FLOOD INSURANCE STUDY

GRAND TRAVERSE COUNTY, MICHIGAN
(ALL JURISDICTIONS)

Community Name	***Community Number***
ACME, TOWNSHIP OF	260749
BLAIR, TOWNSHIP OF	260780
EAST BAY, CHARTER TOWNSHIP OF	260746
*FIFE LAKE, TOWNSHIP OF	260405
*FIFE LAKE, VILLAGE OF	260406
GARFIELD, CHARTER TOWNSHIP OF	260753
*GRANT, TOWNSHIP OF	261802
GREEN LAKE, TOWNSHIP OF	261877
GRAND TRAVERSE BAND OF OTTAWA AND CHIPPEWA INDIANS	261803
KINGSLEY, VILLAGE OF	261878
LONG LAKE, TOWNSHIP OF	260782
*MAYFIELD, TOWNSHIP OF	261879
PARADISE, TOWNSHIP OF	260830
PENINSULA, TOWNSHIP OF	260747
TRAVERSE CITY, CITY OF	260082
UNION, TOWNSHIP OF	260805
WHITEWATER, TOWNSHIP OF	260794

* NO SPECIAL FLOOD HAZARD AREAS IDENTIFIED

EFFECTIVE: AUGUST 28, 2018

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
26055CV000A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) report may not contain all data available within the Community Map Repository. Please contact the Community Map Repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changed as follows:

Old Zone(s)	New Zone
Al through A30	AE
B	X
C	X

Initial Countywide FIS Effective Date: August 28, 2018

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FLOOD INSURANCE STUDY
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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Grand Traverse County, including the City of Traverse City; the Charter Townships of East Bay and Garfield; the Grand Traverse Band of Ottawa and Chippewa Indians, the Townships of Acme, Blair, Fife Lake, Grant, Green Lake, Long Lake, Mayfield, Paradise, Peninsula, Union, and Whitewater; and the Villages of Fife Lake and Kingsley (referred to collectively herein as Grand Traverse County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the City of Traverse City is geographically located in Grand Traverse and Leelanau Counties. Only the Grand Traverse portion of the City of Traverse City is included in this FIS report. See the separately published FIS report and Flood Insurance Rate Map (FIRM) for flood-hazard information.

Please note that the Townships of Fife Lake, Grant, and Mayfield; and the Village of Fife Lake have no mapped special flood hazard areas.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

The Digital Flood Insurance Rate Map (DFIRM) and FIS report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the Federal Emergency Management Agency (FEMA) DFIRM database specifications and Geographic Information System (GIS) format requirements. The flood hazard information was created and is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Precountywide Analyses

Information on the authority and acknowledgements for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown below:

Traverse City, City of:	The hydrologic and hydraulic analyses for Boardman River, East Branch Mitchell Creek, Kid's Creek, Mitchell Creek, and Tributary A for the June 15, 1982, FIS report were performed by U.S. Army Corps of Engineers (USACE), Detroit District, for FEMA, under Interagency Agreement No. IAA-H-9-79, Project Order No. 21 (FEMA, 1982). The work was completed in March 1981.

The Charter Townships of East Bay and Garfield, the Townships of Acme, Blair, Fife Lake, Grant, Green Lake, Long Lake, Mayfield, Paradise, Peninsula, Union, and Whitewater; and the Villages of Fife Lake and Kingsley have no previously printed FIS reports.

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This Countywide FIS Report

The hydrologic and hydraulic analyses for all areas studied by approximate methods, for this FIS Report, except the Boardman River, from approximately 5,200 feet upstream of Great Lakes Central Railroad to just upstream of Brown Bridge Road, and coastal mapping for this study were performed by Atkins for FEMA, under Contract No. HSFE05-05-D-0023, Project Order No. HSFE05-08-J-0027. The work was completed in March 2011.

The Boardman River was analyzed in April 2008 as part of the USACE Section 506 Great Lakes Fishery and Ecosystem Restoration program (USACE, 2008). Approximately 24 miles of the Boardman River, from its mouth at the West Arm Grand Traverse Bay to just upstream of Brown Bridge Road, was restudied.

Base map information shown on this FIRM was provided in digital format by the National Agricultural Imagery Program (NAIP). This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2007 or later. The projection used in the preparation of this map is Universal Transverse Mercator (UTM) Zone 16, and the horizontal datum used is the North American Datum of 1983 (NAD83), Geodetic Reference System 1980 (GRS80) spheroid.

1.3 Coordination

An initial meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied or restudied. A final meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study.

Precountywide Analyses

The initial and final meeting dates for previous FIS reports for Grand Traverse County and its communities are listed in the following table:

Community	FIS Date	Initial Meeting	Final Meeting
Traverse City, City of	June 15, 1982	November 14, 1978	January 12, 1982

This Countywide FIS Report

The initial meeting was held on May 22, 2007, and attended by representatives of FEMA, the communities, and Atkins.

The results of the study were reviewed at the final meeting held on September 14, 2011, and attended by representatives of FEMA, Michigan Department of Environmental Quality, STARR, Grand Traverse County, Grand Traverse Conservation District, Townships of Blair, East Bay, Garfield, Long Lake, Paradise, Peninsula, and Whitewater. All issues and/or concerns raised at that meeting have been addressed.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Grand Traverse County, Michigan, including the incorporated communities listed in Section 1.1. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction through the time of the study.

The following streams and lakes were studied by detailed methods in this FIS report:

Boardman River	Mitchell Creek
East Branch Mitchell Creek	Tributary A
East Arm Grand Traverse Bay	West Arm Grand Traverse Bay
Kid's Creek	

The limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

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This Countywide FIS Report

The USACE study for the Boardman River was included as a detailed study, from the confluence with the West Arm Grand Traverse Bay to approximately 5,200 feet upstream of Great Lakes Central Railroad, and as an approximate study from, approximately 5,200 feet upstream of Great Lakes Central Railroad to just upstream of Brown Bridge Road.

The East and West Arm Grand Traverse Bay were mapped using the stillwater elevation of 584.3 feet, North American Vertical Datum of 1988 (NAVD), from the USACE Flood Levels Report for Grand Traverse Bay and Little Traverse Bay (USACE, 1990).

For Kid's Creek, just upstream of the convergence of Tributary A to approximately 1,900 feet upstream of Silver Lake Road, Bullhead Lake, Coffield Lake, Fern Lake, North Twin Lake, Root Lake, the Sand Lakes, South Twin Lake, and the Twin Lakes, the Special Flood Hazard Area (SFHA) floodplain boundaries were digitally captured from the previous precountywide study.

Revised hydraulic and hydrologic analyses were preformed for all other remaining streams and lakes studied by approximate methods.

Also for this countywide FIS, the FIS report and FIRM were converted to countywide format, and the flooding information for the entire county, including both incorporated and unincorporated areas, is shown. Also, the vertical datum was converted from the National Geodetic Vertical Datum of 1929 (NGVD) to the NAVD. In addition, the UTM coordinates, previously referenced to the North American Datum of 1927 (NAD 27), are now referenced to the NAD83.

Approximate analyses were used to study those areas having low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by FEMA and Grand Traverse County.

The following tabulation presents Letters of Map Change (LOMCs) incorporated into this countywide study:

LOMC	Case Number	Date Issued	Project Identifier
LOMR*	04-05-1641P	April 6, 2004	Elk Lake Project
LOMR*	15-05-0036P	September 10, 2015	Channel Relocation Culvert

*Letter of Map Revision (LOMR)

The following tabulation lists streams that have names in this countywide FIS other than those used in the previously printed FIS reports for the communities in which they are located.

Community	Old Name	New Name
City of Traverse City	Boardman Lake	Boardman River

2.2 Community Description

Grand Traverse County is located in the northwestern part of the Lower Peninsula of Michigan. The corporate boundaries are defined by Atrim County to the northeast, Kalkaska County to the east, Wexford County to the south, Benzie County to the west, and Leelanau County to the northwest. The total area of Grand Traverse County is 465 square miles, and in 2009 the population of Grand Traverse County was estimated to be 86,333 (U.S. Census Bureau, 2011).

The climate of the City of Traverse City is dependent upon wind direction. The prevailing westerly winds passing over Lake Michigan create a moderation in annual temperature variations. Cool lake water cools warm air reaching the area in the fall. The climate during periods of prevailing westerly winds is quasi-maritime. When the wind shifts to the south of southeast and passes over a large land mass, the climate becomes modified continental with more abrupt variations in temperature.

The average temperature in the City of Traverse City is 45 degrees Fahrenheit. The average annual precipitation is 28.6 inches, and the average annual snowfall is 77.5 inches (Weatherbase, 2011).

The topography in Grand Traverse County varies from rolling terrain with steep slopes to level to gently sloping.

The geomorphic characteristics of the region are a result of several periods of glaciations, with the most recent being the Wisconsin stage which receded about 10,000 to 12,000 years ago. Therefore geologically speaking, the formation of the land in the region is very recent and correspondingly, the drainage patterns are in the early stages of development. This resulted in branching or dendrites drainage systems which drain slowly and have a high potential for flooding storage.

