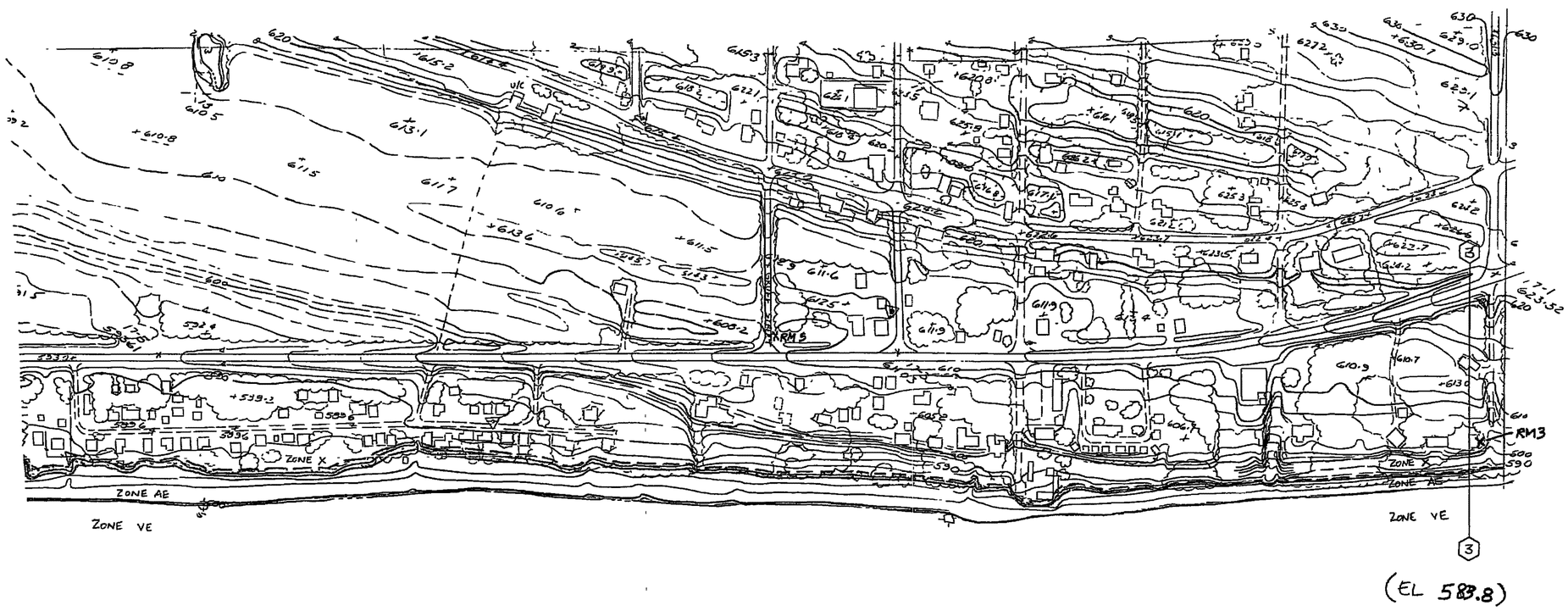
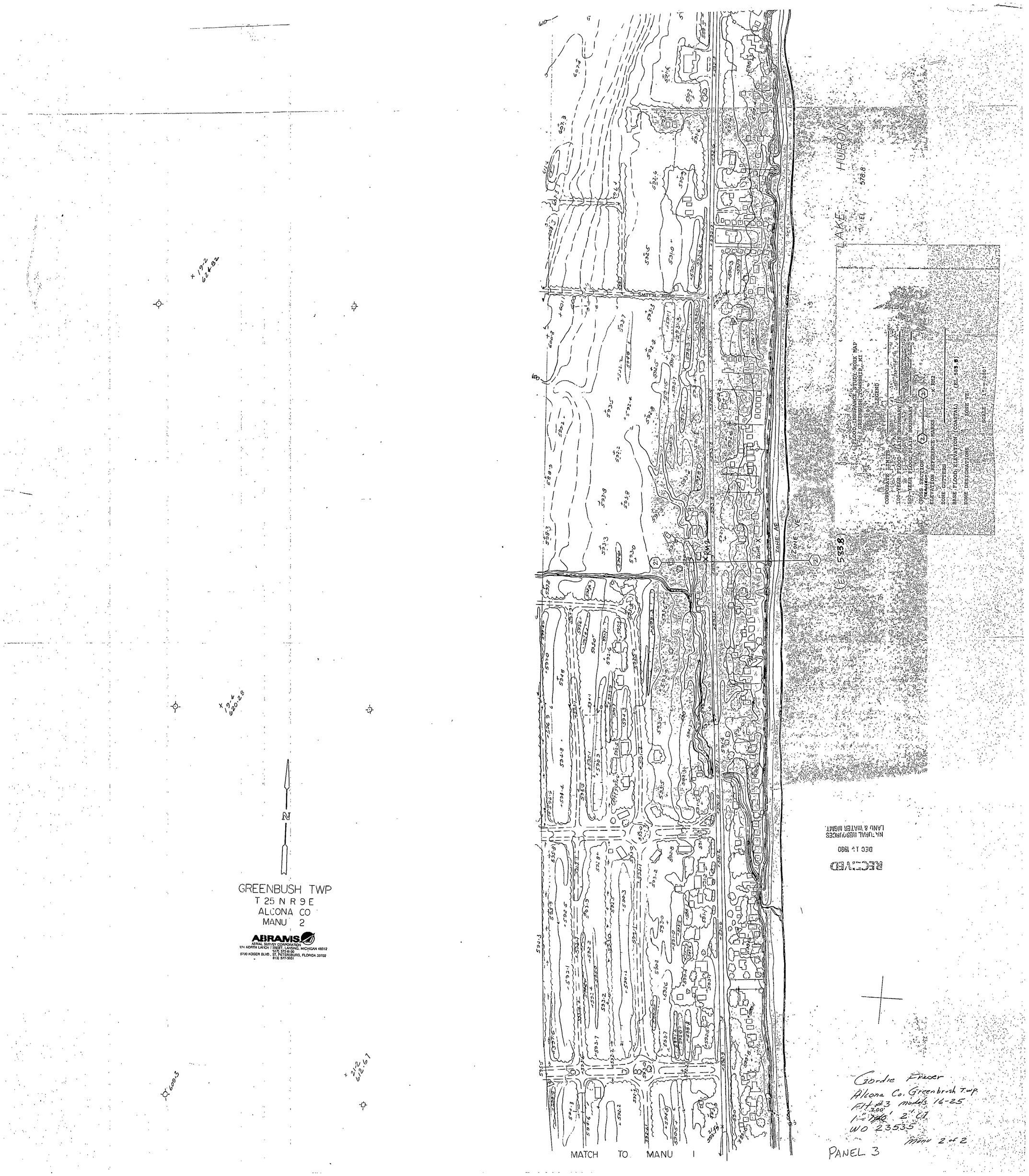
17-6
631.72

17-4
640.18

17-2
647.93



(EL 583.8)



