Final Independent External Peer Review Report

Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study, North Dakota and Minnesota

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Flood Risk Management Planning Center of Expertise
Sacramento District

Contract No. W911NF-07-D-0001
Task Control Number: 10085
Delivery Order: 0874

May 17, 2010

SHORT-TERM ANALYSIS SERVICE (STAS)

on

Final Independent External Peer Review Report
Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study
North Dakota and Minnesota

by

Battelle
505 King Avenue
Columbus, OH 43201

for

Department of the Army
U.S. Army Corps of Engineers
Flood Risk Management Planning Center of Expertise
Sacramento District

May 17, 2010

Contract Number W911NF-07-D-0001
Task Control Number: 10-085
Delivery Order Number: 0874

Scientific Services Program

This page is intentionally left blank.

FINAL
INDEPENDENT EXTERNAL PEER REVIEW REPORT
for the

Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study, North Dakota and Minnesota

EXECUTIVE SUMMARY

Fargo-Moorhead is located on the Red River of the North, but the Wild Rice, Sheyenne, Maple, and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area. The primary problem in the study area is a high risk of flood damage to urban infrastructure from the Red River of the North, the Wild Rice River, the Buffalo River, and the Sheyenne River. Fargo and Moorhead are on the west and east banks, respectively, of the Red River of the North, approximately 453 river miles south of the mouth of the river at Lake Winnipeg in Manitoba, Canada. The drainage area of the Red River of the North above the U.S. Geological Survey gauging station at Fargo is approximately 6,800 square miles, of which about 2,175 square miles do not contribute to runoff.

The Fargo-Moorhead metropolitan area has a relatively high risk of flooding. The highest river stages usually occur as a result of spring snowmelt, but summer rainfall events have also caused significant flood damages. The Red River of the North has exceeded the National Weather Service flood stage of 17 feet in 51 of the past 107 years, and every year from 1993 through 2009. The study area is between the Wild Rice River, the Sheyenne River, and the Red River of the North; interbasin flows complicate the hydrology of the region and contribute to extensive flooding. Average annual flood damages in the Fargo-Moorhead metropolitan area are currently estimated at more than $74 million.

The planning objectives of the study are to:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota).
- Provide additional wetland habitat in conjunction with other project features.
- Provide recreational opportunities in conjunction with other project features.

USACE is conducting an Independent External Peer Review (IEPR) of the Fargo-Moorhead Metropolitan Flood Risk Management Draft Feasibility Report and Environmental Impact Statement (Fargo-Moorhead DFR/EIS). Battelle, as a 501(c)(3) non-profit science and technology organization with experience in establishing and administering peer review panels for USACE, was engaged to coordinate the IEPR of the Fargo-Moorhead DFR/EIS. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses. The IEPR was external to the agency and conducted following USACE and Office of

Management and Budget (OMB) guidance described in USACE (2010), USACE (2007), and OMB (2004). This final report describes the IEPR process, describes the panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel (the Panel).

Five panel members were selected for the IEPR from nearly 40 identified candidates. Based on the technical content of the Fargo-Moorhead DFR/EIS and the overall scope of the project, the final panel members were selected for their technical expertise in the following key areas: biology and the National Environmental Policy Act (NEPA), hydrology and hydraulics engineering, geotechnical engineering, civil design and construction cost engineering, and economics.

The IEPR Panel received electronic versions of the Fargo-Moorhead decision documents, along with a charge that solicited its comments on specific sections of the documents to be reviewed. The Fargo-Moorhead DFR/EIS Project Delivery Team briefed the Panel and Battelle during a kick-off meeting held via teleconference prior to the start of the review. Other than this teleconference, there was no direct communication between the Panel and USACE during the peer review process. The Panel produced more than 320 individual comments in response to the 121 charge questions.

IEPR Panel members reviewed the Fargo-Moorhead DFR/EIS documents individually. The panel members then met via teleconference with Battelle to review key technical comments, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a four-part format consisting of: (1) a comment statement; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations on how to resolve the comment. Overall, 23 Final Panel Comments were identified and documented. Of these, 7 were identified as having high significance, 13 had medium significance, and 3 had low significance.

Table ES-1 summarizes the Final Panel Comments by level of significance. Detailed information on each comment is contained in Appendix A of this report.

Table ES-1. Overview of 23 Final Comments Identified by the Fargo-Moorhead DFR/EIS IEPR Panel

Significance – High	
1	There are insufficient geotechnical analyses to justify the proposed channel slopes, channel depth, spoil pile configuration, cost estimates, and real estate requirements for the North Dakota Diversion Alternative.
2	The stability of the channel slopes, foundation deposits, and related spoil piles should be evaluated using ultimate or near ultimate soil strength values for the End of Construction (EOC) condition.
3	An explanation should be provided for the difference in channel bottom width dimensions between the Red and Wild Rice Rivers and the downstream end of the diversion for the North Dakota East Diversion Alternative.

4	Physical hydraulic modeling and computational fluid dynamics (CFD) modeling studies should be conducted on the project hydraulic structures and flow conditions described in Figures 17, 18, 19, 20, 21, and 22.
5	A 3D (three-dimensional) hydrodynamic model, rather than a 2D (two-dimensional) hydrodynamic model should be used to compute the flow velocity field and flow depths at the Red River Control Structure.
6	The plan acceptability discussion should be expanded to include the impacts and risks associated with each alignment alternative such as flood plain impacts, upstream and downstream effects, and tolerable risks.
7	The No-Action Alternative should be clarified by incorporating a discussion of flood fighting in the cost-benefit calculations.
Significance – Medium	
8	The proposed re-establishment of river channel meanders along previously straightened portions of the Red River and its tributaries presents a potential high risk of streambank erosion and earth slides and should be evaluated.
9	A more comprehensive analysis of sediment characteristics (i.e., size distribution) and sediment transport (i.e., bedload and suspended load) is needed for the Red River of the North and its tributaries.
10	The performance of existing and future upstream flood control measures needs to be better quantified with respect to their effect on the magnitude and frequency of floods in the defined project area.
11	The assumptions about relocating the existing rail yard for the Minnesota Diversion Alternative are a concern because of the potential environmental cleanup, increased construction costs, and potential disruption to rail traffic.
12	The conclusion that the downstream adverse effects are acceptable is contrary to the latest policy in floodplain management.
13	The cost estimate should reflect the techniques and details used to construct the earthworks excavation in similar clay deposits for the diversion on the Red River at Winnipeg, Manitoba.
14	Project cost estimates associated with non-structural flood reduction techniques need to be explained and referenced.
15	The statement that “the probability of success with an emergency flood fight is not zero but is very low” is confusing and contradicts historical experience.
16	The lists of land and water and economic opportunities that may arise from the execution of the project should be expanded in order to support the decision making process.
17	It is unclear if growth expansion was incorporated into the HEC-FDA model and if a sensitivity analysis will be conducted.
18	The predicted impact of the project alternatives on wetland areas would benefit from a more detailed description within the Fargo-Moorhead DFR/EIS.
19	Details for fish passage and structures need to be developed beyond the broad conceptual level.

20	The overall readability of the document could be improved with some reorganization, some additional discussion, and by incorporating some of the material from the appendices into the main report.
Significance – Low	
21	There are inconsistencies in the estimated costs, flood damages, and design parameters that should be cross-checked for accuracy.
22	The potential effect of ice jams and debris loading on the performance of hydraulic structures is unclear and should be addressed.
23	The study area needs to be clearly defined in text and illustrations.

The Panel agreed on its assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used in the Fargo-Moorhead DFR/EIS document. The planning methods were sound and adequate for a project of this size and complexity, and all the models used in the study were adequate and represent the state-of-the-art in flood control and risk assessment. Additionally, the public involvement process appeared to be comprehensive and extensive. The following statements summarize the Panel's findings, which are described in more detail in the Final Panel Comments (see Appendix A).

The Panel found that the hydrologic, biological, and economic analyses were sound and comprehensive. Most of the assumptions were very sound, and in general the study was very thorough. The description of the potential climate changes due to global warming were handled in a reasonable and thoughtful manner, and considered a necessary step to evaluate the increased flood frequency associated with climate change. The organization of the report could be improved to avoid the need to frequently reference the appendices by linking statements within the report to specific parts of each appendix. In general, it was often difficult for the Panel to determine how conclusions in the draft report were directly supported by information contained in the technical appendices. More detailed discussion or direct references in the text to specific pages in the appendices would improve the understanding of how conclusions were drawn from supporting data. The Panel found that some improvements could be made to the engineering, economic, and environmental parts of the project, as described in the following sections.

Economics: Since one of the most fundamental inputs to the benefit analysis – the flow/frequency relationship – is being reevaluated, the validity of the conclusions to be drawn from the economics analysis is difficult to assess at this time. Assuming that the same approach will be followed with the updated analysis, the conclusions will be well supported. Because there will be an updated analysis of flood damages and project benefits, it is difficult at this point to evaluate the report conclusions of the National Economic Development (NED) analysis. Assuming the same analysis will be completed with updated data; there will still be a need to clarify key elements and assumptions in the economic analysis, such as why flood fights are assumed to be unsuccessful for the purpose of benefit quantification, and how growth in the floodplain is handled in the different portions of the report. In general, the new analysis is likely to point toward greater benefits of the project and the new analysis could point toward a new NED plan, but since the Locally Preferred Plan (LPP) is the recommended plan, the new analysis is not likely to result in a new recommended plan. The economic analysis along with much of

the report is difficult to follow. For example, the main report has many references to the recent successes of local flood fighting efforts, but then assumes a zero percent success in flood fighting efforts for the purpose of quantifying benefits. Similarly, it is not clear how future growth in the floodplain is handled in different elements of the report. Finally, the down-selection process of determining and comparing alternatives should be explained more clearly in the report.

Engineering: The Panel raised several concerns related to hydraulics, geotechnical design, and environmental cleanup. One major concern was adverse impacts upstream and downstream of the project reach. The natural gradient of the Red River Valley is so small that relatively small changes in water depth can propagate for many miles. Other engineering concerns included the need for physical and computational modeling studies on the proposed hydraulic structures and information on the potential effect of ice jams and debris loading on these hydraulic structures. The channel design for the Minnesota Diversion alternatives was based upon a systematic geotechnical analysis using available subsurface data. Similar hydraulic and geotechnical analyses were not conducted for the North Dakota Diversion alternative, which creates uncertainty regarding the accuracy of the project costs for this alternative. The soil strength assumptions used for the geotechnical analyses may be less conservative when compared to the performance of other projects in the area. There is also uncertainty about the performance of the hydraulic structures proposed for the crossings between the diversion channel and the Red River tributaries. The analyses of sediment characteristics, sediment loads, and potential geomorphic effects are insufficient for the Panel to evaluate potential impacts. The assumptions about relocating the existing rail yard for the Minnesota Diversion alternative are a concern because of the potential environmental cleanup, increased construction costs, and potential disruption to rail traffic.

Environmental: The major concern regarding environmental issues was providing better documentation, specifically, how hydrologic impacts to wetland were evaluated, given that some wetlands will be affected by the changes in frequency and magnitude of future flooding events. The report provides a narrative discussion of the methods, but the related appendix lacks supporting calculations. The environmental discussion should also include a discussion on how upstream land use and proposed flood reduction measures may alter the magnitude and frequency of design flood events for the study area. The document should include engineering details (such as design drawings), demonstrating that the hydraulic parameters required to facilitate fish passage are provided by the proposed structures.

