FLOOD INSURANCE STUDY

ARENAC COUNTY, MICHIGAN

(ALL JURISDICTIONS)

Community Name	Community Number
* Adams, Township of	261487
Arenac, Township of	260251
Au Gres, City of	260012
Au Gres, Township of	260013
Clayton, Township of	261488
Deep River, Township of	260350
Lincoln, Township of	260014
Mason, Township of	261489
Moffatt, Township of	261490
Omer, City of	260622
Sims, Township of	260015
Standish, City of	260016
Standish, Township of	260017
* Sterling, Village of	261491
Turner, Township of	260351
Turner, Village of	260550
* Twining, Village of	261492
Whitney, Township of	260018

* No Special Flood Hazard Areas identified

EFFECTIVE

MARCH 16, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
26011CV000A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program (NFIP) 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. It is advisable to contact the Community Map Repository for any additional data.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study 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 Zones	New Zone
A1 through A30	AE
B	X
C	X

Initial Countywide FIS Effective Date: March 16, 2015

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PUBLISHED SEPARATELY
Flood Insurance Rate Maps
Flood Insurance Rate Map Index

FLOOD INSURANCE STUDY

ARENAC COUNTY, MICHIGAN (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) revises and supersedes the FIS reports, Flood Insurance Rate Maps (FIRMs), and/or Flood Boundary and Floodway Maps (FBFMs) in the geographic area of Arenac County, including the Cities of Au Gres, Omer, and Standish; the Townships of Adams, Arenac, Au Gres, Clayton, Deep River, Lincoln, Mason, Moffatt, Sims, Standish, Turner, and Whitney; and the Villages of Sterling, Turner, and Twining (hereinafter referred to collectively as Arenac County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Please note that the Township of Adams and the Villages of Sterling and Twining have no Special Flood Hazard Areas (SFHAs) identified. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Arenac County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), 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.

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 countywide FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Information pertaining to the authority and acknowledgements for the previously effective FIS report and new floodplain studies for communities within Arenac County was compiled for this FIS report and is shown below.

City of Au Gres	The hydrologic and hydraulic analyses for the May 1989 study for the City of Au Gres were performed by the U.S. Army Corps of Engineers (USACE), Detroit District, for

	FEMA under Inter-Agency Agreement No. EMW-85-E-1822, Project Order No. 1. The analysis for this study was completed in May 1987 (Reference 1).
Township of Au Gres	The hydrologic and hydraulic analyses for the May 1989 study for the Township of Au Gres were performed by the USACE, Detroit District, for FEMA under Inter-Agency Agreement No. EMW-85-E-1822, Project Order No. 1. The analysis for this study was completed in May 1987 (Reference 2).
Township of Sims	The hydrologic and hydraulic analyses for the February 1993 study for the Township of Sims were performed by the USACE, Detroit District, for FEMA under Interagency Agreement No. EMW-90-E-3263, Project Order No. 2. The analysis for this study was completed in February 1991 (Reference 3).
Township of Standish	The hydrologic and hydraulic analyses for the April 1993 study for the Township of Standish were performed by the USACE, Buffalo District, for FEMA under Interagency Agreement No. EMW-90-E-3263, Project Order No. 2. The analysis for this study was completed in February 1991 (Reference 4).
Township of Whitney	The hydrologic and hydraulic analyses for the December, 1977 study for the Township of Whitney were performed by Johnson & Anderson, Inc. for FEMA under Contract No. H-3816. The analysis for this study was completed in December 1976 (Reference 5).

In addition to the previously printed studies shown above, new and revised studies have been incorporated into this countywide FIS. Information on the sources of these studies is provided below.

New flood elevations for Saginaw Bay computed by detailed methods were obtained from a report published by the USACE in September 1989 (Reference 6).

New approximate hydrologic and hydraulic analyses for stream reaches in Arenac County were performed for this study by STARR for FEMA under Contract No. HSFEHQ-09-D-0370, Task Order No. 01. This work was completed in October 2010 and April 2012 (References 7 and 8).

This countywide FIS includes new detailed and approximate studies and incorporation of approved Letters of Map Change (LOMCs). The vertical datum was shifted to North American Vertical Datum of 1988 (NAVD88). The digital floodplain data was merged into a single, updated Digital Flood Insurance Rate Map (DFIRM). The DFIRM includes 2010 digital orthophotography, a 3-meter cell size Digital Elevation Model capable of producing 4-foot contours, political boundaries, road centerlines with street names, railroads with names, airports, rivers, lakes, streams, bridges and other hydraulic structures, and elevation reference marks. This work, which was completed in April 2013, covered unprotected flooding sources affecting Arenac County.

The digital base mapping information was provided by Intermap Technologies, Inc., and the Michigan Center for Geographic Information. These files were compiled by photogrammetric methods and meet or exceed National Map Accuracy Standards at the original compilation scale of 1:12,000. The coordinate system used for the production of this FIRM is Michigan State Plane Zone 6376, North American Datum of 1983. Differences in the datum used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on this FIRM.

1.3 Coordination

The purpose of an initial Consultation Coordination Officer's (CCO's) meeting is to discuss the scope of the FIS. A final CCO meeting is held to review the results of the study. The dates of the initial and final CCO meetings held for the previous FIS for the communities in Arenac County are shown in Table 1 (References 1-5).

TABLE 1 – Arenac County CCO Meetings

Community Name	Initial CCO Date	Final CCO Date
City of Au Gres	May 14, 1985	June 16, 1988
Township of Au Gres	May 14, 1985	June 15, 1988
Township of Sims	September 25, 1989	January 14, 1992
Township of Standish	September 26, 1989	April 28, 1992
Township of Whitney	February 1976	April 19, 1977

Results of the technical aspects of this study were coordinated with and reviewed and approved by the Michigan Department of Natural Resources and Environment (DNRE), the State coordinating agency.

The initial CCO meeting concerning this countywide FIS was held on December 2, 2009, and attended by representatives of FEMA, DNRE, Arenac County, the study contractor, and other local participants.

The results of this study were reviewed at the final CCO meeting held on July 10, 2013, and attended by representatives of FEMA, DNRE, Arenac County, the study contractor, and other local participants. All problems raised at that meeting have been addressed in this study.

2.0 AREA STUDIED

2.1 Scope of Study

This countywide FIS covers the geographic area of Arenac County, Michigan.

The flood sources studied previously by detailed methods for the previously published FISs that are incorporated into this countywide FIS are presented in Table 2.

TABLE 2 – Limits of Previous Detailed Studies

Flooding Source	Limits of Detailed Study
Au Gres River	From approximately 1.4 miles downstream of Michigan Avenue to approximately 0.5 mile upstream of the confluence with Burnt Drain
Sager Creek	From the mouth at Au Gres River to approximately 0.5 mile upstream of Court Street

Saginaw Bay has also been studied by detailed methods. This study, which covers Saginaw Bay, the entire shoreline of Arenac County, was published by the USACE in September 1989 (Reference 6).

