FINAL TECHNICAL MEMORANDUM

FM DIVERSION POST-FEASIBILITY SOUTHERN ALIGNMENT ANALYSIS: VE-13, NORTH OF WILD RICE RIVER, SOUTH OF OXBOW

Final – October 10, 2012

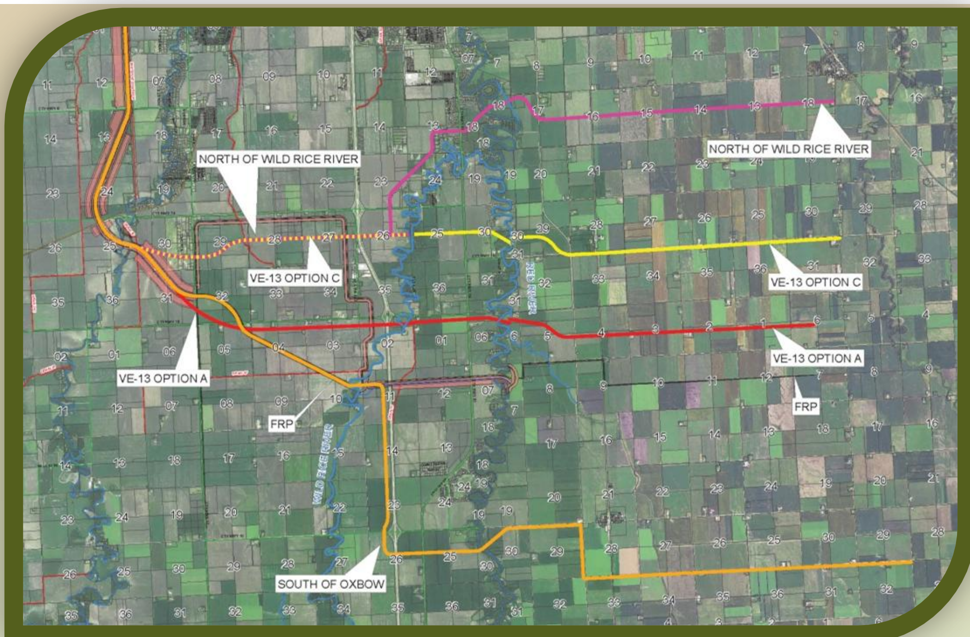


TABLE OF CONTENTS

Tables

Figures

Appendices

EXECUTIVE SUMMARY

The Fargo-Moorhead Area Diversion (FM Diversion) Project was developed as part of a feasibility study conducted by the U.S. Army Corps of Engineers (USACE) to provide flood risk management for the Fargo-Moorhead area and is presented in the Integrated Final Feasibility Report and the Final Environmental Impact Statement (FR/FEIS) dated July 2011. The project consists of a 20,000 cfs diversion channel with upstream staging and storage, and was referred to as the Locally Preferred Plan (LPP, aka North Dakota Diversion) in the FR/FEIS. This plan is now known as the Federally Recommended Plan (FRP).

The proposed FRP begins approximately 4 miles south of the confluence of the Red River of the North (RRN) and Wild Rice River and extends west around the cities of Horace, Fargo, West Fargo, and Harwood. The project includes gated control structures at the RRN and Wild Rice River. The 36 mile long diversion channel also includes aqueducts that allow low flows in the Sheyenne and Maple Rivers to cross over the diversion channel, in addition to intersecting the Rush and Lower Rush Rivers and several drains. The diversion channel ultimately re-enters the RRN downstream from the confluence of the Sheyenne River and RRN near the city of Georgetown, MN.

This study, referred to as the Post-Feasibility Southern Alignment Analysis (PFSAA) evaluates and compares several alternative alignments to the FRP that have the potential to increase project value by further optimizing the project functionality for the estimated cost and impacts. The analysis generally includes alternative alignments and features for the area upstream of the Sheyenne River aqueduct site, including staging and storage areas. These are referred to as the southern alignment alternatives. Examples of how value may be increased include reducing project impacts or costs, by incrementally increasing the properties benefitting from risk reduction for the southern portion of the FM Diversion project, or optimizing the project's performance upon a set of defined PFSAA assessment criteria.

The four base alternative alignments for this comparative analysis to the FRP, and the perceived value of investigating it further are described below:

1. **VE-13, Option A (VE13A)**, shown in Figure 3 was conceptually identified as part of a USACE Value Engineering proposal (VE-13) developed during 2011 post-feasibility value engineering work. The alternative possibly adds value and reduces cost by eliminating Storage Area 1, eliminating the Wolverton Creek Control Structure and decreasing tieback embankment length.
2. **VE-13, Option C (VE13C)**, shown in Figure 4 was conceptually identified as part of a USACE Value Engineering proposal (VE-13) developed during 2011 post-feasibility value engineering work. The alternative possibly adds value and reduces cost by eliminating Storage Area 1, eliminating the Wolverton Creek Control Structure, decreasing tieback embankment length and reducing staging elevation at communities of Oxbow, Bakke, Hickson, Christine, and Comstock and at the Richland County line.
3. **South of Oxbow (OXBOW)**, shown in Figure 5, possibly adds value by inclusion of communities of Oxbow, Hickson, Bakke, and Comstock in the flood damage reduction area.
4. **North of Wild Rice River (NWRR)**, shown in Figure 6, possibly adds value and reduces cost by eliminating Storage Area 1, eliminating the Wolverton Creek Control Structure, eliminating the Wild Rice River Control Structure and Fish Passage System, decreasing tieback embankment length and reducing staging elevation at communities of Oxbow, Bakke, Hickson, Christine, and Comstock and at the Richland County line.

The four base alignment alternatives for this comparative analysis to the FRP were generally established using the following five stages of development:

1. Using the features and estimated costs and impacts of the Federally Recommended Plan (FRP) as a basis, several realignments of the southern portion of the project (upstream of the Sheyenne River aqueduct) were proposed. These include alternatives identified during value engineering (VE13A and VE13C) as well as alternatives identified by the local project sponsors (NWRR and OXBOW). The alternative alignments were proposed as options to possibly increase project value; the PFSAA analysis is structured to evaluate the value of the alternatives.
2. The alignment alternatives were analyzed using the same design methodology and assumptions for consistent comparison to the FRP. These alternatives are referred to as the PFSAA base alternatives.
3. The PFSAA base alternatives were subjected to the assessment criteria comparative analysis, factor scoring and ranking.
4. During analysis of the PFSAA base alternatives, concurrent analysis work (outside of the PFSAA analysis) was performed on infrastructure features that were not included in the FRP, such as a gated inlet to the diversion and increasing flows through the risk reduction area.
5. The estimated costs for the PFSAA base alternatives and the FRP were modified to include the estimated costs for the bundles of infrastructure enhancements.

The study includes two alignments (VE-13 Option A and VE-13 Option C) that relate to a USACE Value Engineering proposal (VE-13) developed during 2011 post-feasibility value engineering work. The VE-13 proposal recommends the relocation of the RRN outlet control structure and associated southern alignment project features north of the current proposed FRP location. The study also includes two alignments identified by the local project sponsors, including the South of Oxbow and North of Wild Rice River alternatives. The South of Oxbow (OXBOW) alternative relocates the diversion channel and associated features south of the communities of Oxbow, Hickson, and the Bakke Subdivision. The North of Wild Rice River (NWRR) alternative relocates the diversion channel and associated features north of the confluence of the RRN and Wild Rice Rivers. The alignments included in this study are identical from the Sheyenne River aqueduct northward to the diversion outlet to the RRN and are shown in Figure 1. The alternative alignments are investigated with the intent of characterizing the value of each alternative relative to the FRP based on a set of assessment criteria developed during the June 19, 2012 VE-13 workshop and modified during the August 15-16, 2012 Local Sponsor Local Consultant Technical Team (LSLCTT) Integration Workshop. The assessment criteria include:

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

The different assessment factor categories were originally weighted based on their perceived importance using group consensus during the June 19, 2012 VE-13 workshop. This analysis was revisited again during the August 15-16, 2012 LSLCTT Integration Workshop where assessment factor scores were computed.

Estimated costs for construction features, lands and easements for each alternative were developed for consideration in conjunction with the characterization of the assessment criteria listed above. The design considerations used for comparing the base PFSAA alternatives to the FRP are consistent with methodology and assumptions presented in the Phase 4 FRP April 19, 2011 A/E deliverable to the USACE.

During the August 2, 2012 LSLCTT meeting, the PFSAA base alternatives were presented and the decision was made to bundle the estimated cost of PFSAA base alternatives with the estimated cost of features developed as part of separate concurrent studies. These include the *Final Technical Memorandum, AWD-00002 – Flows Through Flood Damage Reduction Area* study, dated July 16, 2012 and the *Draft Technical Memorandum, Diversion Inlet Gate Analysis* study, dated August 7, 2012. The estimated cost of bundled alternatives include the addition of gates on the diversion inlet, rather than a fixed weir as proposed in the FR/FEIS and a target stage of 35 feet at the RRN Fargo Gage, rather than 31 feet as proposed in the FR/FEIS. The estimated cost of additional features was included for all base alternatives, including the FRP, VE13A, VE13C, NWRR, and OXBOW alternatives. The NWRR alternative also included estimated costs for a second bundle that added a levee around the communities of Oxbow, Hickson, and the Bakke Subdivision. The assessment factor scores and estimated cost for the bundled alternatives developed during the August 15-16 LSLCTT Integration Workshop and costs are presented in the table below.

Assessment Factor Score and Cost Comparison for Southern Alignment Alternatives

Alternative	Assessment Factor Score (Lower Score Indicates a More Favorable Alternative) (%)	PFSAA Cost Project Features Upstream of the Sheyenne River (Sta. 1514+00) Estimated Cost with Bundles [(2) (3)] ($)	PFSAA Cost All Project Features Estimated Total Cost with Bundles [(2) (3)] ($)
FRP	100%	630M	1,767M
VE13A	87%	561M	1,685M
VE13C	88%	573M	1,697M
North of Wild Rice River (NWRR)	107%	607M	1,728M
North of Wild Rice River (NWRR) + Levee at Oxbow	98%	614M	1,738M
South of Oxbow (OXBOW)	104%	628M [(1)]	1,773M [(1)]

(1) During the August 2, 2012 LSLCTT meeting, HMG was directed not to bundle infrastructure enhancements for the South of Oxbow alternative. However for consistency for the comparison to the FRP, a bundled cost has been estimated and is shown.
(2) Estimated costs do not include operation and maintenance costs or escalation costs.
(3) Estimated costs include contingency.

VE13A has the lowest assessment factor score with VE13C being very close. The difference between the scores is small enough that the scores could be considered equal for this type of qualitative comparison. Comparing the assessment factor score with the cost can assist in deciding which PFSAA alternative best meets project objectives and provides the greatest value. Because it has the lowest cost and assessment factor score of the two VE options, VE13A with flows through the flood damage reduction area and with diversion inlet gates was identified as the technically recommended alternative during the August 15-16 LSLCTT Integration Workshop.

1 BACKGROUND AND OVERVIEW

The Fargo-Moorhead Area Diversion (FM Diversion) Project was developed as part of a feasibility study conducted by the U.S. Army Corps of Engineers (USACE) to provide flood risk reduction for the Fargo-Moorhead area and is presented in the Integrated Final Feasibility Report and the Final Environmental Impact Statement (FR/FEIS) dated July 2011. Readers unfamiliar with the project should reference these documents for additional detail about the project. The project consists of a 20,000 cfs diversion channel with upstream staging and storage, and was referred to as the Locally Preferred Plan (LPP, aka North Dakota Diversion) in the FR/FEIS. This plan is now known as the Federally Recommended Plan (FRP).

The proposed FRP begins approximately 4 miles south of the confluence of the Red River of the North (RRN) and Wild Rice River and extends west around the cities of Horace, Fargo, West Fargo, and Harwood. The project includes gated control structures at the RRN and Wild Rice River. The 36 mile long diversion channel also includes aqueducts that allow the Sheyenne and Maple Rivers to cross over the diversion channel, and also crosses the Rush and Lower Rush Rivers and several drains. The diversion channel ultimately re-enters the RRN downstream from the confluence of the Sheyenne River and RRN near the city of Georgetown, MN.

The Post Feasibility Southern Alignment Analysis (PFSAA) report was developed to compare four base alternative alignments to the FRP. Southern alignment alternatives compared in the PFSAA are:

1. Federally Recommended Plan (FRP)
2. VE-13 Option A (VE13A)
3. VE-13 Option C (VE13C)
4. North of Wild Rice River (NWRR)
5. South of Oxbow (OXBOW)

1.1 PURPOSE OF STUDY

The purpose of this study, referred to as the Post-Feasibility Southern Alignment Analysis (PFSAA) is to evaluate and compare alternative alignments that have the potential to increase project value. Value is defined as:

> "…the relationship between functions and resources where function is measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish that function. Therefore, this process focuses on creating a best value solution by identifying the most resource efficient way to reliably accomplish the functions that meet the performance expectations for the project" as defined by USACE in Report No. CEMVP-VE-FY12-02_FMM Outlet, *Value Based Design Charrette, Outlet Structure & Diversion Reach 1,* dated December 2011.

In the context of the PFSAA, various assessment criteria were used to characterize the function and performance requirements of the southern alignment alternatives. Estimated construction cost was used to characterize the resources invested. In this way, this assessment aims to characterize and compare "value" as defined, for the alternatives versus the FRP.

Examples of how value may be increased include reducing project impacts or costs, or by incrementally increasing the properties benefitting from risk reduction for the southern portion of the FM Diversion project, which generally includes the area upstream of the Sheyenne River aqueduct. The FRP alignment for this area is shown in Figure 2 and Exhibit H9 and includes hydraulic control structures on the RRN and Wild Rice River; a control structure for Wolverton Creek; an inlet weir for the diversion channel; a storage area (SA 1); and a staging area. The communities of Oxbow, Hickson, Bakke, Christine, and Comstock are located in the FRP staging area.

The alternatives included in this study are shown in Figure 1 and described in Section 1.2 of this technical memorandum. The designs and costs presented in this technical memorandum were developed using the same general design assumptions and to a comparable feasibility-level as those presented in the FR/FEIS, and are presented in the following sections.

1.2 ALTERNATIVES

The study includes two alignments (VE13A and VE13C) that relate to a Value Engineering proposal (VE-13) developed during 2011 post-feasibility value engineering work, which recommends the relocation of the RRN outlet control structure and associated project features north of the Wolverton Creek and RRN confluence (see Figure 1). The goal of these proposed alignments is to increase project value through providing potential cost savings by eliminating the Wolverton Creek structure and FRP Storage Area 1 (SA 1), while providing the same level of protection through the flood damage reduction area as the FRP. Though similar, the alignments result in different residential and non-residential structures being included on the flood risk reduction side of the project and different impacted property at the FRP staging area.

The study also includes two alignments that could reduce project impacts in the current FRP staging and storage areas. Study of NWRR and OXBOW were initiated by the Local Sponsors. During the southern alignments alternatives analysis, the alternatives initiated by USACE (VE13A and VE13C) as well as the alternatives initiated by the Local Sponsors (NWRR and OXBOW) were discussed and included in the comparative assessment. The OXBOW alternative relocates the diversion channel and associated features south of the communities of Oxbow, Hickson, and the Bakke Subdivision. The NWRR alternative relocates the diversion channel and associated features north of the confluence of the RRN and Wild Rice River.

The alignments as defined at this time are included in this study and shown in Figure 1. Alignments may be revised during final design. The alternatives are identical from the Sheyenne River aqueduct downstream to the outlet, but include varying alignments and project features upstream of the Sheyenne River aqueduct (commencing eastward from FRP diversion centerline Sta. 1514+00). The alternative alignments are changes to the southern portion of the FRP that could potentially offer cost savings and increased value across multiple categories of the assessment factors listed below. The design considerations, cost estimating methodology, and impact mitigation methodology is the same for all alternatives, allowing an objective comparison, although some criteria are subjective.

The alternative alignments are investigated with the intent of characterizing the value of each alternative relative to the FRP based on a set of assessment factors developed during the June 19, 2012 VE-13 workshop and modified during the August 15-16, 2012 Local Sponsor Local Consultant Technical Team (LSLCTT) Integration Workshop:

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

Estimated costs for each alternative are presented for consideration in conjunction with the characterization of the factors listed above.

1.2.1 FRP

The Federally Recommended Plan (FRP), shown in Figure 2, is the plan developed during feasibility and the basis for the project Final Environmental Impact Statement and Record of Decision. The downstream reaches of the FRP are currently undergoing post-feasibility design. Upstream of the Sheyenne River aqueduct, the FRP alignment roughly follows a line to a point on the Wild Rice River in Section 10 of Pleasant Township that is approximately 1.25 miles south of Cass Highway 16 (CH16). The alignment between the Wild Rice River and RRN follows an east-west line. The FRP includes a tie-back embankment which ties off to existing high ground directly east of the RRN Structure in Minnesota and an overflow embankment parallel and immediately east of Cass Highway 17 (CH17). These embankments are intended to contain floodwaters, resulting in the staging of floodwater upstream of the project to prevent downstream impacts. The FRP also includes a water storage area (Storage Area 1) which augments the staging area upstream of the project by storing approximately 50,000 acre-feet of water during the 1-Percent and 0.2-Percent Chance Events. This encloses an area roughly bordered by CH14 and CH16 on the north and south and Interstate Highway 29 and CH17 on the east and west.

The current FRP has not changed significantly since the feasibility FRP (previously referred to as LPP) was developed in April 2011. Between April 2011 and July 2012, hydraulic models have been updated upstream of the project and the tie-back embankments are now intended to be designed based on dam design standards rather than levee standards. The determination of the top of embankment elevation is discussed in more detail in Section 2.2 of this report. The design and cost estimates for the FRP are updated in this report to reflect this change.

1.2.2 VE-13 OPTION A

VE-13, Option A (VE13A), shown in Figure 3, is an alternative developed based on a proposal from a Value Engineering (VE) Study done in late 2011. The VE proposal recommended that the portion of the alignment east of the Sheyenne River be moved north. The possible advantages of pursuing this alignment instead of the FRP alignment include:

1. Eliminate the Wolverton Creek Hydraulic Structure
2. Reduce Cost
3. Decrease tieback embankment length
4. Eliminate a portion of the Storage Area 1 lands and damages

5. Eliminate Storage Area 1 embankment and drainage control structures
6. Decrease channel length between the RRN and the inlet structure

Following the completion of the VE Study, representatives of the Corps of Engineers and the Diversion Authority developed several potential alternative alignments based on the VE recommendation. Of these alternatives, two alignments, one of which is Option A, are included in this study.

The VE13A alignment differs from the FRP only east of CH17. Unlike the FRP, which follows a line southeast of CH17 to the Wild Rice River, the Option A alignment follows a line parallel to and approximately 1/8 mile south of CH16. This alternative eliminates the need for SA 1. VE13A includes a tie-back embankment which ties off to existing high ground directly east of the RRN control Structure in Minnesota. VE13A is included in this report partly because based on rough volume calculations prior to this VE13 investigation; it was likely to result in staged elevations similar to the FRP upstream of the project.

1.2.3 VE-13 OPTION C

VE-13, Option C (VE13C) is a second alternative developed based on the recommendations of the VE study. The VE13C alignment, shown in Figure 4, is generally north of both the FRP and VE13A east of the Sheyenne River aqueduct. The alignment is generally parallel to, and ½ mile south of CH14. The possible advantages of pursuing this alignment instead of the FRP alignment were identified:

1. Eliminate the Wolverton Creek Hydraulic Structure
2. Reduce Cost
3. Decrease tieback embankment length
4. Eliminate a portion of the Storage Area 1 lands and damages
5. Eliminate Storage Area 1 embankment and drainage control structures
6. Decrease channel length between the RRN and the inlet structure
7. Reduce staging elevation at communities of Oxbow, Bakke, Hickson, Christine, and Comstock as well as at the Richland County line.

This alternative also does not include SA 1. VE13C includes a tie-back embankment which ties off to existing high ground directly east of the RRN control Structure in Minnesota. Unlike VE13A, VE13C is included in this analysis because its location results in lowered stage elevation for similar flooding events upstream of the project.

1.2.4 SOUTH OF OXBOW

The South of Oxbow (OXBOW) alignment, shown in Figure 5, follows the same alignment as the FRP except for the portion of the alignment east of the Wild Rice River control structure. The OXBOW alignment, unlike the VE alignments, includes SA 1. The main difference between the OXBOW alignment and the FRP is that, rather than being located 1.25 miles south of CH16 east of the Wild Rice River, it extends south parallel to and west of I-29 to a point south of CH18. The alignment east of I-29 is located south of and roughly parallel to CH18. OXBOW alignment includes a tie-back embankment which ties off to existing high ground directly east of the RRN control Structure in Minnesota. The possible advantages of pursuing this alignment instead of the FRP alignment were identified:

1. Inclusion of communities of Oxbow, Hickson, Bakke, and Comstock in the flood damage reduction area
2. Reduced length of I-29, U.S. Highway 75, and BNSF Railway grade raise in the staging area.

This alternative is included in this analysis at the request of the Local Sponsors because the population center in the Hickson, Bakke Subdivision, and Oxbow area would be north of the diversion alignment. The FRP requires all homes and businesses in Hickson, Bakke Subdivision, and Oxbow be removed. The OXBOW alignment would preserve this community as well as reduce the cost of buy-outs.

1.2.5 NORTH OF WILD RICE RIVER

The North of Wild Rice River (NWRR) alternative is the farthest north of the alternatives included in this report and was included at the request of the Local Sponsors. The NWRR alternative alignment, shown in Figure 6, is identical to the VE13C alignment west of I-29. Unlike the VE13C alignment, which crosses the Wild Rice River and RRN along an alignment south of CH16, the NWRR alignment follows a path roughly parallel to the Wild Rice River between I-29 and the RRN. The alignment crosses the RRN south of 76th Avenue south and the tie-back embankment extends eastward from that point to existing high ground. The possible advantages of this alignment instead of the FRP alignment were identified:

1. Eliminate the Wolverton Creek Hydraulic Structure
2. Eliminate the Wild Rice River Control Structure and Fish Passage System
3. Reduce Cost
4. Eliminate Storage Area 1 lands and damages
5. Eliminate Storage Area 1 embankment and drainage control structures
6. Decrease channel length between the RRN and the inlet structure
7. Reduce staging elevation at communities of Oxbow, Bakke, Hickson, Christine, and Comstock as well as at the Richland County line.

The NWRR alternative is included in this report because it offers several potential advantages over other alignments. The main advantages are that the alignment requires no structure on the Wild Rice River and that the resulting staging area is significantly lower. The lowered staging elevation may allow the Hickson, Bakke Subdivision, Oxbow area to be minimally impacted allowing the potential for the community to remain, even if modified through local flood damage reduction measures.

2 MODELING

The hydraulic modeling completed for the PFSAA was conducted using the U.S. Army Corps of Engineers Hydrologic Engineering Center – River Analysis System (HEC-RAS) hydraulic modeling software (version 4.2 Beta). Minor improvements have been made to the model since the FR/FEIS model (Phase 4 - February, 2011) was developed and October, 2011 updates (Phase 5) were made. The most recent updates are referred to as Phase 6 and were made to better define hydraulic interaction at various locations along the diversion channel. The primary model changes were made to the lower reaches of the diversion where additional investigation and design has taken place. In addition, minor improvements have been made to the geometry storage areas in the upstream staging area to better define conveyance characteristics. Additional detail pertaining to the hydraulic changes is discussed in Section 2.2 – Hydraulics. All Phase 6 improvements and changes were made to the model prior to developing the alternatives specific to this analysis. The hydraulic modeling results presented in this report were developed for comparison to the FRP and do not include increased flows through town or a gated diversion inlet.

2.1 HYDROLOGY

The hydrology utilized in the Phase 6 analysis is the same hydrology that was developed by the USACE for the FR/FEIS. The project design utilizes the 10-, 2-, 1-, and 0.2-percent chance flood events, also commonly referred to as the 10-, 50-, 100-, and 500-year flood events. As part of the Phase 6 analysis, additional models were developed to represent a Probable Maximum Flood (PMF) and a one-half PMF event which is being referred to as the “103k cfs Event”. The 103k cfs event is similar in magnitude to the Standard Project Flood (SPF). Table 2.1 displays the design discharges for the respective return intervals for USGS Gage 05054000 on the RRN at Fargo.

Table 2.1 Design Discharges for the RRN at Fargo, ND

RRN Peak Discharges USGS Gage 05054000 at Fargo, ND						
Event	**10%**	**2%**	**1%**	**0.20%**	**103k cfs (0.5 PMF)**	**PMF**
Discharge (cfs)	17,000	29,300	34,700	61,400	103,000	205,000

2.2 HYDRAULICS

The Phase 6 unsteady HEC-RAS models consist of existing condition and FRP models based on the FR/FEIS design. The Phase 6 FRP model geometry created a baseline for the alternative geometries as described in the following sections. Appendix A presents the hydraulic model geometry layouts for the upstream portion of the project for existing conditions as well as each alternative. The Phase 6 unsteady HEC-RAS model was used for hydraulic design as well as to quantify impacts upstream and downstream from the diversion project. Impacts are defined as increases in water levels as a result of the project.

The downstream impacts from the diversion project have been understood to be a result of reduced natural floodplain storage in the flood damage reduction area and a shorter travel time for the with-project hydrograph.

Each respective alternative generates a different with-project residual floodplain depending on the diversion alignment and tieback. An increase in mitigated area (protected land) would typically be expected to require additional mitigation efforts (increased upstream staging elevations). Conversely, reduced mitigated areas would be expected to need less mitigation staging volume. The difference in hydrograph travel time can generally be compared between the existing condition hydrographs (RRN, Wild Rice, Sheyenne, Maple, Rush, Lower Rush Rivers) and the respective alternative, through-town and diversion hydrographs. Natural RRN conveyance is typically slower due to hydraulic losses associated with channel meandering when compared to a straighter diversion channel. The meandering RRN channel also has a longer meandering flow path when compared to the diversion channel. The decreased diversion travel time correlates to a downstream hydrograph that arrives sooner than an existing hydrograph which typically produces impacts at downstream locations. All of these factors are significant in determining how the results of each alternative compare and contrast. For all of the alternatives considered, the downstream impacts are mitigated by the upstream staging area and for some alternatives (FRP and OXBOW), SA1. Modeling results for each of the alternate alignments are discussed below.

2.2.1 FRP

The results of the FRP are similar to those reported in the FR/FEIS. The differences in project impacts compared to those reported in the FR/FEIS are likely due to the differences related to subsequent updates in the hydraulic model including hydrograph timing of the rivers downstream of the project, modifications to the inlet weir dimensions, and the gate operations used to maintain minimal downstream impacts. The overflow embankment elevation near CH17 is set just above the 1-Percent Chance Event (922.98). This elevation is critical for the 103k cfs event, which is the maximum flow in the diversion occurring just before the RRN and Wild Rice River control structures would be opened to prevent the loss of freeboard in the staging area. In April 2011, the top of embankment was assumed to be at elevation 927.0 feet, or the Standard Project Flood (SPF) event peak water surface elevation (approximately 925 feet) plus 2 feet of freeboard. Modifications to the FRP since that time have resulted in a revised top of embankment elevation of 929.4 feet based on the 103k cfs event peak water surface elevation (925.4) plus a minimum of 4 feet of freeboard or the Probable Maximum Flood (PMF) peak water surface elevation (926.1) plus 3 feet of freeboard. Further analysis of freeboard requirements will occur during final design. Appendix B.1 provides results for the FRP.

2.2.2 VE-13 OPTION A

VE13A is located approximately 1 mile north of the FRP just south of CH16. The VE options also differ from the FRP in that they do not include SA 1. The alignment is shown in Figure 3. The staging area elevations of VE13A are slightly lower than the FRP. These staging area elevation reductions can be attributed to the slight increase in available land within the staging area, despite the loss of SA 1, which is a prominent project feature for the FRP. The staging elevation just upstream of the RRN control structure for the 1-Percent Chance Event is 922.82, which is 0.16 feet lower than the FRP, while the elevation at Oxbow is 922.83, which is 0.17 feet lower than the FRP. The 103k cfs event has a staging area elevation of 924.83, which is 0.57 feet lower than the FRP. The proposed modifications to the FRP for this alternative alignment assumes a top of embankment elevation of 928.8 feet based on the 103k cfs event peak water surface elevation (924.8) plus a minimum of 4 feet of freeboard or the Probable Maximum Flood (PMF) peak water surface elevation (925.5) plus 3 feet of freeboard. Further analysis of freeboard requirements will occur during final design. Appendix B.2 presents the impact and mitigation profile tables associated with the VE13A alternative.

2.2.3 VE-13 OPTIONS C

VE13C, shown in Figure 4, is located approximately 2.5 miles north of the FRP and about ½ mile south of CH14. The staging area elevations associated with VE13C are less than the FRP. Appendix B.3 presents the impact and mitigation profile tables associated with the VE13C alternative. These staging area elevation reductions can be attributed to the significant increase in available land within the staging area due to the alignment's more downstream location. The staging elevation just upstream of the RRN control structure for the 1-Percent Chance Event is 920.18, which is 2.8 feet lower than the FRP, while the elevation at Oxbow is 920.22, which is 2.78 feet lower than the FRP. The proposed modifications to the FRP for this alternative alignment assumes a top of embankment elevation 927.3 feet based on the 103k cfs event peak water surface elevation (922.3) plus a minimum of 4 feet of freeboard or the Probable Maximum Flood (PMF) flood event peak water surface elevation (924.4) plus 3 feet of freeboard. Further analysis of freeboard requirements will occur during final design. The 103k cfs event staging area elevation of 922.30 is 2.1 feet lower than the FRP.

2.2.4 SOUTH OF OXBOW

The OXBOW alternative moves the RRN control structure further upstream than the FRP alignment which changes the location and extent of the upstream staging area. The alignment change is highlighted in Figure 5. Previously, the upstream staging area footprint was generally centered on Interstate 29 (I-29) and the RRN. Since the OXBOW diversion alignment extends farther south along I-29, it produces an upstream staging area that has a higher proportion of water stored on the Wild Rice River side than on the RRN side. The change in the upstream staging area removes properties in the communities of Bakke, Hickson, and Oxbow from the staging area and maintains certain roadway corridors. However, it also introduces additional flooding in areas not directly impacted by the FRP. The loss of additional floodplain storage for the OXBOW alternative, although minor in comparison to the entire project, must be accounted for in the upstream staging area to prevent additional downstream impacts. Since the RRN control structure for this alternative is farther upstream than the FRP structure, there is an increased RRN and diversion travel distance. This further separates the with-project hydrograph from the existing condition hydrograph downstream of the project, requiring additional mitigation to overcome the impacts due to the timing differences.

The overall staging area as documented on the RRN, upstream of the RRN control structure is 925.69 for the 1-percent chance event. The 103k cfs event has a staging area elevation of 927.37. The proposed modifications to the FRP for this alternative alignment assumes a top of embankment elevation 931.4 feet based on the 103k cfs event peak water surface elevation (927.4) plus a minimum of 4 feet of freeboard or the Probable Maximum Flood (PMF) flood peak water surface elevation (928.5) plus 3 feet of freeboard. Further analysis of freeboard requirements will occur during final design. Appendix B.4 presents the impact and mitigation profile tables associated with the South of Oxbow alternative.

2.2.5 NORTH OF WILD RICE RIVER

The NWRR alternative, shown in Figure 6, crosses the RRN approximately 5 miles north of the FRP between 76th and 88th Avenue South. In addition to the location of the alignment, the NWRR alternative differs from the FRP in that it does not include a separate storage area and does not cross the Wild Rice River. The staging area elevations associated with the NWRR option are significantly less than the FRP. These staging area elevation reductions can be attributed to the significant increase in available land and lower natural ground elevation within the staging area due to the alignment's more downstream location. The staging elevation just upstream of the RRN control structure for the 1-Percent Chance Event is 917.91, which is about 5 feet lower than the FRP, while the elevation at Oxbow is 918.04, which is also about 5 feet lower than the FRP. The 103k cfs event has a staging area elevation of 920.51, also about 5 feet lower than the FRP. The proposed modifications to the FRP for this alternative alignment assumes a top of embankment elevation 927.5 feet based on the 103k cfs event peak water surface elevation (920.5) plus a minimum of 4 feet of freeboard or the Probable Maximum Flood (PMF) peak water surface elevation (924.5) plus 3 feet of freeboard. Further analysis of freeboard requirements will occur during final design. Appendix B.5 presents the impact and mitigation profile tables associated with the NWRR alternative

3 DESIGN

The design considerations used for the PFSAA are the same design methodology as the Phase 4 FRP April 19, 2011 A/E deliverable to the USACE, except as noted in this PFSAA report. Assumptions allow for consistent comparison to the FRP. Feasibility-level design was performed for alternative alignments and hydraulic structures as discussed in this section. The purpose of feasibility design was to generate alternative specific costs and assess differences in the alternatives as compared to the FRP. See the additional PFSAA geotechnical, structural and civil design appendices for additional explanation of assumptions and design criteria used for this study. Important considerations for future design efforts are detailed in Appendix J and should be referenced when scoping future design efforts. The design and cost estimates were broken down into several reaches for the PFSAA, commencing eastward from FRP diversion channel centerline Sta. 1514+00 (roughly corresponding to the eastern edge of the Sheyenne River Hydraulic Structure site). The SH-WRR reach extends from the Sheyenne River to the diversion inlet weir; the Inlet-WRR reach extends from the diversion inlet weir to the Wild Rice River; the WRR-RRN reach extends from the Wild Rice River to the RRN; the RRN-MN reach extends from the RRN eastward; and the CH17 reach covers the Cass County Highway 17 corridor. See Exhibits H9 through H13 for GIS maps of these reaches for each alignment alternative.

3.1 GEOTECHNICAL CONSIDERATIONS

The geotechnical considerations and methodology used for the PFSAA are generally consistent with assumptions presented in the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE, except as noted in this section. Assumptions allow for consistent comparison to the FRP. See Appendix E for a more in depth explanation of the structural design criteria used for this study.

A feasibility slope stability analysis was performed to estimate the required offset distance between the toe of the embankment to the top of borrow excavation (in some places also referred to as the connectivity channel), necessary for constructing embankments. The borrow excavation is assumed to roughly extend from the Main Inlet Weir eastward to the RRN (reaches SH-WRR and WRR-RRN). USACE directed HMG to use assumed cross sections for embankments. An embankment height of greater than or equal to 20 feet is an embankment are assumed to consist of upstream slopes of 5H:1V and downstream slopes of 6H:1V while embankments under 20 feet are assumed to consist of side slopes of 4H:1V (see the USACE March 2012 white paper entitled "FMM-Estimated Costs for Dam vs. Levee Design"). Both embankments have a crest width of 15 feet. The borrow trench was assumed to have sides slopes of 5H:1V, maximum depth of 10 feet, maximum trench bottom width of 100 feet, and a minimum 50 foot trench offset from the toe of the embankment.

The results of the borrow trench offset distances determined from the stability analysis is summarized in Table 3.1. These distances meet the required factor of safety value of 1.4 for levees and embankments. This stability analysis is typical for the project reaches SH-WRR and WRR-RRN. However, the analysis may not apply to CH17 or RRN-MN project reaches. More detailed site specific information and detailed analysis will be required for analyzing this offset for additional representative embankment segments in future design efforts.

Table 3.1 Results of Stability Analysis meeting FS=1.4

Embankment Height (ft)	Offset Distance (ft)	Crest Width (ft)	Slopes (ft)
<20	50	15	4H:1V
20	50	15	5H:1V U/S, 6H:1V D/S
>20	60	15	5H:1V U/S, 6H:1V D/S

For a detailed discussion of important geotechnical considerations to reference in future design efforts see Appendix J.

3.2 STRUCTURAL DESIGN CONSIDERATIONS

The structural design of the hydraulic structures for the PFSAA utilized methodology generally consistent with assumptions presented in the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE, except as noted in this section. Assumptions allow for consistent comparison to the FRP. See Appendix F for a more in-depth explanation of the structural design criteria used for this study.

Changes to the maximum flood event were modified in the VE13, NWRR, and OXBOW alternatives to include a protection level for the 103k cfs event plus free board as defined following July 31, 2012. Revisions to the top-of-structure elevations for VE13C and NWRR following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates. In Phase 4, the top of structures were based on the 0.2-percent chance event plus free board. It should be noted that the 103k cfs event is approximately 2 feet higher than the 0.2-percent chance event. Updated geotechnical capacity of the piles was evaluated at each of the new Control Structures locations. The feasibility design procedures follow those developed for Phase 3 and Phase 4. Drained and undrained axial pile and lateral pile capacities were computed using the design parameters previously developed for Phase 3 and Phase 4.

For a detailed discussion of important structural design considerations to reference in future design efforts see Appendix J.

3.3 CIVIL DESIGN CONSIDERATIONS

The civil design considerations and methodology used for the PFSAA are generally consistent with assumptions presented in the Phase 4 FRP April 19, 2011 A/E deliverable to the USACE, except as noted in this section. Assumptions allow for consistent comparison to the FRP. See Appendix G for a more in depth explanation of the civil design criteria used for this study.

In general, the hydraulic structures remained approximately the same order-of-magnitude size as their comparable structure in the FRP (see Exhibits G1 and G3). This is because of a relatively small change in the design flood elevations used to design the structures. However, due to recurrence of upstream staging events modeled, water surface elevations were interpolated for the 2% and 20% floods and were used to design the fish passage systems for the various alternatives. An increased differential between headwater and tailwater elevations was noted, and the fish passage system footprint increased, sometimes significantly, driving up earthwork quantities. Major design considerations generally follow FRP methodology, including:

- Red River (RRN) control structures are sited in Minnesota.
- Control structures are assumed to be constructed in dry conditions (off the existing river channel).
- A 300 foot minimum buffer between the proposed control structure and the existing river channel is assumed.
- Excavation slope grading for realigned river channel was assumed to be 7H:1V.
- Access roadways, maintenance buildings, and SCADA are included at each site.
- Fish passage systems are included with each control structure.
- A tie-back embankment into Minnesota is assumed and is constructed using borrow from North Dakota.
- Embankment borrow excavations in North Dakota are assumed.
- Stratigraphy and elevations of the soil layers for determining earthwork quantities for the hydraulic structures was assumed to be the same as what was used for the FRP.
- Deed restricted properties were considered and avoided when developing layouts for the hydraulic structures.
- A permanent easement of 30 feet, offset from the extents of the grading work, is assumed for the site work at each hydraulic structure.
- A temporary easement of 15 feet, offset from the extent of the permanent easement, is assumed for the site work at each hydraulic structure.

For a detailed discussion of important civil design considerations to reference in future design efforts see Appendix J.

4 COST COMPARISON

Estimated costs are presented for the alternative alignments for comparison to the Federally Recommended Plan (FRP). The construction features and Lands and Damages quantity summaries and estimated costs presented are intended to be used for consistent comparison to similar project features and estimated costs presented for the FRP. The estimated costs are intended to be used for evaluating if the alternative alignments are cost competitive with the FRP.

4.1 METHODOLOGY

Quantity takeoff methodology, unit costs, contingency, and other cost model assumptions are generally consistent with assumptions presented in the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE. Assumptions allow for consistent comparison to the FRP. Costs presented are in 2010 US Dollars ($) for consistent comparison with FRP cost estimates. Costs presented do not include escalation or operations and maintenance costs.

The primary comparative unit for the estimated costs is the cost of Lands and Damages and Construction Costs for work upstream of the eastern edge of the Sheyenne River Hydraulic Structure site (diversion channel centerline Sta. 1514+00), as discussed at the June 19, 2012 VE-13 Workshop. These costs are presented in Table 4.1 below. The project design and project costs downstream of diversion centerline Sta. 1514+00 were not revised as part of this effort.

Some project-wide costs (such as mitigation, utility relocations, etc.) were not revised as part of this PFSAA effort and are presented in Appendix H Exhibits for comparison only. The comparative tables presented in Exhibits H1 and H3 summarize what costs were revised for this effort. The total costs presented in Exhibits H1, H2, H3 and H4 are for comparison only, and present what categorical cost items were revised as part of the alternatives analysis, and to present which categorical cost items were not revised. At the June 19, 2012 VE-13 Workshop, it was decided that some categorical cost items are not thought to be differentiating factors in evaluating alternative alignments (for example, are a minor cost in the scope of the overall project) and would not be revisited as part of this effort.

This PFSAA report was issued in Draft on July 31st, 2012 to obtain comments from the PMC, USACE and Local Sponsors at the August 2nd LSLCTT meeting and the August 15-16th, 2012 LSLCTT Integration Workshop. A summary of important assumptions, QA/QC revisions and changes made to the document since that Draft issue is included in Appendix H.

For a detailed discussion of cost estimate methodology see Appendix H.

For a detailed discussion of important cost estimate methodology considerations to reference in future design efforts see Appendix J.

4.2 LAND ACQUISITION

Lands and damages cost methodology are consistent with assumptions used by USACE in the FR/FEIS. The lands and damages are separated into two categories: lands needed for the project features and lands impacted by staged water. A more detailed description of the methodology used for estimating costs follows.

The lands and damages cost for the areas required for the project features include a combination of permanent and temporary easements. Permanent easements are assumed for areas directly within the footprint of the project features, and an additional 30 feet beyond the footprint. In addition to permanent easements, the cost estimate assumes a temporary easement 15 feet wide outside of the permanent easement. The permanent easement cost assumptions include an average cost per acre for all acreage. In addition to the acreage cost, average values are used for all residential and non-residential structures. Similar to the permanent easements, an average cost per acre is used for temporary easements. The cost estimate also assumes an average administrative cost per parcel and another per structure.

Cost assumptions for lands impacted by staged water are based on the type of property, as well as the depth of inundation in the impacted area. The impacted area has been defined by USACE as any inundated area in which the increased water surface elevation during a 1-Percent Chance Event is at least one foot higher than under existing conditions. The land categories, similar to the lands required for project features, are split into three categories: acreage, residential structures, and non-residential structures. Within the impacted area, properties are divided based on the total depth of inundation during a 1-Percent Chance Event. The depth categories used include those areas and structures with three feet or more of total inundation and those areas and structures with less than 3 feet of total inundation. Appendix D shows depth grid maps for the staging area used to compute land acquisition costs.

The cost estimate assumes that all acreage within the impacted area on which 3 feet or more of total inundation occurs during the 1-Percent Chance Event would be purchased at the same average per acre rate as is used for property needed for project features. The cost of flowage easements on land with less than 3 feet of total inundation is 25% of the value used for areas inundated with 3 feet or more.

Similar to structures purchased within the project area, average values are used for all residential and non-residential structures that are inundated by 3 feet or more during the 1-Percent Chance Event. Separate, smaller average values are used for structures inundated by less than 3 feet of water. The cost estimate assumes an average administrative cost per parcel and another per structure. A summary of costs for each alternative is summarized in the next section (Cost Summary). A detailed breakdown of features and costs developed for the cost estimates is included in Appendix H.

4.3 COST SUMMARY

A comparison of estimated costs for alternative alignments for work upstream (east) of the Sheyenne River Hydraulic Structure Site (FRP diversion centerline channel Sta. 1514+00) is presented in Table 4.1.

Table 4.1 Cost Comparison Summary – Southern Alignment Alternatives (Base Cost with No Bundles)

Cost Category	FRP ($)	VE13A ($)	VE13C ($)	NWRR ($)	OXBOW ($)
Lands and Damages	225M	216M	228M	272M	189M
Construction Cost	368M	309M	304M	292M	403M
[1 2] Subtotal for Comparison	593M	525M	532M	564M	592M

[1] Costs shown are for southern alignment features only in millions of US Dollars.

[2] Costs include 26% contingency. Costs do not include escalation or O&M costs. Costs do not include enhancement bundles.

For a detailed breakdown of estimated costs for each southern alignment alternative see Exhibit H2. For a detailed breakdown of features and revisions included in each southern alignment alternative see Exhibit H4.

The details presented in Appendix G of the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE should be considered prior to development of future MII cost models and cost estimates on this project. A summary of additional important considerations for scoping and executing future cost estimate is included in Exhibit J of this PFSAA report.

The feasibility level construction cost estimate provided in this report is made on the basis of HMG's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. This opinion is based on project-related information available to HMG at this time, current information about probable future costs and a feasibility level design of the project.

5 ASSESSMENT FACTORS

As indicated in Section 1 of this report, the purpose of this study is to evaluate alternative alignments that could best meet project objectives and provide the greatest value for the southern portion of the FM Diversion project. A number of assessment criteria should be considered when comparing alternatives. Seven factors were identified to represent the assessment criteria at the June 19, 2012 VE-13 workshop, August 2, 2012 LSLCTT meeting, and August 15-16, 2012 LSLCTT Integration Workshop:

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

A description of these factors is presented in the following sections for the FRP, VE13A, VE13C, NWRR, and OXBOW alternatives. **Additional discussion and comparative data of these factors is presented in *Appendix I: Assessment Factors*.**

5.1 RISK REDUCTION CONSIDERATIONS

Limiting risk to the public by constructing a system that limits risk of failure of critical features is important to consider when evaluating alternatives. Once constructed, the project will be in operation for many years. Long term risk considerations are necessary to evaluate alternatives.

Risk characterization generally considers the risk of failure or robustness of an alternative, and the consequences that could result from a possible failure. The lowest cost or easiest to construct alternative is not necessarily the most favorable from a risk-management perspective. Increased risk exists where, for a given set of alignment features, the flood risk reduction features have a greater potential exposure to the risk of being compromised and ultimately failing. The risk is greater where a potential failure can cause greater loss of life or damage to property.

Risk factors identified during the workshops with input from Diversion Authority and USACE representatives were not intended to be a complete list of all potential risk factors. However, for a relative comparison of alternatives, the risk factors considered in this assessment provide a preliminary characterization of initiators and failure mechanisms, with consequence of failure being equally high for all alternatives. This assessment does not replace or supersede a more formal Potential Failure Mode Analysis (PFMA), which was outside the scope of the analysis agreed upon by the working group.

For comparison of risk, several big-picture risk parameters were identified for consideration as risk factors. This scoping of the risk characterization was performed by the working group during the June 19, 2012 VE-13 workshop, August 2, 2012 LSLCTT meeting and August 15-16, 2012 LSLCTT Integration workshop. The risk factors identified include:

- Length and height of embankment (and potential depth of water along the face of embankment)
- Difference in headwater to tailwater across hydraulic closure structures and height of the hydraulic structures
- Number of hydraulic structures requiring human intervention for flood risk reduction
- Resilience of a design to a variety of floods

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.2 IMPLEMENTABILITY

Implementability is a qualitative criterion, as it is difficult to quantify from a technical perspective. Ultimately, decision makers need to weigh available data and making a qualified judgment when making a decision. Key implementability considerations include:

- Compliance with USACE Record of Decision and Chief's Report and other permitting requirements
- Public policy considerations

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.3 PROPERTY IMPACTS – NUMBER OF RESIDENTIAL STRUCTURES

The number of structures (in particular-residential structures) impacted varies between the alternatives. For the purpose of this analysis, an impacted structure is defined as a structure that is located under the footprint of the project and would require purchase or is within the defined staging area and would require purchase or other mitigation measures. Additionally, the residential structures within the staging area are categorized based on estimated depth of inundation. In general, the fewer number of residential structures impacted, the more favorable an alternative.

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.4 ENVIRONMENTAL CONSIDERATIONS

Another way to compare the alternatives is to estimate the environmental impact of each alternative as compared to the FRP. The scope of work for this task did not extend to preparing an extended analysis of environmental impacts, so a detailed comparison of these impacts cannot be performed. However, several factors were calculated to roughly compare the scalar change in environmental impacts for southern alignment alternatives:

- Wetland Impact: Wetlands were not field or photo-delineated in this phase of work. Actual field delineation of wetlands is preferred to estimate wetland impacts. However, given similar land use, constructed project footprint area can be used as a rough proxy. In general, a project with a larger footprint has a greater chance to impact wetlands.

- River miles impacted: Closure structures resulted in the abandonment of some river channel, resulting in riparian habitat impacts. Due to the configuration of each alternative, some impacted more river channel than others.

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.5 PROPERTY IMPACTS – NUMBER OF ACRES

The number of acres impacted varies between the alternatives and can generally be split into two categories: acres located within the footprint of the project, and acres impacted by the staging area. In general, the fewer number of acres impacted, the more favorable an alternative.

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.6 FLOODPLAIN CONSIDERATIONS

In assessment of alignment alternatives, consideration should be given for the area removed from the floodplain. Executive Order 11988 provides guidance related to development in floodplains. Part of this guidance is that, in the case that impact to the base floodplain (1-percent chance floodplain) is unavoidable; it is preferable to minimize the amount of area removed from the base floodplain. Because of the nature and location of the project, impacts to the floodplain are unavoidable. Additionally, large portions of the area south of Fargo and Moorhead are in the base floodplain based on mapping performed for the FR/FEIS and this study. In general, more congruence to the number of acres impacted by the approved FRP, the more favorable an alternative.

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

5.7 TRANSPORTATION SAFETY CONSIDERATIONS

The degree to which alignment alternatives alter the transportation safety characteristics of the roads and railroads in the project vicinity is characterized versus the FRP. In general, alternatives with less water alongside roadways and fewer bridges across the diversion channel pose fewer transportation safety issues from the perspective of this investigation.

Additional discussion and comparative data of this assessment factor is presented in *Appendix I: Assessment Factors*.

6 RANKING AND CONCLUSIONS

The purpose of this study is to evaluate and compare alternative alignments for the southern portion of the FM Diversion Project, which generally includes the area upstream of the Sheyenne River aqueduct. This study evaluates and compares several alternative alignments that have the potential to increase project value by further optimizing the project functionality for the estimated cost and impacts. Examples of how value may be increased include reducing project impacts or costs, by incrementally increasing the properties benefitting from risk reduction for the southern portion of the FM Diversion project, or optimizing the project's performance upon a set of defined PFSAA assessment criteria.

The study includes a quantitative and qualitative value comparison of alignment options based on several assessment factors including:

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

The different assessment factor categories were originally weighted based on their perceived importance using group consensus during the June 19, 2012 VE-13 Workshop. This analysis was revisited again during the August 15-16, 2012 LSLCTT Integration Workshop. The group's consensus from the August 15-16, 2012 LSLCTT Integration Workshop is described in detail in Appendix I.

The PFSAA base alternatives were subjected to the assessment criteria comparative analysis, factor scoring and ranking. This report includes a general comparison of the assessment factors outlined above based on project features and operation comparable to the FRP, as described in FR/FEIS. The final assessment of southern alignment options includes additional enhancements that are products of several post feasibility studies. During analysis of the PFSAA base alternatives, concurrent analysis work (outside of the PFSAA analysis) was performed on infrastructure features that were not included in the FRP, such as a gated inlet to the diversion and increasing flows through the risk reduction area. The estimated costs for the PFSAA base alternatives and the FRP were modified to include the estimated costs for the bundles of infrastructure enhancements. These enhancements are described in this report and below. The alignment alternatives with additional enhancements are referred to as "Bundles" in this document.

6.1 BUNDLED OPTIONS

Several studies related to potential modifications to the design and operation of the diversion project have taken place since the completion of the Feasibility Study and FEIS. These post feasibility studies include the following:

- Flows Through Flood Damage Reduction Area (July 16, 2012)

- Diversion Inlet Gate Analysis (Draft, August 7, 2012)
- Land Management Improvements Evaluation No.1

Flows Through Flood Damage Reduction Area study includes an analysis of costs and benefits related to the addition of structural features within the Cities of Fargo and Moorhead as well as rural areas between southern alignment and Fargo-Moorhead. The additional features, generally levees and transportation improvements, would allow the frequency and duration of operation of the FM Diversion to be reduced. Rather than operating on any event larger than roughly a 28-percent (3.6-year) chance event, the addition of the improvements outlined in the report would allow the project to operate only on events larger than a 10-percent (10-year) chance event. The reduction in frequency of operation results in the potential to eliminate fish passage features on the RRN and Wild Rice River hydraulic structures as well as minimizing the risk of summer operation; which limits the risk of damage to growing crops in the staging area.

Diversion Inlet Gate Analysis study includes an evaluation of the costs and benefits of a gated structure at the inlet to the diversion channel rather than the fixed weir included during the FR/FEIS. The addition of a gated inlet structure results in a small reduction in the staged water surface elevation within the FRP staging area as well as increased flexibility of operation.

Land Management Improvements Evaluation No. 1 study includes an examination of the potential for the construction of ring dikes to reduce the risk of flooding for communities impacted by the staging area. The evaluation included conceptual ring dikes for the City of Christine as well as for the combined communities of City of Oxbow, the Village of Hickson, and Bakke Subdivision.

The assessment of alignment options was completed based on the following "Bundles".

- Federally Recommended Plan alignment plus increased flow through flood damage reduction area and gated inlet structure.
- VE-13A alignment plus increased flow through flood damage reduction area and gated inlet structure.
- VE-13C alignment plus increased flow through flood damage reduction area and gated inlet structure.
- North of Wild Rice River alignment plus increased flow through flood damage reduction area and gated inlet structure.
- North of Wild Rice River alignment plus increased flow flood damage reduction area, gated inlet structure, and levee for Oxbow, Hickson, and Bakke Subdivision.
- South of Oxbow alignment plus increased flow through flood damage reduction area and gated inlet structure.

6.2 RANKING OF OPTIONS

The intent of this ranking is to provide decision makers with an assessment of these factors and estimated costs to aide in selecting a preferred southern alignment. The assessment is not intended to provide the decision regarding the ultimate southern alignment option for the project, but rather to serve as a guide to help in making a decision regarding a final project alignment. In a project as complex as the FM Diversion, cost alone does not adequately capture the differences between alternatives. Rather, multiple assessment factors must be considered when evaluating the alignment alternatives and then compared against cost. The ranking of options, described in detail in Appendix I, is based on the assessment factors described above.

In order to rank the options, a group consensus exercise was first performed to rank each bundle from a technical perspective. The first step in the ranking process was to identify key metrics and rank them against each other to develop a relative weighting for each metric. The results of this ranking process are summarized in Table 6.1. A more detailed description of the ranking methodology is presented in Appendix I.

Table 6.1 Relative Weights of the Assessment Factors

Assessment Factor	Relative Weight
Risk Reduction Considerations	29%
Implementability	24%
Property Impacts (Number of Residential Structures)	19%
Environmental Considerations	14%
Property Impacts (Number of Acres)	7%
Floodplain Considerations	5%
Transportation Safety Considerations	2%
Total	100%

After the determination of the relative weights of each assessment factor, the alignment options were compared using the appropriate relative weights. The results of the assessment factor comparison are shown in Table 6.2. It is important to understand that possible scores for the categories and subcategories presented here could only range from about 70% to 130%. Lower scores indicate a more favorable alternative. A more detailed description of the scoring methodology is presented in Appendix I.

Table 6.2 Assessment Factor Score and Cost Comparison for Southern Alignment Alternatives

Alternative	Assessment Factor Score (Lower Score Indicates a More Favorable Alternative)	PFSAA Cost Upstream of the Sheyenne River (Sta. 1514+00) with Bundles ($)	Total Cost with Bundles ($)
FRP	100%	630M	1,767M
VE13A	87%	561M	1,685M
VE13C	88%	573M	1,697M
North of Wild Rice River (NWRR)	107%	607M	1,728M
North of Wild Rice River (NWRR) + Levee at Oxbow	98%	614M	1,738M
South of Oxbow (OXBOW)	104%	628M [1]	1,773M [1]

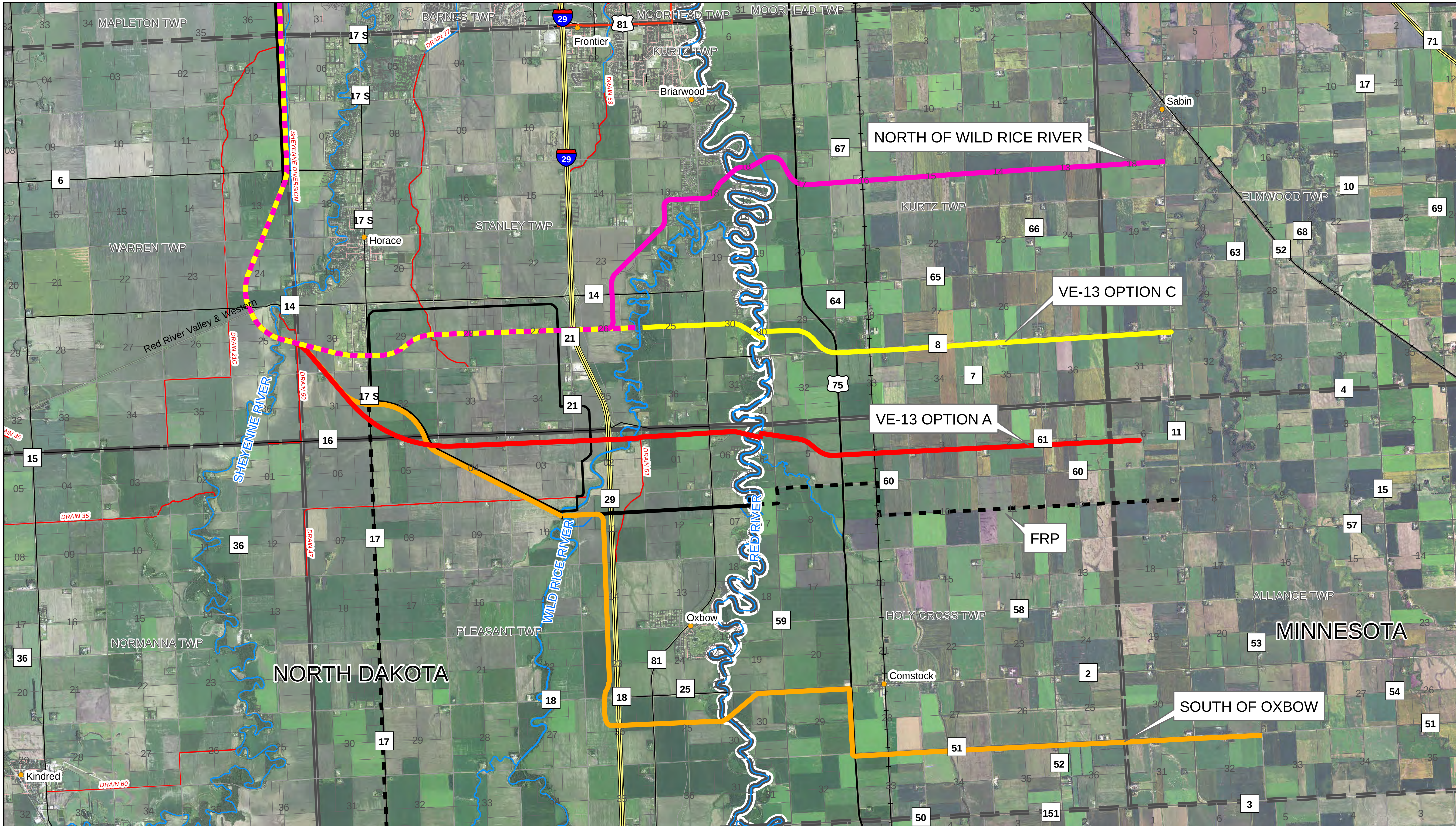
(4) During the August 2, 2012 LSLCTT meeting, HMG was directed not to bundle infrastructure enhancements for the *South of Oxbow* alternative. However for consistency for the comparison to the FRP, a bundled cost has been estimated and is shown.

VE13A has the lowest assessment factor score with VE13C being very close. The difference between the scores is small enough that the scores could be considered equal. Comparing the assessment factor score against the cost can assist in deciding which PFSAA alternative best meets project objectives and provides the greatest value. Because it has the lowest cost of the two VE options and the lowest assessment factor score, VE13A, with increased flows through the flood damage reduction area and with diversion inlet gates, was identified as the preferred alternative during the August 15-16 LSLCTT Integration Workshop.

6.3 CONCLUSIONS

The purpose of this study is to evaluate and compare alternative alignments for the southern portion of the FM Diversion project, which generally includes the area upstream of the Sheyenne River aqueduct. The study includes a quantitative and qualitative comparison of alignment options based on several assessment factors. The intent of this ranking is to provide decision makers with an assessment of these factors and estimated costs to aide in selecting a preferred southern alignment. Based on the technical comparison of alignment options, VE13A and VE13C scored better than the other alignment options. Because of both the cost and assessment factor score, VE13A, with flows through the flood damage reduction area and with diversion inlet gates, is the technically recommended alternative.

FIGURES



ALTERNATIVES
FARGO MOORHEAD METRO DIVERSION

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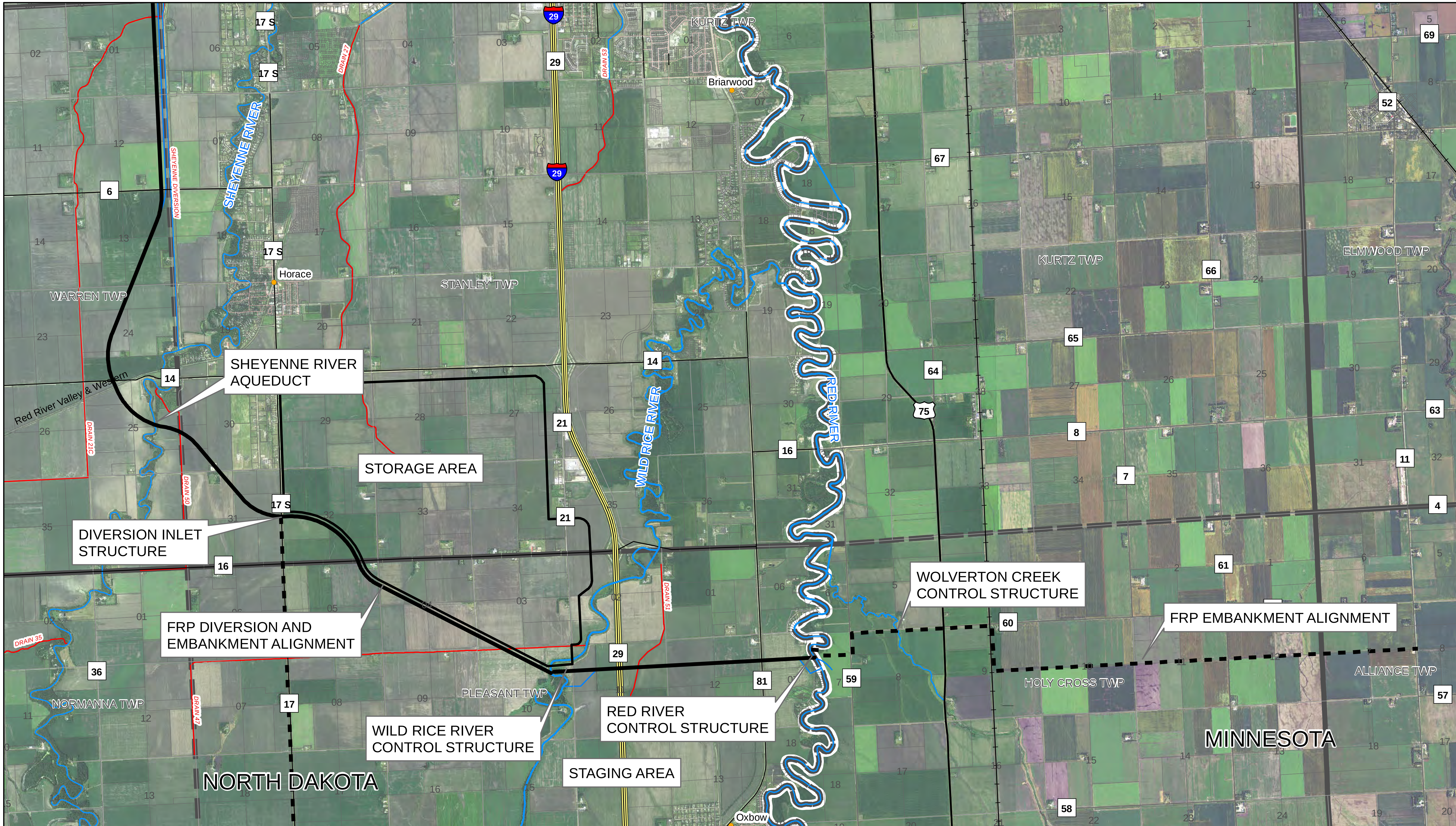
Horizontal Datum: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Vertical Datum: NAVD1988
T:\Numbered Projects\16474\16474_PostROD_Figure1_11x17_2012_09_27.mxd

N W E S

0 3,500 7,000 14,000 Feet

FIGURE 1

HMG



FEDERALLY RECOMMENDED PLAN (FRP)
FARGO MOORHEAD METRO DIVERSION

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Parcel Date: N/A Aerial Image: 2010 County NAIP SIDS Elevation Data: IWI Lidar
Horizontal Datum: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Vertical Datum: NAVD1988
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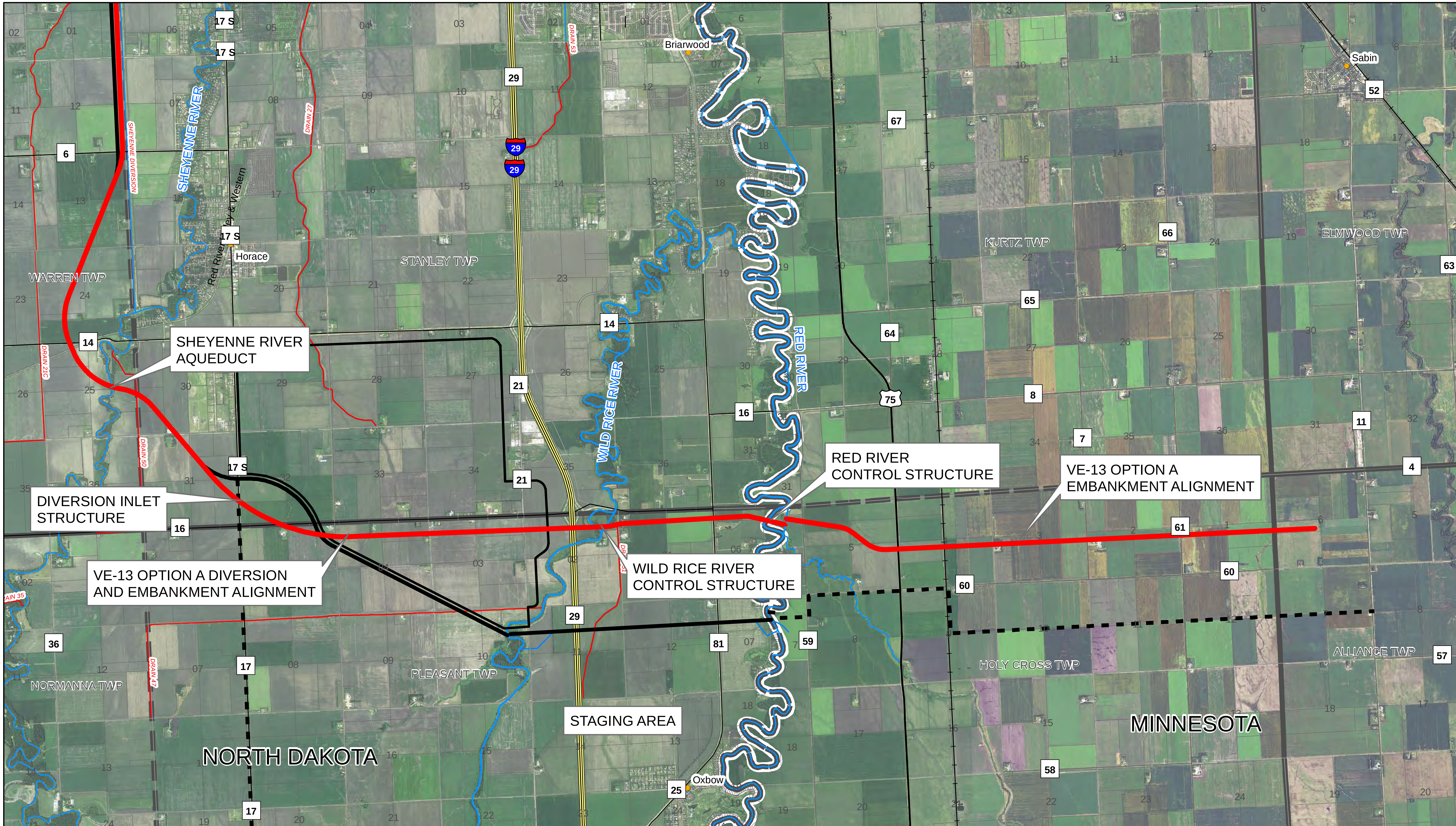
N W E S

0 2,500 5,000 10,000 Feet

FIGURE 2



VE 13 - OPTION A
FARGO MOORHEAD METRO DIVERSION

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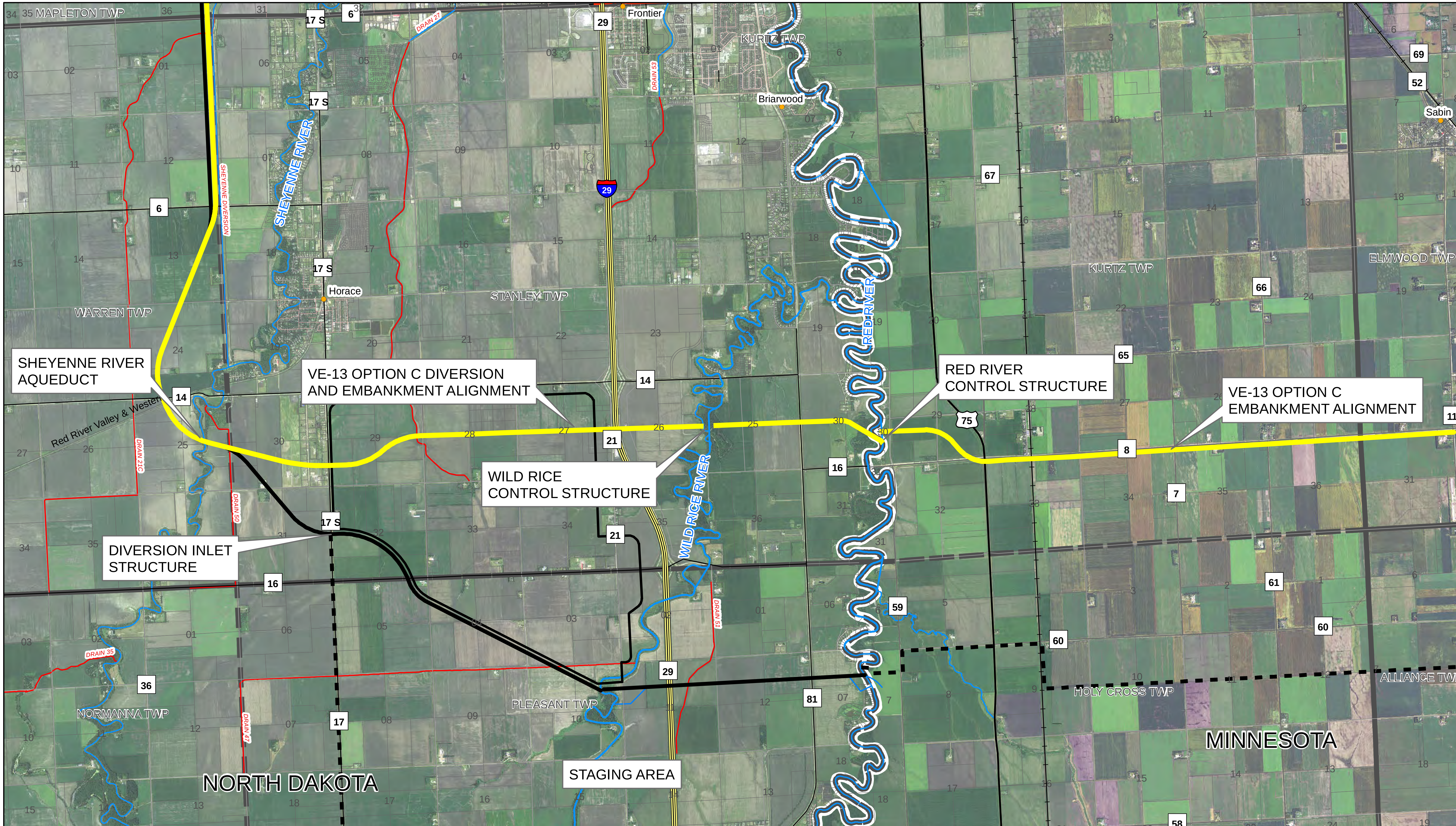
Horizontal Datum: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Vertical Datum: NAVD1988
T:\Numbered Projects\16474\16474_PostROD_Figure3_11x17_2012_09_27.mxd

N W E S

0 2,500 5,000 10,000 Feet

FIGURE 3

HMG



VE-13 - OPTION C
FARGO MOORHEAD METRO DIVERSION

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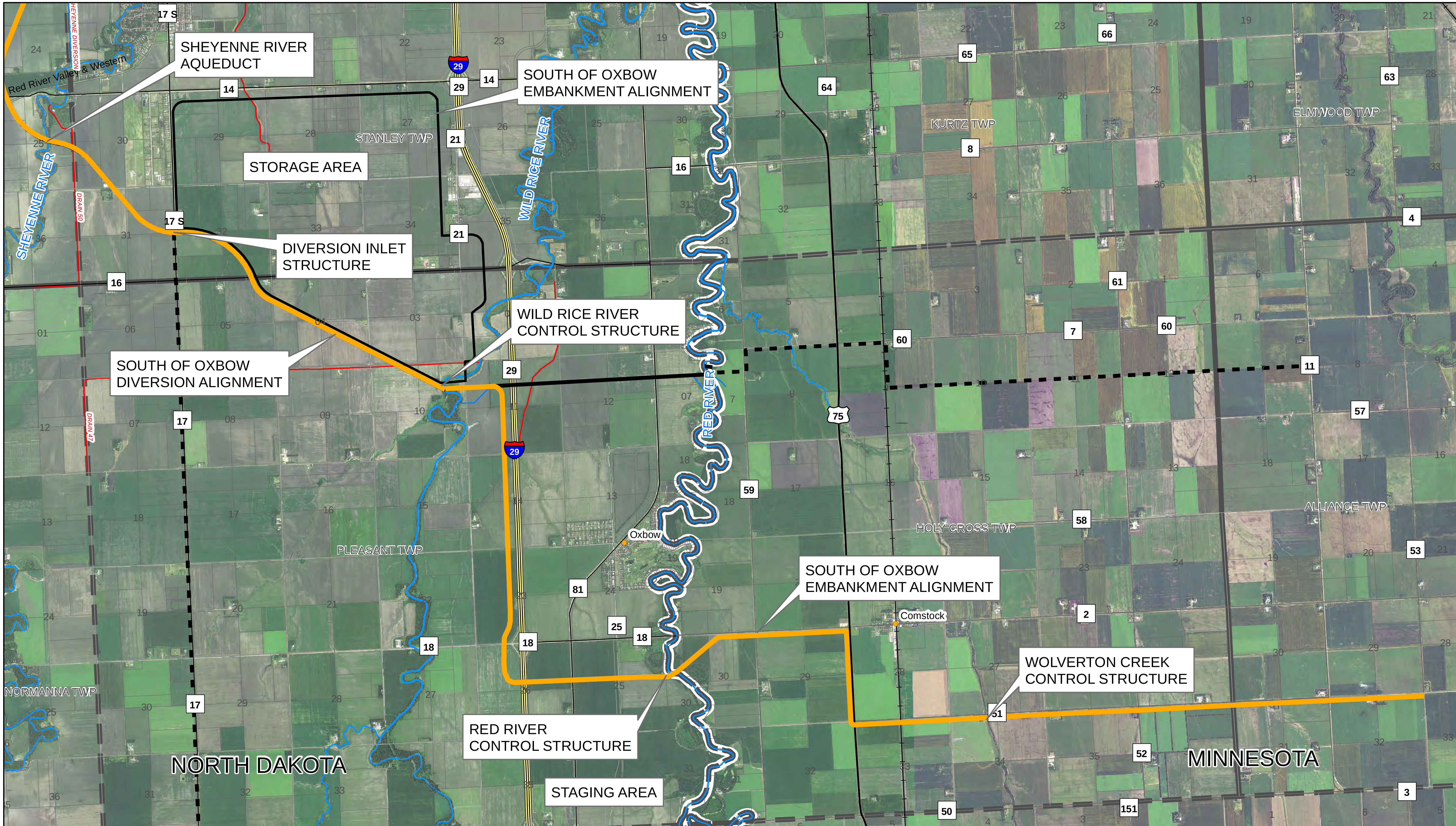
N W E S

0 2,500 5,000 10,000 Feet

FIGURE 4

HMG



SOUTH OF OXBOW
FARGO MOORHEAD METRO DIVERSION

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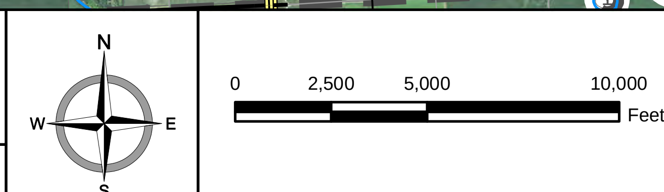
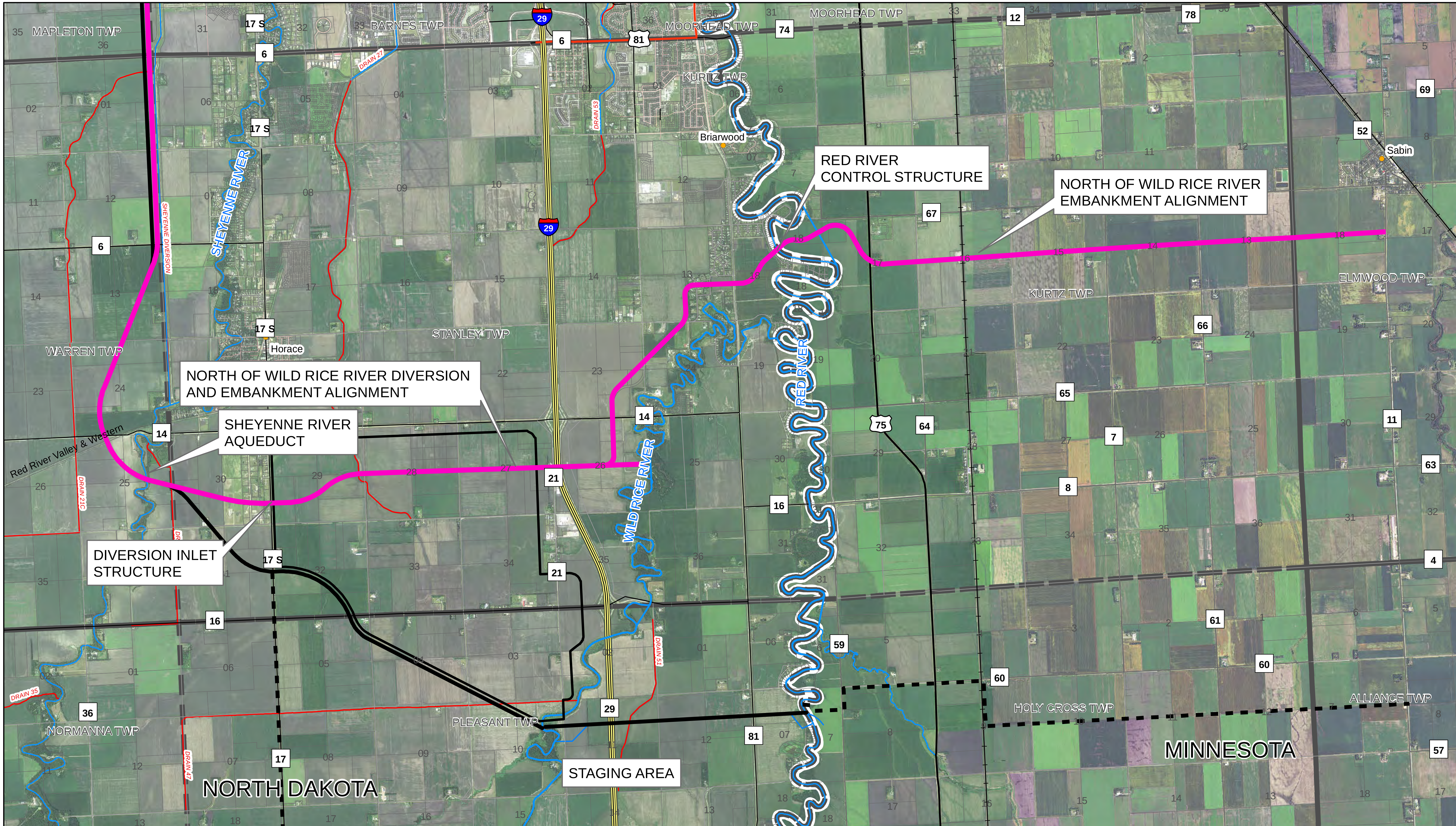