This page is intentionally left blank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

ATR	Agency Technical Review
CFD	Computational Fluid Dynamics model
DrChecks	Design Review and Checking System
DFR	Draft Feasibility Report
EIS	Environmental Impact Statement
EQ	Environmental Quality
EOC	End of Construction
IEPR	Independent External Peer Review
LPP	Locally Preferred Plan
NED	National Economic Development
NEPA	National Environmental Policy Act
NTP	Notice to Proceed
OMB	Office of Management and Budget
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UU	Unconsolidated-Undrained
WRDA	Water Resources Development Act

1. INTRODUCTION

Fargo-Moorhead is located on the Red River of the North, but the Wild Rice, Sheyenne, Maple, and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area. The primary problem in the study area is a high risk of flood damage to urban infrastructure from the Red River of the North, the Wild Rice River, the Buffalo River, and the Sheyenne River. Fargo and Moorhead are on the west and east banks, respectively, of the Red River of the North, approximately 453 river miles south of the mouth of the river at Lake Winnipeg in Manitoba, Canada. The drainage area of the Red River of the North above the U.S. Geological Survey gauging station at Fargo is approximately 6,800 square miles, of which about 2,175 square miles do not contribute to runoff.

The Fargo-Moorhead metropolitan area has a relatively high risk of flooding. The highest river stages usually occur as a result of spring snowmelt, but summer rainfall events have also caused significant flood damages. The Red River of the North has exceeded the National Weather Service flood stage of 17 feet in 51 of the past 107 years, and every year from 1993 through 2009. The study area is between the Wild Rice River, the Sheyenne River, and the Red River of the North; interbasin flows complicate the hydrology of the region and contribute to extensive flooding. Average annual flood damages in the Fargo-Moorhead metropolitan area are currently estimated at more than $74 million.

The planning objectives of the study are to:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota).
- Provide additional wetland habitat in conjunction with other project features.
- Provide recreational opportunities in conjunction with other project features.

The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the Fargo-Moorhead Metropolitan Flood Risk Management Draft Feasibility Report and Environmental Impact Statement (Fargo-Moorhead DFR/EIS) in accordance with procedures described in the Department of the Army, U.S. Army Corps of Engineers Engineer Circular *Civil Works Review Policy* (EC No. 1165-2-209) (USACE, 2010), USACE CECW-CP memorandum *Peer Review Process* (USACE, 2007), and Office of Management and Budget (OMB) bulletin *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Battelle, as a 501(c)(3) non-profit science and technology organization with experience in establishing and administering peer review panels, was engaged to coordinate the IEPR of the Fargo-Moorhead DFR/EIS. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses.

This final report details the IEPR process, describes the panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel on the existing environmental,

economic, and hydrologic and hydraulic engineering analyses contained in the Fargo-Moorhead DFR/EIS. Detailed information on the Final Panel Comments is provided in Appendix A.

2. PURPOSE OF THE IEPR

To ensure that USACE documents are supported by the best scientific and technical information, USACE has implemented a peer review process that uses IEPR to complement the Agency Technical Review (ATR), as described in USACE (2010) and USACE (2007).

In general, the purpose of peer review is to strengthen the quality and credibility of the USACE decision documents in support of its Civil Works program. IEPR provides an independent assessment of the economic, engineering, and environmental analysis of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions, methods, analyses, and calculations and identifies the need for additional data or analyses to make a good decision regarding implementation of alternatives and recommendations.

In this case, the IEPR of the Fargo-Moorhead DFR/EIS was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization under section 501(c)(3) of the U.S. Internal Revenue Code with experience conducting IEPRs for USACE.

3. METHODS

This section describes the methodology followed in selecting the members for the IEPR Panel (the Panel) and in planning and conducting the IEPR. The IEPR was conducted following procedures described in USACE (2010) and in accordance with USACE (2007) and OMB (2004). Supplemental guidance on evaluation for conflicts of interest was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

3.1 Planning and Schedule

After receiving the notice to proceed (NTP), Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., clarify expertise areas needed for panel members). Any revisions to the schedule were submitted as part of the final Work Plan.

Table 1 defines the schedule followed in executing the IEPR. Due dates for milestones and deliverables are based on the NTP date of February 15, 2010. Note that the work items listed in Task 7 occur after the submission of this report. Battelle will enter the 23 Final Panel Comments into USACE's Design Review and Checking System (DrChecks), a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE and the Panel can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (Backcheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle.

Table 1. Fargo-Moorhead DFR/EIS IEPR Schedule

TASK	ACTION	DUE DATE
	Pre-award funding approval[a]	February 12, 2010
1	NTP	February 15, 2010
	Review documents available	February 17, 2010
	End of Period of Performance	September 30, 2010
	Battelle prepares draft Work Plan[b]	March 10, 2010
	USACE provides comments on draft Work Plan	March 17, 2010
	Teleconference (if necessary)	March 17, 2010
	Battelle submits final Work Plan, including final charge[b]	March 22, 2010
	USACE approves final Work Plan (including final charge)	March 23, 2010
2	Battelle requests input from USACE on the COI questionnaire	February 23, 2010
	USACE provides comments on the COI questionnaire	February 23, 2010
	Battelle submits list of selected panel members[a,b]	March 12, 2010
	USACE provides comments on list of panel members	March 17, 2010
	Battelle completes subcontracts for panel members	March 31, 2010
3	Battelle submits draft charge (combined with draft Work Plan)[b]	March 10, 2010
	USACE provides comments on draft charge	March 17, 2010
	Battelle submits final charge (combined with final Work Plan)[b]	March 22, 2010
	USACE approves final charge	March 23, 2010
4	Kick-off meeting convened with USACE and Battelle	February 26, 2010
	Battelle sends review documents and charge to IEPR Panel	April 1, 2010
	Kick-off meeting convened with Battelle and IEPR Panel	April 2, 2010
	Kick-off meeting convened with USACE, Battelle, and IEPR Panel	April 2, 2010
	IEPR Panel completes review and provides comments to Battelle	April 22, 2010
5	Battelle consolidates comments from IEPR Panel	April 23- 25, 2010
	Panel review teleconference convened with IEPR Panel and Battelle	April 26, 2010
	IEPR Panel provides draft Final Panel Comments to Battelle	May 3, 2010
6	Battelle submits final IEPR Report to USACE[b]	May 17, 2010
7[c]	Battelle inputs Final Panel Comments to DrChecks. Battelle provides Final Panel Comment response template to USACE.	May 19, 2010
	USACE PDT provides draft Evaluator responses and clarifying questions to Battelle	June 1, 2010
	Final Panel Comment Teleconference convened with USACE, Battelle, and IEPR Panel to discuss Final Panel Comments, draft responses and clarifying questions	June 11, 2010
	USACE inputs final Evaluator responses to Final Panel Comments in DrChecks	June 22, 2010
	Battelle inputs BackCheck responses in DrChecks	July 6, 2010

TASK	ACTION	DUE DATE
7[c]	Battelle submits pdf of DrChecks file and closes out DrChecks[b]	July 7, 2010
	Project Closeout	September 9, 2010

[a] Requested to start on recruitment to meet the aggressive schedule

[b] Deliverable

[c] Task occurs after the submission of this report.

3.2 Identification and Selection of IEPR Panel Members

The candidates for the Panel were evaluated based on their technical expertise in the following key areas: biology and the National Environmental Policy Act (NEPA), hydrology and hydraulics engineering, geotechnical engineering, civil design and construction cost engineering, and economics. These areas correspond to the technical content of the Fargo-Moorhead DFR/EIS and overall scope of the Fargo-Moorhead project.

Battelle initially identified nearly 40 candidates for the Panel, evaluated their technical expertise, and inquired about potential conflicts of interest. Of these, Battelle chose eight of the most qualified candidates and confirmed their interest and availability. Of the eight candidates, five were proposed for the final Panel and three were proposed as backup reviewers. The final Panel consisted of four proposed primary reviewers and one of the proposed backup reviewers. The primary proposed hydrology and hydraulics engineering expert could not participate in this review due to an unforeseen scheduling conflict. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed conflicts of interest, or lack of the precise technical expertise required.

The candidates were screened for the following potential exclusion criteria or conflicts of interest.[1] Participation in previous USACE technical peer review committees and other technical review panel experience was also considered.

[1] Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. See OMB (2004, p. 18), "….when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects."

Potential Exclusion Criteria/Conflicts of Interest

- Involvement by the expert or his/her firm in any part of the Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study, including the Fargo-Moorhead Feasibility Report and Environmental Impact Statement (EIS), and supporting appendices.
- Involvement by the expert or his/her firm in any work related to the Red River of the North Basin, including the Fargo-Moorhead Metropolitan Area.
- Involvement by the expert or his/her firm in any work on the Red River Basin Reconnaissance Study.
- Involvement by the expert or his/her firm in the conceptual or actual design, construction, or O&M of flood damage reduction projects in the Fargo-Moorhead Metropolitan Area or the Red River of the North Basin.
- Current employment by the U.S. Army Corps of Engineers (USACE).
- Involvement with paid or unpaid expert testimony related to the Red River of the North Basin, including the Fargo-Moorhead Metropolitan Area.
- Current or previous employment or affiliation with the non-Federal sponsors, including the City of Fargo, North Dakota, and the City of Moorhead, Minnesota, or any of the following Federal, state, county, local and regional agencies, environmental organizations, and interested groups: the Red River Basin Commission (RRBC), International Red River Board (IRRB), Red River Watershed Management Board (RRWMB), North Dakota Red River Joint Water Resource District (NDJWRD), Minnesota Department of Natural Resources (MDNR), Minnesota Pollution Control Agency (MPCA), U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (EPA), North Dakota Game, Fish and Parks (NDGFP), Fargo-Moorhead Metropolitan Council of Governments (FM COG), North Dakota State Water Commission (ND SWC), North Dakota Department of Health, Federal Emergency Management Agency (FEMA), North Dakota Wildlife Federation, Buffalo Red River Watershed District (BRRWD), Cass County, North Dakota, Clay County, Minnesota, Southeast Cass Water Resources District (SE Cass WRD), Federal Aviation Administration (FAA), Minnesota Natural Resource Conservation Service (MN NRCS), North Dakota Natural Resource Conservation Service (ND NRCS), National Wildlife Federation (NWF), Minnesota Board of Water and Soil Resources (BWSR), and currently working on Fargo-Moorhead Metropolitan Area or Red River of the North Basin-related projects (for pay or pro bono).
- Past, current, or future interests or involvements (financial or otherwise) related to the Fargo-Moorhead Metropolitan Area.
- Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. Expert must provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Expert must also highlight and discuss in greater detail any projects that are specifically with the St. Paul District.

- Current firm involvement with other USACE projects, specifically those projects/contracts that are with the St. Paul District. Firm must provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role.
- Previous employment by the USACE as a direct employee or contractor (either as an individual or through the firm) within the last 10 years, notably if those projects/contracts are with the St. Paul District. Expert must provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous experience conducting technical peer reviews. Expert must highlight and discuss any technical reviews concerning flood risk reduction, and include the client/agency and duration of review (approximate dates).
- Pending, current, or future financial interests in the Fargo-Moorhead Metropolitan Area or Red River of the North Basin related contracts/awards from USACE.
- A significant portion (i.e., greater than 50%) of personal or firm revenues within the last 3 years from USACE contracts.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study, including the EIS and supporting appendices.
- Participation in relevant prior Federal studies relevant to this project:
  a. USACE, May 1967. Flood Control Reconnaissance Report, Red River of the North at Fargo, North Dakota, Section 205
  b. USACE, May 1985. Fargo-Moorhead Urban Study
  c. International Joint Commission, November 2000. "Living with the Red"
  d. USACE, September 2001. Reconnaissance Study, Red River Basin, Minnesota, North Dakota, South Dakota
  e. U.S. Department of the Interior, Bureau of Reclamation, December 2007. Final Environmental Impact Statement for the Red River Valley Water Supply Project
  f. USACE, August 2004. Fargo-Moorhead and Upstream Feasibility Study.
- Participation in prior non-Federal studies relevant to this project such as:
  a. City of Fargo and City of Moorhead, June 2007, Fargo-Moorhead Downtown Framework Plan Update
  b. City of Fargo, Fargo Southside Flood Control Project
  c. Flood risk management reduction project for Oakport Township, Minnesota.
- Any past, present or future activity, relationship, or interest (financial or otherwise) that could make it appear that the expert would be unable to provide unbiased services on this project.

