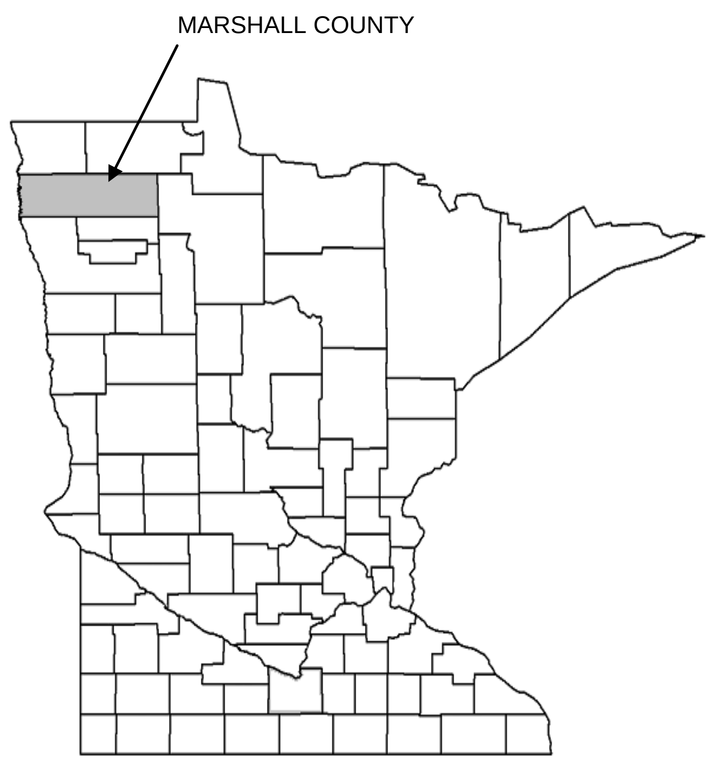
FLOOD INSURANCE STUDY



MARSHALL COUNTY, MINNESOTA

AND INCORPORATED AREAS

Community Name	***Community Number***
ALVARADO, CITY OF	270267
ARGYLE, CITY OF	270268
GRYGLA, CITY OF	270269
*HOLT, CITY OF	270811
MARSHALL COUNTY (UNINCORPORATED AREAS)	270638
MIDDLE RIVER, CITY OF	270270
NEWFOLDEN, CITY OF	270271
OSLO, CITY OF	270272
STEPHEN, CITY OF	270273
*STRANDQUIST, CITY OF	270813
*VIKING, CITY OF	270814
WARREN, CITY OF	270274

*NO SPECIAL FLOOD HAZARD AREAS IDENTIFIED

Revised Preliminary: October 20, 2016

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
27089CV000A

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: To Be Determined

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FLOOD INSURANCE STUDY
MARSHALL COUNTY, MINNESOTA AND INCORPORATED AREAS

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 Marshall County, including the Cities of Alvarado, Argyle, Grygla, Holt, Middle River, Newfolden, Oslo, Stephen, Strandquist, Viking, and Warren, and the unincorporated areas of Marshall County (referred to collectively herein as Marshall 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 no special flood hazard areas have been identified in the Cities of Holt, Strandquist, and Viking. This does not preclude future determinations of SFHAs that could be necessitated by changed conditions affecting the community (i.e., annexation of new lands) or the availability of new scientific or technical data about flood hazards.

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:

Alvarado, City of:	The hydrologic and hydraulic analyses for the Snake River for the July 16, 1980, FIS were performed by the U.S. Army Corps of Engineers (USACE), St. Paul District, for the Federal Insurance Administration (FIA), under Interagency Agreement No. IAA-H-10-77, Project Order No. 25 (FIA, 1980a). The work was completed in February 1979. For the April 3, 1996, FIS revision (FEMA, 1996), the hydraulic analyses for the Snake River were prepared by the USACE, St. Paul District, for the City of Alvarado to reflect the completion of a flood control project. The work was completed in July 1994.
Argyle, City of:	The hydrologic and hydraulic analyses for the Middle River for the June 15, 1982, FIS (FEMA, 1982a) were performed by Edwards and Kelcey, Inc., for FEMA, under Contract No. EMW-C-0322. The work was completed in May 1981. For the October 18, 1994, FIS revision (FEMA, 1994), the hydrologic and hydraulic analyses for the Middle River were prepared by the USACE, St. Paul District, for the City of Argyle to reflect the completion of the Middle River Flood Control Project. The work was completed in March 1993.
Grygla, City of:	The hydrologic and hydraulic analyses for the Mud River for the March 30, 1982, FIS (FEMA, 1982b) were performed by Edwards and Kelcey, Inc., for FEMA, under Contract No. EMW-C-0322. The work was completed in March 1981.
Marshall County (Unincorporated Areas):	The hydrologic and hydraulic analyses for the Middle River, Mud River, Red River of the North, Snake River, and Tamarac River for the January 18, 1983, FIS (FEMA, 1983b) were performed by Edwards and Kelcey, Inc., for FEMA, under Contract No. EMW-C-0322. The work was completed in October 1981.

Marshall County (Unincorporated Areas) *(continued):*	For the October 16, 1987, FIS revision (FEMA, 1987b), the hydrologic and hydraulic analyses for the Snake River were taken from the FIS report for the City of Warren (FEMA, 1987a).
Middle River, City of:	The hydrologic and hydraulic analyses for the Middle River for the August 1, 1983, FIS (FEMA, 1983b) were taken from the FIS for the unincorporated areas of Marshall County (FEMA, 1983a).
Oslo, City of:	The hydrologic and hydraulic analyses for the Red River of the North for the March 16, 1982, FIS (FEMA, 1982c) were performed by Edwards and Kelcey, Inc., for FEMA, under Contract No. EMW-C-0322. The work was completed in March 1981.
Stephen, City of:	The hydrologic and hydraulic analyses for the Tamarac River for the March 16, 1982, FIS (FEMA, 1982d) were performed by Edwards and Kelcey, Inc., for FEMA, under Contract No. EMW-C-0322. The work was completed in May 1981.
Warren, City of:	The hydrologic and hydraulic analyses for the Snake River for the August 18, 1980, FIS (FIA, 1980b) were performed by the USACE, St. Paul District, for the FIA, under Interagency Agreement No. IAA-H-10-77, Project Order No. 25. The work was completed in February 1979.
	For the November 19, 1987, FIS revision (FEMA, 1987a), the hydraulic analyses for a portion of the Snake River were prepared by the Minnesota Department of Natural Resources (MNDNR). Hydrologic and hydraulic analyses for other portions of the Snake River were taken from the FIS for the unincorporated areas of Marshall County (FEMA, 1983b).

Please note that the Cities of Holt, Newfolden, Strandquist, and Viking have no previously printed FIS reports.

This Countywide FIS Report

The redelineation of portions of the Middle River, Snake River, and Tamarac River, and the hydrologic and hydraulic analyses for all streams studied by approximate methods in this countywide study were performed by Atkins, for FEMA, under Contract No. HSFE05-05-D-0023, Task Order 21. The work was completed in July 2011.

The hydrologic and hydraulic analyses for the Red River of the North were performed by the USACE, St. Paul District, and FEMA. The work was completed in January 2003.

Base map information shown on the Flood Insurance Rate Map (FIRM) was derived from digital orthorectified imagery from the National Agriculture Imagery Program, at a scale of 1:12,000, dated 2010. The projection used in the preparation of this map is Universal Transverse Mercator Zone 14, and the horizontal datum used is North American Datum 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 Marshall County and its communities are listed in the following table:

Table 1 – Initial and Final Community Meetings

Community	FIS Date	Initial Meeting	Final Meeting
Alvarado, City of	July 16, 1980 April 3, 1996	September 1, 1976 November 3, 1994*	September 19, 1979 **
Argyle, City of	June 15, 1982 October 18, 1994	June 1979 August 16, 1993*	October 5, 1981 **
Grygla, City of	March 30, 1982	June 1979	October 7, 1981
Marshall County (Unincorporated Areas)	January 18, 1983 October 16, 1987	June 1979 **	July 28, 1982 **
Middle River, City of	August 1, 1983	**	February 28, 1983
Oslo, City of	March 16, 1982	June 1979	October 6, 1981
Stephen, City of	March 16, 1982	June 1979	October 5, 1981
Warren, City of	August 18, 1980 November 19, 1987	September 1976 **	September 19, 1979 **

*Notified by letter
**Data not available

The Countywide FIS Report

The initial meeting for this countywide study was held on June 15, 2007, and attended by representatives of FEMA, MNDNR, Atkins, and community representatives.

The results of the study were reviewed at the final meeting held on _____________, and attended by representatives of _____________. 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 Marshall County, Minnesota, 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.

The following streams are studied by detailed methods in this FIS report:

Table 2 – Streams Studied by Detailed Methods

Middle River	Snake River
Mud River	Snake River Diversion Channel
Red River of the North	Tamarac River

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

This Countywide FIS Report

The USACE, St. Paul District, completed modeling for the Red River of the North, which has been incorporated into this study. The model includes the entire portion within Marshall County.

The detailed studied portions of Middle River, from 330th Street to approximately 3.8 miles upstream of 320th Street/County Highway 4, and from approximately 2.2 miles downstream of 150th Avenue to approximately 3.2 miles upstream of 330th Street/Minnesota Avenue East, Mud River, Snake River, from County Highway 100/240th Street to approximately 300 feet upstream of State Highway 220, and from approximately 1.3 miles upstream of 210th Street, to approximately 2.8 miles upstream of Snake River Diversion Structure, and Tamarac River, were redelineated using new topographic data.

New or revised hydrologic and hydraulic analyses were performed for all streams studied by approximate methods.

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 North American Vertical Datum of 1988 (NAVD). In addition, the Universal Transverse Mercator coordinates, previously referenced to the North American Datum of 1927 (NAD 27), are now referenced to the NAD 83.

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 Marshall County.

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

Table 3 – Incorporated LOMCs

LOMC	Case Number	Date Issued	Project Identifier
LOMR*	07-05-1900P	June 27, 2007	Channelization, Culvert, Fill, Levee

*Letter of Map Revision (LOMR)

2.2 Community Description

Marshall County is located in the northwest corner of Minnesota. The total land area within Marshall County is approximately 1,772 square miles. It is bordered to the west by the Red River of the North and North Dakota, including Grand Forks County to the southwest, Walsh County to the west, and Pembina County to the northwest; to the north by Kittson and Roseau Counties; to the east by Beltrami County; and to the south by Polk and Pennington Counties. The 2009 population estimate for Marshall County was 9,184 and the total land area is approximately 1,772 square miles (U.S. Census Bureau, 2011).

The climate of the area is continental, characterized by wide variations in temperatures, scant winter precipitation, and a general tendency towards extremes (National Oceanic and Atmospheric Administration, 1975). Average temperatures for Marshall County range from an average low of -8 degrees Fahrenheit (°F) in the winter months to an average high of 81°F in the summer months. The average monthly rainfall for the county is 1.65 inches with the majority of the precipitation falling as rain during the summer months (The Weather Channel, 2010).

Western Marshall County is in the geographic region of Minnesota known as the Red River Valley. This flat expanse of land was not technically formed by the

Red River of the North, but by the action of glacial Lake Agassiz. The flat lake bed which covers a large portion of the northwestern Minnesota was formed by sediments hundreds of feet thick.

The topography of Marshall County is generally flat, sloping downward from east to west. Elevations throughout the county range from 800 to 1,200 feet NAVD (USGS, various dates).

The lake plain in Marshall County is an area of fine textured prairie soil that is intensively farmed. The principal crops are small grains and sugar beets. Prior to settlement in the area, the lake plain was covered primarily by prairie grasses and plants with trees along the major streams and rivers.

The Red River of the North begins at the confluence of the Bois de Sioux and Otter Tail Rivers at the City of Breckenridge, Minnesota, and flows approximately 600 river miles north through the center of the Old Lake Agassiz bed to its mouth at Lake Winnipeg (Waters, 1977). The floodplain of the Red River of the North is not very well defined, as it was not formed by the river's action but rather by lake sediments. Western Marshall County is directly adjacent to the Red River of the North and is subject to out-of-bank flooding.

Land use in the unincorporated areas of Marshall County is primarily agricultural in nature. Industry in the county is generally agricultural in nature. Floodplain development consists mainly of farmsteads and farm outbuildings. Within the incorporated areas, development consists of primarily single family residences, commercial structures, and some agriculture.

2.3 Principal Flood Problems

Flooding in Marshall County occurs primarily along the Red River of the North, the Middle River, the Snake River, the Snake River Diversion Channel, the Tamarac River, and the Mud River. The principal flood season in Marshall County is in the spring as a result of rapid snowmelt accompanied by spring rains. The region is also susceptible to flooding as a result of intense regional storms.

The Red River of the North flows north, which compounds the flooding problem; the downstream reaches of the river are still frozen while the upstream reaches are beginning to flow from spring snowmelt. Runoff from tributary streams is generally synchronized with mainstream flows, increasing the resulting flood peak. A major flood event occurred on the Red River of the North in 2009.

Major flooding on the Red River of the North occurred on the dates listed in the following table:

Table 4 – Red River of the North Flooding Events

Flood Date	Elevation (Feet NAVD)	Discharge (cfs[1])	Estimated Frequency (% Annual-Chance)
May 1950	810.71	63,000	3.4
April 1966	810.96	59,000	4.0
April 1969	810.80	56,500	4.5
April 1978	811.79	56,200	5.0
April 1979	812.48	91,000	1.0
April 1996	*	59,200	*
April 1997	*	120,000	*
April 2006	*	77,600	*
April 2009	*	80,600	*

*Data not available
[1] Cubic feet per second

Low-lying areas of the City of Alvarado as well as the City of Warren are subject to periodic overflow from the Snake River. The most severe flooding occurs in early spring because of heavy rain and snowmelt. Major flooding events on the Snake River have occurred on the dates listed in the following table:

Table 5 – Snake River Flooding Events

Flood Date	Elevation (Feet NAVD)	Discharge (cfs)	Estimated Frequency (% Annual-Chance)
City of Alvarado			
1950	811.0[1]	3,260	5.6
1965	810.8	*	*
1966	811.3	*	*
1969	810.9	5,500	1.0
1975	809.9	2,600	10.0
1979	811.8	3,410	5.0
City of Warren			
1950	*	3,510	2.9
1965	*	3,250	3.7
1966	*	3,410	3.0
1969	*	4,300	1.5
1979	*	4,000	1.9

[1] High stage due partly to backwater from Red River of the North
*Data not available

The most severe flooding in the City of Argyle occurs due to flooding on the Middle River. Major flooding on the Middle River occurred on the dates listed in the following table:

Table 6 – Middle River Flooding Events

Flood Date	Elevation (Feet NAVD)	Discharge (cfs)	Estimated Frequency (% Annual-Chance)
April 1950	845.1	2,790	7.4
April 1965	845.0	2,590	9.1
April 1966	843.9	1,820	18.1
April 1969	844.8	2,530	9.5
May 1970	844.5	2,200	12.9
April 1974	844.4	2,070	14.5
July 1975	846.35	4,260	2.2
April 1979	*	2,140	*
March 1996	*	5,020	*
April 1997	*	4,330	*
April 1999	*	2,370	*
April 2001	*	2,290	*
June 2002	*	2,730	*
May 2004	*	2,090	*
August 2005	*	2,500	*
April 2006	*	3,500	*

*Data not available

The most severe flooding in the City of Grygla occurs due to flooding on the Mud River. Past flooding problems have occurred due to water backing up to the east of the State Highway 89 bridge. A major flood occurred in July 1919 following 19 inches of rain. No record of discharges is available for this flood. Subsequent floods of record are listed in the following table (USGS, 2007):

Table 7 – Mud River Flooding Events

Flood Date	Discharge (cfs)
April 1979	1,480
April 1996	1,950
April 1997	1,400
March 1999	1,960
August 2001	1,400
June 2002	2,840
April 2006	2,230

The most severe flooding in the City of Stephen occurs due to flooding on the Tamarac River. The flood of record occurred on April 18, 1979, following heavy snows and a late spring thaw. No record of discharges exists for this or subsequent floods.

2.4 Flood Protection Measures

Levees that provide some degree of protection against flooding exist in the study area. However, it has been ascertained that some of these levees may not protect the community from rare events such as the 1-percent-annual-chance flood. The criteria used to evaluate protection against the 1-percent-annual-chance flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 1-pecent-annual-chance flood are not considered in the hydraulic analysis of the 1-percent-annual-chance floodplain.

The City of Argyle is serviced by the Middle River Flood Control Project. Built by the USACE, St. Paul District, and completed in March 1993, the project consists of intermittent sections of levees, road raises, and drainage facilities consisting of interceptor ditches, pipes, and ponding areas with gated outlet structures.

In the late 1960s, approximately 7,700 feet of emergency levee was constructed by the City of Alvarado, with technical assistance from the USACE. The levee was built to withstand an event similar to the 1969 flood. Much of the work on the levee was undertaken without foundation investigation, and no design control was maintained over the selection of foundation materials or placement; therefore, the existing levee could not be regarded as reliable against a 1-percent-annual-chance flood. However, the USACE has constructed the Alvarado Snake River Flood Control Project to replace this levee. The flood control project consists of an earthen levee, two reaches of pre-cast concrete floodwall, closure areas, and interior drainage facilities. The two separate reaches of pre-cast concrete floodwall, located near the city's western corporate limits, are approximately 600 feet long. State Highway 1, located near the city's northern corporate limits, serves as the northern flood barrier. A sandbag or earthen fill closure ranging from 0.0 to 1.5 feet is required along State Highway 1 to ensure standard project flood protection to the top of the barrier. Sandbag closures are also required where the railroad crosses the levee on the east and west of the city, and at State Highway 220 near the southern portion of the city. Interior drainage facilities for the project consist of six gravity outlets, four ponding areas, an interceptor, and a pump station.