FIGURE 5

HMG



NORTH OF WILD RICE RIVER
FARGO MOORHEAD METRO DIVERSION

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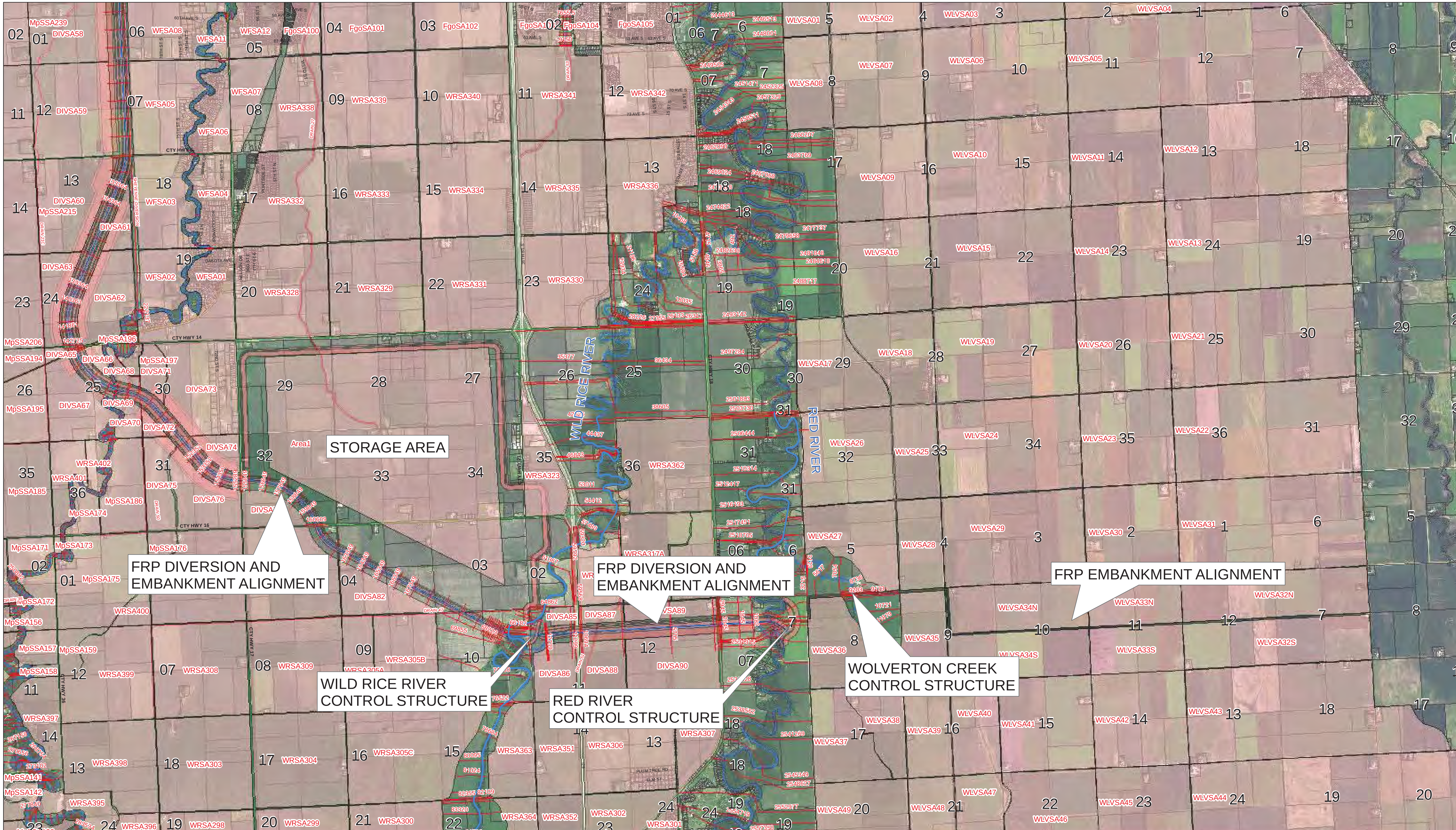
N W E S

0 2,500 5,000 10,000 Feet

FIGURE 6

HMG

APPENDIX A – HYDRAULIC MODEL GEOMETRY



FEDERALLY RECOMMENDED PLAN (FRP)
FARGO MOORHEAD METRO DIVERSION

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Parcel Date: XX/XX/2011 Aerial Image: 2010 County SIDS Elevation Data: IWI Lidar 2008/09
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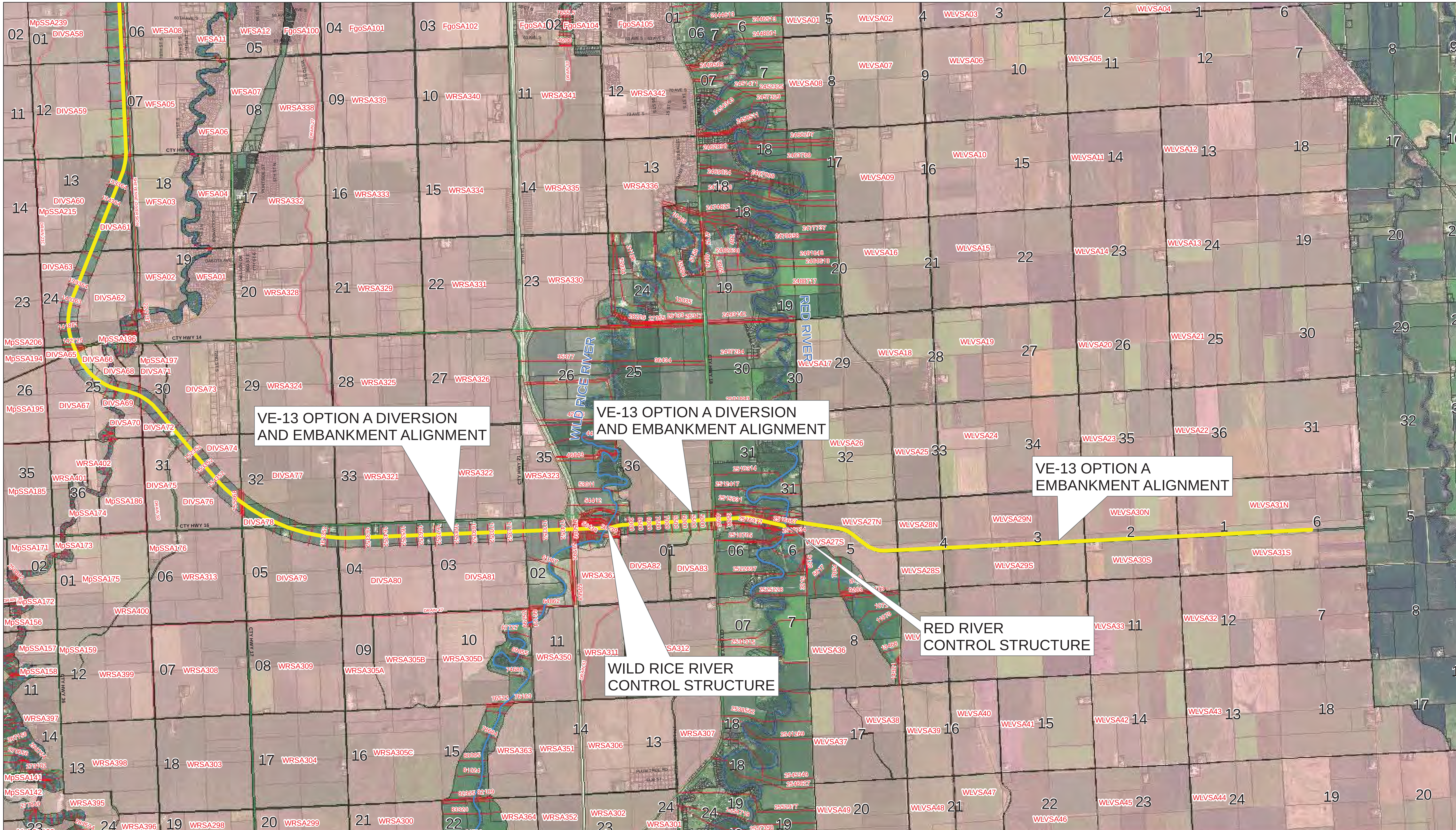
Appendix A.1



VE 13 - OPTION A
FARGO MOORHEAD METRO DIVERSION

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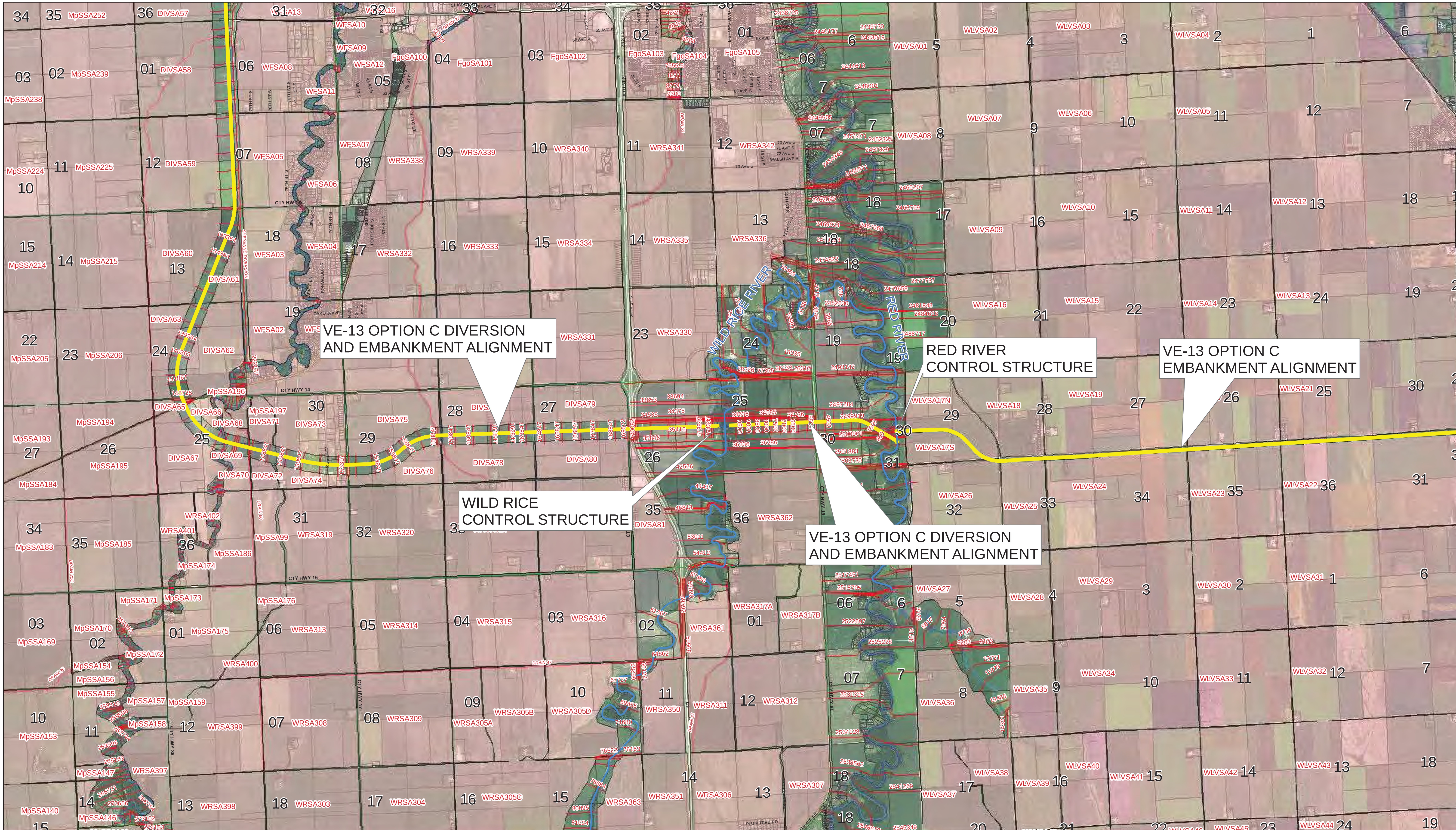
Appendix A.2



VE-13 - OPTION C
FARGO MOORHEAD METRO DIVERSION

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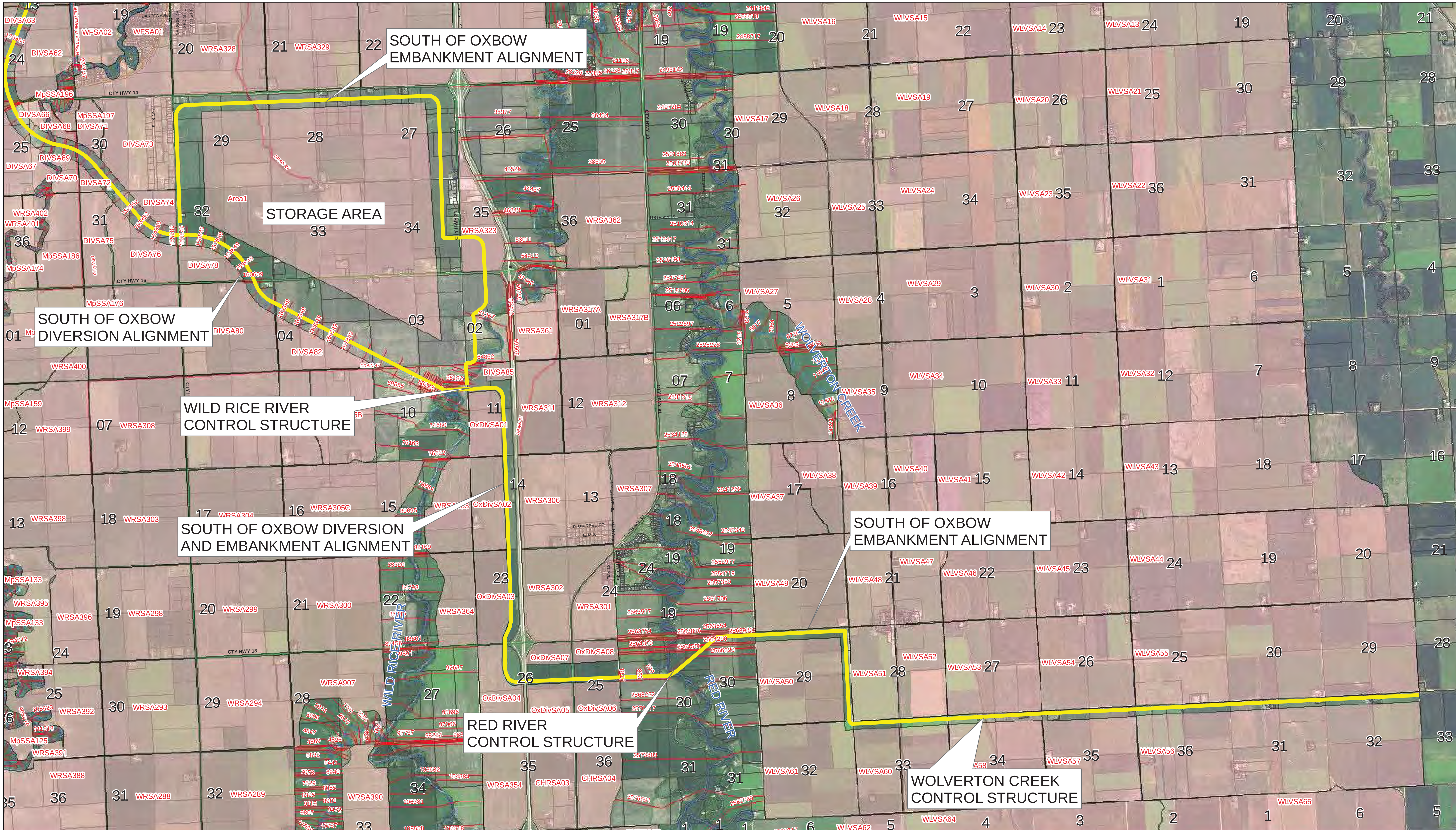
Appendix A.3

HMG



SOUTH OF OXBOW
FARGO MOORHEAD METRO DIVERSION

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Parcel Date: XX/XX/2011 Aerial Image: 2010 County SIDS Elevation Data: IWI Lidar 2008/09
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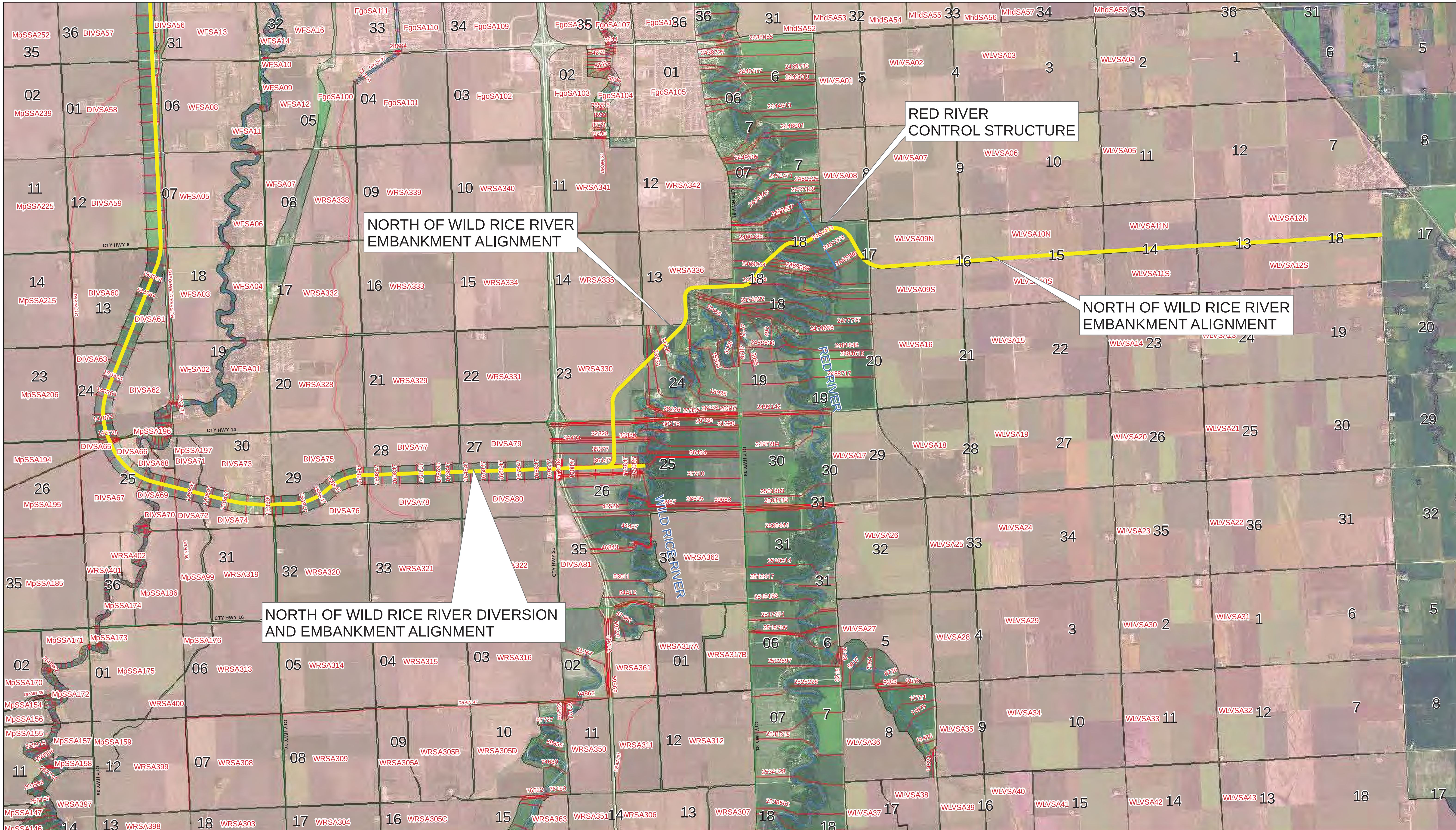
Appendix A.4



NORTH OF WILD RICE RIVER
FARGO MOORHEAD METRO DIVERSION

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Parcel Date: XX/XX/2011 Aerial Image: 2010 County SIDS Elevation Data: IWI Lidar 2008/09
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N
W E
S

HMG

Appendix A.5

APPENDIX B – HYDRAULIC MODELING RESULTS

APPENDIX B.1 – FEDERALLY RECOMMENDED PLAN (FRP)

Appendix B.1.1 – 10-percent Chance Event

Appendix B.1.2 – 2-percent Chance Event

Appendix B.1.3 – 1-percent Chance Event

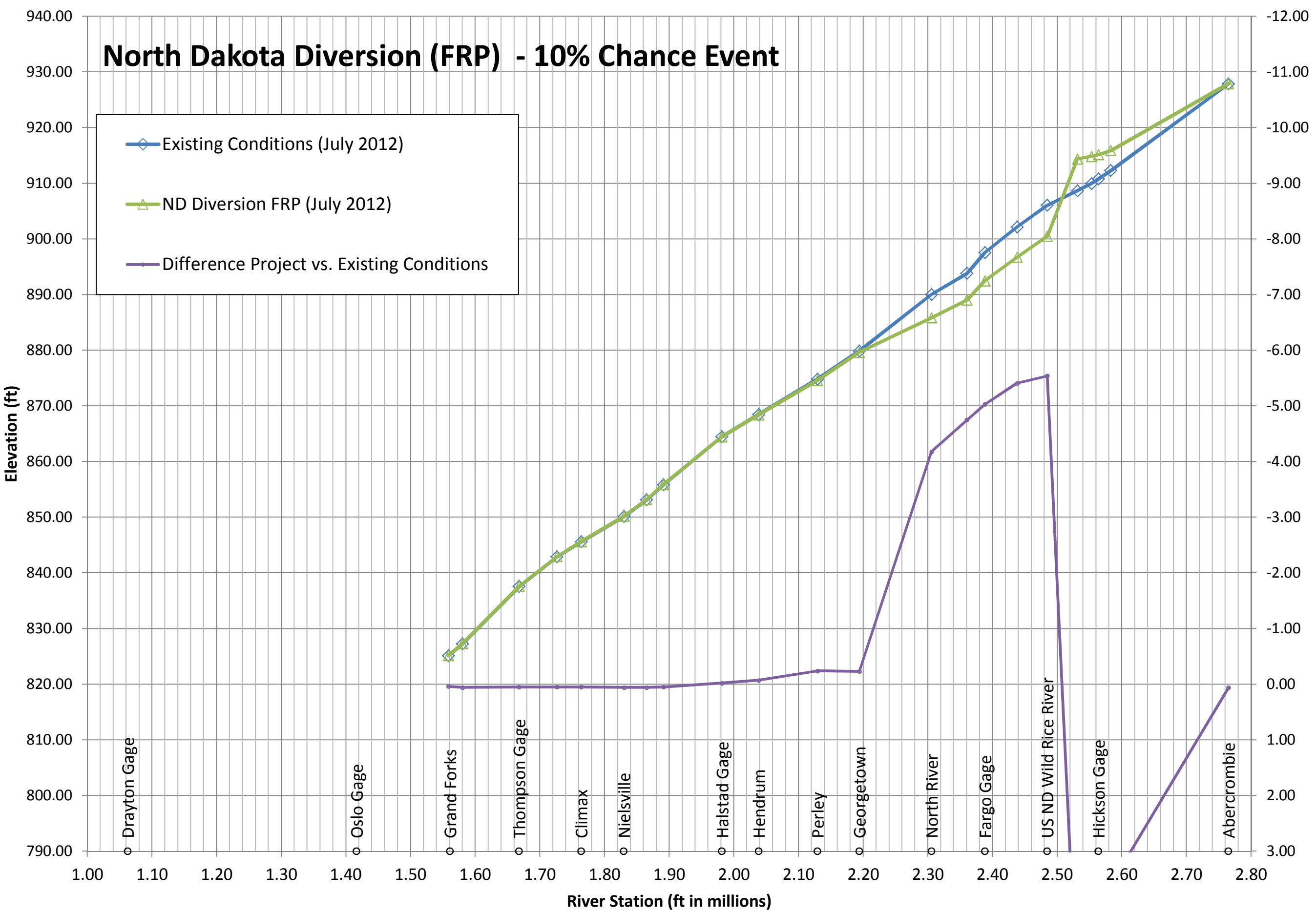
Appendix B.1.4 – 0.2-percent Chance Event

Appendix B.1.1 Federally Recommended Plan (FRP) - 10% Chance Event

North Dakota Diversion (FRP) - 10% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion FRP (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	825.15	825.19	0.04	0.11	-0.07		
32nd Ave, Grand Forks	1580152	827.25	827.31	0.06	0.11	-0.05		
Thompson Gage	1667877	837.58	837.63	0.05	0.04	0.01		
Co. Hwy 25/ Co. Rd 221	1726274	842.90	842.95	0.05	0.04	0.01		
DS Sandhill River/ Climax	1763746	845.59	845.64	0.05	0.03	0.02		
Nielsville	1829877	850.14	850.20	0.06	0.03	0.03		
DS Marsh River	1864960	853.13	853.19	0.06	0.04	0.02		
US Goose River/ Shelly	1891054	855.86	855.91	0.05	0.03	0.02		
Halstad Gage	1981580	864.50	864.48	-0.02	-0.12	0.10		
Hendrum	2038409	868.48	868.41	-0.07	-0.25	0.18		
Perley	2129181	874.83	874.59	-0.24	-0.54	0.30		
Georgetown	2194021	879.88	879.65	-0.23	-0.43	0.20		
North River/ Clay Co. Hwy 93	2305647	890.04	885.86	-4.18	-5.49	1.31		
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	893.81	889.06	-4.75	-5.36	0.61		
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.54 (34.8*)	892.51 (29.77*)	-5.03	-5.47	0.44		
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	902.15	896.74	-5.41	-5.49	0.08		
US ND Wild Rice River	2484618	906.05	900.51	-5.54	-5.15	-0.39		
US FRP Diversion	2531315	908.66	914.40	5.74	8.23	-2.49		
Oxbow	2552977	909.96	914.86	4.90	7.13	-2.23		
Hickson Gage	2563754	910.78	915.15	4.37	6.59	-2.22		
Cass/Richland County Line	2582760	912.29	915.89	3.60	5.64	-2.04		
Abercrombie	2764908	927.87	927.93	0.06	0.11	-0.05		

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

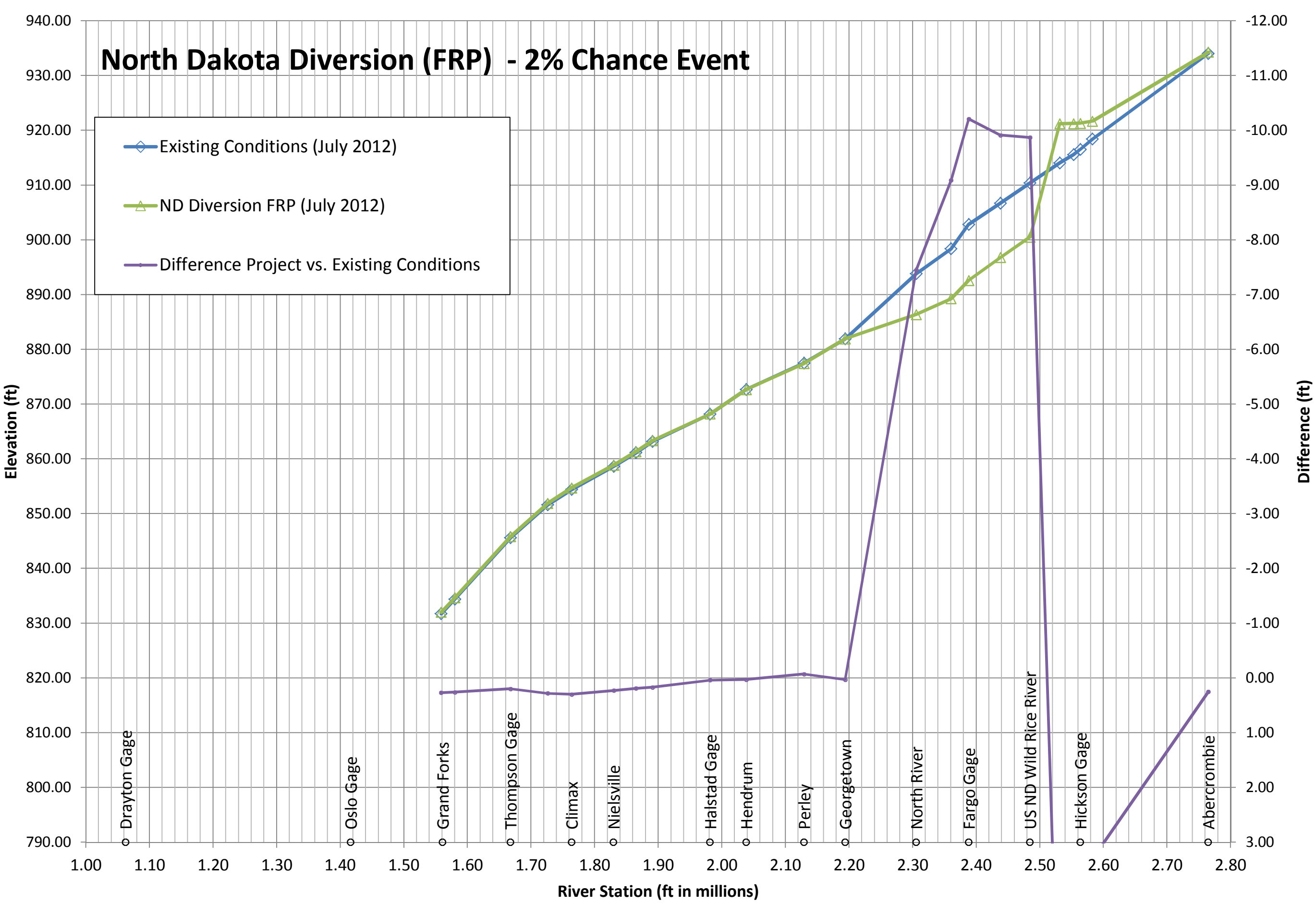


Appendix B.1.2 Federally Recommended Plan (FRP) - 2% Chance Event

North Dakota Diversion (FRP) - 2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion FRP (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	831.74	832.01	0.27	0.18	0.09		
32nd Ave, Grand Forks	1580152	834.40	834.66	0.26	0.28	-0.02		
Thompson Gage	1667877	845.64	845.84	0.20	0.24	-0.04		
Co. Hwy 25/ Co. Rd 221	1726274	851.65	851.93	0.28	0.21	0.07		
DS Sandhill River/ Climax	1763746	854.41	854.71	0.30	0.21	0.09		
Nielsville	1829877	858.65	858.88	0.23	0.18	0.05		
DS Marsh River	1864960	861.16	861.35	0.19	0.16	0.03		
US Goose River/ Shelly	1891054	863.20	863.37	0.17	0.12	0.05		
Halstad Gage	1981580	868.18	868.22	0.04	0.00	0.04		
Hendrum	2038409	872.67	872.70	0.03	-0.12	0.15		
Perley	2129181	877.51	877.44	-0.07	-0.32	0.25		
Georgetown	2194021	881.93	881.96	0.03	-0.23	0.26		
North River/ Clay Co. Hwy 93	2305647	893.82	886.37	-7.45	-6.75	-0.70		
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.37	889.28	-9.09	-8.35	-0.74		
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.83 (40.09*)	892.62 (29.88*)	-10.21	-9.88	-0.33		
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.71	896.80	-9.91	-10.21	0.30		
US ND Wild Rice River	2484618	910.41	900.54	-9.87	-9.41	-0.46		
US FRP Diversion	2531315	914.05	921.22	7.17	7.10	0.07		
Oxbow	2552977	915.57	921.25	5.68	5.40	0.28		
Hickson Gage	2563754	916.52	921.29	4.77	4.58	0.19		
Cass/Richland County Line	2582760	918.40	921.70	3.30	3.52	-0.22		
Abercrombie	2764908	934.04	934.29	0.25	0.14	0.11		

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

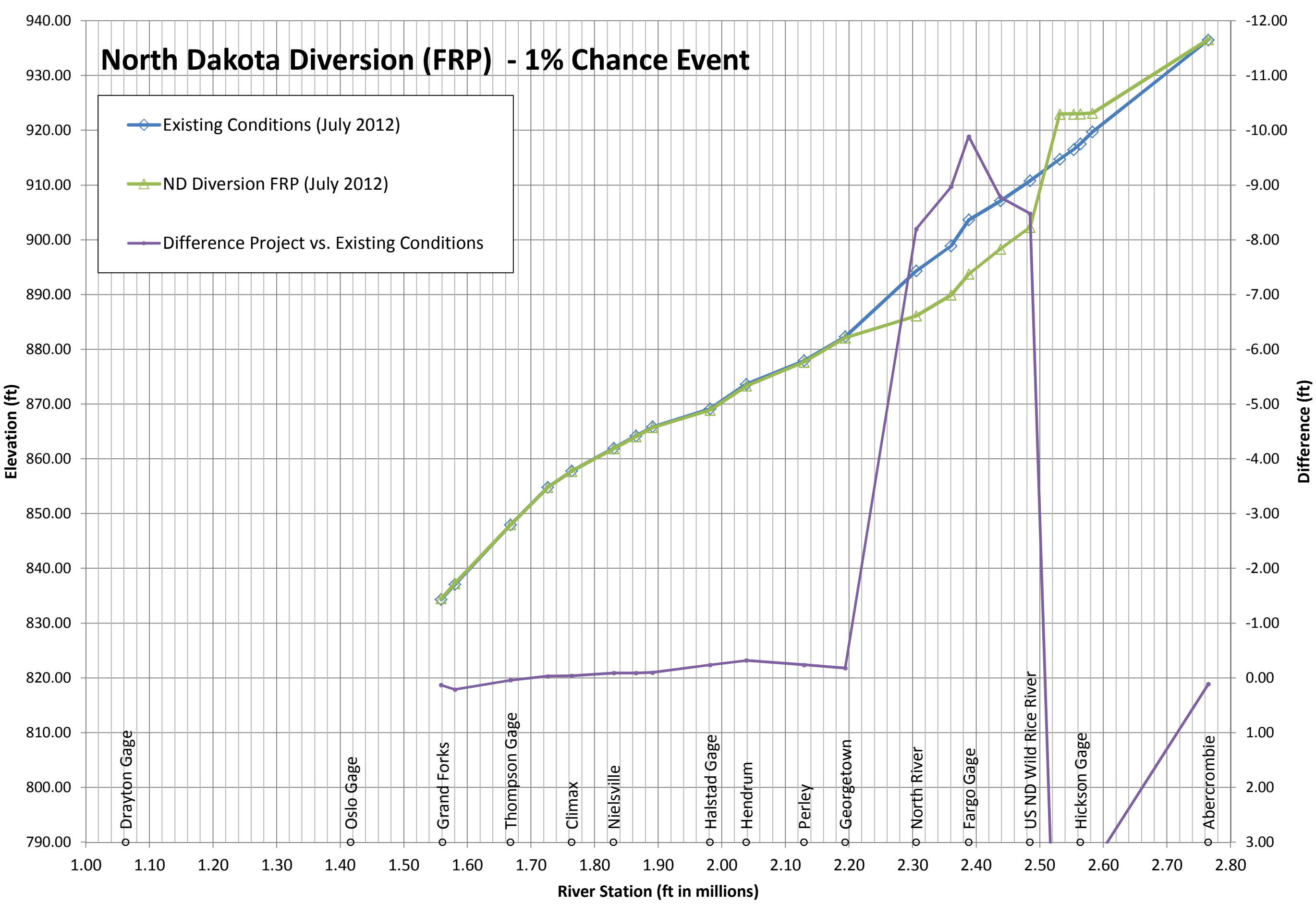


Appendix B.1.3 Federally Recommended Plan (FRP) - 1% Chance Event

North Dakota Diversion (FRP) - 1% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion FRP (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	834.36	834.49	0.13	0.24	-0.11		
32nd Ave, Grand Forks	1580152	837.06	837.27	0.21	0.28	-0.07		
Thompson Gage	1667877	847.97	848.01	0.04	0.04	0.00		
Co. Hwy 25/ Co. Rd 221	1726274	854.83	854.80	-0.03	-0.02	-0.01		
DS Sandhill River/ Climax	1763746	857.78	857.74	-0.04	-0.04	0.00		
Nielsville	1829877	861.96	861.87	-0.09	-0.04	-0.05		
DS Marsh River	1864960	864.20	864.11	-0.09	-0.03	-0.06		
US Goose River/ Shelly	1891054	865.86	865.76	-0.10	-0.04	-0.06		
Halstad Gage	1981580	869.15	868.91	-0.24	-0.06	-0.18		
Hendrum	2038409	873.64	873.32	-0.32	-0.06	-0.26		
Perley	2129181	877.93	877.69	-0.24	-0.28	0.04		
Georgetown	2194021	882.31	882.13	-0.18	-0.25	0.07		
North River/ Clay Co. Hwy 93	2305647	894.32	886.12	-8.20	-7.25	-0.95		
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.91	889.94	-8.97	-8.58	-0.39		
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.65 (40.91*)	893.76 (31.02*)	-9.89	-10.32	0.43		
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.12	898.34	-8.78	-10.05	1.27		
US ND Wild Rice River	2484618	910.80	902.32	-8.48	-8.99	0.51		
US FRP Diversion	2531315	914.74	922.98	8.24	8.23	0.01		
Oxbow	2552977	916.47	923.00	6.53	6.30	0.23		
Hickson Gage	2563754	917.55	923.01	5.46	5.38	0.08		
Cass/Richland County Line	2582760	919.72	923.14	3.42	4.02	-0.60		
Abercrombie	2764908	936.52	936.63	0.11	0.11	0.00		

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

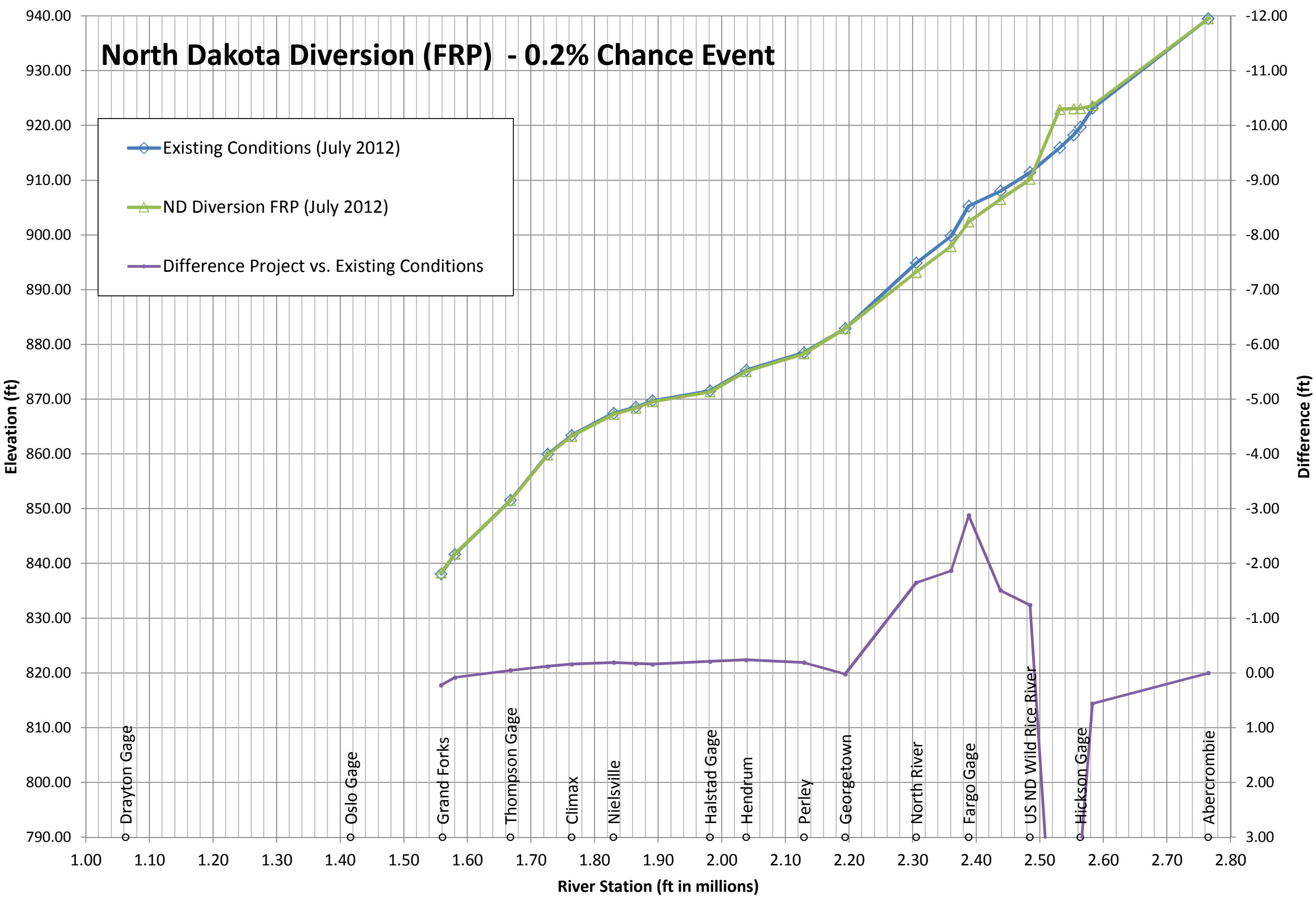


Appendix B.1.4 Federally Recommended Plan (FRP) - 0.2% Chance Event

North Dakota Diversion (FRP) - 0.2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion FRP (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	838.09	838.31	0.22	0.22	0.00		
32nd Ave, Grand Forks	1580152	841.66	841.74	0.08	0.27	-0.19		
Thompson Gage	1667877	851.59	851.54	-0.05	-0.05	0.00		
Co. Hwy 25/ Co. Rd 221	1726274	859.99	859.87	-0.12	-0.12	0.00		
DS Sandhill River/ Climax	1763746	863.41	863.25	-0.16	-0.15	-0.01		
Nielsville	1829877	867.47	867.28	-0.19	-0.16	-0.03		
DS Marsh River	1864960	868.60	868.43	-0.17	-0.14	-0.03		
US Goose River/ Shelly	1891054	869.74	869.58	-0.16	-0.13	-0.03		
Halstad Gage	1981580	871.57	871.36	-0.21	-0.22	0.01		
Hendrum	2038409	875.34	875.10	-0.24	-0.30	0.06		
Perley	2129181	878.51	878.32	-0.19	-0.36	0.17		
Georgetown	2194021	882.94	882.96	0.02	-0.33	0.35		
North River/ Clay Co. Hwy 93	2305647	894.89	893.24	-1.65	-2.39	0.74		
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.83	897.96	-1.87	-1.99	0.12		
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.29 (42.55*)	902.41 (39.67*)	-2.88	-3.03	0.15		
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	908.03	906.52	-1.51	-2.05	0.54		
US ND Wild Rice River	2484618	911.46	910.22	-1.24	-1.31	0.07		
US FRP Diversion	2531315	915.95	922.99	7.04	6.50	0.54		
Oxbow	2552977	918.27	923.07	4.80	3.98	0.82		
Hickson Gage	2563754	919.72	923.12	3.40	2.85	0.55		
Cass/Richland County Line	2582760	923.12	923.68	0.56	1.13	-0.57		
Abercrombie	2764908	939.55	939.55	0.00	0.01	-0.01		

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



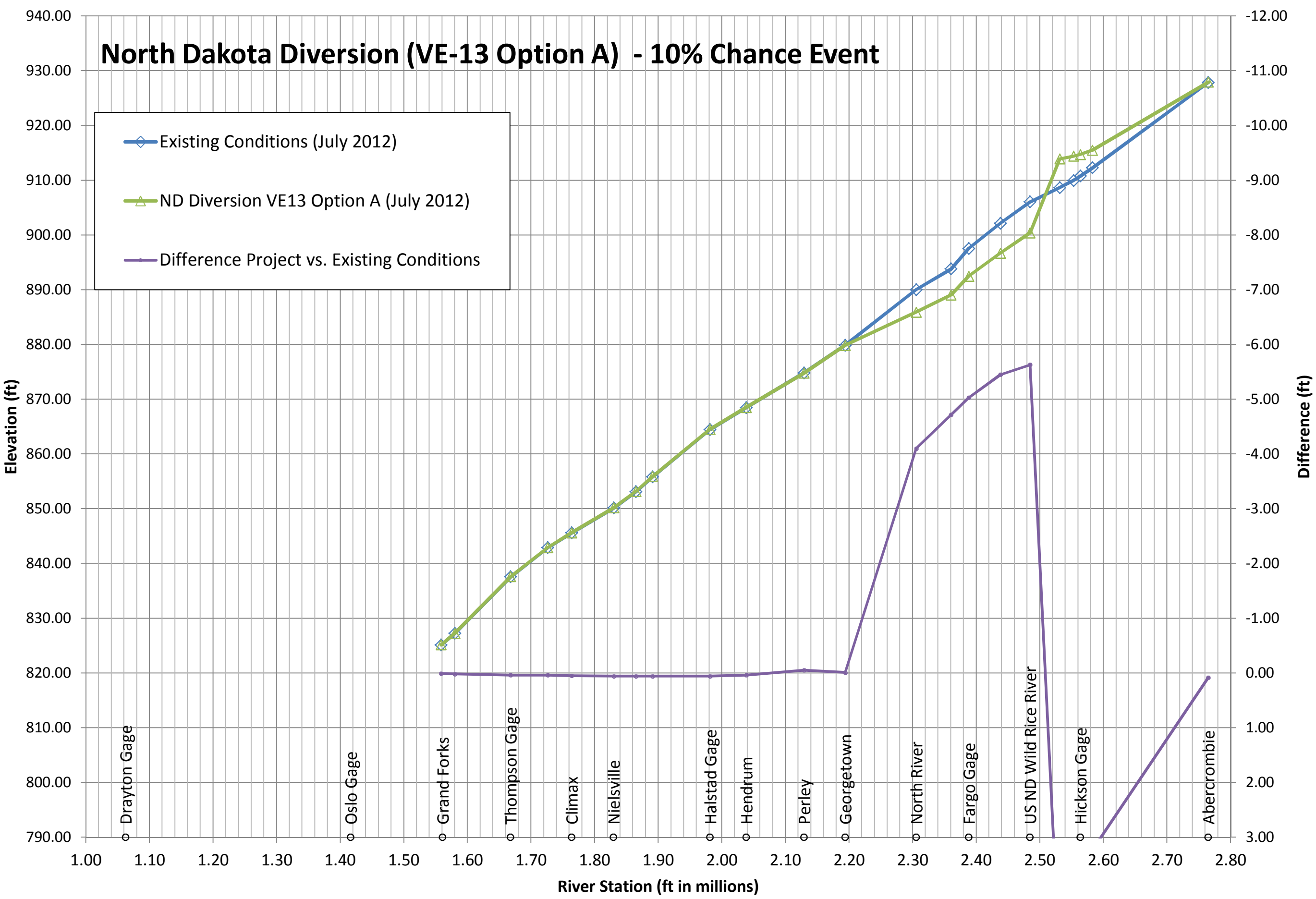
APPENDIX B.2 – VE-13 OPTION A (VE13A)

Appendix B.2.1 VE-13 Option A - 10% Chance Event

North Dakota Diversion (VE-13 Option A) - 10% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option A (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	825.15	825.16	0.01	0.11	-0.10	0.04	-0.03
32nd Ave, Grand Forks	1580152	827.25	827.27	0.02	0.11	-0.09	0.06	-0.04
Thompson Gage	1667877	837.58	837.62	0.04	0.04	0.00	0.05	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	842.90	842.94	0.04	0.04	0.00	0.05	-0.01
DS Sandhill River/ Climax	1763746	845.59	845.64	0.05	0.03	0.02	0.05	0.00
Nielsville	1829877	850.14	850.20	0.06	0.03	0.03	0.06	0.00
DS Marsh River	1864960	853.13	853.19	0.06	0.04	0.02	0.06	0.00
US Goose River/ Shelly	1891054	855.86	855.92	0.06	0.03	0.03	0.05	0.01
Halstad Gage	1981580	864.50	864.56	0.06	-0.12	0.18	-0.02	0.08
Hendrum	2038409	868.48	868.52	0.04	-0.25	0.29	-0.07	0.11
Perley	2129181	874.83	874.78	-0.05	-0.54	0.49	-0.24	0.19
Georgetown	2194021	879.88	879.87	-0.01	-0.43	0.42	-0.23	0.22
North River/ Clay Co. Hwy 93	2305647	890.04	885.94	-4.10	-5.49	1.39	-4.18	0.08
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	893.81	889.09	-4.72	-5.36	0.64	-4.75	0.03
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.54 (34.8*)	892.51 (29.77*)	-5.03	-5.47	0.44	-5.03	0.00
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	902.15	896.70	-5.45	-5.49	0.04	-5.41	-0.04
US ND Wild Rice River	2484618	906.05	900.42	-5.63	-5.15	-0.48	-5.54	-0.09
US FRP Diversion	2531315	908.66	913.92	5.26	8.23	-2.97	5.74	-0.48
Oxbow	2552977	909.96	914.42	4.46	7.13	-2.67	4.90	-0.44
Hickson Gage	2563754	910.78	914.73	3.95	6.59	-2.64	4.37	-0.42
Cass/Richland County Line	2582760	912.29	915.52	3.23	5.64	-2.41	3.60	-0.37
Abercrombie	2764908	927.87	927.95	0.08	0.11	-0.03	0.06	0.02

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

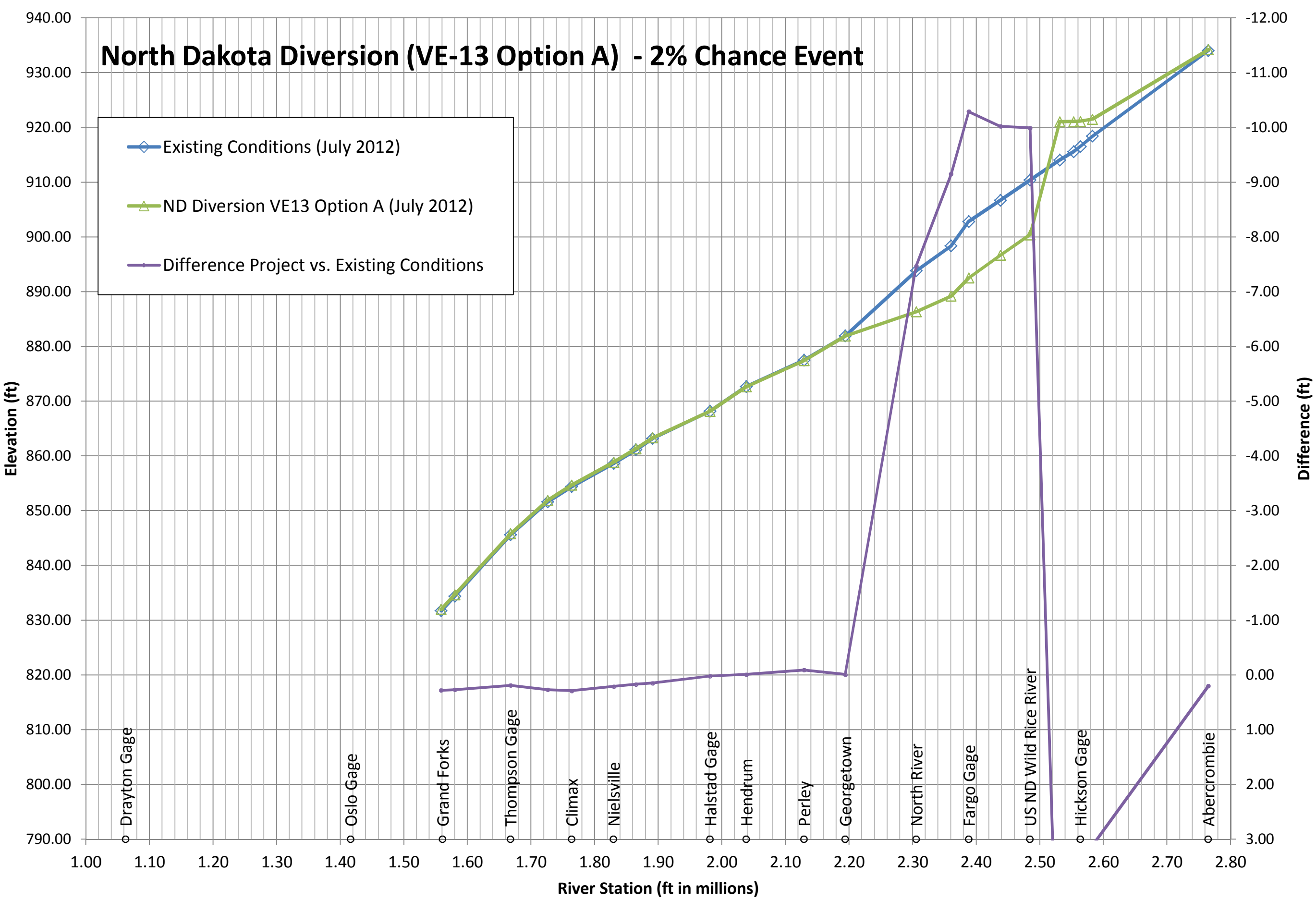


Appendix B.2.2 VE-13 Option A - 2% Chance Event

North Dakota Diversion (VE-13 Option A) - 2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option A (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	831.74	832.02	0.28	0.18	0.10	0.27	0.01
32nd Ave, Grand Forks	1580152	834.40	834.67	0.27	0.28	-0.01	0.26	0.01
Thompson Gage	1667877	845.64	845.83	0.19	0.24	-0.05	0.20	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	851.65	851.92	0.27	0.21	0.06	0.28	-0.01
DS Sandhill River/ Climax	1763746	854.41	854.70	0.29	0.21	0.08	0.30	-0.01
Nielsville	1829877	858.65	858.86	0.21	0.18	0.03	0.23	-0.02
DS Marsh River	1864960	861.16	861.33	0.17	0.16	0.01	0.19	-0.02
US Goose River/ Shelly	1891054	863.20	863.35	0.15	0.12	0.03	0.17	-0.02
Halstad Gage	1981580	868.18	868.20	0.02	0.00	0.02	0.04	-0.02
Hendrum	2038409	872.67	872.66	-0.01	-0.12	0.11	0.03	-0.04
Perley	2129181	877.51	877.42	-0.09	-0.32	0.23	-0.07	-0.02
Georgetown	2194021	881.93	881.92	-0.01	-0.23	0.22	0.03	-0.04
North River/ Clay Co. Hwy 93	2305647	893.82	886.35	-7.47	-6.75	-0.72	-7.45	-0.02
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.37	889.22	-9.15	-8.35	-0.80	-9.09	-0.06
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.83 (40.09*)	892.54 (29.8*)	-10.29	-9.88	-0.41	-10.21	-0.08
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.71	896.69	-10.02	-10.21	0.19	-9.91	-0.11
US ND Wild Rice River	2484618	910.41	900.42	-9.99	-9.41	-0.58	-9.87	-0.12
US FRP Diversion	2531315	914.05	921.05	7.00	7.10	-0.10	7.17	-0.17
Oxbow	2552977	915.57	921.08	5.51	5.40	0.11	5.68	-0.17
Hickson Gage	2563754	916.52	921.13	4.61	4.58	0.03	4.77	-0.16
Cass/Richland County Line	2582760	918.40	921.51	3.11	3.52	-0.41	3.30	-0.19
Abercrombie	2764908	934.04	934.24	0.20	0.14	0.06	0.25	-0.05

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

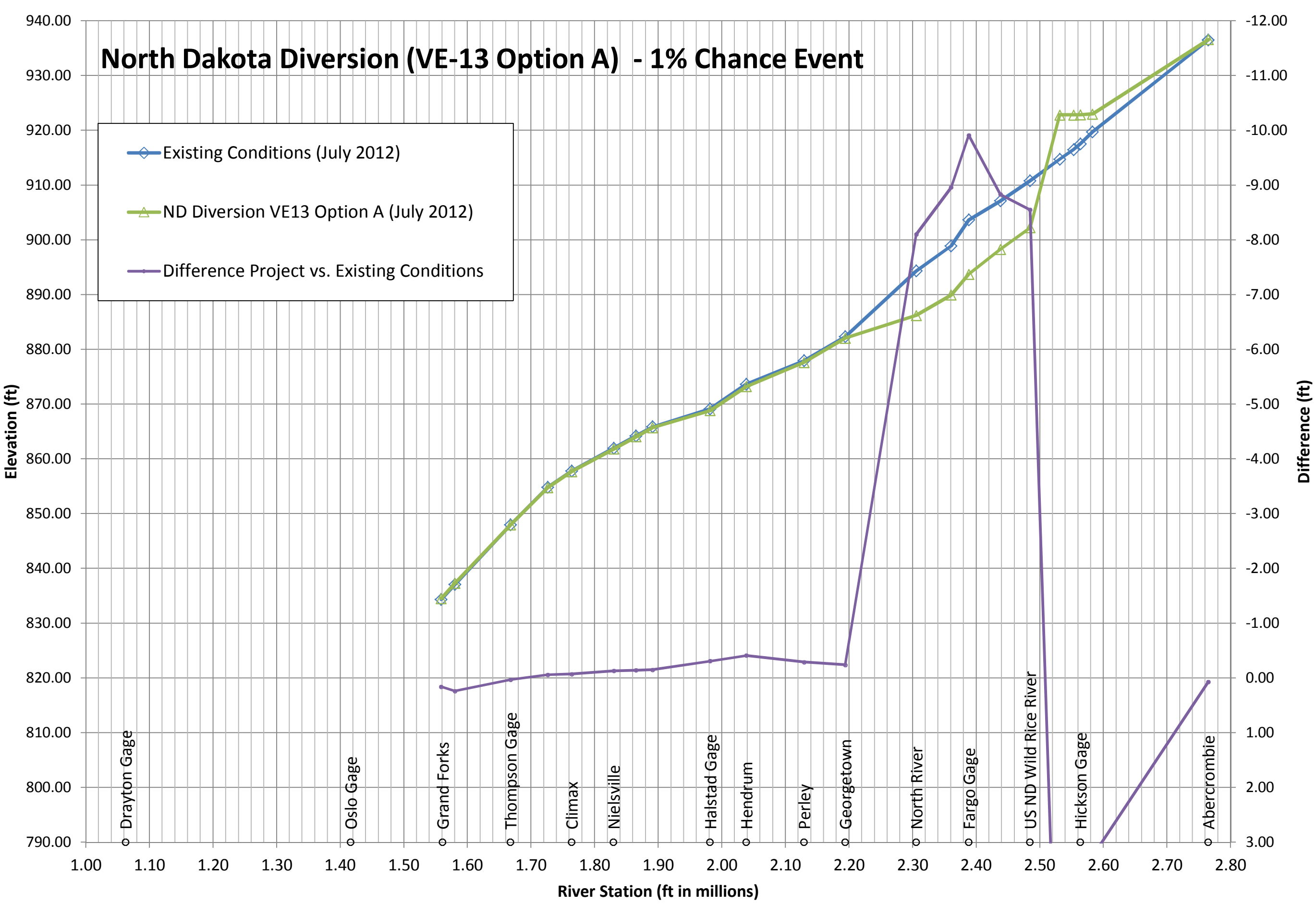


Appendix B.2.3 VE-13 Option A - 1% Chance Event

North Dakota Diversion (VE-13 Option A) - 1% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option A (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	834.36	834.52	0.16	0.24	-0.08	0.13	0.03
32nd Ave, Grand Forks	1580152	837.06	837.30	0.24	0.28	-0.04	0.21	0.03
Thompson Gage	1667877	847.97	848.00	0.03	0.04	-0.01	0.04	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	854.83	854.77	-0.06	-0.02	-0.04	-0.03	-0.03
DS Sandhill River/ Climax	1763746	857.78	857.71	-0.07	-0.04	-0.03	-0.04	-0.03
Nielsville	1829877	861.96	861.83	-0.13	-0.04	-0.09	-0.09	-0.04
DS Marsh River	1864960	864.20	864.06	-0.14	-0.03	-0.11	-0.09	-0.05
US Goose River/ Shelly	1891054	865.86	865.71	-0.15	-0.04	-0.11	-0.10	-0.05
Halstad Gage	1981580	869.15	868.84	-0.31	-0.06	-0.25	-0.24	-0.07
Hendrum	2038409	873.64	873.23	-0.41	-0.06	-0.35	-0.32	-0.09
Perley	2129181	877.93	877.64	-0.29	-0.28	-0.01	-0.24	-0.05
Georgetown	2194021	882.31	882.07	-0.24	-0.25	0.01	-0.18	-0.06
North River/ Clay Co. Hwy 93	2305647	894.32	886.22	-8.10	-7.25	-0.85	-8.20	0.10
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.91	889.95	-8.96	-8.58	-0.38	-8.97	0.01
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.65 (40.91*)	893.74 (31*)	-9.91	-10.32	0.41	-9.89	-0.02
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.12	898.29	-8.83	-10.05	1.22	-8.78	-0.05
US ND Wild Rice River	2484618	910.80	902.25	-8.55	-8.99	0.44	-8.48	-0.07
US FRP Diversion	2531315	914.74	922.82	8.08	8.23	-0.15	8.24	-0.16
Oxbow	2552977	916.47	922.83	6.36	6.30	0.06	6.53	-0.17
Hickson Gage	2563754	917.55	922.85	5.30	5.38	-0.08	5.46	-0.16
Cass/Richland County Line	2582760	919.72	922.98	3.26	4.02	-0.76	3.42	-0.16
Abercrombie	2764908	936.52	936.59	0.07	0.11	-0.04	0.11	-0.04

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

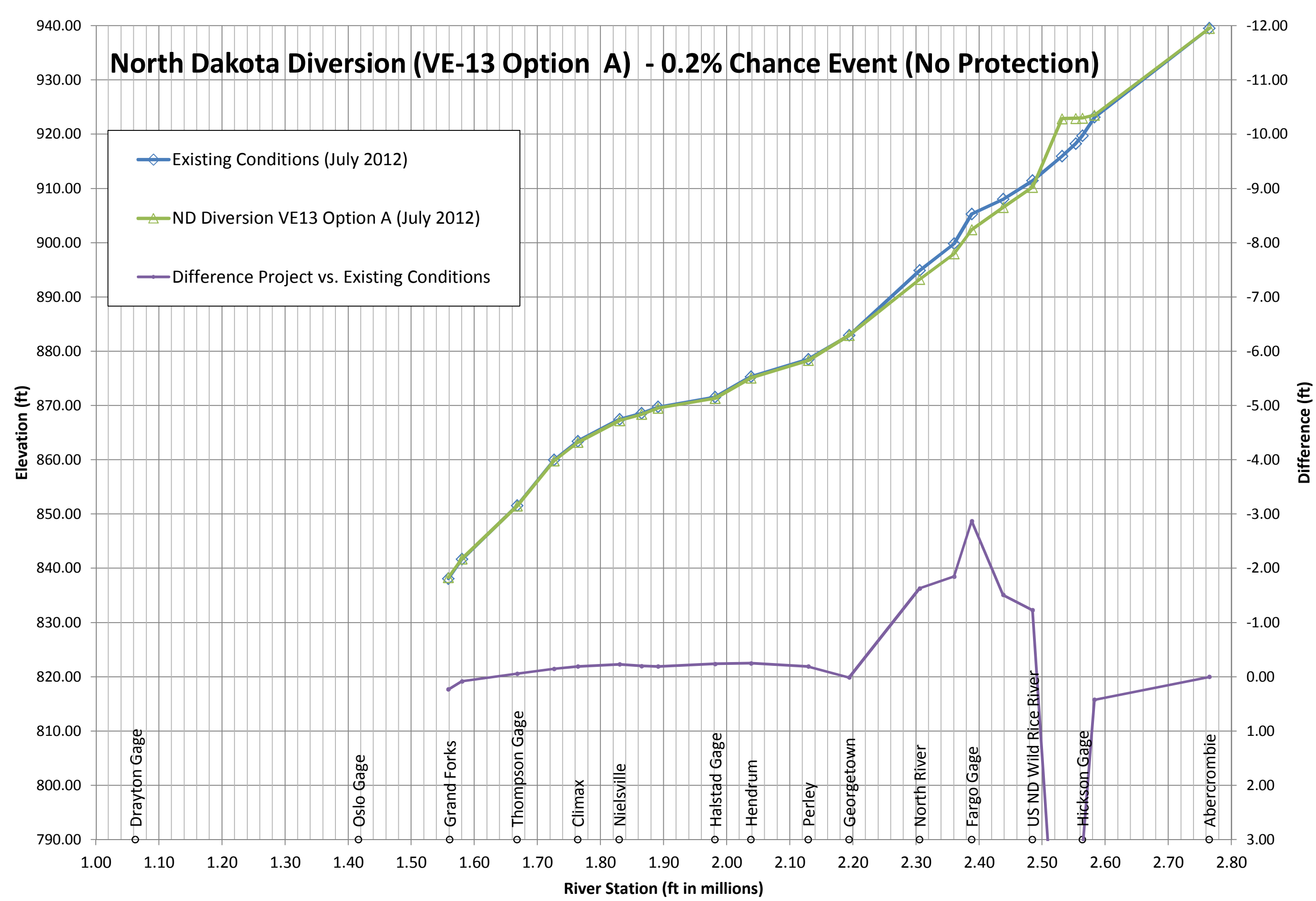


Appendix B.2.4 VE-13 Option A - 0.2% Chance Event

North Dakota Diversion (VE-13 Option A) - 0.2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option A (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	838.09	838.32	0.23	0.22	0.01	0.22	0.01
32nd Ave, Grand Forks	1580152	841.66	841.74	0.08	0.27	-0.19	0.08	0.00
Thompson Gage	1667877	851.59	851.53	-0.06	-0.05	-0.01	-0.05	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	859.99	859.84	-0.15	-0.12	-0.03	-0.12	-0.03
DS Sandhill River/ Climax	1763746	863.41	863.22	-0.19	-0.15	-0.04	-0.16	-0.03
Nielsville	1829877	867.47	867.24	-0.23	-0.16	-0.07	-0.19	-0.04
DS Marsh River	1864960	868.60	868.40	-0.20	-0.14	-0.06	-0.17	-0.03
US Goose River/ Shelly	1891054	869.74	869.55	-0.19	-0.13	-0.06	-0.16	-0.03
Halstad Gage	1981580	871.57	871.33	-0.24	-0.22	-0.02	-0.21	-0.03
Hendrum	2038409	875.34	875.09	-0.25	-0.30	0.05	-0.24	-0.01
Perley	2129181	878.51	878.32	-0.19	-0.36	0.17	-0.19	0.00
Georgetown	2194021	882.94	882.95	0.01	-0.33	0.34	0.02	-0.01
North River/ Clay Co. Hwy 93	2305647	894.89	893.26	-1.63	-2.39	0.76	-1.65	0.02
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.83	897.98	-1.85	-1.99	0.14	-1.87	0.02
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.29 (42.55*)	902.42 (39.68*)	-2.87	-3.03	0.16	-2.88	0.01
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	908.03	906.52	-1.51	-2.05	0.54	-1.51	0.00
US ND Wild Rice River	2484618	911.46	910.23	-1.23	-1.31	0.08	-1.24	0.01
US FRP Diversion	2531315	915.95	922.86	6.91	6.50	0.41	7.04	-0.13
Oxbow	2552977	918.27	922.92	4.65	3.98	0.67	4.80	-0.15
Hickson Gage	2563754	919.72	922.97	3.25	2.85	0.40	3.40	-0.15
Cass/Richland County Line	2582760	923.12	923.54	0.42	1.13	-0.71	0.56	-0.14
Abercrombie	2764908	939.55	939.55	0.00	0.01	-0.01	0.00	0.00

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



APPENDIX B.3 – VE-13 OPTION C (VE13C)

Appendix B.3.1 – 10-percent Chance Event

Appendix B.3.2 – 2-percent Chance Event

Appendix B.3.3 – 1-percent Chance Event

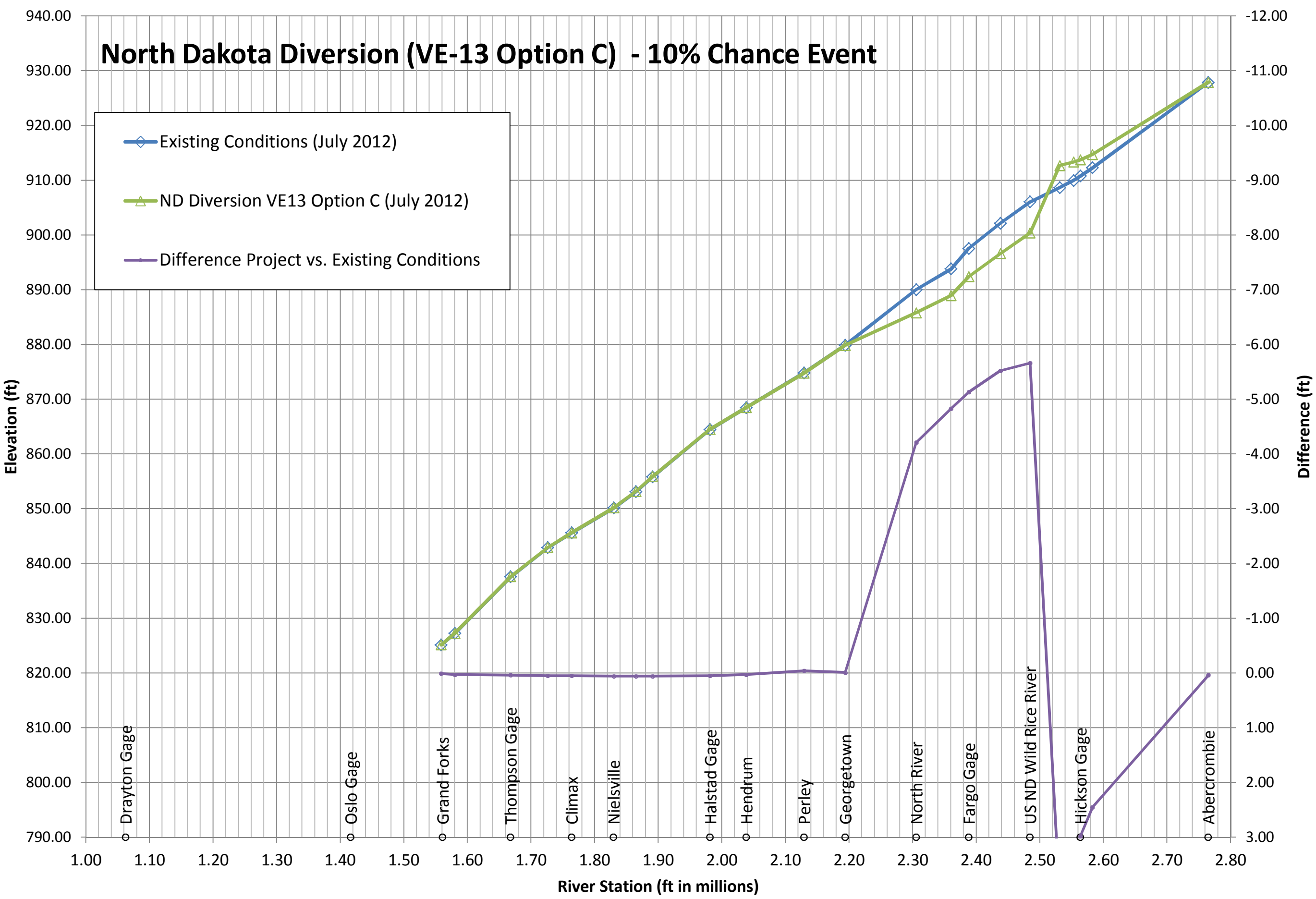
Appendix B.3.4 – 0.2-percent Chance Event

Appendix B.3.1 VE-13 Option C - 10% Chance Event

North Dakota Diversion (VE-13 Option C) - 10% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option C (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	825.15	825.16	0.01	0.11	-0.10	0.04	-0.03
32nd Ave, Grand Forks	1580152	827.25	827.28	0.03	0.11	-0.08	0.06	-0.03
Thompson Gage	1667877	837.58	837.62	0.04	0.04	0.00	0.05	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	842.90	842.95	0.05	0.04	0.01	0.05	0.00
DS Sandhill River/ Climax	1763746	845.59	845.64	0.05	0.03	0.02	0.05	0.00
Nielsville	1829877	850.14	850.20	0.06	0.03	0.03	0.06	0.00
DS Marsh River	1864960	853.13	853.19	0.06	0.04	0.02	0.06	0.00
US Goose River/ Shelly	1891054	855.86	855.92	0.06	0.03	0.03	0.05	0.01
Halstad Gage	1981580	864.50	864.55	0.05	-0.12	0.17	-0.02	0.07
Hendrum	2038409	868.48	868.51	0.03	-0.25	0.28	-0.07	0.10
Perley	2129181	874.83	874.79	-0.04	-0.54	0.50	-0.24	0.20
Georgetown	2194021	879.88	879.87	-0.01	-0.43	0.42	-0.23	0.22
North River/ Clay Co. Hwy 93	2305647	890.04	885.83	-4.21	-5.49	1.28	-4.18	-0.03
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	893.81	888.98	-4.83	-5.36	0.53	-4.75	-0.08
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.54 (34.8*)	892.41 (29.67*)	-5.13	-5.47	0.34	-5.03	-0.10
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	902.15	896.63	-5.52	-5.49	-0.03	-5.41	-0.11
US ND Wild Rice River	2484618	906.05	900.39	-5.66	-5.15	-0.51	-5.54	-0.12
US FRP Diversion	2531315	908.66	912.70	4.04	8.23	-4.19	5.74	-1.70
Oxbow	2552977	909.96	913.36	3.40	7.13	-3.73	4.90	-1.50
Hickson Gage	2563754	910.78	913.76	2.98	6.59	-3.61	4.37	-1.39
Cass/Richland County Line	2582760	912.29	914.74	2.45	5.64	-3.19	3.60	-1.15
Abercrombie	2764908	927.87	927.91	0.04	0.11	-0.07	0.06	-0.02

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

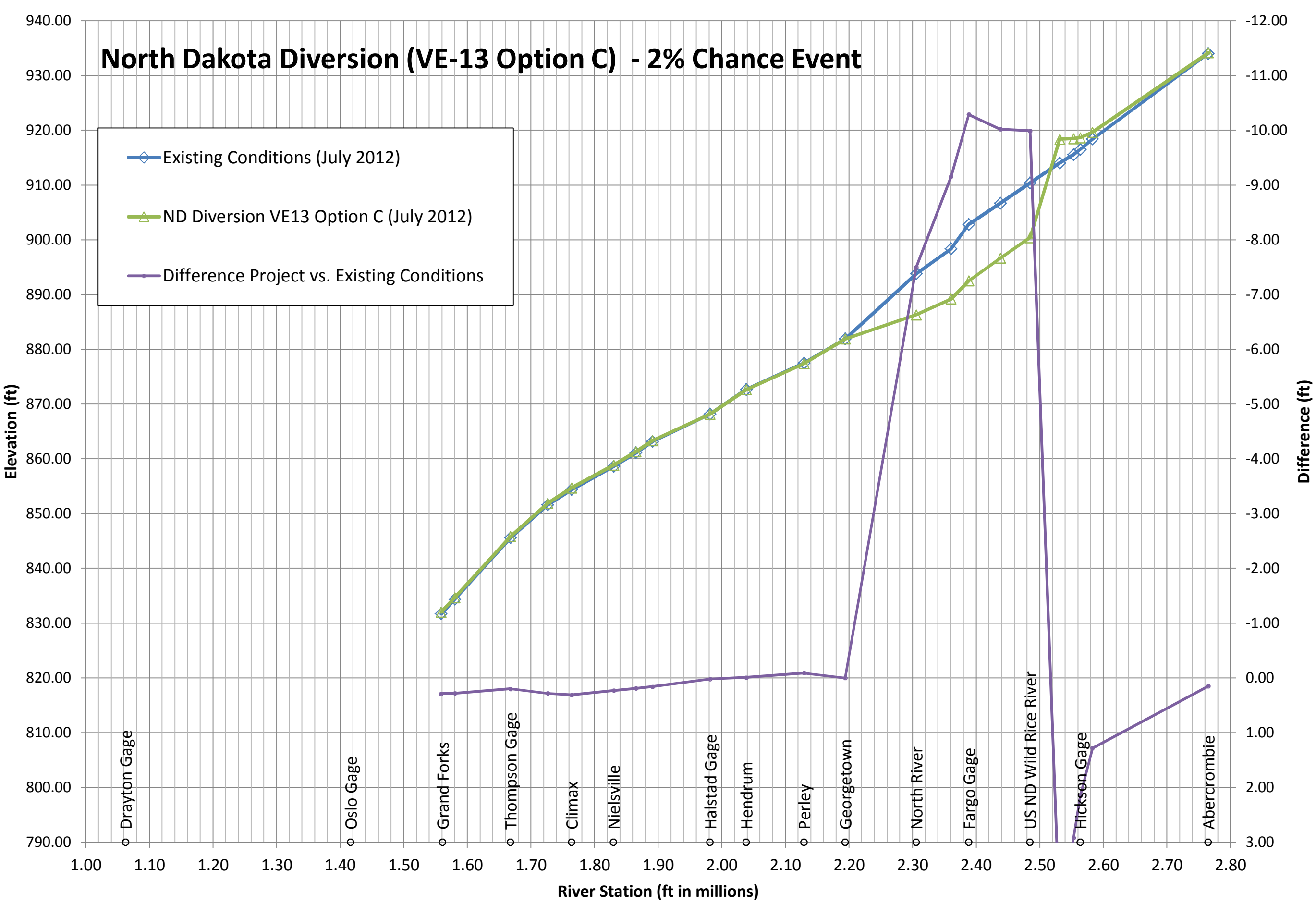


Appendix B.3.2 VE-13 Option C - 2% Chance Event

North Dakota Diversion (VE-13 Option C) - 2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option C (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	831.74	832.03	0.29	0.18	0.11	0.27	0.02
32nd Ave, Grand Forks	1580152	834.40	834.68	0.28	0.28	0.00	0.26	0.02
Thompson Gage	1667877	845.64	845.84	0.20	0.24	-0.04	0.20	0.00
Co. Hwy 25/ Co. Rd 221	1726274	851.65	851.93	0.28	0.21	0.07	0.28	0.00
DS Sandhill River/ Climax	1763746	854.41	854.72	0.31	0.21	0.10	0.30	0.01
Nielsville	1829877	858.65	858.88	0.23	0.18	0.05	0.23	0.00
DS Marsh River	1864960	861.16	861.35	0.19	0.16	0.03	0.19	0.00
US Goose River/ Shelly	1891054	863.20	863.36	0.16	0.12	0.04	0.17	-0.01
Halstad Gage	1981580	868.18	868.20	0.02	0.00	0.02	0.04	-0.02
Hendrum	2038409	872.67	872.66	-0.01	-0.12	0.11	0.03	-0.04
Perley	2129181	877.51	877.42	-0.09	-0.32	0.23	-0.07	-0.02
Georgetown	2194021	881.93	881.93	0.00	-0.23	0.23	0.03	-0.03
North River/ Clay Co. Hwy 93	2305647	893.82	886.32	-7.50	-6.75	-0.75	-7.45	-0.05
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.37	889.21	-9.16	-8.35	-0.81	-9.09	-0.07
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.83 (40.09*)	892.54 (29.8*)	-10.29	-9.88	-0.41	-10.21	-0.08
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.71	896.69	-10.02	-10.21	0.19	-9.91	-0.11
US ND Wild Rice River	2484618	910.41	900.42	-9.99	-9.41	-0.58	-9.87	-0.12
US LPP Diversion	2531315	914.05	918.39	4.34	7.10	-2.76	7.17	-2.83
Oxbow	2552977	915.57	918.49	2.92	5.40	-2.48	5.68	-2.76
Hickson Gage	2563754	916.52	918.67	2.15	4.58	-2.43	4.77	-2.62
Cass/Richland County Line	2582760	918.40	919.68	1.28	3.52	-2.24	3.30	-2.02
Abercrombie	2764908	934.04	934.19	0.15	0.14	0.01	0.25	-0.10

