APPENDIX B

Mouse River Enhanced Flood Protection Project: Progress Update, Flood Recovery, Infrastructure Needs for the City of Minot

Outline of Today's Presentation

- Background on Mouse River Enhanced Flood Protection Plan (MREFPP)
- Minot Area Flood Recovery
- Minot Infrastructure Demands and Needs

Background on Mouse River Enhanced Flood Protection Plan (MREFPP)

Sept 26, 2011

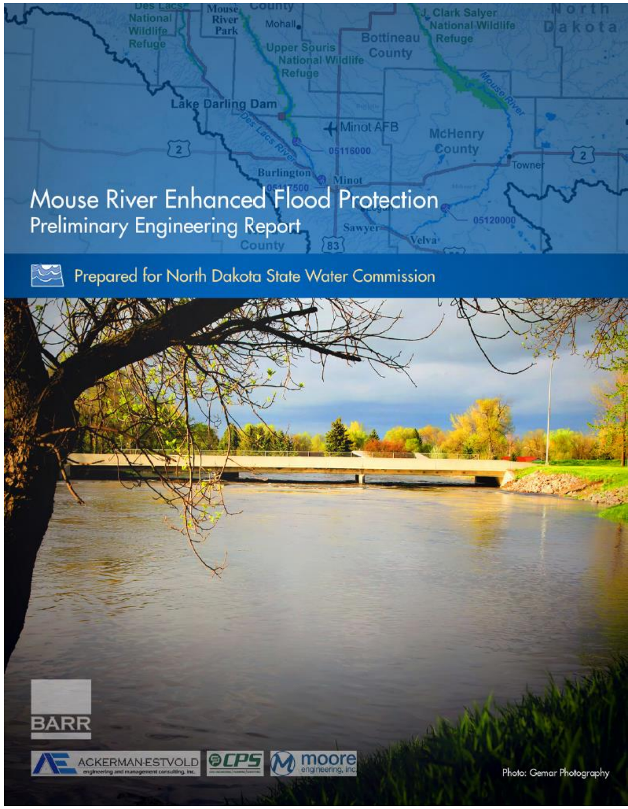
- **NDSWC signs contract with Barr Engineers and Ackerman Estvold Engineers to complete MREFPP – Preliminary Engineering Report**

April 12, 2012

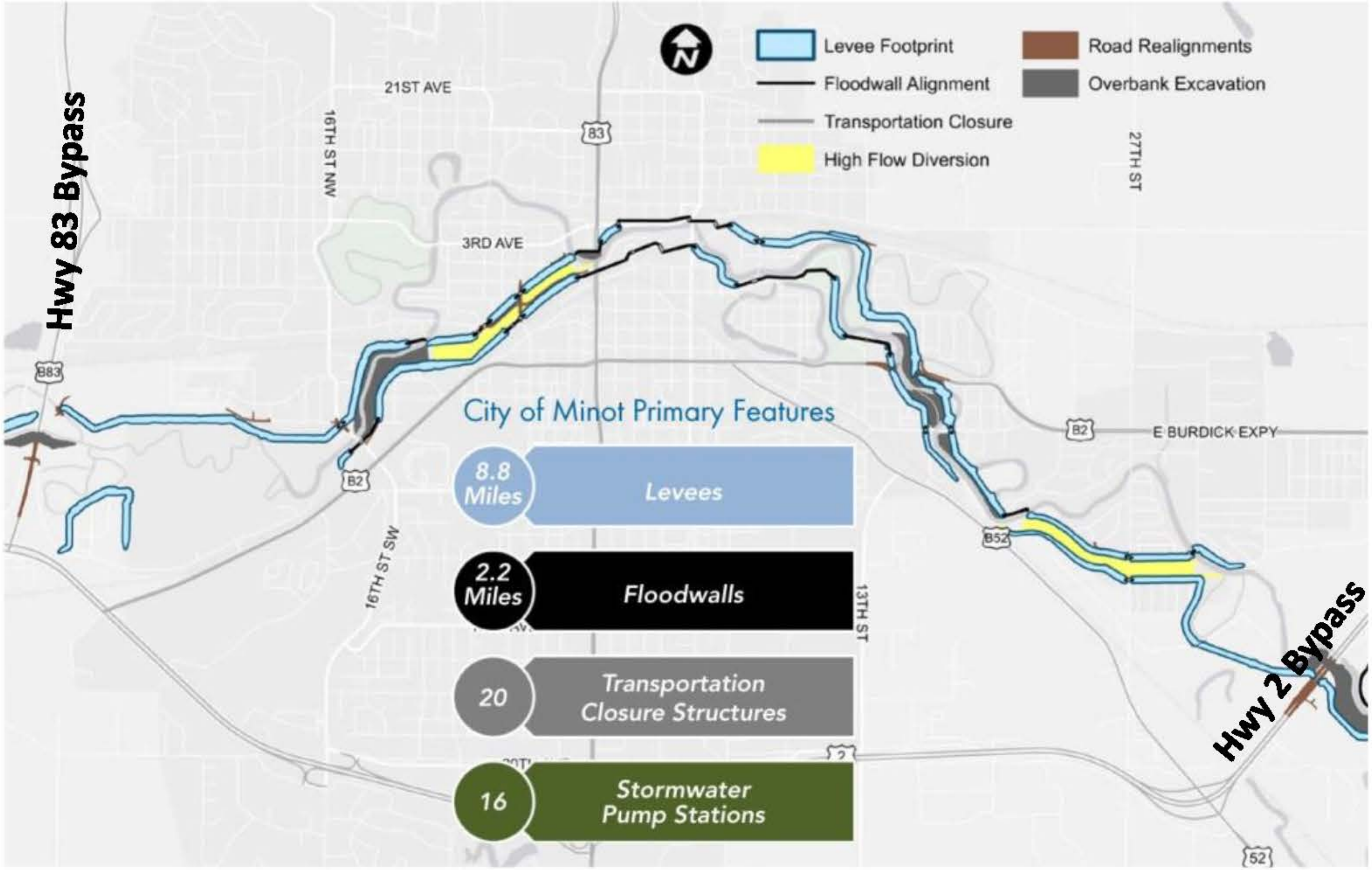
- **Minot City Council Adopts Footprint of Preliminary Engineering Report**
- **Similar Actions Taken by Other Local Governments (Ward County, City of Burlington, etc.)**

December 2013

- **Souris River Joint Water Board Adopts MREFPP**

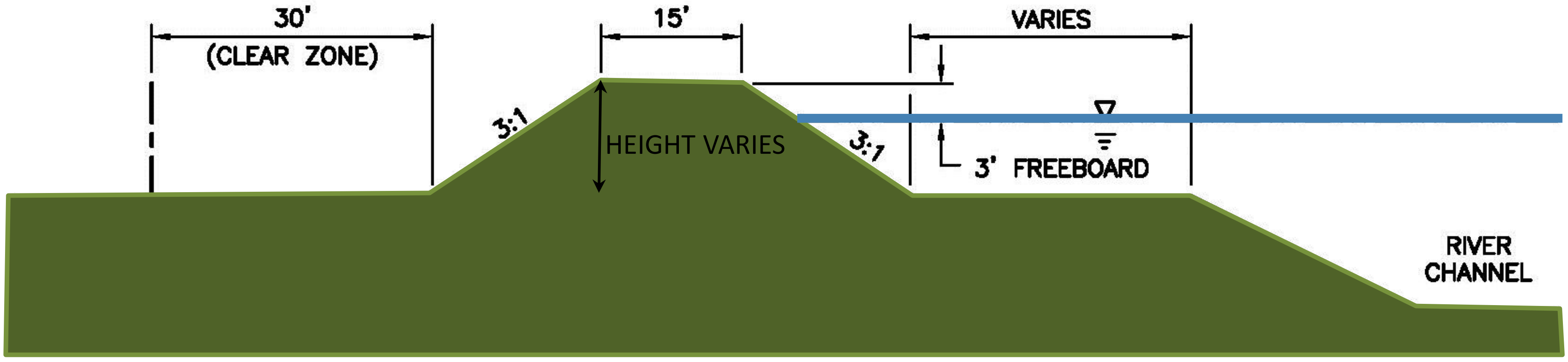


Proposed Minot Features



Preliminary Alignment contains 8 ¾ Miles of Levees in Minot

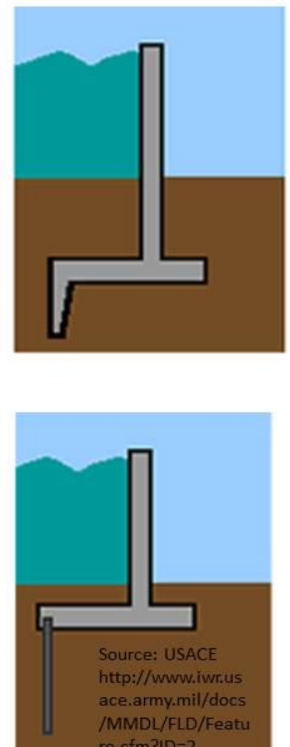
Item	Units	Reaches Upstream of Minot	Reaches Through Minot	Reaches Downstream of Minot	All Project Reaches
Length of Levee	feet	38,200	**46,300**	29,500	114,000



Preliminary Alignment Contains 2 ¼ Miles of Floodwalls in Minot

Item	Units	Reaches Upstream of Minot	Reaches Through Minot	Reaches Downstream of Minot	All Project Reaches
Length of Levee	feet	1,100	**11,800**	2,000	14,900

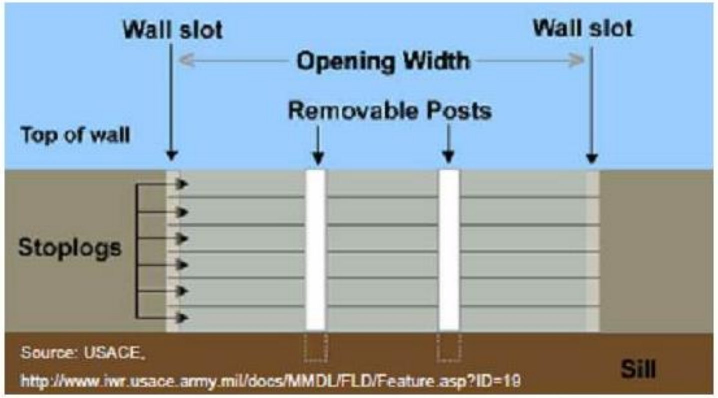
Floodwall Examples



Floodwall Schematics

Preliminary Alignment Contains 20 Transportation Closures in Minot

Item	Reaches Upstream of Minot	Reaches Through Minot	Reaches Downstream of Minot	All Project Reaches
Transportation Closures	2 (1 road & 1 RR)	**20** (16 road & 4 RR)	8 (2 road & 6 RR)	30 (19 road & 11 RR)

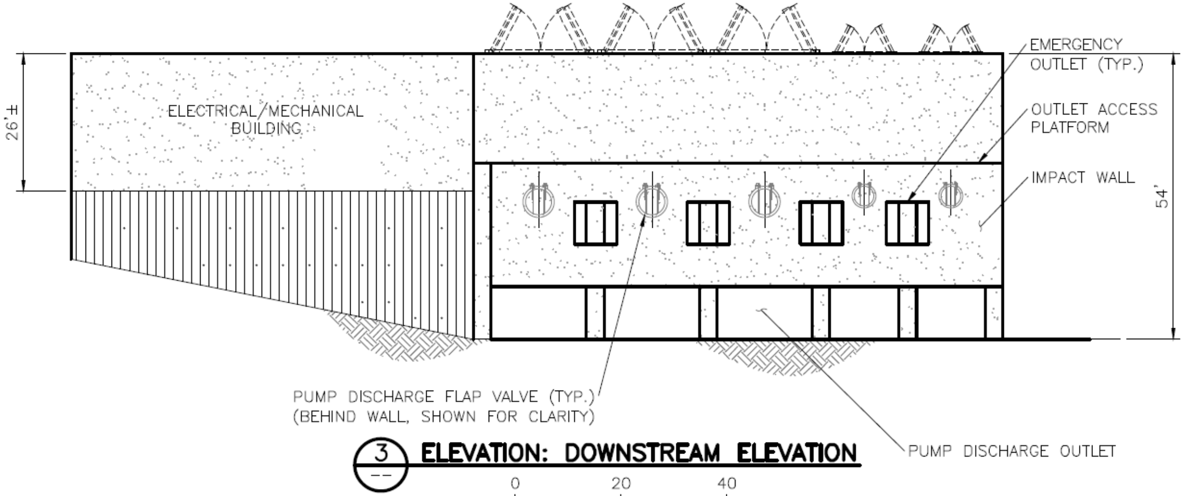


Stoplog Closure Schematic

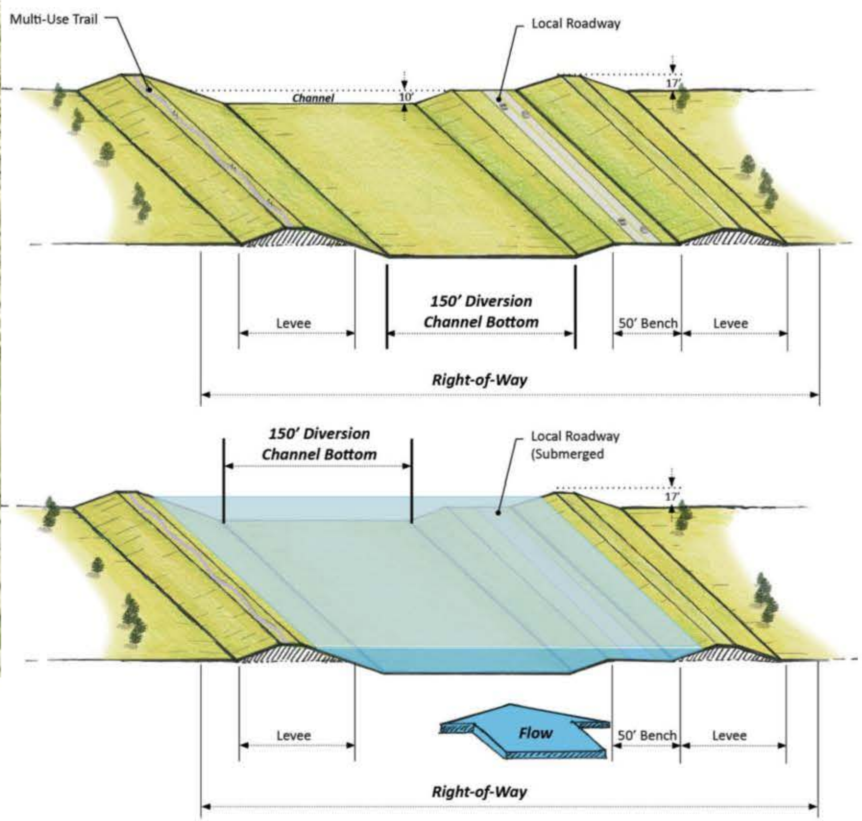
Preliminary Alignment Contains 16 Pump Stations in Minot

Item	Reaches Upstream of Minot	Reaches Through Minot	Reaches Downstream of Minot	All Project Reaches
Pumping Stations	8	**16**	9	33