A Federal flood control project exists in the City of Oslo and the surrounding unincorporated areas of Marshall County. This flood control project consists of a ring levee around the City of Oslo.

The City of Warren is serviced by the Soil Conservation Service (SCS), now the Natural Resources Conservation Service, Snake River Watershed Project. The project consists of a flood storage reservoir located upstream of the city, and a diversion structure, which, during a significant flood event, will divert high flows around the city and into the SCS Snake River Diversion Channel (SCS, 2010).

Many temporary dikes and levees were constructed in Marshall County in advance of the 1978 and 1979 floods. Many of them are still in place and offer some protection against flooding. They are, however, temporary in nature and have not been considered effective for this FIS.

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 portions of Middle River, Mud River, Snake River, from County Highway 100 / 240th Street to approximately 300 feet upstream of State Highway 220, and from County Highway 104 / 370th Avenue to approximately 1.3 miles upstream of 210th Street, and Tamarac River, the discharge-frequency curve is based on data from the U.S. Geological Survey (USGS) gaging station (No. 05087500) Middle River at Argyle, MN. The original frequency analysis was performed by the USGS for the report, “Techniques for Estimating Magnitude and Frequency of Floods in Minnesota” (USGS, 1977). These regional regression equations were derived from multiple regression analyses of data obtained from gaged sites within the basin. The equations relate flood magnitude to basin characteristics such as drainage area, available storage, and channel slope. The values chosen were based on current watershed conditions at the time of study. Discharges for the 0.2-percent-annual-chance flood were interpolated from a graph of the 10-, 2-, and 1-percent-annual-chance flood events.

To determine the discharge split quantitatively, a HEC-2 hydraulic model (see Section 3.2) was prepared for the main channel and overbank areas of the Tamarac River from County Highway 5 to just downstream of Lofgren Avenue / State Highway 75. Several alternative discharges were selected and analyzed to develop a family of profiles for the main stem of the Tamarac River. A normal profile depth analysis of the overbank area at the diversion point was also prepared for various discharges, providing a family of stage-discharge relationships for the bifurcation point. The two families of curves were compared, and that combination of stage-discharge relationships equaling the total discharge computed for Stephen at equivalent water surface elevations (WSELs) was selected to represent the discharges for both the main stem and the diversion area. The resulting stage-discharge relationship for the main stem Tamarac River was verified using an April 1979 high water mark at a structure in the City of Stephen located downstream from the bifurcation point.

For the Snake River, from County Highway 104 to approximately 1.3 miles upstream of 210th Street, the discharge-frequency curves were developed using guidelines and procedures outlined in Water Resources Council (WRC) Bulletin #17A (WRC, 1977) along with gaging station records published by the USGS (USGS, 1978). The Snake River has a short period of miscellaneous discharge records; therefore, longer records from a nearby basin were analyzed and compared. Studies of peak discharges and frequency curves in this area indicate that the long period of record for the adjacent Middle River at the City of Argyle (with a drainage area of 248 square miles) correlates well with the Snake River at the City of Warren (with a drainage area of 175 square miles). This hydrologic analysis is based on a study of 29 years of record (1945 and 1950-1977) at the City of Argyle (USGS, 1976), and was computed using the log-Pearson Type III distribution and a generalized skew value of -0.2 used in accordance with the USACE, St. Paul District, Skew Map (USACE, 1977b). Studies of peak flows at the Cities of Argyle and Warren indicate that the peaks are approximately 0.65 of the drainage area ratio. Using this drainage area ratio method, the City of Argyle frequency curve was transferred to the Snake River in the vicinities of the Cities of Warren and Alvarado.

This Countywide FIS Report

The discharge-frequency curves for the Red River of the North, revised to include floods of record since the regional flood analysis (MNDNR and North Dakota State Water Commission, 1971), and the Red River of the North main stem hydrologic data report (USACE, 1977a) were used to arrive at the final discharge-frequency relationships.

For the Snake River, from approximately 1.3 miles upstream of 210th Street, to approximately 2.8 miles upstream of the Snake River Diversion Structure, and the Snake River Diversion Channel, peak discharges were obtained from rainfall-runoff analysis using the SCS computer program, TR-20 (SCS, 1965). An off channel floodwater retarding structure, located 21 river miles upstream of the City of Warren, is significant in controlling discharges in the study reach and was included in the analysis.

For Middle River, from 330th Street to approximately 1,500 feet upstream of 110th Avenue Northwest, peak discharges were obtained from Minnesota Streamstats that incorporated regression equations for estimating instantaneous peak flows (Lorenz, 2009).

Discharges for approximate analysis streams were estimated using the published USGS regression equations (USGS, 1997). Regression equations estimate peak discharges for ungaged streams based on characteristics of nearby gaged streams.

Peak discharge-drainage area relationships for each flooding source studied in detail are shown in Table 8.

Table 8 – Summary of Discharges

		Peak Discharges (cfs)			
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
MIDDLE RIVER					
At U.S. Highway 75	248	2,570	4,800	5,940	9,300
Approximately 3,500 feet downstream of Burlington Northern Santa Fe Railway	248	2,490	4,350	5,170	7,040
At. U.S. Highway 59	107	1,340	2,250	2,700	3,920
At State Highway 32	45	780	1,320	1,580	2,390
MUD RIVER					
At County Highway 54	116	1,410	2,360	2,840	4,200
RED RIVER OF THE NORTH					
Approximately 10,400 feet downstream of the confluence of Tamarac River	25,865	50,471	91,041	111,824	168,646
Approximately 8,400 feet upstream of the confluence of Tamarac River	25,515	50,264	90,787	111,541	168,078
Approximately 18,800 feet downstream of the confluence of Snake River	24,475	49,638	90,013	110,683	166,355
Approximately 35,550 feet upstream of State Highway 317	22,520	48,408	88,485	108,985	162,962
Approximately 8,875 feet upstream of North Plains Railroad	22,369	48,310	88,363	108,849	162,690

Table 8 – Summary of Discharges (Continued)

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
SNAKE RIVER					
At State Highway 220	220	2,580	4,530	5,460	7,970
Approximately 15,600 feet upstream of County Highway 104	*	2,050	3,500	4,250	6,350
Just downstream of the convergence of Snake River Diversion Channel	191.3	1,830	3,130	3,700	5,620
At Bridge Street	176.9	*	*	600	*
*Data not available					
SNAKE RIVER (continued)					
Just upstream of the divergence of Snake River Diversion Channel	175.2	1,830	3,130	3,700	5,620
SNAKE RIVER DIVERSION CHANNEL					
Just downstream of divergence from Snake River	*	1,030	2,430	3,100	5,600
At U.S. Highway 75	*	1,030	2,430	3,100	5,600
Just upstream of convergence with Snake River	*	1,030	2,430	3,100	5,600
TAMARAC RIVER					
At U.S. Highway 75	274	2,580	4,515	5,450	8,530

*Data Not Available

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.

Precountywide Analyses

Photogrammetric methods were used to obtain data for the overbank portions of the cross sections for the Middle River, Mud River, Red River of the North, Snake River, and Tamarac River; the channel portion of the cross sections, bridge dimensions, and other structures were field surveyed. Cross sections for the analysis were located at close intervals upstream and downstream of bridges, culverts, and other obstructions in order to compute significant backwater effects of these structures. Other cross sections were located along the watercourses in a manner that would provide a representation typical of the stream valley topography.

For the Middle River from 330th Street to 3.8 miles upstream of 320th Street/County Highway 4, cross sections were field surveyed and taken from a USACE report (USACE, 1979). The overbanks of the cross sections were taken from USGS quadrangle sheets at a scale of 1:24,000 and a contour interval of 5 feet for the City of Argyle, Minnesota (USGS, 1982), and from topographic maps at a scale of 1:600 and a contour interval of 1 foot (Ulteig Engineers, Inc., 1983) covering the levee location.

WSELs for the Middle River, Mud River, Snake River from County Highway 104 / 370th Avenue to approximately 1.3 miles upstream of 210th Street, and Tamarac River were computed through the use of the USACE's Hydrologic Engineering Center (HEC), computer program, HEC-2 (HEC, 1976). An updated version of the HEC-2 program was used for the revision to the Snake River in the City of Alvarado (from State Highway 1 to approximately 3,200 feet upstream of State Highway 1) (HEC, 1991). An updated version of the HEC-2 program was also used for the revision to the Middle River at the City of Argyle, the Mud River at the City of Grygla, and the Tamarac River at the City of Stephen (HEC, 1979). An older version of the HEC-2 program was used for the Snake River at Warren (HEC, 1973). A small portion of the model was revised approximately 400 feet downstream of Central Park Avenue and in the vicinity of Montana Street with an updated version of HEC-2 (HEC, 1984).

Weir flow calculations for the Snake River at Warren were used at the Burlington Northern & Santa Fe Railway crossing between Park Avenue and an unnamed tributary to determine flows over the railroad.

Starting WSELs for the Middle River, Mud River, Red River of North, Snake River, and Tamarac River were determined using the slope-area method with the following exceptions.

Starting WSELs within the City of Alvarado on the Snake River were obtained from an elevation-discharge rating curve. For the revision to the Snake River in the City of Alvarado, from State Highway 1 to approximately 3,200 feet upstream of State Highway 1, starting WSELs were obtained from an elevation-frequency curve at the State Highway 1 bridge. The elevation-frequency curve was developed for the design of the flood control project and includes the effects of backwater from the Red River of the North. Both the elevation-discharge rating curve and the elevation-frequency curve were based on recorded high water marks, miscellaneous stage discharge measurements, and detailed backwater computations on the Snake River.

Starting WSELs within the City of Warren on the Snake River were determined using rating curves developed downstream of the City of Warren.

AH zone designations were assigned to areas of shallow flooding due to ponding behind county roads southwest of Warren. AO zone designations were assigned to areas of shallow flooding caused by sheet runoff to the west of Warren, to the west and southwest of the City of Argyle, and to the north of the City of Stephen. The AH and AO zone designations were assigned based on data obtained from advance prints of USGS quadrangle mapping for the area, field inspection, and normal depth analysis.

This Countywide FIS Report

WSELs for the Red River of the North were calculated using the USACE, HEC computer program, HEC-RAS, version 3.0.1 (HEC, 2001). The USGS 7.5-minute series topographic quadrangle maps were used to extend existing cross sections in order to capture effective flow limits for the 1997 flood. Starting WSELs were determined by high water data and rating curves established at the Town of Emerson, Manitoba (USACE, 2003).

For the Snake River, from approximately 1.3 miles upstream of 210th Street, to approximately 2.8 miles upstream of Snake River Diversion Structure, and the Snake River Diversion Channel, the hydraulic analyses were performed for LOMR 07-05-1900P.

For Middle River, from 330th Street to approximately 1,500 feet upstream of 110th Avenue Northwest, the current effective HEC-2 hydraulic model was converted to the HEC-RAS, version 4.1.0, to calculate starting WSELs (HEC, 2010).

For streams studied by approximate methods cross sections were obtained from the topography (MNDNR, 2008 and USGS, various dates). The studied streams were modeled using HEC-RAS version 3.1.3 (HEC, 2005). Starting WSELs were determined using normal depth.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1).

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by field inspection and engineering judgment. The Manning's "n" values for all detailed studied streams are listed in the following table:

Table 9 – Manning's "n" Values

Manning's "n" Values		
Stream	Channel "n"	Overbank "n"
Middle River	0.024-0.045	0.035-0.132
Mud River	0.030	0.035-0.080
Red River of the North	0.036-0.046	0.010-0.125
Snake River	0.030-0.080	0.045-0.108
Snake River Diversion Channel	0.045-0.080	0.045-0.080
Tamarac River	0.030-0.040	0.040-0.150

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 Special Flood Hazard Area.

Although flood elevations can be raised by debris accumulation and ice jams at hydraulic structures, the incidence of ice induced flooding is highly erratic and, based on random weather fluctuations, ice effects are not subject to statistical prediction. 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 VERTCON online utility (NGS, 2007). The data points used to determine the conversion are listed in Table 10.

Table 10 – Vertical Datum Conversion

Quad Name	Corner	Latitude	Longitude	Conversion from NGVD to NAVD (feet)
Drayton	SE	48.500	97.125	1.135
Drayton SE	SE	48.500	97.000	1.109
Donaldson	SE	48.500	96.875	1.135
Kennedy SE	SE	48.500	96.750	1.191
Karlstad SW	SE	48.500	96.625	1.270
Karlstad	SE	48.500	96.500	1.322
Twistal Swamp	SE	48.500	96.375	1.335
Pelan SE	SE	48.500	96.250	1.335
Strathcona	SE	48.500	96.125	1.319
Greenbush SE	SE	48.500	96.000	1.329
Thief Lake	SE	48.500	95.875	1.306
Thief Lake SE	SE	48.500	95.750	1.299
Wannaska SW	SE	48.500	95.625	1.316
Big Woods NW	SE	48.375	97.125	1.099
Big Woods NE	SE	48.375	97.000	1.040
Stephen West	SE	48.375	96.875	1.004
Stephen East	SE	48.375	96.750	1.155
Florian	SE	48.375	96.625	1.220
Forian NE	SE	48.375	69.500	1.240
Strandquist	SE	48.375	96.375	1.266
Nelson Slough	SE	48.375	96.250	1.302
Middle River	SE	48.375	96.125	1.312
Middle River NE	SE	48.375	96.000	1.299
Gatzke NW	SE	48.375	95.875	1.283
Gatzke	SE	48.375	95.750	1.283
Randeen Ridge	SE	48.375	95.625	1.289
Big Woods SW	SE	48.250	97.125	1.109
Big Woods	SE	48.250	97.000	1.093
Stephen SW	SE	48.250	96.875	1.093
Argyle	SE	48.250	96.750	1.142
Florian SW	SE	48.250	96.625	1.204
Florian SE	SE	48.250	96.500	1.230
Ellerth	SE	48.250	96.375	1.260
Newfolden	SE	48.250	96.250	1.312
Holt	SE	48.250	96.125	1.319
Middle River SE	SE	48.250	96.000	1.283
Gatzke SW	SE	48.250	95.875	1.280

Table 10 – Vertical Datum Conversion *(continued)*

Quad Name	Corner	Latitude	Longitude	Conversion from NGVD to NAVD (feet)
Gatzke SE	SE	48.250	95.750	1.280
Grygla SW	SE	48.250	95.625	1.253
Average:				1.232

For additional information regarding conversion between NGVD and NAVD, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey 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 the detailed portion of Red River of the North, Snake River from County Highway 100 / 240th Street to approximately 125 feet upstream of State Highway 220, floodplains were delineated between cross sections, and the boundaries were interpolated using topographic maps, with a contour interval of 1 foot, derived from Light Detection and Ranging (LiDAR), provided by MNDNR (MNDNR, 2008).

For the detailed portions of Middle River, Mud River, Snake River from 370th Avenue / County Highway 104, to approximately 2.8 miles upstream of Snake River Diversion Structure, Snake River Diversion Channel, and Tamarac River, floodplains were delineated between cross sections, and the boundaries were interpolated using topographic maps at a scale of 1:24,000, with a contour interval of 5 feet (USGS, various dates).

For streams studied by approximate methods, 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 a scale of 1:24,000, with a contour interval of 5 feet (USGS, various dates), and using topographic maps, with a contour interval of 1 foot, derived from LiDAR, provided by MNDNR (MNDNR, 2008).

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, AE, AH, and AO), 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 Minnesota, however, floodplain encroachment is limited by Minnesota Regulations to that which would cause a 0.5 foot increase in flood heights above pre-floodway conditions at any point (MNDNR, 1977). Because of particular circumstances relating to the flood situation in the City of Warren, the MNDNR has permitted a flood height increase of 0.7 foot on the Snake River in the City of Warren. 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 in Table 11. 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.

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.