LAKE HURON
EL 578.8
SMITH ROAD
ZONE X
ZONE AE
ZONE VE
EL 583.8
FLOOD INSURANCE STUDY WORK MAP
GREENBUSH TOWNSHIP, MI
LEGEND
CORPORATE LIMITS
100-YEAR FLOOD PLAIN BOUNDARY
500-YEAR FLOOD PLAIN BOUNDARY
CROSS SECTION
ELEVATION REFERENCE MARKS
ZONE GUTTERS
BASE FLOOD ELEVATION (COASTAL)
ZONE DESIGNATIONS
ZONE VE
SCALE 1" = 200'
N
GREENBUSH TWP
T 25 N R 9 E
ALCONA CO
MANU 2
ABRAMS
AERIAL SURVEY CORPORATION
124 NORTH LAUCH STREET, LANSING, MICHIGAN 48912
(517) 372-8100
9700 KOGER BLVD., ST. PETERSBURG, FLORIDA 33702
(813) 577-3101
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NATURAL RESOURCES
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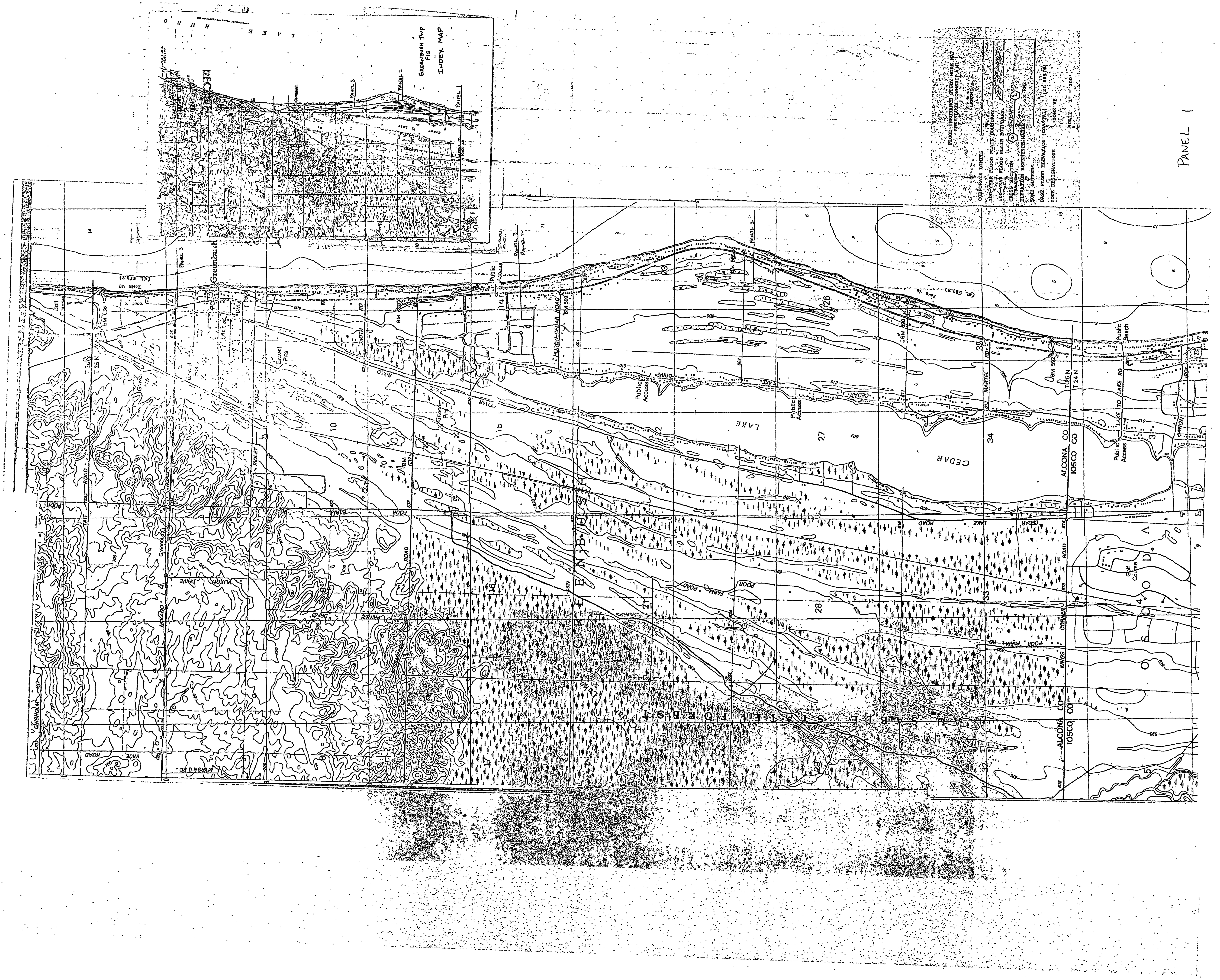
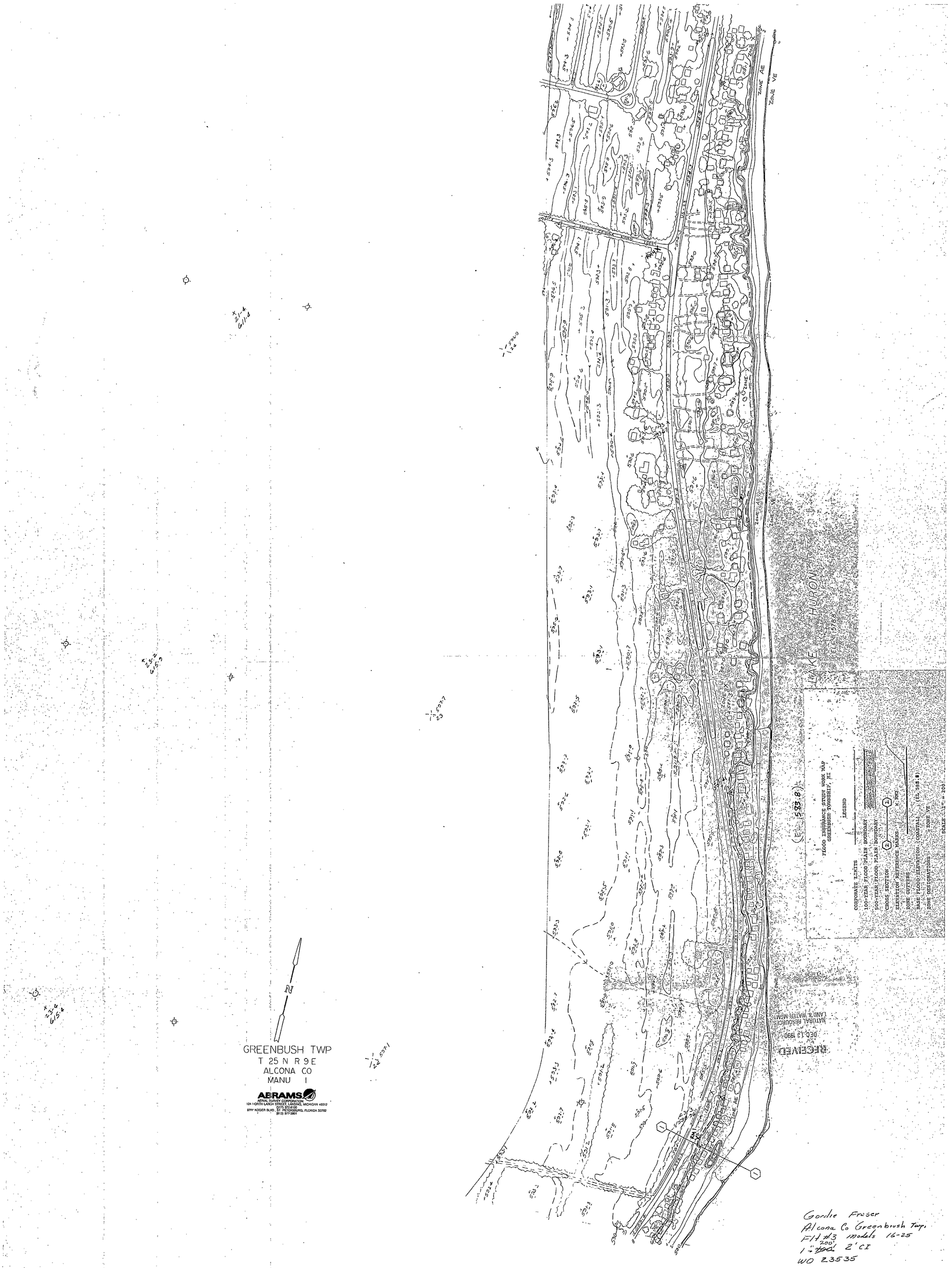
MATCH TO MANU 1
Gordie Fraser
Alcona Co. Greenbrush Twp.
Flt #3 models 16-25
1" = 200' 2' CI
WO 23535
Manu 2 of 2
PANEL 3


FLOOD INSURANCE STUDY WORK MAP
GREENBUSH TOWNSHIP, MI
LEGEND
CORPORATE LIMITS
100-YEAR FLOOD PLAIN BOUNDARY
500-YEAR FLOOD PLAIN BOUNDARY
CROSS SECTION (TRANSECT)
ELEVATION REFERENCE MARKS
ZONE GUTTERS
BASE FLOOD ELEVATION (COASTAL)
ZONE DESIGNATIONS
ZONE VE
SCALE 1" = 200'
PANEL 1
GREENBUSH TWP
FIS
INDEX MAP
PANEL 2
PANEL 3
LAKE HURON
Greenbush
ZONE VE
(EL 583.8)
ZONE X
ZONE AE
Golf Course
Gravel Pits
Public Access
Public Beach
CEDAR LAKE
HURON-CEDAR ROAD
SMITH RD
RIDLEY ROAD
TAIT ROAD
MIKADO
YUKON DRIVE
PRINCE DRIVE
POOR FARM ROAD
CEDAR LAKE ROAD
MARTEL RD
LAKE TO LAKE RD
AARON RD
KINGS CORNER ROAD
CHISHOLM RD
WICE ROAD
MYRON RD
T 25 N
T 24 N
BM 592
BM 590
BM 632
ALCONA CO
IOSCO CO
GREENBUSH
AU SABLE STATE FOREST
OSCODA



