investigation in Lake County (Carter, 1976) aided in the interpretation of the records.

Deposits of sand extend several hundred meters offshore before pinching out on shale along most of the county's shoreline. Preliminary assessment of sediment distribution mapped from the bathymetric records shows little apparent change from the sediment distribution mapped in the early 1970's by Carter (1976). However, size and number of nearshore bars do differ from from those mapped by Carter (1976) (Tables 1 and 2). Further analysis is needed to determine if the changes are due to differences in wave climate, lake level, sand volume, or other factors.

References

Carter, C. H., 1976, Lake Erie shore erosion, Lake County, Ohio: setting, processes, and recession rates from 1876-1973: Ohio Geological Survey Report of Investigations No. 99, 105 p.

TABLE 1.-- COMPARISON OF NEARSHORE BARS FOUND IN 1970 AND 1994 PROFILES IN EASTERN LAKE COUNTY
EASTLAKE AND MENTOR QUADRANGLES

Lake level in 1970 and 1994 was about 0.9 m above LWD. Data from 1970 are from Carter, 1976.
Poorly defined bar has 0.3 to 0.6 m of relief, moderately defined bar has 1.0 to 1.2 m of relief, well defined bar has >1.5 m of relief

	1970		1994	
Range	Distance from shoreline to approx. bar crest, m	Shape	Distance from shoreline to approx. bar crest	Shape
WEST				
XI 12	45.7	Poorly defined	45.7	Moderately defined
XI 14	76.2	Poorly defined	131.1	Moderately defined
	152.4	Poorly defined		
	426.7	Poorly defined		
XI 16	61.0	Poorly defined	145	Well defined
	243.8	Moderately defined		
	381.0	Well defined		
XI 18	137.2	Moderately defined	170.7	Well defined
XI 20	61.0	Moderately defined	21.3	Poorly defined
	198.1	Moderately defined	167.6	Moderately defined
			250	Poorly defined
IX 25	182.9	Poorly defined	No profile run	
	548.6	Moderately defined		
IX 23	289.6	Moderately defined	33.5	Poorly defined
	518.2	Poorly defined	330	Moderately defined (Bar??)
IX 21	61.0	Poorly defined	47.2	Poorly defined
	274.3	Moderately defined	370	Poorly defined
IX 19	121.9	Well defined	121.9	Moderately defined
	320.0	Moderately defined		
IX 17	61.0	Poorly defined	279	Well defined
	213.4	Well defined	520	Moderately defined
	442.0	Well defined		
IX 15	182.9	Moderately defined	267	Well defined
	274.3	Well defined	445	Well defined
	426.7	Well defined		
IX 14	243.6	Moderately defined	185.9	Poorly defined
			290	Well defined
IX 12	800	Moderately defined	346	Well defined
	1500.0	Well defined		
IX 10	182.9	Poorly defined	190	Moderately defined
	320.0	Well defined	395	Poorly defined
	502.9	Poorly defined		
IX 8	76.2	Moderately defined	245	Poorly defined
	381.0	Well defined	423	Moderately defined
	563.9	Poorly defined	600	Poorly defined
IX 6	76.2	Moderately defined	174	Well defined
	213.4	Moderately defined	418	Poorly defined
	411.5	Well defined	544	Well defined
	609.6	Moderately defined	960	Moderately defined
IX 4	45.7	Poorly defined	96	Moderately defined
	106.7	Moderately defined	214.6	Well defined
	304.6	Moderately defined	512	Moderately defined
	609.6	Moderately defined		
IX 1	45.7	Poorly defined	No profile run	
	167.6	Well defined		
	304.6	Poorly defined		
	426.7	Moderately defined		
	594.4	Well defined		
FAIRPORT				

TABLE 2.-- COMPARISON OF NEARSHORE BARS FOUND IN 1970 AND 1994 PROFILES IN WESTERN LAKE COUNTY PERRY AND MADISON QUADRANGLES

Lake level in 1970 and 1994 was about 0.9 m above LWD. Data from 1970 are from Carter, 1976.
Poorly defined bar has 0.3 to 0.6 m of relief, moderately defined bar has 1.0 to 1.2 m of relief, well defined bar has >1.5 m of relief

	1970		1994	
Range	Distance from shoreline to approx. bar crest, m	Shape	Distance from shoreline to approx. bar crest	Shape
FAIRPORT				
III-5	No profile run		130	Poorly defined
III-6		No bars	113	Well defined (part of old roadbed)
			370	Poorly defined
			477	Poorly defined
			585	Poorly defined
III-7	No profile run		197	Well defined (part of old roadbed)
			445	Poorly defined
			549	Poorly defined
III-9		No bars	No profile run	
III-14		No bars	No profile run	
III-20	42.6	Poorly defined	No profile run	
	152.4	Poorly defined		
III-26		No bars		No bars
III-26		No bars	92	Poorly defined
III-32		No bars	373	Poorly defined
			525	Poorly defined
			626	Moderately defined
III-36		No bars	35	Poorly defined
III-39	76.2	Moderately defined	140	Poorly defined
III-43		No bars		No bars
XII-2		No bars		No bars
XII-4		No bars		No bars
XII-6	61	Poorly defined	No profile run	
XII-7	No profile run		79	Moderately defined
XII-8		No bars	No profile run	
XII-11		No bars		No bars
XII-13		No bars		No bars
XII-15		No bars	52	Moderately defined
XII-17	213.4	Poorly defined	91	Moderately defined
EAST				

A PRELIMINARY ASSESSMENT OF RECESSION RATES OF THE BLUFF AT PAINSEVILLE ON-THE-LAKE

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The 17- to 19-m-high till bluff has receded 180 m since the 1870's and 120 m since 1937. The 1.3 km stretch of lakeshore lacks shore protection structures except along the western 370 m of the study area. Preliminary analysis of spatial and temporal changes in recession rates has been performed using data from Mackey and Guy (1994) supplemented with recession data for six intermediate time intervals (1876-1937, 1937-1954, 1954-1968, 1968-1973, 1973-1986, and 1986-1990).

Recession rates prior to 1937 were slow (<1 m/yr) with slightly faster rates in the western part (Figure 1). Since 1937, recession rates have been as high as 6.5 m/yr and show considerable variation alongshore. Low rates at the western end of the study area result from filling and often short-lived shore protection structures. Several groins installed west of transect # 2157 in the mid-1930's may have disrupted littoral processes causing accelerated erosion downdrift (east).

Correlation coefficients calculated for variables from 45 transects (#2125-2169) from the data set of Mackey and Guy (1994) show no correlation between rates and physical variables except for a negative correlation between bluff height and rates (Table 1). The correlation between bluff height and post-1937 rates may be strengthened by the presence of various forms of short-lived shore protection along the higher bluffed, western portion of the study area.

Correlation coefficients for rates from the shorter time intervals are shown in Table 2. The negative correlations between bluff height and recession rates seen in the subset of regional data are also present in rate data for the shorter time intervals. In addition, recession rates from one period show some correlation with rates for succeeding periods. However, this correlation decreases as the time between the intervals increases.

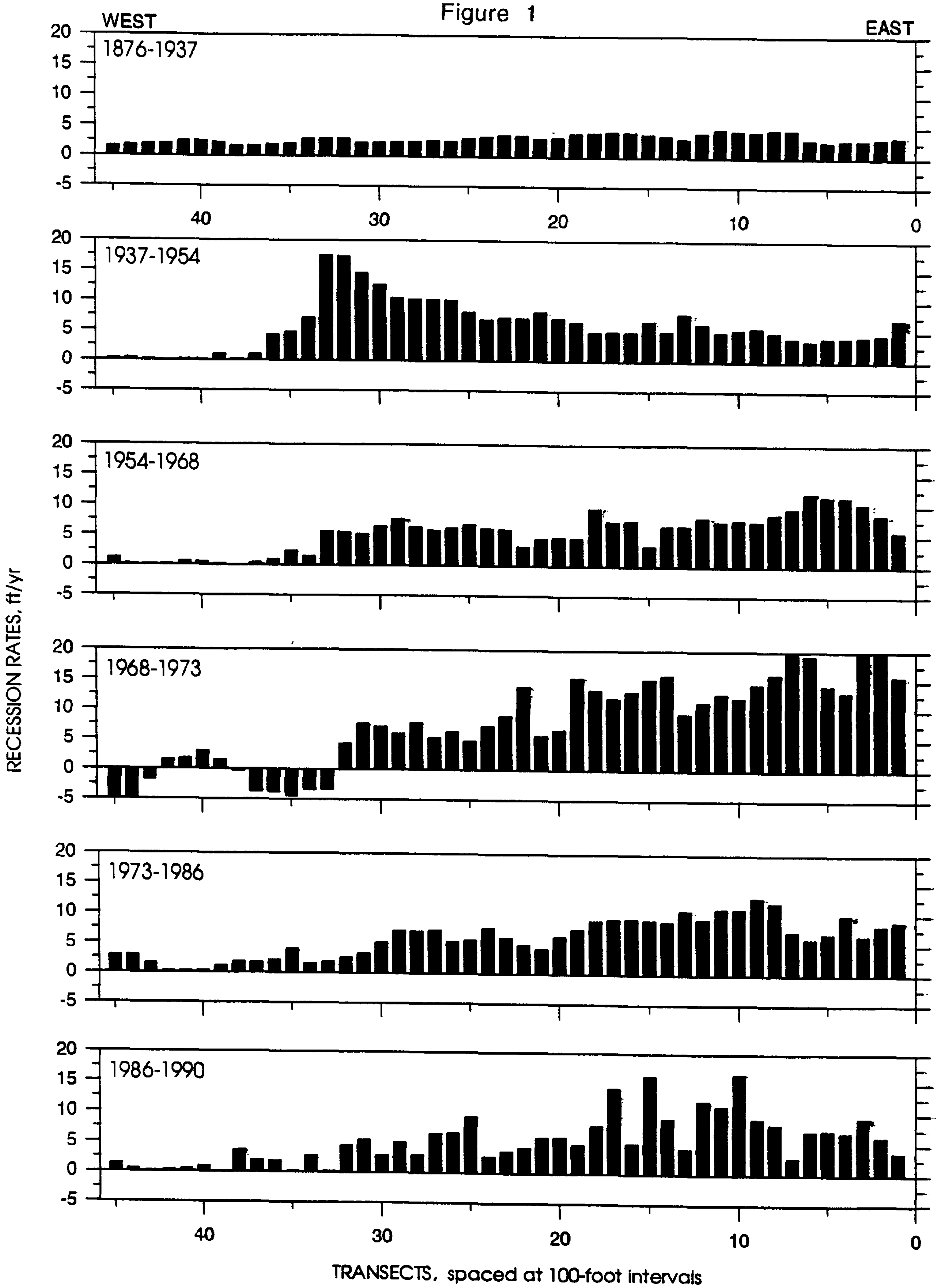
No significant correlation occurs when rates for the 1937-1954 period are paired with any other variable. This suggests that conditions were dramatically different in this time period compared to earlier and later periods. Obvious differences include emplacement of shore protection at the west end of the study area in the 1930's, erosion of an embayment just east of the shore protection stuctures in the 1940's and 1950's, and a rise in lake levels from the record low levels in the mid-1930's to record high levels in 1952. In addition, impacts of increased urban development during this period may have influenced recession rates.

Compilation of data on nearshore slopes, depth to bedrock in the nearshore zone, width of beaches, shore protection, stratigraphy, engineering geology, and ground water is in progress. These data may help explain the variations in rates observed at Painseville on-the-Lake and provide a model for predicting recession along other stretches of the Ohio lakeshore.

References

Mackey, S. M., and Guy, D. E., Jr, 1994, Comparison of long- and short-term recession rates along Ohio's central basin shore of Lake Erie, in Folger, D. W., ed., Second Annual Lake Erie Coastal Erosion Study Workshop: U. S. Geological Survey, Open File Report 94-200, p. 19-27.

Figure 1



RECESSION RATES FOR PAINESVILLE ON THE LAKE, LAKE COUNTY, OHIO

TABLE 1.-- CORRELATION COEFFICIENTS FOR RECESSION RATE FACTORS AT PAINESVILLE ON-THE-LAKE

Pearson product moment correlation
Cell Contents:
Correlation Coefficient
P value
Number of samples

Long-term rate measured between 1876 and 1973.
Short-term rate measured between 1973-1990.
Total rate measured between 1876 and 1990.
Change in rates measured between 1876-1973 and 1973-1990.

