RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

REVISED: April 11, 2011

TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENTS

EXHIBITS

C1.0 RED RIVER DIVERSION - BACKGROUND AND OVERVIEW

C1.1 NEED FOR STUDY

The Red River has posed a repeated threat to the communities of Fargo, ND and Moorhead, MN as it has reached minor flood stage at 18 feet at least once each year since 1993. Although the communities have demonstrated significant ability in defending themselves against floods, the efforts can be massive and highly disruptive to the communities and their residents. Through the years, various flood protection plans have been formulated to protect portions of these communities and some of these plans have been developed and implemented to varying degrees. This study looks at the potential to develop a single comprehensive system to address flooding for the entire Fargo-Moorhead Metropolitan Area. Appendix A of this report covers the hydrology used in the modeling analysis for this study and Appendix B documents the development of the base condition unsteady flow models for this phase. This appendix, Appendix C, presents the unsteady flow hydraulic modeling and design of a Red River Diversion and its impacts on the Red River and its tributaries for the Locally Preferred Plan (LPP) with upstream staging. It also presents updated impact information for the Federally Comparable Plan (FCP) as presented in Phase 3.1 of the feasibility study.

C1.2 RELATED STUDIES AND PROJECT EVOLUTION

This report documents the fourth phase of the Fargo-Moorhead Metro Flood Risk Management Study-Feasibility Study. The first phase of the study began with a draft report issued by the United States Army Corps of Engineers (USACE) in March of 2009, and since that time multiple reports and updates have been published as the study has progressed. A summary of this progression is shown below:

Study Phase	Report Date	Hydrology Phase	Notes
Phase 1	March 2009	Phase 1	Draft Report March 2009 by US Army Corps of Engineers
Phase 2	August 2009	Phase 2	Initial work by Moore Eng, and Others
Phase 2	October 2009	Phase 2	Low Flow Analysis
Phase 2 Part 2	December 2009	Phase 2	Updated in January 2010
Phase 2 Part 2	January 2010	Phase 2	Northwest Diversion
Phase 3	May 2010	Phase 3	Hydrology updated for Wet and Dry cycles
Phase 3 (3.1)	July 2010	Phase 3.1	Hydrology amended, study limited to LPP and FCP
Phase 4	January 2011	Phase 4	Unsteady state design for LPP
Phase 4	February 2011	Phase 4	Update to January 31, 2011 Phase 4 report
Phase 4	April 2011	Phase 4	Update to February 28, 2011 Phase 4 report

For additional detail on how the discharges changed from Phase 1 through Phase 3.1, refer to Appendix A in the July 30, 2010 report. Attachment C1 of this report (Appendix C) contains an excerpt of pages A4 through A7 of the July 30, 2010 report. Consistent with the reports for previous phases, this report is meant to stand alone. It includes adequate information from previous reports, or specific references to the location of the information, in order to provide the reader with enough information to follow this report. Subsequent parts of this section of the report will provide a brief summary of the previous phases of this study.

C1.2.1 Ongoing FEMA Restudy. Since prior to the 1997 flood, FEMA has been in the process of updating the Flood Insurance Rate Map (FIRM) for the area of Cass and Clay counties in the vicinity of Fargo and Moorhead. Two studies in particular have defined the hydrology and hydraulics for much of the area along the Red River adjacent to the two cities. They include the "Stanley and Pleasant Townships, Cass County, ND and Holy Cross and Kurtz Townships, Clay County, MN Flood Insurance Study" (which was formerly referred to as "Flood Insurance Restudy for Southern Cass County, North Dakota, and Clay County, MN" in the Phase 3 report) (Reference A), which defines the hydrology and hydraulics for the area south of Fargo, and the "City of Fargo, North Dakota Flood Insurance Study" (formerly referred to as "City of Fargo CTP Project, Clay County/Oakport Township" in the Phase 3 report) (Reference B), which defines the hydrology and hydraulics through the Fargo-Moorhead area. The model developed by FEMA as part of these efforts served as the basis for hydraulic modeling on the Red and Wild Rice Rivers during the initial phase of the study.

C1.2.2 August 31, 2009 Report. In August 2009, a report entitled "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 2, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN," (Reference C) was completed. That report looked at a variety of alternatives of sizing and flows for a Red River Diversion. Specifically, four alignments were considered around the Fargo-Moorhead (FM) Metro Area. Two of the alignments were considered on the Minnesota side. The Minnesota Long Diversion is the same alignment as the Minnesota Short Diversion downstream of a point west of Sabin, MN. Upstream of that location, the Minnesota Long Diversion alignment extends farther south to intersect the Red River at a location approximately three miles to the south. The two North Dakota alignments are also similar. The primary difference between the North Dakota West Diversion and the North Dakota East Diversion is the portion of the channel between Horace and West Fargo and how they utilize the existing right of way for the Sheyenne River Diversion. The East alignment was developed so that it closely followed the current Sheyenne River Diversion alignment within this area. Figure B1 in the August 2009 report provides a layout of the four alignments from this phase of the study. In addition to the four alignments, nine (9) options of flow in the Red River Diversion were considered. They include:

1. MN Short Alignment 45 Kcfs Alternative
2. MN Short Alignment 35 Kcfs Alternative
3. MN Short Alignment 25 Kcfs Alternative
4. MN Long Alignment 45 Kcfs Alternative
5. MN Long Alignment 35 Kcfs Alternative
6. MN Long Alignment 25 Kcfs Alternative
7. ND West Alignment 45 Kcfs Alternative
8. ND West Alignment 35 Kcfs Alternative
9. ND East Alignment 35 Kcfs Alternative

C1.2.3 Low Flow Modeling. In October 2009, a report on low flow conditions entitled "Appendix H - Red River Diversion Hydraulic Structure Velocities" (Reference D) was completed. This report was developed as an additional appendix to the August 31, 2010 report (Reference C). The purpose of this portion of the overall study was to gain a better understanding of the Red River under frequent flooding events smaller than the 50-percent chance (2-year) event. This analysis was particularly important in looking at fish passage. At this point in the study, the diversion inlet control weir was set higher than the 50-percent chance water surface elevation, so the diversion channel was not utilized for low flows and the Red River Control Structure was allowed to remain fully open. Therefore, the model used for this analysis only involved the main channel and the Red River Control Structure. The low flow events below the 50-percent chance event considered were:

1. 80% Exceedence or a 1.25-year recurrence
2. 90% Exceedence or a 1.11-year recurrence
3. 95% Exceedence or a 1.05-year recurrence
4. 99% Exceedence or a 1.01-year recurrence
5. 50 cfs which was estimated at 99.99% Exceedence

C1.2.4 December 31, 2009 (Updated January 6, 2010) Report. In December 2009, a report entitled "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 2, Part 2, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN" (Reference E) was completed. That report updated the progress of the study and updated the hydrology to Phase 2 Hydrology. Phase 2 Hydrology was developed to update the Red River hydrology to incorporate the 2009 flood event. This report was further updated in January of 2010. As part of this phase of the study, the number of alignments was reduced to two, the Minnesota Short Alignment and the North Dakota East Alignment. No significant changes were made to the alignments from the previous phase. One of the goals with this phase was to determine the National Economic Development (NED) Alternative; therefore, several flow options were considered. These flow options were primarily for the Minnesota Short Alignment because the information presented in the August 31, 2009 report and the subsequent cost/benefit analysis clearly indicated that the NED plan would be associated with this alignment. The options on the North Dakota side were included at the request of the local project sponsors as this was their preferred alignment option. The flow options considered were:

1. MN Short Alignment 10 Kcfs Alternative
2. MN Short Alignment 15 Kcfs Alternative
3. MN Short Alignment 20 Kcfs Alternative
4. MN Short Alignment 25 Kcfs Alternative
5. MN Short Alignment 30 Kcfs Alternative
6. MN Short Alignment 35 Kcfs Alternative
7. ND East Alignment 30 Kcfs Alternative
8. ND East Alignment 35 Kcfs Alternative

<u>C1.2.5 Northwest Diversion.</u> In January 2010, a report was completed on the Northwest Diversion Alternative (Reference F). The Northwest Diversion Alternative was created as a means to deal with flooding north of Fargo and West Fargo from the Sheyenne River and its tributaries if a Minnesota Diversion Alternative was constructed. This diversion needed to consider not only a Red River flood but also local flooding from the Sheyenne River itself. The hydraulic model used for this part of the study used an unsteady model of the Red River and its tributaries, which was under development to look at downstream impacts of the project. The model was reduced to the portion dealing with the Sheyenne River system. The local flood events considered for this part of the study were the 10, 2, 1 and 0.2-pecent chance events.

<u>C1.2.6 May 17, 2010 Report.</u> In May 2010, a report entitled "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 3, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN" (Reference G) was completed. That report updated the study progress and hydrology. Phase 3 Hydrology was developed as part of a need to look at the Red River hydrology as two dissimilar periods of record. One period of record was characterized as "Wet" while the other was characterized as "Dry". From these two records, hydrology was developed for the project year zero, project year 25, and project year 50. Project year zero has the greatest flow through the FM Metro with decreasing flows in the subsequent two project year time periods. Because of this, it was necessary to run models for each alternative and flow option for the three project time periods. Additional discussion on this aspect of the hydrology is provided in Appendix A – Hydrology of the May 17, 2010 report. As part of this phase, only two Red River Diversion alignments were considered: Minnesota Short Alignment and North Dakota East Alignment. With new hydrology, it was necessary to revise the NED analysis. The NED analysis focused on the Minnesota Short Alignment. The North Dakota East Alignment 35 Kcfs alternative was also considered due to being chosen as the Locally Preferred Plan (LPP). The flow options for the Red River Diversion considered during this phase were:

1. MN Short Alignment 20 Kcfs Alternative
2. MN Short Alignment 25 Kcfs Alternative
3. MN Short Alignment 30 Kcfs Alternative
4. MN Short Alignment 35 Kcfs Alternative
5. MN Short Alignment 40 Kcfs Alternative
6. MN Short Alignment 45 Kcfs Alternative
7. ND East Alignment 35 Kcfs Alternative

Following this analysis, the NED plan was determined to be the Minnesota Short Alignment, 40 Kcfs plan.

C1.2.7 July 30, 2010 Report (Phase 3 with Phase 3.1 Hydrology). With the May 2010 Phase 3 report, it was noted that Phase 3 Hydrology significantly increased the flows through Fargo, yet the flows further downstream, at locations such as Halstad and Grand Forks, did not increase significantly and were similar to values used in Phase 2 Hydrology. Further refinement of the hydrology, particularly with the Sheyenne River coincidental flows, resulted in improved results. Given the importance of the Sheyenne River on project parameters, a revision to the Phase 3 Hydrology was developed. Because this new hydrology did not represent a fundamental update but rather a smaller change, it was referenced as Phase 3.1 for the study. On July 30, 2010, a report entitled "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 3 (Phase 3.1 Hydrology), Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN" (Reference H) was published. This report included the updated project design information based on the Phase 3.1 Hydrology. For more details on Phase 3 and Phase 3.1 Hydrology, see Appendix A – Hydrology in the July 30, 2010 report. While the updated hydrology is the fundamental difference between this report and the May 17th version, minor revisions to the diversion alignments were also incorporated into the updates. At this point, the project was narrowed down to two alternatives. These two alternatives represent the Federally Comparable Plan (FCP) and the Locally Preferred Plan (LPP) plan, which were:

1. MN Short Alignment 35 Kcfs Alternative - FCP
2. ND East Alignment 35 Kcfs Alternative – LPP

After the July 30, 2010 report was released, the design of the FCP diversion channel was modified to account for updated geotechnical data provided by the USACE. These changes were completed and documented on August 11, 2010, but the revised report was not officially released. Although the revised design was never officially published, it is considered the FCP for Phase 4 of this study and the impacts and results included in the Phase 4 report are based upon the updated FCP diversion channel design. Because the modifications to the FCP design had not previously been published, Appendix B of the August 11, 2010 report has been included in this version of the Phase 4 study report as Attachment C2 in order to document the current FCP design. In short, the FCP diversion channel was modified due to concerns with hydrostatic water pressure potentially causing uplift on the bottom of the channel. To account for this, the channel bottom was raised four feet beginning at approximately 43rd Avenue North and extending south (upstream) to the inlet of the diversion channel. The slope of the channel bottom remained the same, but it was necessary to include a sheet pile and riprap drop structure to ensure channel stability at the location of the four foot drop. Downstream of this location, the channel remained unchanged from the original Phase 3 design. Upstream of this location, the channel was widened from 225 feet to 400 feet to account for the reduced channel capacity. For the reach between 43rd Avenue North and I-94, the side slope of the channel was flattened from 7:1 (H:V) to 10:1 (H:V) to address additional stability concerns. The current FCP alignment is shown in Figure C1. The project plan drawings included in Appendix D of the Phase 4 report provide typical cross sections for the FCP diversion channel as well as a more detailed plan view of the alignment.

C1.3 PHASE 4 SUMMARY

C1.3.1 January 31, 2011 Report. After the downstream impacts of the project developed in Phase 3 were analyzed, it was determined that they were not fully definable and another approach was needed. Following the consideration of multiple options, the USACE and local project sponsors decided to pursue an option that included raising the water levels, or staging, upstream of the FM Metro area. While this would impact homes and properties on the upstream side of the project, this option allows the impacts to be fully defined and there are fewer structures affected by shifting the impacts upstream and the mitigation measures are also less costly for the upstream staging option. In addition to utilizing the existing topography, much of which is already inundated by flooding, this concept would also include constructed storage areas, specifically an area identified as Storage Area 1 that would provide some control on the storage and subsequent release of the water to help with the timing and the impacts at peak flood stage. These concepts were incorporated into Phase 4 of the project. The initial analysis for this phase was documented in a January 31, 2011 report entitled “Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN” (Reference I).

In order to develop a design that incorporates the benefits of the upstream storage and staging, the design for this phase required the use of unsteady state modeling techniques. Up until this point, unsteady flow models had only been used to analyze the impacts of the project designs that had been developed with steady state methods, which are simpler and less time intensive to use. Phase 4 involved extensive upgrades to the existing unsteady state existing conditions models followed by full project design utilizing these models to analyze the benefits of upstream storage and staging. This phase involved only the redesign of the Locally Preferred Plan (LPP), which is the North Dakota East Diversion. The design for the Federally Comparable Plan (FCP) completed in Phase 3, as discussed in Attachment C2 of this appendix, is adequate since the project impacts have been fully defined and upstream staging is not required to fully define these impacts. Therefore, no updates were completed for the FCP as part of Phase 4. The background information on the FCP design and other information on the alternatives on the Minnesota side of the Red River can be found in Attachment C2 and reports for earlier phases of this study. However, the FCP design was analyzed with the updated models developed for Phase 4 to evaluate the downstream impacts and the results were included in the report.

C1.3.2 February 28, 2011 Report. Following the review of the January 31, 2011 report and the completion of additional information that was not included in that report, most notably Appendix F, which details the structural design of the hydraulic structures, an updated version of the report was published on February 28, 2011. Appendix C of this report included documentation on the comments developed from the internal Quality Assurance/Quality Control (QA/QC) review and the responses to those comments. Also included in this version was some discussion on future updates and improvements that could be made to the models, most of which simply could not be completed on the timeline allotted for this phase. It should be noted that the results associated with the February 28, 2011 version of the report are different from those included in the January 31, 2011 report due to changes that were incorporated after the QA/QC review. The February 28, 2011 report was submitted for Agency Technical Review (ATR).

C1.3.3 April, 2011 Report Summary. Following the ATR review conducted on the February 28, 2011 Phase 4 submittal, the report was updated to account for the comments provided by the ATR reviewers. The comments on Appendix C were minimal and have been addressed within the April 11, 2011 version of the report. In addition to these changes, other updates were added to this version, most notably the inclusion of Attachment C2 which provides documentation on the design of the current FCP originally designed during Phase 3 of the project but never officially documented. The April 11, 2011 report will be the final documentation for the primary LPP and FCP analysis for Phase 4.

C1.3.4 Supplemental Studies. After the February 28, 2011 submittal for Phase 4 of the primary study, a supplemental study was commissioned by the local project sponsors to investigate alternative design scenarios for the LPP. These alternatives included larger or smaller configurations for Storage Area 1, the inclusion of additional storage areas, the elimination of storage areas with an increase in upstream staging and eliminating upstream staging by implementing the Phase 3 design. A scenario with the alignment of the diversion extended south to protect the Oxbow/Hickson area was also analyzed. The results of this supplemental study were documented in a report entitled "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, Alternative Scenarios Analysis, Report for the cities of Fargo, ND & Moorhead, MN" (Reference J) which was published on April 8, 2011.

C2.0 RED RIVER DIVERSION – HYDRAULIC DESIGN

C2.1 OVERVIEW

As stated above, prior phases of this study were completed with steady state modeling techniques, with subsequent unsteady state analysis completed in some instances to determine related impacts. With the project hydrology identified in Appendix A and a change in the design criteria stipulated for the Phase 4 design, unsteady state models are required in order to implement the upstream storage and staging aspects of the project into the design. Additionally, the unsteady flow models also provide a better representation of the flows through the floodplains and a better assessment of the contributions from the tributaries, with respect to timing and magnitude, to flooding within the Red River of the North floodplain. This was a fundamental change in the modeling effort and while some of the preliminary analysis could be completed with steady state models, the bulk of the design requires unsteady state models.

Prior to Phase 4, unsteady state models were being developed in a parallel effort with the project design. Those models were then used to analyze the diversion designs for downstream impacts. These unsteady state models provided a starting point for the models required for Phase 4, but an extensive effort was necessary to generate the necessary base condition models required to begin the design process. With nearly 900 storage areas and 2,000 cross sections, the resulting models are a large collection of interconnected storage areas, river reaches and junctions that utilize the most recent unsteady state hydrology data to reflect real world conditions to the greatest extent possible.

C2.2 MODEL HYDROLOGY

The Phase 3.1 design included three sets of hydrology, which were based on "wet" and "dry" hydrology scenarios covering project year zero, project year 25 and project year 50 (See Attachment C1). This data allowed for the project to be analyzed for the expected changes in hydrologic conditions over the life of the project. For each of these scenarios, the project designs were analyzed for the 20, 10, 5, 2, 1, 0.5 and 0.2-percent chance events. Additional analysis was also completed for lower flow conditions (events smaller than the 20-percent chance event), and for extremely large events such as the 0.1 and 0.01-percent chance events. The Phase 4 design is based only on the hydrology outlined in Appendix A of this report, which includes hydrology based on the "wet", project year zero conditions.

<u>C2.2.1 Design Event Hydrology.</u> The Phase 4 design has been designed for only the 10, 2, 1 and 0.2-percent chance events, in all cases using the hydrology scenario corresponding to project year zero. The geometries for each return event are identical, but the gate operations for the control structures are adjusted to meet the flow criteria established for each structure and each design event.

C2.2.2 Historical Event Hydrology. In addition to the design events listed above, the project design was also analyzed to determine the impacts of the project based on the hydrology corresponding to selected major flood events that have impacted the project area. This analysis included the flood events from 1997, 2006, 2009 and 2010.

C2.2.3 Extreme Event Hydrology. The previous phases of this study included analyses of the design for extreme hydrology events. The Phase 4 design included modeling of the Standard Project Flood (SPF) for the determination of design elevations for certain structures and features. This effort is discussed in greater detail in Appendix F. A more detailed analysis, consistent with previous phases, was not completed for this report. Consideration should be given to this analysis in the future.

C2.2.4 Hydrology Inputs. The flow files used in the steady flow models for Phase 3.1 included initial flow values, flow splits at junctions, flow changes representing inflows from tributaries, and gate settings for structures included in the geometry. The flow files used in the models for Phase 4 represent unsteady flows, so they include flow hydrographs for various inflow locations throughout the model. The development of these hydrographs is discussed in Appendix A. In addition to the hydrographs and flow inputs for the entire model, the unsteady flow files for Phase 4 also include the gate settings and operations for the gated structures included in the geometry.

C2.3 EXISTING CONDITONS MODELS

The existing conditions models for Phase 4 were produced by Houston Engineering, Inc. (HEI). HEI had developed earlier versions of the unsteady state models used to analyze the previous diversion designs. These models underwent extensive updates due to the modeling needs presented in Phase 4, including the addition of hundreds of storage areas and the extension of the model downstream to Drayton, North Dakota and upstream of Hickson, North Dakota. The Sheyenne River and Maple River systems were also added to the models. The updated models were completed through collaboration with other members of the design team- USACE, Moore Engineering, Barr Engineering and HDR Engineering- with support provided for GIS analysis, hydrologic modeling and peer reviews. HEI has documented the development of these models in Appendix B.

C2.3.1 Reference Model. The existing conditions models discussed above include separate geometry files representing conditions with and without emergency protection measures in place within the project area. These emergency measures would be structural barriers like clay levees, sand bag levees and flood walls that were used by the communities for protection during actual flood events. The existing conditions models were calibrated to measured high water marks during historic flood events. Because the emergency measures were in place during the historical flood events, they had to be reflected in the geometry used in the models in order to get an accurate calibration. After calibration, the emergency levees were removed to produce the geometry for the unprotected condition. The impacts of the project were determined by comparing the with-project models to the existing condition models without emergency measures in place. This allows for the determination of the full benefits of the project by comparing it to the damages that would be incurred if nothing was done to protect the communities. All impacts presented in this report reference the “without emergency protection” condition for both existing and with-project conditions.

C2.4 WITH-PROJECT CONDITIONS MODELS

The design for Phase 4 of this study involved new aspects, namely storage cells and staging upstream of the FM Metro area, which could not be properly accounted for with the steady state models that had been used in the previous phases. Refer to Figure C1 for a map depicting the staging and storage areas in the model. The design and subsequent impact analysis for this phase is based on the unsteady state existing conditions models developed by HEI. The development of the existing conditions models was a massive and intensive effort. Given the limited amount of time that was afforded to this phase of the study, the design and impact analysis had to proceed concurrently with the baseline model development. This required a coordinated effort to ensure that all of the updates to the baseline models were also included in the with-project model. While the design for Phase 4 shifted to an unsteady state methodology, the premise behind the design for the diversion channel and the associated hydraulic structures remained essentially the same. The addition of the upstream storage and staging added additional components to the design, but they simply resulted in different design discharges for the diversion channel and structures.

C2.4.1 Model Modifications. Once a preliminary baseline model became available, the process of modifying it for inclusion of the project design components was started. The major modifications to the models are discussed below:

1) The most extensive effort required was the modification of the storage areas along the diversion alignment to allow for the diversion geometry to be merged with the model. Utilizing GIS and HEC-RAS capabilities, a corridor of sufficient width to accommodate the diversion channel and spoil banks was cut through the storage areas included in the model. Some storage areas were split into two smaller areas and some resulted in one smaller storage area. After this was completed, the storage area connections were adjusted to reflect the changes.

2) The upstream storage areas identified for the project design were incorporated into the model along with the associated connections.

After the channel corridor was put in place and the storage areas were modified, the geometry for the new diversion channel was incorporated into the model. Due to the amount of time required for the unsteady state simulations to be completed, utilizing these models for optimizing the diversion channel design would not have been efficient, especially considering the timeline for this phase of the project. As the unsteady state baseline models were being modified as discussed above, a steady state model was created to generate an initial diversion design that could be inserted into the unsteady state model for further refinement. Assumptions were made for flow inputs at various reaches along the diversion and the hydraulic structures were simplified at this stage of the design. A summary of the steps taken to incorporate this preliminary geometry into the unsteady flow model are included below:

1) Junctions were established at the upstream and downstream ends of the diversion at the Red River of the North.

2) Lateral weirs and storage area connections were added or modified to connect the storage areas with the new diversion channel. The existing lateral weirs and connections associated with the Horace/West Fargo Diversion were also modified or deleted so that they were not connecting to storage areas they no longer contributed to due to the new diversion.

3) The hydraulic structures at the Maple River, Sheyenne River and Wild Rice River were added, including provisions for the pass through flow into the protected areas and the connections for the flow diverted into the diversion.

4) Hydraulic structures and culverts for the smaller tributaries (including those at the Lower Rush River and Rush River) were added to the model, with most of them including measures to prevent backflows from the diversion into the adjacent storage areas.

C2.4.2 Model Stabilization. After the geometry was set up as detailed above, attempts were made to get the preliminary with-project model to run. What followed was a repetitive process of run attempts and subsequent improvements to the models to correct instabilities. Many storage areas had to be adjusted to account for the upstream staging and some storage-elevation curves had to be adjusted to account for culverts and weirs that were added to storage area connections. These changes were documented so that necessary changes could be made to the baseline models as well. Likewise, the latest updates generated by HEI for the existing condition models were worked into the with-project models throughout the entire process. Through these efforts, the model was eventually stabilized and allowed to progress through the entire simulation process.

C2.4.3 Initial Design. After the model was able to run completely, the preliminary project design developed with the steady state models was analyzed to see where the design needed to be adjusted for the project to meet the design objectives. From this initial unsteady flow model, numerous models were developed and run to design specific project components and to analyze various design scenarios, many of which were an attempt to reach a balance between the downstream impacts and the impacts of the storage and staging upstream. The goal was to release enough water from the upstream storage areas through the diversion to produce water surface elevations in the Red River downstream of the diversion that were equal to (or slightly lower for conservatism) than existing conditions while meeting the stage elevations targeted at the Fargo gage in Phase 3. This would result in the maximum level of upstream staging required to mitigate the downstream impacts without providing actual benefits to the downstream reaches. The aspects of the project that underwent extensive analysis throughout the development of the project during this phase are discussed in the following sections.

C2.5 ALIGNMENT

The North Dakota Diversion (LPP) diverts water from the Red River, Wild Rice River, Sheyenne River, Maple River, Lower Rush and Rush Rivers and numerous legal drains to a location downstream of the mouth of the Sheyenne River. A map showing the alignment and the project area is shown in Figure C1. The alignment has remained largely unchanged from its initial layout. The background information on the development and previous changes to the alignment can be found in the reports for first three phases of this study.

With the Phase 4 design, some modifications were made to the North Dakota Diversion (LPP) alignment, although they do not have a sizeable impact on the project. The north end of the alignment was adjusted near Argusville to avoid interference with Drain 13. It was determined that Drain 13 was already an efficiently functioning legal drain so it could be utilized for its capacity separately from the diversion. The alignment was shifted to the south and east to accommodate this change. In other areas, minor changes were also incorporated where existing homes and buildings could be reasonably avoided. The existing Horace Diversion channel will be incorporated into the LPP diversion channel so the alignment was adjusted so that the east side of the LPP diversion matched the east side of the existing Horace Diversion channel. The Horace Diversion reach was removed from the HEC-RAS model.

C2.6 CHANNEL SIZING

The diversion channel geometry for Phase 4 was determined based on hydraulic capacity and then modified based on geotechnical analysis at various reaches along the diversion. The sizing of the channel considered the cross section geometry, channel slope and channel bottom invert elevations to determine the optimal channel design. A change in any one of these three design components affects the other two. The optimal channel design has to result in a 1-percent chance water surface profile within the diversion that does not exceed the target elevation established by the Corps in previous phases, which was based on maintaining the 1-percent chance profile below existing ground in most locations. This generally involves an iterative process to analyze a series of combinations before the optimal design is determined.

<u>C2.6.1 Channel Bottom Invert Elevations.</u> The channel bottom elevations for the North Dakota Diversion (LPP) alignment are directly related to the channel slope and the cross section geometry, but there were some additional design constraints on the elevations at certain locations. The most important constraint was the minimum height of the opening under the aqueduct structures at the Maple and Sheyenne Rivers. The USACE requested that the designs for these two structures include a minimum opening of six feet between the bottom of the low flow channel (the low flow channel is expanded to the full width of the aqueduct opening) and the low chord of the aqueduct, which is a fixed elevation

based on the bottom elevation of each tributary. Thus, six feet was subtracted from each low chord elevation and the minimum bottom elevation of the low flow channel in the diversion was established at each location. A constant slope between the two aqueducts was desired, such that additional structures would not be required to incorporate grade changes or channel drops and the associated costs and operational issues could be avoided. The design of the Maple River aqueduct produced an optimal opening height of seven feet. The slope created between bottom of this opening and the six foot opening at the Sheyenne River was deemed to be too steep (see discussion in Section C2.6.2) and a maximum slope of 0.015% was selected in conjunction with the cross section geometry. This resulted in an opening height of 13 feet at the Sheyenne River structure.

C2.6.2 Channel Slope. The North Dakota Diversion (LPP) alignment channel bottom slope was set at a constant slope of 0.015% downstream of the inlet control weir. This was a change from the constant slope of 0.02% that had been included in the design from Phase 1 through Phase 3. As discussed above, the bottom slope was developed along with the bottom elevations and cross section geometry. The 0.015% slope resulted in slower channel velocities than the previous 0.02% profile, which helps reduce the downstream impacts because the timing is adjusted enough that the peak discharges from the diversion and the Red River do not coincide as closely as they did with the Phase 3 design. For the reach between the Wild Rice River and the inlet control weir, the channel sloped toward the inlet control weir for Phases 1 through 3 and for the January 31, 2011 Phase 4 design. For the final Phase 4 design, the channel has been designed to slope from the inlet weir back to the Wild Rice River at 0.005% grade. This reach runs within the staging area so it is not required to convey large flows during larger flood events because the entire area is inundated. Reversing the flow direction for low flow conditions eliminated issues with the low flow outlet to the lower channel bottom downstream of the inlet weir and the amount of hydraulic head present during large events. Figure C6 provides a profile from the HEC-RAS model for the North Dakota Diversion.

C2.6.3 Channel Cross Section. The basic cross section geometry for Phase 4 was determined based on hydraulic capacity and then modified based on geotechnical analysis at various reaches along the diversion. After selecting a bottom profile, the unsteady state models representing with-project conditions were utilized to size the channel. A simple trapezoidal channel with 7:1 (H:V) side slopes was iteratively widened until the 100-year water surface profile in the diversion matched the target elevation established by the Corps. A channel with a bottom width of 250 feet was determined to be the appropriate design for Phase 4, based on the following criteria: (1) allowed design to meet goal of zero impacts downstream; (2) allowed design to meet targeted 1-percent chance profile in the diversion channel; (3) did not increase the volume of excavation with respect to other (wider bottom width) options; (4) resulted in a channel with invert elevations above the Brenna formation for a significant length of the diversion alignment. After this determination was made, the design was forwarded to the Corps for geotechnical analysis on the stability of the channel. The Corps' geotechnical analysis called for benching in five sections along the diversion alignment. The benches were all set at eight feet above the bottom of the main channel and varied in width from 15 to 40 feet. The side slopes above and below the benches all remained at 7:1 (H:V) throughout the length of the diversion. The low flow channel included in Phase 3, which had a depth of three feet, 4:1 (H:V) side slopes and a 10 foot bottom, was also incorporated into the channel geometry. The cross section geometries for the diversion are summarized in Table C1. As discussed in Section C2.6.2 above, the size of the channel in the reach between the Wild Rice River and the diversion inlet weir was reduced for the final Phase 4 design. Within this reach, the channel has a 100 foot bottom and 7:1 (H:V) side slopes. A typical section for the connection channel between the Wild Rice and Red Rivers is shown in Figure C3 and a typical section for the diversion reach between the diversion inlet weir and the Wild Rice River is included in Figure C4. A typical section for the remainder of the diversion is included in Figure C5. Note that these figures reflect a pilot channel extending below the low flow channel. The pilot channel was added to the diversion channel for model stability purposes only and will not be included in the constructed diversion channel.

C2.7 RED RIVER TO WILD RICE CONNECTING REACH

The North Dakota Diversion (LPP) design continues to pull water from both the Red River and the Wild Rice River through a connection channel between the two rivers. With the inclusion of upstream storage and staging in the Phase 4 design, this channel also serves as an outlet to drain the water from these areas. The levees and spoil piles on the south side of this channel will be constructed to elevations that will allow water to freely enter the connection channel from the storage areas. Similar to the design for previous phases, this channel slopes in the opposite direction of the diversion channel with the bottom sloping from the Wild Rice River to the Red River at a 0.02% grade. This prevents water from flowing from the Red River into the diversion during low flow events and allows the local flows to drain to the Red River under low flow conditions as well. As flood stages rise during larger flood events, the flows are able to overcome the adverse slope and make their way west and down the diversion. A control weir on the east side of the Wild Rice River prevents water from discharging from the Wild Rice into the connection channel and into the Red River for low flows. The channel bottom invert at the connection with the Red River is much higher than the bottom of the Red River, so erosion protection is necessary to allow local flows to drain back to the Red River without causing erosion and stability problems when the Red River is lower than the bottom of the connection channel.

C2.8 UPSTREAM STORAGE

The most significant change with the Phase 4 design was the inclusion of storage and staging on the upstream side of the project. This aspect of the design was created by adjusting the operation of the control structures on the Red River, Wild Rice River and Wolverton Creek to back water up behind them and by allowing less water down the diversion through the diversion inlet weir (which was sized considerably smaller than in Phase 3). This forces water levels to build up, or stage, over the land upstream. Much of the land impacted by this staging was already inundated with flood waters under existing conditions, but the forced staging raises the 1-percent chance flood stage about seven feet at the Red River Control Structure. In addition to the mitigation required to offset the impacts to homes and properties within the staging area, the control structures and levees creating the boundaries for the protected area had to be elevated safely above the staging elevations. In addition to the staging on areas outside (upstream) of the protected areas, a large storage area, designated as Storage Area 1, was included in a location that had been within the protected area. This area is located west (downstream) of the Wild Rice River and the approximate boundaries are formed by Interstate 29 on the east, County Road 14 on the north and County Road 17 on the West. The diversion channel abuts the south side of the storage area and water is allowed to flow in and out of storage from the diversion. The inflows and outflows are controlled by a weir to allow for some control on the timing of these flows to provide the greatest benefit in reducing peak flows downstream. The crest of this weir is 1,400 feet wide and is set at an elevation of 910.0.

C2.9 TIE-BACK LEVEES

The tie-back levees required for the North Dakota Diversion (LPP) plan for Phase 4 required some significant changes due to the inclusion of the storage and staging upstream of the diversion. The levee alignment on the Minnesota side begins at the Red River Control structure and runs east, just as it did with the Phase 3 design. With the levees being raised approximately seven feet due to the staging included in Phase 4, the levees were extended to a length of about six miles until they reached far enough east to tie into natural ground. On the North Dakota side, a tie-back levee was implemented on the east side of Cass County Highway 17 to prevent water from breaking out to the west and bypassing the proposed diversion inlet control weir. This levee runs from the diversion channel south to until it ties into high ground about a half mile north of State Highway 46, which runs along the Cass/Richland County line. This tie-back levee helps define the storage and staging area being utilized upstream of the diversion. The top of this levee will be set at an elevation that will allow events larger than the 0.2-percent chance (500-year) event to over top the levee and flow west without overtopping the levee on the north side of the diversion channel and entering the protected area. Refer to Appendix F for further discussion on the design of the tie-back levees and associated features.

C2.10 NORTH DAKOTA TRIBUTARY HYDRAULIC STRUCTURES

The North Dakota Diversion (LPP) alignment intersects many tributaries, thus requiring significant hydraulic structures to allow some of the flow from the tributaries to continue flowing beyond the diversion and into the protected area. The structures proposed in the Phase 4 design are very similar to those included in Phase 3. Appendix F of this report provides greater detail on the designs for the hydraulic structures included in the project. In some locations, such as the Rush and Lower Rush Rivers, the tributaries are completely diverted into the diversion channel and the tributaries do not continue into the protected area. At other locations, namely the Maple and Sheyenne Rivers, aqueducts are required to allow the tributaries to flow over the top of the water flowing in the diversion. These structures allow enough water into the protected area to maintain the environmental integrity of the streams and aquatic ecosystems without causing major flooding. During larger flood events, a majority of the tributary flow gets diverted into the diversion channel.

C2.10.1 Minimum Downstream Flows. As discussed above, the USACE established a design stipulation during Phase 2 of this project that a minimum flow be maintained in each tributary as it flows through the protected area. This requirement was put in place to ensure that an adequate amount of flow was provided to maintain the environmental integrity of the streams and aquatic ecosystems. At that time, this flow requirement was set equal to the 50-percent chance local flow in each tributary. With the diversion alignment intersecting multiple tributaries, aqueducts are required to pass this required flow over the top of the diversion and into the protected area. In the cases of the Rush and Lower Rush Rivers, it was acknowledged that the natural setting corresponded to overland flow and that the current configuration was artificially created by channelization projects completed by USACE several decades ago. These tributaries would be allowed to be completely diverted into the diversion. In order to account for this flow and ensure adequate flow in the Sheyenne River, the 50-percent chance flow amount for these two rivers was added to the amount set on the Maple River. In other words, the minimum amount to pass through to the downstream reach of the Maple River would be the sum of the 50-percent chance local flood flows of the Maple, Lower Rush, and Rush Rivers. The minimum pass through flows for the Sheyenne River remained consistent with the 50-percent chance local flow. With the Phase 3 design, the Wild Rice River minimum flow was set as the coincidental flow associated with the 20-percent chance flow of 9,600 cfs on the Red River at the Fargo USGS gage during Phase 2. This coincidental flow amount for the Wild Rice River was approximately 2,350 cfs. The Phase 4 design utilizes a variable gate operation which results in a variable discharge through the gates and into the protected area. Although the revised hydrology incorporated with Phase 3 and Phase 3.1 resulted in higher flows for each design event, the minimum flow requirements were left at the values set in Phase 2 because that level of flow was still deemed adequate to maintain the environmental integrity of the streams. Similarly, these values were referenced as the target pass through flows for the Phase 4 design. This concept is further discussed in Appendix F.

C2.10.2 Wild Rice Hydraulic Structure. The Wild Rice River structure is similar to the concept presented in Phase 3. The river intersects the diversion channel at-grade, allowing the water in both channels to intermix. A gated control structure on the downstream side of this junction limits the amount of water allowed to enter the protected area. A weir structure east of the Wild Rice River prevents low flows from flowing east down the connection channel to the Red River. This weir is discussed in further detail in Section C2.11.1. On the west side, natural ground elevations and the invert of the diversion channel prevent low flows from flowing west down the diversion channel. High flows from the Wild Rice will merge with high flows entering from the Red River and all flows that cannot pass through the gated control structure will flow west and down the diversion channel to the diversion inlet control weir.

C2.10.3 Sheyenne River Hydraulic Structure. The hydraulic structure at the Sheyenne River is an aqueduct. The North Dakota Diversion flows under the Sheyenne River at this crossing. The flows in the diversion pass beneath the aqueduct through an opening that resembles a series of large box culverts. The opening is 13 feet high with a total width of 240 feet. Above this opening, the Sheyenne River runs perpendicular to the diversion channel through an open concrete channel carrying the targeted amount of flow into the protected area. The excess flows in the tributary are diverted into the diversion channel through a weir structure before reaching the aqueduct.

C2.10.4 Maple River Hydraulic Structure. The Maple River hydraulic structure included in Phase 3 was designed to allow water flowing in the diversion to pass both under and over the top of the aqueduct carrying the Maple River flows into the protected area. With changes to the hydrology and design features associated with Phase 4, water in the diversion no longer flows over the top of the aqueduct. With water no longer overtopping the aqueduct, control gates are no longer needed to restrict the amount of flow entering the protected area. With these changes, the Maple River structure now functions in the same manner as the Sheyenne River structure discussed above. The opening in the diversion channel is seven feet tall and 250 feet wide.

C2.10.5 Rush and Lower Rush Rivers. The Rush and Lower Rush rivers discharge into the diversion channel in the same manner as they did with the Phase 3 design. The two rivers enter the diversion through separate drop structures that direct 100% of the flow in these tributaries into the diversion. Without an aqueduct in place to carry some of the tributary flow into the protected area, additional water is allowed to enter the protected area through the Maple River aqueduct to make up for the lack of flow reaching the Sheyenne River. See Section C2.10.1 for additional discussion on downstream flows for the Maple River.

C2.10.6 Minor Tributaries, Legal Drains and Storage Areas. The project includes diversion inlet structures for smaller tributaries and legal drains that intersect the diversion, namely Cass County Drain 14 and Cass County Drain 21c. The models created for Phase 4 also reflect the intercept culverts that will allow the adjacent lands, which are reflected as storage areas in the models, to drain into the diversion. These intercept culverts are sized for the contributing watershed and include flap gates to prevent water from the diversion backing up through the culverts, similar to those on the existing Horace/West Fargo Diversion. The inlets between the Maple and Sheyenne Rivers have been sized to maintain the existing conditions 100-year floodplain associated with the independent peak flows from these tributaries. Maintaining the existing conditions floodplain was a requirement of environmental agencies reviewing the project. Further study and design is necessary to fully address this issue. Appendix F includes discussion on what has been completed to date and will be completed in the future.

C2.11 LPP DIVERSION STRUCTURES

In addition to the hydraulic structures implemented to handle the junctions with the diversion and the tributaries, there are other structures included within the diversion channel to control the water once it is flowing in the diversion. These structures include control weirs, drop structures and outlet structures, which are discussed below. Refer to Appendix F for more detailed discussion on these structures.

<u>C2.11.1 Diversion Control Weirs.</u> With the Phase 3 design, the two weirs included at the Wild Rice River structure not only controlled when water was allowed to leave the Wild Rice, but they also control when water is allowed to flow through the diversion. The crest of the west weir was set one foot higher than the east weir and served as the control weir for the diversion by limiting how much water could enter it. The crest elevations for these weirs were originally set during Phase 2 when the east weir was set at the Red River 20-percent chance (5-year) flood elevation and the west weir was set at the Red River 20-percent chance flood elevation plus one foot. This ensured that the diversion was not put into use prior to exceeding a Phase 2 Hydrology 20-percent chance event on the Red River. The flow that was associated with the 20-percent chance event was 9,600 cfs downstream of the confluence of the Red and Wild Rice Rivers. This flow level was established as a minimum flow to maintain in the rivers for environmental considerations. During Phase 3, rather than establishing minimum flows based on local flow events, the 9,600 cfs flow was maintained as the benchmark. This flow is equal to approximately a 28-percent chance (3.6-year) flow on the Red River downstream of the Wild Rice River confluence with the Phase 3.1 Hydrology. Based on this target flow, the east weir was left at the 28-percent chance flood elevation and the west weir was set one foot higher. With Phase 4, the targeted Red River flow through Fargo-Moorhead remained at 9,600 cfs and the crests of the weirs were adjusted based on the elevation associated with the 9,600 cfs discharge in the unsteady flow model. The crest elevation of the east weir at the Wild Rice River was lowered to 902.25, one foot lower than the crest of the diversion control weir.

The upstream storage and staging areas incorporated on the upstream side of the project extend west to a point within a few miles from the Sheyenne River. These areas are filled with water by holding back the water being discharged down the diversion. This is accomplished by placing a control weir within the diversion at the downstream end of the storage area. This weir works with the tie-back levees to retain the floodwaters in the desired storage and staging areas. By restricting the flow being discharged down the diversion channel, this control weir acts in the same capacity as the control weir that was placed on the west side of the Wild Rice River in the Phase 3 design. With the staging component included in the Phase 4 design, the control weir near the Sheyenne creates a pool from the weir all the way upstream to the Wild Rice River and beyond. This negates the need for a large scale control weir at the Wild Rice River and because the diversion channel design now prevents low flows from leaving the river channel, the Phase 4 design no longer includes a weir immediately adjacent the west side of the Wild Rice River. The primary inlet control weir designed for Phase 3 was multi-tiered with very wide openings. Due to the amount of water being staged above the weir in Phase 4 and the added hydraulic head it provides, the control weir was reduced to a single opening with a width of 90 feet. With the design incorporating the unsteady flow modeling, the crest elevation was adjusted to 903.25 to allow the diversion to begin operating when the target flow of 9,600 cfs was reached at the Fargo USGS gage. An initial analysis for the 1-percent chance event was conducted which raised the diversion inlet weir up to an elevation of 914.25. The purpose of this was to identify whether there would be any benefit by allowing more volume from the rising limb of the flood hydrograph to be retained in the staging area. However, it was found to provide no additional benefit for the 1-percent chance event.

This structure also coincides with a significant drop in the bottom of the diversion channel. The upstream storage reduced the diversion discharges enough that the size of the channel was significantly reduced from the Phase 3 design. The channel was raised upstream of the control weir to reduce the capacity, but it had to be dropped downstream of the weir to ensure that there was an adequate opening under the Sheyenne River aqueduct. Instead of having a separate drop structure and a control weir, the two were joined together at the location of the control weir at the downstream end of the staging area.

C2.11.2 Channel Outlet. The designs associated with previous phases of this study did not include considerations for a significant hydraulic structure at the outlet of the diversion channel at the junction with the Red River. The bottom of the diversion channel was close enough to the bottom of the river channel that a concrete drop structure was not warranted and a riprap grade control structure would be implemented if necessary. As noted in Section C2.6, the bottom slope and channel bottom inverts were modified with the Phase 4 design and the invert at the downstream end was raised about nine feet. This additional drop brought the total height differential between the diversion channel and the river bottom to about 17 feet. To account for the potential erosion issues that may result with this much drop at the outlet, a concrete hydraulic drop structure is included in the Phase 4 design. Although this structure may be adequately submerged by high water elevations on the Red River during many of the flood events, the continuous discharges from the Rush and Lower Rush Rivers, amongst other regularly contributing sources, would present cases where water is being discharged from the diversion channel while the Red River is considerably lower. In these cases in particular, a concrete drop structure is necessary to protect the diversion channel from head cutting and erosion.

C2.12 RED RIVER CONTROL STRUCTURE

The design of the Red River Control Structure remains the same as the Phase 3.1 design, with the exception of the top of the structure being raised to account for the increased water surface elevations associated with the upstream staging. This structure is a combination earthen berm and concrete structure with three gated openings that are utilized to regulate the amount of flow allowed to pass into the protected area. These gates, along with the diversion control weirs, control the head conditions and produce the desired staging elevations upstream of the structure as well as the target elevations within the protected area. With the steady state design methodology used in previous phases, the gate opening configurations for each design event were static, meaning that they did not change throughout the model simulation. The steady state model implies that the flows in the model are constant and the flow conditions upstream and downstream of the structure do not change over time. Based on this condition, the gate configurations were set to produce the desired flow conditions at the peak conditions produced by the Phase

3.1 hydrology. As previously discussed, the Phase 4 design is based on unsteady state modeling, meaning that the flow conditions are continually changing throughout the model simulation. As the hydrographs being routed through the control structure rise and fall, the hydraulic head conditions change accordingly and the same gate configuration can yield different results. For this reason, the design for Phase 4 utilizes a variable gate operation in the unsteady flow HEC-RAS model capable of accounting for the change in headwater and tailwater conditions to maintain the desired discharges through the structure. This process is discussed in greater detail in Appendix F. The minimum pass through flow targeted for the Red River Control Structure was approximately 7,250 cfs, which combined with the flow in the Wild Rice River to produce a discharge of 9,600 cfs at the Fargo USGS gage, as discussed in Section 2.10.1. The gate operations were designed to result in stages at the Fargo USGS gage (Red River RS 2388233) that closely matched the target elevations determined in Phase 3. These target elevations are shown in the following table:

Frequency	Water Surface Elev.* (ft)	Stage (ft)
10%	891.99	29.25
2%	892.74	30.00
1%	893.40	30.66
0.2%	902.66	39.92

*NAVD 88 Datum

C2.13 WOLVERTON CREEK CROSSING

As the hydrology for this study has progressed, the amount of flow being attributed to the Wolverton Creek tributary has increased and the design for the control structure on this tributary has changed accordingly. This structure allows flows from Wolverton Creek to pass into the protected area through the tie-back levee that extends east from the Red River Control Structure into Minnesota. With the inclusion of upstream staging, the structure also works with the structure on the Red River and the diversion inlet weir to impound water over the staging area. This structure includes two 10 ftx10 ft openings that are controlled by gates that are capable of regulating the flows into the protected areas. Without gates on this structure, the water impounded by the diversion control weir and the Red River Control structure would be able flow freely into the protected area. The flows from Wolverton Creek join with the flow immediately downstream of the Red River Control Structure and the flows in the Wild Rice River to produce the total discharge at the Fargo USGS gage. The gates on this structure are operated to ensure that the combination of these three flows results in the targeted stage the Fargo gage. Additional detail on this design included in Appendix F of this report.

C2.14 HYDRAULIC STRUCTURE MODELING

The Red River Control Structure is modeled as an inline structure with gates. The Sheyenne River and Maple River hydraulic structures were modeled as bridges within the diversion geometry, while the aqueducts for the tributaries passing over the diversion were reflected in the geometry for the tributary cross sections. Lateral weirs were incorporated into the model to reflect the side weirs that will divert water from the tributaries into the diversion at these locations. Lateral weirs were also used to implement the drop inlet structures at the Rush, Lower Rush and other tributaries that do not cross the diversion channel. The Wild Rice River is modeled through a combination of inline structures and lateral structures that reflect the control gates on the river and the side weirs on the diversion. The diversion inlet control weir is included in the model as an inline structure. Separate modeling of the hydraulic crossings was conducted to refine the designs. It should be noted that the geometry for the North Dakota Diversion (LPP) alignment for Phase 4 does not include the bridge crossings that were included in the Phase 3 design for the roadways that will cross the diversion. It was determined that the channel cross sections would not be modified through the bridge openings and the low chord elevations of the bridges would be elevated above the 0.2-percent chance water surface elevations in the diversion channel. The only impedance at the bridges would be caused by the piers extending up from the bottom of the channel to support the bridges. A sensitivity analysis was completed to determine the influence of the bridge piers on the modeling results, and it was determined that the piers did not affect the modeling results on the Red River of the North. Within the diversion channel, the maximum impact of the bridge piers was 0.18 feet with a typical impact of 0.10 feet at most locations. With no significant impact on the design, the bridges were excluded from the model geometry to simplify the modeling effort.

C2.15 INTERNAL MODEL REVIEW

The unsteady flow models developed during Phase 4 of this study underwent a series of Internal Quality Assurance/Quality Control (QA/QC)) reviews conducted by members of the consultant’s team. The members of the Internal QA/QC Team consisted of reviewers that were part of the design team and reviewers that were independent of the design team. The existing conditions models developed by Houston Engineering were reviewed by the other three firms on the team and most of the comments were addressed in the final models. The comments and responses developed during the review of the existing conditions models are documented in Appendix B of this report. The with-project models for the LPP design were primarily developed by Moore Engineering and Barr Engineering. These models underwent internal QA/QC reviews by Houston Engineering and HDR Engineering. The comments and responses from these reviews are included in Exhibit 5 of Appendix C. The QA/QC review of the LPP models was conducted after the January 31, 2011 report was submitted, with a goal of ensuring that the models were free of any significant issues for the February 28, 2011 submittal. With the extremely tight deadlines, the design team was unable to address every comment that was offered; however, the team is confident that any issues that could have potentially affected the results from the model were addressed. The remaining items are minor and do not need to be addressed for the February 28th submittal.

C2.16 FUTURE IMPROVEMENTS AND MODIFICATIONS

With the aggressive timeline associated with Phase 4, certain features within the project design could not be fully analyzed. Additionally, the internal review revealed other aspects of the design that could use further refinement, but are deemed to be insignificant to the results. Throughout the design process, these issues were documented and prioritized for further evaluation as time allowed. A list of these items and a brief discussion of their relevance to the project are included below.

C2.16.1 Junction of Red River and LPP Diversion. From a spatial standpoint, the model appears to show that the junction of the LPP diversion channel with the Red River is downstream of the control structure on the Red River. The project design requires that the junction be located upstream of the control structure to allow the water to be diverted and staged, and the model is actually properly accounting for this. The connection reach of the diversion channel simply needs to be updated graphically in the spatial view within the model.

C2.16.2 Georeferencing of Cross Sections at Control Structures. From a spatial view, reaches for the Wild Rice and Red Rivers do not appear to correspond to the georeferenced cross sections associated with the control structures on those rivers. The cross sections were modified within the model to reflect the with-project conditions, which included the construction of new channels leading to and from the structures. The reaches in the model simply need to be adjusted graphically to correspond to the modified channel locations.

C2.16.3 Interpolated Cross Sections. The models currently contain numerous interpolated cross sections, most of which were added in an effort to stabilize the models. It is anticipated that some of these interpolated cross sections could be removed from the model without influencing the stability of the model. At minimum, the spacing of these sections, currently as short as one foot in some locations, could be expanded. Critical locations with interpolated cross sections could be replaced with actual georeferenced cross sections.

C2.16.4 Bridge Crossings in the Diversion Reaches. As noted in Section 2.14, the bridge crossings along the diversion reaches were not included in the models. In previous phases, the bridges were included but they were assumed to be elevated high enough that the low chords did not impede the flow within the diversion. That assumption was held with Phase 4, and it was also assumed that the channel cross section would not change through the bridge sections (past phases assumed a 5:1 (H:V) side slope through the bridge openings to narrow the length of the bridges). For future design considerations, it was noted that the bridge geometries should be included in the models, including the proposed piers, to obtain a more accurate representation of the actual design.

C2.16.5 Thompson to Drayton Reach. It was noted that additional detail could be included in the reach between Thompson and Drayton. This would include adding culverts and outlets to the storage areas within this reach to more accurately reflect the exchange of flows in the overbank and to allow these areas to drain after the levels in the Red River recede.

C2.16.6 Model Simulation Run Time. After reviewing the hydrographs for the existing and with-project conditions, it was noted that the hydrographs, particularly the ones on the downstream end of the model, did not have enough time to discharge the full volume on the receding limbs. While this volume is essentially trapped in the model at the end of the run, it should have no impact on the project design as it on the end of the receding limb and well after the peak. The simulation time should be extended to allow the system to fully drain. The simulation time will also need to be addressed if the model is extended farther downstream, as this will only become a bigger issue as the model is extended.

C2.16.7 Storage Area Volumes. During the internal QA/QC review process, multiple volume comparisons were completed to verify that the existing and with-project models were conveying the same amount of water. After refinements to storage areas and storage area connections in the model, including the addition of existing culvert crossings that were originally omitted from the models, the models for both conditions passed the same volume of water at a location downstream of the diversion outlet by the end of the simulation. There was, however, about 50,000 acre-feet of water that was left in storage at the end of the model run for both conditions. This volume is insignificant to the results as it accounts for only 1% of the total volume passing through the model at Drayton. A comparison of the models for both conditions revealed that the water was trapped in the same general areas for both cases and this issue was deemed to be minor as far the determination of project impacts was concerned. Some of the water was trapped in storage areas that either did not have any outlet at all or had outlets set above the bottom of the storage-elevation curve, both of which may actually exist in the real world. Further investigation into this trapped volume revealed that most of the water simply did not have enough time to drain from the storage areas back into the river reaches before the simulation ended. A simple review of the hydrographs for the storage areas on the downstream end of the models will reflect this. The inclusion of existing outlets that may have been omitted will reduce this volume, but extending the length of the simulation will account for most of the entrapped water.

C2.16.8 Side Ditch Inlets/Exterior Floodplain. As discussed in Section C2.10.7 further analysis is required for the sizing of the culverts and other inlet structures that drain the adjacent storage areas into the diversion. These structures need to be designed so that the floodplains associated with the independent peaks on the tributaries are maintained.

C2.16.9 Post Processing. Throughout the design analysis for Phase 4, issues were encountered with the post processing routine with HEC-RAS Version 4.1. Significant effort was put into debugging this issue, including consultation with software programmers at the USACE Hydraulic Engineering Center (HEC). In most cases, the models could be successfully post processed using the previous version (Version 4.0). At the present time, all of the models were able to completely process with a beta version of HEC-RAS Version 4.2 provided by HEC. This issue should be investigated further.

C2.16.10 Extreme Event Hydrology Analysis. As noted previously in this report, the Phase 4 design has not been fully analyzed for extreme event hydrologic scenarios, as was done for the previous phases. A brief analysis, documented in Appendix F, was done to determine design criteria for certain design features, but a full analysis should be completed.

C2.16.11 Potential Raise of I-29 South of Fargo. Preliminary modeling of a potential raise of Interstate 29 south of Fargo was completed to determine if connections would be necessary to allow water flow from one side of the highway to the other. The preliminary results indicate that there is only a minor differential in water surface elevations without any connections put in place. A more detailed analysis of this possible design component will be accomplished in future studies.

C3.0 RED RIVER DIVERSION – MODELING RESULTS

C3.1 RESULTS

The results of the unsteady state HEC-RAS hydraulic modeling for the LPP have been extracted from the models and processed for further analysis and simplified for a clear presentation within this report. The following sections include various representations and descriptions of the modeling results and the design for Phase 4.

C3.1.1 HEC-RAS Plan Files. Table C2 provides a listing of the HEC-RAS project and plan files for existing and with-project (LPP) conditions.

C3.1.2 LPP Diversion Profiles. Figure C7 and Figure C8 provide water surface profiles in the LPP diversion channel for the four synthetic design events and the four historic events, respectively. These profiles also show the bottom profile of the diversion in relation to critical subsurface soil layers.

C3.1.3 Red River Profiles, Tables and Graphs. Table C3 provides a summary of results from the HEC-RAS files for existing conditions for the synthetic design events.

Table C4 provides a summary of the results for the with-project conditions for the synthetic events. Table C5 is a summary of the results for existing conditions for the historic events and Table C6 summarizes the with-project results for those events. Figure C9 and Figure C10 depict the water surface profiles through the F-M Metro area for each of the modeled events.

C3.1.4 Stage-Frequency Curve at the Fargo USGS Gage. Figure C11 provides elevation and stage frequency curves for the range of synthetic flood events studied at the Fargo USGS Gage. The figures provide both existing and with-project conditions to allow for comparison.

C3.1.5 Discharge-Frequency Curve at the Fargo USGS Gage. Figure C12 shows the discharge-frequency curves for the Fargo USGS Gage for the existing and with-project conditions.

C3.2 IMPACTS

The proposed project, with either the FCP or LPP diversion alignment, impacts a much larger area than the Fargo-Moorhead metropolitan area. Depending on the location along the Red River, impacts of the project when compared to existing conditions may be adverse or beneficial in terms of discharges and stages during a flood event. While downstream impacts have been a major concern from the start of this study, the inclusion of staging on the upstream end of the project with the Phase 4 LPP design has resulted in significant impacts on these upstream areas. Although the FCP diversion was not redesigned during Phase 4 of the project, the Phase 3 design was modified and analyzed with the Phase 4 models in order to determine the impacts of that design. The new design for the LPP diversion developed in Phase 4 was also analyzed for impacts. In each case, impacts along the Red River were determined for a reach extending from Abercrombie, ND downstream to Drayton, ND, covering over 320 miles of the Red River of the North.

C3.2.1 Red River Impacts-FCP. The impacts of the Minnesota Diversion (FCP) project on the Red River from Abercrombie downstream to Drayton are included in Exhibit 1. Figures C-E1-1 through C-E1-8 reflect the project impacts at the landmarks shown the following table.

Landmark	Station
Drayton Gage	1062362
ND SH#17/ MN SH317	1223286
Co. Hwy 15	1315673
Oslo Gage	1416287
DS Grand Forks Levees	1533523
Grand Forks Gage	1558518
32nd Ave, Grand Forks	1580152
Thompson Gage	1667877
Co. Hwy 25/ Co. Rd 221	1726274
DS Sandhill River/ Climax	1763746
Nielsville	1829877
DS Marsh River	1864960
US Goose River/ Shelly	1891054
Halstad Gage	1981580
Hendrum	2038409
Perley	2129181
Georgetown	2193638
North River/ Clay Co. Hwy 93	2305647
19th Ave N Fargo/ 28th Ave N Moorhead	2360321
Fargo Gage (13th Ave S, 12th Ave S)	2388223
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085
US ND Wild Rice River	2484618
Hickson Gage	2563878
Abercrombie	2764835

The impacts are shown in both tabular and graphical format for the four synthetic design events and the four historic flood events.

The remaining figures included in Exhibit 1 are hydrographs comparing the existing condition and with-project condition hydrographs at each landmark location. There are separate hydrographs for each of the four design events and the four historic events for each location. These figures are organized as shown below:

C-E1-1 -- C-E1-8 : Impact tables and charts
C-E1-9 -- C-E1-19 : 10-percent chance (10-year) hydrographs for FCP
C-E1-20 -- C-E1-30 : 2-percent chance (50-year) hydrographs for FCP
C-E1-31 -- C-E1-41 : 1-percent chance (100-year) hydrographs for FCP
C-E1-42 -- C-E1-52 : 0.2-percent chance (500-year) hydrographs for FCP
C-E1-53 -- C-E1-63 : 1997 historical flood hydrographs for FCP
C-E1-64 -- C-E1-74 : 2006 historical flood hydrographs for FCP
C-E1-75 -- C-E1-85 : 2009 historical flood hydrographs for FCP
C-E1-86 -- C-E1-96 : 2010 historical flood hydrographs for FCP

C3.2.2 Red River Impacts-LPP. The impacts of the North Dakota Diversion (LPP) project on the Red River from Abercrombie, ND downstream to Drayton, ND are included in Exhibit 2. Figures C-E2-1 through C-E2-8 reflect the project impacts at selected landmark locations along the entire reach. The landmarks selected for the LPP analysis correspond to the ones analyzed for the FCP, as discussed in Section 3.1.5. Likewise, the remaining figures included in Exhibit 2 are hydrographs comparing the existing condition and with-project condition hydrographs at each landmark location. These figures are organized as shown below:

C-E2-1 -- C-E2-8 : Impact tables and charts
C-E2-9 -- C-E2-19 : 10-percent chance (10-year) hydrographs for LPP
C-E2-20 -- C-E2-30 : 2-percent chance (50-year) hydrographs for LPP
C-E2-31 -- C-E2-41 : 1-percent chance (100-year) hydrographs for LPP
C-E2-42 -- C-E2-52 : 0.2-percent chance (500-year) hydrographs for LPP
C-E2-53 -- C-E2-63 : 1997 historical flood hydrographs for LPP
C-E2-64 -- C-E2-74 : 2006 historical flood hydrographs for LPP
C-E2-75 -- C-E2-85 : 2009 historical flood hydrographs for LPP
C-E2-86 -- C-E2-96 : 2010 historical flood hydrographs for LPP

C3.2.3 Mapping. The impacts of the FCP and LPP, in relation to increases and decreases in stages, were mapped to provide a more clear and concise means of determining the impacts. The maps included in Exhibit 3 depict the change in water surface elevations for with-project conditions versus existing conditions (without emergency protection) for each of the historic and synthetic design events for the LPP only. Exhibit 4 includes a collection of inundation maps for both the FCP and LPP. The downstream impacts are mapped for both the FCP and LPP and upstream impacts are mapped for the LPP. The maps in Exhibit 4 reflect the actual areas that will be impacted due to the stage increases or decreases shown on the maps on Exhibit 3.

C3.3 ANALYSIS

C3.3.1 Historic Events. As previously discussed, the work completed in Phase 4 includes the modeling of existing and with-project conditions for the four more recent larger flood events in Fargo-Moorhead (1997, 2006, 2009 and 2010). Although these model runs are not intended for project feasibility design or for flood damage reduction evaluation, they provide two very tangible benefits. First, these models offer the possibility to better communicate the project impacts to all stakeholders and the general public because they can relate to how the project would change the conditions that were experienced during the recent larger flood events. It is more reasonable to anticipate that this information could be conveyed in a clear way, as there is no need to explain concepts that are not familiar to a layperson, like the meaning of balanced hydrographs or return periods. However, the caveat to highlight is that the existing conditions models do not include the emergency protection measures that were in place during these historic events. The second benefit of having conducted these model runs is that they allow for estimation of how the magnitude and timing of tributary flows affect the magnitude and timing of flooding downstream; this is better captured with looking at the four historic events versus the synthetic event analysis.

In general, the comparison of existing conditions models and with-project models for these four historic flood events sheds light on the magnitude of upstream staging/storage that is required to eliminate impacts on flood levels downstream of the diversion outlet; for more details on the model results, see the impact tables included in the General Report and the impact tables included in Exhibits 1 and 2 of Appendix C. The review of the existing conditions model shows that the peak stage in the Red River of the North at Fargo was near 40 feet during the historic 1997 and 2009 flood events, whereas the peak stage at this location was near 37 feet during the historic 2006 and 2010 flood events. For additional reference, the first two larger flood events were close to a 2-percent chance event in Fargo, whereas the other two were close to a 5-percent chance event in Fargo. For the two larger historic flood events, if the water levels upstream of the diversion works are staged from modeled existing conditions 912-914 feet to modeled with-project 921-922 feet, then downstream impacts could be eliminated before reaching the downstream end of the model at Drayton. For the 2006 and 2010 events, staging would be from modeled existing conditions 910-911 feet to model with-project 919 feet in order to eliminate downstream impacts. Although the relative staging (difference in modeled with-project and existing conditions immediately upstream of the diversion works) is similar for the four events, it appears that the ultimate water surface elevation upstream of the diversion works is the one dictating the downstream impacts. In other words, the additional volume of approximately 75,000 acre-feet that can be staged and stored between 919 feet (approximately 125,000 acre-feet) and 922 feet (approximately 200,000 acre-feet) explains the elimination of downstream impacts for the two larger historic flood events. And this occurs even when the with-project stage at the Red River of the North in Fargo is very similar for the four historic flood events (29-31 feet). All of this suggests that in order to eliminate downstream impacts, upstream staging and storage to water surface elevations around 922 feet would be required, and more importantly, that the diversion works need to be operated not only based on peak flows but primarily based on total hydrograph volumes, in particular those during the rising limb of the hydrograph.

C3.3.2 Design Events. Work completed in Phase 4 also includes the modeling of existing and with-project conditions for four synthetic events (0.2-percent, 1-percent, 2-percent, and 10-percent chance design floods), which have been used for project feasibility design, flood damage reduction evaluation and impacts assessment on flood levels upstream and downstream of the proposed diversion. It is important to clarify here that the models referred to above and this discussion correspond to peak flows on the Red River of the North paired with coincidental events on the North Dakota tributaries. For project feasibility design, separate models have been created for cases of peak flows on the North Dakota tributaries paired with coincidental events on the Red River of the North in order to appropriately size the hydraulic structures in the North Dakota tributaries for extreme events in these rivers.

Before discussing the results of modeling existing and with-project conditions for the four synthetic events, a very important issue to bring attention to here pertains to the main design criteria used to develop the operational rules of the main line of flood protection at the Red River of the North and Wild Rice River because understanding of these criteria provides the context for qualifying the modeling results. These criteria are the following:

- To match the model Phase 3 with-project stage in the Red River of the North at the Fargo gage within ±0.15 feet, such that the difference in project benefits between the Phase 4 and Phase 3 feasibility designs is less than 5 percent (email communication from Lance Awsumb, USACE-PDT dated February 12, 2011);
- To eliminate impacts on floods levels downstream of the diversion channel outlet at a point that is located upstream of the Canadian border, such that the area to be impacted is well defined and NEPA requirements are met. The elimination of impacts is considered as a difference in water surface elevations between model with-project and existing conditions that is within ±0.04 feet. Because the tolerance used in HEC-RAS is 0.1 feet for water surface elevations, the precision of the model results is not greater than 0.1 feet. Therefore, the impacts on water surface elevations are rounded to the nearest 0.1 feet for flood management purposes, even though the model results are reported to the nearest 0.01 feet for transparency (email communication from Aaron Buesing, USACE-PDT dated January 25, 2011); and
- To limit the amount of staging upstream of the diversion works (in order to accomplish the two criteria above) without the need for an engineered storage area that encroaches too close into the urban centers within the protected area. It is an implicit goal to limit the extent of the area impacted, such that the number of structures affected with this Phase 4 feasibility design is less than that with the previous Phase 3 feasibility design.

The summary results of modeled existing conditions (which do not include emergency protection measures that were in place during the larger historic events) and modeled with-project conditions at gaged locations along the Red River of the North are presented in the General Report and Exhibits 1 and 2 of Appendix C. The review of the modeled existing conditions shows that the flows immediately upstream of the diversion works vary between approximately 10,300 and 28,600 cfs from the 10-percent to the 0.2-percent chance design flood, respectively. Accordingly, the modeled existing conditions flows and stage in the Red River of the North at the Fargo gage (which include the contribution of the Wild Rice River) vary between approximately 17,000 and 61,700 cfs and between approximately 34.6 and 43.1 feet, respectively, from the 10-percent to the 0.2-percent chance design flood. For the two larger synthetic events (i.e., the 0.2-percent and 1-percent chance design floods), if the water levels upstream of the diversion works are staged from modeled existing conditions 915-916 feet to modeled with-project 922-923 feet, then downstream impacts could be eliminated before reaching the downstream end of the model at Drayton and the modeled with-project stage in the Red River of the North at the Fargo gage is within ±0.15 feet of the Phase 3 values. This range of staged water surface elevation upstream of the diversion works is similar to that obtained for the two larger historic flood events in the Red River of the North at Fargo (i.e., 2009 and 1997), and it reinforces the suggestion that in order to eliminate downstream impacts for extreme floods, upstream staging and storage to water surface elevations near 922 feet would be required.

When looking at the magnitude of the relative staging upstream required to eliminate downstream impacts for the smallest synthetic event analyzed (i.e., the 10-percent chance design flood), from water surface elevation 908.1 feet for modeled existing conditions to water surface elevation 916.3 feet for modeled with-project conditions, it becomes clear that the diversion works need to be operated not only based on peak flows but primarily based on total hydrograph volumes, in particular during the rising limb of the hydrograph. That is, the overall performance of the diversion works (to meet the three main design criteria listed above) depends on the trade-off between storage (upstream staging or Storage Area 1) and release (either through the diversion channel or the control structure on the Red River of the North) of the incoming flood flows and volumes during the rising limb of the hydrograph. This in turn may imply that, as found during several trial runs of the HEC-RAS unsteady flow model for with-project conditions, allowing more water to pass into the protected area through the control structure on the Red River of the North does not necessarily help to eliminate impacts downstream if the timing of this release is similar to the timing of the peak flows and flood volumes being conveyed through the diversion channel. Indeed, it was found that the best operational scheme of the gates in the control structure on the Red River of the North (the best to eliminate downstream impacts without increasing the upstream staging) was the one that decoupled the peak flows and flood volumes conveyed through the diversion channel from those passing into the protected side. Thus, for all synthetic events, the operational scheme of these gates proposed at this feasibility level is to progressively close them during the rising limb until approaching (but before) the peak of the incoming hydrograph, keep them at their lowest position until the peak flows and flood volumes in the diversion channel have exited the diversion, and then progressively open the gates to reach the Phase 3 stage in the Red River of the North at the Fargo gage.

Two final issues deserve some discussion here. The first one derives directly from the previous paragraph. With the operational scheme of the gates in the control structure on the Red River of the North proposed at this feasibility level, there is room for increased flood damage reduction, especially for the 0.2-percent chance event. Recall from summary tables that the modeled with-project stage in the Red River of the North at the Fargo gage is estimated at approximately 40 feet. This stage is very similar to the one during the flood of record in 2009, when the cities of Fargo, ND and Moorhead, MN (with support from the USACE) had to implement a very extensive and significant emergency protection plan. We anticipate that a lower with-project stage for the 0.2-percent chance event would be welcome by the local sponsors. The second issue relates to the start and end of the gates operation (in relation to the peak of the flood hydrograph) and their implications on the duration of high stages and fish passage conditions in the Red River of the North, including the functioning of the fishways. From our work to date, it is reasonable to expect that in the next stage of design the operational scheme of the gates in the control structure on the Red River of the North can be optimized to reduce the duration of high stages and to further minimize the restriction on fish passage.

C3.3.3 Timing of Flood Peaks. The LPP diversion causes a change in the hydrograph timing along the Red River when compared to existing conditions. With the LPP diversion, the peak of the flood hydrograph along the Red River downstream of the diversion is shifted ahead in time between 12 and 24 hours. This shift in timing coincides with tributary hydrographs downstream of the diversion, which advances in time the peak in both discharge and stage. As a result of this occurrence, the design of the diversion and the elevation of the staging area upstream of the project area was designed such to minimize the increased water surface elevations downstream of the project area. These hydrographs are shown in detail in Exhibit 2 of Appendix C.

C4.0 REFERENCES

A- Houston Engineering, Inc., Technical Support Data Notebook for Stanley and Pleasant Townships, Cass County, ND and Holy Cross and Kurtz Townships, Clay County, MN Flood Insurance Study, January 5, 2006.

B - Houston Engineering, Inc., Technical Support Data Notebook for City of Fargo, North Dakota Flood Insurance Study, October 8, 2007.

C - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 2, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, August 31, 2009.

D- Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 2, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, Appendix H-Red River Diversion Hydraulic Structure Velocities, October 15, 2009.

E - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 2, Part 2, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, December 31, 2009, Revised January 6, 2010.

F- Moore Engineering, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, Northwest Diversion Channel, January 28, 2010, Revised March 4, 2010.

G - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 3, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, May 17, 2010.

H - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 3 (Phase 3.1 Hydrology), Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, July 30, 2010, Updated August 11, 2010.

I - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN, January 31, 2011

J - Moore Engineering, etal., Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, Alternative Scenarios Analysis, Report for the cities of Fargo, ND & Moorhead, MN, April 8, 2011

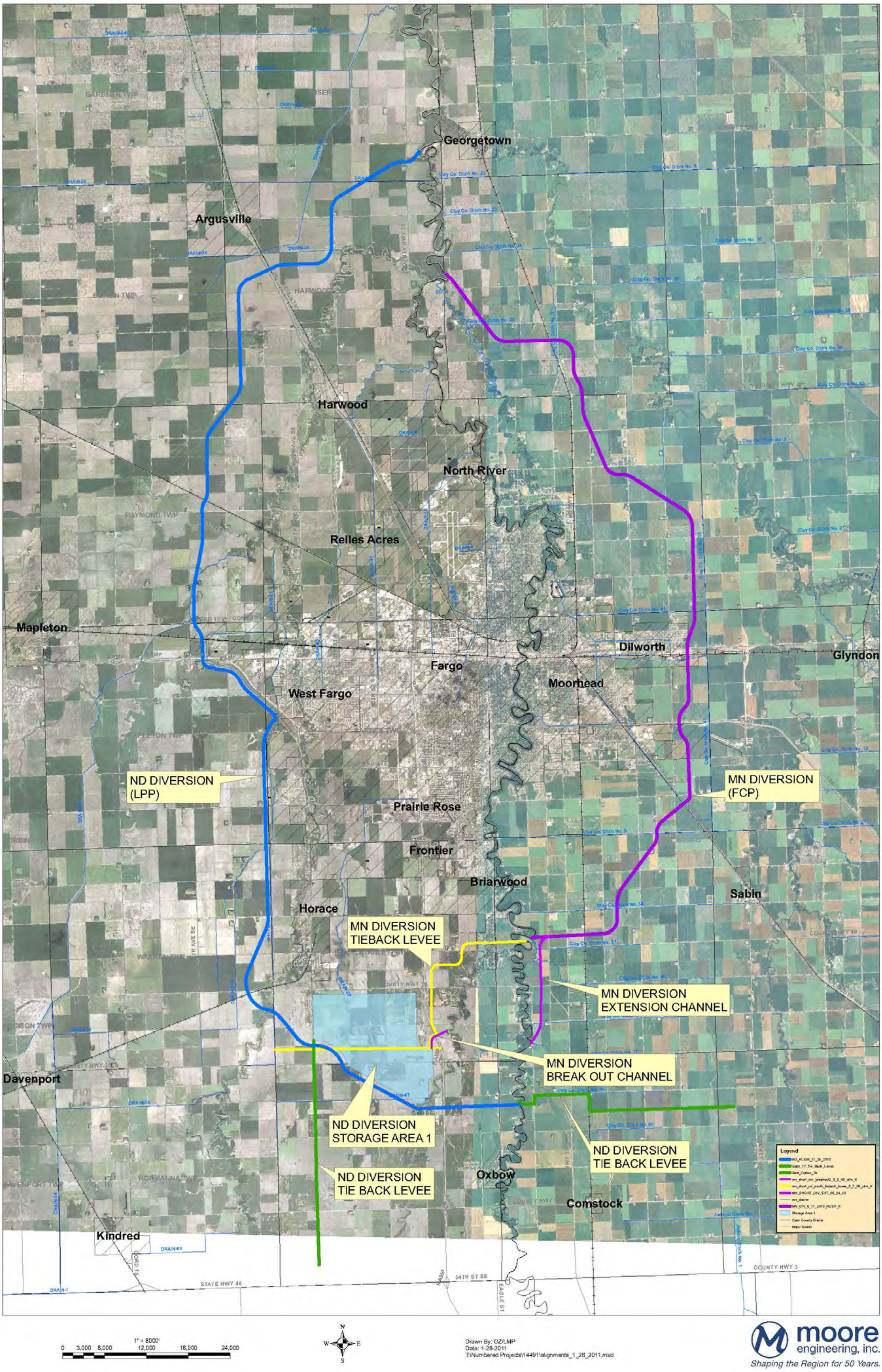


Figure C1-Red River Diversion Channel Alignments (FCP and LPP)

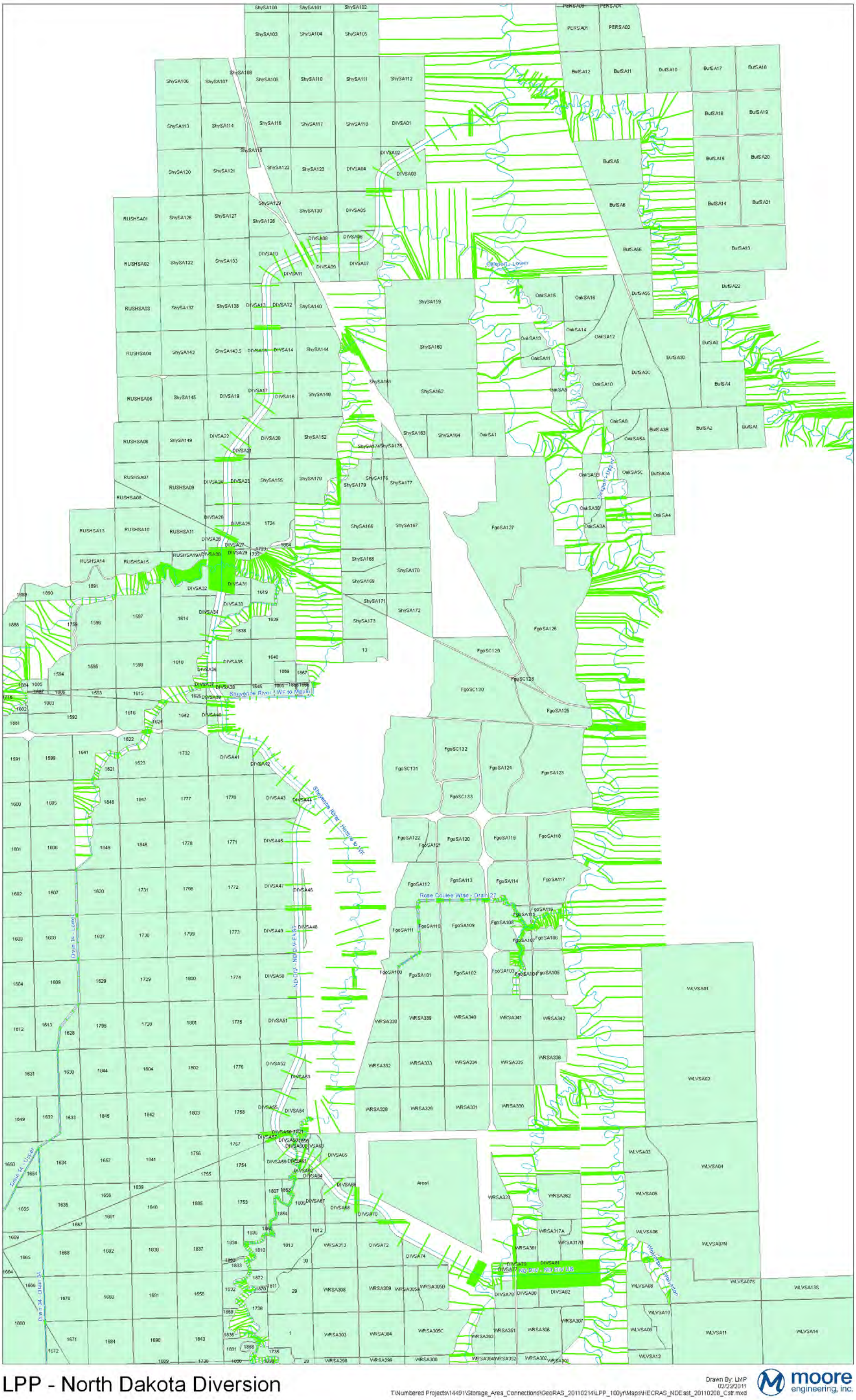


Figure C2-HEC-RAS Georeferenced Cross-Sections for the LPP

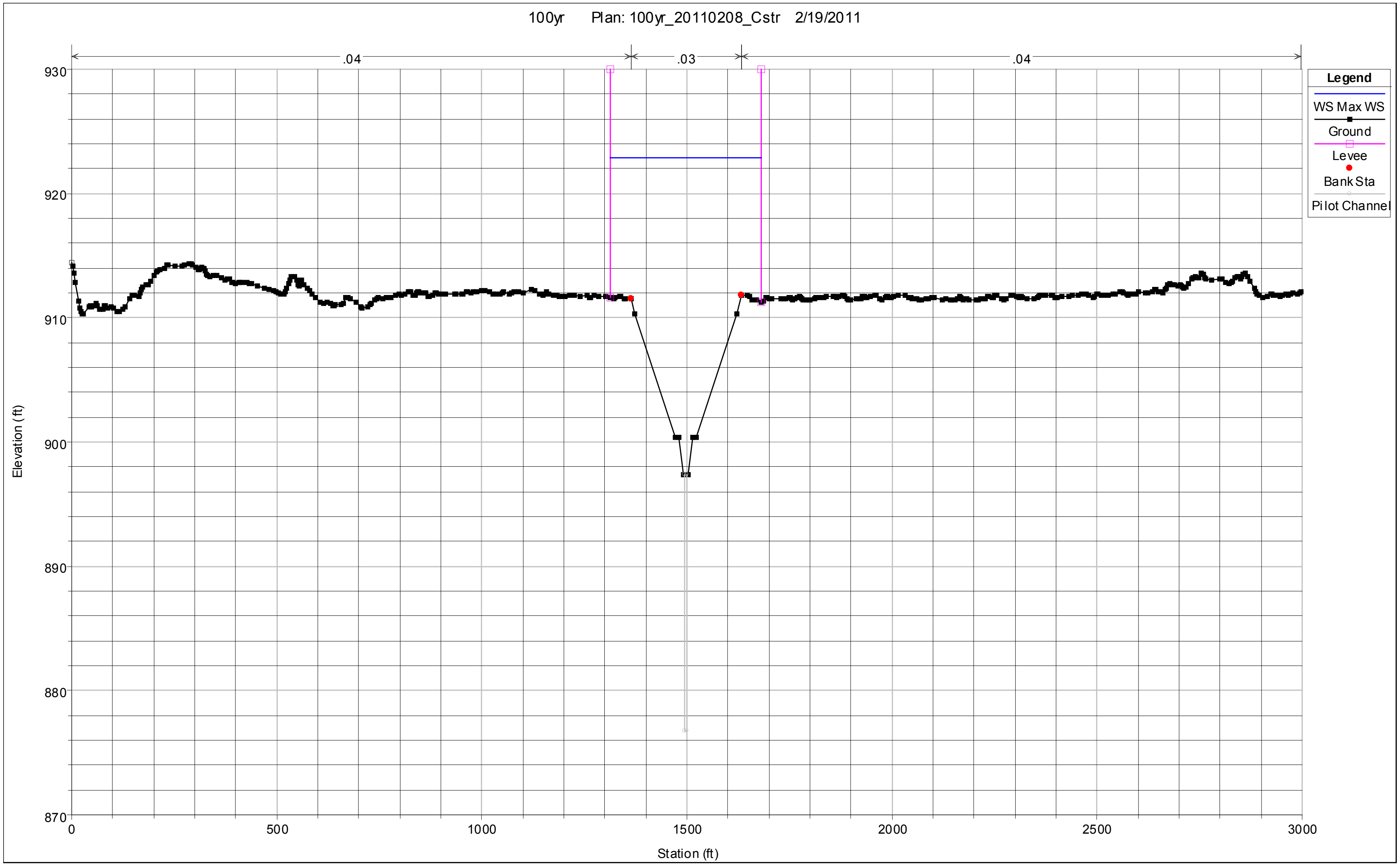


Figure C3- Typical HEC-RAS Model Cross Section -LPP Connection Channel

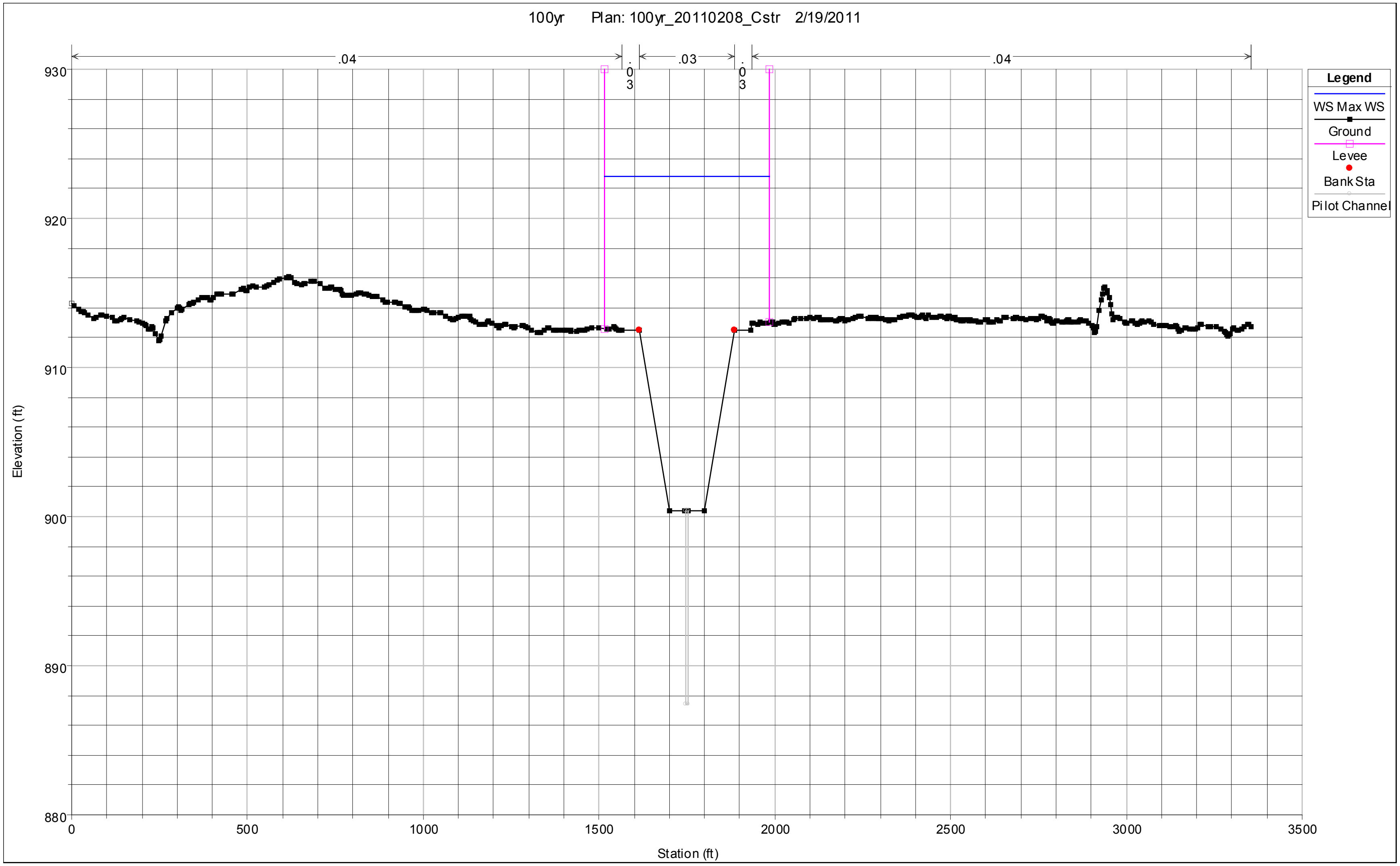


Figure C4- Typical HEC-RAS Model Cross Section- LPP Diversion Upstream of the Diversion Inlet Weir

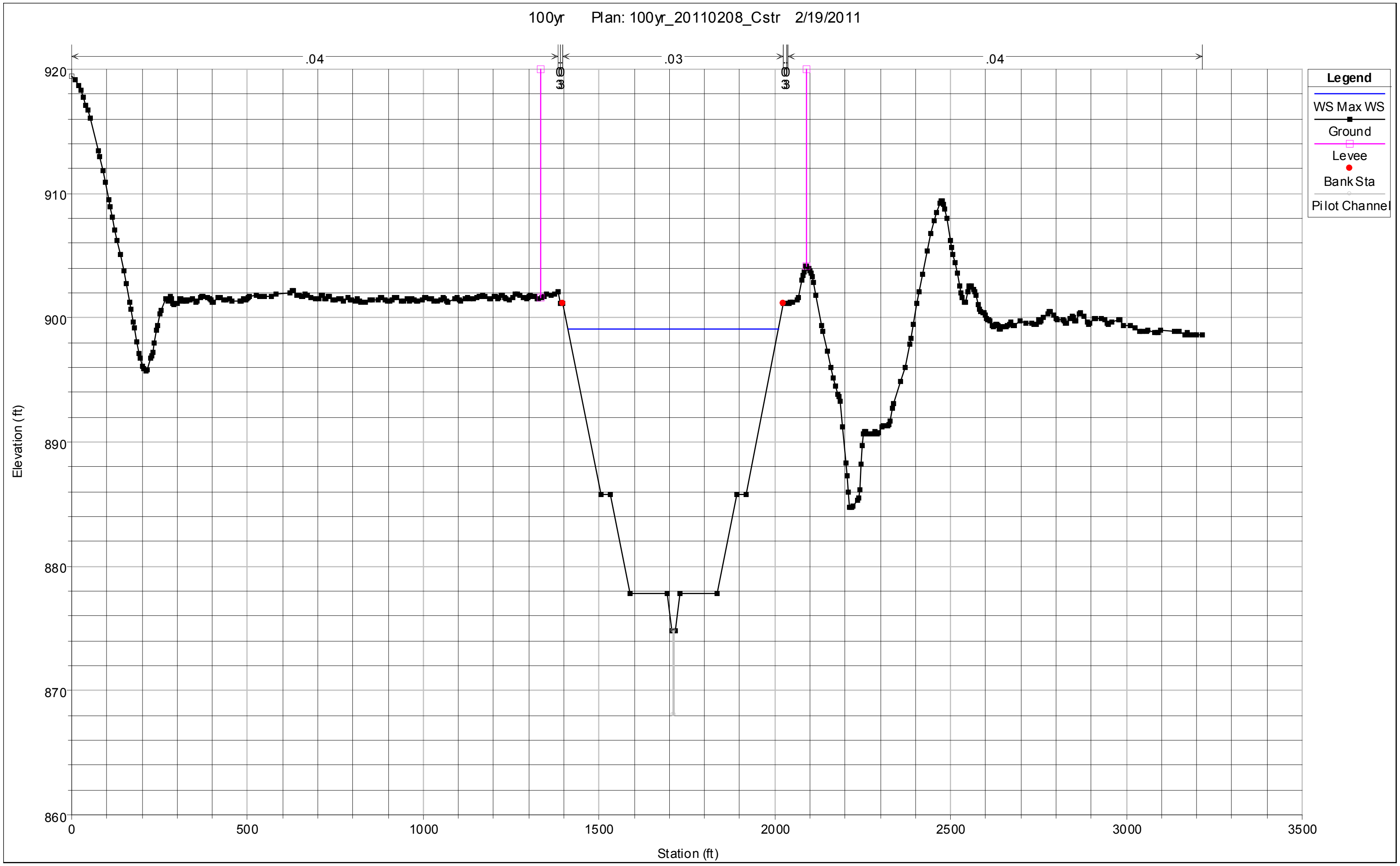


Figure C5- Typical HEC-RAS Model Cross Section- LPP Diversion Downstream of the Diversion Inlet Weir

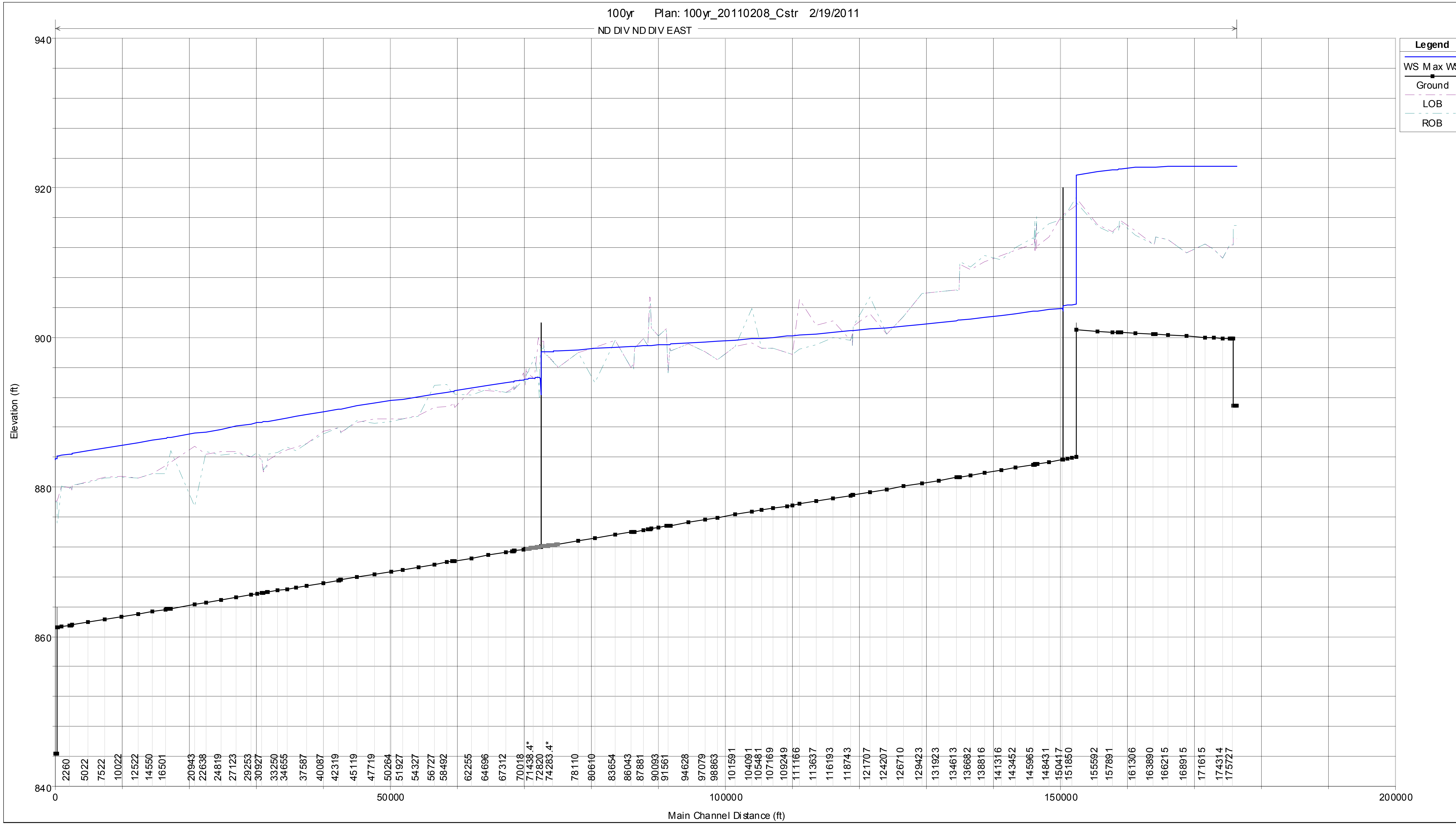


Figure C6- HEC-RAS Model Profile- LPP Diversion Channel

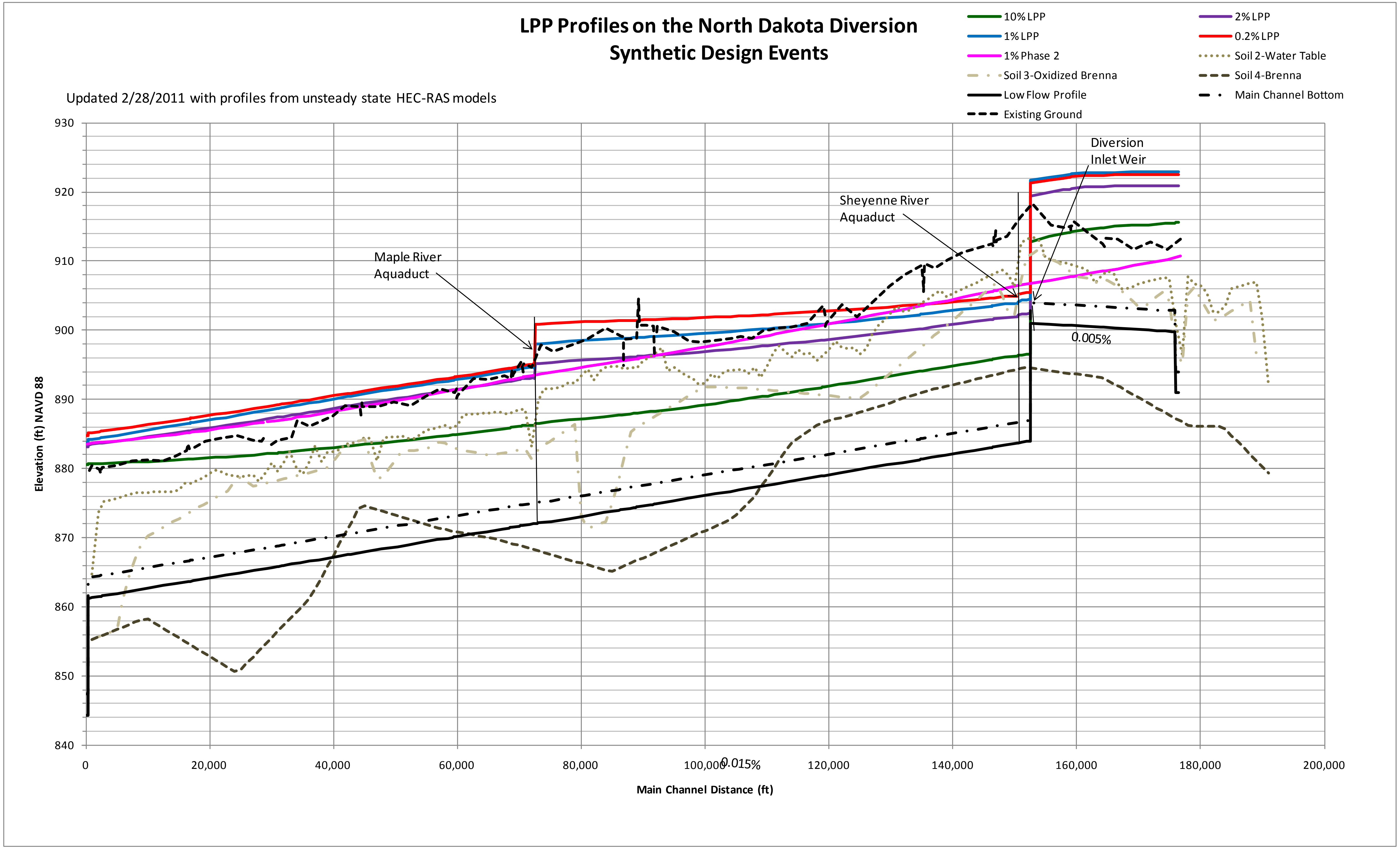


Figure C7-LPP Profiles on the North Dakota Diversion- Synthetic Design Events

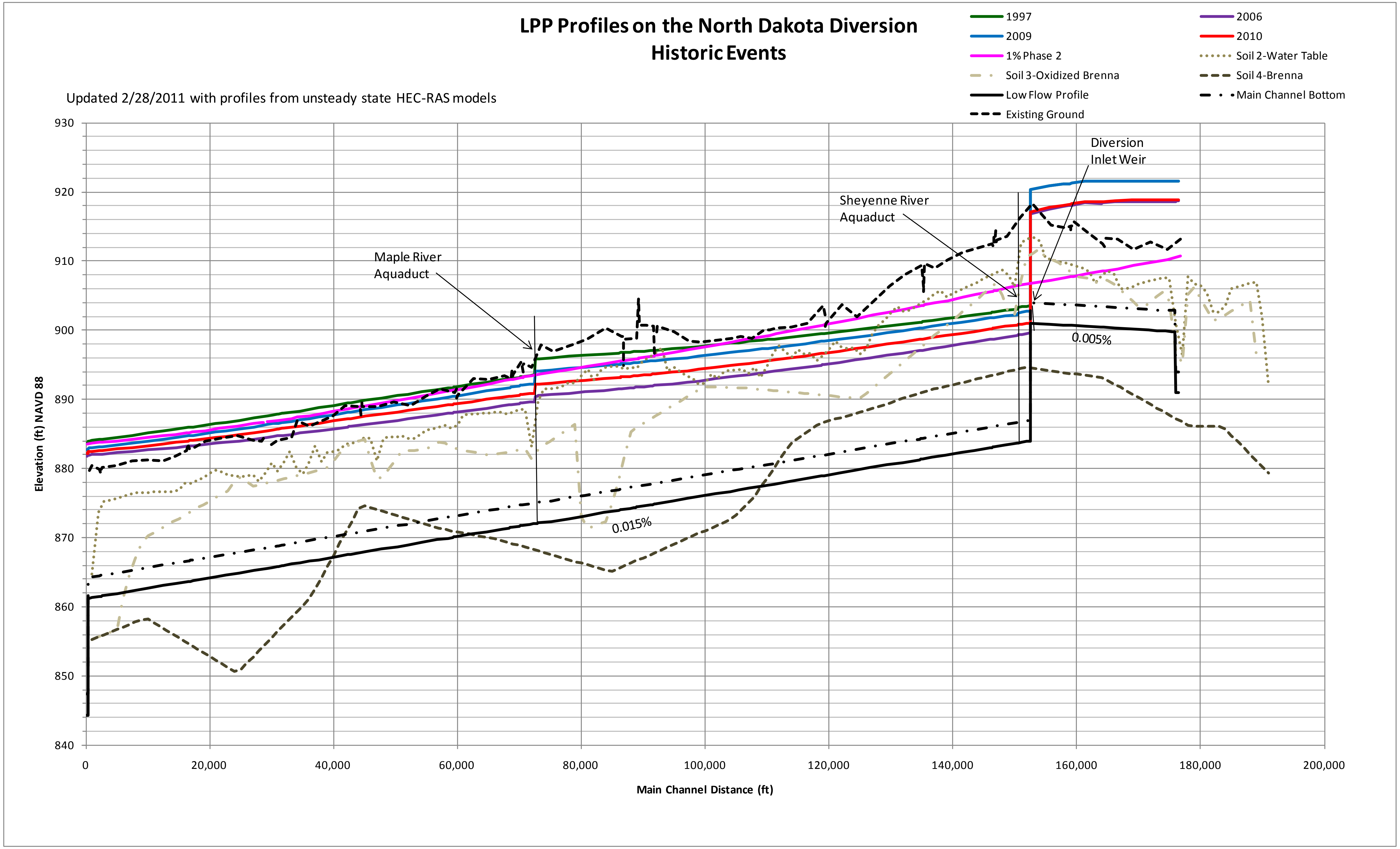


Figure C8- LPP Profiles on North Dakota Diversion-Historic Events

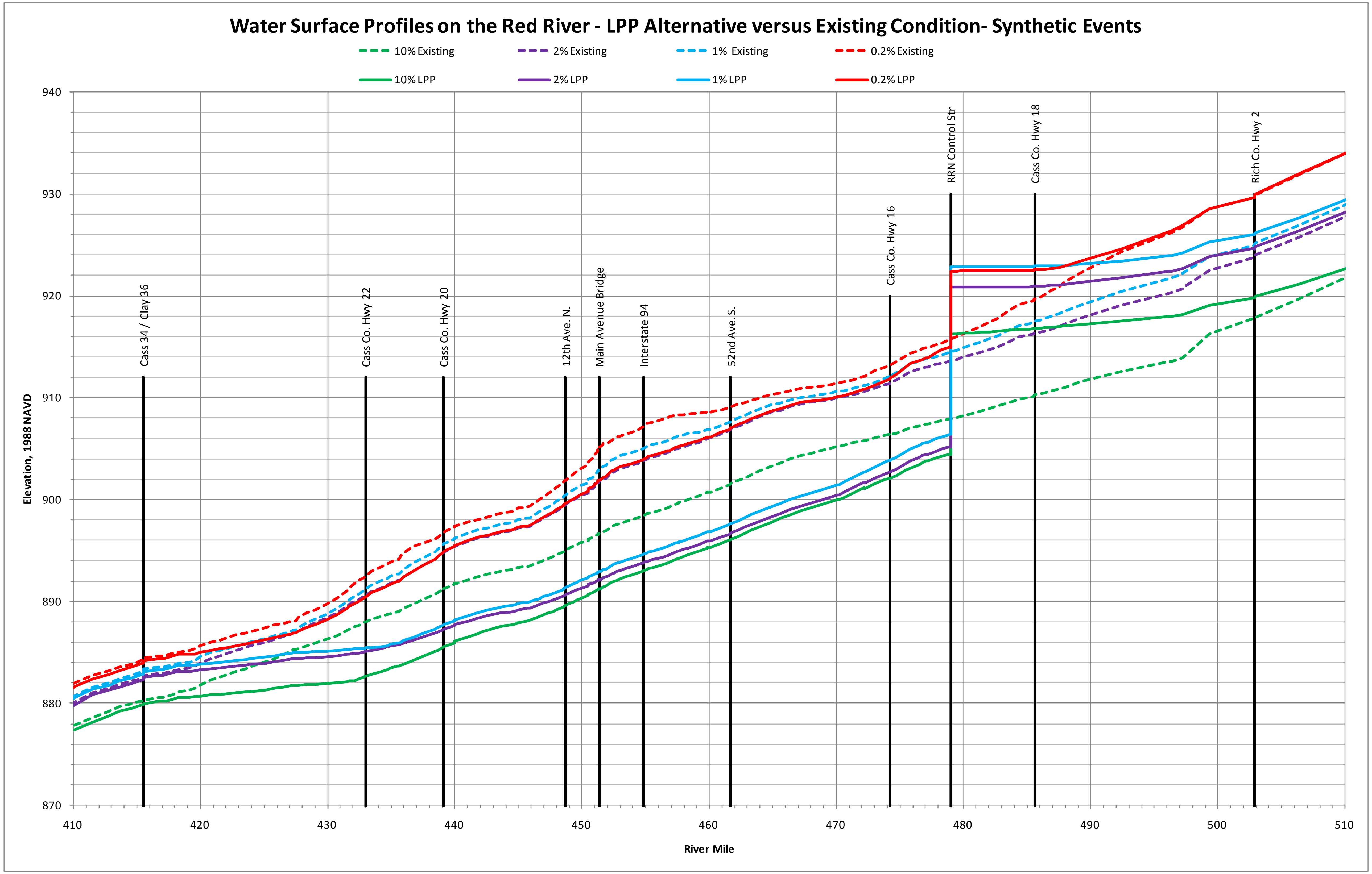


Figure C9-Water Surface Profiles on the Red River- LPP vs. Existing Conditions – Synthetic Design Events

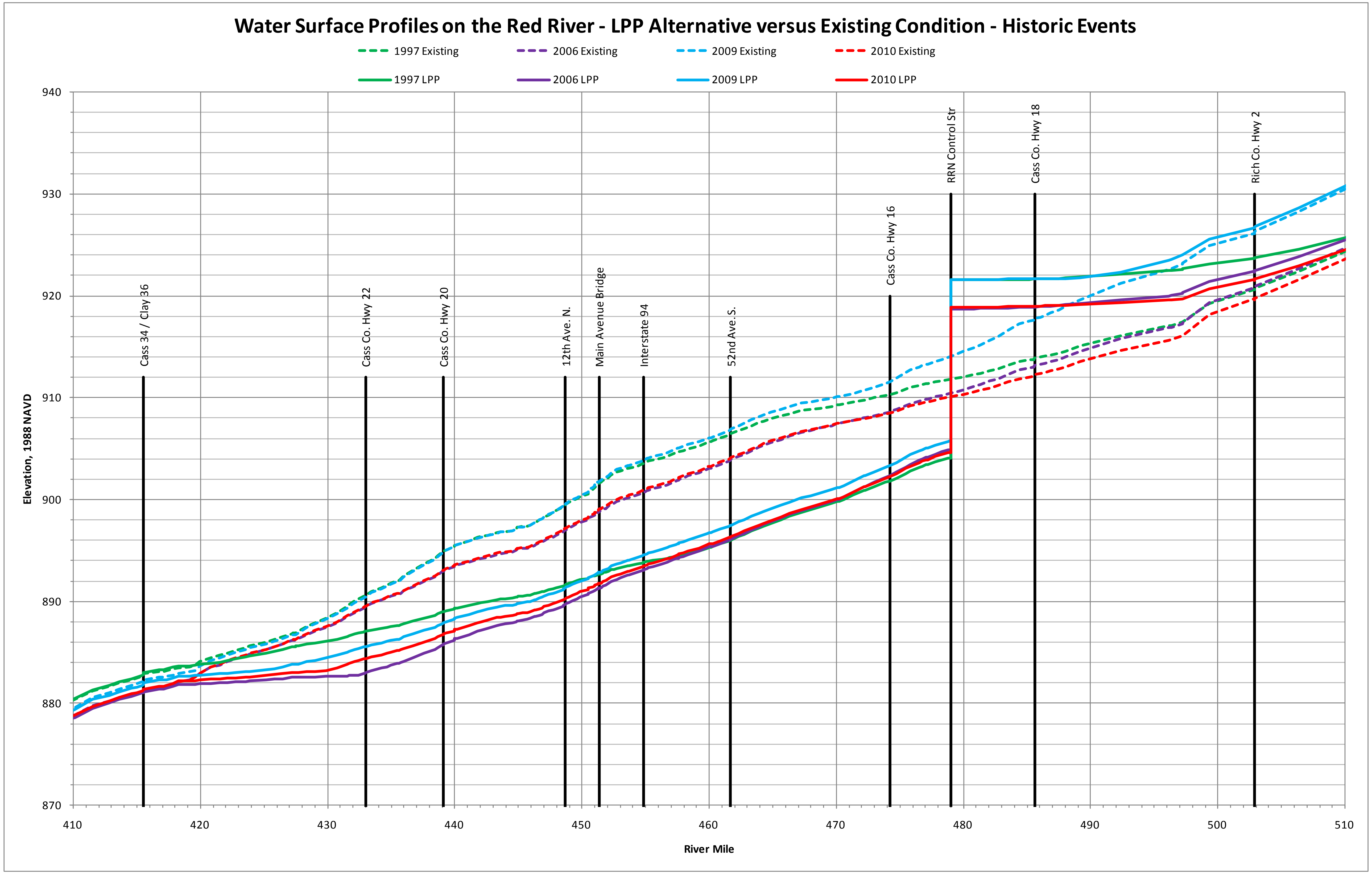


Figure C10-Water Surface Profiles on the Red River- LPP vs. Existing Conditions – Historic Events

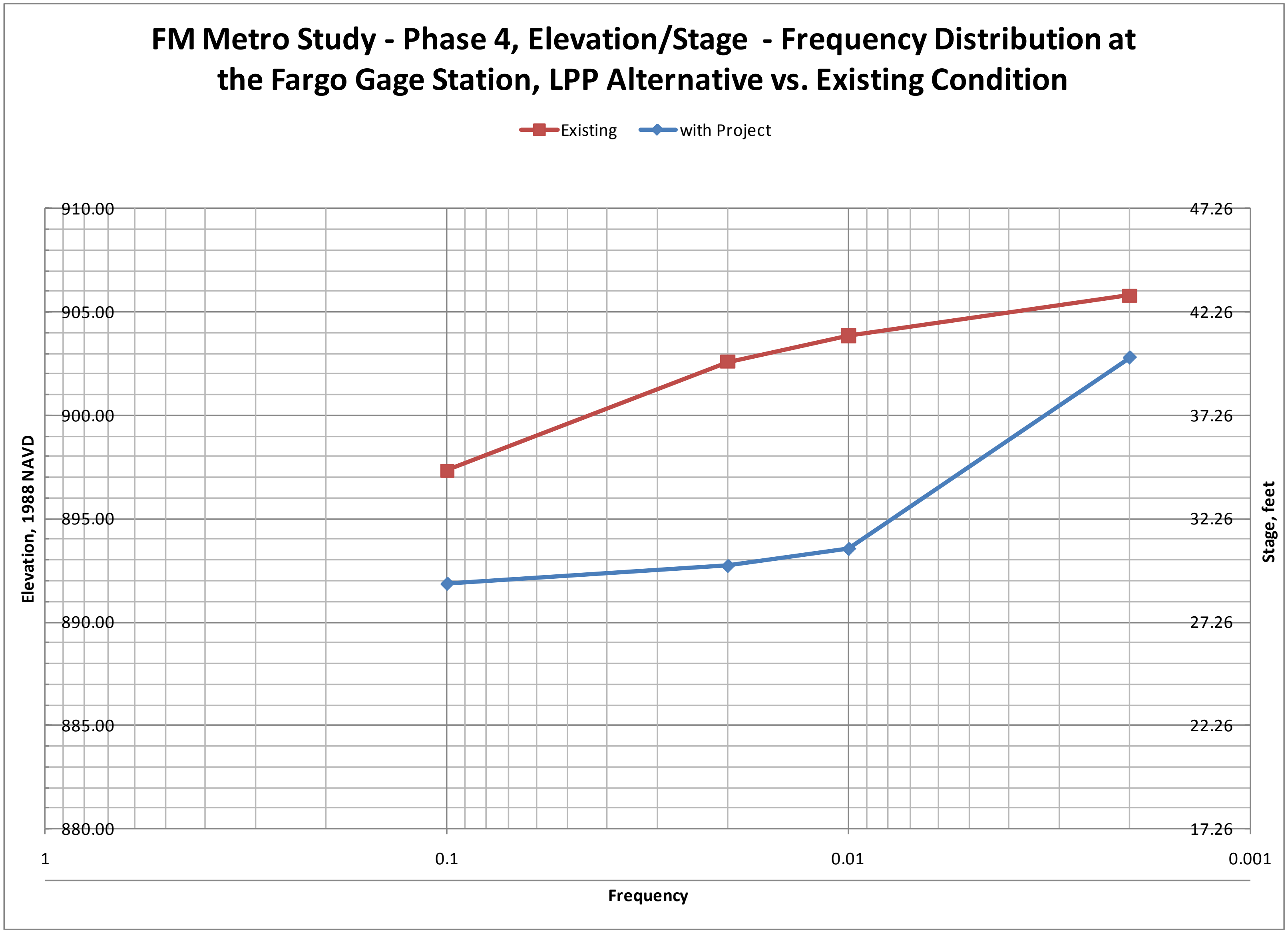


Figure C11-Elevation/Stage - Frequency Distribution at the Fargo Gage Station, LPP vs. Existing

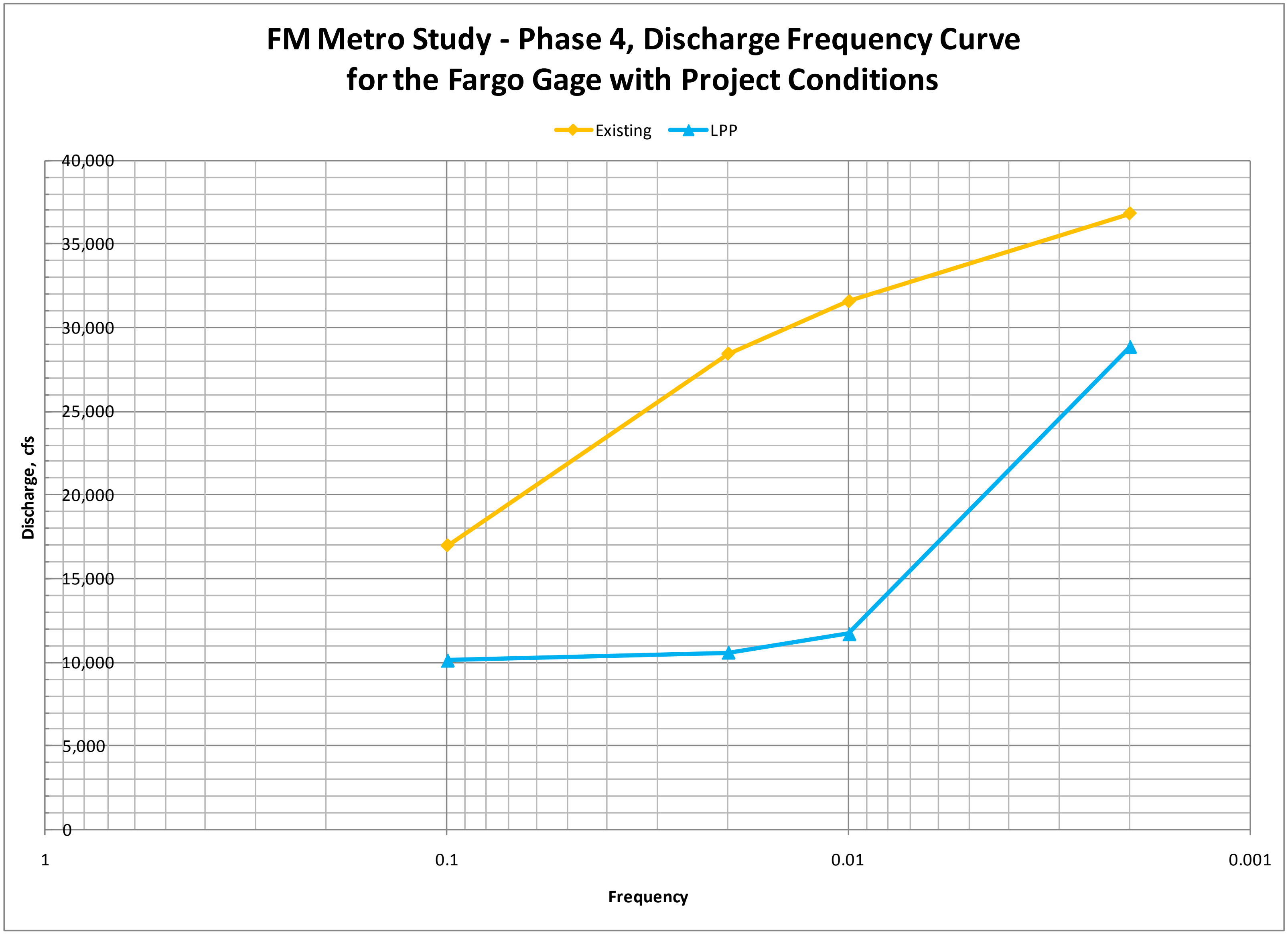


Figure C12-Discharge Frequency Curve for the Fargo Gage with LPP

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

ATTACHMENT C1 – EXCERPT FROM APPENDIX A-HYDROLOGY FROM THE JULY 30, 2010 REPORT

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: February 28, 2011

A1.0 BACKGROUND

A1.1 Need for Study. The Red River has posed a repeated threat to the communities of Fargo, ND and Moorhead, MN. A flood has occurred at least once each year since 1993. Although the communities have demonstrated significant resilience in defending against the floods, the efforts can be massive and highly disruptive to the communities and the people. Various plans have been formulated that address portions of the communities and have been developed to varying degrees. This study looks at the potential to develop a single comprehensive system to address flooding for the entire community.

A1.2 Related Studies and Project Evolution. Since the beginning of this study, several reports have been produced. Although this report is meant to stand alone, the other reports are listed below for completeness. Sufficient data from the other reports will be included in this report to allow the reader an understanding of the evolution of the project hydrology. However, not all details from the previous report will be copied into this report. In order to clarify the progression of the phases of this project and how they relate to the evolution of the hydrology; Table A1 provides a summary of Reports, Phases and Hydrology. Hydrology phases have progressed from Phase 1 to Phase 3.1.

Table A1 - Project Phases as Related to Hydrology

Study Phase	Report Date	Hydrology Phase	Notes
Phase 1	March 2009	Phase 1	Draft Report March 2009 by US Army Corps of Engineers
Phase 2	August 2009	Phase 1	Initial work by Moore Eng, and others
Phase 2	October 2009	Phase 2	Low Flow Analysis
Phase 2 Part 2	December 2010	Phase 2	Updated in January 2010
Phase 2 Part 2	January 2010	Phase 2	Northwest Diversion
Phase 3	May 2010	Phase 3	Hydrology updated for Wet and Dry cycles
Phase 3 (3.1)	July 2010	Phase 3.1	Hydrology amended, study limited to LPP and FCP

A1.2.1 Ongoing FEMA Restudy. Since prior to the 1997 flood, FEMA has been in the process of updating the Flood Insurance Rate Map (FIRM) for the area of Cass and Clay Counties in the vicinity of Fargo and Moorhead as part of its Map Modernization Program. Two studies in particular have defined much of the area of the Red River adjacent to the two cities. They include the "Flood Insurance Restudy for Southern Cass County, North Dakota, and Clay County, MN" (Reference A), which defines the hydrology for the area south of Fargo and the "City of Fargo CTP Project, Clay County/Oakport Township," (Reference B). CTP is short for Coordinating Technical Partner. Table A2 is an abbreviated listing of the Red River hydrology used in these studies. Flows are in terms of cubic feet per second (cfs).

Table A2 - FEMA Hydrology

River Station	10 year	50 year	100 year	500 year
Hickson	7,648	12,307	14,173	21,818
Fargo	10,300	22,300	29,300	50,000

A1.2.2 August 31, 2009 Report. In August 2009, a report entitled *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND and Moorhead, MN, Phase 2"* (Reference C), was completed that looked at a variety of alternatives for a Red River Diversion. Specifically, four alignments were considered around the FM Metro Area. The hydrology was based on Phase 1 Hydrology developed by the US Army Corps of Engineers (USACE) and presented in USACE report of *"Fargo - Moorhead Metro Flood Risk Management Project Red River of the North, Fargo, ND and Moorhead, MN"* (Reference D). Table A3 provides an abbreviated listing of the Red River hydrology used in these studies. Flows are in terms of cfs.

Table A3 - USACE Phase 1 Hydrology

River Station	10 year	50 year	100 year	500 year
Hickson	6,764	12,174	17,879	34,445
Fargo	12,700	23,000	31,000	57,400

A1.2.3 Low Flow Hydrology. In October 2009, a report on low flow conditions entitled *"Appendix H - Red River Diversion Hydraulic Structure Velocities"* (Reference E), was completed. This report was written in terms of an additional appendix to the report provided in Reference C. The purpose of this portion of the overall study was to gain a better understanding of the Red River under frequent flooding events smaller than the 2-year event. This analysis was particularly important in looking at fish Table A4 provides an abbreviated listing of the Red River hydrology used in this analysis. Flows are in terms of cfs. The low flow hydrology provided is based on USACE Phase 2 Hydrology of the Red River. It should be noted that the flows for the 99.99% through 80% exceedance frequencies were not changed in Phase 3 or 3.1 Hydrology. The flow exceedance of 99.99% is an estimate of the exceedance related to 50 cfs of flow. 50 cfs of flow was set as a boundary on the hydraulic modeling. Below this amount of flow, there were concerns about both the relevance of the data to the project and the ability to accurately model the Red River.

Table A4 - Red River Low Flow Phase 2 Hydrology

River Station / Flow Exceedance	99.99% est.(cfs)	99% (cfs)	95% (cfs)	90% (cfs)	80% (cfs)	50% (cfs)	20% (cfs)
Hickson	50	251	547	809	1,250	2,550	5,900
Fargo	50	251	550	829	1,360	3,500	9,600

A1.2.4 December 31, 2009 (updated January 6, 2010) Report. In December 2009, a report entitled, *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND and Moorhead, MN, Phase 2 - Part 2"* (Reference F), was completed that updated the progress of the study and updated the hydrology to Phase 2 Hydrology. Phase 2 Hydrology was developed to update the Red River hydrology to incorporate the 2009 flood event. This report was further updated January 6, 2010. Table A5 provides an abbreviated listing of the Red River hydrology used in this phase of the study. Flows are in terms of cfs.

Table A5 - USACE Phase 2 Hydrology

River Station	2 year	5 year	10 year	20 year	50 year	100 year	200 year	500 year
Hickson	3,139	6,160	9,555	13,729	19,709	23,757	26,164	30,016
Fargo	4,352	10,608	15,394	20,345	27,441	32,921	42,242	57,641

A1.2.5 Northwest Diversion. In January 2010, a report entitled "*Northwest Diversion, Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report, Phase*

2 - Part 2, for the US Army Corps of Engineers, and the Cities of Fargo, ND and Moorhead, MN," (Reference G) was completed. The Northwest Diversion Alternative was created as a means to deal with flooding north of Fargo and West Fargo from the Sheyenne River and its tributaries if only a Minnesota Diversion Alternative was constructed. This diversion needed to consider not only a Red River flood but also local flooding from the Sheyenne River. Table A6 provides a summary of the local flood hydrology for the Sheyenne River. The hydrology was developed from the existing Flood Insurance Study (FIS) and modified to take into account additional modeling done in the area.

Table A6 - Northwest Diversion Reference Hydrology

Location	10 year	50 year	100 year	500 year
Sheyenne River south of Horace, ND	3,400	4,500	4,600	4,600
Local Input, Distributed flow from U/S end to I-94 on the Sheyenne R. / Div	200	750	750	3,100
Split to the H to WF reach of the Sheyenne R. Div (1,2)	1,660	2,510	2,580	2,580
Sheyenne River D/S of Diversion Inlet (2)	1,740	1,990	2,020	2,020
West Fargo reach of Sheyenne R. Div D/S of outlet from H to WF reach (2)	3,400	4,500	4,600	4,600
West Fargo reach of Sheyenne R. Div at I-94	3,600	5,250	5,350	7,700
Local Input, Overland flooding assumed concentrated at Drain 14	0	1,950	1,960	7,600
Maple River Inflow	2,390	5,170	7,940	9,550
Lower Rush River Inflow	40	410	750	1,350
Rush River Inflow	510	820	1,500	2,700
Sheyenne R. at Red R.(3)	6,750	13,600	17,500	28,900

1 - Split is estimated. The hydraulic model conducts an energy balance at this location to determine the actual split.
2 – The listed flow does not include the distributed flow that is applied from the upstream end of the Sheyenne River to Interstate 94.
3 – The listed flow represents the total Sheyenne River system flow at the Red River. A portion of this flow would break out to Drains 45 and 13.

A1.2.6 May 17, 2010 Report. In May 2010 a report entitled, *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND and Moorhead, MN, Phase 3"* (Reference H), was completed that updated the study progress and hydrology. Phase 3 Hydrology was developed as part of a need to look at the Red River hydrology as two dissimilar periods of record. Additional discussion on this aspect of the hydrology is provided below. Table A7, provides an abbreviated listing of the Red River hydrology used in this phase of the study. Flows are in terms of cfs.

Table A7 - USACE Phase 3 Hydrology

River Station	2 year	5 year	10 year	20 year	50 year	100 year	200 year	500 year
Hickson	4,000	7,000	10,500	14,800	21,000	25,000	28,500	32,000
Fargo	5,600	12,150	17,000	22,000	29,300	34,700	46,200	61,700

A1.3 Need for Phase 3 Hydrology. It has been noted that the past few decades represent most of the significant floods on record in the FM Metro Area. A review of the period of record for the Red River gages illustrates two dissimilar hydrology patterns. The first portion of the 20th Century is characterized by many of the lower flows in the Red River including the drought years of the 1930's. The latter portion of the 20th Century and the past decade represent a time of larger flows including the larger floods of 1969, 1993, 1997, and 2009. To characterize this as simply a shift in climate and would be an over simplification considering the flood of 1897. To address the concern with dissimilarity in the period of record, the St. Paul District of the USACE contracted with the USACE Hydrologic Engineering Center (HEC) to regenerate the discharge frequency curves for the Red River.

A1.4 Overview of Phase 3 Hydrology. Phase 3 Hydrology re-characterizes the project discharge frequency curve as three separate curves based on a "Wet" condition and a "Dry" condition. The start of the project is referred to as Year 0 which uses the "Wet" condition as the hydrology. Over time, the hydrology is expected to shift and Year 25 of the project is characterized by a discharge frequency curve that is prorated between the "Wet" and "Dry" curves with an 80% and 20% split. Finally, at Year 50 is the final discharge frequency curve used is a 65/35 split of the "Wet" and "Dry" curves.

A1.5 Phase 3.1 Hydrology, Update to Phase 3. It was noted that Phase 3 Hydrology increased the flows in Fargo significantly. However, the flows further downstream at locations such as Halstad and Grand Forks did not increase significantly and were similar to values used in Phase 2 Hydrology. This in effect reflected an increase in contribution of drainage areas south of Fargo and reduced the overall contribution of watersheds north of Fargo. This effect was also largely confined to events larger than the 50-year event. The Sheyenne River contribution is not calculated through an independent statistical analysis of gage data but rather is derived based on drainage area transfer after accounting for locations such as Fargo, Halstad, and the contributions of the Buffalo River and the Wild Rice River of Minnesota. (Drainage area transfer is a method of calculating flow upstream or downstream of a given location or to another watershed based on a previously determined flow, empirical formulas, and the drainage area).This method of calculation on the Red River Watershed allowed for an anomaly to occur in the data where the 100-year flow contribution from the Sheyenne River could exceed the 200-year or 500-year flow contribution from the Sheyenne River. Phase 3.1 Hydrology was developed to address this anomaly in the data. The flows at Fargo and Halstad were unchanged but the intermediate points along the Red River were adjusted to allow for a more conventional progression of flow from each watershed with increasing return period. Table A8, provides a summary of the contribution from the Sheyenne River. As Phase 3 Hydrology is characterized by the project year, only the Year 0 is provided in this table.

Table A8 - Coincidental Sheyenne River Flows, Phase 3.1 Hydrology (Year 0)

River Station	2 year	5 year	10 year	20 year	50 year	100 year	200 year	500 year
Upstream of Sheyenne R.	5,908	12,618	17,616	22,791	30,340	35,970	47,541	63,141
Downstream of Sheyenne R.	8,857	16,795	23,062	29,776	39,503	47,212	59,029	75,188
Diff (Sheyenne R.)	2,949	4,177	5,446	6,985	9,163	11,242	11,488	12,047

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

ATTACHMENT C2 – RED RIVER DIVERSION, FARGO-MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 3 (PHASE 3.1 HYDROLOGY), REPORT FOR THE US ARMY CORPS OF ENGINEERS, AND THE CITIES OF FARGO, NORTH DAKOTA & MOORHEAD, MINNESOTA, APPENDIX B-HYDRAULICS, AUGUST 11, 2010 VERSION

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: April 11, 2011

RED RIVER DIVERSION

FARGO - MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 3 (PHASE 3.1 HYDROLOGY)

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

APPENDIX B - HYDRAULICS

By: MOORE ENGINEERING

Aug 11, 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

***Tables and Attachments for Appendix B are placed after the write up and figures. No page numbers were assigned.**

ATTACHMENTS

B1.0 RED RIVER DIVERSION - BACKGROUND AND OVERVIEW OF ALIGNMENTS

B1.1 Need for Study. The Red River has posed a repeated threat to the communities of Fargo, ND and Moorhead, MN. Since 1993, a flood has occurred at least once each year. Although the communities have demonstrated significant skill in defending themselves against floods, the efforts can be massive and highly disruptive to the communities and the people. Various plans have been formulated that address portions of the communities and have been developed to varying degrees. This study looks at the potential to develop a single comprehensive system to address flooding for the entire community. Appendix A - Hydrology covered the hydrology of the project area both with and without a project in place. This appendix, Appendix B – Hydraulics, looks at the hydraulic modeling of the Red River and its tributaries in conjunction with a Red River Diversion.

B1.2 Related Studies and Project Evolution. Since the beginning of this study, several reports have been produced. Although this report is meant to stand alone, the other reports are listed below for completeness. Sufficient data from the other reports will be included in this report to allow the reader an understanding of the evolution of the project, but not all details from the previous report will be copied into this report. In order to clarify the progression of the phases of this project and how they relate to the evolution of the hydrology and the hydraulics; a copy of Table A1 from Appendix A – Hydrology is provided below. Hydrology has progressed from Phase 1 to Phase 3.1.

Copy of Table A1 – Project Phases as Related to Hydrology (from Appendix A)

Study Phase	Report Date	Hydrology Phase	Notes
Phase 1	March 2009	Phase 1	Draft Report March 2009 by US Army Corps of Engineers
Phase 2	August 2009	Phase 2	Initial work by Moore Eng, and Others
Phase 2	October 2009	Phase 2	Low Flow Analysis
Phase 2 Part 2	December 2009	Phase 2	Updated in January 2010
Phase 2 Part 2	January 2010	Phase 2	Northwest Diversion
Phase 3	May 2010	Phase 3	Hydrology updated for West and Dry cycles
Phase 3 (3.1)	July 2010	Phase 3.1	Hydrology amended, study limited to LPP and FCP

B1.2.1 Ongoing FEMA Restudy. Since prior to the 1997 flood, FEMA has been in the process of updating the Flood Insurance Rate Map (FIRM) for the area of Cass and Clay counties in the vicinity of Fargo and Moorhead as part of its Map Modernization program. Two studies in particular have defined much of the area of the Red River adjacent to the two cities. They include the "*Flood Insurance Restudy for Southern Cass County, North Dakota, and Clay County, MN*" (Reference A), which defines the hydrology for the area south of Fargo and the "*City of Fargo CTP Project, Clay County/Oakport Township,"* (Reference B) (Note: CTP is short for Coordinating Technical Partner). The FEMA model served as the basis for hydraulic modeling on the Red and Wild Rice Rivers during the initial phase of the FM Metro study.

B1.2.2 August 31, 2009 Report. In August 2009, a report entitled *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Phase 2"* (Reference C), was completed that looked at a variety of alternatives of sizing and flows for a Red River Diversion. Specifically, four alignments were considered around the FM Metro Area. Two of the alignments were considered on the Minnesota side. Minnesota Long Diversion is the same alignment as Minnesota Short Diversion downstream of a point west of Sabin, MN. Upstream of that location, the Minnesota Long Diversion alignment extends farther south to intersect the Red River at a location approximately 3 miles to the south. In a similar fashion, the two North Dakota alignments are also similar. The primary difference between the two alignments, North Dakota West Diversion and North Dakota East Diversion, is the portion of the channel between Horace and West Fargo. As a result of public input, the East alignment was developed so that it closely followed the current Sheyenne River Diversion alignment within this area. Figure B1 provides a layout of the four alignments from this phase of the study. Although these alignments are not current, they serve to show some of the alignments considered. In addition to the four alignments, nine (9) options of flow in the Red River Diversion were considered. They include:

1. MN Short Alignment 45 Kcfs Alternative,
2. MN Short Alignment 35 Kcfs Alternative,
3. MN Short Alignment 25 Kcfs Alternative,
4. MN Long Alignment 45 Kcfs Alternative,
5. MN Long Alignment 35 Kcfs Alternative,
6. MN Long Alignment 25 Kcfs Alternative,
7. ND West Alignment 45 Kcfs Alternative,
8. ND West Alignment 35 Kcfs Alternative,
9. ND East Alignment 35 Kcfs Alternative.

B1.2.3 Low Flow Modeling. In October 2009, a report on low flow conditions entitled "*Appendix H - Red River Diversion Hydraulic Structure Velocities"* (Reference D), was completed. This report was written in terms of an additional appendix to Reference C. The purpose of this portion of the overall study was to gain a better understanding of the Red River under frequent flooding events smaller than the 2-year event. This analysis was particularly important in looking at fish passage. It should be noted that with the Red River 2-year and smaller events the Red River Diversion would not be operating. Therefore, the analysis only involved the main channel and the Red River Control Structure. The low flow events below the 2-year event considered were:

1. 80% Exceedance or a 1.25-year recurrence,
2. 90% Exceedance or a 1.11-year recurrence,
3. 95% Exceedance or a 1.05-year recurrence,
4. 99% Exceedance or a 1.01-year recurrence,
5. 50 cfs which was estimated at 99.99% Exceedance.

B1.2.4 December 31, 2009 (Updated January 6, 2010) Report. In December 2009, a report entitled *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Phase 2 - Part 2"* (Reference E), was completed that updated the progress of the study and updated the hydrology to Phase 2 Hydrology. Phase 2

Hydrology was developed to update the Red River hydrology to incorporate the 2009 flood event. This report was further updated in January of 2010. As part of this phase of the study, the number of alignments was reduced to two, the Minnesota Short Alignment and the North Dakota East Alignment. No significant changes were made to the alignments from the previous phase, therefore a separate set of figures are not provided. This phase looked to determine the National Economic Development (NED) Alternative. Therefore several flow options were considered. These flow options were primarily for the Minnesota Short Alignment as it was determined that this alignment, of the two considered in this phase, would be the NED alignment. The flow options considered were:

1. MN Short Alignment 10 Kcfs Alternative,
2. MN Short Alignment 15 Kcfs Alternative,
3. MN Short Alignment 20 Kcfs Alternative,
4. MN Short Alignment 25 Kcfs Alternative,
5. MN Short Alignment 30 Kcfs Alternative,
6. MN Short Alignment 35 Kcfs Alternative,
7. ND East Alignment 30 Kcfs Alternative,
8. ND East Alignment 35 Kcfs Alternative.

B1.2.5 Northwest Diversion. In January 2010, a report was completed on the Northwest Diversion Alternative. The report entitled "*Northwest Diversion, Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report, Phase 2 - Part 2, for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN*," is listed as Reference F. The Northwest Diversion Alternative was created as a means to deal with flooding north of Fargo and West Fargo from the Sheyenne River and its tributaries if a Minnesota Diversion Alternative was constructed. This diversion needed to consider not only a Red River flood but also local flooding from the Sheyenne River itself. The hydraulic model used for this part of the study used an unsteady model of the Red River and its tributaries, which was under development to look at downstream impacts of the project. The model was reduced to the portion dealing with the Sheyenne River system. The local flood events considered for this part of the study were the 10-, 50-, 100- and 500-year events. Figure B2 provides a plan view of this alternative.

B1.2.6 May 17, 2010 Report. In May 2010, a report entitled *"Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN Phase 3"* (Reference G), was completed that updated the study progress and hydrology. Phase 3 Hydrology was developed as part of a need to look at the Red River hydrology as two dissimilar periods of record. One period of record was characterized as "Wet" while the other was characterized as "Dry". From these two records, hydrology was developed for the project year zero, project year 25, and project year 50. Project year zero has the greatest flow through the FM Metro with decreasing flows in the subsequent two project year time periods. Because of this, it was necessary to run models for each alternative and flow option for three project time periods. Additional discussion on this aspect of the hydrology is provided in Appendix A – Hydrology. As part of this phase, only two Red River

Diversion alignments were considered, Minnesota Short Alignment and North Dakota East Alignment. The May 17th report was the first version of the Phase 3 report and eventually evolved into this current report, which is identified as Phase 3 with Phase 3.1 Hydrology. Changes to the alignments were being considered with the May 17th version and were implemented with the current phase. Figures showing the current alignments are provided later in the report. With new hydrology, it was necessary to revise the NED analysis. The NED analysis focused on the Minnesota Short Alignment. The North Dakota East Alignment 35 Kcfs alternative was also considered due to being chosen as the Locally Preferred Plan (LPP). The flow options for the Red River Diversion considered during this phase were:

1. MN Short Alignment 20 Kcfs Alternative,
2. MN Short Alignment 25 Kcfs Alternative,
3. MN Short Alignment 30 Kcfs Alternative,
4. MN Short Alignment 35 Kcfs Alternative,
5. MN Short Alignment 40 Kcfs Alternative,
6. MN Short Alignment 45 Kcfs Alternative,
7. ND East Alignment 35 Kcfs Alternative.

B1.3 Phase 3.1 Hydrology, Update to Phase 3. It was noted that Phase 3 Hydrology increased the flows in Fargo significantly. Conversely, the flows further downstream at locations such as Halstad and Grand Forks did not increase significantly and were similar to values used in Phase 2 Hydrology. As a result, some inconsistencies were noted, particularly with the Sheyenne River coincidental flows. Given the importance of the Sheyenne River on project parameters, a revision to the Phase 3 Hydrology was developed. As this new hydrology did not represent a fundamental update but rather a smaller change, it was referenced as Phase 3.1 for the study. For more details on Phase 3 and Phase 3.1 Hydrology, see Appendix A - Hydrology. The current phase of the project is still considered Phase 3, but it now references Phase 3.1 hydrology. This is the fundamental difference between this report and the May 17th version. At this point, the alternatives have still been narrowed down to two alternatives. These two alternatives represent the Federally Comparable Plan (FCP) and the Locally Preferred Plan (LPP) plan which are:

1. MN Short Alignment 35 Kcfs Alternative - FCP
2. ND East Alignment 35 Kcfs Alternative - LPP

B1.4 Overview of Channel Alignments. The two channel alignments still under consideration are the Minnesota Short Diversion and the North Dakota East Diversion. The Minnesota Short Diversion diverts water from the Red River just downstream of the Wild Rice River mouth to just downstream of the Sheyenne River mouth. The North Dakota East Diversion diverts water from both the Red River and Wild Rice River to a location farther downstream of the Sheyenne River mouth. Figure B3 shows the location of the two alignments. A more detailed map for each channel alignment is provided in Figures 1 and 2 of the Main Report.

B2.0 MINNESOTA DIVERSION - ALIGNMENT DESIGN CONSTRAINTS

B2.1 Initial Limitations (Minnesota Short and Long Alignments). As discussed above, the alignment on the Minnesota side- referred to as the Minnesota Short Alignment- was developed during the initial phase of the study as one of two potential alignments on the Minnesota side of the Red River. Both Minnesota alignments were restricted by a few key elements. The first objective was that no rivers be crossed. This meant that the downstream outlet had to enter the Red River prior to the Buffalo River and that the alignment could not go east of the Buffalo River. Another condition on the outlet was that it needed to be located such that the diversion flow entered the Red River parallel to a river tangent rather than at a right angle to minimize river channel erosion and to provide better outflow conditions. Another objective was to have the diversion pass east of the urban area as far as possible. This objective was balanced with the need to remain west of the Buffalo Aquifer. Some existing features were avoided due to the higher cost of replacement, such as highway bridge interchanges and the Moorhead Airport. The impact to the Dilworth Rail yard was also considered. The overall length was reduced by using a centerline not parallel to section lines to reduce the overall cost.

B2.2 Extension Channels.

B2.2.1 Minnesota Long Alignment Connecting Channel. The Minnesota Long Diversion intersects the Red River south of Cass County Highway 16 and has an extension channel that extends from the Red River to the Wild Rice River near Cass County Drain 47. This extension channel if referred to as the Minnesota Long Diversion Connecting Channel as it connects the Wild Rice and Red Rivers. Because Red River is intercepted so far to the south and the channel connects to the Wild Rice River, the Minnesota Long Alignment could pick up flows from the two rivers before they would cause the breakouts that occur between the two rivers and the breakouts into the Rose Coulee Watershed. See Figure B1 for additional detail on the Minnesota Long Diversion Alignment.

B2.2.2 Minnesota Short Alignment Extension and Breakout Channels. The Minnesota Short Alignment intersects the Red River north (downstream) of the confluence with the Wild Rice River. This location allows it to pull flow into the Red River Diversion from the total flow of both rivers. By itself; however, this alignment does not prevent the exchange of flows between the two rivers and it does not prevent the breakout flows into the Rose Coulee Watershed. An extension channel added to the Minnesota Short Alignment extends from near the inlet of the diversion south to intersect the Red River near Cass County Highway 16. This extension channel allows the Minnesota Short Alignment to pick up additional flow from the Red River at the location where breakouts from the Wild Rice River enter the Red River. This is of particular importance because a tie-back levee associated with the Minnesota Short Alignment would prevent flow into Rose Coulee. This would likely force more water from the Wild Rice to the Red River in this breakout location; thus causing stage increases on the Red River. A second extension channel with the Minnesota Short Alignment connects an existing breakout location at Cass County Highway 16 and west of the I-29 interchange to the St. Benedict Coulee where the coulee intercepts the Wild Rice River. This extension channel is referred to as the Wild Rice River Breakout Channel. This breakout channel is in place to mimic an existing breakout location and prevent stage increases on the Wild Rice River. See Figure B3 for additional detail on the Minnesota Short Diversion Alignment.

B2.3 Tie-back Levees. Both Minnesota Alignments require a tie-back levee to tie into high ground on the North Dakota side of the Red River. The Minnesota Long Alignment tie-back levee continues from the extension channel between the Red and Wild Rice Rivers and then proceeds west along Cass County Drain 47 to tie into higher ground near the Sheyenne River. The Minnesota Short Alignment requires a longer tie-back levee, which extends from the control structure on the Red River; then west and south near the Wild Rice River to the extension channel at St. Benedict; then west on the north side of Cass County Highway 16 to tie into high ground near the Sheyenne River. The tie-back levee not only ties the system into high ground, but also serves to prevent breakouts into the Rose Coulee Watershed.

B2.4 Alignment Changes. During Phase 3 of the study, issues related to right-of-way, geotechnical considerations and other factors came to light. These issues resulted in changes to the diversion alignment, particularly in the reach north of Dilworth, MN, and the location of the Red River Control Structure was moved north approximately one river mile. Finally, the turn radii were increased to three-times the channel width (top flow width for 500-year event), which allows for better hydraulic performance and reduces erosion potential. These changes are reflected within this report.

B3.0 NORTH DAKOTA DIVERSION - ALIGNMENT DESIGN CONSTRAINTS

B3.1 Initial Limitations (North Dakota East and West Alignments). As discussed above, the alignment on the North Dakota side- referred to as the North Dakota East Alignment- was developed during the initial phase of the study as one of two potential alignments on the North Dakota side of the Red River. Both North Dakota alignments were restricted by a few key elements. On the North Dakota side, river crossings could not be avoided, but the diversion outlet was placed downstream of the Sheyenne - Red River confluence to minimize the number of crossings. Similar to the Minnesota alignments, the North Dakota outlet was located so that the diversion flow would enter the Red River parallel to a river tangent rather than at right angle to minimize river channel erosion. Cass County Drain 13 is a major drainage area north and west of Fargo, ND. The crossing of this drain under Interstate 29 is only a couple of miles north of the Sheyenne River and formed a logical crossing place for the diversion under Interstate 29. In order to minimize the length of the Red River Diversion, and in turn its cost, the alignment was situated close to the Sheyenne River. The crossing points of the other river systems, such as the Rush River and the Maple River, are within a mile or two of their confluences with the Sheyenne River. Similar to the Minnesota alignment, the alignment was designed to avoid, as much as possible, significant urban areas. As a result, the alignment passes south of Argusville, west of West Fargo, and south of

Horace. The inlet to the Red River Diversion was placed at the Wild Rice River and Red River at a location that would ensure sufficient was flow available to divert. (See Appendix A - Hydrology.) Furthermore, by using a location south of Cass County 16, the diversion is upstream of the existing breakouts into the Rose Coulee Watershed.

B3.2 West versus East Alignments. The North Dakota West and East alignments vary only between West Fargo and Horace. In this area, the west alignment goes roughly due north whereas the east alignment follows the existing Sheyenne River (Horace) Diversion. The east alignment was created at the request of the public, whom expressed a desire to utilize the existing Sheyenne River Diversion right-of way-corridor within the proposed Red River Diversion. As a result, the Red River Diversion - North Dakota East Alignment incorporates a portion of the Sheyenne River Diversion between Horace and West Fargo but preserves the West Fargo leg of the Sheyenne River Diversion.

B3.3 Alignment Changes. There have been no significant alignment changes to the North Dakota East Alignment from the alignment initially proposed at the start of this study to the current alignment; other than increasing curve radii similar to the Minnesota Short Alignment and the extension of the tie-back levee in Minnesota. Similar updates have not been incorporated into the North Dakota West Alignment because it is not currently under consideration as the Federally Comparable Plan or Locally Preferred Plan.

B3.4 Tie-back Levee. Phase 3.1 Hydrology represents a significant increase in Red River flows above that presented in Phase 1 Hydrology (see Appendix A - Hydrology). As a result, the height of the tie-back levees needed to be increased and the tie-back levee for the North Dakota East Alignment had to be extended to higher ground. Three alignments for the levee were considered, as discussed below. Figure B4 provides a plan layout of the three alignments considered. Figure B5 provides a layout of the Wolverton Creek crossing with the overflow channel (discussed later).

B3.4.1 North Dakota East Alignment Tie-Back Levee, South Option. This alignment starts at the Red River Control Structure and terminates just south of Comstock, Minnesota in Section 27 of Holy Cross Township. This option is intended to eliminate the need for a control structure on Wolverton Creek since the alignment stays west of Wolverton Creek. The disadvantage of this option is that there is not sufficient high ground west of Wolverton Creek other than the existing high ground on the left (west) bank of Wolverton Creek. While the ground might appear adequate on the profile, the tie-in is only marginal and would not be adequate if there are any future increases in the height of the proposed tie-back levee. There also is a concern with water entering Wolverton Creek upstream of the tie-back levee. This could circumvent the levee system and result in additional flow to Wolverton Creek.

B3.4.2 North Dakota East Alignment Tie-Back Levee, East Option 1. This alignment starts at the Red River control structure and terminates northeast of Comstock in Section 22 of Holy Cross Township. This alignment crosses Wolverton Creek so that a control structure is required in addition to the tie-back levee. As with South Option, the ground might appear adequate on the profile; however, the tie-in is only marginal and would not be adequate if there are any future increases in the height of the proposed tie-back levee. There is also a concern with water entering Wolverton Creek upstream of the tie-back levee, similar to the South Option. This could circumvent the levee system and result in additional flow to Wolverton Creek.

B3.4.3 North Dakota East Alignment Tie-Back Levee, East Option 2. This alignment is similar to East Option 1; however, instead of extending south from Section 10 of Holy Cross Township, the tie-back levee is extended to a high ridge located just west of the Buffalo River. This option is the preferred option since there is sufficient high ground for a good tie-in with the existing ground, even if the levee is raised in the future. As with East Option 1, a control structure is required for Wolverton Creek.

B3.4.4 Hydraulic Sizing of the Wolverton Creek Control Structure. Hydraulic sizing of the Wolverton Creek Control Structure is discussed below as part of Section B6 - North Dakota East Alignment Conceptual Design.

B4.0 RED RIVER DIVERSION - MODEL CONSTRUCTION

B4.1 Overview. During the initial phase of the study, many of the channel design parameters were determined as part of establishing the feasibility of the project and establishing an estimated cost. Hydraulic modeling of the Red River Diversion was accomplished using the steady state routine within the HEC-RAS software developed by the US Army Corps of Engineers, Hydrologic Engineering Center. The hydraulic models of the Red River were originally developed as part of ongoing Flood Insurance Studies for the local area as provided in References A and B. The models have since been recalibrated for the 2009 flood event and the location and number of lateral weirs representing breakout flow locations has been adjusted. The models for the Red River Diversion were initially developed as separate models, which allowed for more efficient optimization of the channels and then were merged with the Red River model. Although some attempts were made to add the Wild Rice River to the model, it generally was found to be unnecessary and the Wild Rice is indirectly modeled through flow inputs. In addition, the Wild Rice River Breakout Channel that allows for breakouts from Cass County Highway 16 to St. Benedict Coulee was modeled in the earlier phases to optimize the size. This modeling has not been updated with the later phases.

B4.2 Modeling Assumptions. Although several assumptions were made early in the modeling process, many of these assumptions have since been verified or removed. Some of the remaining assumptions are provided below.

1) *A single “n” value for the diversion channel is assumed (0.03).* A single “n” value for all overbank areas are assumed (0.04). The “n” value for the channel was discussed at the kickoff meeting and is based on data from the Winnipeg Floodway. On the North Dakota side, “n” values have been adjusted to reflect the concrete and riprap channel linings associated with the hydraulic structures at the Sheyenne and Maple Rivers. Much of the area adjacent to the channel is

farmland allowing use of a single value in the overbanks. The actual value is based on past modeling experience.

2) *MINNESOTA ALIGNMENTS: Tributary flows entering the diversion were assumed to be inconsequential.* The upstream flow is the same as the downstream flow in the diversion. This assumption is consistent with the discussion presented in Appendix A - Hydrology.
3) *The Dilworth railroad yard may be treated as a single bridge.* This assumption will be refined with additional bridge design if necessary. However, the gaps between individual bridges would likely be small. Modeling as a single bridge is conservative. This issue is left pending final design. This same assumption was used where parallel roads and railroads are very close.
4) *Features in a reach could be used to prevent counting conveyance areas twice in two adjacent reaches.* Ineffective flow areas, levees, and blocked obstructions were used near the inlet and outlet of the diversion to account for the control structure and spoil banks. With the Minnesota Short Alignment, the effective flow limits for the Red River and the extension channel were adjusted to that they did not overlap as the two alignments are parallel and in close proximity to each other.
5) *Containment levees on the diversion above existing ground were modeled with levee cards.* The location of these levee cards were offset 50 feet from bank stations, which were placed where the channel excavation daylighted with existing ground. The 50 feet represents the required geotechnical bench as the diversion geometry daylights into existing ground. The location of these levee cards would then represent the toe of the diversion containment levees above existing ground.

B4.3 Modeling North Dakota Tributary Flows. The tributary rivers, such as the Sheyenne, Maple, Lower Rush, and Rush Rivers, are not directly modeled in the North Dakota East Alignment model. Rather, a change in flow is made at these locations. Early in the modeling process, it was necessary to determine through hydrology the flow input at each tributary river (see Appendix A – Hydrology). However, a significant amount of work has taken place to refine this method of accounting for the tributary rivers. As a conceptual design for the river crossings at the diversion was developed, these crossings were inserted into the diversion models as bridge structures. This allowed for direct determination of the head loss at each structure. It was also possible to refine the flow input at each structure. Initially, the flow input was based on Appendix A; however, with separate modeling associated with the design of the structures, an actual flow was determined. This separate modeling effort used rating curves developed for each tributary for both local and Red River coincidental flooding at the location of the hydraulic structure and the flows presented in Appendix A as target design flows. Based on this analysis, the actual performance of the hydraulic structures was determined and then these calculated flows were put back into the diversion models. Expanded discussion of the details of construction and operation of the various channel structures is found within Appendix F - Hydraulic Structures.

B4.4 Recalibration of the Red River Model. In Phase 2 of this study, (Phase 1 Hydrology) the Red River model was based on the preliminary FIS model. This model was calibrated for the 1997 flood. During Phase 2 Part 2 of this study, the Red River model was modified and recalibrated for the 2009 event. A summary of study phases was provided above in Section B1.2. Since Phase 2 Part 2 of this study, the USACE Agency Technical Review (ATR) committee has reviewed the models. In response to their comments, additional extensive re-calibration was done during this phase. The changes to the Red River model are summarized in a Moore Engineering Memorandum attached as Attachment B1 to this report. Many of the changes focused on two areas. The first area was the cross section resistance (Manning's "n" values) and bank station locations. The second area was the location of the flow optimization points in the model, namely lateral weirs and junctions.

B4.4.1 Calibration of Red River Bank Stations and Flow Resistance. The previous version of the Red River model often had the channel subdivided into different "n" values. When looking at these values in aggregate, the values tended to be larger than expected. To deal with this issue, the bank locations were adjusted with the aid of aerial views of the river corridor. The channel "n" values were then aggregated into a single value between the banks. By utilizing the discharge-elevation curve at the Fargo gage, the model channel "n" values were calibrated for low flows. Having calibrated the channel resistance "n", it was then necessary to also calibrate it for large flows, which involves extensive flow in the overbank areas. With the aid of 50 observed high water mark elevations from the 2009 flood throughout the Fargo-Moorhead area, the overbank "n" values were calibrated to best fit the observed data. Figure B6 is a Discharge - Elevation Curve for the recalibrated model at the Fargo gage. Figure B7 provides a modeled profile of the Red River versus the observed water surface elevations. Upon completion of this calibration, the values for channel resistance tended to vary from 0.038 to 0.045 with overbank values of 0.10 to 0.16, which are within the range of expected values.

B4.4.2 Model Optimization Locations- Weirs and Junctions. The Red River model has several weirs and junctions, which allow the model to split flows based on energy and momentum equations between separate channels. On the south side of Fargo, these channels are the Red and Wild Rice Rivers. On the north side of Fargo, the channels are the Red River and the Oakport Coulee. On the south side of Fargo, the weirs were turned off. This approach was followed because the Wild Rice River reach is not included in the model and the weirs did not accurately reflect breakout flows associated with modeling a single river system. It was still possible to model the effect of exchange of flows in terms of flow attenuation. Significant attenuation due to storage occurs for large flows along the Red and Wild Rice Rivers. The hydrologic analysis conducted by the USACE provided the necessary increase or reduction of flow along the Red River from Hickson to the confluence of the Wild Rice River. On the north side of Fargo, several issues with balancing flows at junctions and weirs led to the inability for the model to converge in the Oakport region. One issue had to do with a connecting reach that allowed for flow from Oakport Coulee to the Red River near the Highland Park subdivision. It was noticed that, given the difference in water surface elevations between the Red River and Oakport Coulee, this channel could flow in either direction; however, the limits of the model did not properly allow for that interaction. With regards to the junctions, at very low flow conditions water should not flow into the Oakport Coulee, but without a separate geometry file this could not be modeled with a junction. It was decided to replace several of the junctions in the Oakport area with weirs. This method is also more similar to that used in the unsteady flow modeling, which removes the Oakport Coulee and replaces it with weirs and storage cells. Several weirs connect the Red River with the Oakport Coulee. To ensure sufficient tailwater on the weirs, the location of the tailwater was moved upstream in some cases. A discussion was had with regard to possibly simplifying this reach by removing the Oakport reach altogether and replacing it with longer Red River cross sections; however, this in itself would present problems with the flow balancing routines between cross sections. Barr Engineering conducted a sensitivity analysis of the weirs and their initial estimated flows within the model. It was determined that even if the model was still unable to converge in this region the changes in water surface elevations dependent on input values did not change significantly. Therefore these results had little impact upstream where the economic analysis was conducted. Further discussion of the sensitivity analysis can be found in the Moore Engineering Responses to the Barr Engineering Memorandum on the 2009 HEC-RAS Calibration Model, Fargo Moorhead Metro Study, included as Reference H. Additional discussion on use of an equivalent reach can be found in a Barr Engineering Memorandum, which is included as Reference I.

B4.4.3 Emergency Levees*.* Several emergency levees were in place during the 2009 flood. The locations of these levees were digitized and incorporated into the calibration model. During another large flood, these levees would likely be reconstructed, but since they were temporary and not certified, they were not used in the reference or project models.

B4.5 Team Development of the Models. Given the time constraints of the study, it was necessary to conduct the modeling using a team of three engineering firms. Moore Engineering developed the reference models and completed modeling of several of the alternatives. Barr Engineering modeled the hydraulic structures. Additional modeling of the alternatives and project time frames during Phase 3 was conducted by Barr Engineering and Houston Engineering. To ensure consistent quality work, the models developed by one engineering firm were reviewed by one or both of the other engineering firms listed above. The reviews conducted were in-depth, with comments passed verbally and in writing. A set of the comments is provided as Attachment B2.

B5.0 MINNESOTA SHORT ALIGNMENT - CONCEPTUAL DESIGN

B5.1 Minnesota Long Alignment. The Minnesota Long Alignment had many of the same design features as the Minnesota Short Alignment such as cross section, depth, outlet and inlet design, channel grade, and more. Where they differed was in the alignment, the location of tie-back levees, and auxiliary channels. As the Minnesota Long Alignment is no longer under consideration, no further discussion on its conceptual design will be included.

B5.2 Channel Cross Section. During the initial phase it was determined that the most cost beneficial channel geometry (in terms of excavation volume) incorporated a deeper channel as opposed to a wider channel having the same capacity. This led to consideration of a "V" notch channel. It was further considered that an even more economical section may be parabolic or a semicircle. The determination was made that channel designs of this fashion were not practical and a trapezoidal channel with a minimum channel bottom width of 50 to 100 feet was established. This bottom width was further modified by other design constraints. The next parameter in the channel cross section was the channel side slope. Based on guidance received at the Project Kickoff meeting, the side slopes were to be 7:1 horizontal to vertical. The 7:1 slope was selected to ensure stability of the channel in lieu of conducting soils testing at that phase of the study. At bridges, the 7:1 slope was reduced to a 5:1 slope to reduce bridge span lengths. This side slopes have been modified in the current phase as a result of geotechnical considerations and the cross sections now include benches and flatter slopes in some areas. Table B1 provides a list of the various cross sections used in the channel and their locations.

B5.3 Geotechnical Considerations. One of the early concerns with the channel alignment and channel cross section was the avoidance of the Buffalo Aquifer. Even if the channel did not impact the aquifer, it was still possible for ground water to impact the stability of the channel. Early geotechnical testing concluded that ground water and soil stability would preclude maximizing the depth of the channel. Discussions with the US Army Corps of Engineers concluded that a channel excavation deeper than 35 feet on the Minnesota alignments may be problematic in terms of underground aquifers. To ensure additional safety on this issue, a limit of approximately 30 feet was suggested and this limit was incorporated into the design. Since then, additional geotechnical work has placed additional constraints on the channel. These include a change made in the alignment during the current phase and a change in cross section as discussed above. Another recent change was to raise the bottom an additional four feet in the area south of approximately Station 566+58. Due to concern with the effects of uplift, on the channel bottom, as a result of potential hydrostatic water pressure; it was determined that the channel should be raised at this point and to the south for several miles. However, given the nearly flat channel slope, it was not possible to simply raise a portion of the channel. Therefore the entire channel south of approximately Station 566+58 was raised the four feet. At Station 566+58, a sheetpile and riprap drop structure is provided to ensure channel stability.

B5.4 Channel Depth versus Vegetative Requirements. Maintaining vegetation on the diversion channel was identified as an initial project feature. In order to accomplish this goal, a criteria was set that the minimum elevation at the outlet should not fall below the 75% flow duration for the month of May on the Red River. Figure B8 provides guidance for setting the channel minimum elevation at the outlet of the Minnesota Short Alignment at the Red River.

B5.5 Channel Slope. Channel slope is governed by two factors. The first is to pursue a sufficient slope to allow water in the channel to drain in sufficient time to preserve vegetation on the channel bottom. The second factor is to ensure adequate depth of the channel at the upstream end to provide the required channel capacity. Based on these competing requirements, a channel slope of 0.01% was used for the downstream half of the channel and 0.02% for the upstream half of the channel.

B5.6 Auxiliary Channels, Tie-back Levees, and Channel Breakouts. The Minnesota Short Alignment has the advantage of both the Red and Wild Rice Rivers having already converged upstream of the diversion to provide sufficient flow to the diversion. However, this also means that breakout flows have also occurred prior to the diversion. These breakouts flow into the Rose Coulee Watershed and would impact Fargo. An initial concept was to add a tie-back levee extending from the Red River Control Structure west to high ground near Horace, ND. With this levee, it was also necessary to construct a side channel to return the breakout flows to the rivers. After several hydraulic computations, it was determined that after the breakout flows had reached the side channel, insufficient hydraulic grade remained to return the flow to the rivers and that the side channel then actually presented a potential path for breakout from the river to areas to the west. As a result, it was necessary to look at moving the tie-back levee upstream. The east - west leg of the levee was finally moved to a location just north of Cass County Highway 16, with a north - south leg adjacent to the Wild Rice River, which tied the east - west leg back to the Red River Control Structure and the Red River Diversion. Refer to Figure B3 for more details on the exact alignment of the final tie-back levee. The tie-back levee prevents breakouts from the Wild Rice River north of Cass County Highway 14 from entering the Rose Coulee Watershed. As a result, more water remains in the river. To offset the potential for stage increase an auxiliary channel is added to the Red River Diversion that extends from a point north of the Wolverton Creek confluence with the Red River to the diversion northward on the east side of the Red River. This channel then pulls off over 14,000 cfs on the 500-year, project year zero, Red River event. In the model, this auxiliary channel is referred to as the Extension Channel. A second smaller channel is constructed to allow water that breaks across Cass County Highway 16 on the west side of Interstate 29 to return to the Wild Rice River at the St Benedict Coulee (1 mile north or Cass Hwy 16). This channel is referred to in the hydraulic model as the Wild Rice River Breakout Channel since it deals with the Cass County Highway 16 breakout. The combination of the two auxiliary channels then effectively eliminates the potential stage increases that would be a result of the prevention of breakouts due to project tie-back levees. In the hydraulic model, the Extension Channel parallel to the Red River is included as a reach to allow direct modeling of its impact.

B5.7 Minnesota Short Diversion Weirs. Initially it was decided that the Red River Diversion should not operate prior to the Red River exceeding the 5-year flood event. During Phase 2 Hydrology, it was determined that the 5-year event equated to approximately 9,600 cfs on the Red River downstream of the Wild Rice River confluence. As part of Phase 3 Hydrology, the flow objective was kept at 9,600 cfs rather than strictly a 5-year event. With Phase 3.1 Hydrology, 9,600 cfs equates to approximately a 3.6-year event. Two weirs are used in conjunction with the Red River Diversion with the Minnesota Short alignment. The weirs control when the Red River Diversion begins to flow and how much flow is directed to the channel. The weir on the Extension Channel is set at approximately the 3.6 year event plus one and a half feet. The weir on the Diversion Channel is set at approximately the 3.6 year event plus one half foot. Both of these weirs ensure the Red River Diversion begins operation soon after a 3.6 year event. The use of one half foot and one and a half feet above the 3.6 year level for the two weirs is driven by hydraulic balancing of the diversion with the Red River Control Structure. It is not intended to establish a starting operation point of the diversion other than above a 3.6 year event. The minimum flow in the Red River prior to operation of the Red River Diversion is based on environmental concerns

B5.8 Red River and Diversion Control Structures. The Red River Control Structure is a combination earthen berm and concrete structure with three gated openings. Initial concepts of this structure included several culvert openings. To increase the efficiency of the structure, to address velocity concerns, and to deal with ice issues, those openings have been consolidated into three larger openings. The gates for the three openings will not be allowed to close off flow within two feet of the gate invert elevation. Appendix F discusses the purpose of this design. The operation of the gates will allow normal flows during non-flood conditions and floods less than 9,600 cfs to pass unimpeded at this structure. The upper portion of the openings are gated to control flow downstream. The gates, along with the Red River Diversion Inlet Weir, also control head conditions upstream of the structure. The control structure is modeled in HEC-RAS as an inline structure with gates. The inlet weir to the Red River Diversion is envisioned as a sheetpile and rock weir. It is also modeled using the inline structure routine as a compound weir embankment. The compound weir allows better response for intermediate flows. For more information on this or other hydraulic structures, see Appendix F - Hydraulic Structures.

B5.9 Maintaining the Upstream Water Surface Profile. Phase 3 of the study involved changing hydrology during different time periods for the project (see Appendix A – Hydrology). As the flows for the different time periods, project years 0, 25, and 50, would vary, the design of the inlet weir may also need to vary. Since the weir is designed for the project year 0 condition and no changes to its design are made in the future, then it may pass insufficient flows on the later years due to insufficient head on the weir (because the flows decreased). Because of this concern, it was initially decided that the weir should be designed for Year 0 and that to ensure sufficient head on subsequent hydrologic time periods, the Year 0 upstream water surface would be allowed for all project time frames. This was later modified into 3 priorities; 1) In all cases, 9,600 cfs should be allowed to pass downstream of the Red River closure structure toward Fargo; 2) At the Year 25, it would first be attempted to operate the system such that the water surface is not raised above the existing condition for Year 25; 3) If necessary the water surface upstream of the weir would be allowed to rise above the existing Year 25 water surface, but not above the existing Year 0 water surface.

B6.0 NORTH DAKOTA EAST ALIGNMENT - CONCEPTUAL DESIGN

B6.1 North Dakota West Alignment. The North Dakota West Alignment has many of the same design features as the North Dakota East Alignment such as cross section, depth, outlet and inlet design, channel grade, and more. Where they differ is in the alignment between Horace and West Fargo. As the North Dakota West Alignment is not currently the Local Preferred Plan or the Federal Comparable Plan, no further discussion on its conceptual design will be included.

B6.2 Channel Cross Section. During the initial phase it was determined that the most cost beneficial channel geometry (in terms of excavation volume) incorporated a deeper channel as opposed to a wider channel having the same capacity. This led to consideration of a "V" notch channel. It was further considered that an even more economical section may be parabolic or a semicircle. The determination was made that channel designs of this fashion were not practical and a trapezoidal channel with a minimum channel bottom width of 50 to 100 feet was established. This bottom width was further modified by other design constraints. The next parameter in the channel cross section was the channel side slope. Based on guidance received at the Project Kickoff meeting, the side slopes were to be 7:1 horizontal to vertical. The 7:1 slope was selected to ensure stability of the channel in lieu of conducting soils testing at that phase of the study. At bridges, the 7:1 slope was reduced to a 5:1 slope to reduce bridge span lengths. This side slopes have been modified in the current phase as a result of geotechnical considerations and the cross sections now include benches and flatter slopes in some areas. Table B2 provides a list of the various cross sections used in the channel and their locations.

B6.3 Channel Depth versus Vegetative Requirements. As with the Minnesota Short Alignment, maintaining vegetation on the diversion channel was identified as an initial project feature. In order to accomplish this goal, a criteria was set that the minimum elevation at the outlet should not fall below the 75% flow duration for the month of May on the Red River. Figure B9 provides guidance for setting the minimum channel elevation at the outlet of the North Dakota East Alignment at the Red River.

B6.4 Channel Slope. The North Dakota East Diversion Alignment channel bottom slope is 0.02% and has remained unchanged with each phase.

B6.5 Red River to Wild Rice River Connecting Reach. With the North Dakota East Alignment, it is necessary to start the diversion channel at the Red River to pull water from both the Red and Wild Rice Rivers. However, the design of the connecting reach between these two rivers is different from the rest of the diversion. This unique design is to ensure proper balance of flow is maintained between the two rivers. Among the design features, the channel is graded at a 0.02% slope but sloped from the Wild Rice River to the Red River. This allows the channel to drain to the Red River. It also provides that the channel will fill from back water from the Red River prior to actually flowing. The invert of the channel at the Red River is set at the Phase 2 Hydrology 2-year water surface elevation on the Red River. Section B6.9 North Dakota East Diversion Weirs, provides a detailed discussion of the weirs that govern the operation of this connecting reach.

B6.6 Tie-Back Levees. Tie-back levees extend from the Red River closure structure east until hitting high ground in Minnesota. No other tie-back levees were added to this alignment for the area south of Fargo. The initial tie-back levee extended east across

Wolverton Creek and approximately two to three miles into Minnesota to find high ground. See Figure B1 for the exact line of the levee. With Phase 3.1 Hydrology it was necessary to update the tie-back levee with the increased height of the Red River. Three alignments have been proposed. See Section B3.4 for additional details on the alignments and which is preferred.

B6.7 Wolverton Creek Crossing. As the preferred alignment for the North Dakota East Alignment tie-back crosses Wolverton Creek, it was necessary to start a discussion of how to size the crossing structure. This structure was provided in the initial reports, however, with the preliminary FIS hydrology (See Appendix A - Hydrology) and Phase 1 Hydrology, this crossing represented a flow of less than 2,500 cfs at the 500-year Red River event. With the current hydrology, the 500-year, project year zero flow could be as much as 9,200 cfs. Some of the ongoing discussion on this crossing is provided below.

B6.7.1 Unimpeded 500-year flow. The current hydraulic modeling assumes that this crossing allows the coincidental flow for a 500-year Red River event to proceed unimpeded. However, sizing a structure large enough to allow that amount of flow within the provided hydraulic head constraints may be as large as four (4) 11' wide by 22' high box culverts. It should be noted that the road crossing at this location has two (2) 10' x 10' box culverts today and that the road submerges under many flood events. The invert of the levee crossing box culverts would be set at approximately 895.0 to closely match the invert of the existing box culverts under the road. This is not a preferred solution.

B6.7.2 Gated Flow. If four (4) 11' wide by 22' high box culverts were used at this crossing, there would likely be a need to place gates on this crossing. This is to ensure that such a crossing could not pose a risk of too much flow through the line of protection. A large gated structure at this location is not a preferred solution.

B6.7.3 Fish Passage. With placing a crossing on Wolverton Creek the issue of fish passage is raised. Any crossing should be designed to minimize velocities and to allow for fish passage. Minimizing velocities could entail larger boxes or roughening of the lower box to provide areas of lower velocity. It should be noted that with the existing road crossing and the preliminary FIS hydrology, a 10-year local flood event would see a velocity over 8 fps within the existing road crossing. Velocities as high as 12 fps are evident at this crossing on a 100 or 500-year local flood event. The 10-year preliminary FIS event flows as an open channel, or non-pressurized, event through the existing crossing. The 50-year preliminary FIS event on Wolverton Creek overtops the existing road at this location.

B6.7.4 Auxiliary Channel. The preferred solution to placing large box culverts at this crossing would be to size culverts to match the road culverts or to move this portion of the levee onto the road with a road raise and use the existing culverts. With these options, an auxiliary channel would be constructed to divert larger flows to the Red River, to ensure stage impacts are not seen upstream of the crossing. This approach would reduce the risk of large openings on a tie-back levee while preventing stage increases. Under this scenario, provisions could be made to even enhance fish passage on

Wolverton Creek by starting to divert water on smaller floods; however, a minor adjustment in the operation of the Red River Control Structure may be necessary to deal with additional water upstream.

B6.8 North Dakota Tributary Hydraulic Structures. Hydraulic structures were necessary at the North Dakota tributaries. These hydraulic structures allow lower flows to continue downstream in the rivers while diverting a majority of all river flows into the Red River Diversion during larger flood flows.

B6.8.1 Minimum Downstream Flows. An objective established by the USACE stipulated that a minimum flow at each river be allowed to pass the Red River Diversion and enter the downstream reach of the River. This flow was set as the 2-year local flood flow at the Sheyenne River and the Maple River. Under project conditions, the Lower Rush River and Rush Rivers are diverted completely to the Red River Diversion, so the 2-year flow amount for these two rivers was added to the amount set on the Maple River. In other words, the minimum amount to pass through to the downstream reach of the Maple River would be the sum of the 2-year local flood flows of the Maple, Lower Rush, and Rush Rivers. A minimum flow objective was also set for the Wild Rice River. The Red River minimum flow was set as 9,600 cfs during Phase 2 Hydrology, which was a 5-year event flow downstream of the Wild Rice River. With Phase 3 and 3.1 Hydrology, the 9,600 cfs flow amount was maintained which is equivalent to approximately a 3.6 year event on the Red River. The Wild Rice River minimum flow was set as the coincidental flow associated with 9,600 cfs on the Red River. This flow amount for the Wild Rice River is approximately 2,350 cfs.

B6.8.2 Sheyenne River Hydraulic Structure. The Red River Diversion flows under the Sheyenne River at this crossing. The crossing exists as a series of bays similar to a row of precast box culverts through which the diversion flows. On top of the boxes is an open concrete channel through which the Sheyenne River flows perpendicular to the Diversion Channel. The sizing of the top channel dictates the amount of flow that passes the diversion and reaches the downstream reach of the Sheyenne River. Flows above this amount are directed into the Red River Diversion. For more details on this structure, see Appendix F - Hydraulic Structures.

B6.8.3 Maple River Hydraulic Structure. The Red River Diversion flows under and over the Maple River at this crossing. The crossing exists as a series of bays similar to a row of precast box culverts through which the diversion flows. On top of the boxes is an open concrete channel through which the Maple River flows perpendicular to the Diversion Channel. When the diversion flows exceed what will pass underneath the river open channel, additional flows will flow over the top and continue downstream in the diversion. The sizing of the concrete open channel dictates the amount of flow that passes the diversion and reaches the downstream reach of the Maple River. As the diversion can flow over the top of this structure, it was also necessary to gate the downstream end of the open river channel to control flows into the Maple River downstream of the crossing. For more details on this structure, see Appendix F - Hydraulic Structures.

B6.8.4 Rush and Lower Rush Rivers. The Rush and Lower Rush Rivers have separate outlets to the Red River Diversion. However, there is not a crossing as 100% of both rivers are diverted into the diversion. To maintain adequate flows in the Sheyenne River at this location, additional water, was allowed to enter the Sheyenne River from the Maple River crossing. See Section B6.8.1 for additional discussion on downstream flows for the Maple River.

B6.8.5 Wild Rice Hydraulic Structure. The Wild Rice River hydraulic structure has changed in concept since the first phase of this study. With Phase 1 Hydrology, a structure was envisioned to allow small flows in the Wild Rice River to proceed downstream in the river. Under larger floods, the entire river would be diverted to the diversion channel but some water would be pulled from the Red River Diversion to enter the Wild Rice River to maintain flow in the downstream reach of the river. During Phase 2 Hydrology, this crossing was simplified. It now consists of two weirs on the diversion and a control structure on the Wild Rice River downstream of the diversion.

B6.9 North Dakota East Diversion Weirs. Two weirs are used on the Red River Diversion with the North Dakota East Alignment. The weirs control when the Red River Diversion begins to flow and how much flow is directed to the channel. The east weir is located on the diversion channel on the east side of the Wild Rice River, which is referred to as the "Red River to Wild Rice River Connection Reach." The west weir is located on the diversion channel on the west side of the Wild Rice River. During Phase 2 Hydrology, the east weir was set at the Red River 5-year flood elevation and the west weir was set at the Red River 5-year flood elevation plus one foot. This ensured that the diversion was not put into use prior to exceeding a Phase 2 Hydrology 5-year event on the Red River. The flow that was associated with the 5-year event was 9,600 cfs downstream of the confluence of the Red and Wild Rice Rivers. This flow level was established as a minimum flow to maintain in the rivers for environmental considerations. During Phase 3 Hydrology, rather than establishing minimum flows based on local flow events, the 9,600 cfs flow was maintained as the benchmark. This flow now equates to approximately a 3.6- year flow on the Red River downstream of the Wild Rice River confluence with the Phase 3.1 Hydrology. Based on this target flow, the east weir was reset to the elevation of a 3.6-year flood elevation. The west weir was set one foot higher than the east weir (3.6-year flood elevation plus one foot).

B6.10 Red River Control Structure. The Red River Control Structure is a combination earthen berm and concrete structure with three gated openings. Initial concepts of this structure included several culvert openings. To increase the efficiency of the structure, to address velocity concerns for fish passage and to deal with ice issues, those openings have been consolidated into three larger openings. The gates for the three openings will not be allowed to close off flow within two feet of the gate invert elevation. Appendix F discusses the purpose of this design. The operation of the gates will allow normal flows during non-flood conditions and floods less than 6,100 cfs to pass unimpeded at this structure. The 6,100 cfs is the flow at the control structure, which when added together with additional flow inputs downstream equates to 9,600 cfs through Fargo-Moorhead. The upper portion of the openings are gated to control flow downstream. The gates, along with the North Dakota East Diversion Inlet weirs, also control head conditions upstream of the structure.

B7.0 ADDITIONAL CHANNEL FEATURES

B7.1 Channel Outlet. During Phase 1 of this study, several project personnel had an opportunity to visit the Winnipeg Floodway project. That project has a significant structural outlet to reduce outlet velocities by taking up grade. However, in the FM Metro area, there is significantly less overall drop in the Red River than in Winnipeg. Further, given the depth of the channels, water will back into the channel several feet deep prior to water entering upstream. As a result, it was decided that an exit structure is not necessary on the Red River Diversion beyond general riprap erosion protection.

B7.2 Low Flow Channel. Given the large width of the channel bottom of both alignments, there is concern with maintaining vegetation on the bottom. This is particularly important as the Red River Diversion will ultimately have drainage systems entering it and thus will have low flows in it frequently. To address this issue, a low flow channel is proposed. The low flow channel would convey most of the base flow level of drainage flows, which would keep the remaining portion of the Red River Diversion Channel bottom dry allowing vegetation to grow. Flows from larger rain events would likely overflow the low flow channel. Initial designs of the low flow channel consist of a trapezoidal channel with 4:1 horizontal to vertical side slopes, a 10 foot bottom width, and a depth of 3 feet. Detailed design of this feature will be conducted later in the design process. A conceptual design of the low flow channel has been incorporated into the hydraulic models. Although a low flow channel is incorporated into the diversion, actual non-flood flows may fill more than the low flow channel. This is particularly true downstream of the Lower Rush and Rush Rivers on the North Dakota East Diversion Alignment.

B8.0 DISCUSSION OF MODELING RESULTS

B8.1 Low Flow Cases. The Red River Diversion is designed primarily for the Red River 500-year, project year zero, event, but to achieve benefits on smaller events, significant design has gone into the process to ensure the system performs through the full range of flood events down to the 3.6 year Red River event. As mentioned above, the system is designed to first start operating when the discharge at Fargo is above 9,600 cfs. Thus, for the Red River 2-year flood events, the diversion system would not be in operation. However, design for these smaller events was conducted to ensure the Red River Control Structure does not adversely impact the Red River, even on these small events. Fish passage is maintained even on low flow events, as well as the use of the river by boats.

B8.2 Model Geometry. As discussed under Section B4 - Red River Model Construction, the model geometry was originally based on the 500-year Red River model developed by the preliminary Flood Insurance Studies cited in References A and B and later modified as discussed above. The Red River Diversion reaches were developed using HEC-GeoRAS from the LIDAR developed by the International Water Institute and provided by the US Army Corps of Engineers. Additional cross sections were added to the Red River adjacent to the Red River Control Structure. These additional cross sections were generated using the LIDAR and merging existing channel bathometry from the existing model. The Red River Control Structure is modeled as an inline structure with gates. The North Dakota tributary crossings were modeled as bridges. The Sheyenne River and Maple River aqueducts, which is the portion of the hydraulic structure connecting the upstream and downstream reaches of the rivers above the diversion channel, are modeled as a bridge deck. The tributary rivers, namely the Wild Rice, Sheyenne, Maple, Lower Rush and Rush Rivers, were not modeled directly but are implied as flow changes. Separate modeling of the hydraulic crossings was conducted to refine the flow inputs. Two dimensional modeling has also been conducted on selected features, however, that modeling effort is not part of this appendix. Figure B10 provides a layout of the stationing on the Minnesota Short Alignment used in the model. Figure B11 provides a layout of the stationing on the North Dakota East Alignment used in the model.

B8.3 Hydrology Inputs. Appendix A - Hydrology provides the hydrology used for this study. This hydrology was further refined as input into the models. These inputs are summarized in Tables B3 through B11 for the reference condition and two alternatives with three project time periods each. Table B3 provides the extreme events of the 1,000-year and 10,000-year Red River events. The tables are placed in order of:

1. Reference Condition Year 0
2. Reference Condition Year 25
3. Reference Condition Year 50
4. Minnesota Short Alignment Year 0
5. Minnesota Short Alignment Year 25
6. Minnesota Short Alignment Year 50
7. ND East Alignment Year 0
8. ND East Alignment Year 25
9. ND East Alignment Year 50

The top section of the table provides flow values representing the local contributions at the north end of the study area. The middle portion of the table incorporates initial flows within the area of Oakport, MN based on upstream flows on the Red River and local flows. The bottom portion of the table contains local contributions for the area south of Fargo. The bottom portion of the table also provides values inputted into the HEC-RAS flow files where a direct input is used for the Red River Diversion. The amount diverted into the diversion channel then dictates the corresponding flow through the Fargo-Moorhead Metro area. Descriptions are provided on both sides of the table indicating the purpose of each flow change. These tables are initial flows throughout the project area. The actual flows are calculated by the hydraulic model.

B8.4 Plan Layout. Table B12 provides a listing of the HEC-RAS project and plan files that model the reference conditions and the two diversion alternatives. Typically, four plan files are provided for each project directory. These plan files take the project from very small floods to greater than the 500-year flood. Two of the files represent the existing conditions. The remaining two files represent the "with project" condition. One file represents the 2-year and smaller flood, while the other file represents larger floods.

B8.5 Red River Control Structure and Diversion Inlet Weir. During the conceptual design of the diversions, it was necessary to optimize the operation of the Red River Control Structure to maintain upstream head conditions. However, final operation of the gates would likely be provided in a Operation and Maintenance Plan. For additional data on the gates, see Appendix F - Hydraulic Structures.

B8.6 Red River Diversion Typical Sections and Profiles. Figures providing typical cross sections of the Red River Diversion and its extension channels are provided. Also provided are profile plots of the Red River Diversion. The typical cross sections are for project year zero unless otherwise specified. The profile plots are for project years 0, 25, and 50. Figure B12 provides a typical cross section of the Wild Rice River Breakout Channel used with Minnesota Short Diversion for the breakout flow from Cass County Highway 16 to St. Benedict. The water levels on this typical cross section are not from the current hydrology. Figure B13 through B16 provide a typical cross section and profile plots for the Minnesota Short Diversion Extension Channel. Figure B17 provides a sample cross section of the Minnesota Short Diversion (see Table B1 for additional cross sections). Figures B18 through B20 provide profile plots for the Minnesota Short Diversion. Figure B21 provides a typical section for the North Dakota East Diversion Connection Channel. Figure B22 provides a sample cross section for the North Dakota East Diversion (see Table B2 for additional cross sections). Figures B23 to B25 provide profile plots for the North Dakota East Diversion.

B8.7 Red River Profiles, Tables and Graphs. Tables B13 through B15 provide a summary of results from the HEC-RAS files for the existing condition for project year 0, project year 25, and project year 50, respectively. Table B16 provides a similar table for the two existing extreme events considered; the 1,000 year and the 10,000 year Red River flood events. Tables B17 through B22 provide the summary of results from the HEC-RAS files for the two alternatives in the order provided above in Section B8.3. Similarly, Figures B26 through B31 provide a summary of the same results in the form of water surface profiles.

B8.8 Stage Frequency Curve at the Fargo USGS Gage. Figures B32 through B37 provide a frequency distribution of elevation and stage for the range of flood events studied at the Fargo USGS Gage. The figures provide both existing and with-project conditions to allow for comparison. As expected, the project significantly lowers the elevation, or stage, at each flood event above a 9,600 cfs flood event on the Red River.

B8.9 Discharge Frequency Curve at the Fargo USGS Gage. Figures B38 through B40 provide discharge frequency curves for the Fargo USGS Gage for the existing and with project conditions for the project Year 0, 25, and 50.

B8.10 Minnesota Diversion versus North Dakota Diversion River Profiles. The Minnesota Short Diversion and the North Dakota East Diversion have different starting and ending locations where they intercept the Red River. Not only does this affect the total square miles that are protected but it also has an impact in tailwater through Fargo. The Minnesota Short and North Dakota East Alignments were compared for the 35 Kcfs alternatives. Figures B41 through B46 provide a comparison of the water surface profiles on the Red River through the FM Metro area for the 100 and 500-year events for the project years of 0, 25, and 50. Although the two alternatives have the same design capacity, the points of intercept on the Red River have an impact on the water surface profile.

B9.0 REFERENCES

A - Flood Insurance Restudy for Southern Cass County, North Dakota, and Clay County, MN, Dated: ongoing

B - City of Fargo CTP Project, Clay County / Oakport Township, Dated: ongoing

C - Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Moore Engineering, Etal., August 31, 2009.

D - Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Moore Engineering, Etal., Appendix H- Red River Hydraulic Structure Velocities, October 15, 2009.

E - Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report, Phase 2 - Part 2, for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Moore Engineering, Etal., December 31, 2009, with a Revised Addition on January 6, 2010.

F - Northwest Diversion, Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report, Phase 2 - Part 2, for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Moore Engineering, January 27, 2010.

G - Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study Report, Phase 3, for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN, Moore Engineering, Etal. May 17, 2010.

H - Memorandum, Moore Engineering Responses to April 12,2010 Comments by Barr Engineering, 2009 HEC-RAS Calibration Model, Fargo Moorhead Metro Study, Economics Profiles for the NED Plan Determination with the Phase 3 Hydrology, April 23, 2010.

I - Memorandum, Barr Engineering, May 5, 2010

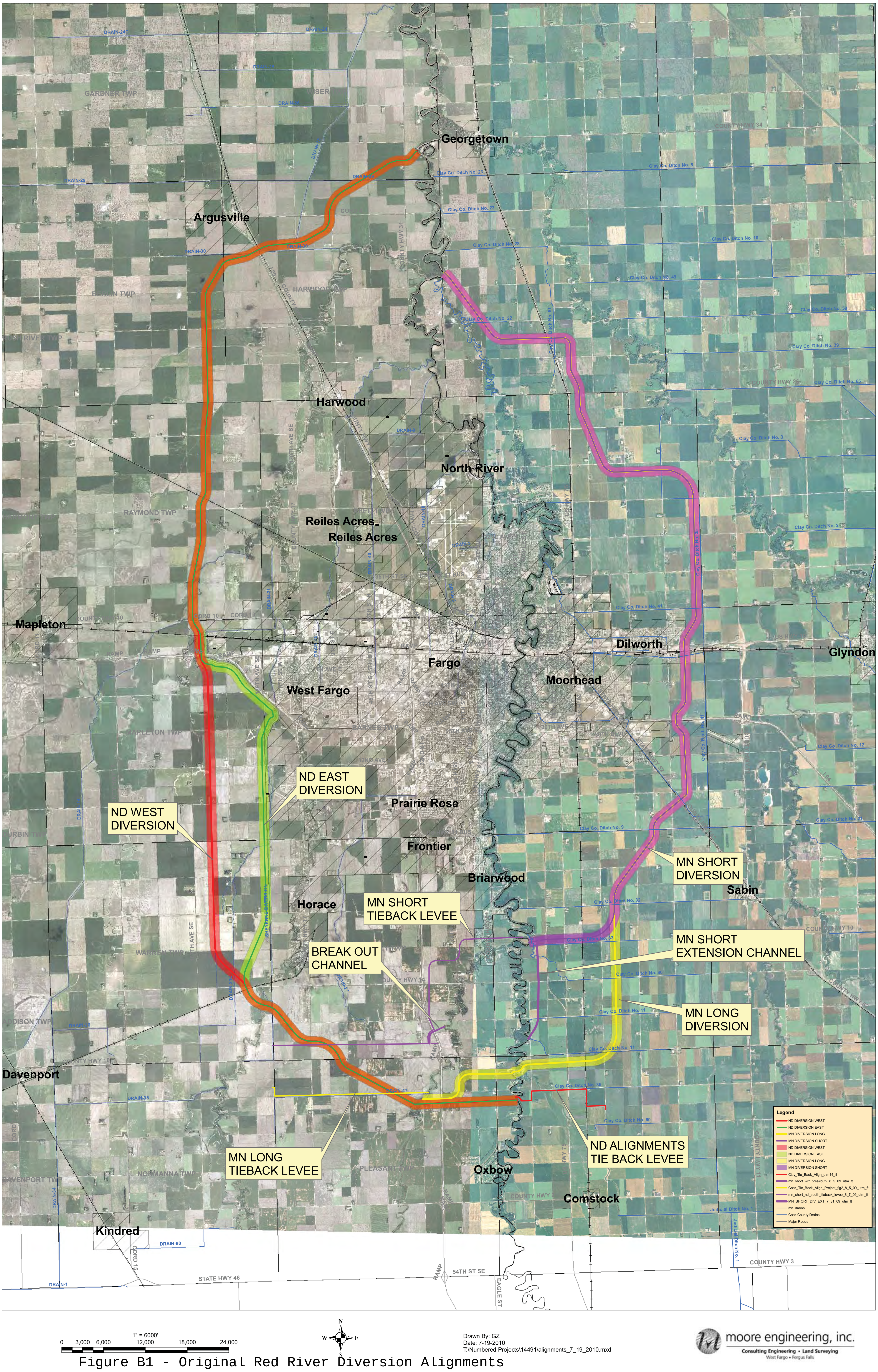
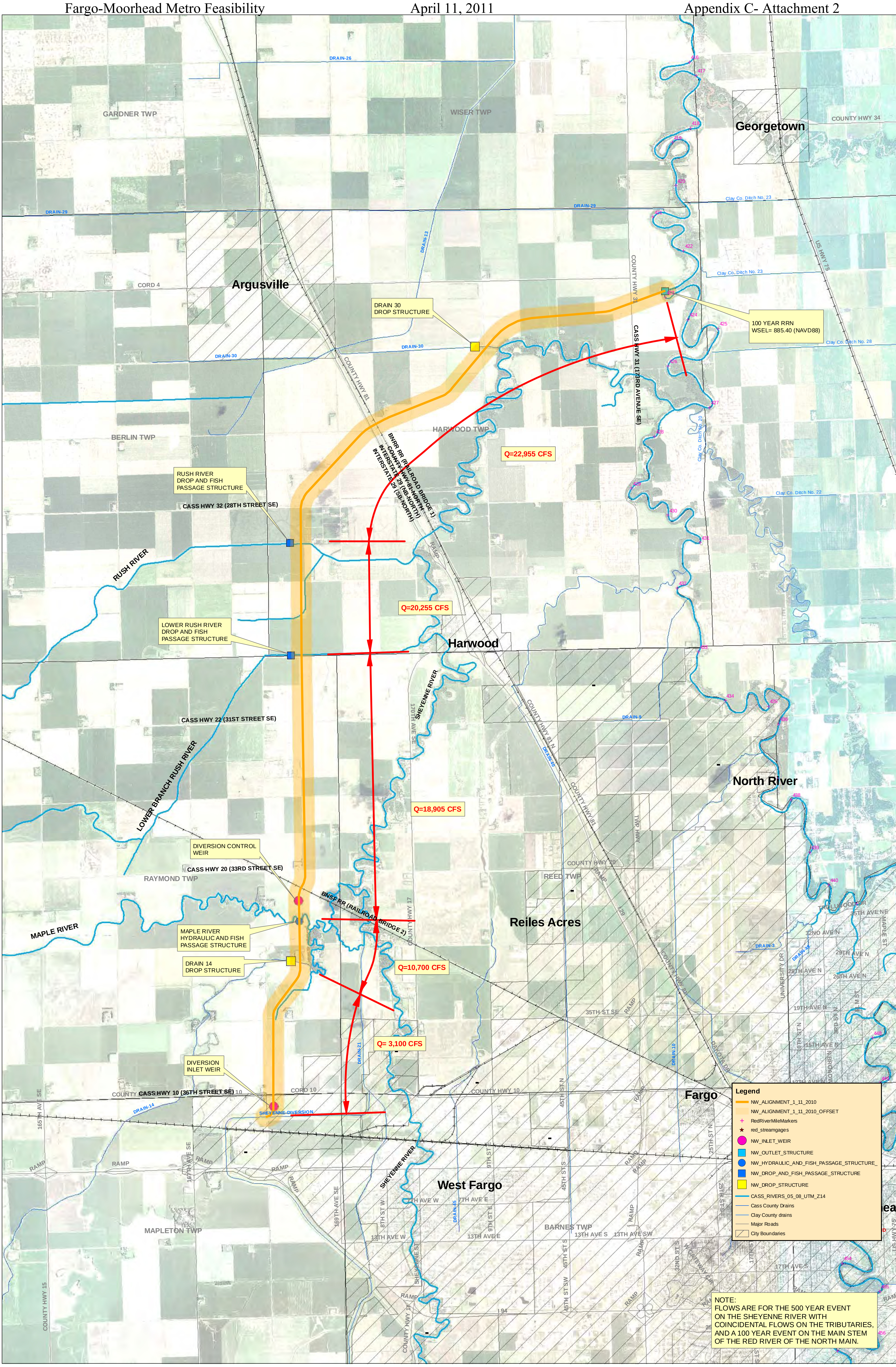


Figure B1 - Original Red River Diversion Alignments



NORTHWEST DIVERSION
500 YEAR DESIGN EVENT

Figure 1

Drawn By: GZ
Date: 01-22-10
T:\Numbered Projects\14491\NW_ALIGNMENT_DESIGN_EVENT_FLOWS_d_size.mxd

moore engineering, inc.
Consulting Engineering • Land Surveying
West Fargo • Fergus Falls

Figure B2 - Northwest Diversion Channel Alignment

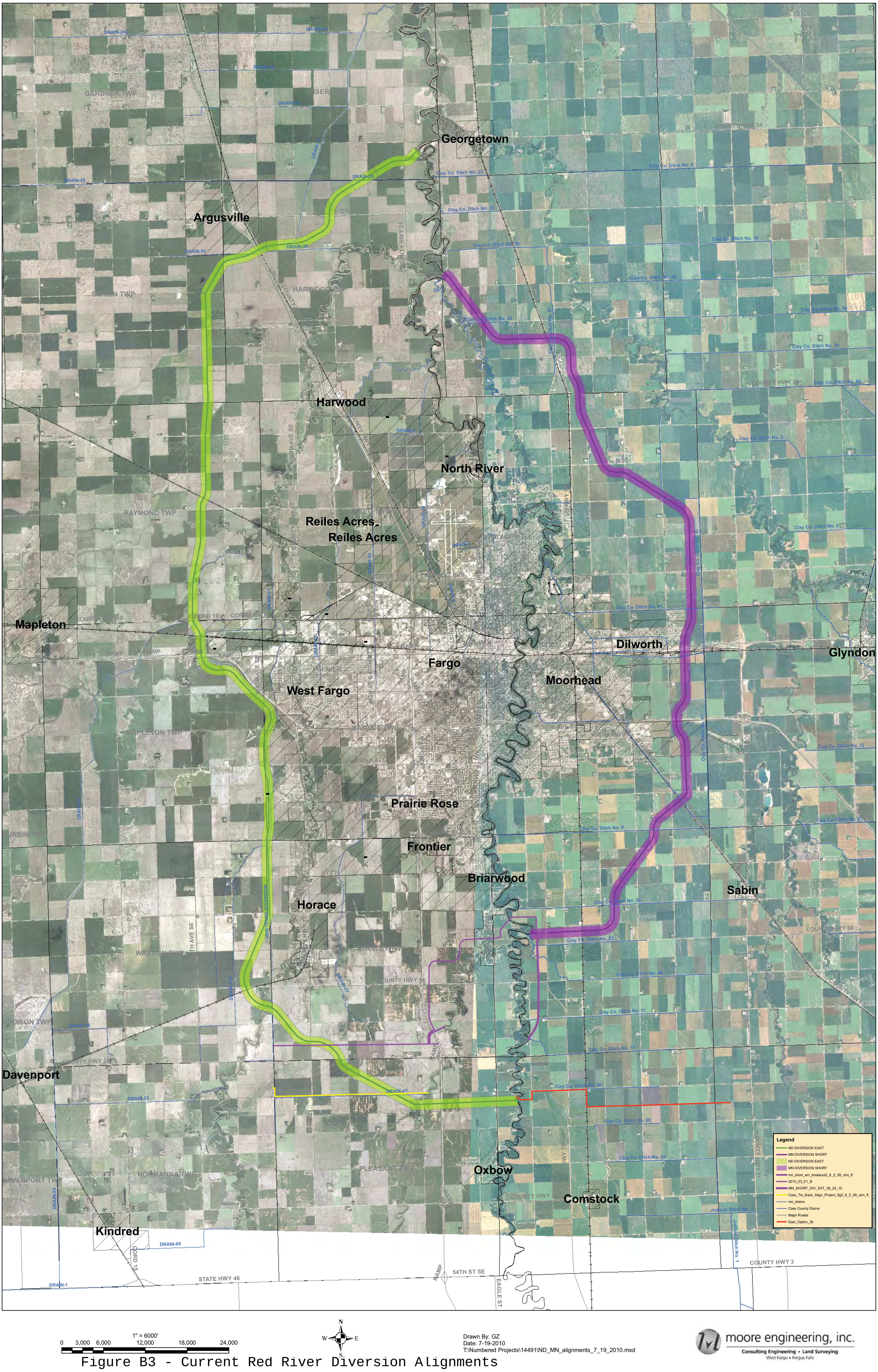


Figure B3 - Current Red River Diversion Alignments

Figure B4 - ND East Diversion Alignment, Tie-Back Levee Options

Clay County Tieback Levee Crossing
Clay County, MN
2009 Aerial NAIP Photo

Figure B5 - Wolverton Creek Crossing and Overflow Channel Layout

N

1" = 50'
0 25 50 100 150 200

Drawn by: GZ
Date: 7-22-2010
T:\Numbered Projects\14491\14491_Clay_levee_crossing_2.mxd

moore engineering, inc.
Shaping the Region for 50 Years.

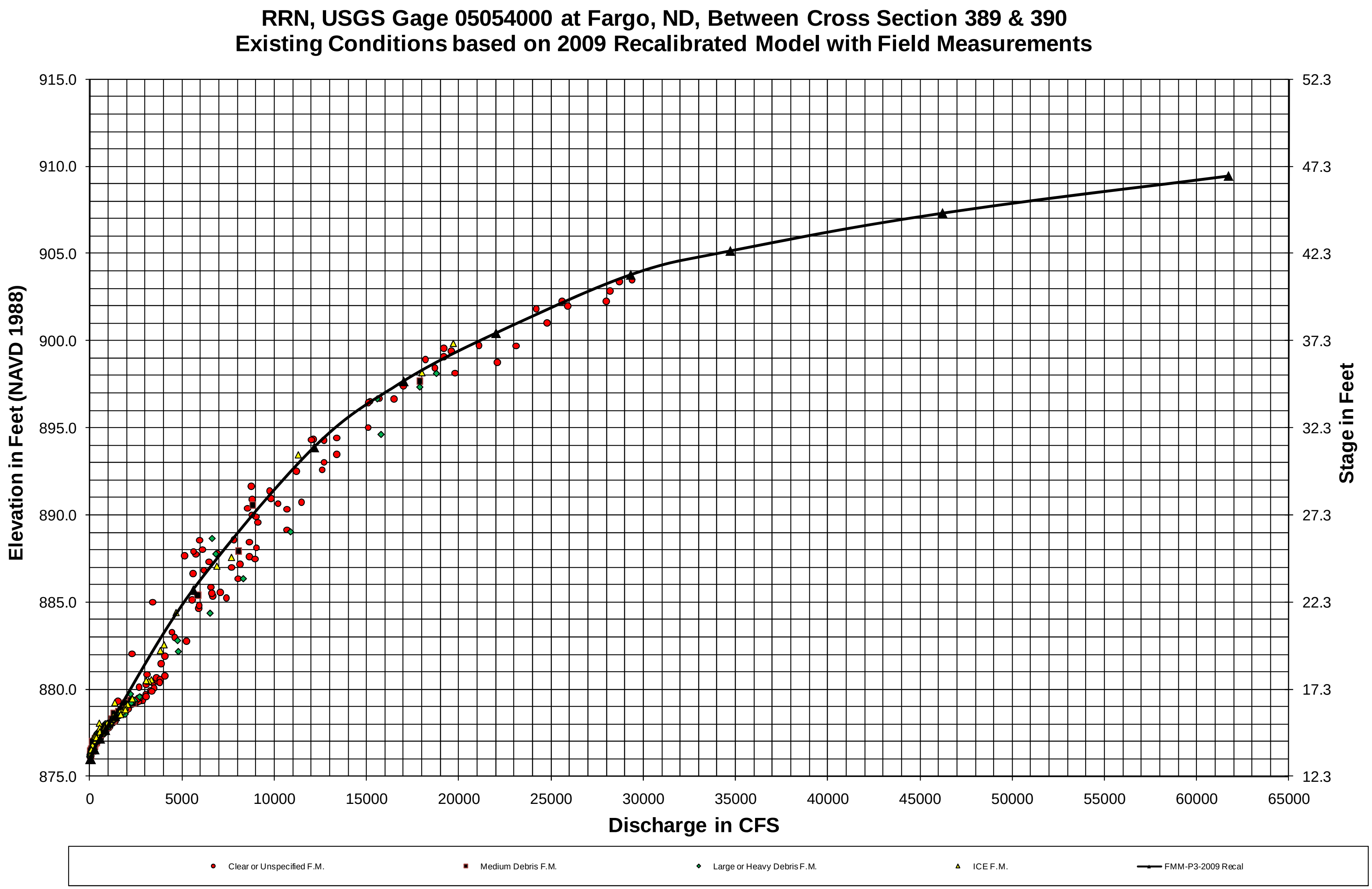


Figure B6 - RRN, USGS Gage 05054000 at Fargo, ND, Gage Located Between Cross Sections 389 & 390 Existing Conditions based on 2009 Recalibrated Model with Field Measurements

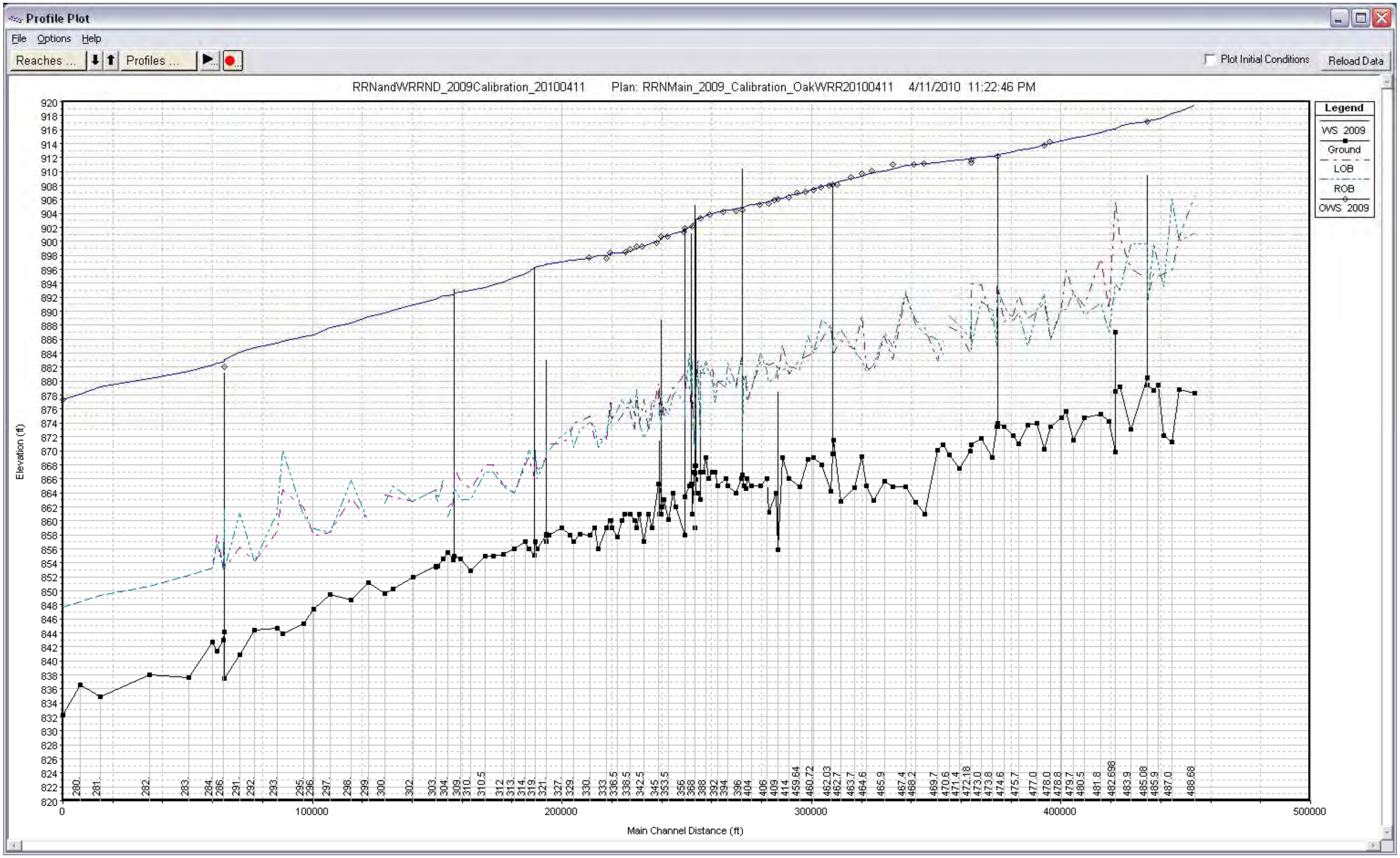


Figure B7 - Red River Model Profile of the 2009 Calibrated Model

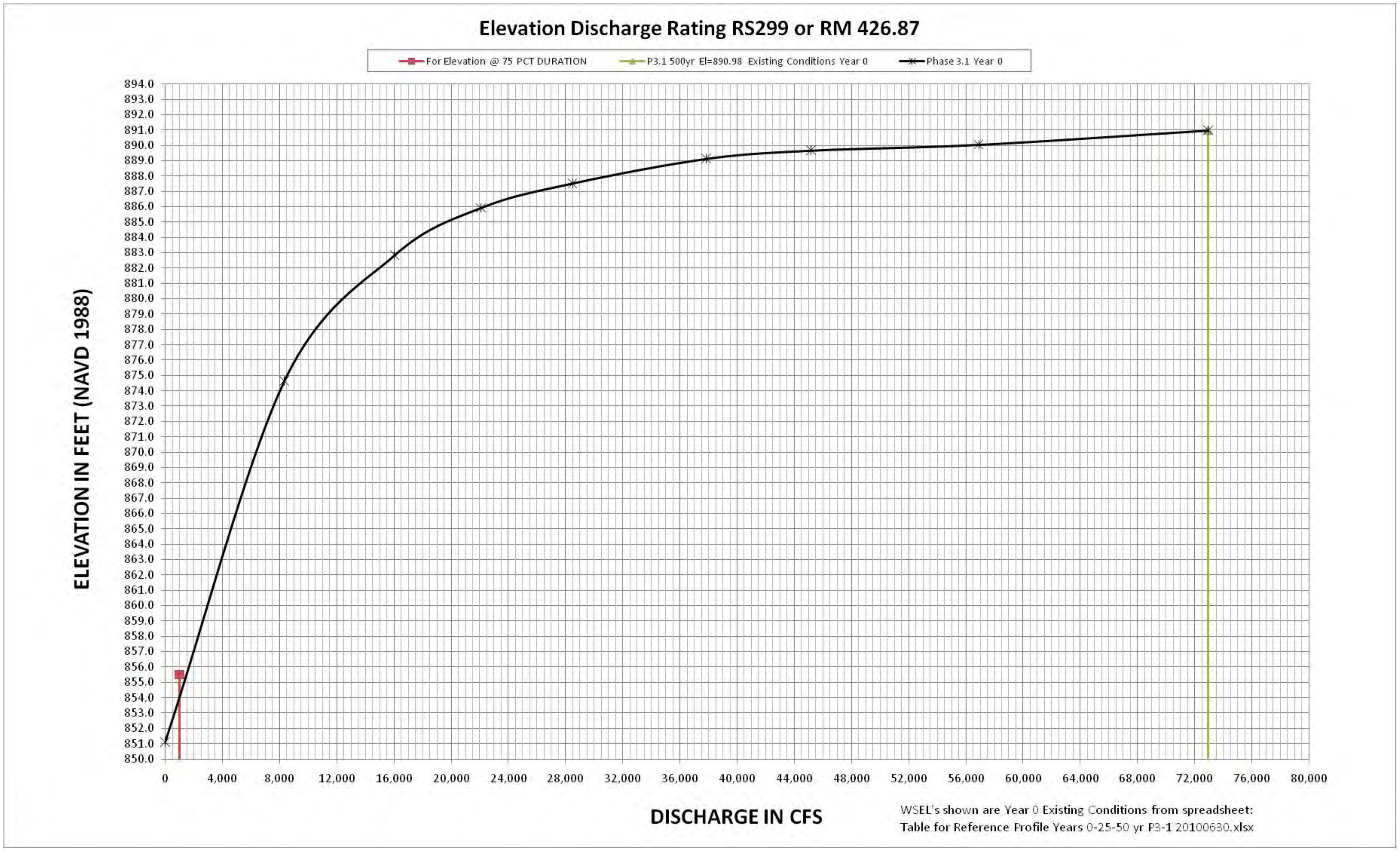


Figure B8 - Elevation Discharge Rating Curve for RS 299

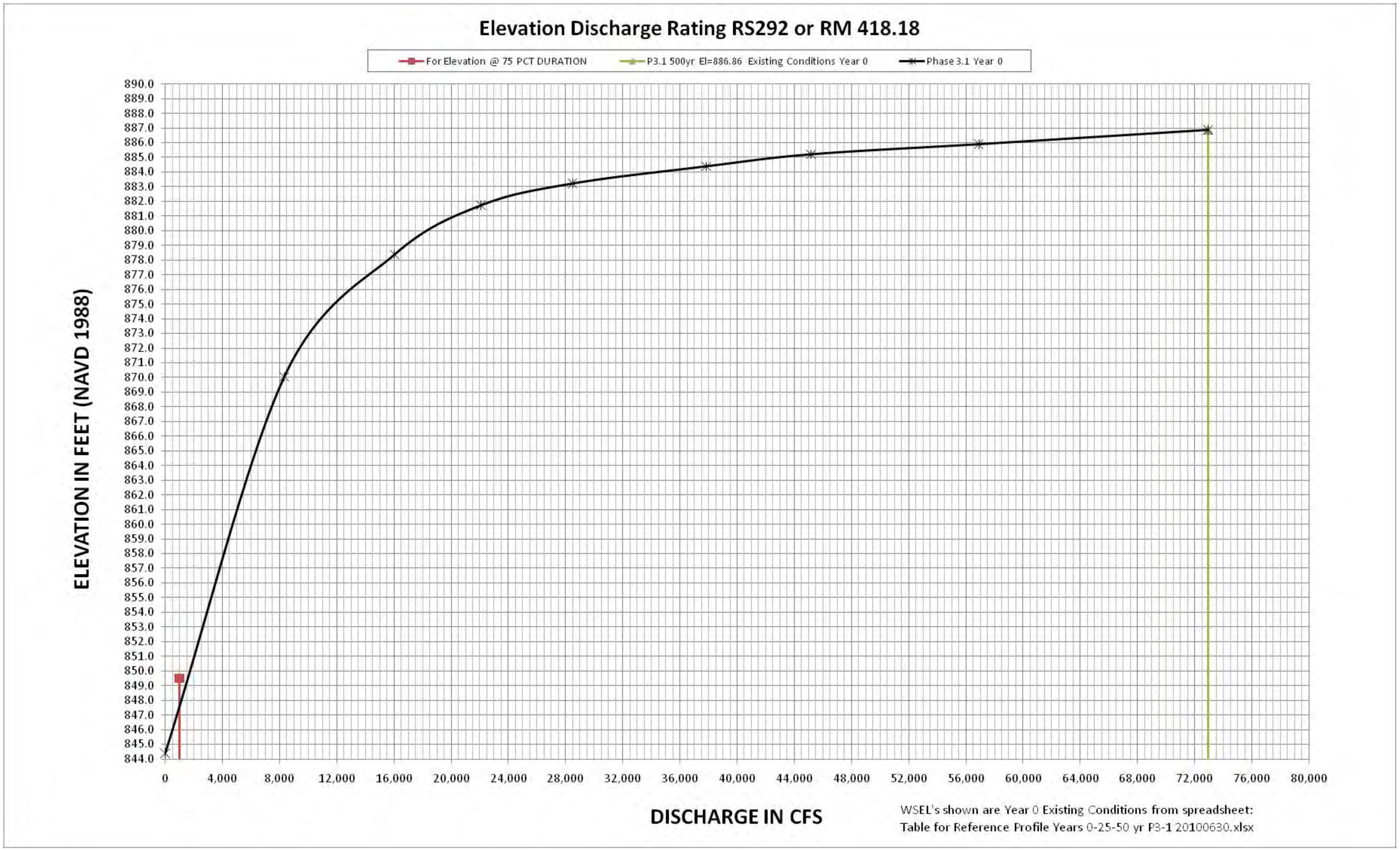


Figure B9 - Elevation Discharge Rating Curve for RS 292

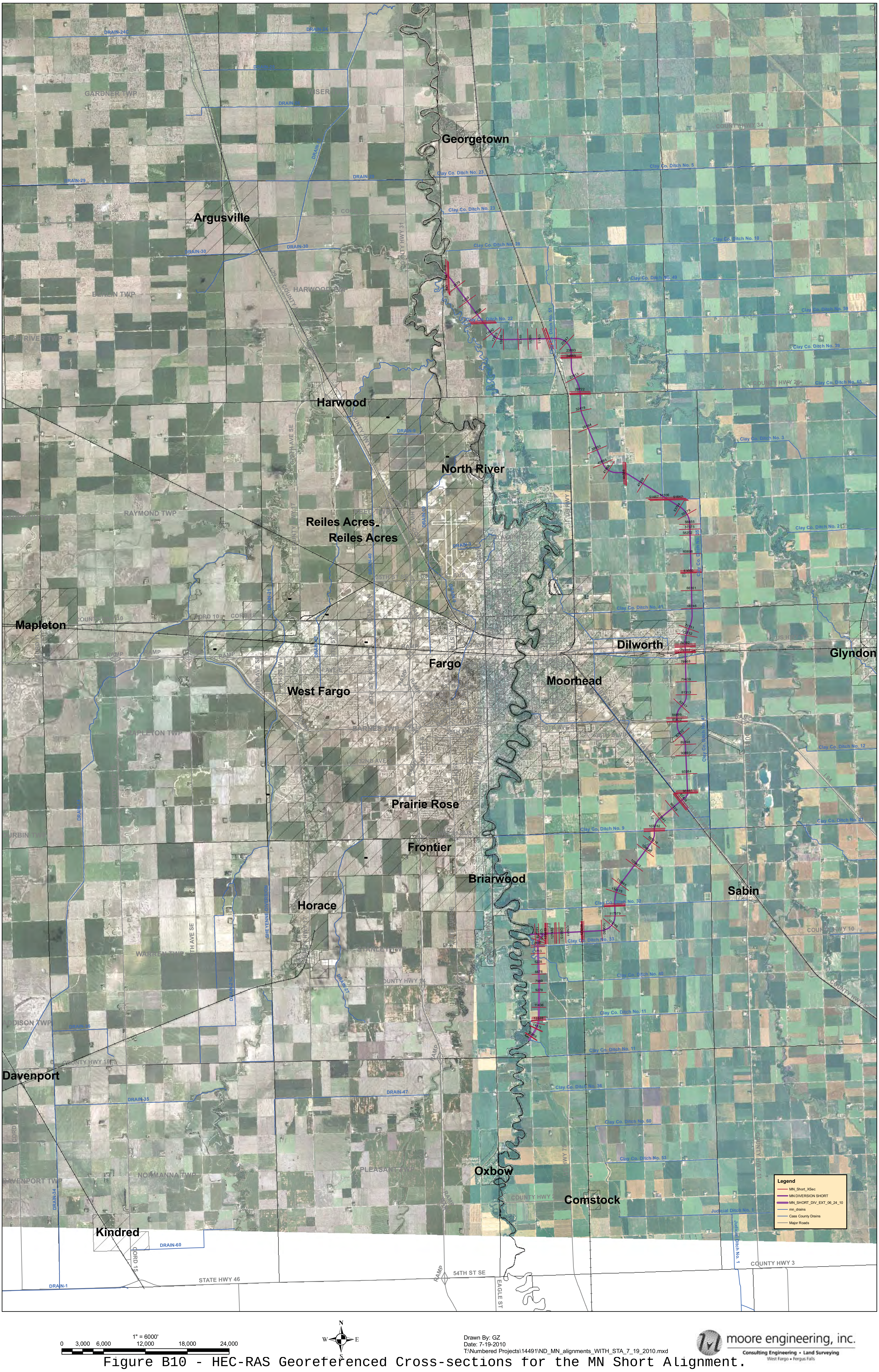
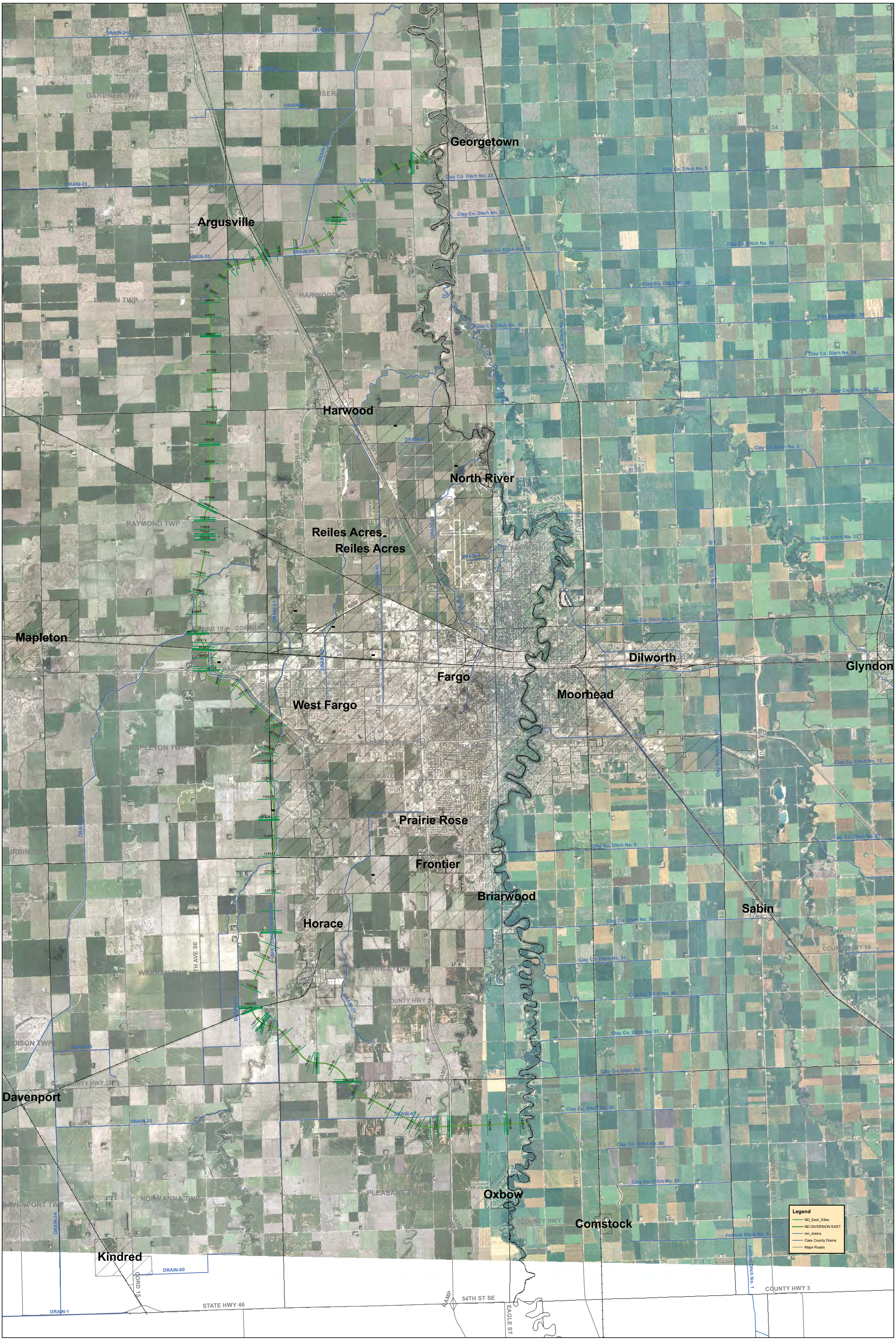


Figure B10 - HEC-RAS Georeferenced Cross-sections for the MN Short Alignment.