Gordie Fraser
Alcona Co Greenbush Twp.
FIH #3 models 16-25
1" = 200' 2' CI
WO 23535

Manu 1 of 2

PANEL 2

1) COUNTY: ALCONA

2) STUDY NAME: Greenbush Twp

3) WATERCOURSE: Wave Run-up

4) DOCUMENT TYPE: Report

TECHNICAL LETTER REPORT ON GREENBUSH TOWNSHIP, MICHIGAN

Prepared by the U.S. Army Corps of Engineers
for the Federal Emergency Management Agency

Detroit, Michigan
November 1990

TECHNICAL LETTER REPORT ON
GREENBUSH TOWNSHIP, MICHIGAN

TABLE OF CONTENTS

Title	Page
TABLE OF CONTENTS	i
LIST OF FIGURES	ii
LIST OF TABLES	ii
1.0 INTRODUCTION	1
1.1 PURPOSE OF STUDY	1
1.2 AUTHORITY AND ACKNOWLEDGMENTS	1
1.3 COORDINATION	3
2.0 AREA STUDIED	3
2.1 COMMUNITY DESCRIPTION	3
2.2 PRINCIPAL FLOOD PROBLEMS	5
3.0 ENGINEERING METHODS	5
4.0 A-ZONE AND V-ZONE DELINEATION	6
5.0 CONCLUSIONS	11
6.0 GLOSSARY	13
7.0 REFERENCES	15

LIST OF FIGURES

Number	Title	Page
1.	GREENBUSH TOWNSHIP LOCATION MAP	4
2.	GREENBUSH TOWNSHIP A & V-ZONE DELINEATIONS ON A BEACH/BLUFF SYSTEM (PROFILE G-1)	8
3.	GREENBUSH TOWNSHIP A & V-ZONE DELINEATIONS ON A BEACH SYSTEM (PROFILE G-2)	9
4.	GREENBUSH TOWNSHIP A & V-ZONE DELINEATIONS ON A BEACH SYSTEM (PROFILE G-3)	10

LIST OF TABLES

Number	Title	Page
1.	SHORELINE PROFILES, GREENBUSH TOWNSHIP, MICHIGAN	2
2.	WAVE RUNUP ELEVATIONS	12

Appendix	Title
A	FIS PROFILES

TECHNICAL LETTER REPORT ON
GREENBUSH TOWNSHIP, MICHIGAN

1.0 INTRODUCTION

1.1 Purpose of Study

This report describes the application of the procedures developed in the 1989 "Great Lakes Wave Runup Methodology Study" to flood levels on Saginaw Bay, specifically in Greenbush Township, Michigan. The flood levels applicable to Greenbush Township were developed in the April 1988 "Revised Report on Great Lakes Open-Coast Flood Levels".

1.2 Authority and Acknowledgments

The "Great Lakes Wave Runup Methodology Study" was prepared in 1989 by the U.S. Army Corps of Engineers (COE) for the Federal Emergency Management Agency (FEMA), for application to future coastal Flood Insurance Studies (FIS) and/or restudies of communities bordering the Great Lakes. The work was conducted under Inter-Agency Work Agreement, EMW-89-E-3218, Project Order No. 1, between the COE and FEMA. The 100-year and 500-year flood levels from the April 1988 report referenced above, were used to compute the maximum wave runup elevations required for updating the previous study in Greenbush Township on Lake Huron. TABLE 1 lists profile locations, and the 100-year and 500-year "base" flood levels at three locations along the Greenbush Township shoreline. The three profiles were plotted from data obtained from a June 1990 survey.

SHORELINE PROFILES
GREENBUSH TOWNSHIP, MICHIGAN

	Profile Location	100-year Flood Level	500-year Flood Level
1.	Greenbush-1	583.8	584.7
2.	Greenbush-2	583.8	584.7
3.	Greenbush-3	583.8	584.7

* NOTE: All elevations are in FT, NGVD and were obtained from the April 1988 "Revised Report on Great Lakes Open-Coast Flood Levels".

TABLE 1

1.3 Coordination

The "Revised Report on Great Lakes Open-Coast Flood Levels", along with examples of the application of the methodology from the 1989 "Great Lakes Wave Runup Methodology Study", were presented to FEMA on March 1, 1990. The procedures outlined in the above references were approved at this meeting for application to all Saginaw Bay FIS sites, including Greenbush Township.

2.0 AREA STUDIED

2.1 Community Description

Greenbush Township, Michigan, shown on FIGURE 1, is located in Bay County along 6 miles of shoreline on Lake Huron. There are no major populated communities located along the Greenbush Township shoreline. The developed shoreline consists of small seasonal and year-round residential homes, having a population of about 1.300.

The entire Greenbush Township shoreline located on Lake Huron is exposed from the northeast to a Lake Huron fetch length of about 150 miles. Bathymetry in Lake Huron along the Greenbush Township shoreline varies from 40-foot depths offshore to less than five feet deep near the shore. Ordinary fluctuations of water levels along this shoreline are of the same magnitude and frequency as apply generally to harbors on Lake Huron. The lowest seasonal lake stages usually prevail during the winter months and the highest during the summer months. In the past 100 years, fluctuations of water levels on Lake Huron, as measured by