Grand Traverse Bay is a U-shaped extension of Lake Michigan. The principal axis of the bay is in a north-south direction and 30 miles long. The East and West Arms Grand Traverse Bay in the City of Traverse City are divided by the Old Mission peninsula which extends northward from the City of Traverse City into the bay.

Kid's Creek is also known as Aslyum Creek and Hospital Creek. The Kid's Creek watershed drains 7.0 square miles and is approximately 2.7 miles wide and 4.5 miles long. About 14 percent of the watershed lies within the City of Traverse City with the remainder lying in the Township of Garfield.

Tributary A is one of many small tributaries to Kid's Creek. Its drainage area is 1.5 square miles at its confluence with Kid's Creek and encompasses a portion of the Kid's Creek watershed.

Boardman Lake had a drainage area of 276 square miles at its upstream end where Boardman River empties into it. The level of Boardman Lake and the outflow to Boardman River is controlled by outlet works at the Boardman Lake Dam site located between Cass and South Union Streets in the City of Traverse City. The minimum top of the Boardman Lake Dam elevation is about 5.1 feet above the normal upstream water-surface elevation (WSEL), and the Boardman Lake Dam is 182 feet wide. Downstream of the Boardman Lake Dam, the Boardman River flows to its confluence with the West Arm Grand Traverse Bay.

2.3 Principal Flood Problems

The history of flooding on the streams, lake, and bays within the community indicates that flooding may occur during any season of the year, although the worst flooding conditions are normally the result of spring rains combined with snow melt.

The highest lake levels occur on Grand Traverse Bay during April to October, although rises of a lesser magnitude can be expected to occur at various times during the year.

Past floods on Kid's Creek and Tributary A have damaged residential areas. Large floods were documented on these streams in 1969, 1970, and 1972.

No flooding damage has been documented on Boardman Lake, Boardman River, or the East and West Arms Grand Traverse Bay, although interviews with local residents indicate that fluctuations in Grand Traverse Bay lake levels and beach erosion cause minor problems along bay shoreline areas. Shoreline erosion is due primarily to storm induced waves. High water levels can cause acceleration of shore erosion by inundating beaches and allowing wave action to reach the bluffs. High water levels occur over protracted periods of above-normal precipitation, when drainage into Lake Michigan exceeds the flow out. High water levels can also occur on the downwind shore of the lake during severe windstorms.

2.4 Flood Protection Measures

Concrete channel retaining walls exist along the Boardman River. The Boardman Lake Dam is functional in maintaining a pool elevation upstream, but it was not designed as a flood control structure. Other than these minimal structures, there are no other known flood protection structures in Grand Traverse County.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance (100-year) flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Precountywide Analyses

For the detailed study of Boardman Lake, recoded discharge data from the U.S. Geological Survey (USGS) gaging station at Mayfield, Michigan was used. The period of record used included water years 1953 through 1978, inclusive. A log-Pearson Type III frequency analysis was performed on the data using a computed station skew coefficient. A graphical analysis of maximum annual peak discharges were plotted according to median plotting position values was used to verify the results (USACE, 1962). The resulting peak discharges were transferred downstream to Boardman Lake by means if a drainage area ratio exponent (USGS, 1965).

The Michigan Department of Environmental Quality (MDEQ) coordinated the elevation-frequency relationships on Boardman Lake and the discharge-frequency relationships for the Boardman River. Synthetic inflow hydrographs into Boardman Lake were developed and routed through the Boardman Lake Dam site using the Soil Conservation Service (SCS), now the National Resources Conservation Service (NRCS), TR-20 computer program (SCS, 1965); the peak discharges of the inflow hydrographs were derived from USGS gage No. 04127000 frequency curve. In addition, the hydrograph of the flood of record at the City of Traverse City, USGS gage No. 04127000 (September 1961) was reviewed and the hydrologic model was adjusted to insure that the synthetic inflow hydrograph into Boardman Lake reflects actual basin characteristics.

Field surveys were performed to ascertain outlet conditions and other physical parameters of the Boardman Lake Dam site. USGS 7.5-minute series topographic quadrangle maps (USGS, 1956) were used to compute elevation-storage relationships.

For the detailed study of Boardman River, the four frequency discharges were obtained from the outflows resulting from the routing procedure through the Boardman Lake Dam.

For the detailed study of East Branch Mitchell Creek and Mitchell Creek, channel flood routings to establish peak-discharge-frequency relationships were made using the SCS, TR-20 computer program and SCS computer facilities (SCS 1965; SCS, 1981). An important storage area exists just upstream of the Chessie System fill on East Branch Mitchell Creek and this causes a reduction in the discharge downstream of the fill.

The discharges for Kid's Creek and Tributary A were based on the data presented in the 1973 Kid's Creek watershed study performed by the SCS (SCS, 1973). The adjustments procedure assumes that within the boundaries of the original SCS study, a linear relationship exists between percent development in the watershed and discharge. The flood profiles presented in the SCS report were reviewed by the Hydrologic Survey Division of MDEQ and recommended for use in implementing flood plain ordinances.

Elevation-frequency relationships used in the detailed study of the East and West Arms Grand Traverse Bay were provided by the USACE, Detroit District. The flood elevations for the bay at the City of Traverse City were taken from "Report on Great Lakes Open Coast Flood Levels" prepared by the USACE (USACE, 1977).

Due to the physical connection of Grand Traverse Bay to Lake Michigan, an analysis was made to determine if further adjustment to open coast flood levels to include wind setup in the bay was needed. Two methods were used. The first method employed equation 3-97 of the U.S. Army Coastal Engineering Research Center's (USACERC) "Shore Protection Manual", Volume I (USACERC, 1977). The second method employed equation 5-12 from "Estuary and Coastline Hydrodynamics" (Ippen, 1966).

The results of the analysis indicated that additional wind setup in Grand Traverse Bay would be insignificant based on an evaluation of wind speed, wind direction, length of fetch and depth of water. The analysis showed that the extreme depth of Grand Traverse Bay moderates the effects of wind setup. In addition, the orientations of the longer fetches of Lake Michigan to the mouth of the bay are such that significant compounding of wind setup effects would not occur. The open coast elevations presented in "Report on Great Lakes Open Coast Flood Levels", prepared by the USACE (USACE, 1977) were, therefore, adopted for this study.

Flood discharges for the portion of Kid's Creek studied by approximate methods were based upon the discharges presented in the 1973 SCS report on the Kid's Creek watershed (SCS, 1973) for the reach within the City of Traverse City from Eleventh Street upstream to approximately 1,900 feet upstream of Silver Lake Road, with adjustments made to reflect current conditions in the watershed.

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This Countywide Analysis

For the Boardman River, the flood-flow frequencies were based on the Drainage Area Ratio Method (SCS, 1972), where the base flow (or "known" flow) was the statistical analysis of discharge records covering a 37-year period at the gaging station; Boardman River near Mayfield, Michigan (USGS gage No. 04127000) period of record 1953-1989. This analysis followed the standard log-Pearson Type III method as outlined in the U.S. Water Resources Council (WRC) Bulletin #17B (WRC, 1982), using a regional skew coefficient determined specifically for Michigan (Holtchlang and Croskey, 1983).

For stream locations on the Boardman River for which there is no gage present, the WRC Bulletin #17B (WRC, 1982), annual flow estimates at the gaged site were weighted based on the drainage area ratios of the gaged and ungaged sites. This gage weighting is performed when the ratio of the drainage areas is between 0.5 and 1.5.

Flood elevations for Grand Traverse Bay in portions of Grand Traverse County were taken from the "Flood Levels Report on Grand Traverse Bay and Little Traverse Bay" prepared by the USACE, Detroit District (USACE, 1990). The report lists different WSELs for sections of Grand Traverse Bay, which includes Grand Traverse County. The different WSELs are a result of additional wave run-up analyses that were completed for the report. As a result, the Township of Peninsula has multiple WSELs within their community boundaries. Additional information regarding the exact locations of these sections, and their corresponding WSEL, can be found in the original report (USACE, 1990).

Peak discharges for the streams studied by approximate analyses for this countywide revision except for the Boardman River, from approximately 5,200 feet upstream of Great Lakes Central Railroad to just upstream of Brown Bridge Road, in Grand Traverse County were derived using either the USGS regional regression equations, the MDEQ SCS procedures, or the SCS Technical Release 55 methodology (SCS, 1986).

For the majority of the approximate analyses, peak discharges were estimated using the published USGS regional regression equations (Holtchlang and Croskey, 1984). Regression equations estimate peak discharges for ungaged streams based on characteristics of nearby gaged streams.

For streams in Grand Traverse County, studied by approximate methods, that have drainage areas that fall outside the allowable range of the USGS regional regression equations, the methodology presented in the MDEQ guidance document, "Computing Flood Discharges for Small Ungaged Watersheds", was applied (Sorrell, 2008).