1" = 6000'
0 3,000 6,000 12,000 18,000 24,000

Drawn By: GZ
Date: 7-19-2010
T:\Numbered Projects\14491\ND_MN_alignments_WITH_STA_7_19_2010.mxd

moore engineering, inc.
Consulting Engineering • Land Surveying
West Fargo • Fergus Falls

Figure B11 - HEC-RAS Georeferenced Cross-sections for the ND East Alignment

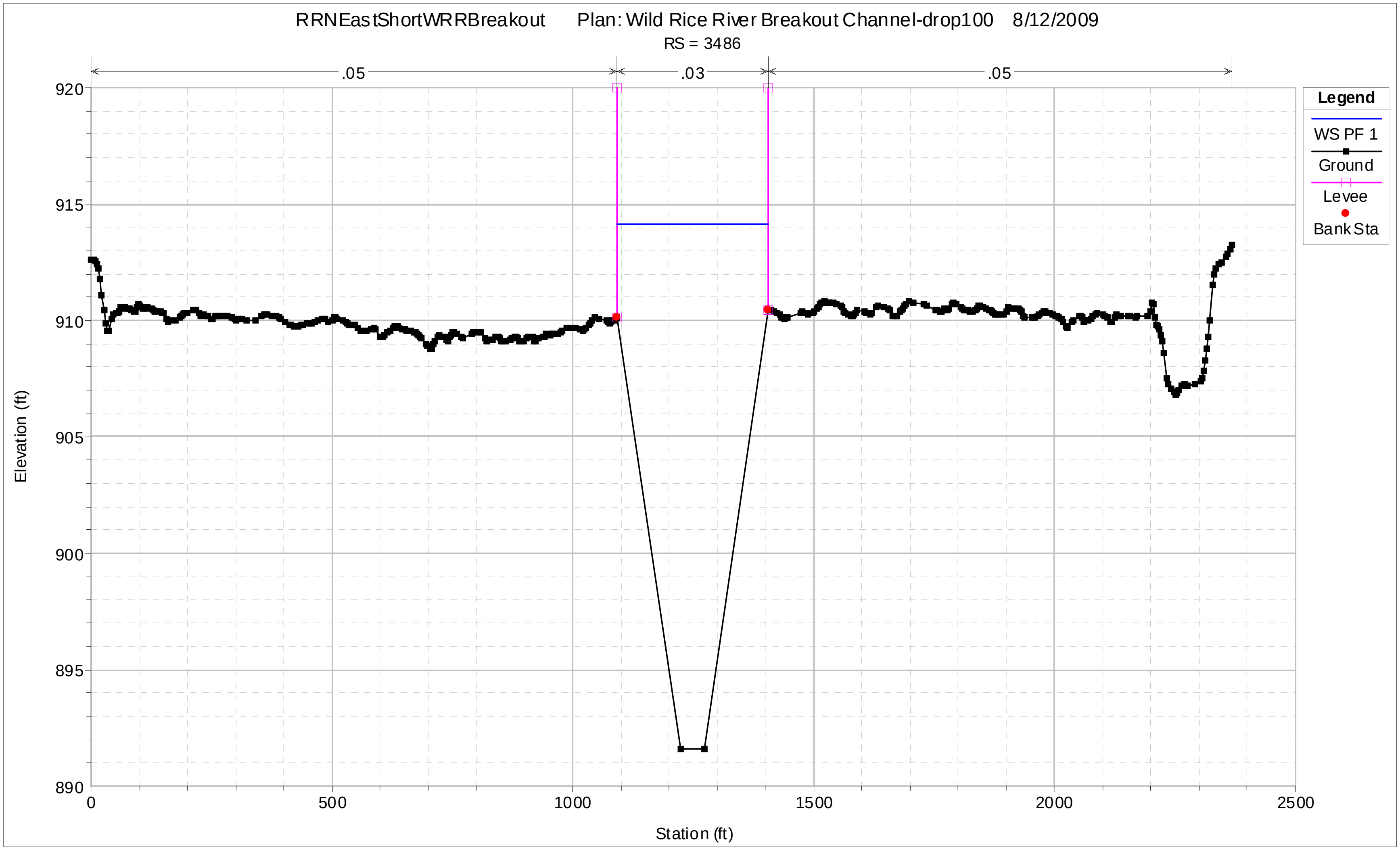


Figure B12 - MN Short Diversion Wild Rice River Breakout Channel - HEC-RAS Typical Cross Section

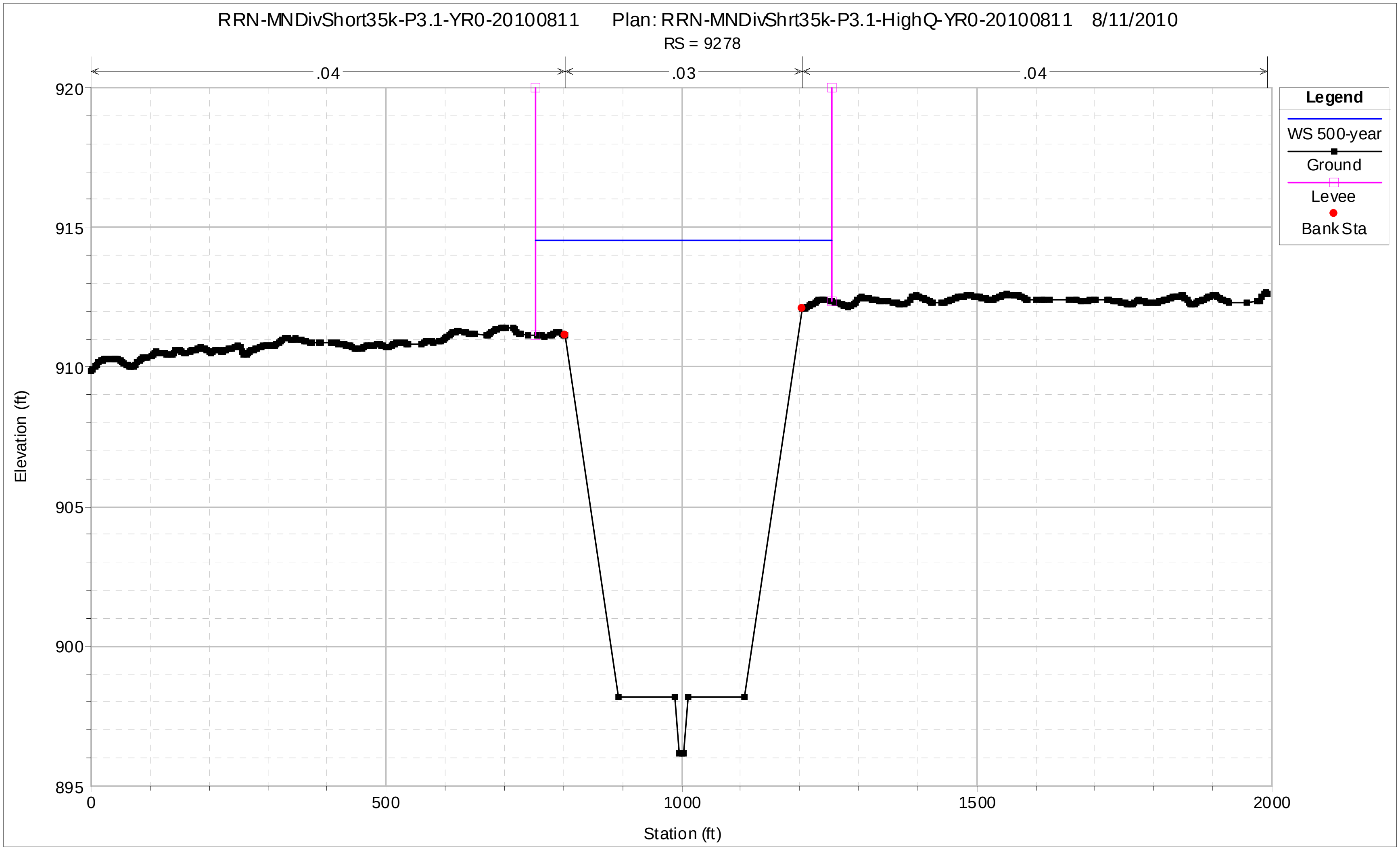


Figure B13 - MN Short Diversion Extension Channel - HEC-RAS Typical Model Cross Section

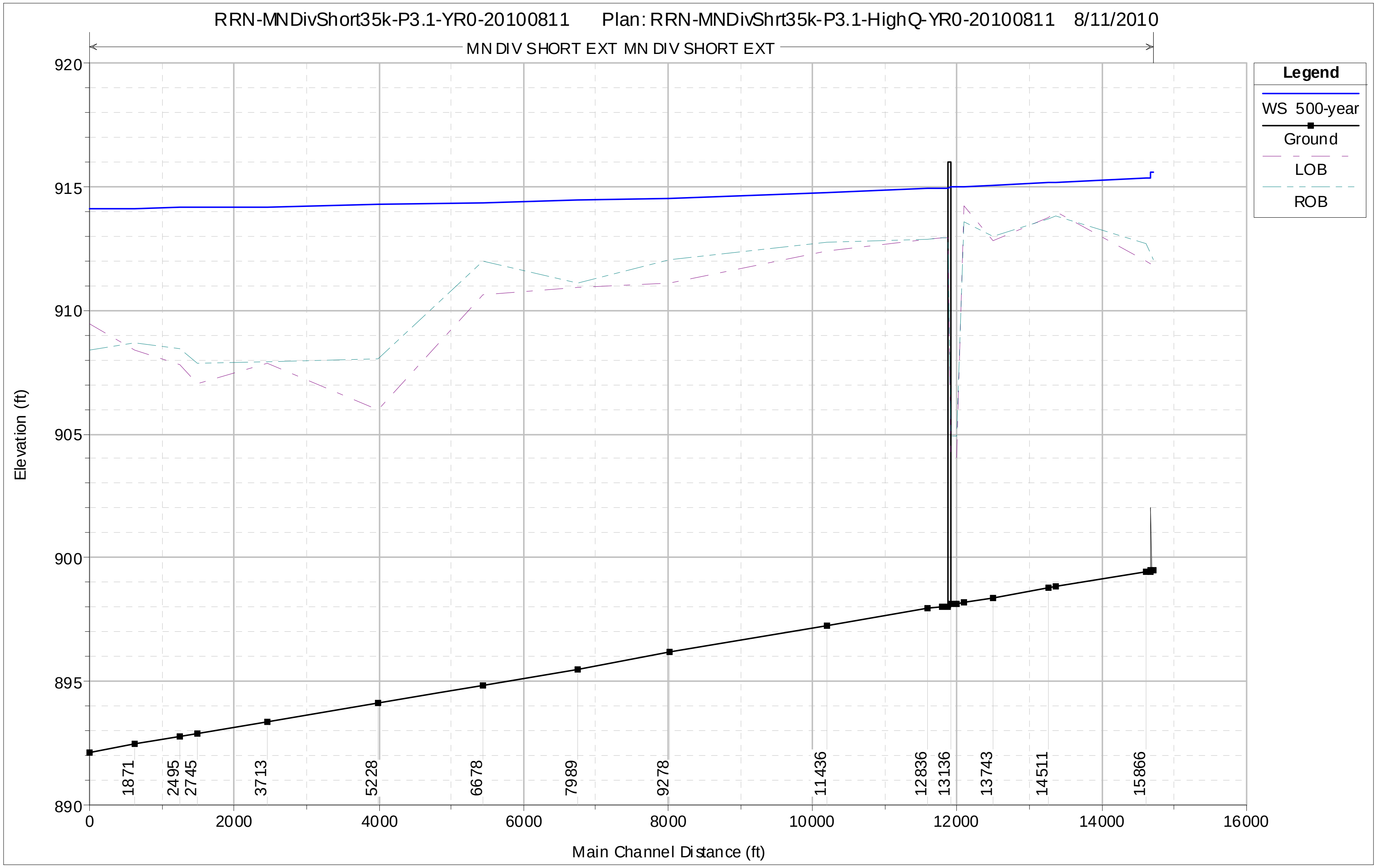


Figure B14 - MN Short Diversion Extension Channel - HEC-RAS Profile, Year 0

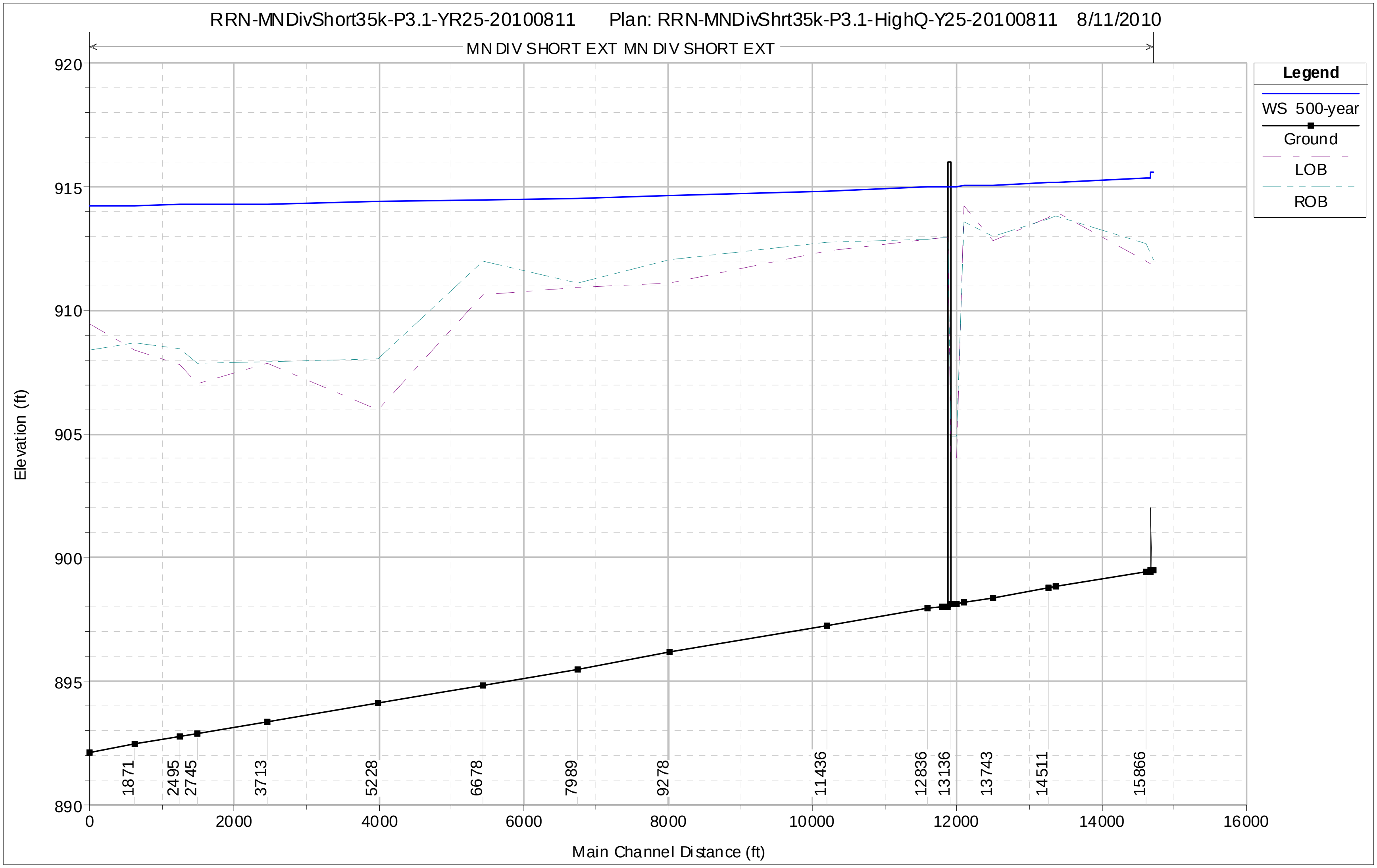


Figure B15 - MN Short Diversion Extension Channel - HEC-RAS Profile, Year 25

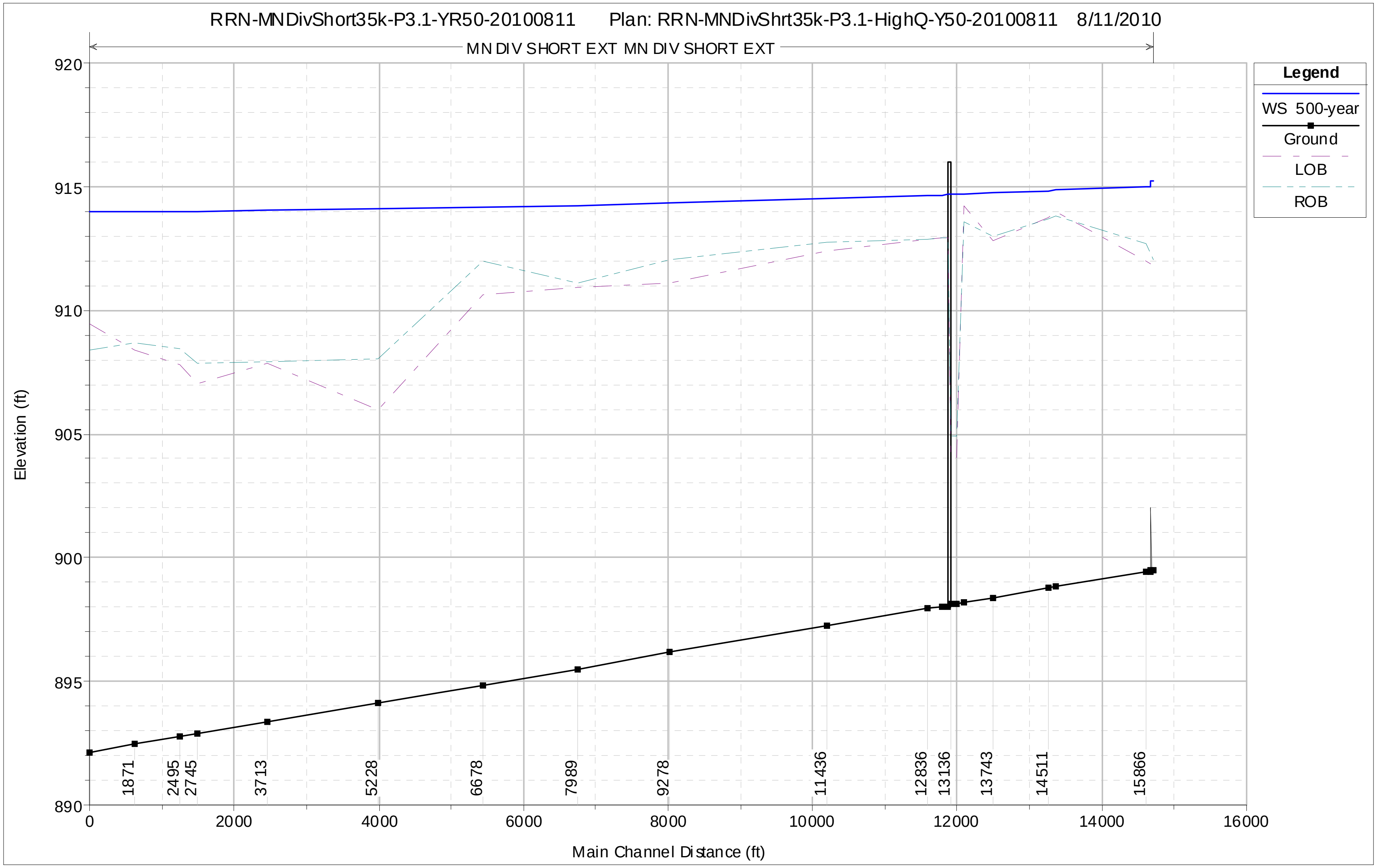


Figure B16 - MN Short Diversion Extension Channel - HEC-RAS Profile, Year 50

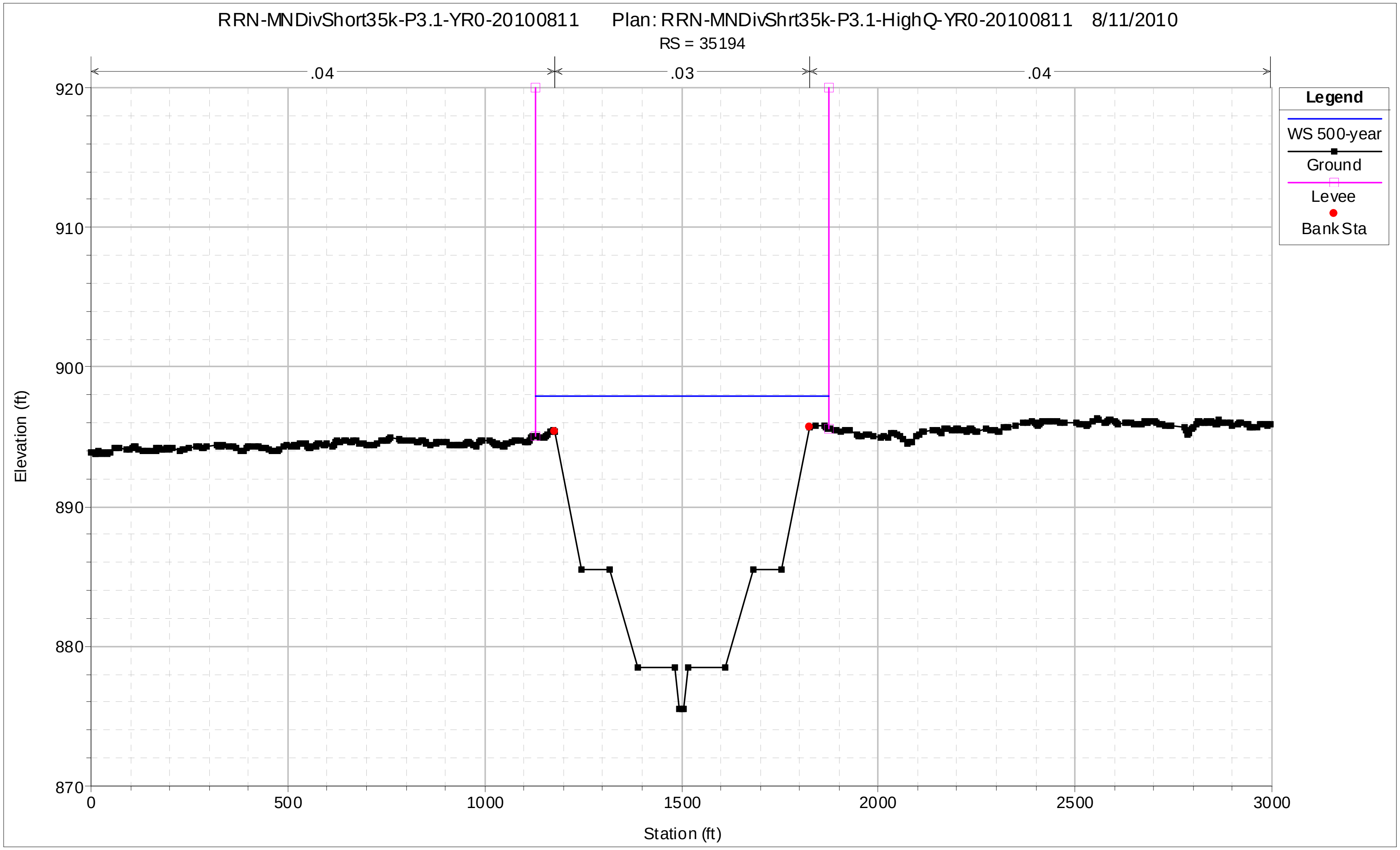


Figure B17 - MN Short Diversion 35 Kcfs Capacity - HEC-RAS Sample Model Cross Section

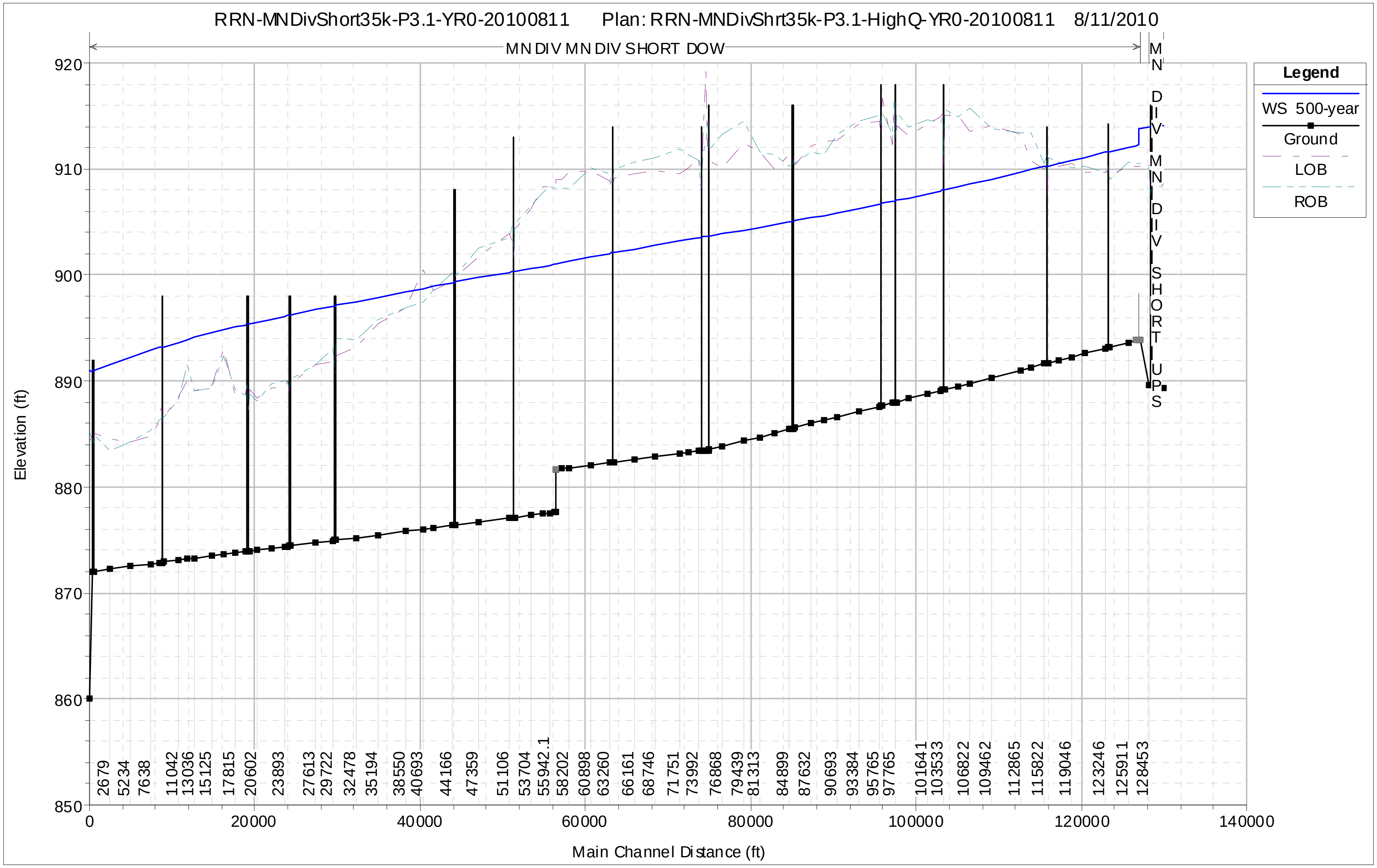


Figure B18 - MN Short Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 0

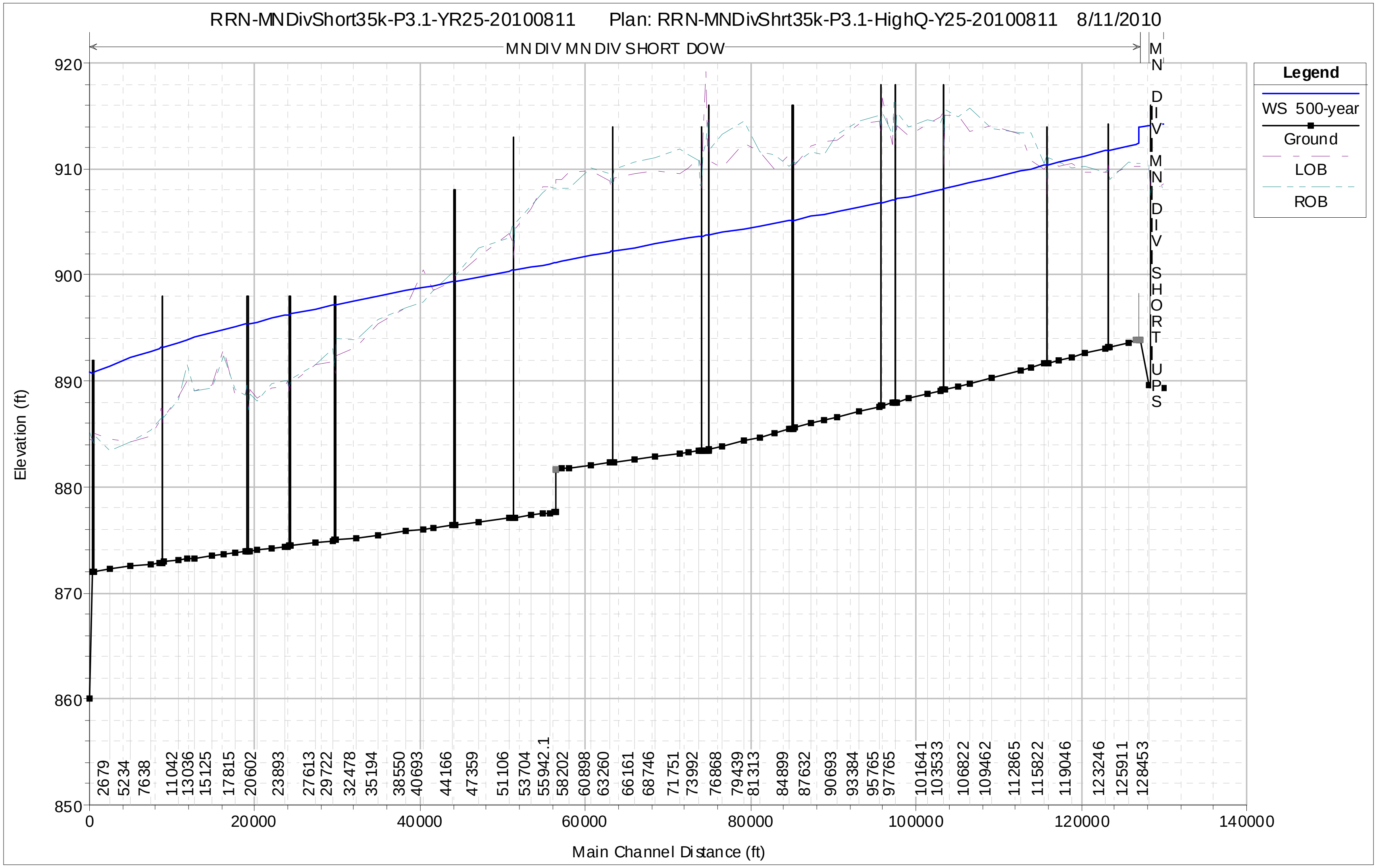


Figure B19 - MN Short Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 25

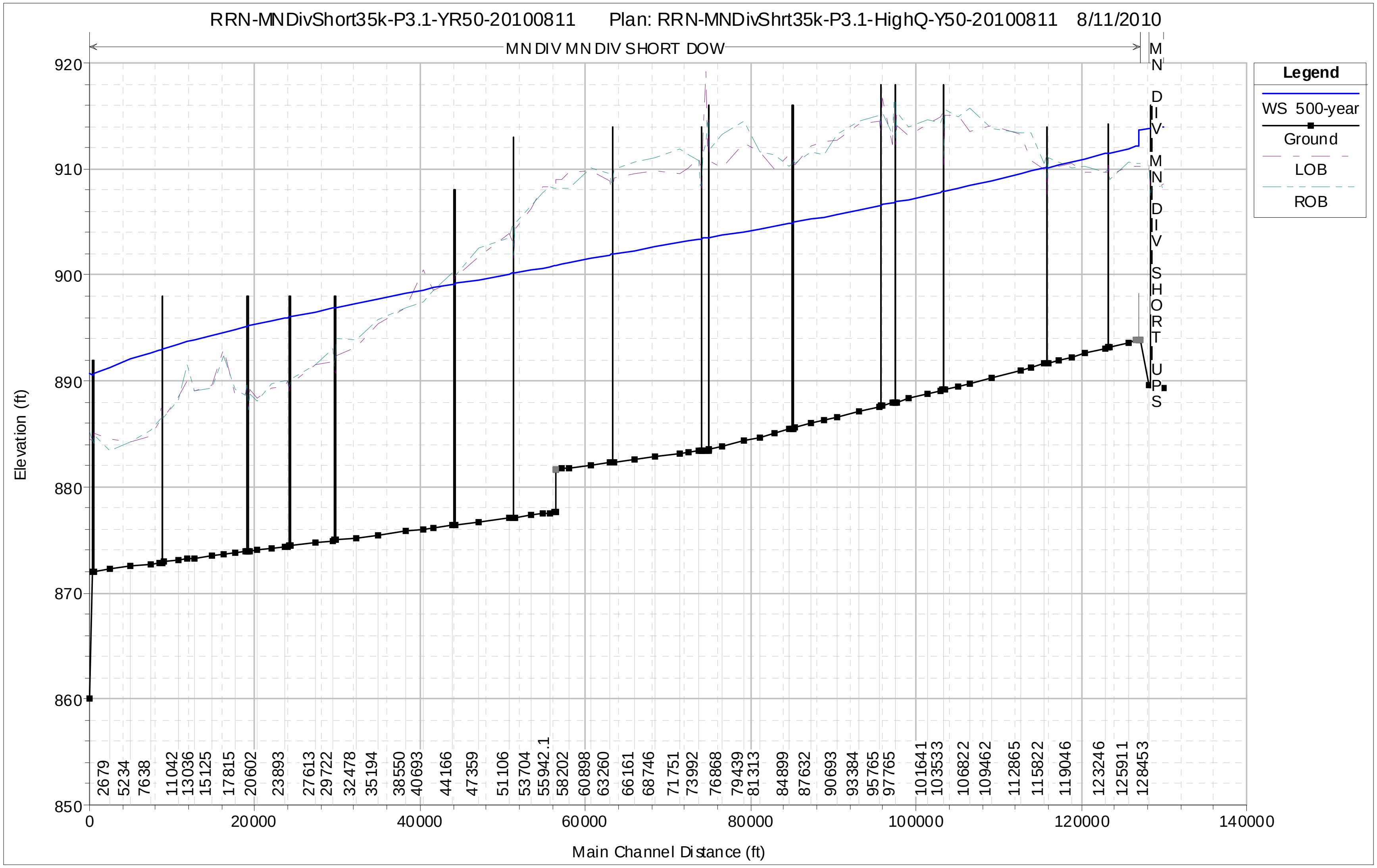


Figure B20 - MN Short Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 50

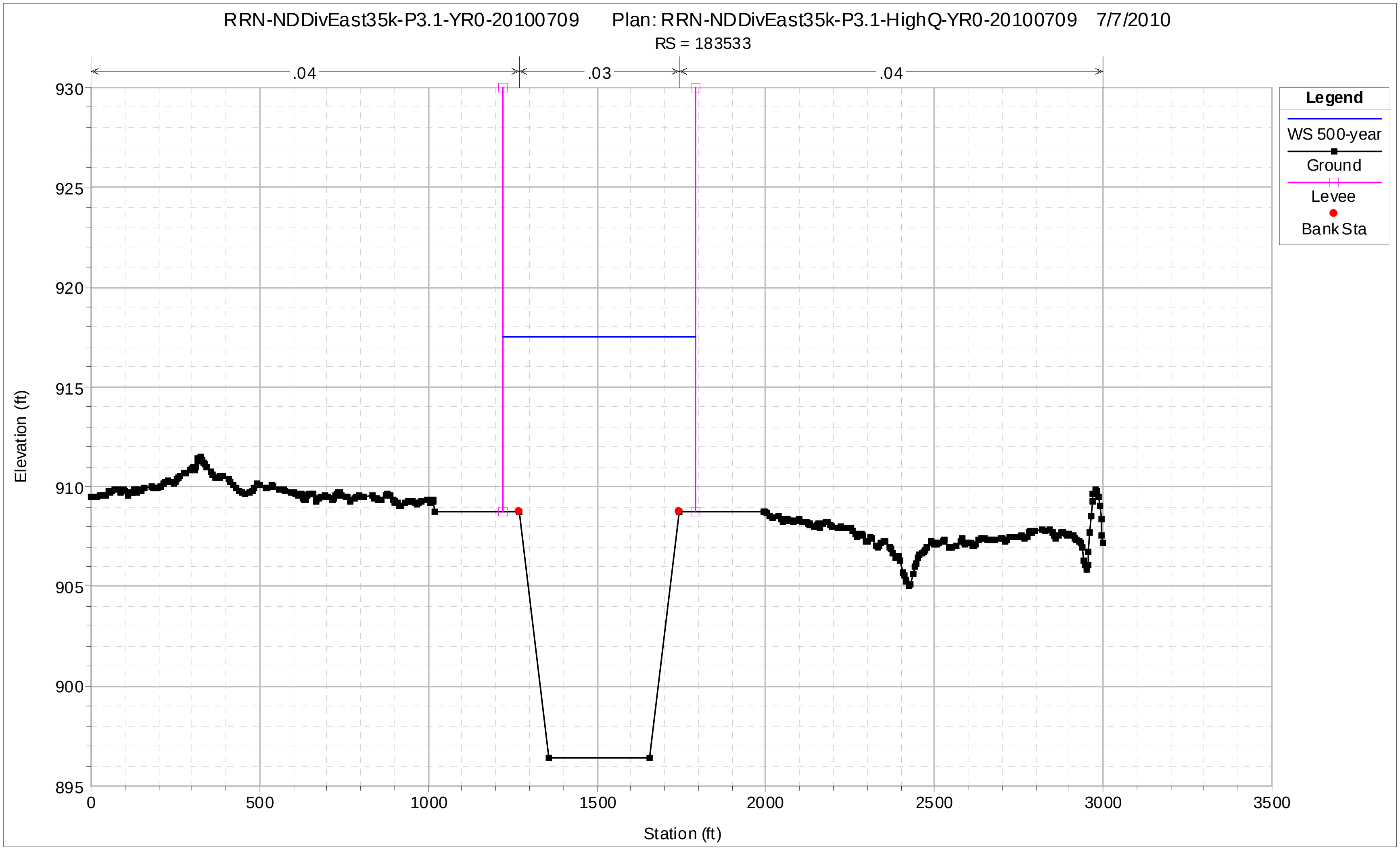


Figure B21 - ND East Alignment Connection Channel - HEC-RAS Typical Model Cross Section

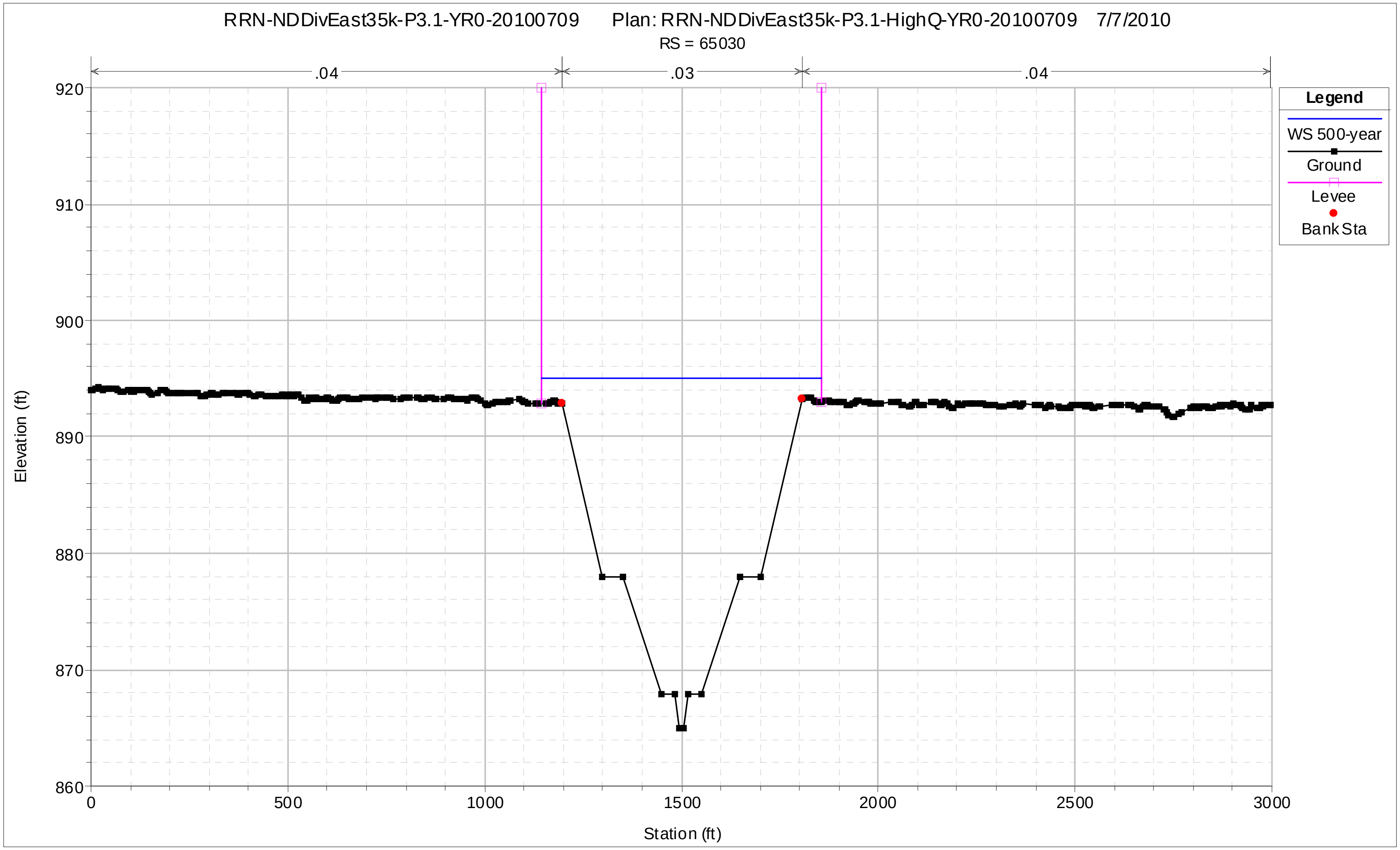


Figure B22 - ND East Diversion 35 Kcfs Capacity - HEC-RAS Sample Model Cross Section

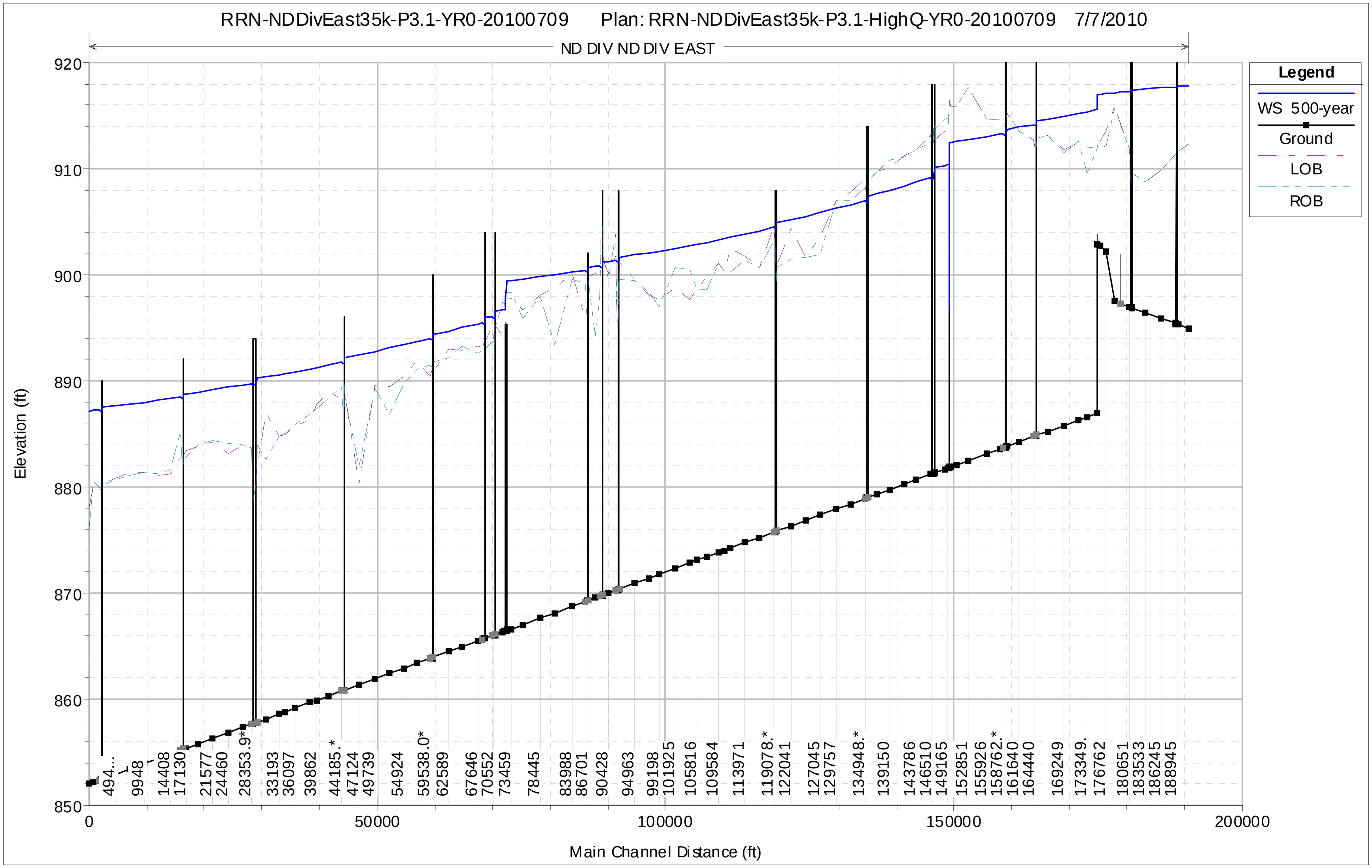


Figure B23 - ND East Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 0

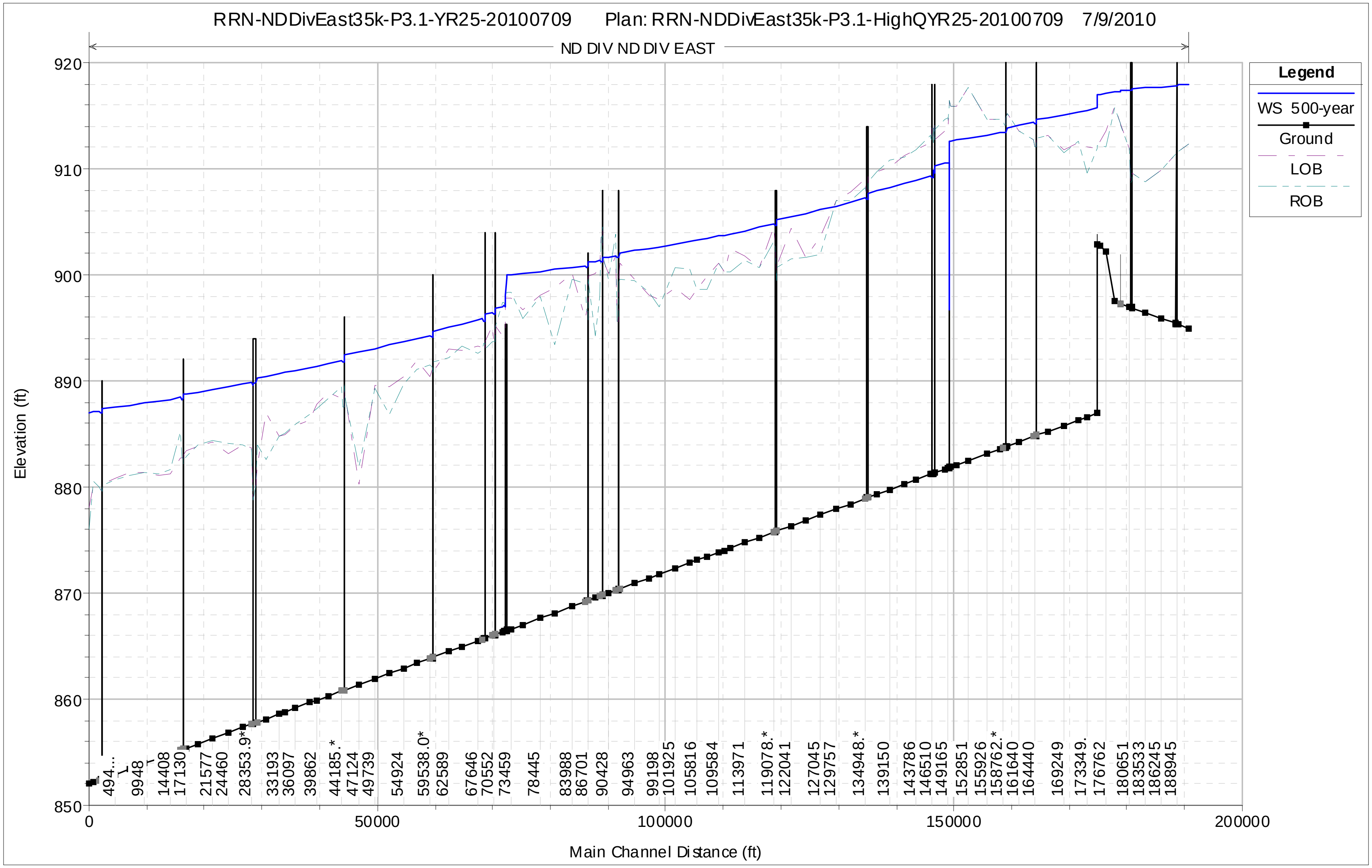


Figure B24 - ND East Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 25

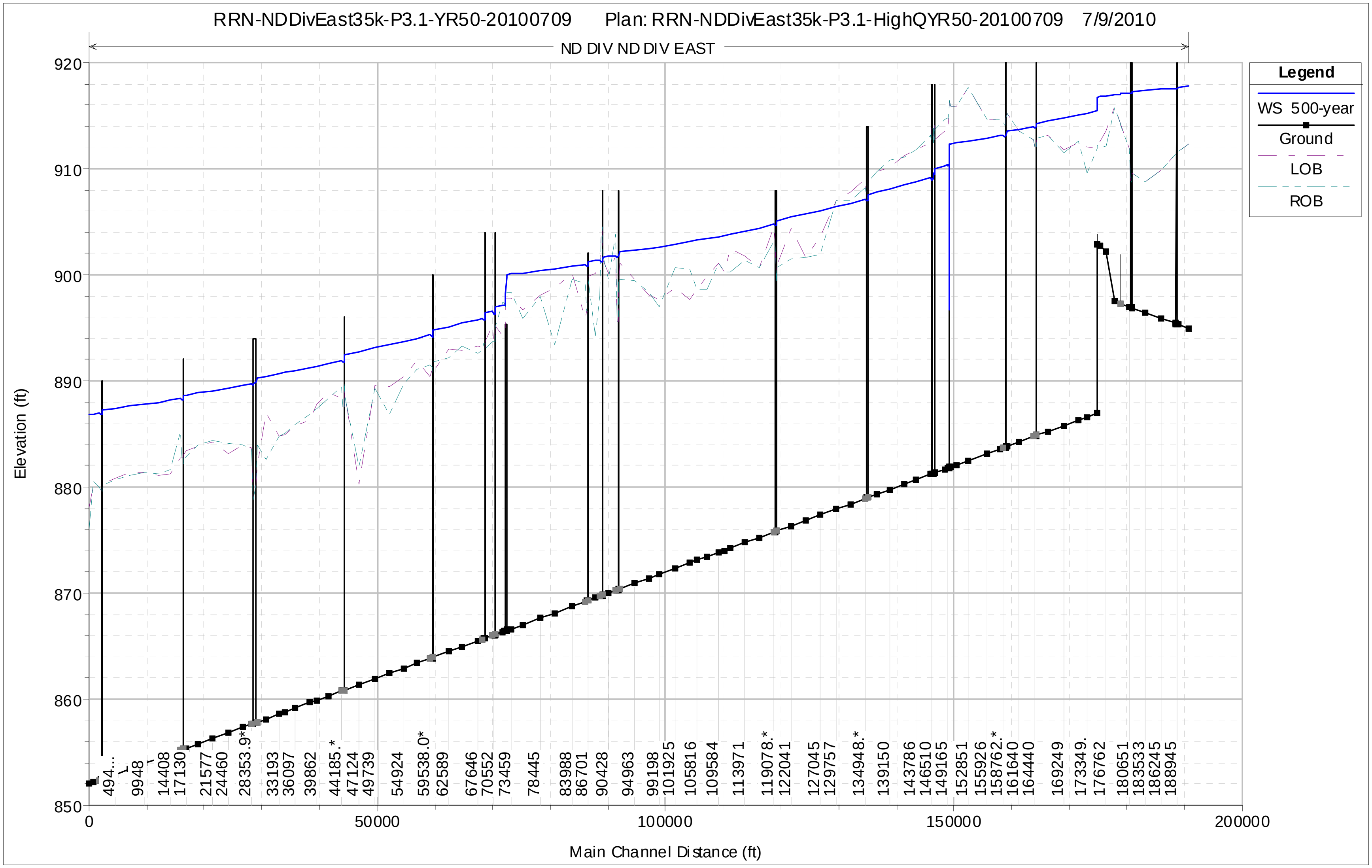


Figure B25 - ND East Diversion 35 Kcfs Capacity - HEC-RAS Profile, Year 50

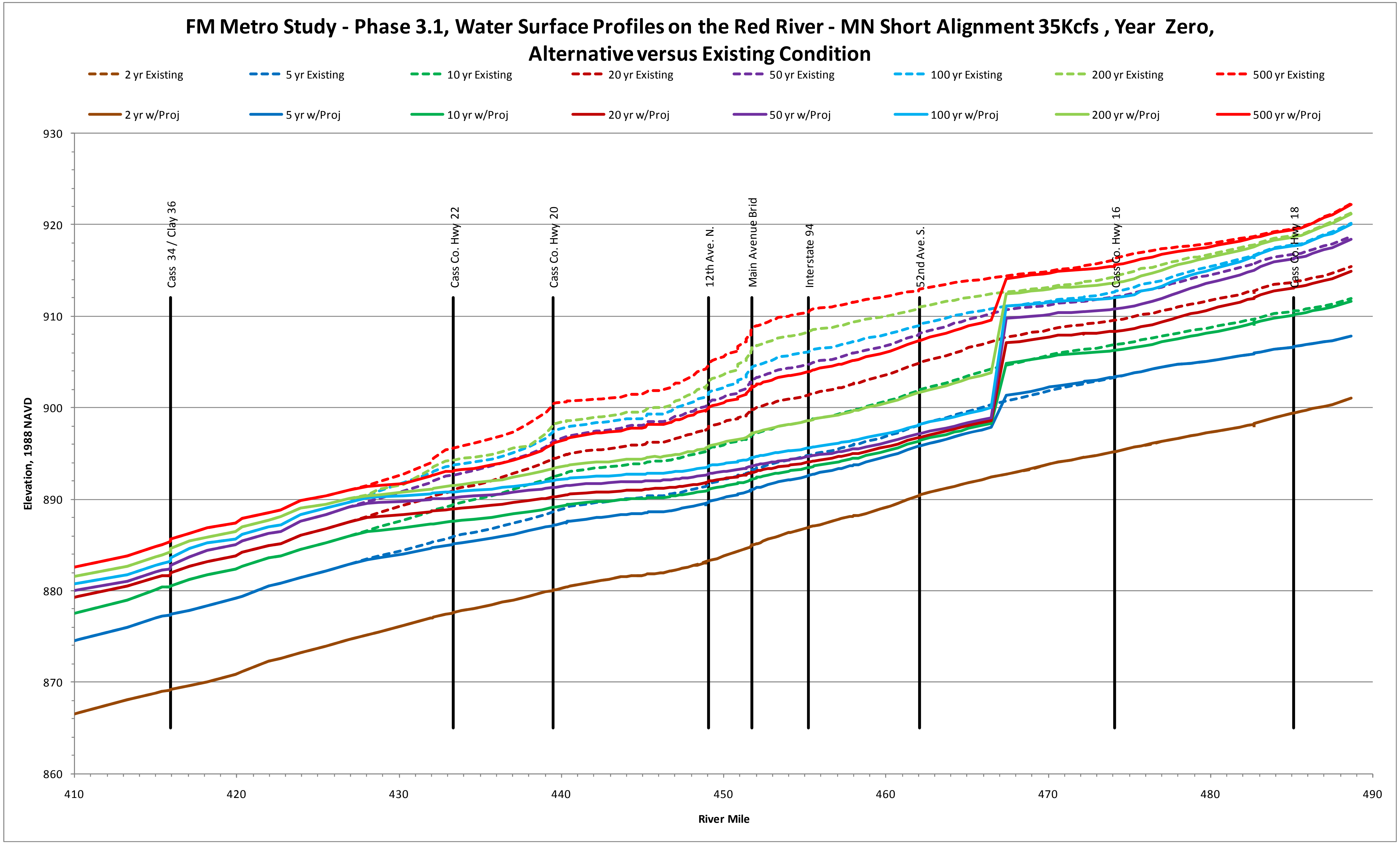


Figure B26 - Water Surface Profiles on the Red River – MN Short Alignment 35 Kcfs vs. Existing Condition, Year 0

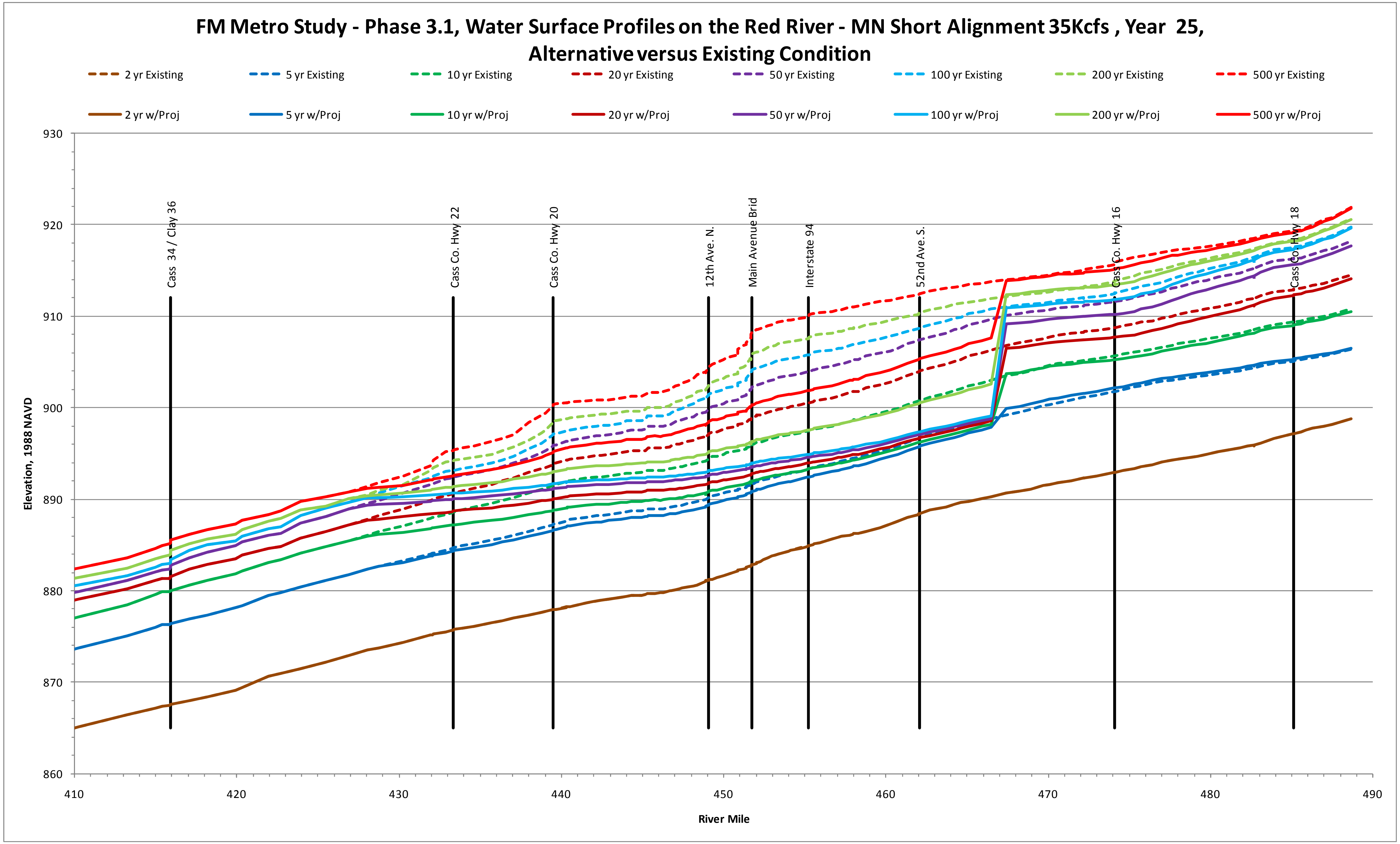


Figure B27 - Water Surface Profiles on the Red River – MN Short Alignment 35 Kcfs vs. Existing Condition, Year 25

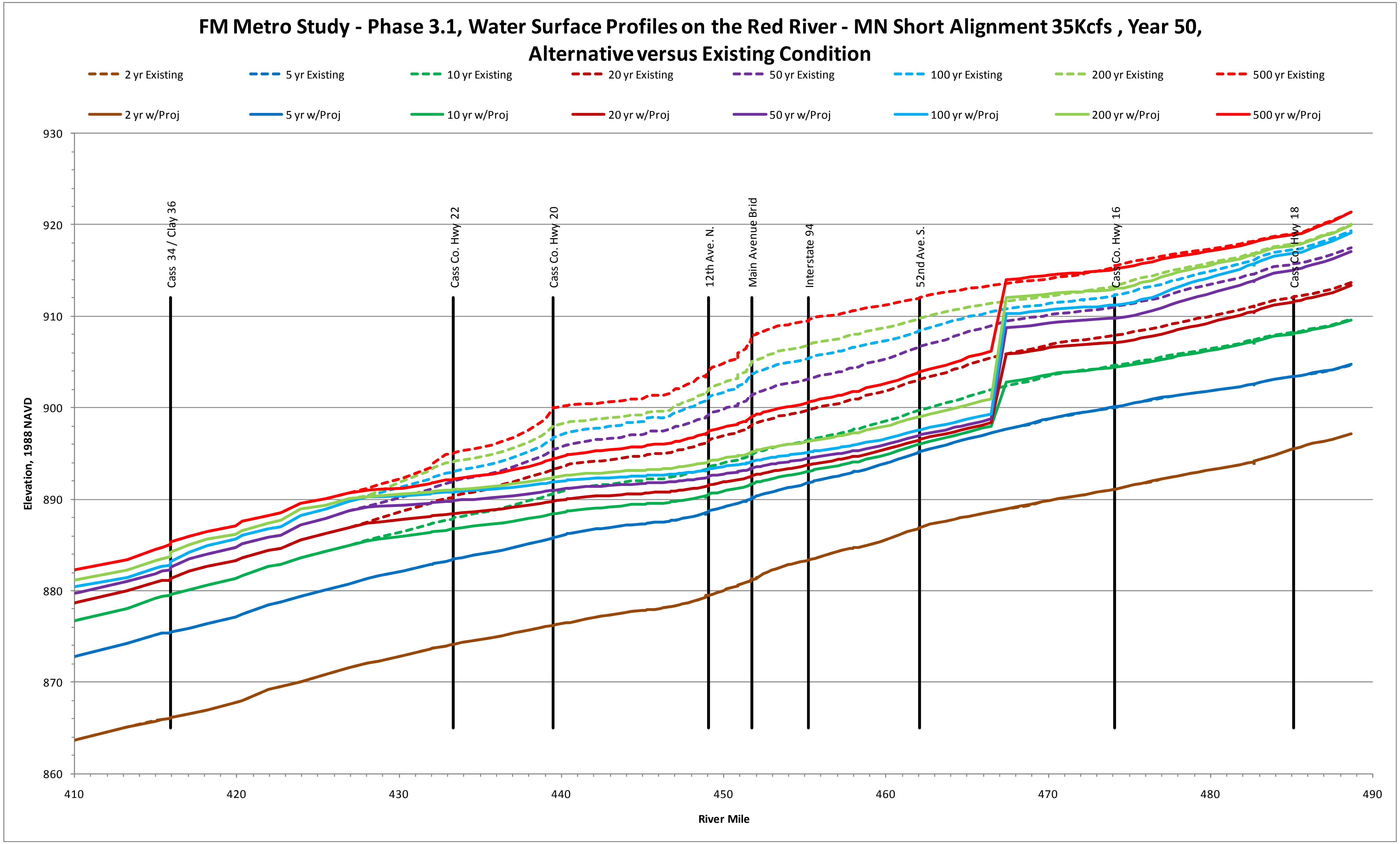


Figure B28 - Water Surface Profiles on the Red River – MN Short Alignment 35 Kcfs vs. Existing Condition, Year 50

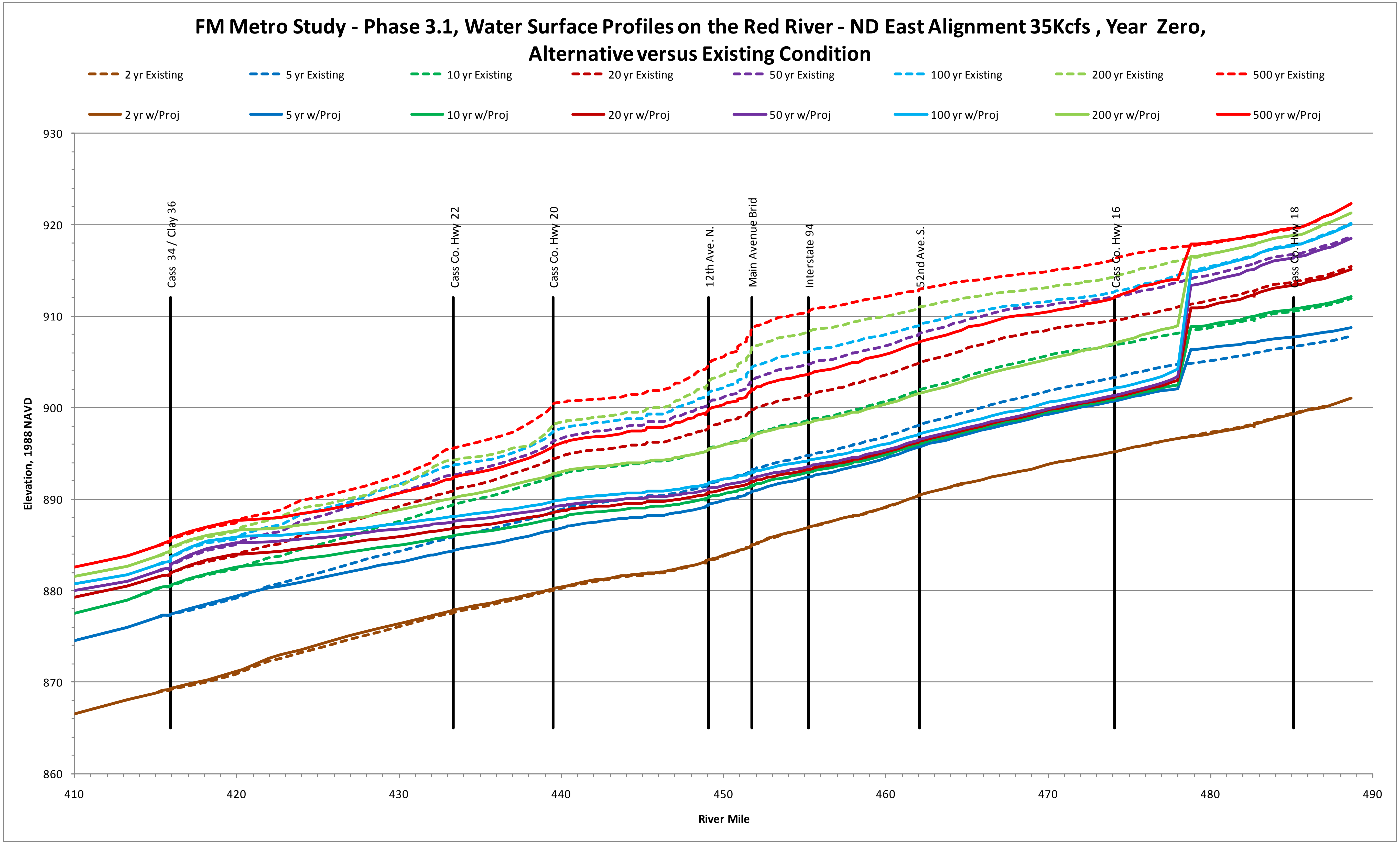


Figure B29 - Water Surface Profiles on the Red River – ND East Alignment 35 Kcfs vs. Existing Condition, Year 0

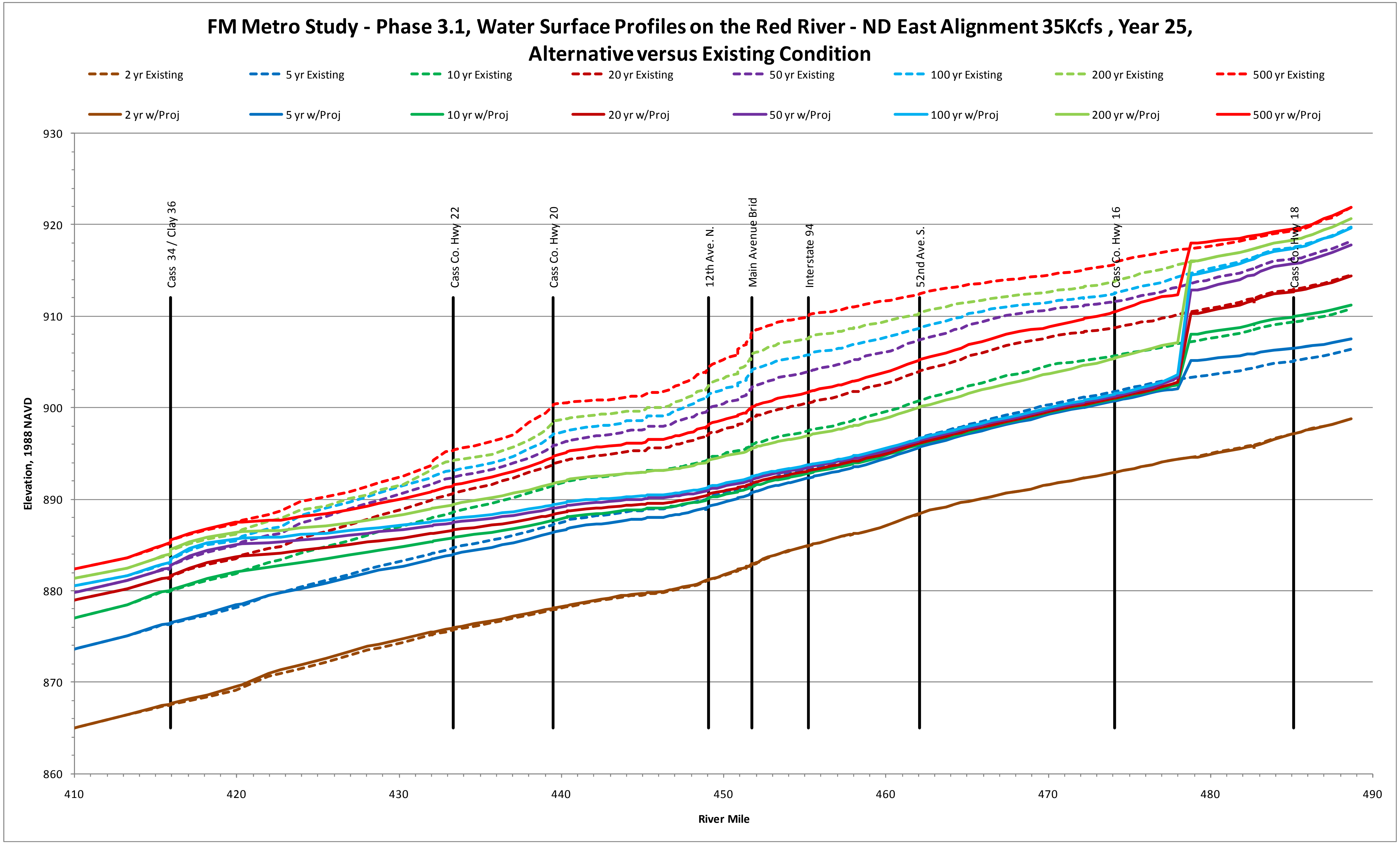


Figure B30 - Water Surface Profiles on the Red River – ND East Alignment 35 Kcfs vs. Existing Condition, Year 25

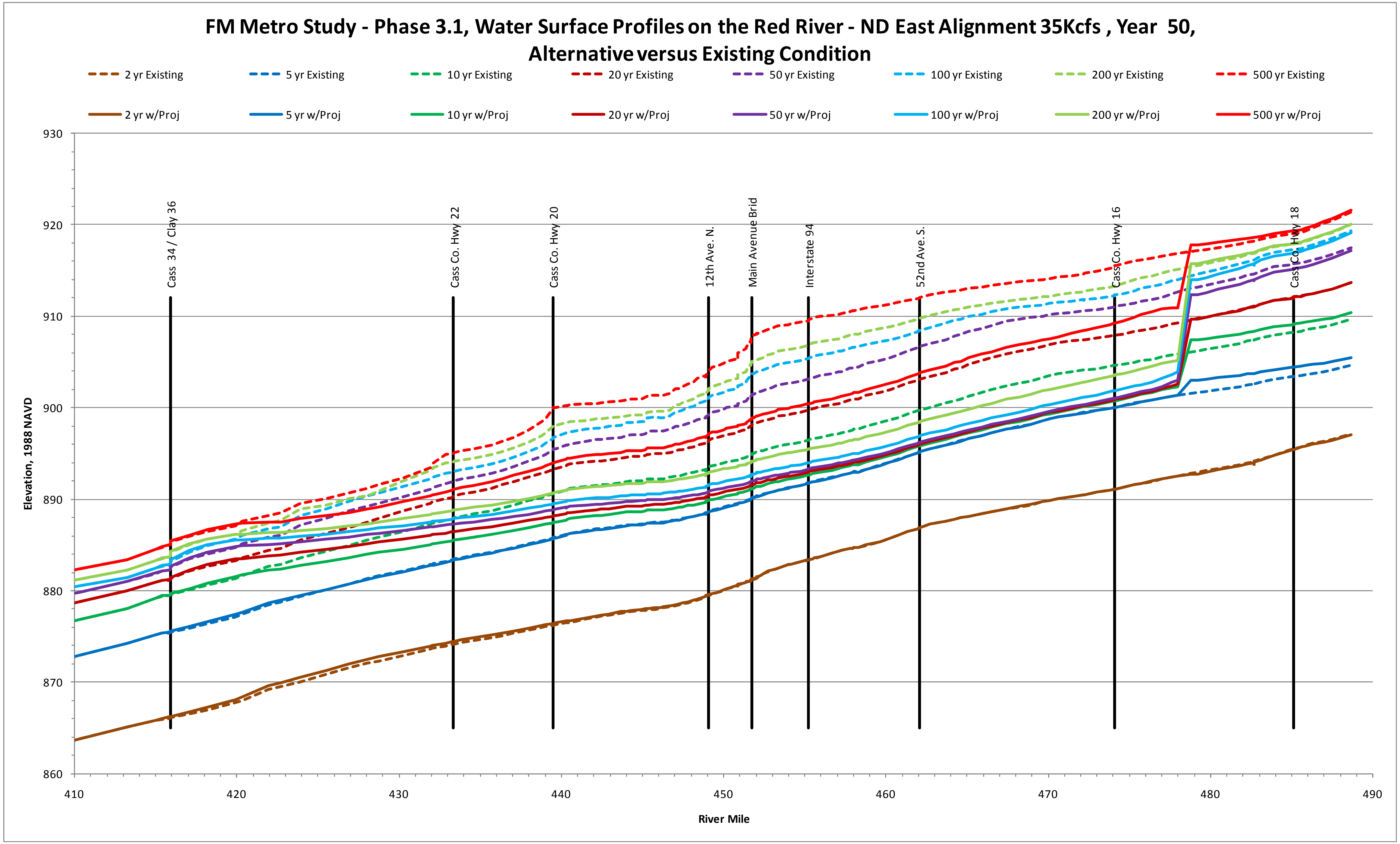


Figure B31 - Water Surface Profiles on the Red River – ND East Alignment 35 Kcfs vs. Existing Condition, Year 50

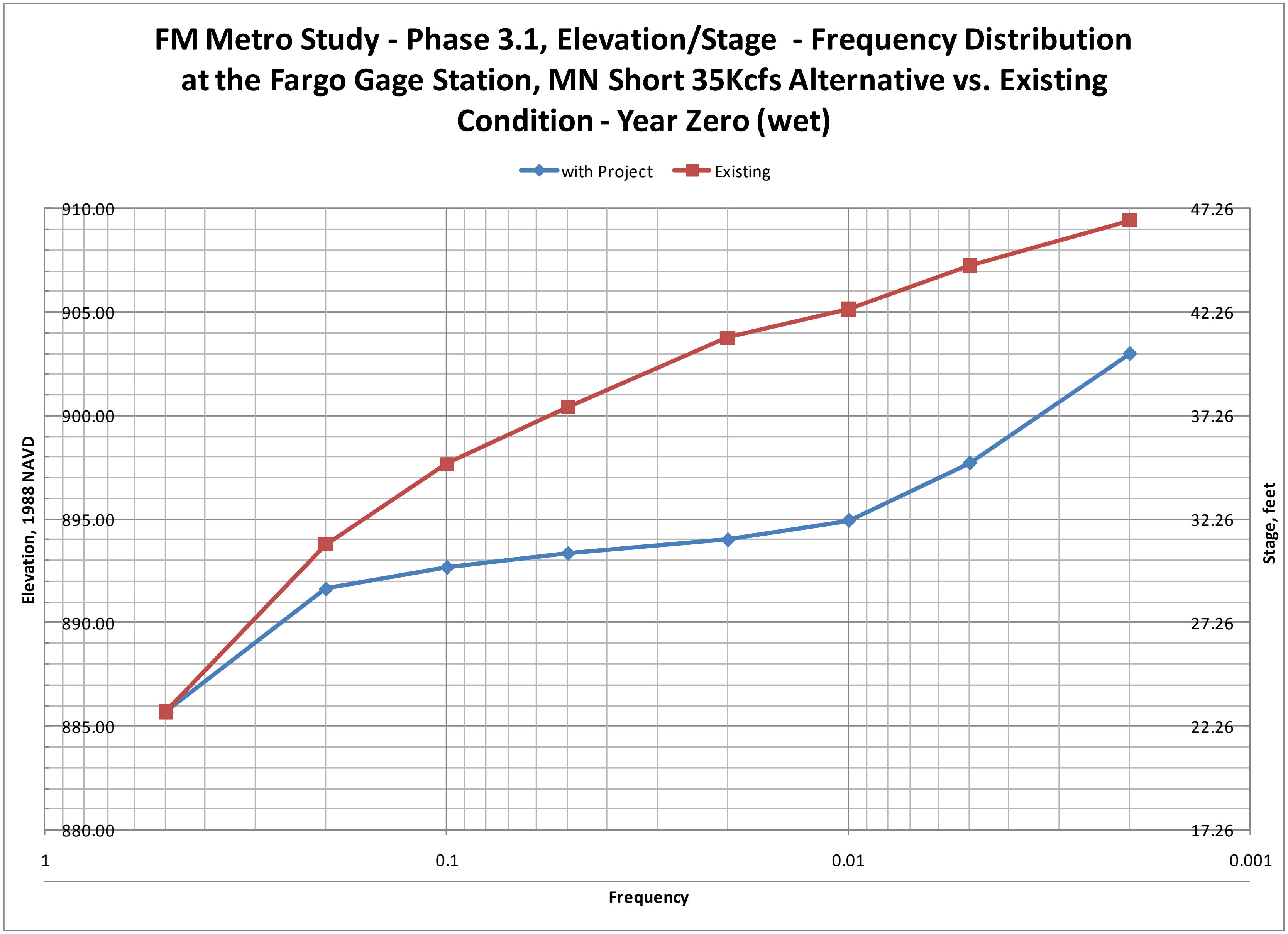


Figure B32 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, MN Short Align 35 Kcfs vs. Existing , Year 0

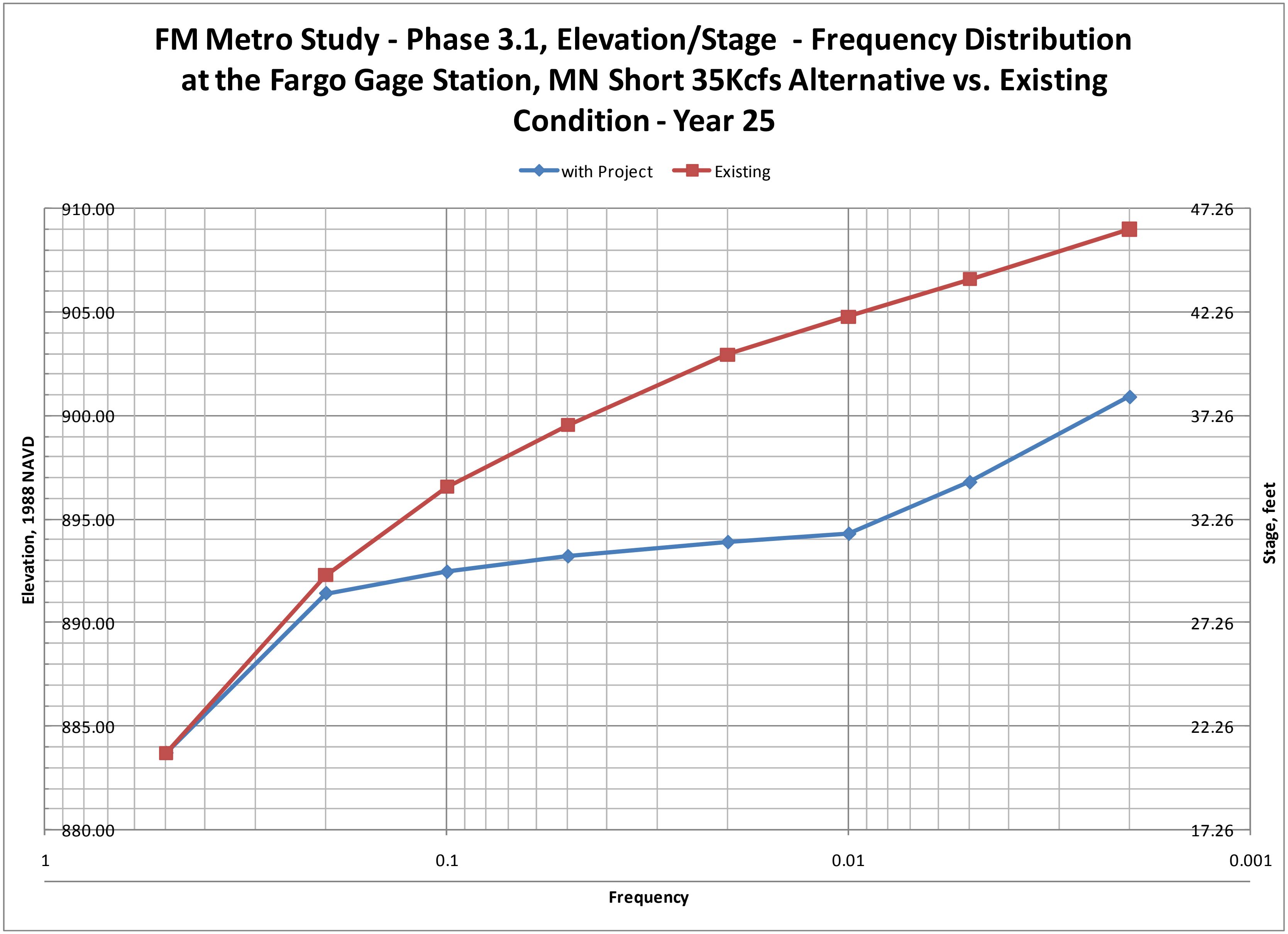


Figure B33 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, MN Short Align 35 Kcfs vs. Existing , Year 25

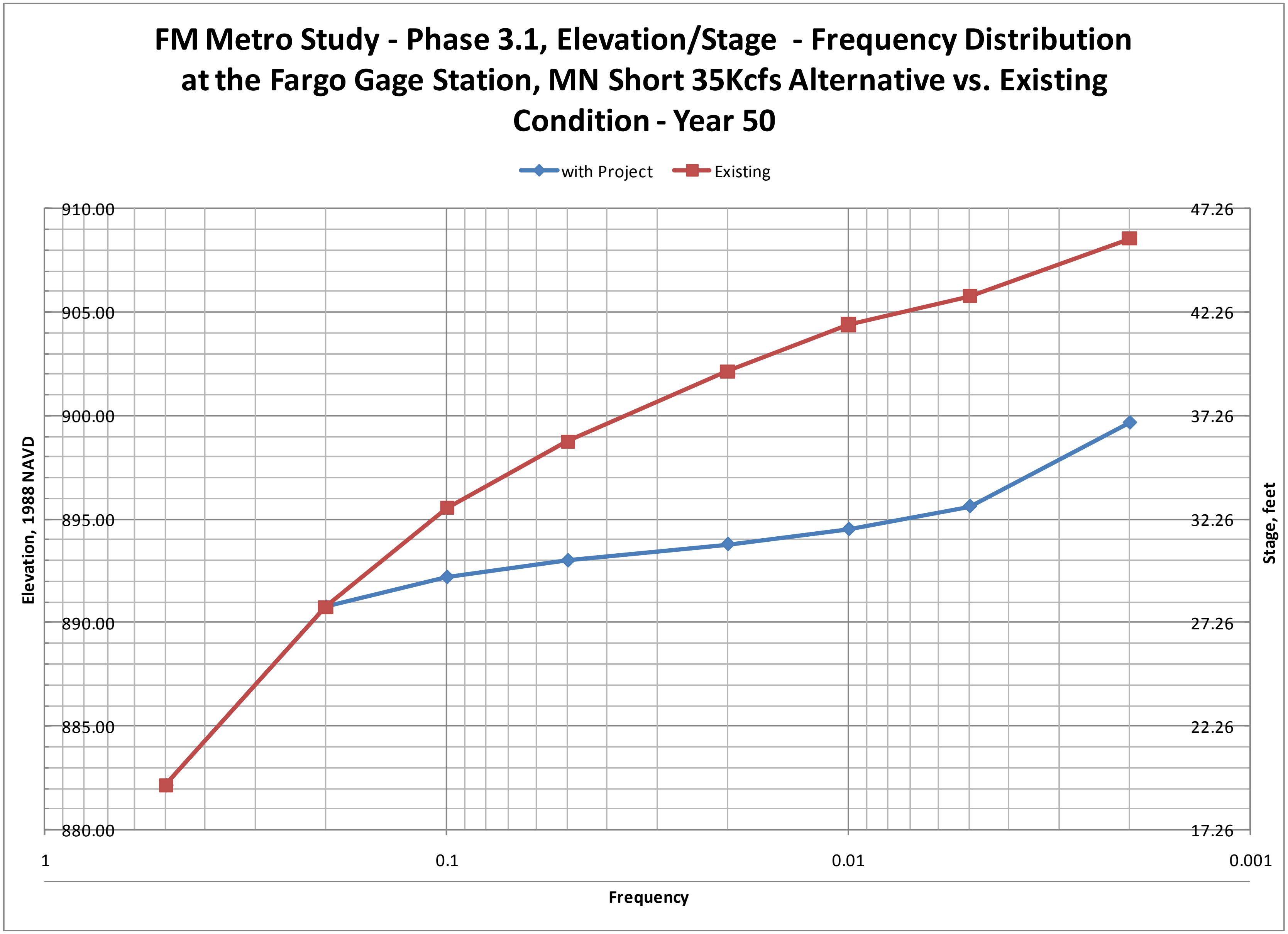


Figure B34 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, MN Short Align 35 Kcfs vs. Existing , Year 50

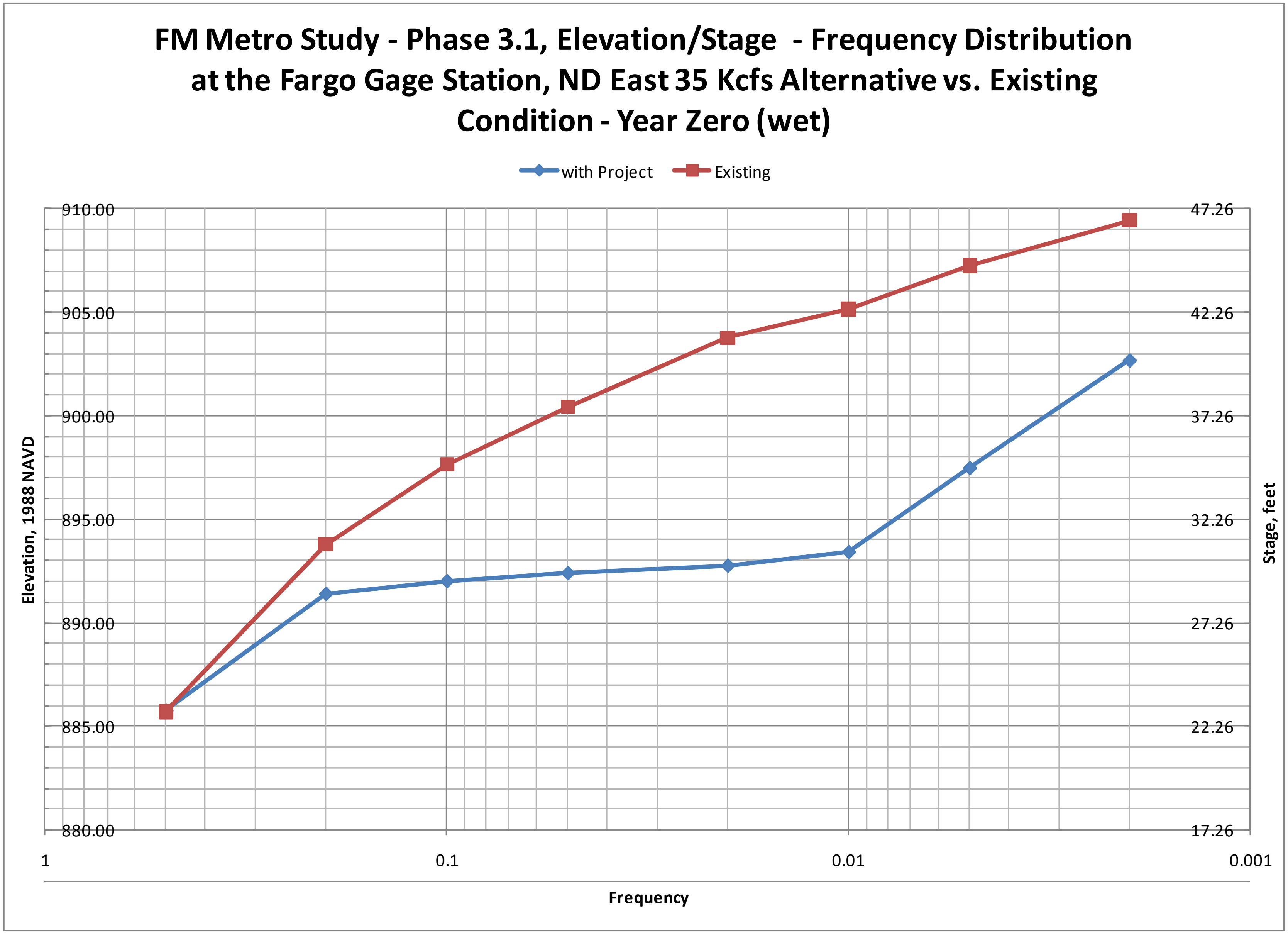


Figure B35 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, ND East Align 35 Kcfs vs. Existing , Year 0

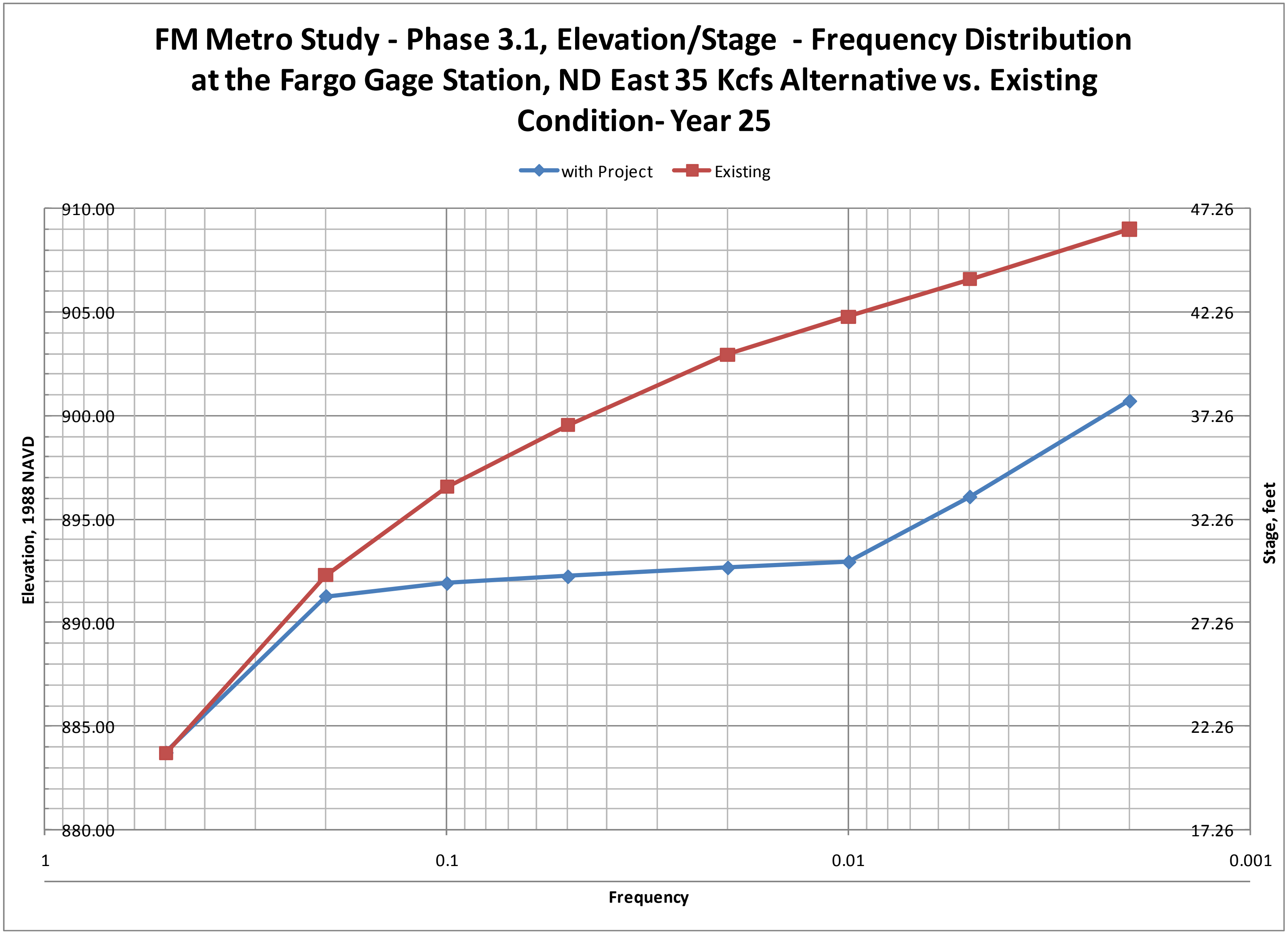


Figure B36 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, ND East Align 35 Kcfs vs. Existing , Year 25

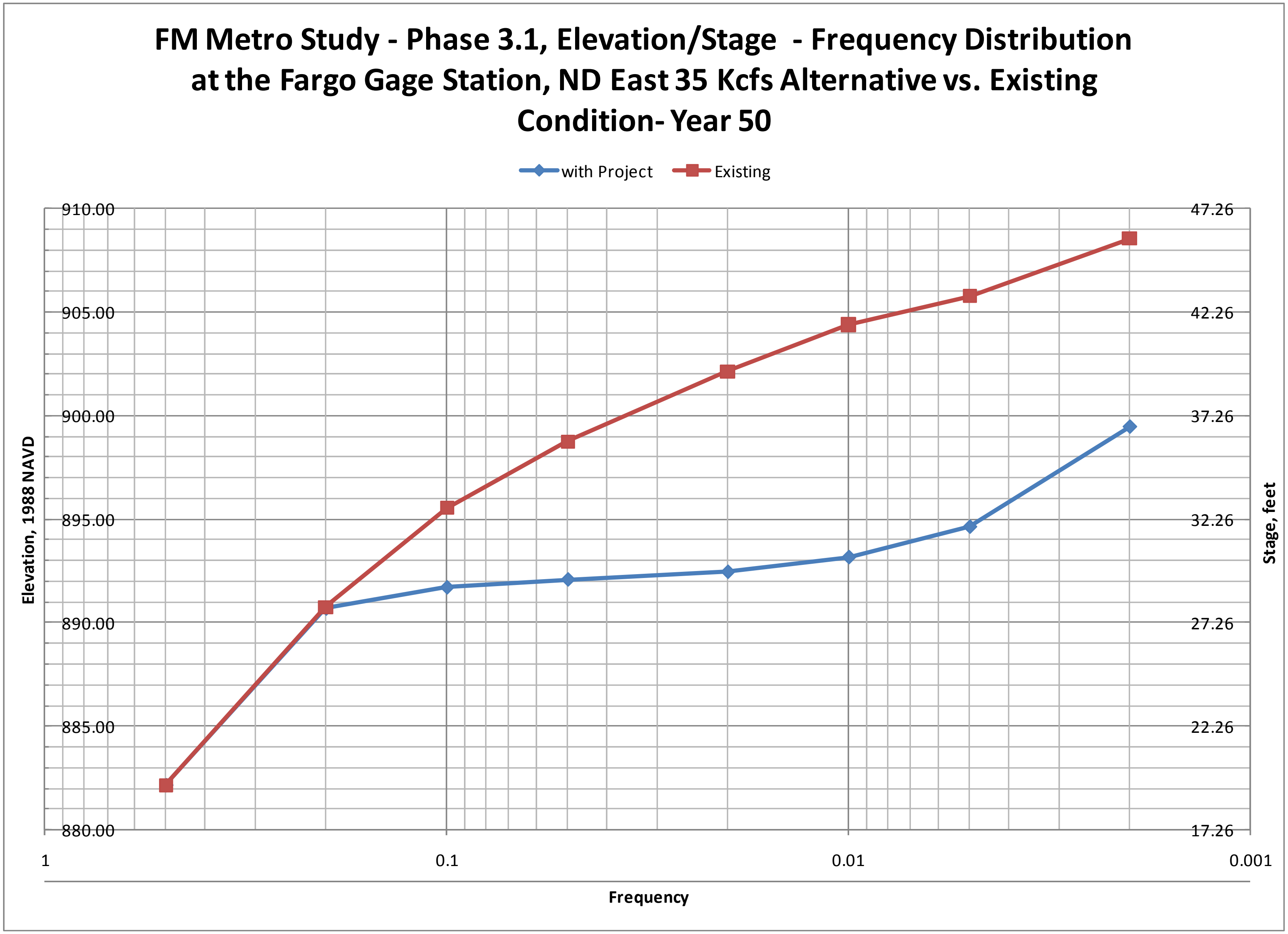


Figure B37 - Elevation/Stage - Frequency Distribution at the Fargo Gage Station, ND East Align 35 Kcfs vs. Existing , Year 50

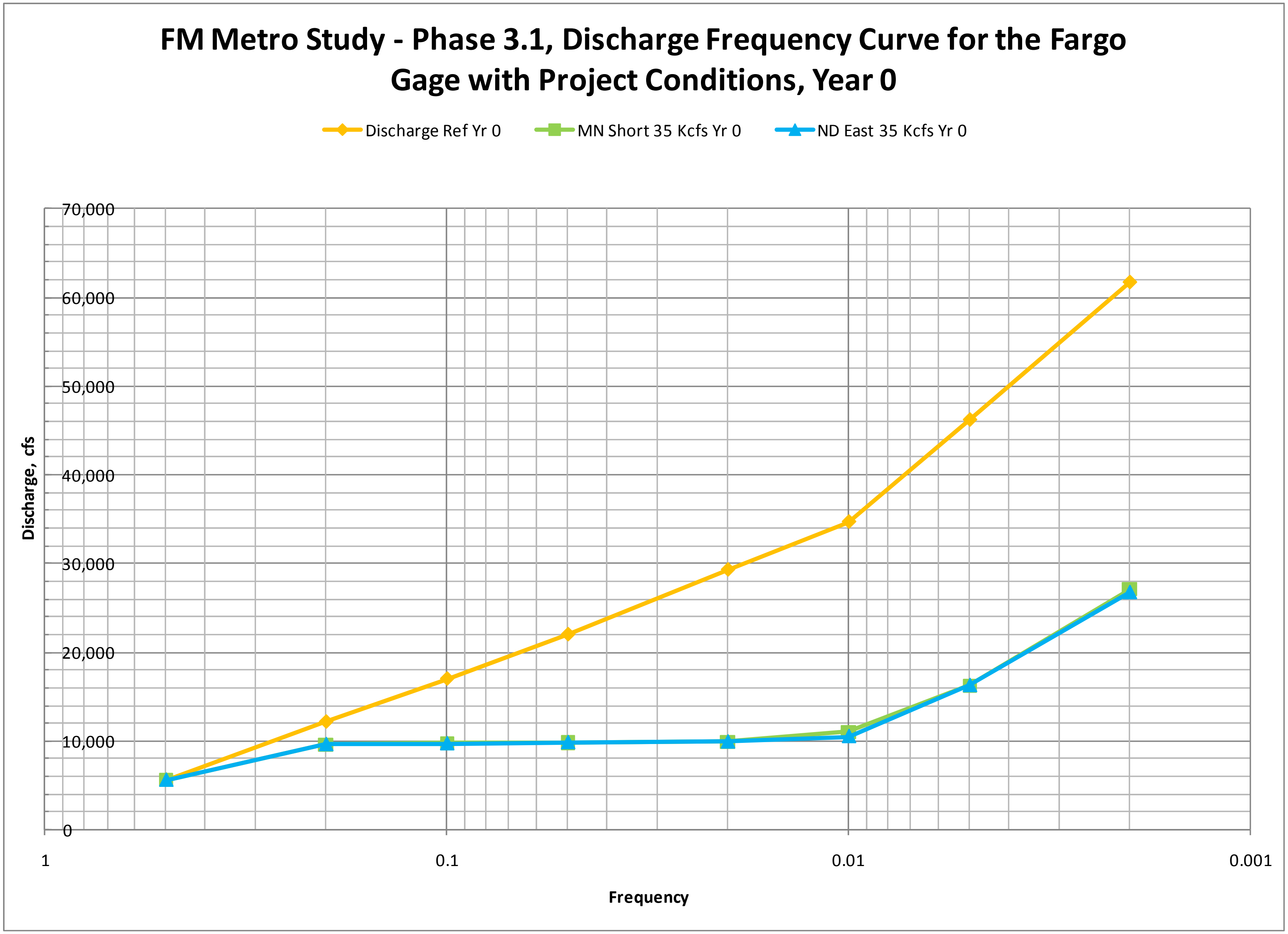


Figure B38 - Discharge Frequency Curve for the Fargo Gage with Project Conditions, Year 0

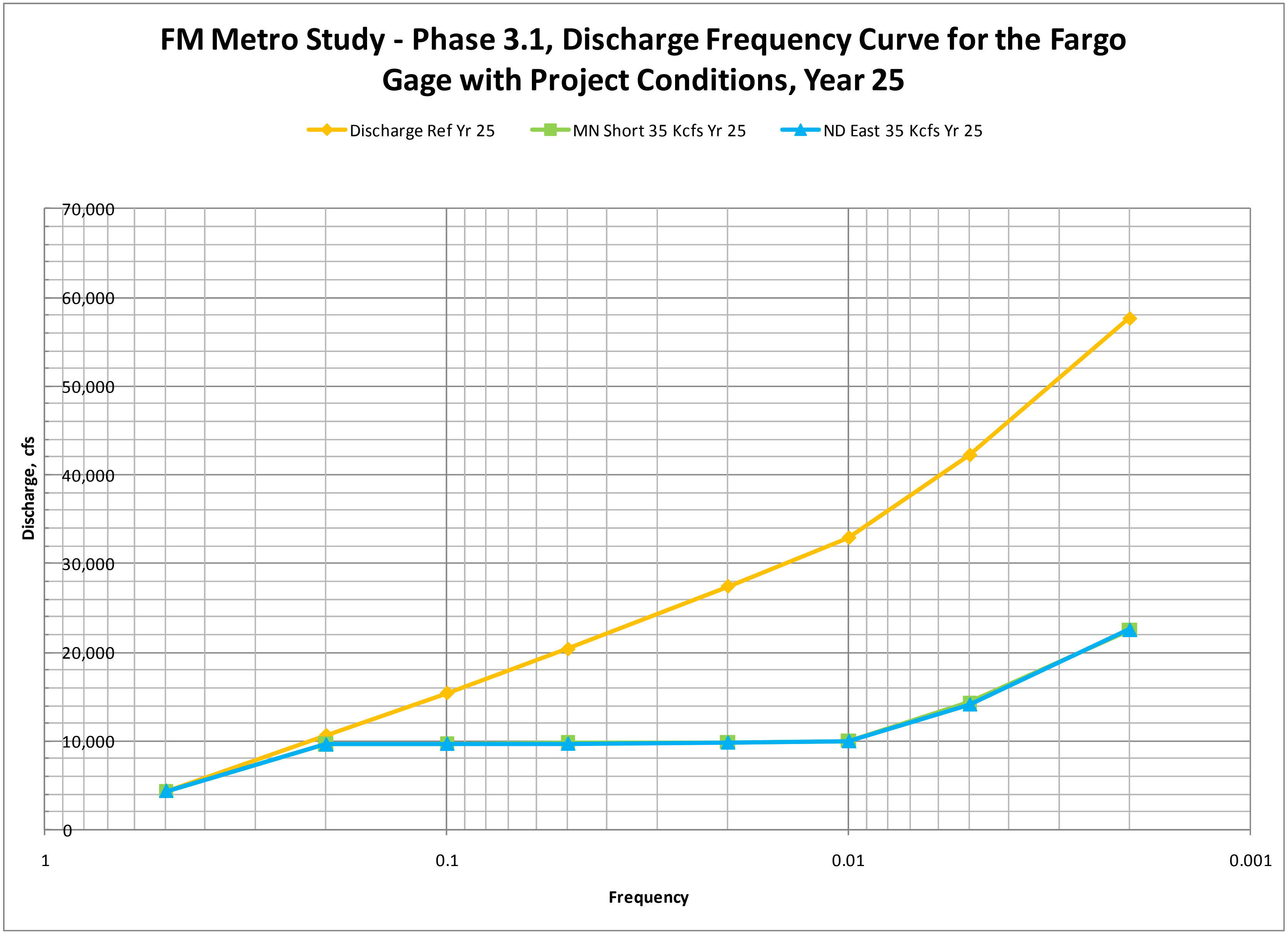


Figure B39 - Discharge Frequency Curve for the Fargo Gage with Project Conditions, Year 25

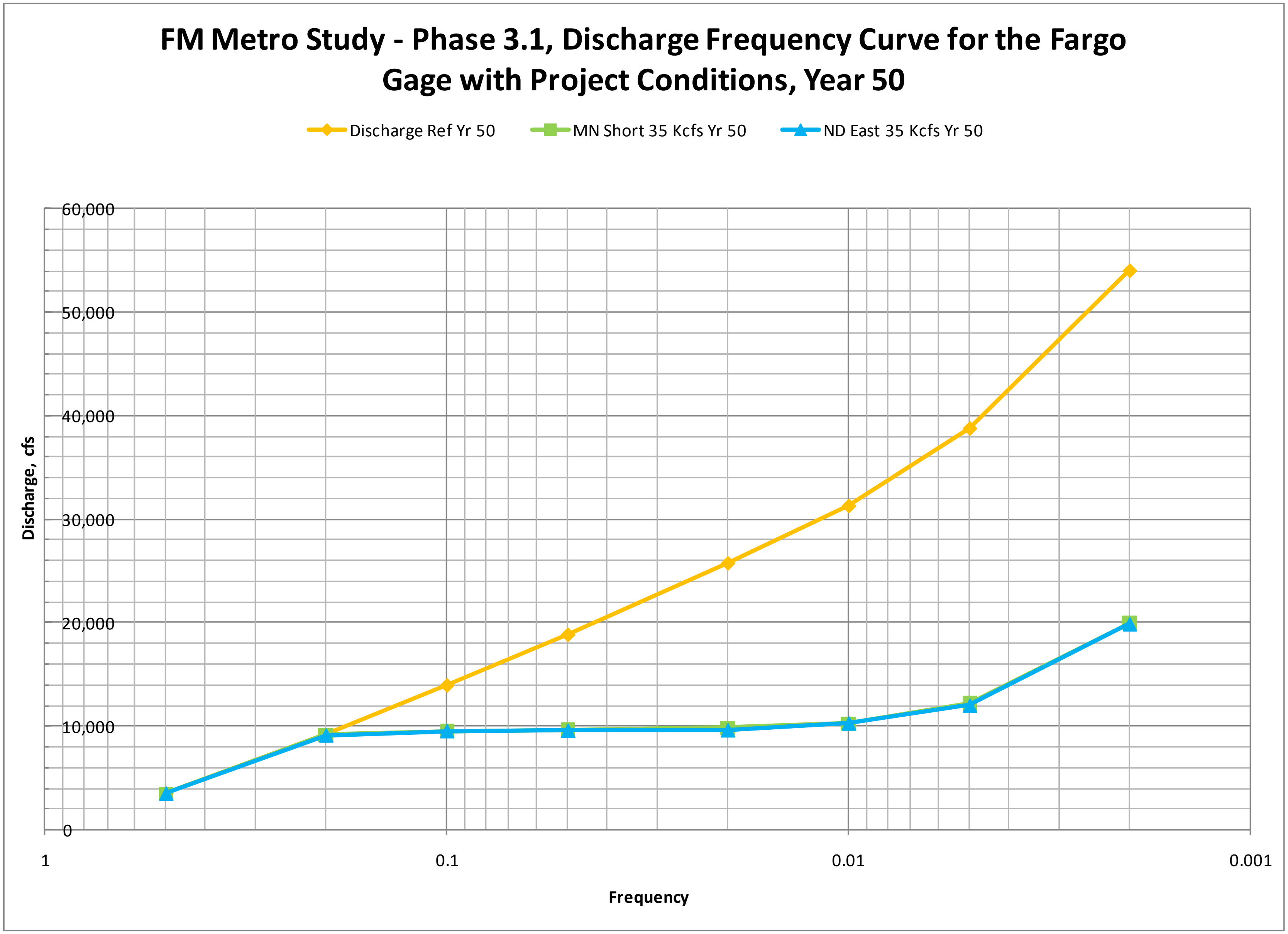


Figure B40 - Discharge Frequency Curve for the Fargo Gage with Project Conditions, Year 50

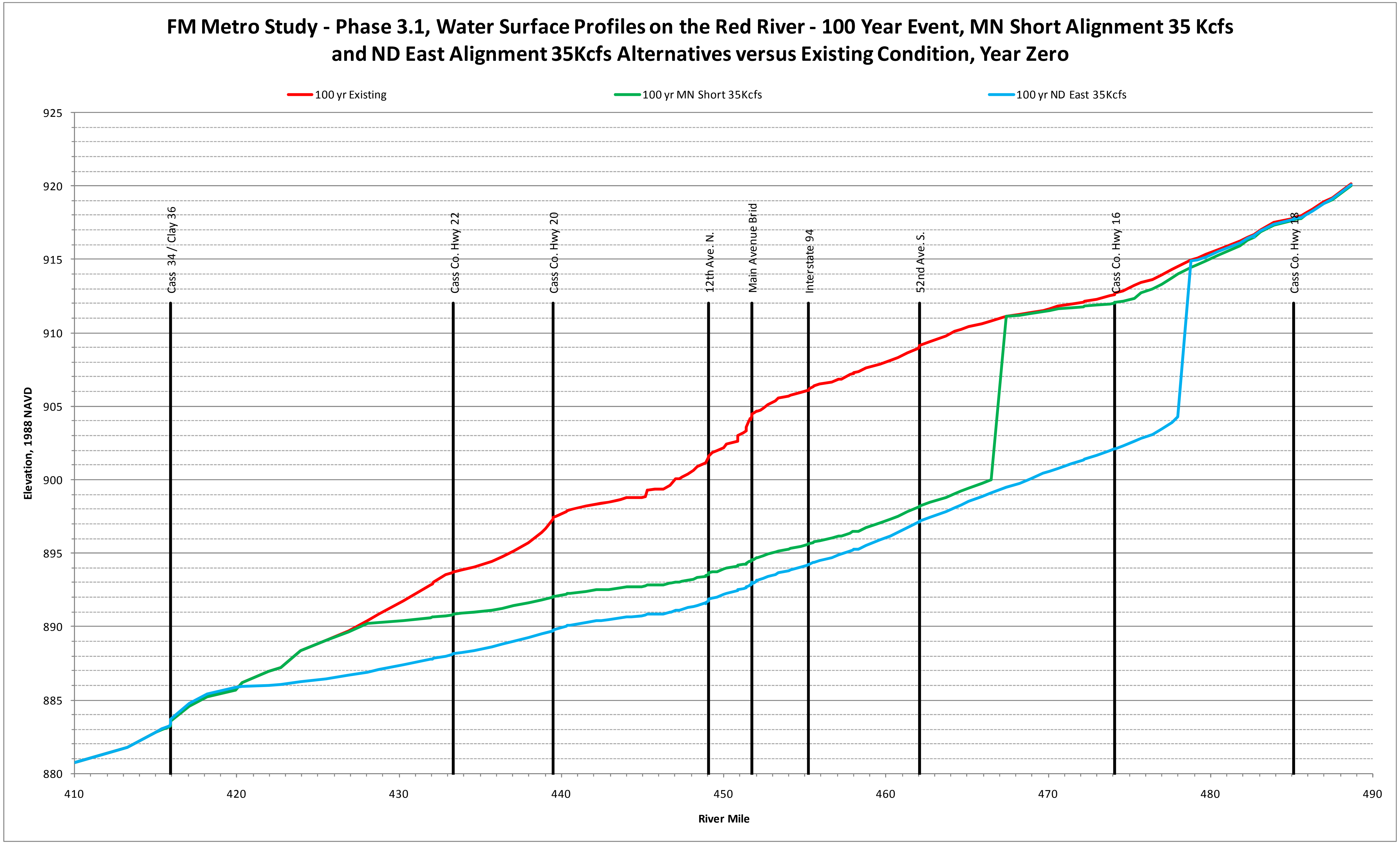


Figure B41 - Water Surface Profiles on the Red River - 100-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 0

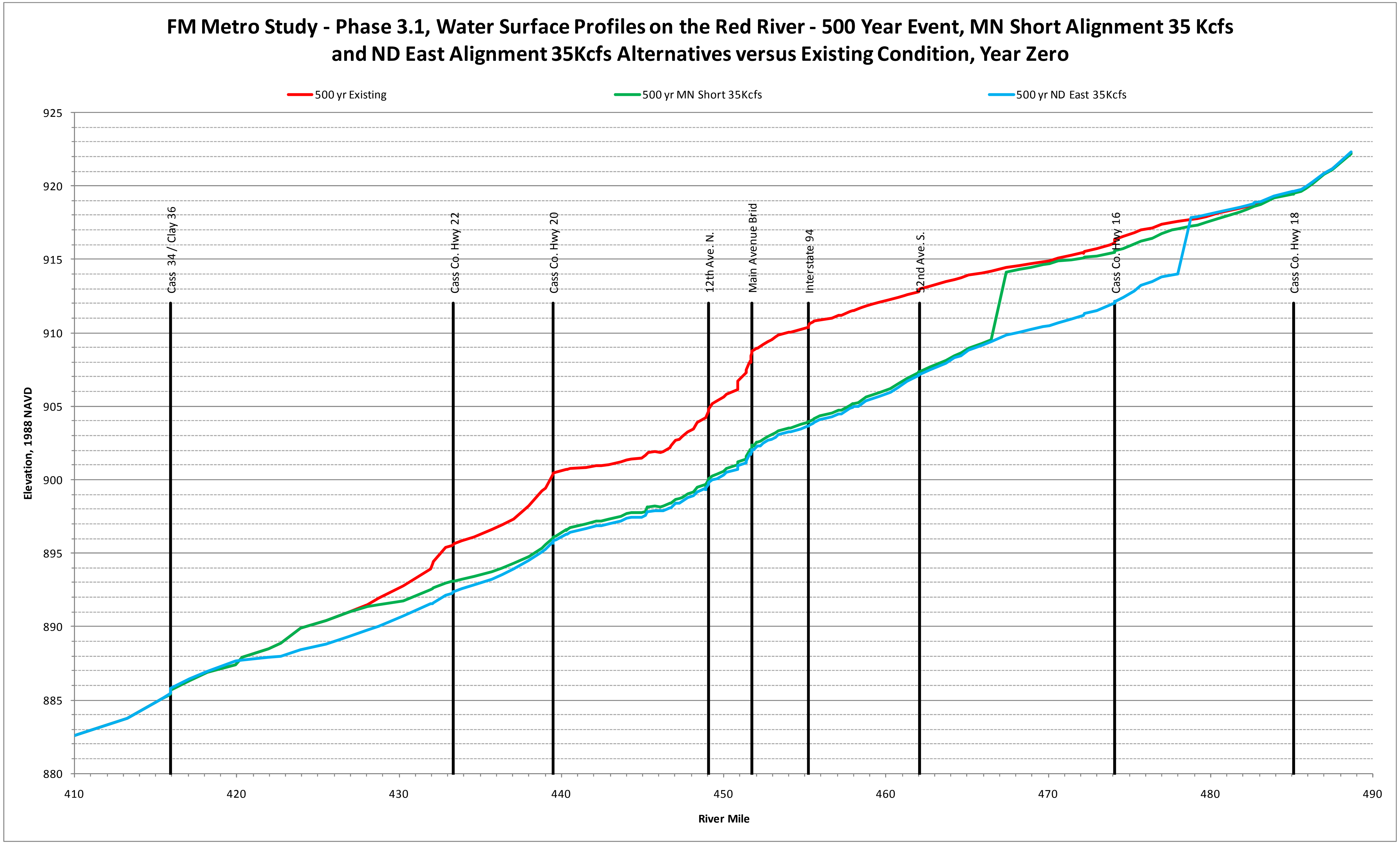


Figure B42 - Water Surface Profiles on the Red River - 500-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 0

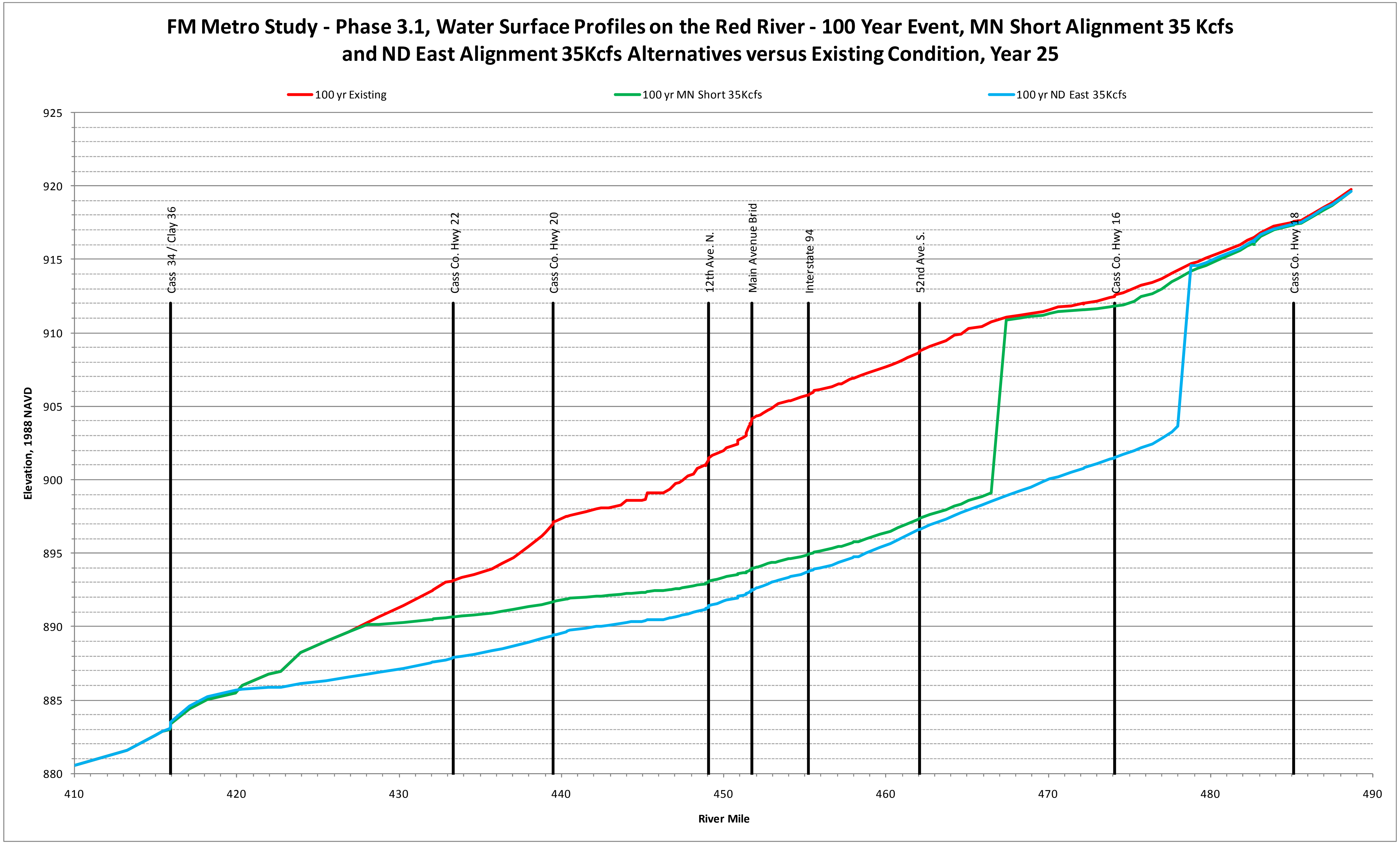


Figure B43 - Water Surface Profiles on the Red River - 100-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 25

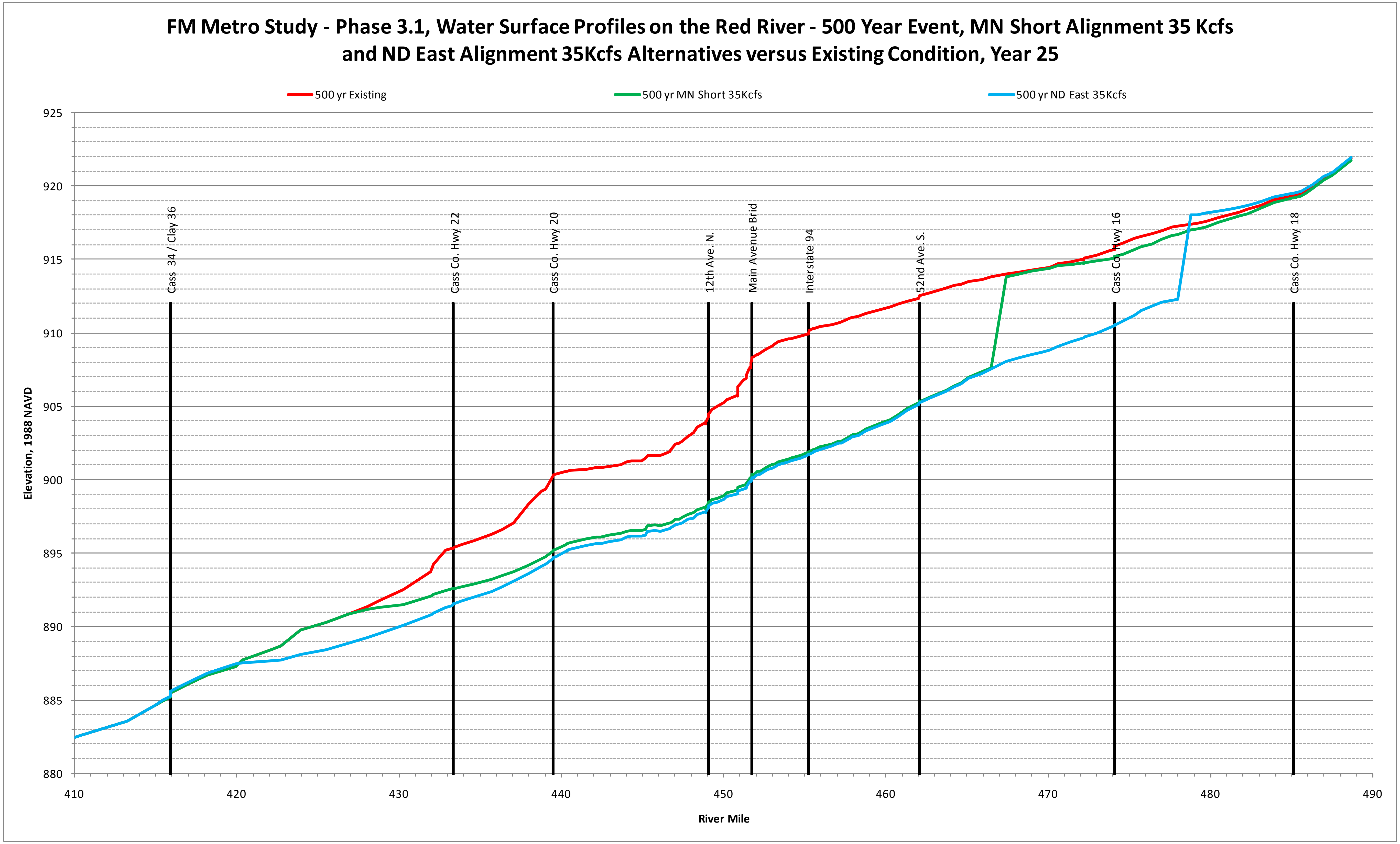


Figure B44 - Water Surface Profiles on the Red River - 500-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 25

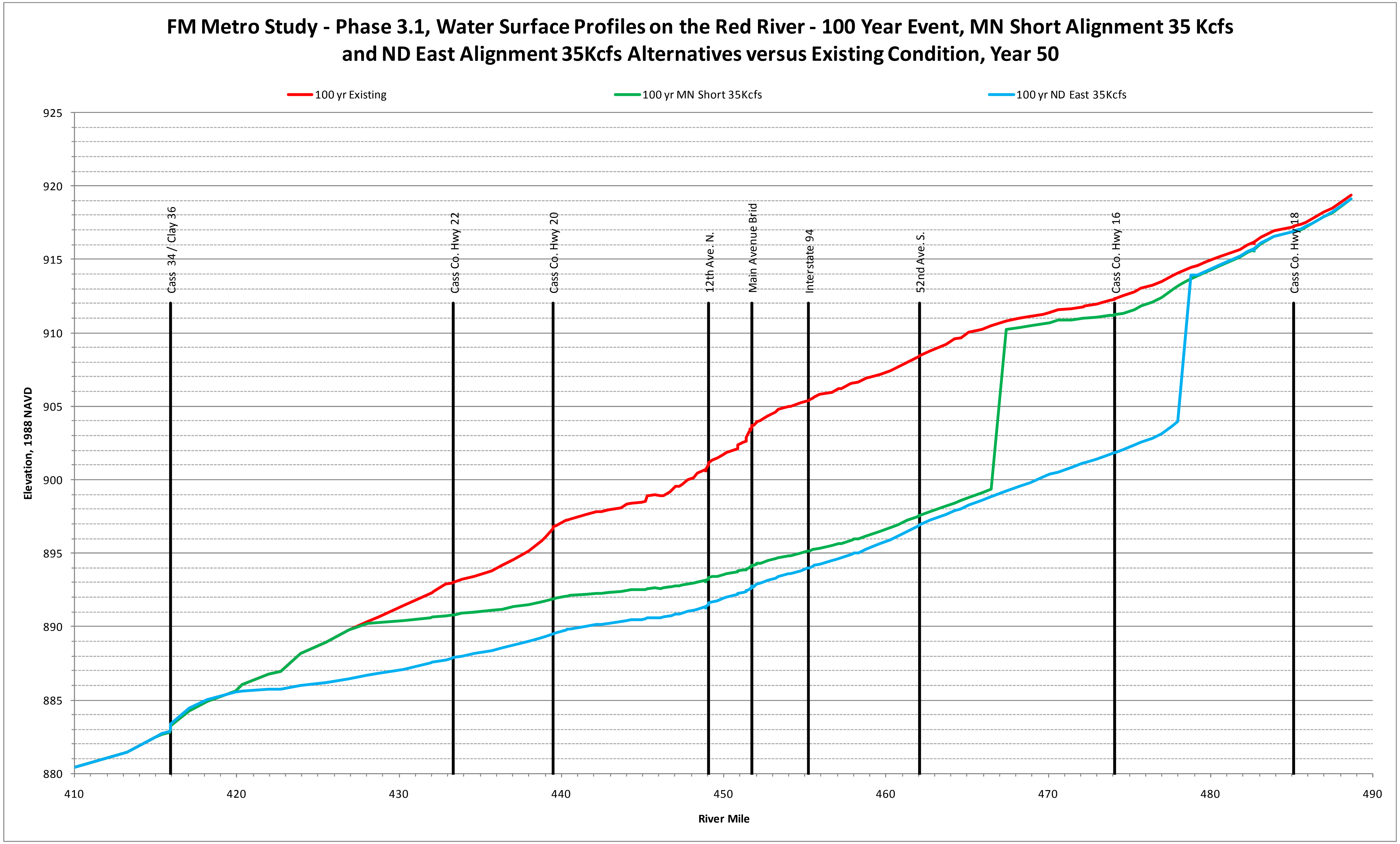


Figure B45 - Water Surface Profiles on the Red River - 100-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 50

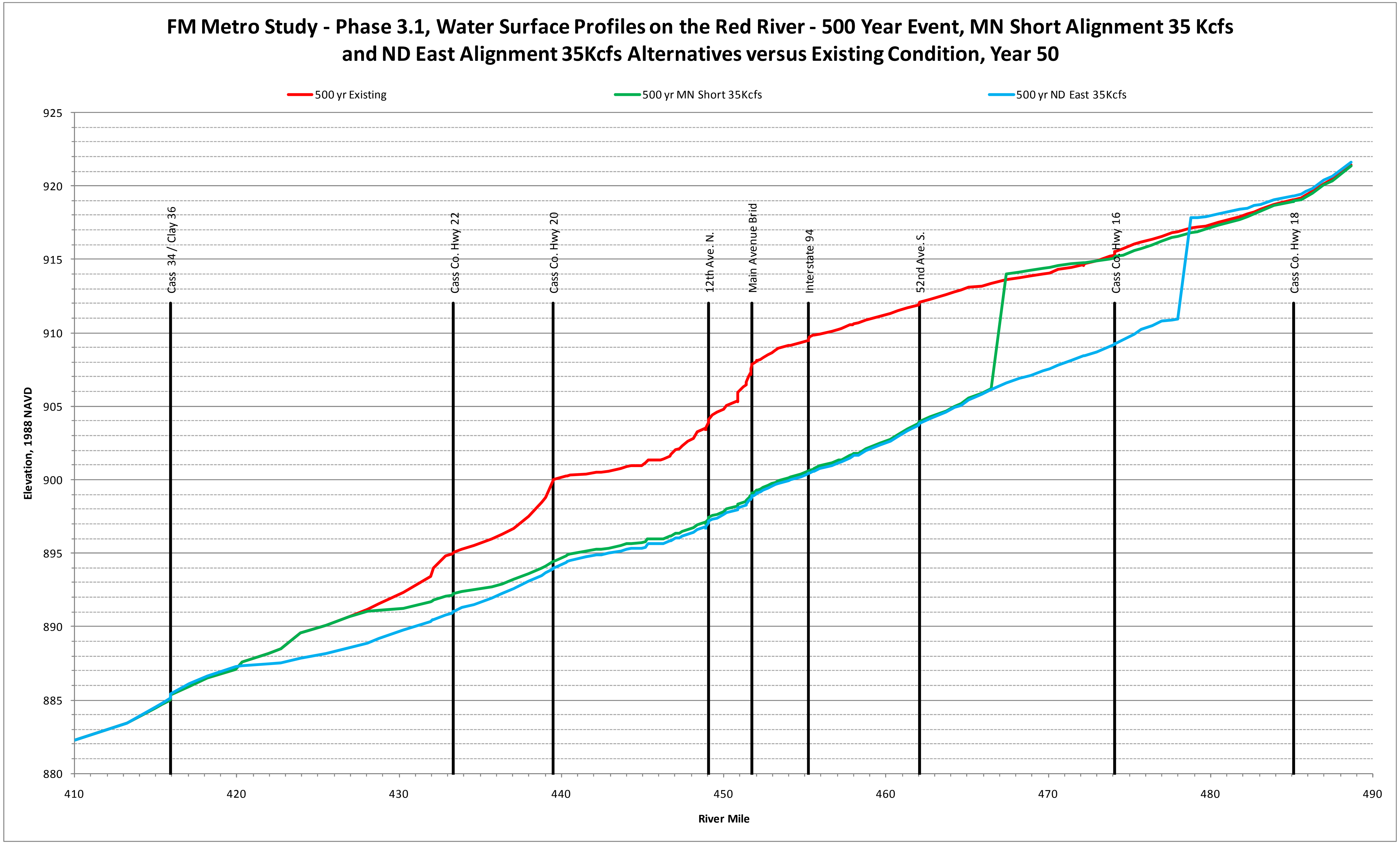
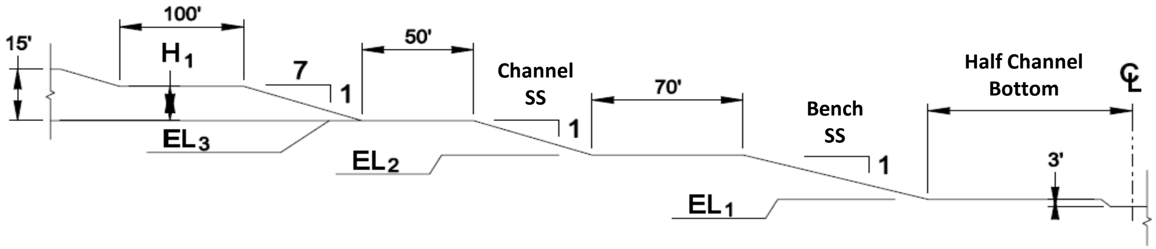


Figure B46 - Water Surface Profiles on the Red River - 500-Year Event, MN Short Align35 Kcfs and ND East Align 35 Kcfs Alternatives vs. Existing Condition, Year 50

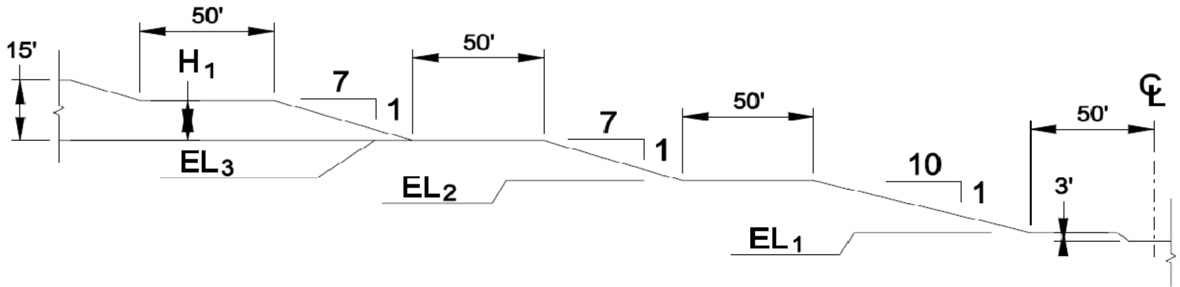
Table B-1. Minnesota Short Cross Section by Station.



STATIONS	Channel Slope	Full Channel Bottom (ft)	Spoil Pile Height (ft)	Channel Invert (1)	Bench Height (ft)	Bench Elevation	Channel SS	Bench SS	Ground Surface
			H_1	EL_1		EL_2			EL_3
00+00 - 70+00	0.0001	225	11	875.00	7	882.00	7	10	885
70+00 - 220+00	0.0001	225	15	875.70	7	882.70	7	10	890
220+00 - 445+00	0.0001	225	15	877.20	7	884.20	7	10	895
445+00 - 559+42	0.0001	225	11	879.45	7	886.45	7	10	904
559+42 - 565+55	0.0001	Transition	4	880.59	7 (2)	887.59	7	10	908
565+55 - 566+55	0.0001	400	4	880.66	7	887.66	7	10	908
566+55 - 752+89	0.0001	400	15	884.67	7 (3)	891.67	10	10	910
752+89 - 856+02	0.0002	400	15	886.53	7	893.53	10	10	911
856+02 - 1070+00	0.0002	400	15	888.59	7	895.59	7	10	912
1070+00 - 1150+00	0.0002	400	15	892.87	7	899.87	7	10	914
1150+00 - 1272+53	0.0002	400	15	894.47	7	901.47	7	10	910
1272+53 - 1302+78	0.0002	400	15	896.92	7	903.92	7	10	910
MN Extension Channel	0.0005	215	15	893.50	N/A (4)	N/A	7	N/A	912

Notes:
All Elevations are NAVD 1988
Diversion Channel low flow channel consists of 10 foot bottom width, 3 foot depth, and 4:1 (H:V) side slopes
Extension Channel low flow channel consists of 7 foot bottom width, 2 foot depth, and 4:1 (H:V) side slopes
(1) - Channel Invert is beginning station (e.g., STA 0+00 Invert = 875.0)
(2) - 7:1 channel bottom transition from 400 feet to 225 feet
(3) - Location of 4 foot raise in channel bottom at STATION 566+55
(4) - The invert elevation of the MN Extension Channel was raised such that benching was not required

Table B-2. North Dakota East Cross Section by Station.



STATIONS	Channel Slope	Spoil Pile Height (ft)	Channel Invert (1)	Bench Height (ft)	Bench Elevation	Ground Surface
		H_1	EL_1		EL_2	EL_3
00+00 - 390+00	0.0002	12	855.00	10	865.00	885
390+00 - 660+00	0.0002	12	862.80	10	872.80	891
660+00 - 1000+00	0.0002	15	868.20	10 (2)	878.20	898
1000+00 - 1150+00	0.0002	15	875.00	10	885.00	901
1150+00 - 1300+00	0.0002	14	878.00	10	888.00	904
1300+00 - 1500+00	0.0002	15	881.00	10	891.00	912
1500+00 - 1670+00	0.0002	15	885.00	10	895.00	914
1670+00 - 1752+41	0.0002	15	888.40	10	898.40	912
1752+41 - 1908+67	0.0002	15	890.05 (3)	N/A (4)	N/A	912

Notes:
All Elevations are NAVD 1988
Diversion Channel bottom width is 100 feet
Connection Channel bottom width is 300 feet
Diversion low flow channel consists of 10 foot bottom width, 3 foot depth, and 4:1 (H:V) side slopes
Connection Channel does not have a low flow channel
(1) - Channel Invert is beginning station (e.g., STA 0+00 Invert = 855.0)
(2) - The bench width was increased to 80 feet in order to meet geotechnical requirements.
(3) - The bottom width of the channel for the geotechnical analyses was 125 feet; the bottom width for the hydraulic modeling was 300 feet.
(4) - The invert elevation of the ND Diversion Channel Connection Channel was high enough not to require benching.

Table B-3
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year Zero)

Fargo-Moorhead Metro Study, Phase 3 Hydrology

Location/Source	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		1,000-Year		10,000-Year		**Location/Source**
Hickson Gage	4,000		7,000		10,500		14,800		21,000		25,000		28,500		32,000		35,000		77,714		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	5,600		12,150		17,000		22,000		29,300		34,700		46,200		61,700		74,000		121,000		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		98,660		147,070		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,780		7,990		10,860		14,050		18,420		22,370		22,840		23,840		24,660		26,070		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	30	0.0054	45	0.0049	55	0.0047	65	0.0041	60	0.0034	70	0.0030	75	0.0031	90	0.0032	95	0.0032	100	0.0032	Drains 3 & 49
Drain 10	195	0.0403	280	0.0327	370	0.0307	395	0.0264	430	0.0226	440	0.0198	475	0.0206	510	0.0193	530	0.0193	555	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		24,035		25,415		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,312	Note 1	3,061	Note 1	4,431	Note 1	5,809	Note 1	7,604	Note 1	9,100	Note 1	9,275	Note 1	9,600	Note 1	9,850	Note 1	10,450	Note 1	Buffalo River
Drain 40/45	293	0.0591	424	0.0490	554	0.0448	791	0.0529	1,166	0.0611	1,520	0.0684	1,525	0.0642	1,590	0.0601	1,655	0.0601	1,765	0.0601	Drain 40/45
Sheyenne River	2,950	Note 1	4,180	Note 1	5,450	Note 1	6,990	Note 1	9,160	Note 1	11,240	Note 1	11,490	Note 1	12,050	Note 1	12,530	Note 1	13,200	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalc	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		24,035		25,415		Check Total for Drain 40/45, Sheyenne & Buffalc
Sheyenne River Flow																					Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,210		3,140		4,090		5,240		6,870		8,430		8,620		9,040		9,400		9,900		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	740		1,040		1,360		1,750		2,290		2,810		2,870		3,010		3,130		3,300		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	5,600		12,150		17,000		22,000		29,300		34,700		46,200		61,700		74,000		121,000		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		30		45		55		65		60		70		75		90		95		100	Drains 3 & 49 Flow Enters
XS 326	5,630		12,195		17,055		22,065		29,360		34,770		46,275		61,790		74,095		121,100		**XS 326**
Drain 10 Flow Enters		195		280		370		395		430		440		475		510		530		555	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	5,825		12,475		17,425		22,460		29,790		35,210		46,750		62,300		74,625		121,655		**XS 311**
XS 303.5	5,825		12,475		17,425		22,460		29,790		35,210		46,750		62,300		74,625		121,655		**XS 303.5**
Drain 40/45		293		424		554		791		1,166		1,520		1,525		1,590		1,655		1,765	Drain 40/45
XS 303	6,118		12,899		17,979		23,251		30,956		36,730		48,275		63,890		76,280		123,420		**XS 303**
Sheyenne River flow		2,210		3,140		4,090		5,240		6,870		8,430		8,620		9,040		9,400		9,900	Sheyenne River flow
XS 299	8,328		16,039		22,069		28,491		37,826		45,160		56,895		72,930		85,680		133,320		**XS 299**
Buffalo River flow		1,312		3,061		4,431		5,809		7,604		9,100		9,275		9,600		9,850		10,450	Buffalo River flow
XS 291	9,640		19,100		26,500		34,300		45,430		54,260		66,170		82,530		95,530		143,770		**XS 291**
Drain 13/Sheyenne River flow		740		1,040		1,360		1,750		2,290		2,810		2,870		3,010		3,130		3,300	Drain 13/Sheyenne River flow
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		98,660		147,070		**XS 283**

HEC-RAS Flow File Input- Existing Conditions- Wet Scenario- Year 0

River	Reach	RS	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		1,000-Year		10,000-Year		River	Reach	RS
lob_rrn	overland	2.89	1		1		1		1		1		1		1		1		1		1		lob_rrn	overland	2.89
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Cass_Clay_Fargo	488.68	4000		7000		10500		14800		21000		25000		28500		32000		35000		77714		RRN	Cass_Clay_Fargo	488.68
RRN	Cass_Clay_Fargo	477	4021		7227		10537		14618		20566		24472		28720		33177		36820		79575		RRN	Cass_Clay_Fargo	477
RRN	Cass_Clay_Fargo	476.4	4166		8952		10791		13453		17872		21196		30252		42385		52104		93574		RRN	Cass_Clay_Fargo	476.4
RRN	Cass_Clay_Fargo	470.1	5600		12150		17000		22000		29300		34700		46200		61700		74000		121000		RRN	Cass_Clay_Fargo	470.1
RRN	Cass_Clay_Fargo	326	5630		12195		17055		22065		29360		34770		46275		61790		74095		121100		RRN	Cass_Clay_Fargo	326
RRN	Cass_Clay_Fargo	311	5825		12475		17425		22460		29790		35210		46750		62300		74625		121655		RRN	Cass_Clay_Fargo	311
RRN	Above_Sheyenne	303.8	5825		12475		17425		22460		29790		35210		46750		62300		74625		121655		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	6118		12899		17979		23251		30956		36730		48275		63890		76280		123420		RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	8328		16039		22069		28491		37826		45160		56895		72930		85680		133320		RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	9640		19100		26500		34300		45430		54260		66170		82530		95530		143770		RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	10380		20140		27860		36050		47720		57070		69040		85540		98660		147070		RRN	Sheyenne_R_to_P	283

Note 1 Discharge values based on coincidental frequency analysis.

Table B-4
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 25)

Location/Source	Fargo-Moorhead Metro Study, Phase 3.1 Hydrology																Location/Source
	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		
Hickson Gage	3,139		6,160		9,555		13,729		19,709		23,757		26,164		30,016		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	4,352		10,608		15,394		20,345		27,441		32,921		42,242		57,641		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River	4,598		7,882		10,726		13,895		18,339		22,279		23,908		25,289		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River
Drains 3 & 49	20	0.0054	45	0.0049	55	0.0047	60	0.0041	65	0.0034	70	0.0030	75	0.0031	95	0.0032	Drains 3 & 49
Drain 10	200	0.0403	295	0.0327	390	0.0307	415	0.0264	440	0.0226	450	0.0198	535	0.0206	575	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,076	Note 1	2,719	Note 1	4,036	Note 1	5,385	Note 1	7,149	Note 1	8,623	Note 1	8,846	Note 1	9,213	Note 1	Buffalo River
Drain 40/45	292	0.0591	443	0.0490	565	0.0448	815	0.0529	1,195	0.0611	1,556	0.0684	1,682	0.0642	1,786	0.0601	Drain 40/45
Sheyenne River	3,010	Note 1	4,380	Note 1	5,680	Note 1	7,220	Note 1	9,490	Note 1	11,580	Note 1	12,770	Note 1	13,620	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,260		3,290		4,260		5,420		7,120		8,690		9,580		10,220		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	750		1,090		1,420		1,800		2,370		2,890		3,190		3,400		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	4,352		10,608		15,394		20,345		27,441		32,921		42,242		57,641		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		55		60		65		70		75		95	Drains 3 & 49 Flow Enters
XS 326	4,372		10,653		15,449		20,405		27,506	0	32,991		42,317		57,736		**XS 326**
Drain 10 Flow Enters		200		295		390		415		440		450		535		575	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	4,572		10,948		15,839		20,820		27,946		33,441		42,852		58,311		**XS 311**
XS 303.8	4,572		10,948		15,839		20,820		27,946		33,441		42,852		58,311		**XS 303.8**
Drain 40/45		292		443		565		815		1,195		1,556		1,682		1,786	Drain 40/45
XS 303	4,864		11,391		16,404		21,635		29,141		34,997		44,534		60,097		**XS 303**
Sheyenne River flow		2,260		3,290		4,260		5,420		7,120		8,690		9,580		10,220	Sheyenne River flow
XS 299	7,124		14,681		20,664		27,055		36,261		43,687		54,114		70,317		**XS 299**
Buffalo River flow		1,076		2,719		4,036		5,385		7,149		8,623		8,846		9,213	Buffalo River flow
XS 291	8,200		17,400		24,700		32,440		43,410		52,310		62,960		79,530		**XS 291**
Drain 13/Sheyenne River flow		750		1,090		1,420		1,800		2,370		2,890		3,190		3,400	Drain 13/Sheyenne River flow
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		**XS 283**

River	Reach	RS	HEC-RAS Flow File Input- Existing Conditions- Year 25																River	Reach	RS
			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year				
lob_rrn	overland	2.89	1		1		1		1		1		1		1		1		lob_rrn	overland	2.89
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Cass_Clay_Fargo	488.68	3139		6160		9555		13729		19709		23757		26164		30016		RRN	Cass_Clay_Fargo	488.68
RRN	Cass_Clay_Fargo	477	3147		6349		9577		13547		19288		23242		26339		31093		RRN	Cass_Clay_Fargo	477
RRN	Cass_Clay_Fargo	476.4	3198		7772		9722		12388		16680		20055		27549		39492		RRN	Cass_Clay_Fargo	476.4
RRN	Cass_Clay_Fargo	470.1	4352		10608		15394		20345		27441		32921		42242		57641		RRN	Cass_Clay_Fargo	470.1
RRN	Cass_Clay_Fargo	326	4372		10653		15449		20405		27506		32991		42317		57736		RRN	Cass_Clay_Fargo	326
RRN	Cass_Clay_Fargo	311	4572		10948		15839		20820		27946		33441		42852		58311		RRN	Cass_Clay_Fargo	311
RRN	Above_Sheyenne	303.8	4572		10948		15839		20820		27946		33441		42852		58311		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4864		11391		16404		21635		29141		34997		44534		60097		RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	7124		14681		20664		27055		36261		43687		54114		70317		RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	8200		17400		24700		32440		43410		52310		62960		79530		RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	8950		18490		26120		34240		45780		55200		66150		82930		RRN	Sheyenne_R_to_P	283

Table B-5
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 50)

Fargo-Moorhead Metro Study, Phase 3.1 Hydrology

Location/Source	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		Location/Source
Hickson Gage	2,550		5,366		8,710		12,762		18,543		22,626		24,116		28,246		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	3,506		9,161		13,965		18,855		25,764	25,764	31,304		38,787		54,034		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River	4,384		7,859		10,645		13,795		18,316		22,256		24,803		26,576		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River
Drains 3 & 49	20	0.0054	45	0.0049	60	0.0047	65	0.0041	70	0.0034	75	0.0030	90	0.0031	110	0.0032	Drains 3 & 49
Drain 10	195	0.0403	310	0.0327	405	0.0307	420	0.0264	450	0.0226	465	0.0198	580	0.0206	625	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	903	Note 1	2,413	Note 1	3,684	Note 1	5,004	Note 1	6,738	Note 1	8,190	Note 1	8,456	Note 1	8,861	Note 1	Buffalo River
Drain 40/45	286	0.0591	461	0.0490	586	0.0448	846	0.0529	1,238	0.0611	1,596	0.0684	1,807	0.0642	1,960	0.0601	Drain 40/45
Sheyenne River	2,980	Note 1	4,630	Note 1	5,910	Note 1	7,460	Note 1	9,820	Note 1	11,930	Note 1	13,870	Note 1	15,020	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,240		3,470		4,430		5,600		7,370		8,950		10,400		11,270		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	740		1,160		1,480		1,860		2,450		2,980		3,470		3,750		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	3,506		9,161		13,965		18,855		25,764		31,304		38,787		54,034		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		60		65		70		75		90		110	Drains 3 & 49 Flow Enters
XS 326	3,526		9,206		14,025		18,920		25,834		31,379		38,877		54,144		**XS 326**
Drain 10 Flow Enters		195		310		405		420		450		465		580		625	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	3,721		9,516		14,430		19,340		26,284		31,844		39,457		54,769		**XS 311**
XS 303.8	3,721		9,516		14,430		19,340		26,284		31,844		39,457		54,769		**XS 303.8**
Drain 40/45		286		461		586		846		1,238		1,596		1,807		1,960	Drain 40/45
XS 303	4,007		9,977		15,016		20,186		27,522		33,440		41,264		56,729		**XS 303**
Sheyenne River flow		2,240		3,470		4,430		5,600		7,370		8,950		10,400		11,270	Sheyenne River flow
XS 299	6,247		13,447		19,446		25,786		34,892		42,390		51,664		67,999		**XS 299**
Buffalo River flow		903		2,413		3,684		5,004		6,738		8,190		8,456		8,861	Buffalo River flow
XS 291	7,150		15,860		23,130		30,790		41,630		50,580		60,120		76,860		**XS 291**
Drain 13/Sheyenne River flow		740		1,160		1,480		1,860		2,450		2,980		3,470		3,750	Drain 13/Sheyenne River flow
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		**XS 283**

HEC-RAS Flow File Input- Existing Condtions- Year 50

River	Reach	RS	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		River	Reach	RS
lob_rrn	overland	2.89	1		1		1		1		1		1		1		1		lob_rrn	overland	2.89
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Cass_Clay_Fargo	488.68	2550		5366		8710		12762		18543		22626		24116		28246		RRN	Cass_Clay_Fargo	488.68
RRN	Cass_Clay_Fargo	477	2550		5485		8718		12582		18134		22123		24258		29236		RRN	Cass_Clay_Fargo	477
RRN	Cass_Clay_Fargo	476.4	2548		6358		8774		11434		15609		19019		25243		36927		RRN	Cass_Clay_Fargo	476.4
RRN	Cass_Clay_Fargo	470.1	3506		9161		13965		18855		25764		31304		38787		54034		RRN	Cass_Clay_Fargo	470.1
RRN	Cass_Clay_Fargo	326	3526		9206		14025		18920		25834		31379		38877		54144		RRN	Cass_Clay_Fargo	326
RRN	Cass_Clay_Fargo	311	3721		9516		14430		19340		26284		31844		39457		54769		RRN	Cass_Clay_Fargo	311
RRN	Above_Sheyenne	303.8	3721		9516		14430		19340		26284		31844		39457		54769		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4007		9977		15016		20186		27522		33440		41264		56729		RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	6247		13447		19446		25786		34892		42390		51664		67999		RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	7150		15860		23130		30790		41630		50580		60120		76860		RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	7890		17020		24610		32650		44080		53560		63590		80610		RRN	Sheyenne_R_to_P	283

Table B-6
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year Zero)

Location/Source	Fargo-Moorhead Metro Study, Phase 3.1 Hydrology 2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		Location/Source
Hickson Gage	4,000		7,000		10,500		14,800		21,000		25,000		28,500		32,000		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	5,600		9,620		9,655		9,770		9,808		10,941		16,370		26,978		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,780		7,990		10,860		14,050		18,420		22,370		22,840		23,840		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	30	0.0054	45	0.0049	55	0.0047	65	0.0041	60	0.0034	70	0.0030	75	0.0031	90	0.0032	Drains 3 & 49
Drain 10	195	0.0403	280	0.0327	370	0.0307	395	0.0264	430	0.0226	440	0.0198	475	0.0206	510	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,312	Note 1	3,061	Note 1	4,431	Note 1	5,809	Note 1	7,604	Note 1	9,100	Note 1	9,275	Note 1	9,600	Note 1	Buffalo River
Drain 40/45	293	0.0591	424	0.0490	554	0.0448	791	0.0529	1,166	0.0611	1,520	0.0684	1,525	0.0642	1,590	0.0601	Drain 40/45
Sheyenne River	2,950	Note 1	4,180	Note 1	5,450	Note 1	6,990	Note 1	9,160	Note 1	11,240	Note 1	11,490	Note 1	12,050	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,210		3,140		4,090		5,240		6,870		8,430		8,620		9,040		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	740		1,040		1,360		1,750		2,290		2,810		2,870		3,010		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	5,600		9,620		9,655		9,770		9,808		10,941		16,370		26,978		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		30		45		55		65		60		70		75		90	Drains 3 & 49 Flow Enters
XS 326	5,630		9,665		9,710		9,835		9,868		11,011		16,445		27,068		**XS 326**
Drain 10 Flow Enters		195		280		370		395		430		440		475		510	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	5,825		9,945		10,080		10,230		10,298		11,451		16,920		27,578		**XS 311**
XS 303.8	5,825		9,945		10,080		10,230		10,298		11,451		16,920		27,578		**XS 303.8**
Drain 40/45		293		424		554		791		1,166		1,520		1,525		1,590	Drain 40/45
XS 303	6,118		10,369		10,634		11,021		11,464		12,971		18,445		29,168		**XS 303**
Sheyenne River flow		2,210		3,140		4,090		5,240		6,870		8,430		8,620		9,040	Sheyenne River flow
XS 299	8,328		16,039		22,069		28,491		37,826		45,160		56,895		72,930		**XS 299**
Buffalo River flow		1,312		3,061		4,431		5,809		7,604		9,100		9,275		9,600	Buffalo River flow
XS 291	9,640		19,100		26,500		34,300		45,430		54,260		66,170		82,530		**XS 291**
Drain 13/Sheyenne River flow		740		1,040		1,360		1,750		2,290		2,810		2,870		3,010	Drain 13/Sheyenne River flow
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		**XS 283**

HEC-RAS Flow File Input- MN Short 35,000 cfs- Wet Scenario- Year 0

River	Reach	RS	2-Year	5-Year	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	River	Reach	RS
lob_rrn	overland	2.89	1	1	1	1	1	1	1	1	lob_rrn	overland	2.89
MN DIV	MN DIV SHORT UPS	130278	0.1	1650	4678	7955	13176	16091	19252	20125	MN DIV	MN DIV SHORT UPS	130278
MN DIV	MN DIV SHORT DOW	127463.*	0.2	2530	7345	12230	19492	23759	29830	34722	MN DIV	MN DIV SHORT DOW	127463.*
MN DIV SHORT EXT	MN DIV SHORT EXT	15966	0.1	880	2667	4275	6316	7668	10578	14597	MN DIV SHORT EXT	MN DIV SHORT EXT	15966
Oakport_SI	Oakport	221	1	1	1	1	1	1	1	1	Oakport_SI	Oakport	221
RRN	Upstream_Ext	488.68	4000	7000	10500	14800	21000	25000	28500	32000	RRN	Upstream_Ext	488.68
RRN	Upstream_Ext	477	4021	7227	10537	14618	20566	24472	28720	33177	RRN	Upstream_Ext	477
RRN	Upstream_Ext	476.4	4166	8952	10791	13453	17872	21196	30252	42385	RRN	Upstream_Ext	476.4
RRN	Upstream_Div	474.6	4166	8072	8124	9178	11556	13528	19674	27788	RRN	Upstream_Div	474.6
RRN	Upstream_Div	470.6	4180	8249	8147	9076	11327	13250	19819	28759	RRN	Upstream_Div	470.6
RRN	Upstream_Div	470.1	5600	11270	14333	17725	22984	27032	35622	47103	RRN	Upstream_Div	470.1
RRN	Downstream_Div	467.4	5600	9620	9655	9770	9808	10941	16370	26978	RRN	Downstream_Div	467.4
RRN	Downstream_Div	326	5630	9665	9710	9835	9868	11011	16445	27068	RRN	Downstream_Div	326
RRN	Downstream_Div	311	5825	9945	10080	10230	10298	11451	16920	27578	RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	5825	9945	10080	10230	10298	11451	16920	27578	RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	6118	10369	10634	11021	11464	12971	18445	29168	RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	8328	16039	22069	28491	37826	45160	56895	72930	RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	9640	19100	26500	34300	45430	54260	66170	82530	RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	10380	20140	27860	36050	47720	57070	69040	85540	RRN	Sheyenne_R_to_P	283

Table B-7
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 25)

Location/Source	Fargo-Moorhead Metro Study, Phase 3.1 Hydrology																Location/Source
	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		
Hickson Gage	3,139		6,160		9,555		13,729		19,709		23,757		26,164		30,016		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	4,352		9,608		9,647		9,738		9,759		9,896		14,255		22,721		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,598		7,882		10,726		13,895		18,339		22,279		23,908		25,289		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	20	0.0054	45	0.0049	55	0.0047	60	0.0041	65	0.0034	70	0.0030	75	0.0031	95	0.0032	Drains 3 & 49
Drain 10	200	0.0403	295	0.0327	390	0.0307	415	0.0264	440	0.0226	450	0.0198	535	0.0206	575	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,076	Note 1	2,719	Note 1	4,036	Note 1	5,385	Note 1	7,149	Note 1	8,623	Note 1	8,846	Note 1	9,213	Note 1	Buffalo River
Drain 40/45	292	0.0591	443	0.0490	565	0.0448	815	0.0529	1,195	0.0611	1,556	0.0684	1,682	0.0642	1,786	0.0601	Drain 40/45
Sheyenne River	3,010	Note 1	4,380	Note 1	5,680	Note 1	7,220	Note 1	9,490	Note 1	11,580	Note 1	12,770	Note 1	13,620	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,260		3,290		4,260		5,420		7,120		8,690		9,580		10,220		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	750		1,090		1,420		1,800		2,370		2,890		3,190		3,400		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	4,352		9,608		9,647		9,738		9,759		9,896		14,255		22,721		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		55		60		65		70		75		95	Drains 3 & 49 Flow Enters
XS 326	4,372		9,653		9,702		9,798		9,824		9,966		14,330		22,816		**XS 326**
Drain 10 Flow Enters		200		295		390		415		440		450		535		575	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	4,572		9,948		10,092		10,213		10,264		10,416		14,865		23,391		**XS 311**
XS 303.8	4,572		9,948		10,092		10,213		10,264		10,416		14,865		23,391		**XS 303.8**
Drain 40/45		292		443		565		815		1,195		1,556		1,682		1,786	Drain 40/45
XS 303	4,864		10,391		10,657		11,028		11,459		11,972		16,547		25,177		**XS 303**
Sheyenne River flow		2,260		3,290		4,260		5,420		7,120		8,690		9,580		10,220	Sheyenne River flow
XS 299	7,124		14,681		20,664		27,055		36,261		43,687		54,114		70,317		**XS 299**
Buffalo River flow		1,076		2,719		4,036		5,385		7,149		8,623		8,846		9,213	Buffalo River flow
XS 291	8,200		17,400		24,700		32,440		43,410		52,310		62,960		79,530		**XS 291**
Drain 13/Sheyenne River flow		750		1,090		1,420		1,800		2,370		2,890		3,190		3,400	Drain 13/Sheyenne River flow
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		**XS 283**

River	Reach	RS	HEC-RAS Flow File Input- MN Short 35,000 cfs- Year 25																River	Reach	RS
			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year				
lob_rrn	overland	2.89	1		1		1		1		1		1		1		1		lob_rrn	overland	2.89
MN DIV	MN DIV SHORT UPS	130278	0.1		880		3733		6857		11860		15845		18368		21330		MN DIV	MN DIV SHORT UPS	130278
MN DIV	MN DIV SHORT DOW	127463.*	0.2		1000		5747		10607		17682		23025		27987		34920		MN DIV	MN DIV SHORT DOW	127463.*
MN DIV SHORT EXT	MN DIV SHORT EXT	15966	0.1		120		2014		3750		5822		7180		9619		13590		MN DIV SHORT EXT	MN DIV SHORT EXT	15966
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Upstream_Ext	488.68	3139		6160		9555		13729		19709		23757		26164		30016		RRN	Upstream_Ext	488.68
RRN	Upstream_Ext	477	3147		6349		9577		13547		19288		23242		26339		31093		RRN	Upstream_Ext	477
RRN	Upstream_Ext	476.4	3198		7772		9722		12388		16680		20055		27549		39492		RRN	Upstream_Ext	476.4
RRN	Upstream_Div	474.6	3198		7652		7708		8638		10858		12875		17930		25902		RRN	Upstream_Div	474.6
RRN	Upstream_Div	470.6	3203		7797		7721		8537		10638		12605		18044		26785		RRN	Upstream_Div	470.6
RRN	Upstream_Div	470.1	4352		10488		13380		16595		21619		25741		32623		44051		RRN	Upstream_Div	470.1
RRN	Downstream_Div	467.4	4352		9608		9647		9738		9759		9896		14255		22721		RRN	Downstream_Div	467.4
RRN	Downstream_Div	326	4372		9653		9702		9798		9824		9966		14330		22816		RRN	Downstream_Div	326
RRN	Downstream_Div	311	4572		9948		10092		10213		10264		10416		14865		23391		RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	4572		9948		10092		10213		10264		10416		14865		23391		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4864		10391		10657		11028		11459		11972		16547		25177		RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	7124		14681		20664		27055		36261		43687		54114		70317		RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	8200		17400		24700		32440		43410		52310		62960		79530		RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	8950		18490		26120		34240		45780		55200		66150		82930		RRN	Sheyenne_R_to_P	283

Table B-8
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 50)

Location/Source	Fargo-Moorhead Metro Study, Phase 3.1 Hydrology																Location/Source
	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		
Hickson Gage	2,550		5,366		8,710		12,762		18,543		22,626		24,116		28,246		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	3,506		9,159		9,546		9,587		9,658		10,191		12,103		19,922		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,384		7,859		10,645		13,795		18,316		22,256		24,803		26,576		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	20	0.0054	45	0.0049	60	0.0047	65	0.0041	70	0.0034	75	0.0030	90	0.0031	110	0.0032	Drains 3 & 49
Drain 10	195	0.0403	310	0.0327	405	0.0307	420	0.0264	450	0.0226	465	0.0198	580	0.0206	625	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	903	Note 1	2,413	Note 1	3,684	Note 1	5,004	Note 1	6,738	Note 1	8,190	Note 1	8,456	Note 1	8,861	Note 1	Buffalo River
Drain 40/45	286	0.0591	461	0.0490	586	0.0448	846	0.0529	1,238	0.0611	1,596	0.0684	1,807	0.0642	1,960	0.0601	Drain 40/45
Sheyenne River	2,980	Note 1	4,630	Note 1	5,910	Note 1	7,460	Note 1	9,820	Note 1	11,930	Note 1	13,870	Note 1	15,020	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
75% enters at Sheyenne, XS 299	2,240		3,470		4,430		5,600		7,370		8,950		10,400		11,270		75% enters at Sheyenne, XS 299
25% enters at Drain 13, XS 283	740		1,160		1,480		1,860		2,450		2,980		3,470		3,750		25% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	3,506		9,159		9,546		9,587		9,658		10,191		12,103		19,922		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		60		65		70		75		90		110	Drains 3 & 49 Flow Enters
XS 326	3,526		9,204		9,606		9,652		9,728		10,266		12,193		20,032		**XS 326**
Drain 10 Flow Enters		195		310		405		420		450		465		580		625	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	3,721		9,514		10,011		10,072		10,178		10,731		12,773		20,657		**XS 311**
XS 303.8	3,721		9,514		10,011		10,072		10,178		10,731		12,773		20,657		**XS 303.8**
Drain 40/45		286		461		586		846		1,238		1,596		1,807		1,960	Drain 40/45
XS 303	4,007		9,975		10,597		10,918		11,416		12,327		14,580		22,617		**XS 303**
Sheyenne River flow		2,240		3,470		4,430		5,600		7,370		8,950		10,400		11,270	Sheyenne River flow
XS 299	6,247		13,447		19,446		25,786		34,892		42,390		51,664		67,999		**XS 299**
Buffalo River flow		903		2,413		3,684		5,004		6,738		8,190		8,456		8,861	Buffalo River flow
XS 291	7,150		15,860		23,130		30,790		41,630		50,580		60,120		76,860		**XS 291**
Drain 13/Sheyenne River flow		740		1,160		1,480		1,860		2,450		2,980		3,470		3,750	Drain 13/Sheyenne River flow
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		**XS 283**

River	Reach	RS	HEC-RAS Flow File Input- MN Short 35,000 cfs- Year 50																River	Reach	RS
			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year				
lob_rrn	overland	2.89	1		1		1		1		1		1		1		1		lob_rrn	overland	2.89
MN DIV	MN DIV SHORT UPS	130278	0.1		1		2963		5983		10724		14266		17842		21446		MN DIV	MN DIV SHORT UPS	130278
MN DIV	MN DIV SHORT DOW	127463.*	0.2		2		4419		9268		16106		21113		26684		34112		MN DIV	MN DIV SHORT DOW	127463.*
MN DIV SHORT EXT	MN DIV SHORT EXT	15966	0.1		1		1456		3285		5382		6847		8842		12666		MN DIV SHORT EXT	MN DIV SHORT EXT	15966
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Upstream_Ext	488.68	2550		5366		8710		12762		18543		22626		24116		28246		RRN	Upstream_Ext	488.68
RRN	Upstream_Ext	477	2550		5485		8718		12582		18134		22123		24258		29236		RRN	Upstream_Ext	477
RRN	Upstream_Ext	476.4	2548		6358		8774		11434		15609		19019		25243		36927		RRN	Upstream_Ext	476.4
RRN	Upstream_Div	474.6	2548		6357		7318		8149		10227		12172		16401		24261		RRN	Upstream_Div	474.6
RRN	Upstream_Div	470.6	2548		6443		7323		8049		10014		11910		16494		25067		RRN	Upstream_Div	470.6
RRN	Upstream_Div	470.1	3506		9160		12509		15570		20382		24457		29945		41368		RRN	Upstream_Div	470.1
RRN	Downstream_Div	467.4	3506		9159		9546		9587		9658		10191		12103		19922		RRN	Downstream_Div	467.4
RRN	Downstream_Div	326	3526		9204		9606		9652		9728		10266		12193		20032		RRN	Downstream_Div	326
RRN	Downstream_Div	311	3721		9514		10011		10072		10178		10731		12773		20657		RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	3721		9514		10011		10072		10178		10731		12773		20657		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4007		9975		10597		10918		11416		12327		14580		22617		RRN	Above_Sheyenne	303
RRN	Sheyenne_R_to_P	299	6247		13447		19446		25786		34892		42390		51664		67999		RRN	Sheyenne_R_to_P	299
RRN	Sheyenne_R_to_P	291	7150		15860		23130		30790		41630		50580		60120		76860		RRN	Sheyenne_R_to_P	291
RRN	Sheyenne_R_to_P	283	7890		17020		24610		32650		44080		53560		63590		80610		RRN	Sheyenne_R_to_P	283

Table B-9

Red River of the North - Fargo-Moorhead Metro Area to Perley

Initial HEC-RAS Discharges (Year Zero)

Location/Source	**Fargo-Moorhead Metro Study, Phase 3.1 Hydrology**																**Location/Source**
	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		
Hickson Gage	4,000		7,000		10,500		14,800		21,000		25,000		28,500		32,000		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	5,600		9,616		9,717		9,834		9,915		10,524		16,291		26,806		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,780		7,990		10,860		14,050		18,420		22,370		22,840		23,840		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	30	0.0054	45	0.0049	55	0.0047	65	0.0041	60	0.0034	70	0.0030	75	0.0031	90	0.0032	Drains 3 & 49
Drain 10	195	0.0403	280	0.0327	370	0.0307	395	0.0264	430	0.0226	440	0.0198	475	0.0206	510	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,312	Note 1	3,061	Note 1	4,431	Note 1	5,809	Note 1	7,604	Note 1	9,100	Note 1	9,275	Note 1	9,600	Note 1	Buffalo River
Drain 40/45 -Existing Condtions	293	0.0591	424	0.0490	554	0.0448	791	0.0529	1,166	0.0611	1,520	0.0684	1,525	0.0642	1,590	0.0601	Drain 40/45 -Existing Condtions
Drain 40/45 - With Project Conditions	293		300		300		300		300		300		300		300		Drain 40/45 - With Project Conditions
Sheyenne River	2,570	Note 1	3,049	Note 1	3,239	Note 1	3,447	Note 1	3,688	Note 1	3,750	Note 1	3,999	Note 1	4,123	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,555		7,665		10,435		13,590		17,930		21,860		22,290		23,240		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
100% enters at Sheyenne, XS 299	2,570		3,049		3,239		3,447		3,688		3,750		3,999		4,123		100% enters at Sheyenne, XS 299
0% enters at Drain 13, XS 283	0		0		0		0		0		0		0		0		0% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	5,600		9,616		9,717		9,834		9,915		10,524		16,291		26,806		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		30		45		55		65		60		70		75		90	Drains 3 & 49 Flow Enters
XS 326	5,630		9,661		9,772		9,899		9,975		10,594		16,366		26,896		**XS 326**
Drain 10 Flow Enters		195		280		370		395		430		440		475		510	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	5,825		9,941		10,142		10,294		10,405		11,034		16,841		27,406		**XS 311**
XS 303.8	5,825		9,941		10,142		10,294		10,405		11,034		16,841		27,406		**XS 303.8**
Drain 40/45		293		300		300		300		300		300		300		300	Drain 40/45
XS 303	6,118		10,241		10,442		10,594		10,705		11,334		17,141		27,706		**XS 303**
Sheyenne River flow		2,570		3,049		3,239		3,447		3,688		3,750		3,999		4,123	Sheyenne River flow
XS 299	8,688		13,290		13,681		14,041		14,393		15,084		21,140		31,829		**XS 299**
Buffalo River flow		1,312		3,061		4,431		5,809		7,604		9,100		9,275		9,600	Buffalo River flow
XS 291	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		**XS 291**
Drain 13/Sheyenne River flow		0		0		0		0		0		0		0		0	Drain 13/Sheyenne River flow
XS 283	10,380		20,140		27,860		36,050		47,720		57,070		69,040		85,540		**XS 283**

River	Reach	RS	**HEC-RAS Flow File Input- ND East 35,000 cfs- Wet Scenario- Year 0**																River	Reach	RS
			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year				
lob_rrn	overland	2.89	1	1419	1	3021	1	6185	1	8648	1	11655	1	13780	1	15801	1	18342	lob_rrn	overland	2.89
ND DIV	ND DIV EAST	190867	0	NO	1863	YES	3448	YES	5868	YES	10080	YES	12746	YES	16458	YES	18902	YES	ND DIV	ND DIV EAST	190867
ND DIV	ND DIV EAST	176762	0	1419	2534	2350	7283	2350	12166	2350	19385	2350	24176	2350	29909	2350	34894	2350	ND DIV	ND DIV EAST	176762
ND DIV	ND DIV EAST	148766	125	125	3119	585	8405	1122	13985	1819	22199	2814	27069	2893	32802	2893	37787	2893	ND DIV	ND DIV EAST	148766
ND DIV	ND DIV EAST	124541	125	0	3119	0	8405	0	13985	0	22199	0	27569	500	33362	560	38487	700	ND DIV	ND DIV EAST	124541
ND DIV	ND DIV EAST	80945	125	0	3119	0	8405	0	13985	0	22460	261	28939	1370	34837	1475	40272	1785	ND DIV	ND DIV EAST	80945
ND DIV	ND DIV EAST	71959	125	0	3420	301	9259	854	15570	1585	24868	2408	31821	2882	37545	2708	42971	2699	ND DIV	ND DIV EAST	71959
ND DIV	ND DIV EAST	57083	210	85	3543	123	9422	163	15780	210	25153	285	32176	355	37905	360	43351	380	ND DIV	ND DIV EAST	57083
ND DIV	ND DIV EAST	47124	380	170	3789	246	9748	326	16200	420	25723	570	32886	710	38625	720	44111	760	ND DIV	ND DIV EAST	47124
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Upstream_Div	488.68	4000		7000		10500		14800		21000		25000		28500		32000		RRN	Upstream_Div	488.68
RRN	Downstream_Div	478.81	4000		5137		7052		8932		10920		12254		12042		13098		RRN	Downstream_Div	478.81
RRN	Downstream_Div	477	4021		5364		7089		8750		10486		11726		12262		14275		RRN	Downstream_Div	477
RRN	Downstream_Div	476.4	4166		7089		7343		7585		7792		8450		13794		23483		RRN	Downstream_Div	476.4
RRN	Downstream_Div	470.6	4180		7266		7366		7483		7563		8172		13939		24454		RRN	Downstream_Div	470.6
RRN	Downstream_Div	470.1	5600		9616		9717		9834		9915		10524		16291		26806		RRN	Downstream_Div	470.1
RRN	Downstream_Div	326	5630		9661		9772		9899		9975		10594		16366		26896		RRN	Downstream_Div	326
RRN	Downstream_Div	311	5825		9941		10142		10294		10405		11034		16841		27406		RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	5825		9941		10142		10294		10405		11034		16841		27406		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	6118		10241		10442		10594		10705		11334		17141		27706		RRN	Above_Sheyenne	303
RRN	Shey_Upstrm_Div	299	8688		13290		13681		14041		14393		15084		21140		31829		RRN	Shey_Upstrm_Div	299
RRN	Shey_Dwnstrm_Div	292	9068		17079		23429		30241		40116		47970		59765		75940		RRN	Shey_Dwnstrm_Div	292
RRN	Shey_Dwnstrm_Div	291	10380		20140		27860		36050		47720		57070		69040		85540		RRN	Shey_Dwnstrm_Div	291
RRN	Shey_Dwnstrm_Div	283	10380		20140		27860		36050		47720		57070		69040		85540		RRN	Shey_Dwnstrm_Div	283

Table B-10
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 25)

Location/Source	Fargo-Moorhead Metro Study, Phase 3.1 Hydrology																Location/Source
	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		
Hickson Gage	3,139		6,160		9,555		13,729		19,709		23,757		26,164		30,016		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	4,352		9,607		9,690		9,702		9,823		9,974		14,133		22,570		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,598		7,882		10,726		13,895		18,339		22,279		23,908		25,289		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	20	0.0054	45	0.0049	55	0.0047	60	0.0041	65	0.0034	70	0.0030	75	0.0031	95	0.0032	Drains 3 & 49
Drain 10	200	0.0403	295	0.0327	390	0.0307	415	0.0264	440	0.0226	450	0.0198	535	0.0206	575	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	1,076	Note 1	2,719	Note 1	4,036	Note 1	5,385	Note 1	7,149	Note 1	8,623	Note 1	8,846	Note 1	9,213	Note 1	Buffalo River
Drain 40/45 -Existing Condtions	292	0.0591	443	0.0490	565	0.0448	815	0.0529	1,195	0.0611	1,556	0.0684	1,682	0.0642	1,786	0.0601	Drain 40/45 -Existing Condtions
Drain 40/45 - With Project Conditions	292		300		300		300		300		300		300		300		Drain 40/45 - With Project Conditions
Sheyenne River	2,611	Note 1	3,083	Note 1	3,268	Note 1	3,475	Note 1	3,713	Note 1	3,938	Note 1	3,778	Note 1	4,187	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,378		7,542		10,281		13,420		17,834		21,759		23,298		24,619		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
100% enters at Sheyenne, XS 299	2,611		3,083		3,268		3,475		3,713		3,938		3,778		4,187		100% enters at Sheyenne, XS 299
0% enters at Drain 13, XS 283	0		0		0		0		0		0		0		0		0% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	4,352		9,607		9,690		9,702		9,823		9,974		14,133		22,570		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		55		60		65		70		75		95	Drains 3 & 49 Flow Enters
XS 326	4,372		9,652		9,745		9,762		9,888		10,044		14,208		22,665		**XS 326**
Drain 10 Flow Enters		200		295		390		415		440		450		535		575	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	4,572		9,947		10,135		10,177		10,328		10,494		14,743		23,240		**XS 311**
XS 303.8	4,572		9,947		10,135		10,177		10,328		10,494		14,743		23,240		**XS 303.8**
Drain 40/45		292		300		300		300		300		300		300		300	Drain 40/45
XS 303	4,864		10,247		10,435		10,477		10,628		10,794		15,043		23,540		**XS 303**
Sheyenne River flow		2,611		3,083		3,268		3,475		3,713		3,938		3,778		4,187	Sheyenne River flow
XS 299	7,475		13,330		13,703		13,952		14,341		14,732		18,821		27,727		**XS 299**
Buffalo River flow		1,076		2,719		4,036		5,385		7,149		8,623		8,846		9,213	Buffalo River flow
XS 291	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		**XS 291**
Drain 13/Sheyenne River flow		0		0		0		0		0		0		0		0	Drain 13/Sheyenne River flow
XS 283	8,950		18,490		26,120		34,240		45,780		55,200		66,150		82,930		**XS 283**

River	Reach	RS	HEC-RAS Flow File Input- ND East 35,000 cfs- Year 25																River	Reach	RS
			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year				
lob_rrn	overland	2.89	1	1148	1	2691	1	5658	1	8057	1	10980	1	13134	1	14577	1	17264	lob_rrn	overland	2.89
ND DIV	ND DIV EAST	190867	0	NO	660	YES	2396	YES	4936	YES	8988	YES	12163	YES	15882	YES	20157	YES	ND DIV	ND DIV EAST	190867
ND DIV	ND DIV EAST	176762	0	1148	1001	2350	5704	2350	10643	2350	17618	2350	22947	2350	28109	2350	35071	2350	ND DIV	ND DIV EAST	176762
ND DIV	ND DIV EAST	148766	144	144	1669	668	6921	1217	12555	1912	20511	2893	25840	2893	31002	2893	37964	2893	ND DIV	ND DIV EAST	148766
ND DIV	ND DIV EAST	124541	144	0	1669	0	6921	0	12555	0	20546	35	26425	585	31887	885	39064	1100	ND DIV	ND DIV EAST	124541
ND DIV	ND DIV EAST	80945	144	0	1669	0	6921	0	12573	18	20871	325	27786	1361	34121	2234	41951	2887	ND DIV	ND DIV EAST	80945
ND DIV	ND DIV EAST	71959	144	0	2057	388	7874	953	14246	1673	23405	2534	30750	2964	37280	3159	44706	2755	ND DIV	ND DIV EAST	71959
ND DIV	ND DIV EAST	57083	229	85	2185	128	8043	169	14465	219	23700	295	31115	365	37681	401	45134	428	ND DIV	ND DIV EAST	57083
ND DIV	ND DIV EAST	47124	399	170	2441	256	8381	338	14903	438	24290	590	31845	730	38483	802	45990	856	ND DIV	ND DIV EAST	47124
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Upstream_Div	488.68	3139		6160		9555		13729		19709		23757		26164		30016		RRN	Upstream_Div	488.68
RRN	Downstream_Div	478.81	3139		5500		7159		8793		10721		11594		10282		9859		RRN	Downstream_Div	478.81
RRN	Downstream_Div	477	3147		5689		7181		8611		10300		11079		10457		10936		RRN	Downstream_Div	477
RRN	Downstream_Div	476.4	3198		7112		7326		7452		7692		7892		11667		19335		RRN	Downstream_Div	476.4
RRN	Downstream_Div	470.6	3203		7257		7339		7351		7472		7622		11781		20218		RRN	Downstream_Div	470.6
RRN	Downstream_Div	470.1	4352		9607		9690		9702		9823		9974		14133		22570		RRN	Downstream_Div	470.1
RRN	Downstream_Div	326	4372		9652		9745		9762		9888		10044		14208		22665		RRN	Downstream_Div	326
RRN	Downstream_Div	311	4572		9947		10135		10177		10328		10494		14743		23240		RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	4572		9947		10135		10177		10328		10494		14743		23240		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4864		10247		10435		10477		10628		10794		15043		23540		RRN	Above_Sheyenne	303
RRN	Shey_Upstrm_Div	299	7475		13330		13703		13952		14341		14732		18821		27727		RRN	Shey_Upstrm_Div	299
RRN	Shey_Dwnstrm_Div	292	7874		15771		22084		28855		38631		46577		57304		73717		RRN	Shey_Dwnstrm_Div	292
RRN	Shey_Dwnstrm_Div	291	8950		18490		26120		34240		45780		55200		66150		82930		RRN	Shey_Dwnstrm_Div	291
RRN	Shey_Dwnstrm_Div	283	8950		18490		26120		34240		45780		55200		66150		82930		RRN	Shey_Dwnstrm_Div	283

Table B-11
Red River of the North - Fargo-Moorhead Metro Area to Perley
Initial HEC-RAS Discharges (Year 50)

Fargo-Moorhead Metro Study, Phase 3.1 Hydrology

Location/Source	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		Location/Source
Hickson Gage	2,550		5,366		8,710		12,762		18,543		22,626		24,116		28,246		Hickson Gage
Phase 3.1 Drainage Area Analysis_Fargo Gage	3,506		9,135		9,550		9,581		9,637		10,287		12,013		19,869		Phase 3.1 Drainage Area Analysis_Fargo Gage
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		XS 283
Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions	4,384		7,859		10,645		13,795		18,316		22,256		24,803		26,576		Drains 3, 49, 10, 40/45, Sheyenne River & Buffalo River Contributions
Drains 3 & 49	20	0.0054	45	0.0049	60	0.0047	65	0.0041	70	0.0034	75	0.0030	90	0.0031	110	0.0032	Drains 3 & 49
Drain 10	195	0.0403	310	0.0327	405	0.0307	420	0.0264	450	0.0226	465	0.0198	580	0.0206	625	0.0193	Drain 10
Drain 40/45, Sheyenne River & Buffalo River Contributions	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Drain 40/45, Sheyenne River & Buffalo River Contributions
Buffalo River	903	Note 1	2,413	Note 1	3,684	Note 1	5,004	Note 1	6,738	Note 1	8,190	Note 1	8,456	Note 1	8,861	Note 1	Buffalo River
Drain 40/45 -Existing Condtions	286	0.0591	461	0.0490	586	0.0448	846	0.0529	1,238	0.0611	1,596	0.0684	1,807	0.0642	1,960	0.0601	Drain 40/45 -Existing Condtions
Drain 40/45 - With Project Conditions	286		300		300		300		300		300		300		300		Drain 40/45 - With Project Conditions
Sheyenne River	2,590	Note 1	3,121	Note 1	3,297	Note 1	3,499	Note 1	3,719	Note 1	3,761	Note 1	3,784	Note 1	4,213	Note 1	Sheyenne River
Check Total for Drain 40/45, Sheyenne & Buffalo	4,169		7,504		10,180		13,310		17,796		21,716		24,133		25,841		Check Total for Drain 40/45, Sheyenne & Buffalo
Sheyenne River Flow																	Sheyenne River Flow
100% enters at Sheyenne, XS 299	2,590		3,121		3,297		3,499		3,719		3,761		3,784		4,213		100% enters at Sheyenne, XS 299
0% enters at Drain 13, XS 283	0		0		0		0		0		0		0		0		0% enters at Drain 13, XS 283

Location/Source	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	RRN	Inflow or Breakout	Location/Source
XS 415	3,506		9,135		9,550		9,581		9,637		10,287		12,013		19,869		**XS 415**
Oakport Breakout LS, XS 221		1		1		1		1		1		1		1		1	Oakport Breakout LS, XS 221
Drains 3 & 49 Flow Enters		20		45		60		65		70		75		90		110	Drains 3 & 49 Flow Enters
XS 326	3,526		9,180		9,610		9,646		9,707		10,362		12,103		19,979		**XS 326**
Drain 10 Flow Enters		195		310		405		420		450		465		580		625	Drain 10 Flow Enters
LOB_RRN breakout LS, XS 2.89		1		1		1		1		1		1		1		1	LOB_RRN breakout LS, XS 2.89
XS 311	3,721		9,490		10,015		10,066		10,157		10,827		12,683		20,604		**XS 311**
XS 303.8	3,721		9,490		10,015		10,066		10,157		10,827		12,683		20,604		**XS 303.8**
Drain 40/45		286		300		300		300		300		300		300		300	Drain 40/45
XS 303	4,007		9,790		10,315		10,366		10,457		11,127		12,983		20,904		**XS 303**
Sheyenne River flow		2,590		3,121		3,297		3,499		3,719		3,761		3,784		4,213	Sheyenne River flow
XS 299	6,597		12,911		13,612		13,865		14,176		14,888		16,767		25,117		**XS 299**
Buffalo River flow		903		2,413		3,684		5,004		6,738		8,190		8,456		8,861	Buffalo River flow
XS 291	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		**XS 291**
Drain 13/Sheyenne River flow		0		0		0		0		0		0		0		0	Drain 13/Sheyenne River flow
XS 283	7,890		17,020		24,610		32,650		44,080		53,560		63,590		80,610		**XS 283**

HEC-RAS Flow File Input- ND East 35,000 cfs- Year 50

River	Reach	RS	2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year		River	Reach	RS
lob_rrn	overland	2.89	1	957	1	2375	1	5185	1	7520	1	10367	1	12545	1	13450	1	16299	lob_rrn	overland	2.89
ND DIV	ND DIV EAST	190867	0	NO	1	YES	1580	YES	4104	YES	8110	YES	10822	YES	15674	YES	20216	YES	ND DIV	ND DIV EAST	190867
ND DIV	ND DIV EAST	176762	0	957	26	2350	4415	2350	9274	2350	16127	2350	21017	2350	26774	2350	34165	2350	ND DIV	ND DIV EAST	176762
ND DIV	ND DIV EAST	148766	135	135	796	770	5733	1318	11293	2019	19020	2893	23910	2893	29667	2893	37058	2893	ND DIV	ND DIV EAST	148766
ND DIV	ND DIV EAST	124541	135	0	796	0	5733	0	11293	0	19140	120	24585	675	30827	1160	38508	1450	ND DIV	ND DIV EAST	124541
ND DIV	ND DIV EAST	80945	135	0	796	0	5733	0	11333	40	19660	520	26371	1786	33846	3019	42289	3781	ND DIV	ND DIV EAST	80945
ND DIV	ND DIV EAST	71959	135	0	1288	492	6789	1056	13100	1767	22248	2588	29357	2986	37059	3213	45213	2924	ND DIV	ND DIV EAST	71959
ND DIV	ND DIV EAST	57083	220	85	1424	136	6964	175	13327	227	22554	306	29732	375	37495	436	45686	473	ND DIV	ND DIV EAST	57083
ND DIV	ND DIV EAST	47124	390	170	1696	272	7314	350	13781	454	23166	612	30482	750	38367	872	46632	946	ND DIV	ND DIV EAST	47124
Oakport_SI	Oakport	221	1		1		1		1		1		1		1		1		Oakport_SI	Oakport	221
RRN	Upstream_Div	488.68	2550		5366		8710		12762		18543		22626		24116		28246		RRN	Upstream_Div	488.68
RRN	Downstream_Div	478.81	2550		5365		7130		8658		10433		11804		8442		8030		RRN	Downstream_Div	478.81
RRN	Downstream_Div	477	2550		5484		7138		8478		10024		11301		8584		9020		RRN	Downstream_Div	477
RRN	Downstream_Div	476.4	2548		6357		7194		7330		7499		8197		9569		16711		RRN	Downstream_Div	476.4
RRN	Downstream_Div	470.6	2548		6443		7199		7230		7286		7935		9662		17517		RRN	Downstream_Div	470.6
RRN	Downstream_Div	470.1	3506		9135		9550		9581		9637		10287		12013		19869		RRN	Downstream_Div	470.1
RRN	Downstream_Div	326	3526		9180		9610		9646		9707		10362		12103		19979		RRN	Downstream_Div	326
RRN	Downstream_Div	311	3721		9490		10015		10066		10157		10827		12683		20604		RRN	Downstream_Div	311
RRN	Above_Sheyenne	303.8	3721		9490		10015		10066		10157		10827		12683		20604		RRN	Above_Sheyenne	303.8
RRN	Above_Sheyenne	303	4007		9790		10315		10366		10457		11127		12983		20904		RRN	Above_Sheyenne	303
RRN	Shey_Upstrm_Div	299	6597		12911		13612		13865		14176		14888		16767		25117		RRN	Shey_Upstrm_Div	299
RRN	Shey_Dwnstrm_Div	292	6987		14607		20926		27646		37342		45370		55134		71749		RRN	Shey_Dwnstrm_Div	292
RRN	Shey_Dwnstrm_Div	291	7890		17020		24610		32650		44080		53560		63590		80610		RRN	Shey_Dwnstrm_Div	291
RRN	Shey_Dwnstrm_Div	283	7890		17020		24610		32650		44080		53560		63590		80610		RRN	Shey_Dwnstrm_Div	283

Table B-12

LAYOUT OF HEC-RAS MODELING PLAN FILES

Scenario	Capacity	HEC-RAS Project Filename	HEC-RAS Plan Filename	HEC-RAS Project Description	HEC-RAS Plan Description
Year 0	Existing	RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p19	RRNandWRRND_2009Calibration_20100630	RRNMain_P3.1_Exist_HighQ_Year0_20100630
		RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p20	RRNandWRRND_2009Calibration_20100630	RRNMain_P3.1_Exist_LowQ_Year0_20100630
Year 25	Existing	RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p21	RRNandWRRND_2009Calibration_20100630	RRNMain_P3.1_Exist_HighQ_Year25_20100630
Year 50	Existing	RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p22	RRNandWRRND_2009Calibration_20100630	RRNMain_P3.1_Exist_HighQ_Year50_20100630
Year 0	Existing	RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p23	RRNandWRRND_2009Calibration_20100702	RRNMain_P3.1_Exist_1000_Year0_20100702
Year 0	Existing	RRNandWRRND_Existing.prj	RRNandWRRND_Existing.p24	RRNandWRRND_2009Calibration_20100702	RRNMain_P3.1_Exist_10000_Year0_20100702
Year 0	MN 35K	RRNandMNDivShort35kP3_1YR0.prj	RRNandMNDivShort35kP3_1YR0.p03	RRN-MNDivShort35k-P3.1-YR0-20100811	RRN-MNDivShrt35k-P3.1-HighQ-YR0-20100811
		RRNandMNDivShort35kP3_1YR0.prj	RRNandMNDivShort35kP3_1YR0.p04	RRN-MNDivShort35k-P3.1-YR0-20100811	RRN-MNDivShrt35k-P3.1-LowQ-YR0-20100702
Year 25	MN 35K	RRNandMNDivShort35kP3_1YR25.prj	RRNandMNDivShort35kP3_1YR25.p03	RRN-MNDivShort35k-P3.1-YR25-20100811	RRN-MNDivShrt35k-P3.1-HighQ-Y25-20100811
		RRNandMNDivShort35kP3_1YR25.prj	RRNandMNDivShort35kP3_1YR25.p04	RRN-MNDivShort35k-P3.1-YR25-20100811	RRN-MNDivShrt35k-P3.1-LowQ-Y25-20100702
Year 50	MN 35K	RRNandMNDivShort35kP3_1YR50.prj	RRNandMNDivShort35kP3_1YR50.p03	RRN-MNDivShort35k-P3.1-YR50-20100811	RRN-MNDivShrt35k-P3.1-HighQ-Y50-20100811
		RRNandMNDivShort35kP3_1YR50.prj	RRNandMNDivShort35kP3_1YR50.p04	RRN-MNDivShort35k-P3.1-YR50-20100811	RRN-MNDivShrt35k-P3.1-LowQ-Y50-20100702
Year 0	ND 35K	RRNandNDDivEast35kP3_1YR0.prj	RRNandNDDivEast35kP3_1YR0.p03	RRN-NDDivEast35k-P3.1-YR0-20100709	RRN-NDDivEast35k-P3.1-HighQ-YR0-20100709
		RRNandNDDivEast35kP3_1YR0.prj	RRNandNDDivEast35kP3_1YR0.p04	RRN-NDDivEast35k-P3.1-YR0-20100709	RRN-NDDivEast35k-P3.1-LowQ-YR0-20100709
Year 25	ND 35K	RRNandNDDivEast35kP3_1YR25.prj	RRNandNDDivEast35kP3_1YR25.p03	RRN-NDDivEast35k-P3.1-YR25-20100709	RRN-NDDivEast35k-P3.1-HighQYR25-20100709
		RRNandNDDivEast35kP3_1YR25.prj	RRNandNDDivEast35kP3_1YR25.p04	RRN-NDDivEast35k-P3.1-YR25-20100709	RRN-NDDivEast35k-P3.1-LowQ-YR25-20100709
Year 50	ND 35K	RRNandNDDivEast35kP3_1YR50.prj	RRNandNDDivEast35kP3_1YR50.p03	RRN-NDDivEast35k-P3.1-YR50-20100709	RRN-NDDivEast35k-P3.1-HighQYR50-20100709
		RRNandNDDivEast35kP3_1YR50.prj	RRNandNDDivEast35kP3_1YR50.p04	RRN-NDDivEast35k-P3.1-YR50-20100709	RRN-NDDivEast35k-P3.1-LowQ-YR50-20100709

Table B13

Fargo Moorhead Metro Study - Phase 3.1
Reference, Wet - Year Zero, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	10380	863.05	20140	871.03	27860	874.18	36050	875.88	47720	877.03	57070	877.85	69040	878.81	85540	879.53
280	404.98	836.6	10380	863.75	20140	871.81	27860	874.78	36050	876.6	47720	877.78	57070	878.66	69040	879.62	85540	880.37
281	406.51	834.9	10380	864.68	20140	872.74	27860	875.86	36050	877.71	47720	878.82	57070	879.66	69040	880.42	85540	881.28
282	410.21	838	10380	866.68	20140	874.62	27860	877.64	36050	879.39	47720	880.1	57070	880.81	69040	881.67	85540	882.67
283	413.23	837.6	10380	868.04	20140	876	27860	879	36050	880.5	47720	881	57070	881.76	69040	882.67	85540	883.75
284	414.98	842.7	9640	868.81	19100	876.99	26500	880.15	34300	881.42	45430	882.01	54260	882.77	66170	883.71	82530	884.82
285	415.38	841.4	9640	869	19100	877.22	26500	880.37	34300	881.61	45430	882.29	54260	883	66170	883.95	82530	885.08
286	415.84	843	9640	869.12	19100	877.29	26500	880.42	34300	881.67	45430	882.39	54260	883.15	66170	884.2	82530	885.35
287	415.90	844.1	9640	869.17	19100	877.37	26500	880.55	34300	881.87	45430	882.54	54260	883.27	66170	884.18	82530	885.41
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	9640	869.17	19100	877.36	26500	880.54	34300	881.89	45430	882.67	54260	883.47	66170	884.65	82530	885.65
290	415.93	837.5	9640	869.19	19100	877.38	26500	880.55	34300	881.9	45430	882.77	54260	883.58	66170	884.65	82530	885.69
291	417.10	840.8	9640	869.62	19100	877.88	26500	881.21	34300	882.69	45430	883.74	54260	884.6	66170	885.4	82530	886.31
292	418.18	844.4	8328	870.05	16039	878.37	22069	881.72	28491	883.21	37826	884.38	45160	885.2	56895	885.89	72930	886.86
293	419.92	844.7	8328	870.85	16039	879.19	22069	882.39	28491	883.83	37826	885.06	45160	885.67	56895	886.43	72930	887.43
294	420.32	843.8	8328	871.12	16039	879.42	22069	882.67	28491	884.16	37826	885.46	45160	886.16	56895	886.94	72930	887.88
295	421.93	845.3	8328	872.31	16039	880.5	22069	883.55	28491	884.92	37826	886.22	45160	886.93	56895	887.74	72930	888.51
296	422.69	847.4	8328	872.64	16039	880.82	22069	883.82	28491	885.15	37826	886.43	45160	887.18	56895	888.07	72930	888.84
297	423.95	849.5	8328	873.19	16039	881.43	22069	884.56	28491	886.08	37826	887.56	45160	888.33	56895	889.02	72930	889.9
298	425.51	848.7	8328	873.93	16039	882.17	22069	885.27	28491	886.79	37826	888.31	45160	889.05	56895	889.47	72930	890.41
299	426.87	851.1	8328	874.63	16039	882.84	22069	885.93	28491	887.53	37826	889.13	45160	889.67	56895	890.05	72930	890.98
300	428.06	849.6	6119	875.21	12900	883.46	17979.56	886.54	21314.4	888.12	25302.55	889.73	29304.55	890.39	37201.99	890.46	54993.26	891.52
301	428.74	850.3	6119	875.52	12900	883.81	17979.56	886.96	21314.4	888.55	25302.55	890.11	29304.55	890.81	37201.99	891.04	54993.26	891.96
302	430.23	852	6119	876.15	12900	884.41	17979.56	887.7	21314.4	889.32	25302.55	890.92	29304.55	891.71	37201.99	891.64	54993.26	892.76
303	431.94	853.5	6119	877	12900	885.24	17979.56	888.64	21640.56	890.21	29847.61	891.84	36509.41	892.75	41972.05	893.21	59204.82	893.95
303.4	432.07	853.42	5826	877.05	12476	885.32	17425.56	888.79	20743.93	890.34	28331.87	891.9	34610.68	892.83	40178.12	893.43	57406.94	894.24
303.5	432.10	853.46	5826	877.09	12476	885.36	17425.56	888.83	20577.2	890.39	27770.36	891.99	33999.95	892.94	39724.64	893.55	56999.13	894.46
303.8	432.53	854.5	5826	877.28	12476	885.54	17425.56	889.03	20180.08	890.64	26103.22	892.41	32091.27	893.39	38207.77	894.06	55472.32	895.23
304	432.84	855.5	5827	877.38	12477	885.65	17226.11	889.12	19571.74	890.72	21355.76	892.49	24669.57	893.49	26841.65	894.17	39394.39	895.4
305	433.26	854.4	5827	877.57	12477	885.85	17226.11	889.32	19564.56	890.88	22163.24	892.6	21996.86	893.59	22441.66	894.27	34116.52	895.54
306	433.35	855	5827	877.65	12477	885.95	17226.11	889.46	19562.85	891.02	22355.76	892.63	21360.11	893.61	21372.79	894.29	32772.67	895.57
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	5827	877.65	12477	885.96	17226.11	889.47	19562.85	891.04	22355.76	892.68	21360.11	893.66	21372.79	894.32	32772.67	895.63
309	433.83	854.5	5827	877.81	12477	886.15	17226.11	889.69	19562.85	891.27	22355.76	892.88	21360.11	893.8	21372.79	894.45	32772.67	895.86
310	434.61	852.8	5827	878.09	12477	886.4	17226.11	889.97	19562.85	891.54	22355.76	893.14	21360.11	893.97	21372.79	894.59	32772.67	896.08
310.5	435.70	855	5827	878.49	12477	886.79	17226.11	890.38	19562.85	892.03	22355.76	893.61	21360.11	894.33	21372.79	894.91	32772.67	896.59
311	436.34	855	5827	878.74	12477	887.07	16711.44	890.71	19538.96	892.4	21653.78	893.98	22745.29	894.64	24702.53	895.2	33679.75	896.95
312	437.05	863.83	5632	879.01	12197	887.38	16341.44	891.07	19143.96	892.79	20968.85	894.36	23932.2	895.01	11766.78	895.58	37943.85	897.32
313	437.95	856	5631	879.39	12196	887.83	16540.89	891.56	19752.3	893.35	25971.24	894.88	29726.99	895.6	35593.65	895.82	49247.68	898.23
314	438.78	857	5631	879.76	12196	888.23	16540.89	891.98	19752.3	893.84	25971.24	895.51	29726.99	896.31	35593.65	896.79	49247.68	899.21
315	439.05	856	5631	879.86	12196	888.35	16540.89	892.12	19752.3	894.02	25971.24	895.75	29726.99	896.59	35593.65	897.16	49247.68	899.41
316	439.46	855.1	5631	880.04	12196	888.59	16540.89	892.42	19752.3	894.37	23378.22	896.29	24229.16	897.25	24124.94	898.08	26991.72	900.36
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	5631	880.05	12196	888.6	16540.89	892.42	19752.3	894.37	23378.22	896.29	24229.16	897.28	24124.94	898.12	26991.72	900.4
319	439.50	857	5631	880.07	12196	888.66	16540.89	892.49	19752.3	894.44	23378.22	896.38	24229.16	897.38	24124.94	898.23	26991.72	900.45
320	439.66	856	5631	880.13	12196	888.73	16540.89	892.56	19752.3	894.51	23378.22	896.44	24229.16	897.45	24124.94	898.29	26991.72	900.49
321	440.31	858	5631	880.37	12196	889.02	16540.89	892.88	19752.3	894.86	23378.22	896.83	24229.16	897.75	24124.94	898.54	26991.72	900.68
322	440.32	858.1	5631	880.36	12196	889.01	16540.89	892.87	19752.3	894.86	23378.22	896.83	24229.16	897.75	24124.94	898.53	26991.72	900.68
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	5631	880.41	12196	889.12	16540.89	892.94	19752.3	894.91	23378.22	896.87	24229.16	897.78	24124.94	898.56	26991.72	900.7
325	440.34	857	5631	880.41	12196	889.14	16540.89	892.95	19752.3	894.92	23378.22	896.88	24229.16	897.78	24124.94	898.56	26991.72	900.7
326	440.54	858	5631	880.46	12196	889.19	16540.89	893.01	19752.3	894.99	23378.22	896.97	24229.16	897.86	24124.94	898.63	26991.72	900.74
327	441.53	859	5601	880.85	12151	889.47	16485.89	893.26	19687.3	895.26	23292.36	897.25	24208.3	898.11	24131.7	898.84	26869.85	900.86
328	442.14	858	5601	881.05	12151	889.62	16658.77	893.41	20448.98	895.42	24794.7	897.43	29256.02	898.28	33160.77	899	39396.47	900.94
329	442.45	857	5601	881.12	12151	889.64	16989.04	893.42	21904.67	895.43	28860.41	897.44	34010.02	898.31	43641.26	899.03	56214.89	900.97
329.5	442.93	858.06	5600	881.26	12150	889.75	17000	893.51	22000	895.52	29300	897.55	34700	898.37	46200	899.11	61700	901.03
330	443.69	858	5600	881.49	12150	889.95	17000	893.67	22000	895.68	29300	897.73	34700	898.58	46200	899.29	61700	901.2
331	443.99	859	5600	881.58	12150	890.06	17000	893.8	22000	895.84	29300	897.97	34700	898.7	46200	899.46	61700	901.36
332	444.33	856	5600	881.62	12150	890.1	17000	893.84	22000	895.89	29300	898.03	34700	898.74	46200	899.52	61700	901.42
333	444.92	859	5600	881.69	12150	890.14	17000	893.86	22000	895.91	29300	898.04	34700	898.71	46200	899.55	61700	901.47
334	445.18	860	5600	881.78	12150	890.22	17000	893.95	22000	896	29300	898.13	34700	898.81	46200	899.72	61700	901.63
335	445.31	860	5600	881.85	12150	890.33	17000	894.09	22000	896.21	29300	898.45	34700	899.24	46200	899.94	61700	901.81
336	445.36	859	5600	881.85	12150	890.34	17000	894.11	22000	896.23	29300	898.47	34700	899.24	46200	899.96	61700	901.83
336.5	445.76	857.69	5600	881.89	12150	890.36	17000	894.14	22000	896.26	29300	898.52	34700	899.3	46200	900.01	61700	901.89
337	446.09	860	5600	881.91	12150	890.36	17000	894.13	22000	896.25	29300	898.5	34700	899.28	46200	900	61700	901.88
338	446.29	861	5600	881.98	12150	890.39	17000	894.14	22000	896.26	29300	898.5	34700	899.28	46200	900.04	61700	901.94
338.5	446.70	860.9	5600	882.13	12150	890.53	17000	894.29	22000	896.44	29300	898.72	34700	899.53	46200	900.28	61700	902.17
339	446.76	861	5600	882.16	12150	890.55	17000	894.3	22000	896.45	29300	898.76	34700	899.59	46200	900.37	61700	902.27
340	447.04	860	5600	882.25	12150	890.66	17000	894.46	22000	896.67	29300	899.06	34700	899.97	46200	900.77	61700	902.66
341	447.24	859	5600	882.33	12150	890.72	17000	894.5	22000	896.71	29300	899.1	34700	900.05	46200	900.83	61700	902.72
342	447.42	861	5600	882.44	12150	890.8	17000	894.58	22000	896.8	29300	899.21	34700	900.19	46200	901.03	61700	902.92
342.5	447.78	856.99	5600	882.6	12150	890.95	17000	894.74	22000	897	29300	899.49	34700	900.38	46200	901.32	61700	903.24
343	448.13	861	5600	882.72	12150	891.06	17000	894.85	22000	897.13	29300	899.63	34700	900.58	46200	901.53	61700	903.48
344	448.36	859	5600	882.83	12150	891.18	17000	895.02	22000	897.36	29300	899.95	34700	900.89	46200	901.99	61700	903.93
345	448.89	865.3	5600	883.14	12150	891.39	17000	895.2	22000	897.55	29300	900.17	34700	901.15	46200	902.27	61700	904.23
348	448.90	864.3	5600	883.13	12150	891.36	17000	895.16	22000	897.5	29300	900.1	34700	901.09	46200	902.2	61700	904.2
348.4			North Dam															
348.8	448.90	864.3	5600	883.2	12150	891.42	17000	895.21	22000	897.57	29300	900.17	34700	901.14	46200	902.25	61700	904.23
351	448.91	861	5600	883.21	12150	891.42	17000	895.21	22000	897.57	29300	900.17	34700	901.14	46200	902.26	61700	904.24
351.4	449.06	861	5600	883.3	12150	891.58	17000	895.41	22000	897.81	29300	900.48	34700	901.48	46200	902.73	61700	904.67
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	5600	883.31	12150	891.71	17000	895.51	22000	897.88	29300	900.53	34700	901.56	46200	902.86	61700	904.8
352	449.09	862	5600	883.32	12150	891.73	17000	895.54	22000	897.92	29300	900.58	34700	901.59	46200	902.88	61700	904.8
353	449.28	863	5600	883.41	12150	891.83	17000	895.67	22000	898.09	29300	900.8	34700	901.83	46200	903.19	61700	905.15
353.5	449.61	860.13	5600	883.54	12150	891.91	17000	895.73	22000	898.16	29300	900.89	34700	901.95	46200	903.35	61700	905.35
354	449.97	864	5600	883.79	12150	892.17	17000	895.96	22000	898.39	29300	901.12	34700	902.18	46200	903.63	61700	905.61
355	450.19	862	5600	883.91	12150	892.27	17000	896.09	22000	898.55	29300	901.31	34700	902.38	46200	903.86	61700	905.83
356	450.84	858	5600	884.26	12150	892.5	17000	896.31	22000	898.78	29300	901.55	34700	902.63	46200	904.17	61700	906.16
357	450.86	863.4	5600	884.27	12150	892.51	17000	896.31	22000	898.79	29300	901.56	34700	902.63	46200	904.14	61700	906.11
358			BNRR Bridge															
359	450.87	863.4	5600	884.35	12150	892.59	17000	896.36	22000	898.92	29300	901.81	34700	902.96	46200	904.71	61700	906.68
361	451.20	865	5600	884.5	12150	892.71	17000	896.49	22000	899.07	29300	901.98	34700	903.18	46200	905.04	61700	907.11
361.5	451.37	865.2	5600	884.59	12150	892.78	17000	896.56	22000	899.14	29300	902.06	34700	903.28	46200	905.17	61700	907.26
362.5			1st Ave. No. Bridge															
364	451.39	865.2	5600	884.61	12150	892.8	17000	896.58	22000	899.17	29300	902.2	34700	903.59	46200	905.32	61700	907.48
366	451.41	861	5600	884.66	12150	892.85	17000	896.61	22000	899.21	29300	902.23	34700	903.6	46200	905.32	61700	907.48
367	451.57	867	5600	884.72	12150	892.98	17000	896.82	22000	899.49	29300	902.61	34700	904.01	46200	905.82	61700	907.94
368	451.61	866.8	5600	884.76	12150	893.03	17000	896.87	22000	899.55	29300	902.68	34700	904.07	46200	905.88	61700	907.99
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	5600	884.77	12150	893.04	17000	896.9	22000	899.57	29300	902.76	34700	904.16	46200	905.94	61700	908.07
371	451.65	859	5600	884.79	12150	893.03	17000	896.89	22000	899.55	29300	902.73	34700	904.12	46200	905.89	61700	908.02
372	451.67	867.9	5600	884.78	12150	893.02	17000	896.88	22000	899.55	29300	902.73	34700	904.12	46200	905.86	61700	907.97
373			BNRR Bridge															
374	451.68	867.9	5600	884.89	12150	893.12	17000	896.95	22000	899.61	29300	902.83	34700	904.17	46200	906.16	61700	908.28
375	451.69	864	5600	884.9	12150	893.12	17000	896.94	22000	899.59	29300	902.81	34700	904.16	46200	906.19	61700	908.42
376	451.71	865.9	5600	884.91	12150	893.15	17000	897.01	22000	899.7	29300	902.98	34700	904.37	46200	906.44	61700	908.63
377			Main Ave. Bridge															
378	451.72	865.9	5600	884.93	12150	893.16	17000	897.03	22000	899.74	29300	903.02	34700	904.43	46200	906.53	61700	908.74
379	451.73	864	5600	885.01	12150	893.26	17000	897.12	22000	899.82	29300	903.11	34700	904.49	46200	906.57	61700	908.75
380	451.85	864	5600	885	12150	893.23	17000	897.09	22000	899.79	29300	903.08	34700	904.53	46200	906.62	61700	908.82
381	452.03	863	5600	885.12	12150	893.4	17000	897.28	22000	900	29300	903.3	34700	904.66	46200	906.75	61700	908.94
381.5	452.04	863	5600	885.13	12150	893.42	17000	897.29	22000	900.01	29300	903.32	34700	904.67	46200	906.76	61700	908.95
384			Midtown Dam															
385.5	452.05	867	5600	885.15	12150	893.43	17000	897.3	22000	900.02	29300	903.33	34700	904.68	46200	906.77	61700	908.96
386	452.06	867	5600	885.15	12150	893.43	17000	897.3	22000	900.03	29300	903.34	34700	904.69	46200	906.78	61700	908.96
387	452.25	867	5600	885.26	12150	893.49	17000	897.36	22000	900.09	29300	903.39	34700	904.76	46200	906.86	61700	909.06
388	452.46	869	5600	885.43	12150	893.59	17000	897.46	22000	900.21	29300	903.54	34700	904.88	46200	906.99	61700	909.19
389	452.70	866.08	5600	885.65	12150	893.76	17000	897.63	22000	900.39	29300	903.74	34700	905.1	46200	907.21	61700	909.4
390	452.94	867	5600	885.77	12150	893.85	17000	897.71	22000	900.48	29300	903.84	34700	905.21	46200	907.33	61700	909.53
391	453.16	867	5600	885.9	12150	893.96	17000	897.83	22000	900.61	29300	903.98	34700	905.38	46200	907.51	61700	909.7
392	453.39	865	5600	886	12150	894.05	17000	897.94	22000	900.74	29300	904.15	34700	905.54	46200	907.66	61700	909.84
393	454.02	866	5600	886.34	12150	894.28	17000	898.13	22000	900.92	29300	904.32	34700	905.71	46200	907.83	61700	910.01
394	454.10	865	5600	886.38	12150	894.32	17000	898.16	22000	900.95	29300	904.34	34700	905.73	46200	907.86	61700	910.04
395	454.75	864	5600	886.66	12150	894.54	17000	898.38	22000	901.18	29300	904.56	34700	905.94	46200	908.07	61700	910.25
396	455.16	866	5600	886.86	12150	894.75	17000	898.58	22000	901.37	29300	904.71	34700	906.09	46200	908.21	61700	910.38
397	455.20	866.6	5600	886.9	12150	894.78	17000	898.61	22000	901.41	29300	904.75	34700	906.1	46200	908.21	61700	910.36
399			I-94 Bridge															
401	455.23	866.6	5600	886.9	12150	894.78	17000	898.61	22000	901.41	29300	904.75	34700	906.1	46200	908.25	61700	910.43
402	455.28	865	5600	886.93	12150	894.8	17000	898.64	22000	901.43	29300	904.77	34700	906.17	46200	908.38	61700	910.64
402.5	455.52	864.58	5600	887.05	12150	894.92	17000	898.75	22000	901.55	29300	904.91	34700	906.32	46200	908.52	61700	910.77
403	455.59	866	5600	887.08	12150	894.96	17000	898.78	22000	901.58	29300	904.98	34700	906.37	46200	908.56	61700	910.8
404	455.92	865	5600	887.22	12150	895.09	17000	898.93	22000	901.77	29300	905.15	34700	906.49	46200	908.65	61700	910.87
405	456.65	865	5600	887.57	12150	895.33	17000	899.14	22000	901.97	29300	905.3	34700	906.64	46200	908.79	61700	911.01
406	457.09	866	5600	887.79	12150	895.52	17000	899.33	22000	902.17	29300	905.51	34700	906.83	46200	908.96	61700	911.17

Table B13

Fargo Moorhead Metro Study - Phase 3.1
Reference, Wet - Year Zero, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	5600	887.86	12150	895.58	17000	899.38	22000	902.21	29300	905.54	34700	906.86	46200	908.99	61700	911.21
408	457.80	864	5600	888.07	12150	895.83	17000	899.65	22000	902.51	29300	905.88	34700	907.16	46200	909.27	61700	911.46
409	457.95	855.9	5600	888.14	12150	895.93	17000	899.75	22000	902.61	29300	905.96	34700	907.24	46200	909.33	61700	911.51
409.1	457.97	855.9	5600	888.14	12150	895.93	17000	899.75	22000	902.61	29300	905.96	34700	907.25	46200	909.34	61700	911.51
409.5			South Dam															
409.6	457.98	855.9	5600	888.19	12150	895.96	17000	899.78	22000	902.64	29300	905.97	34700	907.26	46200	909.35	61700	911.52
409.7	457.99	855.9	5600	888.19	12150	895.97	17000	899.78	22000	902.65	29300	906	34700	907.26	46200	909.36	61700	911.53
413	458.32	869	5600	888.2	12150	896	17000	899.82	22000	902.69	29300	906.07	34700	907.34	46200	909.45	61700	911.63
414	458.75	866	5600	888.47	12150	896.28	17000	900.13	22000	903.04	29300	906.31	34700	907.58	46200	909.65	61700	911.81
459.64	459.64	864.81	5600	888.9	12150	896.68	17000	900.49	22000	903.39	29300	906.61	34700	907.87	46200	909.92	61700	912.07
460.28	460.28	868.74	5600	889.28	12150	897.01	17000	900.8	22000	903.69	29300	906.87	34700	908.12	46200	910.13	61700	912.25
460.72	460.72	869.04	5600	889.58	12150	897.28	17000	901.08	22000	904	29300	907.19	34700	908.33	46200	910.31	61700	912.42
461.3	461.3	868.04	5600	889.99	12150	897.66	17000	901.49	22000	904.43	29300	907.6	34700	908.63	46200	910.55	61700	912.62
462.03	462.03	864.16	5600	890.38	12150	898.06	17000	901.86	22000	904.8	29300	907.98	34700	908.93	46200	910.8	61700	912.81
462.04	462.04	869.5	5600	890.42	12150	898.09	17000	901.88	22000	904.85	29300	908.01	34700	908.95	46200	910.81	61700	912.82
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	5600	890.42	12150	898.1	17000	901.9	22000	904.93	29300	908.15	34700	909.13	46200	910.98	61700	912.95
462.07	462.07	871.5	5600	890.46	12150	898.13	17000	901.94	22000	904.92	29300	908.13	34700	909.13	46200	910.98	61700	912.95
462.7	462.7	862.82	5600	890.81	12150	898.45	17000	902.24	22000	905.23	29300	908.47	34700	909.41	46200	911.23	61700	913.17
463.7	463.7	864.71	5600	891.18	12150	898.88	17000	902.69	22000	905.67	29300	908.9	34700	909.8	46200	911.58	61700	913.49
464.2	464.2	869.2	5600	891.44	12150	899.17	17000	903.01	22000	906.01	29300	909.25	34700	910.08	46200	911.78	61700	913.65
464.6	464.6	865	5600	891.64	12150	899.37	17000	903.18	22000	906.17	29300	909.4	34700	910.2	46200	911.9	61700	913.76
465.1	465.1	862.9	5600	891.84	12150	899.63	17000	903.51	22000	906.56	29300	909.72	34700	910.42	46200	912.08	61700	913.92
465.9	465.9	865.6	5600	892.14	12150	900	17000	903.89	22000	906.93	29300	910	34700	910.6	46200	912.22	61700	914.04
466.5	466.5	864.9	5600	892.39	12150	900.29	17000	904.19	22000	907.23	29300	910.29	34700	910.82	46200	912.4	61700	914.2
467.4	467.4	864.8	5600	892.77	12150	900.72	17000	904.66	22000	907.71	29300	910.68	34700	911.1	46200	912.65	61700	914.42
468.2	468.2	862.6	5600	893.04	12150	901.01	17000	904.96	22000	907.96	29300	910.87	34700	911.26	46200	912.8	61700	914.56
468.9	468.9	861	5600	893.29	12150	901.31	17000	905.27	22000	908.19	29300	911.03	34700	911.4	46200	912.94	61700	914.69
469.7	469.7	870	5600	893.66	12150	901.71	17000	905.59	22000	908.39	29300	911.14	34700	911.53	46200	913.06	61700	914.81
470.1	470.1	870.9	5600	893.84	12150	901.9	17000	905.78	22000	908.55	29300	911.25	34700	911.62	46200	913.14	61700	914.88
470.6	470.6	869.4	4166	894.02	8952	902.09	10791	905.97	13453	908.76	17872	911.4	21196	911.81	30252	913.35	42385	915.1
471.4	471.4	867.5	4166	894.27	8952	902.36	10791	906.17	13453	908.92	17872	911.5	21196	911.93	30252	913.49	42385	915.25
472.18	472.18	869.9	4166	894.53	8952	902.64	10791	906.37	13453	909.09	17872	911.63	21196	912.09	30252	913.67	42385	915.45
472.2	472.2	870.8	4166	894.53	8952	902.63	10791	906.36	13453	909.08	17872	911.61	21196	912.06	30252	913.63	42385	915.41
472.22	472.22	870.8	4166	894.54	8952	902.65	10791	906.38	13453	909.12	17872	911.68	21196	912.15	30252	913.75	42385	915.54
473	473	871.8	4166	894.79	8952	902.88	10791	906.54	13453	909.25	17872	911.79	21196	912.29	30252	913.91	42385	915.71
473.8	473.8	869	4166	895.06	8952	903.18	10791	906.77	13453	909.47	17872	911.99	21196	912.52	30252	914.18	42385	916.01
474.08	474.08	873.5	4166	895.17	8952	903.29	10791	906.86	13453	909.55	17872	912.08	21196	912.61	30252	914.27	42385	916.1
474.09	474.09	873.5	4166	895.18	8952	903.32	10791	906.89	13453	909.58	17872	912.11	21196	912.66	30252	914.34	42385	916.13
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	4166	895.18	8952	903.32	10791	906.89	13453	909.58	17872	912.13	21196	912.68	30252	914.37	42385	916.35
474.12	474.12	874	4166	895.19	8952	903.33	10791	906.89	13453	909.59	17872	912.16	21196	912.71	30252	914.38	42385	916.37
474.6	474.6	873.4	4166	895.39	8952	903.49	10791	907.02	13453	909.72	17872	912.29	21196	912.87	30252	914.56	42385	916.53
475.3	475.3	872.2	4166	895.66	8952	903.78	10791	907.26	13453	909.97	17872	912.57	21196	913.21	30252	914.91	42385	916.84
475.7	475.7	871	4166	895.8	8952	903.95	10791	907.42	13453	910.16	17872	912.81	21196	913.45	30252	915.19	42385	916.98
476.4	476.4	873.7	4166	896.07	8952	904.2	10791	907.62	13453	910.34	17872	912.97	21196	913.64	30252	915.37	42385	917.14
477	477	874	4021	896.34	7227	904.45	10537	907.85	14618	910.57	20566	913.2	24472	913.91	28720	915.6	33177	917.36
477.6	477.6	870.2	4000	896.53	7000	904.61	10500	908.06	14800	910.85	21000	913.55	25000	914.31	28500	915.92	32000	917.5
478	478	873.4	4000	896.67	7000	904.71	10500	908.18	14800	911	21000	913.72	25000	914.51	28500	916.09	32000	917.56
478.8	478.8	874.8	4000	896.91	7000	904.9	10500	908.42	14800	911.31	21000	914.1	25000	914.94	28500	916.41	32000	917.7
479.2	479.2	875.7	4000	897.02	7000	904.99	10500	908.53	14800	911.44	21000	914.25	25000	915.1	28500	916.49	32000	917.78
479.7	479.7	871.5	4000	897.2	7000	905.1	10500	908.67	14800	911.61	21000	914.44	25000	915.33	28500	916.7	32000	917.89
480.5	480.5	874.7	4000	897.48	7000	905.3	10500	908.93	14800	911.9	21000	914.76	25000	915.67	28500	916.99	32000	918.14
481.8	481.8	875.3	4000	897.88	7000	905.64	10500	909.33	14800	912.35	21000	915.28	25000	916.22	28500	917.47	32000	918.48
482.3	482.3	874.2	4000	898.09	7000	905.82	10500	909.57	14800	912.62	21000	915.56	25000	916.5	28500	917.66	32000	918.62
482.698	482.698	869.74	4000	898.2	7000	905.92	10500	909.68	14800	912.75	21000	915.72	25000	916.71	28500	917.84	32000	918.75
482.7	482.7	887.04	4000	898.1	7000	905.86	10500	909.62	14800	912.68	21000	915.67	25000	916.67	28500	917.83	32000	918.75
482.702	482.702	878.54	4000	898.23	7000	905.93	10500	909.69	14800	912.75	21000	915.72	25000	916.71	28500	917.84	32000	918.75
483.1	483.1	879.2	4000	898.47	7000	906.12	10500	909.93	14800	913.04	21000	916.04	25000	917.02	28500	918.05	32000	918.87
483.9	483.9	873	4000	898.87	7000	906.39	10500	910.26	14800	913.45	21000	916.47	25000	917.5	28500	918.47	32000	919.25
485.08	485.08	880.5	4000	899.37	7000	906.62	10500	910.48	14800	913.69	21000	916.74	25000	917.8	28500	918.78	32000	919.55
485.09	485.09	880.5	4000	899.38	7000	906.61	10500	910.48	14800	913.69	21000	916.74	25000	917.8	28500	918.77	32000	919.55
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	4000	899.38	7000	906.63	10500	910.56	14800	913.77	21000	916.79	25000	917.84	28500	918.81	32000	919.58
485.12	485.12	879.4	4000	899.39	7000	906.66	10500	910.56	14800	913.77	21000	916.79	25000	917.85	28500	918.82	32000	919.59
485.6	485.6	878.62	4000	899.58	7000	906.77	10500	910.65	14800	913.85	21000	916.88	25000	917.94	28500	918.92	32000	919.69
485.9	485.9	879.5	4000	899.74	7000	906.88	10500	910.77	14800	913.99	21000	917.05	25000	918.15	28500	919.15	32000	919.91
486.3	486.3	872.1	4000	899.9	7000	907	10500	910.91	14800	914.15	21000	917.25	25000	918.39	28500	919.42	32000	920.2
487	487	871.3	4000	900.12	7000	907.18	10500	911.13	14800	914.44	21000	917.66	25000	918.9	28500	919.99	32000	920.83
487.5	487.5	878.8	4000	900.35	7000	907.36	10500	911.33	14800	914.66	21000	917.91	25000	919.19	28500	920.31	32000	921.14
488.68	488.68	878.24	4000	901.04	7000	907.87	10500	911.93	14800	915.39	21000	918.75	25000	920.14	28500	921.33	32000	922.26

Table B14

Fargo Moorhead Metro Study - Phase 3.1
Reference, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	8950	861.67	18490	870.2	26122.73	873.73	34240	875.7	45780	876.86	55200	877.69	66150	878.58	82929.99	879.41
280	404.98	836.6	8950	862.33	18490	870.94	26122.73	874.31	34240	876.38	45780	877.66	55200	878.49	66150	879.38	82929.99	880.24
281	406.51	834.9	8950	863.21	18490	871.84	26122.73	875.33	34240	877.45	45780	878.67	55200	879.48	66150	880.19	82929.99	881.14
282	410.21	838	8950	865.13	18490	873.73	26122.73	877.12	34240	879.09	45780	879.9	55200	880.64	66150	881.44	82929.99	882.51
283	413.23	837.6	8950	866.44	18490	875.11	26122.73	878.49	34240	880.2	45780	881.15	55200	881.59	66150	882.44	82929.99	883.58
284	414.98	842.7	8200	867.17	17400	876.04	24702.73	879.62	32440	881.11	43410	882.04	52310	882.6	62960	883.47	79529.99	884.65
285	415.38	841.4	8200	867.35	17400	876.26	24702.73	879.85	32440	881.31	43410	882.29	52310	882.83	62960	883.72	79529.99	884.9
286	415.84	843	8200	867.48	17400	876.34	24702.73	879.9	32440	881.35	43410	882.38	52310	882.97	62960	883.87	79529.99	885.17
287	415.90	844.1	8200	867.53	17400	876.41	24702.73	880.01	32440	881.55	43410	882.52	52310	883.1	62960	883.98	79529.99	885.23
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	8200	867.53	17400	876.4	24702.73	880	32440	881.57	43410	882.63	52310	883.29	62960	884.42	79529.99	885.46
290	415.93	837.5	8200	867.55	17400	876.42	24702.73	880.02	32440	881.58	43410	882.72	52310	883.39	62960	884.42	79529.99	885.5
291	417.10	840.8	8200	867.97	17400	876.89	24702.73	880.6	32440	882.37	43410	883.63	52310	884.41	62960	885.17	79529.99	886.13
292	418.18	844.4	7124	868.37	14681	877.36	20666.73	881.13	27055	882.89	36261	884.24	43687	885.01	54114	885.66	70316.99	886.67
293	419.92	844.7	7124	869.15	14681	878.16	20666.73	881.86	27055	883.52	36261	884.9	43687	885.49	54114	886.2	70316.99	887.26
294	420.32	843.8	7124	869.42	14681	878.39	20666.73	882.14	27055	883.85	36261	885.3	43687	885.98	54114	886.7	70316.99	887.74
295	421.93	845.3	7124	870.63	14681	879.47	20666.73	883.09	27055	884.63	36261	886.04	43687	886.75	54114	887.57	70316.99	888.36
296	422.69	847.4	7124	870.95	14681	879.8	20666.73	883.37	27055	884.87	36261	886.25	43687	886.97	54114	887.88	70316.99	888.68
297	423.95	849.5	7124	871.49	14681	880.39	20666.73	884.07	27055	885.78	36261	887.36	43687	888.24	54114	888.83	70316.99	889.75
298	425.51	848.7	7124	872.22	14681	881.11	20666.73	884.78	27055	886.48	36261	888.09	43687	889.03	54114	889.27	70316.99	890.25
299	426.87	851.1	7124	872.92	14681	881.76	20666.73	885.43	27055	887.2	36261	888.9	43687	889.62	54114	890.07	70316.99	890.83
300	428.06	849.6	4865	873.48	11392	882.37	16407.73	886.03	20438.81	887.79	24558.68	889.5	26882.98	890.28	36722.73	890.44	51625.63	891.35
301	428.74	850.3	4865	873.76	11392	882.7	16407.73	886.42	20438.81	888.22	24558.68	889.87	26882.98	890.65	36722.73	891.01	51625.63	891.77
302	430.23	852	4865	874.35	11392	883.25	16407.73	887.06	20438.81	888.97	24558.68	890.68	26882.98	891.45	36722.73	891.6	51625.63	892.52
303	431.94	853.5	4865	875.15	11392	884.03	16407.73	887.9	20727.7	889.87	27375.36	891.57	32307.96	892.36	41268.12	893.15	58100.14	893.7
303.4	432.07	853.42	4573	875.2	10949	884.11	15842.74	888.01	19758.38	890.01	26029.58	891.62	30435.12	892.43	39095.07	893.38	55742.19	894.04
303.5	432.10	853.46	4573	875.23	10949	884.14	15842.74	888.05	19522.3	890.06	25786.9	891.7	29928.15	892.52	38244.53	893.5	54815.82	894.26
303.8	432.53	854.5	4573	875.4	10949	884.32	15842.74	888.23	19208.64	890.28	25045.02	892.1	28476.34	892.93	35389.43	893.97	51771.56	895.02
304	432.84	855.5	4574	875.49	10950	884.43	15745.36	888.33	18862.04	890.36	22093.19	892.19	21781.94	893.02	25470.43	894.07	36586.48	895.18
305	433.26	854.4	4574	875.66	10950	884.62	15745.36	888.53	18862.04	890.53	19942.84	892.28	21701.19	893.11	23798.73	894.16	31982.32	895.31
306	433.35	855	4574	875.73	10950	884.71	15745.36	888.64	18862.04	890.67	19430.39	892.4	21681.94	893.14	23403.76	894.19	30886.33	895.33
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	4574	875.74	10950	884.72	15745.36	888.66	18862.04	890.68	19430.39	892.42	21681.94	893.18	23403.76	894.23	30886.33	895.39
309	433.83	854.5	4574	875.89	10950	884.88	15745.36	888.86	18862.04	890.9	19430.39	892.62	21681.94	893.35	23403.76	894.39	30886.33	895.6
310	434.61	852.8	4574	876.14	10950	885.13	15745.36	889.12	18862.04	891.18	19430.39	892.83	21681.94	893.55	23403.76	894.56	30886.33	895.82
310.5	435.70	855	4574	876.51	10950	885.51	15745.36	889.51	18862.04	891.6	19430.39	893.21	21681.94	893.95	23403.76	894.94	30886.33	896.3
311	436.34	855	4574	876.73	10950	885.77	15629.2	889.82	18451.33	891.97	21764.75	893.52	22058.02	894.28	25780.14	895.28	32507.69	896.64
312	437.05	863.83	4374	876.98	10655	886.05	15239.2	890.15	18036.33	892.35	21474	893.92	28199.87	894.68	26820.77	895.73	47117.78	897.05
313	437.95	856	4373	877.32	10654	886.48	15336.58	890.64	18382.93	892.89	24276.58	894.49	28302.42	895.46	35164.14	896.38	47117.78	898.33
314	438.78	857	4373	877.66	10654	886.85	15336.58	891.05	18382.93	893.32	24276.58	895.09	28302.42	896.13	35164.14	897.24	47117.78	899.21
315	439.05	856	4373	877.75	10654	886.96	15336.58	891.18	18382.93	893.47	24276.58	895.31	28302.42	896.39	35164.14	897.55	47117.78	899.39
316	439.46	855.1	4373	877.91	10654	887.18	15336.58	891.47	18382.93	893.8	22681.07	895.8	23600.97	897	23276.18	898.41	25520.56	900.26
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	4373	877.92	10654	887.19	15336.58	891.47	18382.93	893.79	22681.07	895.79	23600.97	897.01	23276.18	898.46	25520.56	900.3
319	439.50	857	4373	877.93	10654	887.25	15336.58	891.54	18382.93	893.86	22681.07	895.87	23600.97	897.11	23276.18	898.55	25520.56	900.34
320	439.66	856	4373	877.99	10654	887.31	15336.58	891.6	18382.93	893.93	22681.07	895.94	23600.97	897.18	23276.18	898.61	25520.56	900.39
321	440.31	858	4373	878.21	10654	887.58	15336.58	891.91	18382.93	894.26	22681.07	896.33	23600.97	897.48	23276.18	898.82	25520.56	900.56
322	440.32	858.1	4373	878.21	10654	887.58	15336.58	891.91	18382.93	894.25	22681.07	896.33	23600.97	897.48	23276.18	898.82	25520.56	900.56
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	4373	878.22	10654	887.69	15336.58	891.98	18382.93	894.31	22681.07	896.37	23600.97	897.51	23276.18	898.84	25520.56	900.58
325	440.34	857	4373	878.23	10654	887.7	15336.58	891.99	18382.93	894.31	22681.07	896.38	23600.97	897.52	23276.18	898.84	25520.56	900.58
326	440.54	858	4373	878.28	10654	887.76	15336.58	892.05	18382.93	894.38	22681.07	896.46	23600.97	897.59	23276.18	898.9	25520.56	900.61
327	441.53	859	4353	878.66	10609	888.04	15281.58	892.31	18322.93	894.63	22627.84	896.76	23579.8	897.85	23269.71	899.09	25685.54	900.73
328	442.14	858	4353	878.86	10609	888.2	15314.36	892.46	19086.22	894.78	24866.78	896.94	28342.62	898.02	31218.69	899.22	40608.48	900.8
329	442.45	857	4353	878.94	10609	888.22	15390.92	892.47	20285.08	894.79	27224.61	896.95	32378.56	898.05	40232.64	899.26	53648.67	900.83
329.5	442.93	858.06	4352	879.08	10608	888.34	15394	892.56	20345	894.89	27441	897.06	32921	898.1	42242	899.32	57641	900.89
330	443.69	858	4352	879.32	10608	888.53	15394	892.72	20345	895.05	27441	897.23	32921	898.29	42242	899.46	57641	901.05
331	443.99	859	4352	879.4	10608	888.64	15394	892.84	20345	895.2	27441	897.47	32921	898.58	42242	899.59	57641	901.2
332	444.33	856	4352	879.45	10608	888.68	15394	892.88	20345	895.25	27441	897.53	32921	898.62	42242	899.64	57641	901.25
333	444.92	859	4352	879.53	10608	888.72	15394	892.91	20345	895.27	27441	897.53	32921	898.59	42242	899.66	57641	901.29
334	445.18	860	4352	879.62	10608	888.8	15394	892.99	20345	895.35	27441	897.63	32921	898.68	42242	899.8	57641	901.44
335	445.31	860	4352	879.67	10608	888.89	15394	893.12	20345	895.55	27441	897.93	32921	899.08	42242	899.98	57641	901.61
336	445.36	859	4352	879.68	10608	888.9	15394	893.13	20345	895.56	27441	897.95	32921	899.08	42242	899.99	57641	901.63
336.5	445.76	857.69	4352	879.71	10608	888.93	15394	893.16	20345	895.59	27441	897.99	32921	899.13	42242	900.04	57641	901.68
337	446.09	860	4352	879.75	10608	888.93	15394	893.15	20345	895.58	27441	897.98	32921	899.11	42242	900.03	57641	901.67
338	446.29	861	4352	879.82	10608	888.96	15394	893.17	20345	895.6	27441	897.98	32921	899.12	42242	900.06	57641	901.73
338.5	446.70	860.9	4352	879.97	10608	889.1	15394	893.31	20345	895.76	27441	898.2	32921	899.35	42242	900.26	57641	901.94
339	446.76	861	4352	879.99	10608	889.12	15394	893.33	20345	895.78	27441	898.22	32921	899.41	42242	900.33	57641	902.04
340	447.04	860	4352	880.08	10608	889.22	15394	893.46	20345	895.97	27441	898.5	32921	899.76	42242	900.67	57641	902.4
341	447.24	859	4352	880.16	10608	889.28	15394	893.51	20345	896.01	27441	898.54	32921	899.79	42242	900.72	57641	902.46
342	447.42	861	4352	880.28	10608	889.37	15394	893.59	20345	896.1	27441	898.64	32921	899.92	42242	900.89	57641	902.65
342.5	447.78	856.99	4352	880.43	10608	889.51	15394	893.74	20345	896.29	27441	898.9	32921	900.24	42242	901.14	57641	902.95
343	448.13	861	4352	880.56	10608	889.62	15394	893.85	20345	896.41	27441	899.04	32921	900.4	42242	901.33	57641	903.17
344	448.36	859	4352	880.66	10608	889.73	15394	894	20345	896.62	27441	899.33	32921	900.77	42242	901.73	57641	903.6
345	448.89	865.3	4352	881.01	10608	889.95	15394	894.18	20345	896.81	27441	899.55	32921	901.01	42242	901.98	57641	903.89
348	448.90	864.3	4352	881	10608	889.93	15394	894.15	20345	896.76	27441	899.49	32921	900.93	42242	901.92	57641	903.85
348.4			North Dam															
348.8	448.90	864.3	4352	881.07	10608	889.99	15394	894.2	20345	896.83	27441	899.56	32921	901.02	42242	901.97	57641	903.88
351	448.91	861	4352	881.09	10608	889.99	15394	894.2	20345	896.84	27441	899.56	32921	901.02	42242	901.97	57641	903.89
351.4	449.06	861	4352	881.17	10608	890.13	15394	894.38	20345	897.06	27441	899.86	32921	901.34	42242	902.4	57641	904.31
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	4352	881.18	10608	890.23	15394	894.49	20345	897.14	27441	899.89	32921	901.4	42242	902.51	57641	904.45
352	449.09	862	4352	881.19	10608	890.25	15394	894.52	20345	897.18	27441	899.94	32921	901.44	42242	902.53	57641	904.45
353	449.28	863	4352	881.27	10608	890.35	15394	894.64	20345	897.33	27441	900.15	32921	901.66	42242	902.82	57641	904.78
353.5	449.61	860.13	4352	881.41	10608	890.44	15394	894.7	20345	897.4	27441	900.23	32921	901.77	42242	902.96	57641	904.97
354	449.97	864	4352	881.65	10608	890.67	15394	894.94	20345	897.63	27441	900.47	32921	901.99	42242	903.22	57641	905.22
355	450.19	862	4352	881.79	10608	890.77	15394	895.06	20345	897.79	27441	900.65	32921	902.17	42242	903.44	57641	905.45
356	450.84	858	4352	882.17	10608	891.02	15394	895.27	20345	898.02	27441	900.89	32921	902.41	42242	903.73	57641	905.76
357	450.86	863.4	4352	882.18	10608	891.02	15394	895.28	20345	898.02	27441	900.9	32921	902.42	42242	903.71	57641	905.71
358			BNRR Bridge															
359	450.87	863.4	4352	882.25	10608	891.12	15394	895.33	20345	898.13	27441	901.1	32921	902.71	42242	904.19	57641	906.35
361	451.20	865	4352	882.4	10608	891.24	15394	895.45	20345	898.27	27441	901.27	32921	902.9	42242	904.48	57641	906.76
361.5	451.37	865.2	4352	882.5	10608	891.31	15394	895.52	20345	898.34	27441	901.35	32921	903.01	42242	904.6	57641	906.89
362.5			1st Ave. No. Bridge															
364	451.39	865.2	4352	882.52	10608	891.33	15394	895.53	20345	898.37	27441	901.46	32921	903.17	42242	904.72	57641	907.1
366	451.41	861	4352	882.56	10608	891.38	15394	895.58	20345	898.41	27441	901.49	32921	903.2	42242	904.72	57641	907.1
367	451.57	867	4352	882.62	10608	891.49	15394	895.75	20345	898.66	27441	901.85	32921	903.64	42242	905.2	57641	907.56
368	451.61	866.8	4352	882.67	10608	891.54	15394	895.8	20345	898.72	27441	901.91	32921	903.71	42242	905.27	57641	907.61
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	4352	882.68	10608	891.55	15394	895.81	20345	898.73	27441	901.98	32921	903.82	42242	905.34	57641	907.67
371	451.65	859	4352	882.71	10608	891.55	15394	895.8	20345	898.71	27441	901.95	32921	903.79	42242	905.3	57641	907.63
372	451.67	867.9	4352	882.69	10608	891.54	15394	895.79	20345	898.71	27441	901.95	32921	903.79	42242	905.28	57641	907.59
373			BNRR Bridge															
374	451.68	867.9	4352	882.8	10608	891.64	15394	895.87	20345	898.77	27441	902.01	32921	903.86	42242	905.54	57641	907.87
375	451.69	864	4352	882.82	10608	891.64	15394	895.86	20345	898.76	27441	901.99	32921	903.83	42242	905.54	57641	907.99
376	451.71	865.9	4352	882.82	10608	891.66	15394	895.92	20345	898.86	27441	902.14	32921	904.06	42242	905.8	57641	908.2
377			Main Ave. Bridge															
378	451.72	865.9	4352	882.84	10608	891.67	15394	895.94	20345	898.89	27441	902.2	32921	904.11	42242	905.87	57641	908.3
379	451.73	864	4352	882.92	10608	891.77	15394	896.03	20345	898.98	27441	902.29	32921	904.18	42242	905.92	57641	908.32
380	451.85	864	4352	882.91	10608	891.74	15394	896	20345	898.95	27441	902.27	32921	904.21	42242	905.97	57641	908.39
381	452.03	863	4352	883.02	10608	891.9	15394	896.18	20345	899.15	27441	902.48	32921	904.34	42242	906.1	57641	908.5
381.5	452.04	863	4352	883.03	10608	891.91	15394	896.2	20345	899.16	27441	902.5	32921	904.35	42242	906.11	57641	908.51
384			Midtown Dam															
385.5	452.05	867	4352	883.07	10608	891.92	15394	896.2	20345	899.17	27441	902.51	32921	904.36	42242	906.12	57641	908.52
386	452.06	867	4352	883.08	10608	891.92	15394	896.21	20345	899.18	27441	902.52	32921	904.37	42242	906.13	57641	908.53
387	452.25	867	4352	883.2	10608	891.99	15394	896.26	20345	899.23	27441	902.57	32921	904.43	42242	906.21	57641	908.62
388	452.46	869	4352	883.39	10608	892.09	15394	896.36	20345	899.35	27441	902.72	32921	904.55	42242	906.33	57641	908.75
389	452.70	866.08	4352	883.64	10608	892.26	15394	896.52	20345	899.52	27441	902.91	32921	904.75	42242	906.55	57641	908.95
390	452.94	867	4352	883.77	10608	892.35	15394	896.61	20345	899.61	27441	903.01	32921	904.86	42242	906.67	57641	909.08
391	453.16	867	4352	883.89	10608	892.46	15394	896.72	20345	899.74	27441	903.15	32921	905.04	42242	906.85	57641	909.25
392	453.39	865	4352	884.01	10608	892.55	15394	896.82	20345	899.87	27441	903.31	32921	905.2	42242	907	57641	909.38
393	454.02	866	4352	884.36	10608	892.8	15394	897.02	20345	900.05	27441	903.49	32921	905.37	42242	907.18	57641	909.56
394	454.10	865	4352	884.39	10608	892.84	15394	897.06	20345	900.08	27441	903.51	32921	905.38	42242	907.2	57641	909.58
395	454.75	864	4352	884.68	10608	893.07	15394	897.27	20345	900.31	27441	903.73	32921	905.6	42242	907.42	57641	909.79
396	455.16	866	4352	884.87	10608	893.28	15394	897.47	20345	900.51	27441	903.89	32921	905.75	42242	907.55	57641	909.92
397	455.20	866.6	4352	884.91	10608	893.31	15394	897.5	20345	900.54	27441	903.93	32921	905.76	42242	907.56	57641	909.9
399			I-94 Bridge															
401	455.23	866.6	4352	884.92	10608	893.32	15394	897.5	20345	900.54	27441	903.93	32921	905.76	42242	907.59	57641	909.96
402	455.28	865	4352	884.95	10608	893.33	15394	897.52	20345	900.57	27441	903.95	32921	905.8	42242	907.71	57641	910.16
402.5	455.52	864.58	4352	885.06	10608	893.46	15394	897.64	20345	900.68	27441	904.09	32921	905.94	42242	907.86	57641	910.29
403	455.59	866	4352	885.09	10608	893.5	15394	897.68	20345	900.71	27441	904.16	32921	906.05	42242	907.9	57641	910.32
404	455.92	865	4352	885.23	10608	893.62	15394	897.81	20345	900.89	27441	904.34	32921	906.16	42242	907.99	57641	910.4
405	456.65	865	4352	885.6	10608	893.88	15394	898.02	20345	901.1	27441	904.51	32921	906.32	42242	908.13	57641	910.53
406	457.09	866	4352	885.83	10608	894.07	15394	898.21	20345	901.3	27441	904.73	32921	906.51	42242	908.31	57641	910.69