Approximate analyses are usually used to study areas having a low development potential or minimal flood hazards. For this countywide FIS, streams previously studied by approximate methods were restudied to update existing flood hazard areas and additional approximate analyses were performed to identify flood hazards not previously identified. Portions of the streams listed in Table 3 were studied by approximate methods as a part of this study.

TABLE 3 – Streams Studied by Approximate Methods

Alabaster Whitney Drain	Cedar Creek Drain Tributary 6
Alabaster Whitney Drain Tributary	Cedar Creek Drain Tributary 6.2
Au Gres River	Cedar Creek Drain Tributary 7
Au Gres River Tributary 1	Cedar Creek Drain Tributary 7.1
Au Gres River Tributary 1.1	Cedar Creek Drain Tributary 8
Au Gres River Tributary 2	Cedar Creek Drain Tributary 9
Au Gres River Tributary 2.1	Chief Creek Drain
Baum Drain	Chief Creek Drain Tributary 1
Baum Drain Tributary 1	Delano Drain
Bear Creek	Dime Drain
Big Creek	Dime Drain Tirbutary 1
Big Creek Tributary 1	Dime Drain Tributary 2.1
Big Creek Tributary 1.1	Dime Drain Tributary 2.2
Big Creek Tributary 1.2	Dime Drain Tributary 2.3
Big Creek Tributary 1.3	Dime Drain Tributary 3
Big Creek Tributary 2	Dime Drain Tributary 3.1
Big Creek Tributary 3	Dime Drain Tributary 4
Big Creek Tributary 3.1	Dixie H. Drain
Big Creek Tributary 3.1.1	Dixie H. Drain Tributary
Big Creek Tributary 4	Duck Lake Drain
Bum Drain	Duck Lake Drain Tributary 1
Burnt Drain	East Branch Au Gres River
Cedar Creek Drain	East Branch Au Gres River (Old Channel)
Cedar Creek Drain Tributary 1	Geese Drain
Cedar Creek Drain Tributary 2	Geese Drain Tributary 1
Cedar Creek Drain Tributary 3	Geese Drain Tributary 1.1
Cedar Creek Drain Tributary 4	Geese Drain Tributary 1.2
Cedar Creek Drain Tributary 5	

TABLE 3 – Streams Studied by Approximate Methods *(continued)*

Hammel Creek	Saganing River
Kelcher Drain	Sager Creek
Kelcher Drain Tributary 1	Sager Creek Tributary 1
Laundrie Drain	Saverine Creek
Laundrie Drain Tributary 1	Saverine Creek Tributary
Laundrie Drain Tributary 2	Schnitzelbank Creek
Laundrie Drain Tributary 3	Scott Drain
Laundrie Drain Tributary 4	Scott Drain Tributary 1
Laundrie Drain Tributary 5	Scott Drain Tributary 2
Mattison Drain	Scott Drain Tributary 3
Middle Branch Pine River	Scott Drain Tributary 3.1
Mosquito Drain	Scott Drain Tributary 3.2
North Branch Pine River	Scott Drain Tributary 4
North Branch Pine River Tributary	Scott Drain Tributary 5
Perrin Drain	Scott Drain Tributary 6
Pine River	Scott Drain Tributary 7.1
Pine River Tributary 1	Silver Drain
Ray Drain	Silver Drain Tributary 1
Ray Drain Tributary 1	Silver Drain Tributary 2
Red Drain	Silver Drain Tributary 3
Rifle River	Silver Drain Tributary 4
Rifle River (Old Channel)	South Branch Pine River
Rifle River Tributary 1	South Branch Pine River Tributary 1
Rifle River Tributary 2	South Branch Pine River Tributary 2
Rifle River Tributary 3	South Branch Pine River Tributary 3
Rifle River Tributary 4	South Branch Pine River Tributary 4
Rifle River Tributary 5	Stowell Drain
Roberts Drain	Turner A. Drain Extended
Roberts Drain Tributary 1	Unnamed Drain

Letters of Map Amendment (LOMAs) incorporated for this study are summarized in the Summary of Map Actions (SOMA) included in the Technical Support Data Notebook (TSDN) associated with this FIS update. Copies of the SOMA may be obtained from the Community Map Repository. Copies of the TSDN may be obtained from FEMA. Please note that no Letters of Map Revision (LOMRs) were identified for Arenac County.

2.2 Community Description

Arenac County is located in the east-central portion of the lower peninsula of Michigan and encompasses a total area of approximately 681 square miles, of which approximately 367 square miles are land and approximately 314 square miles are water. It is bordered on the north by Ogemaw and Iosco Counties, on the west by Gladwin County, on the south by Bay County, and on the west by Saginaw Bay. According to U.S. Census Bureau figures, the April 1, 2000, population of Arenac County was 17,269. The estimated July 1, 2009, population was 16,092. The county seat is the City of Standish.

Arenac County is drained to Lake Huron by way of several watersheds. These include the Au Gres River, East Branch Au Gres River, and Rifle River watersheds within 8-digit

HUC basin number 04080101. A small watershed that drains to Lake Huron via several small tributaries is located within 8-digit HUC basin number 04080102.

Lake Huron and Saginaw Bay noticeably influence the climate of Arenac County. Northwest winds may lower the maximum temperatures by as much as 10 degrees Fahrenheit (°F) in the summer and raise minimum daily temperatures during the winter to those of similar latitudes at inland locations. July is the warmest month, with a mean monthly temperature of approximately 66°F; January is the coldest month, with a mean monthly temperature of approximately 18°F. The annual mean monthly temperature is approximately 46°F. The average annual precipitation is 27.8 inches, which includes 42.5 inches of snowfall (References 9 and 10).

Along the Saginaw Bay shoreline in the Township of Simms, soils consist of beach sands and organic deposits. Dominant soils in the western portion of the community are clay loams. The north-central portion of the community consists primarily of clay loams and sandy clay loam glacial material. Drainage is generally poor (Reference 11).

A 1967 soil survey published by the U.S. Department of Agriculture states that the majority of the land within the boundaries of Arenac County was once a lakebed. However, small areas within the county were deposited by glaciers in the form of ground and water-laid moraines (Reference 12).

The northern portion of the Township of Whitney is noted as a ground moraine, while the eastern portion of the community is thought to be water-laid moraine. Soil material in the moraines within the Township of Whitney varies greatly and ranges from clay to very coarse sand. Most of the soils in the agricultural areas of the community are poorly drained (Reference 5).

