BROWNS VALLEY FLOOD MITIGATION PROJECT

ENGINEER'S REPORT

Prepared For:
Upper Minnesota River Watershed District
342 NW 2nd Street
Ortonville, MN 56278

Prepared By:
Houston Engineering, Inc.
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January 2008

PRELIMINARY ENGINEER'S REPORT
Browns Valley Flood Mitigation Project
Upper Minnesota River Watershed District
342 N.W. Second Street
Ortonville, Minnesota 56278

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Brent H. Johnson	Mark R. Deutschman
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Date: January 17, 2008

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Project No. 5304-002

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SECTION 1.0
INTRODUCTION

1.1 OVERVIEW AND REPORT PURPOSE

The March 2007 flood caused substantial damages to the City of Browns Valley, Minnesota (the "City") placing severe social and economic hardship on the residents and the community. Unfortunately, the spring 2007 flood is one of several documented floods dating back to the early 1940's that have affected Browns Valley. Although several studies evaluating flood mitigation solutions were completed by a variety of agencies, earlier efforts to implement a permanent flood mitigation project proved unsuccessful.

The City working cooperatively with Traverse County, Minnesota (i.e., the County) intends to plan, design and construct a permanent flood mitigation solution. The City and the County requested technical assistance to evaluate the various permanent flood mitigation solutions from the Upper Minnesota River Watershed District (UMRWD) in August 2007 (see **Appendix A**). The UMRWD agreed to evaluate the various flood mitigation solutions and to assume responsibility for leading the planning, design and construction effort on behalf of the City and the County. The UMRWD retained Houston Engineering, Inc. to provide technical assistance for the completion of the Browns Valley Flood Mitigation Project in August 2007.

The UMRWD initiated a watershed district project in accordance with Minnesota Statute (MS) 103D by majority resolution of the Board of Managers on August 14, 2007. The process described by MS 103D requires the preparation of an "Engineer's Report" (see MS 103D.711). Based upon MS 103D.711 the Engineer's Report must include findings and recommendations about the proposed project, including a determination of whether the Engineer finds the project feasible and a plan for the proposed project. The minimum plan content must include:

- a map of the project area drawn to scale, showing the location of the proposed improvements, if any. The map must include (as applicable):
    - the location and adequacy of the outlet, if the project is related to drainage;

- the watershed of the project area;
- the location of existing highways, bridges, and culverts;
- the property, highways, and utilities affected by the project with the names of the known property owners;
- the location of public land and water affected by the project; and
- other physical characteristics of the watershed necessary to understand the area

- the estimated total cost of completing the project including construction, operation, implementation, supervision, and administrative costs;
- the acreage required as right-of-way listed by each lot and 40-acre tract or fraction of the lot or tract under separate ownership, if required to implement the project; and
- other details and information to inform the Managers of the practicability and necessity of the proposed project with the Engineer's recommendations on these matters.

The Engineer's Report can include additional details at the discretion of the Engineer as needed for the determination of feasibility. This report presents information relevant to the Browns Valley Flood Mitigation Project and serves as the Engineer's Report in accordance with MS 103D.711. Expectations are that following selection of the preferred flood mitigation solution by the Board of Managers, additional more detailed information specific to design, construction and environmental issues will be prepared.

1.2 GENERAL DESCRIPTION OF THE PROBLEM

The City is located within a unique geologic setting, which leads to a heightened susceptibility to flooding. The City is located essentially on a glacial outwash plain, at the continental divide between the Red River of the North and the Minnesota River. The Red River flows north to Lake Winnipeg, whereas the Minnesota River flows to the Mississippi River (which flows south to the Gulf of Mexico). Two water bodies contribute to flooding within the City; i.e., the Little Minnesota River and an unnamed coulee (coined "Toelle Coulee") located just northeast of the City (see **Figure 1-1**).

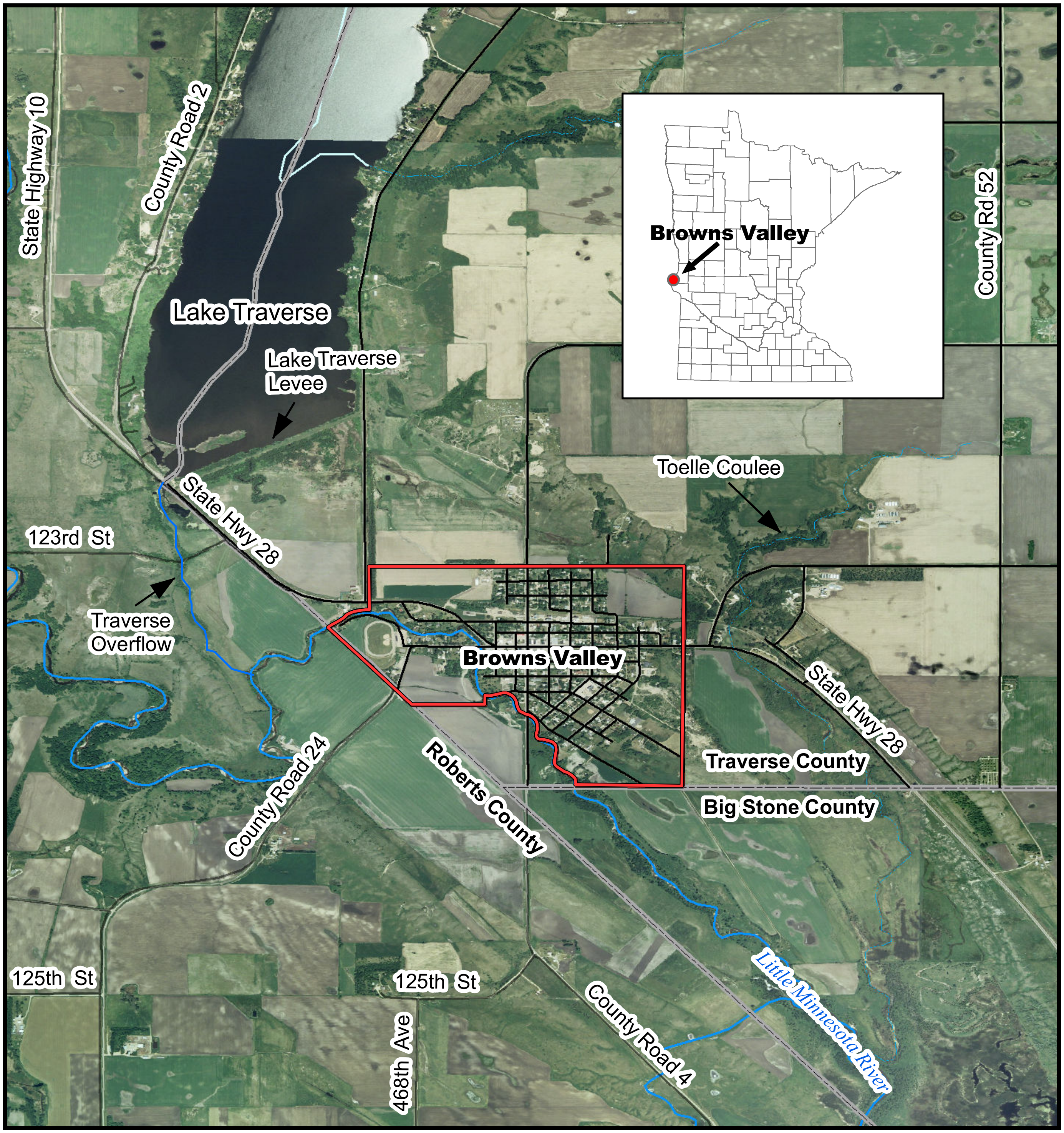

Figure 1-1

General Location Map
Browns Valley Flood Mitigation
Project

Legend

- Roberts Co. Roads
- Traverse County Roads
- City Boundary
- County Boundary

N
W E
S

0.5 0.25 0 0.5 Miles

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The origin of both of these water bodies is relatively steep terrain associated with the glacial till plain. The terrain tends to lead to "flashy" streams, with high peak flows that overflow the river channel near Browns Valley. Ice during early spring also contributes to the flood problem by raising the water level sufficient to leave the banks of the Little Minnesota River. Man has also changed the landscape by constructing roads, reservoirs, and changing land uses.

1.3 HISTORY OF FLOODING AND PREVIOUS EFFORTS TO ADDRESS FLOODING

Browns Valley has a long history of flooding. The causes and effects of flooding in the city are many and have changed through time as the watershed has evolved. Many documents exist; addressing flooding issues as they are related to the regional geology, hydrology, topography, and infrastructure (see **Appendix B**). This section provides a general description of historical and physical flooding issues in Browns Valley, as well as previous efforts to address flooding.

1.3.1 General Description of Historic Flooding

The Little Minnesota River discharges into Big Stone Lake which is controlled by Big Stone Dam. Big Stone Lake is the headwaters of the Minnesota River. The Little Minnesota River also passes within approximately 800 yards of Lake Traverse, which outlets to the Bois de Sioux River, which along with the Ottertail River forms the headwaters for the Red River of the North[1]. Following the last ice age, Glacial Lake Agassiz drained south for a period through the Glacial River Warren. This river formed the valley of the Minnesota River and the beds of Lake Traverse and Big Stone Lake. The valley of the River Warren is about 1 mile wide and 130 feet deep near Browns Valley. The Little Minnesota River flows from the coteau in South Dakota to Big Stone Lake, and the river flows through the valley of the River Warren from near Browns Valley to Big Stone Lake. Where the Little Minnesota River enters the valley of the River Warren the channel slope decreases from about 8 feet per mile (near the Peaver Gage) to about 2

[1] Report: Browns Valley Dike, History and Potential for Interbasin Flow. Kenton Spading, U.S. Army Corps of Engineers, July 1999, Revised January 2000.

feet per mile near Browns Valley. Over time an alluvial fan has developed where the Little Minnesota River enters the valley of the River Warren.

Floodwaters from the Little Minnesota River have historically overflowed on the alluvial fan[2] area at the Valley entrance west of Browns Valley. This alluvial fan has developed over thousands of years where the Little Minnesota River enters the glacial outwash channel (Glacial River Warren). Some overflows go south and others north across the continental divide and into Lake Traverse. High water in Lake Traverse can also cause water to discharge the opposite way into the Little Minnesota River in rare instances.

Floods on the Little Minnesota River have historically resulted from excessive spring snowmelt runoff—often occurring along with ice jams on the river, and from runoff stemming from intense summer rainfalls. **Table 1-1** lists recorded historic floods in Browns Valley and corresponding peak discharges at the USGS gage near Peever, South Dakota.

Another potential source of flooding is Toelle Coulee, located northeast of Browns Valley. The city experienced serious flooding in June 1965, which resulted from a critical combination of meteorological conditions. During the evening of June 1, 1965, the Lake Traverse area received 4 to 10 inches of rainfall in about one hour. Within the Toelle Coulee watershed, ½ inch of rain fell at about 5 P.M. (saturating the soil). A very intense rainstorm occurred later in the evening from 8:00 to 8:45 P.M. Total rainfall depths within the Toelle Coulee watershed were 3.75 to 5.0 inches. The resulting runoff flowed across saturated ground into the coulee and was impounded to a depth of about 25 feet upstream from the County Highway 2 crossing, at which point it overflowed into the west ditch of the highway and discharged down into the eastern portion of the village.[3]

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[2] Alluvial fans are fan-shaped deposits of water-transported material (alluvium).

[3] Section 205, Flood Control Reconnaissance Report. Unnamed Coulee at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, January, 1966.

Table 1-1

Historic Floods in Browns Valley

Year	Peak Flow (cfs)[4]	Month	Flood influenced by icejams
1943	4,320	March	No
1952	4,730	April	No
1962	3,140	May	No
1965	2,920	June	No
1969	3,270	April	No
1989	N/A	Spring	Yes
1993	N/A	Spring	Yes
1993	8,900	July	No
1995	2,700	March	Yes
1997	3,590	March	Yes
2001	3,180[5]	April	No
2007	4,467[6]	March	Yes

1.3.2 Previous Efforts to Address Flooding

The following paragraphs describe some of the major efforts to address flooding by modifying the natural drainage pattern of the Little Minnesota River. Some of these efforts were very beneficial to their targeted areas, but some also came along with side effects which caused increased flooding risk elsewhere.

1.3.2.1 Browns Valley Dike

One of the most significant infrastructure improvements in the region was the construction of the Browns Valley Dike in 1941. The dike is located on the southern end of Lake Traverse. The dike was part of the Lake Traverse Flood Control Project, a flood control

[4] Browns Valley Dike, History and Potential for Interbasin Flow. Kenton Spading, U.S. Army Corps of Engineers, July 1999, Revised January 2000.
[5] USGS National Water Information System: http://waterdata.usgs.gov/nwis.
[6] Estimated from a single measured high water mark and the existing USGS rating curve.

and water conservation project which also included the construction of Reservation Dam and White Rock Dam. The purpose of the dike was to prevent water from the reservoir from spilling into the Little Minnesota River during an extremely high pool level.[7]

Prior to the construction of the Brown's Valley Dike, floodwaters from the Little Minnesota River could overflow the continental divide and spill northwest into Lake Traverse. However, soon after the construction of the dike in late March and early April of 1943, a large flood occurred on the Little Minnesota River. This flood resulted from the rapid melting of snow and ice jams formed just upstream of Browns Valley. Water overflowing the left bank of the Little Minnesota River discharged toward the north, and unable to follow the natural historical discharge path to Lake Traverse, overtopped Minnesota State Highway No. 28 (TH 28). After crossing this highway, the water was prevented from discharging in to Lake Traverse by the Browns Valley Dike, which caused ponding in the areas south of the dike until the water level overtopped Minnesota State Highway No. 27 (TH 27) to the east. From here the water followed low areas in the north and east part of Browns Valley where it was ponded behind the Great Northern Railway and TH 28, flooding many homes. Not long after this flood, three concrete box culverts were placed through the dike to restore the natural flow path.[8]

1.3.2.2 Raising of Roberts County Road No. 24 (Roberts CR 24)

Another infrastructure project affecting the flood mechanism in the region included the raising of the Roberts County Road No. 24 (Roberts CR 24) (Dakota Street) about 18 inches by the County Highway Department (occurring at unknown *time* prior to 1972). A levee was also constructed beside the Little Minnesota River at the point just upstream of Browns Valley where the river emerges onto the outwash plain. This levee was intended to prevent overbank discharge from damaging the improved road. Before the raising of this road, a significant portion of the flood discharge on the Little Minnesota River could overtop the roadway and discharge southeast to rejoin the river channel downstream of Browns Valley, via the natural overland drainage

[7] Browns Valley Dike, History and Potential for Interbasin Flow. Kenton Spading, U.S. Army Corps of Engineers, July 1999, Revised January 2000.
[8] Review of Report. Minnesota River, Minnesota for Diversion of Floodwaters of Little Minnesota River into Lake Traverse. War Department, United States Engineer Office, St. Paul, Minnesota. 17 September 1945.

system, effectively bypassing the village. Raising the road reduced the frequency of flood discharges which follow this natural bypass, and as a result, increased the extent of flooding to agricultural lands both north and west of the raised road and within the village.[9]

1.3.2.3 Agricultural Levees

Between 1943 and 2007, most of the flooding impacted the southwest side of the City. In both 2007 and 1943, the flood primarily impacted the north side of the city. However, in the 2007 flood caused by an ice jam on the river near the state line west of Browns Valley, significantly more water broke out to the north and exceeded the capacity of the 3 - 9' x 6' culverts leading into Lake Traverse. As in 1943, without the culverts the excess water overtopped both TH 28 and TH 27, and then proceeded to flood the north side of the city, overtopping Traverse County Highway No. 4 (Traverse CSAH 4) and TH 28 again on the east side of town. Some believe that more discharge broke out to the north rather than the south because of the influence of agricultural levees, which flank both sides of the Little Minnesota River in South Dakota. Higher levees on the south side may have caused more water to flow north.[10]

1.3.2.4 Traverse County Highway No. 4 (Traverse CSAH 4) Improvements

Traverse CSAH 4 was modified in the year of 2000. Construction included the replacement of an overland flood discharge opening and a grade re-alignment. The road was modified to create a lower sag curve to convey flood discharges at a lower elevation.

1.3.2.5 Toelle Coulee Improvements

A 1995 document indicates that the conditions along Toelle Coulee have changed since the 1965 flood, and that at the time the document was written, the coulee had not experienced

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[9] Memo for Record. Flood Emergency in Browns Valley, Minnesota. Thomas Raster, Planning Branch, Engineering Division. U.S. Army Corps of Engineers. 20 March, 1972.
[10] Report: Spring Flood 2007, Browns Valley, Minnesota. JOR Engineering, Inc. May 15, 2007.

flooding since 1965. Traverse County Highway No. 2 (Traverse CSAH 2) had been raised and realigned.[11]

[11] Post Ice Jam Flood Field Trip Report, Little Minnesota River at Browns Valley, MN, Richard Pomerleau, P.E., U.S. Army Corps of Engineers, St. Paul District, March 28, 1995.

SECTION 2.0
DESIGN GOALS

Design goals and functional requirements describing the intended performance of the flood mitigation project were initially developed by HEI and confirmed by the Browns Valley Flood Mitigation Task Force (BVFMTF) during their September 13, 2007. Project design goals and the functional requirements for the Browns Valley Flood Mitigation Project (BVFMP) are described within this section.

Design goals are essentially "criteria" established to evaluate the effectiveness of the various flood mitigation concept alternatives in achieving the desired outcomes. Design goals were also used to evaluate the performance and rank the desirability of the flood mitigation concept alternatives and to select the "preferred" concept alternative.

The following design goals were established for review and consideration by the Task Force:

- Provide flood protection for the 1% chance (100-year) or a less frequent flood (providing the additional protection is at nominal additional cost) within the Corporate Limits for the City of Browns Valley;
- Provide flood protection for the 1% chance (100-year) or a less frequent flood (providing the additional protection is at nominal additional cost) for a buffer area extending some distance beyond the Corporate Limits for the City of Browns Valley;
- Provide for a distribution of flows between Lake Traverse and the Little Minnesota River based upon an understanding of the historic distribution;
- Incorporate a safety factor into the design of the flood mitigation solution reflecting the unpredictable nature of the flood mechanism within Browns Valley (e.g., summer floods versus spring floods caused by ice);
- Avoid moving the flood problem downstream, based upon criteria for the increase in elevation within Big Stone Lake and historic flows to Lake Traverse;

- Use the least amount of land possible for construction of the project features for the selected alternative;
- Maintain minimum flows less than the 5-year recurrence interval within the Little Minnesota River through Browns Valley to provide for ecological integrity within the river through town; and
- Technical feasibility.

The design goals were accepted by the BVFMTF subsequent to their September 13, 2007 meeting. The design goals along with technical feasibility were used to evaluate an initial set of concept alternatives believed capable of mitigating flooding within Browns Valley. These alternatives were screened by the BVFMTF during their September 13, 2007 meeting (see Section 4.0, Range of Flood Mitigation Alternatives Considered).

SECTION 3.0
METHODS

3.1 SURVEY DATA COLLECTION

The two primary sources of survey data used for hydrologic and hydraulic modeling, preliminary design and the estimation of plan quantities, are a traditional ground survey completed by Houston Engineering, Inc. during September, 2007 and an aerial survey completed by AERO-METRIC, Inc. during late October, 2007. The primary uses of the traditional ground control survey included developing the channel, culvert and bridge geometry for the hydraulic model, establishing existing waterway and channel slopes within the hydraulics model, modeling roadway overtopping, developing rating curves for hydrologic modeling and for roadway design. The results of the topographic data from the aerial survey were used to construct the channel geometry within the hydraulic model for the overbank areas, mapping the flood inundation results, establishing floodway alignments, and estimating earthwork quantities. The aerial and traditional survey data were merged into a common file for purposes of design.

The aerial survey collect area is shown within **Figure 3-1**. Products resulting from the aerial survey included:

- color photography at scale of approximately 1' = 425' suitable for preparing 1 ft. topographic contours and 0.25 ft orthophoto mapping;
- digital terrain model (DTM) consisting of a series of mass points (x,y,z) and breaklines;
- mass points and breaklines processed to generate continuous contours with a one (1.0) foot contour interval;
- planimetric base maps at a scale of 1" = 50' digitally compiled from the aerial photography. Planimetric features collected included roads, bridges, railroads, culverts, roadway shoulders, and water features in 2-dimensions; and
- 0.25-foot color digital orothophotography.

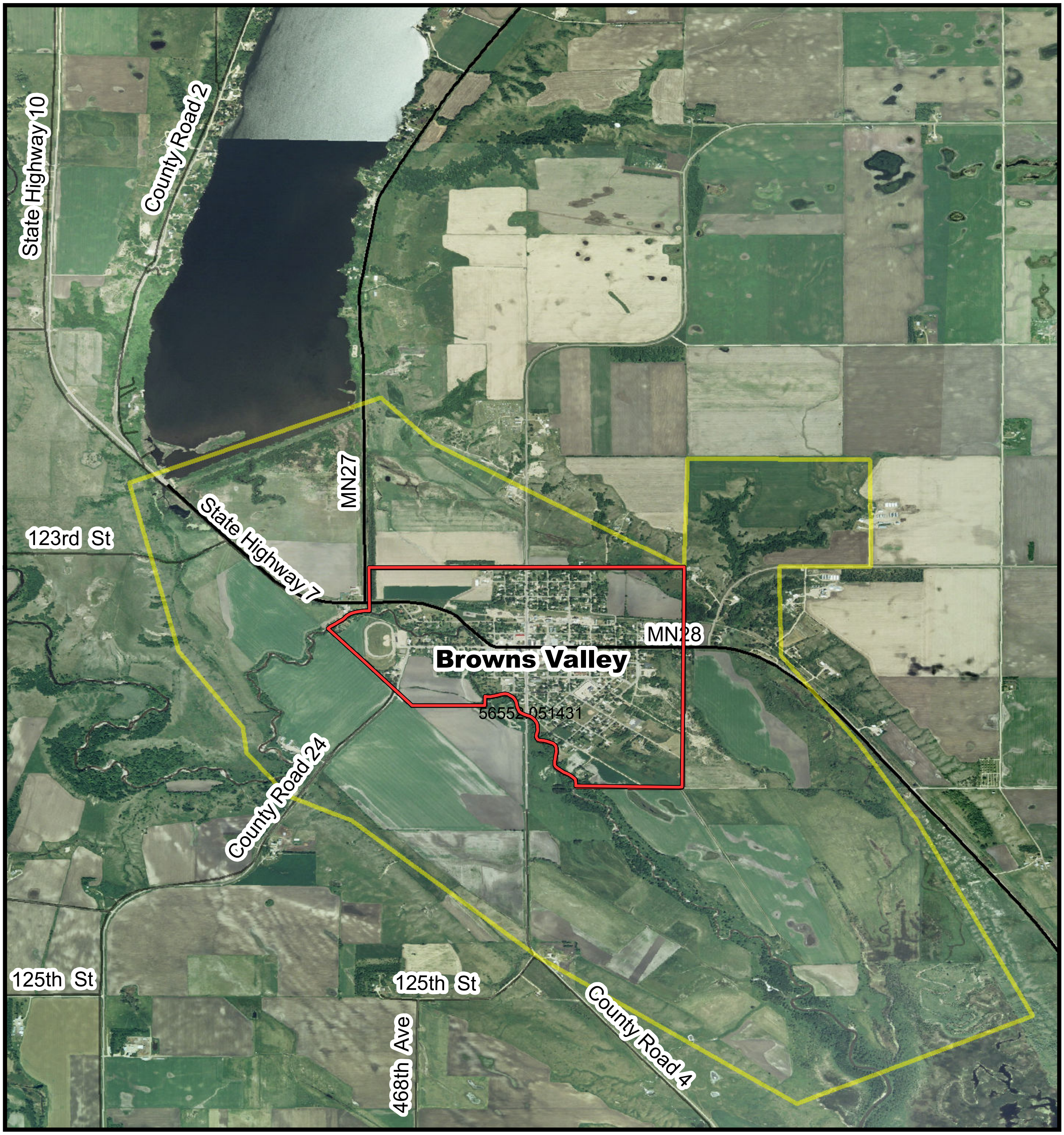

Figure 3-1

Approximate Aerial Survey Boundary

Legend

Aerial Survey Limits
MN State Hwy
Roberts Co. Roads
City Boundary

N W E S

0.5 0.25 0 0.5 Miles

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The specifications for the final map aerial survey products were consistent with United States National Map Accuracy Standards. Topographic information generated by the aerial survey was independently verified using traditional ground control survey. The analysis showed an average elevation difference across bare earth, high grass, urban, plowed fields and hard surfaces (e.g., roads) of 0.18 feet. The maximum absolute difference occurred within high grass, which is a limited portion of the project area.

3.2 HYDROLOGY

This section presents the hydrologic analyses performed for the BVFMP. The purpose of the hydrologic analysis is to establish input data for the hydraulic model, which is the tool used to simulate the behavior of the Little Minnesota River through Browns Valley and assist in the design of the flood mitigation alternatives (see **Section 4.0**, Range of Flood Mitigation Alternatives Considered). This section includes descriptions of the methods used in the following hydrology tasks:

- hydrologic frequency analysis, used in the selection of historical flood events to be analyzed, as well as to generate peak discharges and stages for various runoff events in the Little Minnesota River and downstream lakes (**Section 3.2.1**);
- the estimation of discharge/stage versus time data (hydrographs) for historical flood events in Browns Valley, which is used in the calibration and validation of the hydraulic model (**Section 3.2.2**); and
- the estimation of design discharges for sizing the flood mitigation project (**Section 3.2.3**).

3.2.1 Frequency Analysis of Discharge and Stage

Flood frequency analysis is the determination of flood flows at different recurrence intervals (i.e. the 1% chance of occurrence in any given year, also known as the "100-year recurrence interval"). Frequency analysis is used to determine how often on average a certain discharge or stage is expected to occur. Discharge and stage frequency analyses were performed in this study for three primary purposes:

- to aid in the selection of historic storm events for hydraulic model calibration. Calibration is the process by which the model's input parameters are estimated and adjusted so that computed results agree as well as possible with observed data and in accordance with expected physical performance. Calibration will concentrate on those events most pertinent to the study purpose of developing a flood mitigation plan for the City of Browns Valley;
- to aid in the selection of historic storm events for model validation. Validation is the process of testing the calibrated model. The model is tested with data not used in the calibration process, i.e. historical flood events, other than the calibration events; and
- to estimate steady state peak discharges and stages in the Little Minnesota River which are used in the hydraulic model to design the flood mitigation project.

A hydrologic frequency analysis determines probabilities of discharges by fitting the observed stream discharge record to specific probability distributions and estimating the parameters of the distribution. In this study, the data of interest are the annual maximum discharges, stages, and volumes in the Little Minnesota River and downstream receiving waters. The analytical frequency procedure recommended for annual maximum data is the logarithmic Pearson type III distribution.

The US Army Corps of Engineers HEC-FFA Flood Frequency Analysis (FFA) model was used to complete the frequency analyses. The analyses targeted the boundary conditions of the hydraulic model, which are the hydrologic data (discharge or stage) representing the upstream and downstream ends of the model network used for calibration and design (see **Section 3.3**). The FFA was performed with historic data collected at the USGS Gage at Peever, South Dakota, which is the upstream boundary condition of the hydraulic model. The model network has two downstream boundaries, Lake Traverse and Big Stone Lake, for which historic stage data were collected and FFA analyses also performed.

3.2.1.1 USGS Gage at Peever, SD

An FFA analysis was performed for the Peever Gage (438 square miles) for 55 years of record (1940 – 1981; 1990 – 2002) to analyze annual peak discharges, annual maximum stages, and annual maximum 24-hour and 10-day run-off volumes. (The Peever Gage is an upstream boundary for the hydraulic model). The period of record includes data affected by ice and debris and therefore, potentially the statistical relationship between stage and discharge.[1]

Annual peak discharge and stage data were retrieved from the USGS National Water Information System website http://mn.water.USGS.gov for the entire period of record for the USGS Gauging Station, USGS 05290000 Little Minnesota River near Peever, South Dakota (see **Figures 3-2 and 3-3**). For the discharge frequency analysis, the computed station skew was weighted with a generalized skew coefficient of -0.30 and a mean square error of 0.182, based on the location of Browns Valley.[2] For the stage and volume frequency analyses, the skew of the computed curve was based solely on the station skew computed from the data points, and no weighting was performed.

The annual maximum 24-hour volumes and 10-day volumes were computed from the mean daily discharges at the Peever Gage. The annual maximum series was used as input to the FFA program. **Table 3-1** lists the estimated peak discharges, stages, and volumes resulting from the frequency analysis. **Figures 3-4, 3-5, 3-6, and 3-7** present the FFA model results graphically for discharge, stage, and volume (median plotting positions). Full FAA input data and output files are presented in **Appendix C**.

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[1] For design purposes, the effects of ice and debris were assessed using an unsteady hydraulic HEC-RAS model for historic floods caused by ice and debris conditions and period of non-ice and debris conditions, rather than reflected in the FFA analysis.
[2] Generalized Skew Coefficients for Flood-Frequency Analysis in Minnesota, U.S. Geological Survey, Water-Resources Investigations Report 97-4089. D.L. Lorenz, Mounds View, Minnesota 1997.

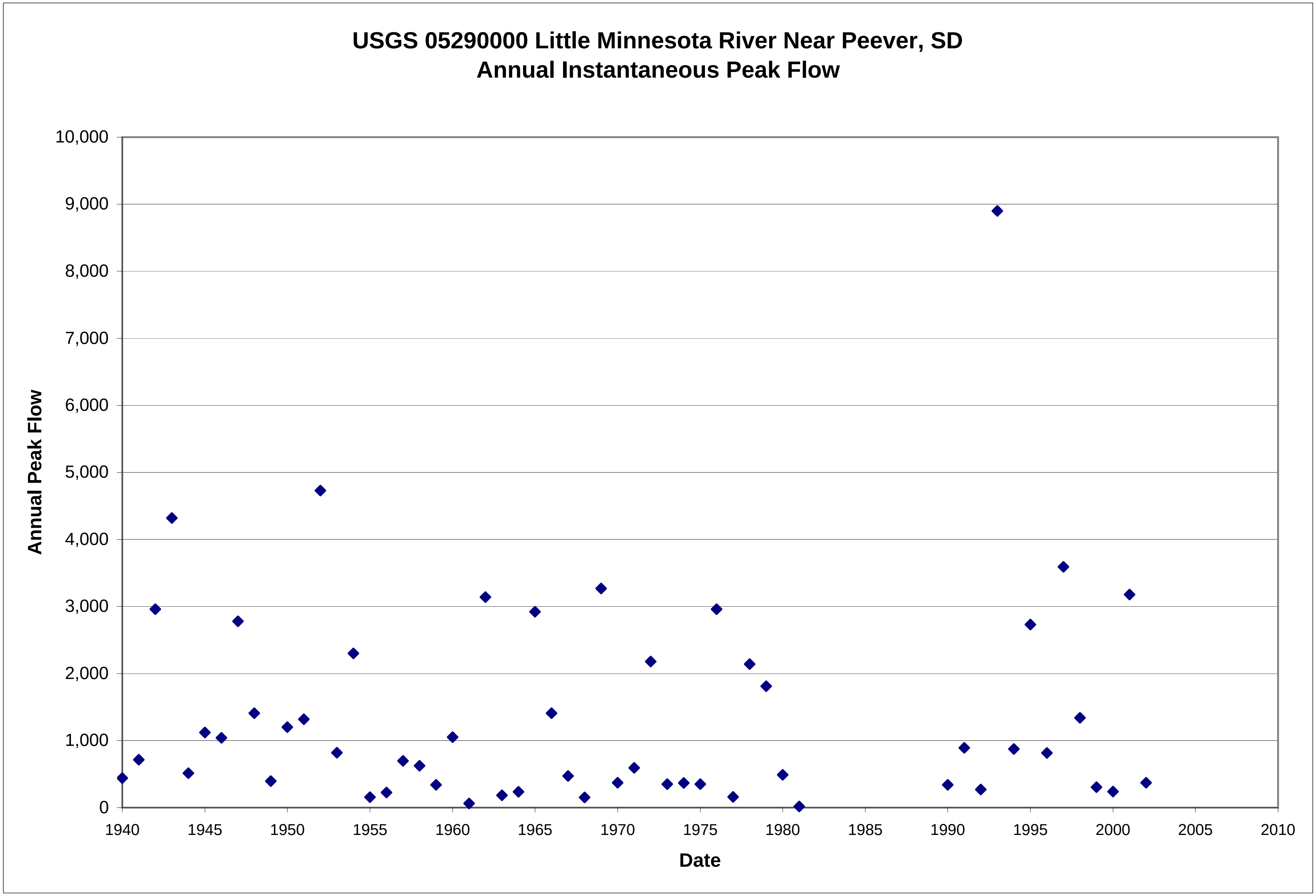

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Figure 3-2

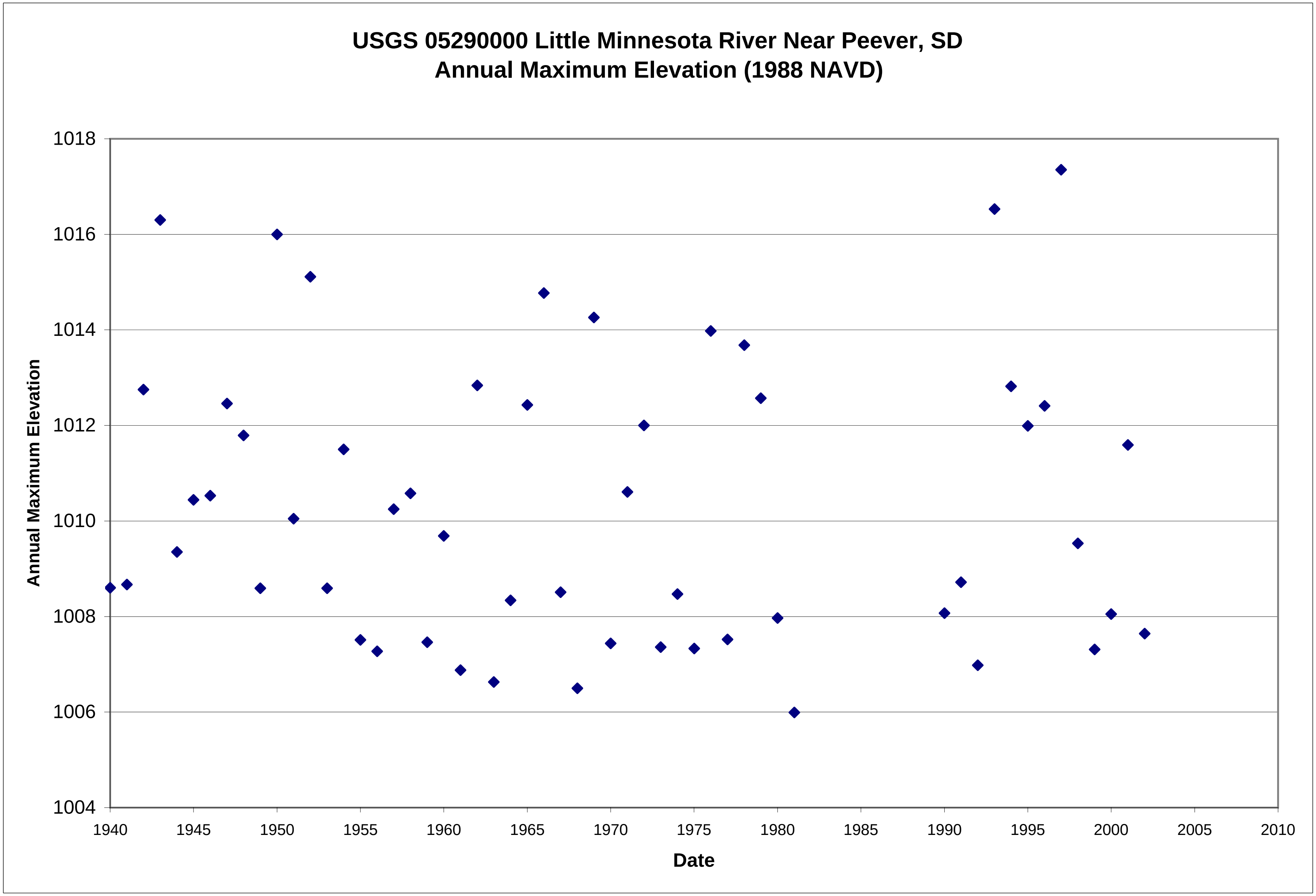

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Figure 3-3

Flow Frequency Curve - USGS Gage at Peevers 05290000

(Annual Maximum Series, 1940-2002)

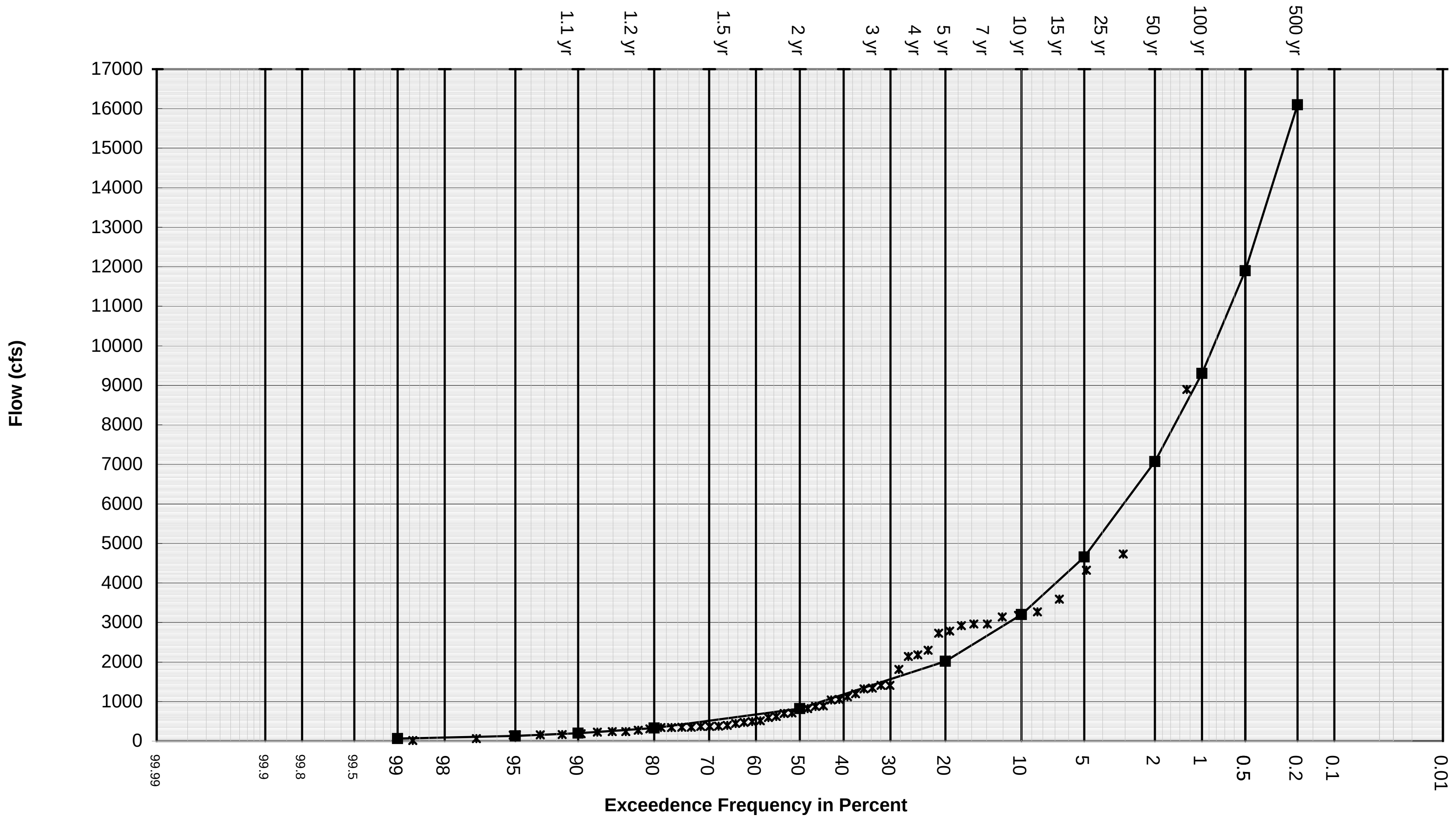

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Figure 3-4

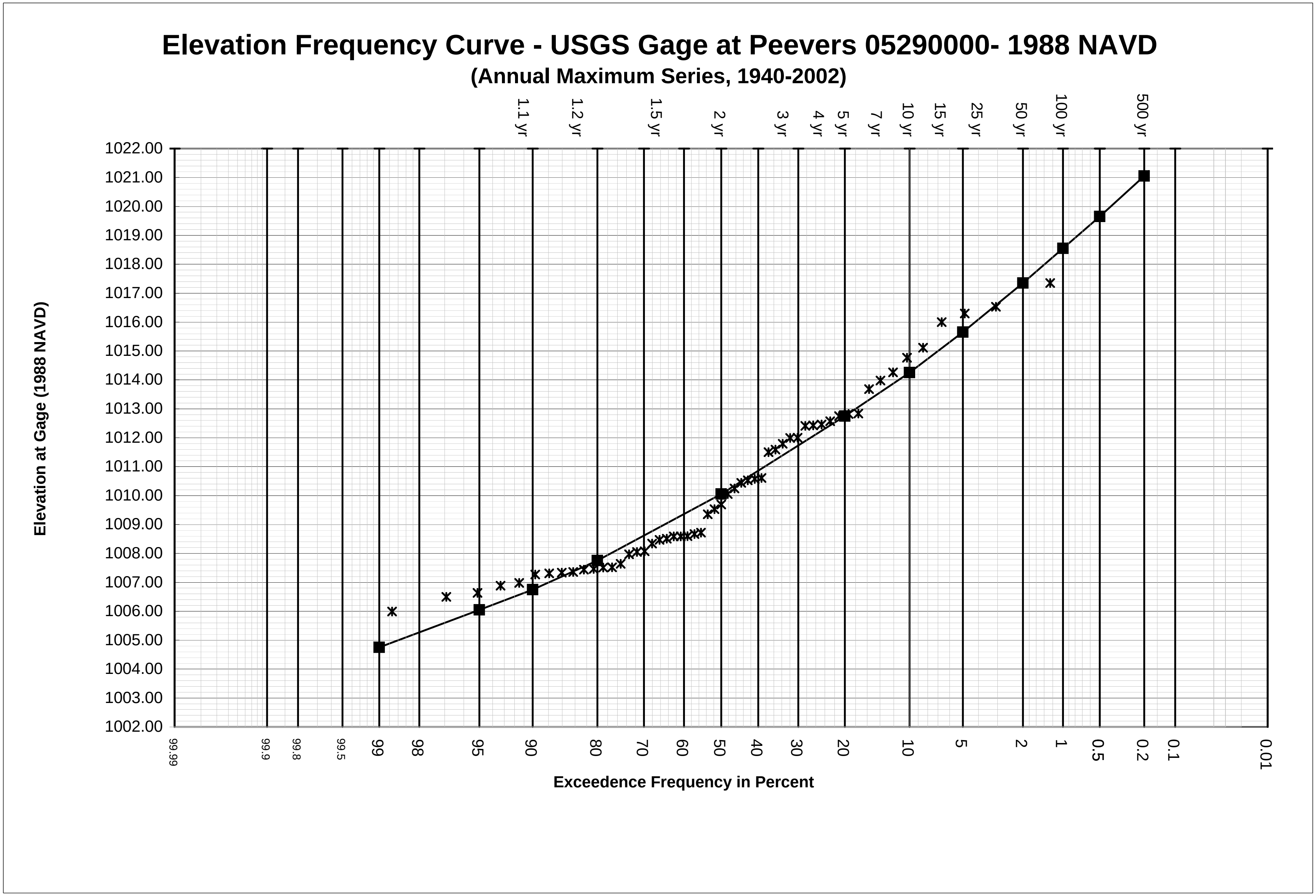

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Figure 3-5

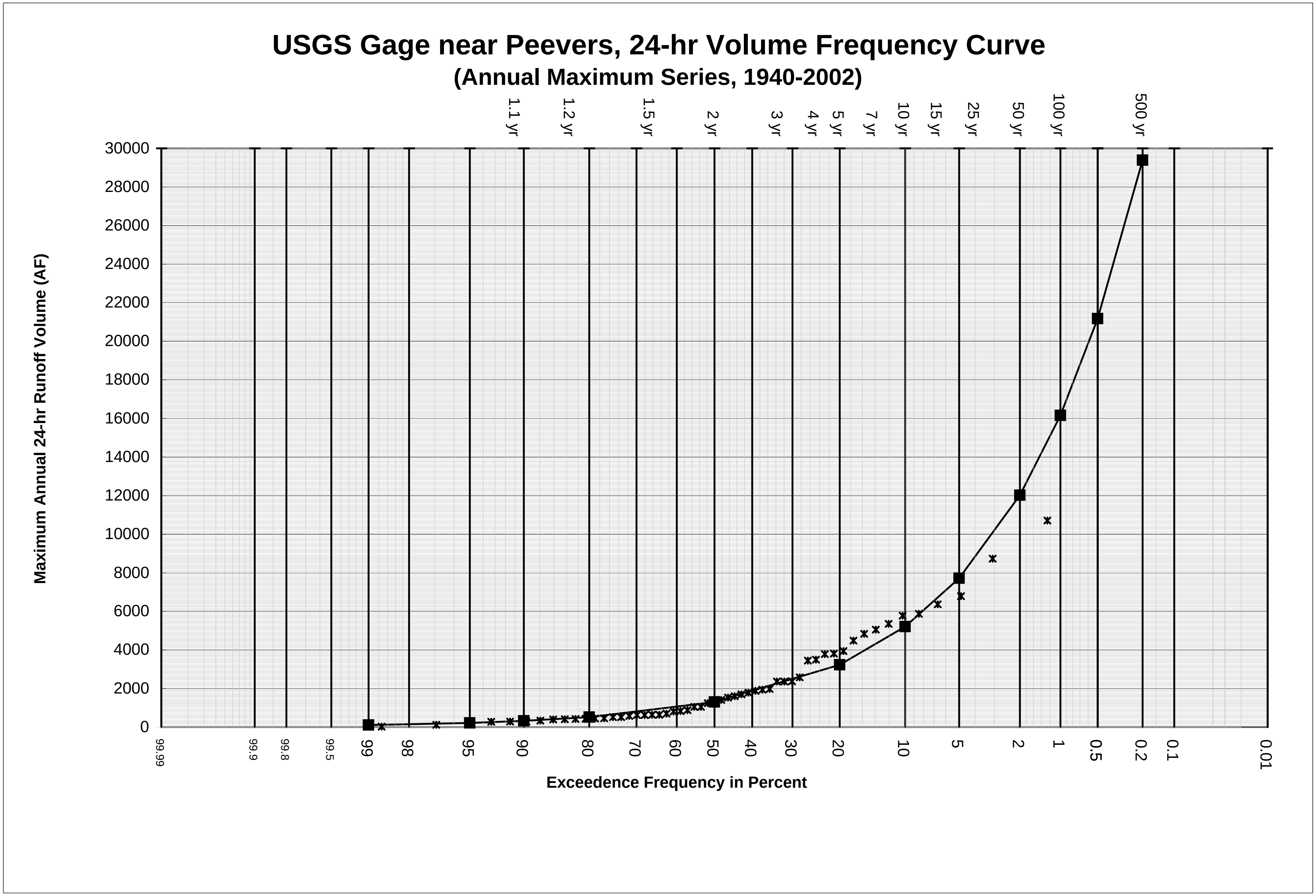

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Figure 3-6

USGS Gage near Peevers, 10-Day Volume Frequency Curve
(Annual Maximum Series, 1940-2002)

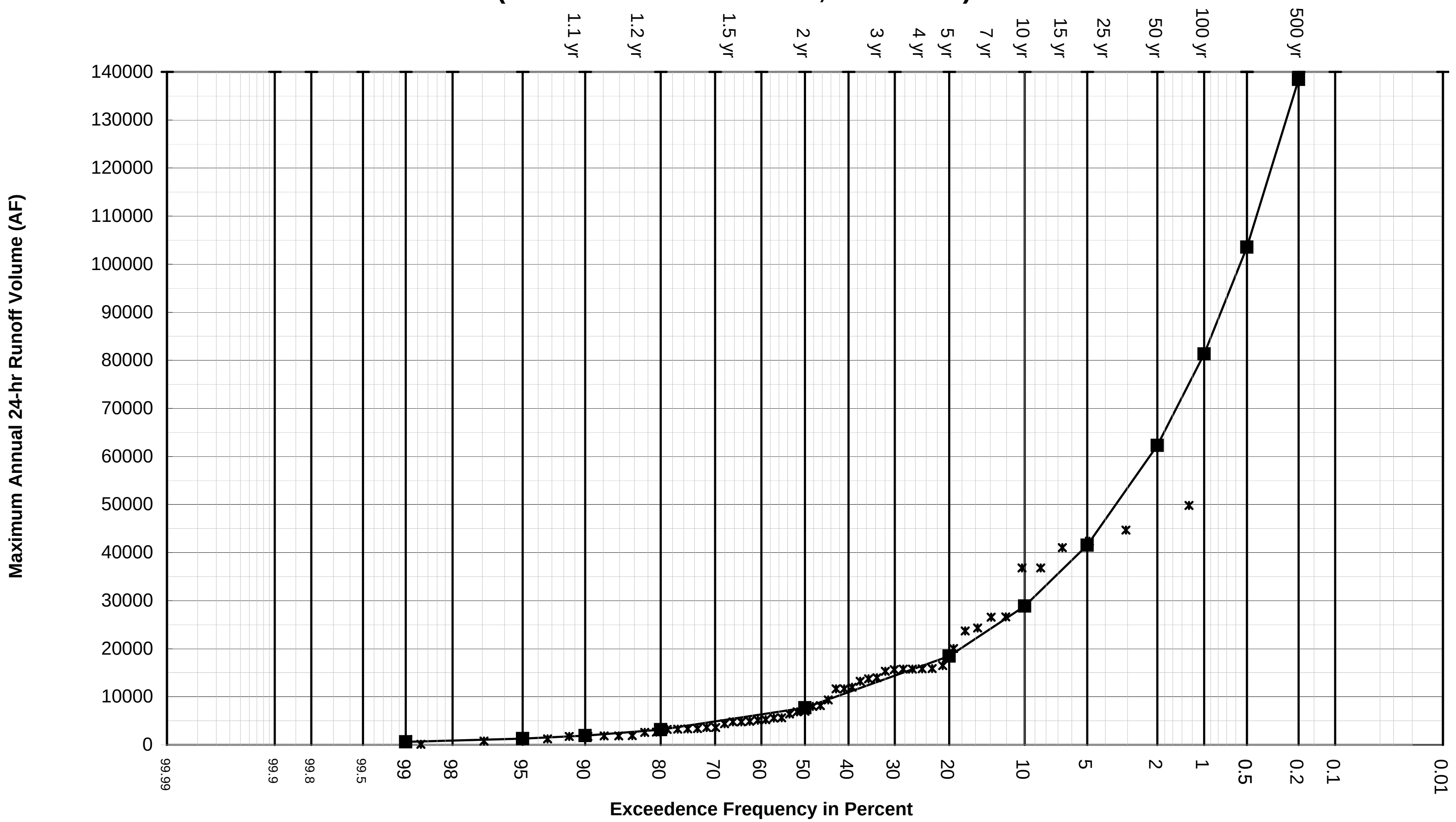

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Figure 3-7

Table 3-1
Results of FFA Analysis* for USGS Gage near Peever, South Dakota

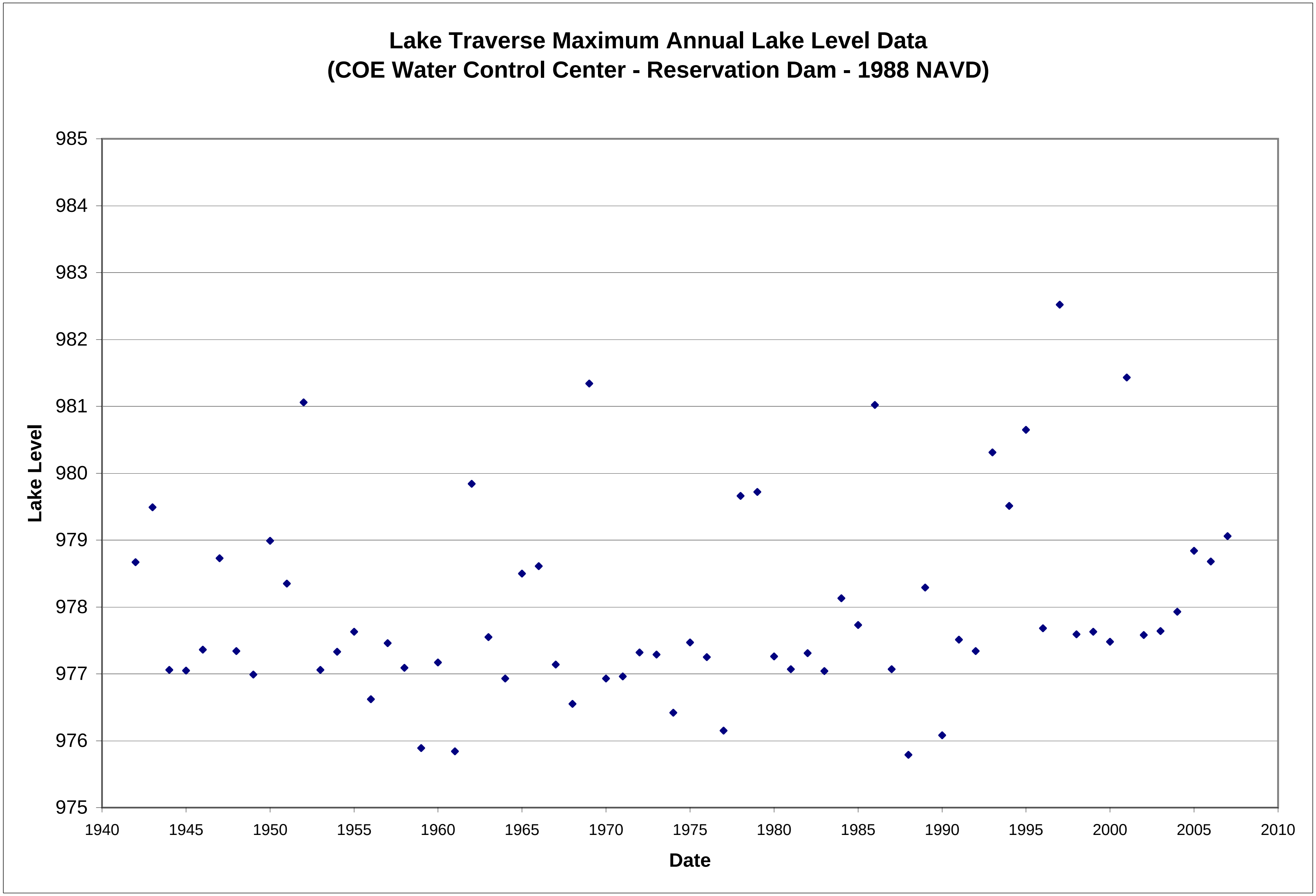
Chance Exceedance (%)	Recurrence Interval (year)	Discharge (cfs)	Elevation (NAVD 1988)	24-hr Vol. (acre-feet)	10-Day Vol. (acre-feet)
0.2	500	16,100	1021.05	29,381	138,410
0.5	200	11,900	1019.65	21,170	103,540
1	100	9,300	1018.55	16,153	81,303
2	50	7,070	1017.35	12,020	62,273
5	20	4,660	1015.65	7,716	41,545
10	10	3,200	1014.25	5,204	28,857
20	5	2,020	1012.75	3,230	18,447
50	2	822	1010.05	1,297	7,692
80	1.25	326	1007.75	521	3,129
90	1.11	199	1006.75	323	1,935
95	1.05	131	1006.05	218	1,295
99	1.01	60	1004.75	104	602

* For design purposes, the effects of ice and debris were assessed using an unsteady hydraulic HEC-RAS model for historic floods caused by ice and debris conditions and periods of non-ice and debris conditions

3.2.1.2 Lake Traverse

Lake Traverse is one of two downstream locations in the hydraulic model network (see **Section 3.3**) that is a boundary condition. An FFA analysis was performed for the period 1942 – 2007 to analyze annual maximum lake stage for the period of record.

Daily stage records from Lake Traverse were retrieved from the U.S. Army Corps of Engineers Water Control Center website (the stage data may be downloaded from http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm). The maximum stage for each year was determined and used to create an annual maximum series to use in the FFA program (see **Figure 3-8**). Note that the lake stage data is not a continuous daily record. The data includes an average of 256 values per year recorded primarily during the open water period. This period generally includes the maximum recorded stage in any given year.



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\Historical Data\Lake Traverse\traverse20239 Corps Water Control Center.xlsChart1 (3)

Figure 3-8

The results of the stage frequency analysis[3] are summarized in **Table 3-2**. **Figure 3-9** presents the results graphically. Full model input data and output files are presented in **Appendix D**.

Table 3-2
Results of FFA Analysis for Lake Traverse Elevation

% Chance Exceedance	Recurrence Interval (year)	Elevation (NAVD 1988)
0.2	500	984.15
0.5	200	983.22
1	100	982.50*
2	50	981.77
5	20	980.75
10	10	979.94
20	5	979.07
50	2	977.72
80	1.25	976.75
90	1.11	976.37
95	1.05	976.11
99	1.01	975.77

* Comments provided by the U.S. Army Corps of Engineers through the Interagency Hydrology and Hydraulics Review Committee recommend an alternative curve fit approach which results in a 1% chance elevation of 981.56 (1988 NAVD)

3.2.1.3 Big Stone Lake

Big Stone Lake is one of two downstream locations in the hydraulic model network (see Section 3.3). Results of an Army Corps of Engineer's Analysis from October, 2001, were adopted for this study.[4] **Figure 3-10** displays the FFA model results for Big Stone Lake stage as

[3] The Army Corps of Engineers generally recommends a linear fit to the annual maximum series, rather than use of a Log Pearson Type II analysis. The use of a linear fit results in a lower value for the 100-year flood. From a practical perspective this would result in more water entering Lake Traverse (rather than Browns Valley) when completing hydraulic analyses.
[4] Based on Army Corps of Engineers Flood Frequency Analysis of Big Stone Lake, "Section 22 Study – Minnesota River Main Stem Hydrologic Analysis." October, 2001.

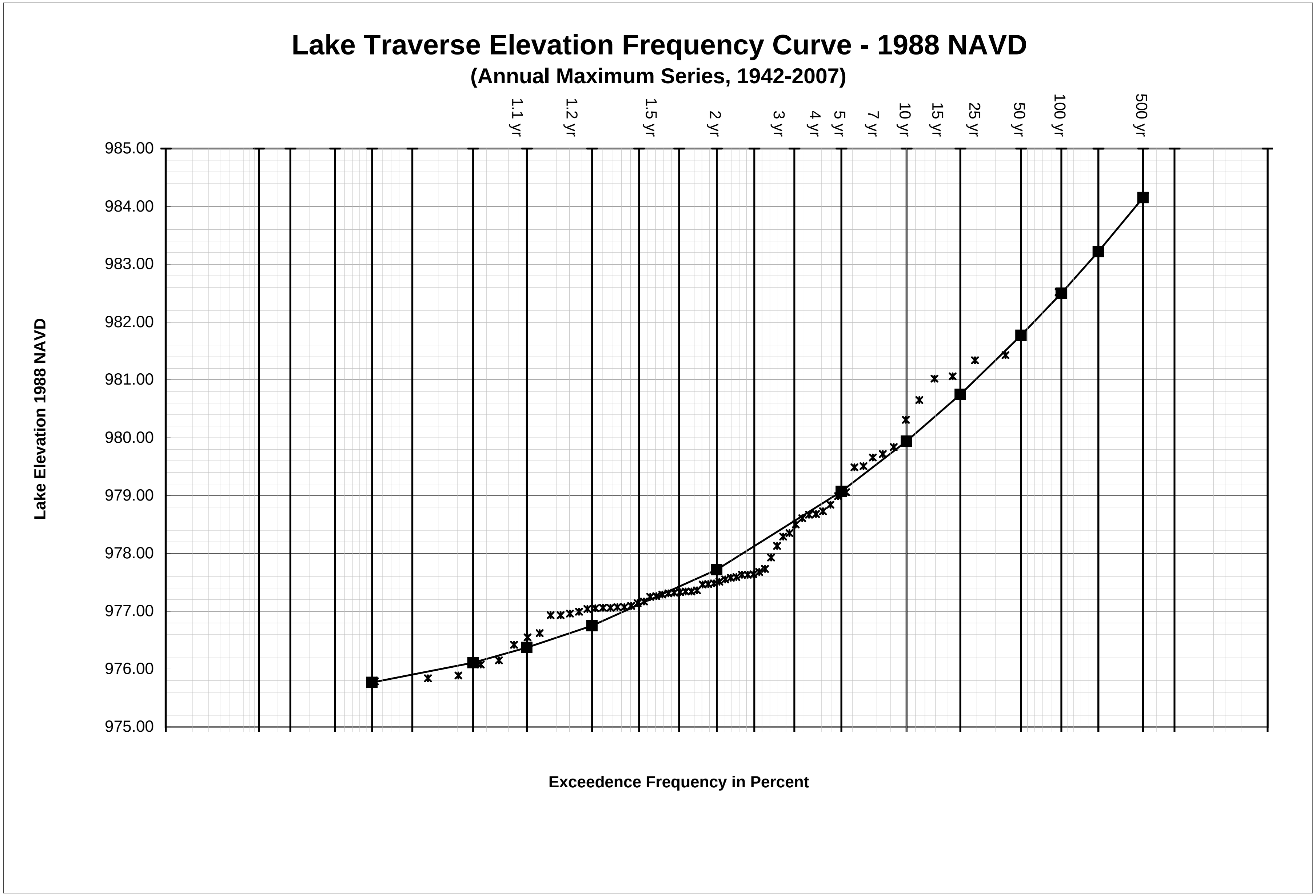


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Figure 3-9

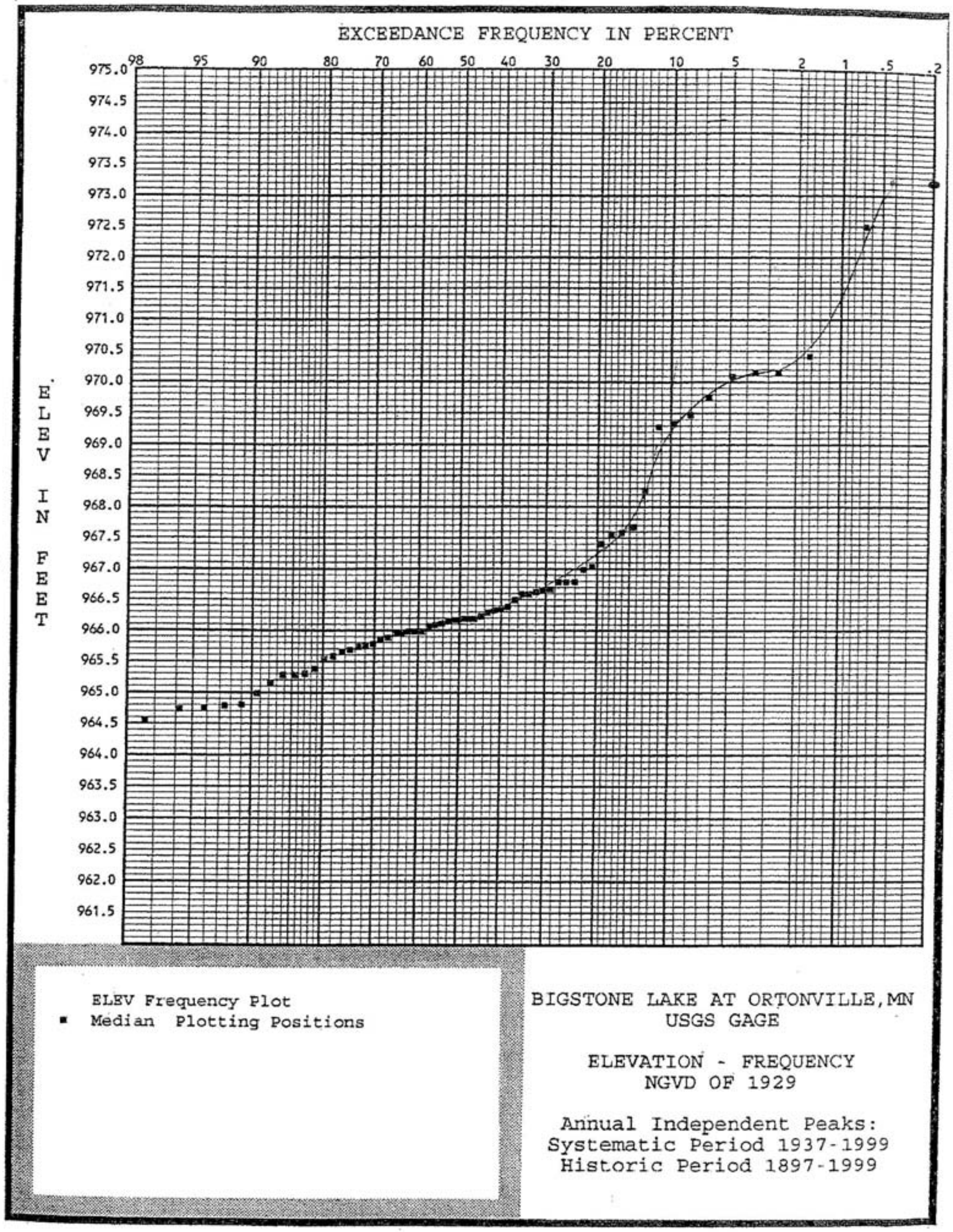


FIGURE 1

Figure 3-10

Excerpt from Flood Frequency Analysis of Big Stone Lake
"Section 22 Study – Minnesota River Main Stem Hydrologic Analysis."
Army Corps of Engineers. October, 2001

presented in the Corps study, in NGVD 1929 datum. **Figure 3-11** graphically displays a partial data set in NAVD 1988 datum. The results of the Corps study are listed in **Table 3-3.**

Table 3-3
Results of FFA Analysis for Big Stone Lake Elevation

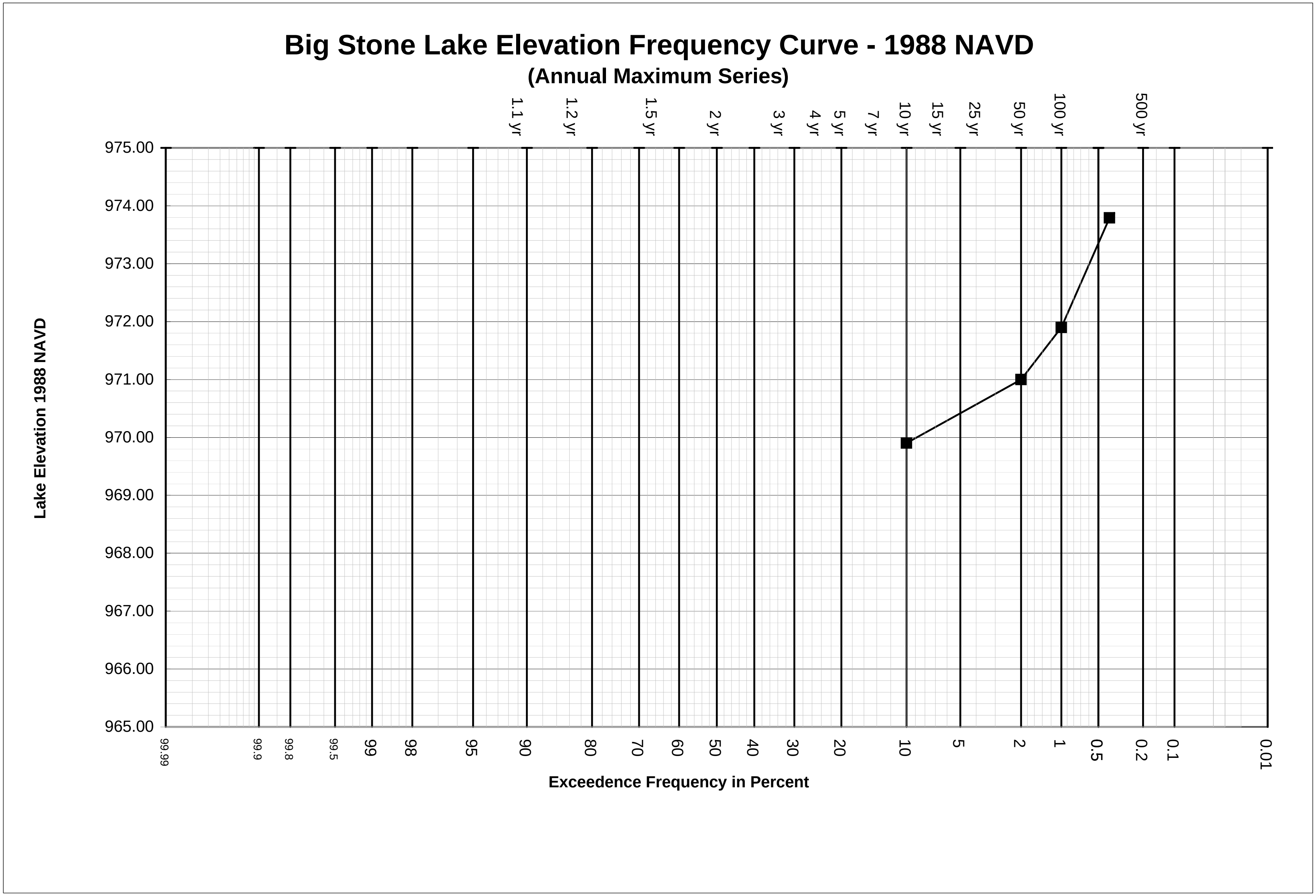
% Chance Exceedance	Recurrence Interval (year)	Elevation (NAVD 1988)
0.2	500	- -
0.4	250	973.79
1	100	971.89
2	50	970.99
5	20	- -
10	10	969.89
20	5	- -
50	2	- -
80	1.25	- -
90	1.11	- -
95	1.05	- -
99	1.01	- -

3.2.1.4 Selection of Historic Modeling Events

The hydrologic event selected for calibration should be reflective of the purpose of the study, i.e. to develop a flood mitigation plan for the City of Browns Valley. Browns Valley has historically experienced flooding problems due to: (1) spring ice jams in the Little Minnesota River, which reduces the capacity of the river channel, causing it to overtop its banks, and (2) spring or summer peak flows in the Little Minnesota River. In addition to satisfying this criterion regarding the type of event, the other criterion is that there is sufficient observed data to which to calibrate.