Table B14

Fargo Moorhead Metro Study - Phase 3.1
Reference, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	4352	885.91	10608	894.13	15394	898.26	20345	901.34	27441	904.75	32921	906.53	42242	908.34	57641	910.73
408	457.80	864	4352	886.1	10608	894.37	15394	898.52	20345	901.63	27441	905.09	32921	906.83	42242	908.62	57641	910.98
409	457.95	855.9	4352	886.15	10608	894.47	15394	898.62	20345	901.73	27441	905.18	32921	906.9	42242	908.69	57641	911.03
409.1	457.97	855.9	4352	886.16	10608	894.47	15394	898.62	20345	901.73	27441	905.18	32921	906.91	42242	908.69	57641	911.04
409.5			South Dam															
409.6	457.98	855.9	4352	886.22	10608	894.5	15394	898.66	20345	901.76	27441	905.21	32921	906.92	42242	908.7	57641	911.05
409.7	457.99	855.9	4352	886.22	10608	894.51	15394	898.66	20345	901.77	27441	905.22	32921	906.93	42242	908.71	57641	911.05
413	458.32	869	4352	886.22	10608	894.53	15394	898.7	20345	901.81	27441	905.26	32921	907	42242	908.8	57641	911.15
414	458.75	866	4352	886.49	10608	894.81	15394	899	20345	902.15	27441	905.63	32921	907.25	42242	909.02	57641	911.33
459.64	459.64	864.81	4352	886.9	10608	895.24	15394	899.37	20345	902.5	27441	905.96	32921	907.54	42242	909.3	57641	911.59
460.28	460.28	868.74	4352	887.28	10608	895.57	15394	899.68	20345	902.8	27441	906.22	32921	907.78	42242	909.55	57641	911.78
460.72	460.72	869.04	4352	887.59	10608	895.84	15394	899.95	20345	903.1	27441	906.54	32921	907.99	42242	909.73	57641	911.94
461.3	461.3	868.04	4352	887.99	10608	896.22	15394	900.34	20345	903.52	27441	906.97	32921	908.3	42242	909.99	57641	912.15
462.03	462.03	864.16	4352	888.36	10608	896.62	15394	900.72	20345	903.9	27441	907.34	32921	908.62	42242	910.24	57641	912.35
462.04	462.04	869.5	4352	888.4	10608	896.66	15394	900.75	20345	903.95	27441	907.38	32921	908.63	42242	910.25	57641	912.36
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	4352	888.41	10608	896.66	15394	900.76	20345	904.03	27441	907.43	32921	908.78	42242	910.43	57641	912.5
462.07	462.07	871.5	4352	888.45	10608	896.69	15394	900.79	20345	904.03	27441	907.41	32921	908.79	42242	910.43	57641	912.5
462.7	462.7	862.82	4352	888.81	10608	897.02	15394	901.11	20345	904.33	27441	907.74	32921	909.07	42242	910.69	57641	912.72
463.7	463.7	864.71	4352	889.14	10608	897.44	15394	901.55	20345	904.77	27441	908.18	32921	909.47	42242	911.04	57641	913.05
464.2	464.2	869.2	4352	889.4	10608	897.72	15394	901.86	20345	905.1	27441	908.54	32921	909.83	42242	911.27	57641	913.22
464.6	464.6	865	4352	889.61	10608	897.91	15394	902.05	20345	905.26	27441	908.7	32921	909.93	42242	911.38	57641	913.32
465.1	465.1	862.9	4352	889.78	10608	898.16	15394	902.35	20345	905.64	27441	909.05	32921	910.27	42242	911.56	57641	913.49
465.9	465.9	865.6	4352	890.05	10608	898.52	15394	902.73	20345	906.03	27441	909.35	32921	910.45	42242	911.72	57641	913.61
466.5	466.5	864.9	4352	890.29	10608	898.79	15394	903.02	20345	906.34	27441	909.65	32921	910.77	42242	911.9	57641	913.78
467.4	467.4	864.8	4352	890.64	10608	899.22	15394	903.48	20345	906.81	27441	910.08	32921	911.03	42242	912.16	57641	914
468.2	468.2	862.6	4352	890.89	10608	899.51	15394	903.76	20345	907.09	27441	910.28	32921	911.18	42242	912.31	57641	914.14
468.9	468.9	861	4352	891.11	10608	899.8	15394	904.08	20345	907.32	27441	910.45	32921	911.31	42242	912.45	57641	914.27
469.7	469.7	870	4352	891.47	10608	900.2	15394	904.41	20345	907.55	27441	910.6	32921	911.44	42242	912.58	57641	914.39
470.1	470.1	870.9	4352	891.63	10608	900.38	15394	904.61	20345	907.74	27441	910.72	32921	911.56	42242	912.66	57641	914.46
470.6	470.6	869.4	3198	891.8	7772	900.58	9722	904.8	12388	907.94	16680	910.88	20055	911.74	27549	912.86	39492	914.68
471.4	471.4	867.5	3198	892.04	7772	900.85	9722	904.99	12388	908.11	16680	910.99	20055	911.85	27549	913	39492	914.83
472.18	472.18	869.9	3198	892.28	7772	901.12	9722	905.19	12388	908.29	16680	911.13	20055	911.99	27549	913.17	39492	915.03
472.2	472.2	870.8	3198	892.29	7772	901.11	9722	905.19	12388	908.28	16680	911.11	20055	911.97	27549	913.14	39492	914.99
472.22	472.22	870.8	3198	892.29	7772	901.12	9722	905.2	12388	908.31	16680	911.17	20055	912.05	27549	913.26	39492	915.12
473	473	871.8	3198	892.53	7772	901.36	9722	905.37	12388	908.45	16680	911.29	20055	912.17	27549	913.41	39492	915.29
473.8	473.8	869	3198	892.79	7772	901.66	9722	905.6	12388	908.67	16680	911.49	20055	912.39	27549	913.68	39492	915.58
474.08	474.08	873.5	3198	892.89	7772	901.76	9722	905.69	12388	908.75	16680	911.57	20055	912.48	27549	913.77	39492	915.68
474.09	474.09	873.5	3198	892.9	7772	901.79	9722	905.72	12388	908.78	16680	911.61	20055	912.52	27549	913.84	39492	915.71
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	3198	892.9	7772	901.78	9722	905.72	12388	908.77	16680	911.62	20055	912.54	27549	913.87	39492	915.93
474.12	474.12	874	3198	892.91	7772	901.79	9722	905.72	12388	908.78	16680	911.64	20055	912.57	27549	913.89	39492	915.95
474.6	474.6	873.4	3198	893.12	7772	901.96	9722	905.85	12388	908.91	16680	911.77	20055	912.72	27549	914.06	39492	916.11
475.3	475.3	872.2	3198	893.37	7772	902.24	9722	906.08	12388	909.15	16680	912.04	20055	913.04	27549	914.42	39492	916.43
475.7	475.7	871	3198	893.51	7772	902.41	9722	906.23	12388	909.33	16680	912.27	20055	913.26	27549	914.7	39492	916.57
476.4	476.4	873.7	3198	893.78	7772	902.66	9722	906.43	12388	909.51	16680	912.44	20055	913.44	27549	914.9	39492	916.74
477	477	874	3147	894.04	6349	902.89	9577	906.64	13547	909.74	19288	912.66	23242	913.7	26339	915.14	31093	916.96
477.6	477.6	870.2	3139	894.23	6160	903.05	9555	906.85	13729	910.01	19709	913.02	23757	914.08	26164	915.45	30016	917.19
478	478	873.4	3139	894.37	6160	903.15	9555	906.98	13729	910.17	19709	913.2	23757	914.28	26164	915.61	30016	917.25
478.8	478.8	874.8	3139	894.6	6160	903.34	9555	907.22	13729	910.46	19709	913.59	23757	914.69	26164	915.94	30016	917.39
479.2	479.2	875.7	3139	894.71	6160	903.42	9555	907.33	13729	910.59	19709	913.74	23757	914.85	26164	916.07	30016	917.46
479.7	479.7	871.5	3139	894.9	6160	903.54	9555	907.48	13729	910.76	19709	913.93	23757	915.07	26164	916.26	30016	917.58
480.5	480.5	874.7	3139	895.18	6160	903.75	9555	907.74	13729	911.06	19709	914.25	23757	915.4	26164	916.54	30016	917.83
481.8	481.8	875.3	3139	895.57	6160	904.08	9555	908.16	13729	911.51	19709	914.76	23757	915.97	26164	917	30016	918.24
482.3	482.3	874.2	3139	895.77	6160	904.26	9555	908.39	13729	911.79	19709	915.04	23757	916.28	26164	917.21	30016	918.39
482.698	482.698	869.74	3139	895.88	6160	904.36	9555	908.51	13729	911.93	19709	915.2	23757	916.49	26164	917.39	30016	918.54
482.7	482.7	887.04	3139	895.77	6160	904.3	9555	908.44	13729	911.86	19709	915.13	23757	916.44	26164	917.37	30016	918.54
482.702	482.702	878.54	3139	895.92	6160	904.37	9555	908.51	13729	911.93	19709	915.2	23757	916.49	26164	917.39	30016	918.54
483.1	483.1	879.2	3139	896.16	6160	904.56	9555	908.76	13729	912.22	19709	915.53	23757	916.81	26164	917.62	30016	918.7
483.9	483.9	873	3139	896.59	6160	904.84	9555	909.08	13729	912.62	19709	916.01	23757	917.24	26164	918.03	30016	919.06
485.08	485.08	880.5	3139	897.17	6160	905.1	9555	909.32	13729	912.86	19709	916.27	23757	917.52	26164	918.32	30016	919.33
485.09	485.09	880.5	3139	897.18	6160	905.09	9555	909.29	13729	912.86	19709	916.27	23757	917.52	26164	918.32	30016	919.33
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	3139	897.19	6160	905.09	9555	909.35	13729	912.96	19709	916.32	23757	917.57	26164	918.36	30016	919.37
485.12	485.12	879.4	3139	897.19	6160	905.12	9555	909.42	13729	912.96	19709	916.33	23757	917.57	26164	918.37	30016	919.38
485.6	485.6	878.62	3139	897.4	6160	905.23	9555	909.51	13729	913.04	19709	916.4	23757	917.66	26164	918.46	30016	919.47
485.9	485.9	879.5	3139	897.58	6160	905.34	9555	909.64	13729	913.18	19709	916.57	23757	917.86	26164	918.67	30016	919.68
486.3	486.3	872.1	3139	897.75	6160	905.47	9555	909.78	13729	913.34	19709	916.76	23757	918.09	26164	918.92	30016	919.94
487	487	871.3	3139	897.97	6160	905.64	9555	910	13729	913.62	19709	917.14	23757	918.56	26164	919.43	30016	920.52
487.5	487.5	878.8	3139	898.19	6160	905.83	9555	910.2	13729	913.84	19709	917.38	23757	918.84	26164	919.72	30016	920.81
488.68	488.68	878.24	3139	898.83	6160	906.35	9555	910.79	13729	914.55	19709	918.19	23757	919.75	26164	920.67	30016	921.85

Table B15

Fargo Moorhead Metro Study - Phase 3.1
Reference, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	7890	860.38	17020	869.46	24610	873.29	32650	875.42	44080	876.69	53560	877.55	63590	878.37	80610	879.31
280	404.98	836.6	7890	861.02	17020	870.16	24610	874.14	32650	876.09	44080	877.53	53560	878.34	63590	879.15	80610	880.13
281	406.51	834.9	7890	861.88	17020	871.03	24610	875.07	32650	877.15	44080	878.68	53560	879.33	63590	879.96	80610	881.01
282	410.21	838	7890	863.78	17020	872.89	24610	876.78	32650	878.78	44080	879.82	53560	880.48	63590	881.22	80610	882.37
283	413.23	837.6	7890	865.06	17020	874.26	24610	878.09	32650	880.03	44080	881.03	53560	881.43	63590	882.22	80610	883.43
284	414.98	842.7	7150	865.78	15860	875.14	23130	879.17	30790	880.91	41630	881.89	50580	882.45	60120	883.26	76860	884.49
285	415.38	841.4	7150	865.95	15860	875.34	23130	879.4	30790	881.11	41630	882.13	50580	882.67	60120	883.5	76860	884.74
286	415.84	843	7150	866.08	15860	875.42	23130	879.45	30790	881.14	41630	882.22	50580	882.82	60120	883.65	76860	885
287	415.90	844.1	7150	866.12	15860	875.48	23130	879.55	30790	881.37	41630	882.36	50580	882.96	60120	883.76	76860	885.06
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	7150	866.12	15860	875.48	23130	879.54	30790	881.36	41630	882.46	50580	883.12	60120	884.18	76860	885.29
290	415.93	837.5	7150	866.14	15860	875.49	23130	879.55	30790	881.37	41630	882.55	50580	883.23	60120	884.18	76860	885.33
291	417.10	840.8	7150	866.55	15860	875.94	23130	880.11	30790	882.14	41630	883.45	50580	884.24	60120	885	76860	885.96
292	418.18	844.4	6247	866.96	13447	876.38	19446	880.64	25786	882.66	34892	884.04	42390	884.91	51664	885.65	67999	886.5
293	419.92	844.7	6247	867.73	13447	877.16	19446	881.37	25786	883.29	34892	884.7	42390	885.61	51664	886.15	67999	887.09
294	420.32	843.8	6247	868	13447	877.39	19446	881.62	25786	883.61	34892	885.09	42390	886.05	51664	886.61	67999	887.57
295	421.93	845.3	6247	869.23	13447	878.47	19446	882.62	25786	884.4	34892	885.84	42390	886.76	51664	887.44	67999	888.19
296	422.69	847.4	6247	869.55	13447	878.8	19446	882.92	25786	884.65	34892	886.06	42390	886.97	51664	887.73	67999	888.51
297	423.95	849.5	6247	870.08	13447	879.37	19446	883.58	25786	885.52	34892	887.14	42390	888.17	51664	888.91	67999	889.59
298	425.51	848.7	6247	870.82	13447	880.09	19446	884.3	25786	886.22	34892	887.88	42390	888.93	51664	889.3	67999	890.09
299	426.87	851.1	6247	871.54	13447	880.72	19446	884.94	25786	886.92	34892	888.68	42390	889.78	51664	890.02	67999	890.68
300	428.06	849.6	4008	872.07	9978	881.3	15017	885.53	19746.67	887.51	22353.59	889.25	25377.91	890.37	32964.36	890.36	48752.31	891.19
301	428.74	850.3	4008	872.33	9978	881.6	15017	885.89	19746.67	887.94	22353.59	889.59	25377.91	890.69	32964.36	890.89	48752.31	891.58
302	430.23	852	4008	872.9	9978	882.11	15017	886.47	19746.67	888.68	22353.59	890.31	25377.91	891.4	32964.36	892	48752.31	892.3
303	431.94	853.5	4008	873.65	9978	882.84	15017	887.26	19931.73	889.58	25305.74	891.14	30681.32	892.24	38065.91	893.19	54130.79	893.43
303.4	432.07	853.42	3722	873.69	9517	882.9	14431	887.36	18829.62	889.73	23947.99	891.22	28996.08	892.3	35992.23	893.37	51640.3	893.78
303.5	432.10	853.46	3722	873.72	9517	882.94	14431	887.4	18435.61	889.77	23757.49	891.28	28854.42	892.38	35590.23	893.47	50785.38	893.98
303.8	432.53	854.5	3722	873.88	9517	883.11	14431	887.57	17804.72	889.97	23241.29	891.66	28492.7	892.78	34907.98	893.89	48157.75	894.69
304	432.84	855.5	3723	873.96	9518	883.21	14420.55	887.66	17424	890.05	21106.97	891.73	23149.58	892.87	26500.46	893.99	35271.27	894.84
305	433.26	854.4	3723	874.11	9518	883.38	14420.55	887.85	17747.64	890.21	19411.48	891.87	21773.76	892.97	23941.6	894.08	30655.17	894.97
306	433.35	855	3723	874.18	9518	883.46	14420.55	887.95	17826.32	890.33	19006.97	892	21447.1	893.01	23333.11	894.11	29558.07	895
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	3723	874.19	9518	883.47	14420.55	887.97	17826.32	890.35	19006.97	892.01	21447.1	893.05	23333.11	894.16	29558.07	895.07
309	433.83	854.5	3723	874.33	9518	883.62	14420.55	888.15	17826.32	890.56	19006.97	892.21	21447.1	893.22	23333.11	894.31	29558.07	895.27
310	434.61	852.8	3723	874.56	9518	883.85	14420.55	888.4	17826.32	890.81	19006.97	892.43	21447.1	893.42	23333.11	894.49	29558.07	895.49
310.5	435.70	855	3723	874.9	9518	884.22	14420.55	888.77	17826.32	891.21	19006.97	892.82	21447.1	893.82	23333.11	894.87	29558.07	895.96
311	436.34	855	3723	875.11	9518	884.46	14383.68	889.06	17366.53	891.56	21464.23	893.13	22720.87	894.16	24054.21	895.21	31326.24	896.3
312	437.05	863.83	3528	875.34	9208	884.73	13978.68	889.36	16946.53	891.92	21071.17	893.55	23144.82	894.56	25426.5	895.6	33917.35	896.69
313	437.95	856	3527	875.65	9207	885.11	13989.13	889.82	17327.25	892.41	23148.55	894.14	27598.99	895.15	31881.74	896.19	43587.72	897.51
314	438.78	857	3527	875.97	9207	885.46	13989.13	890.21	17327.25	892.82	23148.55	894.72	27598.99	895.82	31881.74	896.92	43587.72	898.45
315	439.05	856	3527	876.06	9207	885.57	13989.13	890.33	17327.25	892.95	23148.55	894.94	27598.99	896.08	31881.74	897.21	43587.72	898.77
316	439.46	855.1	3527	876.2	9207	885.76	13989.13	890.59	17327.25	893.25	21617.13	895.4	24018.56	896.68	22677.43	897.94	24179.65	899.95
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	3527	876.21	9207	885.77	13989.13	890.59	17327.25	893.25	21617.13	895.39	24018.56	896.69	22677.43	897.98	24179.65	899.98
319	439.50	857	3527	876.22	9207	885.82	13989.13	890.66	17327.25	893.32	21617.13	895.46	24018.56	896.78	22677.43	898.07	24179.65	900.02
320	439.66	856	3527	876.27	9207	885.88	13989.13	890.72	17327.25	893.38	21617.13	895.53	24018.56	896.84	22677.43	898.12	24179.65	900.07
321	440.31	858	3527	876.48	9207	886.13	13989.13	891.01	17327.25	893.7	21617.13	895.91	24018.56	897.23	22677.43	898.35	24179.65	900.23
322	440.32	858.1	3527	876.48	9207	886.12	13989.13	891	17327.25	893.69	21617.13	895.9	24018.56	897.22	22677.43	898.35	24179.65	900.23
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	3527	876.49	9207	886.24	13989.13	891.09	17327.25	893.75	21617.13	895.95	24018.56	897.26	22677.43	898.38	24179.65	900.25
325	440.34	857	3527	876.49	9207	886.25	13989.13	891.1	17327.25	893.76	21617.13	895.95	24018.56	897.26	22677.43	898.38	24179.65	900.25
326	440.54	858	3527	876.54	9207	886.3	13989.13	891.15	17327.25	893.82	21617.13	896.03	24018.56	897.34	22677.43	898.44	24179.65	900.29
327	441.53	859	3507	876.9	9162	886.58	13929.13	891.4	17262.25	894.06	21536.03	896.32	23967.18	897.62	22682.97	898.63	24528.17	900.4
328	442.14	858	3507	877.11	9162	886.75	13929.13	891.55	16181.65	894.2	20972.32	896.49	27250.07	897.8	30523.76	898.77	47392.84	900.48
329	442.45	857	3507	877.19	9162	886.78	13929.13	891.56	18725.21	894.21	25353.2	896.5	30858.57	897.81	37506.85	898.8	54034	900.53
329.5	442.93	858.06	3506	877.33	9161	886.89	13965	891.65	18855	894.29	25764	896.59	31304	897.93	38787	898.87	54034	900.6
330	443.69	858	3506	877.57	9161	887.09	13965	891.82	18855	894.46	25764	896.77	31304	898.11	38787	899.01	54034	900.75
331	443.99	859	3506	877.65	9161	887.18	13965	891.93	18855	894.59	25764	896.96	31304	898.36	38787	899.14	54034	900.89
332	444.33	856	3506	877.71	9161	887.22	13965	891.97	18855	894.64	25764	897.02	31304	898.43	38787	899.19	54034	900.94
333	444.92	859	3506	877.8	9161	887.26	13965	892	18855	894.66	25764	897.02	31304	898.44	38787	899.21	54034	900.98
334	445.18	860	3506	877.88	9161	887.34	13965	892.07	18855	894.75	25764	897.13	31304	898.53	38787	899.33	54034	901.13
335	445.31	860	3506	877.93	9161	887.42	13965	892.19	18855	894.92	25764	897.4	31304	898.88	38787	899.52	54034	901.3
336	445.36	859	3506	877.94	9161	887.43	13965	892.2	18855	894.94	25764	897.42	31304	898.9	38787	899.54	54034	901.31
336.5	445.76	857.69	3506	877.98	9161	887.46	13965	892.23	18855	894.97	25764	897.46	31304	898.95	38787	899.58	54034	901.36
337	446.09	860	3506	878.03	9161	887.46	13965	892.22	18855	894.96	25764	897.44	31304	898.93	38787	899.57	54034	901.35
338	446.29	861	3506	878.1	9161	887.5	13965	892.24	18855	894.97	25764	897.45	31304	898.93	38787	899.61	54034	901.41
338.5	446.70	860.9	3506	878.25	9161	887.64	13965	892.38	18855	895.13	25764	897.66	31304	899.15	38787	899.72	54034	901.61
339	446.76	861	3506	878.27	9161	887.66	13965	892.39	18855	895.14	25764	897.67	31304	899.21	38787	899.8	54034	901.7
340	447.04	860	3506	878.36	9161	887.75	13965	892.52	18855	895.32	25764	897.93	31304	899.53	38787	900.3	54034	902.06
341	447.24	859	3506	878.44	9161	887.81	13965	892.56	18855	895.36	25764	897.97	31304	899.57	38787	900.34	54034	902.12
342	447.42	861	3506	878.56	9161	887.9	13965	892.64	18855	895.45	25764	898.08	31304	899.68	38787	900.5	54034	902.31
342.5	447.78	856.99	3506	878.71	9161	888.04	13965	892.79	18855	895.62	25764	898.32	31304	899.99	38787	900.74	54034	902.59
343	448.13	861	3506	878.83	9161	888.14	13965	892.89	18855	895.74	25764	898.45	31304	900.13	38787	900.91	54034	902.8
344	448.36	859	3506	878.94	9161	888.25	13965	893.02	18855	895.92	25764	898.73	31304	900.47	38787	901.29	54034	903.23
345	448.89	865.3	3506	879.32	9161	888.48	13965	893.21	18855	896.11	25764	898.94	31304	900.7	38787	901.53	54034	903.5
348	448.90	864.3	3506	879.32	9161	888.46	13965	893.18	18855	896.07	25764	898.88	31304	900.64	38787	901.46	54034	903.46
348.4			North Dam															
348.8	448.90	864.3	3506	879.42	9161	888.51	13965	893.23	18855	896.14	25764	898.95	31304	900.68	38787	901.51	54034	903.49
351	448.91	861	3506	879.44	9161	888.51	13965	893.23	18855	896.14	25764	898.95	31304	900.68	38787	901.52	54034	903.5
351.4	449.06	861	3506	879.51	9161	888.64	13965	893.4	18855	896.35	25764	899.23	31304	901.04	38787	901.91	54034	903.93
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	3506	879.52	9161	888.7	13965	893.52	18855	896.44	25764	899.29	31304	901.1	38787	902.01	54034	904.06
352	449.09	862	3506	879.53	9161	888.72	13965	893.55	18855	896.48	25764	899.34	31304	901.14	38787	902.04	54034	904.06
353	449.28	863	3506	879.61	9161	888.81	13965	893.66	18855	896.62	25764	899.54	31304	901.35	38787	902.31	54034	904.39
353.5	449.61	860.13	3506	879.75	9161	888.91	13965	893.72	18855	896.69	25764	899.62	31304	901.45	38787	902.45	54034	904.57
354	449.97	864	3506	879.99	9161	889.13	13965	893.96	18855	896.92	25764	899.86	31304	901.7	38787	902.7	54034	904.82
355	450.19	862	3506	880.16	9161	889.22	13965	894.07	18855	897.06	25764	900.03	31304	901.88	38787	902.92	54034	905.04
356	450.84	858	3506	880.54	9161	889.5	13965	894.28	18855	897.28	25764	900.27	31304	902.12	38787	903.19	54034	905.35
357	450.86	863.4	3506	880.55	9161	889.5	13965	894.28	18855	897.28	25764	900.28	31304	902.13	38787	903.18	54034	905.3
358			BNRR Bridge															
359	450.87	863.4	3506	880.62	9161	889.6	13965	894.34	18855	897.38	25764	900.46	31304	902.38	38787	903.59	54034	905.93
361	451.20	865	3506	880.77	9161	889.72	13965	894.46	18855	897.51	25764	900.62	31304	902.56	38787	903.84	54034	906.31
361.5	451.37	865.2	3506	880.88	9161	889.79	13965	894.53	18855	897.58	25764	900.7	31304	902.65	38787	903.95	54034	906.45
362.5			1st Ave. No. Bridge															
364	451.39	865.2	3506	880.9	9161	889.81	13965	894.54	18855	897.61	25764	900.74	31304	902.82	38787	904.03	54034	906.64
366	451.41	861	3506	880.94	9161	889.86	13965	894.58	18855	897.65	25764	900.77	31304	902.85	38787	904.04	54034	906.64
367	451.57	867	3506	881	9161	889.95	13965	894.74	18855	897.88	25764	901.11	31304	903.26	38787	904.51	54034	907.11
368	451.61	866.8	3506	881.04	9161	890	13965	894.79	18855	897.93	25764	901.17	31304	903.33	38787	904.58	54034	907.16
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	3506	881.05	9161	890.01	13965	894.8	18855	897.97	25764	901.23	31304	903.43	38787	904.67	54034	907.22
371	451.65	859	3506	881.08	9161	890.01	13965	894.79	18855	897.95	25764	901.2	31304	903.4	38787	904.62	54034	907.17
372	451.67	867.9	3506	881.07	9161	890	13965	894.78	18855	897.95	25764	901.2	31304	903.4	38787	904.62	54034	907.13
373			BNRR Bridge															
374	451.68	867.9	3506	881.17	9161	890.1	13965	894.88	18855	898.01	25764	901.26	31304	903.44	38787	904.71	54034	907.45
375	451.69	864	3506	881.19	9161	890.1	13965	894.87	18855	898	25764	901.24	31304	903.42	38787	904.7	54034	907.55
376	451.71	865.9	3506	881.19	9161	890.11	13965	894.92	18855	898.09	25764	901.38	31304	903.61	38787	904.95	54034	907.77
377			Main Ave. Bridge															
378	451.72	865.9	3506	881.21	9161	890.12	13965	894.93	18855	898.11	25764	901.41	31304	903.65	38787	905.02	54034	907.87
379	451.73	864	3506	881.29	9161	890.22	13965	895.03	18855	898.2	25764	901.49	31304	903.73	38787	905.08	54034	907.89
380	451.85	864	3506	881.28	9161	890.19	13965	894.99	18855	898.17	25764	901.47	31304	903.71	38787	905.13	54034	907.95
381	452.03	863	3506	881.38	9161	890.34	13965	895.17	18855	898.36	25764	901.68	31304	903.93	38787	905.26	54034	908.07
381.5	452.04	863	3506	881.39	9161	890.35	13965	895.18	18855	898.38	25764	901.7	31304	903.95	38787	905.28	54034	908.08
384			Midtown Dam															
385.5	452.05	867	3506	881.46	9161	890.36	13965	895.19	18855	898.39	25764	901.71	31304	903.96	38787	905.29	54034	908.09
386	452.06	867	3506	881.47	9161	890.36	13965	895.19	18855	898.39	25764	901.72	31304	903.96	38787	905.29	54034	908.09
387	452.25	867	3506	881.61	9161	890.43	13965	895.25	18855	898.45	25764	901.77	31304	904.04	38787	905.37	54034	908.18
388	452.46	869	3506	881.83	9161	890.54	13965	895.35	18855	898.56	25764	901.92	31304	904.17	38787	905.5	54034	908.31
389	452.70	866.08	3506	882.1	9161	890.72	13965	895.51	18855	898.73	25764	902.1	31304	904.36	38787	905.73	54034	908.51
390	452.94	867	3506	882.23	9161	890.81	13965	895.59	18855	898.82	25764	902.21	31304	904.47	38787	905.85	54034	908.63
391	453.16	867	3506	882.35	9161	890.92	13965	895.7	18855	898.94	25764	902.34	31304	904.61	38787	906.03	54034	908.81
392	453.39	865	3506	882.48	9161	891.01	13965	895.8	18855	899.06	25764	902.49	31304	904.79	38787	906.2	54034	908.94
393	454.02	866	3506	882.83	9161	891.28	13965	896	18855	899.25	25764	902.67	31304	904.97	38787	906.38	54034	909.11
394	454.10	865	3506	882.87	9161	891.32	13965	896.04	18855	899.28	25764	902.7	31304	904.99	38787	906.41	54034	909.14
395	454.75	864	3506	883.14	9161	891.55	13965	896.25	18855	899.5	25764	902.92	31304	905.21	38787	906.63	54034	909.34
396	455.16	866	3506	883.33	9161	891.76	13965	896.45	18855	899.71	25764	903.09	31304	905.36	38787	906.78	54034	909.47
397	455.20	866.6	3506	883.37	9161	891.8	13965	896.48	18855	899.74	25764	903.14	31304	905.39	38787	906.79	54034	909.45
399			I-94 Bridge															
401	455.23	866.6	3506	883.38	9161	891.8	13965	896.48	18855	899.74	25764	903.14	31304	905.39	38787	906.82	54034	909.5
402	455.28	865	3506	883.41	9161	891.82	13965	896.5	18855	899.76	25764	903.16	31304	905.42	38787	906.92	54034	909.7
402.5	455.52	864.58	3506	883.52	9161	891.94	13965	896.61	18855	899.88	25764	903.31	31304	905.56	38787	907.07	54034	909.83
403	455.59	866	3506	883.54	9161	891.98	13965	896.65	18855	899.91	25764	903.34	31304	905.64	38787	907.12	54034	909.86
404	455.92	865	3506	883.7	9161	892.1	13965	896.78	18855	900.08	25764	903.52	31304	905.79	38787	907.23	54034	909.94
405	456.65	865	3506	884.09	9161	892.38	13965	897.01	18855	900.29	25764	903.7	31304	905.95	38787	907.38	54034	910.07
406	457.09	866	3506	884.33	9161	892.57	13965	897.19	18855	900.48	25764	903.92	31304	906.17	38787	907.57	54034	910.23

Table B15

Fargo Moorhead Metro Study - Phase 3.1
Reference, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	3506	884.4	9161	892.64	13965	897.24	18855	900.53	25764	903.95	31304	906.19	38787	907.6	54034	910.27
408	457.80	864	3506	884.57	9161	892.86	13965	897.49	18855	900.81	25764	904.29	31304	906.5	38787	907.9	54034	910.52
409	457.95	855.9	3506	884.62	9161	892.96	13965	897.59	18855	900.91	25764	904.38	31304	906.57	38787	907.97	54034	910.57
409.1	457.97	855.9	3506	884.62	9161	892.96	13965	897.59	18855	900.91	25764	904.38	31304	906.58	38787	907.98	54034	910.58
409.5			South Dam															
409.6	457.98	855.9	3506	884.7	9161	893	13965	897.63	18855	900.94	25764	904.41	31304	906.59	38787	907.99	54034	910.59
409.7	457.99	855.9	3506	884.7	9161	893	13965	897.64	18855	900.95	25764	904.42	31304	906.6	38787	908	54034	910.6
413	458.32	869	3506	884.7	9161	893.02	13965	897.67	18855	900.99	25764	904.46	31304	906.66	38787	908.08	54034	910.7
414	458.75	866	3506	884.96	9161	893.29	13965	897.96	18855	901.31	25764	904.83	31304	906.9	38787	908.32	54034	910.88
459.64	459.64	864.81	3506	885.35	9161	893.73	13965	898.33	18855	901.67	25764	905.17	31304	907.19	38787	908.61	54034	911.14
460.28	460.28	868.74	3506	885.73	9161	894.07	13965	898.65	18855	901.97	25764	905.45	31304	907.44	38787	908.86	54034	911.33
460.72	460.72	869.04	3506	886.06	9161	894.34	13965	898.91	18855	902.26	25764	905.78	31304	907.66	38787	909.06	54034	911.49
461.3	461.3	868.04	3506	886.45	9161	894.73	13965	899.29	18855	902.67	25764	906.22	31304	907.98	38787	909.35	54034	911.7
462.03	462.03	864.16	3506	886.79	9161	895.12	13965	899.68	18855	903.04	25764	906.62	31304	908.36	38787	909.63	54034	911.91
462.04	462.04	869.5	3506	886.83	9161	895.16	13965	899.7	18855	903.06	25764	906.66	31304	908.4	38787	909.64	54034	911.92
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	3506	886.84	9161	895.17	13965	899.72	18855	903.08	25764	906.71	31304	908.43	38787	909.83	54034	912.07
462.07	462.07	871.5	3506	886.88	9161	895.2	13965	899.75	18855	903.12	25764	906.7	31304	908.41	38787	909.83	54034	912.07
462.7	462.7	862.82	3506	887.24	9161	895.53	13965	900.06	18855	903.43	25764	907.01	31304	908.77	38787	910.1	54034	912.3
463.7	463.7	864.71	3506	887.56	9161	895.93	13965	900.49	18855	903.87	25764	907.46	31304	909.23	38787	910.48	54034	912.62
464.2	464.2	869.2	3506	887.8	9161	896.21	13965	900.79	18855	904.19	25764	907.82	31304	909.58	38787	910.72	54034	912.8
464.6	464.6	865	3506	888	9161	896.4	13965	900.98	18855	904.36	25764	907.99	31304	909.68	38787	910.84	54034	912.91
465.1	465.1	862.9	3506	888.15	9161	896.63	13965	901.26	18855	904.72	25764	908.37	31304	910.02	38787	911.04	54034	913.08
465.9	465.9	865.6	3506	888.41	9161	896.98	13965	901.64	18855	905.12	25764	908.68	31304	910.21	38787	911.2	54034	913.2
466.5	466.5	864.9	3506	888.63	9161	897.25	13965	901.93	18855	905.43	25764	908.99	31304	910.51	38787	911.4	54034	913.38
467.4	467.4	864.8	3506	888.95	9161	897.66	13965	902.36	18855	905.9	25764	909.46	31304	910.8	38787	911.67	54034	913.6
468.2	468.2	862.6	3506	889.18	9161	897.94	13965	902.65	18855	906.17	25764	909.68	31304	911	38787	911.82	54034	913.74
468.9	468.9	861	3506	889.39	9161	898.22	13965	902.95	18855	906.43	25764	909.86	31304	911.14	38787	911.97	54034	913.88
469.7	469.7	870	3506	889.73	9161	898.61	13965	903.32	18855	906.72	25764	910.02	31304	911.26	38787	912.1	54034	914
470.1	470.1	870.9	3506	889.88	9161	898.79	13965	903.51	18855	906.91	25764	910.15	31304	911.38	38787	912.18	54034	914.07
470.6	470.6	869.4	2548	890.04	6358	898.99	8774	903.7	11434	907.1	15609	910.32	19019	911.55	25243	912.38	36927	914.29
471.4	471.4	867.5	2548	890.27	6358	899.23	8774	903.9	11434	907.28	15609	910.44	19019	911.65	25243	912.52	36927	914.44
472.18	472.18	869.9	2548	890.5	6358	899.47	8774	904.1	11434	907.46	15609	910.59	19019	911.79	25243	912.7	36927	914.63
472.2	472.2	870.8	2548	890.51	6358	899.47	8774	904.09	11434	907.45	15609	910.57	19019	911.77	25243	912.66	36927	914.6
472.22	472.22	870.8	2548	890.51	6358	899.47	8774	904.11	11434	907.47	15609	910.62	19019	911.84	25243	912.77	36927	914.72
473	473	871.8	2548	890.74	6358	899.69	8774	904.27	11434	907.62	15609	910.74	19019	911.97	25243	912.93	36927	914.89
473.8	473.8	869	2548	890.99	6358	899.95	8774	904.51	11434	907.83	15609	910.94	19019	912.18	25243	913.19	36927	915.19
474.08	474.08	873.5	2548	891.09	6358	900.05	8774	904.6	11434	907.91	15609	911.02	19019	912.27	25243	913.29	36927	915.28
474.09	474.09	873.5	2548	891.1	6358	900.07	8774	904.62	11434	907.95	15609	911.06	19019	912.31	25243	913.35	36927	915.31
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	2548	891.1	6358	900.07	8774	904.62	11434	907.94	15609	911.05	19019	912.33	25243	913.39	36927	915.54
474.12	474.12	874	2548	891.11	6358	900.07	8774	904.62	11434	907.95	15609	911.07	19019	912.36	25243	913.41	36927	915.55
474.6	474.6	873.4	2548	891.32	6358	900.23	8774	904.75	11434	908.07	15609	911.21	19019	912.5	25243	913.58	36927	915.72
475.3	475.3	872.2	2548	891.56	6358	900.49	8774	904.97	11434	908.31	15609	911.47	19019	912.8	25243	913.95	36927	916.04
475.7	475.7	871	2548	891.69	6358	900.64	8774	905.12	11434	908.48	15609	911.68	19019	913.06	25243	914.21	36927	916.19
476.4	476.4	873.7	2548	891.96	6358	900.87	8774	905.31	11434	908.66	15609	911.85	19019	913.24	25243	914.42	36927	916.36
477	477	874	2550	892.23	5485	901.09	8718	905.53	12582	908.89	18134	912.08	22123	913.48	24258	914.66	29236	916.58
477.6	477.6	870.2	2550	892.42	5366	901.25	8710	905.73	12762	909.15	18543	912.45	22626	913.86	24116	914.97	28246	916.81
478	478	873.4	2550	892.55	5366	901.35	8710	905.86	12762	909.3	18543	912.64	22626	914.04	24116	915.12	28246	916.86
478.8	478.8	874.8	2550	892.79	5366	901.54	8710	906.1	12762	909.6	18543	913.03	22626	914.45	24116	915.45	28246	917.11
479.2	479.2	875.7	2550	892.9	5366	901.63	8710	906.21	12762	909.73	18543	913.19	22626	914.6	24116	915.58	28246	917.18
479.7	479.7	871.5	2550	893.1	5366	901.75	8710	906.35	12762	909.9	18543	913.38	22626	914.81	24116	915.76	28246	917.29
480.5	480.5	874.7	2550	893.38	5366	901.96	8710	906.61	12762	910.2	18543	913.7	22626	915.14	24116	916.04	28246	917.53
481.8	481.8	875.3	2550	893.76	5366	902.3	8710	907.05	12762	910.66	18543	914.19	22626	915.69	24116	916.5	28246	917.93
482.3	482.3	874.2	2550	893.97	5366	902.48	8710	907.28	12762	910.94	18543	914.47	22626	915.99	24116	916.73	28246	918.09
482.698	482.698	869.74	2550	894.07	5366	902.57	8710	907.4	12762	911.07	18543	914.63	22626	916.16	24116	916.91	28246	918.24
482.7	482.7	887.04	2550	893.94	5366	902.51	8710	907.33	12762	911	18543	914.57	22626	916.1	24116	916.88	28246	918.23
482.702	482.702	878.54	2550	894.12	5366	902.58	8710	907.4	12762	911.08	18543	914.62	22626	916.16	24116	916.91	28246	918.24
483.1	483.1	879.2	2550	894.35	5366	902.78	8710	907.64	12762	911.36	18543	914.93	22626	916.51	24116	917.16	28246	918.41
483.9	483.9	873	2550	894.81	5366	903.07	8710	907.96	12762	911.75	18543	915.4	22626	916.94	24116	917.59	28246	918.76
485.08	485.08	880.5	2550	895.47	5366	903.38	8710	908.21	12762	912	18543	915.66	22626	917.23	24116	917.86	28246	919.03
485.09	485.09	880.5	2550	895.47	5366	903.37	8710	908.19	12762	912	18543	915.66	22626	917.23	24116	917.86	28246	919.03
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	2550	895.48	5366	903.38	8710	908.23	12762	912.11	18543	915.71	22626	917.28	24116	917.9	28246	919.06
485.12	485.12	879.4	2550	895.49	5366	903.4	8710	908.29	12762	912.12	18543	915.72	22626	917.28	24116	917.9	28246	919.07
485.6	485.6	878.62	2550	895.71	5366	903.52	8710	908.39	12762	912.2	18543	915.8	22626	917.37	24116	917.99	28246	919.16
485.9	485.9	879.5	2550	895.92	5366	903.65	8710	908.53	12762	912.34	18543	915.96	22626	917.55	24116	918.18	28246	919.36
486.3	486.3	872.1	2550	896.09	5366	903.77	8710	908.67	12762	912.5	18543	916.15	22626	917.78	24116	918.41	28246	919.62
487	487	871.3	2550	896.32	5366	903.95	8710	908.88	12762	912.77	18543	916.5	22626	918.22	24116	918.88	28246	920.16
487.5	487.5	878.8	2550	896.52	5366	904.15	8710	909.08	12762	912.99	18543	916.74	22626	918.49	24116	919.15	28246	920.44
488.68	488.68	878.24	2550	897.12	5366	904.69	8710	909.67	12762	913.69	18543	917.53	22626	919.36	24116	920.04	28246	921.42

Table B16

Fargo Moorhead Metro Study - Phase 3.1
Reference, Wet - Year Zero, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			0.1%		0.01%	
Recurrence Interval			1,000 -Year		10,000 -Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	98659.99	880.12	147070	881.68
280	404.98	836.6	98659.99	881.03	147070	882.87
281	406.51	834.9	98659.99	881.98	147070	884.03
282	410.21	838	98659.99	883.45	147070	885.77
283	413.23	837.6	98659.99	884.56	147070	887.02
284	414.98	842.7	95529.99	885.65	143770	888.19
285	415.38	841.4	95529.99	885.91	143770	888.49
286	415.84	843	95529.99	886.2	143770	888.81
287	415.90	844.1	95529.99	886.26	143770	888.88
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36			
289	415.91	844.1	95529.99	886.52	143770	889.1
290	415.93	837.5	95529.99	886.56	143770	889.13
291	417.10	840.8	95529.99	887.15	143770	889.67
292	418.18	844.4	85679.99	887.7	133320	890.27
293	419.92	844.7	85679.99	888.27	133320	890.85
294	420.32	843.8	85679.99	888.71	133320	891.28
295	421.93	845.3	85679.99	889.33	133320	891.9
296	422.69	847.4	85679.99	889.7	133320	892.35
297	423.95	849.5	85679.99	890.69	133320	893.02
298	425.51	848.7	85679.99	891.21	133320	893.58
299	426.87	851.1	85679.99	891.74	133320	894.06
300	428.06	849.6	68030.84	892.33	123420	894.47
301	428.74	850.3	68030.84	892.83	123420	894.78
302	430.23	852	68030.84	893.75	123420	895.32
303	431.94	853.5	71326.44	895.03	123420	896.02
303.4	432.07	853.42	69366.71	894.7		
303.5	432.10	853.46	68873.58	895		
303.8	432.53	854.5	67268.64	895.94		
304	432.84	855.5	47592.07	896.15	121655	896.74
305	433.26	854.4	40305.18	896.31	121655	897.34
306	433.35	855	38570.34	896.35	121655	897.47
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge			
308	433.37	855	38570.34	896.42	121655	897.55
309	433.83	854.5	38570.34	896.68	121655	898.03
310	434.61	852.8	38570.34	896.93	121655	898.59
310.5	435.70	855	38570.34	897.53	121655	899.22
311	436.34	855	39705.46	897.91	121655	901.66
312	437.05	863.83	46383.54	898.32	121100	902.9
313	437.95	856	58852.04	899.4	121100	903.4
314	438.78	857	58852.04	900.49	121100	904.03
315	439.05	856	58852.04	900.76	121100	904.29
316	439.46	855.1	33308.34	901.55	121100	904.8
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge			
318	439.47	855.1	33308.34	901.59	121100	904.92
319	439.50	857	33308.34	901.64	121100	904.97
320	439.66	856	33308.34	901.7	121100	905.1
321	440.31	858	33308.34	901.91	121100	905.36
322	440.32	858.1	33308.34	901.92	121100	905.38
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge			
324	440.33	858.1	33308.34	901.93	121100	905.41
325	440.34	857	33308.34	901.94	121100	905.42
326	440.54	858	33308.34	901.97	121100	905.49
327	441.53	859	33543.25	902.11	121000	905.76
328	442.14	858	52469.98	902.2	121000	905.92
329	442.45	857	68967.81	902.24	121000	905.99
329.5	442.93	858.06	74000	902.3	121000	906.06
330	443.69	858	74000	902.47	121000	906.24
331	443.99	859	74000	902.62	121000	906.39
332	444.33	856	74000	902.68	121000	906.44
333	444.92	859	74000	902.74	121000	906.52
334	445.18	860	74000	902.9	121000	906.69
335	445.31	860	74000	903.07	121000	906.83
336	445.36	859	74000	903.08	121000	906.84
336.5	445.76	857.69	74000	903.14	121000	906.91
337	446.09	860	74000	903.14	121000	906.92
338	446.29	861	74000	903.21	121000	907.01
338.5	446.70	860.9	74000	903.45	121000	907.27
339	446.76	861	74000	903.53	121000	907.34
340	447.04	860	74000	903.91	121000	907.69
341	447.24	859	74000	903.98	121000	907.79
342	447.42	861	74000	904.18	121000	907.99
342.5	447.78	856.99	74000	904.5	121000	908.33
343	448.13	861	74000	904.75	121000	908.63
344	448.36	859	74000	905.2	121000	909.04
345	448.89	865.3	74000	905.51	121000	909.41
348	448.90	864.3	74000	905.5	121000	909.43
348.4			North Dam			
348.8	448.90	864.3	74000	905.53	121000	909.46
351	448.91	861	74000	905.54	121000	909.47
351.4	449.06	861	74000	905.94	121000	909.8
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge			
351.6	449.07	861	74000	906.07	121000	909.92
352	449.09	862	74000	906.07	121000	909.93
353	449.28	863	74000	906.41	121000	910.24
353.5	449.61	860.13	74000	906.64	121000	910.54
354	449.97	864	74000	906.88	121000	910.77
355	450.19	862	74000	907.11	121000	910.99
356	450.84	858	74000	907.45	121000	911.38
357	450.86	863.4	74000	907.39	121000	911.33
358			BNRR Bridge			
359	450.87	863.4	74000	907.49	121000	911.6
361	451.20	865	74000	908.02	121000	912.15
361.5	451.37	865.2	74000	908.19	121000	912.32
362.5			1st Ave. No. Bridge			
364	451.39	865.2	74000	908.46	121000	912.58
366	451.41	861	74000	908.47	121000	912.59
367	451.57	867	74000	908.95	121000	912.98
368	451.61	866.8	74000	909	121000	913.02
369			NP Ave. (Fargo) / Center Ave. (Moorhead)			
370	451.63	866.8	74000	909.13	121000	913.16
371	451.65	859	74000	909.08	121000	913.12
372	451.67	867.9	74000	909.03	121000	913.07
373			BNRR Bridge			
374	451.68	867.9	74000	909.35	121000	913.6
375	451.69	864	74000	909.52	121000	913.78
376	451.71	865.9	74000	909.73	121000	913.93
377			Main Ave. Bridge			
378	451.72	865.9	74000	909.85	121000	914.08
379	451.73	864	74000	909.86	121000	914.08
380	451.85	864	74000	909.94	121000	914.19
381	452.03	863	74000	910.07	121000	914.31
381.5	452.04	863	74000	910.08	121000	914.32
384			Midtown Dam			
385.5	452.05	867	74000	910.08	121000	914.33
386	452.06	867	74000	910.09	121000	914.33
387	452.25	867	74000	910.2	121000	914.47
388	452.46	869	74000	910.35	121000	914.62
389	452.70	866.08	74000	910.56	121000	914.83
390	452.94	867	74000	910.71	121000	914.99
391	453.16	867	74000	910.89	121000	915.16
392	453.39	865	74000	911.03	121000	915.29
393	454.02	866	74000	911.22	121000	915.49
394	454.10	865	74000	911.24	121000	915.52
395	454.75	864	74000	911.47	121000	915.76
396	455.16	866	74000	911.6	121000	915.89
397	455.20	866.6	74000	911.56	121000	915.85
399			I-94 Bridge			
401	455.23	866.6	74000	911.71	121000	916.05
402	455.28	865	74000	911.92	121000	916.23
402.5	455.52	864.58	74000	912.05	121000	916.36
403	455.59	866	74000	912.08	121000	916.39
404	455.92	865	74000	912.16	121000	916.46
405	456.65	865	74000	912.3	121000	916.61
406	457.09	866	74000	912.46	121000	916.77

Table B16

Fargo Moorhead Metro Study - Phase 3.1
Reference, Wet - Year Zero, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			0.1%		0.01%	
Recurrence Interval			1,000 -Year		10,000 -Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	74000	912.51	121000	916.83
408	457.80	864	74000	912.76	121000	917.07
409	457.95	855.9	74000	912.8	121000	917.11
409.1	457.97	855.9	74000	912.81	121000	917.11
409.5			South Dam			
409.6	457.98	855.9	74000	912.82	121000	917.13
409.7	457.99	855.9	74000	912.82	121000	917.14
413	458.32	869	74000	912.94	121000	917.26
414	458.75	866	74000	913.11	121000	917.43
459.64	459.64	864.81	74000	913.38	121000	917.69
460.28	460.28	868.74	74000	913.56	121000	917.87
460.72	460.72	869.04	74000	913.72	121000	918.02
461.3	461.3	868.04	74000	913.91	121000	918.18
462.03	462.03	864.16	74000	914.09	121000	918.33
462.04	462.04	869.5	74000	914.1	121000	918.33
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge			
462.06	462.06	869.5	74000	914.18	121000	918.39
462.07	462.07	871.5	74000	914.19	121000	918.4
462.7	462.7	862.82	74000	914.4	121000	918.59
463.7	463.7	864.71	74000	914.71	121000	918.86
464.2	464.2	869.2	74000	914.86	121000	918.98
464.6	464.6	865	74000	914.97	121000	919.08
465.1	465.1	862.9	74000	915.12	121000	919.21
465.9	465.9	865.6	74000	915.23	121000	919.3
466.5	466.5	864.9	74000	915.39	121000	919.44
467.4	467.4	864.8	74000	915.6	121000	919.62
468.2	468.2	862.6	74000	915.73	121000	919.74
468.9	468.9	861	74000	915.87	121000	919.87
469.7	469.7	870	74000	915.98	121000	919.97
470.1	470.1	870.9	74000	916.05	121000	920.02
470.6	470.6	869.4	52104	916.28	93574	920.27
471.4	471.4	867.5	52104	916.44	93574	920.46
472.18	472.18	869.9	52104	916.65	93574	920.69
472.2	472.2	870.8	52104	916.62	93574	920.67
472.22	472.22	870.8	52104	916.74	93574	920.78
473	473	871.8	52104	916.92	93574	921
473.8	473.8	869	52104	917.24	93574	921.36
474.08	474.08	873.5	52104	917.32	93574	921.44
474.09	474.09	873.5	52104	917.34	93574	921.44
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge			
474.11	474.11	874	52104	917.54	93574	921.53
474.12	474.12	874	52104	917.56	93574	921.55
474.6	474.6	873.4	52104	917.72	93574	921.7
475.3	475.3	872.2	52104	918.03	93574	922.02
475.7	475.7	871	52104	918.16	93574	922.13
476.4	476.4	873.7	52104	918.32	93574	922.29
477	477	874	36820	918.53	79575	922.49
477.6	477.6	870.2	35000	918.64	77714	922.6
478	478	873.4	35000	918.69	77714	922.69
478.8	478.8	874.8	35000	918.8	77714	922.85
479.2	479.2	875.7	35000	918.87	77714	922.96
479.7	479.7	871.5	35000	918.96	77714	923.1
480.5	480.5	874.7	35000	919.11	77714	923.3
481.8	481.8	875.3	35000	919.38	77714	923.62
482.3	482.3	874.2	35000	919.49	77714	923.69
482.698	482.698	869.74	35000	919.58	77714	923.76
482.7	482.7	887.04	35000	919.59	77714	923.77
482.702	482.702	878.54	35000	919.59	77714	923.77
483.1	483.1	879.2	35000	919.68	77714	923.84
483.9	483.9	873	35000	919.96	77714	924.06
485.08	485.08	880.5	35000	920.24	77714	924.36
485.09	485.09	880.5	35000	920.24	77714	924.36
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge			
485.11	485.11	879.4	35000	920.28	77714	924.41
485.12	485.12	879.4	35000	920.29	77714	924.42
485.6	485.6	878.62	35000	920.39	77714	924.56
485.9	485.9	879.5	35000	920.57	77714	924.71
486.3	486.3	872.1	35000	920.86	77714	925.06
487	487	871.3	35000	921.5	77714	925.58
487.5	487.5	878.8	35000	921.82	77714	925.95
488.68	488.68	878.24	35000	923.01	77714	926.74

Table B17

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year Zero - Wet, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	10380	863.05	20140	871.03	27860	874.18	36050.16	875.88	47720	877.03	57070	877.85	69040	878.81	85540	879.53
280	404.98	836.6	10380	863.75	20140	871.81	27860	874.78	36050.16	876.6	47720	877.78	57070	878.66	69040	879.62	85540	880.37
281	406.51	834.9	10380	864.68	20140	872.74	27860	875.86	36050.16	877.71	47720	878.82	57070	879.66	69040	880.42	85540	881.28
282	410.21	838	10380	866.68	20140	874.62	27860	877.64	36050.16	879.39	47720	880.1	57070	880.81	69040	881.67	85540	882.67
283	413.23	837.6	10380	868.04	20140	876	27860	879	36050.16	880.5	47720	881	57070	881.76	69040	882.67	85540	883.75
284	414.98	842.7	9640	868.81	19100	876.99	26500	880.15	34300.16	881.42	45430	882.01	54260	882.77	66170	883.71	82530	884.82
285	415.38	841.4	9640	868.99	19100	877.22	26500	880.37	34300.16	881.61	45430	882.29	54260	883	66170	883.95	82530	885.08
286	415.84	843	9640	869.12	19100	877.29	26500	880.42	34300.16	881.67	45430	882.39	54260	883.15	66170	884.2	82530	885.35
287	415.90	844.1	9640	869.17	19100	877.37	26500	880.55	34300.16	881.87	45430	882.54	54260	883.27	66170	884.18	82530	885.41
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	9640	869.17	19100	877.36	26500	880.54	34300.16	881.89	45430	882.67	54260	883.47	66170	884.65	82530	885.65
290	415.93	837.5	9640	869.19	19100	877.38	26500	880.55	34300.16	881.9	45430	882.77	54260	883.58	66170	884.65	82530	885.69
291	417.10	840.8	9640	869.62	19100	877.88	26500	881.21	34300.16	882.69	45430	883.74	54260	884.6	66170	885.4	82530	886.31
292	418.18	844.4	8328	870.05	16039	878.37	22069	881.72	28491.16	883.21	37826	884.38	45160	885.2	56895	885.89	72930	886.86
293	419.92	844.7	8328	870.85	16039	879.19	22069	882.39	28491.16	883.83	37826	885.06	45160	885.67	56895	886.43	72930	887.43
294	420.32	843.8	8328	871.12	16039	879.42	22069	882.67	28491.16	884.16	37826	885.46	45160	886.16	56895	886.94	72930	887.88
295	421.93	845.3	8328	872.31	16039	880.5	22069	883.55	28491.16	884.92	37826	886.22	45160	886.93	56895	887.74	72930	888.51
296	422.69	847.4	8328	872.64	16039	880.82	22069	883.82	28491.16	885.15	37826	886.43	45160	887.18	56895	888.07	72930	888.84
297	423.95	849.5	8328	873.19	16039	881.43	22069	884.56	28491.16	886.08	37826	887.56	45160	888.33	56895	889.02	72930	889.9
298	425.51	848.7	8328	873.93	16039	882.17	22069	885.27	28491.16	886.79	37826	888.31	45160	889.05	56895	889.47	72930	890.41
299	426.87	851.1	8328	874.63	16039	882.84	22069	885.93	28491.16	887.53	37826	889.13	45160	889.67	56895	890.05	72930	890.98
300	428.06	849.6	6118	875.2	10378.13	883.41	10737.53	886.43	11044.33	888	9784.71	889.59	10398.12	890.21	14549.75	890.38	26556.14	891.37
301	428.74	850.3	6118	875.52	10378.13	883.64	10737.53	886.59	11044.33	888.13	9784.71	889.65	10398.12	890.26	14549.75	890.48	26556.14	891.48
302	430.23	852	6118	876.15	10378.13	884.04	10737.53	886.86	11044.33	888.36	9784.71	889.79	10398.12	890.4	14549.75	890.74	26556.14	891.75
303	431.94	853.5	6118	877	10378.13	884.62	10737.53	887.24	11044.33	888.67	10817.06	889.98	12896.99	890.6	17911.14	891.09	28630.37	892.52
303.4	432.07	853.42	5825	877.05	9954.13	884.68	10183.53	887.3	10274.01	888.73	9674.05	890.02	11210.65	890.65	16273.81	891.14	26579.11	892.58
303.5	432.10	853.46	5825	877.09	9954.13	884.71	10183.53	887.32	10298.43	888.75	9713.7	890.03	10932.06	890.66	16092.89	891.17	25836.66	892.64
303.8	432.53	854.5	5825	877.28	9954.13	884.84	10183.53	887.4	10298.43	888.81	9797.46	890.08	10226.65	890.73	15535.12	891.34	23565.6	892.94
304	432.84	855.5	5825	877.38	9955.13	884.92	10184.53	887.45	10271.75	888.85	9677.93	890.1	9973.35	890.75	15123.19	891.38	18725.59	892.99
305	433.26	854.4	5825	877.56	9955.13	885.06	10184.53	887.55	10271.75	888.93	10145.3	890.15	10478.9	890.79	13732.16	891.46	18749.24	893.06
306	433.35	855	5825	877.64	9955.13	885.13	10184.53	887.6	10271.75	888.98	10258.29	890.19	10598.92	890.83	13400.69	891.53	18754.87	893.08
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	5825	877.65	9955.13	885.14	10184.53	887.61	10271.75	888.98	10258.29	890.2	10598.92	890.83	13400.69	891.53	18754.87	893.12
309	433.83	854.5	5825	877.81	9955.13	885.27	10184.53	887.71	10271.75	889.06	10258.29	890.27	10598.92	890.9	13400.69	891.64	18754.87	893.25
310	434.61	852.8	5825	878.09	9955.13	885.46	10184.53	887.84	10271.75	889.17	10258.29	890.36	10598.92	890.99	13400.69	891.76	18754.87	893.39
310.5	435.70	855	5825	878.49	9955.13	885.75	10184.53	888.04	10271.75	889.34	10258.29	890.5	10598.92	891.13	13400.69	891.98	18754.87	893.71
311	436.34	855	5825	878.74	9955.13	885.96	10184.53	888.2	10257.49	889.48	10242	890.61	11189.51	891.25	14862.29	892.16	20004.9	893.97
312	437.05	863.83	5630	879.01	9675.13	886.19	9814.53	888.37	9862.49	889.62	9812.01	890.75	10749.51	891.41	14394.56	892.4	20158.79	894.29
313	437.95	856	5630	879.39	9674.13	886.53	9813.53	888.63	9889.18	889.84	9931.54	890.94	11002.81	891.62	14799.23	892.74	24334.91	894.77
314	438.78	857	5630	879.76	9674.13	886.84	9813.53	888.87	9889.18	890.04	9931.54	891.11	11002.81	891.81	14799.23	893.03	24334.91	895.34
315	439.05	856	5630	879.86	9674.13	886.93	9813.53	888.94	9889.18	890.1	9931.54	891.16	11002.81	891.87	14799.23	893.12	24334.91	895.56
316	439.46	855.1	5630	880.04	9674.13	887.12	9813.53	889.09	9889.18	890.23	9931.54	891.28	11002.81	892	14799.23	893.34	23141.39	896.03
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	5630	880.05	9674.13	887.12	9813.53	889.09	9889.18	890.23	9931.54	891.28	11002.81	892	14799.23	893.34	23141.39	896.03
319	439.50	857	5630	880.07	9674.13	887.17	9813.53	889.13	9889.18	890.27	9931.54	891.31	11002.81	892.04	14799.23	893.39	23141.39	896.12
320	439.66	856	5630	880.13	9674.13	887.22	9813.53	889.17	9889.18	890.3	9931.54	891.34	11002.81	892.07	14799.23	893.43	23141.39	896.18
321	440.31	858	5630	880.36	9674.13	887.45	9813.53	889.35	9889.18	890.46	9931.54	891.47	11002.81	892.22	14799.23	893.66	23141.39	896.58
322	440.32	858.1	5630	880.36	9674.13	887.44	9813.53	889.34	9889.18	890.45	9931.54	891.47	11002.81	892.22	14799.23	893.66	23141.39	896.57
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	5630	880.4	9674.13	887.54	9813.53	889.41	9889.18	890.5	9931.54	891.51	11002.81	892.25	14799.23	893.7	23141.39	896.62
325	440.34	857	5630	880.41	9674.13	887.55	9813.53	889.41	9889.18	890.51	9931.54	891.51	11002.81	892.26	14799.23	893.7	23141.39	896.62
326	440.54	858	5630	880.46	9674.13	887.6	9813.53	889.45	9889.18	890.54	9931.54	891.54	11002.81	892.29	14799.23	893.75	23141.39	896.71
327	441.53	859	5600	880.84	9629.13	887.84	9758.53	889.62	9824.18	890.68	9871.54	891.66	10932.81	892.41	14724.56	893.93	23063.66	897.01
328	442.14	858	5600	881.05	9629.13	887.98	9758.53	889.72	9824.18	890.76	9871.54	891.73	10976.09	892.49	15395.08	894.04	25148.86	897.2
329	442.45	857	5600	881.11	9629.13	887.99	9758.53	889.73	9824.18	890.77	9871.54	891.73	11045.61	892.5	16190.31	894.05	26957	897.2
329.5	442.93	858.06	5600	881.26	9628.13	888.09	9757.53	889.8	9837.27	890.82	9909.81	891.77	11044.73	892.54	16248.62	894.11	27125.26	897.31
330	443.69	858	5600	881.49	9628.13	888.27	9757.53	889.93	9837.27	890.92	9909.81	891.86	11044.73	892.63	16248.62	894.24	27125.26	897.48
331	443.99	859	5600	881.58	9628.13	888.35	9757.53	890	9837.27	890.99	9909.81	891.91	11044.73	892.69	16248.62	894.35	27125.26	897.69
332	444.33	856	5600	881.62	9628.13	888.39	9757.53	890.03	9837.27	891.01	9909.81	891.93	11044.73	892.71	16248.62	894.38	27125.26	897.75
333	444.92	859	5600	881.69	9628.13	888.42	9757.53	890.05	9837.27	891.03	9909.81	891.95	11044.73	892.73	16248.62	894.4	27125.26	897.75
334	445.18	860	5600	881.78	9628.13	888.49	9757.53	890.1	9837.27	891.07	9909.81	891.99	11044.73	892.77	16248.62	894.47	27125.26	897.84
335	445.31	860	5600	881.85	9628.13	888.57	9757.53	890.17	9837.27	891.14	9909.81	892.04	11044.73	892.83	16248.62	894.6	27125.26	898.13
336	445.36	859	5600	881.85	9628.13	888.58	9757.53	890.18	9837.27	891.14	9909.81	892.05	11044.73	892.84	16248.62	894.61	27125.26	898.15
336.5	445.76	857.69	5600	881.88	9628.13	888.6	9757.53	890.2	9837.27	891.16	9909.81	892.06	11044.73	892.86	16248.62	894.64	27125.26	898.19
337	446.09	860	5600	881.91	9628.13	888.6	9757.53	890.19	9837.27	891.16	9909.81	892.06	11044.73	892.85	16248.62	894.63	27125.26	898.17
338	446.29	861	5600	881.98	9628.13	888.63	9757.53	890.21	9837.27	891.17	9909.81	892.07	11044.73	892.86	16248.62	894.64	27125.26	898.18
338.5	446.70	860.9	5600	882.13	9628.13	888.75	9757.53	890.31	9837.27	891.25	9909.81	892.14	11044.73	892.94	16248.62	894.76	27125.26	898.37
339	446.76	861	5600	882.15	9628.13	888.77	9757.53	890.32	9837.27	891.26	9909.81	892.15	11044.73	892.95	16248.62	894.77	27125.26	898.41
340	447.04	860	5600	882.24	9628.13	888.86	9757.53	890.39	9837.27	891.33	9909.81	892.22	11044.73	893.02	16248.62	894.91	27125.26	898.67
341	447.24	859	5600	882.33	9628.13	888.91	9757.53	890.43	9837.27	891.36	9909.81	892.24	11044.73	893.05	16248.62	894.94	27125.26	898.71
342	447.42	861	5600	882.44	9628.13	888.99	9757.53	890.49	9837.27	891.41	9909.81	892.28	11044.73	893.09	16248.62	895.01	27125.26	898.81
342.5	447.78	856.99	5600	882.6	9628.13	889.12	9757.53	890.59	9837.27	891.5	9909.81	892.36	11044.73	893.18	16248.62	895.15	27125.26	899.06
343	448.13	861	5600	882.72	9628.13	889.21	9757.53	890.67	9837.27	891.56	9909.81	892.42	11044.73	893.24	16248.62	895.24	27125.26	899.19
344	448.36	859	5600	882.82	9628.13	889.31	9757.53	890.75	9837.27	891.64	9909.81	892.49	11044.73	893.32	16248.62	895.39	27125.26	899.47
345	448.89	865.3	5600	883.13	9628.13	889.51	9757.53	890.9	9837.27	891.76	9909.81	892.59	11044.73	893.43	16248.62	895.54	27125.26	899.68
348	448.90	864.3	5600	883.13	9628.13	889.49	9757.53	890.88	9837.27	891.74	9909.81	892.58	11044.73	893.41	16248.62	895.51	27125.26	899.62
348.4			North Dam															
348.8	448.90	864.3	5600	883.2	9628.13	889.54	9757.53	890.92	9837.27	891.78	9909.81	892.61	11044.73	893.46	16248.62	895.56	27125.26	899.69
351	448.91	861	5600	883.21	9628.13	889.54	9757.53	890.92	9837.27	891.79	9909.81	892.61	11044.73	893.46	16248.62	895.56	27125.26	899.69
351.4	449.06	861	5600	883.3	9628.13	889.66	9757.53	891.03	9837.27	891.88	9909.81	892.7	11044.73	893.56	16248.62	895.73	27125.26	899.97
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	5600	883.31	9628.13	889.74	9757.53	891.12	9837.27	891.97	9909.81	892.78	11044.73	893.63	16248.62	895.81	27125.26	900.02
352	449.09	862	5600	883.32	9628.13	889.76	9757.53	891.14	9837.27	891.98	9909.81	892.79	11044.73	893.65	16248.62	895.84	27125.26	900.07
353	449.28	863	5600	883.41	9628.13	889.85	9757.53	891.21	9837.27	892.04	9909.81	892.85	11044.73	893.72	16248.62	895.95	27125.26	900.27
353.5	449.61	860.13	5600	883.54	9628.13	889.93	9757.53	891.27	9837.27	892.09	9909.81	892.89	11044.73	893.76	16248.62	896.01	27125.26	900.35
354	449.97	864	5600	883.79	9628.13	890.14	9757.53	891.44	9837.27	892.26	9909.81	893.03	11044.73	893.9	16248.62	896.21	27125.26	900.58
355	450.19	862	5600	883.91	9628.13	890.22	9757.53	891.51	9837.27	892.32	9909.81	893.09	11044.73	893.97	16248.62	896.32	27125.26	900.76
356	450.84	858	5600	884.26	9628.13	890.46	9757.53	891.69	9837.27	892.47	9909.81	893.22	11044.73	894.11	16248.62	896.51	27125.26	900.99
357	450.86	863.4	5600	884.27	9628.13	890.46	9757.53	891.7	9837.27	892.48	9909.81	893.23	11044.73	894.11	16248.62	896.51	27125.26	900.99
358			BNRR Bridge															
359	450.87	863.4	5600	884.35	9628.13	890.55	9757.53	891.76	9837.27	892.53	9909.81	893.27	11044.73	894.15	16248.62	896.56	27125.26	901.19
361	451.20	865	5600	884.5	9628.13	890.66	9757.53	891.85	9837.27	892.61	9909.81	893.34	11044.73	894.23	16248.62	896.67	27125.26	901.35
361.5	451.37	865.2	5600	884.59	9628.13	890.73	9757.53	891.91	9837.27	892.66	9909.81	893.38	11044.73	894.27	16248.62	896.73	27125.26	901.43
362.5			1st Ave. No. Bridge															
364	451.39	865.2	5600	884.61	9628.13	890.75	9757.53	891.93	9837.27	892.67	9909.81	893.39	11044.73	894.28	16248.62	896.75	27125.26	901.53
366	451.41	861	5600	884.65	9628.13	890.79	9757.53	891.96	9837.27	892.7	9909.81	893.42	11044.73	894.31	16248.62	896.78	27125.26	901.57
367	451.57	867	5600	884.72	9628.13	890.89	9757.53	892.05	9837.27	892.79	9909.81	893.51	11044.73	894.41	16248.62	896.97	27125.26	901.91
368	451.61	866.8	5600	884.76	9628.13	890.93	9757.53	892.09	9837.27	892.82	9909.81	893.53	11044.73	894.44	16248.62	897.01	27125.26	901.97
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	5600	884.77	9628.13	890.94	9757.53	892.09	9837.27	892.83	9909.81	893.54	11044.73	894.44	16248.62	897.04	27125.26	902.04
371	451.65	859	5600	884.79	9628.13	890.94	9757.53	892.09	9837.27	892.83	9909.81	893.54	11044.73	894.44	16248.62	897.03	27125.26	902.01
372	451.67	867.9	5600	884.78	9628.13	890.93	9757.53	892.08	9837.27	892.82	9909.81	893.53	11044.73	894.43	16248.62	897.02	27125.26	902.02
373			BNRR Bridge															
374	451.68	867.9	5600	884.89	9628.13	891.02	9757.53	892.16	9837.27	892.89	9909.81	893.59	11044.73	894.49	16248.62	897.08	27125.26	902.07
375	451.69	864	5600	884.9	9628.13	891.02	9757.53	892.16	9837.27	892.89	9909.81	893.59	11044.73	894.49	16248.62	897.07	27125.26	902.05
376	451.71	865.9	5600	884.9	9628.13	891.04	9757.53	892.18	9837.27	892.9	9909.81	893.61	11044.73	894.52	16248.62	897.14	27125.26	902.2
377			Main Ave. Bridge															
378	451.72	865.9	5600	884.93	9628.13	891.05	9757.53	892.19	9837.27	892.91	9909.81	893.62	11044.73	894.53	16248.62	897.16	27125.26	902.26
379	451.73	864	5600	885.01	9628.13	891.14	9757.53	892.26	9837.27	892.98	9909.81	893.68	11044.73	894.59	16248.62	897.24	27125.26	902.35
380	451.85	864	5600	885	9628.13	891.11	9757.53	892.24	9837.27	892.96	9909.81	893.66	11044.73	894.57	16248.62	897.21	27125.26	902.33
381	452.03	863	5600	885.12	9628.13	891.26	9757.53	892.37	9837.27	893.08	9909.81	893.76	11044.73	894.69	16248.62	897.38	27125.26	902.53
381.5	452.04	863	5600	885.13	9628.13	891.27	9757.53	892.38	9837.27	893.09	9909.81	893.77	11044.73	894.7	16248.62	897.39	27125.26	902.55
384			Midtown Dam															
385.5	452.05	867	5600	885.15	9628.13	891.28	9757.53	892.38	9837.27	893.09	9909.81	893.78	11044.73	894.7	16248.62	897.4	27125.26	902.56
386	452.06	867	5600	885.15	9628.13	891.28	9757.53	892.39	9837.27	893.1	9909.81	893.78	11044.73	894.71	16248.62	897.4	27125.26	902.57
387	452.25	867	5600	885.26	9628.13	891.34	9757.53	892.43	9837.27	893.14	9909.81	893.82	11044.73	894.74	16248.62	897.45	27125.26	902.62
388	452.46	869	5600	885.42	9628.13	891.44	9757.53	892.52	9837.27	893.21	9909.81	893.88	11044.73	894.81	16248.62	897.55	27125.26	902.77
389	452.70	866.08	5600	885.65	9628.13	891.6	9757.53	892.65	9837.27	893.33	9909.81	893.99	11044.73	894.92	16248.62	897.69	27125.26	902.95
390	452.94	867	5600	885.77	9628.13	891.69	9757.53	892.72	9837.27	893.39	9909.81	894.05	11044.73	894.98	16248.62	897.77	27125.26	903.05
391	453.16	867	5600	885.89	9628.13	891.79	9757.53	892.81	9837.27	893.47	9909.81	894.11	11044.73	895.05	16248.62	897.87	27125.26	903.18
392	453.39	865	5600	886	9628.13	891.87	9757.53	892.88	9837.27	893.54	9909.81	894.18	11044.73	895.12	16248.62	897.98	27125.26	903.34
393	454.02	866	5600	886.34	9628.13	892.11	9757.53	893.07	9837.27	893.7	9909.81	894.32	11044.73	895.27	16248.62	898.15	27125.26	903.51
394	454.10	865	5600	886.38	9628.13	892.15	9757.53	893.1	9837.27	893.73	9909.81	894.35	11044.73	895.3	16248.62	898.18	27125.26	903.53
395	454.75	864	5600	886.66	9628.13	892.36	9757.53	893.29	9837.27	893.9	9909.81	894.5	11044.73	895.45	16248.62	898.37	27125.26	903.74
396	455.16	866	5600	886.86	9628.13	892.56	9757.53	893.46	9837.27	894.05	9909.81	894.64	11044.73	895.6	16248.62	898.56	27125.26	903.9
397	455.20	866.6	5600	886.9	9628.13	892.6	9757.53	893.49	9837.27	894.08	9909.81	894.66	11044.73	895.62	16248.62	898.59	27125.26	903.94
399			I-94 Bridge															
401	455.23	866.6	5600	886.9	9628.13	892.6	9757.53	893.49	9837.27	894.08	9909.81	894.66	11044.73	895.62	16248.62	898.59	27125.26	903.94
402	455.28	865	5600	886.93	9628.13	892.62	9757.53	893.5	9837.27	894.09	9909.81	894.67	11044.73	895.63	16248.62	898.61	27125.26	903.96
402.5	455.52	864.58	5600	887.05	9628.13	892.74	9757.53	893.6	9837.27	894.19	9909.81	894.76	11044.73	895.72	16248.62	898.72	27125.26	904.09
403	455.59	866	5600	887.08	9628.13	892.77	9757.53	893.64	9837.27	894.22	9909.81	894.79	11044.73	895.75	16248.62	898.75	27125.26	904.16
404	455.92	865	5600	887.22	9628.13	892.89	9757.53	893.74	9837.27	894.31	9909.81	894.87	11044.73	895.84	16248.62	898.89	27125.26	904.34
405	456.65	865	5600	887.57	9628.13	893.14	9757.53	893.95	9837.27	894.5	9909.81	895.04	11044.73	896.01	16248.62	899.08	27125.26	904.51
406	457.09	866	5600	887.79	9628.13	893.33	9757.53	894.11	9837.27	894.65	9909.81	895.18	11044.73	896.15	16248.62	899.25	27125.26	904.72
407	457.27	861.18	5600	887.86	9628.13	893.38	9757.53	894.16	9837.27	894.69	9909.81	895.22	11044.73	896.18	16248.62	899.29	27125.26	904.74
408	457.80	864	5600	888.07	9628.13	893.61	9757.53	894.36	9837.27	894.88	9909.81	895.39	11044.73	896.37	16248.62	899.54	27125.26	905.08
409	457.95	855.9	5600	888.14	9628.13	893.7	9757.53	894.45	9837.27	894.96	9909.81	895.47	11044.73	896.45	16248.62	899.64	27125.26	905.16
409.1	457.97	855.9	5600	888.14	9628.13	893.7	9757.53	894.45	9837.27	894.96	9909.81	895.47	11044.73	896.45	16248.62	899.64	27125.26	905.17

Table B17

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year Zero - Wet, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
409.5			South Dam															
409.6	457.98	855.9	5600	888.19	9628.13	893.74	9757.53	894.48	9837.27	895	9909.81	895.5	11044.73	896.48	16248.62	899.67	27125.26	905.2
409.7	457.99	855.9	5600	888.19	9628.13	893.74	9757.53	894.49	9837.27	895	9909.81	895.5	11044.73	896.48	16248.62	899.67	27125.26	905.2
413	458.32	869	5600	888.2	9628.13	893.76	9757.53	894.51	9837.27	895.02	9909.81	895.52	11044.73	896.51	16248.62	899.71	27125.26	905.24
414	458.75	866	5600	888.47	9628.13	894.02	9757.53	894.74	9837.27	895.24	9909.81	895.73	11044.73	896.72	16248.62	899.99	27125.26	905.61
459.64	459.64	864.81	5600	888.9	9628.13	894.44	9757.53	895.11	9837.27	895.58	9909.81	896.03	11044.73	897.03	16248.62	900.33	27125.26	905.92
460.28	460.28	868.74	5600	889.28	9628.13	894.77	9757.53	895.4	9837.27	895.85	9909.81	896.29	11044.73	897.28	16248.62	900.62	27125.26	906.19
460.72	460.72	869.04	5600	889.58	9628.13	895.02	9757.53	895.64	9837.27	896.06	9909.81	896.49	11044.73	897.49	16248.62	900.88	27125.26	906.5
461.3	461.3	868.04	5600	889.99	9628.13	895.4	9757.53	895.98	9837.27	896.38	9909.81	896.79	11044.73	897.8	16248.62	901.26	27125.26	906.92
462.03	462.03	864.16	5600	890.38	9628.13	895.78	9757.53	896.33	9837.27	896.71	9909.81	897.1	11044.73	898.12	16248.62	901.62	27125.26	907.29
462.04	462.04	869.5	5600	890.42	9628.13	895.82	9757.53	896.36	9837.27	896.75	9909.81	897.12	11044.73	898.14	16248.62	901.64	27125.26	907.33
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	5600	890.42	9628.13	895.83	9757.53	896.37	9837.27	896.75	9909.81	897.13	11044.73	898.15	16248.62	901.66	27125.26	907.37
462.07	462.07	871.5	5600	890.46	9628.13	895.86	9757.53	896.39	9837.27	896.78	9909.81	897.15	11044.73	898.18	16248.62	901.69	27125.26	907.36
462.7	462.7	862.82	5600	890.81	9628.13	896.17	9757.53	896.69	9837.27	897.05	9909.81	897.41	11044.73	898.44	16248.62	901.98	27125.26	907.68
463.7	463.7	864.71	5600	891.18	9628.13	896.57	9757.53	897.06	9837.27	897.41	9909.81	897.76	11044.73	898.8	16248.62	902.41	27125.26	908.11
464.2	464.2	869.2	5600	891.44	9628.13	896.84	9757.53	897.32	9837.27	897.66	9909.81	897.99	11044.73	899.04	16248.62	902.71	27125.26	908.47
464.6	464.6	865	5600	891.64	9628.13	897.03	9757.53	897.5	9837.27	897.82	9909.81	898.15	11044.73	899.21	16248.62	902.88	27125.26	908.63
465.1	465.1	862.9	5600	891.84	9628.13	897.27	9757.53	897.72	9837.27	898.04	9909.81	898.36	11044.73	899.43	16248.62	903.19	27125.26	908.98
465.9	465.9	865.6	5600	892.14	9628.13	897.61	9757.53	898.04	9837.27	898.35	9909.81	898.66	11044.73	899.75	16248.62	903.56	27125.26	909.27
466.4	466.4	865.6	5600	892.35	9628.13	897.83	9757.53	898.26	9837.27	898.56	9909.81	898.86	11044.73	899.96	16248.62	903.79	27125.26	909.51
466.5	466.5	864.9	5600	892.39	9628.13	897.88	9757.53	898.31	9837.27	898.61	9909.81	898.91	11044.73	900.01	16248.62	903.85	27125.26	909.54
466.9	466.9	865	5600	892.45	9628.13	897.96	9757.53	898.38	9837.27	898.68	9909.81	898.97	11044.73	900.07	16248.62	903.92	27125.26	909.58
467			Proposed Red River Closure Structure															
467.1	467.1	865	5600	892.49	9628.13	901.16	9757.53	904.75	9837.27	907.06	9909.81	909.71	11044.73	911.03	16248.62	912.32	27125.26	913.76
467.2	467.2	864.8	5600	892.48	9628.13	901.16	9757.53	904.76	9837.27	907.07	9909.81	909.73	11044.73	911.04	16248.62	912.36	27125.26	913.87
467.3	467.3	864.8	5600	892.52	9628.13	901.18	9757.53	904.77	9837.27	907.08	9909.81	909.73	11044.73	911.05	16248.62	912.37	27125.26	913.91
467.4	467.4	864.8	5600	892.78	9628.13	901.35	9757.53	904.88	9837.27	907.16	9909.81	909.78	11044.73	911.1	16248.62	912.46	27125.26	914.1
468.2	468.2	862.6	5600	893.05	11276.93	901.55	14279.39	905.01	17683.42	907.26	23006.7	909.86	27015.66	911.18	35510.02	912.57	47229.36	914.29
468.9	468.9	861	5600	893.3	11276.93	901.79	14279.39	905.23	17683.42	907.43	23006.7	910	27015.66	911.32	35510.02	912.74	47229.36	914.48
469.7	469.7	870	5600	893.67	11276.93	902.1	14279.39	905.46	17683.42	907.6	23006.7	910.13	27015.66	911.43	35510.02	912.87	47229.36	914.62
470.1	470.1	870.9	5600	893.85	11276.93	902.25	14279.39	905.6	17683.42	907.74	23006.7	910.23	27015.66	911.52	35510.02	912.97	47229.36	914.73
470.6	470.6	869.4	4166	894.03	8255.93	902.41	8093.39	905.74	9034.42	907.89	11349.7	910.38	13233.66	911.66	19707.01	913.12	28885.36	914.9
471.4	471.4	867.5	4166	894.28	8078.93	902.63	8070.39	905.85	9136.42	907.98	11578.7	910.44	13511.66	911.71	19562.01	913.19	27914.36	914.99
472.18	472.18	869.9	4166	894.54	8078.93	902.84	8070.39	905.97	9136.42	908.09	11578.7	910.52	13511.66	911.78	19562.01	913.28	27914.36	915.09
472.2	472.2	870.8	4166	894.54	8078.93	902.84	8070.39	905.97	9136.42	908.08	11578.7	910.51	13511.66	911.77	19562.01	913.27	27914.36	915.08
472.22	472.22	870.8	4166	894.55	8078.93	902.85	8070.39	905.98	9136.42	908.09	11578.7	910.54	13511.66	911.81	19562.01	913.32	27914.36	915.14
473	473	871.8	4166	894.8	8078.93	903.03	8070.39	906.08	9136.42	908.18	11578.7	910.61	13511.66	911.87	19562.01	913.4	27914.36	915.23
473.8	473.8	869	4166	895.07	8078.93	903.27	8070.39	906.22	9136.42	908.3	11578.7	910.72	13511.66	911.98	19562.01	913.54	27914.36	915.39
474.08	474.08	873.5	4166	895.17	8078.93	903.36	8070.39	906.28	9136.42	908.35	11578.7	910.77	13511.66	912.03	19562.01	913.6	27914.36	915.46
474.09	474.09	873.5	4166	895.19	8078.93	903.39	8070.39	906.3	9136.42	908.37	11578.7	910.79	13511.66	912.05	19562.01	913.63	27914.36	915.48
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	4166	895.19	8078.93	903.38	8070.39	906.29	9136.42	908.36	11578.7	910.78	13511.66	912.06	19562.01	913.69	27914.36	915.59
474.12	474.12	874	4166	895.2	8078.93	903.39	8070.39	906.3	9136.42	908.37	11578.7	910.79	13511.66	912.08	19562.01	913.7	27914.36	915.6
474.6	474.6	873.4	4166	895.39	8078.93	903.52	8070.39	906.38	9136.42	908.44	11578.7	910.87	13511.66	912.16	19562.01	913.79	27914.36	915.71
475.3	475.3	872.2	4166	895.66	8952	903.78	10791	906.56	13453	908.63	17872	911.07	21196	912.37	30252	914.09	42385	916.05
475.7	475.7	871	4166	895.81	8952	903.95	10791	906.73	13453	908.85	17872	911.35	21196	912.72	30252	914.45	42385	916.25
476.4	476.4	873.7	4166	896.08	8952	904.2	10791	906.95	13453	909.09	17872	911.6	21196	912.95	30252	914.72	42385	916.46
477	477	874	4021	896.35	7227	904.45	10537	907.2	14618	909.37	20566	911.91	24472	913.27	28720	915.02	33177	916.75
477.6	477.6	870.2	4000	896.54	7000	904.61	10500	907.43	14800	909.7	21000	912.34	25000	913.76	28500	915.4	32000	917.02
478	478	873.4	4000	896.68	7000	904.71	10500	907.57	14800	909.89	21000	912.6	25000	913.99	28500	915.6	32000	917.1
478.8	478.8	874.8	4000	896.91	7000	904.9	10500	907.83	14800	910.25	21000	913.1	25000	914.48	28500	915.99	32000	917.26
479.2	479.2	875.7	4000	897.03	7000	904.99	10500	907.95	14800	910.41	21000	913.3	25000	914.67	28500	916.14	32000	917.35
479.7	479.7	871.5	4000	897.21	7000	905.1	10500	908.11	14800	910.61	21000	913.53	25000	914.92	28500	916.36	32000	917.49
480.5	480.5	874.7	4000	897.48	7000	905.3	10500	908.39	14800	910.97	21000	913.93	25000	915.31	28500	916.69	32000	917.78
481.8	481.8	875.3	4000	897.88	7000	905.64	10500	908.84	14800	911.5	21000	914.52	25000	915.95	28500	917.21	32000	918.25
482.3	482.3	874.2	4000	898.09	7000	905.82	10500	909.09	14800	911.83	21000	914.85	25000	916.3	28500	917.43	32000	918.42
482.698	482.698	869.74	4000	898.2	7000	905.92	10500	909.22	14800	911.98	21000	915.04	25000	916.52	28500	917.62	32000	918.59
482.7	482.7	887.04	4000	898.1	7000	905.86	10500	909.15	14800	911.9	21000	914.98	25000	916.47	28500	917.61	32000	918.63
482.702	482.702	878.54	4000	898.23	7000	905.93	10500	909.22	14800	911.99	21000	915.03	25000	916.52	28500	917.62	32000	918.62
483.1	483.1	879.2	4000	898.47	7000	906.12	10500	909.48	14800	912.32	21000	915.43	25000	916.87	28500	917.86	32000	918.76
483.9	483.9	873	4000	898.87	7000	906.39	10500	909.83	14800	912.77	21000	915.98	25000	917.33	28500	918.31	32000	919.15
485.08	485.08	880.5	4000	899.38	7000	906.62	10500	910.08	14800	913.04	21000	916.28	25000	917.65	28500	918.63	32000	919.46
485.09	485.09	880.5	4000	899.38	7000	906.61	10500	910.08	14800	913.04	21000	916.28	25000	917.64	28500	918.63	32000	919.46
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	4000	899.39	7000	906.63	10500	910.19	14800	913.15	21000	916.33	25000	917.69	28500	918.66	32000	919.49
485.12	485.12	879.4	4000	899.4	7000	906.66	10500	910.19	14800	913.15	21000	916.34	25000	917.7	28500	918.67	32000	919.5
485.6	485.6	878.62	4000	899.58	7000	906.77	10500	910.29	14800	913.24	21000	916.43	25000	917.79	28500	918.78	32000	919.61
485.9	485.9	879.5	4000	899.75	7000	906.88	10500	910.42	14800	913.4	21000	916.61	25000	918.01	28500	919.01	32000	919.83
486.3	486.3	872.1	4000	899.91	7000	907	10500	910.57	14800	913.58	21000	916.83	25000	918.26	28500	919.29	32000	920.12
487	487	871.3	4000	900.12	7000	907.18	10500	910.8	14800	913.89	21000	917.26	25000	918.77	28500	919.87	32000	920.76
487.5	487.5	878.8	4000	900.36	7000	907.36	10500	911.01	14800	914.13	21000	917.53	25000	919.07	28500	920.2	32000	921.07
488.68	488.68	878.24	4000	901.05	7000	907.87	10500	911.64	14800	914.93	21000	918.42	25000	920.03	28500	921.23	32000	922.21

Table B18

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	8950	861.67	18490	870.2	26120	873.73	34240	875.7	45780	876.86	55200	877.69	66177.08	878.58	82930	879.41
280	404.98	836.6	8950	862.33	18490	870.94	26120	874.31	34240	876.38	45780	877.66	55200	878.49	66177.08	879.38	82930	880.24
281	406.51	834.9	8950	863.21	18490	871.84	26120	875.33	34240	877.45	45780	878.67	55200	879.48	66177.08	880.19	82930	881.14
282	410.21	838	8950	865.13	18490	873.73	26120	877.12	34240	879.09	45780	879.9	55200	880.64	66177.08	881.44	82930	882.51
283	413.23	837.6	8950	866.44	18490	875.11	26120	878.49	34240	880.2	45780	881.15	55200	881.59	66177.08	882.44	82930	883.58
284	414.98	842.7	8200	867.17	17400	876.04	24700	879.61	32440	881.11	43410	882.04	52310	882.6	62987.08	883.48	79530	884.65
285	415.38	841.4	8200	867.35	17400	876.26	24700	879.85	32440	881.31	43410	882.29	52310	882.83	62987.08	883.72	79530	884.9
286	415.84	843	8200	867.48	17400	876.34	24700	879.9	32440	881.35	43410	882.38	52310	882.97	62987.08	883.87	79530	885.17
287	415.90	844.1	8200	867.53	17400	876.41	24700	880.01	32440	881.55	43410	882.52	52310	883.1	62987.08	883.98	79530	885.23
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	8200	867.53	17400	876.4	24700	880	32440	881.57	43410	882.63	52310	883.29	62987.08	884.42	79530	885.46
290	415.93	837.5	8200	867.55	17400	876.42	24700	880.02	32440	881.58	43410	882.72	52310	883.39	62987.08	884.43	79530	885.5
291	417.10	840.8	8200	867.97	17400	876.89	24700	880.6	32440	882.37	43410	883.63	52310	884.41	62987.08	885.17	79530	886.13
292	418.18	844.4	7124	868.38	14681	877.36	20664	881.13	27055	882.89	36261	884.24	43687	885.01	54141.08	885.66	70317	886.67
293	419.92	844.7	7124	869.15	14681	878.16	20664	881.86	27055	883.52	36261	884.9	43687	885.49	54141.08	886.2	70317	887.26
294	420.32	843.8	7124	869.42	14681	878.39	20664	882.14	27055	883.85	36261	885.3	43687	885.98	54141.08	886.7	70317	887.74
295	421.93	845.3	7124	870.63	14681	879.47	20664	883.08	27055	884.63	36261	886.04	43687	886.75	54141.08	887.57	70317	888.36
296	422.69	847.4	7124	870.95	14681	879.8	20664	883.37	27055	884.87	36261	886.25	43687	886.97	54141.08	887.88	70317	888.68
297	423.95	849.5	7124	871.49	14681	880.39	20664	884.07	27055	885.78	36261	887.36	43687	888.24	54141.08	888.83	70317	889.75
298	425.51	848.7	7124	872.22	14681	881.11	20664	884.78	27055	886.48	36261	888.09	43687	889.03	54141.08	889.27	70317	890.25
299	426.87	851.1	7124	872.92	14681	881.76	20664	885.43	27055	887.2	36261	888.9	43687	889.62	54141.08	890.07	70317	890.83
300	428.06	849.6	4864	873.48	10430.06	882.35	10704.88	885.95	11103.7	887.69	10146.55	889.36	9483.57	890.12	13805.42	890.37	22390.43	891.19
301	428.74	850.3	4864	873.76	10430.06	882.63	10704.88	886.12	11103.7	887.82	10146.55	889.43	9483.57	890.17	13805.42	890.46	22390.43	891.28
302	430.23	852	4864	874.35	10430.06	883.1	10704.88	886.41	11103.7	888.06	10146.55	889.59	9483.57	890.29	13805.42	890.69	22390.43	891.48
303	431.94	853.5	4864	875.15	10430.06	883.78	10704.88	886.82	11103.7	888.4	10613.41	889.79	11849.72	890.46	16670.2	891.01	24061.47	892.08
303.4	432.07	853.42	4572	875.2	9987.06	883.84	10139.88	886.88	10288.7	888.45	9529.77	889.83	10160.58	890.5	14815.88	891.06	22060.58	892.12
303.5	432.10	853.46	4572	875.23	9987.06	883.87	10139.88	886.9	10288.7	888.46	9721.8	889.84	9921.79	890.51	14528.41	891.09	21718.56	892.17
303.8	432.53	854.5	4572	875.4	9987.06	884.03	10139.88	886.99	10288.7	888.54	10076.98	889.9	9283.7	890.57	13870.71	891.23	20763.58	892.42
304	432.84	855.5	4572	875.49	9988.06	884.12	10140.88	887.04	10278.64	888.57	9988.1	889.92	9058.88	890.59	13472.3	891.25	18155.42	892.47
305	433.26	854.4	4572	875.66	9988.06	884.28	10140.88	887.15	10278.64	888.65	10243.04	889.98	9587.65	890.63	12786.45	891.32	17836.17	892.55
306	433.35	855	4572	875.73	9988.06	884.36	10140.88	887.2	10278.64	888.7	10283.77	890.02	9715.33	890.66	12623.87	891.38	17760	892.57
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	4572	875.74	9988.06	884.37	10140.88	887.21	10278.64	888.71	10283.77	890.03	9715.33	890.66	12623.87	891.38	17760	892.6
309	433.83	854.5	4572	875.88	9988.06	884.52	10140.88	887.31	10278.64	888.79	10283.77	890.1	9715.33	890.72	12623.87	891.48	17760	892.73
310	434.61	852.8	4572	876.14	9988.06	884.74	10140.88	887.45	10278.64	888.91	10283.77	890.19	9715.33	890.8	12623.87	891.59	17760	892.9
310.5	435.70	855	4572	876.5	9988.06	885.08	10140.88	887.67	10278.64	889.08	10283.77	890.33	9715.33	890.92	12623.87	891.79	17760	893.21
311	436.34	855	4572	876.73	9988.06	885.31	10140.88	887.83	10268.28	889.22	10253.33	890.45	10251.99	891.03	13818.73	891.96	18262.22	893.46
312	437.05	863.83	4372	876.97	9693.06	885.56	9750.88	888.01	9853.28	889.38	9813.33	890.59	9801.99	891.16	13283.73	892.17	17816.13	893.75
313	437.95	856	4372	877.32	9692.06	885.94	9749.88	888.28	9863.34	889.6	9902.21	890.78	10026.81	891.34	13682.14	892.44	20295.38	894.16
314	438.78	857	4372	877.66	9692.06	886.28	9749.88	888.52	9863.34	889.81	9902.21	890.95	10026.81	891.5	13682.14	892.69	20295.38	894.61
315	439.05	856	4372	877.75	9692.06	886.38	9749.88	888.59	9863.34	889.87	9902.21	891	10026.81	891.55	13682.14	892.78	20295.38	894.78
316	439.46	855.1	4372	877.91	9692.06	886.58	9749.88	888.74	9863.34	890	9902.21	891.12	10026.81	891.67	13682.14	892.97	19900.53	895.13
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	4372	877.92	9692.06	886.58	9749.88	888.75	9863.34	890	9902.21	891.12	10026.81	891.67	13682.14	892.97	19900.53	895.12
319	439.50	857	4372	877.93	9692.06	886.63	9749.88	888.79	9863.34	890.04	9902.21	891.16	10026.81	891.7	13682.14	893.01	19900.53	895.18
320	439.66	856	4372	877.99	9692.06	886.69	9749.88	888.83	9863.34	890.08	9902.21	891.19	10026.81	891.72	13682.14	893.05	19900.53	895.25
321	440.31	858	4372	878.2	9692.06	886.94	9749.88	889.01	9863.34	890.23	9902.21	891.32	10026.81	891.86	13682.14	893.26	19900.53	895.58
322	440.32	858.1	4372	878.2	9692.06	886.93	9749.88	889.01	9863.34	890.23	9902.21	891.32	10026.81	891.85	13682.14	893.26	19900.53	895.58
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	4372	878.22	9692.06	887.04	9749.88	889.08	9863.34	890.28	9902.21	891.36	10026.81	891.89	13682.14	893.3	19900.53	895.62
325	440.34	857	4372	878.22	9692.06	887.05	9749.88	889.09	9863.34	890.29	9902.21	891.36	10026.81	891.89	13682.14	893.3	19900.53	895.62
326	440.54	858	4372	878.27	9692.06	887.1	9749.88	889.12	9863.34	890.32	9902.21	891.39	10026.81	891.92	13682.14	893.34	19900.53	895.69
327	441.53	859	4352	878.66	9647.06	887.37	9694.88	889.3	9803.34	890.46	9837.21	891.51	9956.81	892.03	13607.14	893.51	19805.53	895.96
328	442.14	858	4352	878.86	9647.06	887.52	9694.88	889.41	9803.34	890.55	9837.21	891.58	9956.81	892.1	13848.37	893.61	21058.39	896.11
329	442.45	857	4352	878.93	9647.06	887.54	9694.88	889.42	9803.34	890.56	9837.21	891.59	9994.46	892.1	14334.29	893.61	22432.78	896.12
329.5	442.93	858.06	4352	879.08	9646.06	887.65	9693.88	889.49	9812.94	890.61	9872.9	891.63	10025.81	892.14	14350.13	893.67	22531.17	896.2
330	443.69	858	4352	879.32	9646.06	887.84	9693.88	889.63	9812.94	890.72	9872.9	891.72	10025.81	892.22	14350.13	893.78	22531.17	896.35
331	443.99	859	4352	879.4	9646.06	887.93	9693.88	889.7	9812.94	890.78	9872.9	891.77	10025.81	892.27	14350.13	893.87	22531.17	896.5
332	444.33	856	4352	879.45	9646.06	887.97	9693.88	889.73	9812.94	890.81	9872.9	891.79	10025.81	892.29	14350.13	893.9	22531.17	896.55
333	444.92	859	4352	879.53	9646.06	888	9693.88	889.76	9812.94	890.83	9872.9	891.81	10025.81	892.31	14350.13	893.92	22531.17	896.55
334	445.18	860	4352	879.61	9646.06	888.08	9693.88	889.81	9812.94	890.87	9872.9	891.85	10025.81	892.34	14350.13	893.98	22531.17	896.64
335	445.31	860	4352	879.67	9646.06	888.16	9693.88	889.88	9812.94	890.94	9872.9	891.91	10025.81	892.4	14350.13	894.08	22531.17	896.85
336	445.36	859	4352	879.68	9646.06	888.17	9693.88	889.89	9812.94	890.95	9872.9	891.91	10025.81	892.41	14350.13	894.09	22531.17	896.87
336.5	445.76	857.69	4352	879.71	9646.06	888.2	9693.88	889.91	9812.94	890.96	9872.9	891.93	10025.81	892.42	14350.13	894.11	22531.17	896.9
337	446.09	860	4352	879.75	9646.06	888.2	9693.88	889.9	9812.94	890.96	9872.9	891.92	10025.81	892.42	14350.13	894.11	22531.17	896.89
338	446.29	861	4352	879.82	9646.06	888.23	9693.88	889.92	9812.94	890.97	9872.9	891.93	10025.81	892.42	14350.13	894.11	22531.17	896.9
338.5	446.70	860.9	4352	879.97	9646.06	888.37	9693.88	890.02	9812.94	891.06	9872.9	892.01	10025.81	892.49	14350.13	894.22	22531.17	897.07
339	446.76	861	4352	879.99	9646.06	888.38	9693.88	890.03	9812.94	891.07	9872.9	892.01	10025.81	892.5	14350.13	894.23	22531.17	897.08
340	447.04	860	4352	880.08	9646.06	888.47	9693.88	890.11	9812.94	891.14	9872.9	892.08	10025.81	892.56	14350.13	894.34	22531.17	897.29
341	447.24	859	4352	880.16	9646.06	888.53	9693.88	890.15	9812.94	891.17	9872.9	892.11	10025.81	892.59	14350.13	894.37	22531.17	897.33
342	447.42	861	4352	880.28	9646.06	888.62	9693.88	890.21	9812.94	891.22	9872.9	892.15	10025.81	892.63	14350.13	894.43	22531.17	897.42
342.5	447.78	856.99	4352	880.43	9646.06	888.75	9693.88	890.32	9812.94	891.31	9872.9	892.23	10025.81	892.7	14350.13	894.55	22531.17	897.62
343	448.13	861	4352	880.56	9646.06	888.86	9693.88	890.4	9812.94	891.38	9872.9	892.28	10025.81	892.76	14350.13	894.63	22531.17	897.74
344	448.36	859	4352	880.66	9646.06	888.96	9693.88	890.48	9812.94	891.45	9872.9	892.35	10025.81	892.83	14350.13	894.75	22531.17	897.96
345	448.89	865.3	4352	881.01	9646.06	889.18	9693.88	890.64	9812.94	891.58	9872.9	892.46	10025.81	892.93	14350.13	894.89	22531.17	898.15
348	448.90	864.3	4352	881	9646.06	889.16	9693.88	890.62	9812.94	891.57	9872.9	892.44	10025.81	892.91	14350.13	894.86	22531.17	898.1
348.4			North Dam															
348.8	448.90	864.3	4352	881.07	9646.06	889.22	9693.88	890.66	9812.94	891.61	9872.9	892.48	10025.81	892.95	14350.13	894.91	22531.17	898.15
351	448.91	861	4352	881.09	9646.06	889.22	9693.88	890.66	9812.94	891.61	9872.9	892.48	10025.81	892.95	14350.13	894.91	22531.17	898.15
351.4	449.06	861	4352	881.17	9646.06	889.35	9693.88	890.77	9812.94	891.71	9872.9	892.57	10025.81	893.04	14350.13	895.05	22531.17	898.38
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	4352	881.17	9646.06	889.43	9693.88	890.86	9812.94	891.79	9872.9	892.65	10025.81	893.11	14350.13	895.13	22531.17	898.44
352	449.09	862	4352	881.19	9646.06	889.45	9693.88	890.88	9812.94	891.81	9872.9	892.66	10025.81	893.12	14350.13	895.16	22531.17	898.48
353	449.28	863	4352	881.27	9646.06	889.54	9693.88	890.95	9812.94	891.87	9872.9	892.72	10025.81	893.18	14350.13	895.25	22531.17	898.65
353.5	449.61	860.13	4352	881.4	9646.06	889.63	9693.88	891.01	9812.94	891.92	9872.9	892.76	10025.81	893.22	14350.13	895.3	22531.17	898.72
354	449.97	864	4352	881.65	9646.06	889.85	9693.88	891.19	9812.94	892.09	9872.9	892.91	10025.81	893.35	14350.13	895.48	22531.17	898.93
355	450.19	862	4352	881.79	9646.06	889.93	9693.88	891.26	9812.94	892.15	9872.9	892.97	10025.81	893.41	14350.13	895.58	22531.17	899.09
356	450.84	858	4352	882.17	9646.06	890.19	9693.88	891.45	9812.94	892.31	9872.9	893.1	10025.81	893.54	14350.13	895.75	22531.17	899.31
357	450.86	863.4	4352	882.18	9646.06	890.19	9693.88	891.45	9812.94	892.32	9872.9	893.1	10025.81	893.54	14350.13	895.75	22531.17	899.31
358			BNRR Bridge															
359	450.87	863.4	4352	882.25	9646.06	890.29	9693.88	891.53	9812.94	892.37	9872.9	893.15	10025.81	893.58	14350.13	895.79	22531.17	899.46
361	451.20	865	4352	882.4	9646.06	890.41	9693.88	891.62	9812.94	892.45	9872.9	893.22	10025.81	893.65	14350.13	895.89	22531.17	899.59
361.5	451.37	865.2	4352	882.5	9646.06	890.48	9693.88	891.68	9812.94	892.5	9872.9	893.26	10025.81	893.69	14350.13	895.94	22531.17	899.66
362.5			1st Ave. No. Bridge															
364	451.39	865.2	4352	882.52	9646.06	890.5	9693.88	891.69	9812.94	892.52	9872.9	893.27	10025.81	893.7	14350.13	895.95	22531.17	899.7
366	451.41	861	4352	882.56	9646.06	890.54	9693.88	891.73	9812.94	892.55	9872.9	893.3	10025.81	893.72	14350.13	895.99	22531.17	899.73
367	451.57	867	4352	882.62	9646.06	890.64	9693.88	891.82	9812.94	892.64	9872.9	893.39	10025.81	893.81	14350.13	896.14	22531.17	900.02
368	451.61	866.8	4352	882.66	9646.06	890.69	9693.88	891.86	9812.94	892.67	9872.9	893.42	10025.81	893.84	14350.13	896.18	22531.17	900.07
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	4352	882.68	9646.06	890.69	9693.88	891.86	9812.94	892.68	9872.9	893.42	10025.81	893.84	14350.13	896.18	22531.17	900.1
371	451.65	859	4352	882.7	9646.06	890.69	9693.88	891.86	9812.94	892.67	9872.9	893.42	10025.81	893.84	14350.13	896.18	22531.17	900.08
372	451.67	867.9	4352	882.69	9646.06	890.68	9693.88	891.85	9812.94	892.67	9872.9	893.41	10025.81	893.83	14350.13	896.17	22531.17	900.08
373			BNRR Bridge															
374	451.68	867.9	4352	882.79	9646.06	890.78	9693.88	891.93	9812.94	892.74	9872.9	893.47	10025.81	893.89	14350.13	896.23	22531.17	900.14
375	451.69	864	4352	882.82	9646.06	890.78	9693.88	891.93	9812.94	892.73	9872.9	893.47	10025.81	893.89	14350.13	896.22	22531.17	900.12
376	451.71	865.9	4352	882.82	9646.06	890.79	9693.88	891.95	9812.94	892.75	9872.9	893.49	10025.81	893.91	14350.13	896.27	22531.17	900.23
377			Main Ave. Bridge															
378	451.72	865.9	4352	882.84	9646.06	890.81	9693.88	891.96	9812.94	892.76	9872.9	893.5	10025.81	893.92	14350.13	896.29	22531.17	900.26
379	451.73	864	4352	882.92	9646.06	890.9	9693.88	892.04	9812.94	892.83	9872.9	893.56	10025.81	893.98	14350.13	896.36	22531.17	900.35
380	451.85	864	4352	882.91	9646.06	890.88	9693.88	892.01	9812.94	892.81	9872.9	893.54	10025.81	893.96	14350.13	896.34	22531.17	900.32
381	452.03	863	4352	883.02	9646.06	891.02	9693.88	892.14	9812.94	892.93	9872.9	893.65	10025.81	894.06	14350.13	896.49	22531.17	900.52
381.5	452.04	863	4352	883.03	9646.06	891.04	9693.88	892.15	9812.94	892.94	9872.9	893.66	10025.81	894.07	14350.13	896.5	22531.17	900.53
384			Midtown Dam															
385.5	452.05	867	4352	883.07	9646.06	891.05	9693.88	892.16	9812.94	892.95	9872.9	893.66	10025.81	894.08	14350.13	896.51	22531.17	900.54
386	452.06	867	4352	883.08	9646.06	891.05	9693.88	892.16	9812.94	892.95	9872.9	893.67	10025.81	894.08	14350.13	896.51	22531.17	900.55
387	452.25	867	4352	883.2	9646.06	891.11	9693.88	892.21	9812.94	892.99	9872.9	893.7	10025.81	894.12	14350.13	896.55	22531.17	900.6
388	452.46	869	4352	883.39	9646.06	891.22	9693.88	892.3	9812.94	893.07	9872.9	893.77	10025.81	894.18	14350.13	896.64	22531.17	900.72
389	452.70	866.08	4352	883.64	9646.06	891.39	9693.88	892.43	9812.94	893.19	9872.9	893.88	10025.81	894.28	14350.13	896.77	22531.17	900.89
390	452.94	867	4352	883.76	9646.06	891.48	9693.88	892.51	9812.94	893.25	9872.9	893.93	10025.81	894.34	14350.13	896.85	22531.17	900.99
391	453.16	867	4352	883.89	9646.06	891.59	9693.88	892.59	9812.94	893.33	9872.9	894	10025.81	894.4	14350.13	896.94	22531.17	901.11
392	453.39	865	4352	884.01	9646.06	891.67	9693.88	892.67	9812.94	893.4	9872.9	894.07	10025.81	894.46	14350.13	897.02	22531.17	901.24
393	454.02	866	4352	884.36	9646.06	891.92	9693.88	892.87	9812.94	893.57	9872.9	894.22	10025.81	894.61	14350.13	897.19	22531.17	901.42
394	454.10	865	4352	884.39	9646.06	891.96	9693.88	892.9	9812.94	893.6	9872.9	894.24	10025.81	894.63	14350.13	897.22	22531.17	901.44
395	454.75	864	4352	884.67	9646.06	892.19	9693.88	893.09	9812.94	893.77	9872.9	894.39	10025.81	894.77	14350.13	897.4	22531.17	901.66
396	455.16	866	4352	884.87	9646.06	892.4	9693.88	893.27	9812.94	893.93	9872.9	894.53	10025.81	894.91	14350.13	897.57	22531.17	901.84
397	455.20	866.6	4352	884.91	9646.06	892.43	9693.88	893.3	9812.94	893.96	9872.9	894.56	10025.81	894.93	14350.13	897.59	22531.17	901.88
399			I-94 Bridge															
401	455.23	866.6	4352	884.91	9646.06	892.43	9693.88	893.3	9812.94	893.96	9872.9	894.56	10025.81	894.93	14350.13	897.59	22531.17	901.88
402	455.28	865	4352	884.95	9646.06	892.45	9693.88	893.31	9812.94	893.97	9872.9	894.57	10025.81	894.94	14350.13	897.61	22531.17	901.91
402.5	455.52	864.58	4352	885.06	9646.06	892.57	9693.88	893.42	9812.94	894.06	9872.9	894.65	10025.81	895.02	14350.13	897.71	22531.17	902.02
403	455.59	866	4352	885.09	9646.06	892.61	9693.88	893.45	9812.94	894.09	9872.9	894.68	10025.81	895.05	14350.13	897.74	22531.17	902.05
404	455.92	865	4352	885.23	9646.06	892.73	9693.88	893.56	9812.94	894.19	9872.9	894.77	10025.81	895.14	14350.13	897.86	22531.17	902.23
405	456.65	865	4352	885.6	9646.06	893	9693.88	893.77	9812.94	894.39	9872.9	894.94	10025.81	895.3	14350.13	898.04	22531.17	902.42
406	457.09	866	4352	885.83	9646.06	893.19	9693.88	893.94	9812.94	894.54	9872.9	895.08	10025.81	895.43	14350.13	898.21	22531.17	902.62
407	457.27	861.18	4352	885.91	9646.06	893.25	9693.88	893.99	9812.94	894.58	9872.9	895.12	10025.81	895.47	14350.13	898.25	22531.17	902.65
408	457.80	864	4352	886.1	9646.06	893.48	9693.88	894.19	9812.94	894.77	9872.9	895.3	10025.81	895.64	14350.13	898.47	22531.17	902.96
409	457.95	855.9	4352	886.15	9646.06	893.57	9693.88	894.28	9812.94	894.85	9872.9	895.37	10025.81	895.71	14350.13	898.56	22531.17	903.05
409.1	457.97	855.9	4352	886.15	9646.06	893.57	9693.88	894.28	9812.94	894.85	9872.9	895.37	10025.81	895.72	14350.13	898.56	22531.17	903.05

Table B18

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
409.5			South Dam															
409.6	457.98	855.9	4352	886.22	9646.06	893.61	9693.88	894.32	9812.94	894.89	9872.9	895.41	10025.81	895.75	14350.13	898.6	22531.17	903.08
409.7	457.99	855.9	4352	886.22	9646.06	893.61	9693.88	894.32	9812.94	894.89	9872.9	895.41	10025.81	895.75	14350.13	898.6	22531.17	903.09
413	458.32	869	4352	886.22	9646.06	893.63	9693.88	894.34	9812.94	894.91	9872.9	895.43	10025.81	895.77	14350.13	898.64	22531.17	903.13
414	458.75	866	4352	886.49	9646.06	893.9	9693.88	894.58	9812.94	895.13	9872.9	895.64	10025.81	895.97	14350.13	898.9	22531.17	903.47
459.64	459.64	864.81	4352	886.9	9646.06	894.33	9693.88	894.95	9812.94	895.48	9872.9	895.95	10025.81	896.27	14350.13	899.23	22531.17	903.81
460.28	460.28	868.74	4352	887.28	9646.06	894.67	9693.88	895.25	9812.94	895.75	9872.9	896.2	10025.81	896.51	14350.13	899.51	22531.17	904.1
460.72	460.72	869.04	4352	887.59	9646.06	894.93	9693.88	895.49	9812.94	895.97	9872.9	896.4	10025.81	896.71	14350.13	899.75	22531.17	904.41
461.3	461.3	868.04	4352	887.99	9646.06	895.31	9693.88	895.84	9812.94	896.3	9872.9	896.71	10025.81	897.01	14350.13	900.1	22531.17	904.86
462.03	462.03	864.16	4352	888.36	9646.06	895.71	9693.88	896.19	9812.94	896.63	9872.9	897.02	10025.81	897.31	14350.13	900.45	22531.17	905.22
462.04	462.04	869.5	4352	888.4	9646.06	895.74	9693.88	896.23	9812.94	896.66	9872.9	897.05	10025.81	897.34	14350.13	900.47	22531.17	905.27
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	4352	888.41	9646.06	895.75	9693.88	896.23	9812.94	896.67	9872.9	897.05	10025.81	897.35	14350.13	900.49	22531.17	905.34
462.07	462.07	871.5	4352	888.45	9646.06	895.78	9693.88	896.26	9812.94	896.69	9872.9	897.08	10025.81	897.37	14350.13	900.51	22531.17	905.33
462.7	462.7	862.82	4352	888.81	9646.06	896.1	9693.88	896.55	9812.94	896.97	9872.9	897.34	10025.81	897.62	14350.13	900.8	22531.17	905.63
463.7	463.7	864.71	4352	889.14	9646.06	896.51	9693.88	896.94	9812.94	897.33	9872.9	897.68	10025.81	897.96	14350.13	901.21	22531.17	906.06
464.2	464.2	869.2	4352	889.4	9646.06	896.78	9693.88	897.19	9812.94	897.58	9872.9	897.92	10025.81	898.19	14350.13	901.5	22531.17	906.41
464.6	464.6	865	4352	889.61	9646.06	896.98	9693.88	897.37	9812.94	897.75	9872.9	898.08	10025.81	898.35	14350.13	901.67	22531.17	906.56
465.1	465.1	862.9	4352	889.78	9646.06	897.21	9693.88	897.6	9812.94	897.97	9872.9	898.29	10025.81	898.56	14350.13	901.94	22531.17	906.97
465.9	465.9	865.6	4352	890.05	9646.06	897.56	9693.88	897.93	9812.94	898.28	9872.9	898.59	10025.81	898.86	14350.13	902.3	22531.17	907.32
466.4	466.4	865.6	4352	890.25	9646.06	897.79	9693.88	898.14	9812.94	898.49	9872.9	898.79	10025.81	899.05	14350.13	902.52	22531.17	907.57
466.5	466.5	864.9	4352	890.3	9646.06	897.84	9693.88	898.19	9812.94	898.54	9872.9	898.84	10025.81	899.1	14350.13	902.57	22531.17	907.61
466.9	466.9	865	4352	890.35	9646.06	897.91	9693.88	898.26	9812.94	898.61	9872.9	898.9	10025.81	899.17	14350.13	902.64	22531.17	907.66
467			Proposed Red River Closure Structure															
467.1	467.1	865	4352	890.37	9646.06	899.65	9693.88	903.58	9812.94	906.37	9872.9	909.1	10025.81	910.83	14350.13	912.27	22531.17	913.6
467.2	467.2	864.8	4352	890.36	9646.06	899.65	9693.88	903.59	9812.94	906.37	9872.9	909.11	10025.81	910.85	14350.13	912.3	22531.17	913.68
467.3	467.3	864.8	4352	890.4	9646.06	899.68	9693.88	903.6	9812.94	906.38	9872.9	909.11	10025.81	910.85	14350.13	912.31	22531.17	913.71
467.4	467.4	864.8	4352	890.65	9646.06	899.89	9693.88	903.73	9812.94	906.47	9872.9	909.17	10025.81	910.9	14350.13	912.38	22531.17	913.84
468.2	468.2	862.6	4352	890.9	10487.04	900.13	13380.91	903.87	16559.85	906.58	21661.6	909.25	25791.55	910.97	32667.25	912.48	43804.1	913.99
468.9	468.9	861	4352	891.12	10487.04	900.39	13380.91	904.11	16559.85	906.76	21661.6	909.41	25791.55	911.1	32667.25	912.62	43804.1	914.17
469.7	469.7	870	4352	891.47	10487.04	900.74	13380.91	904.36	16559.85	906.97	21661.6	909.54	25791.55	911.22	32667.25	912.74	43804.1	914.3
470.1	470.1	870.9	4352	891.64	10487.04	900.9	13380.91	904.51	16559.85	907.11	21661.6	909.65	25791.55	911.3	32667.25	912.82	43804.1	914.4
470.6	470.6	869.4	3198	891.81	7796.04	901.07	7721.91	904.66	8501.85	907.25	10680.6	909.8	12655.55	911.43	18088.25	912.96	26538.1	914.56
471.4	471.4	867.5	3198	892.04	7651.04	901.32	7708.91	904.78	8602.85	907.35	10900.6	909.87	12925.55	911.49	17974.25	913.02	25655.1	914.64
472.18	472.18	869.9	3198	892.29	7651.04	901.56	7708.91	904.91	8602.85	907.45	10900.6	909.96	12925.55	911.56	17974.25	913.1	25655.1	914.74
472.2	472.2	870.8	3198	892.29	7651.04	901.55	7708.91	904.91	8602.85	907.45	10900.6	909.95	12925.55	911.55	17974.25	913.09	25655.1	914.73
472.22	472.22	870.8	3198	892.3	7651.04	901.57	7708.91	904.92	8602.85	907.46	10900.6	909.97	12925.55	911.58	17974.25	913.14	25655.1	914.78
473	473	871.8	3198	892.53	7651.04	901.78	7708.91	905.03	8602.85	907.54	10900.6	910.05	12925.55	911.64	17974.25	913.21	25655.1	914.87
473.8	473.8	869	3198	892.8	7651.04	902.05	7708.91	905.19	8602.85	907.66	10900.6	910.16	12925.55	911.75	17974.25	913.33	25655.1	915.03
474.08	474.08	873.5	3198	892.9	7651.04	902.14	7708.91	905.25	8602.85	907.71	10900.6	910.21	12925.55	911.8	17974.25	913.38	25655.1	915.08
474.09	474.09	873.5	3198	892.91	7651.04	902.17	7708.91	905.27	8602.85	907.73	10900.6	910.23	12925.55	911.82	17974.25	913.41	25655.1	915.11
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	3198	892.91	7651.04	902.16	7708.91	905.26	8602.85	907.73	10900.6	910.23	12925.55	911.82	17974.25	913.46	25655.1	915.21
474.12	474.12	874	3198	892.92	7651.04	902.17	7708.91	905.27	8602.85	907.73	10900.6	910.23	12925.55	911.84	17974.25	913.47	25655.1	915.22
474.6	474.6	873.4	3198	893.12	7651.04	902.32	7708.91	905.36	8602.85	907.8	10900.6	910.31	12925.55	911.91	17974.25	913.56	25655.1	915.32
475.3	475.3	872.2	3198	893.38	7772	902.59	9722	905.54	12388	907.98	16680	910.5	20055	912.12	27549	913.82	39492	915.65
475.7	475.7	871	3198	893.51	7772	902.74	9722	905.71	12388	908.17	16680	910.77	20055	912.44	27549	914.14	39492	915.86
476.4	476.4	873.7	3198	893.78	7772	902.98	9722	905.92	12388	908.4	16680	911.01	20055	912.67	27549	914.39	39492	916.08
477	477	874	3147	894.05	6349	903.21	9577	906.16	13547	908.67	19288	911.33	23242	912.98	26339	914.68	31093	916.36
477.6	477.6	870.2	3139	894.23	6160	903.36	9555	906.38	13729	908.99	19709	911.75	23757	913.46	26164	915.04	30016	916.63
478	478	873.4	3139	894.37	6160	903.45	9555	906.52	13729	909.17	19709	911.98	23757	913.69	26164	915.22	30016	916.7
478.8	478.8	874.8	3139	894.6	6160	903.63	9555	906.78	13729	909.52	19709	912.47	23757	914.17	26164	915.59	30016	916.99
479.2	479.2	875.7	3139	894.72	6160	903.71	9555	906.9	13729	909.67	19709	912.66	23757	914.36	26164	915.73	30016	917.08
479.7	479.7	871.5	3139	894.91	6160	903.82	9555	907.05	13729	909.87	19709	912.89	23757	914.6	26164	915.95	30016	917.21
480.5	480.5	874.7	3139	895.19	6160	904.02	9555	907.33	13729	910.22	19709	913.3	23757	914.98	26164	916.26	30016	917.49
481.8	481.8	875.3	3139	895.57	6160	904.34	9555	907.79	13729	910.75	19709	913.89	23757	915.61	26164	916.76	30016	917.94
482.3	482.3	874.2	3139	895.78	6160	904.51	9555	908.04	13729	911.06	19709	914.23	23757	915.95	26164	916.99	30016	918.12
482.698	482.698	869.74	3139	895.89	6160	904.6	9555	908.16	13729	911.22	19709	914.41	23757	916.14	26164	917.18	30016	918.28
482.7	482.7	887.04	3139	895.77	6160	904.55	9555	908.09	13729	911.13	19709	914.34	23757	916.06	26164	917.16	30016	918.28
482.702	482.702	878.54	3139	895.92	6160	904.61	9555	908.17	13729	911.22	19709	914.41	23757	916.14	26164	917.18	30016	918.28
483.1	483.1	879.2	3139	896.16	6160	904.8	9555	908.42	13729	911.54	19709	914.77	23757	916.53	26164	917.44	30016	918.47
483.9	483.9	873	3139	896.59	6160	905.06	9555	908.76	13729	911.98	19709	915.31	23757	917	26164	917.89	30016	918.86
485.08	485.08	880.5	3139	897.17	6160	905.31	9555	909.01	13729	912.26	19709	915.6	23757	917.3	26164	918.19	30016	919.16
485.09	485.09	880.5	3139	897.18	6160	905.3	9555	908.99	13729	912.26	19709	915.6	23757	917.3	26164	918.18	30016	919.15
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	3139	897.19	6160	905.3	9555	909.05	13729	912.38	19709	915.67	23757	917.35	26164	918.22	30016	919.19
485.12	485.12	879.4	3139	897.19	6160	905.33	9555	909.11	13729	912.38	19709	915.67	23757	917.36	26164	918.23	30016	919.2
485.6	485.6	878.62	3139	897.4	6160	905.43	9555	909.21	13729	912.48	19709	915.77	23757	917.45	26164	918.33	30016	919.3
485.9	485.9	879.5	3139	897.58	6160	905.55	9555	909.35	13729	912.63	19709	915.95	23757	917.65	26164	918.54	30016	919.52
486.3	486.3	872.1	3139	897.75	6160	905.66	9555	909.5	13729	912.81	19709	916.16	23757	917.89	26164	918.79	30016	919.79
487	487	871.3	3139	897.97	6160	905.84	9555	909.72	13729	913.1	19709	916.56	23757	918.38	26164	919.31	30016	920.38
487.5	487.5	878.8	3139	898.19	6160	906.02	9555	909.94	13729	913.34	19709	916.83	23757	918.66	26164	919.61	30016	920.69
488.68	488.68	878.24	3139	898.84	6160	906.52	9555	910.55	13729	914.11	19709	917.71	23757	919.6	26164	920.58	30016	921.75

Table B19

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	7890	860.38	17020	869.46	24610	873.29	32650	875.42	44080	876.69	53560	877.55	63590	878.37	80610	879.31
280	404.98	836.6	7890	861.02	17020	870.16	24610	874.14	32650	876.09	44080	877.53	53560	878.34	63590	879.15	80610	880.13
281	406.51	834.9	7890	861.88	17020	871.03	24610	875.07	32650	877.15	44080	878.68	53560	879.33	63590	879.96	80610	881.01
282	410.21	838	7890	863.78	17020	872.89	24610	876.78	32650	878.78	44080	879.82	53560	880.48	63590	881.22	80610	882.37
283	413.23	837.6	7890	865.06	17020	874.26	24610	878.09	32650	880.03	44080	881.03	53560	881.43	63590	882.22	80610	883.43
284	414.98	842.7	7150	865.77	15860	875.14	23130	879.17	30790	880.91	41630	881.89	50580	882.45	60120	883.26	76860	884.49
285	415.38	841.4	7150	865.94	15860	875.34	23130	879.4	30790	881.11	41630	882.13	50580	882.67	60120	883.5	76860	884.74
286	415.84	843	7150	866.08	15860	875.42	23130	879.45	30790	881.14	41630	882.22	50580	882.82	60120	883.65	76860	885
287	415.90	844.1	7150	866.12	15860	875.48	23130	879.55	30790	881.37	41630	882.36	50580	882.96	60120	883.76	76860	885.06
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	7150	866.12	15860	875.48	23130	879.54	30790	881.36	41630	882.46	50580	883.12	60120	884.18	76860	885.29
290	415.93	837.5	7150	866.14	15860	875.49	23130	879.55	30790	881.37	41630	882.55	50580	883.23	60120	884.18	76860	885.33
291	417.10	840.8	7150	866.55	15860	875.94	23130	880.11	30790	882.14	41630	883.45	50580	884.24	60120	885	76860	885.96
292	418.18	844.4	6247	866.96	13447	876.38	19446	880.64	25786	882.66	34892	884.04	42390	884.91	51664	885.65	67999	886.5
293	419.92	844.7	6247	867.73	13447	877.16	19446	881.37	25786	883.29	34892	884.7	42390	885.61	51664	886.15	67999	887.09
294	420.32	843.8	6247	868	13447	877.39	19446	881.62	25786	883.61	34892	885.09	42390	886.05	51664	886.61	67999	887.57
295	421.93	845.3	6247	869.23	13447	878.47	19446	882.62	25786	884.4	34892	885.84	42390	886.76	51664	887.44	67999	888.19
296	422.69	847.4	6247	869.55	13447	878.8	19446	882.92	25786	884.65	34892	886.06	42390	886.97	51664	887.73	67999	888.51
297	423.95	849.5	6247	870.08	13447	879.37	19446	883.58	25786	885.52	34892	887.14	42390	888.17	51664	888.91	67999	889.59
298	425.51	848.7	6247	870.82	13447	880.09	19446	884.3	25786	886.22	34892	887.88	42390	888.93	51664	889.3	67999	890.09
299	426.87	851.1	6247	871.53	13447	880.72	19446	884.94	25786	886.92	34892	888.68	42390	889.78	51664	890.02	67999	890.68
300	428.06	849.6	4007	872.07	9978	881.3	10598	885.47	10994.9	887.41	10244.1	889.14	10162.13	890.24	11631.11	890.29	18390.06	891.02
301	428.74	850.3	4007	872.33	9978	881.6	10598	885.65	10994.9	887.54	10244.1	889.21	10162.13	890.29	11631.11	890.36	18390.06	891.08
302	430.23	852	4007	872.89	9978	882.11	10598	885.95	10994.9	887.8	10244.1	889.38	10162.13	890.42	11631.11	890.53	18390.06	891.23
303	431.94	853.5	4007	873.65	9978	882.84	10598	886.39	10994.9	888.15	10438.72	889.6	12257.95	890.61	14337.65	890.77	22588.62	891.71
303.4	432.07	853.42	3721	873.69	9517	882.9	10012	886.45	10148.9	888.2	9375.91	889.64	10536.74	890.65	12417.95	890.82	20426.39	891.76
303.5	432.10	853.46	3721	873.72	9517	882.94	10012	886.47	10148.9	888.21	9706.64	889.65	10346.61	890.66	12206.51	890.84	20082.66	891.81
303.8	432.53	854.5	3721	873.88	9517	883.11	10012	886.56	10148.9	888.29	10244.77	889.71	9914.28	890.73	11579.62	890.93	19005.26	892.05
304	432.84	855.5	3721	873.96	9518	883.21	10013	886.62	10147.46	888.32	10181	889.73	9690.23	890.75	11299.55	890.95	17802.35	892.09
305	433.26	854.4	3721	874.11	9518	883.38	10013	886.73	10147.46	888.41	10285.2	889.79	9938.39	890.78	11082.17	891	15044.98	892.16
306	433.35	855	3721	874.18	9518	883.46	10013	886.79	10147.46	888.46	10294.47	889.84	9997.93	890.82	11030.36	891.04	14968.65	892.23
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	3721	874.19	9518	883.47	10013	886.8	10147.46	888.46	10294.47	889.84	9997.93	890.82	11030.36	891.05	14968.65	892.24
309	433.83	854.5	3721	874.32	9518	883.62	10013	886.9	10147.46	888.55	10294.47	889.92	9997.93	890.89	11030.36	891.12	14968.65	892.36
310	434.61	852.8	3721	874.56	9518	883.85	10013	887.05	10147.46	888.66	10294.47	890.01	9997.93	890.96	11030.36	891.21	14968.65	892.49
310.5	435.70	855	3721	874.9	9518	884.22	10013	887.27	10147.46	888.84	10294.47	890.16	9997.93	891.09	11030.36	891.36	14968.65	892.73
311	436.34	855	3721	875.11	9518	884.46	10013	887.44	10140.39	888.98	10265.56	890.28	10482.44	891.2	12199.26	891.49	17243.31	892.93
312	437.05	863.83	3526	875.33	9208	884.73	9608	887.63	9720.4	889.14	9815.56	890.42	10017.44	891.34	11619.26	891.67	16651.75	893.21
313	437.95	856	3526	875.65	9207	885.11	9607	887.9	9721.84	889.36	9879.34	890.61	10241.49	891.52	11899.32	891.91	17821.22	893.6
314	438.78	857	3526	875.97	9207	885.46	9607	888.15	9721.84	889.57	9879.34	890.79	10241.49	891.68	11899.32	892.12	17821.22	893.99
315	439.05	856	3526	876.06	9207	885.57	9607	888.22	9721.84	889.63	9879.34	890.84	10241.49	891.74	11899.32	892.19	17821.22	894.13
316	439.46	855.1	3526	876.2	9207	885.76	9607	888.37	9721.84	889.77	9879.34	890.97	10241.49	891.86	11899.32	892.34	17821.22	894.41
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	3526	876.21	9207	885.77	9607	888.38	9721.84	889.77	9879.34	890.97	10241.49	891.86	11899.32	892.34	17821.22	894.41
319	439.50	857	3526	876.22	9207	885.82	9607	888.42	9721.84	889.8	9879.34	891	10241.49	891.89	11899.32	892.38	17821.22	894.46
320	439.66	856	3526	876.27	9207	885.88	9607	888.46	9721.84	889.84	9879.34	891.03	10241.49	891.91	11899.32	892.41	17821.22	894.52
321	440.31	858	3526	876.47	9207	886.13	9607	888.65	9721.84	890	9879.34	891.17	10241.49	892.05	11899.32	892.58	17821.22	894.81
322	440.32	858.1	3526	876.47	9207	886.12	9607	888.64	9721.84	889.99	9879.34	891.16	10241.49	892.04	11899.32	892.58	17821.22	894.81
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	3526	876.48	9207	886.24	9607	888.72	9721.84	890.05	9879.34	891.2	10241.49	892.08	11899.32	892.61	17821.22	894.85
325	440.34	857	3526	876.49	9207	886.25	9607	888.73	9721.84	890.05	9879.34	891.21	10241.49	892.08	11899.32	892.62	17821.22	894.85
326	440.54	858	3526	876.53	9207	886.3	9607	888.76	9721.84	890.08	9879.34	891.24	10241.49	892.11	11899.32	892.65	17821.22	894.92
327	441.53	859	3506	876.9	9162	886.58	9547	888.95	9656.84	890.23	9809.34	891.36	10166.49	892.22	11809.32	892.79	17711.22	895.13
328	442.14	858	3506	877.1	9162	886.75	9547	889.06	9656.84	890.32	9809.34	891.43	10177.6	892.29	11950.05	892.87	18759.55	895.27
329	442.45	857	3506	877.18	9162	886.78	9547	889.07	9656.84	890.33	9809.34	891.44	10233.32	892.29	12219.64	892.88	19890.08	895.27
329.5	442.93	858.06	3506	877.33	9161	886.89	9546	889.15	9662.98	890.38	9838.57	891.48	10249.66	892.33	12228.27	892.93	19959.57	895.36
330	443.69	858	3506	877.57	9161	887.09	9546	889.29	9662.98	890.49	9838.57	891.57	10249.66	892.41	12228.27	893.03	19959.57	895.49
331	443.99	859	3506	877.65	9161	887.18	9546	889.36	9662.98	890.56	9838.57	891.63	10249.66	892.47	12228.27	893.1	19959.57	895.63
332	444.33	856	3506	877.7	9161	887.22	9546	889.4	9662.98	890.58	9838.57	891.65	10249.66	892.49	12228.27	893.12	19959.57	895.67
333	444.92	859	3506	877.8	9161	887.26	9546	889.42	9662.98	890.6	9838.57	891.66	10249.66	892.5	12228.27	893.14	19959.57	895.69
334	445.18	860	3506	877.88	9161	887.34	9546	889.48	9662.98	890.65	9838.57	891.7	10249.66	892.54	12228.27	893.19	19959.57	895.77
335	445.31	860	3506	877.93	9161	887.42	9546	889.55	9662.98	890.71	9838.57	891.76	10249.66	892.6	12228.27	893.27	19959.57	895.94
336	445.36	859	3506	877.94	9161	887.43	9546	889.56	9662.98	890.72	9838.57	891.77	10249.66	892.6	12228.27	893.28	19959.57	895.96
336.5	445.76	857.69	3506	877.98	9161	887.46	9546	889.58	9662.98	890.74	9838.57	891.78	10249.66	892.62	12228.27	893.29	19959.57	895.99
337	446.09	860	3506	878.03	9161	887.46	9546	889.58	9662.98	890.73	9838.57	891.78	10249.66	892.61	12228.27	893.29	19959.57	895.98
338	446.29	861	3506	878.1	9161	887.5	9546	889.6	9662.98	890.75	9838.57	891.79	10249.66	892.62	12228.27	893.3	19959.57	895.99
338.5	446.70	860.9	3506	878.24	9161	887.64	9546	889.7	9662.98	890.83	9838.57	891.87	10249.66	892.69	12228.27	893.39	19959.57	896.14
339	446.76	861	3506	878.26	9161	887.66	9546	889.71	9662.98	890.84	9838.57	891.88	10249.66	892.7	12228.27	893.4	19959.57	896.15
340	447.04	860	3506	878.35	9161	887.75	9546	889.79	9662.98	890.91	9838.57	891.94	10249.66	892.76	12228.27	893.48	19959.57	896.33
341	447.24	859	3506	878.44	9161	887.81	9546	889.83	9662.98	890.95	9838.57	891.97	10249.66	892.79	12228.27	893.51	19959.57	896.36
342	447.42	861	3506	878.55	9161	887.9	9546	889.9	9662.98	891	9838.57	892.01	10249.66	892.83	12228.27	893.56	19959.57	896.45
342.5	447.78	856.99	3506	878.71	9161	888.04	9546	890	9662.98	891.09	9838.57	892.09	10249.66	892.9	12228.27	893.66	19959.57	896.62
343	448.13	861	3506	878.83	9161	888.14	9546	890.08	9662.98	891.16	9838.57	892.15	10249.66	892.96	12228.27	893.73	19959.57	896.73
344	448.36	859	3506	878.94	9161	888.25	9546	890.17	9662.98	891.23	9838.57	892.22	10249.66	893.03	12228.27	893.82	19959.57	896.92
345	448.89	865.3	3506	879.32	9161	888.48	9546	890.33	9662.98	891.36	9838.57	892.33	10249.66	893.13	12228.27	893.94	19959.57	897.1
348	448.90	864.3	3506	879.32	9161	888.46	9546	890.31	9662.98	891.35	9838.57	892.31	10249.66	893.11	12228.27	893.92	19959.57	897.05
348.4			North Dam															
348.8	448.90	864.3	3506	879.42	9161	888.51	9546	890.36	9662.98	891.39	9838.57	892.35	10249.66	893.14	12228.27	893.97	19959.57	897.1
351	448.91	861	3506	879.44	9161	888.51	9546	890.36	9662.98	891.39	9838.57	892.35	10249.66	893.15	12228.27	893.97	19959.57	897.11
351.4	449.06	861	3506	879.51	9161	888.64	9546	890.47	9662.98	891.49	9838.57	892.44	10249.66	893.24	12228.27	894.09	19959.57	897.31
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	3506	879.52	9161	888.7	9546	890.55	9662.98	891.57	9838.57	892.52	10249.66	893.3	12228.27	894.16	19959.57	897.39
352	449.09	862	3506	879.53	9161	888.72	9546	890.57	9662.98	891.59	9838.57	892.53	10249.66	893.32	12228.27	894.18	19959.57	897.42
353	449.28	863	3506	879.61	9161	888.81	9546	890.64	9662.98	891.65	9838.57	892.59	10249.66	893.38	12228.27	894.26	19959.57	897.57
353.5	449.61	860.13	3506	879.75	9161	888.91	9546	890.71	9662.98	891.71	9838.57	892.64	10249.66	893.42	12228.27	894.3	19959.57	897.63
354	449.97	864	3506	879.99	9161	889.13	9546	890.89	9662.98	891.87	9838.57	892.78	10249.66	893.55	12228.27	894.47	19959.57	897.84
355	450.19	862	3506	880.16	9161	889.22	9546	890.96	9662.98	891.93	9838.57	892.84	10249.66	893.61	12228.27	894.54	19959.57	897.99
356	450.84	858	3506	880.54	9161	889.5	9546	891.16	9662.98	892.1	9838.57	892.98	10249.66	893.74	12228.27	894.69	19959.57	898.2
357	450.86	863.4	3506	880.55	9161	889.5	9546	891.16	9662.98	892.1	9838.57	892.98	10249.66	893.74	12228.27	894.7	19959.57	898.2
358			BNRR Bridge															
359	450.87	863.4	3506	880.62	9161	889.6	9546	891.24	9662.98	892.16	9838.57	893.03	10249.66	893.78	12228.27	894.74	19959.57	898.31
361	451.20	865	3506	880.77	9161	889.72	9546	891.33	9662.98	892.24	9838.57	893.1	10249.66	893.85	12228.27	894.82	19959.57	898.44
361.5	451.37	865.2	3506	880.88	9161	889.79	9546	891.39	9662.98	892.29	9838.57	893.15	10249.66	893.89	12228.27	894.87	19959.57	898.51
362.5			1st Ave. No. Bridge															
364	451.39	865.2	3506	880.9	9161	889.81	9546	891.41	9662.98	892.3	9838.57	893.16	10249.66	893.9	12228.27	894.88	19959.57	898.53
366	451.41	861	3506	880.94	9161	889.86	9546	891.44	9662.98	892.33	9838.57	893.18	10249.66	893.93	12228.27	894.91	19959.57	898.57
367	451.57	867	3506	881	9161	889.95	9546	891.53	9662.98	892.42	9838.57	893.27	10249.66	894.01	12228.27	895.03	19959.57	898.81
368	451.61	866.8	3506	881.04	9161	890	9546	891.57	9662.98	892.46	9838.57	893.3	10249.66	894.04	12228.27	895.06	19959.57	898.86
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	3506	881.05	9161	890.01	9546	891.58	9662.98	892.46	9838.57	893.3	10249.66	894.05	12228.27	895.07	19959.57	898.88
371	451.65	859	3506	881.08	9161	890.01	9546	891.58	9662.98	892.46	9838.57	893.3	10249.66	894.04	12228.27	895.06	19959.57	898.86
372	451.67	867.9	3506	881.07	9161	890	9546	891.57	9662.98	892.45	9838.57	893.29	10249.66	894.04	12228.27	895.05	19959.57	898.86
373			BNRR Bridge															
374	451.68	867.9	3506	881.17	9161	890.1	9546	891.65	9662.98	892.52	9838.57	893.36	10249.66	894.1	12228.27	895.12	19959.57	898.92
375	451.69	864	3506	881.19	9161	890.1	9546	891.65	9662.98	892.52	9838.57	893.35	10249.66	894.09	12228.27	895.12	19959.57	898.9
376	451.71	865.9	3506	881.19	9161	890.11	9546	891.66	9662.98	892.54	9838.57	893.37	10249.66	894.12	12228.27	895.15	19959.57	898.99
377			Main Ave. Bridge															
378	451.72	865.9	3506	881.21	9161	890.12	9546	891.67	9662.98	892.55	9838.57	893.38	10249.66	894.12	12228.27	895.16	19959.57	899.02
379	451.73	864	3506	881.29	9161	890.22	9546	891.75	9662.98	892.62	9838.57	893.44	10249.66	894.18	12228.27	895.23	19959.57	899.11
380	451.85	864	3506	881.28	9161	890.19	9546	891.73	9662.98	892.59	9838.57	893.42	10249.66	894.16	12228.27	895.21	19959.57	899.08
381	452.03	863	3506	881.38	9161	890.34	9546	891.86	9662.98	892.72	9838.57	893.53	10249.66	894.27	12228.27	895.34	19959.57	899.27
381.5	452.04	863	3506	881.39	9161	890.35	9546	891.87	9662.98	892.73	9838.57	893.54	10249.66	894.28	12228.27	895.35	19959.57	899.28
384			Midtown Dam															
385.5	452.05	867	3506	881.46	9161	890.36	9546	891.88	9662.98	892.73	9838.57	893.55	10249.66	894.29	12228.27	895.36	19959.57	899.29
386	452.06	867	3506	881.47	9161	890.36	9546	891.88	9662.98	892.74	9838.57	893.55	10249.66	894.29	12228.27	895.36	19959.57	899.3
387	452.25	867	3506	881.61	9161	890.43	9546	891.93	9662.98	892.78	9838.57	893.59	10249.66	894.32	12228.27	895.4	19959.57	899.35
388	452.46	869	3506	881.83	9161	890.54	9546	892.02	9662.98	892.86	9838.57	893.66	10249.66	894.39	12228.27	895.48	19959.57	899.46
389	452.70	866.08	3506	882.1	9161	890.72	9546	892.16	9662.98	892.97	9838.57	893.76	10249.66	894.49	12228.27	895.59	19959.57	899.62
390	452.94	867	3506	882.22	9161	890.81	9546	892.24	9662.98	893.04	9838.57	893.82	10249.66	894.54	12228.27	895.66	19959.57	899.71
391	453.16	867	3506	882.35	9161	890.92	9546	892.33	9662.98	893.12	9838.57	893.89	10249.66	894.61	12228.27	895.74	19959.57	899.83
392	453.39	865	3506	882.48	9161	891.01	9546	892.4	9662.98	893.19	9838.57	893.96	10249.66	894.67	12228.27	895.81	19959.57	899.95
393	454.02	866	3506	882.83	9161	891.28	9546	892.61	9662.98	893.36	9838.57	894.11	10249.66	894.82	12228.27	895.97	19959.57	900.13
394	454.10	865	3506	882.87	9161	891.32	9546	892.64	9662.98	893.4	9838.57	894.14	10249.66	894.84	12228.27	896	19959.57	900.16
395	454.75	864	3506	883.14	9161	891.55	9546	892.83	9662.98	893.56	9838.57	894.29	10249.66	894.98	12228.27	896.16	19959.57	900.37
396	455.16	866	3506	883.33	9161	891.76	9546	893.01	9662.98	893.73	9838.57	894.43	10249.66	895.12	12228.27	896.32	19959.57	900.56
397	455.20	866.6	3506	883.37	9161	891.8	9546	893.04	9662.98	893.75	9838.57	894.46	10249.66	895.14	12228.27	896.34	19959.57	900.59
399			I-94 Bridge															
401	455.23	866.6	3506	883.38	9161	891.8	9546	893.04	9662.98	893.75	9838.57	894.46	10249.66	895.14	12228.27	896.34	19959.57	900.59
402	455.28	865	3506	883.41	9161	891.82	9546	893.06	9662.98	893.77	9838.57	894.47	10249.66	895.15	12228.27	896.36	19959.57	900.62
402.5	455.52	864.58	3506	883.52	9161	891.94	9546	893.16	9662.98	893.86	9838.57	894.55	10249.66	895.24	12228.27	896.45	19959.57	900.73
403	455.59	866	3506	883.54	9161	891.98	9546	893.2	9662.98	893.89	9838.57	894.58	10249.66	895.26	12228.27	896.48	19959.57	900.76
404	455.92	865	3506	883.7	9161	892.1	9546	893.3	9662.98	893.99	9838.57	894.67	10249.66	895.35	12228.27	896.58	19959.57	900.93
405	456.65	865	3506	884.09	9161	892.38	9546	893.53	9662.98	894.18	9838.57	894.85	10249.66	895.51	12228.27	896.76	19959.57	901.12
406	457.09	866	3506	884.33	9161	892.57	9546	893.7	9662.98	894.33	9838.57	894.99	10249.66	895.64	12228.27	896.91	19959.57	901.31
407	457.27	861.18	3506	884.4	9161	892.64	9546	893.75	9662.98	894.38	9838.57	895.03	10249.66	895.68	12228.27	896.95	19959.57	901.35
408	457.80	864	3506	884.57	9161	892.86	9546	893.95	9662.98	894.57	9838.57	895.2	10249.66	895.85	12228.27	897.15	19959.57	901.63
409	457.95	855.9	3506	884.62	9161	892.96	9546	894.04	9662.98	894.65	9838.57	895.28	10249.66	895.93	12228.27	897.23	19959.57	901.73
409.1	457.97	855.9	3506	884.62	9161	892.96	9546	894.04	9662.98	894.65	9838.57	895.28	10249.66	895.93	12228.27	897.24	19959.57	901.73

Table B19

Fargo Moorhead Metro Study - Phase 3.1
MN Short 35Kcfs, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
409.5			South Dam															
409.6	457.98	855.9	3506	884.7	9161	893	9546	894.08	9662.98	894.69	9838.57	895.32	10249.66	895.96	12228.27	897.27	19959.57	901.76
409.7	457.99	855.9	3506	884.7	9161	893	9546	894.08	9662.98	894.69	9838.57	895.32	10249.66	895.96	12228.27	897.27	19959.57	901.77
413	458.32	869	3506	884.7	9161	893.02	9546	894.1	9662.98	894.71	9838.57	895.34	10249.66	895.98	12228.27	897.29	19959.57	901.81
414	458.75	866	3506	884.96	9161	893.29	9546	894.34	9662.98	894.93	9838.57	895.55	10249.66	896.19	12228.27	897.53	19959.57	902.13
459.64	459.64	864.81	3506	885.35	9161	893.73	9546	894.73	9662.98	895.28	9838.57	895.86	10249.66	896.48	12228.27	897.84	19959.57	902.47
460.28	460.28	868.74	3506	885.73	9161	894.07	9546	895.03	9662.98	895.56	9838.57	896.12	10249.66	896.73	12228.27	898.11	19959.57	902.77
460.72	460.72	869.04	3506	886.06	9161	894.34	9546	895.27	9662.98	895.78	9838.57	896.32	10249.66	896.93	12228.27	898.33	19959.57	903.05
461.3	461.3	868.04	3506	886.45	9161	894.73	9546	895.62	9662.98	896.11	9838.57	896.63	10249.66	897.22	12228.27	898.65	19959.57	903.46
462.03	462.03	864.16	3506	886.79	9161	895.12	9546	895.98	9662.98	896.44	9838.57	896.94	10249.66	897.53	12228.27	898.98	19959.57	903.83
462.04	462.04	869.5	3506	886.83	9161	895.16	9546	896.02	9662.98	896.47	9838.57	896.97	10249.66	897.55	12228.27	899.01	19959.57	903.88
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	3506	886.84	9161	895.17	9546	896.02	9662.98	896.48	9838.57	896.98	10249.66	897.56	12228.27	899.02	19959.57	903.96
462.07	462.07	871.5	3506	886.88	9161	895.2	9546	896.05	9662.98	896.51	9838.57	897	10249.66	897.58	12228.27	899.04	19959.57	903.95
462.7	462.7	862.82	3506	887.24	9161	895.53	9546	896.35	9662.98	896.79	9838.57	897.26	10249.66	897.84	12228.27	899.32	19959.57	904.25
463.7	463.7	864.71	3506	887.56	9161	895.93	9546	896.73	9662.98	897.15	9838.57	897.61	10249.66	898.18	12228.27	899.7	19959.57	904.68
464.2	464.2	869.2	3506	887.8	9161	896.21	9546	896.99	9662.98	897.4	9838.57	897.85	10249.66	898.41	12228.27	899.96	19959.57	905
464.6	464.6	865	3506	888	9161	896.4	9546	897.17	9662.98	897.57	9838.57	898.01	10249.66	898.57	12228.27	900.13	19959.57	905.16
465.1	465.1	862.9	3506	888.15	9161	896.63	9546	897.4	9662.98	897.78	9838.57	898.22	10249.66	898.79	12228.27	900.37	19959.57	905.53
465.9	465.9	865.6	3506	888.41	9161	896.98	9546	897.73	9662.98	898.1	9838.57	898.53	10249.66	899.09	12228.27	900.71	19959.57	905.91
466.4	466.4	865.6	3506	888.6	9161	897.21	9546	897.94	9662.98	898.31	9838.57	898.72	10249.66	899.29	12228.27	900.92	19959.57	906.16
466.5	466.5	864.9	3506	888.64	9161	897.25	9546	897.99	9662.98	898.36	9838.57	898.77	10249.66	899.33	12228.27	900.97	19959.57	906.21
466.9	466.9	865	3506	888.68	9161	897.33	9546	898.06	9662.98	898.42	9838.57	898.84	10249.66	899.4	12228.27	901.04	19959.57	906.26
467			Proposed Red River Closure Structure															
467.1	467.1	865	3506	888.7	9161	897.39	9546	902.66	9662.98	905.75	9838.57	908.68	10249.66	910.19	12228.27	911.94	19959.57	913.8
467.2	467.2	864.8	3506	888.7	9161	897.38	9546	902.67	9662.98	905.75	9838.57	908.69	10249.66	910.21	12228.27	911.96	19959.57	913.86
467.3	467.3	864.8	3506	888.73	9161	897.43	9546	902.69	9662.98	905.77	9838.57	908.69	10249.66	910.21	12228.27	911.97	19959.57	913.88
467.4	467.4	864.8	3506	888.96	9161	897.71	9546	902.82	9662.98	905.86	9838.57	908.75	10249.66	910.26	12228.27	912.02	19959.57	913.98
468.2	468.2	862.6	3506	889.19	9161	897.99	12509	902.98	15532.81	905.97	20409.9	908.84	24432.98	910.34	30003.36	912.1	41338.51	914.11
468.9	468.9	861	3506	889.4	9161	898.27	12509	903.22	15532.81	906.2	20409.9	908.99	24432.98	910.48	30003.36	912.23	41338.51	914.26
469.7	469.7	870	3506	889.74	9161	898.66	12509	903.49	15532.81	906.41	20409.9	909.13	24432.98	910.61	30003.36	912.34	41338.51	914.38
470.1	470.1	870.9	3506	889.89	9161	898.84	12509	903.64	15532.81	906.55	20409.9	909.24	24432.98	910.7	30003.36	912.42	41338.51	914.46
470.6	470.6	869.4	2548	890.05	6444	899.03	7323	903.79	8011.81	906.69	10041.9	909.39	11885.98	910.84	16552.36	912.55	25037.51	914.6
471.4	471.4	867.5	2548	890.28	6358	899.28	7318	903.92	8111.81	906.78	10254.9	909.46	12147.98	910.9	16459.36	912.61	24231.51	914.68
472.18	472.18	869.9	2548	890.51	6358	899.52	7318	904.07	8111.81	906.89	10254.9	909.55	12147.98	910.98	16459.36	912.69	24231.51	914.76
472.2	472.2	870.8	2548	890.52	6358	899.51	7318	904.06	8111.81	906.88	10254.9	909.55	12147.98	910.97	16459.36	912.68	24231.51	914.75
472.22	472.22	870.8	2548	890.52	6358	899.52	7318	904.07	8111.81	906.89	10254.9	909.57	12147.98	910.99	16459.36	912.72	24231.51	914.8
473	473	871.8	2548	890.75	6358	899.73	7318	904.19	8111.81	906.98	10254.9	909.64	12147.98	911.06	16459.36	912.79	24231.51	914.88
473.8	473.8	869	2548	891	6358	900	7318	904.35	8111.81	907.1	10254.9	909.75	12147.98	911.18	16459.36	912.91	24231.51	915.01
474.08	474.08	873.5	2548	891.1	6358	900.09	7318	904.42	8111.81	907.14	10254.9	909.79	12147.98	911.22	16459.36	912.96	24231.51	915.07
474.09	474.09	873.5	2548	891.1	6358	900.11	7318	904.44	8111.81	907.16	10254.9	909.82	12147.98	911.25	16459.36	912.98	24231.51	915.09
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	2548	891.1	6358	900.11	7318	904.43	8111.81	907.16	10254.9	909.81	12147.98	911.24	16459.36	913	24231.51	915.18
474.12	474.12	874	2548	891.11	6358	900.11	7318	904.44	8111.81	907.16	10254.9	909.82	12147.98	911.26	16459.36	913.02	24231.51	915.19
474.6	474.6	873.4	2548	891.32	6358	900.27	7318	904.53	8111.81	907.23	10254.9	909.89	12147.98	911.34	16459.36	913.11	24231.51	915.28
475.3	475.3	872.2	2548	891.57	6358	900.54	8774	904.71	11434	907.4	15609	910.07	19019	911.54	25243	913.35	36927	915.58
475.7	475.7	871	2548	891.7	6358	900.68	8774	904.86	11434	907.58	15609	910.32	19019	911.85	25243	913.67	36927	915.76
476.4	476.4	873.7	2548	891.97	6358	900.91	8774	905.07	11434	907.79	15609	910.56	19019	912.09	25243	913.92	36927	915.96
477	477	874	2550	892.24	5485	901.13	8718	905.29	12582	908.05	18134	910.87	22123	912.42	24258	914.25	29236	916.22
477.6	477.6	870.2	2550	892.42	5366	901.28	8710	905.5	12762	908.35	18543	911.27	22626	912.92	24116	914.6	28246	916.48
478	478	873.4	2550	892.56	5366	901.39	8710	905.64	12762	908.52	18543	911.5	22626	913.19	24116	914.78	28246	916.54
478.8	478.8	874.8	2550	892.79	5366	901.58	8710	905.89	12762	908.86	18543	911.95	22626	913.7	24116	915.14	28246	916.81
479.2	479.2	875.7	2550	892.91	5366	901.66	8710	906	12762	909.01	18543	912.13	22626	913.89	24116	915.28	28246	916.88
479.7	479.7	871.5	2550	893.1	5366	901.79	8710	906.15	12762	909.19	18543	912.37	22626	914.13	24116	915.48	28246	917.06
480.5	480.5	874.7	2550	893.38	5366	902	8710	906.42	12762	909.54	18543	912.77	22626	914.53	24116	915.79	28246	917.32
481.8	481.8	875.3	2550	893.76	5366	902.33	8710	906.86	12762	910.07	18543	913.35	22626	915.16	24116	916.29	28246	917.74
482.3	482.3	874.2	2550	893.97	5366	902.51	8710	907.1	12762	910.37	18543	913.69	22626	915.5	24116	916.54	28246	917.92
482.698	482.698	869.74	2550	894.07	5366	902.6	8710	907.22	12762	910.52	18543	913.86	22626	915.69	24116	916.73	28246	918.07
482.7	482.7	887.04	2550	893.94	5366	902.54	8710	907.15	12762	910.44	18543	913.78	22626	915.62	24116	916.69	28246	918.07
482.702	482.702	878.54	2550	894.12	5366	902.61	8710	907.23	12762	910.52	18543	913.86	22626	915.69	24116	916.73	28246	918.07
483.1	483.1	879.2	2550	894.36	5366	902.81	8710	907.47	12762	910.84	18543	914.22	22626	916.06	24116	917.01	28246	918.26
483.9	483.9	873	2550	894.82	5366	903.1	8710	907.8	12762	911.26	18543	914.74	22626	916.55	24116	917.46	28246	918.64
485.08	485.08	880.5	2550	895.47	5366	903.41	8710	908.06	12762	911.53	18543	915.03	22626	916.86	24116	917.74	28246	918.92
485.09	485.09	880.5	2550	895.48	5366	903.4	8710	908.04	12762	911.54	18543	915.03	22626	916.86	24116	917.74	28246	918.92
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	2550	895.48	5366	903.4	8710	908.08	12762	911.66	18543	915.11	22626	916.92	24116	917.78	28246	918.95
485.12	485.12	879.4	2550	895.49	5366	903.43	8710	908.14	12762	911.66	18543	915.11	22626	916.92	24116	917.79	28246	918.96
485.6	485.6	878.62	2550	895.71	5366	903.55	8710	908.25	12762	911.76	18543	915.2	22626	917.01	24116	917.88	28246	919.06
485.9	485.9	879.5	2550	895.92	5366	903.67	8710	908.38	12762	911.91	18543	915.38	22626	917.21	24116	918.07	28246	919.27
486.3	486.3	872.1	2550	896.1	5366	903.8	8710	908.53	12762	912.08	18543	915.59	22626	917.44	24116	918.3	28246	919.52
487	487	871.3	2550	896.32	5366	903.98	8710	908.74	12762	912.36	18543	915.96	22626	917.9	24116	918.78	28246	920.08
487.5	487.5	878.8	2550	896.52	5366	904.17	8710	908.96	12762	912.59	18543	916.23	22626	918.18	24116	919.05	28246	920.36
488.68	488.68	878.24	2550	897.12	5366	904.71	8710	909.55	12762	913.34	18543	917.09	22626	919.11	24116	919.96	28246	921.35

Table B20

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year Zero - Wet, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	10380	863.05	20140	871.03	27860	874.18	36050	875.88	47720	877.03	57070	877.85	69040	878.81	85540	879.53
280	404.98	836.6	10380	863.75	20140	871.81	27860	874.78	36050	876.6	47720	877.78	57070	878.66	69040	879.62	85540	880.37
281	406.51	834.9	10380	864.68	20140	872.74	27860	875.86	36050	877.71	47720	878.82	57070	879.66	69040	880.42	85540	881.28
282	410.21	838	10380	866.68	20140	874.62	27860	877.64	36050	879.39	47720	880.1	57070	880.81	69040	881.67	85540	882.67
283	413.23	837.6	10380	868.04	20140	876	27860	879	36050	880.5	47720	881	57070	881.76	69040	882.67	85540	883.75
284	414.98	842.7	10380	868.85	20140	877.02	27860	880.18	36050	881.44	47720	882.04	57070	882.8	69040	883.73	85540	884.85
285	415.38	841.4	10380	869.07	20140	877.28	27860	880.42	36050	881.66	47720	882.34	57070	883.06	69040	884	85540	885.12
286	415.84	843	10380	869.21	20140	877.35	27860	880.48	36050	881.72	47720	882.46	57070	883.22	69040	884.26	85540	885.41
287	415.90	844.1	10380	869.27	20140	877.44	27860	880.62	36050	881.93	47720	882.62	57070	883.35	69040	884.24	85540	885.48
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	10380	869.26	20140	877.43	27860	880.6	36050	881.96	47720	882.76	57070	883.58	69040	884.76	85540	885.73
290	415.93	837.5	10380	869.29	20140	877.45	27860	880.62	36050	881.97	47720	882.87	57070	883.69	69040	884.76	85540	885.77
291	417.10	840.8	10380	869.78	20140	878	27860	881.33	36050	882.81	47720	883.9	57070	884.76	69040	885.53	85540	886.42
292	418.18	844.4	9068	870.26	17079	878.54	23429	881.88	30241	883.37	40116	884.57	47970	885.39	59765	886.04	75940	886.98
293	419.92	844.7	8688	871.15	13290	879.4	13680.08	882.53	14039.03	883.96	14391.02	885.2	15081.65	885.86	21139.43	886.6	31807.62	887.65
294	420.32	843.8	8688	871.42	13290	879.55	13680.08	882.63	14039.03	884.04	14391.02	885.25	15081.65	885.91	21139.43	886.66	31807.62	887.74
295	421.93	845.3	8688	872.65	13290	880.3	13680.08	883	14039.03	884.25	14391.02	885.38	15081.65	886.02	21139.43	886.81	31807.62	887.89
296	422.69	847.4	8688	872.99	13290	880.53	13680.08	883.13	14039.03	884.33	14391.02	885.43	15081.65	886.05	21139.43	886.86	31807.62	887.98
297	423.95	849.5	8688	873.56	13290	880.97	13680.08	883.46	14039.03	884.62	14391.02	885.67	15081.65	886.28	21139.43	887.2	31807.62	888.4
298	425.51	848.7	8688	874.32	13290	881.52	13680.08	883.84	14039.03	884.91	14391.02	885.88	15081.65	886.47	21139.43	887.47	31807.62	888.81
299	426.87	851.1	8688	875.03	13290	882.03	13680.08	884.2	14039.03	885.21	14391.02	886.13	15081.65	886.7	21139.43	887.81	31807.62	889.32
300	428.06	849.6	6118	875.6	10242	882.51	10442.08	884.54	10593.03	885.5	10704.02	886.37	11332.31	886.92	16940.61	888.12	22924.77	889.74
301	428.74	850.3	6118	875.9	10242	882.77	10442.08	884.74	10593.03	885.68	10704.02	886.53	11332.31	887.08	16940.61	888.4	22924.77	890.05
302	430.23	852	6118	876.48	10242	883.22	10442.08	885.08	10593.03	885.98	10704.02	886.8	11332.31	887.37	16940.61	888.91	22924.77	890.73
303	431.94	853.5	6118	877.27	10242	883.86	10442.08	885.58	10593.03	886.42	10704.02	887.18	11332.31	887.76	17021.09	889.54	26758.36	891.53
303.4	432.07	853.42	5825	877.32	9942	883.92	10142.08	885.63	10293.03	886.47	10404.02	887.24	11032.31	887.81	16696.73	889.65	26307.2	891.57
303.5	432.10	853.46	5825	877.36	9942	883.95	10142.08	885.66	10293.03	886.5	10404.02	887.25	11032.31	887.83	16655.68	889.68	26063.31	891.65
303.8	432.53	854.5	5825	877.54	9942	884.1	10142.08	885.77	10293.03	886.59	10404.02	887.34	11032.31	887.92	16586.96	889.84	25296.24	892.07
304	432.84	855.5	5825	877.64	9943	884.19	10143.08	885.84	10294.03	886.65	10405.02	887.39	11032.71	887.97	16319.54	889.91	22404.75	892.15
305	433.26	854.4	5825	877.81	9943	884.35	10143.08	885.97	10294.03	886.77	10405.02	887.5	11032.71	888.08	16510.89	890.06	20331.37	892.25
306	433.35	855	5825	877.89	9943	884.43	10143.08	886.03	10294.03	886.83	10405.02	887.56	11032.71	888.14	16574.01	890.17	19837.48	892.38
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	5825	877.9	9943	884.44	10143.08	886.04	10294.03	886.84	10405.02	887.56	11032.71	888.14	16574.01	890.18	19837.48	892.4
309	433.83	854.5	5825	878.05	9943	884.58	10143.08	886.16	10294.03	886.95	10405.02	887.67	11032.71	888.25	16574.01	890.37	19837.48	892.61
310	434.61	852.8	5825	878.31	9943	884.8	10143.08	886.33	10294.03	887.1	10405.02	887.8	11032.71	888.39	16574.01	890.6	19837.48	892.83
310.5	435.70	855	5825	878.7	9943	885.13	10143.08	886.59	10294.03	887.34	10405.02	888.02	11032.71	888.61	16574.01	890.95	19837.48	893.22
311	436.34	855	5825	878.94	9943	885.36	10143.08	886.78	10294.03	887.51	10405.02	888.18	11024.92	888.78	15924.61	891.26	21488.16	893.54
312	437.05	863.83	5630	879.2	9663	885.61	9773.08	886.99	9899.03	887.71	9975.02	888.37	10584.92	888.97	15449.61	891.58	21087.35	893.93
313	437.95	856	5630	879.57	9662	885.98	9772.08	887.3	9898.03	888	9974.02	888.63	10584.52	889.25	15717.04	892	23869.66	894.48
314	438.78	857	5630	879.92	9662	886.32	9772.08	887.58	9898.03	888.25	9974.02	888.88	10584.52	889.49	15717.04	892.35	23869.66	895.06
315	439.05	856	5630	880.03	9662	886.42	9772.08	887.66	9898.03	888.33	9974.02	888.95	10584.52	889.57	15717.04	892.47	23869.66	895.28
316	439.46	855.1	5630	880.2	9662	886.61	9772.08	887.83	9898.03	888.49	9974.02	889.1	10584.52	889.73	15717.04	892.73	22545.57	895.75
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	5630	880.21	9662	886.62	9772.08	887.84	9898.03	888.5	9974.02	889.1	10584.52	889.73	15717.04	892.73	22545.57	895.74
319	439.50	857	5630	880.22	9662	886.67	9772.08	887.88	9898.03	888.54	9974.02	889.14	10584.52	889.78	15717.04	892.8	22545.57	895.82
320	439.66	856	5630	880.29	9662	886.72	9772.08	887.93	9898.03	888.58	9974.02	889.19	10584.52	889.82	15717.04	892.85	22545.57	895.89
321	440.31	858	5630	880.52	9662	886.97	9772.08	888.14	9898.03	888.78	9974.02	889.37	10584.52	890	15717.04	893.13	22545.57	896.28
322	440.32	858.1	5630	880.51	9662	886.96	9772.08	888.14	9898.03	888.77	9974.02	889.38	10584.52	890	15717.04	893.13	22545.57	896.27
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	5630	880.56	9662	887.07	9772.08	888.23	9898.03	888.85	9974.02	889.43	10584.52	890.06	15717.04	893.18	22545.57	896.32
325	440.34	857	5630	880.56	9662	887.08	9772.08	888.23	9898.03	888.86	9974.02	889.44	10584.52	890.07	15717.04	893.19	22545.57	896.32
326	440.54	858	5630	880.61	9662	887.13	9772.08	888.27	9898.03	888.9	9974.02	889.47	10584.52	890.11	15717.04	893.23	22545.57	896.4
327	441.53	859	5600	880.98	9617	887.39	9717.08	888.49	9833.03	889.09	9914.02	889.65	10514.52	890.28	15642.04	893.46	22468.45	896.7
328	442.14	858	5600	881.18	9617	887.54	9717.08	888.61	9833.03	889.2	9914.02	889.75	10514.52	890.38	15866.36	893.59	24473.8	896.88
329	442.45	857	5600	881.24	9617	887.57	9717.08	888.63	9833.03	889.21	9914.02	889.76	10514.52	890.39	16275.85	893.6	26572.38	896.89
329.5	442.93	858.06	5600	881.38	9616	887.67	9716.08	888.72	9832.03	889.29	9913.02	889.83	10521.65	890.46	16290.43	893.68	26784.62	896.99
330	443.69	858	5600	881.61	9616	887.86	9716.08	888.87	9832.03	889.44	9913.02	889.96	10521.65	890.59	16290.43	893.82	26784.62	897.16
331	443.99	859	5600	881.69	9616	887.95	9716.08	888.95	9832.03	889.52	9913.02	890.04	10521.65	890.66	16290.43	893.93	26784.62	897.38
332	444.33	856	5600	881.74	9616	887.98	9716.08	888.99	9832.03	889.55	9913.02	890.06	10521.65	890.69	16290.43	893.97	26784.62	897.44
333	444.92	859	5600	881.81	9616	888.02	9716.08	889.02	9832.03	889.58	9913.02	890.09	10521.65	890.72	16290.43	893.99	26784.62	897.45
334	445.18	860	5600	881.89	9616	888.09	9716.08	889.08	9832.03	889.64	9913.02	890.14	10521.65	890.77	16290.43	894.07	26784.62	897.54
335	445.31	860	5600	881.96	9616	888.18	9716.08	889.16	9832.03	889.71	9913.02	890.21	10521.65	890.84	16290.43	894.2	26784.62	897.83
336	445.36	859	5600	881.96	9616	888.19	9716.08	889.17	9832.03	889.72	9913.02	890.22	10521.65	890.85	16290.43	894.21	26784.62	897.84
336.5	445.76	857.69	5600	881.99	9616	888.21	9716.08	889.19	9832.03	889.74	9913.02	890.24	10521.65	890.87	16290.43	894.24	26784.62	897.89
337	446.09	860	5600	882.01	9616	888.21	9716.08	889.19	9832.03	889.73	9913.02	890.24	10521.65	890.87	16290.43	894.23	26784.62	897.87
338	446.29	861	5600	882.08	9616	888.25	9716.08	889.21	9832.03	889.76	9913.02	890.26	10521.65	890.88	16290.43	894.24	26784.62	897.87
338.5	446.70	860.9	5600	882.24	9616	888.38	9716.08	889.32	9832.03	889.86	9913.02	890.35	10521.65	890.98	16290.43	894.38	26784.62	898.08
339	446.76	861	5600	882.26	9616	888.4	9716.08	889.34	9832.03	889.87	9913.02	890.37	10521.65	890.99	16290.43	894.39	26784.62	898.11
340	447.04	860	5600	882.34	9616	888.49	9716.08	889.42	9832.03	889.95	9913.02	890.44	10521.65	891.08	16290.43	894.53	26784.62	898.37
341	447.24	859	5600	882.43	9616	888.55	9716.08	889.47	9832.03	890	9913.02	890.48	10521.65	891.11	16290.43	894.57	26784.62	898.41
342	447.42	861	5600	882.54	9616	888.63	9716.08	889.54	9832.03	890.06	9913.02	890.54	10521.65	891.17	16290.43	894.64	26784.62	898.52
342.5	447.78	856.99	5600	882.69	9616	888.77	9716.08	889.66	9832.03	890.17	9913.02	890.64	10521.65	891.28	16290.43	894.79	26784.62	898.76
343	448.13	861	5600	882.81	9616	888.87	9716.08	889.75	9832.03	890.25	9913.02	890.72	10521.65	891.35	16290.43	894.89	26784.62	898.9
344	448.36	859	5600	882.91	9616	888.97	9716.08	889.84	9832.03	890.34	9913.02	890.81	10521.65	891.44	16290.43	895.04	26784.62	899.19
345	448.89	865.3	5600	883.22	9616	889.18	9716.08	890.02	9832.03	890.51	9913.02	890.96	10521.65	891.59	16290.43	895.21	26784.62	899.4
348	448.90	864.3	5600	883.21	9616	889.16	9716.08	890	9832.03	890.49	9913.02	890.94	10521.65	891.57	16290.43	895.17	26784.62	899.34
348.4			North Dam															
348.8	448.90	864.3	5600	883.28	9616	889.21	9716.08	890.05	9832.03	890.53	9913.02	890.98	10521.65	891.62	16290.43	895.22	26784.62	899.41
351	448.91	861	5600	883.29	9616	889.22	9716.08	890.05	9832.03	890.54	9913.02	890.98	10521.65	891.63	16290.43	895.22	26784.62	899.41
351.4	449.06	861	5600	883.38	9616	889.34	9716.08	890.17	9832.03	890.65	9913.02	891.09	10521.65	891.74	16290.43	895.4	26784.62	899.7
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	5600	883.39	9616	889.42	9716.08	890.25	9832.03	890.74	9913.02	891.19	10521.65	891.83	16290.43	895.49	26784.62	899.75
352	449.09	862	5600	883.4	9616	889.44	9716.08	890.27	9832.03	890.76	9913.02	891.2	10521.65	891.85	16290.43	895.52	26784.62	899.79
353	449.28	863	5600	883.49	9616	889.53	9716.08	890.35	9832.03	890.83	9913.02	891.27	10521.65	891.93	16290.43	895.64	26784.62	899.99
353.5	449.61	860.13	5600	883.61	9616	889.62	9716.08	890.42	9832.03	890.9	9913.02	891.34	10521.65	891.98	16290.43	895.7	26784.62	900.08
354	449.97	864	5600	883.86	9616	889.83	9716.08	890.62	9832.03	891.08	9913.02	891.51	10521.65	892.17	16290.43	895.91	26784.62	900.31
355	450.19	862	5600	883.98	9616	889.92	9716.08	890.7	9832.03	891.16	9913.02	891.59	10521.65	892.25	16290.43	896.03	26784.62	900.49
356	450.84	858	5600	884.32	9616	890.18	9716.08	890.91	9832.03	891.36	9913.02	891.77	10521.65	892.43	16290.43	896.23	26784.62	900.72
357	450.86	863.4	5600	884.33	9616	890.18	9716.08	890.92	9832.03	891.36	9913.02	891.77	10521.65	892.43	16290.43	896.23	26784.62	900.73
358			BNRR Bridge															
359	450.87	863.4	5600	884.41	9616	890.28	9716.08	891	9832.03	891.44	9913.02	891.84	10521.65	892.49	16290.43	896.28	26784.62	900.93
361	451.20	865	5600	884.56	9616	890.39	9716.08	891.1	9832.03	891.54	9913.02	891.93	10521.65	892.59	16290.43	896.4	26784.62	901.09
361.5	451.37	865.2	5600	884.65	9616	890.46	9716.08	891.17	9832.03	891.59	9913.02	891.99	10521.65	892.64	16290.43	896.46	26784.62	901.17
362.5			1st Ave. No. Bridge															
364	451.39	865.2	5600	884.67	9616	890.49	9716.08	891.18	9832.03	891.61	9913.02	892	10521.65	892.66	16290.43	896.48	26784.62	901.26
366	451.41	861	5600	884.71	9616	890.53	9716.08	891.22	9832.03	891.65	9913.02	892.04	10521.65	892.69	16290.43	896.52	26784.62	901.3
367	451.57	867	5600	884.77	9616	890.63	9716.08	891.32	9832.03	891.74	9913.02	892.13	10521.65	892.79	16290.43	896.71	26784.62	901.65
368	451.61	866.8	5600	884.82	9616	890.67	9716.08	891.36	9832.03	891.78	9913.02	892.17	10521.65	892.83	16290.43	896.75	26784.62	901.71
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	5600	884.83	9616	890.68	9716.08	891.37	9832.03	891.79	9913.02	892.18	10521.65	892.83	16290.43	896.78	26784.62	901.77
371	451.65	859	5600	884.85	9616	890.68	9716.08	891.37	9832.03	891.79	9913.02	892.17	10521.65	892.83	16290.43	896.77	26784.62	901.74
372	451.67	867.9	5600	884.84	9616	890.67	9716.08	891.36	9832.03	891.78	9913.02	892.17	10521.65	892.82	16290.43	896.76	26784.62	901.74
373			BNRR Bridge															
374	451.68	867.9	5600	884.94	9616	890.77	9716.08	891.44	9832.03	891.86	9913.02	892.24	10521.65	892.9	16290.43	896.83	26784.62	901.8
375	451.69	864	5600	884.96	9616	890.77	9716.08	891.44	9832.03	891.86	9913.02	892.24	10521.65	892.9	16290.43	896.82	26784.62	901.78
376	451.71	865.9	5600	884.96	9616	890.78	9716.08	891.46	9832.03	891.88	9913.02	892.26	10521.65	892.92	16290.43	896.88	26784.62	901.93
377			Main Ave. Bridge															
378	451.72	865.9	5600	884.98	9616	890.79	9716.08	891.47	9832.03	891.89	9913.02	892.27	10521.65	892.93	16290.43	896.9	26784.62	901.96
379	451.73	864	5600	885.07	9616	890.89	9716.08	891.56	9832.03	891.97	9913.02	892.35	10521.65	893.01	16290.43	896.99	26784.62	902.05
380	451.85	864	5600	885.05	9616	890.86	9716.08	891.53	9832.03	891.95	9913.02	892.33	10521.65	892.98	16290.43	896.96	26784.62	902.02
381	452.03	863	5600	885.17	9616	891.01	9716.08	891.67	9832.03	892.08	9913.02	892.45	10521.65	893.12	16290.43	897.14	26784.62	902.24
381.5	452.04	863	5600	885.18	9616	891.02	9716.08	891.68	9832.03	892.09	9913.02	892.46	10521.65	893.13	16290.43	897.15	26784.62	902.25
384			Midtown Dam															
385.5	452.05	867	5600	885.2	9616	891.03	9716.08	891.69	9832.03	892.1	9913.02	892.47	10521.65	893.14	16290.43	897.16	26784.62	902.26
386	452.06	867	5600	885.21	9616	891.03	9716.08	891.69	9832.03	892.1	9913.02	892.48	10521.65	893.14	16290.43	897.16	26784.62	902.27
387	452.25	867	5600	885.31	9616	891.1	9716.08	891.75	9832.03	892.15	9913.02	892.52	10521.65	893.19	16290.43	897.21	26784.62	902.32
388	452.46	869	5600	885.47	9616	891.2	9716.08	891.84	9832.03	892.24	9913.02	892.61	10521.65	893.27	16290.43	897.31	26784.62	902.47
389	452.70	866.08	5600	885.7	9616	891.37	9716.08	891.99	9832.03	892.38	9913.02	892.74	10521.65	893.4	16290.43	897.46	26784.62	902.66
390	452.94	867	5600	885.81	9616	891.46	9716.08	892.07	9832.03	892.46	9913.02	892.81	10521.65	893.47	16290.43	897.55	26784.62	902.76
391	453.16	867	5600	885.94	9616	891.57	9716.08	892.17	9832.03	892.55	9913.02	892.9	10521.65	893.56	16290.43	897.65	26784.62	902.89
392	453.39	865	5600	886.04	9616	891.66	9716.08	892.25	9832.03	892.63	9913.02	892.98	10521.65	893.64	16290.43	897.76	26784.62	903.05
393	454.02	866	5600	886.38	9616	891.9	9716.08	892.47	9832.03	892.84	9913.02	893.17	10521.65	893.82	16290.43	897.94	26784.62	903.23
394	454.10	865	5600	886.41	9616	891.94	9716.08	892.51	9832.03	892.87	9913.02	893.2	10521.65	893.86	16290.43	897.97	26784.62	903.25
395	454.75	864	5600	886.69	9616	892.17	9716.08	892.71	9832.03	893.06	9913.02	893.39	10521.65	894.04	16290.43	898.17	26784.62	903.47
396	455.16	866	5600	886.89	9616	892.38	9716.08	892.9	9832.03	893.25	9913.02	893.56	10521.65	894.21	16290.43	898.37	26784.62	903.63
397	455.20	866.6	5600	886.93	9616	892.41	9716.08	892.93	9832.03	893.28	9913.02	893.59	10521.65	894.24	16290.43	898.4	26784.62	903.67
399			I-94 Bridge															
401	455.23	866.6	5600	886.94	9616	892.41	9716.08	892.93	9832.03	893.28	9913.02	893.59	10521.65	894.24	16290.43	898.4	26784.62	903.67
402	455.28	865	5600	886.96	9616	892.43	9716.08	892.95	9832.03	893.29	9913.02	893.6	10521.65	894.26	16290.43	898.42	26784.62	903.69
402.5	455.52	864.58	5600	887.08	9616	892.56	9716.08	893.06	9832.03	893.4	9913.02	893.71	10521.65	894.36	16290.43	898.53	26784.62	903.83
403	455.59	866	5600	887.11	9616	892.59	9716.08	893.1	9832.03	893.44	9913.02	893.74	10521.65	894.39	16290.43	898.57	26784.62	903.89
404	455.92	865	5600	887.25	9616	892.71	9716.08	893.21	9832.03	893.54	9913.02	893.84	10521.65	894.5	16290.43	898.71	26784.62	904.08
405	456.65	865	5600	887.59	9616	892.98	9716.08	893.45	9832.03	893.77	9913.02	894.06	10521.65	894.71	16290.43	898.9	26784.62	904.26
406	457.09	866	5600	887.82	9616	893.17	9716.08	893.62	9832.03	893.94	9913.02	894.22	10521.65	894.87	16290.43	899.09	26784.62	904.47

Table B20

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year Zero - Wet, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	5600	887.89	9616	893.23	9716.08	893.68	9832.03	893.99	9913.02	894.27	10521.65	894.92	16290.43	899.13	26784.62	904.5
408	457.80	864	5600	888.09	9616	893.45	9716.08	893.89	9832.03	894.2	9913.02	894.47	10521.65	895.12	16290.43	899.39	26784.62	904.84
409	457.95	855.9	5600	888.16	9616	893.55	9716.08	893.98	9832.03	894.29	9913.02	894.56	10521.65	895.21	16290.43	899.48	26784.62	904.92
409.1	457.97	855.9	5600	888.17	9616	893.55	9716.08	893.99	9832.03	894.29	9913.02	894.56	10521.65	895.21	16290.43	899.48	26784.62	904.93
409.5			South Dam															
409.6	457.98	855.9	5600	888.21	9616	893.59	9716.08	894.02	9832.03	894.33	9913.02	894.6	10521.65	895.25	16290.43	899.51	26784.62	904.96
409.7	457.99	855.9	5600	888.21	9616	893.59	9716.08	894.02	9832.03	894.33	9913.02	894.6	10521.65	895.25	16290.43	899.52	26784.62	904.97
413	458.32	869	5600	888.22	9616	893.61	9716.08	894.05	9832.03	894.35	9913.02	894.62	10521.65	895.27	16290.43	899.56	26784.62	905
414	458.75	866	5600	888.5	9616	893.88	9716.08	894.3	9832.03	894.6	9913.02	894.86	10521.65	895.51	16290.43	899.85	26784.62	905.37
459.64	459.64	864.81	5600	888.92	9616	894.31	9716.08	894.7	9832.03	894.98	9913.02	895.23	10521.65	895.88	16290.43	900.2	26784.62	905.7
460.28	460.28	868.74	5600	889.3	9616	894.65	9716.08	895.02	9832.03	895.29	9913.02	895.53	10521.65	896.17	16290.43	900.5	26784.62	905.97
460.72	460.72	869.04	5600	889.6	9616	894.91	9716.08	895.26	9832.03	895.53	9913.02	895.76	10521.65	896.4	16290.43	900.76	26784.62	906.29
461.3	461.3	868.04	5600	890	9616	895.29	9716.08	895.63	9832.03	895.88	9913.02	896.1	10521.65	896.74	16290.43	901.15	26784.62	906.72
462.03	462.03	864.16	5600	890.39	9616	895.68	9716.08	896	9832.03	896.24	9913.02	896.46	10521.65	897.09	16290.43	901.52	26784.62	907.1
462.04	462.04	869.5	5600	890.43	9616	895.72	9716.08	896.04	9832.03	896.28	9913.02	896.49	10521.65	897.12	16290.43	901.54	26784.62	907.14
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	5600	890.44	9616	895.73	9716.08	896.04	9832.03	896.29	9913.02	896.5	10521.65	897.13	16290.43	901.56	26784.62	907.18
462.07	462.07	871.5	5600	890.47	9616	895.75	9716.08	896.07	9832.03	896.31	9913.02	896.52	10521.65	897.16	16290.43	901.59	26784.62	907.18
462.7	462.7	862.82	5600	890.82	9616	896.08	9716.08	896.38	9832.03	896.61	9913.02	896.82	10521.65	897.45	16290.43	901.89	26784.62	907.49
463.7	463.7	864.71	5600	891.19	9616	896.48	9716.08	896.77	9832.03	897	9913.02	897.2	10521.65	897.83	16290.43	902.33	26784.62	907.93
464.2	464.2	869.2	5600	891.45	9616	896.76	9716.08	897.04	9832.03	897.26	9913.02	897.45	10521.65	898.09	16290.43	902.63	26784.62	908.29
464.6	464.6	865	5600	891.66	9616	896.95	9716.08	897.23	9832.03	897.44	9913.02	897.63	10521.65	898.27	16290.43	902.81	26784.62	908.45
465.1	465.1	862.9	5600	891.85	9616	897.19	9716.08	897.46	9832.03	897.67	9913.02	897.86	10521.65	898.5	16290.43	903.12	26784.62	908.81
465.9	465.9	865.6	5600	892.15	9616	897.53	9716.08	897.79	9832.03	898.01	9913.02	898.19	10521.65	898.84	16290.43	903.49	26784.62	909.11
466.5	466.5	864.9	5600	892.4	9616	897.8	9716.08	898.06	9832.03	898.27	9913.02	898.44	10521.65	899.09	16290.43	903.78	26784.62	909.41
467.4	467.4	864.8	5600	892.78	9616	898.21	9716.08	898.46	9832.03	898.66	9913.02	898.84	10521.65	899.49	16290.43	904.24	26784.62	909.86
468.2	468.2	862.6	5600	893.05	9616	898.49	9716.08	898.73	9832.03	898.93	9913.02	899.1	10521.65	899.76	16290.43	904.54	26784.62	910.06
468.9	468.9	861	5600	893.29	9616	898.77	9716.08	899.01	9832.03	899.21	9913.02	899.37	10521.65	900.04	16290.43	904.85	26784.62	910.24
469.7	469.7	870	5600	893.67	9616	899.16	9716.08	899.4	9832.03	899.59	9913.02	899.75	10521.65	900.42	16290.43	905.16	26784.62	910.39
470.1	470.1	870.9	5600	893.84	9616	899.34	9716.08	899.58	9832.03	899.77	9913.02	899.92	10521.65	900.59	16290.43	905.36	26784.62	910.51
470.6	470.6	869.4	4166	894.02	7266	899.54	7365.08	899.76	7481.03	899.95	7561.02	900.11	8169.65	900.77	13938.43	905.55	24432.62	910.68
471.4	471.4	867.5	4166	894.28	7089	899.82	7342.08	900.05	7583.03	900.24	7790.02	900.4	8447.65	901.07	13793.43	905.89	23461.62	910.92
472.18	472.18	869.9	4166	894.54	7089	900.09	7342.08	900.32	7583.03	900.52	7790.02	900.69	8447.65	901.37	13793.43	906.24	23461.62	911.2
472.2	472.2	870.8	4166	894.54	7089	900.08	7342.08	900.32	7583.03	900.52	7790.02	900.68	8447.65	901.37	13793.43	906.22	23461.62	911.16
472.22	472.22	870.8	4166	894.54	7089	900.09	7342.08	900.33	7583.03	900.53	7790.02	900.69	8447.65	901.38	13793.43	906.25	23461.62	911.29
473	473	871.8	4166	894.79	7089	900.33	7342.08	900.57	7583.03	900.78	7790.02	900.95	8447.65	901.65	13793.43	906.52	23461.62	911.51
473.8	473.8	869	4166	895.07	7089	900.63	7342.08	900.88	7583.03	901.09	7790.02	901.27	8447.65	901.98	13793.43	906.9	23461.62	911.88
474.08	474.08	873.5	4166	895.17	7089	900.73	7342.08	900.98	7583.03	901.2	7790.02	901.38	8447.65	902.1	13793.43	907.04	23461.62	912.03
474.09	474.09	873.5	4166	895.19	7089	900.76	7342.08	901.01	7583.03	901.23	7790.02	901.41	8447.65	902.13	13793.43	907.1	23461.62	912.1
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	4166	895.18	7089	900.75	7342.08	901.01	7583.03	901.22	7790.02	901.4	8447.65	902.12	13793.43	907.08	23461.62	912.13
474.12	474.12	874	4166	895.19	7089	900.76	7342.08	901.01	7583.03	901.23	7790.02	901.41	8447.65	902.13	13793.43	907.1	23461.62	912.17
474.6	474.6	873.4	4166	895.39	7089	900.93	7342.08	901.18	7583.03	901.41	7790.02	901.59	8447.65	902.31	13793.43	907.3	23461.62	912.41
475.3	475.3	872.2	4166	895.66	7089	901.22	7342.08	901.48	7583.03	901.71	7790.02	901.9	8447.65	902.63	13793.43	907.67	23461.62	912.87
475.7	475.7	871	4166	895.81	7089	901.38	7342.08	901.64	7583.03	901.88	7790.02	902.07	8447.65	902.81	13793.43	907.93	23461.62	913.26
476.4	476.4	873.7	4166	896.08	7089	901.63	7342.08	901.9	7583.03	902.14	7790.02	902.34	8447.65	903.09	13793.43	908.22	23461.62	913.51
477	477	874	4021	896.34	5364	901.86	7088.08	902.16	8748.03	902.43	10484.02	902.67	11723.65	903.44	12261.43	908.54	14253.62	913.81
477.6	477.6	870.2	4000	896.53	5137	901.99	7051.08	902.37	8930.03	902.75	10918.02	903.11	12251.65	903.93	12041.43	908.8	13076.62	913.95
478	478	873.4	4000	896.67	5137	902.08	7051.08	902.52	8930.03	902.97	10918.02	903.42	12251.65	904.27	12041.43	908.94	13076.62	914.01
478.58	478.58	875	4000	896.8	5137	902.16	7051.08	902.68	8930.03	903.2	10918.02	903.75	12251.65	904.63	12041.43	909.12	13076.62	914.11
478.72	478.72	875.38	4000	896.81	5137	902.17	7051.08	902.69	8930.03	903.23	10918.02	903.78	12251.65	904.66	12041.43	909.14	13076.62	914.11
478.76	478.76	875.51	4000	896.82	5137	902.17	7051.08	902.69	8930.03	903.22	10918.02	903.77	12251.65	904.65	12041.43	909.13	13076.62	914.1
478.765	478.765		Proposed Red River Closure Structure															
478.77	478.77	875.51	4000	896.85	5137	906.37	7051.08	908.83	8930.03	910.84	10918.02	913.38	12251.65	914.87	12041.43	916.49	13076.62	917.84
478.81	478.81	875.64	4000	896.85	5137	906.38	7051.08	908.85	8930.03	910.86	10918.02	913.42	12251.65	914.92	12041.43	916.51	13076.62	917.85
479	479	876.35	4000	896.88	7000	906.39	10500	908.86	14800	910.87	21000	913.42	25000	914.92	28500	916.51	32000	917.85
479.2	479.2	875.7	4000	896.9	7000	906.39	10500	908.86	14800	910.88	21000	913.43	25000	914.93	28500	916.52	32000	917.89
479.7	479.7	871.5	4000	897.09	7000	906.48	10500	908.99	14800	911.06	21000	913.66	25000	915.16	28500	916.72	32000	918
480.5	480.5	874.7	4000	897.37	7000	906.65	10500	909.24	14800	911.39	21000	914.05	25000	915.52	28500	917.01	32000	918.24
481.8	481.8	875.3	4000	897.78	7000	906.93	10500	909.62	14800	911.88	21000	914.65	25000	916.1	28500	917.49	32000	918.56
482.3	482.3	874.2	4000	897.99	7000	907.08	10500	909.84	14800	912.18	21000	914.98	25000	916.4	28500	917.68	32000	918.7
482.698	482.698	869.74	4000	898.11	7000	907.16	10500	909.95	14800	912.33	21000	915.16	25000	916.61	28500	917.86	32000	918.82
482.7	482.7	887.04	4000	898	7000	907.11	10500	909.89	14800	912.25	21000	915.08	25000	916.57	28500	917.85	32000	918.83
482.702	482.702	878.54	4000	898.14	7000	907.16	10500	909.96	14800	912.33	21000	915.16	25000	916.61	28500	917.86	32000	918.83
483.1	483.1	879.2	4000	898.38	7000	907.32	10500	910.19	14800	912.65	21000	915.54	25000	916.95	28500	918.07	32000	918.94
483.9	483.9	873	4000	898.79	7000	907.54	10500	910.5	14800	913.08	21000	916.08	25000	917.4	28500	918.49	32000	919.31
485.08	485.08	880.5	4000	899.31	7000	907.72	10500	910.72	14800	913.33	21000	916.37	25000	917.7	28500	918.79	32000	919.6
485.09	485.09	880.5	4000	899.31	7000	907.71	10500	910.72	14800	913.33	21000	916.37	25000	917.7	28500	918.79	32000	919.6
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	4000	899.31	7000	907.74	10500	910.77	14800	913.42	21000	916.43	25000	917.75	28500	918.82	32000	919.63
485.12	485.12	879.4	4000	899.33	7000	907.77	10500	910.78	14800	913.43	21000	916.43	25000	917.75	28500	918.83	32000	919.64
485.6	485.6	878.62	4000	899.51	7000	907.85	10500	910.86	14800	913.51	21000	916.52	25000	917.85	28500	918.93	32000	919.74
485.9	485.9	879.5	4000	899.68	7000	907.94	10500	910.98	14800	913.66	21000	916.7	25000	918.06	28500	919.16	32000	919.96
486.3	486.3	872.1	4000	899.84	7000	908.04	10500	911.11	14800	913.84	21000	916.92	25000	918.31	28500	919.43	32000	920.25
487	487	871.3	4000	900.06	7000	908.19	10500	911.33	14800	914.14	21000	917.34	25000	918.82	28500	920	32000	920.87
487.5	487.5	878.8	4000	900.3	7000	908.34	10500	911.52	14800	914.37	21000	917.61	25000	919.11	28500	920.32	32000	921.18
488.68	488.68	878.24	4000	901	7000	908.78	10500	912.1	14800	915.13	21000	918.48	25000	920.07	28500	921.33	32000	922.29

Table B21

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	8950	861.67	18490	870.2	26120	873.73	34240	875.7	45780	876.86	55200	877.69	66150	878.58	82930	879.41
280	404.98	836.6	8950	862.33	18490	870.94	26120	874.31	34240	876.38	45780	877.66	55200	878.49	66150	879.38	82930	880.24
281	406.51	834.9	8950	863.21	18490	871.84	26120	875.33	34240	877.45	45780	878.67	55200	879.48	66150	880.19	82930	881.14
282	410.21	838	8950	865.13	18490	873.73	26120	877.12	34240	879.09	45780	879.9	55200	880.64	66150	881.44	82930	882.51
283	413.23	837.6	8950	866.44	18490	875.11	26120	878.49	34240	880.2	45780	881.15	55200	881.59	66150	882.44	82930	883.58
284	414.98	842.7	8950	867.22	18490	876.08	26120	879.65	34240	881.14	45780	882.07	55200	882.63	66150	883.51	82930	884.68
285	415.38	841.4	8950	867.43	18490	876.32	26120	879.9	34240	881.36	45780	882.34	55200	882.89	66150	883.77	82930	884.95
286	415.84	843	8950	867.59	18490	876.41	26120	879.96	34240	881.4	45780	882.45	55200	883.04	66150	884.03	82930	885.24
287	415.90	844.1	8950	867.64	18490	876.49	26120	880.08	34240	881.62	45780	882.6	55200	883.18	66150	884.02	82930	885.3
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	8950	867.64	18490	876.48	26120	880.07	34240	881.64	45780	882.73	55200	883.4	66150	884.51	82930	885.55
290	415.93	837.5	8950	867.67	18490	876.5	26120	880.1	34240	881.66	45780	882.82	55200	883.51	66150	884.51	82930	885.59
291	417.10	840.8	8950	868.15	18490	877.02	26120	880.73	34240	882.51	45780	883.79	55200	884.59	66150	885.3	82930	886.25
292	418.18	844.4	7874	868.62	15771	877.54	22084	881.31	28855	883.07	38631	884.43	46577	885.21	57304	885.81	73717	886.81
293	419.92	844.7	7475	869.49	13326.77	878.42	13700.4	882.02	13949.59	883.68	14340.77	885.05	14732	885.69	18820.89	886.37	27706.46	887.45
294	420.32	843.8	7475	869.77	13326.77	878.6	13700.4	882.14	13949.59	883.76	14340.77	885.11	14732	885.74	18820.89	886.43	27706.46	887.52
295	421.93	845.3	7475	871.01	13326.77	879.48	13700.4	882.58	13949.59	883.99	14340.77	885.25	14732	885.85	18820.89	886.56	27706.46	887.65
296	422.69	847.4	7475	871.34	13326.77	879.75	13700.4	882.73	13949.59	884.08	14340.77	885.3	14732	885.88	18820.89	886.6	27706.46	887.73
297	423.95	849.5	7475	871.89	13326.77	880.24	13700.4	883.08	13949.59	884.39	14340.77	885.54	14732	886.11	18820.89	886.89	27706.46	888.09
298	425.51	848.7	7475	872.64	13326.77	880.85	13700.4	883.49	13949.59	884.69	14340.77	885.76	14732	886.3	18820.89	887.13	27706.46	888.43
299	426.87	851.1	7475	873.35	13326.77	881.41	13700.4	883.88	13949.59	885.01	14340.77	886.02	14732	886.54	18820.89	887.44	27706.46	888.87
300	428.06	849.6	4864	873.9	10244.77	881.93	10433.4	884.25	10475.59	885.31	10628.77	886.26	10795	886.75	14671.33	887.71	19853.47	889.24
301	428.74	850.3	4864	874.16	10244.77	882.22	10433.4	884.46	10475.59	885.49	10628.77	886.42	10795	886.9	14671.33	887.94	19853.47	889.5
302	430.23	852	4864	874.71	10244.77	882.7	10433.4	884.81	10475.59	885.79	10628.77	886.69	10795	887.16	14671.33	888.36	19853.47	890.09
303	431.94	853.5	4864	875.45	10244.77	883.4	10433.4	885.33	10475.59	886.23	10628.77	887.08	10795	887.53	14673.93	888.9	21828.18	890.77
303.4	432.07	853.42	4572	875.5	9944.77	883.46	10133.4	885.38	10175.59	886.29	10328.77	887.13	10495	887.58	14475.24	889	21491.71	890.86
303.5	432.10	853.46	4572	875.53	9944.77	883.49	10133.4	885.41	10175.59	886.31	10328.77	887.15	10495	887.6	14645.87	889.02	21433.25	890.9
303.8	432.53	854.5	4572	875.69	9944.77	883.66	10133.4	885.53	10175.59	886.41	10328.77	887.24	10495	887.68	14695.19	889.15	21263.31	891.2
304	432.84	855.5	4572	875.77	9945.77	883.76	10134.4	885.6	10176.59	886.47	10329.77	887.29	10496	887.73	14572	889.22	20377.99	891.27
305	433.26	854.4	4572	875.93	9945.77	883.93	10134.4	885.73	10176.59	886.59	10329.77	887.4	10496	887.83	14572.06	889.37	18767.03	891.42
306	433.35	855	4572	876	9945.77	884.01	10134.4	885.8	10176.59	886.65	10329.77	887.45	10496	887.88	14572.06	889.46	18382.9	891.55
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	4572	876.01	9945.77	884.02	10134.4	885.81	10176.59	886.65	10329.77	887.46	10496	887.89	14572.06	889.47	18382.9	891.56
309	433.83	854.5	4572	876.14	9945.77	884.17	10134.4	885.93	10176.59	886.76	10329.77	887.56	10496	887.99	14572.06	889.63	18382.9	891.75
310	434.61	852.8	4572	876.39	9945.77	884.41	10134.4	886.11	10176.59	886.92	10329.77	887.7	10496	888.13	14572.06	889.83	18382.9	891.98
310.5	435.70	855	4572	876.74	9945.77	884.76	10134.4	886.38	10176.59	887.16	10329.77	887.92	10496	888.33	14572.06	890.13	18382.9	892.38
311	436.34	855	4572	876.95	9945.77	885.01	10134.4	886.58	10176.59	887.33	10329.77	888.08	10496	888.49	14500.07	890.38	19814.9	892.69
312	437.05	863.83	4372	877.18	9650.77	885.27	9744.4	886.79	9761.59	887.53	9889.77	888.26	10046	888.67	13965.07	890.64	19239.9	893.07
313	437.95	856	4372	877.51	9649.77	885.66	9743.4	887.11	9760.59	887.82	9888.77	888.53	10045	888.93	14088.26	891.03	20125.22	893.6
314	438.78	857	4372	877.84	9649.77	886.01	9743.4	887.39	9760.59	888.07	9888.77	888.77	10045	889.17	14088.26	891.36	20125.22	894.09
315	439.05	856	4372	877.93	9649.77	886.12	9743.4	887.48	9760.59	888.15	9888.77	888.85	10045	889.24	14088.26	891.46	20125.22	894.27
316	439.46	855.1	4372	878.08	9649.77	886.32	9743.4	887.65	9760.59	888.31	9888.77	889	10045	889.39	14088.26	891.7	20125.22	894.62
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	4372	878.09	9649.77	886.33	9743.4	887.66	9760.59	888.31	9888.77	889	10045	889.39	14088.26	891.7	20125.22	894.62
319	439.50	857	4372	878.1	9649.77	886.38	9743.4	887.7	9760.59	888.36	9888.77	889.04	10045	889.43	14088.26	891.75	20125.22	894.69
320	439.66	856	4372	878.16	9649.77	886.44	9743.4	887.75	9760.59	888.4	9888.77	889.08	10045	889.47	14088.26	891.81	20125.22	894.76
321	440.31	858	4372	878.37	9649.77	886.69	9743.4	887.96	9760.59	888.6	9888.77	889.26	10045	889.65	14088.26	892.06	20125.22	895.12
322	440.32	858.1	4372	878.37	9649.77	886.68	9743.4	887.96	9760.59	888.59	9888.77	889.26	10045	889.64	14088.26	892.06	20125.22	895.11
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	4372	878.39	9649.77	886.8	9743.4	888.05	9760.59	888.67	9888.77	889.33	10045	889.71	14088.26	892.12	20125.22	895.16
325	440.34	857	4372	878.39	9649.77	886.81	9743.4	888.06	9760.59	888.68	9888.77	889.34	10045	889.71	14088.26	892.13	20125.22	895.17
326	440.54	858	4372	878.44	9649.77	886.86	9743.4	888.1	9760.59	888.72	9888.77	889.37	10045	889.75	14088.26	892.18	20125.22	895.25
327	441.53	859	4352	878.81	9604.77	887.14	9688.4	888.32	9700.59	888.91	9823.77	889.55	9975	889.92	14013.26	892.39	20031.6	895.51
328	442.14	858	4352	879	9604.77	887.3	9688.4	888.45	9700.59	889.02	9823.77	889.65	9975	890.01	13980.6	892.51	21152.81	895.67
329	442.45	857	4352	879.07	9604.77	887.32	9688.4	888.46	9700.59	889.04	9823.77	889.66	9975	890.02	14124.71	892.52	22451.36	895.68
329.5	442.93	858.06	4352	879.22	9603.77	887.43	9687.4	888.56	9699.59	889.12	9822.77	889.73	9974	890.09	14132.89	892.59	22549.46	895.77
330	443.69	858	4352	879.44	9603.77	887.63	9687.4	888.71	9699.59	889.26	9822.77	889.86	9974	890.21	14132.89	892.73	22549.46	895.93
331	443.99	859	4352	879.52	9603.77	887.72	9687.4	888.8	9699.59	889.34	9822.77	889.93	9974	890.29	14132.89	892.83	22549.46	896.09
332	444.33	856	4352	879.57	9603.77	887.76	9687.4	888.83	9699.59	889.37	9822.77	889.96	9974	890.31	14132.89	892.87	22549.46	896.15
333	444.92	859	4352	879.65	9603.77	887.8	9687.4	888.86	9699.59	889.4	9822.77	889.99	9974	890.34	14132.89	892.89	22549.46	896.16
334	445.18	860	4352	879.73	9603.77	887.87	9687.4	888.93	9699.59	889.46	9822.77	890.04	9974	890.39	14132.89	892.95	22549.46	896.25
335	445.31	860	4352	879.79	9603.77	887.96	9687.4	889	9699.59	889.53	9822.77	890.11	9974	890.46	14132.89	893.07	22549.46	896.47
336	445.36	859	4352	879.79	9603.77	887.97	9687.4	889.01	9699.59	889.54	9822.77	890.12	9974	890.47	14132.89	893.08	22549.46	896.49
336.5	445.76	857.69	4352	879.83	9603.77	888	9687.4	889.03	9699.59	889.56	9822.77	890.14	9974	890.48	14132.89	893.1	22549.46	896.52
337	446.09	860	4352	879.86	9603.77	888	9687.4	889.03	9699.59	889.56	9822.77	890.14	9974	890.48	14132.89	893.1	22549.46	896.51
338	446.29	861	4352	879.93	9603.77	888.03	9687.4	889.06	9699.59	889.58	9822.77	890.15	9974	890.5	14132.89	893.11	22549.46	896.52
338.5	446.70	860.9	4352	880.08	9603.77	888.17	9687.4	889.17	9699.59	889.69	9822.77	890.25	9974	890.59	14132.89	893.23	22549.46	896.7
339	446.76	861	4352	880.1	9603.77	888.19	9687.4	889.19	9699.59	889.7	9822.77	890.26	9974	890.6	14132.89	893.24	22549.46	896.72
340	447.04	860	4352	880.18	9603.77	888.28	9687.4	889.27	9699.59	889.78	9822.77	890.34	9974	890.68	14132.89	893.36	22549.46	896.94
341	447.24	859	4352	880.26	9603.77	888.34	9687.4	889.32	9699.59	889.83	9822.77	890.38	9974	890.72	14132.89	893.4	22549.46	896.98
342	447.42	861	4352	880.38	9603.77	888.43	9687.4	889.4	9699.59	889.89	9822.77	890.44	9974	890.78	14132.89	893.47	22549.46	897.07
342.5	447.78	856.99	4352	880.53	9603.77	888.57	9687.4	889.51	9699.59	890	9822.77	890.54	9974	890.88	14132.89	893.6	22549.46	897.28
343	448.13	861	4352	880.65	9603.77	888.68	9687.4	889.61	9699.59	890.08	9822.77	890.62	9974	890.95	14132.89	893.69	22549.46	897.4
344	448.36	859	4352	880.75	9603.77	888.78	9687.4	889.7	9699.59	890.17	9822.77	890.7	9974	891.03	14132.89	893.82	22549.46	897.63
345	448.89	865.3	4352	881.09	9603.77	889	9687.4	889.89	9699.59	890.34	9822.77	890.86	9974	891.18	14132.89	893.98	22549.46	897.83
348	448.90	864.3	4352	881.08	9603.77	888.98	9687.4	889.87	9699.59	890.32	9822.77	890.84	9974	891.16	14132.89	893.95	22549.46	897.78
348.4			North Dam															
348.8	448.90	864.3	4352	881.15	9603.77	889.05	9687.4	889.91	9699.59	890.36	9822.77	890.88	9974	891.2	14132.89	894	22549.46	897.85
351	448.91	861	4352	881.17	9603.77	889.05	9687.4	889.91	9699.59	890.37	9822.77	890.88	9974	891.21	14132.89	894	22549.46	897.85
351.4	449.06	861	4352	881.25	9603.77	889.18	9687.4	890.03	9699.59	890.48	9822.77	890.99	9974	891.31	14132.89	894.16	22549.46	898.09
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	4352	881.25	9603.77	889.26	9687.4	890.12	9699.59	890.56	9822.77	891.08	9974	891.4	14132.89	894.26	22549.46	898.16
352	449.09	862	4352	881.27	9603.77	889.27	9687.4	890.13	9699.59	890.58	9822.77	891.1	9974	891.42	14132.89	894.28	22549.46	898.21
353	449.28	863	4352	881.35	9603.77	889.37	9687.4	890.22	9699.59	890.66	9822.77	891.17	9974	891.49	14132.89	894.38	22549.46	898.37
353.5	449.61	860.13	4352	881.48	9603.77	889.46	9687.4	890.29	9699.59	890.73	9822.77	891.24	9974	891.55	14132.89	894.44	22549.46	898.45
354	449.97	864	4352	881.72	9603.77	889.68	9687.4	890.49	9699.59	890.91	9822.77	891.41	9974	891.72	14132.89	894.65	22549.46	898.68
355	450.19	862	4352	881.86	9603.77	889.77	9687.4	890.57	9699.59	890.99	9822.77	891.48	9974	891.79	14132.89	894.76	22549.46	898.84
356	450.84	858	4352	882.23	9603.77	890.04	9687.4	890.79	9699.59	891.19	9822.77	891.67	9974	891.97	14132.89	894.95	22549.46	899.07
357	450.86	863.4	4352	882.24	9603.77	890.04	9687.4	890.8	9699.59	891.19	9822.77	891.67	9974	891.98	14132.89	894.95	22549.46	899.07
358			BNRR Bridge															
359	450.87	863.4	4352	882.31	9603.77	890.14	9687.4	890.88	9699.59	891.27	9822.77	891.74	9974	892.04	14132.89	895	22549.46	899.21
361	451.20	865	4352	882.46	9603.77	890.26	9687.4	890.98	9699.59	891.37	9822.77	891.83	9974	892.13	14132.89	895.11	22549.46	899.36
361.5	451.37	865.2	4352	882.55	9603.77	890.33	9687.4	891.05	9699.59	891.43	9822.77	891.89	9974	892.18	14132.89	895.17	22549.46	899.43
362.5			1st Ave. No. Bridge															
364	451.39	865.2	4352	882.58	9603.77	890.35	9687.4	891.07	9699.59	891.44	9822.77	891.9	9974	892.2	14132.89	895.18	22549.46	899.47
366	451.41	861	4352	882.62	9603.77	890.4	9687.4	891.11	9699.59	891.48	9822.77	891.94	9974	892.23	14132.89	895.22	22549.46	899.5
367	451.57	867	4352	882.68	9603.77	890.49	9687.4	891.2	9699.59	891.57	9822.77	892.03	9974	892.33	14132.89	895.37	22549.46	899.79
368	451.61	866.8	4352	882.72	9603.77	890.54	9687.4	891.25	9699.59	891.61	9822.77	892.07	9974	892.36	14132.89	895.42	22549.46	899.85
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	4352	882.73	9603.77	890.55	9687.4	891.25	9699.59	891.62	9822.77	892.07	9974	892.37	14132.89	895.42	22549.46	899.88
371	451.65	859	4352	882.76	9603.77	890.55	9687.4	891.25	9699.59	891.62	9822.77	892.07	9974	892.37	14132.89	895.42	22549.46	899.86
372	451.67	867.9	4352	882.75	9603.77	890.54	9687.4	891.24	9699.59	891.61	9822.77	892.06	9974	892.36	14132.89	895.41	22549.46	899.86
373			BNRR Bridge															
374	451.68	867.9	4352	882.85	9603.77	890.64	9687.4	891.33	9699.59	891.69	9822.77	892.14	9974	892.44	14132.89	895.48	22549.46	899.91
375	451.69	864	4352	882.87	9603.77	890.64	9687.4	891.33	9699.59	891.69	9822.77	892.14	9974	892.43	14132.89	895.48	22549.46	899.9
376	451.71	865.9	4352	882.87	9603.77	890.65	9687.4	891.35	9699.59	891.71	9822.77	892.16	9974	892.45	14132.89	895.52	22549.46	900.01
377			Main Ave. Bridge															
378	451.72	865.9	4352	882.89	9603.77	890.66	9687.4	891.36	9699.59	891.72	9822.77	892.17	9974	892.46	14132.89	895.54	22549.46	900.04
379	451.73	864	4352	882.97	9603.77	890.76	9687.4	891.44	9699.59	891.8	9822.77	892.25	9974	892.54	14132.89	895.62	22549.46	900.13
380	451.85	864	4352	882.96	9603.77	890.73	9687.4	891.42	9699.59	891.78	9822.77	892.22	9974	892.51	14132.89	895.59	22549.46	900.1
381	452.03	863	4352	883.07	9603.77	890.88	9687.4	891.56	9699.59	891.91	9822.77	892.35	9974	892.65	14132.89	895.76	22549.46	900.3
381.5	452.04	863	4352	883.08	9603.77	890.9	9687.4	891.57	9699.59	891.92	9822.77	892.36	9974	892.66	14132.89	895.77	22549.46	900.32
384			Midtown Dam															
385.5	452.05	867	4352	883.12	9603.77	890.9	9687.4	891.58	9699.59	891.93	9822.77	892.37	9974	892.66	14132.89	895.78	22549.46	900.33
386	452.06	867	4352	883.13	9603.77	890.91	9687.4	891.58	9699.59	891.93	9822.77	892.37	9974	892.67	14132.89	895.78	22549.46	900.34
387	452.25	867	4352	883.25	9603.77	890.97	9687.4	891.64	9699.59	891.98	9822.77	892.42	9974	892.71	14132.89	895.83	22549.46	900.39
388	452.46	869	4352	883.44	9603.77	891.08	9687.4	891.73	9699.59	892.07	9822.77	892.51	9974	892.8	14132.89	895.92	22549.46	900.52
389	452.70	866.08	4352	883.68	9603.77	891.25	9687.4	891.88	9699.59	892.21	9822.77	892.64	9974	892.92	14132.89	896.07	22549.46	900.69
390	452.94	867	4352	883.8	9603.77	891.35	9687.4	891.97	9699.59	892.29	9822.77	892.71	9974	893	14132.89	896.15	22549.46	900.79
391	453.16	867	4352	883.93	9603.77	891.46	9687.4	892.07	9699.59	892.38	9822.77	892.8	9974	893.08	14132.89	896.25	22549.46	900.92
392	453.39	865	4352	884.04	9603.77	891.55	9687.4	892.15	9699.59	892.46	9822.77	892.87	9974	893.15	14132.89	896.34	22549.46	901.05
393	454.02	866	4352	884.39	9603.77	891.8	9687.4	892.37	9699.59	892.67	9822.77	893.07	9974	893.34	14132.89	896.53	22549.46	901.23
394	454.10	865	4352	884.42	9603.77	891.84	9687.4	892.41	9699.59	892.71	9822.77	893.1	9974	893.38	14132.89	896.57	22549.46	901.26
395	454.75	864	4352	884.71	9603.77	892.07	9687.4	892.62	9699.59	892.9	9822.77	893.29	9974	893.56	14132.89	896.76	22549.46	901.48
396	455.16	866	4352	884.9	9603.77	892.28	9687.4	892.81	9699.59	893.09	9822.77	893.46	9974	893.73	14132.89	896.94	22549.46	901.67
397	455.20	866.6	4352	884.94	9603.77	892.32	9687.4	892.84	9699.59	893.12	9822.77	893.49	9974	893.76	14132.89	896.97	22549.46	901.71
399			I-94 Bridge															
401	455.23	866.6	4352	884.94	9603.77	892.32	9687.4	892.84	9699.59	893.12	9822.77	893.49	9974	893.76	14132.89	896.97	22549.46	901.71
402	455.28	865	4352	884.97	9603.77	892.33	9687.4	892.86	9699.59	893.13	9822.77	893.5	9974	893.77	14132.89	896.99	22549.46	901.74
402.5	455.52	864.58	4352	885.09	9603.77	892.46	9687.4	892.97	9699.59	893.24	9822.77	893.61	9974	893.87	14132.89	897.1	22549.46	901.86
403	455.59	866	4352	885.12	9603.77	892.5	9687.4	893.01	9699.59	893.28	9822.77	893.64	9974	893.91	14132.89	897.13	22549.46	901.89
404	455.92	865	4352	885.26	9603.77	892.62	9687.4	893.12	9699.59	893.38	9822.77	893.74	9974	894.01	14132.89	897.25	22549.46	902.07
405	456.65	865	4352	885.62	9603.77	892.89	9687.4	893.36	9699.59	893.61	9822.77	893.96	9974	894.21	14132.89	897.46	22549.46	902.27
406	457.09	866	4352	885.86	9603.77	893.08	9687.4	893.54	9699.59	893.78	9822.77	894.12	9974	894.37	14132.89	897.64	22549.46	902.47

Table B21

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year 25, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	4352	885.93	9603.77	893.15	9687.4	893.6	9699.59	893.83	9822.77	894.17	9974	894.42	14132.89	897.68	22549.46	902.51
408	457.80	864	4352	886.12	9603.77	893.37	9687.4	893.81	9699.59	894.04	9822.77	894.37	9974	894.62	14132.89	897.92	22549.46	902.82
409	457.95	855.9	4352	886.17	9603.77	893.47	9687.4	893.9	9699.59	894.13	9822.77	894.46	9974	894.71	14132.89	898.02	22549.46	902.91
409.1	457.97	855.9	4352	886.18	9603.77	893.47	9687.4	893.91	9699.59	894.13	9822.77	894.46	9974	894.71	14132.89	898.02	22549.46	902.91
409.5			South Dam															
409.6	457.98	855.9	4352	886.24	9603.77	893.51	9687.4	893.94	9699.59	894.17	9822.77	894.5	9974	894.75	14132.89	898.06	22549.46	902.94
409.7	457.99	855.9	4352	886.24	9603.77	893.51	9687.4	893.94	9699.59	894.17	9822.77	894.5	9974	894.75	14132.89	898.06	22549.46	902.95
413	458.32	869	4352	886.24	9603.77	893.53	9687.4	893.97	9699.59	894.19	9822.77	894.52	9974	894.77	14132.89	898.09	22549.46	902.99
414	458.75	866	4352	886.51	9603.77	893.81	9687.4	894.22	9699.59	894.44	9822.77	894.76	9974	895	14132.89	898.37	22549.46	903.34
459.64	459.64	864.81	4352	886.91	9603.77	894.24	9687.4	894.63	9699.59	894.83	9822.77	895.13	9974	895.37	14132.89	898.72	22549.46	903.69
460.28	460.28	868.74	4352	887.29	9603.77	894.58	9687.4	894.95	9699.59	895.13	9822.77	895.43	9974	895.66	14132.89	899.02	22549.46	903.99
460.72	460.72	869.04	4352	887.61	9603.77	894.84	9687.4	895.2	9699.59	895.37	9822.77	895.66	9974	895.89	14132.89	899.27	22549.46	904.3
461.3	461.3	868.04	4352	888.01	9603.77	895.23	9687.4	895.56	9699.59	895.73	9822.77	896.01	9974	896.23	14132.89	899.64	22549.46	904.76
462.03	462.03	864.16	4352	888.37	9603.77	895.63	9687.4	895.94	9699.59	896.09	9822.77	896.36	9974	896.58	14132.89	900.01	22549.46	905.13
462.04	462.04	869.5	4352	888.41	9603.77	895.66	9687.4	895.98	9699.59	896.13	9822.77	896.39	9974	896.61	14132.89	900.03	22549.46	905.18
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	4352	888.42	9603.77	895.67	9687.4	895.98	9699.59	896.14	9822.77	896.4	9974	896.62	14132.89	900.05	22549.46	905.25
462.07	462.07	871.5	4352	888.46	9603.77	895.7	9687.4	896.01	9699.59	896.16	9822.77	896.43	9974	896.64	14132.89	900.08	22549.46	905.24
462.7	462.7	862.82	4352	888.82	9603.77	896.03	9687.4	896.32	9699.59	896.46	9822.77	896.72	9974	896.93	14132.89	900.37	22549.46	905.54
463.7	463.7	864.71	4352	889.15	9603.77	896.43	9687.4	896.72	9699.59	896.85	9822.77	897.1	9974	897.31	14132.89	900.8	22549.46	905.98
464.2	464.2	869.2	4352	889.41	9603.77	896.71	9687.4	896.98	9699.59	897.11	9822.77	897.36	9974	897.57	14132.89	901.1	22549.46	906.33
464.6	464.6	865	4352	889.62	9603.77	896.9	9687.4	897.17	9699.59	897.3	9822.77	897.54	9974	897.74	14132.89	901.28	22549.46	906.49
465.1	465.1	862.9	4352	889.79	9603.77	897.14	9687.4	897.4	9699.59	897.52	9822.77	897.76	9974	897.97	14132.89	901.56	22549.46	906.88
465.9	465.9	865.6	4352	890.06	9603.77	897.49	9687.4	897.74	9699.59	897.86	9822.77	898.09	9974	898.29	14132.89	901.93	22549.46	907.24
466.5	466.5	864.9	4352	890.3	9603.77	897.76	9687.4	898	9699.59	898.12	9822.77	898.34	9974	898.55	14132.89	902.21	22549.46	907.55
467.4	467.4	864.8	4352	890.64	9603.77	898.17	9687.4	898.41	9699.59	898.51	9822.77	898.74	9974	898.94	14132.89	902.64	22549.46	908.03
468.2	468.2	862.6	4352	890.89	9603.77	898.45	9687.4	898.68	9699.59	898.78	9822.77	899	9974	899.21	14132.89	902.93	22549.46	908.3
468.9	468.9	861	4352	891.12	9603.77	898.73	9687.4	898.96	9699.59	899.05	9822.77	899.27	9974	899.48	14132.89	903.23	22549.46	908.51
469.7	469.7	870	4352	891.47	9603.77	899.13	9687.4	899.34	9699.59	899.44	9822.77	899.65	9974	899.86	14132.89	903.57	22549.46	908.7
470.1	470.1	870.9	4352	891.63	9603.77	899.31	9687.4	899.52	9699.59	899.62	9822.77	899.82	9974	900.03	14132.89	903.76	22549.46	908.85
470.6	470.6	869.4	3198	891.8	7253.77	899.5	7336.4	899.71	7348.59	899.8	7471.77	900.01	7622	900.21	11780.89	903.95	20197.46	909.06
471.4	471.4	867.5	3198	892.04	7108.77	899.79	7323.4	899.99	7449.59	900.09	7691.77	900.29	7892	900.5	11666.89	904.28	19314.46	909.37
472.18	472.18	869.9	3198	892.29	7108.77	900.06	7323.4	900.27	7449.59	900.37	7691.77	900.58	7892	900.79	11666.89	904.61	19314.46	909.68
472.2	472.2	870.8	3198	892.29	7108.77	900.05	7323.4	900.26	7449.59	900.36	7691.77	900.57	7892	900.79	11666.89	904.6	19314.46	909.66
472.22	472.22	870.8	3198	892.29	7108.77	900.06	7323.4	900.27	7449.59	900.37	7691.77	900.59	7892	900.8	11666.89	904.63	19314.46	909.73
473	473	871.8	3198	892.53	7108.77	900.31	7323.4	900.52	7449.59	900.62	7691.77	900.84	7892	901.06	11666.89	904.89	19314.46	909.97
473.8	473.8	869	3198	892.79	7108.77	900.6	7323.4	900.83	7449.59	900.93	7691.77	901.16	7892	901.38	11666.89	905.26	19314.46	910.34
474.08	474.08	873.5	3198	892.89	7108.77	900.71	7323.4	900.93	7449.59	901.04	7691.77	901.27	7892	901.49	11666.89	905.4	19314.46	910.48
474.09	474.09	873.5	3198	892.9	7108.77	900.73	7323.4	900.96	7449.59	901.07	7691.77	901.3	7892	901.52	11666.89	905.44	19314.46	910.54
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	3198	892.9	7108.77	900.73	7323.4	900.95	7449.59	901.06	7691.77	901.3	7892	901.52	11666.89	905.43	19314.46	910.52
474.12	474.12	874	3198	892.91	7108.77	900.74	7323.4	900.96	7449.59	901.07	7691.77	901.3	7892	901.52	11666.89	905.44	19314.46	910.55
474.6	474.6	873.4	3198	893.12	7108.77	900.91	7323.4	901.13	7449.59	901.25	7691.77	901.48	7892	901.7	11666.89	905.63	19314.46	910.78
475.3	475.3	872.2	3198	893.38	7108.77	901.2	7323.4	901.43	7449.59	901.54	7691.77	901.79	7892	902.01	11666.89	905.97	19314.46	911.2
475.7	475.7	871	3198	893.51	7108.77	901.36	7323.4	901.59	7449.59	901.71	7691.77	901.96	7892	902.19	11666.89	906.19	19314.46	911.53
476.4	476.4	873.7	3198	893.78	7108.77	901.62	7323.4	901.85	7449.59	901.97	7691.77	902.22	7892	902.45	11666.89	906.47	19314.46	911.8
477	477	874	3147	894.05	5685.77	901.85	7178.4	902.11	8608.59	902.26	10299.77	902.55	11079	902.8	10456.89	906.77	10915.46	912.11
477.6	477.6	870.2	3139	894.23	5496.77	902	7156.4	902.34	8790.59	902.58	10720.77	902.99	11594	903.28	10281.89	907.02	9838.47	912.24
478	478	873.4	3139	894.37	5496.77	902.1	7156.4	902.49	8790.59	902.8	10720.77	903.29	11594	903.62	10281.89	907.16	9838.47	912.3
478.58	478.58	875	3139	894.49	5496.77	902.2	7156.4	902.65	8790.59	903.03	10720.77	903.61	11594	903.98	10281.89	907.33	9838.47	912.37
478.72	478.72	875.38	3139	894.5	5496.77	902.21	7156.4	902.67	8790.59	903.05	10720.77	903.64	11594	904.01	10281.89	907.34	9838.47	912.38
478.76	478.76	875.51	3139	894.51	5496.77	902.21	7156.4	902.66	8790.59	903.05	10720.77	903.63	11594	904	10281.89	907.33	9838.47	912.37
478.765	478.765		Proposed Red River Closure Structure															
478.77	478.77	875.51	3139	894.53	5496.77	905.18	7156.4	908.04	8790.59	910.23	10720.77	912.8	11594	914.51	10281.89	916.07	9838.47	918.01
478.81	478.81	875.64	3139	894.54	5496.77	905.19	7156.4	908.06	8790.59	910.26	10720.77	912.83	11594	914.55	10281.89	916.08	9838.47	918.01
479	479	876.35	3139	894.57	6160	905.2	9555	908.07	13729	910.26	19709	912.84	23757	914.55	26164	916.08	30016	918.01
479.2	479.2	875.7	3139	894.6	6160	905.21	9555	908.07	13729	910.27	19709	912.85	23757	914.56	26164	916.09	30016	918.04
479.7	479.7	871.5	3139	894.79	6160	905.29	9555	908.2	13729	910.45	19709	913.08	23757	914.79	26164	916.28	30016	918.13
480.5	480.5	874.7	3139	895.08	6160	905.45	9555	908.43	13729	910.77	19709	913.47	23757	915.15	26164	916.56	30016	918.28
481.8	481.8	875.3	3139	895.47	6160	905.7	9555	908.8	13729	911.25	19709	914.04	23757	915.75	26164	917.02	30016	918.56
482.3	482.3	874.2	3139	895.68	6160	905.84	9555	909.01	13729	911.54	19709	914.37	23757	916.08	26164	917.22	30016	918.68
482.698	482.698	869.74	3139	895.79	6160	905.92	9555	909.12	13729	911.69	19709	914.55	23757	916.3	26164	917.4	30016	918.79
482.7	482.7	887.04	3139	895.67	6160	905.87	9555	909.06	13729	911.61	19709	914.48	23757	916.24	26164	917.38	30016	918.79
482.702	482.702	878.54	3139	895.83	6160	905.92	9555	909.12	13729	911.69	19709	914.55	23757	916.3	26164	917.4	30016	918.79
483.1	483.1	879.2	3139	896.07	6160	906.07	9555	909.34	13729	911.99	19709	914.9	23757	916.66	26164	917.63	30016	918.9
483.9	483.9	873	3139	896.51	6160	906.29	9555	909.64	13729	912.4	19709	915.43	23757	917.1	26164	918.04	30016	919.23
485.08	485.08	880.5	3139	897.11	6160	906.47	9555	909.85	13729	912.65	19709	915.72	23757	917.4	26164	918.33	30016	919.49
485.09	485.09	880.5	3139	897.11	6160	906.46	9555	909.85	13729	912.65	19709	915.72	23757	917.4	26164	918.33	30016	919.49
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	3139	897.12	6160	906.48	9555	909.95	13729	912.76	19709	915.78	23757	917.45	26164	918.37	30016	919.52
485.12	485.12	879.4	3139	897.13	6160	906.5	9555	909.96	13729	912.76	19709	915.78	23757	917.45	26164	918.38	30016	919.53
485.6	485.6	878.62	3139	897.34	6160	906.58	9555	910.04	13729	912.85	19709	915.87	23757	917.54	26164	918.47	30016	919.62
485.9	485.9	879.5	3139	897.53	6160	906.67	9555	910.16	13729	912.99	19709	916.05	23757	917.74	26164	918.68	30016	919.82
486.3	486.3	872.1	3139	897.7	6160	906.77	9555	910.28	13729	913.16	19709	916.26	23757	917.98	26164	918.92	30016	920.07
487	487	871.3	3139	897.92	6160	906.92	9555	910.48	13729	913.44	19709	916.66	23757	918.46	26164	919.44	30016	920.64
487.5	487.5	878.8	3139	898.14	6160	907.06	9555	910.67	13729	913.67	19709	916.92	23757	918.74	26164	919.73	30016	920.93
488.68	488.68	878.24	3139	898.79	6160	907.48	9555	911.22	13729	914.4	19709	917.79	23757	919.66	26164	920.68	30016	921.95