	SHORT TERM RATE	TOTAL RATE	CHANGE IN RATES	BLUFF HEIGHT	BLUFF ORIENTATION	SLOPE ANGLE
LONG TERM RATE	0.743 <0.001 45	0.982 <0.001 45	0.337 0.024 45	-0.835 <0.001 45	0.077 0.614 45	0.487 <0.001 45
SHORT TERM RATE		0.857 <0.001 45	0.874 <0.001 45	-0.867 <0.001 45	-0.218 0.15 45	0.354 0.017 45
TOTAL RATE			0.508 <0.001 45	-0.890 <0.001 45	-0.003 0.987 45	0.476 <0.001 45
CHANGE IN RATES				-0.630 <0.001 45	-0.381 0.01 45	0.164 0.281 45
BLUFF HEIGHT					0.225 0.138 45	-0.678 <0.001 45
BLUFF ORIENTATION						-0.353 0.017 45

The pairs of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050 one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

TABLE 2.-- CORRELATION COEFFICIENTS FOR BLUFF HEIGHT AND RECESSION RATES AT PAINESVILLE ON-THE-LAKE, OHIO

Pearson product moment correlation
Cell Contents:
Correlation Coefficient
P value
Number of samples

	1876-1937	1937-1954	1954-1968	1968-1973	1973-1986	1986-1990
BLUFF HEIGHT	-0.823 <0.001 45	-0.224 0.139 45	-0.815 <0.001 45	-0.885 <0.001 45	-0.851 <0.001 45	-0.719 <0.001 45
1876-1937		0.143 0.349 45	0.599 <0.001 45	0.756 <0.001 45	0.794 <0.001 45	0.669 <0.001 45
1937-1954			0.324 0.03 45	0.094 0.54 45	0.148 0.331 45	0.129 0.399 45
1954-1968				0.786 <0.001 45	0.740 <0.001 45	0.567 <0.001 45
1968-1973					0.746 <0.001 45	0.616 <0.001 45
1973-1986						0.722 <0.001 45

The pairs of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050 one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

REMOTE VIDEO MONITORING OF THE SHORELINE AT PAINSEVILLE ON-THE-LAKE

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Data from shoreline video monitoring at Painsville, Ohio, has been analysed from August 1993 through November 1994. The most reliable feature recoverable from the video imagery is the position of the shore/water interface. Automated shoreline detection routines have been developed and the shoreline position is corrected to a stable vertical datum using water level data provided by the Great Lakes Water Level Database (NOAA). When conditions permit, the position of the bluff toe and the bluff top are also determined from video imagery. These features, due to topographic sheltering, vegetation, and overall poor contrast require subjective processing.

The shoreline record is clearly dominated by short-term fluctuations driven by the movement of material from the bluff to the beach. The potential for deriving longer-term trends from the records is still unclear. A prototype CD-ROM has been developed that is suitable for Unix or PC systems that utilizes the Mosaic interface. The data will be published within the USGS Digital Data Series.

PROCESS/PREDICTIVE MODELS OF BLUFF RECESSION ALONG THE OHIO SHORE OF LAKE ERIE

HAINES, John[1]; GUY, Donald[2]; and MACKEY, Scudder[2]

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[2] Ohio Geological Survey, Sandusky, OH 44870-4132

The completed data set of bluff recession rates will serve as the basis for the development of a predictive model for future recession. Modelling efforts will, initially, focus on empirical analyses designed to improve our understanding of the spatial and temporal variability suggested for past recession. The basic model will be of the form:

$$R(x,t)=f(a,B,\ g,....),$$

where R(x,t) is the spatially and temporally varying recession rate and the parameters a, B, and g,.... will be defined by empirical analyses and our understanding of the processes driving bluff recession. The model building effort will require input from all components of the Lake Erie project, especially the bluff composition mapping and bluff and nearshore profiling efforts. Candidate parameters include:

1. Water level: primarily as a temporally varying forcing for bluff recession. Water level data have been obtained for the appropriate period. Clearly, water level variation will not contribute to the explanation of spatial variations, unless susceptibility to elevated water levels varies spatially.

2. Bluff height: describing the mass of material which must be removed for recession to proceed.

3. Bluff composition: describing the erodibility of the bluff. This may include lithology and the density and nature of fractures in the bluff material. Efforts will focus on determination of a single parameter describing the

erodibility.

4. Bluff exposure: the bluff orientation, or exposure to the lake, may provide a measure both of wave energy and of the local sediment transport potential. Exposure will include elements of both bluff orientation and sheltering by offshore or adjacent shoreline features. This parameter may be expected to have both spatial and temporal variability.

5. Nearshore slope: this may serve as a measure of the exposure of the local bluff to wave energy.

6. Nearshore sediment cover: this spatially varying parameter may serve as a measure of the susceptibility of the nearshore substrate to downcutting.

7. Engineering: some qualitative assessment (presence or absence of structures) will clearly have to be included. Development of a parameter describing the effect of engineering structures is likely to be difficult.

The initial model will be a simple empirical relation between local parameters. Clearly, adjacent profiles are not independent. Some spatial averaging or correlation will have to be incorporated in the modelling effort.

Initial investigation of the data suggest that local erosion rates are not highly correlated over the two periods of assessment. This strongly suggests that simple models extending measured rates into the future are subject to large errors. Modelling efforts will focus on explaining this observed variability to improve predictions.

A by-product of the analysis will be assessment of the bluff contribution to the overall sediment budget of the region.

OBJECTIVES FOR THE LAKE ERIE STUDY DURING1995-1996

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The final phase of the Lake Erie Coastal Erosion Study will mainly involve data synthesis and publication of products. Much of the acquired data will serve as input to developing bluff recession and sediment budget models. Our immediate goal is to develop a work plan to achieve goals that bring this project to a successful closure. Among these are:

1. Determine which data are necessary for syntheses.

2. Develop the necessary digital data structure to facilitate data exchange and dissemination.

3. Develop models that will serve as a guide for the assembly and application of requisite data.

4. Schedule the production of stand-alone products (maps, open file reports, peer reviewed publications) by determining time-lines and resource allocations. This will include a status report on efforts in the Metzger Marsh Restoration Project.

5. Final data compilation, with limited interpretation, will be assembled and published in a CD-ROM.

Additional data collection will be limited to those areas that facilitate the maintenance of longer term data bases, such as shoreline profiles, and to support the continuing efforts in the Metzger Marsh restoration project. Further data acquisition such as recession rates and nearshore sidescan sonar will only be considered within the perspective of the primary goal, assembling and publishing existing data.

LAKE ERIE SEDIMENT BUDGET

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Factors that are critical to development of a sediment-budget model include: 1) contribution of coastal bluffs, upland sources, and offshore sand deposits to littoral sediment volumes; 2) identification of sediment transport pathways and determination of transport rates; 3) spatial and temporal variations in sediment supply; 4) areas of sediment accumulation, and; 5) impact of man-made structures, dredging, etc. on sediment supply, transport, and deposition.

Total subaerial volumes derived from erosion of coastal bluffs are calculated using digital recession and bluff height data (Tables 1 and 2). Volume data calculated for each digital transect (spaced at 30-m intervals along the coast) are plotted to illustrate spatial and temporal variation of sediment supplied to the littoral system by erosion of coastal bluffs (Fig. 1). Detailed stratigraphic and textural data are used to determine spatial variation in grain size to estimate subaerial sand volumes provided to the littoral system. Subaqueous volumes have yet to be determined. Recently acquired existing historical profiles enable us to estimate accurately the volume and grain size of material resulting from sub-aqueous recession and down-cutting. However, subaqueous volumes have yet to be determined.

A comprehensive review of existing literature on upland erosion, sediment transport rates, and dredging volumes at river mouths is in progress. Volume estimates and textural data are also being acquired from reservoirs on rivers flowing into Lake Erie.

Nearshore profile and shore-parallel sidescan data are used to map surface sediment distribution in the nearshore zone. These data combined with historical beach width data, jetted hole data, and core sampling data are used to estimate sand volumes in the littoral zone. Most sand deposits do not extend more than several hundred meters offshore and are commonly less than two meters thick.

Changes in beach width over time are used to estimate sediment transport rates in areas where sediment supply has been disrupted.

Areas of sediment accumulation (sinks) are associated with existing geomorphic features such as Cedar Point spit, Little Cedar Point, Metzger Marsh embayment, or large man-made structures such as jetties at Fairport and Ashtabula Harbors (see nearshore mapping by Fuller and others, this volume). More than 165,000 m^3 of sand have been impounded within the Metzger Marsh embayment based on detailed bathymetric surveys and vibracore data. Recession-line mapping, shore-normal profiles, and a detailed bathymetric survey over the Little Cedar Point spit (western basin) are used to estimate changes in sand volume with time. Additional vibracoring and surface sediment sampling is planned for Little Cedar Point this spring. Volume estimates from Fairport Harbor jetty, Geneva State Park, and Ashtabula Harbor jetty will be completed with the acquisition of additional profile and bathymetric data.

Table 1. Total Losses due to Subaerial Erosion of Coastal Bluffs by County for Period 1877 to 1990 (Central Basin)

County	Area (ha)	Volume(m^3)
Ashtabula	158	25,920,996
Lake	299	37,651,879
Cuyahoga (East)	39	3,547,530
Cuyahoga (West)	58	9,970,220
Lorain	103	6,906,107
Erie*	93	5,259,917

* Cedar Point Spit and Sandusky Bay Excluded.

Table 2. Annual Losses due to Subaerial Erosion of Coastal Bluffs by County for Period 1877 to 1990 (Central Basin)

County	Area (ha/yr)	Volume(m^3/yr)
Ashtabula	1.4	229,389
Lake	2.6	333,202
Cuyahoga (East)	0.3	31,394
Cuyahoga (West)	0.5	88,232
Lorain	0.9	61,116
Erie*	0.8	46,548

* Cedar Point Spit and Sandusky Bay Excluded.

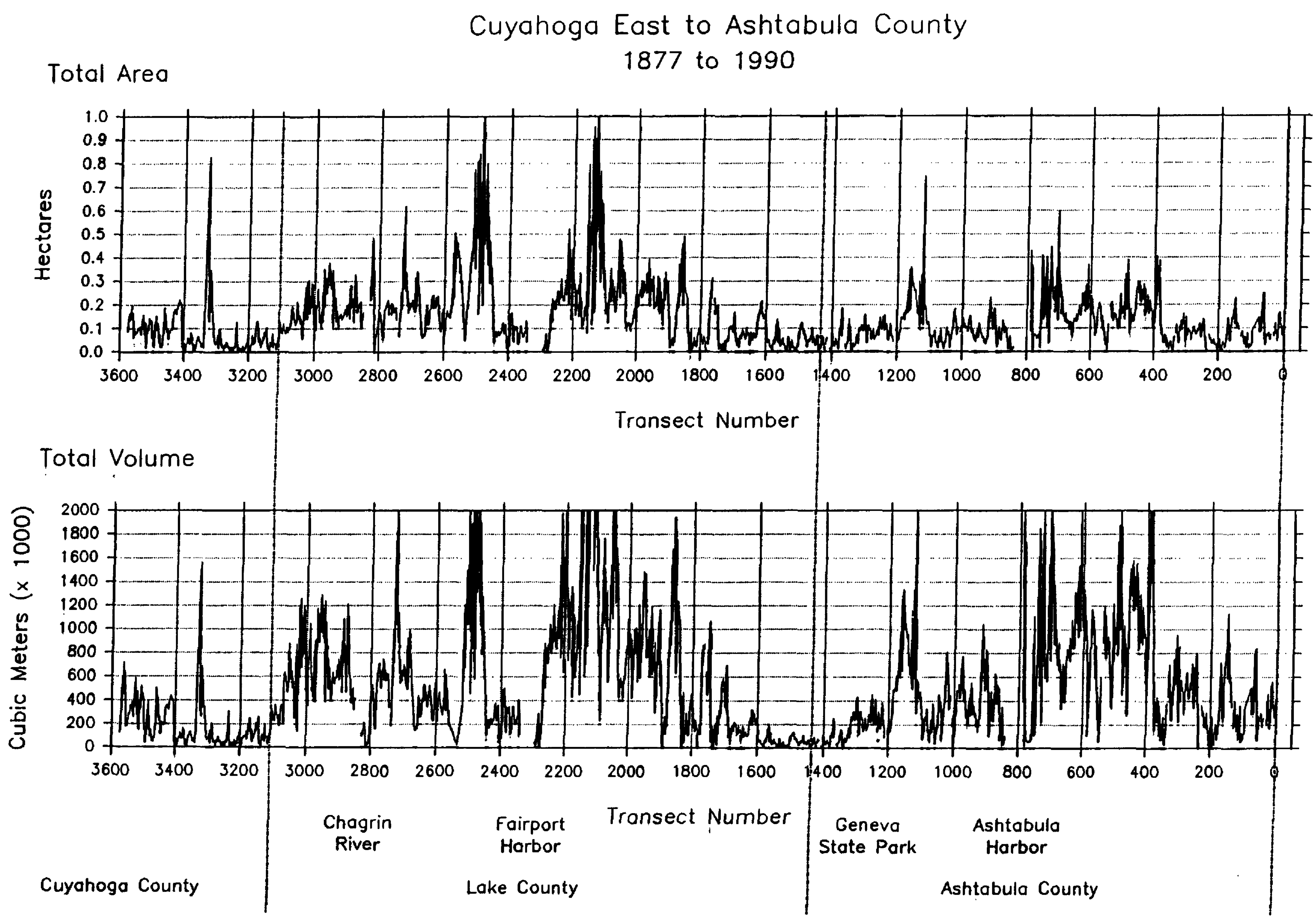
Cuyahoga East to Ashtabula County
1877 to 1990
Total Area
Hectares
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Transect Number
Total Volume
Cubic Meters (x 1000)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Transect Number
Chagrin River
Fairport Harbor
Geneva State Park
Ashtabula Harbor
Cuyahoga County
Lake County
Ashtabula County

Figure 1

LAKE ERIE WETLANDS-METZGER MARSH RESTORATION PROJECT

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The Metzger marsh restoration project design calls for a solid dike to be constructed across the mouth of a 367 hectare embayment to provide water-level management capability and to attenuate Lake Erie wave energy. An inlet will be constructed within the dike to allow marsh water levels to vary with short-term changes in lake level and to provide fish access between the lake and the marsh. Several fundamental questions need to be addressed to design the inlet properly: 1) How have historical marsh water levels varied in response to changing lake seiche period and magnitude? 2) Do marsh water levels respond to short-period or long-period lake level events (on the order of several hours to several days)? and, 3) What is the range of that response? Answers to these questions have a direct impact on water quality and how wildlife and fish use this marsh.