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

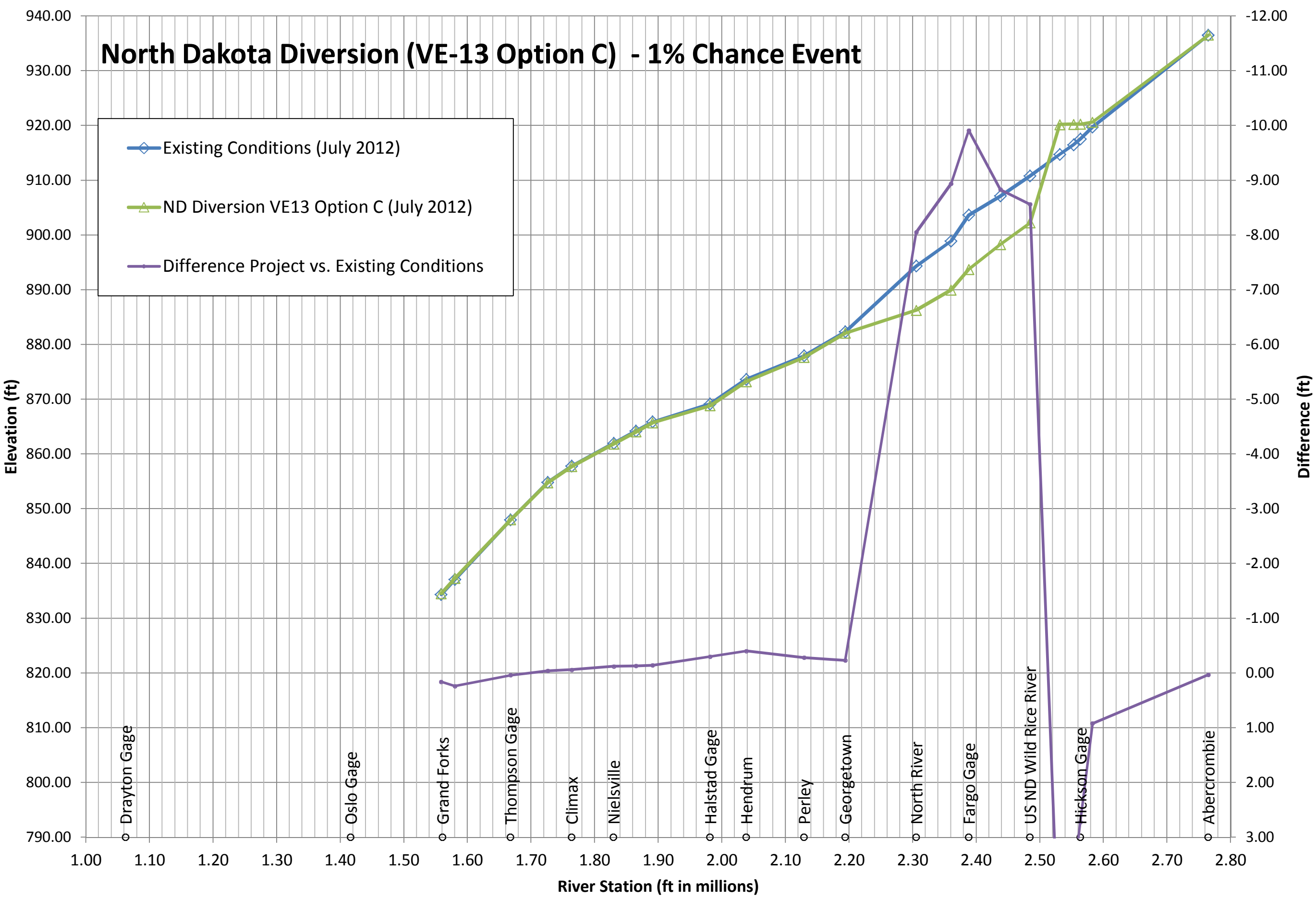


Appendix B.3.3 VE-13 Option C - 1% Chance Event

North Dakota Diversion (VE-13 Option C) - 1% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option C (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	834.36	834.52	0.16	0.24	-0.08	0.13	0.03
32nd Ave, Grand Forks	1580152	837.06	837.30	0.24	0.28	-0.04	0.21	0.03
Thompson Gage	1667877	847.97	848.01	0.04	0.04	0.00	0.04	0.00
Co. Hwy 25/ Co. Rd 221	1726274	854.83	854.79	-0.04	-0.02	-0.02	-0.03	-0.01
DS Sandhill River/ Climax	1763746	857.78	857.72	-0.06	-0.04	-0.02	-0.04	-0.02
Nielsville	1829877	861.96	861.84	-0.12	-0.04	-0.08	-0.09	-0.03
DS Marsh River	1864960	864.20	864.07	-0.13	-0.03	-0.10	-0.09	-0.04
US Goose River/ Shelly	1891054	865.86	865.72	-0.14	-0.04	-0.10	-0.10	-0.04
Halstad Gage	1981580	869.15	868.85	-0.30	-0.06	-0.24	-0.24	-0.06
Hendrum	2038409	873.64	873.24	-0.40	-0.06	-0.34	-0.32	-0.08
Perley	2129181	877.93	877.65	-0.28	-0.28	0.00	-0.24	-0.04
Georgetown	2194021	882.31	882.08	-0.23	-0.25	0.02	-0.18	-0.05
North River/ Clay Co. Hwy 93	2305647	894.32	886.27	-8.05	-7.25	-0.80	-8.20	0.15
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.91	889.97	-8.94	-8.58	-0.36	-8.97	0.03
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.65 (40.91*)	893.74 (31*)	-9.91	-10.32	0.41	-9.89	-0.02
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.12	898.29	-8.83	-10.05	1.22	-8.78	-0.05
US ND Wild Rice River	2484618	910.80	902.24	-8.56	-8.99	0.43	-8.48	-0.08
US FRP Diversion	2531315	914.74	920.18	5.44	8.23	-2.79	8.24	-2.80
Oxbow	2552977	916.47	920.22	3.75	6.30	-2.55	6.53	-2.78
Hickson Gage	2563754	917.55	920.27	2.72	5.38	-2.66	5.46	-2.74
Cass/Richland County Line	2582760	919.72	920.64	0.92	4.02	-3.10	3.42	-2.50
Abercrombie	2764908	936.52	936.55	0.03	0.11	-0.08	0.11	-0.08

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

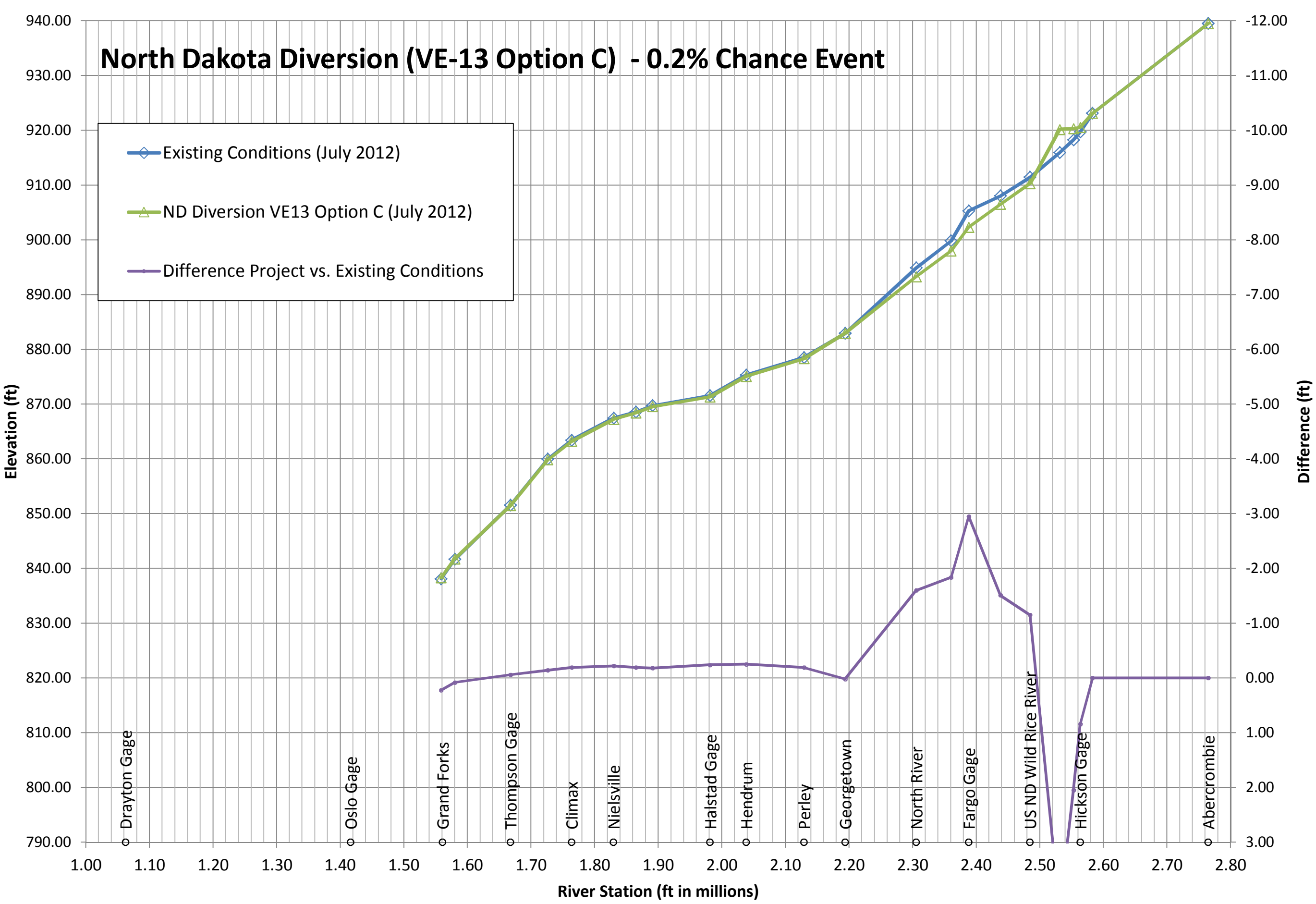


Appendix B.3.4 VE-13 Option C - 0.2% Chance Event

North Dakota Diversion (VE-13 Option C) - 0.2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion VE13 Option C (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	838.09	838.31	0.22	0.22	0.00	0.22	0.00
32nd Ave, Grand Forks	1580152	841.66	841.74	0.08	0.27	-0.19	0.08	0.00
Thompson Gage	1667877	851.59	851.53	-0.06	-0.05	-0.01	-0.05	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	859.99	859.85	-0.14	-0.12	-0.02	-0.12	-0.02
DS Sandhill River/ Climax	1763746	863.41	863.22	-0.19	-0.15	-0.04	-0.16	-0.03
Nielsville	1829877	867.47	867.25	-0.22	-0.16	-0.06	-0.19	-0.03
DS Marsh River	1864960	868.60	868.41	-0.19	-0.14	-0.05	-0.17	-0.02
US Goose River/ Shelly	1891054	869.74	869.56	-0.18	-0.13	-0.05	-0.16	-0.02
Halstad Gage	1981580	871.57	871.33	-0.24	-0.22	-0.02	-0.21	-0.03
Hendrum	2038409	875.34	875.09	-0.25	-0.30	0.05	-0.24	-0.01
Perley	2129181	878.51	878.32	-0.19	-0.36	0.17	-0.19	0.00
Georgetown	2194021	882.94	882.96	0.02	-0.33	0.35	0.02	0.00
North River/ Clay Co. Hwy 93	2305647	894.89	893.29	-1.60	-2.39	0.79	-1.65	0.05
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.83	897.99	-1.84	-1.99	0.15	-1.87	0.03
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.29 (42.55*)	902.34 (39.6*)	-2.95	-3.03	0.08	-2.88	-0.07
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	908.03	906.52	-1.51	-2.05	0.54	-1.51	0.00
US ND Wild Rice River	2484618	911.46	910.31	-1.15	-1.31	0.16	-1.24	0.09
US FRP Diversion	2531315	915.95	920.19	4.24	6.50	-2.26	7.04	-2.80
Oxbow	2552977	918.27	920.32	2.05	3.98	-1.93	4.80	-2.75
Hickson Gage	2563754	919.72	920.56	0.84	2.85	-2.01	3.40	-2.56
Cass/Richland County Line	2582760	923.12	923.12	0.00	1.13	-1.13	0.56	-0.56
Abercrombie	2764908	939.55	939.55	0.00	0.01	-0.01	0.00	0.00

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



APPENDIX B.4 – SOUTH OF OXBOW (OXBOW)

Appendix B.4.1 – 10-percent Chance Event

Appendix B.4.2 – 2-percent Chance Event

Appendix B.4.3 – 1-percent Chance Event

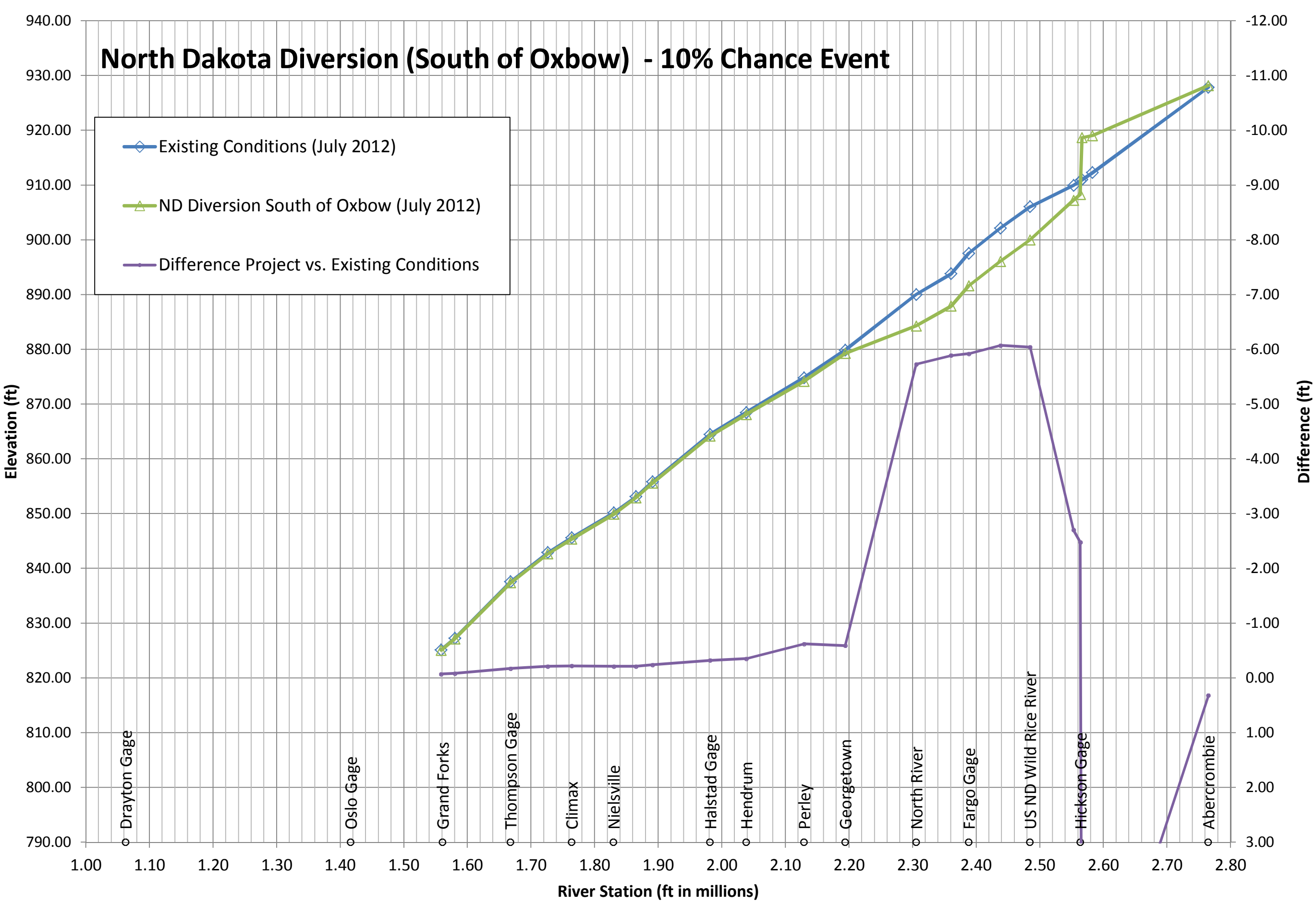
Appendix B.4.4 – 0.2-percent Chance Event

Appendix B.4.1 South of Oxbow - 10% Chance Event

North Dakota Diversion (South of Oxbow) - 10% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion South of Oxbow (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	825.15	825.08	-0.07	0.11	-0.18	0.04	-0.11
32nd Ave, Grand Forks	1580152	827.25	827.17	-0.08	0.11	-0.19	0.06	-0.14
Thompson Gage	1667877	837.58	837.41	-0.17	0.04	-0.21	0.05	-0.22
Co. Hwy 25/ Co. Rd 221	1726274	842.90	842.69	-0.21	0.04	-0.25	0.05	-0.26
DS Sandhill River/ Climax	1763746	845.59	845.37	-0.22	0.03	-0.25	0.05	-0.27
Nielsville	1829877	850.14	849.93	-0.21	0.03	-0.24	0.06	-0.27
DS Marsh River	1864960	853.13	852.92	-0.21	0.04	-0.25	0.06	-0.27
US Goose River/ Shelly	1891054	855.86	855.62	-0.24	0.03	-0.27	0.05	-0.29
Halstad Gage	1981580	864.50	864.18	-0.32	-0.12	-0.20	-0.02	-0.30
Hendrum	2038409	868.48	868.13	-0.35	-0.25	-0.10	-0.07	-0.28
Perley	2129181	874.83	874.21	-0.62	-0.54	-0.08	-0.24	-0.38
Georgetown	2194021	879.88	879.29	-0.59	-0.43	-0.16	-0.23	-0.36
North River/ Clay Co. Hwy 93	2305647	890.04	884.31	-5.73	-5.49	-0.24	-4.18	-1.55
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	893.81	887.92	-5.89	-5.36	-0.53	-4.75	-1.14
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.54 (34.8*)	891.62 (28.88*)	-5.92	-5.47	-0.45	-5.03	-0.89
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	902.15	896.08	-6.07	-5.49	-0.58	-5.41	-0.66
US ND Wild Rice River	2484618	906.05	900.01	-6.04	-5.15	-0.89	-5.54	-0.50
Oxbow	2552977	909.96	907.26	-2.70	7.13	-9.83	4.90	-7.60
Hickson Gage	2563754	910.78	908.30	-2.48	6.59	-9.07	4.37	-6.85
US Diversion	2566320	911.01	918.70	7.69	8.23	-0.54	5.74	1.95
Cass/Richland County Line	2582760	912.29	919.06	6.77	5.64	1.13	3.60	3.17
Abercrombie	2764908	927.87	928.19	0.32	0.11	0.21	0.06	0.26

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

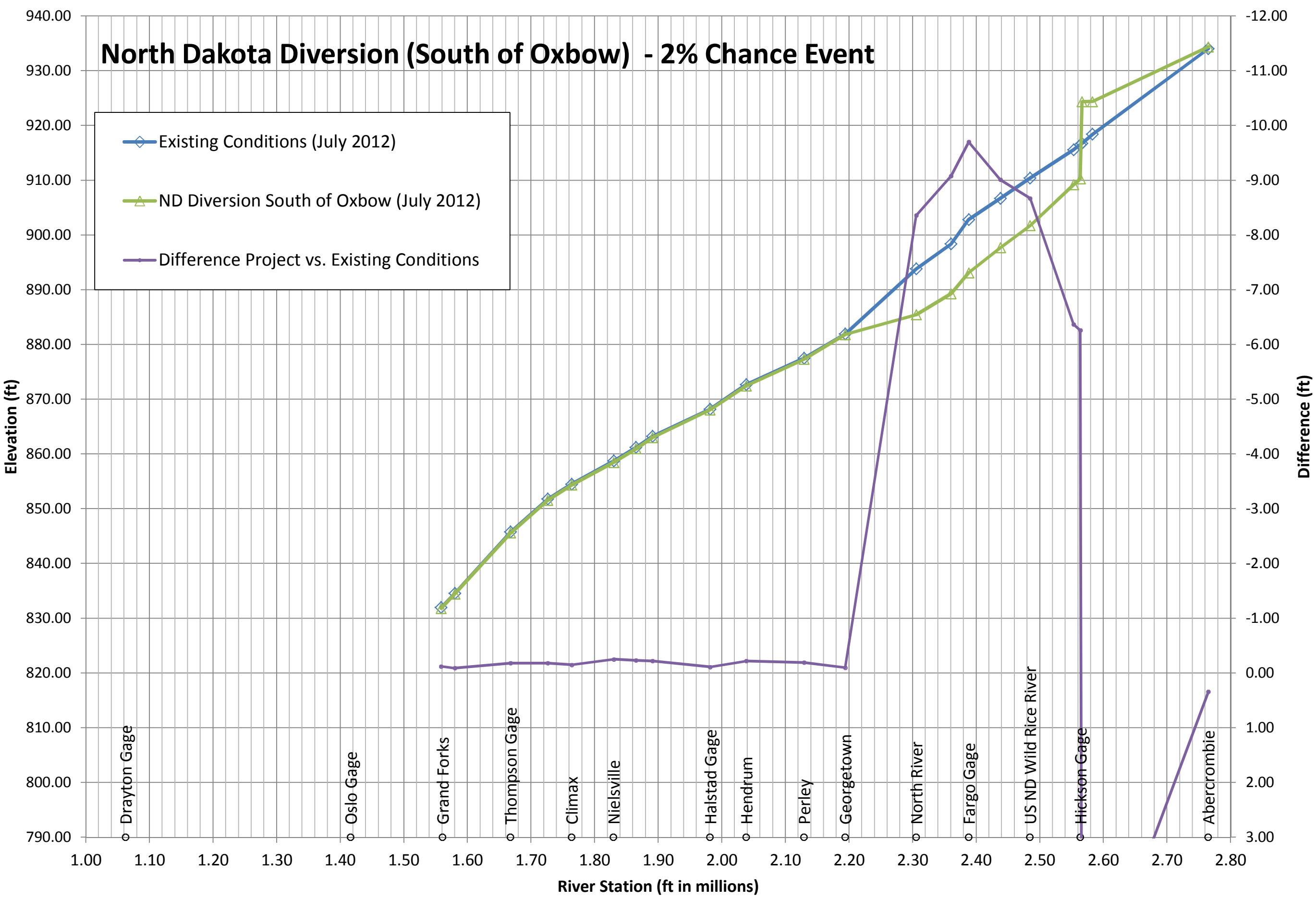


Appendix B.4.2 South of Oxbow - 2% Chance Event

North Dakota Diversion (South of Oxbow) - 2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion South of Oxbow (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	831.95	831.83	-0.12	0.18	-0.30	0.27	-0.39
32nd Ave, Grand Forks	1580152	834.55	834.46	-0.09	0.28	-0.37	0.26	-0.35
Thompson Gage	1667877	845.77	845.59	-0.18	0.24	-0.42	0.20	-0.38
Co. Hwy 25/ Co. Rd 221	1726274	851.77	851.59	-0.18	0.21	-0.39	0.28	-0.46
DS Sandhill River/ Climax	1763746	854.51	854.36	-0.15	0.21	-0.36	0.30	-0.45
Nielsville	1829877	858.73	858.48	-0.25	0.18	-0.43	0.23	-0.48
DS Marsh River	1864960	861.21	860.98	-0.23	0.16	-0.39	0.19	-0.42
US Goose River/ Shelly	1891054	863.24	863.02	-0.22	0.12	-0.34	0.17	-0.39
Halstad Gage	1981580	868.18	868.07	-0.11	0.00	-0.11	0.04	-0.15
Hendrum	2038409	872.67	872.45	-0.22	-0.12	-0.10	0.03	-0.25
Perley	2129181	877.51	877.32	-0.19	-0.32	0.13	-0.07	-0.12
Georgetown	2194021	881.93	881.83	-0.10	-0.23	0.13	0.03	-0.13
North River/ Clay Co. Hwy 93	2305647	893.82	885.46	-8.36	-6.75	-1.61	-7.45	-0.91
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.37	889.29	-9.08	-8.35	-0.73	-9.09	0.01
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.83 (40.09*)	893.13 (30.39*)	-9.70	-9.88	0.18	-10.21	0.51
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.71	897.70	-9.01	-10.21	1.20	-9.91	0.90
US ND Wild Rice River	2484618	910.41	901.74	-8.67	-9.41	0.74	-9.87	1.20
Oxbow	2552977	915.57	909.20	-6.37	5.40	-11.77	5.68	-12.05
Hickson Gage	2563754	916.52	910.26	-6.26	4.58	-10.84	4.77	-11.03
US Diversion	2566320	916.74	924.35	7.61	7.10	0.51	7.17	0.44
Cass/Richland County Line	2582760	918.40	924.40	6.00	3.52	2.48	3.30	2.70
Abercrombie	2764908	934.04	934.38	0.34	0.14	0.20	0.25	0.09

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

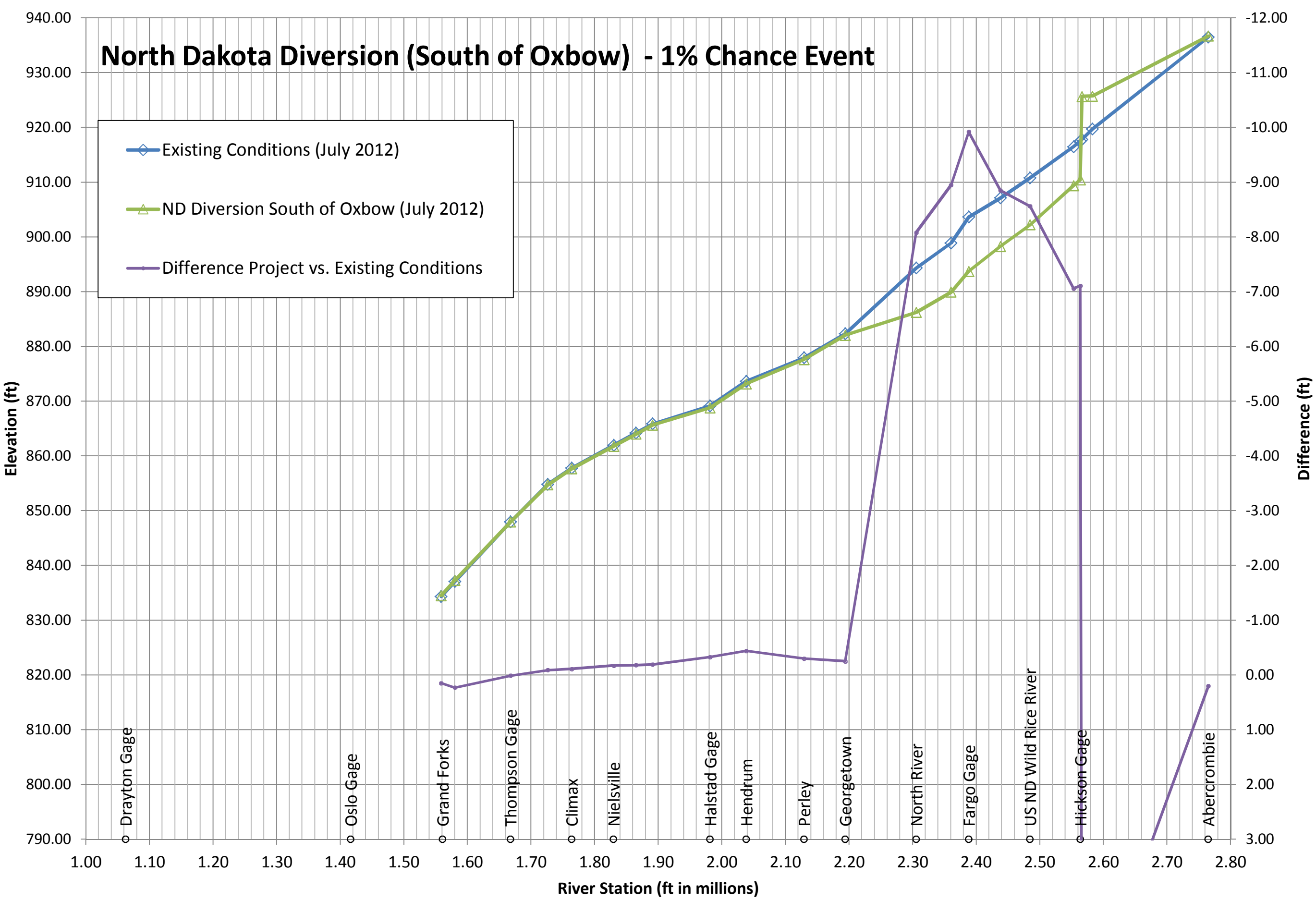


Appendix B.4.3 South of Oxbow - 1% Chance Event

North Dakota Diversion (South of Oxbow) - 1% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion South of Oxbow (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	834.36	834.51	0.15	0.24	-0.09	0.13	0.02
32nd Ave, Grand Forks	1580152	837.06	837.29	0.23	0.28	-0.05	0.21	0.02
Thompson Gage	1667877	847.97	847.98	0.01	0.04	-0.03	0.04	-0.03
Co. Hwy 25/ Co. Rd 221	1726274	854.83	854.74	-0.09	-0.02	-0.07	-0.03	-0.06
DS Sandhill River/ Climax	1763746	857.78	857.67	-0.11	-0.04	-0.07	-0.04	-0.07
Nielsville	1829877	861.96	861.79	-0.17	-0.04	-0.13	-0.09	-0.08
DS Marsh River	1864960	864.20	864.02	-0.18	-0.03	-0.15	-0.09	-0.09
US Goose River/ Shelly	1891054	865.86	865.67	-0.19	-0.04	-0.15	-0.10	-0.09
Halstad Gage	1981580	869.15	868.82	-0.33	-0.06	-0.27	-0.24	-0.09
Hendrum	2038409	873.64	873.20	-0.44	-0.06	-0.38	-0.32	-0.12
Perley	2129181	877.93	877.63	-0.30	-0.28	-0.02	-0.24	-0.06
Georgetown	2194021	882.31	882.06	-0.25	-0.25	0.00	-0.18	-0.07
North River/ Clay Co. Hwy 93	2305647	894.32	886.24	-8.08	-7.25	-0.83	-8.20	0.12
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.91	889.96	-8.95	-8.58	-0.37	-8.97	0.02
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.65 (40.91*)	893.73 (30.99*)	-9.92	-10.32	0.40	-9.89	-0.03
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.12	898.27	-8.85	-10.05	1.20	-8.78	-0.07
US ND Wild Rice River	2484618	910.80	902.24	-8.56	-8.99	0.43	-8.48	-0.08
Oxbow	2552977	916.47	909.41	-7.06	6.30	-13.36	6.53	-13.59
Hickson Gage	2563754	917.55	910.44	-7.11	5.38	-12.49	5.46	-12.57
US Diversion	2566320	917.81	925.69	7.88	8.23	-0.35	8.24	-0.36
Cass/Richland County Line	2582760	919.72	925.72	6.00	4.02	1.98	3.42	2.58
Abercrombie	2764908	936.52	936.72	0.20	0.11	0.09	0.11	0.09

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

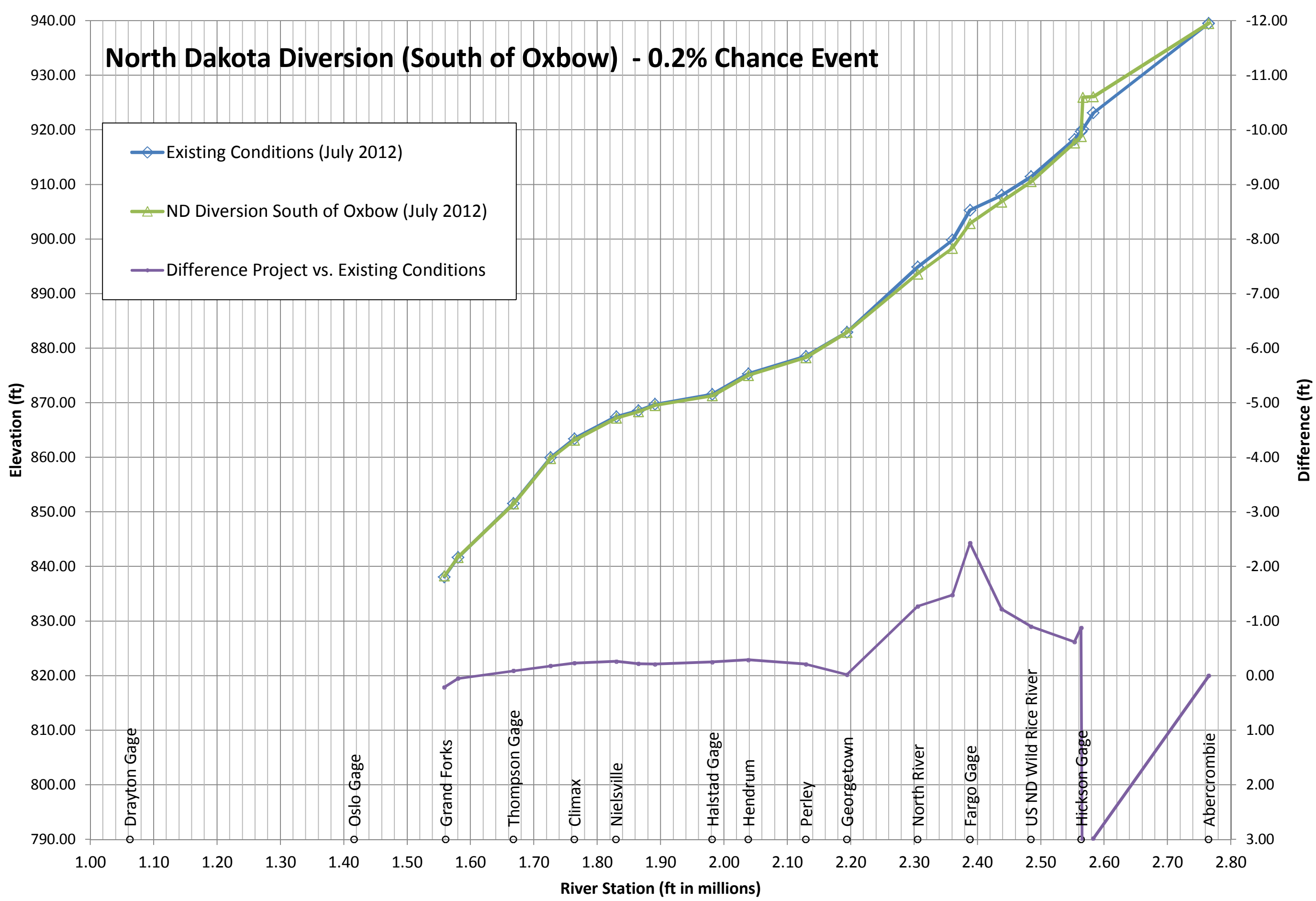


Appendix B.4.4 South of Oxbow - 0.2% Chance Event

North Dakota Diversion (South of Oxbow) - 0.2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion South of Oxbow (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	838.09	838.30	0.21	0.22	-0.01	0.22	-0.01
32nd Ave, Grand Forks	1580152	841.66	841.71	0.05	0.27	-0.22	0.08	-0.03
Thompson Gage	1667877	851.59	851.50	-0.09	-0.05	-0.04	-0.05	-0.04
Co. Hwy 25/ Co. Rd 221	1726274	859.99	859.81	-0.18	-0.12	-0.06	-0.12	-0.06
DS Sandhill River/ Climax	1763746	863.41	863.18	-0.23	-0.15	-0.08	-0.16	-0.07
Nielsville	1829877	867.47	867.21	-0.26	-0.16	-0.10	-0.19	-0.07
DS Marsh River	1864960	868.60	868.38	-0.22	-0.14	-0.08	-0.17	-0.05
US Goose River/ Shelly	1891054	869.74	869.53	-0.21	-0.13	-0.08	-0.16	-0.05
Halstad Gage	1981580	871.57	871.32	-0.25	-0.22	-0.03	-0.21	-0.04
Hendrum	2038409	875.34	875.05	-0.29	-0.30	0.01	-0.24	-0.05
Perley	2129181	878.51	878.30	-0.21	-0.36	0.15	-0.19	-0.02
Georgetown	2194021	882.94	882.92	-0.02	-0.33	0.31	0.02	-0.04
North River/ Clay Co. Hwy 93	2305647	894.89	893.62	-1.27	-2.39	1.12	-1.65	0.38
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.83	898.35	-1.48	-1.99	0.51	-1.87	0.39
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.29 (42.55*)	902.86 (40.12*)	-2.43	-3.03	0.60	-2.88	0.45
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	908.03	906.81	-1.22	-2.05	0.83	-1.51	0.29
US ND Wild Rice River	2484618	911.46	910.56	-0.90	-1.31	0.41	-1.24	0.34
Oxbow	2552977	918.27	917.65	-0.62	3.98	-4.60	4.80	-5.42
Hickson Gage	2563754	919.72	918.84	-0.88	2.85	-3.73	3.40	-4.28
US Diversion	2566320	920.18	926.00	5.82	6.50	-0.68	7.04	-1.22
Cass/Richland County Line	2582760	923.12	926.10	2.98	1.13	1.85	0.56	2.42
Abercrombie	2764908	939.55	939.55	0.00	0.01	-0.01	0.00	0.00

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



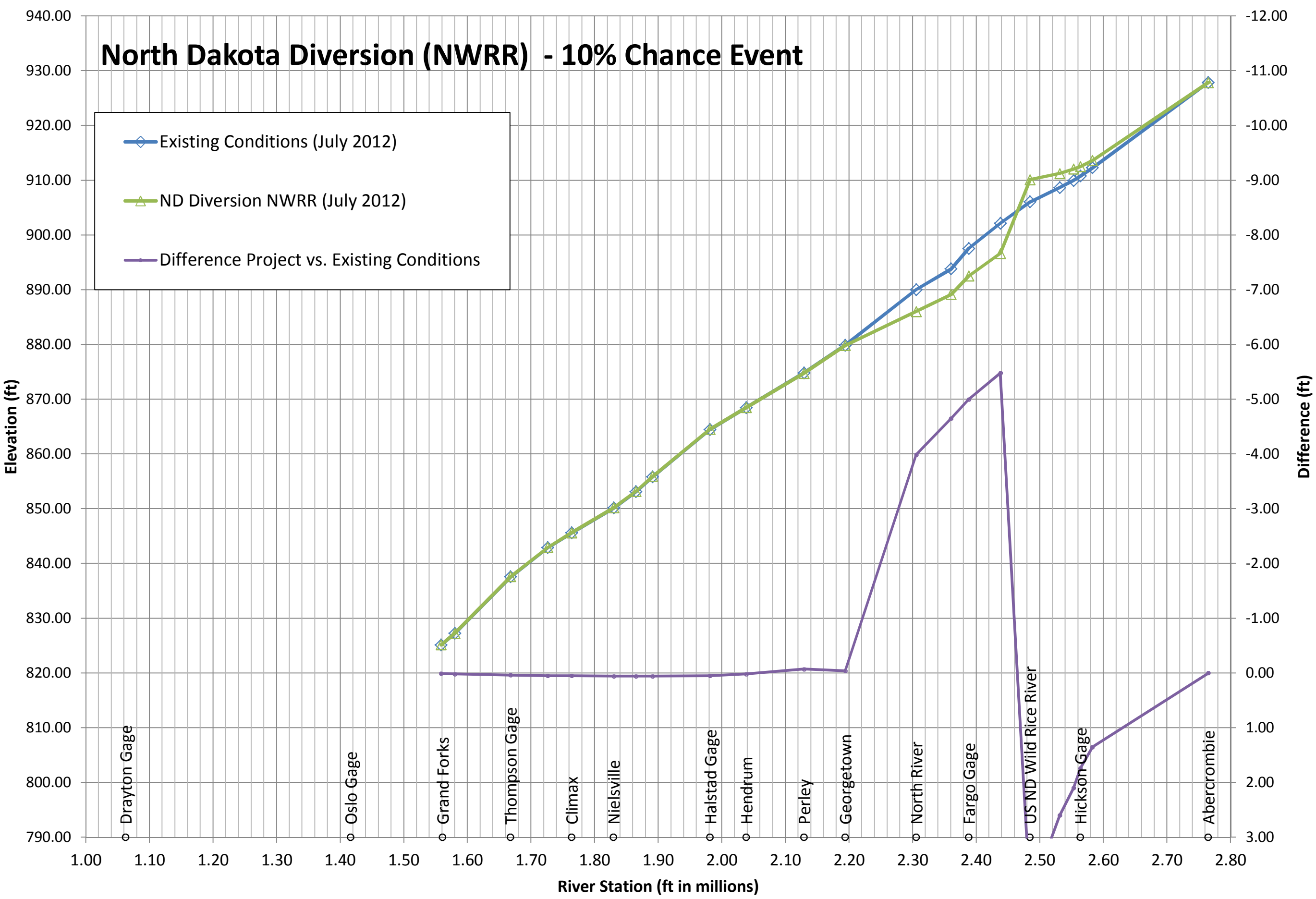
APPENDIX B.5 – NORTH OF WILD RICE RIVER (NWRR)

Appendix B.5.1 North of Wild Rice River - 10% Chance Event

North Dakota Diversion (NWRR) - 10% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion NWRR (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	825.15	825.16	0.01	0.11	-0.10	0.04	-0.03
32nd Ave, Grand Forks	1580152	827.25	827.27	0.02	0.11	-0.09	0.06	-0.04
Thompson Gage	1667877	837.58	837.62	0.04	0.04	0.00	0.05	-0.01
Co. Hwy 25/ Co. Rd 221	1726274	842.90	842.95	0.05	0.04	0.01	0.05	0.00
DS Sandhill River/ Climax	1763746	845.59	845.64	0.05	0.03	0.02	0.05	0.00
Nielsville	1829877	850.14	850.20	0.06	0.03	0.03	0.06	0.00
DS Marsh River	1864960	853.13	853.19	0.06	0.04	0.02	0.06	0.00
US Goose River/ Shelly	1891054	855.86	855.92	0.06	0.03	0.03	0.05	0.01
Halstad Gage	1981580	864.50	864.55	0.05	-0.12	0.17	-0.02	0.07
Hendrum	2038409	868.48	868.50	0.02	-0.25	0.27	-0.07	0.09
Perley	2129181	874.83	874.76	-0.07	-0.54	0.47	-0.24	0.17
Georgetown	2194021	879.88	879.84	-0.04	-0.43	0.39	-0.23	0.19
North River/ Clay Co. Hwy 93	2305647	890.04	886.05	-3.99	-5.49	1.50	-4.18	0.19
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	893.81	889.16	-4.65	-5.36	0.71	-4.75	0.10
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.54 (34.8*)	892.54 (29.8*)	-5.00	-5.47	0.47	-5.03	0.03
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	902.15	896.67	-5.48	-5.49	0.01	-5.41	-0.07
US ND Wild Rice River	2484618	906.05	910.12	4.07	-5.15	9.22	-5.54	9.61
US FRP Diversion	2531315	908.66	911.26	2.60	8.23	-5.63	5.74	-3.14
Oxbow	2552977	909.96	912.06	2.10	7.13	-5.03	4.90	-2.80
Hickson Gage	2563754	910.78	912.52	1.74	6.59	-4.85	4.37	-2.63
Cass/Richland County Line	2582760	912.29	913.64	1.35	5.64	-4.29	3.60	-2.25
Abercrombie	2764908	927.87	927.87	0.00	0.11	-0.11	0.06	-0.06

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

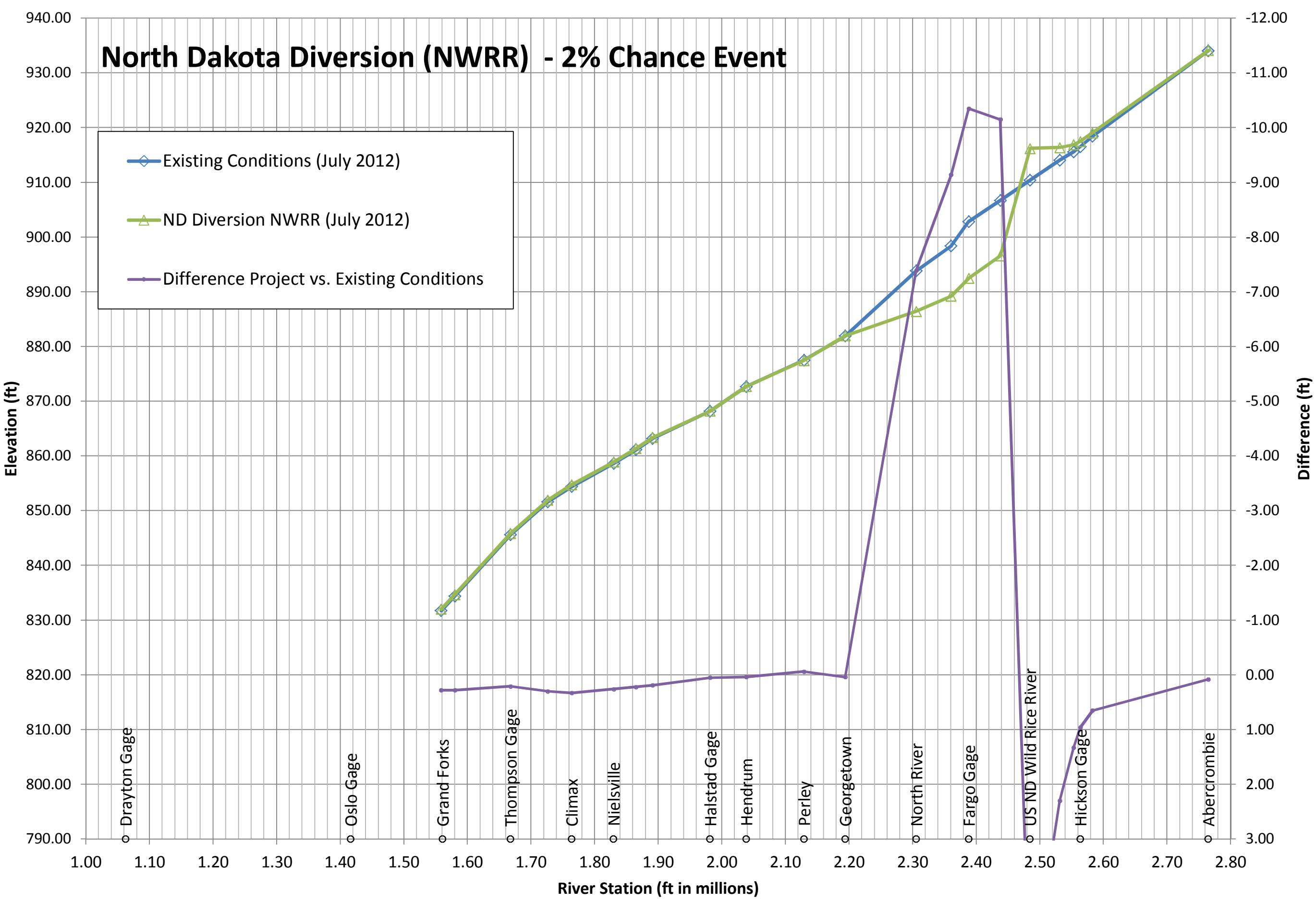


Appendix B.5.2 North of Wild Rice River - 2% Chance Event

North Dakota Diversion (NWRR) - 2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion NWRR (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	831.74	832.02	0.28	0.18	0.10	0.27	0.01
32nd Ave, Grand Forks	1580152	834.40	834.68	0.28	0.28	0.00	0.26	0.02
Thompson Gage	1667877	845.64	845.85	0.21	0.24	-0.03	0.20	0.01
Co. Hwy 25/ Co. Rd 221	1726274	851.65	851.95	0.30	0.21	0.09	0.28	0.02
DS Sandhill River/ Climax	1763746	854.41	854.74	0.33	0.21	0.12	0.30	0.03
Nielsville	1829877	858.65	858.91	0.26	0.18	0.08	0.23	0.03
DS Marsh River	1864960	861.16	861.38	0.22	0.16	0.06	0.19	0.03
US Goose River/ Shelly	1891054	863.20	863.39	0.19	0.12	0.07	0.17	0.02
Halstad Gage	1981580	868.18	868.23	0.05	0.00	0.05	0.04	0.01
Hendrum	2038409	872.67	872.71	0.04	-0.12	0.16	0.03	0.01
Perley	2129181	877.51	877.45	-0.06	-0.32	0.26	-0.07	0.01
Georgetown	2194021	881.93	881.97	0.04	-0.23	0.27	0.03	0.01
North River/ Clay Co. Hwy 93	2305647	893.82	886.43	-7.39	-6.75	-0.64	-7.45	0.06
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.37	889.23	-9.14	-8.35	-0.79	-9.09	-0.05
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.83 (40.09*)	892.48 (29.74*)	-10.35	-9.88	-0.47	-10.21	-0.14
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	906.71	896.56	-10.15	-10.21	0.06	-9.91	-0.24
US ND Wild Rice River	2484618	910.41	916.19	5.78	-9.41	15.19	-9.87	15.65
US FRP Diversion	2531315	914.05	916.35	2.30	7.10	-4.80	7.17	-4.87
Oxbow	2552977	915.57	916.90	1.33	5.40	-4.07	5.68	-4.35
Hickson Gage	2563754	916.52	917.48	0.96	4.58	-3.62	4.77	-3.81
Cass/Richland County Line	2582760	918.40	919.05	0.65	3.52	-2.87	3.30	-2.65
Abercrombie	2764908	934.04	934.12	0.08	0.14	-0.06	0.25	-0.17

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

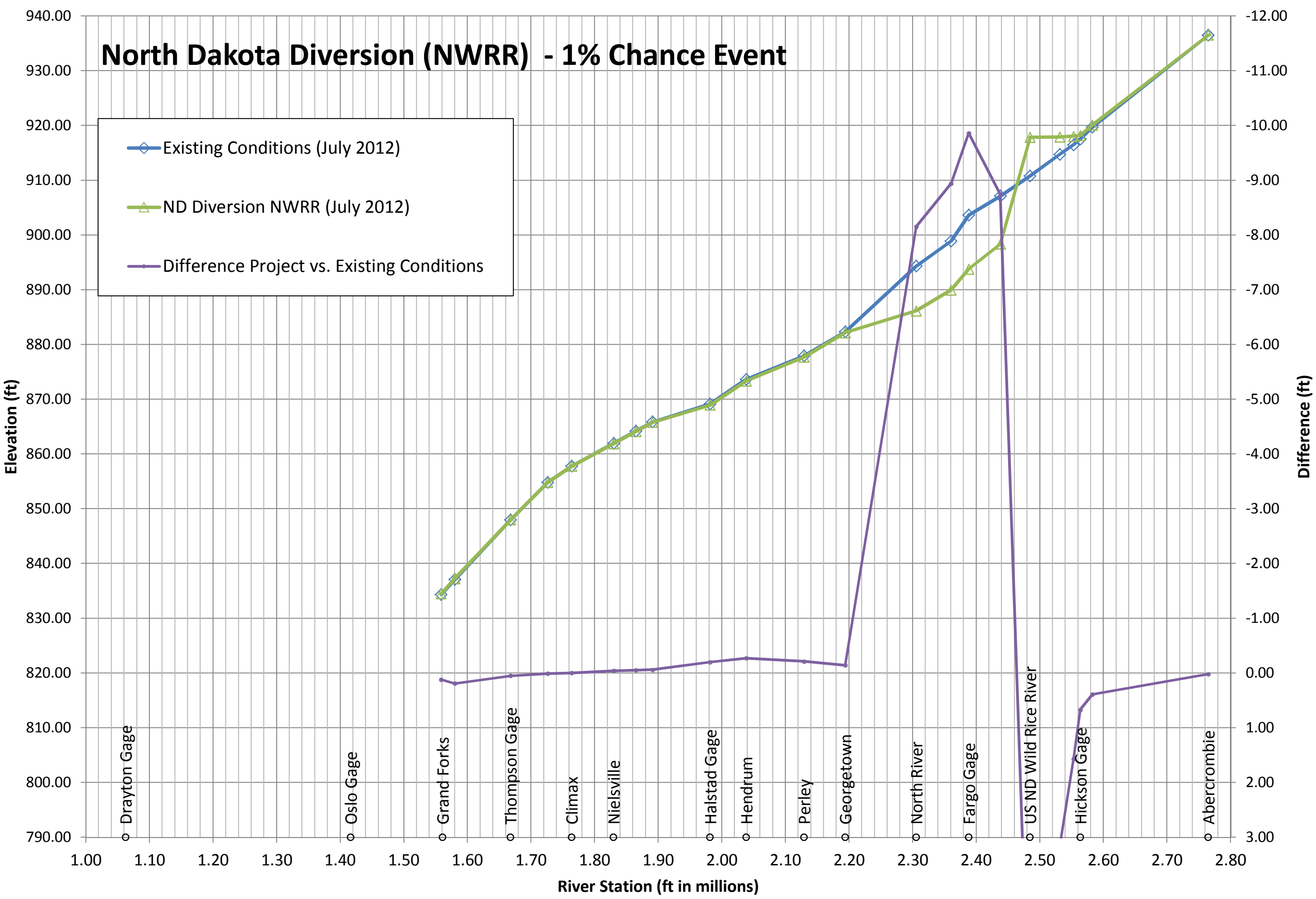


Appendix B.5.3 North of Wild Rice River - 1% Chance Event

North Dakota Diversion (NWRR) - 1% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion NWRR (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	834.36	834.48	0.12	0.24	-0.12	0.13	-0.01
32nd Ave, Grand Forks	1580152	837.06	837.25	0.19	0.28	-0.09	0.21	-0.02
Thompson Gage	1667877	847.97	848.02	0.05	0.04	0.01	0.04	0.01
Co. Hwy 25/ Co. Rd 221	1726274	854.83	854.84	0.01	-0.02	0.03	-0.03	0.04
DS Sandhill River/ Climax	1763746	857.78	857.78	0.00	-0.04	0.04	-0.04	0.04
Nielsville	1829877	861.96	861.92	-0.04	-0.04	0.00	-0.09	0.05
DS Marsh River	1864960	864.20	864.15	-0.05	-0.03	-0.02	-0.09	0.04
US Goose River/ Shelly	1891054	865.86	865.80	-0.06	-0.04	-0.02	-0.10	0.04
Halstad Gage	1981580	869.15	868.95	-0.20	-0.06	-0.14	-0.24	0.04
Hendrum	2038409	873.64	873.37	-0.27	-0.06	-0.21	-0.32	0.05
Perley	2129181	877.93	877.72	-0.21	-0.28	0.07	-0.24	0.03
Georgetown	2194021	882.31	882.17	-0.14	-0.25	0.11	-0.18	0.04
North River/ Clay Co. Hwy 93	2305647	894.32	886.17	-8.15	-7.25	-0.90	-8.20	0.05
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	898.91	889.97	-8.94	-8.58	-0.36	-8.97	0.03
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.65 (40.91*)	893.79 (31.05*)	-9.86	-10.32	0.46	-9.89	0.03
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.12	898.38	-8.74	-10.05	1.31	-8.78	0.04
US ND Wild Rice River	2484618	910.80	917.85	7.05	-8.99	16.04	-8.48	15.53
US FRP Diversion	2531315	914.74	917.91	3.17	8.23	-5.06	8.24	-5.07
Oxbow	2552977	916.47	918.04	1.57	6.30	-4.73	6.53	-4.96
Hickson Gage	2563754	917.55	918.22	0.67	5.38	-4.71	5.46	-4.79
Cass/Richland County Line	2582760	919.72	920.11	0.39	4.02	-3.63	3.42	-3.03
Abercrombie	2764908	936.52	936.54	0.02	0.11	-0.09	0.11	-0.09

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

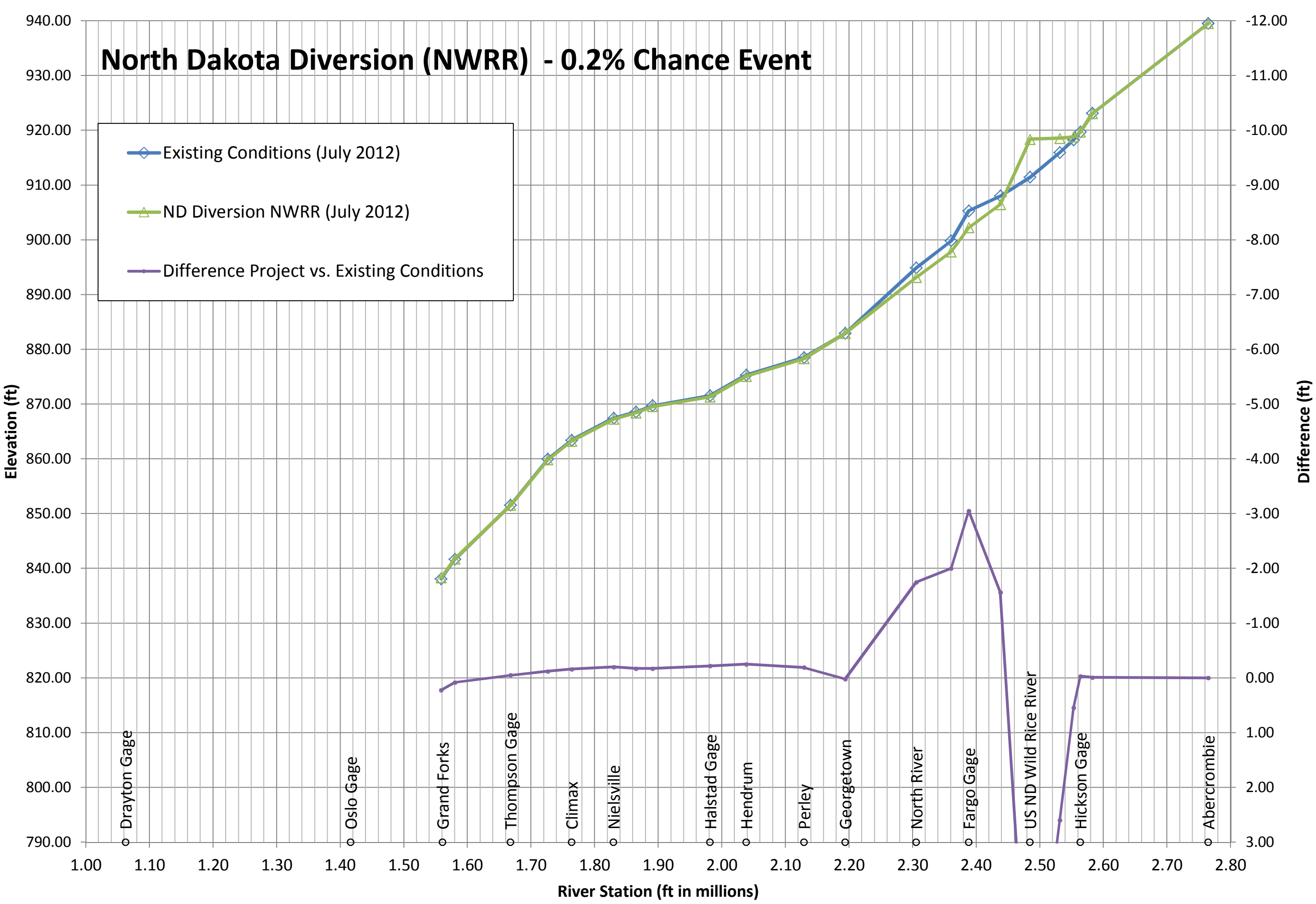


Appendix B.5.4 North of Wild Rice River - 0.2% Chance Event

North Dakota Diversion (NWRR) - 0.2% Chance Event

Location	Station	Existing Conditions (July 2012)	ND Diversion NWRR (July 2012)	Difference Project vs. Existing Conditions	Ph. 4 LPP Impacts (April 2011)	Change in Impacts Relative to Ph.4	Ph. 6 FRP Impacts (July 2012)	Change in Impacts Relative to Ph.6
		Elevation (ft)	Elevation (ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Grand Forks Gage	1558518	838.09	838.31	0.22	0.22	0.00	0.22	0.00
32nd Ave, Grand Forks	1580152	841.66	841.74	0.08	0.27	-0.19	0.08	0.00
Thompson Gage	1667877	851.59	851.54	-0.05	-0.05	0.00	-0.05	0.00
Co. Hwy 25/ Co. Rd 221	1726274	859.99	859.87	-0.12	-0.12	0.00	-0.12	0.00
DS Sandhill River/ Climax	1763746	863.41	863.25	-0.16	-0.15	-0.01	-0.16	0.00
Nielsville	1829877	867.47	867.27	-0.20	-0.16	-0.04	-0.19	-0.01
DS Marsh River	1864960	868.60	868.43	-0.17	-0.14	-0.03	-0.17	0.00
US Goose River/ Shelly	1891054	869.74	869.57	-0.17	-0.13	-0.04	-0.16	-0.01
Halstad Gage	1981580	871.57	871.35	-0.22	-0.22	0.00	-0.21	-0.01
Hendrum	2038409	875.34	875.09	-0.25	-0.30	0.05	-0.24	-0.01
Perley	2129181	878.51	878.32	-0.19	-0.36	0.17	-0.19	0.00
Georgetown	2194021	882.94	882.96	0.02	-0.33	0.35	0.02	0.00
North River/ Clay Co. Hwy 93	2305647	894.89	893.14	-1.75	-2.39	0.64	-1.65	-0.10
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.83	897.83	-2.00	-1.99	-0.01	-1.87	-0.13
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.29 (42.55*)	902.24 (39.5*)	-3.05	-3.03	-0.02	-2.88	-0.17
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	908.03	906.47	-1.56	-2.05	0.49	-1.51	-0.05
US ND Wild Rice River	2484618	911.46	918.39	6.93	-1.31	8.24	-1.24	8.17
US FRP Diversion	2531315	915.95	918.55	2.60	6.50	-3.90	7.04	-4.44
Oxbow	2552977	918.27	918.81	0.54	3.98	-3.44	4.80	-4.26
Hickson Gage	2563754	919.72	919.69	-0.03	2.85	-2.88	3.40	-3.43
Cass/Richland County Line	2582760	923.12	923.11	-0.01	1.13	-1.14	0.56	-0.57
Abercrombie	2764908	939.55	939.55	0.00	0.01	-0.01	0.00	0.00

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



APPENDIX B.6 – ALTERNATIVE SUMMARY

Appendix B.6 – Summary Tables

Appendix B.6: Alternative Summary

10 - Percent Chance Event								
Alternative	Cass/Richland County Line Elevation (ft)	Oxbow Elevation (ft)	Staging Elevation (ft)	Fargo Gage Elevation (ft)	Thompson Elevation (ft)	Diversion Inlet Flow (cfs)	Diversion Inlet Weir Width (ft)	Diversion Inlet Weir Elevation (ft)
	RS 2582760	RS 2552977	RS 2531315	RS 2388223	RS 1667877			
Existing Conditions	912.29	909.96	908.65	897.62 (34.88*)	837.59	-----	-----	-----
FRP	915.89	914.86	914.40	892.51 (29.77*)	837.63	4,590	130	907.00
VE-13 Option A	915.52	914.42	913.92	892.51 (29.77*)	837.62	5,750	90	904.10
VE-13 Option C	914.74	913.36	912.70	892.41 (29.67*)	837.62	6,810	85	900.30
South of Oxbow	919.06	907.26	918.7**	891.62 (28.88*)	837.41	9,400	65	903.25
NWRR Option C	913.64	912.06	911.26	892.54 (29.80*)	837.62	5,080	120	900.30

2 - Percent Chance Event								
Alternative	Cass/Richland County Line Elevation (ft)	Oxbow Elevation (ft)	Staging Elevation (ft)	Fargo Gage Elevation (ft)	Thompson Elevation (ft)	Diversion Inlet Flow (cfs)	Diversion Inlet Weir Width (ft)	Diversion Inlet Weir Elevation (ft)
	RS 2582760	RS 2552977	RS 2531315	RS 2388223	RS 1667877			
Existing Conditions	918.40	915.57	914.05	902.83 (40.09*)	845.64	-----	-----	-----
FRP	921.70	921.25	921.22	892.62 (29.88*)	845.84	16,740	130	907.00
VE-13 Option A	921.51	921.08	921.05	892.54 (29.80*)	845.83	15,890	90	904.10
VE-13 Option C	919.68	918.49	918.39	892.54 (29.80*)	845.84	16,370	85	900.30
South of Oxbow	924.40	909.20	924.35 **	893.13 (30.39*)	845.59	15,860	65	903.25
NWRR Option C	919.05	916.90	916.35	892.48 (29.74*)	845.85	18,310	120	900.30

1 - Percent Chance Event								
Alternative	Cass/Richland County Line Elevation (ft)	Oxbow Elevation (ft)	Staging Elevation (ft)	Fargo Gage Elevation (ft)	Thompson Elevation (ft)	Diversion Inlet Flow (cfs)	Diversion Inlet Weir Width (ft)	Diversion Inlet Weir Elevation (ft)
	RS 2582760	RS 2552977	RS 2531315	RS 2388223	RS 1667877			
Existing Conditions	919.71	916.47	914.74	903.65 (40.91*)	847.97	-----	-----	-----
FRP	923.14	923.00	922.98	893.76 (31.02*)	848.01	20,070	130	907.00
VE-13 Option A	922.98	922.83	922.82	893.74 (31.00*)	848.00	18,420	90	904.10
VE-13 Option C	920.64	920.22	920.18	893.74 (31.00*)	848.01	19,030	85	900.30
South of Oxbow	925.72	909.41	925.69 **	893.73 (30.99*)	847.98	17,460	65	903.25
NWRR Option C	920.11	918.04	917.91	893.79 (31.05*)	848.02	21,720	120	900.30

0.2 - Percent Chance Event								
Alternative	Cass/Richland County Line Elevation (ft)	Oxbow Elevation (ft)	Staging Elevation (ft)	Fargo Gage Elevation (ft)	Thompson Elevation (ft)	Diversion Inlet Flow (cfs)	Diversion Inlet Weir Width (ft)	Diversion Inlet Weir Elevation (ft)
	RS 2582760	RS 2552977	RS 2531315	RS 2388223	RS 1667877			
Existing Conditions	923.12	918.27	915.95	905.29 (42.55*)	851.59	-----	-----	-----
FRP	923.68	923.07	922.99	902.41 (39.67*)	851.54	20,640	130	907.00
VE-13 Option A	923.54	922.92	922.86	902.42 (39.68*)	851.53	18,640	90	904.10
VE-13 Option C	923.12	920.32	920.19	902.34 (39.60*)	851.53	19,160	85	900.30
South of Oxbow	926.10	917.65	926.00 **	902.86 (40.12*)	851.50	17,840	65	903.25
NWRR Option C	923.11	918.81	918.55	902.24 (39.50*)	851.54	23,150	120	900.30

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

** Staging Elevation from Model Cross Section 2566320

103k cfs Event										
Alternative	**Cass/Richland County Line Elevation (ft)**	**Oxbow Elevation (ft)**	**Staging Elevation (ft)**	**Fargo Gage Elevation (ft)**	**Spillway Crest Elevation (ft)**	**Diversion Inlet Elevation (ft)**	**Spillway Flow (cfs)**	**Diversion Inlet Flow (cfs)**	**Wild Rice Control Structure Flow (cfs)**	**Red River Control Structure Flow (cfs)**
	RS 2582760	**RS 2552977**	**RS varies**	**RS 2388223**						
Existing Conditions	924.54	918.92	-----	906.83 (44.09*)	-----	-----	-----	-----	-----	-----
FRP	925.85	925.48	925.40	902.78 (40.04*)	923.00	907.00	33,090	22,630	8,530	17,080
VE-13 Option A	925.51	924.98	924.83	902.76 (40.02*)	922.90	904.10	33,570	20,328	8,400	16,780
VE-13 Option C	924.54	922.55	922.30	902.76 (40.02*)	920.20	900.30	41,824	21,970	8,440	16,800
South of Oxbow	927.52	914.84	927.37	902.73 (39.99*)	925.50	903.25	42,560	18,570	8,370	16,690
NWRR Option C	924.54	920.93	920.51	902.73 (39.99*)	918.00	900.30	30,060	24,970	-----	26,660

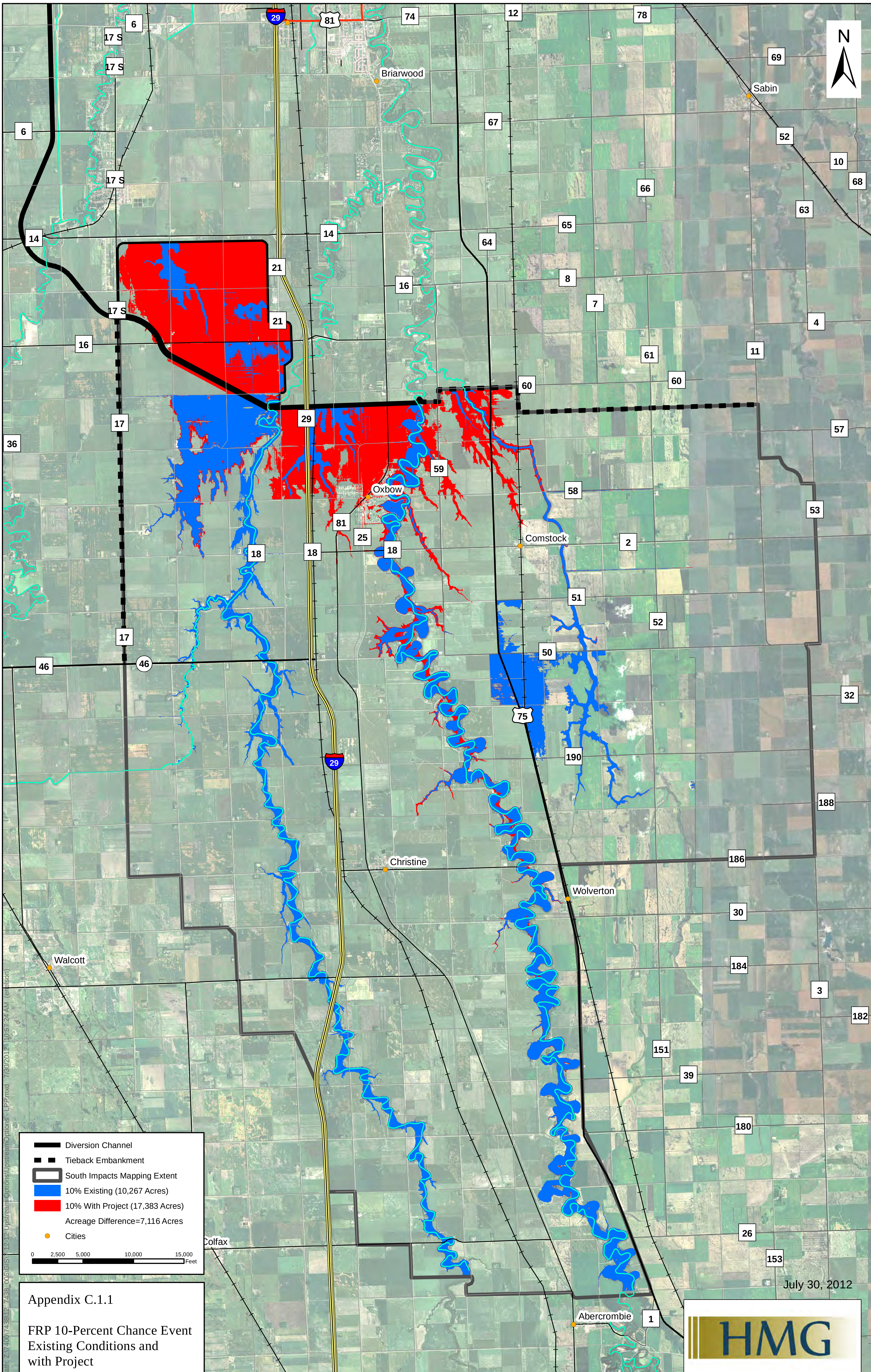
Probable Maximum Flood (PMF) Event										
Alternative	**Cass/Richland County Line Elevation (ft)**	**Oxbow Elevation (ft)**	**Staging Elevation (ft)**	**Fargo Gage Elevation (ft)**	**Spillway Crest Elevation (ft)**	**Diversion Inlet Elevation (ft)**	**Spillway Flow (cfs)**	**Diversion Inlet Flow (cfs)**	**Wild Rice Control Structure Flow (cfs)**	**Red River Control Structure Flow (cfs)**
	RS 2582760	**RS 2552977**	**RS varies**	**RS 2388223**						
Existing Conditions	925.93	919.93	-----	908.23 (45.49*)	-----	-----	-----	-----	-----	-----
FRP	927.03	926.32	926.11	907.05 (44.31*)	923.00	907.00	83,680	23,420	27,340	88,650
VE-13 Option A	926.72	925.76	925.28	907.31 (44.57*)	922.90	904.10	79,710	19,540	28,630	100,720
VE-13 Option C	926.38	924.95	923.98	907.25 (44.51*)	920.20	900.30	79,430	20,890	29,220	96,130
South of Oxbow	928.88	919.66	928.47	906.97 (44.23*)	925.50	903.25	87,090	17,660	27,970	80,930
NWRR Option C	926.44	925.21	924.15	906.86 (44.12*)	918.00	900.30	86,870	25,510	-----	104,250

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

APPENDIX C – FLOODPLAIN INUNDATION MAPS FOR STAGING AREA

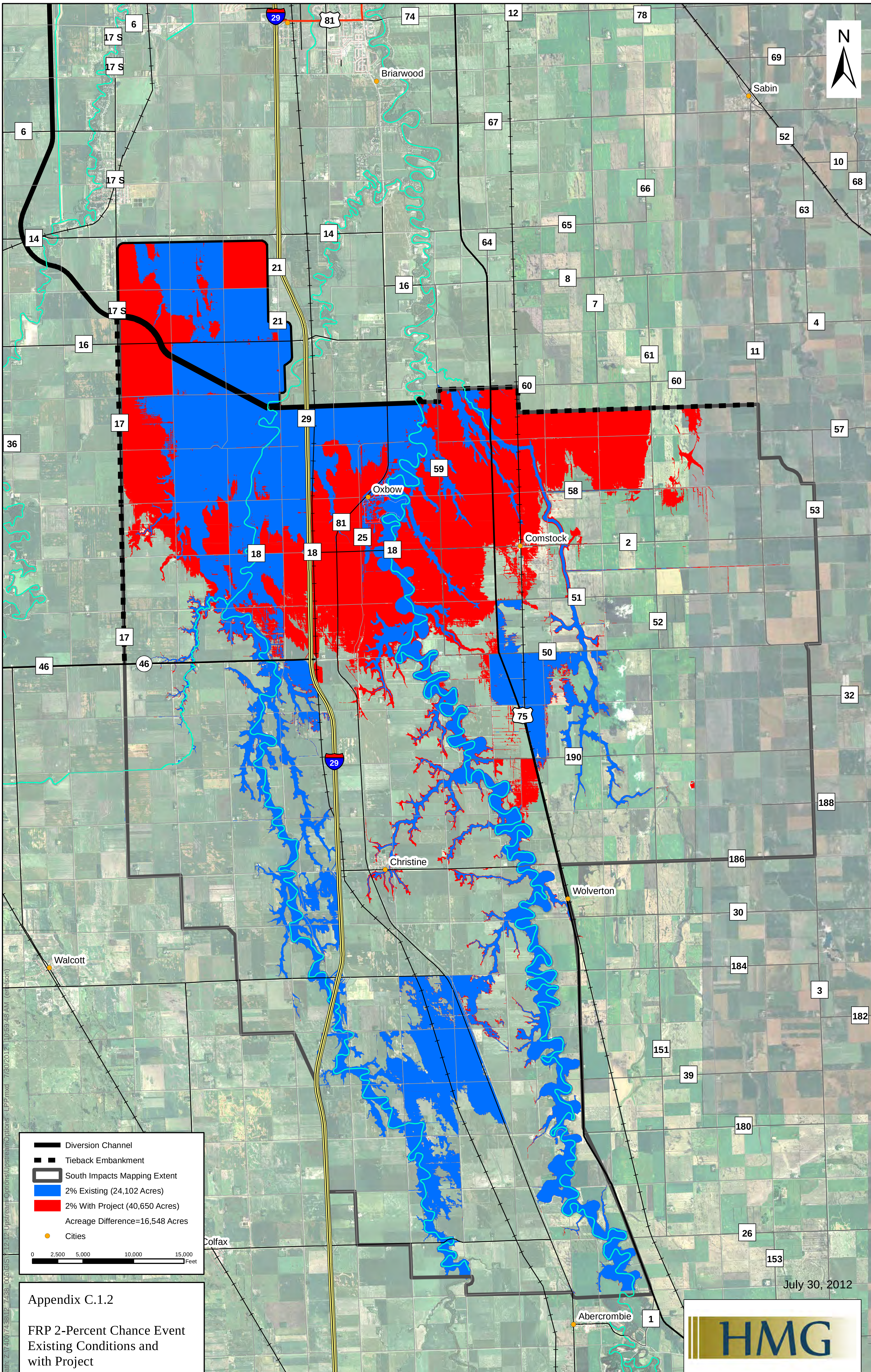
Appendix C.1	Federally Recommended Plan (FRP)
Appendix C.2	VE-13 Option A (VE13A)
Appendix C.3	VE-13 Option C (VE13C)
Appendix C.4	South of Oxbow (OXBOW)
Appendix C.5	North of Wild Rice River (NWRR)

APPENDIX C.1 – FEDERALLY RECOMMENDED PLAN (FRP)



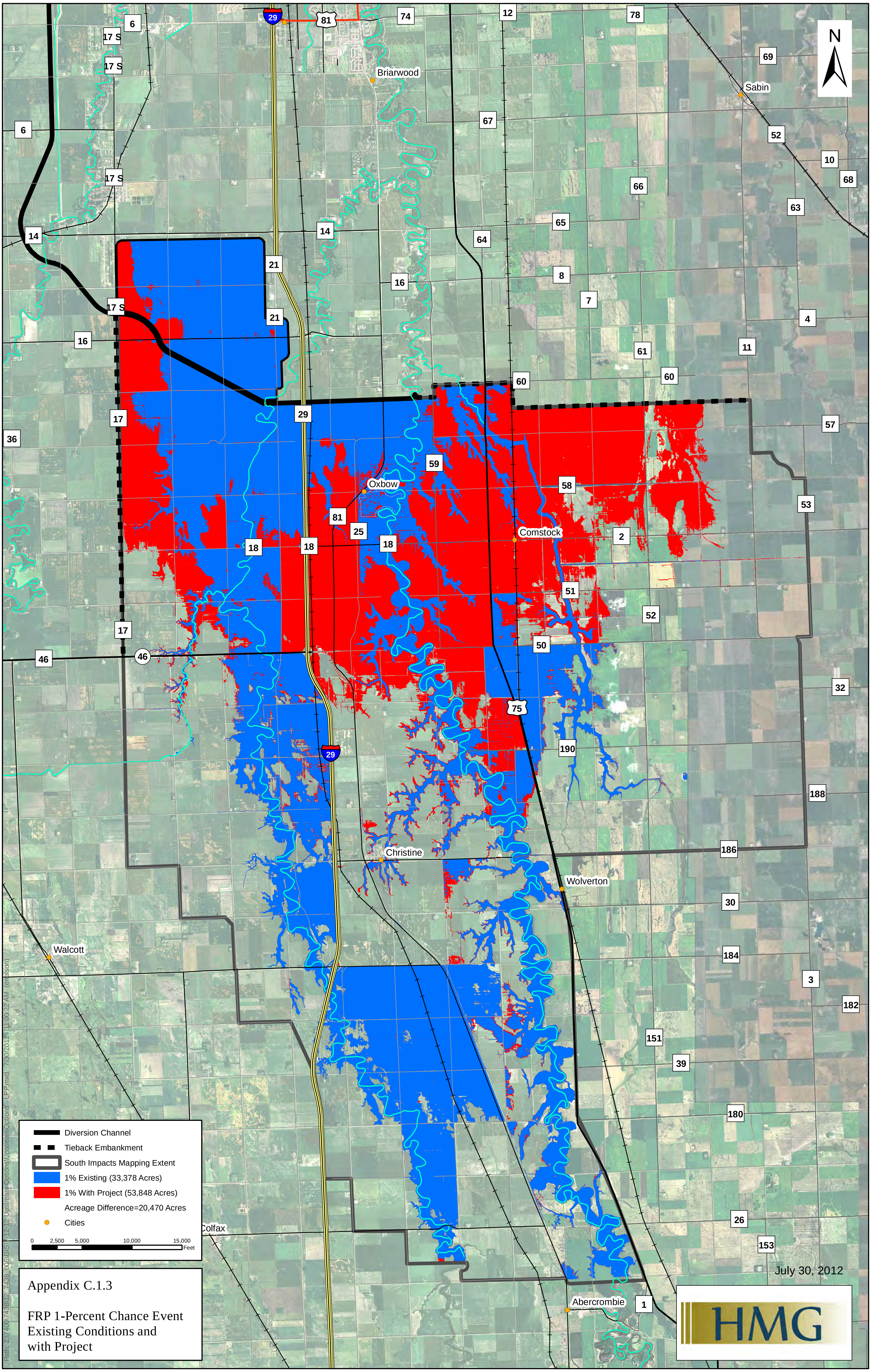
Appendix C.1.1

FRP 10-Percent Chance Event Existing Conditions and with Project



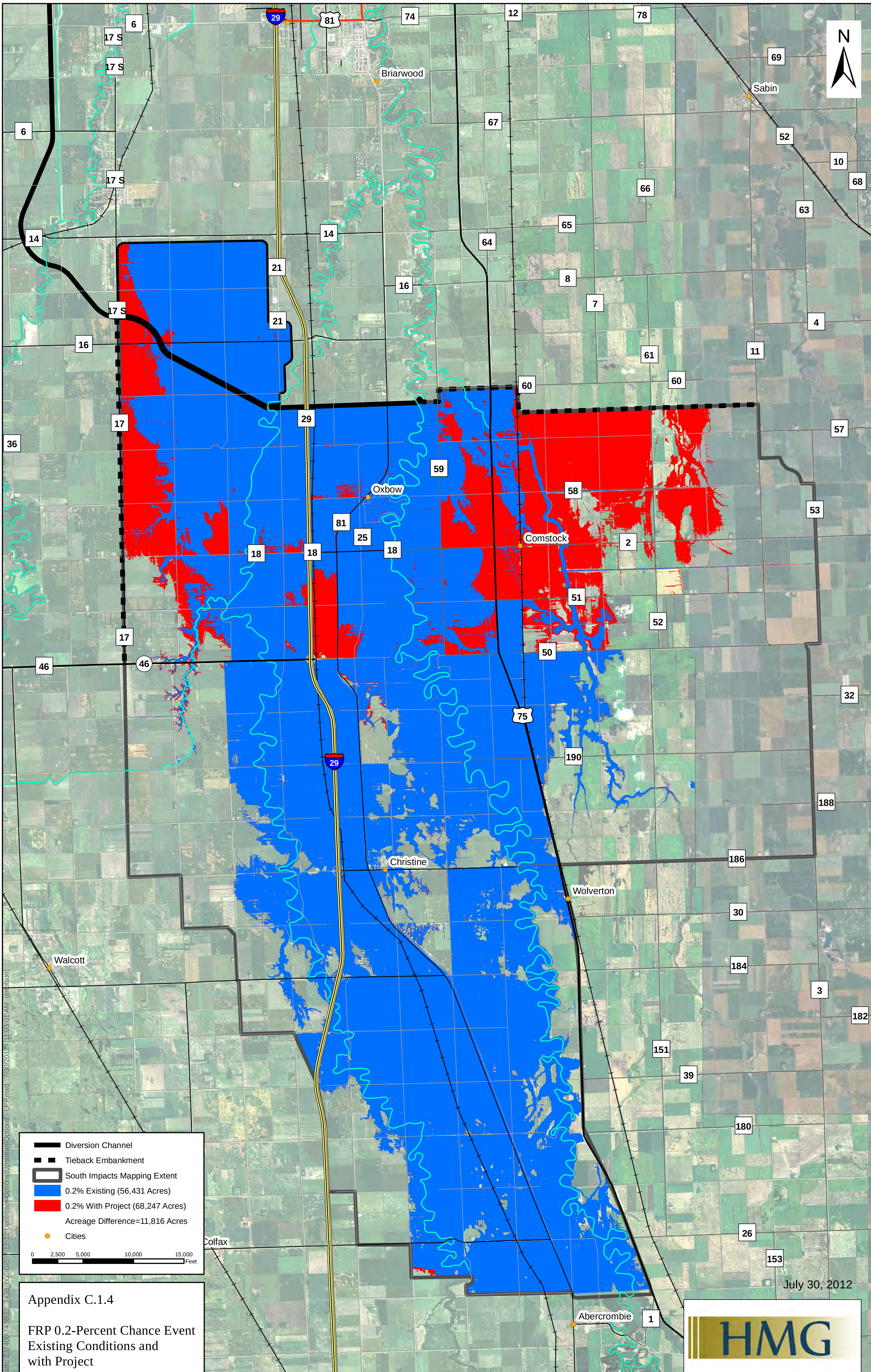
Appendix C.1.2

FRP 2-Percent Chance Event Existing Conditions and with Project



Appendix C.1.3

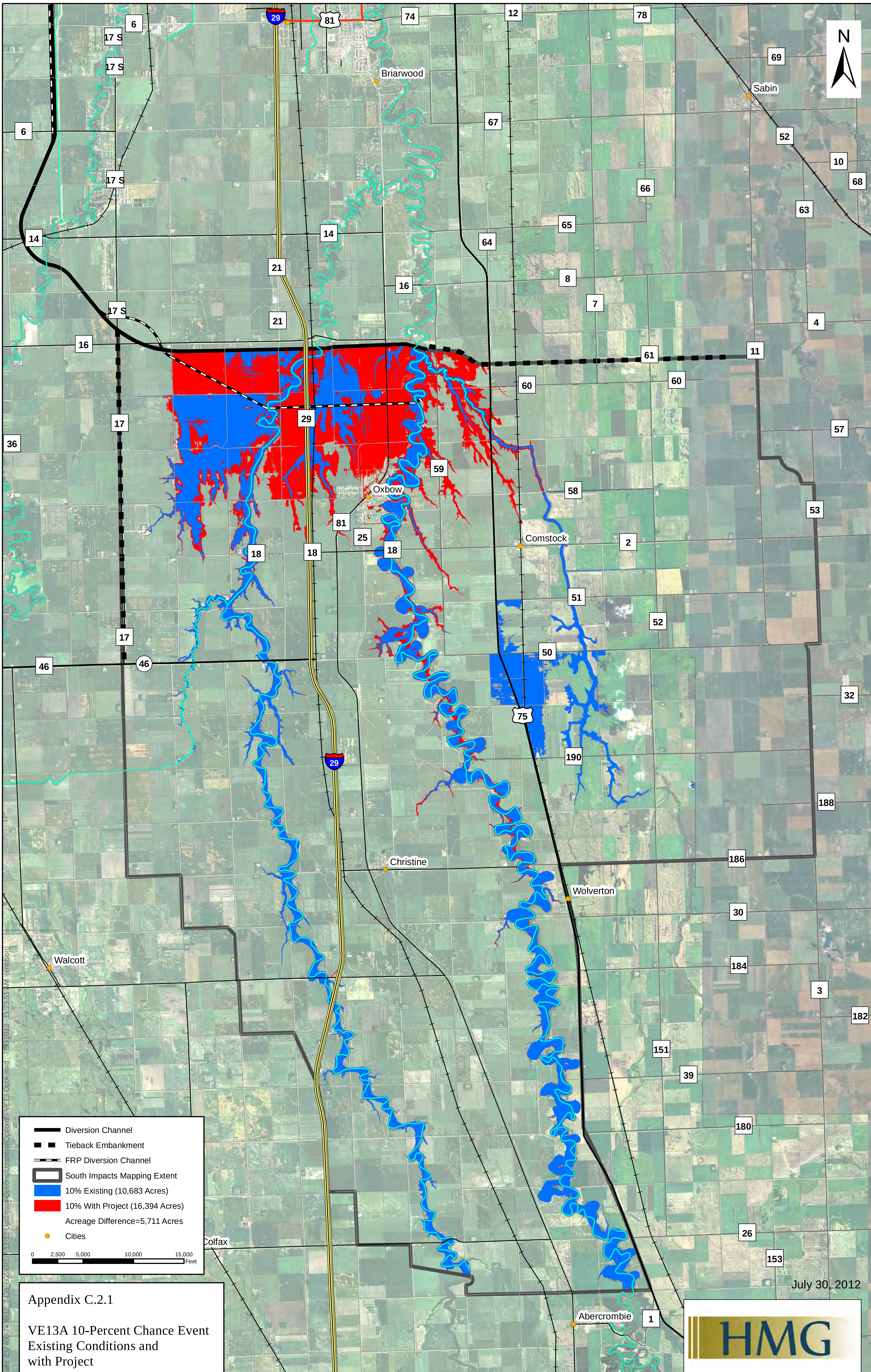
FRP 1-Percent Chance Event Existing Conditions and with Project