In selecting the final members of the Panel from the list of candidates, Battelle chose experts who best fit the expertise areas and had no conflicts of interest. The five final reviewers were either affiliated with academic institutions or consulting companies or were independent engineering consultants. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of conflicts of interest

through a signed Conflict of Interest (COI) form. Section 4 of this report provides names and biographical information on the panel members.

Prior to beginning their review and within 2 days of their subcontracts being finalized, all members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication, and other pertinent information for the Panel.

3.3 Preparation of the Charge and Conduct of the IEPR

Battelle drafted a preliminary charge document, including specific charge questions and discussion points. After it was reviewed and approved by USACE, it was sent to the Panel to guide its review of the Fargo-Moorhead DFR/EIS. The charge was prepared by Battelle to assist the USACE in the development of the charge questions that will guide the peer review, according to guidance provided in USACE (2010), USACE (2007), and OMB (2004). The draft charge was submitted to the USACE for evaluation as part of the draft Work Plan. USACE provided comments and revisions to the draft charge, which were used to produce the final charge. The final charge was submitted to USACE for approval. In addition to a list of 121 charge questions/discussion points, the final charge included general guidance for the Panel on the conduct of the peer review (provided in Appendix B of this final report).

Battelle planned and facilitated a final kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meeting, the IEPR Panel received an electronic version of the Fargo-Moorhead decision documents and the final charge. A full list of the documents reviewed by the Panel is provided in Appendix B of this report. The Panel was instructed to address the charge questions/discussion points within a comment-response form provided by Battelle.

3.4 Review of Individual Comments

The Panel produced more than 320 individual comments in response to the charge questions. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. As a result of the review, Battelle was able to summarize these individual charge question responses into a preliminary list of 52 overall comments and discussion points. Each panel member's individual comments were shared with the full Panel in a merged individual comments table.

3.5 IEPR Panel Teleconference

Battelle facilitated a 4-hour teleconference with the Panel so that the panel experts, many of whom are from diverse scientific backgrounds, could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments and to decide which panel member would serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the final IEPR report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall negative comments, positive comments, and comments that appeared to be conflicting among panel members. In addition, Battelle confirmed each comment's level of significance to the Panel,

added any missing issues of high-level importance to the findings, resolved whether to "agree to disagree" on the conflicting comments, and merged any related individual comments.

The Panel also discussed responses to 17 specific charge questions where there appeared to be disagreement among panel members. The conflicting comments were resolved based on the professional judgment of the Panel; each comment was either incorporated into a Final Panel Comment or determined to be a non-significant issue (i.e., either a true disagreement did not exist, or the issue was not important enough to include as a Final Panel Comment).

At the end of these discussions, the Panel identified 23 comments that should be brought forward as Final Panel Comments.

3.6 Preparation of Final Panel Comments

Following the teleconference, Battelle prepared for the Panel a summary memorandum documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the Fargo-Moorhead DFR/EIS:

- Lead Responsibility: For each Final Panel Comment, one panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist each lead in the development of the Final Panel Comments, Battelle distributed merged individual comments in the comment-response form table, a summary detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and a template for the preparation of the Final Panel Comments.
- Directive to the Lead: Each lead was encouraged to communicate directly with other IEPR Panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- Format for Final Comments: Each Final Panel Comment was presented as part of a four-part structure:
    1. Comment Statement (succinct summary statement of concern)
    2. Basis for Comment (details regarding the concern)
    3. Significance (high, medium, low; see description below)
    4. Recommendation for Resolution (see description below).
- Criteria for Significance: The following were used as criteria for assigning a significance level to each Final Panel Comment:
    1. High: Describes a fundamental problem with the project that could affect the recommendation or justification of the project
    2. Medium: Affects the completeness or understanding of the reports/project
    3. Low: Affects the technical quality of the reports but will not affect the recommendation of the project.

- Guidance for Developing the Recommendation: The recommendation was to include specific actions that the USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

At the end of this process, 23 Final Panel Comments were prepared and assembled. Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Final Panel Comments are presented in Appendix A of this report.

4. PANEL DESCRIPTION

Candidates for the Panel were identified using Battelle's Peer Reviewer Database, targeted Internet searches using key words (e.g., technical area, geographic region), searches of websites of universities or other compiled expert sites, and referrals. Battelle prepared a draft list of primary and backup candidate panel members (which were screened for availability, technical background, and conflicts of interest), provided it to USACE, and Battelle made the final selection of panel members.

An overview of the credentials of the final five members of the Panel and their qualifications in relation to the technical evaluation criteria is presented in Table 2. More detailed biographical information regarding each panel member and his or her area of technical expertise is presented in the text that follows the table.

Table 2. Fargo-Moorhead IEPR Panel: Technical Criteria and Areas of Expertise

	Kulik	Garcia	Spaulding	Greene	Love
NEPA and Biology (one expert needed)	**X**				
Familiar with large, complex Civil Works Projects with high public and interagency interests	X				
Particular knowledge of fisheries biology	X				
Experience with fish passage, migration, and spawning	X				
Knowledge of flood risk management projects	X				
Familiar with all NEPA requirements	X				
Familiarity with wetland and riparian ecology of the Upper Midwest	X				
Familiarity with the USACE planning process (beneficial)	X			X	
Hydrology and Hydraulic Engineer (one expert needed)		**X**			
Familiar with large, complex Civil Works Projects with high public and interagency interests		X			
Experience in hydrology and hydraulic engineering in large public works projects, associated flood risk management, diversion channel design, large river control structures		X			
Familiar with standard USACE hydrologic and hydraulic computer models		X			
Experience with computer simulation of large river systems		X			
Experience with physical modeling of large river systems		X			
Geotechnical Engineer (one expert needed)			**X**		
Experience in the analysis and design of flood risk/reduction type projects, especially			X		
Modeling seepage and slope stability analyses in soft clay soils			X		
Cold climate project experience			X		
Familiar with large, complex Civil Works Projects with high public and interagency interests			X		
Experience in the design and construction of levees and floodwalls, foundations for bridges, large river control structures, dams			X		
Familiar with earthwork required for the construction of levee/floodwall projects			X		
Familiar with major excavation for diversion channels			X		

	Kulik	Garcia	Spaulding	Greene	Love
Economics (one expert needed)				**X**	
Experience directly related to water resource economic evaluation or review				X	
Familiar with large, complex Civil Works Projects with high public and interagency interests				X	
Familiar with the USACE flood risk management analysis and benefit calculations, including use of standard USACE computer programs				X	
Experience with the National Economic Development analysis procedures, including those specifically related to flood risk management				X	
Civil Design/Construction Cost Engineering (one expert needed)					**X**
Demonstrated experience in performing cost engineering/construction management for all phases of flood risk management, or related projects					X
Familiar with large, complex Civil Works Projects with high public and interagency interests					X
Familiar with cost engineering related to similar flood risk management projects across the U.S., including those taking place in cold climates					X
Experience in associated contracting procedures, total cost growth analysis, and related cost risk analysis					See note
Familiar with the construction industry					X

Note: Although our civil design/construction cost engineering expert, Mr. David Love, did not meet the education criterion for this category, he had more than the equivalent gained from more than 35 years of flood control and water resources engineering work with local municipalities, special districts, various state and Federal agencies, and the private sector.

Marcelo Garcia, Ph.D., P.E.

Role: This panel member was chosen primarily for his hydrologic and hydraulic engineering experience and expertise.
Affiliation: University of Illinois, Urbana-Champaign

Dr. Marcelo Garcia, P.E. is a Professor and Director of the Ven Te Chow Hydrosystems Laboratory in the Department of Civil and Environmental Engineering at the University of Illinois, Urbana-Champaign. He has 26 years of experience in hydrologic and hydraulic engineering, and is a certified professional engineer in Santa Fe, Argentina. Dr. Garcia's areas of expertise include river mechanics and sediment transport; environmental hydraulics; and water resources engineering. He has conducted hydrologic and hydraulic studies for the Parana Medio Dam in Argentina, the John Compton Dam in St. Lucia, West Indies, the Valenciano Reservoir in Puerto Rico, and has directed development of a real-time hydrologic-hydraulic model for the $3 billion Deep Tunnel (TARP) project in Chicago, Illinois. Additionally, he has performed flood hazard analysis for Pilar, Paraguay, and Buenos Aires, Argentina, and was responsible for the design of the flood control channel restoration for the Rio Piedras, Puerto Rico. Dr. Garcia has designed several spillways to prevent drowning accidents at low-head dams on the Fox and Vermillion Rivers in Illinois, and has also designed canoe chutes and fish passages for streams in Illinois and Kansas. For more than 20 years he has taught graduate courses in open channel flow, hydraulic engineering and sediment transport that make use of USACE computer river models, and has published and lectured extensively on computer river modeling, including meandering streams and vegetated channels. Dr. Garcia has modeled several rivers numerically, including the Chicago River, Bubbly Creek and the Chicago Sanitary and Ship Canal (CSSC), the Fox River, and the Wabash River. Dr. Garcia has also lead several physical movable-bed model studies including erosion and sedimentation of the Minnesota River at Mankato, Minnesota. Dr. Garcia served as the editor-in-chief of the ASCE Manual of Engineering Practice 110 Sedimentation Engineering and the International Journal of Hydraulic Research (IAHR) from 2001 to 2006, and recently represented the U.S. in the sedimentation studies and computational modeling of the St. Clair River for the International Great Lakes Commission. Dr. Garcia was the 2006 recipient of the ASCE/EWRI/COPRI Hans Albert Einstein Award for contributions to the field of river engineering and sediment transport, and has authored or co-authored numerous peer reviewed publications and technical reports. He is a member of the American Society of Civil Engineers (ASCE), the American Geophysical Union (AGU) and the National Academy of Engineering of Argentina.

Douglas Spalding, P.E.

Role: This panel member was chosen primarily for his geotechnical engineering experience and expertise.
Affiliation: Spaulding Consultants, LLC

Douglas Spalding, P.E., is a Principal with Spaulding Consultants, LLC, responsible for dam and levee design and inspection. He has 42 years of experience as a geotechnical engineer. He earned his MSCE from Purdue University, and is a Certified Professional Engineer in Wisconsin and Minnesota. Mr. Spalding served as Chief of Levee and Channel Design Section for USACE from 1973-1978, and managed environmental and technical studies for licensing or relicensing of more than 20 hydroelectric projects ranging in size from 600 kW to 1000 MW. As a FERC

approved facilitator, Mr. Spalding has facilitated Potential Failure Mode Analysis for more than 55 earth, arch, and gravity dams throughout the United States. He has served as the Principal geotechnical designer for six levee and flood control projects in the Red River valley, and has also conducted geotechnical studies of levees in Red River to determine cause of levee cracking. Mr. Spalding has provided geotechnical design for eight levee and floodwall projects located in Minnesota, North Dakota, and Wisconsin, and developed pile design for pedestrian bridge in Grand Forks, North Dakota. He is experienced in stability analyses and seepage analyses using finite element techniques. Mr. Spalding has also served as a peer reviewer for the geotechnical design of various reaches of the New Orleans Flood Control Project, and has provided dam safety training to USACE and electric utility company operators for more than 25 years. Mr. Spalding was responsible for the geotechnical design of the Highway 75 Dam in Minnesota, and the rehabilitation projects for over 20 other dams throughout the United States. Mr. Spalding's experience with major soft clays excavations for diversion channels includes the geotechnical design for the Breckenridge Diversion Channel (Minnesota), the Wild Rice Felton Ditch Project (Minnesota), the English Coulee Diversion Channel and control structure (Grand Forks, North Dakota), and preliminary design for the Roseau Channel Improvement Project. Mr. Spalding is a member of the American Society of Civil Engineers, the Minnesota Geotechnical Society, the Society of American Military Engineers, and a member of the American Arbitration Association.