The entire shoreline of the Township of Sims along Saginaw Bay is exposed on the northeast to a Lake Huron/Saginaw Bay fetch of about 120 miles. Bathymetry in Saginaw Bay along shoreline varies from 30-foot depths offshore to less than 5 feet near shore. Ordinary fluctuations of water levels along this shoreline are subject to change because of the wind. A northeast storm can push water into the bay and raise the water level along the township shoreline by as much as 3 to 4 feet. The lowest bay stages usually prevail during the winter months and the highest during the summer months. The 1993 Township of Sims FIS reports that fluctuations of monthly mean water levels on Saginaw Bay ranged from a minimum of 577.57 feet NAVD88 to 581.33 feet NAVD88 in years recently preceding the study (Reference 3).

The topography of the Township of Standish is generally flat. Soils are mostly sand and clay. The physiographic features are the product of calcination and deposition of materials during the last glacial period (Reference 4).

Farming and tourism were noted to be the primary sources of income for residents of the Township of Sims and the Township of Whitney in the 1993 and 1977 FISs, respectively. Recreational activities in these communities included hunting, fishing, and boating, which accounted for much of the tourist trade. Development in the communities was concentrated primarily along the shoreline of Saginaw Bay (References 3 and 5).

The 1993 Township of Standish FIS states that landuse within the community was primarily agricultural, with some residential and scattered, light commercial areas along major roads. Floodplain areas were predominantly farm land with some residential development. Farms in the community cultivated a variety of crops, including beans, corn, sugar beets, and potatoes (Reference 4).

2.3 Principal Flood Problems

Fluctuations in the Saginaw Bay water-surface elevations may subject the shoreline to flooding and erosion. Fluctuations in Saginaw Bay's level can be classified as long-term, seasonal, or short-term. Long-term fluctuations occur over periods of several years. These fluctuations are due to climatic variations, which are seen in changes in precipitation, evaporation, and temperature, and are not cyclical. Seasonal fluctuations reflect the annual hydrologic cycle. High volumes of runoff contribute to Saginaw Bay and Lake Huron in spring and early summer as a result of icemelt and rain falling on saturated soils. This is compounded by a low rate of evaporation to produce higher water levels. In fall and early winter, evaporation from the lake is the greatest and runoff volumes are the lowest, which leads to a decrease in water levels. Short-term fluctuations occur over periods of between several hours and several days due to meteorological conditions. These fluctuations are caused by sustained winds and differences in barometric pressures over the lake surface, which result in imbalances in water levels across the surface. The effects of short-term fluctuations are more localized than the effects of long-term and seasonal fluctuations, and are more pronounced in areas with large expanses of off-shore shallow water, such as Saginaw Bay.

The Saginaw Bay shoreline is subject to significant flooding. Extensive damage occurred along the entire Saginaw Bay shoreline as a result of flooding in March 1973. This flooding was the result of high stillwater levels combined with a very strong northeast wind (Reference 4). The entire shoreline has also experienced erosion in varying degrees (Reference 3). Wave action and the accompanying shoreline erosion has been a serious problem along some sections of the shoreline of the Township of Whitney (Reference 5).

TABLE 4 shows high water marks from past Saginaw Bay flooding events as reported by the 1993 Township of Sims FIS (Reference 3).

TABLE 4 - High Water Marks

Flooding Source & Location	Date	(ft NAVD88)	(cfs)
Saginaw Bay			
Township of Sims	Mar. 17, 1973	584.4	N/A
	Apr. 25, 1976	583.8	N/A
	Mar. 21, 1983	583.8	N/A
	May 29, 1986	583.8	N/A
	Nov. 14, 1972	583.3	N/A

Inland, flooding typically occurs during late winter and spring, though flooding may also occur during summer and fall.

At the time of the 1977 Township of Whitney FIS, flood damage in the community had been confined primarily to crops, erosion of farmland, and local roads. While some basement flooding had been reported, no significant structural damage to homes or businesses in the area was known to have occurred (Reference 5).

The area most susceptible to flooding in the Township of Whitney lies within the Au Gres River watershed in the western portion of the community. Early spring flooding along the Au Gres River and the East Branch Au Gres River is a nearly annual occurrence and has been known to occur several times in a relatively short succession. During a 27-day period in April and May 1947, the Au Gres River reached flood stage four separate times. The flooding of May 26–29, 1959, was reported to be one of the most severe floods. Significant flooding also occurred in March 1974 (Reference 5).

Flooding in the Au Gres River Basin is often caused by rain, snowmelt, and ice jams, all of which occur simultaneously. Stretches of the Au Gres River contain many sharp bends that are susceptible to ice jamming and debris collection. These restrictions cause water to back up and spill over the banks onto adjacent fields. Sediment washed from the overbanks may settle in the lower segments of the stream and cause additional restriction in the channel (Reference 5).

The farmland at the confluence of the Au Gres River and the East Branch Au Gres River is particularly hard hit during floods. Flooding in this area is noted to cause backwater along Delano Drain, Dixie H. Drain, Laundrie Drain, and Red Drain (Reference 5).

Serious flooding along the East Branch Au Gres River has occurred along Edmonds Road in the north-central area of the Township of Whitney. One account from an area resident indicated that portions of Edmonds Road on either side of Turner Road were impassable during a flood in spring 1974 (Reference 5).

Individuals have made efforts to improve drainage in upstream areas within the Township of Whitney by straightening the channel and digging new ditches to collect runoff. This has resulted in increased flooding potential in the lower segments (Reference 5).

Standing water has been reported in fields adjacent to Dime Drain and Silver Drain. This is thought to be a result of poor overland flow, low soil permeability, and inadequate drainage resulting from ice formations and vegetation in the channels. The standing water has generally been shallow in depth (Reference 5).

The 1989 City of Au Gres FIS indicates that only minimal agricultural flooding had been observed within the community (Reference 1).

2.4 Flood Protection Measures

A number of flood protection measures were noted in the 1977 Township of Whitney FIS. The most notable flood protection measure at the time of the FIS was Whitney Drain, which runs along the north side of Turner Road toward Saginaw Bay. The drain was originally excavated shortly after 1911, and improvements were later made. It serves as a cutoff channel for normal flow from the East Branch Au Gres River (Old Channel). It was designed to carry approximately 85-percent of the runoff from a 10-percent-annual-chance storm event. A steel sheetpile diversion structure constructed on the East Branch Au Gres River (Old Channel) at the upstream face of the Turner Road culvert and serves to regulate the direction of flow. During large storm events, a portion of streamflow will overtop the sheetpile diversion structure, flow through the culvert, and continue down the East Branch Au Gres River (Old Channel) to the main branch of the Au Gres River (Reference 5).