Table B22

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
279	403.65	832.3	7890	860.38	17020	869.46	24610	873.29	32650	875.42	44080	876.69	53560	877.55	63590	878.37	80610	879.31
280	404.98	836.6	7890	861.02	17020	870.16	24610	874.14	32650	876.09	44080	877.53	53560	878.34	63590	879.15	80610	880.13
281	406.51	834.9	7890	861.88	17020	871.03	24610	875.07	32650	877.15	44080	878.68	53560	879.33	63590	879.96	80610	881.01
282	410.21	838	7890	863.78	17020	872.89	24610	876.78	32650	878.78	44080	879.82	53560	880.48	63590	881.22	80610	882.37
283	413.23	837.6	7890	865.06	17020	874.26	24610	878.09	32650	880.03	44080	881.03	53560	881.43	63590	882.22	80610	883.43
284	414.98	842.7	7890	865.83	17020	875.17	24610	879.2	32650	880.94	44080	881.92	53560	882.48	63590	883.29	80610	884.52
285	415.38	841.4	7890	866.04	17020	875.41	24610	879.46	32650	881.16	44080	882.19	53560	882.73	63590	883.56	80610	884.79
286	415.84	843	7890	866.19	17020	875.49	24610	879.52	32650	881.19	44080	882.29	53560	882.89	63590	883.72	80610	885.08
287	415.90	844.1	7890	866.24	17020	875.57	24610	879.63	32650	881.45	44080	882.45	53560	883.04	63590	883.84	80610	885.14
288			22nd St SE or Cass Co. #34 / 170th Ave NW or Clay Co.36															
289	415.91	844.1	7890	866.24	17020	875.56	24610	879.62	32650	881.44	44080	882.56	53560	883.24	63590	884.31	80610	885.39
290	415.93	837.5	7890	866.27	17020	875.58	24610	879.64	32650	881.45	44080	882.66	53560	883.35	63590	884.32	80610	885.43
291	417.10	840.8	7890	866.76	17020	876.09	24610	880.25	32650	882.29	44080	883.62	53560	884.43	63590	885.11	80610	886.1
292	418.18	844.4	6987	867.23	14607	876.59	20926	880.83	27646	882.85	37342	884.25	45370	885.05	55134	885.62	71749	886.66
293	419.92	844.7	6597	868.1	12912	877.47	13607.03	881.58	13865	883.46	14176	884.87	14896.01	885.53	16775.5	886.16	25146.25	887.3
294	420.32	843.8	6597	868.38	12912	877.67	13607.03	881.7	13865	883.54	14176	884.93	14896.01	885.59	16775.5	886.21	25146.25	887.36
295	421.93	845.3	6597	869.65	12912	878.63	13607.03	882.21	13865	883.8	14176	885.08	14896.01	885.71	16775.5	886.32	25146.25	887.47
296	422.69	847.4	6597	869.98	12912	878.92	13607.03	882.38	13865	883.9	14176	885.13	14896.01	885.75	16775.5	886.36	25146.25	887.54
297	423.95	849.5	6597	870.52	12912	879.45	13607.03	882.73	13865	884.2	14176	885.38	14896.01	885.99	16775.5	886.61	25146.25	887.87
298	425.51	848.7	6597	871.28	12912	880.1	13607.03	883.17	13865	884.52	14176	885.61	14896.01	886.19	16775.5	886.82	25146.25	888.17
299	426.87	851.1	6597	872	12912	880.69	13607.03	883.57	13865	884.84	14176	885.87	14896.01	886.44	16775.5	887.09	25146.25	888.57
300	428.06	849.6	4007	872.54	9792	881.22	10311.03	883.96	10367	885.15	10458	886.11	11136	886.67	12992.5	887.33	18573.3	888.9
301	428.74	850.3	4007	872.77	9792	881.52	10311.03	884.17	10367	885.33	10458	886.27	11136	886.83	12992.5	887.52	18573.3	889.18
302	430.23	852	4007	873.28	9792	882.02	10311.03	884.53	10367	885.63	10458	886.54	11136	887.11	12992.5	887.88	18573.3	889.74
303	431.94	853.5	4007	873.98	9792	882.73	10311.03	885.06	10367	886.08	10458	886.93	11136	887.5	12992.5	888.35	19506.04	890.37
303.4	432.07	853.42	3721	874.02	9492	882.79	10011.03	885.12	10067	886.13	10158	886.98	10836	887.56	12692.5	888.42	19218.64	890.46
303.5	432.10	853.46	3721	874.05	9492	882.82	10011.03	885.14	10067	886.15	10158	887	10836	887.58	12692.5	888.44	19239.57	890.5
303.8	432.53	854.5	3721	874.19	9492	883	10011.03	885.26	10067	886.25	10158	887.09	10836	887.67	12692.5	888.55	19292.8	890.72
304	432.84	855.5	3721	874.26	9493	883.1	10012.03	885.34	10068	886.31	10159	887.14	10837	887.72	12645	888.61	18784.4	890.79
305	433.26	854.4	3721	874.41	9493	883.27	10012.03	885.48	10068	886.43	10159	887.24	10837	887.83	12645	888.73	18311.74	890.94
306	433.35	855	3721	874.47	9493	883.35	10012.03	885.54	10068	886.49	10159	887.3	10837	887.89	12645	888.8	18141.81	891.06
307			76th Ave. No. (Fargo) / 90th Ave NW (Moorhead) Bridge															
308	433.37	855	3721	874.48	9493	883.36	10012.03	885.55	10068	886.5	10159	887.3	10837	887.89	12645	888.81	18141.81	891.07
309	433.83	854.5	3721	874.61	9493	883.52	10012.03	885.67	10068	886.61	10159	887.41	10837	888	12645	888.94	18141.81	891.27
310	434.61	852.8	3721	874.83	9493	883.75	10012.03	885.85	10068	886.77	10159	887.54	10837	888.14	12645	889.11	18141.81	891.51
310.5	435.70	855	3721	875.15	9493	884.12	10012.03	886.13	10068	887.01	10159	887.76	10837	888.36	12645	889.36	18141.81	891.93
311	436.34	855	3721	875.35	9493	884.37	10012.03	886.33	10068	887.18	10159	887.92	10834.26	888.53	12613.67	889.57	18192.53	892.25
312	437.05	863.83	3526	875.56	9183	884.63	9607.03	886.55	9648	887.38	9709	888.1	10369.26	888.72	12033.67	889.79	17567.53	892.6
313	437.95	856	3526	875.86	9182	885.03	9606.03	886.87	9647	887.66	9708	888.36	10368.26	888.99	12081.18	890.1	18075.93	893.09
314	438.78	857	3526	876.17	9182	885.38	9606.03	887.16	9647	887.92	9708	888.6	10368.26	889.24	12081.18	890.39	18075.93	893.5
315	439.05	856	3526	876.25	9182	885.48	9606.03	887.24	9647	888	9708	888.68	10368.26	889.32	12081.18	890.47	18075.93	893.64
316	439.46	855.1	3526	876.39	9182	885.68	9606.03	887.42	9647	888.16	9708	888.82	10368.26	889.48	12081.18	890.66	18075.93	893.95
317			40th Ave. No. (Fargo) / Wall Street NW (Moorhead) Bridge															
318	439.47	855.1	3526	876.4	9182	885.69	9606.03	887.42	9647	888.16	9708	888.83	10368.26	889.48	12081.18	890.66	18075.93	893.95
319	439.50	857	3526	876.41	9182	885.73	9606.03	887.47	9647	888.2	9708	888.87	10368.26	889.52	12081.18	890.71	18075.93	894.01
320	439.66	856	3526	876.46	9182	885.8	9606.03	887.52	9647	888.25	9708	888.91	10368.26	889.56	12081.18	890.76	18075.93	894.07
321	440.31	858	3526	876.66	9182	886.05	9606.03	887.73	9647	888.44	9708	889.09	10368.26	889.75	12081.18	890.97	18075.93	894.39
322	440.32	858.1	3526	876.66	9182	886.04	9606.03	887.73	9647	888.44	9708	889.08	10368.26	889.75	12081.18	890.97	18075.93	894.38
323			Broadway Street No. (Fargo) / Broadway Street NW (Moorhead) Bridge															
324	440.33	858.1	3526	876.66	9182	886.16	9606.03	887.82	9647	888.52	9708	889.15	10368.26	889.81	12081.18	891.03	18075.93	894.43
325	440.34	857	3526	876.67	9182	886.17	9606.03	887.83	9647	888.53	9708	889.16	10368.26	889.82	12081.18	891.04	18075.93	894.44
326	440.54	858	3526	876.71	9182	886.22	9606.03	887.87	9647	888.56	9708	889.19	10368.26	889.85	12081.18	891.08	18075.93	894.51
327	441.53	859	3506	877.06	9137	886.51	9546.03	888.09	9582	888.76	9638	889.37	10293.26	890.03	11991.18	891.27	17965.93	894.74
328	442.14	858	3506	877.26	9137	886.67	9546.03	888.22	9582	888.87	9638	889.47	10293.26	890.13	11991.18	891.38	18721.09	894.88
329	442.45	857	3506	877.34	9137	886.7	9546.03	888.24	9582	888.89	9638	889.48	10293.26	890.14	11991.18	891.39	19838.34	894.89
329.5	442.93	858.06	3506	877.48	9136	886.82	9545.03	888.33	9581	888.97	9637	889.55	10295.01	890.21	12021.5	891.46	19898.25	894.98
330	443.69	858	3506	877.71	9136	887.02	9545.03	888.49	9581	889.12	9637	889.69	10295.01	890.34	12021.5	891.59	19898.25	895.13
331	443.99	859	3506	877.78	9136	887.11	9545.03	888.58	9581	889.19	9637	889.76	10295.01	890.41	12021.5	891.68	19898.25	895.28
332	444.33	856	3506	877.84	9136	887.15	9545.03	888.61	9581	889.22	9637	889.79	10295.01	890.44	12021.5	891.71	19898.25	895.32
333	444.92	859	3506	877.93	9136	887.19	9545.03	888.64	9581	889.25	9637	889.81	10295.01	890.47	12021.5	891.73	19898.25	895.34
334	445.18	860	3506	878	9136	887.27	9545.03	888.71	9581	889.31	9637	889.87	10295.01	890.52	12021.5	891.79	19898.25	895.42
335	445.31	860	3506	878.05	9136	887.35	9545.03	888.78	9581	889.38	9637	889.93	10295.01	890.59	12021.5	891.88	19898.25	895.6
336	445.36	859	3506	878.06	9136	887.36	9545.03	888.79	9581	889.39	9637	889.94	10295.01	890.6	12021.5	891.89	19898.25	895.62
336.5	445.76	857.69	3506	878.1	9136	887.39	9545.03	888.81	9581	889.41	9637	889.96	10295.01	890.62	12021.5	891.91	19898.25	895.65
337	446.09	860	3506	878.15	9136	887.39	9545.03	888.81	9581	889.41	9637	889.96	10295.01	890.62	12021.5	891.9	19898.25	895.64
338	446.29	861	3506	878.22	9136	887.43	9545.03	888.84	9581	889.43	9637	889.98	10295.01	890.63	12021.5	891.92	19898.25	895.65
338.5	446.70	860.9	3506	878.36	9136	887.57	9545.03	888.96	9581	889.54	9637	890.07	10295.01	890.73	12021.5	892.03	19898.25	895.81
339	446.76	861	3506	878.38	9136	887.59	9545.03	888.97	9581	889.55	9637	890.09	10295.01	890.75	12021.5	892.04	19898.25	895.82
340	447.04	860	3506	878.46	9136	887.68	9545.03	889.05	9581	889.63	9637	890.16	10295.01	890.83	12021.5	892.13	19898.25	896.01
341	447.24	859	3506	878.54	9136	887.75	9545.03	889.11	9581	889.68	9637	890.2	10295.01	890.87	12021.5	892.17	19898.25	896.04
342	447.42	861	3506	878.66	9136	887.84	9545.03	889.18	9581	889.74	9637	890.26	10295.01	890.92	12021.5	892.24	19898.25	896.13
342.5	447.78	856.99	3506	878.81	9136	887.98	9545.03	889.3	9581	889.85	9637	890.36	10295.01	891.03	12021.5	892.35	19898.25	896.31
343	448.13	861	3506	878.93	9136	888.08	9545.03	889.39	9581	889.94	9637	890.44	10295.01	891.1	12021.5	892.43	19898.25	896.42
344	448.36	859	3506	879.03	9136	888.18	9545.03	889.48	9581	890.02	9637	890.52	10295.01	891.19	12021.5	892.54	19898.25	896.62
345	448.89	865.3	3506	879.41	9136	888.42	9545.03	889.68	9581	890.19	9637	890.68	10295.01	891.34	12021.5	892.69	19898.25	896.81
348	448.90	864.3	3506	879.41	9136	888.4	9545.03	889.66	9581	890.17	9637	890.66	10295.01	891.32	12021.5	892.67	19898.25	896.76
348.4			North Dam															
348.8	448.90	864.3	3506	879.5	9136	888.45	9545.03	889.7	9581	890.22	9637	890.7	10295.01	891.38	12021.5	892.71	19898.25	896.83
351	448.91	861	3506	879.51	9136	888.45	9545.03	889.71	9581	890.22	9637	890.7	10295.01	891.38	12021.5	892.71	19898.25	896.83
351.4	449.06	861	3506	879.58	9136	888.58	9545.03	889.82	9581	890.33	9637	890.81	10295.01	891.49	12021.5	892.85	19898.25	897.05
351.5			12th Ave. No. (Fargo) / 15th Ave No. (Moorhead) Bridge															
351.6	449.07	861	3506	879.59	9136	888.64	9545.03	889.9	9581	890.42	9637	890.9	10295.01	891.59	12021.5	892.95	19898.25	897.13
352	449.09	862	3506	879.6	9136	888.66	9545.03	889.92	9581	890.43	9637	890.91	10295.01	891.6	12021.5	892.97	19898.25	897.17
353	449.28	863	3506	879.68	9136	888.75	9545.03	890	9581	890.51	9637	890.99	10295.01	891.68	12021.5	893.06	19898.25	897.31
353.5	449.61	860.13	3506	879.81	9136	888.84	9545.03	890.08	9581	890.58	9637	891.05	10295.01	891.74	12021.5	893.11	19898.25	897.38
354	449.97	864	3506	880.05	9136	889.07	9545.03	890.28	9581	890.76	9637	891.22	10295.01	891.92	12021.5	893.31	19898.25	897.6
355	450.19	862	3506	880.22	9136	889.16	9545.03	890.36	9581	890.84	9637	891.29	10295.01	891.99	12021.5	893.4	19898.25	897.75
356	450.84	858	3506	880.6	9136	889.44	9545.03	890.59	9581	891.04	9637	891.48	10295.01	892.18	12021.5	893.58	19898.25	897.97
357	450.86	863.4	3506	880.6	9136	889.44	9545.03	890.59	9581	891.05	9637	891.48	10295.01	892.18	12021.5	893.58	19898.25	897.97
358			BNRR Bridge															
359	450.87	863.4	3506	880.67	9136	889.54	9545.03	890.68	9581	891.12	9637	891.55	10295.01	892.24	12021.5	893.64	19898.25	898.08
361	451.20	865	3506	880.82	9136	889.66	9545.03	890.78	9581	891.22	9637	891.64	10295.01	892.34	12021.5	893.74	19898.25	898.21
361.5	451.37	865.2	3506	880.93	9136	889.73	9545.03	890.85	9581	891.28	9637	891.7	10295.01	892.39	12021.5	893.8	19898.25	898.28
362.5			1st Ave. No. Bridge															
364	451.39	865.2	3506	880.95	9136	889.76	9545.03	890.87	9581	891.3	9637	891.71	10295.01	892.41	12021.5	893.81	19898.25	898.3
366	451.41	861	3506	880.99	9136	889.8	9545.03	890.9	9581	891.34	9637	891.75	10295.01	892.44	12021.5	893.84	19898.25	898.34
367	451.57	867	3506	881.05	9136	889.89	9545.03	891	9581	891.43	9637	891.84	10295.01	892.54	12021.5	893.97	19898.25	898.59
368	451.61	866.8	3506	881.09	9136	889.94	9545.03	891.04	9581	891.47	9637	891.88	10295.01	892.58	12021.5	894.01	19898.25	898.64
369			NP Ave. (Fargo) / Center Ave. (Moorhead)															
370	451.63	866.8	3506	881.1	9136	889.95	9545.03	891.05	9581	891.47	9637	891.88	10295.01	892.58	12021.5	894.01	19898.25	898.67
371	451.65	859	3506	881.13	9136	889.95	9545.03	891.05	9581	891.47	9637	891.88	10295.01	892.58	12021.5	894.01	19898.25	898.66
372	451.67	867.9	3506	881.12	9136	889.94	9545.03	891.04	9581	891.46	9637	891.87	10295.01	892.57	12021.5	894	19898.25	898.65
373			BNRR Bridge															
374	451.68	867.9	3506	881.21	9136	890.04	9545.03	891.13	9581	891.55	9637	891.95	10295.01	892.65	12021.5	894.08	19898.25	898.71
375	451.69	864	3506	881.23	9136	890.04	9545.03	891.13	9581	891.55	9637	891.95	10295.01	892.65	12021.5	894.08	19898.25	898.7
376	451.71	865.9	3506	881.23	9136	890.05	9545.03	891.14	9581	891.56	9637	891.97	10295.01	892.67	12021.5	894.11	19898.25	898.79
377			Main Ave. Bridge															
378	451.72	865.9	3506	881.26	9136	890.06	9545.03	891.15	9581	891.57	9637	891.97	10295.01	892.68	12021.5	894.12	19898.25	898.82
379	451.73	864	3506	881.33	9136	890.16	9545.03	891.24	9581	891.65	9637	892.05	10295.01	892.76	12021.5	894.2	19898.25	898.91
380	451.85	864	3506	881.32	9136	890.14	9545.03	891.22	9581	891.63	9637	892.03	10295.01	892.73	12021.5	894.17	19898.25	898.88
381	452.03	863	3506	881.42	9136	890.28	9545.03	891.35	9581	891.76	9637	892.16	10295.01	892.87	12021.5	894.32	19898.25	899.07
381.5	452.04	863	3506	881.43	9136	890.3	9545.03	891.37	9581	891.77	9637	892.17	10295.01	892.88	12021.5	894.33	19898.25	899.09
384			Midtown Dam															
385.5	452.05	867	3506	881.5	9136	890.3	9545.03	891.37	9581	891.78	9637	892.17	10295.01	892.89	12021.5	894.34	19898.25	899.1
386	452.06	867	3506	881.51	9136	890.31	9545.03	891.38	9581	891.78	9637	892.18	10295.01	892.89	12021.5	894.34	19898.25	899.1
387	452.25	867	3506	881.65	9136	890.38	9545.03	891.44	9581	891.84	9637	892.23	10295.01	892.94	12021.5	894.39	19898.25	899.16
388	452.46	869	3506	881.87	9136	890.49	9545.03	891.53	9581	891.93	9637	892.31	10295.01	893.02	12021.5	894.48	19898.25	899.27
389	452.70	866.08	3506	882.13	9136	890.66	9545.03	891.69	9581	892.07	9637	892.44	10295.01	893.15	12021.5	894.62	19898.25	899.44
390	452.94	867	3506	882.26	9136	890.76	9545.03	891.77	9581	892.15	9637	892.52	10295.01	893.22	12021.5	894.69	19898.25	899.53
391	453.16	867	3506	882.38	9136	890.87	9545.03	891.87	9581	892.24	9637	892.6	10295.01	893.31	12021.5	894.78	19898.25	899.65
392	453.39	865	3506	882.5	9136	890.96	9545.03	891.95	9581	892.32	9637	892.68	10295.01	893.39	12021.5	894.86	19898.25	899.77
393	454.02	866	3506	882.86	9136	891.23	9545.03	892.18	9581	892.53	9637	892.87	10295.01	893.58	12021.5	895.05	19898.25	899.95
394	454.10	865	3506	882.89	9136	891.27	9545.03	892.22	9581	892.56	9637	892.91	10295.01	893.61	12021.5	895.09	19898.25	899.99
395	454.75	864	3506	883.17	9136	891.5	9545.03	892.43	9581	892.76	9637	893.09	10295.01	893.79	12021.5	895.27	19898.25	900.21
396	455.16	866	3506	883.35	9136	891.71	9545.03	892.62	9581	892.94	9637	893.27	10295.01	893.97	12021.5	895.45	19898.25	900.4
397	455.20	866.6	3506	883.39	9136	891.75	9545.03	892.65	9581	892.98	9637	893.3	10295.01	894	12021.5	895.48	19898.25	900.43
399			I-94 Bridge															
401	455.23	866.6	3506	883.4	9136	891.75	9545.03	892.65	9581	892.98	9637	893.3	10295.01	894	12021.5	895.48	19898.25	900.43
402	455.28	865	3506	883.43	9136	891.77	9545.03	892.67	9581	892.99	9637	893.31	10295.01	894.01	12021.5	895.49	19898.25	900.46
402.5	455.52	864.58	3506	883.54	9136	891.89	9545.03	892.79	9581	893.1	9637	893.42	10295.01	894.12	12021.5	895.6	19898.25	900.57
403	455.59	866	3506	883.57	9136	891.93	9545.03	892.82	9581	893.13	9637	893.45	10295.01	894.15	12021.5	895.63	19898.25	900.6
404	455.92	865	3506	883.72	9136	892.05	9545.03	892.94	9581	893.24	9637	893.55	10295.01	894.25	12021.5	895.74	19898.25	900.77
405	456.65	865	3506	884.1	9136	892.33	9545.03	893.18	9581	893.47	9637	893.77	10295.01	894.47	12021.5	895.95	19898.25	900.97
406	457.09	866	3506	884.35	9136	892.53	9545.03	893.36	9581	893.64	9637	893.93	10295.01	894.63	12021.5	896.11	19898.25	901.17

Table B22

Fargo Moorhead Metro Study - Phase 3.1
ND East 35Kcfs, Year 50, Water Surface Profiles
ALL WATER SURFACE ELEVATIONS IN NAVD 1988

Exceedance			50%		20%		10%		5%		2%		1%		0.5%		0.2%	
Recurrence Interval			2-Year		5-Year		10-Year		20-Year		50-Year		100-Year		200-Year		500-Year	
River Sta	River Mile	Invert Stage	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)	Q Total (cfs)	W.S. Elev (ft)
407	457.27	861.18	3506	884.42	9136	892.59	9545.03	893.42	9581	893.7	9637	893.98	10295.01	894.68	12021.5	896.16	19898.25	901.21
408	457.80	864	3506	884.59	9136	892.82	9545.03	893.63	9581	893.9	9637	894.18	10295.01	894.88	12021.5	896.38	19898.25	901.49
409	457.95	855.9	3506	884.64	9136	892.91	9545.03	893.73	9581	893.99	9637	894.27	10295.01	894.97	12021.5	896.47	19898.25	901.59
409.1	457.97	855.9	3506	884.64	9136	892.91	9545.03	893.73	9581	893.99	9637	894.27	10295.01	894.97	12021.5	896.47	19898.25	901.6
409.5			South Dam															
409.6	457.98	855.9	3506	884.72	9136	892.96	9545.03	893.77	9581	894.03	9637	894.31	10295.01	895.01	12021.5	896.51	19898.25	901.63
409.7	457.99	855.9	3506	884.72	9136	892.96	9545.03	893.77	9581	894.03	9637	894.31	10295.01	895.01	12021.5	896.51	19898.25	901.63
413	458.32	869	3506	884.72	9136	892.98	9545.03	893.79	9581	894.05	9637	894.33	10295.01	895.03	12021.5	896.53	19898.25	901.67
414	458.75	866	3506	884.98	9136	893.25	9545.03	894.04	9581	894.3	9637	894.57	10295.01	895.27	12021.5	896.79	19898.25	902
459.64	459.64	864.81	3506	885.36	9136	893.69	9545.03	894.45	9581	894.69	9637	894.94	10295.01	895.64	12021.5	897.15	19898.25	902.35
460.28	460.28	868.74	3506	885.74	9136	894.03	9545.03	894.77	9581	895	9637	895.23	10295.01	895.93	12021.5	897.44	19898.25	902.65
460.72	460.72	869.04	3506	886.07	9136	894.3	9545.03	895.02	9581	895.24	9637	895.47	10295.01	896.16	12021.5	897.68	19898.25	902.93
461.3	461.3	868.04	3506	886.46	9136	894.69	9545.03	895.39	9581	895.6	9637	895.81	10295.01	896.51	12021.5	898.03	19898.25	903.35
462.03	462.03	864.16	3506	886.8	9136	895.09	9545.03	895.77	9581	895.96	9637	896.17	10295.01	896.86	12021.5	898.39	19898.25	903.72
462.04	462.04	869.5	3506	886.83	9136	895.12	9545.03	895.81	9581	896	9637	896.2	10295.01	896.89	12021.5	898.42	19898.25	903.77
462.05			52nd Avenue So. (Fargo) / 60th Ave So. (Moorhead) Bridge															
462.06	462.06	869.5	3506	886.85	9136	895.13	9545.03	895.81	9581	896	9637	896.21	10295.01	896.9	12021.5	898.43	19898.25	903.85
462.07	462.07	871.5	3506	886.88	9136	895.16	9545.03	895.84	9581	896.03	9637	896.23	10295.01	896.92	12021.5	898.46	19898.25	903.85
462.7	462.7	862.82	3506	887.25	9136	895.49	9545.03	896.15	9581	896.33	9637	896.53	10295.01	897.22	12021.5	898.75	19898.25	904.15
463.7	463.7	864.71	3506	887.57	9136	895.9	9545.03	896.55	9581	896.72	9637	896.91	10295.01	897.6	12021.5	899.16	19898.25	904.58
464.2	464.2	869.2	3506	887.81	9136	896.17	9545.03	896.82	9581	896.98	9637	897.16	10295.01	897.86	12021.5	899.43	19898.25	904.91
464.6	464.6	865	3506	888.01	9136	896.37	9545.03	897	9581	897.16	9637	897.34	10295.01	898.04	12021.5	899.61	19898.25	905.07
465.1	465.1	862.9	3506	888.16	9136	896.6	9545.03	897.23	9581	897.39	9637	897.56	10295.01	898.27	12021.5	899.86	19898.25	905.43
465.9	465.9	865.6	3506	888.41	9136	896.95	9545.03	897.57	9581	897.72	9637	897.89	10295.01	898.6	12021.5	900.21	19898.25	905.83
466.5	466.5	864.9	3506	888.64	9136	897.22	9545.03	897.84	9581	897.98	9637	898.14	10295.01	898.85	12021.5	900.48	19898.25	906.13
467.4	467.4	864.8	3506	888.96	9136	897.63	9545.03	898.24	9581	898.38	9637	898.53	10295.01	899.25	12021.5	900.9	19898.25	906.6
468.2	468.2	862.6	3506	889.19	9136	897.9	9545.03	898.51	9581	898.64	9637	898.79	10295.01	899.52	12021.5	901.17	19898.25	906.88
468.9	468.9	861	3506	889.4	9136	898.18	9545.03	898.79	9581	898.92	9637	899.07	10295.01	899.8	12021.5	901.46	19898.25	907.12
469.7	469.7	870	3506	889.73	9136	898.58	9545.03	899.17	9581	899.3	9637	899.45	10295.01	900.18	12021.5	901.84	19898.25	907.39
470.1	470.1	870.9	3506	889.89	9136	898.76	9545.03	899.35	9581	899.47	9637	899.62	10295.01	900.35	12021.5	902.01	19898.25	907.57
470.6	470.6	869.4	2548	890.05	6444	898.95	7194.03	899.54	7230	899.66	7286	899.8	7943.02	900.53	9670.5	902.2	17546.25	907.77
471.4	471.4	867.5	2548	890.27	6358	899.2	7189.03	899.82	7330	899.94	7499	900.09	8205.02	900.83	9577.5	902.51	16740.25	908.11
472.18	472.18	869.9	2548	890.51	6358	899.44	7189.03	900.1	7330	900.22	7499	900.37	8205.02	901.12	9577.5	902.82	16740.25	908.44
472.2	472.2	870.8	2548	890.51	6358	899.44	7189.03	900.09	7330	900.21	7499	900.36	8205.02	901.12	9577.5	902.81	16740.25	908.43
472.22	472.22	870.8	2548	890.52	6358	899.45	7189.03	900.1	7330	900.22	7499	900.37	8205.02	901.13	9577.5	902.83	16740.25	908.47
473	473	871.8	2548	890.74	6358	899.67	7189.03	900.35	7330	900.47	7499	900.63	8205.02	901.39	9577.5	903.08	16740.25	908.72
473.8	473.8	869	2548	890.99	6358	899.93	7189.03	900.65	7330	900.78	7499	900.94	8205.02	901.72	9577.5	903.42	16740.25	909.09
474.08	474.08	873.5	2548	891.09	6358	900.02	7189.03	900.76	7330	900.89	7499	901.05	8205.02	901.84	9577.5	903.54	16740.25	909.23
474.09	474.09	873.5	2548	891.1	6358	900.05	7189.03	900.78	7330	900.92	7499	901.08	8205.02	901.87	9577.5	903.57	16740.25	909.29
474.1			Cass Co Hwy 16/112th Ave So. (Fargo) / 110th Ave So. (Moorhead) Bridge															
474.11	474.11	874	2548	891.1	6358	900.04	7189.03	900.78	7330	900.91	7499	901.07	8205.02	901.86	9577.5	903.57	16740.25	909.27
474.12	474.12	874	2548	891.11	6358	900.05	7189.03	900.79	7330	900.92	7499	901.08	8205.02	901.87	9577.5	903.58	16740.25	909.29
474.6	474.6	873.4	2548	891.32	6358	900.21	7189.03	900.96	7330	901.09	7499	901.26	8205.02	902.05	9577.5	903.75	16740.25	909.5
475.3	475.3	872.2	2548	891.56	6358	900.47	7189.03	901.26	7330	901.39	7499	901.56	8205.02	902.36	9577.5	904.07	16740.25	909.9
475.7	475.7	871	2548	891.69	6358	900.62	7189.03	901.42	7330	901.56	7499	901.73	8205.02	902.54	9577.5	904.26	16740.25	910.2
476.4	476.4	873.7	2548	891.97	6358	900.85	7189.03	901.68	7330	901.81	7499	901.99	8205.02	902.81	9577.5	904.53	16740.25	910.48
477	477	874	2550	892.23	5485	901.07	7133.03	901.94	8478	902.11	10024	902.32	11309.01	903.16	8592.5	904.81	9049.25	910.78
477.6	477.6	870.2	2550	892.42	5366	901.23	7125.03	902.17	8658	902.42	10433	902.75	11812.01	903.64	8450.5	905.03	8059.25	910.88
478	478	873.4	2550	892.56	5366	901.33	7125.03	902.32	8658	902.64	10433	903.05	11812.01	903.97	8450.5	905.16	8059.25	910.93
478.58	478.58	875	2550	892.67	5366	901.44	7125.03	902.49	8658	902.87	10433	903.36	11812.01	904.32	8450.5	905.32	8059.25	910.99
478.72	478.72	875.38	2550	892.69	5366	901.45	7125.03	902.5	8658	902.89	10433	903.39	11812.01	904.35	8450.5	905.33	8059.25	910.99
478.76	478.76	875.51	2550	892.69	5366	901.45	7125.03	902.5	8658	902.89	10433	903.38	11812.01	904.34	8450.5	905.33	8059.25	910.99
478.765	478.765		Proposed Red River Closure Structure															
478.77	478.77	875.51	2550	892.72	5366	902.96	7125.03	907.35	8658	909.65	10433	912.28	11812.01	913.91	8450.5	915.75	8059.25	917.82
478.81	478.81	875.64	2550	892.72	5366	902.98	7125.03	907.37	8658	909.68	10433	912.31	11812.01	913.95	8450.5	915.76	8059.25	917.82
479	479	876.35	2550	892.75	5366	902.99	8710	907.38	12762	909.69	18543	912.31	22626	913.95	24116	915.75	28246	917.81
479.2	479.2	875.7	2550	892.78	5366	903	8710	907.39	12762	909.7	18543	912.32	22626	913.96	24116	915.76	28246	917.84
479.7	479.7	871.5	2550	892.98	5366	903.1	8710	907.5	12762	909.86	18543	912.55	22626	914.2	24116	915.94	28246	917.93
480.5	480.5	874.7	2550	893.28	5366	903.27	8710	907.72	12762	910.17	18543	912.93	22626	914.59	24116	916.21	28246	918.12
481.8	481.8	875.3	2550	893.67	5366	903.54	8710	908.07	12762	910.64	18543	913.49	22626	915.21	24116	916.64	28246	918.39
482.3	482.3	874.2	2550	893.87	5366	903.69	8710	908.27	12762	910.91	18543	913.83	22626	915.54	24116	916.85	28246	918.51
482.698	482.698	869.74	2550	893.98	5366	903.77	8710	908.37	12762	911.05	18543	913.99	22626	915.73	24116	917.02	28246	918.65
482.7	482.7	887.04	2550	893.85	5366	903.71	8710	908.31	12762	910.97	18543	913.92	22626	915.67	24116	917	28246	918.65
482.702	482.702	878.54	2550	894.03	5366	903.77	8710	908.38	12762	911.05	18543	913.99	22626	915.73	24116	917.02	28246	918.65
483.1	483.1	879.2	2550	894.27	5366	903.93	8710	908.58	12762	911.34	18543	914.35	22626	916.1	24116	917.26	28246	918.75
483.9	483.9	873	2550	894.74	5366	904.17	8710	908.86	12762	911.73	18543	914.85	22626	916.59	24116	917.67	28246	919.06
485.08	485.08	880.5	2550	895.41	5366	904.41	8710	909.06	12762	911.98	18543	915.14	22626	916.9	24116	917.94	28246	919.31
485.09	485.09	880.5	2550	895.42	5366	904.4	8710	909.04	12762	911.98	18543	915.14	22626	916.9	24116	917.94	28246	919.31
485.1			Cass Co. Hwy 18/52nd St. SE (Fargo) / 160th Ave So. (Moorhead) Bridge															
485.11	485.11	879.4	2550	895.42	5366	904.4	8710	909.09	12762	912.09	18543	915.21	22626	916.95	24116	917.98	28246	919.34
485.12	485.12	879.4	2550	895.43	5366	904.42	8710	909.15	12762	912.1	18543	915.21	22626	916.95	24116	917.98	28246	919.34
485.6	485.6	878.62	2550	895.66	5366	904.52	8710	909.23	12762	912.18	18543	915.3	22626	917.05	24116	918.07	28246	919.43
485.9	485.9	879.5	2550	895.86	5366	904.62	8710	909.35	12762	912.32	18543	915.48	22626	917.24	24116	918.26	28246	919.62
486.3	486.3	872.1	2550	896.05	5366	904.73	8710	909.47	12762	912.48	18543	915.68	22626	917.47	24116	918.48	28246	919.85
487	487	871.3	2550	896.27	5366	904.88	8710	909.65	12762	912.75	18543	916.05	22626	917.93	24116	918.94	28246	920.37
487.5	487.5	878.8	2550	896.48	5366	905.04	8710	909.83	12762	912.97	18543	916.31	22626	918.21	24116	919.21	28246	920.64
488.68	488.68	878.24	2550	897.08	5366	905.51	8710	910.36	12762	913.68	18543	917.17	22626	919.13	24116	920.09	28246	921.59

moore engineering, inc.
Consulting Engineering • Land Surveying
West Fargo • Fergus Falls

925 10th Ave. E. West Fargo, North Dakota
Phone: 701-282-4692 Fax: 701-282-4530

Memorandum

To: File, FM Metro Diversion Alternatives

From: Lyndon Pease and Stuart Dobberpuhl

Date: 04/12/2010

RE: 2009 Calibration of HEC-RAS Steady State Model (04/11/2010)

Work updating the 2009 HEC-RAS Calibration Steady State Model was accomplished in response to the two USACE ATR Comments on the Fargo-Moorhead Metro Feasibility Study. Each comment is flagged as a critical issue. Specifically, the two comments addressed are:

1. Comment 3087524 regarding the bank stations in the HEC-RAS model.

2. Comment 3087545 regarding the calibration of the HEC-RAS model at discharges less than 20,000 cfs.

In addition to the work for the two ATR comments, additional revisions to the 2009 HEC-RAS Calibration Model were made in response to internal review comments.

Below is a condensed summary of the changes for the 2009 Calibration for the Steady State model dated 03-25-2010. The date of this new calibration in the HEC-RAS model is 04-11-2010. Changes to bank stations, n values, and restructuring to the Oakport network were made.

1. Channel overbanks on the RRN were adjusted to match the primary bank elevation for the Red River of the North channel. Initial placement was governed from Houston Engineering's latest Unsteady Model for their 2009 Calibration. Further modifications ensure a channel width of 130-150 ft within the bank stations. This is a typical width in the primary bank for the RRN from Hickson to Perley. One channel n value is now used for the channel. This takes care of

2. known issues with regard to the HEC-RAS Version 4.0 software. The channel n value was then lowered from 0.055 to:

    a. RS 279 – 328 channel n value of 0.042
    b. RS 329 – 401 channel n value of 0.038
    c. RS 402 – 488.68 channel n value of 0.045

3. Overbank n values were initially increased using Houston Engineering's Unsteady Model. Further modifications were made which provided a consistent majority of overbank n values between 0.10 and 0.16.

4. The Oakport network was modified as shown below.

    a. Junction_1 between RRN RS 328 – 329 was removed. Connection to the Oakport_SI reach is now through RRN LS 329.1. The geometry of this lateral structure comes from Upper_Oakport_SE RS 22.15 (MN_Wall_Street/CR22).
    b. Junction_2 between RRN RS 311 – 312 was removed. Connection to the lob_rrn is now through RRN LS 312.1. The geometry of this lateral structure comes from lob_rrn RS 2.9 (Cass County Road 31).
    c. The Connection_Reach was removed.
    d. Junction_3 between RRN RS 310.5 – 311 was removed. Connection to the Oakport_SI reach is now through RRN LS 310.6. The geometry of this lateral structure comes from the now removed Connection_Reach RS 2.15.
    e. Junction_OakptsI was removed. The Upper_Oakport_SI and Lower Oakport_SI reaches were combined into one now called Oakport_SI. The river stations in the Upper_Oakport_SI reach were multiplied by ten to ensure proper stationing after this reach merge.
    f. RRN RS 310.4 was removed and all downstream distances from the FIS model were reinstated.
    g. Oakport_SI BR 16.5 was converted to an inline structure. The culvert at this crossing was removed as field inspection found no such culvert.

5. The benefits of doing this work are:

    a. The modifications will help with the resolution of the two outstanding ATR comments.
    b. The modifications results in a more reasonable composite n value for the channel in the HEC-RAS model.
    c. The 2009 Flood Event is now better calibrated against observed water surface elevations throughout the model.
    d. The modifications allow for a better calibration of the model for the full range of events. This is accomplished by having a lower n value for the channel and higher n values for the overbanks.

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

EXHIBIT 1 – FCP IMPACTS

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: February 28, 2011

FIGURES

2-28-2011

Minnesota Diversion (FCP) - 10% Chance Event							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.53	62917	798.57	63651	0.04	734
ND SH#17/ MN SH317	1223286	800.78		800.84		0.06	
Co. Hwy 15	1315673	802.60		802.65		0.05	
Minimum Impact Location	1410241	809.75		809.78		0.03	
Oslo Gage	1416287	810.51		810.56		0.05	
DS Grand Forks Levees	1533523	823.07		823.16		0.09	
Grand Forks Gage	1558518	825.98	56662	826.10	57258	0.12	596
32nd Ave, Grand Forks	1580152	827.76		827.90		0.14	
Thompson Gage	1667877	837.58	42815	837.82	43590	0.24	775
Co. Hwy 25/ Co. Rd 221	1726274	842.99		843.29		0.30	
DS Sandhill River/ Climax	1763746	845.62		845.93		0.31	
Nielsville	1829877	850.21	39667	850.54	40402	0.33	735
DS Marsh River	1864960	853.10		853.43		0.33	
US Goose River/ Shelly	1891054	855.90		856.24		0.34	
Halstad Gage	1981580	864.55	34653	864.88	35715	0.33	1063
Hendrum	2038409	868.94	32267	869.27	33471	0.33	1204
Perley	2129181	874.83	28448	875.23	29852	0.40	1404
Georgetown	2194021	880.34	29462	880.65	31317	0.31	1856
Maximum Impact Location	2236491	883.37		883.82		0.45	
North River/ Clay Co. Hwy 93	2305647	889.72		887.50		-2.22	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	894.08		890.23		-3.85	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.33 (34.59*)	17024	892.66 (29.92*)	9933	-4.67	-7091
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	901.61		896.31		-5.30	
US FCP Diversion	2470898	904.54		904.71		0.17	
US ND Wild Rice River	2484618	905.37		905.26		-0.11	
Hickson Gage	2563754	910.21	10428	910.27	10459	0.06	31
Abercrombie	2764835	929.05	11278	929.05	11278	0.00	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

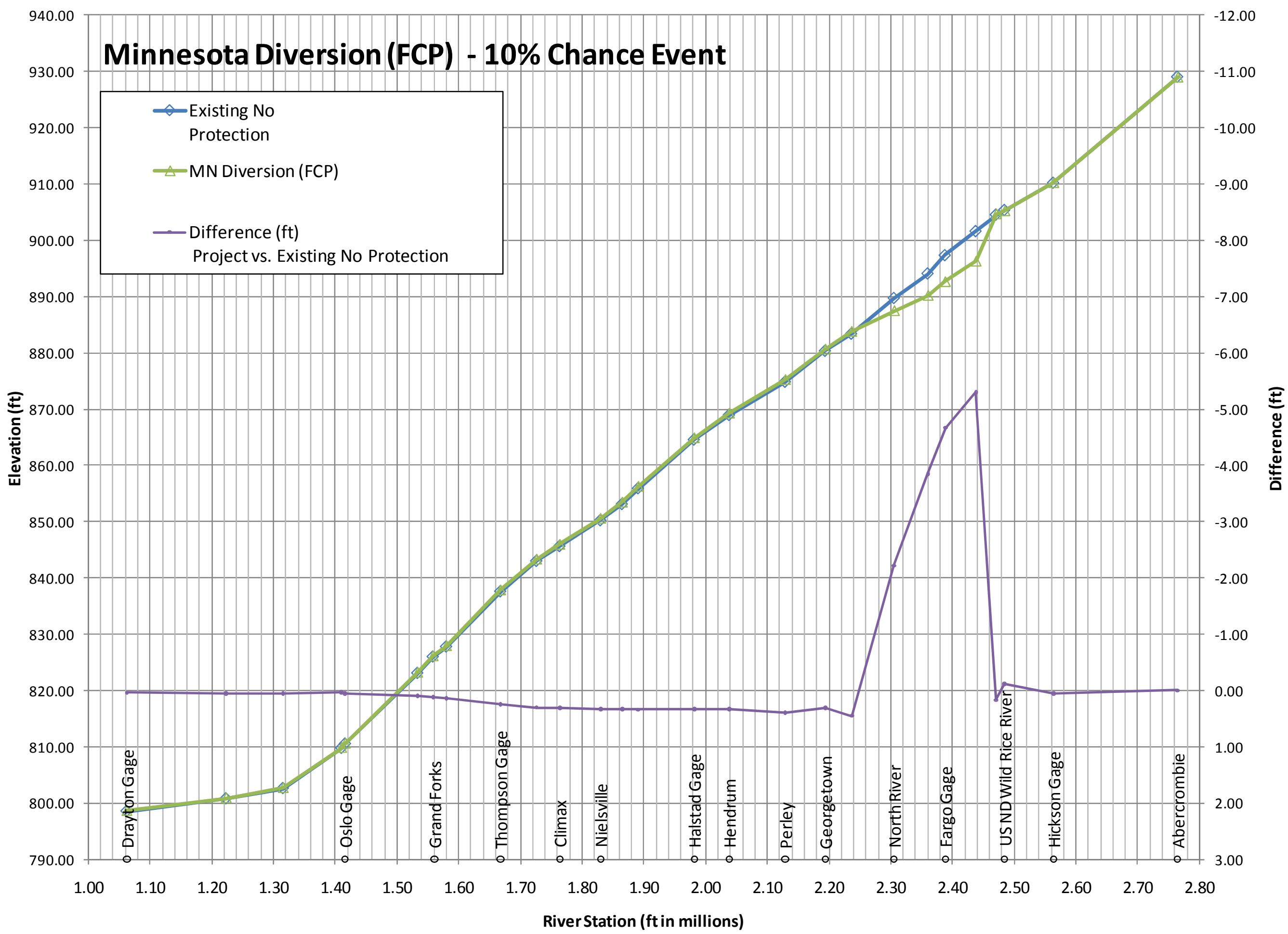


Figure C-E1- 1: 10-Percent Chance Impacts for FCP

Minnesota Diversion (FCP) - 2% Chance Event							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	800.72	100869	800.83	102845	0.11	1976
ND SH#17/ MN SH317	1223286	803.19		803.30		0.11	
Co. Hwy 15	1315673	804.35		804.44		0.09	
Oslo Gage	1416287	812.53		812.56		0.03	
Minimum Impact Location	1448026	814.89		814.91		0.02	
DS Grand Forks Levees	1533523	826.86		826.94		0.08	
Grand Forks Gage	1558518	831.13	91118	831.26	92141	0.13	1023
32nd Ave, Grand Forks	1580152	833.57		833.83		0.26	
Thompson Gage	1667877	844.83	69367	845.61	73330	0.78	3963
Co. Hwy 25/ Co. Rd 221	1726274	851.40		852.33		0.93	
DS Sandhill River/ Climax	1763746	854.11		855.09		0.98	
Maximum Impact Location	1829650	858.51		859.52		1.01	
Nielsville	1829877	858.57	63543	859.57	67968	1.00	4425
DS Marsh River	1864960	860.76		861.65		0.89	
US Goose River/ Shelly	1891054	863.04		863.85		0.81	
Halstad Gage	1981580	867.99	59416	868.47	65150	0.48	5735
Hendrum	2038409	872.82	56143	873.29	62201	0.47	6058
Perley	2129181	877.75	51248	878.15	56562	0.40	5314
Georgetown	2194021	882.76	53909	883.11	59776	0.35	5866
North River/ Clay Co. Hwy 93	2305647	892.97		889.27		-3.70	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.21		891.75		-6.46	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.6 (39.86*)	29167	894.02 (31.28*)	10878	-8.58	-18289
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.94		897.41		-9.53	
US FCP Diversion	2470898	909.54		909.40		-0.14	
US ND Wild Rice River	2484618	910.11		910.17		0.06	
Hickson Gage	2563754	916.34	18898	916.37	18925	0.03	27
Abercrombie	2764835	934.48	20726	934.49	20726	0.01	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

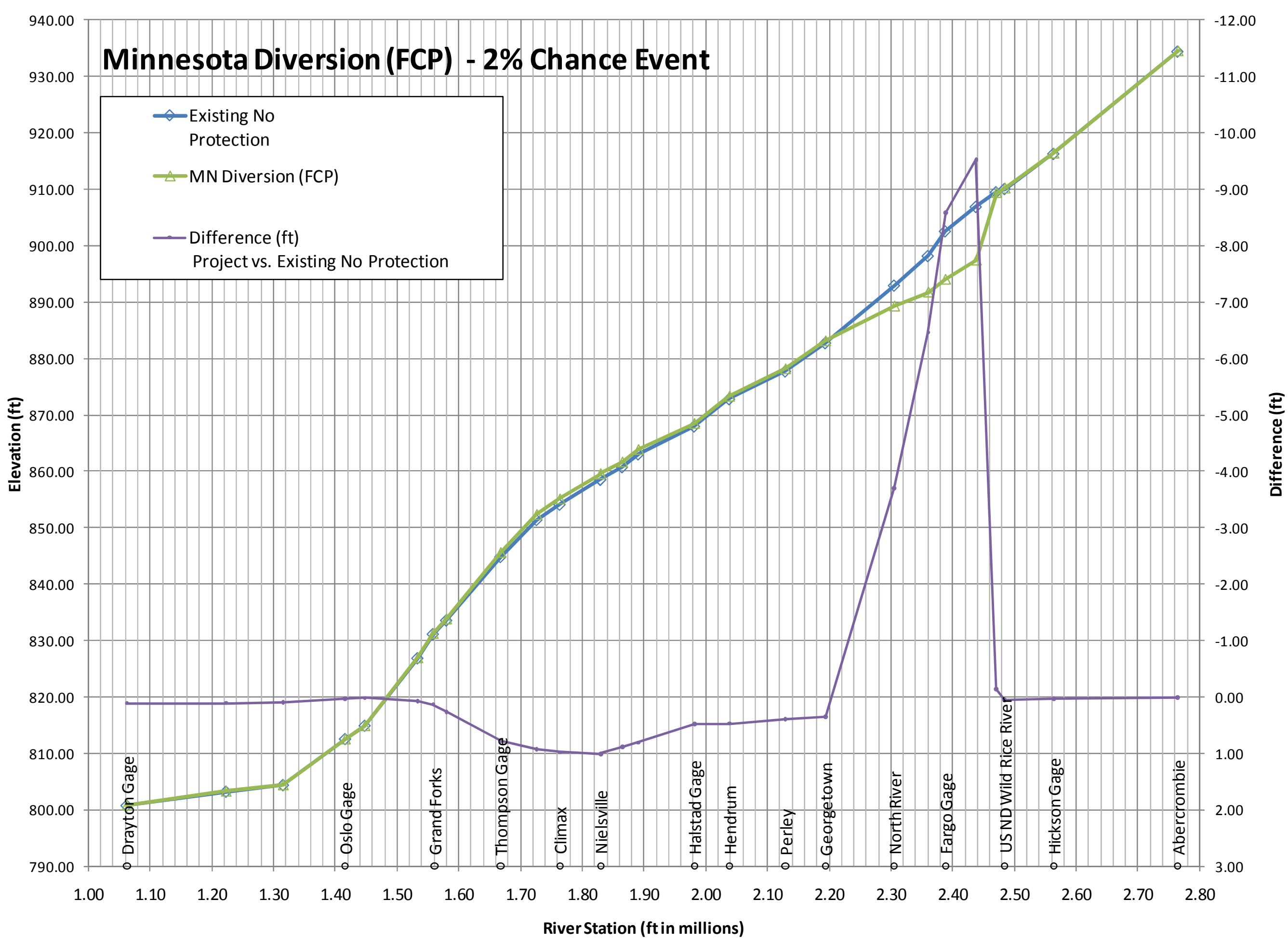


Figure C-E1- 2: 2-Percent Chance Impacts for FCP

Minnesota Diversion (FCP) - 1% Chance Event							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.92	122945	0.19	3690
ND SH#17/ MN SH317	1223286	804.09		804.27		0.18	
Co. Hwy 15	1315673	805.08		805.23		0.15	
Minimum Impact Location	1408098	811.34		811.39		0.05	
Oslo Gage	1416287	813.01		813.09		0.08	
DS Grand Forks Levees	1533523	827.98		828.21		0.23	
Grand Forks Gage	1558518	832.97	107980	833.35	112047	0.38	4067
32nd Ave, Grand Forks	1580152	835.83		836.37		0.54	
Thompson Gage	1667877	847.35	82926	848.11	88519	0.76	5593
Co. Hwy 25/ Co. Rd 221	1726274	854.46		855.56		1.10	
DS Sandhill River/ Climax	1763746	857.34		858.52		1.18	
Maximum Impact Location	1813905	860.78		862.01		1.23	
Nielsville	1829877	861.66	75745	862.87	82280	1.21	6536
DS Marsh River	1864960	863.43		864.47		1.04	
US Goose River/ Shelly	1891054	865.36		866.25		0.89	
Halstad Gage	1981580	869.09	71581	869.68	80624	0.59	9043
Hendrum	2038409	873.75	67278	874.36	77118	0.61	9839
Perley	2129181	878.50	61693	879.11	71345	0.61	9652
Georgetown	2194021	883.36	63847	883.88	75540	0.52	11692
North River/ Clay Co. Hwy 93	2305647	893.73		890.13		-3.60	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		892.65		-6.43	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	894.91 (32.17*)	11756	-8.95	-23119
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		898.26		-9.45	
US FCP Diversion	2470898	910.13		910.71		0.58	
US ND Wild Rice River	2484618	910.70		911.15		0.45	
Hickson Gage	2563754	917.52	21730	917.51	21734	-0.01	3
Abercrombie	2764835	935.62	23000	935.62	23000	0.00	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

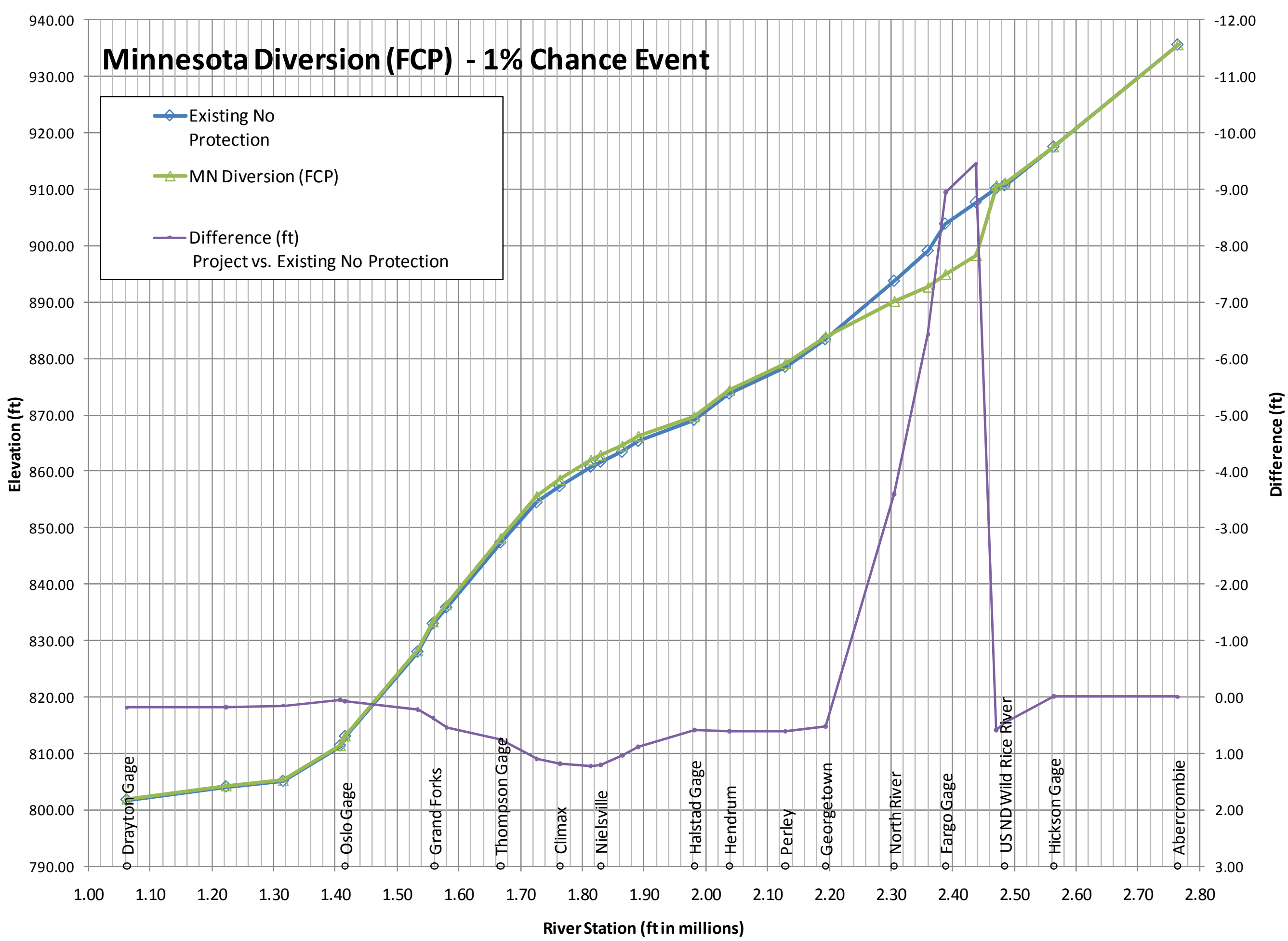


Figure C-E1- 3: 1-Percent Chance Impacts for FCP

Minnesota Diversion (FCP) - 0.2% Chance Event 2-28-2011

Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.27	170409	0.15	2045
ND SH#17/ MN SH317	1223286	805.99		806.10		0.11	
Co. Hwy 15	1315673	806.74		806.87		0.13	
Oslo Gage	1416287	813.88		813.95		0.07	
Minimum Impact Location	1416400	814.23		814.29		0.06	
DS Grand Forks Levees	1533523	829.92		830.11		0.19	
Grand Forks Gage	1558518	836.36	146225	836.72	150748	0.36	4523
32nd Ave, Grand Forks	1580152	839.75		840.20		0.45	
Maximum Impact Location	1580152	839.75		840.20		0.45	
Thompson Gage	1667877	850.69	112422	850.93	115330	0.24	2908
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.71		0.33	
DS Sandhill River/ Climax	1763746	862.75		863.13		0.38	
Nielsville	1829877	867.04	107296	867.45	110696	0.41	3399
DS Marsh River	1864960	868.06		868.43		0.37	
US Goose River/ Shelly	1891054	869.30		869.64		0.34	
Halstad Gage	1981580	871.54	101754	871.72	104334	0.18	2580
Hendrum	2038409	875.77	97650	875.86	98430	0.09	780
Perley	2129181	879.89	90756	879.95	89907	0.06	-849
Georgetown	2194021	884.48	92746	884.46	91337	-0.02	-1409
North River/ Clay Co. Hwy 93	2305647	895.35		893.27		-2.08	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.40		-1.91	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.83 (40.09*)	30044	-2.97	-31673
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		907.28		-1.85	
US FCP Diversion	2470898	910.99		910.81		-0.18	
US ND Wild Rice River	2484618	911.54		911.79		0.25	
Hickson Gage	2563754	919.69	35636	919.67	35565	-0.02	-71
Abercrombie	2764835	940.90	44308	940.90	44308	0.00	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

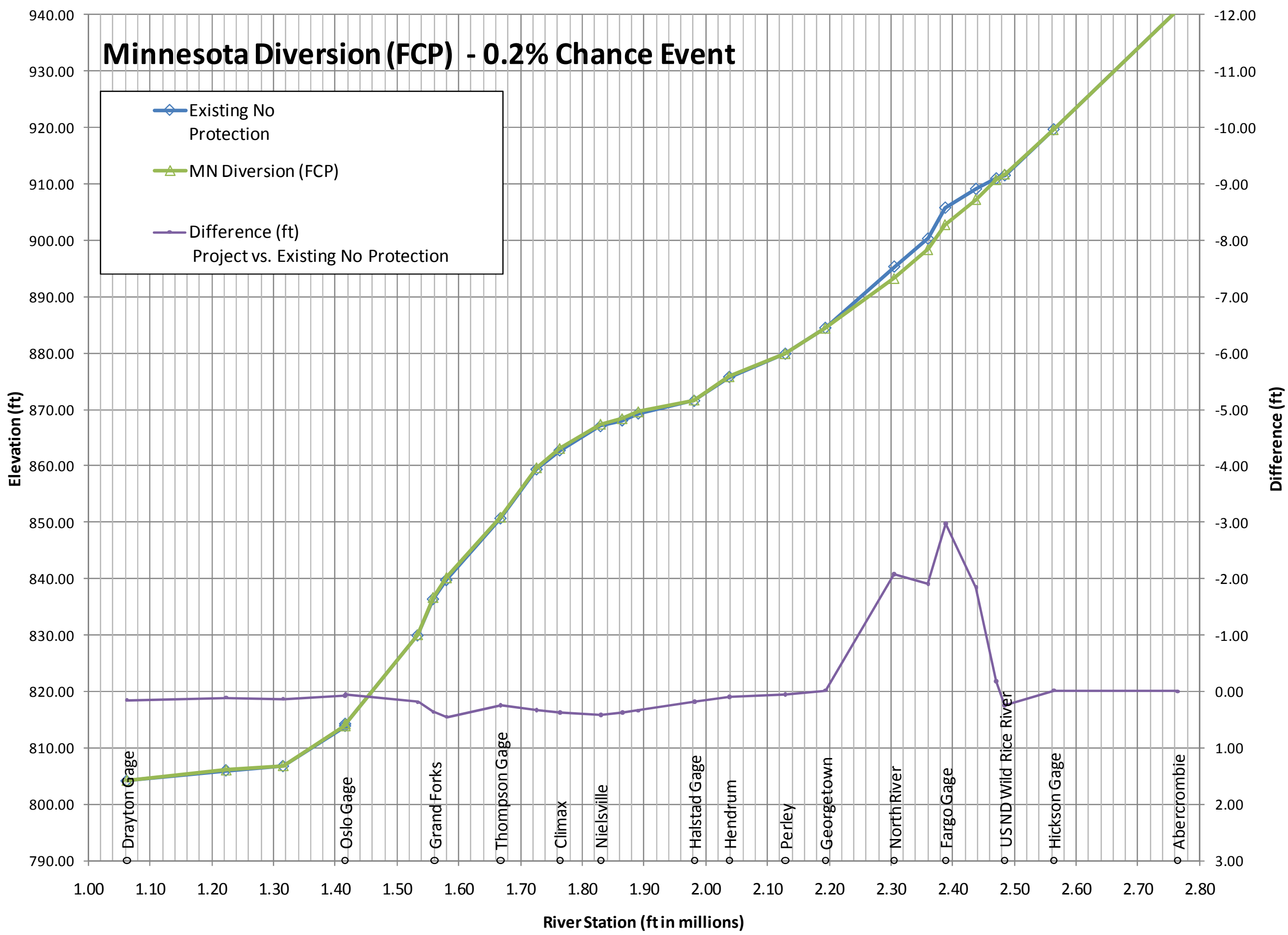


Figure C-E1- 4: 0.2-Percent Chance Impacts for FCP

Minnesota Diversion (FCP) -1997 Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.95	123404	802.05	125375	0.10	1971
ND SH#17/ MN SH317	1223286	804.31		804.40		0.09	
Co. Hwy 15	1315673	805.30		805.39		0.09	
Oslo Gage	1416287	813.29		813.34		0.05	
Minimum Impact Location	1425253	814.37		814.40		0.03	
DS Grand Forks Levees	1533523	828.62		828.72		0.10	
Grand Forks Gage	1558518	834.04	119103	834.21	120893	0.17	1790
32nd Ave, Grand Forks	1580152	837.02		837.24		0.22	
Thompson Gage	1667877	847.29	78351	847.66	81143	0.37	2792
Co. Hwy 25/ Co. Rd 221	1726274	853.81		854.36		0.55	
DS Sandhill River/ Climax	1763746	856.49		857.10		0.61	
Maximum Impact Location	1813905	859.97		860.60		0.63	
Nielsville	1829877	860.86	71728	861.48	74715	0.62	2987
DS Marsh River	1864960	862.72		863.26		0.54	
US Goose River/ Shelly	1891054	864.75		865.21		0.46	
Halstad Gage	1981580	868.65	64821	868.92	68476	0.27	3655
Hendrum	2038409	873.24	55101	873.51	58191	0.27	3090
Perley	2129181	878.05	54689	878.28	58214	0.23	3525
Georgetown	2194021	882.92	56376	883.15	59737	0.23	3361
North River/ Clay Co. Hwy 93	2305647	893.04		889.40		-3.64	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.26		892.05		-6.21	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.42 (39.68*)	27574	894.1 (31.36*)	9978	-8.32	-17596
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.49		896.30		-10.19	
US FCP Diversion	2470898	908.85		908.94		0.09	
US ND Wild Rice River	2484618	909.37		909.60		0.23	
Hickson Gage	2563754	913.85	13729	914.00	13738	0.15	10
Abercrombie	2764835	931.08	13995	931.08	13995	0.00	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

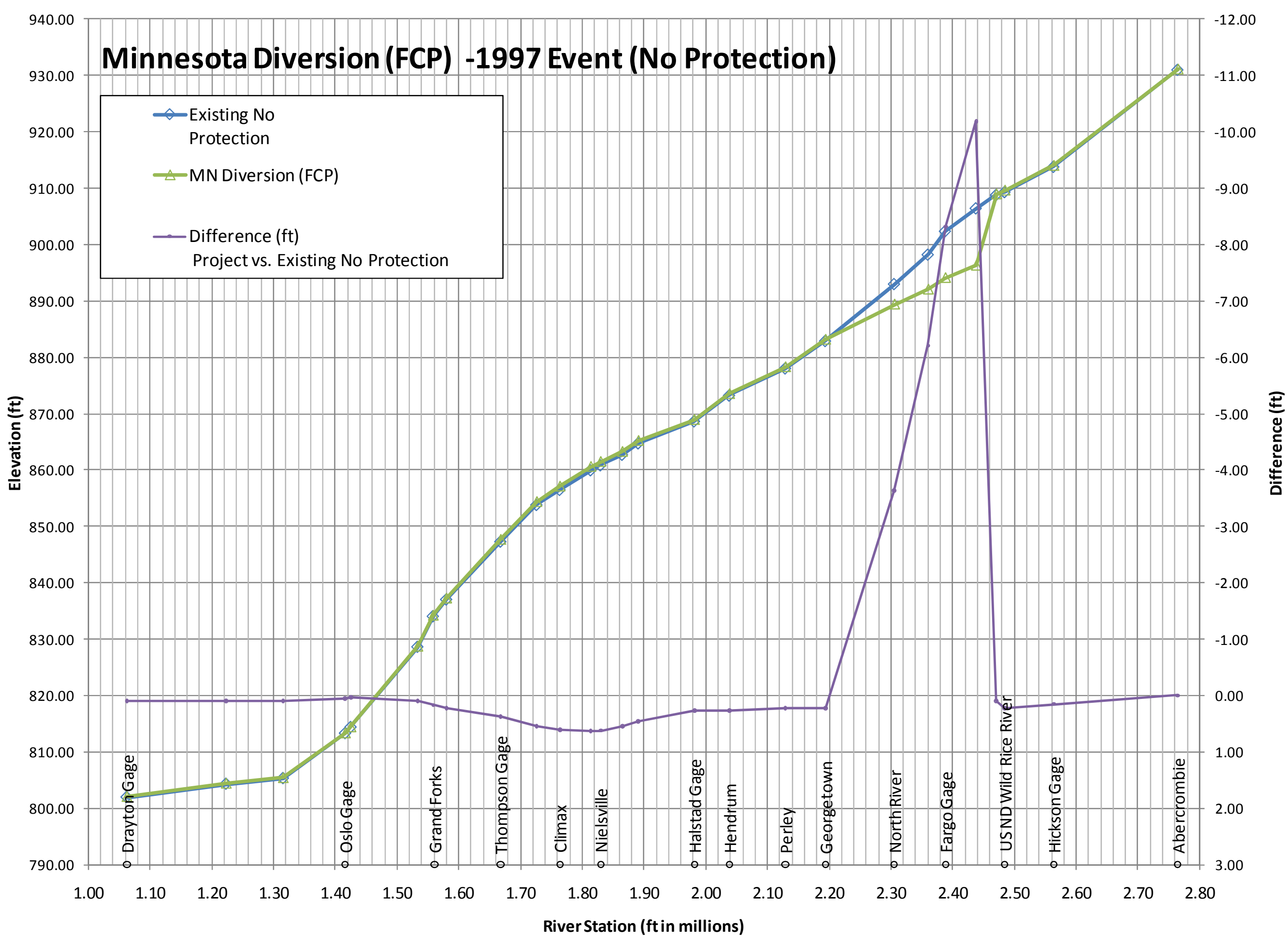


Figure C-E1- 5: 1997 Historical Flood Impacts for FCP

2-28-2011

Minnesota Diversion (FCP) -2006 Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.44	78252	799.47	78770	0.03	518
ND SH#17/ MN SH317	1223286	801.84		801.87		0.03	
Co. Hwy 15	1315673	803.39		803.42		0.03	
Oslo Gage	1416287	811.58		811.60		0.02	
Minimum Impact Location	1448026	814.15		814.16		0.01	
DS Grand Forks Levees	1533523	825.11		825.15		0.04	
Grand Forks Gage	1558518	828.63	72782	828.69	73160	0.06	378
32nd Ave, Grand Forks	1580152	830.60		830.67		0.07	
Thompson Gage	1667877	840.63	52499	840.84	53450	0.21	951
Co. Hwy 25/ Co. Rd 221	1726274	846.54		846.83		0.29	
DS Sandhill River/ Climax	1763746	849.17		849.45		0.28	
Nielsville	1829877	853.70	48037	854.02	49044	0.32	1007
DS Marsh River	1864960	856.33		856.65		0.32	
US Goose River/ Shelly	1891054	859.08		859.42		0.34	
Halstad Gage	1981580	866.64	43060	866.86	44955	0.22	1895
Hendrum	2038409	870.74	36229	871.09	38142	0.35	1913
Maximum Impact Location	2058853	871.99		872.36		0.37	
Perley	2129181	876.40	36253	876.61	38349	0.21	2096
Georgetown	2194021	881.37	36894	881.59	39723	0.22	2829
North River/ Clay Co. Hwy 93	2305647	891.46		888.25		-3.21	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	895.97		890.84		-5.13	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.57 (36.83*)	21028	893.15 (30.41*)	10078	-6.42	-10950
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	903.97		896.67		-7.30	
US FCP Diversion	2470898	906.81		906.53		-0.28	
US ND Wild Rice River	2484618	907.56		907.21		-0.35	
Hickson Gage	2563754	913.11	14313	913.15	14352	0.04	39
Abercrombie	2764835	931.58	15027	931.58	15027	0.00	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

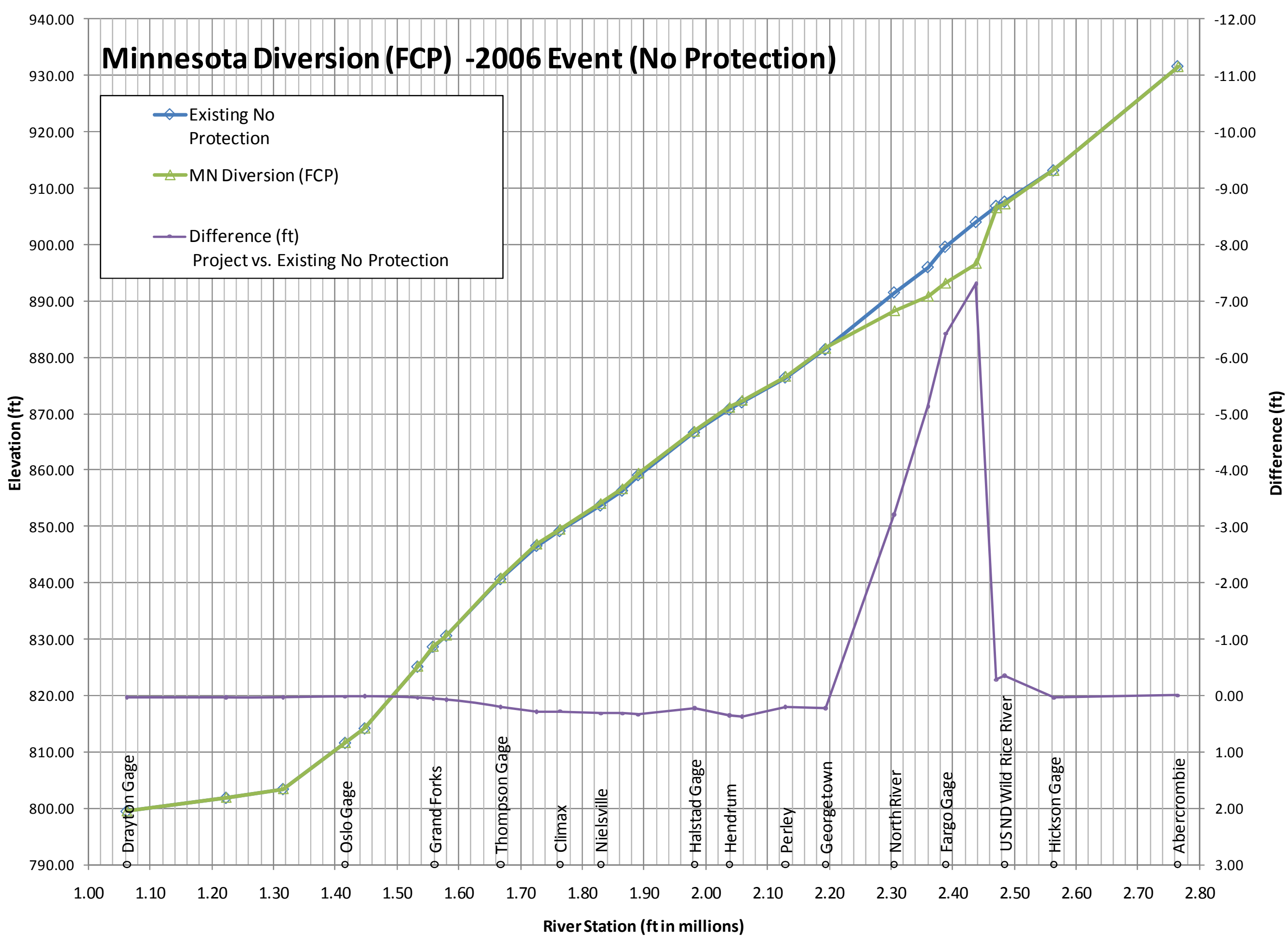


Figure C-E1- 6: 2006 Historical Flood Impacts for FCP

Minnesota Diversion (FCP) -2009 Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.85	85308	799.98	87702	0.13	2393
ND SH#17/ MN SH317	1223286	802.36		802.52		0.16	
Co. Hwy 15	1315673	803.81		803.93		0.12	
Minimum Impact Location	1410241	810.81		810.89		0.08	
Oslo Gage	1416287	812.02		812.16		0.14	
DS Grand Forks Levees	1533523	825.65		826.01		0.36	
Grand Forks Gage	1558518	829.33	77165	829.83	80831	0.50	3666
32nd Ave, Grand Forks	1580152	831.80		832.45		0.65	
Thompson Gage	1667877	843.05	61510	843.97	65379	0.92	3869
Co. Hwy 25/ Co. Rd 221	1726274	849.33		850.39		1.06	
DS Sandhill River/ Climax	1763746	851.96		853.06		1.10	
Maximum Impact Location	1789494	853.76		854.88		1.12	
Nielsville	1829877	856.67	58164	857.79	62482	1.12	4318
DS Marsh River	1864960	859.13		860.15		1.02	
US Goose River/ Shelly	1891054	861.73		862.65		0.92	
Halstad Gage	1981580	867.60	55176	868.02	60798	0.42	5622
Hendrum	2038409	872.25	44075	872.88	48595	0.63	4520
Perley	2129181	877.21	45715	877.73	51361	0.52	5645
Georgetown	2194021	882.32	47470	882.82	54928	0.50	7458
North River/ Clay Co. Hwy 93	2305647	892.95		889.08		-3.87	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.28		891.74		-6.54	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.66 (39.92*)	29234	894.03 (31.29*)	11964	-8.63	-17270
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.96		897.80		-9.16	
US FCP Diversion	2470898	909.61		909.47		-0.14	
US ND Wild Rice River	2484618	910.20		910.22		0.02	
Hickson Gage	2563754	917.76	24393	917.75	24407	-0.01	14
Abercrombie	2764835	937.51	28176	937.51	28176	0.00	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

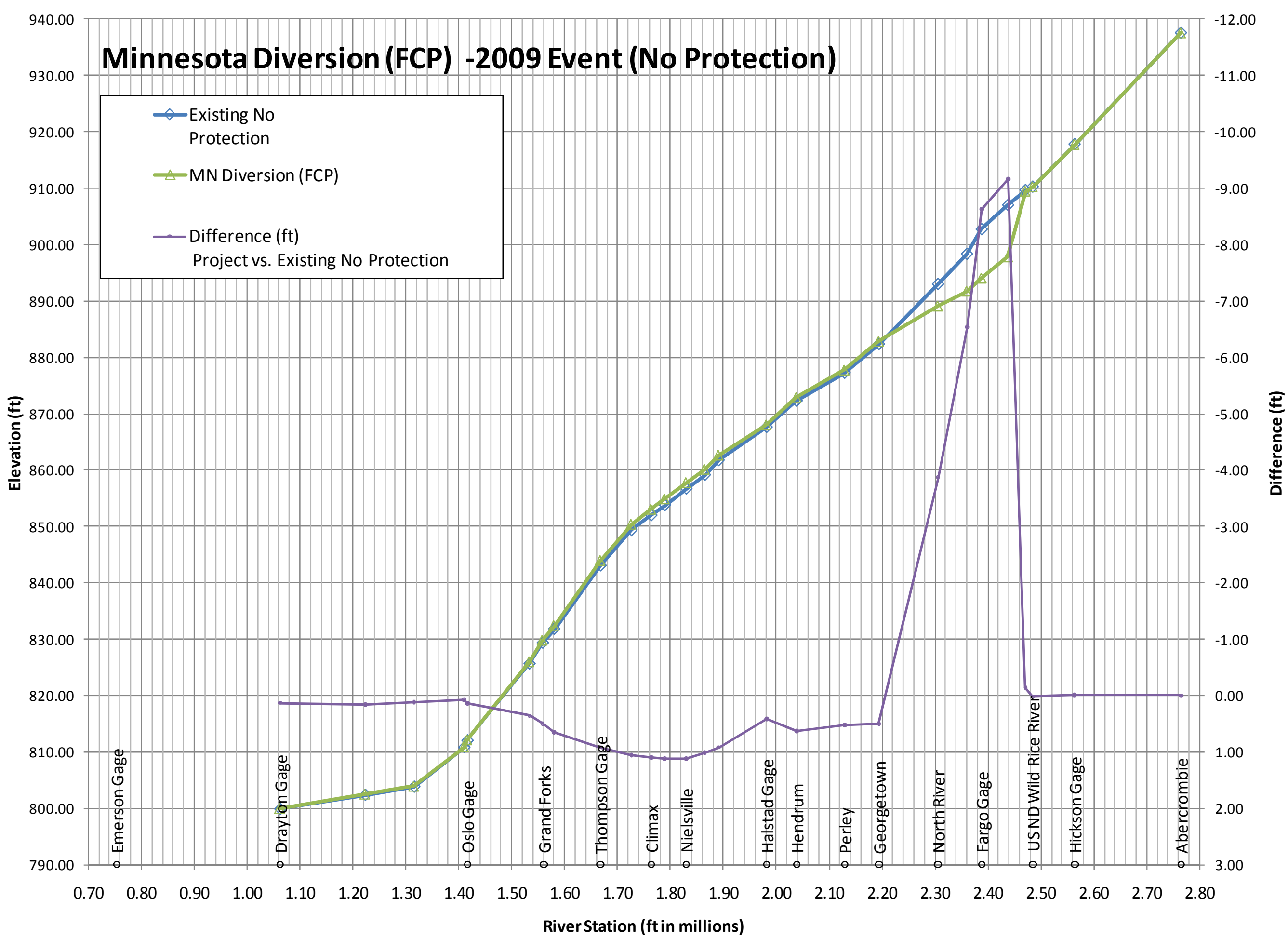


Figure C-E1- 7: 2009 Historical Flood Impacts for FCP

Minnesota Diversion (FCP) -2010 Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.71	65928	798.76	66687	0.05	759
ND SH#17/ MN SH317	1223286	801.04		801.10		0.06	
Co. Hwy 15	1315673	802.96		803.00		0.04	
Oslo Gage	1416287	811.09		811.11		0.02	
Minimum Impact Location	1467237	815.28		815.30		0.02	
DS Grand Forks Levees	1533523	824.07		824.12		0.05	
Grand Forks Gage	1558518	827.23	63406	827.29	63783	0.06	377
32nd Ave, Grand Forks	1580152	829.35		829.42		0.07	
Thompson Gage	1667877	840.28	52023	840.55	53139	0.27	1116
Co. Hwy 25/ Co. Rd 221	1726274	846.28		846.61		0.33	
DS Sandhill River/ Climax	1763746	848.95		849.27		0.32	
Maximum Impact Location	1829650	853.73		854.10		0.37	
Nielsville	1829877	853.84	49914	854.20	51122	0.36	1208
DS Marsh River	1864960	856.61		856.95		0.34	
US Goose River/ Shelly	1891054	859.37		859.71		0.34	
Halstad Gage	1981580	866.55	42389	866.76	43888	0.21	1499
Hendrum	2038409	870.62	38264	870.97	40448	0.35	2183
Perley	2129181	876.31	35431	876.53	37676	0.22	2245
Georgetown	2194021	881.30	36134	881.54	39235	0.24	3100
North River/ Clay Co. Hwy 93	2305647	891.54		888.36		-3.18	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	896.11		891.04		-5.07	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.77 (37.03*)	21481	893.37 (30.63*)	10231	-6.40	-11250
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	904.15		896.74		-7.41	
US FCP Diversion	2470898	906.89		906.80		-0.09	
US ND Wild Rice River	2484618	907.59		907.42		-0.17	
Hickson Gage	2563754	912.23	12677	912.42	12697	0.19	20
Abercrombie	2764835	930.57	13236	930.57	13236	0.00	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