Gretchen Greene, Ph.D.

Role: This panel member was chosen primarily for her economics experience and expertise.
Affiliation: Environ, Inc.

Dr. Gretchen Greene is a senior economist with Environ, Inc. She earned her Ph.D. in food and resource economics from the University of Florida in 1998. Dr. Greene has worked in environmental valuation, economic development, socioeconomic analysis, recreation demand, cost-benefit analysis, regulatory analysis, population projections, and forecasting urban water demand. Dr. Greene has extensive experience with economic analysis of water resource development, having worked on numerous Indian Water Rights litigation cases that hinge on benefit cost analyses following the Principles and Guidelines for Water Resource Development, using the NED approach. She also led the Dredged Material Management Study: Risk-Based Analysis of the Lewiston Levee, which was part of a Dredged Material Management EIS for the Snake River system, in which Dr. Greene estimated flood damage reduction benefits of the Lewiston Levee system. Dr. Greene prepared a benefit-cost economic analysis of various dredge plans, levee alterations, and dredged material disposal options for the Walla Walla District of the USACE. For this effort, she estimated flood damage reduction benefits using the USACE Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) model. The model and results were operated and presented in a manner consistent with USACE Engineering Manual 1110-2-1619, Risk Based Analysis for Flood Damage Reduction Studies. A Monte Carlo simulation approach was used to perform a risk-based analysis of flood damages over the project lifetime of the Lower Granite dam. Other costs estimated included cleanup costs, emergency care costs, transportation losses, and nonphysical damages such as lost wages, temporary housing, additional living expenses, and public infrastructure. Environmental costs and benefits were also analyzed, including consideration of effects of the project on endangered species, water quality, recreation, and wetlands. Dr. Greene also oversaw the development of a socioeconomic analysis of the region, including projections and a regional economic impact

analysis. In addition, Dr. Greene continues on-going research and work on the economic benefits of environmental services. For example, she recently worked with the Carson Water Subconservancy District to explore methods of calculating payments for ecological services to the farmers who experience winter flooding. HEC-RAS output was used to develop the estimates of the monetary value of attenuation, timing of floods (and emergency services costs), and flow changes.

David Love, P.E.

Role: This panel member was chosen primarily for his civil design and construction cost engineering experience and expertise.
Affiliation: Belt Collins West, Ltd.

David Love, P.E., has more than 37 years of experience in civil and water resource engineering and is the Principal at Belt Collins West, Ltd., which specializes in drainage and flood control projects in cold weather climates. He holds a B.S. in Engineering Physics from the Colorado School of Mines and has completed graduate coursework in hydraulics at the University of Colorado. He is also certified as a Professional Engineer in Colorado. Mr. Love has completed dozens of floodplain and major drainageway masterplans, all of which have included cost engineering related to flood risk. Each of these projects typically includes flood damage and cost analysis under existing conditions; cost estimates to implement various flood control improvements; estimates for flood damages and cost analysis under proposed conditions; and a benefit-cost comparison. The recently completed South Platte River Flood Control Improvement project in Denver, Colorado is the most recent example of many large, complex projects with multiple project stakeholders on which he has worked. Mr. Love is experienced in developing construction costs estimates for flood control improvement projects including flood proofing, as well as identifying long-term operation and maintenance costs for these flood control projects. Mr. Love is familiar with contracting procedures through his project experience working with local municipalities, special districts, various state and Federal agencies, as well as private sector clients. Approximately half of Mr. Love's project history has been related to the design and preparation of construction documents followed by a quality assurance (QA) role during construction activities. The QA experience has ranged from periodic site visits to observe construction activities to full-time construction management. Mr. Love has been a featured speaker at several professional conferences and has given multiple engineering-related lectures at the University of Colorado's Schools of Engineering and Environmental Design at Boulder, Colorado. He has also taught construction inspection courses to multiple public works employees. Mr. Love is a member of the American Society of Civil Engineers, American Council of Engineering Consultants, Colorado Association of Stormwater and Floodplain Managers, Association of State Floodplain Managers, National Society of Professional Engineers, and past president of the Professional Engineers of Colorado, Boulder Chapter.

Brandon Kulik

Role: This panel member was chosen primarily for his NEPA and biology experience and expertise.
Affiliation: Kleinschmidt Associates

Brandon Kulik serves as a senior fisheries biologist at Kleinschmidt Associates. He received his M.S. degree in Aquatic Zoology from DePauw University in 1978, with his thesis focused on large river fish assemblages in the Ohio River and the effects of power generation and water quality on fish distributions. He has also received training in Fish Passageways and Diversion Facilities from the U.S. Fish and Wildlife Service. Mr. Kulik has more than 31 years of experience in the design, execution, and reviews of environmental studies pertaining to fish passage, ecology, instream flow and aquatic habitat evaluations, and the bio-response of large river ecosystems to fish passage, habitat, and water quality changes. He has extensive dam and fish passage design experience in the Mohawk River of New York and the Saco and Kennebec Rivers of Maine, and has conducted radio telemetry and other tracking studies evaluating fish movement in the Narraguagus, Sheepscot, and Kennebec Rivers of Maine. Mr. Kulik has a strong working knowledge of flood risk management due to his involvement on interdisciplinary teams of engineers, hydrologists, and regulators evaluating flow control structures in New England, the mid-Atlantic, southeast, and mid-western states. Mr. Kulik has been involved with wetland and riparian ecology, integrating botanical and riparian information for aquatic systems analyses for NOAA Atlantic Salmon recovery projects in Maine, and has worked on teams resolving terrestrial, wildlife, and botanical habitat issues for the East Branch Brandywine Pennsylvania study. He is familiar with USACE planning processes as well as NEPA requirements, developing alternative analyses to inform environmental decision-making Federal licensing, and permitting processes for both the Saluda and Santee-Cooper Projects.

5. SUMMARY OF FINAL PANEL COMMENTS

The Panel agreed on its assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used in the Fargo-Moorhead DFR/EIS document. The planning methods were sound and adequate for a project of this size and complexity, and all the models used in the study were adequate and represent the state-of-the-art in flood control and risk assessment. Additionally, the public involvement process appeared to be comprehensive and extensive. The following statements summarize the Panel's findings, which are described in more detail in the Final Panel Comments (see Appendix A).

The Panel found that the hydrologic, biological, and economic analyses were sound and comprehensive. Most of the assumptions were very sound, and in general the study was very thorough. The description of the potential climate changes due to global warming were handled in a reasonable and thoughtful manner, and considered a necessary step to evaluate the increased flood frequency associated with climate change. The organization of the report could be improved to avoid the need to frequently reference the appendices by linking statements within the report to specific parts of each appendix. In general, it was often difficult for the Panel to determine how conclusions in the draft report were directly supported by information contained in the technical appendices. More detailed discussion or direct references in the text to specific pages in the appendices would improve the understanding of how conclusions were drawn from supporting data. The Panel found that some improvements could be made to the engineering, economic, and environmental parts of the project, as described in the following sections.

Economics: Since one of the most fundamental inputs to the benefit analysis – the flow/frequency relationship – is being reevaluated, the validity of the conclusions to be drawn

from the economics analysis is difficult to assess at this time. Assuming that the same approach will be followed with the updated analysis, the conclusions will be well supported. Because there will be an updated analysis of flood damages and project benefits, it is difficult at this point to evaluate the report conclusions of the National Economic Development (NED) analysis. Assuming the same analysis will be completed with updated data; there will still be a need to clarify key elements and assumptions in the economic analysis, such as why flood fights are assumed to be unsuccessful for the purpose of benefit quantification, and how growth in the floodplain is handled in the different portions of the report. In general, the new analysis is likely to point toward greater benefits of the project and the new analysis could point toward a new NED plan, but since the Locally Preferred Plan (LPP) is the recommended plan, the new analysis is not likely to result in a new recommended plan. The economic analysis along with much of the report is difficult to follow. For example, the main report has many references to the recent successes of local flood fighting efforts, but then assumes a zero percent success in flood fighting efforts for the purpose of quantifying benefits. Similarly, it is not clear how future growth in the floodplain is handled in different elements of the report. Finally, the down-selection process of determining and comparing alternatives should be explained more clearly in the report.

Engineering: The Panel raised several concerns related to hydraulics, geotechnical design, and environmental cleanup. One major concern was adverse impacts upstream and downstream of the project reach. The natural gradient of the Red River Valley is so small that relatively small changes in water depth can propagate for many miles. Other engineering concerns included the need for physical and computational modeling studies on the proposed hydraulic structures and information on the potential effect of ice jams and debris loading on these hydraulic structures. The channel design for the Minnesota Diversion alternatives was based upon a systematic geotechnical analysis using available subsurface data. Similar hydraulic and geotechnical analyses were not conducted for the North Dakota Diversion alternative, which creates uncertainty regarding the accuracy of the project costs for this alternative. The soil strength assumptions used for the geotechnical analyses may be less conservative when compared to the performance of other projects in the area. There is also uncertainty about the performance of the hydraulic structures proposed for the crossings between the diversion channel and the Red River tributaries. The analyses of sediment characteristics, sediment loads, and potential geomorphic effects are insufficient for the Panel to evaluate potential impacts. The assumptions about relocating the existing rail yard for the Minnesota Diversion alternative are a concern because of the potential environmental cleanup, increased construction costs, and potential disruption to rail traffic.

Environmental: The major concern regarding environmental issues was providing better documentation, specifically, how hydrologic impacts to wetland were evaluated, given that some wetlands will be affected by the changes in frequency and magnitude of future flooding events. The report provides a narrative discussion of the methods, but the related appendix lacks supporting calculations. The environmental discussion should also include a discussion on how upstream land use and proposed flood reduction measures may alter the magnitude and frequency of design flood events for the study area. The document should include engineering details (such as design drawings), demonstrating that the hydraulic parameters required to facilitate fish passage are provided by the proposed structures.

Table 3. Overview of 23 Final Panel Comments Identified by Fargo-Moorhead DFR/EIS IEPR Panel

Significance – High	
1	There are insufficient geotechnical analyses to justify the proposed channel slopes, channel depth, spoil pile configuration, cost estimates, and real estate requirements for the North Dakota Diversion Alternative.
2	The stability of the channel slopes, foundation deposits, and related spoil piles should be evaluated using ultimate or near ultimate soil strength values for the End of Construction (EOC) condition.
3	An explanation should be provided for the difference in channel bottom width dimensions between the Red and Wild Rice Rivers and the downstream end of the diversion for the North Dakota East Diversion Alternative.
4	Physical hydraulic modeling and computational fluid dynamics (CFD) modeling studies should be conducted on the project hydraulic structures and flow conditions described in Figures 17, 18, 19, 20, 21, and 22.
5	A 3D (three-dimensional) hydrodynamic model, rather than a 2D (two-dimensional) hydrodynamic model should be used to compute the flow velocity field and flow depths at the Red River Control Structure.
6	The plan acceptability discussion should be expanded to include the impacts and risks associated with each alignment alternative such as flood plain impacts, upstream and downstream effects, and tolerable risks.
7	The No-Action Alternative should be clarified by incorporating a discussion of flood fighting in the cost-benefit calculations.
Significance – Medium	
8	The proposed re-establishment of river channel meanders along previously straightened portions of the Red River and its tributaries presents a potential high risk of streambank erosion and earth slides and should be evaluated.
9	A more comprehensive analysis of sediment characteristics (i.e., size distribution) and sediment transport (i.e., bedload and suspended load) is needed for the Red River of the North and its tributaries.
10	The performance of existing and future upstream flood control measures needs to be better quantified with respect to their effect on the magnitude and frequency of floods in the defined project area.
11	The assumptions about relocating the existing rail yard for the Minnesota Diversion Alternative are a concern because of the potential environmental cleanup, increased construction costs, and potential disruption to rail traffic.
12	The conclusion that the downstream adverse effects are acceptable is contrary to the latest policy in floodplain management.
13	The cost estimate should reflect the techniques and details used to construct the earthworks excavation in similar clay deposits for the diversion on the Red River at Winnipeg, Manitoba.
14	Project cost estimates associated with non-structural flood reduction techniques need to be explained and referenced.