The March 13-14, 2007 event was selected for model calibration because of the large number of high water marks and availability of aerial imagery. This event can be characterized as follows:

- a flooding event caused by an ice jam on the Little Minnesota River;



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\FFA\probability Big Stone Lake.xls2. Freqeuncy Plot (6)

Figure 3-11

- a maximum elevation (high water mark) at the Peever Gage during that event was recorded as 1013.00 (1988 NAVD), which approximately matches a 5 to 6 year peak stage events[5];
- according to the discharge frequency analysis, the peak flow at the Peever Gage of 4,467 cfs (based on USGS stage-discharge rating table) approximately matches a 20-year peak flow event[5];
- the maximum elevation (high water mark) at Lake Traverse of 978.94 (1988 NAVD) approximately matches a 5-year event[6]; and
- the maximum elevation at Big Stone Lake of 967.83 (1988 NAVD) corresponds to less than a 10-year event[7].

The calibrated hydraulic model needs to be subjected to a validation process of testing it with other historical flood events to evaluate its performance. Two flooding events were selected based on their estimated high peak discharges, the availability of photographs to assess model performance, and the desire to understand the flooding mechanism of both a flood caused by an ice jam and high peak discharge without an ice jam.

The first historical flood event selected for model validation is July 25, 1993. The event is characterized as follows:

- summer event – no ice jam;
- a recorded peak flow at the Peever Gage of 8,900 cfs approximately matches a 100-yr event[5];
- a maximum elevation at the Peever Gage of 1,016.53 (1988 NAVD) approximately matches a 35-year event.[5]

---

[5] Houston Engineering, Inc. Annual Maximum Series Flood Frequency Analysis, September, 2007
[6] Assuming 1912 MSL – 0.39 = 1929 NGVD – Source: COE Water Control Center.
[7] Based on COE Flood Frequency Analysis of Big Stone Lake, "Section 22 Study – Minnesota River Main Stem Hydrologic Analysis." October, 2001.

- a maximum elevation at Lake Traverse of 980.31 (1988 NAVD*)* approximately matches a 15-year event[6];
- a maximum elevation at Big Stone Lake of 968.26 (1988 NAVD) corresponds to less than a 10-year event[7]; and
- Drawback: no high water marks or photographs.

The second historical flood event selected for model validation is March 28, 1997. The event is characterized as follows:

- A spring flooding event with ice jam;
- a recorded peak flow at the Peever Gage of 3,590 cfs approximately matches a 12-yr event[5];
- a maximum elevation at the Peever Gage of 1,017.35 (1988 NAVD) approximately matches a 50-year event, reflecting a downstream ice jam[5];
- a maximum elevation at Lake Traverse of 982.52 (1988 NAVD) approximately matches a 100-year event[6]; and
- a maximum elevation at Big Stone Lake was recorded as 973.78 (1988 NAVD), which is the highest stage ever recorded.[7]

3.2.2 Hydrograph Development for Unsteady Hydraulic Model Calibration and Validation

Flow and stage hydrographs need to be generated as input into the unsteady HEC-RAS hydraulic model for the three historical events identified in **Section 3.1.1** for model calibration and validation.

3.2.2.1 Boundary Conditions Hydrographs

The downstream boundary conditions consist of daily stage time series at Big Stone Lake and Lake Traverse, both having continuous daily data available through the time periods necessary to model the three historic events in 1993, 1997, and 2007.

Daily discharge data is also available for the upstream boundary condition, represented by flows from the USGS Gage Station 05290000 Little Minnesota River near Peever, South Dakota, for the selected flooding events in 1993 and 1997. However, because the gage was discontinued in 2002, a hydrograph was estimated for the March 2007 flood event. A high water mark of 10.05 (1013.00 NAVD 1988) provided by Traverse County from the March 2007 flood event at the USGS gage near Peever was translated to a discharge using the stage-discharge rating table from the discontinued gageing station (see **Figure 3-12**).[8]

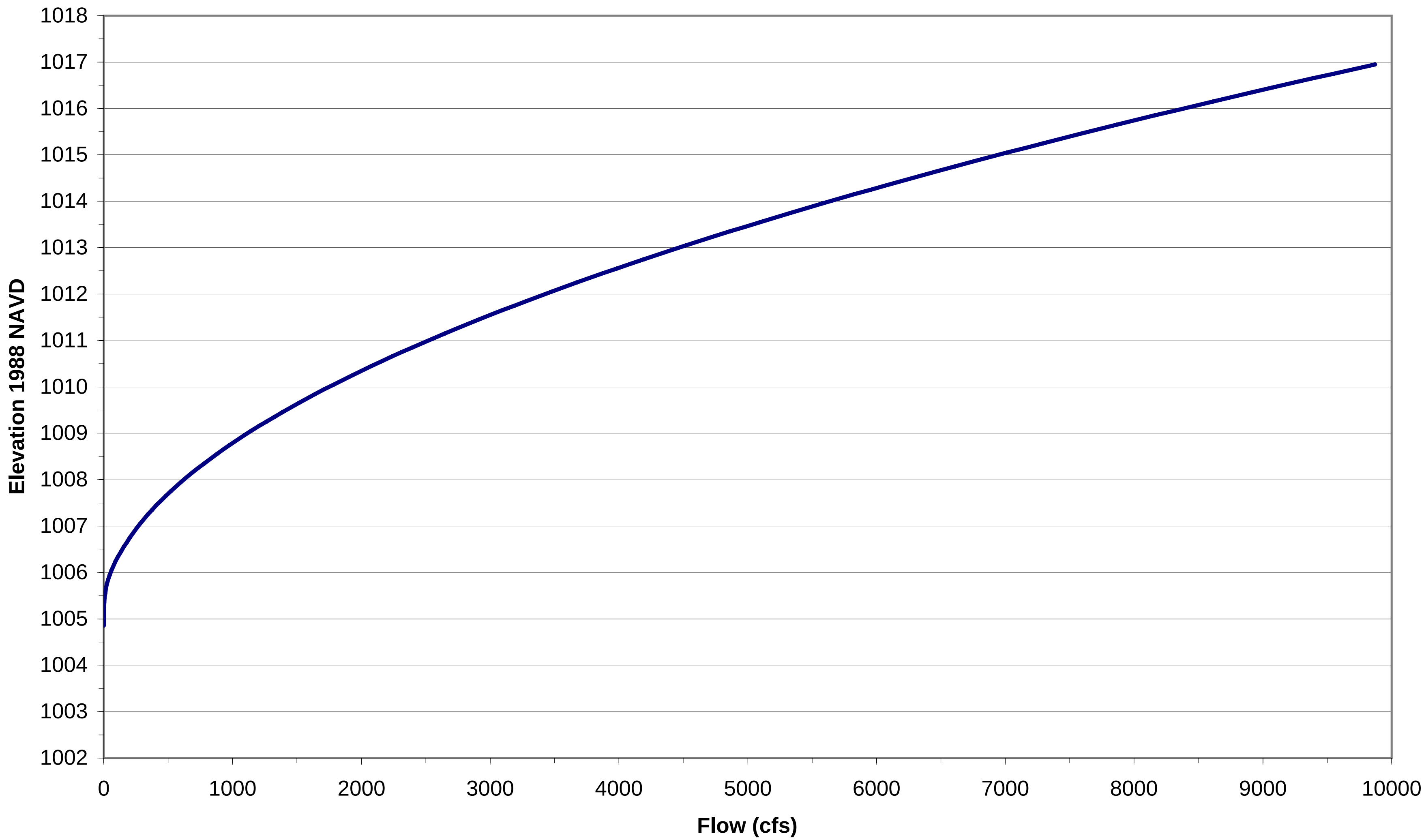
To estimate the shape of the hydrograph, the hydrograph shape of other historic March events were graphed to determine whether a "typical" shape can be expected for this time of year at the Peever Gage. **Figure 3-13** shows that a 10-day duration fits fairly well to the general shape of the other historic events. In addition, according to the 10-day volume-frequency analysis presented in **Section 3.1.1**, the volume under the hydrograph is approximately a 20-year event, the same recurrence interval as the estimated peak flow of 4467 cfs from the March 2007 event. The 10-day triangular-shaped hydrograph was therefore adopted as the estimated hydrograph to be used for the upstream boundary condition in the March, 2007 modeling event.

Two important reasons for selecting the 2007 flood event for calibration and unsteady HEC-RAS simulation included the availability of the large number of known (surveyed) high water reference elevations and the excellent aerial photography suitable for understanding the flood mechanism. The aerial photography proved valuable for not only understanding the extent of flooding but the general flood mechanism. These factors were deemed more critical than the need to estimate the hydrograph shape and volume at the Peever Gage.

[8] "Rating curves are only as stable as the river channel they represent. This curve was established in 1999, and it is unknown whether the 2007 flood changed the shape of the channel, or if downstream ice jam affected the stage-discharge relationship at Peever." James Fallon, USGS, Mounds View, MN.

Stage Discharge Rating Curve USGS Gage near Peever, SD 05290000

(Gage datum 1,002.2 ft NGVD29, 1929 NGVD + 0.75 = 1988 NAVD)



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\05290000_rating.xlsGage Cht 1988 NAVD

Figure 3-12

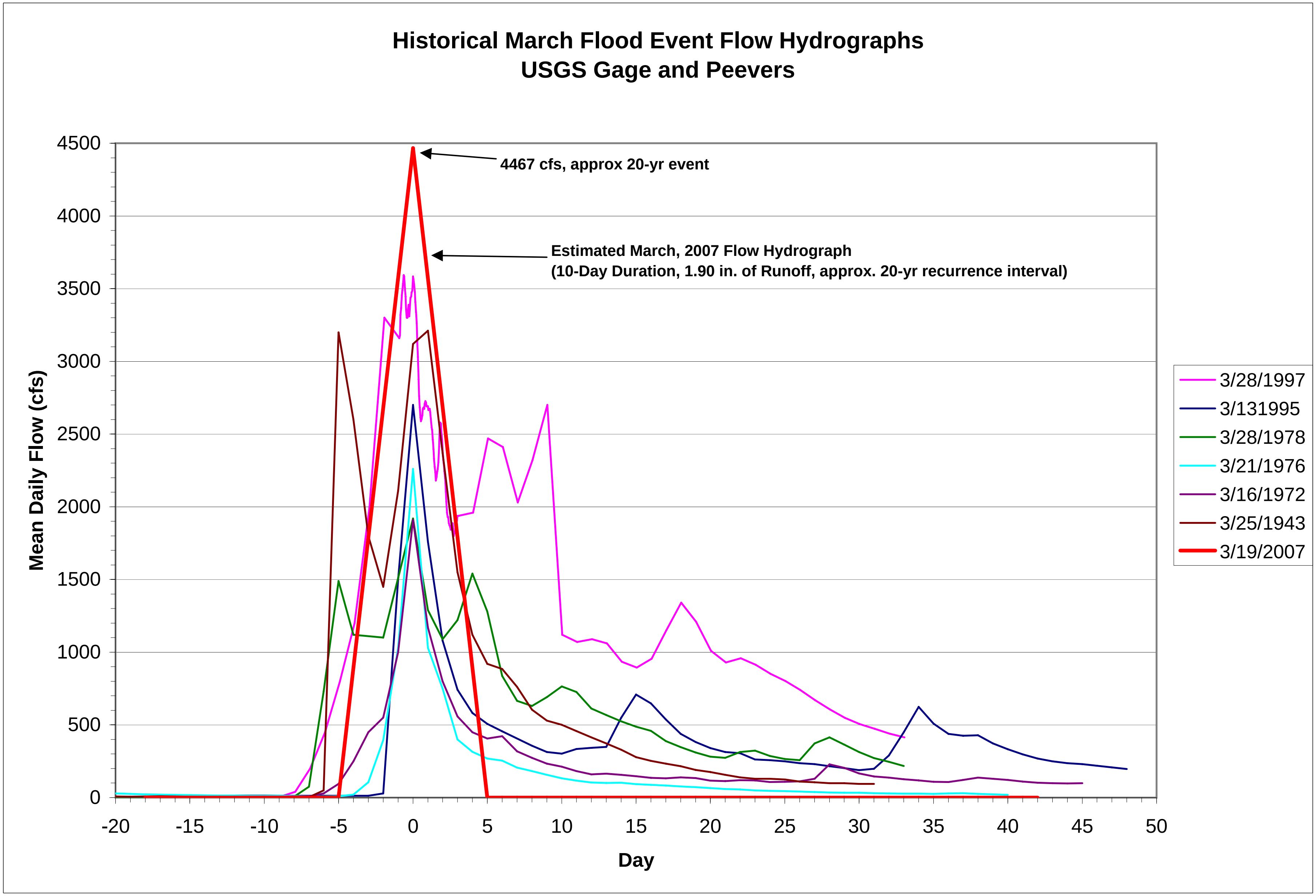

Historical March Flood Event Flow Hydrographs
USGS Gage and Peevers
4467 cfs, approx 20-yr event
Estimated March, 2007 Flow Hydrograph
(10-Day Duration, 1.90 in. of Runoff, approx. 20-yr recurrence interval)
Mean Daily Flow (cfs)
Day
0
500
1000
1500
2000
2500
3000
3500
4000
4500
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
3/28/1997
3/131995
3/28/1978
3/21/1976
3/16/1972
3/25/1943
3/19/2007

Figure 3-13

Figures 3-14, 3-15, and 3-16 show the historic stage hydrographs for the downstream boundary conditions and the mean daily discharge hydrograph for the upstream boundary condition developed for the HEC-RAS hydraulic model.

3.2.2.2 Ungaged Subwatershed Inflow Hydrographs

In addition to the boundary conditions, a number of locations in the hydraulic model receive ungaged tributary inflow from local drainage areas (see **Table 3-4 and Figure 3-17**). These ungaged drainage areas are small and relatively unimportant in terms of sizing the flood mitigation features because of the small amount of discharge compared to the Little Minnesota River. These areas can be important for sizing local drainage features. For purposes of completeness, the discharge hydrographs for these areas were estimated by applying the unit flow (cfs/square mile) determined from the Peever Gage mean daily discharge, to the local drainage areas at each location. This method prorates the observed flow at the Peever gage over the rest of the modeled area and was only used for the historic events where similar flows per square mile throughout the watershed are expected. Given the uncertainties in hydrologic analysis, this approach is likely as accurate as other methods and is reasonable for the design of the flood mitigation purposes. **Figures 3-18, 3-19, and 3-20** show all of the tributary hydrographs for input to the unsteady HEC-RAS model for the three historic modeling events.

Table 3-4
Drainage Areas for Ungaged Locations

No.	Ungaged Locations	Local Drainage Area (sq. mi.)
1.	South Dakota/Minnesota State Line	14.0[9]
2.	Traverse/Big Stone County Line	2.0[7]
3.	Little Minnesota River, confluence with Toelle Coulee	8.6
4.	Toelle Coulee, from TH 28/Traverse CSAH 2 to confluence with Little Minnesota River	1.9
5.	T.H. 28 on east side of Browns Valley	0.45
6.	Toelle Coulee, upstream of Traverse CSAH 2	2.8

[9] Flood Insurance Study, City of Browns Valley, MN, U.S. Army Corps of Engineers. June 17, 1986.

3.2.3 Design Discharges

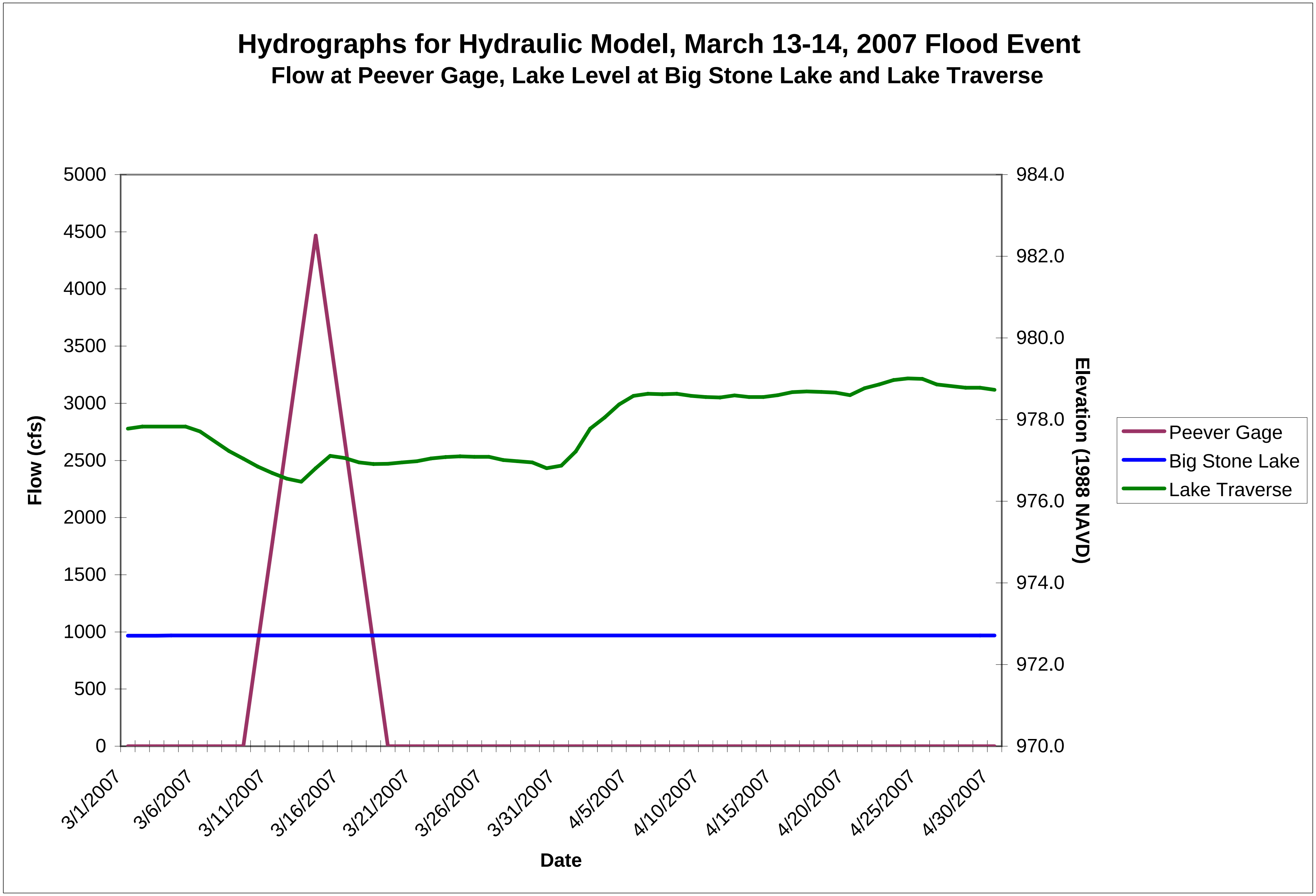
To complete initial design of the flood mitigation solution, a steady state hydraulic model was used to simulate the proposed alternative flood mitigation concepts for discharges with various return periods. (see **Section 3.3**) (Note: once the features were sized, the historic floods using unsteady HEC-RAS were used to evaluate performance.) The hydraulic model requires peak discharges and/or stages at the upstream and downstream ends of the model network (boundary conditions), as well as peak discharges representing the additional flow in the channel from localized ungaged drainage areas.

3.2.3.1 Boundary Conditions

Synthetic peak discharges for the upstream boundary condition and peak stages for the downstream boundary conditions were determined from the frequency analysis described in **Section 3.2.2.** The results are again presented in **Table 3-5**. The sizing and designing of the flood mitigation features initially focused on the 100-year recurrence interval event. A range of flows, representing other recurrence intervals, were then modeled to assess the system response to a range of other hydrologic events (as well as the historic floods).

Table 3-5
Synthetic Event Peaks for Boundary Conditions

Recurrence Interval	Peever Gage (cfs)	Big Stone Lake (NAVD 1988)	Lake Traverse (NAVD 1988)
500	16,100	- -	984.15
200	11,900	973.79	983.22
100	9,300	971.89	982.50
50	7,070	970.99	981.77
20	4,660	- -	980.75
10	3,200	969.89	979.94
5	2,020	- -	979.07
2	822	- -	977.72
1.25	326	- -	976.75



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\Hydrograph Data for Graphs 12-13-07.xls2007 Cht

Figure 3-14

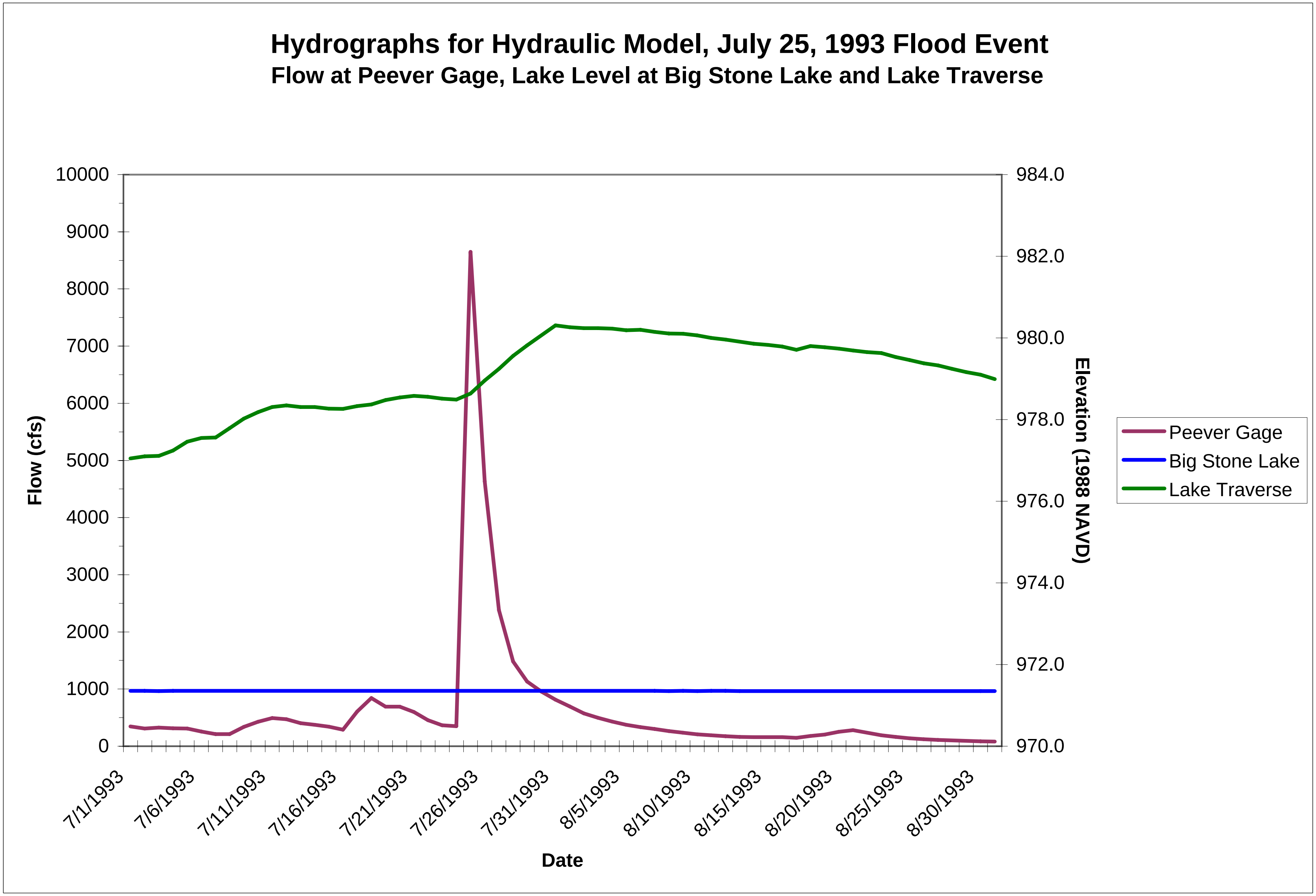


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Figure 3-15

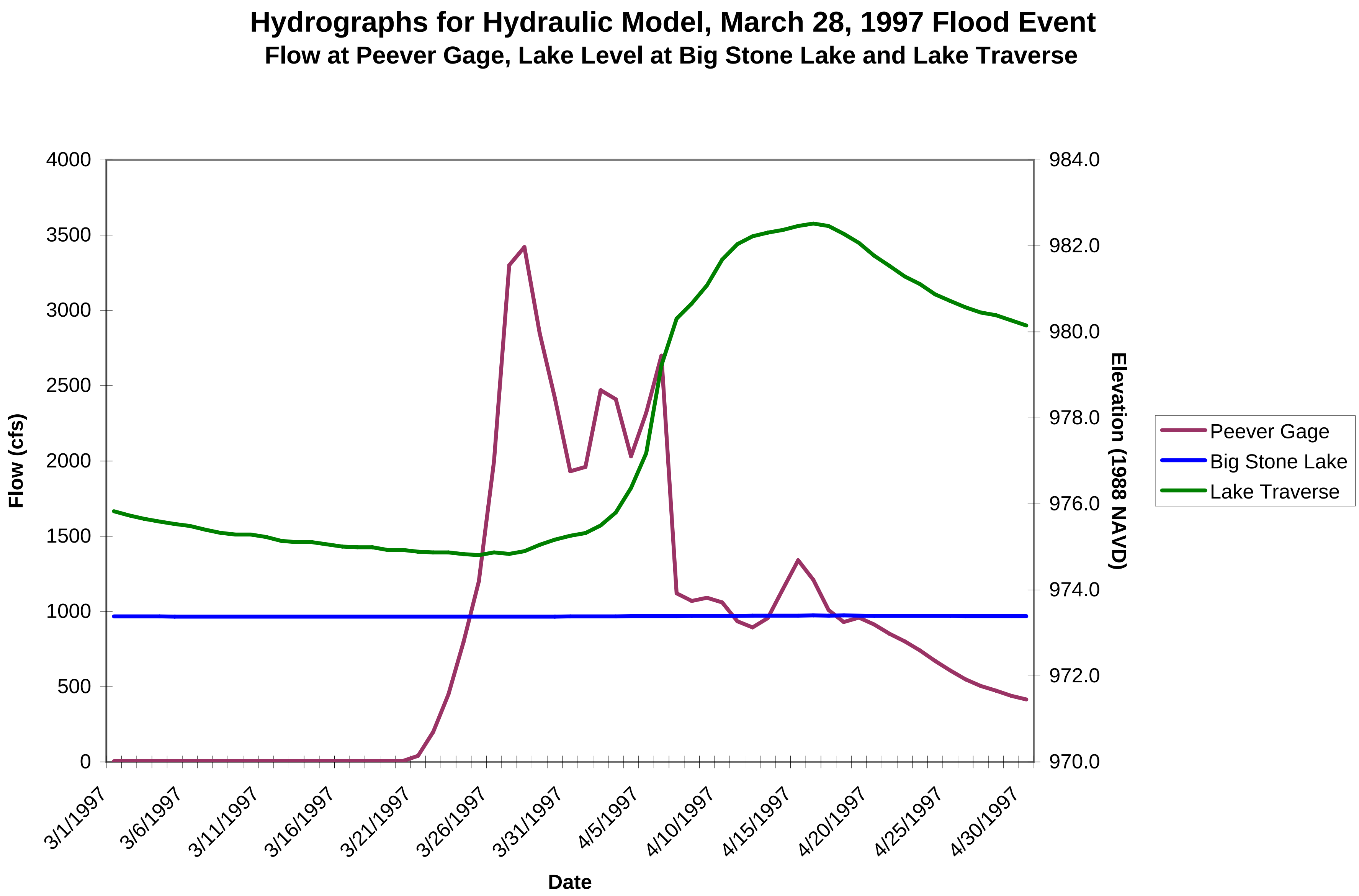

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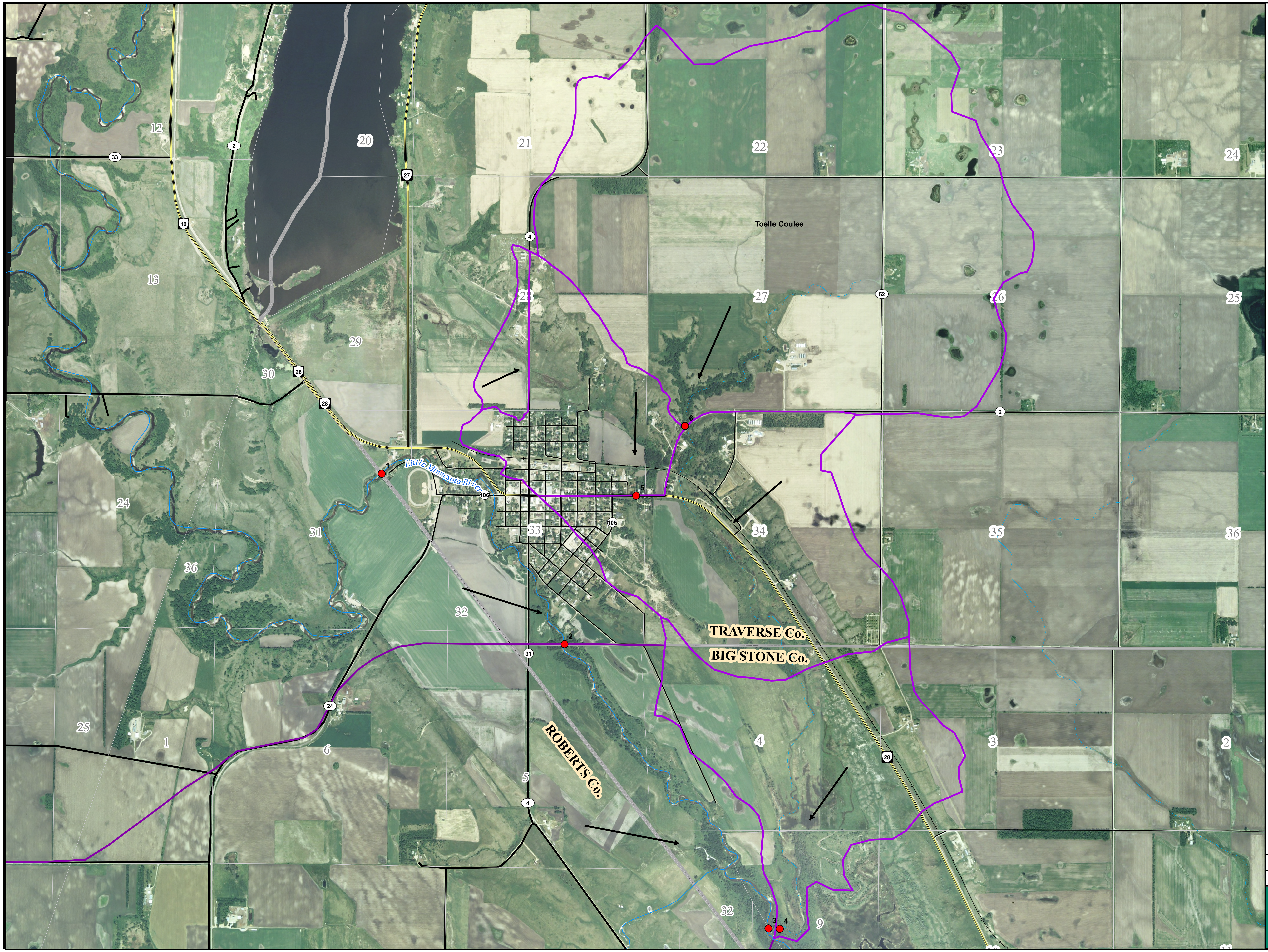
Figure 3-16

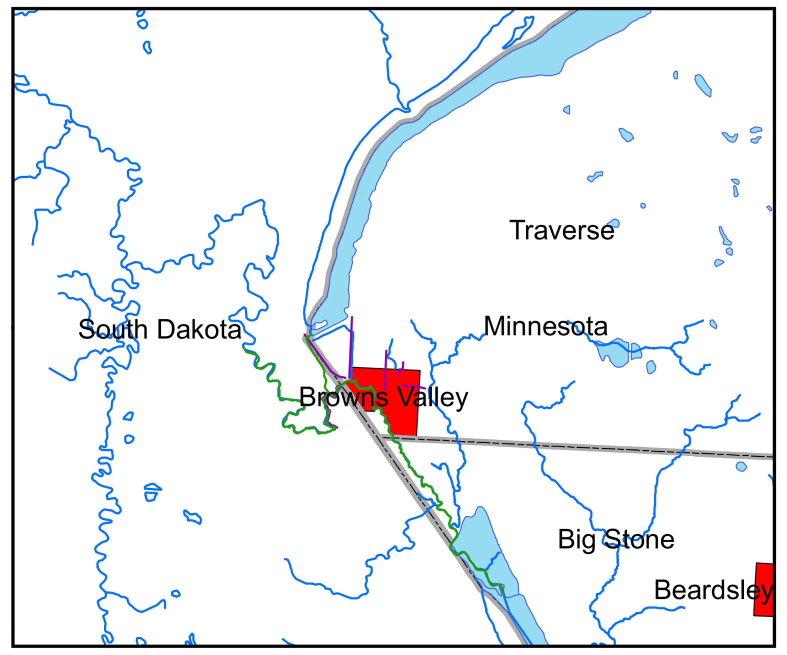


N

Legend

- Ungaged_Flow_Loc
- Routing
- Local Drainage Boundaries
- State Boundary
- County Boundary
- Roads
- Railroads

Location Map



0 800 1,600 3,200 4,800 Feet

Figure 3-17 - Locations of Ungaged Flow

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Houston Engineering, Inc.
6901 E. Fish Lake Rd., Suite 140
Maple Grove, MN 55369
TEL: (763)493-4522
FAX: (763)493-5572

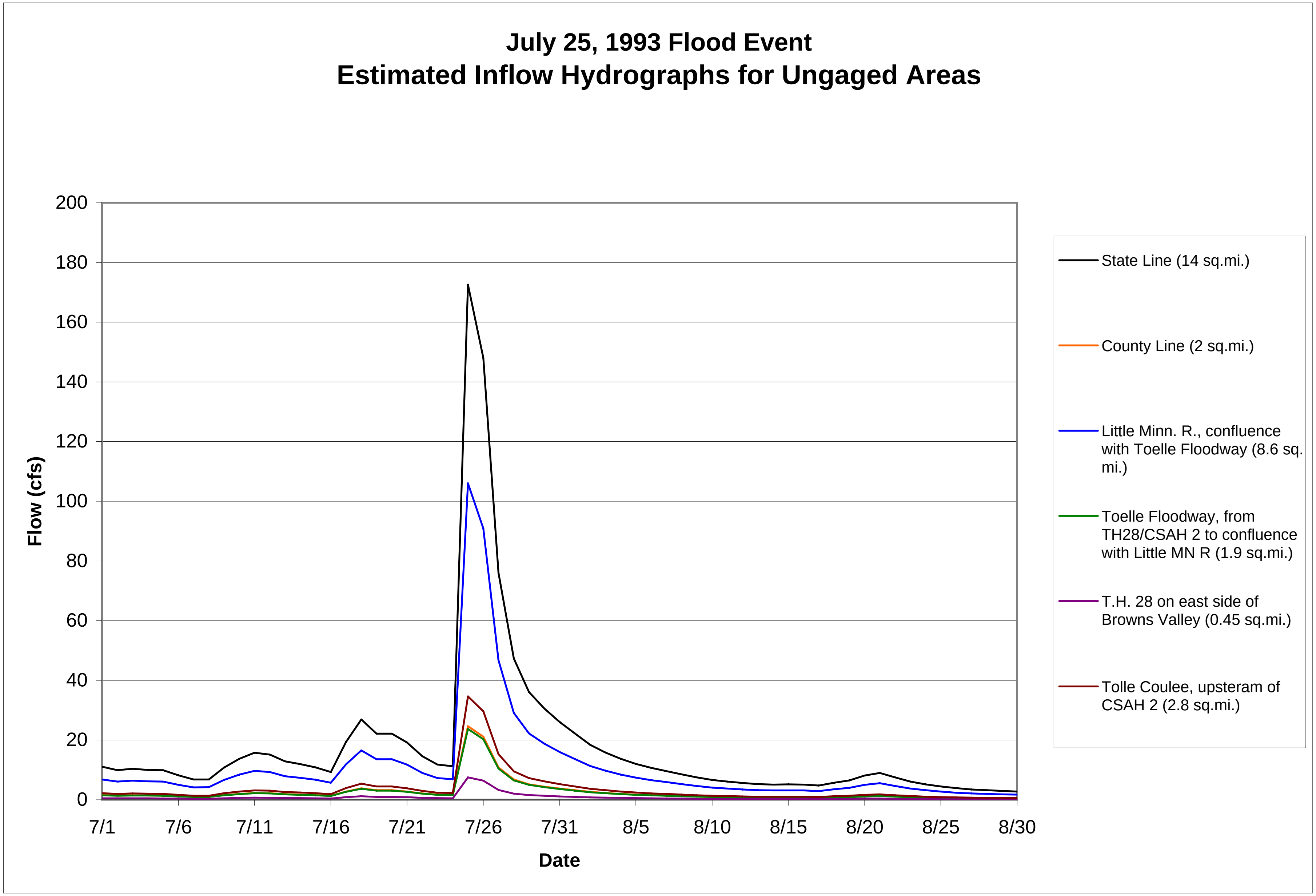

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Figure 3-18

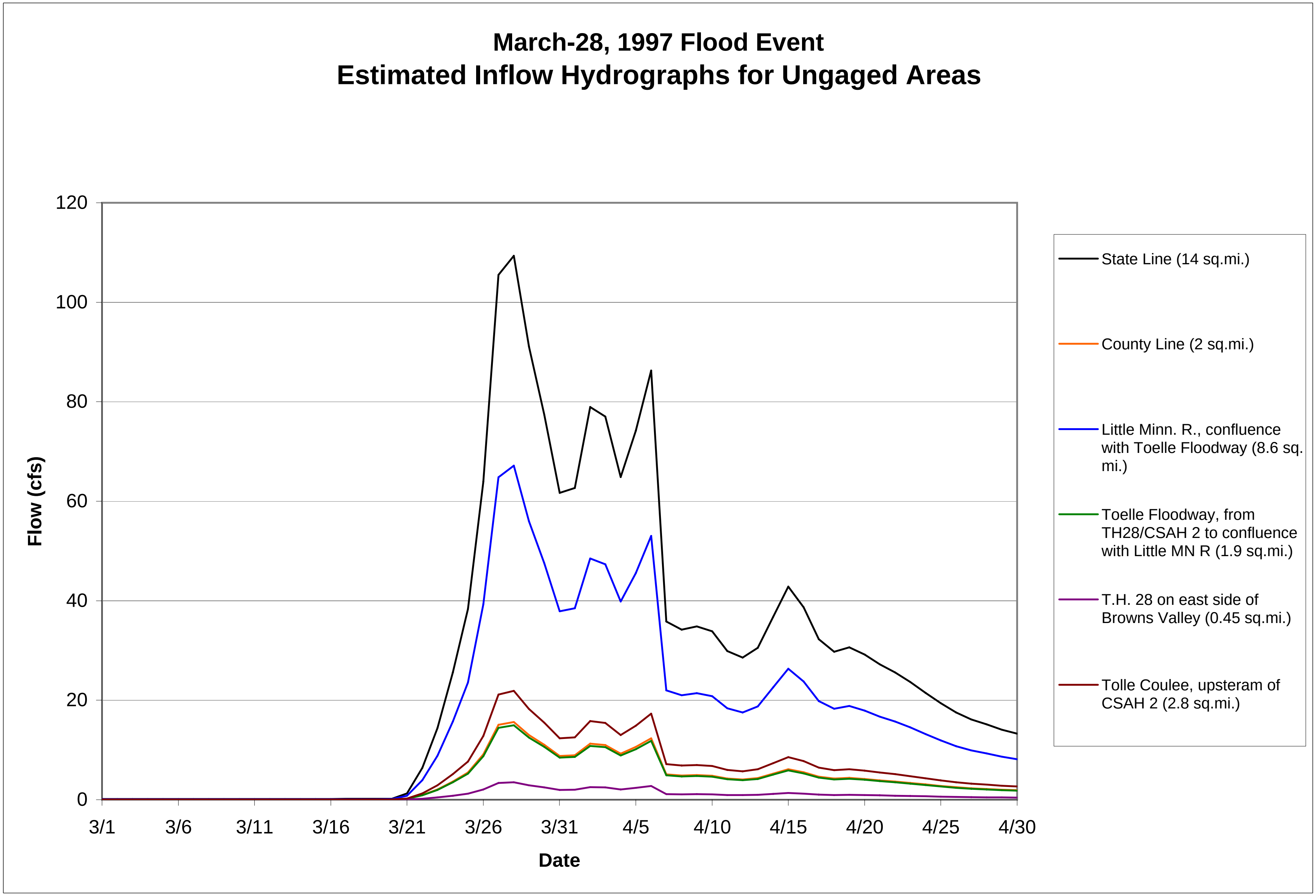

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Figure 3-19

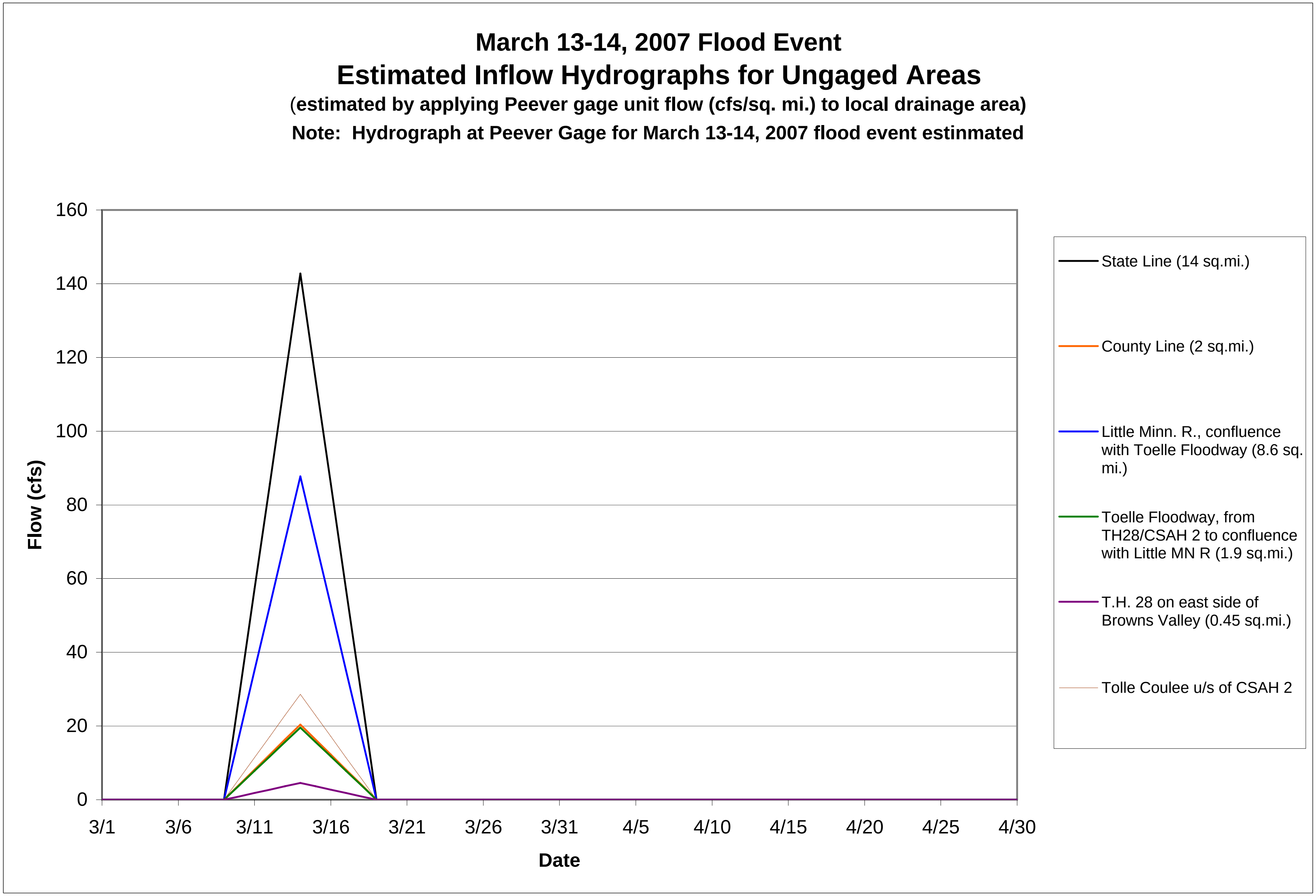

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Figure 3-20

3.2.3.2 Ungaged Subwatersheds

Peak discharges for steady state flow change locations were estimated throughout the model by a drainage area ratio technique. The peak flow values defined for the gageing station at Peever were multiplied by a drainage area ratio raised to an exponent. The ratio is the drainage area for the ungaged site divided by the drainage area for the Peever gageing station. An exponent 0.796 was used, which is that listed in the regional regression equation corresponding to Minnesota Region D.[10] **Table 3-6** shows the resulting peak flows at selected flow change locations using the results of the discharge-frequency analysis at Peever Gage presented in **Section 3.2.1**.

Table 3-6
Synthetic Event Peak Flows for Flow Change Locations

Recurrence Interval	Peever Gage DA=438 sq mi (cfs)	Little Minn. River State Line DA=452 sq mi (cfs)	Little Minn. River County Line DA=454 sq mi (cfs)	Little Minn. River D/S of confluence with Toelle Coulee DA=468 sq mi (cfs)
500	16,100	16,508	16,566	16,970
200	11,900	12,202	12,245	12,543
100	9,300	9,536	9,569	9,802
50	7,070	7,249	7,275	7,452
20	4,660	4,778	4,795	4,912
10	3,200	3,281	3,293	3,373
5	2,020	2,071	2,079	2,129
2	822	843	846	866
1.25	326	334	335	344

3.2.3.3 Toelle Coulee

On June 1, 1965, a flash flood caused significant flooding in the northeastern portion of Browns Valley.[11] Within the Toelle Coulee watershed, ½ inch of rain fell at about 5 P.M. (saturating the soil). A very intense rainstorm occurred later in the evening from 8:00 to 8:45 P.M. Total rainfall depths within the Toelle Coulee watershed were 3.75 to 5.0 inches.

[10] "Techniques for Estimating Peak Flow on Small Streams in Minnesota," USGS, Water-Resources Investigations Report 97-4249.
[11] "Flood Damage Reduction Study for Browns Valley, Minnesota." Widseth Smith Nolting, January, 1989.

The resulting runoff flowed across saturated ground into the coulee and was impounded to a depth of about 25 feet upstream from the County Highway 2 crossing, at which point it overflowed into the west ditch of the highway and discharged down into the eastern portion of the village.[12] To determine the flooding risk due to high flows from Toelle Coulee, as well as provide synthetic peak flows to the hydraulic model, a hydrologic model was developed for Toelle Coulee and the local drainage area on the northeast side of the City draining to culverts crossing TH 28 (see **Figure 3-21**). We used the Hydrologic Modeling System (HEC-HMS) developed by the US Army Corps of Engineers. The model is designed to simulate the precipitation-runoff processes of dendritic watershed systems. The HEC-HMS model allows the simulation of surface runoff from a set of interconnected hydrologic components. HEC-HMS determines the surface runoff in a basin resulting from precipitation. The selected transform and loss methods were the SCS unit hydrograph and the SCS curve number methods, respectively. Time of concentration was determined using methods recommended in the Minnesota Hydrology Guide.[13] The curve number was determined by applying Minnesota DNR land use designations and hydrologic soil groups, as defined by the NRCS. **Table 3-7** summarizes the hydrologic parameters used in the HEC-HMS model.

Table 3-7
Hydrologic Parameters for HMS Hydrologic Model

Subwatershed	Drainage Area (acres)	Drainage Area (sq. mi.)	Curve Number	Time of Concentration (min)
Toelle Coulee	1,795	2.8	76	93
Northeast Browns Valley	329	0.51	68	36
West of CSAH 4	59	0.09	68	9.3

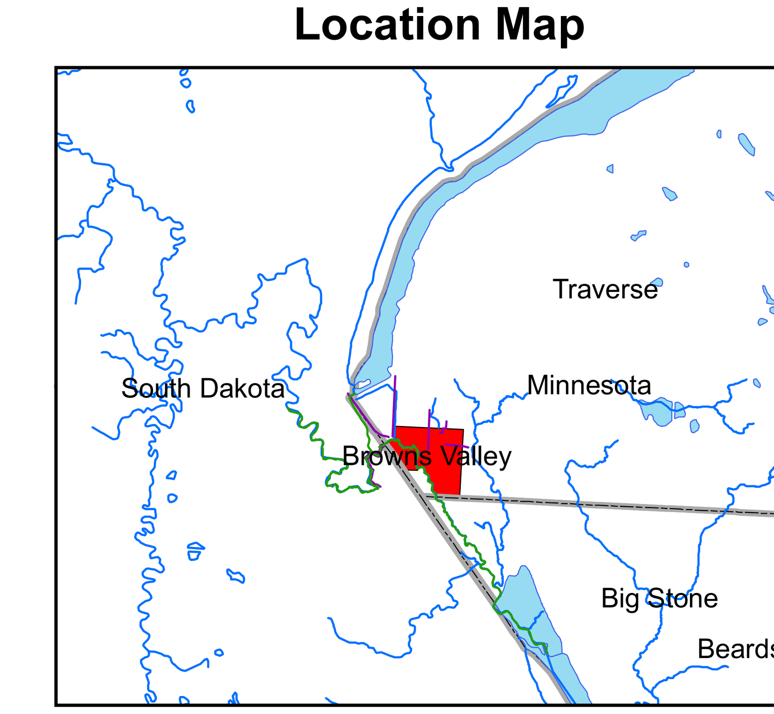
[12] Section 205, Flood Control Reconnaissance Report. Unnamed Coulee at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, January, 1966.
[13] U.S. Department of Agriculture, Soil Conservation Service. 1975, revised 1993. *Hydrology Guide for Minnesota*, St. Paul, Minnesota.

N

Legend

- Ungaged_Flow_Loc
- Routing
- HMS-Subwatersheds
- State Boundary
- County Boundary
- Roads
- Railroads

Location Map



0 500 1,000 2,000 3,000 Feet

Figure 3-21 - HMS Subwatersheds-Toelle Coulee

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Houston Engineering, Inc.
6901 E. Fish Lake Rd., Suite 140
Maple Grove, MN 55369
TEL: (763)493-4522
FAX: (763)493-5572

Storage upstream of Traverse CSAH 2 was estimated using the aerial survey data (see **Figure 3-22**). HydroCAD was used to determine a discharge rating curve at the 60-in culvert crossing Traverse CSAH 2 to the south.

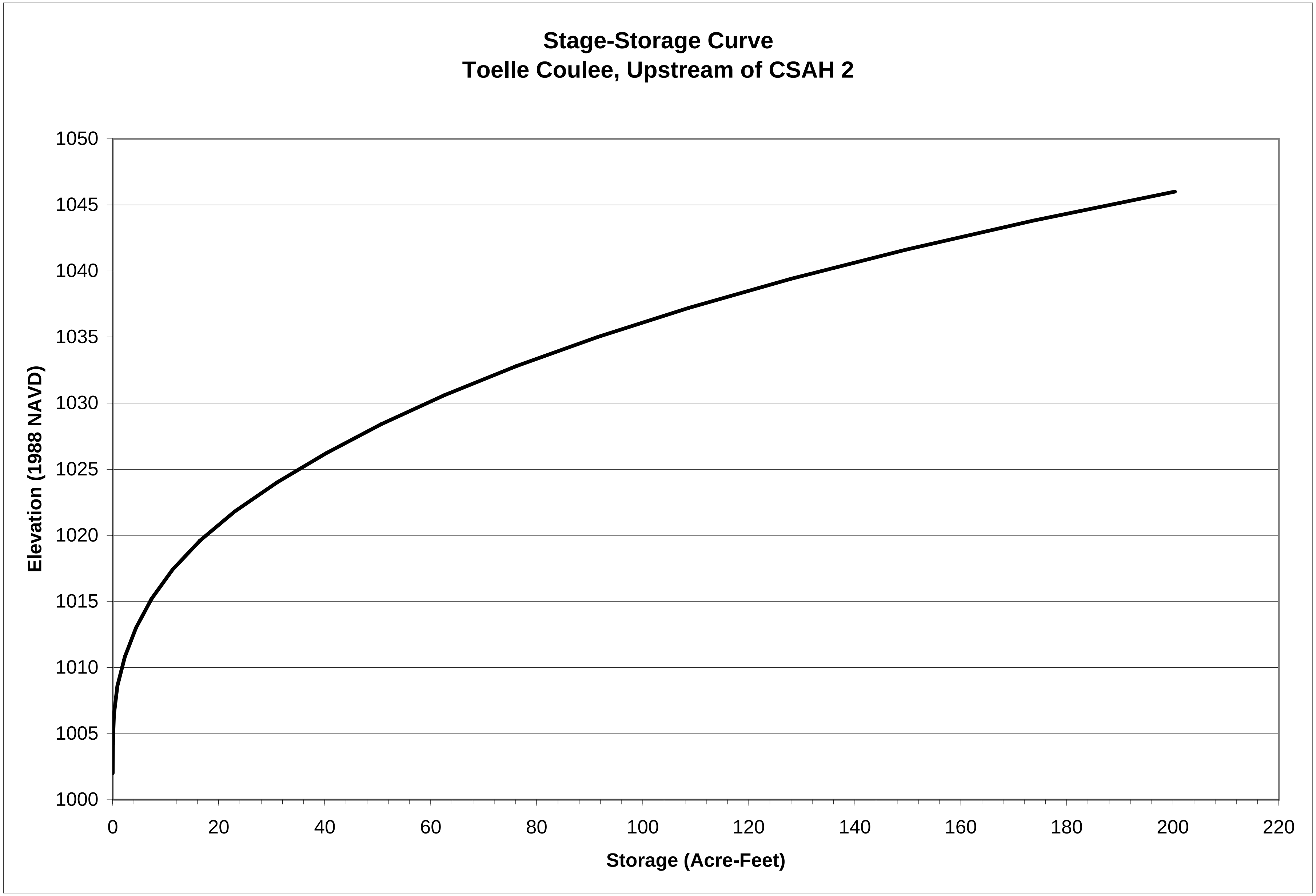
When the water surface elevation upstream of Traverse CSAH 2 exceeds the elevation of 1025.0 NAVD 1988, water flows in the ditch to the south along the west side of Traverse CSAH 2. A HEI survey of the ditch was used to build a HEC-RAS model to determine a relationship between water surface elevation upstream of Traverse CSAH 2 and discharge in the ditch. The rating curves for the 60-in. culvert and ditch were incorporated into the HEC-HMS model to define the distribution of flow at the outlet. These rating curves are shown in **Figure 3-23**. The rainfall amounts applied, as well as peak flows resulting from the HEC-HMS modeling effort, are presented in **Table 3-8.**

Table 3-8
HEC-HMS Rainfall Depths and Resultant 24-hour Peak Flows through CSAH 2 and down west Ditch

Recurrence Interval	Rainfall[14]	Peak Flow (cfs)							
	(24-hour) (inches)	Toelle Coulee Runoff	Traverse CSAH 2 culvert	Ditch along CSAH 2	CSAH 4 Local Runoff	CSAH 4 culvert	TH 28 Local Runoff	To TH 28 storage*	TH 28 culverts
2	2.25	340	283	0	14	5	45	45	36
5	3.0	695	396	1	41	9	132	132	78
10	3.5	965	439	188	63	12	207	235	117
50	5.0	1862	481	1144	139	15	476	1249	298
100	6.0	2504	496	1807	197	17	680	1960	367

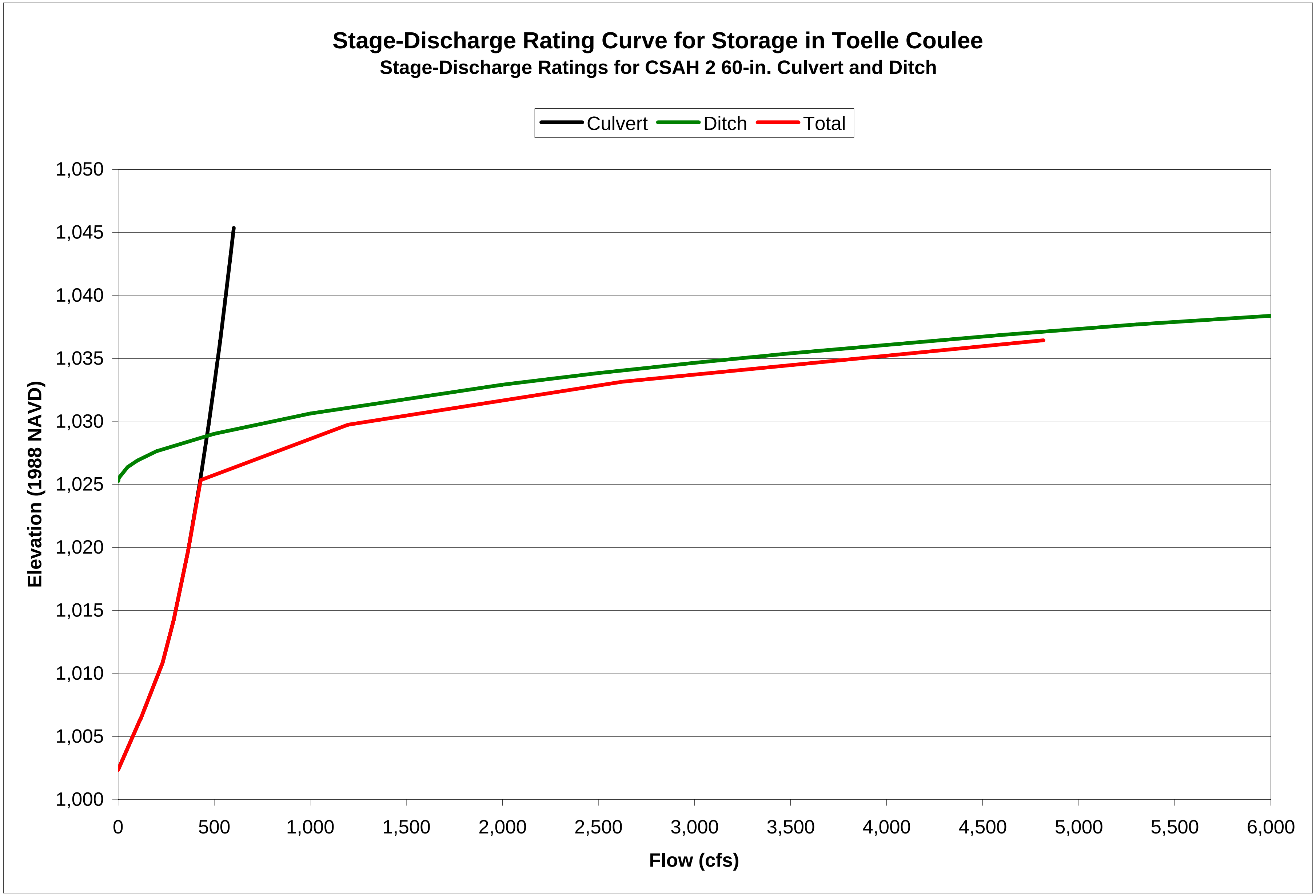
* Flow in ditch and local runoff to TH28 has non-coincident peaks.

[14] "Rainfall Frequency Atlas of the Midwest," Bulletin 71, MCC Research Report 92-03, Floyd A. Huff and James R. Angel.



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\Toelle Coulee\CSAH2 existing storage 12-12-07.xlsChart1 (2)

Figure 3-22



S:\5304-002 Browns Valley Floodway\Eng\Hydrology\Toelle Coulee\CSAH2 Rating-HydroCAD and DitchRating 12-12-07.xlsStage-Discharge Cht (2)

Figure 3-23

3.3 METHODS - HYDRAULICS

This section describes the methods used to complete the hydraulic analyses performed for the Browns Valley Flood Mitigation Project. It describes the development of the existing conditions hydraulic model and how it is used as a tool to analyze alternative flood mitigation design concepts. This section includes descriptions of the methods used in the following tasks:

- hydraulic model development (**Section 3.3.1**);
- hydraulic model calibration (**Section 3.3.2**),
- hydraulic model validation (**Section 3.3.3**), and
- modeling and design of flood mitigation concepts (**Section 3.3.4**).

3.3.1 Model Development

The process of developing the hydraulic model involves data collection, constructing the physical representation of the system (i.e. schematic and geometry of the model), establishing hydrologic boundary conditions, and setting the model's options and tolerances. The HEC-RAS hydraulic model (version 3.1.3), developed by the U.S. Army Corps of Engineers, is the selected model for this analysis. It is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

3.3.1.1 Data Collection

Data collected and used in the development and calibration of the model include the following:

- Ground survey completed by Houston Engineering, Inc.;
- Aerial survey completed by AERO-METRIC, Inc. (see **Section 3.1**);
- Plan drawings from State Aid Project 06-631-01 & 78-604-16 for Traverse County 4 dated March 2000;
- A survey completed by Traverse County on CSAH 4 over the Little Minnesota River in 2006; and

- High water marks from DNR reports, USACE reports and field survey.

The ground survey performed by HEI included a total of 58 cross-sections, 19 culverts, 2 bridges on the Little Minnesota River, dikes and breakout areas along the Little Minnesota River, and sections and profiles along Toelle Coulee. The data collected on the structures included upstream and downstream cross sections, bridge geometry (waterway openings, piers, low steel, railings, etc.) and road profiles. All new survey work was completed in NAVD 1988, and existing surveys were converted to NAVD 1988 as required.

3.3.1.2 Model Schematic and Geometry

Based on the data collected, an existing conditions HEC-RAS geometry file was built for a 9.7 mile reach of the Little Minnesota River, from the USGS gageing station 05290000 at Peever, South Dakota to Big Stone Lake. Areas of breakout flows to the south and west of the river, as well as to Lake Traverse, are also incorporated into the model schematic. **Figure 3-24** is a schematic of the model extents.

An overflow to Lake Traverse was simulated in the hydraulic model by entering a split flow junction. In this manner, the model computes the amount of breakout flow to Lake Traverse versus the flow remaining in the Little Minnesota River channel. The breakout amount is influenced by the ice conditions and agricultural levees, in addition to channel geometry, friction and flow. Breakout flows to Lake Traverse, in excess of the capacity of the box culverts through the Browns Valley Dike, are modeled to overtop TH 28, enter virtual floodplain storage areas, and have the potential to overtop TH 27 and flow into the north side of Browns Valley. The overland flow path of this breakout water is simulated flowing south to where it meets again with the Little Minnesota River and continues on to Big Stone Lake.

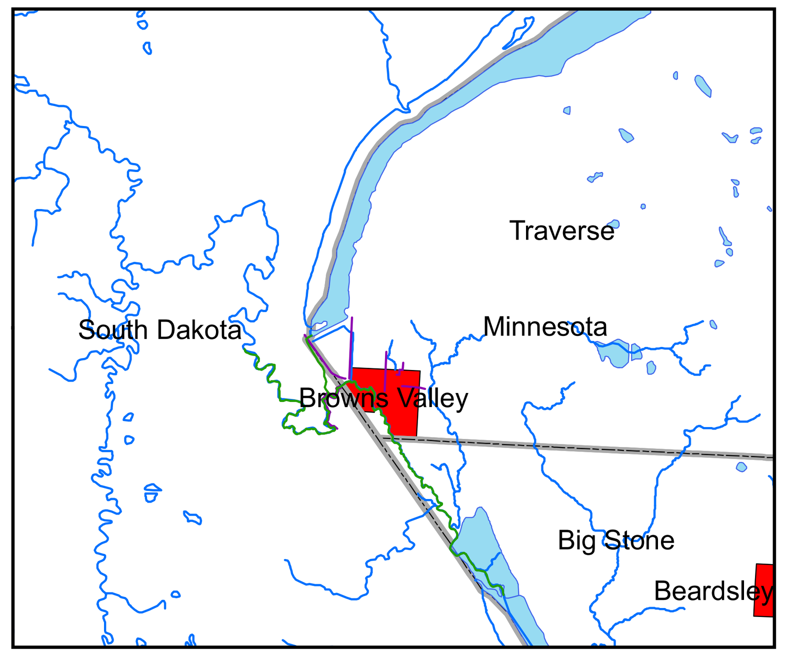
HEC-geoRAS, a GIS software tool, was used to develop the geometric data to the hydraulic model. Together with a digital terrain model (DTM) developed from the aerial survey, the tool develops geometric data, including river centerlines, cross section profiles, reach lengths, bank stations, and storage areas. The field surveyed channel cross sections and road profiles were used to provide more definition to the cross-sections and profiles developed for the DTM.

N

Legend

- Storage Areas
- railroad
- Flow Path
- State Boundary
- County Boundary
- Railroads
- Municipal Boundary

Location Map



0 500 1,000 2,000 3,000 4,000 Feet

Figure 3-24 - Hydraulic Model Schematic

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Where necessary, the surveyed channel cross-sections were copied to nearby cross sections without channel survey and adjusted vertically along the channel slope.

Two storage areas located along the breakout flow path north of Browns Valley were incorporated into the HEC-RAS geometry. This feature was used to simulate flow along the north breakout flow path and account for floodplain storage west and east of TH 27. HEC-geoRAS was used to calculate storage-elevation relationships using the aerial survey 1-foot contours.

3.3.1.3 Boundary Conditions

HEC-RAS was used in unsteady mode for model calibration and validation. This type of model uses time-varying data, i.e. flow/stage versus time hydrographs at boundaries of the model schematic, as well as internal hydrograph input locations. **Section 3.2.2** presents the flow and stage hydrographs which were generated as input into the hydraulic model for three historic events at the upstream and downstream ends of the model to represent the boundary conditions. Steady state boundary conditions used for design, and represented by synthetic event peak flows and elevations are presented in **Table 3-5** in **Section 3.2.2.**

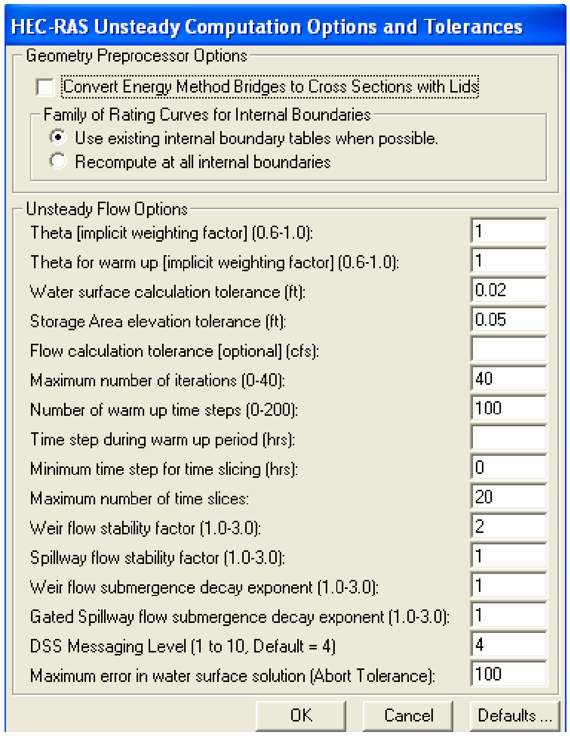
3.3.1.4 Model Options and Tolerance Settings

The HEC-RAS model was run with the computation options and tolerances listed in **Table 3-9**. The default settings were adopted except that the number of warm up time steps was set to 20, with a time step of 1 hour for model stability.

3.3.2 Hydraulic Model Calibration

Calibration is the process by which the model's input parameters are adjusted so that computed results agree as well as possible with observed data and in accordance with the historic flood mechanism. The March 13-14, 2007 historic flood event was selected for model calibration. The selection process of the historic events is presented in **Section 3.1,** and the hydrologic data is presented in **Section 3.2.1.** This flood was caused by rapid snow melt in the watershed leading to an abrupt rise in flow and a major ice jam that formed in the channel of the Little Minnesota River one mile upstream from the city.

Table 3-9
Computation Options and Tolerances set in HEC-RAS Model



HEC-RAS Unsteady Computation Options and Tolerances

Geometry Preprocessor Options

- [ ] Convert Energy Method Bridges to Cross Sections with Lids

Family of Rating Curves for Internal Boundaries

- (•) Use existing internal boundary tables when possible.
- ( ) Recompute at all internal boundaries

Unsteady Flow Options

Theta [implicit weighting factor] (0.6-1.0):	1
Theta for warm up [implicit weighting factor] (0.6-1.0):	1
Water surface calculation tolerance (ft):	0.02
Storage Area elevation tolerance (ft):	0.05
Flow calculation tolerance [optional] (cfs):	
Maximum number of iterations (0-40):	40
Number of warm up time steps (0-200):	100
Time step during warm up period (hrs):	
Minimum time step for time slicing (hrs):	0
Maximum number of time slices:	20
Weir flow stability factor (1.0-3.0):	2
Spillway flow stability factor (1.0-3.0):	1
Weir flow submergence decay exponent (1.0-3.0):	1
Gated Spillway flow submergence decay exponent (1.0-3.0):	1
DSS Messaging Level (1 to 10, Default = 4)	4
Maximum error in water surface solution (Abort Tolerance):	100

OK Cancel Defaults ...

The ice blockage forced water over the river banks, primarily to the north towards Lake Traverse.[15] When the 3 – 9'x 6' reinforced concrete box culverts leading to Lake Traverse through the Browns Valley Dike were unable to carry the entire flow, water overtopped TH 28, then TH 27, and eventually entered the north side of Browns Valley.

3.3.2.1 Calibration Method

The unsteady HEC-RAS model was calibrated by adjusting Manning roughness coefficients and adjusting the thickness of ice placed on the river channel in specific locations, to achieve reasonable agreement between simulated and observed data. The observed data includes high water marks and aerial photos taken during high water. The goal was to match the simulated to the observed to within the following target ranges:

[15] JOR Engineering Inc report on Browns Valley 2007 Spring Flood.