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)	WIDTH REDUCED FROM PRIOR STUDY (FEET)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
MIDDLE RIVER									
A	1,710	252	1,898	3.1		837.9	837.9	838.4	0.5
B	6,760	1,833	5,451	1.1		839.1	839.1	839.6	0.5
C	10,980	835	4,315	1.4	742	839.8	839.8	840.3	0.5
D	19,220	250	1,652	3.1		844.4	844.4	844.4	0.0
E	19,550	250	1,712	3.0		845.9	845.9	845.9	0.0
F	21,575	400	2,182	2.4		846.7	846.7	846.7	0.0
G	25,190	497	3,118	1.7		849.2	849.2	849.4	0.2
H	25,860	520	1,775	2.9		849.3	849.3	849.5	0.2
I	32,490	270	2,175	2.7		852.8	852.8	853.1	0.3
J	36,270	276	2,030	2.9		854.5	854.5	854.8	0.3
K	290,976	306	1,001	3.1		1,070.1	1,070.1	1,070.2	0.1
L	297,003	365	1,953	1.6		1,077.9	1,077.9	1,078.0	0.1
M	314,114	147	882	3.4		1,085.3	1,085.3	1,085.3	0.0
N	336,698	425	1,764	1.3		1,099.3	1,099.4	1,099.4	0.1
O	343,420	182	796	2.8		1,102.0	1,102.0	1,102.1	0.1
P	397,821	171	975	1.6		1,132.8	1,132.8	1,133.2	0.4
Q	405,378	225	954	1.7		1,138.0	1,138.0	1,138.3	0.3
R	408,778	279	822	1.9		1,139.4	1,139.4	1,140.0	0.6
S	409,232	84	342	4.6		1,140.2	1,140.2	1,140.4	0.2
T	409,583	131	1,162	1.4		1,141.7	1,141.7	1,141.8	0.1

[1] Feet above 330th Street

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

MIDDLE 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)
MIDDLE RIVER (CONTINUED)								
U	410,133	150	867	1.8	1,141.8	1,141.8	1,142.0	0.2
V	412,483	165	636	2.5	1,142.4	1,142.4	1,142.7	0.3
W	425,561	353	999	0.8	1,143.8	1,143.8	1,144.0	0.2

[1] Feet above 330th Street

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

MIDDLE 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)
MUD RIVER								
A	640	735	2,061	1.4	1,175.1	1,175.1	1,175.4	0.3
B	3,750	835	2,184	1.3	1,175.5	1,175.5	1,176.0	0.5
C	5,520	260	698	4.1	1,176.3	1,176.3	1,176.7	0.4
D	7,440	187	901	2.3	1,178.5	1,178.5	1,178.6	0.1
E	11,500	455	1,318	1.6	1,179.4	1,179.4	1,179.9	0.5

[1]Feet above 390th Avenue Northeast

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

MUD 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)
RED RIVER OF THE NORTH								
A	1,436,953	361	145,015	1.0	811.6	811.6	811.6	0.0
B	1,439,268	484	138,056	1.1	811.7	811.7	811.7	0.0
C	1,439,824	575	46,484	2.7	812.4	812.4	812.4	0.0

[1]Feet above confluence with Lake Winnipeg

[2]These data represent widths within Marshall County only and reflect adjustments made to ensure compliance with FEMA policy regarding the mapping of floodways of levees

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

RED RIVER OF THE NORTH

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)	WIDTH REDUCED FROM PRIOR STUDY (FEET)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
SNAKE RIVER									
A	2,365	1,407	4,326	1.3		809.8	808.4[2]	808.8	0.4
B	4,315	2,034	4,278	1.3	33	810.2	809.1[2]	809.5	0.4
C	8,195	1,657	6,746	0.8	30	811.0	810.2[2]	810.6	0.4
D	13,725	1,261	3,978	1.4		811.5	810.5[2]	810.9	0.4
E	16,025	1,823	6,706	0.8		811.6	810.9[2]	811.3	0.4
F	19,403	1,124	2,356	2.3		812.9	812.9	813.3	0.4
G	19,903	1,450	5,597	1.0	1,393	813.2	813.2	813.7	0.5
H	20,903	1,166	3,740	1.5		813.4	813.4	813.9	0.5
I	27,055	1,327	3,821	1.4		814.6	814.6	815.0	0.4
J	79,160	3,097	3,891	1.3		836.2	836.2	836.7	0.5
K	88,490	377	3,494	1.4		838.8	838.8	839.3	0.5
L	91,740	545	4,267	1.2		839.5	839.5	840.0	0.5
M	96,040	538	4,522	1.1		840.9	840.9	841.4	0.5
N	97,590	290	2,271	1.9		841.5	841.5	841.7	0.2
O	101,230	323	2,118	1.8		842.7	842.7	842.9	0.2
P	109,350	167	1,222	0.5		844.1	844.1	844.3	0.2
Q	114,460	84	426	1.4		844.4	844.4	844.5	0.1
R	118,160	41	220	2.7		845.5	845.5	845.6	0.1
S	119,000	94	336	1.8		845.9	845.9	846.0	0.1
T	121,065	66	326	1.8		846.8	846.8	846.8	0.0
U	123,463	75	338	1.8		848.2	848.2	848.2	0.0
V	125,310	68	327	1.8		849.8	849.8	849.8	0.0

[1]Feet above County Highway 100 / 240th Street

[2]Elevations computed without consideration of flooding control effects from Red River of the North

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

SNAKE 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)
SNAKE RIVER (CONTINUED)								
W	128,430	95	350	1.7	852.0	852.0	852.0	0.0
X	131,820	107	341	1.8	853.7	853.7	853.7	0.0
Y	134,810	72	384	1.6	854.8	854.8	854.8	0.0
Z	138,390	75	333	1.8	856.4	856.4	856.4	0.0
AA	139,956	53	257	2.3	857.4	857.4	857.4	0.0
AB	141,848	229	1,326	2.8	867.0	867.0	867.0	0.0
AC	143,318	230	1,610	2.3	868.7	868.7	868.7	0.0
AD	150,143	397	1,881	2.0	872.7	872.7	873.0	0.3

[1]Feet above County Highway 100 / 240th Street

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

SNAKE RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)[2]	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
SNAKE RIVER DIVERSION CHANNEL								
A	52	250	612	5.1	844.3	844.3	844.3	0.0
B	2,688	250	772	4.0	846.6	846.6	846.6	0.0
C	4,188	250	814	3.8	847.5	847.5	847.5	0.0
D	5,308	250	871	3.6	849.4	849.4	849.4	0.0
E	7,308	250	863	3.6	850.3	850.3	850.3	0.0
F	10,408	250	834	3.7	853.5	853.5	853.5	0.0
G	12,752	250	771	4.0	861.2	861.2	861.2	0.0
H	17,052	250	914	3.4	863.4	863.4	863.4	0.0
I	18,595	250	932	3.3	865.0	865.0	865.0	0.0
J	20,305	250	949	3.4	865.8	865.8	865.8	0.0
K	21,098	250	1,168	2.7	866.3	866.3	866.3	0.0

[1]Feet above convergence with Snake River
[2]Includes widths of levees to landward toe

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

SNAKE RIVER DIVERSION CHANNEL

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)
TAMARAC RIVER								
A	4,920	255	1,169	2.6	824.3	824.3	843.6	0.3
B	8,020	260	1,340	2.2	825.8	825.8	826.0	0.2
C	12,615	710	3,575	0.8	828.5	828.5	828.6	0.1
D	14,620	300	1,475	2.0	828.8	828.8	828.9	0.1
E	19,110	1,198	4,167	1.3	829.8	829.8	830.1	0.3
F	22,060	640	3,345	1.6	831.3	831.3	831.5	0.2
G	24,780	550	2,678	2.0	831.9	831.9	832.2	0.3
H	31,400	800	3,927	1.4	833.2	833.2	833.7	0.5
I	44,120	1,200	4,847	1.1	835.5	835.5	836.0	0.5

[1]Feet above Limit of Detailed Study (Limit of Detailed Study is approximately 6,400 feet downstream of 400th Street / County Highway 5)

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

FLOODWAY DATA

TAMARAC RIVER

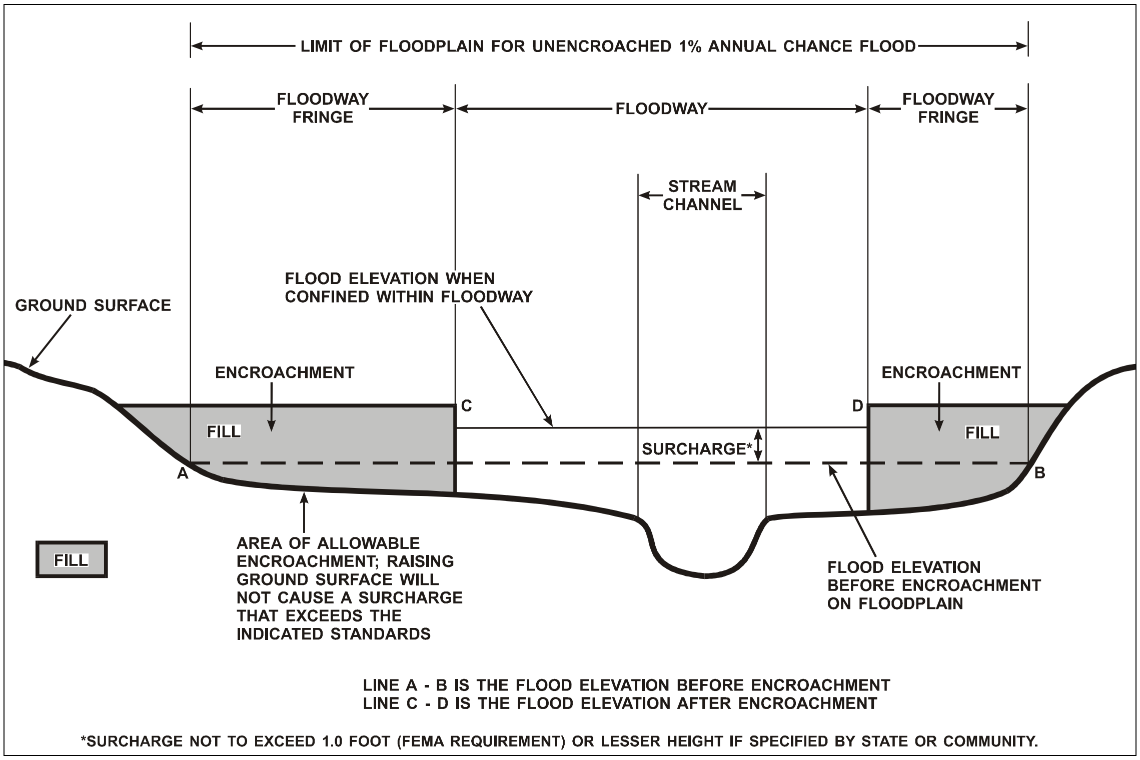

Figure 1 – Floodway Schematic

No floodways were computed for Red River of the North, from the Kittson County boundary to approximately 2,800 feet downstream of State Highway 1, and from approximately 875 feet upstream of Northern Plains Railroad to the Polk County boundary.

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 AH

Zone AH is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot base flood depths derived from the detailed hydraulic analyses are shown 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 Marshall County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. This countywide FIRM also includes flood-hazard information that was presented separately on Flood

Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community are presented in Table 12.

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.

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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Federal Emergency Management Agency, Flood Insurance Study, City of Warren, Marshall County, Minnesota, November 19, 1987a.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE	FIRM EFFECTIVE DATE	FIRM REVISION DATE
Alvarado, City of	August 2, 1974	None	January 16, 1981	April 3, 1996
Argyle, City of	May 3, 1974	June 11, 1976	December 15, 1982	October 18, 1994
Grygla, City of	August 8, 1975	N/A	September 30, 1982	None
Holt, City of[1,2]	N/A	N/A	N/A	None
Marshall County (Unincorporated Areas)	March 27, 1981	N/A	July 18, 1983	October 16, 1987
Middle River, City of	July 19, 1974	May 28, 1976	February 1, 1984	None
Newfolden, City of	N/A	N/A	N/A	None
Oslo, City of	September 16, 1982	N/A	September 16, 1982	None
Stephen, City of	May 17, 1974	June 4, 1976	September 16, 1982	None
Strandquist, City of[1,2]	N/A	N/A	N/A	None
Viking, City of[1,2]	N/A	N/A	N/A	None
Warren, City of	May 3, 1974	February 14, 1975	February 18, 1981	November 19, 1987

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

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

Federal Emergency Management Agency, Flood Insurance Study, Marshall County, Minnesota (Unincorporated Areas), October 16, 1987b.

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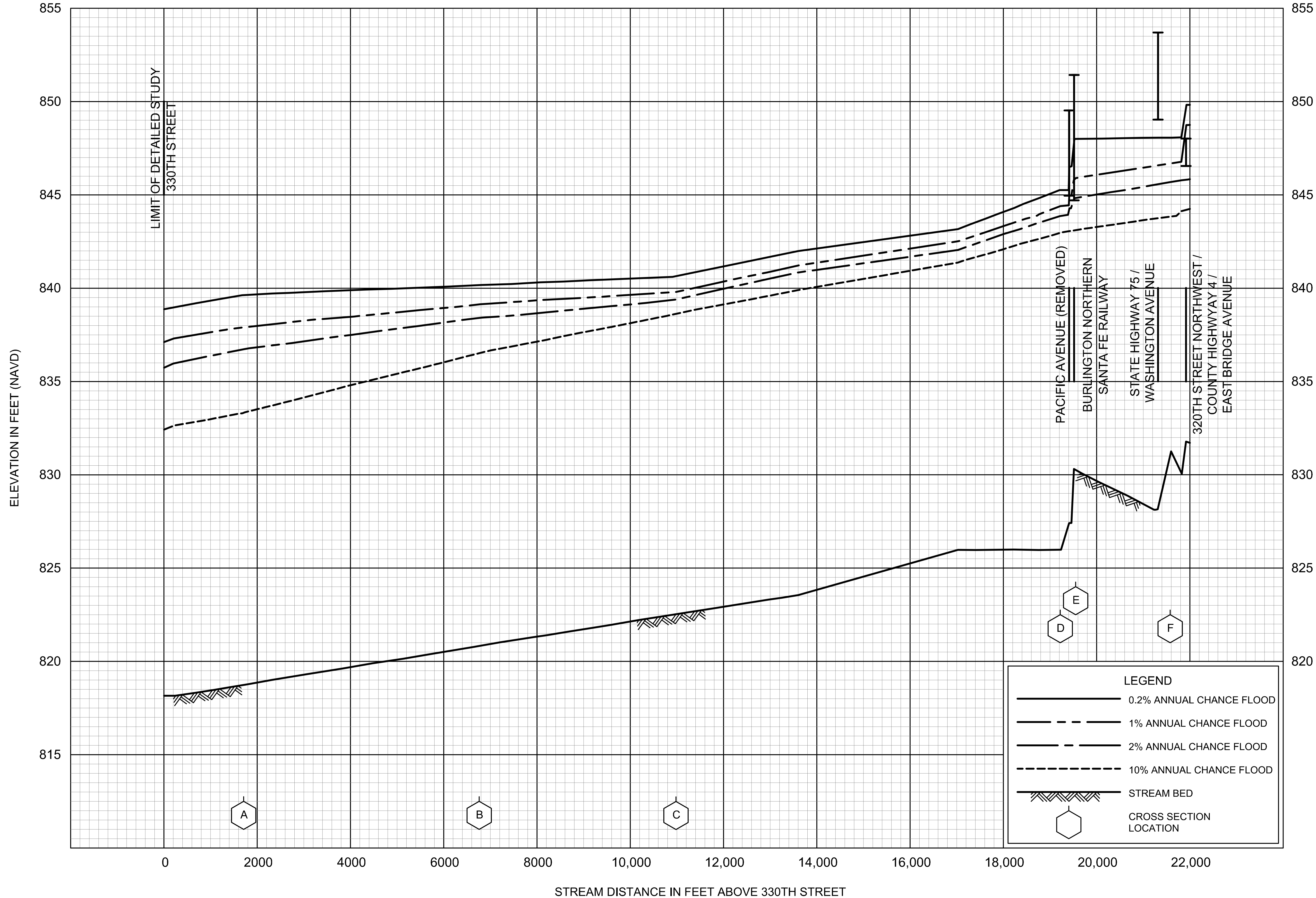


FLOOD PROFILES

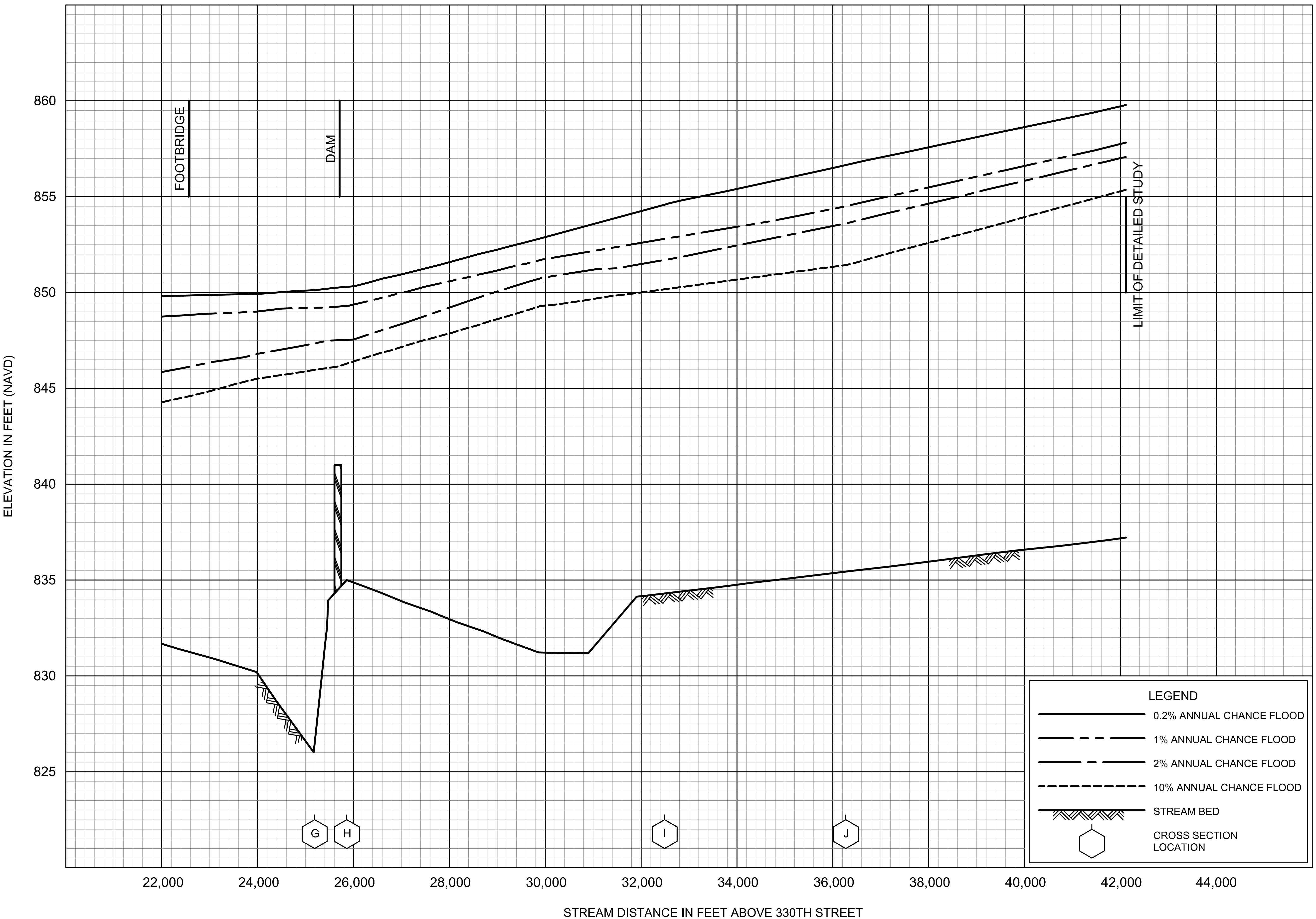
MIDDLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS

01P



FLOOD PROFILES

MIDDLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

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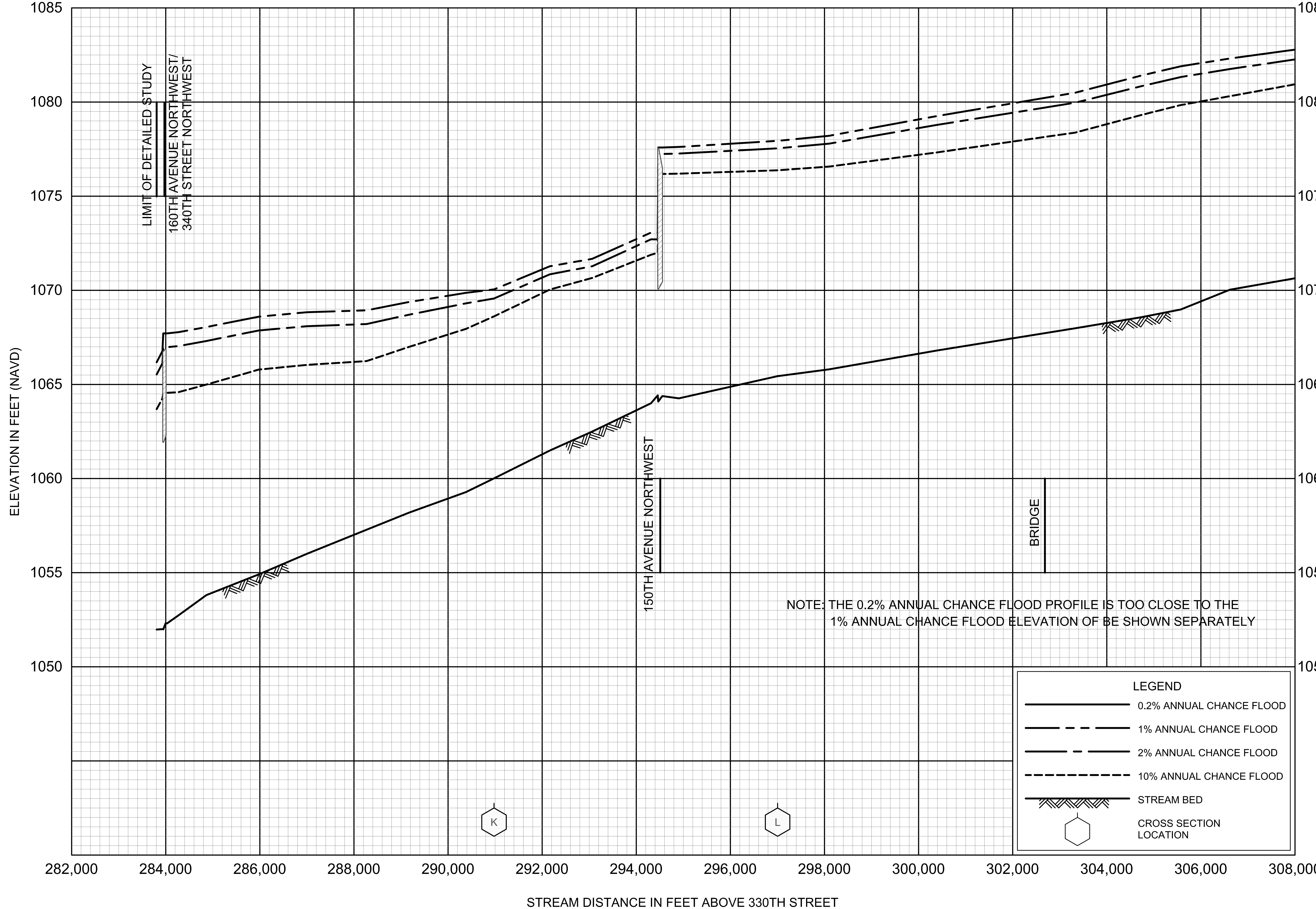

FLOOD PROFILES

MIDDLE RIVER

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MARSHALL COUNTY, MN

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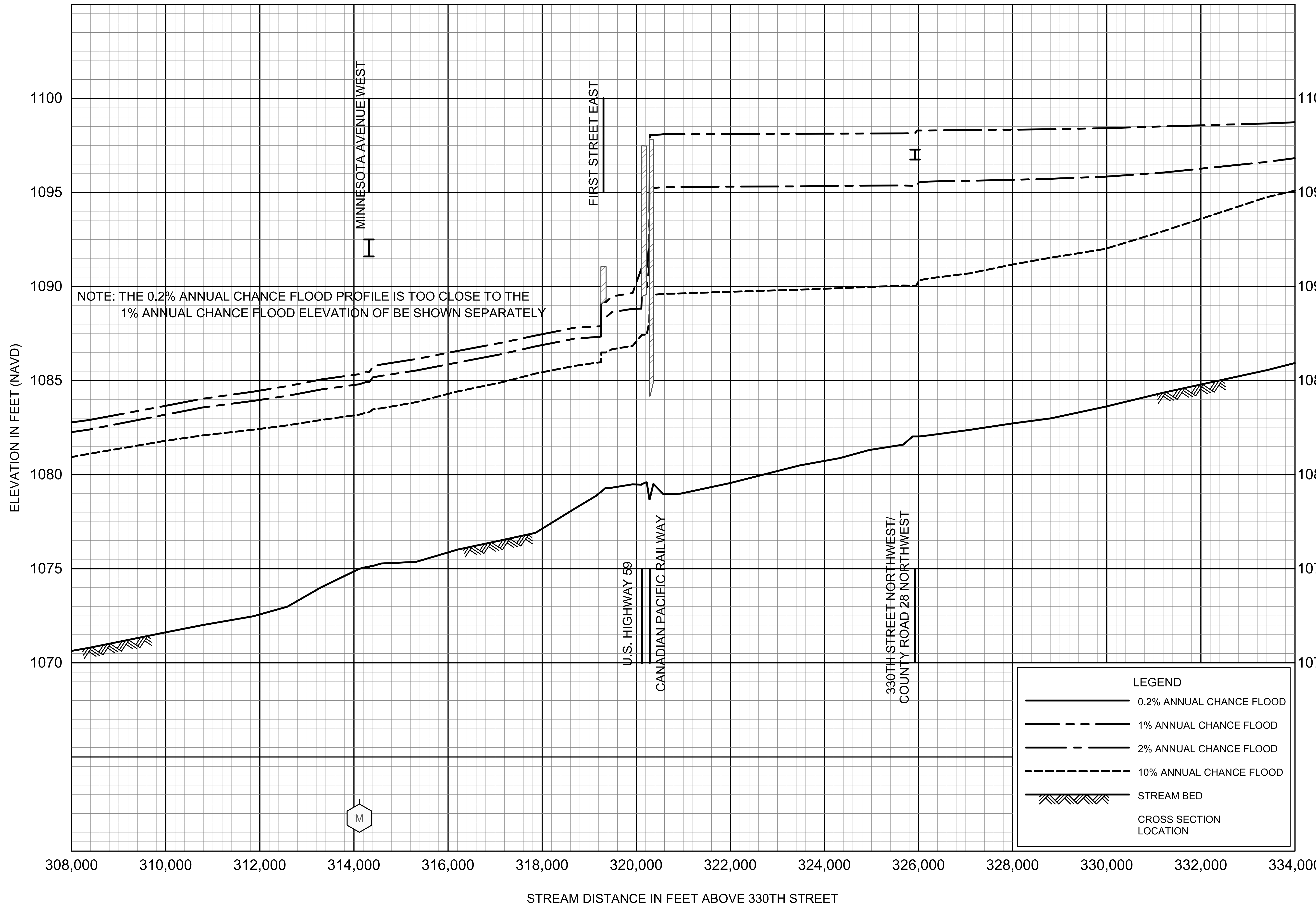


FLOOD PROFILES

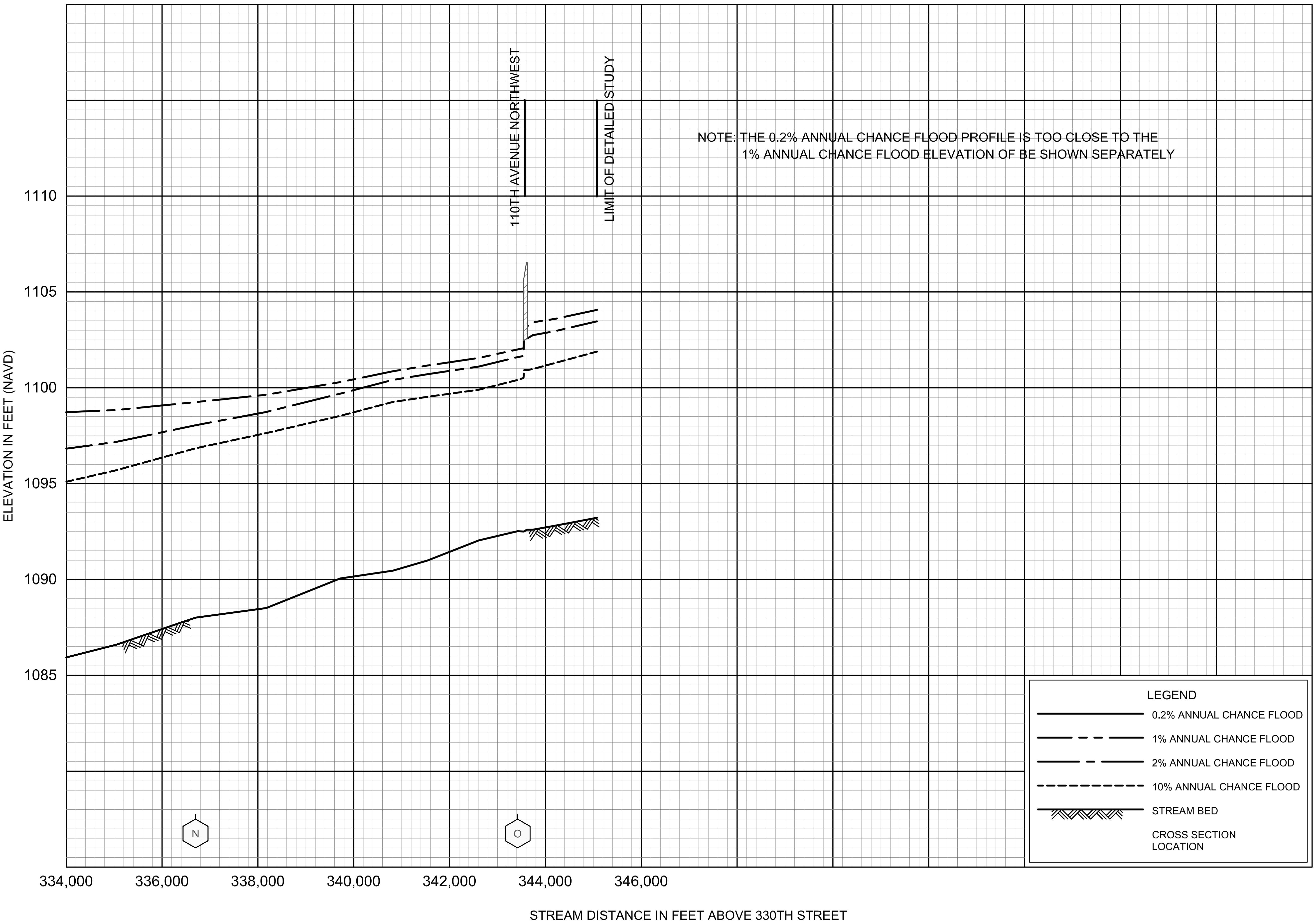
MIDDLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS

04P



FLOOD PROFILES

MIDDLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

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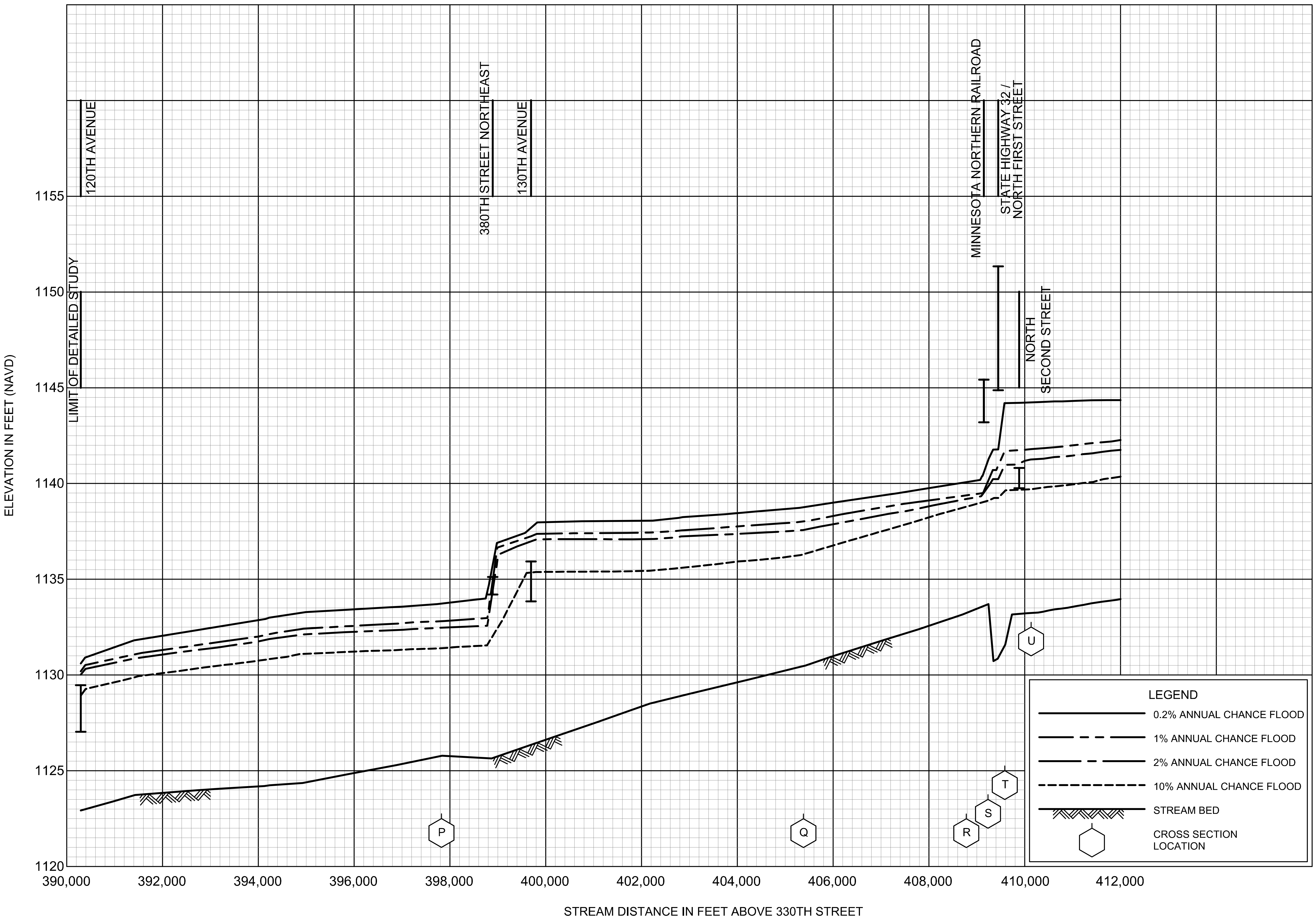