Note that while the construction of Turner Drain reduced the severity of flooding along the East Branch Au Gres River (Old Channel) and lower segments of the Au Gres River, flooding problems continued to exist at the time of the 1977 Township of Whitney FIS.

This was said to be especially true in the area near the confluence of the Au Gres River and the East Branch Au Gres River (Old Channel) (Reference 5).

Residents of the Township of Whitney and other adjacent communities have constructed channels and field tile systems to improve drainage from the relatively flat agricultural areas (Reference 5).

Individual property owners in the Township of Whitney have attempted to minimize damage from shoreline erosion by constructing a variety of devices such as groins and bulkheads. Riprap has been placed in some locations for the same purpose (Reference 5).

Shoreline protection structures within the Township of Sims provide the community with some degree of protection against flooding. However, it has been ascertained that these structures will not protect the community from rare events such as the 1-percent-annual-chance flood (Reference 3).

Similarly, a wide variety of shoreline protection measures are present within the Township of Standish that provide some degree of protection to the community against flooding. These structures include broken-concrete/rubble-mound revetments and vertical concrete or sheetpile seawalls. The type of shoreline protection may vary from one property to the next, often with large areas of unprotected beaches or bluffs in between structures. These shoreline protection structures are expected to provide protection from moderate storm events. However, it has been ascertained that these structures will not protect the community from rare events such as the 1-percent-annual-chance flood (Reference 4).

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 one 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.

A frequency analysis of the Au Gres River was performed on peak discharge records collected at the National City stream gage. The HECWRC computer program, which follows the methodology described in the U.S. Water Resources Council Bulletin No.

17B (Reference 13), was used to compute the 1-percent-annual-chance peak discharge. The runoff-drainage area ratio method was then used to weight the peak discharge estimate to be applied in the City of Au Gres (Reference 1).

When hydraulic analysis revealed that the area inundated by flooding would be extensive, a preliminary flood routing model was set up. It was determined from this model that the available storage would significantly reduce the peak flow on the Au Gres River and a second analysis was performed. Extensive topographic mapping was performed in the majority of the flood-prone areas. Stage-storage relationships for several reaches of the river were determined. A series of flows were used in the HEC-2 step-backwater computer program (Reference 14). For each flow, the storage was added and a table was developed for the total storage versus discharge. Using this data, a HEC-1 computer model was developed with a modified Puls routing reach (Reference 15). The inflow hydrograph was developed by looking at the flow records for the National City stream gage and a representative shape was developed using summer events (Reference 1).

No stream gage data was available for Sager Creek. The U.S. Soil Conservation Service (SCS) unit hydrograph option of the HEC-1 computer program (Reference 15) was used to estimate the 1-percent-annual-chance peak discharge for the stream at its mouth. Drainage area was determined from the topographic maps (Reference 16). Rainfall-duration data were taken from National Weather Service Hydro-35 (Reference 17) and National Weather Surface Technical Paper 40 (Reference 18). SCS curve numbers were used to determine precipitation losses. The percentage of each soil class was estimated using a general soil survey map for Arenac County (Reference 1).

The peak discharge-drainage area relationships for the 1-percent-annual-chance flood events on the Au Gres River and Sager Creek are shown in Table 5.

TABLE 5 – Summary of Discharges

		Peak Discharges (cfs)			
Flooding Source and Location	Drainage Area (Sq. Miles)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Au Gres River					
At the City of Au Gres/Township of Au Gres corporate limits	280.0	*	*	3,820	*
Sager Creek					
at mouth	2.7	*	*	280	*

* Data not available

The peak stillwater flood elevations for Saginaw Bay were obtained from a report published by the USACE in 1989 (Reference 6). These flood elevations were computed using water-surface elevations recorded at a gage at Essexville and the open-coast flood levels published in the USACE report *Revised Report on Great Lakes Open-Coast Flood Levels* (Reference 19). The Harbor Beach and Harrisville gages, which are located on Lake Huron near the entrance to Saginaw Bay, were used to develop open-coast water-surface elevations along the Lake Huron shoreline and at the entrance to Saginaw Bay. Flood elevations at the entrance to Saginaw Bay were matched to the open-coast flood elevations. Flood elevations within Saginaw Bay were gradually increased from the open-coast flood elevations to the higher flood elevations at the Essexville gage, which is located at the extreme southwestern end of Saginaw Bay.

These stillwater elevations for the 10-, 2-, 1-, and 0.2-percent-annual-chance flood events along the Saginaw Bay shoreline are shown in Table 6.

TABLE 6 – Summary of Stillwater Elevations

	Peak Elevation (feet NAVD88)			
Flooding Source and Location	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Saginaw Bay				
Township of Whitney	582.4	583.5	584.0	584.9
Township of Sims	582.6	583.8	584.2	585.1
Township of Au Gres	582.8	583.9	584.4	585.4
Township of Arenac	582.9	584.0	584.5	585.5
Township of Standish	583.1	584.3	584.8	585.8

Hydrologic calculations were performed using approximate methods for each of the streams listed in Table 3. Basins were delineated at locations throughout each reach. The method of analysis used for each basin was selected based upon the size of the watershed and the availability of a systematic record of peak discharge data or previously published estimates of the 1-percent-annual-chance flood discharge.

For stream locations at which a gage is present and there is a systematic record of at least 10 years of peak discharge data available, flood frequency analyses were performed using the USGS PeakFQWin computer program (Reference 20). PeakFQWin provides an estimate of the 1-percent-annual-chance discharge by fitting the log-Pearson Type III distribution to the annual peak discharges following the guidelines of *Bulletin 17B*. For stream locations at which no gage is present but one is present on the stream, the discharge estimate at the gaged site was weighted based on the ratio of the drainage areas of the gaged and ungaged sites. This gage weighting is performed when the ratio of the drainage areas is between 0.5 and 2.0. The equation used to weight the discharges, which was provided by DNRE, is shown below.

$$Q_{100(UG)} = \left(\frac{A_u}{A_g} \right)^{0.89} Q_{100(G)}$$

In the equation above, $Q_{100(UG)}$ is the area-weighted estimate of the 1-percent-annual-chance flood discharge at the ungaged site, $Q_{100(G)}$ is the 1-percent-annual-chance flood discharge estimate at gaged site based on the systematic records; A_u is the drainage area at ungaged site; and A_g is the drainage area at gaged site.

For ungaged streams with drainage areas less than 20 square miles, 1-percent-annual-chance flood discharges were calculated using the methodology described in *Computing Flood Discharges for Small Ungaged Watersheds* (Reference 21). The method detailed in this report is similar to the dimensionless unit hydrograph method developed by the SCS methodology. Times of concentration, curve numbers, and pond and swamp areas are three variables that need to be computed to use this method. Times of concentration are calculated based on the maximum flow path's length, slope and flow regime.