Target 1: Match 2/3, or 66%, of the high water marks within 0.5 feet.[16]

Target 1: Match 2/3, or 66%, of the high water marks within 0.5 feet.[17]

Target 2: Match those locations inundated as seen on historic aerial photographs (visually) by comparing a flood inundation map created from model results.

The following adjustments were made to the model as part of the calibration effort.

"n" values:

The final "n" values used in the calibrated model are listed in **Table 3-10.** These values are within an expected range for natural channels.

Table 3-10
Roughness Coefficients in Calibrated HEC-RAS Hydraulic Model

	Roughness Coefficient, n	
Reach	**Channel**	**Overbank**
Little Minnesota River		
Peever Gage to Browns Valley	0.04	0.065-0.10
Through Browns Valley to Big Stone Lake	0.04	0.075
Traverse Breakout	0.05-0.065	0.065
North Breakout Path		
Through Browns Valley	0.045	0.10
TH 28 to confluence with Little Minnesota River	0.045	0.075

Ice thickness:

Ice thickness and placement was first estimated by studying aerial photographs taken during the March, 2007 flood. The thickness was varied until the Calibration Targets listed above were attained to the extent possible. The final ice thickness in the calibrated model is 3-feet.

[16] FEMA Appendix C, "Guidelines and Specifications for Flood Hazard Mapping Partners: Guidance for Riverine Flooding Analyses and Mapping." FEMA often recommends calibration to within 0.5 feet for flood insurance studies.

[17] FEMA Appendix C, "Guidelines and Specifications for Flood Hazard Mapping Partners: Guidance for Riverine Flooding Analyses and Mapping." FEMA often recommends calibration to within 0.5 feet for flood insurance studies.

3.3.2.2 Assessment of Model Calibration

Target 1: Match 2/3, or 66%, of the high water marks within 0.5 feet

High water marks were obtained from DNR reports, USACE reports, and field survey. **Figure 3-25** displays the locations of these high water marks. **Table 3-11** lists the available 2007 event high water marks, as well as the maximum water surface elevations at the corresponding locations in the HEC-RAS model. The table shows that the simulated maximum water elevations match the observed high water marks to within 0.5 feet in 9 out of the 15 cases, or 60%, of the time, nearly meeting the target of 66%.

Table 3-11
2007 Compiled High Water Marks

		Observed HWMs Spring 2007		HEC-RAS		
ID	Description	HEI[1]	DNR[2]	River Station	Model W.S. Elev.	Computed Elev. Difference
10	Fireworks building west of TH 28 near LT		984.51	2272	984.37	0.14
5	COE HWM on power pole west side on TH 28 north of LT inlet		985.13	517	984.27	0.86
7	COE HWM on power pole west side on TH 28 south of LT inlet		984.34	901	984.29	0.05
19	COE HWM west side TH 28 west of LT inlet		984.31	901	984.29	0.02
9	COE HWM west side Hwy 28 south of LT inlet		983.27	901	984.29	-1.02
6	Debris mark 150' DS on LT inlet		978.93	100	979.3	-0.37
11	West of CSAH 27 near Lake Traverse		981.64	SA-West	981.67	-0.03
12	West of CSAH 4 north of town		981.06	SA-East	980.91	0.15
14	523 4th St. on garage		982.17	SA-East	980.91	1.26
13	524 4th St. in yard		982.26	SA-East	980.91	1.35
20	Broadway Bridge	981.6		23235	980.38	1.22
22	506 E Broadway St. (Reeds Fish Company)		979.73	14432	980.53	-0.80
21	134 E. Broadway St. (Curt Powers Residence)		980.33	14802	980.53	-0.20
16	Broadway Avenue and Jefferson Street	980.13		14802	980.53	-0.40
18	1st Ave N and Washington Street	980.46		14802	980.53	-0.07

Note: All Elevations are in NAVD (1988).
[1] Houston Engineering, Inc. Ground Survey, Summer 2007.
[2] Report: "Spring Flood 2007, Browns Valley, Minnesota, JOR Engineering, Inc," May 15, 2007 (recovered by MNDNR field crew).

N

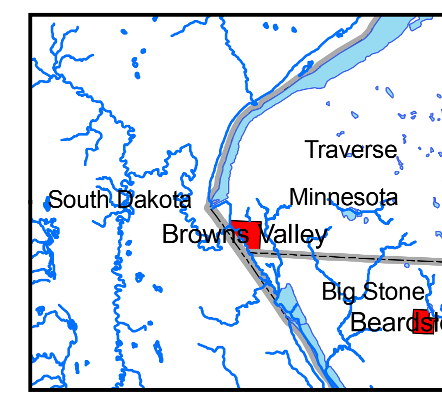
Notes:

1. Results generated from calibrated HEC-RAS model .
2. Represents maximum flood extents from March 13-17, 2007.
3. Little Minnesota is the only mapped flooding source.
4. Flood inundation areas created using aerial photogrammerty data.

Legend

High Water Marks

- <0.5'
- 0.5-1'
- 1-2'
- >2'
- Floodplain Evaluation Areas
- State Boundary
- County Boundary
- Roads
- Railroads



0 750 1,500 3,000 Feet

Figure 3-25 - 2007 Flood Calibration Map

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Target 2: Match flood inundation maps and aerial photographs (visually)

A flood inundation map (**Figure 3-25**) was created from the modeled peak elevations during the March, 2007 flood for comparison to a March, 2007 aerial photograph (**Figure 3-26)**.

By visually evaluating the floodplain, we were able to confirm the model's accuracy. Areas of the floodplain were split into sections and evaluated separately.

- Area 1 – Breakout to Lake Traverse, bounded by the Little Minnesota River on the South and TH 28 on the East. This area matches very well. The entire area is inundated in the aerial photograph. On the modeled inundation map, the entire area is shown as flooded with the exception of a small area along the Little Minnesota River.
- Area 2 – Breakout path around north side of Browns Valley. This area generally matches well. The section immediately south of Lake Traverse is nearly entirely flooded on both the inundation map and the photograph. In the section east of CSAH 4, the inundated area resulting from the modeling covers less of an area than does the flooding seen on the photograph. In the section east of CSAH 4, the inundated area matches well between the simulated and observed on the photograph.
- Area 3 – Little Minnesota River. A comparison between the simulated and observed flooded areas along the Little Minnesota River varies along its length. Some areas match closely while other locations don't match as well, however, the results are considered satisfactory.
- Area 4 – Toelle Coulee. The simulated and observed flooded areas match closely south of TH 28. Further south, the mapped area of inundation is somewhat larger than shown on the aerial photograph, but the overall match is considered satisfactory.

3.3.3 Hydraulic Model Validation

Validation is the process of testing the calibrated model with data not used in the calibration process, i.e. other historical flood events. The July 25, 1993 summer event and the March 28, 1997 spring event, which was influenced by an ice jam, were used to verify that the model behaved properly for these two floods. The selection process for these two events is

2007 Aerial Flood Photograph
(looking southeast from Lake Traverse)

Source of Photograph: Report: Spring Flood 2007, Browns Valley, Minnesota. JOR Engineering, Inc. May 15, 2007

Figure 3-26

discussed in **Section 3.2.1,** and the hydrologic data input is presented in **Section 3.2.2**. Slight modifications of calibrated model geometry were necessary to simulate the 1997 and 1993 events to account for the physical conditions during that time:

- Geometry representing CSAH 4 was changed to reflect its condition prior to modifications made in the year 2000. Construction included the replacement of an overland flood flow opening and a grade re-alignment. The road was modified to create a lower sag curve to convey flood flows at a lower elevation;
- 3-feet of ice cover was again simulated from the Broadway bridge and continued upstream for the 1997 event; and
- agricultural levees were removed from the simulation of this event based on information received from local officials and landowners. This allowed for simulation of the overland breakout south of the city.

The 1993 model geometry is identical to 1997 except for the removal of the ice cover in the river.

As the primary indicator to assess model validation, locations were selected to compare the simulated and observed results, in terms of whether particular roads were overtopped (note that no highwater marks are available). The observed roadway overtopping information was taken from previous reports and first-hand accounts recalled by local officials and residents. **Tables 3-12 and 3-13** present this comparison and indicate that for both the July, 1993 and March, 1997 flood events, the modeling results show the same roads overtopping as were observed. The hydraulic model was therefore considered to satisfactorily represent the flood mechanism and considered validated.

3.3.4 Modeling and Design of Flood Mitigation Concepts

To complete the concept design, a steady state hydraulic model was used to simulate the proposed alternative flood mitigation concepts for runoff events with various return periods (see **Section 3.2.3**). Once the sizing and design was completed with the steady state model, the performance of each of the designs concepts was checked by applying the geometry files to an

Table 3-12
Summer 1993 – Observed versus Modeled Roadway Overtopping

Locations	Roadway Overtopped (yes/no)	
	Observed	**Modeled**
Broadway Bridge	yes	yes
CSAH 4 - South	yes	yes
Low Water Crossing – CR 24	yes	yes
TH 27	no	no
TH 28 near Lake Traverse	no	no
TH 28 - East of town	no	no
CSAH 4 - North of town	no	no

Table 3-13
Spring 1997 – Observed versus Modeled Roadway Overtopping

Locations	Roadway Overtopped (yes/no)	
	Observed	**Modeled**
Broadway Bridge	yes	yes
CSAH 4 - South	yes	yes
Low Water Crossing – CR 24	yes	yes
TH 27	no	no
TH 28 near Lake Traverse	no	no
TH 28 - East of town	no	no
CSAH 4 - North of town	no	no

unsteady modeling analysis of the historic floods of 1993, 1997, and 2007. The following paragraphs describe the process followed to complete the modeling of the concept designs.

3.3.4.1 Blockage Analysis to Determine Maximum Flow through City

Since ice jams and debris blockages are known to be a recurring problem and can worsen the effects of flooding, an analysis was done to determine the amount of flow that should be typically allowed through the town during floods. Free flow bankfull channel capacity through Browns Valley ranges from 1,200-1,600 cfs, with a minimum capacity of 1,200 cfs at a cross section upstream of the Broadway Bridge (a bridge where ice and debris blockage occurs. To determine the capacity of the river at the bridge during an event with an ice jam or debris blockage, a portion of the waterway opening at the Broadway bridge was blocked in the HEC-

RAS model to various degrees. The flow capacity was further constrained by requiring one foot of freeboard, i.e. the river was considered at maximum capacity at one foot below the top of bank, reducing the minimum flow capacity to 980 cfs. **Table 3-14** displays the percentage of the bridge opening blocked and the corresponding capacity in the river. A maximum flow of 500 cfs was selected as a reasonable amount of flow to allow in the Little Minnesota River as it passes through the City.

Table 3-14
Blockage vs. Capacity

Blockage at Broadway Bridge (%)	Waterway Opening (sq. ft.)	Flow Capacity (cfs)
0	417	980
10	375	880
20	334	860
30	292	800
40	250	640
50	209	440

Note: all waterway openings and flow capacities listed correspond to the same elevation, i.e. 1-foot below top of bank

3.3.4.2 Design Discharges and Boundary Conditions

In designing the flood mitigation alternatives, the steady flow simulation component of HEC-RAS was applied. The initial sizing and designing of the flood mitigation features focused on the 100-year recurrence interval event of approximately 9,300 cfs in the Little Minnesota River (see **Section 2.0 Design Goals**). A range of flows, representing other recurrence intervals, as well as historic events, were then also modeled to assess the system performance to a range of other hydrologic events. **Tables 3-5 and 3-6** in **Section 3.2.3** present the steady state discharges used for various recurrence intervals at the boundary conditions and other ungaged flow locations internal to the model, respectively. Coincident flooding is assumed at the upstream and downstream boundary conditions, i.e. if modeling a 100-year upstream boundary condition, than 100-year lake levels at Big Stone Lake and Lake Traverse are used as downstream boundary conditions.

Design discharges used to model Toelle Coulee flood mitigation concepts were determined with a hydrologic model. The methods and resulting synthetic peak flows are presented in **Table 3-8** of **Section 3.2.3**.

The design criteria considered in the hydraulic modeling for the various flood mitigation alternatives included the following:

<u>Little Minnesota River</u>

- maintain approximately 500 cfs in the Little Minnesota River through the City;
- divert 1,020 cfs to Lake Traverse, as determined to be the 100-year breakout flow in the 1986 Flood Insurance Study;[18] and
- divert the remaining 7,780 cfs of the 9,300 cfs (100-year flow) down the flood way to meet up again with the river south of the City.

<u>Toelle Coulee</u>

- Prevent the 100-year synthetic peak flow from flowing west to the City.

The calibrated HEC-RAS model was used as a tool to design the various flood mitigation alternatives to meet the above criteria. **Section 5.0** describes the detailed analyses and results for each alternative.

[18] Flood Insurance Study, City of Browns Valley, Minnesota, Traverse County, Federal Emergency Management Agency, June 17, 1986.

SECTION 4.0
RANGE OF FLOOD MITIGATION ALTERNATIVES CONSIDERED

The UMRWD assembled the BVFMTF to assist with the analysis, design, selection and construction of a flood mitigation project for the City of Browns Valley. This section presents information specific to the range of flood mitigation projects or "alternatives or concepts" considered and describes the technical analyses used to initially evaluate their desirability relative to providing flood protection. The primary basis for the desirability of a specific alternative is the design goals. Some flood mitigation alternatives were eliminated from additional more detailed analysis as a result of this initial analysis, while others were subject to additional more detailed analysis. The initial analysis generally showed that because of technical limitations some of the alternatives were not feasible. Based upon this analysis several floodway and levee alternatives were selected for additional detailed analysis and considered to be the most desirable. These very general concepts were modified during subsequent design efforts as discussed in Section 5.0.

4.1 PURPOSE AND NEED

The purpose of the flood mitigation project is to provide flood mitigation to the City of Browns Valley including an additional land area surrounding the City (i.e., a buffer) as a margin of safety. The need is a minimum of flood protection for the 100-year flood event including consideration of the uncertainty in estimating the magnitude of discharge for the event.

4.2 RANGE OF FLOOD MITIGATION CONCEPT ALTERNATIVES CONSIDERED

The "range" of alternatives initially considered to mitigate flooding within Browns Valley included both structural and non-structural solutions. The source of information used to identify the range of alternatives consisted of previously prepared reports (prepared primarily by the U.S. Army Corps of Engineers and a consulting engineering firm), the experience of the Houston Engineering, Inc. (HEI) design team, and suggestions from the BVFMTF. The alternatives were numbered for ease of reference. The number is not assigned based upon initial preference for an alternative.

The range of alternatives consists of both structural and nonstructural options:

- Complete structural solutions are those alternatives consisting of a single project believed capable of achieving the design goals.
    - Alternative CS1 - Increase the Channel Capacity of the Little Minnesota River;
    - Alternative CS2 - Levees along the Little Minnesota River within Browns Valley;
    - Alternative CS3 - Community Ring Dike;
    - Alternative CS4 – Little Minnesota River Floodway;
    - Alternative CS5 – Little Minnesota River Floodway with Levees; and
    - Alternative CS6 – Little Minnesota River Floodway and Off-Channel Storage.
- Partial structural solutions are those alternatives consisting of a single project believed incapable of achieving the design goals.
    - Alternative PS1 - Impoundment on Unnamed Coulee (now coined "Toelle Coulee");
    - Alternative PS2 - Toelle Coulee Floodway and Levee; and
    - Alternative PS3 – Toelle Coulee Levee.
- Nonstructural options which are neither a complete or partial solution for providing flood mitigation to Browns Valley.
    - Existing Conditions (Do Nothing); and
    - Flood Early Warning System.

An analysis of the range of alternatives sufficient to select the "most promising" alternatives capable of achieving the purpose and need follows.

4.3 ANALYSIS OF THE RANGE OF ALTERNATIVES

4.3.1 Complete Structural Solutions

These alternatives are considered potential “complete” solutions to provide flood mitigation for the City of Browns Valley. This means that the alternatives are theoretically capable of achieving the design goals as well as the purpose and need, without the construction of any additional features; i.e., they are a single and complete solution.

4.3.1.1 Alternative CS1 - Increase the Channel Capacity of the Little Minnesota River

This alternative consists of increasing the capacity of the Little Minnesota River to safely convey floodwaters through the City. The Flood Insurance Study (FIS) for the City of Browns Valley identifies the 100-year discharge within the Little Minnesota River at the Peever Gage as 7,990 cubic feet per second[1] (cfs). The FIS estimates an additional estimated 1,240 cfs for the 100-year discharge results from Toelle Coulee located northeast of Browns Valley (mostly within Section 27, Folsom Township 125N, R 49W, Traverse County, Minnesota).

Figure 4-1 shows the approximate discharge capacities for portions of the Little Minnesota River and various bridges and culverts. Preliminary analysis for the Little Minnesota River shows bank full discharge capacities through the City range from 1,000 to 2,000 cfs. The average capacity is estimated at 1,600 cfs. **Figure 4-2** shows base flood elevations[2] (1988 NAVD) through the City of Browns Valley based upon the FIS study. The estimated discharge for with the 1% chance (i.e., 100-year) event[3] at the Peever, SD gage is 9,300 cfs. An estimated 1,020 cfs is assumed to breakout to the north into Lake Traverse, which results in a flow of 8,280 cfs entering the City. The capacity of the Little Minnesota River through the City will need to be increased by 6,680 cfs to convey the total flow of 8,280 cfs based upon the updated frequency analysis.

---

[1] This discharge is not reflective of the Flood of 2007 or any other flood events subsequent to completion of the FIS hydrology study in June of 1986. The recently completed frequency analysis shows this has increased because of annual floods since 1986 to 9,300 cfs (includes breakout flows to Lake Traverse)

[2] These elevations are based upon the 1986 FIS discharge of 6,970 cfs. The updated 100-year discharge assuming 1,020 cfs overflow to Lake Traverse is 7,280 cfs

[3] This value differs from the FIS study 100-year value of 7,990 cfs – the frequency analysis has been updated for the purposes of this summary to include the annual maximum values since completion of the FIS

N

Approximate structure capacities using assumed average cross-sectional velocity of 5 feet per second to 10 feet per second. (Subsequently refined though hydraulic modeling, see Section 5)

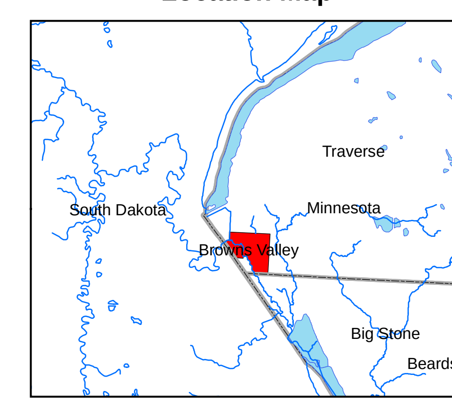
Approximate channel capacities using preliminary hydraulic model.

Detailed hydraulic analysis yet to be completed.

Legend

- Railroads
- Roads
- Streams and Rivers
- Watershed Boundary
- State Boundary
- Municipal Boundary

Location Map



0 1.25 2.5 5 7.5 10 Miles

Figure 4-1. Approximate Channel and Structure Capacities.

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Map created by:
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Maple Grove, MN 55369
Bus: (763) 493-4522
Fax: (763) 493-5572

N

NOTES

1. CROSS SECTION ELEVATION TYPICAL:

BASE FLOOD ELEVATION (1) => 976.6
BASE FLOOD ELEVATION PLUS 3-FT (2) => 979.6

(1)SOURCE: 1986 FLOOD INSURANCE STUDY
BASE FLOOD ELEVATION ADJUSTED TO 1988 NAVD

(2)BASE FLOOD ELEVATIONS ASSUME NO REGULATORY FLOODWAY

2. TOPOGRAPHIC DATA BASED UPON 10-METER DEM.

LEGEND

STATE/COUNTY BOUNDARY
CITY BOUNDARY
REFERENCE LINE
CONTOUR (10-FOOT)

Data source: MN DNR Data Deli

0 1000 2000
Scale Feet

Figure 4-2
Flood Elevations along the Little Minnesota River

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DJL	MRD	5304-002	1-7-2008	1 OF 1

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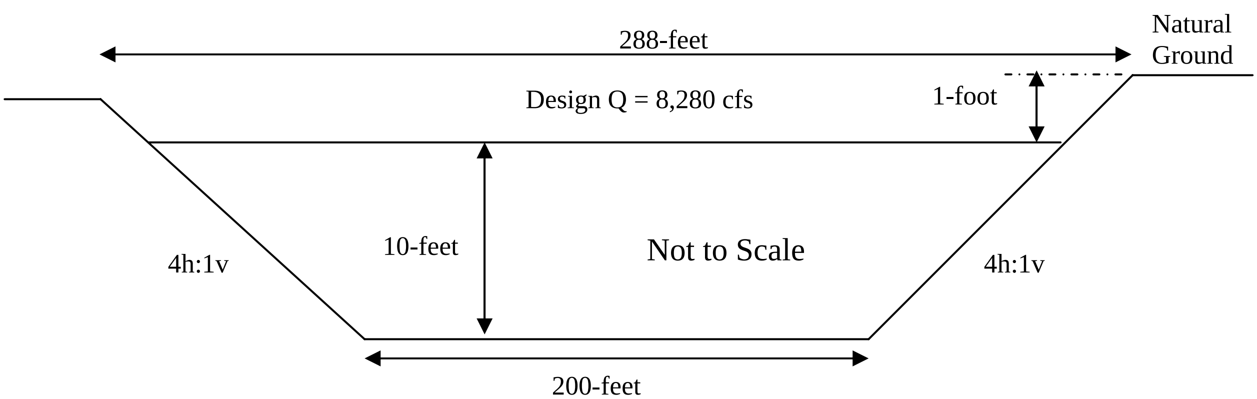
MAPLE GROVE, MINNESOTA 55369
TEL: (763)493-4522
FAX: (763)493-5572

The typical cross sectional area of the Little Minnesota River through Browns Valley is 300 to 600 square feet. Based upon the current slope of the river and assuming 1-foot of difference between the elevation of the water and the minimum natural ground elevation (i.e., freeboard), an increase in the average cross-sectional area to an estimated 2,700 square feet is needed to convey the 1% chance event. This cross sectional area can be obtained by using a trapezoidal channel with 4:1 side slopes, constructed to a depth of 11 feet and a bottom width of 200 feet and a top-width of 288 feet (**Figure 4-3**). The material resulting from the excavation is normally placed adjacent to the river and the material leveled. Therefore, land is needed not only for construction of the channel but the placement of the spoil material.

Figure 4-3
Little Minnesota River Channel Improvement
Functional Design



The estimated amount of material assuming average existing and future channel cross-sectional areas is 433,000 cubic yards per river mile (from the Highway 27 drain to the Big Stone – Traverse County line). Assuming the spoil is spread adjacent to both sides of the channel at 4h:1v side slopes, a top-width of 12-feet and a height of 16-feet, an additional 140-feet is needed on both sides of the channel. Therefore, the likely minimum total cross-sectional width needed is 570-feet.

Figure 4-1 shows the discharge capacity of the bridges through Browns Valleys. Discharge capacities are inadequate to convey the 1% chance event and would need replacing.

Advantages: Probable advantages of this concept include:

- Potentially less amount of excavation as compared to a floodway, provided lengths are similar;
- Potentially less right-of-way required than a floodway, because the excavation volume should be less; and
- Ability to use existing bridges provided capacities are adequate.

Disadvantages: Probable disadvantages of this concept include:

- Little area adjacent to the river for placement of the spoil – likely to require hauling for disposal;
- Loss of ecological integrity within the exiting channel because of excavation – permits and approvals more challenging to obtain;
- Bridge capacities are known to be inadequate and require replacement or enlargement;
- Length of channel longer than floodway – therefore, more excavation likely; and
- Project complexity generally greater than rural floodway and levee because of more building, utilities and structures to avoid.

4.3.1.2 Alternative CS2 - Levees along the Little Minnesota River within Browns Valley

Rather than increasing the discharge capacity of the Little Minnesota River through Browns Valley, levees[4] through the City could be used as the flood mitigation solution. These levees need to safely convey discharges through the City, while protecting homes, building and

[4]Levees could be used along with increasing the discharge capacity of the Little Minnesota River and this is in fact what would likely occur (by using the spoil material from the river)

other infrastructure. Design assumptions used to complete the preliminary analysis of the feasibility of urban levees included:

- Breakout discharge to Lake Traverse during the 1% chance flood event of 1,020 cfs;
- Protection to the 1% chance (100-year) elevation plus three feet of freeboard;
- Placement on both sides of the Little Minnesota River through the corporate city-limits (even though upstream and downstream tie-in locations are unknown);
- Side slopes of 4h:1v and a top-width of 12-feet; and
- Total right-of-way required for levee footprint currently not known, but likely to require a minimum of 200-feet on each side of the channel.

Figure 4-4 shows one approximate alignment for levees placed through the City of Browns Valley based upon the design assumptions.

Advantages: Probable advantages of this concept include:

- Can use the discharge capacity of the Little Minnesota River;
- May be able to construct levees from material excavated from the river bank and channel; and
- Ability to use existing bridges provided capacities are adequate.

Disadvantages: Probable disadvantages of this concept include:

- The number of buildings and residences impacted by the footprint (see **Figure 4-4**);
- Bridge capacities are known to be inadequate and require enlargement or replacement;
- May not be able to construct levees from material excavated from the river bank and channel;
- Need for local drainage within the City, interior to the levee boundary;

N

NOTES

1. CROSS SECTION ELEVATION TYPICAL:

BASE FLOOD ELEVATION (1) => 976.6
BASE FLOOD ELEVATION PLUS 3–FT (2) => 979.6

(1)SOURCE: 1986 FLOOD INSURANCE STUDY
BASE FLOOD ELEVATION ADJUSTED TO 1988 NAVD

(2)BASE FLOOD ELEVATIONS ASSUME NO REGULATORY FLOODWAY

2. TOPOGRAPHIC DATA BASED UPON 10–METER DEM.

LEGEND

STATE/COUNTY BOUNDARY
CITY BOUNDARY
REFERENCE LINE
CONTOUR (10–FOOT)
APPROXIMATE LEVEE

Data source: MN DNR Data Deli

0 1000 2000
Scale Feet

Figure 4-4
Concept Drawing for Urban Levee Footprint (showing BFE's etc.)

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DJL	MRD	5304-002	1-7-2008	1 OF 1

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- Unknown feasibility to tie in levees at upstream and downstream boundary of the City;
- Disruption of local drainage patterns;
- Bridge capacities are known to be inadequate and require replacement; and
- Eminent risk to community in the event of a levee failure.

4.3.1.3 Alternative CS3 - Community Ring Dike

Constructing a dike system around all or portions of the City of Browns Valley (i.e., a ring dike) is a flood mitigation option. Some type of hydraulic control structures would be needed to be placed on the Little Minnesota River at the upstream and downstream borders of the ring dike. This option would also require some type of bypass channel or floodway to be constructed to convey Little Minnesota River discharges downstream.

The upstream structure would need to limit the amount of water entering the City to the capacity of the Little Minnesota River (~ 1,600 cfs) through the City (see **Figure 4-1** and **Figure 4-5**). The downstream structure would need to allow water entering the City to leave. Alternatively, a ring dike could be constructed to provide flood protection for only a portion of Browns Valley, negating the need for these structures.

Design assumptions used to complete the preliminary analysis of the feasibility of a community ring dike included:

- Flood protection for a majority of the City (see **Figure 4-5**);
- Protection to the 1% chance (100-year) elevation plus three feet of freeboard;
- Probable volume of 170,000 cubic yards; and
- Dike side slopes of 4h:1v and a top-width of 12-feet.

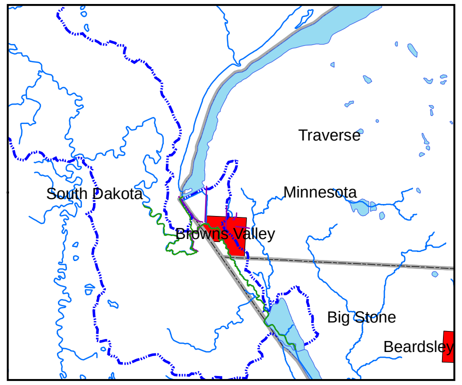
Conceptual design by levee section is described by **Table 4-1**.

N

Legend

- Contour (10-foot)
- Community Ring Dike
- Roads
- Railroads
- County Boundary
- State Boundary
- Municipal Boundary

Location Map



0 1.25 2.5 5 7.5 10 Miles

Figure 4-5. Community Ring Dike Concept.

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	MNL		5304-002	09/11/07	

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Table 4-1
Conceptual Design for Community Ring Dike

Levee Section	Assumed Natural Ground (1988 NAVD)	Design Dike Elevations	Average Height (feet)	Estimated Length (feet)
1	980.5	989.1	8.6	6,312
2	980.0	988.0	8.0	2,365
3	976.0	984.0	8.0	1,301
4	973.0	980.0	7.0	1,403
5	980.0	984.0	4.0	871
6	978.0	983.0	5.0	1,222
Total				13,474

Some type of diversion or floodway would also be needed to divert the flows of the Little Minnesota River unable to enter the City around the City.

Advantages: Probable advantages of this concept include:

- Could regulate flows entering the City to the capacity of the Little Minnesota River and bridges;
- No need to replace bridges within the City; and
- Can reasonably identify the tie in locations for the dike to existing topography.

Disadvantages: Probable disadvantages of this concept include:

- Majority of building and homes could be protected by the ring dike, but not all;
- Still need to construct a floodway or a diversion for Little Minnesota River flows, likely to be similar in length and size to the floodway and levee concept (see above);
- The length of dike is considerably greater than the levee concept or the floodway and a levee concept , but the volume is less;

- Disruption of local drainage patterns;
- Need for local drainage (removal of water internal to the ring dike); and
- Eminent risk to community in the event of a dike failure.

4.3.1.4 Alternative CS4 - Floodway

The purpose of a floodway is to convey flood waters around the area being protected. A portion of the flow would remain within the Little Minnesota River through Browns Valley, but within the existing capacity of the channel. Previous technical analysis preliminarily evaluated a floodway around Browns Valley as a concept for mitigating flooding. Generally, the preferred floodway alignment is along the shortest possible route from upstream to downstream of the area to be protected and sized to convey the design flow within the floodway channel.

Based upon previous technical analysis, one anticipated point of beginning for a floodway could be the Little Minnesota River within either Section 6, Becker Township 124N, R 49W or Section 31, Becker Township 125N, R 49W (Roberts County, South Dakota) (see **Figure 4-6**). The floodway alignment could be oriented in a south-easterly direction following a natural (existing) drainage feature through Section 5, T 124N, R 49W (Roberts County, South Dakota) with the terminus of the floodway joining the Little Minnesota River within either Section 20, T 125N, R 49W (Traverse County, Minnesota or Section 29, T 125N, R 49W Big Stone County, Minnesota).

Other floodway alignments have been preliminarily considered.[5] These include a southeasterly alignment beginning northwest of the racetrack within Section 19, T 125N, R 49W (Traverse County, Minnesota) and generally following the state border to the confluence with the Little Minnesota River within Section 19, T 125N, R 49W (Traverse County, Minnesota). The specific alignment could be based upon several criteria including (not in priority order):

- Avoid / minimize impacts to existing infrastructure and utilities;
- Required modifications to the local transportation system;

[5] Floodway Option 3 was added subsequent to the completion of this analysis.

NOTES

1. TOPOGRAPHIC DATA BASED UPON 10–METER DEM.

FLOODWAY OPTIONS

FLOODWAY OPTION 1
- BOTTOM WIDTH = 225 FT.
- SIDE SLOPES = 4:1 (HORIZONTAL:VERTICAL)
- WATER DEPTH = 7 FT.
- TOTAL DEPTH = 8 FT.
- TOTAL CROSS SECTION AREA = 2,056 SQ.FT.
- TOTAL TOP WIDTH = 289 FT.

FLOODWAY OPTION 2
- BOTTOM WIDTH = 350 FT.
- SIDE SLOPES = 4:1 (HORIZONTAL:VERTICAL)
- WATER DEPTH = 7 FT.
- TOTAL DEPTH = 8 FT.
- TOTAL CROSS SECTION AREA = 3,056 SQ.FT.
- TOTAL TOP WIDTH = 414 FT.

LEGEND

STATE/COUNTY BOUNDARY
CITY BOUNDARY
CONTOUR (10–FOOT)
APPROXIMATE LEVEE
APPROXIMATE FLOODWAY

Data source: MN DNR Data Deli

0 1000 2000
Scale Feet

Figure 4-6
Concept Drawing for Approximate Floodway & Levee Alignments, Little Minnesota River

Scale	Drawn by	Checked by	Project No.	Date	Sheet
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- Shortest alignment (and therefore likely least cost);
- Access to agricultural fields (i.e., along field boundary rather than splitting);
- Availability of land for easements (i.e., willingness of participation);
- Maintaining historic flows to Lake Traverse; and
- Legal authority to acquire lands.

The local transportation system is potentially affected by the floodway. Additional bridges would need to be constructed or the existing openings enlarged for additional flow capacity by placing culverts under the roadways. Depending upon the location of the terminus of the floodway, these roadways are along Traverse CSAH 4 and Roberts CR 24.

An alternative to constructing additional bridges, is to reroute Roberts CR 24 in an easterly direction within Section 6, T 124N, R 49W to join Traverse CSAH 4 within Section 5, T 124N, R 49W south of the floodway alignment. (The portion of Roberts CR 4 approximately 1-mile could be abandoned). A portion of CSAH 106 (Traverse County, Minnesota) within Browns Valley could also be abandoned. Realigning the roads negates the need for two additional structures to construct the floodway.

Design details of the inlet to the floodway and outlet where the floodway joins the Little Minnesota River need to be determined during final design. The inlet may consist of a side channel spillway with erosion protection designed to convey flows through the floodway when some predetermined flood elevation is reached within the Little Minnesota River. The Little Minnesota River could continue to convey “normal” base flows to maintain the ecological integrity of the Little Minnesota River between the floodway inlet and outlet. The outlet would need to include energy dissipation and erosion protection measures.

Appurtenances including side inlet culverts could be placed along the floodway to allow for local drainage from agricultural lands. Permanent right-of-way for the floodway and placing and leveling the spoil would be needed as well as temporary right-of-way for construction. Spoil material may (or may not) be leveled with slopes suitable for continued agricultural use.

This concept includes flood protection measures for the farm located along Roberts CR 4 within the SE ¼, Section 31, T 125N, R 49W (Roberts County, South Dakota). These measures will be designed considering the current protection provided by an existing dike system and the need for additional protection.

Design assumptions used to complete the preliminary analysis of the feasibility of a floodway included:

- Breakout discharge to Lake Traverse during the 1% chance flood event of 1,020 cfs;
- Maximum capacity available within the Little Minnesota River through Browns Valley is 1,600 cfs;
- Cross-sectional area of the floodway designed for the 1% chance event plus a minimum freeboard of 1-foot to natural ground;
- Beginning and ending points of the floodway yet to be determined;
- Spoil material to be placed on both sides of the floodway with the ability to level the spoil within the acquired ROW (yet to be determined);
- May need to provide side inlets because of the placement of the spoil material and the affect upon local agricultural drainage; and
- Current bridges are inadequate to convey the design discharge (see **Figure 4-1**) and will require replacement or increased capacity.

Preliminary concept design has been completed for two options: i.e., Option 1 and Option 2 (see **Figure 4-6** for approximate alignments).

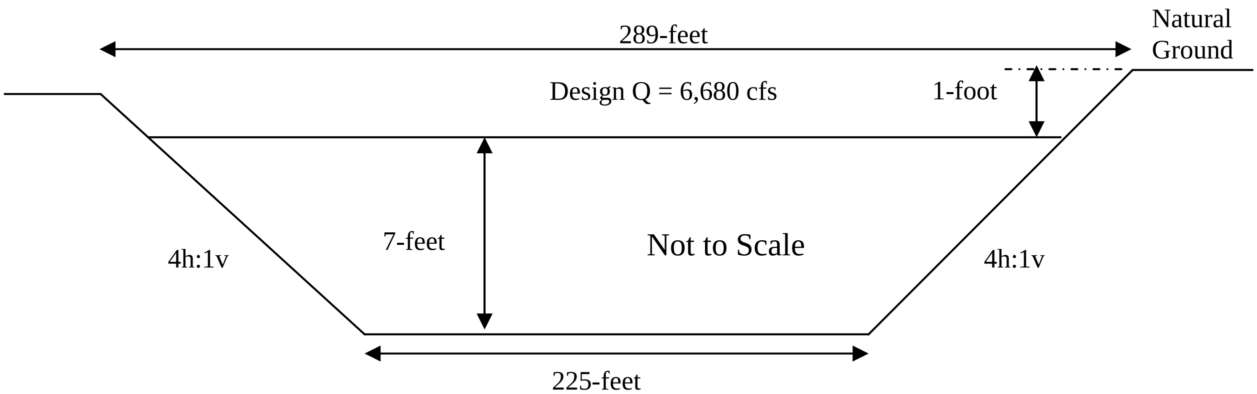
Functional Design for Option 1 consists of:

- Approximate length of 4,500-feet;
- Bottom slope equal to natural ground slope of ~ 0.004 feet per feet;
- Average depth of 8-feet;

- Side slopes 4:h:1v;
- Cross-section area ~ 2,056 square feet (**Figure 4-7**);
- Freeboard 1-foot (water depth of 7-feet);
- Design capacity of 6,680 cfs (100-year discharge);
- Bottom width of 225-feet;
- Average top width of 289-feet; and
- 342,700 cubic yards excavation (~402,100 cubic yards per mile).

Assuming the spoil is spread adjacent to both sides of the channel at 4h:1v side slopes, a top-width of 12-feet and a height of 15-feet[6], an additional 130-feet is needed on both sides of the channel. Therefore, the likely minimum total cross-sectional width needed is 550-feet.

Figure 4-7
Floodway Option 1
Functional Design



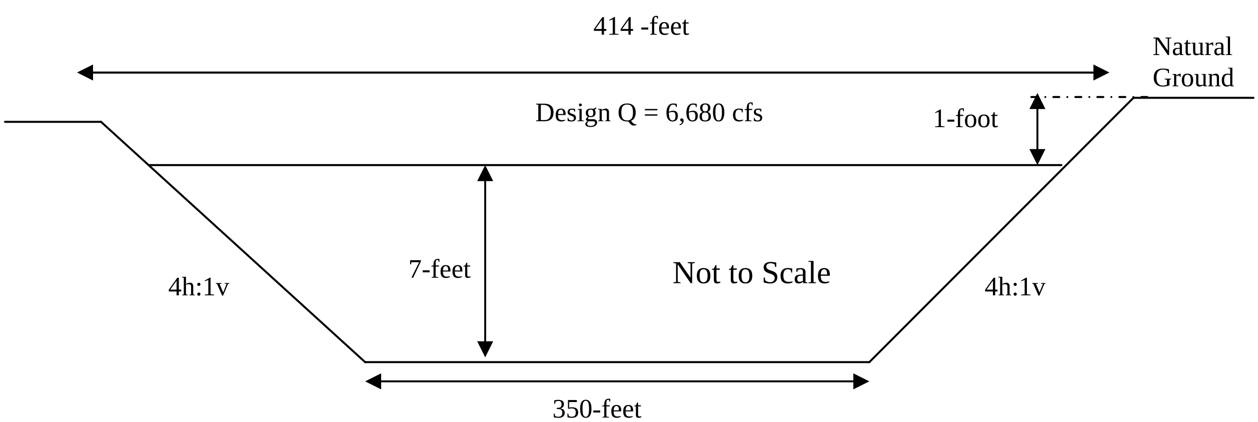
Functional design for Option 2 consists of:

- Approximate length of 3,900-feet;

[6] The dimensions were assumed solely for the purpose of screening the range of alternatives and were subsequently resided

- Bottom slope equal to natural ground slope of ~ 0.00052 feet per feet;
- Average depth of 8-feet;
- Side slopes 4:h:1v;
- Cross-section area ~ 3,056 square feet (**Figure 4-8**);
- Freeboard 1-foot (water depth of 7-feet);
- Design capacity of 6,680 cfs (100-year discharge);
- Bottom width of 350-feet;
- Average top width of 414-feet; and
- 441,000 cubic yards excavation (~597,000 cubic yards per mile).

Figure 4-8
Floodway Option 2
Functional Design



Assuming the spoil is spread adjacent to both sides of the channel at 4h:1v side slopes, a top-width of 12-feet and a height of 18-feet[7], an additional 155-feet is needed on both sides of the channel. Therefore, the likely minimum total cross-sectional width needed is 725 feet.

There are several advantages and disadvantage of this alternative.

---

[7] The dimensions were assumed solely for the purpose of screening the range of alternatives and were subsequently resided

Advantages: Probable advantages of this concept include:

- Floodway removed from the City;
- Ability to design to the needed capacity without constraints imposed by the dimensions of the Little Minnesota River;
- Disposal of soil adjacent to the floodway – in theory, sufficient room; and
- May (or may not) need additional bridges (depends on redesign of local transportation system).

Disadvantages: Probable disadvantages of this concept include:

- Probably requires more excavation than increasing the capacity of the Little Minnesota River; and
- Land requirements and potential disruption to agricultural operations.

4.3.1.5 Alternative CS5 - Floodway with Levees

The floodway and levee concept alternative consists of the features as described previously, but with the addition of levees along the floodway. The levee may be constructed from the material excavated to construct the floodway, provided the material is suitable from a geotechnical perspective. Levees would be constructed on the "city" side of the floodway, by connecting to high ground. From a functional design perspective, this option is essentially the same as Alternative CS4 – Floodway, except that the spoil material is used to construct the levee and the top of the levee set to an elevation equal to the 100-year base flood elevation plus three feet.

A farmstead ring dike (or levees tied into high ground) could be incorporated into the levee design to provide flood protection for the farm located along County Road 24 within the SE ¼, Section 31, T 125N, R 49W (Roberts County, South Dakota). Depending upon the location of the terminus of the floodway and levee, the top-width of the levee could be widened and used to relocate County Roads No. 4 and 24 (Roberts County, South Dakota). Relocating the road eliminates the potential need to increase the capacity of two bridges.

Advantages: Probable advantages of this concept include:

- Alignments are removed from the City – presumably less difficult to design and construct compared to urban levee;
- Reduction in the cross-sectional dimensions of the floodway because of the additional protection provided by the levee system;
- Prohibits the movement of water toward Browns Valley because of water leaving the floodway if the design discharge is exceeded;
- Levee height can likely be reduced because of flow conveyed by the floodway;
- More efficient use of spoil material - can be used to construct the levee; and
- Many of the advantages of the floodway concept.

Disadvantages: Probable disadvantages of this concept include:

- Levee will require higher standards for materials, design, and construction. Levee must meet FEMA Certification Standard.
- Must provide for local drainage; and
- Land requirements may be greater than floodway only concept, because a portion of the flood flow would be conveyed on the land surface.

4.3.1.6 Alternative CS6 - Floodway and Off-Channel Storage

A review of the historic flood events shows that land within Sections 5 and 6, T 124N, R 49W (Roberts, South Dakota) and Sections 31 and 32, T 125N, R 49W (Roberts, South Dakota) typically retains flood water, rather than those waters entering the City of Browns Valley and causing flood damages. This concept alternative consists of constructing a floodway as previously described (likely **Option 1**) with the addition of off-channel storage generally within these sections. The off-channel storage would be designed to maximize the removal of flood waters from the peak of the hydrograph from the Little Minnesota River (i.e., reserve storage capacity until maximum need).

Likely features of the off-channel storage would consist of an embankment to retain the flood water, an inlet channel from the Little Minnesota River, and an outlet channel to return floodwaters to the Little Minnesota River (connected to the Floodway). Easements would be required from landowners.

Design assumptions used to complete a cursory review of the feasibility of the floodway and off-channel storage concept included:

- Breakout discharge to Lake Traverse during the 1% chance flood event of 1,020 cfs;
- Maximum capacity available within the Little Minnesota River through Browns Valley at 1-foot below the minimum bank elevation (~ 1,550 cfs);
- Cross-sectional area of the floodway designed for the 1% chance event plus a minimum freeboard of 1-foot to natural ground;
- Beginning and ending points of the floodway yet to be determined;
- Floodway bottom width similar to the floodway option as described above;
- Storage created by the construction of an embankment to an effective storage elevation of 986 elevation to store an average depth of 4-feet;
- May need to provide side inlets because of the placement of the spoil material and the affect upon local agricultural drainage;
- Current bridges are not adequate to convey the design discharge (see **Figure 4-1**) and will require replacement or increased capacity; and
- Storage requirements based on the removal of the peak of a triangular hydrograph to the maximum discharge for the Little Minnesota River through Browns Valley, exclusive of the Lake Traverse breakout flows.

Two functional estimates of the storage required were made using the 1993 summer flood (peak daily average flow 5,400 cfs) and the 1997 spring flood (peak daily average flow 3,420 cfs). The volume exceeding the design capacity of the channel through Browns Valley (~ 1,600 cfs) less the breakout volume to Lake Traverse for these historic hydrographs is assumed equal to the minimum storage requirement (this approach fails to account for the "efficiency" of the storage or the fact that some flow is leaving the storage area as additional flow enters). Storage estimated storage requirements were:

- 13,550 acre-feet for the 1993 flood; and
- 21,000 acre-feet for the 1997 flood.

Assuming an average storage depth of 4-feet (and an impoundment embankment of 7-feet (3-feet of freeboard) the range of area required is from 3,388 acres to 5,250 acres. A greater average depth of 10-feet still likely requires approximately 2 sections for creation of the off-channel storage area.

Advantages: Probable advantages of this concept include:

- May result in smaller floodway downstream from the storage;
- Solution is removed from the City; and
- Reduction in discharge downstream from the storage area may mean bridges do not need to be replaced or additional capacity added.

Disadvantages: Probable disadvantages of this concept include:

- Embankments will require high standards for materials, design and construction similar to FEMA Certified Levees.
- Large area needed for storage;
- Loss of agricultural production during a summer flood event;
- Storage in this location effective for the protection of Browns Valley but generally of limited benefit downstream because of the large amount of storage within Big Stone Lake; and
- Delay in planting for a spring flood event.

4.3.2 Partial Structural Solutions

These alternatives are considered partial solutions to provide flood mitigation for the City of Browns Valley. This means that the concepts are capable of achieving only a portion of the design goals. These alternatives must be included as a component of a complete structural solution.

4.3.2.1 Alternative PS1 - Impoundment on Toelle Coulee

A portion of the peak discharge resulting from excess rainfall and entering Browns Valley originates within Toelle Coulee located northeast of Browns Valley (mostly within Section 27, T 125N, R 49W, Traverse County, Minnesota). Preliminary estimates completed by Widseth, Smith and Nolting indicated that the uncontrolled 100-year, 24-hour peak discharge is 1,466 cfs. Previous technical analysis suggests that an estimated 180 acre-feet of storage can reduce the 100-year, 24-hour peak discharge from 1,466 cfs to 637 cfs within Toelle Coulee.

The downstream culverts generally lack the ability to pass the 100-year discharge (see **Figure 4-1**) as well as the 50-year discharge of an estimated 880 cfs.

An impoundment within Toelle Coulee alone is not solely capable of providing the flood protection needed. Therefore, this alternative (as well as other Toelle Coulee concepts) is considered only as a component of the other complete solution alternatives. The discharge from Toelle Coulee generally flows along Traverse CSAH 2 and flows under TH 28 and does not enter the main channel of the Little Minnesota River through Browns Valley, but can result in flooding in the northern portion of Browns Valley. The downstream culverts appear to lack the ability to pass the 100-year discharge (see **Figure 4-1**) as well as the 50-year discharge of an estimated 880 cfs.

Because the impoundment is located upstream of the City of Browns Valley (see **Figure 4-9**), the impoundment would likely be considered "high hazard" by the Minnesota Department of Natural Resources during the dam safety review and permitting process. The Federal Emergency Management Agency (FEMA) may also be reluctant to allow revision to the floodplain boundary based on protection provided by a high hazard dam.

N

NOTES

1. TOPOGRAPHIC DATA BASED UPON 10–METER DEM.
2. FUNCTIONAL DESIGN (FROM WSN 1989)
   TOP OF EMBANKMENT 1053.75 (1988 NAVD)
   STORAGE 180 ACRE–FEET

LEGEND

STATE/COUNTY BOUNDARY
CITY BOUNDARY
CONTOUR (10–FOOT)
UNNAMED COULEE STORAGE AREA

Data source: MN DNR Data Deli

0 1000 2000
Scale Feet

Figure 4-9
Toelle Coulee Storage Area

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DJL	MRD	5304-002	9-11-07	1 OF 1

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Advantages: Probable advantages of this concept include:

- Considerable reduction in the flood peak for the small area of storage required;
- May be able to limit the outflow from the impoundment so downstream culverts do not require replacement, depending on the available storage.

Disadvantages: Probable disadvantages of this concept include:

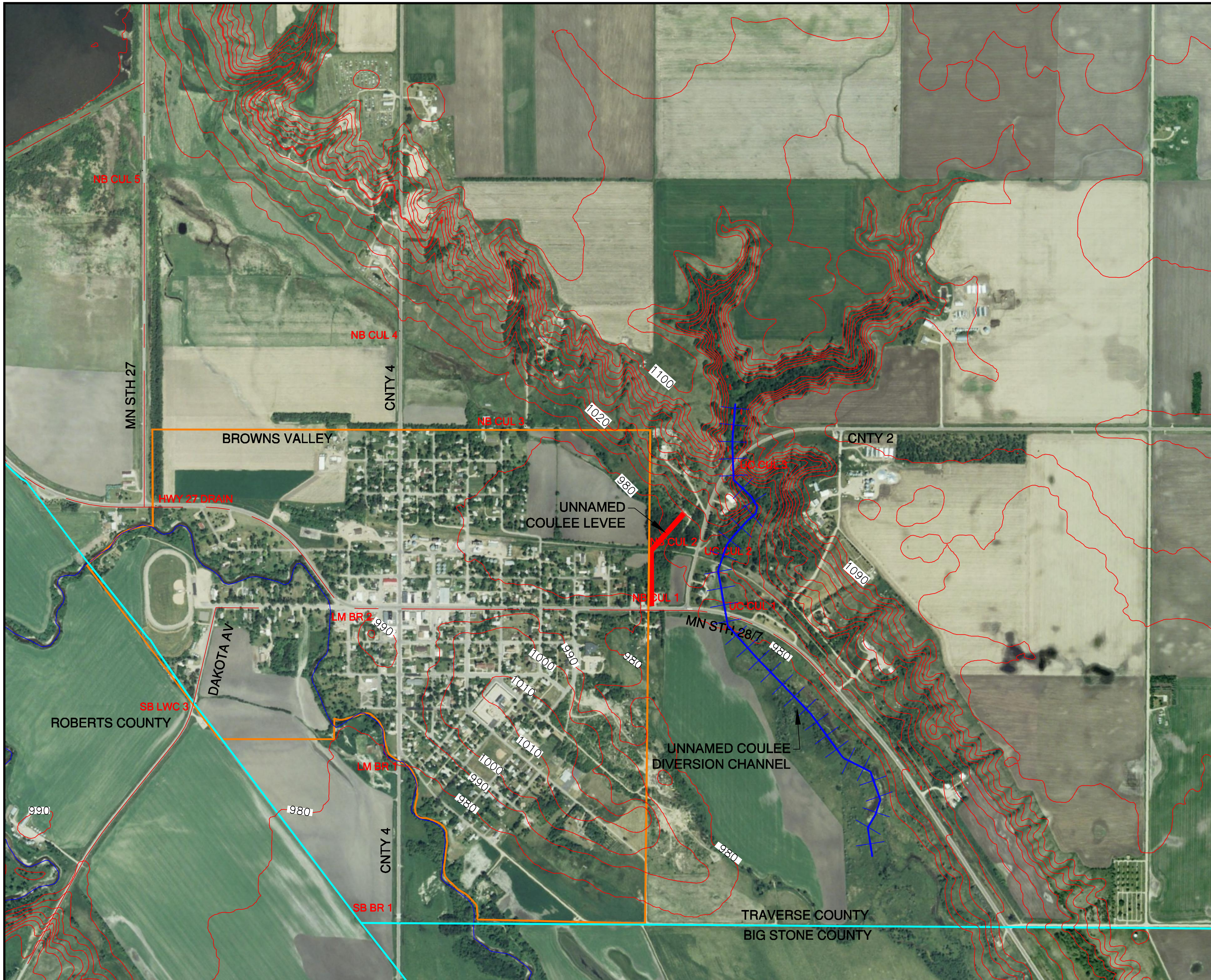
- Solves only a portion of the problem – must be used as in addition to other features;
- Likely requires permitting as a “high hazard” dam and associated high standards for materials, design, and construction; and
- Value – expected to be expensive;
- May be not able to limit the outflow from the impoundment so downstream culverts do not require replacement, depending on the available storage;
- Need additional capacity under the road for an emergency spillway;
- Should include low-head levee to prevent flow from entering the north-east portion of Browns Valley;
- FEMA may not allow “floodplain” credit.

4.3.2.2 Alternative PS2 - Toelle Coulee Floodway and Levee

Constructing a floodway to bypass flows from Toelle Coulee (located mostly within Section 27, T 125N, R 49W, Traverse County, Minnesota) around the City of Browns Valley has been previously identified as a partial solution for mitigating flooding. The floodway could consist of a channel constructed along the west side of Traverse CSAH 2 (see **Figure 4-10**). A levee could also be constructed east of Traverse CSAH 2 to prevent potential breakout flows from reaching Browns Valley.

Functional design for the floodway consists of:

- Approximate length of 5,000-feet;



N

NOTES

1. TOPOGRAPHIC DATA BASED UPON 10–METER DEM.

UNNAMED COULEE

UNNAMED COULEE FLOODWAY
BOTTOM WIDTH = 50 FT.
SIDE SLOPES = 4:1 (HORIZONTAL:VERTICAL)
WATER DEPTH = 7 FT.
TOTAL DEPTH = 8 FT.
TOTAL CROSS SECTION AREA = 656 SQ.FT.
TOTAL TOP WIDTH = 114 FT.

LEGEND

STATE/COUNTY BOUNDARY
CITY BOUNDARY
CONTOUR (10–FOOT)
APPROXIMATE LEVEE
APPROXIMATE FLOODWAY

Data source: MN DNR Data Deli

0 1000 2000
Scale Feet

Figure 4-10
Toelle Coulee Levee and Diversion

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DJL	MRD	5304-002	1-7-2007	1 OF 1

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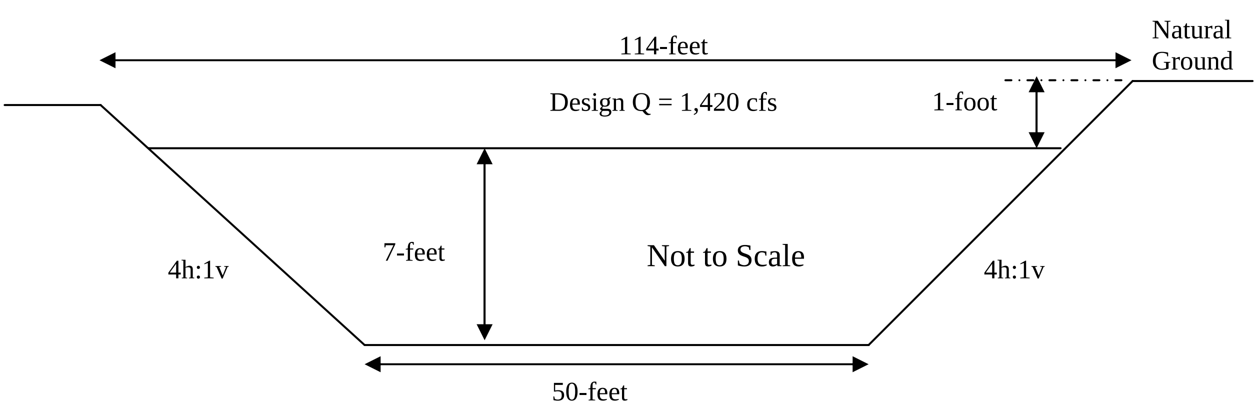
- Bottom slope equal to natural ground slope of 0.001 feet per feet;
- Average depth of 8-feet (**Figure 4-11**);
- Freeboard 1-foot (water depth of 7-feet);
- Side slopes 4:h:1v;
- Cross-section area ~ 655 square feet;
- Design capacity of 1,420 cfs (100-year discharge);
- Bottom width of 50-feet;
- Average top width of 114-feet;
- 121,000 cubic yards excavation;
- Culvert replacements needed because of inadequate capacities (see **Figure 4-1**) at County Road 2, TH 28, and the railroad; and
- Spoil material to be placed on both sides of the floodway with the ability to level the spoil within the acquired ROW.

Figure 4-11
Toelle Floodway
Functional Design



Assuming the spoil is spread adjacent to both sides of the channel at 4h:1v side slopes, a top-width of 12-feet and a height of 8-feet, an additional 75-feet is needed on both sides of the channel. Therefore, the likely minimum total cross-sectional width needed is 265-feet.

Advantages: Probable advantages of this concept include:

- Considerable reduction in the flood peak within Browns Valley may be realized;

Disadvantages: Probable disadvantages of this concept include:

- Solve only a portion of the problem – must be used as in addition to other features.

4.3.2.3 Alternative PS3 - Toelle Coulee Levee

An alternative to constructing a floodway to bypass flows from Toelle Coulee is the use of a levee, constructed west of Traverse CSAH 2. The levee effectively would prevent flow from Toelle Coulee from entering Browns Valley from the east. Additional culverts under TH 28 would be necessary to pass the discharge to the south. Some culverts and drainage features would also be needed to allow for the drainage of water accumulated behind the levee. The alignment could be similar to the alignment shown in **Figure 4-10**.

4.3.3 <u>Nonstructural Options</u>

4.3.3.1 Existing Conditions (Do Nothing)

Although this concept alternative is not considered viable, one option is to do nothing. The flood response would then consist of stringent implementation of floodplain ordinances by the City of Browns Valley. Infrastructure, homes and other buildings would need flood proofing or relocation from the floodplain in order to meet the design goals or if the structure is damaged by 50% or more as per floodplain regulations. Based upon the Flood Insurance Study, base flood elevations are generally:

- Elevation 980 (NAVD 1929) within the northern portion of Browns Valley;
- Elevation 976 to 977 in the southwestern portion of Browns Valley; and
- Elevation 981 to 986 in the western portion of Browns Valley.

Many homes currently exist within the current 100-year floodplain (see **Figure 4-12**). The FIS completed in 1986 is dated and fails to account for several recent floods. Therefore, generation of a new floodplain boundary may show additional affected structures.

Advantages: Probable advantages of this concept include:

- No financial cost for constructing infrastructure.

Disadvantages: Probable disadvantages of this concept include:

- Cost associated with relocation and flood proofing;
- Social disruption; and
- Concept generally considered unacceptable by residents.

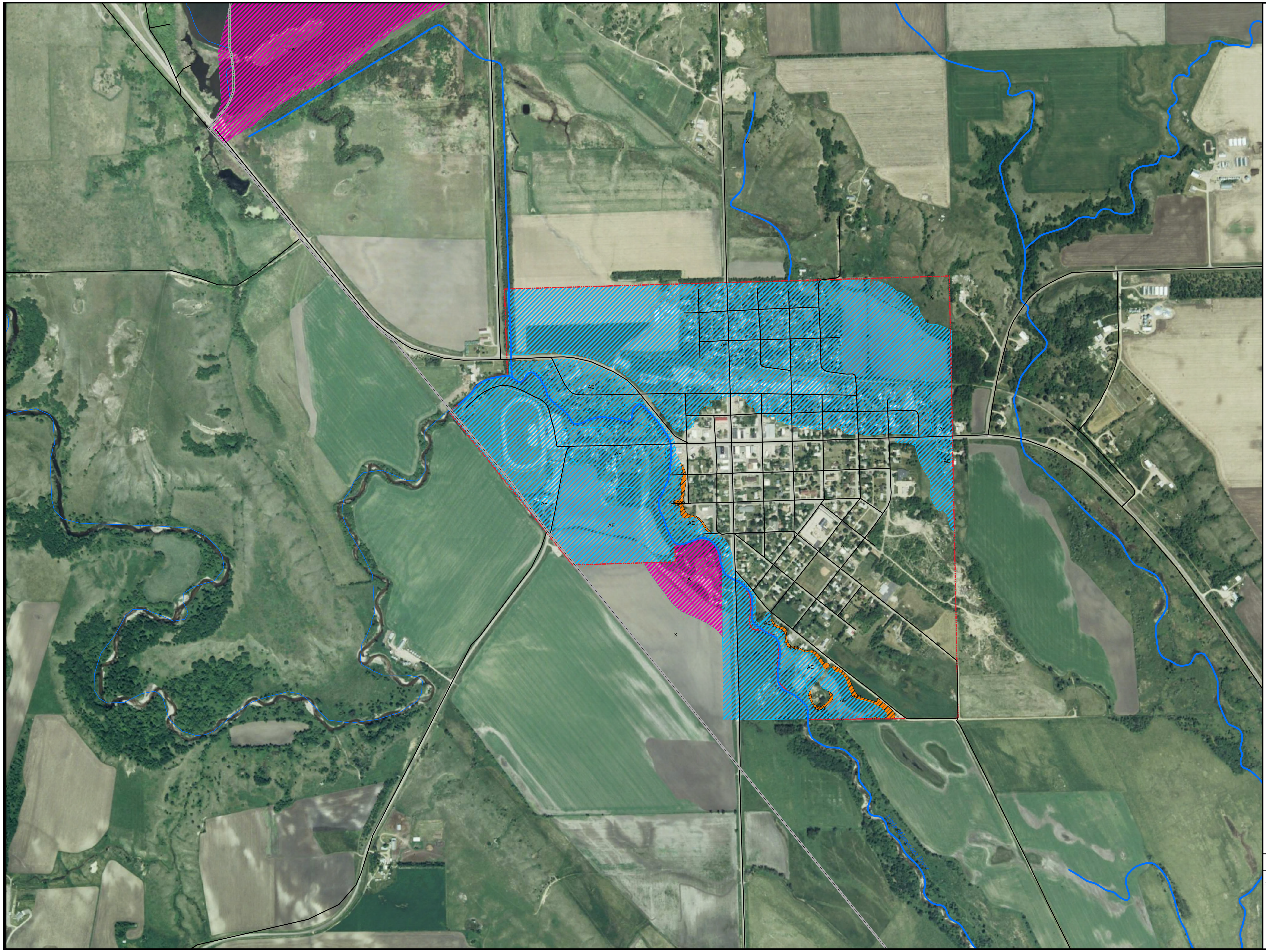
4.3.3.2 Flood Early Warning System

Current technology is available to "connect" the Peever gage to an automated flood early warning system for use by local emergency responders. Various flows or water levels at the Peever gage station could be established as emergency response action levels. Emergency responders could then be notified of an eminent flood risk by the use of telemetry.

4.3.4 <u>Additional Design Considerations</u>

There are several additional design considerations:

- Flood - proofing the City Water Supply – the water supply for the city of Browns Valley consists of several wells and pump stations, located southeast of the City. The construction of ring dikes around the pump stations to the base flood elevation plus three feet is a potential alternative.
- Utilities - a variety of utilities are located within the project area. Within the context of the anticipated total cost for the mitigation project, the financial implication of relocating some utilities can be minor. However, other types of utilities (e.g., gas pipelines) if present within the project area can have important financial implications.



N

Flood insurance boundary for Traverse County only. Boundary based upon FEMA Q3 information.

Legend

- Railroads
- Roads
- Streams and Rivers
- Watershed Boundary
- State Boundary
- Municipal Boundary

Flood Insurace Boundary

ZONE

- A
- AE
- X500

Location Map

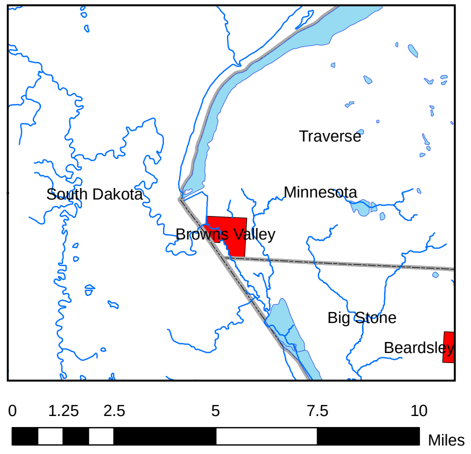


Figure 4-12. Browns Valley floodplain.

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	MNL		5304-002	09/10/07	

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- Existing Private Dikes and Levees – expectations are that the flood control benefits of private dikes and levees protecting agricultural land will be substantially diminished by the flood mitigation project. If private dikes are expected to adversely affect the function of the flood mitigation alternatives, they will be recommended removed. If private dikes are not expected to adversely affect the function of the flood mitigation project, they will be recommended retained.
- Road Realignment - Depending upon the location of the terminus of the floodway and levee, the top-width of the levee could be widened and used to relocate Roberts CR 24 and Traverse CSAH 4. Relocating the road eliminates the potential need to increase the capacity of one bridge.

4.4 ALTERNATIVES ELIMINATED FROM ADDITIONAL DETAILED ANALYSIS

The range of alternatives and the technical information contained within Section 4.3 Analysis of the Range of Alternatives were presented to the BVFMTF during their September 13, 2007 meeting for consideration. Various social, economic, probable environmental and technical feasibility issues were discussed during the meeting. Based upon this discussion and the available technical information, several flood mitigation concept alternatives were eliminated from additional, detailed technical analysis (see **Table 4-2**). The reasons for elimination were generally characterized as an inability to achieve the project goals and purpose and need, poor technical feasibility, considerable severe social impacts, or probable costs.

4.5 ALTERNATIVES SUBJECT TO ADDITIONAL DETAILED ANALYSIS

The following alternatives were considered capable of achieving the project goals, the purpose and need and technically feasible:

- Alternative CS5 - Floodway with Levees (Option 1)
- Alternative CS5 - Floodway with Levees (Option 2)

Alternative PS2 Toelle Coulee Floodway and Levee and Alternative PS3 Toelle Coulee Levee are considered to be a feasible feature when combined with the other complete solution alternatives and was included as a project component. Expectations are that additional more detailed analysis (see Section 5.0) may result in refinement of these alternatives.

Table 4-2
Reasons for Eliminating a Flood Mitigation Concept from Further Consideration

Flood Mitigation Concept Alternative	Reasons
Complete Structural Solutions	
Alternative CS1 - Increase the Channel Capacity of the Little Minnesota River	Technical feasibility – to achieve purpose and need requires a large concept cross-section footprint impacting a large number of homes and portions of the City of Browns Valley. Environmental impacts – loss of ecological integrity to the Little Minnesota River channel through Browns Valley.
Alternative CS2 - Levees along the Little Minnesota River Within Browns Valley	Technical feasibility – to achieve purpose and need requires a large concept cross-section footprint impacting a large number of homes and portions of the City of Browns Valley. Environmental impacts – one source of material to construct the levee is the Little Minnesota River. Loss of ecological integrity to the Little Minnesota River channel through Browns Valley is likely.
Alternative CS3 - Community Ring Dike	Cost – requires construction of a floodway similar in dimension to the floodway options. Social – may limit growth to the area within the Community Ring Dike. Impacts to those outside the community ring dike.
Alternative CS4 - Floodway	Technical – essentially combined into Alternative CS5 – Floodway with Levees. Provided the spoil material from the floodway is suitable, use for the levee to provide additional protection is recommended.
Alternative CS6 - Floodway and Off-Channel Storage	Technical feasibility – amount of land needed to provide storage. Social – economic impacts to land owners and agricultural operators because of the storage component.

Table 4-2 (cont)
Reasons for Eliminating a Flood Mitigation Concept from Further Consideration

Flood Mitigation Concept Alternative	Reasons
Partial Structural Solutions	
Alternative PS1 - Impoundment on Toelle Coulee	Technical Feasibility – ability to construct a high hazard dam. Can not achieve the purpose and need for the project.
Nonstructural Options	
Existing Conditions (Do Nothing)	Can not achieve purpose and need. Impacts to the community will continue. Socially unacceptable.
Flood Early Warning System	Include as a feature within structural solution.

SECTION 5.0
DETAILED ANALYSIS OF LITTLE MINNESOTA RIVER FLOODWAY AND TOELLE COULEE FLOOD MITIGATION ALTERNATIVES

5.1 LITTLE MINNESOTA AND TOELLE COULEE ALTERNATIVES

Based upon the information presented within Section 4.0, Range of Flood Mitigation Alternatives Considered, discussions with the BVFMTF, and consultation with the UMRWD, the range of Little Minnesota River flood mitigation alternatives became reduced to: 1) a Little Minnesota River floodway; ***and***, 2) storage, a floodway, a levee or some combination thereof for Toelle Coulee. This section provides descriptions, detailed information on the engineering design, and an assessment of hydraulic performance for each of the flood mitigation alternatives selected for evaluation. Section 7 provides the rationale for selection of the preferred floodway alternatives for the Little Minnesota River and the design for Toelle Coulee.

5.1.1 Little Minnesota River Floodway Alternatives

Six different alignments and two inlet types (i.e., gate-controlled or "active" and fixed crest or "passive") for a total of twelve different floodway alternatives were considered for the Little Minnesota River to provide flood protection for the City of Browns Valley. Floodway Option 3 was added by Houston Engineering, Inc. subsequent to the November 1, 2007 BVFMTF meeting. Option 3 is intended to better address potential concerns relative to maintaining the historic proportion of flow to Lake Traverse and concerns about modifying low flows through the City of Browns Valley. All floodway designs focused on containing the design discharge (plus 1-foot of freeboard) within the floodway channel, rather than using levees to provide additional capacity. Material from floodway construction will be placed in spoil banks adjacent to the floodway and used to reconstruct Roberts CR 24. The spoil banks will function to contain flow for floods exceeding the freeboard capacity and some portions of the spoilbanks will serve as levees where the 100-year water surface profile is higher than the ground elevation (near Traverse CSAH 4 for example).

The alignments primarily differ relative to the location of the floodway inlet from and outlet to the Little Minnesota River (and therefore slopes and dimensions also differ). Floodway designs were completed using the steady-state HEC-RAS model as described within Section 3.0. Performance was then further evaluated by simulating several historic flood events, also described within Section 3.0. Each alignment has advantages and disadvantages.