FLOOD PROFILES

MIDDLE RIVER

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MARSHALL COUNTY, MN

AND INCORPORATED AREAS

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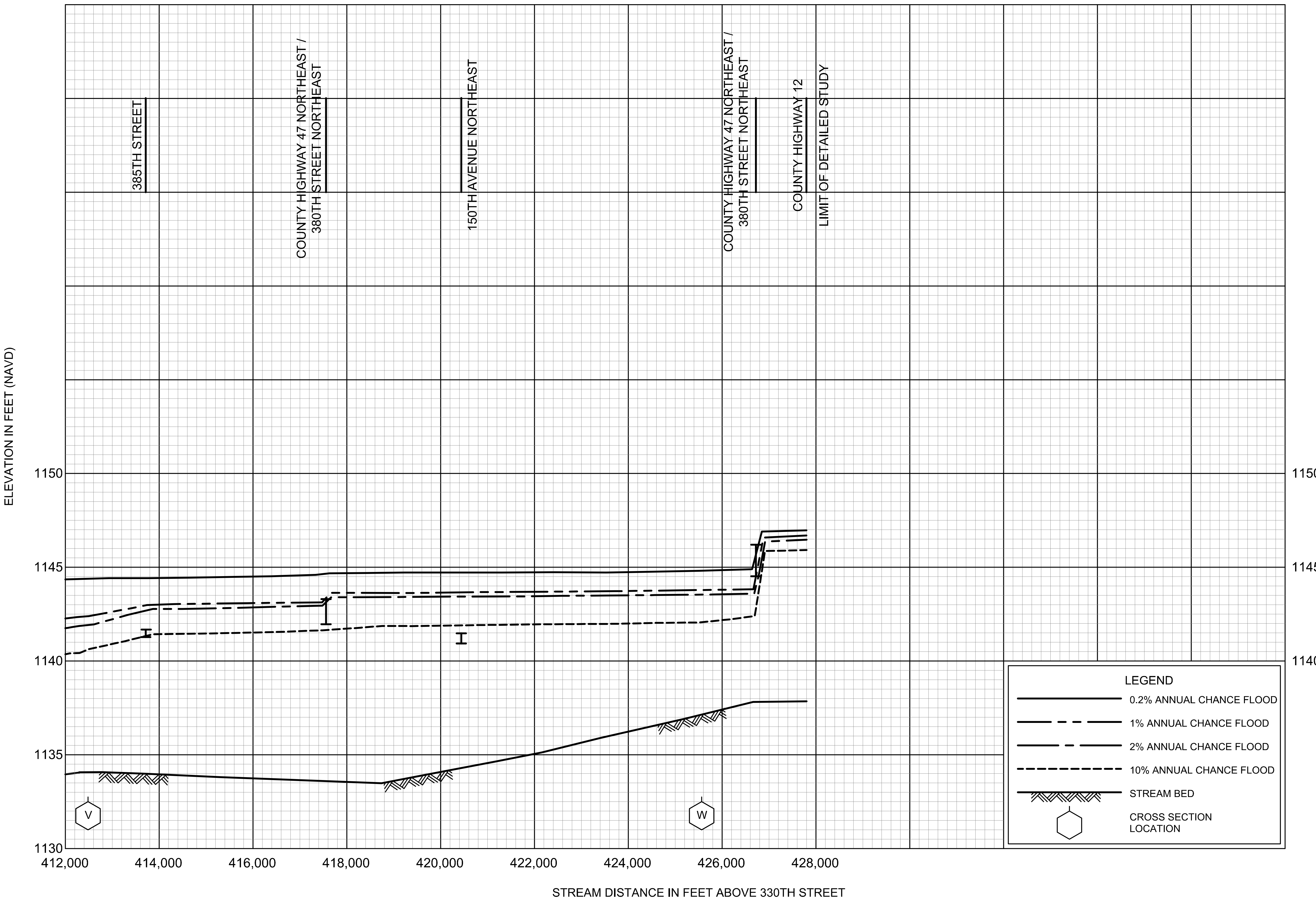

FLOOD PROFILES

MIDDLE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS

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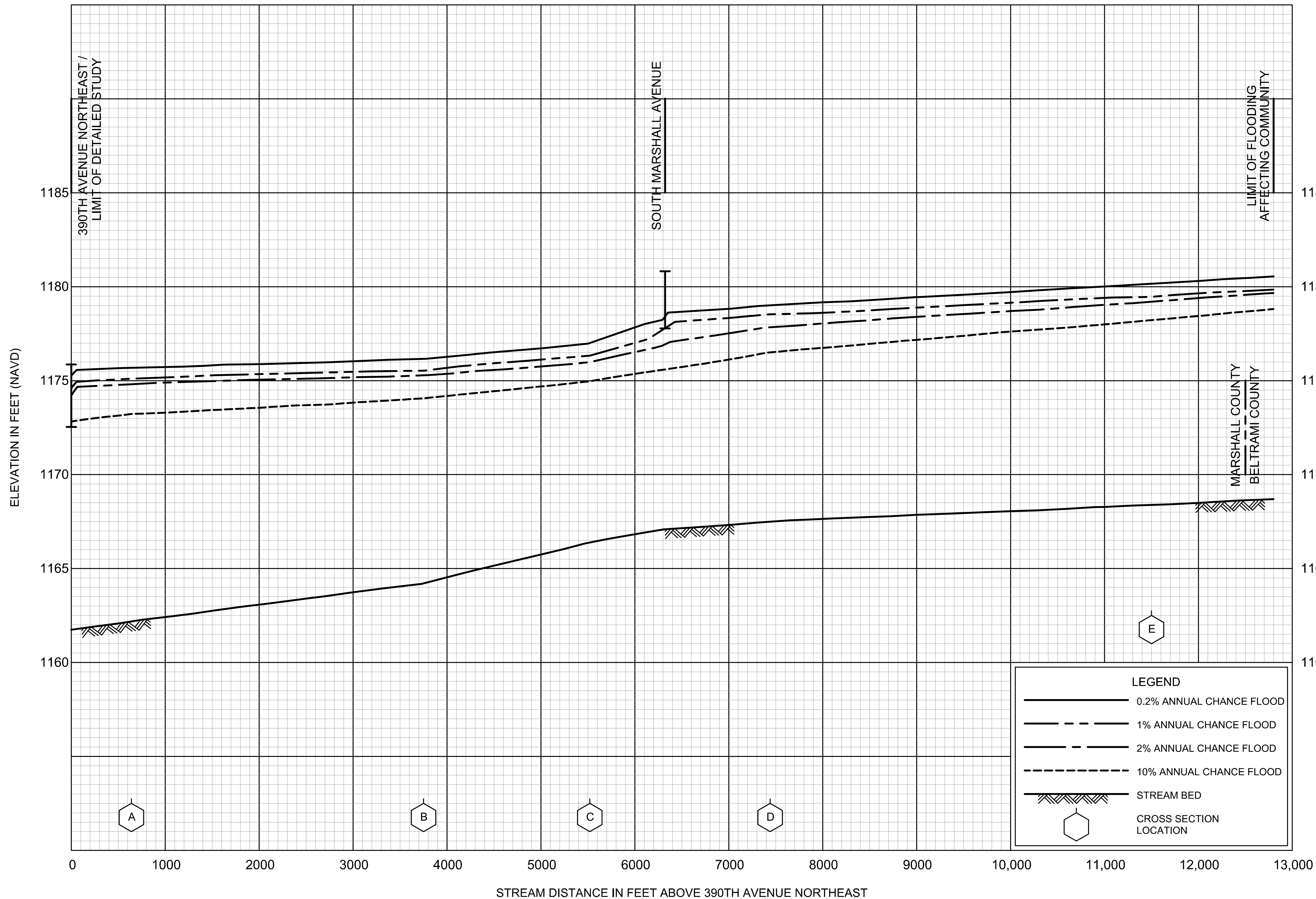


FLOOD PROFILES

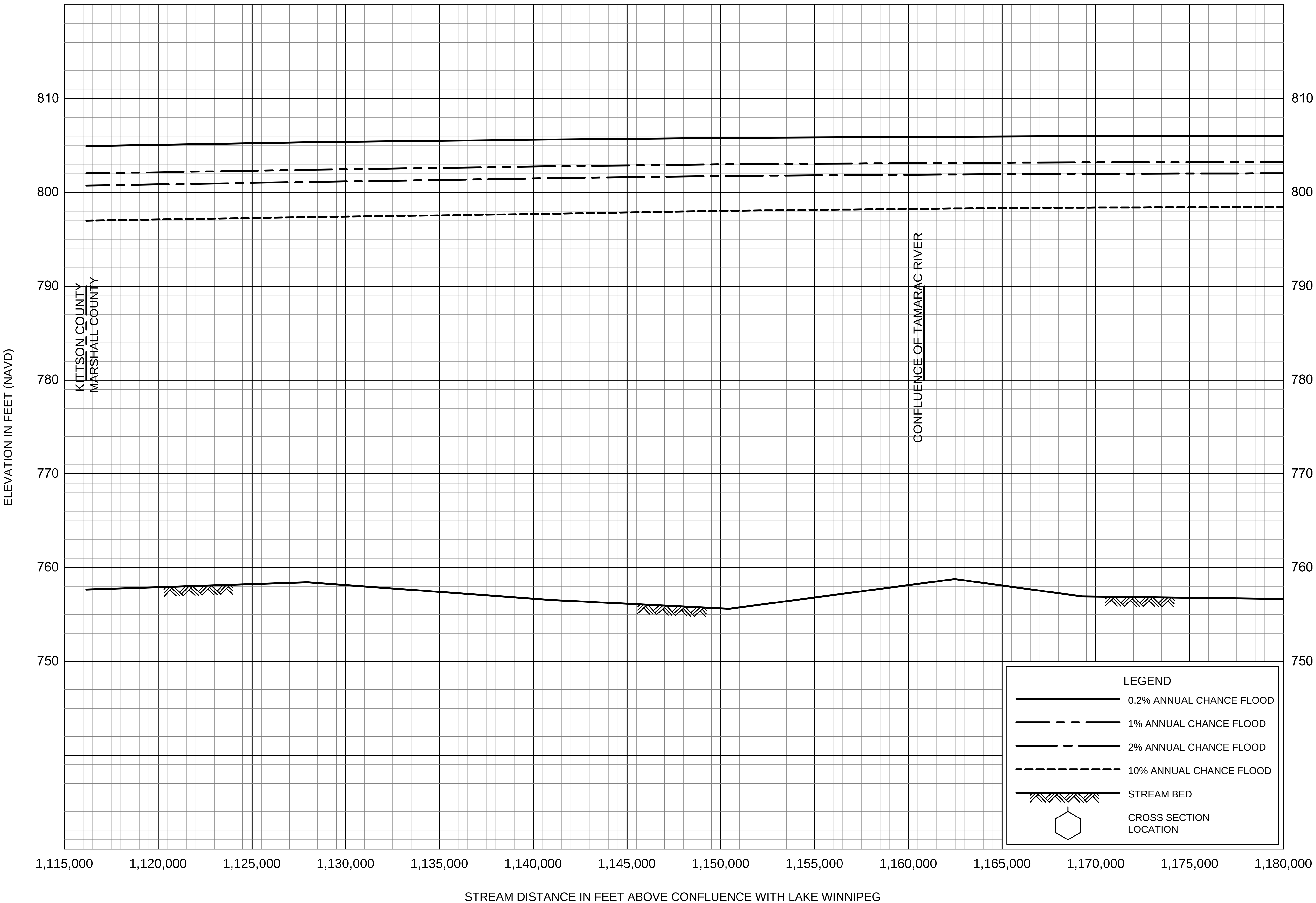
MUD RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS

08P



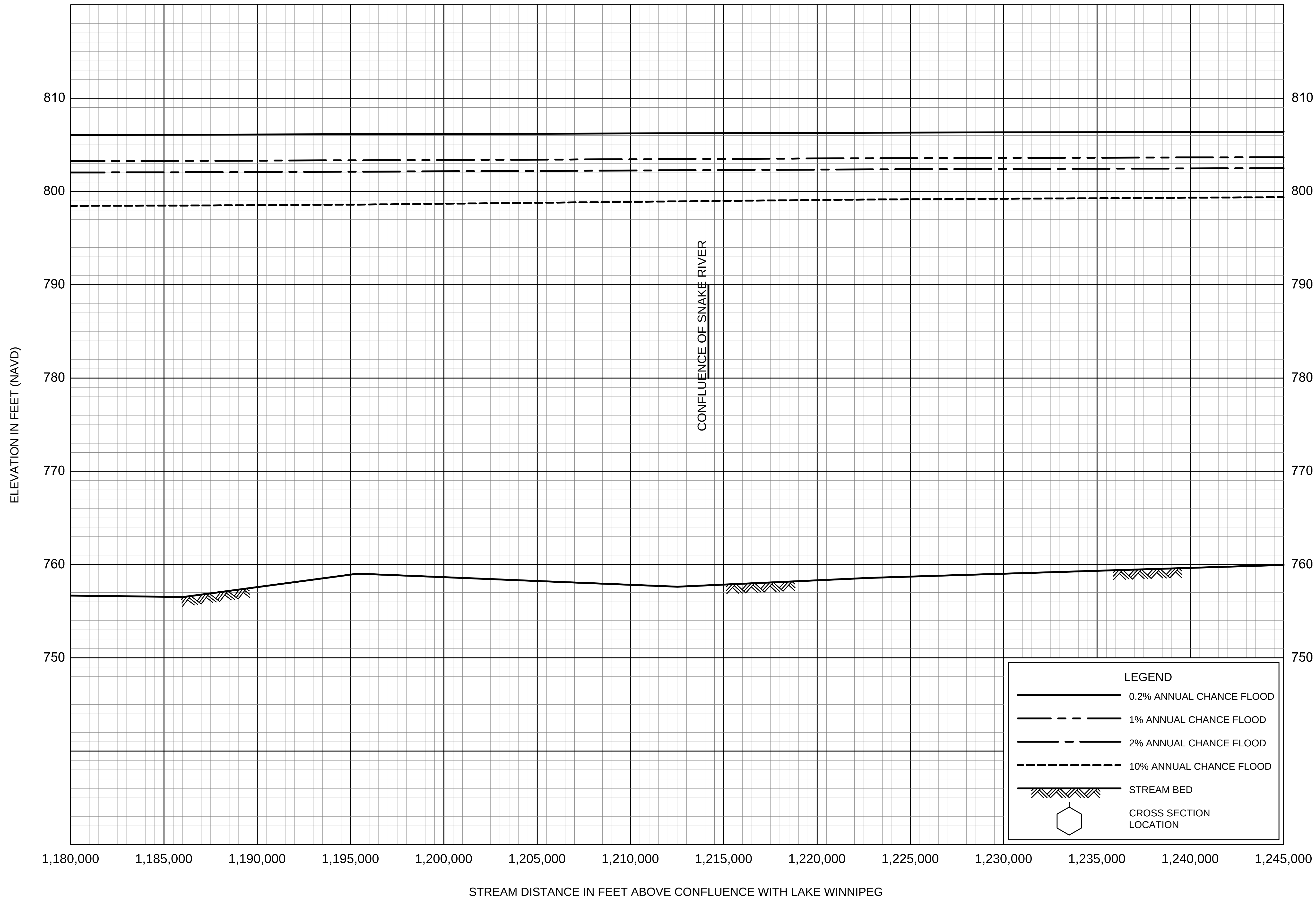
FLOOD PROFILES

RED RIVER OF THE NORTH

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



FLOOD PROFILES

RED RIVER OF THE NORTH

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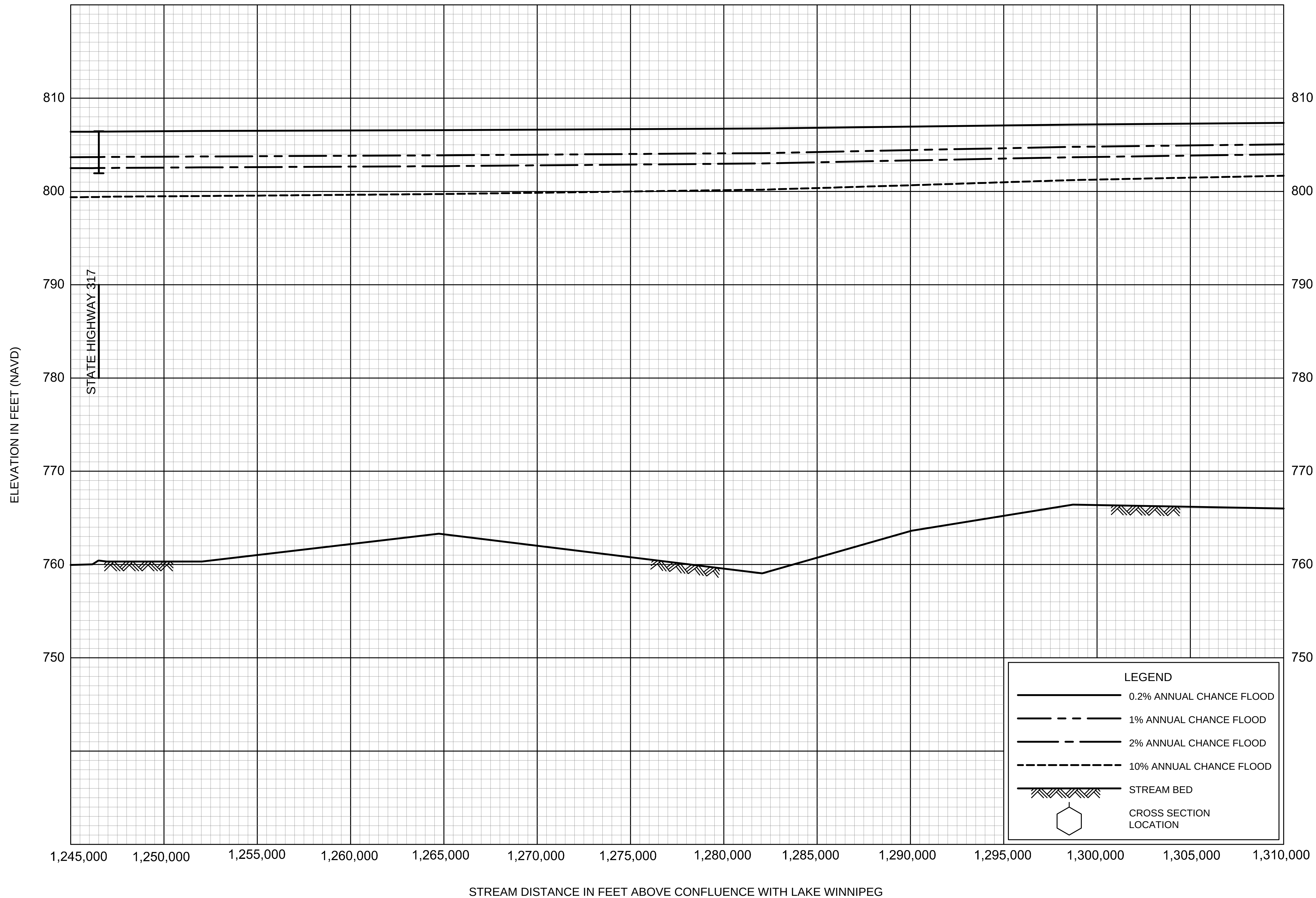