Peak discharge-drainage area relationships for each flooding source studied in detail are shown in Table 1.

Table 1 - Summary of Discharges

		Peak Discharges (cubic feet per second)			
Flooding Source and Location	Drainage Area (square miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
BOARDMAN RIVER					
At Boardman Lake Dam	211.00	1,300	1,600	1,800	2,100
EAST BRANCH MITCHELL CREEK					
At convergence of Mitchell Creek	9.04	120	170	195	220
At divergence with Mitchell Creek	8.95	155	320	400	575
KID'S CREEK					
At confluence with Boardman River	7.00	175	292	331	415
MITCHELL CREEK					
Outlet at East Arm Grand Traverse Bay	14.67	230	345	390	460
At Townline Road	6.92	135	275	345	475
TRIBUTARY A					
At confluence with Kid's Creek	1.50	54	123	148	197
At Sixth Street	0.50	31	71	85	113

Stillwater elevations for each flooding source studied in detail are shown in Table 2.

Table 2 - Summary of Stillwater Elevations

	Water Surface Elevations (Feet NAVD[1])			
Flooding Source	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
EAST ARM GRAND TRAVERSE BAY	582.9	583.9	584.3	585.0
WEST ARM GRANDTRAVERSE BAY (Township of Peninsula-North of Tucker Point)	582.9	583.9	584.3	585.0
WEST ARM GRAND TRAVERSE BAY (Township of Peninsula-South of Tucker Point, City of Traverse City)	582.9	584.0	584.3	585.1

[1] North American Vertical Datum of 1988

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each flooding source studied in detail. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data Table in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS report in conjunction with the data shown on the FIRM.

Precountywide Analysis

Composite cross sections for the backwater analysis of Boardman River were obtained from third order field surveys and stereo compilation from aerial photography flown in January 1980, at a scale of 1:9,600; underwater portions of the cross sections were field surveyed. All bridges and culverts were field measured to obtain elevation data and structural geometry.

Valley cross section data, bridge and culvert elevation data and structural geometry included in the 1973 SCS analysis of the Kid's Creek watershed (SCS, 1973) were obtained from the SCS office in the City of East Lansing, Michigan and used in this study for the hydraulic analysis of Kid's Creek and Tributary A. A completed bridge and culvert replacement program on Kid's Creek and Tributary A has changed the hydraulic carrying capacity of the streams since 1973. Third order field surveys were conducted in 1980 to obtain current bridge and culvert elevation data and structural geometry where replacement has occurred, as determined through field reconnaissance.

For Mitchell Creek, the water-surface profiles were developed using the SCS computer program, WSP2 (SCS, 1976).

For Boardman River, Kid's Creek, and Tributary A, WSELs of the selected recurrence intervals were computed through use of the USACE, Hydraulic Engineering Center's (HEC) computer program, HEC-2 (HEC, 1968).

Starting WSELs for the Boardman River were based on the West Arm Grand Traverse Bay normal pool elevation. For Kid's Creek and Tributary A, the starting WSELs were calculated using the slope-area method.

For Kid's Creek, studied by approximate methods, normal depth calculations and two-foot contour interval mapping were used in the analysis.

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The USACE Boardman River hydraulic analysis model was conducted using the USACE, HEC computer program, HEC-RAS version, 3.1.3 (HEC, 2005). Bridge data in the USACE Boardman River hydraulic model came from field survey data. The channel of the Boardman River is well defined and during field inspections typically ranged in depth from a few inches to five feet. The channel is generally free of vegetation and has a combination of sand, gravel, and cobble. The majority of the banks in the study area from the upstream limit through Beitner Road have thick shrubs and woods. There are intermittent areas where land has been cleared outside of the tree lined banks.

Channel Roughness factors (Manning's "n"), used in the hydraulic computations, were chosen by engineering judgment and based on field observations of the stream and floodplain areas. The Manning's "n" values for all detailed studied streams are listed in the following tabulation:

Manning's "n" Values

Stream	Channel "n"	Overbank "n"
Boardman River	0.03	0.04-0.06
East Branch Mitchell Creek	*	*
Kid's Creek	0.03-0.04	0.035-0.055
Mitchell Creek	*	*
Tributary A	0.028-0.055	0.036-0.045

* Data Not Available

For the streams studied by approximate analyses for this countywide revision, except for the Boardman River, from approximately 5,200 feet upstream of Great Lakes Central Railroad to just upstream of Brown Bridge Road, cross section data was obtained from the topography. Structures were modeled as bridge openings with the open width and deck length values provided by the bridge inventory data, or approximated from the aerial photos. Bridge elevations were derived from the USGS 7.5-minute series topographic quadrangle maps.

In cases where minimal or no structure data was available, the structures were modeled as weirs. The weir elevation was approximated from elevations found on the USGS 7.5-minute topographic quadrangles if available. If no benchmark was available, the weir elevation was approximated as one-half the contour interval above the lowest contour at the structure.

In many cases, assuming the structure as a weir resulted in a floodplain that was overly conservative. In these cases, the weir section was deleted and ineffective flow was added to mimic the constricted flow through the structure.

The streams studied by approximate analyses for this countywide revision except for the Boardman River, from approximately 5,200 feet upstream of Great Lakes Central Railroad to just upstream of Brown Bridge Road, were modeled using the USACE, HEC computer program, HEC-RAS, version 4.0 (HEC, 2008). Starting elevations were calculated using normal depth calculations.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

The profile baselines depicted on the FIRM represent the hydraulic modeling baselines that match the flood profiles on this FIS report. As a result of improved topographic data, the profile baseline, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FIS reports and

FIRMs was NGVD. With the finalization of NAVD, many FIS reports and FIRMs are being prepared using NAVD as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD. Structure and ground elevations in the community must, therefore, be referenced to NAVD. It is important to note that adjacent communities may be referenced to NGVD. This may result in differences in Base Flood Elevations (BFEs) across the corporate limits between the communities. Some of the data used in this study were taken from the prior effective FIS reports and adjusted to NAVD. The average conversion factor that was used to convert the data in this FIS report to NAVD was calculated using the National Geodetic Survey's (NGS) VERTCON online utility (NGS, 2008). The data points used to determine the conversion are listed in Table 3.

Table 3 - Vertical Datum Conversion

Quad Name	Corner	Latitude	Longitude	Conversion from NGVD to NAVD (feet)
Maple City	SE	44.750	-85.750	-0.295
Traverse City SW	SE	44.750	-85.625	-0.361
Traverse City SE	SE	44.750	-85.500	-0.328
Williamsburgh	SE	44.750	-85.375	-0.308
Lake Ann	SE	44.625	-85.750	-0.246
Grawn	SE	44.625	-85.625	-0.230
Mayfield	SE	44.625	-85.500	-0.282
Jacks Landing	SE	44.625	-85.375	-0.295
Karlin	SE	44.500	-85.750	-0.210
Buckley	SE	44.500	-85.625	-0.249
Kingsley	SE	44.500	-85.500	-0.289
Walton	SE	44.500	-85.375	-0.302
Mapleton	SE	44.875	-85.500	-0.341
Omena	SE	45.000	-85.500	-0.341
Elk Rapids	SE	44.875	-85.375	-0.338
			Average:	-0.294

For additional information regarding conversion between NGVD and NAVD, visit the NGS website at www.ngs.noaa.gov, or contact the NGS at the following address:

Vertical Network Branch, N/CG13
National Geodetic Survey, NOAA
Silver Spring Metro Center 3
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3191

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (500-year) floodplain boundaries and 1-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data Table, and Summary of Stillwater Elevations Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community.

For East Branch Mitchell Creek, Kid's Creek, Mitchell Creek, and Tributary A, which were studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:1,200 and 1:2,400 with a contour interval of two feet (Traverse Bay Regional Planning Commission, 1980).

For Kid's Creek, just upstream of the convergence of Tributary A to approximately 1,900 feet upstream of Silver Lake Road, Bullhead Lake, Coffield Lake, Fern Lake, North Twin Lake, Root Lake, the Sand Lakes, South Twin Lake, and the Twin Lakes, the 1-percent-annual-chance floodplain boundaries were delineated using USGS 7.5-minute topographic quadrangle maps (USGS, 1956).

For approximate studied streams, with the exception of Boardman River, the 1-percent-annual-chance floodplain boundaries were delineated using USGS 7.5-minute topographic quadrangle maps (USGS, various; USGS, 1985).

For the portion of Kid's Creek studied by approximate methods, the boundary of the 1-percent-annual-chance flood was developed from normal depth calculations based upon information obtained from field reconnaissance and topographic maps referenced above.

Coastal Light Detection and Ranging (LiDAR) topography was developed and managed by the Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX) (JALBTCX, 2009). The data has a horizontal accuracy of +/- 0.75 meters and a vertical accuracy of +/- 0.20 meters. The coastal LiDAR data was used, where available, to map the East and West Arms Grand Traverse Bay coastal floodplain boundaries. In areas where the coastal LiDAR was not available, the USGS 7.5-minute series topographic quadrangle maps were used (USGS, various).