Appendix C.1.4

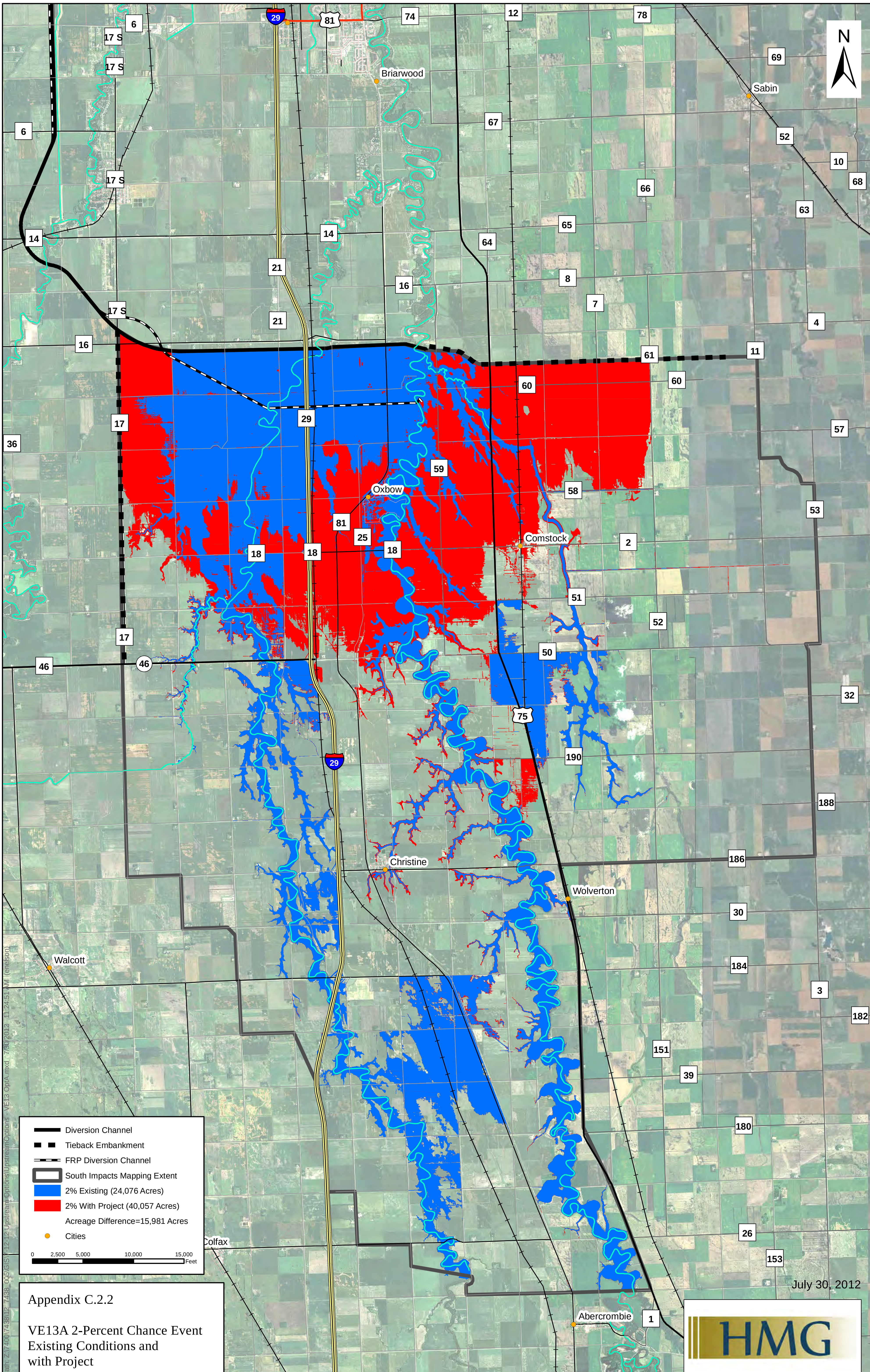
FRP 0.2-Percent Chance Event
Existing Conditions and
with Project

APPENDIX C.2 – VE-13 OPTION A (VE13A)



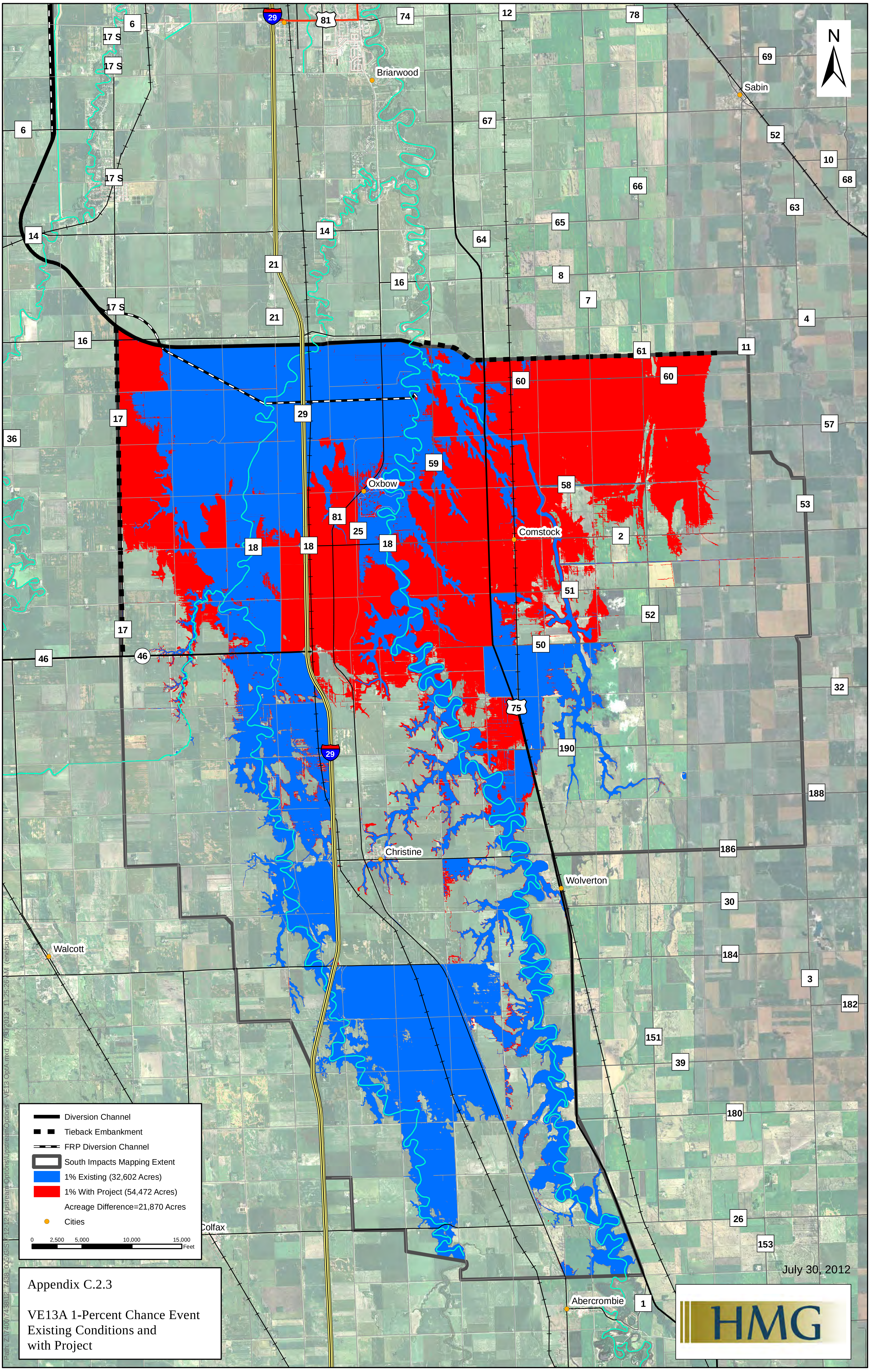
Appendix C.2.1

VE13A 10-Percent Chance Event Existing Conditions and with Project



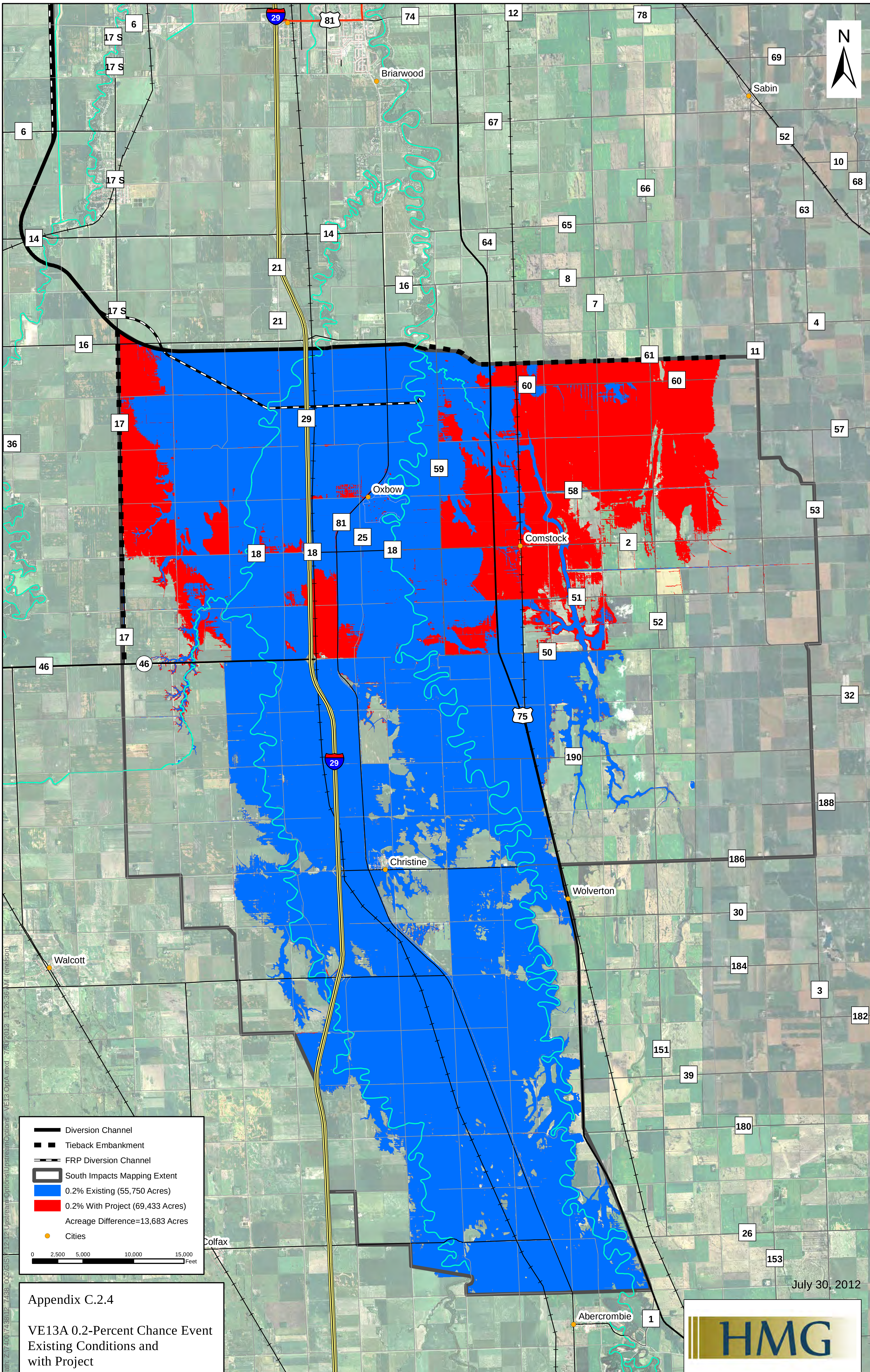
Appendix C.2.2

VE13A 2-Percent Chance Event
Existing Conditions and
with Project



Appendix C.2.3

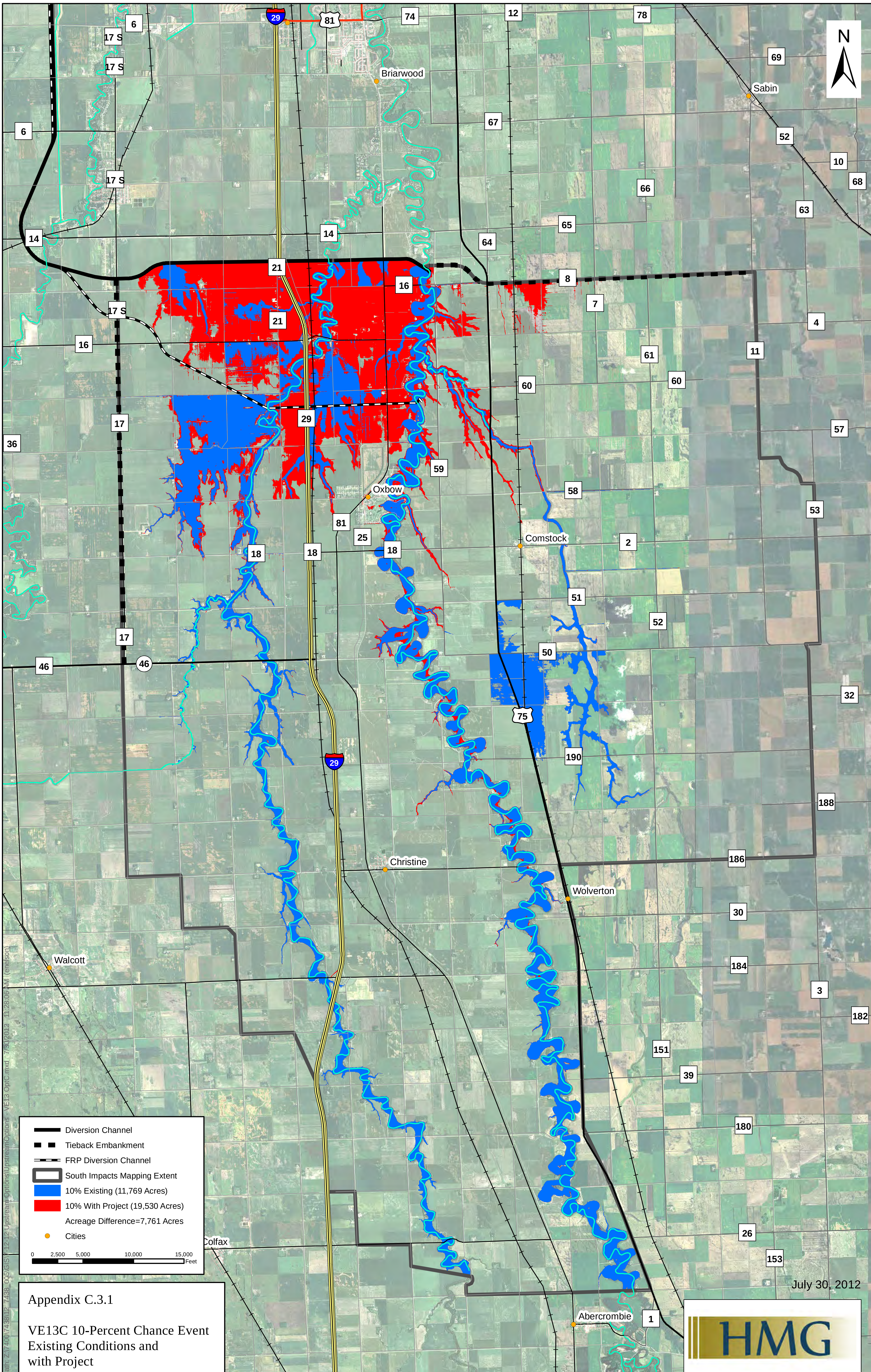
VE13A 1-Percent Chance Event
Existing Conditions and
with Project



Appendix C.2.4

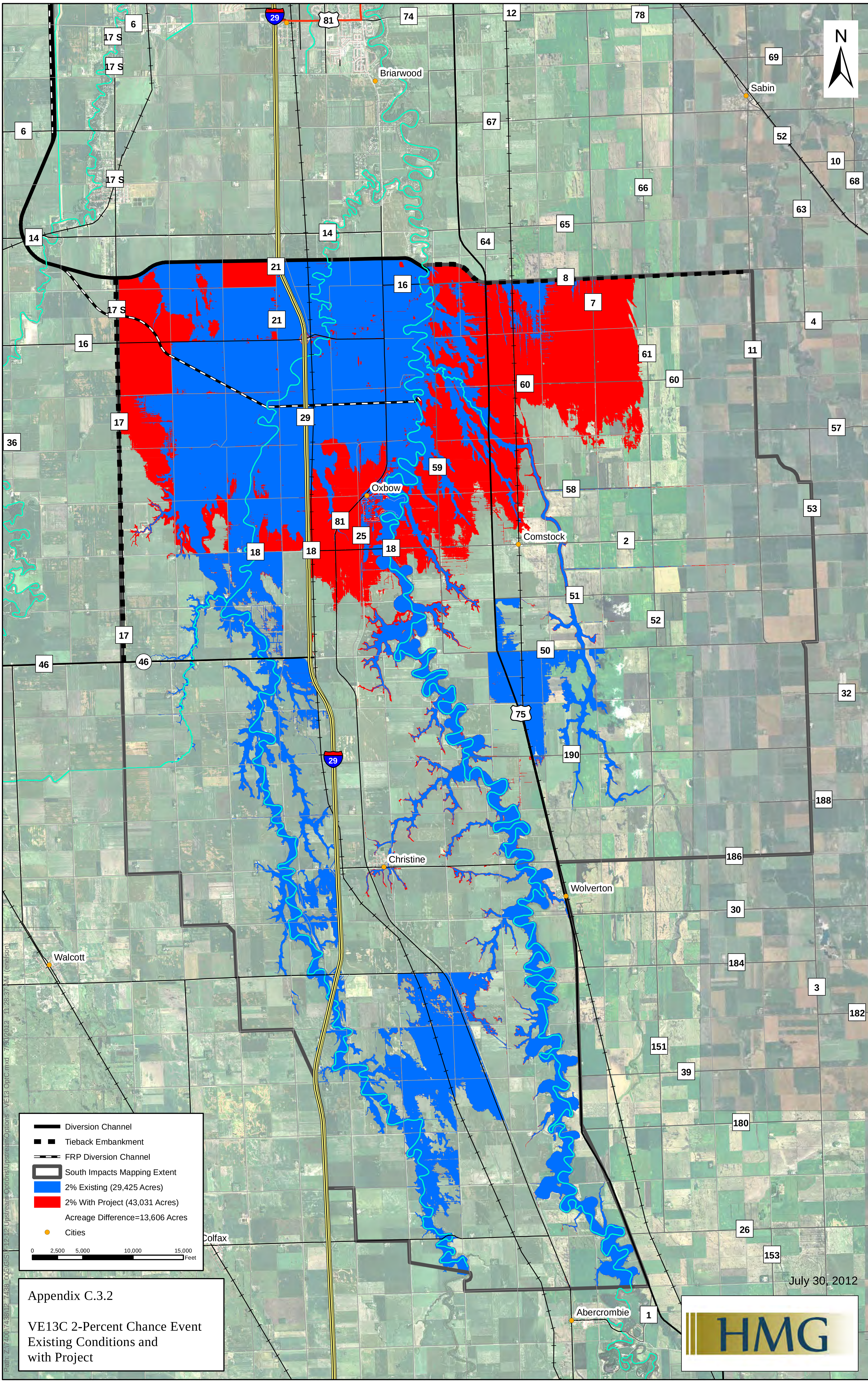
VE13A 0.2-Percent Chance Event Existing Conditions and with Project

APPENDIX C.3 – VE-13 OPTION C (VE13C)



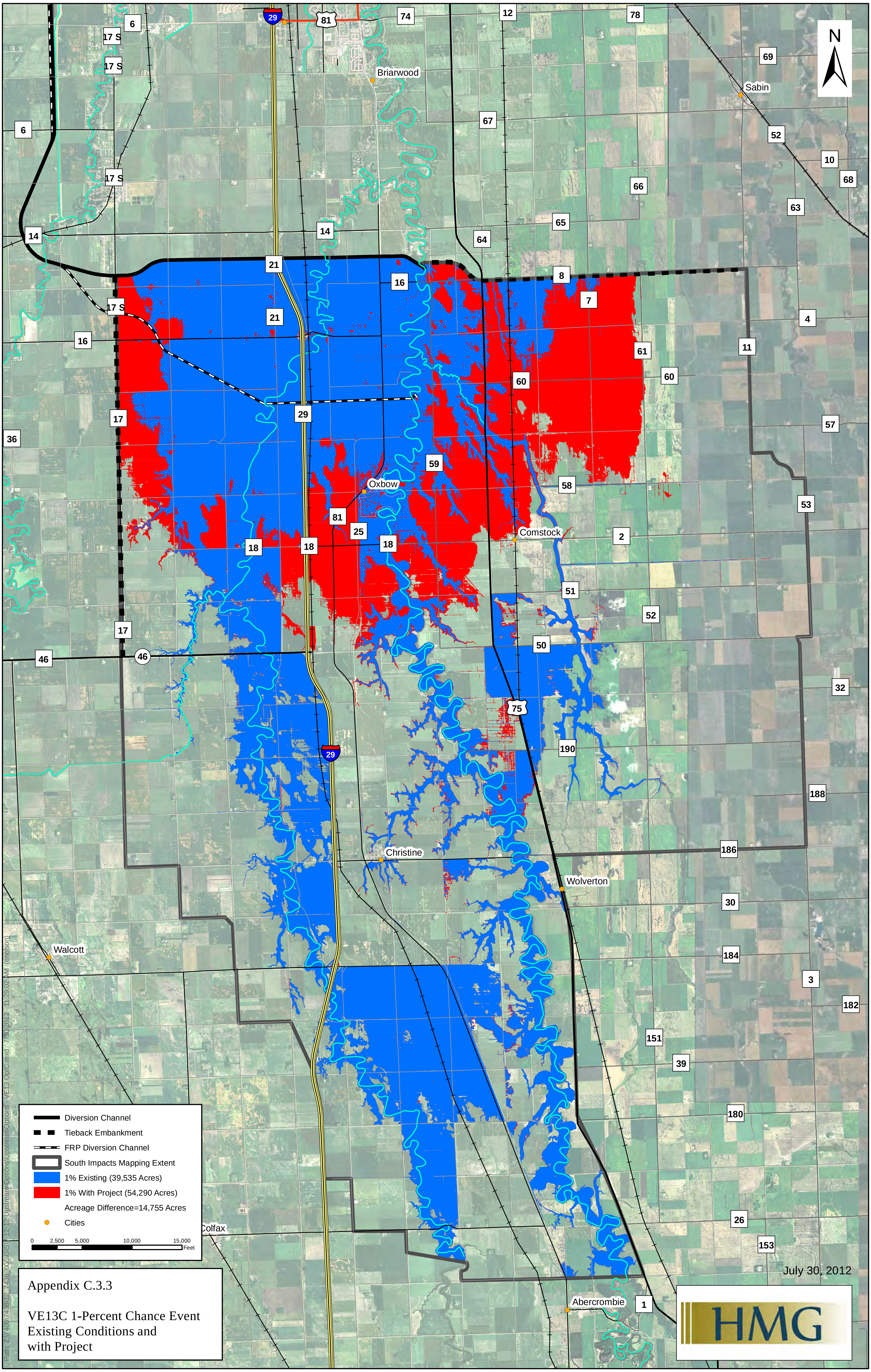
Appendix C.3.1

VE13C 10-Percent Chance Event Existing Conditions and with Project



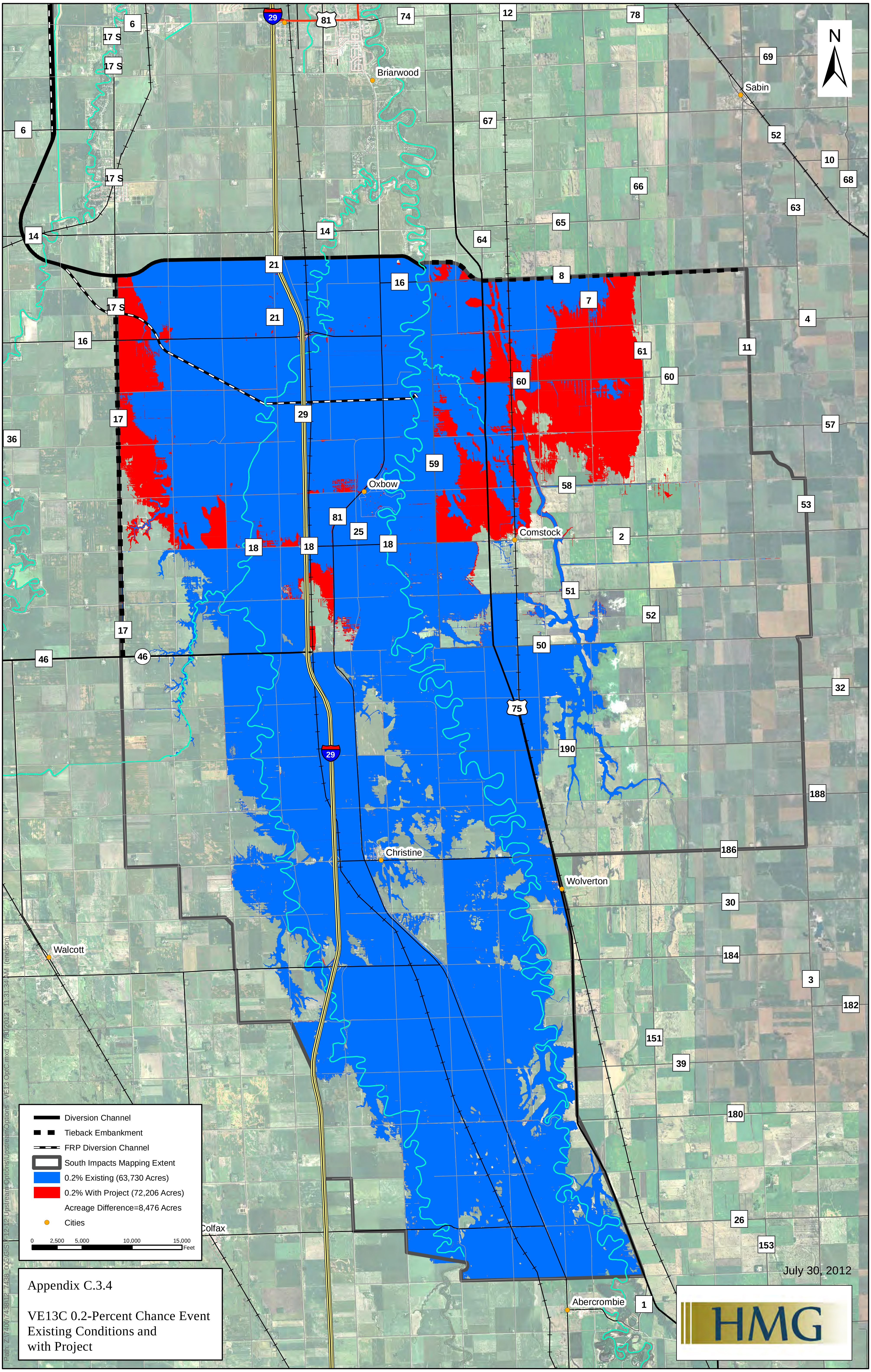
Appendix C.3.2

VE13C 2-Percent Chance Event Existing Conditions and with Project



Appendix C.3.3

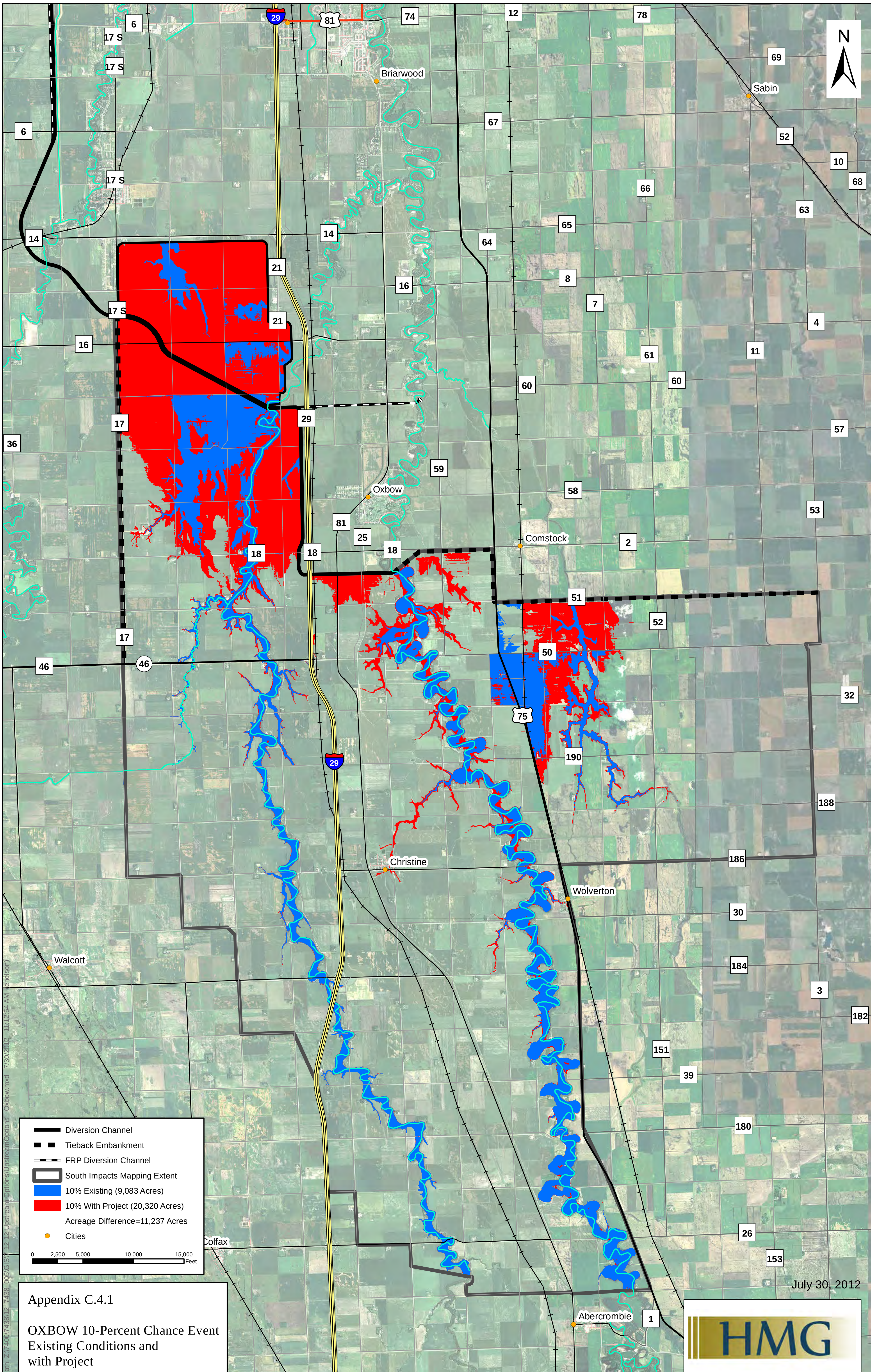
VE13C 1-Percent Chance Event Existing Conditions and with Project



Appendix C.3.4

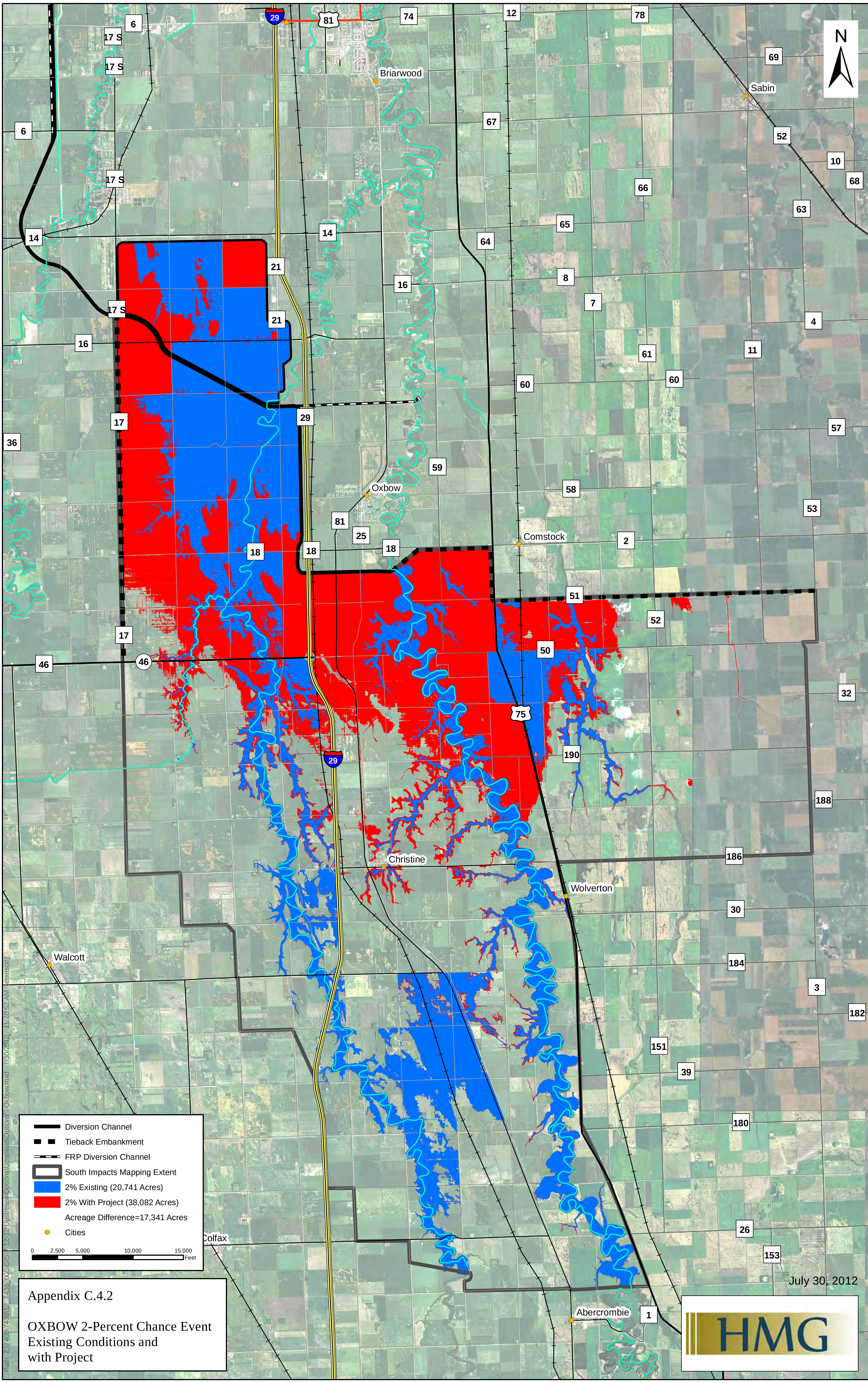
VE13C 0.2-Percent Chance Event Existing Conditions and with Project

APPENDIX C.4 – SOUTH OF OXBOW (OXBOW)



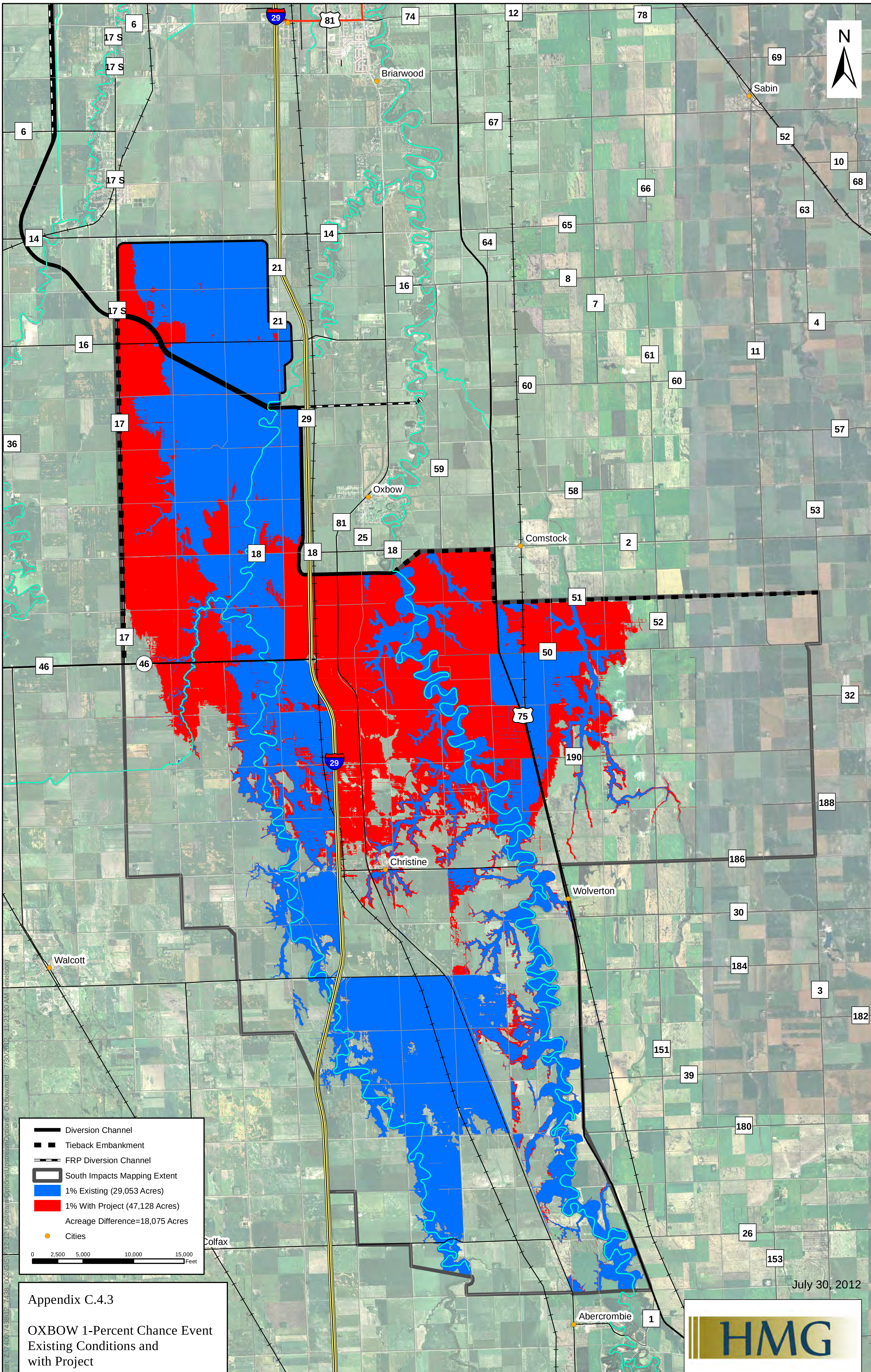
Appendix C.4.1

OXBOW 10-Percent Chance Event
Existing Conditions and
with Project



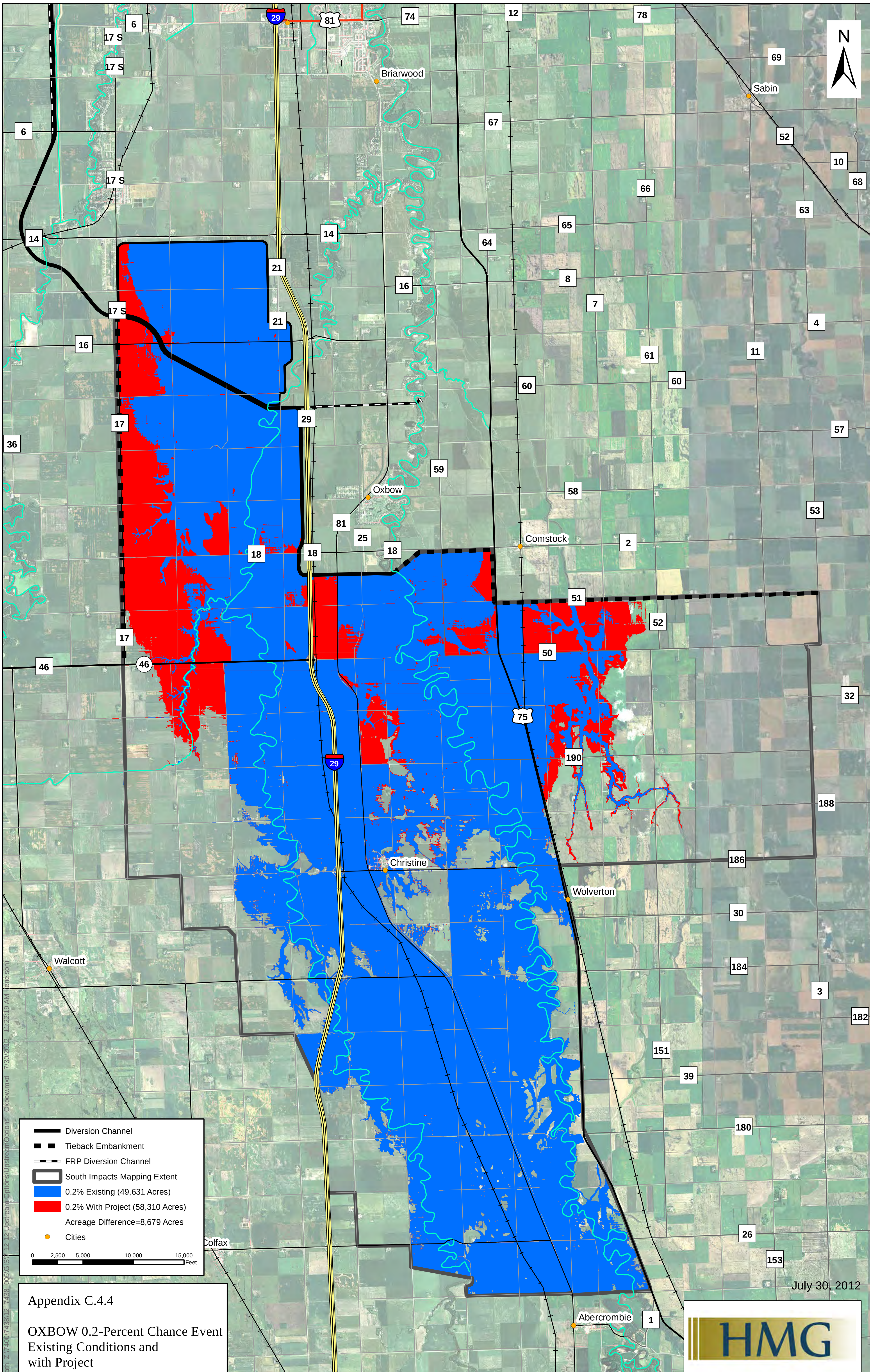
Appendix C.4.2

OXBOW 2-Percent Chance Event Existing Conditions and with Project



Appendix C.4.3

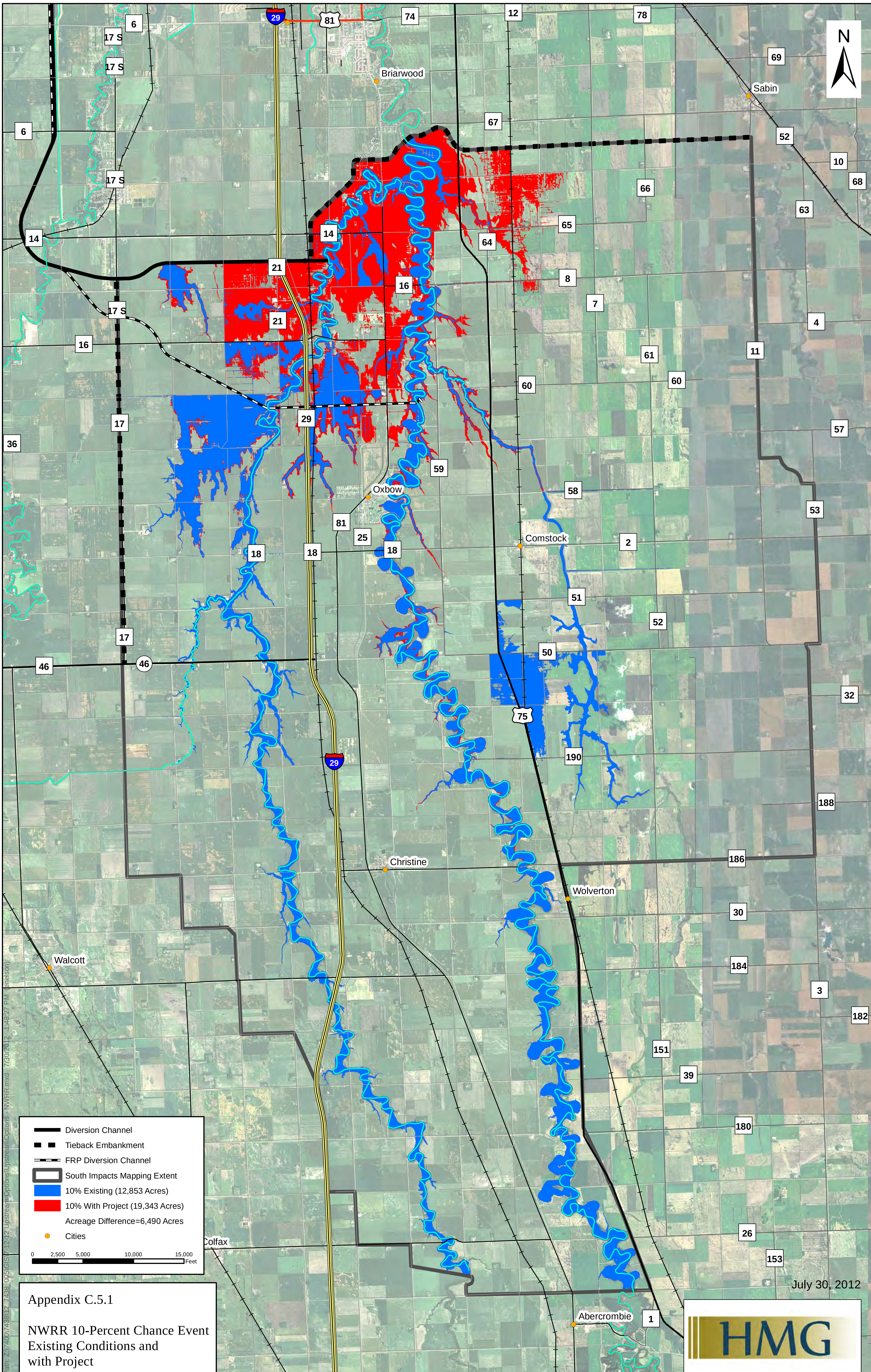
OXBOW 1-Percent Chance Event
Existing Conditions and
with Project



Appendix C.4.4

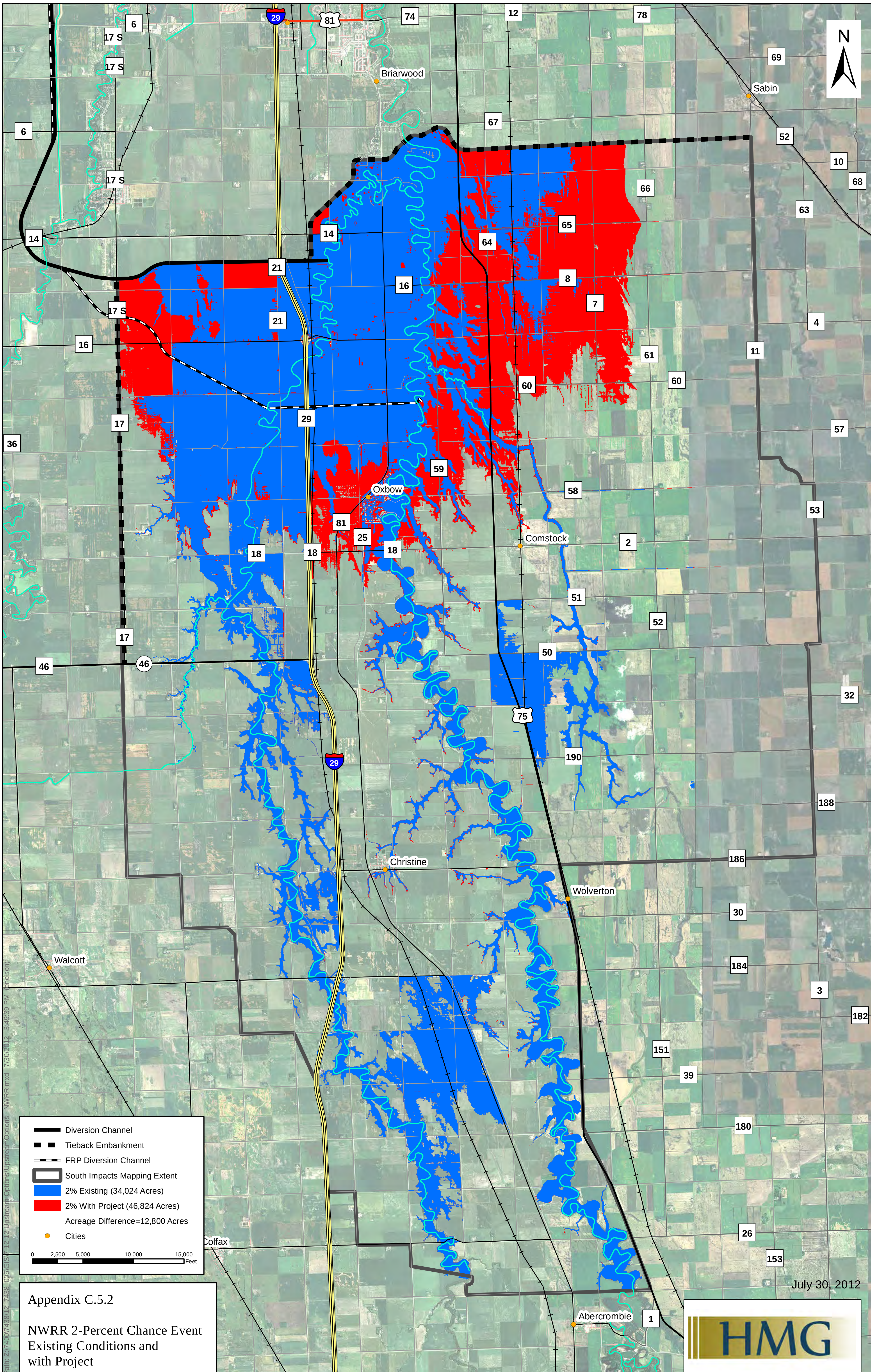
OXBOW 0.2-Percent Chance Event Existing Conditions and with Project

APPENDIX C.5 – NORTH OF WILD RICE RIVER (NWRR)



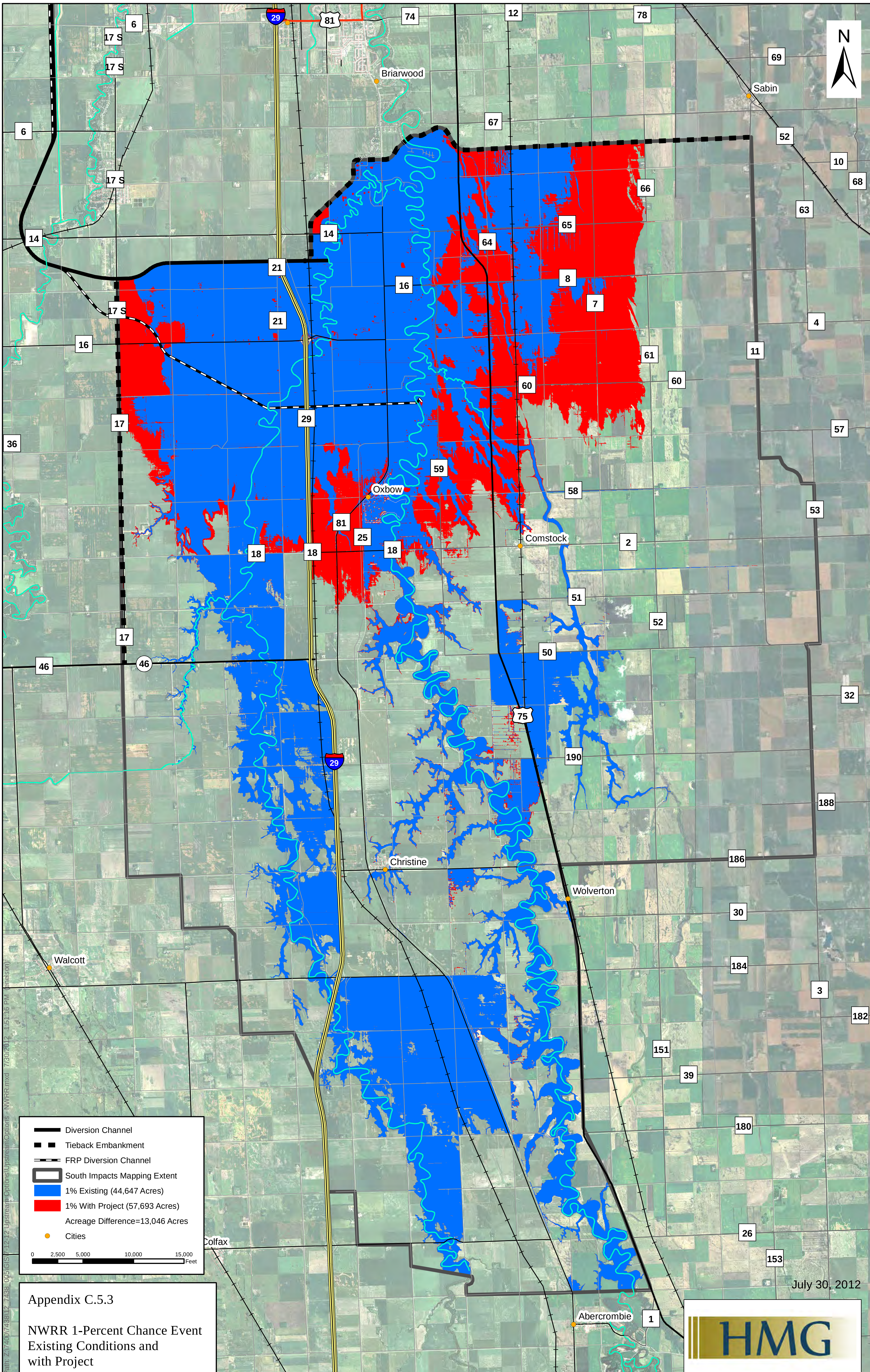
Appendix C.5.1

NWRR 10-Percent Chance Event Existing Conditions and with Project



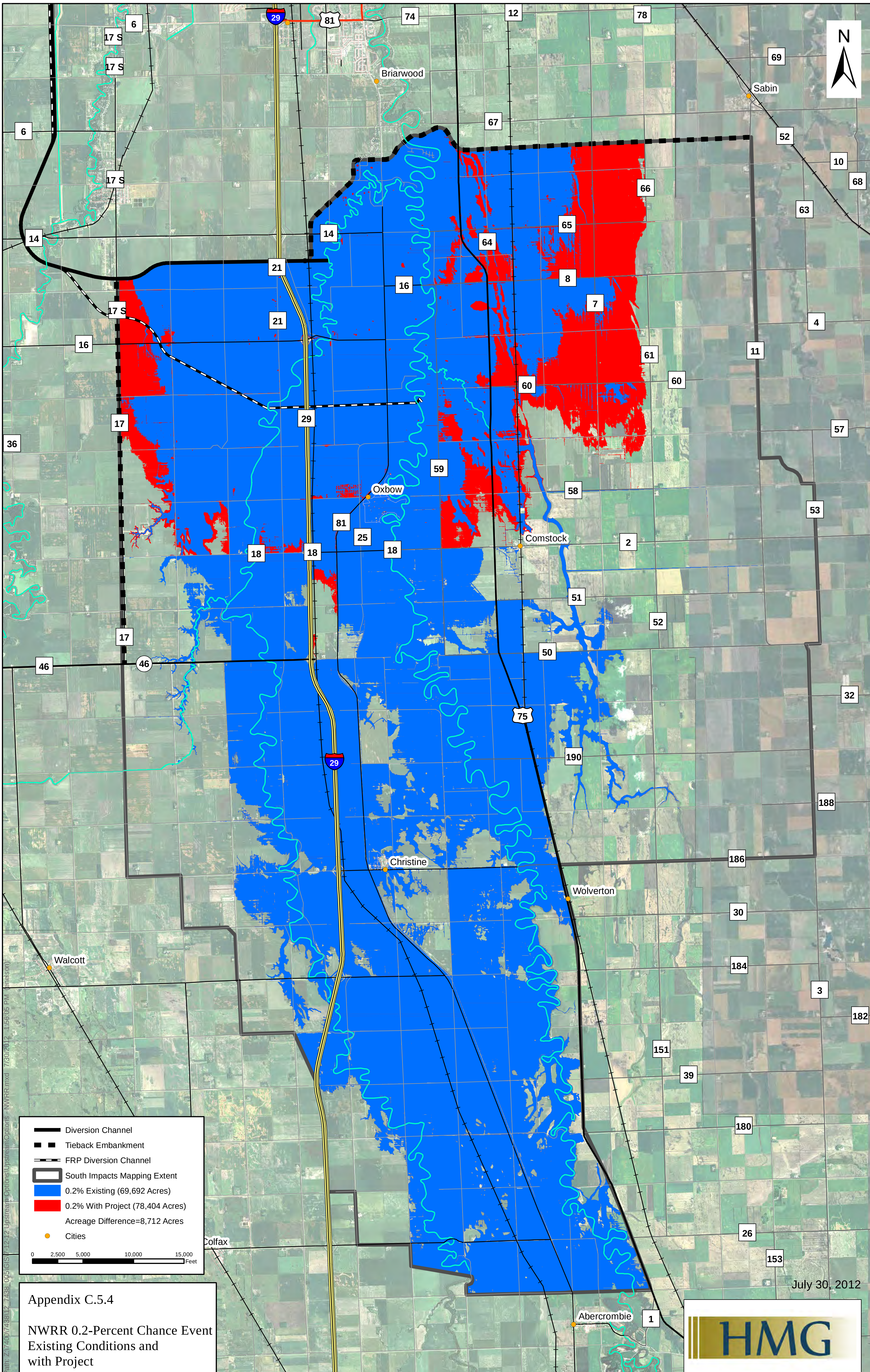
Appendix C.5.2

NWRR 2-Percent Chance Event Existing Conditions and with Project



Appendix C.5.3

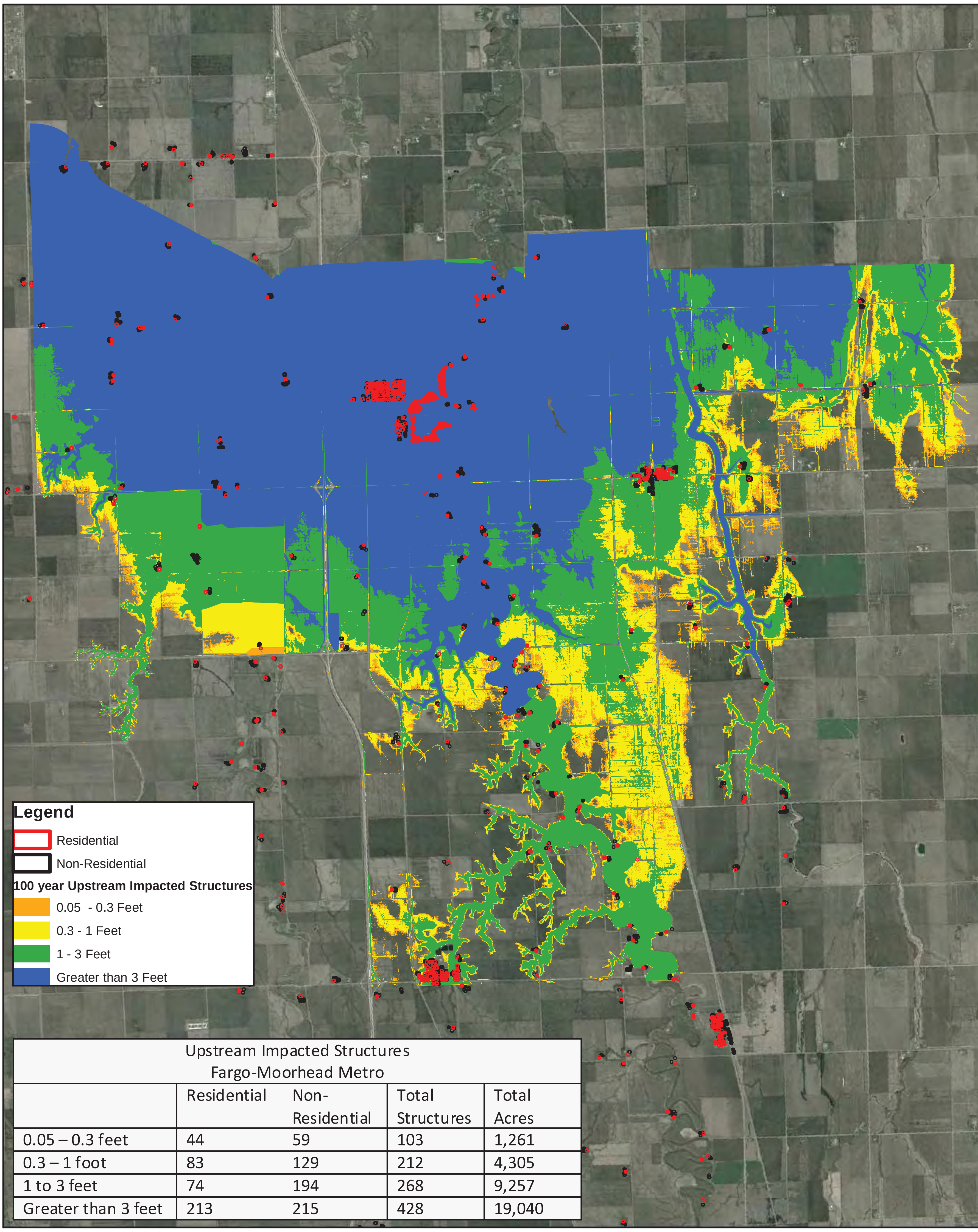
NWRR 1-Percent Chance Event Existing Conditions and with Project



Appendix C.5.4

NWRR 0.2-Percent Chance Event Existing Conditions and with Project

APPENDIX D – STAGING AREA LAND ACQUISTION MAPS



Upstream Impacted Structures Fargo-Moorhead Metro				
	Residential	Non-Residential	Total Structures	Total Acres
0.05 – 0.3 feet	44	59	103	1,261
0.3 – 1 foot	83	129	212	4,305
1 to 3 feet	74	194	268	9,257
Greater than 3 feet	213	215	428	19,040

Appendix D.1

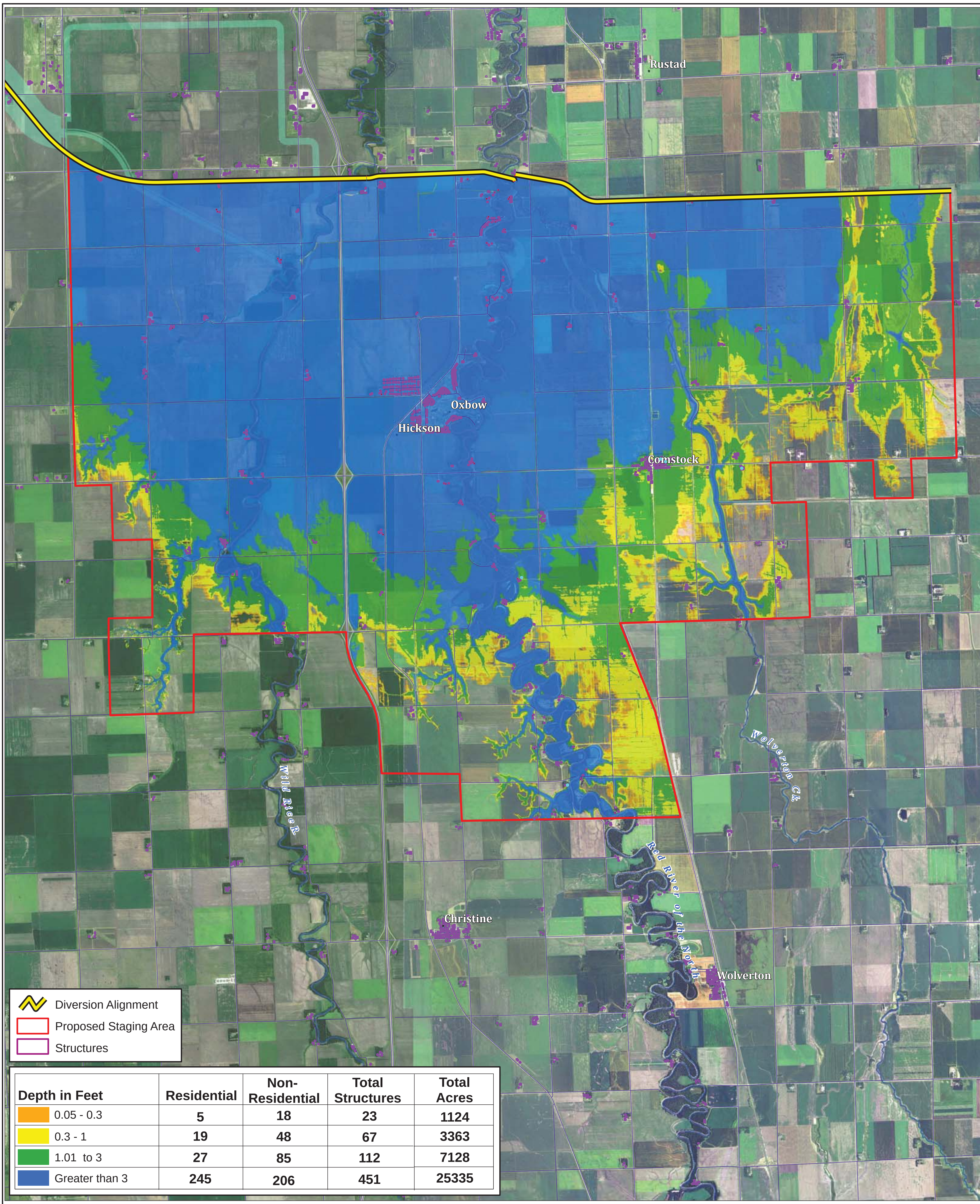
Upstream Impacted Structures 100 Year
Difference from Exisiting to Project Conditons

St. Paul District GIS CENTER
US Army Corps of Engineers

Fargo - Moorhead Metro Study

0 0.350.7 1.4 2.1 2.8 Miles

N



Depth in Feet	Residential	Non-Residential	Total Structures	Total Acres
0.05 - 0.3	5	18	23	1124
0.3 - 1	19	48	67	3363
1.01 to 3	27	85	112	7128
Greater than 3	245	206	451	25335

Option A Alignment Total Depth - Staging Area

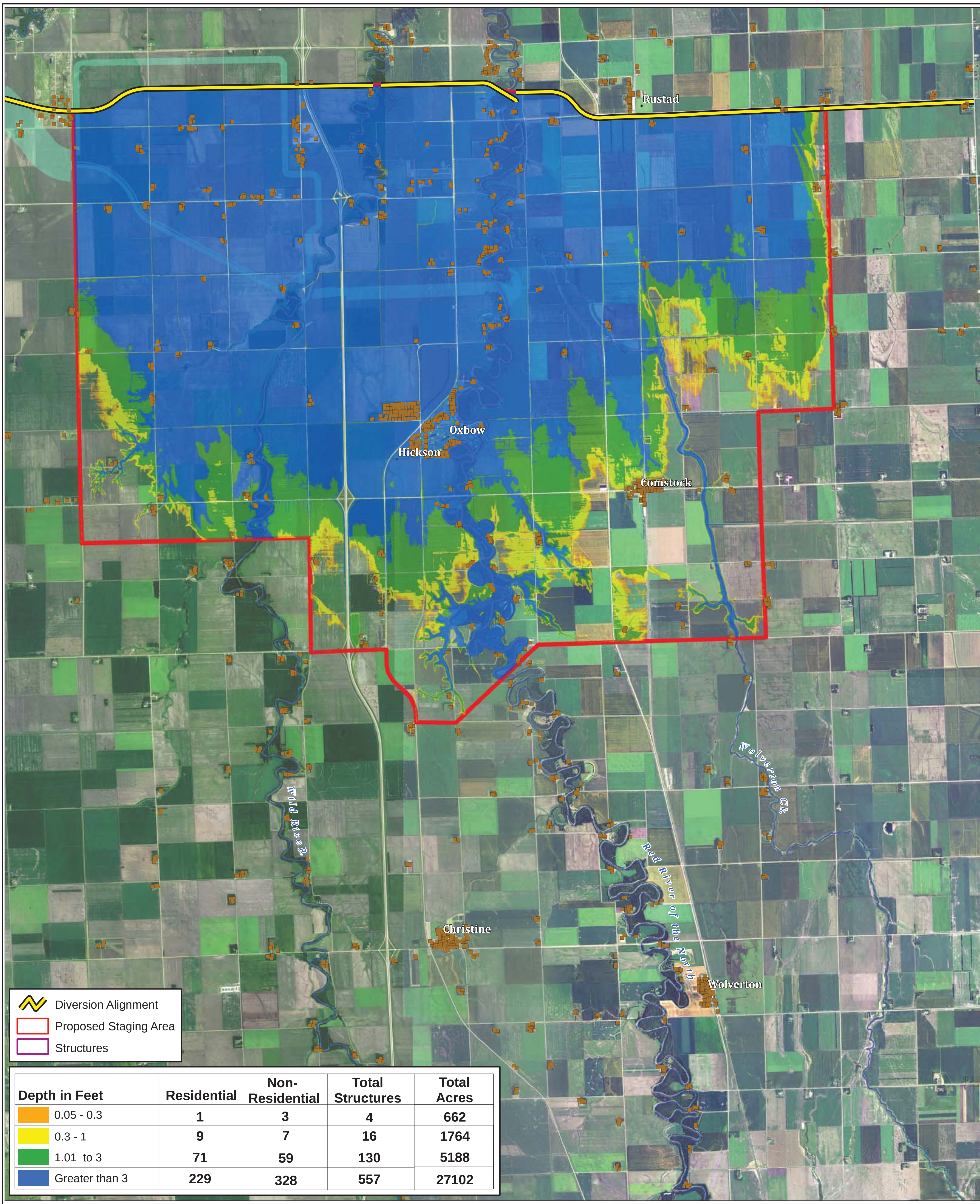
Fargo Moorhead Metro Flood Risk Management Project

Appendix D.2

St. Paul District GIS CENTER
US Army Corps of Engineers

0 0.5 1 2 3 4 Miles

N



Depth in Feet	Residential	Non-Residential	Total Structures	Total Acres
0.05 - 0.3	1	3	4	662
0.3 - 1	9	7	16	1764
1.01 to 3	71	59	130	5188
Greater than 3	229	328	557	27102

Appendix D.3

Option C Alignment Total Depth - Staging Area

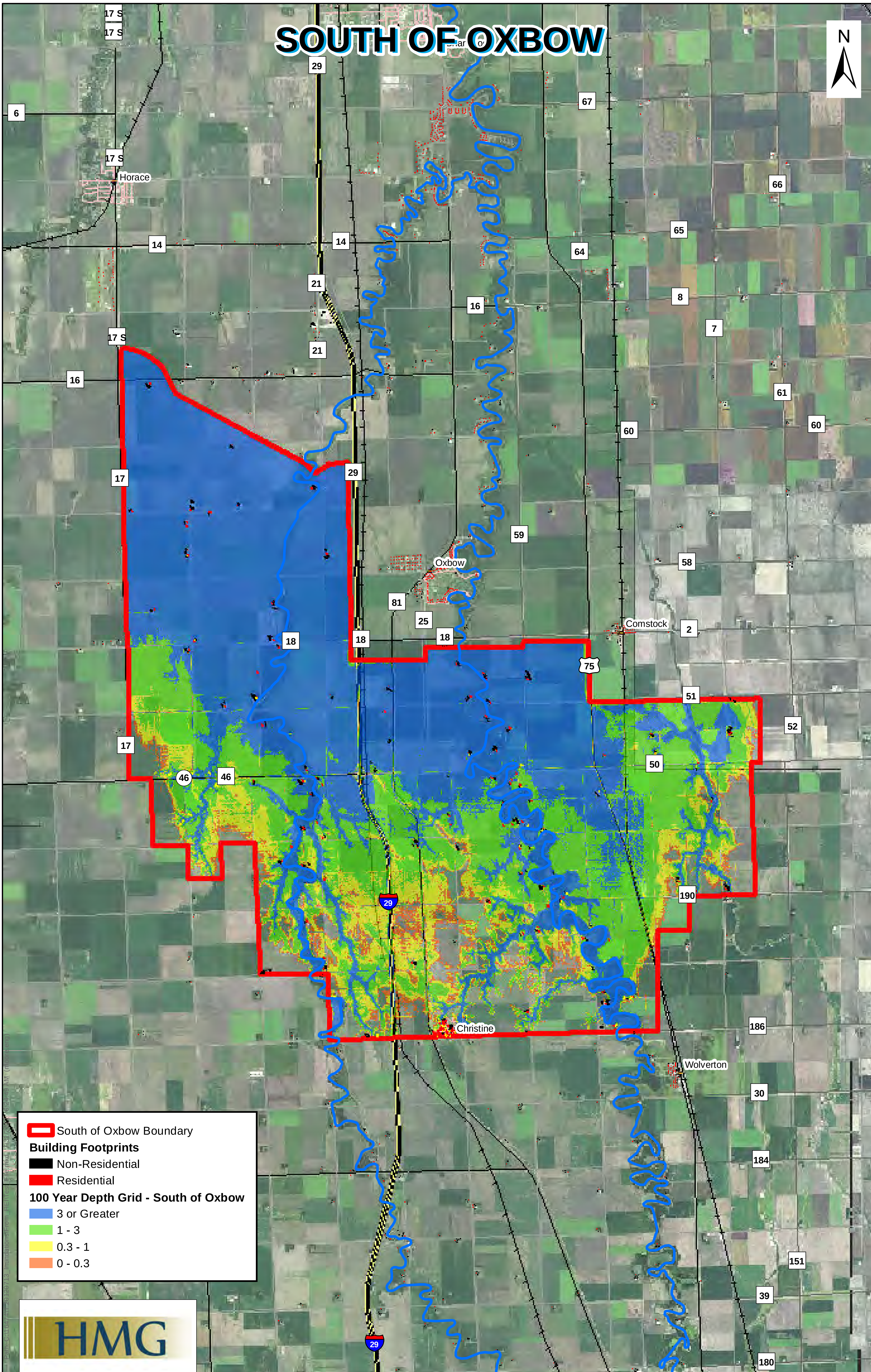
Fargo Moorhead Metro Flood Risk Management Project

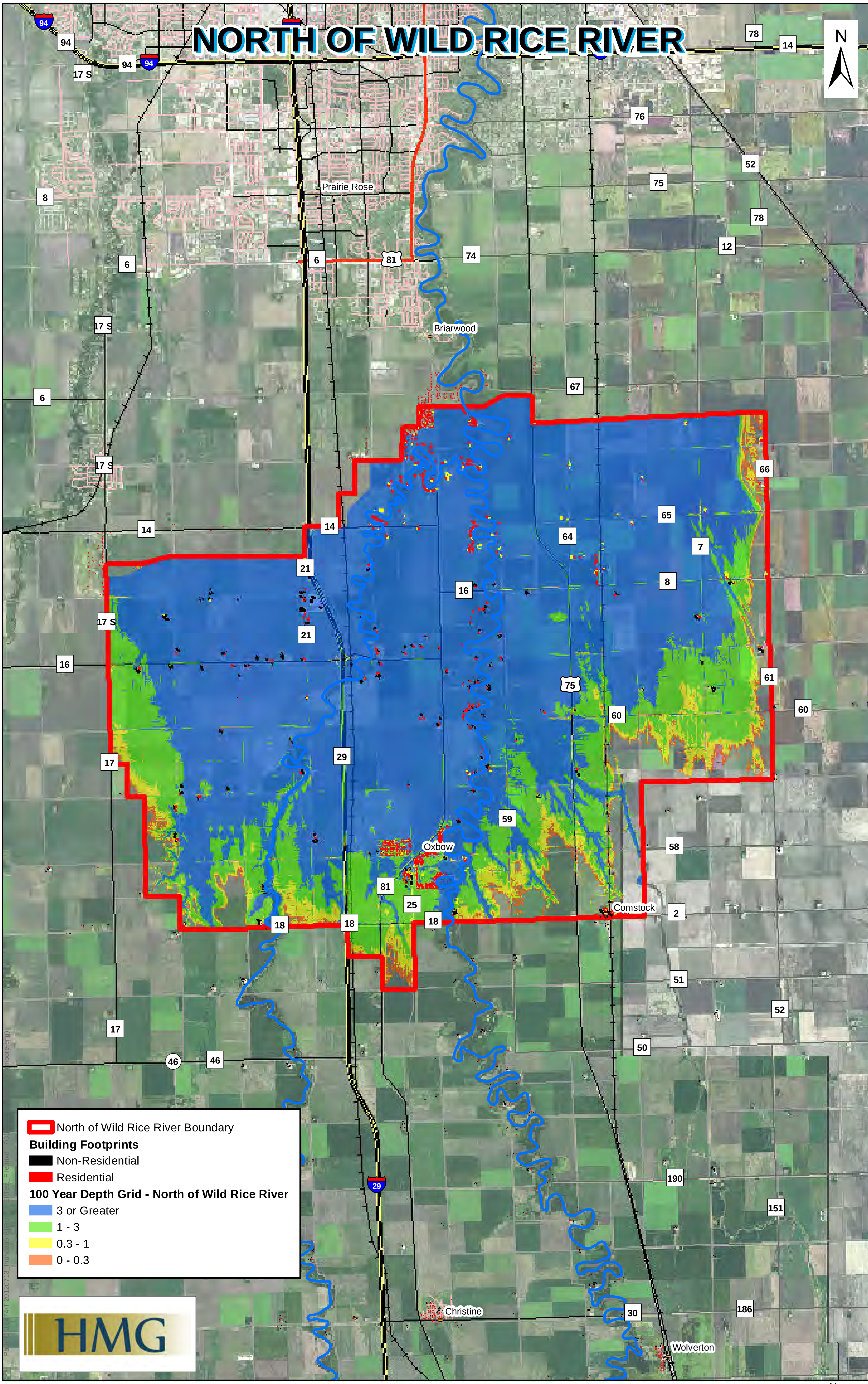
0 0.5 1 2 3 4 Miles

N

St. Paul District GIS CENTER

US Army Corps of Engineers


SOUTH OF OXBOW
N
Horace
Oxbow
Comstock
Christine
Wolverton
South of Oxbow Boundary
Building Footprints
Non-Residential
Residential
100 Year Depth Grid - South of Oxbow
3 or Greater
1 - 3
0.3 - 1
0 - 0.3
HMG


NORTH OF WILD RICE RIVER
N
Prairie Rose
Briarwood
Oxbow
Comstock
Christine
Wolverton
North of Wild Rice River Boundary
Building Footprints
Non-Residential
Residential
100 Year Depth Grid - North of Wild Rice River
3 or Greater
1 - 3
0.3 - 1
0 - 0.3
HMG

Appendix D.5

APPENDIX E – GEOTECHNICAL CONSIDERATIONS

Exhibit E1 (Offset) Stability Modeling Output

E.1. GEOTECHNICAL CONSIDERATIONS

This appendix to the FM Diversion Post-Feasibility Southern Alignment Analysis (PFSAA) is intended to provide additional background information about feasibility-level geotechnical analysis and assumptions used for the alternatives. The geotechnical considerations used for PFSAA analysis are generally consistent with assumptions presented in the Phase 4 Appendix F of the FRP April 19, 2011 A/E deliverable to the USACE, except as noted in this appendix. Similar to the Phase 4 study, the geotechnical analysis performed in the alternatives presented in this study is not intended for final design; rather it is to provide a feasibility cost estimate for the proposed project alternatives.