FLOOD PROFILES

RED RIVER OF THE NORTH

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MARSHALL COUNTY, MN

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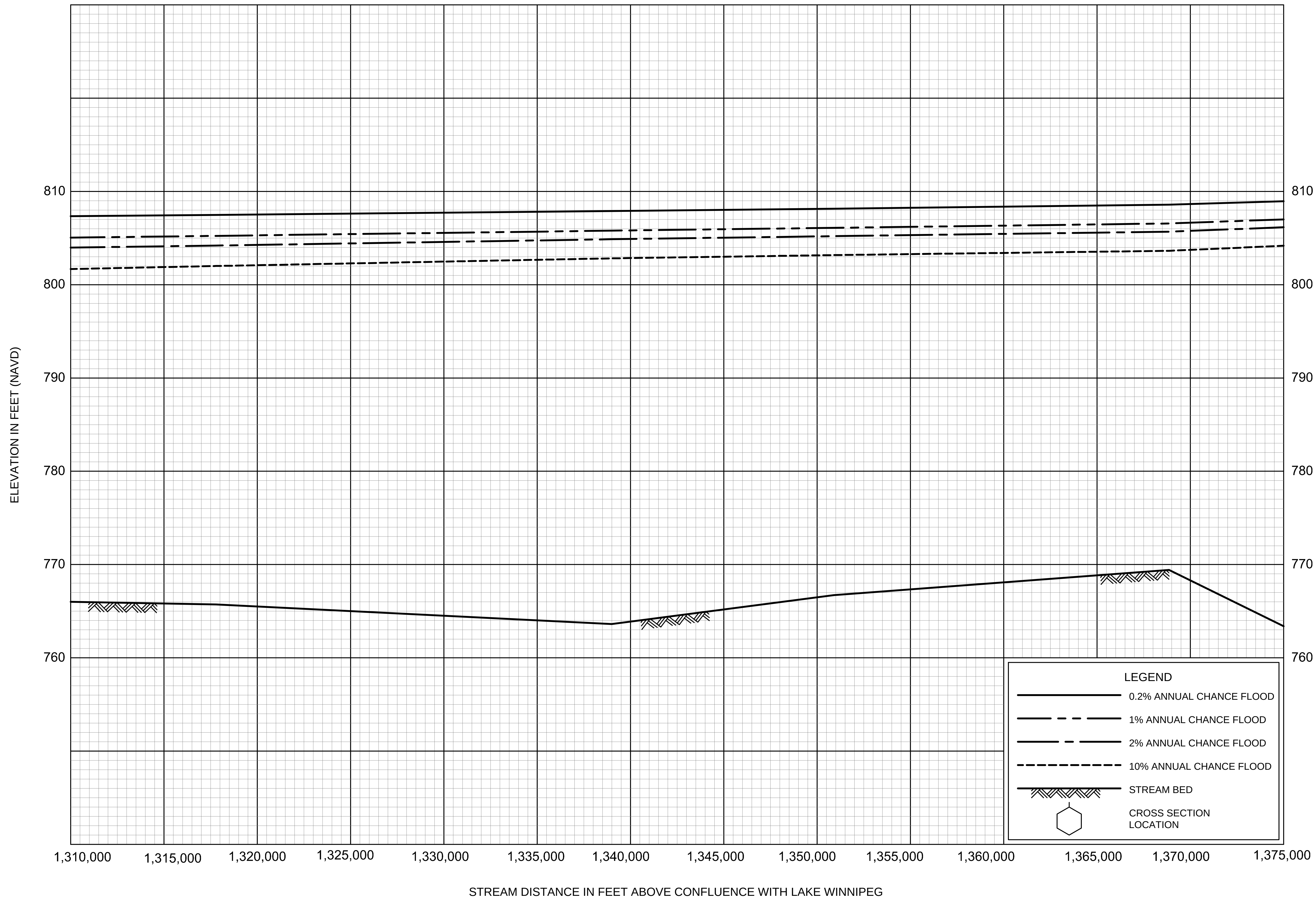

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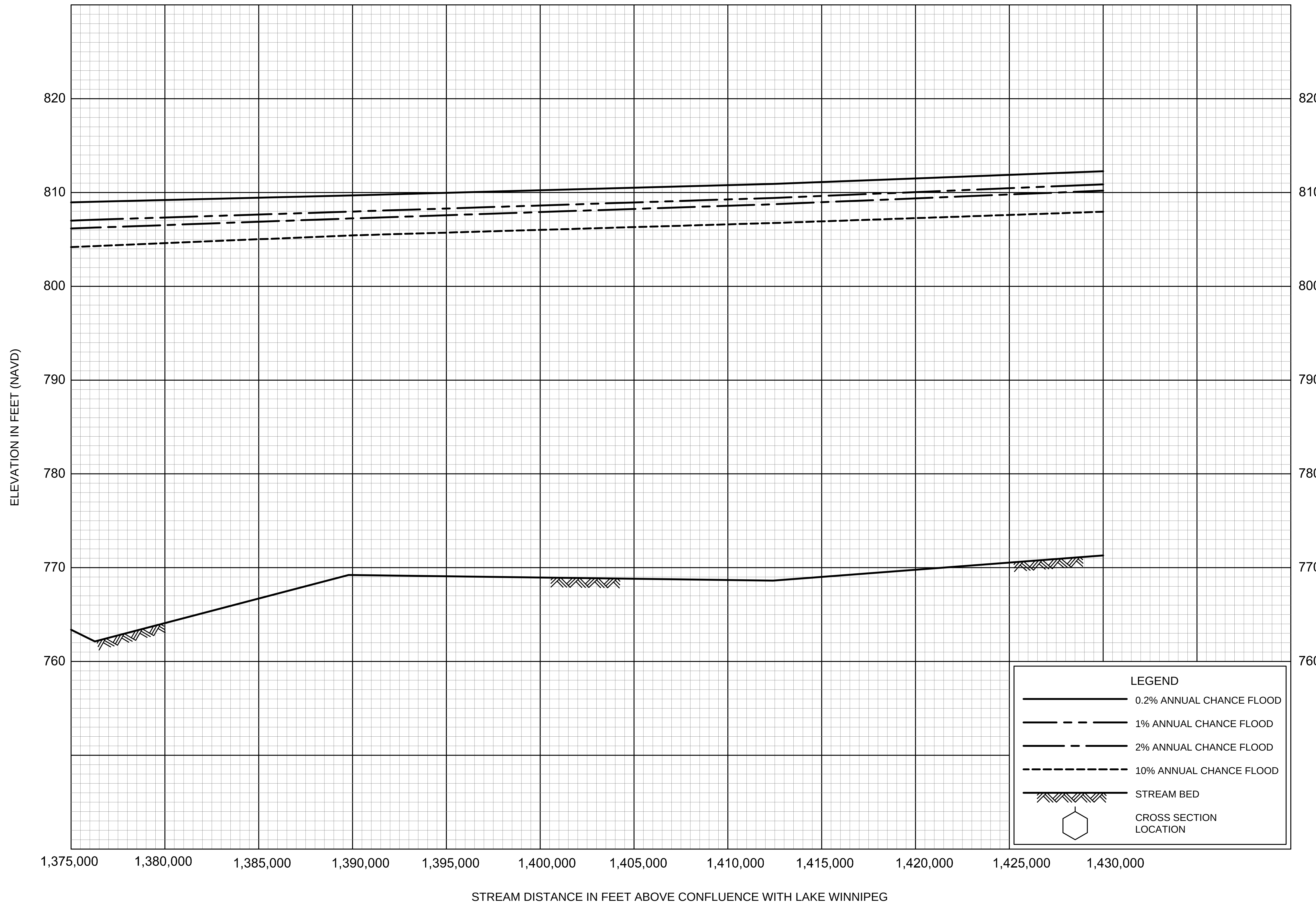

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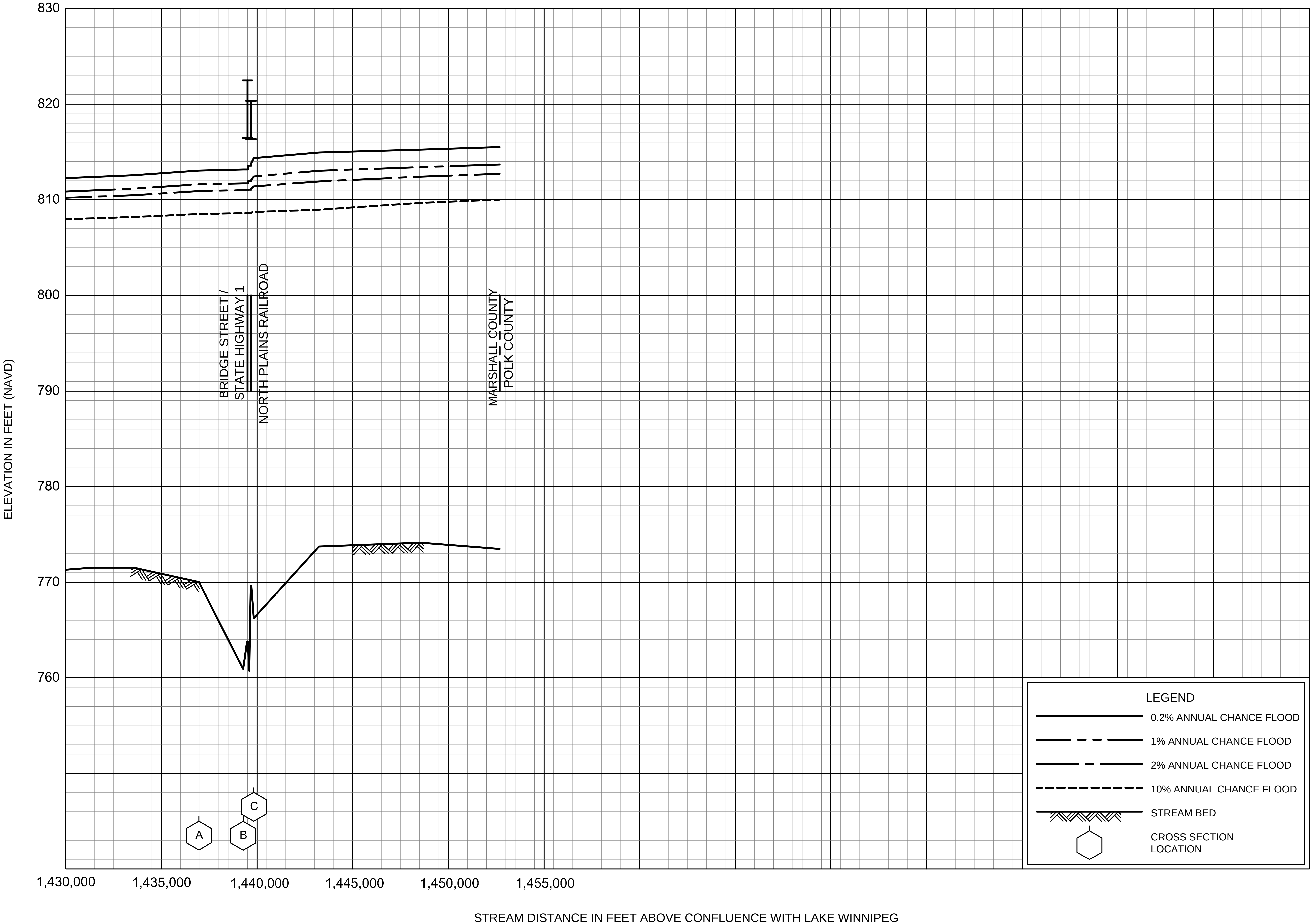

FLOOD PROFILES

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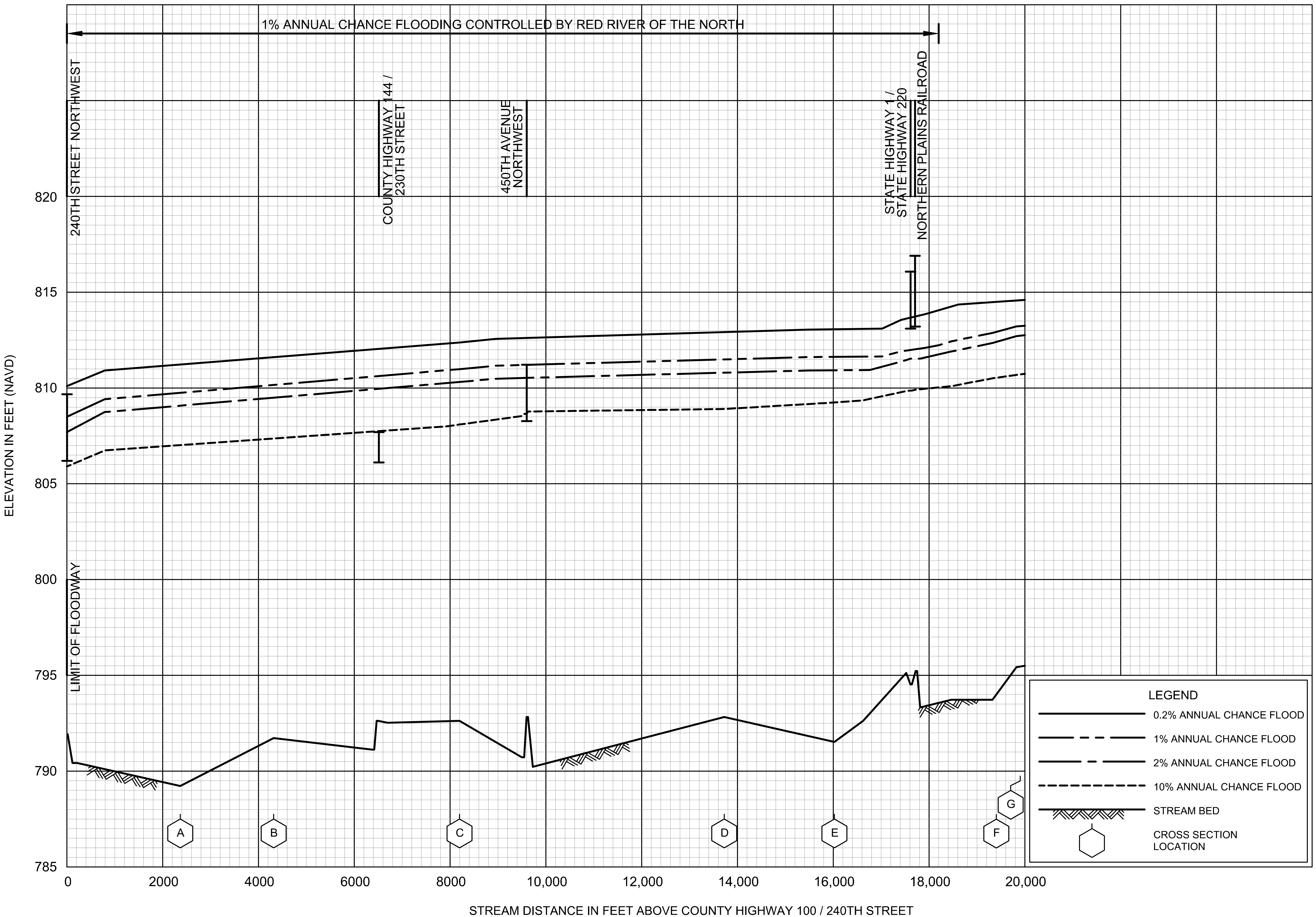