In an attempt to estimate what inlet design criteria are appropriate, we provide the following observations:

1) Based on 1940 aerial photography, the inlet at the east end of the marsh was approximately 24 m wide and ranged from 1-2 m deep. The opening, overall, was more than 91 m wide, but littoral transport of sand filled significant parts of the breach. Moreover, several other breaches are present in the photograph suggesting that several inlets of varying size were active at the same time. Maps based on survey in 1942 and 1943 by the U. S. Beach Erosion Board, show a large, 91-m-wide inlet to the east and many smaller inlets 15-30 m wide along the barrier. On average, lake levels rose by about 0.5 m between 1940 and 1943 inundating many low areas along the barrier. The historical inlet was probably maintained by flows directed lakeward from the marsh to the lake during major storm events. No streams flow into the marsh. Waves overtopping the barrier by washover increased water volumes in the marsh during major storms. The accumulated water then flowed back to the lake

through these inlets.

2) Using equations from the Corps of Engineers Shore Protection Manual, we have calculated changes in marsh water level as function of seiche period and magnitude (Figs. 1 and 2). Anticipated maximum flow velocities through the inlet under several different conditions have also been calculated (Fig. 3). These curves are an approximation because many of the underlying assumptions do not apply to Metzger Marsh. For example, one major assumption is that the bay or marsh margins are vertical and the area of the bay remains constant as water levels decrease, which, clearly, is not the case in Metzger Marsh.

3) Flow velocities are of secondary importance with respect to fish passage in that velocities are time variant as a function of seiche period and magnitude. However, of critical importance are ***maximum*** flow velocities that may have a major impact on design of water and fish access control structures.

We are developing a general mathematical model to calculate marsh level responses to changes in seiche period and magnitude as a function of inlet dimensions. When completed, this model will be used to determine inlet dimensions and structural design criteria that best meet the needs of the restored marsh ecosystem.

METZGER MARSH WATER LEVEL PLOTS

Figure 1. illustrates the response of marsh water levels to two different seiche amplitudes of 0.3 feet (solid lines) and 4.0 feet (dashed lines) for several different seiche periods. The 4.0 foot amplitude is based on data from two major storm events. The total range in lake level is approximately 8 feet. This curve shows that for a 40 foot inlet width, the predicted change in marsh water elevation is approximately 50% of the change in lake level. However, due to initial assumptions, this curve may ***underestimate*** changes in marsh water level for this type of event.

Figure 2. is an expanded plot of the 0.3 foot seiche (interval A, Figure 1.). This seiche represents a daily fluctuation in lake level of 0.6 foot for periods of 2.5 and 5 hours. These curves show that for a 40 foot inlet width, the predicted change in marsh water level is approximately 15% of the change in lake level for a 2.5 hour period and 30% of the change in lake level for a 5 hour period.

Figure 3. illustrates maximum flow velocities as a function of inlet width. Mean flow velocities are equal to two-thirds of the maximum flow velocities.

Figure 1.

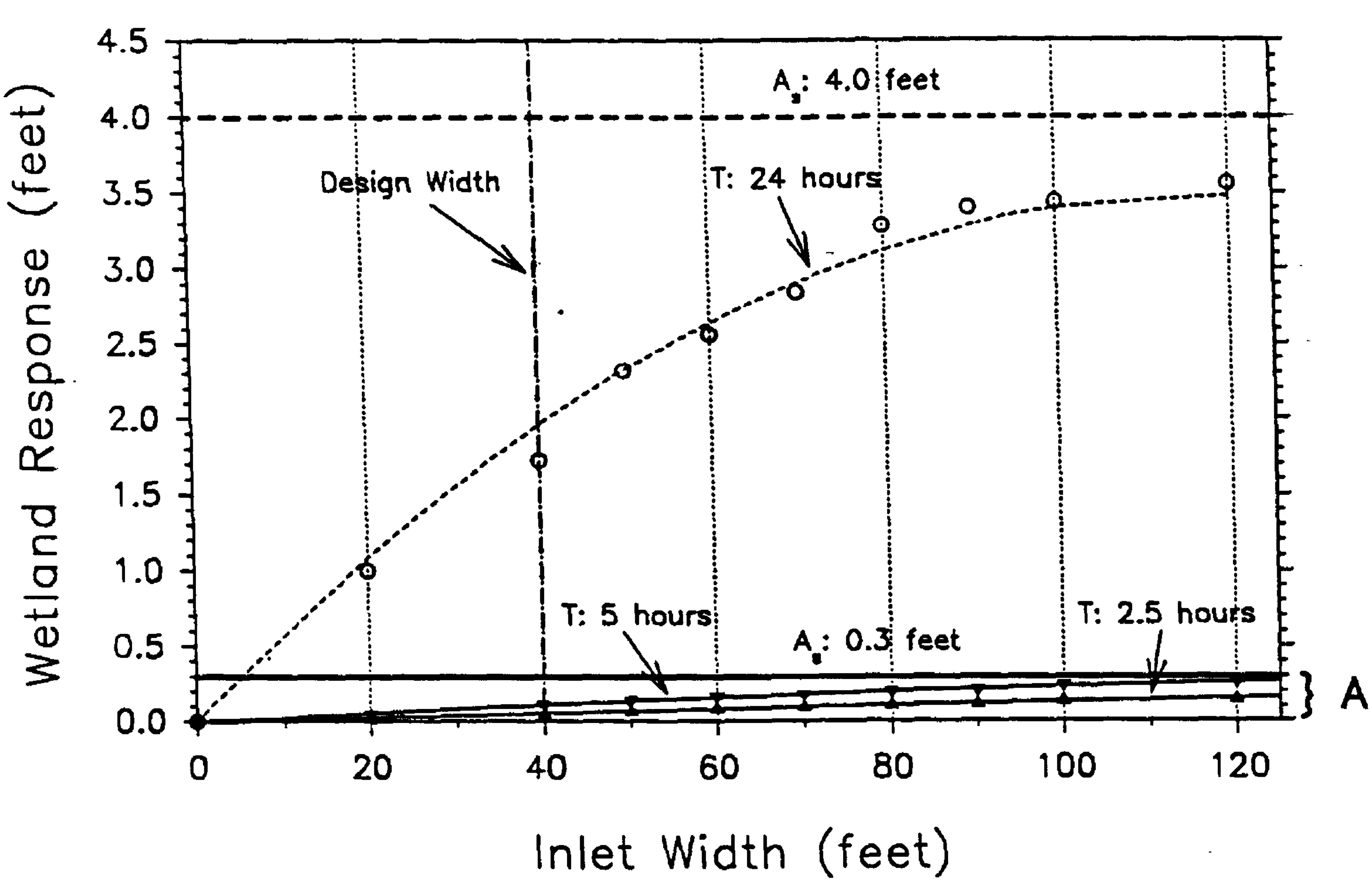


Figure 2.

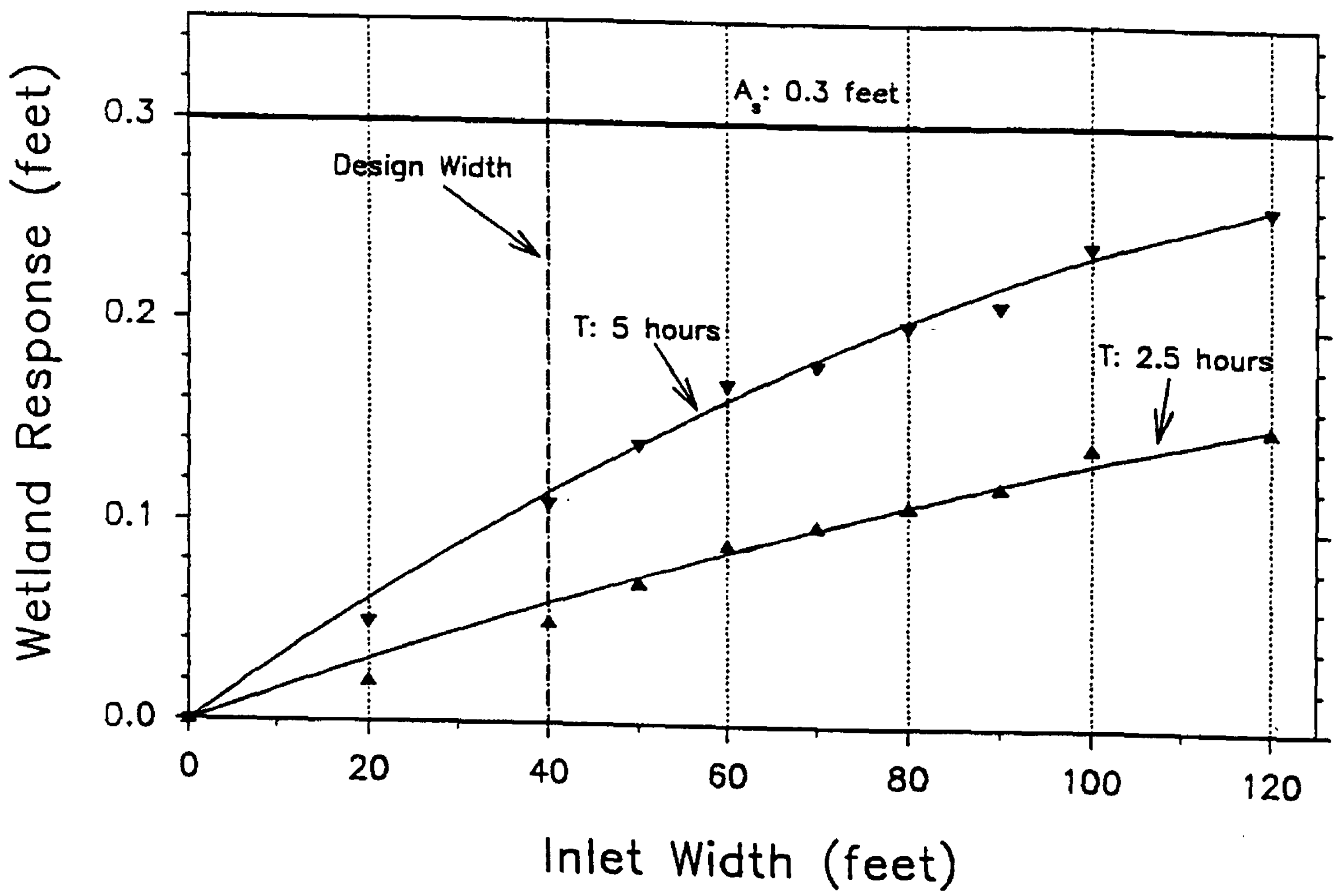
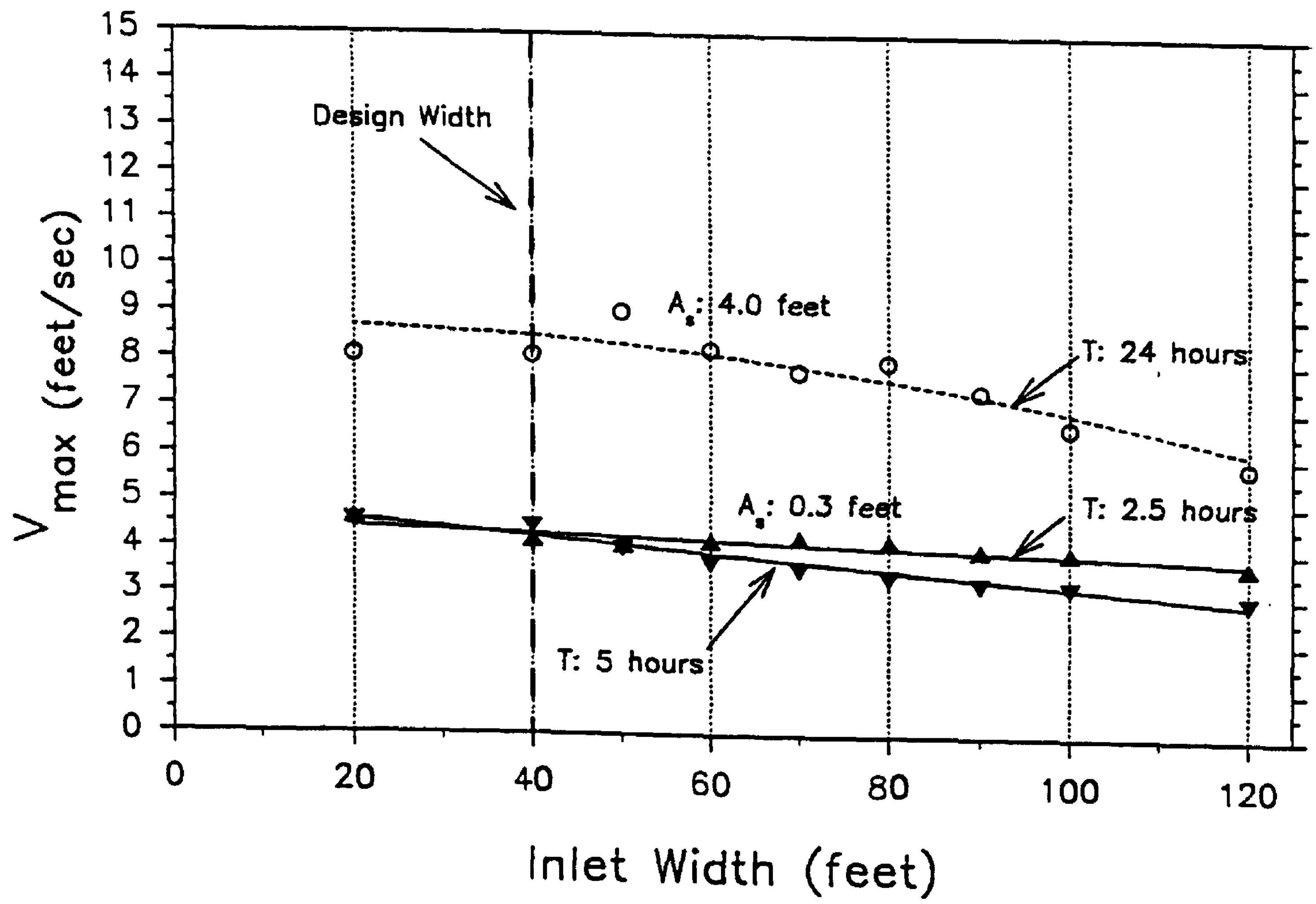