For the Boardman River, floodplain boundaries were delineated using LiDAR topography developed by the USACE (USACE, 2000). The topography has a contour interval of two feet. Adjustments to the mapped floodplain were made to encompass visible waters on the aerial imagery.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE) and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. In Michigan, however, under Michigan Act 245, Public Acts of 1929, as amended by Act 167, Public Acts of 1968 (State of Michigan, 1968), encroachment in the floodplain is limited to that which will cause only an insignificant increase in flood heights. Thus, at the recommendation of the Bureau of the Water Management, a floodway having no more than a 0.1 foot surcharge has been delineated for this study. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this FIS report and on the FIRM were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations have been tabulated for selected cross sections (Table 4). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
BOARDMAN RIVER								
A	333	81	658	2.7	584.3	584.0[2]	584.1	0.1
B	918	82	595	3.0	584.3	584.1[2]	584.2	0.1
C	1,508	58	455	4.0	584.3	584.3	584.4	0.1
D	1,961	61	516	3.5	584.6	584.6	584.6	0.0
E	2,247	57	426	4.2	584.6	584.6	584.7	0.1
F	2,595	86	670	2.7	584.9	584.9	585.0	0.1
G	3,164	76	572	3.2	585.2	585.2	585.3	0.1
H	3,621	73	531	3.4	585.3	585.3	585.4	0.1
I	3,989	55	389	4.6	585.4	585.4	585.5	0.1
J	4,396	94	709	2.5	585.9	585.9	586.0	0.1
K	5,037	77	577	3.1	586.0	586.0	586.1	0.1
L	5,534	119	825	2.2	586.2	586.2	586.2	0.0
M	5,820	113	1,019	1.8	586.2	586.2	586.3	0.1

[1] Feet above confluence with Grand Traverse Bay
[2] Elevation computed without consideration of backwater effects from West Arm Grand Traverse Bay

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI
(ALL JURISDICTIONS)

FLOODWAY DATA

BOARDMAN RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
KID'S CREEK								
A	225	13	49	6.7	586.9	586.9	586.9	0.0
B	500	64	229	1.4	588.4	588.4	588.5	0.1
C	990	55	177	1.9	591.1	591.1	591.1	0.0
D	1,460	95	229	1.4	591.3	591.3	591.3	0.0
E	1,840	55	165	2.0	594.4	594.4	594.4	0.0
F	2,330	50	141	2.3	597.2	597.2	597.2	0.0
G	2,620	39	92	3.6	597.4	597.4	597.4	0.0
H	2,875	100	212	1.6	598.1	598.1	598.2	0.1
I	3,119	120	279	1.2	598.3	598.3	598.4	0.1
J	3,370	100	354	0.9	598.5	598.5	598.6	0.1
K	3,686	80	134	2.5	598.8	598.8	598.8	0.0
L	3,885	50	77	4.3	599.9	599.9	599.9	0.0
M	4,160	60	251	1.3	601.6	601.6	601.6	0.0
N	4,530	60	278	1.2	603.5	603.5	603.5	0.0

[1] Feet above confluence with Boardman River

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI
(ALL JURISDICTIONS)

FLOODWAY DATA

KID'S CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
TRIBUTARY A								
A	90	13	37	4.0	603.5	600.7[2]	600.8	0.1
B	790	16	40	3.7	603.5	602.5[2]	602.6	0.1
C	1,385	79	101	1.5	607.8	607.8	607.8	0.0
D	1,727	34	35	4.4	609.2	609.2	609.3	0.1
E	1,878	17	37	4.1	609.8	609.8	610.1	0.3
F	2,230	27	22	4.0	610.8	610.8	610.9	0.1
G	2,354	54	44	2.1	611.4	611.4	611.6	0.2
H	2,745	26	29	3.1	612.4	612.4	612.6	0.2
I	2,934	40	36	2.5	613.5	613.5	613.7	0.2
J	3,108	9	8	11.8	615.2	615.2	615.2	0.0
K	3,292	8	13	6.9	619.4	619.4	620.0	0.6
L	3,593	11	14	6.3	623.6	623.6	623.9	0.3
M	3,628	38	36	2.5	624.8	624.8	624.9	0.1
N	3,712	20	26	3.5	625.7	625.7	625.7	0.0

[1] Feet above confluence with Kid’s Creek
[2] Elevation computed without consideration of backwater effects from Kid’s Creek

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI
(ALL JURISDICTIONS)

FLOODWAY DATA

TRIBUTARY A

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the WSEL of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

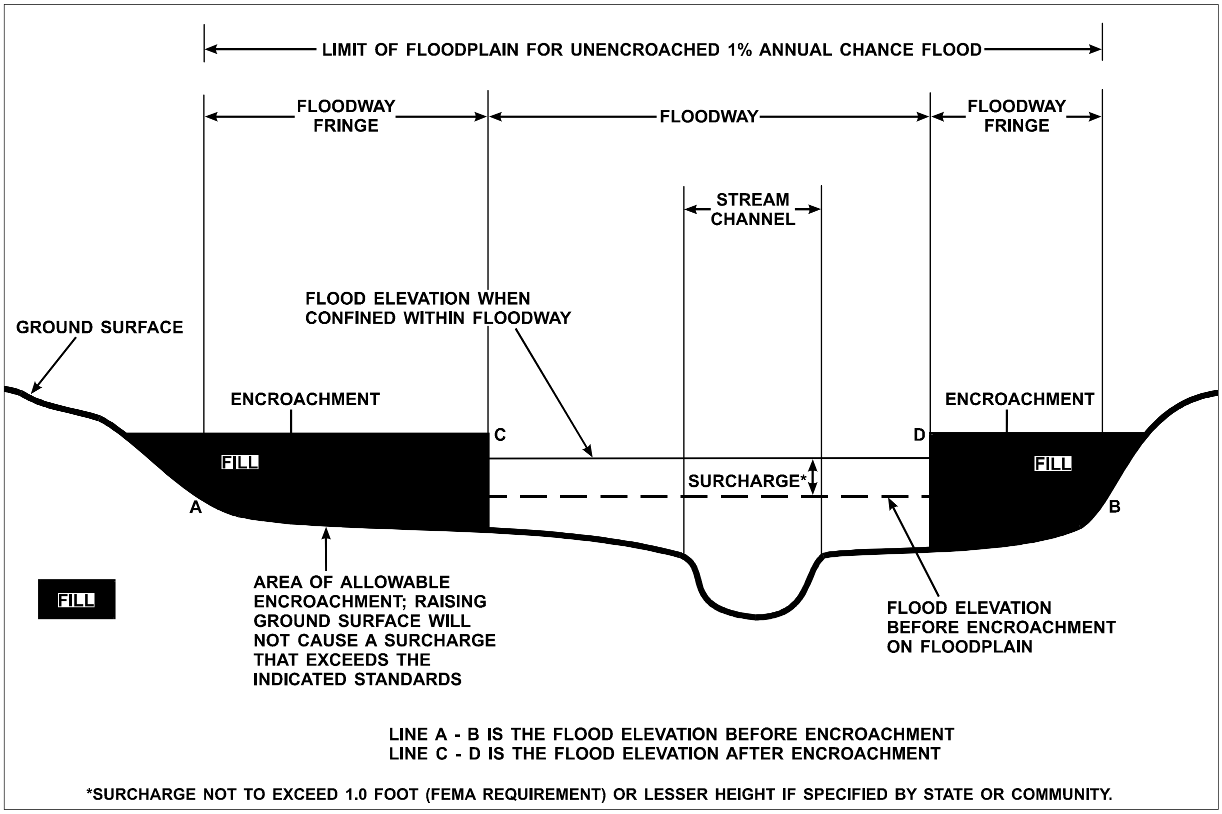

Figure 1 - Floodway Schematic

No floodways were computed for the Boardman River upstream of Boardman Lake Dam, Mitchell Creek, and East Branch Mitchell Creek.

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or base flood depths are shown within this zone.

Zone AE

Zone AE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or base flood depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance risk zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Grand Traverse County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. Historical data relating to the maps prepared for each community are presented in Table 5.

7.0 OTHER STUDIES

This report either supersedes or is compatible with all previous studies on streams studied in this report and should be considered authoritative for purposes of the NFIP.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE	FIRM EFFECTIVE DATE	FIRM REVISION DATE
Acme, Township of [1]	N/A	None	N/A	None
Blair, Township of [1]	N/A	None	N/A	None
East Bay, Charter Township of[1]	N/A	None	N/A	None
*Fife Lake, Township of[1]	N/A	None	N/A	None
*Fife Lake, Village of[1]	N/A	None	N/A	None
Garfield, Charter Township of [1]	N/A	None	N/A	None
*Grant, Township of[1]	N/A	None	N/A	None
Green Lake, Township of[1]	N/A	None	N/A	None
Kingsley, Township of Long[1]	N/A	None	N/A	None
Lake, Township of	September 30,1988	None	September 30, 1988	None
*Mayfield, Township of[1]	N/A	None	N/A	None
Paradise, Township of	May 4, 1992	None	May 4, 1992	None
Peninsula, Township of[1]	N/A	None	N/A	None

*No special flood hazard areas identified

[1] This community does not have map history prior to first countywide mapping

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

TABLE 5

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE	FIRM EFFECTIVE DATE	FIRM REVISION DATE
Traverse City, City of	May 24, 1974	November 14, 1975	December 15, 1982	None
Union, Township of	September 30, 1988	None	September 30, 1988	None
Whitewater, Township of	September 30, 1988	None	September 30, 1988	None

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 536 South Clark Street, Sixth Floor, Chicago, Illinois 60605.