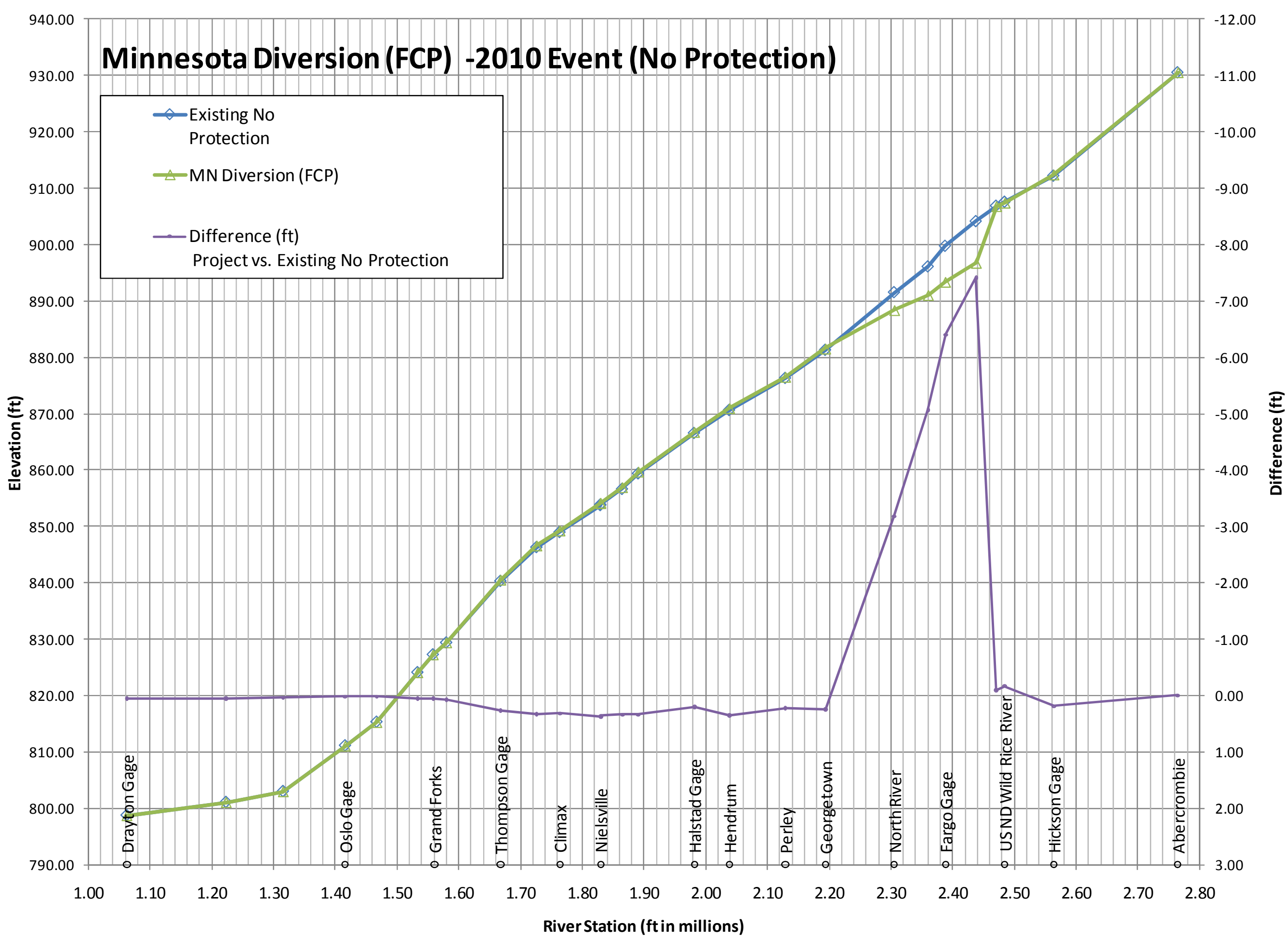


Figure C-E1- 8: 2010 Historical Flood Impacts for FCP

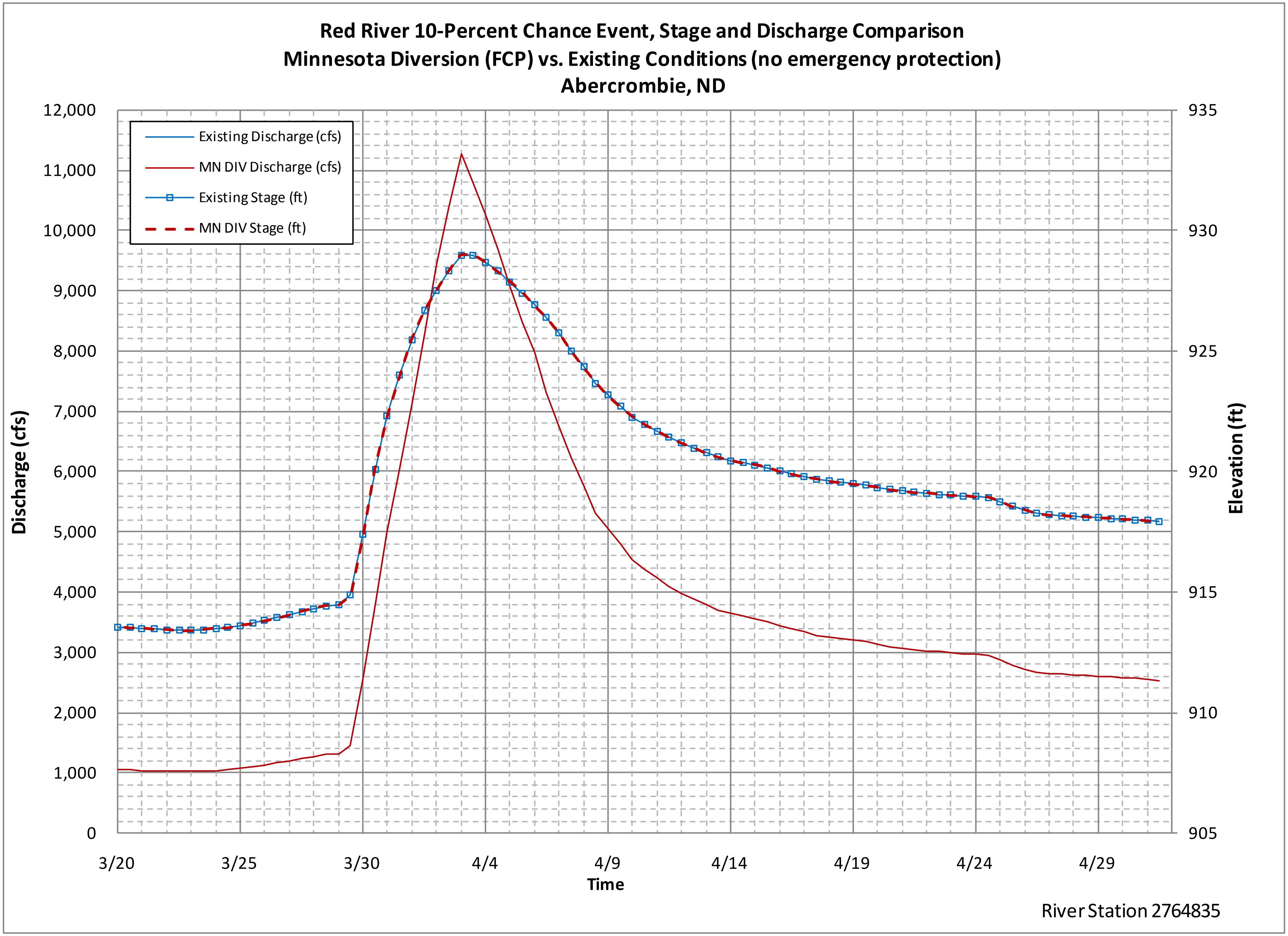


Figure C-E1- 9: 10-Percent Chance Hydrographs for FCP @ Abercrombie

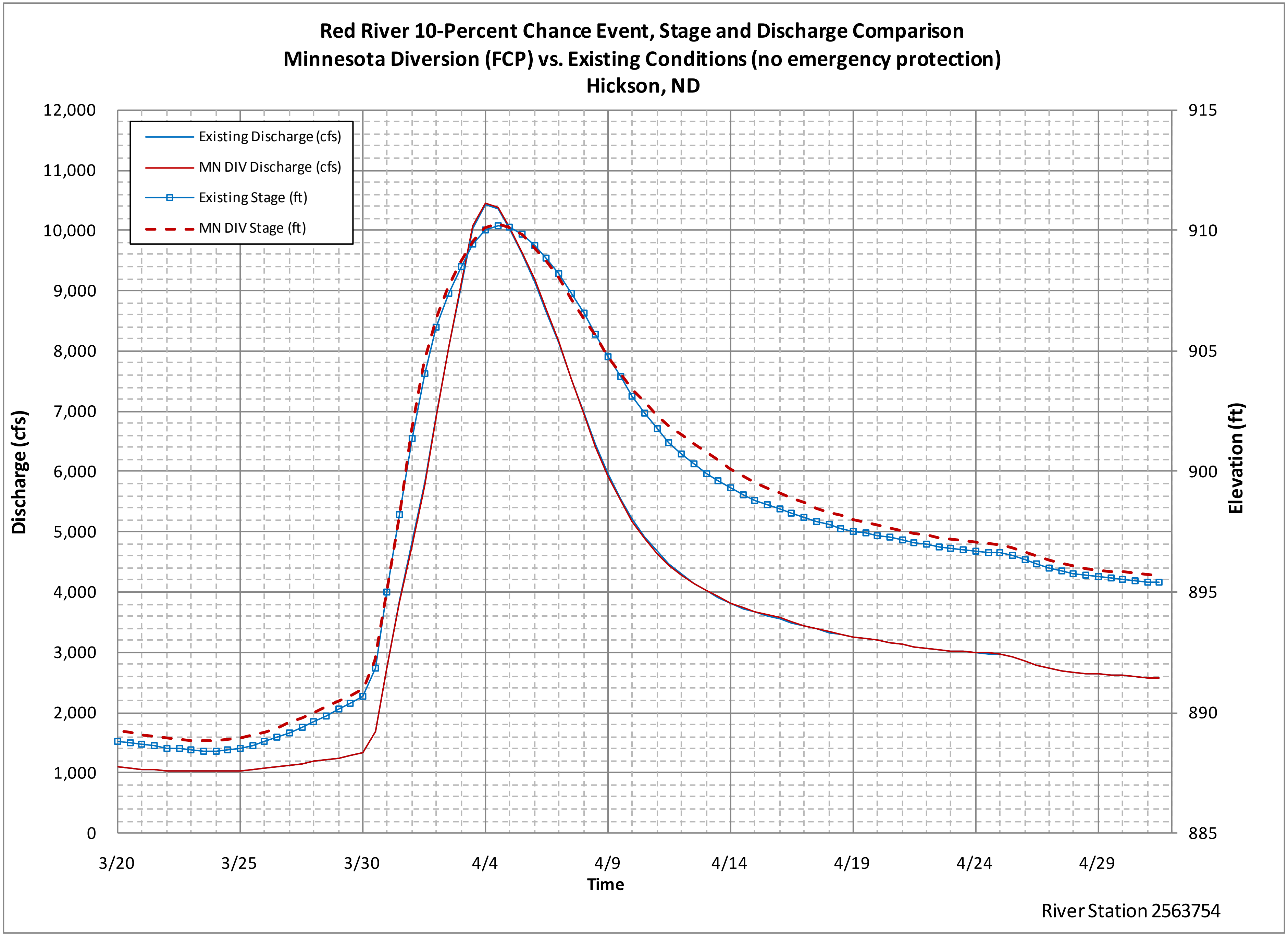


Figure C-E1- 10: 10-Percent Chance Hydrographs for FCP @ Hickson

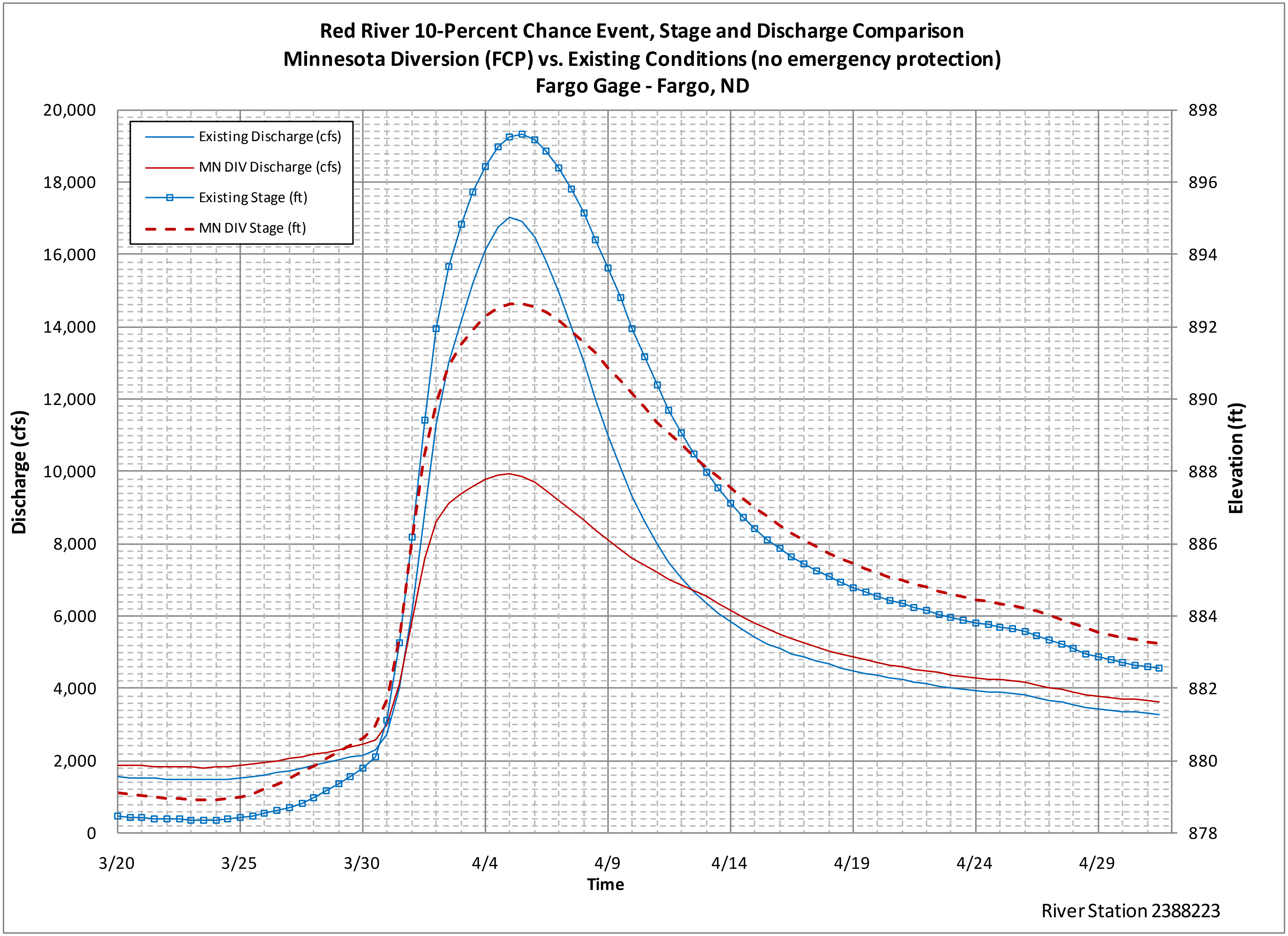


Figure C-E1- 11: 10-Percent Chance Hydrographs for FCP @ Fargo

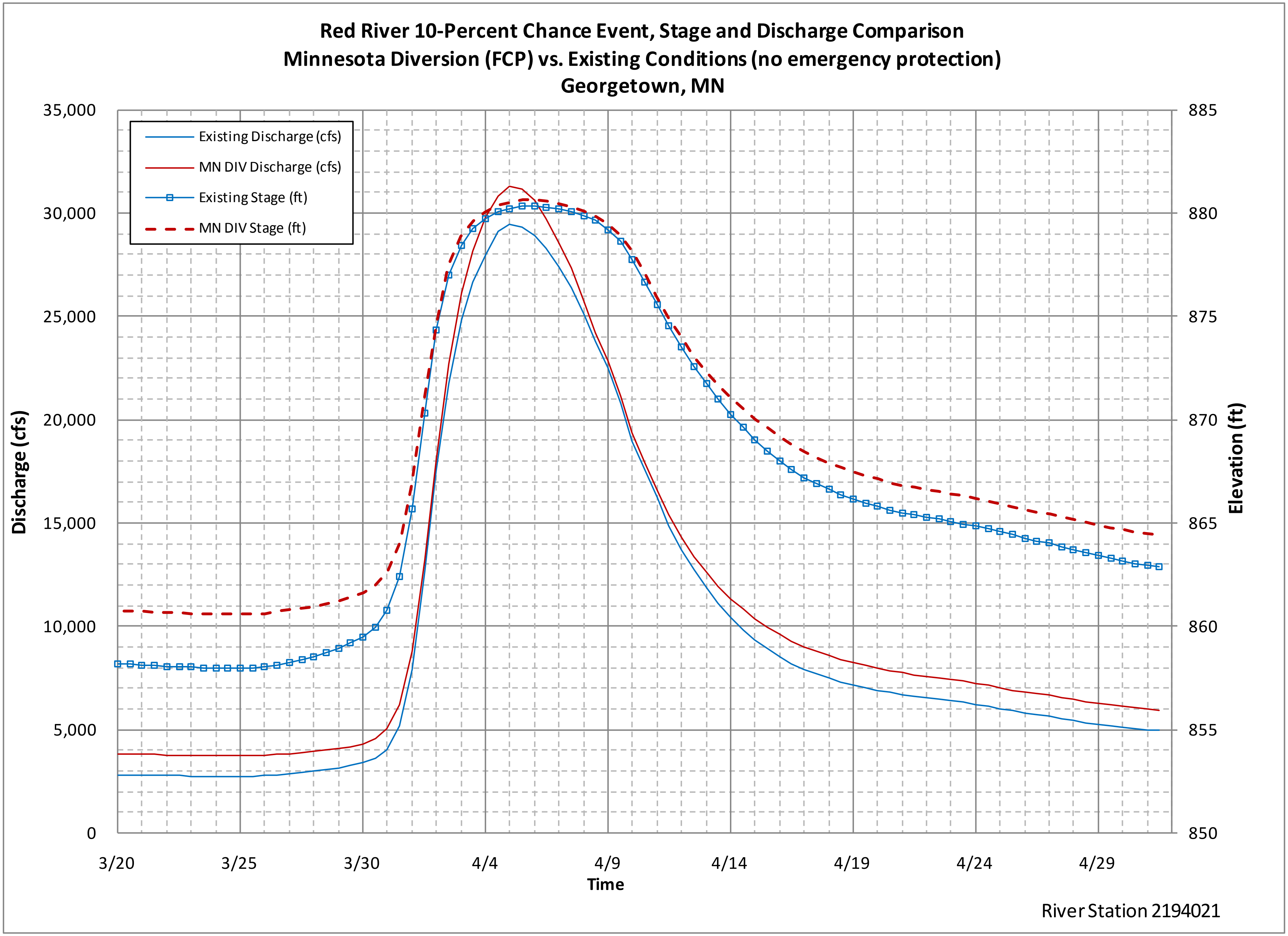


Figure C-E1- 12: 10-Percent Chance Hydrographs for FCP @ Georgetown

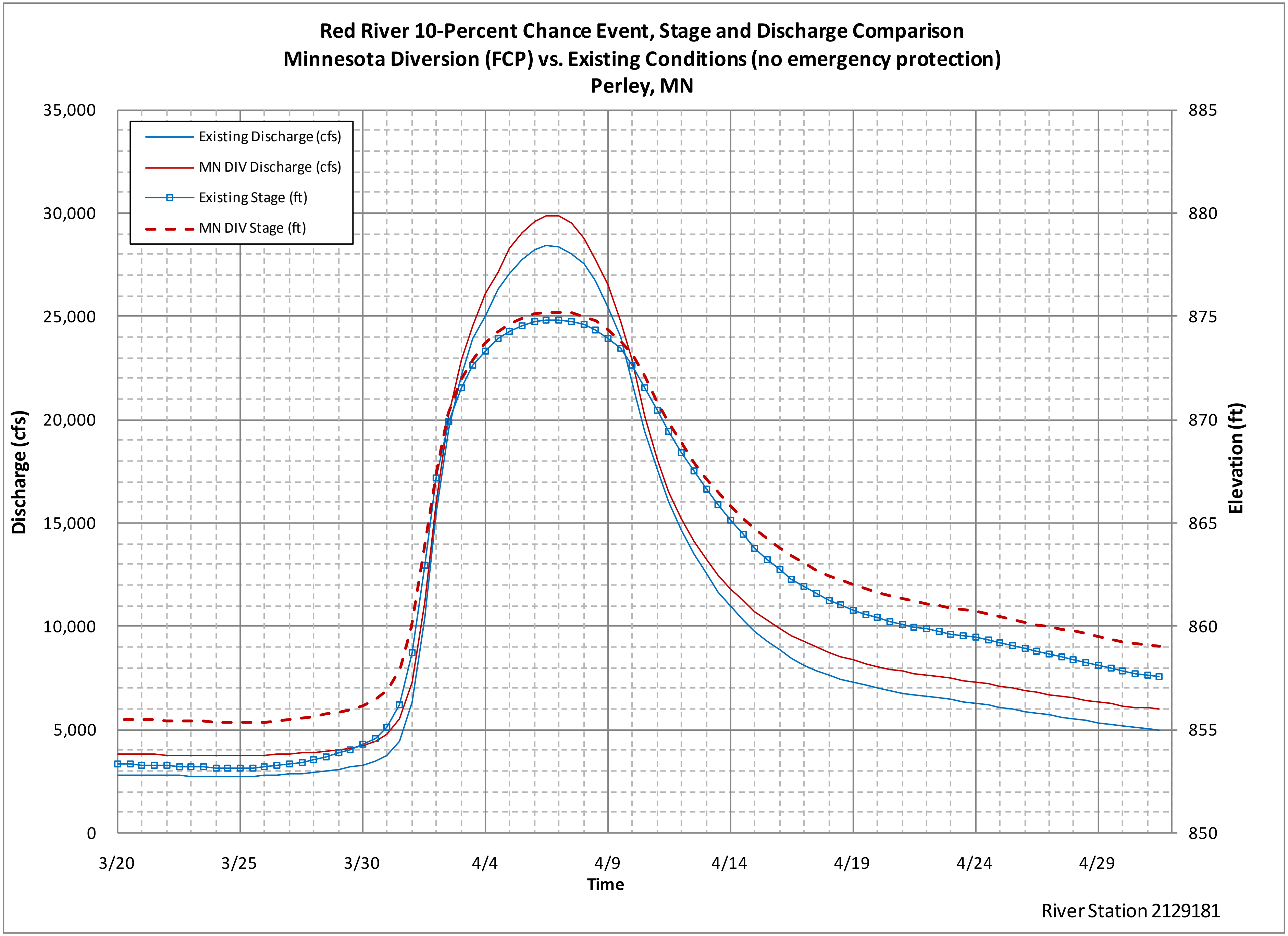


Figure C-E1- 13: 10-Percent Chance Hydrographs for FCP @ Perley

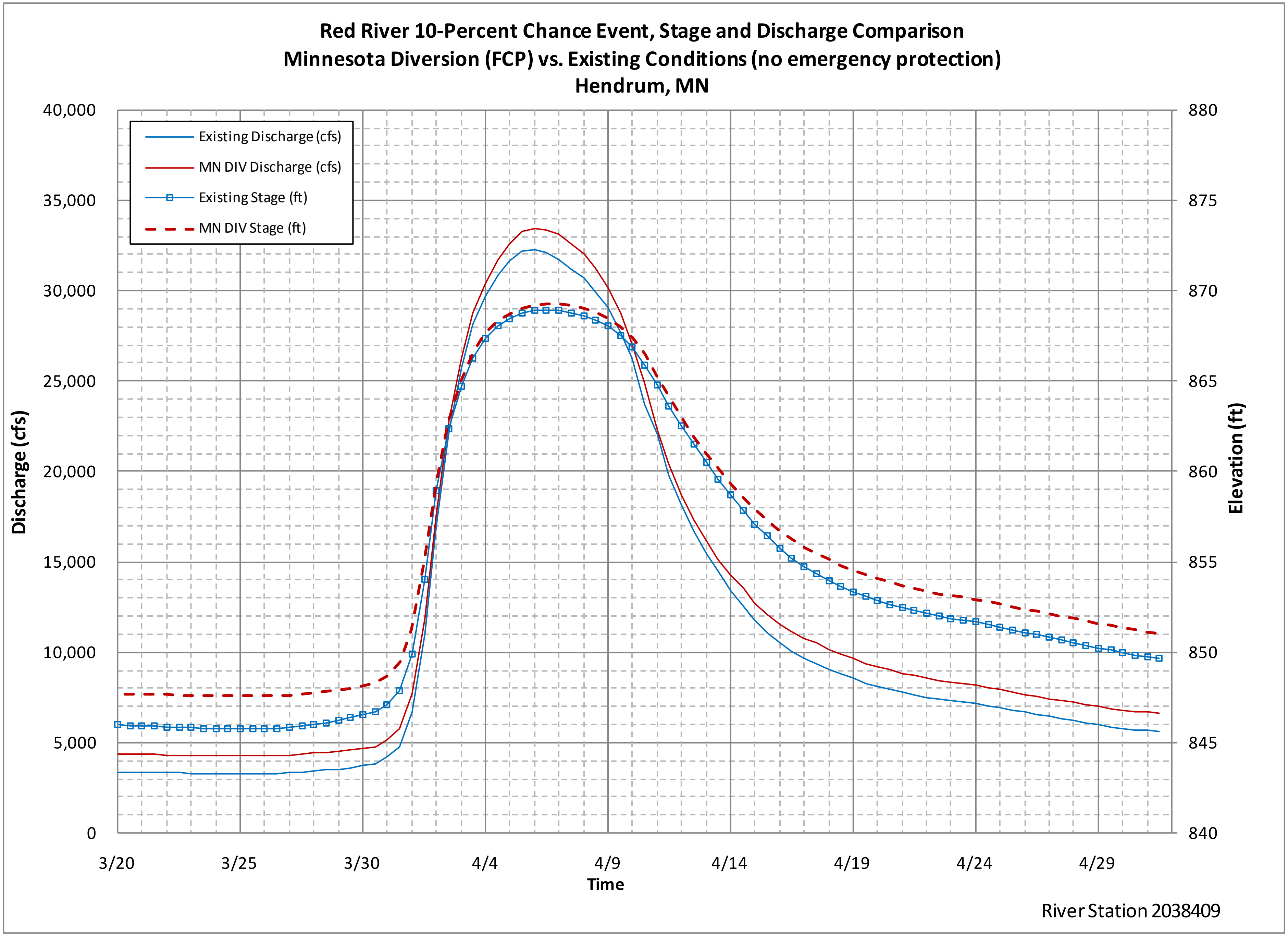


Figure C-E1- 14: 10-Percent Chance Hydrographs for FCP @ Hendrum

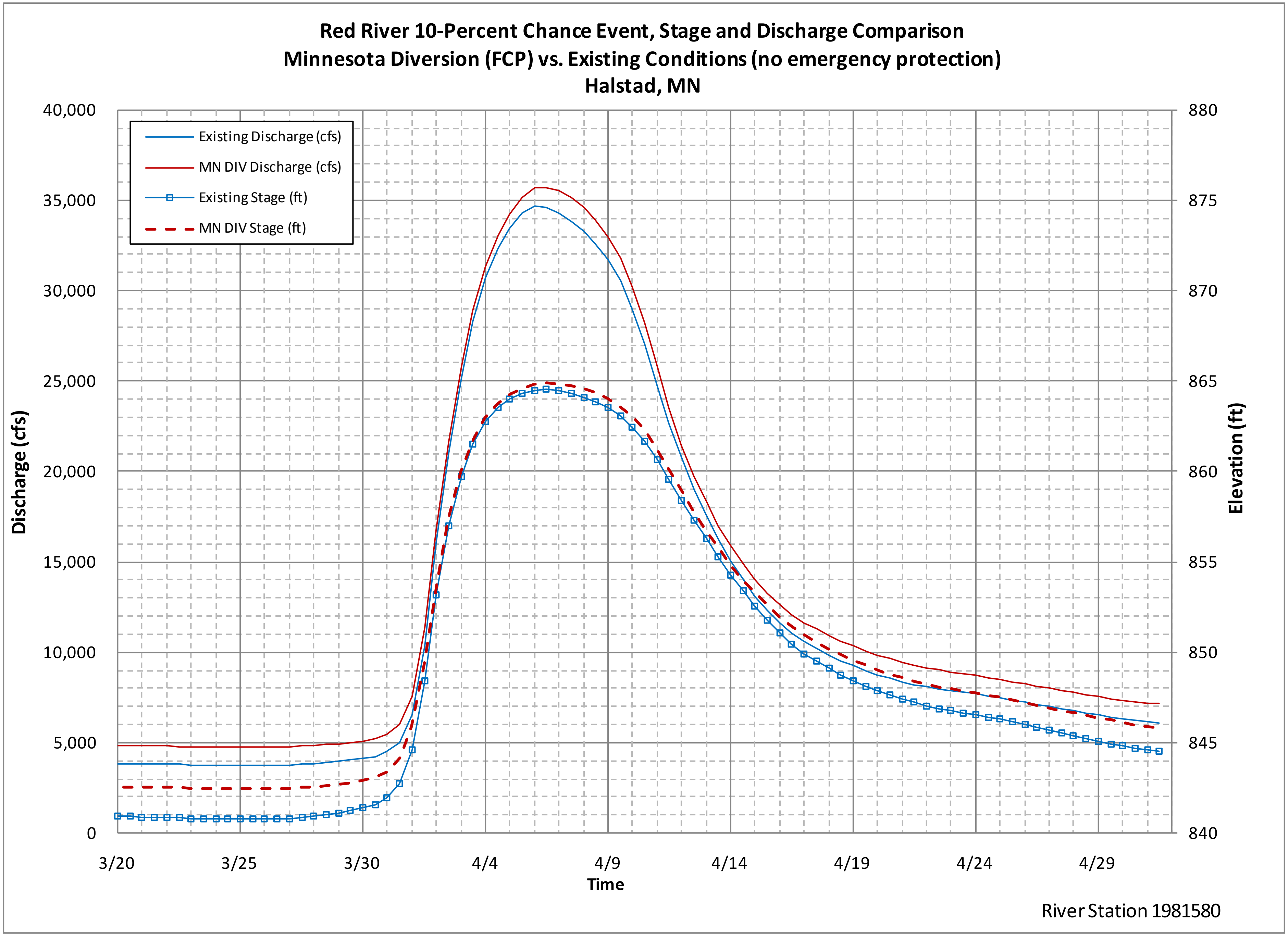


Figure C-E1- 15: 10-Percent Chance Hydrographs for FCP @ Halstad

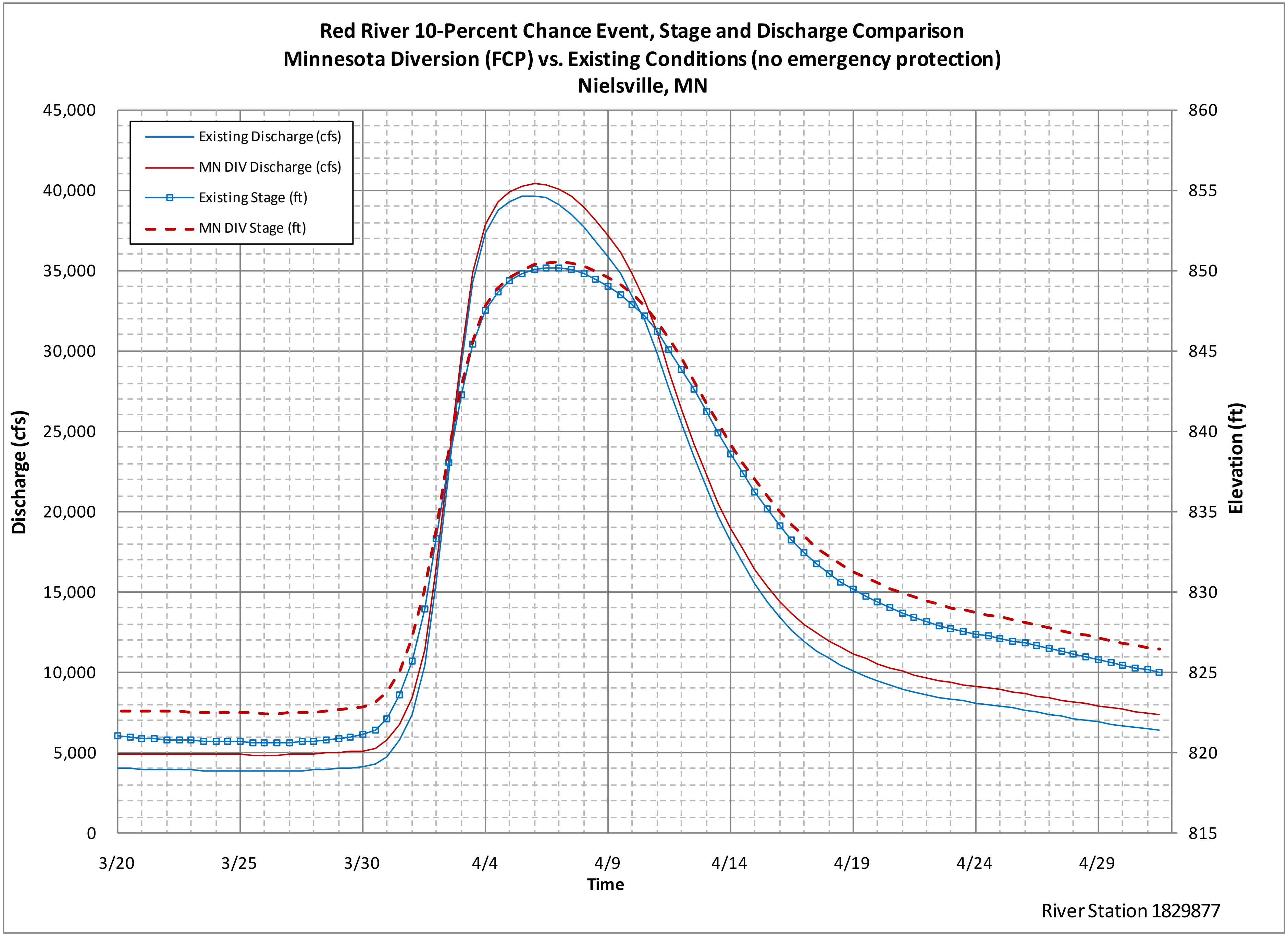


Figure C-E1- 16: 10-Percent Chance Hydrographs for FCP @ Nielsville

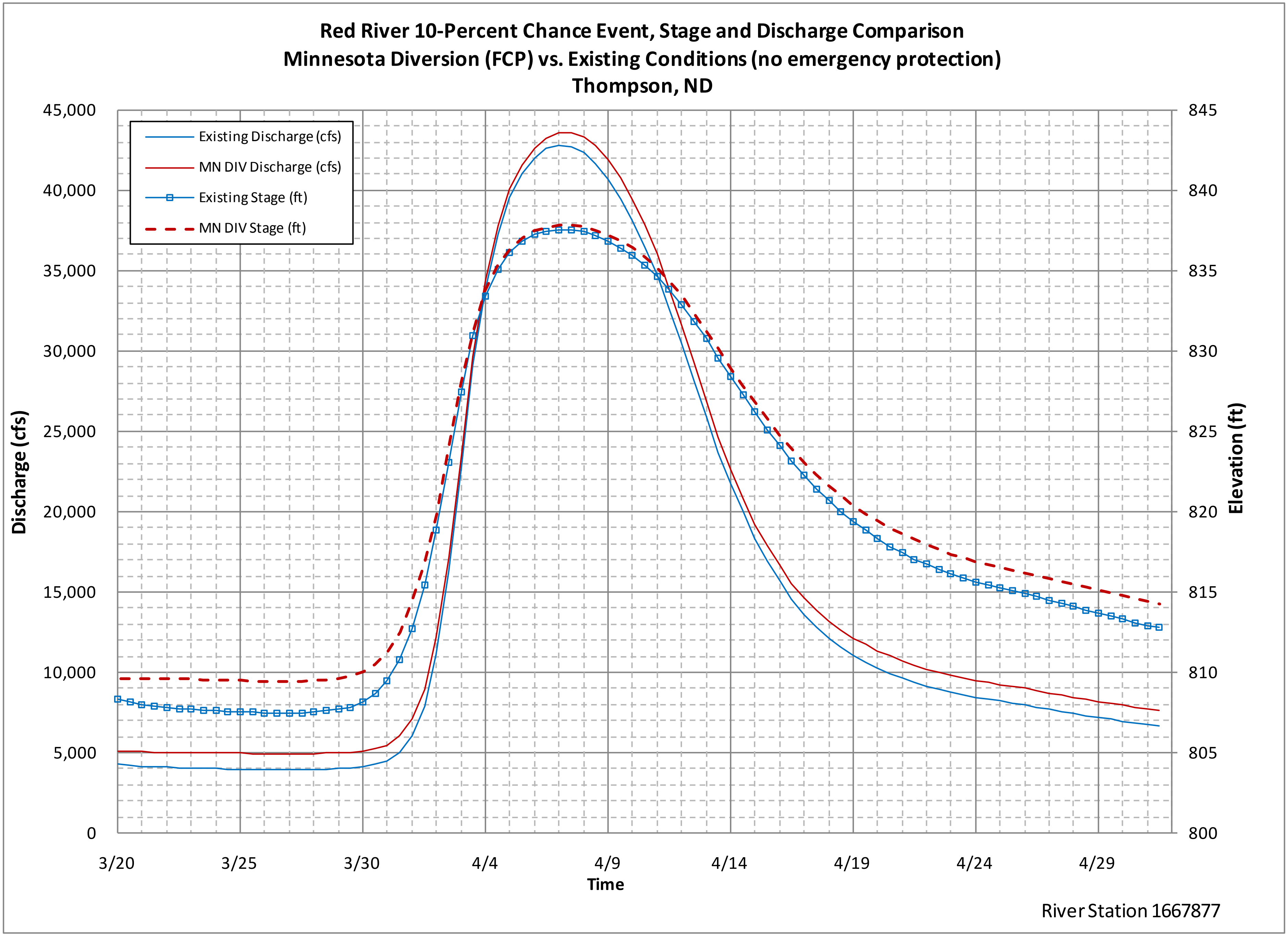


Figure C-E1- 17: 10-Percent Chance Hydrographs for FCP @ Thompson

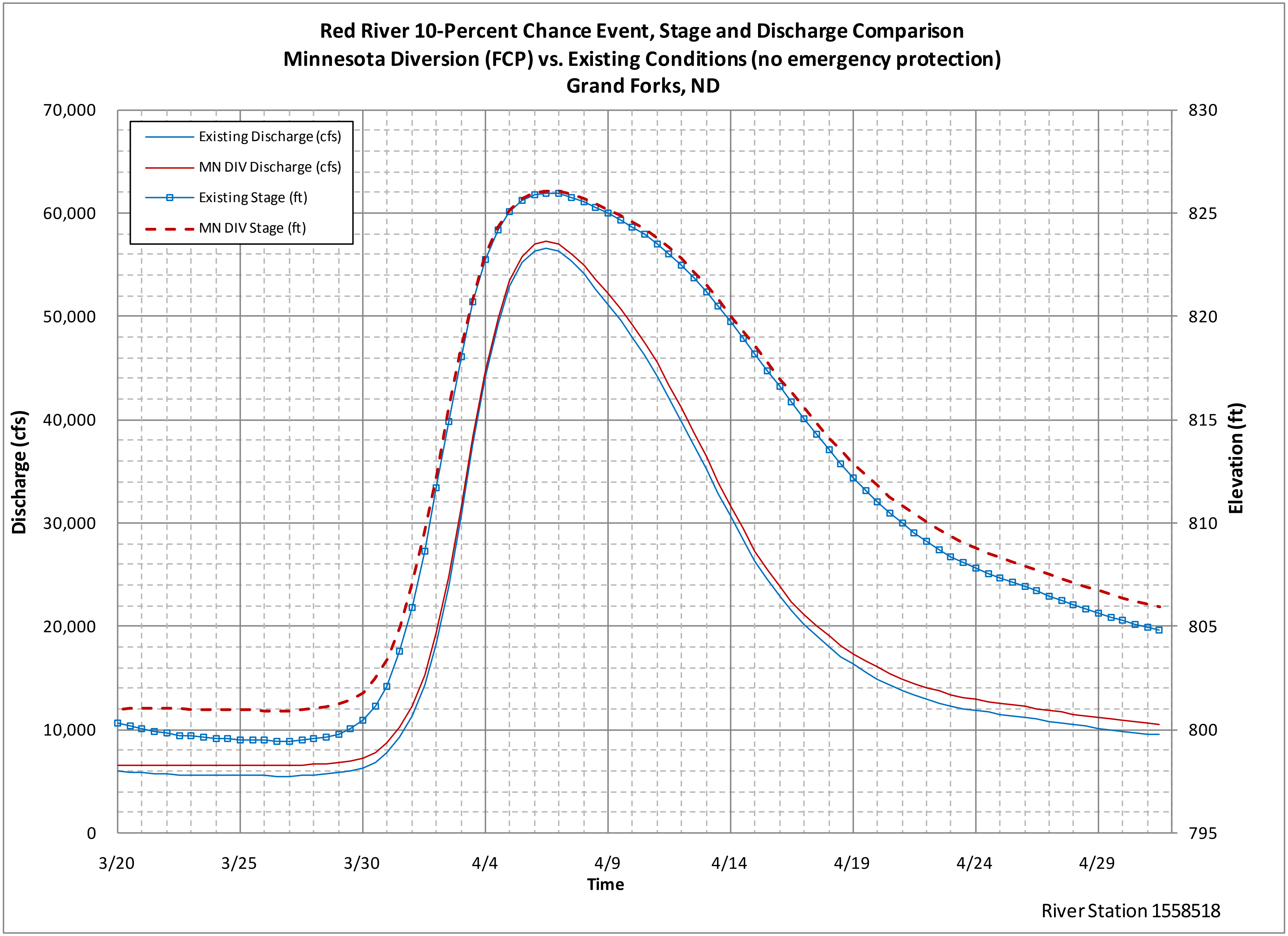


Figure C-E1- 18: 10-Percent Chance Hydrographs for FCP @ Grand Forks

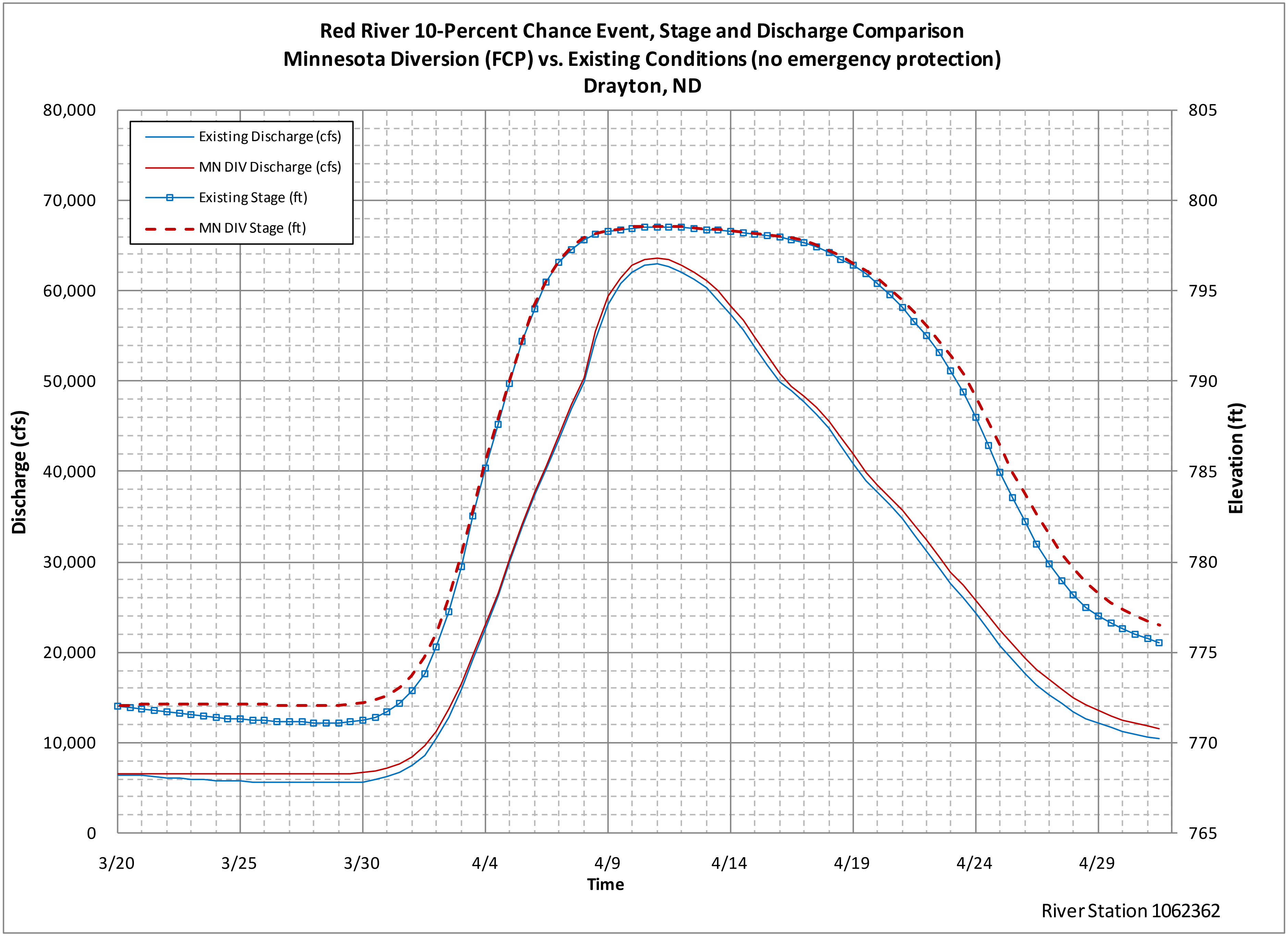


Figure C-E1- 19: 10-Percent Chance Hydrographs for FCP @ Drayton

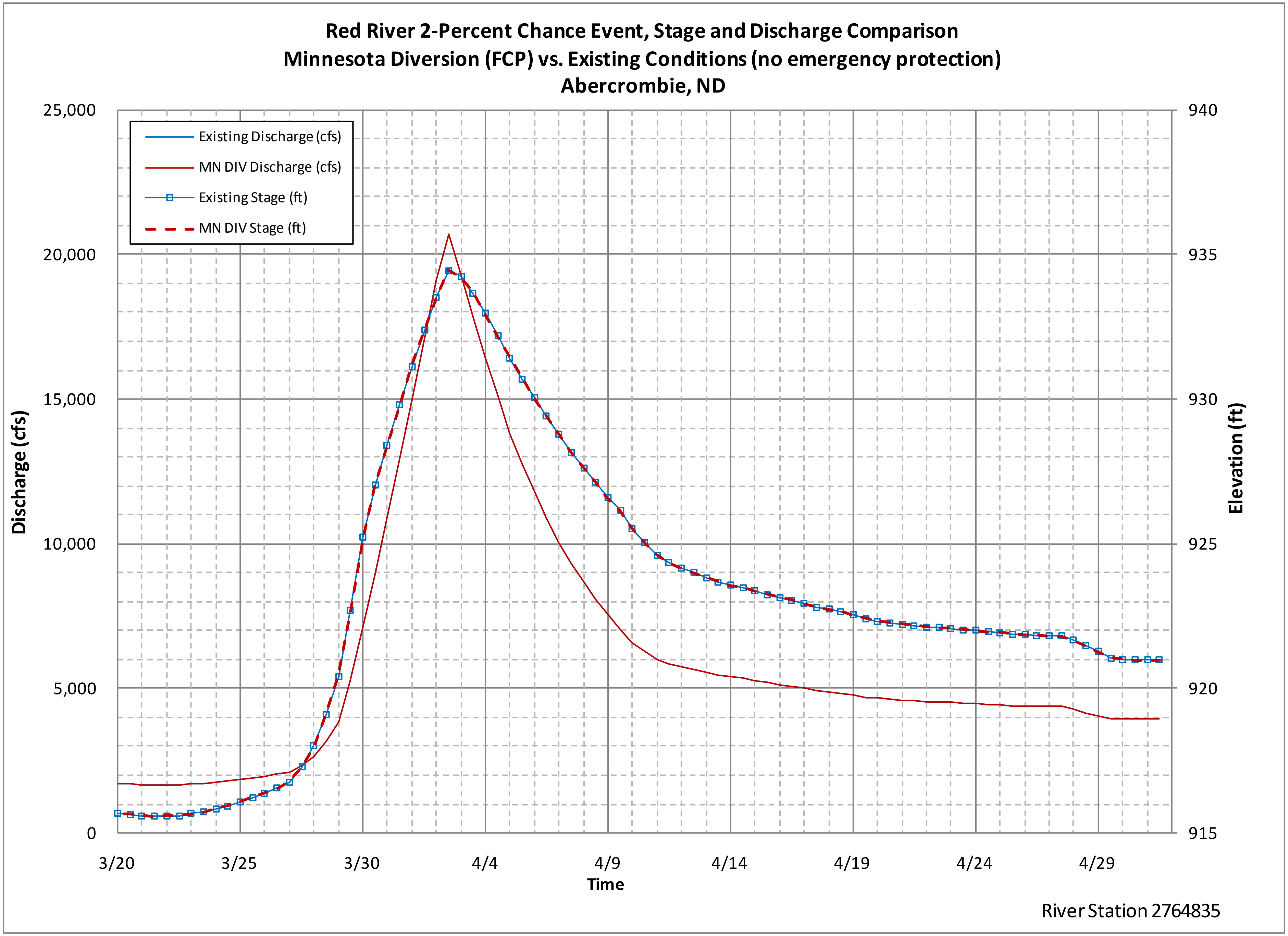


Figure C-E1- 20: 2-Percent Chance Hydrographs for FCP @ Abercrombie

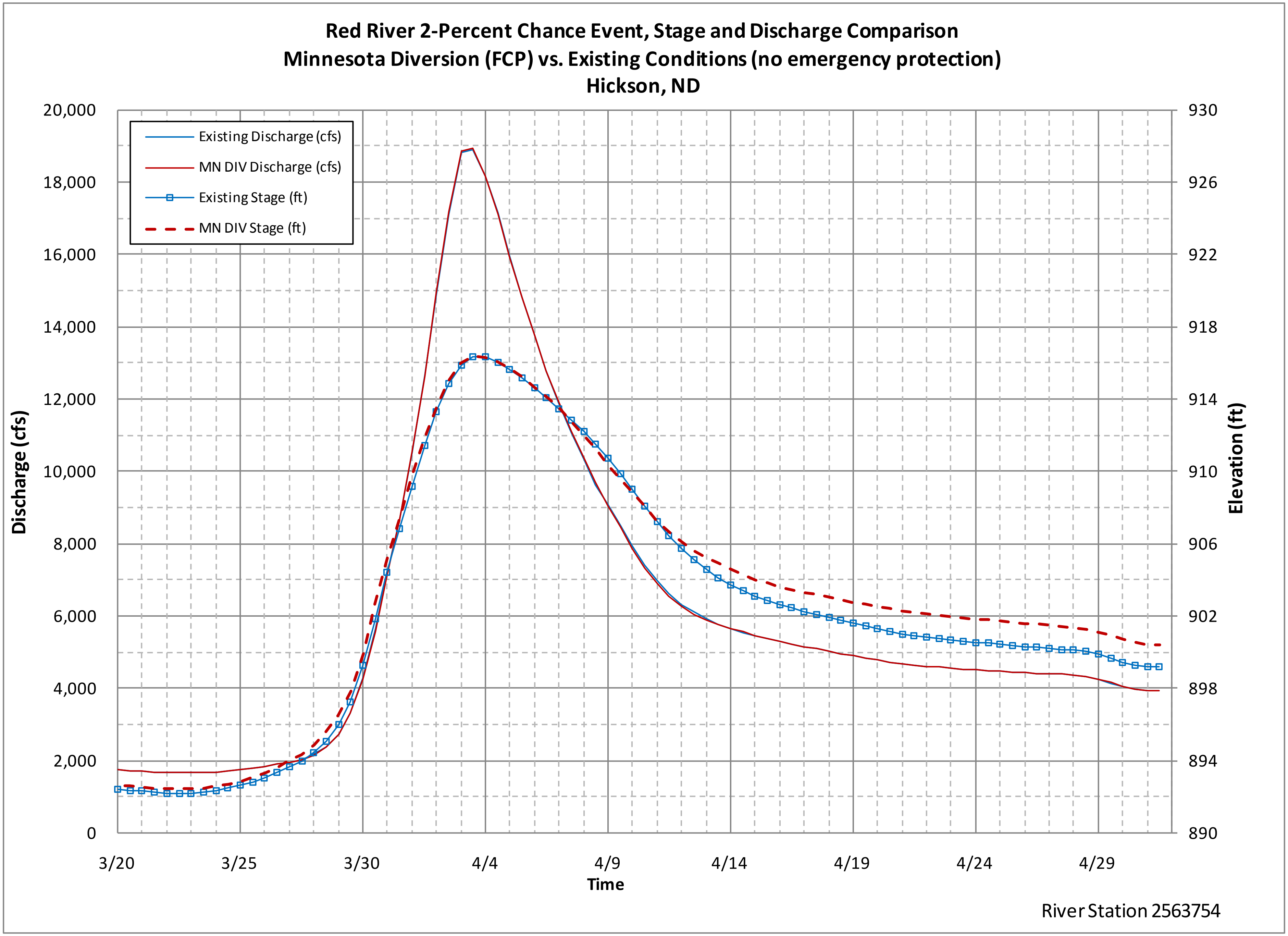


Figure C-E1- 21: 2-Percent Chance Hydrographs for FCP @ Hickson

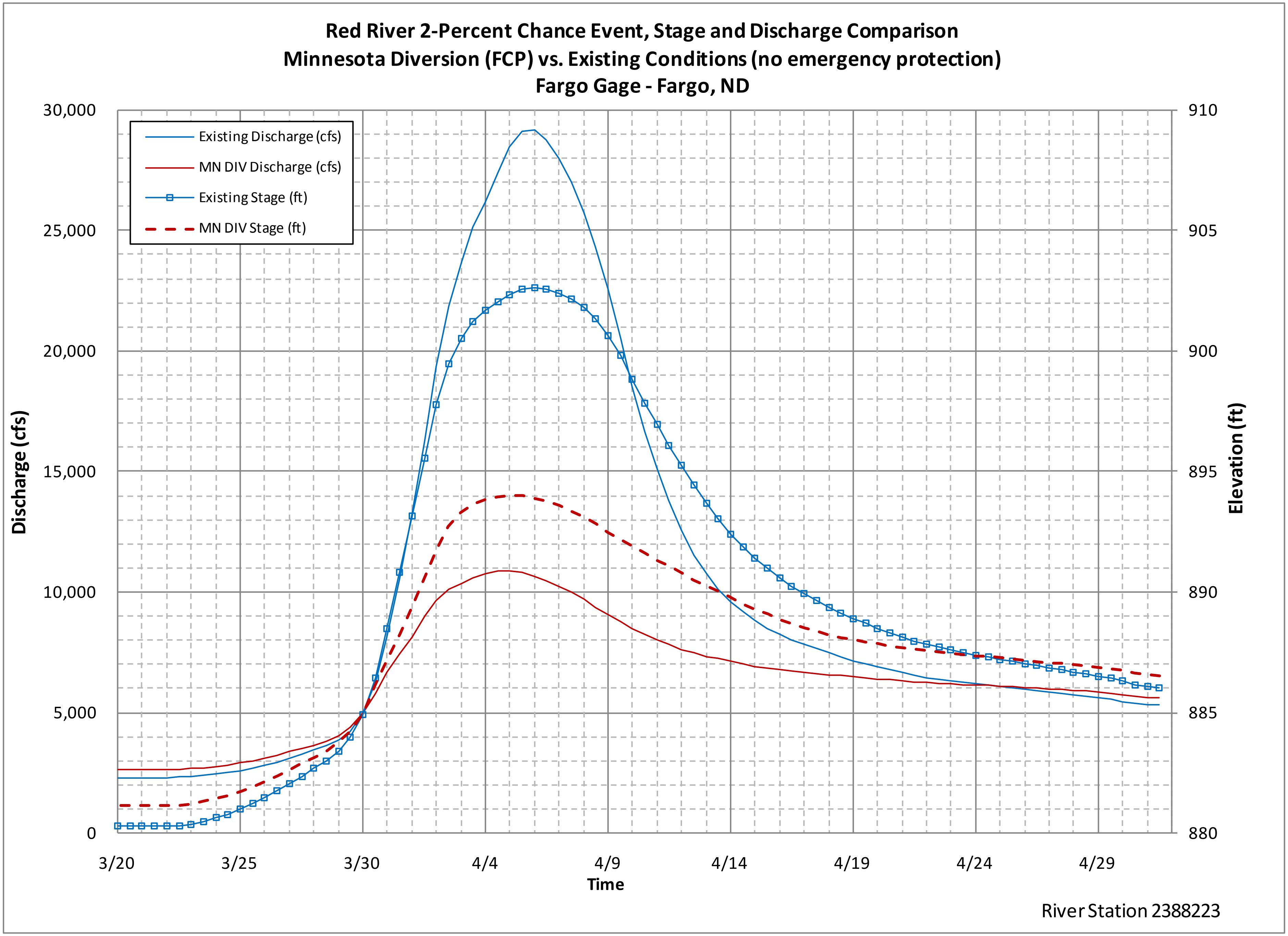


Figure C-E1- 22: 2-Percent Chance Hydrographs for FCP @ Fargo

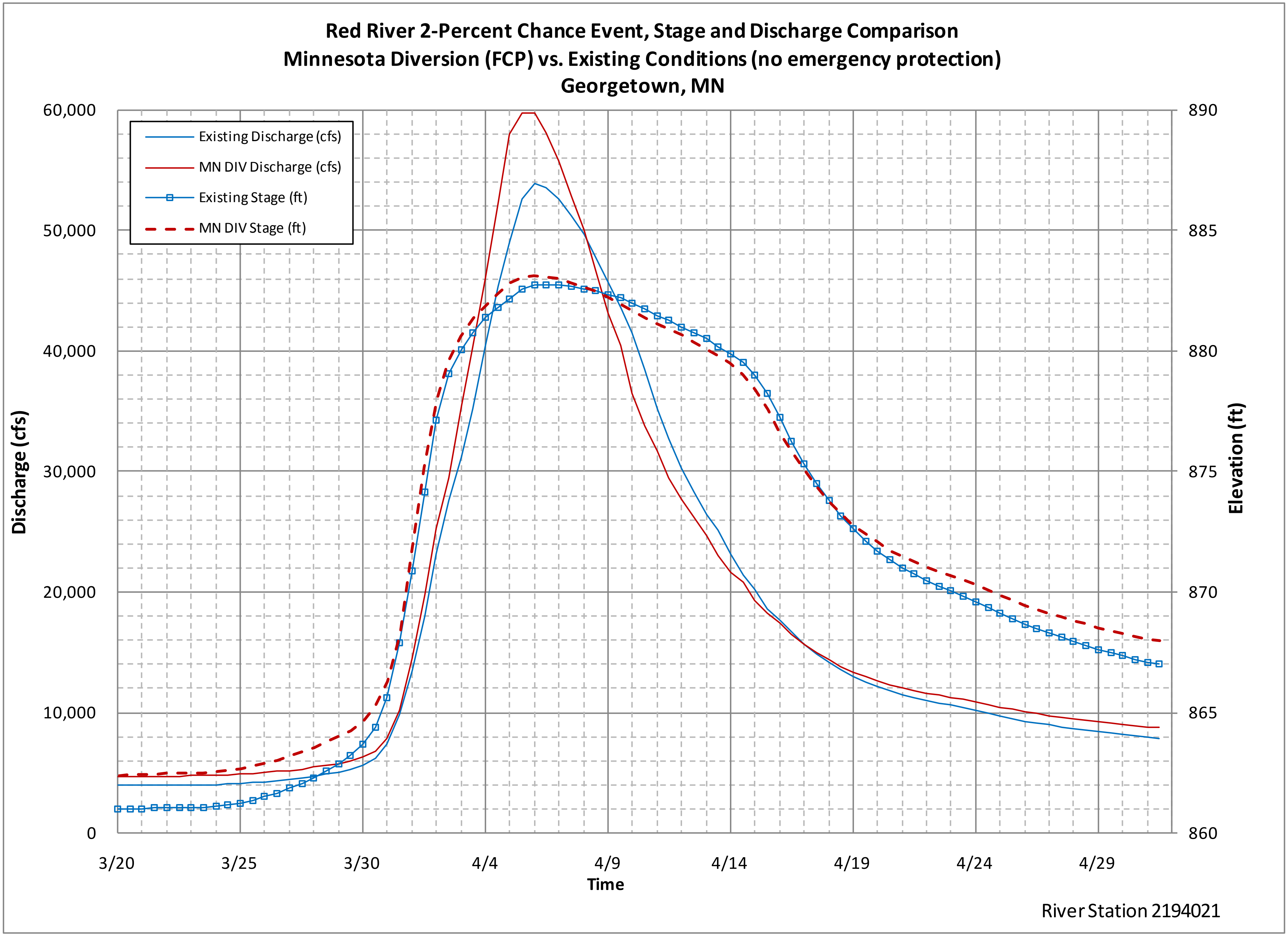


Figure C-E1- 23: 2-Percent Chance Hydrographs for FCP @ Georgetown

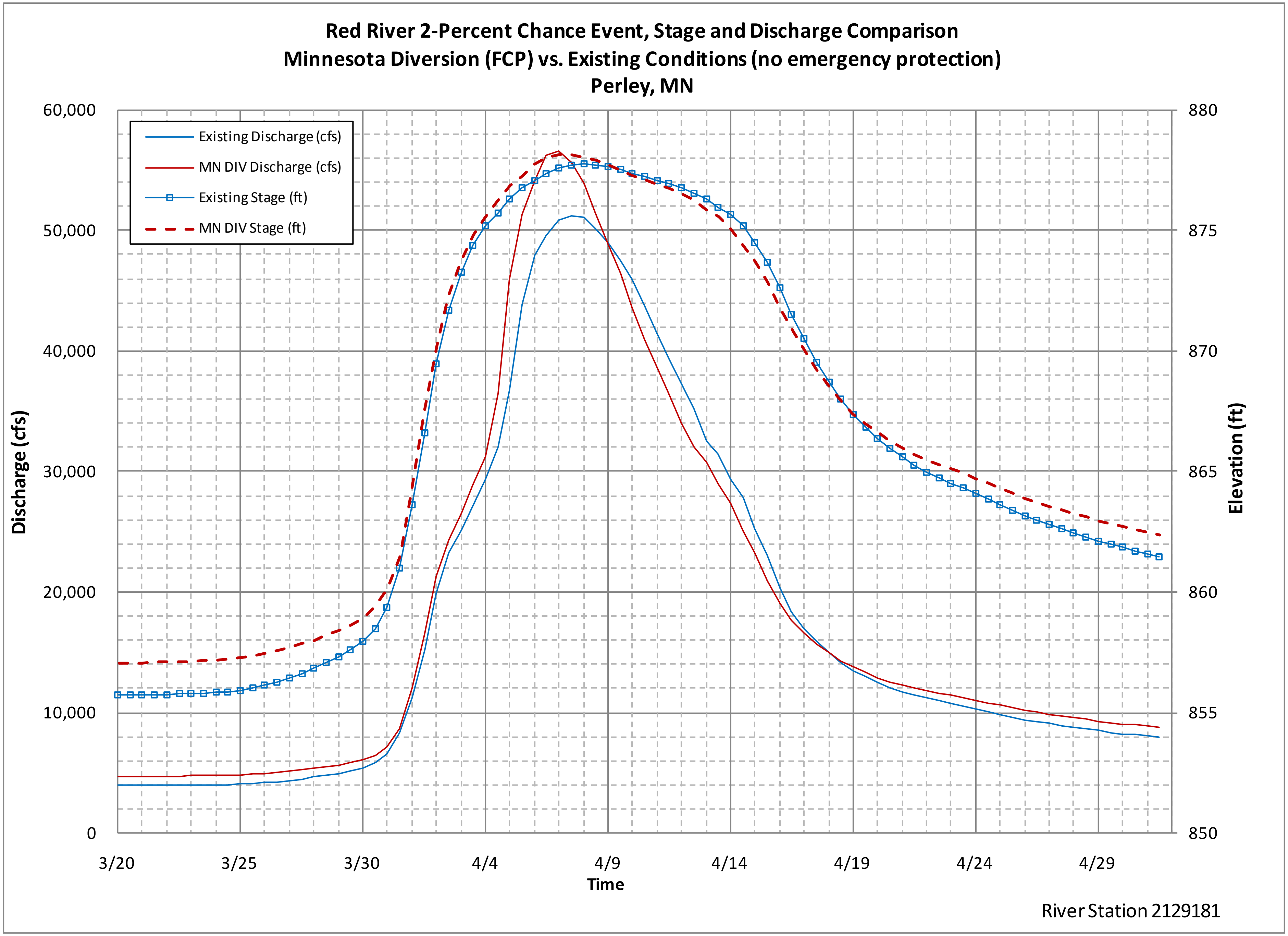


Figure C-E1- 24: 2-Percent Chance Hydrographs for FCP @ Perley

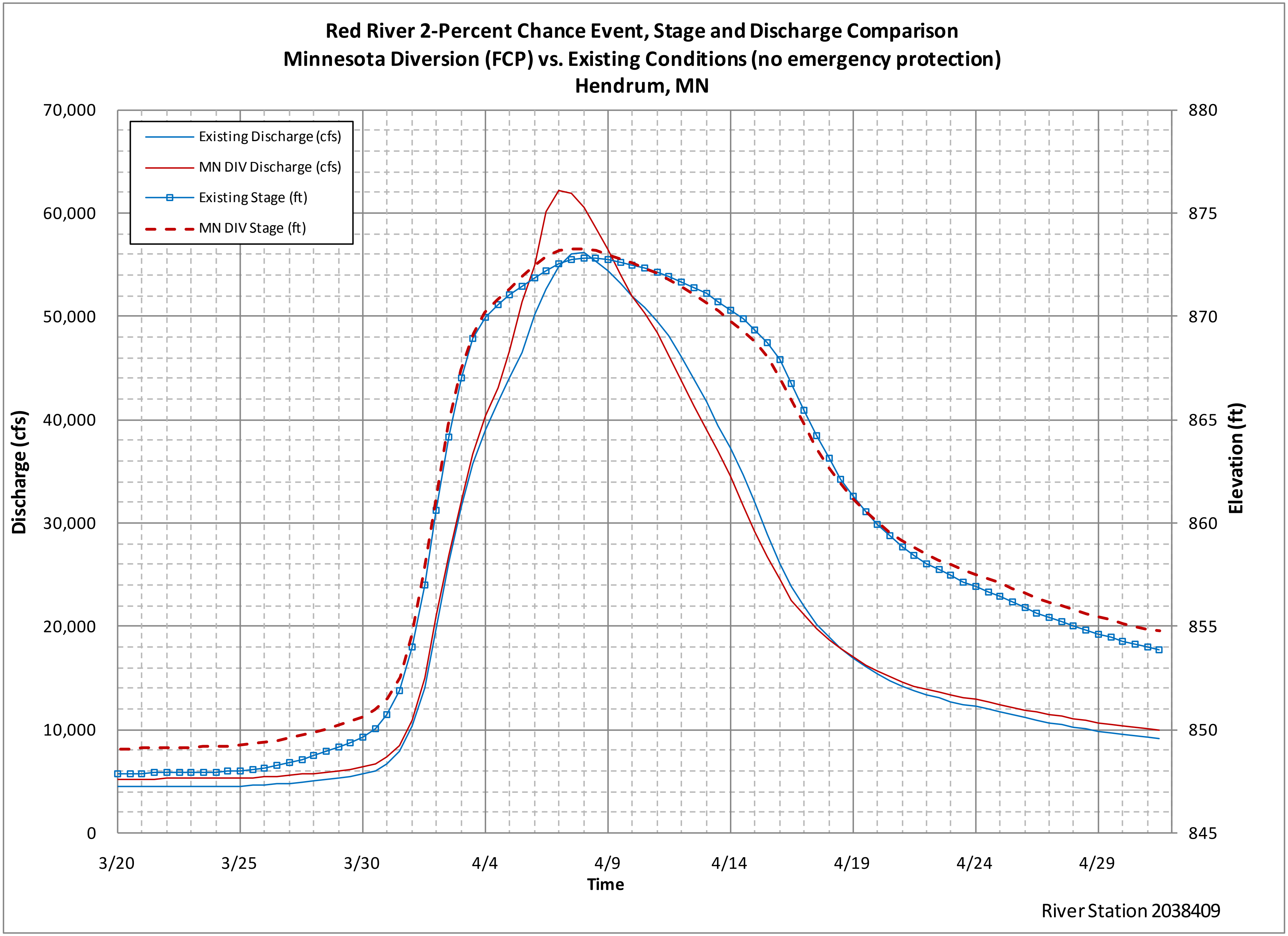


Figure C-E1- 25: 2-Percent Chance Hydrographs for FCP @ Hendrum

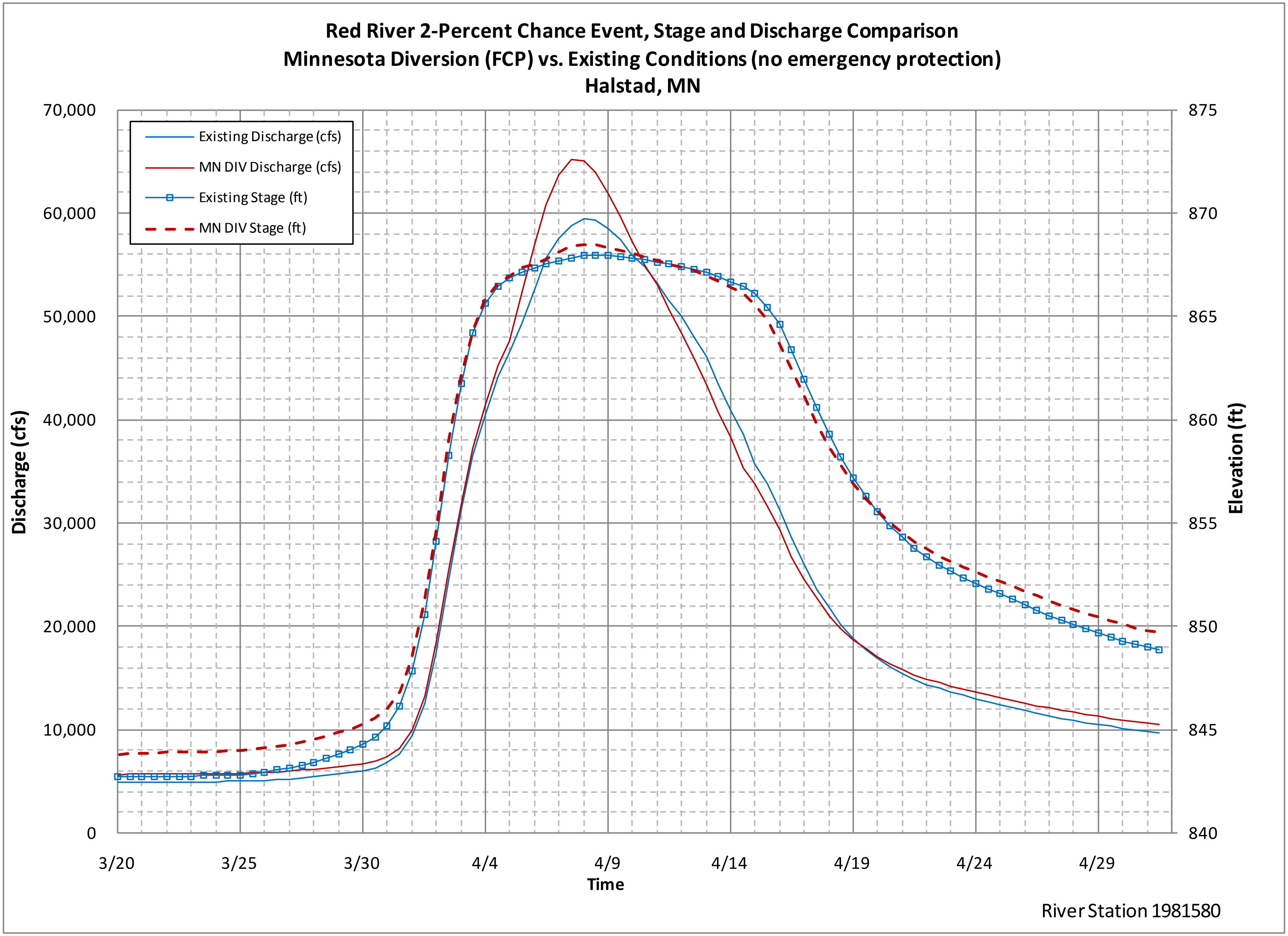


Figure C-E1- 26: 2-Percent Chance Hydrographs for FCP @ Halstad

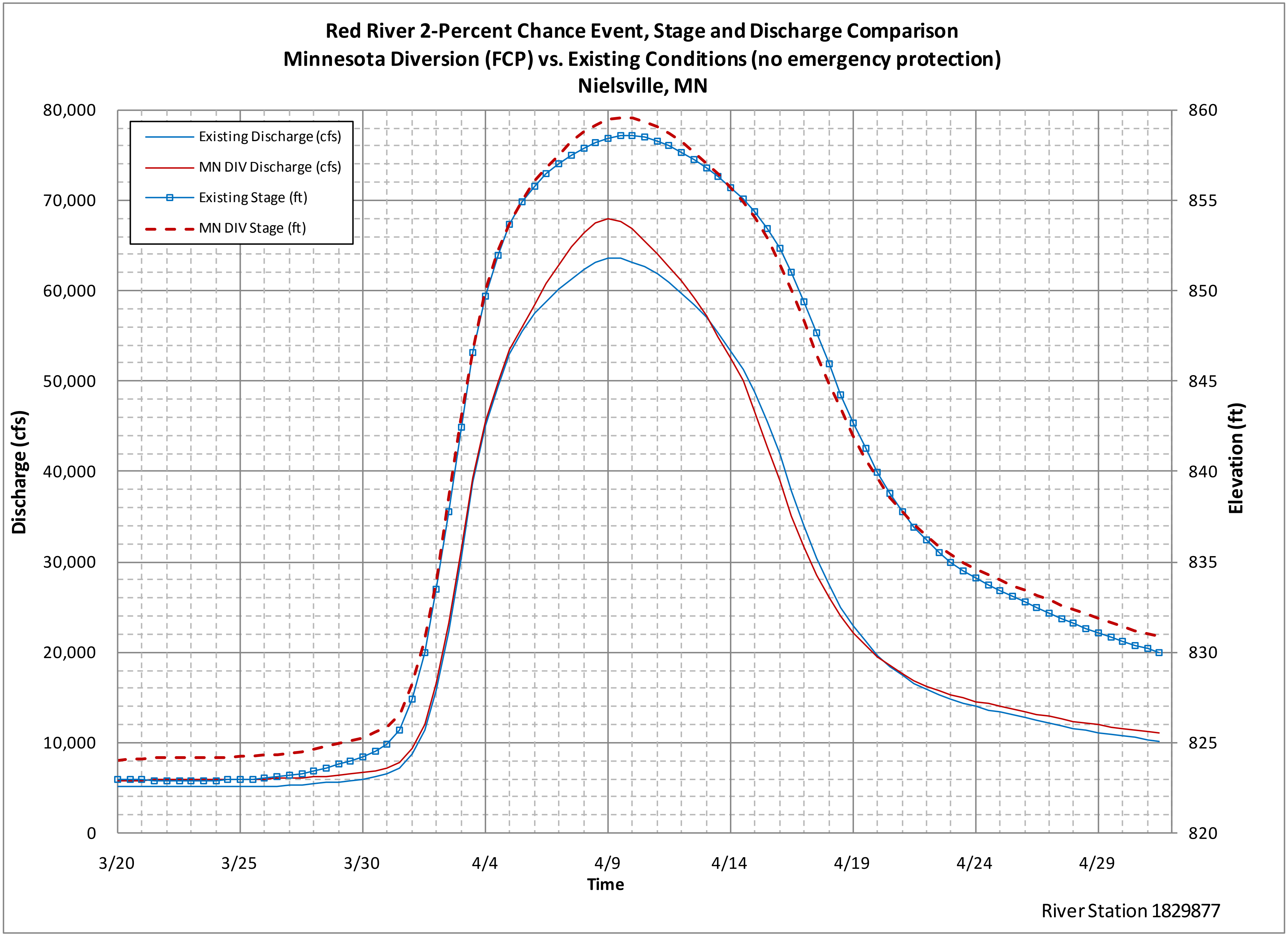


Figure C-E1- 27: 2-Percent Chance Hydrographs for FCP @ Nielsville

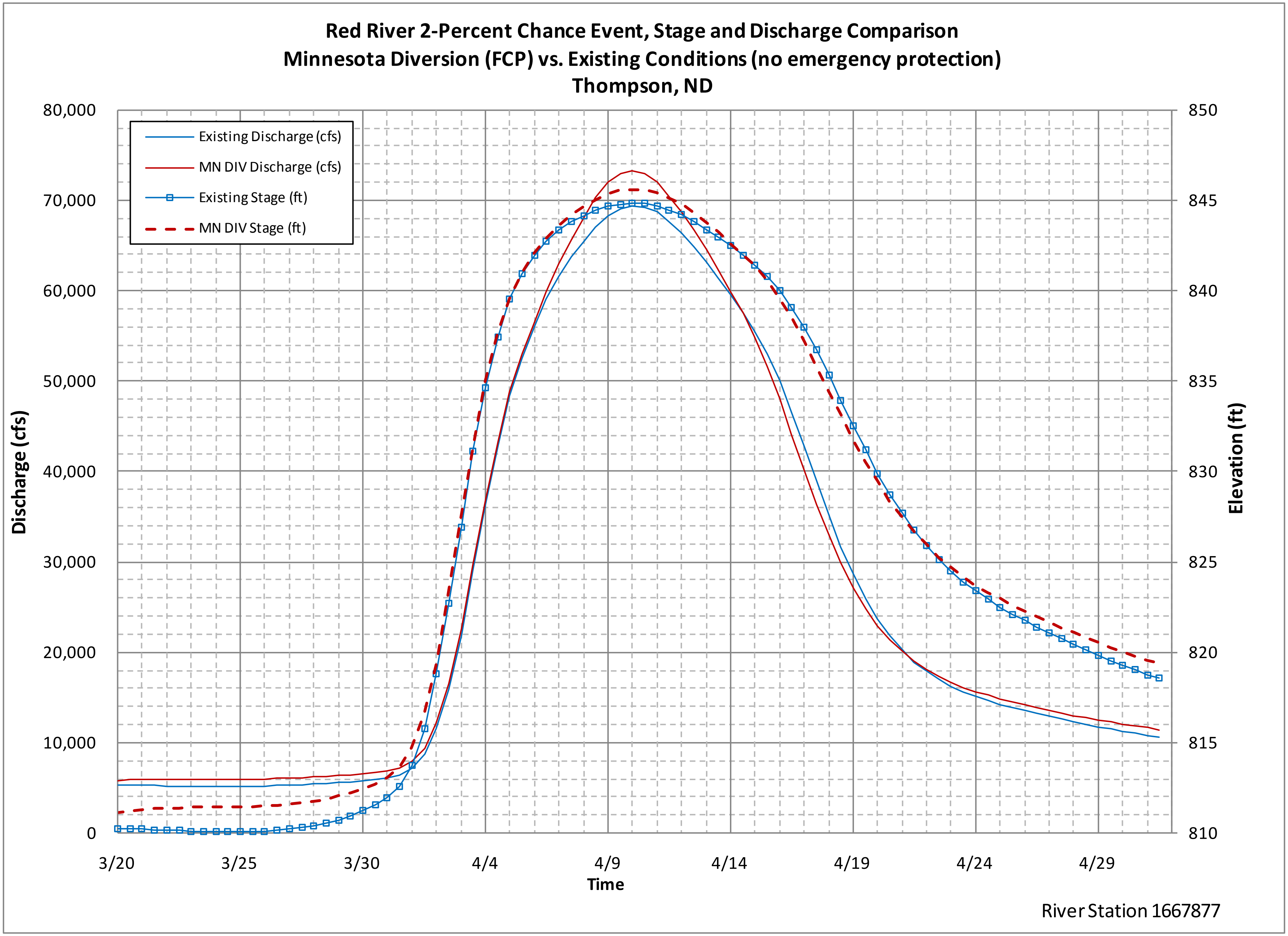


Figure C-E1- 28: 2-Percent Chance Hydrographs for FCP @ Thompson

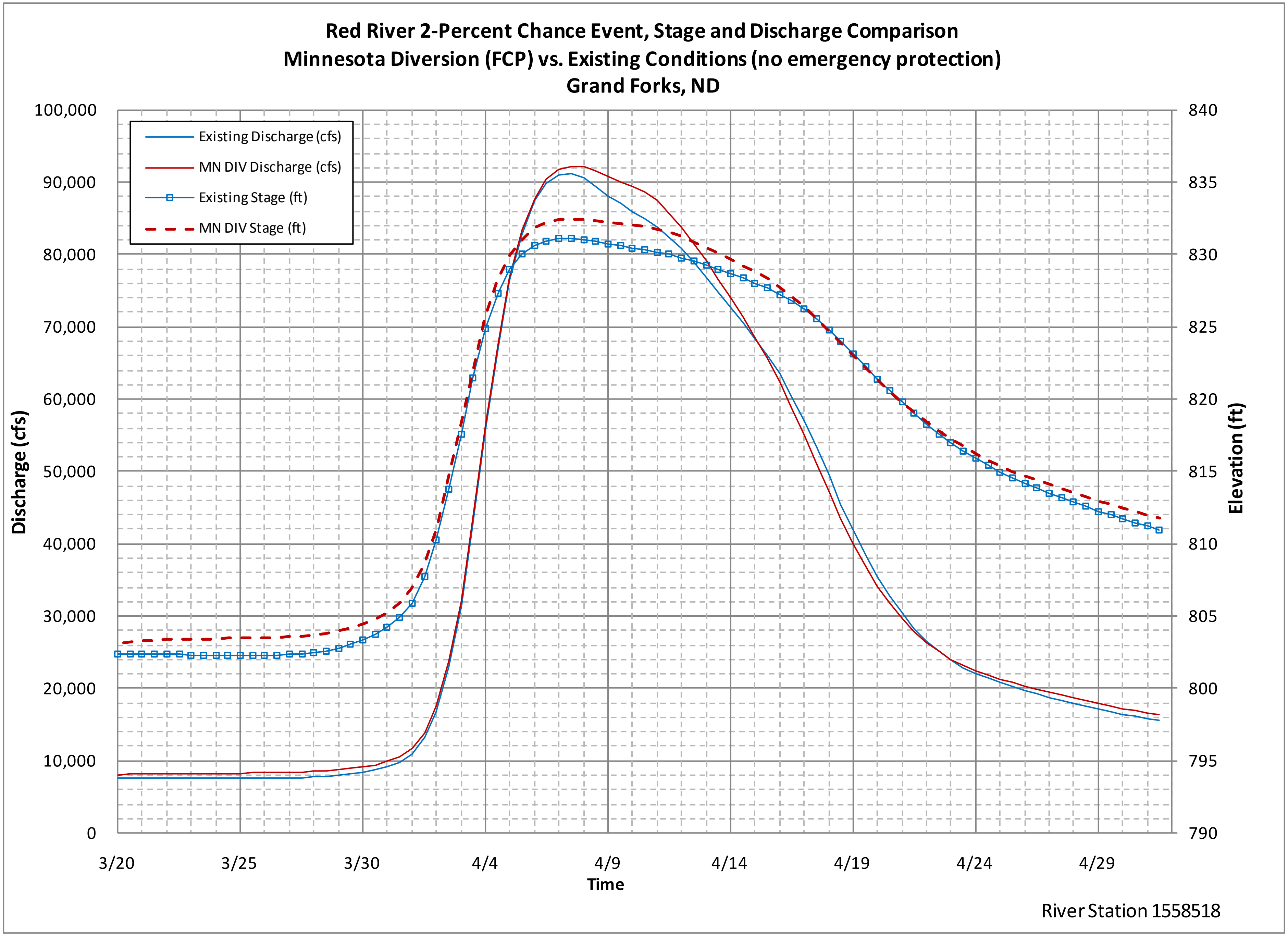


Figure C-E1- 29: 2-Percent Chance Hydrographs for FCP @ Grand Forks

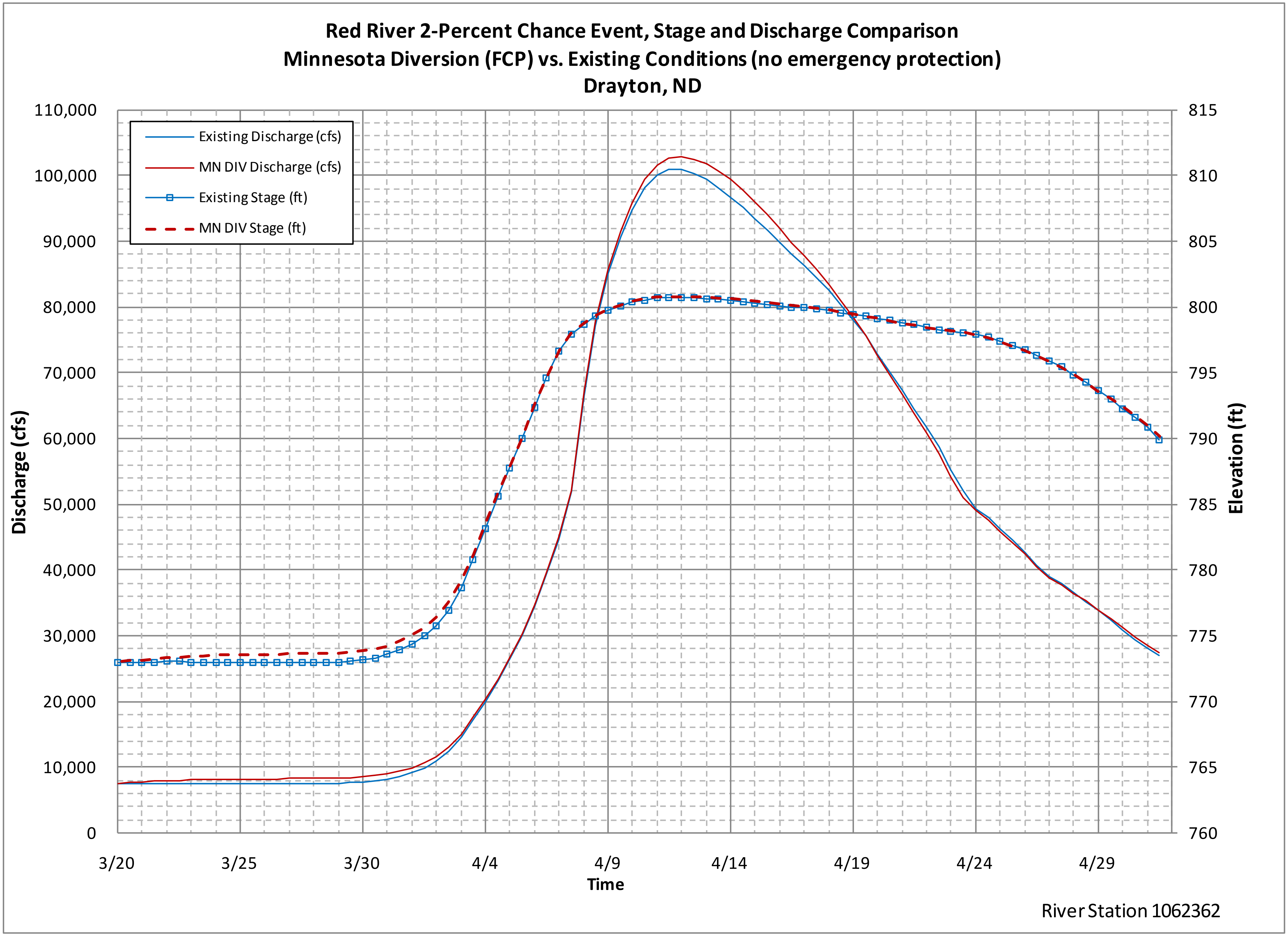


Figure C-E1- 30: 2-Percent Chance Hydrographs for FCP @ Drayton

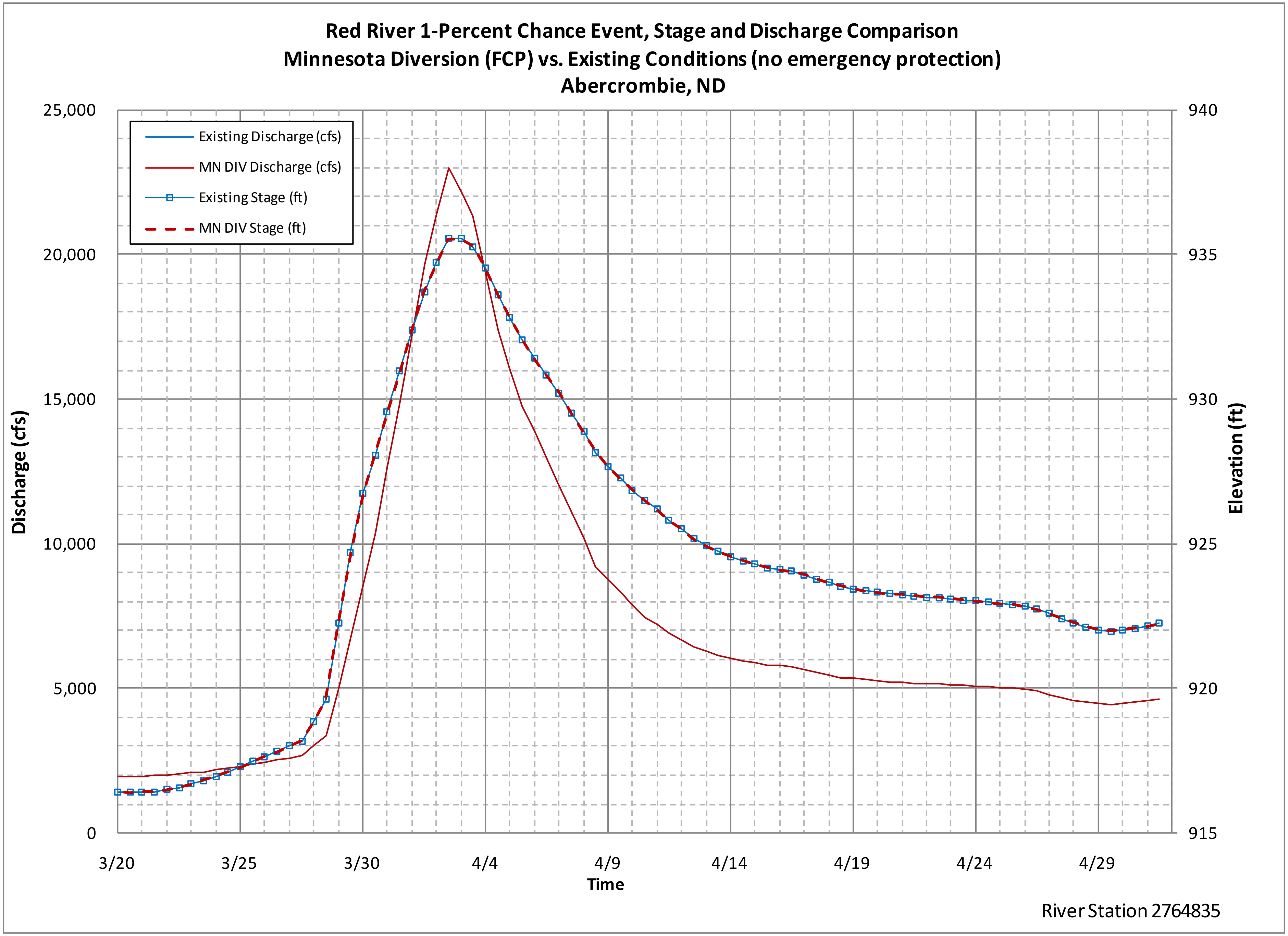


Figure C-E1- 31: 1-Percent Chance Hydrographs for FCP @ Abercrombie

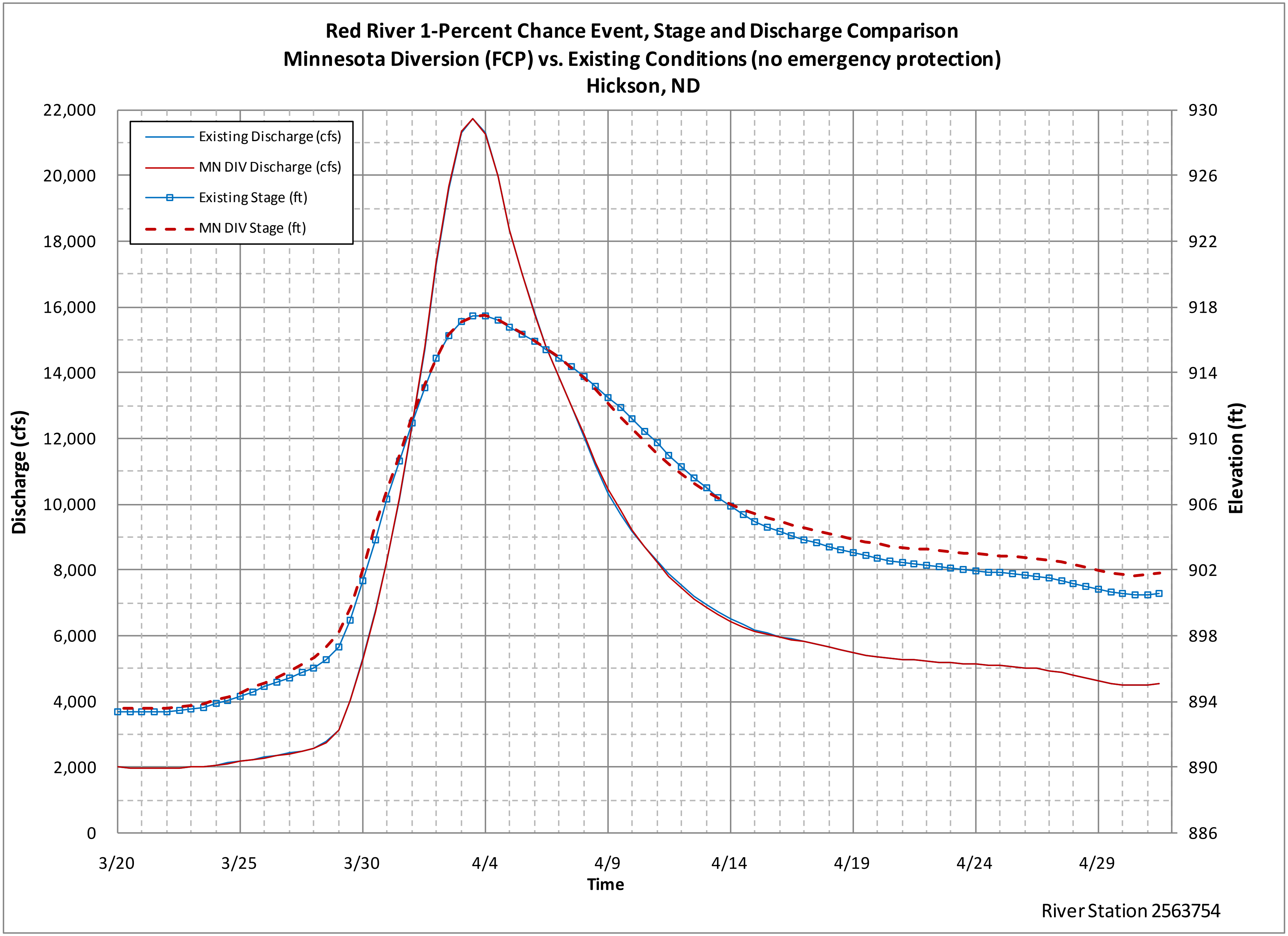


Figure C-E1- 32: 1-Percent Chance Hydrographs for FCP @ Hickson

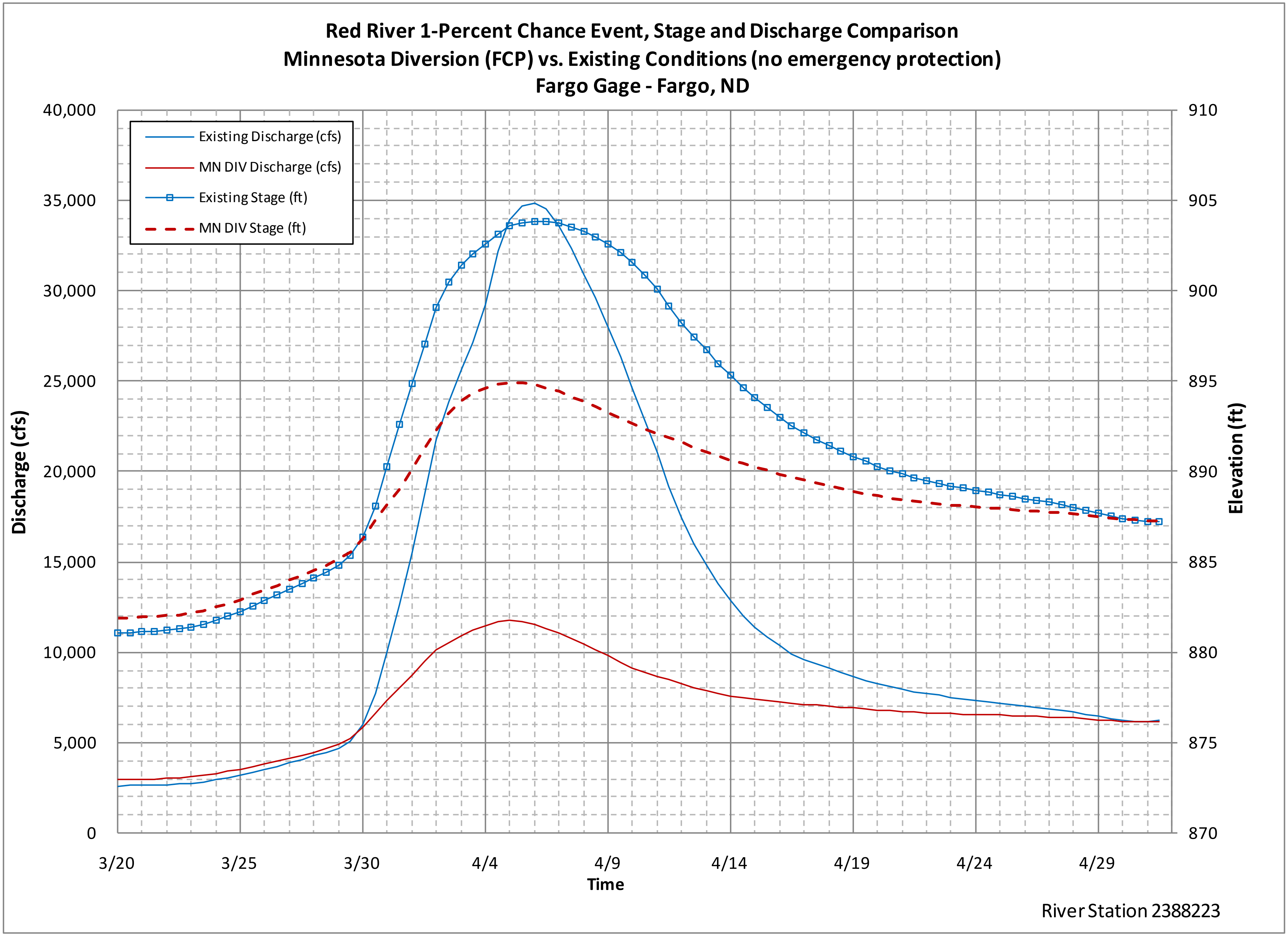


Figure C-E1- 33: 1-Percent Chance Hydrographs for FCP @ Fargo

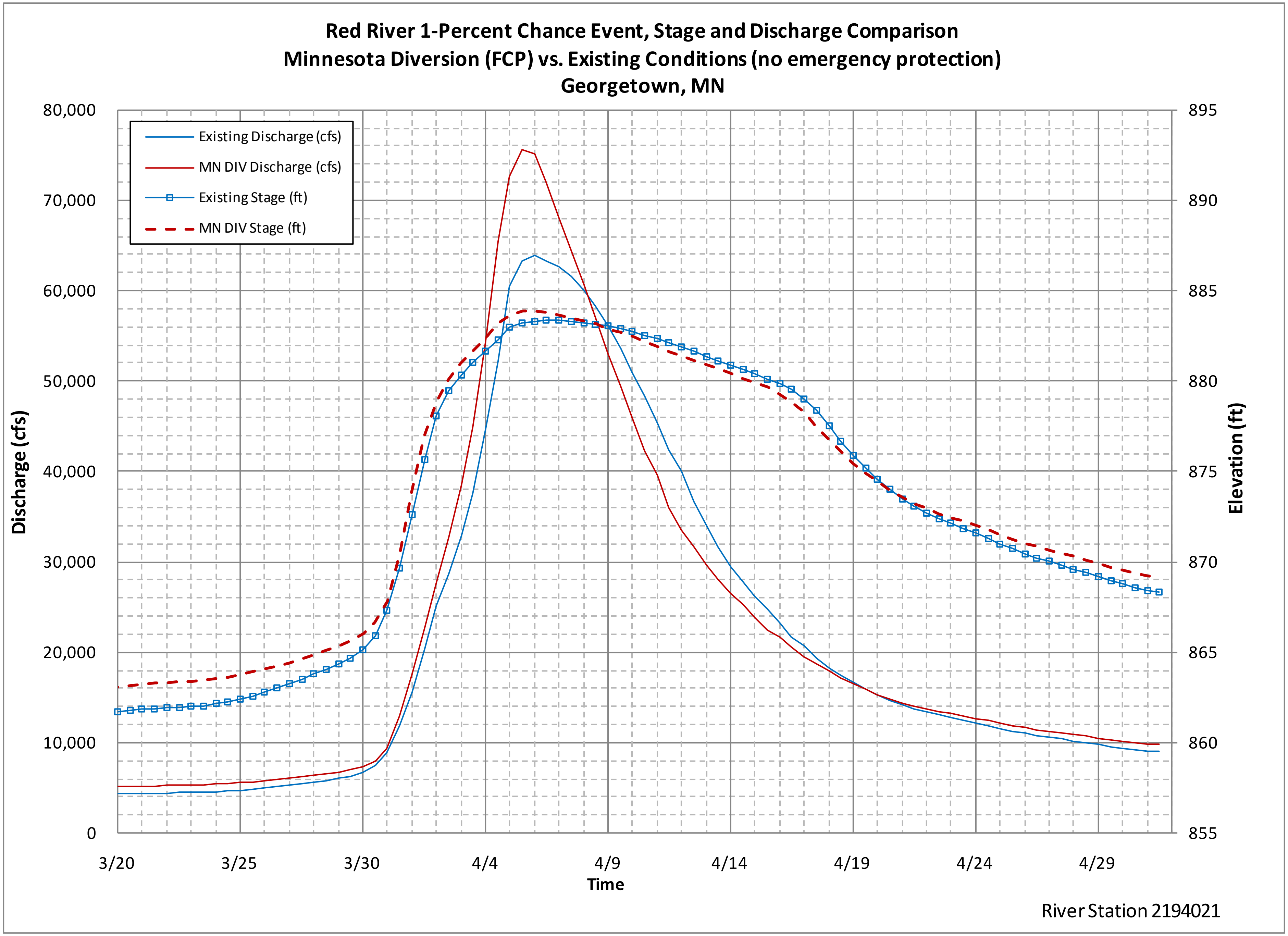


Figure C-E1- 34: 1-Percent Chance Hydrographs for FCP @ Georgetown

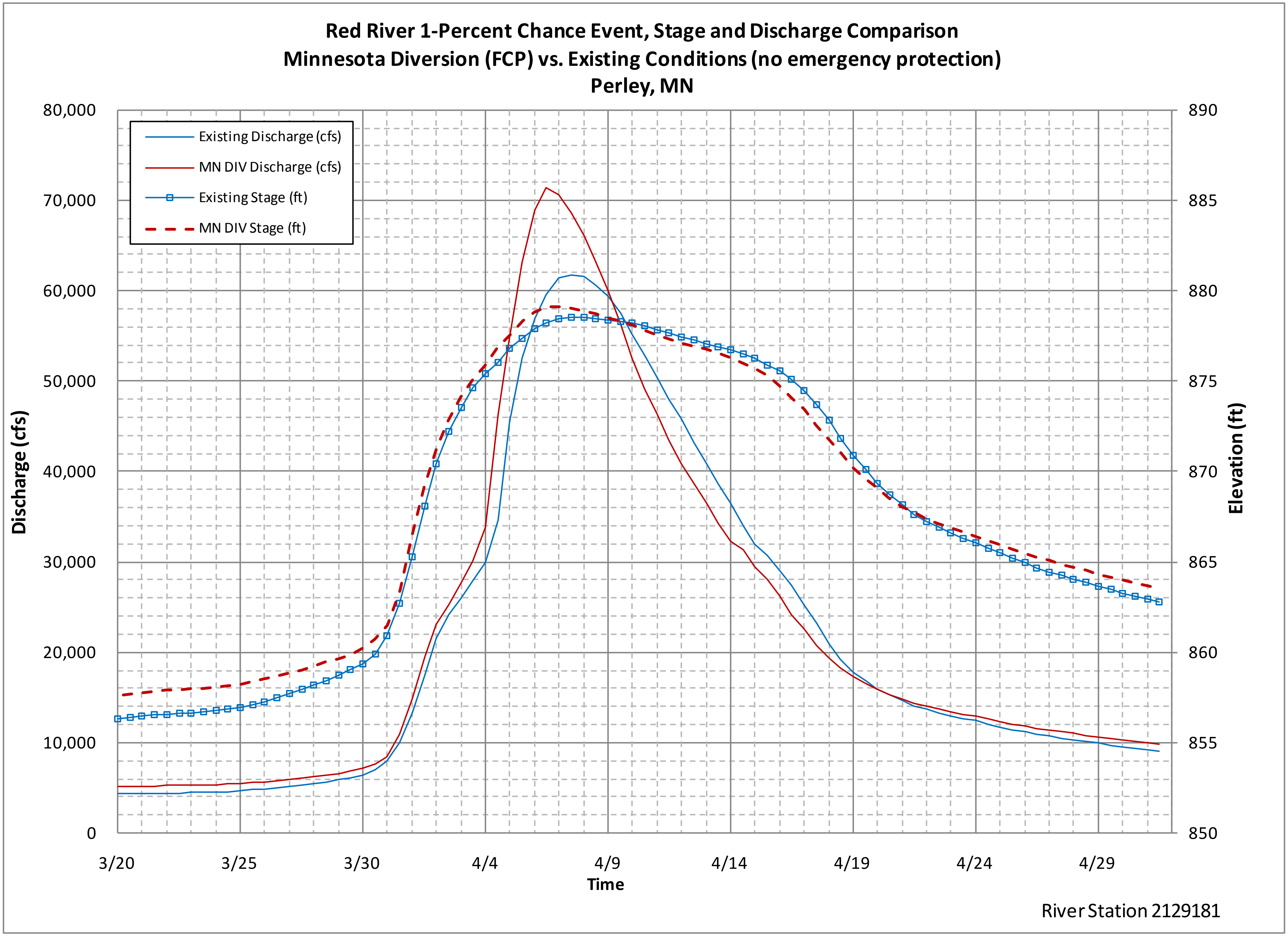


Figure C-E1- 35: 1-Percent Chance Hydrographs for FCP @ Perley

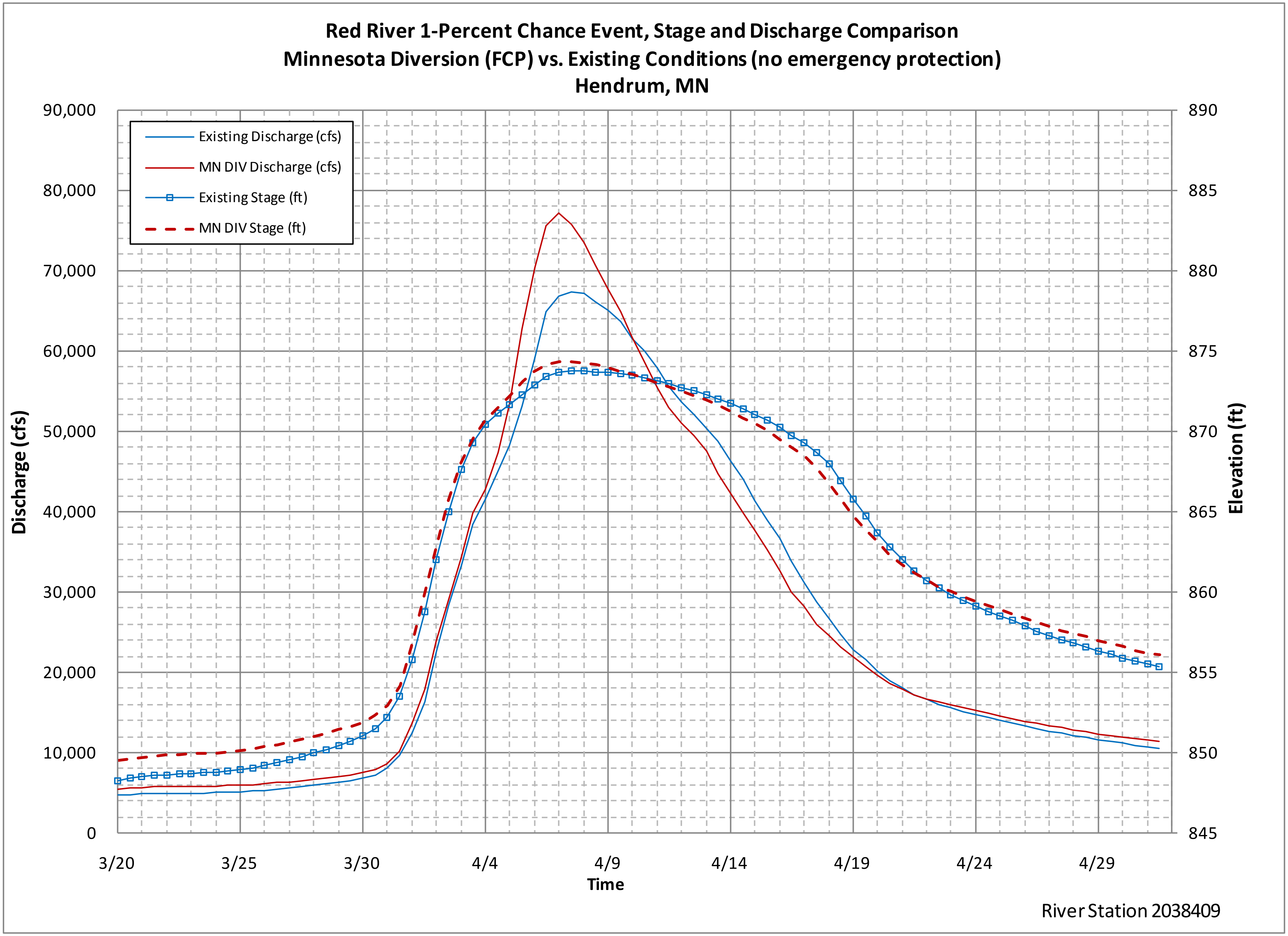


Figure C-E1- 36: 1-Percent Chance Hydrographs for FCP @ Hendrum

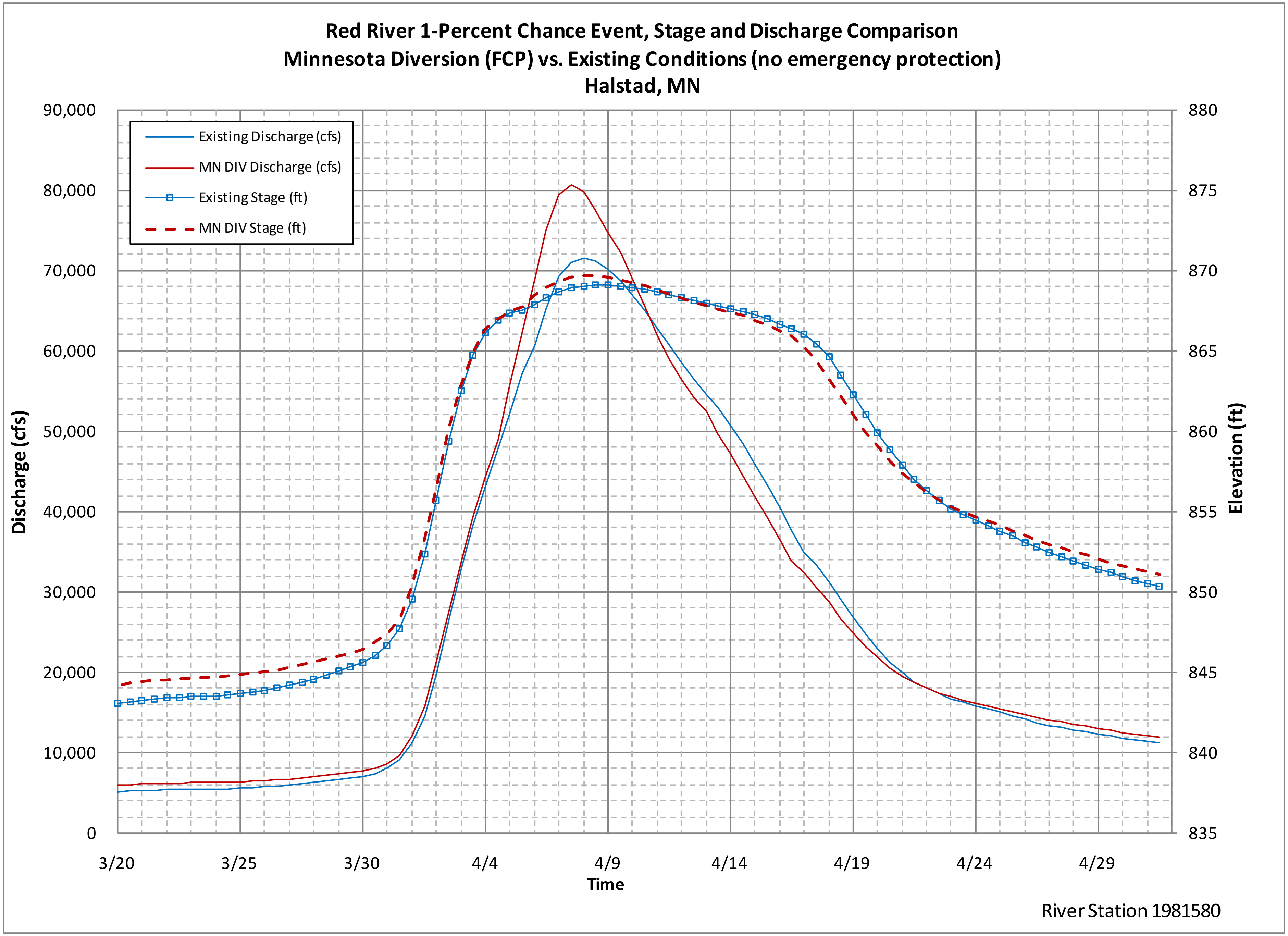


Figure C-E1- 37: 1-Percent Chance Hydrographs for FCP @ Halstad

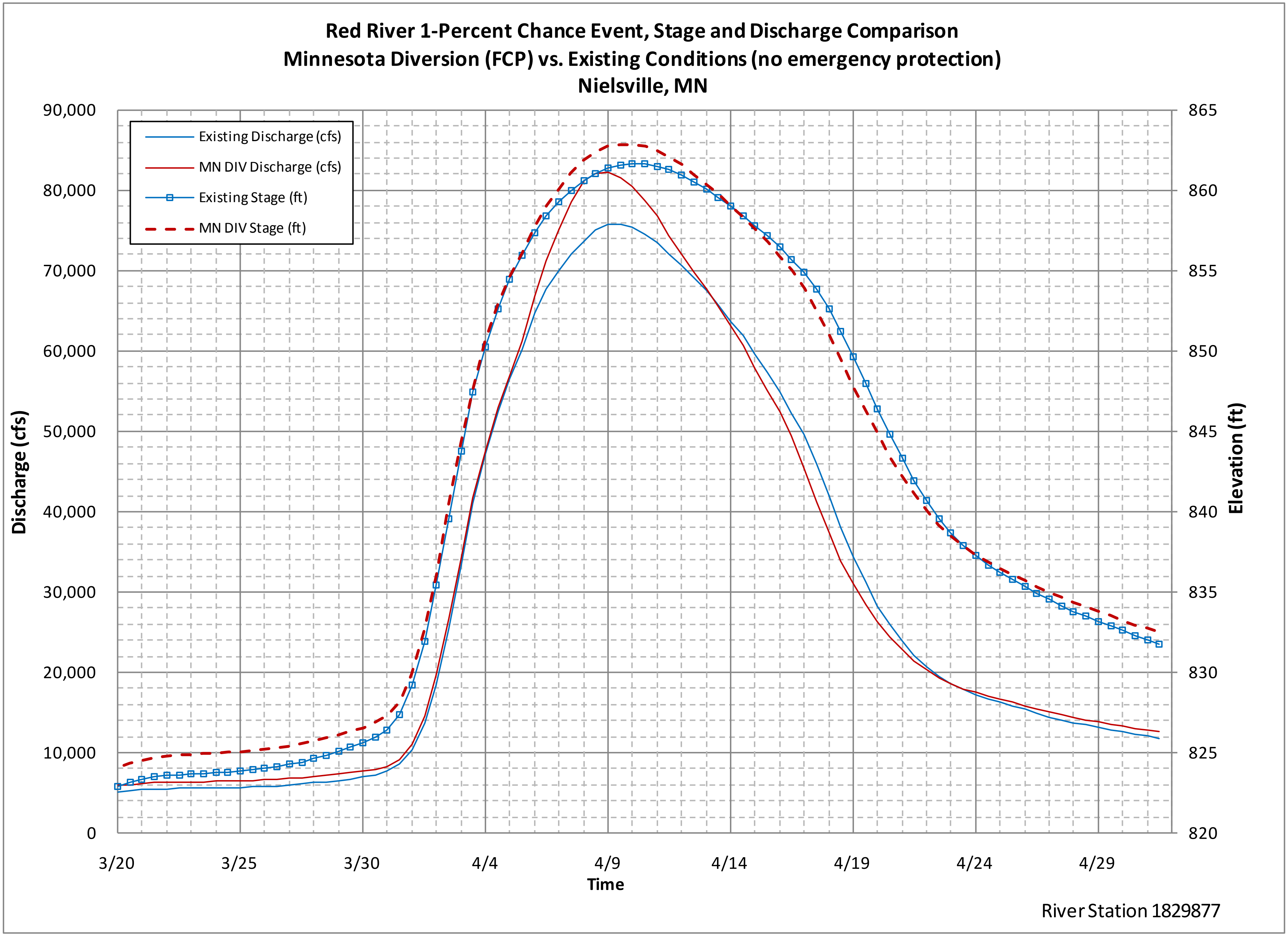


Figure C-E1- 38: 1-Percent Chance Hydrographs for FCP @ Nielsville

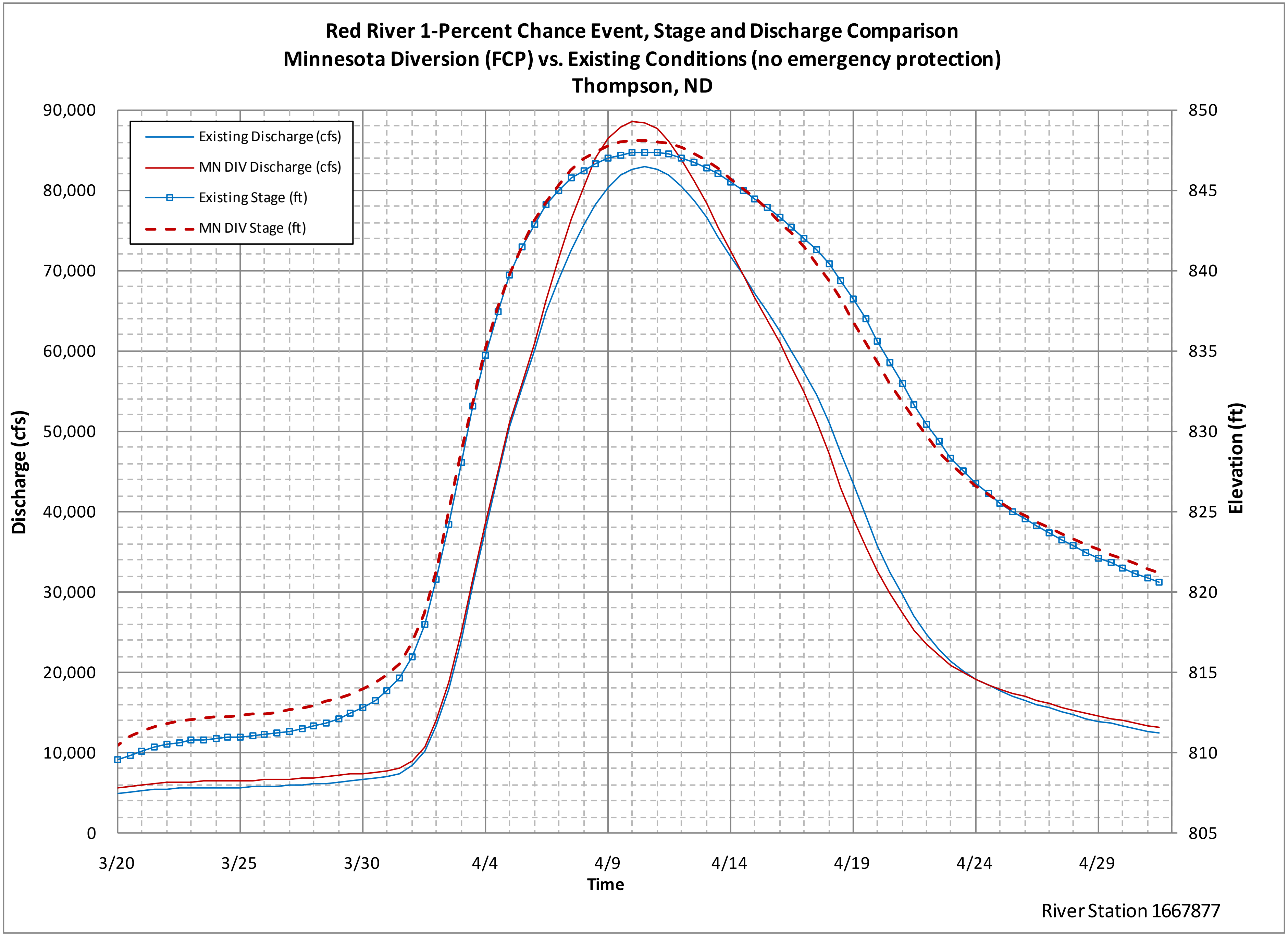


Figure C-E1- 39: 1-Percent Chance Hydrographs for FCP @ Thompson

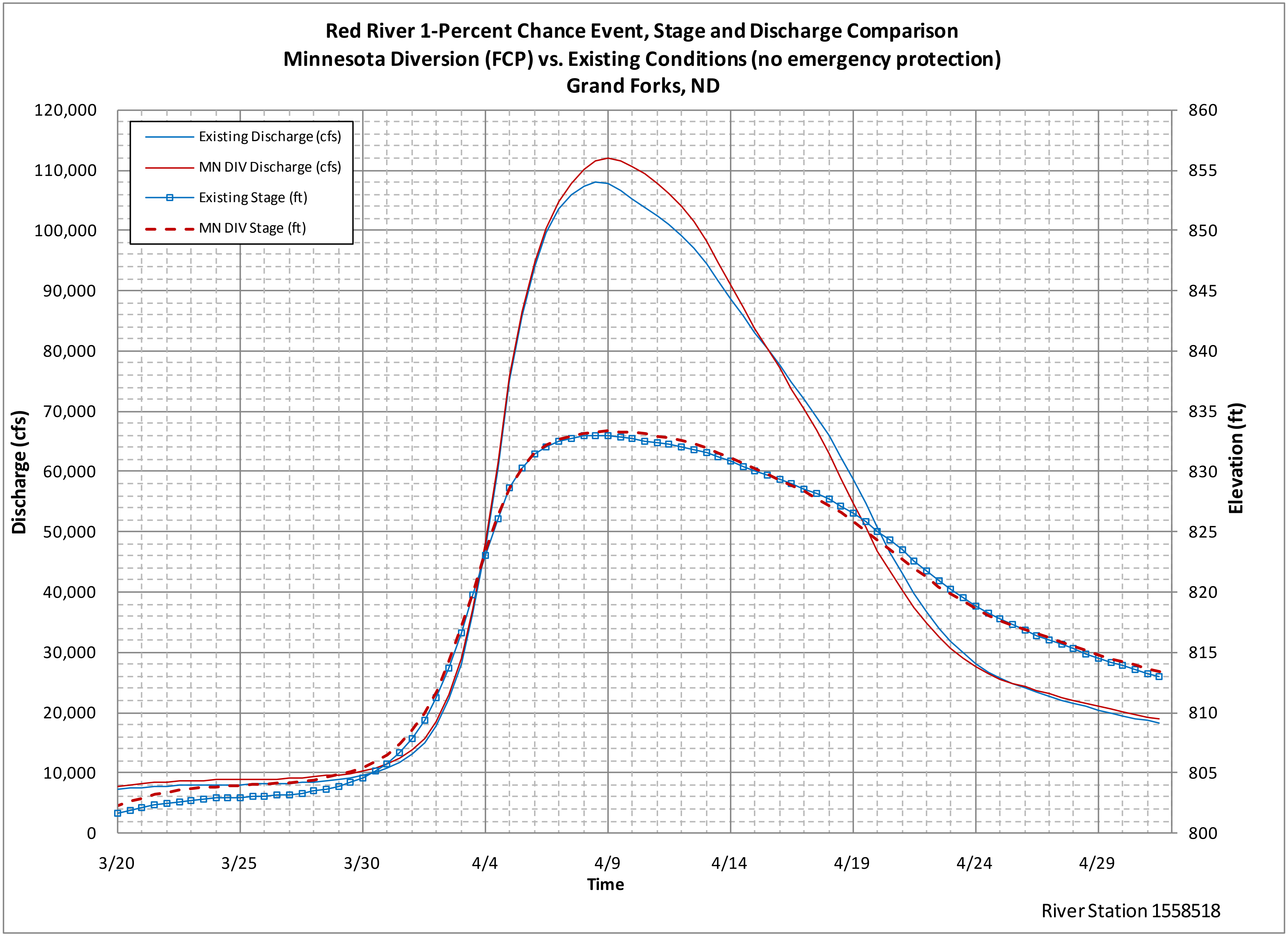


Figure C-E1- 40: 1-Percent Chance Hydrographs for FCP @ Grand Forks

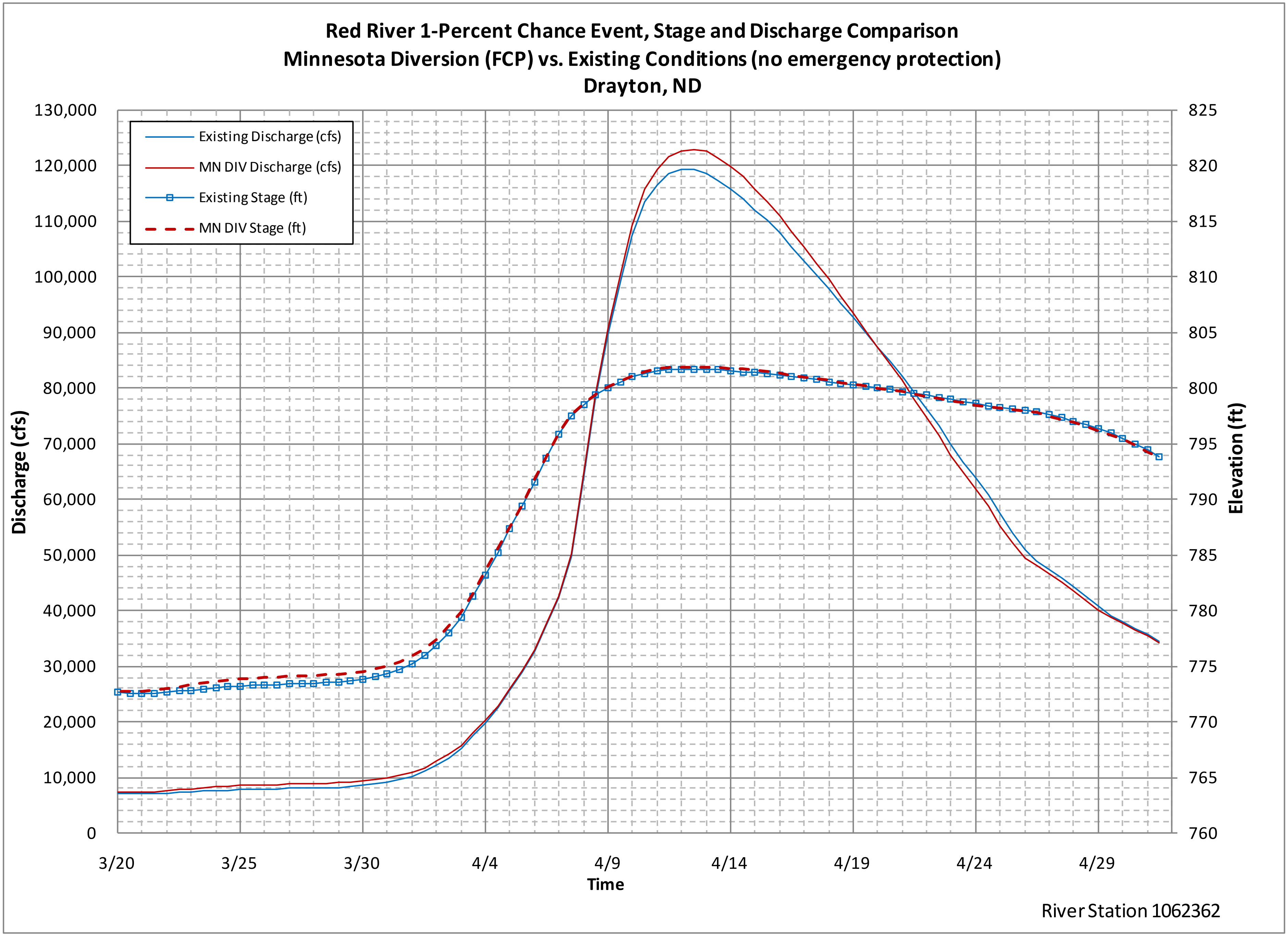


Figure C-E1- 41: 1-Percent Chance Hydrographs for FCP @ Drayton

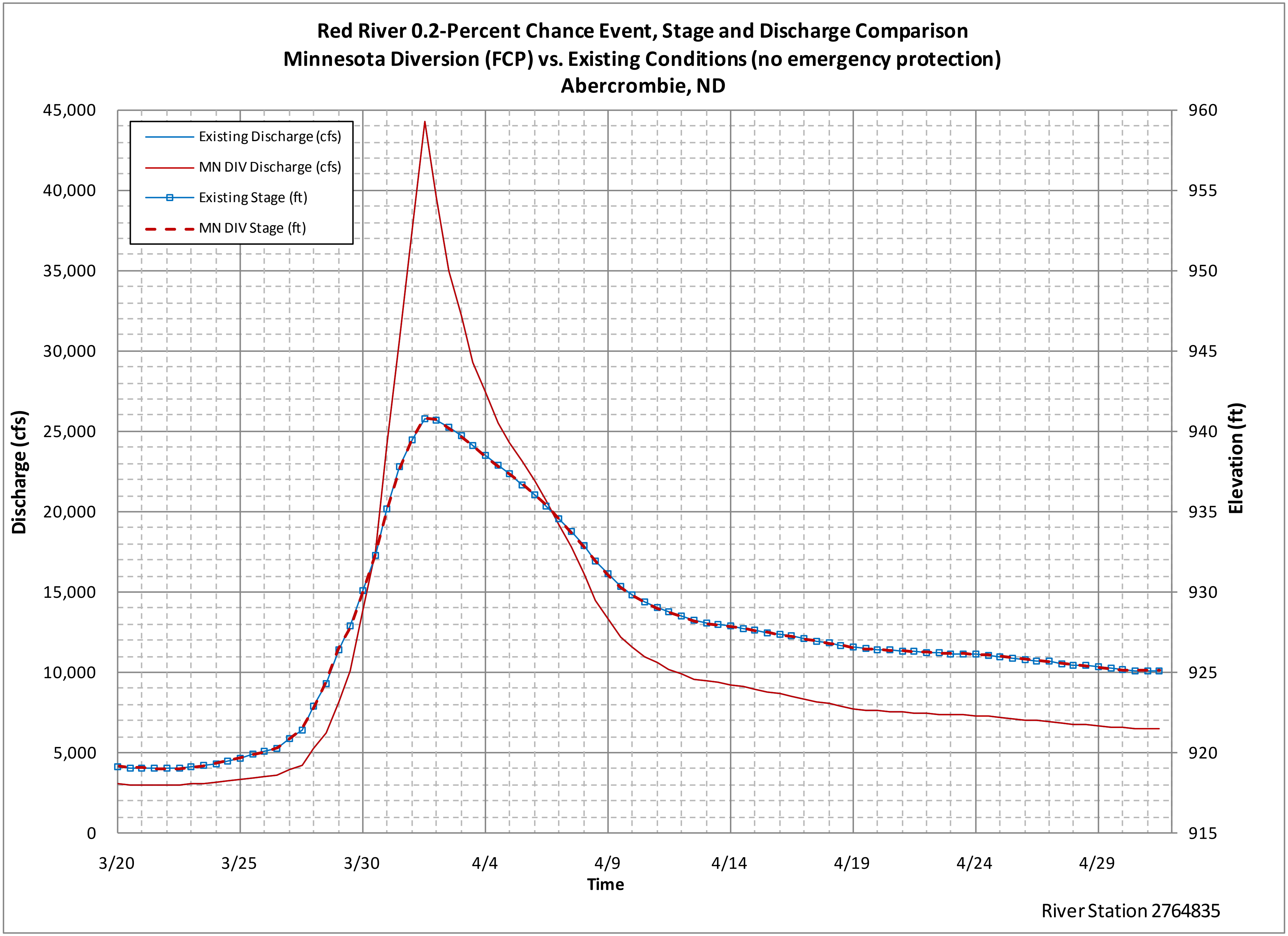


Figure C-E1- 42: 0.2-Percent Chance Hydrographs for FCP @ Abercrombie

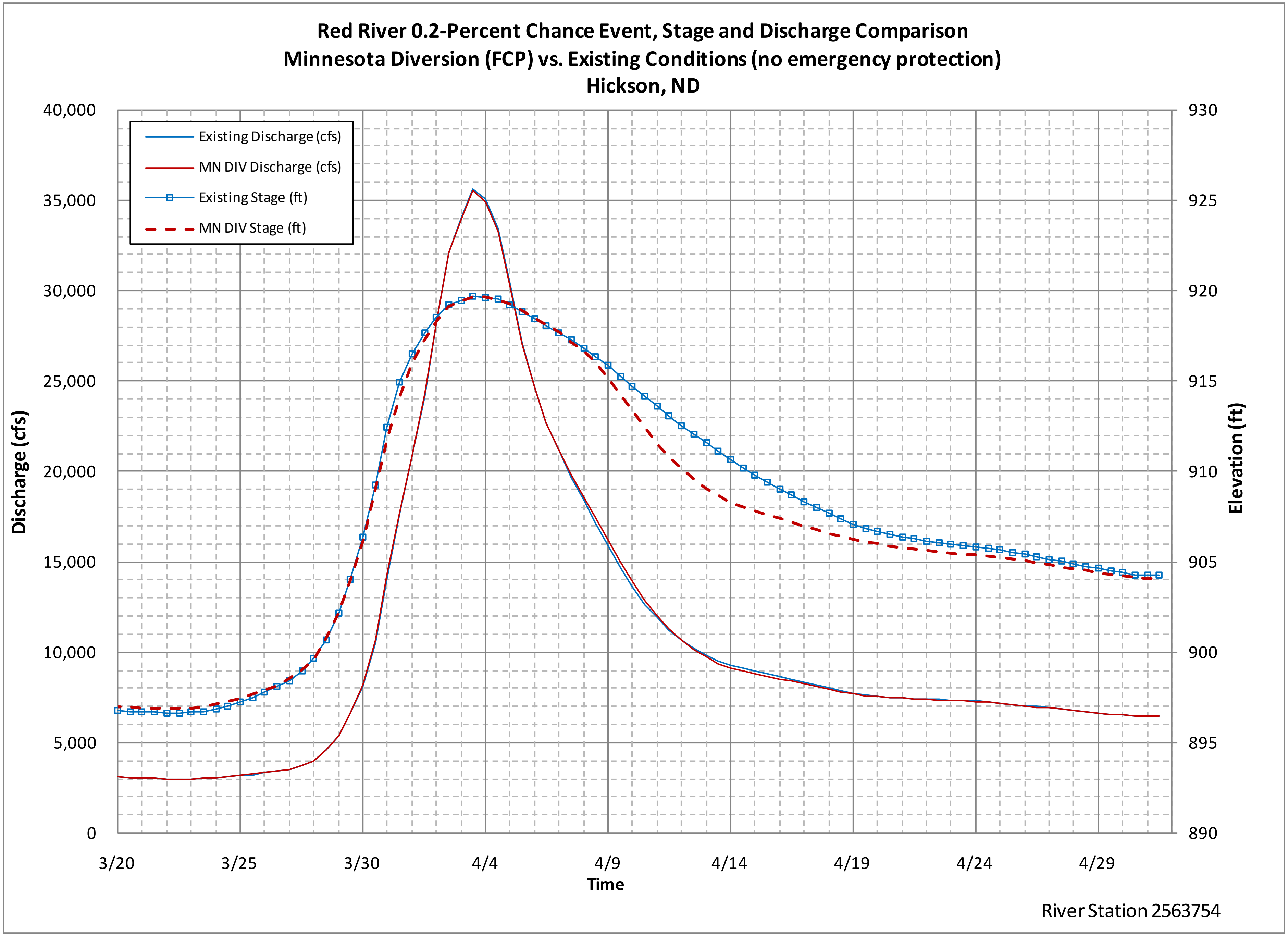


Figure C-E1- 43: 0.2-Percent Chance Hydrographs for FCP @ Hickson

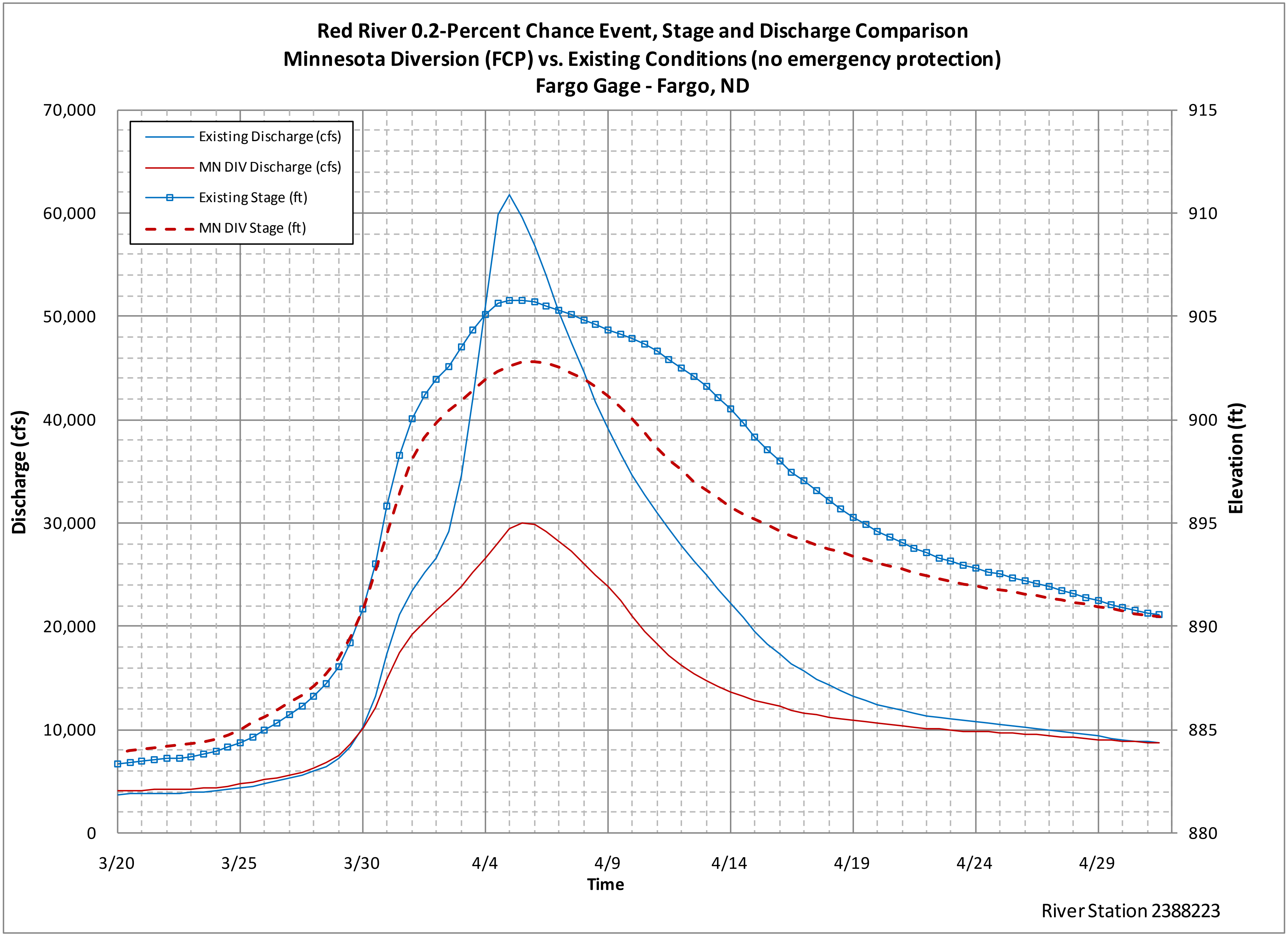


Figure C-E1- 44: 0.2-Percent Chance Hydrographs for FCP @ Fargo

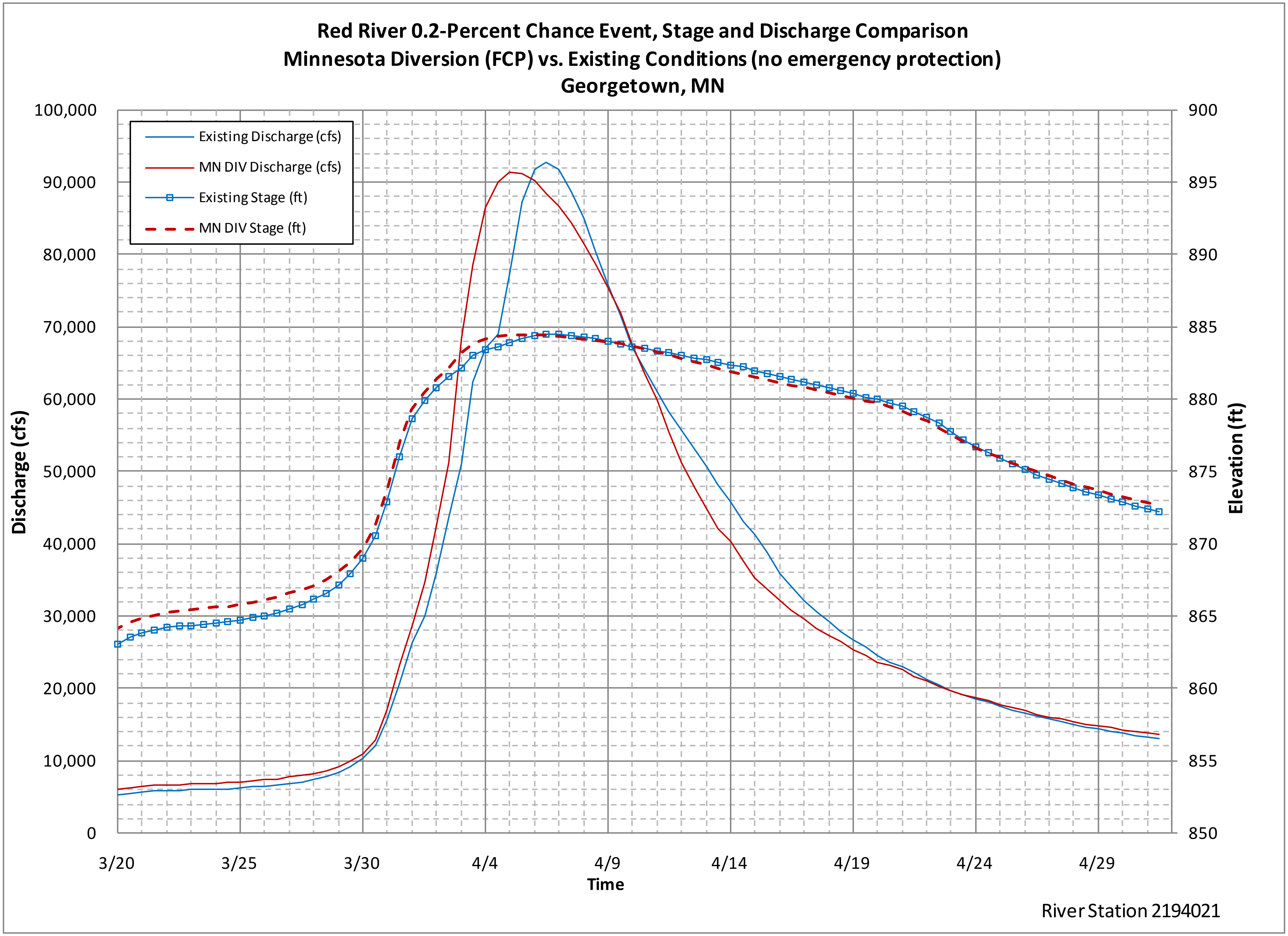


Figure C-E1- 45: 0.2-Percent Chance Hydrographs for FCP @ Georgetown

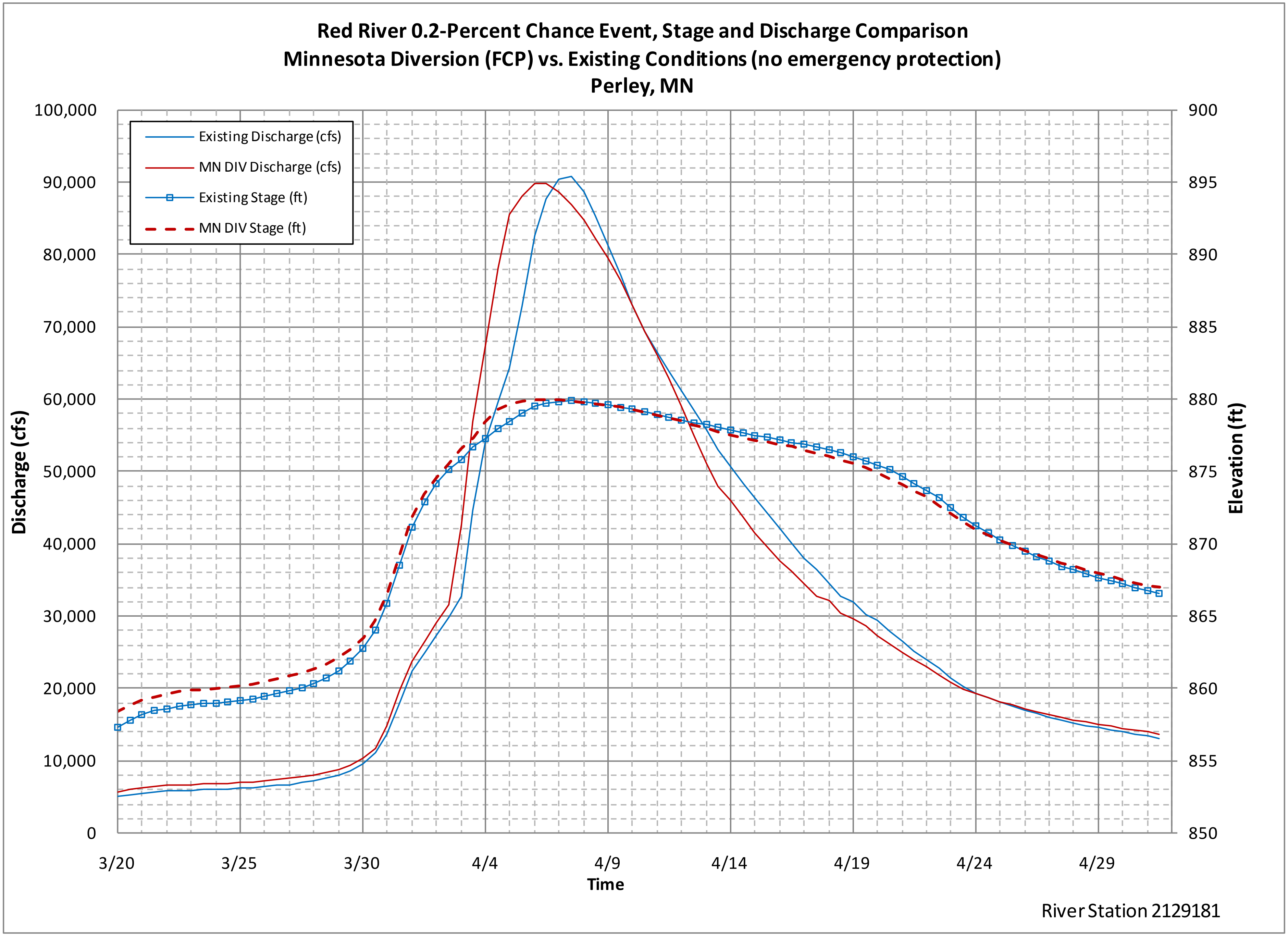


Figure C-E1- 46: 0.2-Percent Chance Hydrographs for FCP @ Perley

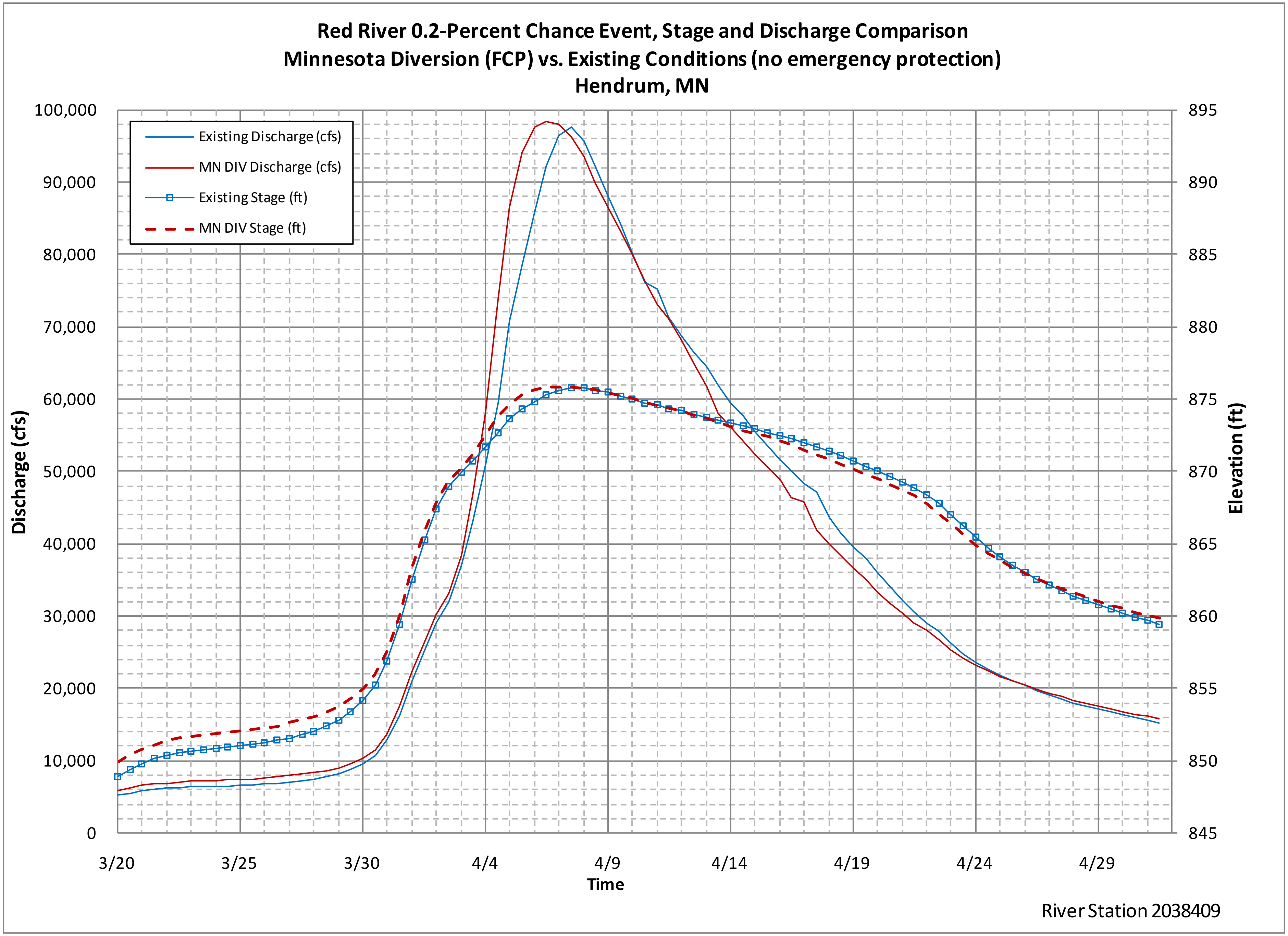


Figure C-E1- 47: 0.2-Percent Chance Hydrographs for FCP @ Hendrum

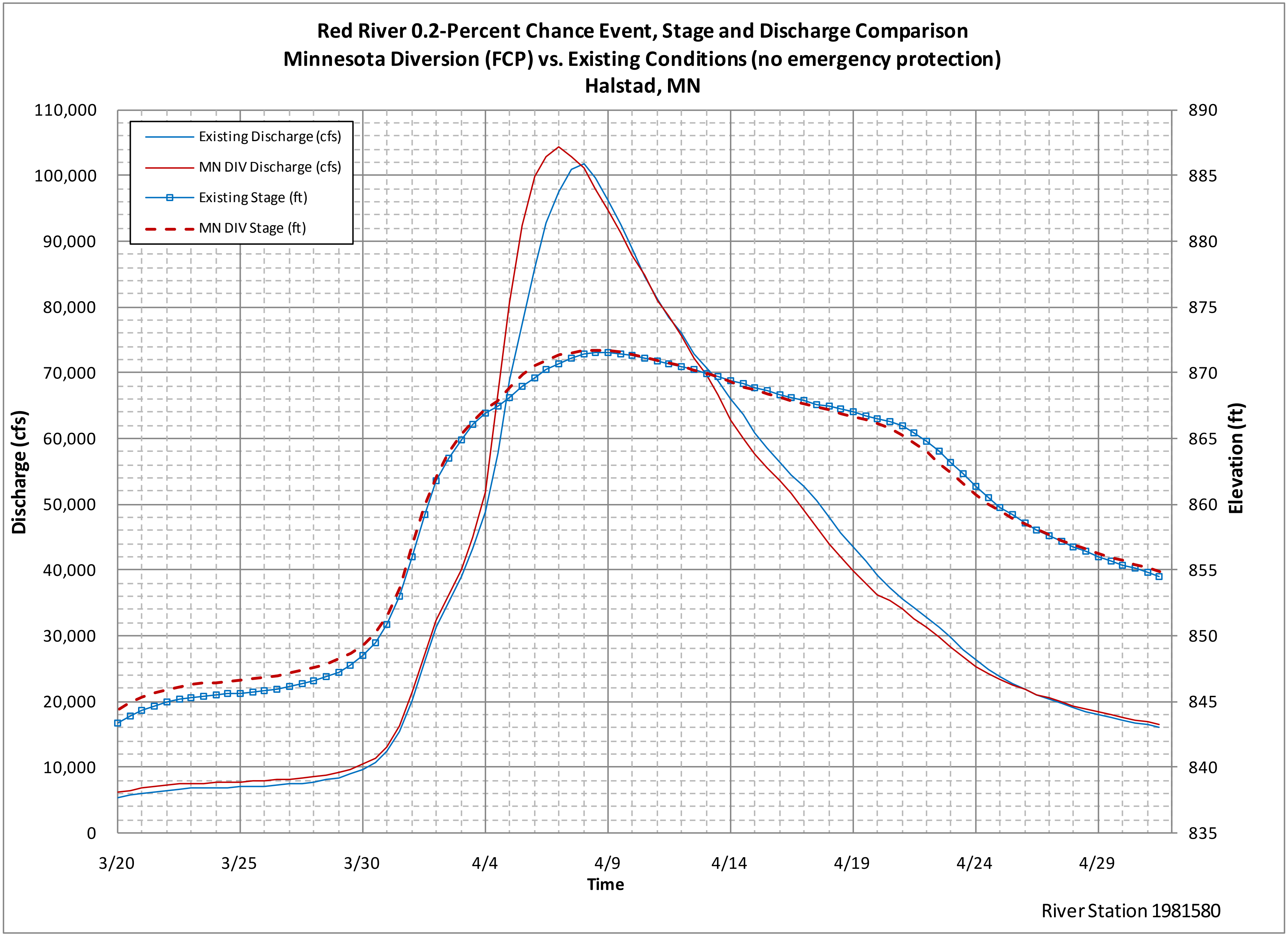


Figure C-E1- 48: 0.2-Percent Chance Hydrographs for FCP @ Halstad

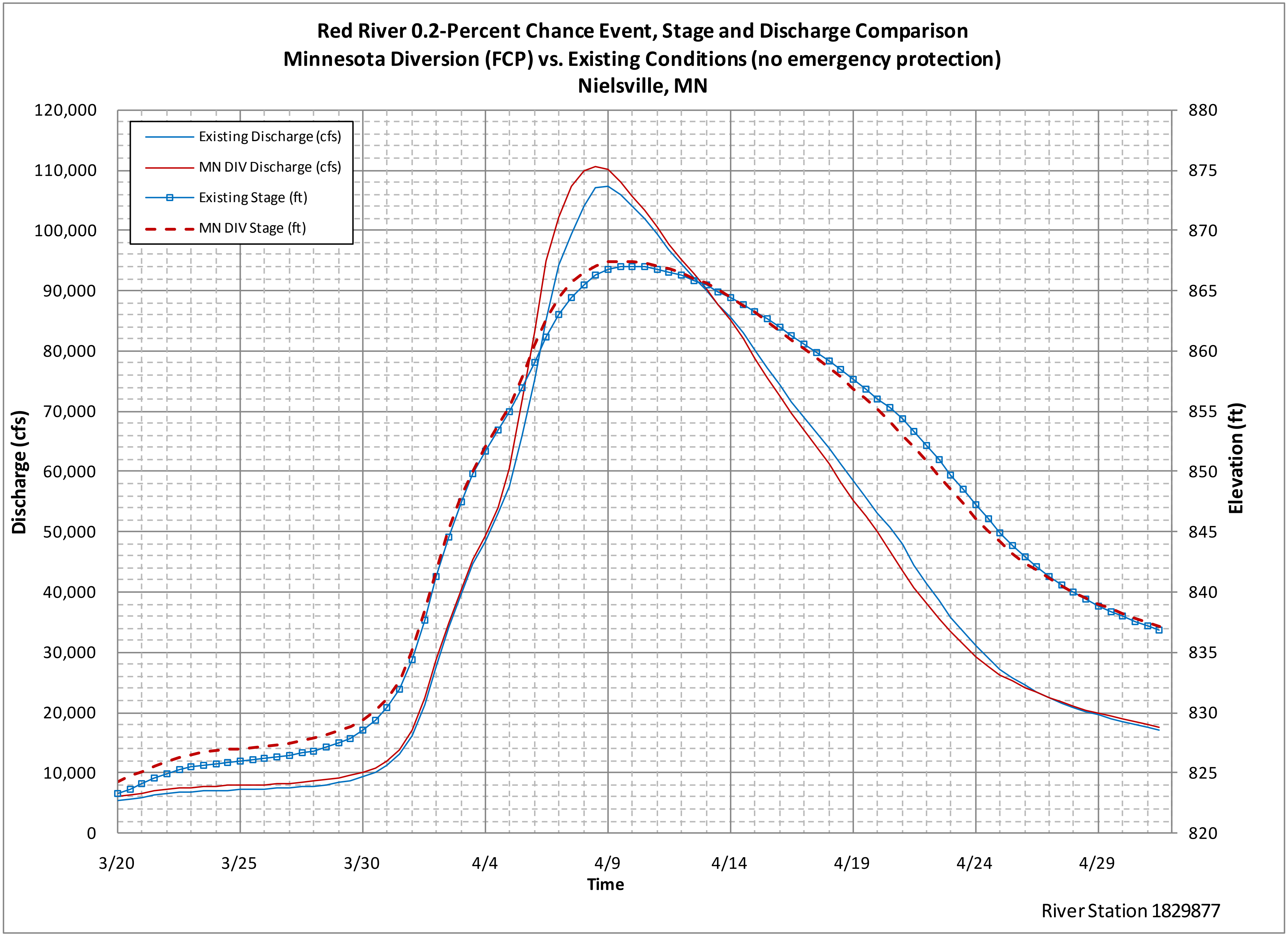


Figure C-E1- 49: 0.2-Percent Chance Hydrographs for FCP @ Nielsville

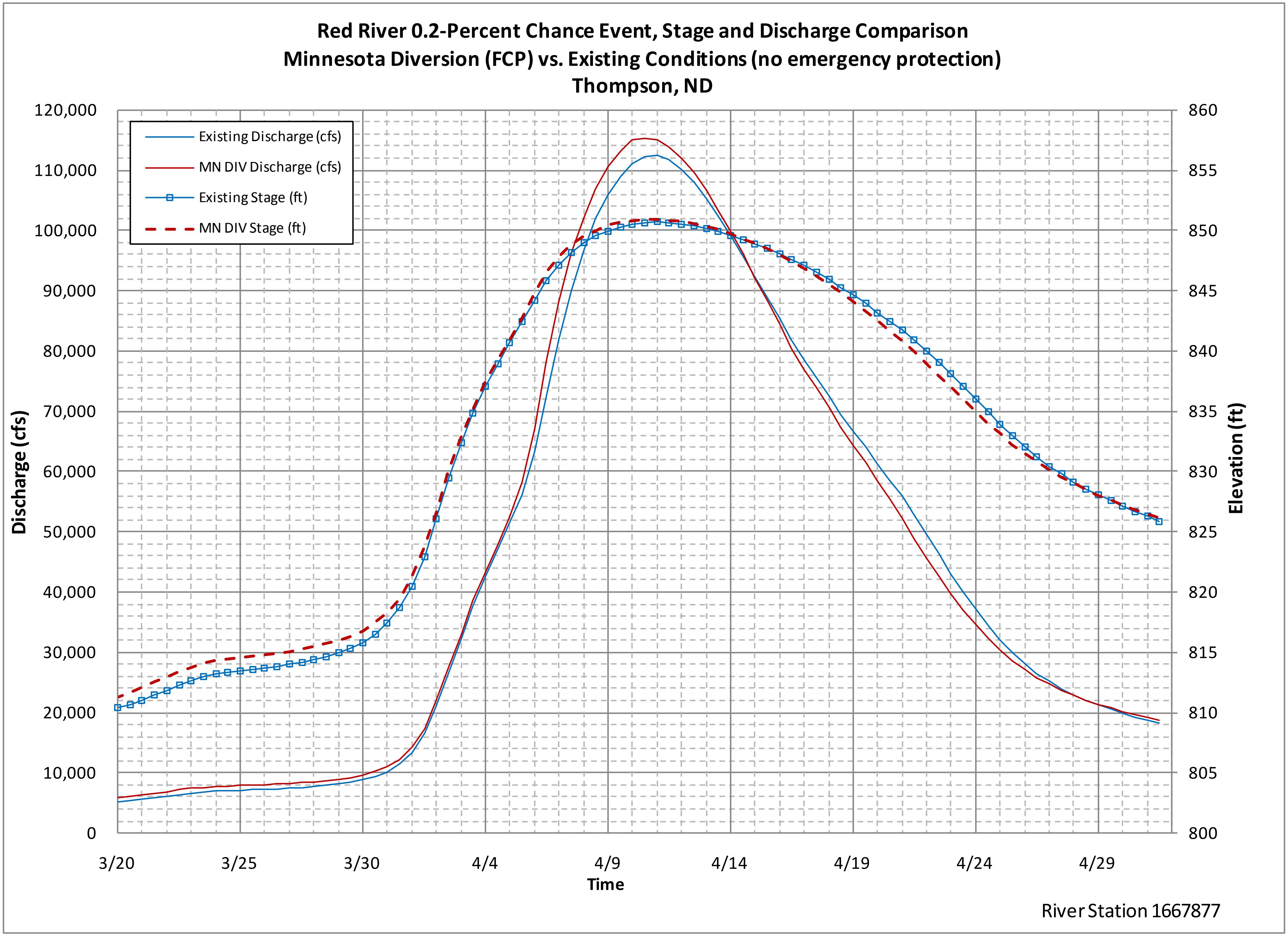


Figure C-E1- 50: 0.2-Percent Chance Hydrographs for FCP @ Thompson

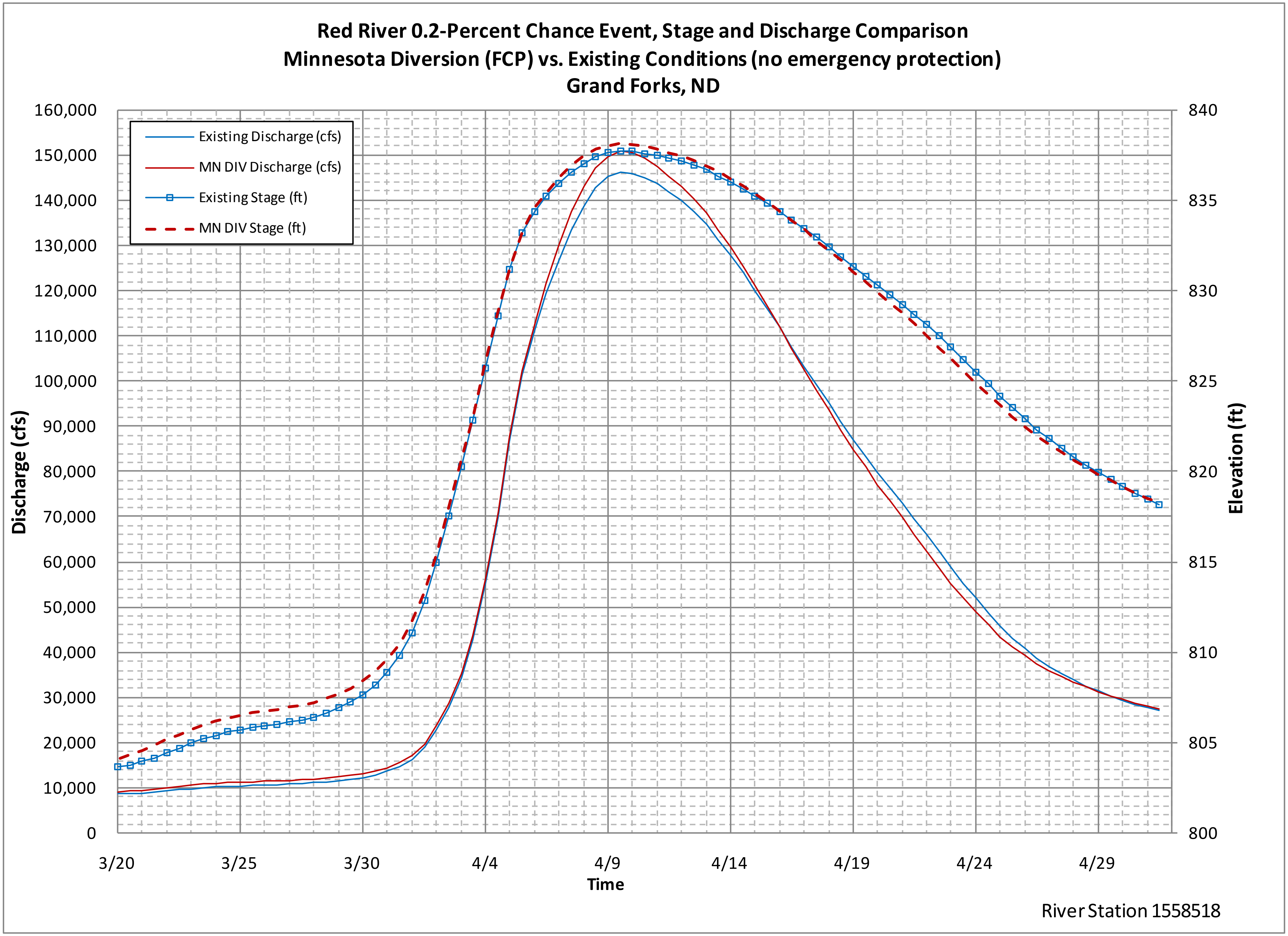


Figure C-E1- 51: 0.2-Percent Chance Hydrographs for FCP @ Grand Forks

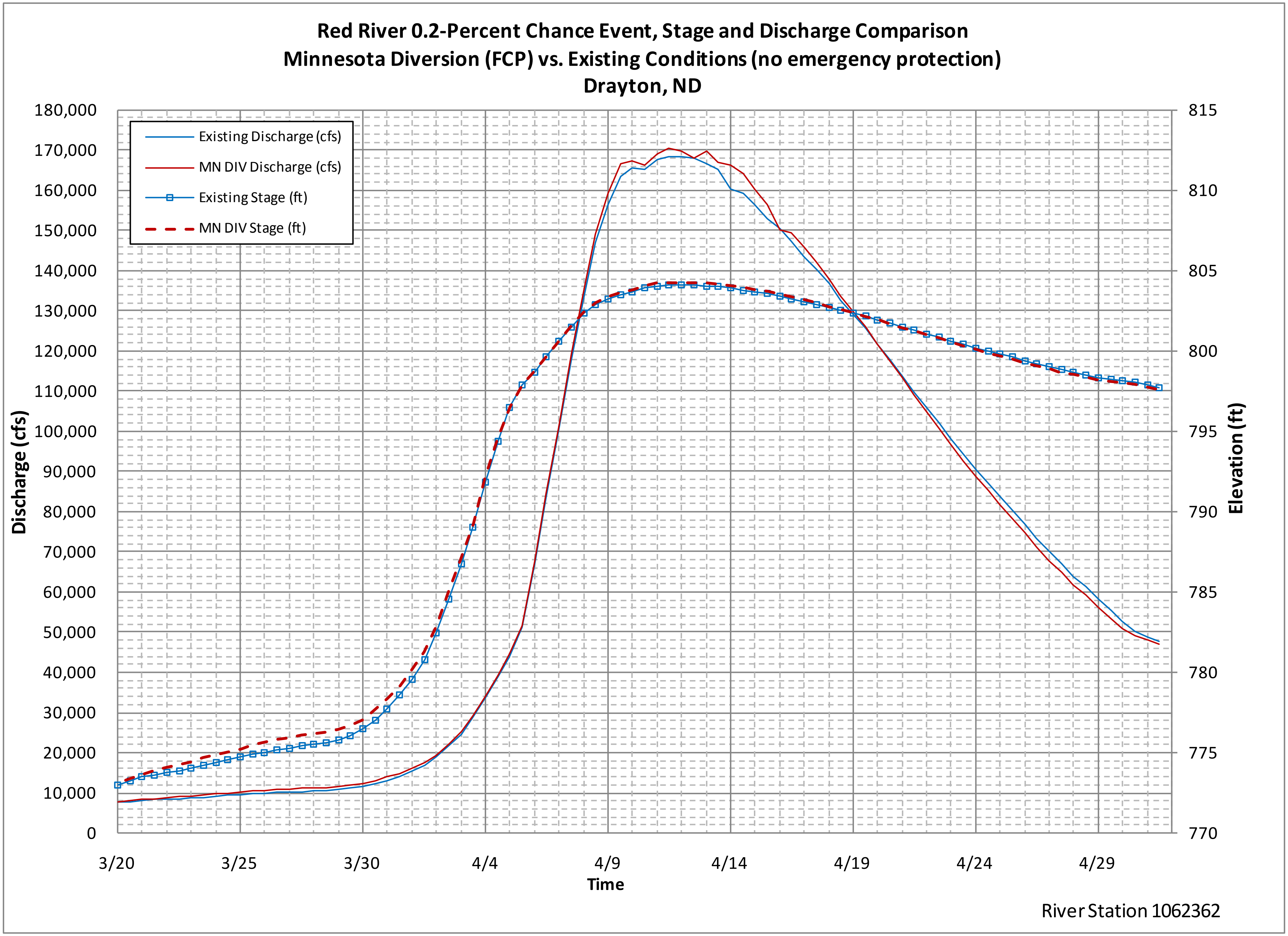


Figure C-E1- 52: 0.2-Percent Chance Hydrographs for FCP @ Drayton

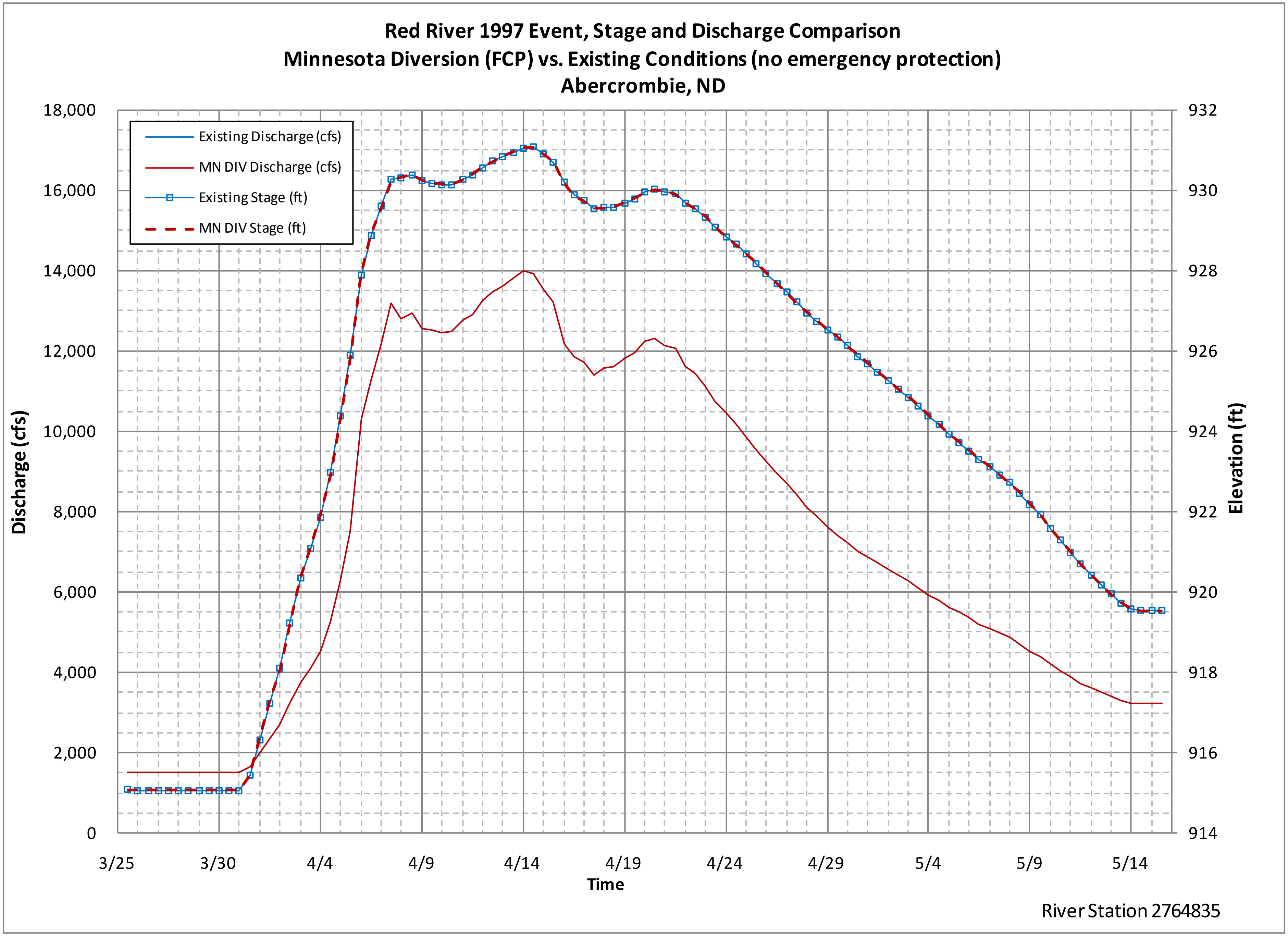


Figure C-E1- 53: 1997 Historical Flood Hydrographs for FCP @ Abercrombie

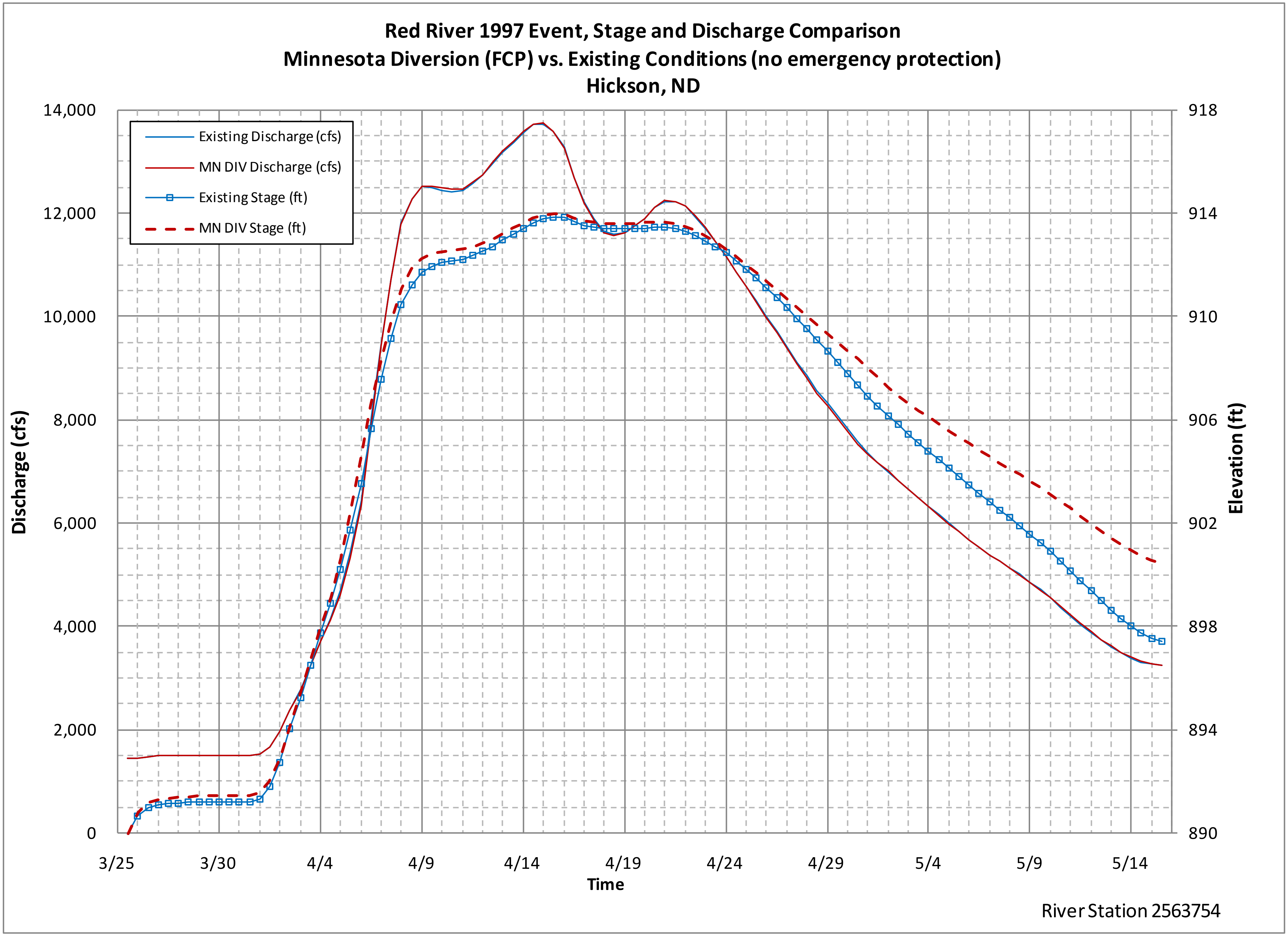


Figure C-E1- 54: 1997 Historical Flood Hydrographs for FCP @ Hickson

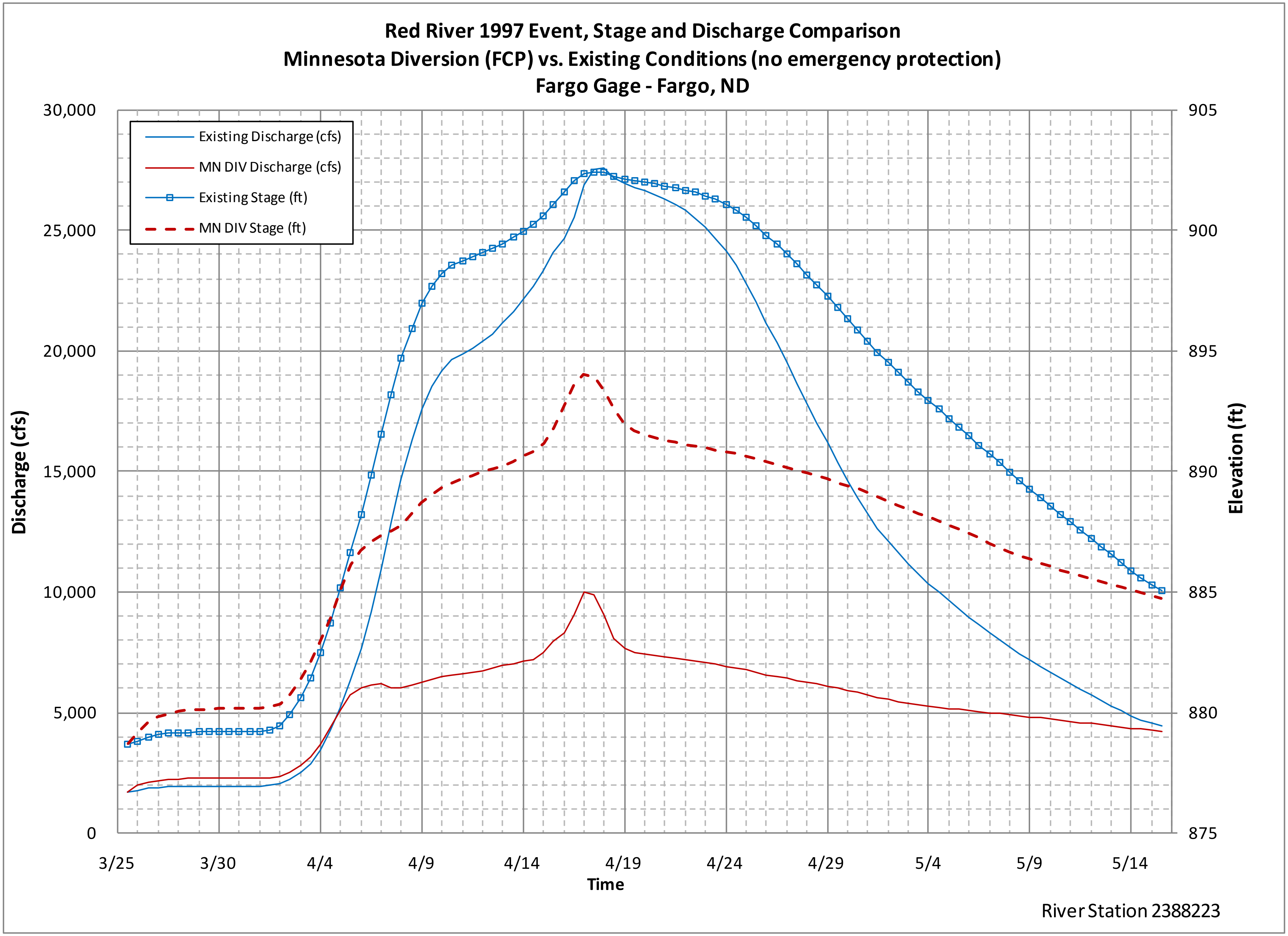


Figure C-E1- 55: 1997 Historical Flood Hydrographs for FCP @ Fargo

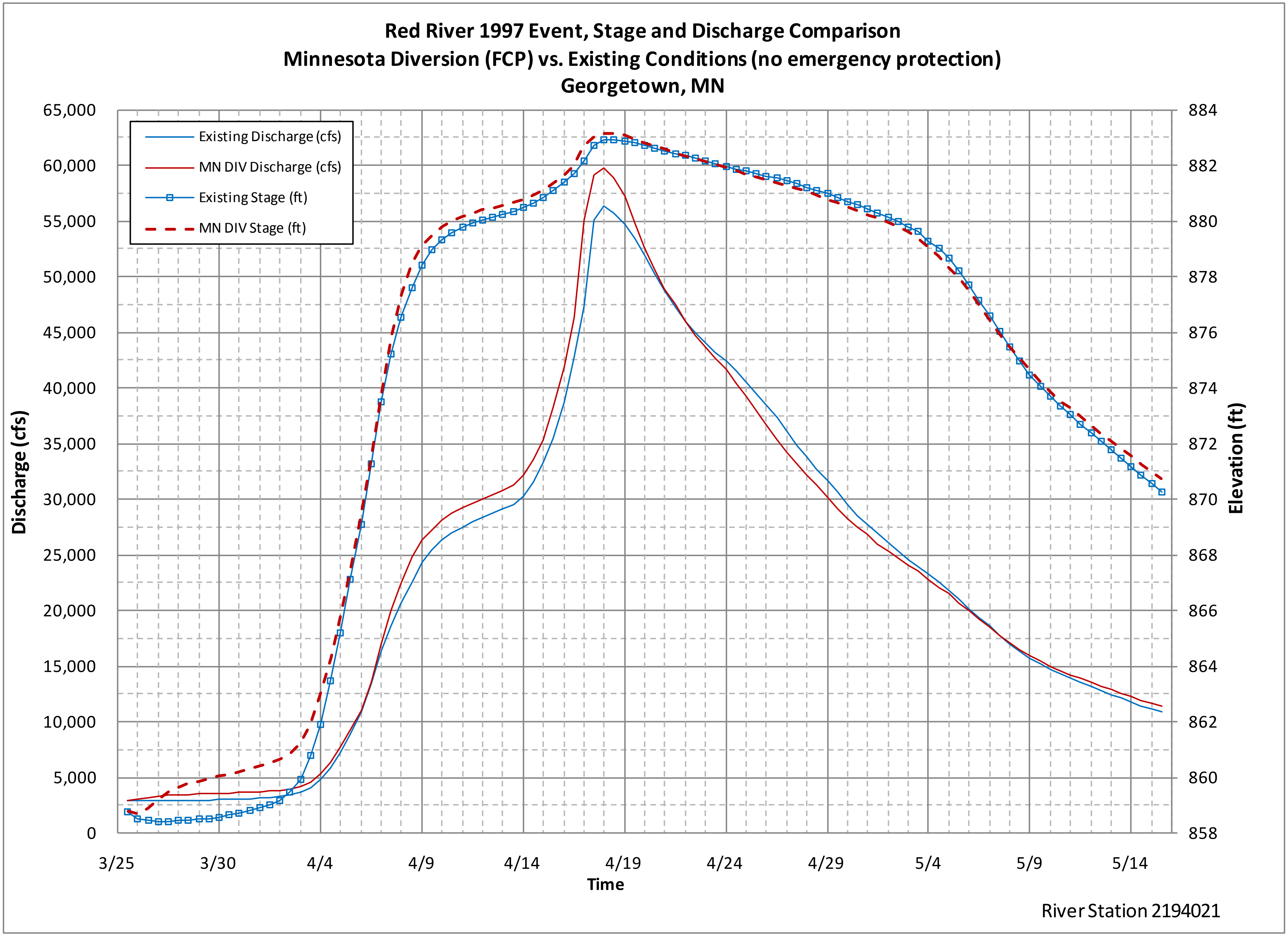


Figure C-E1- 56: 1997 Historical Flood Hydrographs for FCP @ Georgetown

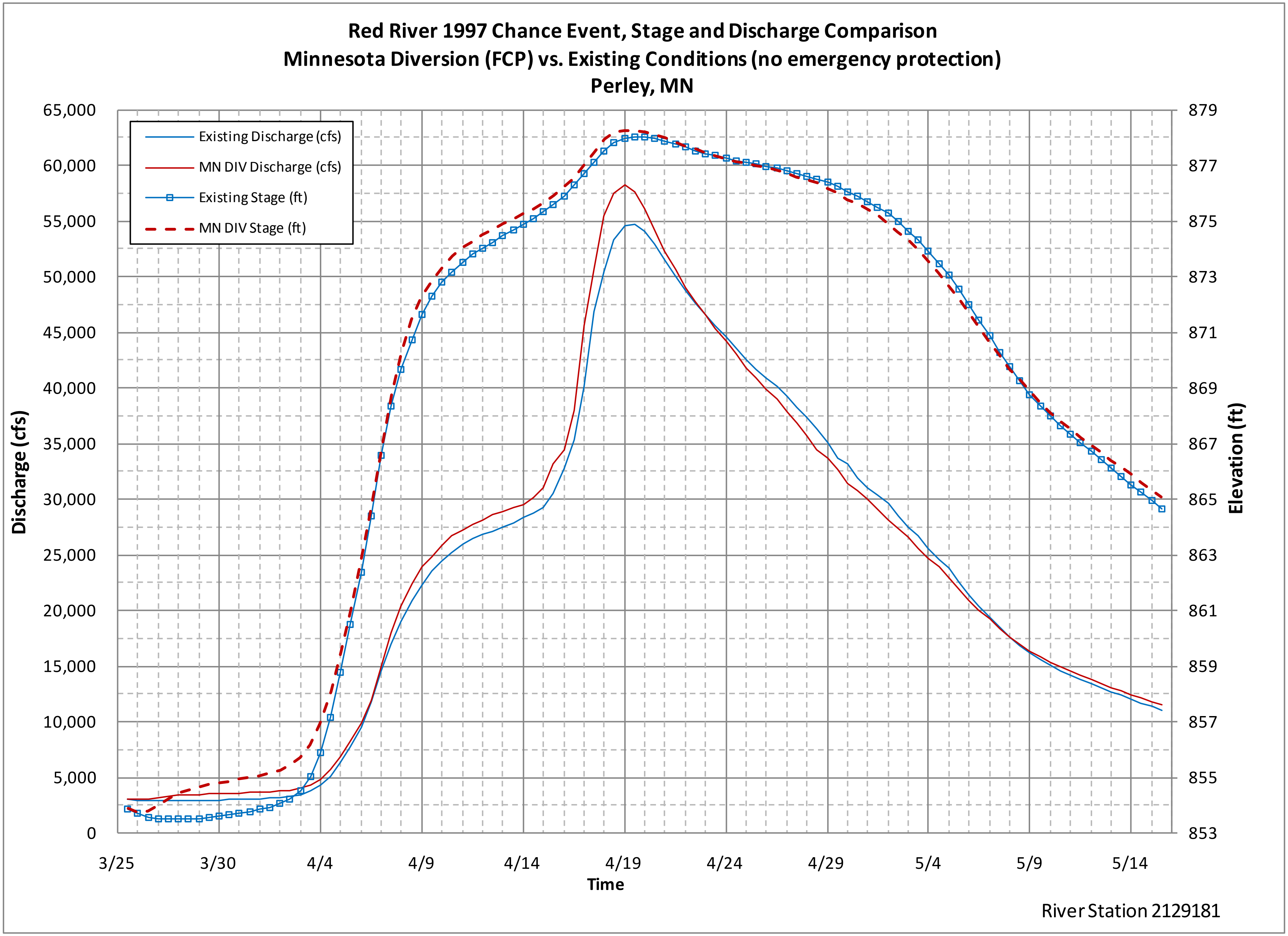


Figure C-E1- 57: 1997 Historical Flood Hydrographs for FCP @ Perley

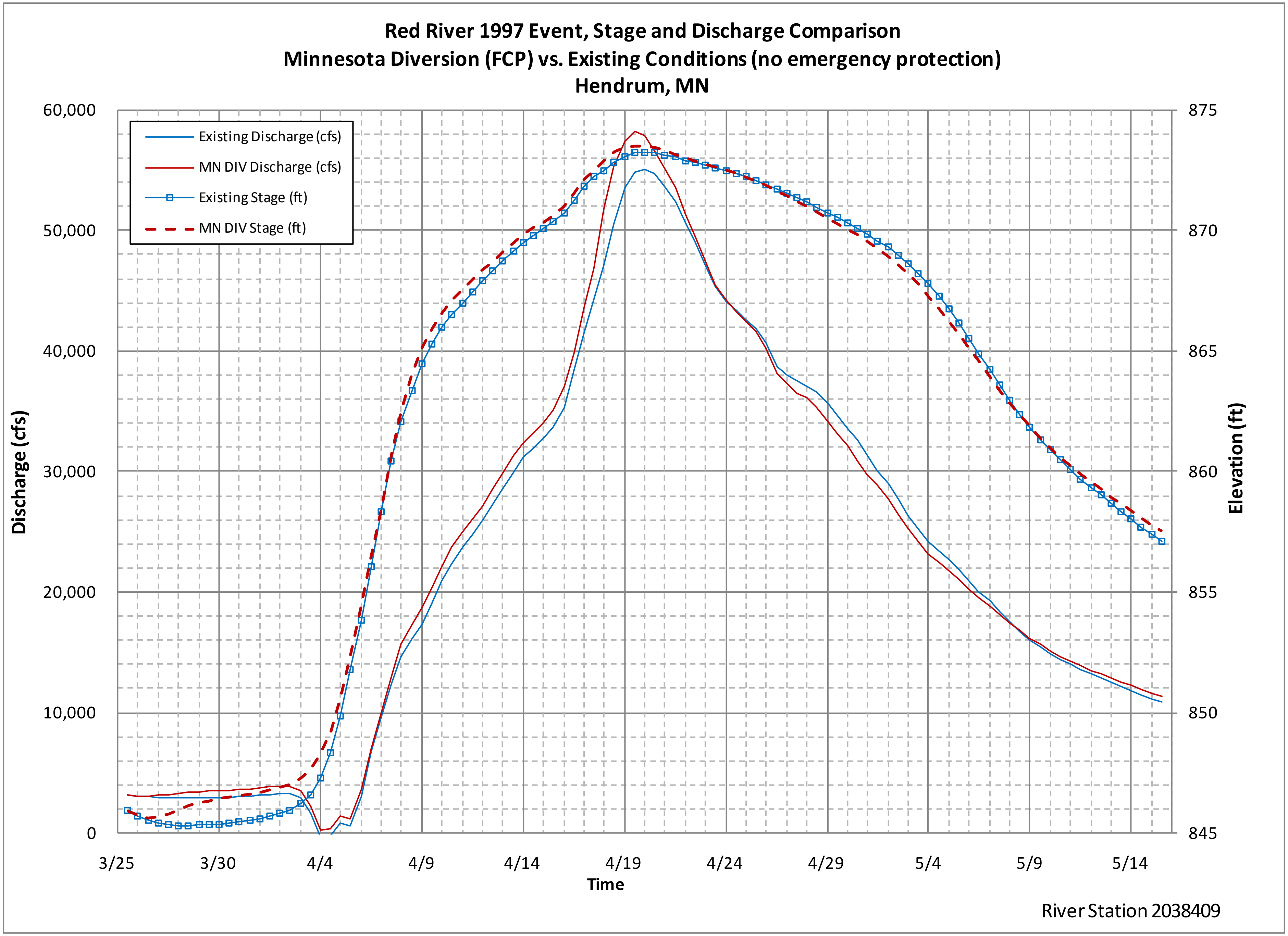


Figure C-E1- 58: 1997 Historical Flood Hydrographs for FCP @ Hendrum

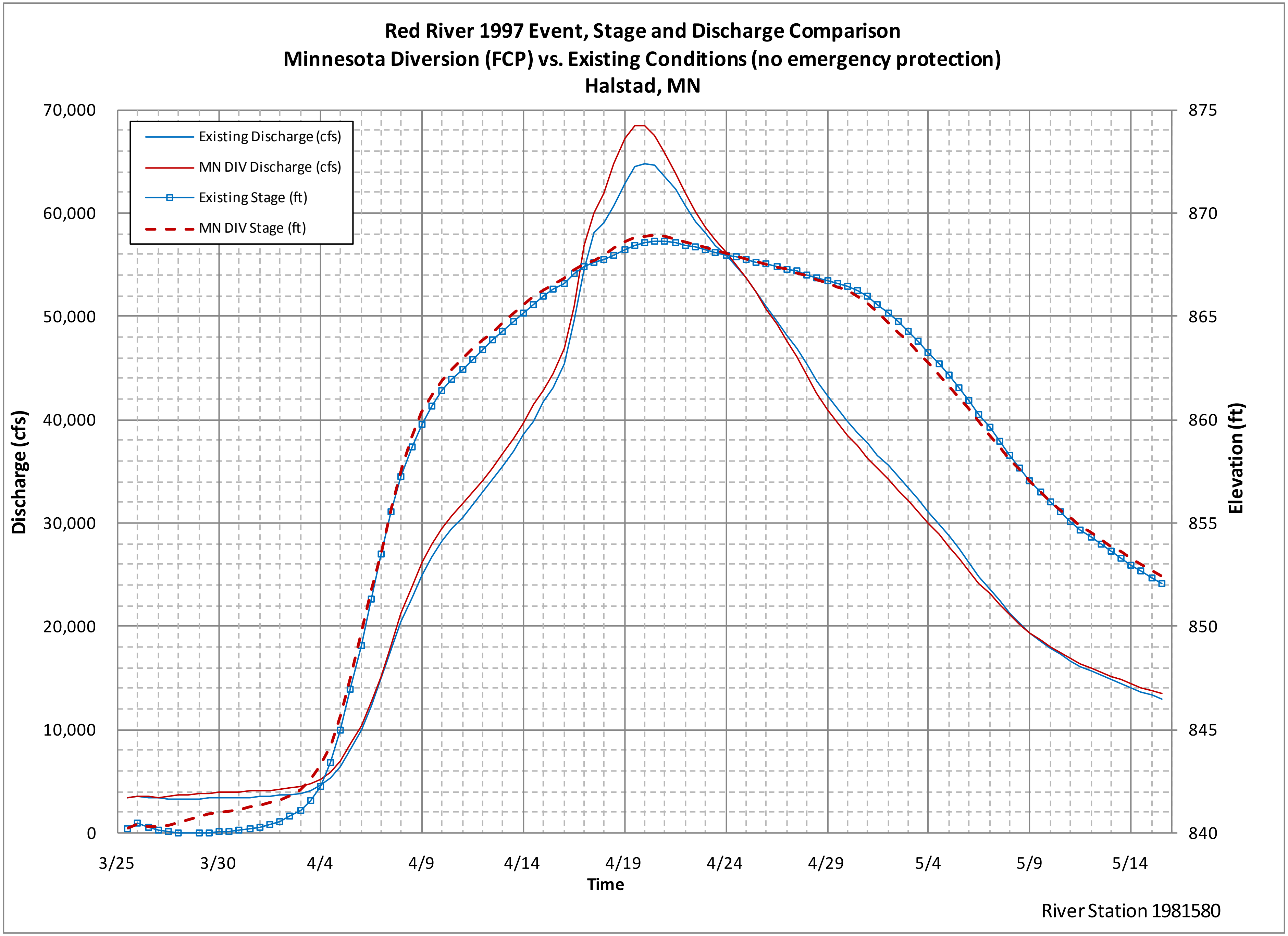


Figure C-E1- 59: 1997 Historical Flood Hydrographs for FCP @ Halstad

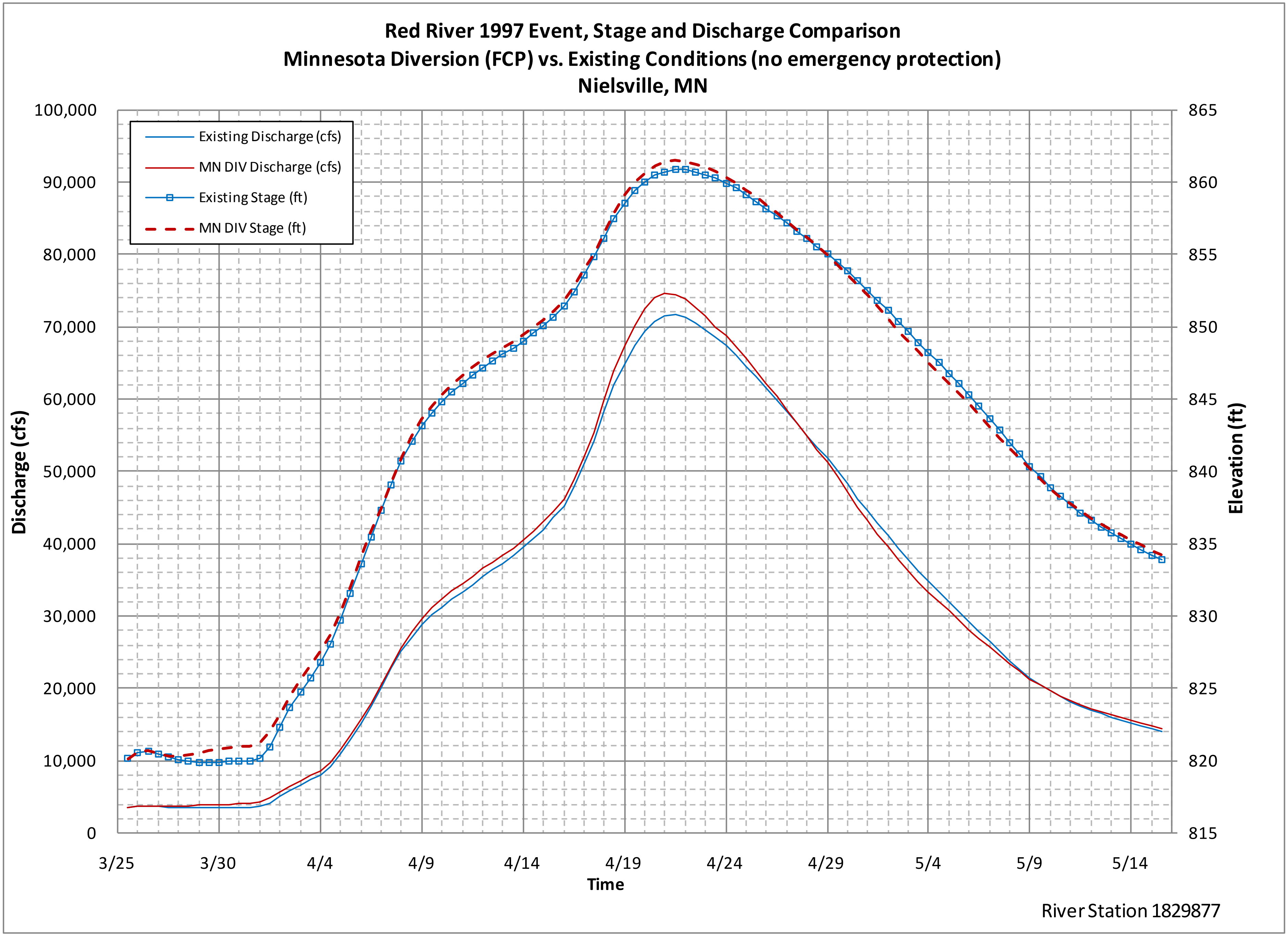


Figure C-E1- 60: 1997 Historical Flood Hydrographs for FCP @ Nielsville

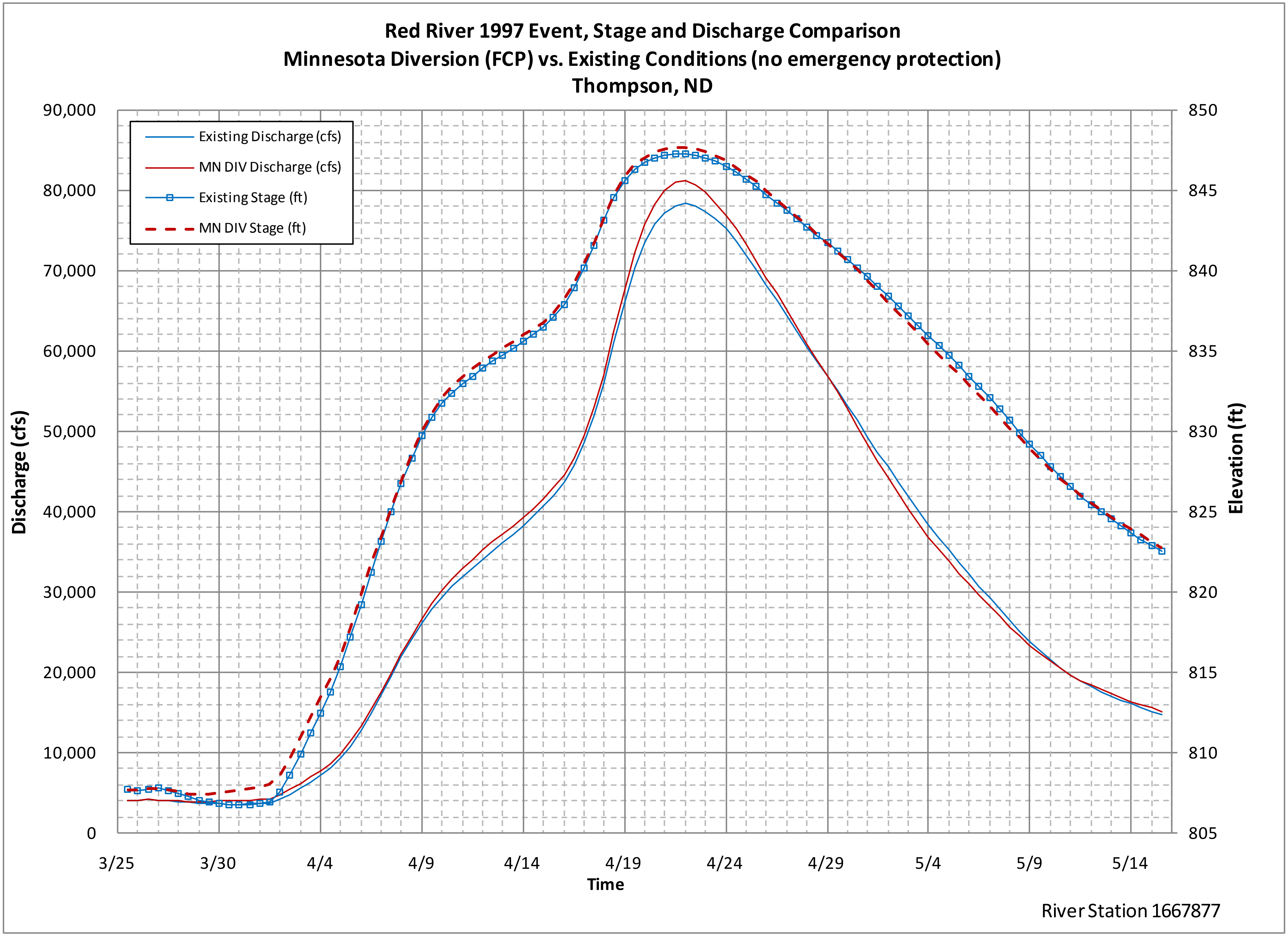


Figure C-E1- 61: 1997 Historical Flood Hydrographs for FCP @ Thompson

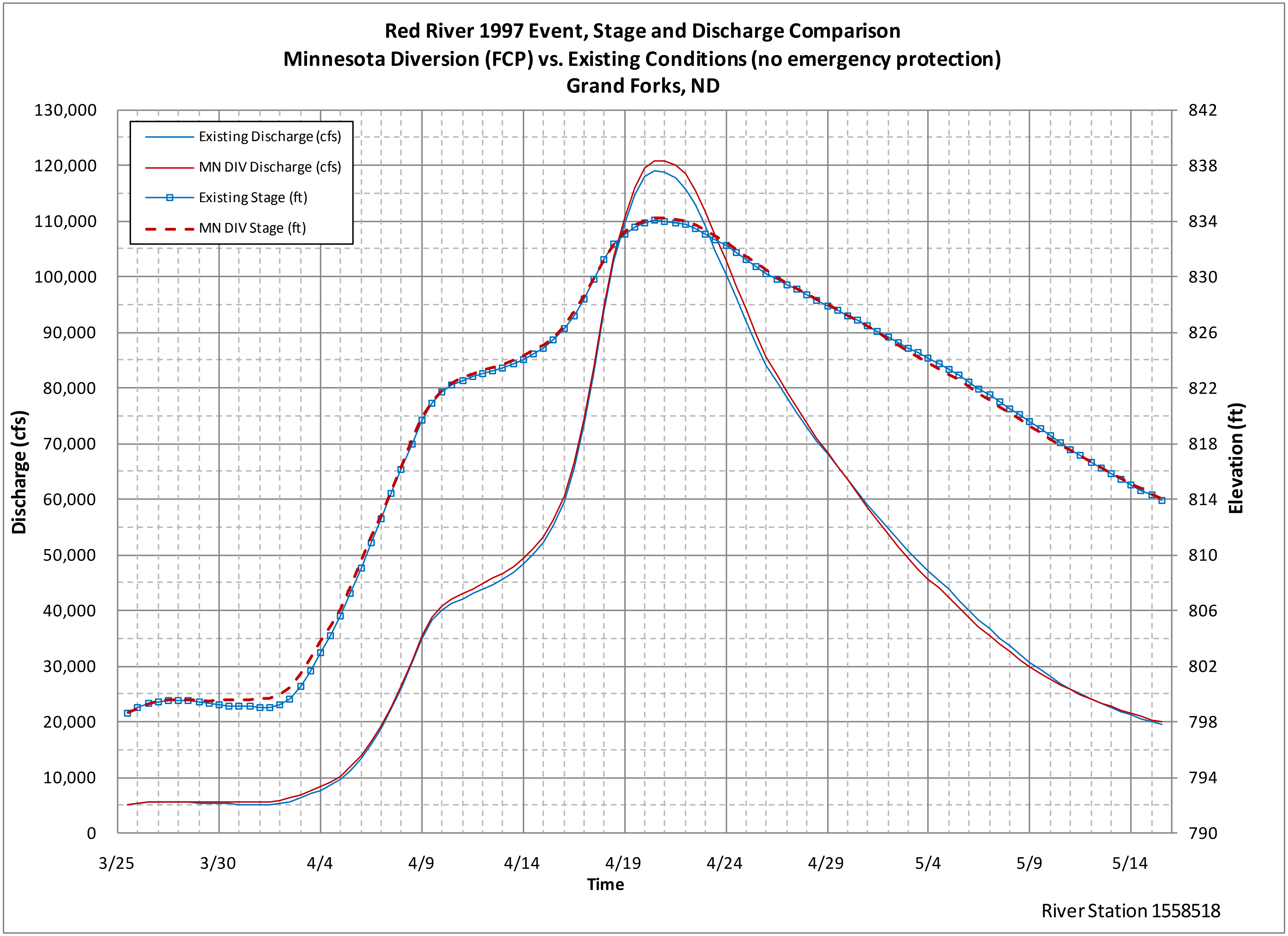


Figure C-E1- 62: 1997 Historical Flood Hydrographs for FCP @ Grand Forks

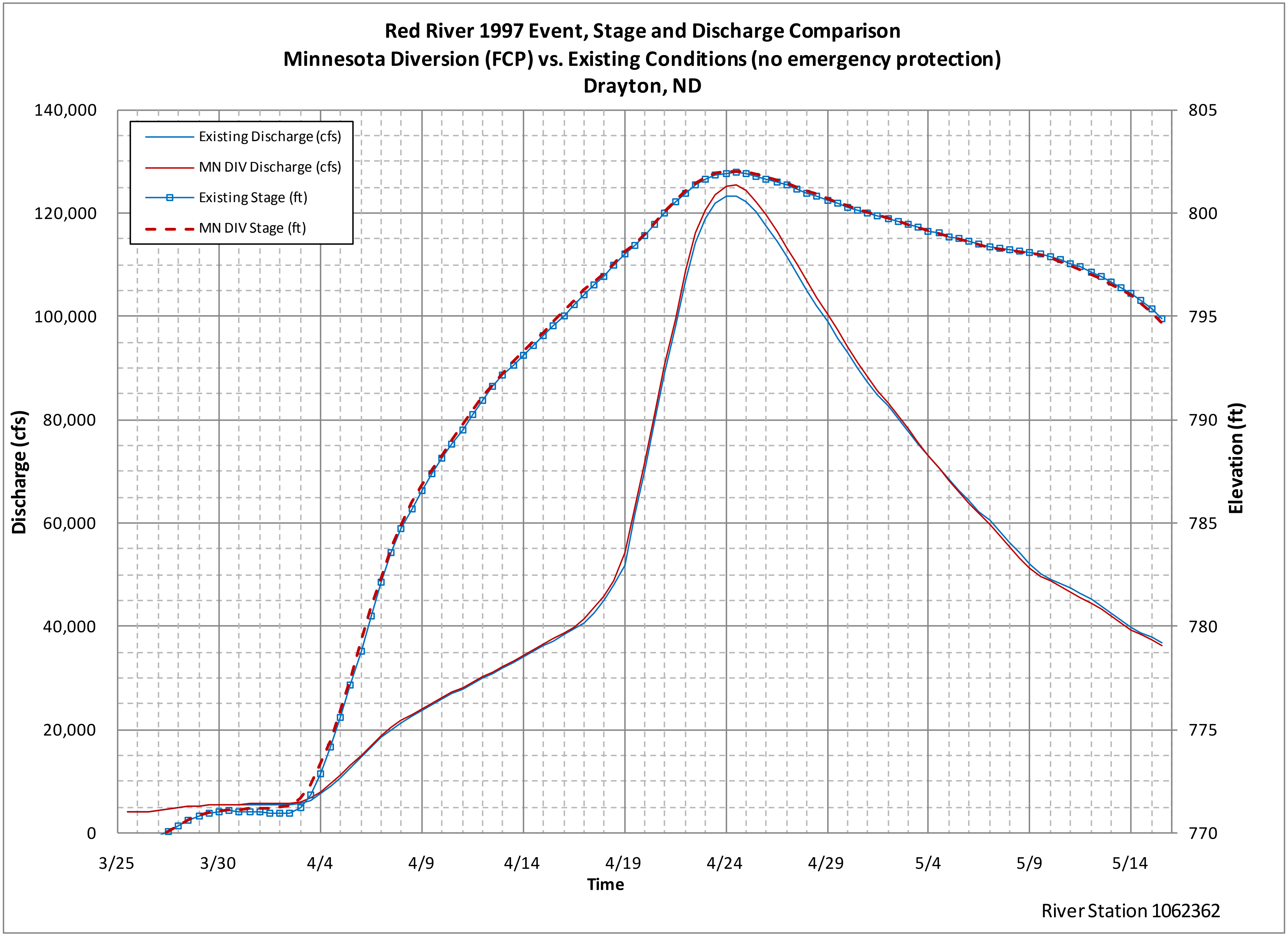


Figure C-E1- 63: 1997 Historical Flood Hydrographs for FCP @ Drayton

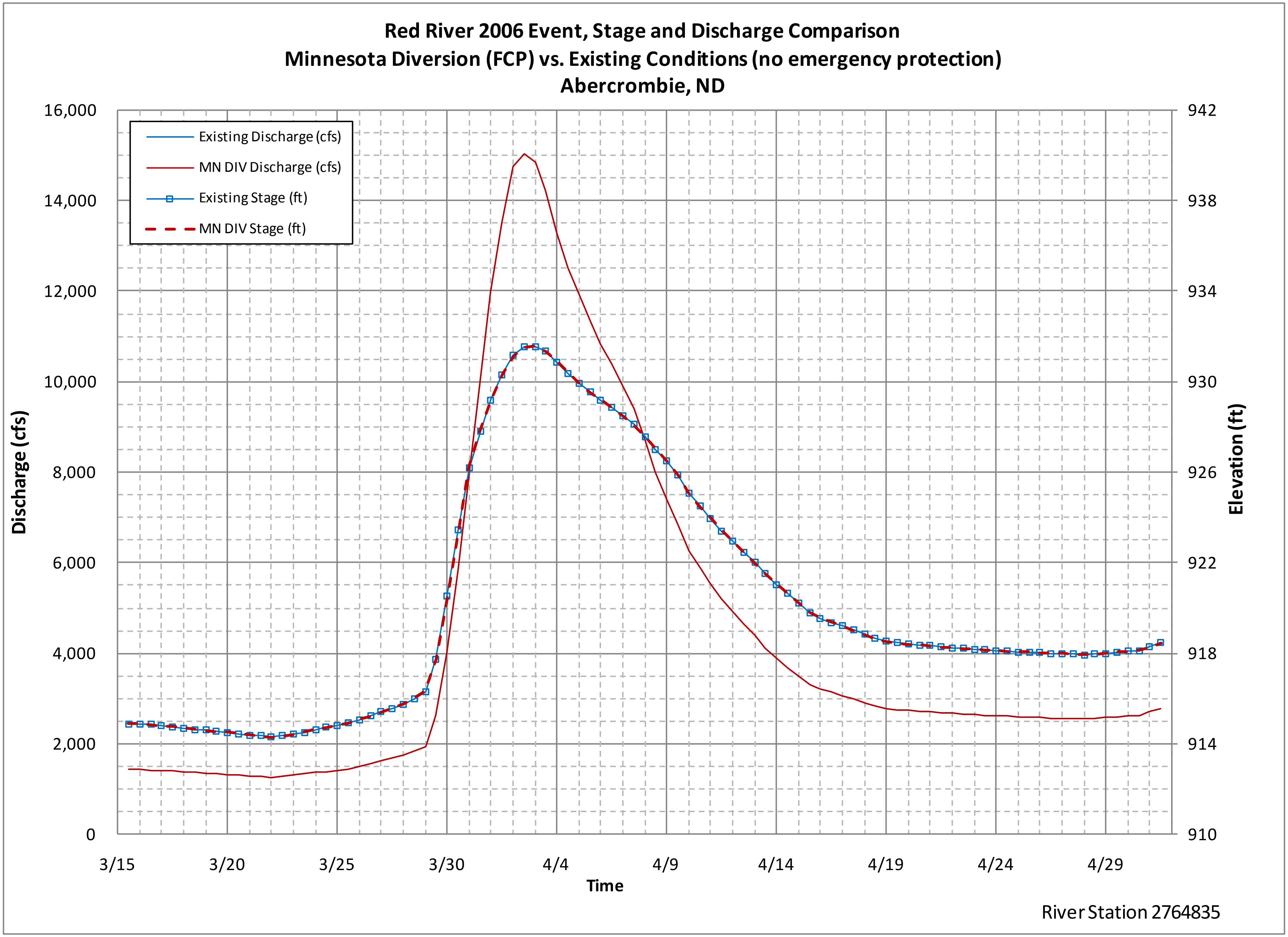


Figure C-E1- 64:2006 Historical Flood Hydrographs for FCP @ Abercrombie

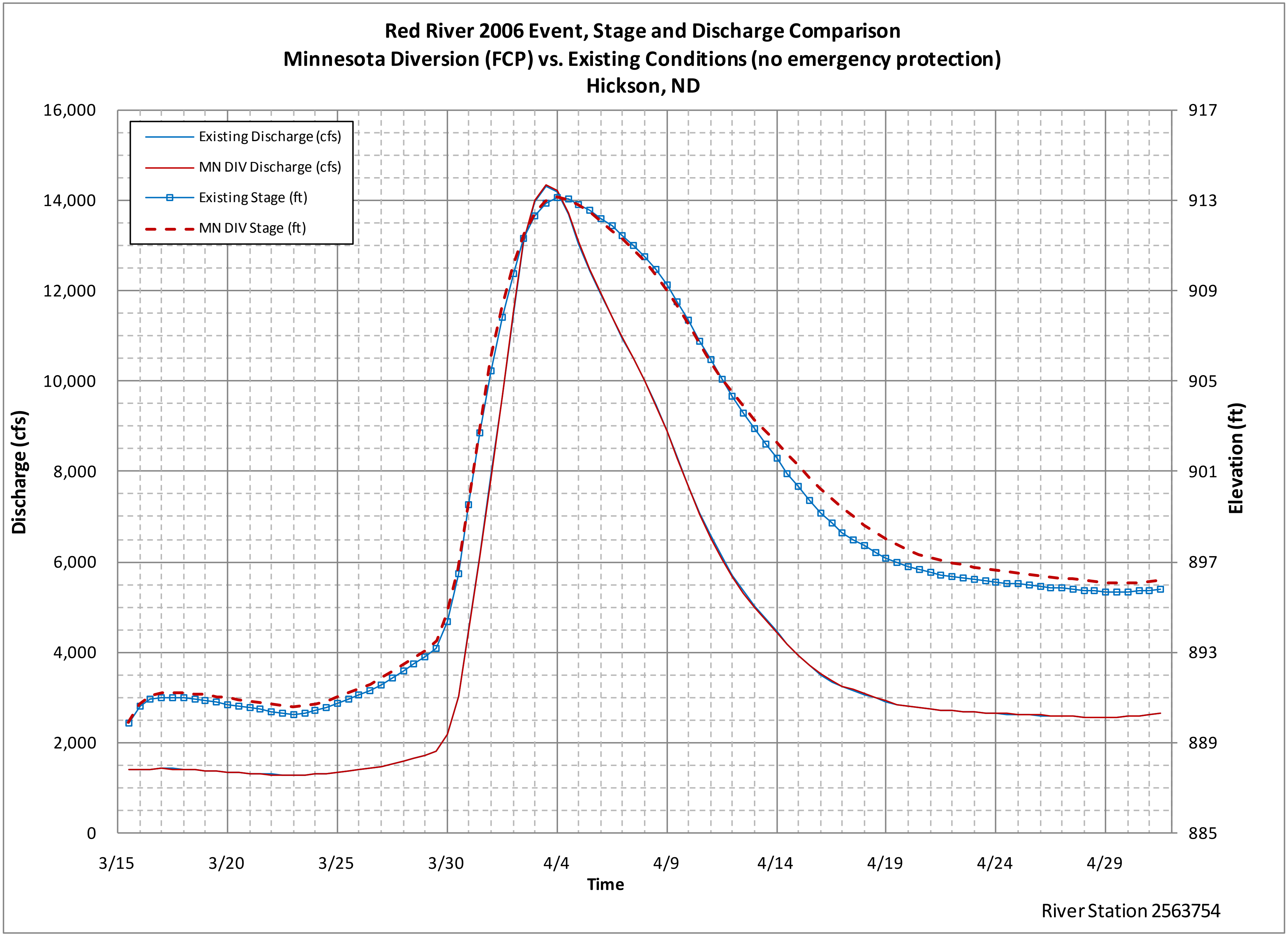


Figure C-E1- 65:2006 Historical Flood Hydrographs for FCP @ Hickson

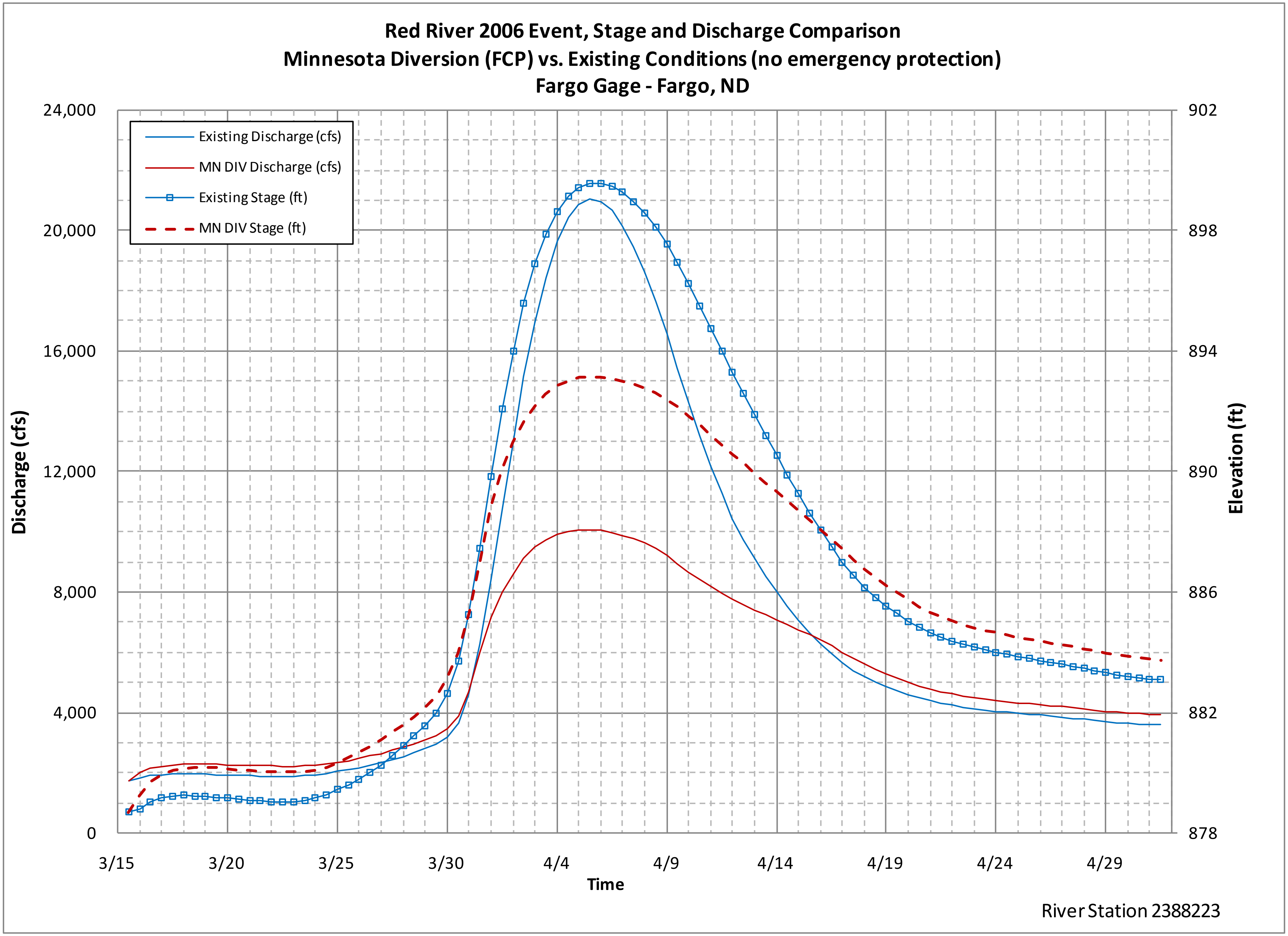


Figure C-E1- 66:2006 Historical Flood Hydrographs for FCP @ Fargo

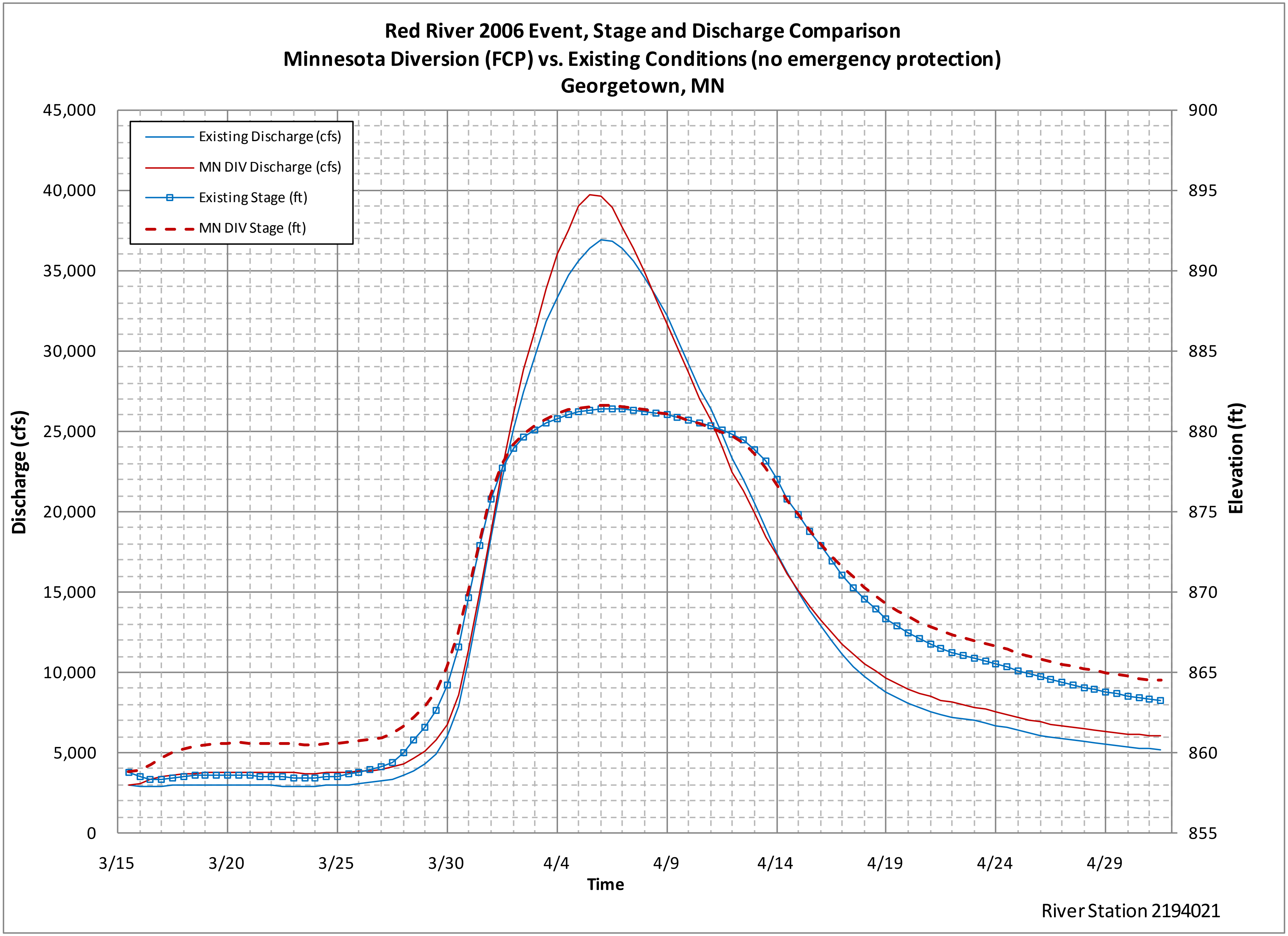


Figure C-E1- 67:2006 Historical Flood Hydrographs for FCP @ Georgetown

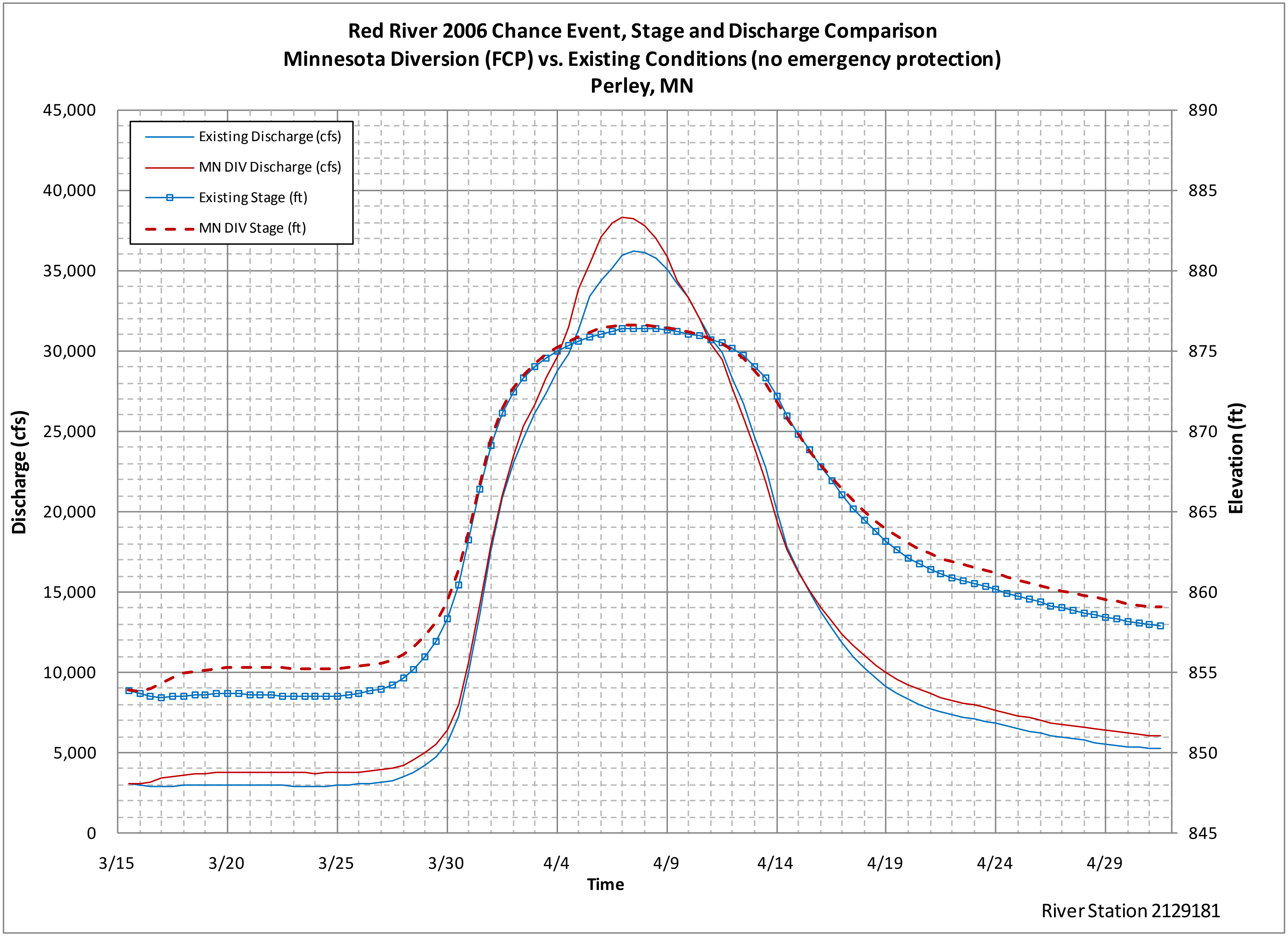


Figure C-E1- 68:2006 Historical Flood Hydrographs for FCP @ Perley

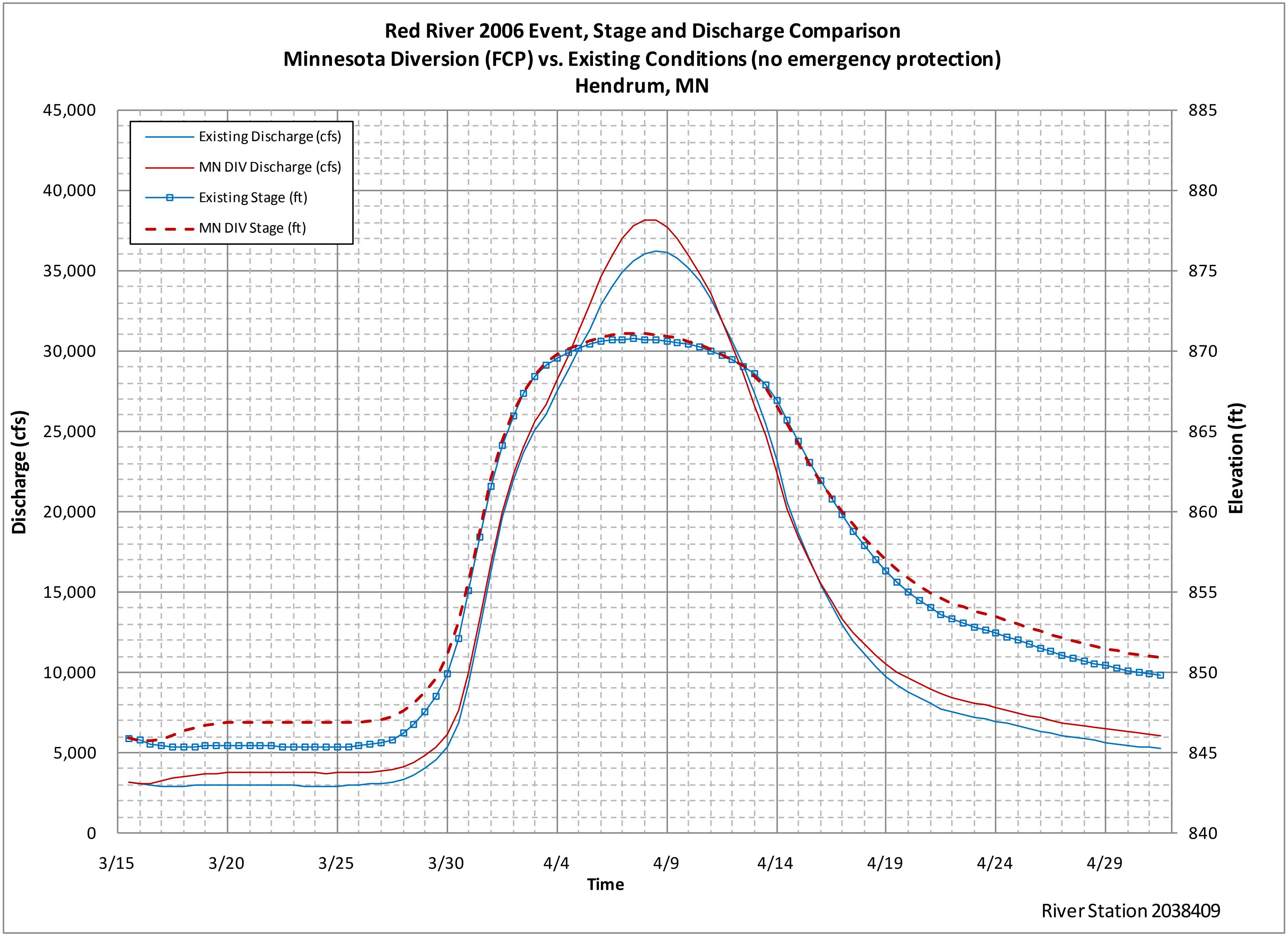


Figure C-E1- 69:2006 Historical Flood Hydrographs for FCP @ Hendrum

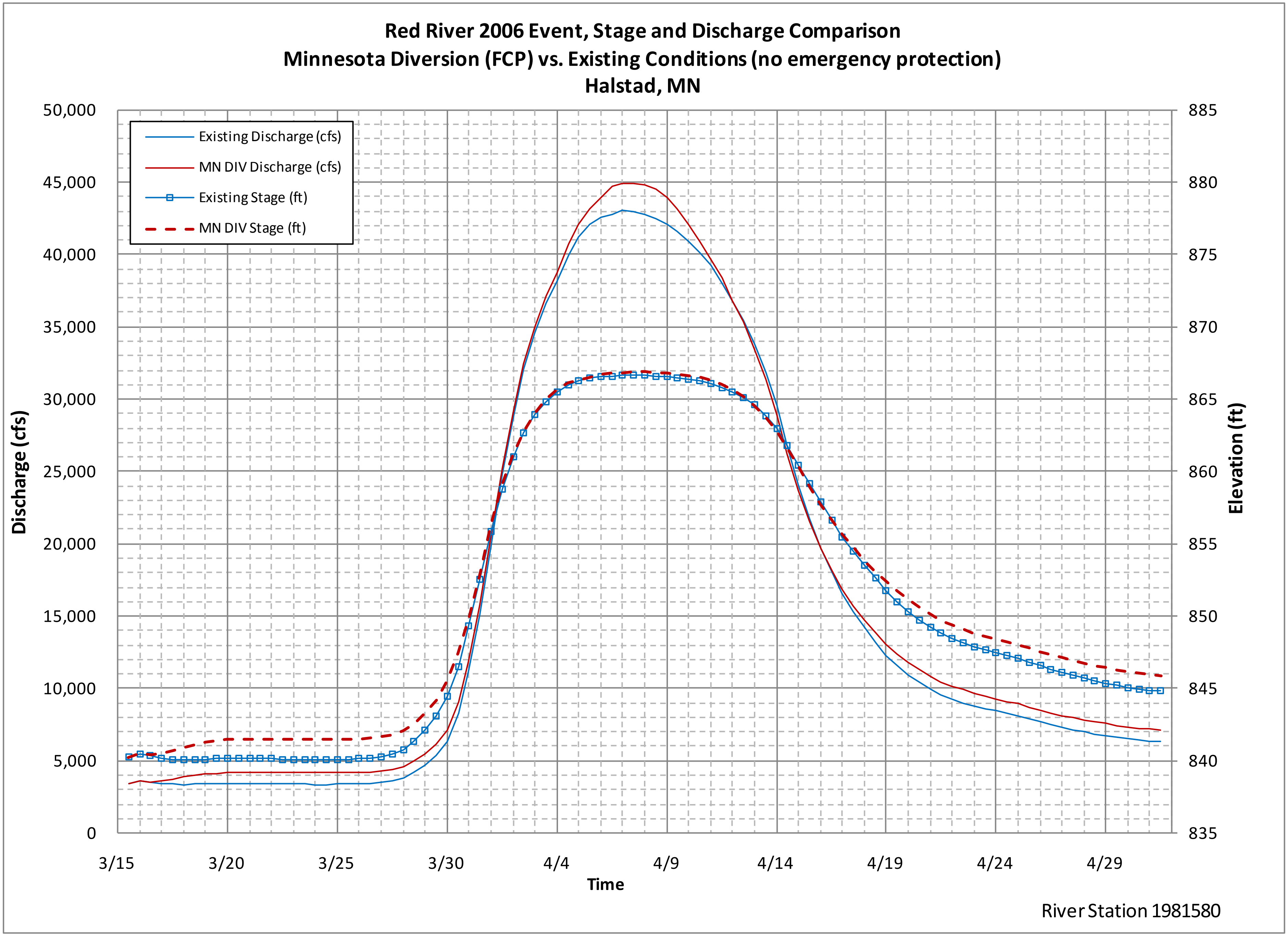


Figure C-E1- 70:2006 Historical Flood Hydrographs for FCP @ Halstad

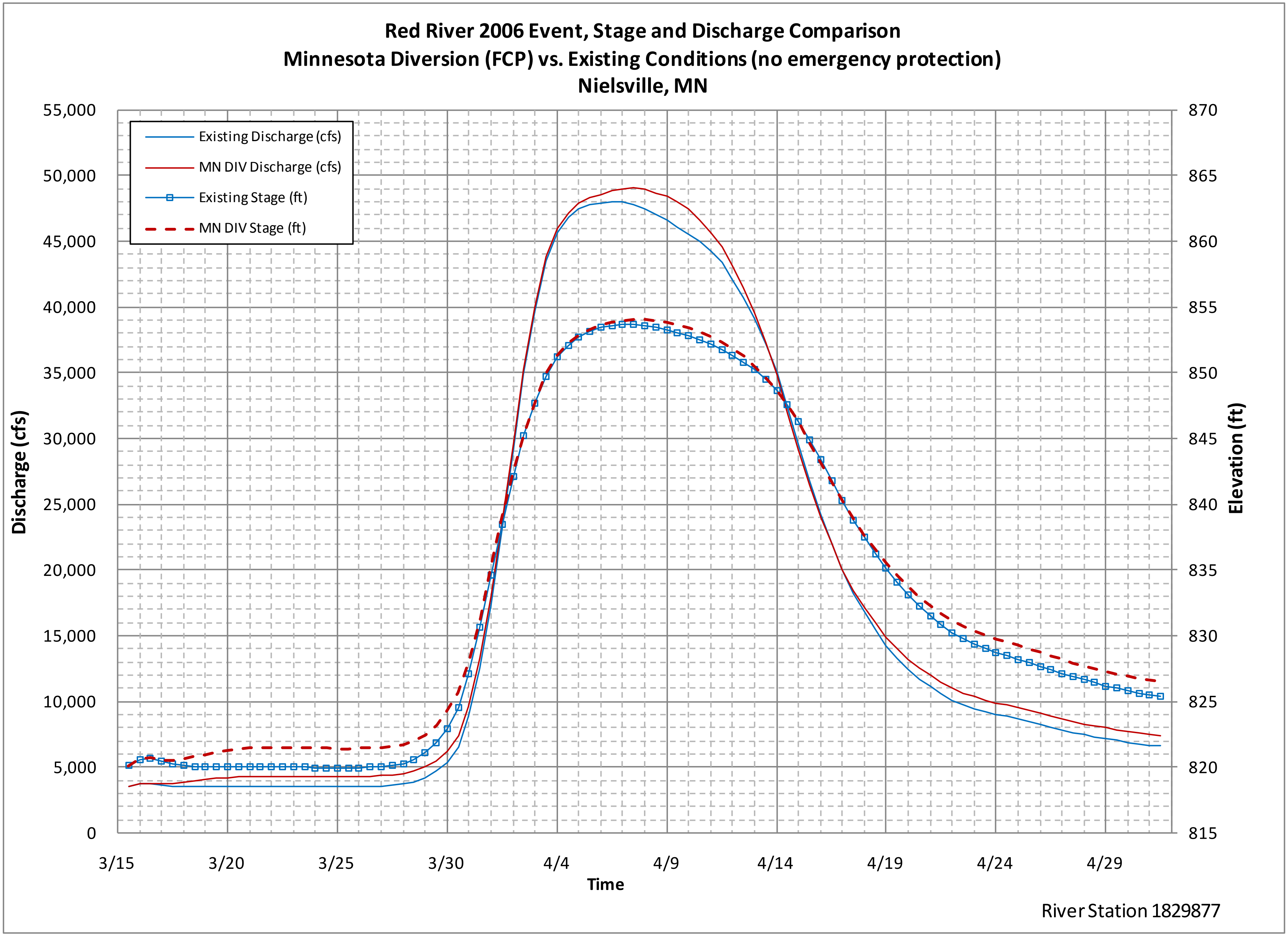


Figure C-E1- 71:2006 Historical Flood Hydrographs for FCP @ Nielsville

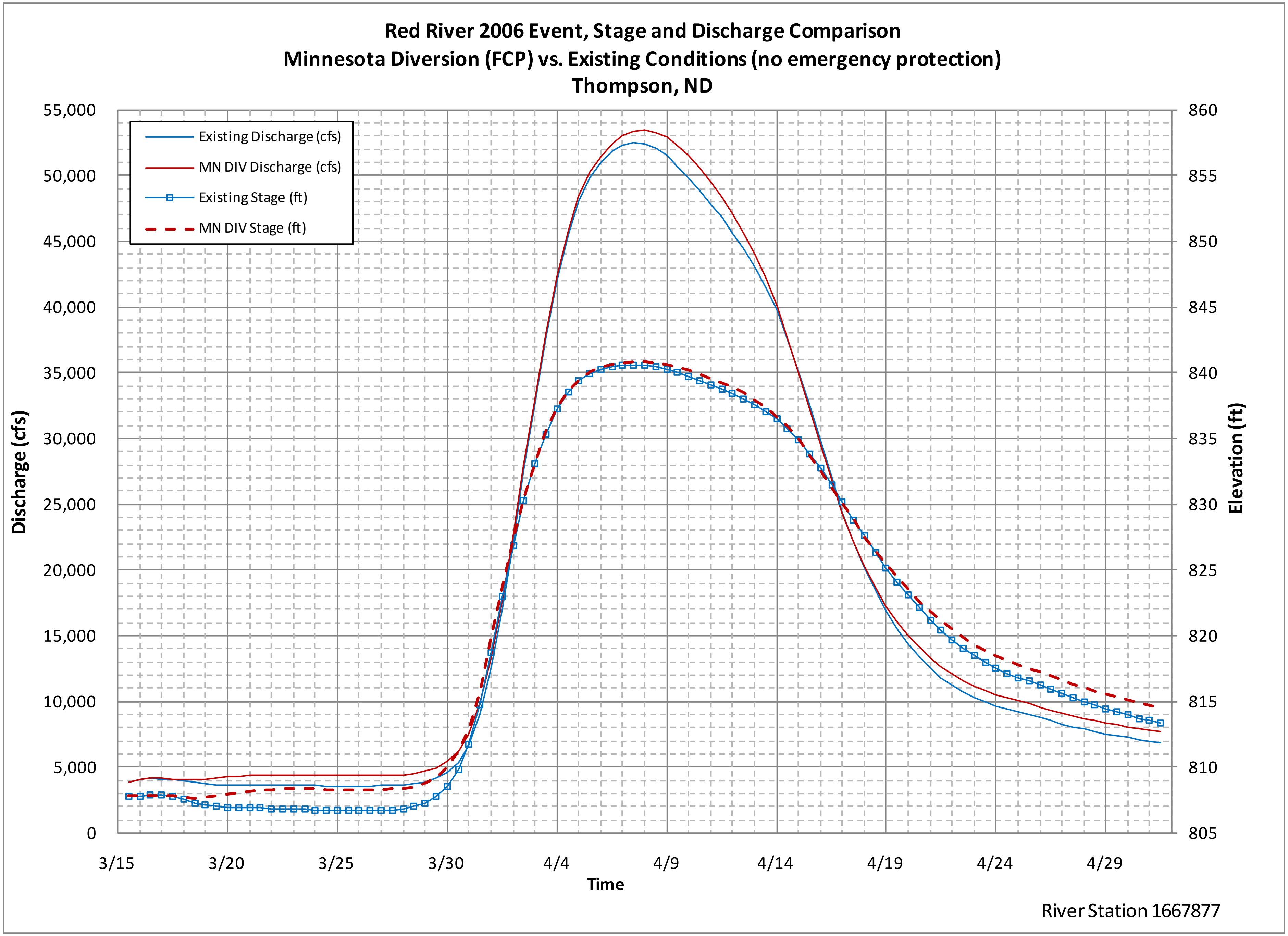


Figure C-E1- 72:2006 Historical Flood Hydrographs for FCP @ Thompson

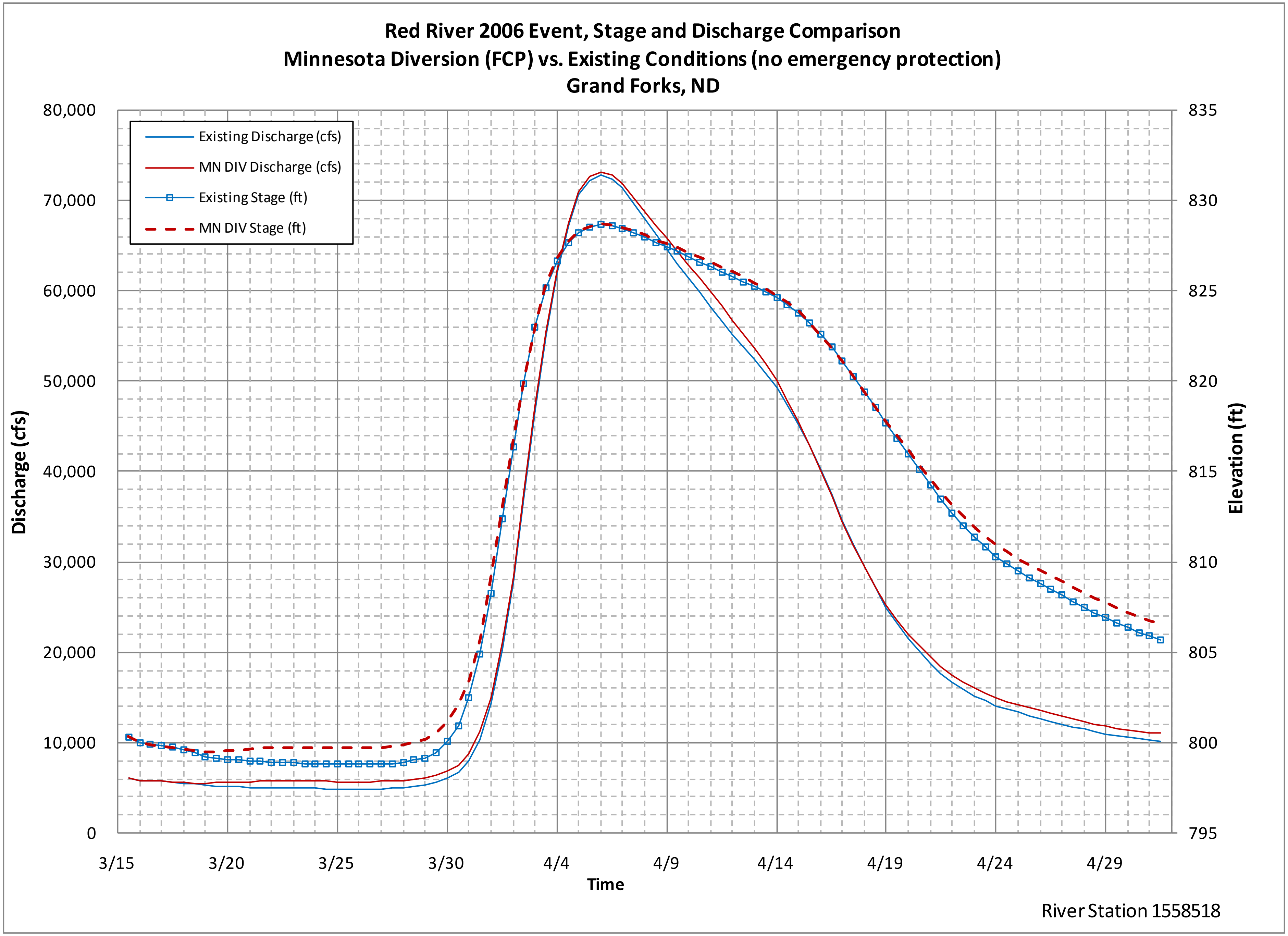


Figure C-E1- 73:2006 Historical Flood Hydrographs for FCP @ Grand Forks

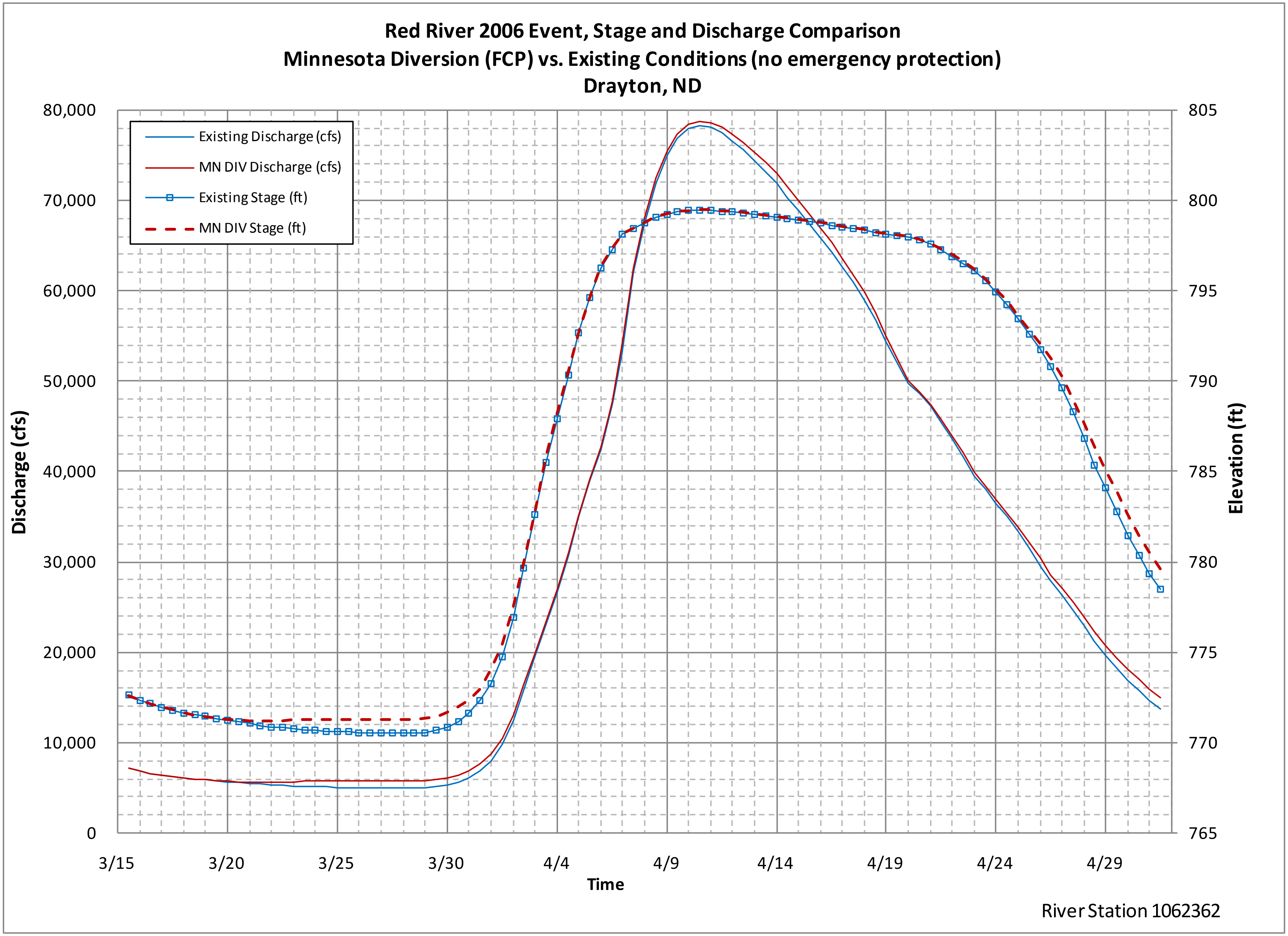


Figure C-E1- 74:2006 Historical Flood Hydrographs for FCP @ Drayton

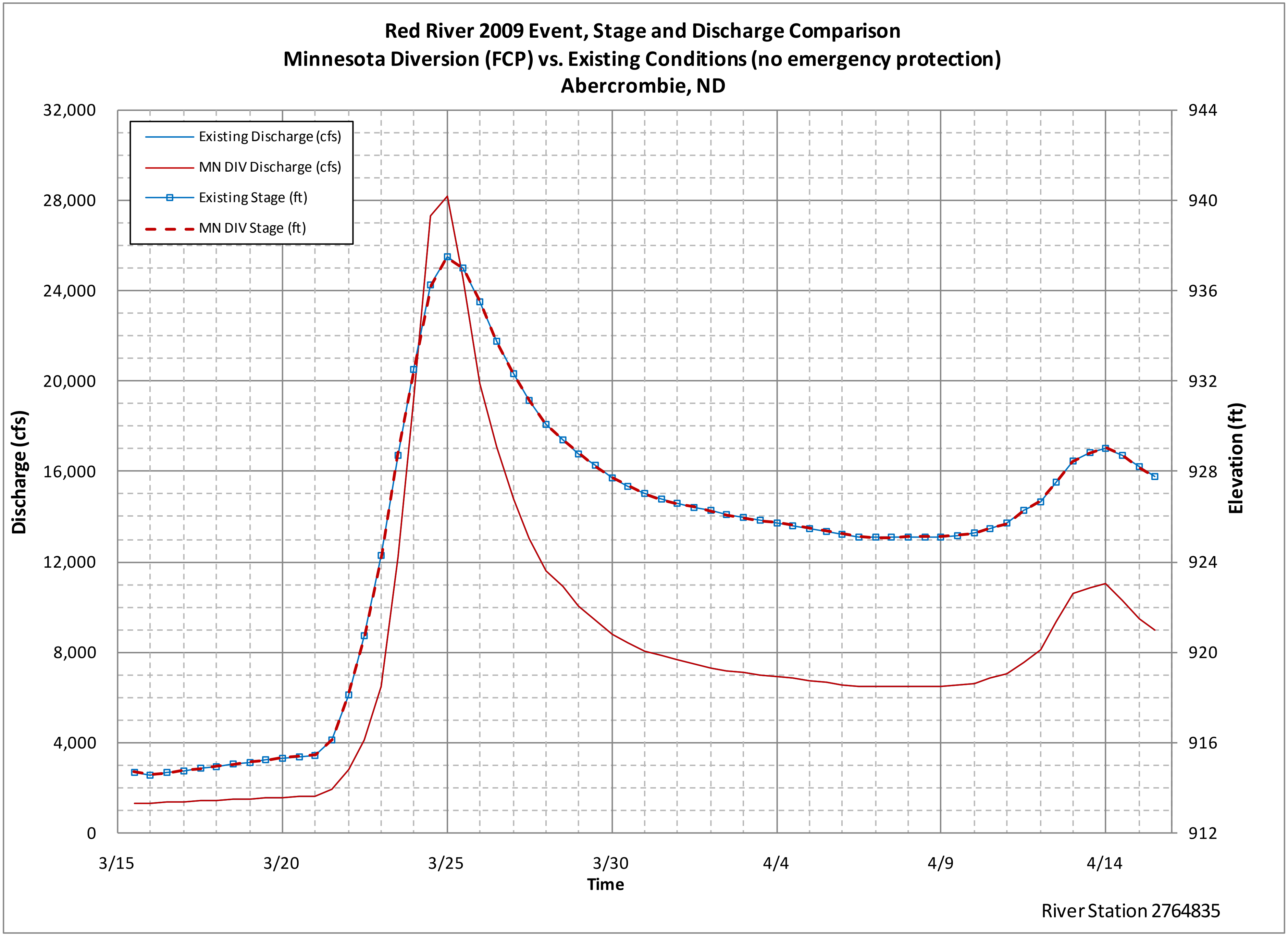


Figure C-E1- 75: 2009 Historical Flood Hydrographs for FCP @ Abercrombie

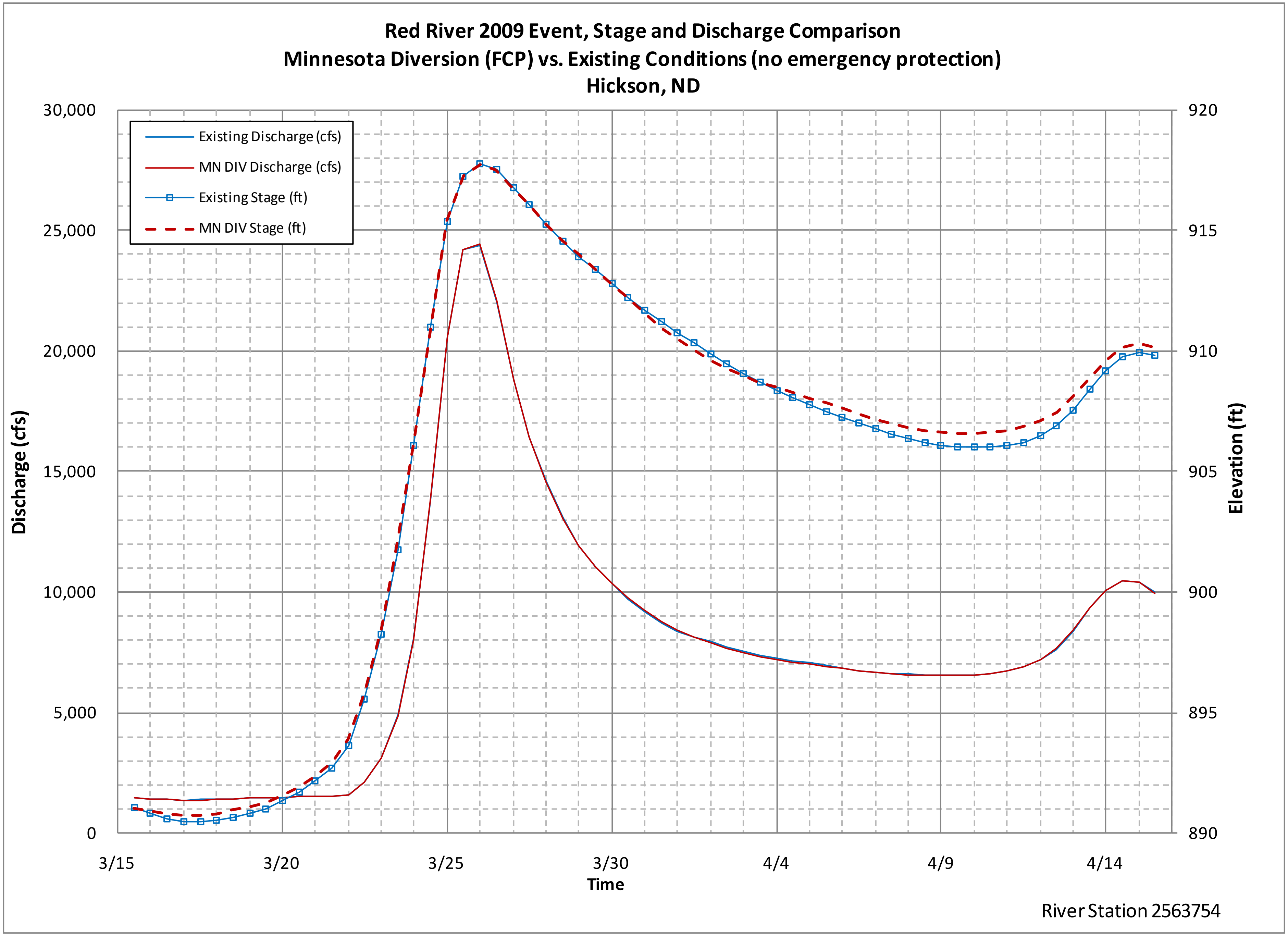


Figure C-E1- 76: 2009 Historical Flood Hydrographs for FCP @ Hickson

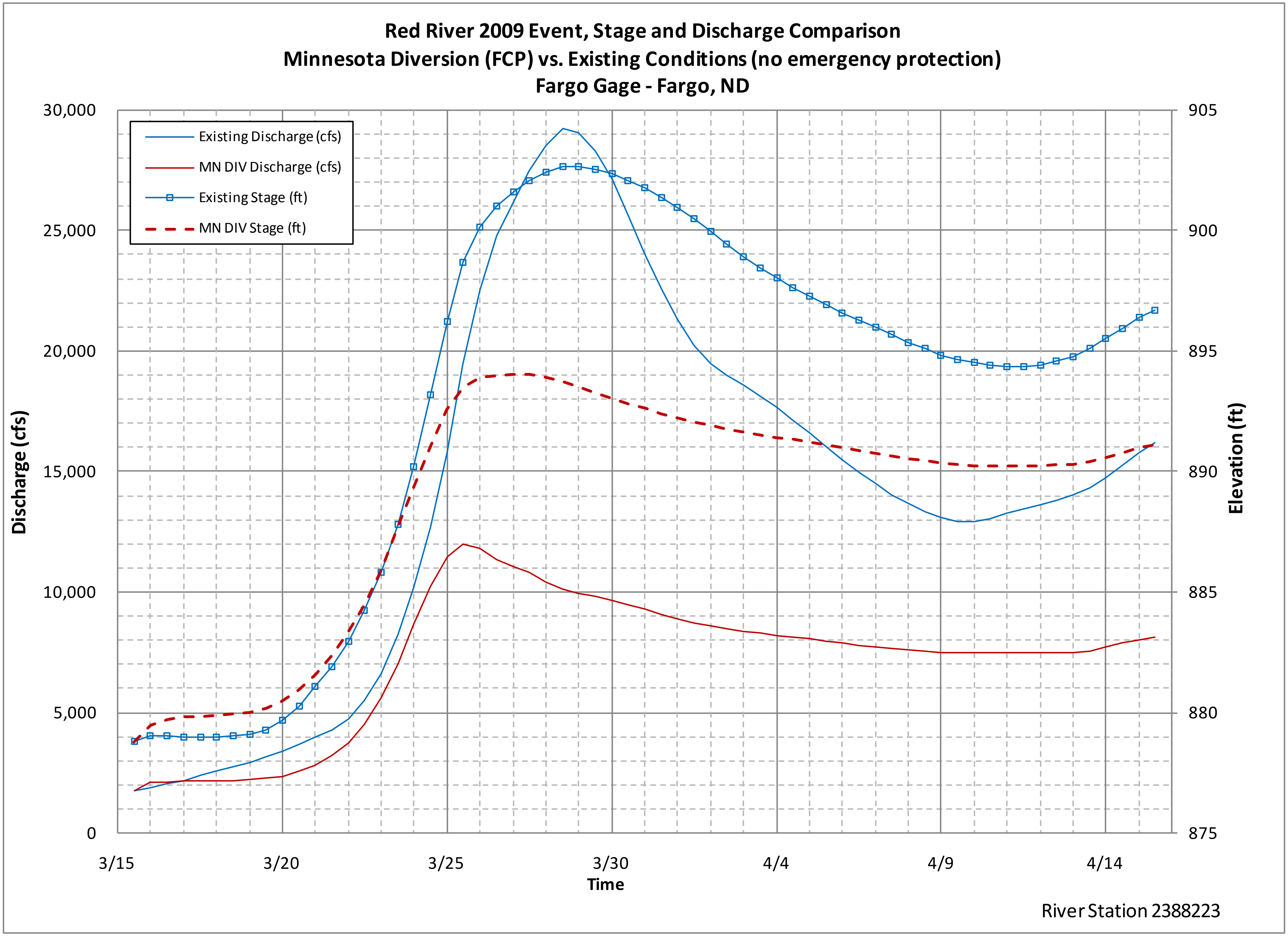


Figure C-E1- 77: 2009 Historical Flood Hydrographs for FCP @ Fargo

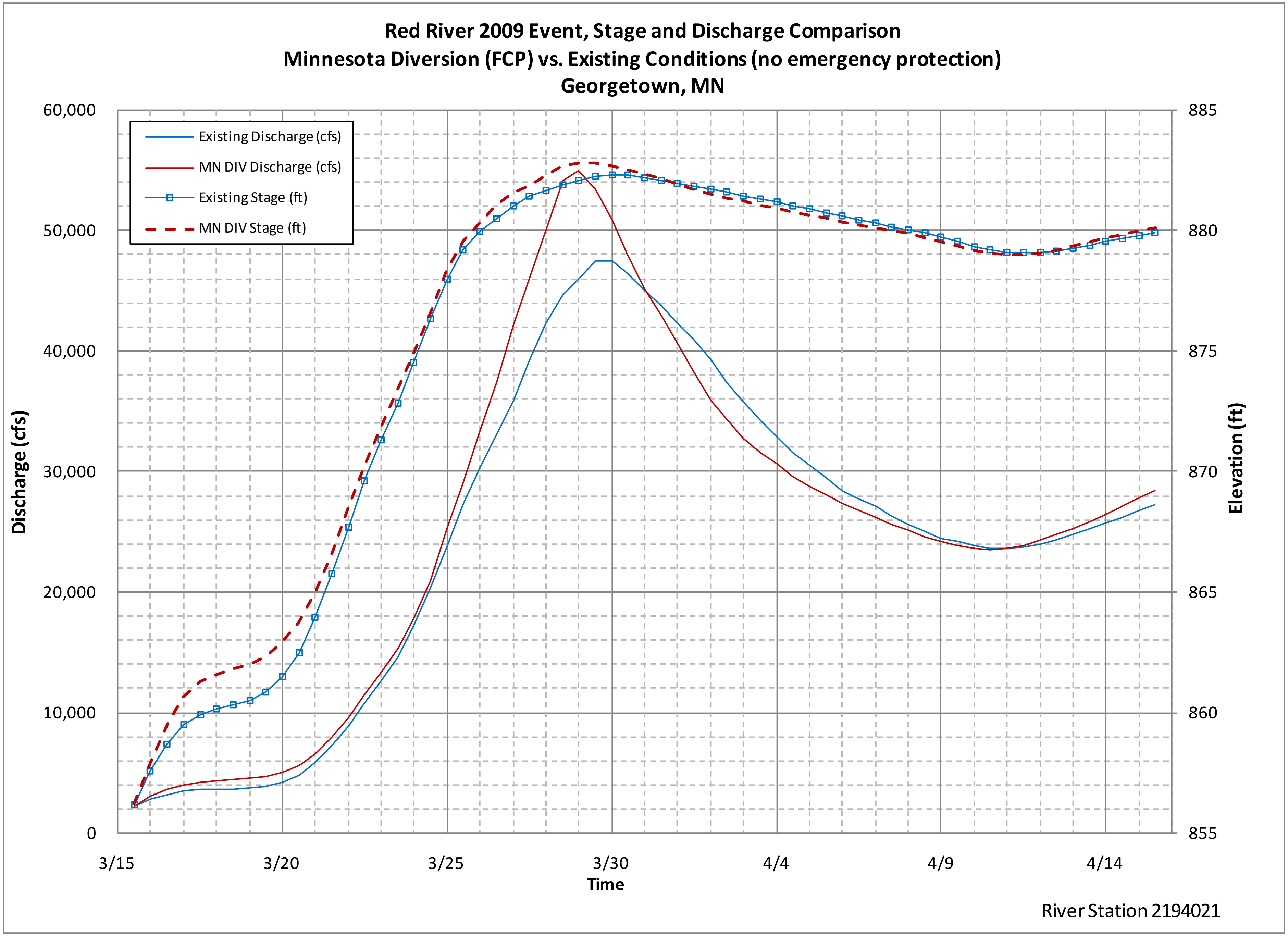


Figure C-E1- 78: 2009 Historical Flood Hydrographs for FCP @ Georgetown

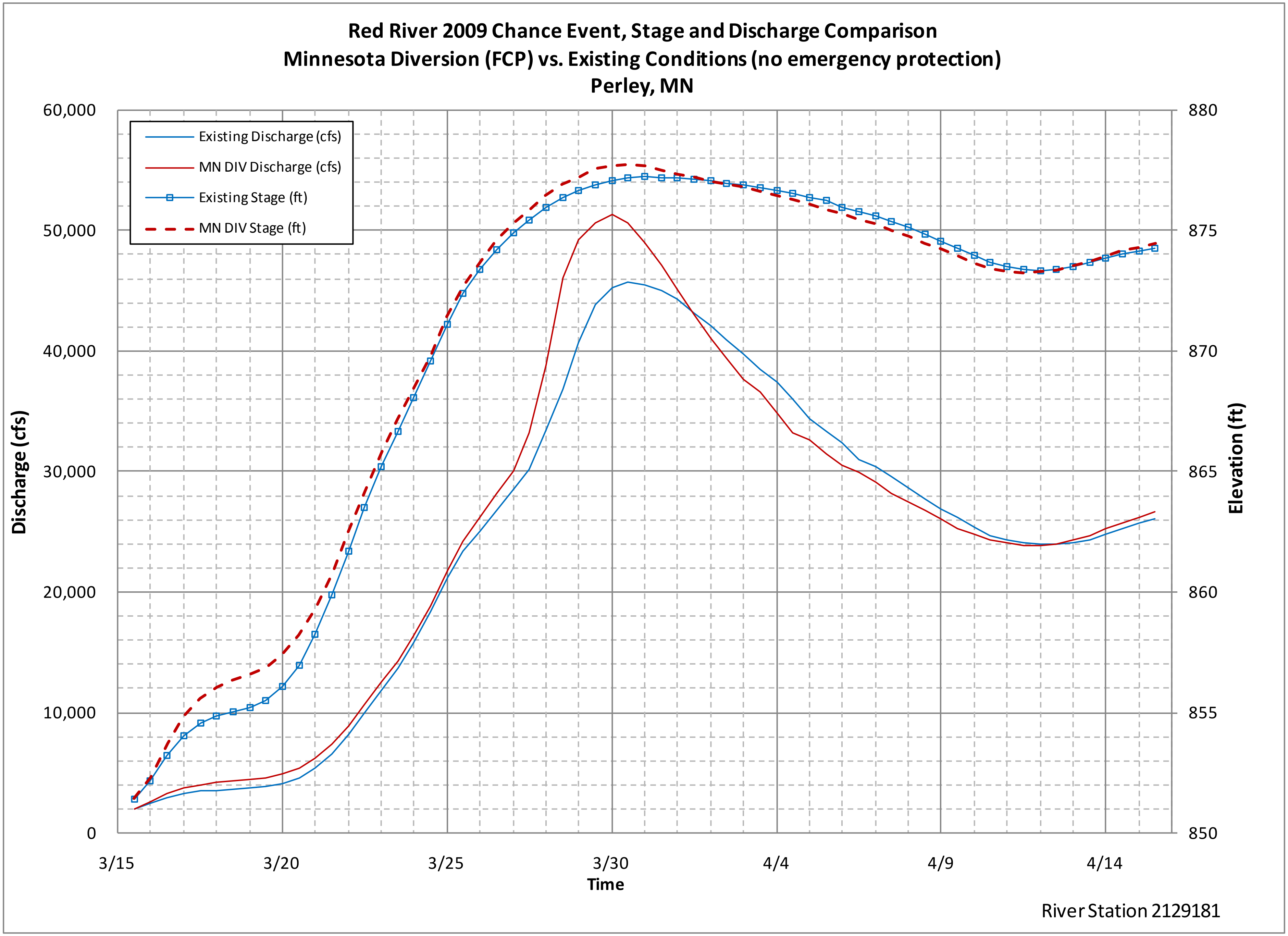


Figure C-E1- 79: 2009 Historical Flood Hydrographs for FCP @ Perley

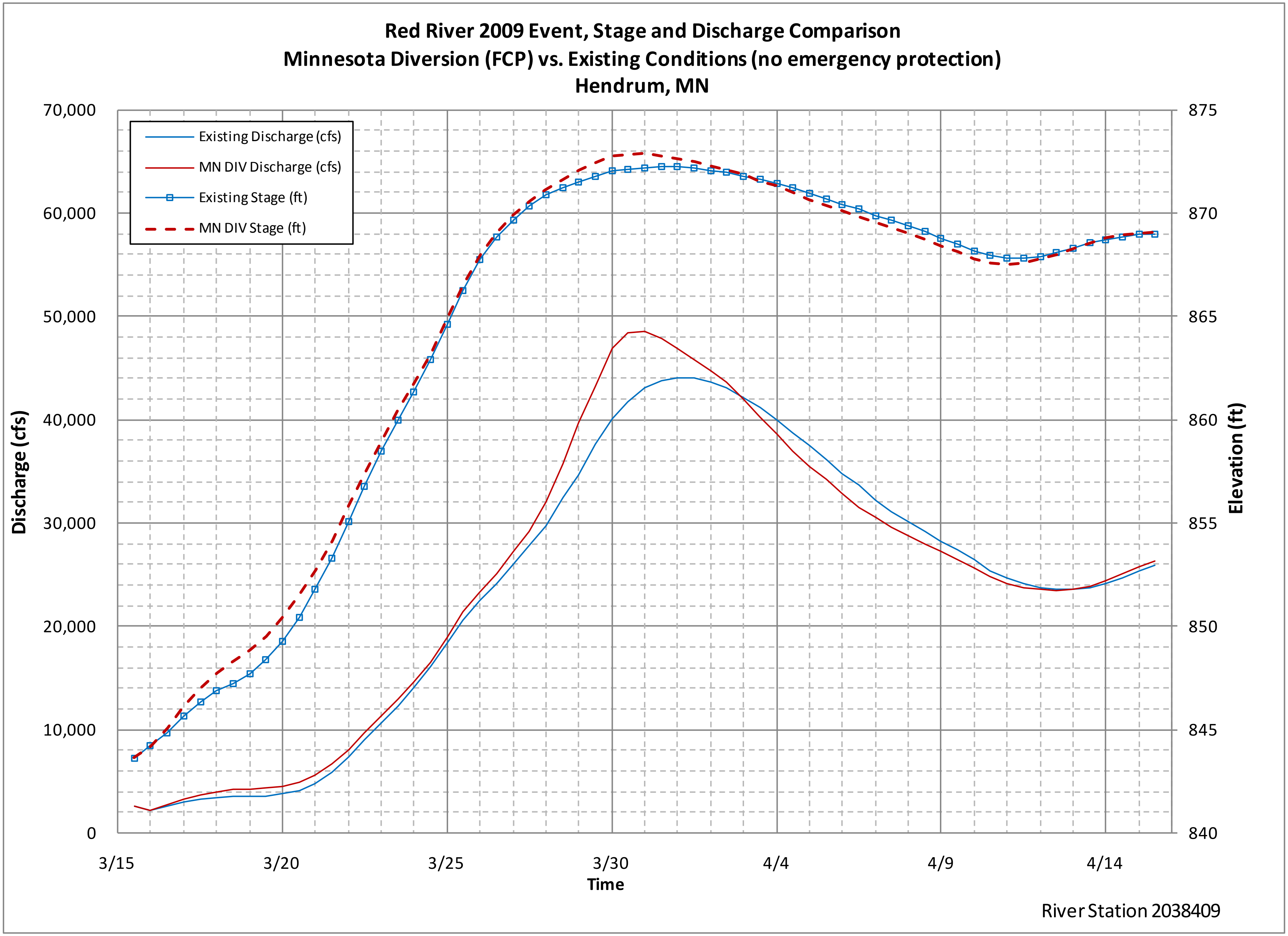


Figure C-E1- 80: 2009 Historical Flood Hydrographs for FCP @ Hendrum

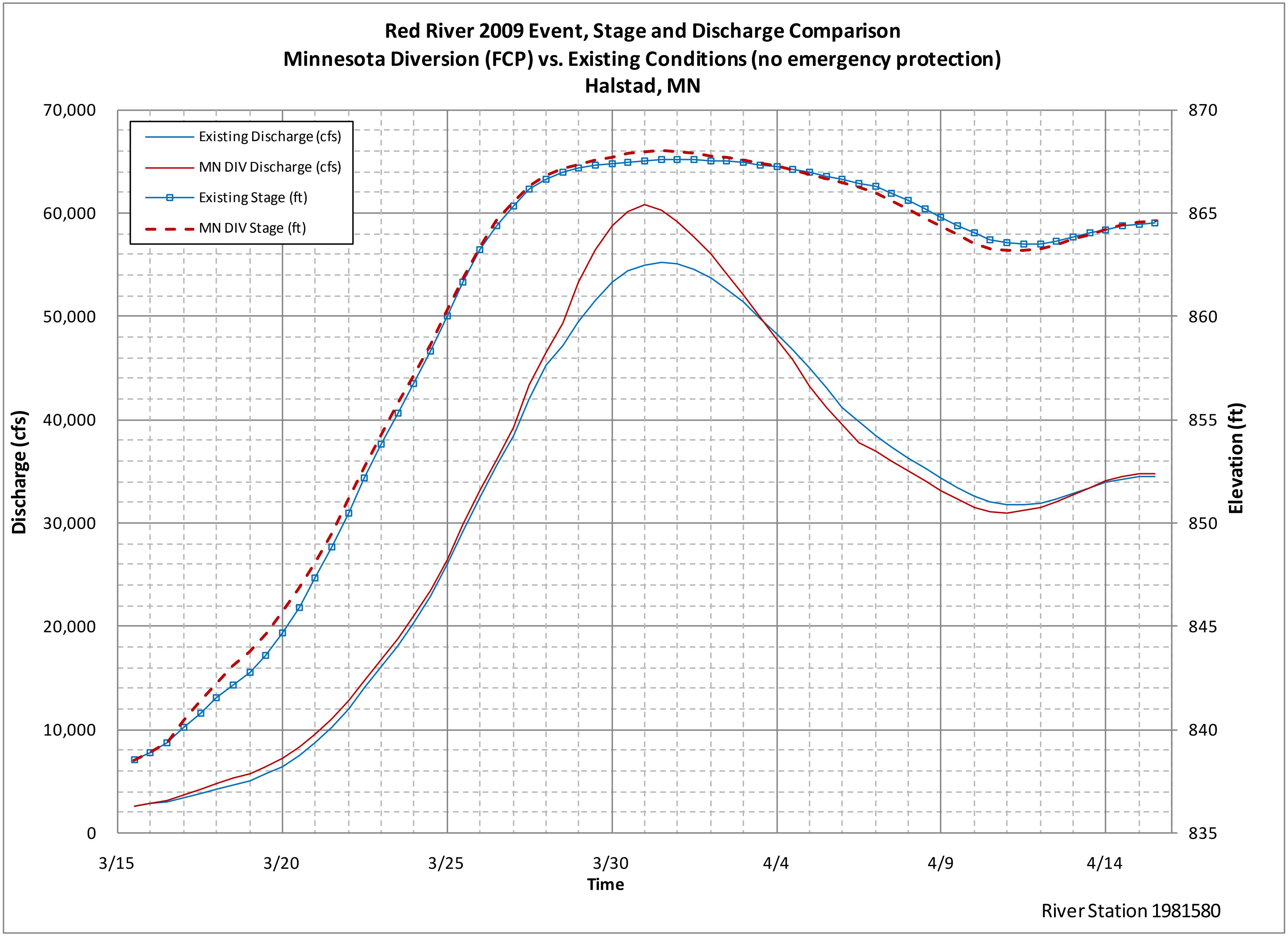


Figure C-E1- 81: 2009 Historical Flood Hydrographs for FCP @ Halstad

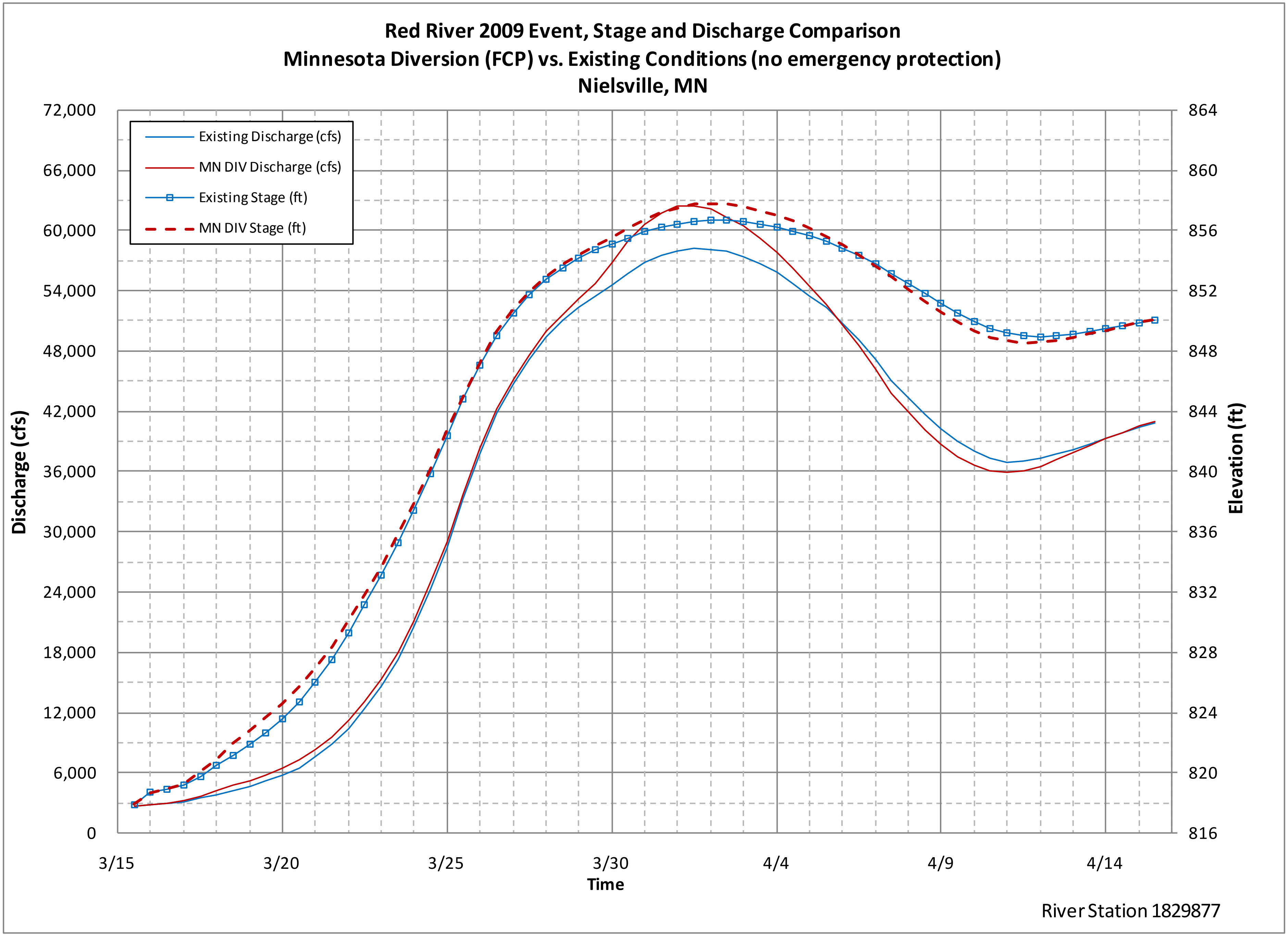


Figure C-E1- 82: 2009 Historical Flood Hydrographs for FCP @ Nielsville

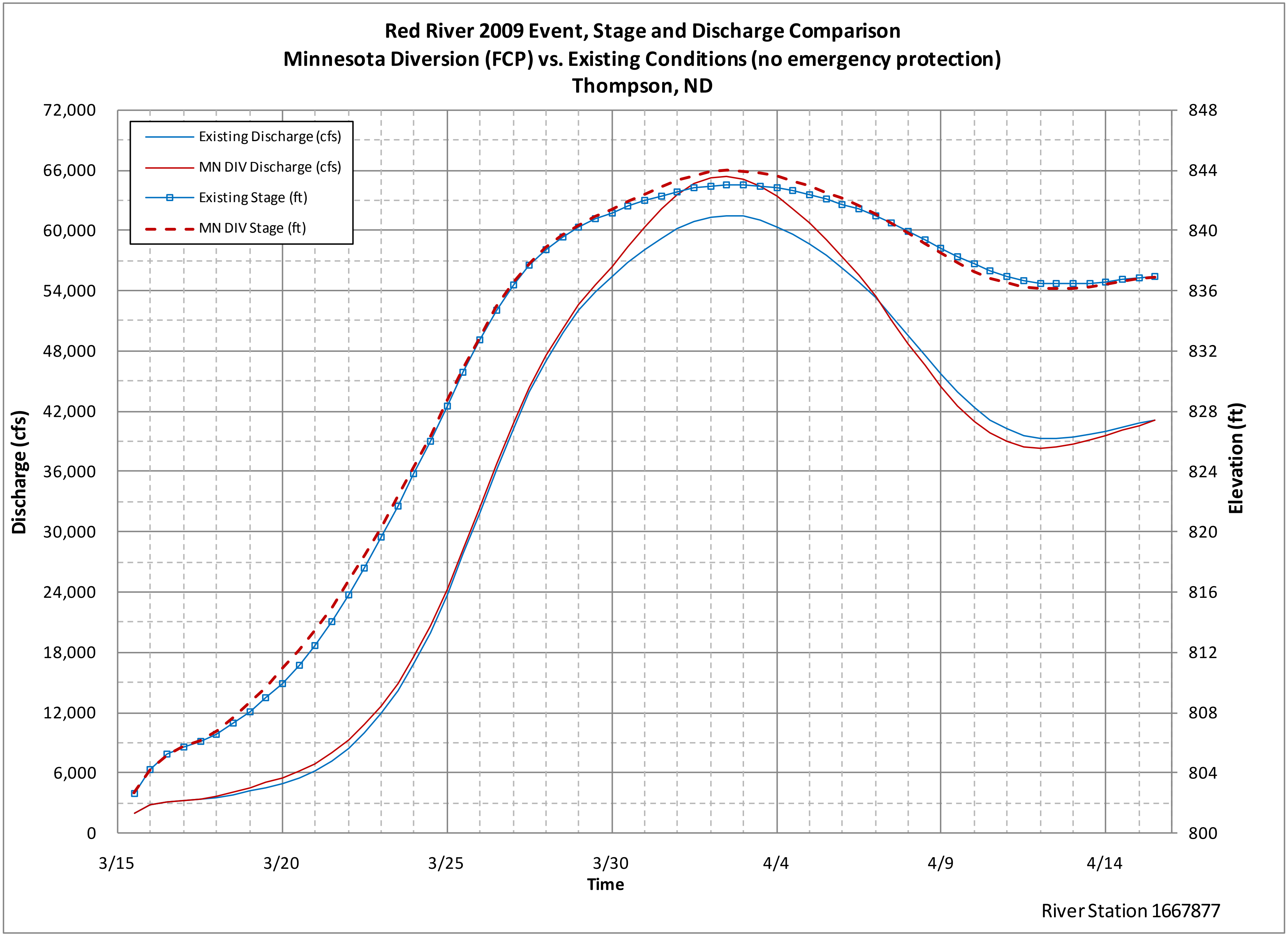


Figure C-E1- 83: 2009 Historical Flood Hydrographs for FCP @ Thompson

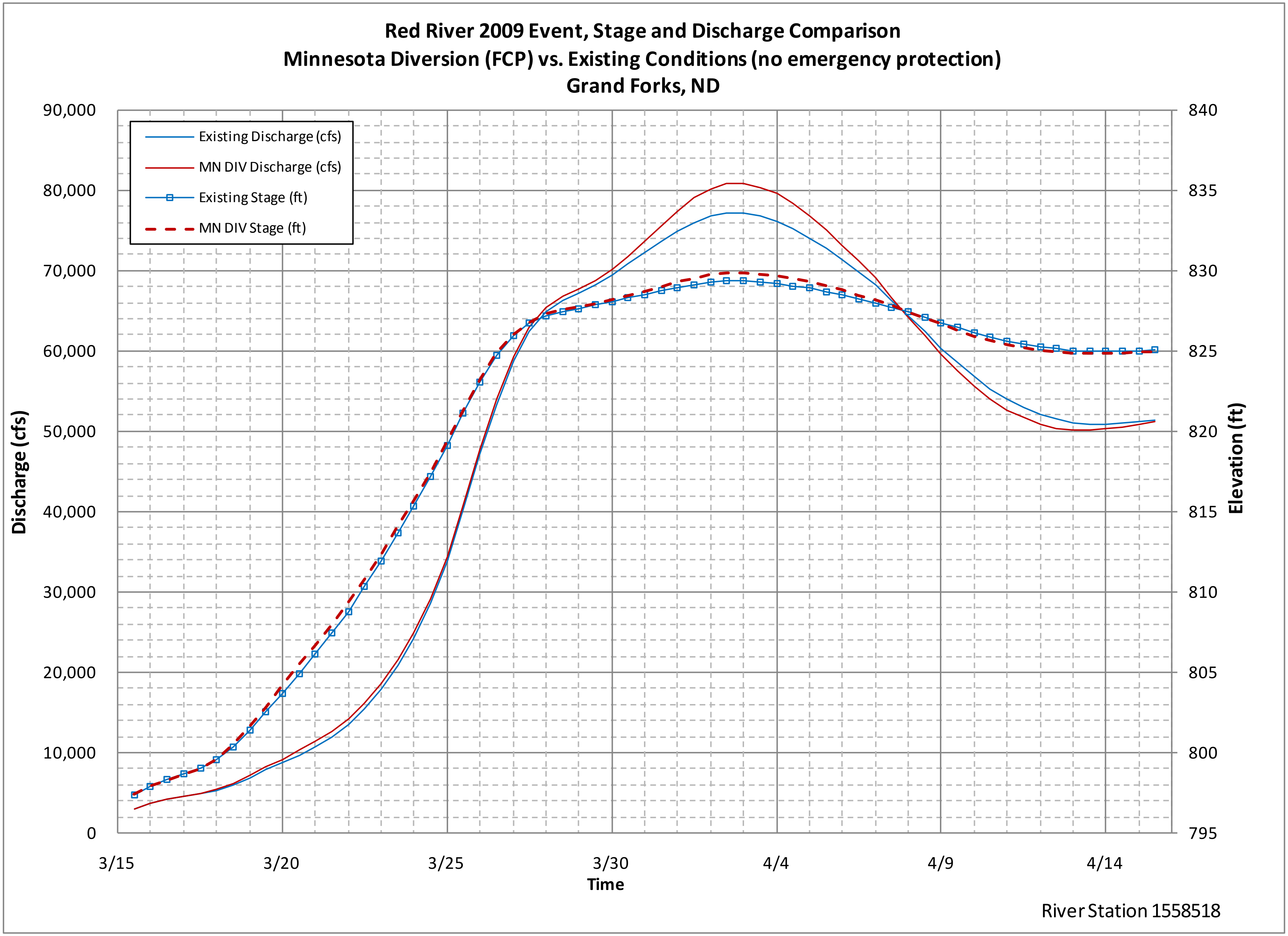


Figure C-E1- 84: 2009 Historical Flood Hydrographs for FCP @ Grand Forks

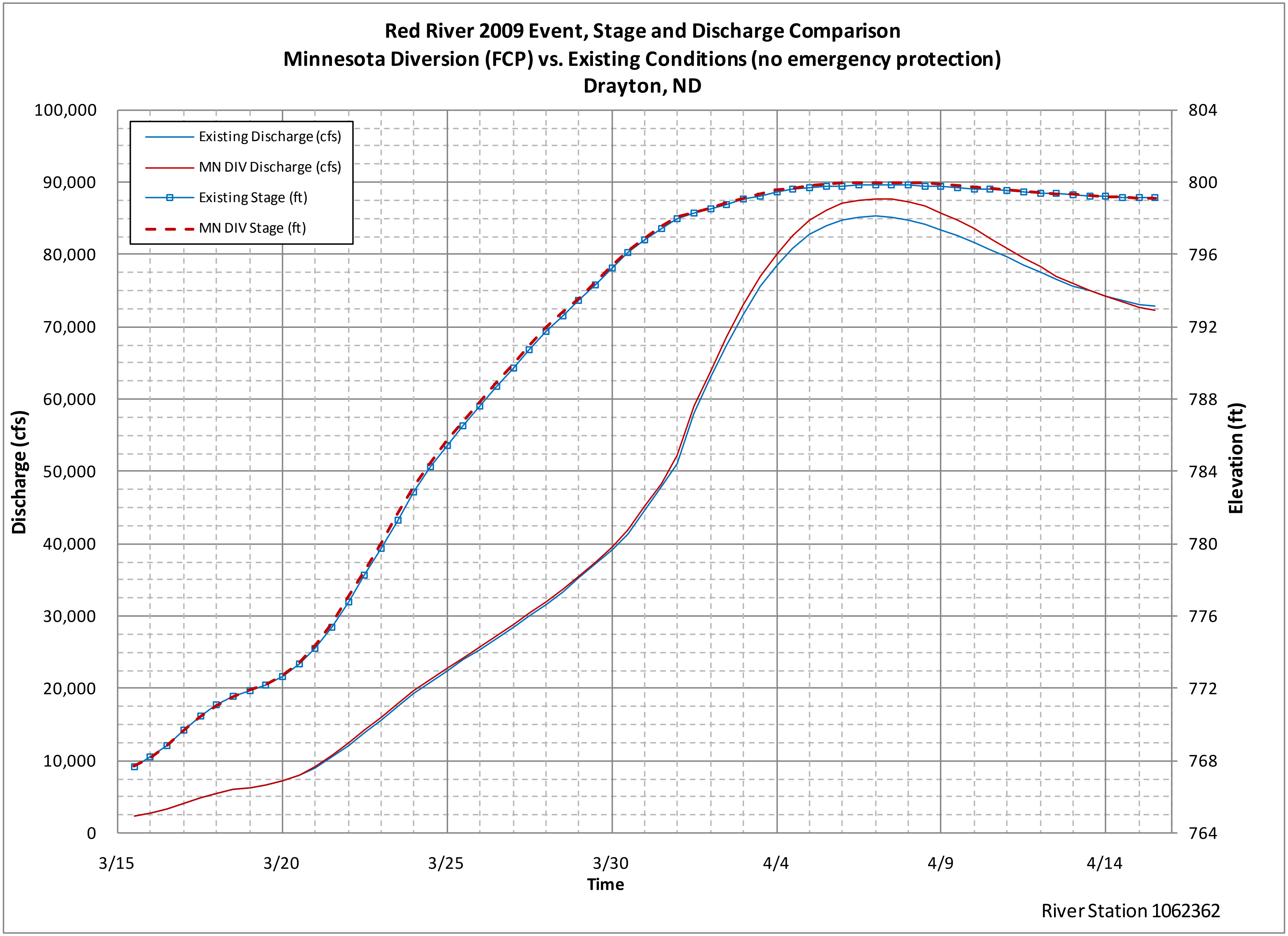


Figure C-E1- 85: 2009 Historical Flood Hydrographs for FCP @ Drayton

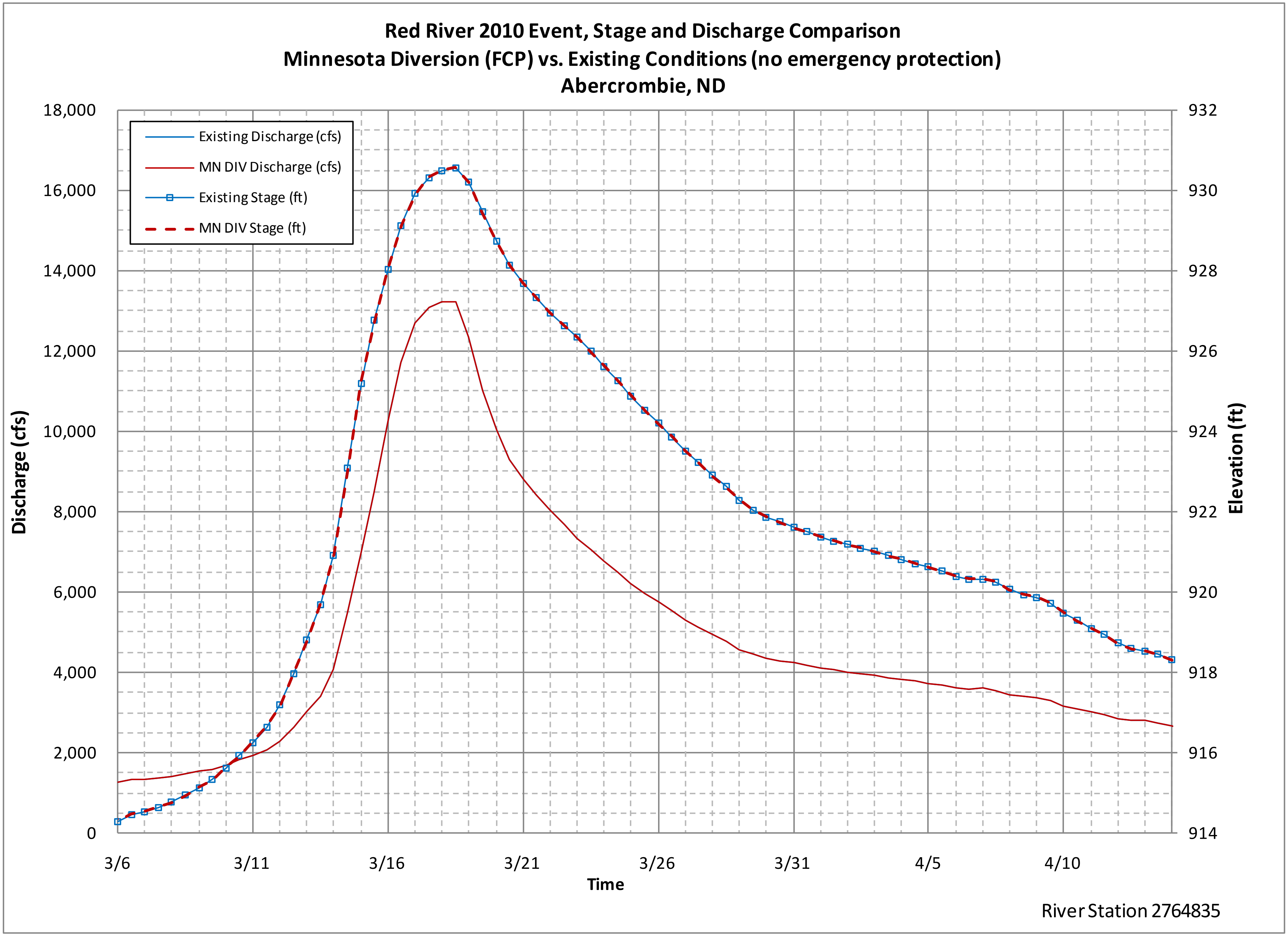


Figure C-E1- 86: 2010 Historical Flood Hydrographs for FCP @ Abercrombie

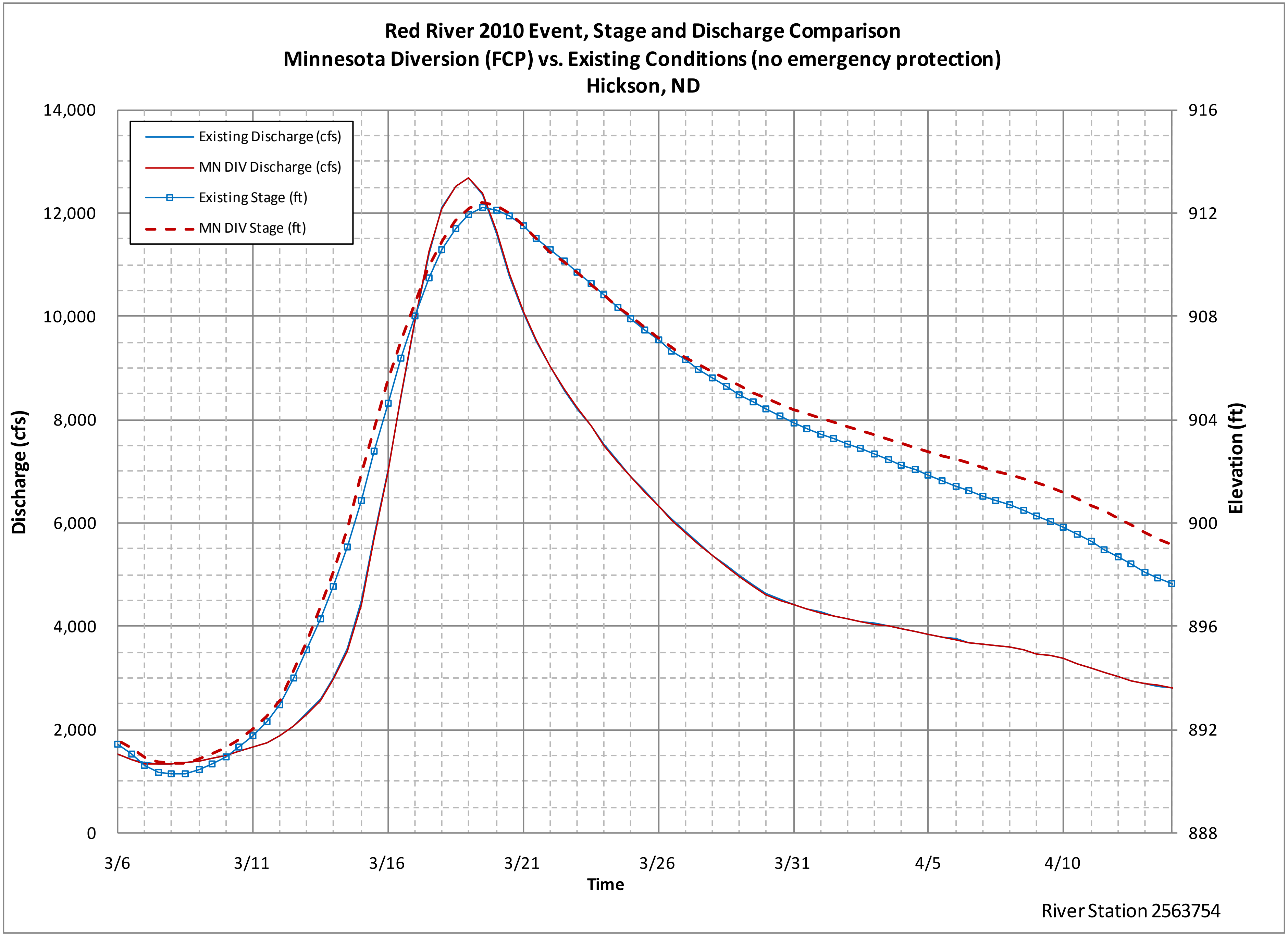


Figure C-E1- 87: 2010 Historical Flood Hydrographs for FCP @ Hickson

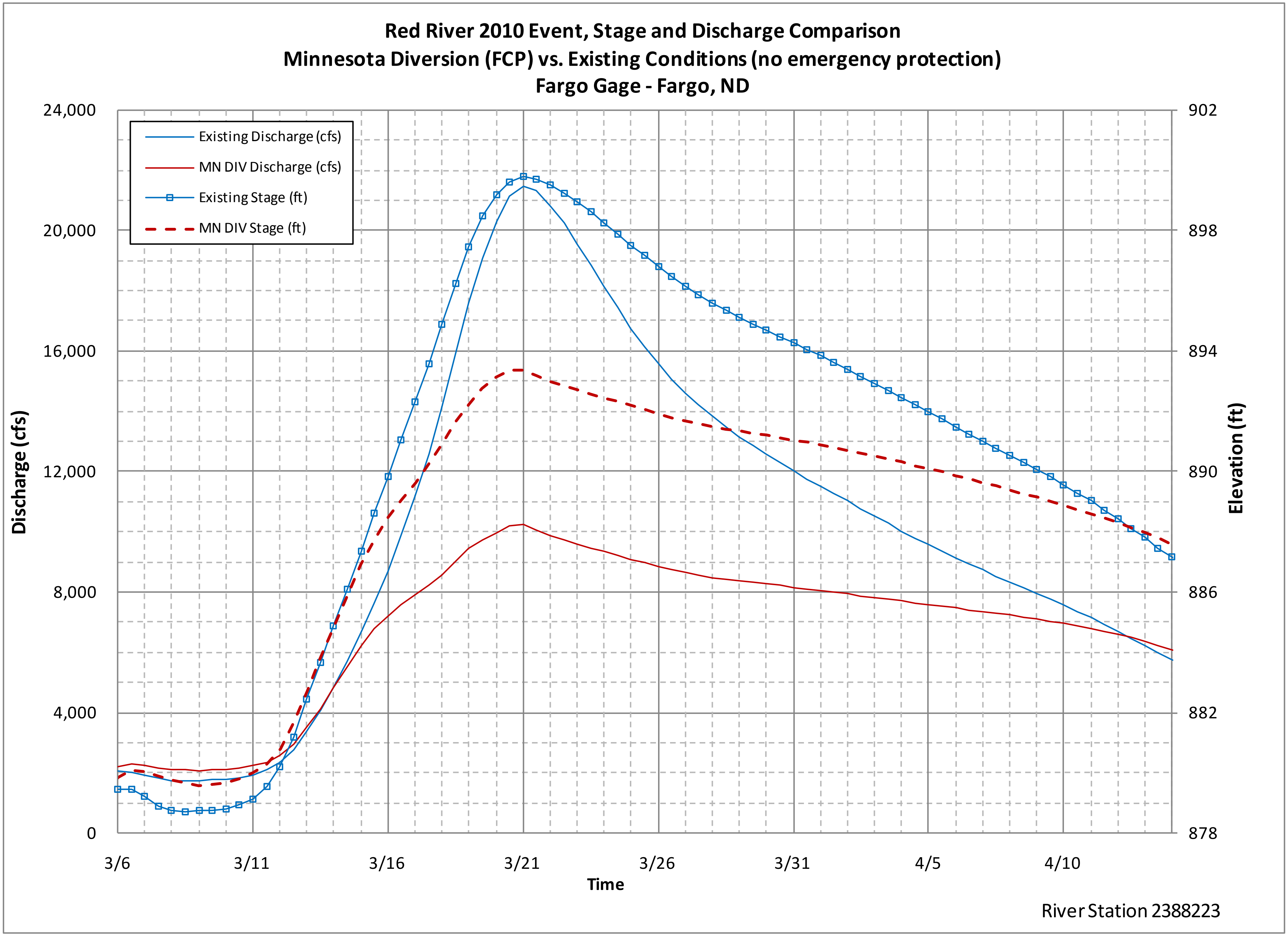


Figure C-E1- 88: 2010 Historical Flood Hydrographs for FCP @ Fargo

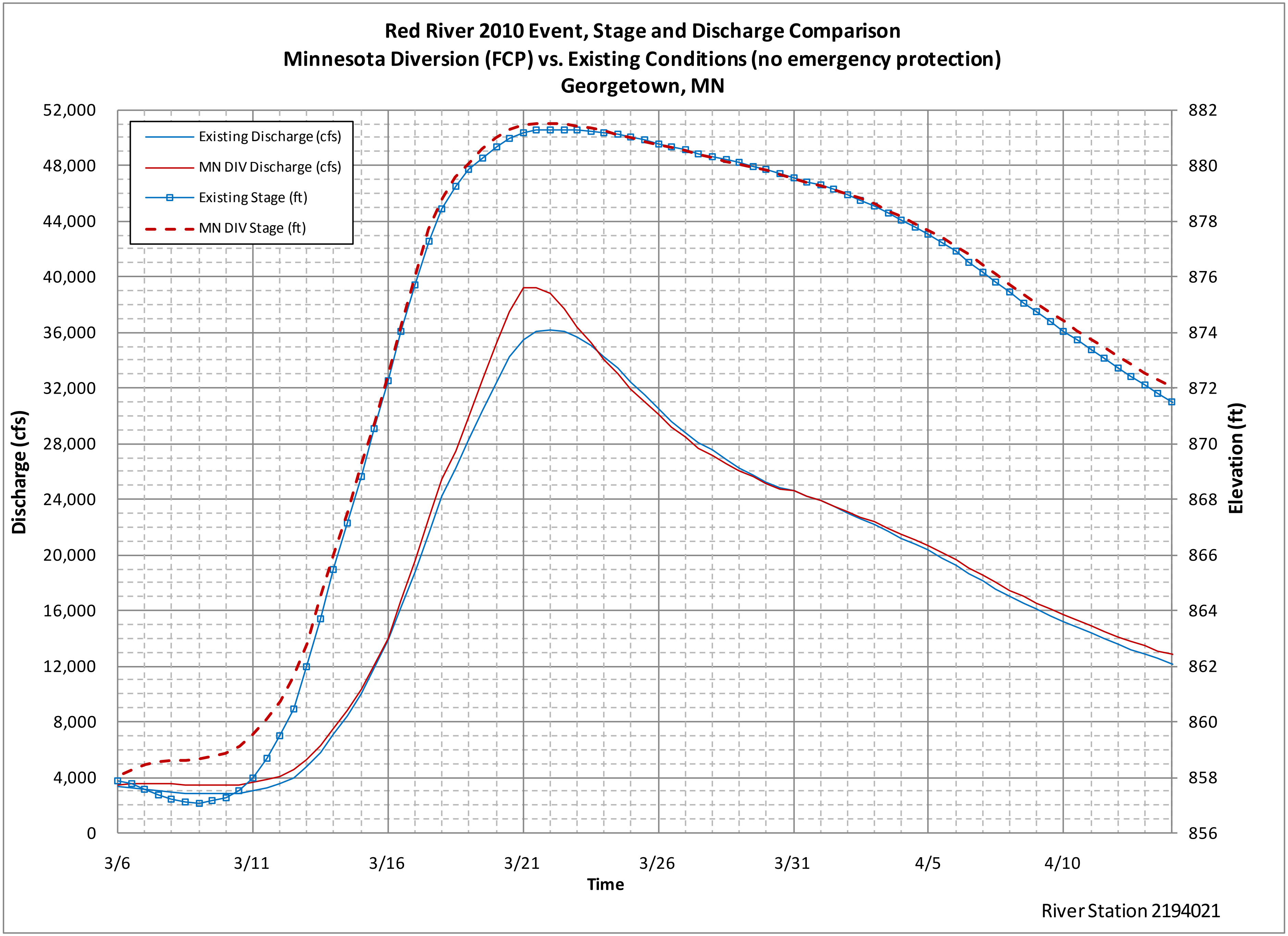


Figure C-E1- 89: 2010 Historical Flood Hydrographs for FCP @ Georgetown

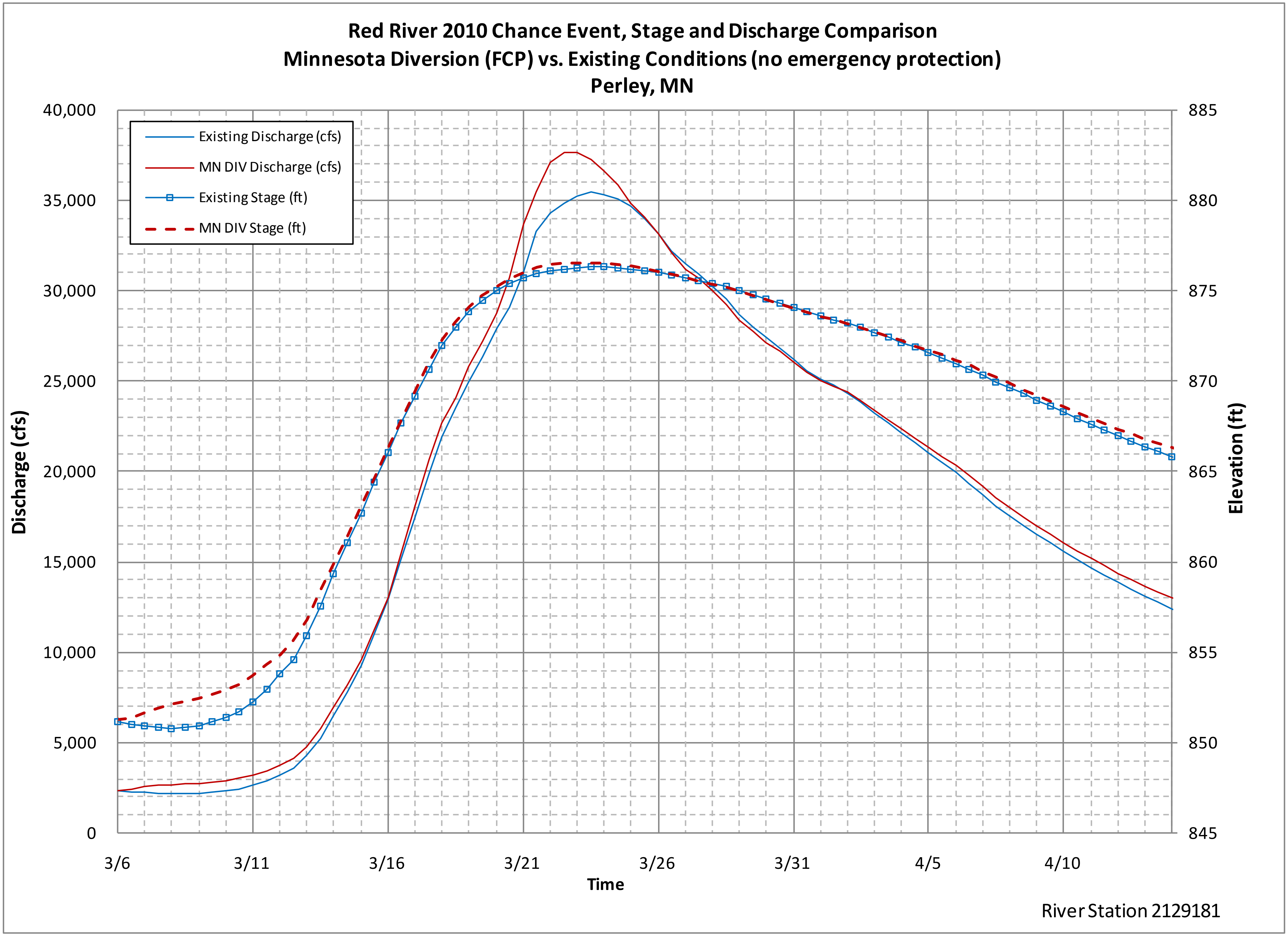


Figure C-E1- 90: 2010 Historical Flood Hydrographs for FCP @ Perley

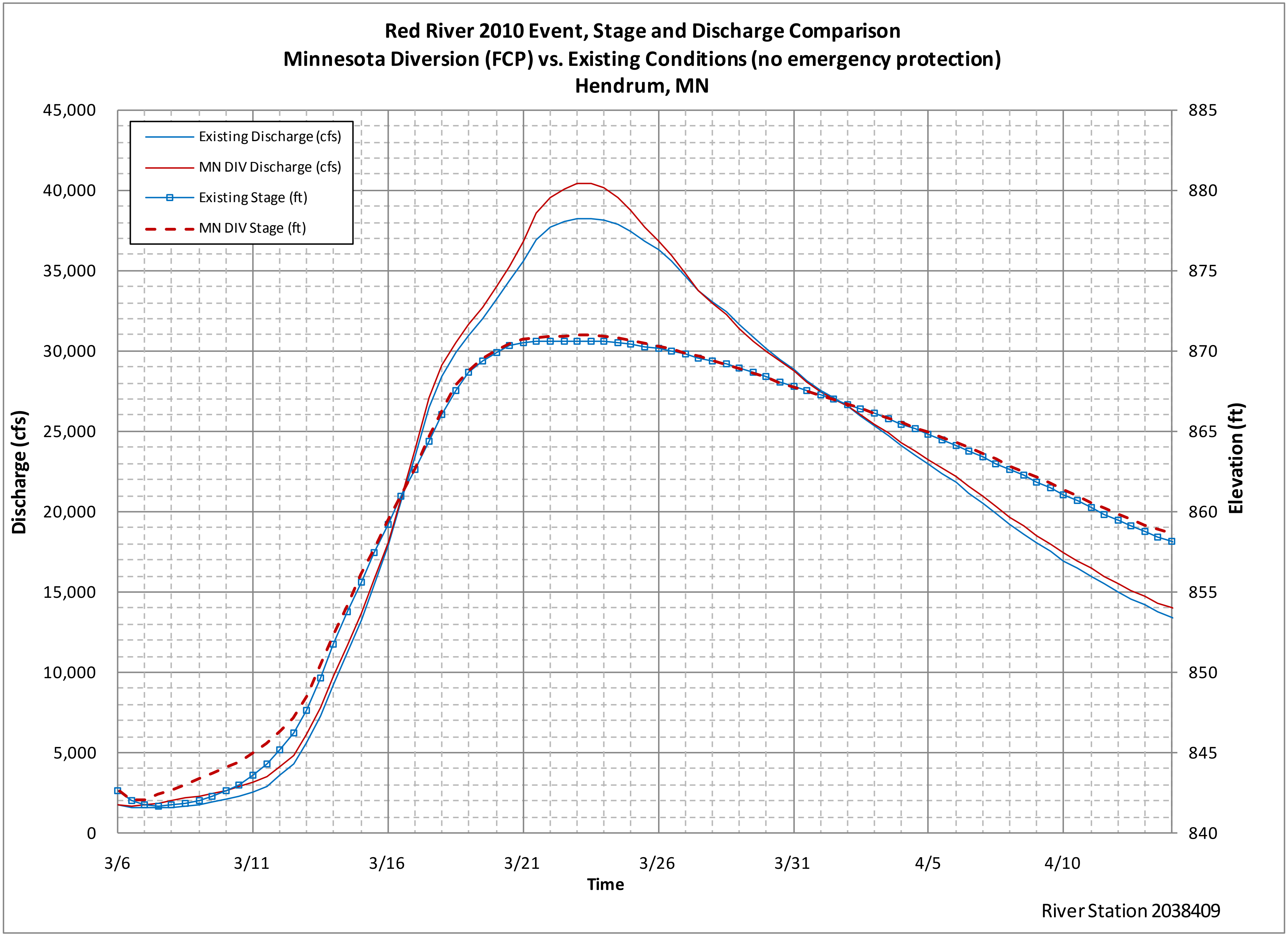


Figure C-E1- 91: 2010 Historical Flood Hydrographs for FCP @ Hendrum

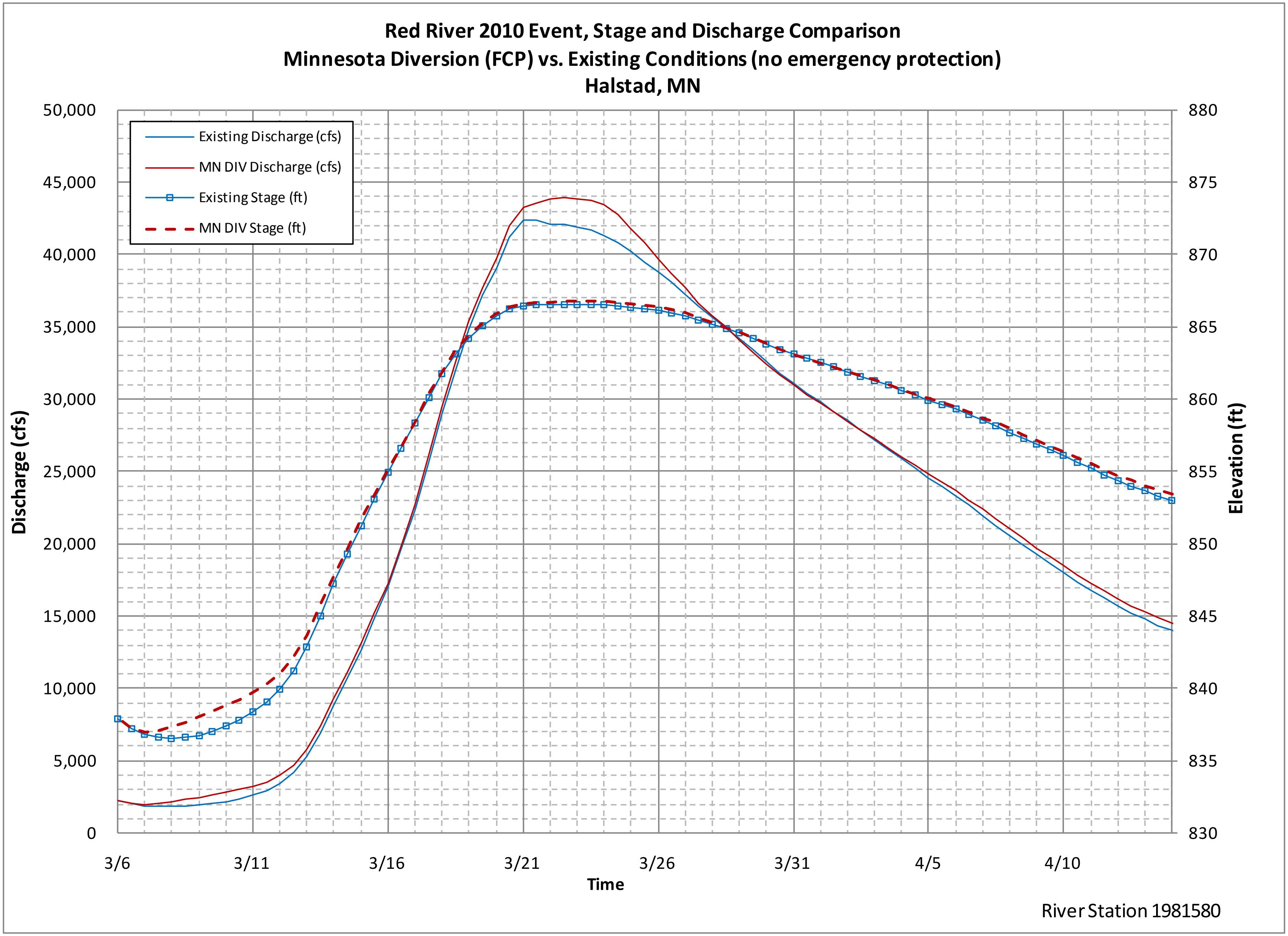


Figure C-E1- 92: 2010 Historical Flood Hydrographs for FCP @ Halstad

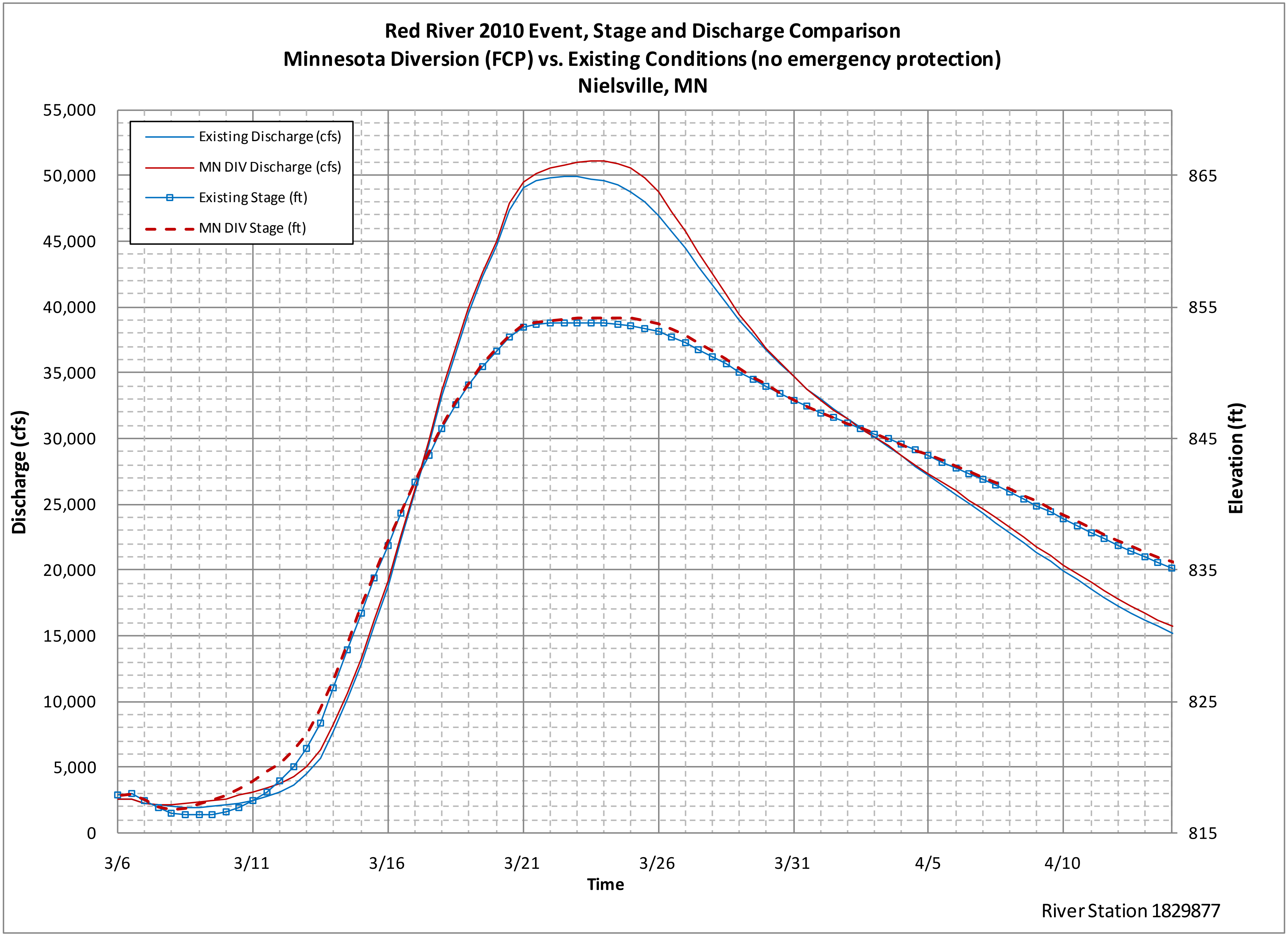


Figure C-E1- 93: 2010 Historical Flood Hydrographs for FCP @ Nielsville

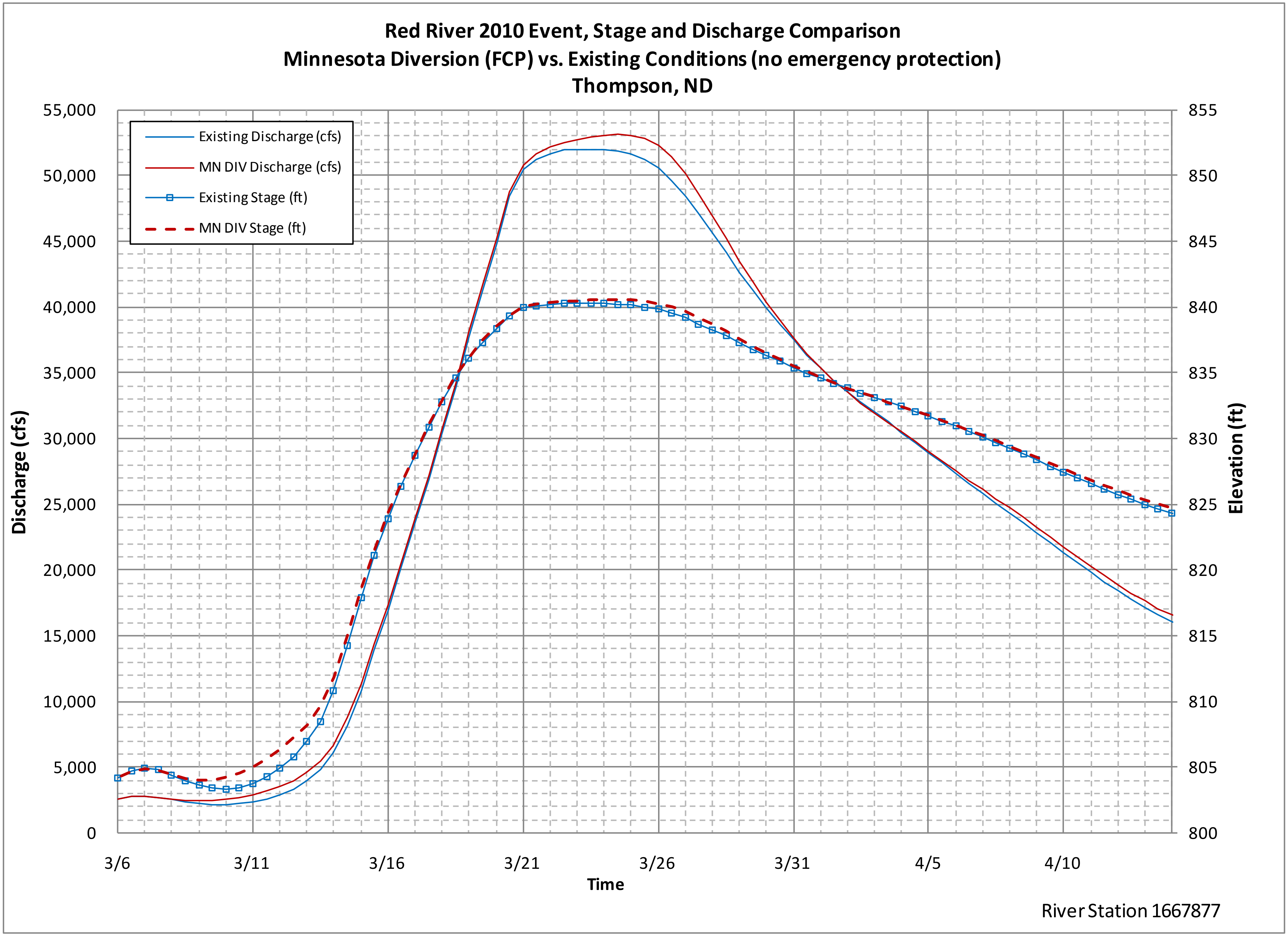


Figure C-E1- 94: 2010Historical Flood Hydrographs for FCP @ Thompson

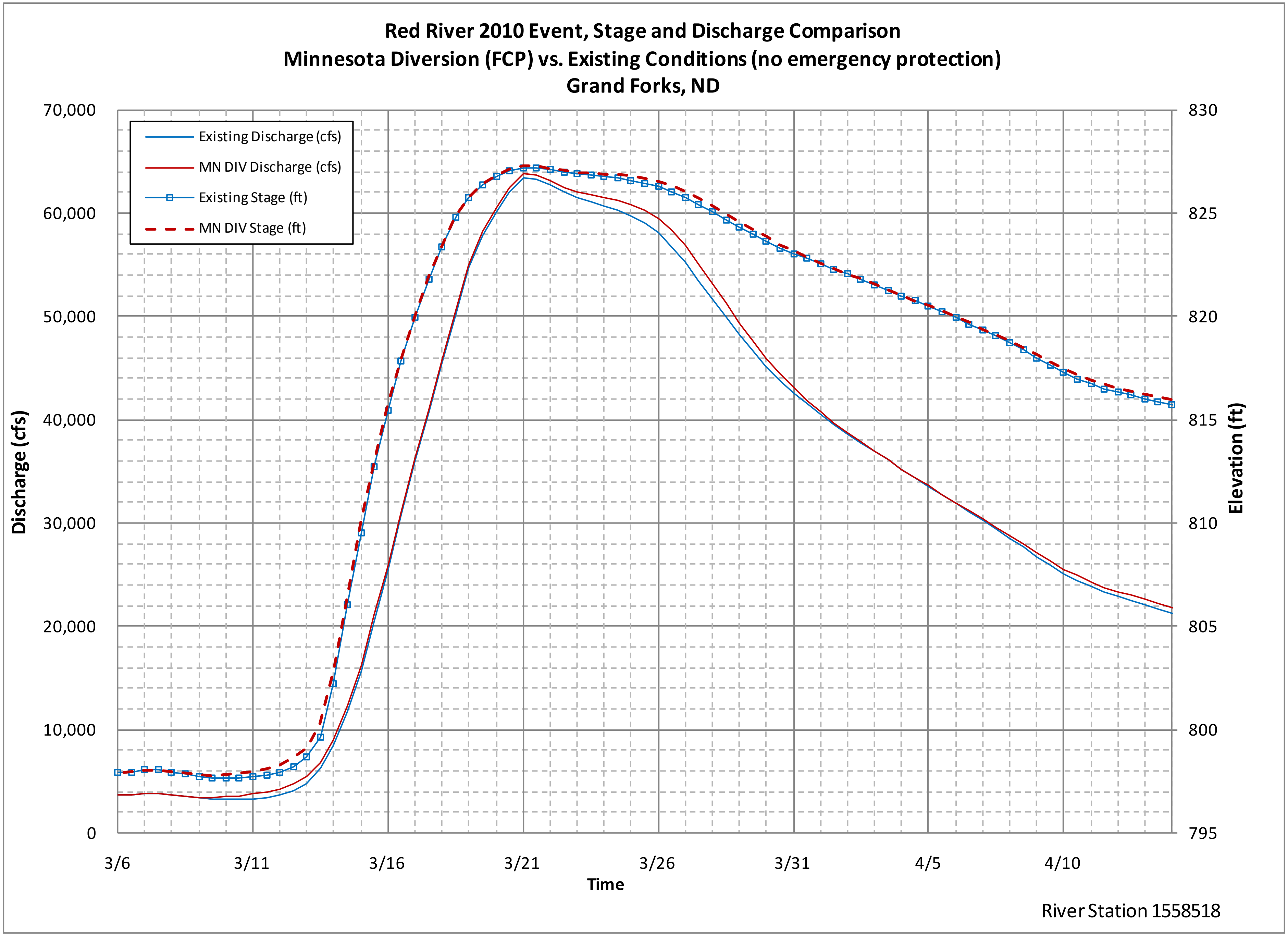


Figure C-E1- 95: 2010 Historical Flood Hydrographs for FCP @ Grand Forks

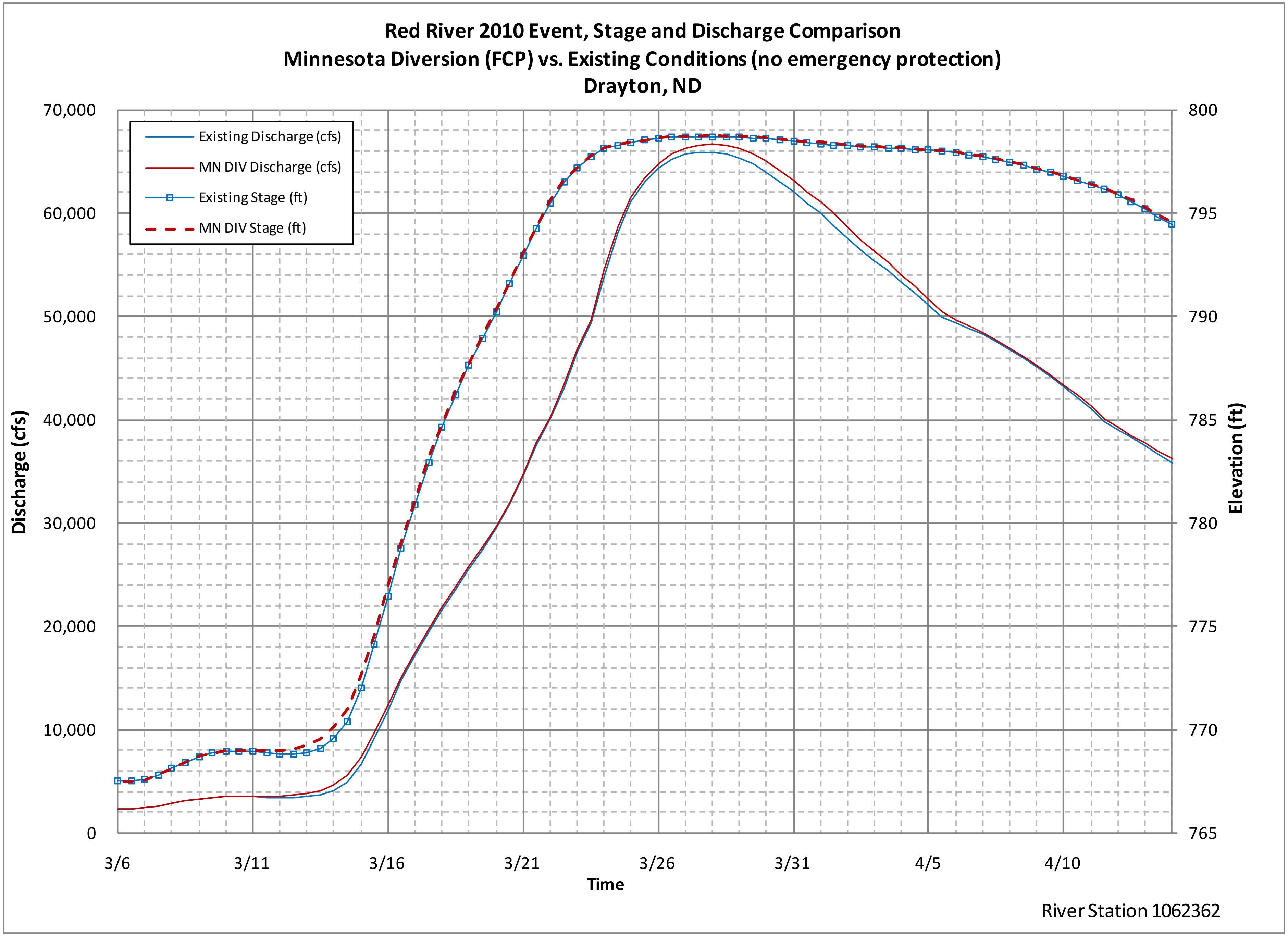


Figure C-E1- 96: 2010 Historical Flood Hydrographs for FCP @ Drayton

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

EXHIBIT 2 – LPP IMPACTS

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: February 28, 2011

FIGURES

2-28-2011

North Dakota Diversion (LPP) - 10% Chance Event							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.53	62917	798.54	63042	0.01	125
ND SH#17/ MN SH317	1223286	800.78		800.80		0.02	
Co. Hwy 15	1315673	802.60		802.61		0.01	
Minimum Impact Location	1327581	803.44		803.45		0.01	
Oslo Gage	1416287	810.51		810.55		0.04	
DS Grand Forks Levees	1533523	823.07		823.15		0.08	
Grand Forks Gage	1558518	825.98	56662	826.09	57169	0.11	507
Maximum Impact Location	1561283	826.49		826.61		0.12	
32nd Ave, Grand Forks	1580152	827.76		827.87		0.11	
Thompson Gage	1667877	837.58	42815	837.62	42843	0.04	28
Co. Hwy 25/ Co. Rd 221	1726274	842.99		843.03		0.04	
DS Sandhill River/ Climax	1763746	845.62		845.65		0.03	
Nielsville	1829877	850.21	39667	850.24	39942	0.03	274
DS Marsh River	1864960	853.10		853.14		0.04	
US Goose River/ Shelly	1891054	855.90		855.93		0.03	
Halstad Gage	1981580	864.55	34653	864.43	34160	-0.12	-493
Hendrum	2038409	868.94	32267	868.69	31580	-0.25	-687
Perley	2129181	874.83	28448	874.29	26476	-0.54	-1972
Georgetown	2194021	880.34		879.91		-0.43	
North River/ Clay Co. Hwy 93	2305647	889.72		884.23		-5.49	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	894.08		888.72		-5.36	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.33 (34.59*)	17024	891.86 (29.12*)	10156	-5.47	-6868
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	901.61		896.12		-5.49	
US ND Wild Rice River	2484618	905.37		900.22		-5.15	
US LPP Diversion	2531315	908.06		916.29		8.23	
Hickson Gage	2563754	910.21	10428	916.80	10077	6.59	-351
Abercrombie	2764835	929.05	11278	929.16	11278	0.11	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

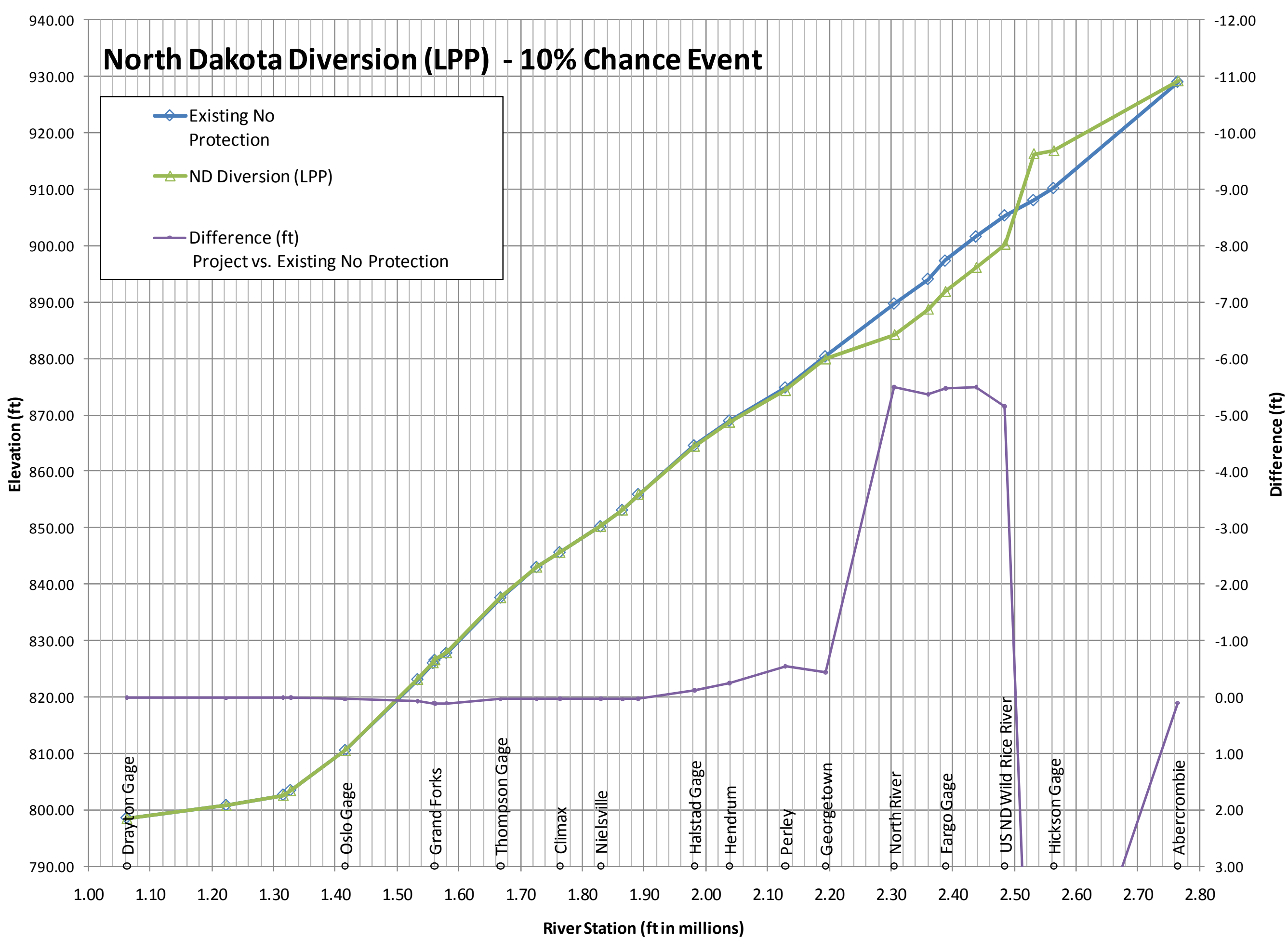


Figure C-E2- 1: 10-Percent Chance Impacts for LPP

2-28-2011

North Dakota Diversion (LPP) - 2% Chance Event							
Location	Station	Existing No Protection		ND Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	800.72	100869	800.80	102165	0.08	1296
ND SH#17/ MN SH317	1223286	803.19		803.26		0.07	
Co. Hwy 15	1315673	804.35		804.40		0.05	
Minimum Impact Location	1410241	811.12		811.15		0.03	
Oslo Gage	1416287	812.53		812.57		0.04	
DS Grand Forks Levees	1533523	826.86		826.97		0.11	
Grand Forks Gage	1558518	831.13	91118	831.31	92619	0.18	1501
32nd Ave, Grand Forks	1580152	833.57		833.85		0.28	
Maximum Impact Location	1602184	836.27		836.65		0.38	
Thompson Gage	1667877	844.83	69367	845.07	70104	0.24	737
Co. Hwy 25/ Co. Rd 221	1726274	851.40		851.61		0.21	
DS Sandhill River/ Climax	1763746	854.11		854.32		0.21	
Nielsville	1829877	858.57	63543	858.75	64333	0.18	791
DS Marsh River	1864960	860.76		860.92		0.16	
US Goose River/ Shelly	1891054	863.04		863.16		0.12	
Halstad Gage	1981580	867.99	59416	867.99	59542	0.00	126
Hendrum	2038409	872.82	56143	872.70	55381	-0.12	-762
Perley	2129181	877.75	51248	877.43	47559	-0.32	-3689
Georgetown	2194021	882.76		882.53		-0.23	
North River/ Clay Co. Hwy 93	2305647	892.97		886.22		-6.75	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.21		889.86		-8.35	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.6 (39.86*)	29167	892.72 (29.98*)	10603	-9.88	-18565
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.94		896.73		-10.21	
US ND Wild Rice River	2484618	910.11		900.70		-9.41	
US LPP Diversion	2531315	913.76		920.86		7.10	
Hickson Gage	2563754	916.34	18898	920.92	18428	4.58	-470
Abercrombie	2764835	934.48	20726	934.62	20726	0.14	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

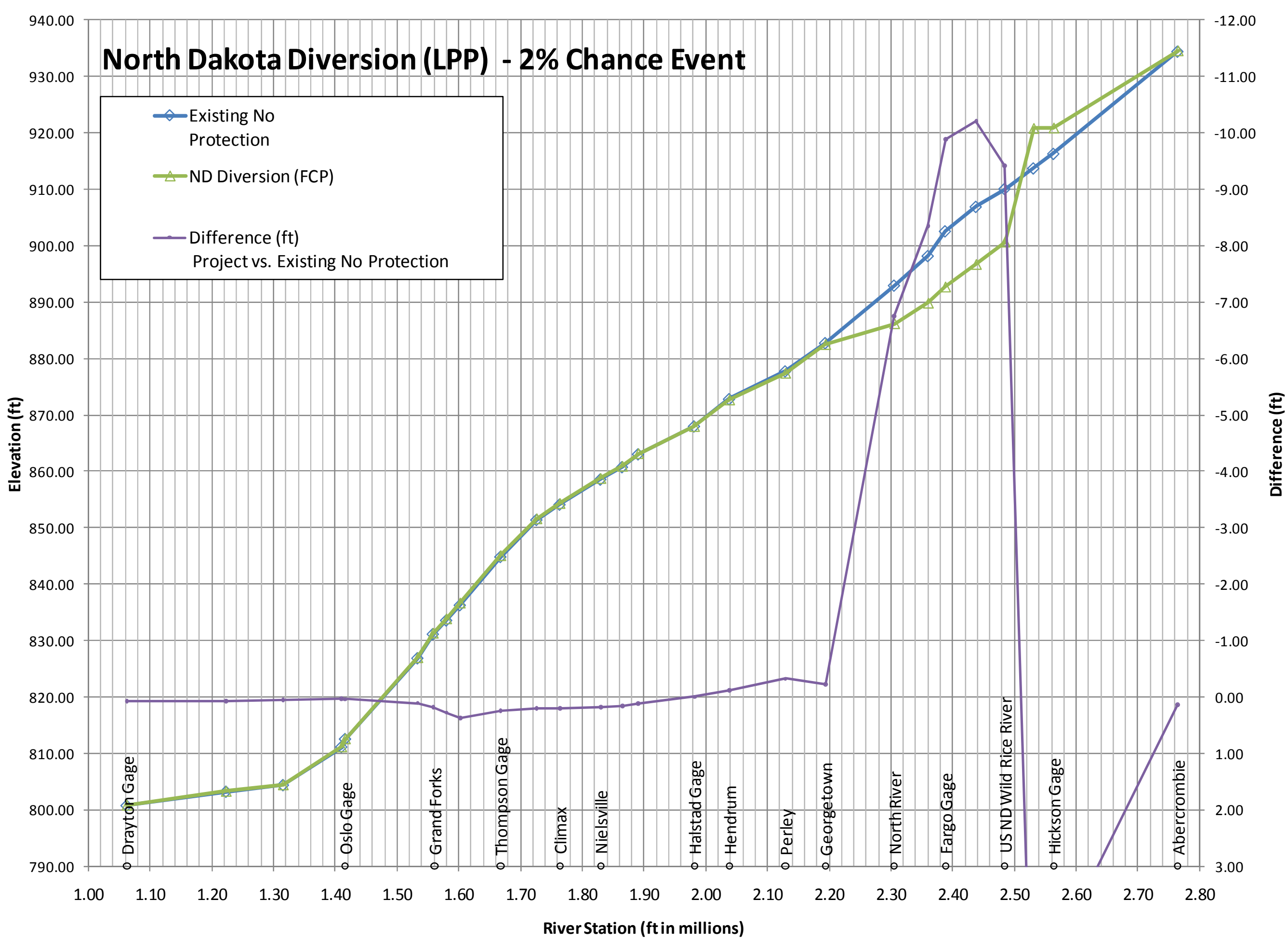


Figure C-E2- 2: 2-Percent Chance Impacts for LPP

North Dakota Diversion (LPP) - 1% Chance Event							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.81	120751	0.08	1496
ND SH#17/ MN SH317	1223286	804.09		804.16		0.07	
Co. Hwy 15	1315673	805.08		805.13		0.05	
Minimum Impact Location	1410241	811.47		811.51		0.04	
Oslo Gage	1416287	813.01		813.07		0.06	
DS Grand Forks Levees	1533523	827.98		828.13		0.15	
Grand Forks Gage	1558518	832.97	107980	833.21	110497	0.24	2517
Maximum Impact Location	1573768	835.27		835.56		0.29	
32nd Ave, Grand Forks	1580152	835.83		836.11		0.28	
Thompson Gage	1667877	847.35	82926	847.39	82608	0.04	-317
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.44		-0.02	
DS Sandhill River/ Climax	1763746	857.34		857.30		-0.04	
Nielsville	1829877	861.66	75745	861.62	76038	-0.04	293
DS Marsh River	1864960	863.43		863.40		-0.03	
US Goose River/ Shelly	1891054	865.36		865.32		-0.04	
Halstad Gage	1981580	869.09	71581	869.03	70992	-0.06	-589
Hendrum	2038409	873.75	67278	873.69	66095	-0.06	-1183
Perley	2129181	878.50	61723	878.22	57044	-0.28	-4679
Georgetown	2194021	883.36		883.11		-0.25	
North River/ Clay Co. Hwy 93	2305647	893.73		886.48		-7.25	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.50		-8.58	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.54 (30.8*)	11718	-10.32	-23157
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.66		-10.05	
US ND Wild Rice River	2484618	910.70		901.71		-8.99	
US LPP Diversion	2531315	914.65		922.88		8.23	
Hickson Gage	2563754	917.52	21730	922.90	18655	5.38	-3075
Abercrombie	2764835	935.62	23000	935.73	23000	0.11	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

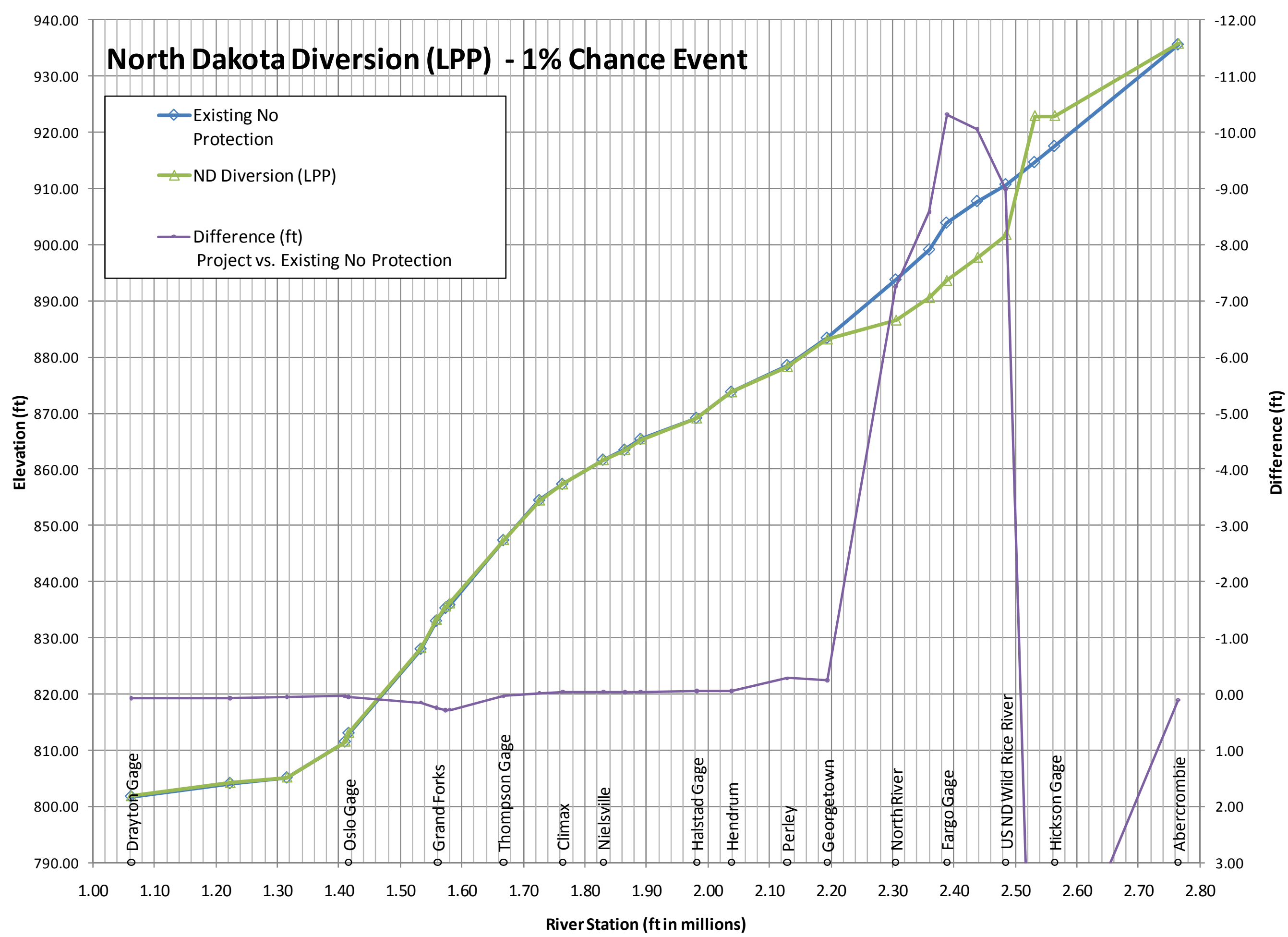


Figure C-E2- 3: 1-Percent Chance Impacts for LPP

North Dakota Diversion (LPP) - 0.2% Chance Event							
Location	Station	Existing No Protection		ND Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.23	171002	0.11	2638
ND SH#17/ MN SH317	1223286	805.99		806.06		0.07	
Co. Hwy 15	1315673	806.74		806.83		0.09	
Minimum Impact Location	1410241	812.15		812.19		0.04	
Oslo Gage	1416287	813.88		813.93		0.05	
DS Grand Forks Levees	1533523	829.92		830.04		0.12	
Grand Forks Gage	1558518	836.36	146225	836.58	149112	0.22	2887
Maximum Impact Location	1561353	838.53		838.80		0.27	
32nd Ave, Grand Forks	1580152	839.75		839.98		0.23	
Thompson Gage	1667877	850.69	112422	850.64	111394	-0.05	-1027
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.26		-0.12	
DS Sandhill River/ Climax	1763746	862.75		862.60		-0.15	
Nielsville	1829877	867.04	107296	866.88	105953	-0.16	-1344
DS Marsh River	1864960	868.06		867.92		-0.14	
US Goose River/ Shelly	1891054	869.30		869.17		-0.13	
Halstad Gage	1981580	871.54	101754	871.32	92746	-0.22	-9007
Hendrum	2038409	875.77	97650	875.47	90871	-0.30	-6779
Perley	2129181	879.89	90756	879.53	79857	-0.36	-10899
Georgetown	2194021	884.48		884.15		-0.33	
North River/ Clay Co. Hwy 93	2305647	895.35		892.96		-2.39	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.32		-1.99	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.77 (40.03*)	29865	-3.03	-31852
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		907.08		-2.05	
US ND Wild Rice River	2484618	911.54		910.23		-1.31	
US LPP Diversion	2531315	915.94		922.44		6.50	
Hickson Gage	2563754	919.69	35636	922.54	32491	2.85	-3145
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

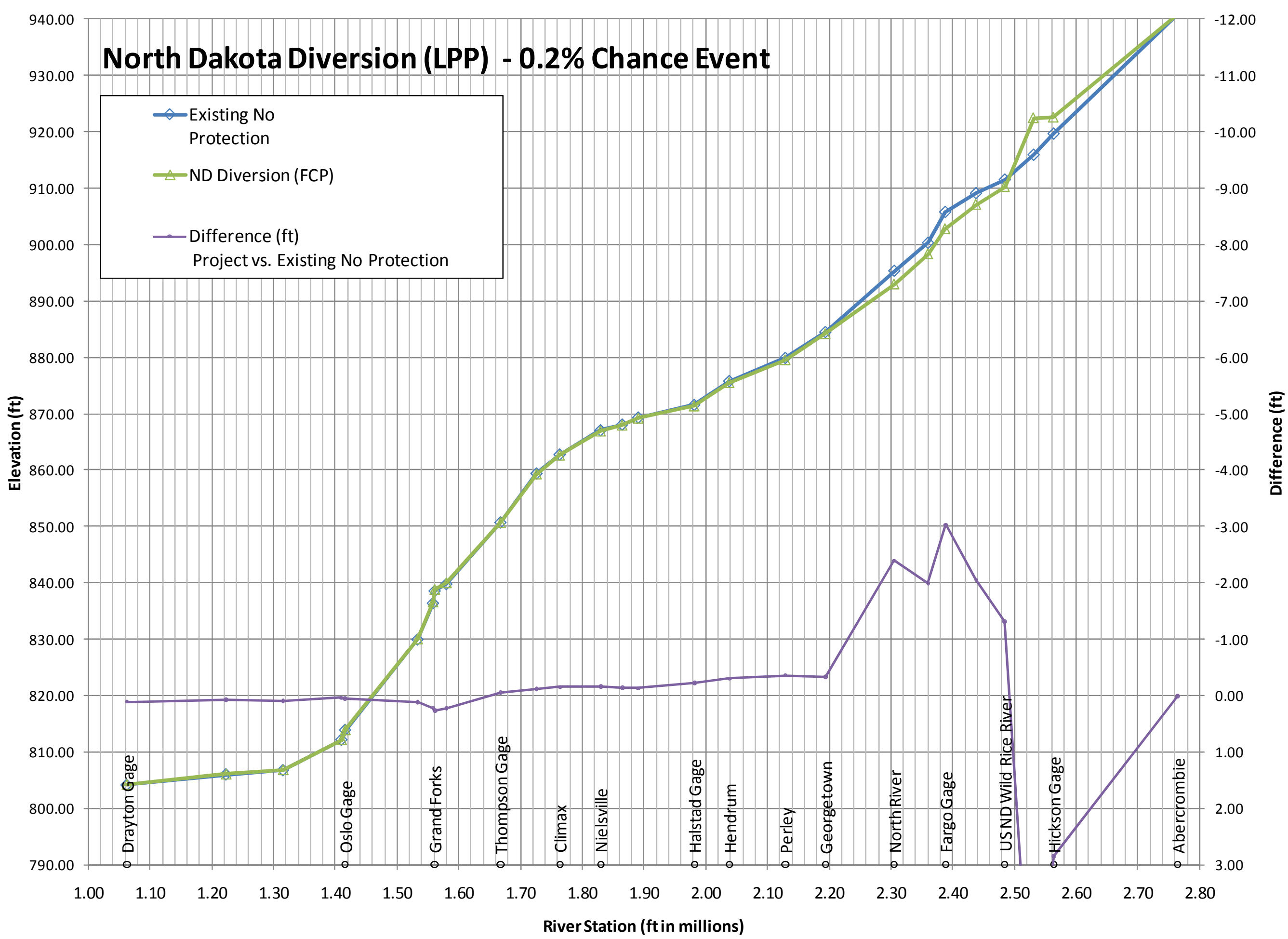


Figure C-E2- 4: 0.2-Percent Chance Impacts for LPP

2-28-2011

North Dakota Diversion (LPP) -1997 Event (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.95	123404	801.94	123251	-0.01	-153
ND SH#17/ MN SH317	1223286	804.31		804.30		-0.01	
Co. Hwy 15	1315673	805.30		805.30		0.00	
Oslo Gage	1416287	813.29		813.30		0.01	
Minimum Impact Location	1555329	833.59		833.60		0.01	
DS Grand Forks Levees	1533523	828.62		828.63		0.01	
Grand Forks Gage	1558518	834.04	119103	834.05	119142	0.01	39
32nd Ave, Grand Forks	1580152	837.02		837.05		0.03	
Thompson Gage	1667877	847.29	78351	847.43	79439	0.14	1088
Co. Hwy 25/ Co. Rd 221	1726274	853.81		854.02		0.21	
DS Sandhill River/ Climax	1763746	856.49		856.72		0.23	
Maximum Impact Location	1829877	860.86		861.11		0.25	
Nielsville	1829877	860.86	71728	861.11	72925	0.25	1197
DS Marsh River	1864960	862.72		862.93		0.21	
US Goose River/ Shelly	1891054	864.75		864.93		0.18	
Halstad Gage	1981580	868.65	64821	868.78	66780	0.13	1959
Hendrum	2038409	873.24	55101	873.38	54197	0.14	-903
Perley	2129181	878.05	54689	878.16	56314	0.11	1625
Georgetown	2194021	882.92		883.03		0.11	
North River/ Clay Co. Hwy 93	2305647	893.04		888.08		-4.96	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.26		891.01		-7.25	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.42 (39.68*)	27574	893.11 (30.37*)	9968	-9.31	-17606
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.49		896.06		-10.43	
US ND Wild Rice River	2484618	909.37		900.01		-9.36	
US LPP Diversion	2531315	911.89		921.60		9.71	
Hickson Gage	2563754	913.85	13729	921.63	13235	7.78	-494
Abercrombie	2764835	931.08	13995	931.36	13995	0.28	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

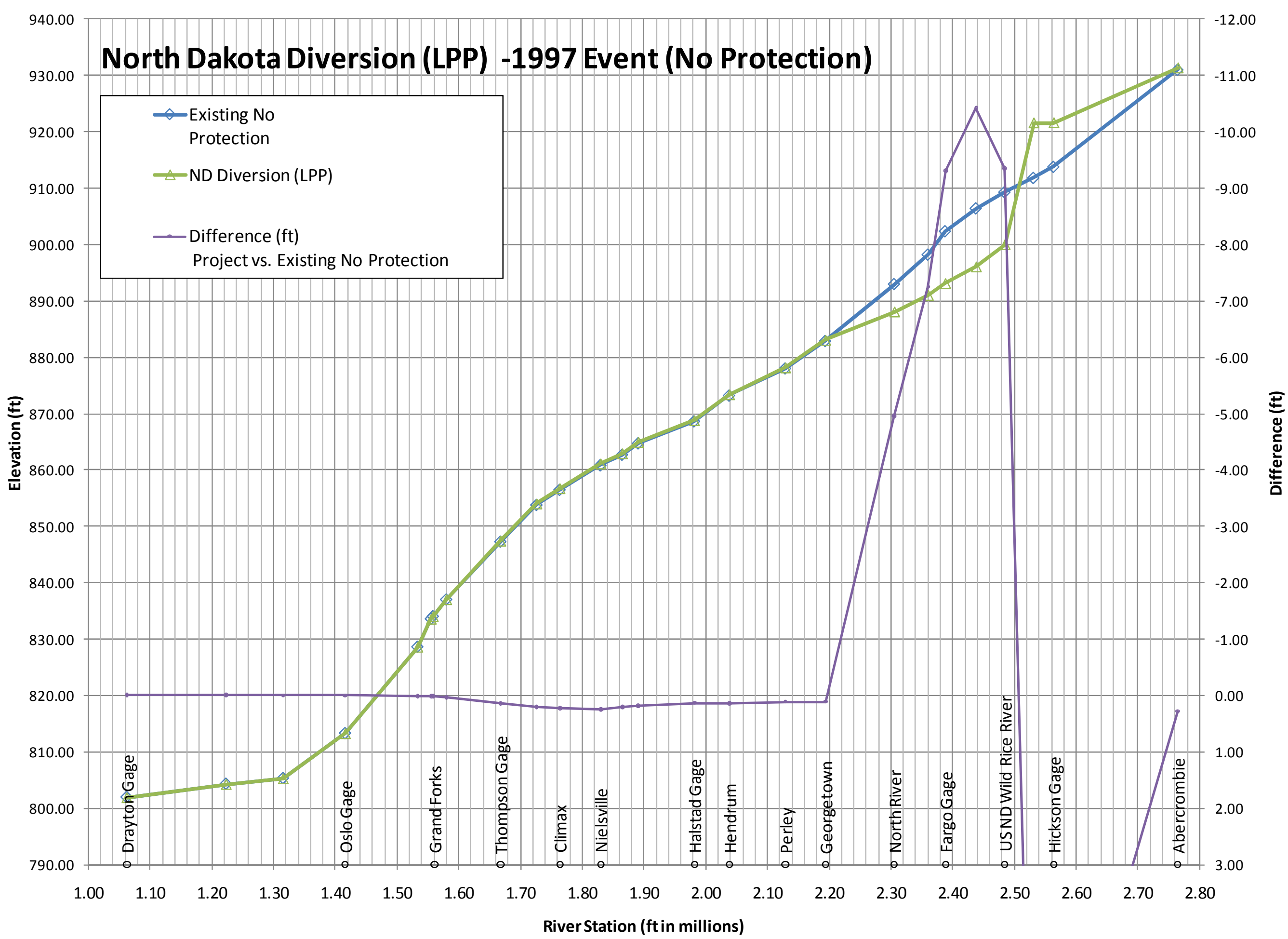


Figure C-E2- 5: 1997 Historical Flood Impacts for LPP

North Dakota Diversion (LPP) -2006 Event (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.44	78252	799.46	78666	0.02	414
ND SH#17/ MN SH317	1223286	801.84		801.87		0.03	
Co. Hwy 15	1315673	803.39		803.41		0.02	
Oslo Gage	1416287	811.58		811.61		0.03	
Minimum Impact Location	1443147	813.86		813.88		0.02	
DS Grand Forks Levees	1533523	825.11		825.18		0.07	
Grand Forks Gage	1558518	828.63	72782	828.72	73387	0.09	605
32nd Ave, Grand Forks	1580152	830.60		830.71		0.11	
Thompson Gage	1667877	840.63	52499	840.84	53273	0.21	775
Co. Hwy 25/ Co. Rd 221	1726274	846.54		846.79		0.25	
Maximum Impact Location	1749702	848.33		848.59		0.26	
DS Sandhill River/ Climax	1763746	849.17		849.41		0.24	
Nielsville	1829877	853.70	48036	853.95	48880	0.25	844
DS Marsh River	1864960	856.33		856.58		0.25	
US Goose River/ Shelly	1891054	859.08		859.31		0.23	
Halstad Gage	1981580	866.64	43060	866.70	43552	0.06	492
Hendrum	2038409	870.74	36229	870.71	33849	-0.03	-2381
Perley	2129181	876.40	36254	876.09	33619	-0.31	-2635
Georgetown	2194021	881.37		881.14		-0.23	
North River/ Clay Co. Hwy 93	2305647	891.46		884.49		-6.97	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	895.97		888.87		-7.10	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.57 (36.83*)	21028	891.96 (29.22*)	10109	-7.61	-10919
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	903.97		896.16		-7.81	
US ND Wild Rice River	2484618	907.56		900.26		-7.30	
US LPP Diversion	2531315	910.60		918.72		8.12	
Hickson Gage	2563754	913.11	14313	918.90	14362	5.79	49
Abercrombie	2764835	931.58	15027	931.74	15027	0.16	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

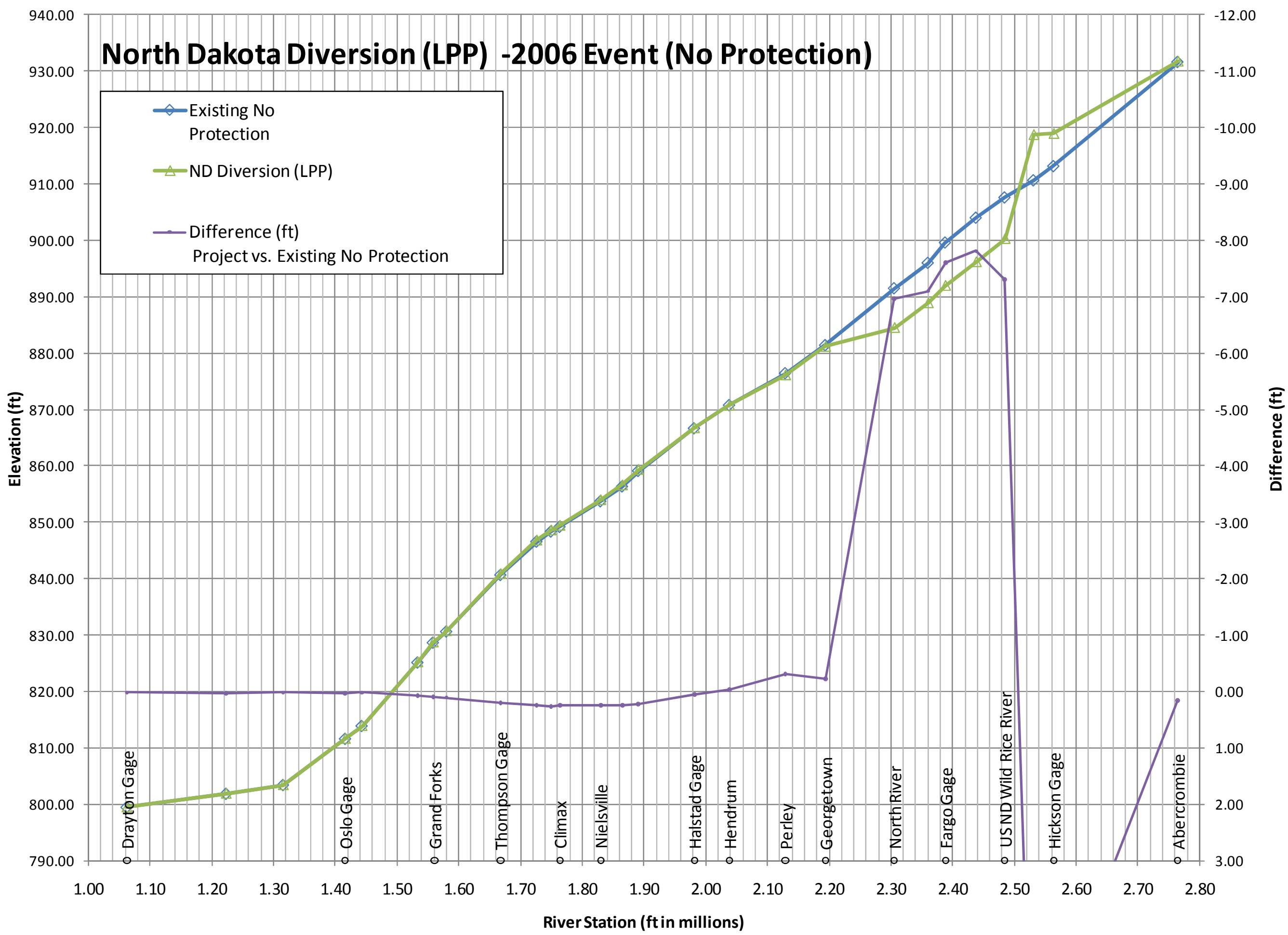


Figure C-E2- 6: 2006 Historical Flood Impacts for LPP

North Dakota Diversion (LPP) -2009 Event (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.85	85308	799.84	85166	-0.01	-143
ND SH#17/ MN SH317	1223286	802.36		802.35		-0.01	
Co. Hwy 15	1315673	803.81		803.80		-0.01	
Minimum Impact Location	1345544	805.87		805.88		0.01	
Oslo Gage	1416287	812.02		812.04		0.02	
DS Grand Forks Levees	1533523	825.65		825.70		0.05	
Grand Forks Gage	1558518	829.33	77165	829.39	77550	0.06	385
Maximum Impact Location	1561353	830.20		830.28		0.08	
32nd Ave, Grand Forks	1580152	831.80		831.86		0.06	
Thompson Gage	1667877	843.05	61510	843.07	61577	0.02	67
Co. Hwy 25/ Co. Rd 221	1726274	849.33		849.35		0.02	
DS Sandhill River/ Climax	1763746	851.96		851.98		0.02	
Nielsville	1829877	856.67	58164	856.67	58406	0.00	242
DS Marsh River	1864960	859.13		859.13		0.00	
US Goose River/ Shelly	1891054	861.73		861.72		-0.01	
Halstad Gage	1981580	867.60	55176	867.56	54910	-0.04	-266
Hendrum	2038409	872.25	44075	872.15	41266	-0.10	-2810
Perley	2129181	877.21	45715	876.99	42804	-0.22	-2911
Georgetown	2194021	882.32		882.00		-0.32	
North River/ Clay Co. Hwy 93	2305647	892.95		886.79		-6.16	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.28		890.52		-7.76	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.66 (39.92*)	29234	893.46 (30.72*)	11561	-9.20	-17674
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.96		897.50		-9.46	
US ND Wild Rice River	2484618	910.20		901.39		-8.81	
US LPP Diversion	2531315	914.24		921.62		7.38	
Hickson Gage	2563754	917.76	24393	921.64	24562	3.88	170
Abercrombie	2764835	937.51	28176	937.59	28176	0.08	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

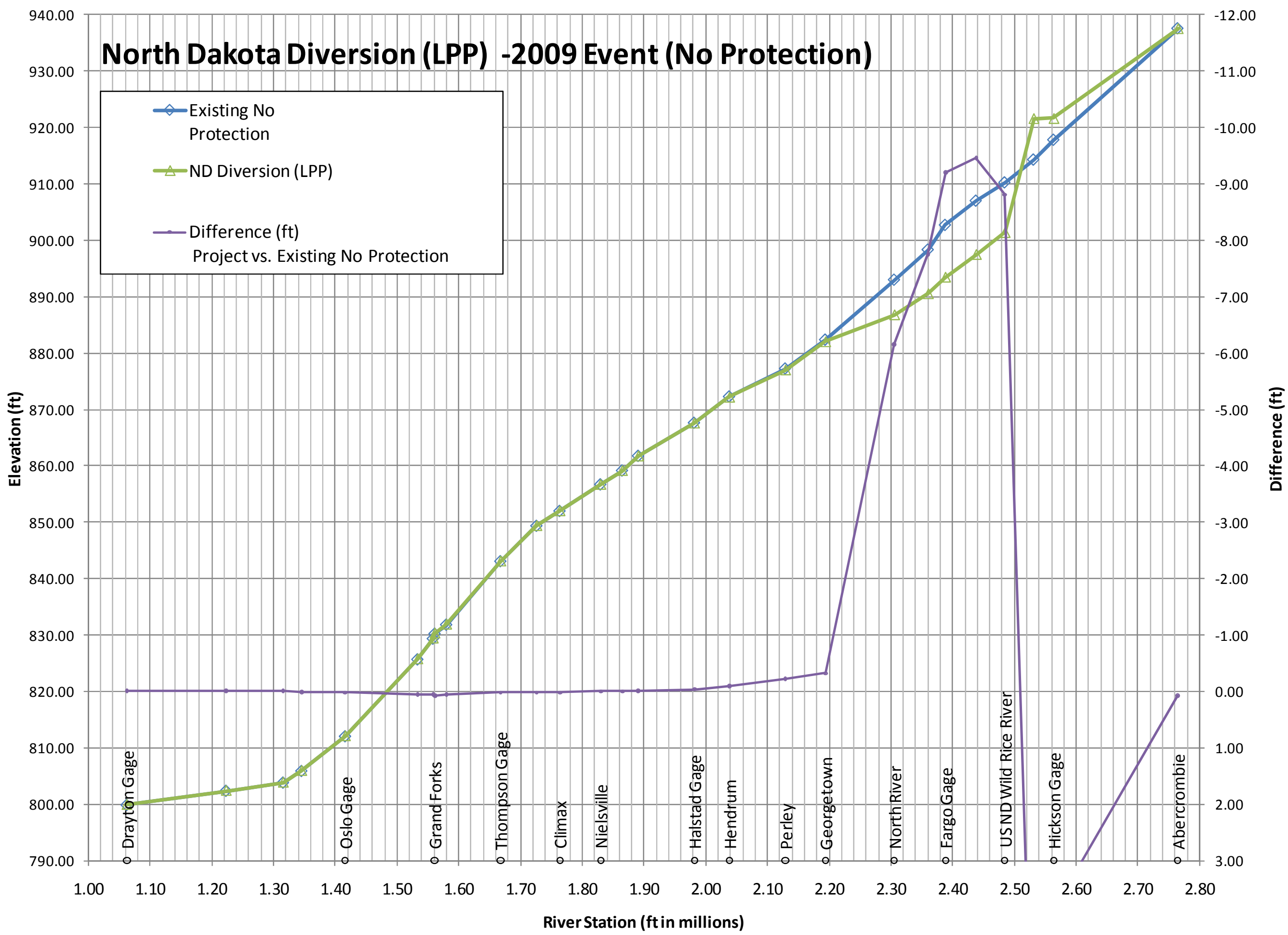


Figure C-E2- 7: 2009 Historical Flood Impacts for LPP

North Dakota Diversion (LPP) -2010 Event (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.71	65928	798.72	66106	0.01	177
ND SH#17/ MN SH317	1223286	801.04		801.05		0.01	
Co. Hwy 15	1315673	802.96		802.97		0.01	
Minimum Impact Location	1327581	803.80		803.81		0.01	
Oslo Gage	1416287	811.09		811.07		-0.02	
DS Grand Forks Levees	1533523	824.07		824.04		-0.03	
Grand Forks Gage	1558518	827.23	63406	827.19	63172	-0.04	-235
32nd Ave, Grand Forks	1580152	829.35		829.31		-0.04	
Thompson Gage	1667877	840.28	52023	840.44	52694	0.16	672
Co. Hwy 25/ Co. Rd 221	1726274	846.28		846.48		0.20	
DS Sandhill River/ Climax	1763746	848.95		849.15		0.20	
Nielsville	1829877	853.84	49914	854.07	50734	0.23	820
DS Marsh River	1864960	856.61		856.83		0.22	
US Goose River/ Shelly	1891054	859.37		859.59		0.22	
Halstad Gage	1981580	866.55	42389	866.70	43585	0.15	1196
Maximum Impact Location	2038409	870.62		870.86		0.24	
Hendrum	2038409	870.62	38264	870.86	39350	0.24	1085
Perley	2129181	876.31	35431	876.36	35863	0.05	433
Georgetown	2194021	881.30		881.41		0.11	
North River/ Clay Co. Hwy 93	2305647	891.54		885.66		-5.88	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	896.11		889.49		-6.62	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.77 (37.03*)	21481	892.38 (29.64*)	10291	-7.39	-11190
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	904.15		896.38		-7.77	
US ND Wild Rice River	2484618	907.59		900.30		-7.29	
US LPP Diversion	2531315	910.17		918.90		8.73	
Hickson Gage	2563754	912.23	12677	918.98	12686	6.75	8
Abercrombie	2764835	930.57	13236	930.74	13236	0.17	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