GREENBUSH TOWNSHIP LOCATION MAP

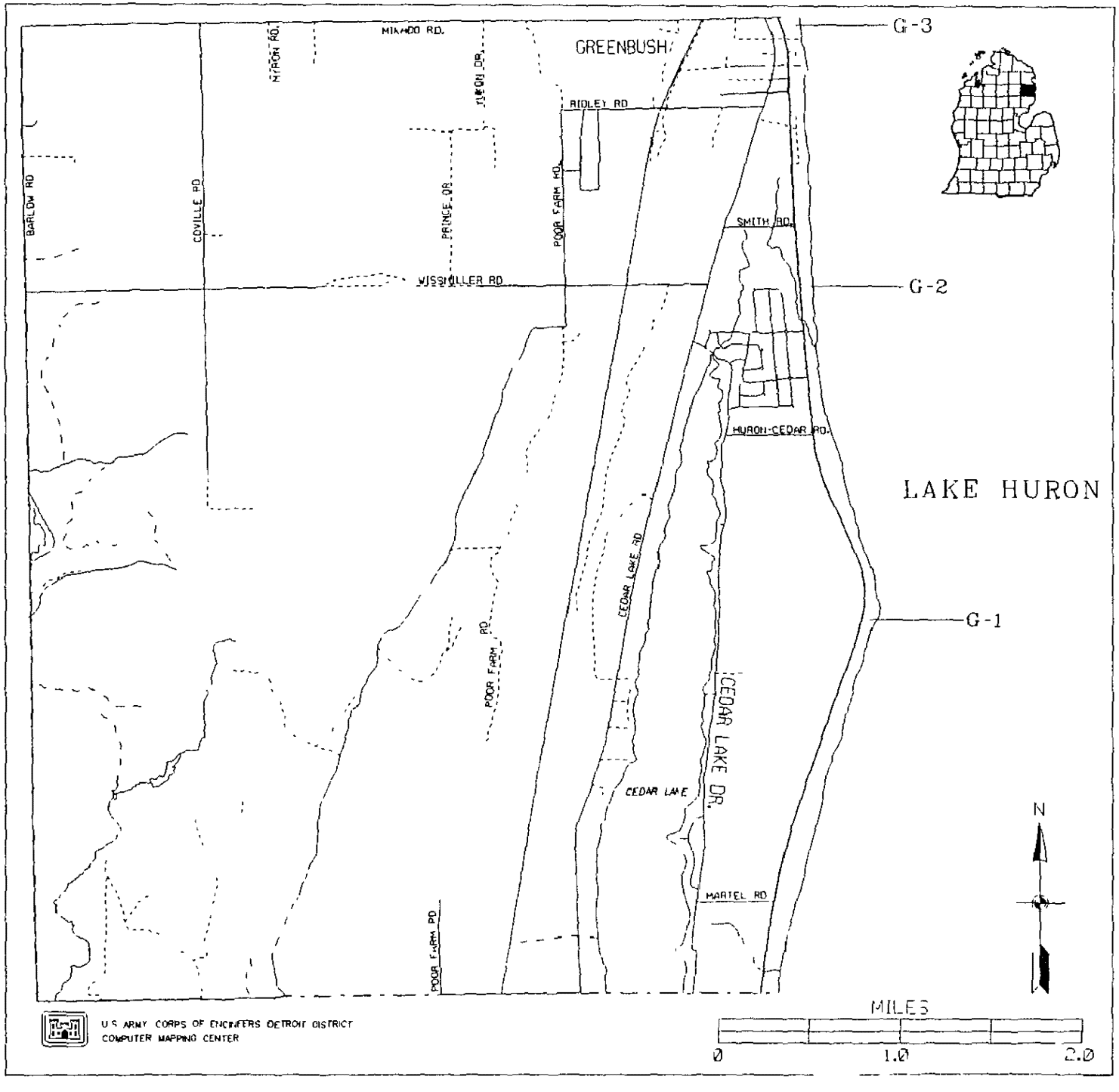


FIGURE 1

monthly means, have ranged from a minimum of 575.35 feet to a maximum of 581.62 feet (IGLD, 1955).

2.2 Principal Flood Problems

Short-term Lake Huron water level fluctuations are most often due to variations in wind and barometric pressure. Occasionally, a surge of considerable proportions takes place within a few hours, due to strong and persistent northerly winds.

When lake levels are high and storms occur from the northeast to southeast directions, Greenbush Township shoreline communities are usually subjected to extreme conditions. Along the Greenbush Township shoreline, substantial flooding has occurred because of the flat topography along the reaches on Lake Huron.

3.0 ENGINEERING METHODS

The flood levels established in the U.S. Army Corps of Engineer's April 1988 "Revised Report on Great Lakes Open-Coast Flood Levels" and the procedures developed in the 1989 "Great Lakes Wave Runup Methodology Study" were used to analyze the flooding potential at the three Greenbush Township FIS sites shown on FIGURE 1. The hydraulic analyses presented herein involved the determination of the wave runup components and maximum wave runup elevations for selected sites.

Input data used for flood calculations include site specific design wave, water depth at the toe of the structure, and wave period. Additional data such as nearshore profiles, high water marks, and existing conditions, bathymetry and topography, were

also analyzed to determine the maximum wave runup elevation at each site. This technical letter report presents the wave runup application procedures for each of the nine FIS sites located in Greenbush Township. Representative profiles for each site are included in APPENDIX A.

4.0 A-Zone and V-Zone Delineations

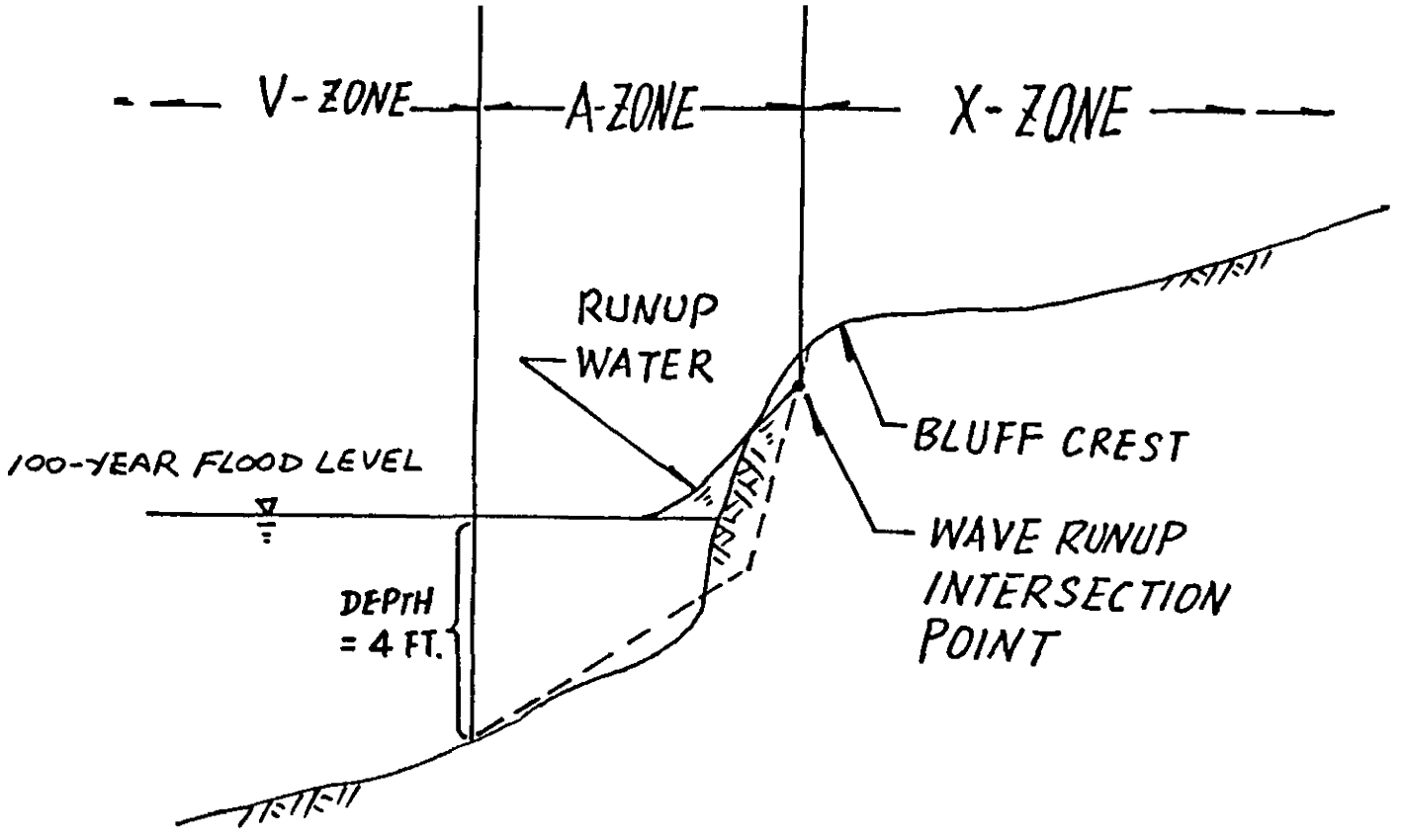
Reaches of the Greenbush Township shoreline in the surf zone which are subject to significant wave attack are referred to by FEMA as Coastal High Hazard Zones or velocity ("V") Zones. A "V" Zone is the flood insurance rate zone that corresponds to the 100-year coastal floodplain that has additional hazards associated with storm waves. The "V" Zone is defined in FEMA's 1990 "Guidelines For Great Lakes Wave Runup Computation And Mapping" as the maximum elevation reached by the wave runup associated with the 100-year flood level. This portion of the shoreline and/or structure is critical in terms of causing significant structural damage. An "A" Zone is the flood insurance rate zone that corresponds to the 100-year flood level that is determined in the FIS using the detailed method. It is further defined as that area that is inundated by the 100-year flood and shoreward of the "V" Zone.

One A and V-Zone flood condition as defined by FEMA, most closely represents the FIS sites in Greenbush Township. This type of condition involves a beach/bluff system where the wave runup does not overtop the existing beach/bluff. The V/A demarcation line is fixed at the point where the 100-year storm water depth

is equal to 4 feet on the lakeward side of the bluff. The A/X demarcation line is fixed at the point where the wave runup intersects the calculated post-storm profile. This mapping is considered appropriate for the Greenbush-1 thru Greenbush-3 profiles, and is shown on FIGURE 2.

The "A" and "V" Zones for these sites have been delineated according to FEMA's 1990 "Guidelines for Great Lakes Wave Runup Computation and Mapping" and are shown on the attached work maps. The formal submittal of the Greenbush Township study will include original mylar copies showing sufficient detail for submittal to FEMA's technical review contractor.