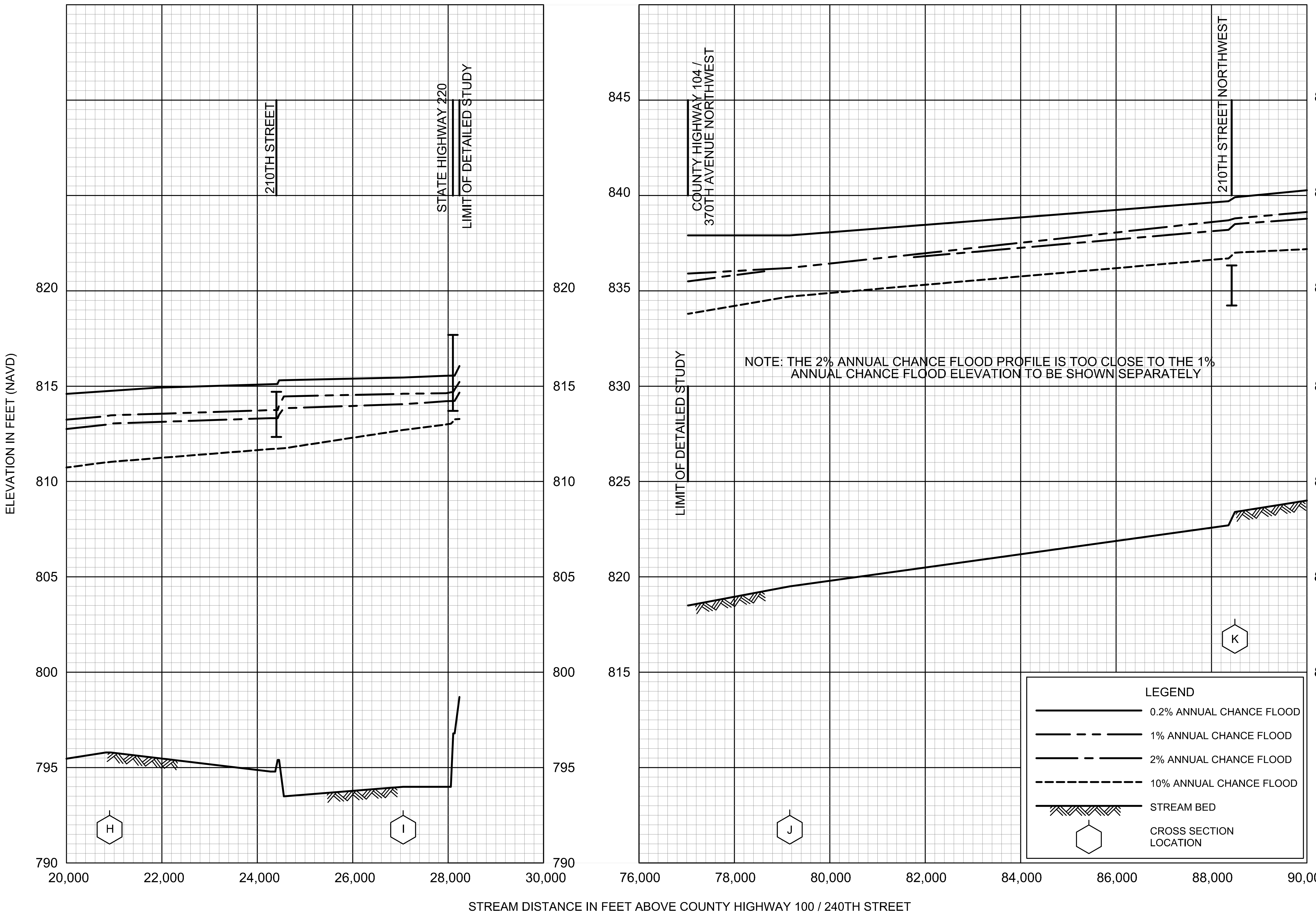
FLOOD PROFILES

SNAKE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



FLOOD PROFILES

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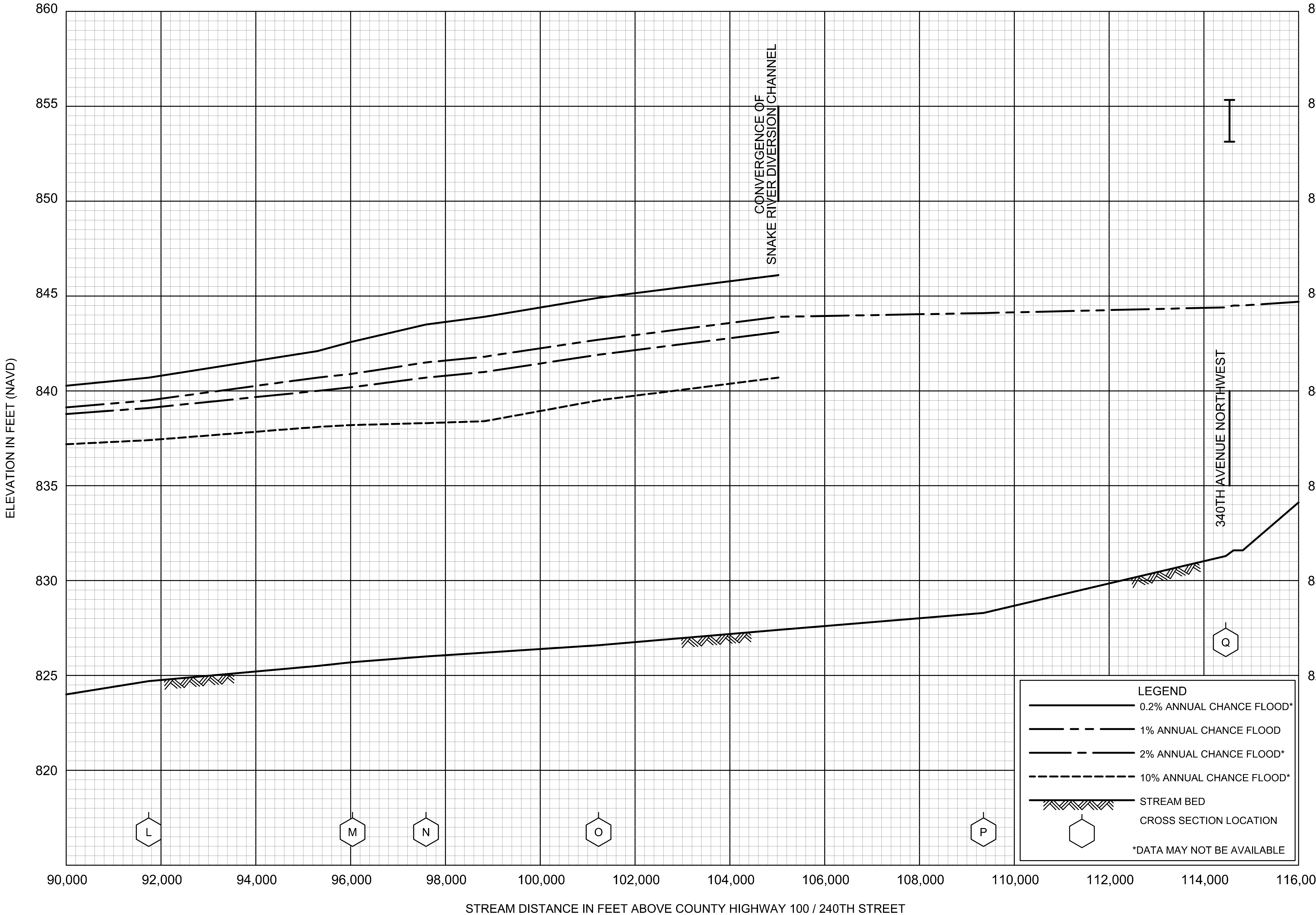

FLOOD PROFILES

SNAKE RIVER

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MARSHALL COUNTY, MN

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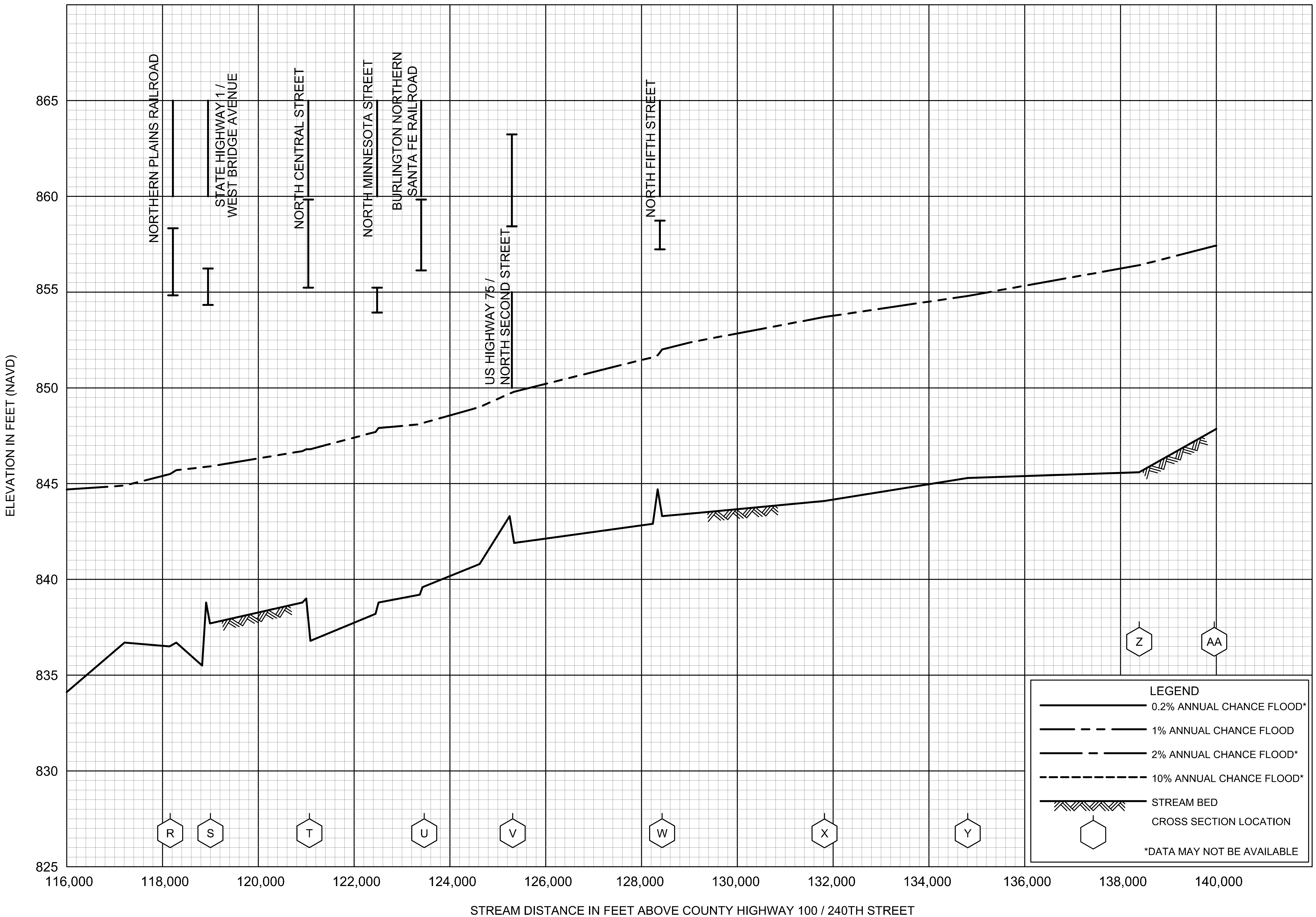

FLOOD PROFILES

SNAKE RIVER

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MARSHALL COUNTY, MN

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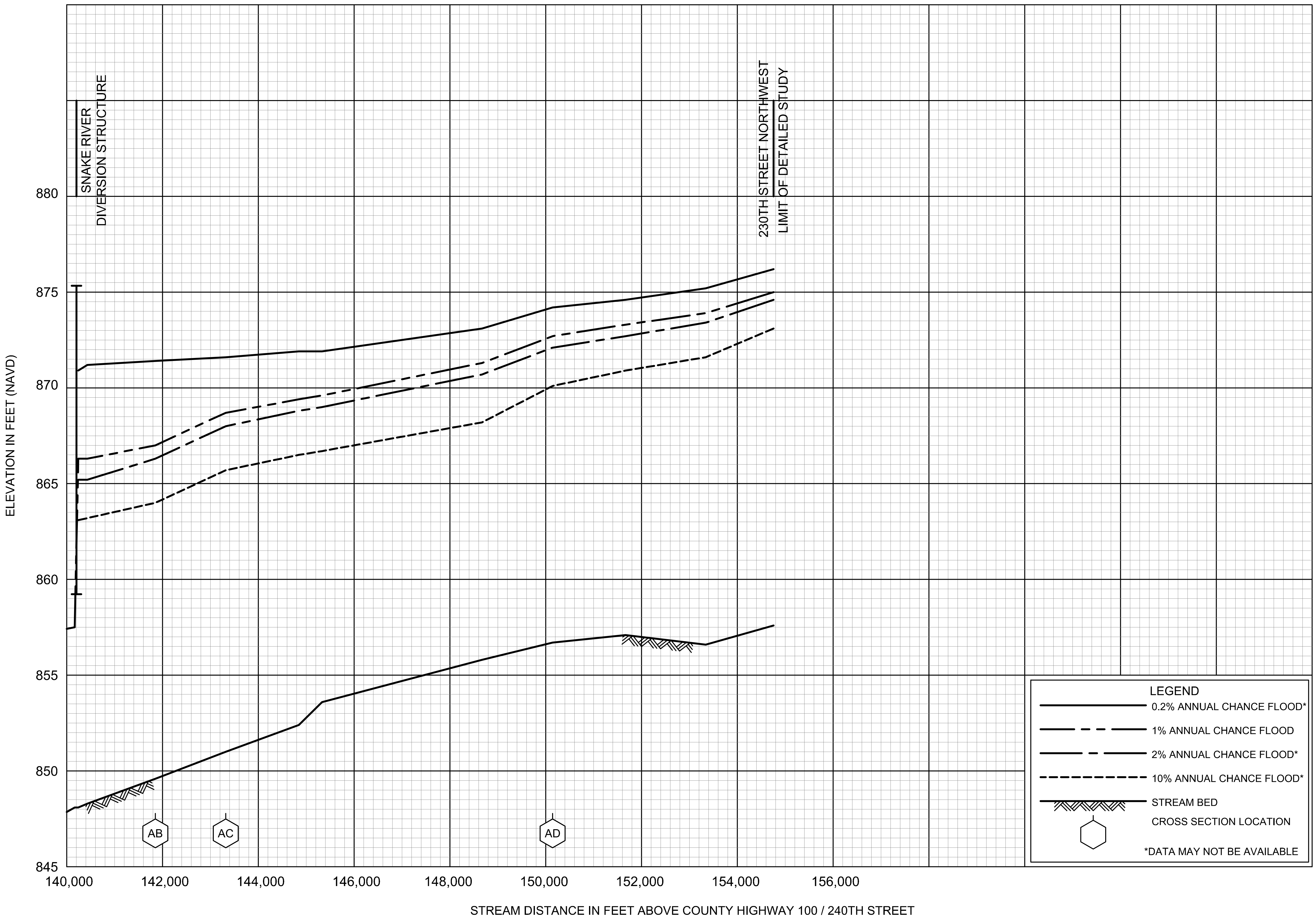

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SNAKE RIVER

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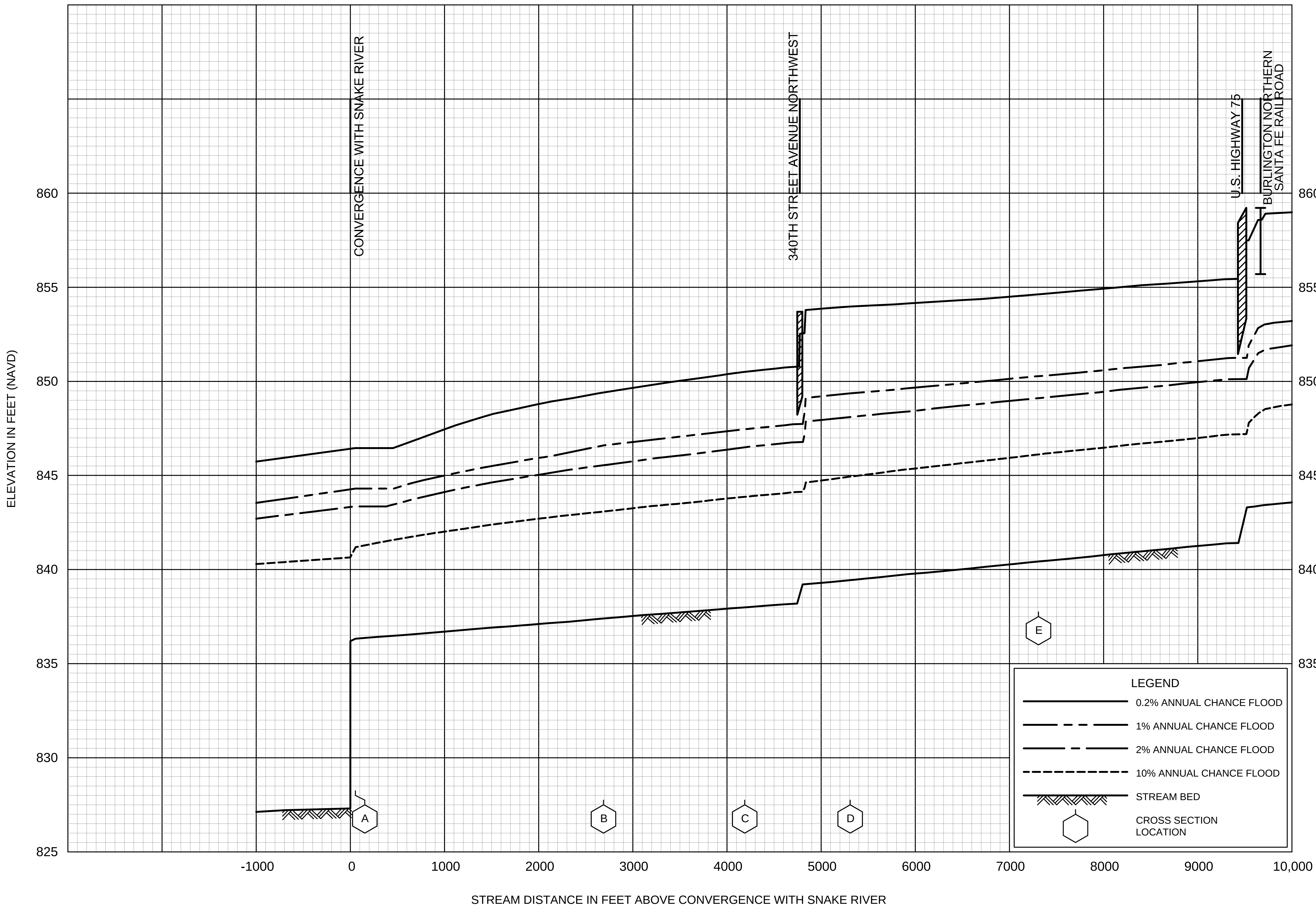