15	The statement that “the probability of success with an emergency flood fight is not zero but is very low” is confusing and contradicts historical experience.
16	The lists of land and water and economic opportunities that may arise from the execution of the project should be expanded in order to support the decision making process.
17	It is unclear if growth expansion was incorporated into the HEC-FDA model and if a sensitivity analysis will be conducted.
18	The predicted impact of the project alternatives on wetland areas would benefit from a more detailed description within the Fargo-Moorhead DFR/EIS.
19	Details for fish passage and structures need to be developed beyond the broad conceptual level.
20	The overall readability of the document could be improved with some reorganization, some additional discussion, and by incorporating some of the material from the appendices into the main report.
Significance – Low	
21	There are inconsistencies in the estimated costs, flood damages, and design parameters that should be cross-checked for accuracy.
22	The potential effect of ice jams and debris loading on the performance of hydraulic structures is unclear and should be addressed.
23	The study area needs to be clearly defined in text and illustrations.

6. REFERENCES

Abad J. D. and García, M. H., (2006). RVR Meander: A toolbox for re-meandering of channelized streams. Computers & Geosciences, 32: 92-101.

Abad, J. D., Buscaglia, G. and Garcia, M. H. (2008a). 2D Stream hydrodynamic, sediment transport and bed morphology model for engineering applications. Hydrol. Proc., 22: 1443-1459.

Abad, J. D., Rhoads, B. L., Guneralp, I., and García, M. H. (2008b). Flow structure at different stages in a meander-bend with bendway weirs. J. Hydraul. Eng., 138 (8): 1-12.

Abad, J. D., Waratuke, A., Barnas, C. and Garcia, M. H. (2009). Hydraulic model study of canoe chute and fish passage for the Chicago River North Branch Dam. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Nania, L., Abad, J. D. and Garcia, M. H. (2009a). Study of the dividing flow at street crossings: CFD modeling. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Abad, J. D. and Garcia, M. H. (2009b). Flow structure and hydraulic capacity for dropshafts: application to tunnel and reservoir plan (TARP) project, Chicago, Illinois. Urban Water Management: Issues and Opportunities. UCOWR/NIWR Annual Conference, July 7-9, Chicago, IL.

Chow, V. T. (1959). *Open Channel Hydraulics*. McGraw-Hill, New York.

Dyhouse, G. R. (1985). Stage-frequency analysis at a major river junction. J. Hydr. Engr., ASCE, 111(4):565-583.

Garcia, M. H. (ed.), (2008). Sedimentation Engineering. In *ASCE Manual of Practice 110*, Reston, VA.

Garcia, M. H., Bittner, L., and Nino, Y. (1994). Mathematical Modeling of Meandering Streams in Illinois: A Tool for Stream Management and Engineering. Civil Engineering Studies, Hydraulic Engineering Series No. 43, UILU-Eng-94-2012, UIUC.

Huang, X., and García, M. H. (2000). Pollution of gravel spawning grounds by deposition of suspended sediment. J. Environ. Eng. ASCE, 126(10): 963-967, October.

Larson, L. (2001). No adverse impact: a new direction in floodplain management policy. Natural Hazards Review. ISSN 1527-6988.

Liu, X., and García, M. H. (2008a). Coupled two-dimensional model for scour based on shallow water equations with unstructured mesh. Coastal Eng., 55(10): 800-810.

Liu, X., and García, M. H. (2008b). A 3D numerical model with free water surface and mesh deformation for local sediment scour. J. Waterway, Port, Coastal, and Ocean Eng., ASCE, 134(4): 203-217.

López, F., and García, M. H. (1997). Open-Channel Flow through Simulated Vegetation: Turbulence Modeling and Sediment Transport. Wetlands Research Program Technical Report WRP-CP-10, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

OMB (2004). Final Information Quality Bulletin for Peer Review. Executive Office of the President, Office of Management and Budget, Washington, DC. Memorandum M-05-03. December 16.

The National Academies (2003). Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. The National Academies (National Academy of Science, National Academy of Engineering, Institute of Medicine, National Research Council). May 12.

Rhoads, B. L., García, M. H., Rodriguez, J., Bombardelli, F., Abad, J. D., and Daniels, M. (2008). Methods for evaluating the geomorphological performance of naturalized rivers: examples from the Chicago metropolitan area. In *Uncertainty in River Restoration*, D. Sears and S. Darby, eds., Wiley InterScience.

USACE (1998). Grand Forks, Split Flow Diversion Evaluation. General Reevaluation Report, East Grand Forks, MN, Grand Forks, ND, Appendices A-D.

USACE (2007). Peer Review Process. Department of the Army, US Army Corps of Engineers, Washington, DC. CECW-CP Memorandum. March 30.

USACE (2010). Water Resources Policies and Authorities: Civil Works Review Policy. Department of the Army, US Army Corps of Engineers, Washington, DC. Engineer Circular (EC) No. 1165-2-209. January 31.

Vanoni, V.A. (ed.), (2006). Sedimentation engineering. In *ASCE Manual of Practice 54 Classic Edition*, Reston, VA.

APPENDIX A

Final Panel Comments

on the

Fargo-Moorhead DFR/EIS

This page is intentionally left blank.

Comment 1:

There are insufficient geotechnical analyses to justify the proposed channel slopes, channel depth, spoil pile configuration, cost estimates, and real estate requirements for the North Dakota Diversion Alternative.

Basis for Comment:

The geotechnical design evaluation in Appendix I does not include analyses to support the proposed channel slopes or spoil pile configuration for the North Dakota Alternative. It appears to the Panel that the evaluation of the North Dakota Alternative was not completed. From the information provided in the Fargo-Moorhead DFR/EIS, it also appears that an assumption was made that the typical channel cross-section for the North Dakota Alternative would be similar to that analyzed for the Minnesota Diversion Alternative. However, this may not be the case. A review of the nine borings available for the North Dakota Alternative indicates subsurface profiles that are different in character from the four stability cross-sections evaluated for the Minnesota Diversion Alternatives. The differences in the subsurface profiles may result in potentially different channel configurations and earthwork quantities. The lack of emphasis on the North Dakota Alternative is also illustrated by the fact that 85 borings were taken for the levee alternatives, 40 borings were taken for the Minnesota Diversion Alternative, but only 9 borings were taken for the North Dakota Alternative. The level of geotechnical analysis and evaluation is not sufficient to support an accurate feasibility cost estimate for the North Dakota Alternative.

The lack of geotechnical continuity is further illustrated by the inconsistencies between the Fargo-Moorhead DFR/EIS and the Geotechnical Appendix I.

- The configuration of both the Minnesota Diversion and North Dakota Diversion cross-sections are described in the Fargo-Moorhead DFR/EIS (pages 42 and 48); however, these descriptions do not correspond to the final geotechnical cross-sections found in geotechnical analysis for the Minnesota Diversion Alternative contained in Appendix I (page I-17). Geotechnical analysis for the Minnesota Diversion stated that in order to achieve adequate factors of safety, the channel would require a slope of 1V to 10H. This proposed slope is not consistent with the Fargo-Moorhead DFR/EIS description or as shown on the cross-section (Figure 13) or the cross-sections shown in Appendix K.
- On page 48, paragraph 3.3.4.1 of the Fargo-Moorhead DFR/EIS states that the Minnesota Diversion Alternative channel was limited to a depth of 30 feet based upon the results of a preliminary analysis of slope stability. The Fargo-Moorhead DFR/EIS also states (first paragraph, page 48) that the maximum depth of 32 feet was used for the North Dakota plan; however, there is no geotechnical analysis or stability evaluation to justify the use of a 32-foot channel depth for the North Dakota Alternative

Overall, it appears that the geotechnical analysis for both Diversion Alternatives was not developed completely and/or was not accurately incorporated into the project cost estimates.

Significance – High:

Without a consistent level of geotechnical analysis between alternatives, it is not possible to develop accurate comparative costs for the North Dakota Alternative and the Minnesota Diversion Alternative.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include:

1. A geotechnical evaluation for the North Dakota Diversion Alternative developed to the same level of detail as that used for the Minnesota Diversion Alternative
2. Revised descriptions to reflect a consistent geotechnical design that provides adequate factors of safety for each alternative (after completing the geotechnical analysis for Diversion Alternatives, Appendix I, the Appendix K cross sections)
3. Recomputed quantity estimates for the channel excavation, and revised cost estimates for all alternatives based on the updated analysis and design
4. A design review of the various hydraulic structures to ensure that the proposed designs are compatible with the final channel configurations based on stability evaluations.

Comment 2:

The stability of the channel slopes, foundation deposits, and related spoil piles should be evaluated using ultimate or near ultimate soil strength values for the End of Construction (EOC) condition.

Basis for Comment:

The stability analyses shown in Appendix I (page I-12) indicate that long-term stability will be the controlling load condition in determining the slope configuration of the proposed diversion channel and spoil piles. This is questionable based on the history of many projects in the Red River Valley that have experienced failure or near failure during construction. The failure or near failure during the "End of Construction (EOC) condition" has occurred on many projects within the Red River Valley including the VA Hospital levee failure in Fargo (1948), the Pembina levee project (1978), the Grand Forks levee project (1953), the Fargo Grain Elevator collapse (1955), the Hartsville Pumping Station levee, Grand Forks (2005), and the I-94 Interstate Highway interchange in Fargo (2008). These failures demonstrated that the EOC is a potentially critical failure mode for any excavation or fill slope in the Red River Valley. Furthermore, the use of peak values of Unconsolidated–Undrained (UU) soil strengths to evaluate the EOC conditions appears to be un-conservative.

In Appendix I, the use of peak UU soil strengths in the stability analyses was justified by the following statement (paragraph 46): "During the process of draining, it can be expected that the soils will experience strains less than 5% to 8% which is a strain at which undrained shear strength occurs." Appendix I of the Fargo-Moorhead DFR/EIS does not clarify the basis of this statement and does not contain analysis or justification to identify the level of strains that may occur during the EOC condition.

Experience and laboratory testing indicate that the Brenna formation, which underlies much of the project area and the Red River Valley, is the weakest and most unreliable lacustrine unit. This is composed of highly active clay minerals with high void ratios, water contents, and liquid limits. Laboratory testing of samples obtained throughout the Red River Valley indicates a brittle stress strain curve that achieves high peak strengths at low values of strain and then drops to much lower values of strength at higher strains. The statement described above regarding the 5 to 8% strains at which the peak undrained strength occurs may be untrue in many cases. The tabulation for the Brenna formation (UU) laboratory testing for the recent Hartsville Pumping Station levee failure in Grand Forks indicated that 35 out of 50 shear strength samples failed in the laboratory at peak strengths less than 5%. If the sliding mass reaches strains greater than 5%, it is likely that the mobilized strength will be significantly less than the peak strength values. It should also be noted that the back calculation of strengths for the Hartsville failure indicated values close to the ultimate strengths as determined by UU testing.

Significance – High:

Using un-conservative strength assumptions could affect the channel design, real estate requirements, and estimated project costs.

Recommendations for Resolution:
To resolve these concerns, the report should be expanded to use data from the recent failure of the I-94 Interchange to back calculate the actual UU strengths mobilized at failure. This information is available from local engineering firms and would provide a realistic basis to assess the methods and test results to evaluate the stability of the proposed channel for the EOC condition.

Comment 3:

An explanation should be provided for the difference in channel bottom width dimensions between the Red and Wild Rice Rivers and the downstream end of the diversion for the North Dakota East Diversion Alternative.