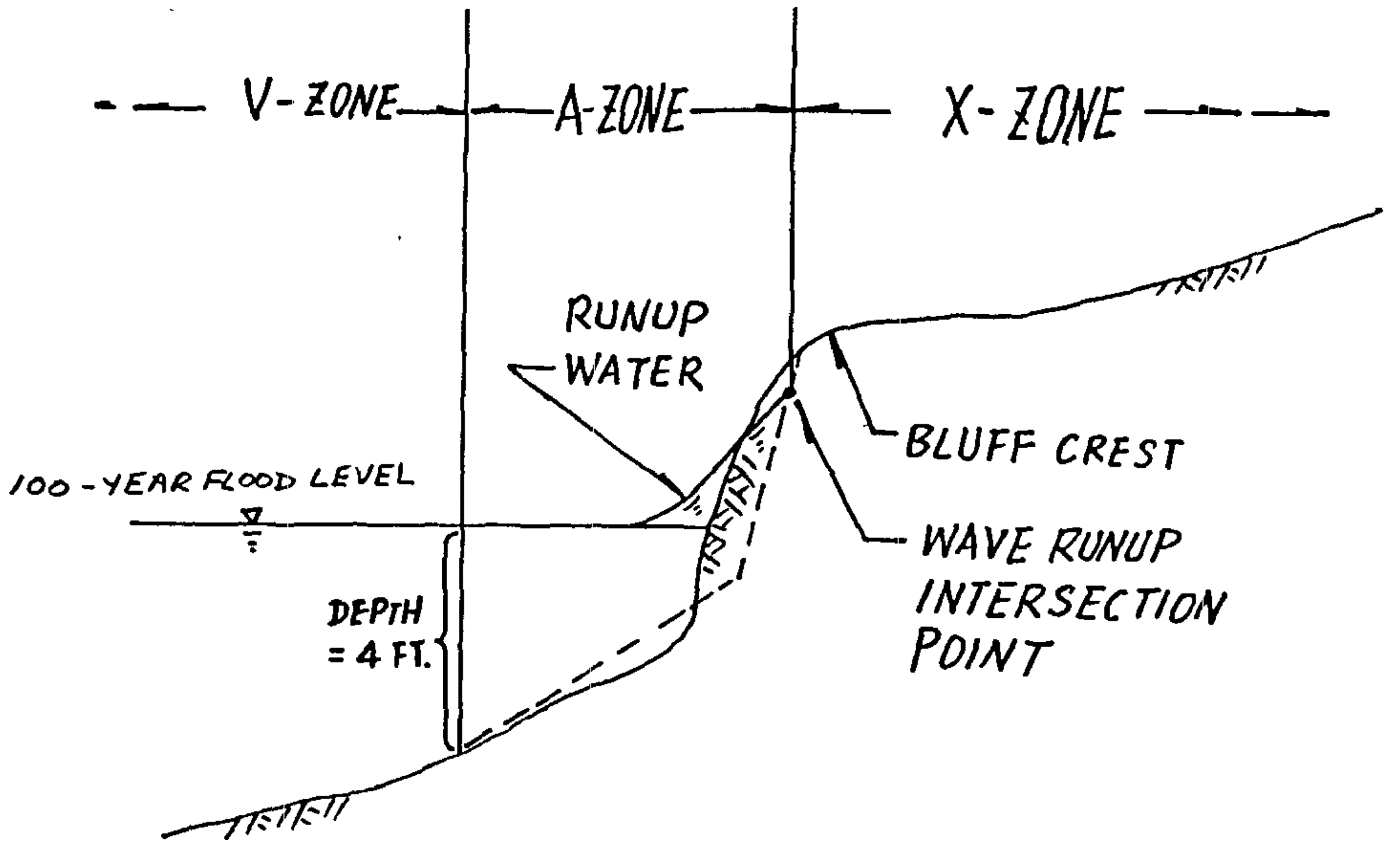
GREENBUSH TOWNSHIP A & V ZONE DELINEATIONS ON A BEACH SYSTEM



Greenbush-1

FIGURE 2

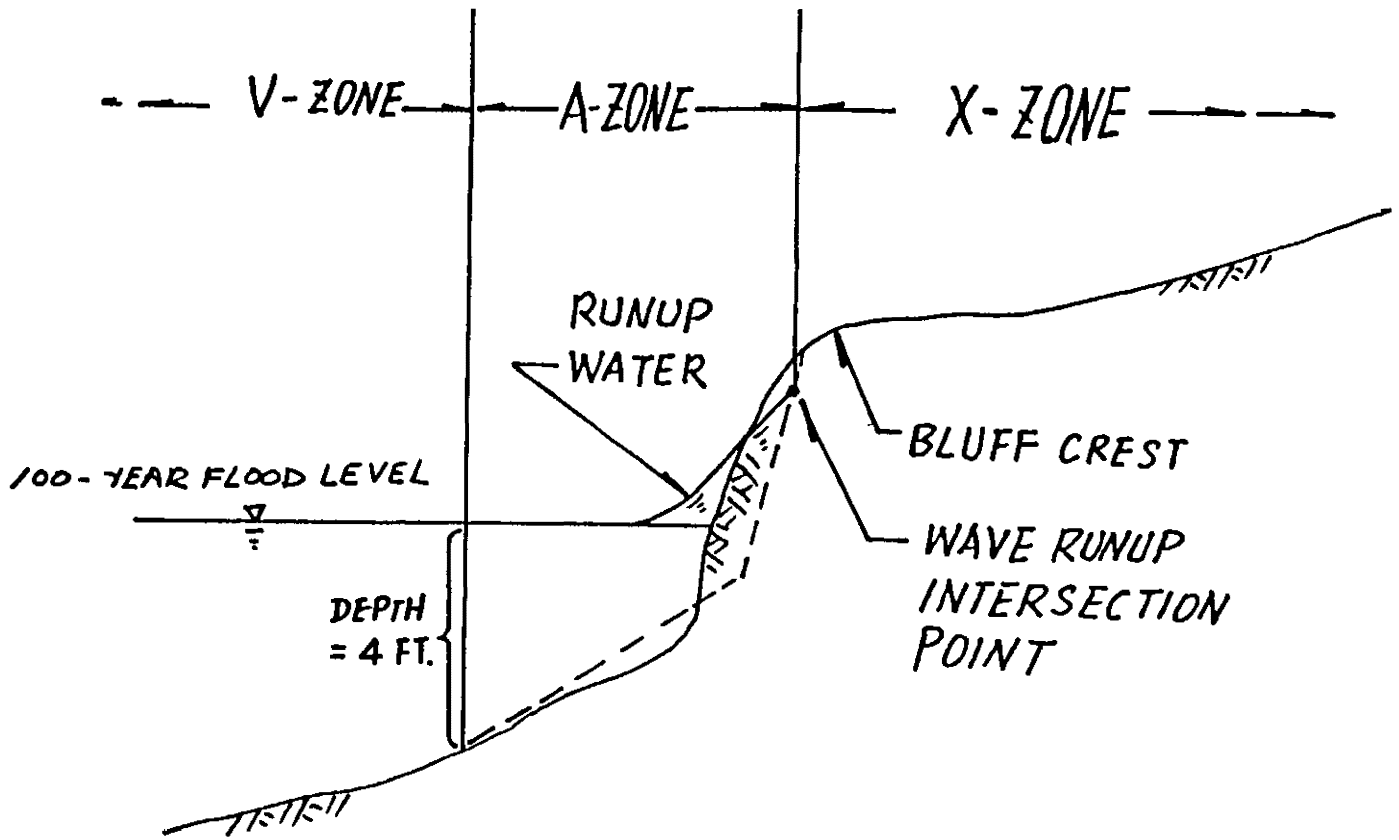
GREENBUSH TOWNSHIP A & V ZONE DELINEATIONS ON A BEACH SYSTEM



Greenbush-2

FIGURE 3

GREENBUSH TOWNSHIP A & V ZONE DELINEATIONS ON A BEACH SYSTEM



Greenbush-3

FIGURE 4

5.0 CONCLUSIONS

For each of the Greenbush Township sites where the 100-year and 500-year flood levels inundate shoreline property, the inundated area will experience a minimal water depth shoreward of the shoreline protection. This water depth will generate a negligible wave across the property. Therefore, the 100-year and 500-year flood levels will be used to delineate the flood profiles at each site.

Accordingly, where structures protect against flooding, the 100-year and 500-year "A" and "V" Zones, based on wave runup elevations, will be delineated on the work maps in the final FIS for the site. TABLE 2 lists the 100-year and 500-year computed wave runup components and the associated wave runup elevations for the three sites.