Figure 3.



COASTAL LITHOLOGIES OF THE PERRY QUADRANGLE, LAKE COUNTY, OHIO

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[2]U.S. Geological Survey, Reston, Va 22092

[3]New England Environmental Association, Mt. Vernon, NH 03057

Erosion rates of Ohio's Lake Erie shore are controlled in part by variations in the lithologies exposed along the coast. Shore-parallel cross-sections and surficial maps for the Perry quadrangle (this abstract) and North Kingsville (Stone, Pavey, and Bruno, (this volume) quadrangle (Fig. 1) depict in-progress lithologic mapping for the cooperative Ohio Geological Survey/U.S. Geological Survey coastal erosion project. These 1:24,000-scale maps will be open-filed and illustrate typically-available lithologic data and compilation methodology for the Ohio coast. Upon completion, cross-sections at 1:50,000 scale and maps at 1:100,000 scale will provide an updated coastal lithologic framework. Features of interest within this quadrangle include Painseville-on-the-Lake, a rapid-erosion site where video data are being collected for this project and the Perry Nuclear Power Plant.

Figure 2 shows the current interpretation of the typical stratigraphic sequence found along the coast in northeast Ohio. Lithologic descriptions of 22 existing and 14 new measured sections provide the basis for reinterpreting coastal stratigraphy, as seen in Figure 3. The new line of section follows the 1990 top-of-bluff line, as defined by Mackey and Guy (1994). New onshore mapping updates the work of White (1980). The shallow offshore substrate is predominantly Devonian Ohio Shale. The shale extends vertically to within 1-5 m of low water datum, and is overlain by till. The nearshore till-shale zone is overlain by temporally-variable amounts of sand, gravel, and cobbles.

Ashtabula Till, deposited by the last Late Wisconsinan ice sheet in

Ohio, underlies portions of the shallowest nearshore areas and the high (15-20 m), steep to vertical shore bluffs. The two facies of Ashtabula Till, both with a dominantly illite/kaolinite clay mineral suite, are present. The basal facies of Ashtabula Till is compact, homogeneous, and calcareous, with an average matrix of 17% sand, 47% silt, and 36% clay. This facies most often displays a subhorizontal fissility marked locally by silt lamina. It has moderate to high dry strength, and locally contains lenses of compacted and sheared laminated clay and fine sand. The overlying compact, locally-stratified facies of the Ashtabula Till characteristically contains lenses of microlaminated to thin-bedded clay to fine sand and some gravel. These lenses are commonly deformed by shear or load. This unit has an average matrix of 12% sand, 50% silt, and 38% clay.

White (1980) defined the basal till unit as a separate "Coastal" Till. Work by Bruno (1988) suggested that this unit represents a lodgement facies of Ashtabula Till. This is supported by preferred SW to WSW till-stone fabrics with s1 (first eigenvalue) values of >0.62 (figure 4b). Fabrics in the upper unit show little preferred orientation (s1 values <0.55, figure 4a). Much of this unit is thus interpreted to be a basal meltout facies, but evidence of shear suggests local inclusion of lodgement till.

The total thickness of both till facies varies from <6 m at the eastern boundary of the quadrangle to >21 m at the western boundary. The till thins southward to nearly zero at the southeast corner of the quadrangle. The unusual thickness of Ashtabula Till at the coast may be related to a recessional subaqueous ice-margin, ice grounding-line deposition, or thrust-stacking of sediment-laden ice near the margin. A prominent vertical joint system extends through both till facies and controls the predominant failure modes of rotational slump and blockfall in these bluffs.

Lacustrine silt and clay overlie the till along the bluff and inland in much of the quadrangle; it is absent along the bluff in the west and is as much as 9 m thick in the east. This unit was deposited in the deep waters of early proglacial lakes in the Lake Erie basin, during and after withdrawal of Ashtabula ice. At lower proglacial lake elevations, shallow-water nearshore or deltaic sands as much as 6 m thick were deposited, predominantly in the eastern part of the quadrangle.

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White, G. W., 1980, Glacial geology of Lake County, Ohio: Ohio Division of Geological Survey Report of Investigations No. 117, 20 p.

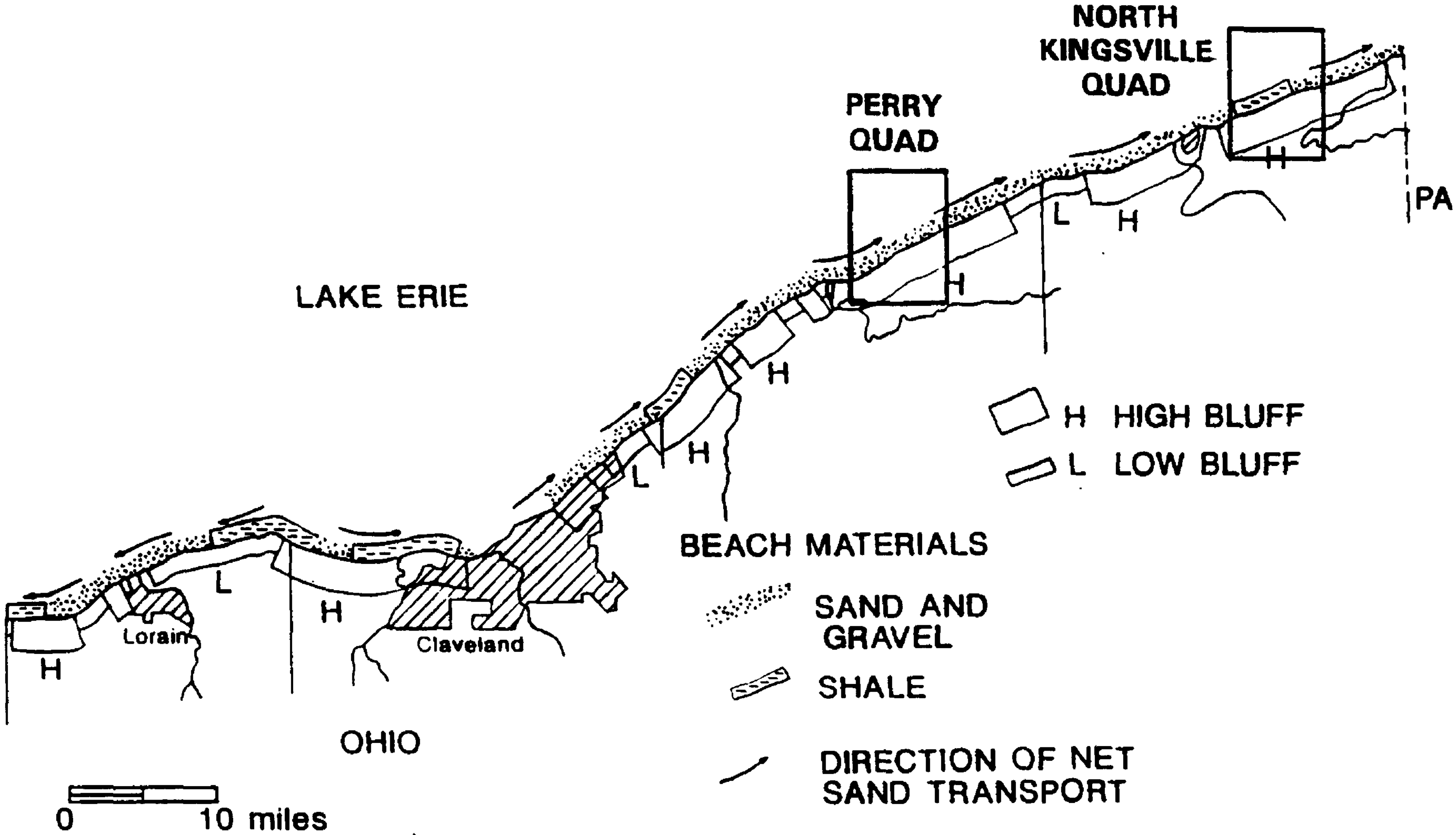
Figures

Figure 1. Location of the Perry and North Kingsville Quadrangles with typical coastal characteristics.

Figure 2. Typical stratigraphic sequence seen in high bluffs along Lake Erie northeast of Cleveland.

Figure 3. Coastal stratigraphy in the eastern part of the Perry Quadrangle. Horizontal scale is 1:48,000; 10X vertical exaggeration. Upper cross-section (Carter, 1976) shows sand over silt-clay over a single till; baseline is 174.3 m elevation IGLD. Lower reinterpretation of this section shows sand (Sd), silt-clay (SC), upper till facies (Tm), lower till facies (Tl), and shale (Sh); datum is NGVD 1927.