Basis for Comment:

The description of the North Dakota Alternative (page 48) indicates that "the channel bottom width between the Red and Wild Rice Rivers is 300 feet for both capacities. For the MD-30K Plan the channel bottom width is 80 feet between the Wild Rice River and the downstream end of the Diversion." This does not appear logical from a hydraulic conveyance point of view since the apparent size of the channel in downstream areas is less than one third the channel size in upstream areas. The channel width downstream cannot be less than one-third the width of the channel upstream. Conservation of flow volume would require a width of at least 300 feet, assuming that the channel flow depth and slope of the channel bottom remain the same throughout the channel alignment.

Significance – High:

The description of the channel bottom widths is not clearly explained, and may represent a major inconsistency in the hydraulic capacity of the channel to convey floods.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include:

1. A review of the hydraulic analysis for the alternatives, and a table with the characteristics of the channel throughout its alignment
2. An explanation in the main report (e.g., increase in channel gradient) to justify the apparent inconsistency in hydraulic conveyance capacity if the channel bottom widths as stated are correct.

Comment 4:
Physical hydraulic modeling and computational fluid dynamics (CFD) modeling studies should be conducted on the project hydraulic structures and flow conditions described in Figures 17, 18, 19, 20, 21, and 22.
Basis for Comment:
Hydraulic structures are proposed where the North Dakota Diversion channel will cross the Sheyenne, Maple, Lower Rush, and Rush Rivers. While water diversion and control structures are commonly found in flood control works, the proposed crossing structures are not common in practice. The proposed design includes construction of the diversion channel under the existing tributary for low to medium flow conditions; however, it is intended that the diversion will overtop the tributary crossing during flooding conditions. Therefore, depending on flow conditions, a tributary might work as a regular channel or as a broad-crested weir depending on the diversion flow discharge (Cataño-Lopera, 2009a). This presents a design challenge due to the unconventional nature of the proposed hydraulic structures.
Significance – High:
The diversion channel and associated hydraulic structures at tributary crossings must be carefully designed to reduce uncertainty about hydraulic performance during floods and to ensure the desired diversion conveyance capacity as well as effective fish passage in the tributary streams.
Recommendations for Resolution:
To resolve these concerns, the report should be expanded to: 1. Include physical hydraulic modeling and 3D CFD modeling of the diversion and its interaction with the hydraulic structures (Abad et al., 2009) 2. Incorporate the physical model to calibrate and test the computational models of the structures 3. Use the calibrated numerical models to optimize the design of the hydraulic structures and their interaction with the North Dakota Diversion channel (Cataño-Lopera, 2009b)

Literature cited

Abad, J. D., Waratuke, A., Barnas, C. and Garcia, M. H. (2009). Hydraulic model study of canoe chute and fish passage for the Chicago River North Branch Dam. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Nania, L., Abad, J. D., and Garcia, M. H. (2009a). Study of the dividing flow at street crossings: CFD modeling. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Abad, J. D. and Garcia, M. H. (2009b). Flow structure and hydraulic capacity for dropshafts: application to tunnel and reservoir plan (TARP) project, Chicago, Illinois. Urban Water Management: Issues and Opportunities, UCOWR/NIWR Annual Conference, July 7-9, Chicago, IL.

Comment 5:
A 3D (three-dimensional) hydrodynamic model, rather than a 2D (two-dimensional) hydrodynamic model should be used to compute the flow velocity field and flow depths at the Red River Control Structure.
Basis for Comment:
The standard USCOE RMA2 depth-averaged model used for modeling the flow at the Red River Control structure is based on the shallow-water equations of motion (i.e., depth-averaged continuity and momentum), which are based on the assumption that water pressure distribution in the vertical is hydrostatic (Chow, 1959). This assumption breaks down when the flow is squeezed while going through the flow control structure. This means that the flow velocities computed with a 2D hydrodynamic model at the control structure are not meaningful and cannot be used to assess the discharge characteristics of the structure as well as potential erosion and scour (e.g., Liu and Garcia, 2008a). The discharge characteristics of the proposed control structure need to be assessed with a 3D hydrodynamic model to ensure that flood diversion is effective and that upstream backwater effects are acceptable and within tolerable risks (Liu and Garcia, 2008b).
Significance – High:
The ability of the Red River Control Structure to regulate floods of different magnitude is a crucial factor for the success of the Fargo-Moorhead Flood Control Project.
Recommendations for Resolution:
To resolve these concerns, the report should be expanded to include: 1. Using a 3D Computational Fluid Dynamics (CFD) model to capture the dynamics of the flow at the proposed Red River Control Structure (Liu and Garcia, 2006b; Cataño-Lopera, 2009a; 2009b). 2. If possible, combining the 3D CFD modeling with a physical model of the control structure so that the final design can be optimized and the discharge characteristics of the proposed control structure can be assessed to ensure the desired hydraulic performance. (e.g., Abad et al., 2009).

Literature cited

Abad, J. D., Waratuke, A., Barnas, C. and Garcia, M. H. (2009). Hydraulic model study of canoe chute and fish passage for the Chicago River North Branch Dam. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Nania, L., Abad, J. D. and Garcia, M. H. (2009a). Study of the dividing flow at street crossings: CFD modeling. World Environmental & Water Resources Congress, ASCE, Kansas City, KS.

Cataño-Lopera, Y., Abad, J. D. and Garcia, M. H. (2009b). Flow structure and hydraulic capacity for dropshafts: application to tunnel and reservoir plan (TARP) project, Chicago, Illinois. Urban Water Management: Issues and Opportunities. UCOWR/NIWR Annual Conference, July 7-9, Chicago, IL.

Chow, V..T. (1959). *Open Channel Hydraulics*. McGraw-Hill, New York.

Liu, X., and García, M..H. (2008a). Coupled two-dimensional model for scour based on shallow water equations with unstructured mesh. Coastal Eng., 55(10): 800-810.

Liu, X., and García, M..H. (2008b). A 3D numerical model with free water surface and mesh deformation for local sediment scour. J. Waterway, Port, Coastal, and Ocean Eng., ASCE, 134(4): 203-217.

Comment 6:
The plan acceptability discussion should be expanded to include the impacts and risks associated with each alignment alternative such as flood plain impacts, upstream and downstream effects, and tolerable risks.
Basis for Comment:
The discussions on Alignment, Downstream Effects, Risks, Natural Resource Impacts and Floodplain Impacts adequately define acceptability (pages 69-71). However, downstream adverse effects are considered acceptable even though they are contrary to the latest trends in floodplain management. The North Dakota alignment can be expected to have a larger downstream effect than the Minnesota alignment, but is still considered acceptable even though the risk of flooding downstream will increase. Tolerable level of risk for Fargo is approximately 36.0 feet at the Fargo gage for a 0.2-percent chance flood (page 70). It is not apparent from the analysis what would be the tolerable risk for the downstream communities for either the North Dakota 35K or the Minnesota 35K Diversion Alternatives.
Significance – High:
Tolerable risks for the upstream and downstream communities cannot be determined from the current analysis.
Recommendations for Resolution:
To resolve these concerns the report should be expanded to include: 1. A more thorough coverage of Natural Resources Impacts for the different alignments. 2. A more detailed discussion of Tolerable Risks for upstream and downstream interests based on stage-frequency analysis (Dyhouse, 1985). 3. An upstream and downstream conveyance analysis for both the North Dakota 35K and the Minnesota 35K Diversion Alternatives.

Literature cited

Dyhouse, G..R. (1985). Stage-frequency analysis at a major river junction. J. Hydr. Engr., ASCE, 111(4):565-583.

Comment 7:

The No-Action Alternative should be clarified by incorporating a discussion of flood fighting in the cost-benefit calculations.

Basis for Comment:

Page 75 of the Fargo-Moorhead DFR/EIS states that the economic analysis does not give credit to flood fighting, but then states that if the flood fight were 70% successful for the National Economic Development (NED) plan, and 30% successful for the selected plan, the project would be rendered unfeasible from a benefit-cost standpoint. Also, there are several references to the idea that the probability of success with respect to flood fighting is "extremely low" although greater than zero (pages 38, 75, and references to Appendix O, page MFR-2. However, on page 38 and elsewhere in the document, reference is made to the fact that "emergency measures have been very successful in the past." Another example is found on page C-69, "despite the fact that Fargo and Moorhead have always had success in the past. In the selection of the NED plan, it is assumed that the flood fight will always fail in the future." These comments are seemingly in conflict and should be clarified.

Further, in many places in the document the description of the No Action Alternative is stated as "continued emergency measures" (page 17 and elsewhere). But, for the purpose of describing the future "without-project" scenario for benefit estimation purposes, without-project means an unsuccessful flood fight.

Significance – High:

Given the past success of flood fighting in the project area, a future rate of 30% can be expected, rendering the project unfeasible.

Recommendations for Resolution:

To resolve this issue, the report should be expanded to include:

1. A more thorough explanation of the rationale for excluding flood fight successes from the quantification of benefits (e.g., regulatory guidance documents)
2. An explanation of why the 30% threshold (or the revised threshold based on the new data) is still not a prudent approach to future flood control management
3. Clarification of the point that although the No Action Alternative implies continued flood fighting; the benefit calculation of the project assumes that future flood fights fail.

Comment 8:

The proposed re-establishment of river channel meanders along previously straightened portions of the Red River and its tributaries presents a potential high risk of streambank erosion and earth slides and should be evaluated.

Basis for Comment:

The discussion (page 233 of the Fargo-Moorhead DFR/EIS) related to creating new meanders and unstraightening existing river channel reaches does not address the historic instability of river bank slopes in the Red River Valley on the outside of bends along the river alignment. This issue is particularly true of the USACE Oslo, MN local flood protection project where the river has continually caused instability near the flood barrier alignment due to erosion. To stabilize the project, USACE installed riprap in this area to prevent or delay the continued cycle of erosion and progressive instability.

Based upon this experience, the re-establishment of meanders to naturalize the long straight portions of the river should be discussed and addressed with the best available tools (e.g., Abad and Garcia, 2006; Abad et al., 2008a). Pronounced streambank erosion because of an unstable channel planform alignment could lead to an increase in turbidity levels due to suspended sediment; this would have a detrimental effect on fish habitat (Huang and Garcia, 2000). Given that stream re-meandering is being proposed to compensate for loss of habitat from the proposed project footprint, this mitigation action needs to be assessed in more detail to ensure a positive outcome for the proposed project

Significance – Medium:

The potential impact of the proposed re-meandering on channel instability and streambank erosion should be identified in the Fargo-Moorhead DFR/EIS.

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to include:

1. A discussion in the current Fargo-Moorhead DFR/EIS regarding this concern along with establishing appropriate contingencies for the acquisition of additional real estate or replacement of slope protection along the outside bends of the river (see Abad et al., 2008b)
2. An investigation of the use of recently developed computational models (Garcia et al., 1994; Abad and Garcia, 2006; Abad et al., 2008a) for re-meandering of rivers that make it possible to assess if a proposed channel planform alignment will be stable and how much streambank erosion and channel migration might occur over time with the goal of minimizing sediment impact on fish habitat.

Literature cited

Abad, J. D., Buscaglia, G. and Garcia, M. H. (2008a). 2D Stream hydrodynamic, sediment transport and bed morphology model for engineering applications. Hydrol. Proc., 22: 1443-1459.

Abad J. D. and García, M. H. (2006). RVR Meander: A toolbox for re-meandering of channelized streams. Computers & Geosciences, 32: 92-101.

Abad, J. D., Rhoads, B. L., Guneralp, I., and García, M. H. (2008b). Flow structure at different stages in a meander-bend with bendway weirs. J. Hydraul. Eng., 138 (8): 1-12.

Garcia, M. H., Bittner, L., and Nino, Y. (1994). Mathematical Modeling of Meandering Streams in Illinois: A Tool for Stream Management and Engineering. Civil Engineering Studies, Hydraulic Engineering Series No. 43, UILU-Eng-94-2012, UIUC.