9.0 BIBLIOGRAPHY AND REFERENCES

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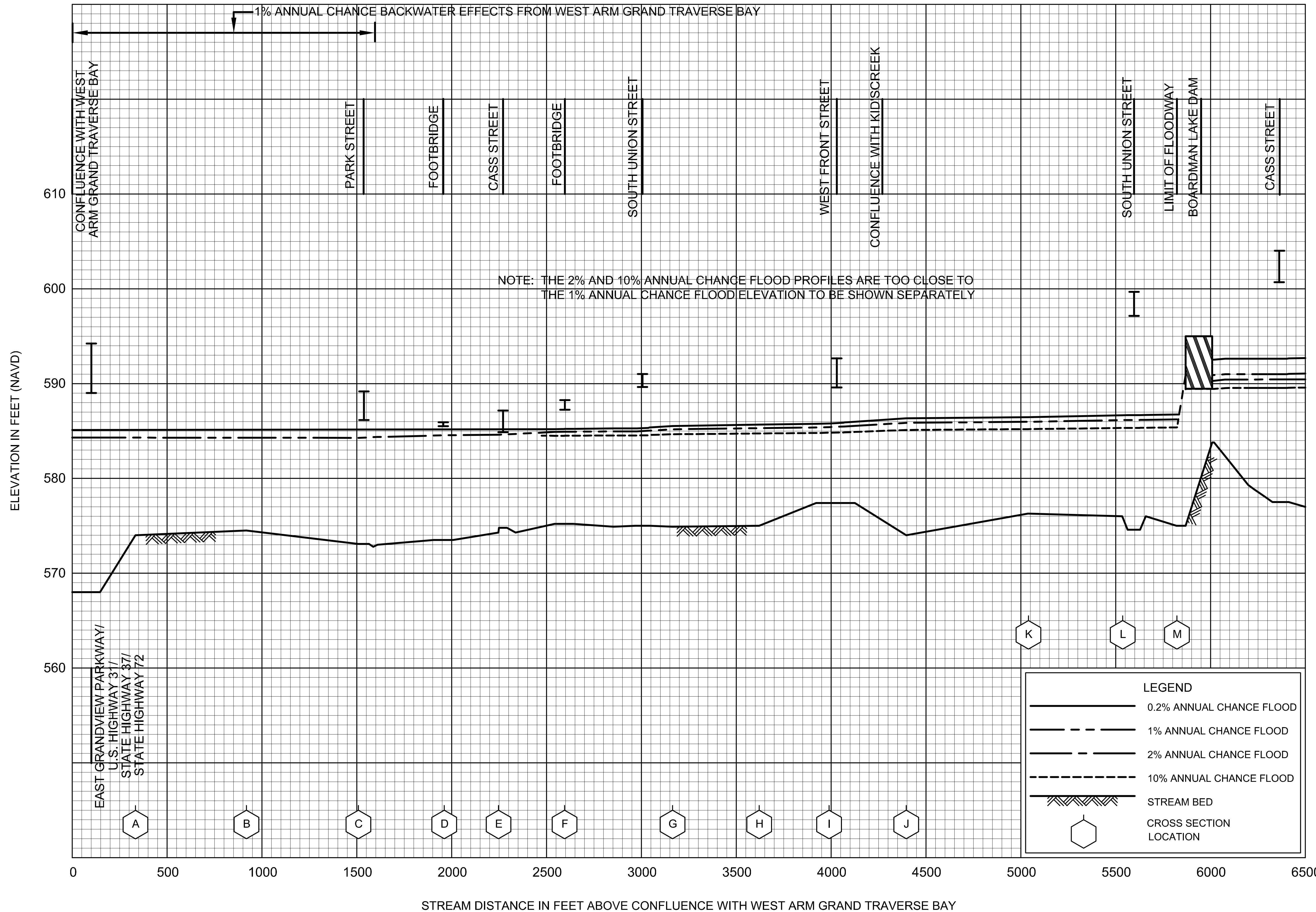


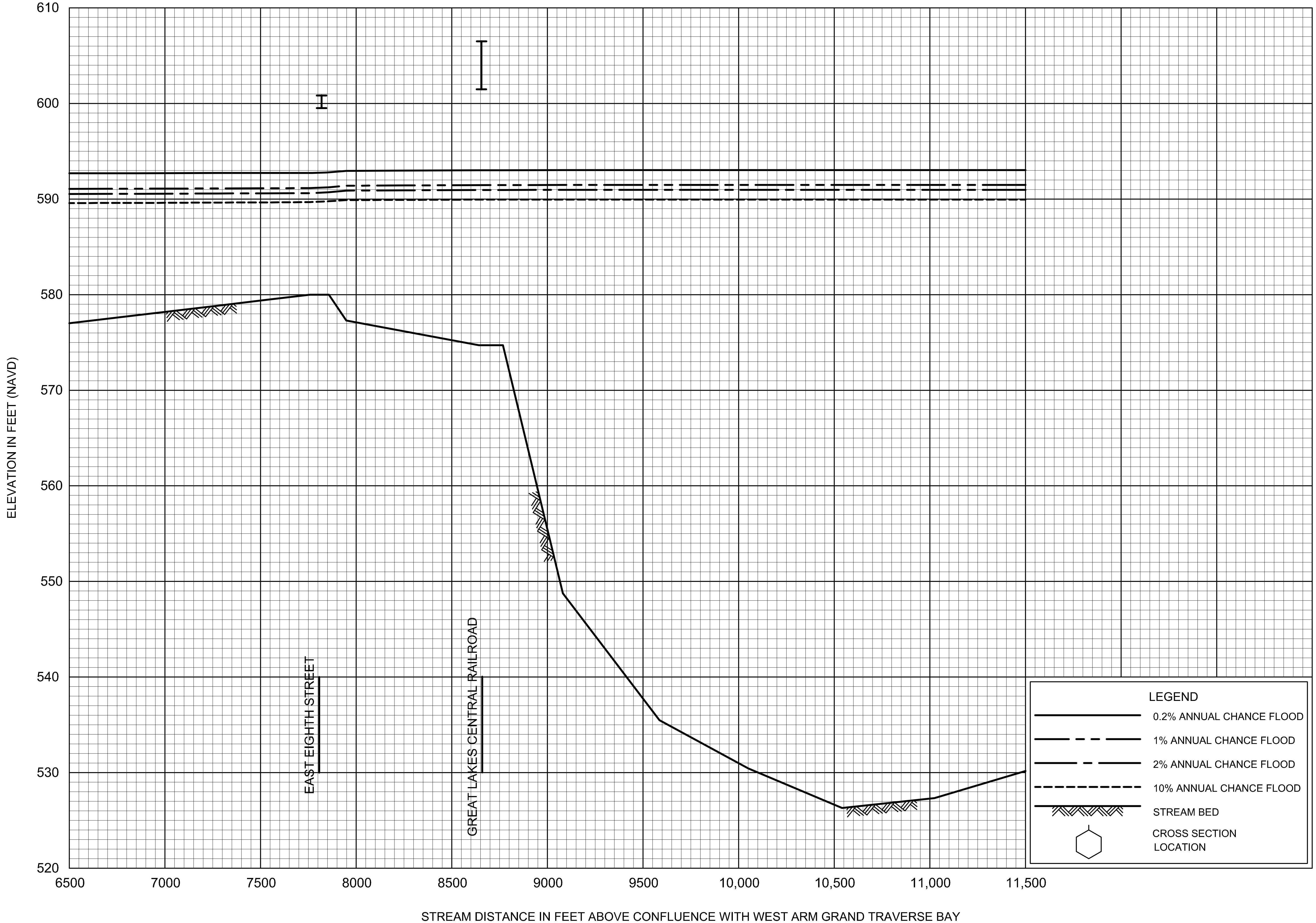
FLOOD PROFILES

BOARDMAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)