Figure 4. Till fabrics at Painseville-on-the-Lake, Perry Quadrangle. (a) Fabric in upper Ashtabula Till facies, s1= 0.489. (b) Fabric in the basal till facies, s1= 0.694. Open squares are individual clast long axes; solid circle is the mean azimuth and plunge.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KINGSVILLE
QUAD
PERRY
QUAD
LAKE ERIE
H
L
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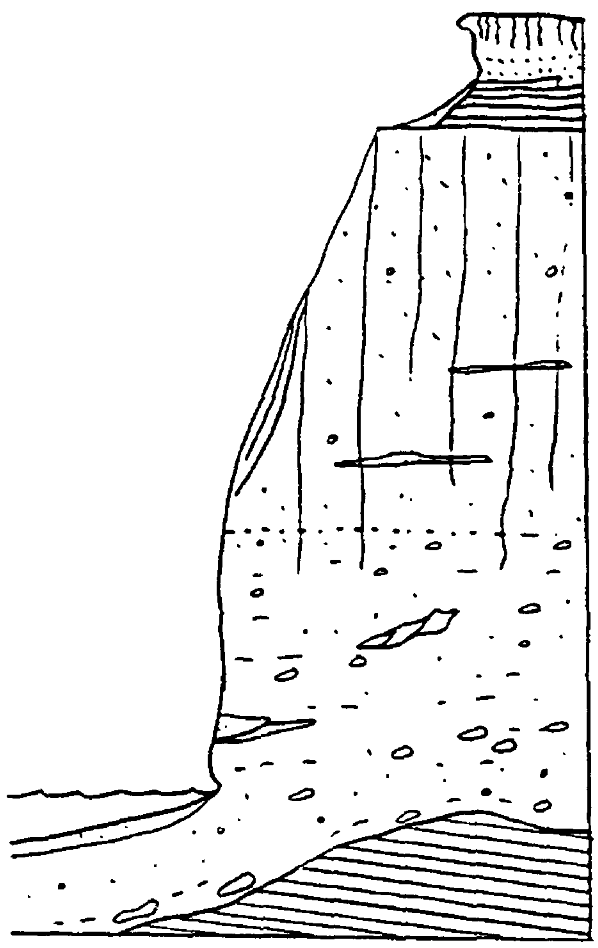
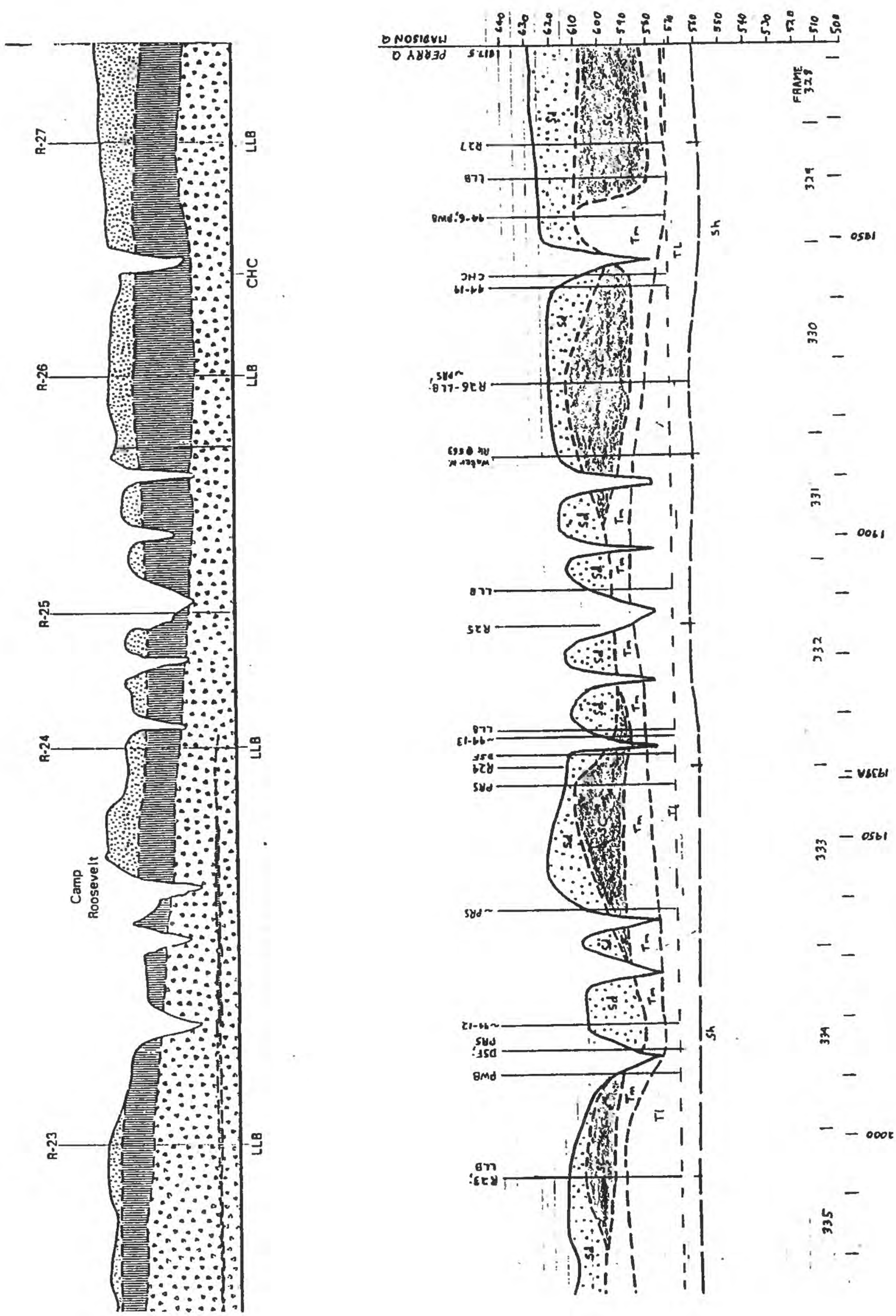
H
H
PA
H HIGH BLUFF
L LOW BLUFF
BEACH MATERIALS
SAND AND
GRAVEL
SHALE
DIRECTION OF NET
SAND TRANSPORT
Lorain
Claveland
OHIO
0
10 miles

Figure 1



HIGH TILL BLUFF
Cohesive, fractured till units in wave erosion zone and in steep bluff faces

Figure 2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Camp Roosevelt
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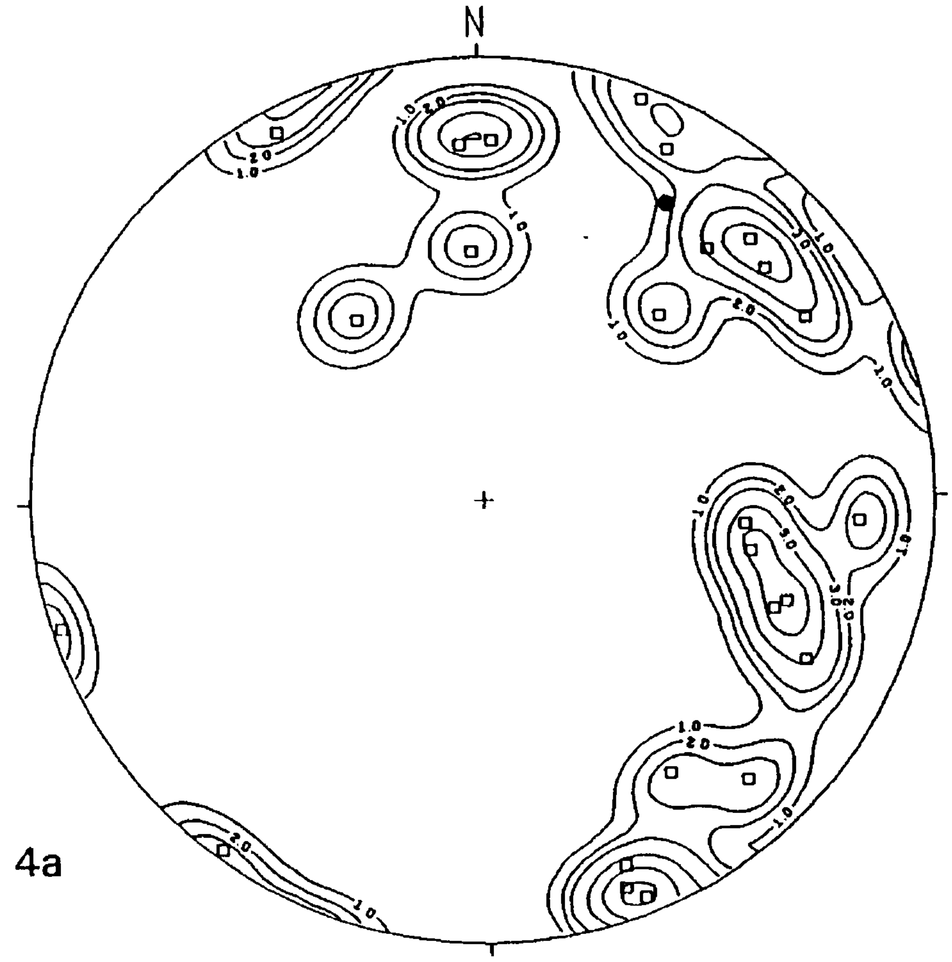
Figure 3



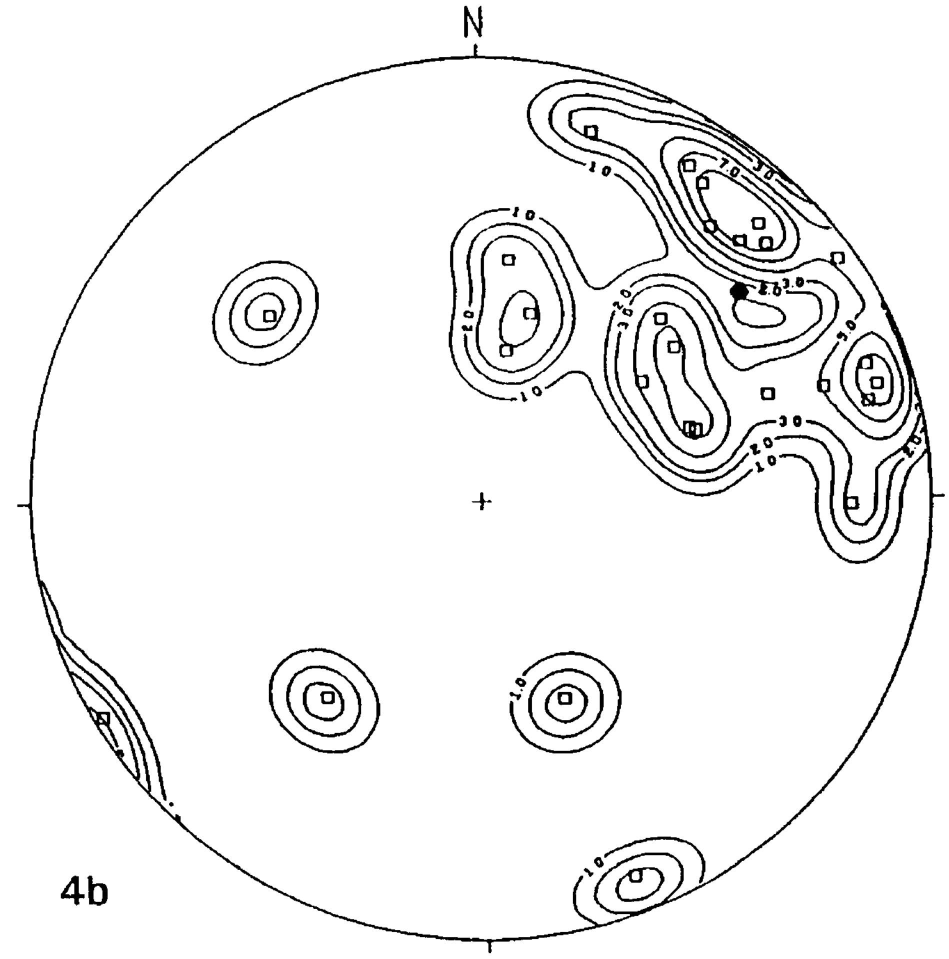


Figure 4

MARINE GEOLOGIC ATLASES ON CD-ROM-A METHOD OF ASSEMBLING, INTEGRATING, AND DISPLAYING INFORMATION

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The U.S. Geological Survey archives data on CD-ROM for publication and distribution. It also provides on-line access to its data holdings via the World Wide Web (WWW). The objective is to provide easy access to information for researchers and the public.

Examples of CD-ROMS, related to the coastal environment, that we have made available are: 1) The Atlas of the Deepwater Parts of the Exclusive Economic Zone in the Atlantic Ocean, the Gulf of Mexico, and the Eastern Caribbean Sea; 2) The Southern Lake Michigan Coastal Erosion Study; and 3) A geologic map of the seafloor in western Massachusetts Bay constructed from digital sidescan sonar images, photography, and sediment samples. These products were designed to replace paper atlases and provide an all-digital entity that can eventually be distributed on-line or copied for distribution.

Data integration tools and concepts utilizing graphic editors such as Correldraw allow the user to prepare final copy of maps prepared with ISM, ARC/INFO, and MAPGEN. We present a novel technique for assembling, integrating, and displaying spatially referenced information in the form of a marine atlas with tools and standard files that allow the user to browse the data with network software such as MOSAIC or NETSCAPE. A demo of the Lake Erie CD-ROM provides an example of an expanded basemap of bathymetry-augmented-sidescan sonar imagery and a new sediment texture interpretation.

SURFICIAL MATERIALS AND EROSION IN THE COASTAL AREA OF THE NORTH KINGSVILLE 7.5' QUADRANGLE, ASHTABULA COUNTY, OHIO

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Surficial materials in the coastal area of the North Kingsville quadrangle (see Fig. 1 in Pavey, Stone, and Bruno, this volume) are typical of materials that overlie the bedrock surface in all of coastal Ashtabula County (Pavey, Stone, and Prosser, 1994; Stone and Pavey, 1994). In this area, Lake Erie shoreline bluff recession averages <1 m/yr (Carter and Guy, 1983), but locally is as much as 3.1 m/yr (short-term recession rate, 1973-1990, Mackey and Guy, 1994). A new map of surficial earth materials in the coastal area modifies previous work by showing the distribution of surface sand and alluvial deposits based on detailed soils maps, aerial photograph interpretation, and field reconnaissance studies. Bedrock-surface contours are revised with new well data and highway test borings. A coast-parallel cross-section showing materials in the shoreline bluff is tied to the 1990 bluff recession line and coast-normal topographic profiles on 30-m post spacing (Mackey and Guy,1994). Stratigraphic relations of materials in the bluffs are based on 20 previously and newly measured sections along the bluffs (data in Carter and Guy, 1983; Bruno, 1988).