For ungaged streams with drainage areas greater than 20 square miles, 1-percent-annual-chance discharge estimates were calculated using regression equations described in "USGS Water-Resources Investigation Report 94-4002" (Reference 22). These regression equations were developed from peak-discharge records available from 1982 through 1985 from gaging stations with 10 or more years of record. They are applicable to unregulated, rural streams draining less than 1,000 square miles and have standard errors of estimation ranging from 30 to 39 percent. The explanatory variables used in these equations are contributing drainage area; main-channel slope; percentage of the main-channel length that passes through swamp, lake, or pond; basin slenderness ratio; 1-percent-annual-chance 24-hour rainfall depth; seven characteristics of surficial geologic material; and a regional factor.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. 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.

Cross sections for the Au Gres River downstream of Michigan Avenue were provided by DNRE. Cross sections for the Au Gres River upstream of Michigan Avenue and for Sager Creek were obtained by field survey. All bridges and culverts were surveyed to obtain elevation data and structural geometry (References 1 and 2).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles and on the Flood Insurance Rate Maps.

Water-surface elevations for the 1-percent-annual-chance flood for the Au Gres River and Sager Creek were computed using the HEC-2 step-backwater computer program (Reference 14).

The starting water-surface elevation for the Au Gres River was set equal to the long-term, mean-annual water-surface elevation of Lake Huron at the City of Harbor Beach. Gage records from 1900 through 1986 were used in computing this water-surface elevation. The starting-water surface elevation for Sager Creek was computed using the slope-area method. Another water-surface elevation on Sager Creek was calculated at the upstream face of the Court Street bridge based on inlet control through the bridge culverts and weir flow over the bridge. The inlet control is the result of a sharp drop in the channel invert immediately downstream of the bridge that was caused by dredging completed between the mouth of the stream and the Court Street bridge (Reference 1).

Manning's "n" values for the channel and overbank areas were chosen by engineering judgment and based on field observation of the streams and floodplain areas. The selected "n" values for the channels of the Au Gres River and Sager Creek ranged from 0.024 to

0.042; the selected "n" values for the overbanks ranged from 0.030 to 0.070 (References 1 and 2).

Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals.

Water-surface elevations for the 1-percent-annual-chance flood for the streams listed in Table 3 were computed using approximate methods. Cross section geometric data was extracted from a digital elevation model (DEM) with a cell size of 11.7 feet, obtained from Intermap Technologies Inc. The DEM was originally published in 2010. No structures (i.e. bridges or culverts) were included in the models. Hydraulic computations were performed using the USACE HEC-RAS computer program (Reference 23). Starting water-surface elevations were determined using one of two methods: the normal depth routine in the HEC-RAS computer program or a known water-surface elevation. The known water-surface elevation was used if the study reach was found to be upstream of a lake for which 1-percent-annual-chance flood elevation was provided by DNRE. These lakes are identified in Section 2.1. When the normal depth routine was used, the downstream gradient was estimated using the DEM. Roughness factors for these streams were estimated based on visual observation of the aerial photography and standard, accepted values published in Open-Channel Hydraulics by V.T. Chow (Reference 24). Separate overbank and channel roughness values were selected for each stream reach. No structures (i.e. bridges or culverts) were included in the models. The 1-percent-annual-chance flood discharge estimates computed using the methods described in Section 3.1 were applied in the models. Flow changes were entered at the most upstream point of each stream and at each sub-watershed location along the stream.

The hydraulic analyses for this study are based only on the effects of unobstructed flow unless otherwise noted. The flood elevations as shown on the profiles (Exhibit 1) are, therefore, considered valid only if hydraulic structures, in general, remain unobstructed and if channel and overbank conditions remain essentially the same as ascertained during this study.

All elevations are referenced from NAVD88; elevation reference marks used in the study are shown on the maps.

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 the National Geodetic Vertical Datum of 1929 (NGVD29). With the finalization of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are being prepared using NAVD88 as the referenced vertical datum.

Effective information for this countywide FIS report was converted from NGVD29 to NAVD88 based on data presented in Table 7. The average conversion of NGVD29-0.569=NAVD88 was applied to convert all effective Base Flood Elevations (BFEs). Structure and ground elevations in the community must, therefore, be referenced to NAVD88. It is important to note that adjacent communities in other counties not presented in this countywide FIS may be referenced to NGVD29. This may result in differences in BFEs across the corporate limits between communities.

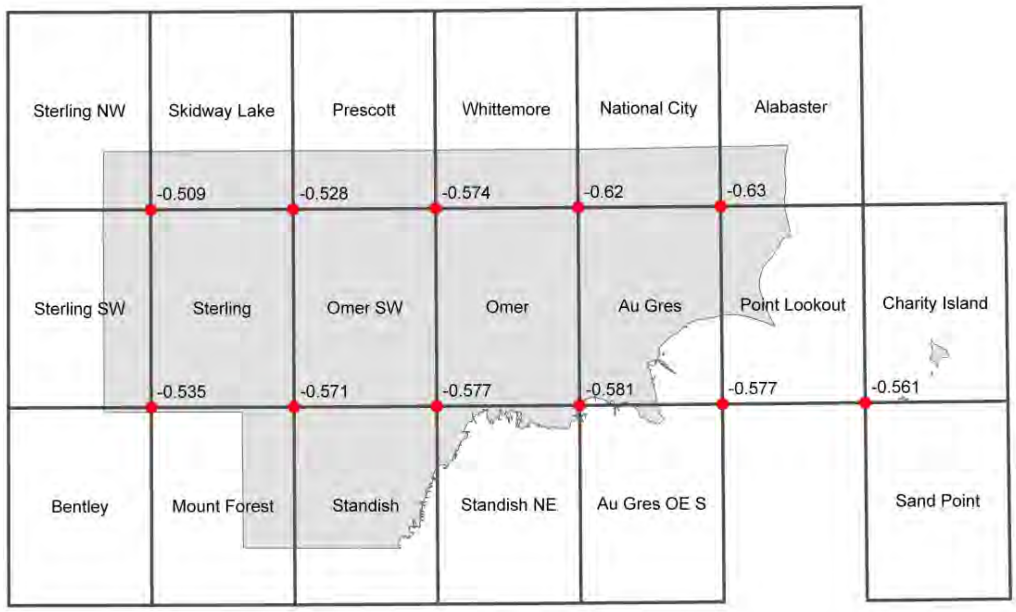

FIGURE 1 – Quadrangle Corner Intersections

TABLE 7 – Vertical Datum Conversion Calculations

Quadrangle Name	Quadrangle Corner	Latitude	Longitude	Difference
Omer	SE	44.000	-83.750	-0.581 ft
Omer	SW	44.000	-83.875	-0.577 ft
Sterling	SE	44.000	-84.000	-0.571 ft
Sterling SW	SE	44.000	-84.125	-0.535 ft
National City	SE	44.125	-83.625	-0.630 ft
Whittemore	SE	44.125	-83.750	-0.620 ft
Prescott	SE	44.125	-83.875	-0.574 ft
Skidway Lake	SE	44.125	-84.000	-0.528 ft
Skidway Lake	SW	44.125	-84.125	-0.509 ft
Point Lookout	SE	44.000	-83.500	-0.561 ft
Au Gres	SE	44.000	-83.625	-0.577 ft

Average Conversion	-0.569
Range	-0.630 to -0.509
Max Offset	0.061

For more information on NAVD88, see the FEMA publication entitled *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988* (Reference 25), or contact the Vertical Network Branch, National Geodetic Survey, Coast and Geodetic Survey, National Oceanic and Atmospheric Administration, Silver Spring, Maryland 20910 (http://www.ngs.noaa.gov).