FLOOD PROFILES

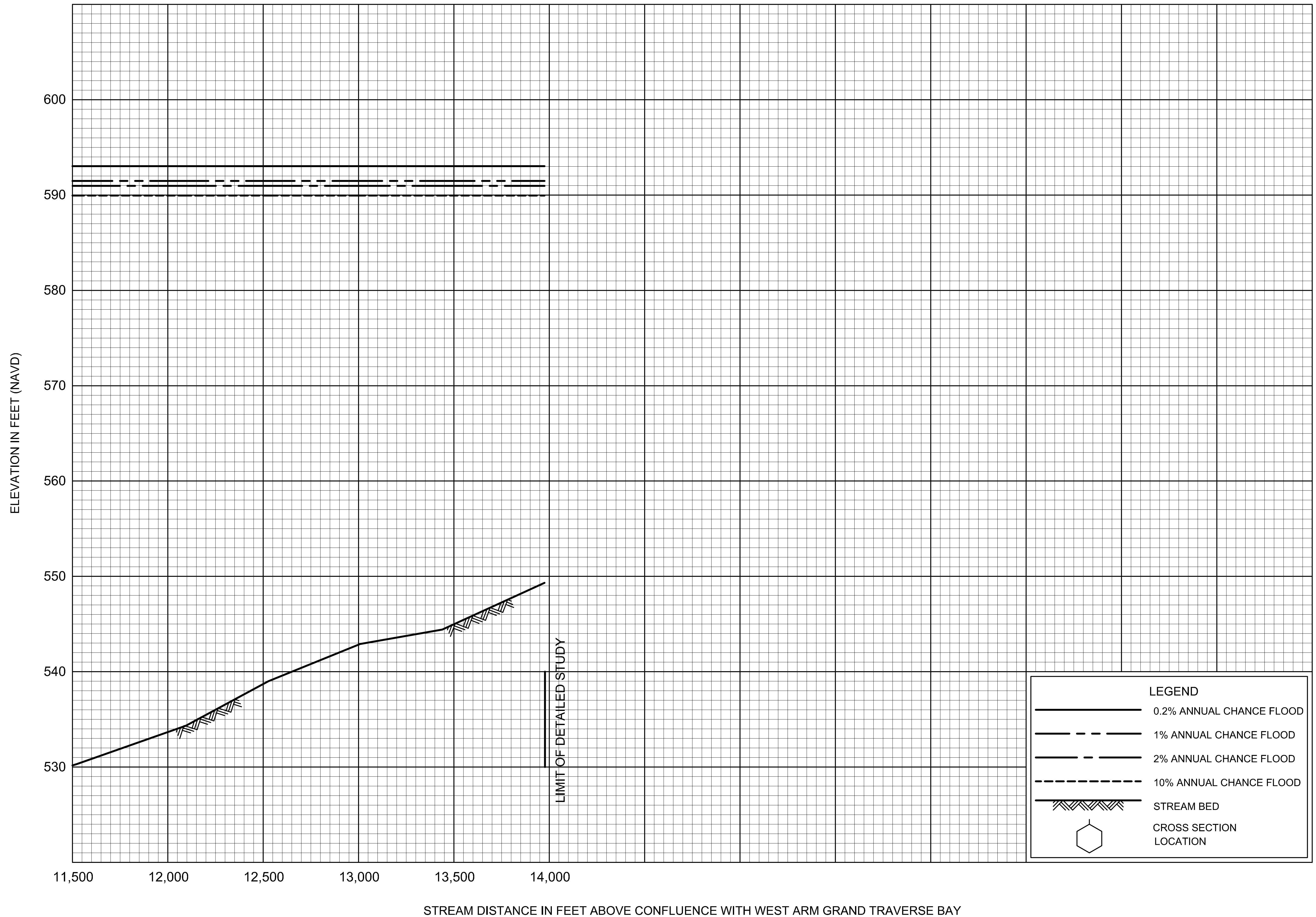
BOARDMAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)

02P



FLOOD PROFILES

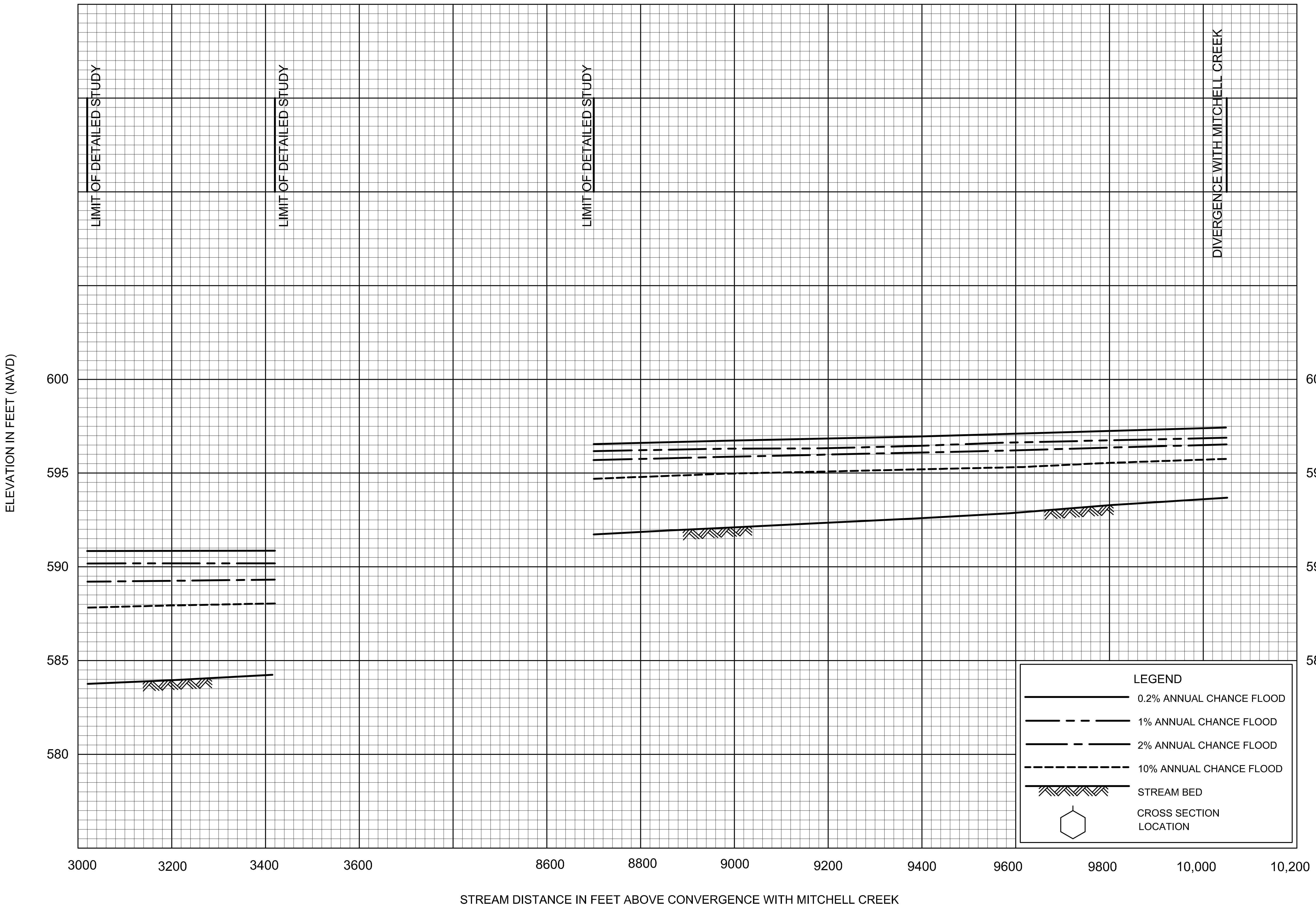
BOARDMAN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)