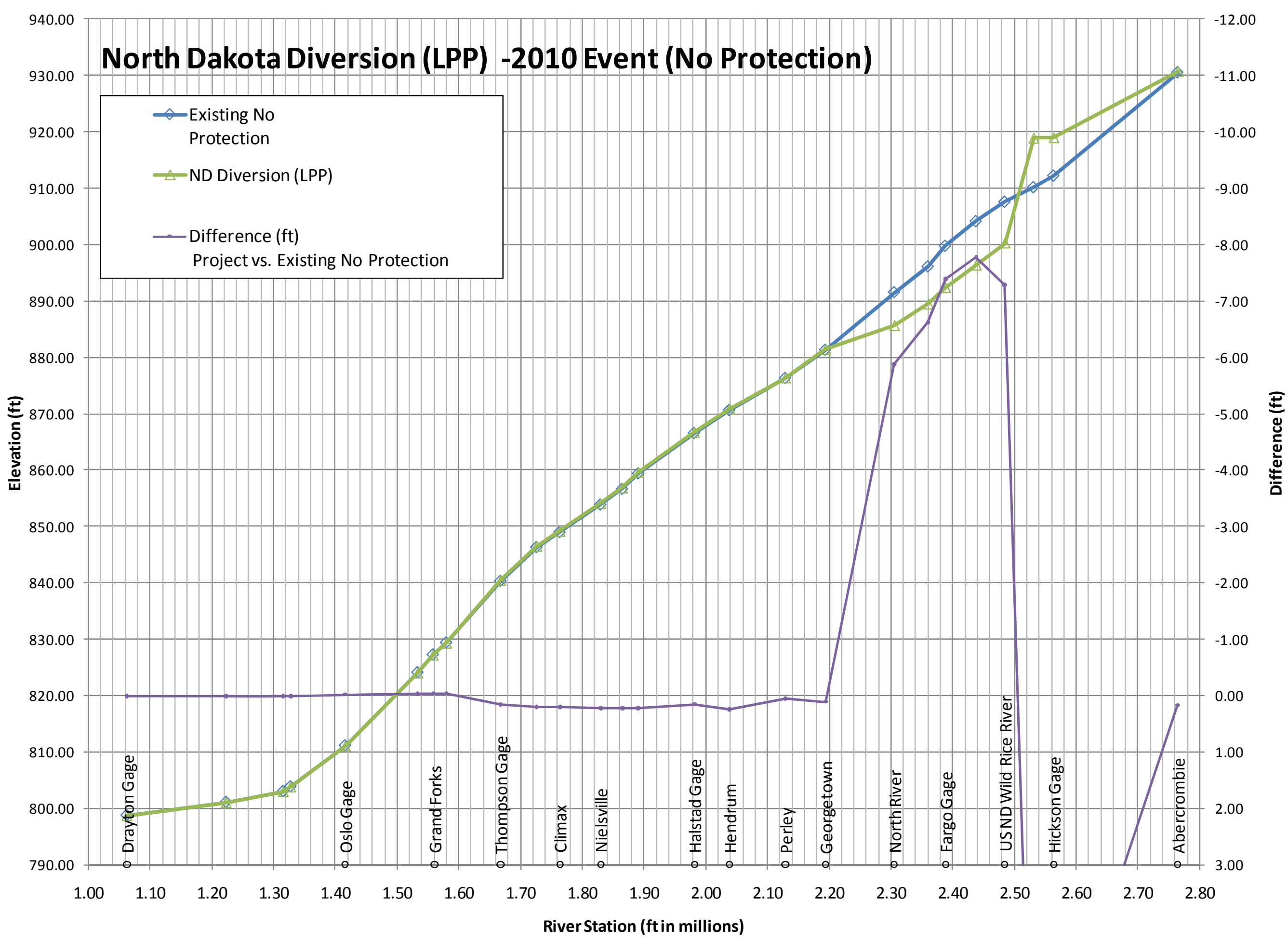


Figure C-E2- 8: 2010 Historical Flood Impacts for LPP

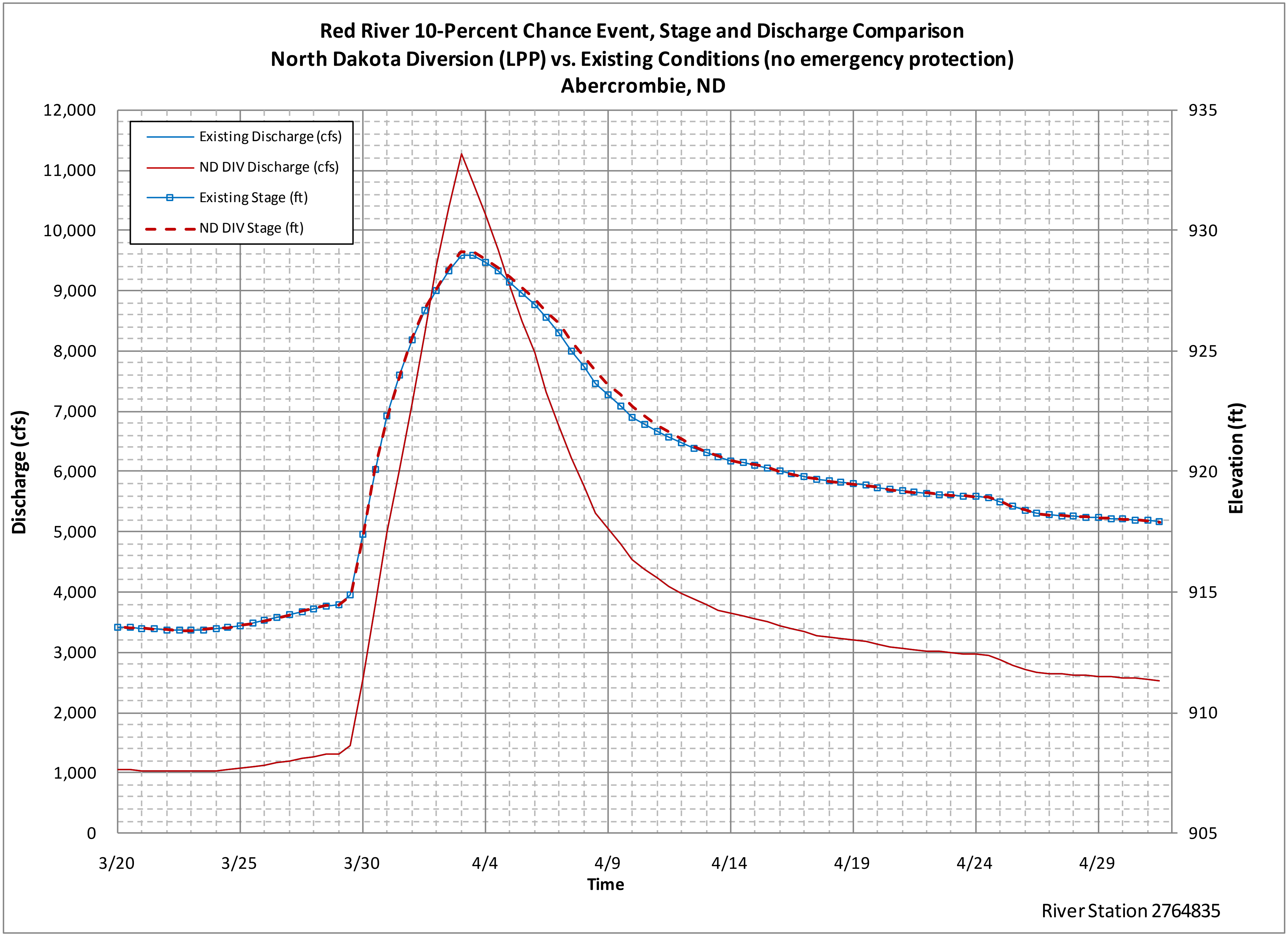


Figure C-E2- 9: 10-Percent Chance Hydrographs for LPP @ Abercrombie

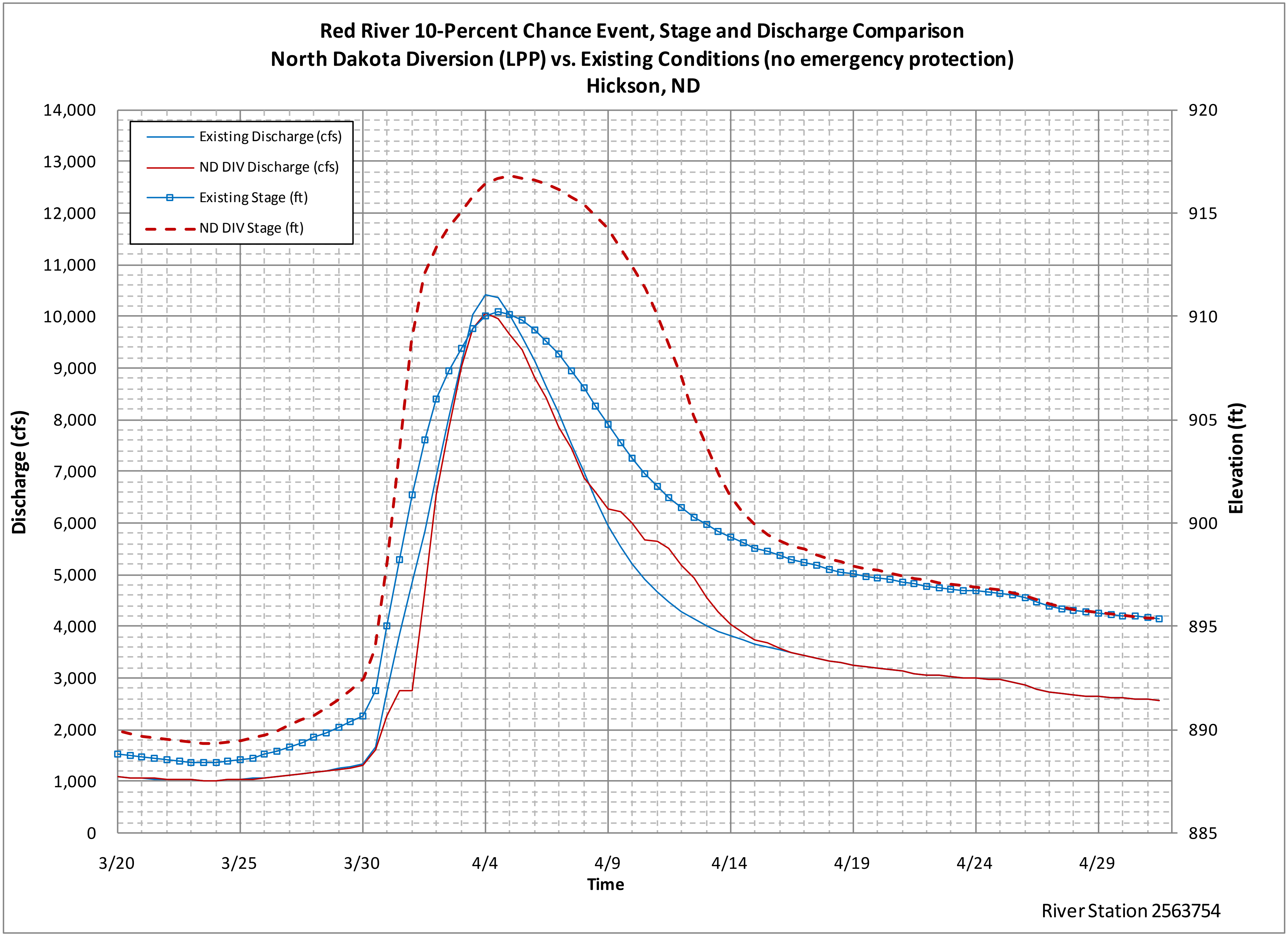


Figure C-E2- 10: 10-Percent Chance Hydrographs for LPP @ Hickson

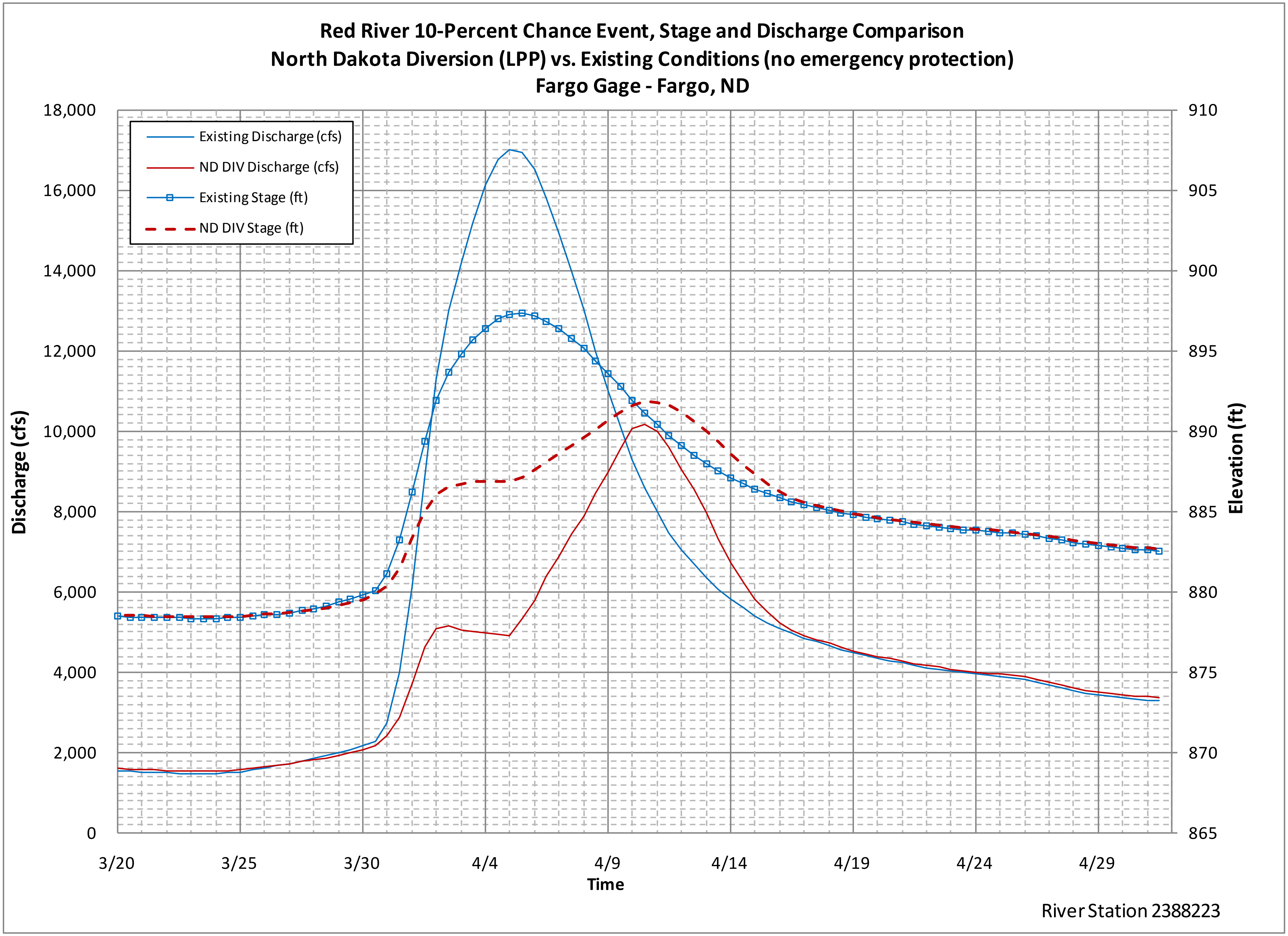


Figure C-E2- 11: 10-Percent Chance Hydrographs for LPP @ Fargo

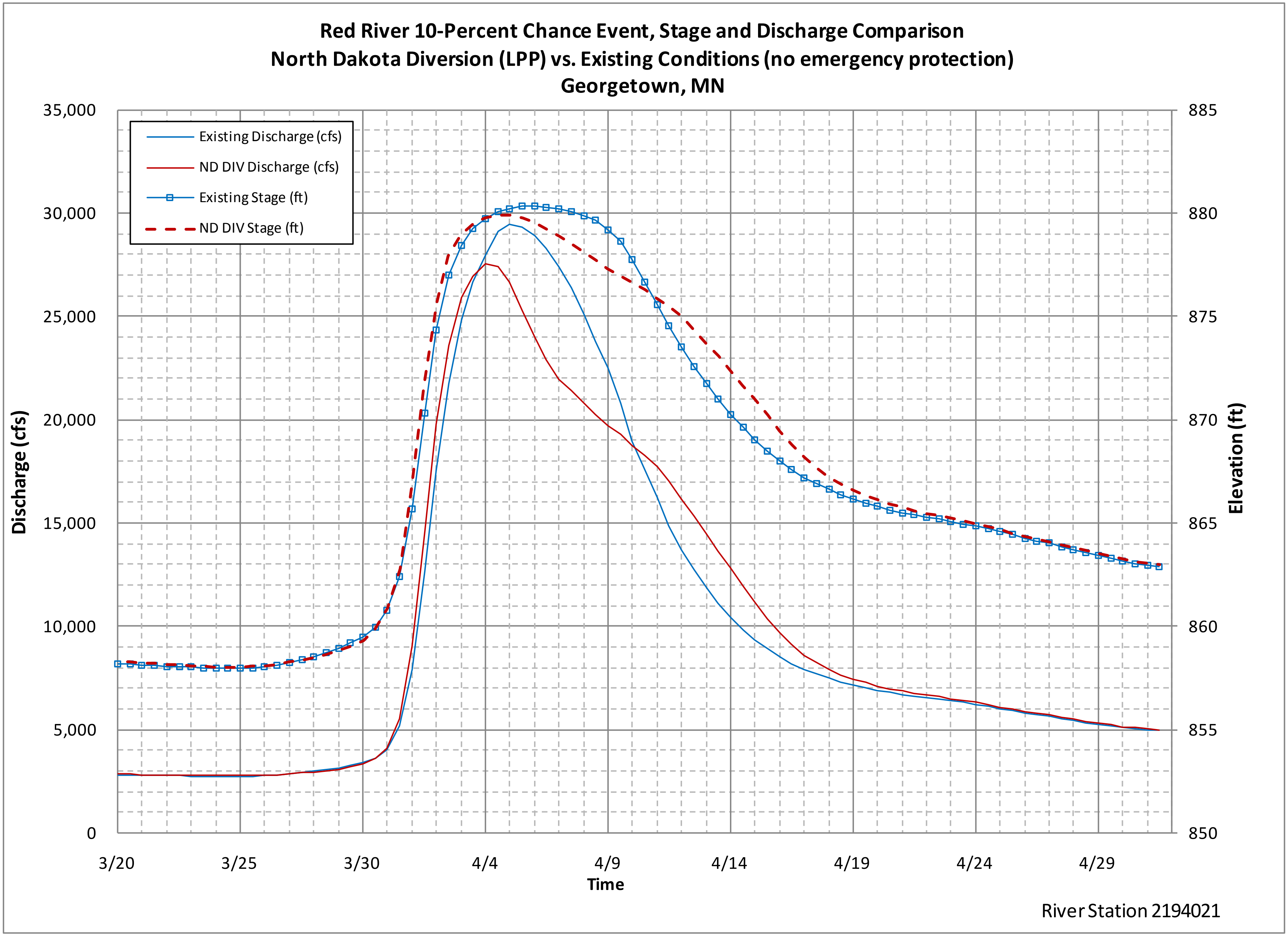


Figure C-E2- 12: 10-Percent Chance Hydrographs for LPP @ Georgetown

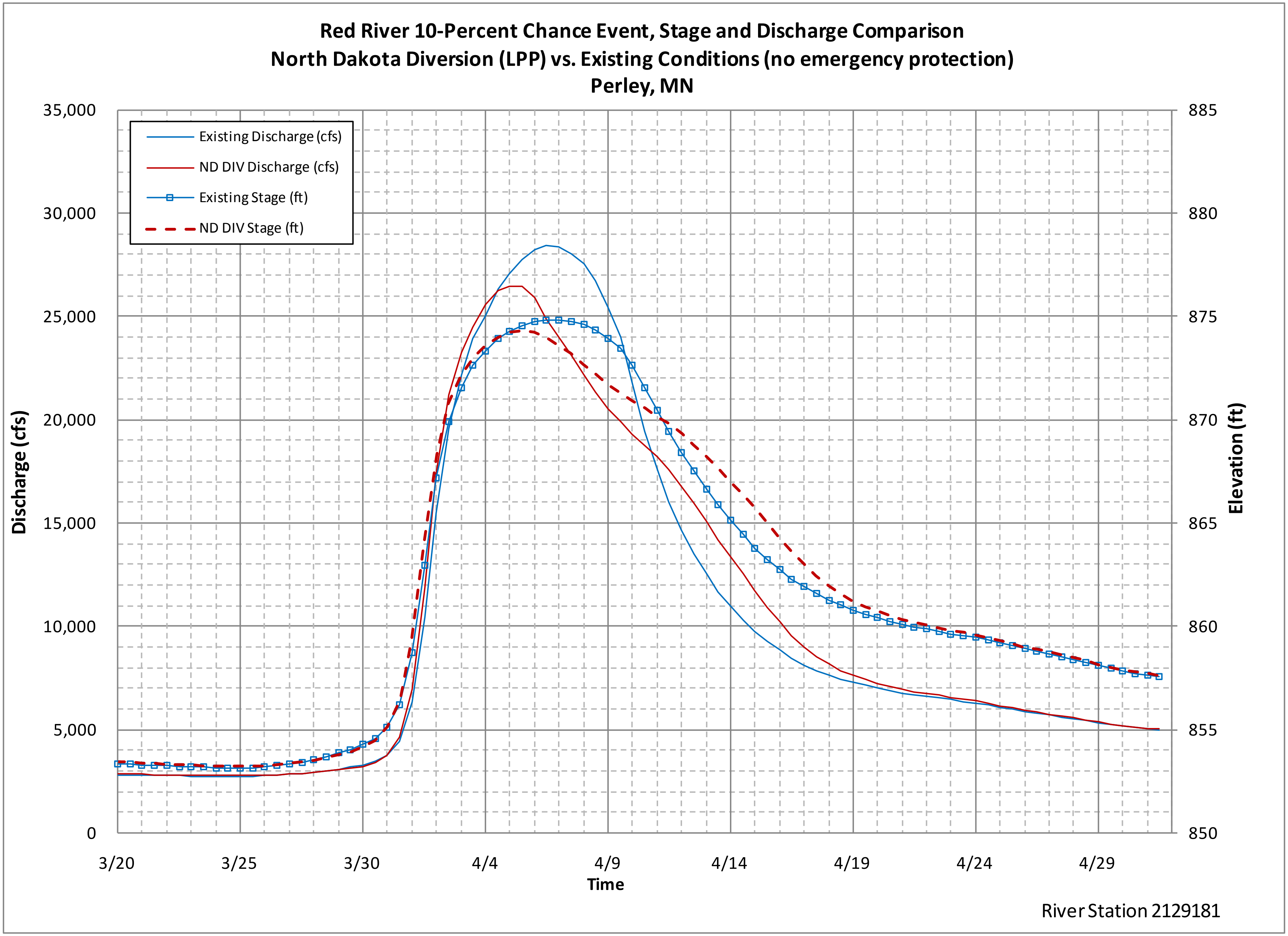


Figure C-E2- 13: 10-Percent Chance Hydrographs for LPP @ Perley

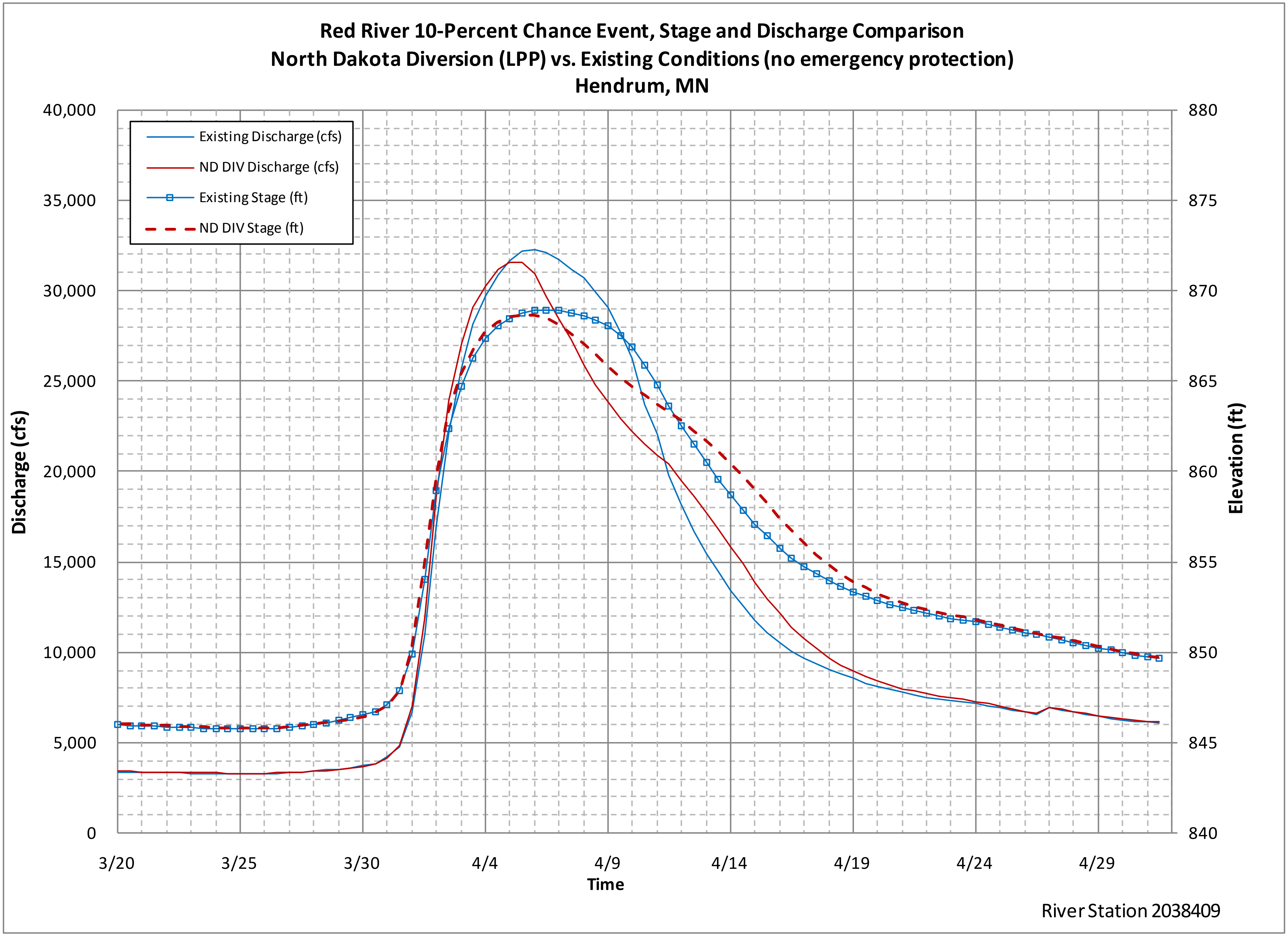


Figure C-E2- 14: 10-Percent Chance Hydrographs for LPP @ Hendrum

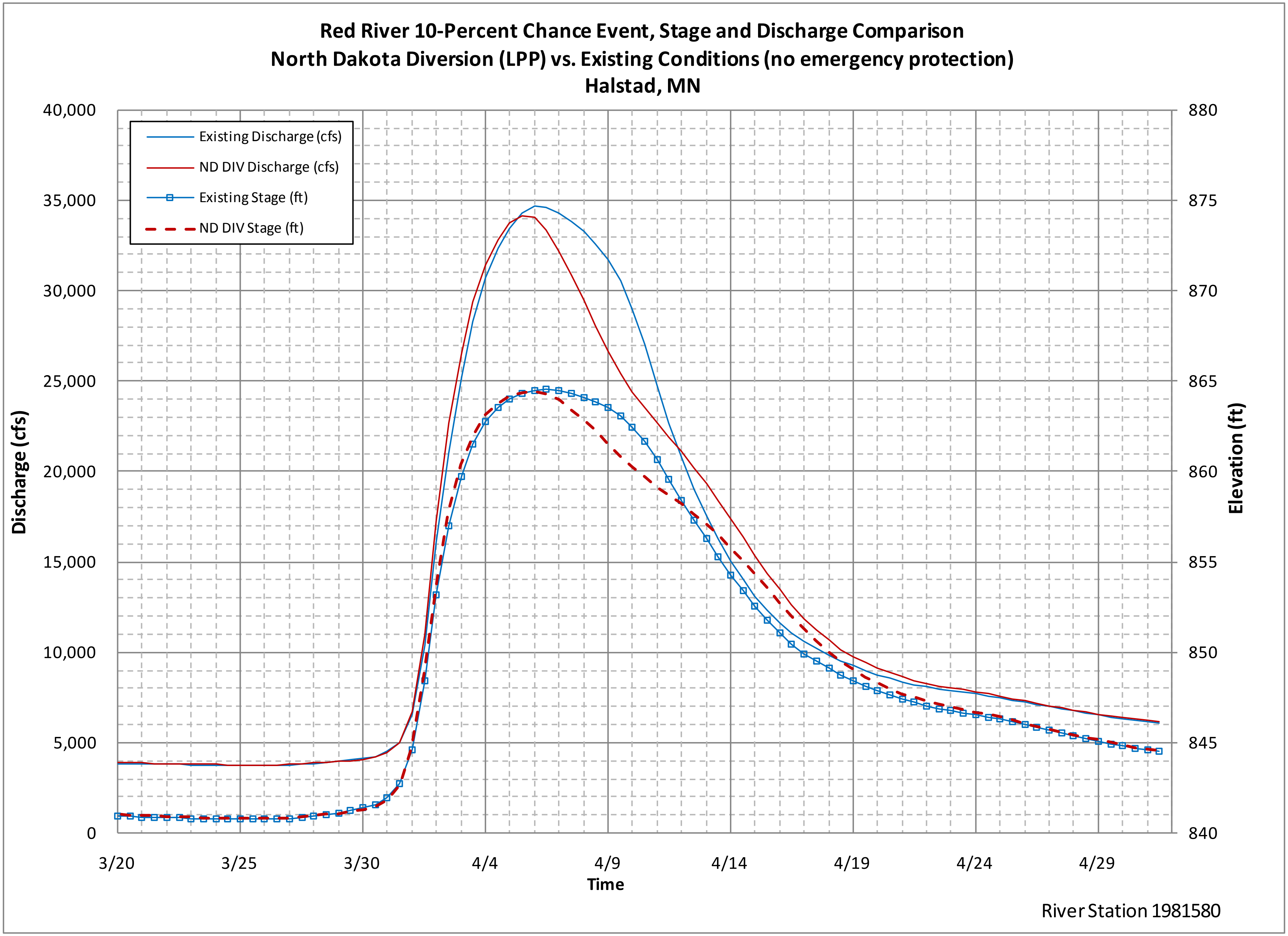


Figure C-E2- 15: 10-Percent Chance Hydrographs for LPP @ Halstad

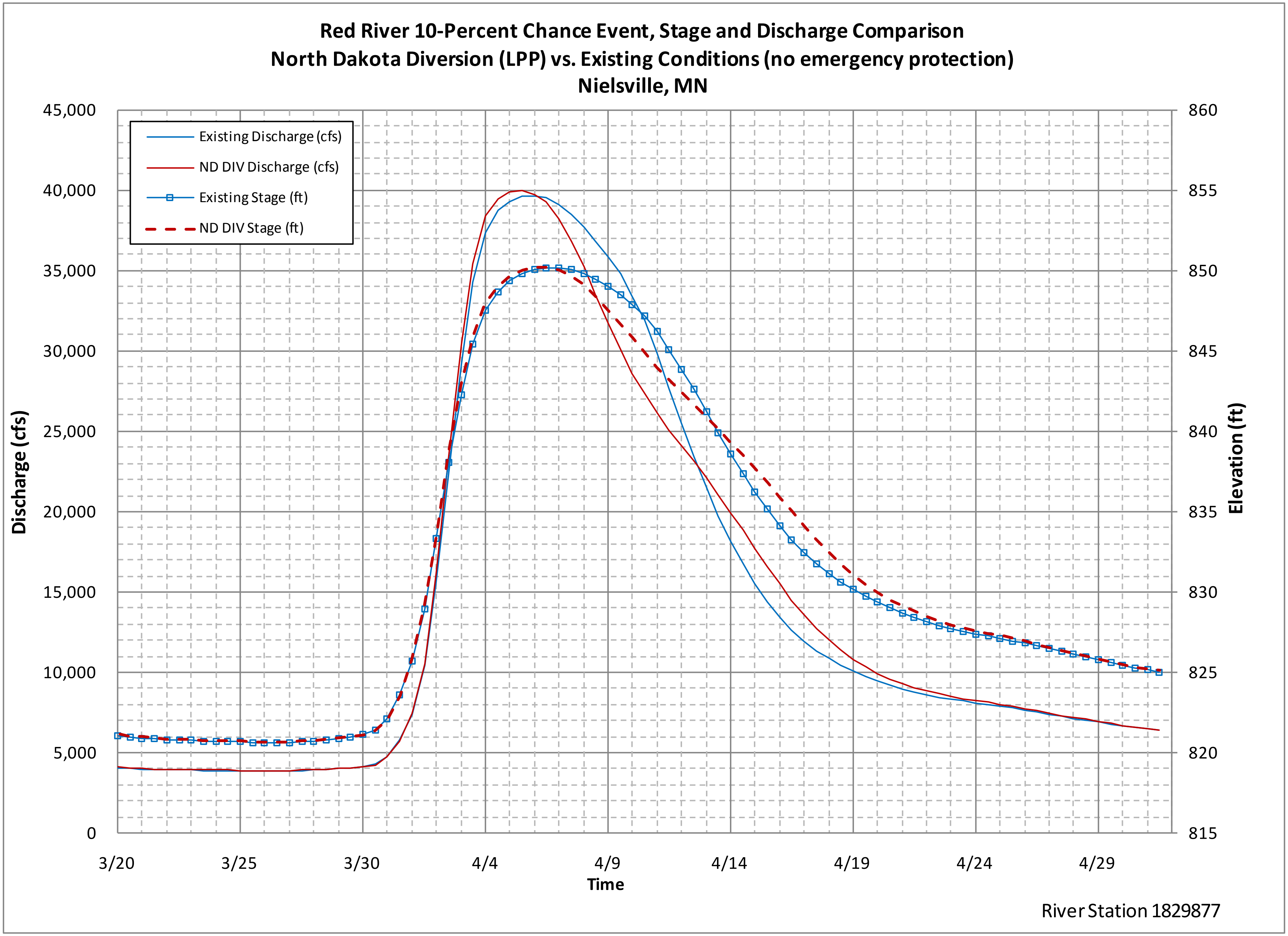


Figure C-E2- 16: 10-Percent Chance Hydrographs for LPP @ Nielsville

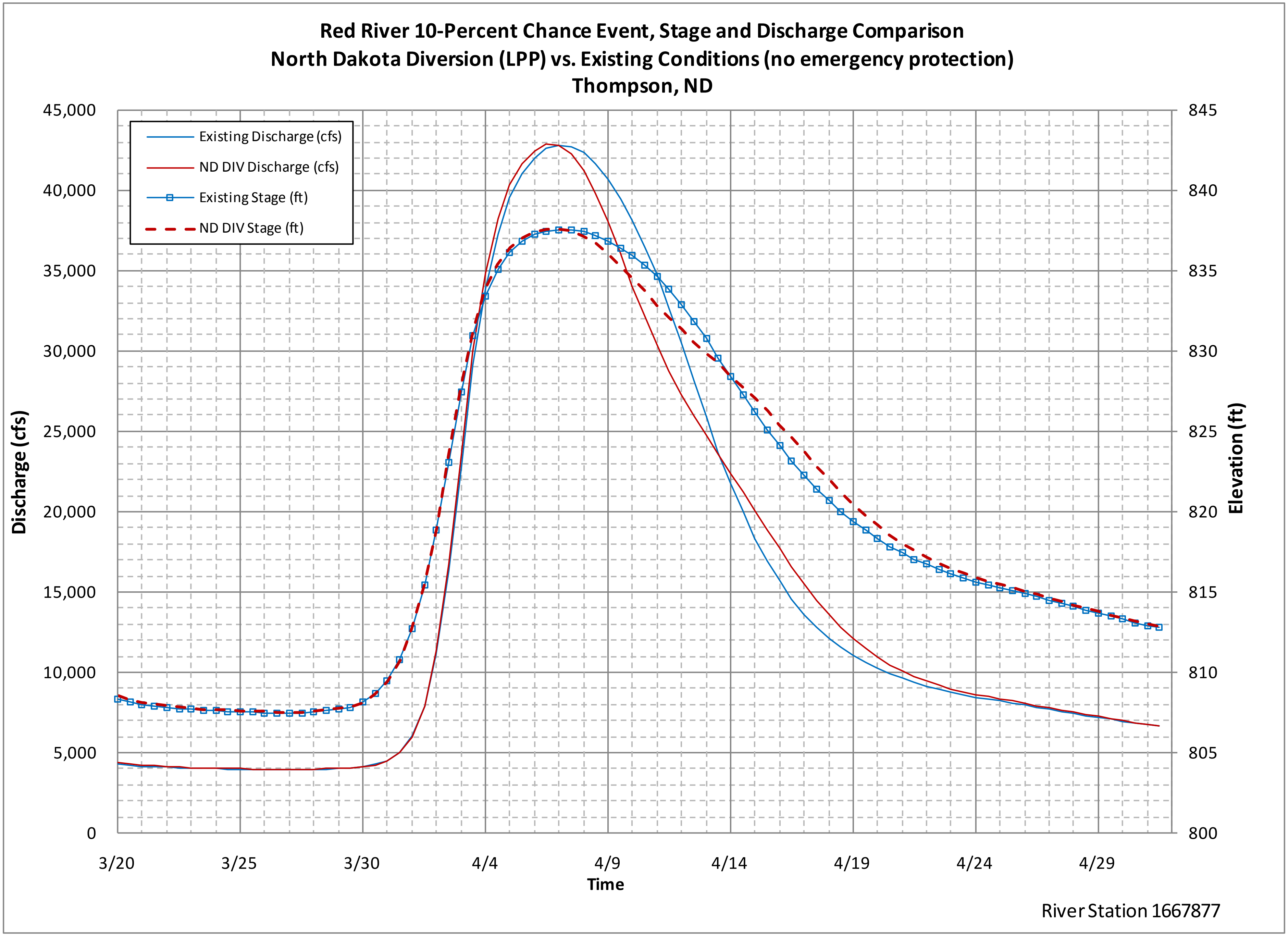


Figure C-E2- 17: 10-Percent Chance Hydrographs for LPP @ Thompson

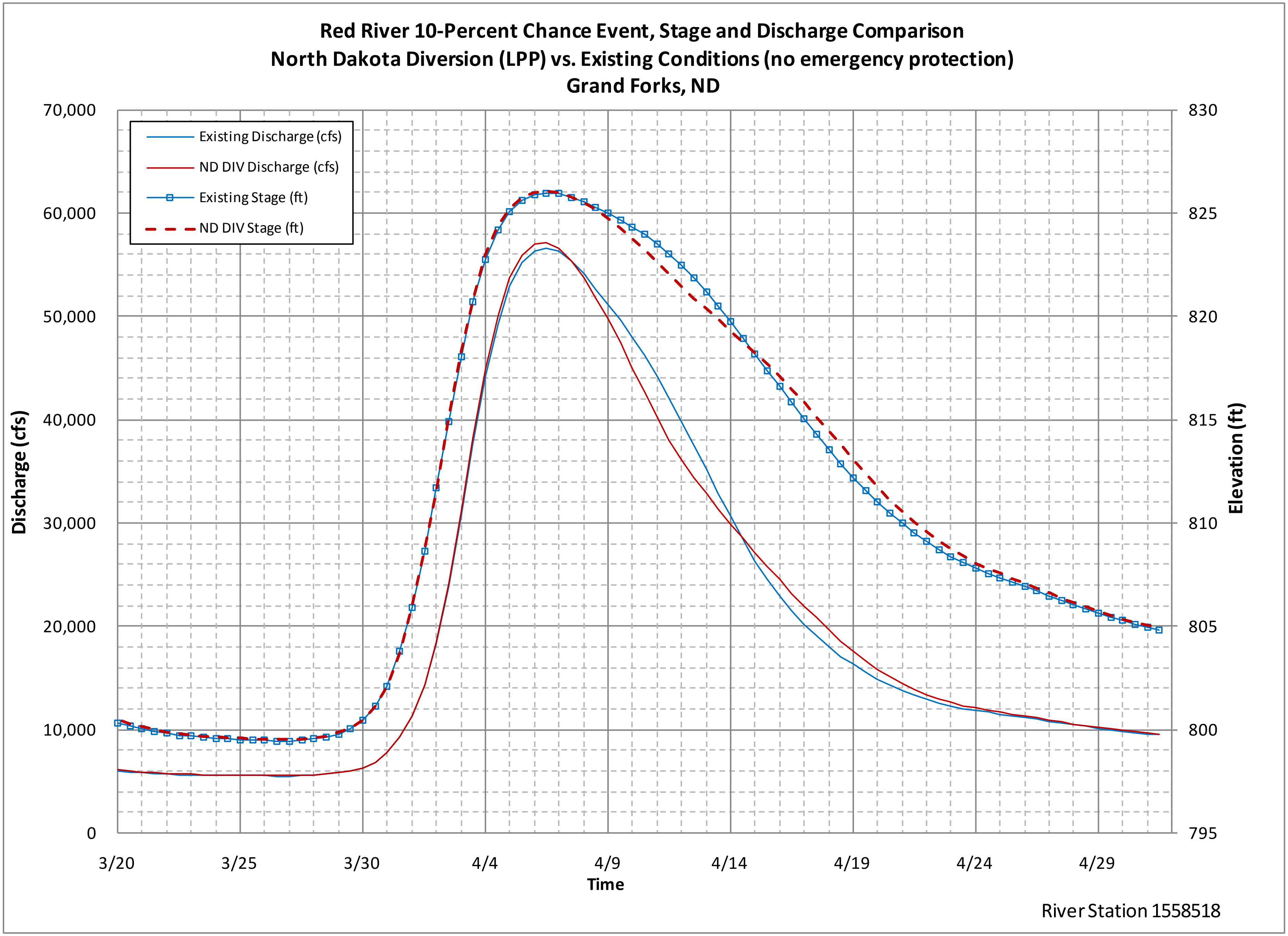


Figure C-E2- 18: 10-Percent Chance Hydrographs for LPP @ Grand Forks

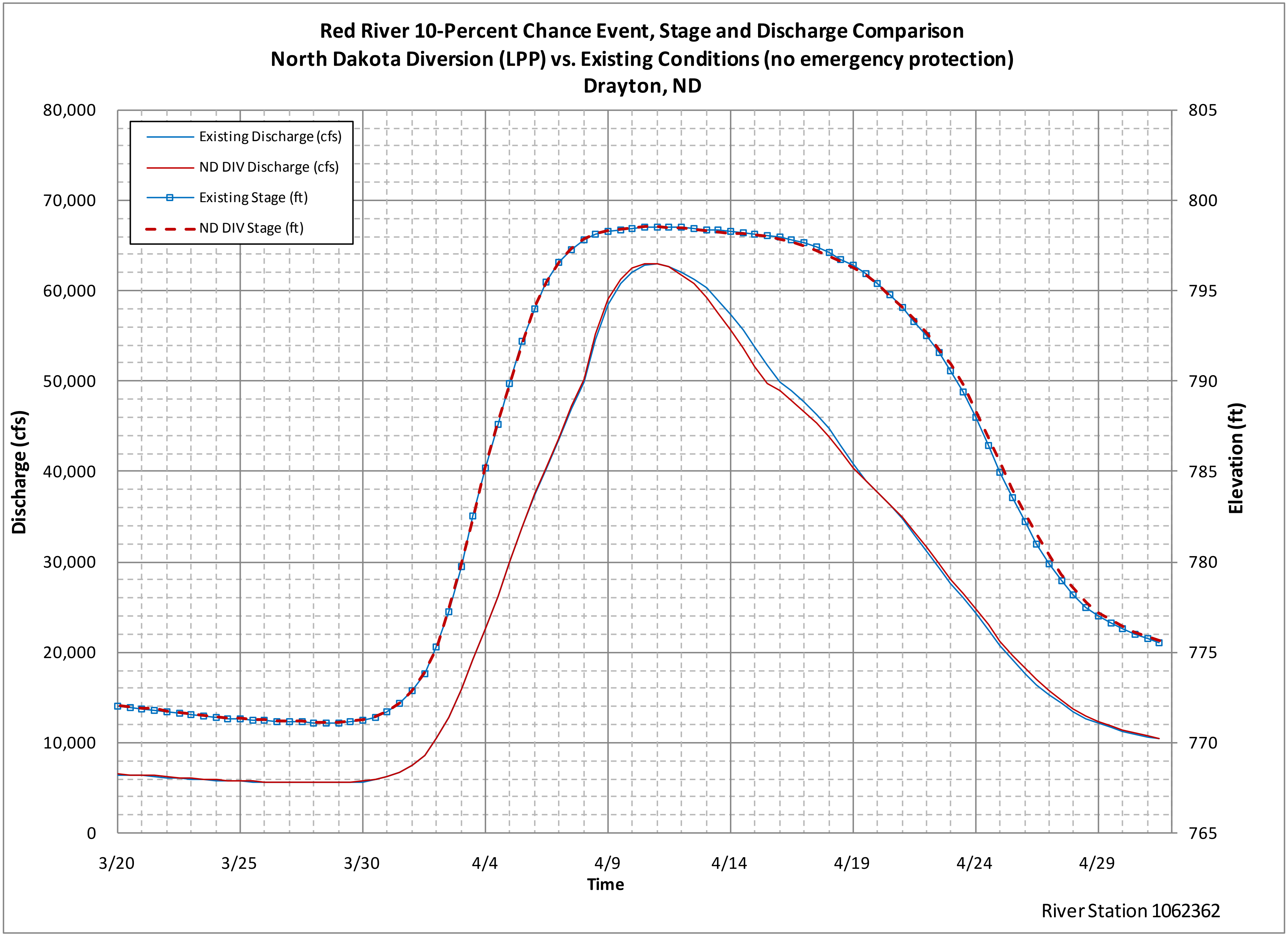


Figure C-E2- 19: 10-Percent Chance Hydrographs for LPP @ Drayton

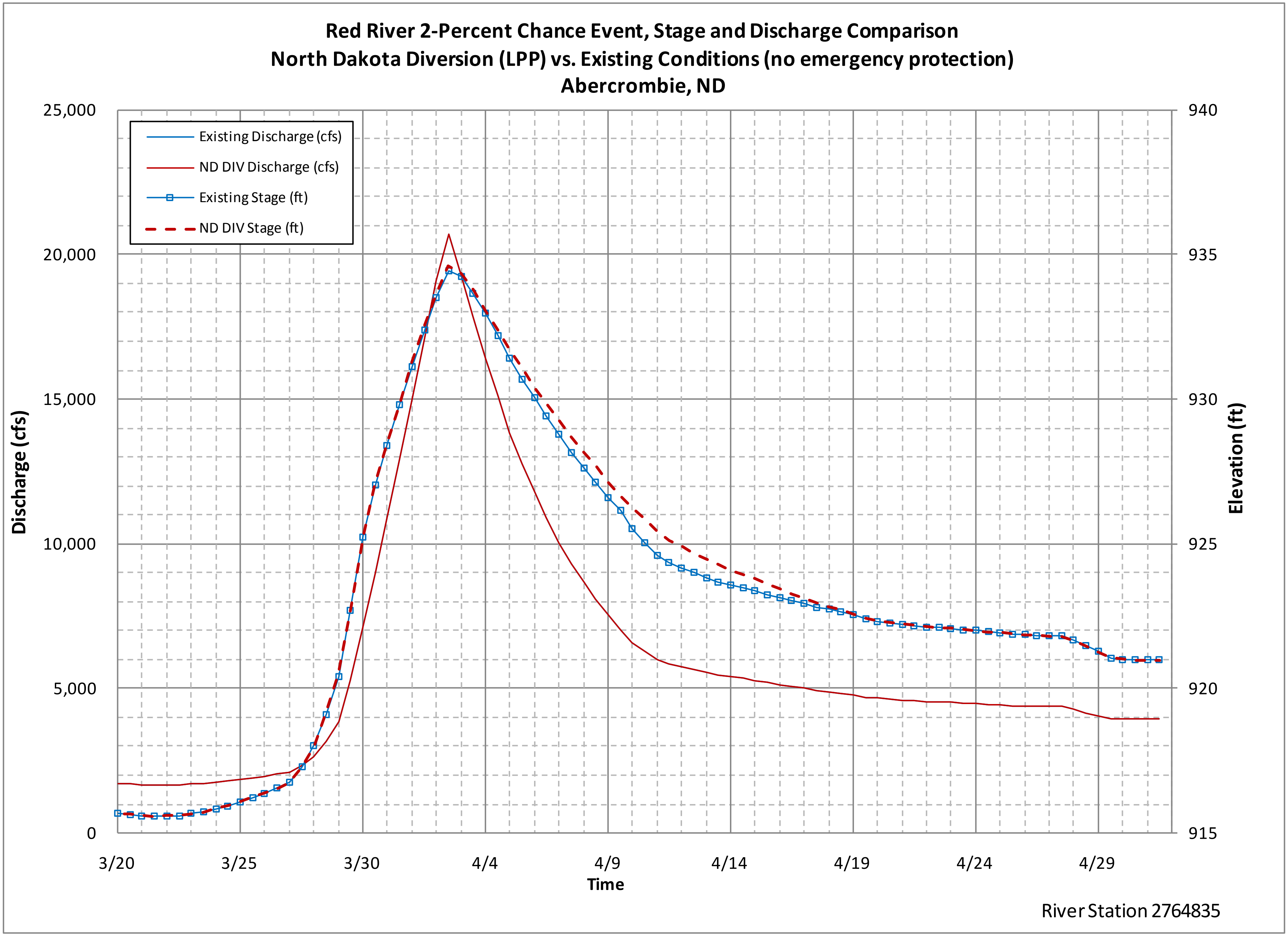


Figure C-E2- 20: 2-Percent Chance Hydrographs for LPP @ Abercrombie

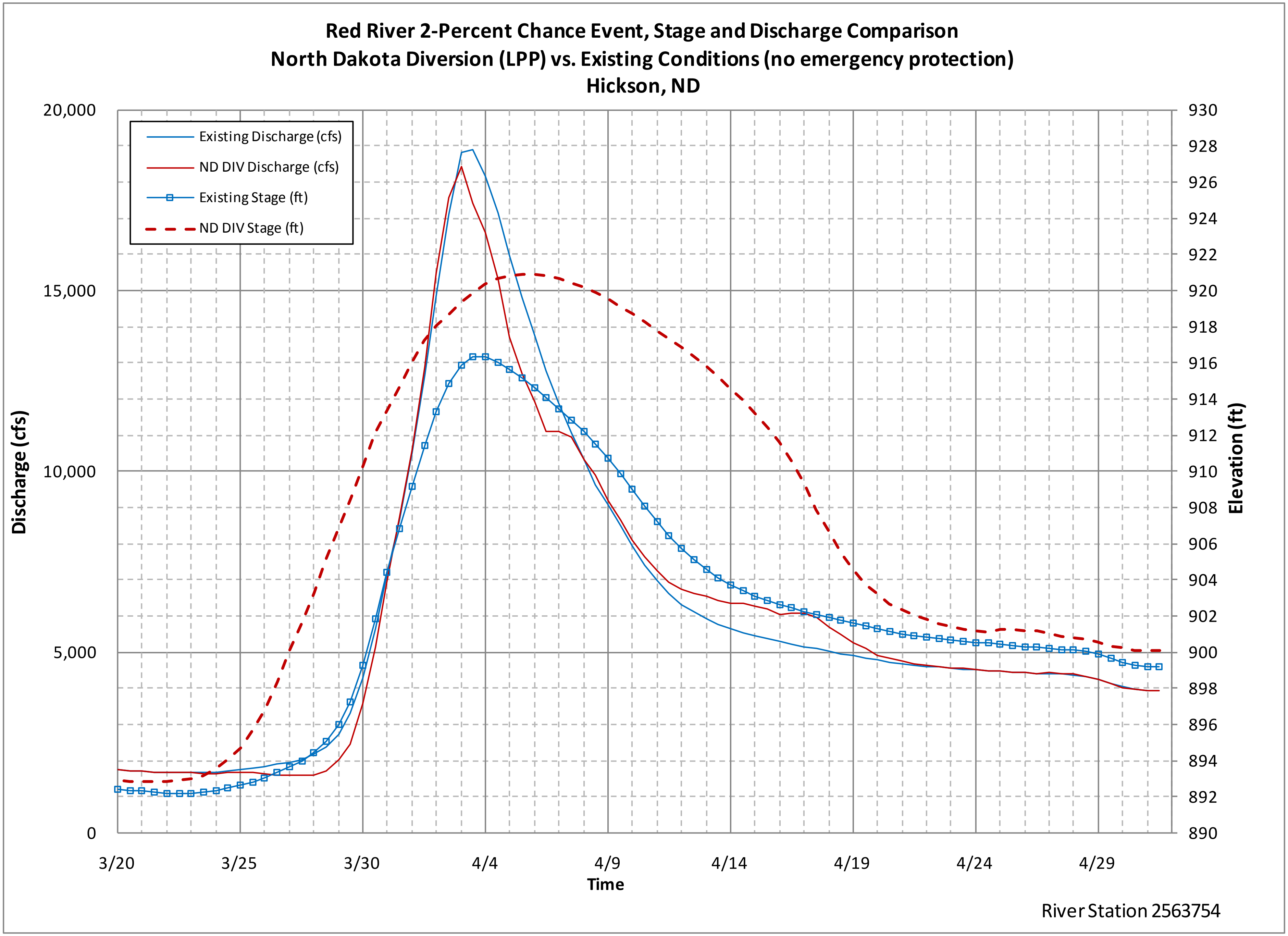


Figure C-E2- 21: 2-Percent Chance Hydrographs for LPP @ Hickson

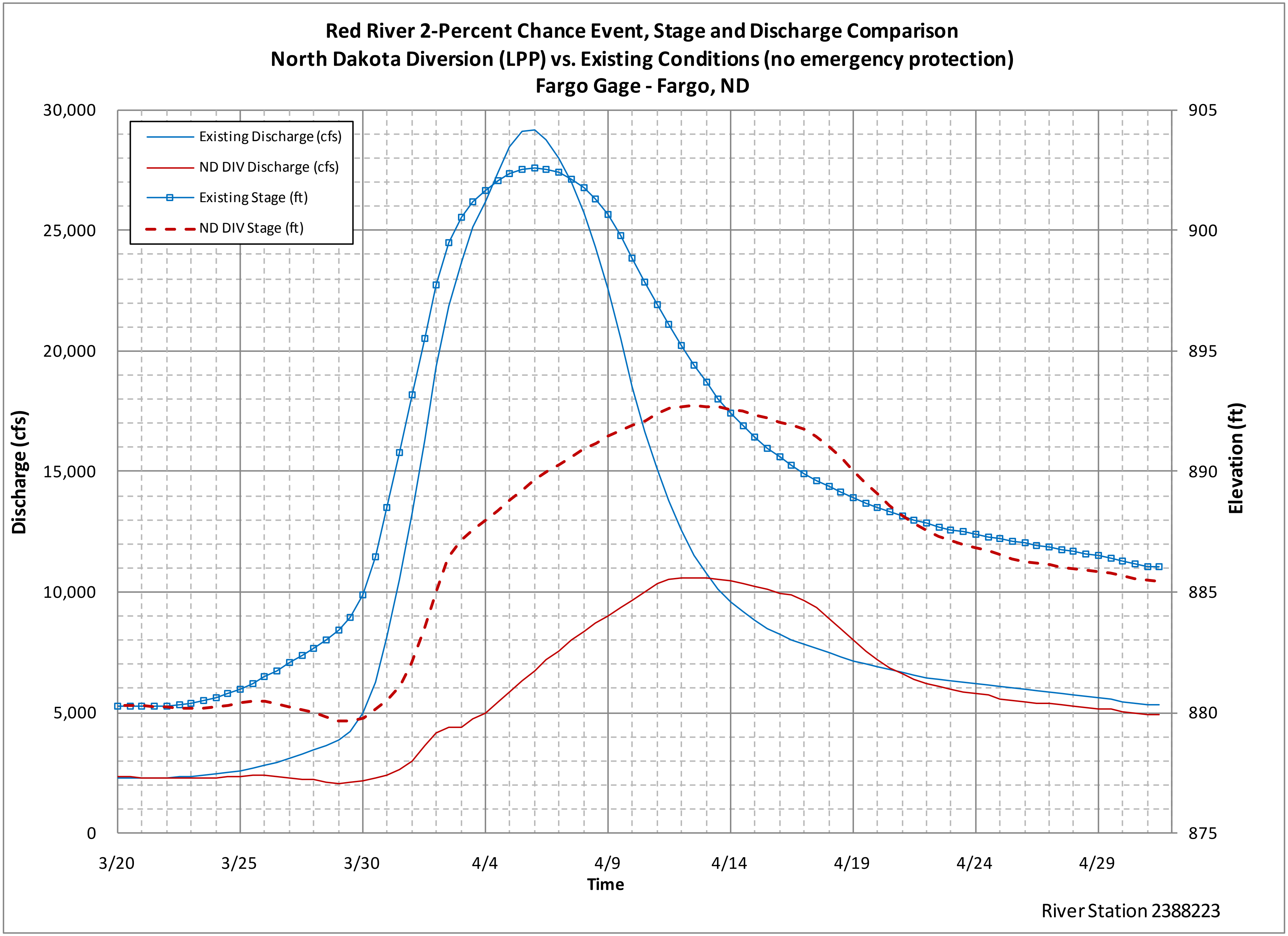


Figure C-E2- 22: 2-Percent Chance Hydrographs for LPP @ Fargo

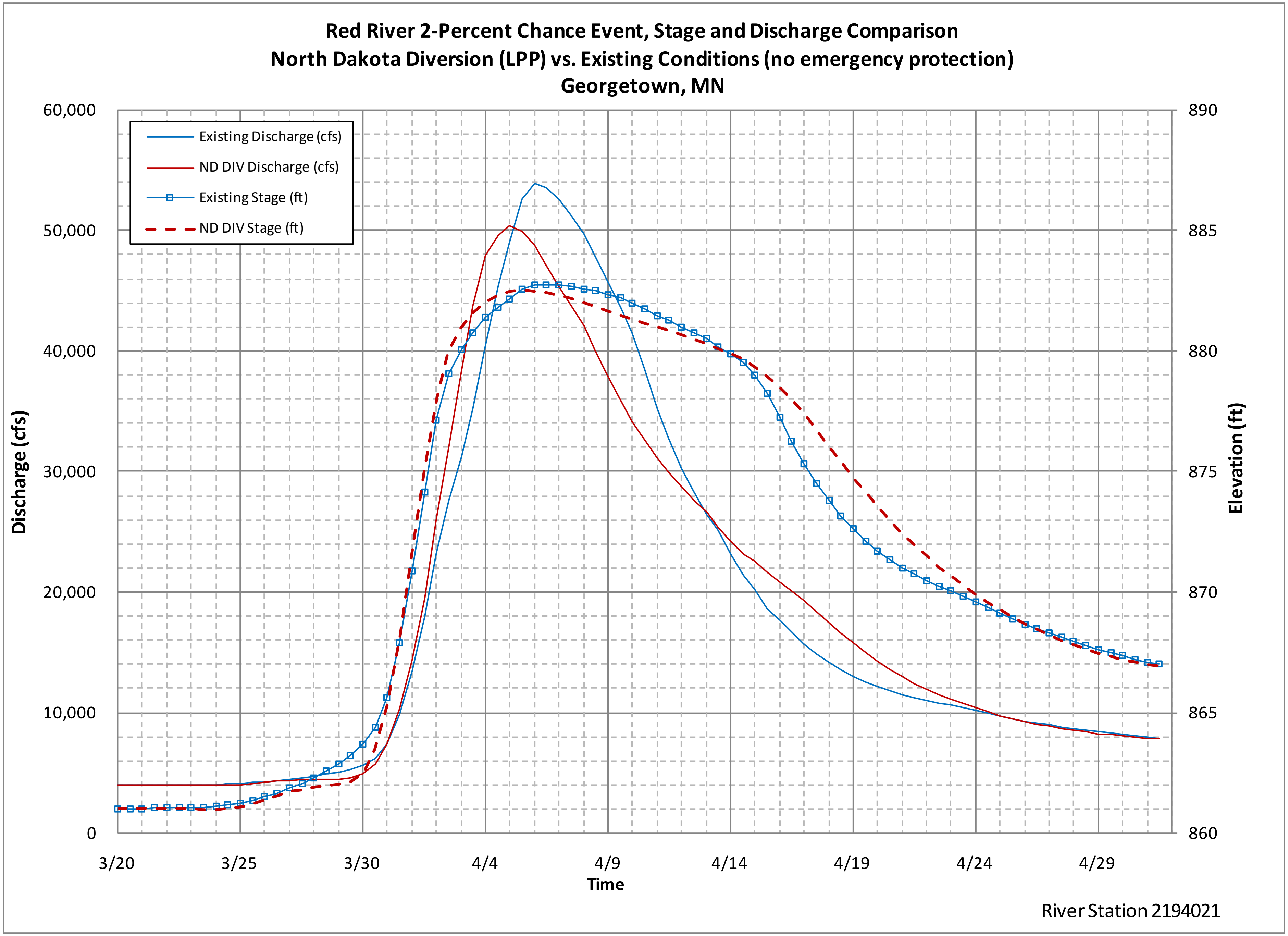


Figure C-E2- 23: 2-Percent Chance Hydrographs for LPP @ Georgetown

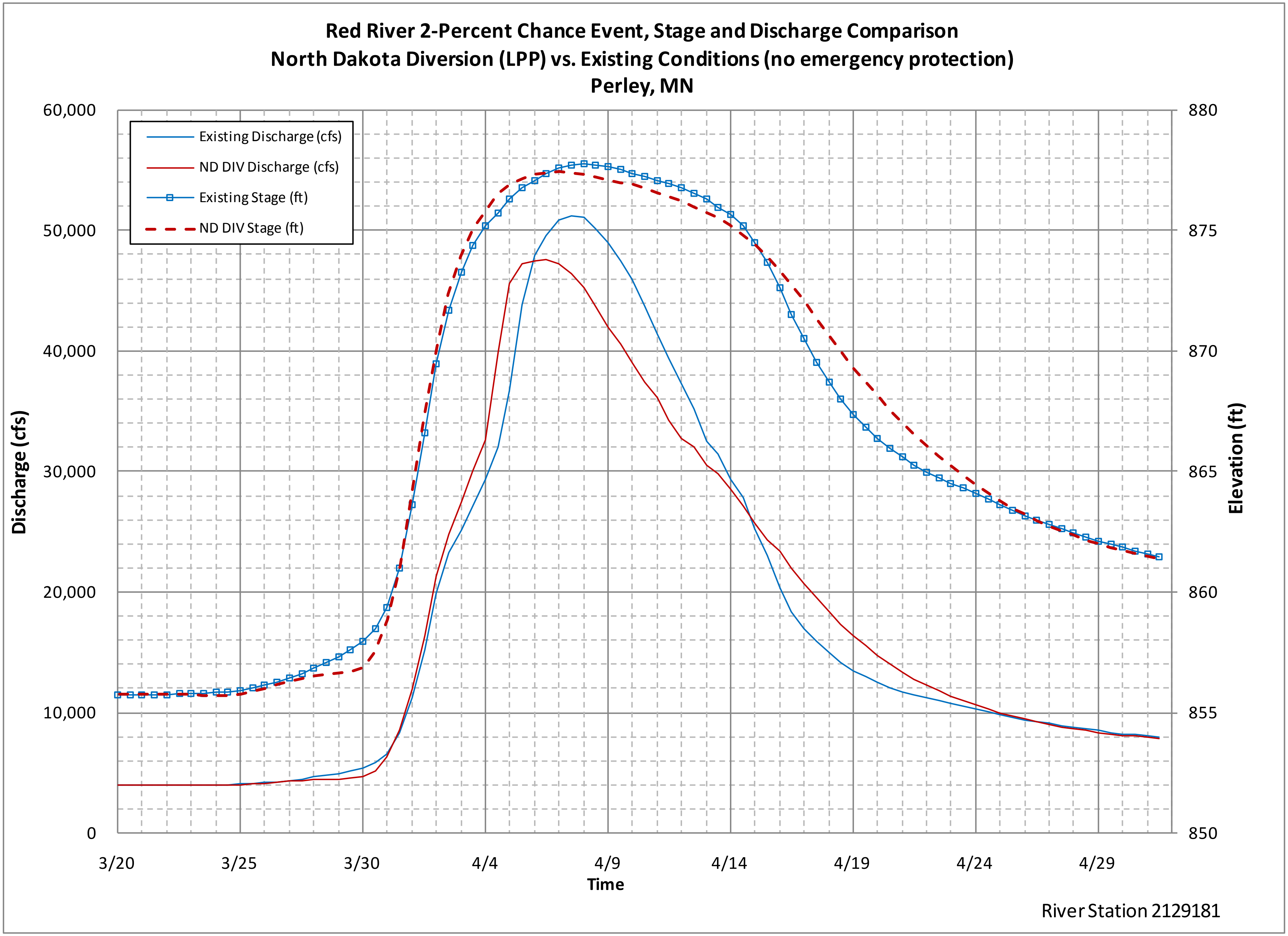


Figure C-E2- 24: 2-Percent Chance Hydrographs for LPP @ Perley

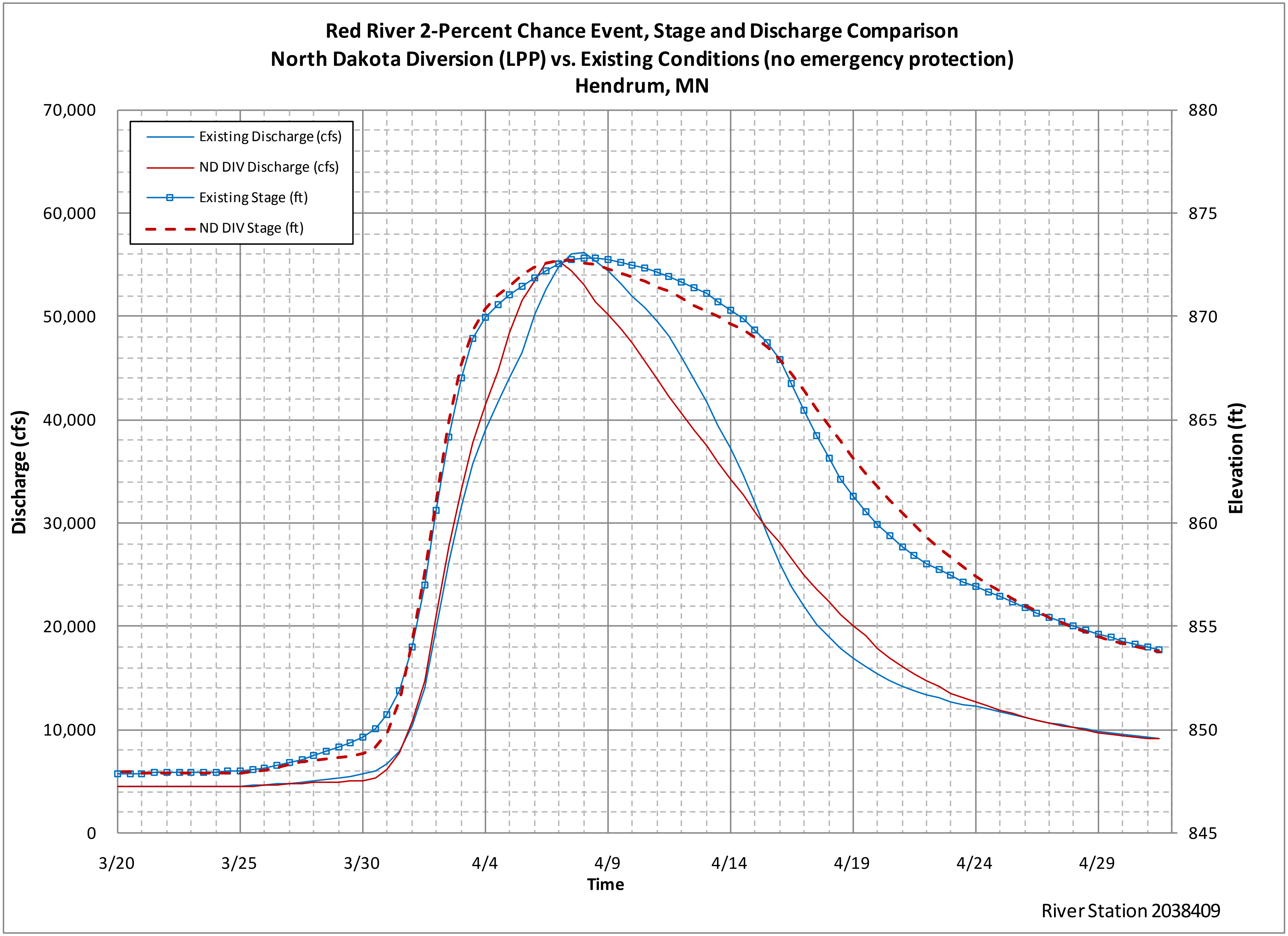


Figure C-E2- 25: 2-Percent Chance Hydrographs for LPP @ Hendrum

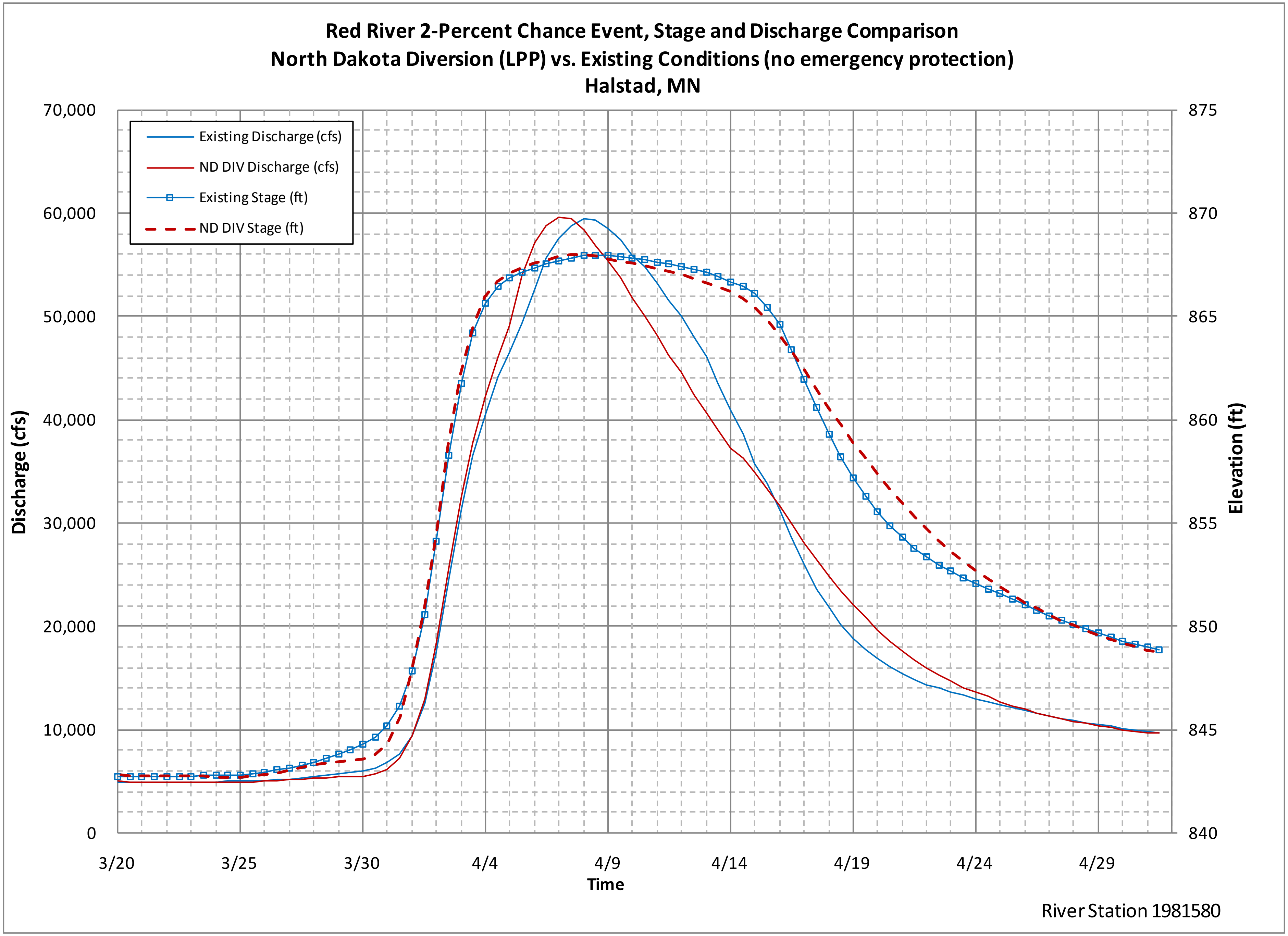


Figure C-E2- 26: 2-Percent Chance Hydrographs for LPP @ Halstad

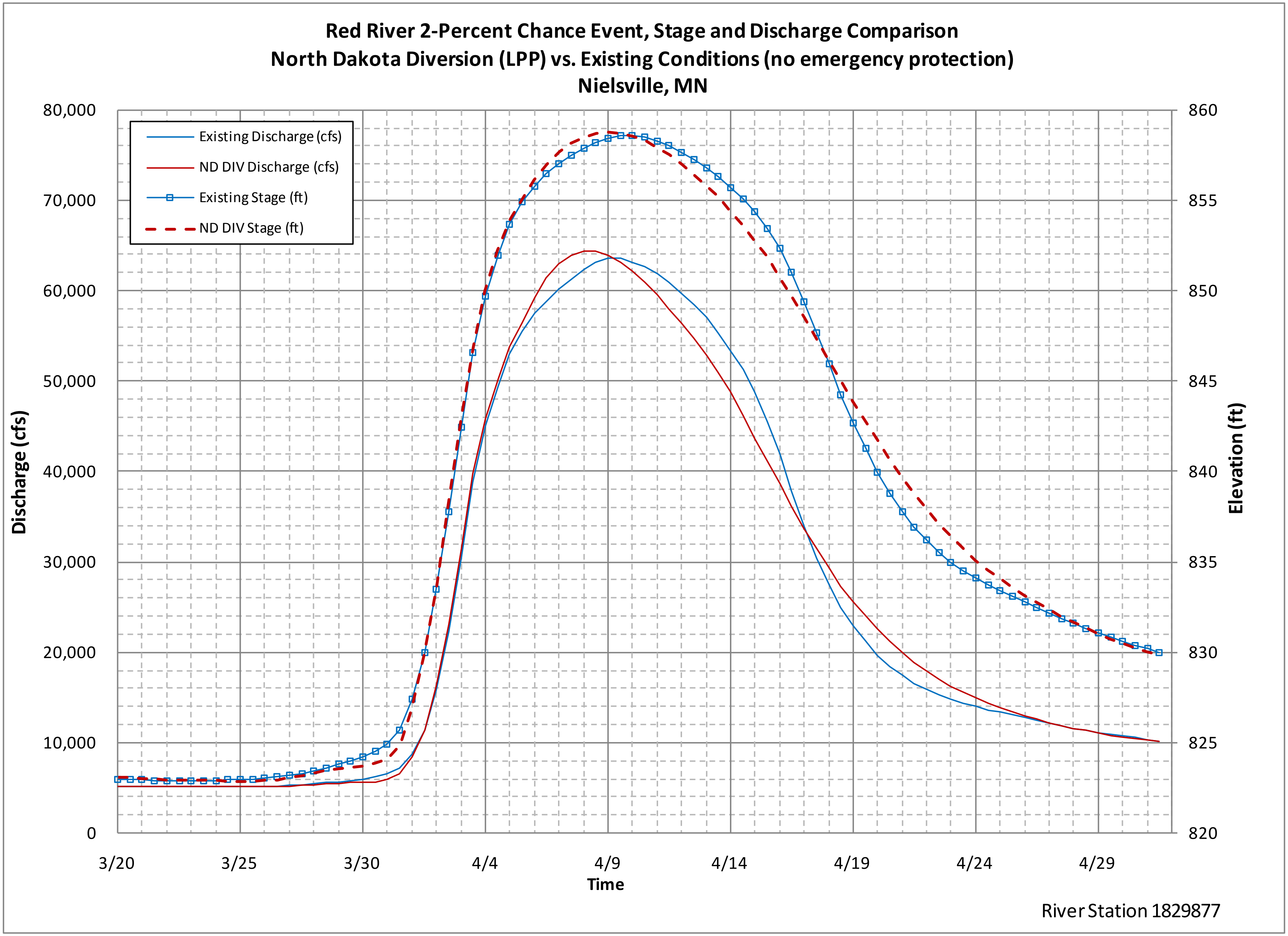


Figure C-E2- 27: 2-Percent Chance Hydrographs for LPP @ Nielsville

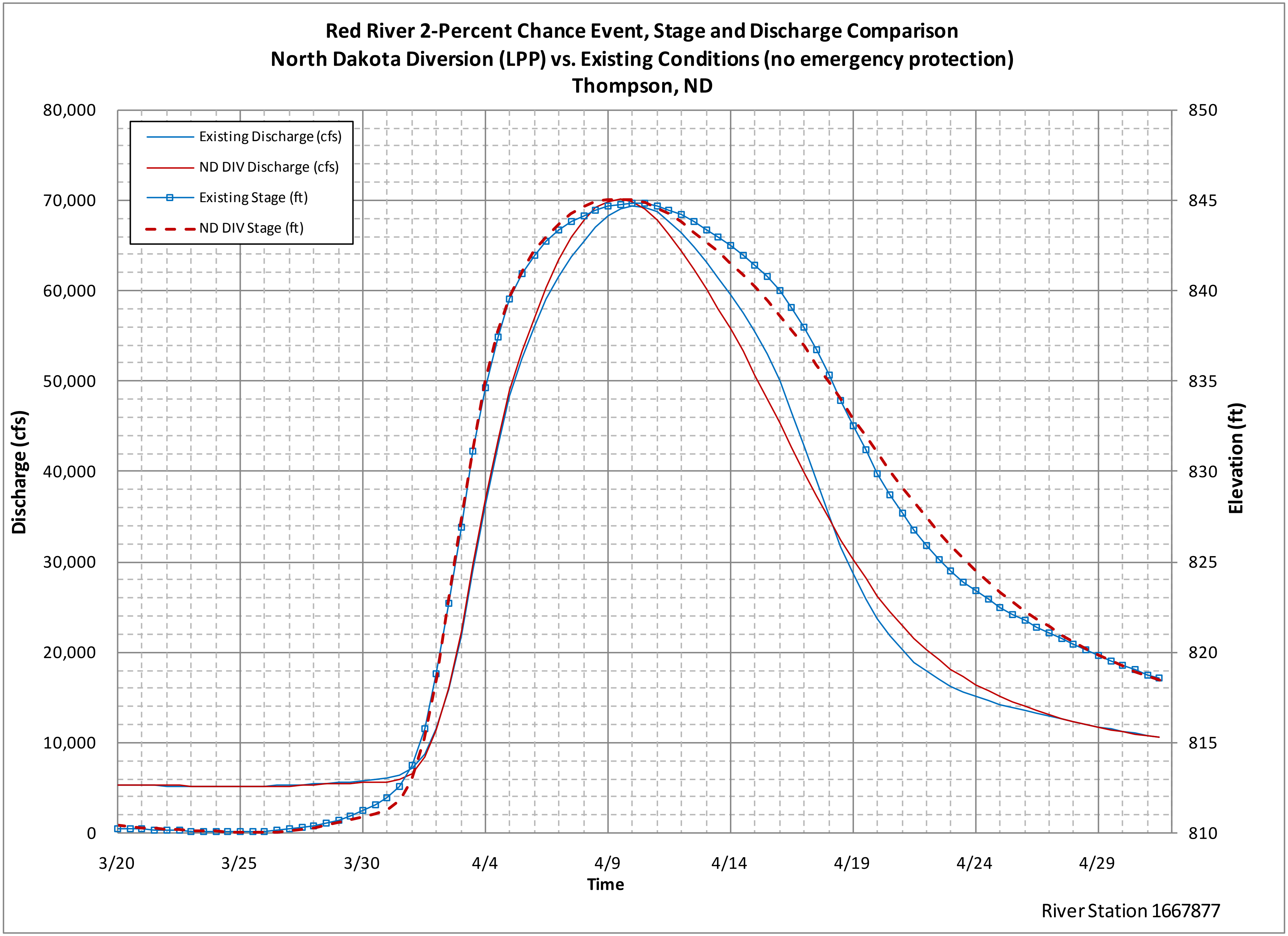


Figure C-E2- 28: 2-Percent Chance Hydrographs for LPP @ Thompson

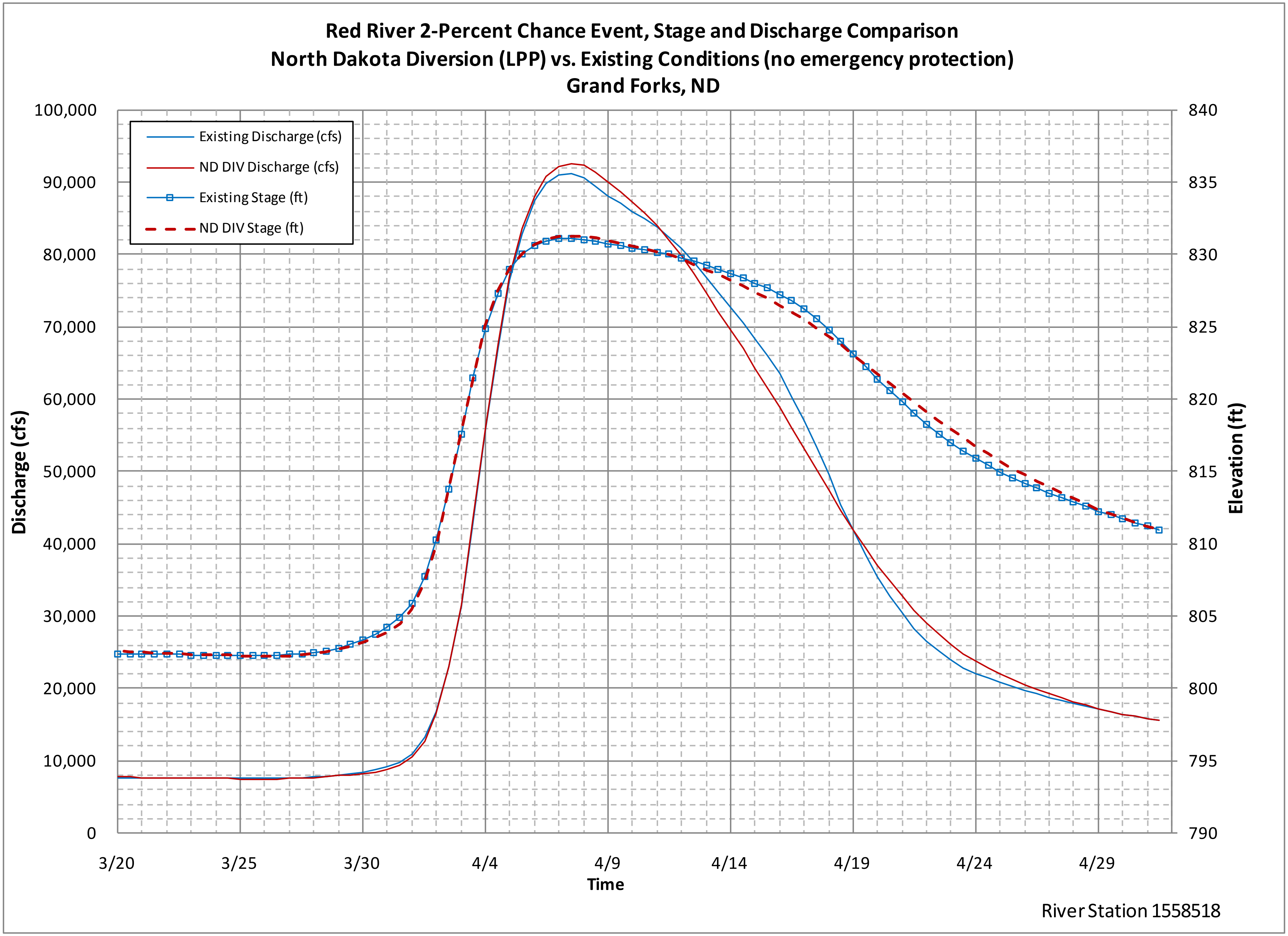


Figure C-E2- 29: 2-Percent Chance Hydrographs for LPP @ Grand Forks

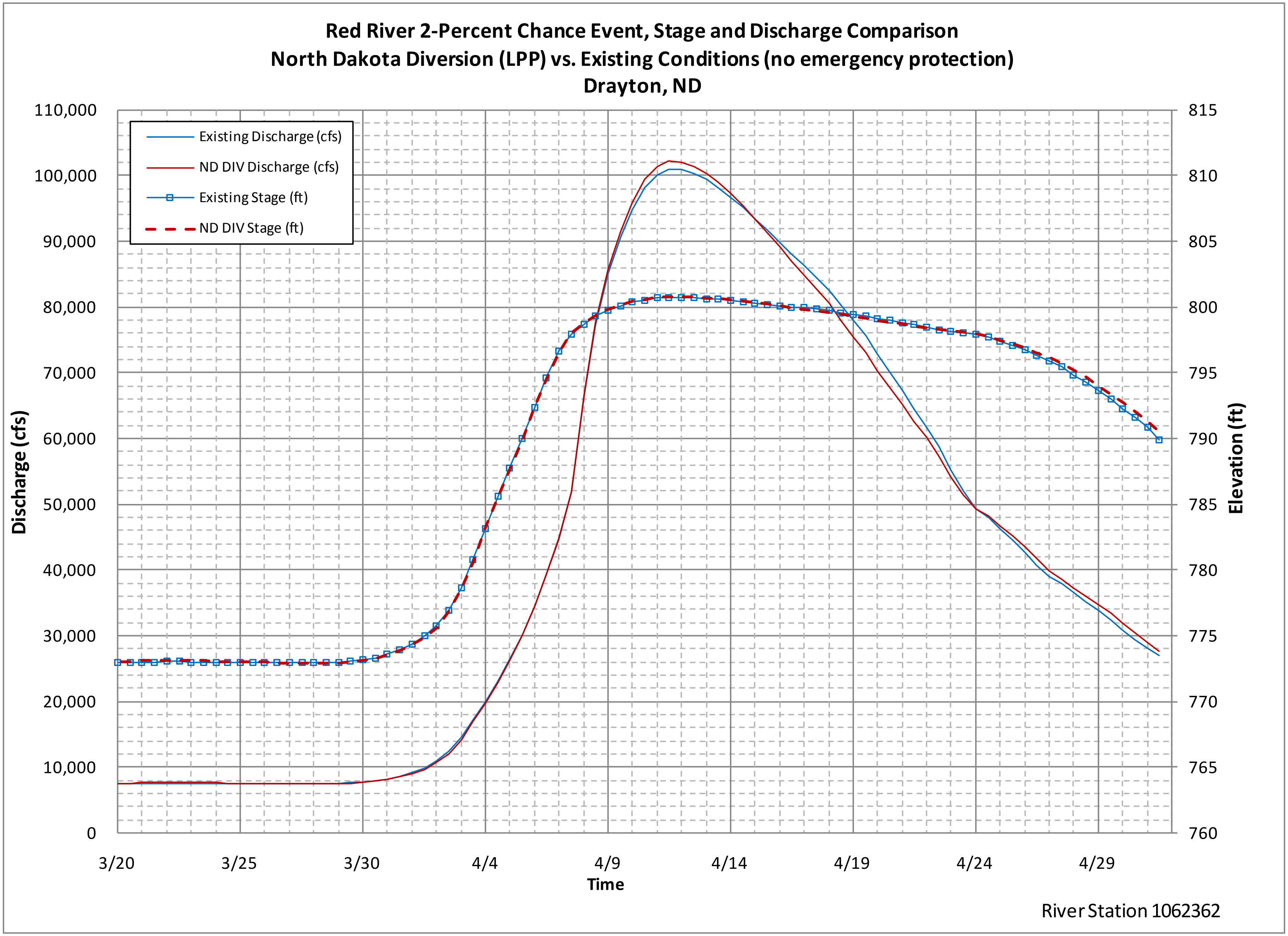


Figure C-E2- 30: 2-Percent Chance Hydrographs for LPP @ Drayton

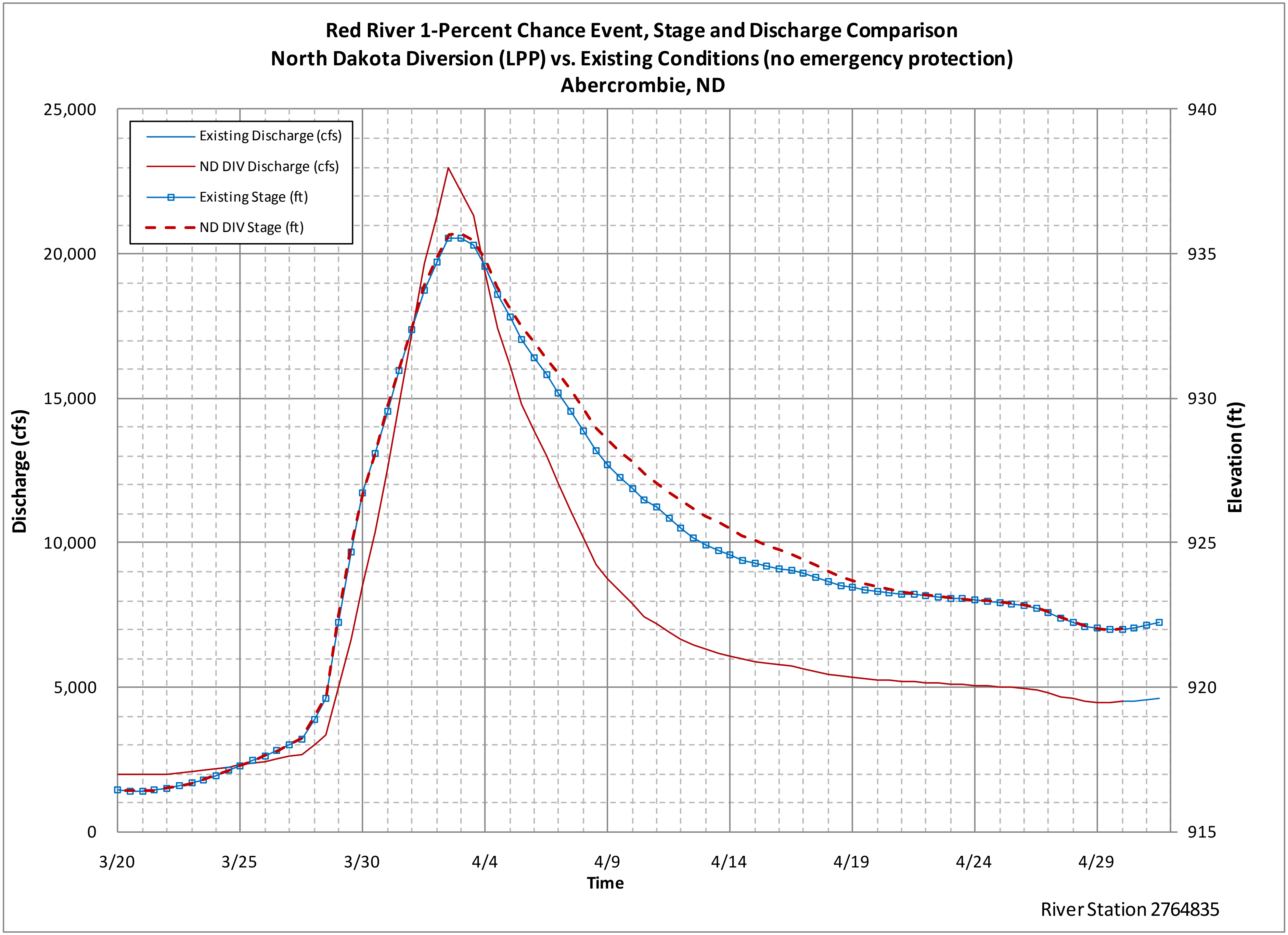


Figure C-E2- 31: 1-Percent Chance Hydrographs for LPP @ Abercrombie

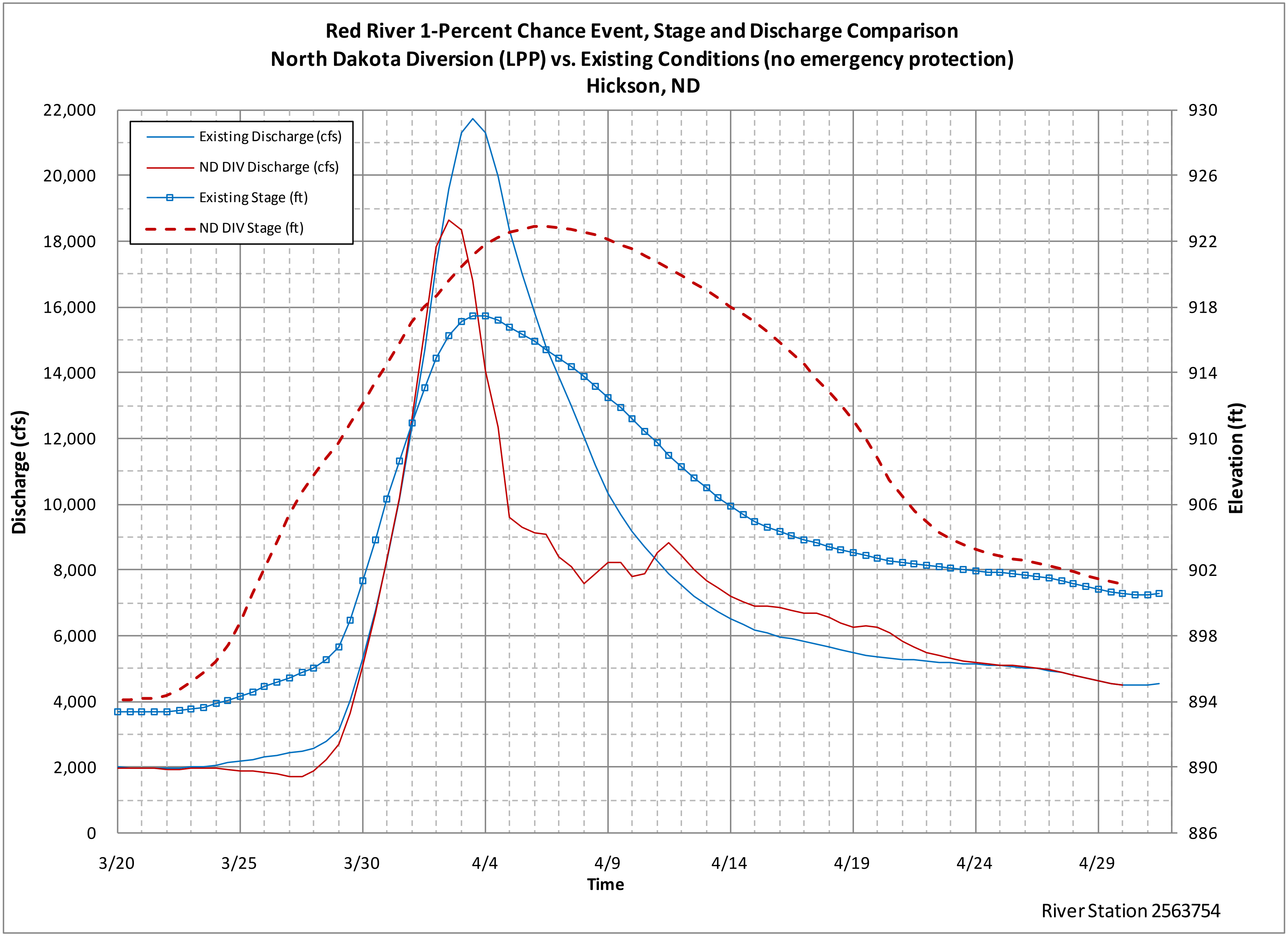


Figure C-E2- 32: 1-Percent Chance Hydrographs for LPP @ Hickson

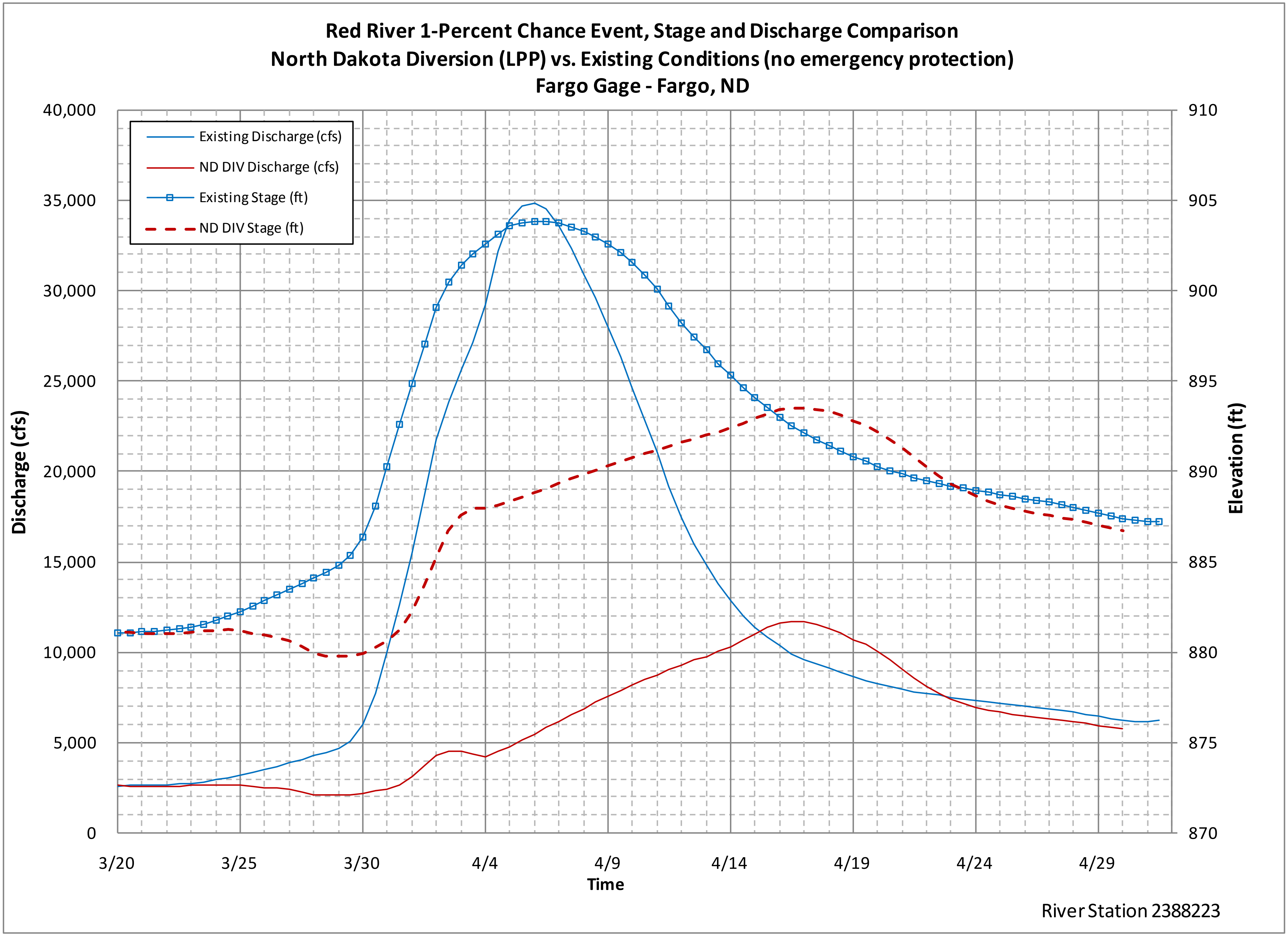


Figure C-E2- 33: 1-Percent Chance Hydrographs for LPP @ Fargo

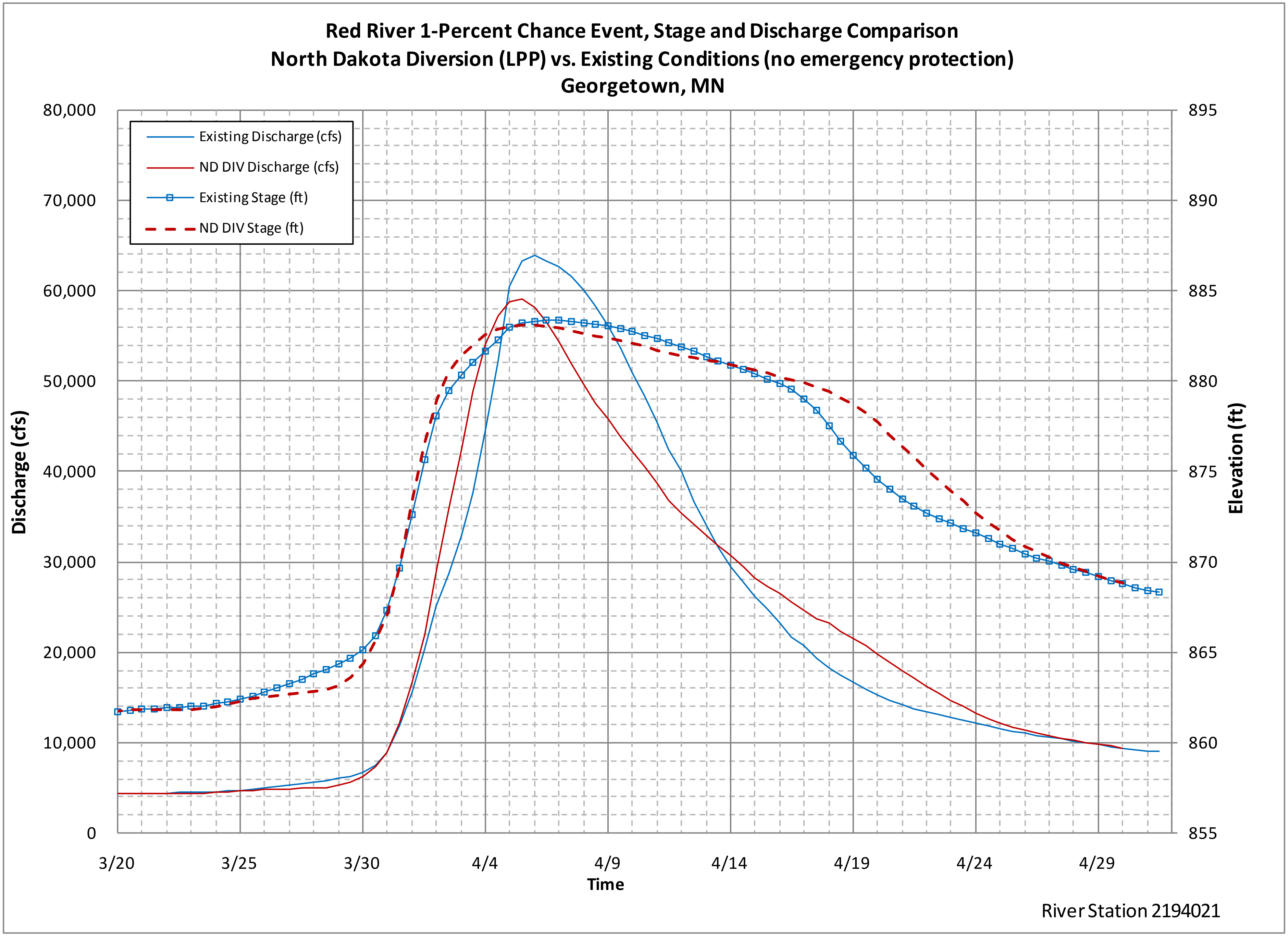


Figure C-E2- 34: 1-Percent Chance Hydrographs for LPP @ Georgetown

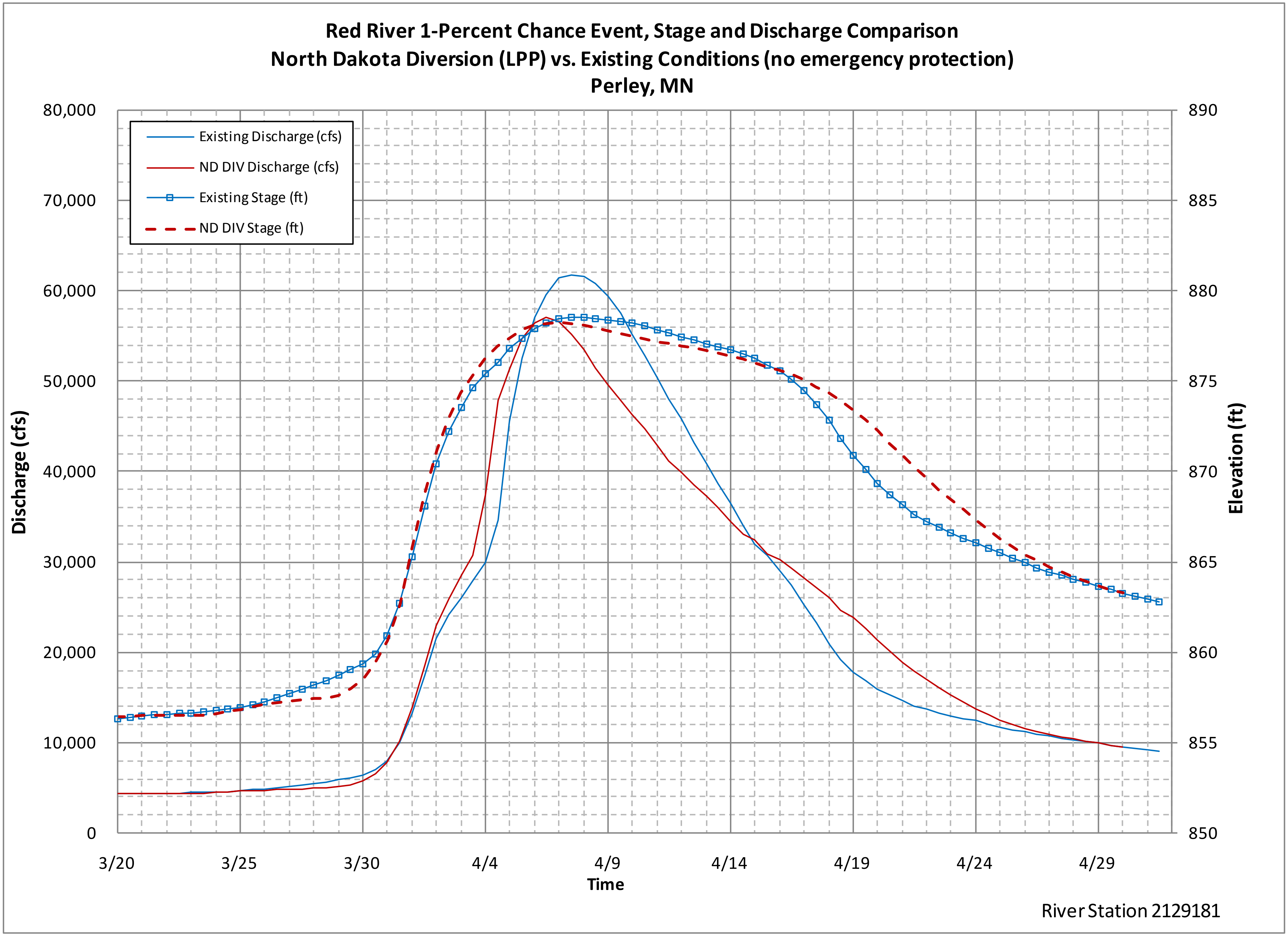


Figure C-E2- 35: 1-Percent Chance Hydrographs for LPP @ Perley

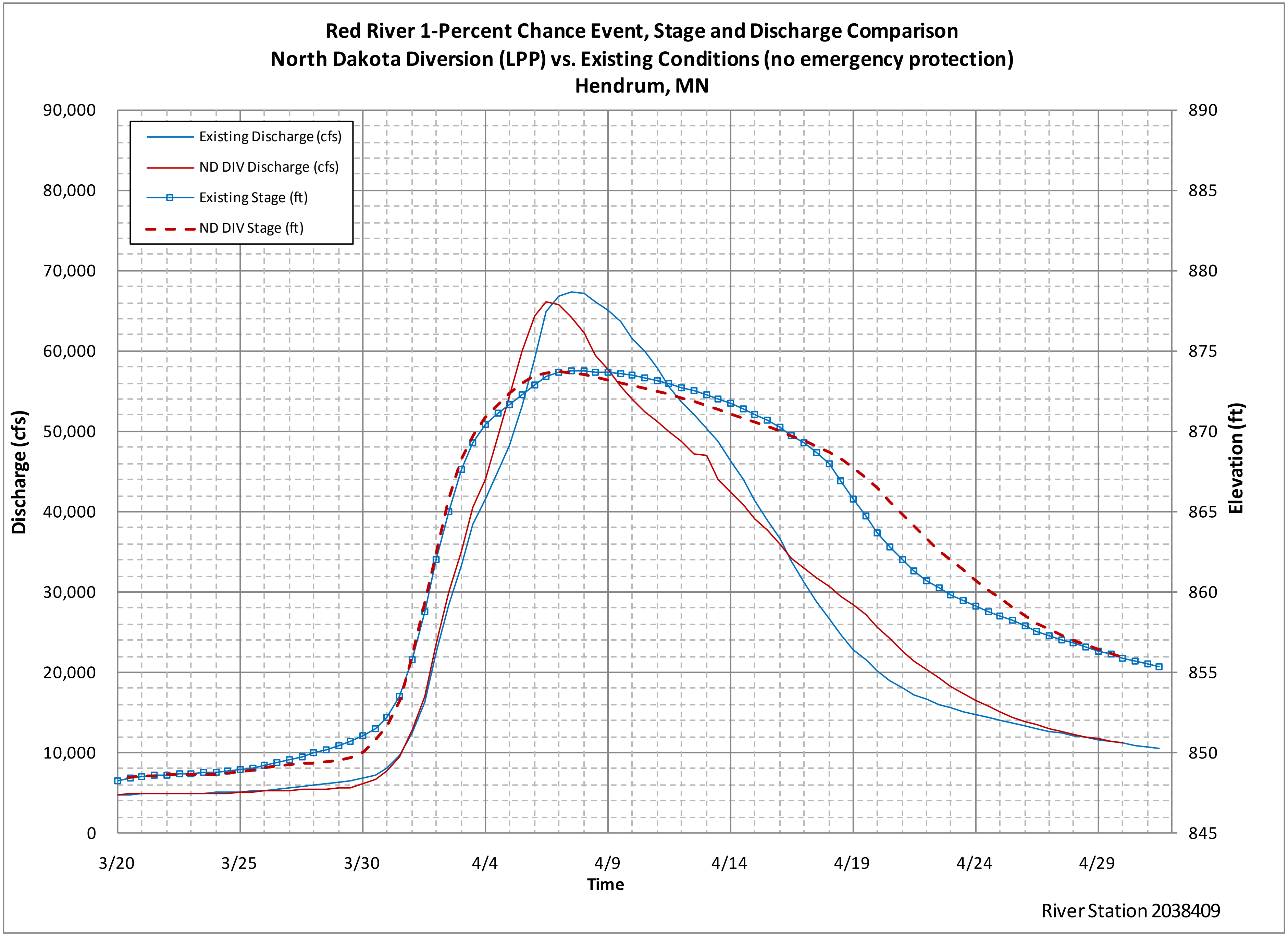


Figure C-E2- 36: 1-Percent Chance Hydrographs for LPP @ Hendrum

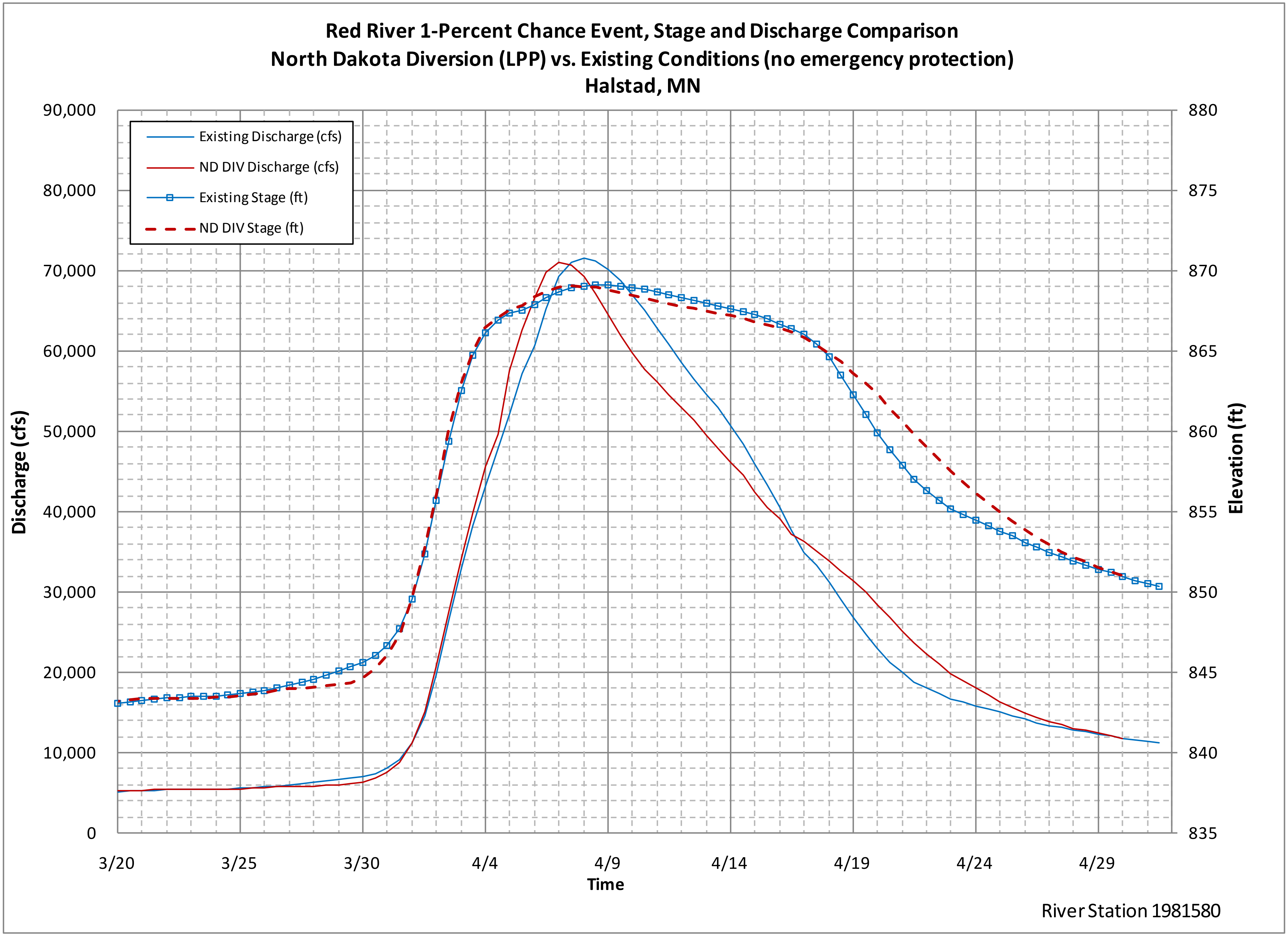


Figure C-E2- 37: 1-Percent Chance Hydrographs for LPP @ Halstad

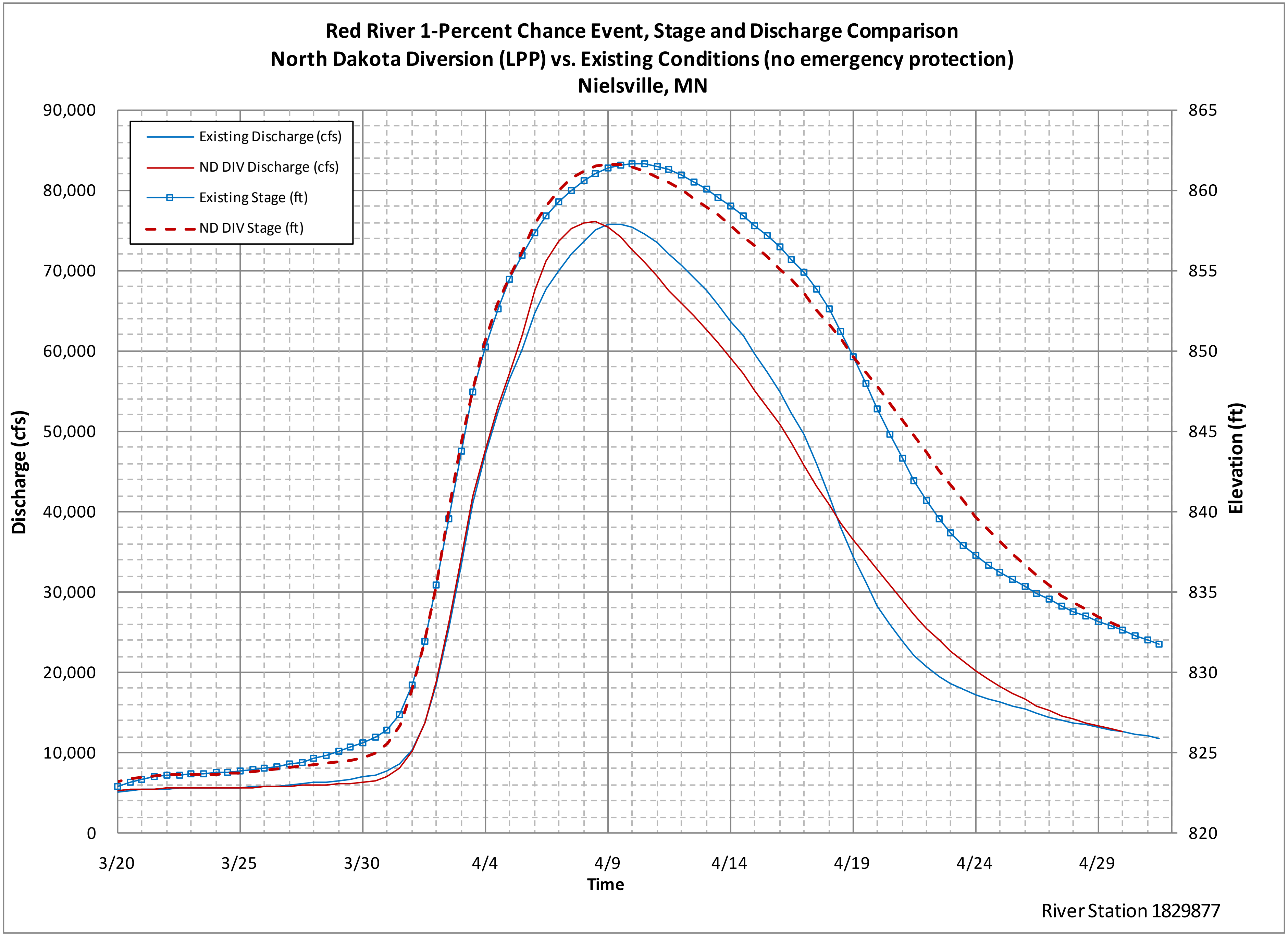


Figure C-E2- 38: 1-Percent Chance Hydrographs for LPP @ Nielsville

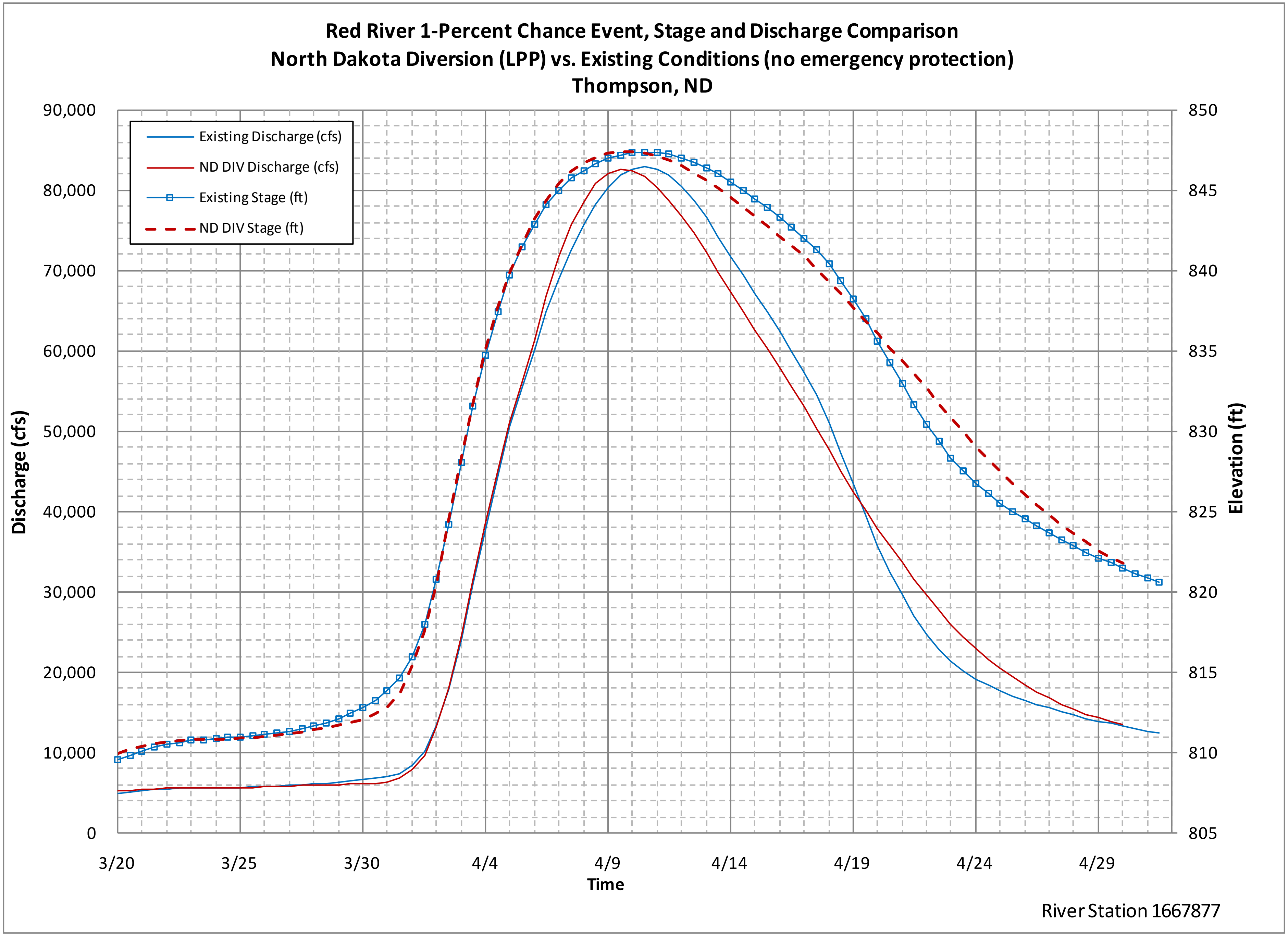


Figure C-E2- 39: 1-Percent Chance Hydrographs for LPP @ Thompson

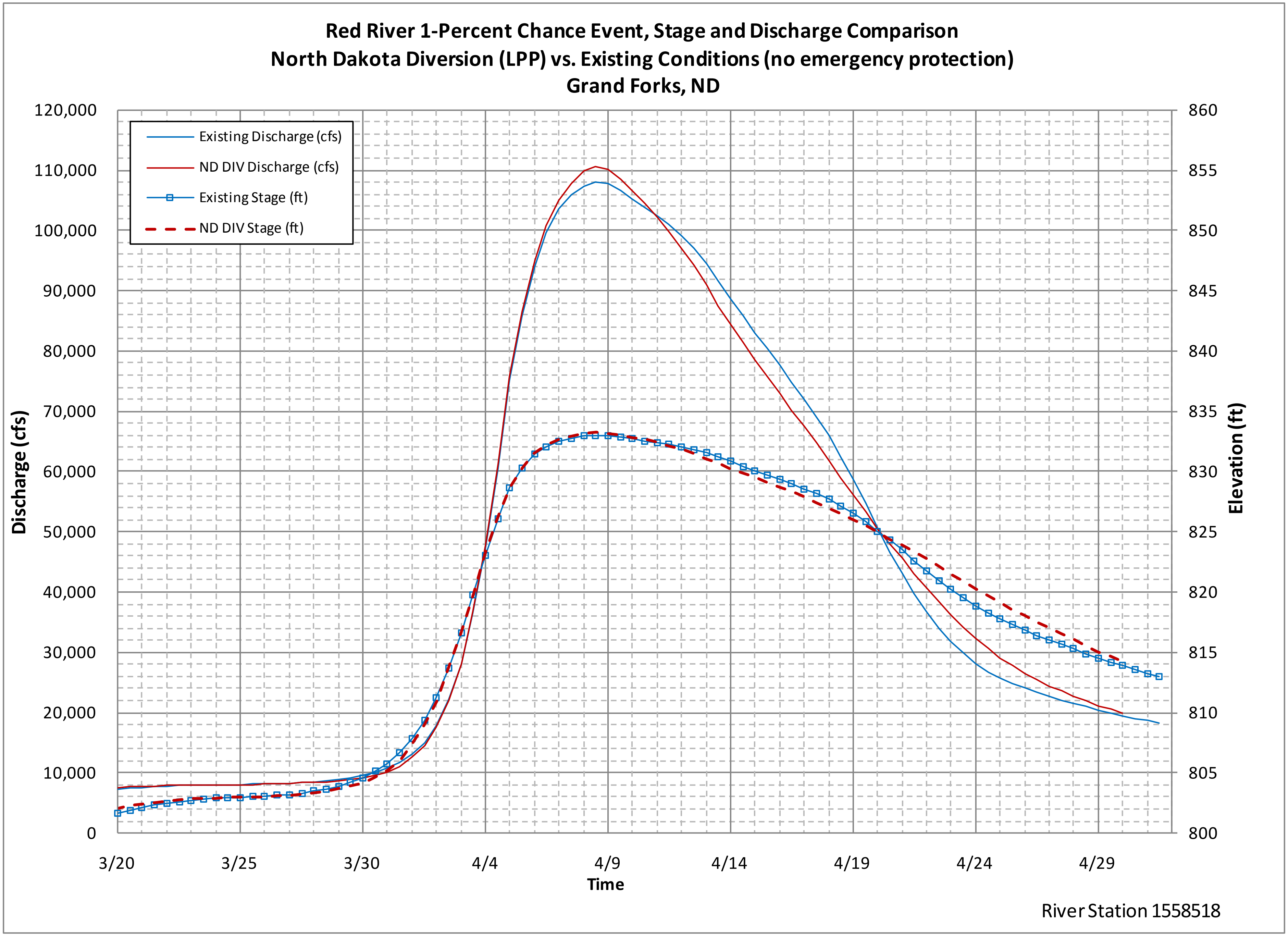


Figure C-E2- 40: 1-Percent Chance Hydrographs for LPP @ Grand Forks

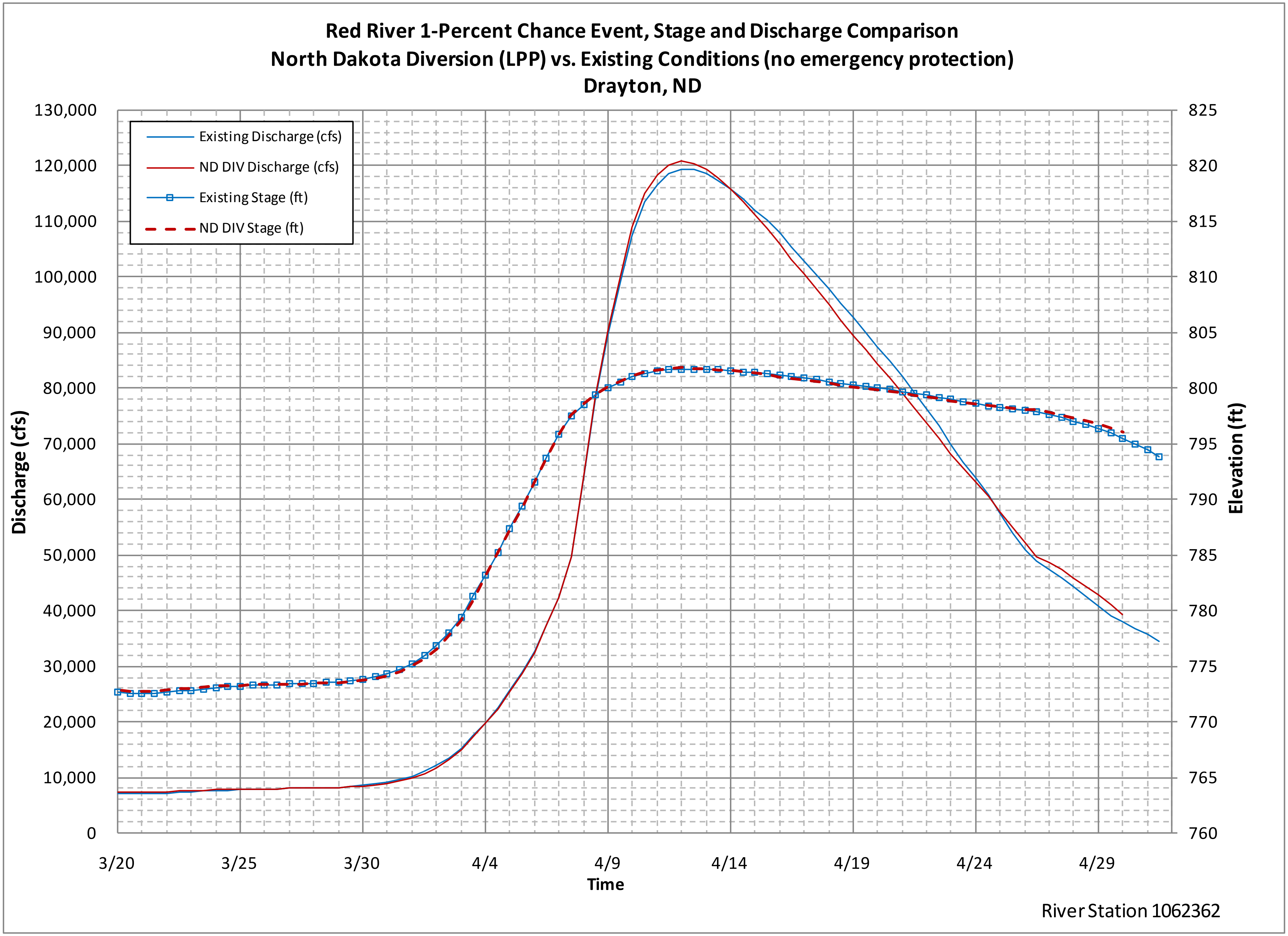


Figure C-E2- 41: 1-Percent Chance Hydrographs for LPP @ Drayton

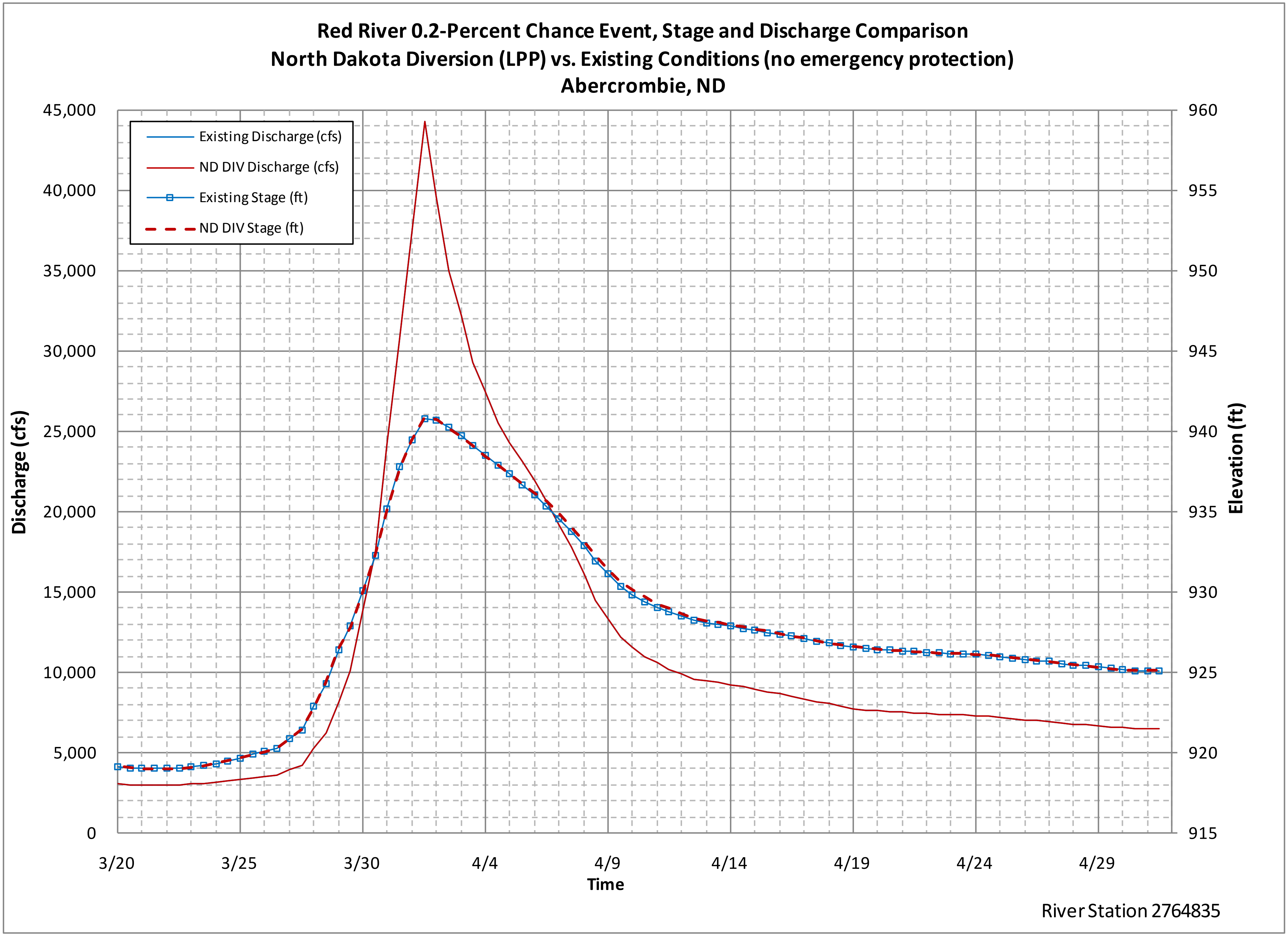


Figure C-E2- 42: 0.2-Percent Chance Hydrographs for LPP @ Abercrombie

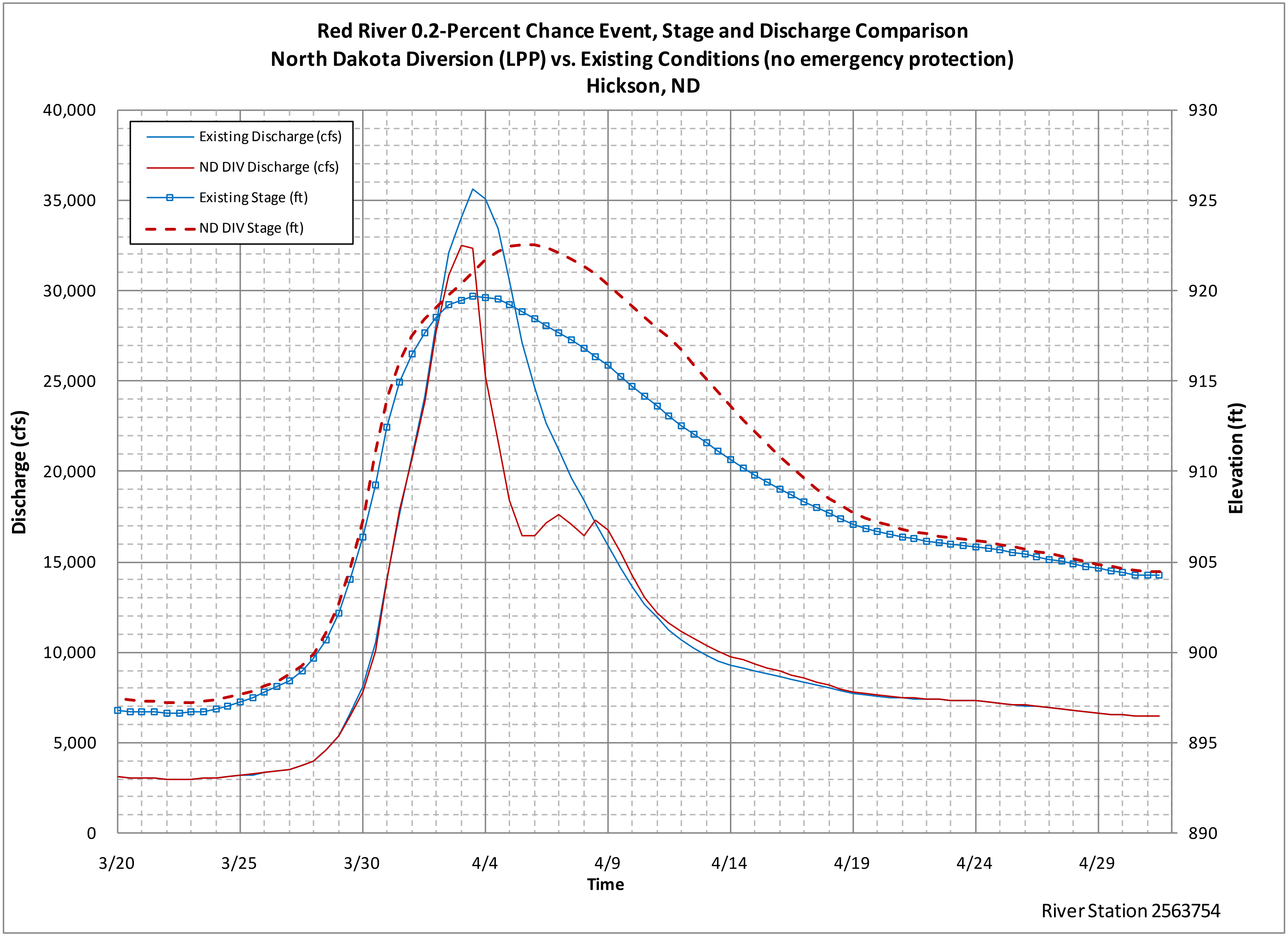


Figure C-E2- 43: 0.2-Percent Chance Hydrographs for LPP @ Hickson

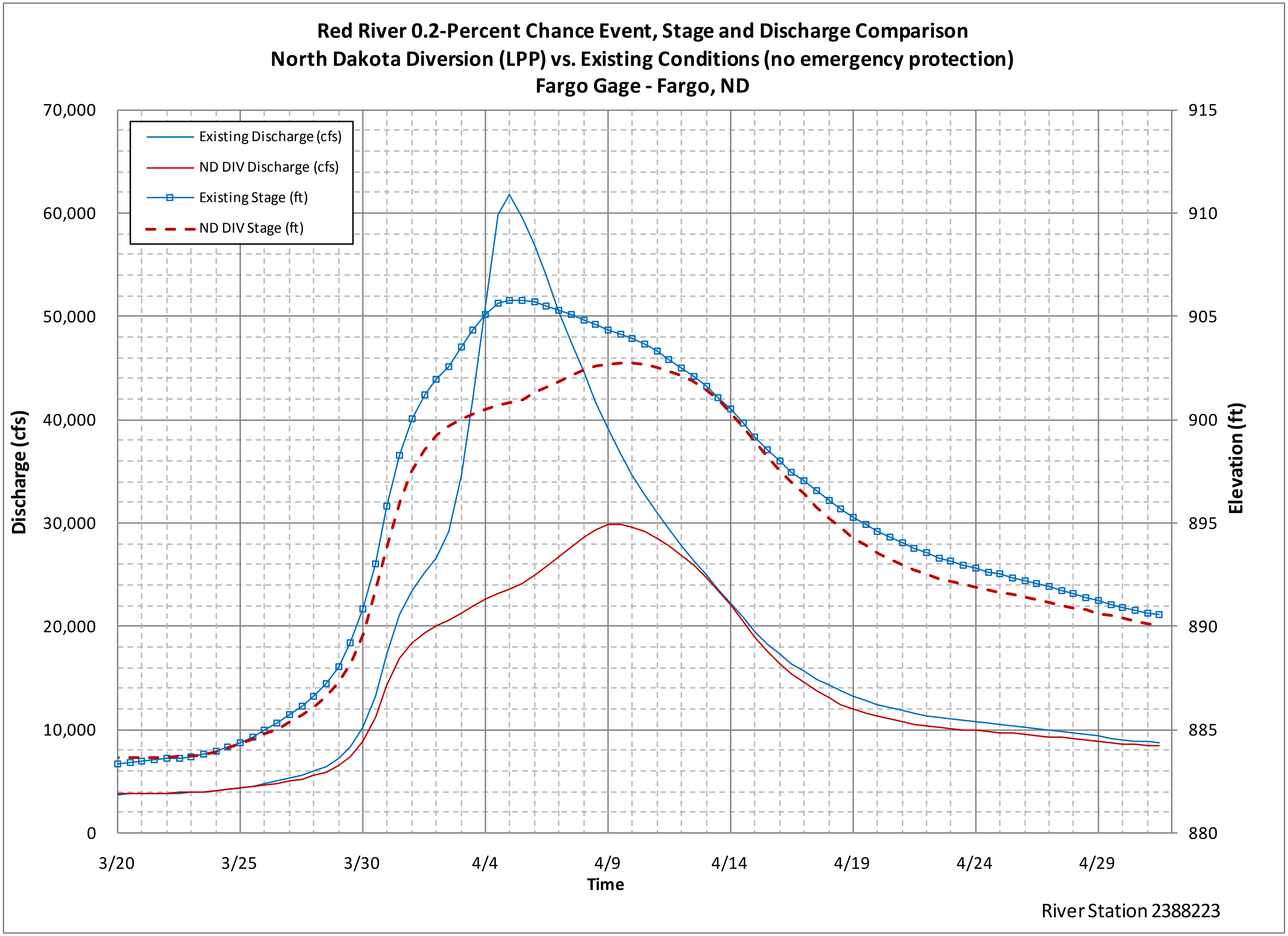


Figure C-E2- 44: 0.2-Percent Chance Hydrographs for LPP @ Fargo

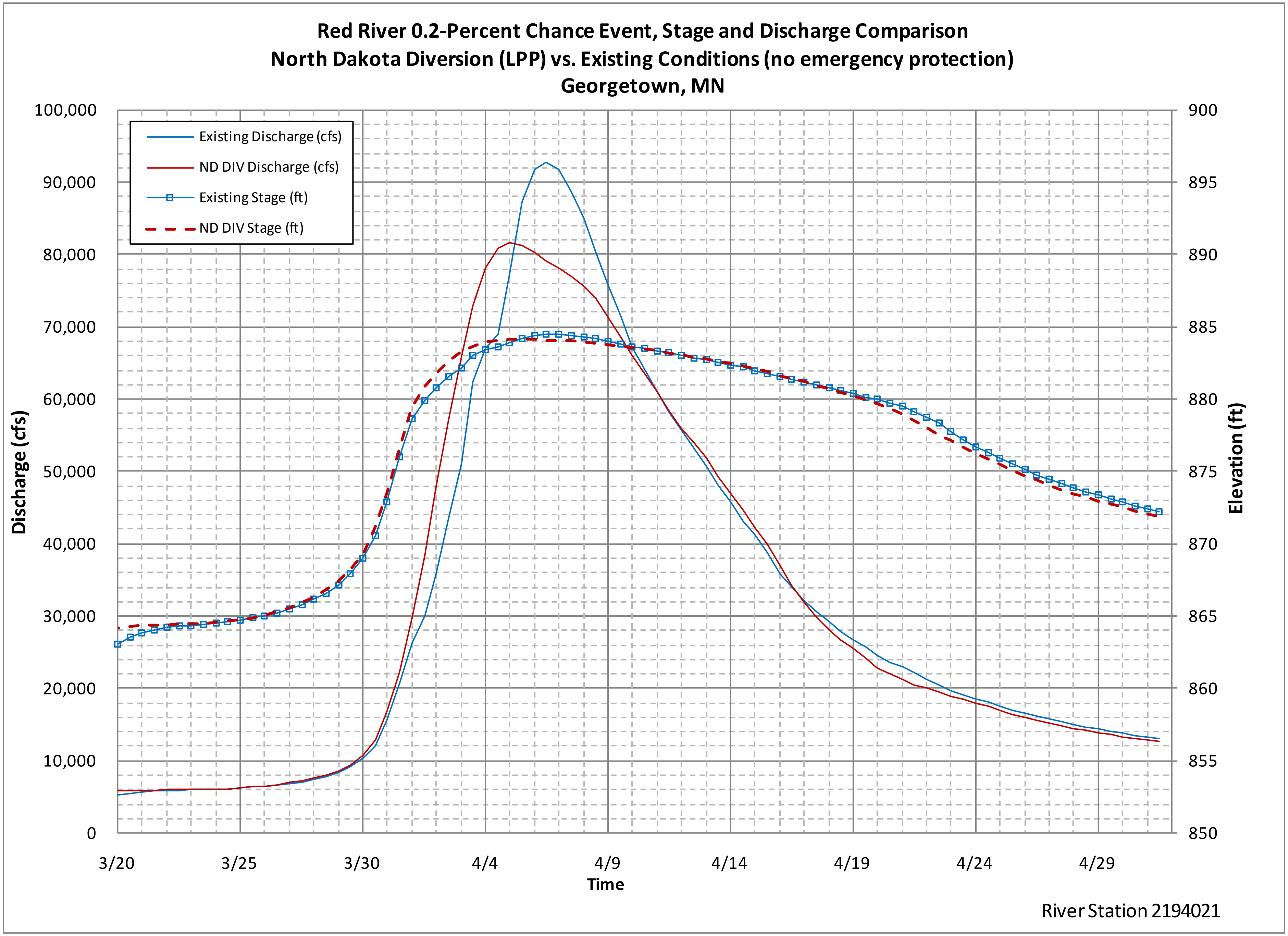


Figure C-E2- 45: 0.2-Percent Chance Hydrographs for LPP @ Georgetown

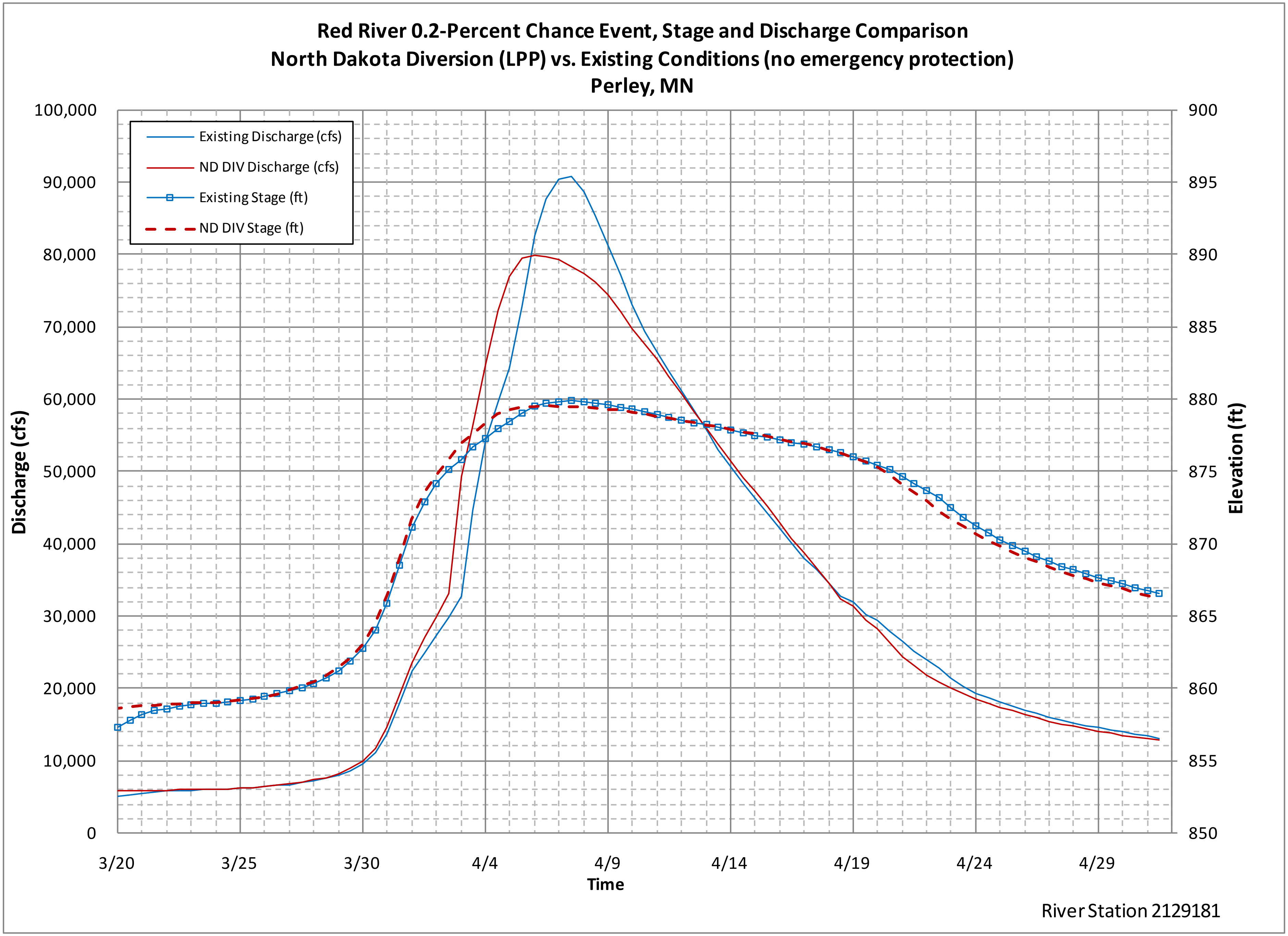


Figure C-E2- 46: 0.2-Percent Chance Hydrographs for LPP @ Perley

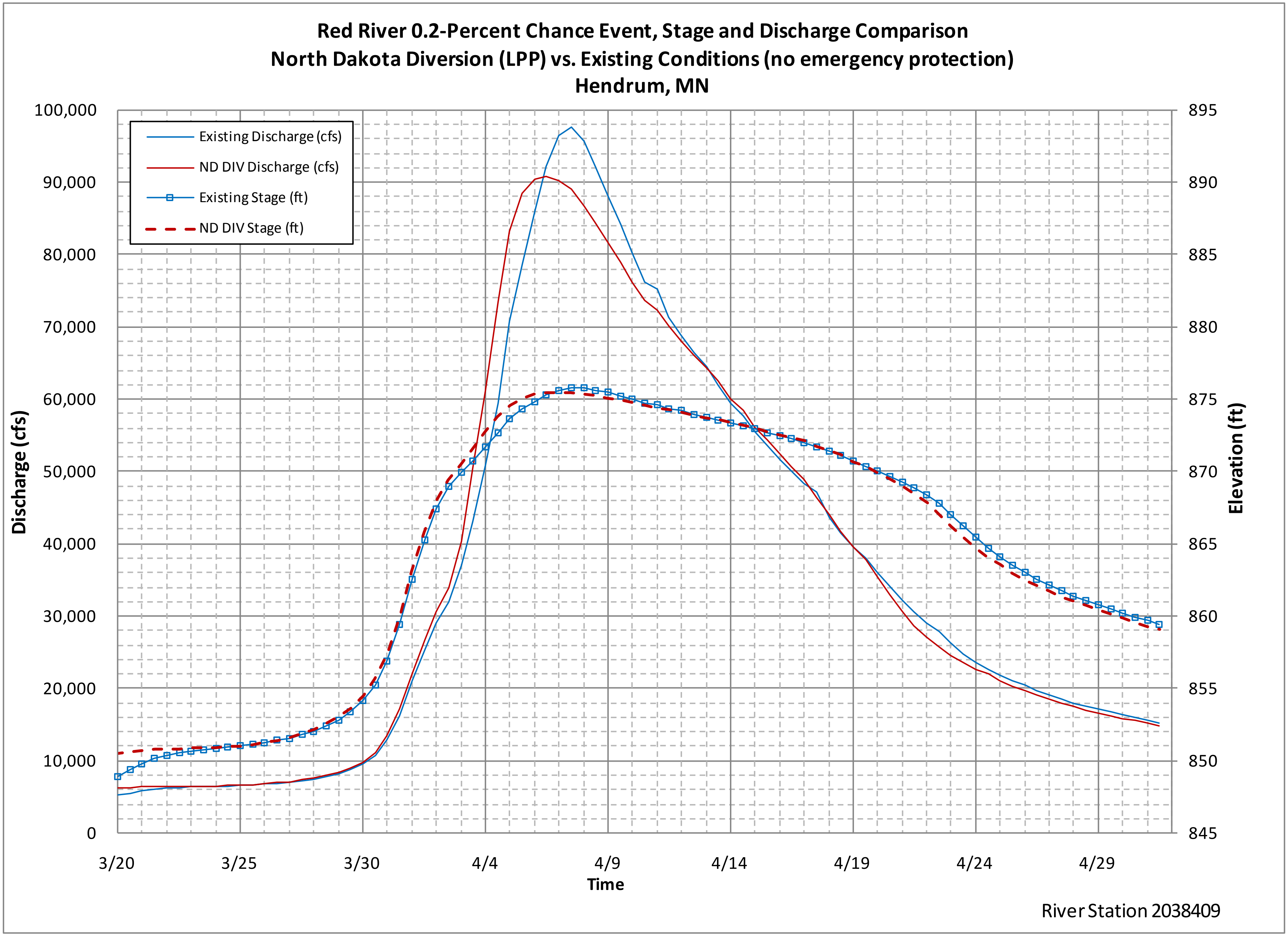


Figure C-E2- 47: 0.2-Percent Chance Hydrographs for LPP @ Hendrum

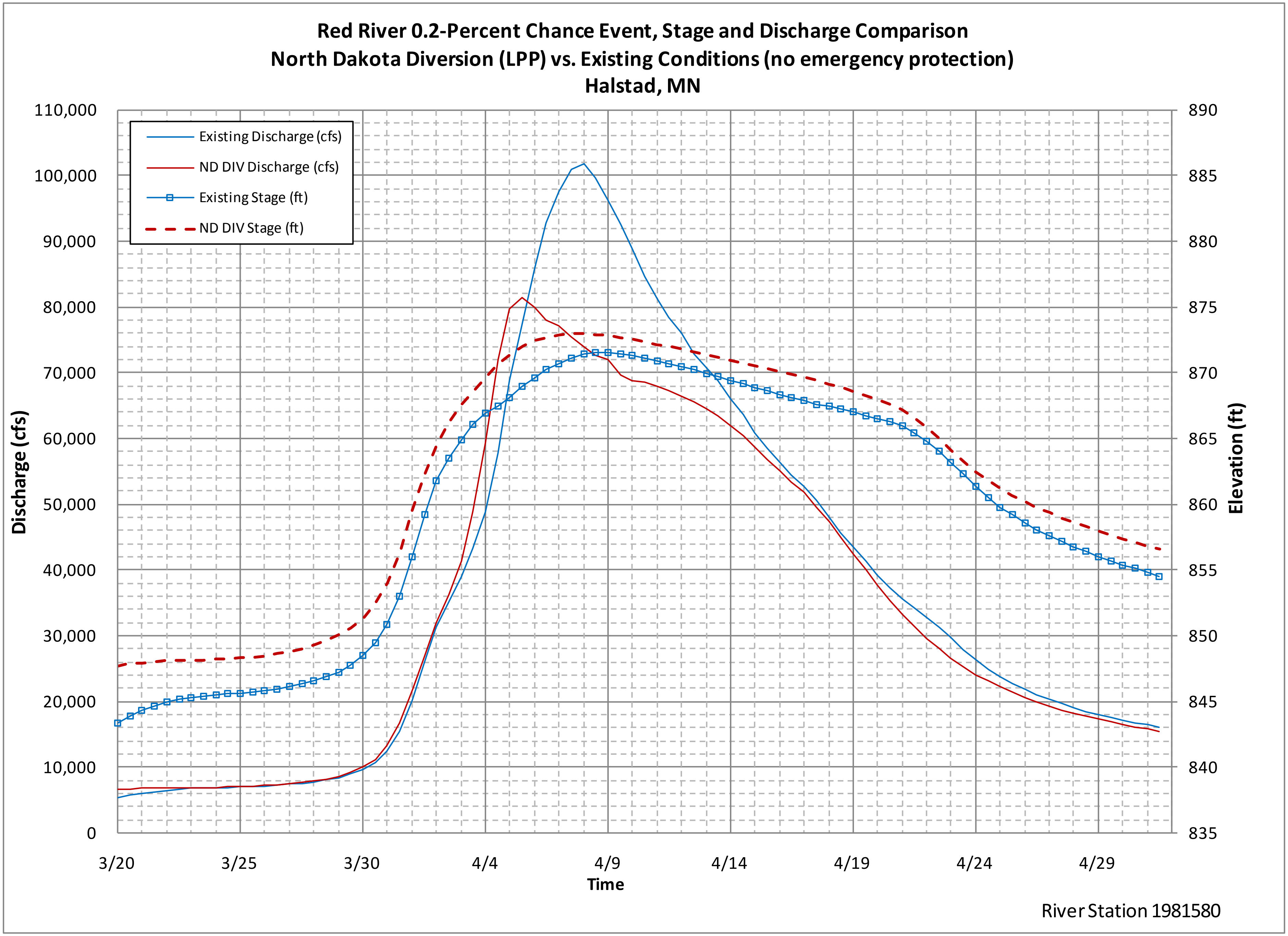


Figure C-E2- 48: 0.2-Percent Chance Hydrographs for LPP @ Halstad

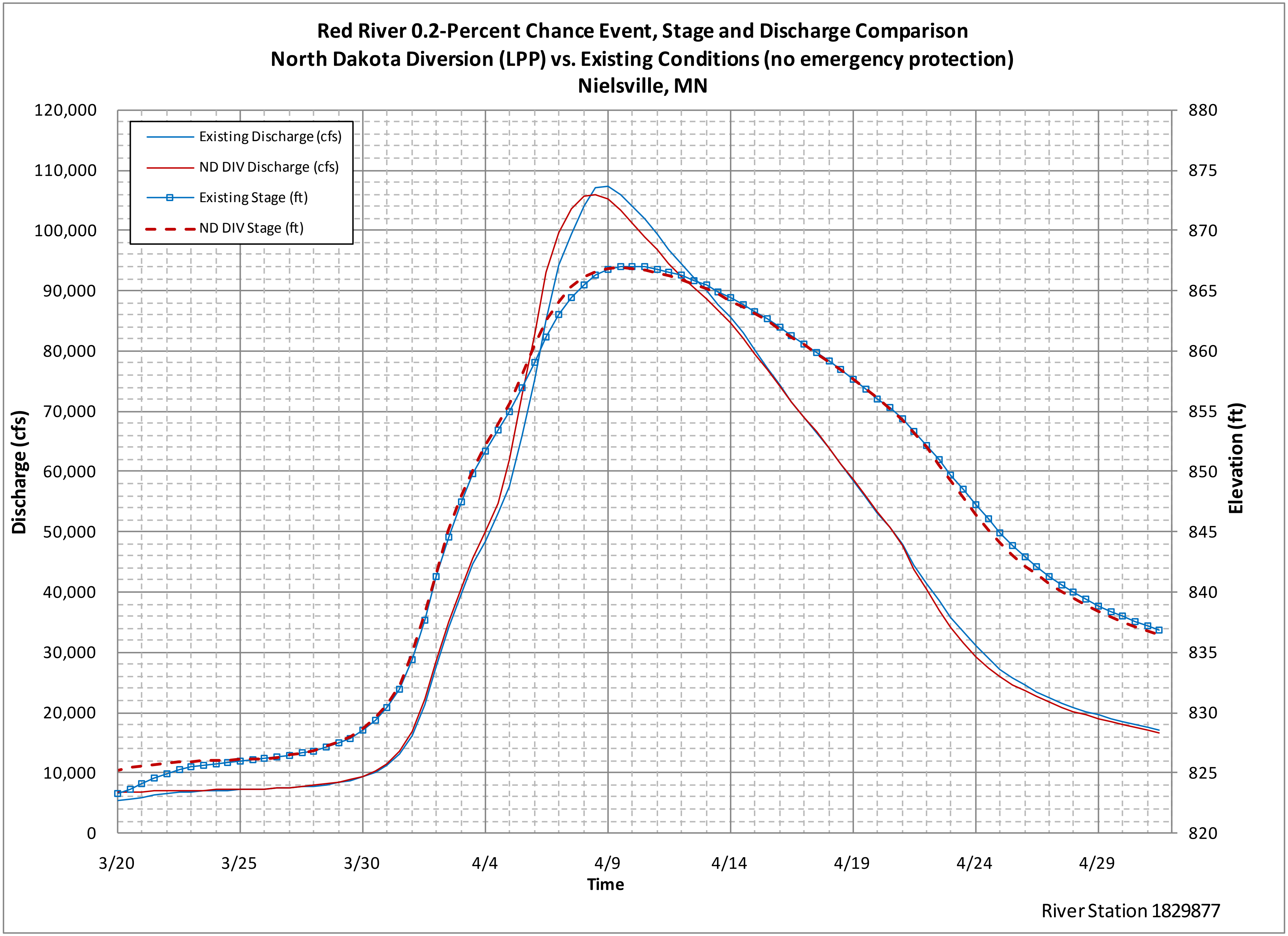


Figure C-E2- 49: 0.2-Percent Chance Hydrographs for LPP @ Nielsville

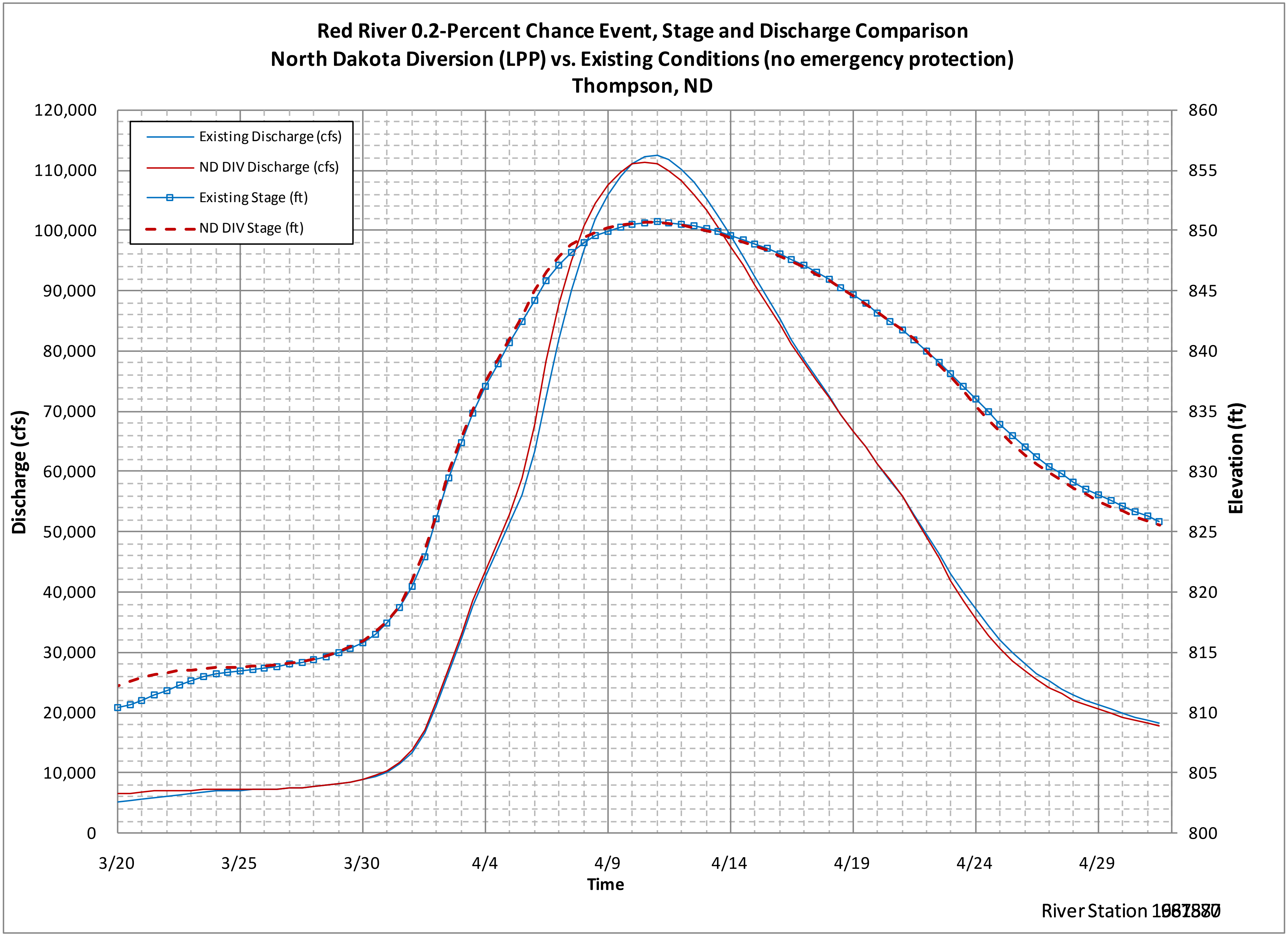


Figure C-E2- 50: 0.2-Percent Chance Hydrographs for LPP @ Thompson

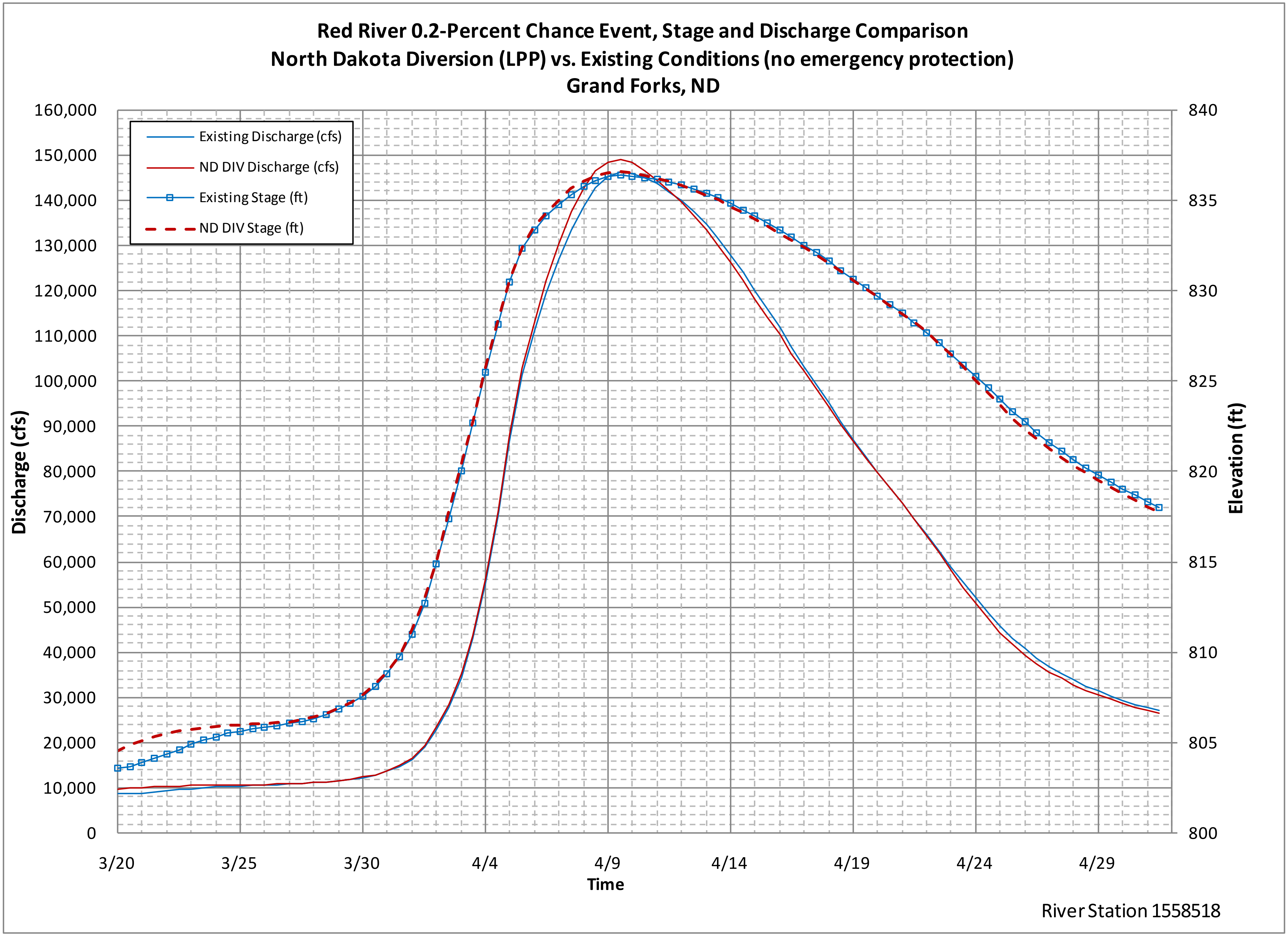


Figure C-E2- 51: 0.2-Percent Chance Hydrographs for LPP @ Grand Forks

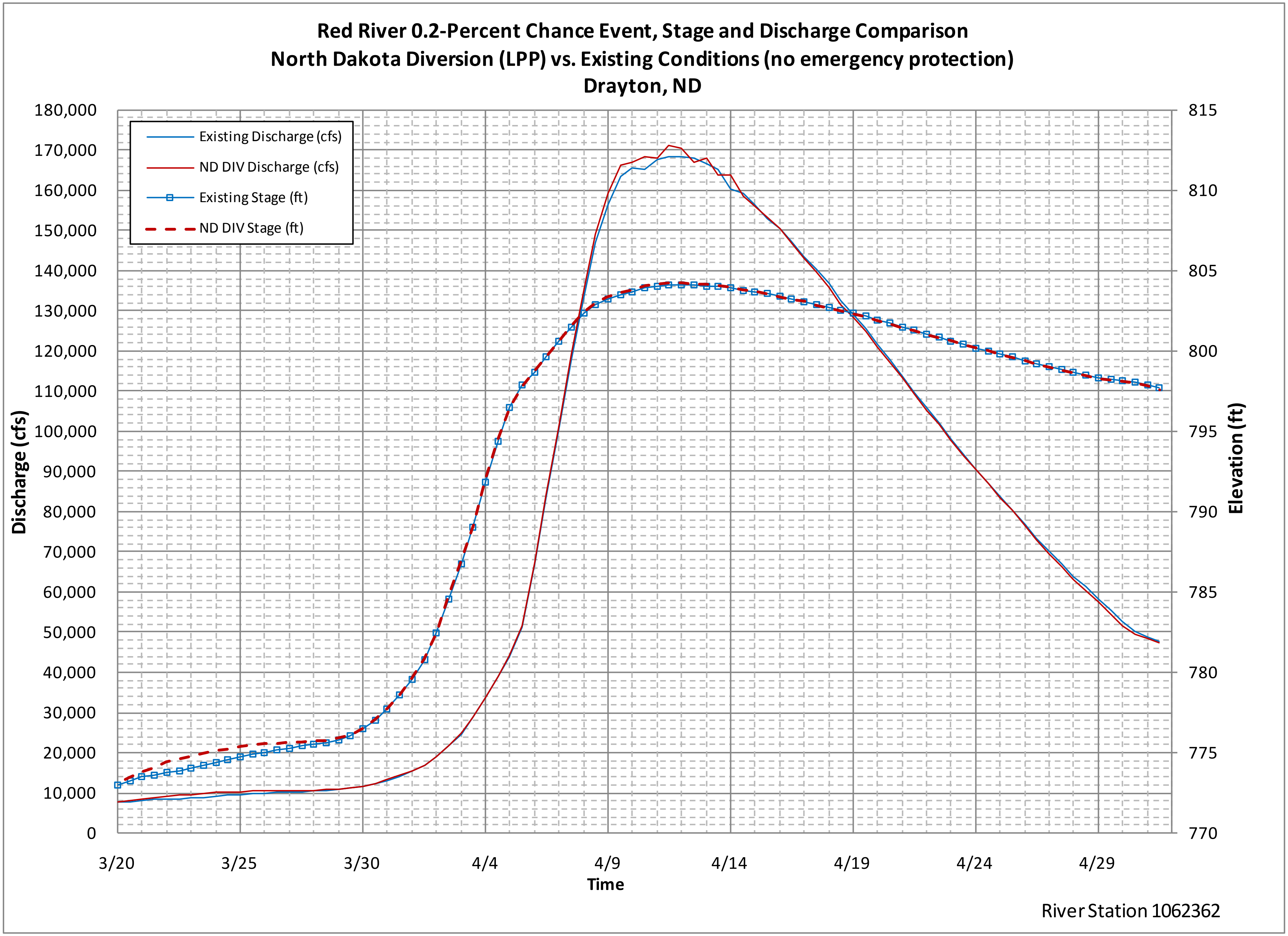


Figure C-E2- 52: 0.2-Percent Chance Hydrographs for LPP @ Drayton

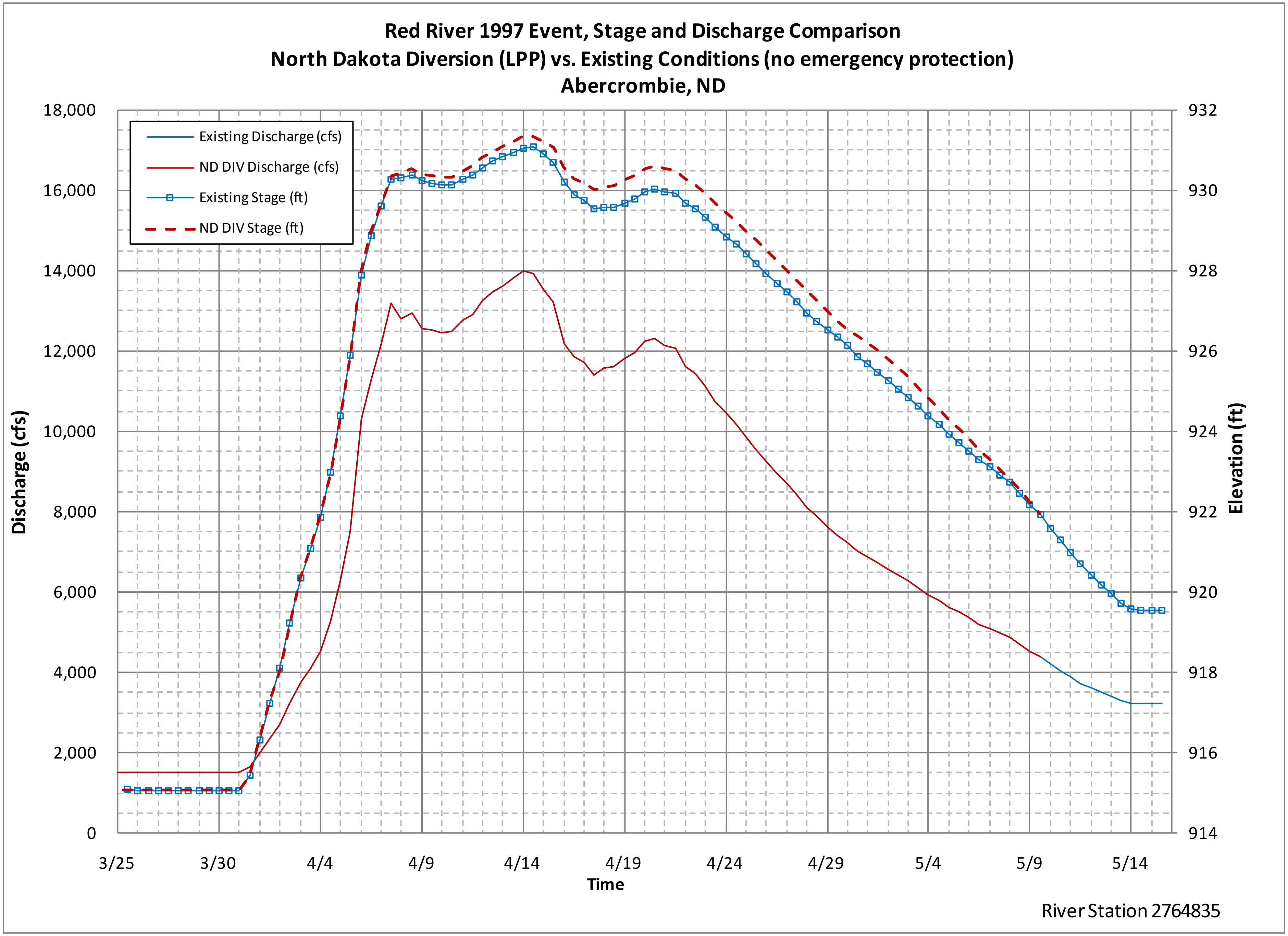


Figure C-E2- 53: 1997 Historical Flood Hydrographs for LPP @ Abercrombie

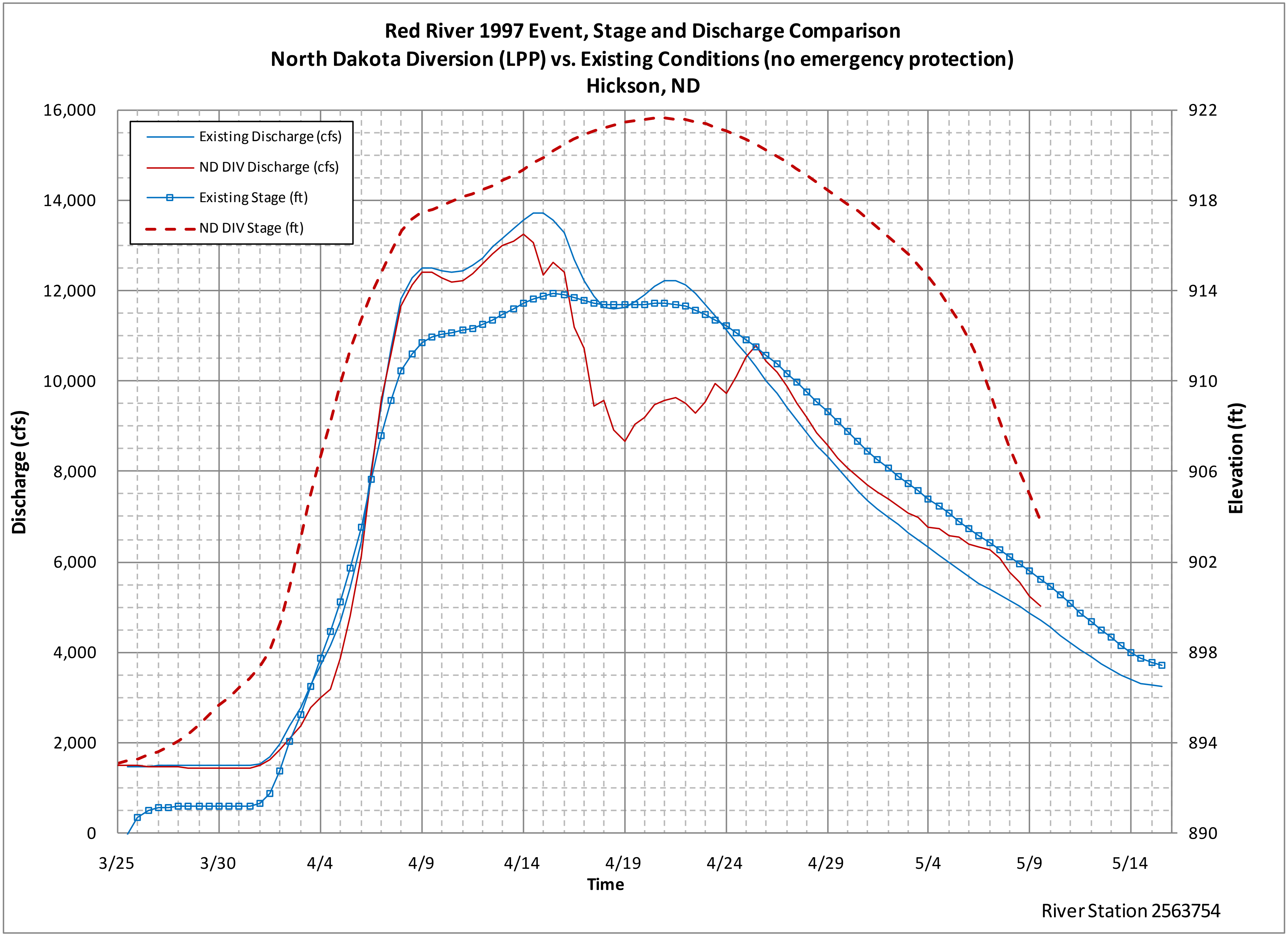


Figure C-E2- 54: 1997 Historical Flood Hydrographs for LPP @ Hickson

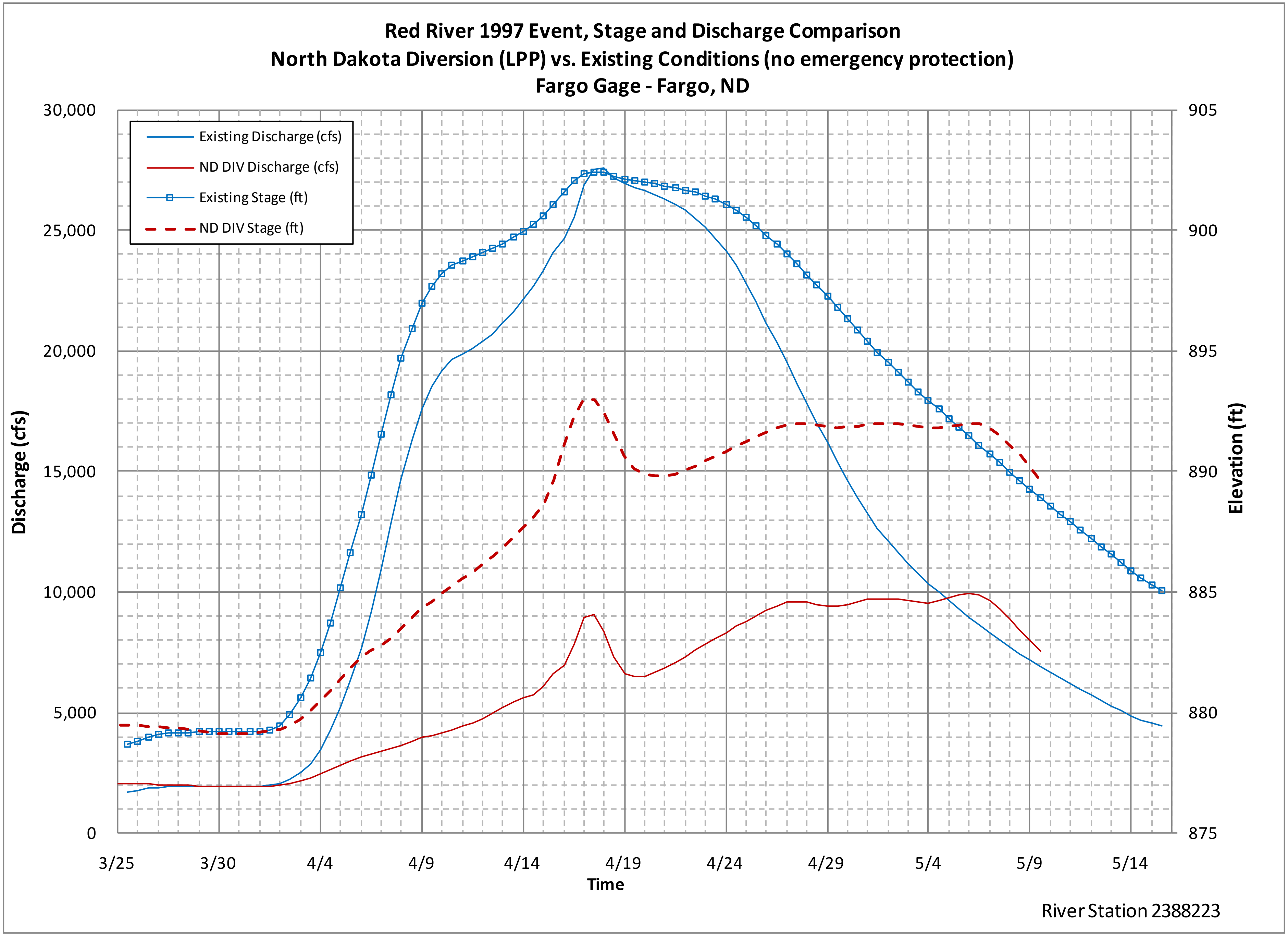


Figure C-E2- 55: 1997 Historical Flood Hydrographs for LPP @ Fargo

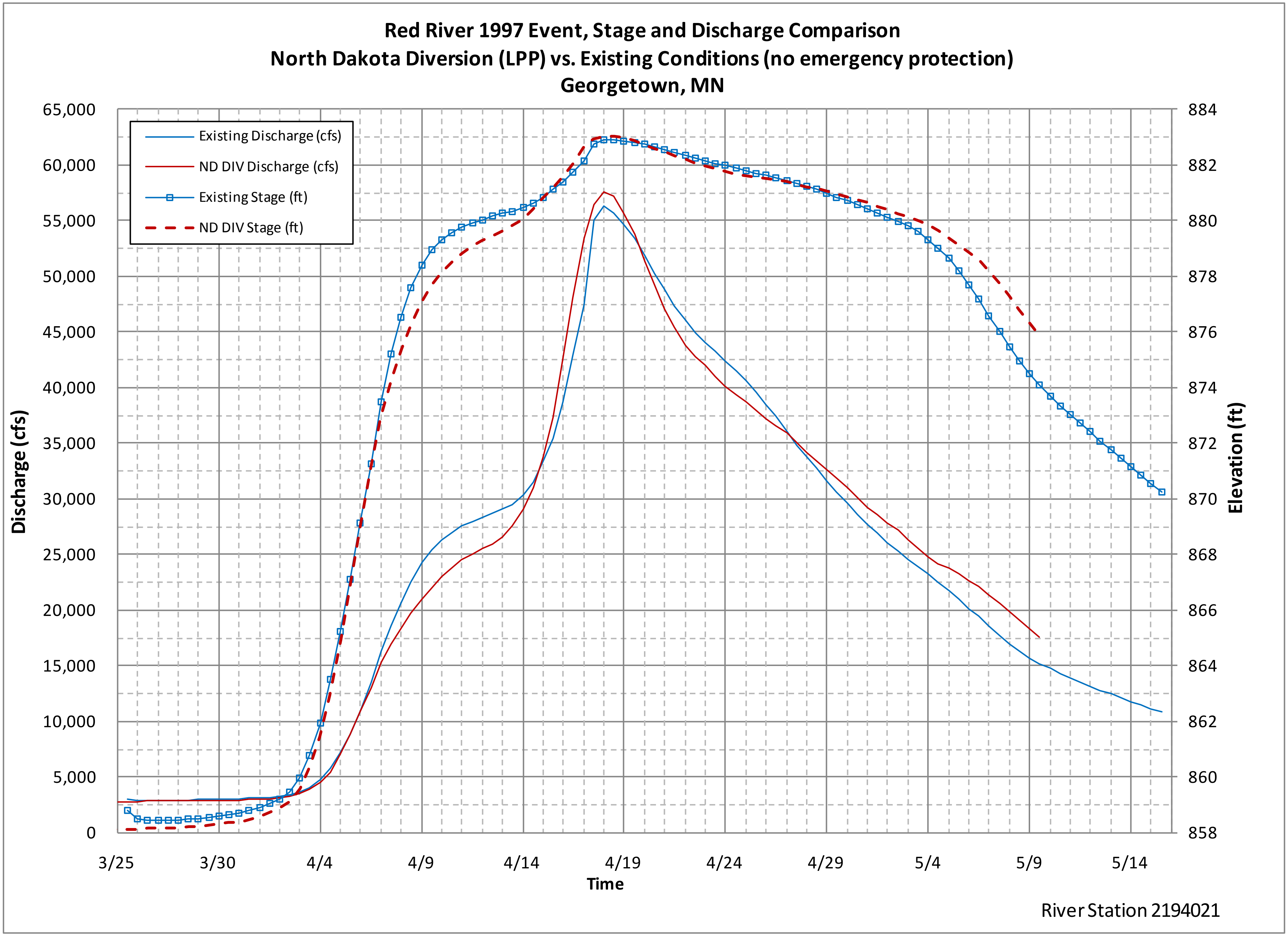


Figure C-E2- 56: 1997 Historical Flood Hydrographs for LPP @ Georgetown

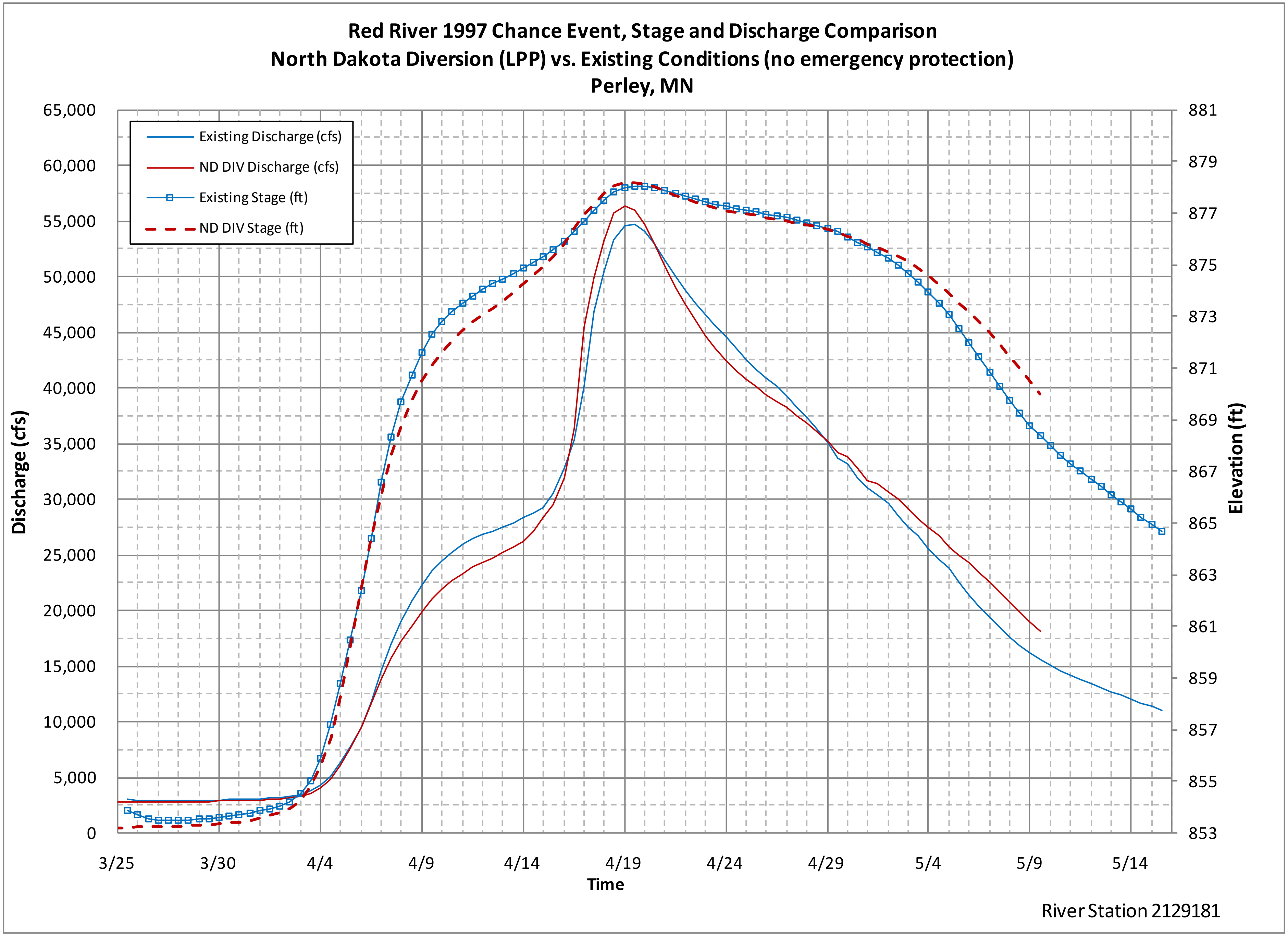


Figure C-E2- 57: 1997 Historical Flood Hydrographs for LPP @ Perley

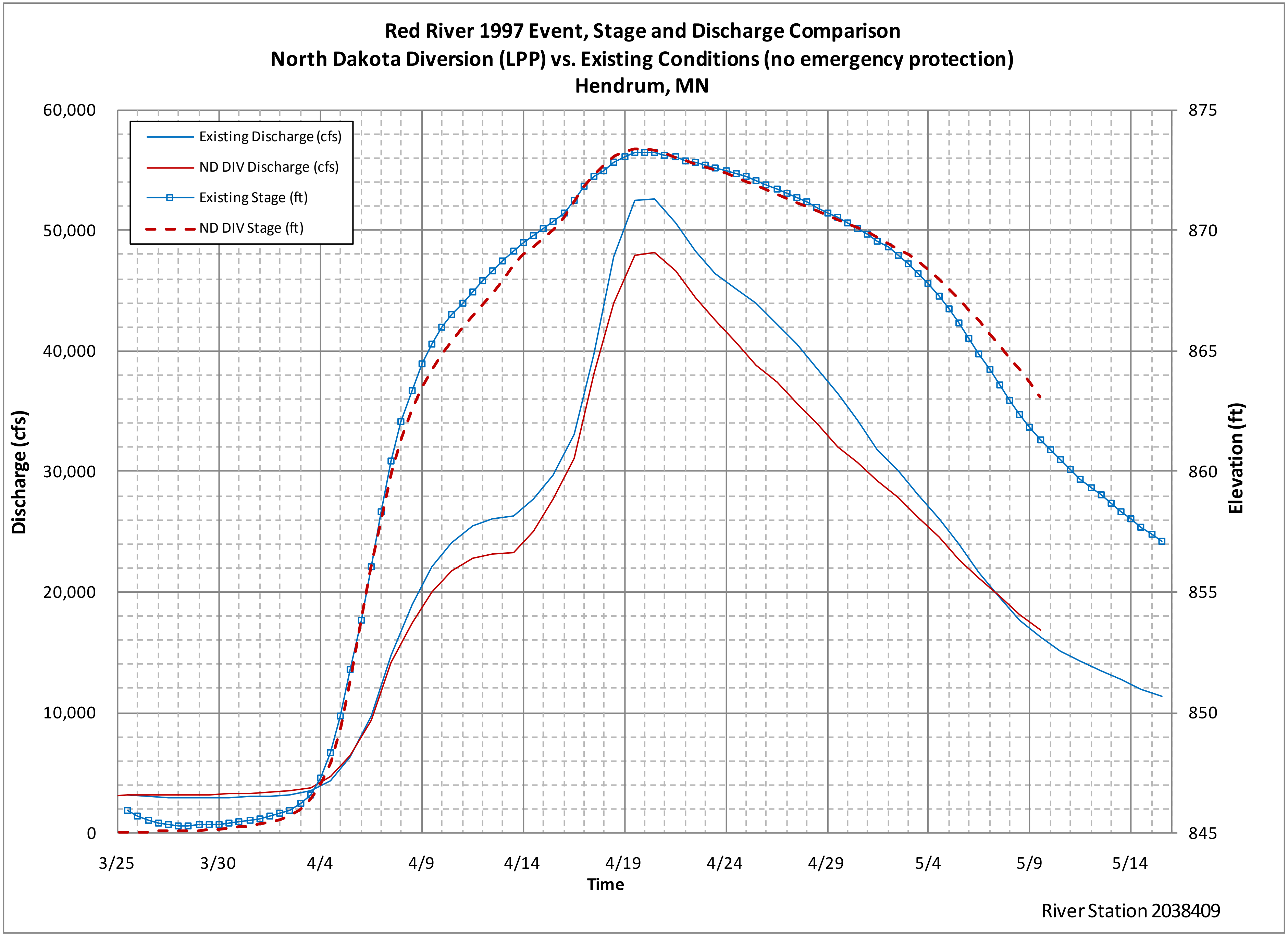


Figure C-E2- 58: 1997 Historical Flood Hydrographs for LPP @ Hendrum

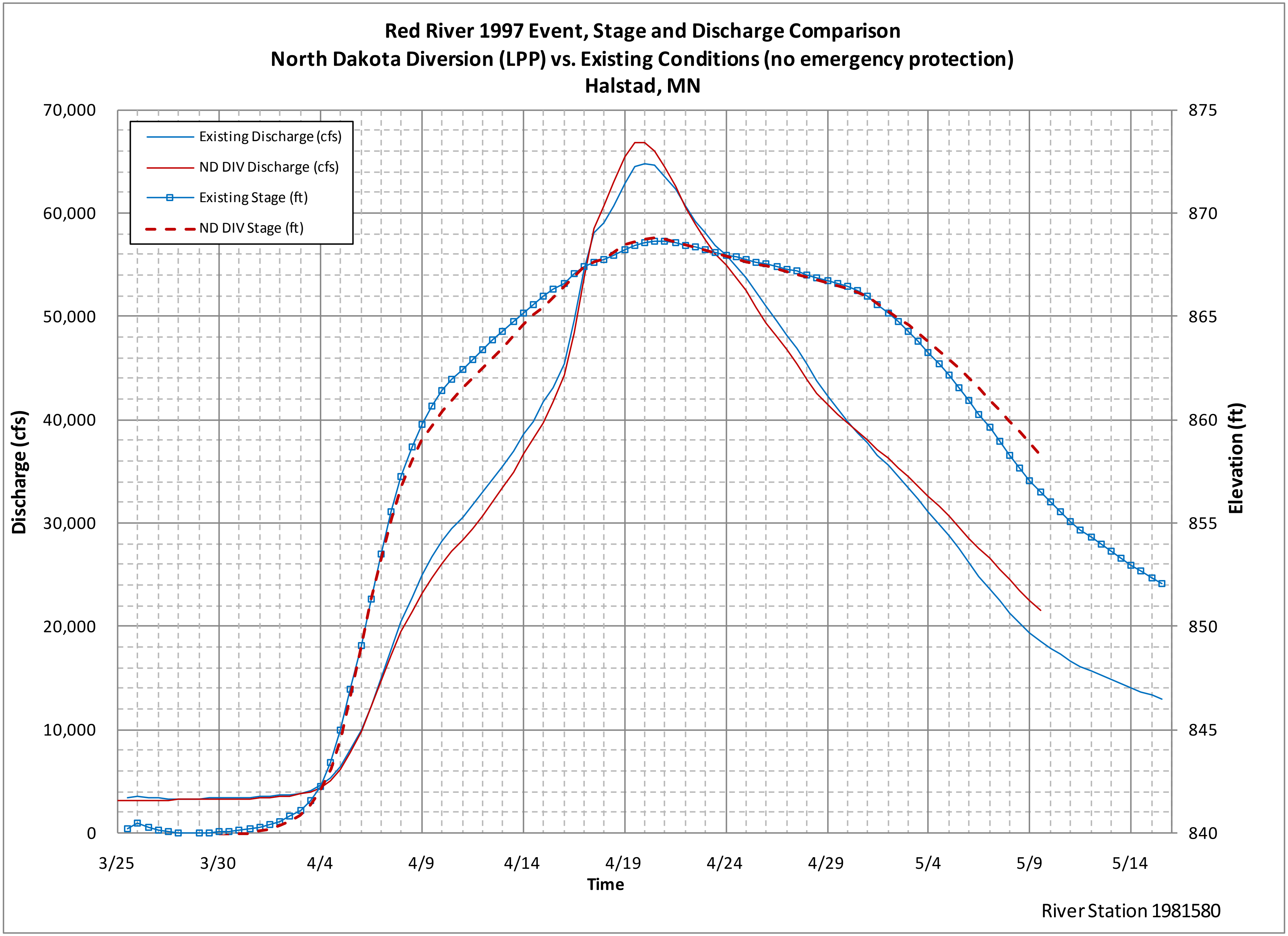


Figure C-E2- 59: 1997 Historical Flood Hydrographs for LPP @ Halstad

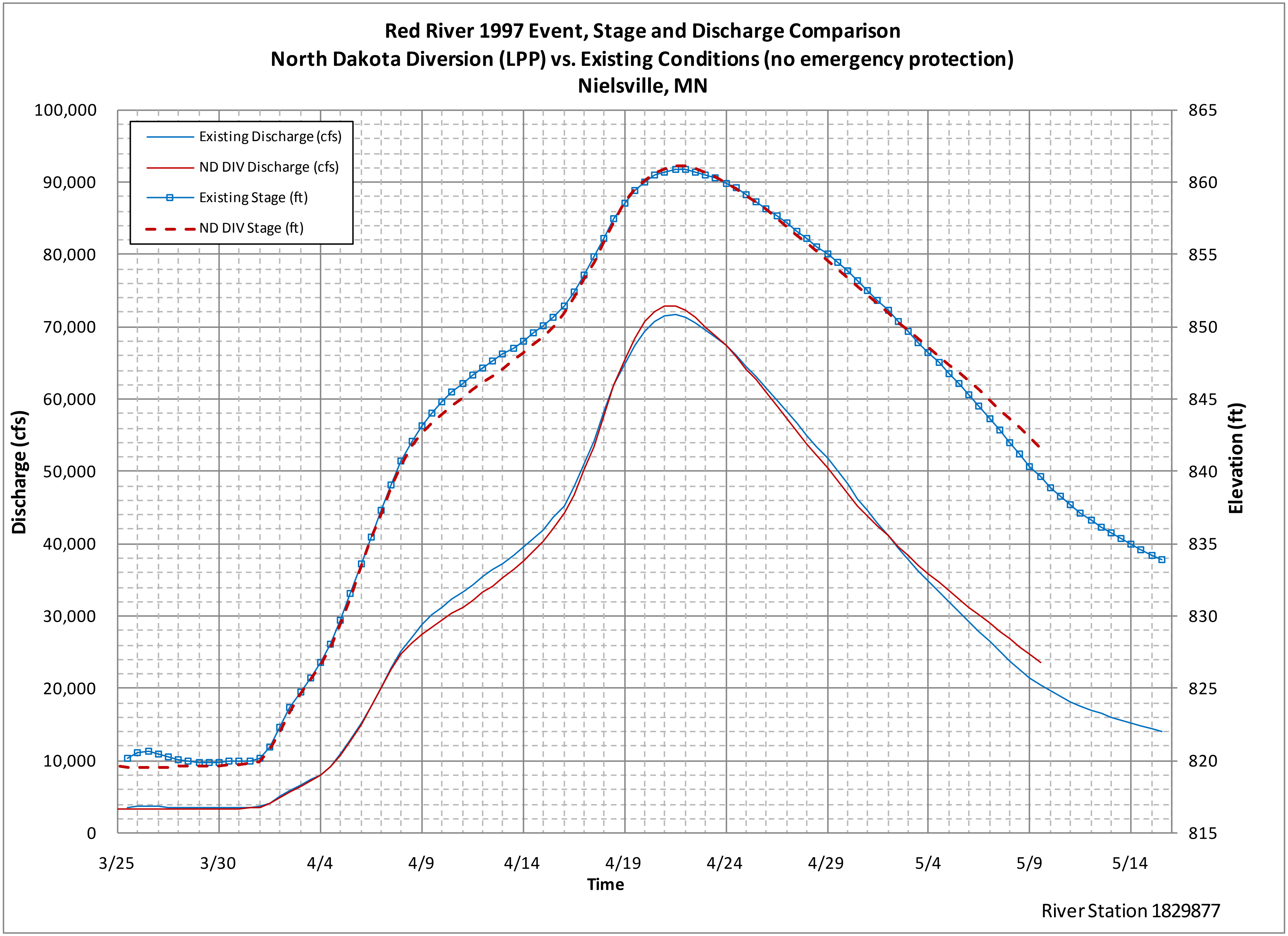


Figure C-E2- 60: 1997 Historical Flood Hydrographs for LPP @ Nielsville

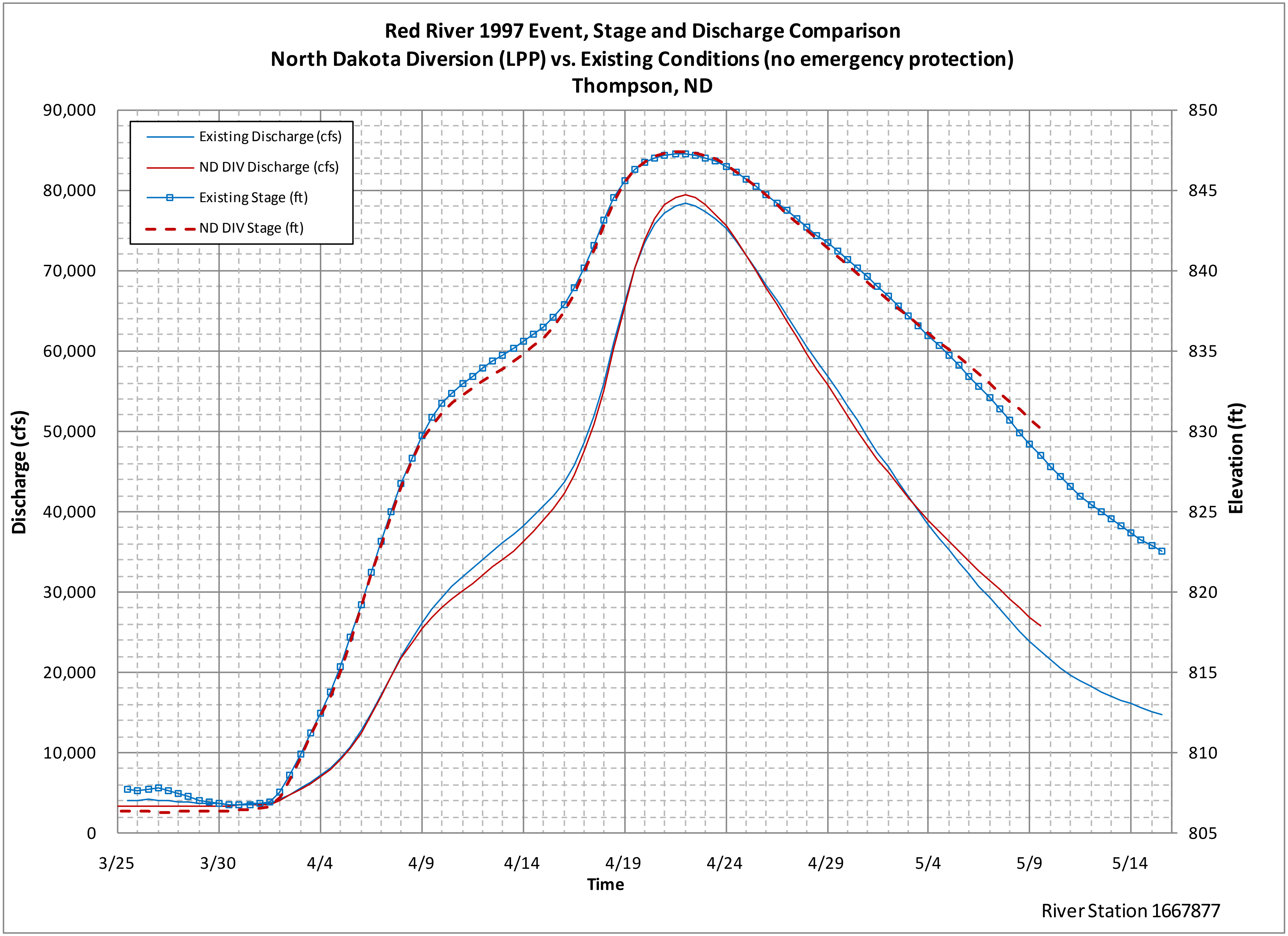


Figure C-E2- 61: 1997 Historical Flood Hydrographs for LPP @ Thompson

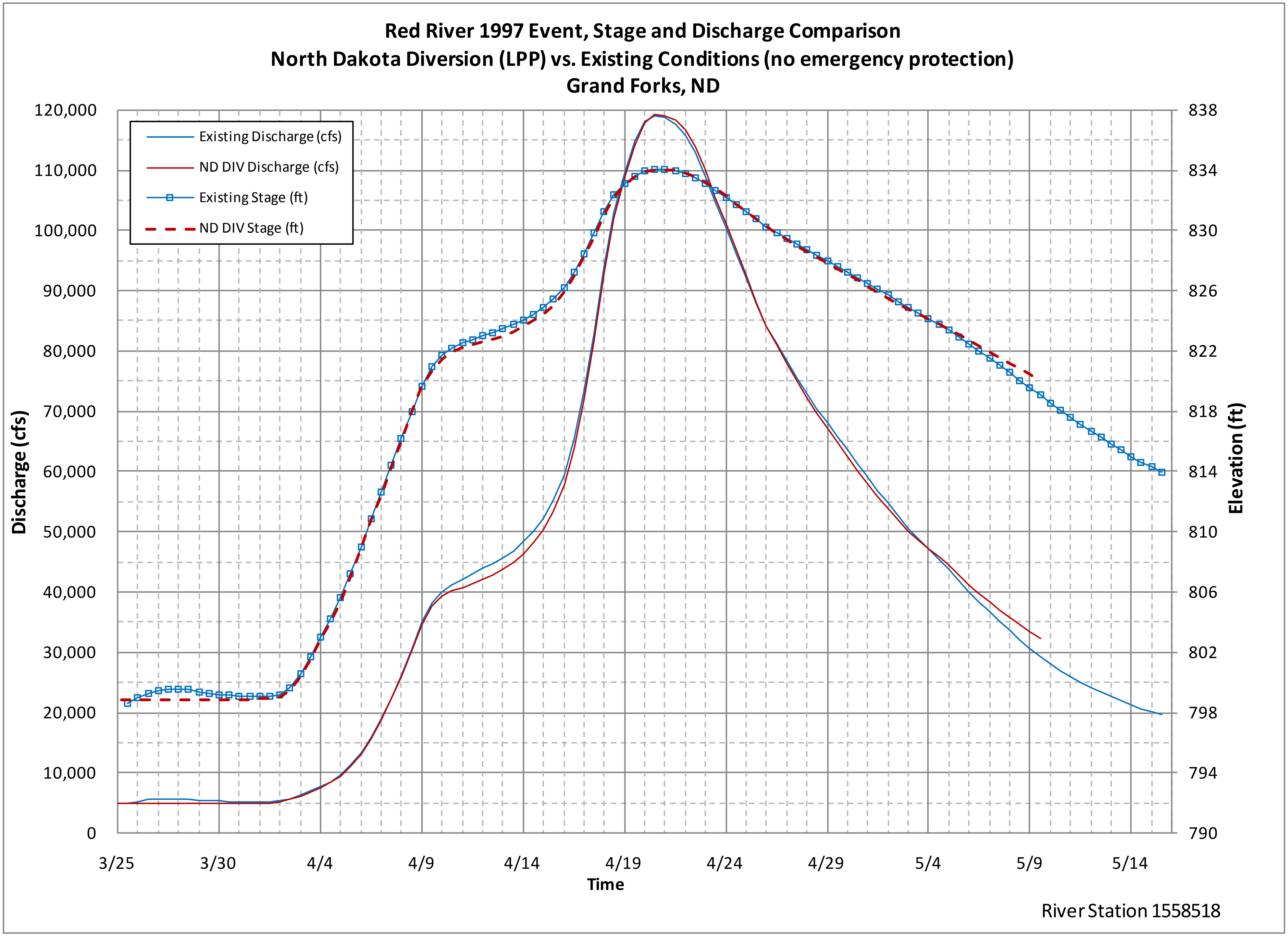


Figure C-E2- 62: 1997 Historical Flood Hydrographs for LPP @ Grand Forks

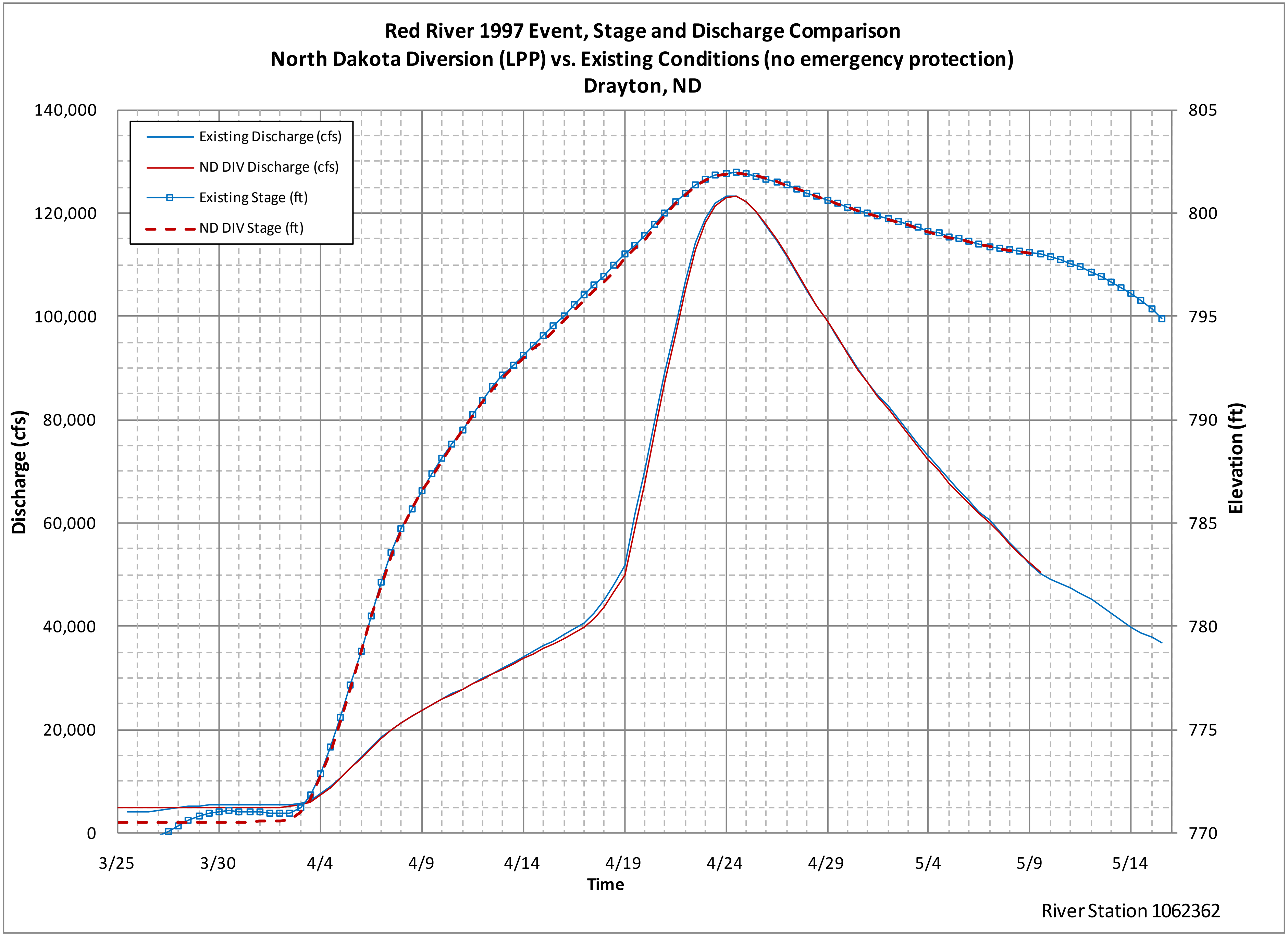


Figure C-E2- 63: 1997 Historical Flood Hydrographs for LPP @ Drayton

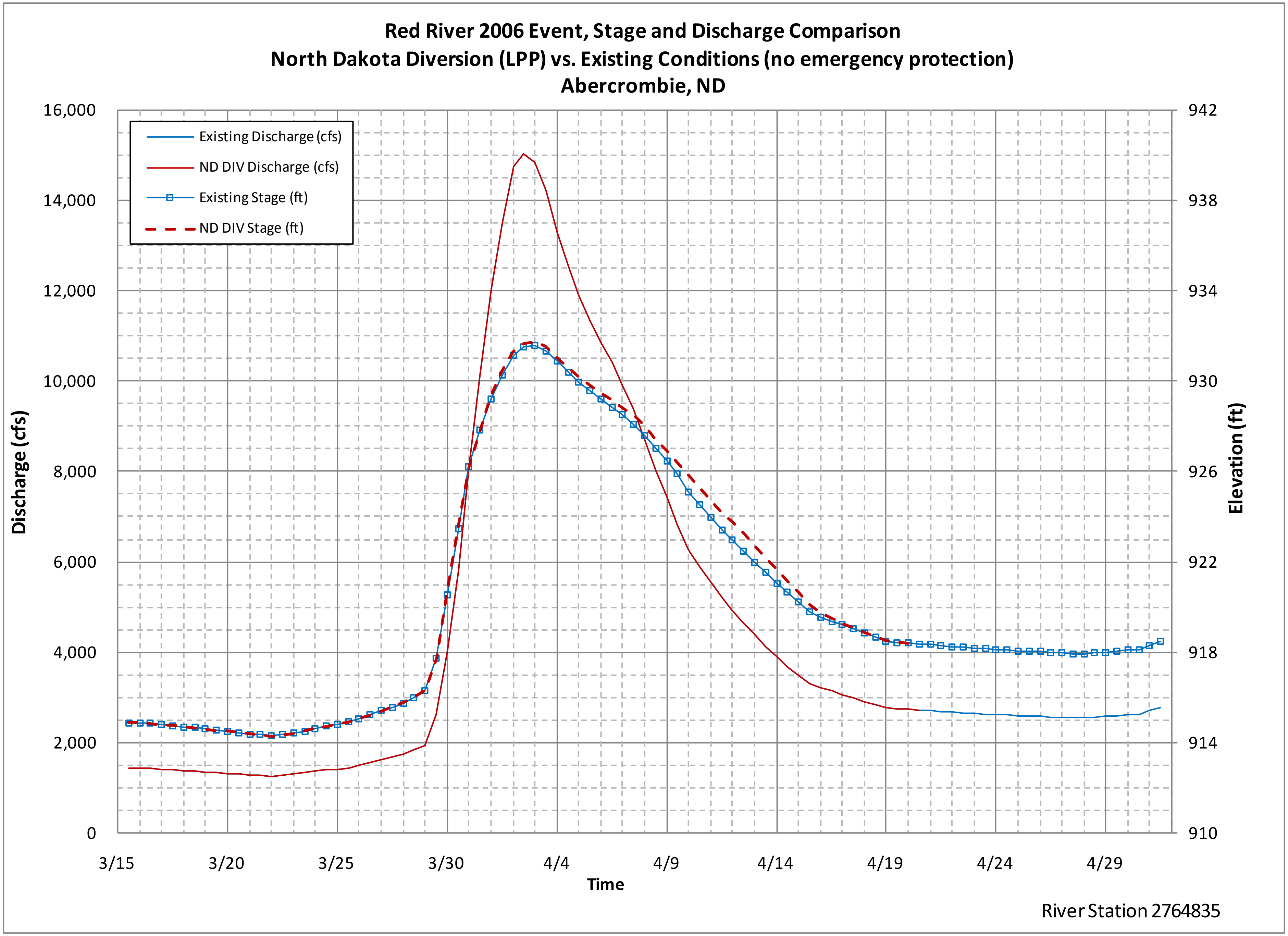


Figure C-E2- 64: 2006 Historical Flood Hydrographs for LPP @ Abercrombie

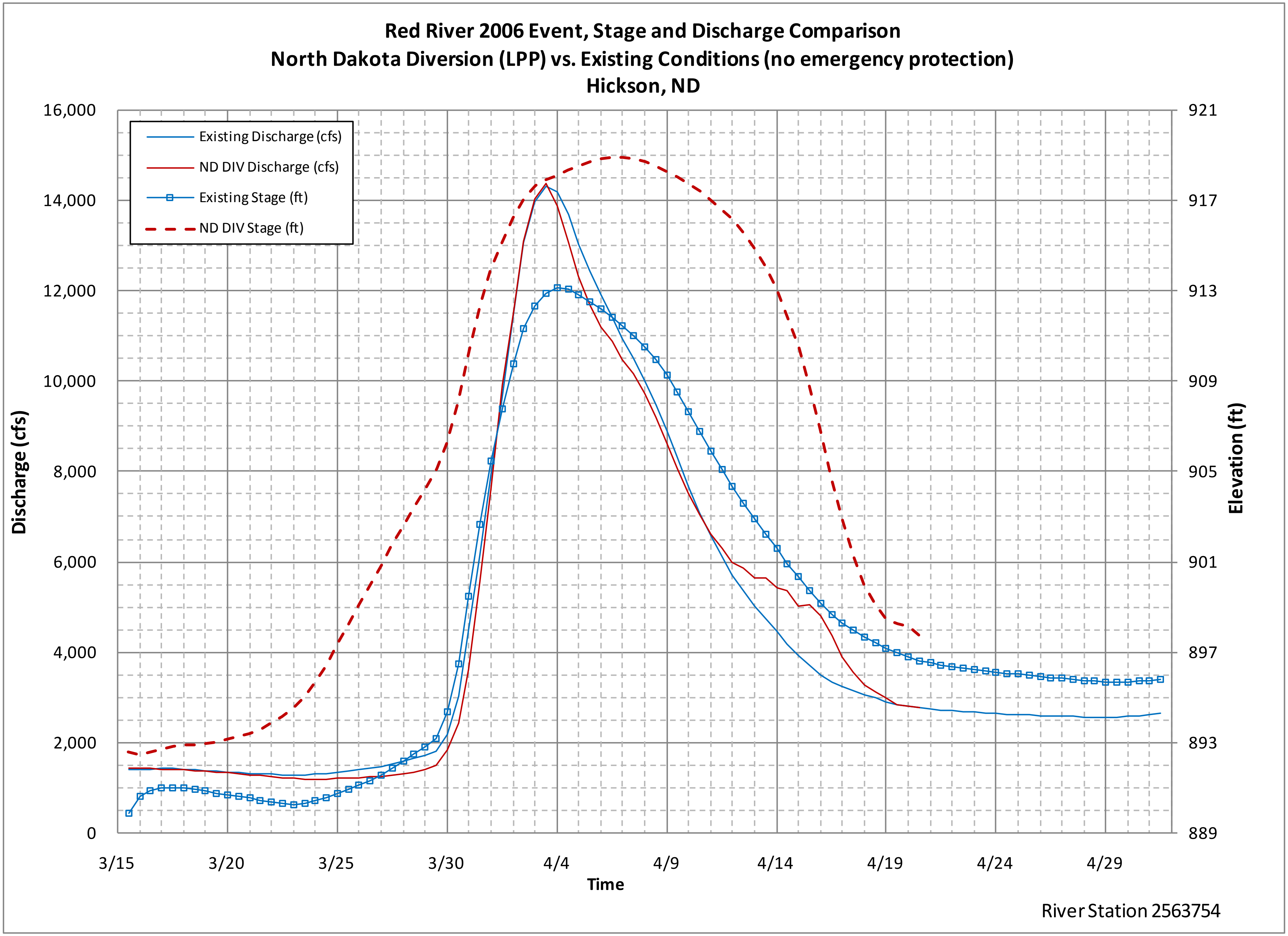


Figure C-E2- 65: 2006 Historical Flood Hydrographs for LPP @ Hickson

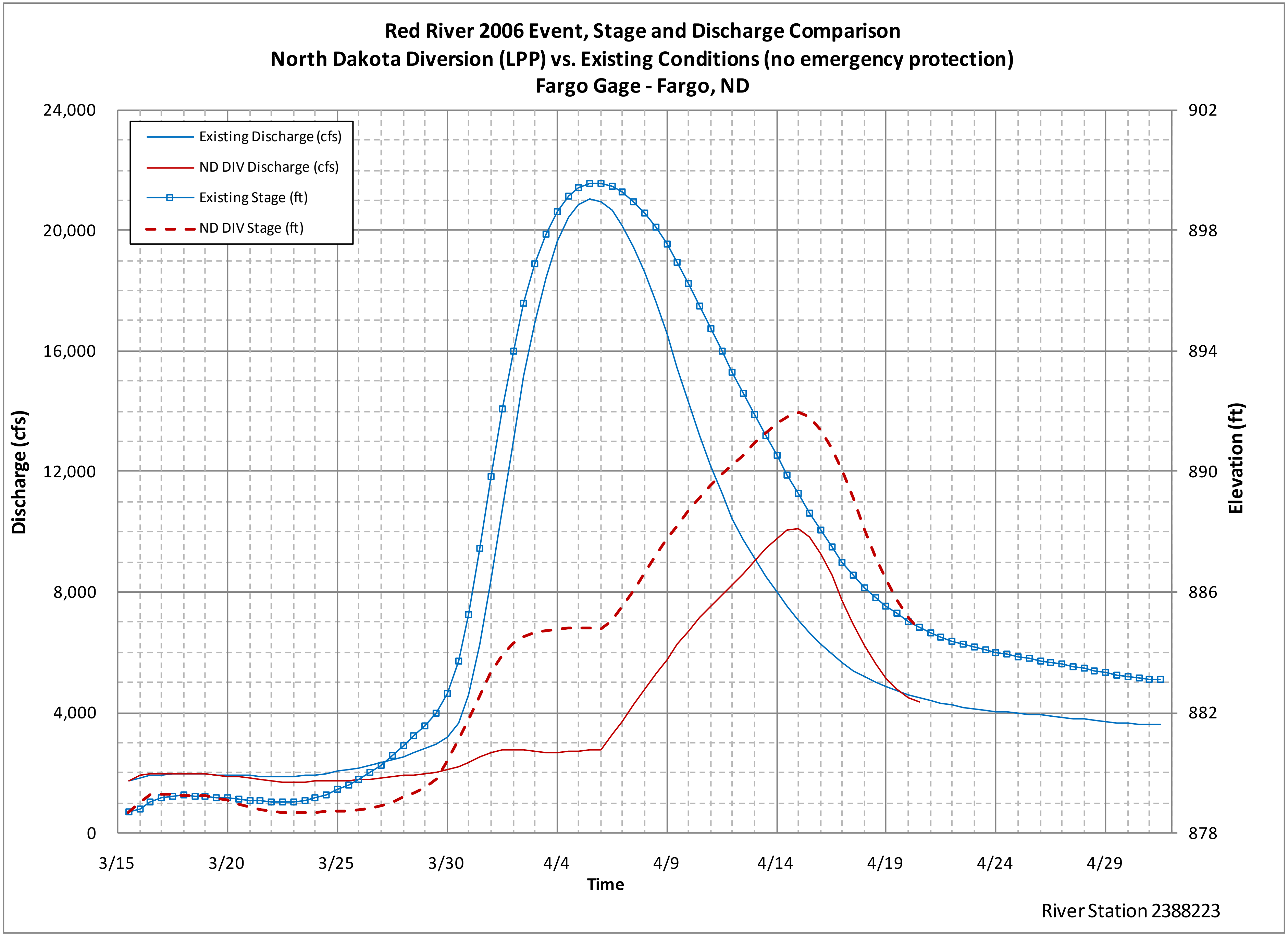


Figure C-E2- 66: 2006 Historical Flood Hydrographs for LPP @ Fargo

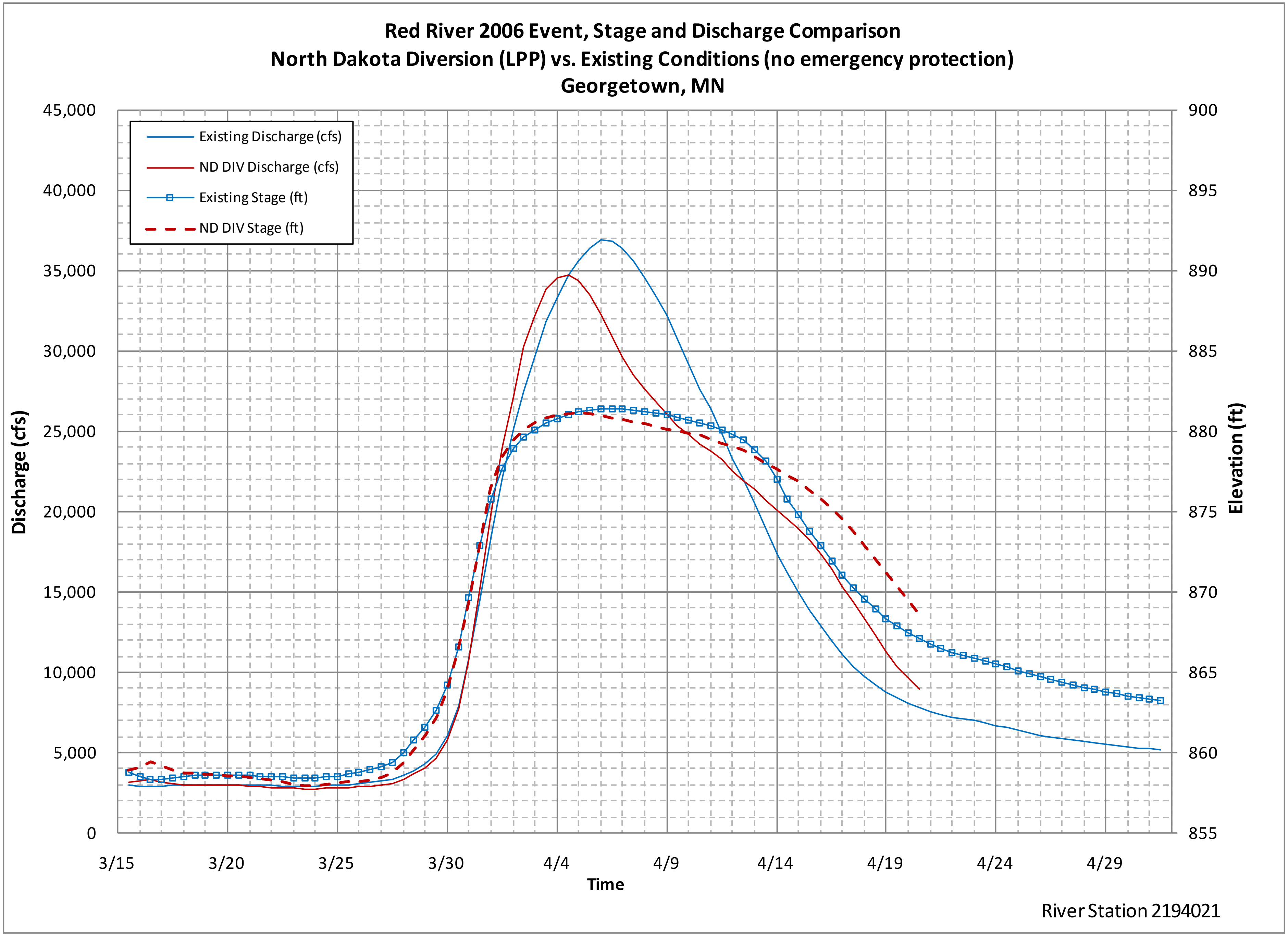


Figure C-E2- 67: 2006 Historical Flood Hydrographs for LPP @ Georgetown

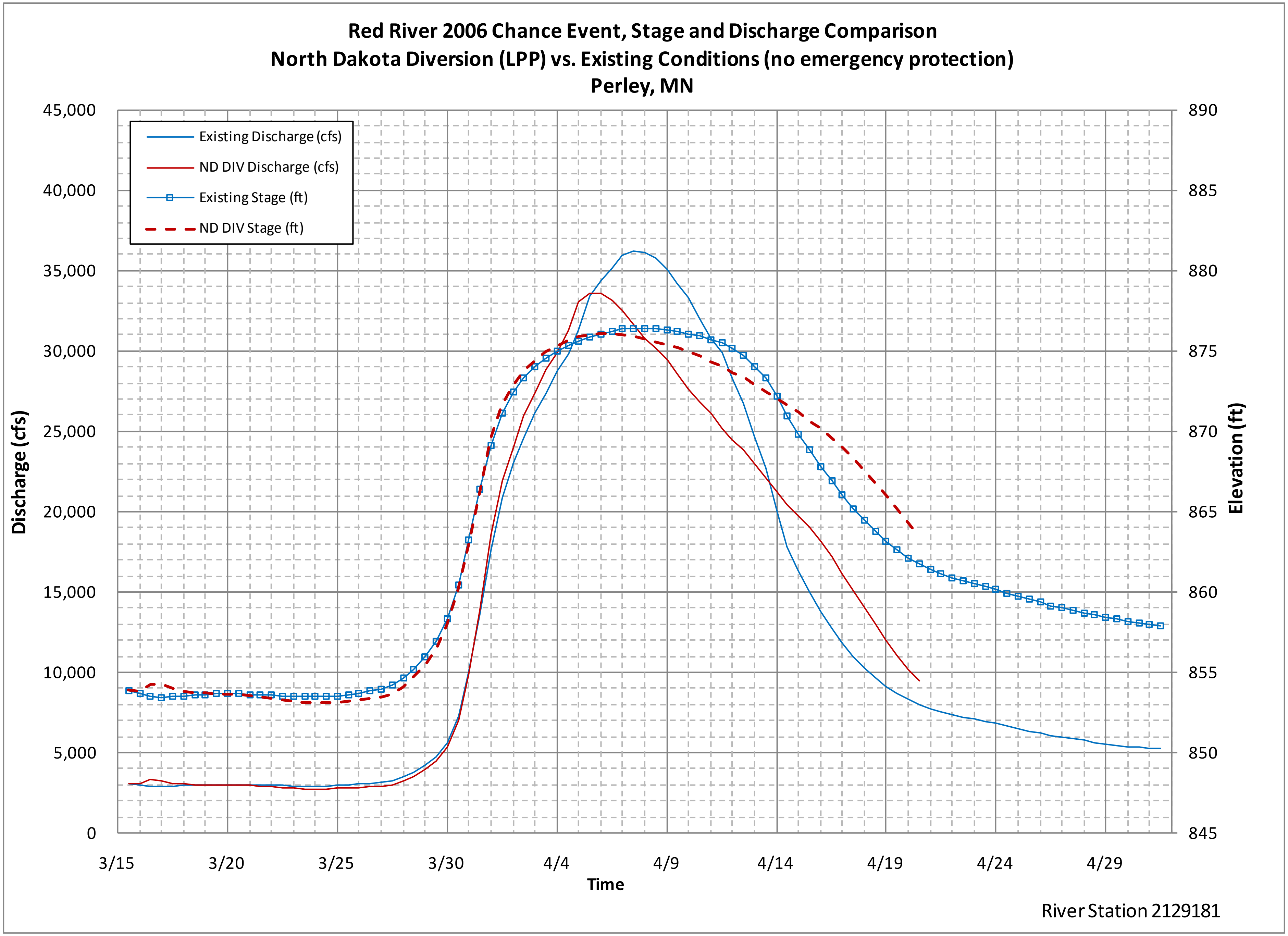


Figure C-E2- 68: 2006 Historical Flood Hydrographs for LPP @ Perley

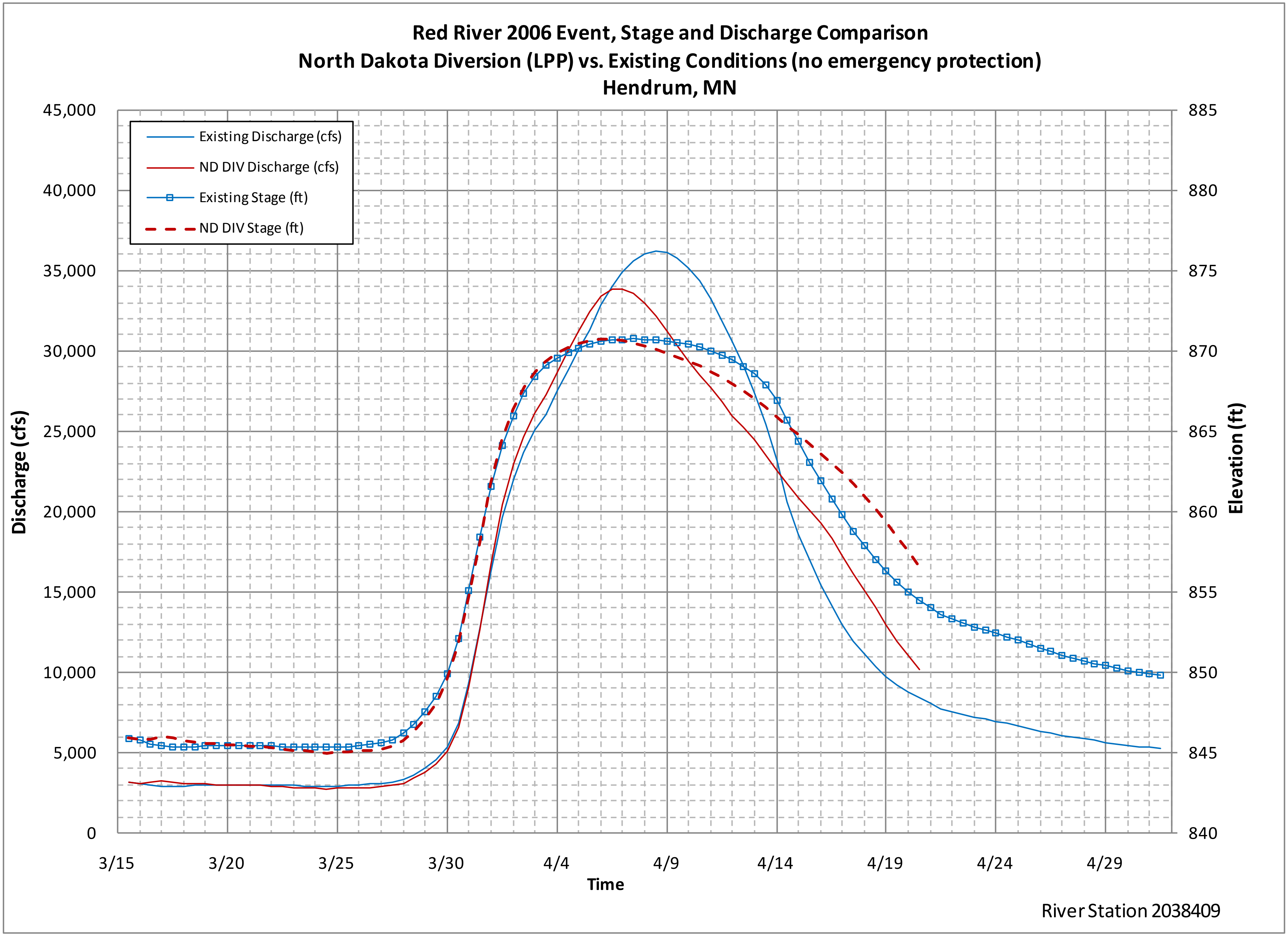


Figure C-E2- 69: 2006 Historical Flood Hydrographs for LPP @ Hendrum

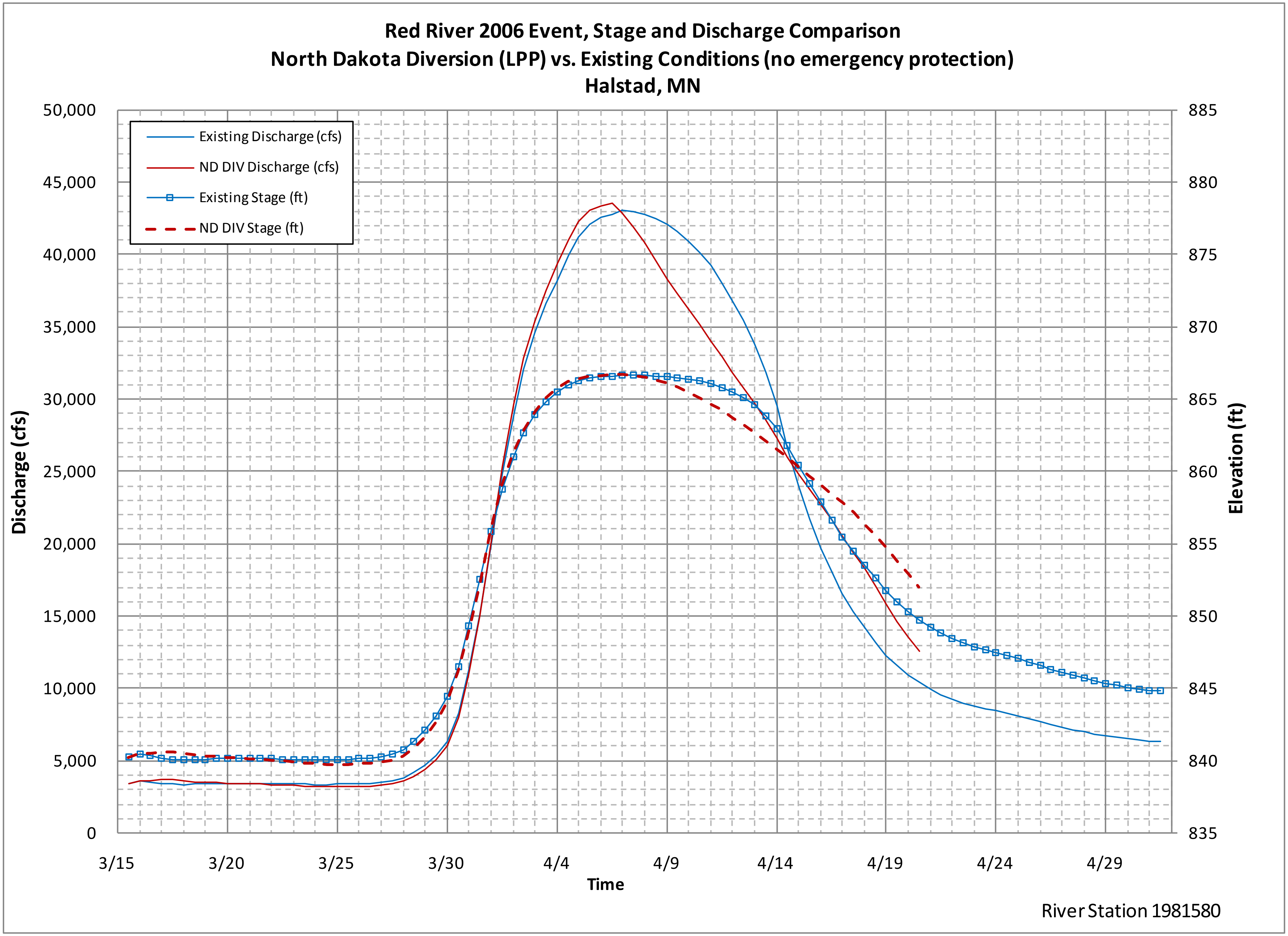


Figure C-E2- 70: 2006 Historical Flood Hydrographs for LPP @ Halstad

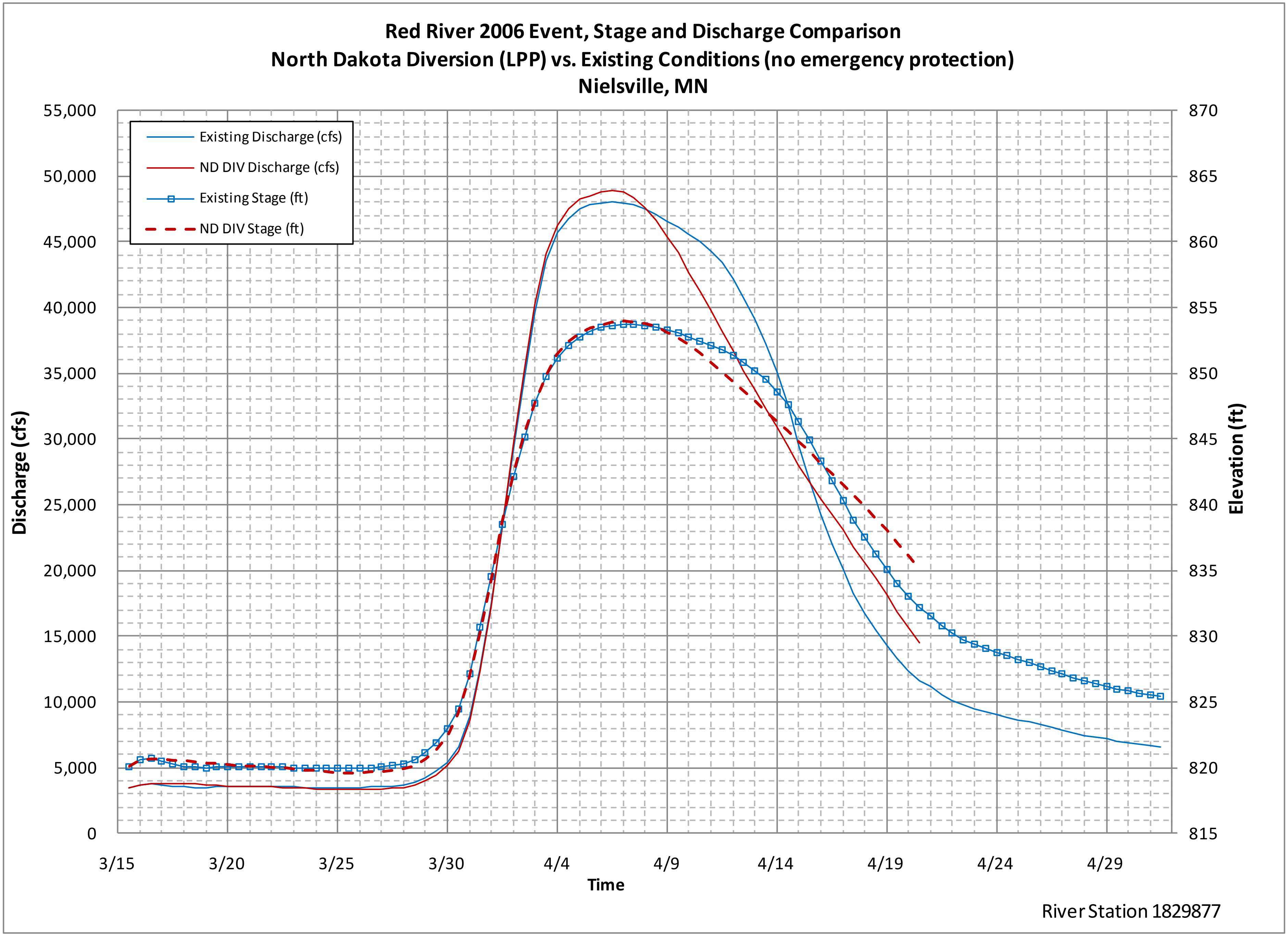


Figure C-E2- 71: 2006 Historical Flood Hydrographs for LPP @ Nielsville

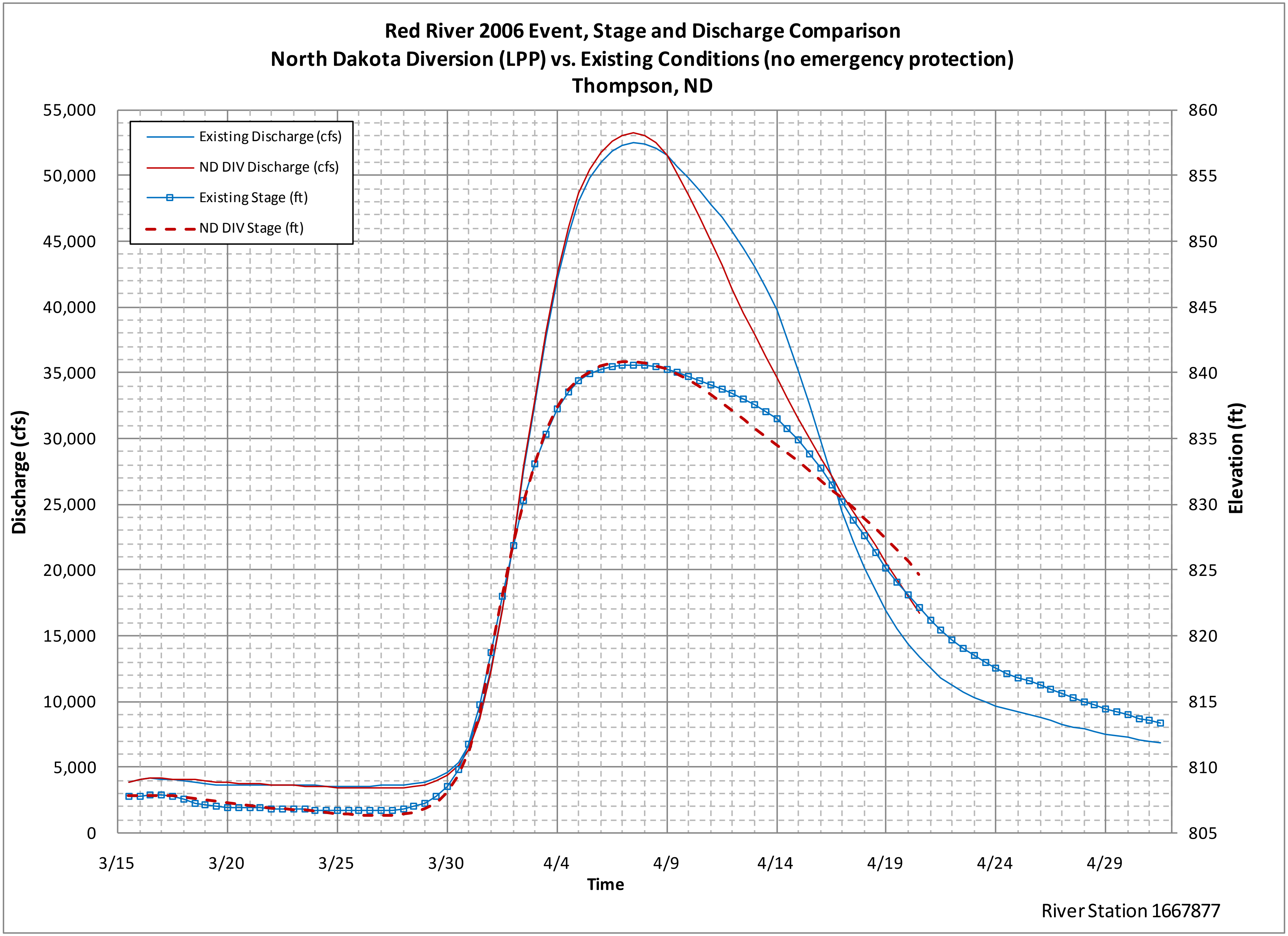


Figure C-E2- 72: 2006 Historical Flood Hydrographs for LPP @ Thompson

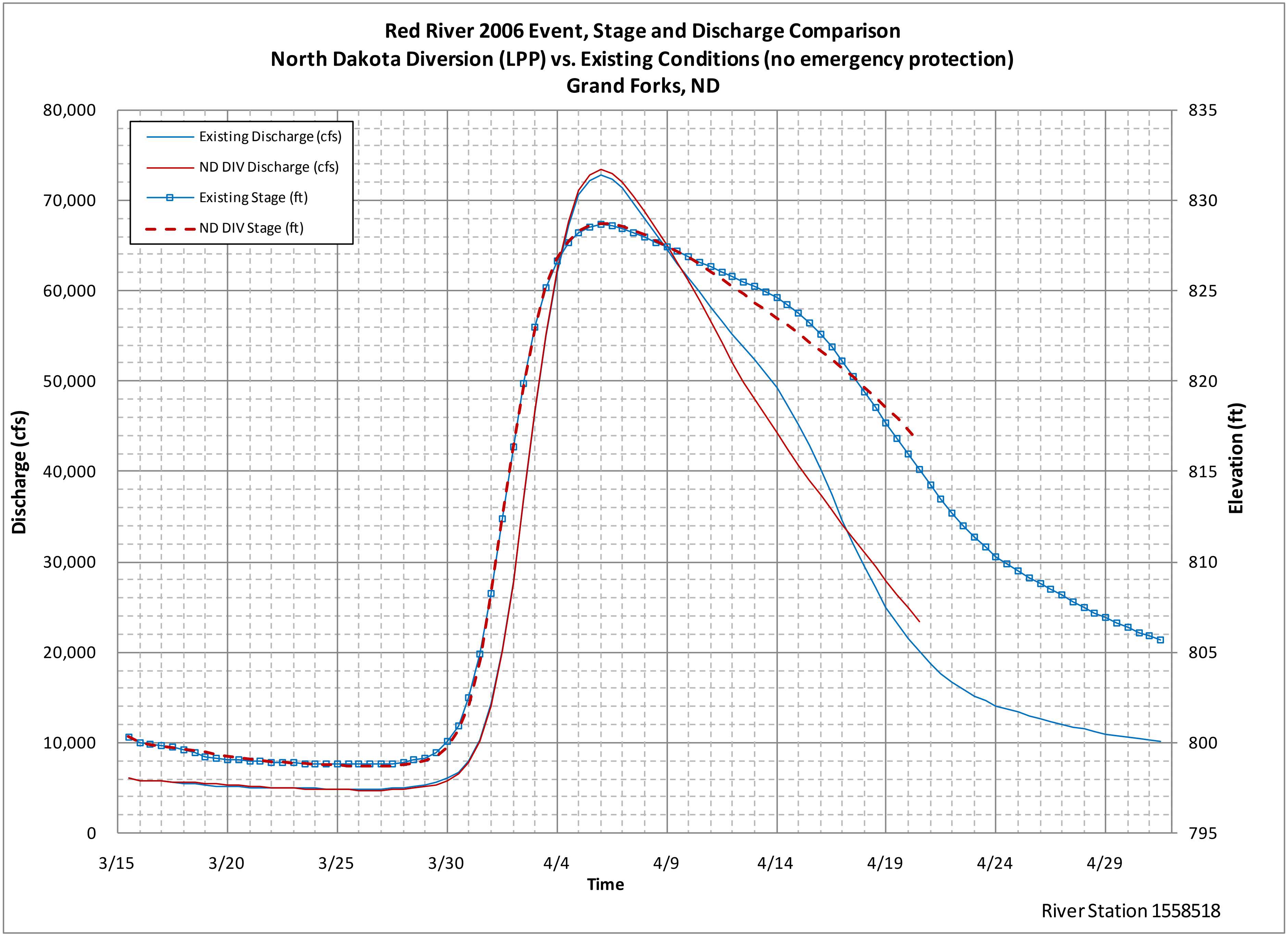


Figure C-E2- 73: 2006 Historical Flood Hydrographs for LPP @ Grand Forks

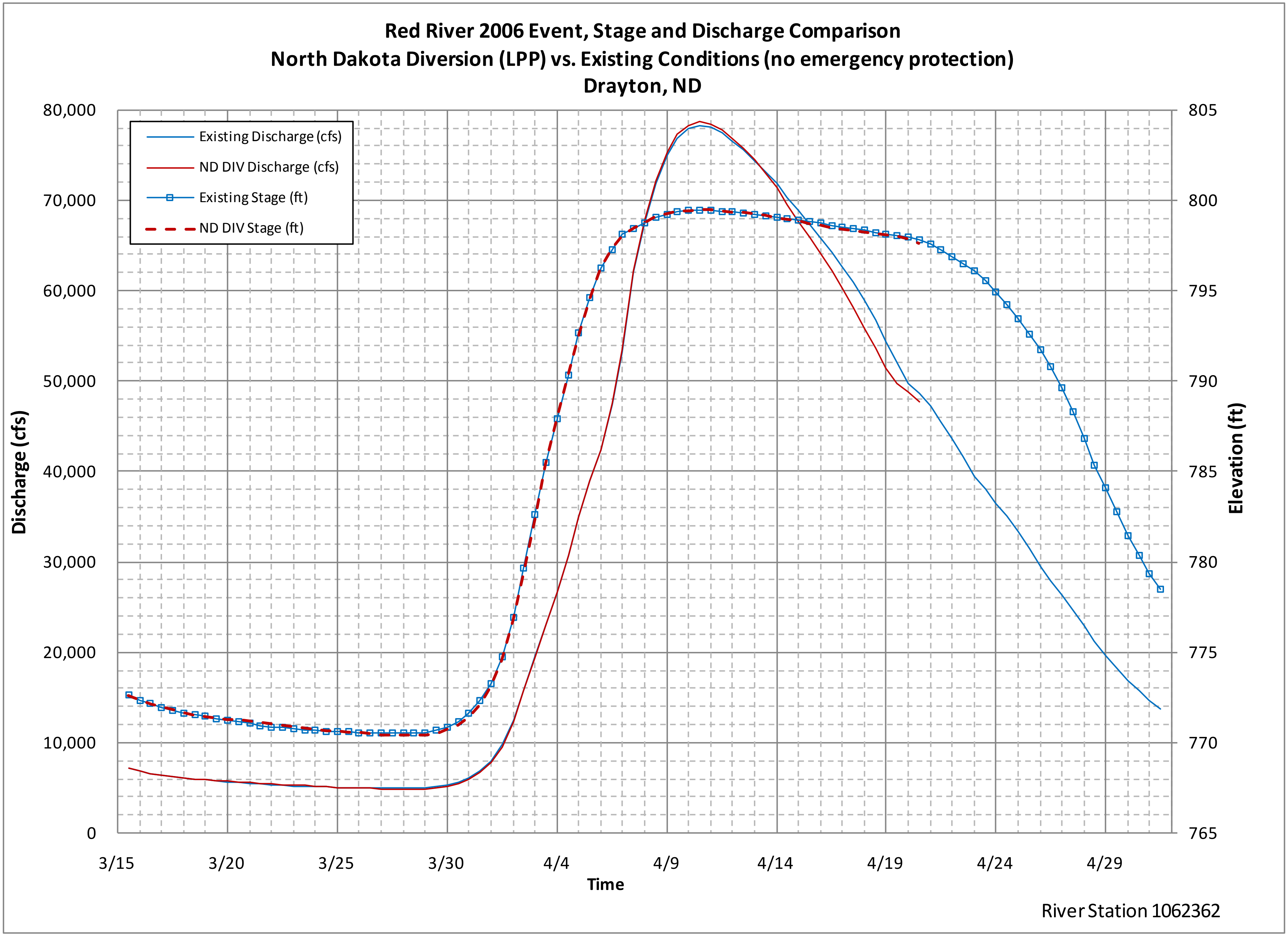


Figure C-E2- 74: 2006 Historical Flood Hydrographs for LPP @ Drayton

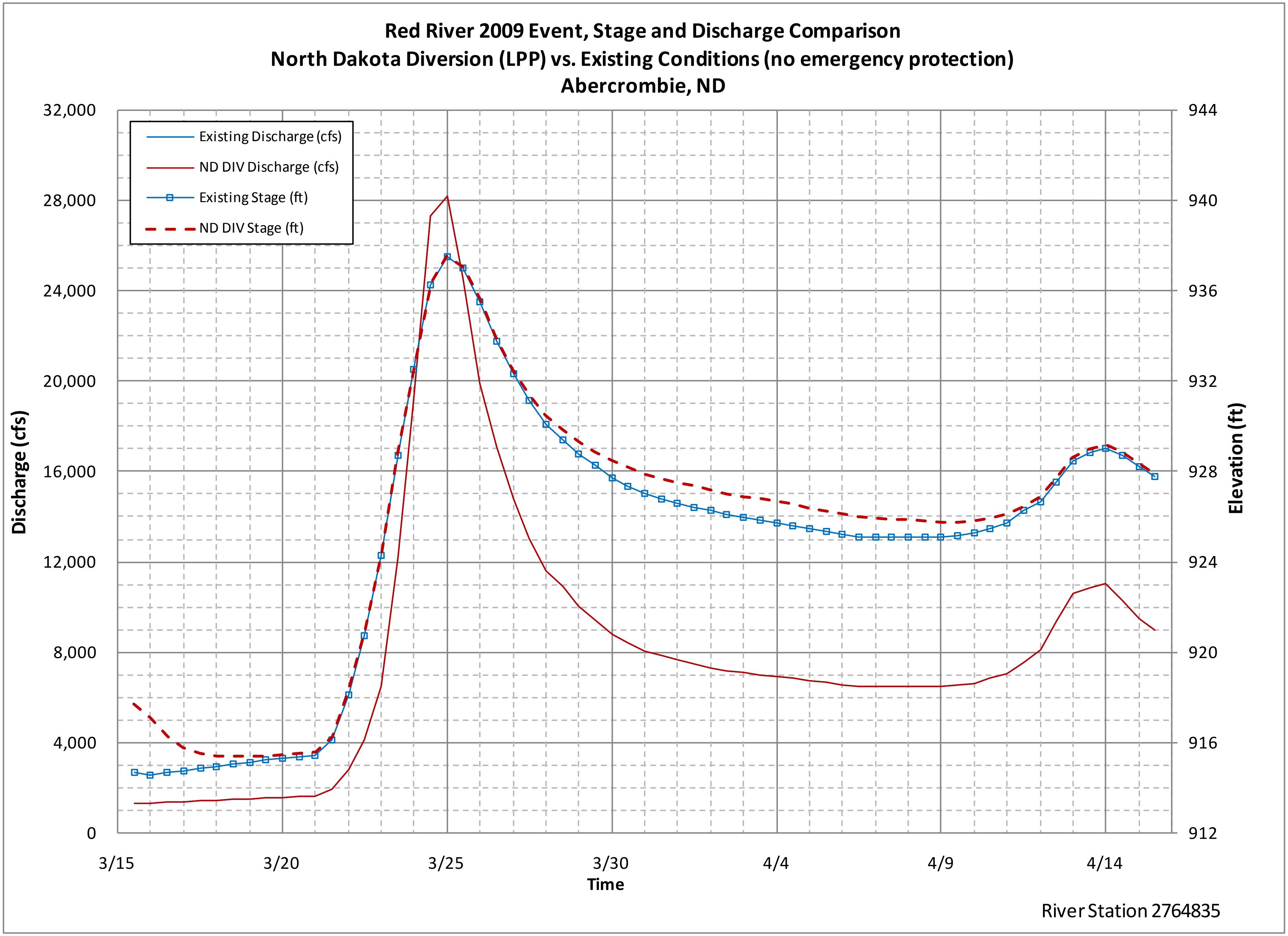


Figure C-E2- 75: 2009 Historical Flood Hydrographs for LPP @ Abercrombie

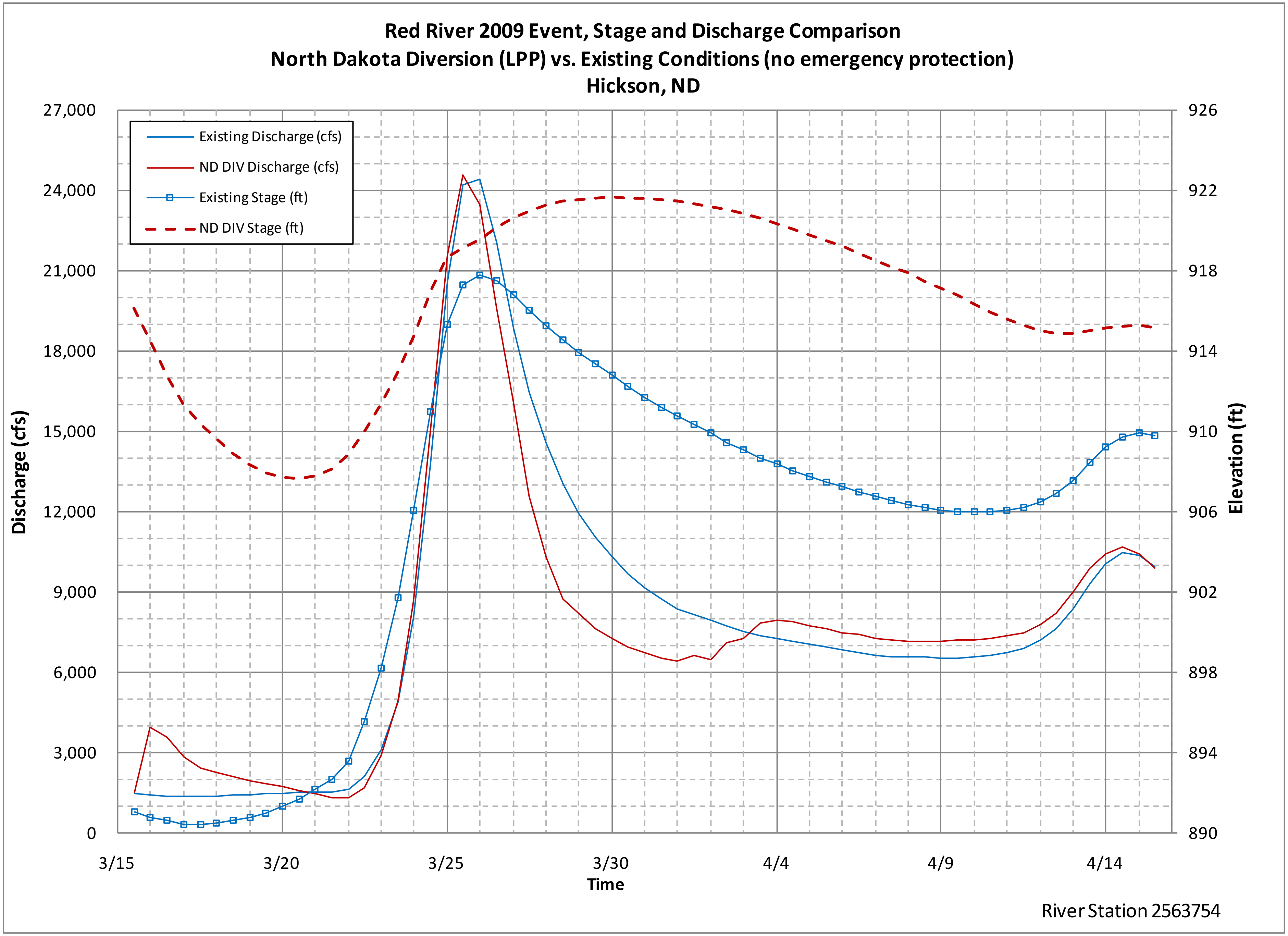


Figure C-E2- 76: 2009 Historical Flood Hydrographs for LPP @ Hickson

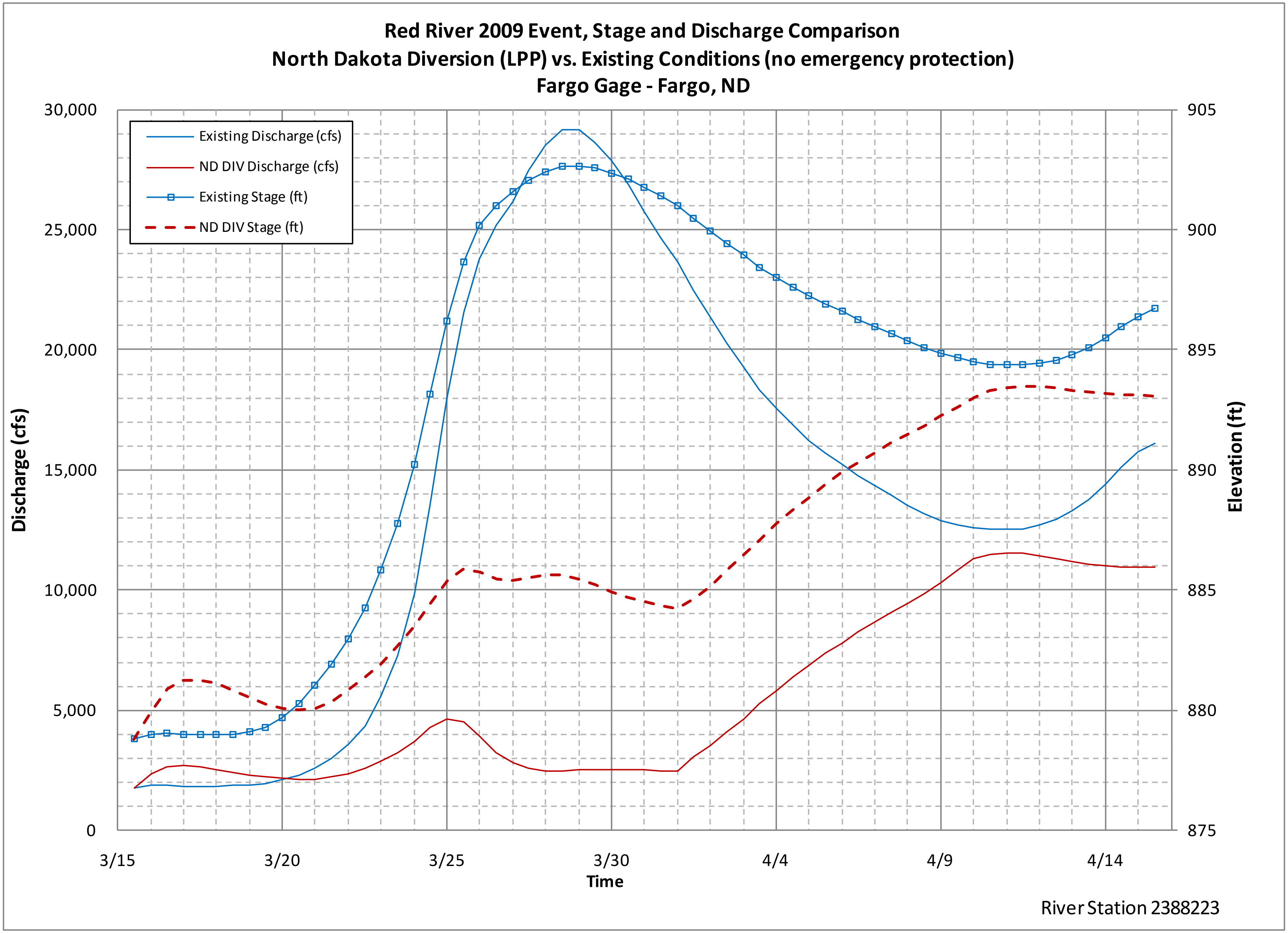


Figure C-E2- 77: 2009 Historical Flood Hydrographs for LPP @ Fargo

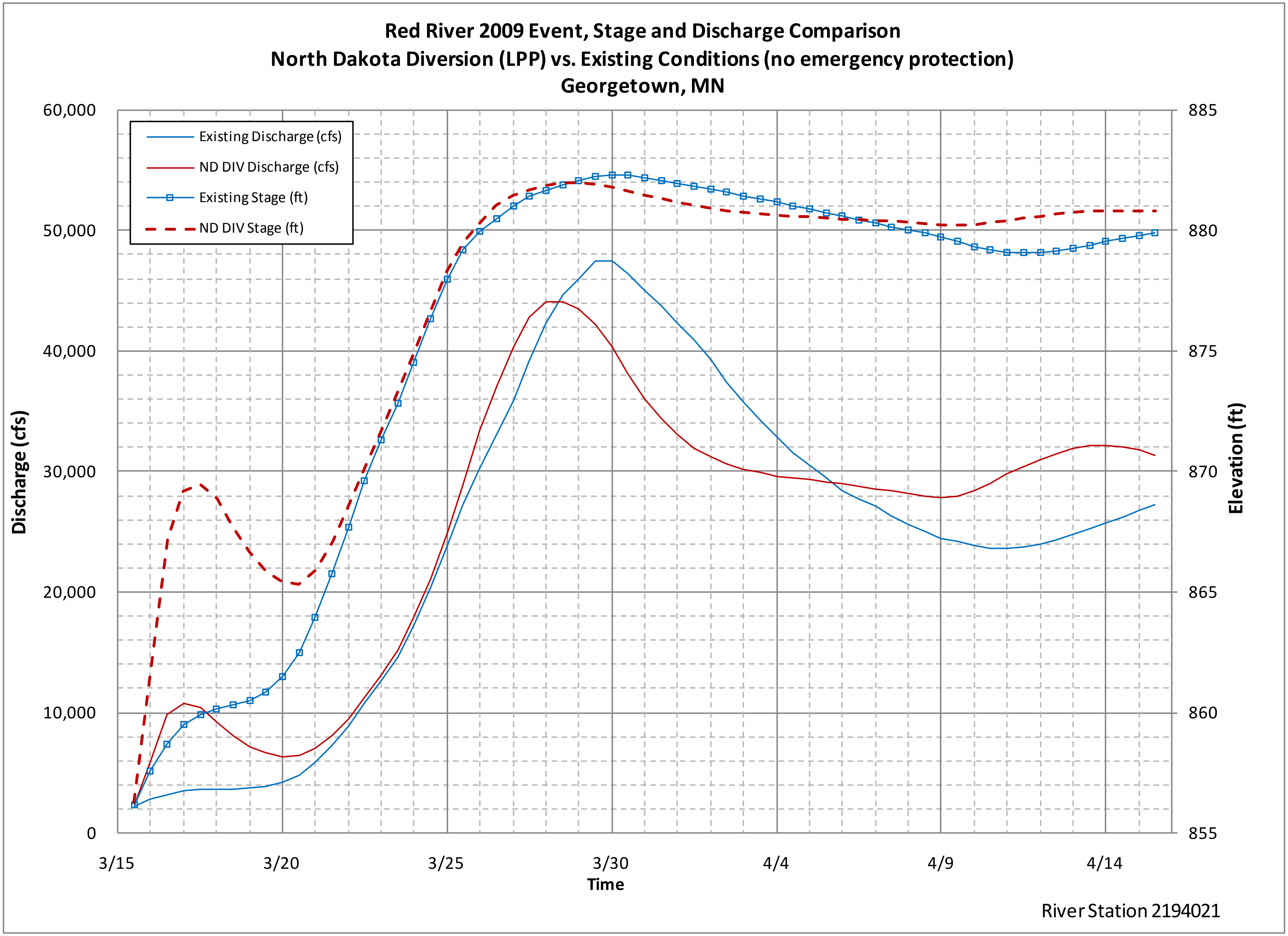


Figure C-E2- 78: 2009 Historical Flood Hydrographs for LPP @ Georgetown

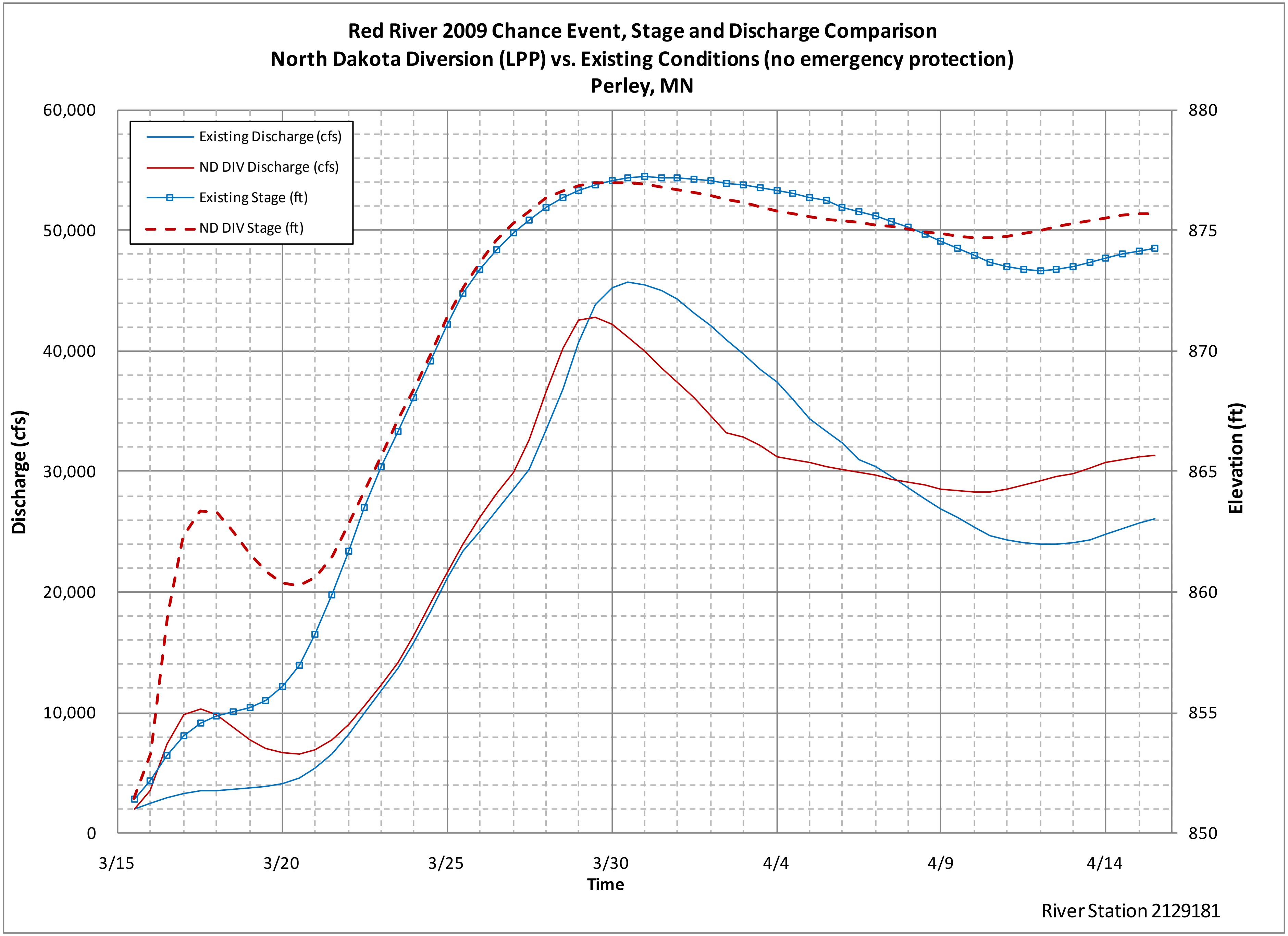


Figure C-E2- 79: 2009 Historical Flood Hydrographs for LPP @ Perley

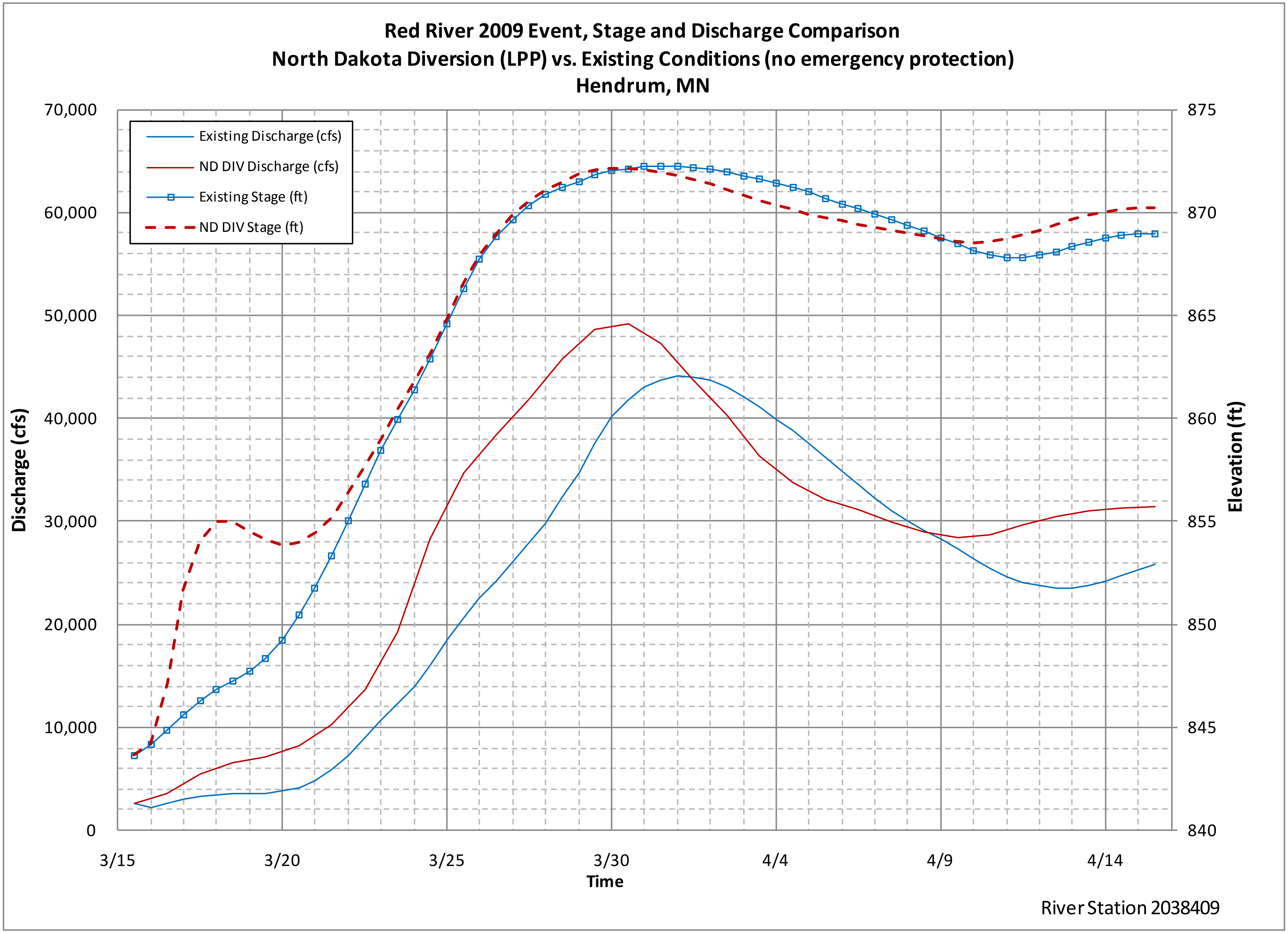


Figure C-E2- 80: 2009 Historical Flood Hydrographs for LPP @ Hendrum

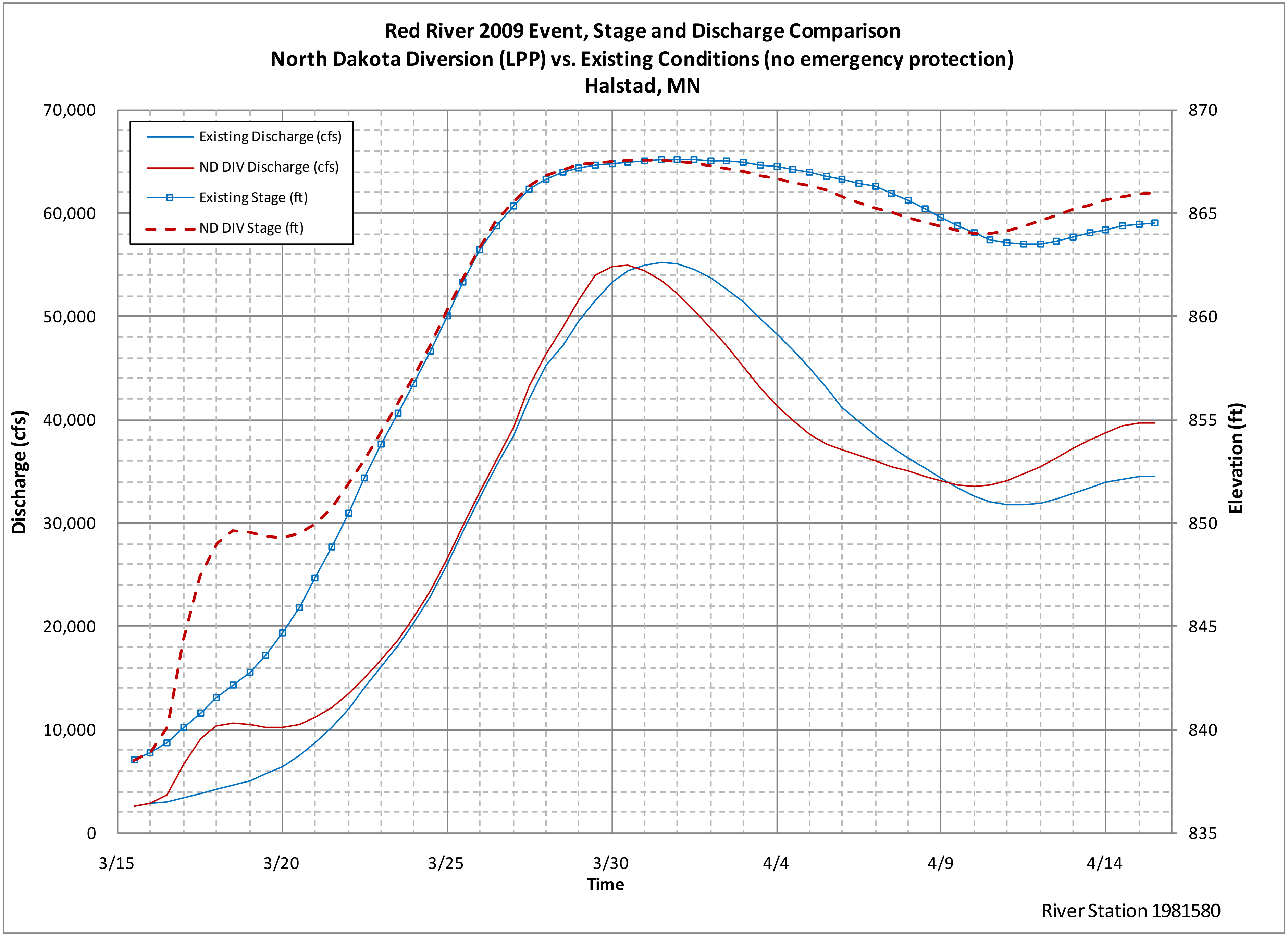


Figure C-E2- 81: 2009 Historical Flood Hydrographs for LPP @ Halstad

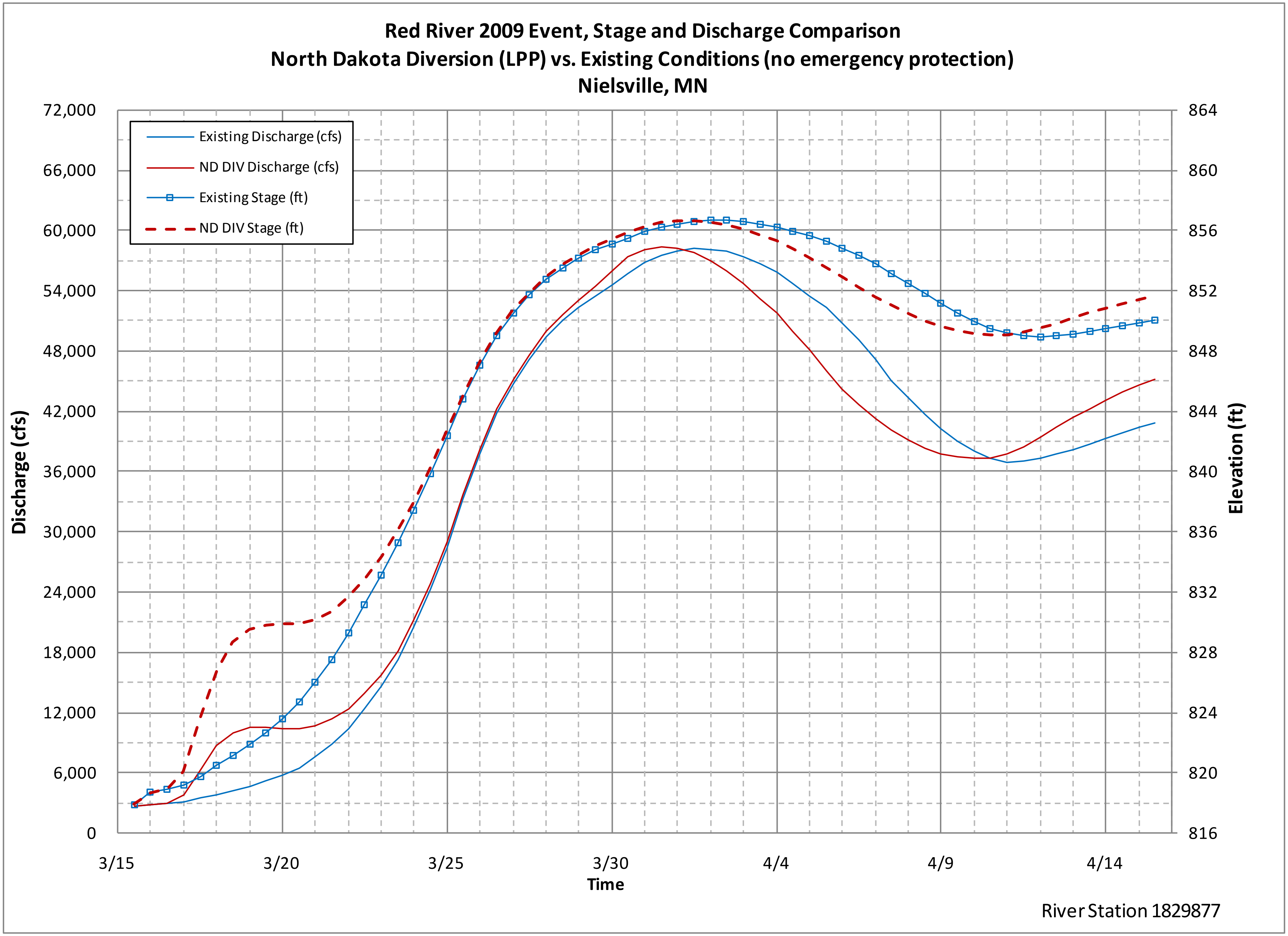


Figure C-E2- 82: 2009 Historical Flood Hydrographs for LPP @ Nielsville

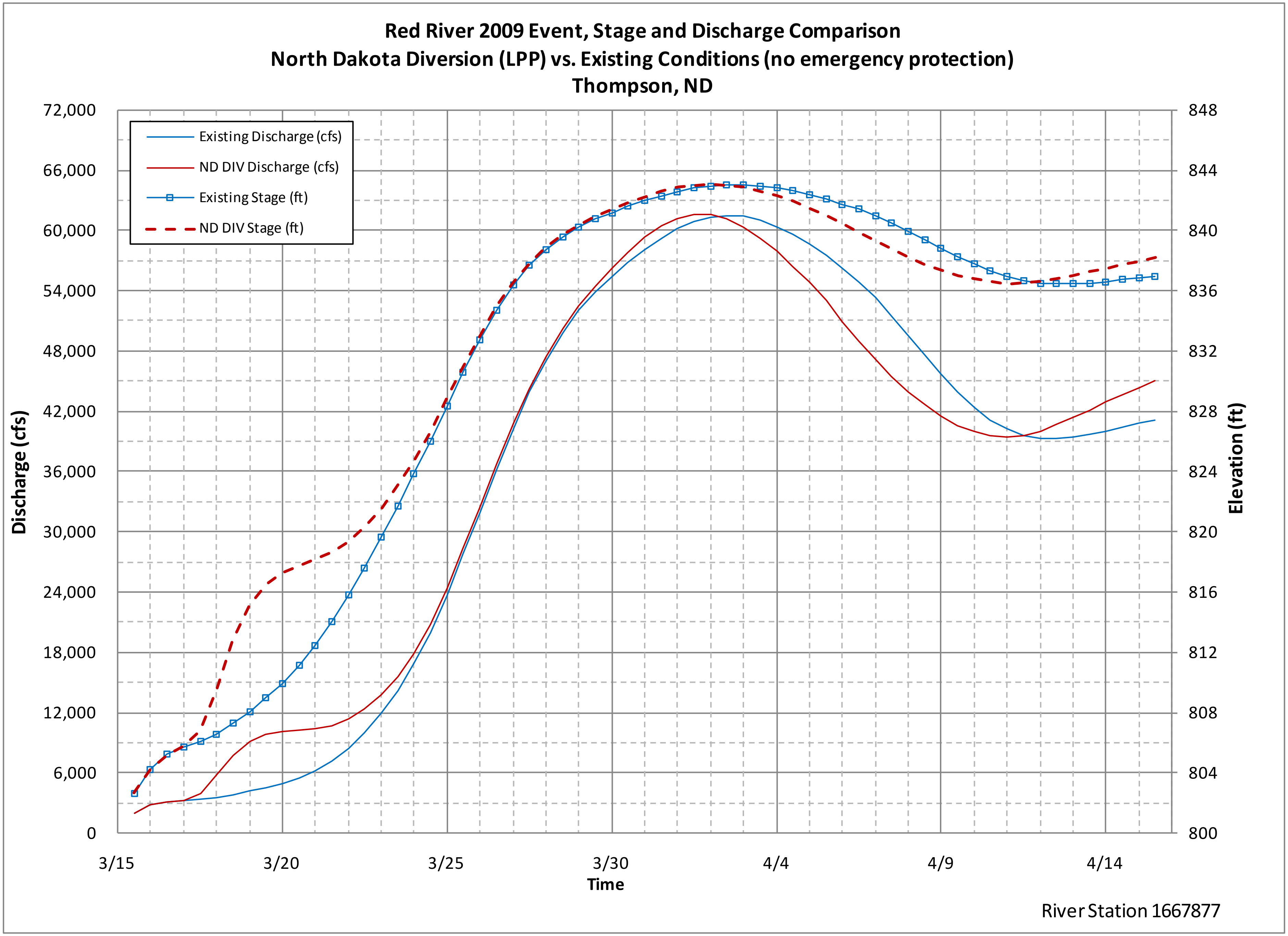


Figure C-E2- 83: 2009 Historical Flood Hydrographs for LPP @ Thompson

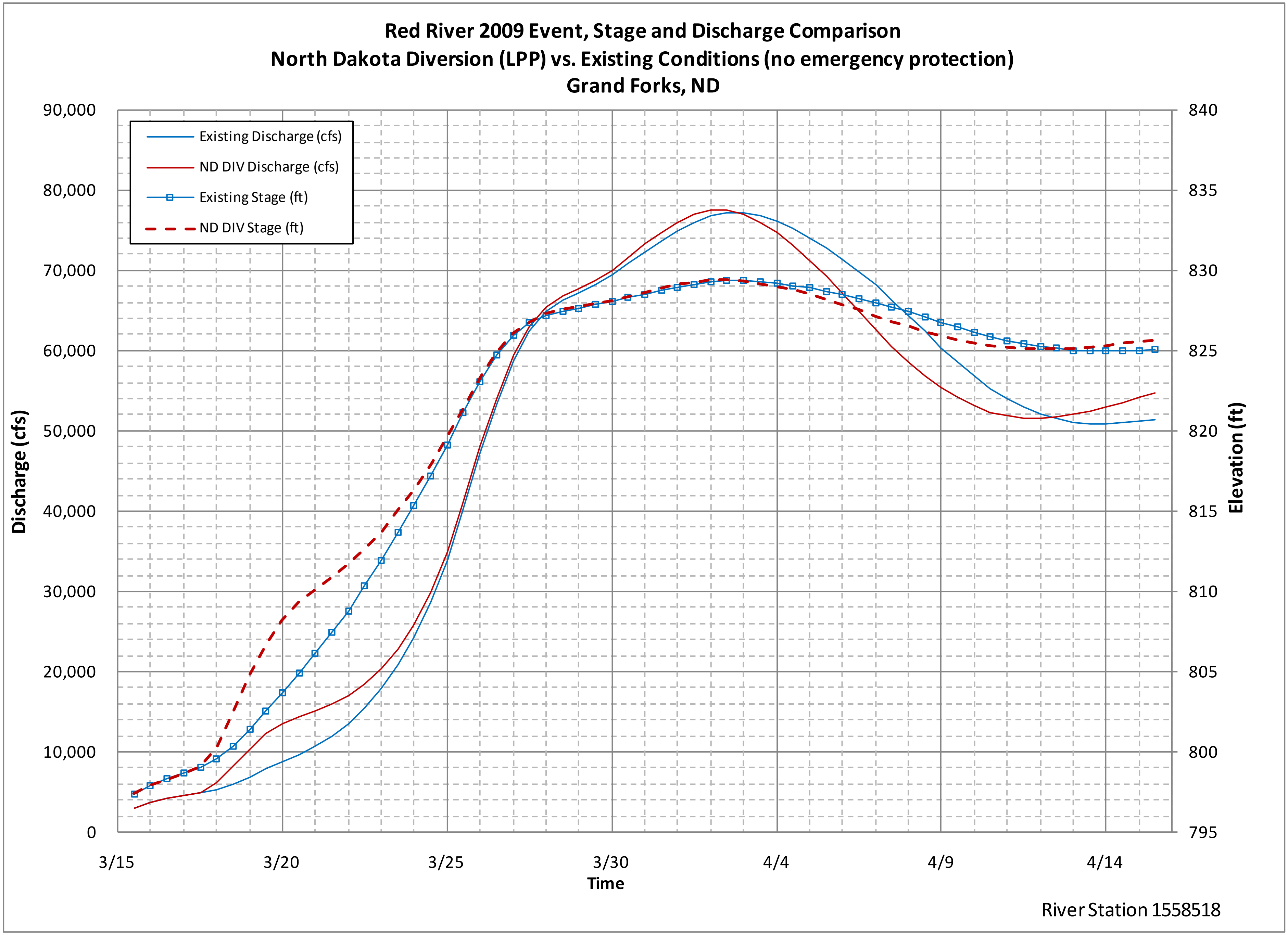


Figure C-E2- 84: 2009 Historical Flood Hydrographs for LPP @ Grand Forks