A preliminary slope stability analysis was performed for the embankments having a borrow trench offset on the upstream side of the embankment (in some places also referred to as the connectivity channel). This analysis provided slope stability estimates for the required offset distance between the toe of the embankment to the top of borrow excavation. The borrow excavation is assumed to extend from the Main Inlet Weir eastward to the Red River (SH-WRR and WRR-RRN project reaches).

E.2. GEOTECHNICAL ANALYSIS

Preliminary geotechnical analysis suggests various offset distances for different heights of embankments. USACE directed HMG to use assumed embankment cross sections developed by USACE. An embankment height of greater than or equal to 20 feet is assumed to consist of upstream slopes of 5H:1V and downstream slopes of 6H:1V while embankments under 20 feet are assumed to consist of side slopes of 4H:1V (see the USACE March 2012 white paper entitled "FMM-Estimated Costs for Dam vs. Levee Design"). Both embankments have a crest width of 15 feet. The borrow trench was assumed to have sides slopes of 5H:1V, a maximum depth of 10 feet, a maximum trench bottom width of 100 feet, and a minimum 50 foot trench offset from the toe of the embankment. A cross-sectional figure showing these dimensions is shown in Exhibit G4 of Appendix G.

Two types of stability analyses are typically performed for slopes: the Undrained Strength Stability Analysis (USSA) and the Effective Stress Stability Analysis (ESSA). The shear strength used in this analysis is the drained (long-term or ESSA) strength. The shear strengths in Lake Agassiz clays can be especially low under drained conditions because of the mineralogical composition of the material, and the drained strength of the material typically controls the design of stable slopes in the Red River Valley. Thus, the ESSA was the controlling case for slope stability.

Stability was examined on both sides of the embankment, with left-right potential failure surfaces checking the downstream side slope of the embankment and right-left surfaces checking the borrow trench offset or upstream side of the embankment.

For typical long-term conditions, the recommended factor of safety (FS) for embankments is 1.40 according to USACE standard EM 1110-2-1913, Table 6-1b (USACE, 2003). For typical flood conditions, assuming steady-state seepage, the recommended factor of safety is also 1.40 (USACE, 2003). At the time of this analysis, no firm determination has been made by USACE or others regarding what FS will be used for embankments during final design. Analysis was completed assuming both FS=1.40 and FS=1.50 and the results are included in this Appendix E.

E.3. STABILITY ANALYSIS

The PFSAA analysis focuses on estimating the required offset between the connecting channel excavation and the toe of embankment, for the purposes of ROW footprint estimates. The embankment cross section was developed by USACE, and HMG was directed by USACE on 7/10/2012 to use the assumed embankment cross sections. At the time of this analysis, USACE had not performed slope stability analysis on southern alignment embankments that are taller and wider than FRP embankments. The PFSAA analysis does not provide an assessment of the southern alignment embankment slope stability. Instead, the analysis estimates the borrow trench offset required to achieve the stated FS. Full stability analysis for the embankments is outside the scope of this PFSAA analysis.

The slope stability analysis was conducted using SLOPE/W, part of the GeoStudio 2007 Version 7.17 software package. SLOPE/W uses the limit equilibrium theory to compute the factor of safety of earth and rock slopes. In the limit equilibrium approach, the geologic material is assumed to be at the state of limiting equilibrium and a factor of safety is computed. Spencer's method was used to calculate the factor of safety of the trench slope in this stability analysis. This method is considered an adequate limit equilibrium method because it satisfies all conditions of static equilibrium and provides a factor of safety based on both force and moment equilibrium.

In SLOPE/W, the critical failure surface was modeled using the entry and exit method. This allows the location of the trial slip surfaces to be chosen manually, or where they will enter and exit the ground surface, with a chosen number of entry and exit points. Once the critical slip surface was found, the technique optimizes the solution of the circular surface, yielding the lowest factor of safety.

The pore pressures used in the SLOPE/W model were computed by a SEEP/W analysis. To evaluate the stability, two cases were analyzed. The first case considered a dry borrow trench with the ground water table 10 feet below ground surface. Potential seepage face review nodes were placed along the entire trench face with no water in the borrow trench. The second case considered flooding conditions with the maximum water level at 4 feet below the top of embankment. To analyze this condition steady-state seepage was performed allowing a phreatic surface to fully develop in the embankment becoming fully saturated and then drawn down to the bottom of the borrow trench. This causes the development of excess pore water pressure which may result in upstream slopes becoming unstable.

E.4. STABILITY MODEL INPUT PARAMETERS

The stratigraphy used for this modeling is the stratigraphy assumed for Storage Area 1 during FRP feasibility (the "previous analysis"). Since the Storage Area 1 embankments were covering a large area, it is assumed this stratigraphy would likely vary at each location. The PFSAA model for the borrow trench offset represents a stratigraphy with a thinner upper Sherack layer and thicker Oxidized Brenna/Brenna layer beneath which results in lower FS values for a conservative approach.

The stratigraphy for modeling was assumed from previous analysis performed in this area consisting of five overlying soil formations. The top soil is a 10 foot thick layer of Sherack Formation. Beneath the Sherack is a 10 foot layer of Oxidized Brenna overlaying 28 feet of Brenna. Below the Brenna layer is 10 feet of Argusville Formation on top of Glacial Till starting at an elevation of 850 feet. Table E-1 and Table E-2 summarizes the strength properties used in the Phase 4 Appendix F of the FRP April 19, 2011 A/E deliverable to the USACE. The excavated embankment was assumed to exhibit the same properties as the Sherack Formation although with a higher unit weight of 121 pcf to account for compaction.

Table E-1 Material Properties Summary

Formation	Unit Weight γsat (pcf)	Shear Strength Parameters: Undrained (ESSA) ϕ'	Undrained (ESSA) c' (psf)	Drained (USSA) c' (psf)
Sherack	115	28	0	900
Oxidized Brenna	108	see curvilinear envelope^		900
Brenna	106	see curvilinear envelope^		575
Argusville	110	see curvilinear envelope^		See note (1)
Glacial Till	123	22	225	1900

^ refer to Table E-2

(1) The Argusville formation ultimate undrained shear strength was assumed to be linearly increasing with depth. Initial cohesion was assumed to be 575 psf, with an increase of 10 psf/ft

Table E-2 Curve-linear Properties Summary

Oxidized Brenna		Brenna		Argusville	
Effective Normal Stress σ' (psf)	Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Shear Stress τ' (psf)
0	25	0	50	0	50
200	113	200	120	200	127
1000	420	1000	333	1000	413
2000	760	2000	540	2000	653
3000	933	3000	673	3000	893
4000	1073	4000	807	4000	1093
7000	1493	6000	1033	6000	1460
				8000	1740

The permeability values used in the SEEP/W analysis are included below in Table E-3. These values are the established USACE parameters.

Table E-3 Material Permeability Properties Summary

Material	Material Model Type	Sample Material	Vertical Permeability		Horizontal Permeability	
			k_y [cm/sec]	k_y [ft/day]	k_y/k_x ratio	k_x [ft/day]
Sherack	Sat / Unsaturated	Silty Clay	1.00E-06	2.80E-03	0.25	0.0113
OX Brenna	Sat / Unsaturated	Silty Clay	5.00E-07	1.40E-03	1	0.0014
Brenna	Saturated Only	N/A	1.00E-07	2.80E-04	1	0.00028
Argusville	Saturated Only	N/A	1.00E-07	2.80E-04	1	0.00028
Glacial Till	Saturated Only	N/A	5.00E-06	1.40E-02	0.25	0.057

E.5. STABILITY MODEL RESULTS

The results of the stability analysis to determine the borrow trench offset distance is summarized in Table E-4. These distances meet the required factor of safety value of 1.4 for embankments.

Table E-4 Results of Stability Analysis meeting FS=1.4

Embankment Height	Offset Distance (1)	Crest Width	Slopes
(ft)	(ft)	(ft)	(ft)
<20	50	15	4H:1V
20	50	15	5H:1V U/S, 6H:1V D/S
>20	60	15	5H:1V U/S, 6H:1V D/S

(1) Offset distance rounded to nearest 10 ft.

The offset results are provided for embankments of varying heights. The distance between the toe of the embankment and the top of the borrow trench can remain at the design offset of 50 feet for an embankment height of 20 feet. For an embankment height under 20 feet and slopes of 4H:1V, the offset will need to be greater than 50 feet. For an embankment greater than 20 feet (modeled at 25 feet), the offset will need to be greater than 60 feet.

If the required factor of safety is increased to 1.5 for the embankments slope stability, greater borrow trench offset distances from the toe of the embankments will be required. The offset results to meet a factor of safety of 1.5 are provided in Table E-5.

Table E-5 Results of Stability Analysis meeting FS=1.5

Embankment Height	Offset Distance (1)	Crest Width	Slopes
(ft)	**(ft)**	**(ft)**	**(ft)**
<20	70	15	4H:1V
20	60	15	5H:1V U/S, 6H:1V D/S
>20	70	15	5H:1V U/S, 6H:1V D/S

(1) Offset distance rounded to nearest 10 ft.

The distance between the toe of the embankment and the top of the borrow trench will increase to 60 feet for an embankment height of 20 feet. For an embankment height under 20 feet and slopes of 4H:1V, the offset will need to be greater than 70 feet. For an embankment greater than 20 feet, the offset will need to be greater than 70 feet. To improve stability results while maintaining an offset distance of 50 feet two adjustments can be made to the borrow trench. The first adjustment could be reducing the trench slopes from 5H:1V to 8.5H:1V. The second adjustment could be maintaining 5H:1V trench slopes with a reduction in the maximum trench depth from 10 feet to 7 feet.

Model output for borrow trench analysis using FS=1.40 and FS=1.50 were generated during the PFSAA report analysis and are presented in Exhibit E1.

E.6. LIMITATIONS OF ANALYSIS

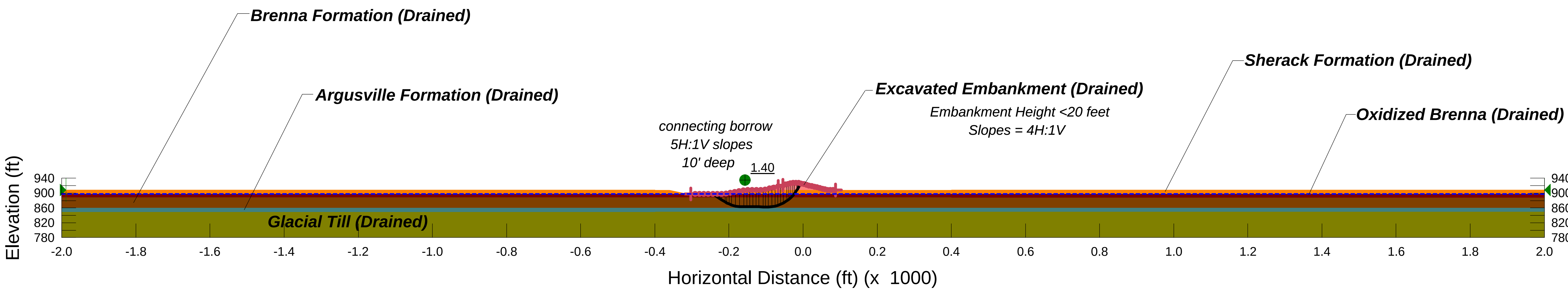
The analysis and conclusions provided are based on the limited dataset available at the time of this analysis. Using generally accepted engineering methods and practices, analyses have been performed using reasonable effort to characterize the site. However, the analyses represent a large area, and variations in stratigraphy, strength, and groundwater conditions may occur. This stability analysis is typical for the SH-WRR and WRR-RRN embankments. However, the analysis may not apply to the CSAH17 or RRN-MN embankments. More detailed site specific information will be required for analyzing this offset for all embankment segments in future design efforts.

APPENDIX E – EXHIBIT E1 – (OFFSET) STABILITY MODELING OUTPUT

Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_20ft_ 4to1.gsz
Last Saved Date: 7/13/2012
Factor of Safety: 1.40

Exhibit E1
Embankment Less Than 20 Foot Height
FOS = 1.4

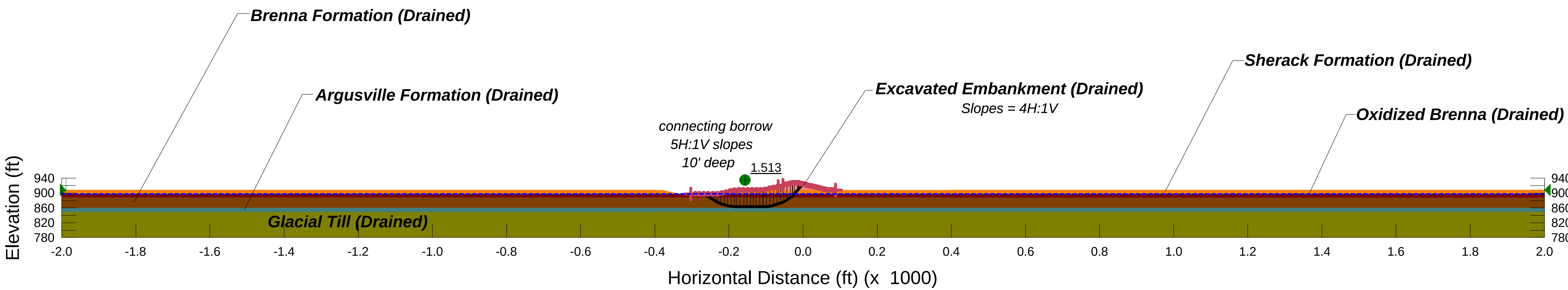
Excavated Embankment (Drained)	Mohr-Coulomb	121 pcf	119 pcf	0 psf	28 °
Sherack Formation (Drained)	Mohr-Coulomb	115 pcf	113 pcf	0 psf	28 °
Glacial Till (Drained)	Mohr-Coulomb	123 pcf	122 pcf	225 psf	22 °
Brenna Formation (Drained)	Shear/Normal Fn.	106 pcf	105.5 pcf	Brenna Formation	
Oxidized Brenna (Drained)	Shear/Normal Fn.	108 pcf	107.2 pcf	Oxidized Brenna Formation	
Argusville Formation (Drained)	Shear/Normal Fn.	110 pcf	109.2 pcf	Argusville Formation	



Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_20ft_4to1.gsz
Last Saved Date: 7/17/2012
Factor of Safety: 1.513

Exhibit E1
Embankment Height Less Than 20 Feet
FOS = 1.5

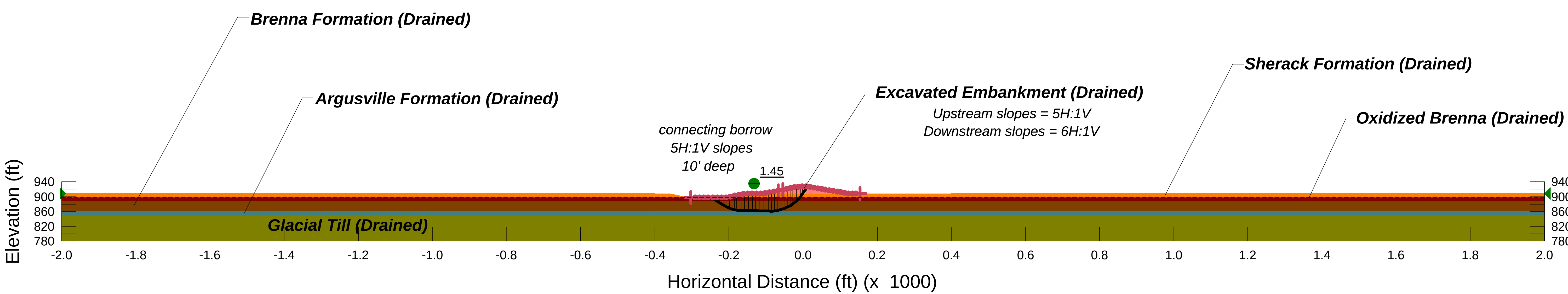
Excavated Embankment (Drained)	Mohr-Coulomb	121 pcf	119 pcf	0 psf	28 °
Sherack Formation (Drained)	Mohr-Coulomb	115 pcf	113 pcf	0 psf	28 °
Glacial Till (Drained)	Mohr-Coulomb	123 pcf	122 pcf	225 psf	22 °
Brenna Formation (Drained)	Shear/Normal Fn.	106 pcf	105.5 pcf	Brenna Formation	
Oxidized Brenna (Drained)	Shear/Normal Fn.	108 pcf	107.2 pcf	Oxidized Brenna Formation	
Argusville Formation (Drained)	Shear/Normal Fn.	110 pcf	109.2 pcf	Argusville Formation	



Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_20ft.gsz
Last Saved Date: 7/13/2012
Factor of Safety: 1.45

Exhibit E1
Embankment Height 20 Feet
FOS = 1.4

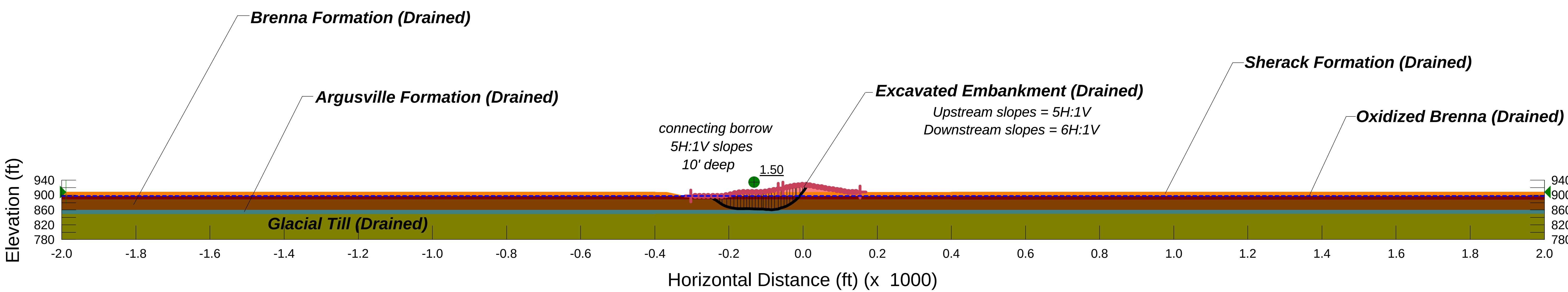
Excavated Embankment (Drained)	Mohr-Coulomb	121 pcf	119 pcf	0 psf	28 °
Sherack Formation (Drained)	Mohr-Coulomb	115 pcf	113 pcf	0 psf	28 °
Glacial Till (Drained)	Mohr-Coulomb	123 pcf	122 pcf	225 psf	22 °
Brenna Formation (Drained)	Shear/Normal Fn.	106 pcf	105.5 pcf	Brenna Formation	
Oxidized Brenna (Drained)	Shear/Normal Fn.	108 pcf	107.2 pcf	Oxidized Brenna Formation	
Argusville Formation (Drained)	Shear/Normal Fn.	110 pcf	109.2 pcf	Argusville Formation	



Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_20ft_10'Sherack.gsz
Last Saved Date: 7/17/2012
Factor of Safety: 1.50

Exhibit E1
Embankment Height 20 Feet
FOS = 1.5

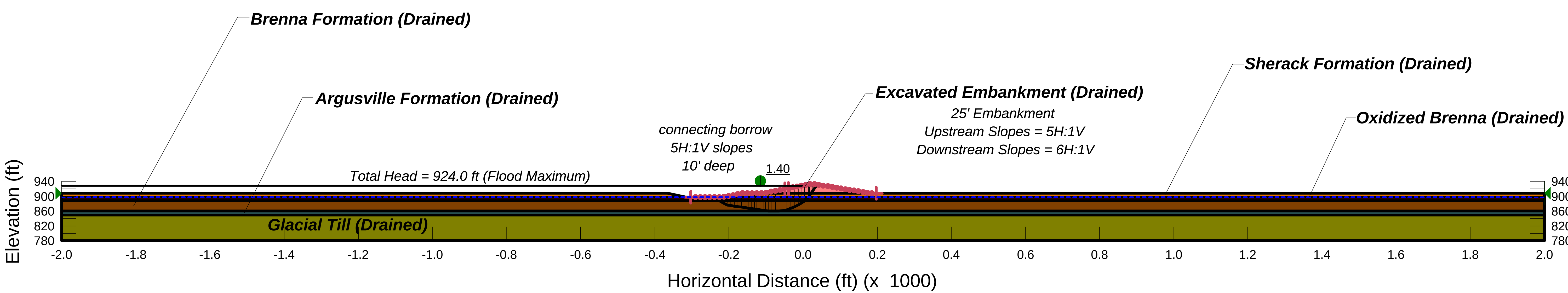
Excavated Embankment (Drained) Mohr-Coulomb 121 pcf 119 pcf 0 psf 28 °
Sherack Formation (Drained) Mohr-Coulomb 115 pcf 113 pcf 0 psf 28 °
Glacial Till (Drained) Mohr-Coulomb 123 pcf 122 pcf 225 psf 22 °
Brenna Formation (Drained) Shear/Normal Fn. 106 pcf 105.5 pcf Brenna Formation
Oxidized Brenna (Drained) Shear/Normal Fn. 108 pcf 107.2 pcf Oxidized Brenna Formation
Argusville Formation (Drained) Shear/Normal Fn. 110 pcf 109.2 pcf Argusville Formation



Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_25ft_Flood.gsz
Last Saved Date: 7/14/2012
Factor of Safety: 1.40

Exhibit E1
Embankment Height 25 Feet
FOS = 1.4

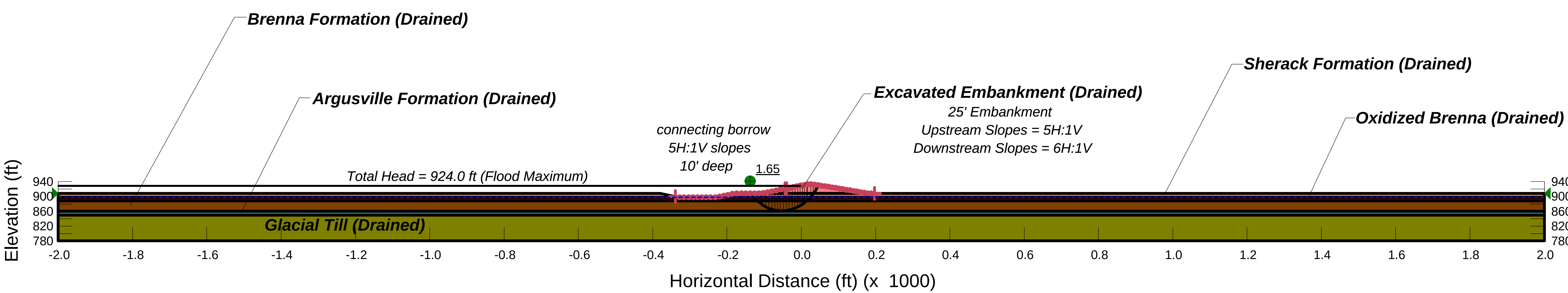
Excavated Embankment (Drained)	Mohr-Coulomb	121 pcf	119 pcf	0 psf	28 °	0 °
Sherack Formation (Drained)	Mohr-Coulomb	115 pcf	113 pcf	0 psf	28 °	0 °
Glacial Till (Drained)	Mohr-Coulomb	123 pcf	122 pcf	225 psf	22 °	0 °
Brenna Formation (Drained)	Shear/Normal Fn.	106 pcf	105.5 pcf	Brenna Formation		0 °
Oxidized Brenna (Drained)	Shear/Normal Fn.	108 pcf	107.2 pcf	Oxidized Brenna Formation		0 °
Argusville Formation (Drained)	Shear/Normal Fn.	110 pcf	109.2 pcf	Argusville Formation		0 °



Fargo-Moorhead, Tie-back Embankments
Stability Analysis, Steady State Seepage, Base Flood Case (Max Head)
File Name: Tie-back Embankment_25ft_Flood.gsz
Last Saved Date: 7/20/2012
Factor of Safety: 1.65

Exhibit E1
Embankment Height 25'
FOS = 1.5

Excavated Embankment (Drained)	Mohr-Coulomb	121 pcf	119 pcf	0 psf	28 °	0 °
Sherack Formation (Drained)	Mohr-Coulomb	115 pcf	113 pcf	0 psf	28 °	0 °
Glacial Till (Drained)	Mohr-Coulomb	123 pcf	122 pcf	225 psf	22 °	0 °
Brenna Formation (Drained)	Shear/Normal Fn.	106 pcf	105.5 pcf	Brenna Formation	0 °	
Oxidized Brenna (Drained)	Shear/Normal Fn.	108 pcf	107.2 pcf	Oxidized Brenna Formation	0 °	
Argusville Formation (Drained)	Shear/Normal Fn.	110 pcf	109.2 pcf	Argusville Formation	0 °	



APPENDIX F – STRUCTURAL DESIGN CONSIDERATIONS

F.1 STRUCTURAL DESIGN

This appendix to the FM Diversion Post-Feasibility Southern Alignment Analysis (PFSAA) is intended to provide additional background information about feasibility-level structural design methodology and assumptions used for the alternatives.

The structural design of the hydraulic structures, including loads, load combinations, reinforced concrete design, pile design, and assumptions are described in Appendix F of the Phase 4 FRP April 2011 A/E deliverable to USACE. This section will only describe changes to the methodology used in Phase 4. Similar to the Phase 4 study, the structural design performed in the alternatives presented in this study is not intended for final design; rather it is to provide a detailed cost estimate for the proposed project alternatives.

F.2 STRUCTURAL DESIGN CRITERIA

Structural design criteria used in Phase 4 was followed in the alternatives presented in this study. Changes to the maximum flood event were modified in the FPSAA to include a protection level for the 103k cfs event plus free board. In Phase 4, the top of structures were based on the 0.2-percent chance event plus free board. For comparative purposes of the structural analysis for this PFSAA deliverable, the 500-year event and the 0.2 percent chance event shall be considered analogous events for the PFSAA. Additionally, the 100-year event and the 1 percent chance event shall be considered analogous events for the PFSAA . It should be noted that the approximate difference between the 103k cfs event and the 0.2-percent chance event is approximately 2 feet.

Changes to the maximum flood event were modified in the VE13, NWRR, and OXBOW alternatives to include a protection level for the 103k cfs event plus free board as defined through July 31, 2012. Revisions to the top-of-structure elevations for VE13C and NWRR following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates.

F.3 CONTROL STRUCTURES

This section is applicable for the following structures:

1. VE-13A: Control Structure on Red River of the North
2. VE-13A: Control Structure on Wild Rice River
3. VE-13C: Control Structure on Red River of the North
4. VE-13C: Control Structure on Wild Rice River
5. South of Oxbow: Control Structure on Red River of the North
6. South of Oxbow: Control Structure on Wolverton Creek
7. North of Wild Rice River: Control Structure on Red River of the North

The Control Structures consist of a gated section in the middle and wing walls on each size. The wing walls have stepped footings which follow up the 7:1 side slopes of the channel section and tie the concrete structure into the adjacent embankment. The top of the structure was set based on the 103k cfs event (as defined on prior to July 31, 2012) plus 4 foot of free board. In Phase 4, the top of structures were based on the 0.2-percent chance event plus 5 feet of free board.

Several structures were excluded from pile capacity and structural analysis at the direction of USACE. See Exhibit H3 for a listing of these structures for which a prorated cost based on the FRP cost was developed in lieu of revised sizing and quantity takeoffs.

F.3.1 PILE DESIGN

Updated geotechnical capacity of the piles was evaluated at each of the new structure locations. The procedures follow those developed for Phase 3 and Phase 4 of the FRP. Drained and undrained axial pile and lateral pile capacities were computed using the design parameters previously developed for Phase 3 and Phase 4. The geotechnical capacity of the piles varies along the project and is generally affected by the differing strata thicknesses at each location. For this PFSAA phase of the project, updated stratigraphy was developed based on the available geotechnical information. In locations where a soil boring or cone penetration test probe was not available, interpreted stratigraphies were created from nearby investigations.

The results of the analyses are presented in Table F-3. The assumed stratigraphy and geotechnical properties used for the pile capacity calculations are presented in Table F-4.

F.3.2 LOADS

Phase 4 loading was also used in the alternatives presented in this study. Hydrostatic water loads used for uplift and lateral load calculations were based on updated hydrology and hydraulics modeling for the new structure locations for each event.

F.3.3 LOAD COMBINATIONS

The maximum design flood event was changed for the alternatives presented in this study, as noted earlier. Therefore, Load Case 2 & 2.1 was changed in this study to represent the 103k cfs event in lieu of the 0.2-percent change event used in Phase 4. A summary of the load cases for the alternatives is shown in Table F-1 and the Phase 4 load Case are shown in Table F-2 (copied from Phase 4 Report).

Table F-1 VE-13, North of Wild Rice River, and South of Oxbow Alternatives: Gated Structures Load Cases

Load Case	**Event Category**	**Allowable Pile Deflection (inches)**	**Factor of Safety for Piles**
1 – 1-Percent Chance Event	Usual	0.67 (note 1)	2.00
1.1 – 1-Percent Chance Event + ice (note 4 and 5)	Unusual	0.875 (note 2)	1.50
2 – 103k cfs event	Unusual	0.875 (note 2)	1.50
2.1 – 103k cfs event + 4ft	Extreme	1.000 (note 3)	1.15
3 – construction	Unusual	0.67	1.50
4 – Normal low flow	Usual	0.50	2.00

Table F-2 Phase 4: Gated Structures Load Cases

Load Case	**Event Category**	**Allowable Pile Deflection (inches)**	**Factor of Safety for Piles**
1 – 1-Percent Chance Event	Usual	0.67 (note 1)	2.00
1.1 – 1-Percent Chance Event + ice (note 4 and 5)	Unusual	0.875 (note 2)	1.50
2 – 0.2-Percent Chance Event	Unusual	0.875 (note 2)	1.50
2.1 – 0.2-Percent Chance Event + 5ft	Extreme	1.000 (note 3)	1.15
3 – construction	Unusual	0.67	1.50
4 – Normal low flow	Usual	0.50	2.00

Note 1: It was agreed with USACE that an allowable deflection of 0.67-inches (as opposed to 0.50 inches) is acceptable even though this is considered a usual load case.

Note 2: It was agreed with USACE that an allowable deflection of 0.875-inches (as opposed to 0.67 inches) is acceptable even though this is considered an unusual load case.

Note 3: It was agreed with USACE that for this extreme event an allowable deflection of 1.0-inch is acceptable.

Note 4: Ice loads on the gated structure during the 1-percent chance event will be considered as dynamic forces due to crushing or bending of ice floes as provided by Andrew Tuthill from the USACE via email to Miguel Wong dated February 1, 2011 at 9:52AM. These loads will be applied to the piers.

Note 5: An ice/debris load of 500 PLF along the structure will be used for the wing and retaining wall structures.

F.4 OGEE SPILLWAYS

This section is applicable for the following structures:

1. VE-13A: Diversion Channel Inlet Ogee Spillway Structure
2. VE-13C: Diversion Channel Inlet Ogee Spillway Structure
3. North of Wild Rice River: Diversion Channel Inlet Ogee Spillway Structure

The spillway structure consists of an ogee weir and a downstream apron which allow the drop in elevation between the upstream and downstream channel bottoms. Geometry for the spillways was based on the hydraulic requirements provided by the H&H team for the PFSAA study. Changes to the maximum flood event were modified in the PFSAA study to include a protection level of the 103k cfs event plus 2 foot of free board. In Phase 4, the top of the spillway structures were based on the 0.2-percent chance event plus 2 feet of free board.

F.4.1 PILE DESIGN

Since no further soil explorations and geotechnical data was provide for the spillway locations, Phase 4 pile spacing and lengths were used for all locations in this study.

F.4.2 STRUCTURAL DESIGN

The Ogee Spillway and Apron were not evaluated for stability due to the lack of geotechnical information and variability of the downstream pool during each event. Geometry was updated based on the H&H data for this study at each structure to determine quantities required for the cost estimate.

Concrete Reinforcing bar quantities were based on ratio's of reinforcement to cubic yards of concrete (lb/cy) as determined in Phase 4.

For the retaining walls (wingwalls) adjacent to the ogee spillway, standard retaining wall charts published by the Minnesota Department of Transportation (MN/DOT) were used for sizing the foundation requirements, concrete reinforcement and stem thickness as in Phase 4. However, a constant stem thickness was used for the total height of each wall section in lieu of a battered wall as shown in the MN/DOT charts. A similar procedure was used to size the walls in the Phase 4 report.

Table F-3 Preliminary Design Pile Capacities

<table>
<tr><th colspan="11">Fargo-Moorhead Food Control Structures
Preliminary Pile Foundation Analyses
HP 14X73</th></tr>
<tr><th colspan="11">A_{tip} = 198.5 in^2, A_{steel} = 21.4 in^2, perimeter = 56.4 in, width (b) = 14.6 in, I = 729 in^4</th></tr>
<tr><th rowspan="4">Structure</th><th rowspan="4">Gate Invert Elevation (ft)</th><th rowspan="4">Estimated Foundation Elevation (ft)</th><th rowspan="4" colspan="2">Design Condition/Tip Elevations</th><th rowspan="4">Ultimate Axial Capacity (kips)</th><th colspan="3">Allowable Lateral Capacity (kips) (fixed head - single pile)</th><th rowspan="4">Estimated Settlement at Allowable Axial Load</th></tr>
<tr><th colspan="3">Factor of Safety</th></tr>
<tr><th>2.0</th><th>1.5</th><th>1.15</th></tr>
<tr><th>0.5”</th><th>0.67”</th><th>0.875”</th></tr>
<tr><td rowspan="4">VE13A - RRN</td><td rowspan="4">876.00</td><td rowspan="4">872.00</td><td rowspan="2">Undrained Analysis
847.0’ (25.0’)</td><td>Total</td><td>197.3</td><td rowspan="2">37</td><td rowspan="2">43.3</td><td rowspan="2">49.9</td><td rowspan="4"><0.5”</td></tr>
<tr><td>Uplift Resistance (1)</td><td>104.3</td></tr>
<tr><td rowspan="2">Drained Analysis
847.0’ (25.0’)</td><td>Total</td><td>101</td><td rowspan="2">24.5</td><td rowspan="2">30.7</td><td rowspan="2">37.1</td></tr>
<tr><td>Uplift Resistance (1)</td><td>60.5</td></tr>
<tr><td rowspan="4">VE13A - WRR</td><td rowspan="4">889.53</td><td rowspan="4">885.53</td><td rowspan="2">Undrained Analysis
835.0’ (50.5’)</td><td>Total</td><td>300.9</td><td rowspan="2">35.9</td><td rowspan="2">41.9</td><td rowspan="2">48.3</td><td rowspan="4"><0.5”</td></tr>
<tr><td>Uplift Resistance (1)</td><td>207.9</td></tr>
<tr><td rowspan="2">Drained Analysis
835.0’ (50.5’)</td><td>Total</td><td>199.9</td><td rowspan="2">22.9</td><td rowspan="2">28.6</td><td rowspan="2">34.5</td></tr>
<tr><td>Uplift Resistance (1)</td><td>98</td></tr>
</table>

Fargo-Moorhead Food Control Structures Preliminary Pile Foundation Analyses HP 14X73									
A_{tip} = 198.5 in^2, A_{steel} = 21.4 in^2, perimeter = 56.4 in, width (b) = 14.6 in, I = 729 in^4									
Structure	**Gate Invert Elevation (ft)**	**Estimated Foundation Elevation (ft)**	**Design Condition/Tip Elevations**		**Ultimate Axial Capacity (kips)**	**Allowable Lateral Capacity (kips) (fixed head - single pile)**			**Estimated Settlement at Allowable Axial Load**
						Factor of Safety			
						2.0	**1.5**	**1.15**	
						0.5”	**0.67”**	**0.875”**	
VE13C - RRN	873.50	869.50	Undrained Analysis 835.0’ (34.5’)	Total	246.4	36.9	43.1	49.6	<0.5”
				Uplift Resistance (1)	157.1				
			Drained Analysis 835.0’ (34.5’)	Total	133.8	24.9	30.5	36.9	
				Uplift Resistance (1)	54.8				
VE13C - WRR	886.71	882.71	Undrained Analysis 830.0’ (52.7’)	Total	307.9	35.6	41.6	47.7	<0.5”
				Uplift Resistance (1)	214.9				
			Drained Analysis 830.0’ (52.7’)	Total	197.5	22.6	28.3	34	
				Uplift Resistance (1)	103.4				

(1) Apply Factor of Safety of 3.0 for preliminary design

Table F-3 Preliminary Design Pile Capacities

Fargo-Moorhead Food Control Structures Preliminary Pile Foundation Analyses HP 14X73									
A_{tip} = 198.5 in^2, A_{steel} = 21.4 in^2, perimeter = 56.4 in, width (b) = 14.6 in, I = 729 in^4									
Structure	**Gate Invert Elevation (ft)**	**Estimated Foundation Elevation (ft)**	**Design Condition/Tip Elevations**		**Ultimate Axial Capacity (kips)**	**Allowable Lateral Capacity (kips) (fixed head - single pile)**			**Estimated Settlement at Allowable Axial Load**
						Factor of Safety			
						2.0	**1.5**	**1.15**	
						0.5”	**0.67”**	**0.875”**	
Oxbow - RRN	879.00	875.00	Undrained Analysis 847.0’ (28.0’)	Total	205.5	37.0	43..3	49.9	<0.5”
				Uplift Resistance (1)	112.5				
			Drained Analysis 847.0’ (28.0’)	Total	109.5	24.5	30.7	37	
				Uplift Resistance (1)	109.5				
Oxbow - WRR	892.80	888.80	Undrained Analysis 835.0’ (53.8’)	Total	312	35.6	41.6	47.8	<0.5”
				Uplift Resistance (1)	219				
			Drained Analysis 835.0’ (53.8’)	Total	201.9	22.6	28.3	34.1	
				Uplift Resistance (1)	106.8				

Fargo-Moorhead Food Control Structures Preliminary Pile Foundation Analyses HP 14X73									
A_{tip} = 198.5 in^2, A_{steel} = 21.4 in^2, perimeter = 56.4 in, width (b) = 14.6 in, I = 729 in^4									
Structure	**Gate Invert Elevation (ft)**	**Estimated Foundation Elevation (ft)**	**Design Condition/Tip Elevations**		**Ultimate Axial Capacity (kips)**	**Allowable Lateral Capacity (kips) (fixed head - single pile)**			**Estimated Settlement at Allowable Axial Load**
						Factor of Safety			
						2.0	**1.5**	**1.15**	
						0.5”	**0.67”**	**0.875”**	
NWRR - RRN	867.78	863.78	Undrained Analysis 825.0’ (38.8’)	Total	257.8	36.9	43.1	49.6	<0.5”
				Uplift Resistance (1)	164.8				
			Drained Analysis 825.0’ (38.8’)	Total	148.0	24.5	30.7	37.2	
				Uplift Resistance (1)	65.1				

(1) Apply Factor of Safety of 3.0 for preliminary design

(2) OXBOW – Wolverton pile capacity was the same as FRP. Stratigraphy data was not available at revised Wolverton structure location for OXBOW.

Table F-4 Stratigraphy and Geotechnical Properties used to Estimate Pile Capacities

Location: VE13A RRN								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth (ft)	Bottom Depth (ft)						
Argusville Formation	0	20	106.5	26	950	205	1.03	20
Till	20	72	130	34	7500	2900	0.29	125

Location: VE13A WRR								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Brenna Formation	0	7.5	104.1	25	900	188	1.07	20
Argusville Formation	7.5	40.5	106.5	26	950	205	1.03	20
Weathered Till	40.5	45.5	130	31	6000	383	0.68	125
Till	45.5	80	130	34	7500	2900	0.29	125

Table F-4 Stratigraphy and Geotechnical Properties used to Estimate Pile Capacities

Location: VE-13C RRN								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Argusville Formation	0	24.5	106.5	26	950	205	1.03	20
Weathered Till	24.5	29.5	130	31	6000	383	0.68	125
Till	29.5	69.5	130	34	7500	2900	0.29	125

Location: VE13C WRR								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Brenna Formation	0	11.7	104.1	25	900	188	1.07	20
Argusville Formation	11.7	42.7	106.5	26	950	205	1.03	20
Weathered Till	42.7	47.7	130	31	6000	383	0.68	125
Till	47.7	82.7	130	34	7500	2900	0.29	125

Table F-4 Stratigraphy and Geotechnical Properties used to Estimate Pile Capacities

Location: Oxbow RRN								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Argusville Formation	0	23	106.5	26	950	205	1.03	20
Till	23	75	130	34	7500	2900	0.29	125

Location: Oxbow WRR								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Brenna Formation	0	10.8	104.1	25	900	188	1.07	20
Argusville Formation	10.8	43.8	106.5	26	950	205	1.03	20
Weathered Till	43.8	48.8	130	31	6000	383	0.68	125
Till	48.8	88.8	130	34	7500	2900	0.29	125

Table F-4 Stratigraphy and Geotechnical Properties used to Estimate Pile Capacities

Location: NWRR RRN								
Soil Stratigraphy Information			Unit Weight, γ' (pcf)	Friction Angle, φ' (degrees)	Undrained Shear Strength, S_u (psf)	Xsxx, Ku (pci)	ε_{50} (%)	Yyy, Kd (pci)
Geologic Formation	Top Depth	Bottom Depth						
Argusville Formation	0	28.8	106.5	26	950	205	1.03	20
Weathered Till	28.8	33.8	130	31	6000	383	0.68	125
Till	33.8	63	130	34	7500	2900	0.29	125

APPENDIX G – CIVIL DESIGN CONSIDERATIONS

G.1 CIVIL DESIGN METHODOLOGY

This appendix to the Post-Feasibility Southern Alignment Analysis (PFSAA) is intended to provide additional background information about feasibility-level civil design methodology and assumptions used for the alternatives.

In addition to the discussion presented herein, a detailed discussion of methodology and assumptions used for feasibility-level civil design is presented in the Phase 4 Appendices D and F of the FRP April 2011 A/E deliverable to the USACE.

G.2 CIVIL DESIGN ASSUMPTIONS

G.2.1 EXISTING CONDITIONS

Similar to Phase 4, existing topographic information at each of the major hydraulic structures is based on Light Detection and Ranging (LIDAR) data obtained from the Red River Basin Mapping Initiative of the International Water Institute Center for Flood Damage and Natural Resources. Existing topographic information and river channel bathymetric data was merged and used to create a 3-dimensional surface model using AutoDesk AutoCAD Civil 3D software. The topographic data was in the form of 1-meter digital elevation model (DEM). Data between cross sections were interpolated in GIS and burned into the existing LIDAR data. Digital drawings reference the horizontal coordinate datum State Plane, ND South NAD 83, US Survey Feet and vertical datum North American Vertical Datum of 1988 (NAVD 1988). The LIDAR data used in this project has a vertical accuracy spec of +/- 15 cm.

The channel bathymetric data used for the FRP and the PFSAA is extracted from the hydraulics model. The channel bathymetric data for the Red River came from the 2010 Red River of the North hydrographic survey completed by the USACE – St. Paul District Fountain City Service Base. All other bathymetric data was interpolated using cross sections from hydraulics models. For additional information, please refer to Table B1 of Section B4.0 of April 2011 Consultant Deliverable to USACE, Appendix B – Hydraulics. For example, this appendix includes detailed information about each part of the hydraulics model bathymetry such as:

> "Channel bathymetry for the Red River of the North reach from River Mile 440.0 to 470.2 was based on RRN soundings that were obtained for Phase 1 of the feasibility study. For areas outside the reach defined above, the channel bathymetry was based on the cross sections from existing HEC-RAS and HEC-2 models."

Existing parcel information for Cass County is based on May 2010 GIS data available on the Cass County Website and as provided in 2009 by Kadrmas Lee and Jackson. Existing parcel information for Clay Country is based on information provided in 2009 by Kadrmas Lee and Jackson.

Parcels in the vicinity of hydraulic structures were checked for deed restrictions, which could limit or restrict the construction of project features on the property. Deed-restricted parcel information for Cass

County, ND is based on GIS data provided by Cass County in June of 2010 as well as parcel map information available on the Cass County website at that time. Deed-restricted parcel information for Clay County, MN was not directly available. All property ownership should be reviewed during future phases of work to ensure deed-restricted properties are avoided.

G.2.2 HYDRAULIC STRUCTURE GENERAL MICROSITING

Similar hydraulic structure siting assumptions were used for this PFSAA as were used for the Phase 4 evaluation. It should be noted that the micrositing of the hydraulic structures is preliminary and is based on a feasibility layout of the alternative alignments of the embankments and avoiding deed restricted properties. An additional iteration of feasibility design to optimize the layout of embankments in consideration of this initial micrositing of hydraulic structures may result in more beneficial micrositing (i.e. optimize the overall footprint of hydraulic structure sitework, streamline the tie-in of embankments to the hydraulic structure, avoid deed-restricted properties, etc.). Exhibit G1 presents drawings showing the various hydraulic structures corresponding to each alternative.

The following assumptions were made for each structure:

- The Red River (RRN) control structure was sited east of the existing river channel (in Minnesota).
- The control structures will be constructed off the existing river channel, in dry conditions.
- Constructed channels were required for the RRN and Wild Rice River (WRR) control structures to redirect river flow from the existing river, to the control structure, and back to the existing river.
- The centerline radii of the constructed channels were chosen using a minimum radius of 3 times the water surface top width in the constructed channel.
- The channel realignments balance large centerline radii while attempting to minimize the overall footprint of the site work.
- A minimum buffer of 300 feet is included between the proposed gated structure and the existing river banks. This assumption was applied to the gated structures, not the wingwalls.
- A permanent easement of 30 ft., offset from the extents of the grading work, is assumed at each structure. A temporary construction easement of 15 feet, offset from the extents of the permanent easement, is assumed at each structure.
- The structures were sited to avoid having grading work on deed restricted properties, minimize impacts to the estimated Ordinary-High-Water-Mark (OHWM), and minimize the length of realigned river channels.

G.2.3 HYDRAULIC STRUCTURE GENERAL CIVIL SITE DESIGN

The feasibility civil site design methodology is generally the same as what was used in Phase 4. Below is a summary of the assumptions used for this PFSAA. Many of the civil site features listed are not shown on the Drawings in this appendix, but quantities and/or allowances were included in the cost estimate.

- Access roadways provide maintenance (not public) access to each structure.
- A maintenance building and small parking area are included.
- Electrical power is brought from nearby power lines; electrical power is assumed to be available within 1 mile of existing 3-phase electrical utilities and roadways.
- Water and sanitary service is not included.
- It is assumed that existing utilities will be impacted by the location of the hydraulic structures; however, individual sites have not been assessed for existing utility conflicts.
- Remote monitoring through a Supervisory Control and Data Acquisition (SCADA) system is assumed.
- A tie-back embankment into Minnesota is assumed. Grading for the MN tie-back embankment is shown with 4H:1V slopes and rise to various elevations, depending on the alternative.
- Excavation slope grading for realigned river channel will be 7H:1V.
- A connectivity channel is included for portions of the route alternatives to provide flow connectivity between the Wild Rice River and the Red River, as well as serve as the borrow excavation from which embankment material could be sourced. See section G.2.4 for additional information regarding specific sites.
- Areas requiring permanent riprap were not evaluated during PFSAA, but are assumed to be similar to Phase 4.
- Ice and debris control measures are located in areas with the strategy to direct ice away from the diversion channel, similar to Phase 4.
- Fish passage systems are included with each of the control structures in the RRN and WRR. They are located downstream of one of the Control Structure wingwalls and provide connectivity up the proposed river channel, from downstream of the control structure to upstream of the structure via a system of operable gates. See Exhibit G2 of this Appendix for more detail.
- Topsoil stripping, replacing and site restoration is assumed to be required for all areas permanently acquired by the project as well as permanent easement areas.
- Stratigraphy and elevations of the soil layers for determining earthwork quantities was assumed to be the same as what was used in Phase 4.

G.2.4 SITE SPECIFIC CONTROL STRUCTURE CONSIDERATIONS

Some site specific considerations were made for each individual hydraulic structure site, and are outlined below. Exhibit G3 in this appendix presents a summary table comparing the alternatives evaluated in this PFSAA to the Federally Recommended Plan (FRP). In addition to the hydraulic structure footprint, a portion of the embankment alignment was included when calculating earthwork quantities. The table below summarizes the ranges of alignment included with each structure.

Table G-1 Alignment Included with Hydraulic Structures

Structure	Alternative	Start Gap	End Gap	Total Length (ft)
RRN	FRP			1,000
	VE13A	1880+00	1916+00	3,600
	VE13C	1862+00	1895+00	3,300
	NWRR	180+00	210+00	3,000
	Oxbow	2045+00	2075+00	3,000
WRR	FRP			3,600
	VE13A	1790+00	1826+00	3,600
	VE13C	1770+00	1806+00	3,600
Inlet Structure to the Diversion	FRP			750
	VE13A	1591+00	1598+50	750
	VE13C	1564+00	1571+50	750
	NWRR	1564+50	1572+00	750

G.2.4.1 VE13A

Value Engineering 13 Option A (VE13A) includes three re-designed hydraulic structures, the control structures on the Red River (RRN) and Wild Rice River (WRR) and the inlet structure to the diversion. The following bullet points summarize the site specific information and comparisons to the FRP feasibility designs:

RRN CONTROL STRUCTURE

- Length of existing river channel realigned is 600 feet less than FRP.
- Length of realigned channel is 1,300 feet less than FRP.
- Permanent R.O.W. required for the structure is 16 acres less than FRP.
- The structure height is 0.7 feet less than the adjusted height of the FRP structure.
- The fish passage overall length is nearly double the FRP length (3,000 feet versus 1,560 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- Due to the location of the tieback embankment in this alternative, the control structure is located on property owned by Rustic Oaks, a retreat and event center with historical buildings from 1895, two thousand trees, a wildlife pond, and restored prairie.
- A portion of County Road 59 would be required to be abandoned or realigned.
- A large FEMA deeded property is located just south of the WRR – RRN embankment. The existing river channel that would be abandoned south of the embankment will not be filled due to this designation. The existing river channel abandoned north of the embankment is assumed to be filled.

- A connectivity channel is included between the RRN and WRR.

WRR CONTROL STRUCTURE

- Length of existing river channel realigned is 800 feet less than FRP.
- Length of realigned channel is 600 feet less than FRP.
- Permanent R.O.W. required for the structure is 16 acres less than FRP.
- The structure height is 2.8 feet more than the adjusted height of the FRP structure.
- The fish passage overall length is approximately 30% more than the FRP length (2,460 feet versus 1,920 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- The existing river channel that would be abandoned is assumed to be filled.
- Due to the location of the tieback embankment and control structure in this alternative, road realignment may be required on Interstate I-29, 124th Ave South, and 174th Ave. SE.
- A connectivity channel is included between the WRR and the inlet structure to the diversion.

INLET STRUCTURE TO THE DIVERSION

- Permanent R.O.W. required for the structure is 4 acres more than FRP.
- The structure height is 0.9 feet less than the adjusted height of the FRP structure.
- Due to stationing ranges, the earthwork quantity computed for this alternative is more than double the quantity determined in the FRP (i.e. this alternative includes more of the wider diversion channel and less of the narrower connectivity channel in its earthwork calculations than the FRP). This will not affect the overall project cost, but may skew the inlet structure cost when comparing it to the inlet structure cost in the FRP.

G.2.4.2 VE13C

Value Engineering 13 Option C (VE13C) includes three re-designed hydraulic structures, the control structures on the Red River (RRN) and Wild Rice River (WRR) and the inlet structure to the diversion. The following bullet points summarize the site specific information and comparisons to the FRP feasibility designs:

RRN CONTROL STRUCTURE

- Length of existing river channel realigned is 1,500 feet less than FRP.
- Length of realigned channel is 1,100 feet less than FRP.
- Permanent R.O.W. required for the structure is 20 acres less than FRP.
- The structure height is 0.3 feet taller than the adjusted height of the FRP structure.

- The fish passage overall length is approximately 85% longer than the FRP length (2,880 feet versus 1,560 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- The existing river channel that would be abandoned is assumed to be filled.
- An existing oxbow located south of the ND embankment is assumed to be filled.
- Due to the location of the tieback embankment and control structure in this alternative, a portion of County Road 59 (3rd Street) in Minnesota would be required to be relocated or abandoned.
- A connectivity channel is included between the RRN and WRR.
- Changes to the maximum flood event were modified in the VE13C alternative to include a protection level for the 103k cfs event (as defined following July 31, 2012) plus free board. The change resulted in an increase of 1.0 feet of the top-of-structure elevation following July 31st. Revisions to the top-of-structure elevations for VE13C following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates.

WRR CONTROL STRUCTURE

- Length of existing river channel realigned is 500 feet more than FRP.
- Length of realigned channel is 100 feet more than FRP.
- Permanent R.O.W. required for the structure is 3 acres less than FRP.
- The structure height is 3.2 feet more than the adjusted height of the FRP structure.
- The fish passage overall length is approximately 35% more than the FRP length (2,460 feet versus 1,920 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- The existing river channel that would be abandoned is assumed to be filled.
- A connectivity channel is included between the WRR and the inlet structure to the diversion.
- Changes to the maximum flood event were modified in the VE13C alternative to include a protection level for the 103k cfs event (as defined following July 31, 2012) plus free board. The change resulted in an increase of 1.0 feet of the top-of-structure elevation following July 31st. Revisions to the top-of-structure elevations for VE13C following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates.

INLET STRUCTURE TO THE DIVERSION

- Permanent R.O.W. required for the structure is 4 acres more than FRP.
- The structure height is 3.3 feet less than the adjusted height of the FRP structure.
- Due to stationing ranges, the earthwork quantity computed for this alternative is more than double the quantity determined in the FRP (i.e. this alternative includes more of the wider diversion channel and less of the narrower connectivity channel in its earthwork calculations

than the FRP). This will not affect the overall project cost, but may skew the inlet structure cost when comparing it to the inlet structure cost in the FRP.

G.2.4.3 NWRR

The North of the Wild Rice River Confluence (NWRR) alternative includes two re-designed hydraulic structures, the control structure on the Red River (RRN) and the inlet structure to the diversion. The following bullet points summarize the site specific information and comparisons to the FRP feasibility designs:

RRN CONTROL STRUCTURE

- Length of existing river channel realigned is 2,200 feet more than FRP.
- Length of realigned channel is 200 feet less than FRP.
- Permanent R.O.W. required for the structure is 33 acres less than FRP.
- The structure height is 6.2 feet more than the adjusted height of the FRP structure.
- The fish passage overall length is approximately 65% longer than the FRP length (2,580 feet versus 1,560 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- Many FEMA deeded properties are located in the area of this alternative. The existing river channel that would be abandoned will not be filled due to this designation.
- Due to FEMA deeded property, floodwalls will be required to install the embankment through the property corridor to avoid excavating or filling within these property boundaries.
- A connectivity channel is not included between the RRN and WRR in this alternative.
- Changes to the maximum flood event were modified in the NWRR alternative to include a protection level for the 103k cfs event (as defined following July 31, 2012) plus free board. The change resulted in an increase of 3.0 feet of the top-of-structure elevation following July 31st. Revisions to the top-of-structure elevations for NWRR following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates.

INLET STRUCTURE TO THE DIVERSION

- Permanent R.O.W. required for the structure is 1 acre more than FRP.
- The structure height is 5.3 feet less than the adjusted height of the FRP structure.
- Due to stationing ranges, the earthwork quantity computed for this alternative is more than double the quantity determined in the FRP (i.e. this alternative includes more of the wider diversion channel and less of the narrower connectivity channel in its earthwork calculations

than the FRP). This will not affect the overall project cost, but may skew the inlet structure cost when comparing it to the inlet structure cost in the FRP.

G.2.4.4 OXBOW

The South of Oxbow (Oxbow) alternative includes two re-designed hydraulic structures, the control structure on the Red River (RRN) and the control structure on Wolverton Creek in Minnesota. The following bullet points summarize the site specific information and comparisons to the FRP feasibility designs:

RRN CONTROL STRUCTURE

- Length of existing river channel realigned is the same as the FRP.
- Length of realigned channel is 200 feet less than FRP.
- Permanent R.O.W. required for the structure is 19 acres more than FRP.
- The structure height is 1.1 feet less than the adjusted height of the FRP structure.
- The fish passage overall length is approximately 2.5 times longer than the FRP length (4,020 feet versus 1,560 feet) due to differences between headwater and tailwater elevations across the structure. This results in increased fish passage channel lengths and excavation volumes relative to the FRP.
- A portion of County Hwy 2 would be required to be abandoned or realigned.
- The existing river channel that would be abandoned is assumed to be filled.
- An existing oxbow located north of the ND embankment is assumed to be filled.
- A connectivity channel is included between the RRN and WRR in this alternative.
- Changes to the maximum flood event were modified in the OXBOW alternative to include a protection level for the 103k cfs event (as defined following July 31, 2012) plus free board. The change resulted in an increase of 0.4 feet of the top-of-structure elevation following July 31st. Revisions to the top-of-structure elevations for NWRR following July 31st are not included in the feasibility structure designs nor the cost estimates, as HMG was directed during the workshops.

WOLVERTON CREEK CONTROL STRUCTURE

- It is assumed the Wolverton Creek control structure will have the same design assumptions as the FRP.

G.2.5 EMBANKMENT AND CHANNEL CIVIL SITE DESIGN

Similar to Phase 4, earthwork quantities for embankment and channel design were calculated using GeoPAK. See Exhibit G4 for typical cross-sections and Exhibit G5 for a summary of earthwork quantities. Earthwork quantities were grouped by alternative with the following segments:

- **FRP**

SH-Inlet	Sta 1514+00 to 1587+50
Inlet-WRR	Sta 1595+00 to 1766+50
WRR-RRN	Sta 1803+00 to 1905+00
RRN-MN	Sta 0+00 to 325+20
CR17	Sta 10+00 to 230+20

- **VE13A**

SH-Inlet	Sta 1514+00 to 1591+00
Inlet-WRR	Sta 1598+50 to 1790+00
WRR-RRN	Sta 1826+00 to 1880+00
RRN-MN (embankment)	Sta 1916+00 to 2215+40
CR17 (embankment)	Sta 55+03 to 263+93

- **VE13C**

SH-Inlet	Sta 1514+00 to 1564+00
Inlet-WRR	Sta 1571+50 to 1770+00
WRR-RRN	Sta 1806+00 to 1862+00
RRN-MN (embankment)	Sta 1895+00 to 2197+60
CR17 (embankment)	Sta 3+22 to 196+11

- **NWRR**

SH-Inlet	Sta 1514+00 to 1564+50
Inlet-WRR	Sta 1572+00 to 1777+02
WRR-RRN (embankment)	Sta 0+00 to 180+00
RRN-MN (embankment)	Sta 210+00 to 534+66
CR17 (embankment)	Sta 3+20 to 155+08

- **OXBOW**

SH-Inlet	Sta 1514+00 to 1585+00
Inlet-WRR	Sta 1592+50 to 1759+00
WRR-RRN	Sta 1795+00 to 2045+00
RRN-MN (embankment)	Sta 2075+00 to 2531+84
CR17 (embankment)	Sta 39+92 to 327+27
SA1 (embankment)	Sta 176+13 to 578+53

Typical channel and embankment cross sections were determined through the hydraulic and geotechnical design and are summarized Table G-2. For the PFSAA analysis, grading models were created to quantify the fill required for embankments. A full balance of excavation and embankment across the extents of the southern alignment alternatives was not performed as part of this grading analysis. Excavation dimensions assumed could be optimized with more detailed efforts.

Earthwork quantities for NWRR and VE13C were recalculated following July 31st to reflect the increased top-of-embankment elevation for these alternatives.

Table G-2 Typical Channel and Embankment Cross Sections

FRP

Reach	Channel Typical Section						Embankment Typical Section			
	Side Slope	Bottom Width	Bottom Slope	Pilot Side Slope	Pilot Bottom Width	Pilot Depth	Protected Side slope	Top Width	Un-Protected Side Slope	Setback From Channel
SH-Inlet	7:1	250'	---	4:1	10'	3'	10:1	---	7:1	50'
Inlet-WRR Connecting Channel	5:1	100'	---	---	---	---	4:1	15'	4:1	50'
WRR-RRN Connecting Channel	5:1	250	---	4:1	10'	3'	4:1	15'	4:1	50'
RRN-MN	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
CR17	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A

VE13A

Reach	Channel Typical Section						Embankment Typical Section			
	Side Slope	Bottom Width	Bottom Slope	Pilot Side Slope	Pilot Bottom Width	Pilot Depth	Protected Side slope	Top Width	Un-Protected Side Slope	Setback From Channel
SH-Inlet	7:1	300'	50:1	4:1	10'	2.5'	6:1	15'	5:1	60' min
Inlet-WRR Connecting Channel	5:1	100'	100:1	---	---	---	6:1	15'	5:1	60' min
WRR-RRN Connecting Channel	5:1	50'	50:1	---	---	---	6:1	15'	5:1	60' min
RRN-MN	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
CR17	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A

VE13C

Reach	Channel Typical Section						Embankment Typical Section			
	Side Slope	Bottom Width	Bottom Slope	Pilot Side Slope	Pilot Bottom Width	Pilot Depth	Protected Side slope	Top Width	Un-Protected Side Slope	Setback From Channel
SH-Inlet	7:1	300'	50:1	4:1	10'	2.5'	6:1	15'	5:1	60' min
Inlet-WRR Connecting Channel	5:1	100'	100:1	---	---	---	6:1	15'	5:1	60' min
WRR-RRN Connecting Channel	5:1	50'	50:1	---	---	---	6:1	15'	5:1	60' min
RRN-MN	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
CR17	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A

North of Wild Rice River

Reach	Channel Typical Section						Embankment Typical Section			
	Side Slope	Bottom Width	Bottom Slope	Pilot Side Slope	Pilot Bottom Width	Pilot Depth	Protected Side slope	Top Width	Un-Protected Side Slope	Setback From Channel
SH-Inlet	7:1	300'	50:1	4:1	10'	2.5'	6:1	15'	5:1	60' min
Inlet-WRR Connecting Channel	5:1	100'	100:1	---	---	---	6:1	15'	5:1	60' min
WRR-RRN (embankment)	5:1	100'	---	---	---	---	6:1	15'	5:1	60' min
RRN-MN	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
CR17	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A

Oxbow

Reach	Channel Typical Section						Embankment Typical Section			
	Side Slope	Bottom Width	Bottom Slope	Pilot Side Slope	Pilot Bottom Width	Pilot Depth	Protected Side slope	Top Width	Un-Protected Side Slope	Setback From Channel
SH-Inlet	7:1	300'	50:1	4:1	10'	2.5'	6:1	15'	5:1	60' min
Inlet-WRR Connecting Channel	5:1	100'	100:1	---	---	---	6:1	15'	5:1	60' min
WRR-RRN Connecting Channel	5:1	75'	---	4:1	35'	3'	6:1	15'	5:1	60' min
RRN-MN	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
CR17	N/A	N/A	N/A	N/A	N/A	N/A	4:1	15'	4:1	N/A
SA1 (with borrow trench)	5:1	100'	---	---	---	---	6:1	15'	5:1	60'

Assumptions used for calculating channel excavation volumes are as follows:

- Earthwork quantities were calculated using the Average End Area method using cross sections placed at 100 foot intervals as well as specific stations.
- Excavation quantities do not include topsoil stripping quantities.
- Excavation quantities include a 4 inch over excavation for Topsoil placement.
- Shrinkage and swell were an assumed 1:1 ratio. Cost estimates adjusted this value to assume the 0.85 ECY/BCY shrink factor for compacted embankments as directed in Phase 4 by USACE.
- Excavation US/DS of river crossings is to be completed by others and included in structure costs. (Sheyenne River, Inlet Structure, Wild Rice River, and Red River)

Assumptions used for calculating topsoil volumes are as follows:

- Quantities for suitable topsoil stripping combine channel and spoil pile plan areas multiplied by an assumed depth of 6 inches This value was then adjusted to account for 12 inches of topsoil to be roughly consistent w/ Phase 4.
- Topsoil placement in the channel excavation was an assumed 4 inch depth to the limits of the cross sectional cut areas.
- The remainder of suitable topsoil was placed over spoil areas and embankments and varies in depth from 6 to 12 in.

G.2.6 TRANSPORTATION AND INFRASTRUCTURE DESIGN

A consistent set of criteria was used for developing transportation feature modifications for all of the alternatives considered as part of this study. The construction of all of the alternatives will require the construction of bridges at major roadways and railroads along the diversion channel. The bridge design criteria utilized for this analysis is the same as for Phase 4. The FRP as presented in the FR/FEIS, includes 19 highway and 4 railroad bridges. All of the railroad bridges are located downstream from the Sheyenne River and will not be impacted by the alternatives considered. The number of highway bridges will vary by alternative, however. Alternative VE13A includes 19 highway bridges, while alternative VE13C includes 18 highway bridges. The OXBOW alternative includes 20 highway bridges while the NWRR alternative includes 17 highway bridges.

The upstream staging area and SA1 will cause impacts to transportation routes upstream from the diversion channel and in SA1 for the alternatives considered. These impacts vary from inundation during project operation to increased water levels adjacent to the road grades without overtopping. Major transportation routes that will be impacted vary by alternative and are summarized below:

FRP: Interstate 29; U.S. Highway 75; Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 2, 58, and 59; the BNSF railroad grade (Moorhead Subdivision); reconstruction of Cass County Highway 18 overpass on I-29; and several township roads.

VE13A: Interstate 29; U.S. Highway 75; Cass County Highways 18, 25, and 81; Clay County Highways 2, 58, 59, and 60; the BNSF railroad grade (Moorhead Subdivision); reconstruction of Cass County Highway 16 and 18 overpasses and Wild Rice River bridges on I-29; and several township roads.

VE13C: Interstate 29; U.S. Highway 75; Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 2, 7, 58, 59, and 60; the BNSF railroad grade(Moorhead Subdivision) ; reconstruction of Cass County Highway 16 and 18 overpasses and Wild Rice River bridges on I-29; and several township roads.

NWRR: Interstate 29; U.S. Highway 75; Cass County Highways 14, 16, 18, 21, 25, and 81; Clay County Highways 2, 7, 8, 58, 59; 60; 64; and 65; the BNSF railroad grade(Moorhead Subdivision) ; reconstruction of Cass County Highway 16 overpass and Wild Rice River bridges on I-29 and several township roads.

OXBOW: Interstate 29; U.S. Highway 75; ND Highway 46; Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 50 and 190; the BNSF railroad grade (Moorhead Subdivision) ; and several township roads.

It should be noted that several of these transportation routes are impacted and in many cases inundated by floodwaters during existing conditions.

It is anticipated that a majority of the structures in the staging area and SA 1 will be purchased and removed as part of the project. Therefore, only critical transportation routes, including Interstate 29, U.S. Highway 75, BNSF railway, and portions of Cass County Highways 18 and 81 (OXBOW and NWRR alternatives) were included as grade raises through the staging area for the FRP and alternatives. Grade raises were also included for roads that cross the embankments to allow access up and over the embankments.

Assumptions used for developing costs for transportation and infrastructure improvements are as follows:

Roadway Assumptions:

- Used existing typical sections for estimated replacement costs.
- Edge of driving lane elevation placed at or above the 1-percent chance elevation.
- Earth work quantities were calculated using the average end area method with 100 foot cross section spacing.
- Estimated approx. 4 30” Dia. pipe under road per mile with a replacement length of 90’ for U.S. Highway 75 and Highway 16.
- Each Pipe will be replaced.
- Side slopes set at 5:1 for estimating pipe length and box culvert extensions.
- Existing and proposed typical section for U.S. Highway 75 is similar to section used north of Fargo.
- Existing and proposed typical section for CH81 taken from typical section used on a project near Wild Rice.

- Proposed typical section for CH18 will be the same as the existing except 3" Agg. Base will be added.

Bridge Assumptions:

- Assumed minimum of 36' clear width on bridges assuming ADT is >400 per NDDOT requirements. Can use 32' if <400, however ADT is unknown at time of estimate preparation. Used 40' to match existing on CH16 bridge over I-29.
- Estimated cost/sq. ft. of deck for new bridge at $130/sq. ft. based on previous work completed.
- New guardrail and approach slabs assumed if bridges are replaced.
- Assumed precast, pre-stressed concrete girders would be used in lieu of plate girders. Estimated required grade raise of bridges was increased slightly to account for potential greater girder depth.

Railroad Assumptions:

- Grade raises for BNSF (Moorhead Sub.) were estimated assuming track reconstruction with embankment raises and ballast replacement. Estimates were based on typical rail sections from recent BNSF grade raise projects in ND
- For each alternative the profiles were set placing ballast at or above the 100yr design elevations.

Interchange Assumptions:

- Clearance to low beam of overpass governed bridge replacement decisions.
- Assumed ramps would be reconstructed to tie into new Interstate elevations.
- Ramps section based on 2010 DOT plans

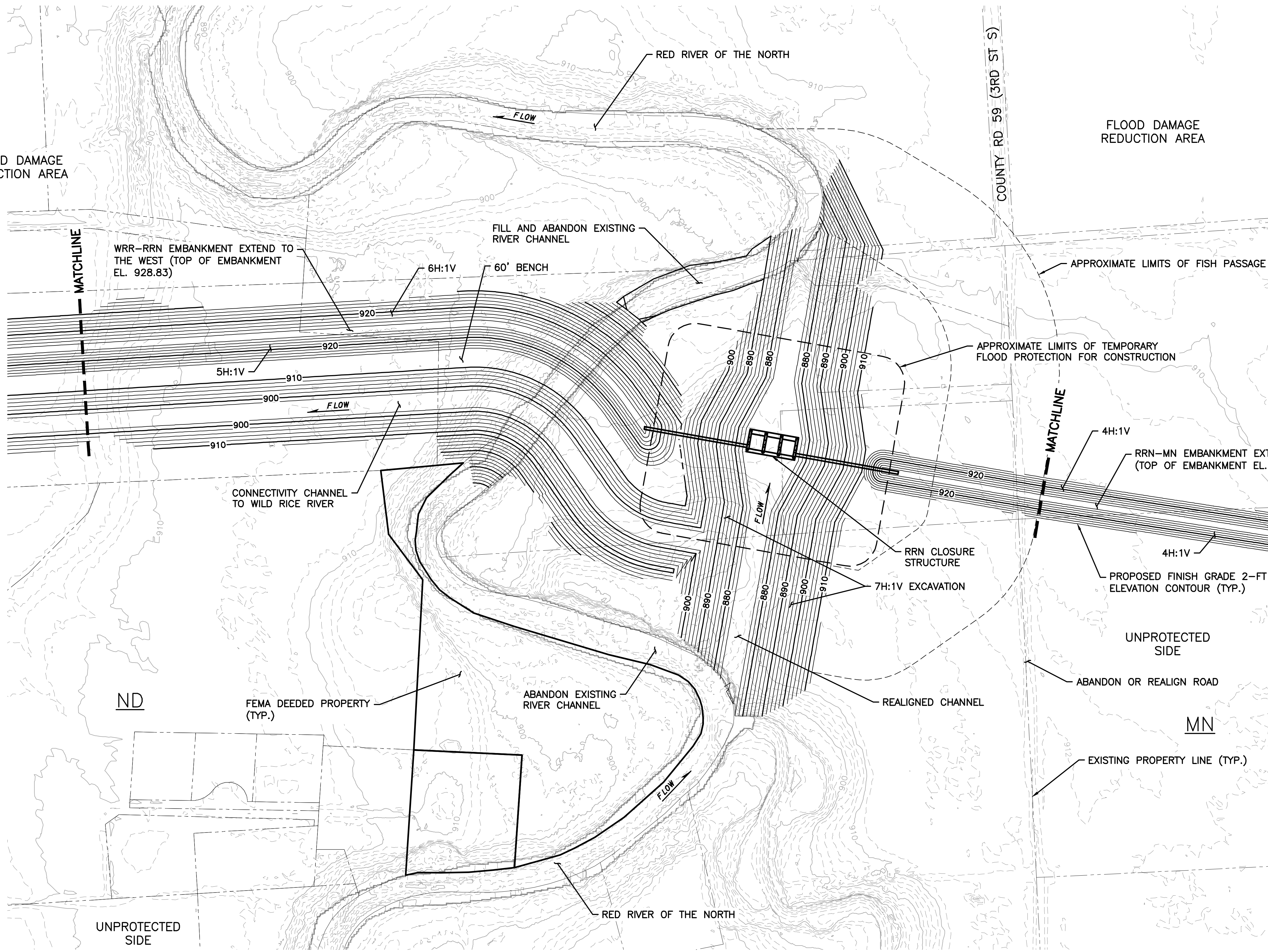
Interstate Assumptions:

- Interstate price based on 2010 bid prices estimated per mile
- Interstate price does not include grade separations or bridges/box culverts.

APPENDIX G – EXHIBIT G1 – DRAWINGS

HORIZONTAL COORDINATE SYSTEM:
STATE PLANE - ND SOUTH
NAD 1983, US SURVEY FEET

VERTICAL COORDINATE SYSTEM:
NAVD 1988, US SURVEY FEET



PLAN VIEW

VE13A-RRN

200 0 200 400
SCALE IN FEET

N

NOTES:

1. NOT FOR CONSTRUCTION. THESE PLANS REPRESENT HYDRAULICALLY AND STRUCTURALLY FEASIBLE CONCEPTS USED FOR COST ESTIMATING AND PHASE 4 COMPARISON ONLY. ADDITIONAL EMBANKMENT ALIGNMENT AND CONTROL STRUCTURE SITING MODIFICATIONS SHOULD BE CONSIDERED IN FUTURE DESIGN PHASES.
2. THE SITING OF THE HYDRAULIC STRUCTURE IS PRELIMINARY AND IS BASED ON THE LAYOUT OF THE ALTERNATIVE ALIGNMENTS OF THE LEVEE EMBANKMENTS AND AVOIDING DEED RESTRICTION PROPERTIES. IF AN ALTERNATIVE ALIGNMENT IS SELECTED FOR FUTURE DESIGN, EFFORTS SHOULD INCLUDE REFINEMENT OF THE LEVEE EMBANKMENT ALIGNMENT AND MICROSITING OF HYDRAULIC STRUCURE.
3. ADDITIONAL SITE SPECIFIC TOPOGRAPHIC AND GEOTECHNICAL INFORMATION AND ANAYSIS IS REQUIRED IN ADDITIONAL PHASES OF DESIGN.
4. FISH PASSAGE POOLS AND RIFFLES, REALIGNED CHANNEL RIPRAP, MAINTENANCE BUILDING, UTILITIES, ICE/DEBRIS CONTROL MEASURES, SCADA MONITORING POINTS AND ACCESS ROADS ARE A PART OF EACH STRUCTURE BASED ON THE SAME ASSUMPTIONS AS IN PHASE 4 BUT ARE NOT SHOWN; QUANTITIES ARE INCLUDED IN COST ESTIMATE AND ARE CONSIDERED COMPARABLE TO PHASE 4 QUANTITIES.