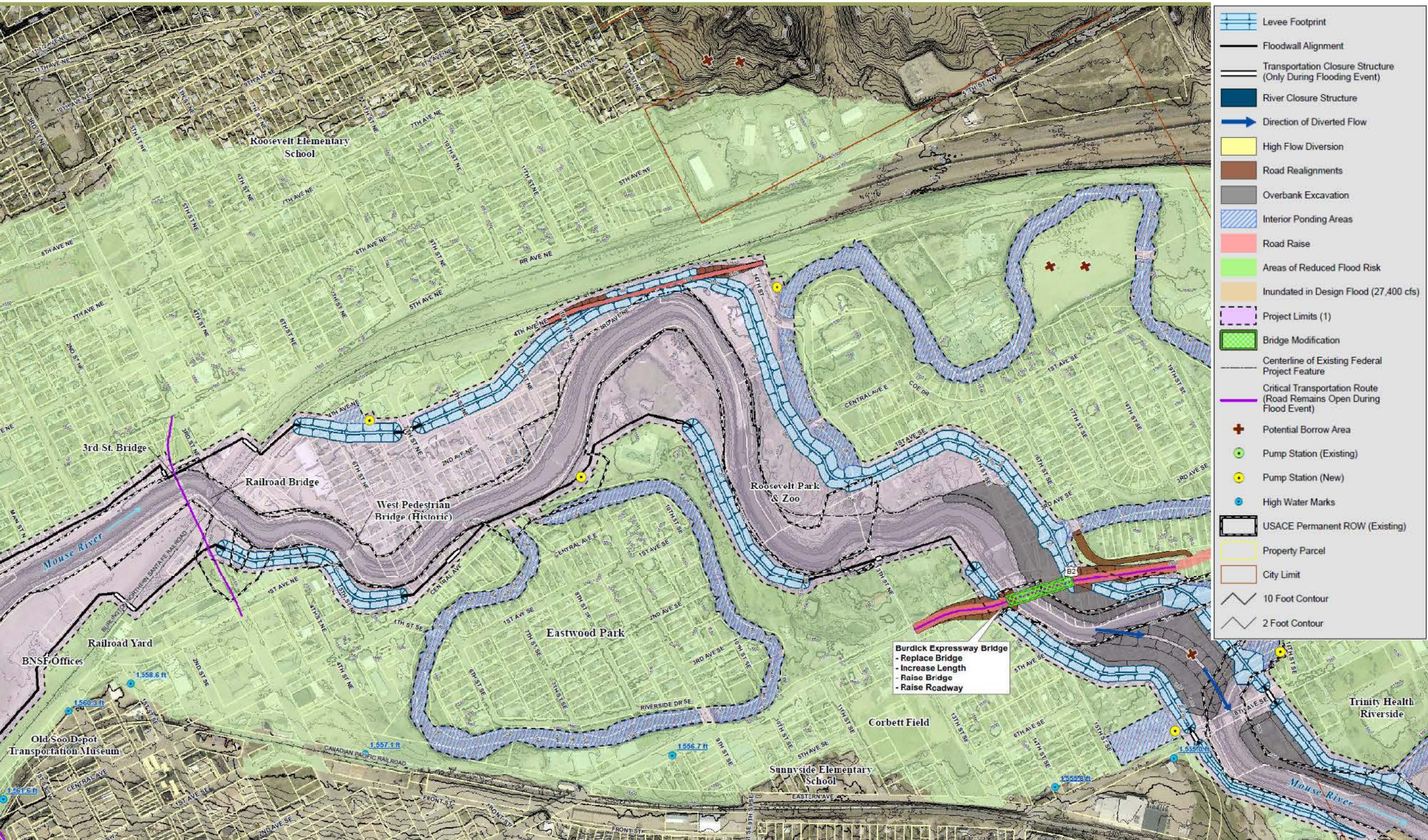
- Pump stations in Minot range in size from 2,000 gpm to 360,000 gpm
- Largest pump station is sized to handle Livingston Coulee flows
- Upgrades to storm sewer system will be needed



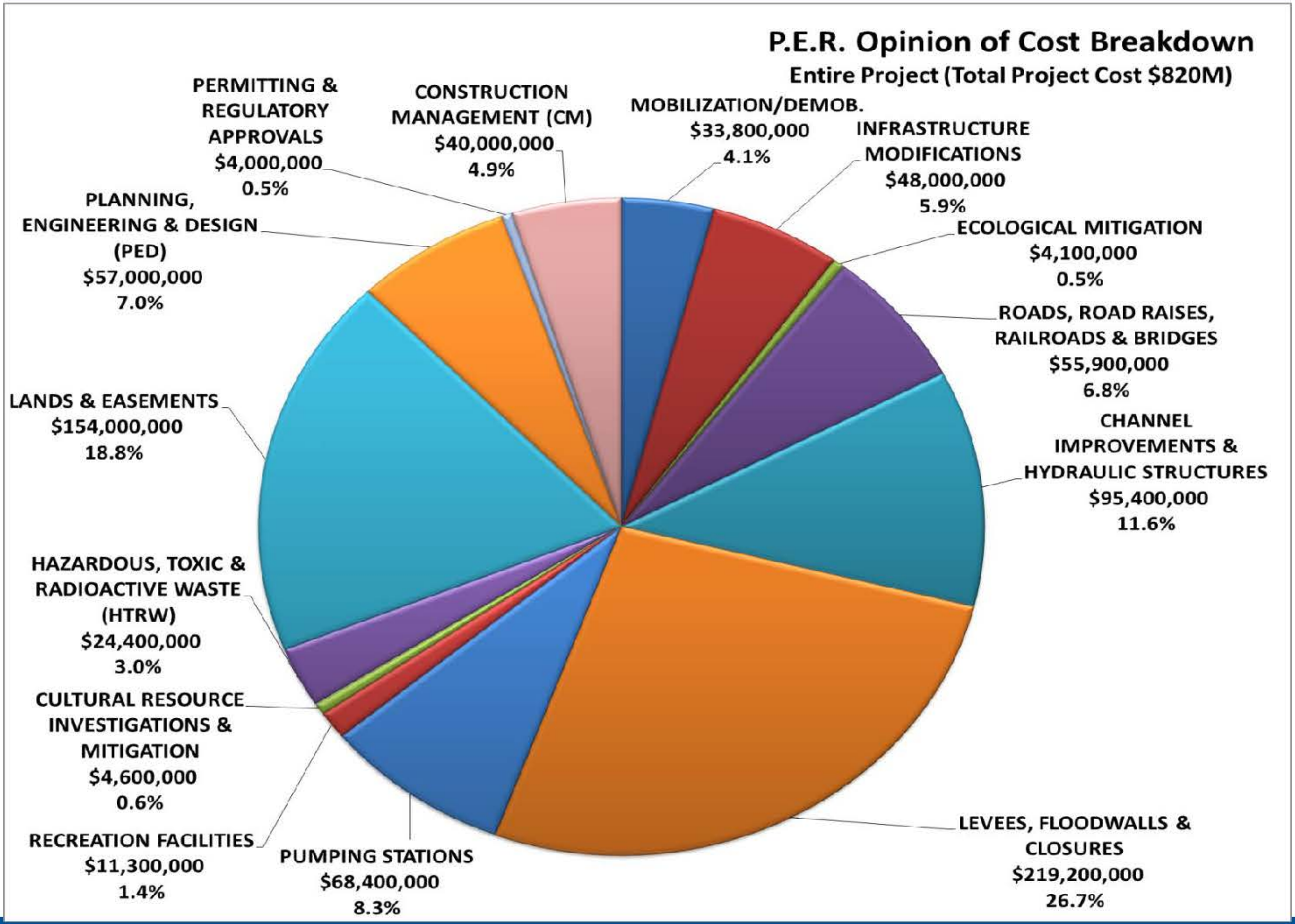
Preliminary Alignment Contains 2 High Flow Diversions in Minot



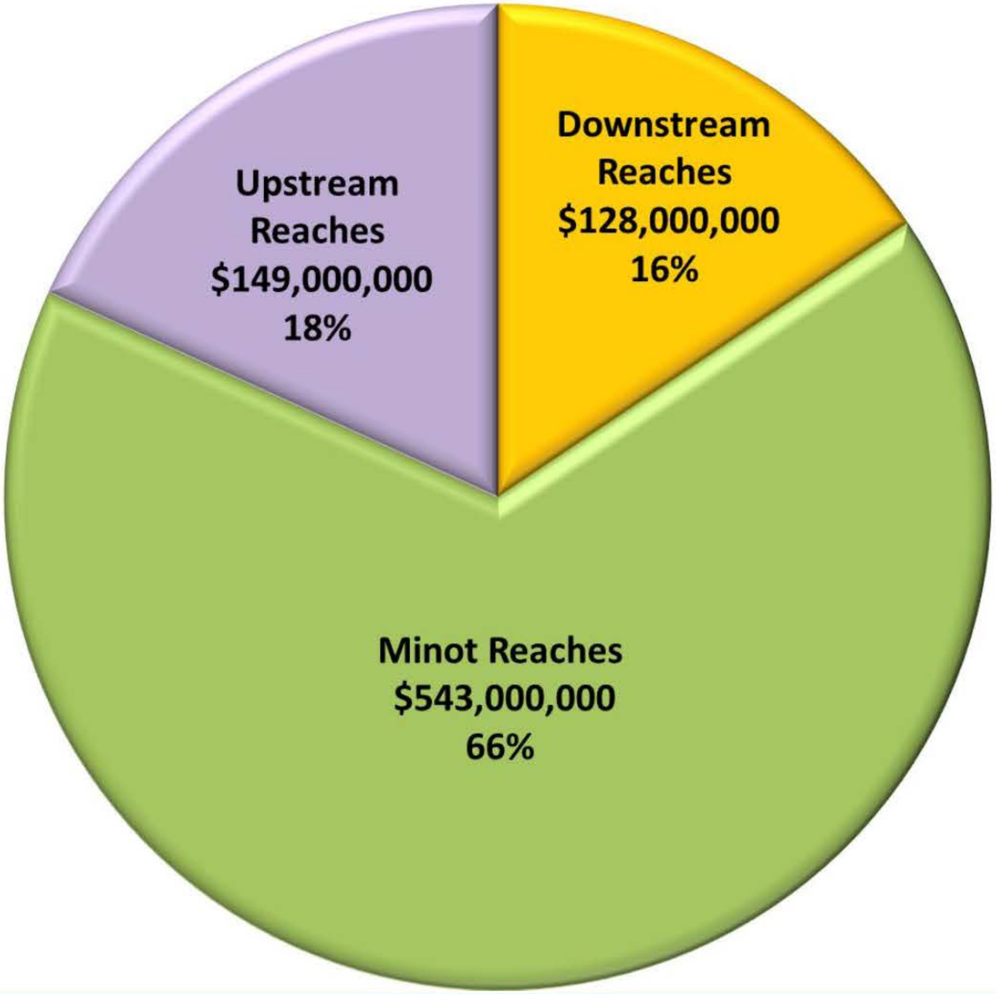
Part 1 – Alignment Features



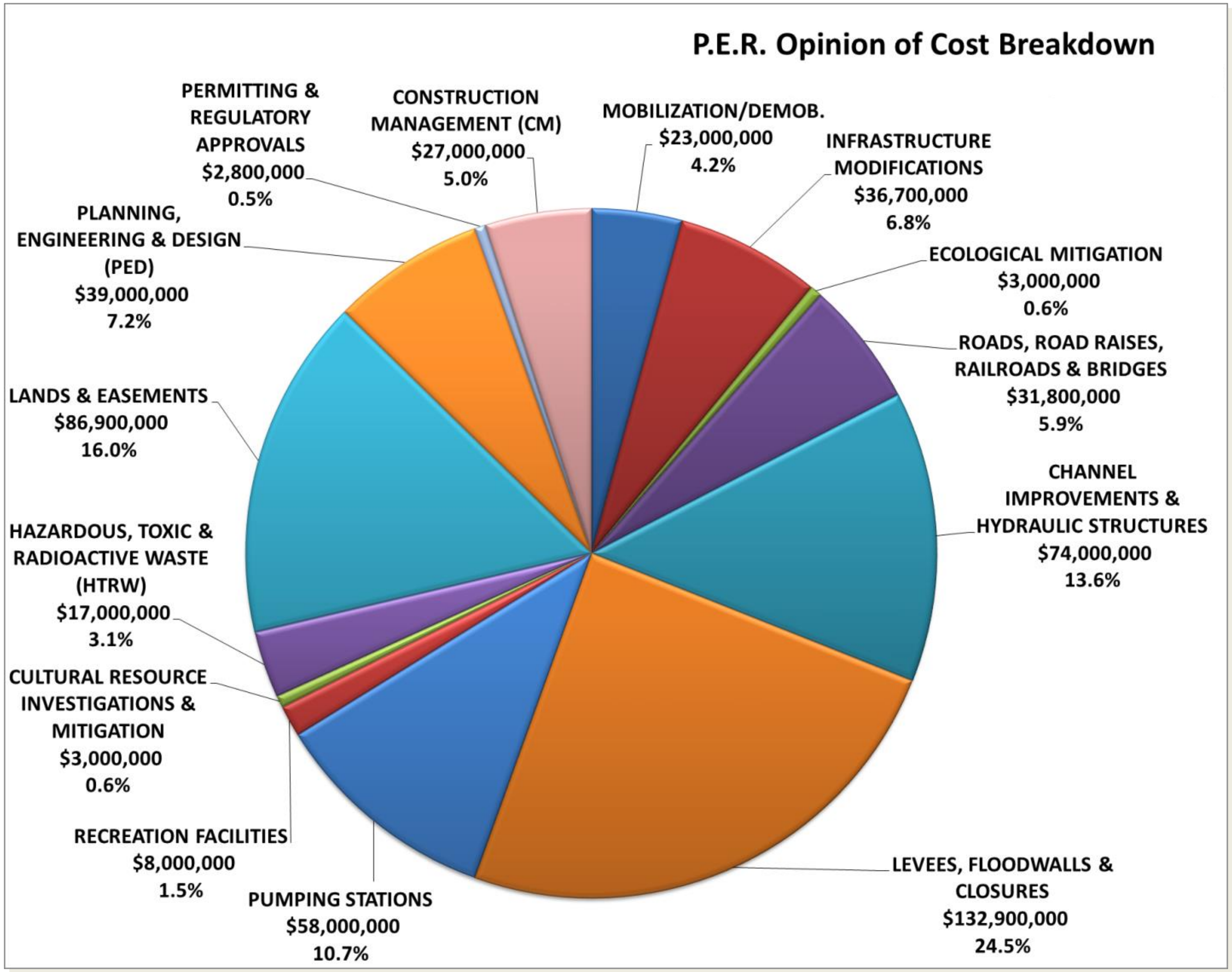
Opinion of Probable Cost – Part 1
$820 Million (Burlington to Velva & MRP)



66% of Part 1 Costs are Associated with Activities in Minot



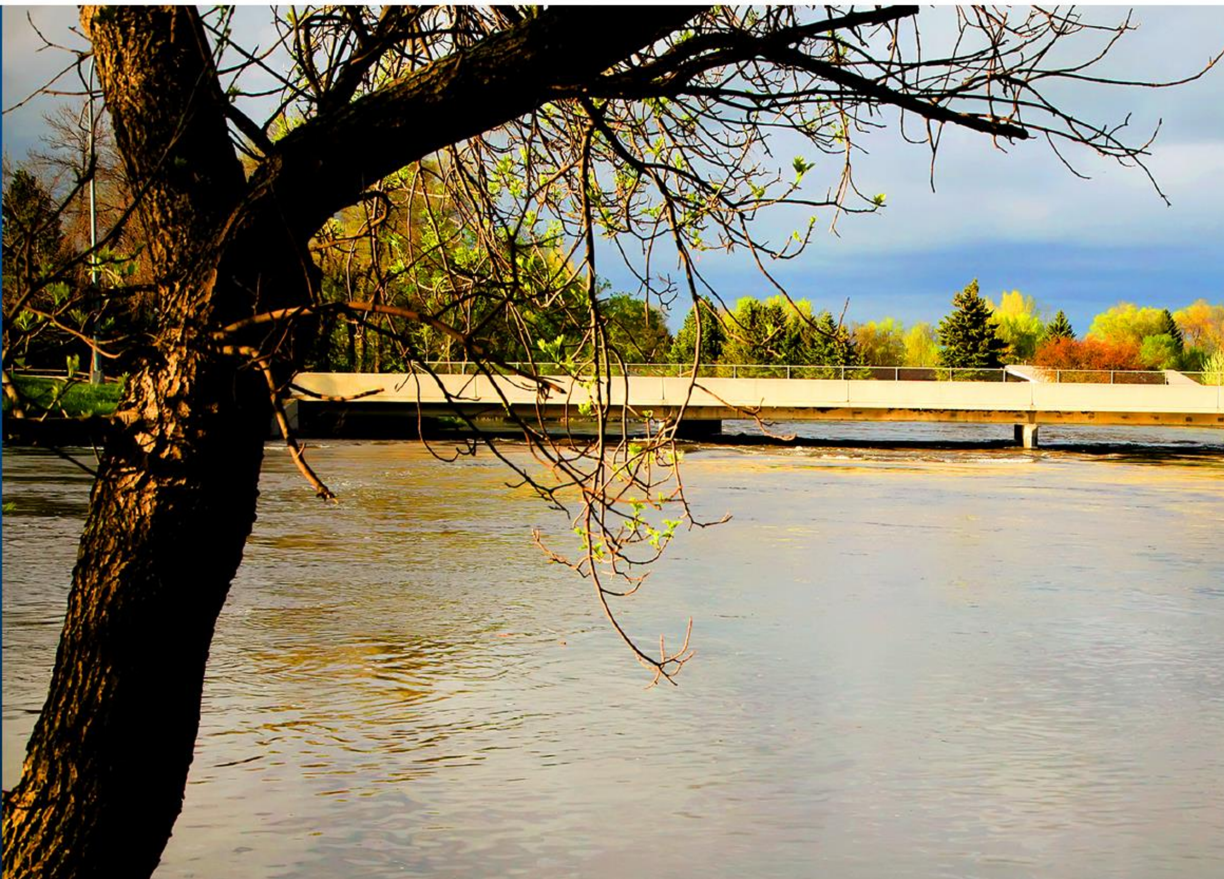
Proposed Minot Costs

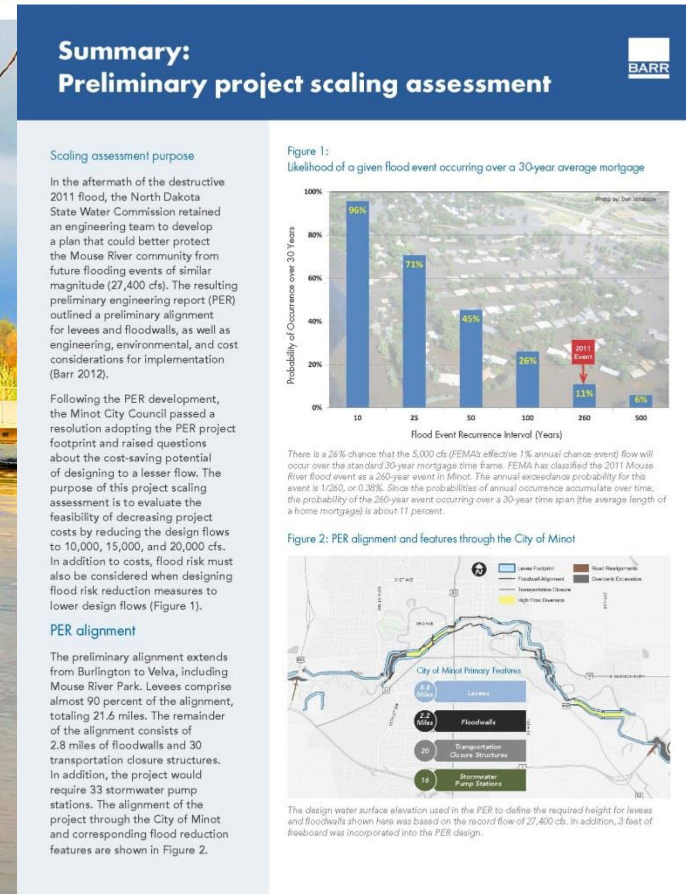


Hwy 83 Bypass to Hwy 2 Bypass Costs:

$543 Million

Mouse River Enhanced Flood Protection Project: Project Scaling Assessment – Minot Reach





Summary: Preliminary project scaling assessment

BARR

Scaling assessment purpose

In the aftermath of the destructive 2011 flood, the North Dakota State Water Commission retained an engineering team to develop a plan that could better protect the Mouse River community from future flooding events of similar magnitude (27,400 cfs). The resulting preliminary engineering report (PER) outlined a preliminary alignment for levees and floodwalls, as well as engineering, environmental, and cost considerations for implementation (Barr 2012).

Following the PER development, the Minot City Council passed a resolution adopting the PER project footprint and raised questions about the cost-saving potential of designing to a lesser flow. The purpose of this project scaling assessment is to evaluate the feasibility of decreasing project costs by reducing the design flows to 10,000, 15,000, and 20,000 cfs. In addition to costs, flood risk must also be considered when designing flood risk reduction measures to lower design flows (Figure 1).

PER alignment

The preliminary alignment extends from Burlington to Velva, including Mouse River Park. Levees comprise almost 90 percent of the alignment, totaling 21.6 miles. The remainder of the alignment consists of 2.8 miles of floodwalls and 30 transportation closure structures. In addition, the project would require 33 stormwater pump stations. The alignment of the project through the City of Minot and corresponding flood reduction features are shown in Figure 2.

Figure 1: Likelihood of a given flood event occurring over a 30-year average mortgage

There is a 26% chance that the 5,000 cfs (FEMA's effective 1% annual chance event) flow will occur over the standard 30-year mortgage time frame. FEMA has classified the 2011 Mouse River flood event as a 260-year event in Minot. The annual exceedance probability for this event is 1/260, or 0.38%. Since the probabilities of annual occurrence accumulate over time, the probability of the 260-year event occurring over a 30-year time span (the average length of a home mortgage) is about 11 percent.

Figure 2: PER alignment and features through the City of Minot

The design water surface elevation used in the PER to define the required height for levees and floodwalls shown here was based on the record flow of 27,400 cfs. In addition, 3 feet of freeboard was incorporated into the PER design.

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ACKERMAN SURVEYING & ASSOCIATES, INC.

CPS
CIVIL ENGINEERING | PLANNING | SURVEYING

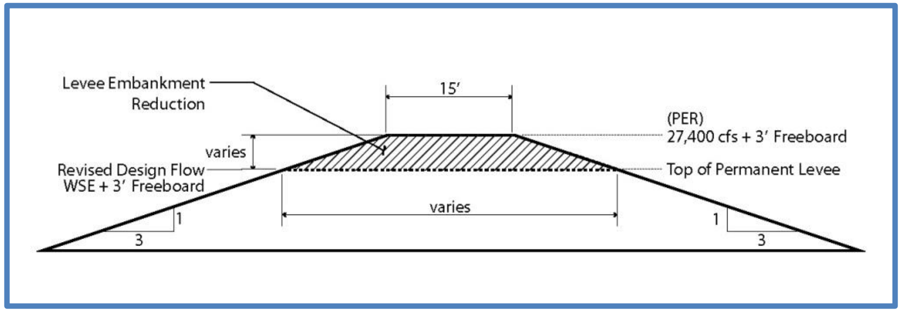
moore engineering, inc.

Summary of Assumptions

- **Project Footprint Does Not Change**
- **Ultimate Goal is to Construct or Have Ability to Flood Fight to 2011 Flood Level (27,400 cfs)**
- **Minimum Desired Protection Level is 10,000 cfs**

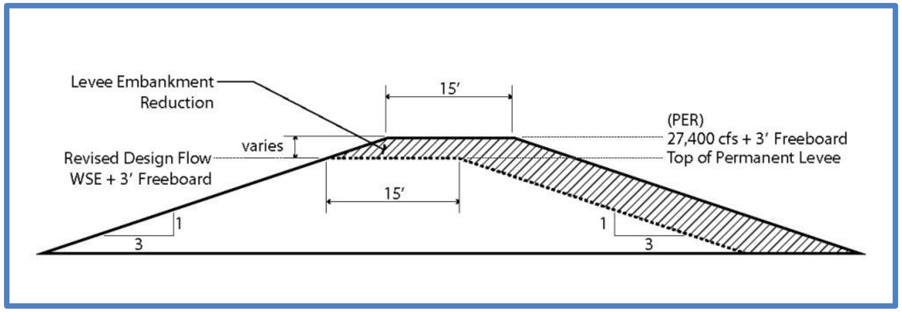
Potential Cost Reductions – 10,000 cfs

Scaled Levee A



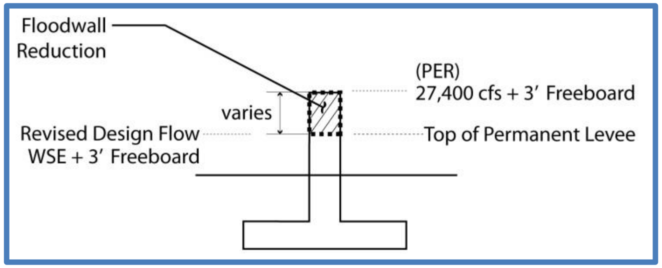
Savings - $8.4 Million (16% of Levee Costs)

Scaled Levee B



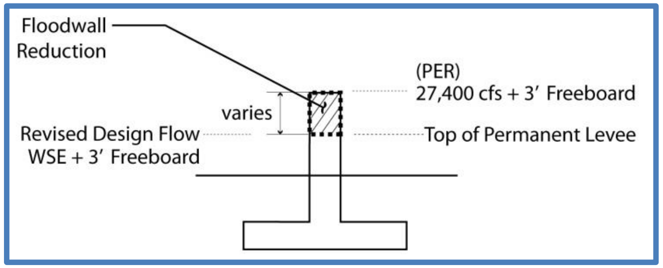
Savings - $15.9 Million (29% of Levee Costs)

Scaled Floodwall



Savings - $14.7 Million (19% of Floodwall Costs)

Scaled Floodwall

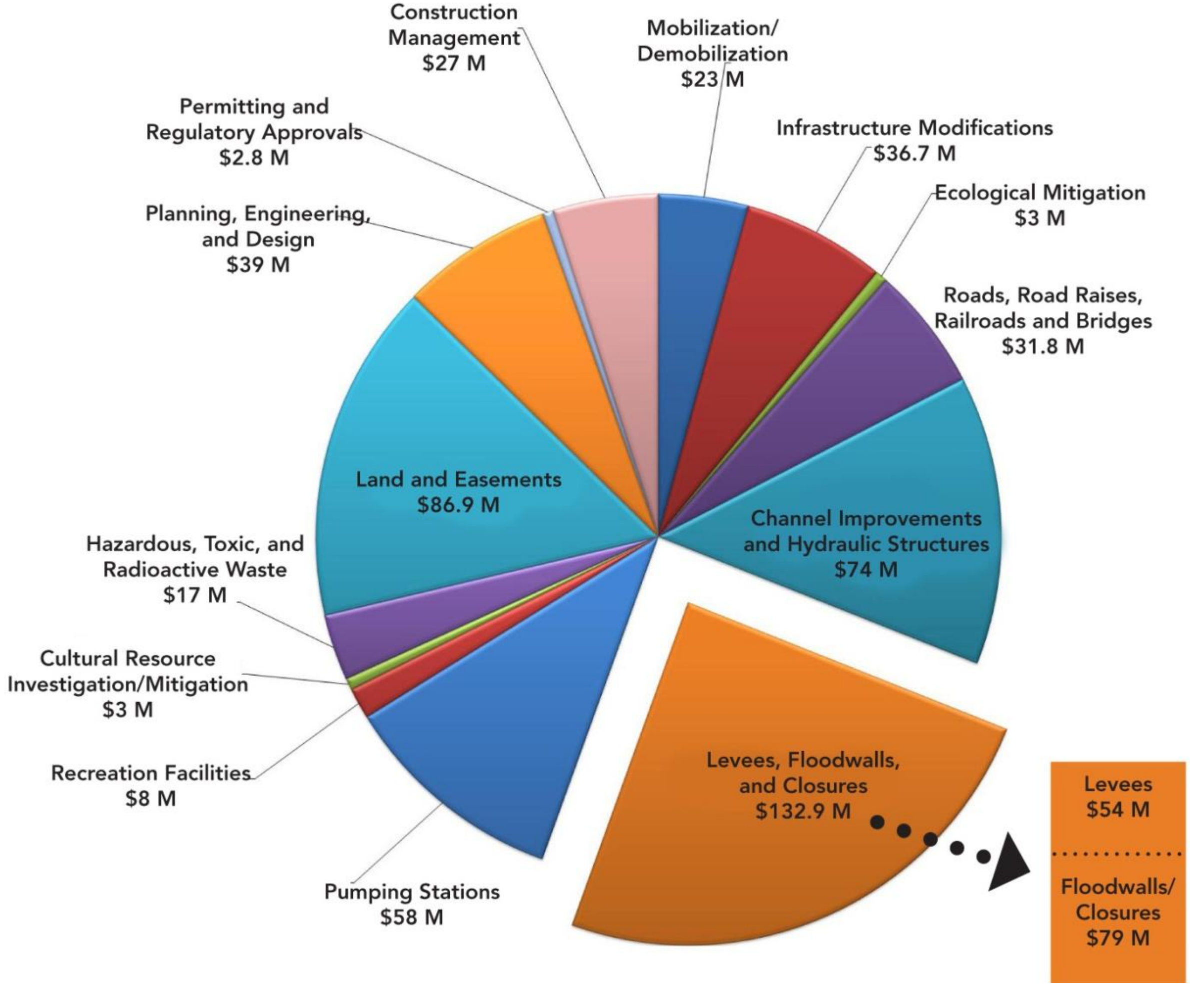


Savings - $14.7 Million (19% of Floodwall Costs)

Total Savings - $23.2 Million (4.3% of Total Costs)

Total Savings - $30.7 Million (5.6% of Total Costs)

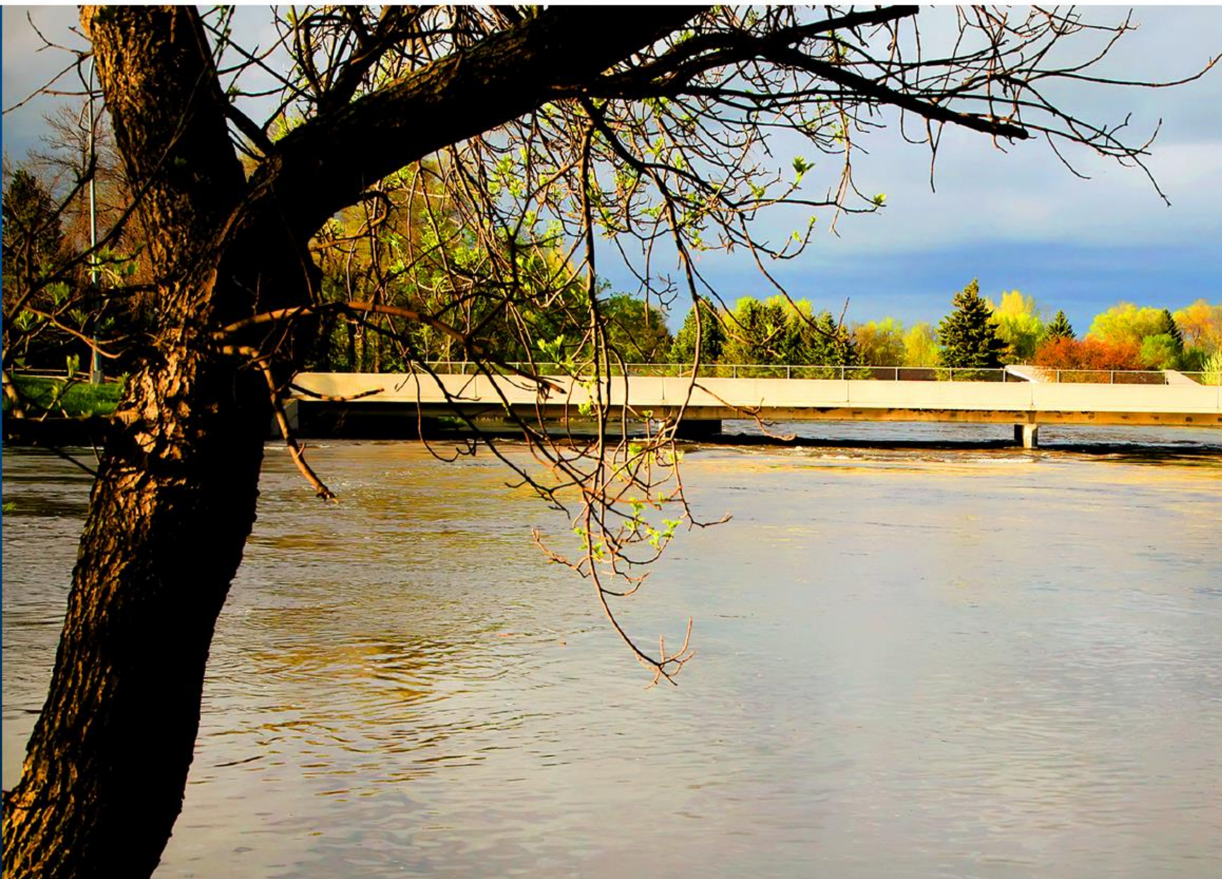
Impacted Cost Categories

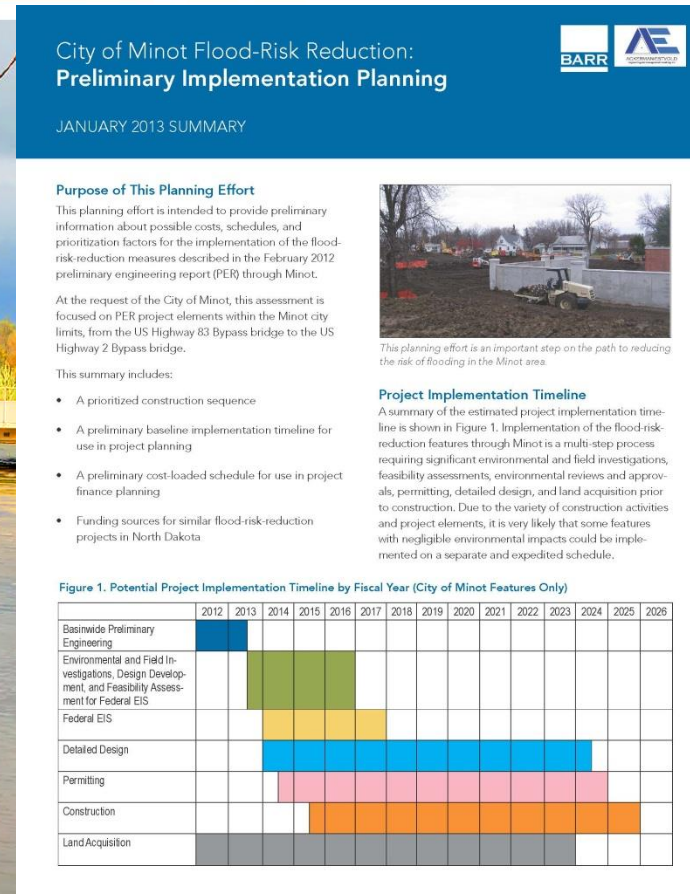


Additional Impact to Incidental Cost Categories Estimated as Percentage of Construction Cost:

- **Planning, Engineering, Design (7.2%)**
- **Construction Management (5.0%)**

Mouse River Enhanced Flood Protection Project: Project Implementation Assessment – Minot Reach





City of Minot Flood-Risk Reduction:
Preliminary Implementation Planning

JANUARY 2013 SUMMARY

Purpose of This Planning Effort

This planning effort is intended to provide preliminary information about possible costs, schedules, and prioritization factors for the implementation of the flood-risk-reduction measures described in the February 2012 preliminary engineering report (PER) through Minot.