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 TSDN associated with this countywide FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides l-percent-annual-chance (100-year) flood elevations and delineations of the 1- and 0.2-percent-annual-chance (500-year) floodplain boundaries and l-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of this countywide FIS report, including Flood Profiles, Floodway Data table, and Summary of Stillwater Elevations table. Users should reference the data presented in this countywide 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 (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream 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 the 2010 Lower Peninsula LiDAR project dataset that generated 1/9 arc second (3-meter) Digital Elevation Models which produced 4-foot contours.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the l-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 l-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 l-percent-annual-chance floodplain boundary is shown on the FIRM.

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 l-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 l-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. 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 floodway presented in this countywide FIS report and on the FIRM was 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. In cases where the floodway and l-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and l-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 water-surface elevation of the l-percent-annual-chance flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

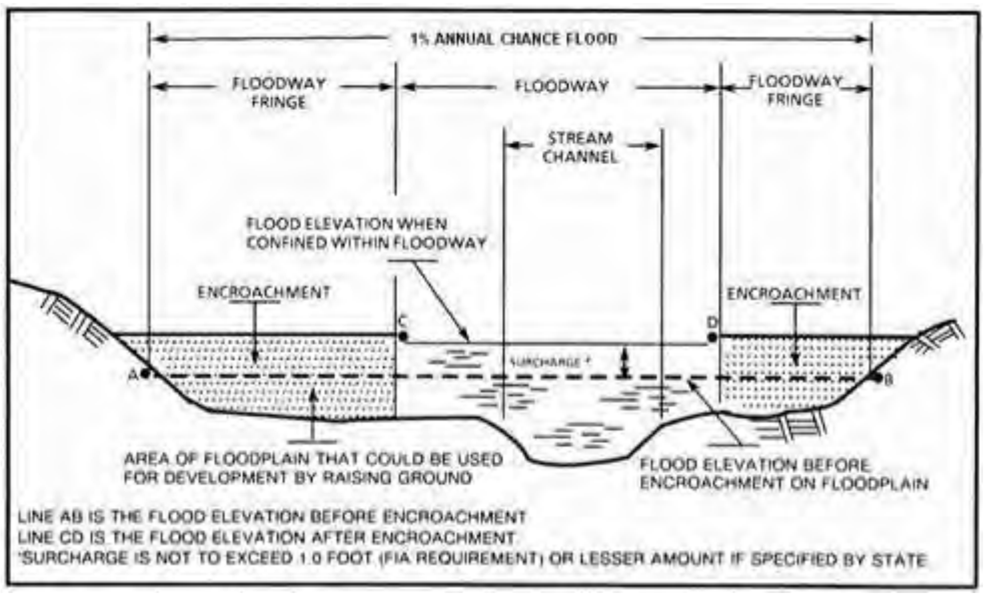

FIGURE 2 – Floodway Schematic

In Michigan, under the State's Floodplain Regulatory Authority, found in Part 31 of the *Natural Resources and Environmental Protection Act*, 1994 PA 451 (Reference 26), encroachment in the floodplain is limited to that which will cause only insignificant increases in flood heights. At the recommendation of MDEQ, Land and Water Management Division, a floodway having no more that a 0.1-foot surcharge has been delineated for this countywide FIS.

In the redelineation efforts, the floodway was not recalculated. As a result, there may have been areas where the previous floodway did not fit within the boundaries of the 1-percent-annual-chance floodplain. In areas where this occurred, the floodway was reduced. The water-surface elevations with and without a floodway, the mean velocity in the floodway, and the location and area at each surveyed cross section as determined by hydraulic methods can be seen in TABLE 8, Floodway Data. The width of the floodway depicted by the FIRM panels and the amount of reduction to fit the floodway inside the 1-percent-annual-chance floodplain, if necessary, is also listed.

FLOODING SOURCE		FLOODWAY				1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WIDTH REDUCED FROM PRIOR STUDY (FEET)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
AU GRES RIVER									
A	12,400	111	1,003	3.8		584.4	582.4[2]	582.4	0.0
B	13,180	119	989	3.9		584.4	582.8[2]	582.8	0.0
C	14,017	115	866	4.4		584.4	583.3[2]	583.3	0.0
D	17,050	315	1,109	4.7		586.0	586.0	586.1	0.1
E	21,940	1700	5,798	0.7		588.0	588.0	588.1	0.1
F	24,850	2141	3,779	1.0		588.2	588.2	588.3	0.1
G	29,200	1221	2,896	1.3		589.6	589.6	589.7	0.1
H	33,750	833	2,105	1.8		591.8	591.8	591.9	0.1

[1]Feet above mouth

[2]Elevation computed without consideration of backwater effects from Saginaw Bay

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI
(ALL JURISDICTIONS)

FLOODWAY DATA

AU GRES RIVER

FLOODING SOURCE		FLOODWAY				1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WIDTH REDUCED FROM PRIOR STUDY (FEET)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
SAGER CREEK									
A	1,195	108	123	2.3		584.4	573.8[2]	573.8	0.0
B	3,265	330	802	0.4		585.4	585.4	585.5	0.1

[1]Feet above mouth

[2]Elevation computed without consideration of backwater effects from Saginaw Bay

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI
(ALL JURISDICTIONS)

FLOODWAY DATA

SAGER 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 current FIRM presents flooding information for the entire geographic area of Arenac County. Previously, separate FIRMs were prepared for each identified flood prone incorporated community and for the unincorporated areas of the county. Historical data relating to the maps prepared for each community are presented in Table 9.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
[1,2] Adams, Township of	N/A	None	N/A	
Arenac, Township of	August 16, 1974	June 25, 1976	July 3, 1986	None
Au Gres, City of	June 7, 1974	March 5, 1976 May 7, 1982	May 17, 1989	None
Au Gres, Township of	June 21, 1974	August 20, 1976	May 17, 1989	None
[2] Clayton, Township of	N/A	None	N/A	None
Deep River, Township of	June 24, 1977	None	August 19, 1985	None
[2] Lincoln, Township of	N/A	None	N/A	None
[2] Mason, Township of	N/A	None	N/A	None
[2] Moffatt, Township of	N/A	None	N/A	None
[2] Omer, City of	N/A	None	N/A	None
Sims, Township of	June 21, 1974	June 25, 1976	June 1, 1978	February 3, 1993
Standish, City of	September 20, 1974	June 11, 1976	September 27, 1985	None
Standish, Township of	August 16, 1974	July 9, 1976	August 4, 1987	April 2, 1993

[1] No Special Flood Hazard Areas identified.
[2] This community does not have map history prior to the first countywide mapping.