5.1.1.1 General Description of the Alternatives

Each alternative requires the construction of a weir inlet at the entrance to the floodway. The dimensions of the weirs differ, depending upon whether water from the Little Minnesota River is allowed to passively flow over the weir into the floodway (i.e., a passive inlet), or a dam and gated structure is used to restrict the Little Minnesota River, increasing head and the amount of water entering the floodway (i.e., an active inlet).

Each alignment includes plans for relocating Roberts CR 24 along the south side of the floodway and the construction of one new bridge on Traverse CSAH 4/Bigstone CSAH 31 across the floodway near the boundary of Big Stone and Traverse Counties. Each alignment uses the existing bridge south of Browns Valley on Traverse CSAH 4. The spoil placed along the northerly portion of the floodway is expected to be used as an access trail. Each option also requires the construction of an outlet to create a transition from the floodway into the Little Minnesota River, south of Browns Valley. The transition is needed for hydraulic and erosion protection purposes.

The advantages and disadvantages of the various floodway alignments and inlet controls are shown in **Table 5-1.** Four categories were used to compare the alternative floodway alignments and alternatives: hydrologic effects, engineering/cost, operation/maintenance and environmental issues.

Alternative CS4, Floodway Option 1

Two alignments share a similar location for the floodway inlet located within Section 31, Becker Township 125N, R 49W (Roberts County, South Dakota). The floodway alignment is generally oriented in a south-easterly or easterly direction through Section 5, T 124N, R 49W (Roberts County, South Dakota). The terminus of the floodway joining the Little Minnesota River is located within either Section 20, T 125N, R 49W (Traverse County, Minnesota) or

Table 5-1

Little Minnesota River Floodway Alternatives Analysis Matrix

	HYDROLOGY								ENGINEERING, DESIGN & CAPITAL COST							OPERATION & MAINTENANCE					ENVIRONMENTAL					
	Control Flood Flows Through City (to about 500 cfs)	Control Flood Flow to Diversion	Non-Flood Flows Through City (i.e., environmental flows)	Non-Flood Flow Through Diversion	Replicate Historic Flows to Lake Traverse	Ability to Prevent Flows from Reaching North Side of City (i.e., overtopping Hwy. 28)	Likelihood of Flooding from South of City	Ability to address flooding from Lake Traverse	Length of Diversion Channel (ft)	Diversion Channel Excavation (cu.yd.)	Transportation Features	Ease of Road Realignment / Traffic Patterns	Use of Land by Landowner (e.g. bisecting parcels)	Bridge Span (and Cost)	Relative Cost Factor	Degree of Maintenance	Operational Requirements	Sediment Issues, Low Flows, Geomorphology	Extent of Debris and Ice Issues	Relative Cost	Percieved Ease of Obtaining Permits	Perceived Issues Related to Channel Morphology	Perceived Magnitude of Aquatic Resource Impacts	Relative Environmental Impacts	Safety Issues (to Swimmers, Boaters, Snowmobilers, Fishermen)	Potential for Adverse Downstream Impacts (Big Stone Lake)
Passive Floodway Inlet (Inoperable Weir)																										
Alternative CS4, Option 1A	FAIR	GOOD	REDUCED	HIGHER THAN DESIRED	NO	GOOD	LEAST	POOR	4,500	400,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	OK	POOR	LESSER SPAN	1	HIGHEST	NO OPERATION	HIGH	LEAST LIKELY	LOW	SAME	GREATEST	GREATEST	GREATEST	FEWER ISSUES	GREATEST
Alternative CS4, Option 2B	FAIR	GOOD	REDUCED	HIGHER THAN DESIRED	MAYBE	MAYBE	MODERATE	GOOD	6,500	630,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	GREATEST SPAN	2	HIGHEST	NO OPERATION	HIGH	MOST LIKELY	MODERATE	SAME	GREATEST	GREATEST	GREATEST	FEWER ISSUES	MODERATE
Alternative CS4, Option 3	FAIR	GOOD	REDUCED	HIGHER THAN DESIRED	YES	GOOD	GREATEST	GOOD	7,000	575,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	SMALLEST SPAN	2	HIGHEST	NO OPERATION	HIGH	LEAST LIKELY	MODERATE	SAME	GREATEST	GREATEST	GREATEST	FEWER ISSUES	MODERATE
Passive Floodway Inlet (Bladder Weir or Gate on Floodway)																										
Alternative CS4, Option 1A	GOOD	EXCELLENT	LOW TO MODERATE SAME	ACHIEVE DESIRED RANGE	NO	GOOD	LEAST	POOR	4,500	400,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	OK	POOR	LESSER SPAN	2	LOWEST	SIMPLE OPERATION	LOW TO MODERATE	LEAST LIKELY	LOW	SAME	MODERATE	REDUCED COMPARED TO INOPERABLE WEIR	SAME AS GATED STRUCTURE IN RIVER	FEWER ISSUES	GREATEST
Alternative CS4, Option 2B	GOOD	EXCELLENT	LOW TO MODERATE SAME	ACHIEVE DESIRED RANGE	MAYBE	MAYBE	MODERATE	GOOD	6,500	630,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	GREATEST SPAN	3	LOWEST	SIMPLE OPERATION	LOW TO MODERATE	MOST LIKELY	MODERATE	SAME	MODERATE	REDUCED COMPARED TO INOPERABLE WEIR	SAME AS GATED STRUCTURE IN RIVER	FEWER ISSUES	MODERATE
Alternative CS4, Option 3	GOOD	EXCELLENT	LOW TO MODERATE SAME	ACHIEVE DESIRED RANGE	YES	GOOD	GREATEST	GOOD	7,000	575,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	SMALLEST SPAN	3	LOWEST	SIMPLE OPERATION	LOW TO MODERATE	LEAST LIKELY	MODERATE	SAME	MODERATE	REDUCED COMPARED TO INOPERABLE WEIR	SAME AS GATED STRUCTURE IN RIVER	FEWER ISSUES	MODERATE
Active Floodway Inlet (Gated Structure in River)																										
Alternative CS4, Option 1A	EXCELLENT	EXCELLENT	FLOW RANGE SAME	ACHIEVE DESIRED RANGE	NO	GOOD	LEAST	POOR	4,500	400,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	OK	POOR	LESSER SPAN	3	LOWER	COMPLEX IN ADVANCE OF FLOOD	LOW	LEAST LIKELY	LOW	SAME	LEAST	DAM IN RIVER MANAGEABLE	SAME AS GATED STRUCTURE IN FLOODWAY	MORE ISSUES	GREATEST
Alternative CS4, Option 2B	EXCELLENT	EXCELLENT	FLOW RANGE SAME	ACHIEVE DESIRED RANGE	MAYBE	MAYBE	MODERATE	GOOD	6,500	630,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	GREATEST SPAN	4	LOWER	COMPLEX IN ADVANCE OF FLOOD	LOW	MOST LIKELY	MODERATE	SAME	LEAST	DAM IN RIVER MANAGEABLE	SAME AS GATED STRUCTURE IN FLOODWAY	MORE ISSUES	MODERATE
Alternative CS4, Option 3	EXCELLENT	EXCELLENT	FLOW RANGE SAME	ACHIEVE DESIRED RANGE	YES	GOOD	GREATEST	GOOD	7,000	575,000	1 BRIDGE WITH ROAD REALIGNMENTS & CLOSURE	NOT AS GOOD	POOR	SMALLEST SPAN	4	LOWER	COMPLEX IN ADVANCE OF FLOOD	LOW	LEAST LIKELY	MODERATE	SAME	LEAST	DAM IN RIVER MANAGEABLE	SAME AS GATED STRUCTURE IN FLOODWAY	MORE ISSUES	MODERATE

Ability of Option 2 ability to replicate historic flows depends upon where ice and debris jams form relative to the floodway inlet.

Option 3 requires the addition of stop log bays in culverts through Th 28 to control water moving south from Lake Traverse.

Option 3 has shortest bridge span because it uses an existing bridge on Traverse CSAH 4; all options could use this bridge.

Cost factor is relative with 1 being lowest cost and 4 being the highest cost.

Section 29, T 125N, R 49W (Big Stone County, Minnesota). Each alignment uses the existing Traverse CSAH 4 bridge.

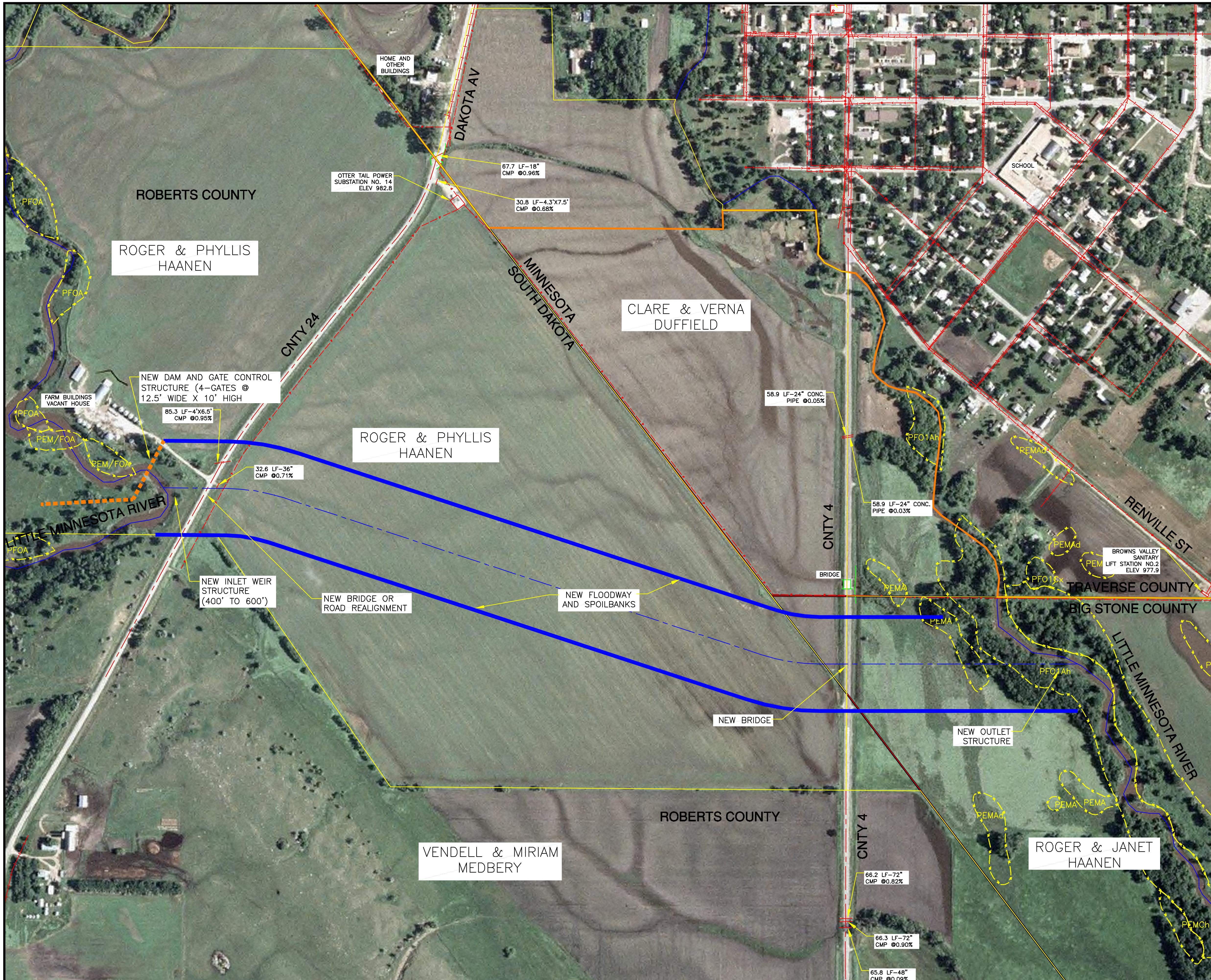
Option 1A represents the shortest probable floodway alignment to bring flood waters from the Little Minnesota River where it leaves the escarpment of South Dakota to a location south of Browns Valley (see **Figure 5-1**). Option 1B represents a similar alignment (see **Figure 5-2**), but adjusted in a southerly direction to better align the floodway along property boundaries. The orientation of the outlet is aligned in a manner for a reasonable downstream transition into the Little Minnesota River.

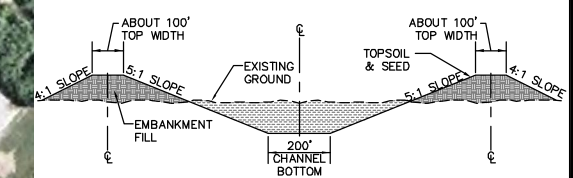
Both Little Minnesota River Floodway Options 1A and 1B envision realigning Roberts CR 24 at the floodway inlet to avoid the need for a new bridge crossing. Option 1 B is generally less favorable for the transition of traffic to the east. Spoil material from excavation of the floodway would be used to realign and reconstruct Roberts CR 24 from the existing location at the floodway inlet, in an east-west direction, to a new intersection with CSAH 4, south of Browns Valley. Engineered materials are also expected to be needed to construct the road. An additional bridge is needed on CSAH 4 for both of these options. This new bridge, as well as an existing bridge on CSAH 4, will provide a crossing of the floodway and will allow traffic flow north and south to and from Browns Valley. A graveled access trail (secured by gates) will be constructed on the spoil bank along the north side of the floodway, suitable for accessing the project and agricultural fields. The centerline elevation of the Roberts CR 24 is less than the access trail.

A new driveway / access road would be constructed to provide access to the Haanen farmstead. Local agricultural drainage will be provided by the placement of culverts with flap gates through the spoil banks along each side of the floodway.

Alternative CS4, Option 2

Option 2 represents an alignment whose inlet is located downstream of the natural overflow channel to Lake Traverse and generally along the Minnesota – South Dakota boundary. This second floodway alignment is oriented in a southeasterly direction beginning northwest of





TYPICAL CHANNEL AND SPOILBANKS
NOT TO SCALE

LEGEND

PROPERTY BOUNDARY
CITY BOUNDARY
FLOODWAY AND SPOIL BANK LIMITS
APPROXIMATE FLOODWAY CENTERLINE
WATER MAIN
SANITARY SEWER MAIN
SANITARY SEWER FORCEMAIN
STORM SEWER MAIN
OVERHEAD POWER
UNDERGROUND TELEPHONE
UNDERGROUND FIBER OPTIC
NATIONAL WETLAND INVENTORY

Data source: MN DNR Data Deli, City of Browns Valley, Traverse County, Roberts County, Minnesota DOT, South Dakota DOT, Midland Atlas Co., Otter Tail Power, Valley Telephone, BDM Rural Water, and October 2007 Field Surveys by Houston Engineering.

N

0 500 1000
Scale Feet

Figure 5-1
Little Minnesota River Floodway
Option 1A

Scale	Drawn by	Checked by	Project No.	Date	Sheet
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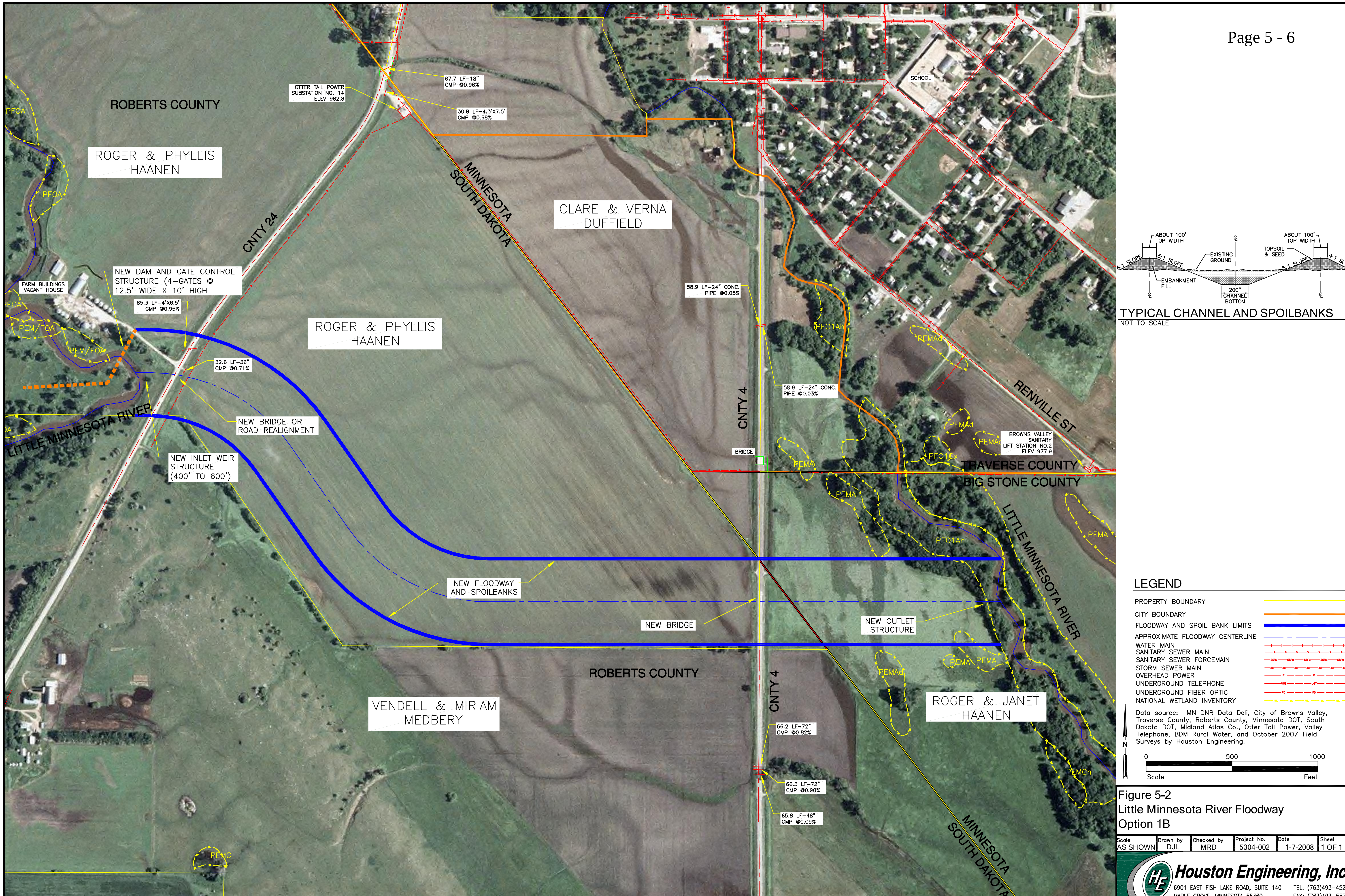


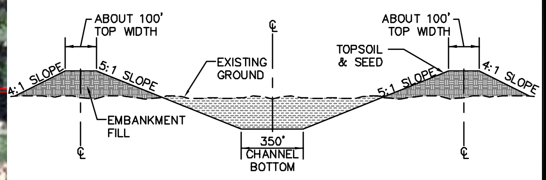
Figure 5-2
Little Minnesota River Floodway
Option 1B

the racetrack within Section 19, T 125N, R 49W (Traverse County, Minnesota) and generally following the South Dakota side or the Minnesota side of the state border to the confluence with the Little Minnesota River within Section 19, T 125N, R 49W (Traverse County, Minnesota).

Option 2A represents an alignment wholly located within the State of Minnesota capable of allowing existing breakout flows to move north into Lake Traverse (see **Figure 5-3**). One advantage of Option 2A is the potential to use an existing bridge over the Little Minnesota River located near the south edge of Browns Valley. Little Minnesota River Floodway Option 2B represents an alignment along the Minnesota - South Dakota border also capable of allowing existing breakout flows to move north into Lake Traverse (see **Figure 5-4**). The westerly shift in the alignment for Little Minnesota River Floodway Option 2B avoids the impacts to homes and other infrastructure impacted by Little Minnesota River Floodway Option 2A. The Option 2B alignment uses the existing bridge south of Browns Valley on Traverse CSAH 4 and requires the construction of an additional adjacent bridge.

As with Options 1A and 1B, Little Minnesota River Options 2A and 2B envision realigning Roberts CR 24 at the floodway inlet, to avoid the need for a new bridge crossing at the inlet to the floodway. Spoil material from excavation of the floodway would be used to realign and reconstruct Roberts CR 24 from the existing location at the floodway inlet, in a southwesterly direction, joining CSAH 4, south of Browns Valley near the boundary of Big Stone and Traverse Counties. Roadway construction is also expected to require the use of engineered materials. An additional bridge is needed on CSAH 4 for both of these options. This new bridge, as well as an existing bridge on CSAH 4, will provide a crossing of the floodway and will allow traffic flow north and south to and from Browns Valley. A graveled access trail (secured by gates) will be constructed on the spoil bank along the north side of the floodway, suitable for accessing the project and agricultural fields.

No new road is needed to provide local access to the Haanen farmstead. Local agricultural drainage is expected to be provided by the placement of culverts with flap gates through the spoil banks along the floodway.



TYPICAL CHANNEL AND SPOILBANKS
NOT TO SCALE

LEGEND

- PROPERTY BOUNDARY
- CITY BOUNDARY
- FLOODWAY AND SPOIL BANK LIMITS
- APPROXIMATE FLOODWAY CENTERLINE
- WATER MAIN
- SANITARY SEWER MAIN
- SANITARY SEWER FORCEMAIN
- STORM SEWER MAIN
- OVERHEAD POWER
- UNDERGROUND TELEPHONE
- UNDERGROUND FIBER OPTIC
- NATIONAL WETLAND INVENTORY

Data source: MN DNR Data Deli, City of Browns Valley, Traverse County, Roberts County, Minnesota DOT, South Dakota DOT, Midland Atlas Co., Otter Tail Power, Valley Telephone, BDM Rural Water, and October 2007 Field Surveys by Houston Engineering.

N

Scale 0 500 1000 Feet

Figure 5-3
Little Minnesota River Floodway
Option 2A

Scale	Drawn by	Checked by	Project No.	Date	Sheet
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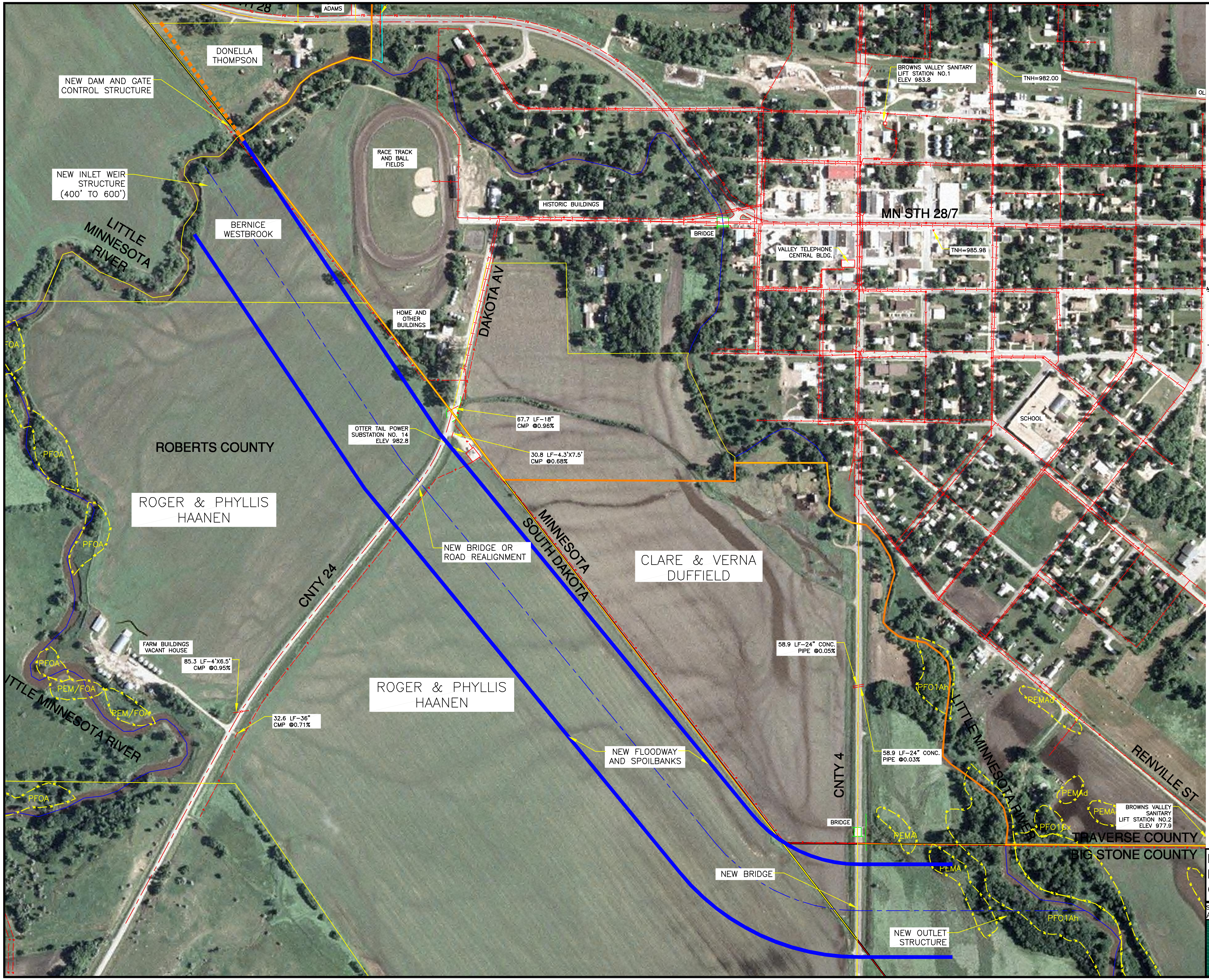

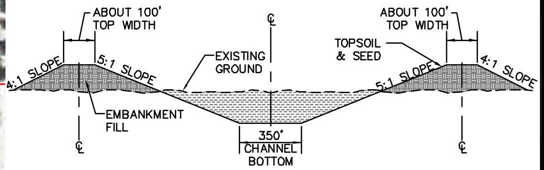

TYPICAL CHANNEL AND SPOILBANKS
NOT TO SCALE

LEGEND

- PROPERTY BOUNDARY
- CITY BOUNDARY
- FLOODWAY AND SPOIL BANK LIMITS
- APPROXIMATE FLOODWAY CENTERLINE
- WATER MAIN
- SANITARY SEWER MAIN
- SANITARY SEWER FORCEMAIN
- STORM SEWER MAIN
- OVERHEAD POWER
- UNDERGROUND TELEPHONE
- UNDERGROUND FIBER OPTIC
- NATIONAL WETLAND INVENTORY

Data source: MN DNR Data Deli, City of Browns Valley, Traverse County, Roberts County, Minnesota DOT, South Dakota DOT, Midland Atlas Co., Otter Tail Power, Valley Telephone, BDM Rural Water, and October 2007 Field Surveys by Houston Engineering.

Scale: 0 — 500 — 1000 Feet

Figure 5-4
Little Minnesota River Floodway
Option 2B

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DJL	MRD	5304-002	1-7-2008	1 OF 1

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Each option requires the construction of a weir inlet at the entrance to the floodway. The dimensions of the weirs differ, depending upon whether water from the Little Minnesota River is allowed to passively flow over the weir into the floodway, or a dam and gated structure is used to restrict the Little Minnesota River, increasing the hydraulic head and the amount of water entering the floodway.

Each option also requires the construction of an outlet to create a transition from the floodway into the Little Minnesota River, south of Browns Valley. The transition is needed for hydraulic and erosion control purposes.

Alternative CS4, Option 3

Option 3 represents an alignment whose inlet is located at approximately the same location of the natural overflow channel to Lake Traverse, with the intended capability of replicating historic breakout flows (north) to Lake Traverse (**Figure 5-5**). This third floodway alignment is also oriented generally in a southeasterly direction beginning northwest of Roberts CR 24 near the center of Section 31, Becker Township 125N, R 49W (Roberts County, South Dakota). The alignment would use the existing bridge south of Browns Valley along Traverse CSAH 4, (in conjunction with a new bridge over the floodway) and terminate at the Little Minnesota River within Section 20, T 125N, R 49W (Traverse County, Minnesota) or Section 29, T 125N, R 49W (Big Stone County, Minnesota). Excavated materials will be placed within spoil banks along each side of the floodway. The north spoil bank could potentially be moved to near the state boundary to cause less impact to the agricultural fields along the floodway and to increase the capacity for floodplain storage and conveyance during unforeseen events that exceed the floodway capacity.

Option 3 includes an access road and levee along the north side of the Little Minnesota River oriented in north-east to south-west direction from TH 28 to the hill at the valley edge. A set of box culverts placed on the north side of the Little Minnesota River in a new levee is intended to provide a fixed hydraulic control for breakout flows to Lake Traverse. The culvert design generally maintains the frequency and magnitude of historic breakout peak flows to Lake Traverse, but restricts the flow to match the capacity of the TH 28 triple box culverts so

LEGEND

- PROPERTY BOUNDARY
- CITY BOUNDARY
- FLOODWAY AND SPOIL BANK LIMITS
- APPROXIMATE FLOODWAY CENTERLINE
- WATER MAIN
- SANITARY SEWER MAIN
- SANITARY SEWER FORCEMAIN
- STORM SEWER MAIN
- OVERHEAD POWER
- UNDERGROUND TELEPHONE
- UNDERGROUND FIBER OPTIC

Data source: MN DNR Data Deli, City of Browns Valley, Traverse County, Roberts County, Minnesota DOT, South Dakota DOT, Midland Atlas Co., Otter Tail Power, Valley Telephone, BDM Rural Water, and October 2007 Field Surveys by Houston Engineering.

N

0 500 1000
Scale Feet

Figure 5-5
Little Minnesota River Floodway
Option 3

Scale	Drawn by	Checked by	Project No.	Date	Sheet
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overtopping of TH 28 is avoided and breakout flows are prevented from flooding Browns Valley.

The remaining features of Option 3 are generally the same Options 1 and 2 (i.e., realignment of Roberts CR 24, a new bridge at Traverse CSAH 4/Bigstone CSAH 31, and access trail along the floodway).

5.1.1.2 Floodway Inlet Types

Two different inlet types were considered to control the water surface elevation at the location of the floodway inlet for the purposes of diverting water into the floodway and the discharge through Browns Valley; i.e., a "passive inlet" and an "active inlet." A passive inlet essentially consists of a weir adjacent and parallel to the bank of the Little Minnesota River (or simply an open channel cut into the Little Minnesota River). Water simply spills into the floodway inlet as it reaches a predetermined elevation. Not all of the flow enters the floodway and a portion continues down the Little Minnesota River into Browns Valley.

An active inlet consists of a dam with gates or some other device placed within the Little Minnesota River downstream of the floodway inlet. The gates are operated to reduce flow within the Little Minnesota River through Browns Valley. By closing the gates the Little Minnesota River is restricted, the water surface elevation upstream of the gates is raised and flow is diverted down the floodway. The gate opening can be adjusted to allow some portion of the flow to continue down the Little Minnesota River into Browns Valley. Alternatively, the active inlet could be placed at the opening of the floodway, to control the amount of water entering the floodway. Several types of active inlets were considered, including radial gates, leaf gates and bladder dams. The various inlet types were considered for each of the alignment alternatives.

5.1.1.3 Detailed Design of Project Features for Floodway Option 3 (Passive)

Detailed designs sufficient to develop Opinions of Probable Costs of comparable detail for floodway alignments 1 and 3 were completed. This means hydrologic and hydraulic design to determine dimensions, alignments, evaluate performance and estimate quantities were determined for each alignment.

The most challenging project goals were providing flood protection to Browns Valley (i.e. reducing flood flows through town to about 500 cfs), maintaining low and moderate flows in the river within Browns Valley for ecologic and geomorphic benefits, and preserving the historic flow split to Lake Traverse. Option 3 is the only floodway alignment perceived consistent with the initial project goals established by the BVFMTF. Therefore, this section presents design details for this alignment, but provides relevant references to the other alignments. A discussion of the design goals and their relevancy to the Engineer's recommendation is provided within Section 7.0. Option 3 (passive inlet) should be viewed as the "base alternative" for evaluating the merits of the other Little Minnesota River Floodway alignments.

The Option 3 (passive) includes two major features; i.e., an inlet structure and the floodway channel. The inlet structure provides a connection between the Little Minnesota River and the floodway channel at the point of diversion. The inlet structure consists of a 600-foot weir with a crest at elevation 981.0 and three leaf gates each 12.5-feet wide by 8-feet high at invert elevation 973.0. The leaf gates could be closed to allow normal flows and smaller flood events to be passed in the river through Browns Valley for ecologic and geomorphic purposes. For example, the 1.5 year recurrence interval flood is often considered to be the channel forming flow. Therefore, flows of this magnitude are needed to maintain the river channel and its cross section, pattern and profile. A permanent reduction in flow within the river may cause aggradation in the river channel and cause a reduction in the cross sectional dimensions. The leaf gates could be opened to increase flow to the floodway during larger flood events and possibly in smaller flood events if ice jams or debris decrease the river capacity within Browns Valley.

Multiple combinations of weir lengths and crest elevations were analyzed in our attempts to achieve the challenging project goals of providing flood protection to Browns Valley by reducing flood flows through town to about 500 cfs (approximately 5% of the 100-year peak discharge) and diverting the remaining discharges (up to about 95% of flood discharge) into the floodway while maintaining channel forming flows in the river. The 500 cfs design discharge through Browns Valley provides a margin of safety (of about 2) should an ice or debris jam reduce channel capacity.

Fixed inlets (i.e., without leaf gates) that maintained normal flows within the river did not achieve the desired flood diversion capacity and fixed inlets that diverted up to 95% of flood flows also diverted most of the normal flows into the floodway. Besides contributing to possible aggradations of the river, diversion of a large portion of normal flows and smaller floods is more likely to allow for vegetative growth within the Little Minnesota River through Browns Valley. Directing a larger portion of normal and moderate flows to the floodway will also cause more wear and tear on the floodway from sedimentation or by flooding out the grass cover and causing additional erosion. To evaluate the ability to attain the challenging design goals placing an operable dam in the river ("active" controls) and options for placing a moveable crest or adjustable gates on the floodway inlet were evaluated. Both a dam in the river and an adjustable floodway inlet is capable of attaining the challenging design goals, but at considerable cost.

The Option 3 floodway channel is 6500-feet in length from the inlet structure to the outlet to the Little Minnesota River. The channel bottom is 250-feet wide with side slopes of 5h:1v. The floodway channel includes a rip-rapped low flow channel with an invert 3-feet below the main channel invert. The low flow channel bottom width is 17-feet, with side slopes of 5.5h:1v, and a top width of 50-feet. The low flow channel is designed to convey runoff for frequent (i.e., 1-year to 2-year and more frequent) events. The low flow channel is designed to carry sediment and intended to improve the growth of the grass vegetation in the main channel bottom, as compared to a completely horizontal bottom that would likely be wet for extended periods.

The floodway channel will be established with a permanent grass cover crop to prevent erosion. A grass cover is generally considered adequate to prevent erosion within the range of velocities and tractive forces expected during the channel design flows (i.e. 2-year to 100-year recurrence intervals). Soils along the channel alignment are typically silt loams. These soils would likely erode if not adequately vegetated. Since grass will not grow well in the low flow channel and tractive forces will be erosive to bare soil, a layer of MNDOT Class I rock riprap will be placed within the low flow channel to armor the bed. **Figure 5-6** shows the tractive

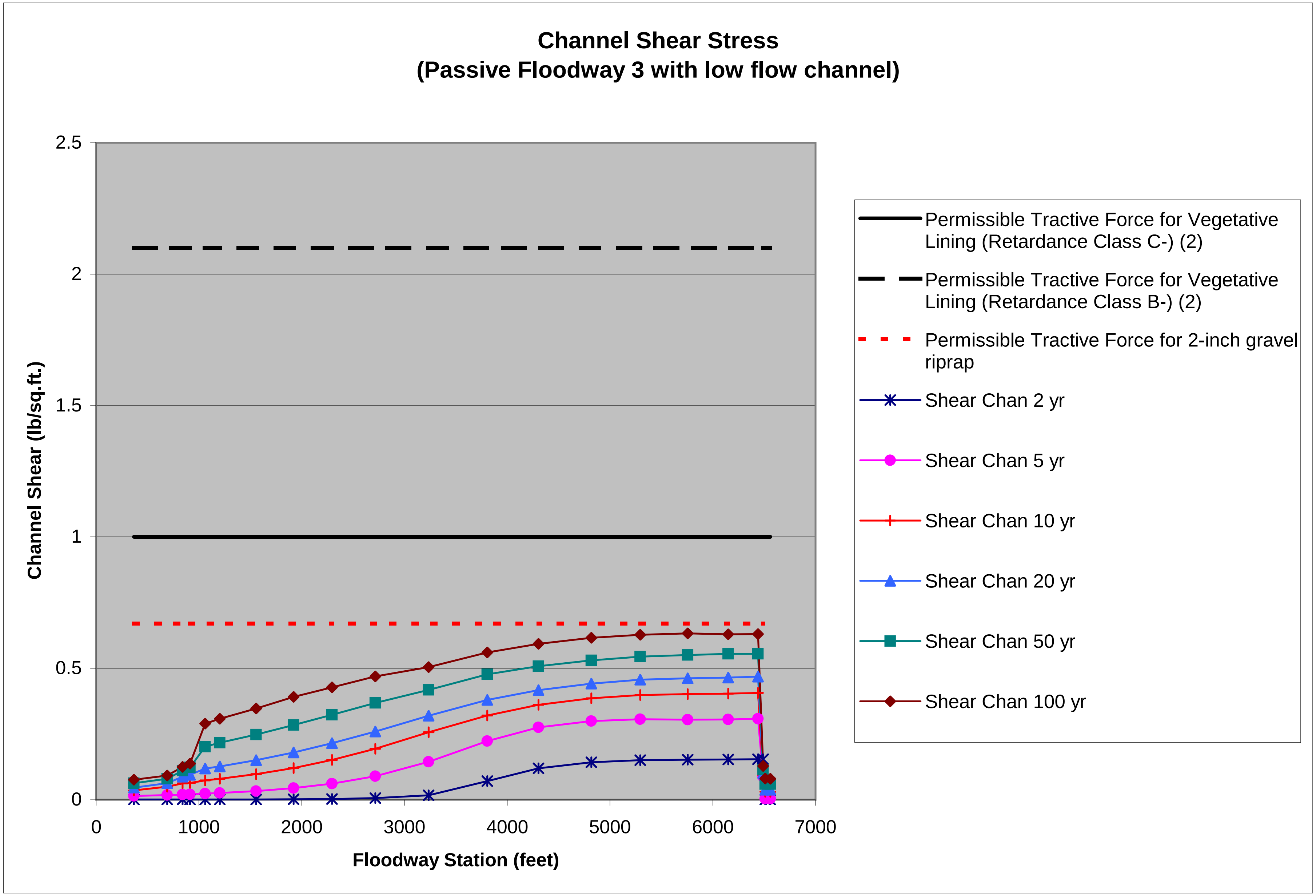

Channel Shear Stress
(Passive Floodway 3 with low flow channel)
Channel Shear (lb/sq.ft.)
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000
6000
7000
Floodway Station (feet)
Permissible Tractive Force for Vegetative Lining (Retardance Class C-) (2)
Permissible Tractive Force for Vegetative Lining (Retardance Class B-) (2)
Permissible Tractive Force for 2-inch gravel riprap
Shear Chan 2 yr
Shear Chan 5 yr
Shear Chan 10 yr
Shear Chan 20 yr
Shear Chan 50 yr
Shear Chan 100 yr

Figure 5-6

forces within the low flow channel along with the permissible tractive forces for various channel protection strategies.

The floodway outlet is located at the confluence of the floodway channel and the Little Minnesota River. The location has been selected so that the direction of flow entering the river from the floodway will be similar to the current direction of flow in the river. The floodway channel bottom elevation will be set to generally match the bottom elevation of the river so that erosion or headcutting are avoided. Excavation at the outlet section will be used to curve and blend the floodway channel into the river section. Rock riprap will be placed to armor the slopes of the floodway near the river confluence, but since floodway velocities and tractive forces are low in this area, extensive riprap armoring is not warranted or planned. Excavated materials will be hauled away, rather than placed in spoil banks, in the reach from the outlet section to Traverse CSAH 4/Bigstone CSAH 31 so that overbank flows from the floodway or river are not restricted. The outlet section is located near station 0+00 and Traverse CSAH 4/Bigstone CSAH 31 is near station 10+00 (see **Figures 5-6 and 5-7).** The velocities and tractive forces are both very low on the downstream end of the floodway because of backwater effect of the Little Minnesota River.

Rather than constructing a new bridge crossing over the floodway for Roberts CR 24, plans are to realign the road to follow the south side of the floodway to a new intersection with Traverse CSAH 4/Bigstone CSAH 31. A new bridge is required on Traverse CSAH 4/Bigstone CSAH 31 near the boundary of Big Stone and Traverse Counties. The floodway will be aligned to make use of an existing Traverse CSAH 4 bridge, but an additional bridge is required to provide an adequate floodway crossing. The estimated total bridge span for the new Traverse CSAH 4/Bigstone CSAH 31 bridge is 220 feet. The bridge concept consists of four spans of 50 to 60-feet with a total waterway area of approximately 2000 square feet. The combined waterway area of the two bridges will be approximately 2250 square feet. **Table 5-2** provides a summary of hydraulic data for the proposed bridge on Traverse CSAH 4/Bigstone CSAH 31.

Breakout flows from the Little Minnesota River may drain across the continental divide to Lake Traverse. Breakout flows are intended to follow the natural channel north to Lake Traverse through the TH 28 triple box culvert (each culvert is 6-foot rise by 9-foot span)

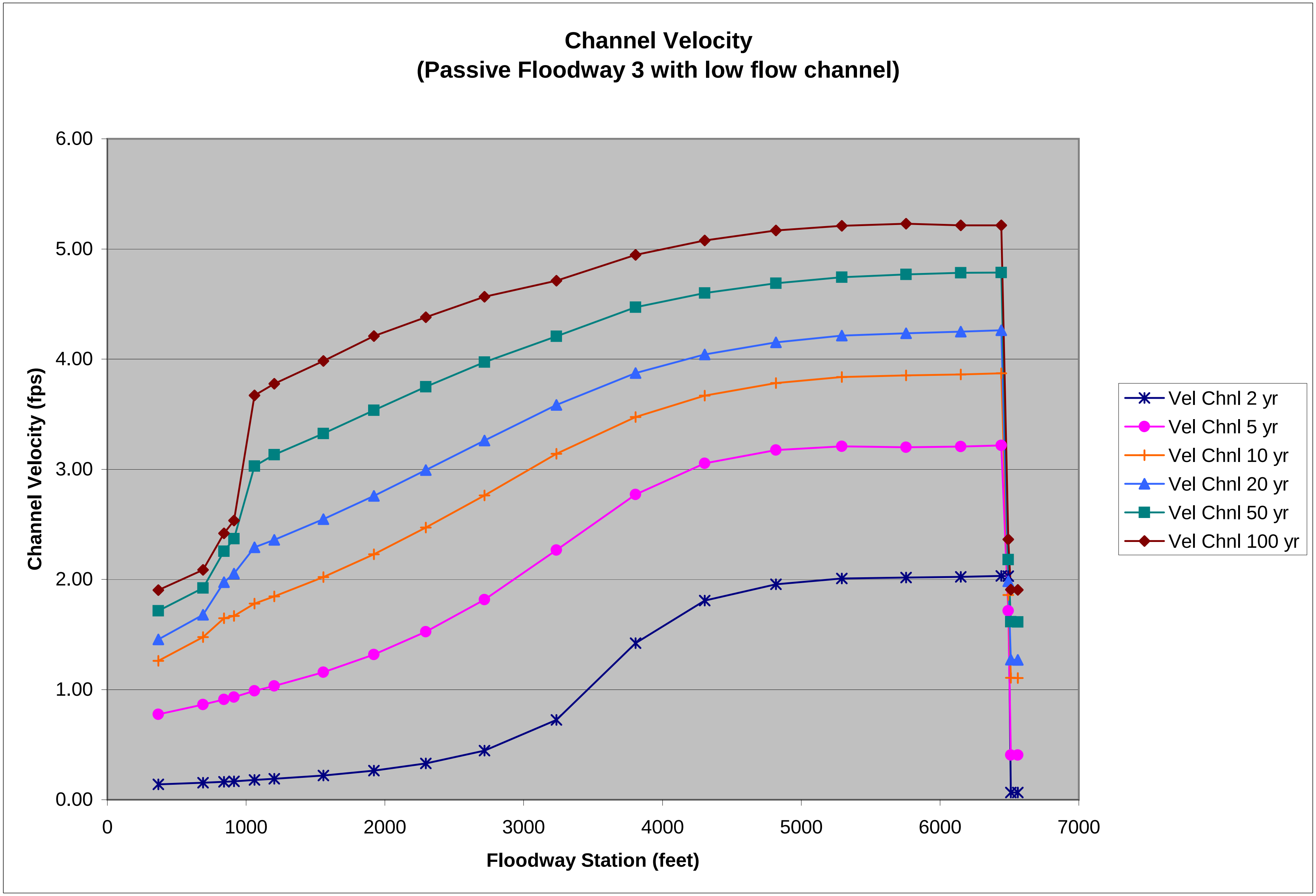

Channel Velocity
(Passive Floodway 3 with low flow channel)
Channel Velocity (fps)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
1000
2000
3000
4000
5000
6000
7000
Floodway Station (feet)
Vel Chnl 2 yr
Vel Chnl 5 yr
Vel Chnl 10 yr
Vel Chnl 20 yr
Vel Chnl 50 yr
Vel Chnl 100 yr

Figure 5-7

Table 5-2

Little Minnesota River Option 3 Floodway (Passive)
Hydraulic Data at Proposed Traverse CSAH 4/Bigstone CSAH 31 Bridge Crossing

Design Discharge		Headwater	Tailwater	Road Elevation at Bridge	Road Sag Elevation (1000 feet north or 1200 feet south)
	(cfs)	(NAVD 1988)	(NAVD 1988)		(NAVD 1988)
50-year	5,169	975.60	975.46	980.0	978
100-year	6,978	976.24	976.06	980.0	978

constructed by the Corps of Engineers as part of the Lake Traverse Project's Browns Valley Dike. To prevent breakout flows to Lake Traverse from overtopping TH 28 and flooding the north and east sides of town, a control structure is necessary. The control structure will limit the amount of breakout flow from the Little Minnesota River to the capacity of the three 6-foot by 9-foot box culverts entering Lake Traverse. The new control structure consists of three box culverts installed in a new dike constructed on the north side of the Little Minnesota River. The dike will tie into TH 28 on the east and the hillside on the west.

Water from Lake Traverse can flow south across the continental divide from Lake Traverse toward the Little Minnesota River. The task force discussed Lake Traverse as a potential flooding source on several occasions. There is a 0.5% chance of Lake Traverse reaching or exceeding elevation 983.2 feet (still water elevation) in any given year (i.e. a 200-year recurrence interval event). At about this elevation water could potentially overtop TH 28 southeast of the triple box culvert. **Table 5-3** provides a listing of pertinent elevations and **Table 5-4** provides stage-frequency data for Lake Traverse.

Water overflowing TH 28 at this point could potentially flow easterly overland to Browns Valley, similarly to what occurred during the 2007 Flood. Since potential damages from this flooding source are expected less frequently than the design standard 1% annual chance, no actions are planned to address this potential flooding source. If a higher level of flood protection in Browns Valley is desired, a relatively simple protective measure may be to install stoplog controls on the northern end of the triple box culvert. This measure requires installation of stoplog channel guides on the headwall along each side of the triple box culvert barrels and procurement of stoplogs for each bay to be held in a storage shed at the site until needed. Since the rate of rise of Lake Traverse during floods occurs over days rather than hours, there should be adequate time to manually install stoplogs when needed.

Table 5-3
Elevations near overflow route

Description	Elevation (feet NAVD 88)
TH 28 Triple Box Culvert (each 6-foot rise by 9-foot span) South Invert	974.40
TH 28 Centerline Elevation over Triple Box Culvert	987.40
TH 28 Sag Elevation near Lake Traverse	983.35
Continental Divide Elevation near Little Minnesota River	985.00

Table 5-4
Lake Traverse Elevation vs. Frequency

Annual Probability of Exceedence	Lake Traverse Elevation (feet NAVD 88)
10% (10-year)	979.94
2% (50-year)	981.77
1% (100-year)	982.5
.5% (200-year)	983.2
.2% (500-year)	984.15

The floodway will also contain some other minor features, including side inlet culverts with flapgates (where necessary) to provide drainage for the adjoining agricultural lands. The spoil banks for the floodway will be lower on the side away from town (i.e., the west spoil bank). In the event that the floodway would overtop the water would flow to the west and away from town. The design discharge is contained within the floodway with 1-foot of freeboard except in the lower end of the floodway reach near Traverse CSAH 4/Bigstone CSAH 31. Preliminary plans for floodway Option 3 Passive are attached in **Appendix F**.

5.1.1.4 Assessment of Project Performance Relative to Design Goals – Comparison of Options 1 and 3

Two different Little Minnesota River floodway alignments were assessed in detail; i.e., Option 1 and Option 3. (Note: the BVFMTF in consultation with the UMRD and the Project Engineer eliminated Option 2 from further consideration. Option 3 effectively replaced Option 2). Both active and passive inlets were evaluated for each of the alignments. The active inlet consists of a dam with 4 gates placed within the Little Minnesota River. The gates would be closed to raise the water surface and divert the flow into the floodway channel. These gates could also be opened during non-flood periods to allow water into Browns Valley within the Little Minnesota River to satisfy aquatic and geomorphic flow needs.

The passive inlet consists of a long weir (562 feet) with an additional three leaf gates. The gates allow "normal" flows and smaller floods to be passed through Browns Valley by closing the openings in the floodway inlet. The leaf gates are then opened during larger events to allow more water to enter the floodway. The geometry of the passive inlet (with leaf gates) is discussed in detail in Section 5.1.1.3. Fixed crest passive inlets (with no leaf gates) were also evaluated. These inlets have lesser flow regulation capability, but are less costly than inlets with leaf gates.

Flows through Browns Valley and Flow Split to Lake Traverse

Initial design goals established by the BVFMTF included maintaining the channel forming flow through Browns Valley (so sediment doesn't accumulate and vegetation grow within and close the channel) to limit flood flows through Browns Valley to provide a margin of safety (i.e. a maximum flow of about 500 cfs) for flood protection and to remove the City from the 100-year floodplain. Discharges for the two floodway alignments are shown by return period in **Table 5-5** assuming both passive and active inlets. Two operational modes for the gates are possible. One operational mode is to allow as much flow as possible through Browns Valley (limited to the maximum bankfull channel capacity of ~ 1,200 cfs) to maintain channel forming flows. The other operational mode is to restrict the discharge through Browns Valley to a maximum of about 500 cfs to provide for a margin of safety in the event of an ice jam or debris

Table 5-5

Peak Discharges (cfs) through the Little Minnesota River Floodway and Browns Valley

	T_R	Discharge @ Peever	Discharge to Traverse	Discharge Through Floodway	Discharge Through Browns Valley	Dam Gates Open
Option 3 Active	2	822	0	181	641	4 @ 8-feet
	2	822	0	417	405	1 @ 3-feet
	5	2020	86	1071	863	4 @ 8-feet
	5	2020	90	1463	467	1 @ 3-feet
	10	3200	244	2387	571	1 @ 3.5-feet
	20	4660	503	3643	515	1 @ 3-feet
	50	7070	957	5567	546	1 @ 3-feet
	100	9300	1162	7565	575	1 @ 3-feet
	T_R	Flow @ Peever	Flow to Traverse	Flow to Floodway	Flow to Browns Valley	Inlet Gates Open
Option 3 Passive	2	822	0	164	658	0
	2	822	0	744	78	3 @ 8-feet
	5	2020	84	1152	785	0
	5	2020	84	1656	280	3 @ 8-feet
	10	3200	250	2397	554	3 @ 8-feet
	20	4660	505	3418	739	3 @ 8-feet
	50	7070	957	5169	944	3 @ 8-feet
	100	9300	1172	6980	1149	3 @ 8-feet
	T_R	Flow @ Peever	Flow to Traverse	Flow to Floodway	Flow to Browns Valley	Dam Gates Open
Option 1 Active	2	822	0	154	668	4 @ 8-feet
	2	822	0	281	541	1 @ 3-feet
	5	2020	0	1051	969	4 @ 8-feet
	5	2020	0	1370	650	1 @ 3-feet
	10	3200	0	2510	690	1 @ 3-feet
	20	4660	0	3932	728	1 @ 3-feet
	50	7070	0	6292	778	1 @ 3-feet
	100	9300	0	8485	815	1 @ 3-feet
	T_R	Flow @ Peever	Flow to Traverse	Flow to Floodway	Flow to Browns Valley	Inlet Gates Open
Option 1 Passive	2	822	0	188	634	0
	2	822	0	808	14	3 @ 8-feet
	5	2020	0	1208	812	0
	5	2020	0	1797	223	3 @ 8-feet
	10	3200	0	2621	579	3 @ 8-feet
	20	4660	0	3926	734	3 @ 8-feet
	50	7070	0	6120	950	3 @ 8-feet
	100	9300	0	8110	1190	3 @ 8-feet

blockage. These operational modes are reflected in Table 5-3 by providing results for the 2-year and 5-year recurrence intervals. **Table 5-6** describes the dimensions for the inlet structure and the floodway for the floodway options.

Table 5-6
Inlet and Floodway Dimensions

Floodway Inlet	**Option 1 Active**	**Option 1 Passive**	**Option 3 Active**	**Option 3 Passive**
Weir length	250	600	250	600
Crest Elevation	984.5	984.5	981	981
Leaf Gates	None	3 @ 8'x12.5'	None	3 @ 8'x12.5'
Active Control	Option 1 Active	Option 1 Passive	Option 3 Active	Option 3 Passive
Structure	4 Bays 12.5' x 8'	None	4 Bays 12.5' x 8'	none
Floodway	Option 1 Active	Option 1 Passive	Option 3 Active	Option 3 Passive
Bottom Width	150	250	150	250
Side Slopes	5	5	5	5
Average Depth of Cut	6.2	6.2	9.1	9.1
Average Spoil Bank Height:				
East	5.9	7.8	7.9	10.4
West	3.9	5.8	5.9	8.4
Length	4650	4650	6500	6500
Slope	0.0024	0.0024	0.0014	0.0014
Low Flow Channel:				
Bottom Width	17	17	17	17
Side Slopes	5.55	5.55	5.55	5.55
Top Width	50	50	50	50
Downstream Invert	964.27	964.27	964.27	964.27
Upstream Invert	975.43	975.43	973.37	973.37
Friction Factor	0.04	0.04	0.04	0.04

The peak discharges to Lake Traverse for the large (i.e., > 50-year) flood events are similar in magnitude to the discharges identified by the Flood Insurance Study (i.e., the historic peak discharges can reasonably be maintained). Normal Discharges through Browns Valley in the absence of leaf gates within the passive inlet are considerably reduced (and can not be maintained). Adding the leaf gates into a fixed crest structure provides the flexibility for increasing the channel forming flows through Browns Valley. Essentially, some form of gate is needed in order to maintain the channel forming flows. For the large flood events a fixed crest passive structure with no leaf gates is not capable of restricting flows to the 500 cfs design discharge goal within Browns Valley, therefore this structure does not full achieve the design goal.

Impacts to Big Stone Lake

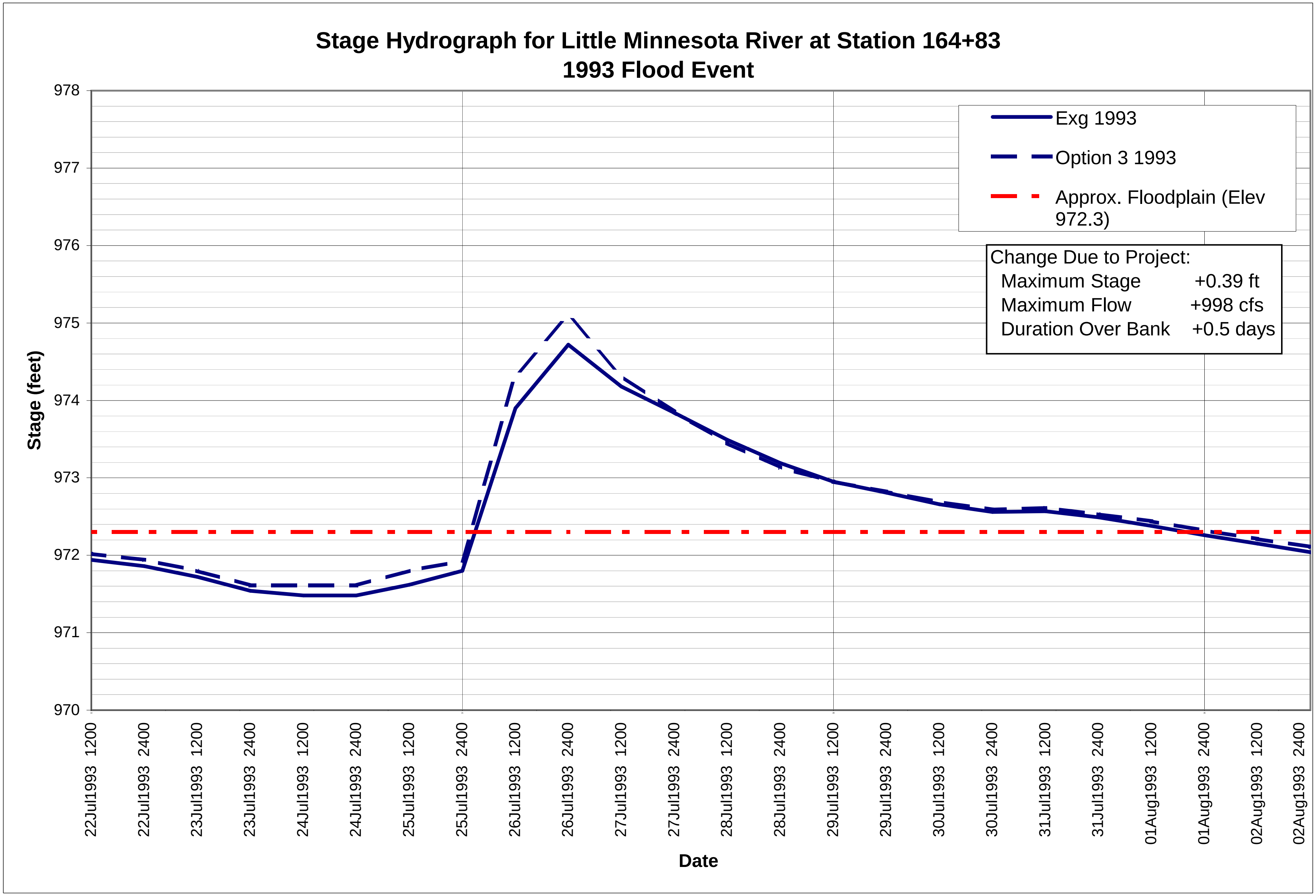
One of several project goals is to solve the Browns Valley flood but not to move the problem downstream. Determining whether the problem is moved downstream from an engineering perspective is largely based upon the anticipated increase in elevation within Big Stone Lake and land upstream of the lake, and whether the increase may result in damages. The yardstick can differ between assessing increases in stage across agricultural land verses within Big Stone Lake. Generally, a more frequent flood event (e.g., < 10-year return period) is used to assess agricultural concerns and a less frequent event (e.g., 100-year return period) to assess elevation increases in Big Stone Lake.

The design team in association with the UMRWD and the BVFMTF established maintaining the historic flow split (presumed to mean the rate and volume subsequent to construction of the Corp of Engineer's project on Lake Traverse) as a design goal (see Section 2.0, Design Goals) early in the project development process. Through hydrologic and hydraulic analysis and a review of the mechanisms causing historic floods the design team gained an improved understanding of the processes and reasons for flooding in and around Browns Valley. One reason for the historic flooding within Browns Valley is water leaving the Little Minnesota River, flowing north toward Lake Traverse, and then some portion flowing to the east across TH 28 and ultimately flooding the northern portion of the City. A portion of the total volume leaving the channel potentially enters Lake Traverse, but a portion of the volume also floods the northern portion of the City, ultimately draining south to Big Stone Lake. This flood mechanism is believed to be more common for spring flooding caused by ice jams rather (and affected by agricultural dikes) than summer floods. Summer floods tend to break south, toward Big Stone Lake.

Constructing a floodway around Browns Valley does not necessarily mean that the depth of flooding on agricultural lands or the water surface elevation within Big Stone Lake will be increased, as only a portion of the historic floods resulted in water entering Lake Traverse (and hence the volume not reaching Big Stone Lake). Not all of the historic floods resulted in breakout flows to the north, which entered Lake Traverse. During the 1943 flood, deliberate breaching of the Lake Traverse Dike resulted in some portion of the total flood volume entering Lake Traverse. Breakout flows from the Little Minnesota River, which entered Lake Traverse, occurred during the 1993 flood, were believed to occur during the 1997 flood and occurred during the 2007 flood.

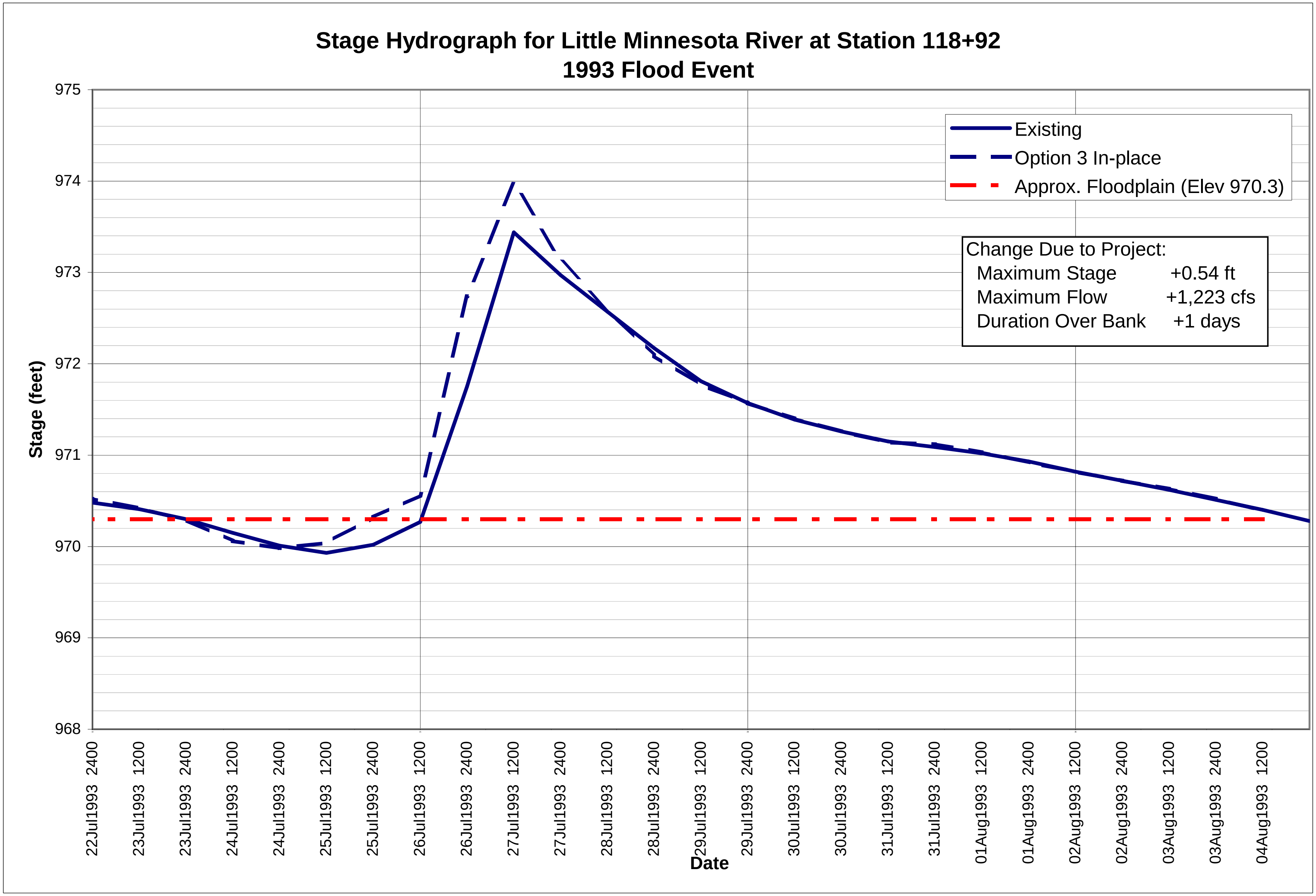
Although some portion of the floodwater leaving the Little Minnesota River for these historic floods entered Lake Traverse, estimates of the total volumes are generally lacking. Estimates of the peak discharge leaving the river for these floods came largely from the use of engineering equations or steady-state hydraulic models rather than the use of unsteady models capable of estimating daily discharges and therefore flood event volumes. An understanding of the volume of water is most critical for assessing issues related to Big Stone Lake. An understanding of these volumes can be gained from the unsteady hydraulic modeling performed by the design team.

A comparison of the peak flow, depth and duration of flooding downstream of the Option 3 floodway outlet was completed by simulating the 1993 Flood and a hypothetical simulation of the flood with the floodway in place. The 1993 Flood was caused by widespread heavy rainfall and had a very high peak discharge of approximate 100-year recurrence interval. The simulation was completed using the HEC-RAS unsteady hydraulic model. **Figure 5-8** (cross section located about ¼ mile downstream of floodway outlet) and **Figure 5-9** (cross section located about 1 mile downstream of floodway outlet) provide a summary of the changes in stage, flow and flood duration that would have resulted had the project been in place during the 1993 flood. In this example, flow downstream from the floodway outlet would have increased about 1000 cfs, stage would have increased about ½ foot and duration of overbank flow would have increased about ½ day.



Stage Hydrograph for Little Minnesota River at Station 164+83
1993 Flood Event
Stage (feet)
978
977
976
975
974
973
972
971
970
Exg 1993
Option 3 1993
Approx. Floodplain (Elev 972.3)
Change Due to Project:
Maximum Stage +0.39 ft
Maximum Flow +998 cfs
Duration Over Bank +0.5 days
22Jul1993 1200
22Jul1993 2400
23Jul1993 1200
23Jul1993 2400
24Jul1993 1200
24Jul1993 2400
25Jul1993 1200
25Jul1993 2400
26Jul1993 1200
26Jul1993 2400
27Jul1993 1200
27Jul1993 2400
28Jul1993 1200
28Jul1993 2400
29Jul1993 1200
29Jul1993 2400
30Jul1993 1200
30Jul1993 2400
31Jul1993 1200
31Jul1993 2400
01Aug1993 1200
01Aug1993 2400
02Aug1993 1200
02Aug1993 2400
Date

Figure 5-8



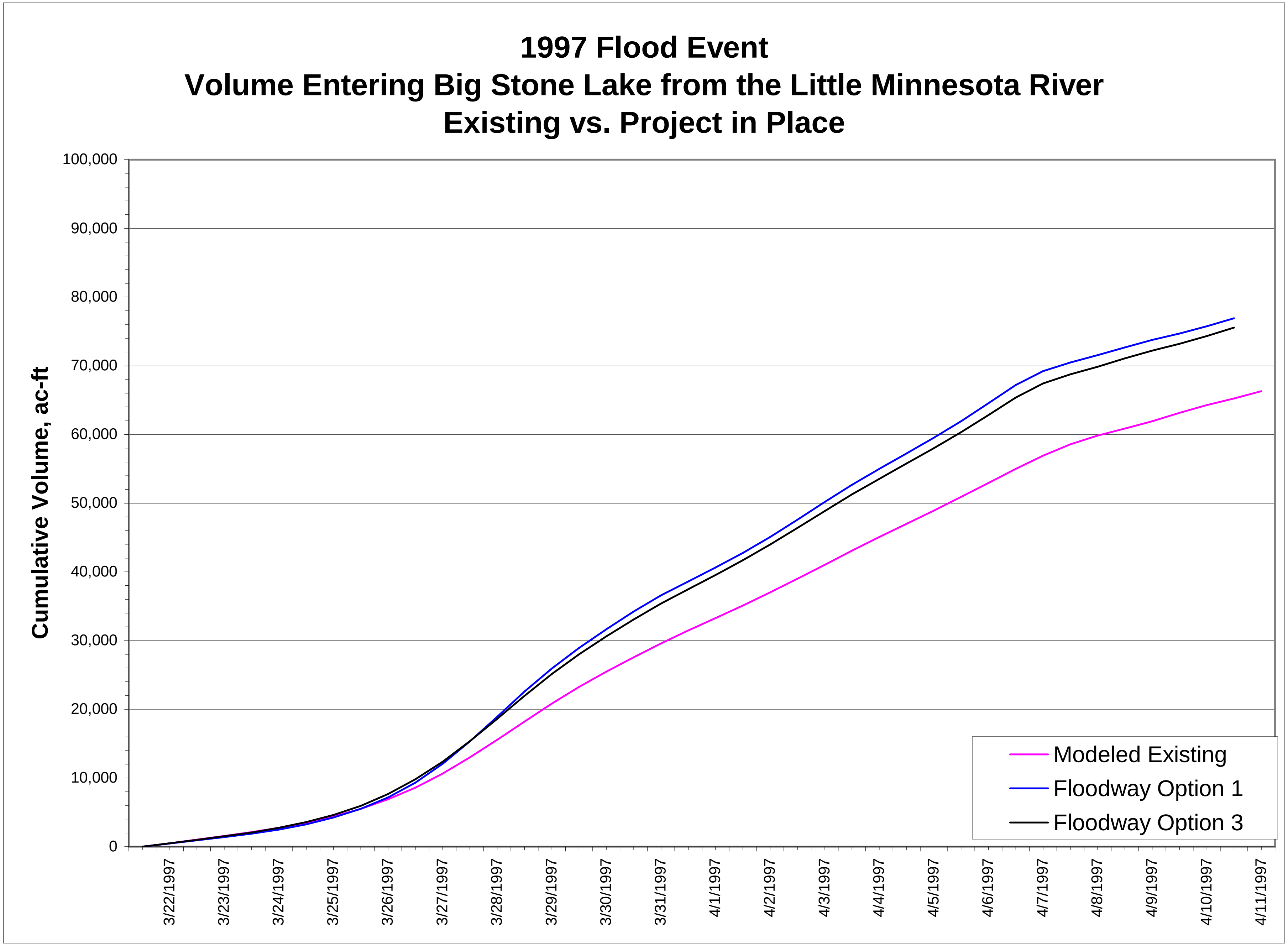
Stage Hydrograph for Little Minnesota River at Station 118+92
1993 Flood Event
Stage (feet)
975
974
973
972
971
970
969
968
Existing
Option 3 In-place
Approx. Floodplain (Elev 970.3)
Change Due to Project:
Maximum Stage +0.54 ft
Maximum Flow +1,223 cfs
Duration Over Bank +1 days
22Jul1993 2400
23Jul1993 1200
23Jul1993 2400
24Jul1993 1200
24Jul1993 2400
25Jul1993 1200
25Jul1993 2400
26Jul1993 1200
26Jul1993 2400
27Jul1993 1200
27Jul1993 2400
28Jul1993 1200
28Jul1993 2400
29Jul1993 1200
29Jul1993 2400
30Jul1993 1200
30Jul1993 2400
31Jul1993 1200
31Jul1993 2400
01Aug1993 1200
01Aug1993 2400
02Aug1993 1200
02Aug1993 2400
03Aug1993 1200
03Aug1993 2400
04Aug1993 1200
Date

Figure 5-9

The design goal to replicate the "historic flow split" to Lake Traverse (and therefore to Big Stone Lake) established when beginning the project, although well intended, is in fact problematic. Although the peak flow reaching Lake Traverse can be replicated, replicating the peak flow and volume leaving the Little Minnesota River is likely to result in the very flooding which now occurs within Browns Valley; i.e., the flooding the proposed flood mitigation project is intended to solve. An important concern addressed during design of the flood mitigation project is the ability to explicitly control the rate of breakout flows to the north. A flood mitigation project unable to control breakout flows to the north perpetuates the risk of a future flood within Browns Valley. The peak flow and volume of breakout flow to the north must be controlled.