Bedrock is at or near lake level along the entire coast of the qudarangle, and the rock surface seems to be related to shoreline embayments and headlands. Broad lakeward convexities in nearshore bathymetric contours where rock forms the lake bottom may be related to minor (<2 m) relief of the rock surface in onshore areas or prehistoric bedrock-bluff headlands in offshore areas. At Camp Luther, the bathymetric convexity coincides with a shoreline headland, although bedrock does not crop out in the bluff. West of LaBounty Road, convex bathymetic contours coincide with a low rock outcrop along the shoreline. Onshore in the coastal area, the rock surface rises to the south as a planar feature to 177 m altitude at the base of the physiographic lake escarpment. The planar bedrock surface predates deposition of the Ashtabula Till and may record coastal erosional bevelling during the Erie interstade or older shoreline regressions.

Clayey silt till (Fig. 1a), interbedded lenses of clayey silt (Fig. 1b), laminated clay, silt, sand, and cross-bedded pebble gravel are exposed in the clay bluffs. The Ashtabula Till underlies the 15 m- to 21 m-high, near-vertical and slump-faced shoreline bluffs in the area. Two subtly contrasting facies of the till are consistently superposed along the bluff. The basal facies is a compact, homogeneous deposit with a clayey silt matrix and scattered pebbles, cobbles, and very few small boulders. The overlying facies is compact and has clayey silt matrix but characteristically contains elongate lenses of microlaminated to thin-bedded clay, silt, fine sand, and some gravel. In the quadrangle, the lower till facies has a mean matrix sand content of 16.3% (13.7-18.8%; Fig. 1c), mean silt content of 53.9% (49.1-61.2% range), and mean clay content of 29.8% (22.8-37.2% range). The deposit contains 5-10% small pebbles by volume, mostly composed of locally-derived shale. Cobbles and small boulders, composed of sandstone and igneous and metamorphic crystalline rock types derived from areas north and east of the Lake Erie basin are scattered through the unit but make up probably <3% by volume. The till most often displays a subhorizontal fissility marked by local silt lamina, and has gravel-clast long-axis fabrics with preferred NE to ENE orientations (Fig. 2). The fabric diagrams show that the long axes of most clasts lie in a plane that dips northeasterly, the direction from which the ice advanced. The lower till facies at Sunset Park, 0.6 km east of Kingsville-on-the-Lake, contains dipping beds of brown silty diamicton sand that have been thrust toward the SSW (199^{o} azimuth; Fig. 2) in a direction similar to the direction of ice sheet movement deduced from the till clast fabric mean (213^{o} azimuth). Similarly deformed and sheared lenses of stratified silt and sand are also present in an unusual zone that extends about 75 m laterally.

The upper till facies has a mean matrix sand content of 12.9% (0.7-

49.7% range, Fig. 1d), mean silt content of 63.1% (34.7-94.6% range), and mean clay content of 24.0% (3.8-51.2% range). In most sections, discontinuous lenses or blocks of sheared, stratified sand, silt, and clay comprise <10% of the total section. Grain-size analysis indicates mixing of silt-rich materials in the matrix (95.6% silt) of some till units. Sheared bedding and flattened folds are common, indicating sediment or glacial overriding. At Sunset Park, a 4-m-thick, upward coarsening sequence of glacial-lake sand, silt, and clay fills a shallow, 2400 m-wide depression near the top of the till section. Silty till, 0.8 to 3 m thick, overlies the stratified sediments at the land surface. There is no evidence of glacial overriding or shearing at the top of the sand deposit, which indicates lake-bottom deposition of the upper till facies by debris-flow processes, locally intercalated with stratified sediments deposited by meltwater or lake-bottom currents.

An extensive surface deposit of sand and gravel covers the coastal area in the eastern third of the North Kingsville quadrangle. It includes apparent eolian dunes and shoreline beach and foreshore materials that extend as a shoestring sand in the 690-720 ft (210-219 m) topographic interval. One km northeast of North Kingsville, the dune and beach morphology ends and a broad, thin bed of pebbly gravel and sand that extends to the east. This gravelly sand appears to be a late Wisconsin-age deltaic deposit of the ancestral Conneaut Creek that was contemporaneous with the shoreline deposits. Lower shoreline deposits and associated erosional features truncate the deltaic material, and a lower sand sheet extends as a suface cover to the present lake bluff. In the bluff at Camp Luther, this surface deposit is an upward-coarsening 4 m-thick sequence of sand, silt, and clay. Ripples in the fine sand indicate westward paleocurrents, presumably related to long-shore transport from the mouth of ancestral Conneaut Creek which lay to the east.

The depositional history of surficial sediments in the area is related to persistence of late Pleistocene glacial lakes in the Erie basin. The indistinct contact between the two Ashtabula Till facies, their similar grain size and composition, and lack of evidence of ice recession (such as laterally continuous stratified deposits, weathered zones, glaciotectonic zone, stone lines) indicate a continuous depositional sequence from advance of ice into the basin to meltout sedimentation in the deep glacial lake and final ice recession. Perhaps the entire Ashtabula Till dates from ice readvance following the Erie interstade. Alternatively, the deposit may date from a later Erie ice-lobe readvance that formed a thick ice-marginal deposit of the upper meltout-till facies along the present coast. Final ice recession from the area was followed closely by progradational sedimentation of coastal deposits in a series of lowering lakes in the basin that persisted during deglaciation of the Erie-Ontario region. The large deltaic sand deposit of ancestral Conneaut Creek, and subsequent erosion and deposition of the sand at lowering lake levels provided sand and gravel for beaches in the area, which persist to the present. Man-made shore structures such as groins and other erosion-control measures (Carter and Guy, 1983) locally contribute to slow erosion rates.

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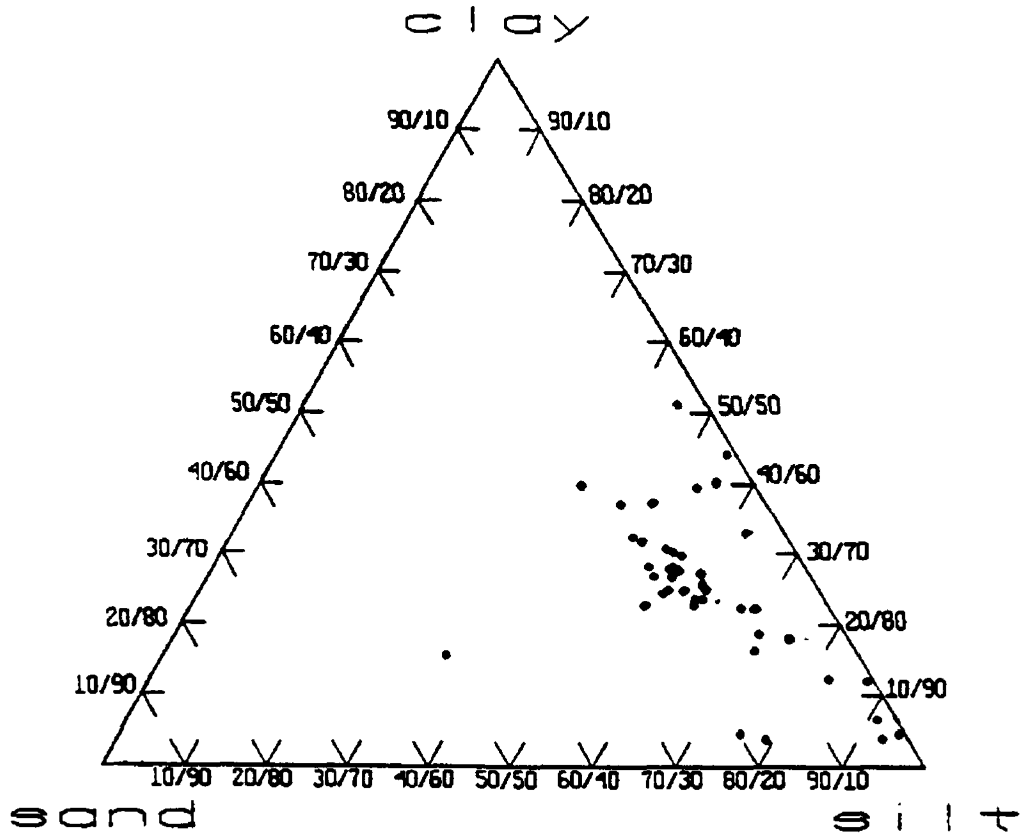
Figure 1. Ternary diagrams of sand, silt, and clay grain-size values for samples of surficial earth materials in the North Kingsville, Ohio quadrangle; data from Bruno (1988) Kingsville and Camp Luther sections. a) 42 samples from clayey silt till; b) 6 samples from clayey silt lenses within till; c) 35 samples from upper meltout facies, Ashtabula Till; d) 7 samples from lower lodgement facies Ashtabula Till.

Figure 2. Till clast fabric diagrams from the lower lodgement facies of Ashtabula Till; lower hemisphere projections of gravel clast long axes; contour intervals 1, 2, 3, 5, 7, 9 percent; square symbols show data points; mean clast azimuth shown by filled circle.



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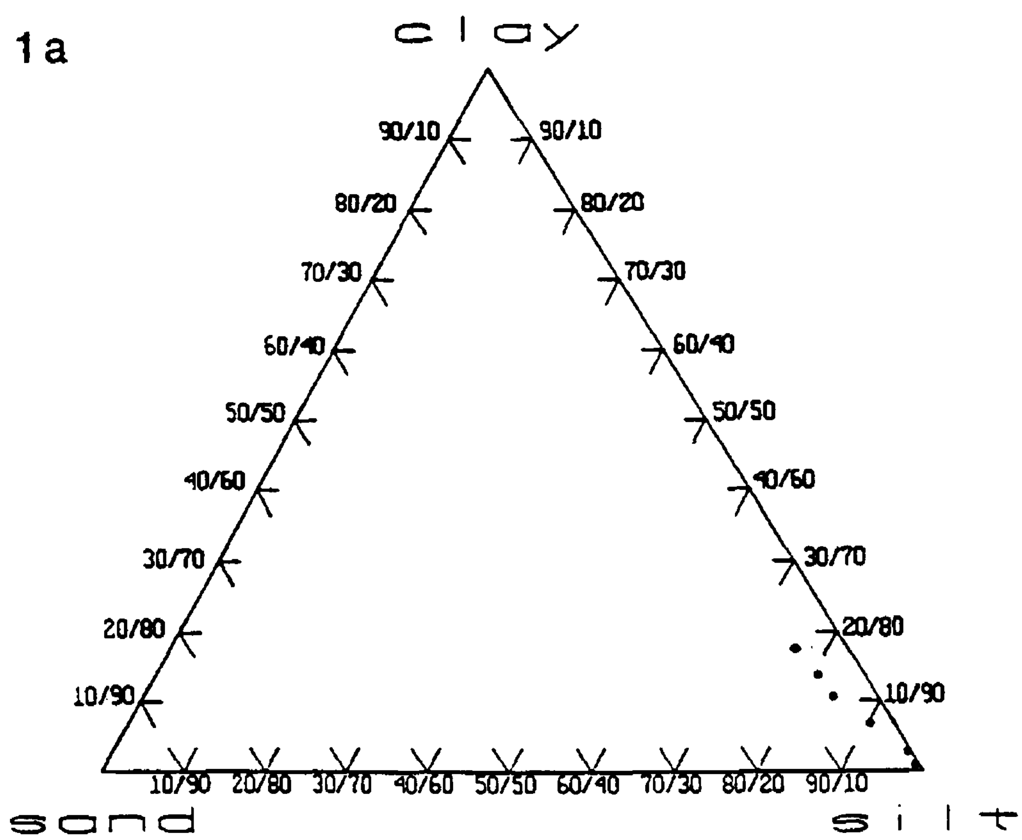
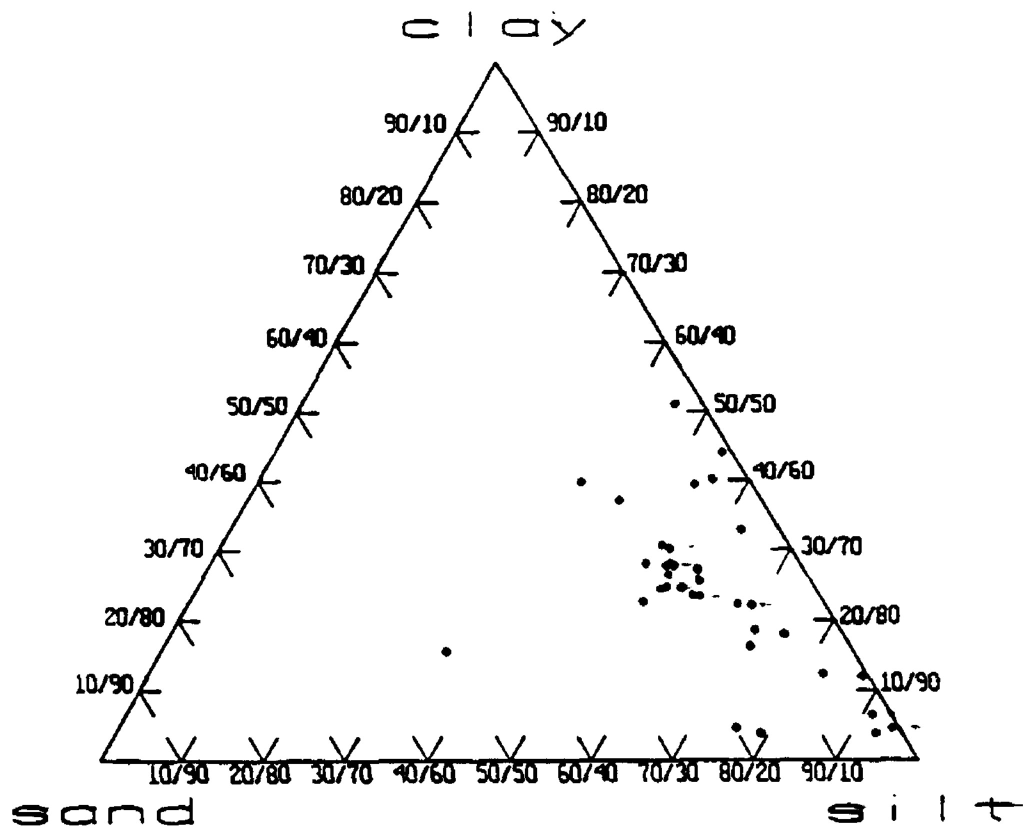