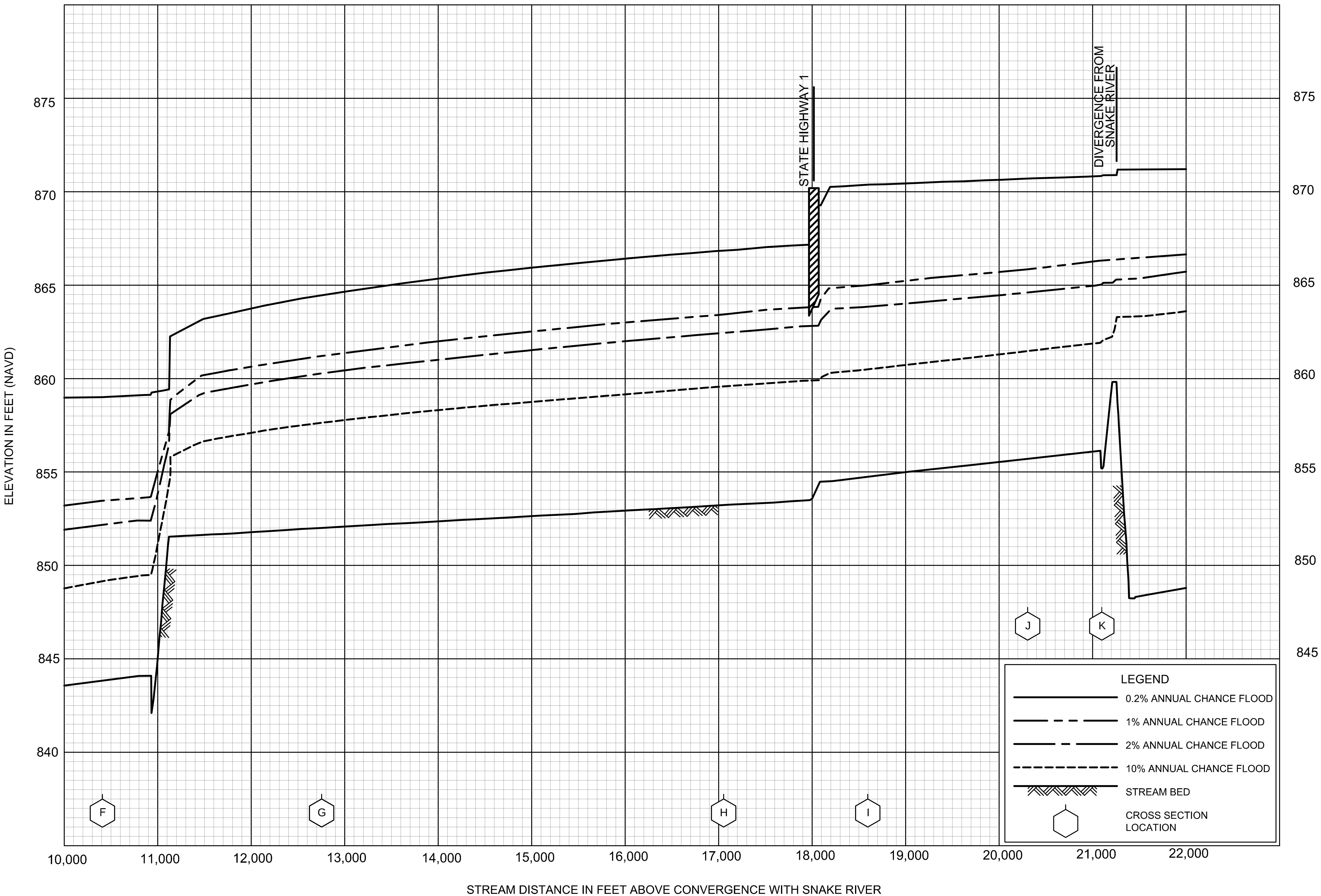
FLOOD PROFILES

SNAKE RIVER DIVERSION CHANNEL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



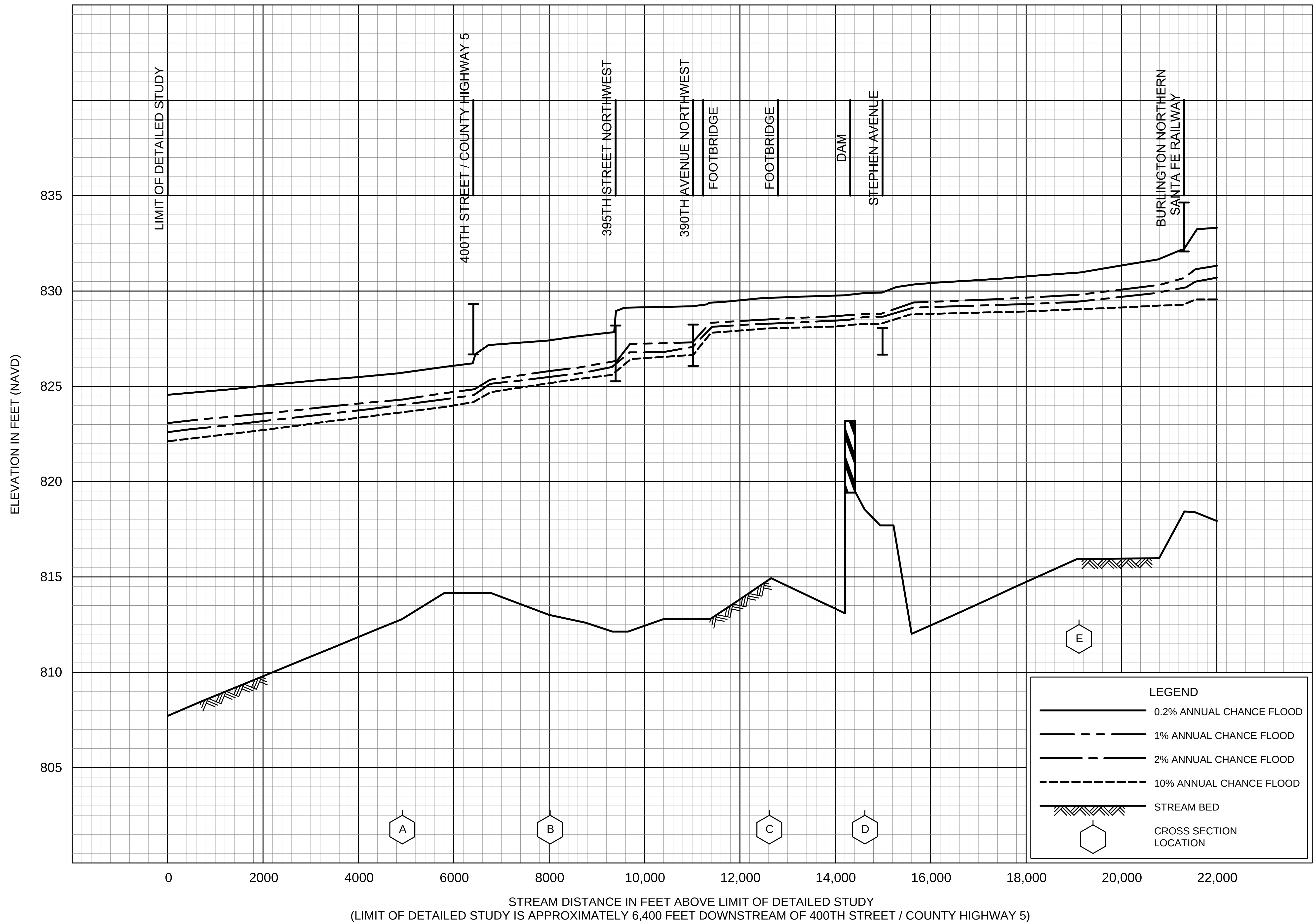
FLOOD PROFILES

SNAKE RIVER DIVERSION CHANNEL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



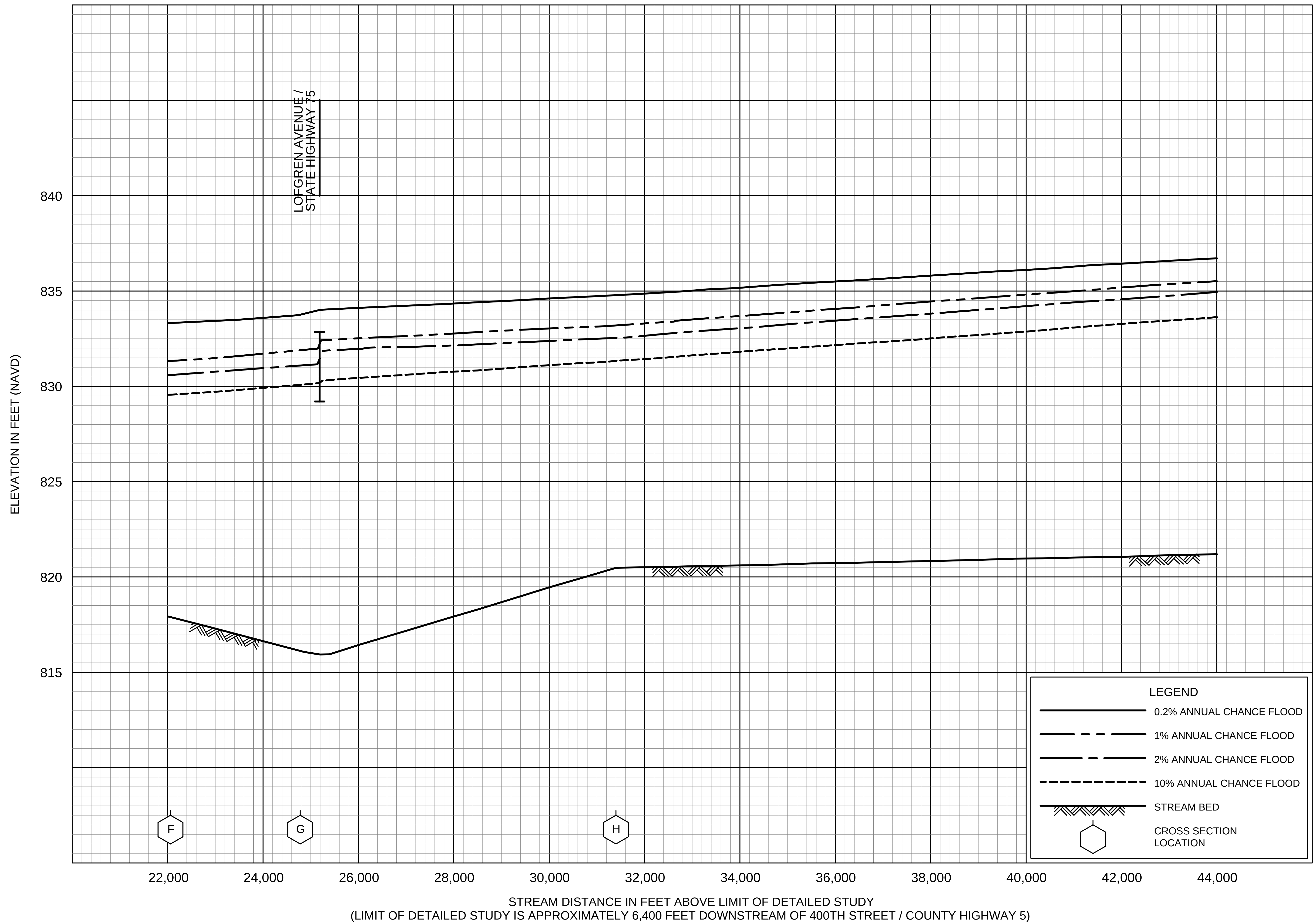
FLOOD PROFILES

TAMARAC RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



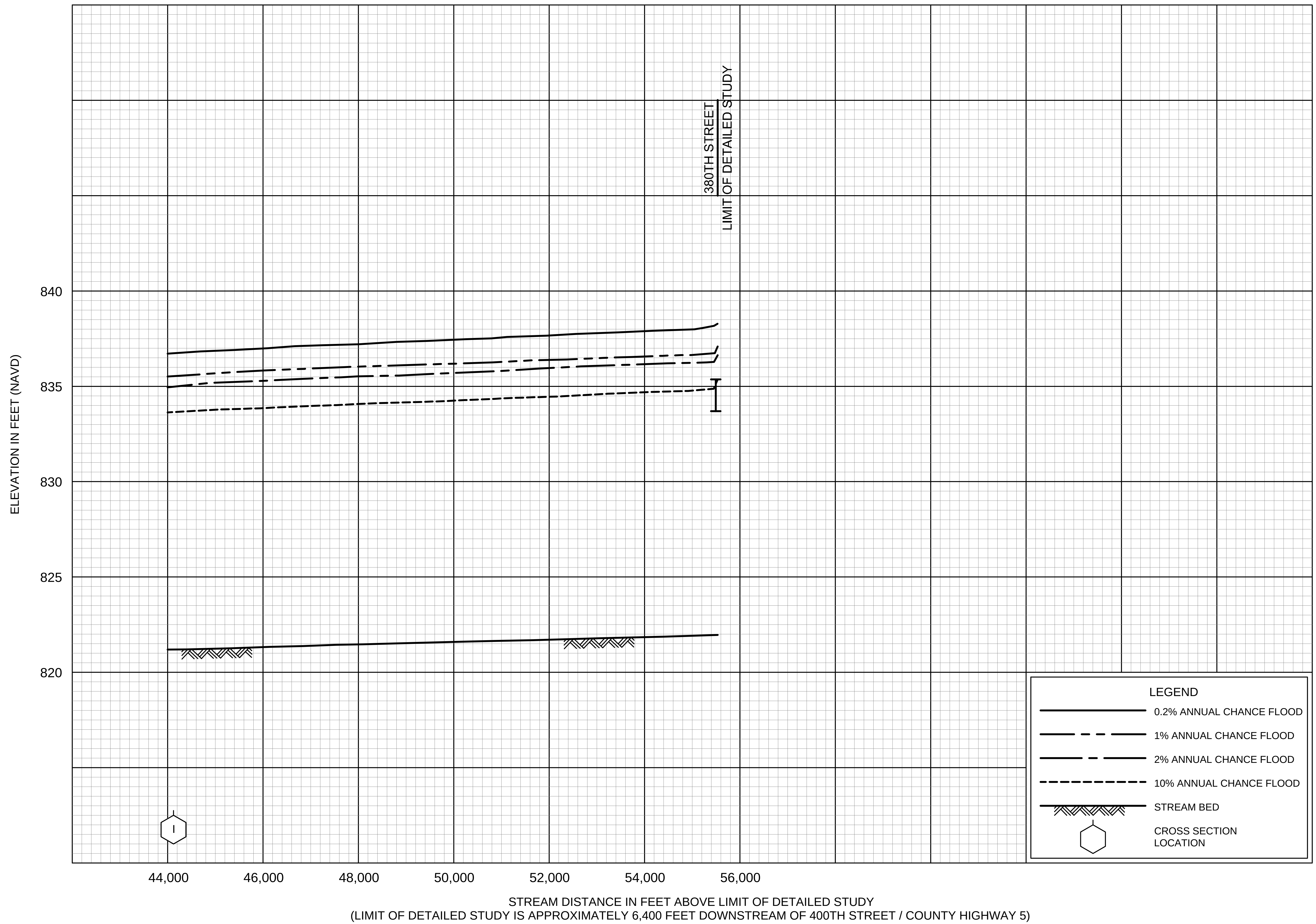
FLOOD PROFILES

TAMARAC RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS



FLOOD PROFILES

TAMARAC RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARSHALL COUNTY, MN

AND INCORPORATED AREAS