At the request of the City of Minot, this assessment is focused on PER project elements within the Minot city limits, from the US Highway 83 Bypass bridge to the US Highway 2 Bypass bridge.

This summary includes:

- A prioritized construction sequence
- A preliminary baseline implementation timeline for use in project planning
- A preliminary cost-loaded schedule for use in project finance planning
- Funding sources for similar flood-risk-reduction projects in North Dakota

This planning effort is an important step on the path to reducing the risk of flooding in the Minot area.

Project Implementation Timeline

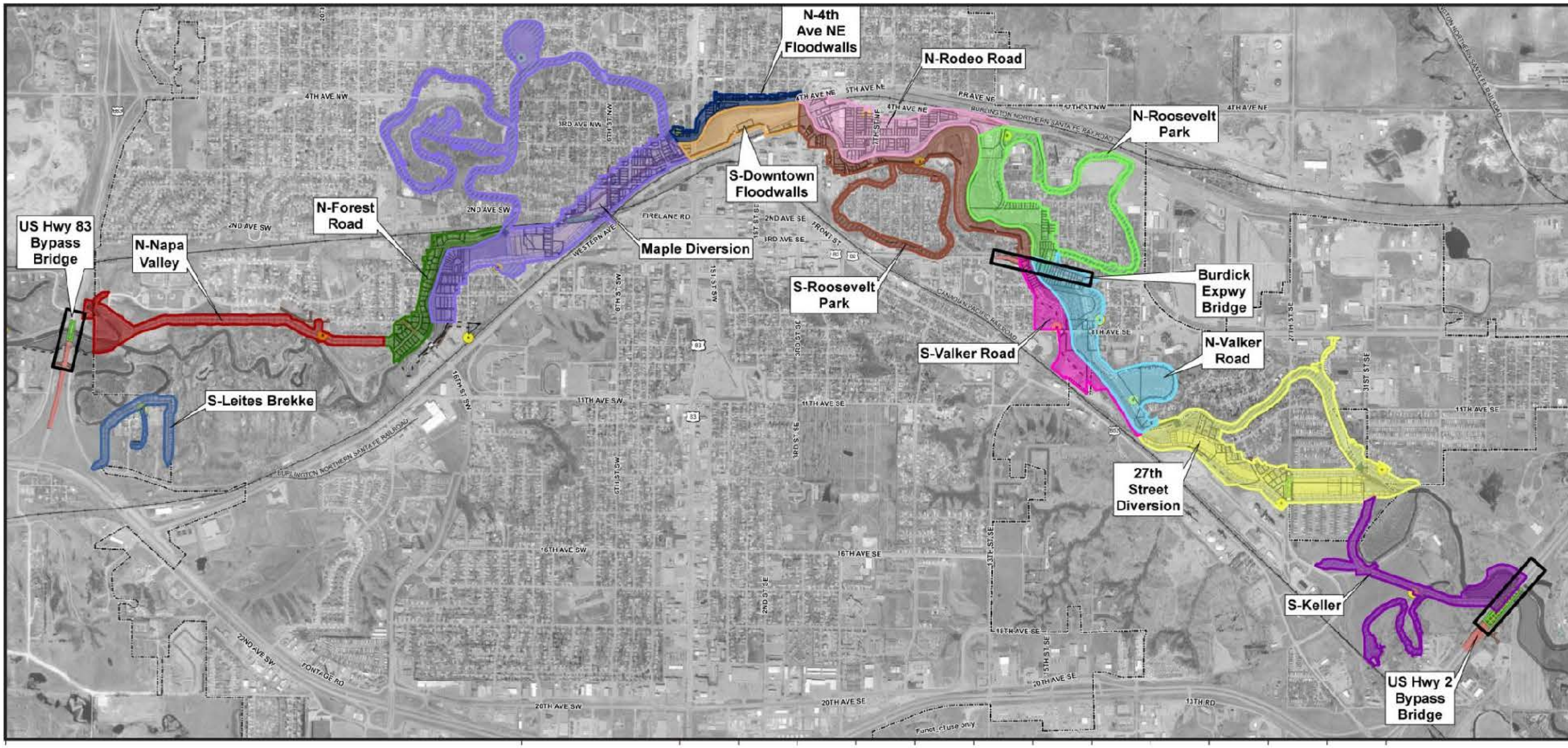
A summary of the estimated project implementation timeline is shown in Figure 1. Implementation of the flood-risk-reduction features through Minot is a multi-step process requiring significant environmental and field investigations, feasibility assessments, environmental reviews and approvals, permitting, detailed design, and land acquisition prior to construction. Due to the variety of construction activities and project elements, it is very likely that some features with negligible environmental impacts could be implemented on a separate and expedited schedule.

Figure 1. Potential Project Implementation Timeline by Fiscal Year (City of Minot Features Only)

Prioritization of Sub-Projects

- **Sub-Projects Prioritized Based on:**
  - **Critical Regional Infrastructure Value**
  - **Flood Fighting Benefits**
  - **Anticipated Permitting Effort**

Identification of Sub-Projects



Preliminary Implementation Summary

TABLE 1: SUMMARY OF SUBPROJECTS AND ESTIMATED TIMELINE (MINOT REACHES) [1] Description		Projected Time Frame (Fiscal Year)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Opinion of Cost (2012 Dollars)
Feasibility Investigations and Design During EIS Timeframe (Minot Reaches)		2014-2017 [2]													$35.4 M
Lands and Easements (Minot Reaches) [3]		2014-2023													$86.9 M
Subprojects (Minot Reaches)	N – 4th Avenue NE Floodwalls	2014-2016													$26.4 M
	CP Rail Bridge	2014-2019													$5.3 M
	Hwy 83 Bypass Bridge	2015-2018													$5.4 M
	Hwy 2 Bypass Bridge	2015-2018													$6.3 M
	Maple Diversion	2015-2019													$103.9 M
	N – Forest Road	2017-2018													$8.3 M
	N – Napa Valley	2018-2019													$18.3 M
	Burdick Expressway Bridge	2018-2020													$9.3 M
	N – Rodeo Road	2019-2020													$12.0 M
	N – Roosevelt Park	2019-2020													$24.2 M
	S – Roosevelt Park (Zoo)	2020-2022													$38.9 M
	27th Street Diversion	2020-2023													$94.5 M
	N – Valker Road	2023-2024													$17.6 M
	S – Valker Road	2023-2024													$13.2 M
	S – Downtown Floodwalls	2023-2025													$10.0 M
	S – Keller	2024-2025													$6.7 M
	S – Leites Brekke	2024-2025													$8.0 M
Subtotal [1]															**$530 M** [4]

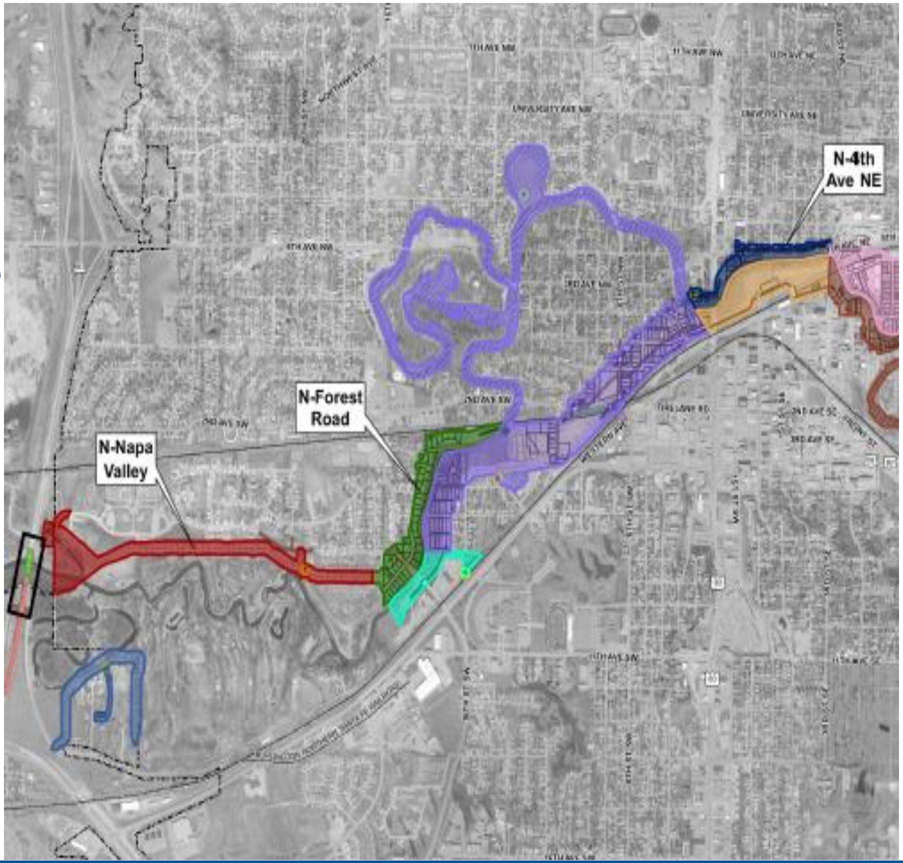
RECONNAISSANCE STUDY

- Defines if there is a federal interest in completing a feasibility study to reduce flood risk in Souris (Mouse) river basin
- Prepared by Barr/Ackerman in 2012-2013
- Typically prepared by USACE
- Conclusion of study was that there is a federal interest
- Recon Study submitted to St. Paul District of the USACE in August of 2013
- USACE needs to complete the Recon Study but does not have authority from Congress or funding source to review the study and complete it.
- SRJB and City of Minot are submitting a letter to USACE to request that they program the study into their budget for review.

CURRENT MREFPP

- **RFQ Advertised for Phases 1-3 in Minot**
  - 4th Ave NE (est. $26.4M)
  - N Forrest Road (est. $8.3M)
  - N Napa Valley (est. $18.3M)
  - Engineer selection to be made on April 15, 2014

Design, environmental and plans estimated to take 2 years to complete.



CURRENT MREFPP

- **Rural Reaches Study Completed**
  - SRJB reviewing all reaches outside of Minot throughout the Mouse River Basin
  - Prioritization being developed
    - Mouse River Park
    - Burlington
    - Sawyer
    - Velva
    - All Rural Reaches
  - Projects in reaches outside of Minot will include
    - Levees
    - Floodwalls
    - Road/bridge raises
    - Ring dikes
    - Acquisition of outbuildings

Flood Recovery

- 124 residential homes offered buyouts (Phase 1) that were next to current levees
  - 84 acquired
  - $11.1 million (does not include relocation or demolition costs)
- 113 residential homes offered buyouts (Phase 2) these are homes in Phase 1-3 of project and Maple Diversion
  - $24.4 million estimated cost (does include relocation and comparable home costs)

Flood Recovery

- Infrastructure
  - 13 Water wells inundated by flood rebuilt and are online
    - 8 Well in Minot Aquifer (all)
    - 5 wells in Sundre Aquifer (all)
  - 12 Sanitary lift stations inundated (75% of city sewage passes through these lifts) rebuilt and operating
  - Storm Sewer Lines – continue to find issues and repair
  - 12 Traffic signal intersections repaired
  - 25 Lighting feed points and over 150 light posts
  - Sanitary sewer lines
    - Over 30 sinkholes due to damaged and separated sanitary sewer line repairs

Flood Recovery

- Infrastructure (con't.)
  - $3.5 Million spent on repair of Federal Aid Roadways (flood damage)
  - $2 Million spent on local street – non-federal aid roadways
  - $9+ Million projected to be spent repairing roads under water and damaged due to the flood inundation and utility trench settlements in 2015

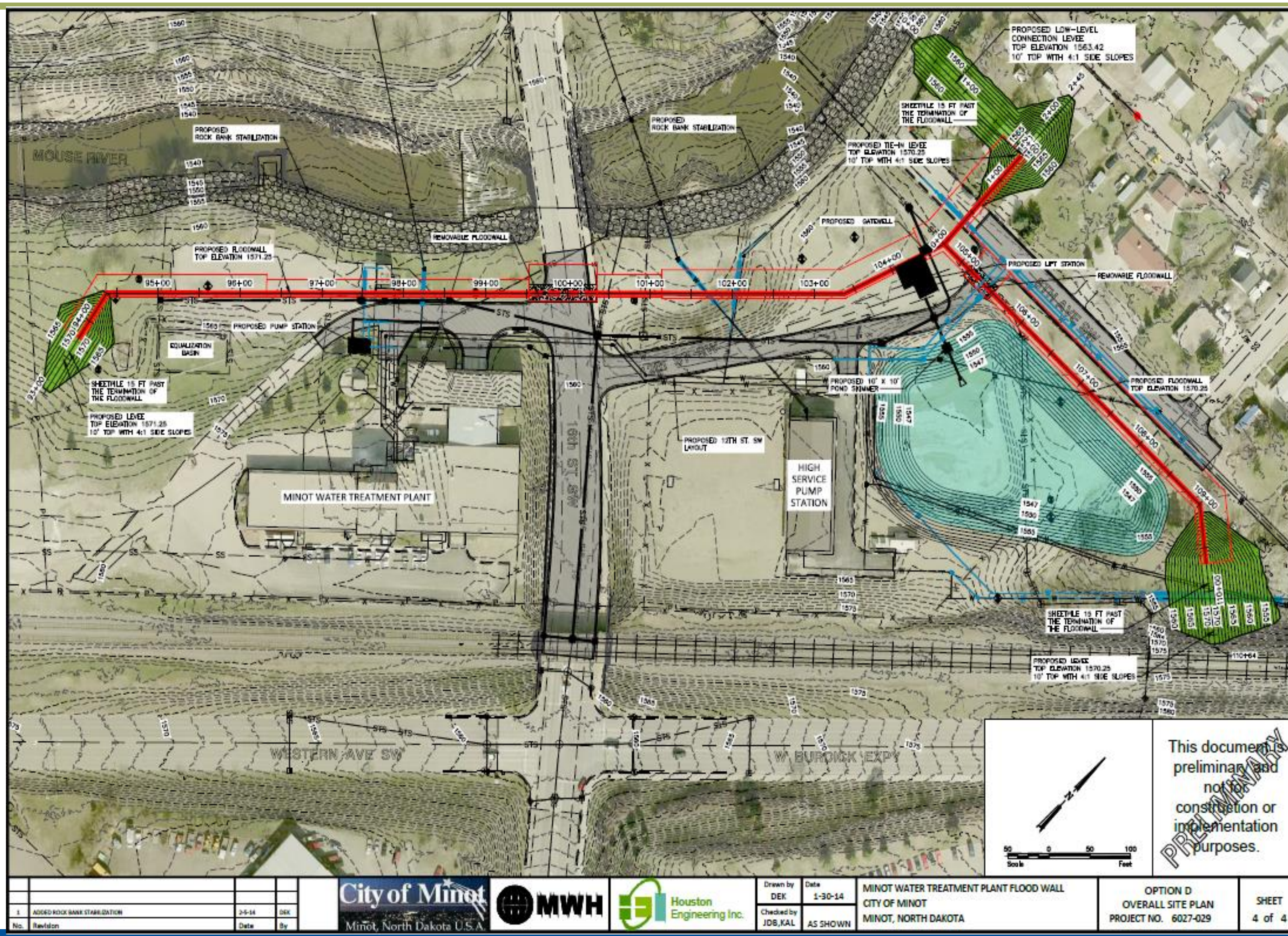
Water Treatment Plant HMGP Project Has Stand Alone Benefits