1b

Figure 1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sand
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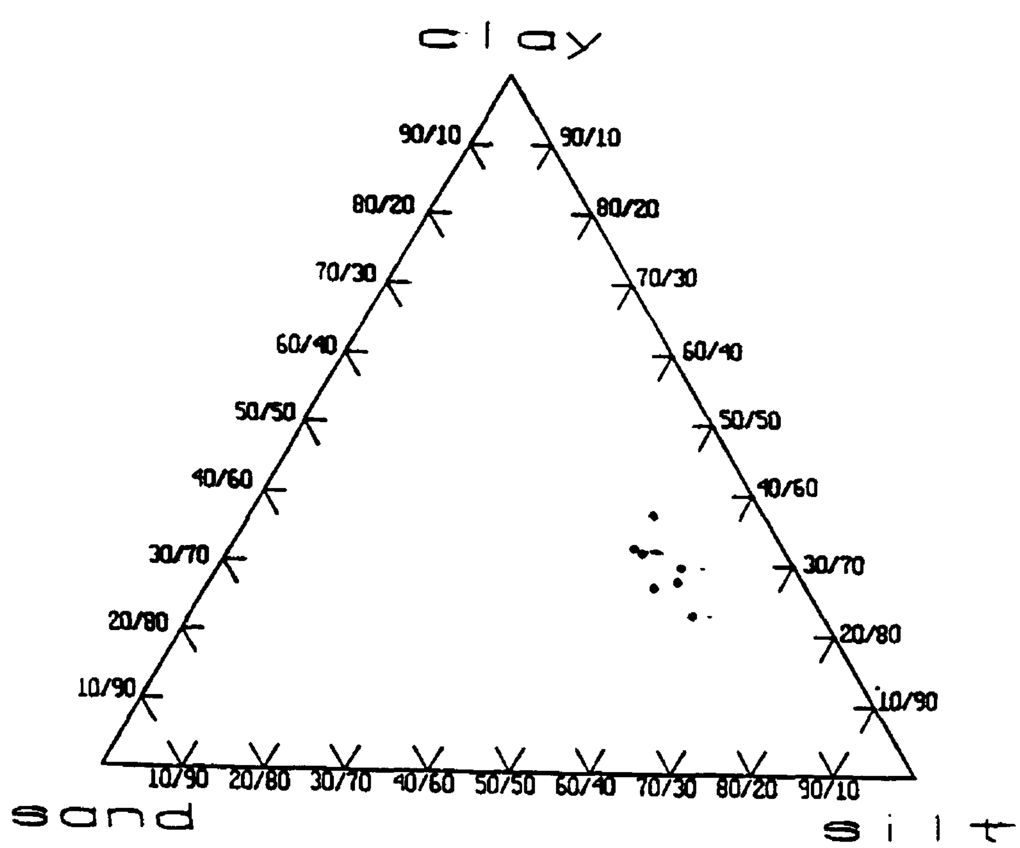
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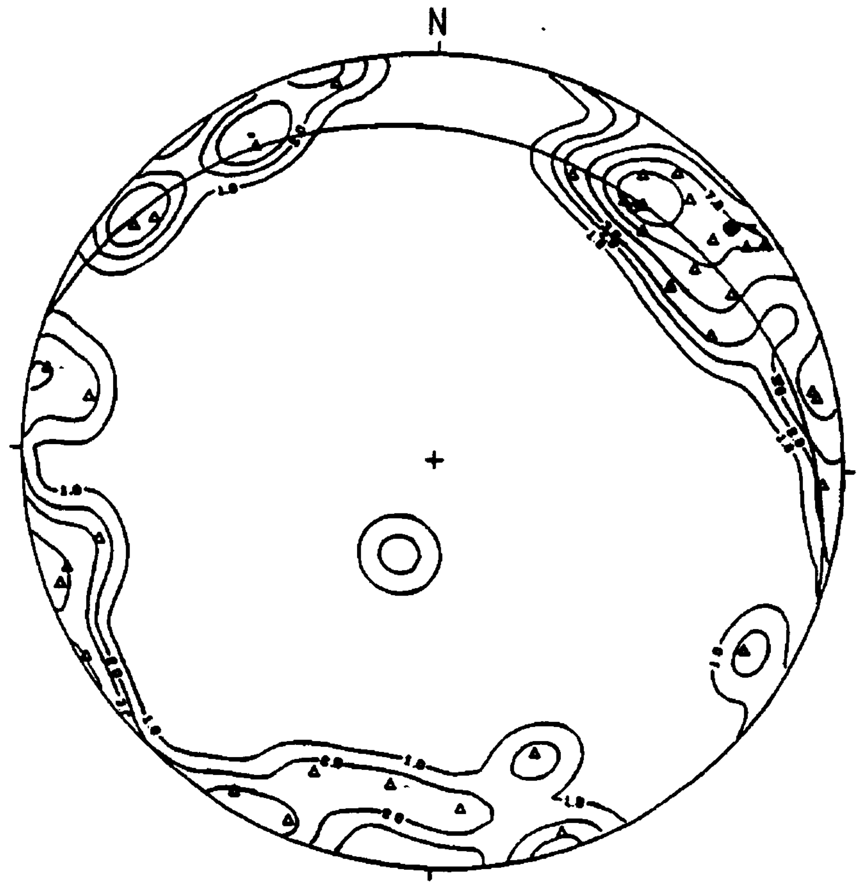
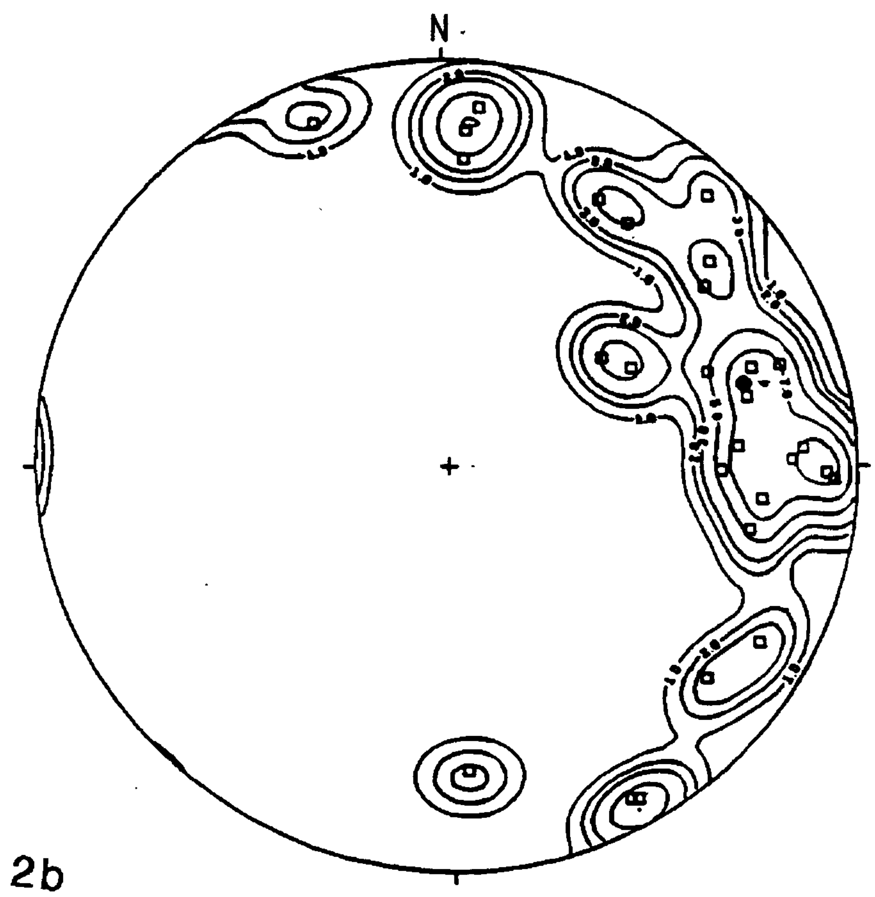
silt

1d



2a



2b

Figure 2

GLACIALLY MODIFIED BEDROCK-SURFACE TOPOGRAPHY AND OVERLYING SURFICIAL GEOLOGIC MATERIALS IN THE WESTERN LAKE ERIE COASTAL AREA, NORTHWESTERN OHIO AND SOUTHEASTERN MICHIGAN

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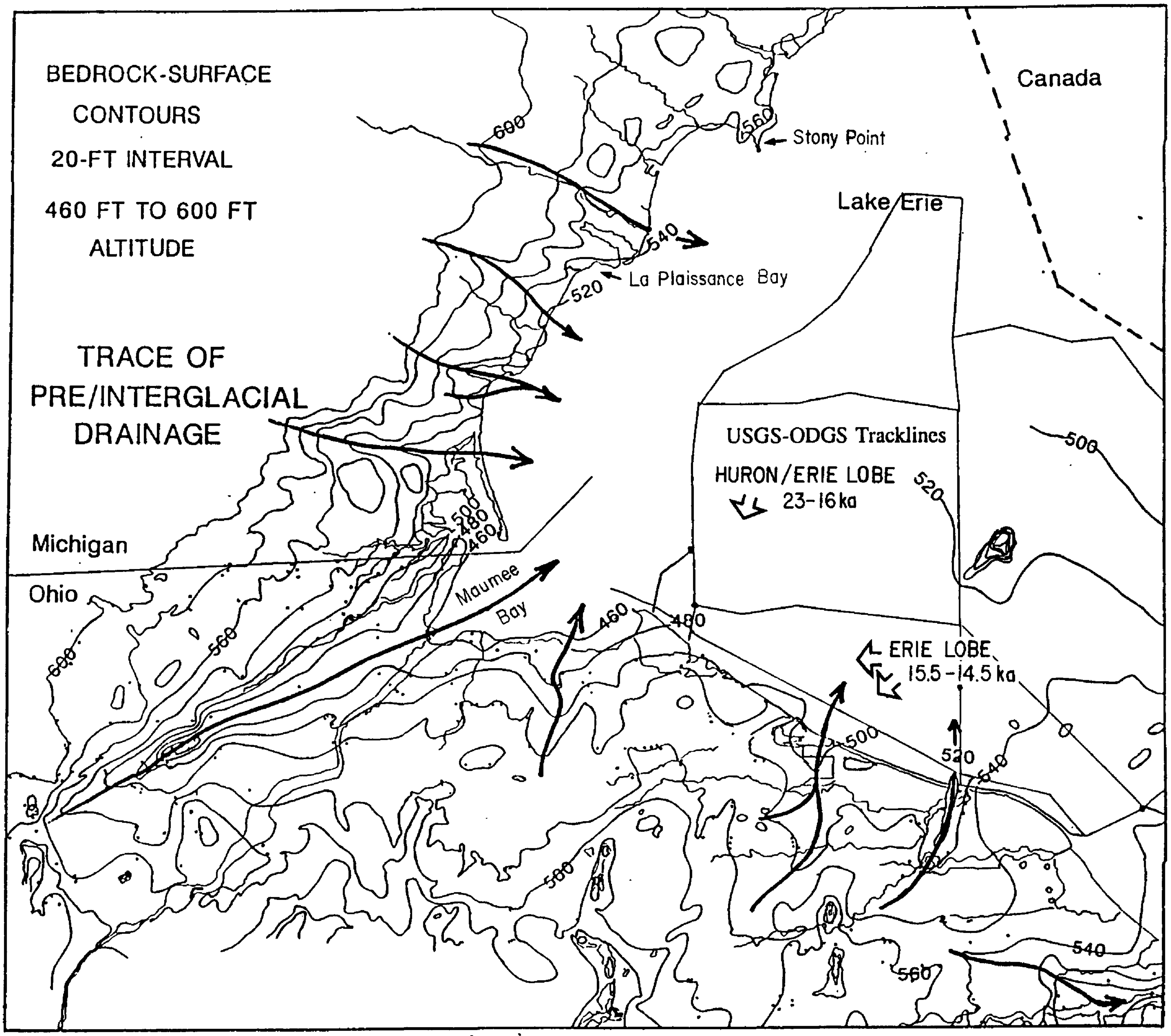
A preliminary digital map of the bedrock-surface topography of the western Lake Erie region (Toledo 1:100,000-scale map sheet) depicts a glacially-modified relict landscape that ranges in altitude from a low of below 460 ft (140 m) in Maumee Bay, to a high of about 680 ft (207 m) in Lenawee County, Michigan (Fig.1). The map is based on more than 3500 water, oil, and gas wells, engineering test borings, and offshore control by 80 km of newly collected (1994) detailed seismic reflection profiles. The map modifies previous bedrock-surface topographic maps by including smoothed and U-shaped contours in upstream valley reaches, and local closed-basin contours, reflecting glacial erosion of preexisting topographic features. The bedrock topography appears to represent a complex, palimpsest, geomorphic surface originally dissected by pre- or interglacial fluvial systems, with subsequent extensive modification of bedrock valleys and interfluves by glacial erosion during multiple advances and recessions of ice lobes in the Erie basin.