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CONCEPT DOCUMENTATION DRAWINGS
RED RIVER DIVERSION HYDRAULIC STRUCTURES
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - VE13 OPTION A
STRUCTURE ON RED RIVER OF THE NORTH
PLAN VIEW

SHEET IDENTIFICATION
G1.1

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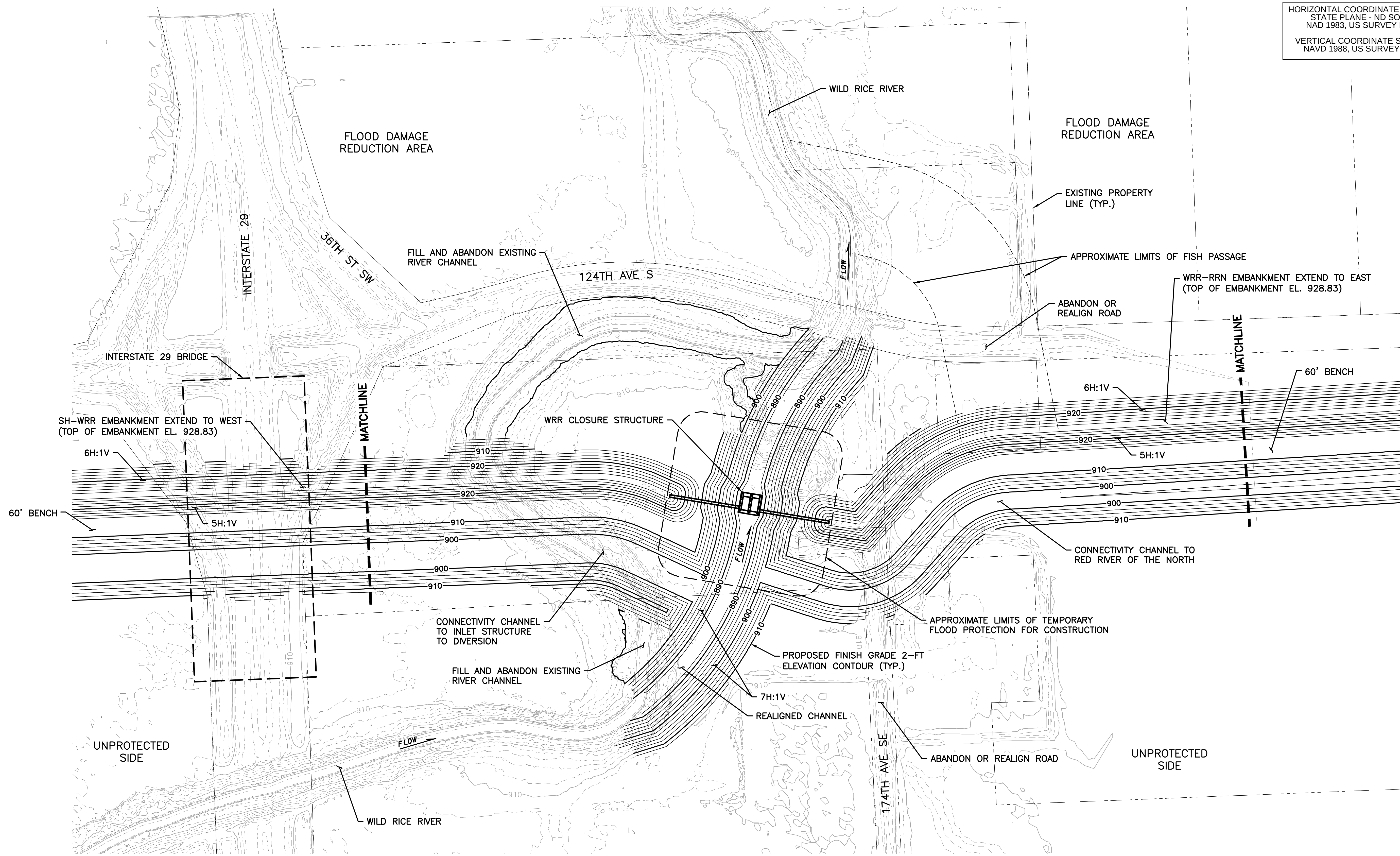

PLAN VIEW

VE13A - WRR

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SCALE IN FEET

N

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FLOOD CONTROL - VE13 OPTION A
STRUCTURE ON WILD RICE RIVER
PLAN VIEW

SHEET IDENTIFICATION
G1.2

HORIZONTAL COORDINATE SYSTEM:
STATE PLANE - ND SOUTH
NAD 1983, US SURVEY FEET

VERTICAL COORDINATE SYSTEM:
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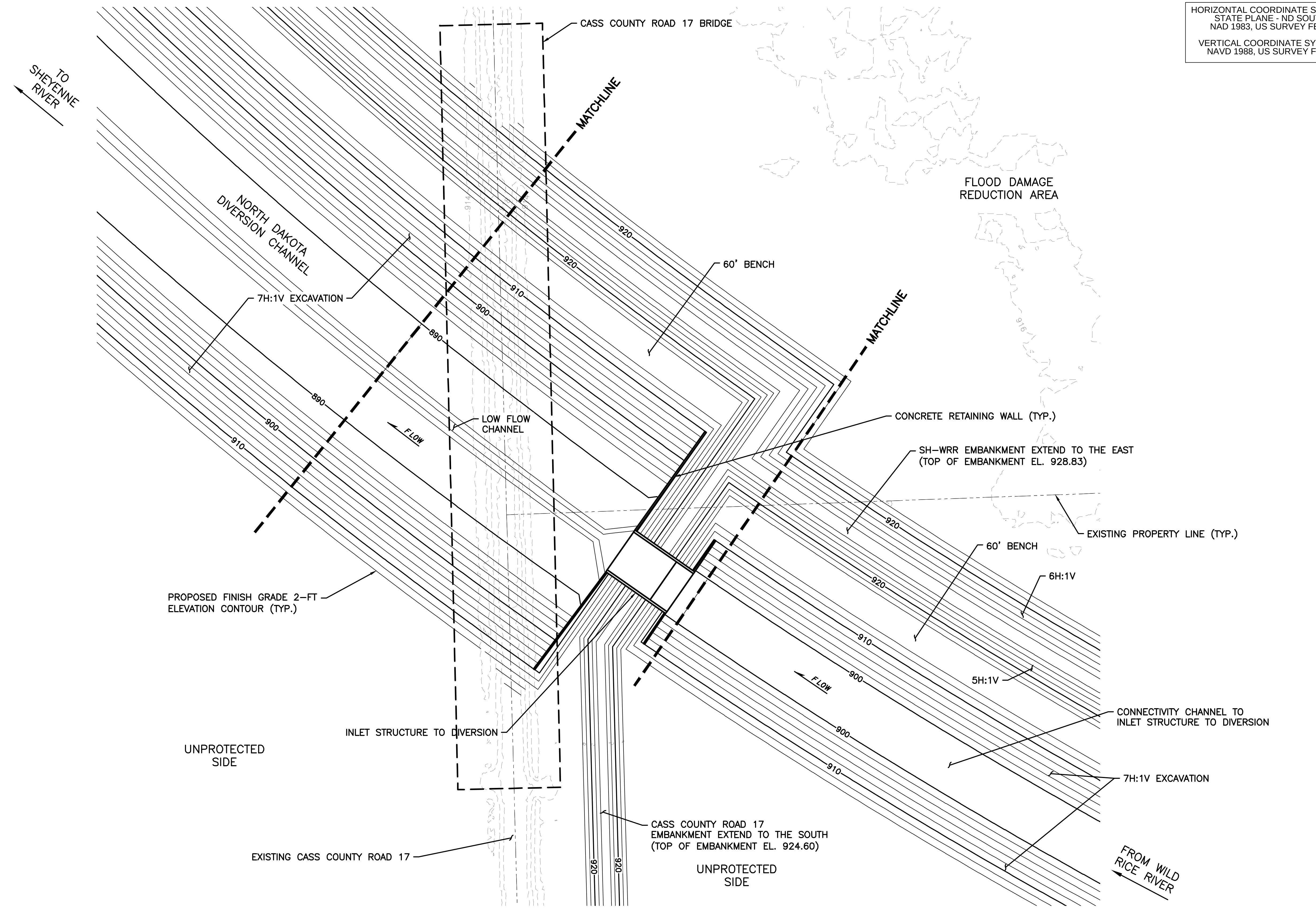

PLAN VIEW

VE13A - INLET

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SCALE IN FEET

N

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FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - VE13 OPTION A
INLET STRUCTURE ON RED RIVER DIVERSION
PLAN VIEW

SHEET IDENTIFICATION
G1.3

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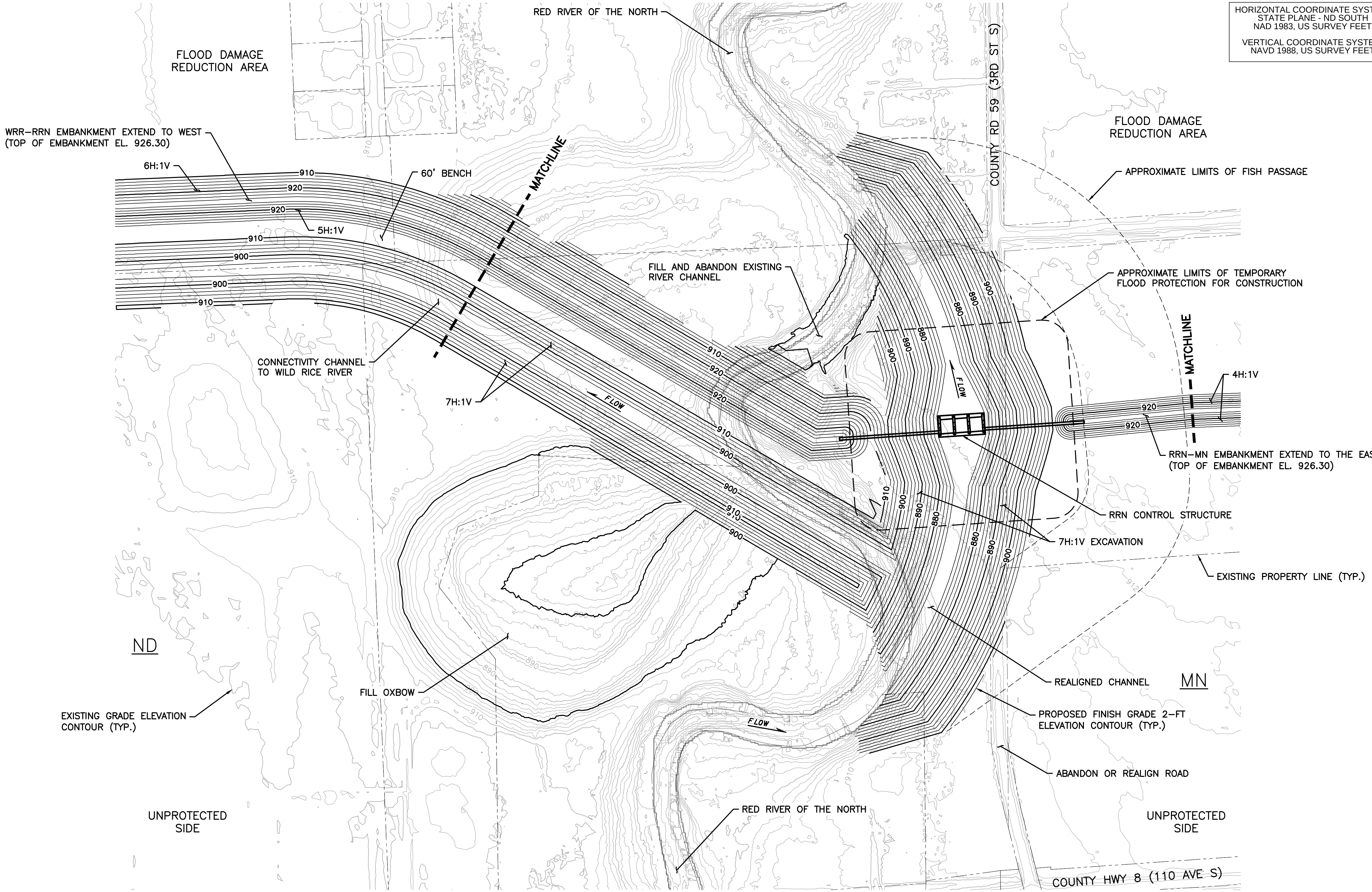
VERTICAL COORDINATE SYSTEM:
NAVD 1988, US SURVEY FEET



PLAN VIEW

VE13C-RRN

NOTES:

1. NOT FOR CONSTRUCTION. THESE PLANS REPRESENT HYDRAULICALLY AND STRUCTURALLY FEASIBLE CONCEPTS USED FOR COST ESTIMATING AND PHASE 4 COMPARISON ONLY. ADDITIONAL EMBANKMENT ALIGNMENT AND CONTROL STRUCTURE SITING MODIFICATIONS SHOULD BE CONSIDERED IN FUTURE DESIGN PHASES.
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FLOOD CONTROL - VE13 OPTION C
STRUCTURE ON RED RIVER OF THE NORTH
PLAN VIEW

SHEET IDENTIFICATION
G1.4

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VERTICAL COORDINATE SYSTEM:
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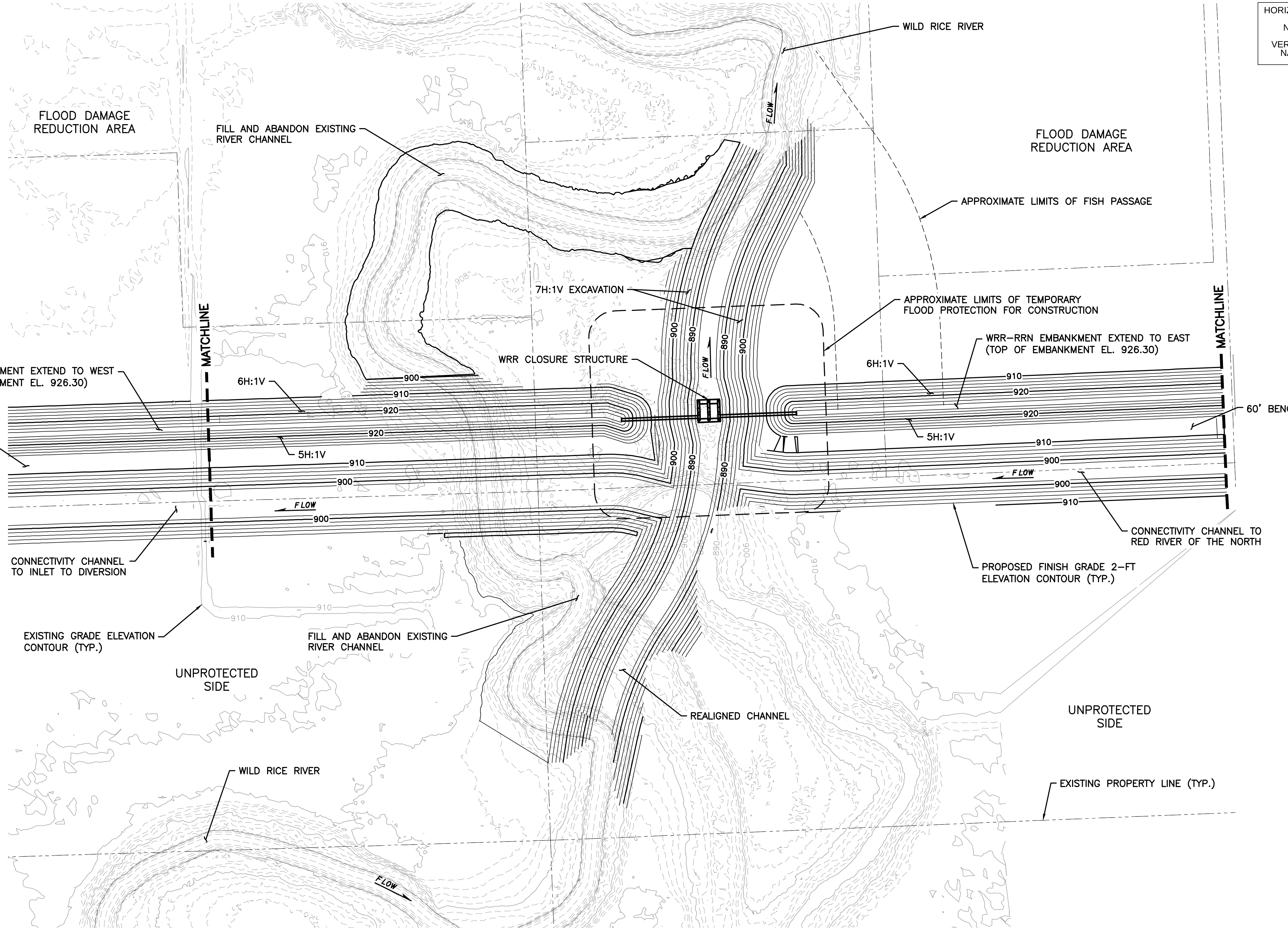

PLAN VIEW

VE13C-WRR

200 0 200 400
SCALE IN FEET

N

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CONCEPT DOCUMENTATION DRAWINGS
RED RIVER DIVERSION HYDRAULIC STRUCTURES
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - VE13 OPTION C
STRUCTURE ON WILD RICE RIVER
PLAN VIEW

SHEET IDENTIFICATION
G1.5

HORIZONTAL COORDINATE SYSTEM:
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VERTICAL COORDINATE SYSTEM:
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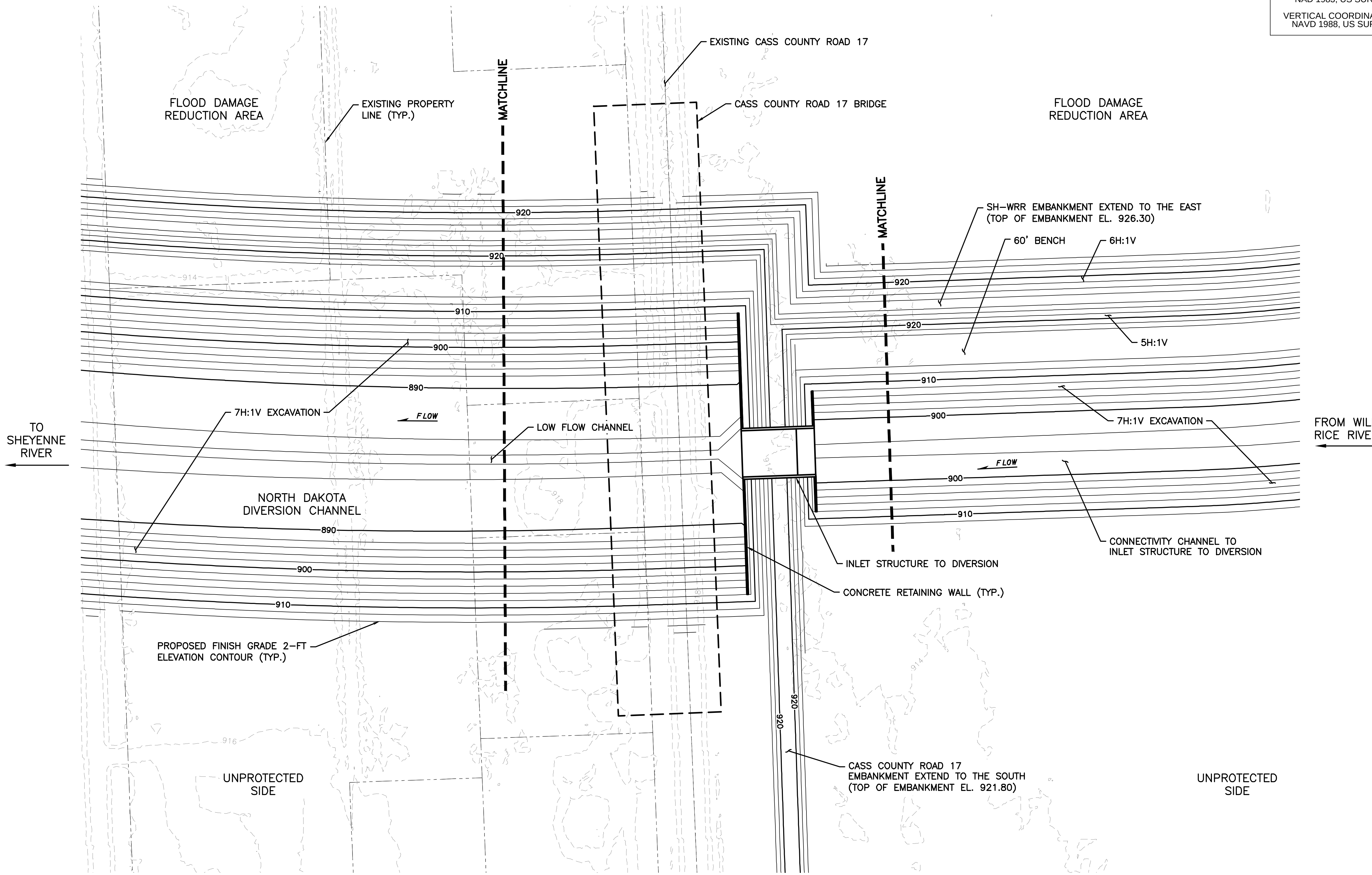

PLAN VIEW

VE13C - INLET

100 0 100 200
SCALE IN FEET

N

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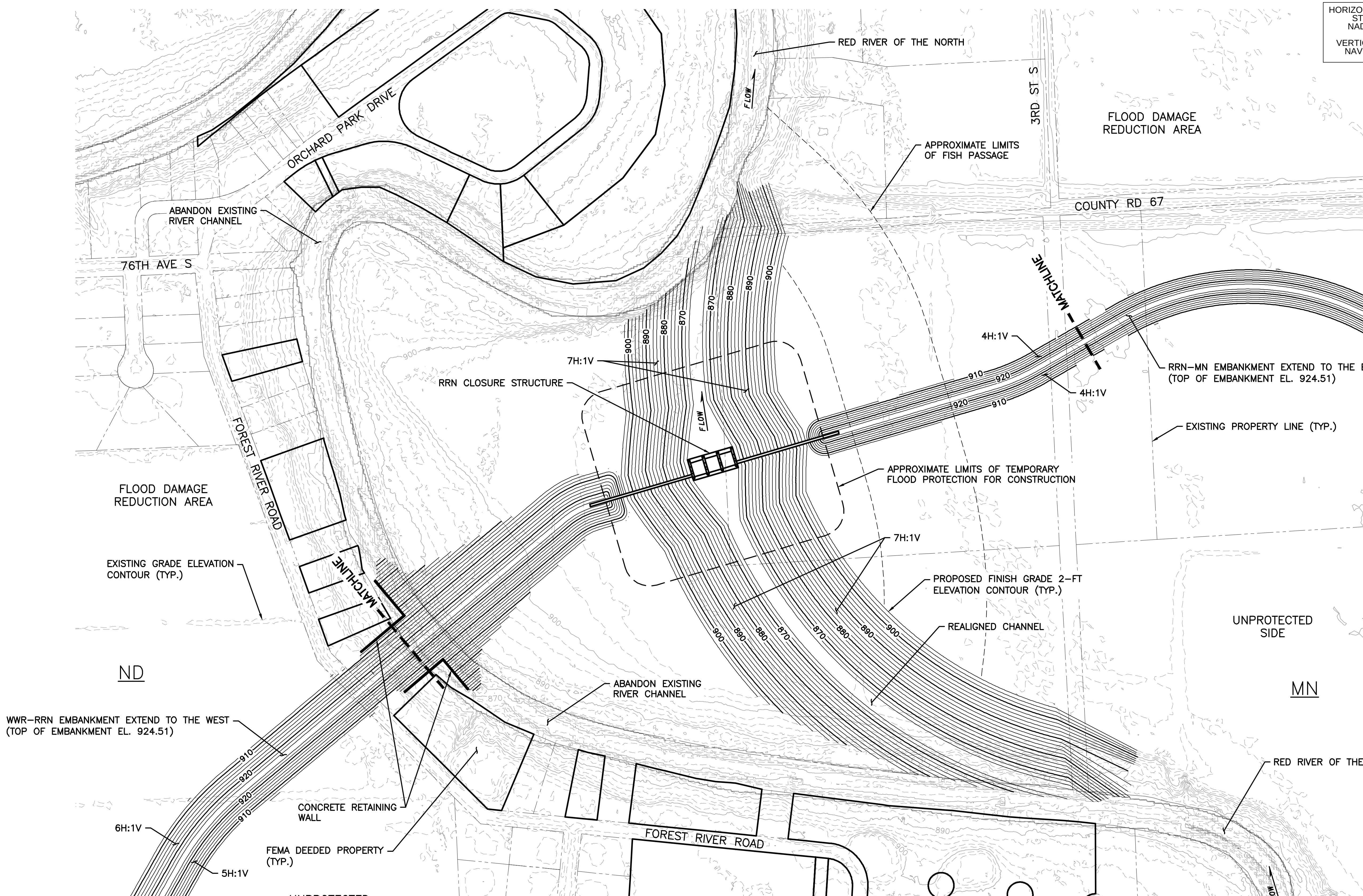
RED RIVER DIVERSION HYDRAULIC STRUCTURES
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - VE13 OPTION C
INLET STRUCTURE ON RED RIVER DIVERSION
PLAN VIEW

SHEET IDENTIFICATION
G1.6

CADD USER: Max J. Jouppe FILE: M:\DESIGN\34091004.02\34091004.02_BASE_C3D_DESIGN_VE13C_INLET.DWG PLOT SCALE: 1:2 PLOT DATE: 7/30/2012 8:47 AM



PLAN VIEW

NWRR - RRN

N

200 0 200 400
SCALE IN FEET

HORIZONTAL COORDINATE SYSTEM:
STATE PLANE - ND SOUTH
NAD 1983, US SURVEY FEET

VERTICAL COORDINATE SYSTEM:
NAVD 1988, US SURVEY FEET

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SIZE: ANSI D	FILE NAME: -	

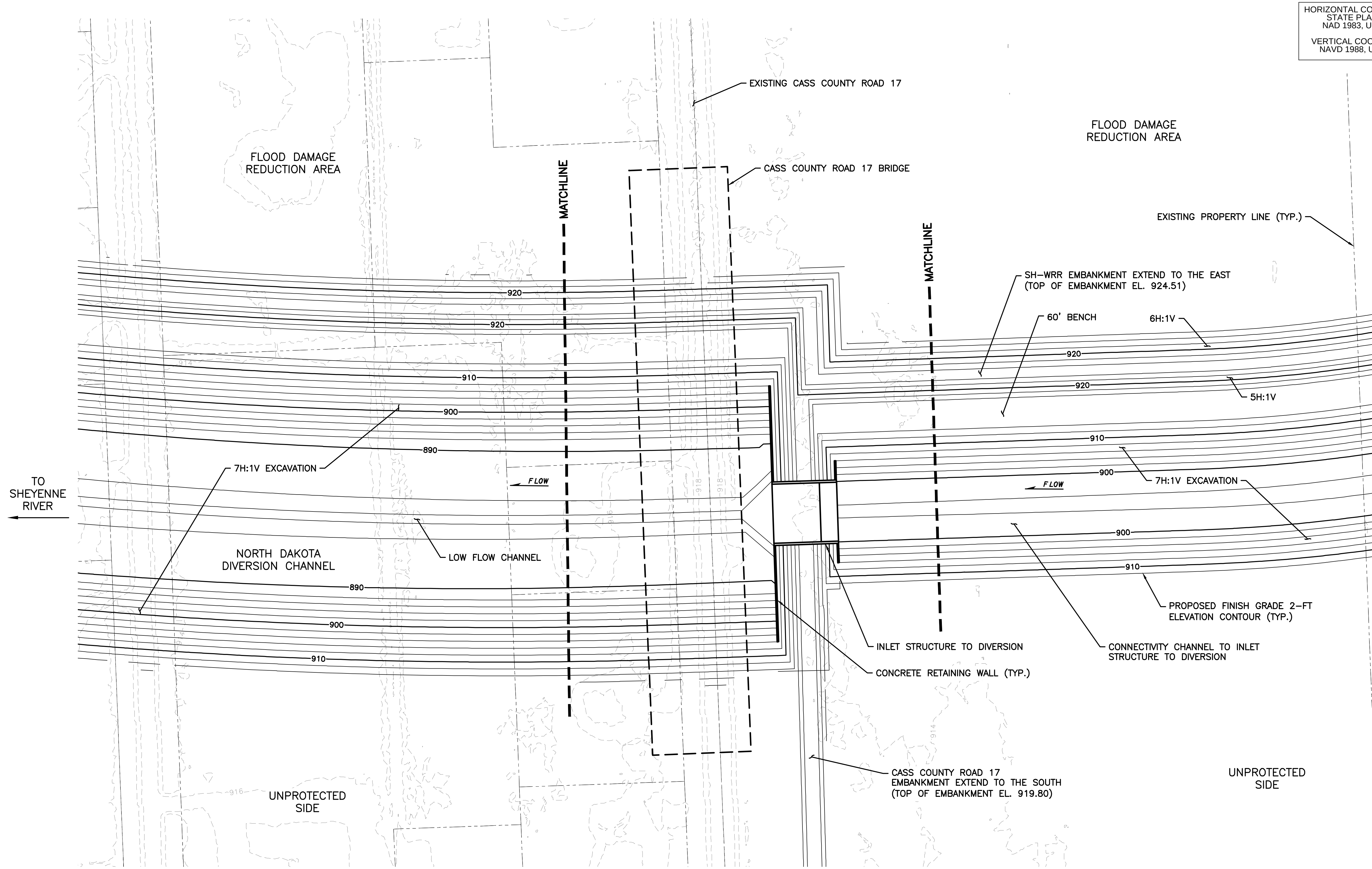
CONCEPT DOCUMENTATION DRAWINGS
RED RIVER DIVERSION HYDRAULIC STRUCTURES
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - NWRR OPTION
STRUCTURE ON RED RIVER OF THE NORTH
PLAN VIEW

SHEET IDENTIFICATION
G1.7

HORIZONTAL COORDINATE SYSTEM:
STATE PLANE - ND SOUTH
NAD 1983, US SURVEY FEET

VERTICAL COORDINATE SYSTEM:
NAVD 1988, US SURVEY FEET



PLAN VIEW

NWRR - INLET

100 0 100 200
SCALE IN FEET

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FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - NWRR OPTION
INLET STRUCTURE ON RED RIVER DIVERSION
PLAN VIEW

SHEET IDENTIFICATION
G1.8

HORIZONTAL COORDINATE SYSTEM:
STATE PLANE - ND SOUTH
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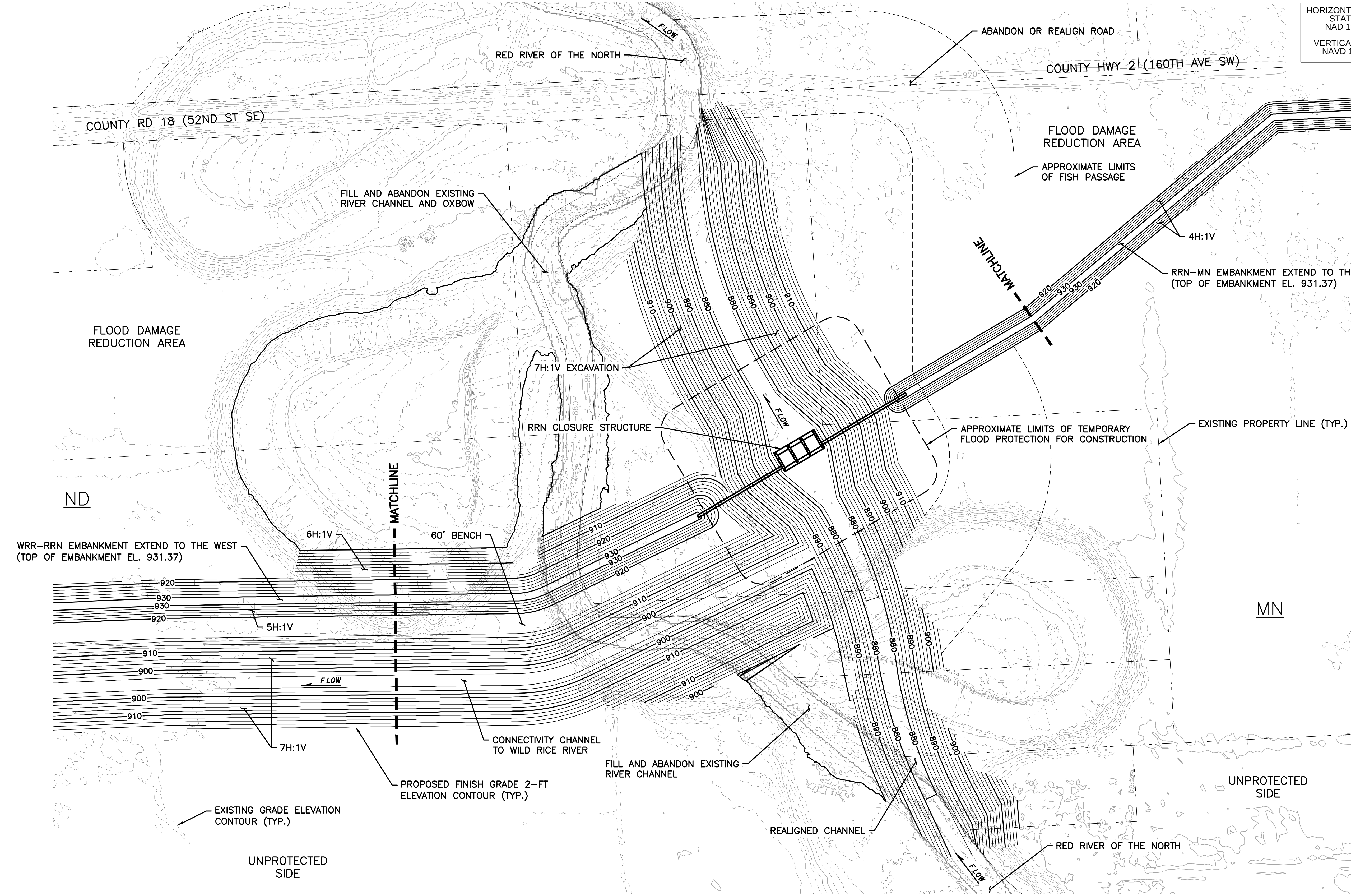

PLAN VIEW

OXBOW - RRN

200 0 200 400
SCALE IN FEET

N

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FLOOD CONTROL - OXBOW OPTION
STRUCTURE ON RED RIVER OF THE NORTH
PLAN VIEW

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SHEET IDENTIFICATION
G1.9

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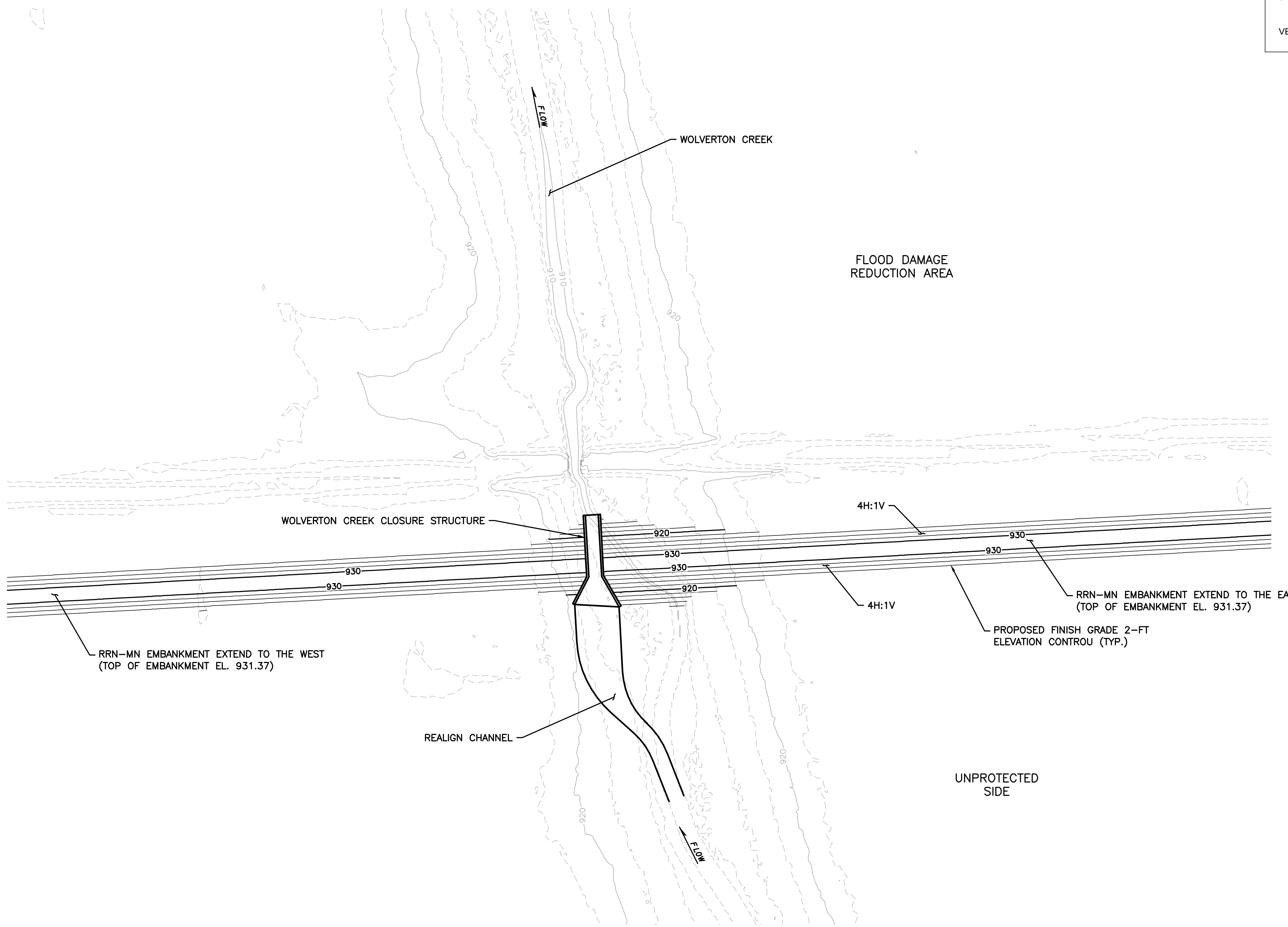

PLAN VIEW

OXBOW - WOLVERTON

100 0 100 200
SCALE IN FEET

N

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CONCEPT DOCUMENTATION DRAWINGS
RED RIVER DIVERSION HYDRAULIC STRUCTURES
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
FARGO, ND AND MOORHEAD, MN

FLOOD CONTROL - OXBOW OPTION
STRUCTURE ON WOLVERTON CREEK
PLAN VIEW

SHEET IDENTIFICATION
G1.10

APPENDIX G – EXHIBIT G2 – FISH PASSAGE ANALYSIS

G2.1 FISH PASSAGE ANALYSIS

As part of the Post Feasibility Southern Alignment Alternatives (PFSAA), fish passage was designed for the structure on the Red River for the following alternative diversion alignments:

- VE-13 Option A (VE13A)
- VE-13 Option C (VE13C)
- North of the Wild Rice River Confluence (NWRR)
- South of Oxbow (Oxbow)

Fish passage was also designed for the structure on the Wild Rice River for the following alternative diversion alignments:

- VE-13 Option A (VE13A)
- VE-13 Option C (VE13C)

This PFSAA report was issued in Draft on July 31, 2012 to obtain comments from the PMC, USACE and Local Sponsors at workshops on August 2nd and August 15-16th, 2012. Changes to the maximum flood event were modified for the VE13C and NWRR alternatives to include a protection level for the 103k cfs event (as defined following July 31, 2012) plus free board. The change resulted in an increase of the top-of-structure elevation following July 31st. Revisions to the top-of-structure elevations for VE13C and NWRR following July 31st are not included in the feasibility structure designs, but were included as pro-rated cost increases in the cost estimates. Revised tailwater conditions due to increased flows through town are not reflected in the fish passage assumptions provided herein.

The fish passage for PFSAA alignments follows the same design methodology as in the Phase 4 FRP analysis to the extent possible (see Appendix F – Exhibit G of the Phase 4 FRP April 19, 2011 A/E deliverable to the USACE). Fish passage gate and channel dimensions are identical to the Phase 4 FRP designs. Changes from the Phase 4 FRP designs are limited to the upstream invert elevations of the fish passage gates, the downstream outlet elevations of the fish passage channels, and the overall length of the fish passage channels. The design methodology applied to the PFSAA alignments differs from the Phase 4 FRP design in the following ways:

- Limits of Fish Passage Operation – The Phase 4 FRP fish passage design provided continuous (with respect to upstream water surface elevation (WSEL)) fish passage from the 2-percent chance event to events less than the 20-percent chance event; the range of operation was determined starting with the upper limit of operation, the 2-percent chance event. For the PFSAA, two fish passages are included at each structure providing fish passage extending upwards from the 20-percent chance event WSEL; the range of operation is determined from the lower limit or operation, the 20-percent chance event. This is due to the uncertainty in WSELs corresponding to the 2-percent chance event, which was not modeled in HEC-RAS.

- Interpolation of Critical Tailwater – The Phase 4 FRP design included a minimum downstream fish passage elevation 1.5 feet below the 20-percent chance event tailwater. The HEC-RAS modeling for the PFSAA alignments indicates the 1-percent chance event tailwater elevations are below the 10-percent chance event tailwater elevations. Thus, the 20-percent chance event tailwater cannot be assumed as governing the downstream fish passage elevation. Instead, the minimum tailwater elevations are interpolated using the 1-percent chance event and 10-percent chance event HEC-RAS model results and the maximum upstream fish passage WSEL. The minimum downstream fish passage elevations are set 1.5 feet below the tailwater elevations.

Differences between headwater and tailwater across the Red River control structure and Wild Rice River control structure are increased for the PFSAA alignments relative to Phase 4 FRP, resulting in increased fish passage channel lengths relative to the Phase 4 FRP. It is not possible to directly compare the range (with regard to flood event) of fish passage operation in the Phase 4 FRP to the PFSAA alignments, as the 2-percent chance flood event was not modeled for the PFSAA alignments. The fish passage design for the PFSAA alignments provides the same range (with regard to headwater elevation) of operation as the Phase 4 FRP fish passage design. Table G2-1 summarizes the fish passage design for the PFSAA alignments.

Table G2-1 Summary of Fish Passage Design for PFSAA

Alignment	Structure	Fish Passage	Gate Invert (ft)	Outlet Elevation (ft)	No. of Pools	No. of Riffles	Total Length (ft)
VE13 Option A	Red River	1	911.65	891.61	21	21	1260
		2	915.15	887.00	29	29	1740
	Wild Rice River	1	911.66	893.80	18	18	1080
		2	915.16	892.65	23	23	1380
VE 13 Option C	Red River	1	909.65	890.28	20	20	1200
		2	913.15	885.73	28	28	1680
	Wild Rice River	1	909.65	891.02	19	19	1140
		2	913.15	889.08	25	25	1500
North of Wild Rice River	Red River	1	907.98	891.85	17	17	1020
		2	911.48	885.97	26	26	1560
South of Oxbow	Red River	1	916.7	886.21	31	31	1860
		2	920.2	884.34	36	36	2160

APPENDIX G – EXHIBIT G3 – HYDRAULIC CONTROL STRUCTURES – CIVIL DESIGN SUMMARY TABLE

Exhibit G3 - Hydraulic Control Structures - Civil Design Summary

Fargo-Moorhead Metro Flood Risk Management Project
FM Diversion Post-Feasibility Southern Alignment Analysis

Notes:
(1) Structure concrete quantity adjusted by a factor of 1.08 due to revised design event since FRP April 2011 deliverable, as determined by USACE
(2) Structure concrete quantity does not include floodwall required at deeded property
(3) Structure height raised by 2 feet due to revised design event since FRP April 2011 deliverable

Red River Control Structures

Alternative	Length of Existing River Centerline Realigned (LF)	Realigned Channel Length (LF)	Hydraulic Structure Site Permanent R.O.W. (AC)	Structure Concrete Quantity (CY)	Structure Height (invert to top of embankment) (VLF)	Fish Passage Footprint (SF)	Comments
FRP	4000	3200	110	20200 (1)	55.5 (3)	294,000	
VE13 Option A	3400	1900	94	18500	54.8	300,000	Realigned channel through Rustic Oaks Event Center
VE13 Option C	2500	2100	90	18300	55.8	288,000	Realigned channel intersects CR 59
North of Wild Rice River	6200	3000	77	20200 (2)	61.7	258,000	Floodwall needed to avoid FEMA deeded properties
Oxbow	4000	3000	129	18600	54.4	402,000	

Wild Rice River Control Structures

Alternative	Length of Existing River Centerline Realigned (LF)	Realigned Channel Length (LF)	Hydraulic Structure Site Permanent R.O.W. (AC)	Structure Concrete Quantity (CY)	Structure Height (invert to top of embankment) (VLF)	Fish Passage Footprint (SF)	Comments
FRP	4000	2400	114	8800 (1)	38.2 (3)	210,000	
VE13 Option A	3200	1800	98	8900	41.0	246,000	
VE13 Option C	4500	2500	111	9000	42.5	264,000	
North of Wild Rice River	N/A	N/A	N/A	N/A	N/A	N/A	
Oxbow	Same as FRP	Same as FRP	Same as FRP	Same as FRP	Same as FRP	Same as FRP	

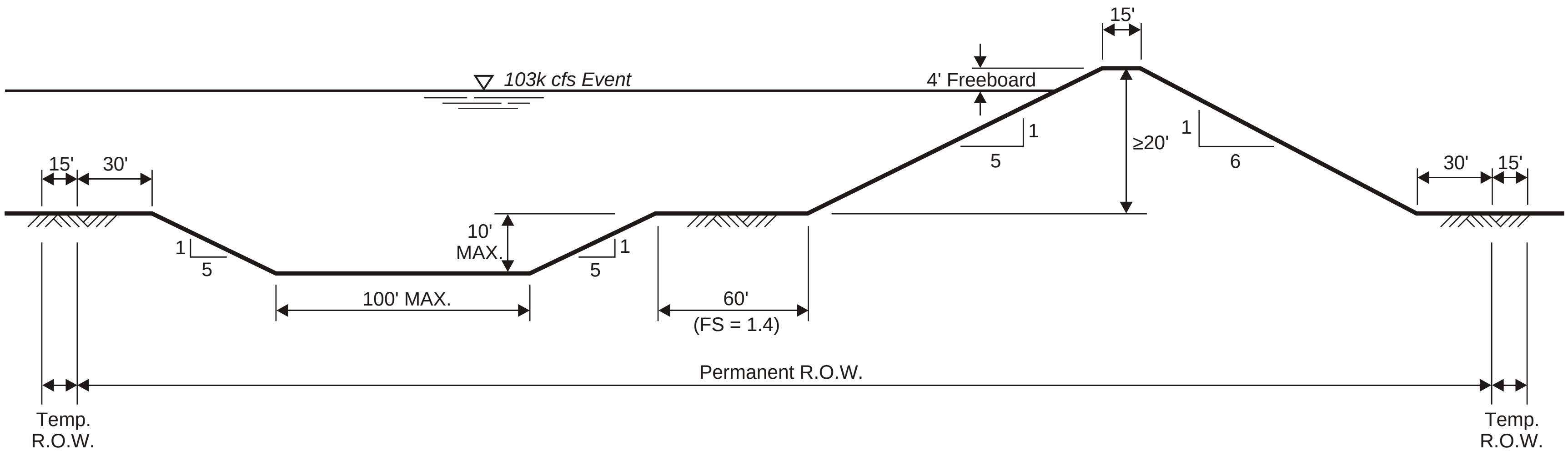
Wolverton Creek Control Structures

Alternative	Length of Existing River Centerline Realigned (LF)	Realigned Channel Length (LF)	Hydraulic Structure Site Permanent R.O.W. (AC)	Structure Concrete Quantity (CY)	Structure Height (invert to top of embankment) (VLF)	Fish Passage Footprint (SF)	Comments
FRP	N/A	N/A	4	3700 (1)	34 (3)	N/A	
VE13 Option A	N/A	N/A	N/A	N/A	N/A	N/A	
VE13 Option C	N/A	N/A	N/A	N/A	N/A	N/A	
North of Wild Rice River	N/A	N/A	N/A	N/A	N/A	N/A	
Oxbow	N/A	N/A	Same as FRP	Same as FRP	Same as FRP	N/A	

Diversion Inlet Structures

Alternative	Length of Existing River Centerline Realigned (LF)	Realigned Channel Length (LF)	Hydraulic Structure Site Permanent R.O.W. (AC)	Structure Concrete Quantity (CY)	Structure Height (invert to top of embankment) (VLF)	Fish Passage Footprint (SF)	Comments
FRP	N/A	N/A	13	7200 (1)	40 (3)	N/A	
VE13 Option A	N/A	N/A	17	6200	39.1	N/A	
VE13 Option C	N/A	N/A	16	5500	36.7	N/A	
North of Wild Rice River	N/A	N/A	14	5500	34.7	N/A	
Oxbow	N/A	N/A	Same as FRP	Same as FRP	Same as FRP	N/A	

APPENDIX G – EXHIBIT G4 – LEVEE EMBANKMENT CROSS SECTIONS



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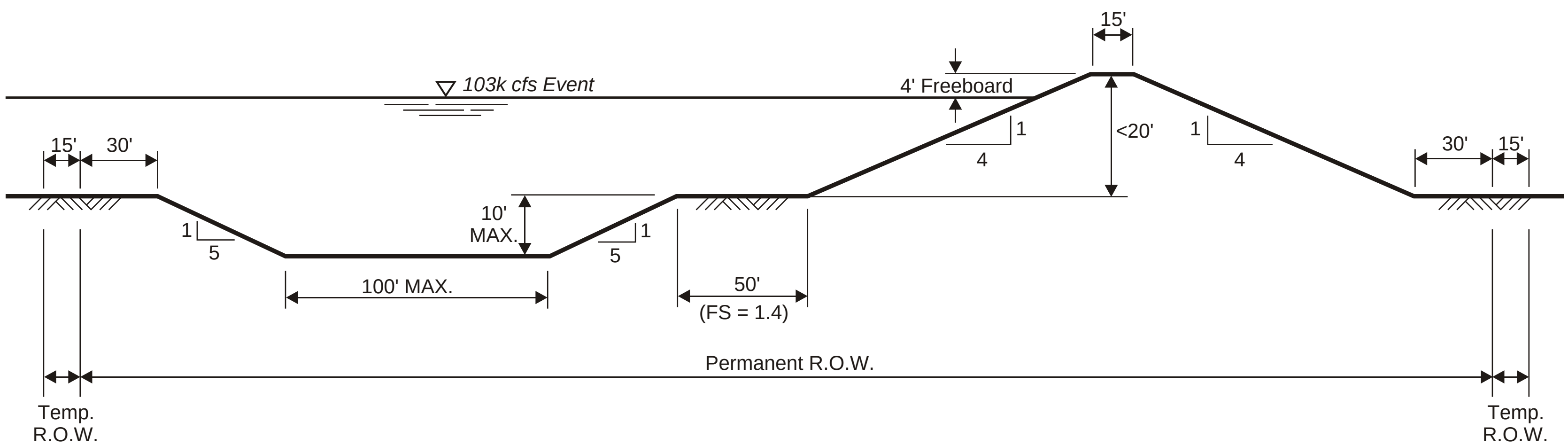
Not to Scale



EMBANKMENT HEIGHT <20'

Not to Scale

Exhibit G4

APPENDIX G – EXHIBIT G5 – EARTHWORK QUANTITIES SUMMARY

Exhibit G5
Summary of Civil3D Earthwork Volume Calculations

FRP

	Centerline Length LF
Total	**110,656**

VE13A

Alignment	Structure	Station Range Begin	Station Range End	Centerline Length LF	Exc Soil 1 CY	Exc Soil 2 CY	Exc Soil 3 CY	Exc Soil 4 CY	Excavation CY	Embankment CY	Topsoil CY	ROW Permanent Acre	ROW Temporary Acre
SH-Inlet		1514+00	1591+00	7700	891,302	168,901	2,177,503	505,575	3,743,281	326,233	118,865	170	5
	Inlet	1591+00	1598+50	750	49,481	24,347	134,898	34,223	242,949	47,501	22,459	17	1
Inlet-WRR		1598+50	1790+00	19150	861,309	185,868	703,248	0	1,750,425	1,233,173	170,635	266	13
	WRR	1790+00	1826+00	3600	374,773	83,942	0	0	458,715	436,268	101,394	98	4
WRR-RRN		1826+00	1880+00	5400	195,985	59,472	100,175	0	355,632	407,420	44,821	71	4
	RRN	1880+00	1916+00	3600	363,001	304,053	91,247	0	758,301	505,481	91,676	94	4
RRN-MN		1916+00	2215+40	29940	0	0	0	0	0	864,266	63,028	119	21
CSAH17		55+03	263+93	20890	0	0	0	0	0	100,479	17,805	53	15
Total				**91,030**	**2,735,851**	**826,583**	**3,207,071**	**539,798**	**7,309,303**	**3,920,821**	**630,683**	**887**	**67**

VE13C

Alignment	Structure	Station Range Begin	Station Range End	Centerline Length LF	Exc Soil 1 CY	Exc Soil 2 CY	Exc Soil 3 CY	Exc Soil 4 CY	Excavation CY	Embankment CY	Topsoil CY	ROW Permanent Acre	ROW Temporary Acre
SH-Inlet		1514+00	1564+00	5000	369,990	172,663	1,476,009	343,172	2,361,834	167,968	75,139	107	3
	Inlet	1564+00	1571+50	750	47,558	22,385	116,906	29,633	216,482	38,025	20,972	16	1
Inlet-WRR		1571+50	1770+00	19850	581,658	194,019	950,999	0	1,726,676	1,474,454	176,661	274	14
	WRR	1770+00	1806+00	3600	262,394	173,925	0	0	436,319	704,659	124,675	111	4
WRR-RRN		1806+00	1862+00	5600	191,087	56,627	115,347	0	363,061	480,004	46,695	74	4
	RRN	1862+00	1895+00	3300	340,966	398,009	148,201	0	887,176	837,832	126,343	90	3
RRN-MN		1895+00	2197+60	30260	0	0	0	0	0	875,141	64,034	121	21
CSAH17		3+22	196+11	19289	0	0	0	0	0	65,993	14,709	46	13
Total				**87,649**	**1,793,653**	**1,017,628**	**2,807,462**	**372,805**	**5,991,548**	**4,644,076**	**649,228**	**840**	**64**

NWRR

Alignment	Structure	Station Range Begin	Station Range End	Centerline Length LF	Exc Soil 1 CY	Exc Soil 2 CY	Exc Soil 3 CY	Exc Soil 4 CY	Excavation CY	Embankment CY	Topsoil CY	ROW Permanent Acre	ROW Temporary Acre
SH-Inlet		1514+00	1564+50	5050	374,921	172,711	1,490,294	346,344	2,384,270	174,362	76,057	109	3
	Inlet	1564+50	1572+00	750	42,494	19,785	100,980	25,056	188,315	25,951	18,287	14	1
Inlet-WRR		1572+00	1777+02	20502	643,553	200,967	16,493	950,717	1,811,730	1,384,961	180,576	273	14
WRR-RRN		0+00	180+00	18000	0	0	0	0	1,007,248	1,543,099	159,993	215	12
	RRN	180+00	210+00	3000	331,017	576,567	362,957	0	1,270,541	267,696	75,363	77	4
RRN-MN		210+00	534+66	32466	0	0	0	0	0	1,201,891	77,010	139	22
CSAH17		3+20	155+08	15188	0	0	0	0	0	20,939	8,059	33	11
Total				**94,956**	**1,391,985**	**970,030**	**1,970,724**	**1,322,117**	**6,662,104**	**4,618,899**	**595,345**	**860**	**67**

South of Oxbow

Alignment	Structure	Station Range Begin	Station Range End	Centerline Length LF	Exc Soil 1 CY	Exc Soil 2 CY	Exc Soil 3 CY	Exc Soil 4 CY	Excavation CY	Embankment CY	Topsoil CY	ROW Permanent Acre	ROW Temporary Acre
SH-Inlet		1514+00	1585+00	7100	812,551	161,415	2,017,697	461,435	3,453,098	415,533	102,995	158	5
	Inlet	1585+00	1592+50	750	30,317	14,551	51,548	8,087	104,503	17,272	14,626	13	1
Inlet-WRR		1592+50	1759+00	16650	760,426	185,017	442,515	0	1,387,958	0	88,887	109	6
	WRR	1759+00	1795+00	3600	433,484	50,126	5,744	0	489,354	134,648	73,616	114	2
WRR-RRN		1795+00	2045+00	25000	2,071,532	310,781	470,506	0	2,852,819	1,601,077	234,580	372	17
	RRN	2045+00	2075+00	3000	1,010,441	392,711	77,595	0	1,480,747	825,609	156,841	77	4
RRN-MN		2075+00	2531+84	45684	0	0	0	0	0	648,280	67,079	148	32
CSAH17		39+92	327+27	28735	0	0	0	0	0	241,538	31,732	80	20
SA1		176+13	578+53	40240	0	0	0	0	2,377,451	5,231,603	473,424	4546	13
Total				**170,759**	**5,118,751**	**1,114,601**	**3,065,605**	**469,522**	**12,145,930**	**9,115,560**	**1,243,780**	**5,617**	**100**

APPENDIX H – COST ESTIMATES

H.1 COST ESTIMATE METHODOLOGY - INTRODUCTION

This appendix to the technical memorandum *FM Diversion Post-Feasibility Southern Alignment Analysis: VE-13* (PFSAA) is intended to provide additional background information about feasibility-level cost estimate methodology and assumptions used for the alternatives cost estimates.

The alternative costs (southern alignment Lands and Damages plus Construction Cost only, with no "bundled enhancements") are presented in Table H-1. These costs are for features upstream of station 1514+00 upstream of the Sheyenne River Hydraulic Structure.

Table H-1 Base Cost Comparison for Southern Alignment Alternatives

Alternative	Base Cost ($)	Compared to FRP ($)
FRP	593M	N/A
VE13A	525M	68M Less
VE13C	532M	61M Less
NWRR	564M	29M Less
OXBOW	592M	1M Less

Note: Costs include construction costs and lands and damages only.

Estimated costs are presented for alternative alignments VE-13A, VE-13C, NWRR and OXBOW for comparison to the Federally Recommended Plan (FRP). The construction features and Lands and Damages quantity summaries and estimated costs presented are intended to be used for consistent comparison of PFSAA alignment alternatives to analogous project features and estimated costs presented for the FRP. The estimated costs are intended to be used for evaluating if the alternative alignments are cost competitive with the FRP. An additional consideration, though it is not quantified as part of the PFSAA, could be the possible alteration of benefits on the flood risk reduction areas of the project for each alternative alignment; the magnitude of changes to the benefits remains to be investigated. In terms of benefits alteration, consideration could be given to how the increase or decrease in benefits compare to the project-wide benefits, on a percentage basis for example.

PFSAA cost estimates are built upon unit costs, contractor assumptions and other assumptions developed during Phase 4. The primary basis of the cost estimate methodology is the MII cost model and cost estimates developed by Barr Engineering Co. (Barr) with assistance from the U.S. Army Corps of Engineers

(USACE) and presented in the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE. That deliverable included estimated construction costs for feasibility-level designed project features. MII files for PFSAA cost estimates were developed using the April 20, 2011 TPCS MII files provided by USACE as a basis.

This PFSAA report was issued in Draft on July 31st, 2012 to obtain comments from the PMC, USACE and Local Sponsors at workshops on August 2nd and August 15-16th. A summary of important assumptions, QA/QC revisions and changes made to the document since that Draft issue includes:

1. Revisions to the top-of-structure elevations for VE13C and NWRR following July 31st are not included in the quantity takeoffs and MII cost estimate files developed from feasibility structure designs, but were included as pro-rated cost increases in the cost estimates.
2. The top elevation of the control structures and tieback embankment was revised for alternative VE13C, from elevation 926.3 feet to elevation 927.3 feet. Embankment volumes were revised accordingly.
3. The top elevation of the control structures and tieback embankment was revised for alternative NWRR, from elevation 924.5 feet to elevation 927.5 feet. Embankment volumes were revised accordingly.
4. The top elevation of the control structures and tieback embankment was revised for alternative OXBOW, from elevation 931.4 feet to elevation 931.8 feet. Structures and embankments were not revised to reflect this as agreed upon during the workshops.
5. Control structure costs were prorated on a cost per vertical foot basis to reflect the increased height of the NWRR and VE13C embankments as described above.
6. The unit costs of embankments were revised to reflect an important ATR comment. The productivity of the embankment compaction crews was increased and new embankment unit costs were benchmarked against regional embankment projects. This changes was applied to all alternative alignments as well as the FRP for consistent comparison.
7. Revised Lands and Damages costs for NWRR.
8. PFSAA alignment base costs are presented in this report for consistent comparison to the FRP. These costs do not include PFSAA Enhancement bundles. For additional information on Enhancement bundles, see the companion document to this report entitled *Appendix I: Assessment Factors*.
9. Changes to estimated costs due to proposed PFSAA Enhancement bundles are not included in this report.
10. Detailed balance of Type 1 material and Type 2 material in connecting channel excavations as borrow for embankment volumes is not included. Instead, a conservative cross section is assumed and connecting channel costs are estimated on a pro-rated cost per mile, based on the Reach 2018 and Reach 2019 excavation and site work costs presented in the FRP.

A summary of features included in each cost estimate for the entire project organized by category is presented in Exhibit H1.

A summary of features for the proposed work associated with each upstream alignment alternative is presented in Exhibit H2.

The basis for the revised costs for each major feature is summarized in Exhibits H3 and H4.

Additional discussion of **considerations important for future scoping and execution of cost estimate efforts** is included in Appendix J.

H.2 COST ESTIMATE ASSUMPTIONS

Project Title:	Final Technical Memorandum, *FM Diversion Post-Feasibility Southern Alignment Analysis (PFSAA): VE-13, North of Wild Rice River, South of Oxbow,* Report for the U.S. Army Corps of Engineers (USACE) and the Local Sponsors.
Project Location:	Cass County, ND and Clay County, MN
Software:	MCACES cost estimating software MII, version 3.01 (MII)
Work Breakdown:	Civil Works Breakdown Structure (as coordinated with USACE)
Costbook:	2008 Cost Book for MII (English units)
Measurements:	English
Currency:	August 2010 US Dollars ($); temporal escalation to be performed by USACE
Quantities:	Quantity calculations are performed by Houston-Moore Group (HMG)
Schedule:	The schedule assumed in these estimates is the $200 million per year funding scenario breakdown, as developed by HDR Engineering, Inc. in the report titled DRAFT – Project Phasing and Project Scheduling, dated June 11, 2010
Estimator:	This feasibility construction cost estimate was compiled by Barr Engineering Co. for Houston-Moore Group (HMG)

The PFSAA cost estimates for hydraulic structure, embankment work was estimated using the USACE MII cost estimating software. Portions of the PFSAA cost estimates for transportation features, Lands and Damages, connecting channel, structure cost pro-rating and other costs for alternatives were completed outside of MII, using Microsoft Excel spreadsheets, as noted in Exhibits H3 and H4.

Estimated costs presented in the PFSAA are estimated construction-only costs and do not include revised costs for Fish and Wildlife Facilities (ecological mitigation), HTRW, Recreation Facilities, Planning

Engineering & Design (PED), Construction Management (CM), time value-of-money escalation, or Operation and Maintenance Costs (O&M). The phase 4 costs for these categories were carried forward unaltered to develop a surrogate total project cost for comparison, were noted. Exhibits H3 and H4 summarize the cost categories where costs were excluded from re-analysis for the PFSAA.

Feasibility-level cost estimates presented in the PFSAA are based on proposed alignment modifications to the Phase 4 FRP feasibility design, as presented in the Final Feasibility Report and the Final Environmental Impact Statement (FR/FEIS). The designs presented in the FEIS were carried out to a feasibility level using general hydrologic, hydraulic, environmental, geotechnical, structural and general civil design considerations. It is acknowledged that additional investigations of the alternative selected for detailed design may result in changes to the proposed configuration, estimated cost and functioning of some of the project features. This may include further investigation into:

- aquatic ecosystems
- fish passage
- ice engineering
- sediment transport and geomorphology
- future updates to the hydrology
- future revisions and updates of the HEC-RAS unsteady flow models
- additional site specific information (e.g., topography, soil borings, soil mechanics laboratory tests, field-scale pile-driving tests)

H.2.1 COST ESTIMATE ASSUMPTIONS – FEDERALLY RECOMMENDED PLAN (FRP)

The PFSAA cost estimates use the same design methodology and assumptions for consistent comparison to the FRP as during April 2011 Phase 4 feasibility cost estimate work. The following discussion of assumptions is intended to provide background information related to the methodology and assumptions used to develop quantities and unit costs presented in the PFSAA. If additional reference to FRP assumptions is required, a detailed discussion of methodology and assumptions used for feasibility cost estimates is presented in the Phase 4 Appendix G of the FRP April 19, 2011 A/E deliverable to the USACE. The details presented in Appendix G of the referenced report should be considered prior to development of future MII cost models or cost estimates on the project.

H.2.2 CONSTRUCTION CRITICAL PATH AND SCHEDULE CONSIDERATIONS

Schedule assumptions for the PFSAA cost estimates are generally consistent with assumptions made during April 2011 Phase 4 FRP feasibility cost estimate work. Cost estimates presented in the FRP TPCS and PFSAA do not incorporate any construction schedule and critical path work performed since April of 2011. Construction sequence work was not performed for proposed features of the southern alignment alternatives.

H.2.3 DIRECT COST ASSUMPTIONS (CONSTRUCTION COSTS)

Direct cost assumptions for the PFSAA cost estimates are generally consistent with assumptions made during April 2011 Phase 4 FRP feasibility cost estimate work, except for updated embankment compaction costs. Unit costs presented in the FRP TPCS are based on information obtained during 2010 and 2011 cost estimate development phases.

Fuel cost assumptions for the PFSAA are generally consistent with assumptions made during April 2011 Phase 4 FRP feasibility cost estimate work. Fluctuation of fuel costs could also have a major impact on the unit price of earthwork items because of the requirement to use heavy equipment performing at high rates of productivity. Nothing has been included in the feasibility cost estimates to account for future changes in fuel costs because it is assumed that the USACE considers these possible fluctuations in the escalation factors and project cost risk assessment assumptions. Therefore, the assumed fuel costs (on-road diesel, off-road diesel and gasoline) assumed in the MII estimates are from the 2008 equipment library only. Revisions of the fuel costs are recommended in detailed design to use more current data such as that from the US Energy Information Administration. Construction of the proposed project will take several years, a period over which fuel costs may fluctuate.

Future estimate efforts should obtain updated cost quotes for materials as needed to estimate material costs with less uncertainty. This is of particular importance the further out the construction start date is anticipated. Likewise, future changes to wage rates, equipment rates and fuel costs should be considered for all future cost estimating efforts.

Similar to future work that was required following the Phase 4 cost estimates, Agency Technical Review (ATR) comments received during development of the FRP TPCS should be reviewed and taken into consideration in future development of MII cost model assumptions related to crew productivities, unit costs, etc. Should any of the PFSAA alternatives be developed in greater detail, recommendations for future refinement, such as ATR comments should be reviewed and addressed at that time.

The unit costs of embankments were revised to reflect an ATR comment provided by USACE. The productivity of the levee compaction crews was increased from 120 BCY/HR to 200 BCY/HR and the resulting embankment unit costs were benchmarked against regional embankment projects. This change was applied to all tieback embankments in alternative alignments as well as the FRP for consistent comparison.

H.2.4 INDIRECT COST ASSUMPTIONS (CONTRACTOR COSTS)

Indirect cost assumptions (contractor costs) for the PFSAA cost estimates are consistent with assumptions made during April 2011 Phase 4 FRP feasibility cost estimate work. The cost estimates presented in the SDEIS assume a single Prime Broker Contractor oversees Subcontractors that perform the work. This contractor scenario is assumed for very large contracts (in excess of $200M). This contracting scenario results in significant contractor markup costs which are reflected in the unit costs.

H.2.5 COST ESTIMATE CATEGORICAL CONSIDERATIONS

Categorical cost assumptions for the PFSAA cost estimates are consistent with assumptions made during April 2011 Phase 4 FRP feasibility cost estimate work. However, some unique assumptions were made for some features as discussed below. These assumptions still provide a consistent comparison to the FRP.

In addition to the list below, a summary of features included in each cost estimate organized by category is presented in Exhibit H3 for the entire project and Exhibit H4 for the work specific to the southern alignment alternatives.

01 Lands and Damages (e.g. easements, right-of-way acquisition)

- Estimated costs for Lands and Damages are included in the estimated costs presented in the PFSAA for the alignment alternatives, unless otherwise noted. Methodology is consistent with the Phase 4 April 2011 FRP.
- Permanent right-of-way is estimated assuming 30-foot offset from grading or work extents. Temporary right-of-way is estimated assuming 15-foot offset from edge of estimated permanent right-of-way extent. This assumption is consistent with the Phase 4 April 2011 FRP.
- Estimated Lands and Damages costs are based on methodology as set forth by USACE for estimating Lands and Damages costs for the FRP.

02 Utility Relocations (e.g. electric power, natural gas pipelines, petroleum pipelines, fiber optic lines, water mains, sewer lines, local stormwater pipes, subsurface drain pipes, etc.)

- Estimated Utility Relocation costs are not revised in the estimated costs presented in the PFSAA for the alignment alternatives. Where appropriate, estimated costs presented are equivalent to values presented in the April 2011 Total Project Cost Summary for the FRP.
- Cost estimates are performed with feasibility-level site information. This assumption is consistent with the Phase 4 April 2011 FRP.

06 Fish and Wildlife Facilities

- Estimated Fish and Wildlife Facilities costs are not revised in the estimated costs presented in the PFSAA for the alignment alternatives. Where appropriate, estimated costs presented are equivalent to values presented in the April 2011 Total Project Cost Summary for the FRP.

09 Channels & Canals

- Estimated Channels and Canals (and hydraulic structure) costs are included in the estimated site work costs presented in the PFSAA. Estimated site work costs at the Hydraulic Structure at Wild Rice River, Red River Control Structure and Main Inlet Weir are for a site that includes a portion of the embankment alignment in addition to the Hydraulic Structure at Wild Rice River footprint. For tables summarizing these values see Exhibits G3 and G5 of Appendix G.

- FRP Diversion Channel Facilities and Hydraulic Structure Site Work
    1. The estimated costs presented in the PFSAA assume the Low Flow Channel as configured in April 2011 developed for the FRP Total Project Cost Summary, in order to provide a consistent cost comparison. See Appendix G for additional information about cross section assumptions.
    2. The estimated costs for embankment embankments take into account the 0.85 ECY/BCY shrink factor as directed by USACE, consistent with Phase 4.

3. The unit costs of embankments were revised to reflect an ATR comment provided by USACE. The productivity of the levee compaction crews was increased from 120 BCY/HR to 200 BCY/HR and the resulting embankment unit costs were benchmarked against regional embankment projects. This change was applied to all tieback embankments in alternative alignments as well as the FRP for consistent comparison.
4. 12 inches of topsoil stripping is assumed, consistent with Phase 4.
5. Hydraulic structure quantity takeoffs are based on feasibility design of hydraulic structures. This assumption is consistent with the Phase 4 April 2011 FRP.
6. Hydraulic structure site work and earthwork quantity takeoffs are based on feasibility design of the site work at hydraulic structures. Digital earthwork models were used to compare proposed grading to existing topographic contour information to estimate earthwork quantities. Estimated permanent and temporary ROW is based on the grading extents developed during this effort. This assumption is similar to the Phase 4 April 2011 FRP.
7. Diversion channel and embankment site work and earthwork quantity takeoffs are based on feasibility design of hydraulic structures. Digital earthwork models were used to compare proposed grading to existing topographic contour information to estimate earthwork quantities for VE13A, VE13C, NWRR and OXBOW embankments and connectivity channels. Estimated permanent and temporary ROW is based on the grading extents developed during this effort. This assumption is consistent with the Phase 4 April 2011 FRP.
8. Conversations with a contractor that has worked on the channel expansion in Winnipeg and worked on the original Winnipeg diversion project indicate that it was not possible to work on soils in the rain and that a construction ditch to capture surface water was essential to maintaining drainage during construction. A strategy that proved successful in that project, but is not included in these cost estimates, was excavation of softer material in the winter when it is made more rigid and trafficable due to freezing. In this method, areas of softer soil are left exposed to freezing temperatures and then removed with self-propelled scrapers or tractors with pan scrapers. This assumption is not accounted for in FRP or PFSAA cost estimates. This assumption is similar to the Phase 4 April 2011 FRP. Future estimating efforts should investigate the applicability of this technique and its potential benefits in terms of schedule and cost.
9. Native prairie seeding (including cover crop) and disk-anchored straw mulching of disturbed areas are assumed. This assumption is consistent with the Phase 4 April 2011 FRP. Estimated costs for two years of vegetation establishment and maintenance are included, to encourage establishment of vegetation. The estimated costs assumed are to achieve vegetative stabilization with deep-rooted native prairie and meadow and do not include costs for more complex native plant community ecological restorations or other plantings. Costs for other additional landscaping, trees and plantings are provided by USACE under separate estimate category(s).
10. Cost estimates for diversion channel assume one access road (12’ width, one-way, aggregate surfaced) along one side of the diversion channel. This assumption is consistent with the Phase 4 April 2011 FRP.
11. Cost estimates for hydraulic structure site work include allowances for the restoration of aggregate-surfaced roadways and bituminous-surfaced roadways that may be damaged as a result of the work. This assumption is consistent with the Phase 4 April 2011 FRP.
12. Cost estimates include allowances for site preparation and traffic control, erosion and sedimentation control measures, control of water and dewatering, and other miscellaneous features (dust control, snow removal during construction, monuments and markers, etc.).

These features appear as single lump sum (L.S.) allowances in the MII estimates. This assumption is consistent with the Phase 4 April 2011 FRP.

13. Preliminary work analysis was used to estimate a unit cost for installing riprap. The estimated material cost for riprap was based on similar type projects as well as a material price quote from Aggregate Industries in Fargo-Moorhead ranging from $38.50/ton (Class III riprap) to $42.50/ton (Class V riprap), delivered. Riprap costs are included and is an allowance pending further design efforts to better determine necessity, protection extents and sizing. Uncertainty exists in the unit price for very large sizes of stone, should they be required by additional phases of design. Conversations with suppliers indicated riprap would likely be imported by train on a regional basis. Uncertainty exists in the quantity of riprap, due to the fact that riprap has not been sized using a detailed engineering analysis. More in-depth analysis of flow velocities at the hydraulic structures will reduce uncertainty, and add or subtract to assumed layer thicknesses shown on Drawings of both riprap and underlying filter aggregate. 2-Dimensional velocity modeling was used to develop preliminary riprap protection extents for the FRP, but not for the PFSAA. Where soft underlying soils exist (such as on Brenna clays), riprap may be installed in the winter, as was performed for portions of the Winnipeg, Manitoba Floodway. A similar strategy could be used to install the low-flow channel in these weaker soils. Nominal amounts of snow removal are included in the estimates at hydraulic structures and in each diversion channel reach to facilitate riprap installation. Additional design refinement and velocity modeling may identify locations of high localized velocities that could require more robust protection, such as concrete sills or baffling, neither of which is included in this estimate. These assumptions are consistent with the Phase 4 April 2011 FRP.
14. Cost estimates include allowances for the restoration of aggregate-surfaced roadways and bituminous-surfaced roadways that may be damaged as a result of the work. This assumption is consistent with the Phase 4 April 2011 FRP.
15. Cost estimates include allowances for site preparation and traffic control, erosion and sedimentation control measures, control of water and dewatering, electrical utilities, temporary flood risk reduction embankment for the construction site, signage, fencing, safety features, Supervisory Control and Data Acquisition (SCADA), and other miscellaneous features. These features appear as single lump sum (L.S.) allowances in the MII estimates. This assumption is similar to the Phase 4 April 2011 FRP. Future cost estimate efforts could refine these assumptions for the individual reach/structure/site under consideration.
16. Any future changes to the micrositing of hydraulic structures will change quantities and costs; in particular, it may change the amount of excavation required and the sizing/dimensions of the hydraulic structures.
17. Fish passage costs are estimated on a $/SF basis consistent with the FRP. Extension wall costs were carried forward from the FRP and not revised.

08 Roads, Railroads and Bridges

- There are no railway facilities, railway bridges and track raises within the assumed Site of the PFSAA comparisons. Where appropriate, estimated costs presented are equivalent to values presented in the April 2011 Total Project Cost Summary for the FRP.

11 Levees & Floodwalls

- Feasibility cost estimates assumed the embankment cross sections provided by USACE in the March 2012 white paper entitled “FMM-Estimated Costs for Dam vs. Levee Design.” The estimates assume a 50 foot offset from top of connecting channel excavation to toe of embankment, based on preliminary geotechnical analysis. Future cost estimate efforts should evaluate this assumption with geotechnical analysis and incorporation of any pending development of design criteria for the embankments. The size of the embankments, the geotechnical offset from excavations and the additional right-of-way required for this corridor all contribute to the estimated cost. A summary of the costs presented in the USACE report is included in Exhibit H5. The costs presented in the USACE report were referenced when developing additional quantity takeoffs and cost estimates developed by HMG for the PFSAA.

- A borrow trench is assumed between the Main Inlet Weir to the Red River. This excavation also serves as the connectivity channel between the Wild Rice River and the Red River. No borrow trench is assumed along County Road 17 nor in Minnesota for tie-back embankments. It is assumed this material is hauled in from diversion channel or connectivity channel excavations. This extent is similar to the Phase 4 April 2011 FRP. A detailed earthwork balance and mass haul analysis was not performed for the southern alignments, but should be considered in future efforts. Costs for the borrow trench (connecting channel) are estimated using a cost per mile pro-rated based on Reach 2018 and Reach 2019 FRP costs.
- For embankments of 20 feet or greater in height, a cross section with 15' top width, 5H:1V upstream slopes, 6H:1V downstream slopes and an offset of 60 feet from toe-of-embankment to top-of-borrow-excavation is assumed. This assumption is different than Phase 4 April 2011 FRP. The larger footprint is reflected in revised Lands and Damages costs.
- For embankments less than 20 feet in height, a cross section with 15' top width, 4H:1V upstream slopes, 4H:1V downstream slopes and an offset of 50 feet from toe-of-embankment to top-of-borrow-excavation is assumed. This assumption is different than Phase 4 April 2011 FRP. The larger footprint is reflected in revised Lands and Damages costs.
- Costs for levees associated with increased flows through town, Oxbow ring levee and a gated diversion inlet are not included in this PFSAA report.

14 Recreation Facilities (e.g. multi-purpose trails, soft trails, trail river crossing(s), trailhead facilities, parking lots, interpretive signage, landscaping other than site restoration)

- Estimated Recreation Facilities costs are not revised in the estimated costs presented in the PFSAA for the alignment alternatives. Where appropriate, estimated costs presented are equivalent to values presented in the April 2011 Total Project Cost Summary for the FRP.

Other Costs

- 30 Planning, Engineering and Design (PED): estimated costs for PED are not included in the estimated costs presented in the PFSAA for the alignment alternatives, unless specifically noted. Where project-wide costs are presented, PED is estimated as 15% of construction costs. This assumption is consistent with Phase 4 April 2011 FRP.
- 31 Construction Management (CM): estimated costs for CM are not included in the estimated costs presented in the PFSAA for the alignment alternatives, unless specifically noted. Where project-wide costs are presented, PED is estimated as 7% of construction costs. This assumption is consistent with Phase 4 April 2011 FRP.
- Estimated time-value-of-money escalation costs are not included in the estimated costs presented in the PFSAA for the alignment alternatives.
- Contingency generated by USACE cost risk analysis is included in the estimated costs presented in the PFSAA for the alignment alternatives. **A contingency of 26% was assumed for all alternatives evaluated.** This assumption is consistent with Phase 4 April 2011 FRP.

The contingencies, cost estimates, documentation and discussion provided in the PFSAA and the FRP April 19, 2011 A/E deliverable to the USACE are intended to provide background information for feasibility cost and (if desired) schedule risk assessment (CSRA) and analysis purposes by the USACE for contingency-appropriation purposes, and to identify areas where additional design effort in future stages of refinement could significantly reduce uncertainty of the project cost. Unknowns and uncertainties have been identified that could affect project designs and costs, and are not included in the project costs or contingencies provided with the cost estimate. A detailed discussion of uncertainties and unknowns identified during development of feasibility cost estimates is presented in the Phase 4 Appendix G of the April 19, 2011 A/E deliverable to the USACE. The details and assumptions presented in Appendix G of the referenced report are also applicable to the PFSAA and should be fully understood and considered prior to development of future risk analysis and MII cost estimates on this project.

APPENDIX H – EXHIBIT H1 – PFSAA COST SUMMARY FOR ALL PROJECT WORK

EXHIBIT H1 - PFSAA Cost Summary for All Project Work

October 10, 2012
Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)
Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

North Dakota Diversion

Feature Code	Description	FRP Phase 4 April 2011 Project Cost	FRP August 13, 2012 Project Cost	VE13A Project Cost	VE13C Project Cost	NWRR Project Cost	OXBOW Project Cost
1	**LANDS & DAMAGES**						
	ROW and Easements - Diversion Channel (D/S of Sta. 1514+00 at Sheyenne River Hydraulic Structure Site)	N/A	29,051,500	29,051,500	29,051,500	29,051,500	29,051,500
	ROW and Easements - Diversion Channel (U/S of Sta. 1514+00 from Sheyenne Structure Site to Inlet Weir)	N/A	1,250,400	999,883	1,670,480	2,551,300	1,835,700
	ROW and Easements - Levee Embankments, Storage Area 1 and Connecting Channel (From Inlet Weir U/S)	N/A	35,928,700	6,612,467	7,196,660	9,852,700	59,667,100
	ROW and Easements - Upstream Storage Area (U/S of Inlet Weir)	N/A	187,684,400	208,292,250	219,039,156	259,718,800	126,976,500
	ROW and Easements - Diversion Channel	66,230,600	N/A	N/A	N/A	N/A	N/A
	ROW and Easements - Upstream Storage Area	187,684,400	N/A	N/A	N/A	N/A	N/A
	Mitigation Area Easements [5]	17,696,700	17,696,700	17,696,700	17,696,700	17,696,700	17,696,700
2	**RELOCATIONS**						
	Utility Relocations [5]	19,993,800	19,993,800	19,993,800	19,993,800	19,993,800	19,993,800
	Roadway Bridges	78,901,200	78,901,200	78,157,800	74,352,600	71,127,000	80,652,600
	Road Raises	50,474,500	32,162,760	54,129,600	52,083,083	47,354,580	11,041,380
	Local Road Construction [5]	1,175,200	1,175,200	1,175,200	1,175,200	1,175,200	1,175,200
6	**FISH & WILDLIFE FACILITIES [5]**						
	Environmental Mitigation Features [5]	60,554,600	60,554,600	60,554,600	60,554,600	60,554,600	60,554,600
8	**ROADS, RAILROADS & BRIDGES [5]**						
	Railroad Bridges [5]	58,586,800	58,586,800	58,586,800	58,586,800	58,586,800	58,586,800
9	**CHANNELS AND CANALS [1 2]**						
	Reach 1 - 2012 [5]	1,633,400	1,633,400	1,633,400	1,633,400	1,633,400	1,633,400
	Reach 2 - 2013 [5]	4,854,100	4,854,100	4,854,100	4,854,100	4,854,100	4,854,100
	Reach 3 - 2014 [5]	35,768,200	35,768,200	35,768,200	35,768,200	35,768,200	35,768,200
	Reach 4 - 2015 [5]	123,448,700	123,448,700	123,448,700	123,448,700	123,448,700	123,448,700
	Reach 5 - 2016 [5]	28,860,600	28,860,600	28,860,600	28,860,600	28,860,600	28,860,600
	Reach 6 - 2017 Downstream of Sta. 1514+00 (Sheyenne) [5]	173,558,300	173,558,300	173,558,300	173,558,300	173,558,300	173,558,300
	Reach6 - 2017 Upstream of Sta. 1514+00 (Sheyenne) to Inlet Weir	36,080,100	36,080,100	33,856,907	22,021,979	22,249,726	34,201,369
	Reach 7 - 2018	14,253,300	14,253,300	N/A	N/A	N/A	N/A
	Reach 8 - 2019	7,678,400	7,678,400	N/A	N/A	N/A	N/A
	Reach 7 and 8 Revised [3]	N/A	N/A	25,051,088	26,106,881	36,760,793	41,463,870
	Control Structure on Red River [4]	60,828,100	59,124,913	54,899,000	59,529,000	58,967,000	64,305,000
	Hydraulic Structure at Wolverton Creek	5,501,600	5,347,555	N/A	N/A	N/A	4,686,000
	Hydraulic Structure at Wild Rice River [4]	37,334,100	36,288,745	41,961,000	44,576,000	N/A	35,938,000
	Hydraulic Structure - East Weir (at Connecting Channel)	271,800	271,800	271,800	271,800	271,800	271,800
	Hydraulic Structure - Inlet Weir to Diversion	12,527,100	12,407,000	13,776,000	13,478,000	12,174,000	12,407,000
	Hydraulic Structures at Sheyenne River [5]	64,015,300	64,015,300	64,015,300	64,015,300	64,015,300	64,015,300
	Hydraulic Structure - Drain 14 - Large Drain Structure [5]	10,556,500	10,556,500	10,556,500	10,556,500	10,556,500	10,556,500
	Hydraulic Structures at Maple River [5]	57,707,500	57,707,500	57,707,500	57,707,500	57,707,500	57,707,500
	Hydraulic Structures at Lower Rush River [5]	22,357,000	22,357,000	22,357,000	22,357,000	22,357,000	22,357,000
	Hydraulic Structures at Rush River [5]	22,314,300	22,314,300	22,314,300	22,314,300	22,314,300	22,314,300
	Small Drain Structures (2) [5]	320,500	320,500	320,500	320,500	320,500	320,500
	Large Drain Structure (1) [5]	563,700	563,700	563,700	563,700	563,700	563,700
	Side Channel Inlets 1x72" (19) [5]	10,650,900	10,650,900	10,650,900	10,650,900	10,650,900	10,650,900
	Side Channel Inlets 2x72" (7) [5]	7,134,500	7,134,500	7,134,500	7,134,500	7,134,500	7,134,500
	Outlet to Red River [5]	28,607,600	28,607,600	28,607,600	28,607,600	28,607,600	28,607,600
	Diversion Channel Landscape Plantings [5]	1,383,500	1,383,500	1,383,500	1,383,500	1,383,500	1,383,500
11	**LEVEES AND FLOODWALLS [1 2]**						
	Tie-Back Levee - TBL East 2B (Constructed in MN) [1]	24,981,000	23,000,000	N/A	N/A	N/A	N/A
	Tie-Back Levee - TBL Cass 17 (Constructed in ND) [1]	8,570,100	4,600,000	N/A	N/A	N/A	N/A
	Levee - Connecting Channel - Reach 2018 (ND-23, 26) [1]	2,307,500	2,800,000	N/A	N/A	N/A	N/A
	Levee - Connecting Channel - Reach 2019 (ND-25) [1]	9,538,700	11,500,000	N/A	N/A	N/A	N/A
	Embankment - CSAH17 [1]	N/A	N/A	4,000,000	2,900,000	1,300,000	8,500,000
	Embankment - INLET-WRR [1]	N/A	N/A	23,900,000	27,800,000	26,600,000	see SA1
	Embankment - WRR-RRN 1	N/A	N/A	7,700,000	8,900,000	28,700,000	31,000,000
	Embankment - RRN-MN [1]	N/A	N/A	27,100,000	27,500,000	39,000,000	21,600,000
	Storage Area 1 Embankment and Inlet [1]	78,761,100	83,700,000	N/A	N/A	N/A	99,254,000
	Storage Area 1 Closure/Drainage Structure (North)	6,718,700	7,256,196	N/A	N/A	N/A	7,256,196
	Storage Area 1 Closure/Drainage Structure (East)	6,718,700	7,256,196	N/A	N/A	N/A	7,256,196
	Road Raise for Levees	2,504,300	2,408,276	1,343,916	1,707,552	4,188,618	567,756
14	**RECREATION FACILITIES [5]**						
	Recreation Facilities [5]	29,010,700	29,010,700	29,010,700	29,010,700	29,010,700	29,010,700
30	**PLANNING, ENGINEERING & DESIGN (PED)**						
	PED	181,050,700	178,213,821	169,380,422	168,642,389	166,762,383	183,518,530
	181,050,900						
31	**CONSTRUCTION MANAGEMENT (CM)**						
	CM	84,490,600	83,166,450	79,044,197	78,699,782	77,822,445	85,641,981
	84,490,420						
	Total [1 2 3 4]	**$1,744,000,000**	**$1,721,000,000**	**$1,640,000,000**	**$1,646,000,000**	**$1,675,000,000**	**$1,728,000,000**
	Compared to FRP	**N/A**	**N/A**	**-$81,000,000**	**-$75,000,000**	**-$46,000,000**	**$7,000,000**
	Compared to FRP (% Change)	**N/A**	**N/A**	**-4.9%**	**-4.6%**	**-2.7%**	**0.4%**

[1] Levee compaction crew productivity and unit cost revised inn August 2012 to address an ATR comment, causing a lower unit cost for embankment construction.
[2] PFSAA enhancement bundles not included. See Appendix I for bundle enhancement information.
[3] Connecting channel costs are based on a pro-rated cost per mile based on the cost per mile from Reach 2018 and Reach 2019 of the April 2011 FRP.
[4] Following July 31, 2012 the increase in top-of-structure elevation was incorporated as a prorated cost per vertical linear foot.
[5] Categorical cost carried forward from FRP and not revised, as directed by USACE.