Modeling of the historic floods for 1993 (summer flood), 1997 (spring flood) and 2007 (spring flood) formed the basis for analyzing the potential for moving the flood problem downstream. Without and with project conditions were simulated for each of the historic floods and the volume reaching Big Stone Lake derived from the daily discharges (see **Figure 5-10** for an example). Because the UMRWD also recently completed an unsteady HEC-RAS model for Big Stone Lake downstream to the Highway 75 Dam for the 1997 flood (for completing a dam breach analysis) additional, more detailed analyses were also completed for this flood.

Without and with project cumulative volume hydrographs at the downstream boundary of the HEC-RAS model (just upstream of Big Stone Lake) for the 1993, 1997, and 2007 were compared (see **Table 5-7**). This analysis shows that the additional volume reaching the 12,610 acre Big Stone Lake ranges from less than 2000 acre-feet to 16,000 acre-feet. An extremely conservative assumption is to assume this volume instantaneously reaches Big Stone Lake (the volume in fact reaches Big Stone Lake over several weeks) and that there is no outflow through the Big Stone Lake Dam. (Note: the outflow from Big Stone Lake in fact ranges from 4 to 50 times the additional volume reaching the lake – see **Table 5-7**.). This simple conservative approach shows a ***maximum*** increase in lake stage ranging from **2-inches** for the 1993 flood to **16-inches** for the 2007 flood.



1997 Flood Event
Volume Entering Big Stone Lake from the Little Minnesota River
Existing vs. Project in Place
Cumulative Volume, ac-ft
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
3/22/1997
3/23/1997
3/24/1997
3/25/1997
3/26/1997
3/27/1997
3/28/1997
3/29/1997
3/30/1997
3/31/1997
4/1/1997
4/2/1997
4/3/1997
4/4/1997
4/5/1997
4/6/1997
4/7/1997
4/8/1997
4/9/1997
4/10/1997
4/11/1997
Modeled Existing
Floodway Option 1
Floodway Option 3

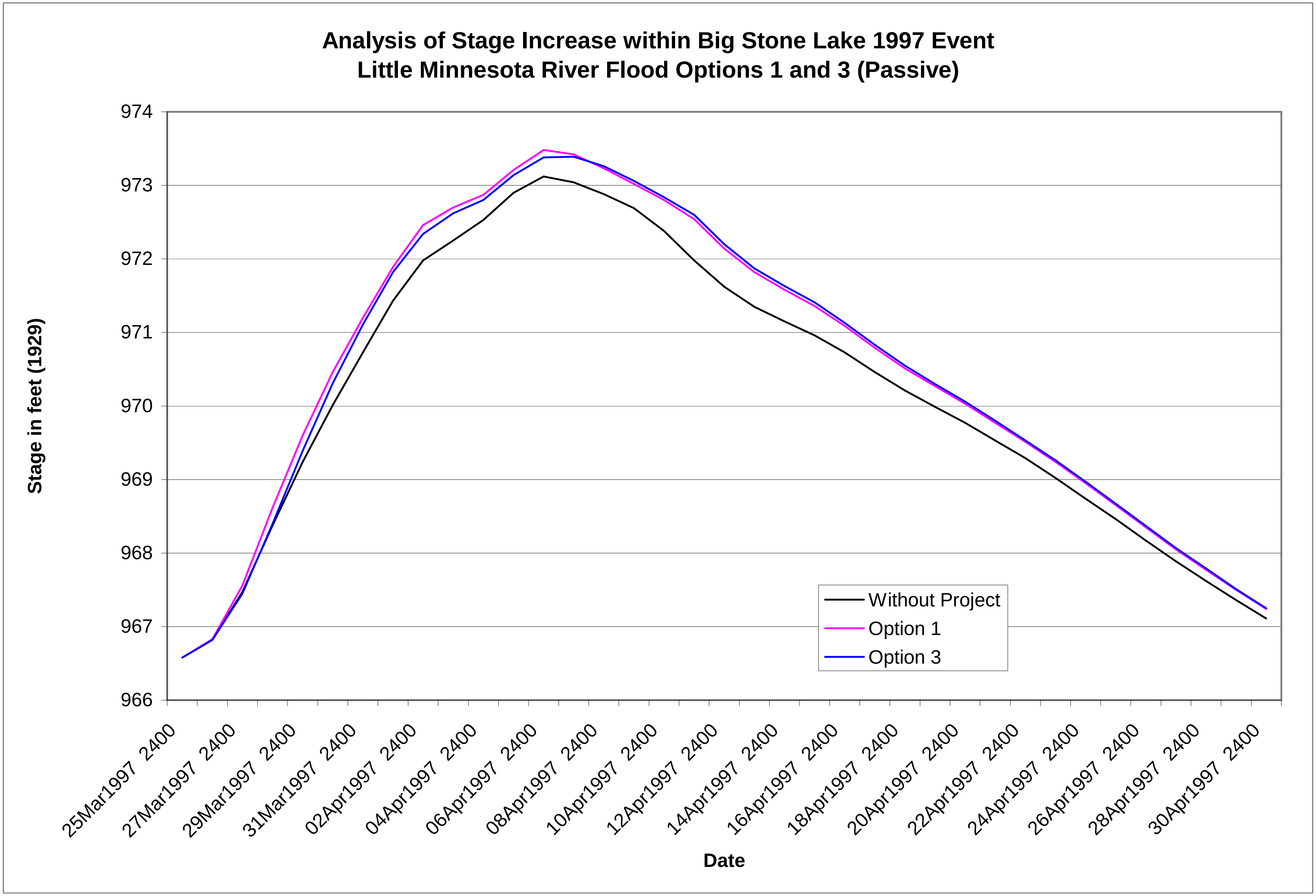
Figure 5-10

Table 5-7

Analysis of Select Historic Flood Volumes (acre-feet) Reachin Big Stone Lake Based Upon Unsteady HEC-RAS modeling analysis.

Metric for Big Stone Lake	**Historic Flood Event**		
	1993	**1997**	**2007**
Additional Volume Reaching Big Stone Lake Compared to Without Project Conditions (ac-ft)	1,016 (Option 1) 0 (Option 3)	10,611 (Option 1) 9,255 (Option 3)	16,815 (Option 1) 13,436 (Option 3)
Difference in Volume Between Options 1 and 3 Reaching Big Stone Lake (ac-ft)	1,016	1,357	3,379
Amount Leaving Big Stone Lake During Historic Flood Through Spillway (ac-ft)	84,661	117,820	60,693
Additional Volume as a Percent of Outflow Volume	2.3%	8.4%	26%
Maximum Depth Increase in Big Stone Lake	~ 1 inch (Option 1) 0 (Option 2)	10-inches (Option 1) 9 inches (Option 3)	16-inches (Option 1) 13-inches (Option 3)

The hydraulic analysis completed for the 1997 flood provides a considerably more realistic assessment of the potential for moving the problem downstream. **Figure 5-11** and **Figure 5-12** show the stage within and discharge leaving Big Stone Lake, respectively for the with and without project conditions. Option 1 and (passive inlet) and Option 3 (passive inlet) show little difference in stage for the 1997 flood on Big Stone Lake. The analysis shows a maximum increase in stage of 0.3-feet during the flood event (~ 4-inches compared to the



Analysis of Stage Increase within Big Stone Lake 1997 Event
Little Minnesota River Flood Options 1 and 3 (Passive)
Stage in feet (1929)
974
973
972
971
970
969
968
967
966
25Mar1997 2400
27Mar1997 2400
29Mar1997 2400
31Mar1997 2400
02Apr1997 2400
04Apr1997 2400
06Apr1997 2400
08Apr1997 2400
10Apr1997 2400
12Apr1997 2400
14Apr1997 2400
16Apr1997 2400
18Apr1997 2400
20Apr1997 2400
22Apr1997 2400
24Apr1997 2400
26Apr1997 2400
28Apr1997 2400
30Apr1997 2400
Date
Without Project
Option 1
Option 3

Figure 5-11

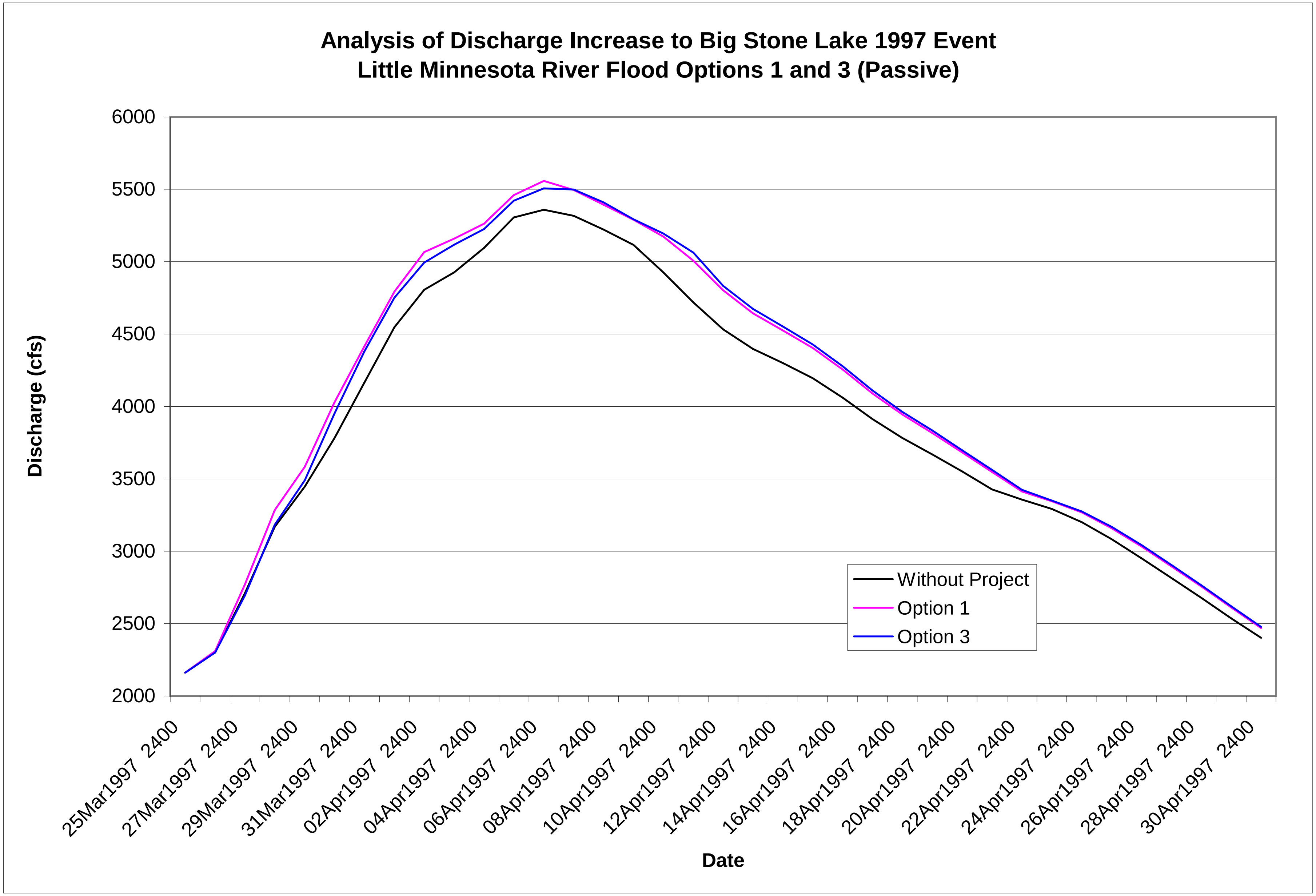

Analysis of Discharge Increase to Big Stone Lake 1997 Event
Little Minnesota River Flood Options 1 and 3 (Passive)
Discharge (cfs)
6000
5500
5000
4500
4000
3500
3000
2500
2000
25Mar1997 2400
27Mar1997 2400
29Mar1997 2400
31Mar1997 2400
02Apr1997 2400
04Apr1997 2400
06Apr1997 2400
08Apr1997 2400
10Apr1997 2400
12Apr1997 2400
14Apr1997 2400
16Apr1997 2400
18Apr1997 2400
20Apr1997 2400
22Apr1997 2400
24Apr1997 2400
26Apr1997 2400
28Apr1997 2400
30Apr1997 2400
Date
Without Project
Option 1
Option 3

Figure 5-12

conservative estimate of 12-inches). The difference in discharge between the Options is small (~ 200 cfs) compared to without the project.

An understanding of the operation of the Big Stone Lake Dam is needed to place this information within the proper context. The draft operational plan for Big Stone Lake (dated 1988) indicates some flood storage is available within Big Stone Lake, although the operation of the dam is primarily for the purpose of maintaining recreational water levels. The flood control storage within Big Stone Lake is that storage above elevation 965.9 (1929 NGVD) and is intended for "surcharge" only. The 100-year flood elevation is established at 971.8 (1929 NGVD). (Note: Damages to structures are known to occur at an elevation less than the 100-year flood elevation for Big Stone Lake). Therefore, more than 75,000 acre feet of storage occurs between elevation 965.9 and the 100-year flood elevation.

In reality, there is additional 1.3-feet of storage in Big Stone Lake which occurs between the "normal" operating level and the flood storage elevation of 965.9. The intent of the draft operational plan for Big Stone Lake is in general to maintain the lake at or near an elevation above the silt barrier (964.6 NGVD 1929) for recreational purposes with a year-end elevation of 964.6 NGVD. The operational plan is as follows beginning in late winter:

- Within 1-foot above elevation 964.6 (silt barrier crest) (NGVD 1929) during May 1 to September 30;
    - Normal or above normal snowpack exists and the lake level reaches 964.1 (lake gage 6.4) or above, the spillway is opened.
    - Below normal snowpack exists and the lake level reaches 964.6 (lake gage 6.4) or above, the spillway is opened.

During the period from May 1 through September 30, the gates are fully opened once the flood control elevation of 965.6 is reached. Between elevation 964.6 and 965.6 the gates are adjusted so that flows to the Minnesota River are approximately equal to the Whetstone River but to maintain a minimum instream flow.

This analysis suggests that the flood problem for large flood events is not being moved downstream (at least using the 1997 as a basis). The analysis also suggests that at least for the 1997 flood there is little difference in the volume of water moving downstream for Options 1 and 3. This fact needs consideration in selecting the preferred Little Minnesota River floodway option. Option 3 however, does result in some reduction in moving additional volume downstream.

Ability to Remove Browns Valley from the Floodplain

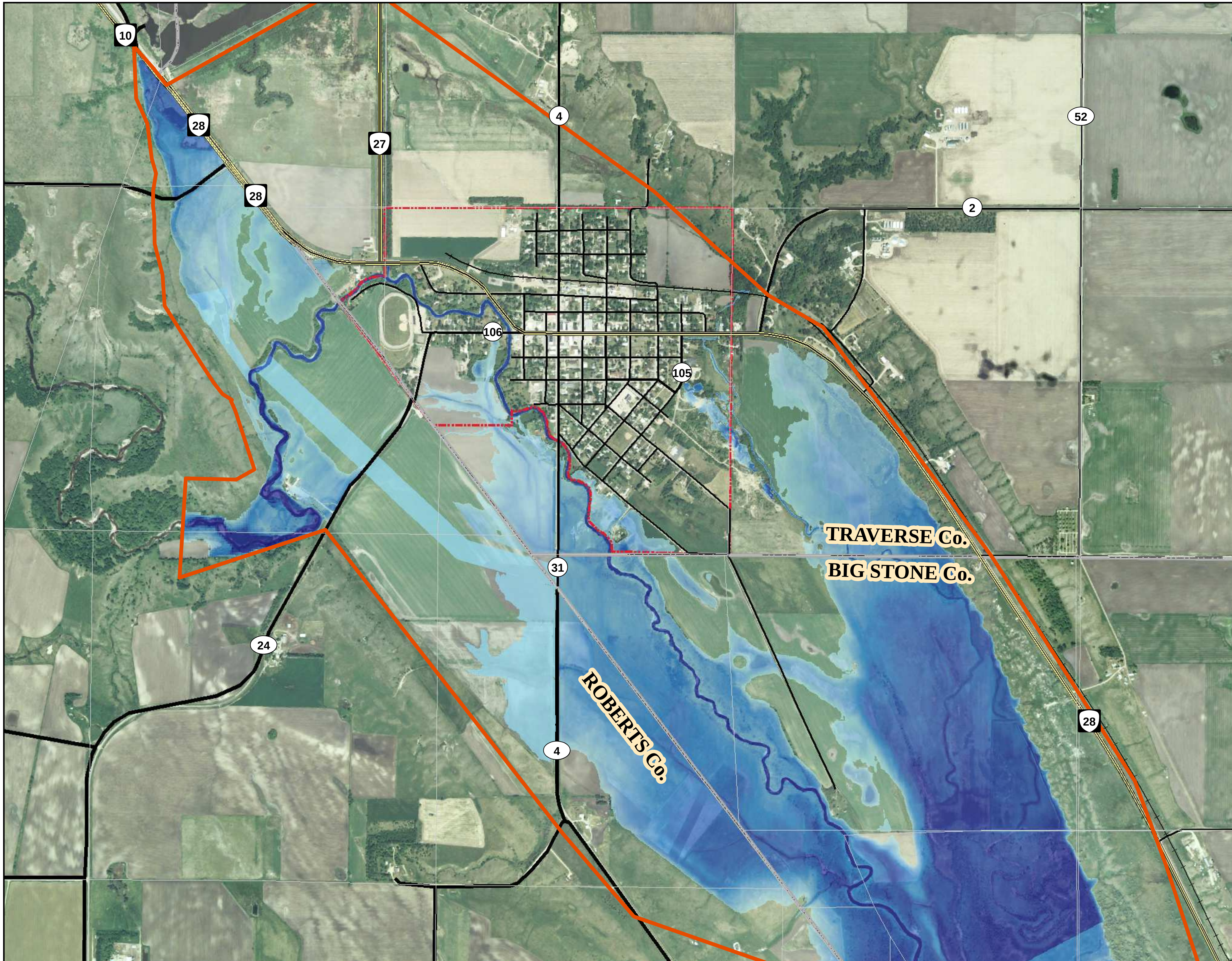
Two approaches were used to evaluate the ability to remove Browns Valley from the floodplain. These approaches included simulating historic flood events and for the 1% chance annual flood event assuming the Little Minnesota River floodway was constructed. Inundation maps were also developed for the historic floods for the existing condition. Mapping was completed only for Option 3, as this option is capable of attaining the design goals established by the BVFMTF.

The analysis shows that Option 3 is capable of removing Browns Valley from the 100-year floodplain (**Figure 5-13**) and would have been provided protection during the 1993 flood event (**Figure 5-14),** the 1997 flood event **(Figure 5-15)** and the 2007 flood event (**Figure 5-16**). Analysis for Option 1 and Option 2 show that these alignments are capable of attaining similar results.

Opinions of Probable Cost

Table 5-8 shows the Opinions of Probable Cost for Options 1 and 3, with two different inlet types. Option 1 is less than Option 3 due to the shorter length of the floodway and no need for a control structure to Lake Traverse. However, Option 1 does not provide for the historic flow split Lake Traverse. Detailed Opinions of Probable Cost for all options are included in **Appendix E**.

Many features could be added or deleted to modify the project function and cost. If the passive floodway inlet is built with a fixed crest rather than with leaf gates, costs of Option 1A and Option 3 Passive will be reduced by $770,000.



N

Notes:
1. Results generated from HEC-RAS model .
2. Little Minnesota is the only mapped flooding source.
3. Flood inundation areas created using aerial photogrammerty data.

Legend

- Mapping Extents
- State Boundary
- County Boundary
- Roads
- Railroads

0 750 1,500 3,000 Feet

Figure 5-13 - 1% Chance Annual Flood with Option 3

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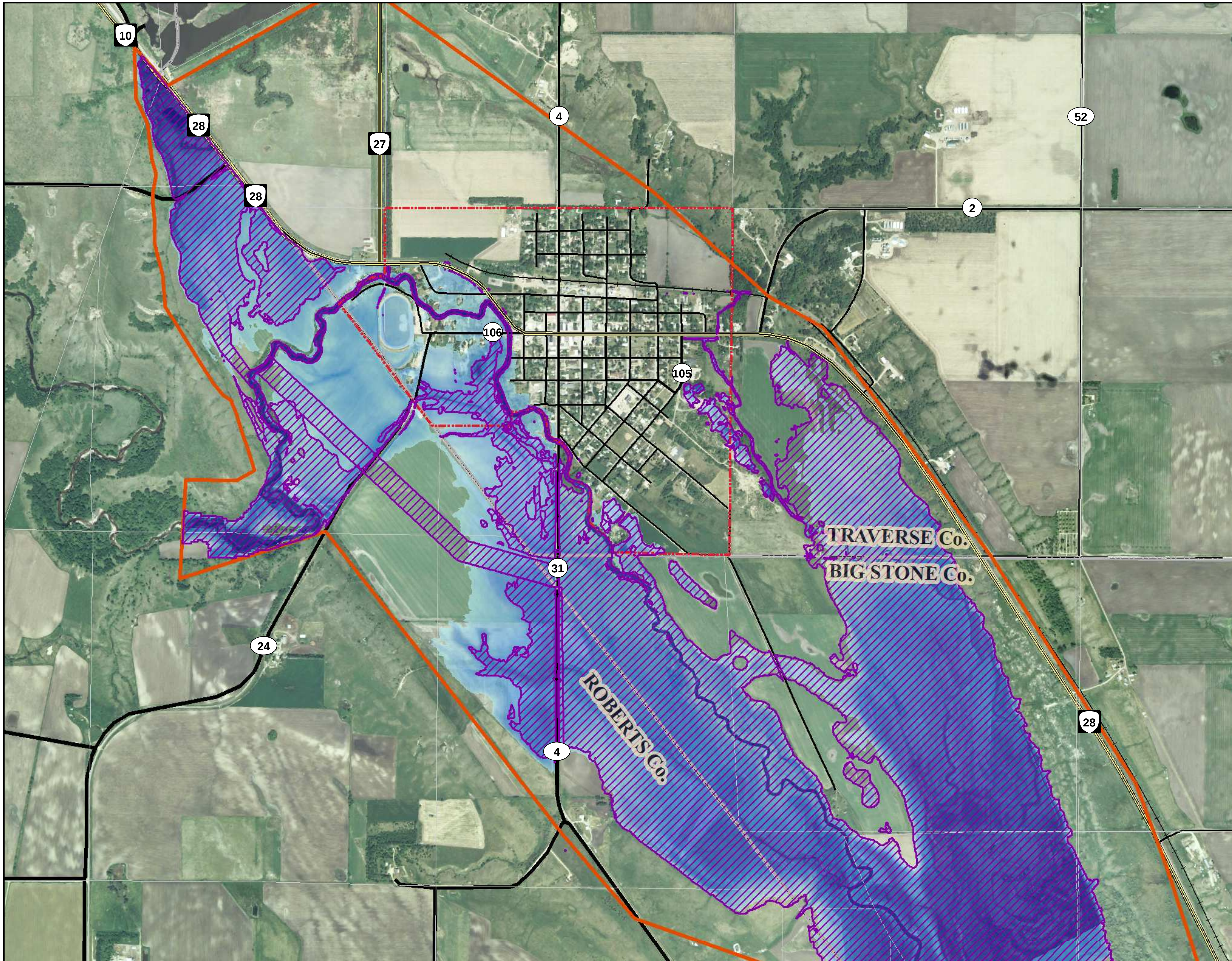

Notes:

1. Results generated from calibrated HEC-RAS model .
2. Represents maximum flood extents from July 25-29, 1993.
3. Little Minnesota is the only mapped flooding source.
4. Flood inundation areas created using aerial photogrammerty data.

Legend

- 1993 Floodplain with Option 3
- Mapping Extents
- State Boundary
- County Boundary
- Roads
- Railroads

0 750 1,500 3,000 Feet

Figure 5-14 - 1993 Flood Event - Flood Inundation for Existing and with Option 3

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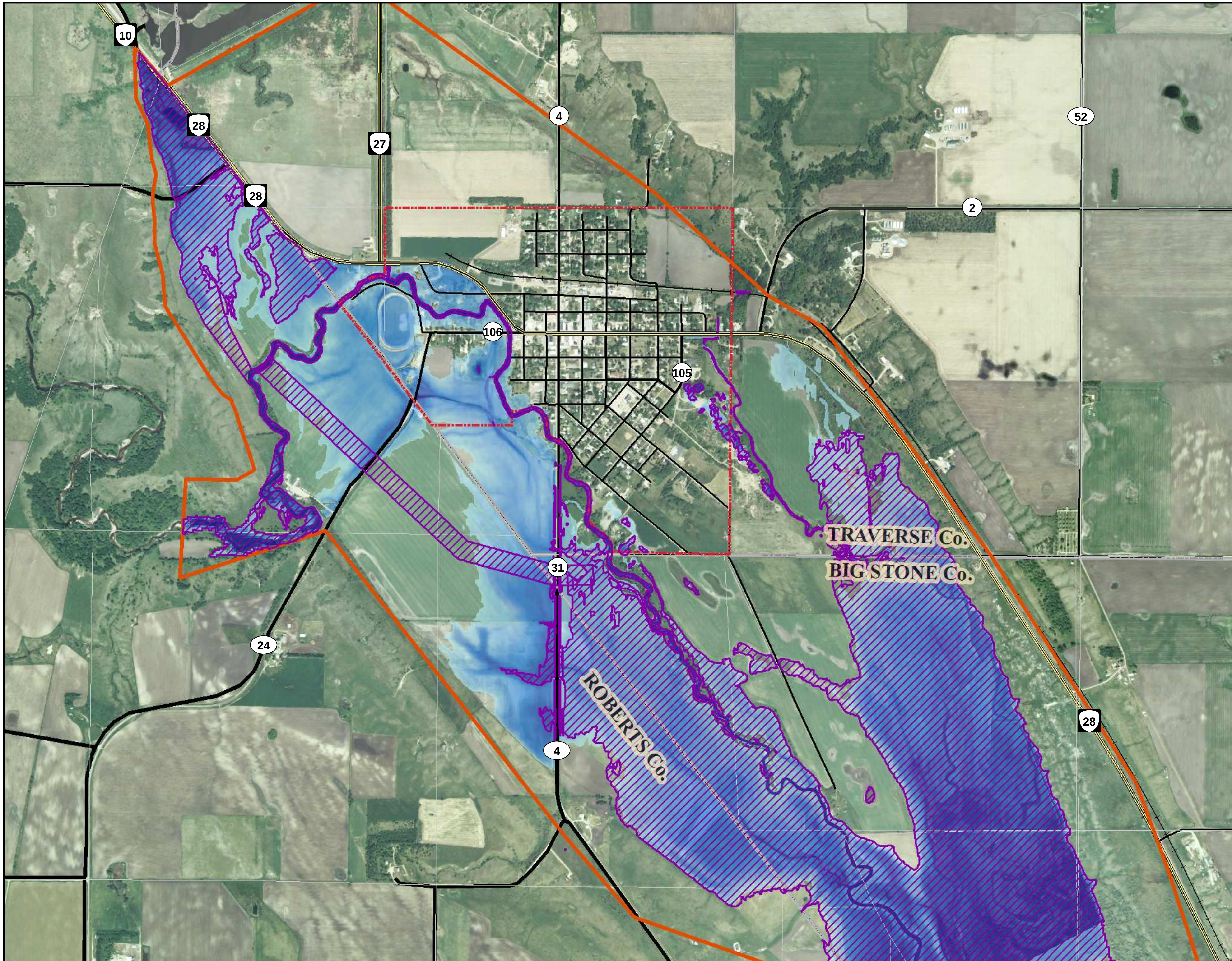

N

Notes:

1. **Results generated from calibrated HEC-RAS model .**
2. **Represents maximum flood extents from March 26-31, 1997.**
3. **Little Minnesota is the only mapped flooding source.**
4. **Flood inundation areas created using aerial photogrammerty data.**

Legend

- 1997 Floodplain with Option 3
- Mapping Extents
- State Boundary
- County Boundary
- Roads
- Railroads

0 750 1,500 3,000 Feet

Figure 5-15 - 1997 Flood Event - Flood Inundation for Existing and with Option 3

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
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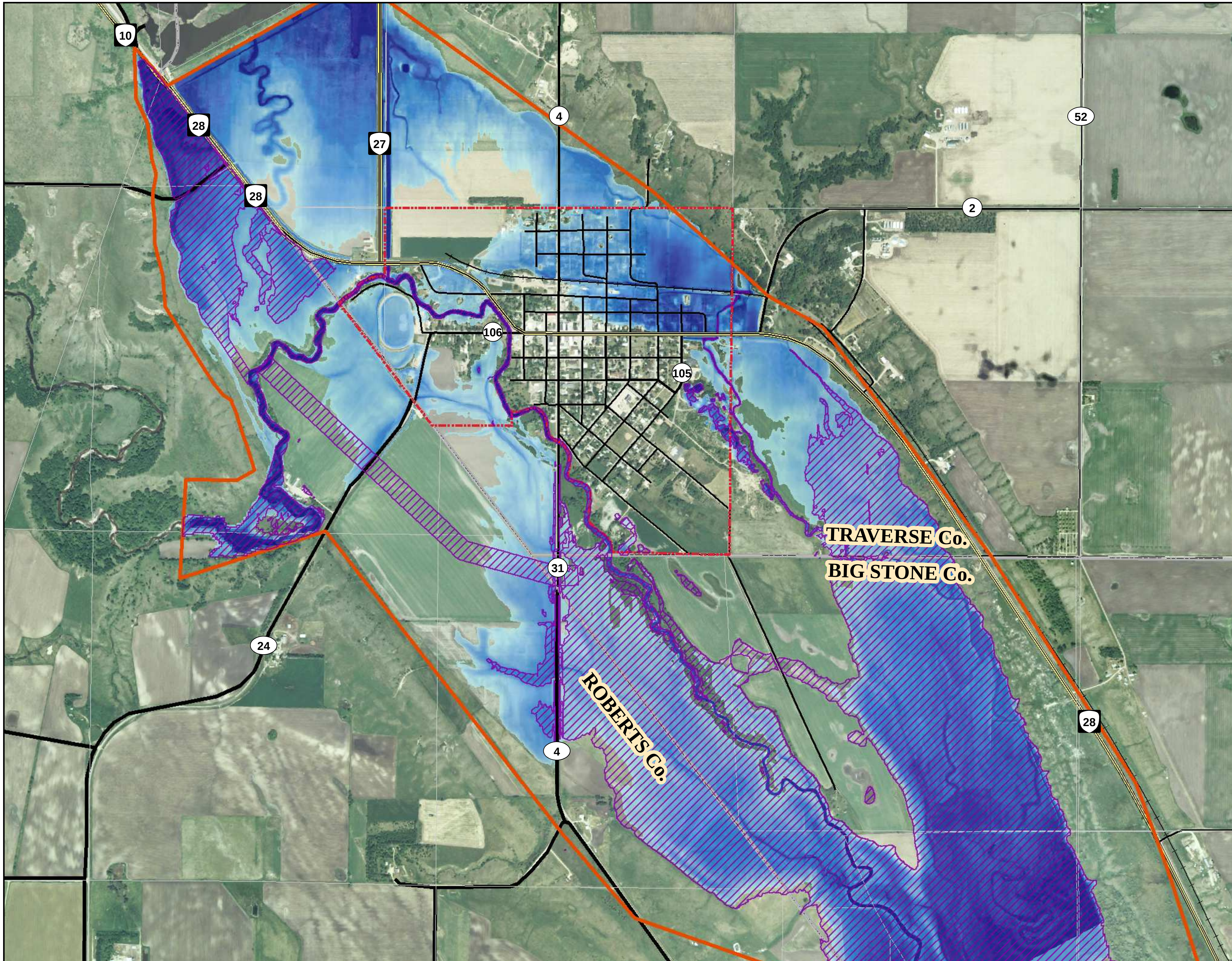

Notes:

1. Results generated from calibrated HEC-RAS model .
2. Represents maximum flood extents from March 13-17, 2007.
3. Little Minnesota is the only mapped flooding source.
4. Flood inundation areas created using aerial photogrammerty data.

Legend

- 2007 Floodplain with Option 3
- Mapping Extents
- State Boundary
- County Boundary
- Roads
- Railroads

Figure 5-16 - 2007 Flood Event - Flood Inundation for Existing and with Option 3

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Table 5-8

Opinions of Probable Cost for Little Minnesota Floodway Options 1 and 3

Floodway Option	Opinion of Cost
Option 1A Passive (with leaf gates)	$5,740,000
Option 1A Active	$5,640,000
Option 3 Passive (with leaf gates)	$7,370,000
Option 3A Active	$6,970,000

Installing a bridge over the floodway at CR-24 is estimated to cost about $520,000 more than realigning the road to follow the floodway. Replacing the dam and active control gates in the Little Minnesota River with a box culvert and embankment would likely reduce the construction costs for the control from $1.1 Million (dam with gates) to about $220,000 (dam with culvert).

5.1.2 Toelle Coulee

Three different flood mitigation alternatives are presented in this section, which protect the City of Browns Valley from extreme runoff events in the Toelle Coulee. The problem is identified, and the design issues and challenges of the coulee are discussed. Engineering details, the hydraulic performance of each alternative, and an opinion of probable cost are also provided.

5.1.2.1 Problem Identification

On June 1, 1965, severe flooding occurred in the northeastern portion of Browns Valley due to runoff from the Toelle Coulee. A 1966 Army Corps of Engineer's Section 205 Flood Control Reconnaissance Report best describes the event:

> "The damaging flood of June 1965 in Browns Valley resulted from a critical combination of meteorological conditions. During the evening of 1 June, the Lake Traverse area received a deluge of 4 to 10 inches of rainfall in about 1 hour. In the 3.8-square-mile watershed northeast of Browns Valley about 0.5 inches of rainfall at 5 pm saturated the ground surface prior to the severe evening storm which began at about 8 pm and lasted for about 45 minutes. For both storms the total rainfall varied from 3.75 to over 5 inches

in the watershed as indicated by several rain gages. Up to 10 inches of rainfall was reported in northern Folsom Township and in Windsor Township, both just north of the coulee watershed. The effects of antecedent soil saturation, the impervious nature of the heavy clay soils and the well-defined drainage pattern in the watershed combined to produce a very heavy flash runoff. This runoff funneled into the coulee just northeast of Browns Valley and was impounded to a depth of about 25 feet upstream from the County Highway 2 crossing. When the stored water reached a depth of 25 feet, it overflowed into the west (upstream) ditch of the highway and rushed down the hills into the eastern portion of the village. The coulee overflow scoured the ditch to a depth of about 10 feet and washed out much of the highway embankment downhill from the coulee crossing. The remainder of the flood flow discharged through the 5-foot-diameter conduit (318 feet long) beneath the highway grade and passed down to the lower end of the coulee valley where it overtopped a gravel road and washed out about a 50-foot length of the Great Northern Railway embankment. State Highway 28 was overtopped to a depth of about 8 inches. The Little Minnesota River reached near a bankfull stage during the 1965 flood and no damage was reported from this source. Coulee flooding less severe than that of 1965 occurred in 1962 after construction of County Highway 2 in 1960."[1]

Since 1965, there has been no recorded flooding due to runoff from the Toelle Coulee. However, since no significant improvements have been made to modify drainage, the City lives under continued risk of flooding in the future. Hydrologic analysis of the local drainage to the TH 28 crossing west of CSAH 2 has shown that the 100-year storm event has potential for flooding of structures upstream of TH 28, as well as upstream of the old railroad. This area, therefore, was also included in the Toelle Coulee flood mitigation analysis.

5.1.2.2 Design Issues and Challenges

The primary goal in the design of flood mitigation measures to manage excessive runoff from the Toelle Coulee is to create a drainage system which would prevent water from entering

[1] Section 205, Flood Control Reconnaissance Report. Unnamed Coulee at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, January, 1966.

the northeast part of Browns Valley, while also protecting the homes near the coulee itself. The challenges for the area stem back to the construction of Traverse CSAH 2 in1960, which, in spite of the 60-inch RCP culvert set though the embankment, created a blockage in the historic flow path for the runoff from the coulee. Borrow used to construct the road embankment was taken from the area on the west side of Traverse CSAH 2 culvert, creating an overflow to the west towards the City. The general site topography is arranged so that excessive runoff could flow westerly to flood the city.

Because of the steep nature of Toelle Coulee upstream of TH 28, peak discharges are large relative to the drainage area. This, in combination with the large Traverse CSAH 2 embankment, presents a financial challenge in providing sufficient drainage capacity through Traverse CSAH 2, as well as the coulee channel downstream.

Early discussion about a flood mitigation option for Toelle Coulee focused on storage, the use of a floodway, the use of a levee, or some combination of these (see Section 4.3, Analysis of the Range of Alternatives). After analysis of the aerial survey data, the concept of excavating a large floodway channel to the Little Minnesota River to accommodate the large peak discharges was deemed impractical. This would require considerable excavation, and since there are no homes or other structures along the coulee downstream of TH 28, protection is not necessary. The area along the coulee from TH 28 down to the confluence with the Little Minnesota River includes many acres of wetlands, and the tailwater from the river was shown to control the water surface elevation during large floods. It was found that flood protection can be provided to structures for a 100-year event through other conceptual designs, including levees, culvert replacements or a dam. The following section describes the three alternative concepts developed and analyzed for the Toelle Coulee.

5.1.2.3 General Description of Alternatives

Three alternatives were selected to be assessed for feasibility to provide flood protection. Each alternative prevents water from entering the northeast part of Browns Valley in a 100-year recurrence interval event, while also protecting the homes near the coulee itself:

1. West Levee Alternative
2. CSAH 2 Culvert Upgrade and East Levee Alternative
3. Coulee Impoundment Alternative

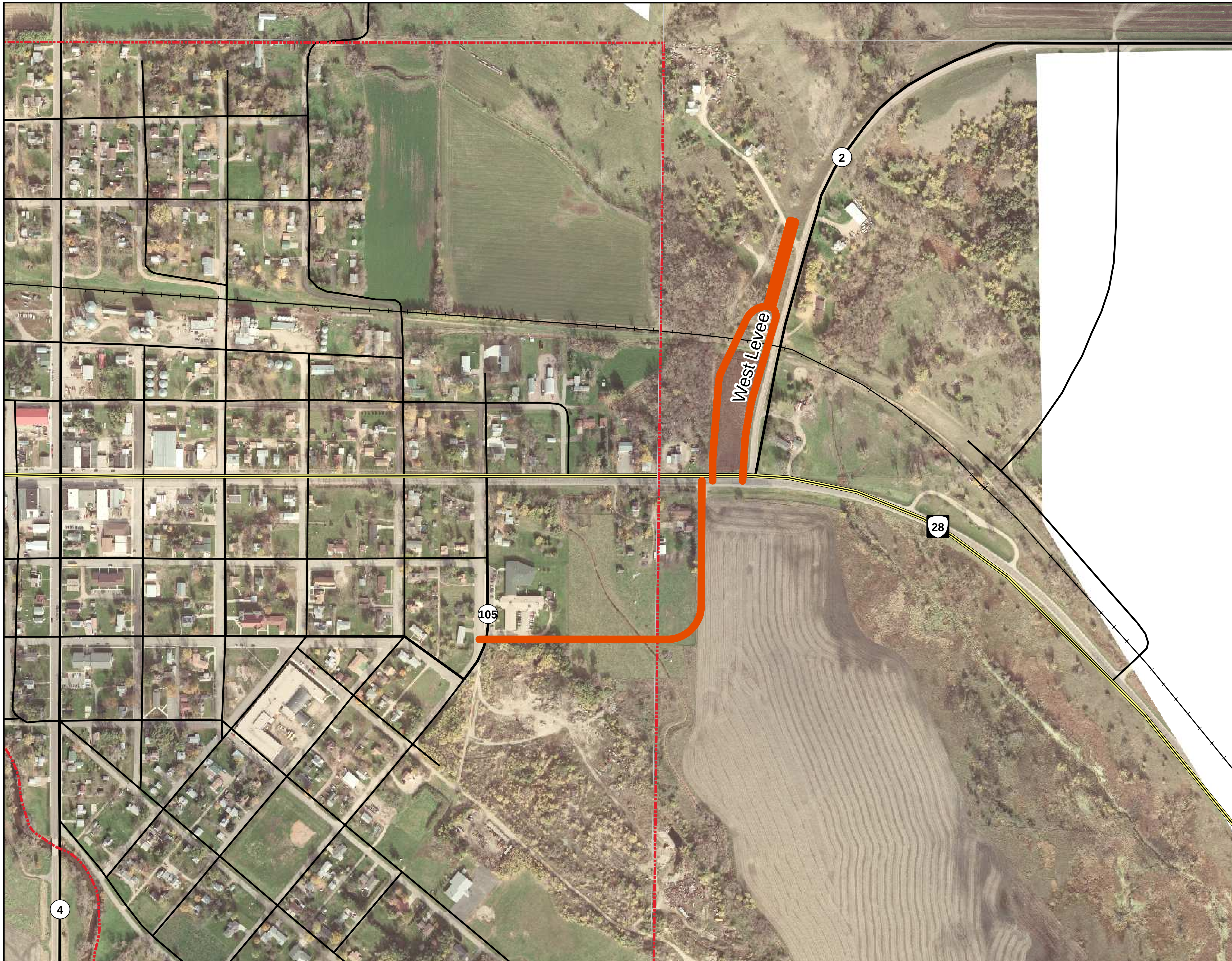
Toelle Coulee Alternative 1 - West Levee

Alternative 1 consists of the construction of a concrete flume, leading to earthen levees running along the west side of Traverse CSAH 2 to convey overflow from the coulee in a southerly direction and prevent it from heading west into town (see **Figure 5-17**). The design top elevation of the levees would be equivalent to the 100-year peak water surface elevation plus an additional 3 feet but will be reduced to near the 100-year level within the clear zone of TH 28. This alternative also requires the placement of a new crossing through TH 28 on the west side of Traverse CSAH 2, consisting of 4, 4-feet high x 8-feet span box culverts. The culverts were designed so that TH 28 is not overtopped for a 50-year recurrence interval event. The concrete flume is necessary to prevent erosion of the slope and road bank, as occurred in the 1965 flood, and to prevent erosion on or near the levees. The function of the more westerly levee is to prevent runoff from flowing into Browns Valley, while the primary function of the levee along Traverse CSAH 2 is to protect two homes on the east side of Traverse CSAH 2.

To protect structures in Browns Valley, another levee would be needed to the south of TH 28, as seen on **Figure 5-17,** also at an elevation equivalent to the 100-year peak water surface elevation plus 3-feet. Two lines of 4-feet high x 6-feet span box culverts would be needed to pass discharge from the west branch of Toelle Coulee through the levee.

The area to the north of TH 28 and west of CSAH 2 has potential for flooding even with the removal of overflow from the Toelle Coulee. In order to reduce water surface elevations to levels below local structures, the existing channel would be cleaned and widened (10-foot bottom, 3:1 sides) from TH 28 approximately 2,280 feet upstream. The existing overflow on the railroad grade/trail crossing would also be lowered about 5.6 feet to elevation 974.6.

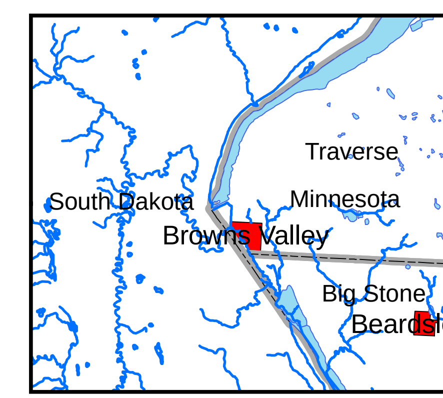
Since maintaining the drainage capacity of the west branch of the Toelle Coulee is very important, we recommend that permanent right-of-way be purchased along the channel. We



N

Legend

- Levee Alignment
- State Boundary
- County Boundary
- Roads
- Railroads



0 205 410 820 Feet

Figure 5-17 - Toelle Coulee West Levee Alternative

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propose that approximately 12 acres of right-of-way be established from near the City well field upstream though northeast Browns Valley so that future maintenance work to remove sediment, debris, and brush can be performed as needed.

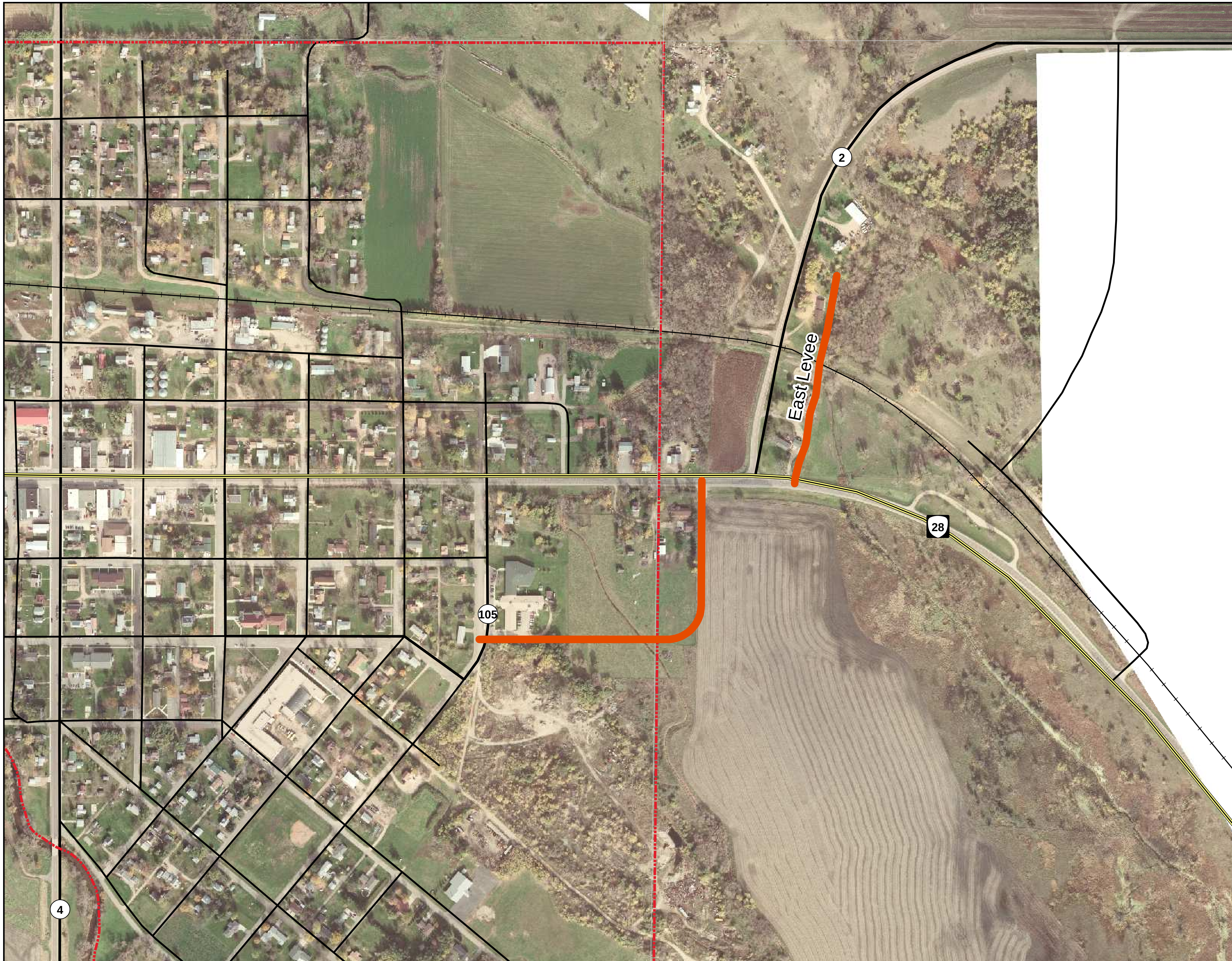
Toelle Coulee Alternative 2 - CSAH 2 Culvert Upgrade and East Levee

Alternative 2 consists of the installation of an additional culvert (1 line of 12-foot x 12-foot reinforced concrete box) through Traverse CSAH 2 above the existing 60-inch reinforced concrete pipe to prevent overflow to the west towards the city in the 50-year and 100-year recurrence interval events (see **Figure 5-18 and Appendix F, Sheet 7**). A levee is also proposed running north from TH 28 on the west side of the channel to protect two homes just to the east of Traverse CSAH 2. The levee design top elevation is 3-feet above the 100-year peak water surface elevation, but will be reduced to near the 100-year level within the clear zone of TH 28. This alternative also requires the replacement of the existing culverts crossing TH 28 (four lines of 60-inch diameter) on the east side of Traverse CSAH 2 to pass the peak discharge though the system. This new crossing would consist of 3 lines of 7-foot rise x 12-foot span box culverts.

As described in the Alternative 1 description, to protect structures in Browns Valley, another levee would be needed to the south of TH 28, as seen on **Figure 5-17,** also at an elevation equivalent to the 100-year peak water surface elevation plus 3-feet. Two lines of 4-feet high x 6-feet span box culverts would be needed to pass discharge from the west branch of Toelle Coulee through the levee.

The area to the north of TH 28 and west of CSAH 2 has potential for flooding even with the removal of overflow from the Toelle Coulee. In order to reduce water surface elevations to levels below local structures, the existing channel would be cleaned and widened (10-foot bottom, 3:1 sides) from TH 28 approximately 2,280 feet upstream. The existing overflow on the railroad grade/trail crossing would also be lowered about 5.6 feet to elevation 974.6.

Since maintaining the drainage capacity of the west branch of the Toelle Coulee is very important, we recommend that permanent right-of-way be purchased along the channel. We propose that approximately 12 acres of right-of-way be established from near the City well field



Legend

- Levee Alignment
- State Boundary
- County Boundary
- Roads
- Railroads

0 205 410 820 Feet

Figure 5-18 - Toelle Coulee East Levee Alternative

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upstream though northeast Browns Valley so that future maintenance work to remove sediment, debris, and brush can be performed as needed.

Preliminary plans for floodway for Toelle Coulee Alternative 2 are attached in **Appendix F**.

Toelle Coulle Alternative 3: Impoundment

Alternative 3 consists of constructing an impoundment upstream of Traverse CSAH 2 to store approximately 230 acre-feet in a 100-year runoff event on Toelle Coulee (see **Figure 5-19**). The proposed dam would be built just upstream from CSAH 2 to a top of embankment elevation of 955 feet (a height of about 53 feet) and would in part use the existing highway embankment as part of the downstream section of the dam. Since several homes and important highways are located a short distance downstream from the dam site, special care will be required to design the dam and high quality materials and construction methods will be needed. The existing 60-inch culvert crossing Traverse CSAH 2 would need to be removed and replaced with a 60-inch PCCP steel cylinder pipe. Reinforced concrete would be used to construct an inlet riser (SCS drop inlet type) and an outlet energy dissipation section.

As described for Alternatives 2 and 3, the area to the north of TH 28 and west of CSAH 2 has potential for flooding even with the removal of overflow from the Toelle Coulee. In order to reduce water surface elevations to levels below local structures, the existing channel would be cleaned and widened (10-foot bottom, 3:1 sides) from TH 28 approximately 2,280 feet upstream. The existing overflow on the railroad grade/trail crossing would also be lowered about 5.6 feet to elevation 974.6.

5.1.2.4 Design Details and Hydraulic Performance

The design peak discharges used to size each of the three alternatives are shown in **Table 5-9**. The design discharges shown in **Table 5-9** were also used in the hydraulic model to size the drainage structures. The resulting peak water surface elevations at TH 28 are listed in **Tables 5-10, 5-11, and 5-12**.

N

Legend

- Impoundment Alignment
- State Boundary
- County Boundary
- Roads
- Railroads

0 150 300 600 Feet

Figure 5-19 - Toelle Coulee Impoundment Alternative

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Table 5-9
Design Peak Discharges (cfs) for Toelle Coulee Flood Mitigation Alternatives

Return Period	Alternative 1 West Levee		Alternative 2 CSAH Culvert Upgrade and East Levee	Alternative 3 Impoundment
	Coulee Channel	CSAH 2 West Ditch	Coulee Channel	Coulee Channel
50-year	481	1144	1625	574
100-year	496	1800	2303	625

Table 5-10
Alternative 1 – West Levee
Hydraulic Data / Elevations (1988 NAVD) at TH 28 Crossings

Return Period	Headwater		Tailwater		Road Sag	
	West of CSAH2	East of CSAH2	West of CSAH2	East of CSAH2	West of CSAH2	East of CSAH2
50-year	979.18	977.89	977.50	976.33	979.58	979.77
100-year	980.69	978.06	977.94	976.67	979.58	979.77

Table 5-11
Alternative 2 – Traverse CSAH 2 Culvert Upgrade and East Levee
Hydraulic Data / Elevations (1988 NAVD) at TH 28 Crossing

Design Event	Headwater	Tailwater	Road Sag
50-year	979.63	976.29	979.77
100-year	980.36	976.60	979.77

Table 5-12
Alternative 3 – Toelle Impoundment
Hydraulic Data / Elevations (1988 NAVD) at TH 28 Crossing

Design Event	Headwater	Tailwater	Road Sag
50-yr	977.81	975.74	979.77
100-year	978.28	975.79	979.77

All three alternatives evaluated for Toelle Coulee protect the city and nearby homes for the 100-year recurrence interval event. As an example, **Figure 5-20** is a map of the 100-year floodplain for the potential future condition with Alternative 2. This map illustrates the alternative is effective in protecting the city and nearby homes from the 1% chance annual flood. While part of Browns Valley north of TH 28 is mapped as shallow floodplain, the proposed elevation of the 100-year flood is up to 5 feet lower than the elevation in the effective flood insurance study.

The floodplain mapping results shown are preliminary and may need to be refined in the final design process. Flood mitigation measures such as low head levees, culverts, or channel modifications/improvements may also be added or removed as the final project design in completed.

5.1.2.5 Opinions of Probable Cost

Detailed opinions of probable cost were developed for each of the three flood mitigation alternatives for Toelle Coulee. Estimated quantities and details of the estimate are provided in **Appendix E**. **Table 5-13** shows the opinions of probable cost including materials, construction, engineering services, and contingencies. The opinion of probable cost for each alternative exceeds $1 Million. Part of the reason for these (high) estimates is that each alternative is aimed at controlling a large flood on the coulee after the flood has fully developed. It may be less expensive to control the runoff closer to its source; i.e. to "treat the raindrops where they fall" by constructing smaller dams or other watershed management practices further upstream in the Toelle Coulee watershed.

Notes:
1. Results generated from HEC-RAS model .
2. Toelle Coulee is the only mapped flooding source.
3. Flood inundation areas created using aerial photogrammerty data.

Legend

- Levee Alignment
- State Boundary
- County Boundary
- Roads
- Railroads

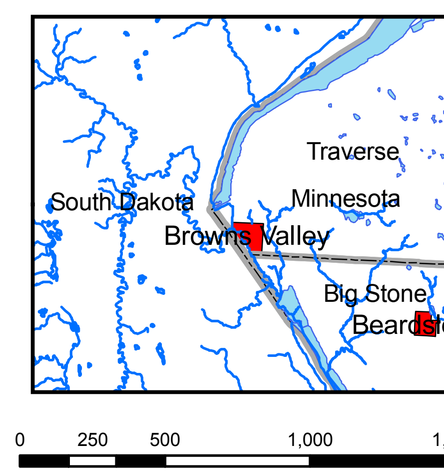

Figure 5-20 - 1% Chance Annual Flood with East Levee Alternative

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Table 5-13
Opinion of Probable Costs
Toelle Coulee Flood Mitigation Alternatives

Alternative 1 West Levee	Alternative 2 CSAH 2 Culvert Upgrade and East Levee	Alternative 3 Impoundment
$1,130,000.00	$1,140,000.00	$1,360,000.00

SECTION 6.0
ENVIRONMENTAL SETTING AND IMPACT

6.1 ENVIRONMENTAL SETTING

The project is located within the North Central Glaciated Plains region. The region is dominated by glacial till materials from the Des Moines Lobe Glaciation. Glacial till materials are typically 100 to 400 feet deep, overlaying granite bedrock. Glacial till is an unconsolidated mixture of sand, silt, clay, gravel and boulders.

Two soil types comprise the majority of the project area; Lamoure Silty Clay Loam and La Prairie Loam. These soils are very similar in composition. Lamoure soils are located at toe slopes along the Little Minnesota River and in the Toelle Coulee area and have a higher clay content than La Prairie soils. La Prairie soils are most prominent in the upland areas along the Little Minnesota within the overbank areas. Both soils were formed from alluvial material on floodplains. They range between moderately well drained and somewhat poorly drained, depending on the local clay content. The area is spotted with clay, sand and gravel deposits, particularly in the Toelle Coulee area.

Vegetation native to the area consists of dry prairie and woodland complexes. These communities consist of primarily oak forests and dry grassland areas. The Minnesota DNR identified an area of these native communities north of the City of Browns Valley.

6.2 DISCUSSION OF POTENTIAL ENVIRONMENTAL IMPACTS

6.2.1 Soil and Prime Farmland Impacts

Both soil types in the project area are moderately susceptible to wind and water erosion. Because these soils are susceptible to erosion, best management practices such as watering dirt roads, vegetating soil stock piles, and other measures should be evaluated and utilized during the construction phase. Limiting erosion will help maintain water quality in the Little Minnesota River. Subsoils and gravel materials need to be evaluated on site after the final routes are chosen to determine engineering suitability. It should also be noted that soils in the area of the project are classified as prime farm land. This classification requires contact the local NRCS office prior to construction of the project.

6.2.2 Aquatic and Geomorphic Flows

The main surface water feature in the project area is the Little Minnesota River. The project is designed to direct floodwaters from this river (and Toelle Coulee) away from Browns Valley. The Little Minnesota River Floodway is being designed to minimize floodwaters through the City during high flow events. Depending upon the type of inlet to the floodway, moderate to low flows will be affected through Browns Valley. Selection of Option 1, Option 2, and Option 3 are expected to potentially affect 2.7 miles, 1.7 miles, and 2.0 miles of stream channel respectively, through Browns Valley (distance from the floodway inlet to the floodway outlet).

The primary potential adverse impact is modifying the dominant discharge, which maintains the form and function of the river channel (see **Table 6-1**). Lowering the dominant discharge can result in sediment accumulation and the growth of trees and shrubs in the Little Minnesota River downstream from the inlet. A second potential impact is the loss of aquatic habitat, because of the reduction in discharge.

6.2.3 Wetland and Woodland Habitat Impacts

The proposed project will affect relatively small amounts of wetland and woodland habitats used by wildlife. Wetland information was obtained from the National Wetland Inventory (NWI). Most of the wetlands are riparian areas located along the Little Minnesota River. **Table 6-2** shows approximate wetland and woodland impacts by option.

The majority of wetlands in the area fall into two categories; i.e., Palustine Emergent Temporarily Flooded (PEMA) and Palustrine Forested Broad Leaf Deciduous Temporarily and Seasonally Flooded (PFO1A and PFO1C respectively). The PFO1A and PFO1C wetlands represent riparian areas. Constructing and grading the floodways will eliminate all wetlands within the construction easement (i.e., direct impacts). Indirect impact along the Little Minnesota River through Browns Valley may occur because of the lower flows through this portion of the river. A wetland and rare species survey should be completed following the selection of the final alignment.

The areas of the Little Minnesota Floodway and the Tollee Levee are primarily agricultural, providing limited wildlife habitat. The Creek Heelsplitter Mussel has been located along the inlet portion of the Little Minnesota Floodway and is identified as a species of greatest concern by the Minnesota DNR. The Creek Heelspiltter Mussel attaches itself to host fish rather than stationary surfaces as many mussels do. Host species may include black crappie, yellow perch and other fish.

The field survey completed for the selected alignments should confirm the presence or absence of this species. Mitigation measures to limit impacts to this species (should it be present) during project construction could include efforts to limit fish kill during construction of the floodway. Streambank elimination should have limited impact on this species. No other endangered species are known to be in the project area.

Table 6-1
Change in Discharge (Aquatic and Geomorphic Flows)
Within the Little Minnesota River through Browns Valley
Option 3, Passive Inlet

Return Period (Year)	Current Little Minnesota River Discharge (cfs)	Approximate Discharges (cfs) Through Browns Valley	
		Passive Inlet	Active Inlet
2	822	657[1]	641[2]
5	2020	784[1]	863[2]
10	3200	553[3]	570[4]
20	4660	737[3]	514[5]
50	7070	944[3]	546[5]
100	9300	1150[3]	574[5]

[1] 3 leaf gates fully raised.
[2] 4 gates on active structure fully open.
[3] 3 leaf gates fully lowered.
[4] 1 gate on active structure opened 3.5 feet.
[5] 1 gate on active structure opened 3 feet.

Table 6-2
Potential Physical Impacts to Wetlands, Woodlands and Streambanks

Flood Mitigation Option	Stream Bank (ft)	Woodland[1] (acres)	Wetlands[2] (acres)
Little Minnesota River Floodway			
Option 1A			
Inlet	850	Negligible	0
Floodway			0
Outlet	1,120	4.6 Acres	3.1 PFO1Ah 0.2 PEMA
Option 1B			
Inlet	850	Negligible	0
Floodway			0
Outlet	600	3.6	1.0 PFO1Ah 0.15 PEMA
Option 2A			
Inlet	800	1.8	0
Floodway			0
Outlet	1,120	2.2	0
Option 2B			
Inlet	1,150	1.1	0
Floodway			0
Outlet	1,150	4.9	2.8 PFO1Ah 1.0 PEMA
Option 3 (Estimated)			
Inlet	1,230	1.5	0.8 PFO1Ah
Floodway			
Outlet	1,230	6.9	3.1 PFO1Ah 0.2 PEMA
Toelle Coulee	None	0.37	0

[1] Determined from 2006 aerial imagery.

[2] Based on National Wetland Inventory Maps.

6.2.4 <u>Groundwater Impacts</u>

The regional soil surveys suggest that the local water table may be within 10 feet of the surface in the project area. The current floodway depth as proposed is about 7 feet, similar to the Little Minnesota River. Although construction of the floodway may interseet with the water table, no significant groundwater impacts are anticipated.

6.2.5 <u>Cultural Resource Impacts</u>

The Minnesota and South Dakota State Historic Preservation Offices (SHPO) were contacted relative to the proposed project. No response has been received from the South Dakota SHPO. According to the Minnesota SHPO, no known archaeological sites or historical architectural properties were identified in the project area. A report from SHPO does not guarantee no historic resources are in the area of the property.

The nature of the proposed project has the potential to affect or eliminate unidentified archaeological sites. River bank areas, such as the proposed project location, are common areas to find archaeological sites. According to early Minnesota state maps, Native American reservations were present in the area of the property up to the 1870s. Related tribes should be consulted prior to construction during an archaeological survey of the area. A full archaeological survey should be conducted of the final routes to locate and mitigate any found sites prior to construction. Should important archeological resources be present, additional protection measures can be developed.

6.3 PERMITS AND APPROVALS REQUIRED

A variety of regulatory processes, permits, and approvals, are likely needed prior to construction of this project. We anticipate the completion of the following studies or documents as the basis for subsequent permitting and regulatory approvals:

- Environmental Assessment Worksheet (Minnesota);
- Wetland and threatened and endangered species field review; and
- Cultural resources field survey.

The anticipated regulatory permits and approvals needed include:

- National Point Discharge Elimination System Stormwater Construction Permit (Minnesota Pollution Control Agency and South Dakota Department of Environment and Natural Resources);
- 401 Water Quality Certification (Minnesota Pollution Control Agency and South Dakota Department of Environment and Natural Resources);
- Public Waters Permit (Minnesota DNR);
- Water Rights Permit (South Dakota Department of Environment and Natural Resources);
- Wetland Conservation Act Permit (Local Governmental Unit);
- Section 404 and Section 10 Permits (U.S. Army Corps of Engineers);
- Section 106 Memorandum of Agreement with Minnesota and South Dakota SHPO's;
- Utility Permit on Trunk Highway Right of Way (MNDOT);
- Local (County) approvals for Road modifications;
- State Department of Transportation Plan review for transportation modifications; and
- Permit to construct a Flooding and Water Impoundment structure (Upper Minnesota River Watershed District).

The City also expects to prepare and submit a Conditional Letter of Map Revision to the Minnesota DNR and the Federal Emergency Management Agency concurrent with the completion of final construction plans, to obtain the needed revisions to the 100-year floodplain.

SECTION 7.0
PROJECT FEASIBILITY, ENGINEER'S RECOMMENDATION AND DESIGN ISSUES NEEDING RESOLUTION

7.1 PROJECT FEASIBILITY

The determination of project feasibility is based upon several criteria established by the Project Engineer in consultation with the UMRWD and the BVFMTF. These criteria include:

- The ability to attain the design goals as presented in Section 2.1, Project Design Goals of this report;
- An understanding of the perceived magnitude of the potential environmental impacts and the likelihood of obtaining the necessary regulatory approvals and permits;
- The perceived constructability of the project;
- Cost; and
- The ability of the owner to operate and maintain the project as designed.

Based upon the information presented within this report, it is the opinion of the Project Engineer that all Little Minnesota River floodways are capable of solving the river flooding problem within Browns Valley. Flood protection accomplished through engineering improvements within the Toelle Coulee are also considered feasible. Some mitigation for potential adverse environmental impact is anticipated. The amount of mitigation is yet to be determined through the completion of additional field studies and consultation with the various regulatory agencies. The UMRWD anticipate owning and operating the project on behalf of the City of Browns Valley. The UMRWD currently operates the Big Stone Lake dam and has a history of successful project operation. The Project Engineer believes based upon current information constructability issues for the Browns Valley Flood Mitigation Project is manageable.

7.2 ENGINEER'S RECOMMENDATION

Considerable technical analyses have been completed to evaluate the various floodway alternatives for the Little Minnesota River and Toelle Coulee and to select an acceptable alternative. This section presents the rationale for the Engineer's recommendation.

7.2.1 Little Minnesota River Floodway

Several Little Minnesota floodway alternatives (i.e., defined as Alternative CS4) are capable of removing the part of the City from the 100-year floodplain, as identified as a goal within Section 2.1, Project Design Goals, of this report. Toelle Coulee is another flooding source to part of the City. The various floodway alternatives have advantages and disadvantages.

Alternative CS4 (Little Minnesota River), Option 1 is less costly than Option 2 and Option 3, assuming the same type of floodway inlet. Option 1 lacks the ability to directly address flooding that may originate within Lake Traverse and move south toward Browns Valley (a concern raised by the BVFMTF). Technical analysis indicates that an elevation with a 250 year return period is needed within Lake Traverse, for water to flow south and cross TH 28 and reach Browns Valley. (Note: stop log rails could be added into the box culverts under TH 28. Stop logs could then be inserted into the box culverts if a flood from Lake Traverse to the south is eminent).

Option 1 is only indirectly capable of addressing flooding originating from Lake Traverse, but since coincident flood flows from the Little Minnesota River will be diverted downstream and the maximum capacity through Browns Valley limited to about 500 cfs, some capacity in the Little Minnesota River will be available for unforeseen events. The bankfull channel capacity within the City approaches 1,200 cfs. Therefore, some channel capacity would remain for moving water flowing south from Lake Traverse toward Browns Valley through the City. Because the occurrence of flooding from Lake Traverse south occurs infrequently (in fact this flood mechanism has only been documented once since construction of the Lake Traverse Project), the Project Engineer feels the selection of another Option (i.e., Option 2 or 3) ***solely*** to address this flood mechanism is unwarranted.

One of the largest potential environmental concerns is modifying the low flow regime through the City of Browns Valley, which is a function of the type of inlet and floodway alignment. The "passive" inlet will reduce low flows through Browns Valley. The "active" or gated inlet could be operated to pass the desired amount of flow through the Little Minnesota River for ecologic and geomorphic purposes (e.g., 2-year through 5-year flows), while also providing very good flood protection when needed. An active inlet within the Little Minnesota

River would be subject to blockage by debris and ice. Modifying the low flow regime is likely to result in some additional sediment accumulation, some reduction in aquatic habitat and the need for periodic maintenance to remove sediment and accumulated vegetation (Note: some maintenance is also expected with a gated inlet). The active (gated) inlet has more potential operational issues. An active inlet within the Little Minnesota River would be subject to blockage by debris and ice so maintenance will be required. Someone must be present at the time of the flood to operate the gates and divert flows from the Little Minnesota River, downstream through the floodway. Flooding within Browns Valley occurs rapidly, sometimes with little warning. Human intervention is not needed for the operation of a passive inlet. The passive floodway represents the concept with the least potential for operational issues.