Huang, X., and García, M. H. (2000). Pollution of gravel spawning grounds by deposition of suspended sediment. J. Environ. Eng. ASCE, 126(10): 963-967, October.

Comment 9:
A more comprehensive analysis of sediment characteristics (i.e., size distribution) and sediment transport (i.e., bedload and suspended load) is needed for the Red River of the North and its tributaries.
Basis for Comment:
Erosion and sedimentation impacts for the different alternatives are summarized in the Environmental Quality (EQ) Account Table 10 (page 63). It is not clear what type of sedimentation analyses and methods were used to arrive at these conclusions (Garcia, 2008). Potential geomorphic effects of the alternatives are also discussed (page 175). In the case of the Wild Rice River it is recognized that sediment scour and deposition could impact fisheries habitat. However, no sediment transport analysis is presented to assess the magnitude and extent of this impact (Abad et al., 2008b). Furthermore, the current layout (page 176) calls for "flows from the Rush River and the Lower Rush River to be permanently diverted into the diversion channel, and away from the Sheyenne River." It is not clear how the sediment transport capacity of the Sheyenne River will be affected by the reduction in flow or the long-term effects this will have on fisheries and river morphology for the 43 mile section between the proposed control structure and its confluence with the Red River. The Fargo-Moorhead DFR/EIS states that the Maple River and Sheyenne River sediment load is dominated by clay and silt (page 176) and that the future sediment content will be proportional to the amount of water diverted into the proposed diversion channel. However, it is well documented in the literature that the amount of sediment diverted is always greater than the proportional amount of water being diverted. This is known as the "Bulle effect" (Vanoni, 2006).
Significance – Medium:
The baseline condition of sediment dynamics within the Red River of the North and its tributaries must be quantified to assess erosion and sedimentation issues associated with the different alternatives, as well geomorphic effects and sediment impact on natural and man-made channels, floodplains, and fisheries (Rhoads et al., 2008).

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to include:

1. An explanation of the methods that were used to assess erosion and sedimentation in Table 10, Environmental Quality (EQ) Account (Garcia, 2008)
2. Data collection and analyses of sediment properties (i.e., size distribution, density), as well as sediment transport rates (i.e., washload, bedload, suspended load) for the Red River and its tributaries
3. An analysis of watershed sediment erosion and yield for the Red River of the North and its tributaries
4. An analysis of sediment transport capacity of diversion channels for proposed design flow conditions
5. An analysis coupling flood routing with sediment routing to assess the effect of sediment erosion, transport, and deposition on fisheries for different alternatives
6. A floodplain sedimentation analysis for different alternatives, including the effect of vegetation (Lopez and Garcia, 1997) to estimate long-term impact on flood stage of different flood control alternatives (Garcia, 2008, Chapter 3, page 214)
7. Sediment transport modeling to predict potential morphological changes associated with channel re-meandering (page 233), including stream bank erosion and channel migration (Abad and Garcia, 2006).

Literature cited

Abad J. D. and García, M. H., (2006). RVR Meander: A toolbox for re-meandering of channelized streams. Computers & Geosciences, 32: 92-101.

Abad, J. D., Rhoads, B. L., Guneralp, I., and García, M. H. (2008b). Flow structure at different stages in a meander-bend with bendway weirs. J. Hydraul. Eng., 138(8): 1-12.

Garcia, M. H. (ed.), (2008). Sedimentation engineering. In *ASCE Manual of Practice 110*, Reston, VA.

López, F., and García, M. H. (1997). Open-Channel Flow through Simulated Vegetation: Turbulence Modeling and Sediment Transport. Wetlands Research Program Technical Report WRP-CP-10, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Rhoads, B. L., García, M. H., Rodriguez, J., Bombardelli, F., Abad, J. D., and Daniels, M. (2008). Methods for evaluating the geomorphological performance of naturalized rivers: examples from the Chicago metropolitan area. In *Uncertainty in River Restoration*, D. Sears and S. Darby, eds., Wiley InterScience.

Vanoni, V.A. (ed.), (2006). Sedimentation engineering. In *ASCE Manual of Practice 54 Classic Edition*, Reston, VA.

Comment 10:
The performance of existing and future upstream flood control measures needs to be better quantified with respect to their effect on the magnitude and frequency of floods in the defined project area.
Basis for Comment:
The Fargo-Moorhead DFR/EIS notes that flooding has increasingly been a destructive force in the study area. Section 1.5.2.1 references an ongoing study (Fargo-Moorhead and Upstream Feasibility Study, Corps of Engineers) of upstream flood mitigation alternatives that would restore wetland habitat and reduce flood damages. The major underlying assumption is that a system of surface water storage sites upstream of Fargo-Moorhead would reduce flood stages and flood damages downstream. The results of this study may identify strategies that potentially alleviate the size or frequency of floods that this project is designed to handle.
Significance – Medium:
Reduction in the size and frequency of flood events within the study area may result if upstream flood mitigation measures are identified and adopted, which may change the capacity, design, or need for this project.
Recommendations for Resolution:
To resolve these concerns, the report should be expanded to include: 1. The development and discussion of an alternative scenario in which upstream measures that reduce the flooding conditions in the project area are adopted. 2. A discussion, based on what is currently known, the extent to which such flooding can or cannot be reduced by the upstream measures. 3. A revision of the draft report pending the conclusion of the referenced Upstream Study.

Comment 11:

The assumptions about relocating the existing rail yard for the Minnesota Diversion Alternative are a concern because of the potential environmental cleanup, increased construction costs, and potential disruption to rail traffic.

Basis for Comment:

Historically, railroads have not been concerned about fuel or chemical spillage in their rail yards. There may be environmental hazards that may have accumulated over the years that will need to be cleaned up if the existing rail yard is used for the Minnesota diversion. Railroads have specific design criteria for 100-year freeboard below bridge low chords, track geometry, railroad flagging during construction, and continuous rail traffic detours. New road crossings by railroads are time-consuming to permit, expensive, and could be difficult to obtain due to public or regulatory opposition. Appendix L (page L-4) states that additional investigations into this issue for the final feasibility study cost estimate are being undertaken. The lack of these data could change project layout, construction costs, and sequencing, which could then affect project decision making.

Significance – Medium:

Relocation of the existing rail yard could have major cost implications for the Minnesota Diversion Alternative.

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to include:

1. Additional investigations and engineering into environmental hazards
2. Railroad-specific design criteria
3. New required railroad crossings of roadways, related to the possibility of having to relocate the existing rail yard for the final feasibility study cost estimate of the Minnesota Diversion.

Comment 12:
The conclusion that the downstream adverse effects are acceptable is contrary to the latest policy in floodplain management.
Basis for Comment:
Section 3.5.3.4.2 of the Fargo-Moorhead DFR/EIS states that all diversion alternatives have increased flood stages downstream of the project. This is contrary to the latest policy in floodplain management published by the Association of State Floodplain Managers (Larson, 2001) that requires new projects not raise flood levels downstream. Increasing flood levels downstream could create legal liability issues for the project. Since the downstream water quantity is predicted to change, a brief analysis of potential fish habitat effects in the downstream river reach should also be addressed.
Significance – Medium:
This project should be consistent with current floodplain management policy of no adverse impact to adjacent river reaches.
Recommendations for Resolution:
To resolve these concerns, the report should be expanded to include: 1. An analysis of a combination alternative that would not raise flood levels downstream; this could require modifying proposed channel velocities or floodplain storage. 2. Additional hydraulic analyses to better define increased flood stages downstream for all alternates under consideration 3. A legal opinion on project liabilities if downstream flood levels increase. 4. An analysis of potential fish and wetland habitat effects downstream of the project.

Literature cited

Larson, L. (2001). No adverse impact: a new direction in floodplain management policy. Natural Hazards Review. ISSN 1527-6988.

Comment 13:

The cost estimate should reflect the techniques and details used to construct the earthworks excavation in similar clay deposits for the diversion on the Red River at Winnipeg, Manitoba.

Basis for Comment:

Appendix L generally provides a good description of the process involved in developing the project cost estimate. One major factor affecting the cost estimate for channel excavation is the difference between the excavation techniques used for material above the natural groundwater level and for material below the groundwater level. The description in Appendix L does not include or recognize the procedures used to construct the Winnipeg Flood Control Channel, which diverts the Red River around Winnipeg, Manitoba. USACE (1998) describes the procedures for construction of the Winnipeg flood control project as follows:

> Near surface material was excavated with rubber tire scrapers. From the groundwater elevation to the bottom of the channel, the channel was excavated in the winter months. The surface will be allowed to freeze to a depth of about one foot then track-mounted scrapers with a push and puller would be used to excavate the upper one foot of material. After removal of the upper foot, the surface would again be too slick to operate on and the surface would be allowed to re-freeze. The process was then repeated until the bottom of the channel was reached.

This procedure appears to be a valuable technique that should be described and incorporated into Appendix L. The use of this procedure for the massive earthwork excavation required for any of the diversion alternatives has the potential to significantly influence project costs and project scheduling.

Significance – Medium:

Incorporating the construction technique used for the Winnipeg Flood Control Channel may result in substantial cost savings, thereby increasing project feasibility.

Recommendations for Resolution:

To resolve these concerns, Appendix L should be expanded to include a discussion describing the Winnipeg Channel construction technique in detail. This will ensure that the use of this procedure is considered in future design and construction stages for the project.

Literature cited

USACE (1998). Grand Forks, Split Flow Diversion Evaluation. General Reevaluation Report, East Grand Forks, MN, Grand Forks, ND, Appendices A-D.

Comment 14:
Project cost estimates associated with non-structural flood reduction techniques need to be explained and referenced.
Basis for Comment:
Appendix P does not explain how the unit costs were developed for non-structural alternatives and does not supply reference information on unit cost components. In additional, it does not state if the same cost estimating software program used in Appendix L was also used for estimating costs in Appendix P.
Significance – Medium:
The addition of unit cost information adds credibility to the costs developed and aids in the evaluation of project.
Recommendations for Resolution:
To resolve this concern, the report should be expanded to include: 1. Reference sources for unit costs used in all tables located in Appendix P; Refer to Appendix L, Section L2.0, for reference sources used in cost estimation 2. An explanation of how complex unit costs were developed and the assumptions used in developing these costs 3. References to software programs used in developing the cost estimate for non-structural alternatives.

Comment 15:
The statement that "the probability of success with an emergency flood fight is not zero but is very low" is confusing and contradicts historical experience.
Basis for Comment:
The discussion contained on page 75 of the Fargo-Moorhead DFR/EIS indicates "the probability of success with an emergency flood fight is not zero but it is very low." This statement contradicts the history of successful flood fights in the Red River area and the general content of Appendix H. Over the last 42 years, there have been a number of successful flood fights involving emergency levee construction in communities throughout the Red River Valley. The only notable flooding failure was in Grand Forks in 1997, where the levee failure was caused by overtopping rather than structural failure. This was not a structural failure of the Grand Forks levee but rather a hydrologic failure. It is agreed that the flood fights which use hastily constructed emergency levees involve a relatively high degree of risk. However, to characterize the probability of success as "very low" belies the history of these types of flood fights.
Significance –Medium
Revision of this statement in the report will better characterize the probability of success with these types of flood fights.
Recommendations for Resolution:
To resolve these concerns, the report should redefine the probability of success (on page 75) as "uncertain" or "low."

Comment 16:

The lists of land and water and economic opportunities that may arise from the execution of the project should be expanded in order to support the decision making process.

Basis for Comment:

Chapter 2 of the Fargo-Moorhead DFR/EIS should include a discussion of the National Economic Development (NED) approach, and how NED is an opportunity to increase the net economic development status of the country. Additional economic opportunities could include:

- Opportunity to improve aquatic habitat connectivity and quality
- Improved public health and safety
- Lower flood insurance costs to residents
- Increased property values
- Improved traffic movement during floods
- Improved emergency response
- Improved water quality
- The potential for creating scientific, educational, cultural, and historical amenities

Significance – Medium:

The addition of more land and water and economic opportunities listed in the Fargo-Moorhead DFR/EIS increases the completeness and understanding of the project goals.