$25 million estimated cost of project

Project independent of flood protection project

Design complete 9/2014

Construction in 2015 and 2016 provides protection to Minot Water Plant/NAWS water system (regional water supplier)

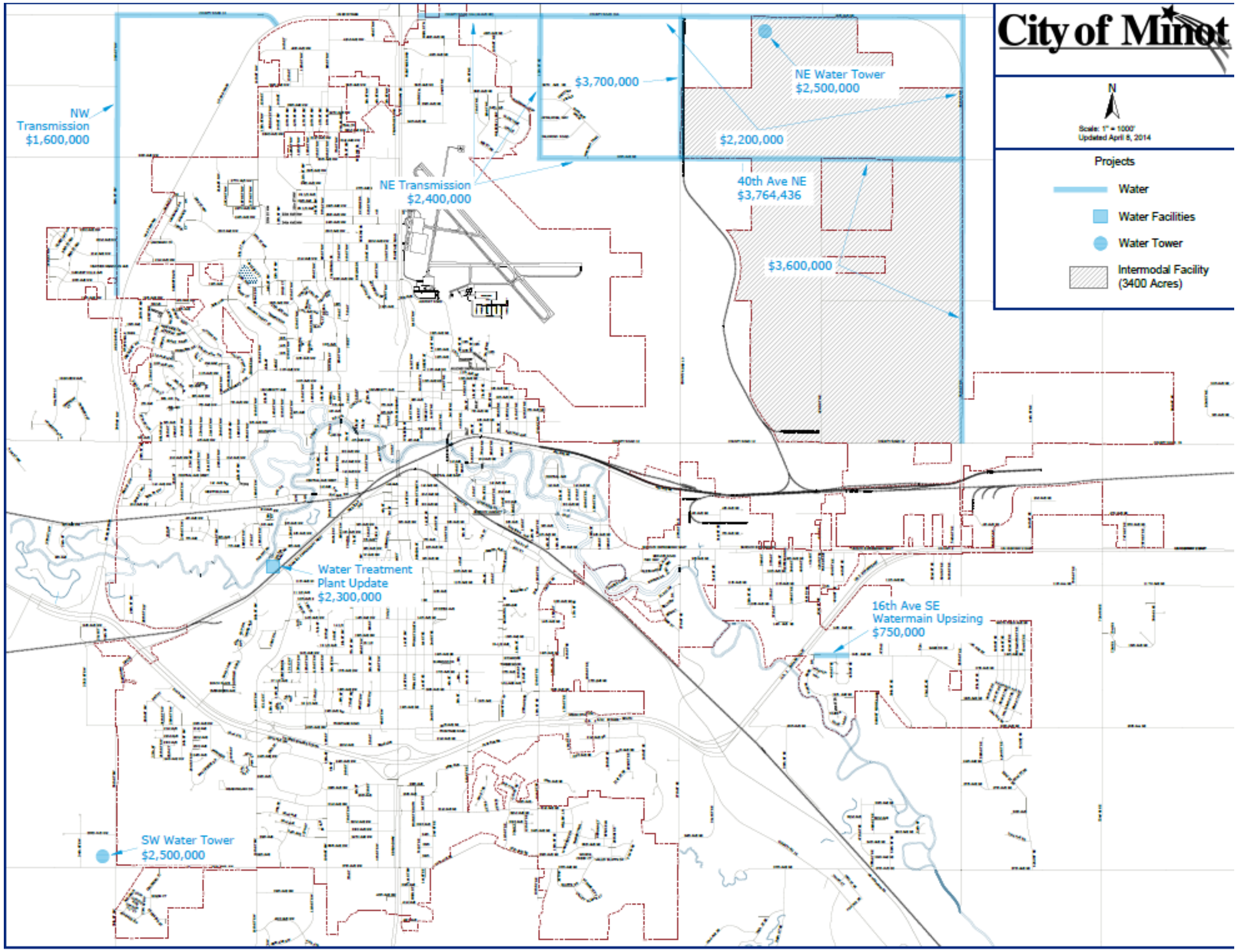


MINOT INFRASTRUCTURE NEEDS

- Trunk Waterline $16M
- Water Towers $5M

Trunk waterlines and water tower will provide fire flow to 3,400 acre intermodal site in NE Minot, as well as new Ramstad school in NW Minot and residential growth in North Minot

Water tower in SW Minot will provide fire flow & storage for 480 acres of new development

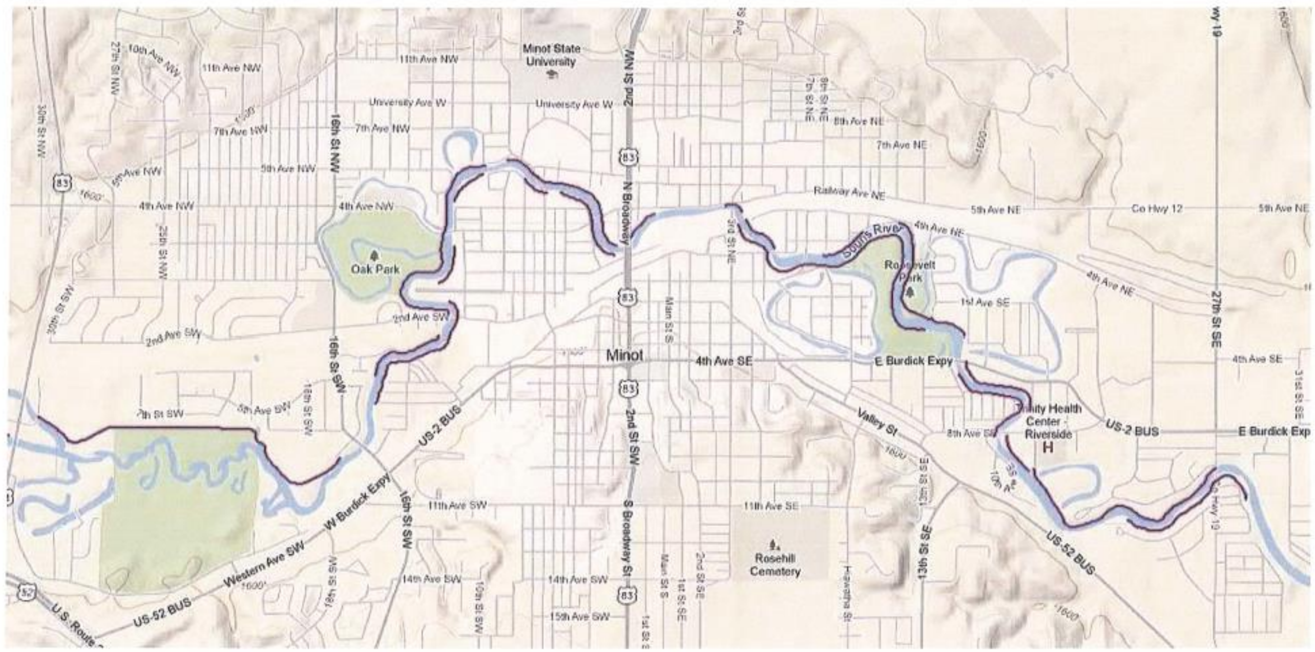


MINOT INFRASTRUCTURE NEEDS

- Levee Safety repairs 6^{+}M

USACE completed an inspection of the existing Minot flood control project and determined areas that need to be brought up to current USACE requirements. This included correcting erosion of riverbank, tree removal on the levees, replacement of riprap on outfalls, etc.

Minot, ND Levee Embankments
Levees identified in Project As-Built Drawings
Including Incorporated Emergency Embankments

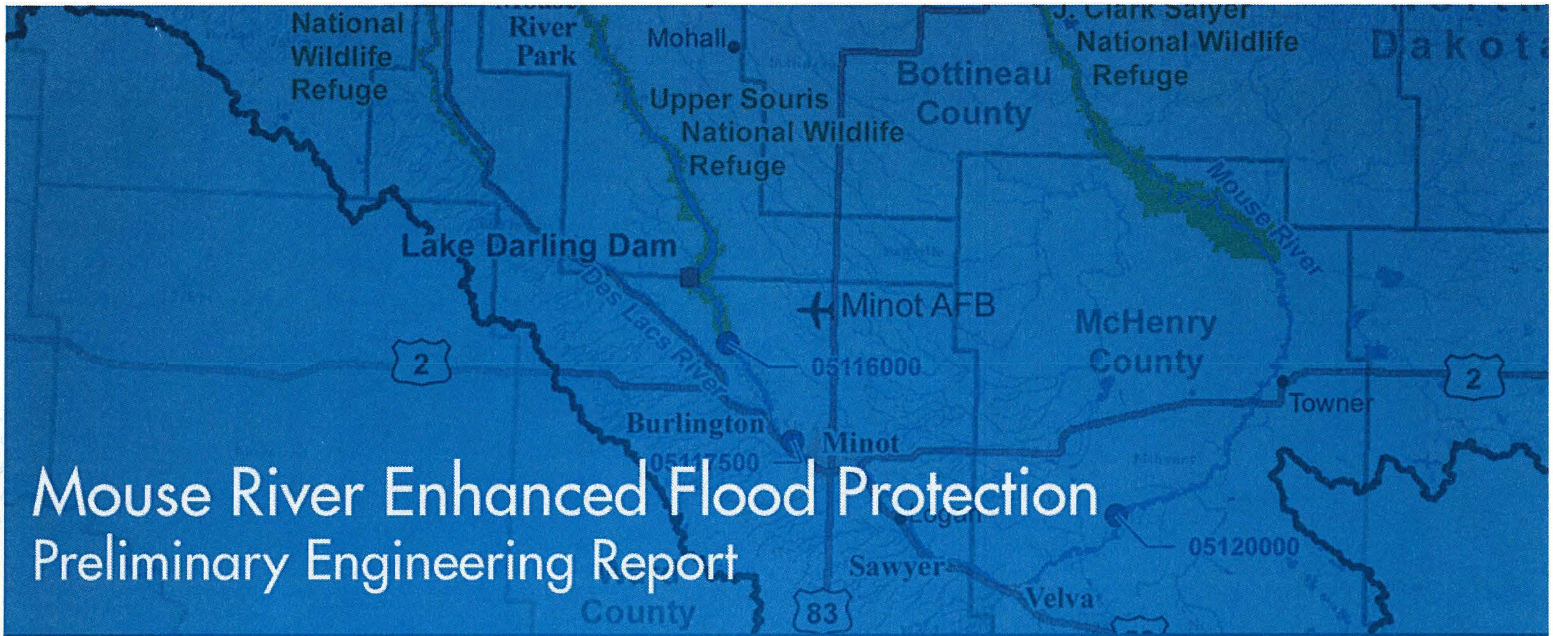


MINOT INFRASTRUCTURE NEEDS

- Trunk NE Sanitary Sewer 30^{+}M
- Puppy Dog/First Larson Sewer $5M
- Sewage Treatment Facility $77M
- Road / Street Improvements 22^{+}M
- Airport $44M

2014 – 2018 Over $295 million needs without the sewage treatment facility.

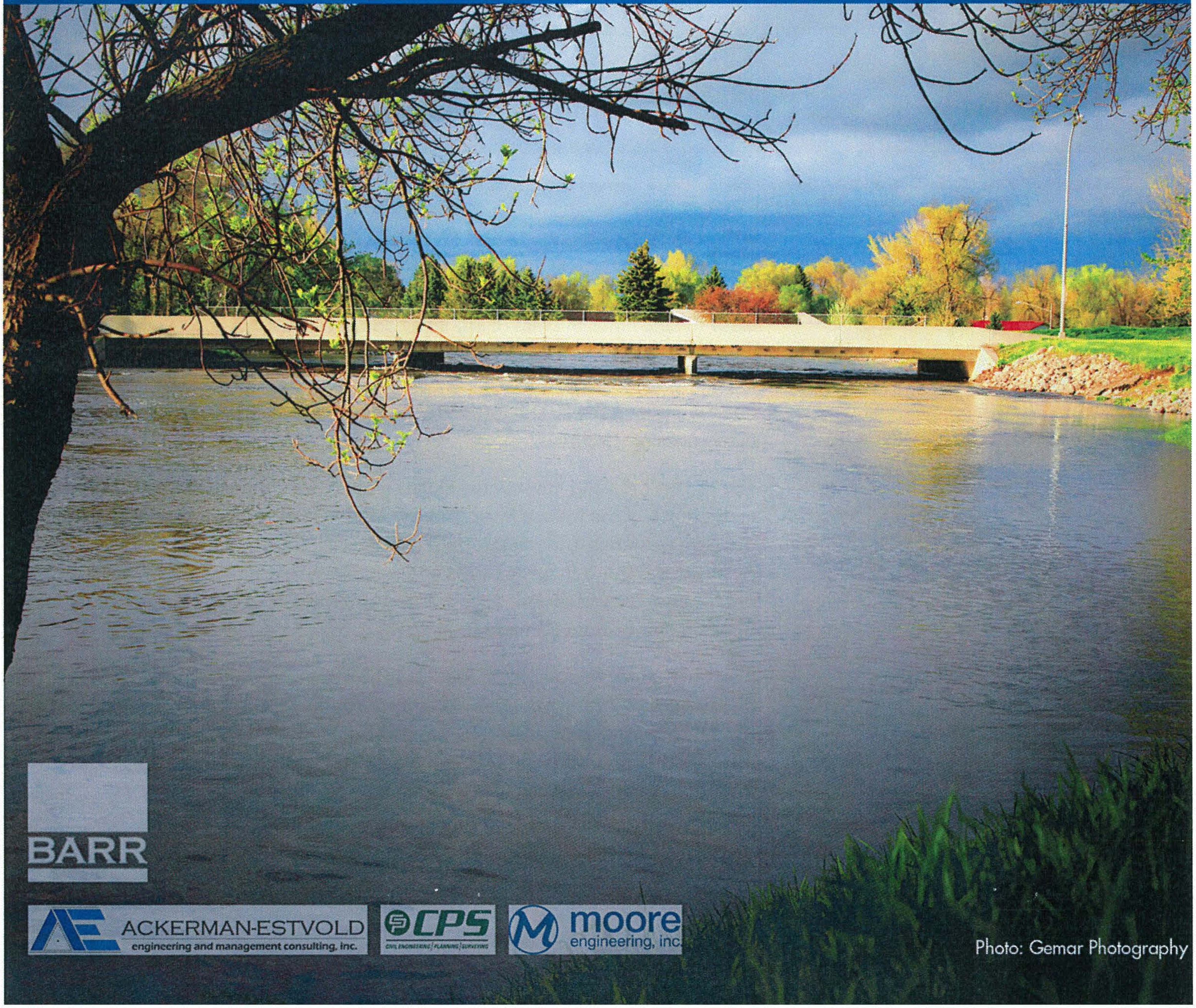
Questions?



Mouse River Enhanced Flood Protection

Preliminary Engineering Report

Prepared for North Dakota State Water Commission



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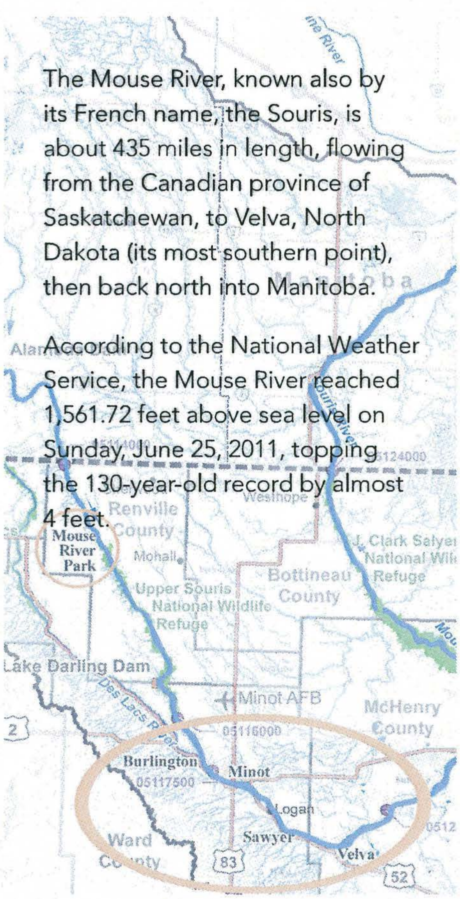
CPS

moore engineering, inc.