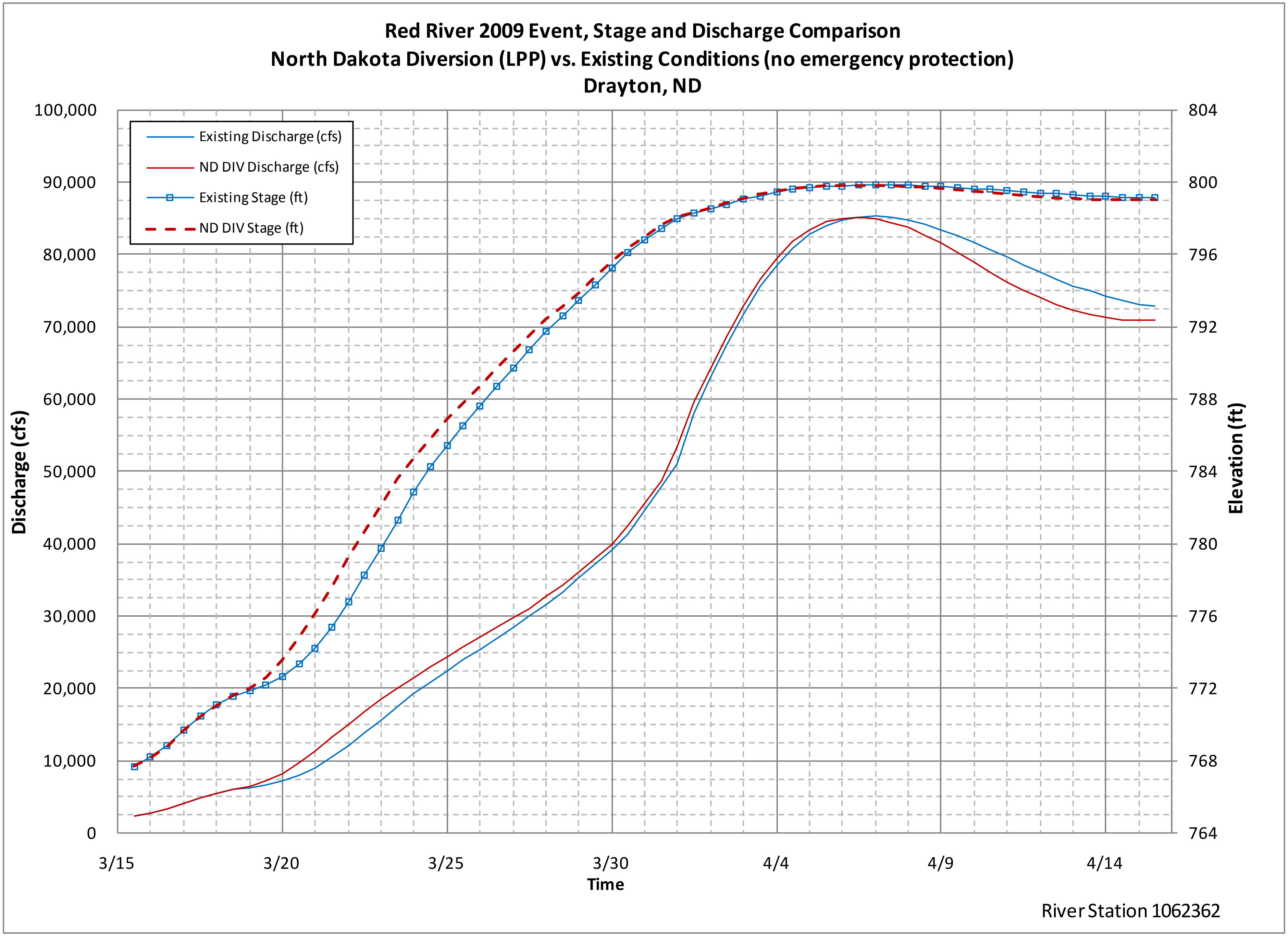


Figure C-E2- 85: 2009 Historical Flood Hydrographs for LPP @ Drayton

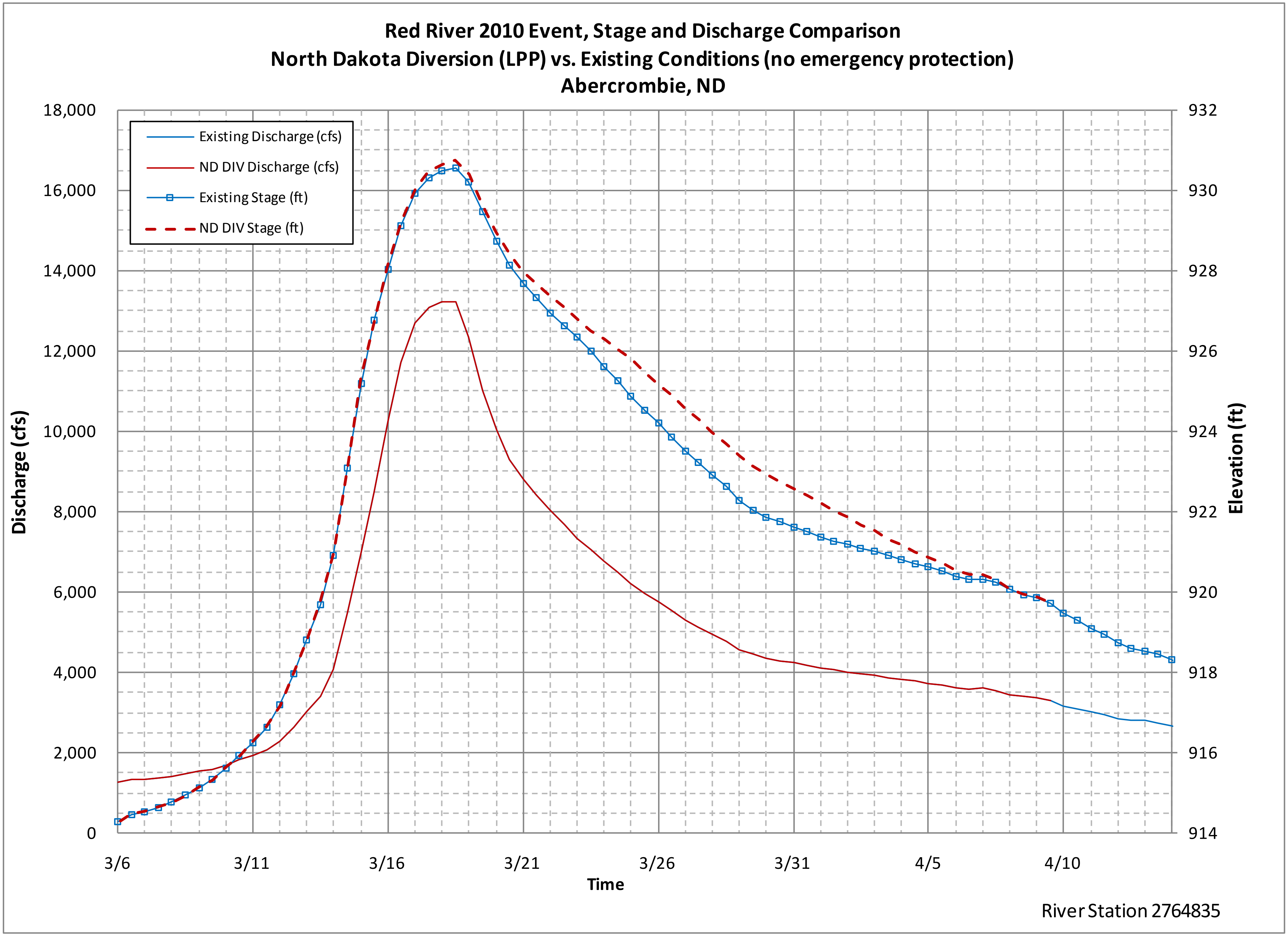


Figure C-E2- 86: 2010 Historical Flood Hydrographs for LPP @ Abercrombie

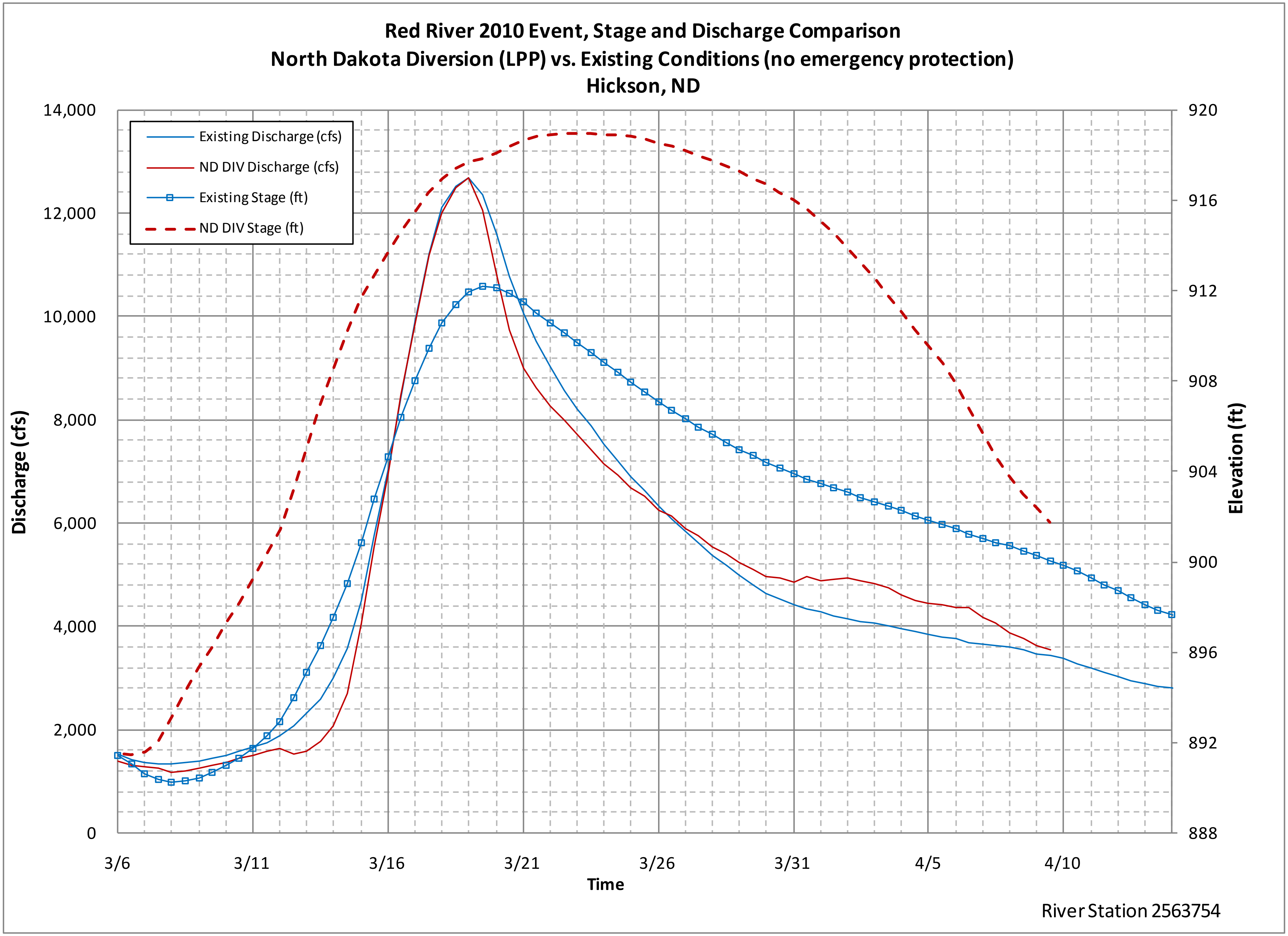


Figure C-E2- 87: 2010 Historical Flood Hydrographs for LPP @ Hickson

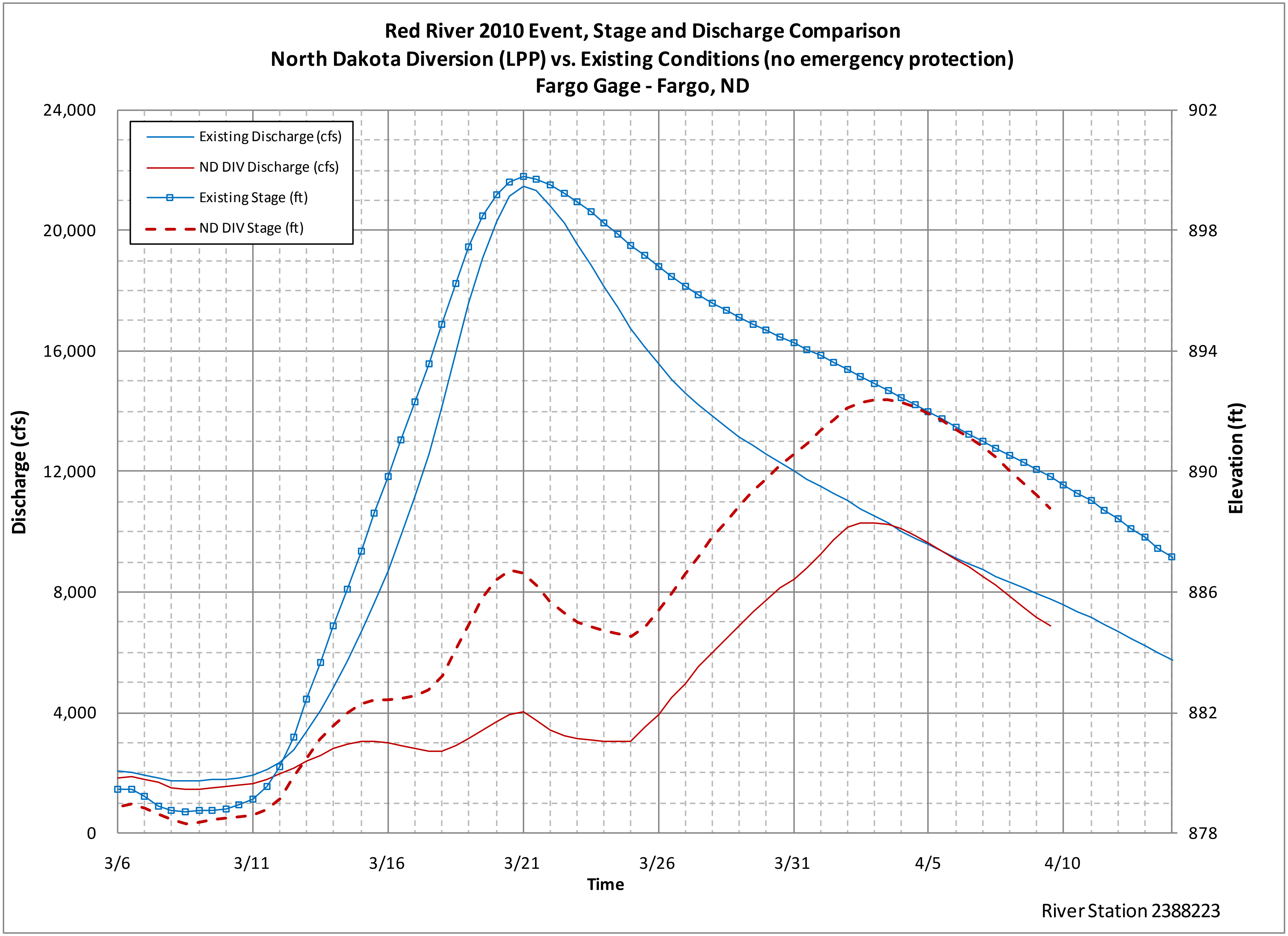


Figure C-E2- 88: 2010 Historical Flood Hydrographs for LPP @ Fargo

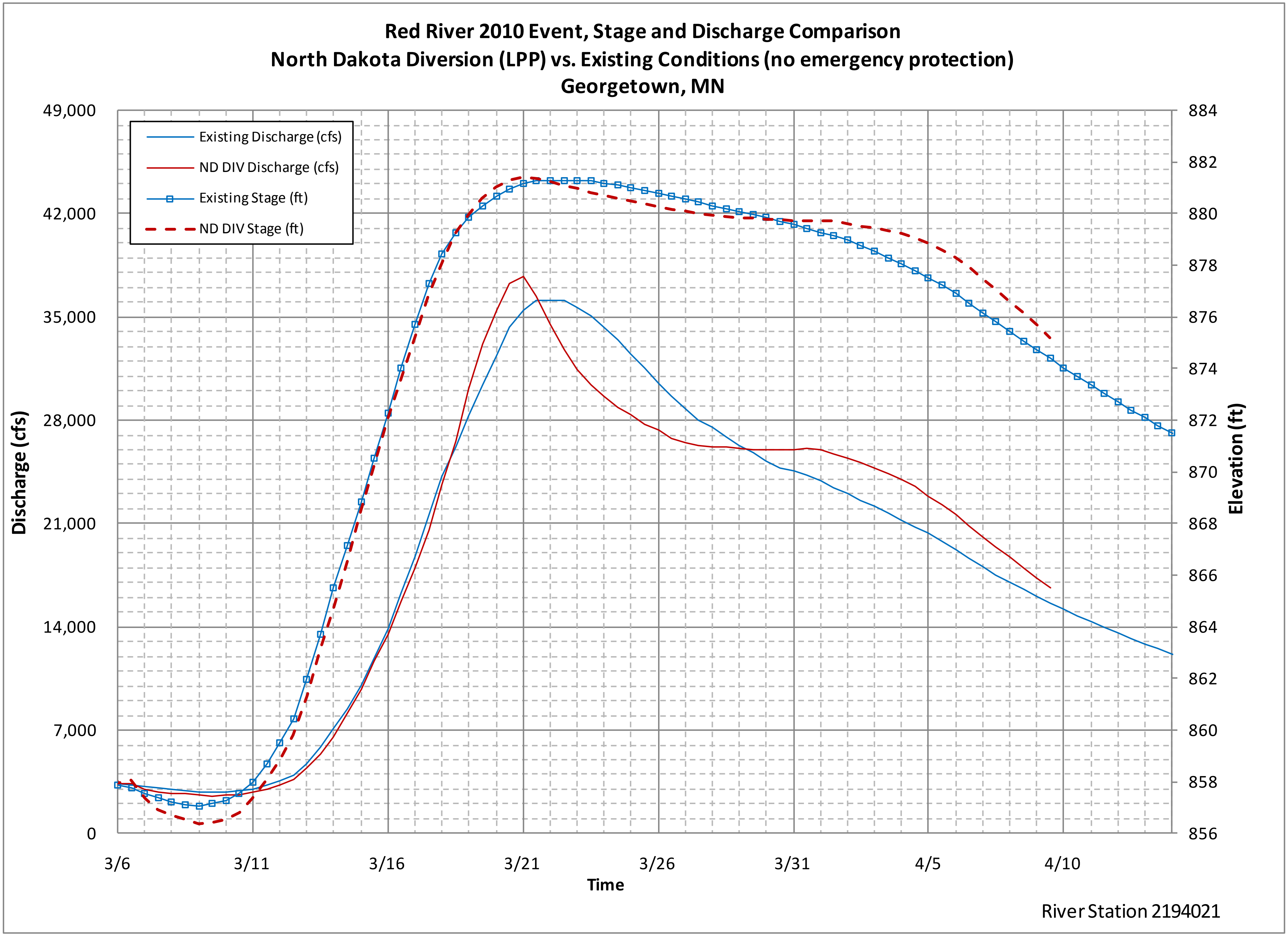


Figure C-E2- 89: 2010 Historical Flood Hydrographs for LPP @ Georgetown

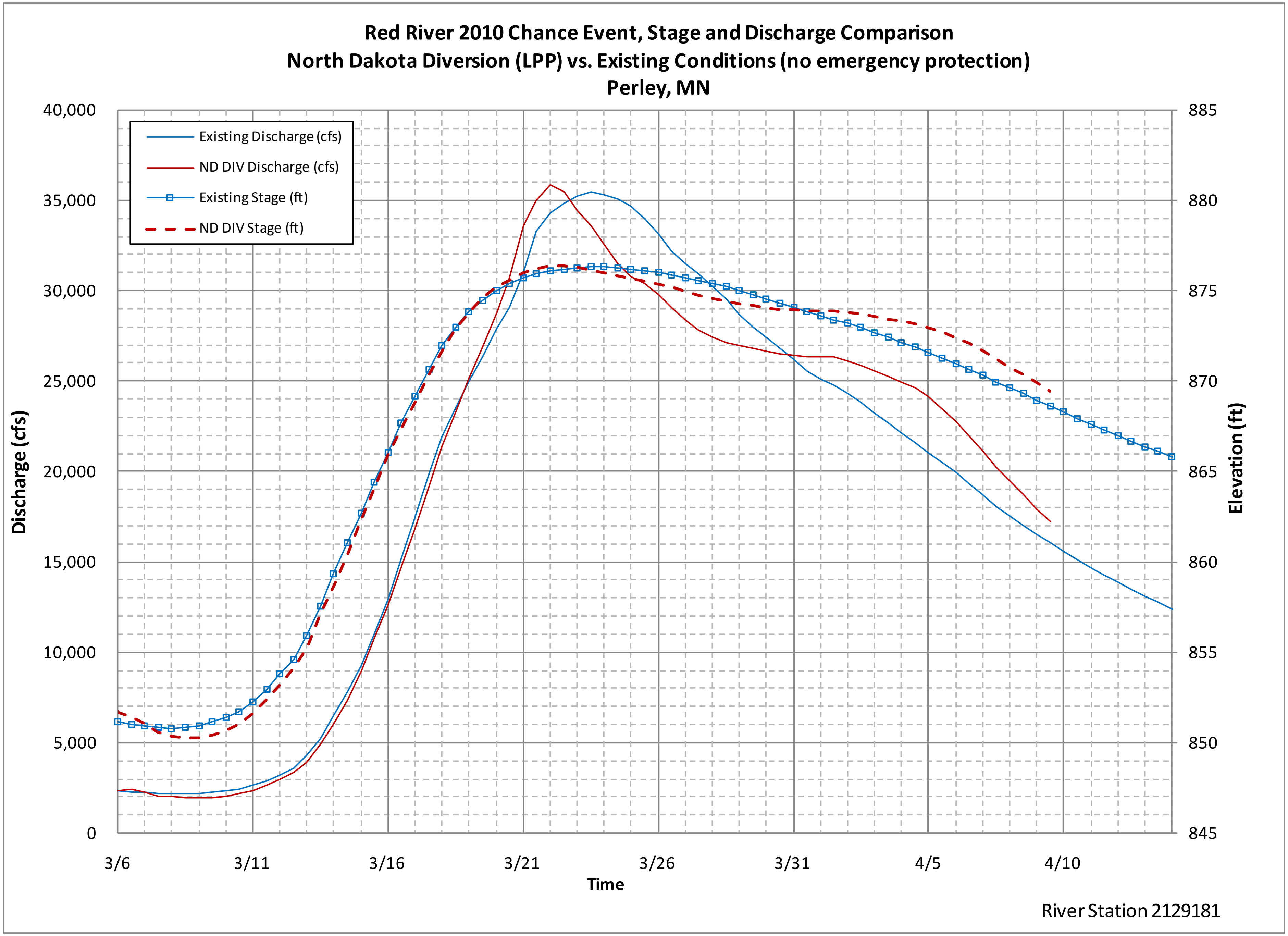


Figure C-E2- 90: 2010 Historical Flood Hydrographs for LPP @ Perley

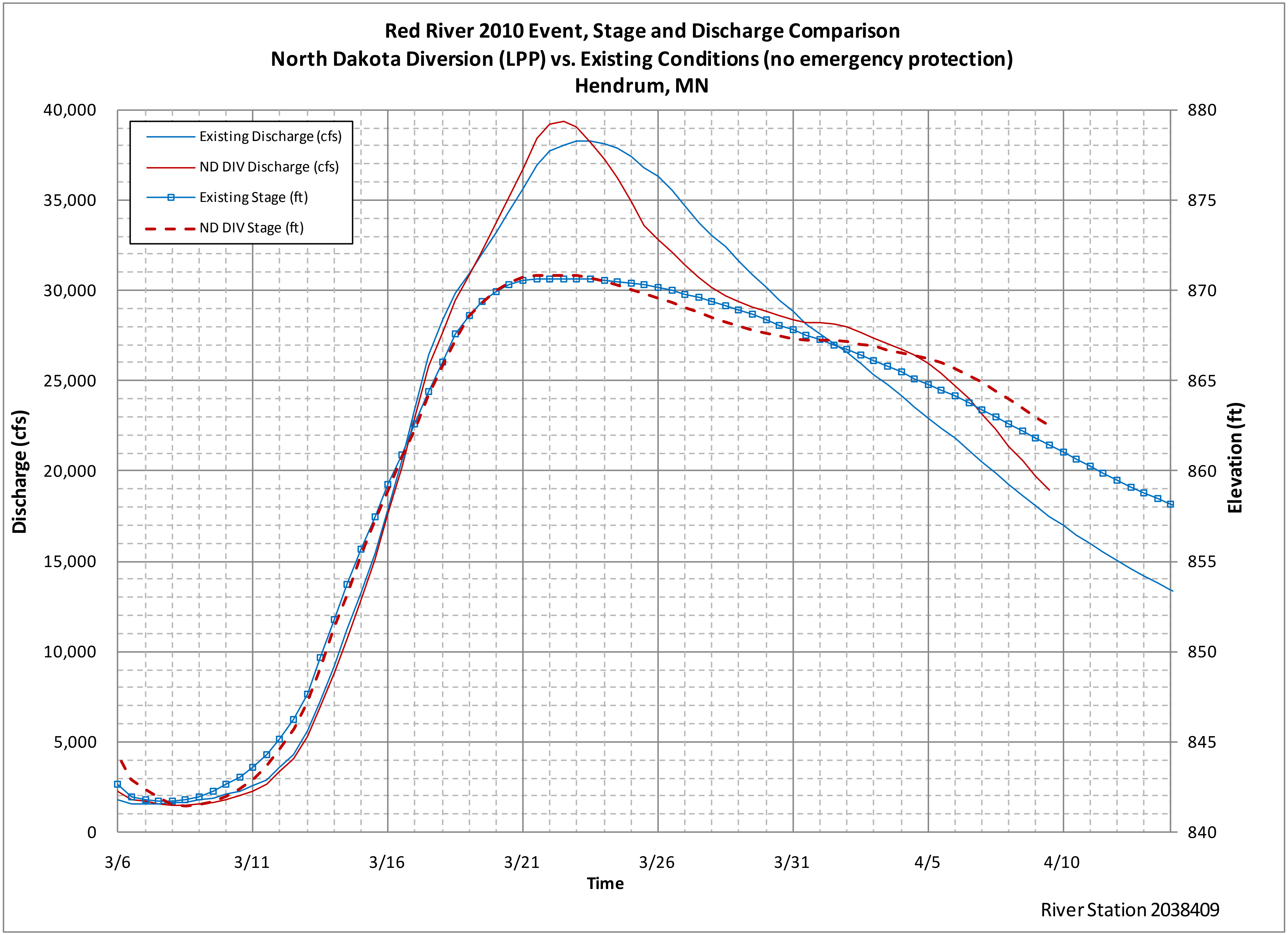


Figure C-E2- 91: 2010 Historical Flood Hydrographs for LPP @ Hendrum

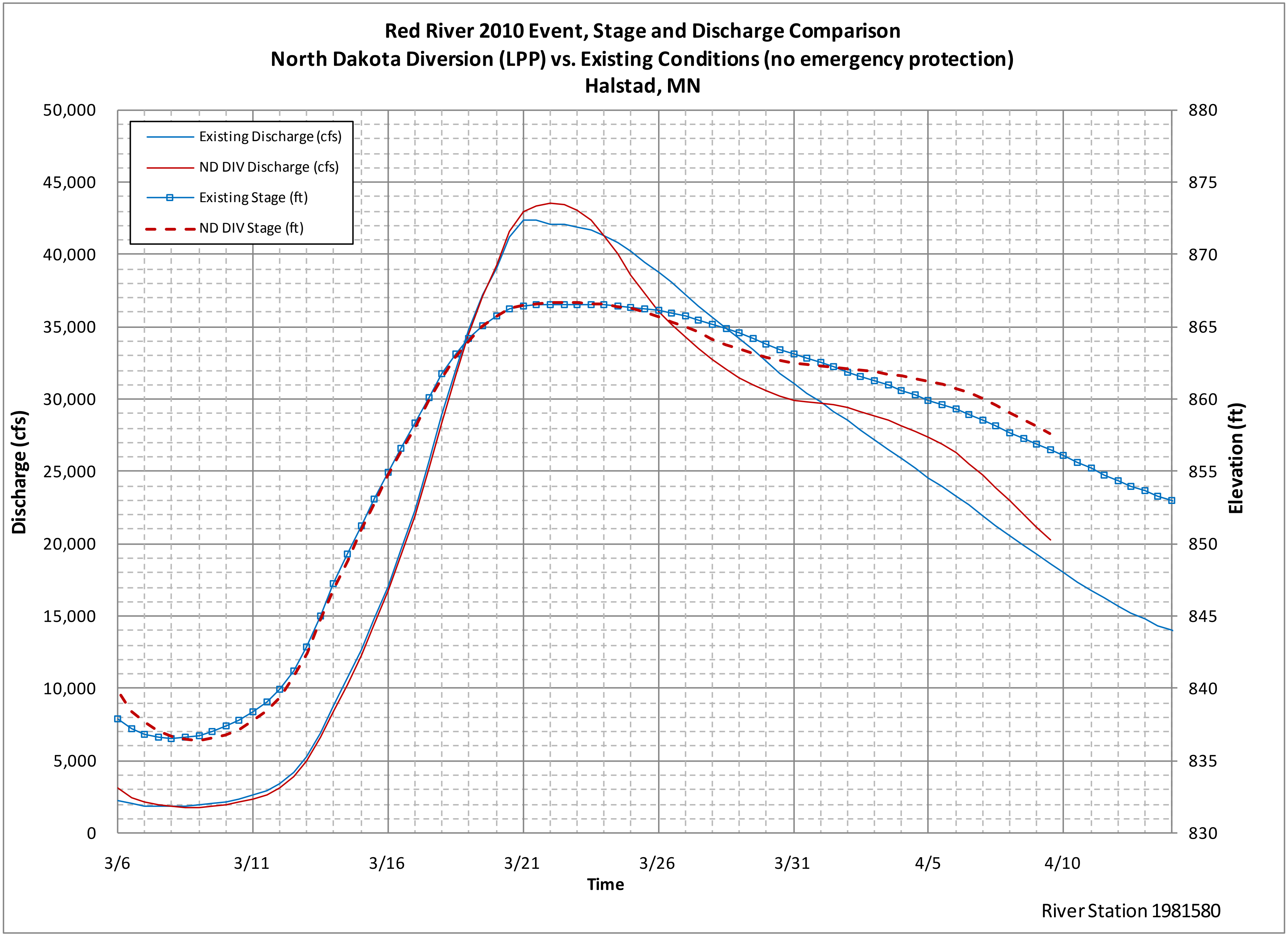


Figure C-E2- 92: 2010 Historical Flood Hydrographs for LPP @ Halstad

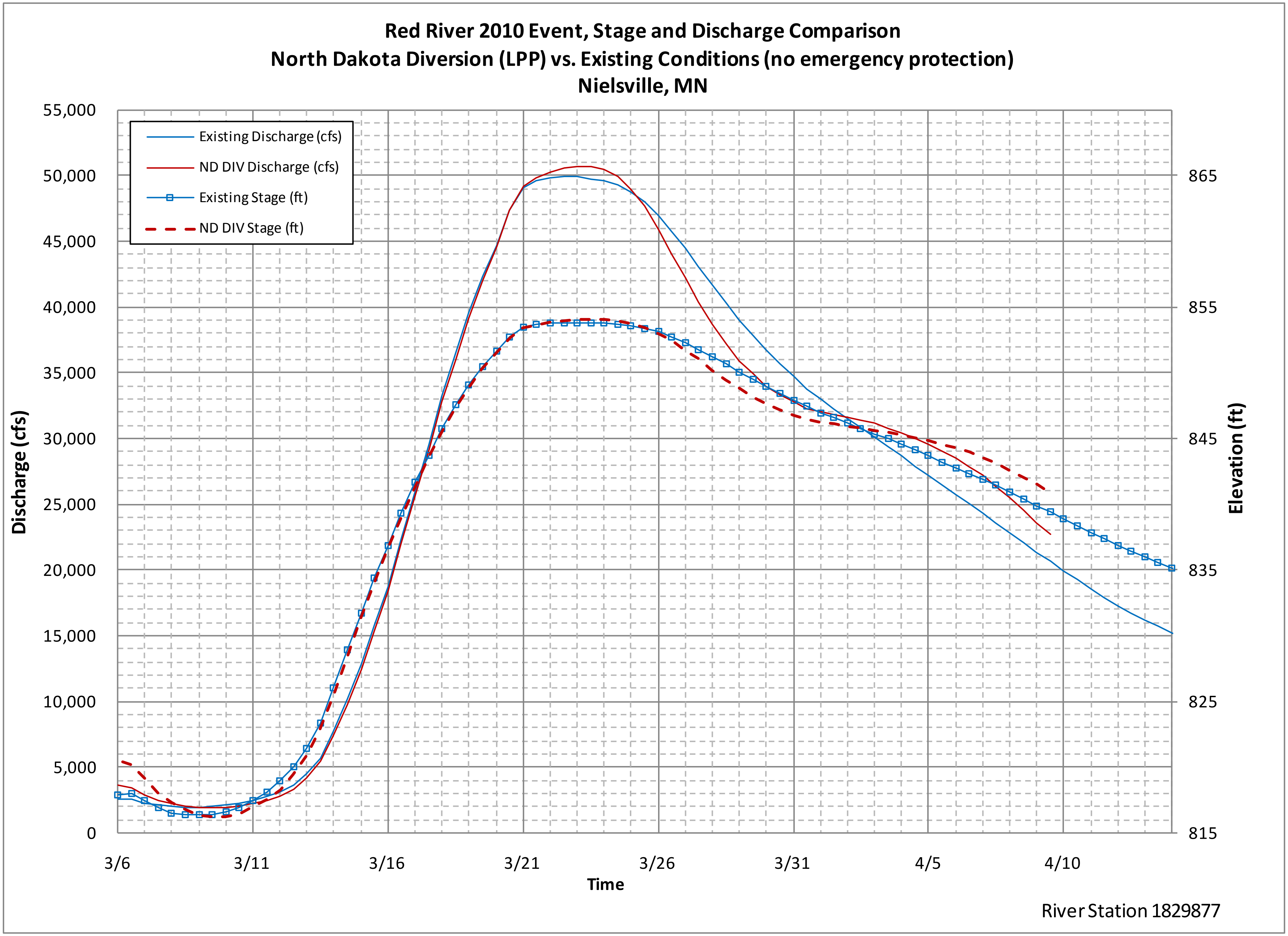


Figure C-E2- 93: 2010 Historical Flood Hydrographs for LPP @ Nielsville

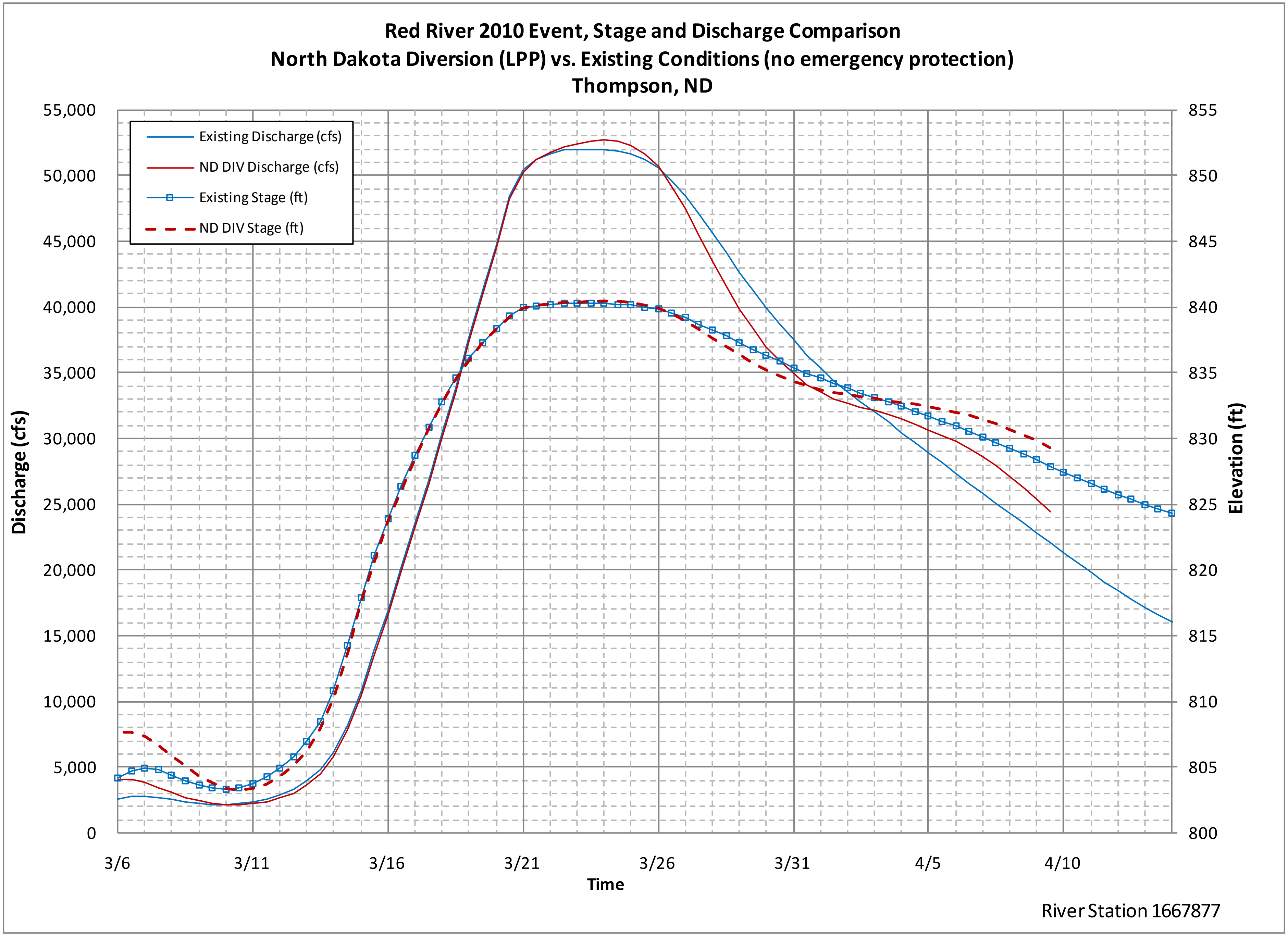


Figure C-E2- 94: 2010Historical Flood Hydrographs for LPP @ Thompson

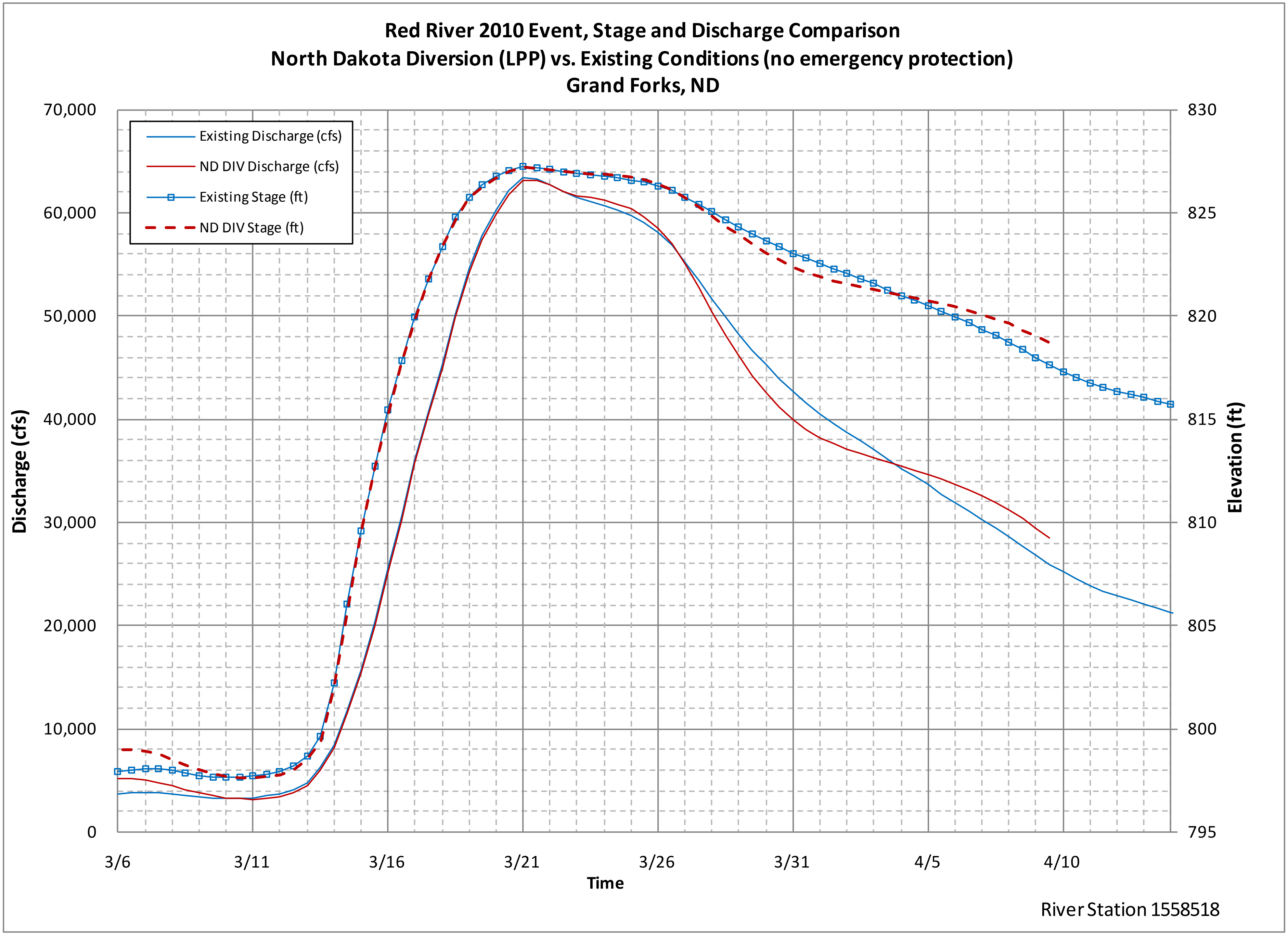


Figure C-E2- 95: 2010 Historical Flood Hydrographs for LPP @ Grand Forks

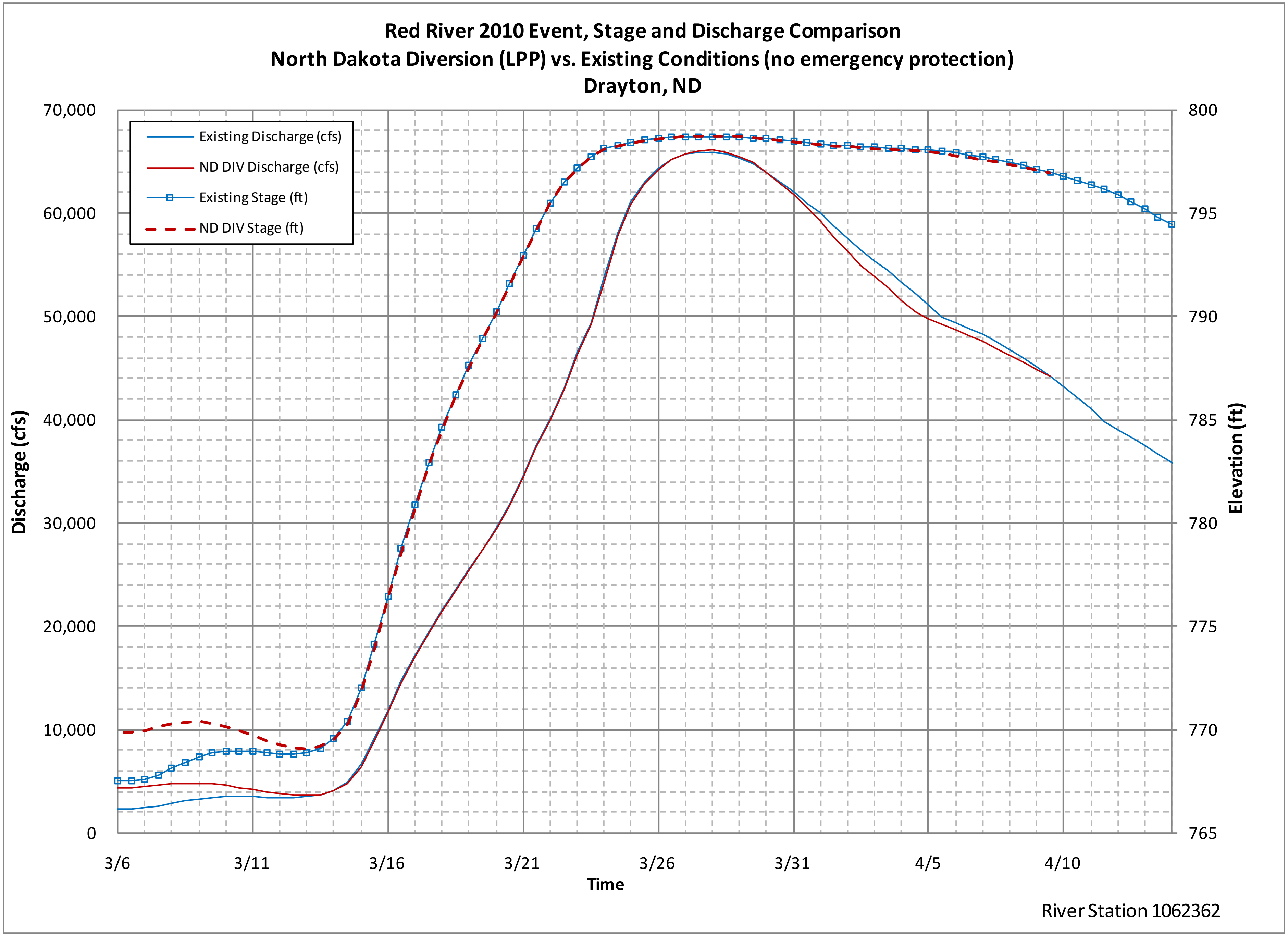


Figure C-E2- 96: 2010 Historical Flood Hydrographs for LPP @ Drayton

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

EXHIBIT 3 – PROJECT IMPACT MAPS

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: February 28, 2011

FIGURES

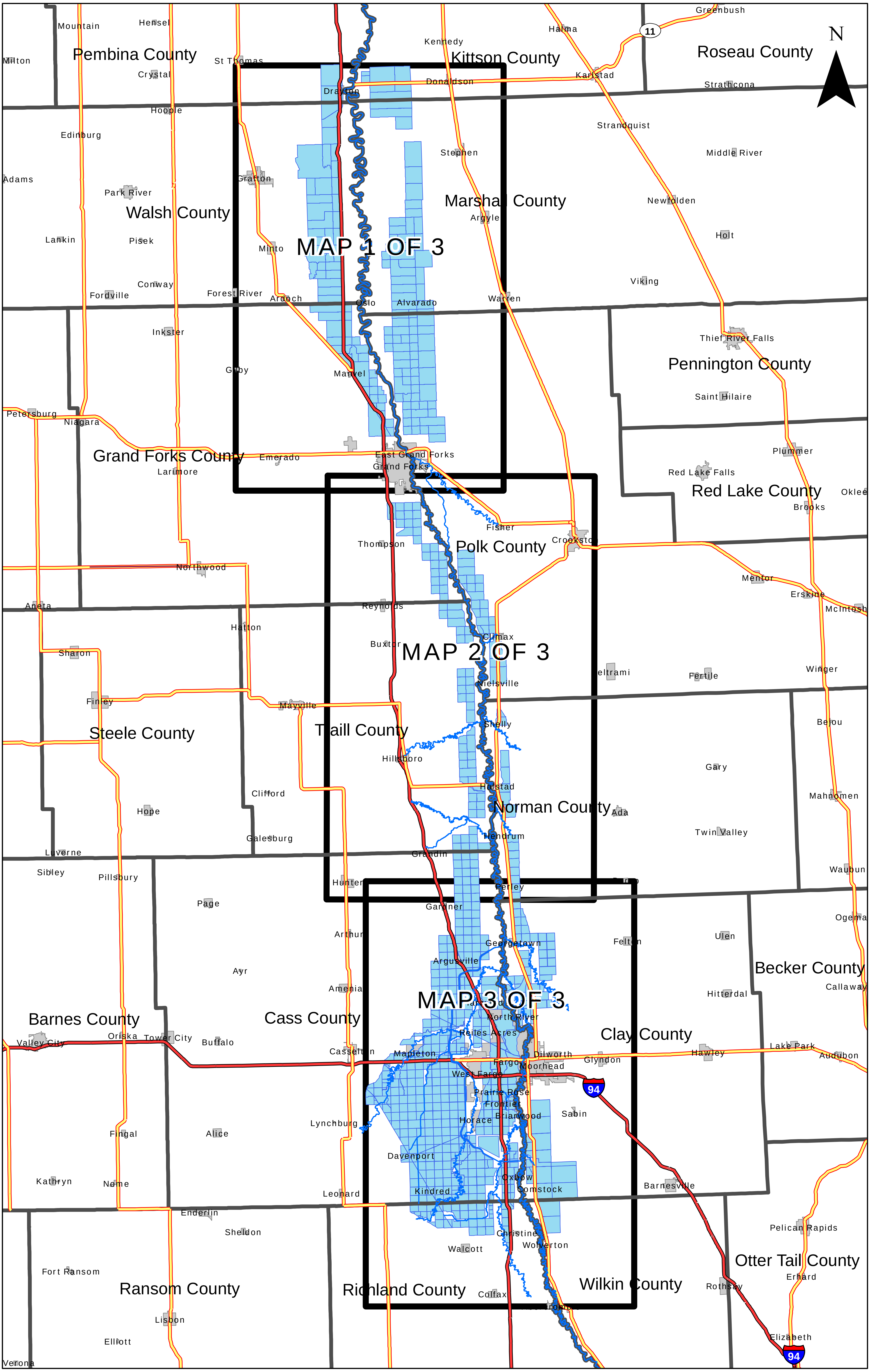


Figure C-E3-1: Change in Maximum Water Surface Elevations Layout

moore engineering, inc.

February 28, 2011

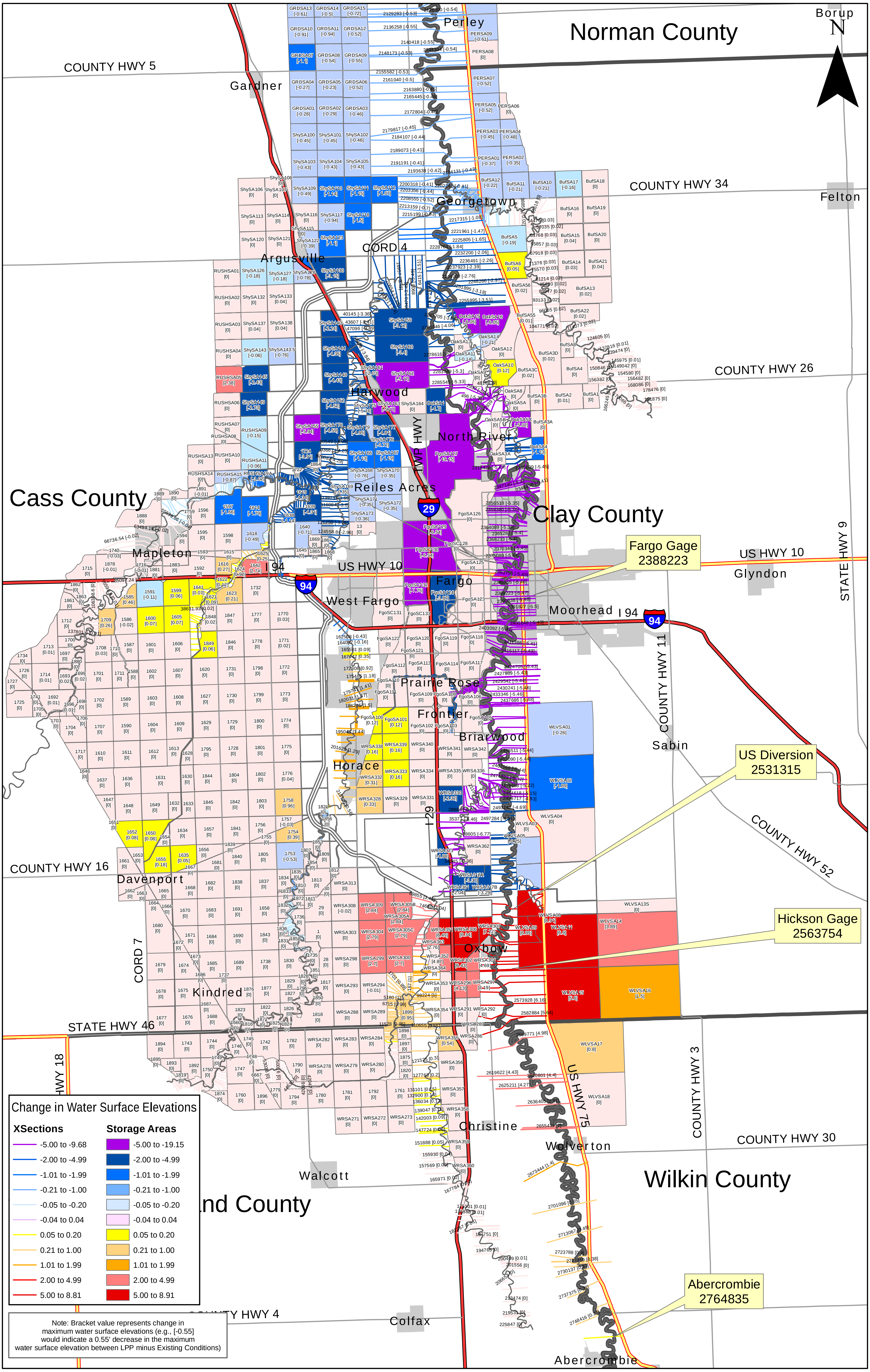


Figure C-E3-2: 10-Percent Chance Change in Maximum Water Surface Elevation
(Map 1 of 3)

moore engineering, inc.

February 28, 2011

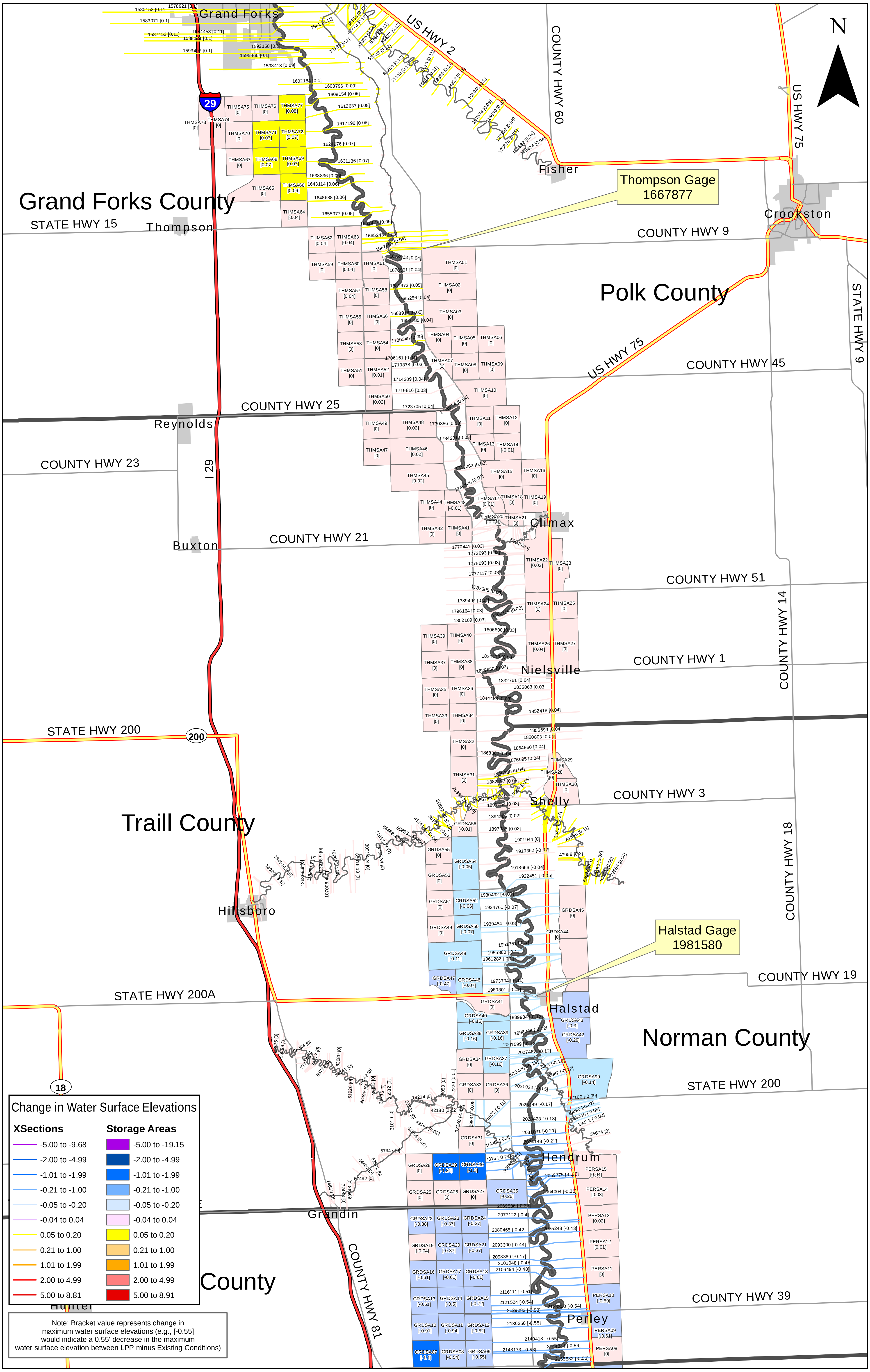


Figure C-E3-3: 10-Percent Chance Change in Maximum Water Surface Elevation
(Map 2 of 3)

moore engineering, inc.

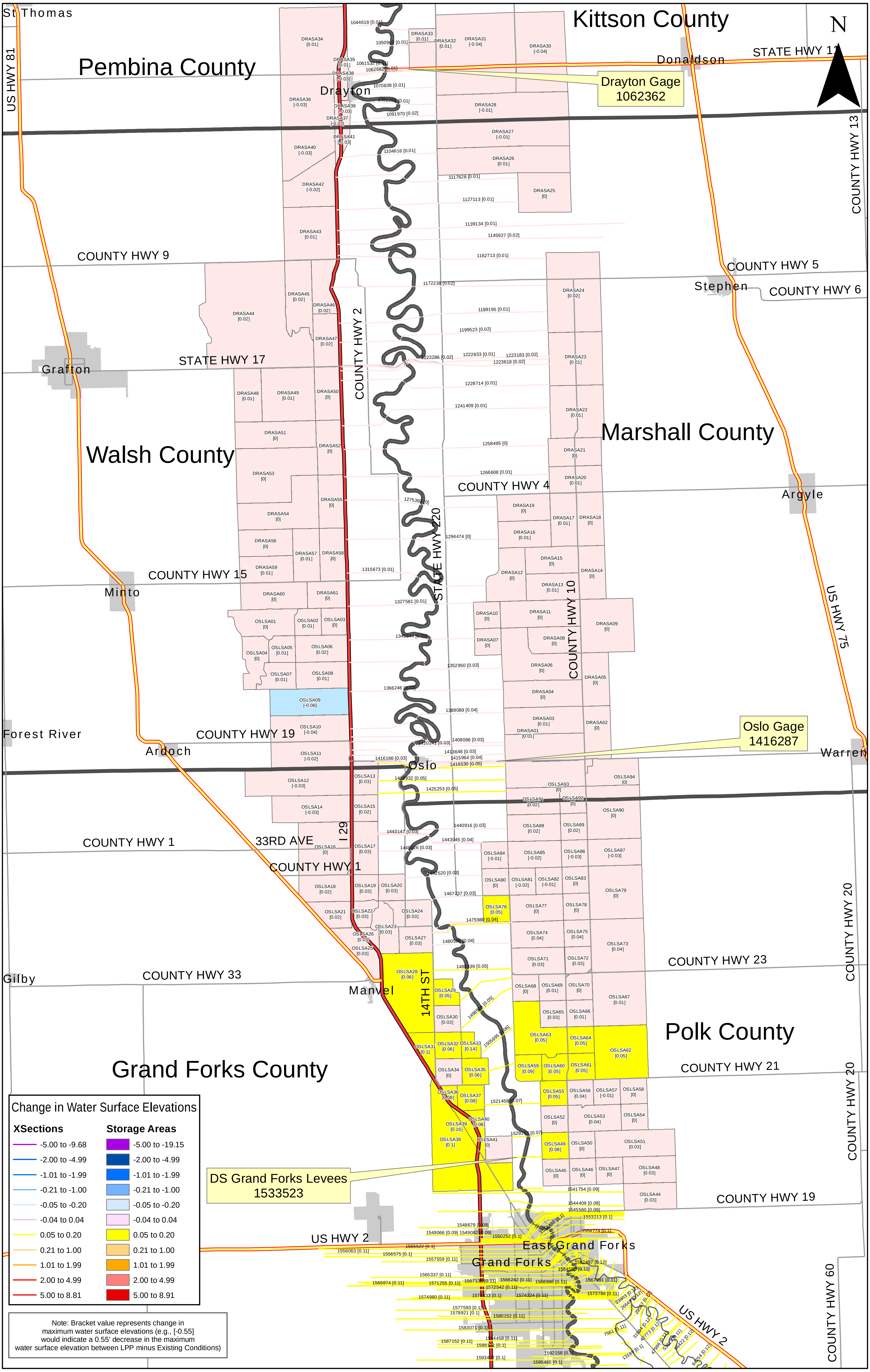


Figure C-E3-4: 10-Percent Chance Change in Maximum Water Surface Elevation
(Map 3 of 3)

moore engineering, inc.

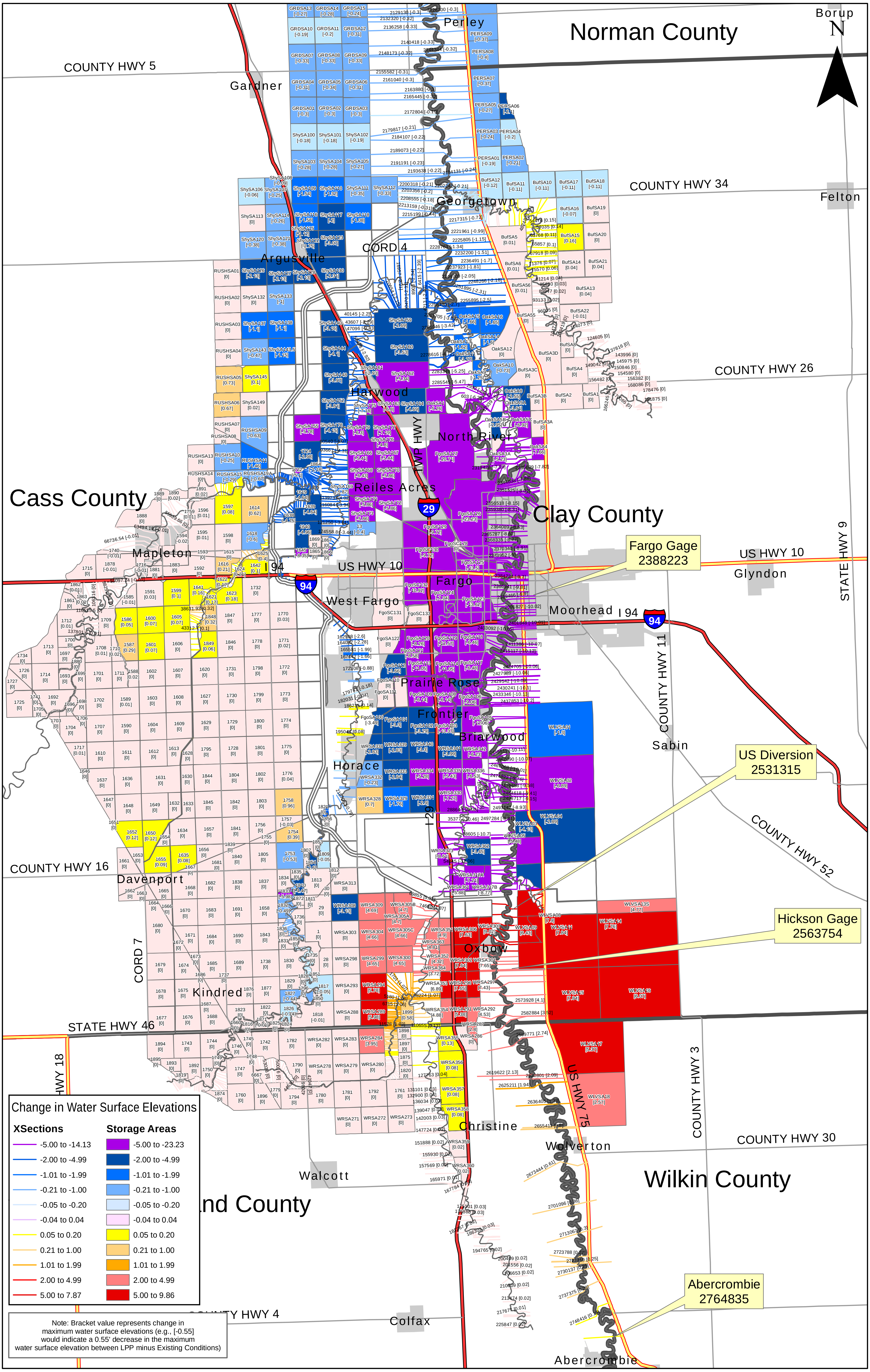


Figure C-E3-5: 2-Percent Chance Change in Maximum Water Surface Elevation
(Map 1 of 3)

moore engineering, inc.

February 28, 2011

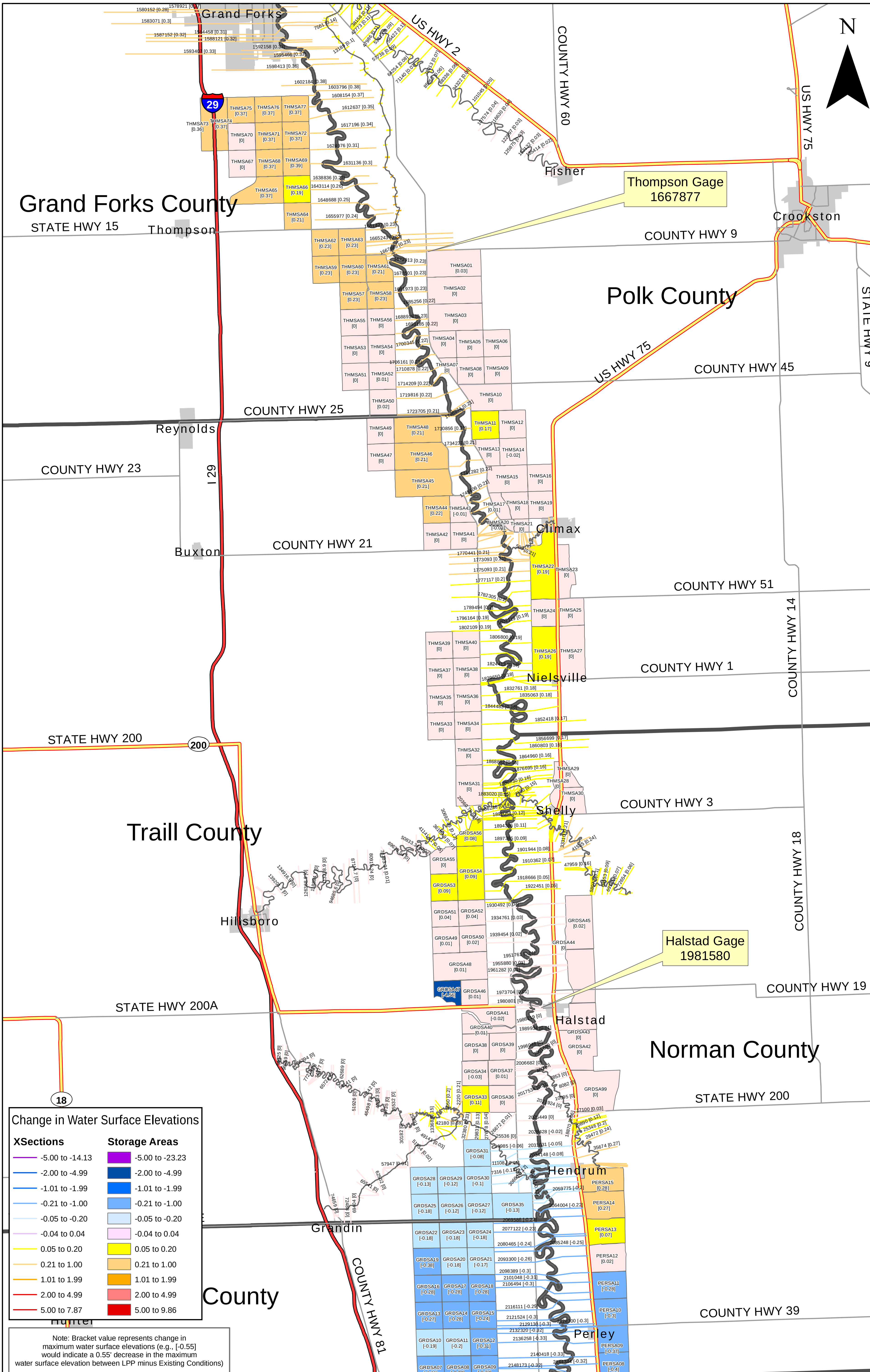


Figure C-E3-6: 2-Percent Chance Change in Maximum Water Surface Elevation
(Map 2 of 3)

moore engineering, inc.

February 28, 2011

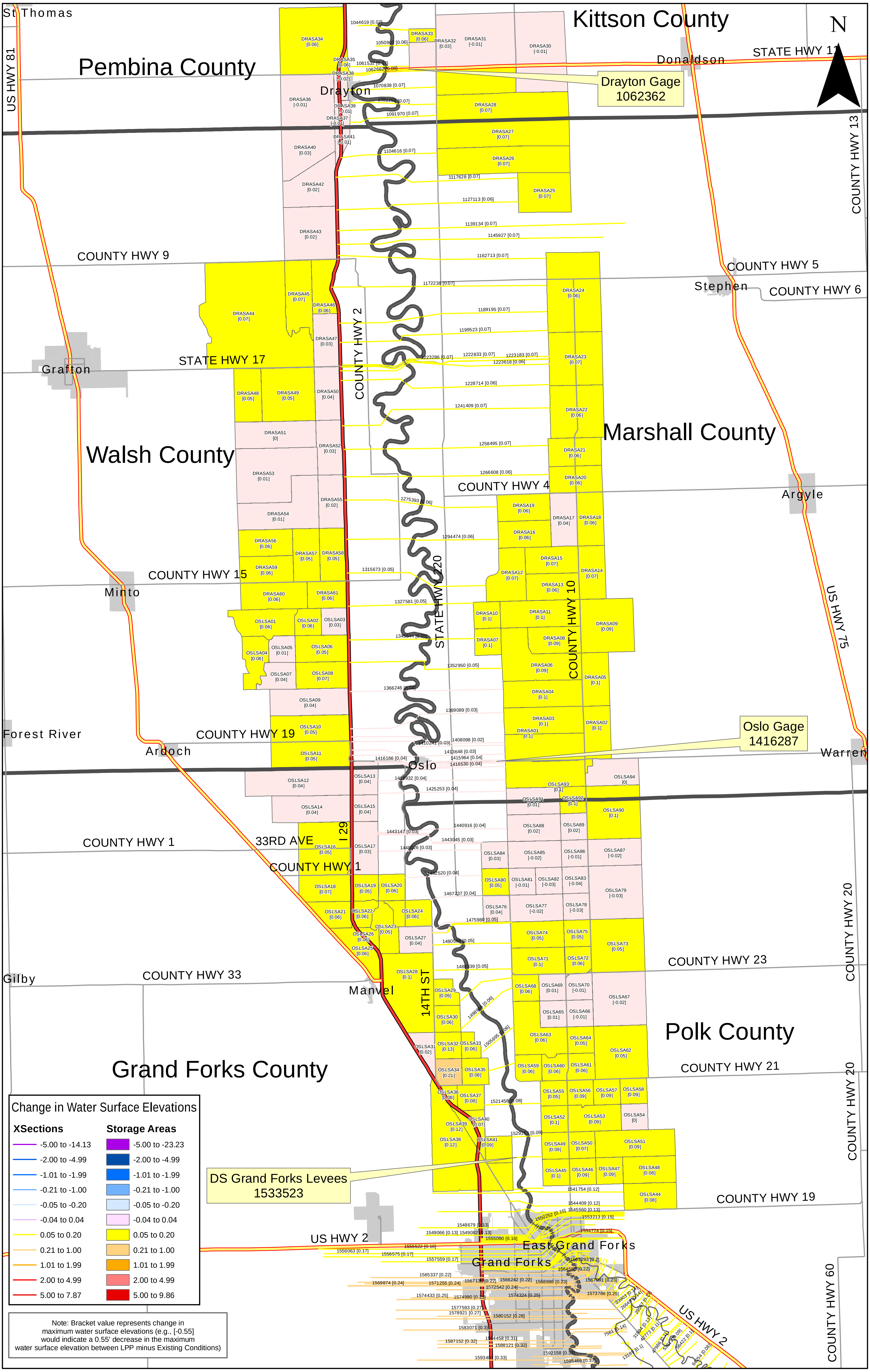


Figure C-E3-7: 2-Percent Chance Change in Maximum Water Surface Elevation
(Map 3 of 3)

moore engineering, inc.

February 28, 2011

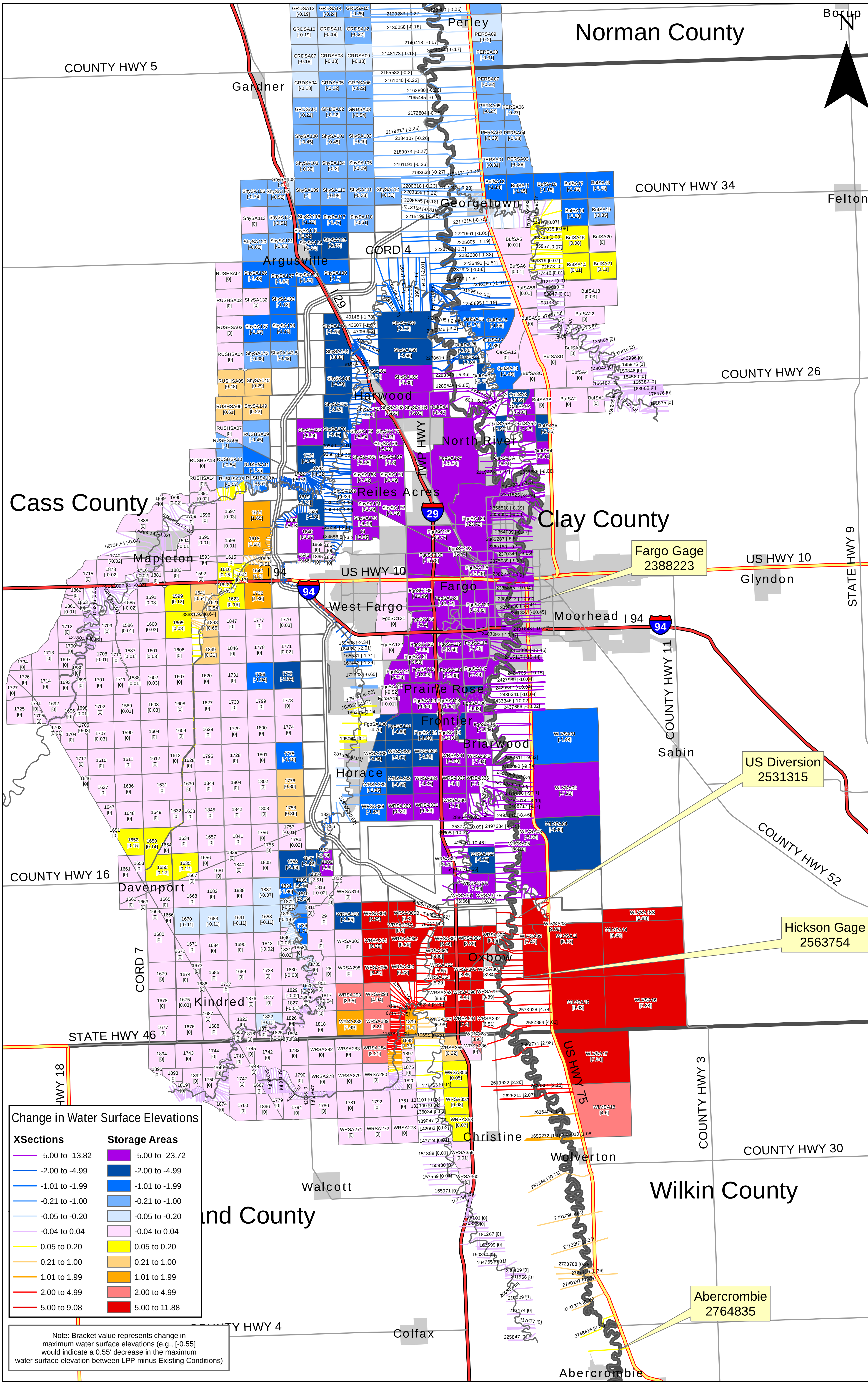


Figure C-E3-8: 1-Percent Chance Change in Maximum Water Surface Elevation
(Map 1 of 3)

moore engineering, inc.

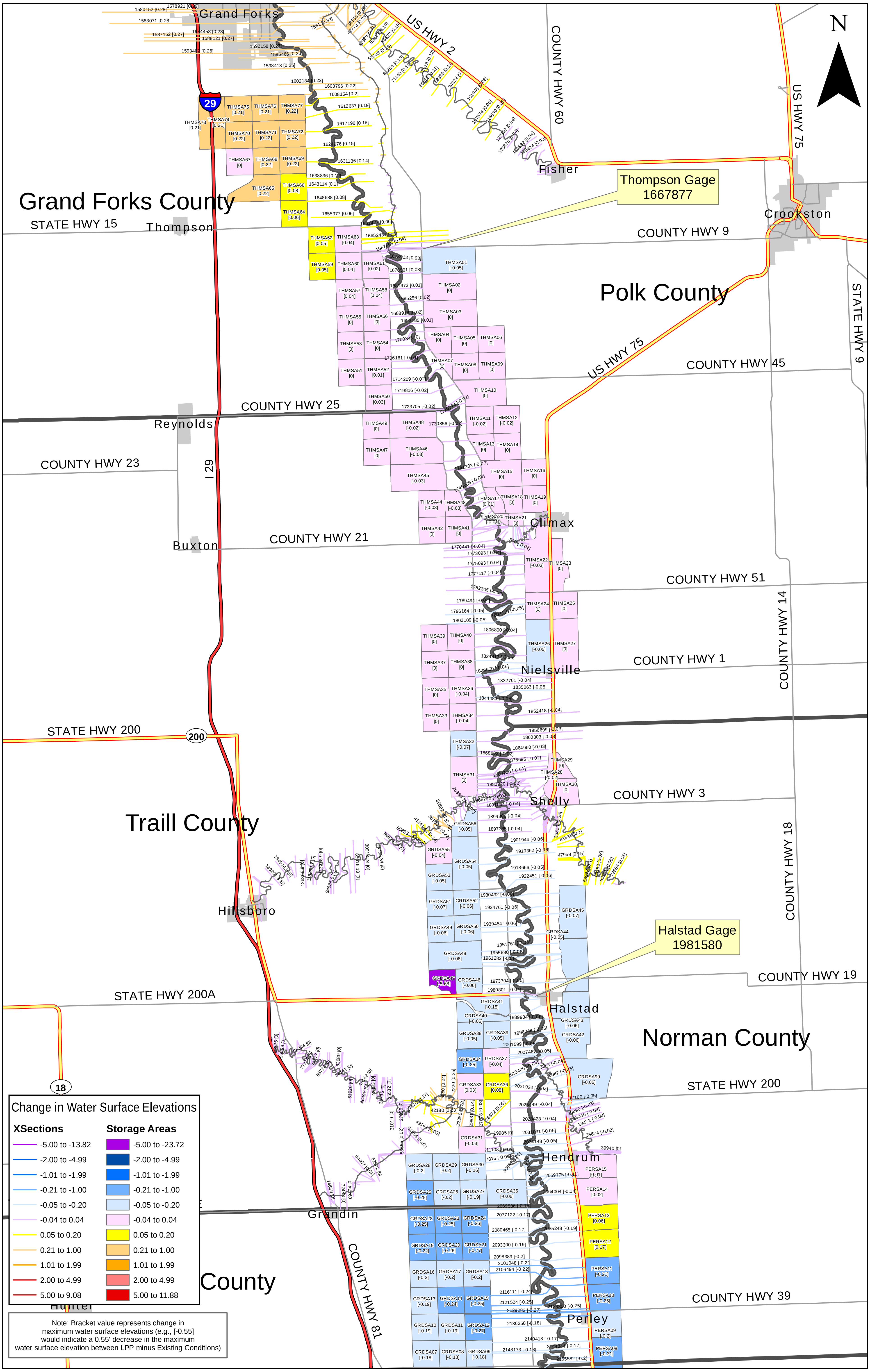


Figure C-E3-9: 1-Percent Chance Change in Maximum Water Surface Elevation
(Map 2 of 3)

moore engineering, inc.

February 28, 2011

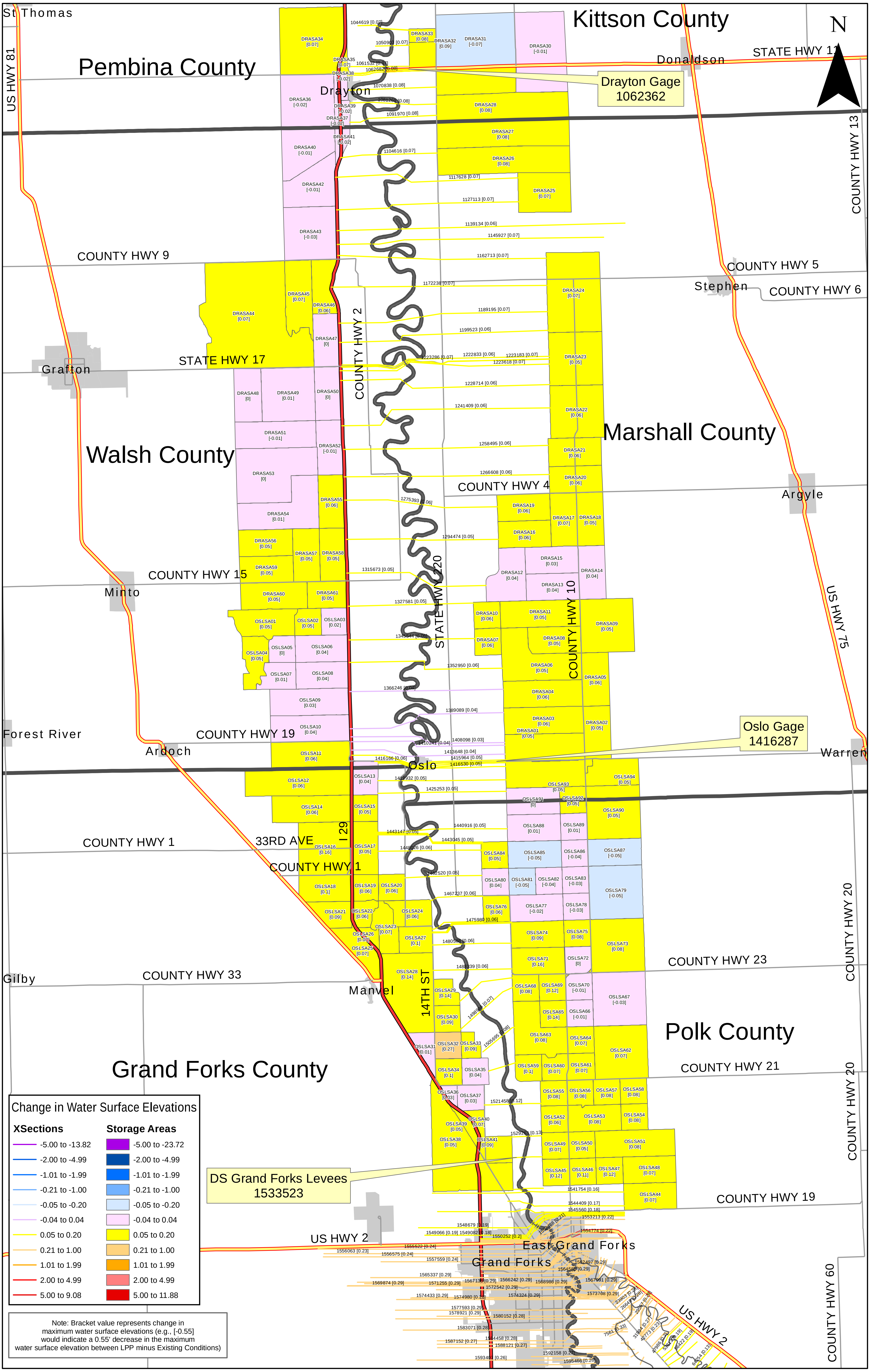


Figure C-E3-10: 1-Percent Chance Change in Maximum Water Surface Elevation
(Map 3 of 3)

moore engineering, inc.

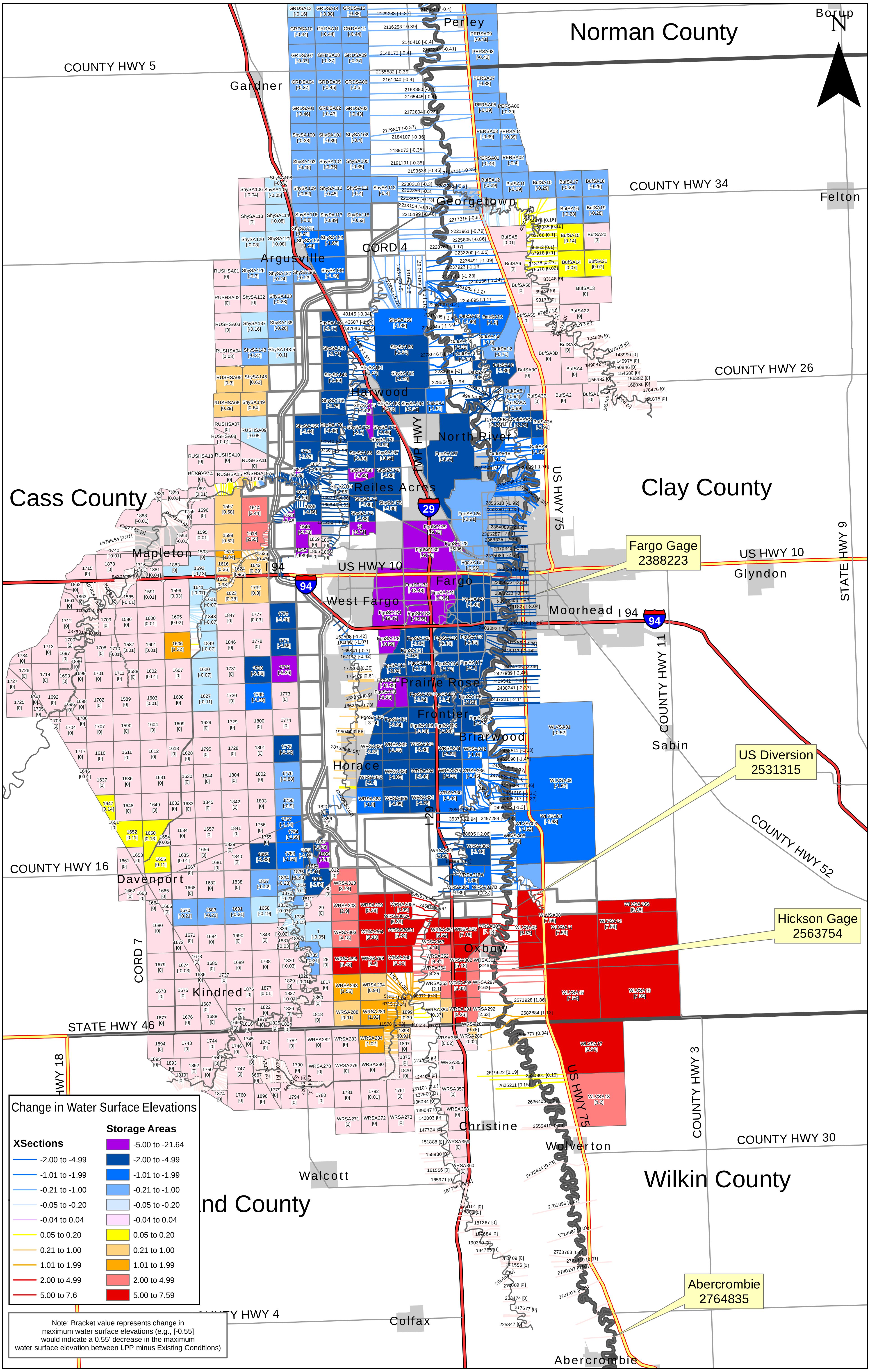


Figure C-E3-11: 0.2-Percent Chance Change in Maximum Water Surface Elevation
(Map 1 of 3)

moore engineering, inc.

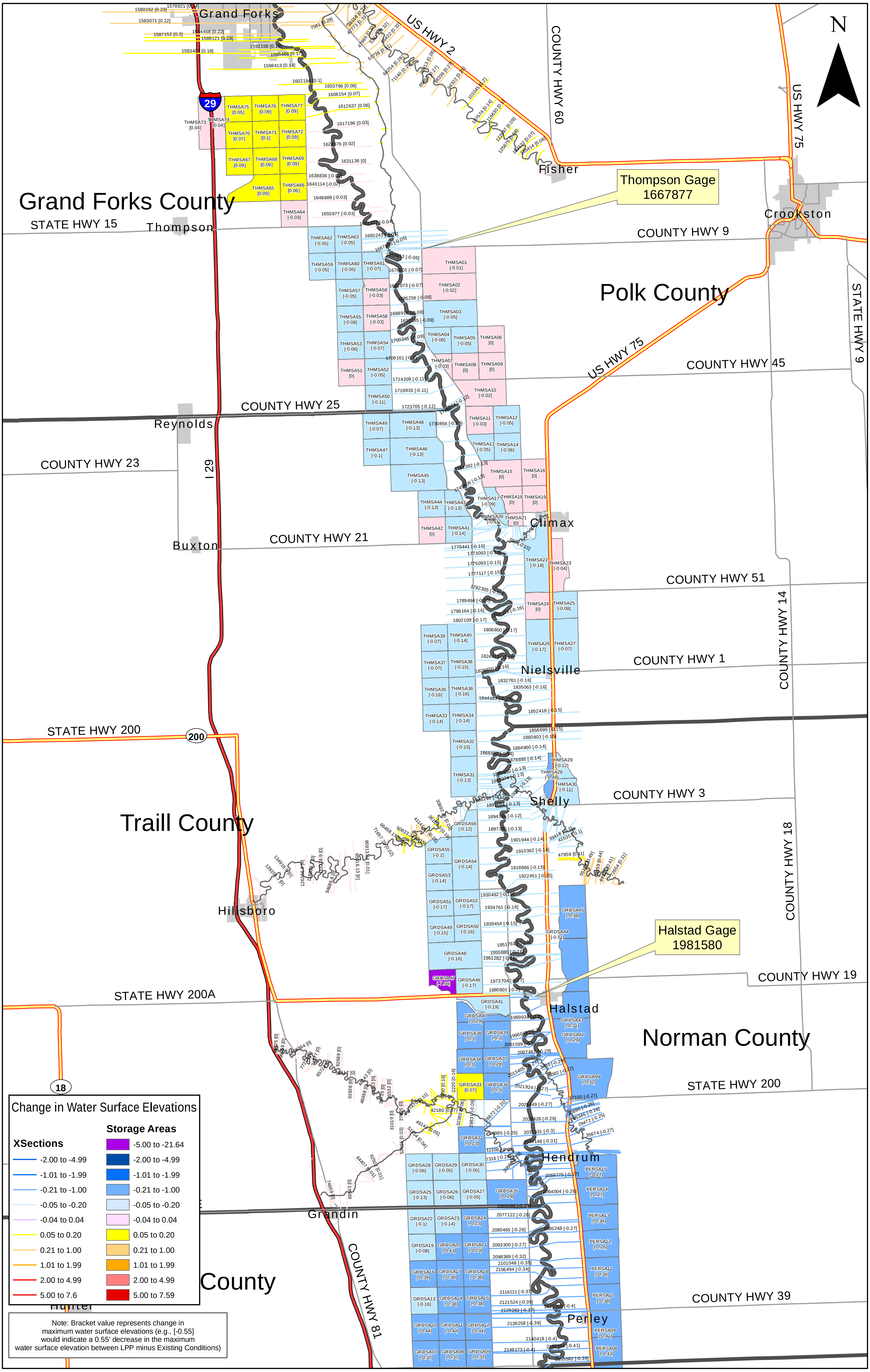


Figure C-E3-12: 0.2-Percent Chance Change in Maximum Water Surface Elevation
(Map 2 of 3)

moore engineering, inc.

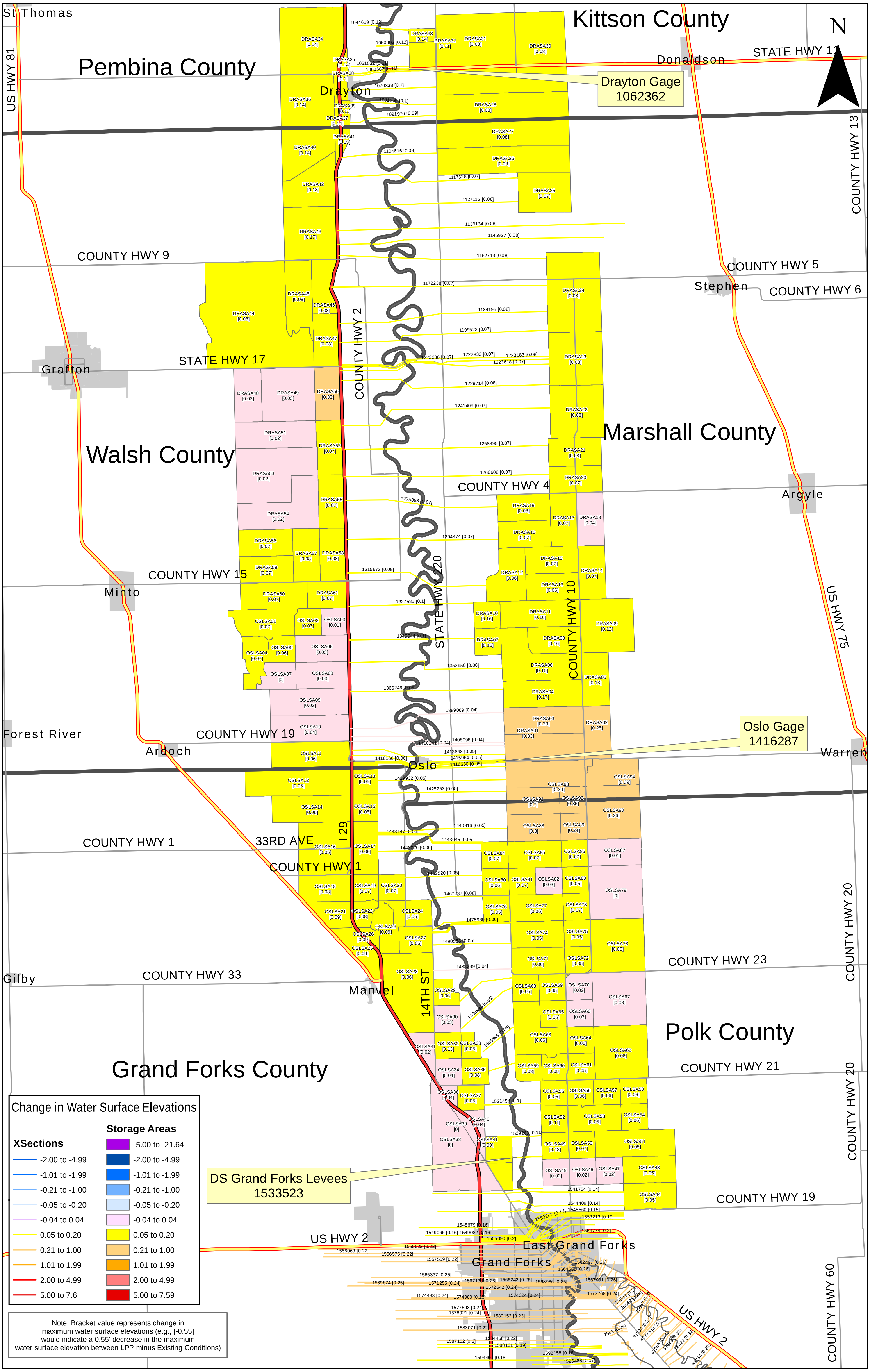


Figure C-E3-13: 0.2-Percent Chance Change in Maximum Water Surface Elevation
(Map 3 of 3)

moore engineering, inc.

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

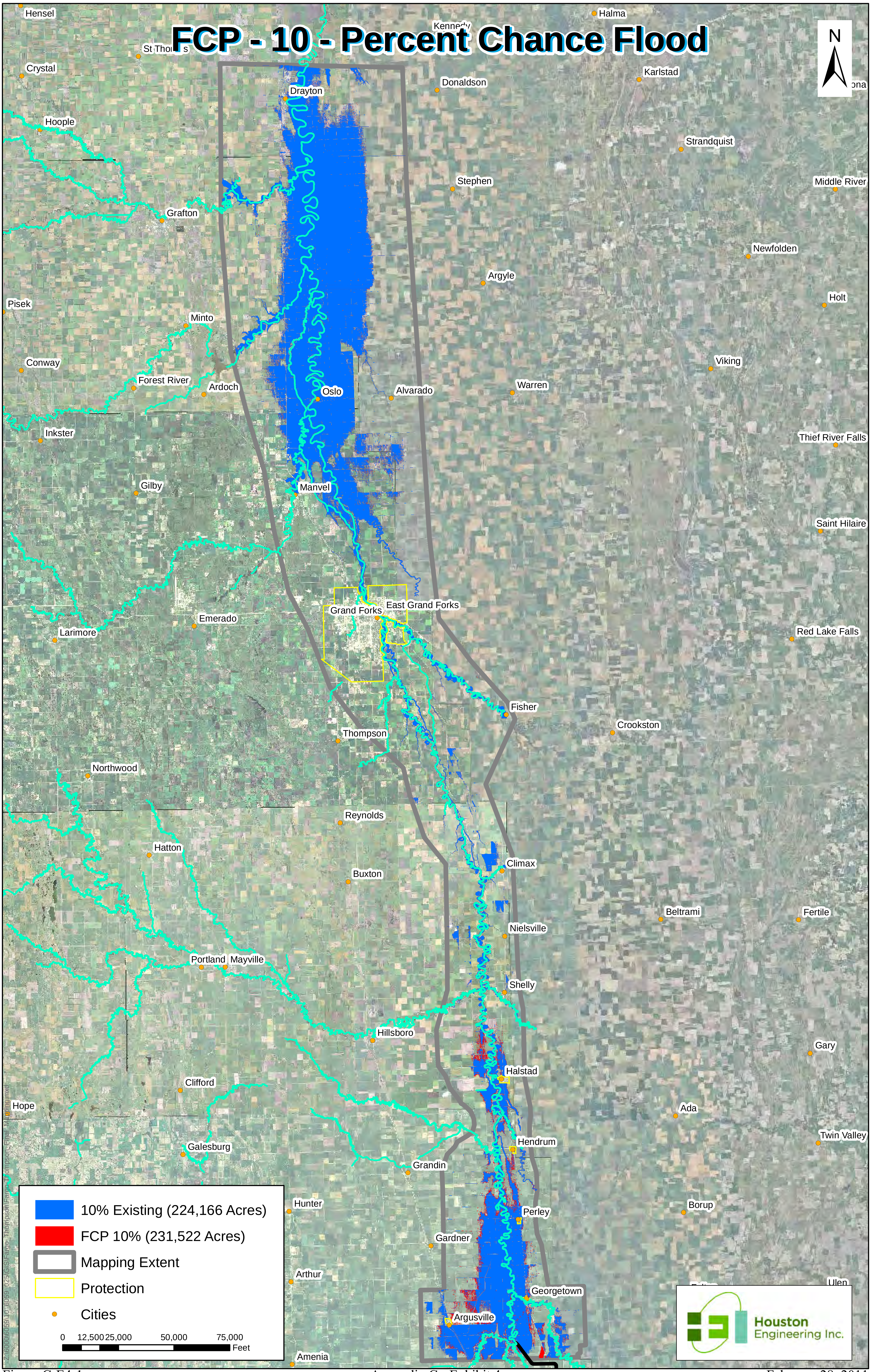
APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

EXHIBIT 4 – INUNDATION MAPS

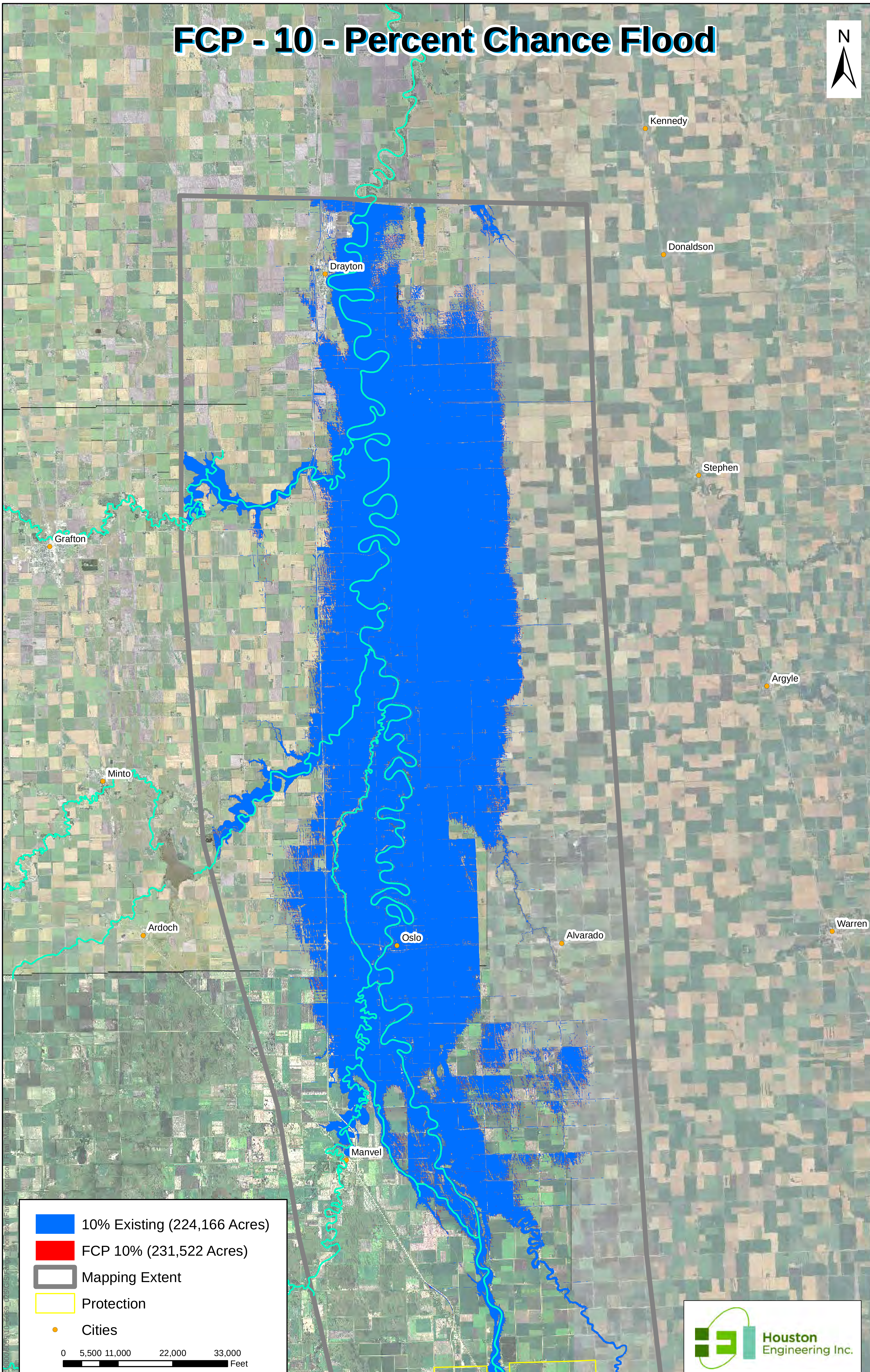
Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

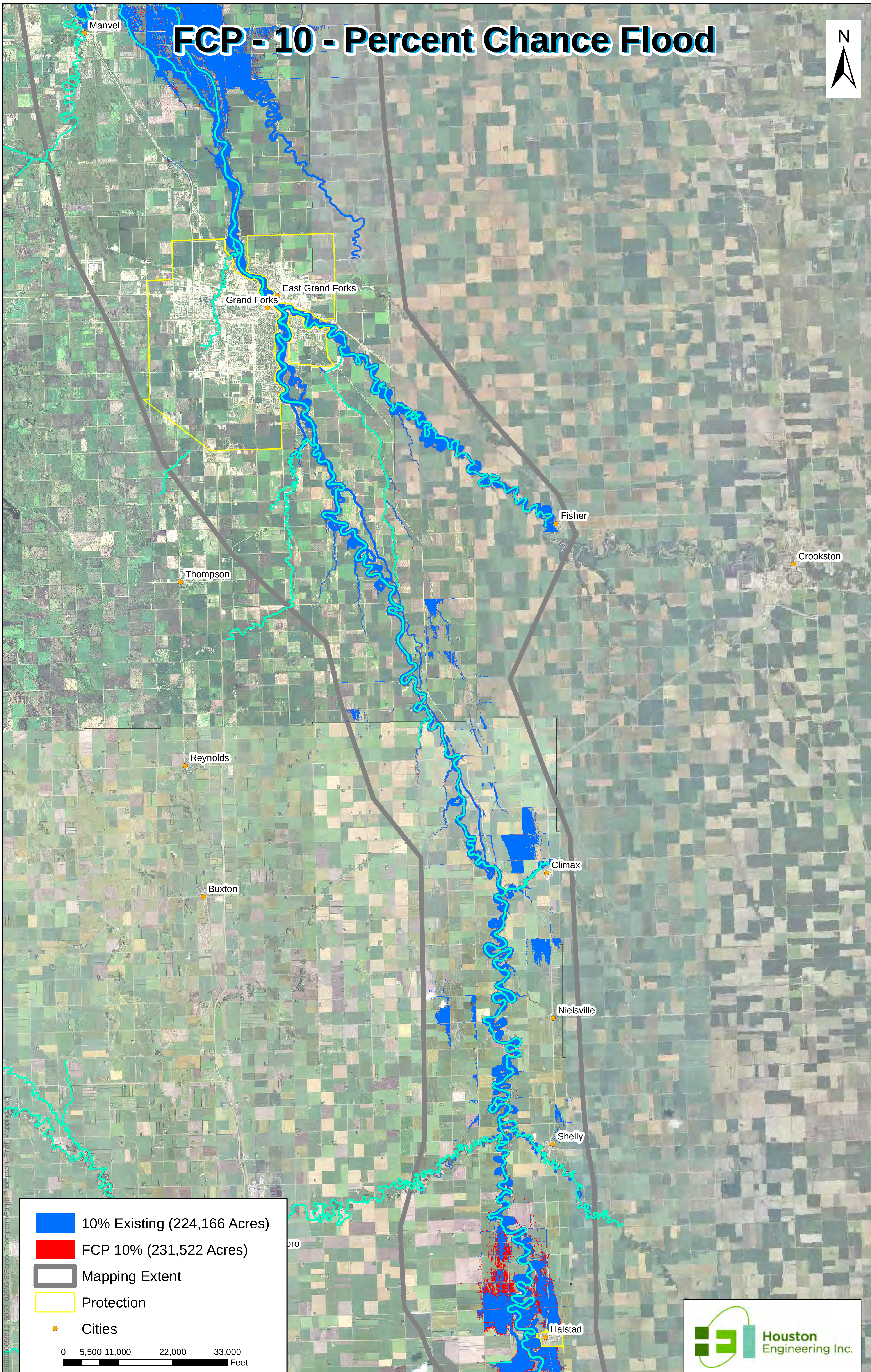
FINAL: February 28, 2011

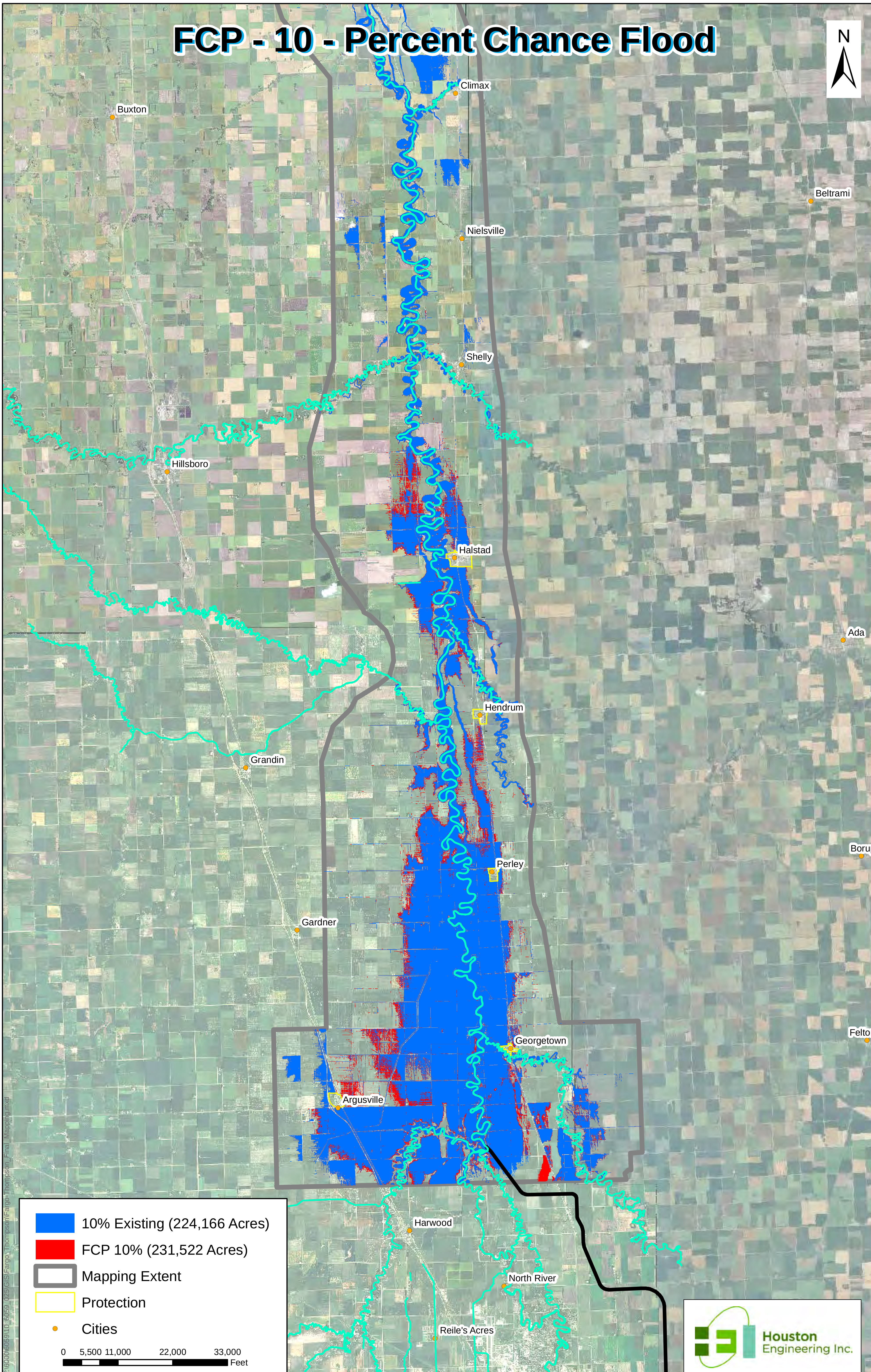
FIGURES

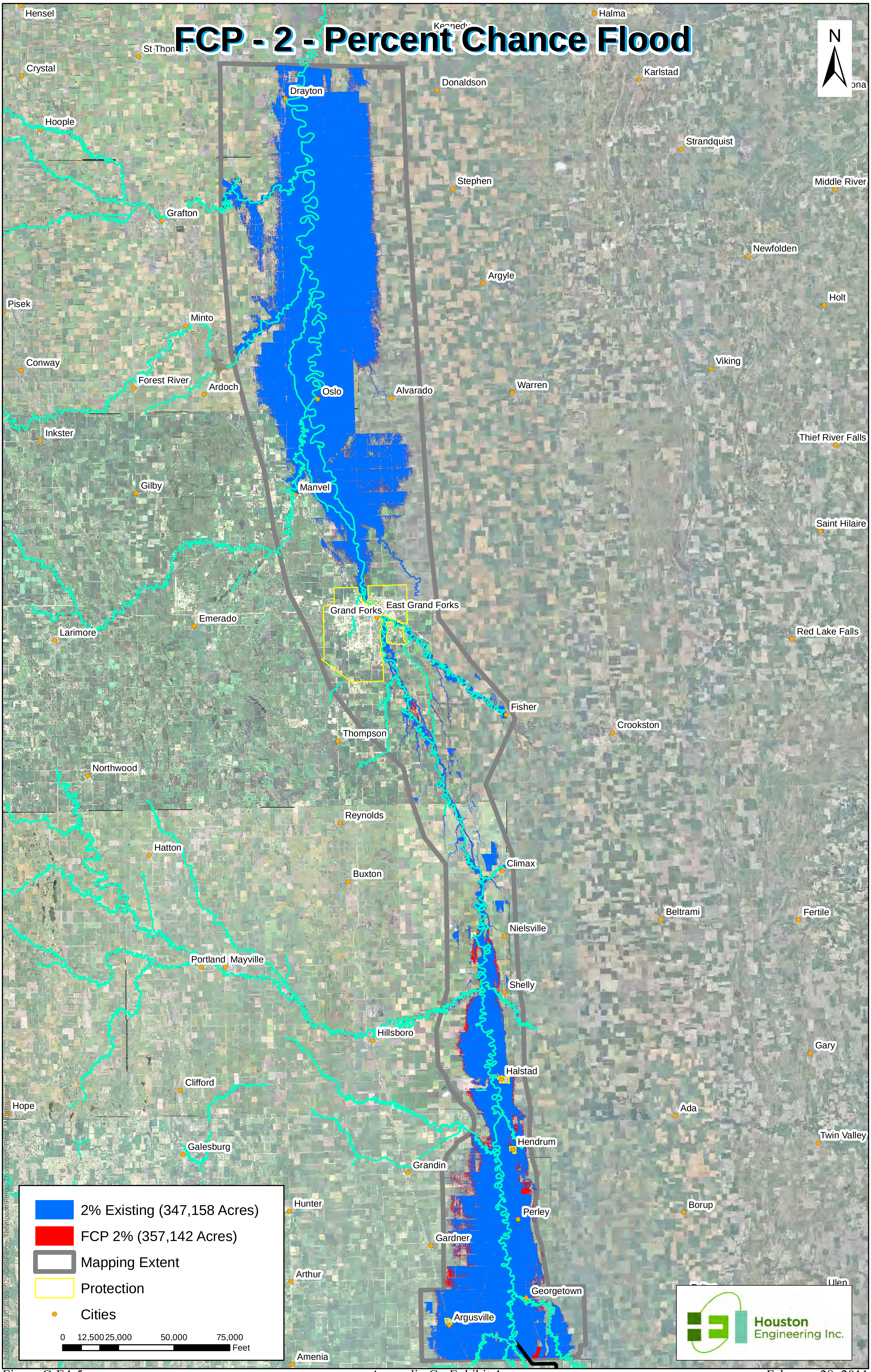

FCP - 10 - Percent Chance Flood
N
Hensel
Halma
Kennedy
Crystal
Karlstad
Drayton
Donaldson
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Perley
Borup
Gardner
Arthur
Georgetown
Ulen
Argusville
Amenia
10% Existing (224,166 Acres)
FCP 10% (231,522 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

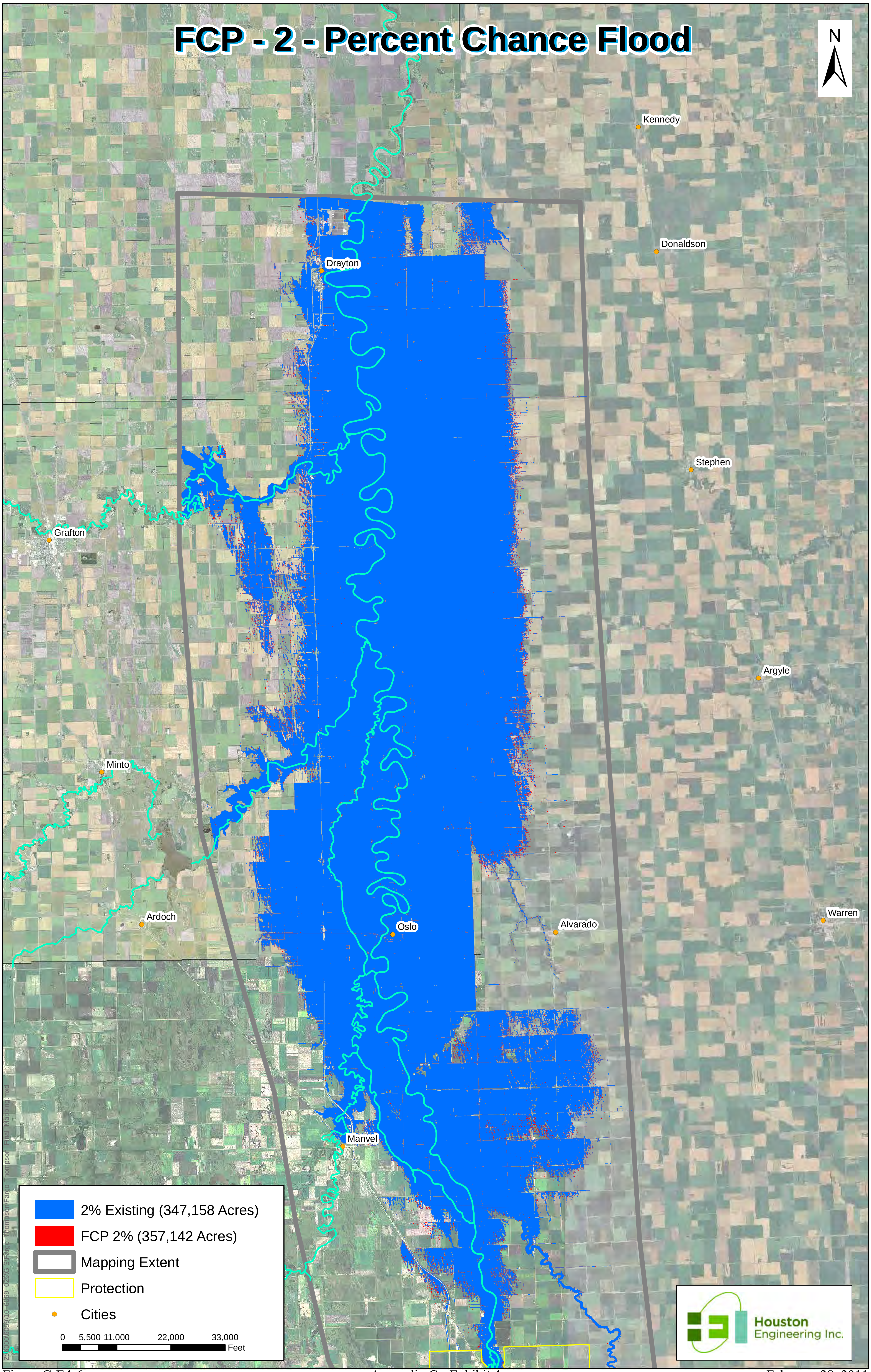
FCP - 10 - Percent Chance Flood

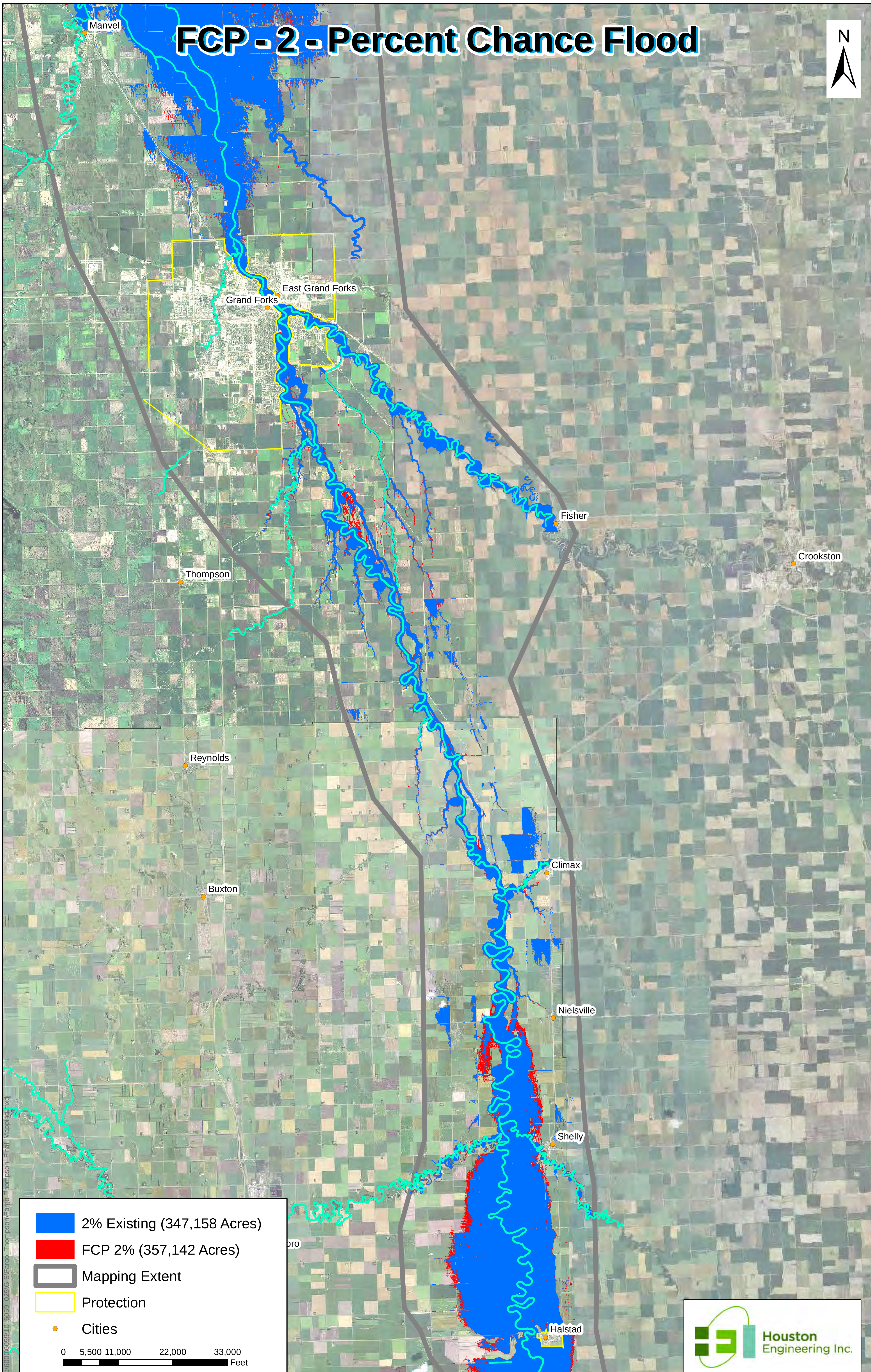



FCP - 10 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
10% Existing (224,166 Acres)
FCP 10% (231,522 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

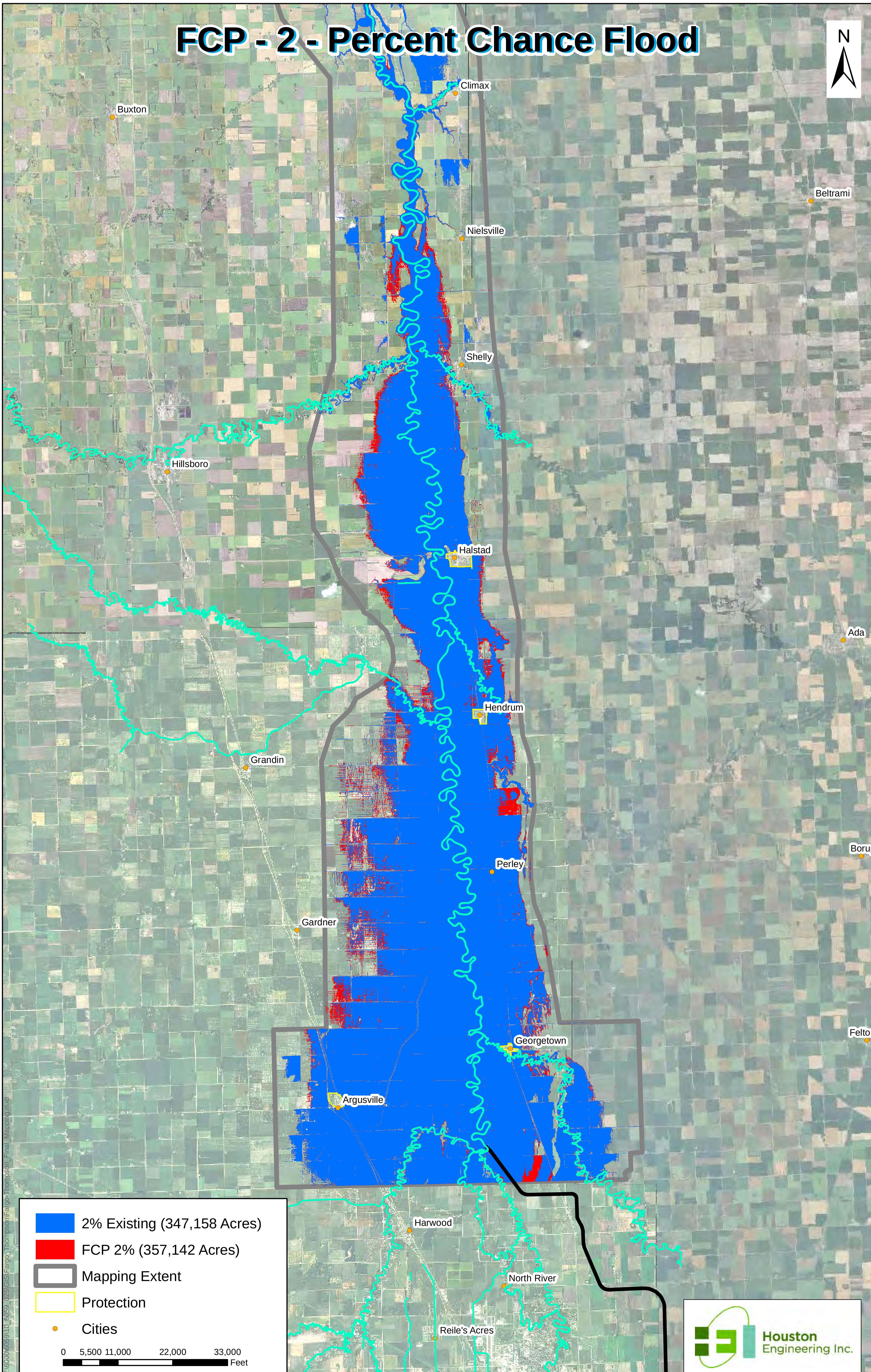

FCP - 10 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
10% Existing (224,166 Acres)
FCP 10% (231,522 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

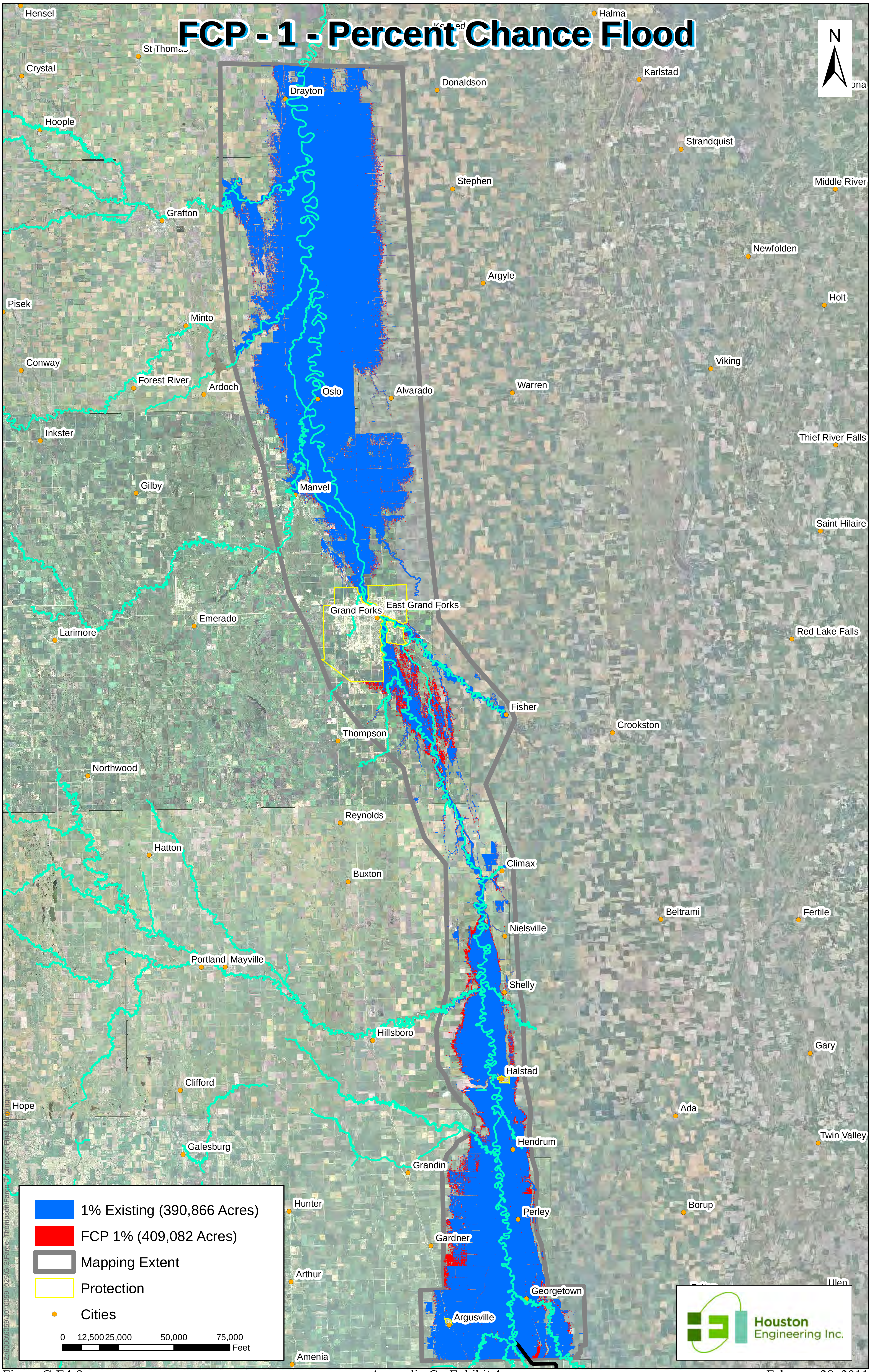

FCP - 2 - Percent Chance Flood
N
Hensel
Halma
Crystal
Drayton
Donaldson
Karlstad
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Conway
Viking
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
2% Existing (347,158 Acres)
FCP 2% (357,142 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

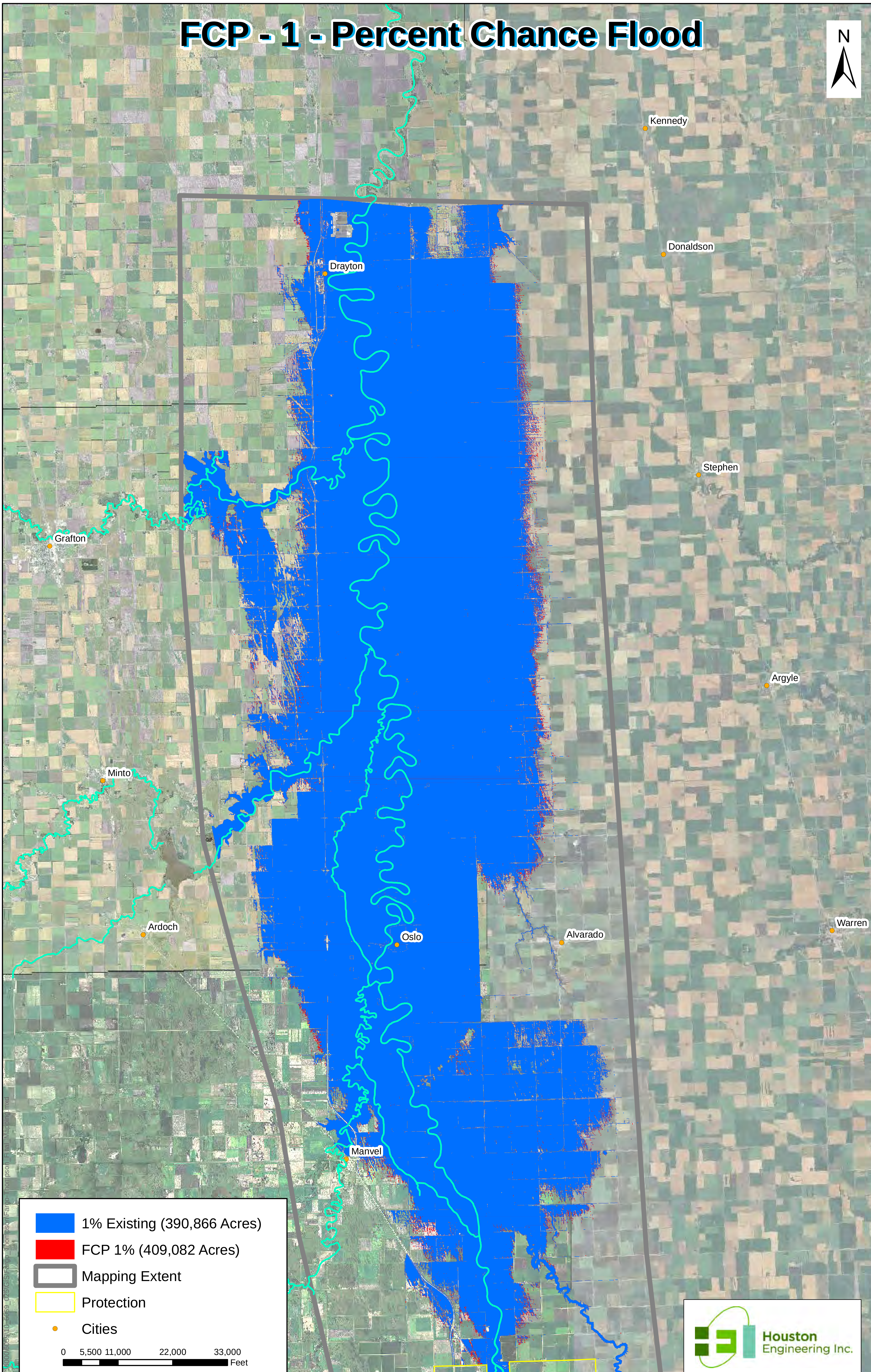

FCP - 2 - Percent Chance Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2% Existing (347,158 Acres)
FCP 2% (357,142 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

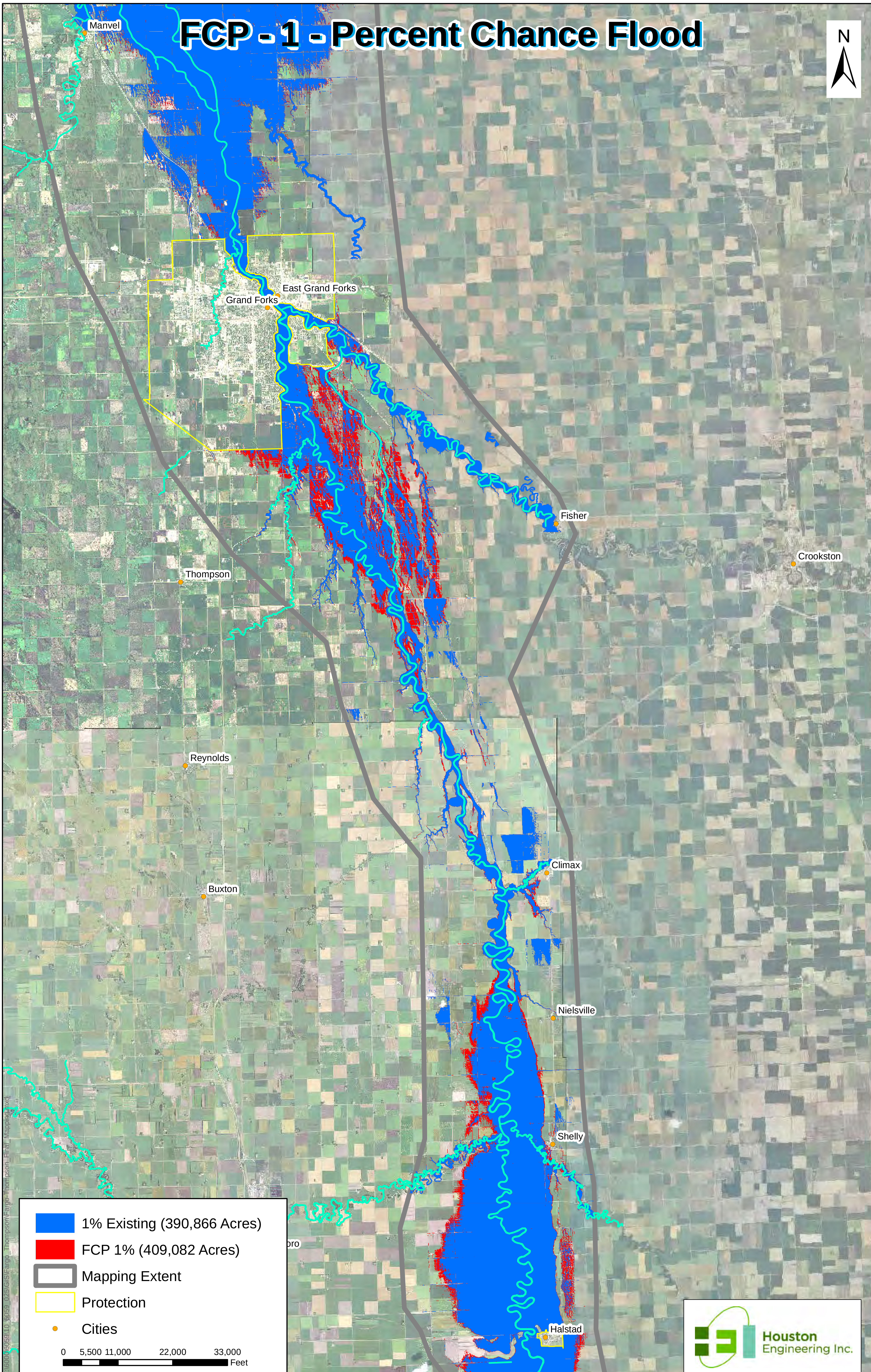


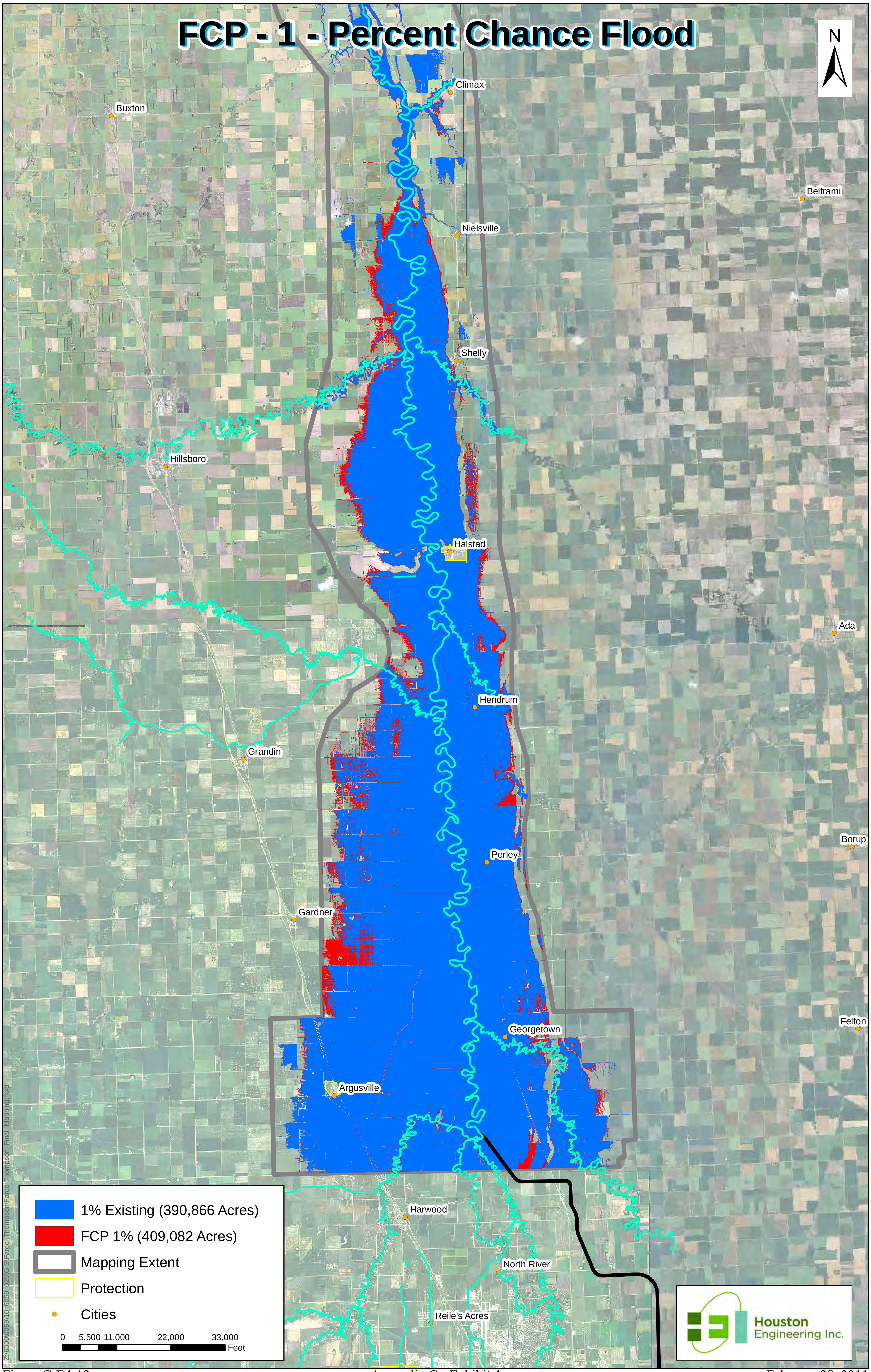
FCP - 2 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2% Existing (347,158 Acres)
FCP 2% (357,142 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

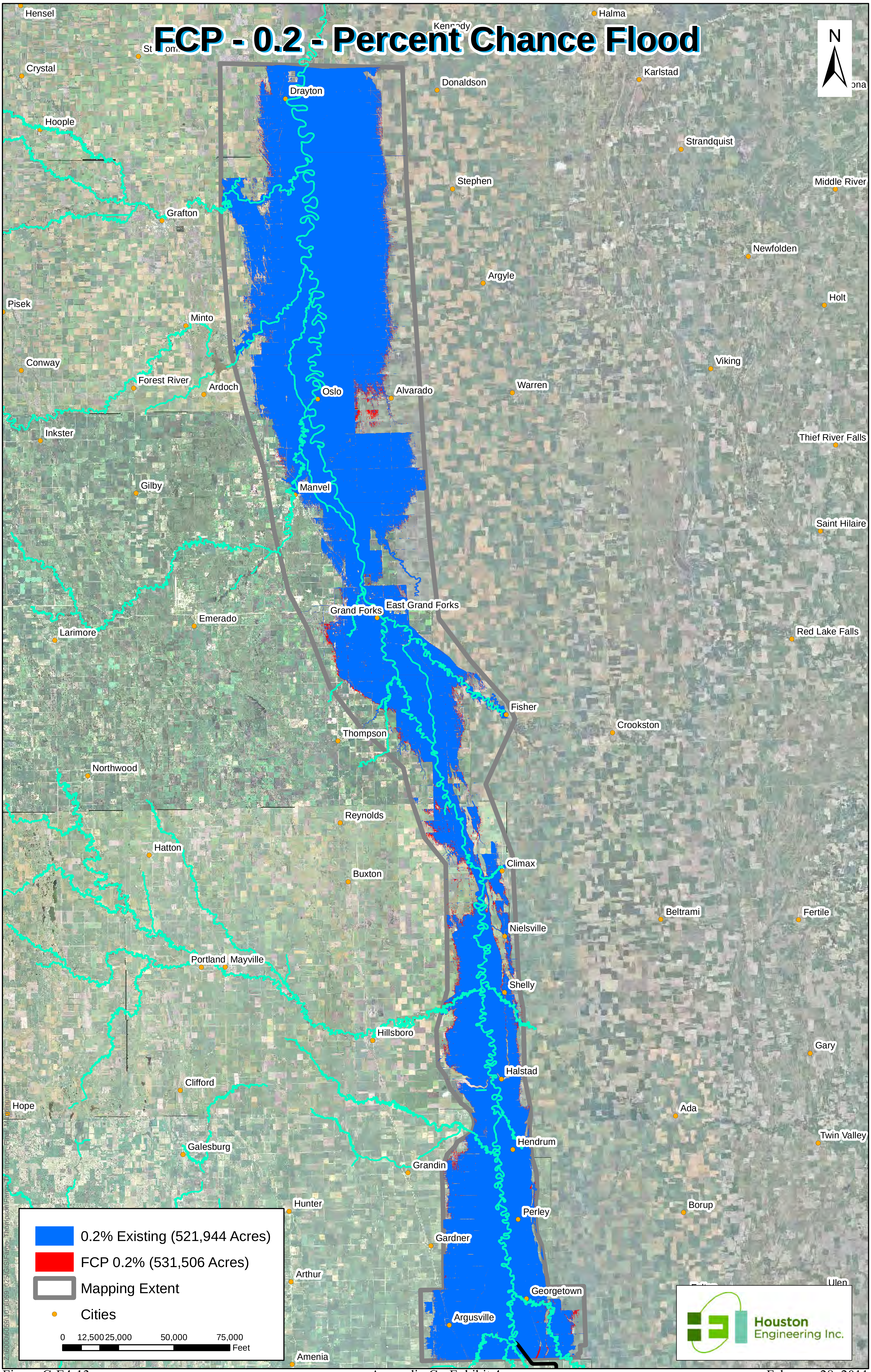

FCP - 2 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2% Existing (347,158 Acres)
FCP 2% (357,142 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

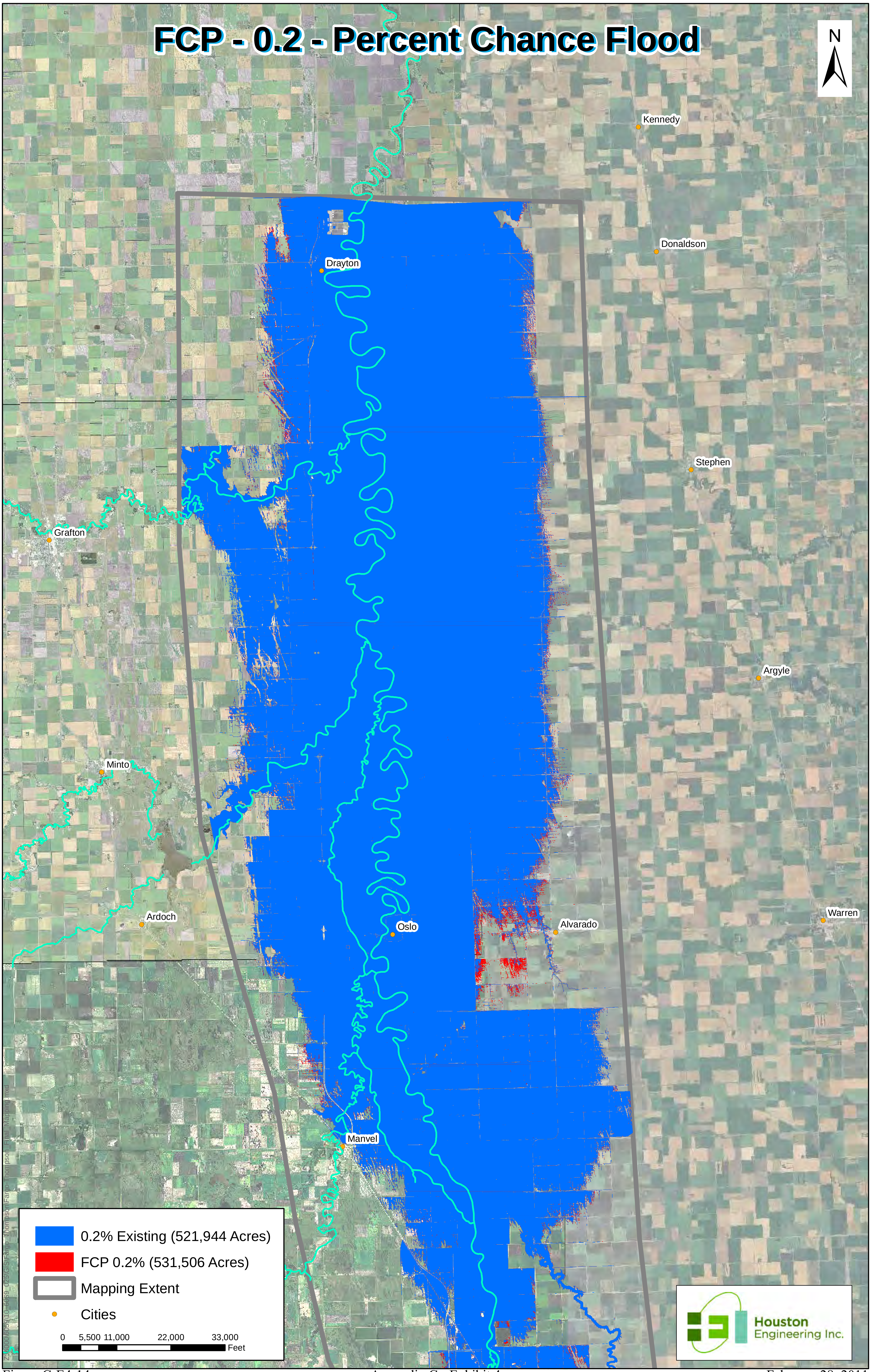

FCP - 1 - Percent Chance Flood
N
Hensel
Halma
St Thomas
Crystal
Karlstad
Drayton
Donaldson
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Twin Valley
Hendrum
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
1% Existing (390,866 Acres)
FCP 1% (409,082 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000 Feet
Houston Engineering Inc.

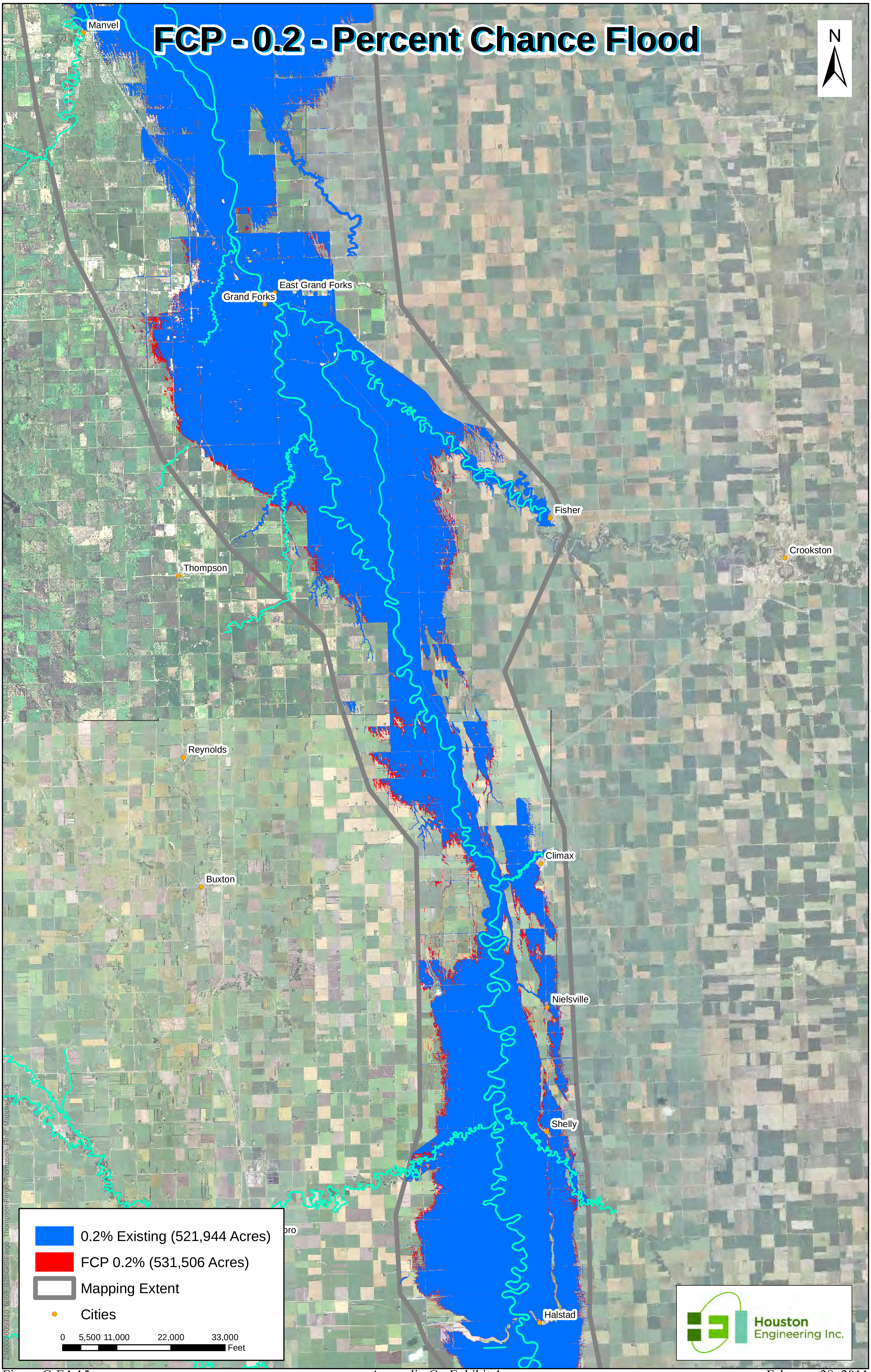

FCP - 1 - Percent Chance Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
1% Existing (390,866 Acres)
FCP 1% (409,082 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

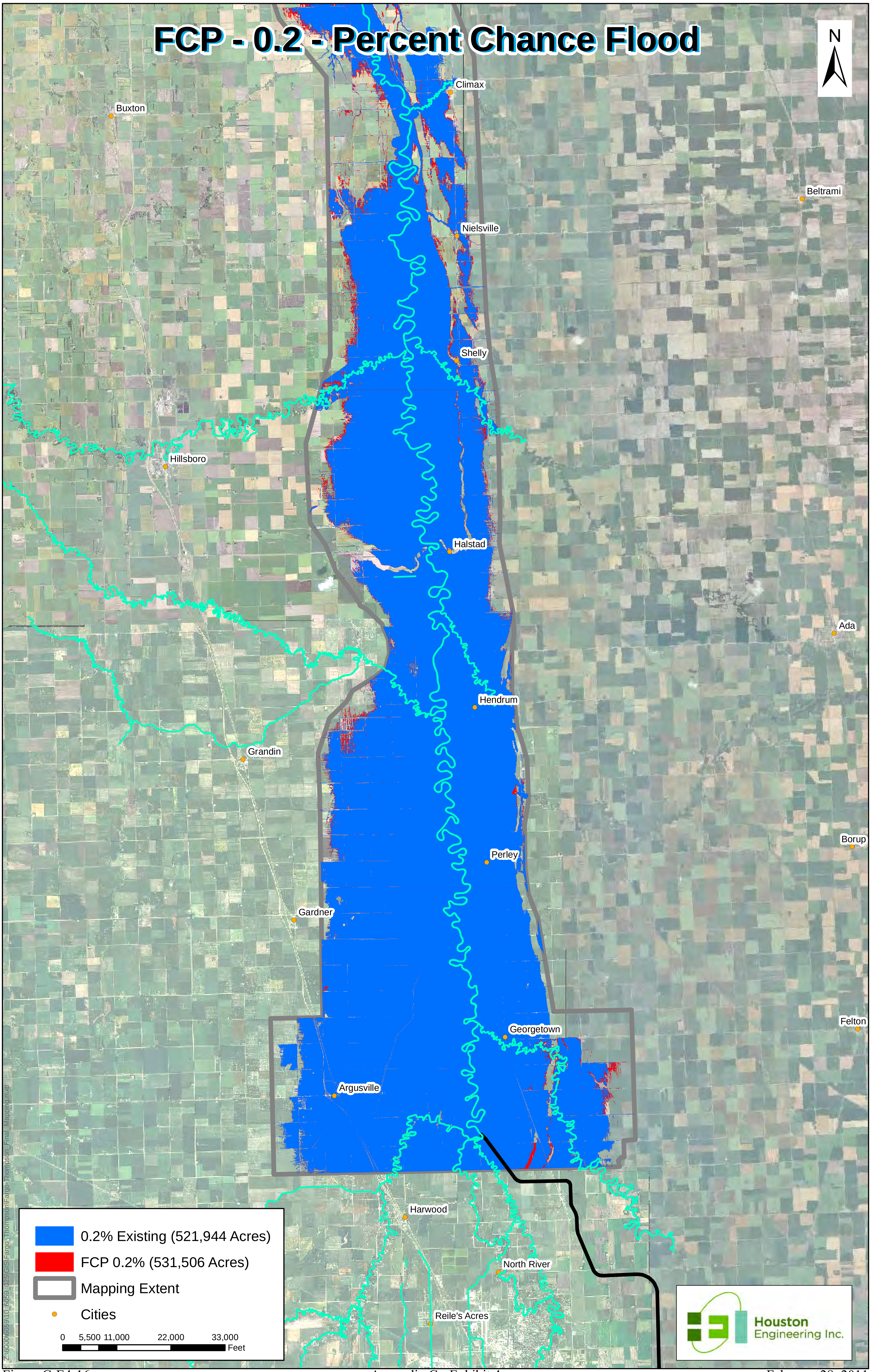

FCP - 1 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
1% Existing (390,866 Acres)
FCP 1% (409,082 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

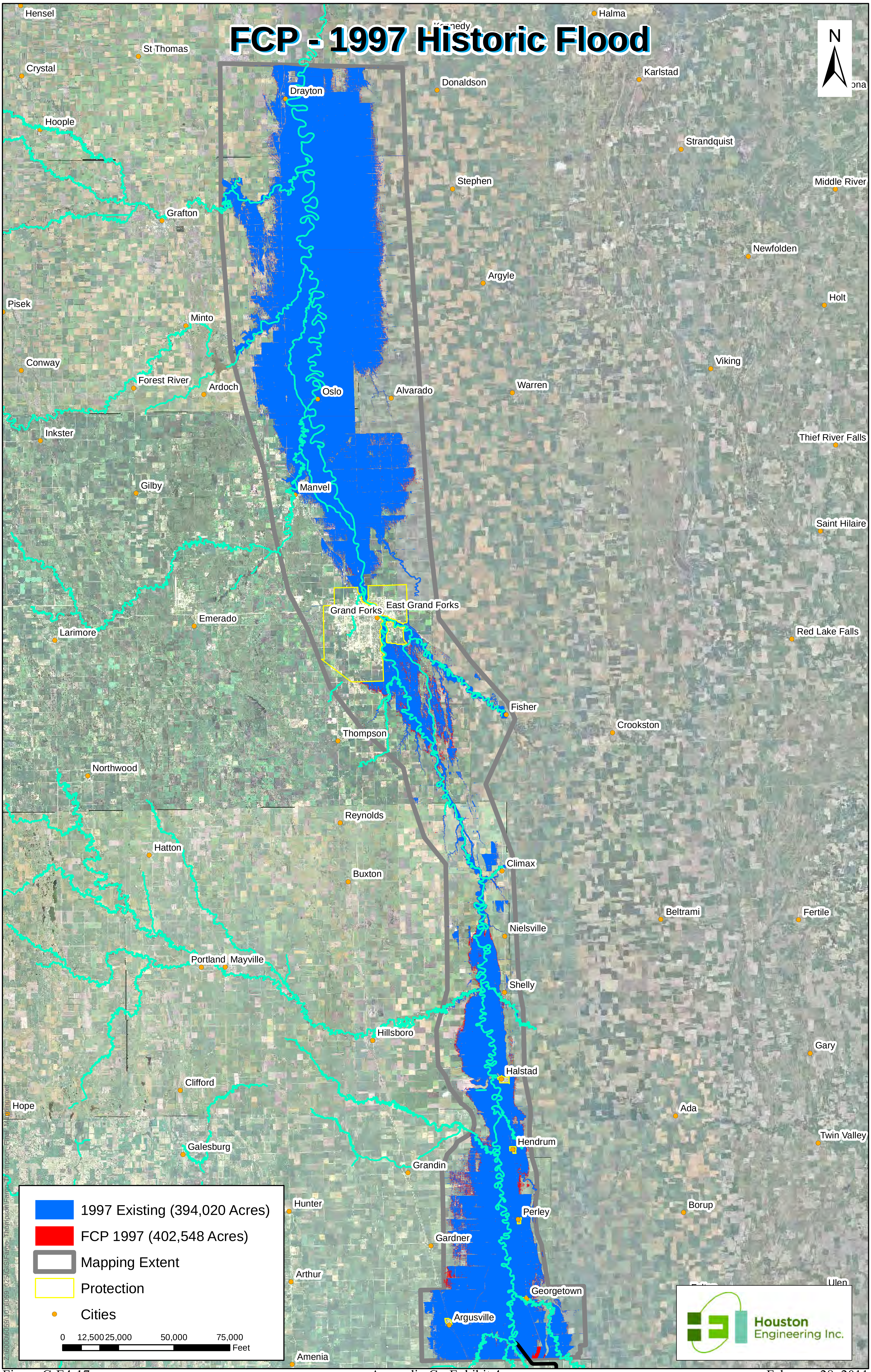

FCP - 1 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
1% Existing (390,866 Acres)
FCP 1% (409,082 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

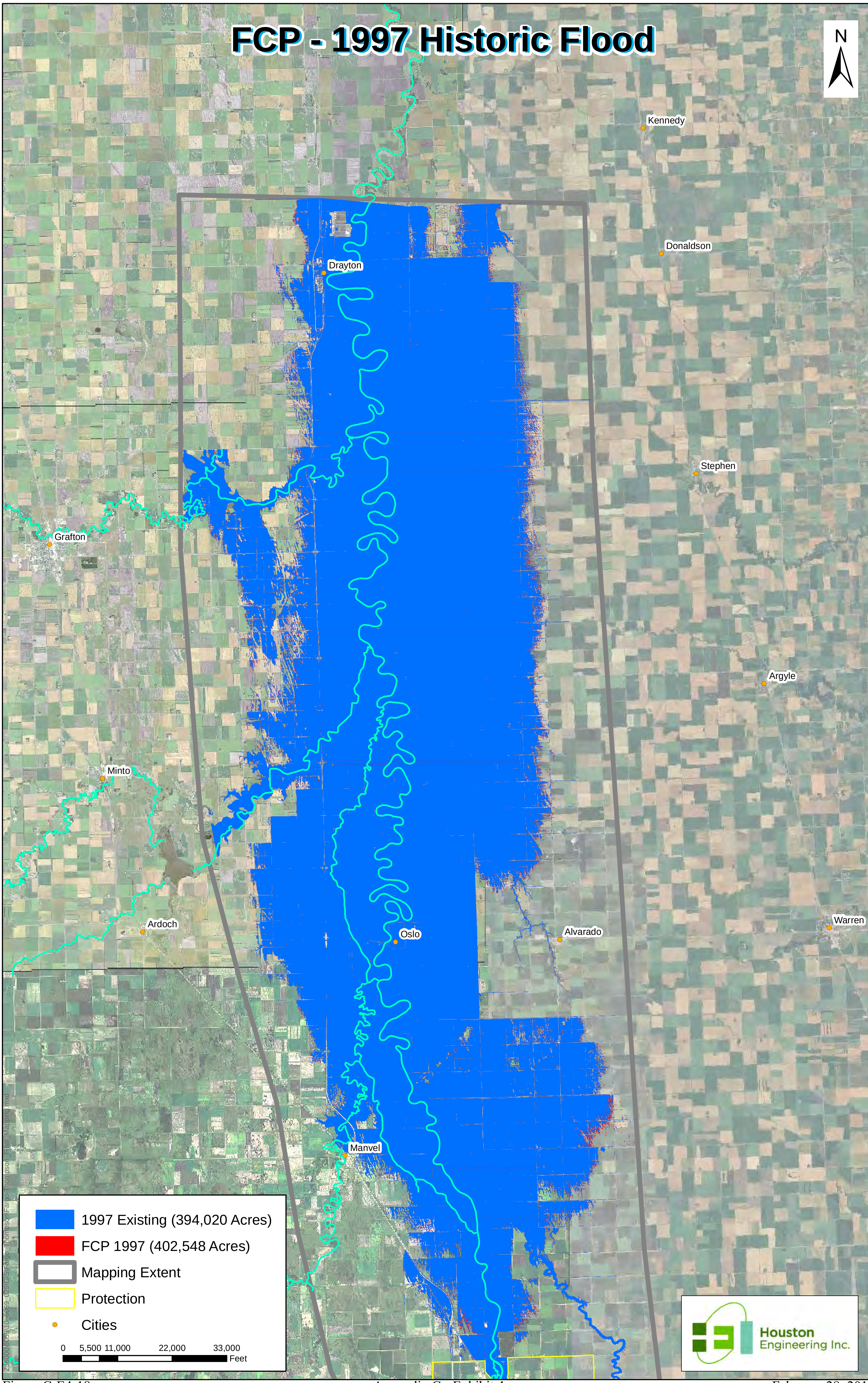

FCP - 0.2 - Percent Chance Flood
N
Hensel
Halma
Crystal
Drayton
Donaldson
Karlstad
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Pisek
Holt
Minto
Conway
Viking
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Georgetown
Argusville
Amenia
0.2% Existing (521,944 Acres)
FCP 0.2% (531,506 Acres)
Mapping Extent
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

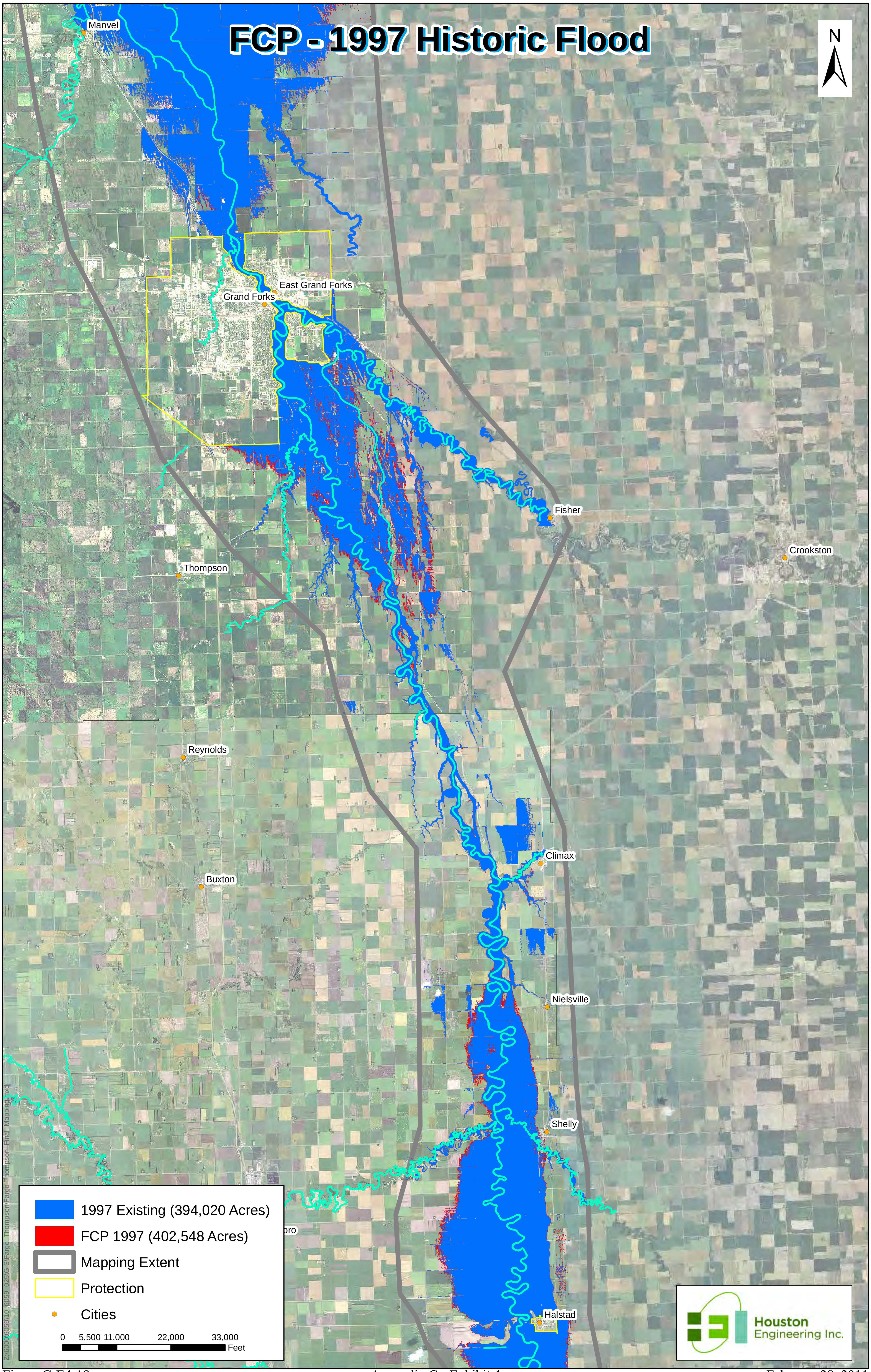

FCP - 0.2 - Percent Chance Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
0.2% Existing (521,944 Acres)
FCP 0.2% (531,506 Acres)
Mapping Extent
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

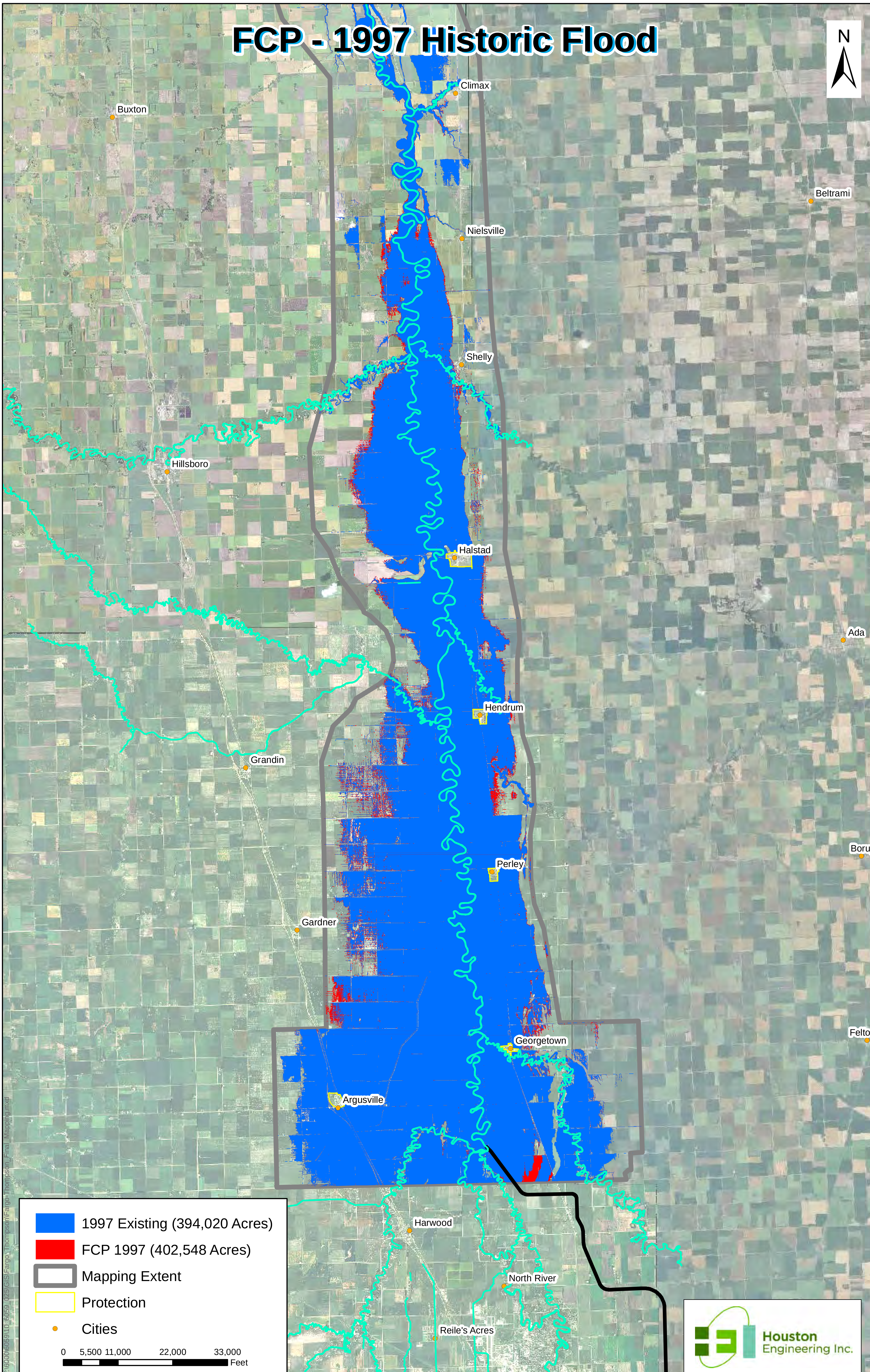

FCP - 0.2 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
0.2% Existing (521,944 Acres)
FCP 0.2% (531,506 Acres)
Mapping Extent
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


FCP - 0.2 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Georgetown
Felton
Argusville
Harwood
North River
Reile's Acres
0.2% Existing (521,944 Acres)
FCP 0.2% (531,506 Acres)
Mapping Extent
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

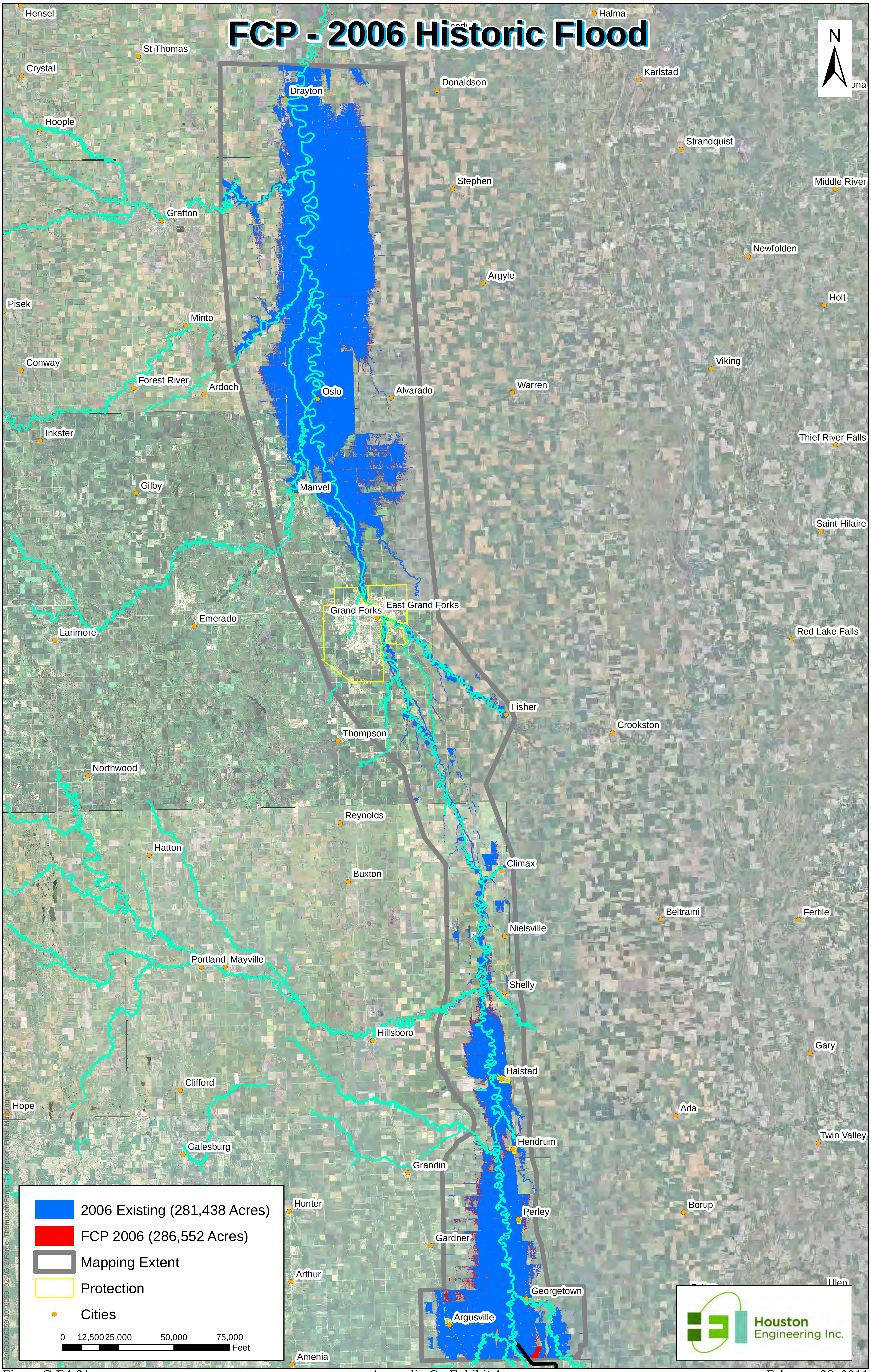

FCP - 1997 Historic Flood
N
Hensel
Halma
St Thomas
Crystal
Drayton
Donaldson
Karlstad
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Manvel
Gilby
Saint Hilaire
East Grand Forks
Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Perley
Borup
Gardner
Arthur
Georgetown
Ulen
Argusville
Amenia
1997 Existing (394,020 Acres)
FCP 1997 (402,548 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.