APPENDIX H – EXHIBIT H2 – PFSAA COST SUMMARY FOR SOUTHERN ALIGNMENT ALTERNATIVE WORK

EXHIBIT H2 - PFSAA Cost Summary for Southern Alignment Alternative Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)

Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.
Cost shown are for work commencing east of FRP Diversion Channel Centerline Sta. 1514+00

North Dakota Diversion

Feature Code	Description	FRP Phase 4 April 2011 Project Cost	FRP August 13, 2012 Project Cost	VE13A Project Cost	VE13C Project Cost	NWRR Project Cost	OXBOW Project Cost
1	**LANDS & DAMAGES**						
	ROW and Easements - Diversion Channel (U/S of Sta. 1514+00 from Sheyenne Structure Site to Inlet Weir)	N/A	1,250,400	999,883	1,670,480	2,551,300	1,835,700
	ROW and Easements - Levee Embankments, Storage Area 1 and Connecting Channel (From Inlet Weir U/S)	N/A	35,928,700	6,612,467	7,196,660	9,852,700	59,667,100
	ROW and Easements - Upstream Storage Area (U/S of Inlet Weir)	N/A	187,684,400	208,292,250	219,039,156	259,718,800	126,976,500
	ROW and Easements - Diversion Channel	66,230,600	N/A	N/A	N/A	N/A	N/A
	ROW and Easements - Upstream Storage Area	187,684,400	N/A	N/A	N/A	N/A	N/A
2	**RELOCATIONS**						
	Roadway Bridges	20,449,800	20,449,800	19,706,400	15,901,200	12,675,600	22,201,200
	Road Raises	50,474,500	32,162,760	54,129,600	52,083,083	47,354,580	11,041,380
	Local Road Construction[5]	1,175,200	1,175,200	1,175,200	1,175,200	1,175,200	1,175,200
9	**CHANNELS AND CANALS[1 2]**						
	Reach6 - 2017 Upstream of Sta. 1514+00 (Sheyenne) to Inlet Weir	36,080,100	36,080,100	33,856,907	22,021,979	22,249,726	34,201,369
	Reach 7 - 2018	14,253,300	14,253,300	N/A	N/A	N/A	N/A
	Reach 8 - 2019	7,678,400	7,678,400	N/A	N/A	N/A	N/A
	Reach 7 and 8 Revised[3]	N/A	N/A	25,051,088	26,106,881	36,760,793	41,463,870
	Control Structure on Red River[4]	60,828,100	59,124,913	54,899,000	59,529,000	58,967,000	64,305,000
	Hydraulic Structure at Wolverton Creek	5,501,600	5,347,555	N/A	N/A	N/A	4,686,000
	Hydraulic Structure at Wild Rice River[4]	37,334,100	36,288,745	41,961,000	44,576,000	N/A	35,938,000
	Hydraulic Structure - East Weir (at Connecting Channel)	271,800	271,800	271,800	271,800	271,800	271,800
	Hydraulic Structure - Inlet Weir to Diversion	12,527,100	12,407,000	13,776,000	13,478,000	12,174,000	12,407,000
11	**LEVEES AND FLOODWALLS[1 2]**						
	Tie-Back Levee - TBL East 2B (Constructed in MN)[1]	24,981,000	23,000,000	N/A	N/A	N/A	N/A
	Tie-Back Levee - TBL Cass 17 (Constructed in ND)[1]	8,570,100	4,600,000	N/A	N/A	N/A	N/A
	Levee - Connecting Channel - Reach 2018 (ND-23, 26)[1]	2,307,500	2,800,000	N/A	N/A	N/A	N/A
	Levee - Connecting Channel - Reach 2019 (ND-25)[1]	9,538,700	11,500,000	N/A	N/A	N/A	N/A
	Embankment - CSAH17[1]	N/A	N/A	4,000,000	2,900,000	1,300,000	8,500,000
	Embankment - INLET-WRR[1]	N/A	N/A	23,900,000	27,800,000	26,600,000	see SA1
	Embankment - WRR-RRN 1	N/A	N/A	7,700,000	8,900,000	28,700,000	31,000,000
	Embankment - RRN-MN[1]	N/A	N/A	27,100,000	27,500,000	39,000,000	21,600,000
	Storage Area 1 Embankment and Inlet[1]	78,761,100	83,700,000	N/A	N/A	N/A	99,254,000
	Storage Area 1 Closure/Drainage Structure (North)	6,718,700	7,256,196	N/A	N/A	N/A	7,256,196
	Storage Area 1 Closure/Drainage Structure (East)	6,718,700	7,256,196	N/A	N/A	N/A	7,256,196
	Road Raise for Levees	2,504,300	2,408,276	1,343,916	1,707,552	4,188,618	567,756
	Southern Alignment Alternatives Subtotal[1 2 3 4]	**$641,000,000**	**$593,000,000**	**$525,000,000**	**$532,000,000**	**$564,000,000**	**$592,000,000**
	Compared to FRP	**N/A**	**N/A**	**-$68,000,000**	**-$61,000,000**	**-$29,000,000**	**-$1,000,000**
	Compared to FRP (% Change)	**N/A**	**N/A**	**-13.0%**	**-11.5%**	**-5.1%**	**-0.2%**

[1] Levee compaction crew productivity and unit cost revised inn August 2012 to address an ATR comment, causing a lower unit cost for embankment construction.
[2] PFSAA enhancement bundles not included. See Appendix I for bundle enhancement information.
[3] Connecting channel costs are based on a pro-rated cost per mile based on the cost per mile from Reach 2018 and Reach 2019 of the April 2011 FRP.
[4] Following July 31, 2012 the increase in top-of-structure elevation was incorporated as a prorated cost per vertical linear foot.
[5] Categorical cost carried forward from FRP and not revised, as directed by USACE.

APPENDIX H – EXHIBIT H3 – PFSAA DETAILED FEATURE AND COST SUMMARY FOR ALL PROJECT WORK

EXHIBIT H3 - PFSAA Detailed Feature and Cost Summary for All Project Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)

Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

Notes shown indicate revisions made since April 2011 FRP Total Project Cost Summary.

Feature Code	Description	Federally Recommended Plan (FRP) Phase 4 April 2011 Project Cost	Federally Recommended Plan (FRP) August 13, 2012 Project Cost		VE13A Project Cost		VE13C Project Cost		NWRR Project Cost		OXBOW Project Cost	
1	**LANDS & DAMAGES**											
	ROW and Easements - Diversion Channel (D/S of Sta. 1514+00 at Sheyenne River Hydraulic Structure Site)	N/A	Revised (USACE & MEI)	29,051,500	Revised (USACE & MEI)	29,051,500	Revised (USACE & MEI)	29,051,500	Revised (MEI)	29,051,500	Revised (MEI)	29,051,500
	ROW and Easements - Diversion Channel (U/S of Sta. 1514+00 from Sheyenne Structure Site to Inlet Weir)	N/A	Revised (USACE & MEI)	1,250,400	Revised (USACE & MEI)	999,883	Revised (USACE & MEI)	1,670,480	Revised (MEI)	2,551,300	Revised (MEI)	1,835,700
	ROW and Easements - Levee Embankments, Storage Area 1 and Connecting Channel (From Inlet Weir U/S)	N/A	Revised (USACE & MEI)	35,928,700	Revised (USACE & MEI)	6,612,467	Revised (USACE & MEI)	7,196,660	Revised (MEI)	9,852,700	Revised (MEI)	59,667,100
	ROW and Easements - Upstream Storage Area (U/S of Inlet Weir)	N/A	Revised (USACE & MEI)	187,684,400	Revised (USACE & MEI)	208,292,250	Revised (USACE & MEI)	219,039,156	Revised (MEI)	259,718,800	Revised (MEI)	126,976,500
	ROW and Easements - Diversion Channel	66,230,600	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	ROW and Easements - Upstream Storage Area	187,684,400	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	MITIGATION AREA EASEMENTS [5]											
	Acquisition of Aquatic Mitigation Easements [5]	10,155,600	No Change From Phase 4 FRP	10,155,600	No Change From Phase 4 FRP	10,155,600	No Change From Phase 4 FRP	10,155,600	No Change From Phase 4 FRP	10,155,600	No Change From Phase 4 FRP	10,155,600
	Acquisition of Wetlands Impacts Mitigation Easements [5]	6,287,400	No Change From Phase 4 FRP	6,287,400	No Change From Phase 4 FRP	6,287,400	No Change From Phase 4 FRP	6,287,400	No Change From Phase 4 FRP	6,287,400	No Change From Phase 4 FRP	6,287,400
	Acquisition of Riparian Forest Footprint Mitigation Easement [5]	1,253,700	No Change From Phase 4 FRP	1,253,700	No Change From Phase 4 FRP	1,253,700	No Change From Phase 4 FRP	1,253,700	No Change From Phase 4 FRP	1,253,700	No Change From Phase 4 FRP	1,253,700
2	**RELOCATIONS**											
	UTILITY RELOCATIONS [5]											
	Electric Power [5]	9,921,400	No Change From Phase 4 FRP	9,921,400	No Change From Phase 4 FRP	9,921,400	No Change From Phase 4 FRP	9,921,400	No Change From Phase 4 FRP	9,921,400	No Change From Phase 4 FRP	9,921,400
	Natural Gas Pipeline [5]	997,600	No Change From Phase 4 FRP	997,600	No Change From Phase 4 FRP	997,600	No Change From Phase 4 FRP	997,600	No Change From Phase 4 FRP	997,600	No Change From Phase 4 FRP	997,600
	Petroleum Pipelines [5]	1,016,000	No Change From Phase 4 FRP	1,016,000	No Change From Phase 4 FRP	1,016,000	No Change From Phase 4 FRP	1,016,000	No Change From Phase 4 FRP	1,016,000	No Change From Phase 4 FRP	1,016,000
	Fiber Optic Lines [5]	5,376,400	No Change From Phase 4 FRP	5,376,400	No Change From Phase 4 FRP	5,376,400	No Change From Phase 4 FRP	5,376,400	No Change From Phase 4 FRP	5,376,400	No Change From Phase 4 FRP	5,376,400
	Water Utilities [5]	2,313,000	No Change From Phase 4 FRP	2,313,000	No Change From Phase 4 FRP	2,313,000	No Change From Phase 4 FRP	2,313,000	No Change From Phase 4 FRP	2,313,000	No Change From Phase 4 FRP	2,313,000
	Sanitary Sewer [5]	369,400	No Change From Phase 4 FRP	369,400	No Change From Phase 4 FRP	369,400	No Change From Phase 4 FRP	369,400	No Change From Phase 4 FRP	369,400	No Change From Phase 4 FRP	369,400
	ROADWAY BRIDGES, ROAD RAISES RAISES & LOCAL ROAD CONSTRUCTION											
	173rd Avenue SE	3,628,800	No Change From Phase 4 FRP	3,628,800	No Change From Phase 4 FRP	3,628,800	No Change From Phase 4 FRP	3,628,800	No Change From Phase 4 FRP	3,628,800	No Change From Phase 4 FRP	3,628,800
	25th Street SE	3,654,000	No Change From Phase 4 FRP	3,654,000	No Change From Phase 4 FRP	3,654,000	No Change From Phase 4 FRP	3,654,000	No Change From Phase 4 FRP	3,654,000	No Change From Phase 4 FRP	3,654,000
	County Hwy 81 (North)	4,233,600	No Change From Phase 4 FRP	4,233,600	No Change From Phase 4 FRP	4,233,600	No Change From Phase 4 FRP	4,233,600	No Change From Phase 4 FRP	4,233,600	No Change From Phase 4 FRP	4,233,600
	Interstate 29 (NB-North)	4,699,800	No Change From Phase 4 FRP	4,699,800	No Change From Phase 4 FRP	4,699,800	No Change From Phase 4 FRP	4,699,800	No Change From Phase 4 FRP	4,699,800	No Change From Phase 4 FRP	4,699,800
	Interstate 29 (SB-North)	4,687,200	No Change From Phase 4 FRP	4,687,200	No Change From Phase 4 FRP	4,687,200	No Change From Phase 4 FRP	4,687,200	No Change From Phase 4 FRP	4,687,200	No Change From Phase 4 FRP	4,687,200
	28th Street SE	3,578,400	No Change From Phase 4 FRP	3,578,400	No Change From Phase 4 FRP	3,578,400	No Change From Phase 4 FRP	3,578,400	No Change From Phase 4 FRP	3,578,400	No Change From Phase 4 FRP	3,578,400
	31st Street SE	3,641,400	No Change From Phase 4 FRP	3,641,400	No Change From Phase 4 FRP	3,641,400	No Change From Phase 4 FRP	3,641,400	No Change From Phase 4 FRP	3,641,400	No Change From Phase 4 FRP	3,641,400
	33rd Street SE	4,485,600	No Change From Phase 4 FRP	4,485,600	No Change From Phase 4 FRP	4,485,600	No Change From Phase 4 FRP	4,485,600	No Change From Phase 4 FRP	4,485,600	No Change From Phase 4 FRP	4,485,600
	36th Street SE	4,170,600	No Change From Phase 4 FRP	4,170,600	No Change From Phase 4 FRP	4,170,600	No Change From Phase 4 FRP	4,170,600	No Change From Phase 4 FRP	4,170,600	No Change From Phase 4 FRP	4,170,600
	Interstate 94 (WB)	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400
	Interstate 94 (EB)	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400	No Change From Phase 4 FRP	4,649,400
	41st Street SE	4,447,800	No Change From Phase 4 FRP	4,447,800	No Change From Phase 4 FRP	4,447,800	No Change From Phase 4 FRP	4,447,800	No Change From Phase 4 FRP	4,447,800	No Change From Phase 4 FRP	4,447,800
	44th Street SE	3,792,600	No Change From Phase 4 FRP	3,792,600	No Change From Phase 4 FRP	3,792,600	No Change From Phase 4 FRP	3,792,600	No Change From Phase 4 FRP	3,792,600	No Change From Phase 4 FRP	3,792,600
	46th Street SE	4,132,800	No Change From Phase 4 FRP	4,132,800	No Change From Phase 4 FRP	4,132,800	No Change From Phase 4 FRP	4,132,800	No Change From Phase 4 FRP	4,132,800	No Change From Phase 4 FRP	4,132,800
	170th Avenue SE	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000
	48th Street SE	3,150,000	No Change From Phase 4 FRP	3,150,000	Revised	3,805,200	Feature Eliminated	0	Feature Eliminated	0	No Change From Phase 4 FRP	3,150,000
	52nd St. SE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	New Item	3,150,000
	Interstate 29 (SB-South)	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000
	Interstate 29 (NB-South)	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600
	County Hwy 81 (South)	4,624,200	No Change From Phase 4 FRP	4,624,200	Revised	3,225,600	Feature Eliminated	3,225,600	Feature Eliminated	0	Revised	3,225,600
	ROAD RAISES											
	Road Raise for I-29	31,739,900	Revised	24,542,280	Revised	42,632,100	Revised	44,170,258	Revised	31,425,660	Revised	5,286,960
	Road Raise for Hwy 75 over Tie-back Levee	17,599,300	Revised	6,136,200	Revised	6,332,760	Revised	6,335,860	Revised	9,258,480	Revised	302,400
	Road Raise - Rail Road over Tie-back Levee	1,135,300	Revised	1,107,540	Revised	3,331,440	Revised	1,245,586	Revised	4,823,280	Revised	501,480

EXHIBIT H3 - PFSAA Detailed Feature and Cost Summary for All Project Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)

Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

Notes shown indicate revisions made since April 2011 FRP Total Project Cost Summary.

Feature Code	Description	Federally Recommended Plan (FRP) Phase 4 April 2011 Project Cost	Federally Recommended Plan (FRP) August 13, 2012 Project Cost		VE13A Project Cost		VE13C Project Cost		NWRR Project Cost		OXBOW Project Cost	
	Road Raise - Highway 81	N/A	N/A	NA	N/A	N/A	N/A	N/A	New Item	1,520,820	N/A	N/A
	Road Raise - County Road 16	N/A	N/A	N/A	New Item	1,501,920	N/A	N/A	N/A	N/A	N/A	N/A
	Road Raise - Highway 46	N/A	N/A	NA	N/A	N/A	N/A	N/A	N/A	N/A	New Item	4,704,840
	General	N/A	New Item	376,740	New Item	331,380	New Item	331,380	New Item	326,340	New Item	245,700
	LOCAL ROAD CONSTRUCTION [5]											
	Local Road Construction [5]	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200
6	**FISH AND WILDLIFE FACILITIES [5]**											
	Aquatic Impacts Mitigation [5]	3,172,900	No Change From Phase 4 FRP	3,172,900	No Change From Phase 4 FRP	3,172,900	No Change From Phase 4 FRP	3,172,900	No Change From Phase 4 FRP	3,172,900	No Change From Phase 4 FRP	3,172,900
	Fish Bypass Channel Optimization - Red River & Wild Rice River [5]	31,941,000	No Change From Phase 4 FRP	31,941,000	No Change From Phase 4 FRP	31,941,000	No Change From Phase 4 FRP	31,941,000	No Change From Phase 4 FRP	31,941,000	No Change From Phase 4 FRP	31,941,000
	Wetland Impacts Mitigation [5]	17,290,400	No Change From Phase 4 FRP	17,290,400	No Change From Phase 4 FRP	17,290,400	No Change From Phase 4 FRP	17,290,400	No Change From Phase 4 FRP	17,290,400	No Change From Phase 4 FRP	17,290,400
	Riparian Forest Impacts Mitigation [5]	2,896,100	No Change From Phase 4 FRP	2,896,100	No Change From Phase 4 FRP	2,896,100	No Change From Phase 4 FRP	2,896,100	No Change From Phase 4 FRP	2,896,100	No Change From Phase 4 FRP	2,896,100
	Adaptive Management [5]	5,254,200	No Change From Phase 4 FRP	5,254,200	No Change From Phase 4 FRP	5,254,200	No Change From Phase 4 FRP	5,254,200	No Change From Phase 4 FRP	5,254,200	No Change From Phase 4 FRP	5,254,200
8	**ROADS, RAILROADS AND BRIDGES [5]**											
	Railroad Bridges [5]	58,586,800	No Change From Phase 4 FRP	58,586,800	No Change From Phase 4 FRP	58,586,800	No Change From Phase 4 FRP	58,586,800	No Change From Phase 4 FRP	58,586,800	No Change From Phase 4 FRP	58,586,800
9	**CHANNELS AND CANALS [1 2]**											
	Reach 1 - 2012 [5]	1,633,400	No Change From Phase 4 FRP	1,633,400	No Change From Phase 4 FRP	1,633,400	No Change From Phase 4 FRP	1,633,400	No Change From Phase 4 FRP	1,633,400	No Change From Phase 4 FRP	1,633,400
	Reach 2 - 2013 [5]	4,854,100	No Change From Phase 4 FRP	4,854,100	No Change From Phase 4 FRP	4,854,100	No Change From Phase 4 FRP	4,854,100	No Change From Phase 4 FRP	4,854,100	No Change From Phase 4 FRP	4,854,100
	Reach 3 - 2014 [5]	35,768,200	No Change From Phase 4 FRP	35,768,200	No Change From Phase 4 FRP	35,768,200	No Change From Phase 4 FRP	35,768,200	No Change From Phase 4 FRP	35,768,200	No Change From Phase 4 FRP	35,768,200
	Reach 4 - 2015 [5]	123,448,700	No Change From Phase 4 FRP	123,448,700	No Change From Phase 4 FRP	123,448,700	No Change From Phase 4 FRP	123,448,700	No Change From Phase 4 FRP	123,448,700	No Change From Phase 4 FRP	123,448,700
	Reach 5 - 2016 [5]	28,860,600	No Change From Phase 4 FRP	28,860,600	No Change From Phase 4 FRP	28,860,600	No Change From Phase 4 FRP	28,860,600	No Change From Phase 4 FRP	28,860,600	No Change From Phase 4 FRP	28,860,600
	Reach 6 - 2017 Downstream of Sta. 1514+00 (Sheyenne) [5]	173,558,300	No Change From Phase 4 FRP	173,558,300	No Change From Phase 4 FRP	173,558,300	No Change From Phase 4 FRP	173,558,300	No Change From Phase 4 FRP	173,558,300	No Change From Phase 4 FRP	173,558,300
	Reach6 - 2017 Upstream of Sta. 1514+00 (Sheyenne) to Inlet Weir	36,080,100	No Change From Phase 4 FRP	36,080,100	Revised Alignment	33,856,907	Revise Alignment	22,021,979	Revise Alignment	22,249,726	Revise Alignment	34,201,369
	Reach 7 - 2018	14,253,300	No Change From Phase 4 FRP	14,253,300	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A
	Reach 8 - 2019	7,678,400	No Change From Phase 4 FRP	7,678,400	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A
	Rech 7 and 8 Revised [3]	N/A	N/A	N/A	New Item	25,051,088	New Item	26,106,881	New Item	36,760,793	New Item	41,463,870
	Control Structure on Red River [4]	60,828,100	Revised (x1.08), Revise Levee Unit Cost	59,124,913	Revised	54,899,000	Revised	59,529,000	Revised	58,967,000	Revised	64,305,000
	Hydraulic Structure at Wolverton Creek	5,501,600	Revised (x1.08), Revise Levee Unit Cost	5,347,555	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised	4,686,000
	Hydraulic Structure at Wild Rice River [4]	37,334,100	Revised (x1.08), Revise Levee Unit Cost	36,288,745	Revised	41,961,000	Revised	44,576,000	Feature Eliminated	N/A	Revised (x1.08)	35,938,000
	Hydraulic Structure - East Weir (at Connecting Channel)	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800
	Hydraulic Structure - Inlet Weir to Diversion	12,527,100	No Change From Phase 4 FRP, Revised Levee Unit Cost	12,407,000	Revised	13,776,000	Revised	13,478,000	Revised	12,174,000	No Change From Phase 4 FRP, Revised Levee Unit Cost	12,407,000
	Hydraulic Structures at Sheyenne River [5]	64,015,300	No Change From Phase 4 FRP	64,015,300	No Change From Phase 4 FRP	64,015,300	No Change From Phase 4 FRP	64,015,300	No Change From Phase 4 FRP	64,015,300	No Change From Phase 4 FRP	64,015,300
	Hydraulic Structure - Drain 14 - Large Drain Structure [5]	10,556,500	No Change From Phase 4 FRP	10,556,500	No Change From Phase 4 FRP	10,556,500	No Change From Phase 4 FRP	10,556,500	No Change From Phase 4 FRP	10,556,500	No Change From Phase 4 FRP	10,556,500
	Hydraulic Structures at Maple River [5]	57,707,500	No Change From Phase 4 FRP	57,707,500	No Change From Phase 4 FRP	57,707,500	No Change From Phase 4 FRP	57,707,500	No Change From Phase 4 FRP	57,707,500	No Change From Phase 4 FRP	57,707,500
	Hydraulic Structures at Lower Rush River [5]	22,357,000	No Change From Phase 4 FRP	22,357,000	No Change From Phase 4 FRP	22,357,000	No Change From Phase 4 FRP	22,357,000	No Change From Phase 4 FRP	22,357,000	No Change From Phase 4 FRP	22,357,000
	Hydraulic Structures at Rush River [5]	22,314,300	No Change From Phase 4 FRP	22,314,300	No Change From Phase 4 FRP	22,314,300	No Change From Phase 4 FRP	22,314,300	No Change From Phase 4 FRP	22,314,300	No Change From Phase 4 FRP	22,314,300
	Small Drain Structures (2) [5]	320,500	No Change From Phase 4 FRP	320,500	No Change From Phase 4 FRP	320,500	No Change From Phase 4 FRP	320,500	No Change From Phase 4 FRP	320,500	No Change From Phase 4 FRP	320,500
	Large Drain Structure (1) [5]	563,700	No Change From Phase 4 FRP	563,700	No Change From Phase 4 FRP	563,700	No Change From Phase 4 FRP	563,700	No Change From Phase 4 FRP	563,700	No Change From Phase 4 FRP	563,700
	Side Channel Inlets 1x72" (19) [5]	10,650,900	No Change From Phase 4 FRP	10,650,900	No Change From Phase 4 FRP	10,650,900	No Change From Phase 4 FRP	10,650,900	No Change From Phase 4 FRP	10,650,900	No Change From Phase 4 FRP	10,650,900
	Side Channel Inlets 2x72" (7) [5]	7,134,500	No Change From Phase 4 FRP	7,134,500	No Change From Phase 4 FRP	7,134,500	No Change From Phase 4 FRP	7,134,500	No Change From Phase 4 FRP	7,134,500	No Change From Phase 4 FRP	7,134,500
	Outlet to Red River [5]	28,607,600	No Change From Phase 4 FRP	28,607,600	No Change From Phase 4 FRP	28,607,600	No Change From Phase 4 FRP	28,607,600	No Change From Phase 4 FRP	28,607,600	No Change From Phase 4 FRP	28,607,600
	Diversion Channel Landscape Plantings [5]	1,383,500	No Change From Phase 4 FRP	1,383,500	No Change From Phase 4 FRP	1,383,500	No Change From Phase 4 FRP	1,383,500	No Change From Phase 4 FRP	1,383,500	No Change From Phase 4 FRP	1,383,500
11	**LEVEES AND FLOODWALLS [1 2]**											

EXHIBIT H3 - PFSAA Detailed Feature and Cost Summary for All Project Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)
Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

Notes shown indicate revisions made since April 2011 FRP Total Project Cost Summary.

Feature Code	Description	Federally Recommended Plan (FRP) Phase 4 April 2011 Project Cost	Federally Recommended Plan (FRP) August 13, 2012 Project Cost		VE13A Project Cost		VE13C Project Cost		NWRR Project Cost		OXBOW Project Cost	
	Tie-Back Levee - TBL East 2B (Constructed in MN) [1]	24,981,000	Revised Section and Productivity	23,000,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Tie-Back Levee - TBL Cass 17 (Constructed in ND) [1]	8,570,100	Revised Section and Productivity	4,600,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Levee - Connecting Channel - Reach 2018 (ND-23, 26) [1]	2,307,500	Revised Section and Productivity	2,800,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Levee - Connecting Channel - Reach 2019 (ND-25) [1]	9,538,700	Revised Section and Productivity	11,500,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Embankment - CSAH17 [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	4,000,000	Revised Section, Alignment and Productivity	2,900,000	Revised Section, Alignment and Productivity	1,300,000	Revised Section, Alignment and Productivity	8,500,000
	Embankment - INLET-WRR [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	23,900,000	Revised Section, Alignment and Productivity	27,800,000	Revised Section, Alignment and Productivity	26,600,000	Revised Section, Alignment and Productivity	see SA1
	Embankment - WRR-RRN [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	7,700,000	Revised Section, Alignment and Productivity	8,900,000		28,700,000	Revised Section, Alignment and Productivity	31,000,000
	Embankment - RRN-MN [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	27,100,000	Revised Section, Alignment and Productivity	27,500,000	Revised Section, Alignment and Productivity	39,000,000	Revised Section, Alignment and Productivity	21,600,000
	Storage Area 1 Embankment and Inlet [1]	78,761,100	Revised (x1.08), Revise Levee Unit Cost	83,700,000	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised	99,254,000
	Storage Area 1 Closure/Drainage Structure (North)	6,718,700	Revised (x1.08)	7,256,196	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised (x1.08)	7,256,196
	Storage Area 1 Closure/Drainage Structure (East)	6,718,700	Revised (x1.08)	7,256,196	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised (x1.08)	7,256,196
	Road Raise for Levees	2,504,300	Revised	2,408,276	Revised	1,343,916	Revised	1,707,552	Revised	4,188,618	Revised	567,756
14	**RECREATION FACILITIES [5]**											
	Recreation Facilities [5]	29,010,700	No Change From Phase 4 FRP	29,010,700	No Change From Phase 4 FRP	29,010,700	No Change From Phase 4 FRP	29,010,700	No Change From Phase 4 FRP	29,010,700	No Change From Phase 4 FRP	29,010,700
30	**PLANNING, ENGINEERING & DESIGN (PED)**											
	PED	181,050,700	Use 15% (Ph4)	178,213,821	Use 15% (Ph4)	169,380,422	Use 15% (Ph4)	168,642,389	Use 15% (Ph4)	166,762,383	Use 15% (Ph4)	183,518,530
31	**CONSTRUCTION MANAGEMENT (CM)**											
	CM	84,490,600	Use 7% (Ph4)	83,166,450	Use 7% (Ph4)	79,044,197	Use 7% (Ph4)	78,699,782	Use 7% (Ph4)	77,822,445	Use 7% (Ph4)	85,641,981
	Total	**$ 1,744,000,000**	**$**	**1,721,000,000**	**$**	**1,640,000,000**	**$**	**1,646,000,000**	**$**	**1,675,000,000**	**$**	**1,728,000,000**
		FRP - April 2011 Project Cost	**FRP - Revised Project Cost**		**VE13A Project Cost**		**VE13C Project Cost**		**NWRR Project Cost**		**OXBOW Project Cost**	

[1] Levee compaction crew productivity and unit cost revised inn August 2012 to address an ATR comment, causing a lower unit cost for embankment construction.

[2] PFSAA enhancement bundles not included. See Appendix I for bundle enhancement information.

[3] Connecting channel costs are based on a pro-rated cost per mile based on the cost per mile from Reach 2018 and Reach 2019 of the April 2011 FRP.

[4] Following July 31, 2012 the increase in top-of-structure elevation was incorporated as a prorated cost per vertical linear foot.

[5] Categorical cost carried forward from FRP and not revised, as directed by USACE.

APPENDIX H – EXHIBIT H4 – PFSAA DETAILED FEATURE AND COST SUMMARY FOR ALL PROJECT WORK

EXHIBIT H4 - PFSAA Detailed Feature and Cost Summary for Southern Alignment Alternative Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)

Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

Notes shown indicate revisions made since April 2011 FRP Total Project Cost Summary.

Feature Code	Description	Federally Recommended Plan (FRP) Phase 4 April 2011 Project Cost	Federally Recommended Plan (FRP) August 13, 2012 Project Cost		VE13A Project Cost		VE13C Project Cost		NWRR Project Cost		OXBOW Project Cost	
1	LANDS & DAMAGES											
	ROW and Easements - Diversion Channel (U/S of Sta. 1514+00 from Sheyenne Structure Site to Inlet Weir)	N/A	Revised (USACE & MEI)	1,250,400	Revised (USACE & MEI)	999,883	Revised (USACE & MEI)	1,670,480	Revised (MEI)	2,551,300	Revised (MEI)	1,835,700
	ROW and Easements - Levee Embankments, Storage Area 1 and Connecting Channel (From Inlet Weir U/S)	N/A	Revised (USACE & MEI)	35,928,700	Revised (USACE & MEI)	6,612,467	Revised (USACE & MEI)	7,196,660	Revised (MEI)	9,852,700	Revised (MEI)	59,667,100
	ROW and Easements - Upstream Storage Area (U/S of Inlet Weir)	N/A	Revised (USACE & MEI)	187,684,400	Revised (USACE & MEI)	208,292,250	Revised (USACE & MEI)	219,039,156	Revised (MEI)	259,718,800	Revised (MEI)	126,976,500
	ROW and Easements - Diversion Channel	66,230,600	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	ROW and Easements - Upstream Storage Area	187,684,400	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	RELOCATIONS											
	ROADWAY BRIDGES, ROAD RAISES RAISES & LOCAL ROAD CONSTRUCTION											
	170th Avenue SE	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000	No Change From Phase 4 FRP	3,465,000
	48th Street SE	3,150,000	No Change From Phase 4 FRP	3,150,000	Revised	3,805,200	Feature Eliminated	0	Feature Eliminated	0	No Change From Phase 4 FRP	3,150,000
	52nd St. SE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	New Item	3,150,000
	Interstate 29 (SB-South)	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000	No Change From Phase 4 FRP	4,599,000
	Interstate 29 (NB-South)	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600	No Change From Phase 4 FRP	4,611,600
	County Hwy 81 (South)	4,624,200	No Change From Phase 4 FRP	4,624,200	Revised	3,225,600	Feature Eliminated	3,225,600	Feature Eliminated	0	Revised	3,225,600
	ROAD RAISES											
	Road Raise for I-29	31,739,900	Revised	24,542,280	Revised	42,632,100	Revised	44,170,258	Revised	31,425,660	Revised	5,286,960
	Road Raise for Hwy 75 over Tie-back Levee	17,599,300	Revised	6,136,200	Revised	6,332,760	Revised	6,335,860	Revised	9,258,480	Revised	302,400
	Road Raise - Rail Road over Tie-back Levee	1,135,300	Revised	1,107,540	Revised	3,331,440	Revised	1,245,586	Revised	4,823,280	Revised	501,480
	Road Raise - Highway 81	N/A	N/A	NA	N/A	N/A	N/A	N/A	New Item	1,520,820	N/A	N/A
	Road Raise - County Road 16	N/A	N/A	N/A	New Item	1,501,920	N/A	N/A	N/A	N/A	N/A	N/A
	Road Raise - Highway 46	N/A	N/A	NA	N/A	N/A	N/A	N/A	N/A	N/A	New Item	4,704,840
	General	N/A	New Item	376,740	New Item	331,380	New Item	331,380	New Item	326,340	New Item	245,700
	LOCAL ROAD CONSTRUCTION [5]											
	Local Road Construction [5]	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200	N/A	1,175,200
9	CHANNELS AND CANALS [1 2]											
	Reach6 - 2017 Upstream of Sta. 1514+00 (Sheyenne) to Inlet Weir	36,080,100	No Change From Phase 4 FRP	36,080,100	Revised Alignment	33,856,907	Revise Alignment	22,021,979	Revise Alignment	22,249,726	Revise Alignment	34,201,369
	Reach 7 - 2018	14,253,300	No Change From Phase 4 FRP	14,253,300	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A
	Reach 8 - 2019	7,678,400	No Change From Phase 4 FRP	7,678,400	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A
	Rech 7 and 8 Revised [3]	N/A	N/A	N/A	New Item	25,051,088	New Item	26,106,881	New Item	36,760,793	New Item	41,463,870
	Control Structure on Red River [4]	60,828,100	Revised (x1.08), Revise Levee Unit Cost	59,124,913	Revised	54,899,000	Revised	59,529,000	Revised	58,967,000	Revised	64,305,000
	Hydraulic Structure at Wolverton Creek	5,501,600	Revised (x1.08), Revise Levee Unit Cost	5,347,555	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised	4,686,000
	Hydraulic Structure at Wild Rice River [4]	37,334,100	Revised (x1.08), Revise Levee Unit Cost	36,288,745	Revised	41,961,000	Revised	44,576,000	Feature Eliminated	N/A	Revised (x1.08)	35,938,000
	Hydraulic Structure - East Weir (at Connecting Channel)	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800	No Change From Phase 4 FRP	271,800
	Hydraulic Structure - Inlet Weir to Diversion	12,527,100	No Change From Phase 4 FRP, Revised Levee Unit Cost	12,407,000	Revised	13,776,000	Revised	13,478,000	Revised	12,174,000	No Change From Phase 4 FRP, Revised Levee Unit Cost	12,407,000
11	LEVEES AND FLOODWALLS [1 2]											
	Tie-Back Levee - TBL East 2B (Constructed in MN) [1]	24,981,000	Revised Section and Productivity	23,000,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Tie-Back Levee - TBL Cass 17 (Constructed in ND) [1]	8,570,100	Revised Section and Productivity	4,600,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Levee - Connecting Channel - Reach 2018 (ND-23, 26) [1]	2,307,500	Revised Section and Productivity	2,800,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Levee - Connecting Channel - Reach 2019 (ND-25) [1]	9,538,700	Revised Section and Productivity	11,500,000	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A	Deleted and Replace w/ New Reach	N/A
	Embankment - CSAH17 [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	4,000,000	Revised Section, Alignment and Productivity	2,900,000	Revised Section, Alignment and Productivity	1,300,000	Revised Section, Alignment and Productivity	8,500,000
	Embankment - INLET-WRR [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	23,900,000	Revised Section, Alignment and Productivity	27,800,000	Revised Section, Alignment and Productivity	26,600,000	Revised Section, Alignment and Productivity	see SA1
	Embankment - WRR-RRN [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	7,700,000	Revised Section, Alignment and Productivity	8,900,000		28,700,000	Revised Section, Alignment and Productivity	31,000,000

EXHIBIT H4 - PFSAA Detailed Feature and Cost Summary for Southern Alignment Alternative Work

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis (PFSAA)

Fargo-Moorhead Metro Flood Risk Management Project

Notes: Costs shown include contingency (26%). Costs shown do not include escalation, O&M.

Notes shown indicate revisions made since April 2011 FRP Total Project Cost Summary.

Feature Code	Description	Federally Recommended Plan (FRP) Phase 4 April 2011 Project Cost	Federally Recommended Plan (FRP) August 13, 2012 Project Cost		VE13A Project Cost		VE13C Project Cost		NWRR Project Cost		OXBOW Project Cost	
	Embankment - RRN-MN [1]	N/A	N/A	N/A	Revised Section, Alignment and Productivity	27,100,000	Revised Section, Alignment and Productivity	27,500,000	Revised Section, Alignment and Productivity	39,000,000	Revised Section, Alignment and Productivity	21,600,000
	Storage Area 1 Embankment and Inlet [1]	78,761,100	Revised (x1.08), Revise Levee Unit Cost	83,700,000	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised	99,254,000
	Storage Area 1 Closure/Drainage Structure (North)	6,718,700	Revised (x1.08)	7,256,196	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised (x1.08)	7,256,196
	Storage Area 1 Closure/Drainage Structure (East)	6,718,700	Revised (x1.08)	7,256,196	Feature Eliminated	N/A	Feature Eliminated	N/A	Feature Eliminated	N/A	Revised (x1.08)	7,256,196
	Road Raise for Levees	2,504,300	Revised	2,408,276	Revised	1,343,916	Revised	1,707,552	Revised	4,188,618	Revised	567,756
	Total	**$ 641,000,000**	**$**	**593,000,000**	**$**	**525,000,000**	**$**	**532,000,000**	**$**	**564,000,000**	**$**	**592,000,000**
		FRP - April 2011 Project Cost	**FRP - Revised Project Cost**		**VE13A Project Cost**		**VE13C Project Cost**		**NWRR Project Cost**		**OXBOW Project Cost**	

[1] Levee compaction crew productivity and unit cost revised inn August 2012 to address an ATR comment, causing a lower unit cost for embankment construction.

[2] PFSAA enhancement bundles not included. See Appendix I for bundle enhancement information.

[3] Connecting channel costs are based on a pro-rated cost per mile based on the cost per mile from Reach 2018 and Reach 2019 of the April 2011 FRP.

[4] Following July 31, 2012 the increase in top-of-structure elevation was incorporated as a prorated cost per vertical linear foot.

[5] Categorical cost carried forward from FRP and not revised, as directed by USACE.

APPENDIX H – EXHIBIT H5 – USACE ESTIMATED COSTS FOR FRP DAM VS. LEVEE

Exhibit H5 - FMM - USACE Estimated Costs for FRP Dam vs Levee Design

Technical Memorandum: FM Diversion Post-Feasibility Analysis VE-13

USACE 29-March 2012; paraphrased by Barr 30-July 2012

	Feasibility	Dam w/ 4' Freeboard		Dam w/ 5' Freeboard	
Embankment Section	Top Elev. 928.0	Top Elev. 929.2	Difference from Feasibility	Top Elev. 930.2	Difference from Feasibility
MN Tie-Back Levee	$ 12,521,220	$ 14,861,550	$ 2,340,330	$ 16,972,400	$ 4,451,180
ND Tie-Back Embankment	$ 10,281,270	$ 15,241,390	$ 4,960,120	$ 16,748,085	$ 6,466,815
CR 17 Tie-Back Levee	$ 5,816,970	$ 7,056,145	$ 1,239,175	$ 8,182,860	$ 2,365,890
Storage Area Embankment (W,N,E)	$ 28,623,125	$ 42,529,800	$ 13,906,675	$ 46,870,275	$ 18,247,150
Subotal	$ 57,242,585	$ 79,688,885	$ 22,446,300	$ 88,773,620	$ 31,531,035
Difference from Feasibility		$ 22,446,300		$ 31,531,035	

Estimate is for stripping and stockpiling topsoil, excavation, hauling, placement and compaction of Levee material, and placing topsoil. Other common items of work such as Site Preparation and Traffic Contro Temporary Erosion and Sedimentation Control, Site Restoration, Inspection Trench, Aggregate Base for Access Roads, Road Raises, Dewatering and Control of Water and other miscelleneous minor items of work are not included in the above estimate numbers but should be approximately constant for each respective embankment scenario. Values shown do not include 0.85 ECY/BCY factor or contingency. Note that feasibility Phase 4 LPP top-of-embankments was elev. 927.0.

For full report w/ details see the white paper by USACE entitled FMM Dam vs. Levee Design Criteria Document dated March 2012.

APPENDIX H – EXHIBIT H6 – PFSAA ROAD RAISE COST SUMMARY

Exhibit H6 - PFSAA Road Raise Cost Summary

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis VE-13

Fargo-Moorhead Metro Flood Risk Management Project

Federally Recommended Plan (FRP) costs are Phase 4 - LPP Costs Presented in 20-Apr-2011 TPCS provided by USACE.

Estimated Costs for Upstream (east) of Sta. 1514+00 (Sheyenne River Structure)

Item	Description	FRP Phase 4 Estimated Cost	VE13A Estimated Cost	VE13C Estimated Cost	NWRR Estimated Cost	OXBOW Estimated Cost
2	**RELOCATIONS**					
	ROAD RAISES					
	I-29 Road Raise	19,478,000	33,835,000	35,055,760	24,941,000	4,196,000
	Hwy 75 Road Raise	4,870,000	5,026,000	5,028,460	7,348,000	240,000
	Rail Raise	879,000	2,644,000	988,560	3,828,000	398,000
	General	299,000	263,000	263,000	259,000	195,000
	Hwy 81 Road Raise	N/A	N/A	N/A	1,207,000	N/A
	CR 16 Road Realignment	N/A	1,192,000	N/A	N/A	N/A
	CR 18 Road Raise	N/A	N/A	N/A	N/A	N/A
	Hwy 46 Road Raise	N/A	N/A	N/A	N/A	3,734,000
	Subtotal	25,526,000	42,960,000	41,335,780	37,583,000	8,763,000
	Contingency (26%)	6,636,760	11,169,600	10,747,303	9,771,580	2,278,380
	Total	**32,162,760**	**54,129,600**	**52,083,083**	**47,354,580**	**11,041,380**
11	**LEVEES AND FLOODWALLS**					
	ROAD RAISE FOR LEVEES					
	RRN-MN Hwy 75	344,250	0	0	0	0
	RRN-MN RR	354,500	0	0	0	0
	RRN-MN 14th St S	0	0	0	484,600	0
	RRN-MN 28th St S	271,800	311,000	493,200	503,200	29,000
	RRN-MN CR 7	118,800	179,800	306,000	232,400	30,000
	RRN-MN CR 61	0	28,000	28,000	71,600	0
	RRN-MN 60th St S	0	0	0	108,800	0
	RRN-MN CR59	345,400	489,200	479,600	0	178,800
	RRN-MN 170th Ave S	0	0	0	0	32,400
	RRN-MN 50th St S	75,700	0	0	0	0
	RRN-MN PD (off CR 59)	2,400	0	0	0	0
	RRN-MN 130th Ave S (at 75)	134,100	0	0	0	0
	RRN-MN 130th Ave S (at RR)	179,400	0	0	0	0
	RRN-MN PD (off 130 Ave E of RR)	3,830	0	0	0	0
	CR-17 124 Ave	40,100	0	0	0	0
	CR-17 49 Ave	21,000	0	0	0	69,600
	CR-17 50 Ave	10,500	0	0	0	0
	CR-17 51 Ave	9,550	0	0	0	0
	CR-17 47 St	0	0	22,400	0	0
	CR-17 CR 16	0	28,000	15,800	0	71,600
	CR-17 49th St	0	22,400	10,200	15,800	0
	CR-17 50th St	0	8,200	0	0	23,400
	CR-17 51st St	0	0	0	0	15,800
	WRR-RRN CR 14	0	0	0	677,400	0
	WRR-RRN CR 81	0	0	0	1,230,500	0
	Subtotal	1,911,330	1,066,600	1,355,200	3,324,300	450,600
	Contingency (26%)	496,946	277,316	352,352	864,318	117,156
	Total	**2,408,276**	**1,343,916**	**1,707,552**	**4,188,618**	**567,756**

APPENDIX H – EXHIBIT H7 – PFSAA BRIDGE COST SUMMARY

Exhibit H7 - PFSAA Bridge Cost Summary

October 10, 2012

Technical Memorandum: FM Diversion Post-Feasibility Analysis VE-13

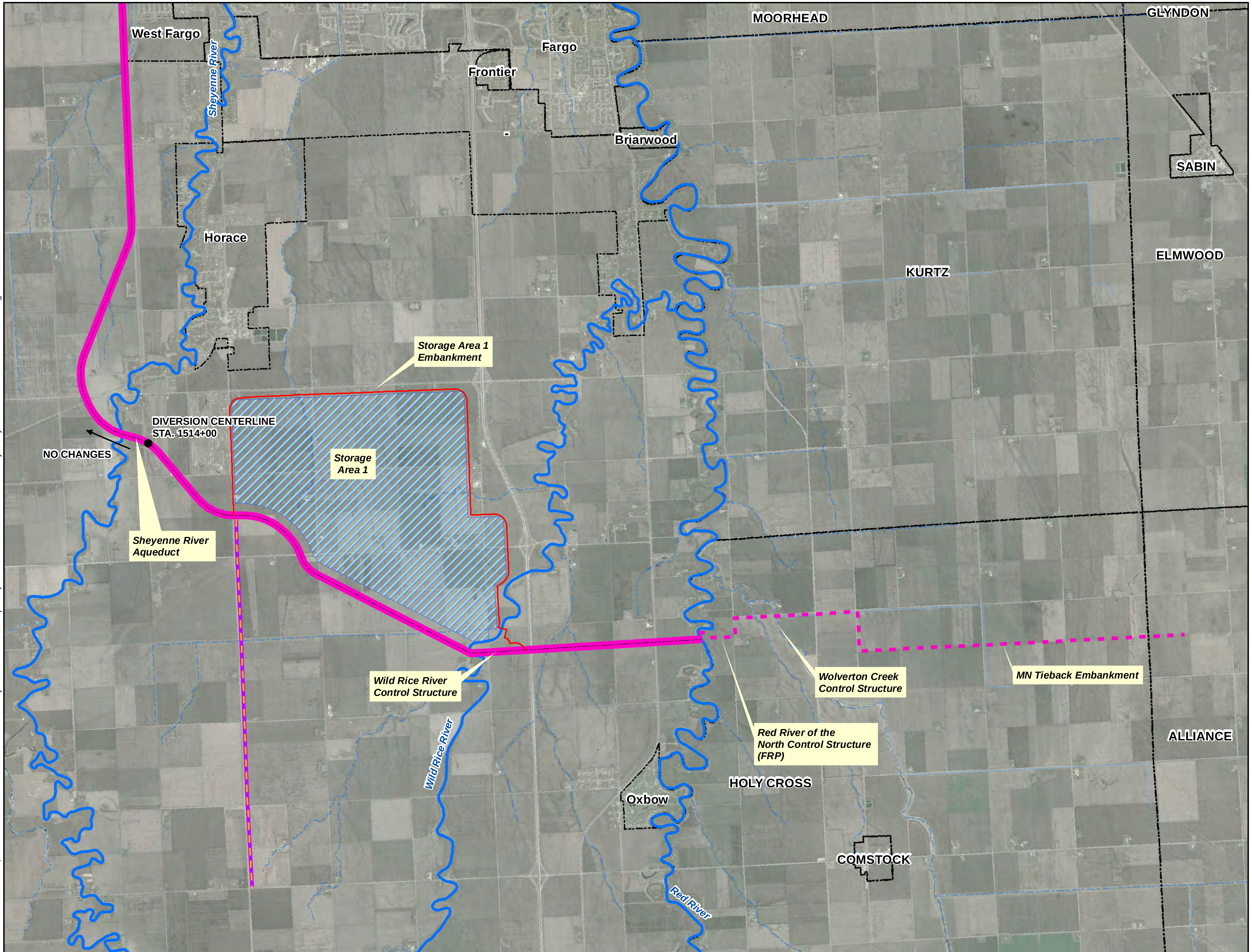
Fargo-Moorhead Metro Flood Risk Management Project

Federally Recommended Plan (FRP) costs are Phase 4 - LPP Costs Presented in 20-Apr-2011 TPCS provided by USACE.

Estimated Costs for Roadway Bridges (All Project Work)

Item	Description	FRP Phase 4 Estimated Cost	VE13A Estimated Cost	VE13C Estimated Cost	NWRR Estimated Cost	OXBOW Estimated Cost
U/S of Sta. 1514+00	County Road 81	3,670,000	2,560,000	2,560,000		2,560,000
	Interstate 29 North Bound	3,660,000	3,660,000	3,660,000	3,660,000	3,660,000
	Interstate 29 South Bound	3,650,000	3,650,000	3,650,000	3,650,000	3,650,000
	52nd St. SE	0	0	0	0	2,500,000
	48th St. SE	2,500,000	3,020,000	0	0	2,500,000
	170th Ave. SE	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000
	Subtotal	16,230,000	15,640,000	12,620,000	10,060,000	17,620,000
	Contingency (26%)	4,219,800	4,066,400	3,281,200	2,615,600	4,581,200
	Extension	20,449,800	19,706,400	15,901,200	12,675,600	22,201,200
D/S of Sta. 1514+00	46th St. SE	3,280,000	3,280,000	3,280,000	3,280,000	3,280,000
	44th St. SE	3,010,000	3,010,000	3,010,000	3,010,000	3,010,000
	41st St. SE	3,530,000	3,530,000	3,530,000	3,530,000	3,530,000
	Interstate 94 East Bound	3,690,000	3,690,000	3,690,000	3,690,000	3,690,000
	Interstate 94 West Bound	3,690,000	3,690,000	3,690,000	3,690,000	3,690,000
	36th St. SE	3,310,000	3,310,000	3,310,000	3,310,000	3,310,000
	33rd St. SE	3,560,000	3,560,000	3,560,000	3,560,000	3,560,000
	31st St. SE	2,890,000	2,890,000	2,890,000	2,890,000	2,890,000
	28th St. SE	2,840,000	2,840,000	2,840,000	2,840,000	2,840,000
	Interstate 29 South Bound	3,720,000	3,720,000	3,720,000	3,720,000	3,720,000
	Interstate 29 North Bound	3,730,000	3,730,000	3,730,000	3,730,000	3,730,000
	County Road 81	3,360,000	3,360,000	3,360,000	3,360,000	3,360,000
	25th St. SE	2,900,000	2,900,000	2,900,000	2,900,000	2,900,000
	173rd Ave. SE	2,880,000	2,880,000	2,880,000	2,880,000	2,880,000
	Subtotal	46,390,000	46,390,000	46,390,000	46,390,000	46,390,000
	Contingency (26%)	12,061,400	12,061,400	12,061,400	12,061,400	12,061,400
	Extension	58,451,400	58,451,400	58,451,400	58,451,400	58,451,400
	Total	78,901,200	78,157,800	74,352,600	71,127,000	80,652,600

APPENDIX H – EXHIBIT H9 – (MAP) FRP ALIGNMENT



North Dakota Diversion Federal Recommended Plan (FRP)
FRP Tieback Levee
CR 17 Tieback Levee
Storage Area 1

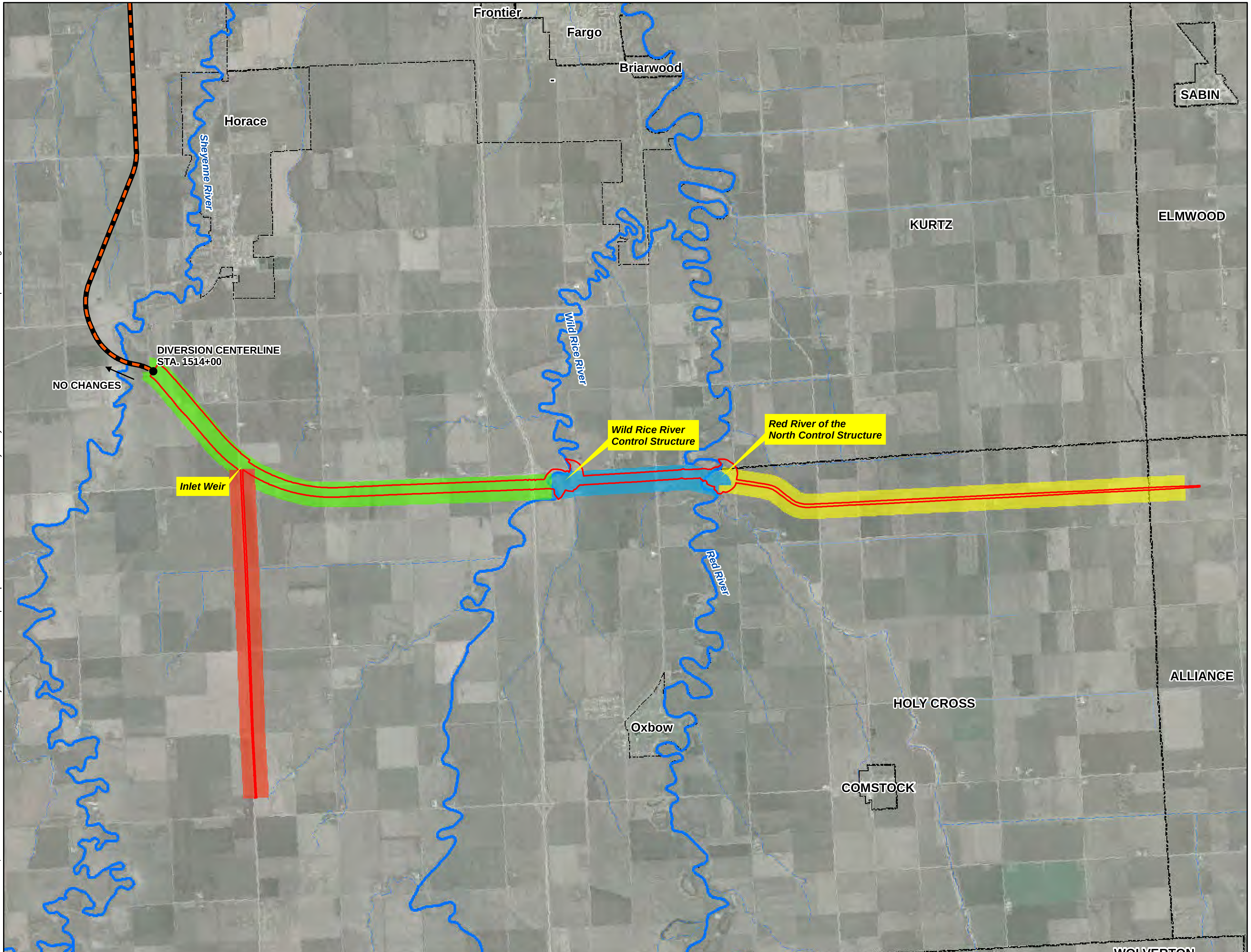
N

0 2,900 5,800 11,600
Feet

Exhibit H9

FRP Alignment
Fargo - Moorhead Area

APPENDIX H – EXHIBIT H10 – (MAP) VE13 OPTION A ALIGNMENT



VE13 Option A Alignment (Same as FRP)
VE13 Option A Alignment Permanent ROW

Project Reach

- CSAH17
- RRN-MN
- SH-WRR
- WRR-RRN

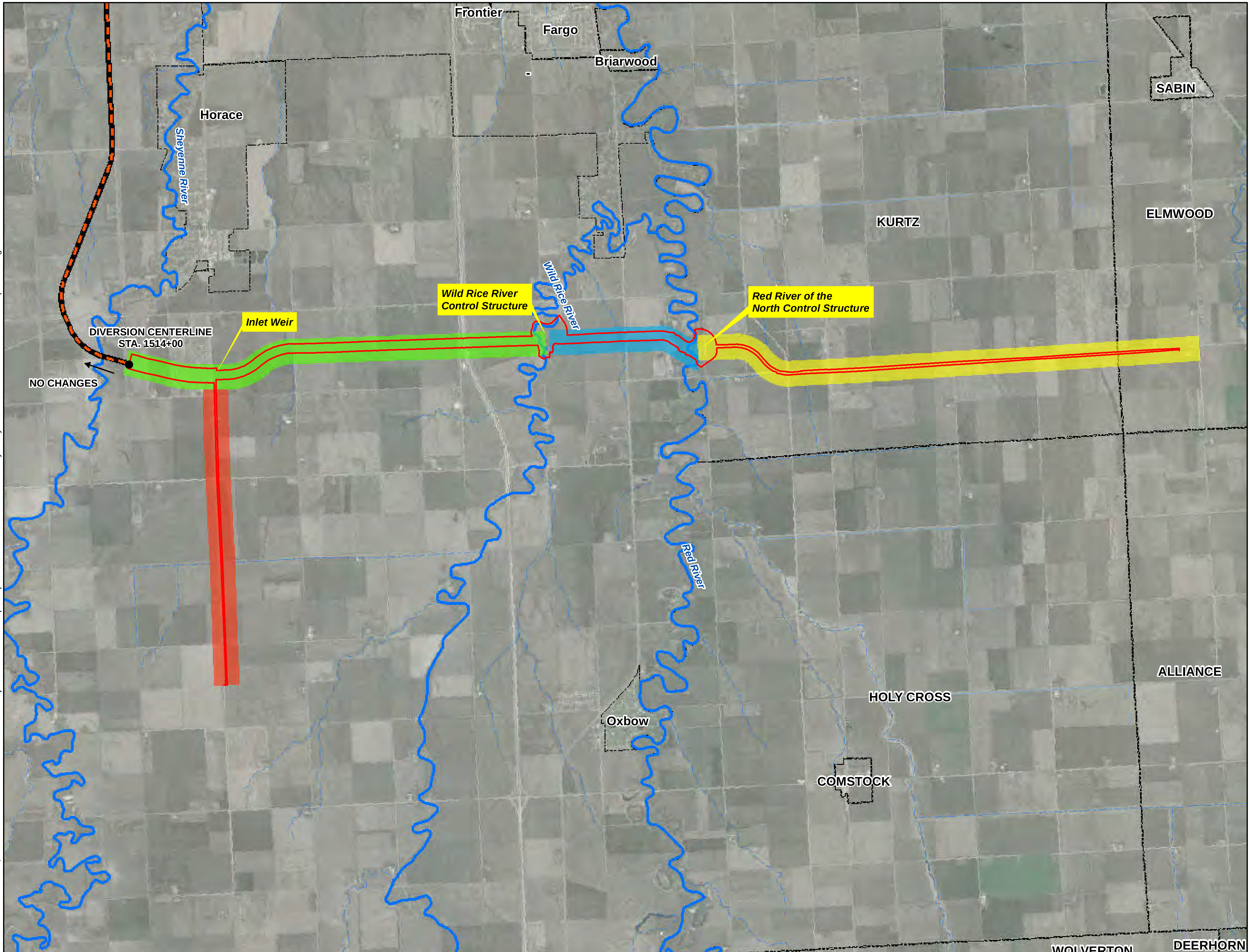
N

0 2,900 5,800 11,600
Feet

Exhibit H10

VE13 Option A Alignment
Fargo - Moorhead Area

APPENDIX H – EXHIBIT H11 – (MAP) VE13 OPTION C ALIGNMENT



VE13 Option C Alignment (Same as FRP)

VE13 Option C Alignment Permanent ROW

Project Reach

- CSAH17
- RRN-MN
- SH-WRR
- WRR-RRN

N

0 2,900 5,800 11,600

Feet

Exhibit H11

VE13 Option C Alignment
Fargo - Moorhead Area

APPENDIX H – EXHIBIT H12 – (MAP) SOUTH OF OXBOW ALIGNMENT

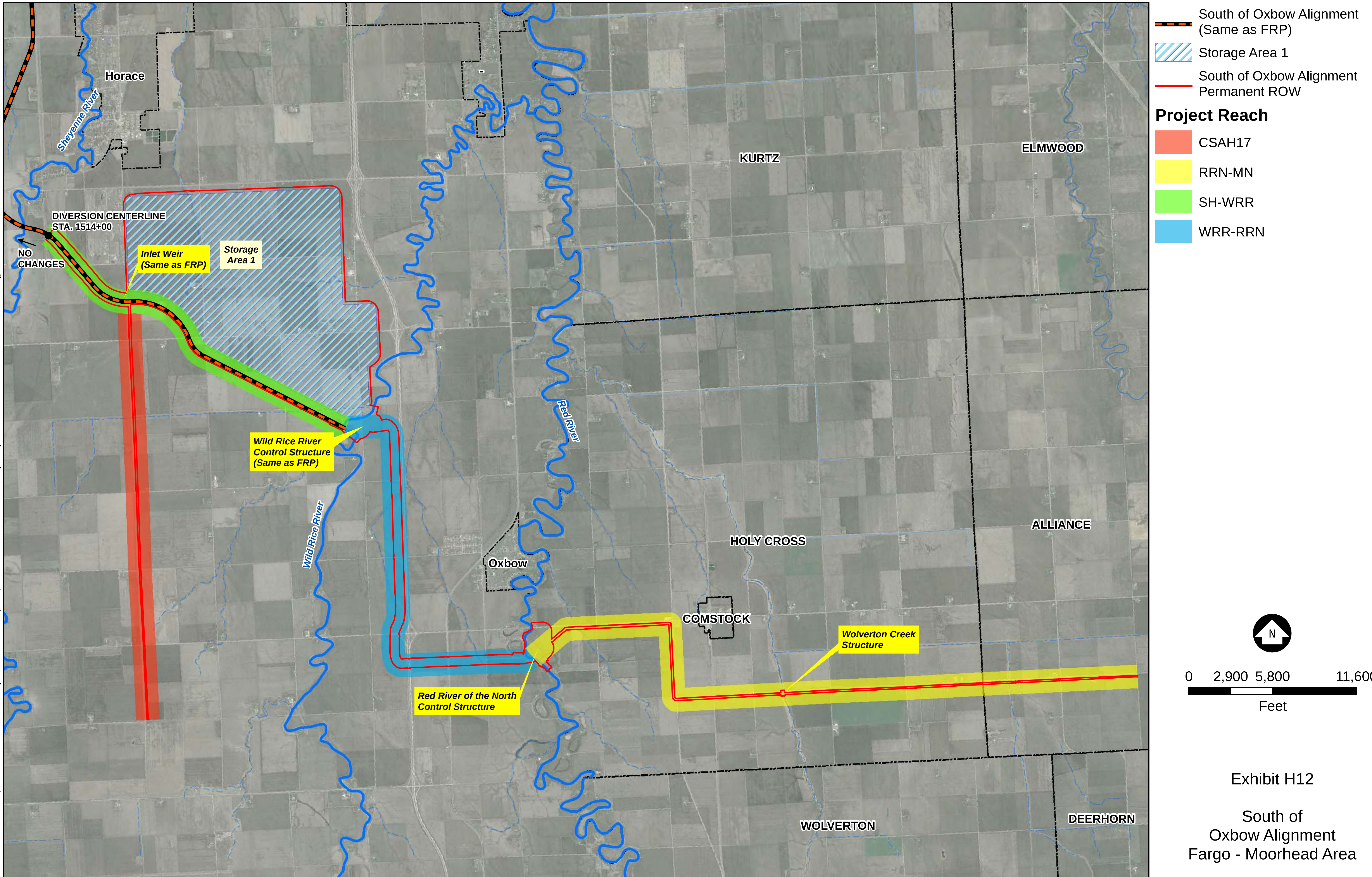
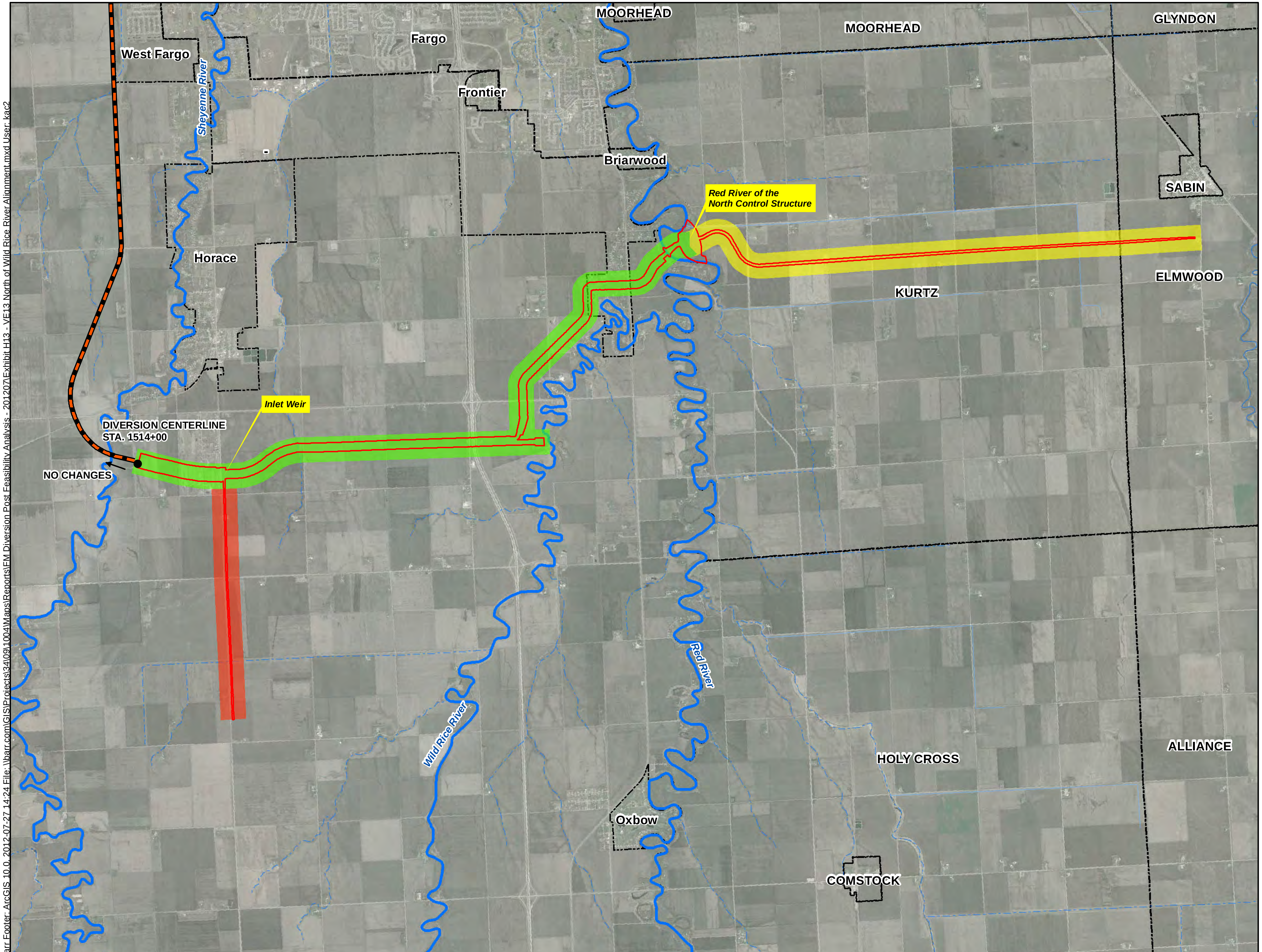


Exhibit H12

South of Oxbow Alignment
Fargo - Moorhead Area

APPENDIX H – EXHIBIT H13 – (MAP) NORTH OF WILD RICE RIVER ALIGNMENT



North WRR Alignment (Same as FRP)

North WRR Alignment Permanent ROW

Project Reach

- CSAH17
- RRN-MN
- SH-RRN
- WRR-RRN

N

0 2,900 5,800 11,600
Feet

Exhibit H13

North of Wild Rice River Alignment
Fargo - Moorhead Area

APPENDIX I – ASSESSMENT FACTORS

I.1 ASSESSMENT FACTORS

This appendix to the FM Diversion Post-Feasibility Southern Alignment Analysis (PFSAA) is intended to provide a qualitative and quantitative assessment of feasibility-level assessment factors used for the alternatives. The assessment compares the value of alternatives to that of the FRP. Value is defined as:

> "…the relationship between functions and resources where function is measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish that function. Therefore, this process focuses on creating a best value solution by identifying the most resource efficient way to reliably accomplish the functions that meet the performance expectations for the project" as defined by USACE in Report No. CEMVP-VE-FY12-02_FMM Outlet, *Value Based Design Charrette, Outlet Structure & Diversion Reach 1,* dated December 2011.

In the context of the PFSAA, seven categorical assessment factors were identified by the working group to characterize the function and performance requirements of the southern alignment alternatives. Assessment factor weighting and scoring was developed by the working group to compare relative ranking of the functionality portion of the value definition. Estimated construction cost was used to characterize the resources invested. In this way, this assessment aims to characterize "value" as defined, for comparing the alternatives versus the FRP. These factors were developed in cooperation with the USACE and the working group at two workshop meetings during 2012.

The purpose of the assessment is to evaluate the various southern alignment alternatives and to aid in determining which alignment and features best meet project objectives and provide the greatest value. In a project as complex as the Fargo-Moorhead Diversion, cost alone does not adequately capture the differences between alternatives. Rather, multiple criteria must be considered when evaluating the alignment alternatives and then considered with cost. The intent of this Appendix is to provide decision makers with an assessment of these criteria and estimated costs alternatives to aid in selecting a preferred southern alignment. The seven factors developed to represent the criteria for consideration of southern alignment alternatives at the June 19, 2012 VE-13 workshop, and modified during the August 2, 2012 LSLCTT meeting and August 15-16, 2012 LSLCTT Integration Workshop include:

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

A discussion of key assessment criteria identified and comparative data, where available, are presented in the following sections for the base alternatives, which do not include enhancement "bundles". These base alternatives are discussed in more detail in the main PFSAA report:

1. Federally Recommended Plan (FRP)
2. VE-13 Option A (VE13A)
3. VE-13 Option C (VE13C)
4. North of Wild Rice River (NWRR)
5. South of Oxbow (OXBOW)

Appendix I also includes consideration of PFSAA enhancement bundles, which consist of a set of features that are added to individual southern alignment alternative base cases. Development of the bundles is in response to several studies related to potential modifications to the design and operation of the diversion project which have taken place since the completion of the Feasibility Study and FEIS. These post feasibility studies include the following:

- Flows Through Flood Damage Reduction Area (July 16, 2012)
- Diversion Inlet Gate Analysis (Draft, August 7, 2012)
- Land Management Improvements Evaluation No.1

More details about these studies can be found in Section 6 of the PFSAA main report. The assessment of alignment options in Appendix I was completed based on the following "Bundles".

- Federally Recommended Plan (FRP) alignment plus increased flow through flood damage reduction area and gated inlet structure.
- VE-13A (VE13A) alignment plus increased flow through flood damage reduction area and gated inlet structure.
- VE-13C (VE13C) alignment plus increased flow through flood damage reduction area and gated inlet structure.
- North of Wild Rice River (NWRR) alignment plus increased flow through flood damage reduction area and gated inlet structure.
- North of Wild Rice River (NWRR+OXBOW Levee) alignment plus increased flow flood damage reduction area, gated inlet structure, and levee for Oxbow, Hickson, and Bakke Subdivision.
- South of Oxbow (OXBOW) alignment plus increased flow through flood damage reduction area and gated inlet structure.

I.2 ASSESSMENT CRITERIA

The following assessment criteria were identified and developed at the June 19, 2012 VE-13 workshop, August 2, 2012 LSLCTT meeting, and August 15-16, 2012 LSLCTT Integration Workshop during a combined (Local Sponsor and USACE) group exercise. Seven factors identified to represent the assessment criteria, as well as estimated cost, should be evaluated when considering southern alignment alternatives and selecting a preferred alignment.

1. Risk Reduction Considerations
2. Implementability
3. Property Impacts (Number of Residential Structures)
4. Environmental Considerations
5. Property Impacts (Number of Acres)
6. Floodplain Considerations
7. Transportation Safety Considerations

I.2.1 RISK REDUCTION CONSIDERATIONS

Limiting risk to the public by constructing a system that limits risk of failure of critical features is important to consider when evaluating alternatives. Once constructed, the project will be in operation for many years. Long term risk considerations are necessary to evaluate alternatives.

Risk characterization generally considers the risk of failure or robustness of an alternative, and the consequences that could result from a possible failure. The lowest cost or easiest to construct alternative is not necessarily the most favorable from a risk-management perspective. Increased risk exists where, for a given set of alignment features, the flood risk reduction features have a greater potential exposure to the risk of being compromised and ultimately failing. The risk is greater where a potential failure can cause greater loss of life or damage to property.

Risk factors identified during the workshops with input from Diversion Authority and USACE representatives were not intended to be a complete list of all potential risk factors. However, for a relative comparison of alternatives, the risk factors considered in this assessment provide a preliminary characterization of initiators and failure mechanisms, with consequence of failure being equally high for all alternatives. This assessment does not replace or supersede a more formal Potential Failure Mode Analysis (PFMA), which was outside the scope of the analysis agreed upon by the working group.

For comparison of risk, several big-picture risk parameters were identified for consideration as risk factors. This scoping of the risk characterization was performed by the working group during the June 19, 2012 VE-13 workshop, August 2, 2012 LSLCTT meeting and August 15-16, 2012 LSLCTT Integration Workshop. The risk factors identified include:

- Length and height of embankment (and potential depth of water along the face of embankment)
- Difference in headwater to tailwater across hydraulic closure structures and height of the hydraulic structures
- Number of hydraulic structures requiring human intervention for flood risk reduction
- Resilience of a design to a variety of floods

Each of these risk factors is discussed in detail in the sections below. The nature of the risk assessment discussion provided for evaluation of the southern alignment alternatives was not performed in congruence with detailed USACE methodology. Rather, the risk factors presented herein are generalized considerations for comparing how features of southern alignment alternatives compare to one another. A detailed risk assessment should be completed in future detailed phases of design, if determined necessary by USACE or the Local Sponsors.

I.2.1.1 RISK REDUCTION – LENGTH AND HEIGHT OF EMBANKMENT

Risk must be considered relative to levee and dam embankments. In general, for other factors remaining equal and for the conditions presented at the southern alignment alternatives, an embankment with lower height and shorter length are preferable from a risk-management perspective, as suggested by the USACE Levee Screening Tool and other similar risk assessment methodologies. Other things being equal (including height), a longer embankment is more predisposed to having a greater statistical risk of failure than a shorter one. In general, embankments with lower height are considered lower risk.

Shorter length of embankment constructed is:

- less embankment to construct and ensure QA/QC of the constructed product during design and construction
- less embankment exposed to possible weakest-point failure during flood events
- less embankment to operate, maintain, inspect and recertify in the future

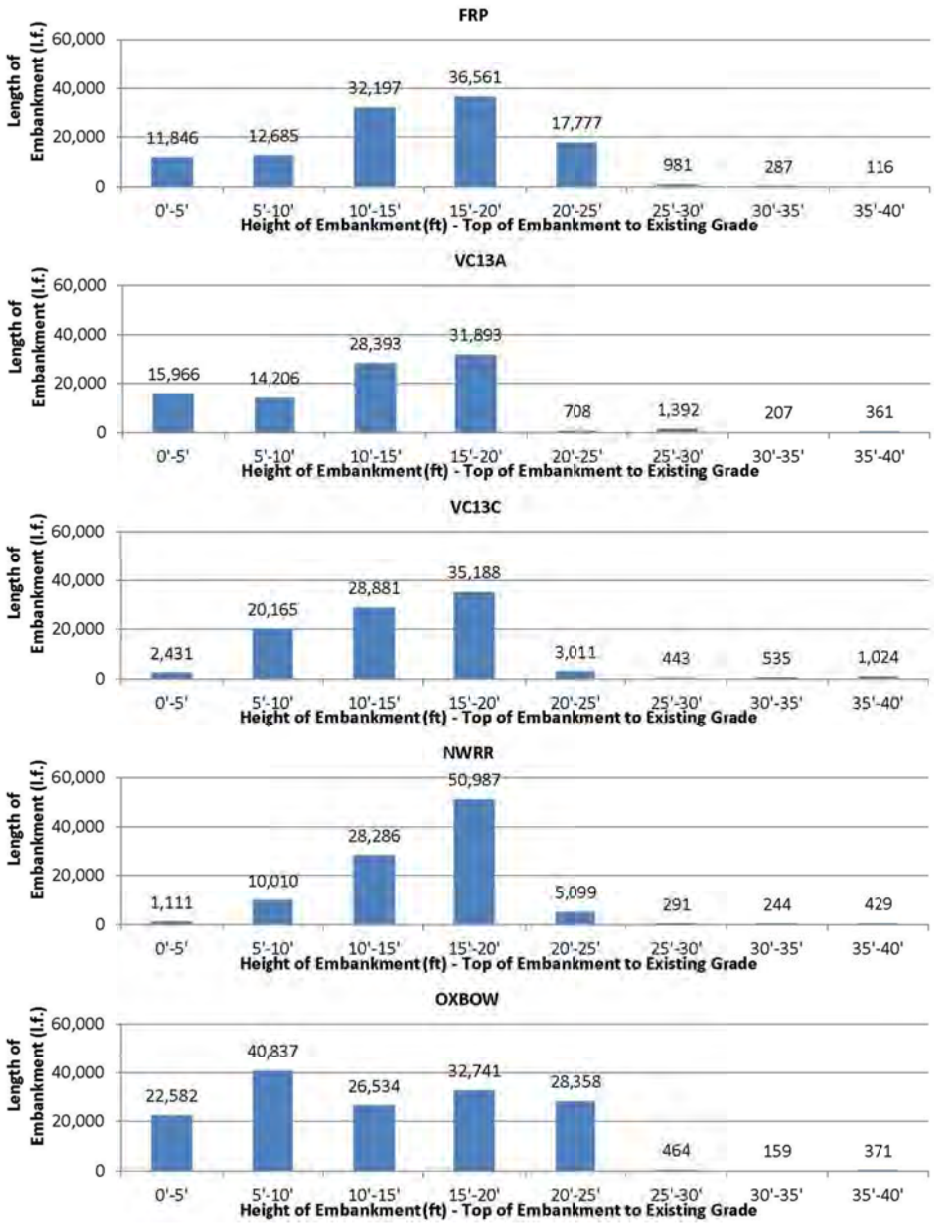
In general, the larger the difference in elevation of headwater to tailwater across the embankments, the greater the degree of risk (i.e. embankments with lower height are considered lower risk). Other things being equal, a higher embankment has a greater risk of failure than a lower one due to the greater amount of potential energy (hydraulic head) stored in the pool upstream of the embankment and the increased geotechnical loading over underlying soil. As embankment height increases, the potential maximum loading on the face of the embankment increases, posing a higher risk of the embankment being compromised. Additionally, for the same fetch, higher embankments that hold back deeper water may be subject to increased risk of being compromised by wave action and associated wave overtopping during flooding events. In general, deeper pools of water may facilitate higher maximum wave heights than shallower pools. In shallower pools, the bottom interrupts wave development, limiting the maximum height of waves generated.