In the Ohio coastal area, the bedrock surface most often is at altitudes below 545 ft (166 m), thus lying about 25 ft (8 m) below the level of Lake Erie (571 ft or174 m altitude). Northward along the Michigan coast to La Plaisance Bay, bedrock is below 540 ft (165 m); north of the bay, the rock surface rises irregularly to above 570 ft (174 m) at Stoney Point. The dominant topographic feature in the coastal area is a 25-km-long, linear east-trending valley that underlies the City of Toledo and extends into Maumee Bay. The valley floor varies in width from 1-2 km. The floor contains a closed, glacially overdeepened depression more than 8 m deep. The valley coincides with the probable trend of an ancestral Maumee river. Vestiges of tributary valleys are present, as are wide, shallow, poorly defined valleys east of Toledo. In southwestern Michigan, the trends of large east-draining valleys, with as much as 30 m of relief to crests of interfluves are preserved on the north side of the area of the Erie ice lobe. Subsurface data indicate that all bedrock-surface valleys are overlain by silty or clayey till of Late Wisconsinan age. Thus, these valleys may have been last eroded by fluvial systems in pre- or early Wisconsinan time, when the Erie basin was ice-free and contained no high lakes dammed by ice or surficial sediments.

Bedrock lithologic units, also shown on the map, in the coastal area are chiefly carbonate rocks, varying from interbedded, fine- to medium-grained cherty dolomite and limestone (Bois Blanc Formation) at the north edge of the coastal area, to dense dolomites, shaley dolomite, and limestone, with subordinate amounts of dolomitic shale, shale, gypsum, and anhydrite (Bass Islands Group, Salina Group, Lockport Dolomite) to the south. Most of the area is located on the west side of the broad crest of the Findlay Arch, where bedrock units dip gently to the west or northwest toward the interior of the Michigan Basin. The strike of rock units appears to have minimal effect on location of ancestral stream courses or other features on the bedrock surface. Areas of bedrock outcrops are at crests of linear topographic highs that are underlain by massive, dolomitized coralline reef structures. Stripped rock surfaces adjacent to quarries reveal linear and irregular, positive topographic features on the rock surface, 0.5-10 m in length and 0.3-1.0 m in height, that conform to linear reef structures and irregular algal mounds in the rock. These small features and the overall patterns of bedrock-surface relief across different rock units in the area demonstrate the relation between resistant rock types and topographic features on the glacially-abraded bedrock surface.

At North Curtice, Ohio, a pit excavated in 1994 revealed the regional succession of surficial materials that overlie the bedrock. At the base, the lower hardpan till is characterized by gray, silt-clay loam matrix containing Canadian Shield crystalline gravel clasts. The overlying till is more clayey and contains sheared lake-bottom clay, silt, and sand near the top. Distal lake clay deposits overlie the clayey till. In 1994, the thin edge of these deposits was mapped from Port Clinton to Walbridge, Ohio. Further west in Oregon, Ohio, a lake-bottom sand cap overlies the clay; the sand deposit thickens toward the west.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CONTOURS
20-FT INTERVAL
460 FT TO 600 FT
ALTITUDE
TRACE OF
PRE/INTERGLACIAL
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Canada
Stony Point
Lake Erie
La Plaissance Bay
USGS-ODGS Tracklines
HURON/ERIE LOBE
23-16ka
ERIE LOBE
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Michigan
Ohio
Maumee
Bay
600
560
540
520
500
480
460

Figure 1

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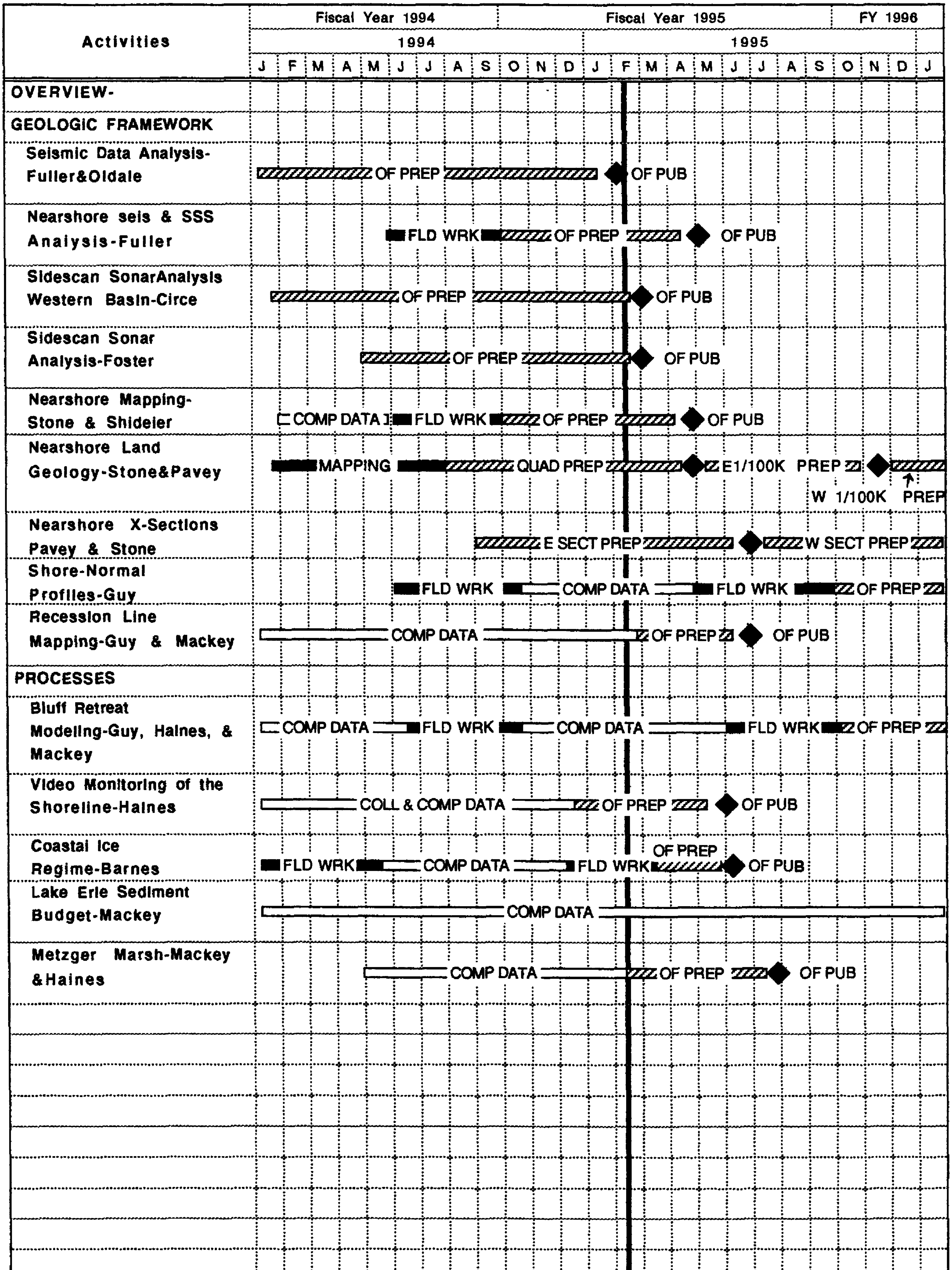
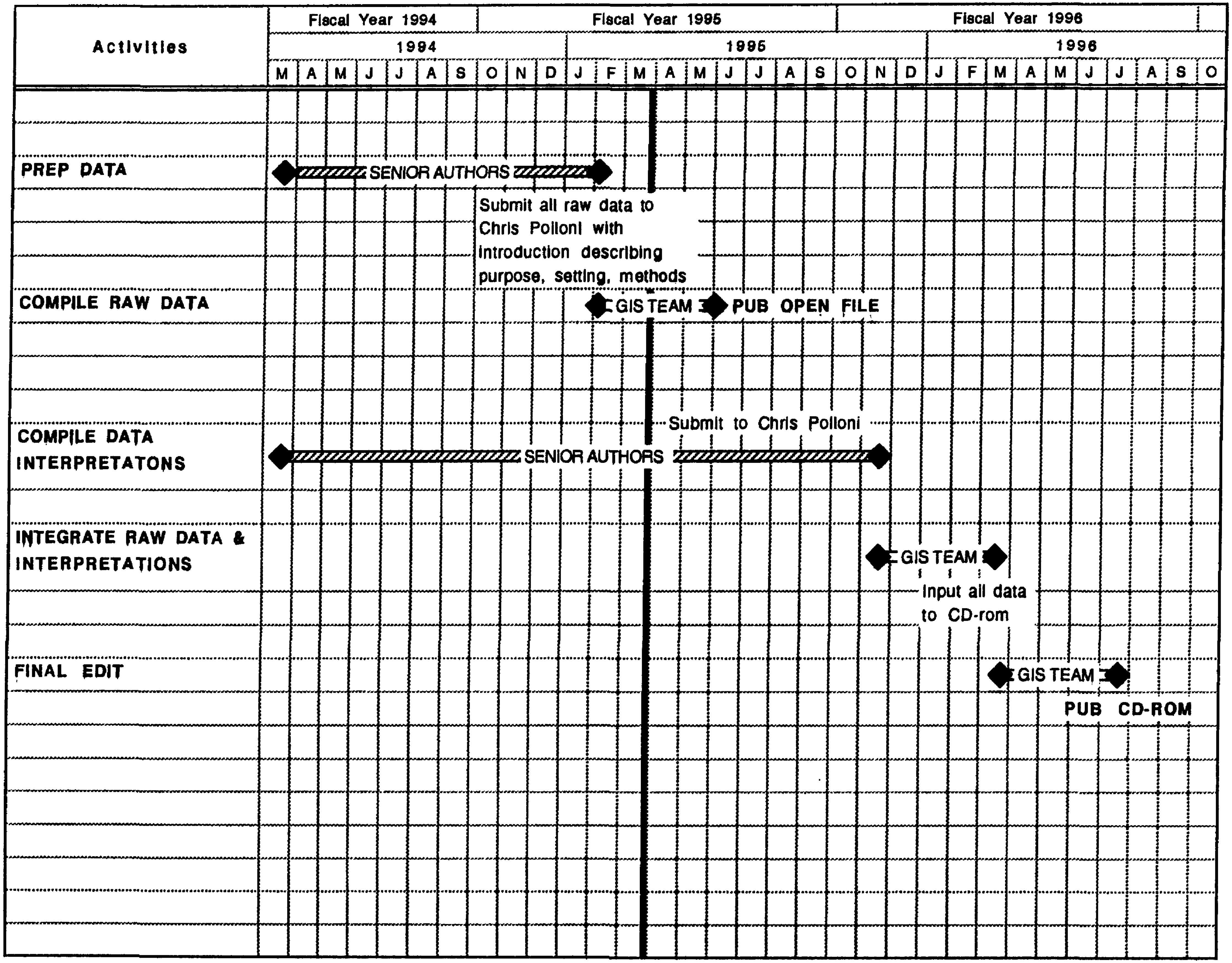
APPENDIX A

LAKE ERIE SCHEDULE



APPENDIX B

LAKE ERIE CD ROM PREP SCHEDULE



APPENDIX C

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Columbus, OH 43224-1362	

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Byron D. Stone U. S. Geological Survey National Center MS 928 12201 Sunrise Valley Dr. Reston, Va. 22092	703 648 6910 203 240 3060 703 648 6953 FAX