FCP - 1997 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
1997 Existing (394,020 Acres)
FCP 1997 (402,548 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

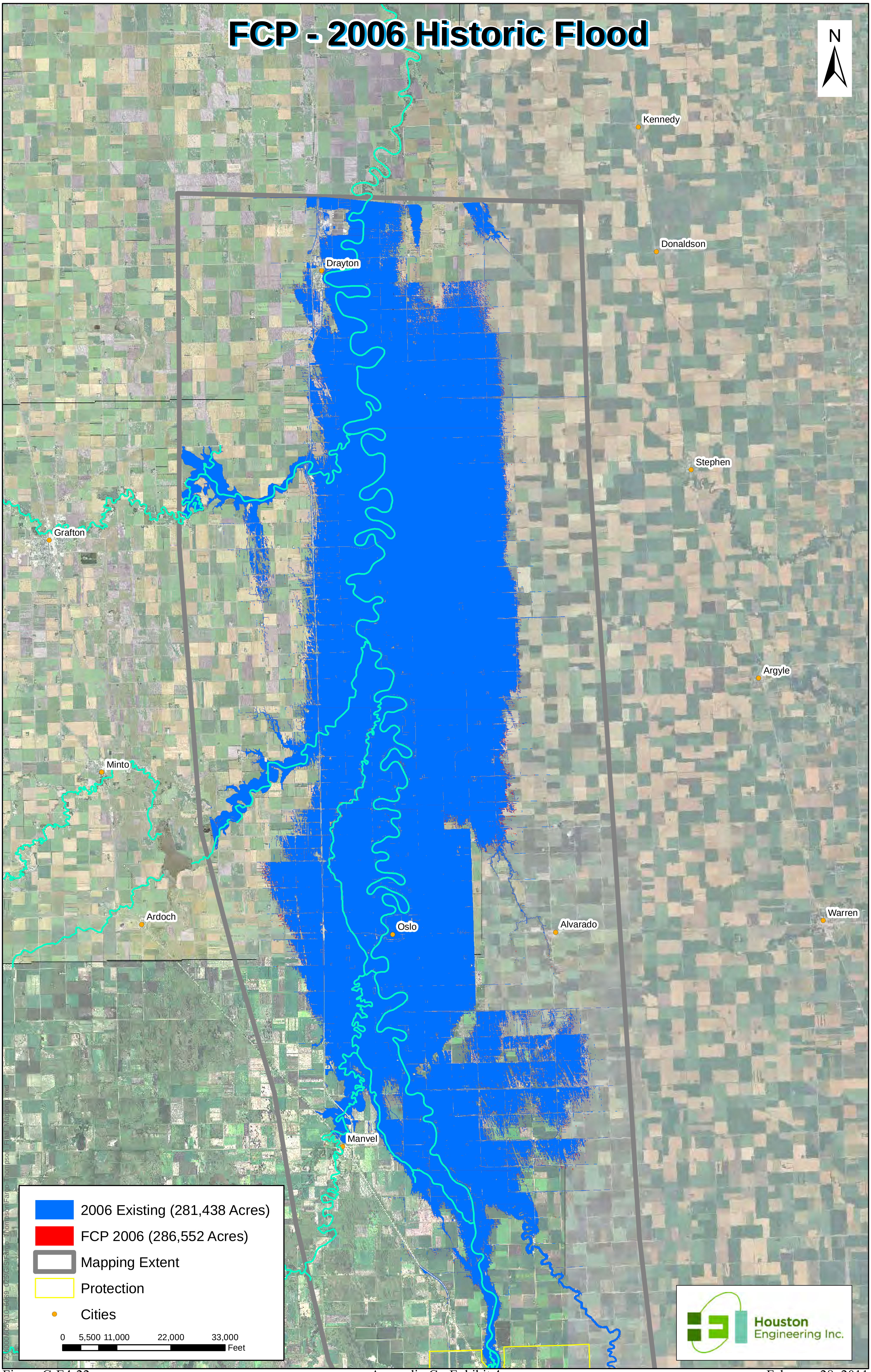

FCP - 1997 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
1997 Existing (394,020 Acres)
FCP 1997 (402,548 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

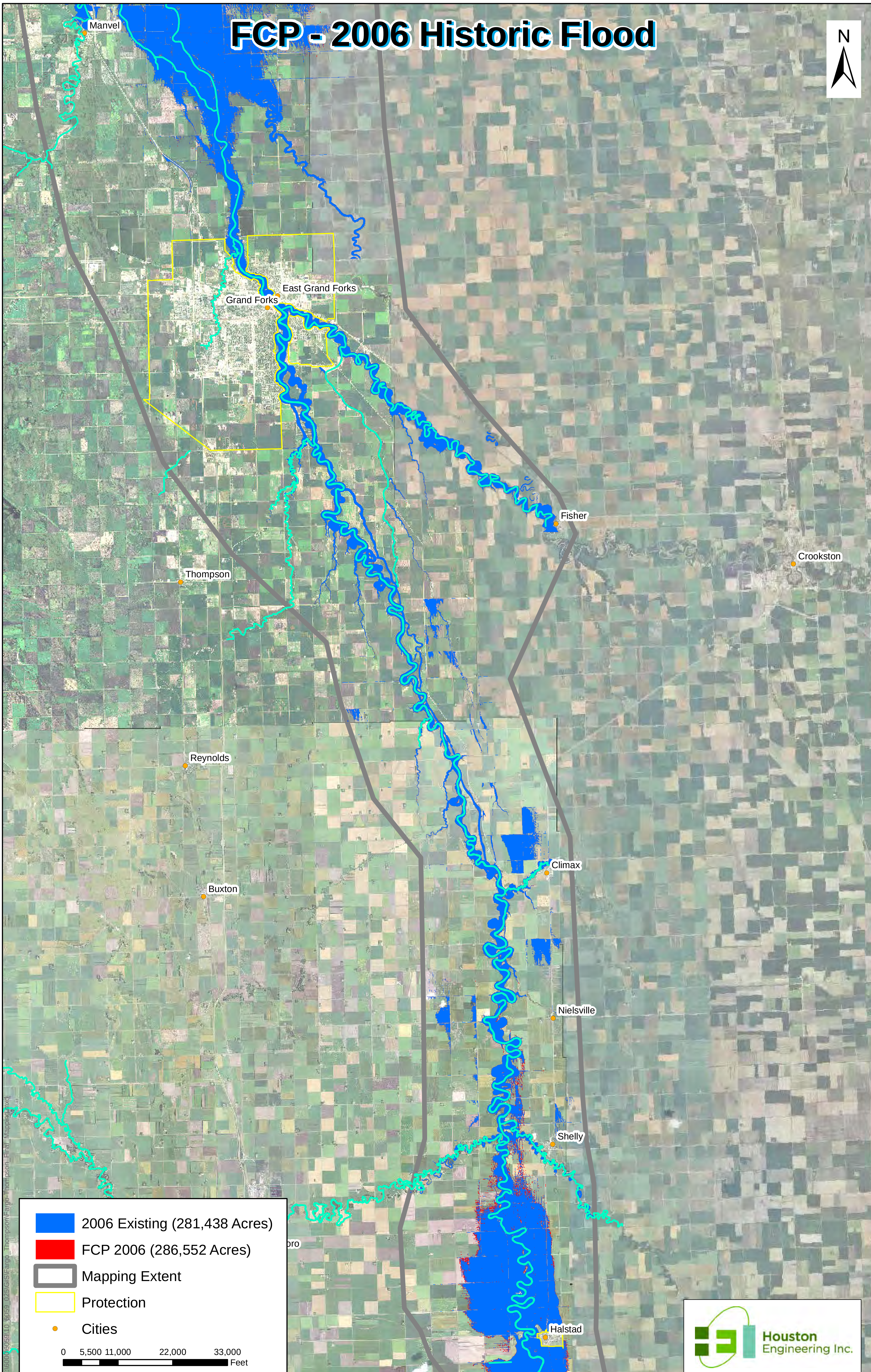

FCP - 1997 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
1997 Existing (394,020 Acres)
FCP 1997 (402,548 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

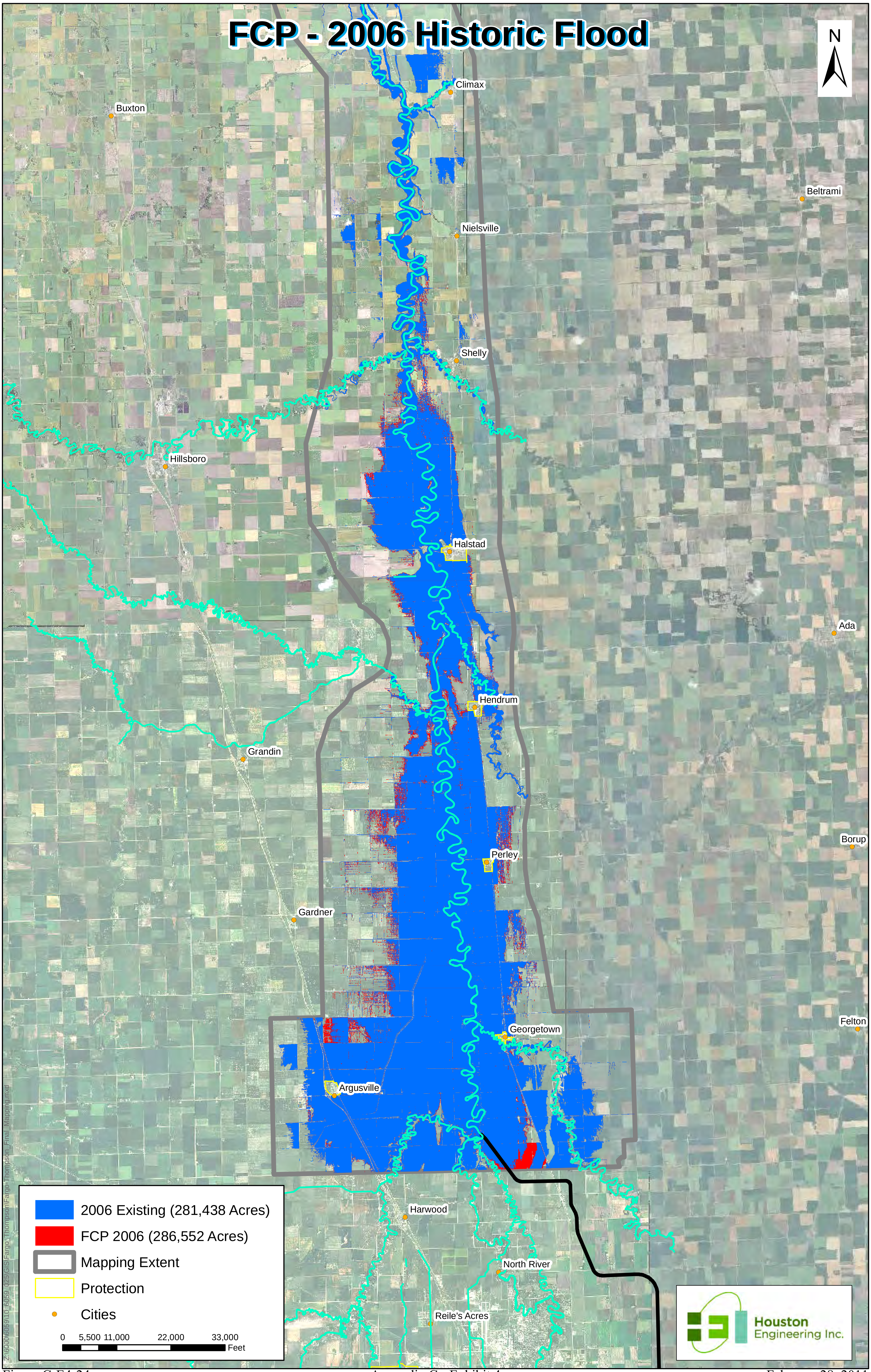
FCP - 2006 Historic Flood



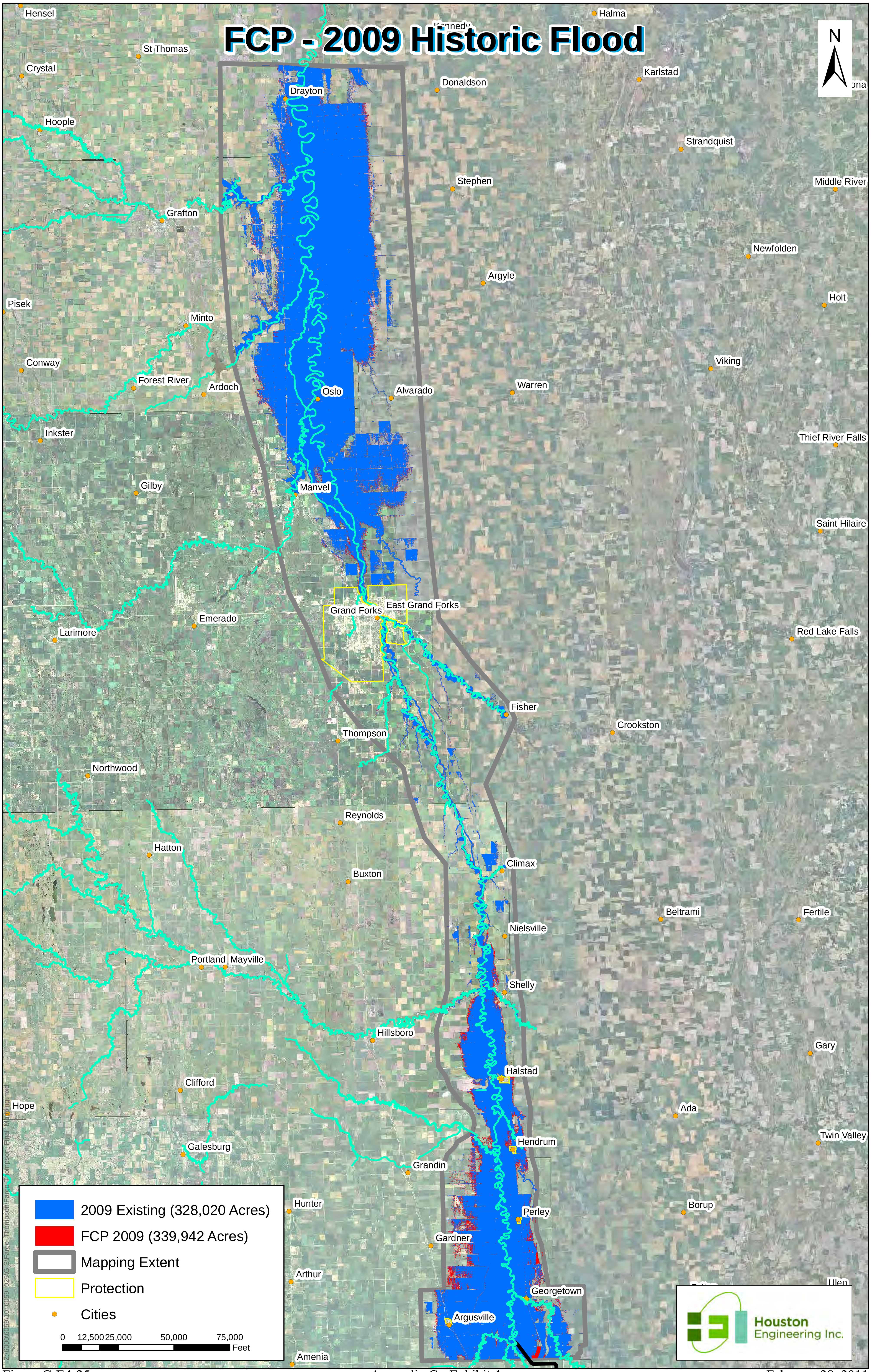
FCP - 2006 Historic Flood



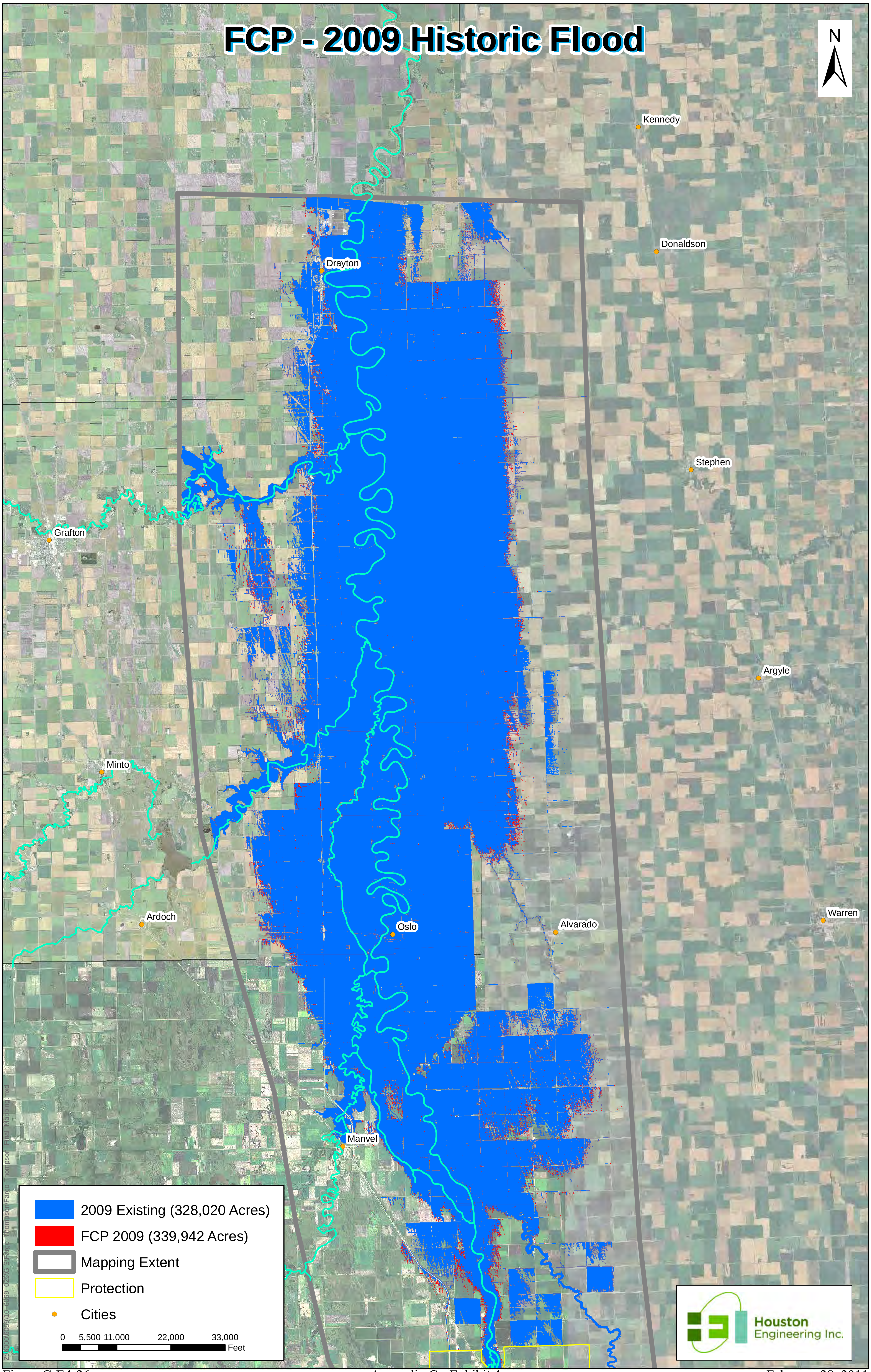

FCP - 2006 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2006 Existing (281,438 Acres)
FCP 2006 (286,552 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

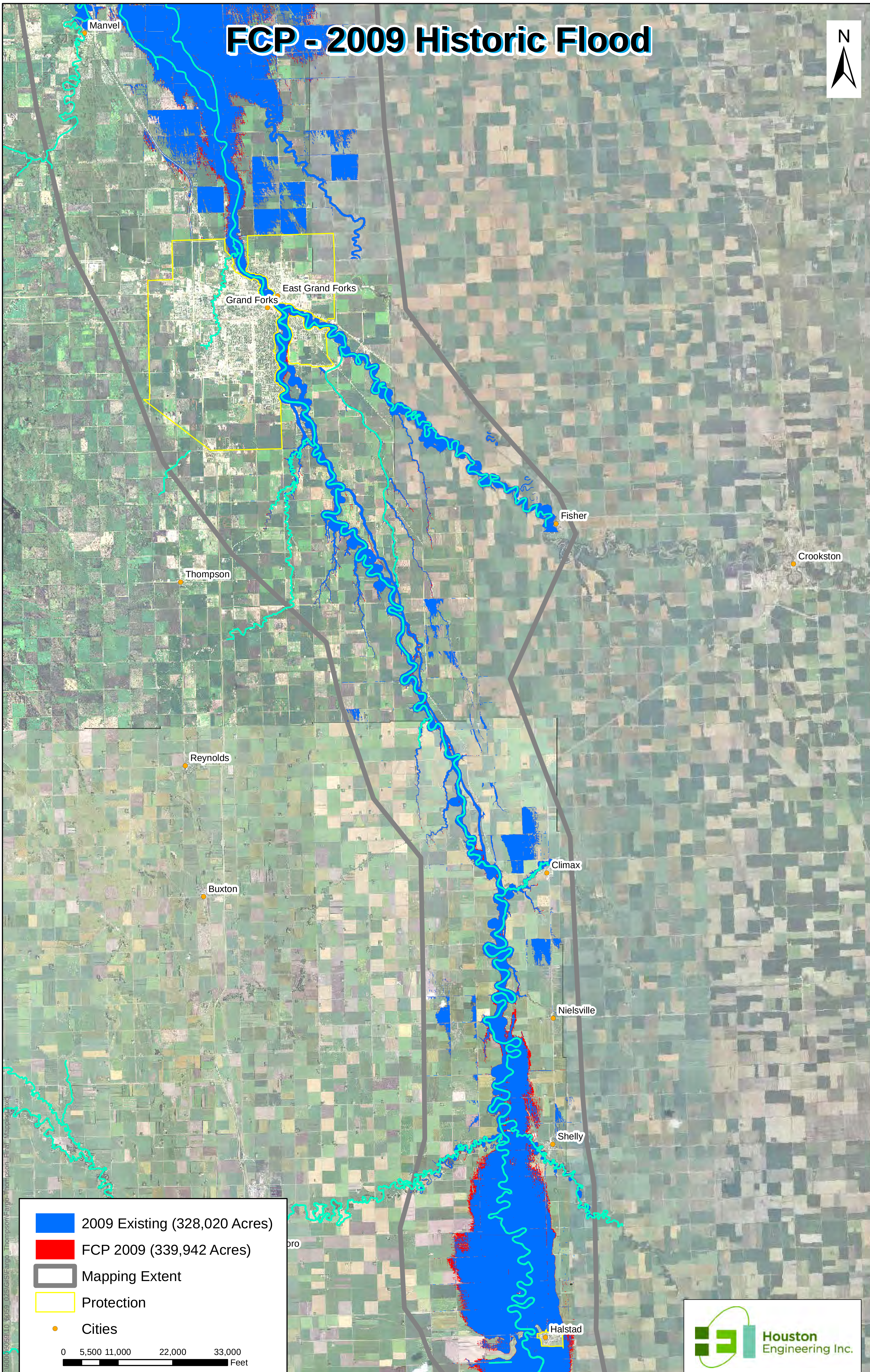


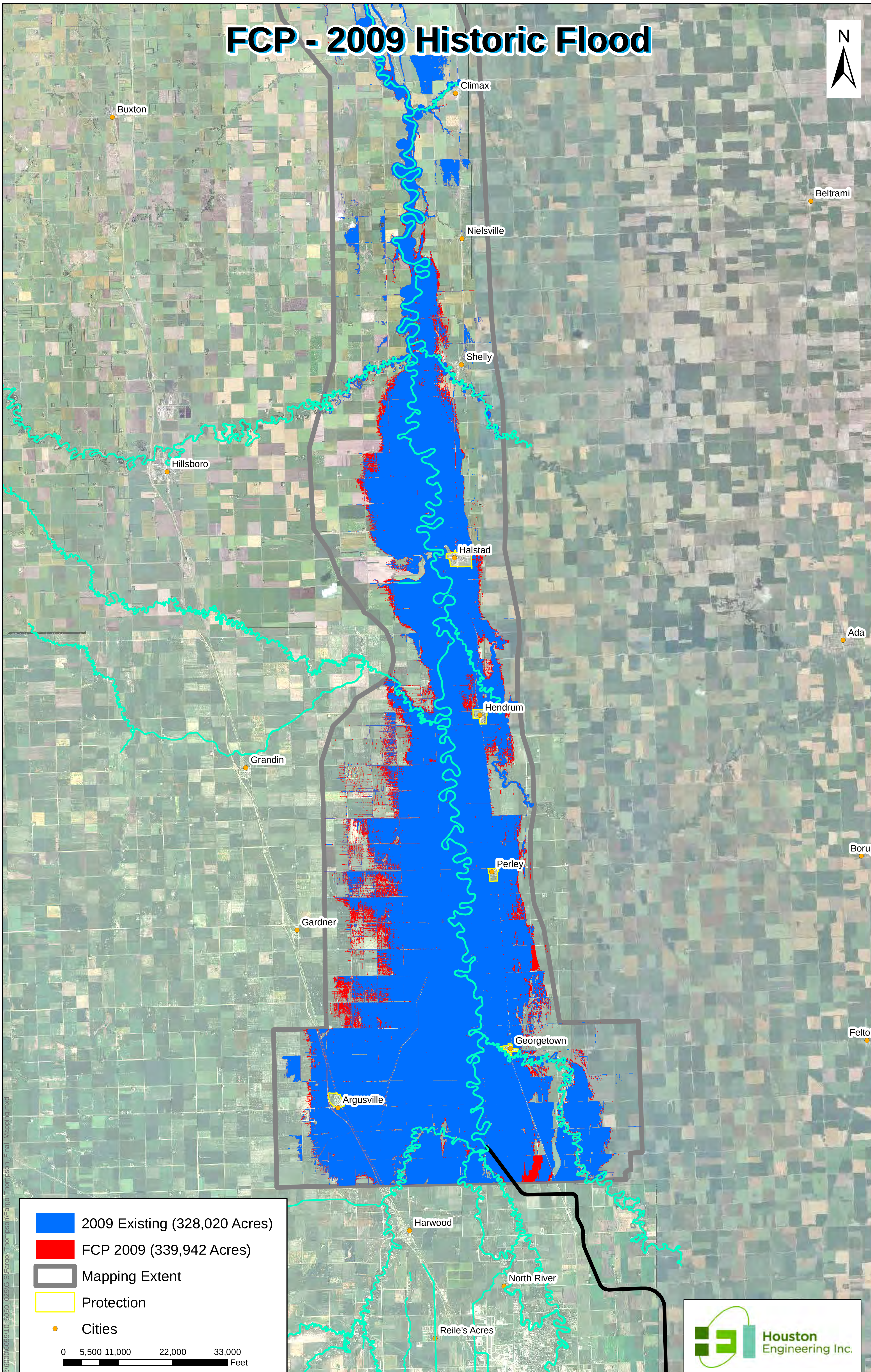
FCP - 2006 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2006 Existing (281,438 Acres)
FCP 2006 (286,552 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

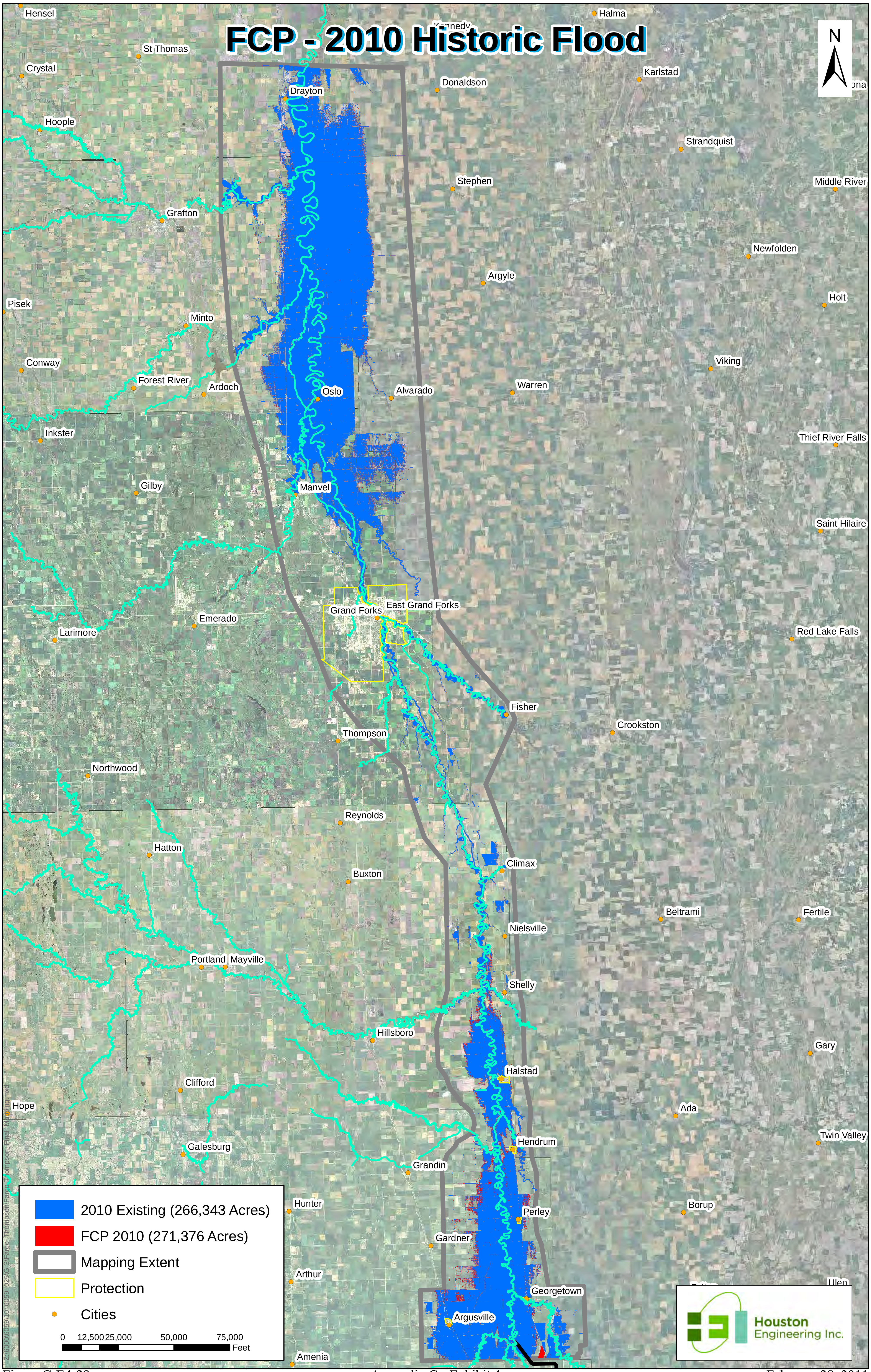


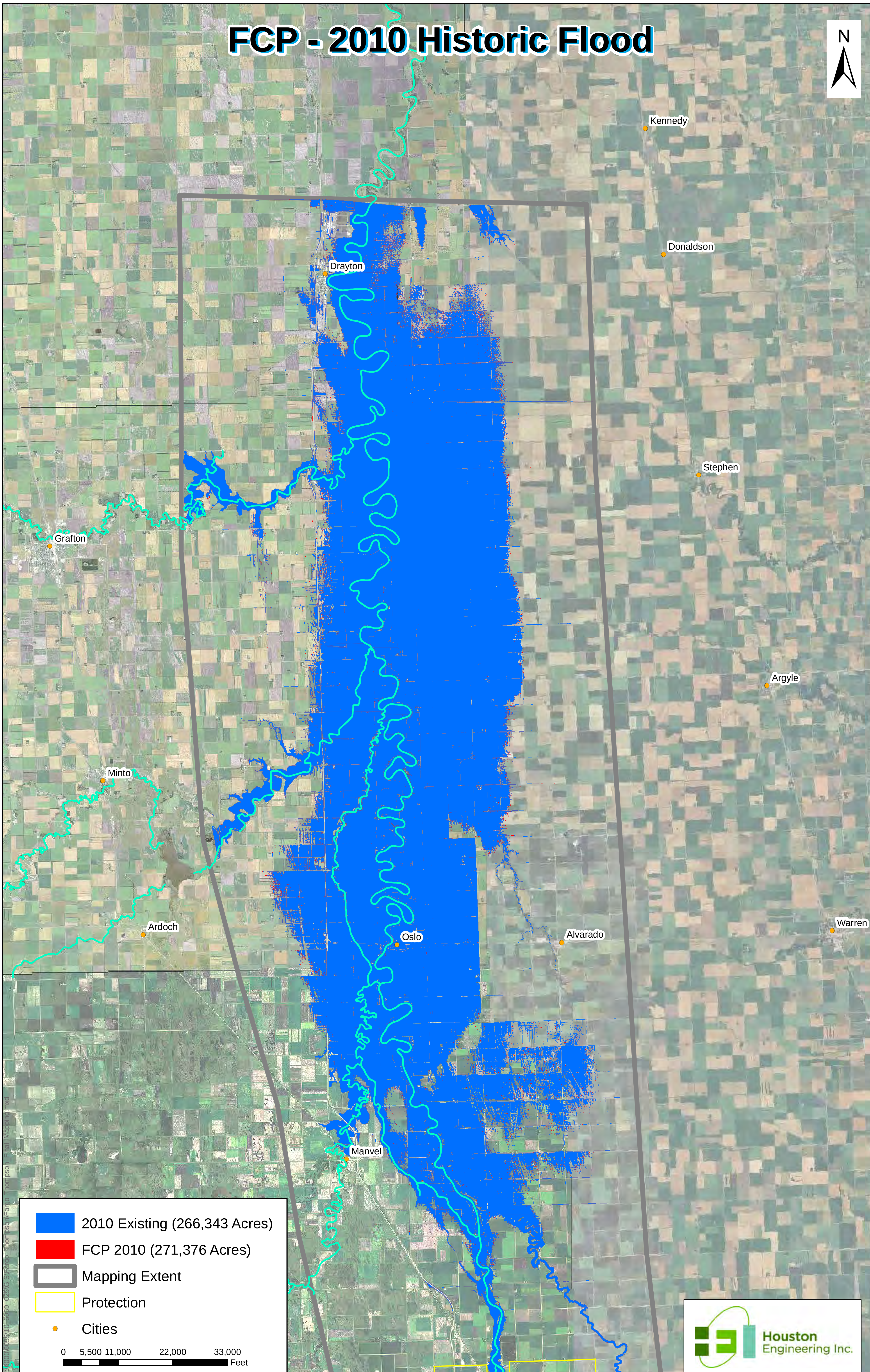
FCP - 2009 Historic Flood
N
Hensel
Halma
Kennedy
St Thomas
Crystal
Karlstad
Drayton
Donaldson
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
2009 Existing (328,020 Acres)
FCP 2009 (339,942 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

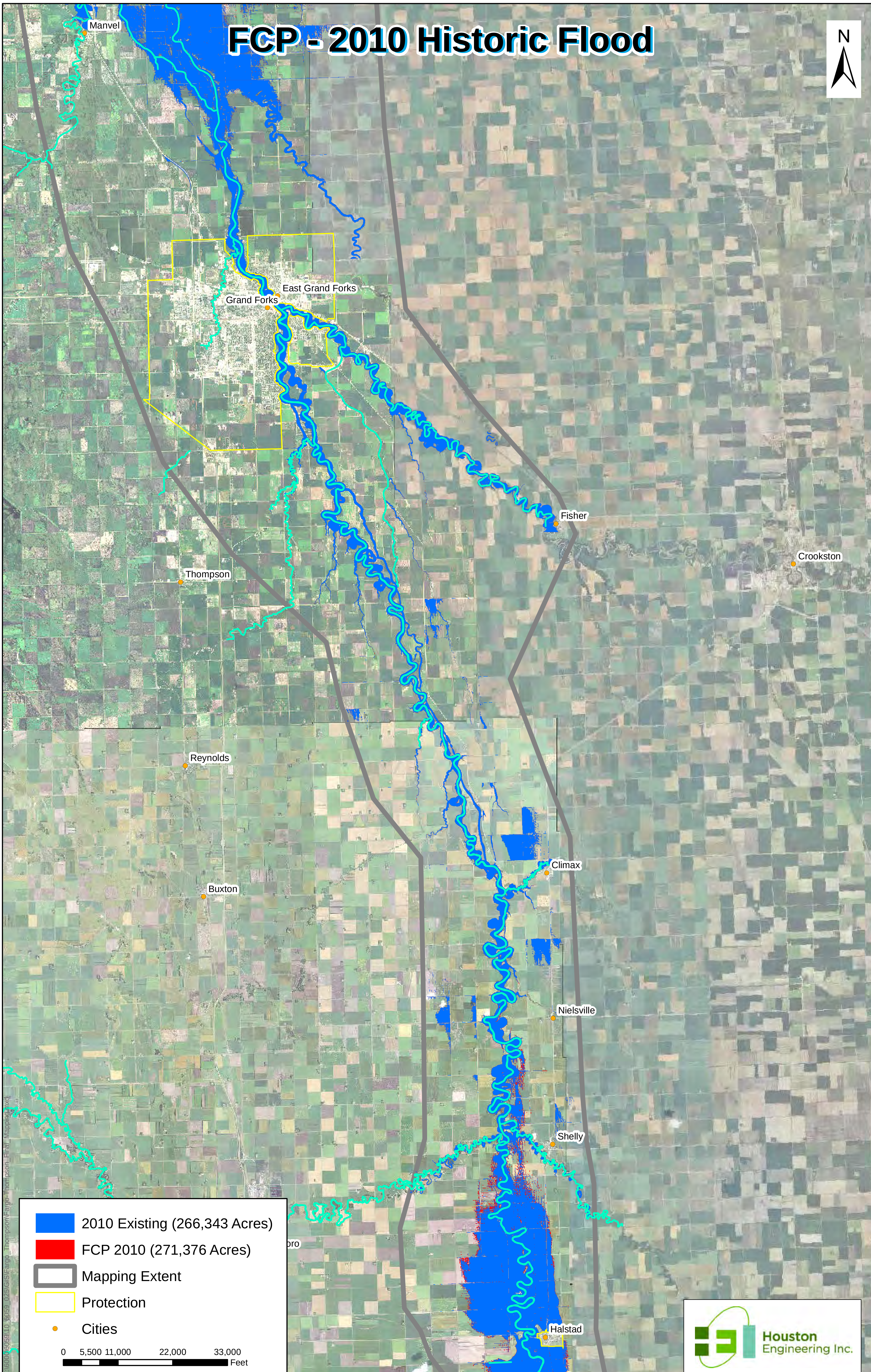

FCP - 2009 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2009 Existing (328,020 Acres)
FCP 2009 (339,942 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

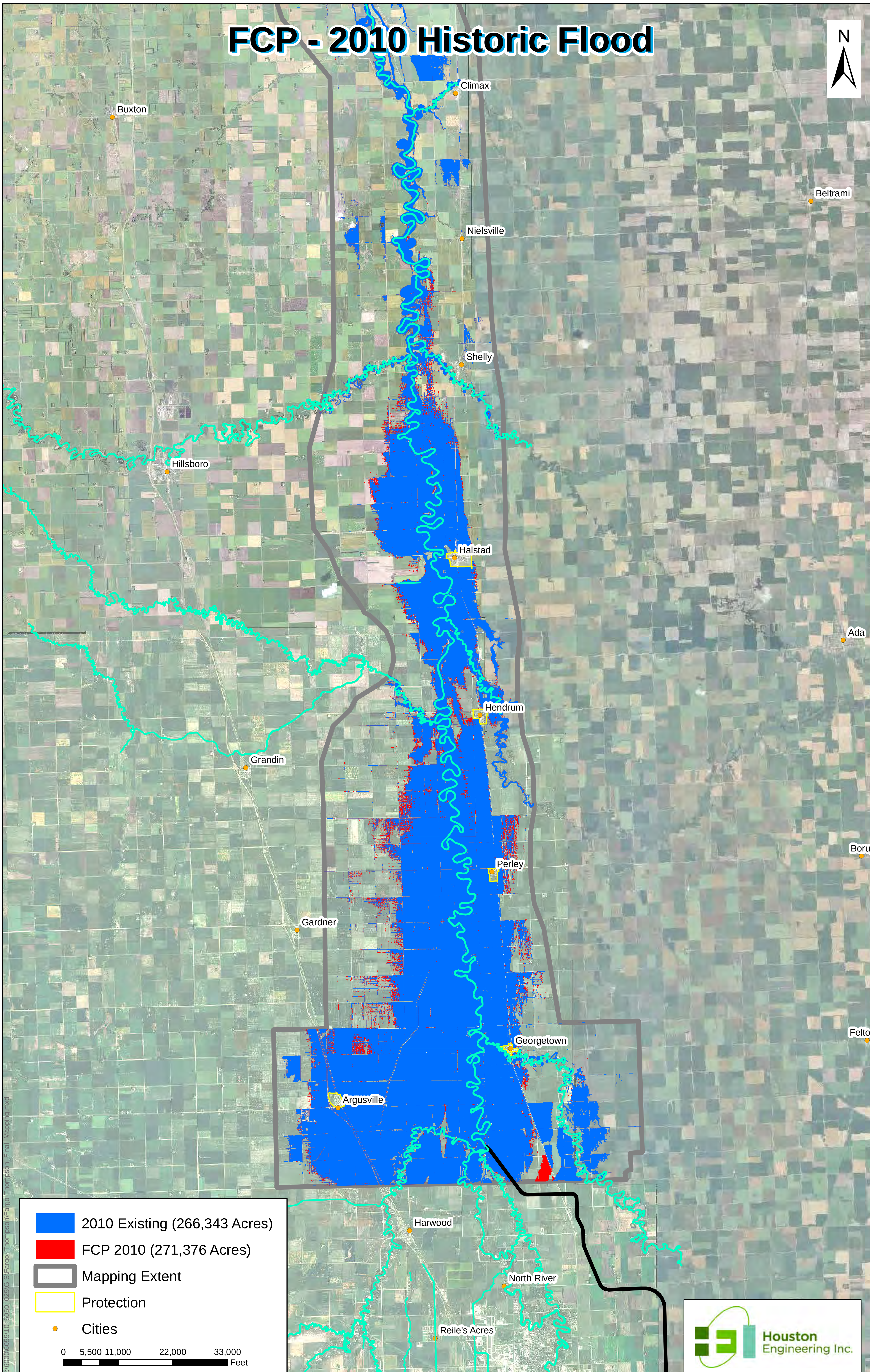

FCP - 2009 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2009 Existing (328,020 Acres)
FCP 2009 (339,942 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


FCP - 2009 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2009 Existing (328,020 Acres)
FCP 2009 (339,942 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

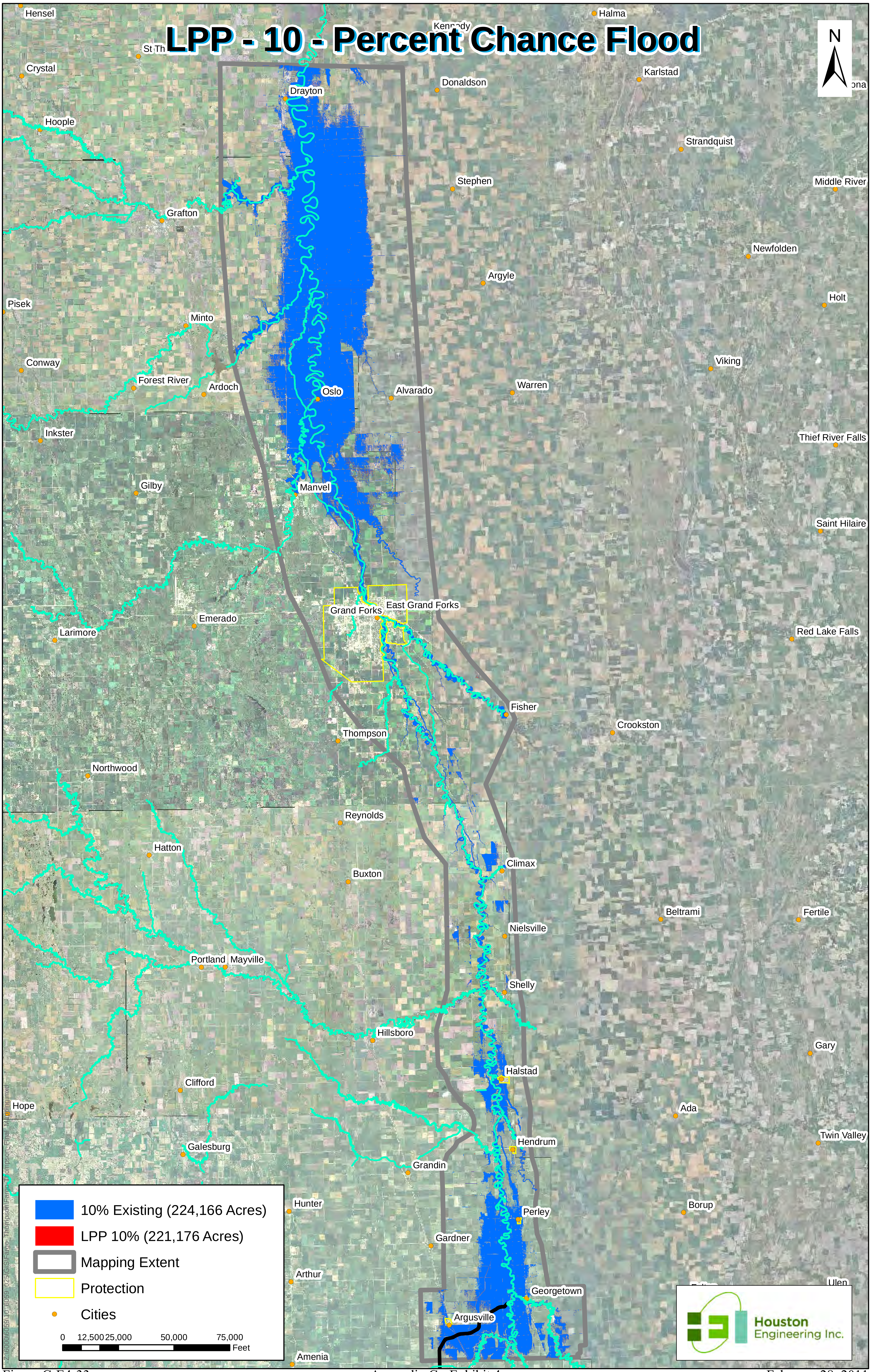

FCP - 2010 Historic Flood
N
Hensel
Halma
St Thomas
Crystal
Karlstad
Drayton
Donaldson
Hoople
Strandquist
Grafton
Stephen
Middle River
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Manvel
Gilby
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Georgetown
Ulen
Argusville
Amenia
2010 Existing (266,343 Acres)
FCP 2010 (271,376 Acres)
Mapping Extent
Protection
Cities
0
12,500
25,000
50,000
75,000
Feet
Houston Engineering Inc.

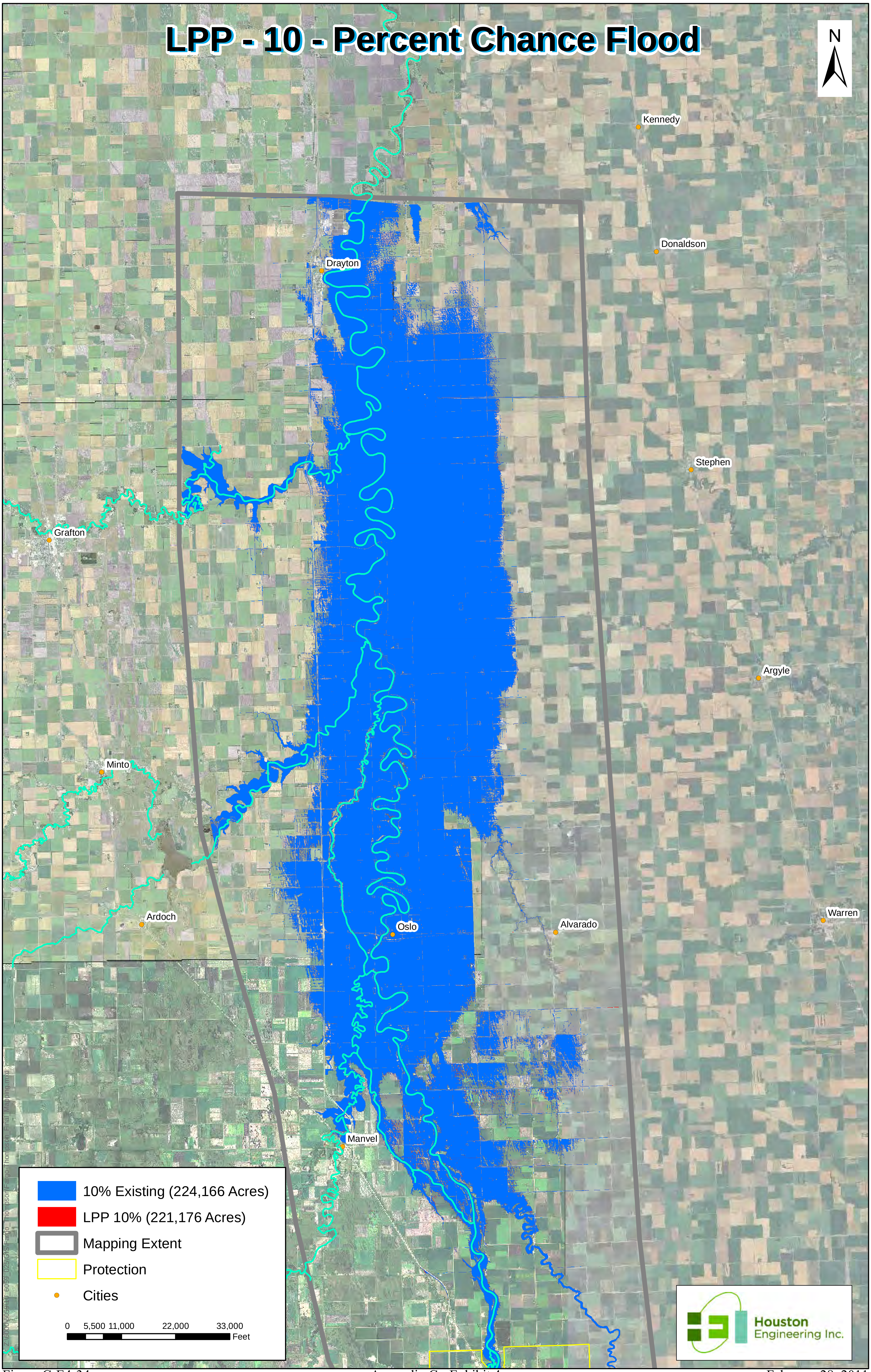

FCP - 2010 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2010 Existing (266,343 Acres)
FCP 2010 (271,376 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


FCP - 2010 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2010 Existing (266,343 Acres)
FCP 2010 (271,376 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

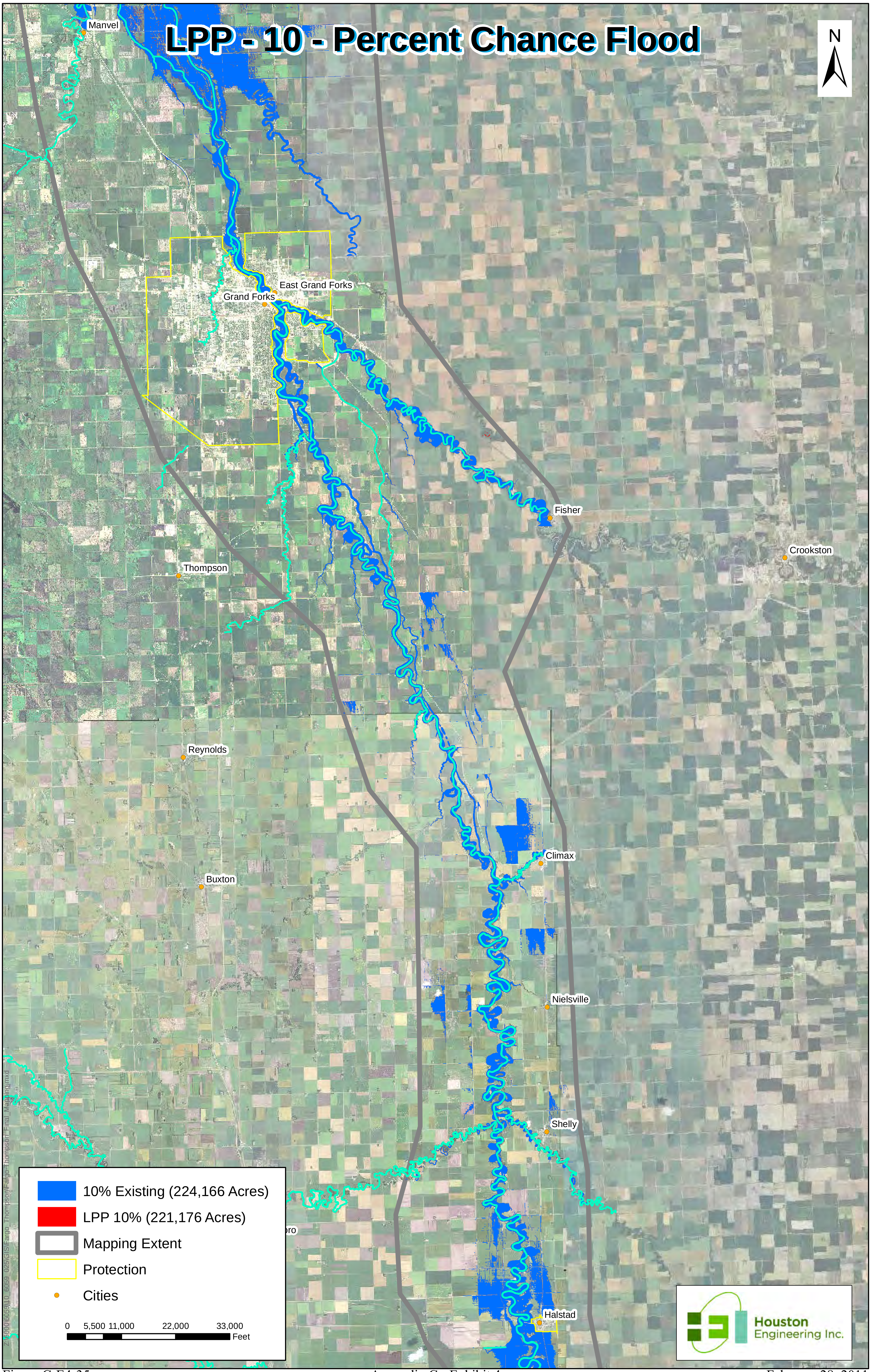

FCP - 2010 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2010 Existing (266,343 Acres)
FCP 2010 (271,376 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston
Engineering Inc.

LPP - 10 - Percent Chance Flood

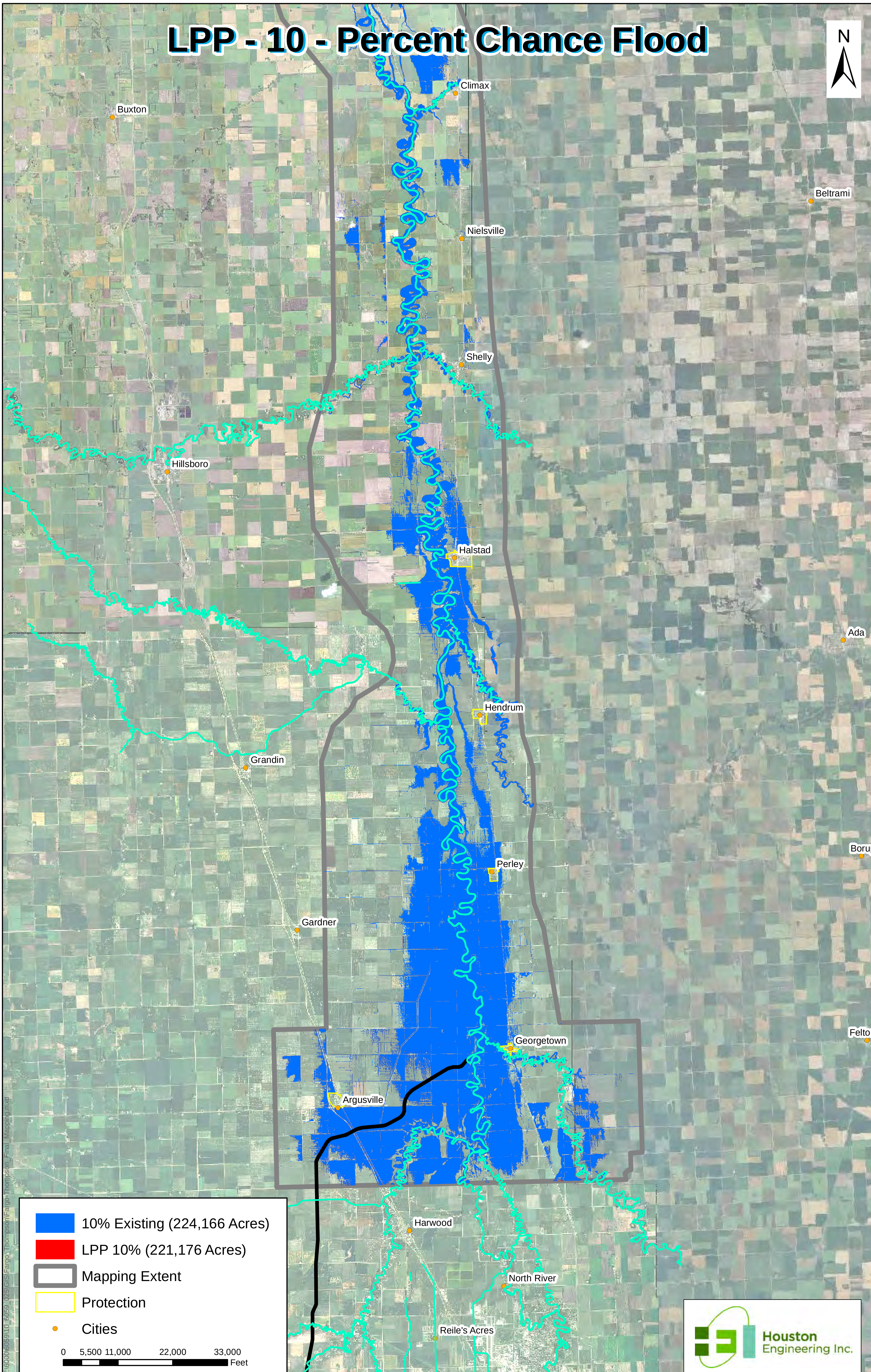


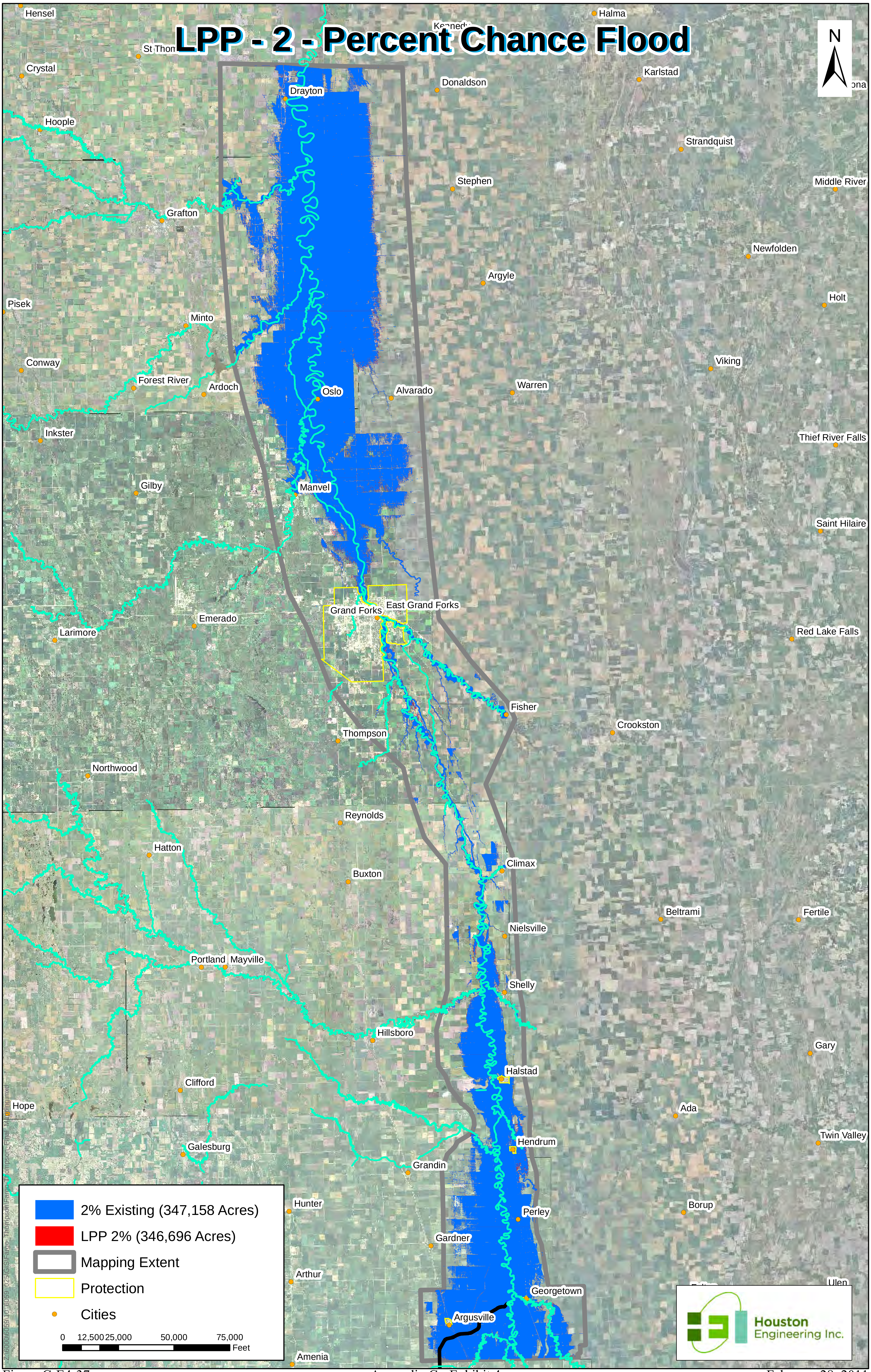


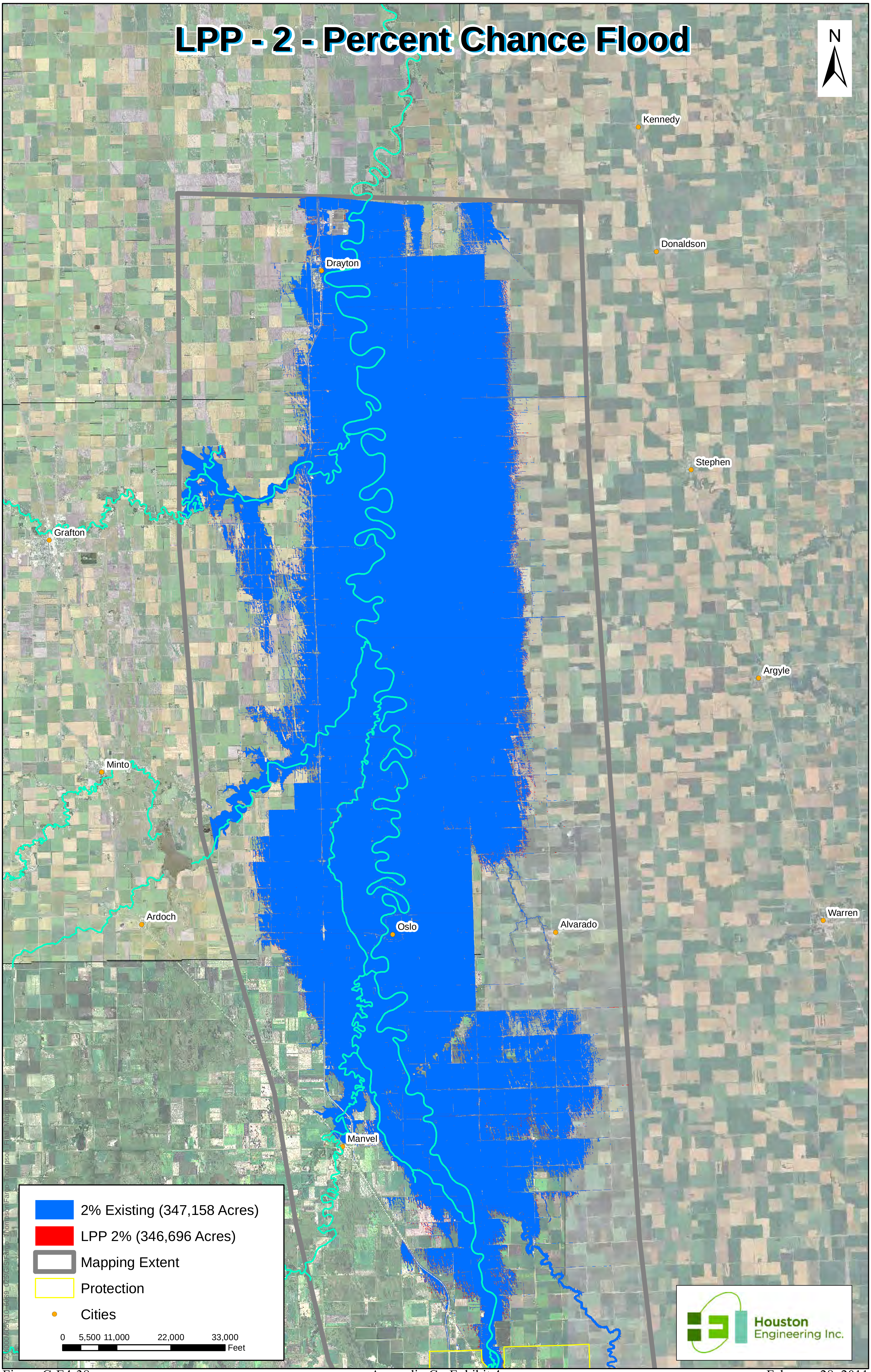
LPP - 10 - Percent Chance Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
10% Existing (224,166 Acres)
LPP 10% (221,176 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston
Engineering Inc.

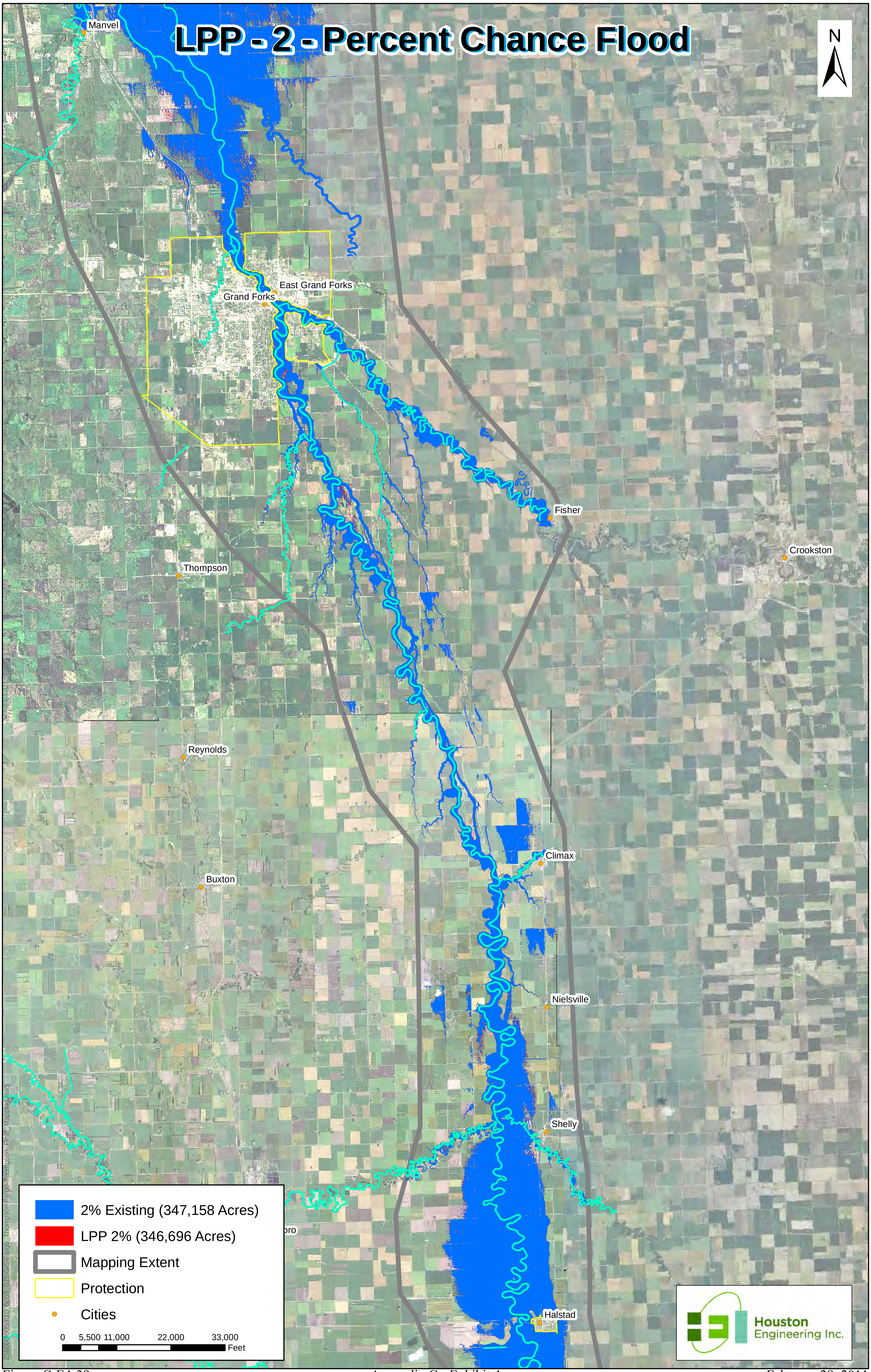


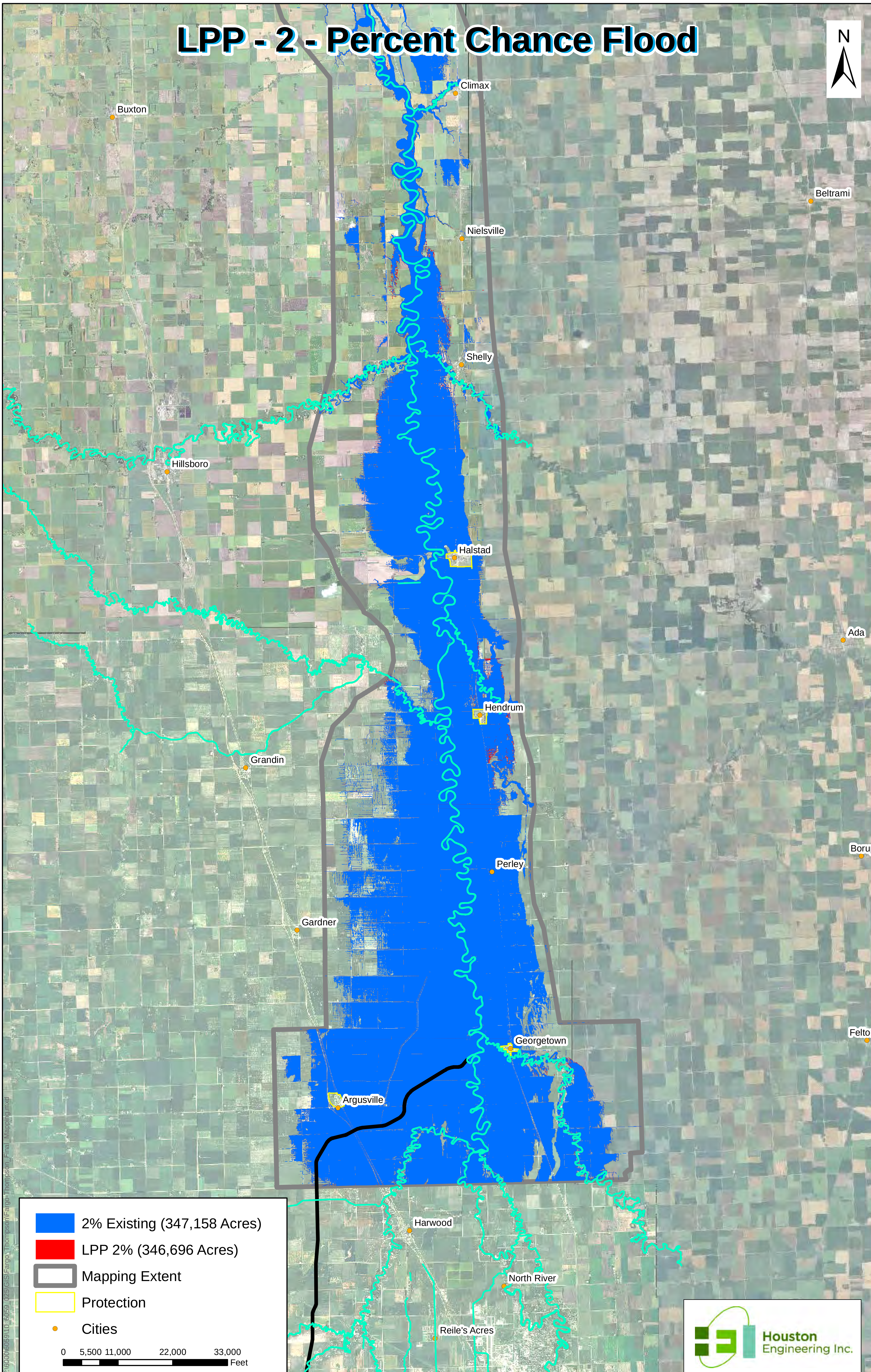
LPP - 10 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
10% Existing (224,166 Acres)
LPP 10% (221,176 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston
Engineering Inc.


LPP - 10 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
10% Existing (224,166 Acres)
LPP 10% (221,176 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 2 - Percent Chance Flood
N
Hensel
Halma
Crystal
Karlstad
Donaldson
Drayton
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
2% Existing (347,158 Acres)
LPP 2% (346,696 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

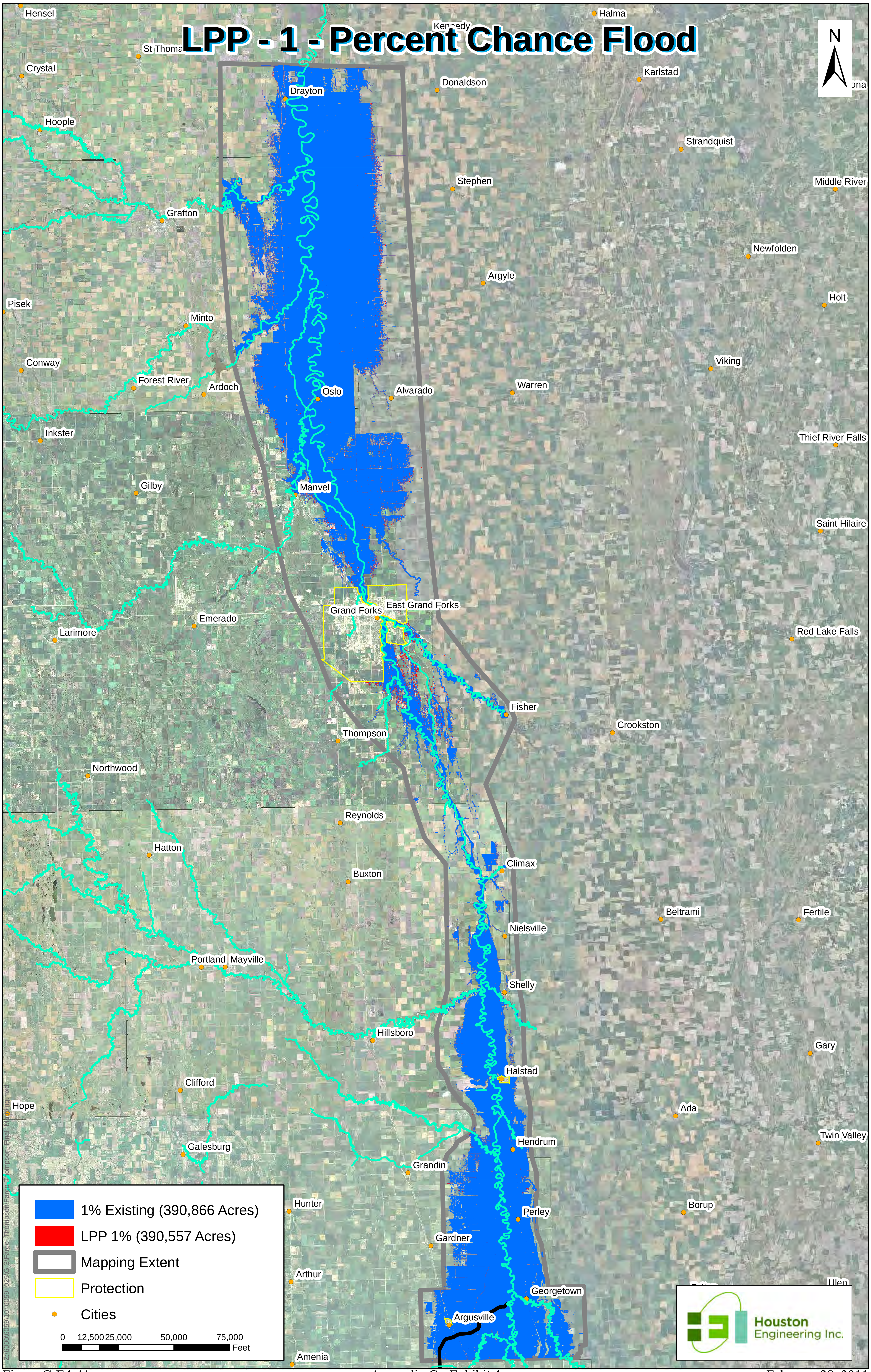

LPP - 2 - Percent Chance Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2% Existing (347,158 Acres)
LPP 2% (346,696 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston
Engineering Inc.


LPP - 2 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2% Existing (347,158 Acres)
LPP 2% (346,696 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

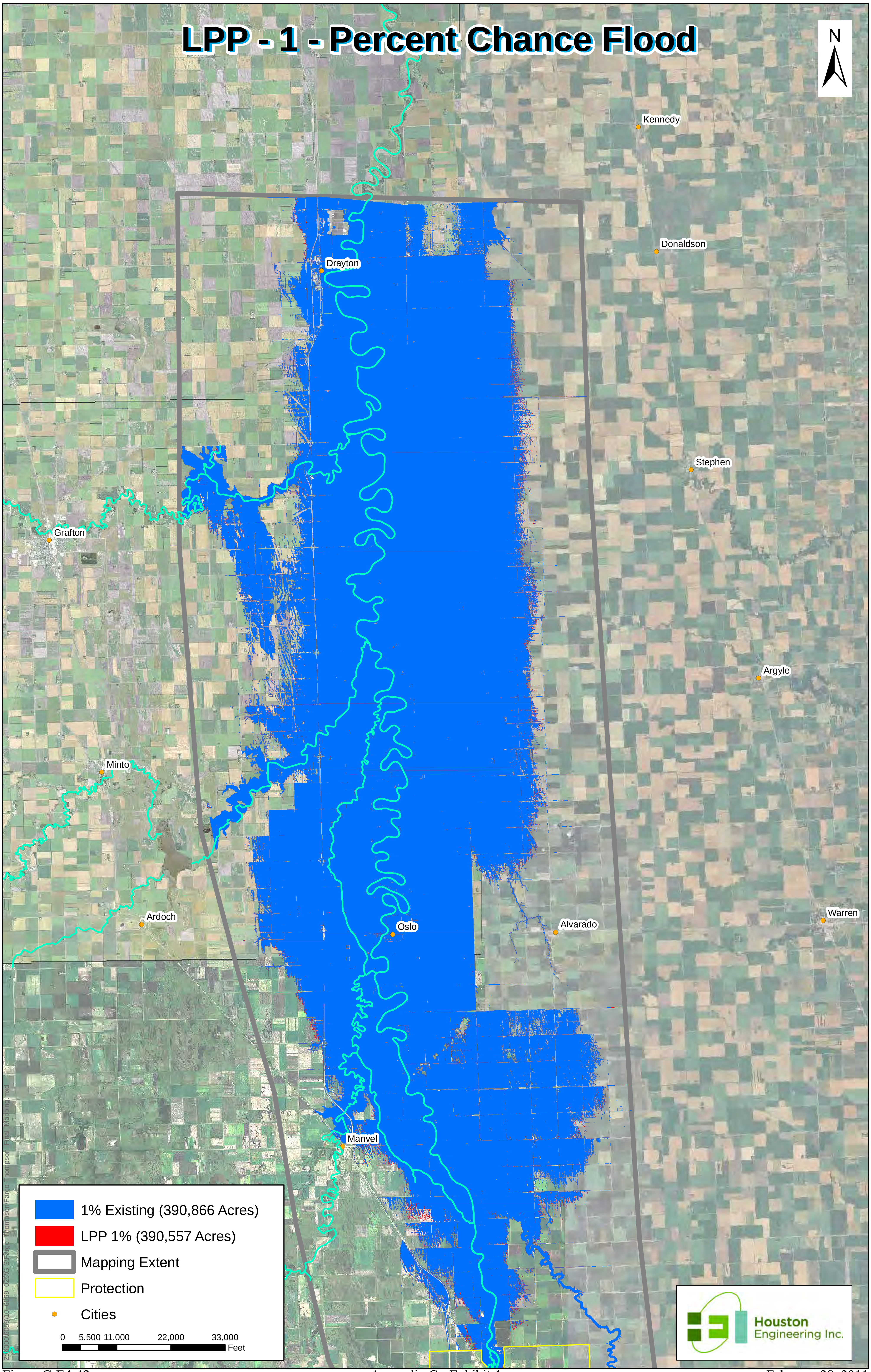


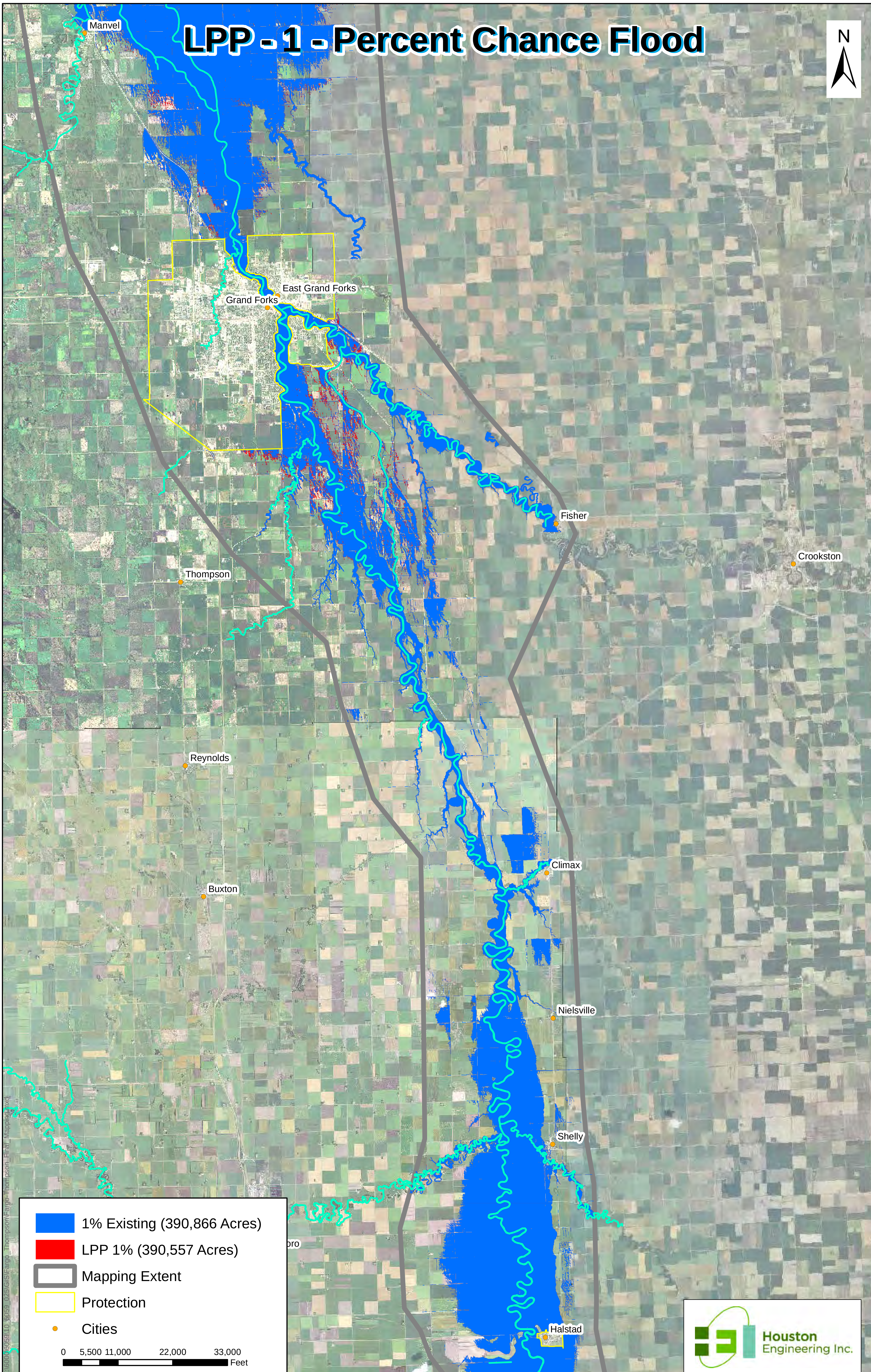
LPP - 2 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2% Existing (347,158 Acres)
LPP 2% (346,696 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

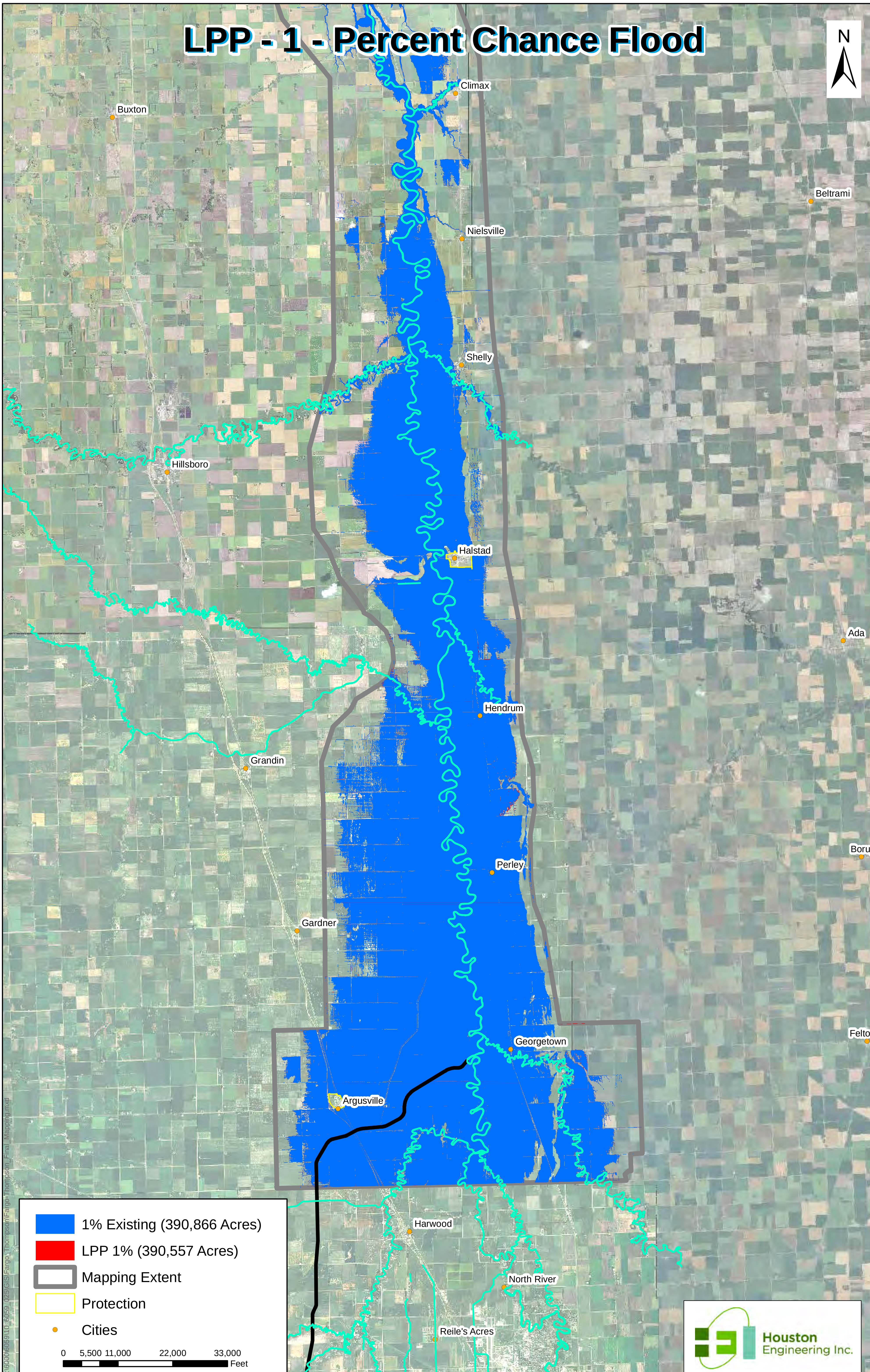
LPP - 1 - Percent Chance Flood



LPP - 1 - Percent Chance Flood

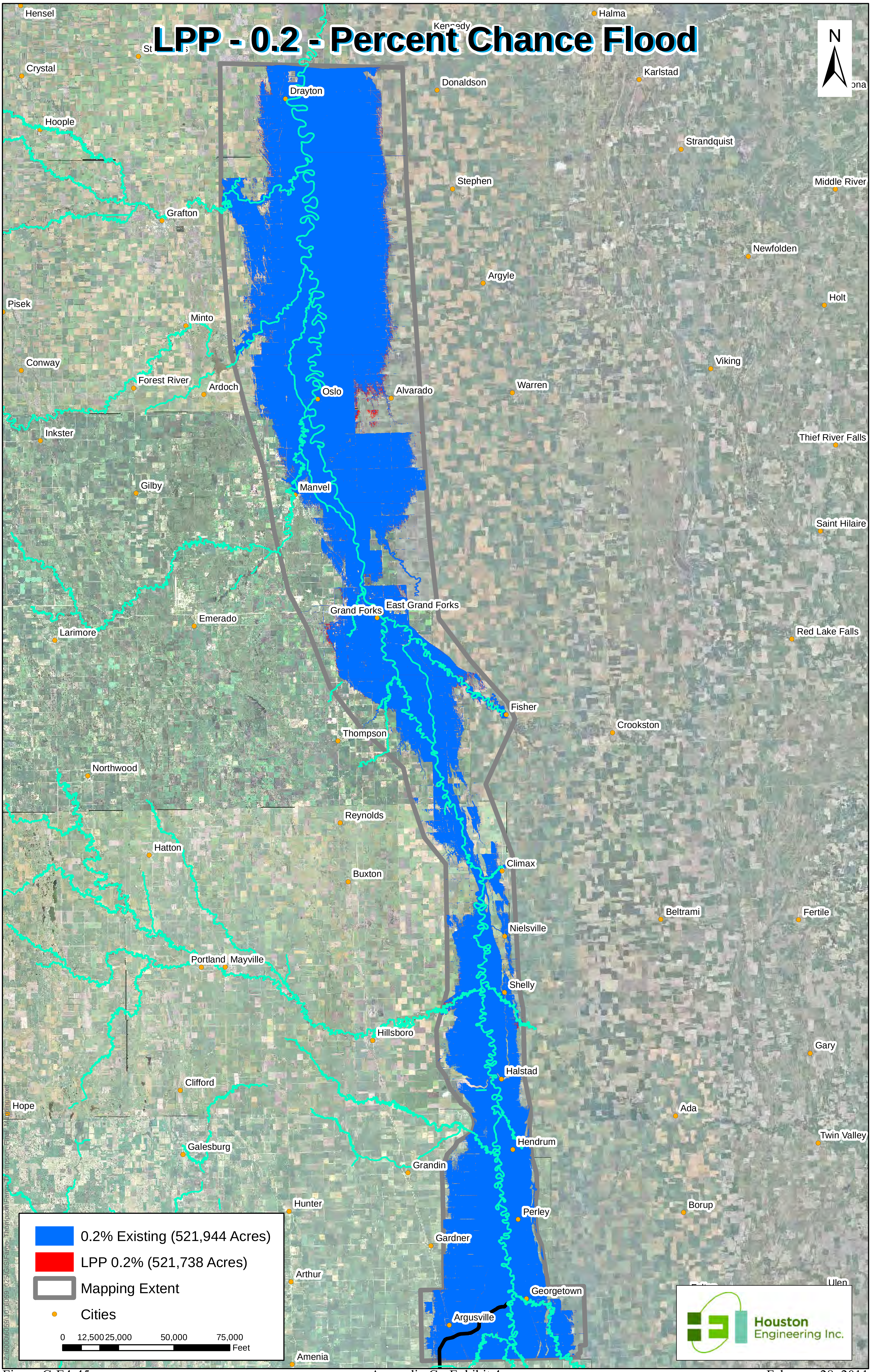



LPP - 1 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
1% Existing (390,866 Acres)
LPP 1% (390,557 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.



LPP - 1 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
1% Existing (390,866 Acres)
LPP 1% (390,557 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

LPP - 0.2 - Percent Chance Flood



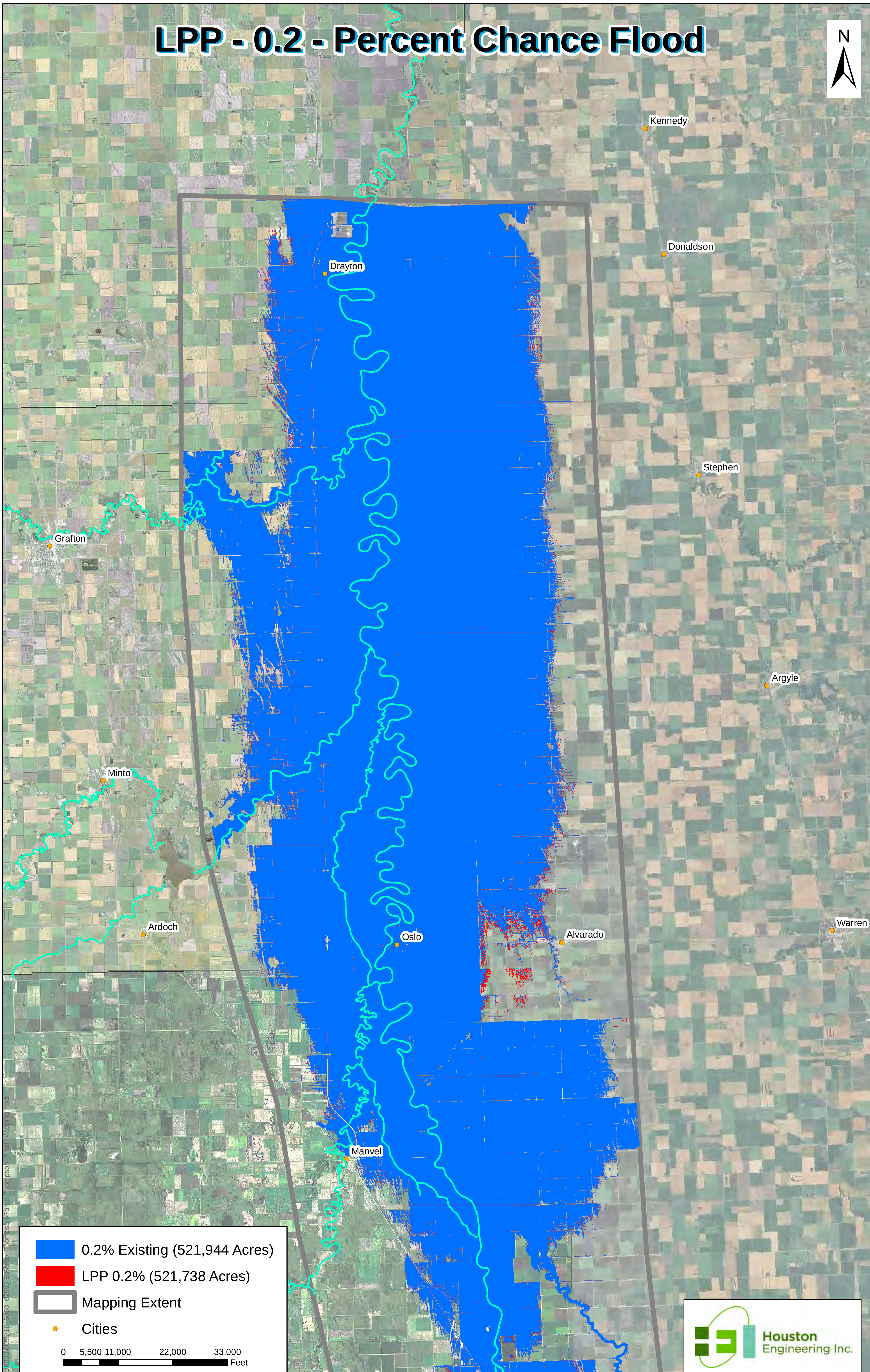
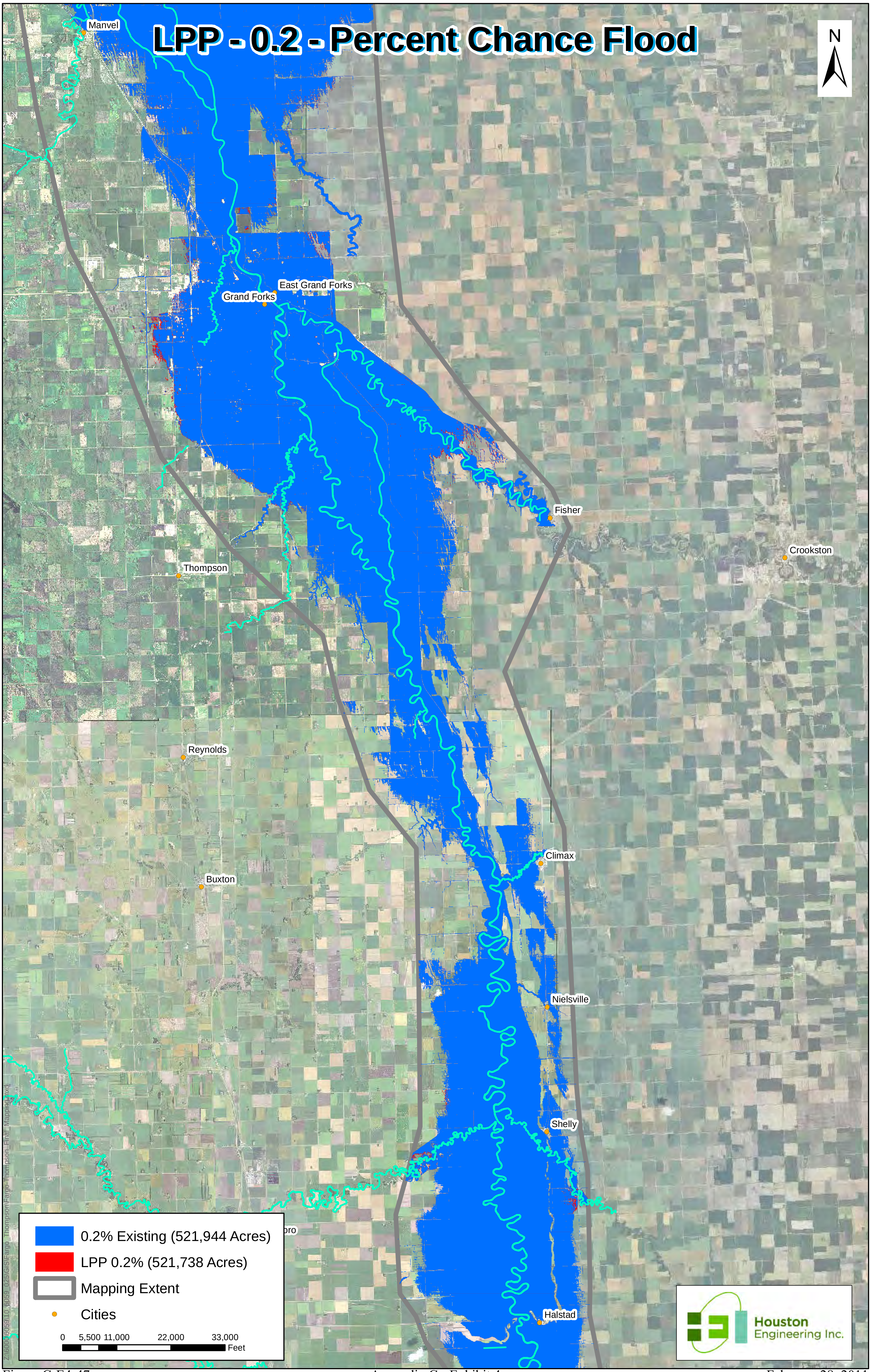
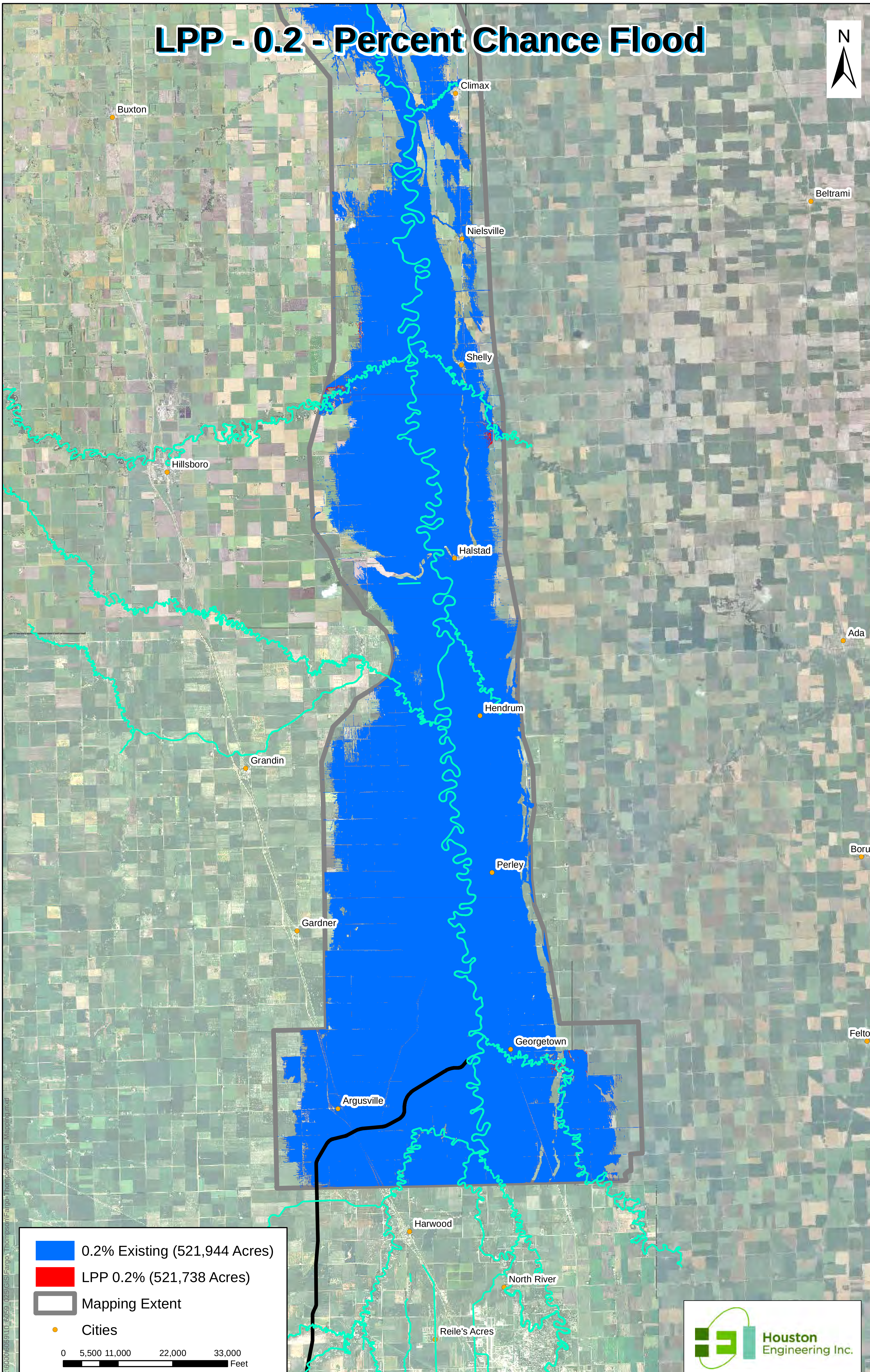
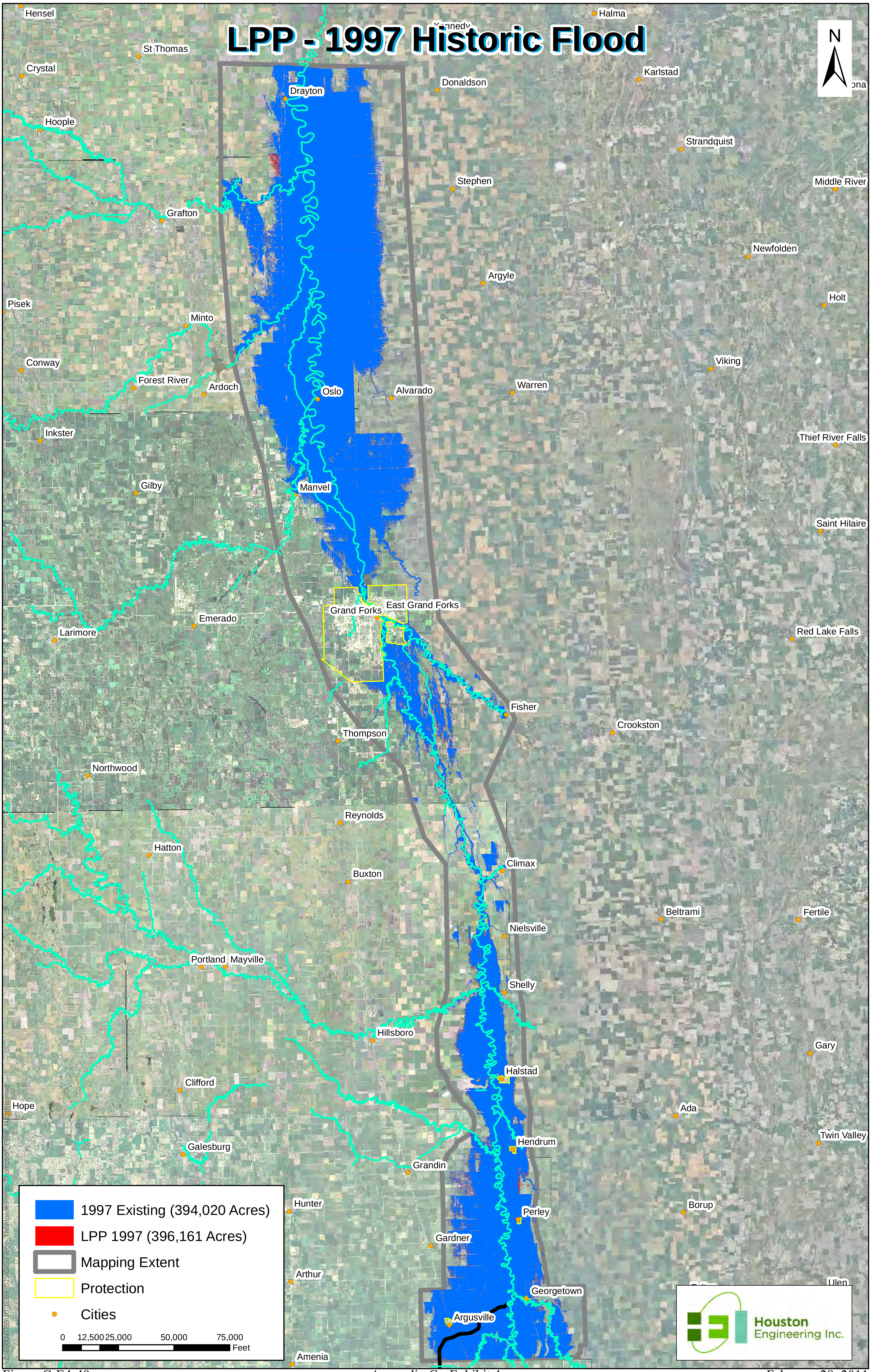


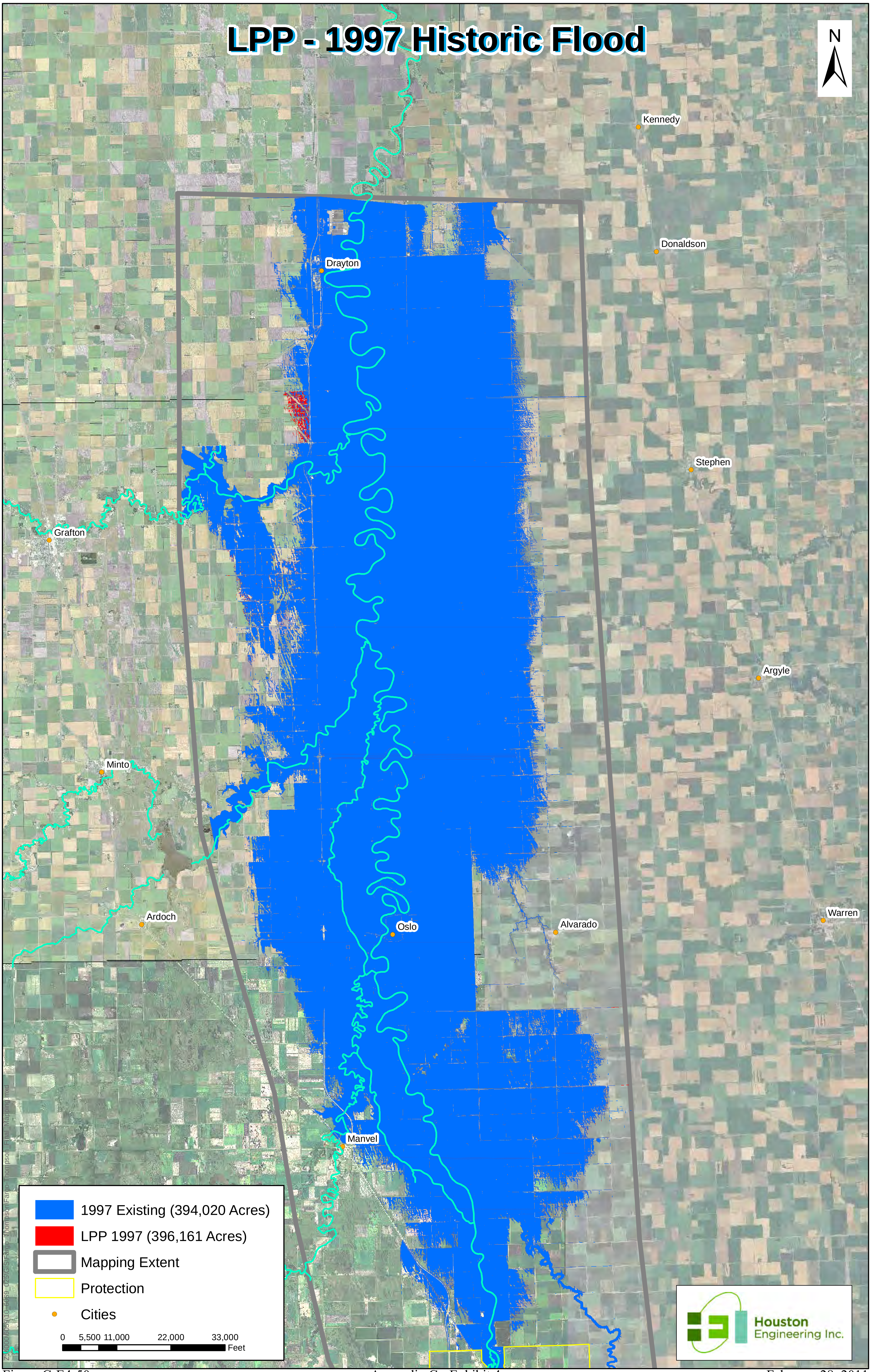
Figure C-E4-46 Appendix C - Exhibit 4 February 28, 2011



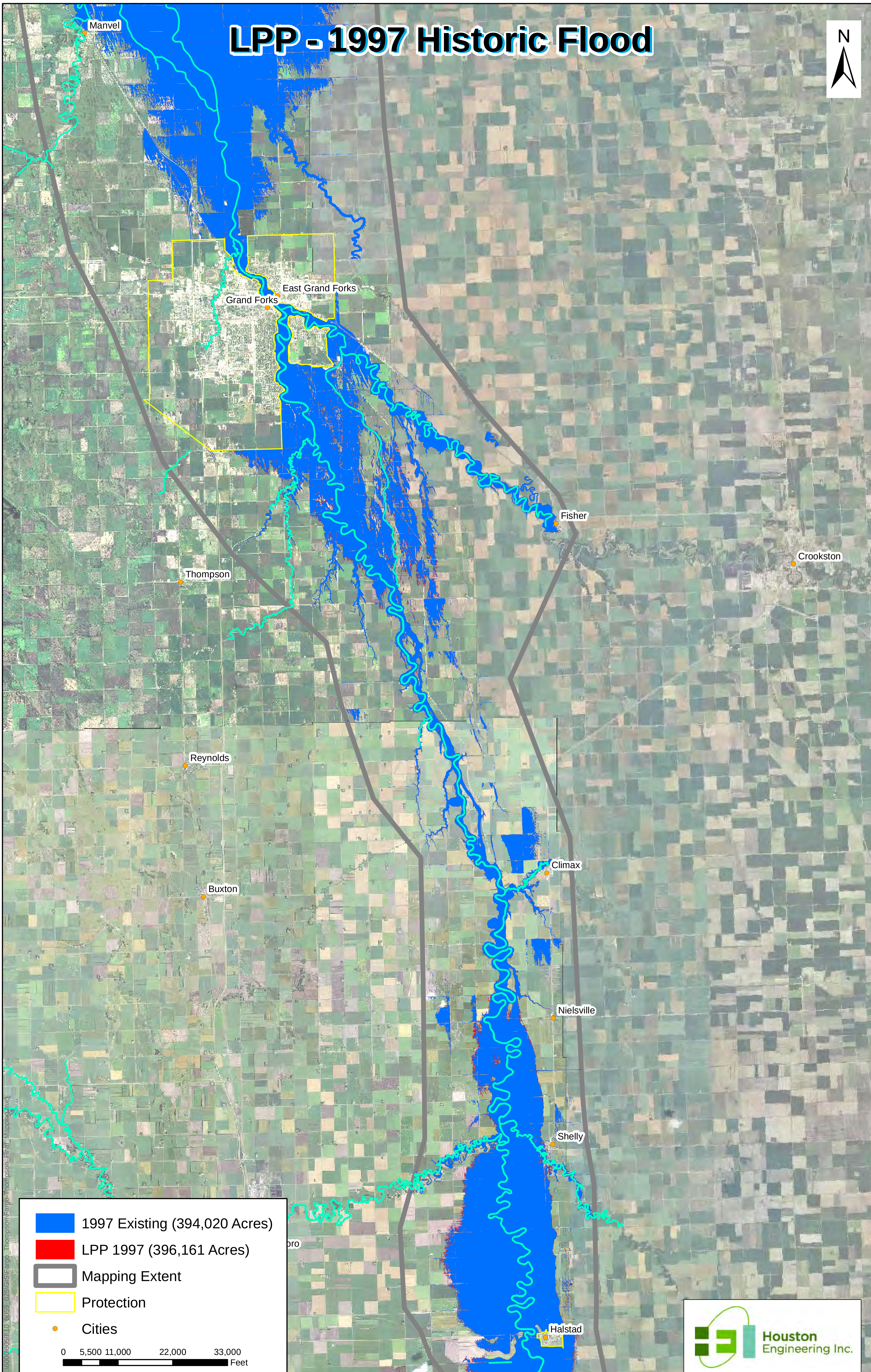
LPP - 0.2 - Percent Chance Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
0.2% Existing (521,944 Acres)
LPP 0.2% (521,738 Acres)
Mapping Extent
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

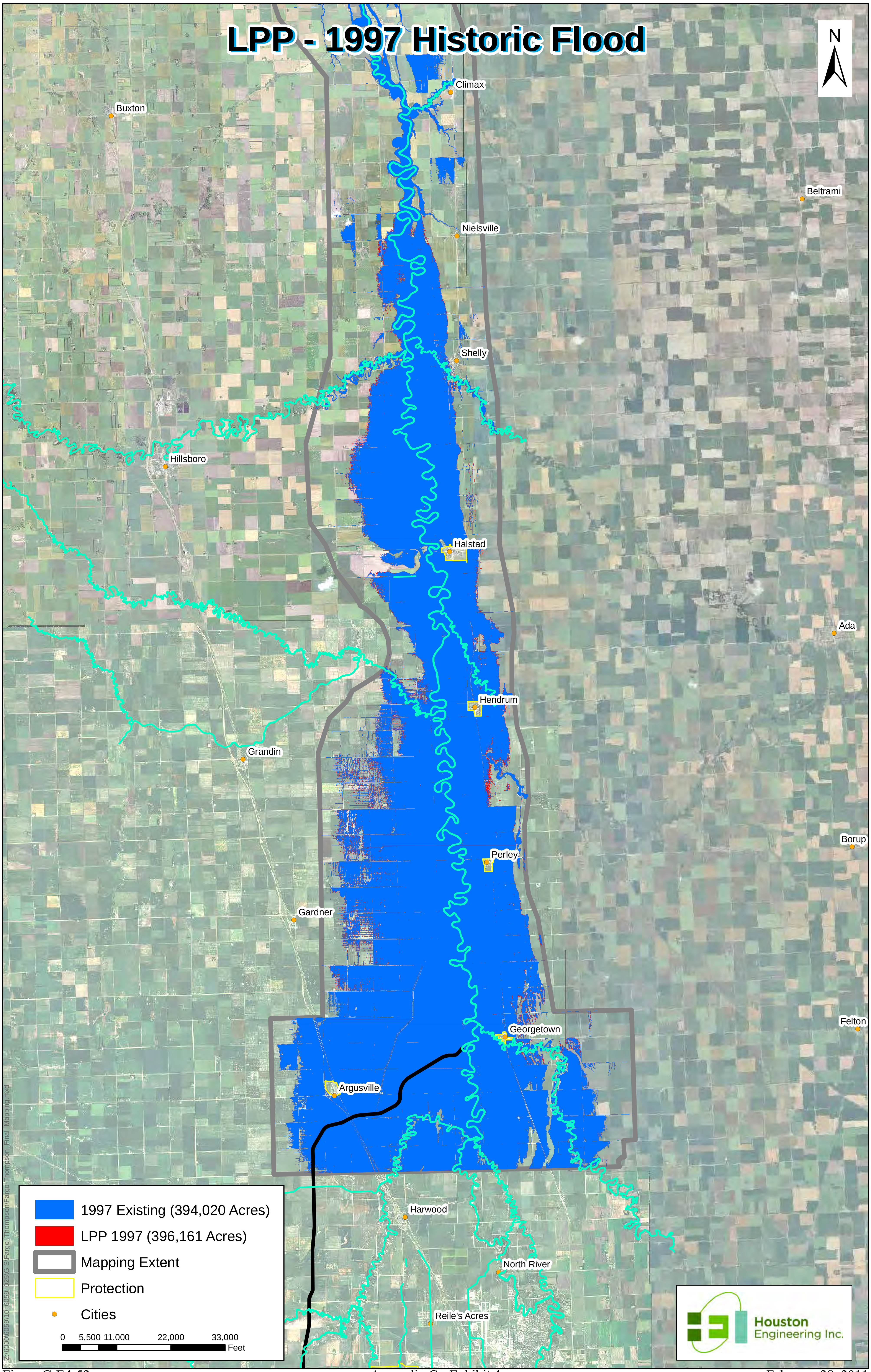

LPP - 0.2 - Percent Chance Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
0.2% Existing (521,944 Acres)
LPP 0.2% (521,738 Acres)
Mapping Extent
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 1997 Historic Flood
N
Hensel
Halma
St Thomas
Crystal
Drayton
Donaldson
Karlstad
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Gilby
Manvel
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Hope
Ada
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
1997 Existing (394,020 Acres)
LPP 1997 (396,161 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.

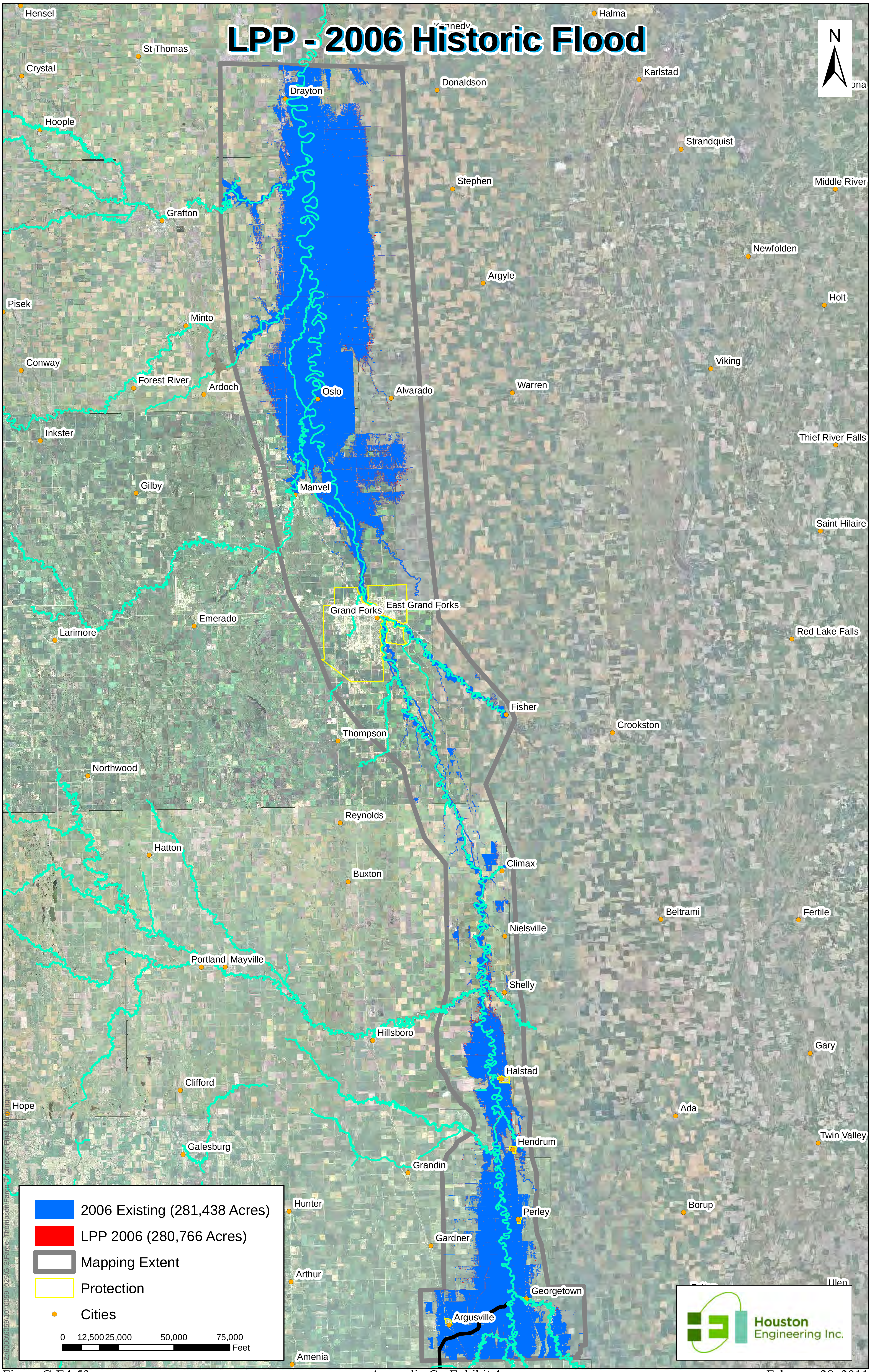


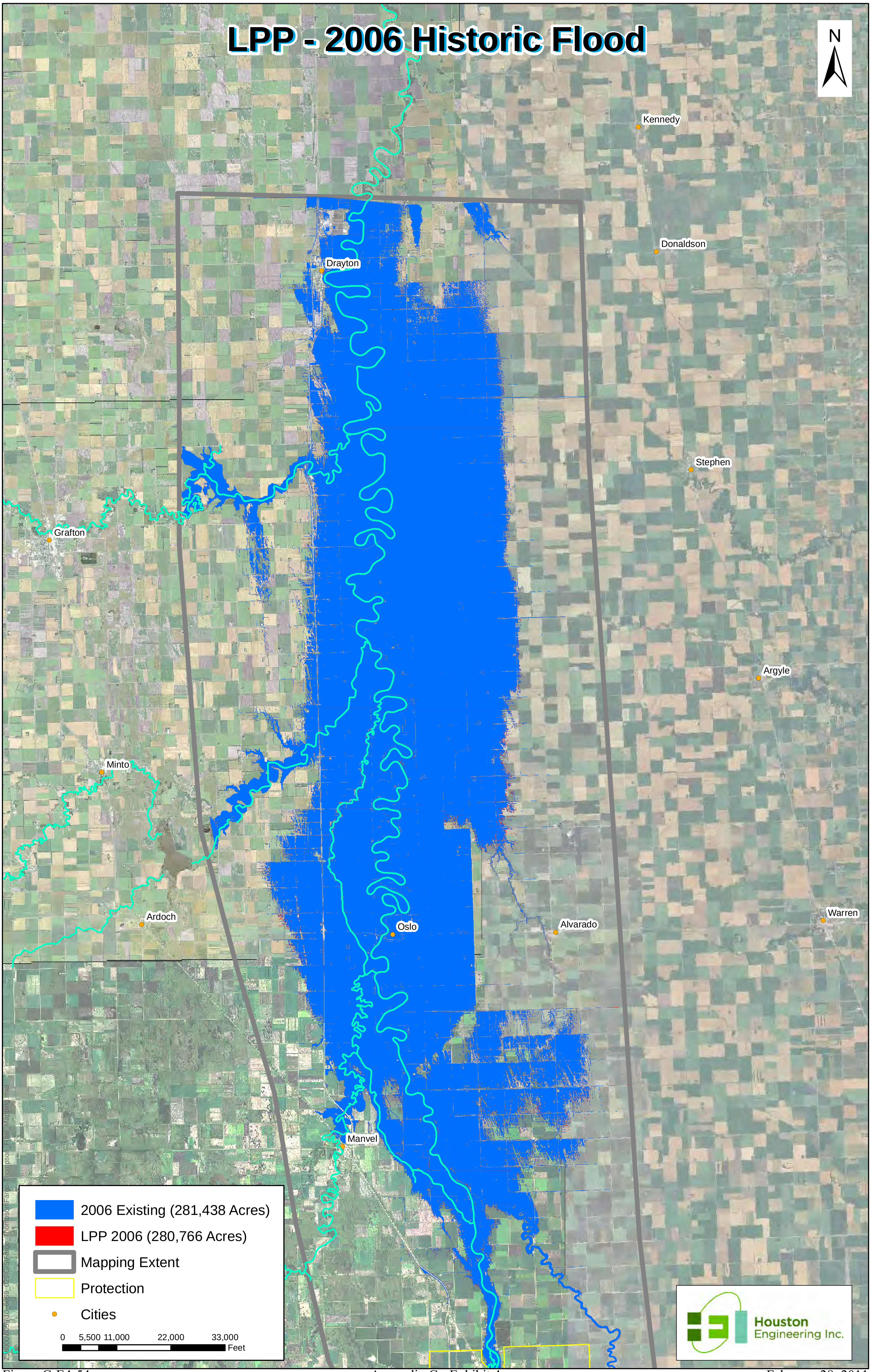
LPP - 1997 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
1997 Existing (394,020 Acres)
LPP 1997 (396,161 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

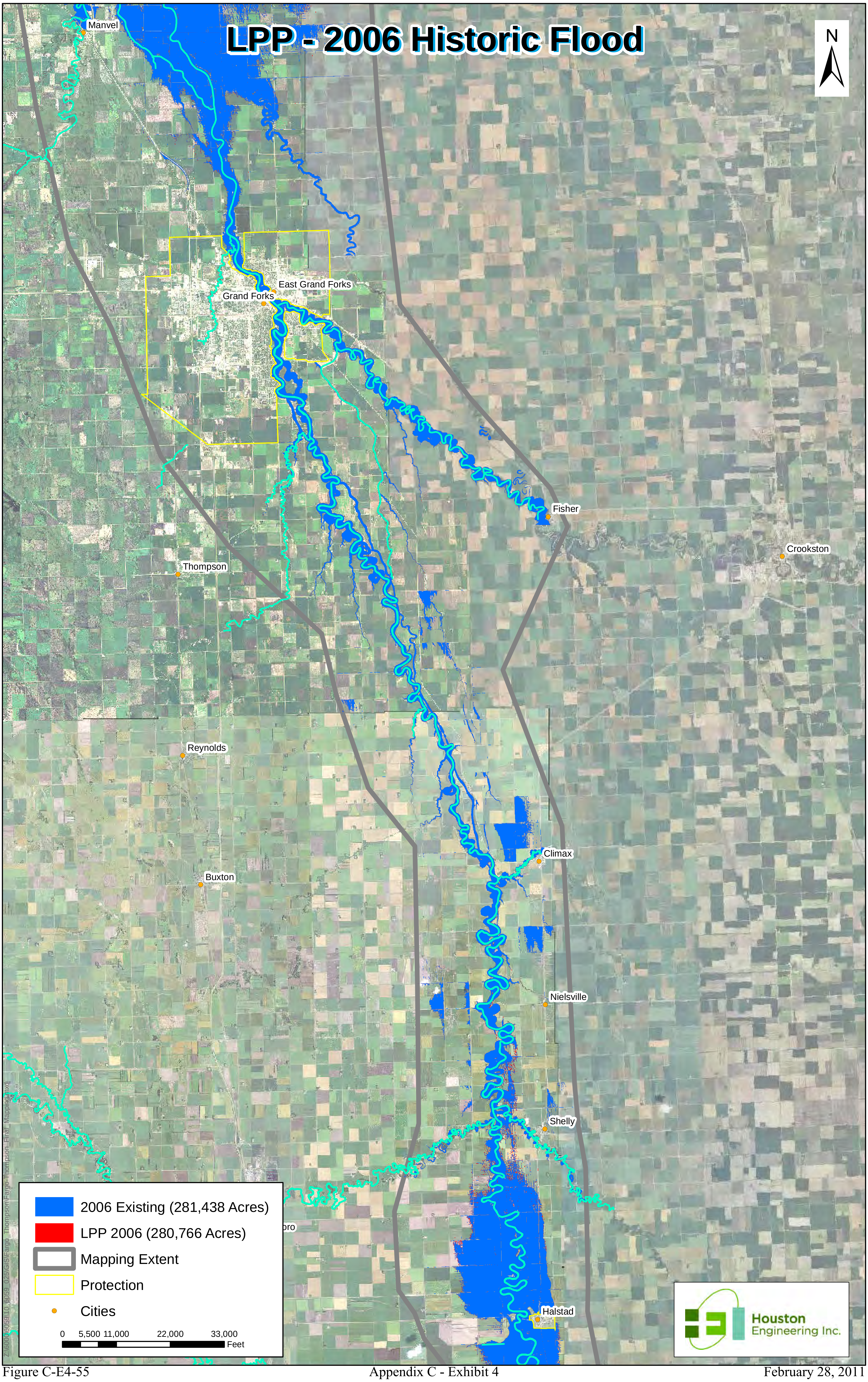

LPP - 1997 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
1997 Existing (394,020 Acres)
LPP 1997 (396,161 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.



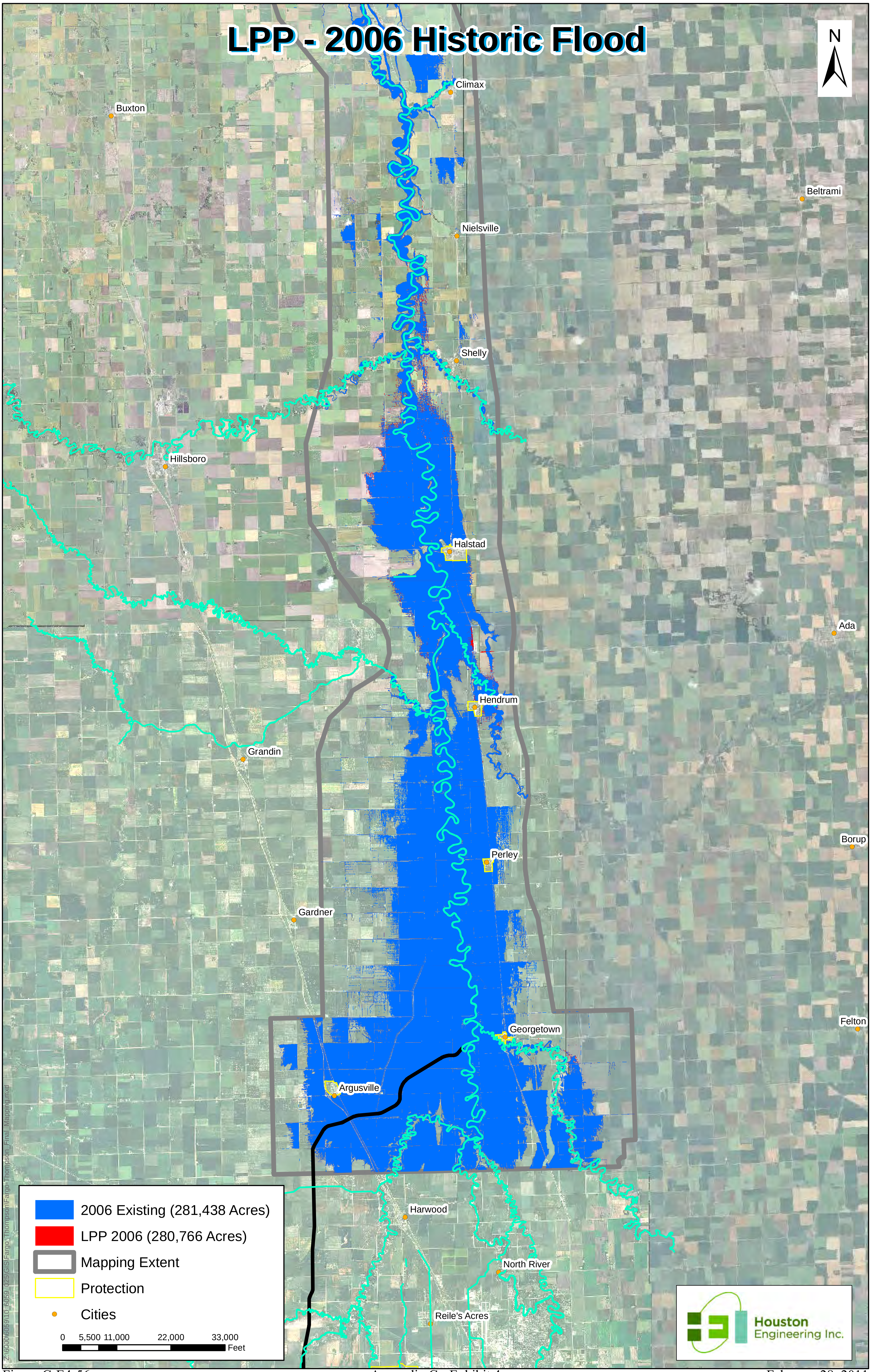
LPP - 1997 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
1997 Existing (394,020 Acres)
LPP 1997 (396,161 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 2006 Historic Flood
N
Hensel
Halma
St Thomas
Crystal
Drayton
Donaldson
Karlstad
Hoople
Strandquist
Stephen
Middle River
Grafton
Newfolden
Argyle
Holt
Pisek
Minto
Viking
Conway
Forest River
Ardoch
Oslo
Alvarado
Warren
Inkster
Thief River Falls
Manvel
Gilby
Saint Hilaire
Grand Forks
East Grand Forks
Emerado
Larimore
Red Lake Falls
Fisher
Crookston
Thompson
Northwood
Reynolds
Hatton
Climax
Buxton
Beltrami
Fertile
Nielsville
Portland
Mayville
Shelly
Hillsboro
Gary
Halstad
Clifford
Ada
Hope
Hendrum
Twin Valley
Galesburg
Grandin
Hunter
Borup
Perley
Gardner
Arthur
Ulen
Georgetown
Argusville
Amenia
2006 Existing (281,438 Acres)
LPP 2006 (280,766 Acres)
Mapping Extent
Protection
Cities
0 12,500 25,000 50,000 75,000
Feet
Houston Engineering Inc.


LPP - 2006 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2006 Existing (281,438 Acres)
LPP 2006 (280,766 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 2006 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2006 Existing (281,438 Acres)
LPP 2006 (280,766 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

LPP - 2006 Historic Flood



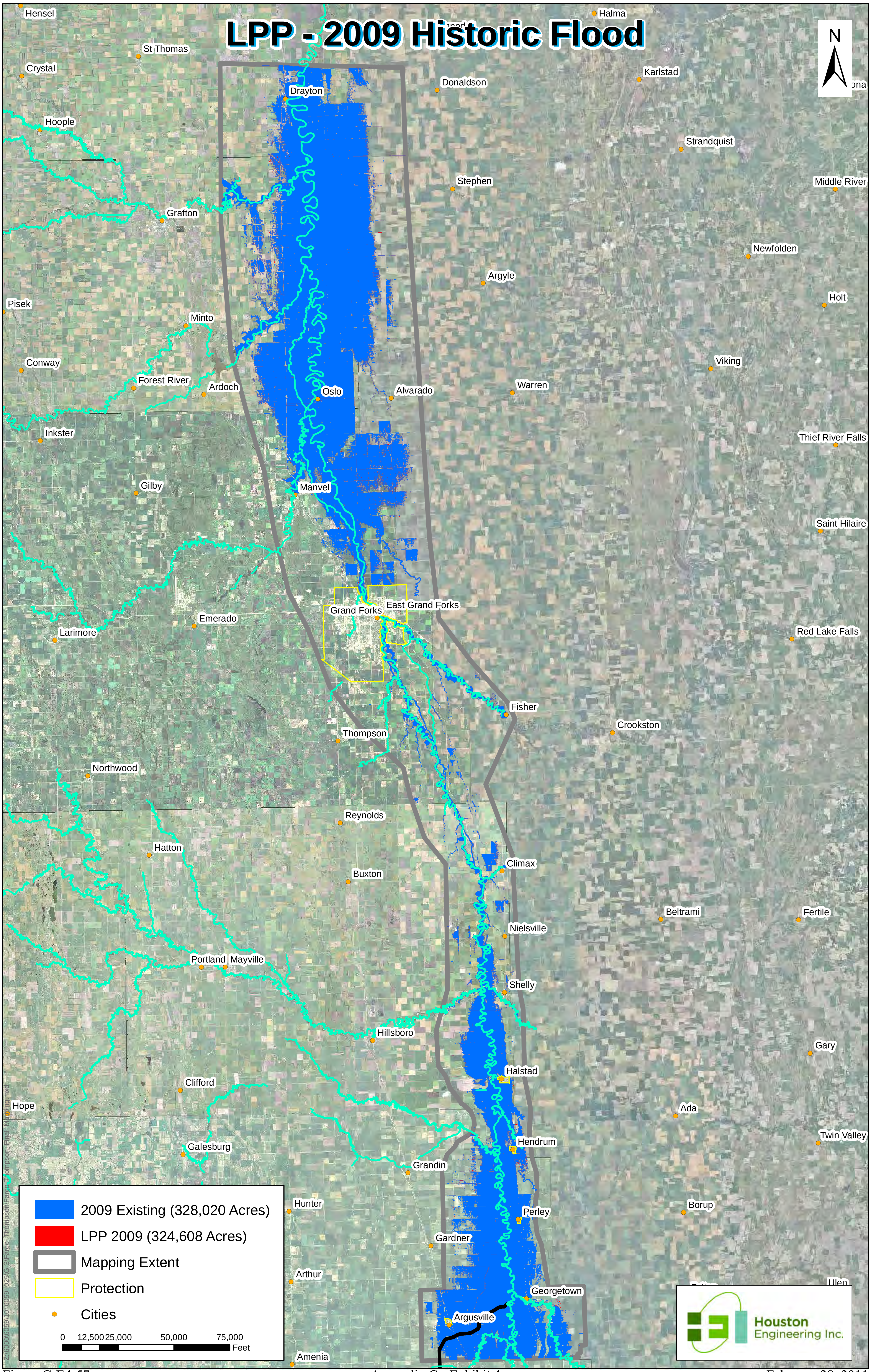
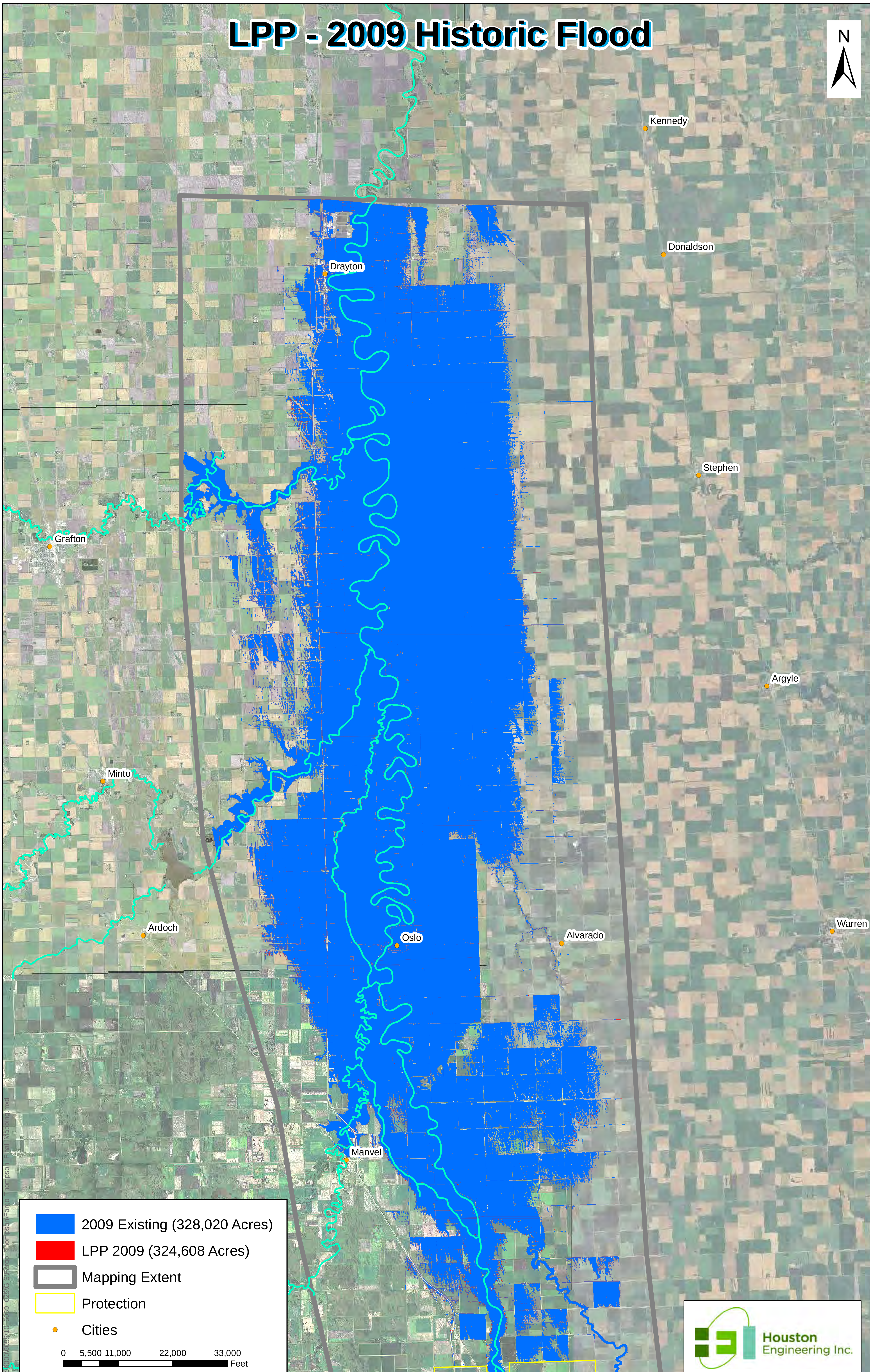
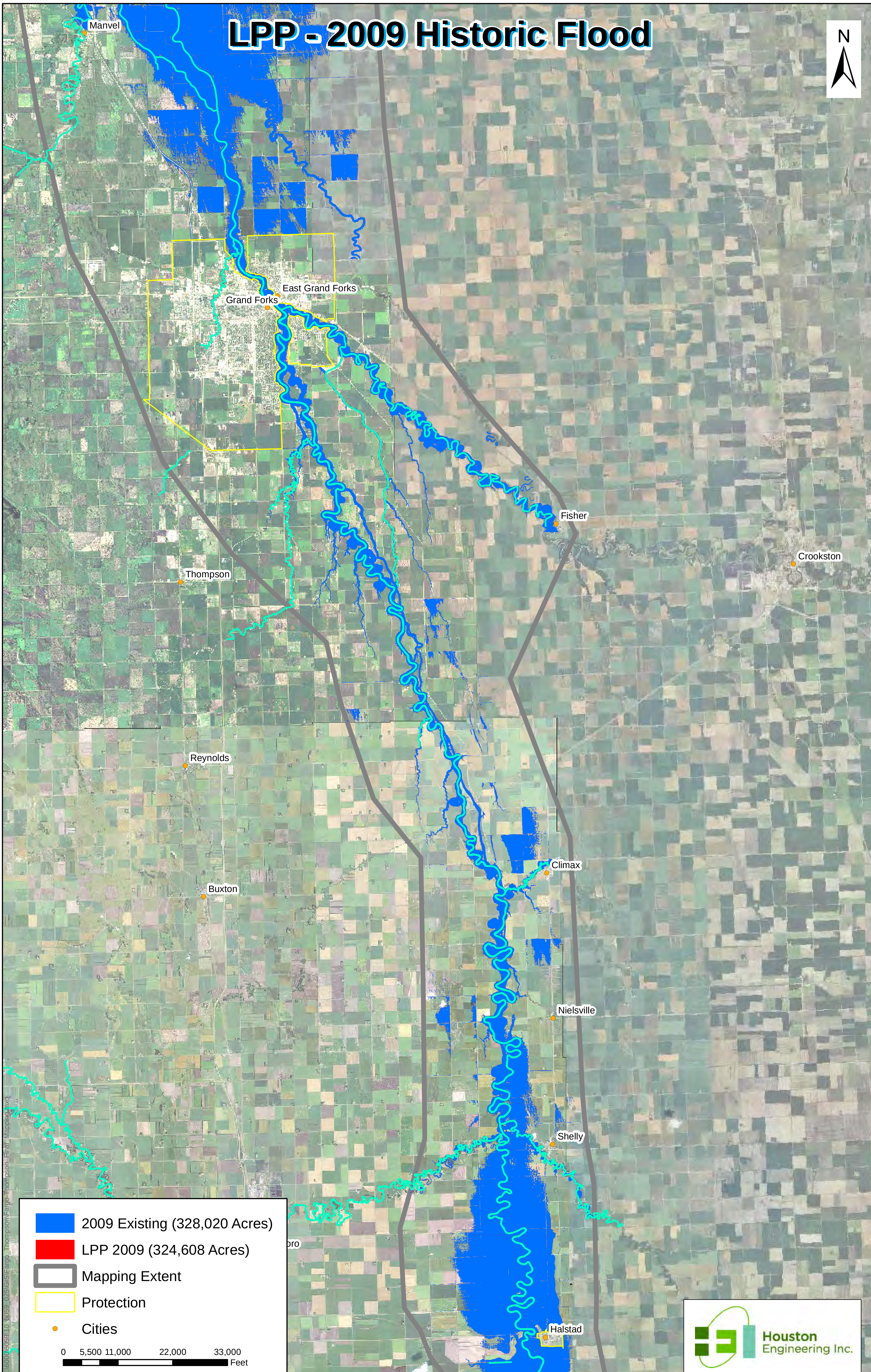
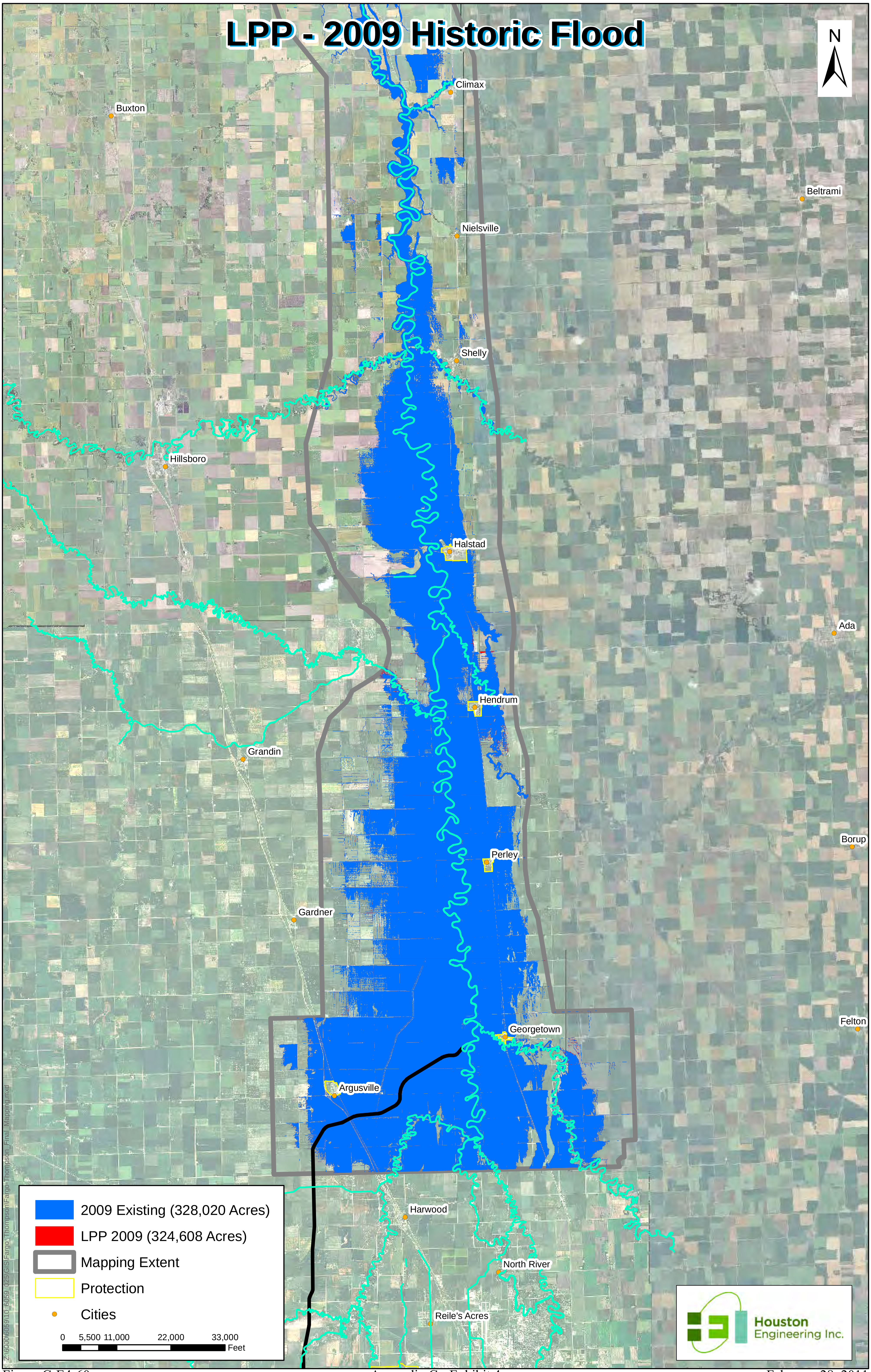


Figure C-E4-57 Appendix C - Exhibit 4 February 28, 2011

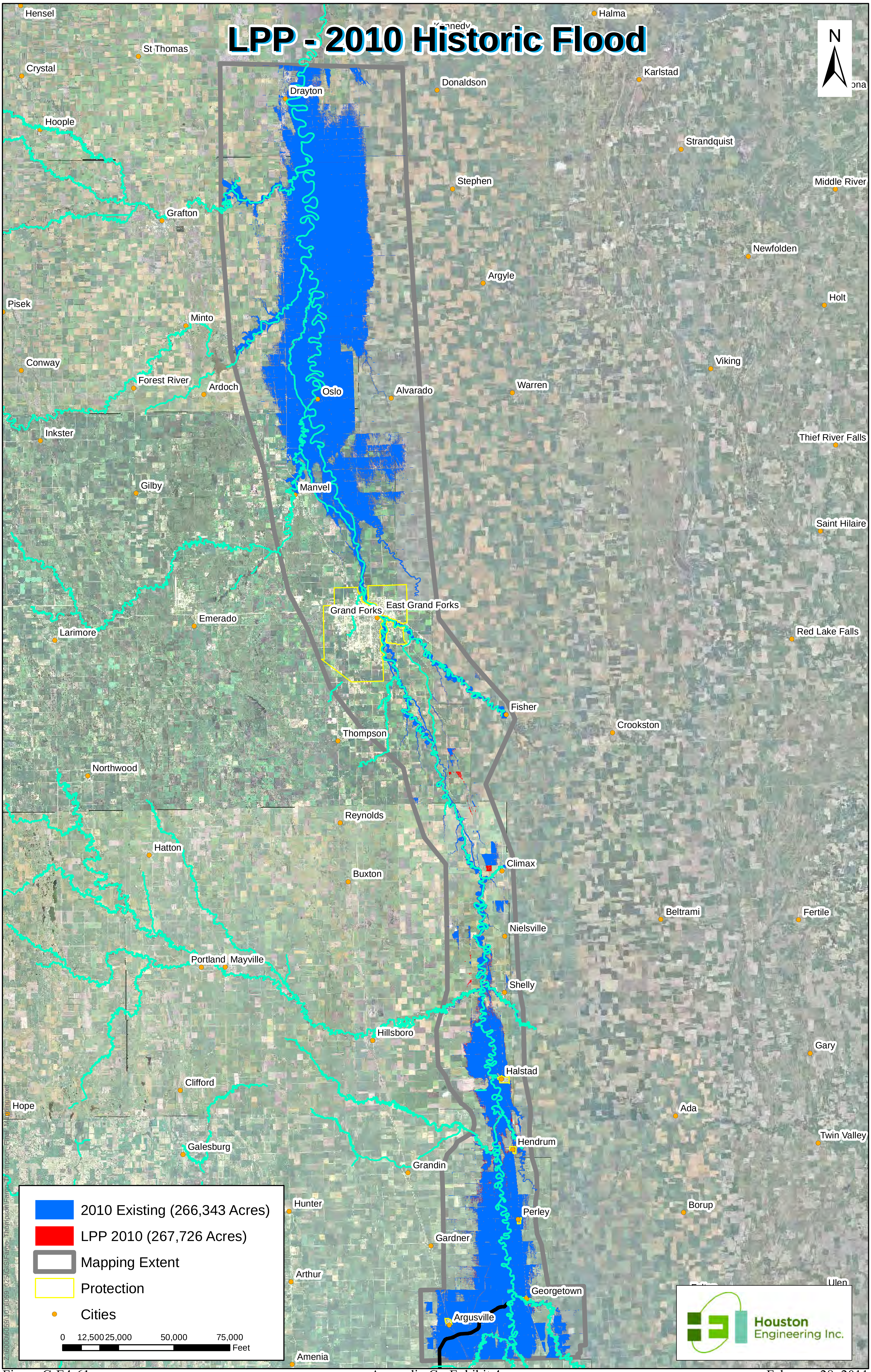

LPP - 2009 Historic Flood
N
Kennedy
Donaldson
Drayton
Stephen
Grafton
Argyle
Minto
Ardoch
Oslo
Alvarado
Warren
Manvel
2009 Existing (328,020 Acres)
LPP 2009 (324,608 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 2009 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2009 Existing (328,020 Acres)
LPP 2009 (324,608 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.



LPP - 2009 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2009 Existing (328,020 Acres)
LPP 2009 (324,608 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.

LPP - 2010 Historic Flood



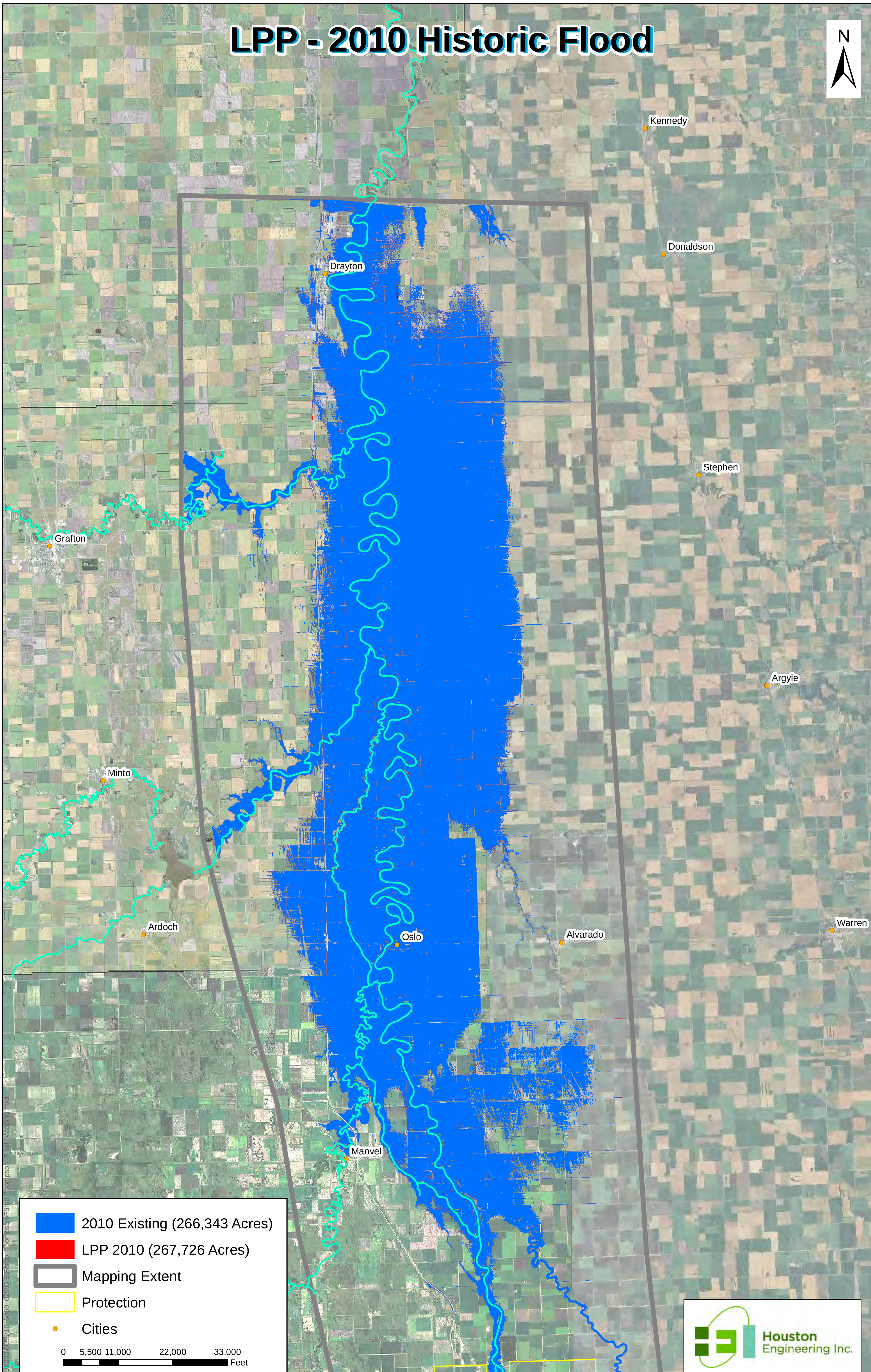
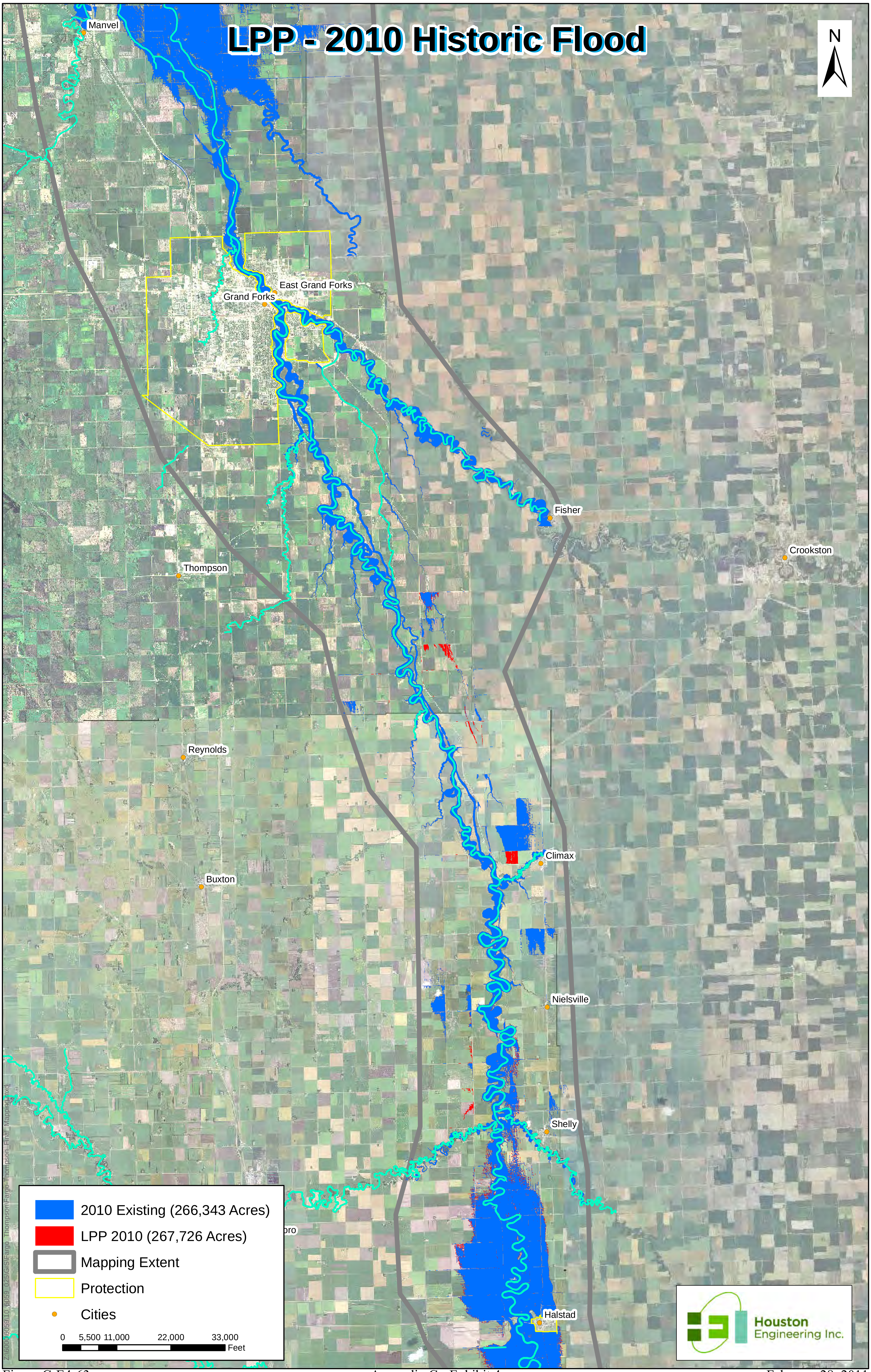
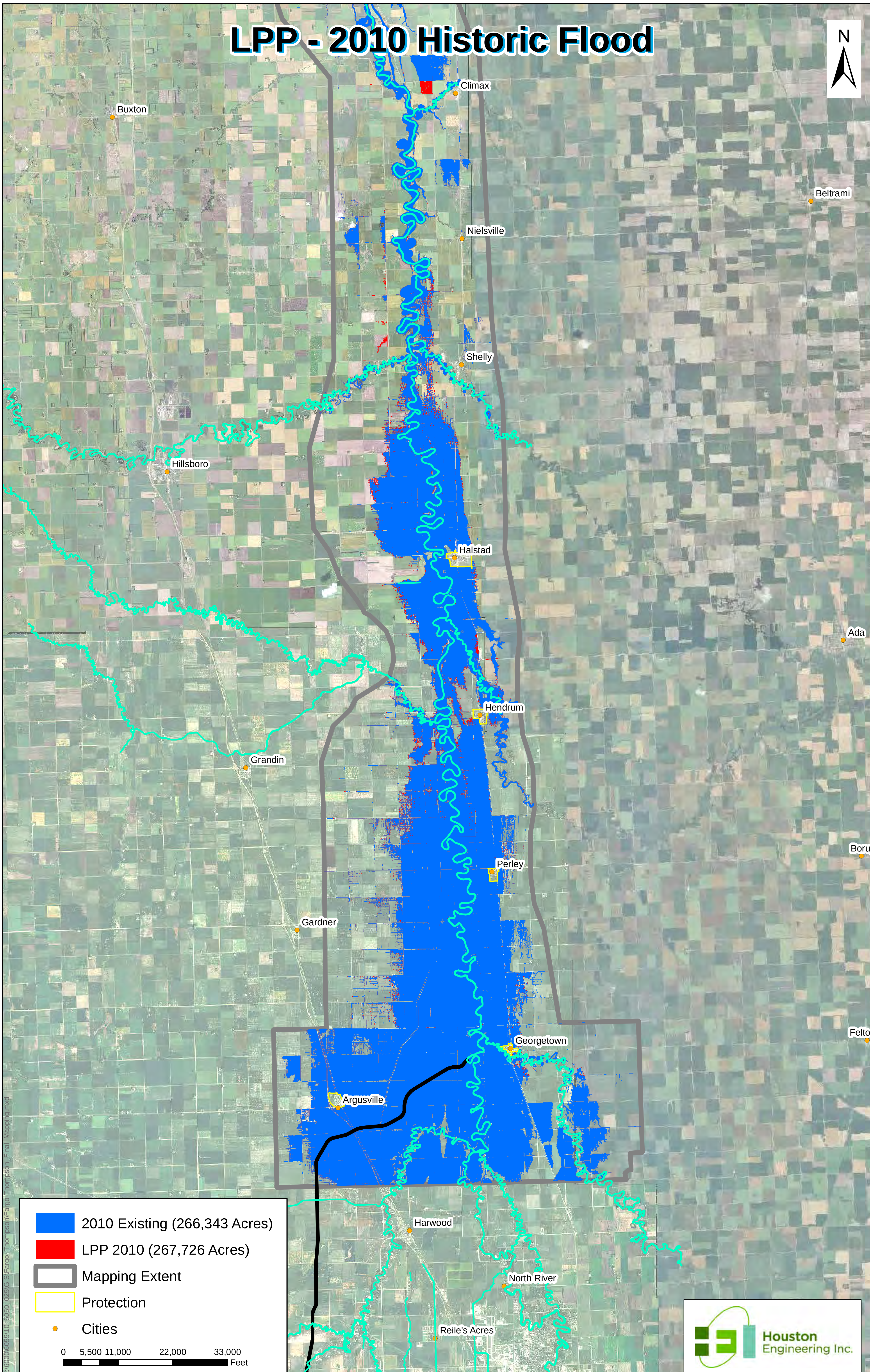
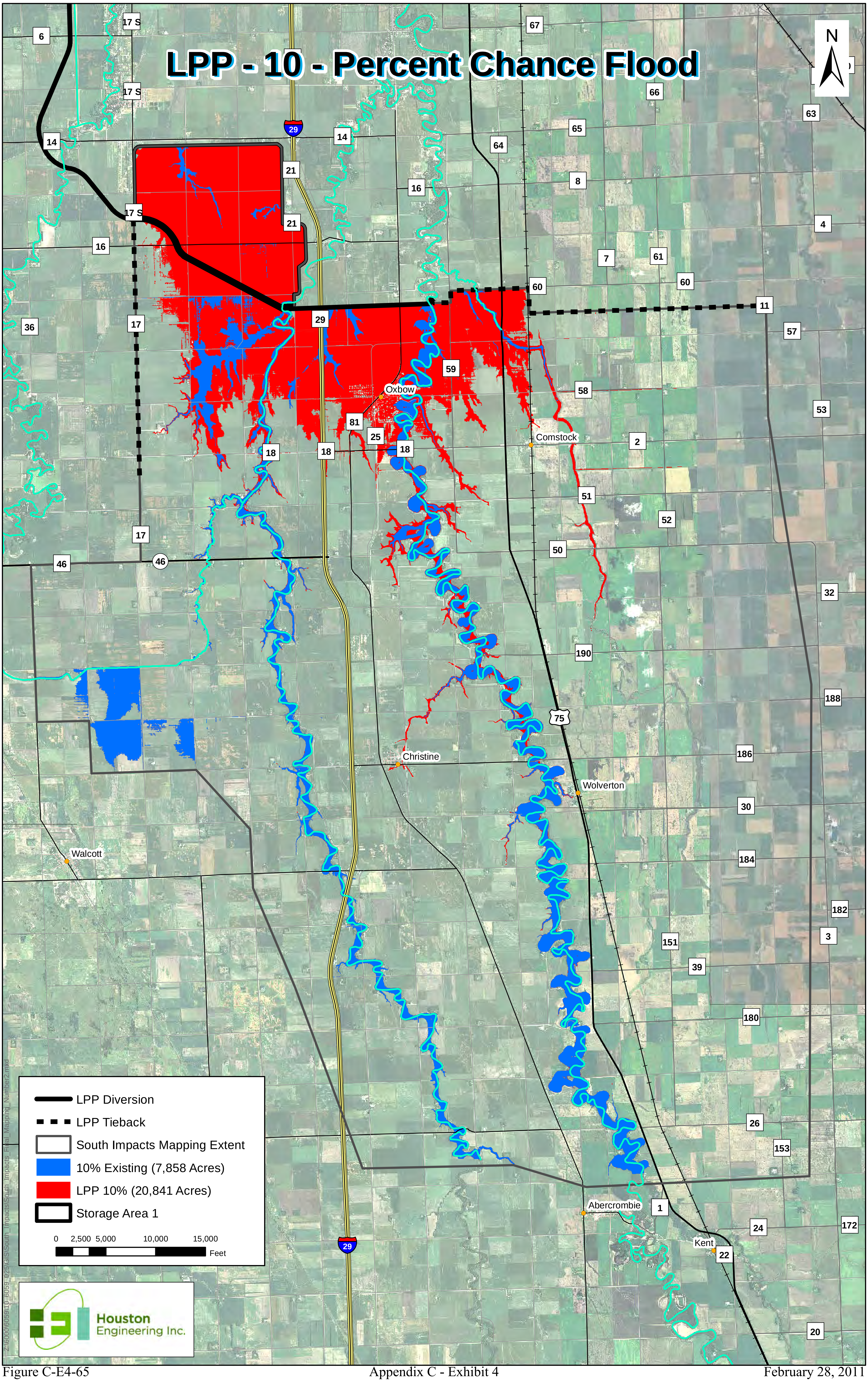


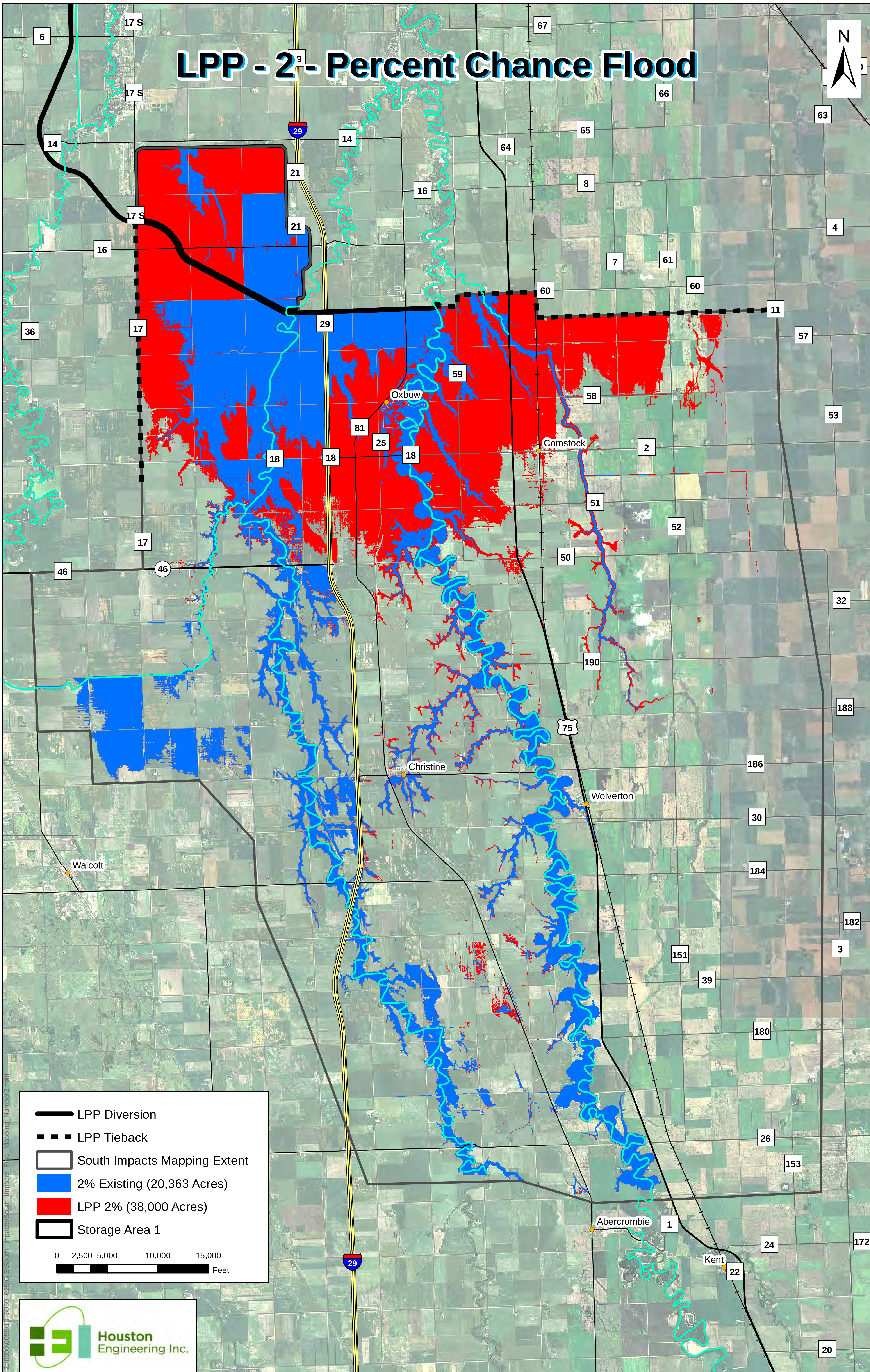
Figure C-E4-62 Appendix C - Exhibit 4 February 28, 2011

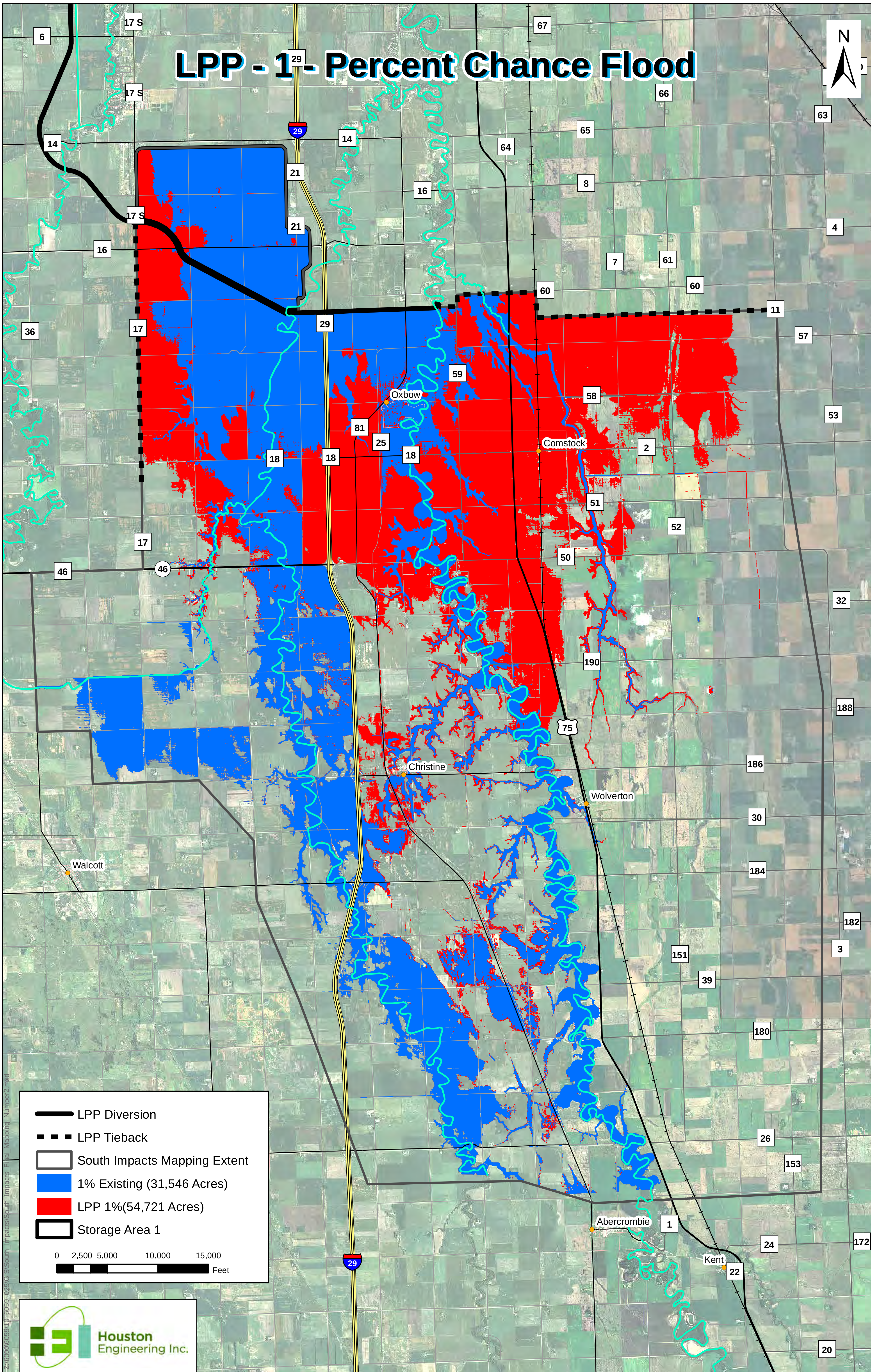

LPP - 2010 Historic Flood
N
Manvel
East Grand Forks
Grand Forks
Fisher
Crookston
Thompson
Reynolds
Climax
Buxton
Nielsville
Shelly
Halstad
2010 Existing (266,343 Acres)
LPP 2010 (267,726 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.


LPP - 2010 Historic Flood
N
Climax
Buxton
Beltrami
Nielsville
Shelly
Hillsboro
Halstad
Ada
Hendrum
Grandin
Borup
Perley
Gardner
Felton
Georgetown
Argusville
Harwood
North River
Reile's Acres
2010 Existing (266,343 Acres)
LPP 2010 (267,726 Acres)
Mapping Extent
Protection
Cities
0 5,500 11,000 22,000 33,000
Feet
Houston Engineering Inc.



LPP - 10 - Percent Chance Flood
N
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
10% Existing (7,858 Acres)
LPP 10% (20,841 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Houston
Engineering Inc.


LPP - 2 - Percent Chance Flood
N
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
2% Existing (20,363 Acres)
LPP 2% (38,000 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Houston
Engineering Inc.


LPP - 1 - Percent Chance Flood
N
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
1% Existing (31,546 Acres)
LPP 1%(54,721 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent
Houston
Engineering Inc.

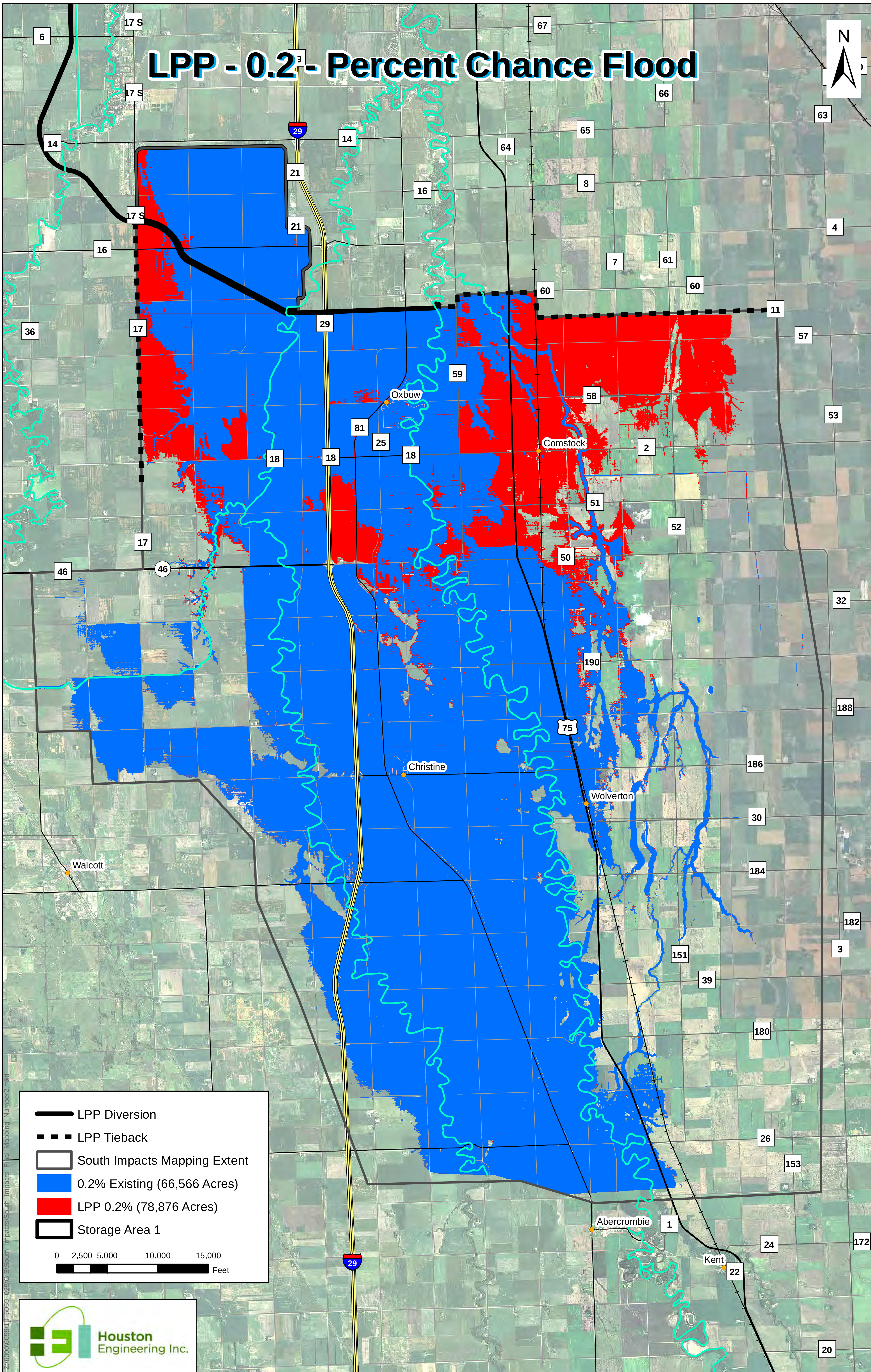
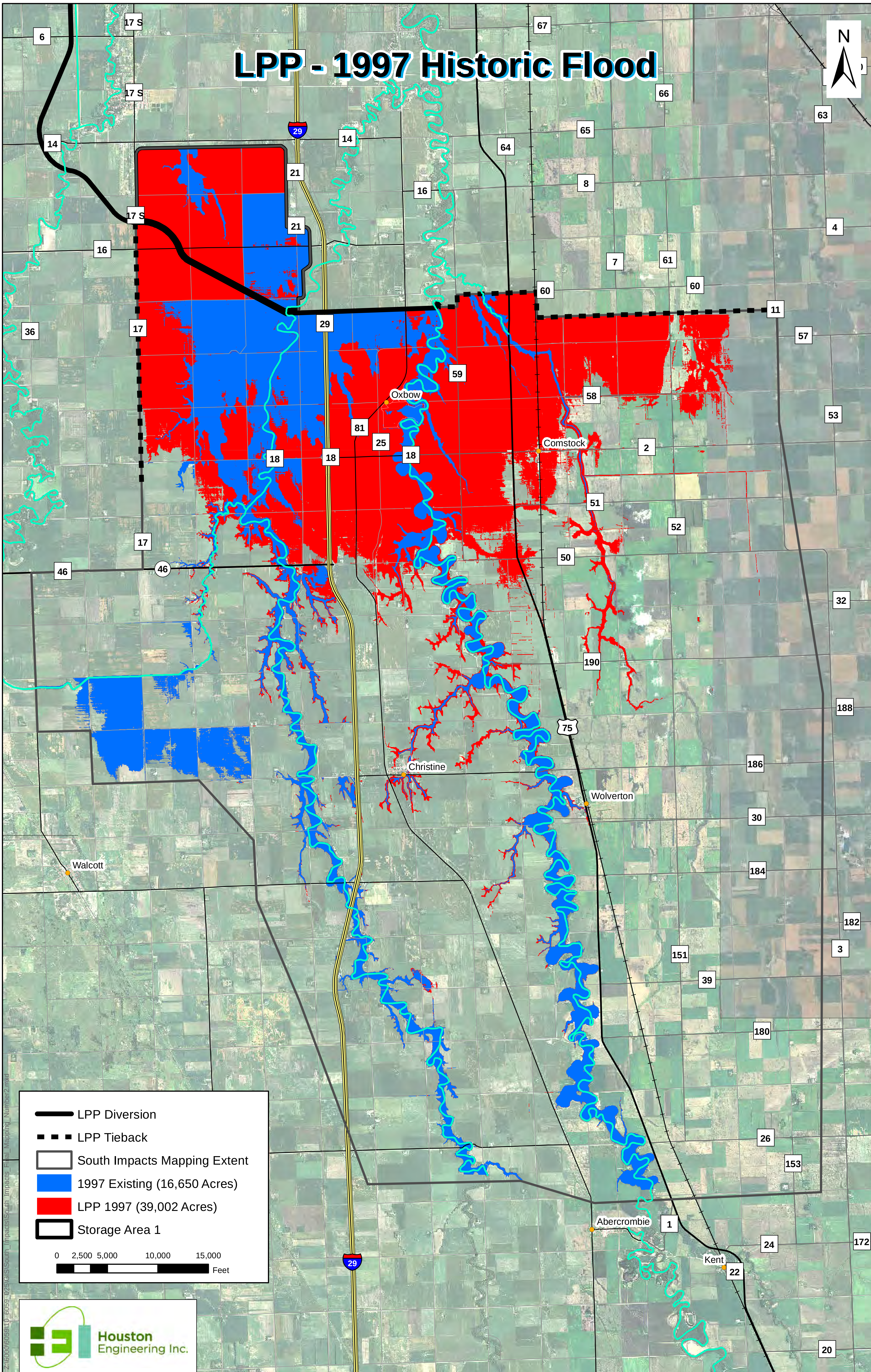
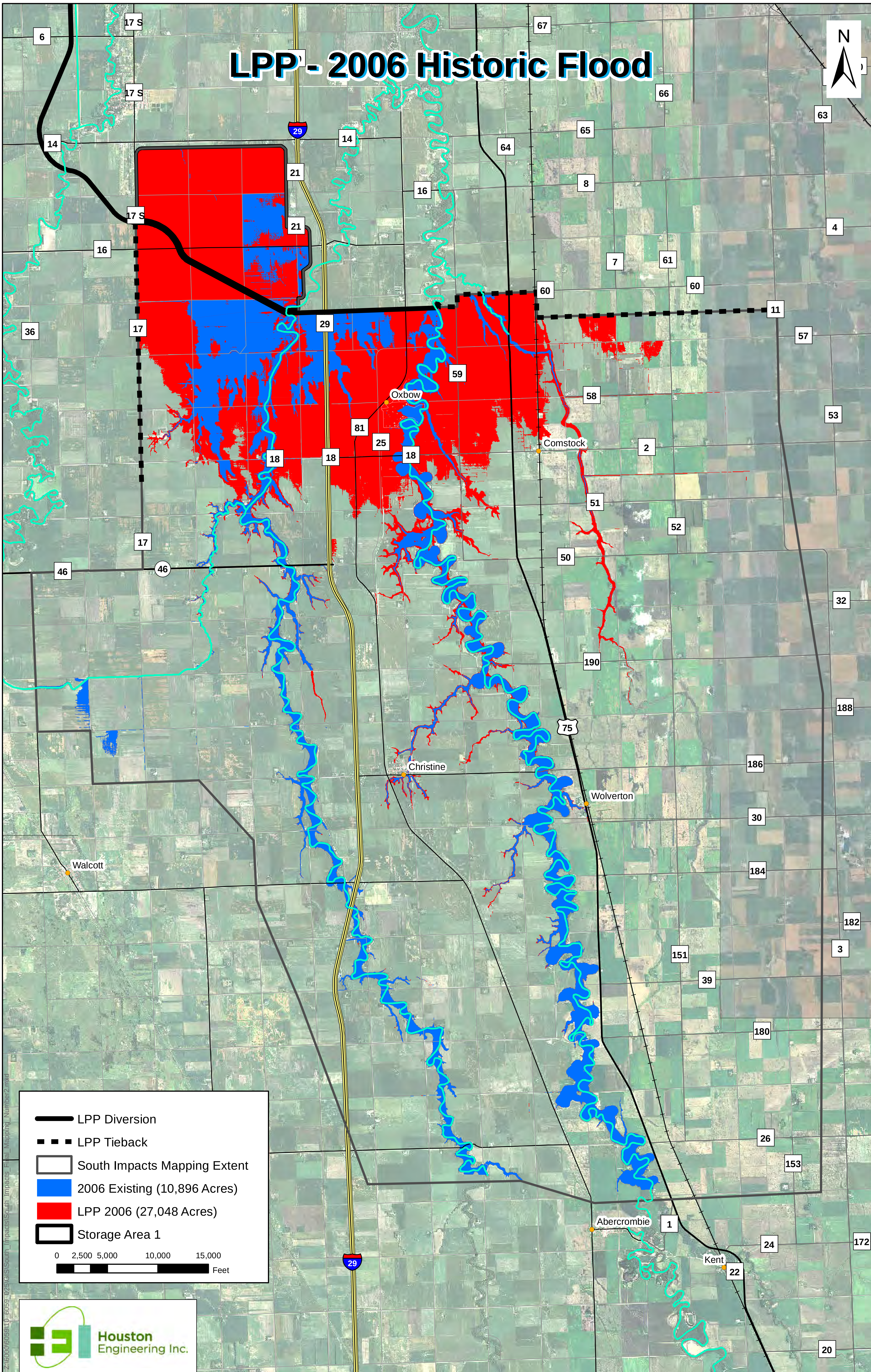
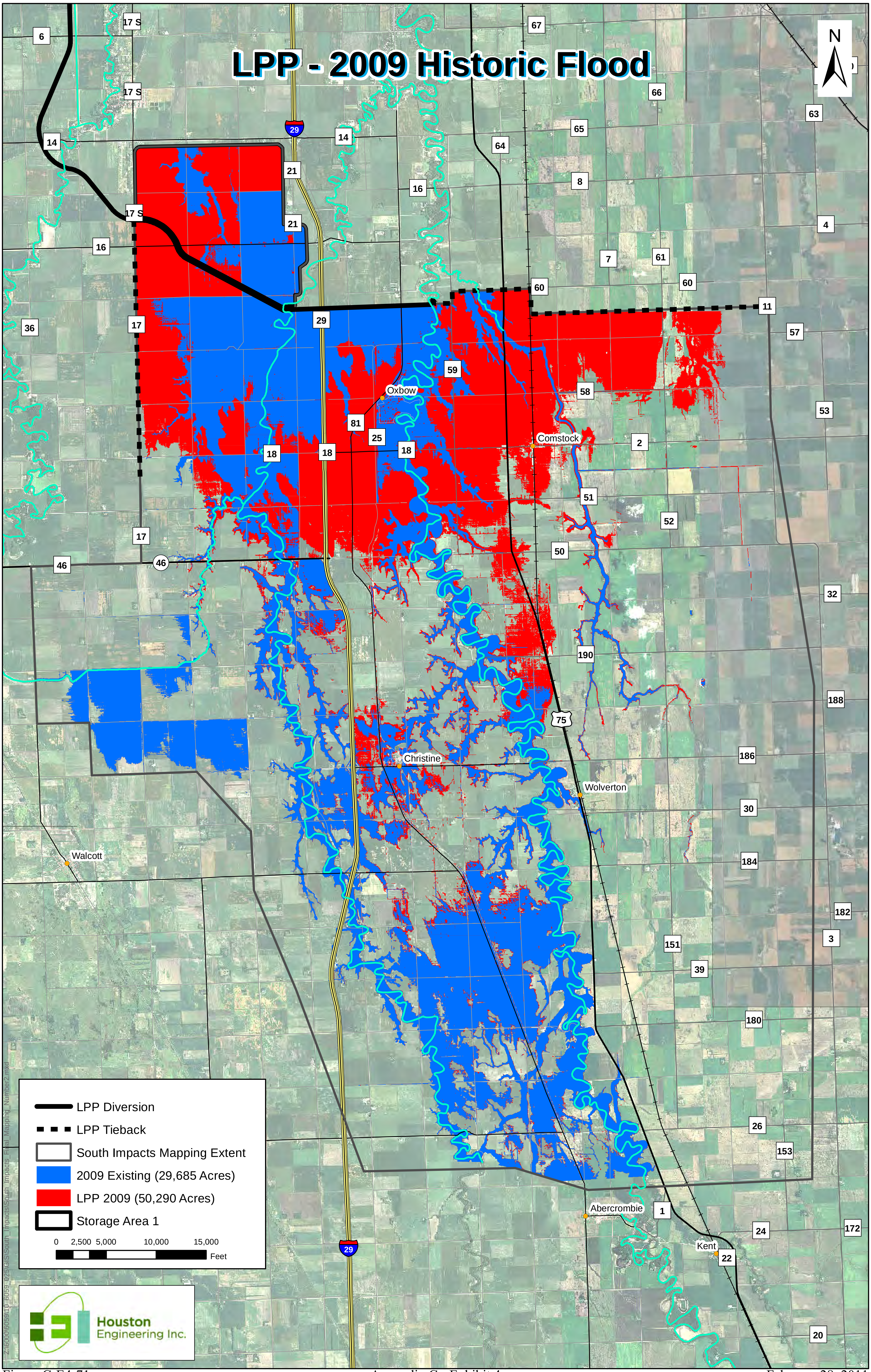


Figure C-E4-68 Appendix C - Exhibit 4 February 28, 2011


LPP - 1997 Historic Flood
N
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
1997 Existing (16,650 Acres)
LPP 1997 (39,002 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Houston Engineering Inc.


LPP - 2006 Historic Flood
N
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
2006 Existing (10,896 Acres)
LPP 2006 (27,048 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Houston Engineering Inc.
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent



LPP - 2009 Historic Flood
N
LPP Diversion
LPP Tieback
South Impacts Mapping Extent
2009 Existing (29,685 Acres)
LPP 2009 (50,290 Acres)
Storage Area 1
0 2,500 5,000 10,000 15,000
Feet
Houston Engineering Inc.
Oxbow
Comstock
Christine
Wolverton
Walcott
Abercrombie
Kent

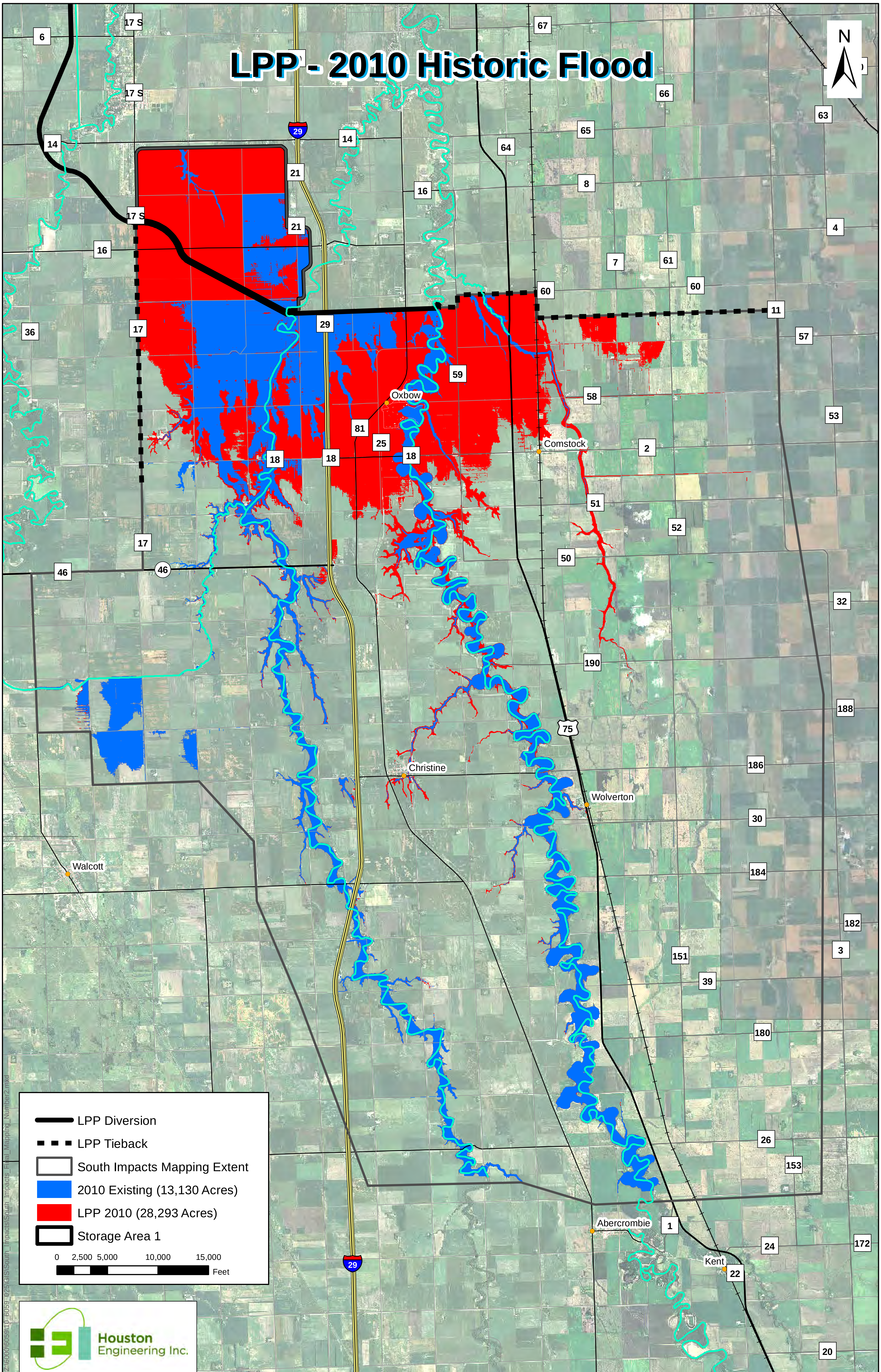


Figure C-E4-72 Appendix C - Exhibit 4 February 28, 2011

RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

APPENDIX C – HYDRAULICS WITH–PROJECT CONDITIONS

EXHIBIT 5 – QA/QC COMMENTS AND RESPONSES

Report for the US Army Corps of Engineers, and the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL: February 28, 2011

moore engineering, inc.

Consulting Engineering • Land Surveying

West Fargo • Fergus Falls

925 10th Ave. E. West Fargo, North Dakota
Phone: 701-282-4692 Fax: 701-282-4530

Memorandum

To: File

From: Stu Dobberpuhl, Mike Opat & Lyndon Pease- Moore Engineering, Inc.

Date: February 24, 2011

RE: Fargo-Moorhead Metro Feasibility Study- Phase 4

Ref: February 1-2, 2011 QA/QC review of existing conditions and with-project (LPP) models

---

Introduction:

Following the submittal of the January 31, 2011 report documenting the Phase 4 design of the Fargo-Moorhead Metro Feasibility Study, members of the design team (Moore Engineering, Houston Engineering, Barr Engineering & HDR Engineering) met at Moore Engineering to begin an internal QA/QC review process on the modeling that was completed at that point. With a final report expected to be submitted on February 28, 2011, the goal of the review was to identify any major issues with the models and have them corrected before the final report was released. Through this review, comments on minor issues having no potential impact on the results were also documented. While some of these comments were incorporated into the final models, many of them were deemed to be beyond the feasibility level of the study and many others simply could not be addressed given the timeline for this phase of the study.

The list of comments developed during this review is attached to this memo. Tasks were assigned to members of the design for follow-up on each of the comments. Regular progress meetings were convened to follow up on the status of each task and the attached tables were updated accordingly. Task No. 9 under the February 1st review comments includes a list of items that were identified for future updates and improvements. These tasks were further documented in Appendix C of the February 28, 2011 Phase 4 report.

FMM PHASE 4 INTERNAL QA/QC - January 31st - February 4th, 2011			
Task No.	Priority	Tasks Identified on February 1 for the February 28th submittal	Status
1	1	More Detailed Appendix B (HEI will consult with Aaron Buesing.) Task 1 - HEI will add detail. Aaron requested this, especially factored 2006 flows	
		This will be done for the 2/28/2011 Report Write-up.	Complete 2/28/2011
2		Determine if there is a need for additional detail in the Thompson-Drayton Reach (HEI will consult with Aaron Buesing.) Task 2 - Not necessary for feasibility study; Discussion of additional needs will be identified as part of Task 9	
		This will be done as a part of Task 9.	Complete under Task 9.
3	1	"Fixes" on the January 31st Models (Responsible: Barr)	
		a. Drain 14 Task 3a - Complete	√
		Completed.	√
		b. Lateral Structures Maple River included in Existing Conditions. Task 3b - Barr is working on, encountering stability issues	
		Completed.	√
		c. Small Side Ditch Inlet Structures Task 3c - Barr is using peaks on Tribs. If unable to complete, additonal needs will be identified as part of Task 9	
		Completed for the most part. Only two storage cells that need additional work. PH 3 culverts are too large. Appendix F will discuss this subject. The remaining work for those two areas can be done under Task 9.	√–
4	2	Extend the model to Emerson (Responsible: HEI) Task 4 - HEI is working on. May not get to 0.00 for FCP, since preliminary results for FCP is 0.08 impacts downstream. All historical events will be completed, with goal for results by Feb 11. Feb 7 historical events complete, and Feb 11 a few synthetic events complete (in order of priority: 100, 10, 500, and then 50 year).	
		February 28th Report will document this modeling effort. Expected completion was February 11th.	√
5	2	Runs down to Emerson for the LPP Task 5 - HEI will be working on, and will be completed for Feb 28th report	
		Based on discussions with the COE, the February 28th Report will document models extended to Drayton only. The results to Emerson will be included in an addendum.1. It is acceptable to report only to Drayton for the February 28th, 2011 submittal. The updated model with the Drayton to Emerson reach should be made available by March 15th, 2011 for additional District Quality Control. Unless something "strange" happens between Drayton and Emerson, the report shouldn't need to be ATR'd again. Therefore the updated report isn't needed on the 15th but should be provided by March 21st, 2011. Results to be presented for a location roughly 5 miles upstream of Drayton.	Complete by March 21st.
6	1	Inundation Maps upstream and downstream (Responsible: HEI) Task 6 - these are completed and posted on HEI's ftp site	√
		Updated impact maps and shapefiles for the 10-,2-,1- and 0.2 percent chance flood events were posted on HEI's ftp site on February 11th.	√
7	1	Finalize QC Review (Responsible: HDR - Big Picture, HEI - Check List) Task 7 - anticipated completion date was not set	
		Review by Mark and Greg is scheduled for completion on February 15th.	Complete by February 15th.
7.1	1	Update models to incorporate suggestions. Task 7.1 - will include a separate attachment as was done in Phase 3.1 report.	
		Updates for the February 28th submittal will be done by February 17th. Otherwise, the remaining updates will be done under Task 9.	Complete by February 17th.
8		Workplan for Gaging in 2011(Lead: Stu/Gregg) Task 8 - Aaron is coordinating, Monday Feb 7 is last day for input	
		Michelle Schneider/Aaron have a tentative plan for Data Collection. This was presented in Michelle Schneider's February 8th, 2011 email.	√
9		Recommendations for additional updates/improvements of the unsteady flow models (Lead: ~~Gregg/Stu~~ Lyndon) Task 9 - in progress	
		Lyndon will summarize Task 9 items.	Date to be determined.
10		Sensitivity Analysis for 1997 & 2009 (Responsible: Gregg/Brandon) Task 10 - Will have results for appendix, may fall into Task 9	
		This item will be put into the Task 9 Item list for tasks that will be done later.	Date to be determined.
11	1	Alternative Designs for LPP (Responsible: MEI)	
		a. No Storage Area 1	Complete H&H by March 4th.
		b. "Smart" Storage with minimum upstream staging	Complete H&H by March 4th.
		c. 3-inch impact downstream with minimum upstream staging & No "Smart" Storage & No Storage Area 1.	Complete H&H by March 4th.
		d. 6-inch impact downstream with minimum upstream staging & No "Smart" Storage & No Storage Area 1.	Complete H&H by March 4th.
		e. Alignment south of Oxbow	Complete H&H by March 31st.
		f. Off channel storage downstream of the FMM Diversion Project	Complete H&H by March 4th.
		Task 11 - all these items excluding (e) will be completed by ~~Feb 28th~~ March 4th~~, but~~ and will not be included in Feb 28th report	
		In progress!	

FMM PHASE 4 INTERNAL QA/QC - January 31st - February 4th, 2011

Task No.	Priority	Tasks Identified on Febuary 2nd for the February 28th submittal	Status
1	1	Volume check for storage areas. Maps will be generated for existing and proposed conditions. (Responsible: MEI) Task 1 - will need to verify impact of releasing SA volume from Fargo area. Will see if this affects volume for existing conditions.	
		Completed for previous version of the model. Need to verify that the February 15th models do not have any issues at Georgetown and other locations downstream.	√–
2	1	Check culverts on storage areas. (Responsible: ~~MEI~~ Barr) Task 2 - see Task 1 above	
		See Task 1. The remaining work can be done under Task 9.	√–
3	1	Sensitivity on Diversion Channel /Staging Interaction. (Responsible: Barr) Task 3 - complete, will make changes to LPP model once Task's 1 and 2 are complete	√
		In progress.	Complete by February 15th.
4		Diversion Channel Weir - Invert Elevation / Gates ? (Responsible: MEI) Task 4 - raising invert weir to 914.25 had no impact downstream; these findings will need to be documented. Aaron sees advantage of raising weir.	
		Analysis is done. Need to document in Appendix C.	√–
5	1	RRN Gates Open at the start of the simulation. (Responsible: Barr) Task 5 - this process has not yet begun	
		This item will be put into the Task 9 Item list for tasks that will be done later.	Date to be determined.
6	1	Verify Sheyenne River Pass Through flow (Responsible: Barr) a. "Turn Off" Horace to West Fargo Diversion Task 6a - will wait until Task's 1 and 2 are complete	
		Completed.	√
7		Sensitivity of 2009 Flood Event with current Balanced Hydrographs (Responsible: HEI) Task 7 - this is referred to with Day 1 (Feb 1) Task 10	
		This item will be put into the Task 9 Item list for tasks that will be done later.	Date to be determined.
8		Geometry differences between historic and synthetic events - Maple/Sheyenne Rivers (Responsible: MEI) Task 8 - Greg and Lyndon will look into differences	
		Completed.	√
9	1	Post Processing to completion (Responsible: HEI) Task 9 - working on, Aaron will follow up with HEC	
		Post Processing is an issue yet with RAS 4.1. Models can be post processsed with RAS 4.0 or 4.2 if RAS 4.1 doesn't work.	√

moore engineering, inc.
Consulting Engineering • Land Surveying
West Fargo • Fergus Falls

925 10th Ave. E. West Fargo, North Dakota
Phone: 701-282-4692 Fax: 701-282-4530

Memorandum

To: Greg Thompson, PE- Houston Engineering

From: Stu Dobberpuhl, Mike Opat & Lyndon Pease- Moore Engineering, Inc.

Date: February 24, 2011

RE: Fargo-Moorhead Metro Feasibility Study- Phase 4

Ref: February 20, 2011 QA/QC review of with-project (LPP) models by Houston Engineering

---

Introduction:

Moore Engineering (MEI) has reviewed the comments developed by Houston Engineering (HEI) after reviewing the Phase 4 unsteady flow models for the with-project (LPP) conditions. The checklist used by HEI to conduct the review is attached this memo. MEI's responses to these comments are included in red text within the checklist, or by notes added to the column on the right side of the list. Many of the comments were noted, but did not require a response. A large number of the comments were identified as items that should be addressed with future improvements and updates to the models. The timeline associated with this phase of the study would not allow for allow for all of these comments to be addressed and some were not deemed to be applicable to the feasibility level of the study. Any comments that had the potential to measurably impact the results were addressed and incorporated into the final Phase 4 models.

HEC-RAS Modeling Check List

Project Number: 6059-025	
Project Name/Description: Fargo Moorhead Metropolitan Feasibility Study	
Model Name: 100yr.prj	
Model Developed By: Barr Engineering	Model Checked By: Houston Engineering Inc.
Model Date: 2/10/2011	Model Check Date: 2/20/2011
Project Plan: 100yr_20110208_Cstr	
Project Geometry: ND East_20110208_Cstr	
Project Flow: NDE 100yr 20110208_Bstrg	

√ Indicates everything checks ok and no additional action is necessary

#		General Information/Checks	Comments	Note
1	√	What version of HEC-RAS was used?	4.1	NC
2		What datum is the survey data and the HEC-RAS model in (NGVD29 or NAVD88)?	Not documented in the model Response: Model is in NAVD 88	(1)
3		Is the datum noted in the "description" box of the main project screen?	No	(1)
4		Is the model georefenced and if so what is the horizontal projection?	Yes it is geo-referenced. Projection is not indicated within the model.	(1)
5		Is the stationing reference noted in the "description" box of the main project screen?	No	(1)
6		Does the stationing in the HEC-RAS model match the map	Not Checked	NC
7		Is the model in the same datum as the mapping? (mapping should be NAVD88)	Not Checked - No Mapping	NC
8		Are photos attached to cross-sections and structures (i.e. photos facing downstream)?	No	NC
9		Are there any modeling or mapping anomalies that should be pointed out to a reviewer?	Overlapping cross sections may cause mapping issues. Cross sections will need to be adjusted during mapping.	(1)
10		Are the "Plan" files clearly labeled/named?	No. Unsure of naming convention. Response: Table provided in Appendix C describes each plan	(1)
11		Was GeoRAS used to create your geometry schematic?	Yes	NC
12		Were cross-sections created using both survey data and digital topography (i.e. LiDAR, 2ft topo, etc.)?	Yes. Parts of the diversion cross sections were from lidar, it is assumed that other parts were designed with channel modification techniques.	NC
13		Is the unsteady model computation time appropriate?	Yes, Warm up time step is 30 seconds, for 50 time steps, then the time step is 5 minutes. Existing conditions is set at 5 min. Iterations = 40 on some, 20 on others.	NC
14		If there are options checked on the plan file do these make sense?	Yes.	NC
15		If the tolerances have been changed are these appropriate?	Yes. Tolerances are 0.03' for XS and 0.1' for storage areas. Same as Ex Cond.	NC

#		Hydrology Checks	Comments	
16		Has the hydrology been reviewed internally?	Yes, Hydrology was compared to existing conditions for the historic events	NC
17		Has the hydrology been reviewed and approved?	n/a	NC
18		Is a write-up of the hydrology included?	n/a Note: See Appendix A	NC
19		Have the reach boundary conditions been reviewed internally?	n/a	NC
20		Is the boundary condition a "Known W.S."?	n/a	NC
21		Do the 10-, 50-, 100-, and 500-yr flows entered in RAS match the flow hydrographs calculated in your model/hydrologic calculations? Are they labeled in HEC-RAS?	Not Checked	NC
22		Are the 10-, 50-, 100-, and 500-yr flow hydrographs labeled as such in the HEC-RAS flow editor?	Yes, Unsteady model references .dss files with corresponding event frequency.	NC

23		Are there any negative flow hydrographs that may indicate correction hydrographs within HEC-RAS?	Yes, to counter balance inflows required for stability in diversion channel.	(1)
24		Do the output hydrographs from HEC-RAS have any abrupt changes?	Yes, ND DIV US between Red and WRR. However, change in flow direction seems reasonable.	(1)
25		Are storage areas adjacent to river reach cascading flow ahead of the river?	Not Checked	NC
26		Do the profiles through the entire hydrograph make sense?	15MAR2006 2400 to 17MAR2006 2400 profile does not display correctly. Likely due to inverse slope in the upper end of ND DIV, ND DIV EAST reach. Response: This is caused by the presence of a pilot channel included in the model for stability. This is not an issue.	NC
27		Do any river reaches have negative flow?	Yes. Flows on ND DIV, ND DIV US	NC

#	Hydraulics Checks		Comments	
28		Is a write-up of the hydraulics included?	No. Response: See Appendix B and Appendix C	
29		Do discharge values match hydrologic analysis results?	Not Checked	NC
30		Do the locations where discharges change in the model agree with locations on drainage area map?	Yes	NC
31		Do the discharges change along the stream at the appropriate location?	Yes	NC
32		Have the "Summary of Errors, Warnings, and Notes" been reviewed and addressed for each profile and floodway?	It was reviewed. Many "Divided Flow", "Conveyance Ratio" warnings. Divided flow occurs where conveyance is allowed outside of diversion. Levees are not set at top of diversion bank. Example: ND DIV, ND DIV EAST, XS 119218.	(1)
33		Has Check-RAS been run, and each issue addressed?	Not Checked	NC
34		For any remaining Check-RAS issues, has the Check-RAS output been annotated?	Not Checked	NC
35		What is the boundary conditions for the starting water surface elevation?	n/a	NC
36		Have you reviewed the HEC-RAS profiles?	yes, 100-year	NC
37		Do profiles cross for different return periods?	Profiles do not plot correctly for the first few days. It is likely a plotting issue since the Diversion profile is backwards between Sheyenne River and Wild Rice River. Response: This is caused by the presence of a pilot channel included in the model for stability. This is not an issue.	NC
38		Have you checked the water surface elevations to make sure there is no negative water surface slope?	Negative slopes occur in ND DIV, ND DIV EAST, Wild Rice to Sheyenne Area where the profile is backwards.	(1)
39		Have you used the 3D viewer (X-Y-Z plot) to review the 100- and 500-yr floodplains and floodway?	Not Checked	NC
40		Are the WSELs on tributaries lower than the WSELs on the main channel at or near the confluence?	no.	NC
41		Are there drawdowns on the profiles?	Not Checked	NC
42		What is the source for your Manning's N values?	Not documented in model	(1)
43		Has a summary of the range of Manning's N values been created?	Not documented in model	(1)
44		Do the Manning's N values seem reasonable?	Yes. Is there a reason why there is 0.03 and 0.04? Also, there are many horizontally varying breaks where n values remain the same. It would be cleaner if this was fixed.	(1)
45		Do the expansion and contraction coefficients seem reasonable?	Not set for Unsteady flow	NC
46		Are the cross sections lengths appropriate for the model reach?	Length of diversion cross sections are typically 3000 feet long. Will the spoil piles affect conveyance?	(1)
47		Are there interpolated cross sections?	Yes.	NC

48		Have Cross-Sections been placed at least every 1000 feet?	No, there are 72 cross sections in ND DIV, ND DIV East that are greater than 1000' apart. Response: With the relatively straight alignment and constant slope, this spacing was deemed to acceptable.	(1)
49		Are the WSELs for every cross section lower than the cross section end points?	No. The cross sections adequately provide the modeled conveyance.	NC
50		Are the cross sections perpendicular to flow?	Yes	NC
51		Do the cross sections locations model constrictions and expansions in the floodplain?	Yes	NC
52		Do the cross section locations model structures in floodplains	Yes	NC
53		Do cross sections overlap storage areas?	Yes, however levees are placed so conveyance does not seem to be double counted.	NC
54		Do the locations of bank stations make sense?	Yes	NC
55		At road crossings, are there actual road names in the "description" box of your structure data?	No Road crossings modeled on diversion	(1)
56		Are all road crossings being modeled?	No. It appears as though bridges are not modeled.	(1)
57		Are you using the correct "bridge modeling approach" for each bridge?	n/a	NC
58		Is the top of bridge roadway being properly defined?	n/a	NC
59		Is the correct top-of-road elevation, low-chord elevation, and deck width being modeled?	n/a	NC
60		Are the proper coefficients being used for weirs, pressure, and/or culvert flows?	ND DIV East Inline structures have coefficient of 2.6, consistent with remainder of model. ND DIV East Lateral Structures have coefficients of 2.6, remainder of 1.	(1)
61		Are levees used, and if so, is a description included?	Levees are used. I haven't seen a description. Most are likely constructed spoil banks. Response: Levees are in fact used to reflect spoil banks. Levees were placed in model at inside toe of the spoil banks.	(1)
62		Are ineffective flow areas modeled correctly?	Not Checked	NC
63		Have ineffective flow area been placed at correct stations/elevations?	Not Checked	NC
64		Do the ineffective flow areas contain any drastic changes in width?	Not Checked	NC
65		Are the ineffective flow areas being modeled correctly at bridges that are not overtopped?	Not Checked	NC
66		Is there ineffective flow areas where high ground prevents flow?	Not Checked	NC
67		Is there appropriate control for split flow?	Not Checked	NC
68		Are split flows at lateral overflow weirs set up correctly?	Not Checked	NC
69		Are all lateral flow structures connected to another reach or storage area?	Yes	NC
70		Are all storage areas connected to another storage area or reach via lateral structure or storage area connection?	Yes	NC

Additional Notes:

Numerous interpolated cross sections on diversion

Junction and cross sections do not line up at Red River/ND DIV US. Cross sections in downstream reach are spatially placed upstream of structure.

Wild Rice River ND LS 75000 conveys water from WRR to Storage Area 1. This essentially bypasses the inline structure on the diversion. Does the inline structure have the additional capacity to convey the water from WRR to storage area? Or is there enough room to construct all of the weirs that are modeled in that location? This is likely a final design consideration.

Wild Rice cross sections downstream of diversion do not follow channel centerline.

Response Notes:

Some responses were provided in 'red' text above.

Comments noted with "NC" were deemed not to be comments or require no response

Comments noted with (1) will be addressed during future improvements and modifications to the models, after the February 28, 2011 submittal.

moore engineering, inc.
Consulting Engineering • Land Surveying
West Fargo • Fergus Falls

925 10th Ave. E. West Fargo, North Dakota
Phone: 701-282-4692 Fax: 701-282-4530

Memorandum

To: Mark Forest- HDR

From: Stu Dobberpuhl, Mike Opat & Lyndon Pease- Moore Engineering, Inc.

Date: February 26, 2011

RE: Fargo-Moorhead Metro Feasibility Study- Phase 4

Ref: February 25, 2011 QA/QC review of with-project (LPP) models by Mark Forest- HDR Engineering

---

Introduction:

Moore Engineering (MEI) has reviewed the comments developed by HDR Engineering (HDR) after reviewing the Phase 4 u nsteady flow models for the with-project (LPP) conditions. HDR completed a QA/QC review if the 2009 calibration unsteady flow model, the synthetic event models, and the LPP alternative models and provided one set of combined models. The comments for the calibration model and the synthetic event models are addressed by Houston Engineering in Appendix B of the February 28, 2011 Phase 4 report. The comments on the LPP models were extracted from the combined comment document and included in this memo. The LPP models were developed by Moore Engineering (MEI) and Barr Engineering (Barr) and the responses to HDR's comments were developed by MEI. The responses are noted in red text following each comment.

With the timelines involved with this phase of the study, most of the submitted comments could not be fully addressed in the final models. None the comments appeared to have the potential to significantly affect the results of the final models included in the February 28, 2011 submittal. The most important finding from HDR's review is that the current LPP models are suitable for the feasibility level of this study.

HDR Comments- Proposed Condition for LPP

42. Many of the comments above pertain to the proposed condition model also. Noted.

43. The 100-year model goes unstable near the very end of the simulation. This issue went through extensive debugging, including involvement with programmers at the Corps of Engineers Hydraulic Engineering Center, without resolution. This issue has been identified in Appendix C as a task to be addressed with future improvements and updates to the models.

44. I am assuming that independent verification has been performed of the data inputs to assure that the data represented in the model geometry matches the preliminary plans. I did not perform these checks. Barr Engineering coordinated the designs for the hydraulic structures included in the models to be consistent with what is included on the plans for those structures. The project layout plans developed by Houston were developed from the geometry included in the final models.

45. The design concept requires human intervention based on operational criteria for downstream flows and predicted inflows. Have alternatives been explored that do not require gates? Assuming that other outlet configurations have been explored and found to be deficient, how much risk is associated with the range of potential system flow contributions and variability in how the operating criteria might be employed? The gated structure design selected over other alternatives during earlier phases of the feasibility study. The Operations Plan that will be developed for this project is expected to address the operational criteria for the entire system.

46. Area 1 has a bottom elevation that is 25 to 30 feet higher than the diversion channel. Would additional storage benefit be obtained from lowering the bottom of this storage area to gain additional storage volume? While the elevation differential does not appear to be as large as noted (14-17 feet), the potential for additional storage is noted for further study.

47. Minor differences in flow volume are noted between the existing and proposed condition in the downstream reaches that appear to be due to changes in residual storage that occurs in many of the storage areas. Elimination of overflow into these areas as a result of project improvements would result in reductions to these residual volumes that remain in these storage areas after passage of the peak flow. This would be an anticipated result. How much potential residual storage occurs after an event may be difficult to quantify without more drainage structure data. The issue is addressed in Appendix C. Elimination of the retained storage has also been identified for future resolution.

48. The flow conditions at the diversion structures (Figure 25) are complex and vary with stage. This area would likely benefit from the future two dimensional capabilities of HEC-RAS. Agreed.

49. A very large flow value is reported for several of the storage area connections such as DRASC33 (see Figure 26) and many of the OSLSC connections (Figure 27) that should be checked. This reach has specifically been identified for the addition of greater detail and refinement with future updates and improvements to the models (see Appendix C).

50. Attached are some locations in the post-processing of the results that appear to be suspect. In Figure 28 and 30, the abrupt edges either mean that you have a roadway or other “levee-like” structure that is impounding the water or there is overflow that is not being accounted for. If it is an artificial impoundment, how will we ultimately need to treat an embankment of unknown integrity? This reach has specifically been identified for the addition of greater detail and refinement with future updates and improvements to the models (see Appendix C).

51. In other locations, the mapping shows areas of isolated ponding with no apparent way for water to get there (Figure 29). Those locations should be verified. This appears to be an issue with the software used for the mapping and there should not be any issue with actual modeling results.

52. For the post-project condition upstream of the diversion (Figure 31), we will not be able to consider water contained by “levee-like” structures that are not compliant with 44 CFR 65.10 if we are increasing the water surface against those embankments. If there is a need to constrain the water at those locations, the project costs would need to include constructed levees at these locations that will meet FEMA’s minimum standards. Noted.