In an effort to understand the distribution of lengths and heights of embankments of the different alternatives, a histogram of the total length of embankment according to select ranges of the height of embankment (top of embankment to existing ground) for the Red River of the North (RRN) to the Sheyenne River (Sta. 1514+00), including the embankment (103k cfs Spillway) along County Highway 17 (CH17) was created. This information is shown in Figure I-1. The distribution of embankment lengths and heights among alternatives is evident with FRP, OXBOW and NWRR having a greater proportion of embankments over 15 feet. The area of embankment face, taken here as the length of embankment multiplied by the average height in each range of the histogram in Figure I-1, is presented in Table I-1. This calculation takes into account two risk assessment factors, the length and height of embankment. Although the length of embankment is taken into account in Figure I-1 and the area of embankment face, for simplification it is also summarized in Table I-1, rounded to the nearest 100 LF. The alternatives VE13C, VE13A and NWRR have smaller area of embankment face and length of embankment compared to the FRP.

Table I-1 Risk Considerations for Southern Alignment Alternatives

Alternative	Length of Embankment Upstream of Sheyenne River (Sta. 1514+00) (Miles)	Area of Embankment Face (sq-ft)
FRP	21.0	1,607,700
VE13A	17.2	1,133,800
VE13C	16.6	1,269,800
NWRR	18.0	1,470,500
NWRR+OXBOW Levee	22.5	1,720,500
OXBOW	32.3	1,937,500

Figure I-1 Height of Embankment Comparison for PFSAA



Length of Embankment as measured from Red River to the Sheyenne River (Sta. 1514+00), including the embankment along CSAH17

P:\Mpls\34 ND\09\34091004 Fargo Moorhead Metropolitan Feas. Study\WorkFiles\Final Design_FY 2011-2012\Task Order No 5\Documents\Appendix I-AssessmentFactors\embankment height comparison.xls 8/28/2012

Risk should be considered relative to the siting of hydraulic structures and the staging area. As existing topography varies along the southern alignment alternatives, the height of embankments varies. In general, the deeper the water depth staged over existing grade situated closer to a major population center the greater the risk that damage will occur should a system failure occur. For example, the footprint shape, location and depth of the staging area and Storage Area 1 should be considered from a risk standpoint. In the case of the Oxbow alternative, water depth is increased in SA1 and is located relatively closer to population centers than some of the other alternative alignments. Said another way, moving the center of gravity of the staging area pool horizontally away from population centers may be viewed as a risk reduction.

I.2.1.2 RISK REDUCTION – HEADWATER TO TAILWATER DIFFERENTIAL

Risk should also be considered relative to hydraulic structures. In general, the greater the difference in headwater to tailwater elevation, the more predisposed the hydraulic structure is to risk of the feature becoming compromised due to a greater maximum loading potential. From this generalized perspective, control structures with shorter height are considered lower risk. Other things being equal, a control structure has a greater risk of failure when there is a greater amount of potential energy and head stored upstream of the structure and (if present) gates. Increased pool depth (hydraulic head) upstream of hydraulic structures may predispose the feature to increased risk of seepage. Cutoffs manage seepage risk beneath structures, but do not remove this risk completely.

The difference in headwater and tailwater elevations for the RRN control structure for the 1%-chance event is presented in Table I-2.

Table I-2 Head Differential at the Red River Control Structure for 1%-Chance Event

Alternative	Head Differential at RRN Control Structure for 1%-Chance Event (ft)
FRP	38.0
VE13A	38.5
VE13C	36.2
NWRR	33.6
NWRR+OXBOW Levee	33.6
OXBOW	40.4

I.2.1.3 RISK REDUCTION – DEGREE OF HUMAN INTERVENTION REQUIRED

The greater the level of mandatory human intervention needed for a project to provide flood risk reduction, the greater the chance of feature failure, either as a result of a single occurrence or due to wider systemic failure to properly operate and maintain the project. For example, this intervention is present in the form of operating hydraulic structures during flooding events, accessing a structure and providing backup systems (such as bulkheads), properly maintaining facilities and managing ice and debris. From a risk management perspective, fewer active hydraulic structures reduces the degree of human intervention required during flooding events and thereby reduces the risk that features could be managed improperly or could be rendered inoperable during a flood event.

The numbers of hydraulic structures in the southern alignment alternatives requiring human intervention are listed in Table I-3.

Table I-3 Number of Hydraulic Structures Requiring Human Intervention

Alternative	Major Hydraulic Structures	Minor Hydraulic Structures
FRP	3 (RRN, Wild Rice River, Diversion Inlet)	3 (Wolverton Creek, Drain 27, Upstream Drain 53)
VE13A	3 (RRN, Wild Rice River, Diversion Inlet)	0
VE13C	3 (RRN, Wild Rice River, Diversion Inlet)	0
NWRR	2 (RRN, Diversion Inlet)	0
NWRR+OXBOW Levee	2 (RRN, Diversion Inlet)	0
OXBOW	3 (RRN, Wild Rice River, Diversion Inlet)	3 (Wolverton Creek, Drain 27, Upstream Drain 53)

A project with fewer active hydraulic structures reduces the number of interdependent system operations that, if improperly performed or sequenced, can cause the system to malfunction unexpectedly (e.g., gate opening, gate closing, emergency bulkhead installation, timing of these activities, etc.) At the community and economy-level scale, interdependency risk is the risk that operations will be negatively impacted due to a failure in another critical infrastructure sector. Reducing the number of hydraulic structures and features requiring operation and maintenance during flood events can reduce interdependency risk to a degree.

There are a multitude of factors that can increase the risk of a feature malfunctioning when system features are interdependent. Examples of factors that could compromise the functioning of interdependent project features include:

- Interruption of transportation, electrical and/or communication networks due to unforeseen weather such as a concurrent flooding event and a winter storm, and the resulting impact on centralized SCADA control, monitoring, heated gate or bulkhead features, gate operation, etc.
- Interruption of the transportation network, demands on emergency management activities, and the effect on gate operation, the storage, transport, and installation of bulkheads.

Risk must be considered relative to the long-term ownership, operation, and maintenance of the facilities. Hydraulic structures will be operated and maintained for their design life. Throughout their life, and upon decommissioning and replacement, these structures will require ongoing funding and resources. From this perspective, fewer structures to own, operate, and maintain may reduce exposure to risks associated with this.

I.2.1.4 RISK REDUCTION – RESILIENCE OF A DESIGN TO DIFFERENT FLOODS

A highly resilient flood risk reduction system is desired, that is, one that can be operated to effectively reduce flood risk for a variety of flood types and severities.

For example, a highly resilient project would be able to be operated to effectively reduce risk for various flood volumes, peak flows, and timing of peak flows from the Red River and various tributaries. Additionally, a more resilient project would reduce the use of a PMF spillway to the extent possible.

Future consideration should be given to performing sensitivity analysis on the project operational plan to characterize how the project functions for hydrographs and events differing from those modeled to date, such as extended-peak or double peak events on various tributaries. The timing of the hydrographs routed through the project impact both staging elevations, elevations for flows through town, downstream water surface elevations, and water surface elevations on tributaries at the diversion channel. Additional effort is required to understand what risk exposure exists with the potential variation of this natural variable. In lieu of further investigations, resilience to natural hydrograph variation is omitted for the time being from the numerical assessment factor scoring.

I.2.2 IMPLEMENTABILITY

Implementability is a qualitative criterion, as it is difficult to quantify from a technical perspective. Ultimately, decision makers need to weigh available data and make a qualified judgment when making a decision. Key implementability considerations (from a technical perspective), as defined with input from the Local Sponsors and USACE during the August 15-16, 2012 LSLCTT Integration workshop, include:

- Compliance with USACE Record of Decision and Chief’s Report and other permitting requirements
- Public policy considerations

During the August 15-16, 2012 LSLCTT Integration Workshop, a group consensus exercise was performed to rank each alternative in terms of implementability from a technical perspective. The first step in the ranking process was to identify key metrics and rank them "head-to-head" against each other to develop a relative weighting for each metric. The results of this ranking process are summarized in Table I-4. More detailed descriptions of the subcategories that were identified during the Integration Workshop are included following Table I-5.

Table I-4 Ranking Exercise to Determine Relative Weights of the Implementability Categories

Subcategory	Points	Relative Weight	Compliance with USACE ROD/ Chief's Report	Impacts to Land in Richland/ Wilkin Counties	Impacts to Residential Structures in Richland/ Wilkin Counties	Impacts to Residential Structures not Previously Impacted	FEMA Issues	Community Inclusion
Compliance with USACE ROD/ Chief's Report (U)	5	33%		U	U	U	U	U
Impacts to Land in Richland/Wilkin Co. (L)	1	7%			S	N	L	C
Impacts to Residential Structures in Richland/Wilkin Co. (S)	2	13%				N	S	C
Impacts to Residential Structures not Previously Impacted (N)	4	27%					N	N
FEMA Issues (F)	0	0%						C
Community Inclusion (C)	3	20%						
TOTAL	**15**	**100%**						

The subcategories of the matrix were compared "head-to-head," and the subcategory determined to have a higher weight is listed by its abbreviation. The abbreviations are listed in the first column.

The next step in the ranking process was to rank each of the base alternatives for each metric; multiply the ranking by the relative weighting; and add the total for each alternative for an overall implementability total. The results of this scoring process are summarized in Table I-5. The alternatives with the lower score have a higher ease of implementability from a technical perspective based on the LSLCTT group exercise.

Table I-5 Exercise to Rank Each Alternative in Terms of Ease of Implementability from a Technical Perspective

Relative Weight	33%	7%	13%	27%	0%	20%		
	I	II	III	IV	V	VI		
Alternative	Compliance with USACE ROD/ Chief's Report	Impacts to Land in Richland and Wilkin Counties	Impacts to Residential Structures in Richland and Wilkin Counties	Impacts to Residential Structures not Previously Impacted	FEMA Issues	Comm-unity Inclusion	Sub-total	Overall Implementability
FRP	3	5	5	1	2	3	19	2.9
VE13A	1	4	4	3	3	3	18	2.5
VE13C	2	3	1	4	3	3	16	2.7
NWRR	5	1	1	5	3	3	18	3.8
NWRR+OXBOW Levee	5	1	1	5	4	1	17	3.4
OXBOW	6	6	6	2	3	1	24	3.9

Description of Ranking Exercise (ranking of 1 indicates that the alternative is most implementable and 6 indicates that the alternative is the least)

I. Compliance with USACE ROD/Chiefs Report - In terms of compliance, rank from 1 (easiest or shortest time to implement) to 6 (most difficult or longest time to implement)
II. Impacts to Land in Richland/Wilkin Counties - In terms of impacts to Richland and Wilkin Counties, rank from 1 (least land impacted) to 6 (most land impacted)
III. Impacts to Residential Structures in Richland/Wilkin Counties - In terms of impacts to Richland and Wilkin Counties, rank from 1 (least residential structures impacted) to 6 (most residential structures impacted)
IV. Impacts to Residential Structures not Previously Impacted - In terms of impacted residential structures not previously impacted by the FRP, rank from 1 (least number of new structures) to 6 (most number of new structures)
V. FEMA Issues - In terms of the magnitude of issues related to FEMA, rank from 1 (less difficulty to implement) to 6 (more difficulty to implement)
VI. Community Inclusion - In terms of including communities in flood risk reduction, rank from 1 (most communities being included) to 6 (least communities being included)

I.2.3 PROPERTY IMPACTS – NUMBER OF RESIDENTIAL STRUCTURES

The number of structures impacted varies between the alternatives. For the purpose of this analysis, an impacted structure is defined as a structure that located under the footprint of the project and would require purchase or is within the defined staging area and would require purchase or other mitigation measures. The estimated total number of structures impacted is presented in Table I-6. The estimated structure counts are divided between residential and non-residential structures. Additionally, the structures within the staging area are categorized based on the total depth of inundation during a 1-percent chance event.

While the totals are close, more residential structures are categorized as being within the footprint of the project for the FRP than for either VE-13 option. This difference is largely because all structures within SA1, even those that are within the area bounded by the SA1 embankments, are included in the FRP structure total, while neither VE-13 option includes a storage area. The FRP, as well as both VE-13 options, result in staging elevations greater than 3 feet for structures in the Hickson, Bakke Subdivision, and Oxbow area. This analysis assumes that any structure with greater than 3 feet of flooding for the 1-percent chance event would be purchased. While many communities throughout the region and country are behind levees that prevent greater than 3 feet of flooding during a 1-percent chance event, this constraint is consistent with Appendix G of the Final Feasibility Report and FEIS for the project developed by USACE.

The NWRR alternative impacts more residential structures than does the FRP or either VE-13 alternative. This is largely due to the fact that the area between the FRP and the NWRR alternative is more heavily populated than areas further south. The numbers of impacted residential structures for the NWRR alternative, like the FRP and VE-13 options, include the structures in the Hickson, Bakke Subdivision, and Oxbow area. Unlike the FRP and VE-13 options, however, the NWRR results in a staged elevation that results in a total inundation depth at structures within Hickson, Bakke Subdivision, and Oxbow of less than 3 feet, allowing for a potential ring-dike. The City of Oxbow, Village of Hickson, and Bakke Subdivision contain 172 residential structures as well as a number of non-residential structures. Approximately 130 of these residential structures would not be impacted if a ring-dike was constructed. The addition of a ring dike protecting most of the structures in Oxbow, Hickson Subdivision, Bakke, while reducing the number of impacted structures, still results in similar overall structure impacts for the NWRR alternative and the VE alternatives.

The OXBOW alternative, because it is located south of the communities of Oxbow, Hickson, Bakke Subdivision, impacts the lowest number of residential structures, as well as the lowest overall number of structures. The staging area for the OXBOW alternative is centered further south than other alternatives, in a more sparsely populated area.

While the project is located in Cass County, ND and Clay County, MN, the alternatives impact residential and non-residential structures in Richland County, ND, including the City of Christine, and Wilkin County, MN. In addition to the impacted communities in Richland and Wilkin Counties, structures within the communities of Oxbow and Hickson in Cass County and Comstock in Clay County are impacted. Table I-7 below provides a general means to compare the residential structure impacts in these areas.

Table I-6 Property Impact, Number of Residential and Non-Residential Structures

Alternative	Station 1514+00 to Sheyenne Hydraulic Structure	Upstream of Station 1514+00*	Upstream Storage Area - 3' or More	Upstream Storage Area - Less Than 3'	Total
FRP, Residential	1	21	213	84	319
FRP, Non-Residential	3	88	160	164	415
VE13A, Res.	1	12	245	51	309
VE13A, Non-Res.	3	13	206	151	373
VE13C, Res.	4	3	229	81	317
VE13C, Non-Res.	3	9	328	69	409
OXBOW, Residential	1	23	46	61	131
OXBOW, Non-Residential	3	107	207	99	416
NWRR, Residential	4	13	286	174	477
NWRR, Non-Residential	3	7	318	98	426
NWRR+OXBOW Levee, Residential	4	13	286	39	342
NWRR+OXBOW Levee, Non-Residential	3	7	313	91	414

*Includes SA1 where applicable

Table I-7 Number of residential structures impacted

Location	FRP	VE13A	VE13C	OXBOW	NWRR
Richland County*	8	2	0	45	0
Wilkin County*	5	1	0	14	0
Cass County*	244	255	298	57	422
Clay County*	62	51	19	15	55
Total	319	309	317	131	477
Oxbow	99	99	97	0	92
Bakke Subd.	58	58	58	0	58
Hickson	15	15	15	0	15
Christine	2	0	0	13	0
Comstock	44	32	0	0	0

*Structure count includes **ALL residential** structures within county, including those within communities and buffer areas.

I.2.4 ENVIRONMENTAL CONSIDERATIONS

Another way to compare the alternatives is to estimate the environmental impact of each alternative as compared to the FRP. The scope of work for this task did not extend to preparing an extended analysis of environmental impacts, so a detailed comparison of these impacts cannot be performed. However, several simplified factors identified during the June 19, 2012 VE-13 workshop, August 2, 2012 LSLCTT meeting, and August 15-16, 2012 Integration workshop were estimated to roughly compare the scalar change in environmental impacts for southern alignment alternatives:

- Wetland Impact: Wetlands were not field or photo-delineated in this phase of work. Actual field delineation of wetlands is preferred to estimate wetland impacts. However, given similar land use, constructed project footprint area can be used as a rough proxy. In general, a project with a larger footprint has a greater chance to impact wetlands.
- River miles impacted: Hydraulic closure structures resulted in the abandonment of some river channel, resulting in riparian habitat impacts. Due to the configuration of each alternative, some impacted more river channel than others.

Table I-8 summarizes these factors.

Table I-8 Environmental Consideration Assessment Factors for Southern Alignment Alternatives

Alternative	Project footprint (AC)	Length of river impacted (LF)
FRP	1,300	8,600
VE13A	951	6,600
VE13C	904	7,000
NWRR	928	6,200
NWRR+OXBOW Levee	1,013	6,200
OXBOW	1,787	8,600

I.2.5 PROPERTY IMPACTS – NUMBER OF ACRES

The estimated number of acres impacted varies between the alternatives and is defined as acres that are located under the footprint of the project and would require purchase or are within the defined staging area and would require purchase or flowage easements. The total number of acres impacted is presented in Table I-9. The impacted area within the staging area is categorized based on the estimated depth of inundation.

While the FRP impacts more acres than either VE-13 option, the three alternatives vary by less than 15%. It should be noted that FRP acreage totals have been taken from the April 2011 report which was based on an earlier version of the unsteady HEC-RAS model that contained less detail in the upstream portion of the staging area.

The estimated impacted areas for each county are presented in Table I-10.

Table I-9 Property Impact, Number of Acres

Includes Permanent and Temporary Easements (Number of Acres)

Alternative	Station 1514+00 to Sheyenne Hydraulic Structure	Upstream of Station 1514+00*	Upstream Storage Area - 3' or More	Upstream Storage Area - Less Than 3'	Total
FRP	167	5,268	21,384	13,456	40,275
VE13A	184	767	25,335	11,615	37,901
VE13C	121	783	27,102	7,614	35,620
OXBOW	167	5,755	18,971	11,983	36,876
NWRR	121	807	28,440	8,607	37,975
NWRR+OXBOW Levee	121	807	28,235	8,264	37,427

*Includes SA1 where applicable

Table I-10 Acres of Land Impacted

Location	FRP	VE13A	VE13C	OXBOW	NWRR
Richland County	2,399	1,419	149	9,500	0
Wilkin County	3,826	1,685	30	4,549	0
Cass County	20,998	19,023	21,644	19,170	21,669
Clay County	13,052	15,774	13,787	3,657	16,306

I.2.6 FLOODPLAIN CONSIDERATIONS

In assessment of alignment alternatives, consideration should be given for the area removed from the floodplain. Executive Order 11988 provides guidance related to development in floodplains. Part of this guidance is that, in the case that impact to the base floodplain (1-percent chance floodplain) is unavoidable, it is preferable to minimize the amount of area removed from the base floodplain. Because of the nature and location of the project, impacts to the floodplain are unavoidable. Additionally, large portions of the area south of Fargo and Moorhead are in the base floodplain based on mapping performed for the FR/FEIS and this study. For the purposes of this assessment, an alternative with less area removed from the 1-percent chance floodplain is superior to an alternative with more area removed.

Table I-11 presents the number of acres removed from the base floodplain using the FRP as the basis for comparison.

Table I-11 Impacts to 1-Percent Chance Existing Conditions Floodplain

Alternative	Floodplain Removed for Entire Project (acres)
FRP	62,858
VE13A	63,618
VE13C	56,729
NWRR	51,609
NWRR+OXBOW Levee	51,885
OXBOW	67,195

I.2.7 TRANSPORTATION SAFETY CONSIDERATIONS

A consistent set of simplified criteria was used for developing transportation feature modifications for the alternatives considered as part of the PFSAA. The alternatives will require the construction of bridges at major roadways and railroads along the diversion channel. The bridge design criteria utilized for this analysis is the same as for the Phase 4 technical reports prepared in support of the FR/FEIS. The FRP includes 5 highway bridges upstream from the Sheyenne River aqueduct. Alternative VE13A includes 5 highway bridges; alternative VE13C includes 4 highway bridges; the OXBOW alternative includes 6 highway bridges; and the NWRR alternative includes 3 highway bridges.

The upstream staging area will cause impacts to transportation routes upstream from the diversion channel and embankments for the alternatives considered during project operation. These impacts vary from inundation during project operation to increased water levels adjacent to the road grades without overtopping. It should be noted that several of these transportation routes are impacted and in many cases inundated by floodwaters during existing conditions.

Major transportation routes that will be impacted and proposed mitigation measures vary by alternative and are summarized below:

FRP: For the FRP, Interstate 29, U.S. Highway 75, and the BNSF railroad grade (Moorhead Subdivision) will be raised so the edge of driving lanes are above the 1-percent chance elevation. The Cass County Highway 18 overpass on I-29 will also be re-constructed as part of the Interstate 29 grade raise. Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 2, 50, 51, 58, and 59; and several township roads will be impacted when the diversion is operating during large flood events.

VE13A: For VE13A, Interstate 29, U.S. Highway 75, and the BNSF railroad grade (Moorhead Subdivision) will be raised so the edge of driving lanes are above the 1-percent chance elevation. The Cass County Highway 16 and 18 overpasses and Wild Rice River bridges on I-29 will also be re-constructed as part of the Interstate 29 grade raise. Cass County Highways 18, 25, and 81; Clay County Highways 2, 50, 51, 58, 59, and 60; and several township roads will be impacted when the diversion is operating during large flood events.

VE13C: For VE13C, Interstate 29, U.S. Highway 75, and the BNSF railroad grade (Moorhead Subdivision) will be raised so the edge of driving lanes are above the 1-percent chance elevation. The Cass County Highway 16 and 18 overpasses and Wild Rice River bridges on I-29 will also be re-constructed as part of the Interstate 29 grade raise. Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 2, 7, 58, 59, and 60; and several township roads will be impacted when the diversion is operating during large flood events.

NWRR: For NWRR, Interstate 29, U.S. Highway 75, and the BNSF railroad grade (Moorhead Subdivision) will be raised so the edge of driving lanes are above the 1-percent chance elevation. The Cass County Highway 16 overpass and Wild Rice River bridges on I-29 will also be re-constructed as part of the Interstate 29 grade raise. Cass County Highways 14, 16, 18, 21, 25, and 81; Clay County Highways 2, 7, 8, 58, 59; 60; 64; and 65; and several township roads will be impacted when the diversion is operating during large flood events.

OXBOW: For OXBOW, Interstate 29, U.S. Highway 75, and the BNSF railroad grade (Moorhead Subdivision) will be raised so the edge of driving lanes are above the 1-percent chance elevation. ND Highway 46; Cass County Highways 16, 18, 21, 25, and 81; Clay County Highways 50 and 190; and several township roads will be impacted when the diversion is operating during large flood events.

The safety of the traveling public was the primary consideration when comparing alternative relative to the FRP. The factors included in this comparison are the number of bridges that cross the diversion channel and the length of grade raise in the upstream staging area. Drivers lack escape routes when crossing bridges and traveling in areas with water adjacent to the roadway. This increases the potential for accidents. Table I-12 provides a summary of transportation safety considerations for the base alternatives.

Table I-12 Transportation Safety Considerations

Alternative	Number of Bridges	Length of I-29 Grade Raise (miles)	Length of U.S. Hwy 75 Grade Raise (miles)	Length of BNSF Railway Grade Raise (miles)	Total Length of Grade Raise (miles)
FRP	5	3.86	3.00	3.00	9.9
VE13A	5	4.45	3.19	3.88	11.5
VE13C	4	5.93	3.74	0.95	10.6
NWRR	3	4.68	6.26	4.20	15.1
NWRR+Oxbow Levee	3	4.68	6.26	4.20	15.1
OXBOW	6	1.74	0.20	0.67	2.6

I.3 ASSESSMENT FACTOR SUMMARY

Combining the simplified assessment data discussed above from the seven selected assessment factor categories into a single numerical analysis can be another tool to aid in characterizing value and determining which alignment and features best meet project objectives and provide the greatest value, compared to the FRP. The following comparative numerical analysis was customized for this exercise with input from the Local Sponsors and USACE during the June 19, 2012 VE-13 Workshop, August 2, 2012 LSLCTT meeting, and the August 15-16 LSLCTT Integration Workshops. The scoring is intended to develop relative ranking of alternatives (least to most favorable). The degree of differentiation in the point scoring is not the intended use of the scores.

I.3.1 ASSESSMENT FACTOR ANALYSIS INPUTS

The different assessment factor categories were originally weighted based on their perceived importance using group consensus during the June 19, 2012 VE-13 workshop. This analysis was revisited again during the August 15-16, 2012 LSLCTT Integration Workshop. Table I-13 presents the groups' consensus from the August 15-16, 2012 Integration Workshop in determining which assessment factor should carry more weight in the analysis, compared to other assessment factors.

Table I-13 Factor Ranking Exercise to Determine Relative Weights of Assessment Factors

Assessment Factor Category	Points	Relative Weight	Implement-ability	# of Residential Structures	# of Acres	Risk	Floodplain Consid-erations	Environ-mental	Transpor-tation Safety
Implement-ability (I)	5	24%		I	I	R	I	I	I
# of Residential Structures (S)	4	19%			S	R	S	S	S
# of Acres (A)	1.5	7%				R	A	E	T/A
Risk (R)	6	29%					R	R	R
Floodplain Considerations (F)	1	5%						E	F
Environmental (E)	3	14%							E
Transportation Safety (T)	0.5	2%							
TOTAL	**21**	**100%**							

The categories of the matrix were compared "head-to-head," and the category determined to have a higher weight is listed by its abbreviation (both are listed in case of a tie). The abbreviations are listed in the first column.

Table I-14 presents a summary of the data and quantities presented throughout this Appendix I that were used in the assessment factor analysis for the different alternatives. For the risk, number of residential structures, environmental, implementability, and transportation safety categories, there are numerous subcategories that were combined into a single function using relative weights determined by group consensus at the August 15-16, 2012 LSLCTT Integration Workshop. The methodology for using a harmonic mean and an arithmetic mean using equal weighting to combine these subcategories into a single function was also presented at the August 15-16, 2012 LSLCTT Integration Workshop. The implementability category and its subcategories are described in greater detail in Section I.2.1. The relative weights for each subcategory for a chosen base case are shown in Table I-14.

In an effort to simplify the comparison of the alternatives, a single normalized function comparing an alternative to the FRP was created for each assessment factor. Table I-15 presents each function and Table I-14 presents the function symbols. The quantity (e.g., length, area, height, etc.) of the alternative was normalized by dividing by the quantity of the FRP. Therefore if the result from the function was equal to 100%, then the alternative and FRP were viewed as equally favorable for that particular assessment factor. If the result was greater than 100%, then the alternative produces a greater impact than the FRP (e.g., the alternative impacts more residential structures, or has a potentially higher risk than the FRP) and is viewed as less favorable than the FRP. Likewise, if the result was less than 100%, then the alternative produces a smaller impact than the FRP (e.g., the alternative impacts fewer residential structures, or has potentially lower risk than the FRP) and is viewed as more favorable than the FRP.

The functions comparing an alternative to the FRP for each assessment factor category were multiplied by the relative weight presented in Table I-13 and then summed to obtain the assessment factor score. The following relative scoring is observed (a lower score indicates a more favorable alternative):

- A relative score of 100% indicates that the combination of the assessment factor function results and the relative categorical weights for a certain alternative has a similar favorability as the FRP.
- A relative score of greater than 100% indicates that the combination of the function results and the relative categorical weights for a certain alternative is less favorable (greater impacts) than the FRP.
- A relative score of less than 100% indicates that the combination of the function results and the relative weights for a certain alternative is more favorable (lesser impacts) than the FRP.

A figure presenting the breakdown of the assessment factor score among the different categories is presented in Table I-15.

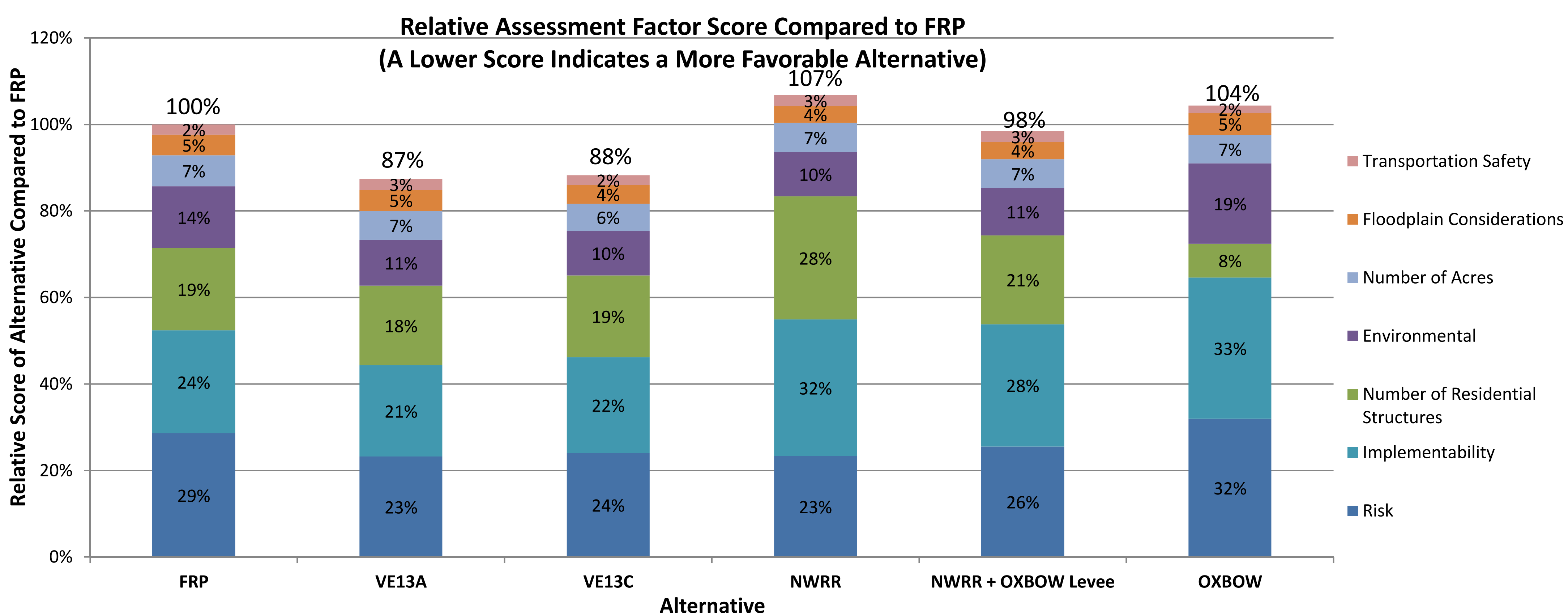
Table I-14 Comparison of Quantities for the Post-Feasibility Southern Alignment Alternatives for the Assessment Factor Categories
Note: Quantity Comparison is for PFSAA Base Alignments, upstream of Sta. 1514+00 near Sheyenne River.

Assessment Factor Category	Southern Alignment Quantity	Function Symbol	Alternative: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	Subcategory Relative Weight - Base Case	Subcategory Relative Weight - Sensitivity #1	Subcategory Relative Weight - Sensitivity #2
Risk Reduction Considerations	Area of Embankment Face (sq-ft)[1]	A_{EM}	1,607,700	1,133,800	1,269,800	1,470,500	1,720,500	1,937,500	50%	25%	40%
	Head Differential at Red River Control Structure for 1%-Chance Event (ft)	$H_{RR\text{-}1\%}$	38.0	38.5	36.2	33.6	33.6	40.4	25%	25%	20%
	Number of Major Hydraulic Structures Requiring Human Intervention for Flood Risk Reduction	$\#_{HIS\text{-}Maj}$	3	3	3	2	2	3	21%	42%	33%
	Number of Minor Hydraulic Structures Requiring Human Intervention for Flood Risk Reduction	$\#_{HIS\text{-}Min}$	3	0	0	0	0	3	4%	8%	7%
Implementability	***See Table I-5***	I	2.9	2.5	2.7	3.8	3.4	3.9			
Number of Residential Structures	Number of Residential Structures Impacted by Constructed Project Footprint and Staging Area >= 1 foot depth	$\#_{STR>1}$	289	285	307	442	337	104	50%	80%	
	Number of Residential Structures Impacted by Constructed Project Footprint and Staging Area < 1 foot depth	$\#_{STR<1}$	30	24	10	35	7	27	50%	20%	
Environmental Considerations	Area of Constructed Project Footprint (ac)	A_{PF}	1,300	951	904	928	1,013	1,787	80%		
	Length of Existing River Riparian Habitat Impacted (lf)	L_{RI}	8,600	6,600	7,000	6,200	6,200	8,600	20%		
Number of Acres	Number of Acres Impacted by Constructed Project Footprint, Easements and Staging Area	$\#_{AC}$	40,275	37,901	35,620	37,975	37,427	36,876			
Floodplain Considerations	Area Removed from the Floodplain (acres)	A_{FL}	62,858	63,618	56,729	51,609	51,885	67,195			
Transportation Safety	Number of Bridges Impacted	$\#_B$	5	5	4	3	3	6	50%		
	Length of Roadway and Railroad Grade raise (miles)	L_{GR}	9.9	11.5	10.6	15.1	15.1	2.6	50%		

Notes:
[1] Area of embankment face is the height of embankment (top of embankment to existing grade) multiplied by the length of embankment (as measured from Red River to the Main Inlet Weir, including the embankment along CH17).

Table I-15 Summary of Assessment Factors used to Compare Alternatives

Assessment Factor Category	Function Comparing Alternatives to FRP: Function (see Table I-14)	Relative Weight (RW)	Function Comparing Alternative to FRP						Relative Assessment Factor Score Compared to FRP					
			FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	$S_R = RW_R * \left(RW_{A_{EM}} \frac{A_{EM-Alt}}{A_{EM-FRP}} + RW_{H_{RR-1\%}} \frac{H_{RR-1\%-Alt}}{H_{RR-1\%-FRP}} + RW_{\#_{HIS-Maj}} \frac{\#_{HIS-Maj-Alt}}{\#_{HIS-Maj-FRP}} + RW_{\#_{HIS-Min}} \frac{\#_{HIS-Min-Alt}}{\#_{HIS-Min-FRP}} \right)$	29%	100%	81%	84%	82%	89%	112%	29%	23%	24%	23%	26%	32%
Implementability	$S_I = RW_I * \frac{I_{Alt}}{I_{FRP}}$	24%	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	$S_S = RW_S * \left(\frac{RW_{>1} * \#_{STR>1-Alt} + RW_{<1} * \#_{STR<1-Alt}}{RW_{>1} * \#_{STR>1-FRP} + RW_{<1} * \#_{STR<1-FRP}} \right)$	19%	100%	97%	99%	150%	108%	41%	19%	18%	19%	28%	21%	8%
Environmental	$S_E = RW_E * \left(RW_{A_{PF}} \frac{A_{PF-Alt}}{A_{PF-FRP}} + RW_{L_{RI}} \frac{L_{RI-Alt}}{L_{RI-FRP}} \right)$	14%	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	$S_A = RW_A * \frac{\#_{AC-Alt}}{\#_{AC-FRP}}$	7%	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	$S_F = RW_F * \frac{A_{FL-Alt}}{A_{FL-FRP}}$	5%	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	$S_T = RW_T * \left(RW_{\#_B} \frac{\#_{B-Alt}}{\#_{B-FRP}} + RW_{L_{GR}} \frac{L_{GR-Alt}}{L_{GR-FRP}} \right)$	2%	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total		100%							100%	87%	88%	107%	98%	104%



I.3.2 ASSESSMENT FACTOR ANALYSIS RESULTS

According to this analysis, with the chosen functions and relative weights, the VE13A and VE13C alternatives are the most favorable (lesser impacts) compared to the FRP and other investigated alternatives with scores of 87% and 88%, respectively. The North of Wild Rice including a levee for the City of Oxbow has a more favorable (lesser impacts) rating than the FRP, but somewhat greater impact than the VE-13 alternatives. The Oxbow and North of Wild Rice alternatives are less favorable (higher impacts) than the FRP. It is important to understand that possible scores for the categories and subcategories presented here could only range from about 70% to 130%.

This analysis is a simplified general means for comparison and should not be considered a definitive and final analysis for choosing one alternative over another. In a project as large as the FM Diversion there may be additional objective factors which were not accounted for in this analysis (e.g., the total number of gates and how that affects risk). Although a wide range of objective factors were included, it is difficult to determine what the relative importance of each factor is and how the factors should be calculated due to their relationship and interdependency. Other important factors are difficult to quantify, such as the resilience of an alternative to different floods, and were therefore not able to be incorporated in the analysis. There are additional subjective factors, such as public opinion, that were not captured for use in this analysis but can play an important role in choosing a viable alternative. The relative weights were chosen during the August 15-16, 2012 LSLCTT Integration Workshop using group consensus and have not been justified using a detailed sensitivity analysis. Choosing a different allocation of relative weights could show a different alternative being the alternative with the least impact, or shift the degree of separation in alternative scoring.

I.3.3 SENSITIVITY TO SUBCATEGORY FACTOR WEIGHTS

It was decided during the August 15-16, 2012 LSLCTT Integration Workshop to conduct a number of sensitivity analyses on the relative weights of the subcategories for the risk and number of residential structures assessment factors to determine if changes in these values made large differences in the assessment factor score.

As presented in Table I-14 for the base case for risk assessment factor, the relative weights were chosen as 50% for area of embankment face, 25% for head differential at the RRN Control Structure for the 1%-Chance event, 21% for number of major hydraulic structures requiring human intervention and 4% for minor hydraulic structures requiring human intervention. For sensitivity case #1, the relative weights were chosen as 25% for area of embankment face, 25% for head differential at the RRN Control Structure for the 1%-Chance event, 42% for number of major hydraulic structures requiring human intervention and 8% for minor hydraulic structures requiring human intervention. For sensitivity case #2, the relative weights were chosen as 40% for area of embankment face, 20% for head differential at the RRN Control Structure for the 1%-Chance event, 33% for number of major hydraulic structures requiring human intervention and 7% for minor hydraulic structures requiring human intervention. The results for the risk sensitivity analysis are presented in Table I-16. Although there are some minor differences between the base case, sensitivity case #1 and sensitivity case #2, overall the results are similar with VE13A and VE13C being the most favorable alternatives.

As presented in Table I-14 for the base case for number of residential structures assessment factor, the relative weights were chosen as 50% for the number of residential structures impacted by constructed project footprint and staging area with a 1-foot or greater depth inundation, and 50% for the number of residential structures impacted by constructed project footprint and staging area with less than a 1-foot depth inundation (i.e., equal weighting for all residential structures, no matter the depth of inundation). For sensitivity case #1, the relative weights were chosen as 80% for 1-foot or greater depth and 20% for less than 1-foot inundation depth. The results for the number of structures sensitivity analysis are shown in Table I-17. Although there are some minor differences between the base case and sensitivity case #1, overall the results are similar with VE13A and VE13C being the most favorable alternatives.

I.3.4 COST AND ASSESSMENT FACTOR COMPARISON

While cost alone should not be a primary comparison of alternatives, it is obviously a significant factor and should be used alongside the results from the assessment factor analysis. The alternative costs (southern alignment Lands and Damages plus Construction Cost only, with no "bundled enhancements") are presented in Table I-18.

Table I-18 Base Cost Comparison for Southern Alignment Alternatives

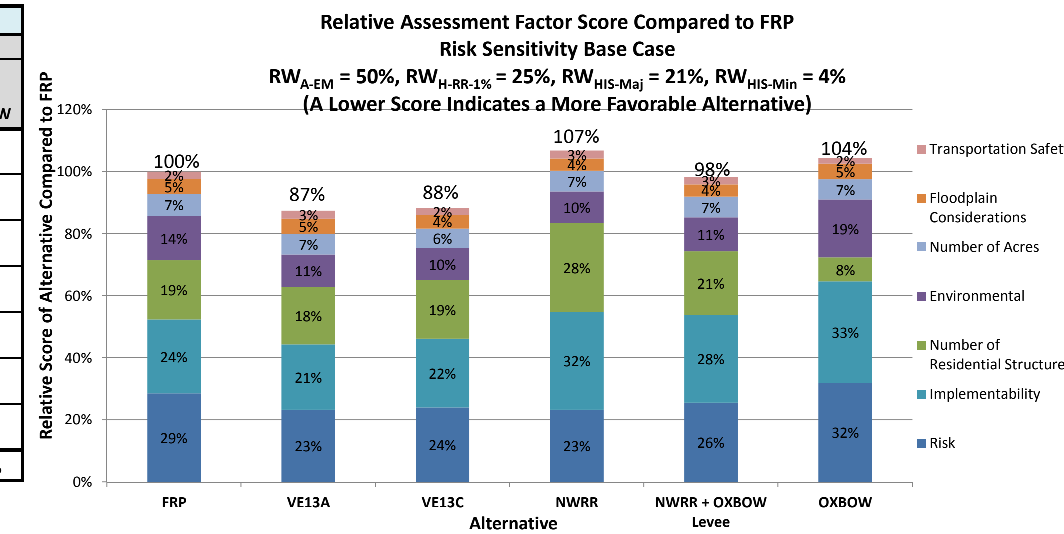
Alternative	Base Cost ($)	Compared to FRP ($)
FRP	593M	N/A
VE13A	525M	68M Less
VE13C	532M	61M Less
NWRR	564M	29M Less
OXBOW	592M	1M Less

The Post-Feasibility Southern Alignment Alternatives presented in Table I-19 are "bundles" of PFSAA alignment and PFSAA features, with the additional enhancement of project features identified during the August 2, 2012 Local Sponsor Local Consultant Technical Team (LSLCTT) meeting in Fargo.

Table I-16 Summary of Assessment Factors used to Compare Alternatives - Risk Sensitivity Analysis

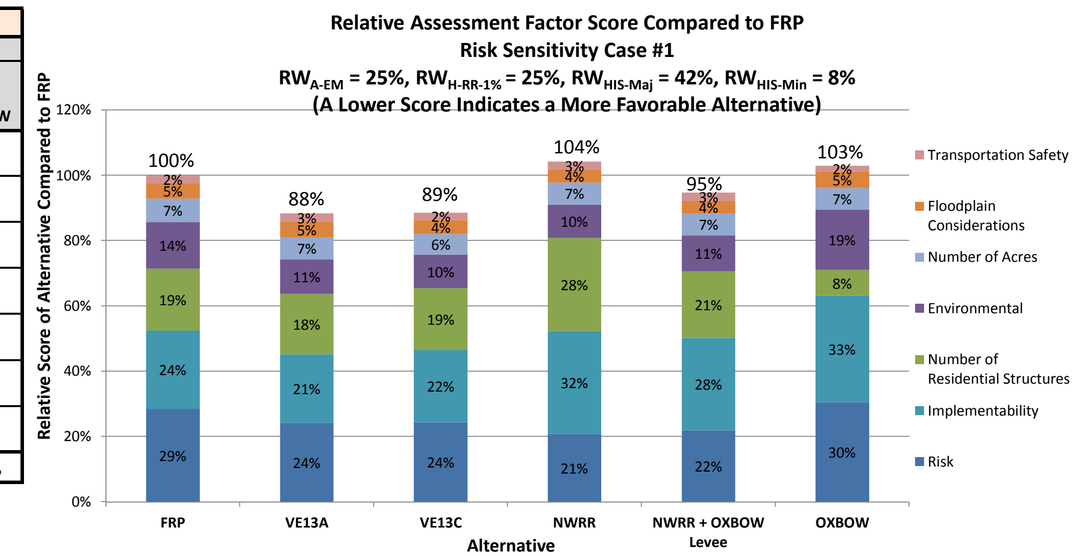
Base Case - $RW_{A\text{-}EM}$ = 50%, $RW_{H\text{-}RR\text{-}1\%}$ = 25%, $RW_{HIS\text{-}Maj}$ = 21%, $RW_{HIS\text{-}Min}$ = 4%

Assessment Factor Category	Function Comparing Alternatives to FRP: Function (see Table I-14)	Relative Weight (RW)	Function Comparing Alternative to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	Relative Assessment Factor Score Compared to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	$S_R = RW_R * \left(RW_{A_{EM}} \frac{A_{EM-Alt}}{A_{EM-FRP}} + RW_{H_{RR-1\%}} \frac{H_{RR-1\%-Alt}}{H_{RR-1\%-FRP}} + RW_{\#_{HIS-Maj}} \frac{\#_{HIS-Maj-Alt}}{\#_{HIS-Maj-FRP}} + RW_{\#_{HIS-Min}} \frac{\#_{HIS-Min-Alt}}{\#_{HIS-Min-FRP}} \right)$	29%	100%	81%	84%	82%	89%	112%	29%	23%	24%	23%	26%	32%
Implementability	$S_I = RW_I * \frac{I_{Alt}}{I_{FRP}}$	24%	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	$S_S = RW_S * \left(\frac{RW_{>1} * \#_{STR>1-Alt} + RW_{<1} * \#_{STR<1-Alt}}{RW_{>1} * \#_{STR>1-FRP} + RW_{<1} * \#_{STR<1-FRP}} \right)$	19%	100%	97%	99%	150%	108%	41%	19%	18%	19%	28%	21%	8%
Environmental	$S_E = RW_E * \left(RW_{A_{PF}} \frac{A_{PF-Alt}}{A_{PF-FRP}} + RW_{L_{RI}} \frac{L_{RI-Alt}}{L_{RI-FRP}} \right)$	14%	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	$S_A = RW_A * \frac{\#_{AC-Alt}}{\#_{AC-FRP}}$	7%	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	$S_F = RW_F * \frac{A_{FL-Alt}}{A_{FL-FRP}}$	5%	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	$S_T = RW_T * \left(RW_{\#_B} \frac{\#_{B-Alt}}{\#_{B-FRP}} + RW_{L_{GR}} \frac{L_{GR-Alt}}{L_{GR-FRP}} \right)$	2%	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total		100%							100%	87%	88%	107%	98%	104%



Sensitivity Case #1 - $RW_{A\text{-}EM}$ = 25%, $RW_{H\text{-}RR\text{-}1\%}$ = 25%, $RW_{HIS\text{-}Maj}$ = 42%, $RW_{HIS\text{-}Min}$ = 8%

Assessment Factor Category	Function Comparing Alternatives to FRP: Function (see Table I-14)	Relative Weight (RW)	Function Comparing Alternative to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	Relative Assessment Factor Score Compared to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	$S_R = RW_R * \left(RW_{A_{EM}} \frac{A_{EM-Alt}}{A_{EM-FRP}} + RW_{H_{RR-1\%}} \frac{H_{RR-1\%-Alt}}{H_{RR-1\%-FRP}} + RW_{\#_{HIS-Maj}} \frac{\#_{HIS-Maj-Alt}}{\#_{HIS-Maj-FRP}} + RW_{\#_{HIS-Min}} \frac{\#_{HIS-Min-Alt}}{\#_{HIS-Min-FRP}} \right)$	29%	100%	85%	85%	73%	77%	107%	29%	24%	24%	21%	22%	30%
Implementability	$S_I = RW_I * \frac{I_{Alt}}{I_{FRP}}$	24%	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	$S_S = RW_S * \left(\frac{RW_{>1} * \#_{STR>1-Alt} + RW_{<1} * \#_{STR<1-Alt}}{RW_{>1} * \#_{STR>1-FRP} + RW_{<1} * \#_{STR<1-FRP}} \right)$	19%	100%	97%	99%	150%	108%	41%	19%	18%	19%	28%	21%	8%
Environmental	$S_E = RW_E * \left(RW_{A_{PF}} \frac{A_{PF-Alt}}{A_{PF-FRP}} + RW_{L_{RI}} \frac{L_{RI-Alt}}{L_{RI-FRP}} \right)$	14%	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	$S_A = RW_A * \frac{\#_{AC-Alt}}{\#_{AC-FRP}}$	7%	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	$S_F = RW_F * \frac{A_{FL-Alt}}{A_{FL-FRP}}$	5%	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	$S_T = RW_T * \left(RW_{\#_B} \frac{\#_{B-Alt}}{\#_{B-FRP}} + RW_{L_{GR}} \frac{L_{GR-Alt}}{L_{GR-FRP}} \right)$	2%	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total		100%							100%	88%	89%	104%	95%	103%



Sensitivity Case #2 - $RW_{A\text{-}EM}$ = 40%, $RW_{H\text{-}RR\text{-}1\%}$ = 20%, $RW_{HIS\text{-}Maj}$ = 33%, $RW_{HIS\text{-}Min}$ = 7%

Assessment Factor Category	Function Comparing Alternatives to FRP: Function (see Table I-14)	Relative Weight (RW)	Function Comparing Alternative to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	Relative Assessment Factor Score Compared to FRP: FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	$S_R = RW_R * \left(RW_{A_{EM}} \frac{A_{EM-Alt}}{A_{EM-FRP}} + RW_{H_{RR-1\%}} \frac{H_{RR-1\%-Alt}}{H_{RR-1\%-FRP}} + RW_{\#_{HIS-Maj}} \frac{\#_{HIS-Maj-Alt}}{\#_{HIS-Maj-FRP}} + RW_{\#_{HIS-Min}} \frac{\#_{HIS-Min-Alt}}{\#_{HIS-Min-FRP}} \right)$	29%	100%	82%	84%	76%	83%	109%	29%	23%	24%	22%	24%	31%
Implementability	$S_I = RW_I * \frac{I_{Alt}}{I_{FRP}}$	24%	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	$S_S = RW_S * \left(\frac{RW_{>1} * \#_{STR>1-Alt} + RW_{<1} * \#_{STR<1-Alt}}{RW_{>1} * \#_{STR>1-FRP} + RW_{<1} * \#_{STR<1-FRP}} \right)$	19%	100%	97%	99%	150%	108%	41%	19%	18%	19%	28%	21%	8%
Environmental	$S_E = RW_E * \left(RW_{A_{PF}} \frac{A_{PF-Alt}}{A_{PF-FRP}} + RW_{L_{RI}} \frac{L_{RI-Alt}}{L_{RI-FRP}} \right)$	14%	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	$S_A = RW_A * \frac{\#_{AC-Alt}}{\#_{AC-FRP}}$	7%	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	$S_F = RW_F * \frac{A_{FL-Alt}}{A_{FL-FRP}}$	5%	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	$S_T = RW_T * \left(RW_{\#_B} \frac{\#_{B-Alt}}{\#_{B-FRP}} + RW_{L_{GR}} \frac{L_{GR-Alt}}{L_{GR-FRP}} \right)$	2%	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total		100%							100%	88%	88%	105%	96%	104%

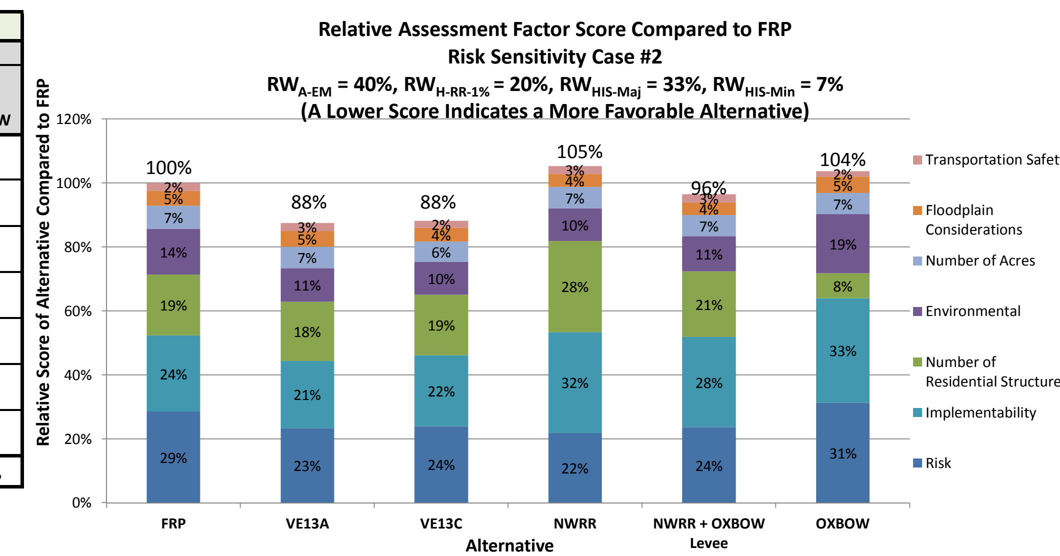
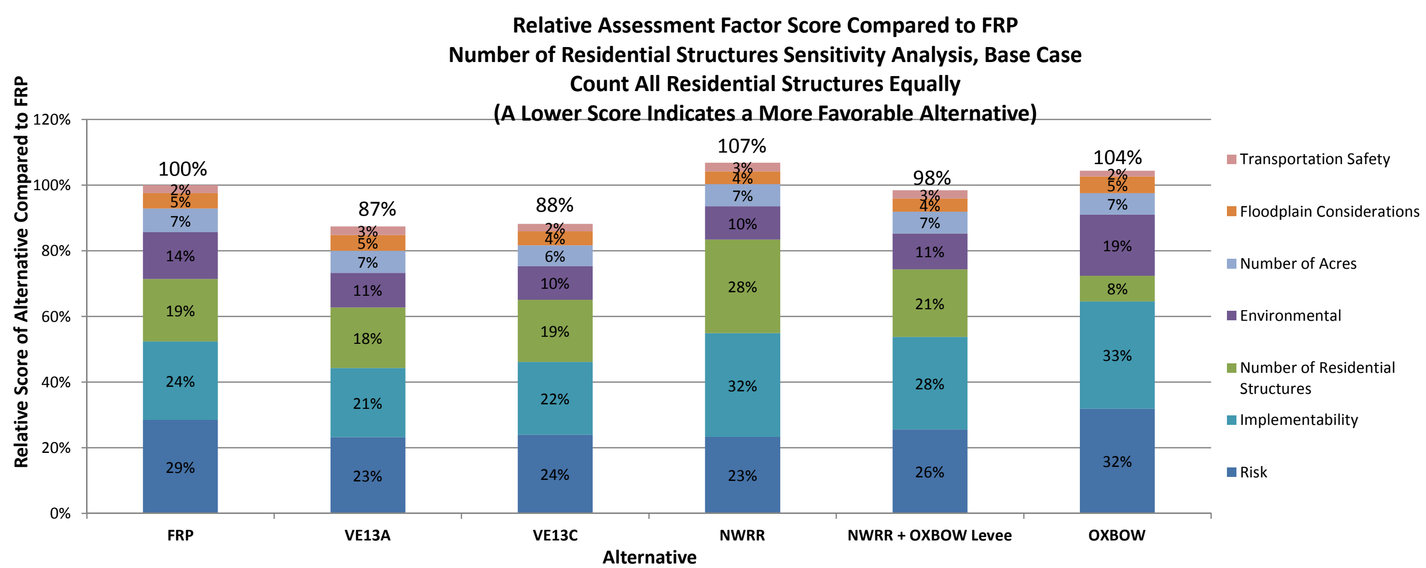
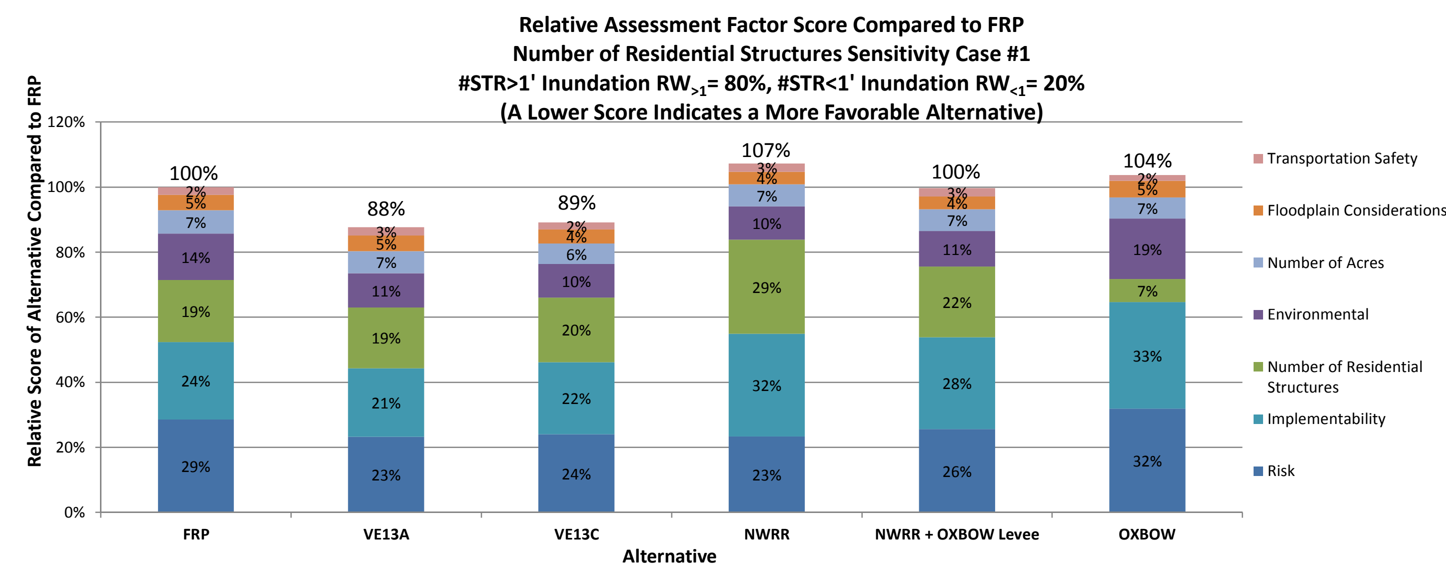


Table I-17 Summary of Assessment Factors used to Compare Alternatives - Number of Residential Structures Sensitivity Analysis

Assessment Factor Category	Function Comparing Alternatives to FRP: Function (see Table I-14)	Relative Weight (RW)	Base Case - Count All Residential Structures Equally: Function Comparing Alternative to FRP						Base Case: Relative Assessment Factor Score Compared to FRP					
			FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	$S_R = RW_R * \left(RW_{A_{EM}} \frac{A_{EM-Alt}}{A_{EM-FRP}} + RW_{H_{RR1\%}} \frac{H_{RR1\%-Alt}}{H_{RR1\%-FRP}} + RW_{\#_{HIS-Maj}} \frac{\#_{HIS-Maj-Alt}}{\#_{HIS-Maj-FRP}} + RW_{\#_{HIS-Min}} \frac{\#_{HIS-Min-Alt}}{\#_{HIS-Min-FRP}} \right)$	29%	100%	81%	84%	82%	89%	112%	29%	23%	24%	23%	26%	32%
Implementability	$S_I = RW_I * \frac{I_{Alt}}{I_{FRP}}$	24%	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	$S_S = RW_S * \left(\frac{RW_{>1} * \#_{STR>1-Alt} + RW_{<1} * \#_{STR<1-Alt}}{RW_{>1} * \#_{STR>1-FRP} + RW_{<1} * \#_{STR<1-FRP}} \right)$	19%	100%	97%	99%	150%	108%	41%	19%	18%	19%	28%	21%	8%
Environmental	$S_E = RW_E * \left(RW_{A_{PF}} \frac{A_{PF-Alt}}{A_{PF-FRP}} + RW_{L_{RI}} \frac{L_{RI-Alt}}{L_{RI-FRP}} \right)$	14%	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	$S_A = RW_A * \frac{\#_{AC-Alt}}{\#_{AC-FRP}}$	7%	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	$S_F = RW_F * \frac{A_{FL-Alt}}{A_{FL-FRP}}$	5%	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	$S_T = RW_T * \left(RW_{\#_B} \frac{\#_{B-Alt}}{\#_{B-FRP}} + RW_{L_{GR}} \frac{L_{GR-Alt}}{L_{GR-FRP}} \right)$	2%	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total		100%							100%	87%	88%	107%	98%	104%

Assessment Factor Category	Sensitivity Case #1, #STR>1' Inundation $RW_{>1}$= 80%, #STR<1' Inundation $RW_{<1}$= 20%: Function Comparing Alternative to FRP						Sensitivity Case #1: Relative Assessment Factor Score Compared to FRP					
	FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW	FRP	VE13A	VE13C	NWRR	NWRR + OXBOW Levee	OXBOW
Risk	100%	81%	84%	82%	89%	112%	29%	23%	24%	23%	26%	32%
Implementability	100%	88%	93%	133%	119%	137%	24%	21%	22%	32%	28%	33%
Number of Residential Structures	100%	98%	104%	152%	114%	37%	19%	19%	20%	29%	22%	7%
Environmental	100%	74%	72%	72%	77%	130%	14%	11%	10%	10%	11%	19%
Number of Acres	100%	94%	88%	94%	93%	92%	7%	7%	6%	7%	7%	7%
Floodplain Considerations	100%	101%	90%	82%	83%	107%	5%	5%	4%	4%	4%	5%
Transportation Safety	100%	108%	94%	107%	107%	73%	2%	3%	2%	3%	3%	2%
Total							100%	88%	89%	107%	100%	104%





The bundles consist of one of the five southern alignment alternatives as a base, which are then supplemented with a set of potential enhancements as follows:

- Bundle 1 consists of the PFSAA base alignment VE13A, with the addition of Lands and Damages and construction features and elimination of fish passage systems at the RRN and WRR control structures for Increased Flows Through Town (associated w/ 35' flood stage), addition of Operable Gates on the Diversion Inlet.
- Bundle 2 consists of the PFSAA base alignment VE13C, with the addition of Lands and Damages and construction features and elimination of fish passage systems at the RRN and WRR control structures for Increased Flows Through Town (associated w/ 35' flood stage), addition of Operable Gates on the Diversion Inlet.
- Bundle 3 consists of the PFSAA base alignment NWRR, with the addition of Lands and Damages and construction features and elimination of fish passage systems at the RRN control structures for Increased Flows Through Town (associated w/ 35' flood stage), addition of Operable Gates on the Diversion Inlet. This bundle also includes property acquisition and construction of a Ring Levee around the communities of Oxbow, Hickson, and Bakke and associated changes to Lands and Damages.
- Bundle 4 consists of the FRP alignment, with the addition of Lands and Damages and construction features and elimination of fish passage systems at the RRN control structures for Increased Flows Through Town (associated w/ 35' flood stage), addition of Operable Gates on the Diversion Inlet.
- Bundle 5 consists of the PFSAA base alignment NWRR, with the addition of Lands and Damages and construction features and elimination of fish passage systems at the RRN control structures for Increased Flows Through Town (associated w/ 35' flood stage), addition of Operable Gates on the Diversion Inlet.
- During the August 2, 2012 LSLCTT meeting, HMG was directed not to bundle infrastructure enhancements for the South of Oxbow alternative. However for consistency for the comparison to the FRP, a bundled cost has been estimated and is shown as Bundle 6.

The estimated cost within bundles for "flow through town" cost is the same. For additional information, see HMG report entitled *Final Technical Memorandum AWD-00002 – Flows Through Flood Damage Reduction Area,* Dated July 16, 2012. The estimated fish passage cost within bundles varies because the extents and cost of each fish passage system is unique to each structure and alternative.

A breakdown of the estimated cost of these enhancements and their contribution to the costs presented in Table I-18 are presented below in Table I-19:

Table I-19 Cost Comparison for Southern Alignment Alternatives with Enhancements

Alternative	Bundle 1 ($)	Bundle 2 ($)	Bundle 3 ($)	Bundle 4 ($)	Bundle 5 ($)	Bundle 6 [8] ($)
PFSAA BASE FEATURES						
FRP [1 5]				593M		
VE13A [5]	525M					
VE13C [5]		532M				
NWRR [5]			564M		564M	
OXBOW [1 5]						592M
Subtotal 1: PFSAA Base [2 6]	**525M**	**532M**	**564M**	**593M**	**564M**	**592M**
PFSAA ENHANCEMENTS						
Increase Flows Through Town (35' Flood Stage, Add'l Levees) [3]	29M	29M	29M	29M	29M	29M
Increase Flows Through Town (Eliminate Fish Passage Systems at WRR and RRN) [3]	(-) 14M	(-) 9M	(-) 7M	(-) 13M	(-) 7M	(-) 14M
Modify Diversion Inlet to Include Operable Gates [3]	21M	21M	21M	21M	21M	21M
Lands and Damages Reduction for Oxbow Ring Levee [4]			(-) 31M			
Oxbow Ring Levee [7]			38M			
Subtotal 2: PFSAA Enhancements [2 6]	**36M**	**41M**	**50M**	**37M**	**43M**	**36M**
Subtotal 1 + Subtotal 2 (u/s of Sta. 1514+00): [2 6]	**561M**	**573M**	**614M**	**630M**	**607M**	**628M**
Change in PED and CM for PFSAA Enhancements	9M	10M	13M	9M	10M	9M
FRP Balance (d/s of Sta. 1514+00) [6]	1,115M	1,114M	1,111M	1,128M	1,111M	1,136M
TOTAL [6]	**1,685M** **VE13A w/ Bundle 1**	**1,697M** **VE13C w/ Bundle 2**	**1,738M** **NWRR w/ Bundle 3**	**1,767M** **FRP w/ Bundle 4**	**1,728M** **NWRR w/ Bundle 5**	**1,773M** **OXBOW w/ Bundle 6**

[1] Includes SA1 where applicable.

[2] Subtotal is for features east (upstream) of Sta. 1514+00 only (Southern Alignment Alternatives Base Cost).

[3] Estimated Cost by Houston Engineering dated 8/10/2012, includes Lands and Damages, contingency and PED.

[4] Estimated Cost by Moore Engineering dated 8/10/2012; includes Lands and Damages, contingency.

[5] Estimated Cost by USACE, Moore Engineering, Houston Engineering and Barr Engineering.

[6] Costs include contingency and PED. Costs do not include Escalation, O&M.

[7] Estimated Cost by Moore Engineering dated 8/10/2012; includes Lands and Damages, contingency and PED.

[8] During the August 2, 2012 workshop, HMG was directed not to bundle infrastructure enhancements for the South of Oxbow alternative. However for consistency for the comparison to the FRP, a bundled cost has been estimated and is shown.

For a breakdown of the Base Cost, see Exhibit H2.

The benefit to cost ratio was not addressed or recalculated for any alternative.

Capital costs are one way to compare project costs, but long-term operation and maintenance (O&M) is another consideration. The southern alignment alternative changes and the associated proportion of O&M may not impact the project-wide O&M cost significantly. In general, more O&M will be associated with:

- More frequent use
- Longer and taller embankment reaches
- Additional hydraulic structures
- Additional active hydraulic structures (structures with gates and moving parts such as the RRN and WRR closures, operable gated Diversion Inlet weir) as opposed to passive structures (Diversion Inlet fixed weir, Rush River or Lower Rush River Drop structures)
- Larger project foot print area

Based on these factors, the following qualitative observations of O&M costs can be made:

- VE13A: The length of southern alignment embankment is 18% shorter than the FRP. There are three (3) fewer active hydraulic structures in this alternative (Wolverton and two (2) SA1 drainage control structures). The project foot print area is smaller than the FRP. Based on these factors, this alternative should be expected to have a lower O&M cost than the FRP.
- VE13C: The length of southern alignment embankment is 21% shorter than the FRP. There are three (3) fewer active hydraulic structures in this alternative (Wolverton and two (2) SA1 drainage control structures). The project foot print area is smaller than the FRP. Based on these factors, this alternative should be expected to have a lower O&M cost than the FRP.
- NWRR: The length of southern alignment embankment is 15% shorter than the FRP. There are four (4) fewer active hydraulic structures in this alternative (Wolverton, WRR and two (2) SA1 drainage control structures). The project foot print area is smaller than the FRP. Based on these factors, this alternative should be expected to have a lower O&M cost than the FRP. This alternative will likely have a lower O&M than FRP, VE13A and VE13C due to the removal of the WRR structure.
- South of Oxbow: The length of southern alignment embankment is significantly (53%) longer than the FRP. There are the same number of hydraulic structures in this alternative as the FRP. However, some of them are larger. The project foot print area is larger than the FRP. Based on these factors this alternative should be expected to have higher O&M costs than the FRP. This alternative would likely have the highest O&M cost.

Comparing the assessment factor score against the cost can assist in deciding which PFSAA alternative best meets project objectives and provides the greatest value and is presented in Table I-20.

Table I-20 Assessment Factor Score and Cost Comparison for Southern Alignment Alternatives

Alternative	Assessment Factor Score (Lower Score Indicates a More Favorable Alternative)	PFSAA Base Cost Upstream of the Sheyenne River (Sta. 1514+00) with Bundles ($)	Total Cost with Bundles ($)
FRP	100%	630M	1,767M
VE13A	87%	561M	1,685M
VE13C	88%	573M	1,697M
North of Wild Rice River (NWRR)	107%	607M	1,728M
North of Wild Rice River (NWRR) + Levee at Oxbow	98%	614M	1,738M
South of Oxbow (OXBOW)	104%	628M (1)	1,773M (1)

(1) During the August 2, 2012 LSLCTT meeting, HMG was directed not to bundle infrastructure enhancements for the South of Oxbow alternative. However for consistency for the comparison to the FRP, a bundled cost has been estimated and is shown.

VE13A has the lowest assessment factor score and the lowest cost. However, the difference between the scores for VE13A and VE13C is only on the order of one-percent, essentially equal given the subjective nature of the analysis. The difference in costs is only 12 million dollars (or less than one-percent of the total project cost). Therefore, decision makers will need to take into account many factors, both objective and subjective to choose the best option.

I.3.5 OTHER CONSIDERATIONS FOR ANALYSIS

Estimated costs, assumptions, assessment factor characterization and assessment factor ranking is based on the feasibility design of the Project as defined at the time of this assessment As more information is collected and analyzed about the region, site conditions and regulatory requirements, the costs and assessment factor analysis could change and alternative ranking could change. For example, the hydrology for the region is currently in the process of being reanalyzed. It is expected that the Probable Maximum Flood water surface elevations may decrease and the height of embankments, especially for the NWRR option, may decrease.

APPENDIX J – CONSIDERATIONS FOR FUTURE DESIGN

J.1 CONSIDERATIONS FOR FUTURE DESIGN

Appendix J presents items and ideas that should be considered as the project moves forward towards final design.

- Geotechnical Considerations:
    1. The stability analysis presented in Appendix E may not apply to the CSAH17 or RRN-MN embankments. More detailed site specific information will be required for analyzing this offset for all embankment segments in future design efforts.
    2. Stratigraphy in the area should be determined by a drilling investigation for an accurate stability analysis.
- Pile Capacity Considerations:
    1. Further evaluation of drained strength parameters, especially the till layer, should be evaluated prior to final design.
    2. The use of the drained pile capacities and their use should be evaluated based on pile load tests and behavior of the soils.
    3. The effect of groundwater and flow direction in the foundation soils and pile capacities should be evaluated.
    4. Alternative pile types and sizes should be evaluated (for example; driven pile and drilled shafts)
- Micro-Siting Considerations:
    1. All property ownership should be reviewed during future phases of work to ensure deed-restricted properties are avoided.
    2. The sites of structures that incorporate fish passage may have to be altered slightly to accommodate the final configuration of those features.
    3. Site locations may need to be modified to accommodate the incorporation of recreational features in final design.
    4. Site locations may need to be altered pending the gathering of design data related to geotechnical parameters, and presence of local groundwater features that my impact structure stability.
    5. Physical modeling of each of these structures, which may dictate a better location or orientation with respect to channel flow, is needed to obtain the desired performance.
- Civil Site Design Considerations:
    1. Due to the critical nature of this project and the unstable soil conditions present in the region, the design should include a full detailed review of the protective embankment to see if shallower side slopes and a wider top section are warranted.
    2. Filling and full abandonment of all unused river channels is recommended to reduce risk of embankment failure in these areas.
    3. Detailed design must address the issue of scour at hydraulic structures.
    4. A detailed review of ground water needs to be included in the final design to ensure that slope stability is not compromised due to local groundwater flow patterns.

5. Due to the critical nature, paved access roads may be required.
6. Site designs may need to be redesigned based on recreational features to be incorporated in final design.
7. Civil site works may need to be modified to include public are or other visual enhancements.
8. Fish passage access should be included.
9. Maintenance access to the areas upstream and downstream of all structures should be provided in final design.
10. Detailed design must address issues and requirements related to the Levee System Evaluation for the National Flood Insurance Program.
11. Permanent and temporary real estate acquisitions and easements will be revised during detailed design.
12. Detailed bathymetric data should be collected where work will occur at existing channels. Bathymetric data used for the PFSAA is based on data obtained for the hydraulics model. For additional information, please refer to Table B1 of Section B4.0 of April 2011 Consultant Deliverable to USACE, Appendix B – Hydraulics. For example, channel bathymetry for the Red River of the North reach from River Mile 440.0 to 470.2 was based on RRN soundings that were obtained for Phase 1 of the feasibility study. For areas outside the reach defined above, the channel bathymetry was based on the cross sections from existing HEC-RAS and HEC-2 models.

- Cost Estimate Considerations:
    1. Recommendations for future refinement to the methodology and assumptions used for the April 2011 Total Project Cost Summary (LPP/FRP) work through July 31, 2012 are presented for consideration.
    2. Comments received during Agency Technical Review included valuable recommendations related to cost estimate assumptions, but such comments have not been fully addressed as part of this evaluation. Future cost estimate efforts should reference these comments when evaluating future cost estimate assumptions.
    3. Cost estimates presented in the FRP TPCS do not incorporate any construction schedule and critical path work performed since April of 2011. Future cost estimating efforts should incorporate the recommendations and assumptions developed during any ongoing or future work related to defining construction schedules, phasing and critical path work sequencing. It is highly recommended that cost estimates for this individual portion of the project, always be evaluated in consideration of construction phases that are located adjacent, upstream, or downstream of the work area. Estimated costs associated with temporary facilities, redirecting or diverting channel flows, and reducing risk associated with seasonal flooding at construction sites should be considered as part of this future effort.
    4. Direct Cost Assumptions (Construction Costs): Future estimate efforts should obtain updated cost quotes for materials as needed to estimate material costs with less uncertainty. This is of particular importance the further out the construction start date

is anticipated. Likewise, future changes to wage rates, equipment rates and fuel costs should be considered for all future cost estimating efforts.

5. Direct Cost Assumptions (Construction Costs): Revisions of the fuel costs are recommended in detailed design to use more current data such as that from the US Energy Information Administration. Construction of the proposed project will take several years, a period over which fuel costs may fluctuate.
6. Direct Cost Assumptions (Construction Costs): Agency Technical Review (ATR) comments received during development of the FRP TPCS should be reviewed and taken into consideration in future development of MII cost model assumptions related to crew productivities, unit costs, etc.
7. Indirect Cost Assumptions (Contractor Costs): Contractor assumptions and markups for Job-Office Overhead (JOOH), Home Office Overhead (HOOH), Mobilization/Demobilization, Profit and Bonding should be revisited for each individual proposed phase of the project. If contracting scenarios and markups differing from what was assumed in the SDEIS MII cost model are considered likely, then it is recommended that these assumptions be revisited and estimated unit costs be recalculated. Consideration should be given to contract size and acquisition strategy for setting appropriate markups and contractor relationships. For example, if smaller phases of the project will be bid and constructed, reconsideration of the Prime Broker Contractor with Subcontractors (double contractor markups) is necessary. Perhaps single-contractor scenarios should be considered for smaller phases if that is what is anticipated during bidding and construction. It is recommended that future contracting assumptions be evaluated by benchmarking project costs and unit costs against similar reference project costs
8. 02 Utility Relocations: A detailed review of on-site utilities and relocation needs should be performed during future cost estimating efforts.
9. 06 Fish and Wildlife Facilities: Future cost estimate efforts should more clearly identify mitigation and costs related to impacts due to realignment of embankments and revised siting of hydraulic structures. As project features are optimized, impacts will be assessed and mitigated for.
10. 09 Channels and Canals: Future cost estimate efforts should incorporate the most updated version of the low flow channel design for grading, erosion control, site restoration, etc.
11. 09 Channels and Canals: Future cost estimates must consider adaptive management strategies that may be developed for the inspection and monitoring of the low flow channel. This should be considered in Operations and Maintenance costs as well.
12. 09 Channels and Canals: Future cost estimating efforts should investigate the applicability of excavating and working on Brenna clays during winter months when the ground is frozen and assess its potential benefits in terms of schedule and cost (if any).
13. 09 Channels and Canals: Estimated costs associated with Site Restoration and Vegetation Establishment and Maintenance costs should consider assumptions

developed as part of any future Adaptive Management strategies developed for the downstream reaches of the diversion channel and the low flow channel. In addition, consideration must be given to the impact of seasonal flooding and flows from upstream connected catchments on the establishment of permanent vegetation.

14. 09 Channels and Canals: Cost estimates assume one access road (12' width, one-way, aggregate surfaced) along one side of the diversion channel. Quantities and costs related to this facility may be conservative and may allow for some access roads on both sides of the channel if they are constructed with a less robust cross section (such as an aggregate surfacing of lesser thickness). Future cost estimating efforts should evaluate if the budget related to aggregate access roads alongside the diversion channel is appropriate. Consideration should be given to using the aggregate budget for access roads along both sides of the channel, but in consideration of the amount of operations and maintenance that may be required if a less robust access road cross section is constructed initially.
15. 09 Channels and Canals: Previous estimates included allowances for the restoration of aggregate-surfaced roadways and bituminous-surfaced roadways that may be damaged as a result of the work. Future cost estimate efforts could refine these assumptions for the individual reach/structure/site under consideration.
16. 09 Channels and Canals: Future cost estimate efforts could refine the assumptions for lump sum items (site preparation and traffic control, erosion and sedimentation control measures, control of water and dewatering, and other miscellaneous features such as dust control, snow removal during construction, monuments and markers, etc.) for the individual reach/structure/site under consideration.
17. 09 Channels and Canals: Additional design refinement, physical modeling and velocity modeling may identify locations of high localized velocities that could require more robust protection and scour protection, such as additional riprap, concrete sills or baffling.
18. 09 Channels and Canals: Future construction phasing and critical path work should consider the seasonality of work. Some earthwork could be conducted during late fall, early spring and some winter periods. Work related to the low flow channel and riprap installation could be performed when the ground is frozen to take advantage of enhanced traffic on softer soils (for example, on areas of Brenna clay). Future construction phasing work should consider this possibility.
19. 09 Channels and Canals: Cost estimates include allowances for the restoration of aggregate-surfaced roadways and bituminous-surfaced roadways that may be damaged as a result of the work. Future cost estimate efforts could refine these assumptions for each specific reach/structure/site under consideration.
20. 09 Channels and Canals: Cost estimates include allowances for site preparation and traffic control, erosion and sedimentation control measures, control of water and dewatering, electrical utilities, temporary flood risk reduction embankment for the construction site, signage, fencing, safety features, Supervisory Control and Data

Acquisition (SCADA), and other miscellaneous features. These features appear as single lump sum (L.S.) allowances in the MII estimates. Future cost estimate efforts could refine these assumptions for the individual reach/structure/site under consideration.

21. 11 Levees and Floodwalls: Feasibility cost estimates assumed the embankment cross sections provided by USACE in the March 2012 white paper entitled "FMM-Estimated Costs for Dam vs. Levee Design." The PFSAA estimates assume a 50 foot offset from top of connecting channel excavation to toe of embankment, based on preliminary geotechnical analysis. Future cost estimate efforts should evaluate this assumption with geotechnical analysis and incorporation of any pending development of design criteria for the embankments. The size of the embankments, the geotechnical offset from excavations and the additional right-of-way required for this corridor all contribute to the estimated cost.
22. 11 Levees and Floodwalls: The assumption of obtaining borrow for RRN-MN embankment from excavations in ND was used in the PFSAA to make for consistent comparison to the FRP. Future cost estimating efforts should investigate the earthwork balance upstream of the Sheyenne River, and optimize borrow sources are located for County Road 17 embankment and RRN-MN embankment. One option to consider is a borrow trench alongside these embankments, which has not been assumed in feasibility grading developed to date. Consider borrowing material for the RRN-MN embankment in MN.
23. 11 Levees and Floodwalls: Future cost estimating efforts should revisit the equipment allocations used in the levee embankment construction crews. The productivity assumed for compaction crews may be conservative. Assumption related to hauling of material may not be conservative enough. These revisions would offset each other to some degree. These crews should be reformulated in future cost estimate efforts if appropriate, and the net unit cost should be benchmarked against available USACE bid tabulations for embankments, or similar.
24. The unit costs of levee embankments were revised between April 2011 and the PFSAA to reflect an ATR comment provided by USACE. The productivity of the levee compaction crews was increased from 120 BCY/HR to 200 BCY/HR and the resulting levee unit costs were benchmarked against regional levee projects. This change was applied to all tieback embankments in alternative alignments as well as the FRP for consistent comparison. This revision should be carried forward when developing new MII cost estimate files.
25. 11 Levees and Floodwalls: The offset required for the necessary geotechnical slope stability factor of safety between embankments and borrow trenches should be evaluated in greater detail during future cost estimating efforts. This parameter is important as it is one of many factors determining right-of-way acquisition requirements.

26. 11 Recreation Facilities: Future cost estimating efforts should clarify site-specific recreational facilities such as a boat ramp and recreational trails and coordinate cost estimating efforts with the most current recreational planning efforts.
27. Uncertainty and Risk: The contingencies, cost estimates, documentation and discussion provided in the feasibility cost estimates and in April 19, 2011 A/E deliverable to the USACE are intended to provide background information for feasibility cost and schedule risk assessment (CSRA) and analysis purposes by the USACE for contingency-appropriation purposes, and to identify areas where additional design effort in future stages of refinement could significantly reduce uncertainty of the project cost. Unknowns and uncertainties have been identified that could affect project designs and costs, and are not included in the project costs or contingencies provided with the cost estimate. A detailed discussion of uncertainties and unknowns identified during development of feasibility cost estimates is presented in the Phase 4 Appendix G of the April 19, 2011 A/E deliverable to the USACE. The details presented in Appendix G of the referenced report should be fully understood and considered prior to development of future risk analysis on this project.