In conclusion, it is recommended that the delineated 100-year and 500-year flood profiles for the three Greenbush Township sites included herein be used by FEMA for updating the Greenbush Township FIS.

TABLE 2

WAVE RUNUP ELEVATIONS

Greenbush Township FIS Sites	100-year Computed Wave Runup(ft.)	100-year Wave Runup Elevation (ft., NGVD)	500-year Computed Wave Runup(ft.)	500-year Wave Runup Elevation (ft., NGVD)
1. Greenbush-1	1.7	585.5	1.7	586.4
2. Greenbush-2	1.7	585.5	1.7	586.4
3. Greenbush-3	1.7	585.5	1.7	586.4

6.0 GLOSSARY

Annual Maximum Instantaneous Water Level: The highest water level that was recorded during a year by a gage with a sampling frequency of an hour or less.

A-Zone: The Flood Insurance Rate Zone that corresponds to the 100-year floodplain that is determined in the Flood Insurance Study by detailed methods.

AO-Zone: The Flood Insurance Rate Zone that corresponds to the inland termination point of water overtopping a beach and/or dune condition.

Beach: The zone of sedimentary material that extends landward from the low water line to the place where there is a marked change in material or form, or to the line of permanent vegetation.

Bluff: A high, steep bank composed of erodible materials.

Floodplain: The area adjoining a river, stream, watercourse, ocean, lake or other body of standing water that has been or may be covered by floodwater.

International Great Lakes Datum (IGLD): Common reference datum for the Great Lakes area established in 1955 based on mean water level in the St. Lawrence River at Father Point, Quebec (near Atlantic Ocean).

Runup: The rush of water up a beach or structure from the breaking of a wave. Also, the vertical height of uprush above the still-water level.

Still-water level: The elevation that the water surface would assume if all wave action were absent.

Storm-water level: The rise above the normal water level on the open-coast, due to wind stress on the water surface.

V-Zone: The maximum elevation reached by the wave runup associated with the 100-year flood level.

Wave height: The vertical distance between the wave crest and the preceding trough.

Wave setup: The superelevation of the water surface over normal surge elevation due to the onshore mass transport of the water by wave action alone.

Wind setup: The vertical rise in the still-water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

X-Zone: The Flood Insurance Rate Zone that corresponds to the landward side of a dune heel point.

7.0 REFERENCES

1. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Vicksburg, MS, "Shore Protection Manual," Volumes I & II, 1984.

2. U.S. Army Corps of Engineers, Detroit District, "Phase I, Revised Report on Great Lakes Open-Coast Flood Levels," April 1988.

3. U.S. Army Corps of Engineers, Detroit District, "Phase II, Revised Report on Great Lakes Open-Coast Flood Levels," April 1988.

4. U.S. Army Corps of Engineers, Detroit District, "Appendices, Revised Report on Great Lakes Open-Coast Flood Levels," April 1988.

5. U.S. Army Corps of Engineers, Coordinating Committee on Great Lakes Basin Hydraulic and Hydrologic Data, "History of Water Level Gauges, Upper Great Lakes and the St. Clair - Detroit Rivers," January 1978.

6. U.S. Army Corps of Engineers, North Central Division, "Great Lakes Region Inventory Report National Shoreline Study," August 1978.

7. U.S. Army Corps of Engineers, Detroit District, "Flood Levels Report - Saginaw Bay," September 1989.

8. U.S. Army Corps of Engineers, Detroit District, "Flood Levels Report - Anchor Bay," September 1989.

9. Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, SCHWAB, D.J., and LYNN, E.W., "Great Lakes Storm Surge Planning Program," 1987.

10. U.S. Army Corps of Engineers, Detroit District, "Phase II Report on Great Lakes Flood Levels - Little Bay De Noc," August 1981.

11. U.S. Army Corps of Engineers, Detroit District, "Phase II Report on Great Lakes Flood Levels - Big Bay De Noc", July 1981.

12. FEMA Great Lakes "A" Zone and "V" Zone Delineations

TECHNICAL LETTER REPORT ON GREENBUSH TOWNSHIP, MICHIGAN

APPENDIX A

Prepared by the U.S. Army Corps of Engineers
for the Federal Emergency Management Agency

Detroit, Michigan
November 1990

SYNOPSIS

APPENDIX A outlines the procedures necessary to calculate the wave runup component and the maximum wave runup elevation associated with the 100-year flood level. These data, with the information provided from the profile surveys will enable the user to delineate the 100-year "VE", "AE", and "X" Zone profiles according to FEMA's 1990 "Guidelines for Great Lakes Wave Runup Computation and Mapping". The following list shows the three Greenbush Township sites and the 100-year wave runup flood profiles. Samples of these computations are included in APPENDIX A.

Greenbush Township FIS Sites	100-year Computed Wave Runup(ft.)	100-year Wave Runup Elevation (ft., NGVD)
1. Greenbush-1	1.4	585.2
2. Greenbush-2	1.4	585.2
3. Greenbush-3	1.4	585.2