Option 3, although more costly, has several potential advantages over Options 1 and 2 and is consistent with the direction and goals established by the BVFMTF. Specifically, because of the location of the floodway opening, Option 3 is able to control the amount of water flowing north toward Lake Traverse; i.e., the historic flow distribution can in part be replicated by construction of a positive hydraulic control. By placing an active inlet at the floodway opening, during non-flood periods the gates can be closed avoiding modification of low and moderate discharges into Browns Valley. By placing an active inlet in the river, during non-flood periods the gates can be opened avoiding modification of low and moderate discharges into Browns Valley. Similarly, during a flood the gates can be closed and head increased for force more water into the floodway.

Should ice or debris occur downstream of the floodway opening, the flow distribution into the floodway and to Lake Traverse are equally affected, because the openings are essentially co-located on opposite sides of the Little Minnesota River. The floodway opening for Option 3 is located sufficiently west, to reasonably ensure flood flows from the Little Minnesota River actually enter the floodway. A critical concern of Option 2 is the location of the floodway inlet. The inlet is located a considerable distance east toward Browns Valley. The capacity of the Little Minnesota River upstream of the inlet is insufficient to carry the floodway design discharge, either requiring a channel improvement or some other means to ensure the flood flows reach the floodway inlet. Ice and debris forming upstream of the floodway opening will result in water leaving the banks of the Little Minnesota River, with little to no means of controlling the rate or direction of these flows.

Option 3 (passive or active) is the only option consistent with the design goals established by the BVFMTF. Based upon our analysis Option 3 (passive-with leaf gates) is recommended (Opinion of Probable Cost of $7.3 million), with the following caveats:

- Provided local operation of a gated structure can be ensured then Option 3 (active) is recommended (Opinion of Probable Cost of $6.9 million).
- Should the Board of Managers concur with the Engineer's perspective (and based upon input received during the hearing and comments provided by the agencies through the Director's reports) that the potential increase in stage within Big Stone Lake is "manageable" **and** local operation of a gated structure can be ensured then Option 1A (active) (Opinion of Probable Cost of $5.6 million) is recommended (rather than Option 3).
- Should the Board of Managers concur with the Engineer's perspective (and based upon input received during the hearing and comments provided by the agencies through the Director's reports) that the potential increase in stage within Big Stone Lake is "manageable" **and** should the natural resource agencies review of the project and those agencies responsible for permitting (e.g., the U.S. Army Corps of Engineers) indicate that the reduction in aquatic and geomorphic flow within the Little Minnesota River through Browns Valley resulting from the use of a passive inlet is acceptable then Option 1A (passive, no leaf gates) (Opinion of Probable Cost of $4.9 million) is recommended.

The decision is essentially a policy decision specific to the importance of maintaining the historic flow split to Lake Traverse and provided for aquatic and geomorphic flows within the Little Minnesota River through Browns Valley.

7.2.2 Toelle Coulee

The flooding from Toelle Coulee is in part a direct consequence of the previous construction of Traverse CR 2. A low spot within the west road ditch of Traverse CR 2 along

Toelle Coulee, presumably a consequence of using material to construct the road, provides for an opportunity for floodwater to overflow into the City of Browns Valley. Because culverts placed through the Traverse CR 2 embankment at the coulee are insufficient to pass the 100-year flood, these large flood events may no longer follow Toelle Coulee, but overflow into the City. Simply closing this low spot seems an obvious solution. However, the Traverse CR 2 embankment is not designed as a dam nor are features typical of a dam (e.g., emergency spillway) present.

Early in the design process construction of a floodway seemed most promising. Technical analysis however, showed that constructing a floodway would require considerable increase in culvert capacities through Traverse CR 2 and TH 28 and that excavation downstream from TH 28 would likely be difficult to permit. Additional potential solutions were evaluated including Toelle Coulee Levee West and Toelle Coulee Levee East. Each of these solutions has similar Opinion of Probable Costs. Because restoring the CSAH 2 crossing capacity appears more practical than maintaining the overflow to Browns Valley, future maintenance costs are expected to be lower (i.e. all flows are kept in a single channel), and because the solution is less visually impacting, Toelle Coulee East ($1.1 million) is recommended.

7.2.3 Additional Recommendations

The following additional recommendations are provided to the Board of Managers for consideration:

- Gage operation at the Peever, South Dakota U.S. Geological survey gage should occur in perpetuity and an early flood warning system implemented at the gage as a component of this project. A cooperative agreement should be established between the U.S. Geological Survey, the Minnesota DNR, the State of South Dakota, the National Weather Service and the UMRWD for the operation of the gage and the early warning system. The Managers should explore working with the National Weather Services to integrate the early warning system into their current operations;
- Include a Supervisory Control and Data Acquisition (SCADA) system linked to the early warning system. The SCADA system should include remote operation of the gates and include a video camera to remotely observe gate position;

- Prior to proceeding with the development of construction plans complete additional consultation with the regulatory and permitting agencies to better define the level of concern associated with flows through the City of Browns Valley and issues specific to Big Stone Lake. Based upon this consultation and the levels of concern, select the option for the Little Minnesota River based upon the guidance provided within Section 7.2.1, Little Minnesota River Floodway;
- Submit the Engineer's Report to the Minnesota DNR and BWSR to obtain comments; and
- Hold a public hearing in accordance with Minnesota Statute to obtain input on the Preliminary Engineer's Report.

These recommendations are provided to the Board of Managers, realizing that the Board of Managers has the discretion to accept, modify, or delete any or all of these recommendations in accordance with their responsibilities under Watershed District Law.

Following action by the Board of Managers (assuming approval) we anticipate the following additional activities necessary for construction:

- Complete the geotechnical analyses necessary for completion of project design;
- Continue discussions with land owners and obtain options for easements and land acquisition necessary for project completion;
- Complete additional environmental field work needed to obtain regulatory approvals. Specifically, complete wetland delineation, impact and mitigation report, and a cultural resource survey. These documents will be required to obtain the necessary permits prior to construction;
- Complete an Environmental Assessment Worksheet for the project;
- Complete and submit permit applications for the project;
- Secure adequate funding based upon the Opinion of Probable Cost developed by the Project Engineer;
- Refer the project to Legal Counsel for review, to ensure an absence of legal issues associated with land acquisition or other project related activities;
- Proceed with the preparation of construction plans and specifications;

- Following final design, complete and submit a Conditional Letter of Map Revision to remove land within the City from the FEMA 100-year floodplain; and
- Complete the bid process, select a contractor and proceed to construction.

7.3 DESIGN ISSUES NEEDING RESOLUTION

The recommendations provided by the Engineer are subject to limitations imposed by the information currently available. As more information is developed and the project proceeds toward the preparation of construction plans, these design issues will become resolved and the Opinion of Probable Cost refined.

The primary design issues potentially affecting the Engineer's recommendation (and the Opinion of Probable Cost) are the structural suitability of the soils and the presence of groundwater which may pose challenges during construction. These issues are currently addressed by the Engineer within the Opinion of Probable Cost by including a contingency. The resolution of these issues is expected subsequent to the completion of this report, as geotechnical analyses of the soils are completed and environmental issues associated with the various floodway inlet options for the Little Minnesota River resolved. Environmental mitigation costs vary widely, and are included as a line item within the Opinion of Probable Cost.

RESOLUTION TO INITIATE THE BROWNS VALLEY FLOOD CONTROL PROJECT

BE IT RESOLVED, that the Upper Minnesota River Watershed District has received a Resolution from the City of Browns Valley and from Traverse County requesting that the Upper Minnesota River Watershed District initiate the Browns Valley Flood Control Project; and

BE IT FURTHER RESOLVED, that the project proposed would be done under an agreement between the Upper Minnesota River Watershed District and the State, Federal and Local Governmental Units, and the cost of the project is to be paid for, in whole or in part, by State, Federal or Local Government; and

BE IT FURTHER RESOLVED, that the managers would be undertaking this project as a portion of the Basic Water Management Plan, as identified in the Upper Minnesota River Watershed Management Plan; and

BE IT FURTHER RESOLVED, under Minnesota Statutes 103D, to contract for a project plan is to be obtained and then proceed through the process outlined in Minnesota Statutes 103D to implement the above project.

Dated this 14 day of August, 2007

Chairperson
Upper Minnesota River Watershed District

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APPENDIX B
Literature Review and Bibliography

1. **Spring Flood 2007, Browns Valley, Minnesota. JOR Engineering, Inc. May 15, 2007**

Contents: This report provides a general history of flooding and geology near and within Browns Valley.

It also presents a comprehensive discussion of the causes of the flooding problems, including the effects of ice jams. Great detail of the 2007 flood mechanism, including aerial photographs, is also provided. Bank full river capacity through town is estimated to be about 1600 cfs.

The document discusses how the naturally developed delta formation historically allowed high water to escape and bypass Browns Valley, thereby providing moderation of flows on the Little Minnesota River. However, this natural flood relief system has been blocked by road and dike construction, so that significantly more water is forced through Browns Valley than there would have been previously.

The document recommends that restoration of that bypass as the preferred approach to reducing the current flood hazard.

Relevance: *This document is a source of information used to assist in identifying the range of flood mitigation alternatives.*

2. **Background on the March 13-14, 2007 Flooding in Browns Valley (Traverse County), Minnesota. Report to the Governor's Office. Minnesota Department of Natural Resources Waters Division. April 20, 2007**

Contents: This report is a summary of the March 13-14, 2007 flooding in Browns Valley. It describes where the ice jamming occurred and its effect on the flow regime of the river, as well as a detailed description of the flow path taken by the breakout flows.

The document also discusses the potential effects of the agricultural dike at the Roger Haanen property and dredging in the Little Minnesota River in the area between Veblen and Claire City, SD.

It also presents a table with measured peak flows at the Peever gage during past flood events and whether or not the peaks were affected by ice.

The report also explains the process by which it is determined whether a damaged structure must be retrofitted to meet the requirements of the current floodplain ordinance, as well as potential cost-share opportunities.

Relevance: *The information in this report was used to assist in understanding the flooding mechanism under conditions of ice jams in the river, specifically regarding the March, 2007 flood event. The table of historical flooding was used in the selection of flood events to simulate for hydraulic model calibration.*

3. Browns Valley High Water Mark Survey, Minnesota Department of Natural Resources, Division of Waters. March 26, 2007

Contents: This document reports the results of an elevation survey to assist in the evaluation of flooding caused by ice jams on March 14, 2007. High water marks and some control features were surveyed in the City of Browns Valley, and at the USGS discontinued stream gage (#05290000). The document includes photographs and a brief review of stream gage data.

Relevance: *The high water marks provided in this document were used to assist in calibrating the hydraulic model.*

4. Section 22 Study, Minnesota River Main Stem Hydrologic Analyses. U.S. Army Corps of Engineers, St. Paul District, October 2001

Contents: This report presents the hydrologic analyses for development of a consistent set of frequency distributions for the main stem of the Minnesota River from Ortonville, Minnesota, to its confluence with the Mississippi River at Mendota Heights, Minnesota. These analyses were performed as part of a joint funding effort between the Minnesota Department of Natural Resources and the St. Paul District Corps of Engineers under Section 22 of the Water Resources Development Act of 1974.

Relevance: *The results of the stage-frequency analysis are used as a guide in selecting elevations to be used at the downstream boundary conditions (Big Stone Lake) for hydraulic analysis.*

5. CEMVP-ED-H Memorandum for Record. Subject: Interbasin Flow, Browns Valley Dike, Browns Valley, Minnesota, 2001 Flood and Historical Information, August 23, 2001

Contents: This memorandum was written following the Spring 2001 flood in Browns Valley and discusses the Little Minnesota River breakout flow that occurred. It describes the flows measured near the time of the flood/breakout, as well as the observations and photographs made by two Corps of Engineers flood reconnaissance engineers. There were no ice jam problems in Browns Valley during the 2001 flood.

By observing the locations of breakout flow, the discharge at the Peever gage, and aerial photographs, the document makes its case that breakout flow from the left bank of the river and into Lake Traverse occurs more frequently than a 10-year event.

Relevance: *This report was used in the selection process of hydraulic model calibration events and in understanding the breakout flow mechanism to Lake Traverse.*

6. Browns Valley Dike, History and Potential for Interbasin Flow. USACE. 2000

Contents: This report examines history and current state of interbasin flow between the Minnesota River basin and the Red River of the North watershed in the vicinity of Browns Valley, Minnesota. It provides a detailed description of the infrastructure and the flow regime of the Little Minnesota River, Big Stone Lake, and Lake Traverse, as well as interbasin flow, including a time-line of how the area has changed over time.

The document provides information on the gages in the vicinity of Browns Valley, recorded hydrometeorological data, and results of a literature search on historical flood events.

Relevance: *This document is a valuable reference for the Task Force to use in understanding the history of flooding issues in Browns Valley.*

7. Post Ice Jam Flood Field Trip Report, Little Minnesota River at Browns Valley, MN, Richard Pomerleau, P.E., U.S. Army Corps of Engineers, St. Paul District, March 28, 1995

Contents: This report includes a memorandum, photographs, and maps from the spring flood in 1995, caused by an ice jam.

It also summarizes information on prior flood events and a reference list of prior reports and studies.

Regarding the Toelee Coulee, it states that the 1965 flooding problems on the coulee were a result of debris plugging a bridges and culverts. The coulee has not experienced flooding since 1965, and conditions along the coulee have changed since then. The document notes that the highway has been raised and re-aligned, and that the city is of the opinion that the actual flood threat on the coulee has been reduced.

Relevance: *This report was used in the selection process of hydraulic model calibration events and in understanding the flood mechanism.*

8. City of Browns Valley Flood Damage Reduction Project, Study of Alternate Diversion Alignments B&D. Widseth Smith Nolting & Assoc., Inc. December 1991

Contents: This report considered two alternative diversion/levee alignments. A HEC-2 hydraulic model was used to develop the functional design of each alternative. The existing FIS model was modified and adapted for this purpose.

One alternative was similar to the proposed project in the 1989 report, a combination diversion channel and levee system along the southwest side of the city, except that the project would be completely within the state of Minnesota.

The other alternative shifted the alignment of the diversion much farther upstream to the point where the river enters the valley. It also included an improved overflow channel from the river to Lake Traverse. Obtaining land rights in South Dakota was deemed too difficult.

Relevance: *This document is a source of information used to assist in identifying the range of flood mitigation alternatives.*

9. Flood Damage Reduction Study for Browns Valley, Minnesota. Widseth Smith Nolting & Assoc., Inc. January 1989

Contents: This report provides a preliminary analysis of the city's flooding problems and possible solutions. The goal of the study was to reduce the threat of flooding sufficiently to remove most or all of the developed area of Browns Valley from the 100-year flood plain.

The report concludes that it would be possible to remove the City from the 100-year floodplain by installing structural measures. Preliminary proposals included a reservoir on the Unnamed Coulee and a combination diversion channel and levee system along the southwest side of the city.

The proposed plan was abandoned due to difficulties related to obtaining land rights in South Dakota.

Relevance: *This document is a source of information used to assist in identifying the range of flood mitigation alternatives.*

10. Section 205, Flood Control, Initial Appraisal Report, Little Minnesota River at Browns Valley. U.S. Army Corps of Engineers, St. Paul District, August, 1986

Contents: Flood control alternatives evaluated included channel improvement, bypass channels, and levees which would protect from Little Minnesota River and coulee flooding.

The preliminary results of this study show that it would not be economically feasible to provide flood protection for Browns Valley against the design flood (100-year) by any of these alternatives.

Relevance: *This document is a source of information used to assist in identifying the range of flood mitigation alternatives*.

11. Flood Insurance Study, City of Browns Valley, Minnesota, Traverse County, Federal Emergency Management Agency, June 17, 1986

Contents: This Flood Insurance Study determined the frequency with which breakout flow occurs from the left bank of the Little Minnesota River to Lake Traverse.

The study used the HEC-2 computer model to compute water surface profiles and revealed that the breakout begins between a discharge of approximately 3,000 and 6,000 cfs (between a 10- and 50-year event), under open-water conditions.

The report also investigated flood hazards and prepared floodplain maps.

Relevance: *This document is used a source for checking reasonability of results for the current flood mitigation hydrologic/hydraulic modeling.*

12. Interim Report: Hydrologic Analysis for Type 15 Flood Insurance Study, Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, June 7, 1983

Contents: This interim report presents the methodology used to develop the hydrology of the Little Minnesota River through Browns Valley.

This report was submitted to FEMA for review before its results (i.e., frequency curves) were used for a hydraulic analysis. Through this hydrologic analysis, it was determined that Little Minnesota River flows would break out from the river just upstream of Browns Valley in South Dakota.

Relevance: *Historical reference.*

13. Section 205, Flood Control Reconnaissance Report. Little Minnesota River at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, February, 1972

Contents: This report describes the developments prior to 1972 affecting the flood situation at Browns Valley, including the raising of the Roberts County, South Dakota Highway No. 24 (Dakota Avenue) by local interests to provide a more reliable farm-to-market route for the area. The document states that prior to the raising of this road, a significant portion of the flood discharge on the Little Minnesota River could overtop the roadway and flow southeast to rejoin the river channel downstream of Browns Valley. The document makes a case that the raising of the road prevents flood flows from following this natural bypass and, as a result, increases flooding to agricultural lands both north and west of the raised road and within the city.

The report notes additional structural constraints affecting the natural drainage pattern including private levees constructed by farmers to protect their fields from overland flow.

The report evaluates both structural and nonstructural flood control solutions, including bypass channels, levees, and evacuation. But the preliminary results of this study show that it would not be economically feasible to provide any of these flood projection alternatives. The report recommends that the village adopt strict floodplain management regulations, and that local officials consider applying to the MNDNR for a floodplain information study to aid in defining the true extent of the local flood problem.

Relevance: *This document provides valuable historical information on structural modifications and their hydraulic effects on the Little Minnesota River and flooding in Browns Valley.*

14. Memo for Record. Flood Emergency in Browns Valley, Minnesota. Thomas Raster, Planning Branch, Engineering Division. U.S. Army Corps of Engineers. 20 March, 1972

Contents: This memo describes the site visit made to Browns Valley during the March, 1972 flood.

It was found that the apparent cause of the high waters to be the sudden breakup of an ice jam located several miles upstream which caused a temporary surge in runoff at Browns Valley.

County Highway No. 24 (Dakota Street) had recently been raised about 18 inches by the County Highway Department.

They also constructed a levee beside the river just upstream of Browns Valley where the river emerges onto the outwash plain, which was intended to prevent overbank flow from damaging the improved road.

Prior to construction of these improvements, a significant portion of any flood flow could bypass Browns Valley via the natural overland drainage system.

Relevance: *This document provides valuable historical information on structural modifications and their hydraulic effects on the Little Minnesota River and flooding in Browns Valley.*

15. Section 205, Flood Control Project; Unnamed Coulee at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, June, 1966

Contents: This document contains a discharge-frequency curve for the Unnamed Coulee based on a drainage area of 3.32 square miles at State Highway No. 28 (Broadway Avenue). Because of limited data available, the annual discharge frequency curve was computed by several synthetic methods.

Rating curves for the culverts under Highway 28 were based on data for the flood of 1 June 1965 when the highwater elevation at the headwater side of Highway 28 was 679.2, and a highwater elevation at the tailwater side was 976.0, as determined from the flood outline and highwater data.

Relevance: *data was recomputed for this study*.

16. Section 205, Flood Control Reconnaissance Report. Unnamed Coulee at Browns Valley, Minnesota. U.S. Army Corps of Engineers, St. Paul District, January, 1966

Contents: This document describes in detail the 1965 event which caused flooding from Unnamed (Toelle) Coulee, including the meteorological information, the flow regime, and the flood damages.

Relevance: *The information in this report is used in understanding the 1965 flood event in the northeastern portion of Browns Valley.*

17. Review of Report . Minnesota River, Minnesota for Diversion of Floodwaters of Little Minnesota River into Lake Traverse. War Department, United States Engineer Office, St. Paul, Minnesota. 17 September 1945

Contents: This comprehensive document reviews previous flood control studies, completed flood control projects in the region, local hydrology, past floods and resulting damages. It presents several alternative plans for improvement.

It finds that the most feasible plan for flood control between Browns Valley and Marsh Lake is by diversion of the excess floodwaters of the Little Minnesota River into Lake Traverse. In addition to the flood control benefit, this plan would provide pollution abatement benefits along the Red River of the North by the availability of an added supply of water during periods of flow deficiency, and more desirable levels would be obtained in Big Stone Lake.

Relevance: *This document is a valuable reference on the history of the region in terms of water conservation and flood control.*

18. Lake Traverse – Bois de Sioux River Flood Control and Water Conservation Project, Red River of the North Watershed. War Department, Corps of Engineers, U.S. Army. March 1, 1941

Contents: The document explains the need for and the details of the flood control and water conservation project, including detailed descriptions of the White Rock Dam, Reservation Dam, Browns Valley Dike and the Bois de Sioux Channel Improvement.

Relevance: *This document provides a historical perspective of hydrology and flooding in the region prior to the major structural modifications affecting the behavior of the Little Minnesota River near Browns Valley.*

```
*************************************    **************************************
*                FFA                *    *                                    *
*      FLOOD FREQUENCY ANALYSIS     *    *   U.S. ARMY CORPS OF ENGINEERS     *
*      PROGRAM DATE:  FEB 1995      *    * THE HYDROLOGIC ENGINEERING CENTER  *
*          VERSION:  3.1            *    *        609 SECOND STREET           *
*      RUN  DATE  AND   TIME:       *    *      DAVIS, CALIFORNIA 95616       *
*        04 SEP 07    11:51:38      *    *          (916) 756-1104            *
*                                   *    *                                    *
*************************************    **************************************



   INPUT FILE NAME: PEEVFLOW.DAT
  OUTPUT FILE NAME: PEEVFLOW.OUT
     DSS FILE NAME: PEEVFLOW.DSS


    -----DSS---ZOPEN:  Existing File Opened,  File: PEEVFLOW.DSS
                       Unit:  71;  DSS Version: 6-JB

 **TITLE RECORD(S)**
 TT  Flow Data MN River Peevers USGS 05290000
 TT  Period of Record 1940-2002
 TT  Annual Peak Flow

 **JOB RECORD(S)**
      IPPC    ISKFX   IPROUT    IFMT     IWYR    IUNIT    ISMRY    IPNCH     IREG
 J1     2       0        0        0        0        0        3        3        2

 **SPECIFIED VARIABLE AND UNITS**
 FU      Flow       cfs

 **STATION IDENTIFICATION**
 ID        Annual Peak Flow Peevers Gage USGS 05290000

 **GENERALIZED SKEW**
      ISTN   GGMSE    SKEW
 GS  Pflow    .182    -.30

 **HP PLOT **
      HP PLOT FILE                       IHPCV  KLIMIT    IPER    BAREA
 HPPeevFlo.pcl                              3      0        0       N

     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          COMPUTED PROBABILITY CURVE
          CONFIDENCE LIMITS

 HPPeak Flow at Peevers
 HPGage USGS 05290000
 HPAnnual Peak Flow

 **SYSTEMATIC EVENTS**
      55 EVENTS TO BE ANALYZED

 **END OF INPUT DATA**
 ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPRELIMINARY RESULTS ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


-SKEW WEIGHTING -
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
BASED ON  55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =    .126
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =    .182
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


 PRELIMINARY RESULTS

-FREQUENCY CURVE-      Annual Peak Flow Peevers Gage USGS 05290
```

COMPUTED CURVE	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05	CONFIDENCE LIMITS .95
Flow IN cfs			Flow IN cfs	
13600.	15300.	.2	25200.	8560.
10700.	11800.	.5	19100.	6930.
8750.	9440.	1.0	15000.	5770.
6920.	7340.	2.0	11400.	4680.
4770.	4970.	5.0	7460.	3350.
3360.	3450.	10.0	5000.	2430.
2140.	2170.	20.0	3020.	1600.
831.	831.	50.0	1090.	636.
288.	283.	80.0	385.	206.
158.	152.	90.0	221.	105.
94.	88.	95.0	138.	58.

33.	29.	99.0	55.	17.

SYSTEMATIC STATISTICS

LOG TRANSFORM: Flow, cfs		NUMBER OF EVENTS	
MEAN	2.8852	HISTORIC EVENTS	0
STANDARD DEV	.5207	HIGH OUTLIERS	0
COMPUTED SKEW	-.4654	LOW OUTLIERS	0
REGIONAL SKEW	-.3000	ZERO OR MISSING	0
ADOPTED SKEW	-.4000	SYSTEMATIC EVENTS	55

FINAL RESULTS

-PLOTTING POSITIONS- Annual Peak Flow Peevers Gage USGS 05290

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	Flow cfs	RANK	WATER YEAR	Flow cfs	MEDIAN PLOT POS
3	30	1940	442.	1	1993	8900.	1.26
6	23	1941	714.	2	1952	4730.	3.07
6	7	1942	2960.	3	1943	4320.	4.87
3	25	1943	4320.	4	1997	3590.	6.68
5	4	1944	515.	5	1969	3270.	8.48
6	1	1945	1120.	6	2001	3180.	10.29
3	21	1946	1040.	7	1962	3140.	12.09
4	11	1947	2780.	8	1976	2960.	13.90
3	24	1948	1410.	9	1942	2960.	15.70
4	2	1949	395.	10	1965	2920.	17.51
4	8	1950	1200.	11	1947	2780.	19.31
4	4	1951	1320.	12	1995	2730.	21.12
4	8	1952	4730.	13	1954	2300.	22.92
6	16	1953	818.	14	1972	2180.	24.73
5	27	1954	2300.	15	1978	2140.	26.53
4	2	1955	156.	16	1979	1810.	28.34
4	15	1956	226.	17	1966	1410.	30.14
5	22	1957	697.	18	1948	1410.	31.95
4	9	1958	625.	19	1998	1340.	33.75
6	27	1959	340.	20	1951	1320.	35.56
4	7	1960	1050.	21	1950	1200.	37.36
5	19	1961	64.	22	1945	1120.	39.17
5	23	1962	3140.	23	1960	1050.	40.97
6	10	1963	183.	24	1946	1040.	42.78
4	17	1964	236.	25	1991	891.	44.58
6	2	1965	2920.	26	1994	874.	46.39
3	18	1966	1410.	27	1953	818.	48.19
3	26	1967	472.	28	1996	816.	50.00
5	9	1968	152.	29	1941	714.	51.81
4	6	1969	3270.	30	1957	697.	53.61
4	7	1970	371.	31	1958	625.	55.42
6	30	1971	595.	32	1971	595.	57.22
3	16	1972	2180.	33	1944	515.	59.03
5	25	1973	352.	34	1980	490.	60.83
3	5	1974	368.	35	1967	472.	62.64
6	21	1975	352.	36	1940	442.	64.44
3	21	1976	2960.	37	1949	395.	66.25
3	31	1977	161.	38	2002	373.	68.05
3	28	1978	2140.	39	1970	371.	69.86
4	19	1979	1810.	40	1974	368.	71.66
3	31	1980	490.	41	1973	352.	73.47
6	15	1981	17.	42	1975	352.	75.27
3	13	1990	339.	43	1959	340.	77.08
6	22	1991	891.	44	1990	339.	78.88
7	13	1992	271.	45	1999	306.	80.69
7	25	1993	8900.	46	1992	271.	82.49
3	21	1994	874.	47	2000	238.	84.30
3	13	1995	2730.	48	1964	236.	86.10
4	12	1996	816.	49	1956	226.	87.91
3	28	1997	3590.	50	1963	183.	89.71
5	17	1998	1340.	51	1977	161.	91.52
6	7	1999	306.	52	1955	156.	93.32
7	20	2000	238.	53	1968	152.	95.13
4	12	2001	3180.	54	1961	64.	96.93
5	9	2002	373.	55	1981	17.	98.74

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 55 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.804

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 26.6

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 54 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.798

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 17332.

-SKEW WEIGHTING -

BASED ON 55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .096
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .182

FINAL RESULTS

-FREQUENCY CURVE- Annual Peak Flow Peevers Gage USGS 05290

COMPUTED CURVE Flow IN cfs	EXPECTED PROBABILITY Flow IN cfs	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 Flow IN cfs	CONFIDENCE LIMITS .95 Flow IN cfs
16100.	18700.	.2	29900.	10100.
11900.	13400.	.5	21100.	7750.
9300.	10200.	1.0	15800.	6210.
7070.	7580.	2.0	11500.	4870.
4660.	4870.	5.0	7090.	3350.
3200.	3300.	10.0	4620.	2380.
2020.	2050.	20.0	2750.	1560.
822.	822.	50.0	1050.	644.
326.	321.	80.0	423.	239.
199.	193.	90.0	268.	137.
131.	125.	95.0	184.	86.
60.	54.	99.0	91.	34.

SYNTHETIC STATISTICS

LOG TRANSFORM: Flow, cfs		NUMBER OF EVENTS	
MEAN	2.9070	HISTORIC EVENTS	0
STANDARD DEV	.4712	HIGH OUTLIERS	0
COMPUTED SKEW	.0312	LOW OUTLIERS	1
REGIONAL SKEW	-.3000	ZERO OR MISSING	0
ADOPTED SKEW	-.1000	SYSTEMATIC EVENTS	55

HP PLOT WRITTEN TO THE FILE: PeevFlo.pcl

TABLE 1. SUMMARY OF STATISTICS -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	YEARS RECD	YEARS SYST	YEARS HIST	MEAN LOG	STD DEV	SKEW ADOPT	SKEW COMP	SKEW GENRL	HIST EVENT	OUTLIER HI	OUTLIER LO	ZERO/ MSNG
Pflow	Annual Peak Flow Peevers Gage USGS 05290000		55	55	0	2.885	.521	-.40	-.465	-.30	0	0	0	0 **
Pflow	Annual Peak Flow Peevers Gage USGS 05290000		55	55	0	2.907	.471	-.10	.031	-.30	0	0	1	0

** PRELIMINARY STATISTICS

TABLE 2. SUMMARY OF FREQUENCY CURVE ORDINATES -- PRELIMINARY AND FINAL RESULTS

STATION STATION NAME AND LOCATION AREA ....YEARS..... ....PERCENT CHANCE

```
EXCEEDANCE...........
  NUMBER  ..............................................  SQ MI  RECD SYST HIST     10.     5.     2.     1.
    .5      .2

-----------------------------------------------------------------------------------------------------------
----------------
   Pflow       Annual Peak Flow Peevers Gage USGS 05290000        55   55    0      3358   4769   6916   8745
 10742    13628
   Pflow       Annual Peak Flow Peevers Gage USGS 05290000        55   55    0      3203   4660   7067   9298
 11924    16073

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+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
```

```
 ************************************        **************************************
 *              FFA                 *        *                                    *
 *   FLOOD FREQUENCY ANALYSIS       *        *  U.S. ARMY CORPS OF ENGINEERS      *
 *   PROGRAM DATE:  FEB 1995        *        * THE HYDROLOGIC ENGINEERING CENTER  *
 *       VERSION:  3.1              *        *        609 SECOND STREET           *
 *   RUN  DATE   AND   TIME:        *        *      DAVIS, CALIFORNIA 95616       *
 *      17 SEP 07    12:04:34       *        *          (916) 756-1104            *
 *                                  *        *                                    *
 ************************************        **************************************


   INPUT FILE NAME: PEEVELEV.DAT
  OUTPUT FILE NAME: PEEVELEV.OUT
     DSS FILE NAME: PEEVELEV.DSS


     -----DSS---ZOPEN:  New File Opened,  File: PEEVELEV.DSS
                        Unit:  71;  DSS Version: 6-JB

  **TITLE RECORD(S)**
  TT  Elevation MN River Peevers USGS 05290000
  TT  Period of Record 1940-2002
  TT  Annual Maximum Elevation

  **JOB RECORD(S)**
       IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
  J1     2      0      0        0       0       0       3       3        2

  **SPECIFIED VARIABLE AND UNITS**
  FU     Elev      Feet

  **STATION IDENTIFICATION**
  ID       Elevation Data Peevers Gage USGS 05290000

  **SPECIAL STATION INFORMATION**
      IYRA     IYRL  HITHRS  LOTHRS     LOGT     NDEC     NSIG
  SI    0        0      0.      0.       0        2        5

  **HP PLOT **
      HP PLOT FILE                     IHPCV  KLIMIT     IPER     BAREA
  HPPeevElN.pcl                           3      0         0        N

       SELECTED CURVES ON HPPLOT
            EXPECTED PROBABILITY CURVE
            COMPUTED PROBABILITY CURVE
            CONFIDENCE LIMITS

  HPElevation at Peevers
  HPGage USGS 05290000
  HPAnnual Maximum Elevation

  **SYSTEMATIC EVENTS**
      55 EVENTS TO BE ANALYZED

  **END OF INPUT DATA**
  ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


  **************************************************************
  CAUTION FROM SUBROUTINE WTSKEW
  ***** NO GENERALIZED SKEW PROVIDED
  ADOPTED SKEW SET TO COMPUTED SKEW


  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ   FINAL RESULTS   ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ

  -PLOTTING POSITIONS-     Elevation Data Peevers Gage USGS 0529000
```

MON	DAY	YEAR	Elev Feet	RANK	WATER YEAR	Elev Feet	MEDIAN PLOT POS
	EVENTS ANALYZED			ORDERED EVENTS			
1	1	1940	1007.85	1	1997	1016.60	1.26
1	1	1941	1007.92	2	1993	1015.78	3.07
1	1	1942	1012.00	3	1943	1015.55	4.87
1	1	1943	1015.55	4	1950	1015.25	6.68
1	1	1944	1008.60	5	1952	1014.36	8.48
1	1	1945	1009.69	6	1966	1014.02	10.29
1	1	1946	1009.78	7	1969	1013.51	12.09
1	1	1947	1011.71	8	1976	1013.23	13.90
1	1	1948	1011.04	9	1978	1012.93	15.70
1	1	1949	1007.84	10	1962	1012.09	17.51
1	1	1950	1015.25	11	1994	1012.07	19.31
1	1	1951	1009.30	12	1942	1012.00	21.12
1	1	1952	1014.36	13	1979	1011.82	22.92
1	1	1953	1007.84	14	1947	1011.71	24.73
1	1	1954	1010.75	15	1965	1011.68	26.53

1	1	1955	1006.76	16	1996	1011.66	28.34
1	1	1956	1006.52	17	1972	1011.25	30.14
1	1	1957	1009.50	18	1995	1011.24	31.95
1	1	1958	1009.83	19	1948	1011.04	33.75
1	1	1959	1006.71	20	2001	1010.84	35.56
1	1	1960	1008.94	21	1954	1010.75	37.36
1	1	1961	1006.13	22	1971	1009.86	39.17
1	1	1962	1012.09	23	1958	1009.83	40.97
1	1	1963	1005.88	24	1946	1009.78	42.78
1	1	1964	1007.59	25	1945	1009.69	44.58
1	1	1965	1011.68	26	1957	1009.50	46.39
1	1	1966	1014.02	27	1951	1009.30	48.19
1	1	1967	1007.76	28	1960	1008.94	50.00
1	1	1968	1005.75	29	1998	1008.78	51.81
1	1	1969	1013.51	30	1944	1008.60	53.61
1	1	1970	1006.69	31	1991	1007.97	55.42
1	1	1971	1009.86	32	1941	1007.92	57.22
1	1	1972	1011.25	33	1940	1007.85	59.03
1	1	1973	1006.61	34	1953	1007.84	60.83
1	1	1974	1007.72	35	1949	1007.84	62.64
1	1	1975	1006.58	36	1967	1007.76	64.44
1	1	1976	1013.23	37	1974	1007.72	66.25
1	1	1977	1006.77	38	1964	1007.59	68.05
1	1	1978	1012.93	39	1990	1007.32	69.86
1	1	1979	1011.82	40	2000	1007.30	71.66
1	1	1980	1007.22	41	1980	1007.22	73.47
1	1	1981	1005.24	42	2002	1006.89	75.27
1	1	1990	1007.32	43	1977	1006.77	77.08
1	1	1991	1007.97	44	1955	1006.76	78.88
1	1	1992	1006.23	45	1959	1006.71	80.69
1	1	1993	1015.78	46	1970	1006.69	82.49
1	1	1994	1012.07	47	1973	1006.61	84.30
1	1	1995	1011.24	48	1975	1006.58	86.10
1	1	1996	1011.66	49	1999	1006.56	87.91
1	1	1997	1016.60	50	1956	1006.52	89.71
1	1	1998	1008.78	51	1992	1006.23	91.52
1	1	1999	1006.56	52	1961	1006.13	93.32
1	1	2000	1007.30	53	1963	1005.88	95.13
1	1	2001	1010.84	54	1968	1005.75	96.93
1	1	2002	1006.89	55	1981	1005.24	98.74

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 55 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.804

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 1018.

LOW OUTLIER TEST

BASED ON 55 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.804

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 1001.3

-SKEW WEIGHTING -

BASED ON 55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- Elevation Data Peevers Gage USGS 0529000

COMPUTED CURVE	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05	.95
Elev IN Feet			Elev IN Feet	
1020.30	1021.10	.2	1022.50	1018.70
1018.90	1019.50	.5	1020.80	1017.50
1017.80	1018.20	1.0	1019.50	1016.50
1016.60	1016.90	2.0	1018.10	1015.50
1014.90	1015.10	5.0	1016.20	1014.00
1013.50	1013.60	10.0	1014.60	1012.70
1012.00	1012.00	20.0	1012.80	1011.20
1009.30	1009.30	50.0	1010.00	1008.60
1007.00	1007.00	80.0	1007.80	1006.20
1006.00	1006.00	90.0	1006.80	1005.10
1005.30	1005.20	95.0	1006.10	1004.20

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º    1004.00      1003.90    ³       99.0     ³    1005.00      1002.80   º
ÌÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¹
º                          SYSTEMATIC STATISTICS                          º
ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
º LOG TRANSFORM: Elev, Feet          ³         NUMBER OF EVENTS           º
ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
º  MEAN                      3.0041  ³  HISTORIC EVENTS          0        º
º  STANDARD DEV               .0013  ³  HIGH OUTLIERS        0            º
º  COMPUTED SKEW              .6132  ³  LOW OUTLIERS         0            º
º  REGIONAL SKEW           -99.0000  ³  ZERO OR MISSING      0            º
º  ADOPTED SKEW               .6000  ³  SYSTEMATIC EVENTS        55       º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼


 HP PLOT WRITTEN TO THE FILE:  PeevElN.pcl


 TABLE 1.  SUMMARY OF STATISTICS -- PRELIMINARY AND FINAL RESULTS

 ----------------------------------------------------------------------------------------------------
 ---------------
  STATION  STATION NAME AND LOCATION                                AREA ....YEARS.....  MEAN   STD .......SKEW........
 HIST OUTLIER ZERO/
  NUMBER  .........................................................  SQ MI RECD SYST HIST  LOG    DEV ADOPT   COMP  GENRL
 EVENT HI LO  MSNG

 ----------------------------------------------------------------------------------------------------
 ---------------

                  Elevation Data Peevers Gage USGS 05290000                 55   55    0  3.004  .001   .60   .613 -99.00
 0     0  0     0 **
                  Elevation Data Peevers Gage USGS 05290000                 55   55    0  3.004  .001   .60   .613 -99.00
 0     0  0     0

 ----------------------------------------------------------------------------------------------------
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  ** PRELIMINARY STATISTICS


 TABLE 2.  SUMMARY OF FREQUENCY CURVE ORDINATES -- PRELIMINARY AND FINAL RESULTS

 ----------------------------------------------------------------------------------------------------
 ---------------
  STATION  STATION NAME AND LOCATION                                AREA  ....YEARS.....  ...........PERCENT CHANCE
 EXCEEDANCE..........
  NUMBER  .........................................................  SQ MI  RECD SYST HIST       10.      5.      2.      1.
     .5       .2

 ----------------------------------------------------------------------------------------------------
 ---------------
                  Elevation Data Peevers Gage USGS 05290000                 55   55    0         1013    1014    1016    1017
    1018    1020
                  Elevation Data Peevers Gage USGS 05290000                 55   55    0         1013    1014    1016    1017
    1018    1020

 ----------------------------------------------------------------------------------------------------
 ---------------


 +++++++++++++++++++++++++
 + END OF RUN            +
 + NORMAL STOP IN FFA    +
 +++++++++++++++++++++++++
```

```
 *************************************          **************************************
 *              FFA                    *          *                                    *
 *     FLOOD FREQUENCY ANALYSIS        *          *   U.S. ARMY CORPS OF ENGINEERS     *
 *     PROGRAM DATE:  FEB 1995         *          * THE HYDROLOGIC ENGINEERING CENTER  *
 *         VERSION:  3.1               *          *        609 SECOND STREET           *
 *     RUN  DATE   AND   TIME:         *          *     DAVIS, CALIFORNIA 95616        *
 *        17 SEP 07    12:34:11        *          *         (916) 756-1104             *
 *                                     *          *                                    *
 *************************************          **************************************


   INPUT FILE NAME: PEEV24HV.DAT
  OUTPUT FILE NAME: PEEV24HV.OUT
     DSS FILE NAME: PEEV24HV.DSS


    -----DSS---ZOPEN:  Existing File Opened,  File: PEEV24HV.DSS
                       Unit:  71;  DSS Version: 6-JB

  **TITLE RECORD(S)**
  TT  Max Volume 24hr MN River Peevers USGS 05290000
  TT  Period of Record 1940-2002
  TT  Annual Maximum 24hr Volume

  **JOB RECORD(S)**
       IPPC   ISKFX  IPROUT    IFMT     IWYR    IUNIT    ISMRY    IPNCH     IREG
  J1     2       0       0       0        0        0        3        3        2

  **SPECIFIED VARIABLE AND UNITS**
  FU       Vol      ac-ft

  **STATION IDENTIFICATION**
  ID       Volume 24hr at Peevers Gage USGS 05290000

  **SPECIAL STATION INFORMATION**
      IYRA     IYRL  HITHRS  LOTHRS     LOGT     NDEC     NSIG
  SI     0        0      0.      0.        0        2        5

  **HP PLOT **
      HP PLOT FILE                   IHPCV  KLIMIT    IPER     BAREA
  HPPee24hV.pcl                          3       0       0        N

      SELECTED CURVES ON HPPLOT
           EXPECTED PROBABILITY CURVE
           COMPUTED PROBABILITY CURVE
           CONFIDENCE LIMITS

 HPVolume 24h at Peevers
 HPGage USGS 05290000
 HPAnnual Maximum 24h Volume

 **SYSTEMATIC EVENTS**
     55 EVENTS TO BE ANALYZED

 **END OF INPUT DATA**
 ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


 ************************************************************
 CAUTION FROM SUBROUTINE WTSKEW
 ***** NO GENERALIZED SKEW PROVIDED
 ADOPTED SKEW SET TO COMPUTED SKEW


ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPRELIMINARY RESULTS ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


 -SKEW WEIGHTING -
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 BASED ON  55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
 DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =    .302
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


 PRELIMINARY RESULTS

 -FREQUENCY CURVE-     Volume 24hr at Peevers Gage USGS 0529000
 ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
 º  COMPUTED   EXPECTED    ³   PERCENT   ³   CONFIDENCE LIMITS   º
 º   CURVE   PROBABILITY   ³   CHANCE    ³      .05        .95   º
 º      Vol IN ac-ft       ³ EXCEEDANCE  ³      Vol IN ac-ft     º
 ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
 º   19143.00    21201.00  ³      .2     ³  34576.00   12203.00  º
 º   15515.00    16845.00  ³      .5     ³  27081.00   10125.00  º
 º   12902.00    13818.00  ³     1.0     ³  21864.00    8589.70  º
 º   10423.00    11009.00  ³     2.0     ³  17085.00    7096.20  º
 º    7390.60     7677.10  ³     5.0     ³  11508.00    5204.20  º
```

5312.10	5447.10	10.0	7900.00	3850.50
3448.20	3497.30	20.0	4863.30	2577.60
1361.30	1361.30	50.0	1788.50	1041.50
466.50	457.16	80.0	621.96	332.87
251.32	241.17	90.0	350.48	166.08
146.14	136.58	95.0	214.58	89.20
48.88	41.71	99.0	81.11	24.96

SYSTEMATIC STATISTICS

LOG TRANSFORM: Vol, ac-ft		NUMBER OF EVENTS	
MEAN	3.0906	HISTORIC EVENTS	0
STANDARD DEV	.5218	HIGH OUTLIERS	0
COMPUTED SKEW	-.4799	LOW OUTLIERS	0
REGIONAL SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-.5000	SYSTEMATIC EVENTS	55

****

CAUTION FROM SUBROUTINE WTSKEW
***** NO GENERALIZED SKEW PROVIDED
ADOPTED SKEW SET TO COMPUTED SKEW

ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ FINAL RESULTS ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ

-PLOTTING POSITIONS- Volume 24hr at Peevers Gage USGS 0529000

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	Vol ac-ft	RANK	WATER YEAR	Vol ac-ft	MEDIAN PLOT POS
1	1	1940	634.71	1	1993	10710.74	1.26
1	1	1941	1273.39	2	1952	8727.27	3.07
1	1	1942	3947.11	3	1997	6783.47	4.87
1	1	1943	6366.94	4	1943	6366.94	6.68
1	1	1944	878.68	5	2001	5871.07	8.48
1	1	1945	1789.09	6	1969	5771.90	10.29
1	1	1946	1943.80	7	1995	5355.37	12.09
1	1	1947	5057.85	8	1947	5057.85	13.90
1	1	1948	2380.17	9	1962	4839.67	15.70
1	1	1949	632.73	10	1976	4482.64	17.51
1	1	1950	1884.30	11	1942	3947.11	19.31
1	1	1951	1983.47	12	1978	3808.26	21.12
1	1	1952	8727.27	13	1972	3788.43	22.92
1	1	1953	1245.62	14	1979	3490.91	24.73
1	1	1954	2360.33	15	1965	3451.24	26.53
1	1	1955	287.60	16	1966	2578.51	28.34
1	1	1956	402.64	17	1948	2380.17	30.14
1	1	1957	1043.31	18	1954	2360.33	31.95
1	1	1958	1053.22	19	1998	2360.33	33.75
1	1	1959	448.26	20	1951	1983.47	35.56
1	1	1960	1535.21	21	1946	1943.80	37.36
1	1	1961	117.02	22	1950	1884.30	39.17
1	1	1962	4839.67	23	1945	1789.09	40.97
1	1	1963	281.65	24	1994	1697.85	42.78
1	1	1964	422.48	25	1996	1600.66	44.58
1	1	1965	3451.24	26	1960	1535.21	46.39
1	1	1966	2578.51	27	1991	1412.23	48.19
1	1	1967	694.21	28	1941	1273.39	50.00
1	1	1968	287.60	29	1953	1245.62	51.81
1	1	1969	5771.90	30	1958	1053.22	53.61
1	1	1970	521.65	31	1957	1043.31	55.42
1	1	1971	813.22	32	1944	878.68	57.22
1	1	1972	3788.43	33	1980	833.06	59.03
1	1	1973	523.64	34	1971	813.22	60.83
1	1	1974	436.36	35	1967	694.21	62.64
1	1	1975	634.71	36	1975	634.71	64.44
1	1	1976	4482.64	37	1940	634.71	66.25
1	1	1977	247.93	38	1949	632.73	68.05
1	1	1978	3808.26	39	2002	630.74	69.86
1	1	1979	3490.91	40	1999	573.22	71.66
1	1	1980	833.06	41	1973	523.64	73.47
1	1	1981	25.79	42	1970	521.65	75.27
1	1	1990	343.14	43	2000	458.18	77.08
1	1	1991	1412.23	44	1959	448.26	78.88
1	1	1992	404.63	45	1974	436.36	80.69
1	1	1993	10710.74	46	1964	422.48	82.49
1	1	1994	1697.85	47	1992	404.63	84.30
1	1	1995	5355.37	48	1956	402.64	86.10
1	1	1996	1600.66	49	1990	343.14	87.91
1	1	1997	6783.47	50	1968	287.60	89.71
1	1	1998	2360.33	51	1955	287.60	91.52
1	1	1999	573.22	52	1963	281.65	93.32
1	1	2000	458.18	53	1977	247.93	95.13
1	1	2001	5871.07	54	1961	117.02	96.93
1	1	2002	630.74	55	1981	25.79	98.74

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 55 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.804

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 42.4

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 54 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.798

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 27782.

-SKEW WEIGHTING -

BASED ON 55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- Volume 24hr at Peevers Gage USGS 0529000

COMPUTED CURVE	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05	CONFIDENCE LIMITS .95
Vol IN ac-ft			Vol IN ac-ft	
29381.00	34795.00	.2	55847.00	18146.00
21170.00	24068.00	.5	38053.00	13595.00
16153.00	17862.00	1.0	27752.00	10703.00
12020.00	12965.00	2.0	19681.00	8231.10
7715.60	8091.40	5.0	11792.00	5533.20
5203.70	5361.90	10.0	7515.80	3869.50
3229.80	3280.50	20.0	4396.90	2486.30
1296.90	1296.90	50.0	1654.50	1016.60
520.74	512.68	80.0	676.44	382.51
323.21	313.67	90.0	434.65	223.78
217.98	207.86	95.0	303.96	142.63
104.12	94.16	99.0	157.14	60.60

SYNTHETIC STATISTICS

LOG TRANSFORM: Vol, ac-ft		NUMBER OF EVENTS	
MEAN	3.1129	HISTORIC EVENTS	0
STANDARD DEV	.4708	HIGH OUTLIERS	0
COMPUTED SKEW	.0422	LOW OUTLIERS	1
REGIONAL SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	.0000	SYSTEMATIC EVENTS	55

HP PLOT WRITTEN TO THE FILE: Pee24hV.pcl

TABLE 1. SUMMARY OF STATISTICS -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	YEARS RECD	YEARS SYST	YEARS HIST	MEAN LOG	STD DEV	SKEW ADOPT	SKEW COMP	SKEW GENRL	HIST EVENT	OUTLIER HI	OUTLIER LO	ZERO/ MSNG
	Volume 24hr at Peevers Gage USGS 05290000		55	55	0	3.091	.522	-.50	-.480	-99.00	0	0	0	0
**	Volume 24hr at Peevers Gage USGS 05290000		55	55	0	3.113	.471	.00	.042	-99.00	0	0	1	0

** PRELIMINARY STATISTICS

TABLE 2. SUMMARY OF FREQUENCY CURVE ORDINATES -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	....YEARS..... RECD	SYST	HIST	...........PERCENT CHANCE EXCEEDANCE........... 10.	5.	2.	1.	.5	.2
	Volume 24hr at Peevers Gage USGS 05290000		55	55	0	5312	7390	10423	12901	15515	19143
	Volume 24hr at Peevers Gage USGS 05290000		55	55	0	5203	7715	12019	16152	21169	29381

```
+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
+++++++++++++++++++++++++
```

```
 ************************************     **************************************
 *              FFA                 *     *                                    *
 *    FLOOD FREQUENCY ANALYSIS      *     *    U.S. ARMY CORPS OF ENGINEERS    *
 *    PROGRAM DATE:  FEB 1995       *     * THE HYDROLOGIC ENGINEERING CENTER  *
 *        VERSION:  3.1             *     *        609 SECOND STREET           *
 *    RUN  DATE   AND   TIME:       *     *     DAVIS, CALIFORNIA 95616        *
 *       17 SEP 07    12:34:48      *     *         (916) 756-1104             *
 *                                  *     *                                    *
 ************************************     **************************************



   INPUT FILE NAME: PEEV10DV.DAT
  OUTPUT FILE NAME: PEEV10DV.OUT
     DSS FILE NAME: PEEV10DV.DSS


     -----DSS---ZOPEN:  Existing File Opened,  File: PEEV10DV.DSS
                        Unit:  71;  DSS Version: 6-JB

  **TITLE RECORD(S)**
 TT  Max Volume 10day MN River Peevers USGS 05290000
 TT  Period of Record 1940-2002
 TT  Annual Maximum 24hr Volume

  **JOB RECORD(S)**
      IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
 J1     2       0       0       0       0       0       3       3       2

  **SPECIFIED VARIABLE AND UNITS**
 FU      Vol     ac-ft

  **STATION IDENTIFICATION**
 ID        Max 10day Volume at Peevers USGS 05290000

  **SPECIAL STATION INFORMATION**
     IYRA    IYRL  HITHRS  LOTHRS     LOGT    NDEC    NSIG
 SI     0       0      0.      0.       0       2       5

  **HP PLOT **
     HP PLOT FILE                       IHPCV  KLIMIT    IPER   BAREA
 HPPee10dV.pcl                              3       0       0       N

      SELECTED CURVES ON HPPLOT
           EXPECTED PROBABILITY CURVE
           COMPUTED PROBABILITY CURVE
           CONFIDENCE LIMITS

 HPVolume 10day Peevers
 HPGage USGS 05290000
 HPAnnual Maximum 10D Volume

 **SYSTEMATIC EVENTS**
      55 EVENTS TO BE ANALYZED

 **END OF INPUT DATA**
 ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


 ****************************************************************
 CAUTION FROM SUBROUTINE WTSKEW
 ***** NO GENERALIZED SKEW PROVIDED
 ADOPTED SKEW SET TO COMPUTED SKEW


ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPRELIMINARY RESULTS ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


 -SKEW WEIGHTING -
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 BASED ON  55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
 DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =   .302
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ


 PRELIMINARY RESULTS

 -FREQUENCY CURVE-      Max 10day Volume at Peevers USGS 0529000
 ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
 º  COMPUTED    EXPECTED   ³    PERCENT    ³    CONFIDENCE LIMITS    º
 º   CURVE    PROBABILITY  ³     CHANCE    ³       .05        .95    º
 º        Vol IN ac-ft     ³   EXCEEDANCE  ³        Vol IN ac-ft     º
 ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
 º   82024.00    88223.00  ³        .2     ³ 140750.00   54186.00    º
 º   70205.00    74613.00  ³        .5     ³ 117520.00   47161.00    º
 º   60922.00    64220.00  ³       1.0     ³  99750.00   41537.00    º
 º   51421.00    53704.00  ³       2.0     ³  82045.00   35666.00    º
 º   38694.00    39951.00  ³       5.0     ³  59218.00   27574.00    º
```

29110.00	29746.00	10.0	42849.00	21255.00
19766.00	20017.00	20.0	27755.00	14831.00
8206.20	8206.20	50.0	10759.00	6303.50
2803.00	2744.60	80.0	3718.70	2013.50
1472.30	1409.20	90.0	2046.40	976.61
827.65	769.61	95.0	1215.80	504.33
251.34	210.78	99.0	422.48	125.89

SYSTEMATIC STATISTICS

LOG TRANSFORM: Vol, ac-ft		NUMBER OF EVENTS	
MEAN	3.8545	HISTORIC EVENTS	0
STANDARD DEV	.5150	HIGH OUTLIERS	0
COMPUTED SKEW	-.6741	LOW OUTLIERS	0
REGIONAL SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-.7000	SYSTEMATIC EVENTS	55

```
*************************************************************
CAUTION FROM SUBROUTINE WTSKEW
***** NO GENERALIZED SKEW PROVIDED
ADOPTED SKEW SET TO COMPUTED SKEW
```

FINAL RESULTS

-PLOTTING POSITIONS- Max 10day Volume at Peevers USGS 0529000

EVENTS ANALYZED				ORDERED EVENTS			
			Vol		WATER	Vol	MEDIAN
MON	DAY	YEAR	ac-ft	RANK	YEAR	ac-ft	PLOT POS
1	1	1940	3223.00	1	1997	49805.00	1.26
1	1	1941	4921.00	2	1943	44688.00	3.07
1	1	1942	15792.00	3	1952	42367.00	4.87
1	1	1943	44688.00	4	1969	40998.00	6.68
1	1	1944	5595.00	5	1993	36803.00	8.48
1	1	1945	11655.00	6	2001	36793.00	10.29
1	1	1946	15620.00	7	1947	26634.00	12.09
1	1	1947	26634.00	8	1978	26559.00	13.90
1	1	1948	15755.00	9	1979	24298.00	15.70
1	1	1949	5117.00	10	1962	23677.00	17.51
1	1	1950	15868.00	11	1995	20015.00	19.31
1	1	1951	12000.00	12	1998	16506.00	21.12
1	1	1952	42367.00	13	1950	15868.00	22.92
1	1	1953	6837.00	14	1942	15792.00	24.73
1	1	1954	6964.00	15	1948	15755.00	26.53
1	1	1955	1866.00	16	1994	15753.00	28.34
1	1	1956	2584.00	17	1946	15620.00	30.14
1	1	1957	6391.00	18	1972	15308.00	31.95
1	1	1958	7981.00	19	1966	13964.00	33.75
1	1	1959	1111.00	20	1976	13706.00	35.56
1	1	1960	9350.00	21	1965	13220.00	37.36
1	1	1961	793.00	22	1951	12000.00	39.17
1	1	1962	23677.00	23	1996	11661.00	40.97
1	1	1963	1894.00	24	1945	11655.00	42.78
1	1	1964	3338.00	25	1960	9350.00	44.58
1	1	1965	13220.00	26	1991	8140.00	46.39
1	1	1966	13964.00	27	1958	7981.00	48.19
1	1	1967	4796.00	28	1954	6964.00	50.00
1	1	1968	1884.00	29	1953	6837.00	51.81
1	1	1969	40998.00	30	1957	6391.00	53.61
1	1	1970	3354.00	31	1980	5651.00	55.42
1	1	1971	3610.00	32	1944	5595.00	57.22
1	1	1972	15308.00	33	1975	5228.00	59.03
1	1	1973	3255.00	34	1949	5117.00	60.83
1	1	1974	1769.00	35	1941	4921.00	62.64
1	1	1975	5228.00	36	1999	4798.00	64.44
1	1	1976	13706.00	37	1967	4796.00	66.25
1	1	1977	1252.00	38	2002	4378.00	68.05
1	1	1978	26559.00	39	1971	3610.00	69.86
1	1	1979	24298.00	40	2000	3584.00	71.66
1	1	1980	5651.00	41	1970	3354.00	73.47
1	1	1981	127.00	42	1964	3338.00	75.27
1	1	1990	1751.00	43	1973	3255.00	77.08
1	1	1991	8140.00	44	1940	3223.00	78.88
1	1	1992	2622.00	45	1992	2622.00	80.69
1	1	1993	36803.00	46	1956	2584.00	82.49
1	1	1994	15753.00	47	1963	1894.00	84.30
1	1	1995	20015.00	48	1968	1884.00	86.10
1	1	1996	11661.00	49	1955	1866.00	87.91
1	1	1997	49805.00	50	1974	1769.00	89.71
1	1	1998	16506.00	51	1990	1751.00	91.52
1	1	1999	4798.00	52	1977	1252.00	93.32
1	1	2000	3584.00	53	1959	1111.00	95.13
1	1	2001	36793.00	54	1961	793.00	96.93
1	1	2002	4378.00	55	1981	127.00	98.74

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 55 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.804

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 257.2

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 54 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.798

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 149038.

-SKEW WEIGHTING -

BASED ON 55 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- Max 10day Volume at Peevers USGS 0529000

COMPUTED CURVE Vol IN ac-ft	EXPECTED PROBABILITY Vol IN ac-ft	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 Vol IN ac-ft	CONFIDENCE LIMITS .95 Vol IN ac-ft
138410.00	160550.00	.2	252920.00	87952.00
103540.00	116000.00	.5	180140.00	68085.00
81303.00	88951.00	1.0	135890.00	54961.00
62273.00	66676.00	2.0	99688.00	43353.00
41545.00	43398.00	5.0	62477.00	30155.00
28857.00	29667.00	10.0	41197.00	21654.00
18447.00	18719.00	20.0	24916.00	14299.00
7691.60	7691.60	50.0	9752.10	6071.90
3128.50	3079.70	80.0	4033.70	2318.80
1935.30	1877.10	90.0	2584.10	1351.50
1294.90	1233.20	95.0	1794.60	853.39
601.68	541.22	99.0	905.90	350.89

SYNTHETIC STATISTICS

LOG TRANSFORM: Vol, ac-ft		NUMBER OF EVENTS	
MEAN	3.8784	HISTORIC EVENTS	0
STANDARD DEV	.4580	HIGH OUTLIERS	0
COMPUTED SKEW	-.0763	LOW OUTLIERS	1
REGIONAL SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-.1000	SYSTEMATIC EVENTS	55

HP PLOT WRITTEN TO THE FILE: Pee10dV.pcl

TABLE 1. SUMMARY OF STATISTICS -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	YEARS RECD	YEARS SYST	YEARS HIST	MEAN LOG	STD DEV	SKEW ADOPT	SKEW COMP	SKEW GENRL	HIST EVENT	OUTLIER HI	OUTLIER LO	ZERO/ MSNG
	Max 10day Volume at Peevers USGS 05290000		55	55	0	3.855	.515	-.70	-.674	-99.00	0	0	0	0 **
	Max 10day Volume at Peevers USGS 05290000		55	55	0	3.878	.458	-.10	-.076	-99.00	0	0	1	0

** PRELIMINARY STATISTICS

TABLE 2. SUMMARY OF FREQUENCY CURVE ORDINATES -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	YEARS RECD	YEARS SYST	YEARS HIST	PERCENT CHANCE EXCEEDANCE 10.	5.	2.	1.	.5	.2
	Max 10day Volume at Peevers USGS 05290000		55	55	0	29109	38693	51421	60921	70204	82024
	Max 10day Volume at Peevers USGS 05290000		55	55	0	28856	41545	62272	81302	103543	138408

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++++++++++++++++++++++++
+ END OF RUN           +
+ NORMAL STOP IN FFA   +
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 *************************************     **************************************
 *              FFA                  *     *                                    *
 *   FLOOD FREQUENCY ANALYSIS        *     *   U.S. ARMY CORPS OF ENGINEERS     *
 *   PROGRAM DATE:  FEB 1995         *     * THE HYDROLOGIC ENGINEERING CENTER  *
 *       VERSION:  3.1               *     *        609 SECOND STREET           *
 *   RUN  DATE   AND   TIME:         *     *     DAVIS, CALIFORNIA 95616        *
 *     17 SEP 07     11:36:07        *     *         (916) 756-1104             *
 *                                   *     *                                    *
 *************************************     **************************************


   INPUT FILE NAME: TRAVERS.DAT
  OUTPUT FILE NAME: TRAVERS.OUT
     DSS FILE NAME: TRAVERS.DSS


     -----DSS---ZOPEN:  New File Opened,  File: TRAVERS.DSS
                        Unit:  71;  DSS Version: 6-JB

  **TITLE RECORD(S)**
  TT  Lake Traverse at Reservation Dam
  TT  Period of Record 1942-2007
  TT  Annual Maximum Lake Level

  **JOB RECORD(S)**
       IPPC    ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
  J1     2       0       0        0       0       0       3       3       2

  **SPECIFIED VARIABLE AND UNITS**
  FU      Elev       Feet

  **STATION IDENTIFICATION**
  ID        Lake Traverse at Reservation Dam

  **SPECIAL STATION INFORMATION**
      IYRA     IYRL  HITHRS  LOTHRS     LOGT     NDEC     NSIG
  SI     0        0      0.      0.       0        2        5

  **HP PLOT **
       HP PLOT FILE                  IHPCV  KLIMIT     IPER     BAREA
  HPTravers.pcl                          3       0        0         N

       SELECTED CURVES ON HPPLOT
            EXPECTED PROBABILITY CURVE
            COMPUTED PROBABILITY CURVE
            CONFIDENCE LIMITS

  HPLake Traverse at
  HPReservation Dam
  HPAnnual Maximum Lake Levels

  **SYSTEMATIC EVENTS**
       66 EVENTS TO BE ANALYZED

  **END OF INPUT DATA**
  ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


  ***************************************************************
  CAUTION FROM SUBROUTINE WTSKEW
  ***** NO GENERALIZED SKEW PROVIDED
  ADOPTED SKEW SET TO COMPUTED SKEW


  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ    FINAL RESULTS    ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ

  -PLOTTING POSITIONS-      Lake Traverse at Reservation Dam
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EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	Elev Feet	RANK	WATER YEAR	Elev Feet	MEDIAN PLOT POS
1	1	1942	978.36	1	1997	982.21	1.05
1	1	1943	979.18	2	2001	981.12	2.56
1	1	1944	976.75	3	1969	981.03	4.07
1	1	1945	976.74	4	1952	980.75	5.57
1	1	1946	977.05	5	1986	980.71	7.08
1	1	1947	978.42	6	1995	980.34	8.58
1	1	1948	977.03	7	1993	980.00	10.09
1	1	1949	976.68	8	1962	979.53	11.60
1	1	1950	978.68	9	1979	979.41	13.10
1	1	1951	978.04	10	1978	979.35	14.61
1	1	1952	980.75	11	1994	979.20	16.11
1	1	1953	976.75	12	1943	979.18	17.62
1	1	1954	977.02	13	2007	978.75	19.13
1	1	1955	977.32	14	1950	978.68	20.63
1	1	1956	976.31	15	2005	978.53	22.14

1	1	1957	977.15	16	1947	978.42	23.64
1	1	1958	976.78	17	2006	978.37	25.15
1	1	1959	975.58	18	1942	978.36	26.66
1	1	1960	976.86	19	1966	978.30	28.16
1	1	1961	975.53	20	1965	978.19	29.67
1	1	1962	979.53	21	1951	978.04	31.17
1	1	1963	977.24	22	1989	977.98	32.68
1	1	1964	976.62	23	1984	977.82	34.19
1	1	1965	978.19	24	2004	977.62	35.69
1	1	1966	978.30	25	1985	977.42	37.20
1	1	1967	976.83	26	1996	977.37	38.70
1	1	1968	976.24	27	2003	977.33	40.21
1	1	1969	981.03	28	1955	977.32	41.72
1	1	1970	976.62	29	1999	977.32	43.22
1	1	1971	976.65	30	1998	977.28	44.73
1	1	1972	977.01	31	2002	977.27	46.23
1	1	1973	976.98	32	1963	977.24	47.74
1	1	1974	976.11	33	1991	977.20	49.25
1	1	1975	977.16	34	2000	977.17	50.75
1	1	1976	976.94	35	1975	977.16	52.26
1	1	1977	975.84	36	1957	977.15	53.77
1	1	1978	979.35	37	1946	977.05	55.27
1	1	1979	979.41	38	1992	977.03	56.78
1	1	1980	976.95	39	1948	977.03	58.28
1	1	1981	976.76	40	1954	977.02	59.79
1	1	1982	977.00	41	1972	977.01	61.30
1	1	1983	976.73	42	1982	977.00	62.80
1	1	1984	977.82	43	1973	976.98	64.31
1	1	1985	977.42	44	1980	976.95	65.81
1	1	1986	980.71	45	1976	976.94	67.32
1	1	1987	976.76	46	1960	976.86	68.83
1	1	1988	975.48	47	1967	976.83	70.33
1	1	1989	977.98	48	1958	976.78	71.84
1	1	1990	975.77	49	1987	976.76	73.34
1	1	1991	977.20	50	1981	976.76	74.85
1	1	1992	977.03	51	1944	976.75	76.36
1	1	1993	980.00	52	1953	976.75	77.86
1	1	1994	979.20	53	1945	976.74	79.37
1	1	1995	980.34	54	1983	976.73	80.87
1	1	1996	977.37	55	1949	976.68	82.38
1	1	1997	982.21	56	1971	976.65	83.89
1	1	1998	977.28	57	1970	976.62	85.39
1	1	1999	977.32	58	1964	976.62	86.90
1	1	2000	977.17	59	1956	976.31	88.40
1	1	2001	981.12	60	1968	976.24	89.91
1	1	2002	977.27	61	1974	976.11	91.42
1	1	2003	977.33	62	1977	975.84	92.92
1	1	2004	977.62	63	1990	975.77	94.43
1	1	2005	978.53	64	1959	975.58	95.93
1	1	2006	978.37	65	1961	975.53	97.44
1	1	2007	978.75	66	1988	975.48	98.95

-OUTLIER TESTS -

HIGH OUTLIER TEST

BASED ON 66 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.871

1 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 982.

NOTE - COLLECTION OF HISTORICAL INFORMATION AND COMPARISONS WITH SIMILAR DATA SETS SHOULD BE EXPLORED IF NOT INCORPORATED IN THIS ANALYSIS.

LOW OUTLIER TEST

BASED ON 66 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.871

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 973.5

-SKEW WEIGHTING -

BASED ON 66 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- Lake Traverse at Reservation Dam

TRAVERS.OUT

COMPUTED CURVE	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05	CONFIDENCE LIMITS .95
Elev IN Feet			Elev IN Feet	
983.84	984.25	.2	984.93	983.01
982.91	983.21	.5	983.85	982.19
982.19	982.41	1.0	983.02	981.56
981.46	981.61	2.0	982.17	980.90
980.44	980.53	5.0	981.01	980.00
979.63	979.69	10.0	980.09	979.26
978.76	978.79	20.0	979.13	978.45
977.41	977.41	50.0	977.71	977.10
976.44	976.42	80.0	976.76	976.06
976.06	976.04	90.0	976.40	975.64
975.80	975.78	95.0	976.17	975.36
975.46	975.43	99.0	975.85	974.97

SYSTEMATIC STATISTICS

LOG TRANSFORM: Elev, Feet		NUMBER OF EVENTS	
MEAN	2.9902	HISTORIC EVENTS	0
STANDARD DEV	.0006	HIGH OUTLIERS	0
COMPUTED SKEW	1.1209	LOW OUTLIERS	0
REGIONAL SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	1.1000	SYSTEMATIC EVENTS	66

HP PLOT WRITTEN TO THE FILE: Travers.pcl

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0
*************************************     *************************************
*              FFA                  *     *                                   *
*     FLOOD FREQUENCY ANALYSIS      *     *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995       *     * THE HYDROLOGIC ENGINEERING CENTER *
*         VERSION:  3.1             *     *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:       *     *     DAVIS, CALIFORNIA 95616       *
*       17 SEP 07    11:36:07       *     *         (916) 756-1104            *
*                                   *     *                                   *
*************************************     *************************************
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  INPUT FILE NAME: TRAVERS.DAT
 OUTPUT FILE NAME: TRAVERS.OUT
    DSS FILE NAME: TRAVERS.DSS


 ***** UNRECOGNIZABLE RECORD
 12345678901234567890123456789012345678901234567890123456789012345678901234567890
 ER
 RECORD IGNORED


 **SYSTEMATIC EVENTS**
      0 EVENTS TO BE ANALYZED

 **END OF INPUT DATA**
 ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

  *** INSUFFICIENT DATA, NVAL =  0
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TABLE 1. SUMMARY OF STATISTICS -- PRELIMINARY AND FINAL RESULTS

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 STATION  STATION NAME AND LOCATION                      AREA ....YEARS.....   MEAN   STD .......SKEW........
HIST OUTLIER ZERO/
  NUMBER  ...............................................  SQ MI RECD SYST HIST   LOG   DEV ADOPT   COMP  GENRL
EVENT HI LO  MSNG
--------------------------------------------------------------------------------------------------------
---------------
          Lake Traverse at Reservation Dam                  66   66    0  2.990  .001  1.10  1.121 -99.00
0    0  0    0 **
          Lake Traverse at Reservation Dam                  66   66    0  2.990  .001  1.10  1.121 -99.00
0    0  0    0
          Lake Traverse at Reservation Dam                   0    0
```