Photo: Gemar Photography

Executive Summary

The sun sets over the Mouse River and Zoo Bridge in Minot. (Photo: Gemar Photography, Minot)



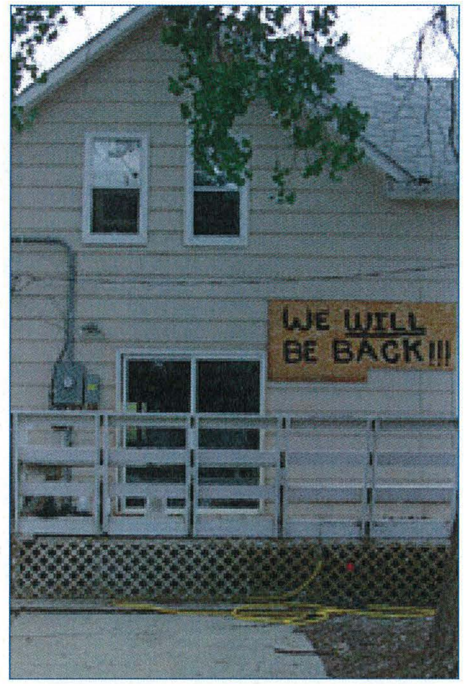
The Mouse River, known also by its French name, the Souris, is about 435 miles in length, flowing from the Canadian province of Saskatchewan, to Velva, North Dakota (its most southern point), then back north into Manitoba.

According to the National Weather Service, the Mouse River reached 1,561.72 feet above sea level on Sunday, June 25, 2011, topping the 130-year-old record by almost 4 feet.

On June 25, 2011, the Mouse River flowed under Minot's Broadway Bridge at a record rate of 27,400 cubic feet per second (cfs)—more than five times the rate that existing channels and levees had been designed to handle and close to nine times the rate of any flood documented since construction of four upstream storage reservoirs. Not since 1882, a time when commercial production of automobiles was just beginning, had flows in excess of 20,000 cfs been seen. For days, during the 2011 flood, water levels were too high for cars to safely cross numerous area bridges.

The record-breaking flow overwhelmed most flood fighting efforts along the entire reach of the Mouse River through North Dakota, causing extensive damage to homes, businesses, public facilities, infrastructure, and rural areas. According to the U.S. Army Corps of Engineers (USACE), 4,700 commercial, public, and residential structures in Ward and McHenry counties sustained building and content damage totaling more than $690 million.

If no emergency flood fighting measures had been implemented, potential building and content damages would total roughly $900 million. This includes the 1,500 structures protected by the emergency levees but still considered at risk. This estimate does not reflect the cost of rebuilding in areas outside of the flood zone, where real estate values are particularly high.



The heroic efforts of residents, volunteers, local officials, and state and federal agencies prevented significant damages. Still, more than 11,000 residents were displaced by the 2011 flood. A preliminary alignment plan was a high priority so that affected residents and business owners could make decisions on whether to rebuild or relocate. (Photo, above left, courtesy of FEMA)

Rural Considerations

The rural areas of the Mouse River Valley, upstream of Burlington and downstream of Velva, were also devastated by the 2011 flood. Damage came in the form of flooded homes and farmsteads, erosion, sedimentation and debris deposition, lost crop production, and road and bridge washouts. These areas will be the focus of further study to address the circumstances and constraints specific to agriculture. A workshop was held on February 16, 2012, to gather stakeholder input for the engineering evaluation of rural areas.

In the aftermath of the flood, local government recognized the need to develop a plan that could provide direction during recovery and better protect the Mouse River community from similar future events. The Souris River Joint Board issued a request to the North Dakota State Water Commission to retain an engineering team to develop a "Mouse River Enhanced Flood Protection Project," including preliminary alignments for levees and floodwalls. The Preliminary Engineering Report provides a summary of the efforts undertaken to develop a preliminary alignment, as well as engineering, environmental, and cost considerations for plan implementation.

Project Objectives and Scope

The primary objective for the Mouse River Enhanced Flood Protection Project (Project) is to develop a preliminary plan that can be used as a guiding document to help reduce the risk of damages from river flows comparable to those seen during the June 2011 flood. The scope of this study is the Mouse River Valley from Burlington to Velva and Mouse River Park.

There are a wide range of flood risk reduction alternatives available, ranging from restoration and maintenance of the existing channel modifications, levees, and upstream flood storage system, to complete removal of at-risk properties within the 2011 flooded area. Previous reports and studies were reviewed to determine the range of options that have been considered for the Mouse River Valley. A more comprehensive review and analysis of potential alternatives to the preliminary alignment plan presented here will be required to comply with the regulatory review process for implementing any major flood risk reduction plan.

A series of workshops and public meetings were held to get stakeholder input and feedback used in the development of the preliminary alignment plan. Community members were also able to stay informed and offer feedback through the Project website (www.mouseriverplan.com), Facebook, and Twitter. Over the course of the Project over 1,200 public comments were received.

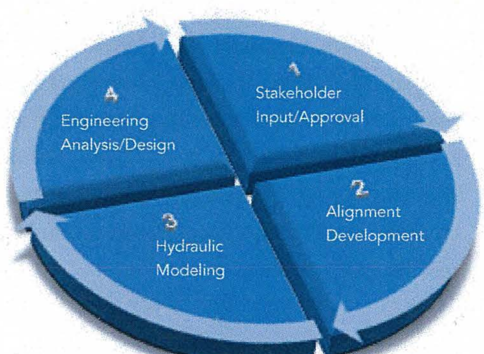
Preliminary Alignment Development Process

The development of a preliminary alignment, including measures such as levees and floodwalls, is a complex process that requires both significant technical analysis and substantial stakeholder input. Rapid identification of an alignment corridor is a key first step because it allows affected property owners to make informed decisions about rebuilding or relocating.

The preliminary alignment described in this report was developed through an iterative process consisting of: (1) obtaining stakeholder input, (2) alignment development, (3) performing detailed hydraulic modeling of the alignment, and (4) performing engineering analysis and design.

Initial input was gathered at an October 2011 workshop. The primary objective for this workshop, which consisted of presentations, dialog, and work sessions, was to engage participants in a discussion of priorities and strategies for flood risk reduction. The resulting consensus priorities and alignments were used to complete hydraulic modeling and plan refinements.

A draft preliminary plan was published on November 3, 2011, for public review and comment. Three additional cycles of input, alignment, and modeling revision (as well as dozens of intermediate iterations) occurred between November 3, 2011, and January 31, 2012. Plan revisions were posted to the Project website (www.mouseriverplan.com).



Project Objectives and Constraints

(1) Reduce the risk of flood damage to as many homes as reasonably possible

(2) Minimize the Project footprint and number of residential acquisitions required

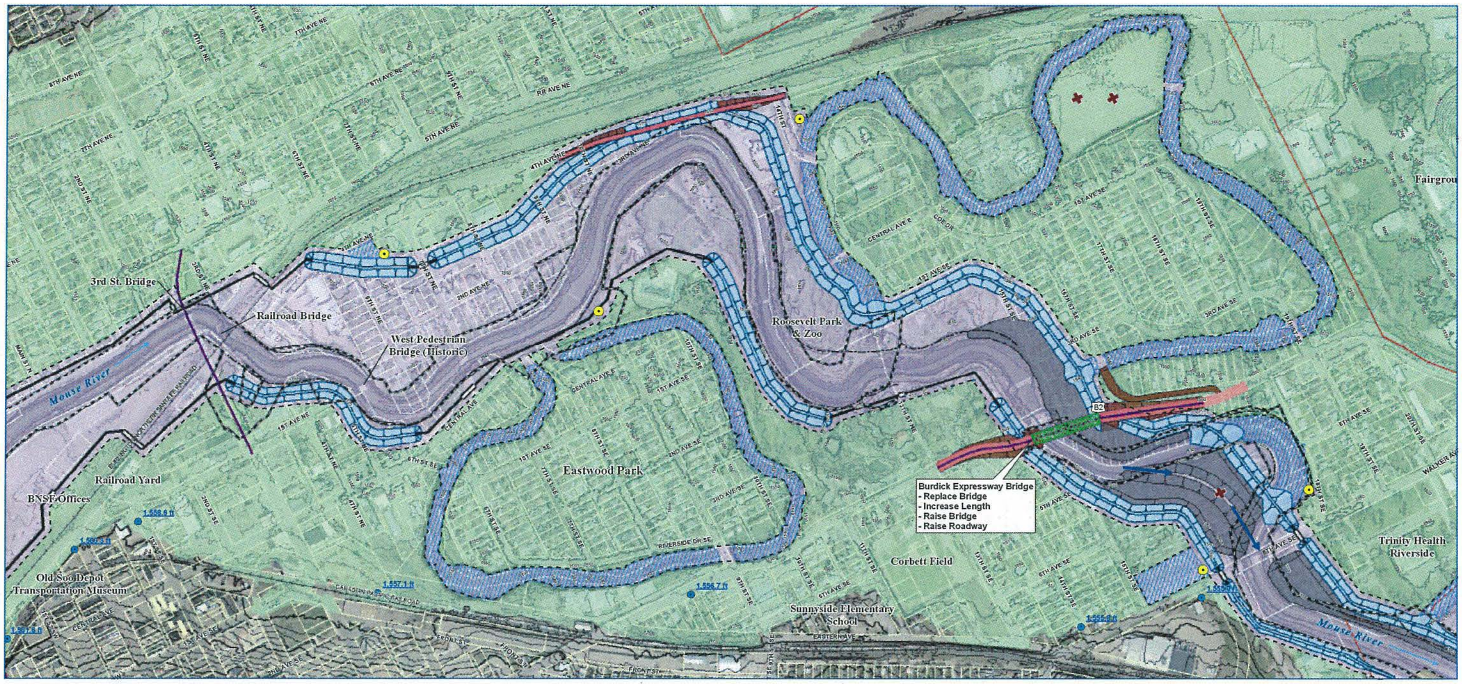
(3) Minimize increases in flood level water surface, flow rates, and duration

(4) Develop a Project that can be implemented at the lowest practical cost

(5) Establish key transportation corridors that can remain open during flood events

(6) Minimize environmental impacts to facilitate necessary regulatory approvals

(7) Design a Project that is consistent with the long-range objectives of the affected communities



The preliminary alignment plan includes levees, floodwalls, and river diversions and closure features to reduce the risk of flooding in populated areas along the Mouse River.

Primary Features

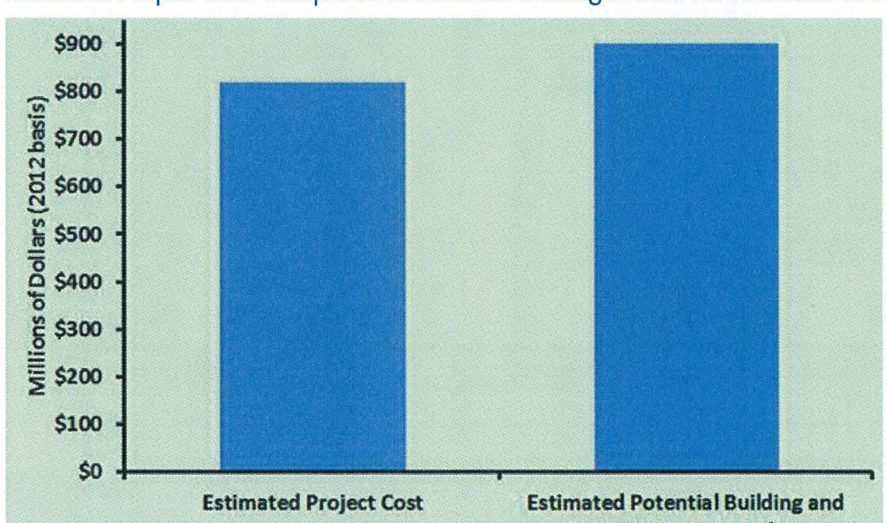
21.6 Miles	Levees
2.8 Miles	Floodwalls
30	Transportation Closure Structures
33	Stormwater Pump Stations

Description of the Preliminary Alignment

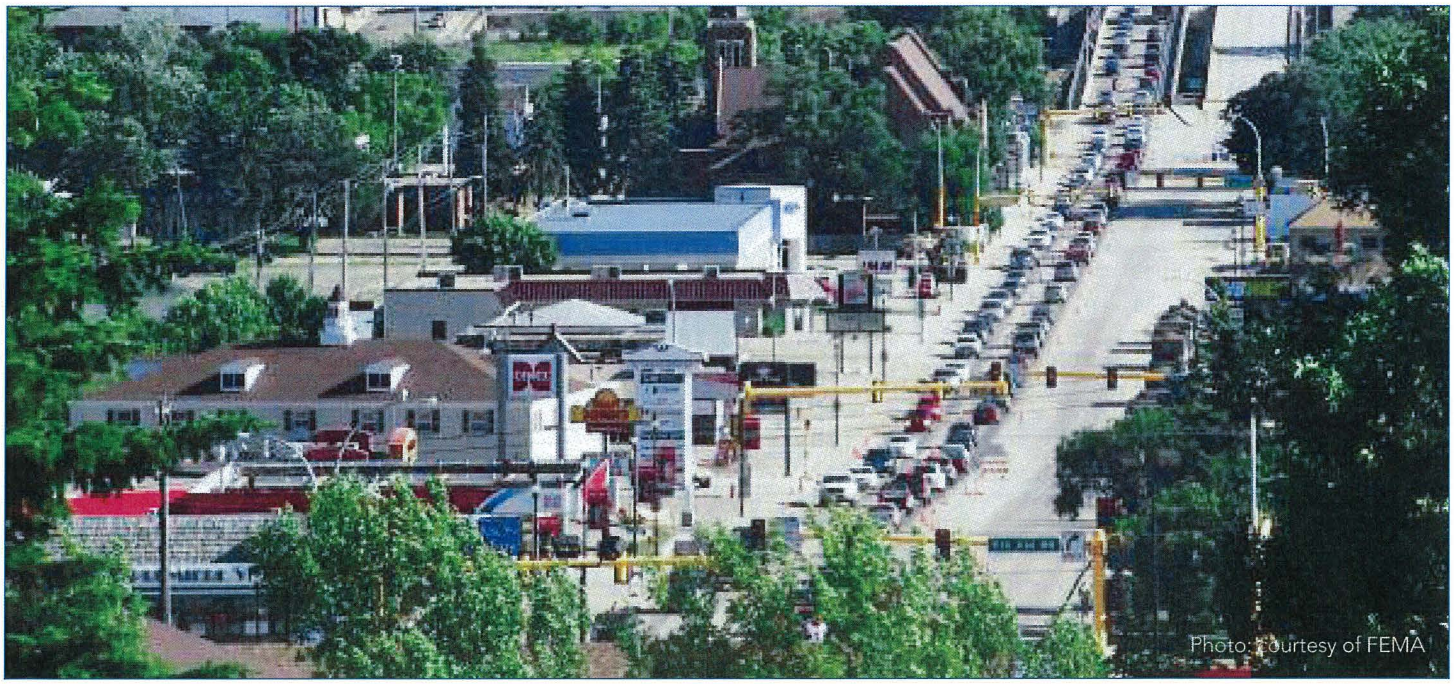
The preliminary alignment plan consists of levees, floodwalls, river diversions and closure features, transportation closure structures, interior pump stations, and 2011 floodplain buyouts. Levees comprise almost 90 percent of the alignment, totaling 21.6 miles. The remainder of the alignment consists of 2.8 miles of floodwalls, and 30 transportation closure structures (19 roadway and 11 railroad). In addition, the Project would require 33 stormwater pump stations.

The estimated total Project cost is $820 million, based on the current level of design and Project understanding. This Project cost is a point estimate, in current dollars, and does not consider the likelihood of cost escalation over the period of implementation. Of the estimated cost, $565 million is related to construction, $154 million is related to property acquisition, and the remaining $101 million covers planning, engineering, and program management costs.