FIS PROFILE
GREENBUSH-1

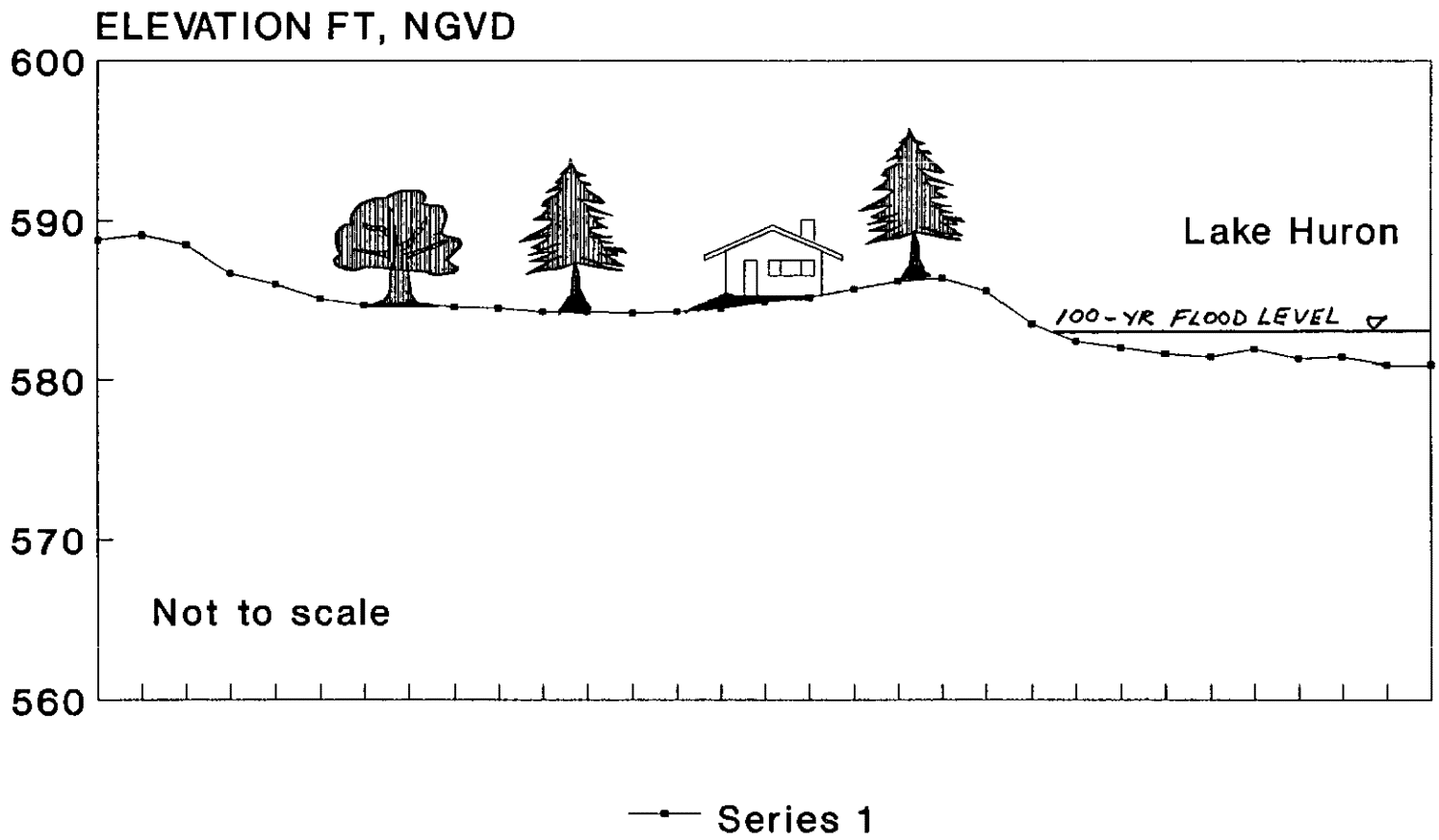


FIGURE G-1

FIS PROFILE
GREENBUSH-2

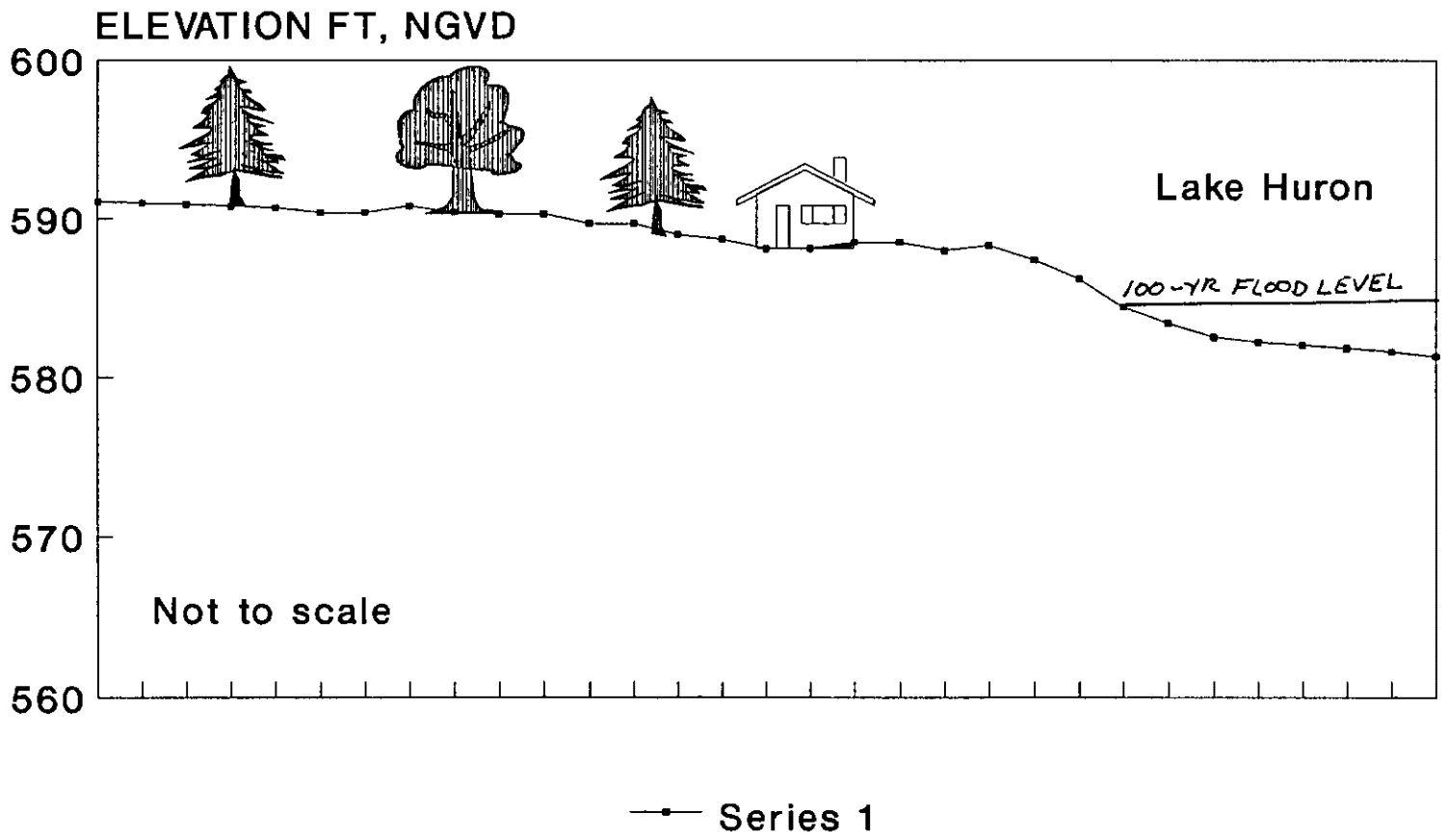


FIGURE G-2

FIS PROFILE
GREENBUSH-3

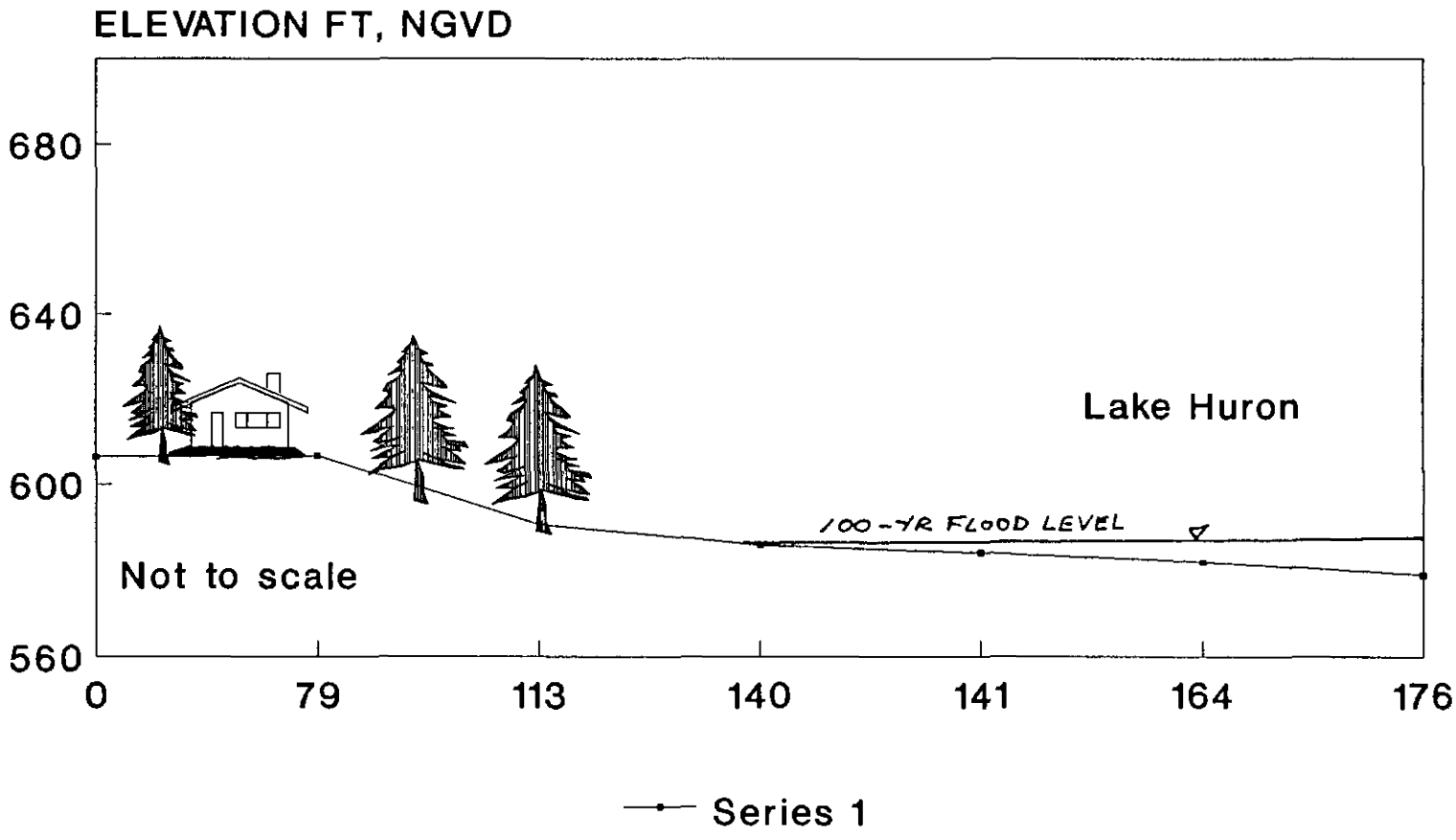


FIGURE G-3

TABLE 2

WAVE RUNUP ELEVATIONS

Greenbush Township FIS Sites	100-year Computed Wave Runup(ft.)	100-year Wave Runup Elevation (ft., NGVD)
1. Greenbush-1	1.4	585.2
2. Greenbush-2	1.4	585.2
3. Greenbush-3	1.4	585.2