03P



FLOOD PROFILES

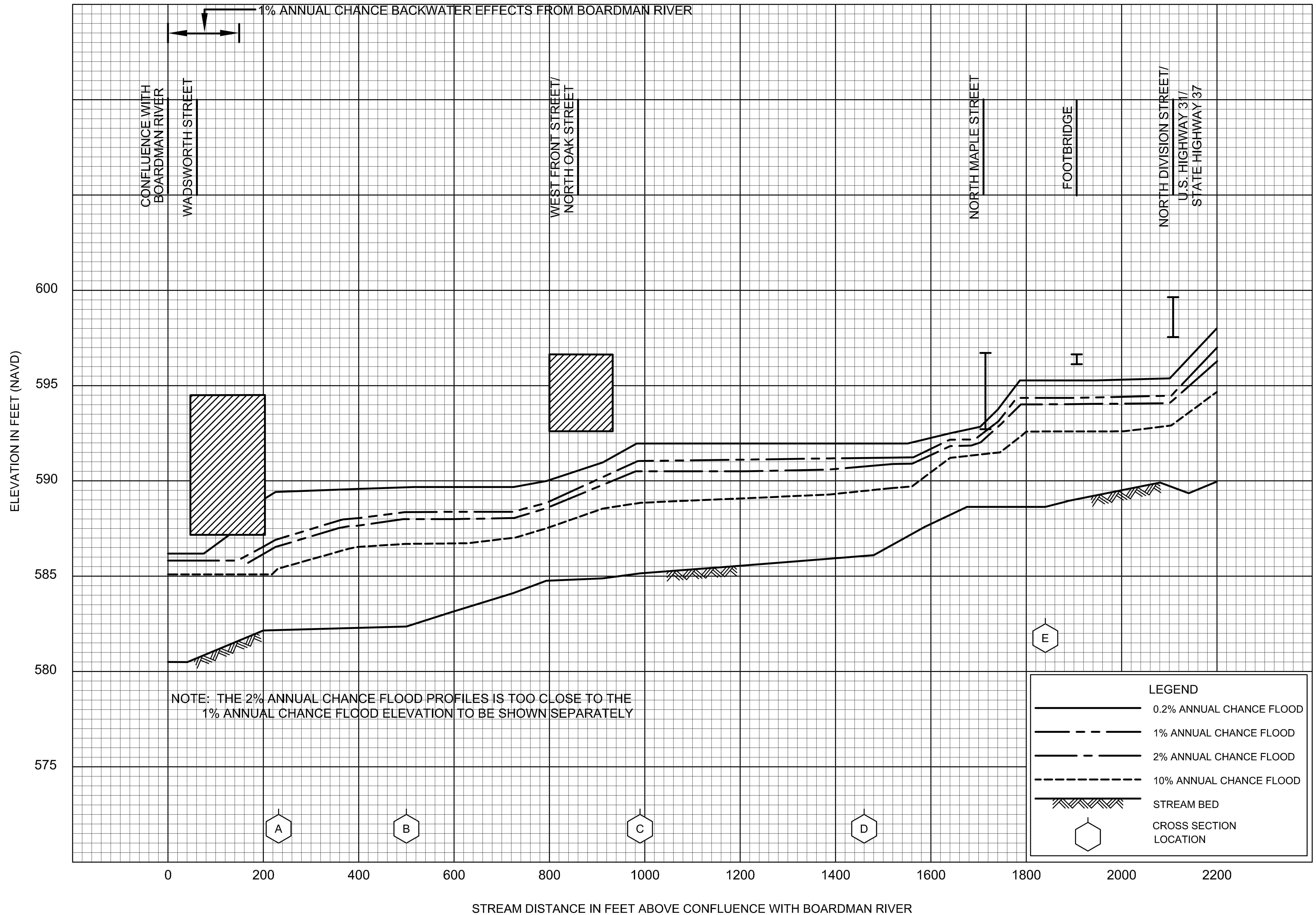
EAST BRANCH MITCHELL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)

04P



FLOOD PROFILES

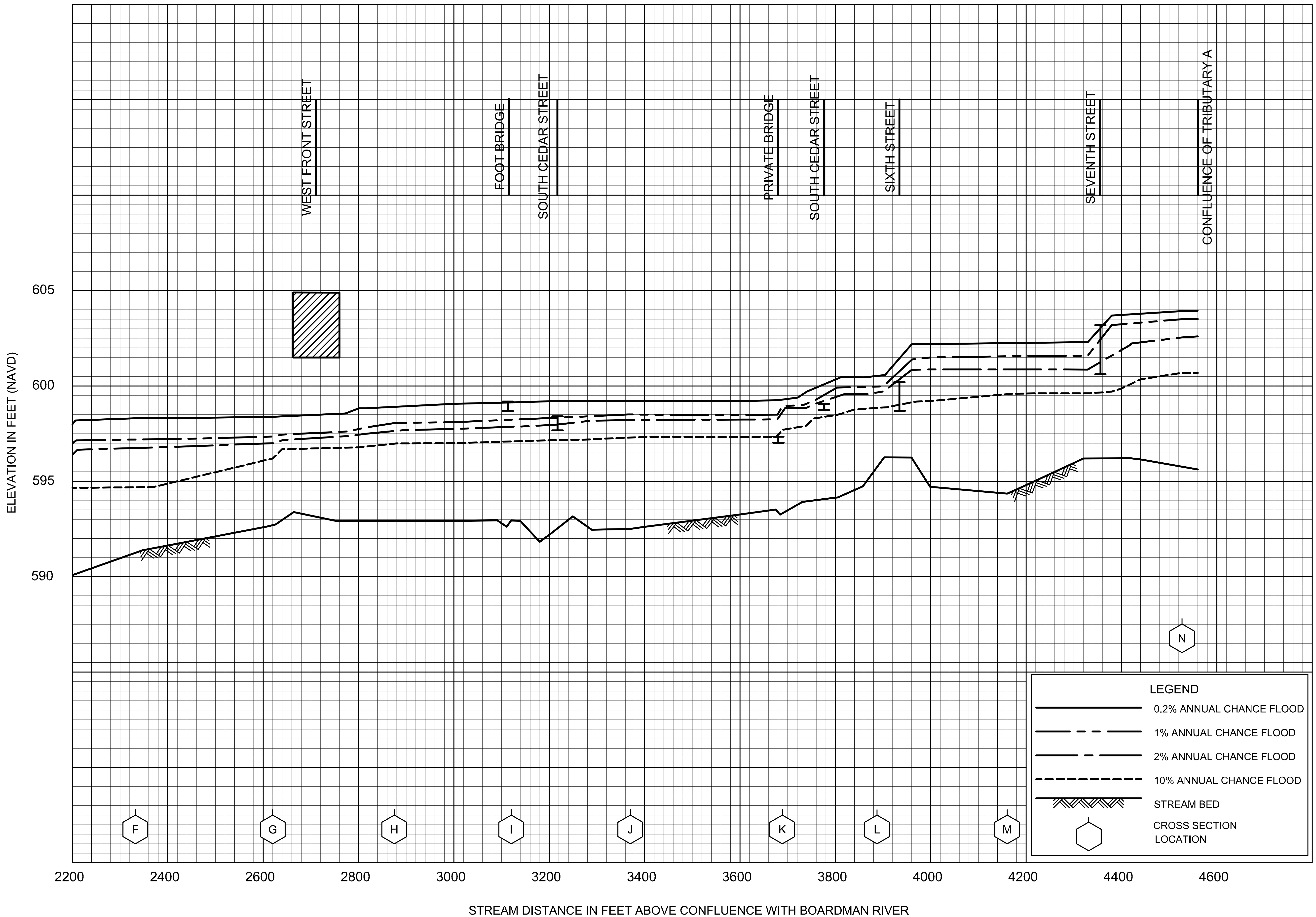
KID'S CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)

05P



FLOOD PROFILES

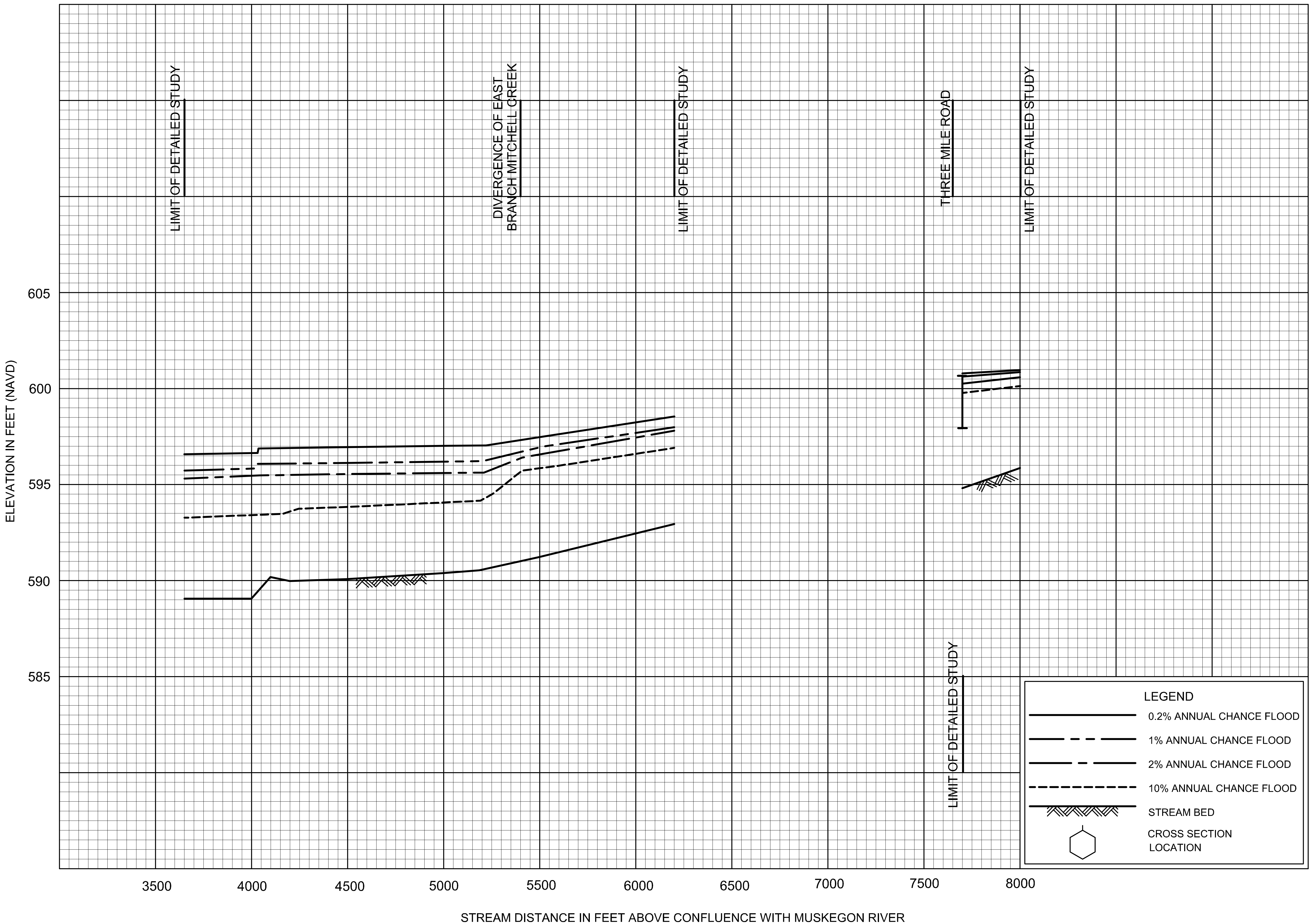
KID'S CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)