Estimated Project Cost Compared to Potential Damages from Flood Similar to 2011



* *Project costs shown exclude the substantial costs related to emergency flood fighting, evacuations, damages to public infrastructure, lost commerce—and the incalculable human costs.*



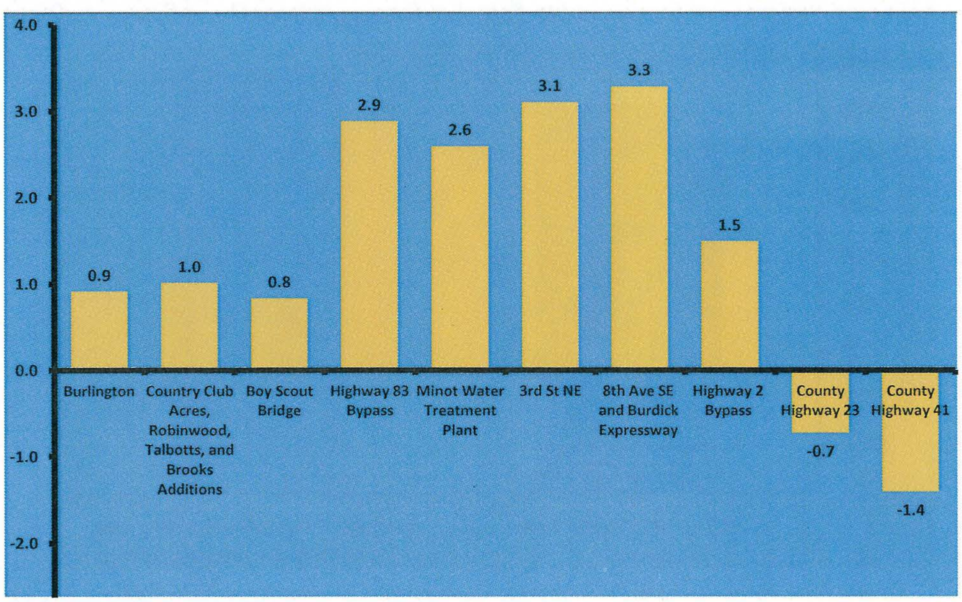
Impacts of Preliminary Alignment

Flood Level Impacts

One of the most critical design constraints of a flood risk reduction system is the estimation of the design water surface elevation. This defines the required height for constructed features such as levees and floodwalls. Potential hydraulic effects of the proposed alignment on upstream and downstream water surface elevations also need to be considered.

The Project will change the flood profile for the design flow (27,400 cfs) at most locations (see chart below). In the majority of cases, this is the result of efforts to narrow the floodplain—minimizing the Project footprint and the number of property acquisitions required.

Summary of Project Effect on 2011 Flood Profile (feet)



Property Impacts

Construction of levees, floodwalls, road raises, road realignments, etc., will require acquisition of property. The table below provides a summary of the estimated number of residential properties that would need to be acquired to implement the Project. This estimate is limited by information available in the Project area.

Summary of Residential Properties to be Acquired for the Preliminary Alignment Project

	Up-stream	Minot	Down-stream	Total
Number of Residential Properties[1]	90	278	15	383

[1] Residential properties includes parcels classified as single family, two-family, and multi-family with a dwelling unit. Data is not readily available for estimating the number of housing units represented by this property count.

Pre-Construction Implementation Steps

✓	Identifying funding mechanisms (local, state, federal)
✓	Extending the Project to consider rural areas downstream of Velva
✓	Investigating additional Project alternatives (e.g., lesser design events, reservoir modification, combinations, etc.)
✓	Adopting a final plan
✓	Performing the necessary field investigations (e.g., geotechnical investigations, wetlands, surveys, etc.)
✓	Completing engineering and environmental studies (e.g., hydrologic, hydraulic, geotechnical, socio-economic, biological resources, etc.)
✓	Developing detailed design
✓	Obtaining permitting and regulatory approvals (e.g., NEPA compliance; USACE Section 10, 404, and 408 approvals; Section 401 water quality certification; FEMA certification, etc.)
✓	Acquiring Project properties
✓	Preparing the corridor
✓	Continuing stakeholder and agency coordination

Implementation of an Enhanced Flood Risk Reduction Project

Implementation of an enhanced flood risk reduction plan is a multi-step process. Phased implementation may provide desirable flexibility for funding and construction of high-priority elements. Steps that must be completed prior to construction are listed in the table shown at left.

The estimated time frame for planning, engineering, environmental, and regulatory steps for the entire Project could be 5 years—or longer. Select components or individual levee system modifications, which have minimal environmental impacts, could potentially proceed on a separate path and at a faster pace. Construction of a project similar to the preliminary alignment plan described in this report is likely to take a minimum of 5 years, and could be phased over an extended period if necessary.

Rendering of the Maple Diversion area, part of the Enhanced Flood Risk Reduction Project

Mouse River Enhanced Flood Protection Plan

Rural Flood Risk Reduction Alternatives Evaluation

Prepared for North Dakota State Water Commission

BARR

ACKERMAN-ESTVOLD engineering and management consulting, inc.

CPS

moore engineering, inc.

May 2013

Contents

Rural Flood Risk Alternatives Evaluation

Background and purpose

The Mouse River Valley of North Dakota has endured frequent flood damages over the last decade. Flooding has had significant impacts on the rural residents who make their livelihood along the river and within the floodplains of the Mouse River Valley. Impacts from flooding in the rural areas are varied and widespread, but have often included damage to agricultural areas resulting in reduced yields, damage to structures, adverse impacts to livestock, and loss of commerce due to inundated roads and bridges.

The Mouse River Enhanced Flood Protection Plan is designed to provide flood relief to Mouse River Valley residents. It was initiated by the North Dakota State Water Commission (NDSWC) in response to a request for assistance from the Souris River Joint Water Resources Board (SRJB) after the record-breaking Mouse River flood of June 2011. In the first phase the consulting team developed a plan to reduce flood risk in the river valley from Burlington to Velva and Mouse River Park, described in the *Preliminary Engineering Report* (PER) of February 2012.

After delivery of the PER the focus was shifted to the rural areas (Figure 1). This evaluation provides information for stakeholders to make informed decisions when considering basin-wide flood risk reduction measures within the Mouse River Valley. The Rural Flood Risk Reduction Alternatives Evaluation concentrated on obtaining answers to the following three questions:

(1) What are the effects of implementing the Project elements (as defined in the February 2012 PER) when compared to existing conditions?

(2) Are the proposed rural flood risk reduction alternatives effective in reducing flood impacts to agriculture and/or infrastructure?

(3) Are the rural alternatives implementable?

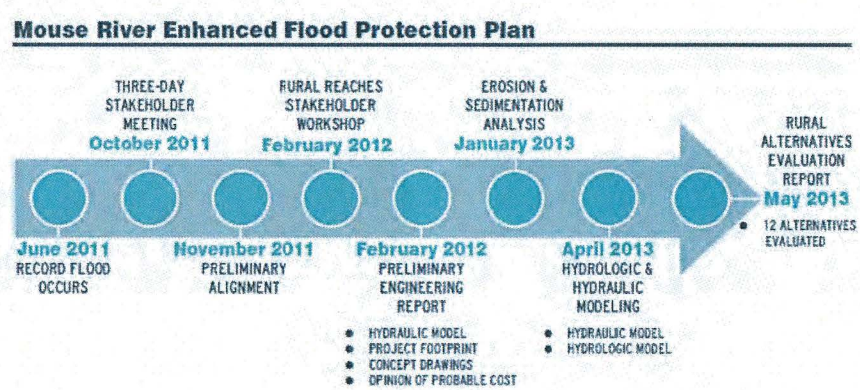


Figure 1: This Rural Alternatives report is the final report for this phase of the Mouse River Enhanced Flood Protection Plan; previous efforts focused on establishing a preliminary alignment for levees and floodwalls, an erosion and sedimentation analysis, and hydrologic and hydraulic modeling.

Study area

The study area consists of the main stem of the Mouse River within North Dakota, analyzed separately within four reaches. Only rural areas, buildings, roadways, railroads, and bridges were in this evaluation. Areas that would be protected by the PER flood risk reduction elements were excluded from the evaluations conducted for this study; the remaining rural areas from Burlington to Velva were included. The study area is shown in Figure 2.

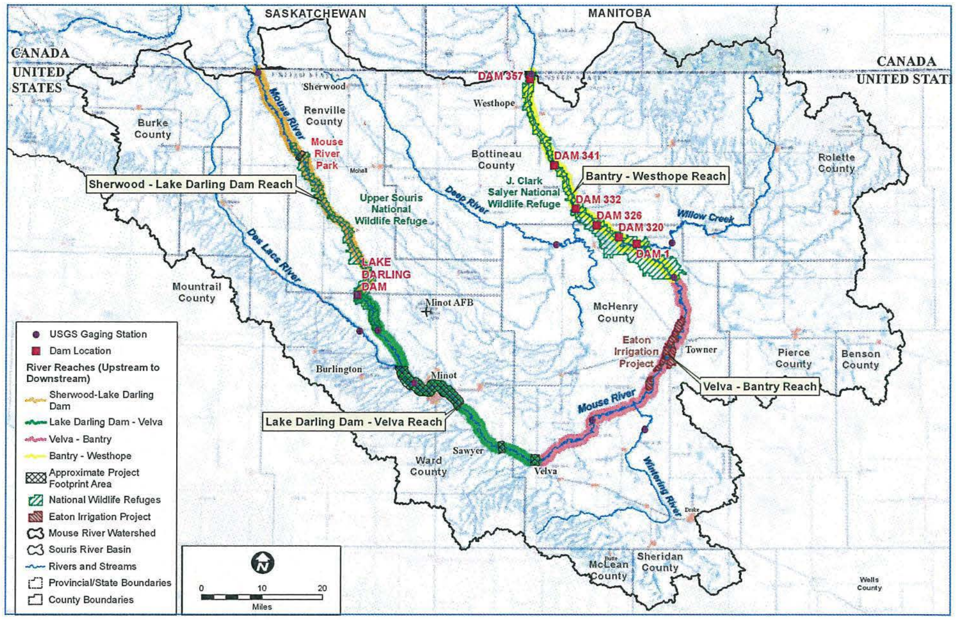


Figure 2: Map of the study area; alternatives were evaluated for four reaches of the Mouse River: (1) Sherwood to Lake Darling Dam, (2) Lake Darling Dam to Velva excluding Project footprint areas, (3) Velva to Bantry, and (4) Bantry to Westhope.

Alternatives

Twelve alternatives were identified by stakeholders to address rural flooding concerns. These alternatives are summarized in Table 1. The with-Project conditions was compared to the existing conditions and then to each of the analyzed alternatives.

The Souris River Joint Board (SRJB) hosted a Rural Reaches Workshop in Minot, North Dakota, on February 16, 2012, to collect information from community stakeholders on the types of flooding problems experienced by rural landowners, river stages and time frames when flooding is an issue, and potential risk-mitigation alternatives.

Table 1: Rural Flood Risk Reduction Alternatives

ALTERNATIVE 1	ADVANCED DISCHARGE FROM LAKE DARLING Modify the operating plan of Lake Darling Dam to drawdown pool level to the maximum drawdown level (El. 1,591) prior to spring flood events.
ALTERNATIVE 2	INCREASED TARGET DISCHARGE AT MINOT Modify the operating plan of Lake Darling Dam to allow discharges up to 10,000 cfs at Minot.
ALTERNATIVE 3	NON-STRUCTURAL FLOOD STORAGE INCREASE IN LAKE DARLING Increase the storage capacity of Lake Darling by lowering the maximum allowed drawdown level by 7 feet (to El. 1,584).
ALTERNATIVE 4	STRUCTURAL FLOOD STORAGE INCREASE IN LAKE DARLING Increase the storage capacity of Lake Darling by raising the dam. (Increase maximum flood storage level by 10 feet to El 1,611.)
ALTERNATIVE 5	RING DIKES Provide ring dikes around homes, businesses, and farmsteads in rural areas.
ALTERNATIVE 6	BOUNDARY DIVERSION Provide a high-flow diversion from Sherwood to Westhope to divert high flows away from the Mouse River Valley in North Dakota.
ALTERNATIVE 7	CHANNELIZATION IMPROVEMENTS DOWNSTREAM OF VELVA Provide increased channel flow capacity through channelization in select areas downstream of Velva.
ALTERNATIVE 8	BRIDGE MODIFICATIONS Raise or enlarge openings of select bridges over the Mouse River to allow key transportation corridors to remain open during flood events and to provide increased conveyance capacity at bridges.
ALTERNATIVE 9	MODIFY J. CLARK SALYER REFUGE DAM OPERATIONS Modify the operations of JCSNWR dams so that all water control structures remain open during events like the 2009, 2010, and 2011 historic events.
ALTERNATIVE 10	MODIFY J. CLARK SALYER REFUGE HYDRAULIC STRUCTURES Modify the physical parameters of the five JCSNWR dams to re-create conditions that existed prior to dam reconstruction work in the early 1990s.
ALTERNATIVE 11	REMOVE TRAPPED FLOODWATER AFTER THE FLOOD RECEDES Improve drainage of low-lying overbank areas to remove trapped floodwater from the floodplain after the flood recedes.
ALTERNATIVE 12	FLOOD STORAGE ON TRIBUTARIES TO THE MOUSE RIVER Provide floodwater storage in tributary watersheds.

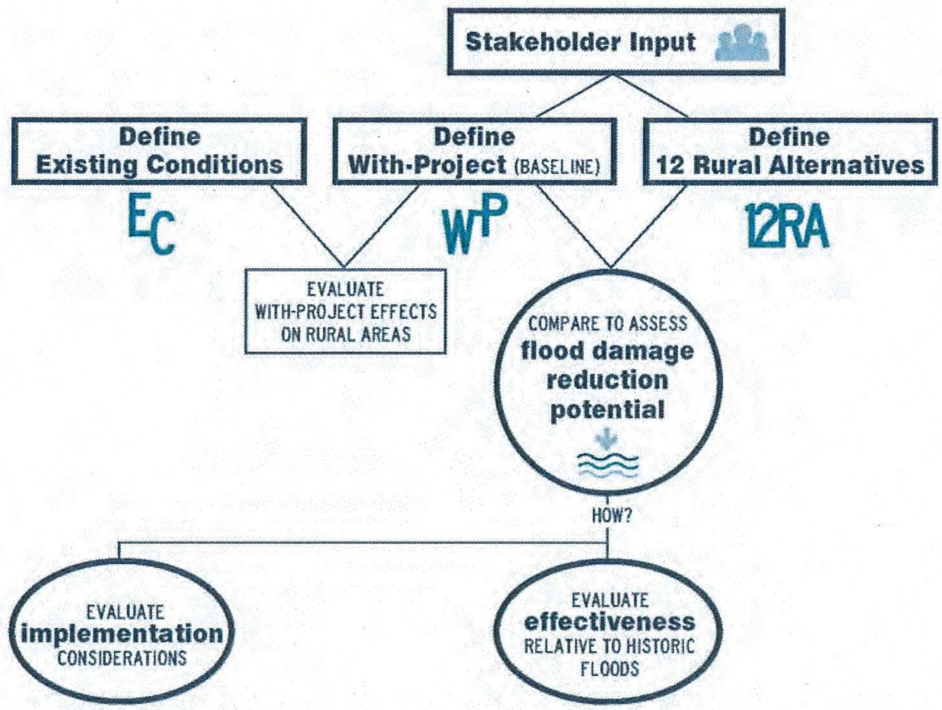


Figure 3: The evaluation process started with stakeholder input; 12 alternatives were identified and compared to assess flood risk reduction potential and implementability.

Study approach

The approach to the rural flood risk reduction alternatives evaluation was: (1) to engage stakeholders in identifying rural area flood concerns and alternatives to be studied, (2) to develop hydrologic and hydraulic models for the entire study area, and (3) to evaluate alternatives using stakeholder criteria and modeled flood scenarios.

The resulting alternatives were evaluated for their effectiveness in reducing flood impacts using qualitative analysis of historic floods as well as computer simulations of specific scenarios. This evaluation relies on the hydrologic and hydraulic models constructed of the Mouse River Valley for both the existing and with-Project conditions. Alternatives were also assessed for implementability to assess the degree of difficulty that might be expected in implementing a particular alternative under practical, technical, and regulatory constraints (Figure 3).

Effectiveness evaluation

The initial evaluation of each alternative was an assessment of the potential for the alternative to provide meaningful flood risk reduction, based on the established stakeholder criteria. USGS gage data for 14 historic floods were used to determine how likely each alternative would be to provide a flood risk reduction benefit under various flood conditions.

The effects of a flood on infrastructure are primarily related to the magnitude of the flood, with "major" flood damage resulting from flows above 5,000 cfs in most areas. Infrastructure impacts would be reduced by decreases in the peak flows or by local protection measures (ring dikes or bridge modifications). Impacts to transportation infrastructure are classified as affecting local roads, county roads, highways, or railroads.