** PRELIMINARY STATISTICS

TABLE 2. SUMMARY OF FREQUENCY CURVE ORDINATES -- PRELIMINARY AND FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	....YEARS..... RECD	SYST	HIST	............PERCENT CHANCE EXCEEDANCE........... 10.	5.	2.	1.	.5	.2
	Lake Traverse at Reservation Dam		66	66	0	979	980	981	982	982	983
	Lake Traverse at Reservation Dam		66	66	0	979	980	981	982	982	983
	Lake Traverse at Reservation Dam		0	0							

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+++++++++++++++++++++++++++
+ END OF RUN              +
+ NORMAL STOP IN FFA      +
+++++++++++++++++++++++++++
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COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 1A-PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT-INCL. NEW CR 24	Acre	83.3	3,000.00	249,900.00
2	RIGHT OF WAY - TEMPORARY	Acre	13.7	300.00	4,110.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$254,010.00**
	SCHEDULE 2.0 FLOODWAY				
1	MOBILIZATION	Lump Sum	1	40,000.00	40,000.00
2	CLEARING AND GRUBBING	Acre	4	3,000.00	12,000.00
3	STRIPPING	Cu. Yd.	64000	1.15	73,600.00
4	TOPSOIL	Cu. Yd.	42000	1.30	54,600.00
5	COMMON EXCAVATION	Cu. Yd.	350000	2.25	787,500.00
6	48"X78" CULVERT, CSP ARCH	Lin. Ft.	100	60.00	6,000.00
7	18" SIDE INLET CULVERTS, CSP	Lin. Ft.	2678	20.00	53,560.00
8	APRON, 48"X78", CSP ARCH	Each	2	3,000.00	6,000.00
9	18" APRONS, CSP	Each	12	150.00	1,800.00
10	18" FLAPGATES	Each	9	1,000.00	9,000.00
11	RIPRAP, FOR LOW FLOW CHANNEL	Cu. Yd.	4276	30.00	128,280.00
12	RIPRAP, CL 3	Cu. Yd.	378	50.00	18,900.00
13	RIPRAP AT OUTLET	Cu. Yd.	400	50.00	20,000.00
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	1000	2.00	2,000.00
16	FLOTATION SILT CURTAIN TYPE MOVING WATER	Lin. Ft.	300	20.00	6,000.00
17	TEMPORARY DITCH CHECK	Lin. Ft.	500	5.00	2,500.00
18	SEEDING	Acre	210	80.00	16,800.00
19	SEED MIXTURE 100 SERIES	Lb.	10500	2.00	21,000.00
20	SEED MIXTURE 200 SERIES	Lb.	10500	2.50	26,250.00
21	MULCH MATERIAL TYPE 1	Ton	420	110.00	46,200.00
22	DISK ANCHORING	Acre	210	20.00	4,200.00
23	EROSION CONTROL BLANKET	Sq. Yd.	700	1.40	980.00
24	WATER CONTROL	Lump Sum	1	5,000.00	5,000.00
25	FLOOD EARLY WARNING SYSTEM	Lump Sum	1	10,000.00	10,000.00
T	**SCHEDULE 2.0 FLOODWAY -- TOTAL**				**$1,362,170.00**
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				
1	MOBILIZATION	Lump Sum	1	35,000.00	35,000.00
2	STEEL SHEET PILE	Sq. Ft.	9440	20.00	188,800.00
3	STRUCTURAL CONCRETE	Cu. Yd.	636	500.00	318,000.00
4	LEAF GATES	Each	3	91,000.00	273,000.00
5	RIPRAP, ROCK	Cu. Yd.	5970	50.00	298,500.00
6	ELECTRIC POWER SUPPLY	Lin. Ft.	3070	10.00	30,700.00
T	**SCHEDULE 3.0 FLOODWAY INLET STRUCTURE -- TOTAL**				**$1,144,000.00**

COST ESTIMATE FOR:
BROWNS VALLEY FLOOD MITIGATION PROJECT
FLOODWAY OPTION 1A-PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24				
1	MOBILIZATION	Lump Sum	1	15,000.00	15,000.00
2	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	60	5.50	330.00
3	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	4333	2.62	11,352.46
4	REMOVE CMP PIPE	Lin. Ft.	150	4.75	712.50
5	EARTHWORK	Cu. Yd.	17000	3.00	51,000.00
6	RCP CULVERTS	Lin. Ft.	150	37.88	5,682.00
7	RC PIPE APRONS	Each	6	629.35	3,776.10
8	SELECT GRANULAR BORROW	Cu. Yd.	5247	12.00	62,964.00
9	6" AGGREGATE BASE	Ton	4758	12.00	57,096.00
10	8" AGGREGATE SHOULDERING	Ton	830	17.08	14,176.40
11	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	614	2.00	1,228.00
12	6" BITUMINOUS BASE	Ton	4220	50.78	214,291.60
13	2" BITUMINOUS WEARING COURSE	Ton	1519	52.81	80,218.39
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
16	TEMPORARY DITCH CHECK	Lin. Ft.	50	5.00	250.00
17	SEEDING	Acre	15	80.00	1,200.00
18	SEED MIXTURE 100 SERIES	Lb.	750	2.00	1,500.00
19	SEED MIXTURE 200 SERIES	Lb.	750	2.50	1,875.00
20	MULCH MATERIAL TYPE 1	Ton	30	110.00	3,300.00
21	DISK ANCHORING	Acre	15	20.00	300.00
22	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
23	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	8500	0.25	2,125.00
24	4" SOLID LINE YELLOW-EPOXY	Lin. Ft.	4250	0.25	1,062.50
25	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	1060	0.25	265.00
T	**SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24 -- TOTAL**				**$542,104.95**
	SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4				
1	MOBILIZATION	Lump Sum	1	30,000.00	30,000.00
2	BRIDGE - CSAH 4	Lump Sum	1	865,000.00	865,000.00
3	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	50	5.50	275.00
4	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	2000	2.62	5,240.00
5	EARTHWORK	Cu. Yd.	4000	3.00	12,000.00
6	SELECT GRANULAR BORROW	Cu. Yd.	675	12.00	8,100.00
7	6" AGGREGATE BASE	Ton	560	12.00	6,720.00
8	8" AGGREGATE SHOULDERING	Ton	100	17.08	1,708.00
9	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	75	2.00	150.00
10	6" BITUMINOUS BASE	Ton	500	50.78	25,390.00
11	2" BITUMINOUS WEARING COURSE	Ton	180	52.81	9,505.80
12	TRAFFIC CONTROL	Lump Sum	1	15,000.00	15,000.00
13	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
14	SEEDING	Acre	1	80.00	80.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 1A-PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
15	SEED MIXTURE 100 SERIES	Lb.	50	2.00	100.00
16	SEED MIXTURE 200 SERIES	Lb.	50	2.50	125.00
17	MULCH MATERIAL TYPE 1	Ton	2	110.00	220.00
18	DISK ANCHORING	Acre	1	20.00	20.00
19	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
20	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	700	0.25	175.00
21	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	700	0.25	175.00
T	**SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4 -- TOTAL**				**$982,383.80**
	SCHEDULE 6.0: Farmstead Ring Dike				
1	Temporary Right of Way	Acre	4	300.00	1,200.00
2	Dike Construction	cu.yd.	4400	3.00	13,200.00
3	18" CULVERTS, CSP	Lin. Ft.	100	20.00	2,000.00
4	18" APRONS, CSP	Each	2	150.00	300.00
5	18" FLAPGATES	Each	2	1000.00	2,000.00
6	Seed,Seeding, Mulch, Disk Anchoring	acre	2	300.00	600.00
7	6" AGGREGATE BASE	Ton	72	12.00	864.00
	SCHEDULE 6.0: Farmstead Ring Dike	**Total**			**$20,164.00**
	SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	4	8712.00	34,848.00
T	**SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION--TOTAL**				$34,848.00

BID SUMMARY

SCHEDULE 1.0 RIGHT OF WAY	$254,010.00
SCHEDULE 2.0 FLOODWAY	$1,362,170.00
SCHEDULE 3.0 FLOODWAY INLET STRUCTURE	$1,144,000.00
SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24	$542,104.95
SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4	$982,383.80
SCHEDULE 6.0: Farmstead Ring Dike	$20,164.00
SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION	$34,848.00

SUBTOTAL	**$4,340,000.00**
15% CONTINGENCIES	**$651,000.00**
TOTAL CONSTRUCTION COST	**$4,991,000.00**
15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$748,650.00**
TOTAL COST ESTIMATE	**$5,740,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY 1A ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT-INCL. NEW CR 24	Acre	83.3	3,000.00	249,900.00
2	RIGHT OF WAY - TEMPORARY	Acre	13.7	300.00	4,110.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$254,010.00**
	SCHEDULE 2.0 FLOODWAY				
1	MOBILIZATION	Lump Sum	1	35,000.00	35,000.00
2	CLEARING AND GRUBBING	Acre	4	3,000.00	12,000.00
3	STRIPPING	Cu. Yd.	64000	1.15	73,600.00
4	TOPSOIL	Cu. Yd.	42000	1.30	54,600.00
5	COMMON EXCAVATION	Cu. Yd.	240000	2.25	540,000.00
6	48"X78" CULVERT, CSP ARCH	Lin. Ft.	100	60.00	6,000.00
7	18" SIDE INLET CULVERTS, CSP	Lin. Ft.	2678	20.00	53,560.00
8	APRON, 48"X78", CSP ARCH	Each	2	3,000.00	6,000.00
9	18" APRONS, CSP	Each	12	150.00	1,800.00
10	18" FLAPGATES	Each	9	1,000.00	9,000.00
11	RIPRAP, FOR LOW FLOW CHANNEL	Cu. Yd.	4276	30.00	128,280.00
12	RIPRAP, CL 3	Cu. Yd.	378	50.00	18,900.00
13	RIPRAP AT OUTLET	Cu. Yd.	400	50.00	20,000.00
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	1000	2.00	2,000.00
16	FLOTATION SILT CURTAIN TYPE MOVING WATER	Lin. Ft.	300	20.00	6,000.00
17	TEMPORARY DITCH CHECK	Lin. Ft.	500	5.00	2,500.00
18	SEEDING	Acre	210	80.00	16,800.00
19	SEED MIXTURE 100 SERIES	Lb.	10500	2.00	21,000.00
20	SEED MIXTURE 200 SERIES	Lb.	10500	2.50	26,250.00
21	MULCH MATERIAL TYPE 1	Ton	420	110.00	46,200.00
22	DISK ANCHORING	Acre	210	20.00	4,200.00
23	EROSION CONTROL BLANKET	Sq. Yd.	700	1.40	980.00
24	WATER CONTROL	Lump Sum	1	5,000.00	5,000.00
25	FLOOD EARLY WARNING SYSTEM	Lump Sum	1	10,000.00	10,000.00
T	**SCHEDULE 2.0 FLOODWAY -- TOTAL**				**$1,109,670.00**
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	STEEL SHEET PILE	Sq. Ft.	5730	20.00	114,600.00
3	RIPRAP	Cu. Yd.	2500	50.00	125,000.00
T	**SCHEDULE 3.0 FLOODWAY INLET STRUCTURE -- TOTAL**				**$249,600.00**
	SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE				
1	12.5' by 13' Radial Tainter Gate	Each	4	105,000.00	420,000.00
2	Installation of Tainter Gates	Each	4	25,000.00	100,000.00
3	Structural Concrete for walls, bases and floors	Cu. Yd	600	500.00	300,000.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY 1A ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
4	Controls and Steel Elements at gates	Each	4	20,000.00	80,000.00
5	Excavation and Foundation Preparation	l.s.	1	50,000.00	50,000.00
6	Rock Protection - Upstream and downstream	Cu. Yd	1,100	50.00	55,000.00
7	Embankment	Cu. Yd	30,000	2.00	60,000.00
T	**SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE -- TOTAL**				**$1,065,000.00**
	SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24				
1	MOBILIZATION	Lump Sum	1	15,000.00	15,000.00
2	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	60	5.50	330.00
3	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	4333	2.62	11,352.46
4	REMOVE CMP PIPE	Lin. Ft.	150	4.75	712.50
5	EARTHWORK	Cu. Yd.	17000	3.00	51,000.00
6	RCP CULVERTS	Lin. Ft.	150	37.88	5,682.00
7	RC PIPE APRONS	Each	6	629.35	3,776.10
8	SELECT GRANULAR BORROW	Cu. Yd.	5247	12.00	62,964.00
9	6" AGGREGATE BASE	Ton	4758	12.00	57,096.00
10	8" AGGREGATE SHOULDERING	Ton	830	17.08	14,176.40
11	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	614	2.00	1,228.00
12	6" BITUMINOUS BASE	Ton	4220	50.78	214,291.60
13	2" BITUMINOUS WEARING COURSE	Ton	1519	52.81	80,218.39
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
16	TEMPORARY DITCH CHECK	Lin. Ft.	50	5.00	250.00
17	SEEDING	Acre	15	80.00	1,200.00
18	SEED MIXTURE 100 SERIES	Lb.	750	2.00	1,500.00
19	SEED MIXTURE 200 SERIES	Lb.	750	2.50	1,875.00
20	MULCH MATERIAL TYPE 1	Ton	30	110.00	3,300.00
21	DISK ANCHORING	Acre	15	20.00	300.00
22	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
23	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	8500	0.25	2,125.00
24	4" SOLID LINE YELLOW-EPOXY	Lin. Ft.	4250	0.25	1,062.50
25	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	1060	0.25	265.00
T	**SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24 -- TOTAL**				**$542,104.95**
	SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4				
1	MOBILIZATION	Lump Sum	1	30,000.00	30,000.00
2	BRIDGE - CSAH 4	Lump Sum	1	865,000.00	865,000.00
3	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	50	5.50	275.00
4	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	2000	2.62	5,240.00
5	EARTHWORK	Cu. Yd.	4000	3.00	12,000.00
6	SELECT GRANULAR BORROW	Cu. Yd.	675	12.00	8,100.00
7	6" AGGREGATE BASE	Ton	560	12.00	6,720.00
8	8" AGGREGATE SHOULDERING	Ton	100	17.08	1,708.00
9	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	75	2.00	150.00
10	6" BITUMINOUS BASE	Ton	500	50.78	25,390.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY 1A ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
11	2" BITUMINOUS WEARING COURSE	Ton	180	52.81	9,505.80
12	TRAFFIC CONTROL	Lump Sum	1	15,000.00	15,000.00
13	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
14	SEEDING	Acre	1	80.00	80.00
15	SEED MIXTURE 100 SERIES	Lb.	50	2.00	100.00
16	SEED MIXTURE 200 SERIES	Lb.	50	2.50	125.00
17	MULCH MATERIAL TYPE 1	Ton	2	110.00	220.00
18	DISK ANCHORING	Acre	1	20.00	20.00
19	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
20	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	700	0.25	175.00
21	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	700	0.25	175.00
T	**SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4 -- TOTAL**				**$982,383.80**
	SCHEDULE 7.0: Farmstead Ring Dike				
1	Temporary Right of Way	Acre	4	300.00	1,200.00
2	Dike Construction	cu.yd.	4400	3.00	13,200.00
3	18" CULVERTS, CSP	Lin. Ft.	100	20.00	2,000.00
4	18" APRONS, CSP	Each	2	150.00	300.00
5	18" FLAPGATES	Each	2	1000.00	2,000.00
6	Seed,Seeding, Mulch, Disk Anchoring	acre	2	300.00	600.00
7	6" AGGREGATE BASE	Ton	72	12.00	864.00
	SCHEDULE 7.0: Farmstead Ring Dike	**Total**			**$20,164.00**
	SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	4	8712.00	34,848.00
T	**SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$34,848.00**

BID SUMMARY

SCHEDULE 1.0 RIGHT OF WAY	$254,010.00
SCHEDULE 2.0 FLOODWAY	$1,109,670.00
SCHEDULE 3.0 FLOODWAY INLET STRUCTURE	$249,600.00
SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE	$1,065,000.00
SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24	$542,104.95
SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4	$982,383.80
SCHEDULE 7.0: Farmstead Ring Dike	$20,164.00
SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION	$34,848.00
SUBTOTAL	**$4,260,000.00**
15% CONTINGENCIES	**$639,000.00**
TOTAL CONSTRUCTION COST	**$4,899,000.00**
15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$734,850.00**
TOTAL COST ESTIMATE	**$5,640,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT-INCL. NEW CR 24	Acre	102.4	3,000.00	307,200.00
2	RIGHT OF WAY - TEMPORARY	Acre	16.6	300.00	4,980.00
3	RIGHT OF WAY - PERMANENT-LMR LEVEE NORTH	Acre	4.2	3,000.00	12,600.00
4	RIGHT OF WAY - TEMPORARY - LMR LEVEE NORTH	Acre	12.4	300.00	3,720.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				$328,500.00
	SCHEDULE 2.0 FLOODWAY				
1	MOBILIZATION	Lump Sum	1	65,000.00	65,000.00
2	CLEARING AND GRUBBING	Acre	4	3,000.00	12,000.00
3	STRIPPING	Cu. Yd.	78000	1.15	89,700.00
4	TOPSOIL	Cu. Yd.	52000	1.30	67,600.00
5	COMMON EXCAVATION	Cu. Yd.	690000	2.25	1,552,500.00
6	48"X78" CULVERT, CSP ARCH	Lin. Ft.	100	60.00	6,000.00
7	18" SIDE INLET CULVERTS, CSP	Lin. Ft.	3238	20.00	64,760.00
8	APRON, 48"X78", CSP ARCH	Each	2	3,000.00	6,000.00
9	18" APRONS, CSP	Each	14	150.00	2,100.00
10	18" FLAPGATES	Each	11	1,000.00	11,000.00
11	RIPRAP, FOR LOW FLOW CHANNEL	Cu. Yd.	6074	30.00	182,220.00
12	RIPRAP, CL 3	Cu. Yd.	378	50.00	18,900.00
13	RIPRAP AT OUTLET	Cu. Yd.	400	50.00	20,000.00
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	600	2.00	1,200.00
16	FLOTATION SILT CURTAIN TYPE MOVING WATER	Lin. Ft.	100	20.00	2,000.00
17	TEMPORARY DITCH CHECK	Lin. Ft.	500	5.00	2,500.00
18	SEEDING	Acre	190	80.00	15,200.00
19	SEED MIXTURE 100 SERIES	Lb.	9500	2.00	19,000.00
20	SEED MIXTURE 200 SERIES	Lb.	9500	2.50	23,750.00
21	MULCH MATERIAL TYPE 1	Ton	380	110.00	41,800.00
22	DISK ANCHORING	Acre	190	20.00	3,800.00
23	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
24	WATER CONTROL	Lump Sum	1	10,000.00	10,000.00
25	FLOOD EARLY WARNING SYSTEM	Lump Sum	1	10,000.00	10,000.00
T	**SCHEDULE 2.0 FLOODWAY -- TOTAL**				**$2,238,430.00**
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				
1	MOBILIZATION	Lump Sum	1	35,000.00	35,000.00
2	STEEL SHEET PILE	Sq. Ft.	9440	20.00	188,800.00
3	STRUCTURAL CONCRETE	Cu. Yd.	636	500.00	318,000.00
4	LEAF GATES	Each	3	91,000.00	273,000.00
5	RIPRAP, ROCK	Cu. Yd.	5970	50.00	298,500.00
6	ELECTRIC POWER SUPPLY	Lin. Ft.	3070	10.00	30,700.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
T	**SCHEDULE 3.0 FLOODWAY INLET STRUCTURE -- TOTAL**				**$1,144,000.00**
	SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24				
1	MOBILIZATION	Lump Sum	1	16,000.00	16,000.00
2	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	60	5.50	330.00
3	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	7944	2.62	20,813.28
4	REMOVE CMP PIPE	Lin. Ft.	150	4.75	712.50
5	EARTHWORK	Cu. Yd.	22000	3.00	66,000.00
6	RCP CULVERTS	Lin. Ft.	150	37.88	5,682.00
7	RC PIPE APRONS	Each	6	629.35	3,776.10
8	SELECT GRANULAR BORROW	Cu. Yd.	5309	12.00	63,708.00
9	6" AGGREGATE BASE	Ton	4814	12.00	57,768.00
10	8" AGGREGATE SHOULDERING	Ton	839	17.08	14,330.12
11	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	621	2.00	1,242.00
12	6" BITUMINOUS BASE	Ton	4270	50.78	216,830.60
13	2" BITUMINOUS WEARING COURSE	Ton	1537	52.81	81,168.97
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
16	TEMPORARY DITCH CHECK	Lin. Ft.	50	5.00	250.00
17	SEEDING	Acre	33	80.00	2,640.00
18	SEED MIXTURE 100 SERIES	Lb.	1650	2.00	3,300.00
19	SEED MIXTURE 200 SERIES	Lb.	1650	2.50	4,125.00
20	MULCH MATERIAL TYPE 1	Ton	62	110.00	6,820.00
21	DISK ANCHORING	Acre	33	20.00	660.00
22	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
23	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	8600	0.25	2,150.00
24	4" SOLID LINE YELLOW-EPOXY	Lin. Ft.	4300	0.25	1,075.00
25	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	1075	0.25	268.75
T	**SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24 -- TOTAL**				**$582,050.32**
	SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4				
1	MOBILIZATION	Lump Sum	1	30,000.00	30,000.00
2	BRIDGE - CSAH 4	Lump Sum	1	865,000.00	865,000.00
3	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	50	5.50	275.00
4	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	2000	2.62	5,240.00
5	EARTHWORK	Cu. Yd.	4000	3.00	12,000.00
6	SELECT GRANULAR BORROW	Cu. Yd.	675	12.00	8,100.00
7	6" AGGREGATE BASE	Ton	560	12.00	6,720.00
8	8" AGGREGATE SHOULDERING	Ton	100	17.08	1,708.00
9	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	75	2.00	150.00
10	6" BITUMINOUS BASE	Ton	500	50.78	25,390.00
11	2" BITUMINOUS WEARING COURSE	Ton	180	52.81	9,505.80
12	TRAFFIC CONTROL	Lump Sum	1	15,000.00	15,000.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
13	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
14	SEEDING	Acre	1	80.00	80.00
15	SEED MIXTURE 100 SERIES	Lb.	50	2.00	100.00
16	SEED MIXTURE 200 SERIES	Lb.	50	2.50	125.00
17	MULCH MATERIAL TYPE 1	Ton	2	110.00	220.00
18	DISK ANCHORING	Acre	1	20.00	20.00
19	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
20	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	700	0.25	175.00
21	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	700	0.25	175.00
T	**SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4 -- TOTAL**				**$982,383.80**
	SCHEDULE 6.0 LITTLE MINNESOTA RIVER LEVEE				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Lump Sum	1	5,000.00	5,000.00
3	STRIPPING	Cu. Yd.	3350	1.15	3,852.50
4	TOPSOIL	Cu. Yd.	2200	1.30	2,860.00
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	7400	2.25	16,650.00
6	IMPERVIOUS FILL	Cu. Yd.	24000	3.00	72,000.00
7	12'X5' PRECAST CONCRETE BOX CULVERT	Lin. Ft.	60	686.40	41,184.00
8	CULVERT END SECTIONS	Lump Sum	6	8,121.00	48,726.00
9	AGGREGATE SURFACING, CLASS 5 (CV)	Ton	1600	12.00	19,200.00
10	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
11	SEEDING	Acre	16.6	80.00	1,328.00
12	SEED MIXTURE 100 SERIES	Lb.	830	2.00	1,660.00
13	SEED MIXTURE 200 SERIES	Lb.	830	2.50	2,075.00
14	MULCH MATERIAL TYPE 1	Ton	33.2	110.00	3,652.00
15	DISK ANCHORING	Acre	16.6	20.00	332.00
16	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
17	WATER CONTROL	Lump Sum	1	2,000.00	2,000.00
T	**SCHEDULE 6.0 LITTLE MINNESOTA RIVER LEVEE -- TOTAL**				**$232,919.50**
	SCHEDULE 7.0: Farmstead Ring Dike				
1	Temporary Right of Way	Acre	4	300.00	1,200.00
2	Dike Construction	cu.yd.	4400	3.00	13,200.00
3	18" CULVERTS, CSP	Lin. Ft.	100	20.00	2,000.00
4	18" APRONS, CSP	Each	2	150.00	300.00
5	18" FLAPGATES	Each	2	1000.00	2,000.00
6	Seed,Seeding, Mulch, Disk Anchoring	acre	2	300.00	600.00
7	6" AGGREGATE BASE	Ton	72	12.00	864.00
	SCHEDULE 7.0: Farmstead Ring Dike	**Total**			**$20,164.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 PASSIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	4	8712.00	34,848.00
T	**SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$34,848.00**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$328,500.00
	SCHEDULE 2.0 FLOODWAY				$2,238,430.00
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				$1,144,000.00
	SCHEDULE 4.0 IMPROVEMENTS TO ROBERTS CR 24				$582,050.32
	SCHEDULE 5.0 IMPROVEMENTS TO CSAH 4				$982,383.80
	SCHEDULE 6.0 LITTLE MINNESOTA RIVER LEVEE				$232,919.50
	SCHEDULE 7.0: Farmstead Ring Dike				$20,164.00
	SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION				$34,848.00
				SUBTOTAL	**$5,570,000.00**
				15% CONTINGENCIES	**$835,500.00**
				TOTAL CONSTRUCTION COST	**$6,405,500.00**
				15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$960,825.00**
				TOTAL COST ESTIMATE	**$7,370,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT-INCL. NEW CR 24	Acre	102.4	3,000.00	307,200.00
2	RIGHT OF WAY - TEMPORARY	Acre	16.6	300.00	4,980.00
3	RIGHT OF WAY - PERMANENT-LMR LEVEE NORTH	Acre	4.2	3,000.00	12,600.00
4	RIGHT OF WAY - TEMPORARY - LMR LEVEE NORTH	Acre	12.4	300.00	3,720.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$328,500.00**
	SCHEDULE 2.0 FLOODWAY				
1	MOBILIZATION	Lump Sum	1	50,000.00	50,000.00
2	CLEARING AND GRUBBING	Acre	4	3,000.00	12,000.00
3	STRIPPING	Cu. Yd.	78000	1.15	89,700.00
4	TOPSOIL	Cu. Yd.	52000	1.30	67,600.00
5	COMMON EXCAVATION	Cu. Yd.	470000	2.25	1,057,500.00
6	48"X78" CULVERT, CSP ARCH	Lin. Ft.	100	60.00	6,000.00
7	18" SIDE INLET CULVERTS, CSP	Lin. Ft.	3238	20.00	64,760.00
8	APRON, 48"X78", CSP ARCH	Each	2	3,000.00	6,000.00
9	18" APRONS, CSP	Each	14	150.00	2,100.00
10	18" FLAPGATES	Each	11	1,000.00	11,000.00
11	RIPRAP, FOR LOW FLOW CHANNEL	Cu. Yd.	6074	30.00	182,220.00
12	RIPRAP, CL 3	Cu. Yd.	378	50.00	18,900.00
13	RIPRAP AT OUTLET	Cu. Yd.	400	50.00	20,000.00
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	600	2.00	1,200.00
16	FLOTATION SILT CURTAIN TYPE MOVING WATER	Lin. Ft.	100	20.00	2,000.00
17	TEMPORARY DITCH CHECK	Lin. Ft.	500	5.00	2,500.00
18	SEEDING	Acre	190	80.00	15,200.00
19	SEED MIXTURE 100 SERIES	Lb.	9500	2.00	19,000.00
20	SEED MIXTURE 200 SERIES	Lb.	9500	2.50	23,750.00
21	MULCH MATERIAL TYPE 1	Ton	380	110.00	41,800.00
22	DISK ANCHORING	Acre	190	20.00	3,800.00
23	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
24	WATER CONTROL	Lump Sum	1	10,000.00	10,000.00
25	FLOOD EARLY WARNING SYSTEM	Lump Sum	1	10,000.00	10,000.00
T	**SCHEDULE 2.0 FLOODWAY -- TOTAL**				**$1,728,430.00**
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	STEEL SHEET PILE	Sq. Ft.	5730	20.00	114,600.00
3	RIPRAP	Cu. Yd.	2500	50.00	125,000.00
T	**SCHEDULE 3.0 FLOODWAY INLET STRUCTURE -- TOTAL**				**$249,600.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE				
1	12.5' by 13' Radial Tainter Gate	Each	4	105,000.00	420,000.00
2	Installation of Tainter Gates	Each	4	25,000.00	100,000.00
3	Structural Concrete for walls, bases and floors	Cu. Yd	600	500.00	300,000.00
4	Controls and Steel Elements at gates	Each	4	20,000.00	80,000.00
5	Excavation and Foundation Preparation	l.s.	1	50,000.00	50,000.00
6	Rock Protection - Upstream and downstream	Cu. Yd	1100	50.00	55,000.00
7	Embankment	Cu. Yd	30000	2.00	60,000.00
T	**SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE -- TOTAL**				**$1,065,000.00**
	SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24				
1	MOBILIZATION	Lump Sum	1	16,000.00	16,000.00
2	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	60	5.50	330.00
3	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	7944	2.62	20,813.28
4	REMOVE CMP PIPE	Lin. Ft.	150	4.75	712.50
5	EARTHWORK	Cu. Yd.	22000	3.00	66,000.00
6	RCP CULVERTS	Lin. Ft.	150	37.88	5,682.00
7	RC PIPE APRONS	Each	6	629.35	3,776.10
8	SELECT GRANULAR BORROW	Cu. Yd.	5309	12.00	63,708.00
9	6" AGGREGATE BASE	Ton	4814	12.00	57,768.00
10	8" AGGREGATE SHOULDERING	Ton	839	17.08	14,330.12
11	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	621	2.00	1,242.00
12	6" BITUMINOUS BASE	Ton	4270	50.78	216,830.60
13	2" BITUMINOUS WEARING COURSE	Ton	1537	52.81	81,168.97
14	TRAFFIC CONTROL	Lump Sum	1	10,000.00	10,000.00
15	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
16	TEMPORARY DITCH CHECK	Lin. Ft.	50	5.00	250.00
17	SEEDING	Acre	33	80.00	2,640.00
18	SEED MIXTURE 100 SERIES	Lb.	1650	2.00	3,300.00
19	SEED MIXTURE 200 SERIES	Lb.	1650	2.50	4,125.00
20	MULCH MATERIAL TYPE 1	Ton	66	110.00	7,260.00
21	DISK ANCHORING	Acre	33	20.00	660.00
22	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
23	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	8600	0.25	2,150.00
24	4" SOLID LINE YELLOW-EPOXY	Lin. Ft.	4300	0.25	1,075.00
25	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	1075	0.25	268.75
T	**SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24 -- TOTAL**				**$582,490.32**
	SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4				
1	MOBILIZATION	Lump Sum	1	30,000.00	30,000.00
2	BRIDGE - CSAH 4	Lump Sum	1	865,000.00	865,000.00
3	SAWING BITUMINOUS PAVEMENT (FULL DEPTH)	Lin. Ft.	50	5.50	275.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
4	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	2000	2.62	5,240.00
5	EARTHWORK	Cu. Yd.	4000	3.00	12,000.00
6	SELECT GRANULAR BORROW	Cu. Yd.	675	12.00	8,100.00
7	6" AGGREGATE BASE	Ton	560	12.00	6,720.00
8	8" AGGREGATE SHOULDERING	Ton	100	17.08	1,708.00
9	BITUMINOUS MATERIAL FOR TACK COAT	Gallons	75	2.00	150.00
10	6" BITUMINOUS BASE	Ton	500	50.78	25,390.00
11	2" BITUMINOUS WEARING COURSE	Ton	180	52.81	9,505.80
12	TRAFFIC CONTROL	Lump Sum	1	15,000.00	15,000.00
13	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
14	SEEDING	Acre	1	80.00	80.00
15	SEED MIXTURE 100 SERIES	Lb.	50	2.00	100.00
16	SEED MIXTURE 200 SERIES	Lb.	50	2.50	125.00
17	MULCH MATERIAL TYPE 1	Ton	2	110.00	220.00
18	DISK ANCHORING	Acre	1	20.00	20.00
19	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
20	4" SOLID LINE WHITE-EPOXY	Lin. Ft.	700	0.25	175.00
21	4" BROKEN LINE YELLOW-EPOXY	Lin. Ft.	700	0.25	175.00
T	**SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4 -- TOTAL**				**$982,383.80**
	SCHEDULE 7.0 LITTLE MINNESOTA RIVER LEVEE				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Lump Sum	1	5,000.00	5,000.00
3	STRIPPING	Cu. Yd.	3350	1.15	3,852.50
4	TOPSOIL	Cu. Yd.	2200	1.30	2,860.00
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	7400	2.25	16,650.00
6	IMPERVIOUS FILL	Cu. Yd.	24000	3.00	72,000.00
7	12'X5' PRECAST CONCRETE BOX CULVERT	Lin. Ft.	120	686.40	82,368.00
8	CULVERT END SECTIONS	Lump Sum	6	8,121.00	48,726.00
8	AGGREGATE SURFACING, CLASS 5 (CV)	Ton	1600	12.00	19,200.00
9	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	2.00	1,000.00
10	SEEDING	Acre	16.6	80.00	1,328.00
11	SEED MIXTURE 100 SERIES	Lb.	830	2.00	1,660.00
12	SEED MIXTURE 200 SERIES	Lb.	830	2.50	2,075.00
13	MULCH MATERIAL TYPE 1	Ton	33.2	110.00	3,652.00
14	DISK ANCHORING	Acre	16.6	20.00	332.00
15	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
16	WATER CONTROL	Lump Sum	1	2,000.00	2,000.00
T	**SCHEDULE 7.0 LITTLE MINNESOTA RIVER LEVEE -- TOTAL**				**$274,103.50**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT

FLOODWAY OPTION 3 ACTIVE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 8.0: Farmstead Ring Dike				
1	Temporary Right of Way	Acre	4	300.00	1,200.00
2	Dike Construction	cu.yd.	4400	3.00	13,200.00
3	18" CULVERTS, CSP	Lin. Ft.	100	20.00	2,000.00
4	18" APRONS, CSP	Each	2	150.00	300.00
5	18" FLAPGATES	Each	2	1000.00	2,000.00
6	Seed,Seeding, Mulch, Disk Anchoring	acre	2	300.00	600.00
7	6" AGGREGATE BASE	Ton	72	12.00	864.00
	SCHEDULE 8.0: Farmstead Ring Dike	**Total**			**$20,164.00**
	SCHEDULE 9.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	4	8712.00	34,848.00
T	**SCHEDULE 9.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$34,848.00**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$328,500.00
	SCHEDULE 2.0 FLOODWAY				$1,728,430.00
	SCHEDULE 3.0 FLOODWAY INLET STRUCTURE				$249,600.00
	SCHEDULE 4.0 ACTIVE CONTROL STRUCTURE				$1,065,000.00
	SCHEDULE 5.0 IMPROVEMENTS TO ROBERTS CR 24				$582,490.32
	SCHEDULE 6.0 IMPROVEMENTS TO CSAH 4				$982,383.80
	SCHEDULE 7.0 LITTLE MINNESOTA RIVER LEVEE				$274,103.50
	SCHEDULE 8.0: Farmstead Ring Dike				$20,164.00
	SCHEDULE 9.0 WETLAND/WOODLAND MITIGATION				$34,848.00
				SUBTOTAL	**$5,270,000.00**
				15% CONTINGENCIES	**$790,500.00**
				TOTAL CONSTRUCTION COST	**$6,060,500.00**
				15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$909,075.00**
				TOTAL COST ESTIMATE	**$6,970,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT **CITY WELL FIELD IMPROVEMENTS**

BROWNS VALLEY, MINNESOTA

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT	Acre	0	3,000.00	0.00
2	RIGHT OF WAY - TEMPORARY	Acre	0	3,000.00	0.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$0.00**
	SCHEDULE 2.0 FLOOD PROTECTION WELLS				
1	MOBILIZATION	Lump Sum	1	1,000.00	1,000.00
2	STRIPPING AT WELL RAISINGS	Cu. Yd.	185	2.30	425.50
3	TOPSOIL AT WELL RAISINGS	Cu. Yd.	125	2.60	325.00
4	EMBANKMENT (CV) FOR WELL RAISING	Cu. Yd.	750	3.00	2,250.00
5	SEEDING AND MULCHING	Acre	0.5	1,000.00	500.00
6	SILT FENCE	Lin. Ft.	100	2.00	200.00
T	**SCHEDULE 2.0 FLOOD PROTECTION WELLS -- TOTAL**				**$4,700.50**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$0.00
	SCHEDULE 2.0 FLOOD PROTECTION WELLS				$4,700.50
				SUBTOTAL	**$4,800.00**
				15% CONTINGENCIES	**$720.00**
				TOTAL CONSTRUCTION COST	**$5,520.00**
				15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$828.00**
				TOTAL COST ESTIMATE	**$6,400.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 1 - WEST LEVEES

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT	Acre	3.5	3,000.00	10,500.00
2	RIGHT OF WAY - TEMPORARY	Acre	8.4	300.00	2,520.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$13,020.00**
	SCHEDULE 2.0 LEVEE WEST OF CSAH 2				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Acre	3	3,000.00	9,000.00
3	STRIPPING	Cu. Yd.	1749	1.15	2,011.44
4	TOPSOIL	Cu. Yd.	1166	1.30	1,515.86
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	2728	2.25	6,137.08
6	IMPERVIOUS FILL	Cu. Yd.	12042	3.00	36,126.00
7	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	100	2.00	200.00
8	SEEDING	Acre	12.3	80.00	983.65
9	SEED MIXTURE 100 SERIES	Lb.	615	2.00	1,229.57
10	SEED MIXTURE 200 SERIES	Lb.	615	2.50	1,536.96
11	MULCH MATERIAL TYPE 1	Ton	24.6	110.00	2,705.05
12	DISK ANCHORING	Acre	12.3	20.00	245.91
13	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
14	WATER CONTROL	Lump Sum	1	1,000.00	1,000.00
T	**SCHEDULE 2.0 LEVEE WEST OF CSAH 2 -- TOTAL**				**$74,091.53**
	SCHEDULE 3.0 LEVEE SOUTH OF TH 28				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Acre	1	3,000.00	3,000.00
3	STRIPPING	Cu. Yd.	1481	1.15	1,703.70
4	TOPSOIL	Cu. Yd.	1185	1.30	1,540.74
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	3259	2.25	7,333.33
6	IMPERVIOUS FILL	Cu. Yd.	4300	3.00	12,900.00
7	4-FT. X 6-FT RC BOX CULVERTS (2)	L.F.	84	403.00	33,852.00
8	CULVERT END SECTIONS	Lump Sum	2	3,322.00	6,644.00
9	FLAP GATE	Lump Sum	2	2,500.00	5,000.00
10	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	100	2.00	200.00
11	SEEDING	Acre	11.0	80.00	882
12	SEED MIXTURE 100 SERIES	Lb.	551	2.00	1,102
13	SEED MIXTURE 200 SERIES	Lb.	551	2.50	1,377
14	MULCH MATERIAL TYPE 1	Ton	22.0	110.00	2,424.24
15	DISK ANCHORING	Acre	11.0	20.00	220.39
16	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
17	WATER CONTROL	Lump Sum	1	1,000.00	1,000.00
T	**SCHEDULE 3.0 LEVEE SOUTH OF TH28 -- TOTAL**				**$90,579.29**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 1 - WEST LEVEES

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 4.0 CULVERT - DRIVEWAY				
1	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	231	2.00	462.00
2	COMMON EXCAVATION AND FILL	Cu. Yd.	812	3.00	2,436.00
3	REMOVE EXISTING 24" RCP	L.F.	80.6	6.06	488.44
3	6-FT. X 12 FT. RC BOX (2)	L.F.	50	800.00	40,000.00
4	CULVERT END SECTIONS	Lump Sum	4	10,000.00	40,000.00
5	SELECT GRANULAR BORROW (CV)	Cu. Yd.	77	12.00	924.00
6	GEOTEXTILE FABRIC, TYPE V	Sq. Yd.	231	1.50	346.50
7	6" AGGREGATE BASE, CLASS 5 (CV)	Ton	73	12.00	873.18
T	**SCHEDULE 4.0 CULVERT REPLACEMENT - DRIVEWAY -- TOTAL**				**$85,530.12**
	SCHEDULE 5.0 CULVERT - TH 28				
1	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	272	2.00	544.00
2	COMMON EXCAVATION AND FILL	Cu. Yd.	1570	5.00	7,850.00
3	4-FT. X 8-FT RC BOX CULVERTS (4)	L.F.	236	436.80	103,084.80
4	CULVERT END SECTIONS	Lump Sum	8	4,928.00	39,424.00
5	SELECT GRANULAR BORROW (CV)	Cu. Yd.	91	12.00	1,088.00
6	GEOTEXTILE FABRIC, TYPE V	Sq. Yd.	272	1.50	408.00
7	6" AGGREGATE BASE, CLASS 5 (CV)	Ton	85.68	12.00	1,028.16
8	TYPE 41 WEARING COURSE MIXTURE	Ton	22.44	52.81	1,185.06
9	TYPE 31 BASE COURSE MIXTURE	Ton	30	50.78	1,519.34
10	BITUMINOUS MATERIAL FOR TACK COAT	Gal.	14	2.00	27.20
11	TRAFFIC CONTROL	Lump Sum	1	20,000.00	20,000.00
T	**SCHEDULE 5.0 CULVERT - TH 28 -- TOTAL**				**$176,158.55**
	SCHEDULE 6.0 FLUME				
1	CONCRETE	Cu. Yd.	550	500.00	275,000.00
2	RIPRAP	Cu. Yd.	1670	50.00	83,500.00
T	**SCHEDULE 6.0 FLUME -- TOTAL**				**$358,500.00**
	SCHEDULE 7.0 WEST DITCH FLOODWAY				
1	COMMON EXCAVATION (CUT RAILROAD)	Cu. Yd.	289	5.00	1,445.00
2	CHANNEL WORK (TH28 TO DRIVEWAY)	Cu. Yd.	1620	2.00	3,240.00
3	DITCH CLEANING	L.F.	2280	1.75	3,990.00
4	PERMANENT ROW	Acre	11.6	3,000.00	34,800.00
5	TEMPORARY ROW	Acre	1.8	300.00	528.00
T	**SCHEDULE 7.0 WEST DITCH FLOODWAY -- TOTAL**				**$44,003.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 1 - WEST LEVEES

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	1	8712.00	8,712.00
T	**SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$8,712.00**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$13,020.00
	SCHEDULE 2.0 LEVEEs WEST OF TH28				$74,091.53
	SCHEDULE 3.0 LEVEE SOUTH OF TH 28				$90,579.29
	SCHEDULE 4.0 CULVERT REPLACEMENT - DRIVEWAY				$85,530.12
	SCHEDULE 5.0 CULVERT REPLACEMENT - TH 28				$176,158.55
	SCHEDULE 6.0 FLUME				$358,500.00
	SCHEDULE 7.0 WEST DITCH FLOODWAY				$44,003.00
	SCHEDULE 8.0 WETLAND/WOODLAND MITIGATION				$8,712.00
				SUBTOTAL	**$851,000.00**
				15% CONTINGENCIES	**$127,650.00**
				TOTAL CONSTRUCTION COST	**$978,650.00**
				15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$146,797.50**
				TOTAL COST ESTIMATE	**$1,130,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 2 - EAST LEVEE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT	Acre	2.4	3,000.00	7,200.00
2	RIGHT OF WAY - TEMPORARY	Acre	5.8	300.00	1,742.42
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$8,942.42**
	SCHEDULE 2.0 LEVEE EAST OF CSAH 2				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Acre	0.5	3,000.00	1,500.00
3	STRIPPING	Cu. Yd.	900	1.15	1,035.00
4	TOPSOIL	Cu. Yd.	810	1.30	1,053.00
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	1894	2.25	4,262.50
6	IMPERVIOUS FILL	Cu. Yd.	5300	3.00	15,900.00
7	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	100	2.00	200.00
8	SEEDING	Acre	8.5	80.00	683.20
9	SEED MIXTURE 100 SERIES	Lb.	427.0	2.00	853.99
10	SEED MIXTURE 200 SERIES	Lb.	427.0	2.50	1,067.49
11	MULCH MATERIAL TYPE 1	Ton	17.1	110.00	1,878.79
12	DISK ANCHORING	Acre	8.5	20.00	170.80
13	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
14	WATER CONTROL	Lump Sum	1	5,000.00	5,000.00
T	**SCHEDULE 2.0 LEVEE EAST OF CSAH 2 -- TOTAL**				**$45,004.77**
	SCHEDULE 3.0 LEVEE SOUTH OF TH 28				
1	MOBILIZATION	Lump Sum	1	10,000.00	10,000.00
2	CLEARING AND GRUBBING	Acre	1	3,000.00	3,000.00
3	STRIPPING	Cu. Yd.	1481	1.15	1,703.70
4	TOPSOIL	Cu. Yd.	1185	1.30	1,540.74
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	3259	2.25	7,333.33
6	IMPERVIOUS FILL	Cu. Yd.	4300	3.00	12,900.00
7	4-FT. X 6-FT RC BOX CULVERTS (2)	L.F.	84	403.00	33,852.00
8	CULVERT END SECTIONS	Lump Sum	2	3,322.00	6,644.00
9	FLAP GATE	Lump Sum	2	2,500.00	5,000.00
10	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	100	2.00	200.00
11	SEEDING	Acre	11.0	80.00	882
12	SEED MIXTURE 100 SERIES	Lb.	551	2.00	1,102
13	SEED MIXTURE 200 SERIES	Lb.	551	2.50	1,377
14	MULCH MATERIAL TYPE 1	Ton	22.0	110.00	2,424.24
15	DISK ANCHORING	Acre	11.0	20.00	220.39
16	EROSION CONTROL BLANKET	Sq. Yd.	1000	1.40	1,400.00
17	WATER CONTROL	Lump Sum	1	1,000.00	1,000.00

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 2 - EAST LEVEE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
T	**SCHEDULE 3.0 LEVEE SOUTH OF CSAH 2 -- TOTAL**				**$90,579.29**
	SCHEDULE 4.0 CULVERT - CSAH 2				
1	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	452	2.00	904.00
2	COMMON EXCAVATION AND FILL	Cu. Yd.	27854	5.00	139,270.00
3	12-FT. X 12 FT. RC BOX	L.F.	176	1,088.10	191,505.60
4	CULVERT END SECTIONS	Lump Sum	2	18,879.00	37,758.00
5	SELECT GRANULAR BORROW (CV)	Cu. Yd.	151	12.00	1,808.00
6	GEOTEXTILE FABRIC, TYPE V	Sq. Yd.	452	1.50	678.00
7	6" AGGREGATE BASE, CLASS 5 (CV)	Ton	142	12.00	1,708.56
8	TYPE 41 WEARING COURSE MIXTURE	Ton	37	52.81	1,969.28
9	TYPE 31 BASE COURSE MIXTURE	Ton	50	50.78	2,524.78
10	BITUMINOUS MATERIAL FOR TACK COAT	Gal.	23	2.00	45.20
11	EROSION CONTROL	Sq. Yd.	14520	1.40	20,328.00
12	TRAFFIC CONTROL	Lump Sum	1	20,000.00	20,000.00
T	**SCHEDULE 4.0 CULVERT REPLACEMENT - CSAH 2 -- TOTAL**				**$418,499.43**
	SCHEDULE 5.0 CULVERT REPLACEMENT - TH 28				
1	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	368	2.00	736.21
2	COMMON EXCAVATION AND FILL	Cu. Yd.	2930	5.00	14,648.86
3	REMOVE EXISTING 4 - 60" RCP	L.F.	280	6.06	1,696.80
3	7-FT. X 12-FT RC BOX CULVERTS (3)	L.F.	168	776.10	130,384.80
4	CULVERT END SECTIONS	Lump Sum	6	10,954.00	65,724.00
5	SELECT GRANULAR BORROW (CV)	Cu. Yd.	123	12.00	1,472.43
6	GEOTEXTILE FABRIC, TYPE V	Sq. Yd.	368	1.50	552.16
7	6" AGGREGATE BASE, CLASS 5 (CV)	Ton	115.9536	12.00	1,391.44
8	TYPE 41 WEARING COURSE MIXTURE	Ton	30.3688	52.81	1,603.78
9	TYPE 31 BASE COURSE MIXTURE	Ton	40	50.78	2,056.17
10	BITUMINOUS MATERIAL FOR TACK COAT	Gal.	18	2.00	36.81
11	TRAFFIC CONTROL	Lump Sum	1	20,000.00	20,000.00
T	**SCHEDULE 5.0 CULVERT REPLACEMENT - TH 28 -- TOTAL**				**$240,303.46**
	SCHEDULE 6.0 WEST DITCH FLOODWAY				
1	COMMON EXCAVATION (CUT RAILROAD)	Cu. Yd.	289	5.00	1,445.00
2	CHANNEL WORK (TH28 TO DRIVEWAY)	Cu. Yd.	1620	2.00	3,240.00
3	DITCH CLEANING	L.F.	2280	1.75	3,990.00
4	PERMANENT ROW	Acre	11.6	3,000.00	34,800.00
5	TEMPORARY ROW	Acre	1.8	300.00	528.00
T	**SCHEDULE 6.0 WEST DITCH FLOODWAY -- TOTAL**				**$44,003.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 2 - EAST LEVEE

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	1	8712.00	8,712.00
T	**SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$8,712.00**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$8,942.42
	SCHEDULE 2.0 LEVEE EAST OF CSAH 2				$45,004.77
	SCHEDULE 3.0 LEVEE SOUTH OF TH 28				$90,579.29
	SCHEDULE 4.0 CULVERT REPLACEMENT - CSAH 2				$418,499.43
	SCHEDULE 5.0 CULVERT REPLACEMENT - TH 28				$240,303.46
	SCHEDULE 6.0 WEST DITCH FLOODWAY				$44,003.00
	SCHEDULE 7.0 WETLAND/WOODLAND MITIGATION				$8,712.00
				SUBTOTAL	**$857,000.00**
				15% CONTINGENCIES	**$128,550.00**
				TOTAL CONSTRUCTION COST	**$985,550.00**
				15% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$147,832.50**
				TOTAL COST ESTIMATE	**$1,140,000.00**

COST ESTIMATE FOR:

BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

TOELLE COULEE ALTERNATIVE 3 - IMPOUNDMENT

CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 1.0 RIGHT OF WAY				
1	RIGHT OF WAY - PERMANENT	Acre	18	3,000.00	54,000.00
2	RIGHT OF WAY - TEMPORARY	Acre	2	300.00	600.00
T	**SCHEDULE 1.0 RIGHT OF WAY -- TOTAL**				**$54,600.00**
	SCHEDULE 2.0 DAM AND CSAH 2 CULVERT REPLACEMENT				
1	MOBILIZATION	Lump Sum	1	50,000.00	50,000.00
2	CLEARING AND GRUBBING	Acre	1.5	3,000.00	4,500.00
3	STRIPPING	Cu. Yd.	1300	1.15	1,495.00
4	TOPSOIL	Cu. Yd.	1050	1.30	1,365.00
5	UNCLASSIFIED EXCAVATION (KEY TRENCH)	Cu. Yd.	1019	2.25	2,291.67
6	REMOVE EXISTING 60" RCP (CSAH 2)	L.F.	324	6.06	1,963.44
7	REMOVE BITUMINOUS PAVEMENT	Sq. Yd.	547	2.00	1,094.00
8	COMMON EXCAVATION AND FILL	Cu. Yd.	67333	5.00	336,663.52
9	EMBANKMENT IMPERVIOUS CLAY FILL (P)	Cu. Yd.	46000	3.00	138,000.00
10	PRESTRESSED CONCRETE CYLINDER PIPE - 60" DIA. SP-12 TYPE DEEP JOINT	L.F.	60	399.00	23,940.00
11	PRESTRESSED CONCRETE CYLINDER PIPE - 60" DIA. SP-12 TYPE DEEP JOINT	L.F.	264	399.00	105,336.00
12	STRUCTURAL CONTRETE RISER	Cu. Yd.	86	500.00	43,000.00
13	INLET DEBRIS RACK	L.S.	1	2,476.12	2,476.12
14	RISER TRASH RACK	L.S.	1	2,476.12	2,476.12
15	STRUCTURAL CONTRETE - OUTLET	Cu. Yd.	145	500.00	72,500.00
16	REINFORCING STEEL - OULET	Lb.	26281	0.60	15,768.60
17	CHAIN-LINK FENCING	L.F.	127	15.00	1,905.00
18	SELECT GRANULAR BORROW (CV)	Cu. Yd.	182	12.00	2,188.00
19	GEOTEXTILE FABRIC, TYPE V	Sq. Yd.	547	1.50	820.50
20	6" AGGREGATE BASE, CLASS 5 (CV)	Ton	172	12.00	2,067.66
21	TYPE 41 WEARING COURSE MIXTURE	Ton	45.1275	52.81	2,383.18
22	TYPE 31 BASE COURSE MIXTURE	Ton	60	50.78	3,055.43
23	BITUMINOUS MATERIAL FOR TACK COAT	Gal.	27	2.00	54.70
24	TRAFFIC CONTROL	Lump Sum	1	15,000.00	15,000.00
25	SILT FENCE, TYPE MACHINE SLICED	Lin. Ft.	500	4.00	2,000.00
26	TEMPORARY DITCH CHECK	Lin. Ft.	300	5.00	1,500.00
27	SEEDING	Acre	8	80.00	640.00
28	SEED MIXTURE 200 SERIES	Lb.	800	2.50	2,000.00
29	MULCH MATERIAL TYPE 1	Ton	2	110.00	220.00
30	DISK ANCHORING	Acre	1	55.00	55.00
31	EROSION CONTROL	Sq. Yd.	14520	1.40	20,328.00
32	WATER CONTROL	L.S.	1	10,000.00	10,000.00
33	SMALL UTILITY RELOCATION	L.S.	1	5,000.00	5,000.00
T	**SCHEDULE 2.0 -- TOTAL**				**$872,086.94**

COST ESTIMATE FOR:

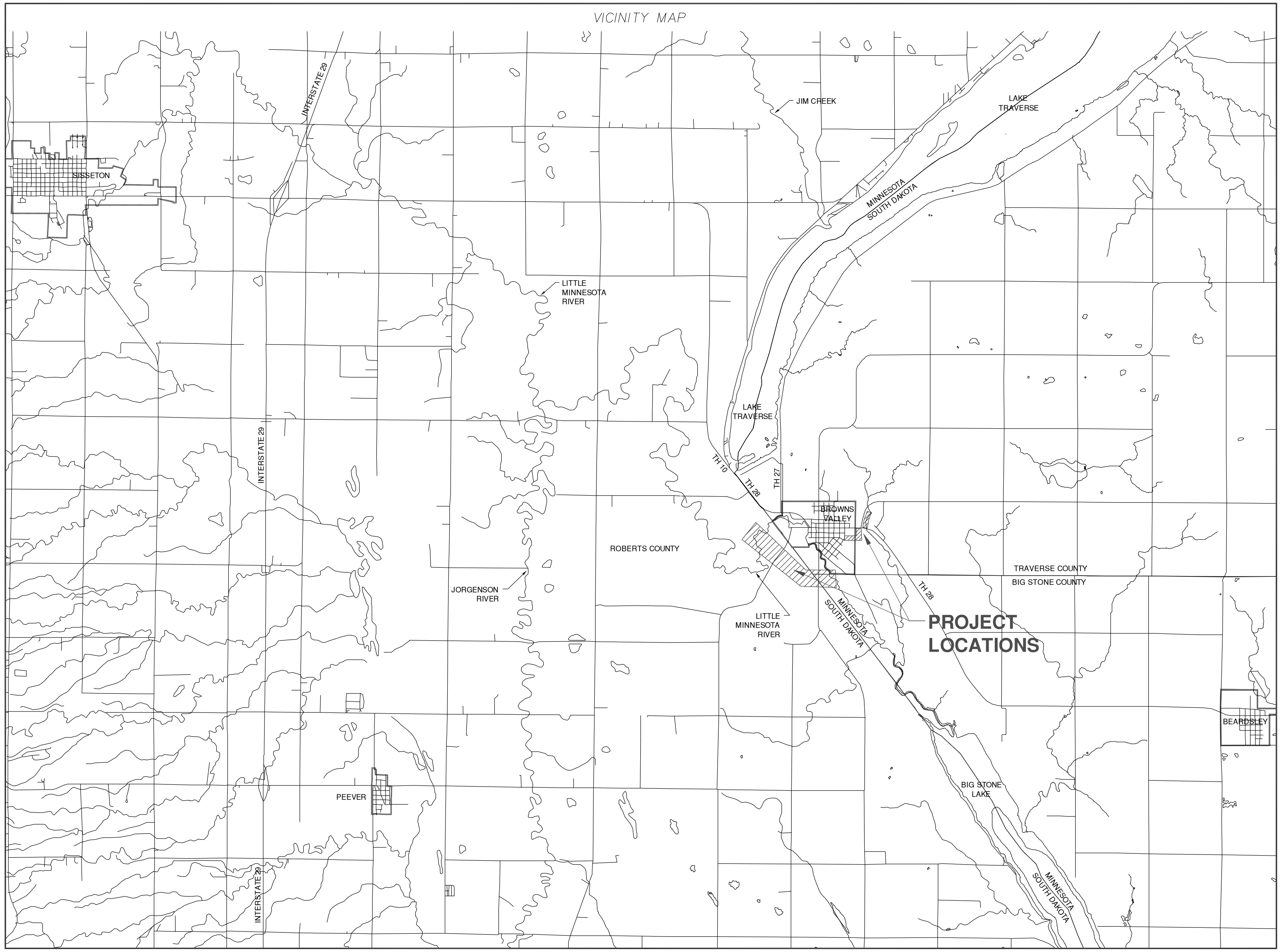
BROWNS VALLEY FLOOD MITIGATION PROJECT, BROWNS VALLEY, MINNESOTA

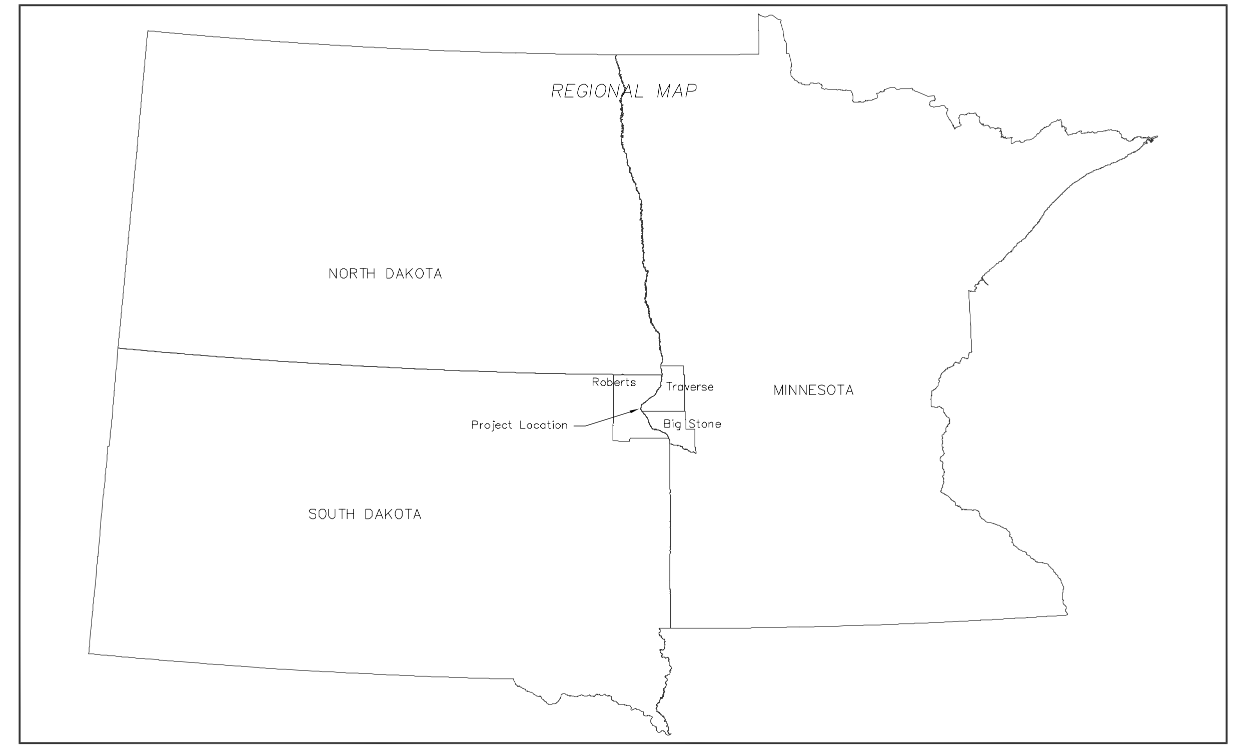
TOELLE COULEE ALTERNATIVE 3 - IMPOUNDMENT

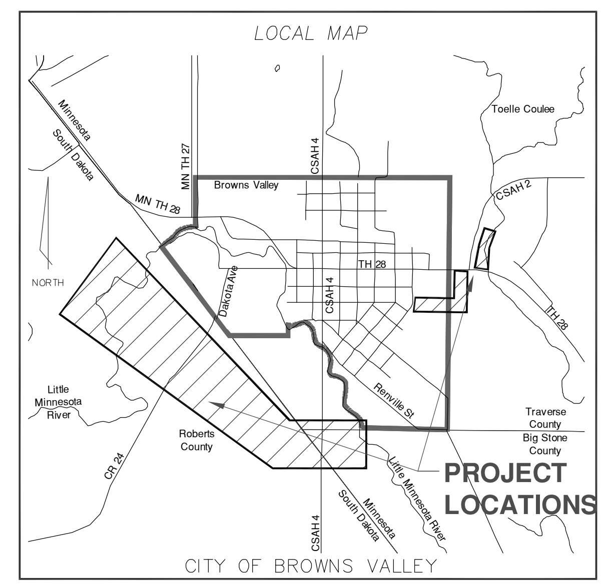
CLIENT: UPPER MINNESOTA RIVER WATERSHED DISTRICT January 17, 2008

Item	Item Description	Unit	Quantity	Unit Price	Total Price
	SCHEDULE 3.0 WEST DITCH FLOODWAY				
1	COMMON EXCAVATION (CUT RAILROAD)	Cu. Yd.	289	5.00	1,445.00
2	CHANNEL WORK (TH28 TO DRIVEWAY)	Cu. Yd.	1620	2.00	3,240.00
3	DITCH CLEANING	L.F.	2280	1.75	3,990.00
4	PERMANENT ROW	Acre	11.6	3,000.00	34,800.00
5	TEMPORARY ROW	Acre	1.8	300.00	528.00
T	**SCHEDULE 3.0 WEST DITCH FLOODWAY -- TOTAL**				**$44,003.00**
	SCHEDULE 4.0 WETLAND/WOODLAND MITIGATION				
1	WETLAND/WOODLAND MITIGATION	Acre	1	8712.00	8,712.00
T	**SCHEDULE 4.0 WETLAND/WOODLAND MITIGATION--TOTAL**				**$8,712.00**
	BID SUMMARY				
	SCHEDULE 1.0 RIGHT OF WAY				$54,600.00
	SCHEDULE 2.0 DAM				$872,086.94
	SCHEDULE 3.0 WEST DITCH FLOODWAY				$44,003.00
	SCHEDULE 4.0 WETLAND/WOODLAND MITIGATION				$8,712.00
				SUBTOTAL	**$980,000.00**
				15% CONTINGENCIES	**$147,000.00**
				TOTAL CONSTRUCTION COST	**$1,127,000.00**
				20% ENGINEERING, INSPECTION, ADMINISTRATIVE COSTS	**$225,400.00**
				TOTAL COST ESTIMATE	**$1,360,000.00**

PRELIMINARY PLANS
BROWNS VALLEY FLOOD MITIGATION PROJECT
FOR
UPPER MINNESOTA RIVER WATERSHED DISTRICT
JANUARY 2008







SHEET INDEX

1 COVER SHEET
2 OVERALL AREA
3 OPTION 3 FLOODWAY IMPROVEMENTS
4 CR 24/CSAH 4/CSAH 31 ROAD IMPROVEMENTS
5 CSAH 31 BRIDGE IMPROVEMENTS
6 FARM RING DIKE/FLOODWAY OUTLET
7 TOELLE COULEE DIKE IMPROVEMENTS
8 WEST BRANCH TOELLE COULEE AND CITY WELL FIELD
9 FLOODWAY INLET TYPICAL DETAILS
10 FLOODWAY/ROAD/DIKE TYPICAL DETAILS
11 RIGHT OF WAY

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Signature:________ Typed or Printed Name: Brent H. Johnson

Date: January 17, 2008 Reg. No. 20378

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

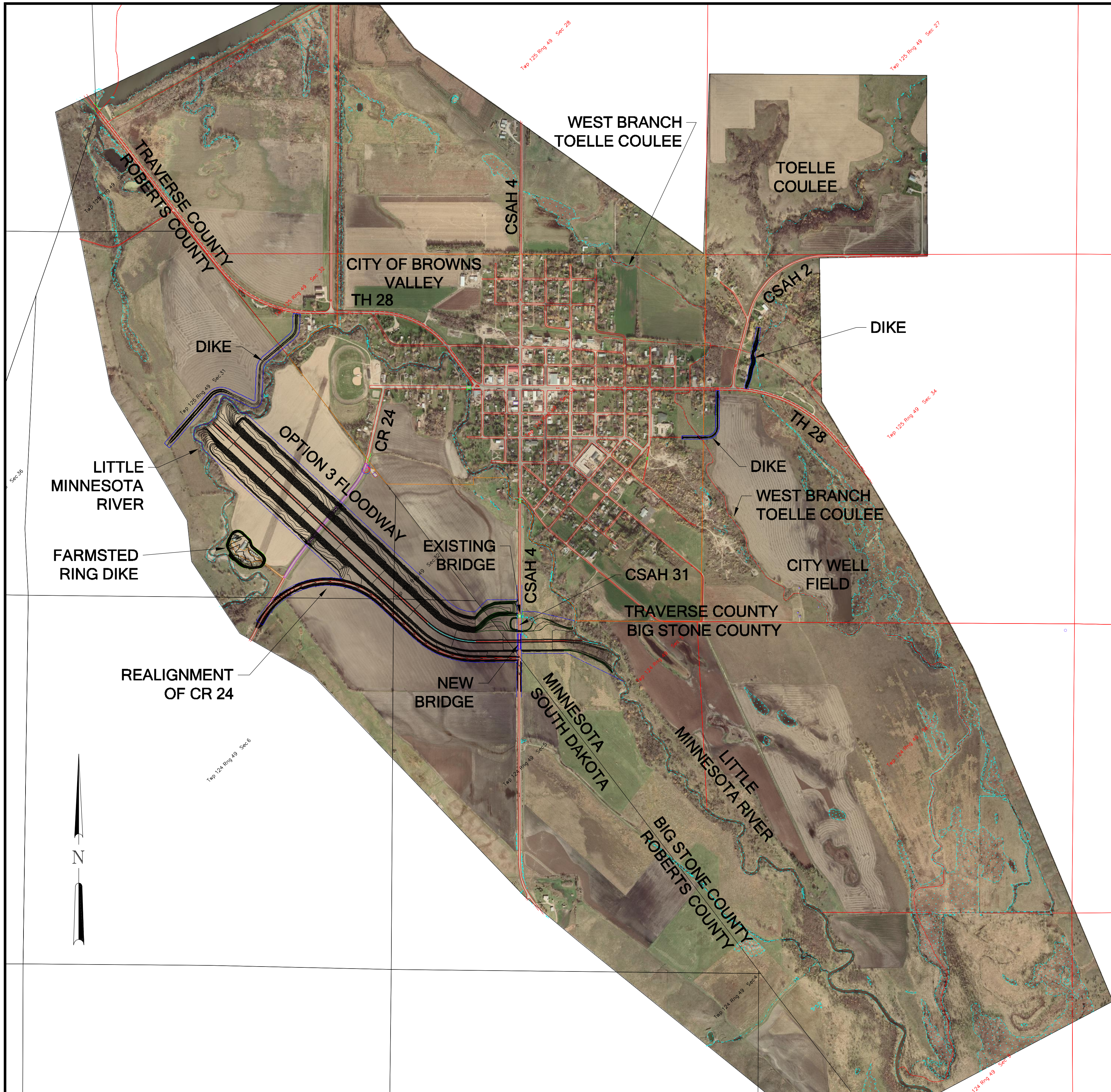
Signature:________ Typed or Printed Name: Mark Deutschman

Date: January 17, 2008 Reg. No. 41259

PREPARED BY:

Houston Engineering, Inc.
Leave Nothing to Chance.