06P



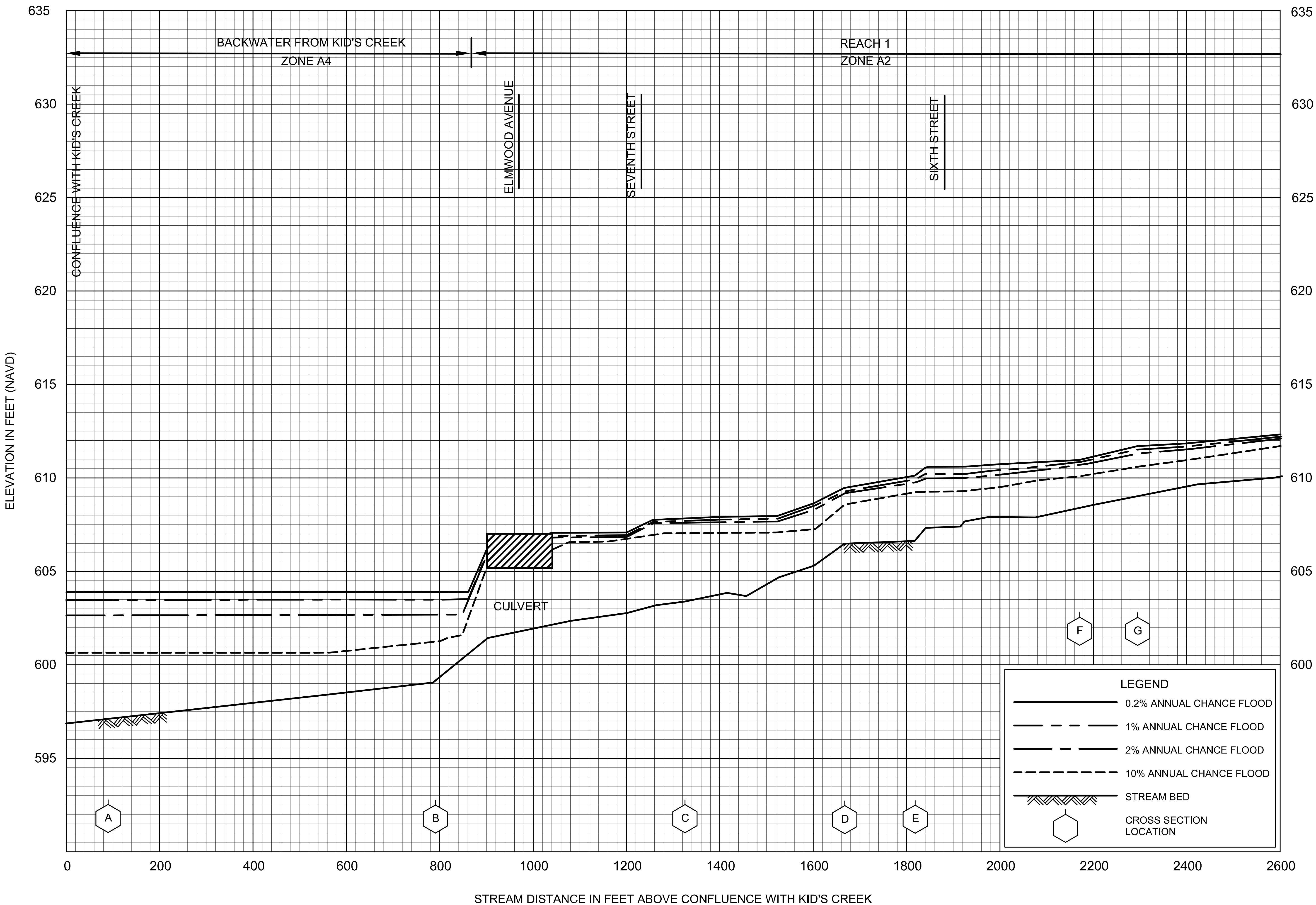
FLOOD PROFILES

MITCHELL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)



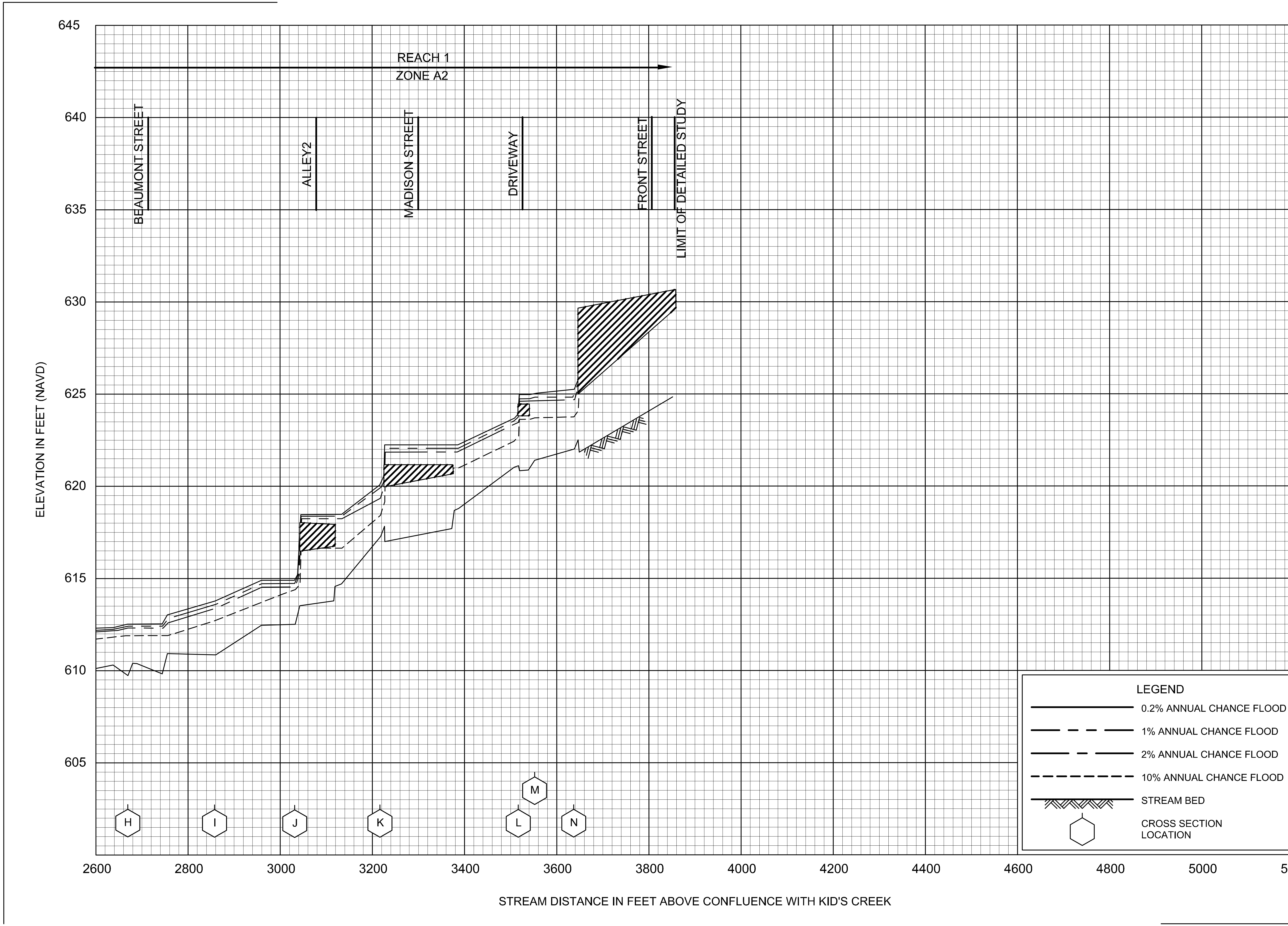
FLOOD PROFILES

TRIBUTARY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)



FLOOD PROFILES

TRIBUTARY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

GRAND TRAVERSE COUNTY, MI

(ALL JURISDICTIONS)