The effects of a flood on agriculture are related to both the magnitude and timing of the flood. "Problematic" flooding occurs at flows above 3,000 cfs in most areas, but even flows above 500 cfs can cause significant impacts to agriculture if they occur during the peak growing season. Agricultural impacts would be reduced by decreases in the peak flows and the duration of high flows in the growing season. Agricultural impacts are defined based on the amount of farmland inundated and the timing/duration of the inundation.

Implementation evaluation

The implementation evaluation assessed the degree of difficulty that might be expected in implementing each alternative under practical, technical, and regulatory constraints. This qualitative analysis identified potential issues with permitting, legal issues, capital cost range, and constructability challenges (Table 2).

Table 2: Implementation Evaluation Criteria	
1	Stakeholder Acceptance*
2	Impacts to Transportation, Commerce, Emergency Response
3	Water Rights Impacts/Issues
4	Impacts to Canada
5	Agricultural Impacts
6	Flood Insurance Impacts
7	Social Impacts
8	Capital Cost Range
9	Operation/Maintenance Requirements
10	Erosion/Sedimentation Impacts
11	Environmental Impacts
12	Permit Requirements
13	Constructability

**While "stakeholder acceptance" is a critical component of implementability, it was not rated as part of this evaluation. The engineering team recognizes that it cannot assume to understand this criterion before stakeholders have had the chance to review and comment on this report.*

Historic flood evaluation

An evaluation of historic floods in the Mouse River Basin was critical to understanding flood-related problems and to defining the potential effectiveness of alternatives in reducing flood impacts for observed floods. Figure 4 summarizes the primary contributing drainage area and the type of flood (snowmelt, rainfall, or combination) for the top 28 floods at Verendrye.

Analysis of historic floods since 1937 resulted in the following conclusions:

- Snowmelt combined with coincidental or subsequent rainfall was the primary cause of the majority of the largest floods. However, over a quarter of the floods at Verendrye were the result of rainfall events.
- The drainage area upstream of Lake Darling Dam was the primary contributor to the majority of the largest floods. About 25 percent of the largest flood events were generated primarily from drainage areas downstream of the dam; therefore, Lake Darling Reservoir provides no flood risk reduction for those events.
- For flood risk reduction measures to be effective in reducing flooding and flood damages for the reaches downstream of Velva, measures that consider flood runoff from all portions of the upstream drainage areas should be considered.

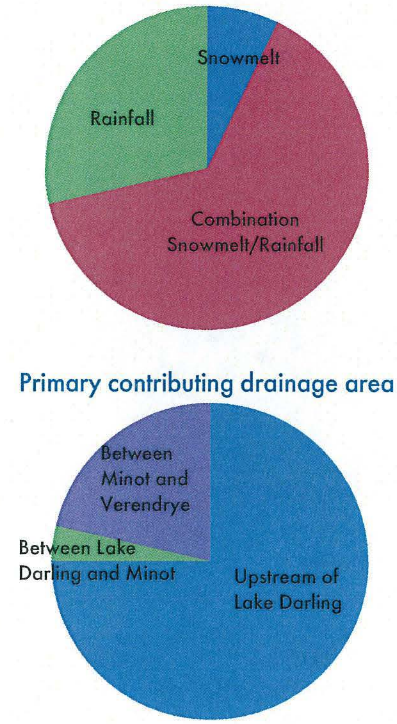


Figure 4: A summary of the primary contributing drainage area and type of flood for the top 28 floods at Verendrye

Conclusions

Effect of Burlington-to-Velva flood risk reduction measures

The hydraulic model of the Mouse River was developed to assess the changes in river hydraulics that could be expected with flood risk reduction measures in place (Figure 5). The results indicate the Project has very little impact on water surface elevations outside of the Burlington-to-Velva Project areas. With the Project elements in place, the impacts to inundated rural areas, number of inundated rural buildings, length of inundated roads, length of inundated railroads, and number of inundated bridges were relatively unchanged from existing conditions for all years (2009, 2010, and 2011) modeled.

Rural flood risk alternatives

The effectiveness and implementation assessments for the 12 alternatives are summarized in Table 3 on the following pages.

Change in water surface elevation due to Project

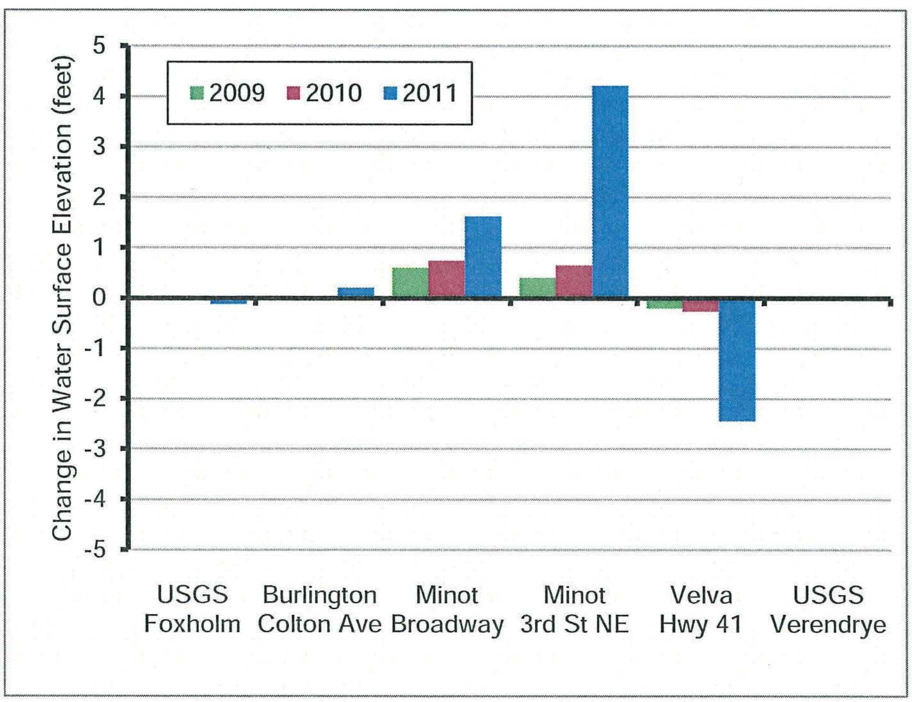


Figure 5: Hydraulic modeling of the 2009, 2010, and 2011 flood events was performed with and without the PER Project elements in place. The Project will minimally impact water surface elevations upstream of Burlington and downstream of Velva, while water surface increases in the developed areas will be contained between the proposed Project levees.

Table 3: Summary of Findings and Conclusions

	Effectiveness Assessment		Implementation Evaluation		
Alternative	**Agricultural Impact Reduction**	**Infrastructure Impact Reduction**	**Overall Imple-mentability**	**Greatest Challenges**	**Anticipated Cost Range**
ALTERNATIVE 1 Advanced Discharge from Lake Darling ★	Effective at reducing duration of inundation from Velva to Bantry during 1999 and 2001 floods; also somewhat effective for the 1975 and 1979 floods	Minor reduction of impacts for other select floods	✓	Concerns about increased winter discharges; requires modification of Annex A; possible water rights and refuge compatibility issues	$ Minimal capital cost
ALTERNATIVE 2 Increased Target Discharge at Minot	Minor reduction of impacts for the 2011 flood; effective at reducing duration of inundation from Velva to Bantry for the 1975, 1976, and 1979 floods	Minor reduction of impacts for the 2011 flood; infrastructure impacts worsened for the 1975, 1976, and 1979 floods	✗	Increased inundation for some floods; more homes in 100-year floodplain; possible water rights and refuge compatibility issues	$ Minimal capital cost
ALTERNATIVE 3 Non-Structural Flood Storage Increase in Lake Darling ★	Effective at reducing duration of inundation from Velva to Bantry for the 1970, 1974, 1975, 1976, and 1979 floods	Minor reduction of impacts for other select floods	!	Concerns about increased winter discharges; requires modification of Annex A; possible water rights and refuge compatibility issues (more so than Alternative 1)	$ Minimal capital cost
ALTERNATIVE 4 Structural Flood Storage Increase in Lake Darling	Minor reduction of impacts for the 2011 flood	Minor reduction of impacts for the 2011 flood	✗	Relocations, cost, coordination with Canada, recreational concerns	$$$ ($200-700 million)
ALTERNATIVE 5 Ring Dikes ★	No agricultural impact reduction (ring dikes only protect structures)	Effective at reducing impacts to buildings for floods up to the 2011 magnitude flood, but no reduction of impacts to roadways, railroads, or bridges	✓	Individual landowners must provide cost share and conduct maintenance	$$ ($10-50 million)
ALTERNATIVE 6 Boundary Diversion	Effective at reducing impacts for the 2011 flood in all reaches	Effective at reducing impacts for the 2011 flood in all reaches	✗	Major negative impacts likely for many of the criteria, including permits, impacts to Canada, relocations, constructability	$$$$ ($2-8 billion)

★ Most attractive basin-wide alternative

Implementability

✓ Minimal challenges currently foreseen to implement the alternative

! Some challenges currently foreseen to implement the alternative

✗ Significant challenges currently foreseen to implement the alternative

Anticipated cost range

$ Minimal cost ($0 to $10 million)

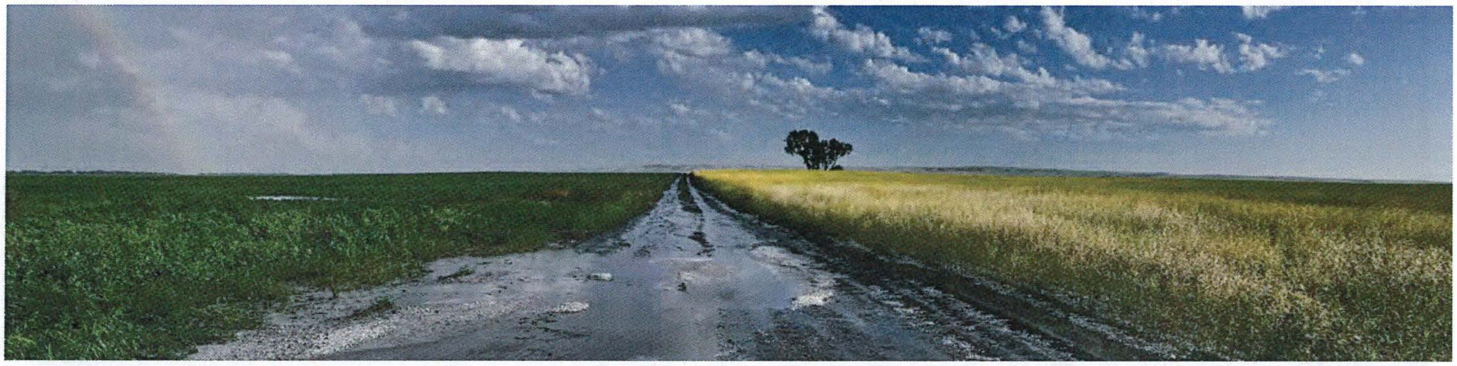
$$ Moderate cost ($10 to $300 million)

$$$ High cost ($300 million to $1 billion)

$$$$ Very high cost (>$1 billion)

Table 3: Summary of Findings and Conclusions

	Effectiveness Assessment		Implementation Evaluation		
Alternative	**Agricultural Impact Reduction**	**Infrastructure Impact Reduction**	**Overall Imple-mentability**	**Greatest Challenges**	**Anticipated Cost Range**
ALTERNATIVE 7: Channelization Improvements Downstream of Velva	Minor reduction of impacts	For the Velva to Bantry reach, effective at reducing impacts to buildings for the 2009 flood; minor reductions in impacts to roadways and railroads for the 2009, 2010, and 2011 floods	✗	Likely difficulty in obtaining USACE permit for channel excavation	$$ ($100-400 million)
ALTERNATIVE 8 Bridge Modifications	Minor reductions of impacts	Effective at reducing impacts to bridges, but minor or no reduction of impacts to buildings, roadways, or railroads	✓	Some environmental and erosion/sedimentation impacts	$$ ($30-100 million)
ALTERNATIVE 9 Modify JCSNWR Dam Operations	Minor reduction of impacts for the 2010 flood in the Bantry to Westhope reach	Minor reduction of impacts to roadways and railroads for the 2010 flood in the Bantry to Westhope reach	✗	Likely difficulty in obtaining USFWS and USACE permits; compatibility issues with refuge missions	$ Minimal capital cost
ALTERNATIVE 10 Modify JCSNWR Hydraulic Structures	Minor reduction of impacts for the 2009, 2010, and 2011 floods in the Bantry to Westhope reach	Minor reduction of impacts for the 2009, 2010, and 2011 floods in the Bantry to Westhope reach	✗	Likely difficulty in obtaining USFWS and USACE permits; compatibility issues with refuge missions	$$ ($30–100 million)
ALTERNATIVE 11 Remove Trapped Water after the Flood Recedes	Impact reduction is likely if (1) topography allows the trapped water to be conveyed back to the channel by gravity and (2) elevation of the river has receded below the drain outlet by approximately May 31	Minimal reduction of impacts expected; depends on final locations implemented	✓	Concerns about erosion downstream of culverts; ongoing maintenance to maintain effectiveness	$ ($3-10 million)
ALTERNATIVE 12 Flood Storage on Tributaries to the Mouse River	50% and 70% reduction scenarios are effective at reducing inundation during the 2009 and 2010 floods	50% and 70% reduction scenarios are effective at reducing inundation during the 2009 and 2010 floods	!	Site identification; possible difficulty in obtaining permits	$$ ($10-340 million)



Effectiveness criteria were developed to help determine which rural alternatives would be identified as the most effective. The objective of the effectiveness criteria was to identify alternatives that appear to provide some substantive relief (greater than 25 percent reduction in inundation area or flood duration or reduces the inundation of some infrastructure) for at least two of the historic flood events.

Based on the results of this rural flood risk reduction evaluation, the most effective basin-wide rural alternatives for reducing impacts to agriculture are Alternatives 1 (Advanced Discharge from Lake Darling) and 3 (Non-Structural Flood Storage Increase in Lake Darling). The most attractive basin-wide alternative for reducing impacts to infrastructure is Alternative 5 (Ring Dikes). Alternatives 1 and 5 have minimal implementation challenges, while Alternative 3 would be more challenging to implement. Additional considerations for these alternatives are shown in Table 4.

Many of the alternatives, including those that were not identified as "most effective," could provide some level of benefit even if the alternative was only partially implemented (i.e., implemented on key tributaries or at key locations along the Mouse River) and would need to be evaluated on a case-by-case basis. The results indicate that no single alternative is likely to provide all-encompassing flood risk reduction in rural areas. However, the most effective basin-wide approach for reducing rural flood impacts to both agricultural land and infrastructure along the Mouse River would likely consist of a combination of two or more of the alternatives.

Next steps

Flooding has had significant impacts on the rural residents who make their livelihood along the river and within the floodplains of the Mouse River Valley. Recognizing that stakeholder acceptance is the key to moving towards implementation of any rural flood risk reduction alternative, the most important next step is to gather feedback from those stakeholders and policy makers who have a vested interest in protecting agricultural land, homes, and infrastructure in the rural areas along the Mouse River.

Table 4: Additional Considerations for Most Effective Basin-Wide Alternatives

Alternative	Potential Advantages	Potential Limitations	Other Considerations	Potential Next Steps
ALTERNATIVE 1 Advanced Discharge from Lake Darling	Relatively inexpensive to implement; reduces agricultural impacts for select floods by allowing earlier access to fields adjacent to the river	Does not provide comprehensive flood risk reduction for all floods; little or no reduction of infrastructure impacts	Assumes that discharges can be predicted months ahead of time, which is not feasible	Study for the review of Annex A currently underway by the International Souris River Board which will review optimizing the operations of Lake Darling Dam
ALTERNATIVE 3 Non-Structural Flood Storage Increase in Lake Darling	Relatively inexpensive to implement; reduces agricultural impacts for select floods by allowing earlier access to fields adjacent to the river	Does not provide comprehensive flood risk reduction for all floods; little or no reduction of infrastructure impacts	Assumes that discharges can be predicted months ahead of time, which is not feasible	Study for the review of Annex A currently underway by the International Souris River Board which will review optimizing the operations of Lake Darling Dam
ALTERNATIVE 5 Ring Dikes	Effective in reducing risks of damage to buildings for floods up to June 2011 flood levels	No reduction of agricultural impacts or impacts to roads, railroads, or bridges	Fewer evacuations in major floods may result in more residents without transportation links due to inundated roads	Obtain input from landowners and compile list of potential ring dike locations; for each potential location compare cost of ring dike, structure relocation, and acquisition; conduct hydraulic modeling, especially in areas with large or many proposed ring dikes