RUNUP COMPUTATION
WAVE RUNUP AT GREENBUSH TOWNSHIP, GREENBUSH-1

```
                runup on:  beach
        100-year flood: 583.8 feet above IGLD, optional
     water depth at toe:  26.0 feet            1st: significant wave computation
  100-year wave period T:   9.7       (enter per Ref. 3)
                     T':   5.7
                      L: 280.44
100-yr deep water wave H:  24.6 feet  (enter per Ref. 3)
                      K:   2.4
                  alpha:   0.0120
                    Hmo:   9.8
                  d bar:   0.0086
                epsilon:   0.0087
                 Hs/Hmo:   1.066     (enter per Ref. 4, Figure 10)
        Hs in deep water:  10.4                (significant wave)
             beach slope:   0.02000  (tan 30H:1V = 0.03333)
              beach zeta:   0.136              2nd: wave runup computation
             beach runup:   1.4
          runup elevation: 585.2 feet above IGLD
```

A:\>NOTE: ALL ELEVATIONS ABOVE ARE IN FEET ABOVE NGVD

RUNUP COMPUTATION
WAVE RUNUP AT GREENBUSH TOWNSHIP, GREENBUSH-2

```
                runup on:  beach
        100-year flood: 583.8 feet above IGLD, optional
    water depth at toe:  26.0 feet          1st: significant wave computation
 100-year wave period T:   9.7       (enter per Ref. 3)
                     T':   5.7
                      L: 280.44
100-yr deep water wave H:  24.6 feet  (enter per Ref. 3)
                      K:   2.4
                  alpha:   0.0120
                    Hmo:   9.8
                  d bar:   0.0086
                epsilon:   0.0087
                 Hs/Hmo:   1.066     (enter per Ref. 4, Figure 10)
       Hs in deep water:  10.4                (significant wave)
            beach slope:   0.02000  (tan 30H:1V = 0.03333)
             beach zeta:   0.136              2nd: wave runup computation
            beach runup:   1.4
         runup elevation: 585.2 feet above IGLD
```

A:\>NOTE: ALL ELEVATIONS ABOVE ARE IN FEET ABOVE NGVD

RUNUP COMPUTATION
WAVE RUNUP AT GREENBUSH TOWNSHIP, GREENBUSH-3

```
              runup on:  beach
        100-year flood: 583.8 feet above IGLD, optional
     water depth at toe:  26.0 feet            1st: significant wave computation
  100-year wave period T:   9.7       (enter per Ref. 3)
                     T':   5.7
                      L: 280.44
100-yr deep water wave H:  24.6 feet  (enter per Ref. 3)
                      K:   2.4
                  alpha:   0.0120
                    Hmo:   9.8
                  d bar:   0.0086
                epsilon:   0.0087
                 Hs/Hmo:   1.066     (enter per Ref. 4, Figure 10)
        Hs in deep water:  10.4                (significant wave)
             beach slope:  0.02000  (tan 30H:1V = 0.03333)
              beach zeta:  0.136              2nd: wave runup computation
             beach runup:  1.4
          runup elevation: 585.2 feet above IGLD
```

A:\>NOTE: ALL ELEVATIONS ABOVE ARE IN FEET ABOVE NGVD

Enclosed for your information are revised wave runup elevations for the Saginaw Bay Flood Insurance Studies submitted to your office in February 1991, for 8 communities. Since approval by FEMA of the Great Lakes wave runup methodology, the Detroit District has employed this methodology in a number of other projects within the District. During this time, it had become apparent to District personnel that certain improprieties existed in the results obtained from these wave runup calculations. Consequently, the District conducted a review of these calculations and discovered that a minor error existed in the program's equations. Subsequent to this review, all runup elevations for the study sites were re-computed. Attached for your use is a summary of the original and revised runup elevations at each site. Although any change in runup elevation will result in a corresponding change to the Base Flood Elevation (BFE), the impacts on the flood zone delineation are minimal, except for Alpena.

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SAGINAW BAY FIS
WAVE RUNUP INFORMATION
7 January 1992

LOCATION	INITIAL RUNUP	REVISED RUNUP	CHANGE	BASE FLOOD ELEVATION INITIAL	BASE FLOOD ELEVATION REVISED	TYPE
Alpena 1 (P-1)	4.7	3.9	0.8	588.5	587.7	beach
Alpena 2 (P-1)	4.7	3.9	0.8	588.5	587.7	beach
Alpena 3 (P-2,4)	3.8	3.2	0.6	587.6	587.0	beach
Alpena 4	-	-	-	583.8	-	open coast
Alpena 5	-	-	-	583.8	-	open coast
Baldwin 1	-	-	-	584.0	-	open coast
Baldwin 2 (P-1,5)	0.4	0.4	0.0	584.4	584.4	beach
Baldwin 3 (P-2)	3.0	2.5	0.5	587.0	586.5	beach
Baldwin 4 (P-2)	3.0	2.5	0.5	587.0	586.5	beach
Baldwin 5	10.0	10.0	0.0	594.0	594.0	beach
Baldwin 6 (P-3)	9.0	7.7	1.3	593.0	591.7	beach
Baldwin 7 (P-3)	2.0	1.7	0.3	586.0	585.7	beach
Baldwin 8 (P-4)	2.0	1.7	0.3	586.0	585.7	beach
Baldwin 9	-	-	-	584.0	584.0	open coast
Greenbush 1 (P-1,2)	1.7	1.4	0.3	585.5	585.2	beach
Greenbush 2 (P-3)	1.7	1.4	0.3	585.5	585.2	beach
Greenbush 3 (P-3)	1.7	1.4	0.3	585.5	585.2	beach
Kawkawlin 1 (P-1)	2.3	1.9	0.4	588.0	587.6	beach
Kawkawlin 2	3.6	-	-	589.3	-	vert. struc.
Kawkawlin 3	0.9	-	-	586.6	-	vert. struc.
Kawkawlin 4	2.9	-	-	588.6	-	vert. struc.
Pinconning 1 (P-1)	2.4	2.0	0.4	587.9	587.5	beach
Pinconning 2	-	-	-	585.5	585.5	open coast
Pinconning 3	-	-	-	585.5	585.5	open coast

SAGINAW BAY FIS
WAVE RUNUP INFORMATION
7 January 1992

LOCATION	INITIAL RUNUP	REVISED RUNUP	CHANGE	BASE FLOOD ELEVATION INITIAL	BASE FLOOD ELEVATION REVISED	STRUCTURE TYPE
Pinconning 4	-	-	-	585.5	585.5	open coast
Pinconning 5	-	-	-	585.5	585.5	open coast
Pinconning 6	-	-	-	585.5	585.5	open coast
Pinconning 7	-	-	-	585.5	585.5	open coast
Pinconning 8	-	-	-	585.5	585.5	open coast
Pinconning 9	-	-	-	585.5	585.5	open coast
Sims 1 (P-1,4)	2.9	2.4	0.5	587.7	587.2	beach
Sims 2 (P-1)	3.3	2.8	0.5	588.1	587.6	beach
Sims 3 (P-2)	2.6	2.2	0.4	587.4	587.0	beach
Sims 4 (P-3)	2.6	2.2	0.4	587.4	587.0	beach
Sims 5	2.6	-	-	587.4	-	vert. struc.
Tawas City 1 (P-1,2)	3.9	3.3	0.6	587.9	587.3	beach
Tawas City 2	2.6	-	-	586.6	-	vert. struc.
Tawas City 3 (P-1)	3.9	3.3	0.6	587.9	587.3	beach
Tawas City 4 (P-1,2)	3.9	3.3	0.6	587.9	587.3	beach
East Tawas 1 (P-1)	0.6	0.5	0.1	584.6	584.5	beach
East Tawas 2	4.8	2.8	2.0	588.8	586.8	revetment
Fraser 2 (new)	-	3.1	3.1	585.7 (open coast)	588.8	revetment