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
[1,2] Sterling, Village of	N/A	None	N/A	
Turner, Township of	July 18, 1975	None	N/A	None
Turner, Village of	March 4, 1977	None	September 30, 1988	None
[1,2] Twining, Village of	N/A	None	N/A	
Whitney, Township of	June 28, 1974	July 23, 1976	June 1, 1978	November 4, 1992

[1] No Special Flood Hazard Areas identified.
[2] This community does not have map history prior to the first countywide mapping.

TABLE 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

A countywide FIS is currently in progress for Gladwin County. The results of that study will be in agreement with the results of this countywide study.

This FIS 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.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Flood Insurance and Mitigation Division, Federal Emergency Management Agency, 536 South Clark Street, Sixth Floor, Chicago, Illinois 60605-1509.

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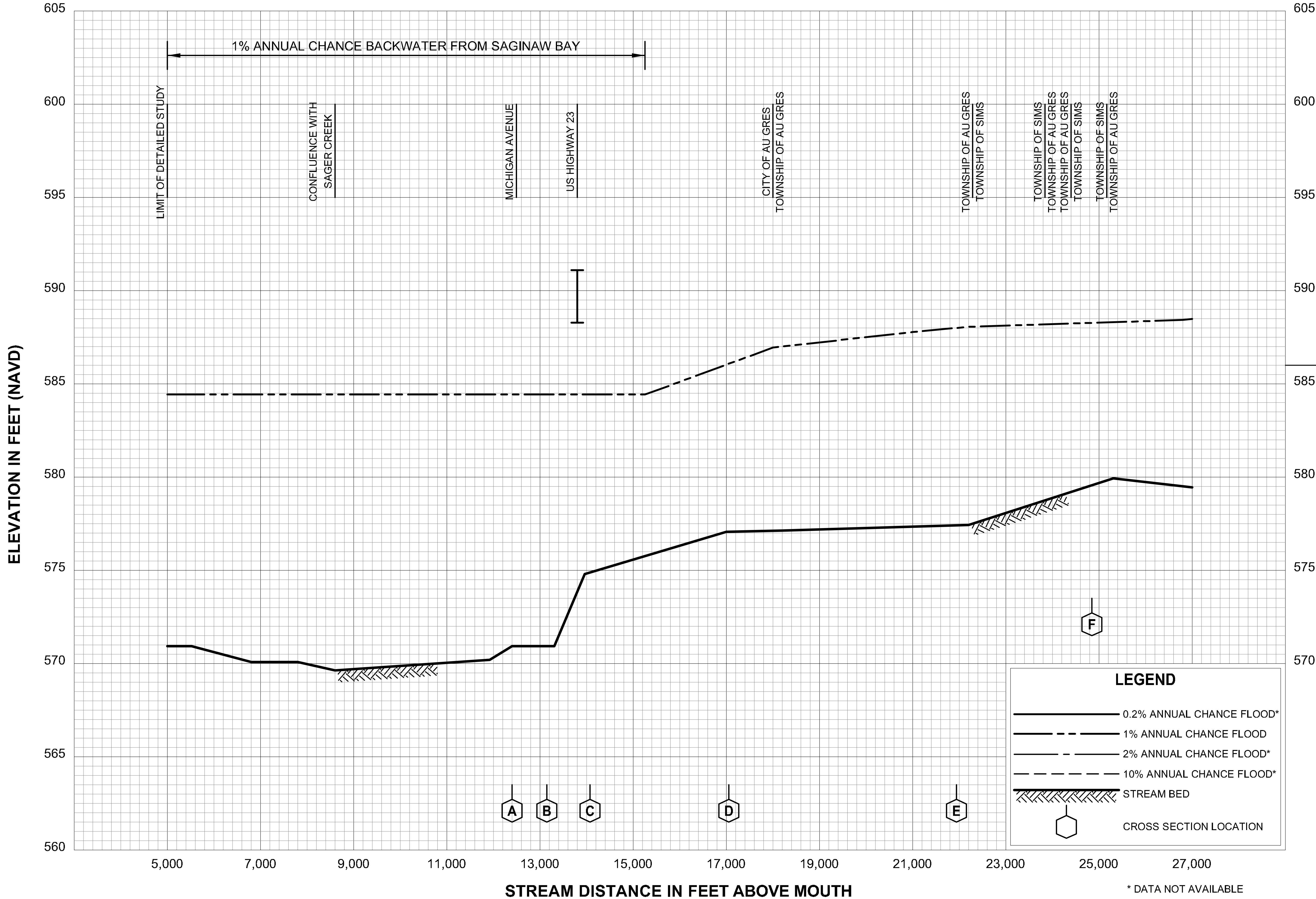