Fargo, North Dakota Maple Grove, Minnesota
Bismarck, North Dakota
Minot, North Dakota Thief River Falls, Minnesota
Billings, Montana Barnesville, Minnesota



LEGEND	EXISTING	NEW
WATER MAIN	—|——|——|—	
SANITARY SEWER MAIN	—>——>——>—	
SANITARY SEWER FORCEMAIN	— SSFM —— SSFM —	
CULVERT/STORM SEWER	—>>——>>—	
OVERHEAD POWER	— P — — —	
UNDERGROUND ELECTRIC	— UGE — — —	
UNDERGROUND TELEPHONE	— UGT — — —	
UNDERGROUND FIBER OPTIC	— FO — — —	
CABLE TV	— CTV — — —	
GAS MAIN	— G — — —	
HEDGE/TREE LINE		
RIGHT OF WAY LINE	—— — — ——	—— — — ——
CONTOUR	— — 999 — —	—— 999 ——

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No.	Revision	Date	By

800 0 800 1600
Scale Feet

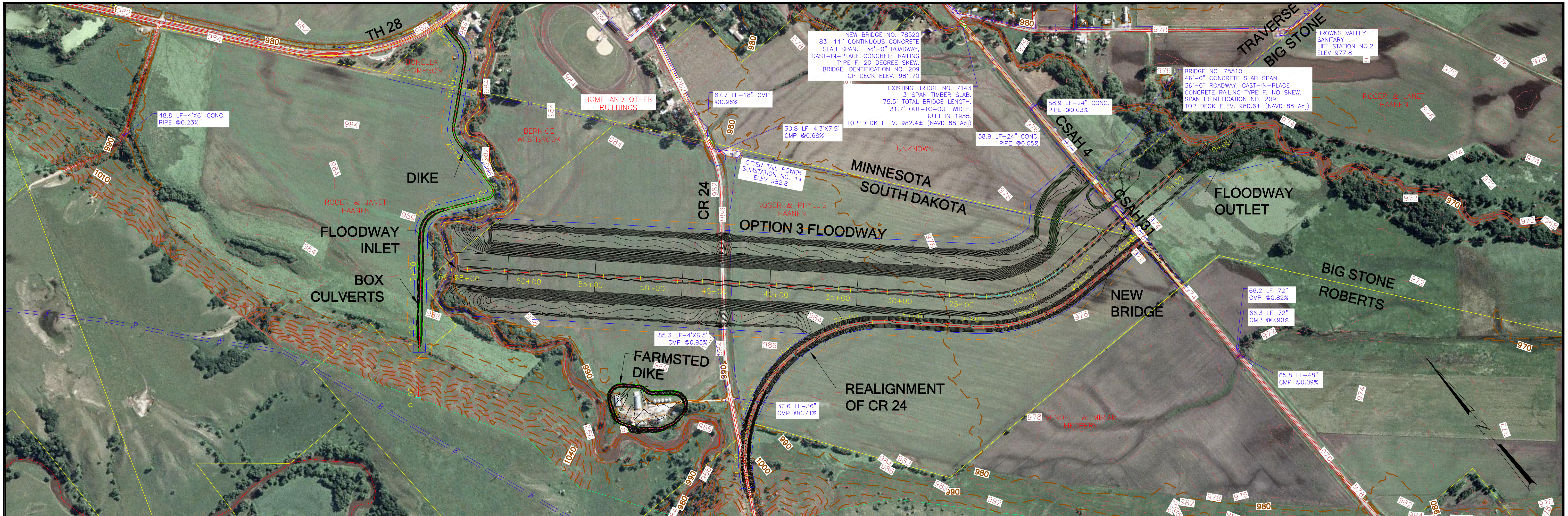
Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 TEL: (763) 493-4522
MAPLE GROVE, MINNESOTA 55369 FAX: (763) 493-5572

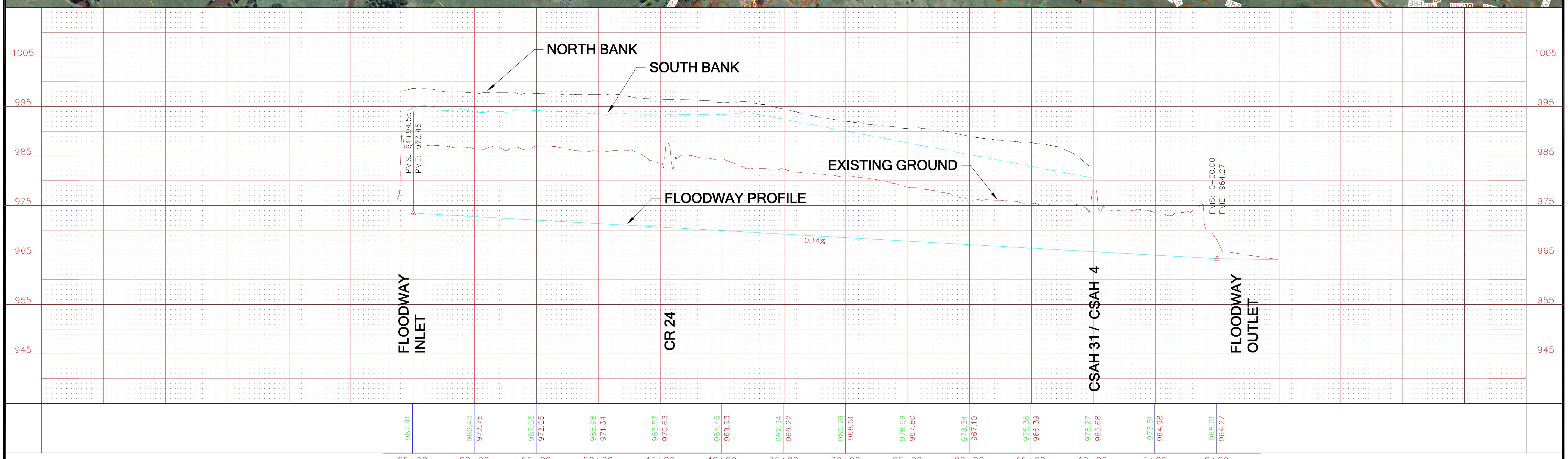
Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

OVERALL AREA
PROJECT NO. 5304-002

SHEET
2 of 11





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No.	Revision	Date	By

Scale: 400 0 400 800 Feet

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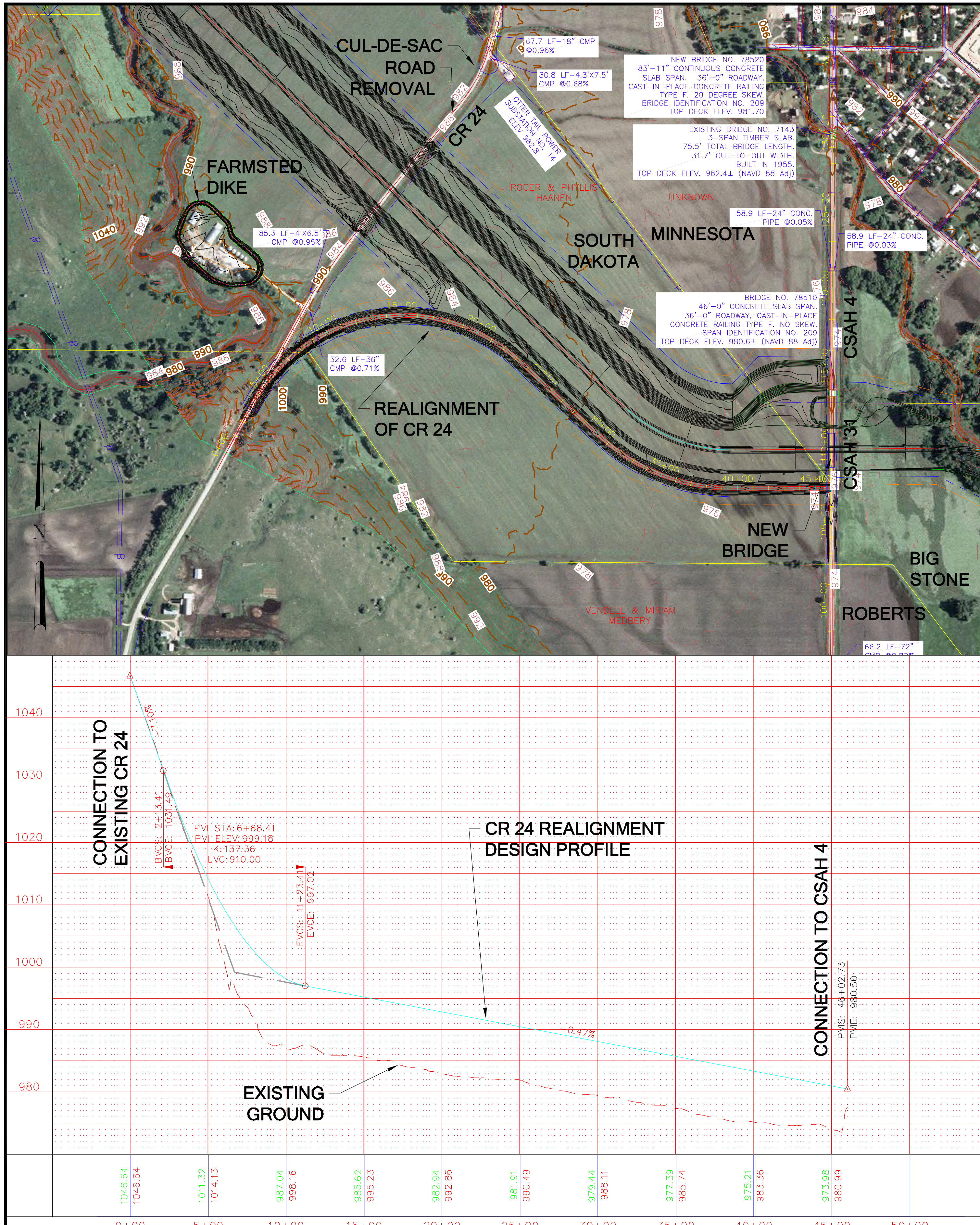
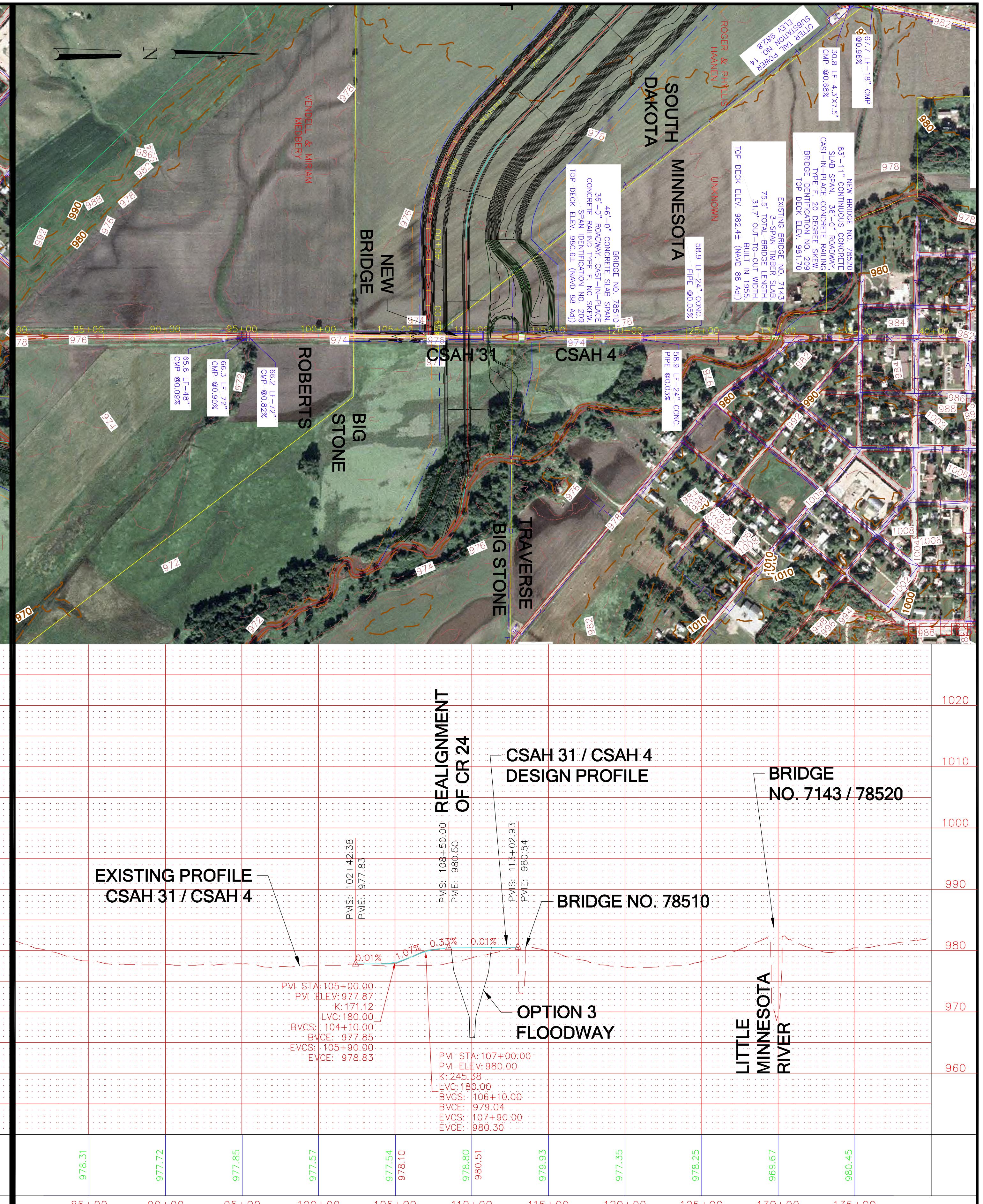
Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

OPTION 3 FLOODWAY IMPROVEMENTS
PROJECT NO. 5304-002

SHEET 3 of 11





No.	Revision	Date	By

Scale: 400 0 400 800 Feet

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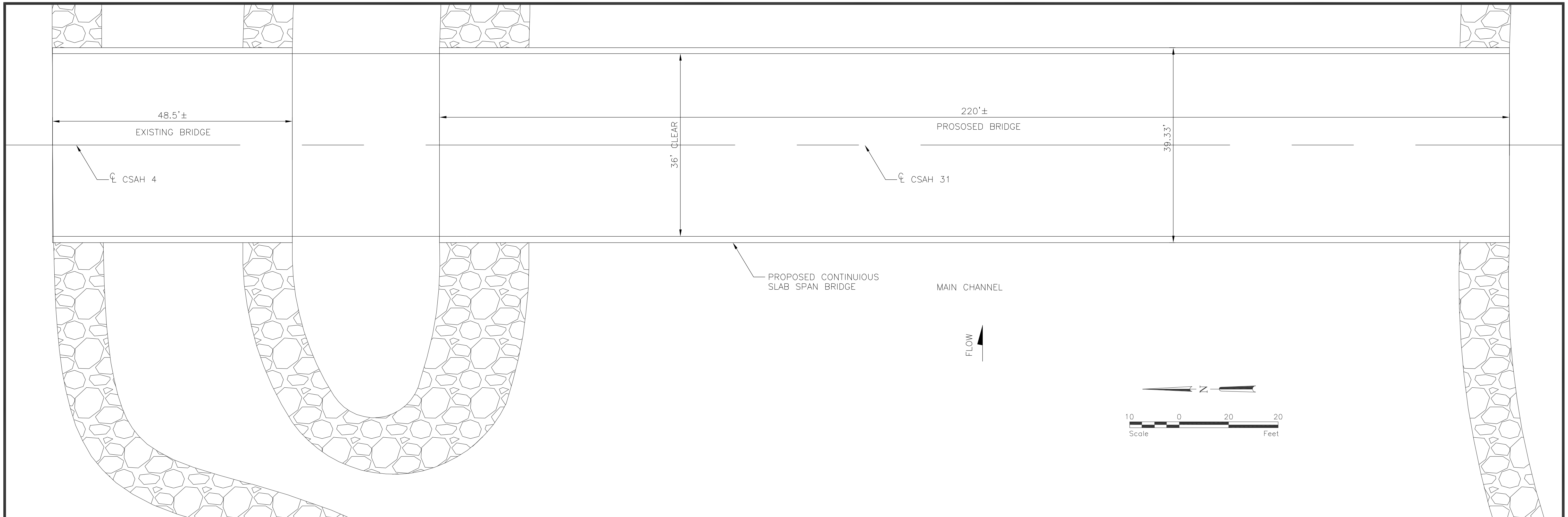
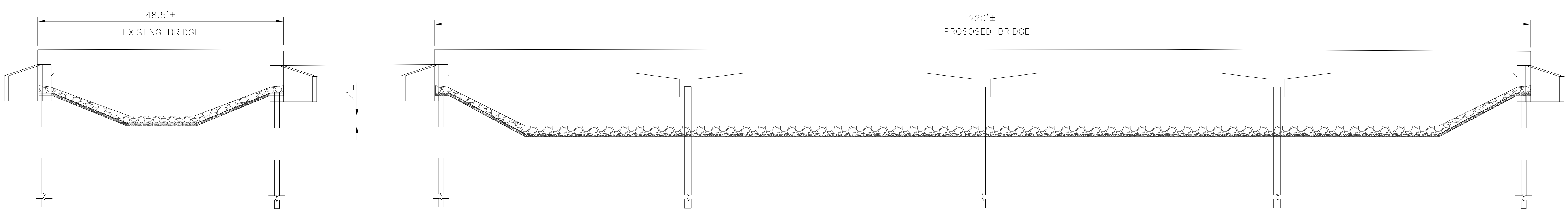
Drawn by: DJL | Date: 01-17-08
Checked by: BHJ | Scale: AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

CR 24 / CSAH 4 / CSAH 31
ROAD IMPROVEMENTS
PROJECT NO. 5304-002

SHEET
4 of 11





No.	Revision	Date	By

Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 TEL: (763) 493-4522
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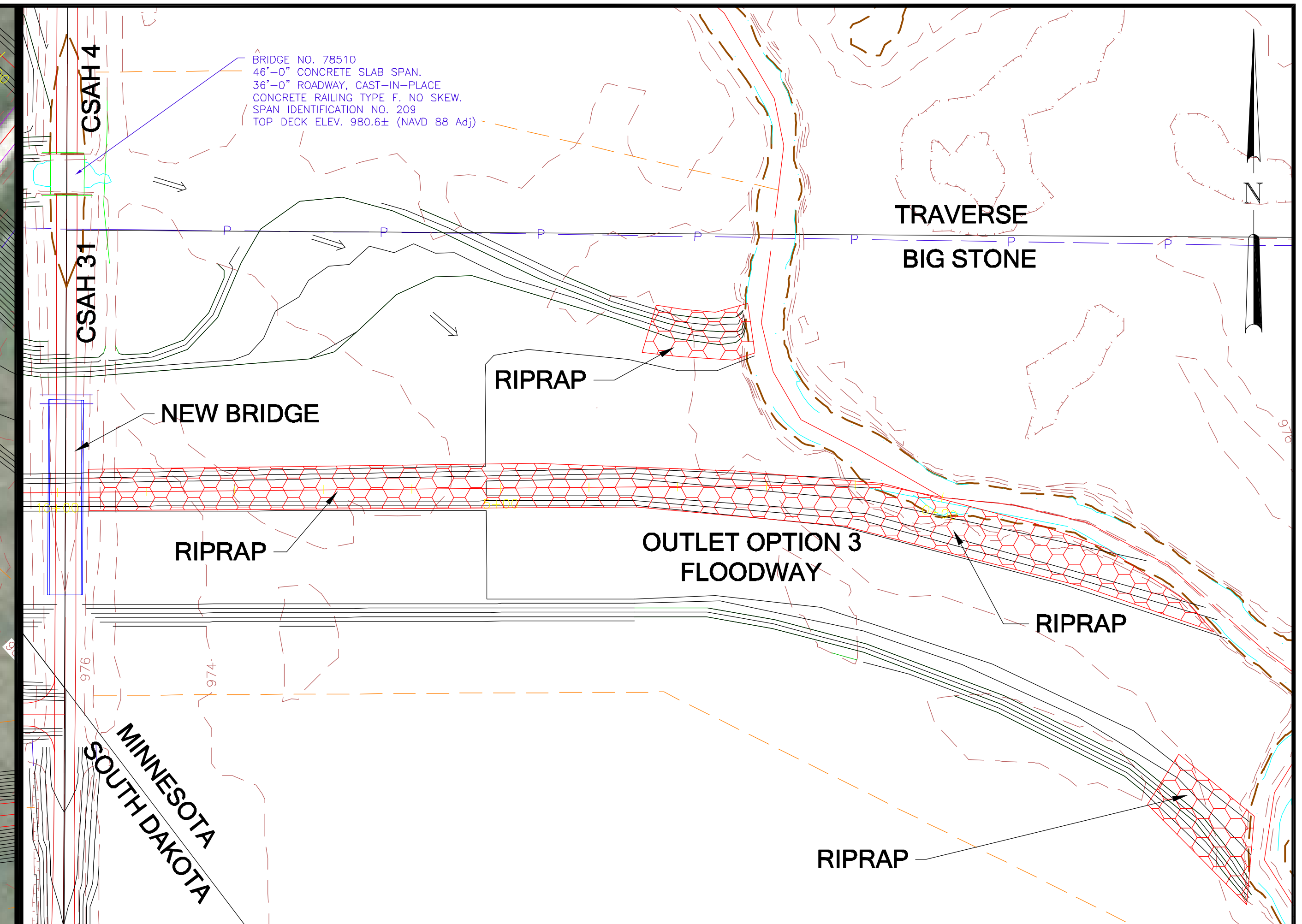
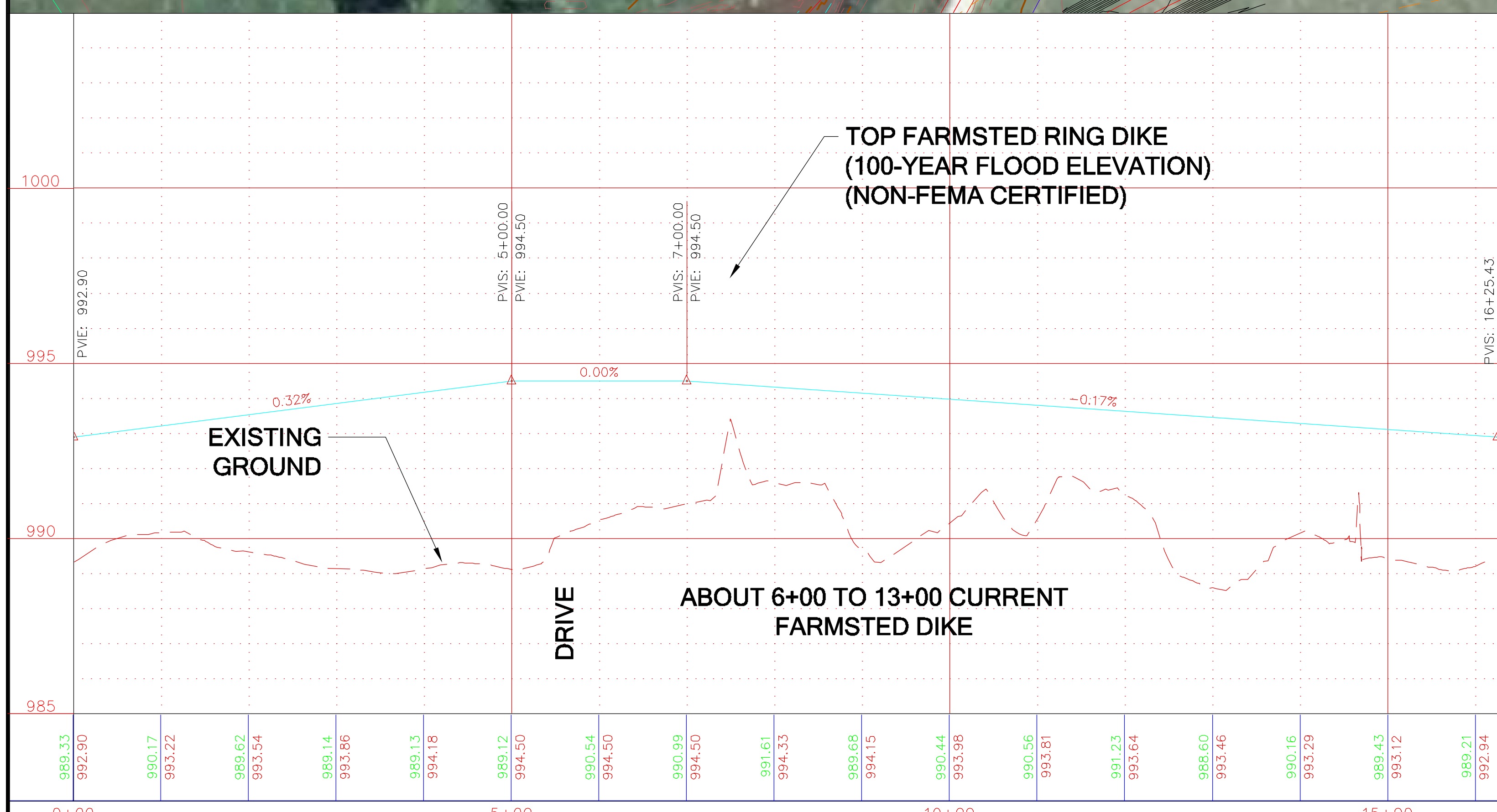
Drawn by	Date
TECH	01-17-08
Checked by	Scale
ENG	AS SHOWN

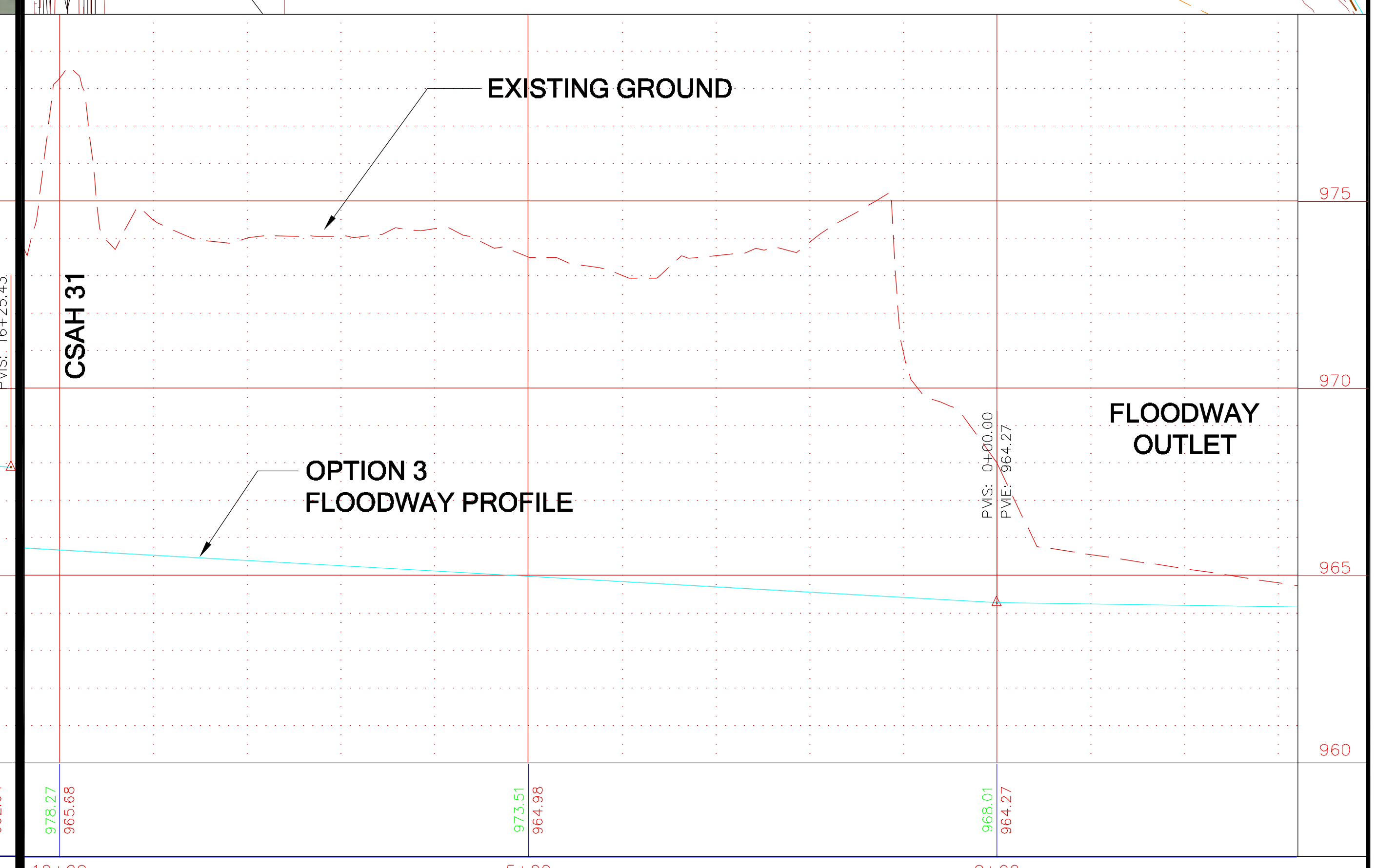
BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

CSAH 31 BRIDGE IMPROVEMENTS
PROJECT NO. 5304-002

SHEET
5 of 11







No.	Revision	Date	By

Scale: 100 0 100 200 Feet

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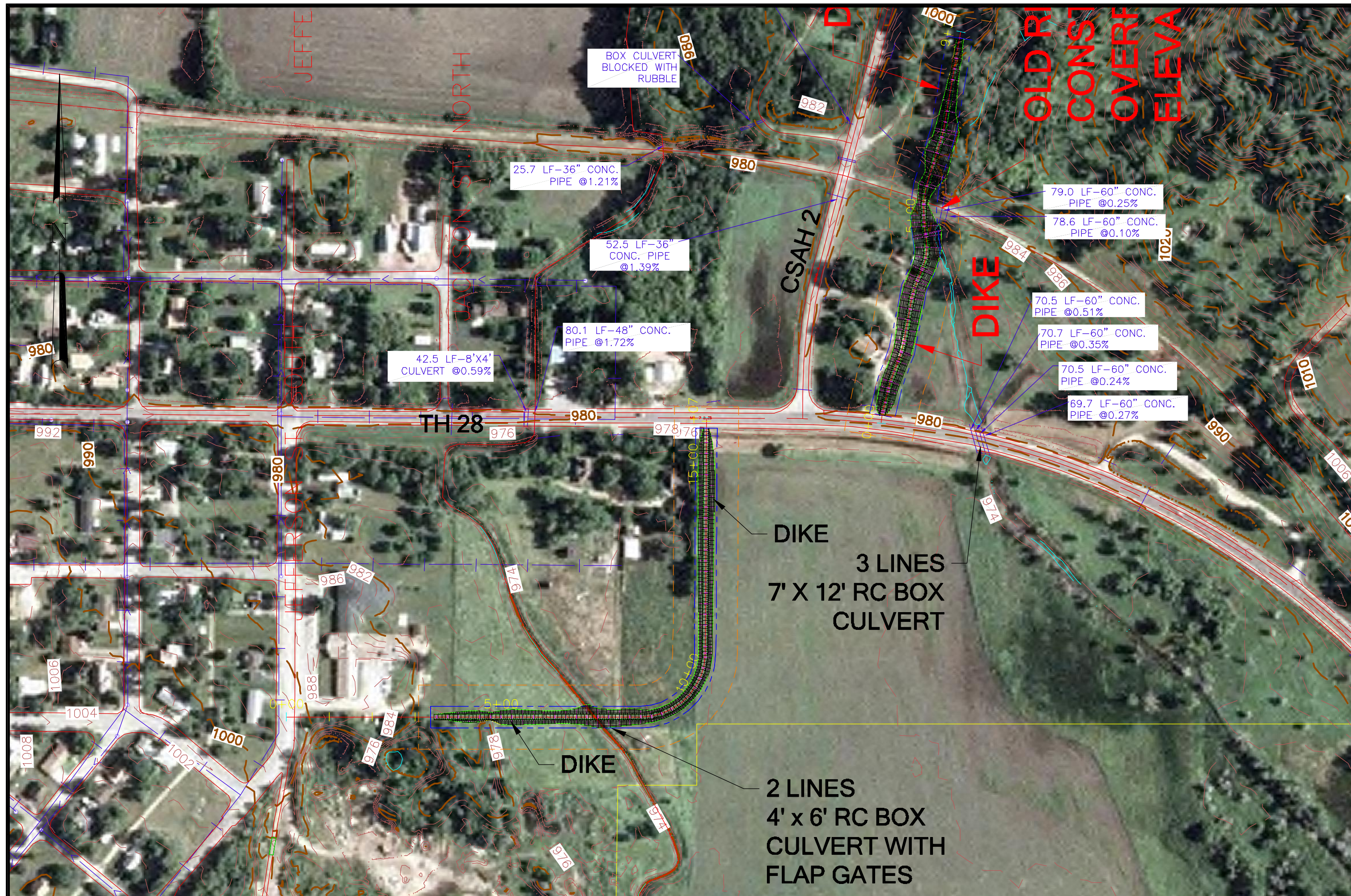
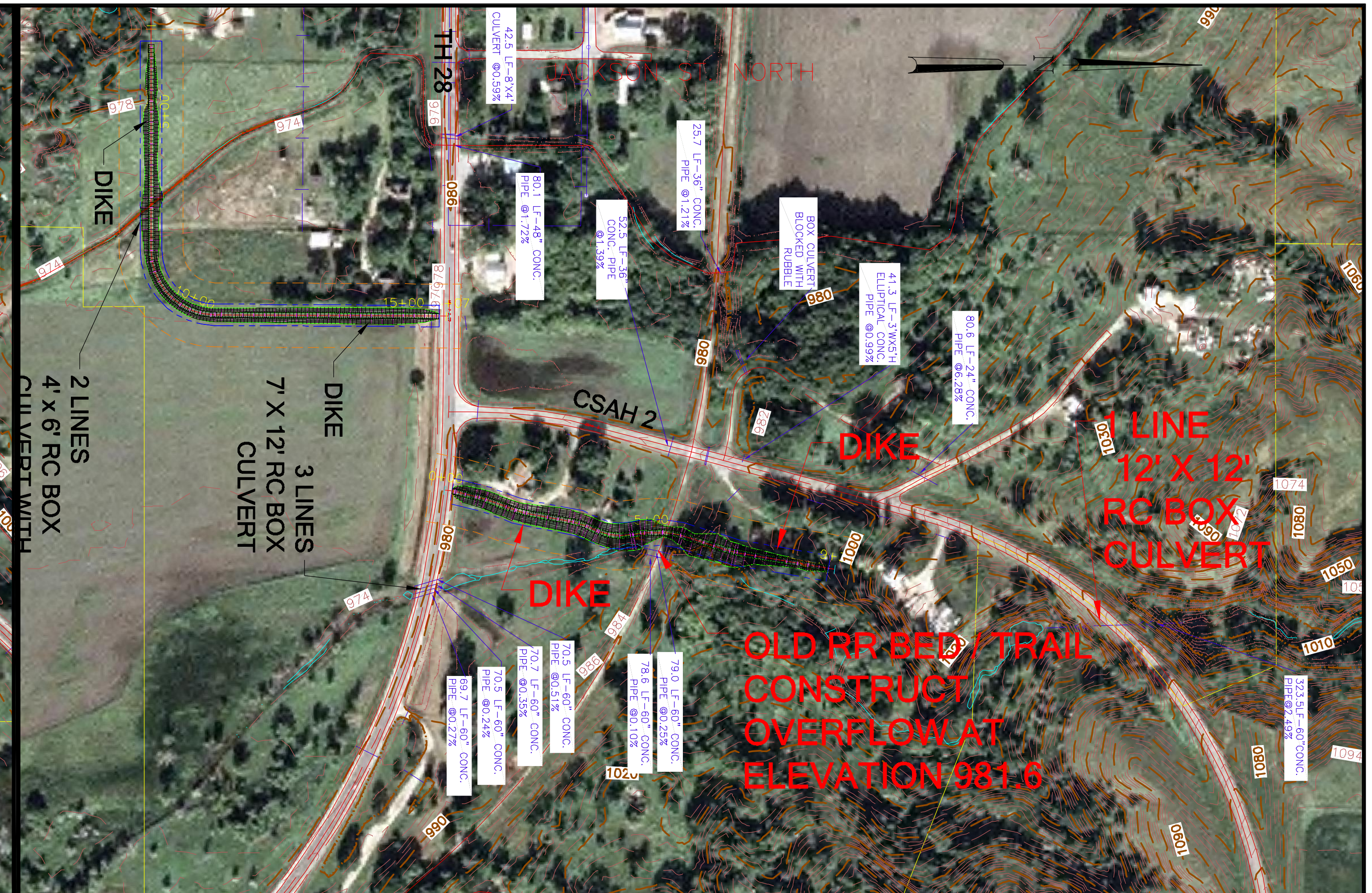
Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

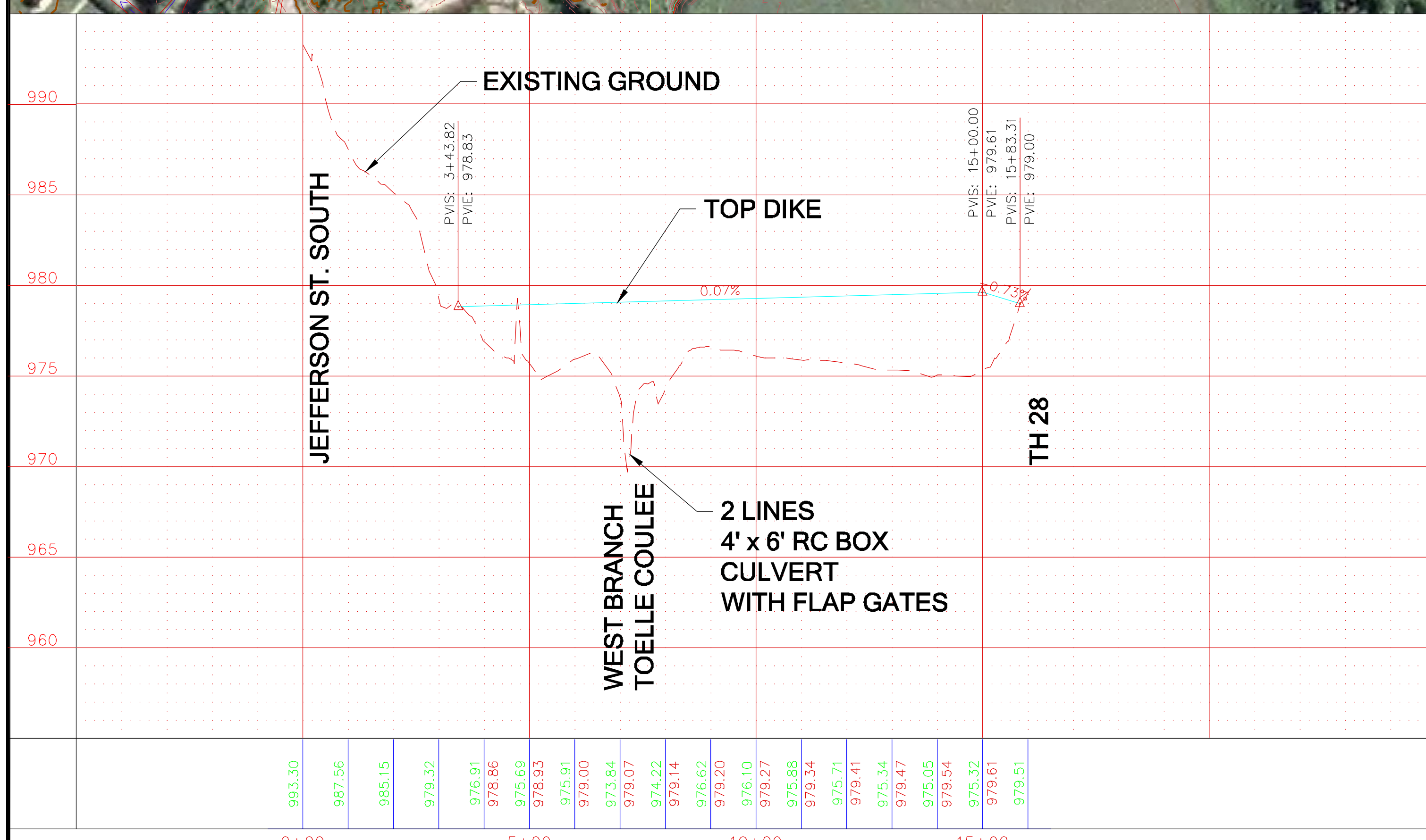
BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

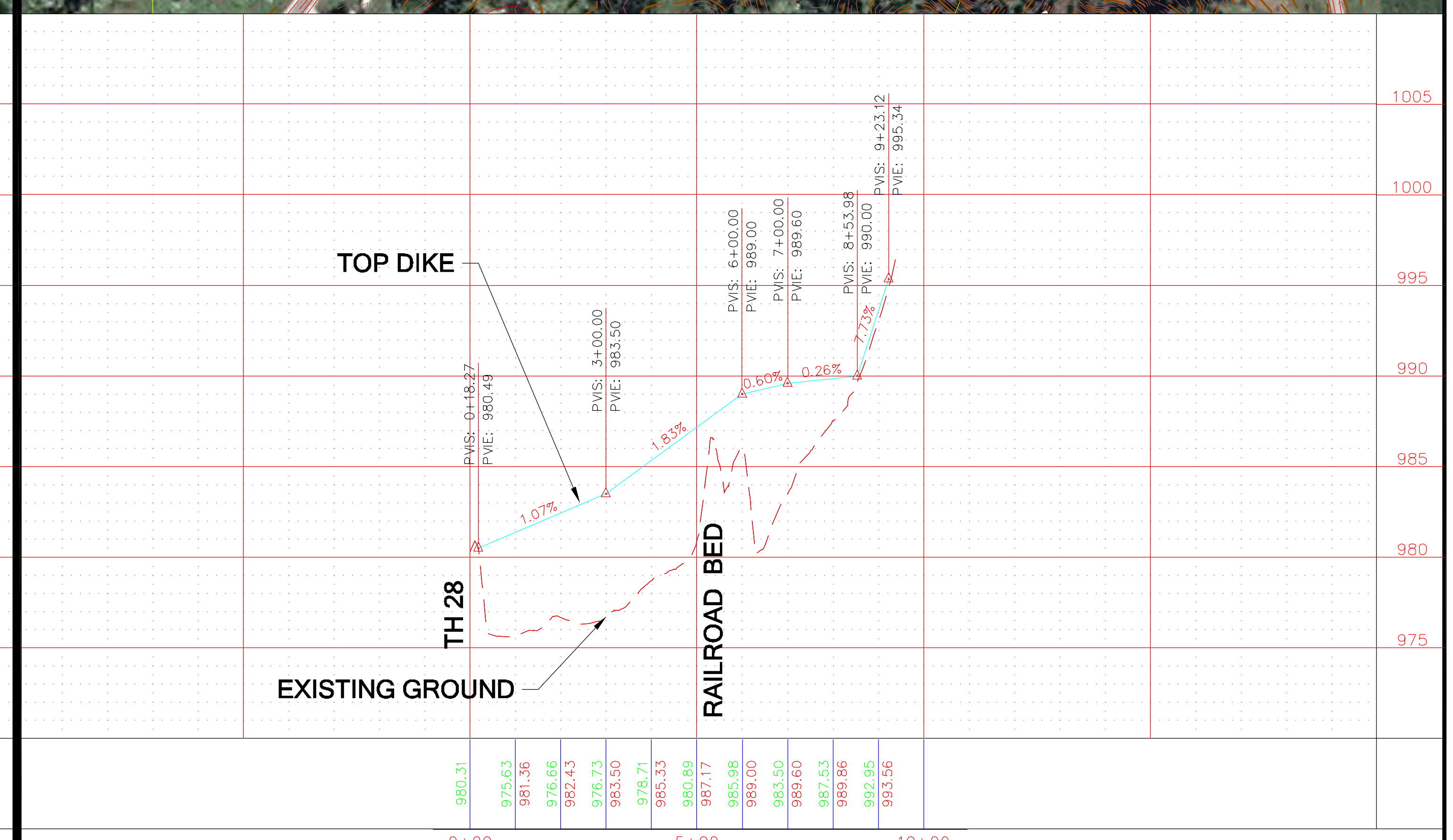
FARM RING DIKE FLOODWAY OUTLET
PROJECT NO. 5304-002

SHEET 6 of 11









No.	Revision	Date	By

Scale: 200 0 200 400 Feet

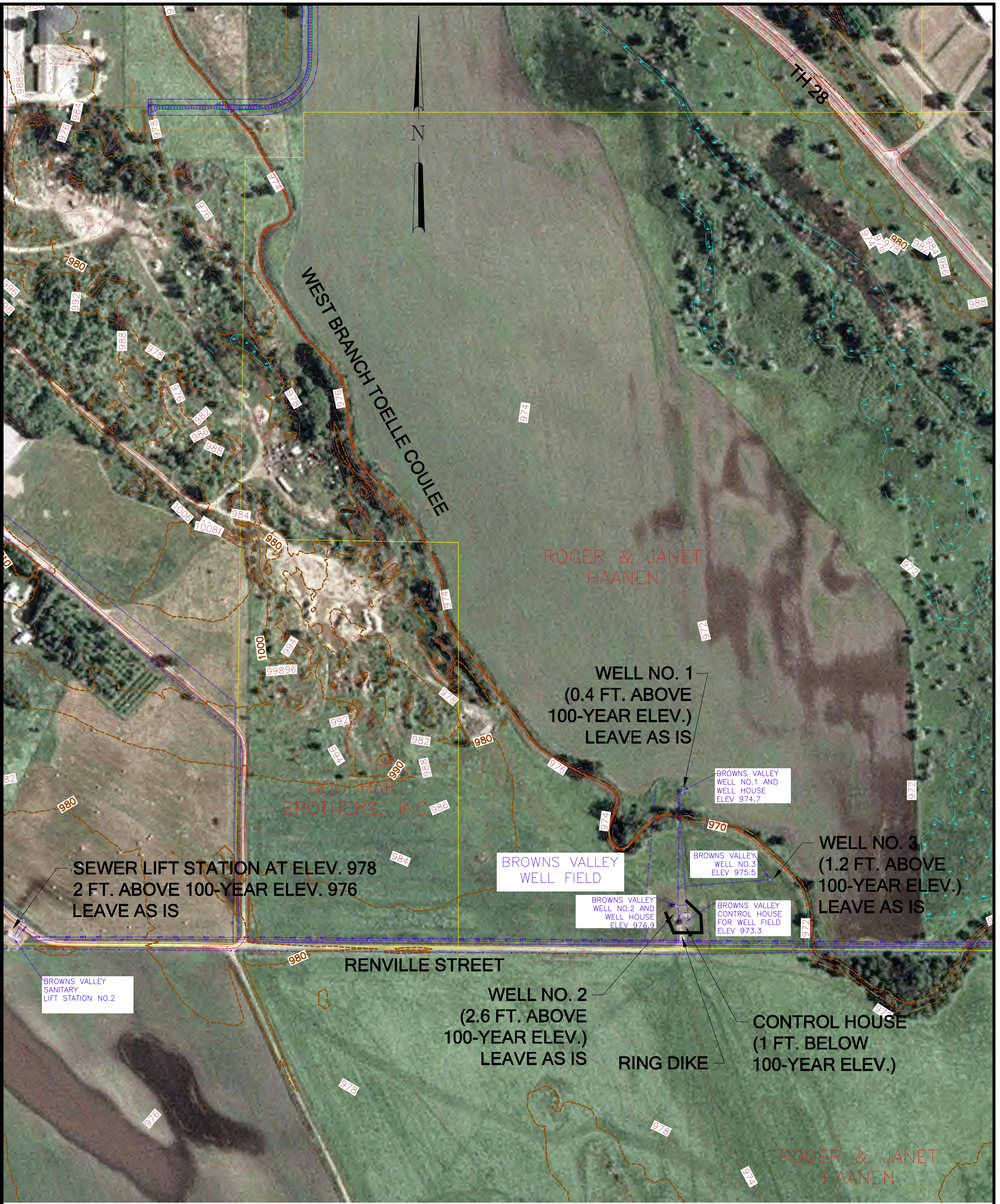
Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140
MAPLE GROVE, MINNESOTA 55369
TEL: (763) 493-4522
FAX: (763) 493-5572

Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

TOELLE COULEE DIKE IMPROVEMENTS
PROJECT NO. 5304-002

WEST BRANCH TOELLE COULEE
CHANNEL EXCAVATION AND CLEANING



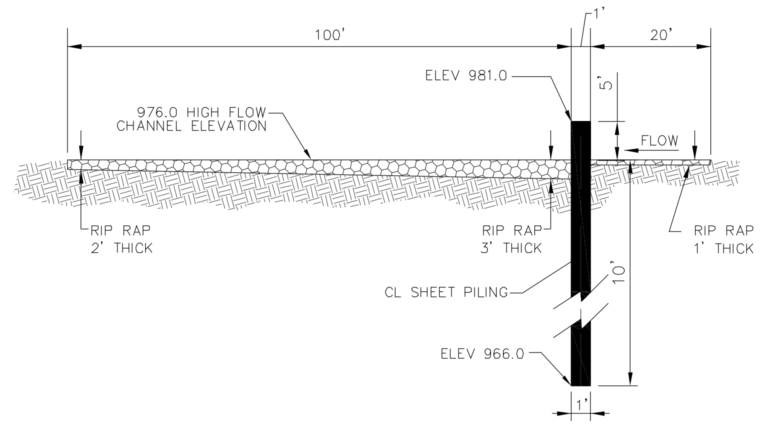
CITY OF BROWNS VALLEY
WELL FIELD AND SANITARY LIFT STATION

No.	Revision	Date	By

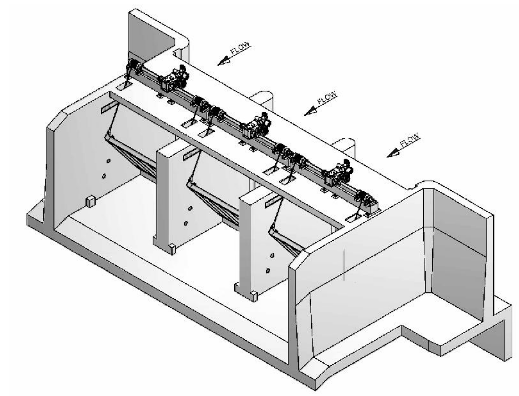
Scale: 200 0 200 400 Feet

Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 MAPLE GROVE, MINNESOTA 55369 TEL: (763) 493–4522 FAX: (763) 493–5572

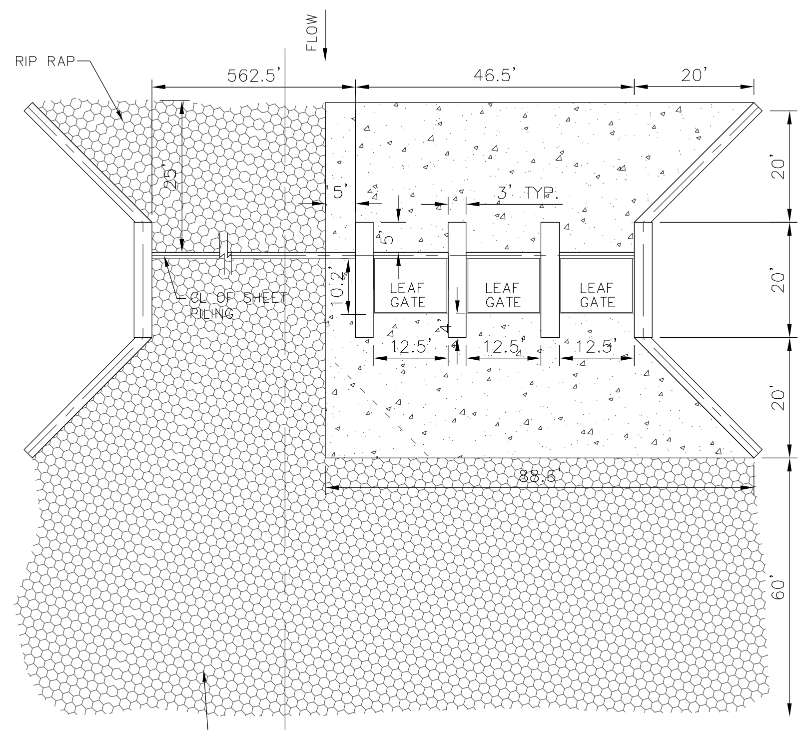
Drawn by	Date			
DJL	01-17-08	BROWNS VALLEY FLOOD MITIGATION PROJECT UPPER MINNESOTA RIVER WATERSHED DISTRICT 342 N.W. 2ND STREET, ORTONVILLE, MN 56278	W. BRANCH TOELLE AND CITY WELL FIELD PROJECT NO. 5304-002	SHEET 8 of 11
Checked by	Scale			
BHJ	AS SHOWN			



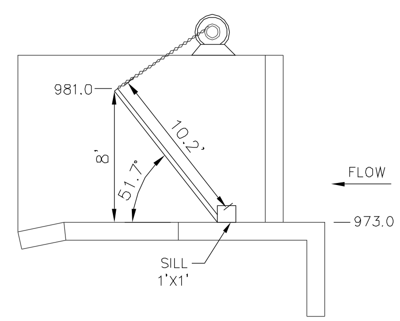
PROFILE AT CENTERLINE OF INLET STRUCTURE
NOT TO SCALE



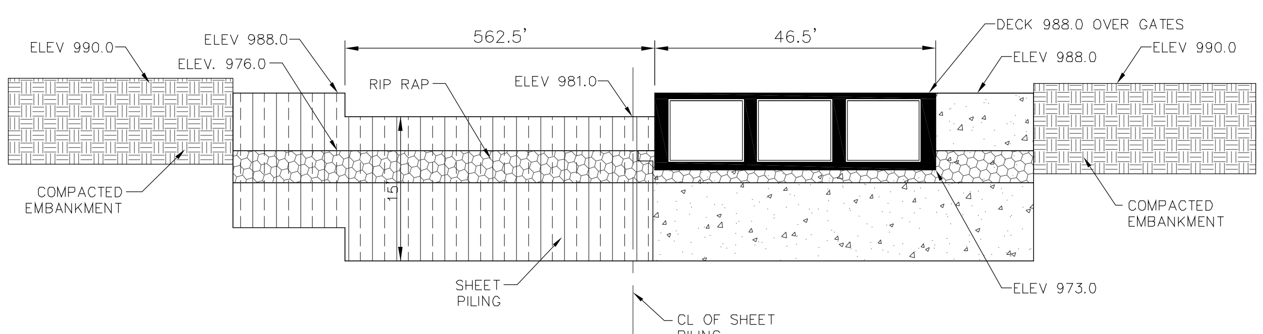
ISOMETRIC VIEW – GATES IN CLOSED POSITION
NOT TO SCALE



OVERHEAD VIEW
NOT TO SCALE



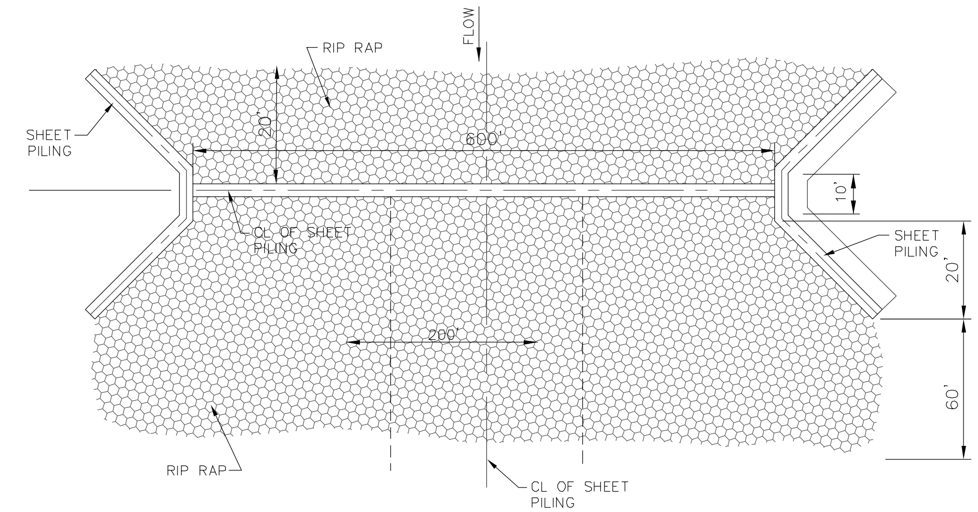
SITE VIEW – GATE STRUCTURE
NOT TO SCALE



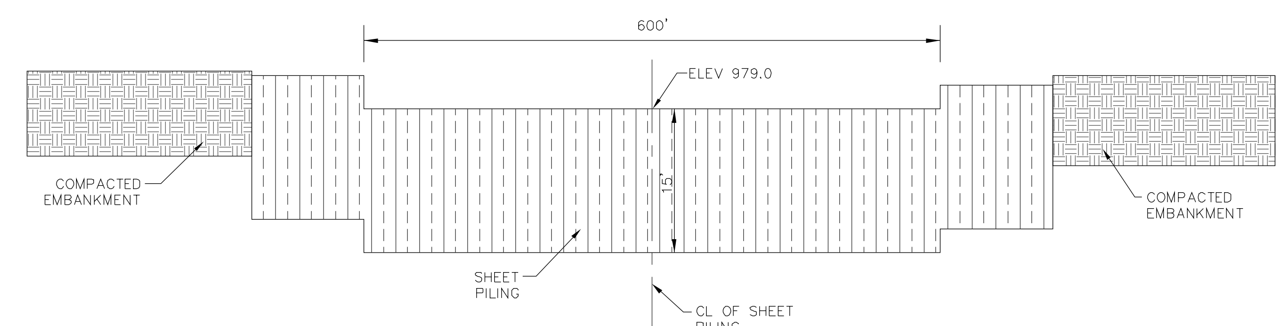
SECTION
NOT TO SCALE

INLET STRUCTURE - WEIR WITH LEAF GATE OPTION

NOT TO SCALE



OVERHEAD VIEW – WEIR W/OUT LEAF GATES
NOT TO SCALE



SECTION
NOT TO SCALE

INLET STRUCTURE - WEIR WITHOUT LEAF GATE OPTION

NOT TO SCALE

No.	Revision	Date	By

Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 TEL: (763) 493-4522
MAPLE GROVE, MINNESOTA 55369 FAX: (763) 493-5572

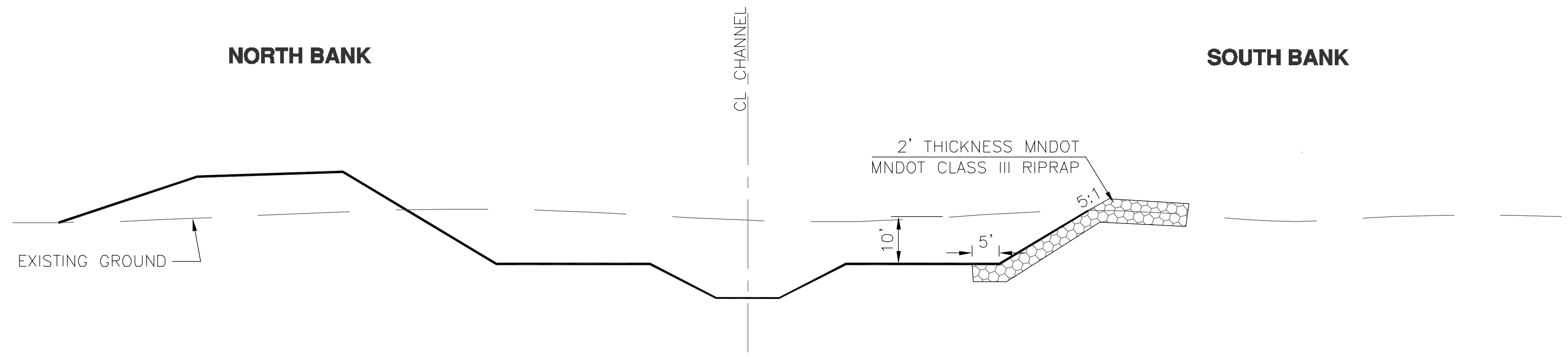
Drawn by DJL	Date 01-17-08
Checked by BHJ	Scale AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

FLOODWAY INLET
TYPICAL DETAILS
PROJECT NO. 5304-002

SHEET
9 of 11

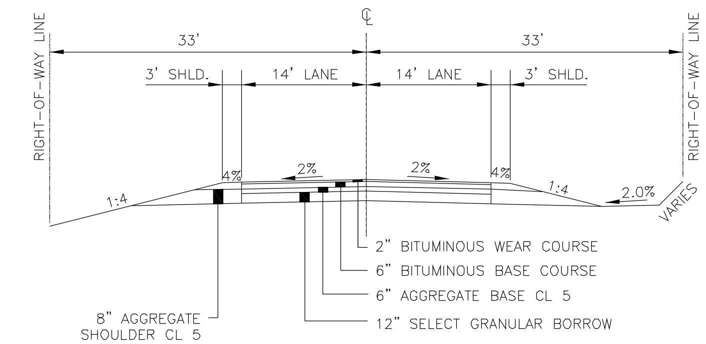
S:\5304-002 Browns Valley Floodway\5304-002_CAD_Civil3d\P1\5304002-09-TD-P1.dwg-Floodway Typ Details-1/15/2008 11:06 AM-(dltterer)



STATION 45+00 R, 55+00 R, AND 63+00 R

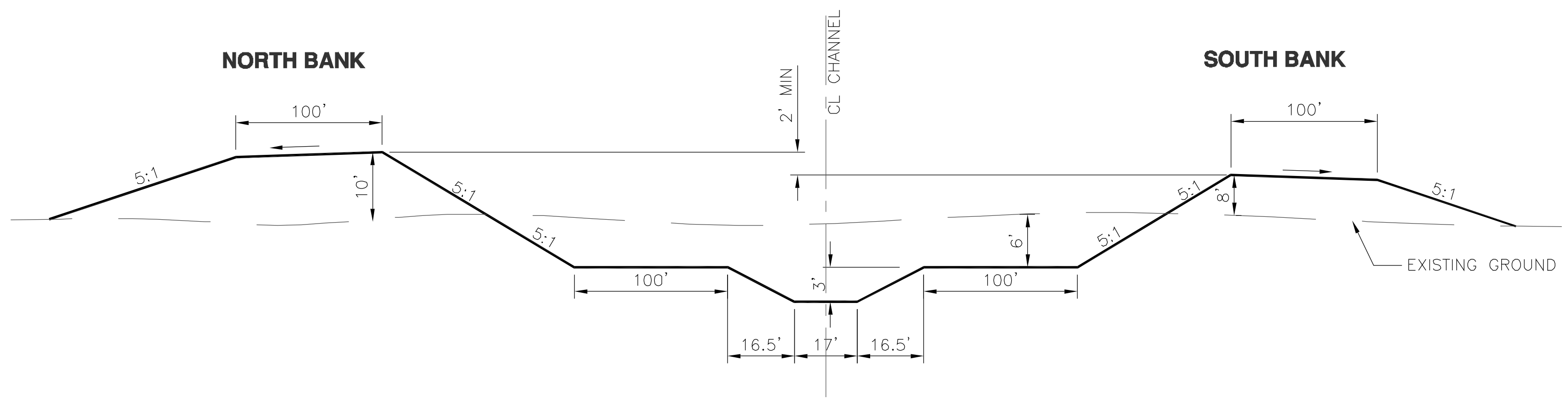
TYPICAL SECTION - ROCK RIPRAP SPILLWAY

NOT TO SCALE



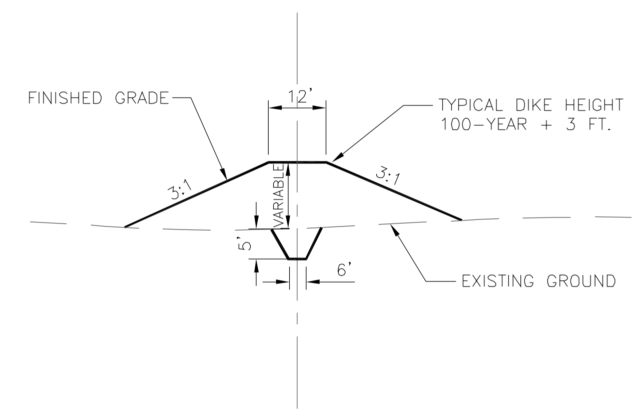
TYPICAL SECTION - PROPOSED CR 24 AND CSAH 4

NOT TO SCALE



TYPICAL FLOODWAY SECTION

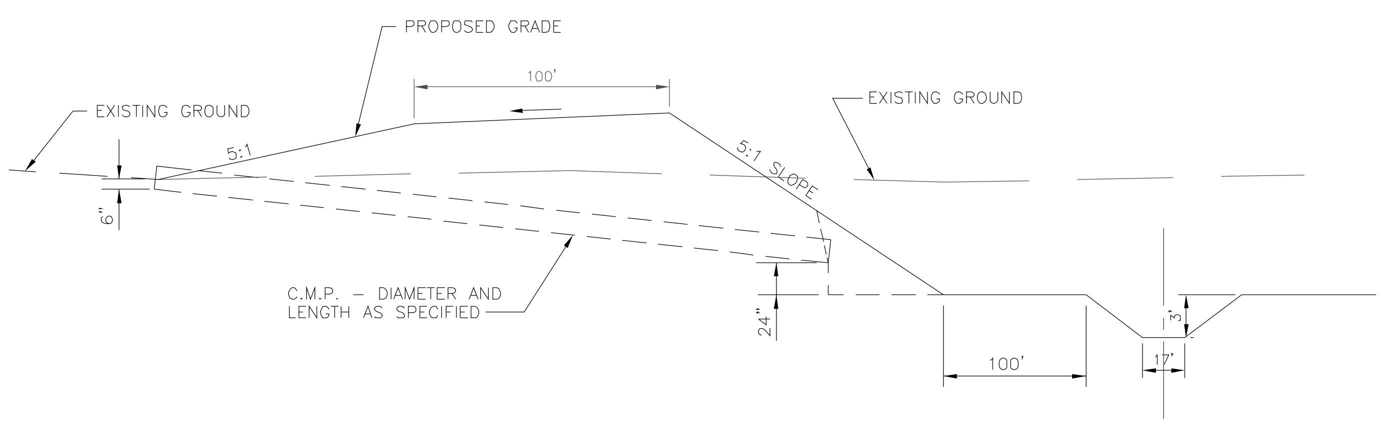
NOT TO SCALE



TYPICAL DIKE SECTION

NOT TO SCALE

Side Inlet Culverts and Spillways						
Station / Location	Diameter (inch)	Type	Length (feet)	Apron	Flapgate	Riprap (cubic yd)
County Road 24 Realignment						
Station 12+00 near Haanen farmstead	48"x78"	CSP-Arch	100	2	0	10
Floodway 3 Passive						
2+00 L	18	CSP	0	1	0	3
2+00 R	18	CSP	0	1	0	3
9+50 R	18	CSP	0	1	0	3
10+50 L	18	CSP	0	1	1	3
10+50 R	18	CSP	0	1	1	3
20+00 L	18	CSP	0	1	1	3
20+00 R	18	CSP	0	1	1	3
30+00 L	18	CSP	0	1	1	3
30+00 R	18	CSP	0	1	1	3
40+00 R	18	CSP	0	1	1	3
44+00 L	18	CSP	0	1	1	3
45+00 L	18	CSP	0	1	1	3
45+00 R		Rock Spillway		0	0	111
55+00 L	18	CSP	0	1	1	3
55+00 R		Rock Spillway		0	0	111
63+00 L	18	CSP	0	1	1	3
63+00 R		Rock Spillway		0	0	104



TYPICAL FIELD INLET SECTION

NOT TO SCALE

S:\5304-002 Browns Valley Floodway\5304-002_CAD_Civil3d\P1\5304002-10-TD-P1.dwg-FW Rd Typ Details-1/15/2008 1:14 AM-(dlitterer)

No.	Revision	Date	By

Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 TEL: (763) 493-4522
MAPLE GROVE, MINNESOTA 55369 FAX: (763) 493-5572

Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

FLOODWAY / ROAD / DIKE
TYPICAL DETAILS
PROJECT NO. 5304-002

PARCEL	SECTION	TOWNSHIP	RANGE	PERMANENT(Acres)	TEMPORARY(Acres)
SE1/4 OF NW1/4	31	125	49	0.98	0.98
NE1/4 OF SW1/4	31	125	49	3.91	1.83
NW1/4 OF SE1/4	31	125	49	26.44	2.31
SW1/4 OF NE1/4	31	125	49	3.65	3.61
NE1/4 OF SE1/4	31	125	49	3.93	1.01
SW1/4 OF SW1/4	31	125	49	4.30	1.54
SE1/4 OF SE1/4	31	125	49	28.24	3.48
NW1/4 OF NE1/4	31	125	49	1.17	1.25
NE1/4 OF NE1/4	6	124	49	1.13	0.58
NW1/4 OF NW1/4	5	124	49	20.27	2.32
SW1/4 OF SW1/4	32	125	49	5.95	1.23
NE1/4 OF NE1/4	30	125	49	0.48	0.00
SE1/4 OF SE1/4	19	125	49	1.86	0.67
SW1/4 OF SW1/4	20	125	49	1.20	1.11
NW1/4 OF NW1/4	29	125	49	12.14	1.80
NE1/4 OF NW1/4	29	125	49	2.40	0.53
NE1/4 OF NE1/4	32	125	49	1.20	1.50
NE1/4 OF SE1/4	33	125	49	0.13	0.43
SE1/4 OF NE1/4	33	125	49	2.53	3.15
SW1/4 OF NW1/4	34	125	49	1.94	3.51
NW1/4 OF NW1/4	34	125	49	0.95	1.01
NW1/4 OF SW1/4	34	125	49	2.57	0.56
NE1/4 OF NE1/4	33	125	49	1.94	1.00
NW1/4 OF NE1/4	33	125	49	0.12	0.07
SW1/4 OF SW1/4	34	125	49	2.49	0.83
SE1/4 OF SW1/4	34	125	49	1.24	0.37
			TOTAL ACRES	133.16	36.68

S:\5304-002 Browns Valley Floodway\5304-002_CAD_Civil3d\P1\5304002-11-PM-P1.dwg-40 ACRE PARCELS-1/15/2008 5:01 PM-(dlitterer)

No.	Revision	Date	By

500 0 500 1000
Scale Feet

Houston Engineering, Inc.
6901 EAST FISH LAKE RD., SUITE 140 MAPLE GROVE, MINNESOTA 55369 TEL: (763) 493-4522 FAX: (763) 493-5572

Drawn by	Date
DJL	01-17-08
Checked by	Scale
BHJ	AS SHOWN

BROWNS VALLEY FLOOD MITIGATION PROJECT
UPPER MINNESOTA RIVER WATERSHED DISTRICT
342 N.W. 2ND STREET, ORTONVILLE, MN 56278

RIGHT OF WAY

PROJECT NO. 5304-002

SHEET