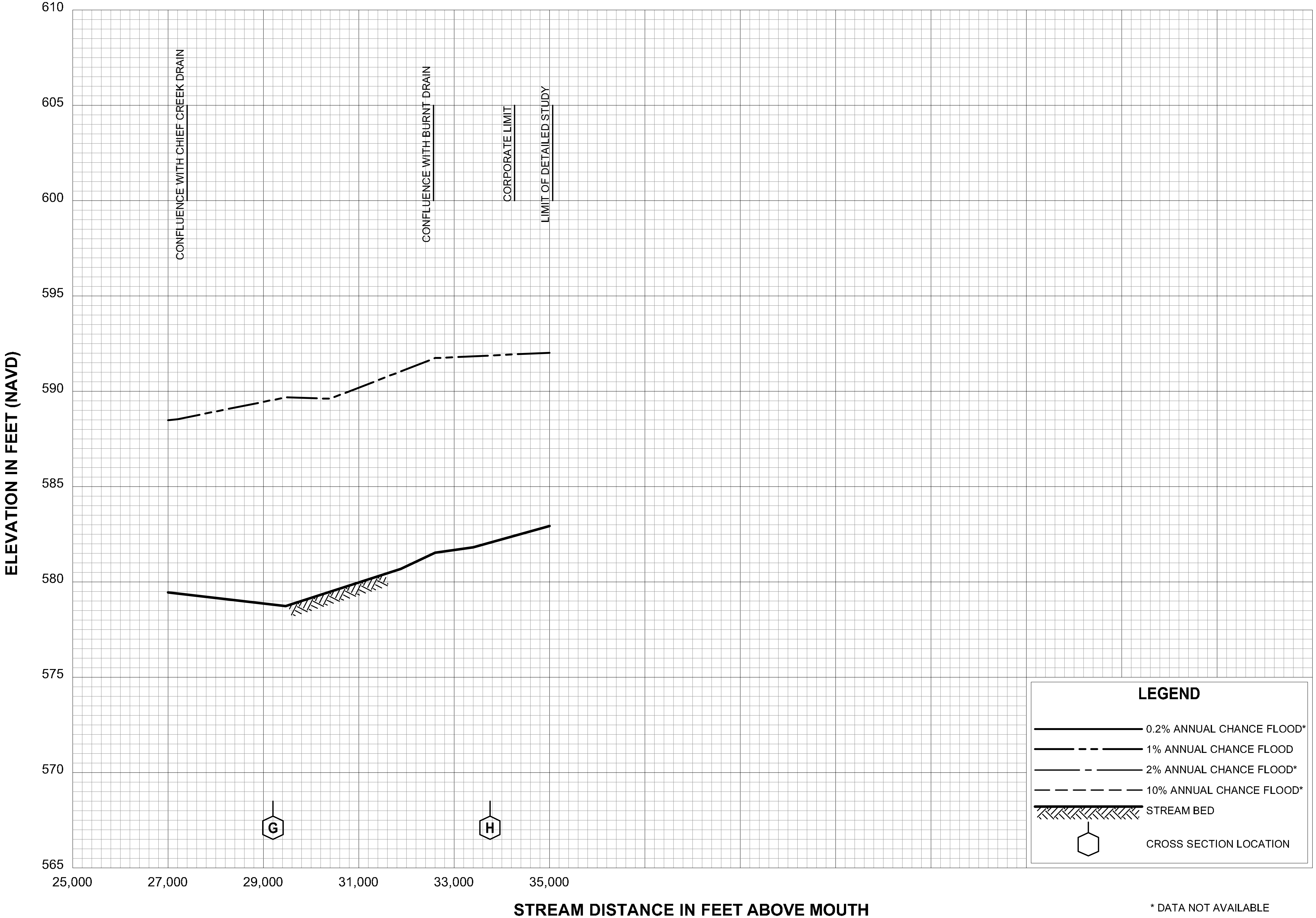
FLOOD PROFILES

AU GRES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI

ALL JURISDICTIONS



FLOOD PROFILES

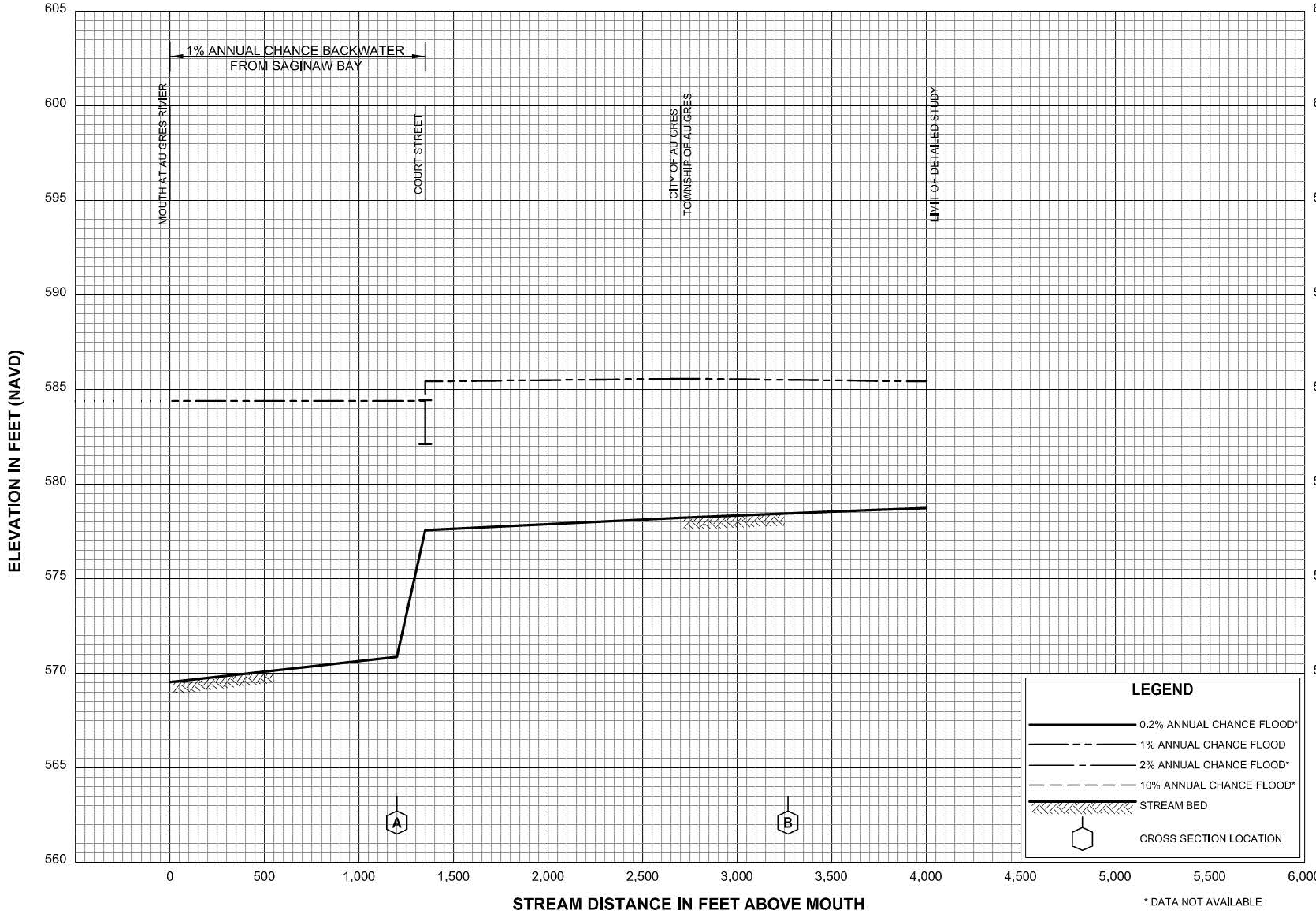
AU GRES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI

ALL JURISDICTIONS

02P



FLOOD PROFILES

SAGER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARENAC COUNTY, MI

ALL JURISDICTIONS

03P