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to include:

1. A discussion of the NED approach and how NED is an opportunity to increase net economic benefit (page 14)
2. Additional appropriate opportunities listed in the Basis for Comment, in Section 2.3.2 (page 14).

Comment 17:

It is unclear if growth expansion was incorporated into the HEC-FDA model and if a sensitivity analysis will be conducted.

Basis for Comment:

The Panel cannot determine if the HEC-FDA model includes an assumption of growth in the floodplain (e.g., increase in the number of structures through time). Page C-19 of Appendix C states, "At present, this analysis does not incorporate new growth in the floodplain. Without-project conditions will be analyzed to account for new development." It appears that new development is included in terms of savings in flood proofing costs, but it is not clear if it is included in HEC-FDA flood damage analysis. If this is the case, it is inconsistent with the analysis.

The Fargo-Moorhead DFR/EIS (page 39) also states that, "It is expected that the average annual damages of more than $77 million will continue and increase as a result of additional development between the 100 and 500 year flood elevations." However, the rationale is not clear, nor is it explained why this analysis would terminate with the 500 year flood elevation.

Significance – Medium:

The inclusion of potential future development in the flood damage analysis will strengthen conclusions currently stated in the report, and aid in the understanding of the project.

Recommendations for Resolution:

To resolve this issue, the report should be expanded to include:

1. A discussion of the anticipated results if the conservative growth assumptions developed in the Regional Economic Development Study (a growth rate of 1.29 percent per year, or 2.18 per year), or from the Fargo Planning Department assumptions, were to be incorporated into the flood damage analysis
2. A discussion of the conservative growth rate assumptions in the Regional Economic Development Study and how these compare with the Fargo Planning Department growth assumptions
3. An explanation and note that the current analysis incorporates growth in the flood proofing cost savings, but not in flood damage reductions. A justification of why this is acceptable in terms of calculating benefits and costs should also be included.
4. A sensitivity analysis of the benefit cost analysis results with respect to growth assumptions.

Comment 18:

The predicted impact of the project alternatives on wetland areas would benefit from a more detailed description within the Fargo-Moorhead DFR/EIS.

Basis for Comment:

The methods for estimating changes in wetlands are described and the outcome is tabulated in Section 5.2.1.5 of the Fargo-Moorhead DFR/EIS. However, the stepwise analysis is not clearly documented, particularly with respect to indirect effects due to localized changes in hydrology. Some changes to wetlands may be more complex than the simple assessment implies. For example, wetlands that may rely on periodic river flooding (as opposed to inputs from direct precipitation, or runoff from sub-catchments away from the river influence) to maintain their structure and function would be affected by modifications to the frequency of flooding. The floodplain analysis identifies the specific number of acres that would be taken out of the floodplain during a 1% chance event. For wetlands, it may be necessary to look at the effects under more frequent flood events, since wetlands are shaped more by the 2-year or 5-year frequency storm. It is these more frequent events that drive the structure and function of floodplain wetlands.

Significance – Medium:

To evaluate the impact of the project alternatives, further analysis is needed of the proportion of the listed wetlands that may experience significant changes in structure or function.

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to include:

1. At least one specific example for each alternative of how examination of aerial photography, soil types etc. was used to estimate the probable indirect wetland impacts
2. A statement of the level of precision the analysis provides. The analysis should more clearly account for changes to wetlands resulting from frequency of flooding on those wetland types that are shaped by periodic flood events.

Comment 19:

Details for fish passage and structures need to be developed beyond the broad conceptual level.

Basis for Comment:

Fishway hydraulics can vary according to changing flow and affect structure effectiveness, operation, and maintenance. The river and project operation flow during the full migration season (likely April-June) should be reviewed since the targeted species of fish may migrate not only in April, but throughout the spring. Although the hydraulic criteria for fish passage in the Fargo-Moorhead DFR/EIS appear reasonable, there is insufficient biological information to document how these were arrived at for the specific fish species in question other than some general discussion in Appendix F. Although it appears that the proposed structures and layout can accommodate these hydraulics at the high end of the flow range, it is not clear at what *low* flow range that hydraulics (depth) would facilitate fish passage as some species are quite large-bodied. The rock ramp weir proposed for the Minnesota Diversion Alternative would likely require an attraction flow to draw fish toward the bypass entrance. Details of this flow and how it would be provided are not clear.

Significance – Medium:

Changing hydrology can influence hydraulic design parameters that affect the size, cost and layout of the structure, as well as the biological effectiveness.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include:

1. Conceptual drawings and dimensions of the Minnesota rock ramp, and bring forward into Section 5.2.1.7.1.5.1 of the draft report supporting calculations from Appendix B to document the full range of operating conditions and flows under which volitional fish passage can occur via the proposed structures
2. A review of the hydrology during each potential fish passage month to determine operating conditions that may exist on the shoulders of peak flow periods
3. Design specifications for attraction flow for the entrance to the rock ramp for the Minnesota Diversion Alternative.

Comment 20:

The overall readability of the document could be improved with some reorganization, some additional discussion, and by incorporating some of the material from the appendices into the main report.

Basis for Comment:

The Panel struggled to locate key information buried in the appendices of the Fargo-Moorhead DFR/EIS, and felt the overall communication of the information contained in the document would be strengthened with some reorganization and some additions. Among specific examples:

- Section 3.3.2.1 and Section 3.3.2.4: Information presented in these sections could be used to strengthen the purpose and need (Section 2).
- Appendix O: Information on the environmental assumptions and other screening results should be included in the main document.
- Jargon and references to programs are used before or without introduction. For example, Section 1.5.1.5 refers to the 905(b) analyses without an explanation of the process.
- The 18' marker is introduced and mentioned without explanation (i.e., pages ES-9, 5, and 26) prior to being explained on page 33 as the stage where impacts to Fargo begin.

Significance – Medium:

It is difficult for the reader to locate information referenced in the main document but contained in the appendices.

Recommendations for Resolution:

To resolve this issue, the report should be expanded to include:

1. A discussion of the flood histories, flood fights, and expected future flooding up front in the purpose and need section
2. A comment stating the importance and relevance of each prior report to the current document in the section on prior reports and existing projects
3. A clear discussion of the alternative formulation process in Chapter 3
4. Expanding Table 15 to include categories for flood plain impacts and tolerable risks
5. A flow chart to explain the alternative identification and down selection process
6. Executive Summaries for each appendix, and placed within a new appendix
7. Information from Appendices O and I in the main report
8. A summary in Chapter 5 of the information in the appendices; for example, information about downstream impacts, transportation, and regional taxes added based on the appendix information
9. Assumptions for all analyses in the main report, with references to the appendix where needed for the analysis; highlights within the document of instances where assumptions differ from one analysis to another (e.g., Phase 21 studies that used different hydrologic assumptions); a table listing these differences.

Comment 21:

There are inconsistencies in the estimated costs, flood damages, and design parameters that should be cross-checked for accuracy.

Basis for Comment:

The Panel understands that for this version of the Fargo-Moorhead DFR/EIS many of the data points will change when the revised flow frequency data are incorporated into the report. However, the Panel has noted several inconsistencies between tables. For example:

- Table 1 (page ES-16) reports that relocation costs will total $71,890, whereas in Table 2 relocation costs are reported as $90,011. In addition, it is not noted in this table that the values are reported in thousands of dollars.
- Table 2 (page ES-17) has no total for the Planning, Engineering, and Design element. Further, the two numbers that appear to be inputs to the total sum to $125,400, whereas the equivalent number from Table 1 is $129,600.
- In Table C-4, the numbers for Public, Residential, and Total structures do not match the totals in the bottom row.
- The estimated annual flood damage cost of $77.1 million is different from the value presented in Appendix C (page C-31), which is $72.6 million.
- Tables 5 and 6 (pages 56-57) show a mix of the new results (from the Expert Opinion Elicitation panel) and the original results. Also, these table titles mention "schedule risk assessment" though this is not addressed until page 74.
- Pages 72 and 73 have two typographical errors. Section 3.6.2, number 2 gives $9,704 million, when the actual total may be $11,665 million. In Section 3.6.3, the total cost of the Locally Preferred Plan (LPP) flood risk management plan is incorrectly shown as $1,113,307 instead of $1,113,307,000.
- In Appendix C, Section 2.2, some figures are cited for median income and poverty levels. These do not match data cited in Section 2.3 (pages C-6,7)
- Table C-3 (page C-11) is not introduced or referred to in the text.

Significance – Low:

The correction of inadvertent technical and typographical errors will lend technical credibility to this document and provide additional value for future applications of this document.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include updated tables showing the data and results of the final analyses; these tables should be carefully proof-read and cross-checked for accuracy and consistency prior to publication.

Comment 22:
The potential effect of ice jams and debris loading on the performance of hydraulic structures is unclear and should be addressed.
Basis for Comment:
After reviewing the Fargo-Moorhead DFR/EIS and Appendix B, the Panel did not find information to support the analysis of the potential of project structures to perform under varying ice and debris conditions. Costs for floating ice booms were included in Appendix L (page L-9); however, this text discusses that much uncertainty exists about required ice handling measures at hydraulic structures.
Significance – Low:
The lack of adequate information describing the impacts of ice and debris affects the technical quality of the report.
Recommendations for Resolution:
To resolve these concerns the report should be expanded to include: 1. Provide additional information on the analysis of ice jams and debris loading on structures 2. Perform additional design development in the areas of ice jams and debris loading.

Comment 23:

The study area needs to be clearly defined in text and illustrations.

Basis for Comment:

The study area is well described in the text of the Fargo-Moorhead DFR/EIS, but Figures 3 and 4 of Section 1.3 could be improved. The inset on Figure 3 only shows the Fargo area and not the Moorhead area. The area that is apparently identified as the study area in Figure 4 does not include the majority of either the area for the Minnesota Alternative or the North Dakota Alternative.

Significance – Low:

Revision of these figures aids in understanding the study area for all of the alternatives since they clearly show where the majority of impacts will occur.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include:

1. Improve Figure 3 by reversing the inset and the map, giving the reader a closer look at the study area
2. Insert a small box in the corner to orient the viewer to where the study area is located in Minnesota and North Dakota
3. Alternatively, include a blowup of the study area within the Location Map extending beyond the two cities of Fargo and Moorhead
4. Improve Figure 4 by including all the areas covered by both the Minnesota and the North Dakota Alternatives
5. Provide a detailed view of the study area with major landmarks, highways, and city and town identified (e.g., Figure 24, page 85).

This page intentionally left blank

APPENDIX B

Final Charge to the Independent External Peer Review Panel

on the

Fargo-Moorhead DFR/EIS

This page is intentionally left blank

Final Charge Guidance and Questions to the Peer Reviewers
for the
Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study,
North Dakota and Minnesota

BACKGROUND

Fargo-Moorhead is located on the Red River of the North, but the Wild Rice, Sheyenne, Maple, and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area. The primary problem in the study area is a high risk of flood damage to urban infrastructure from the Red River of the North, the Wild Rice River, the Buffalo River, and the Sheyenne River. Fargo and Moorhead are on the west and east banks, respectively, of the Red River of the North approximately 453 river miles south of the mouth of the river at Lake Winnipeg in Manitoba, Canada. The drainage area of the Red River of the North above the U.S. Geological Survey gauging station at Fargo is approximately 6,800 square miles, of which about 2,175 square miles do not contribute to runoff.

The Fargo-Moorhead metropolitan area has a relatively high risk of flooding. The highest river stages usually occur as a result of spring snowmelt, but summer rainfall events have also caused significant flood damages. The Red River of the North has exceeded the National Weather Service flood stage of 17 feet in 51 of the past 107 years, and every year from 1993 through 2009. The study area is between the Wild Rice River, the Sheyenne River, and the Red River of the North; interbasin flows complicate the hydrology of the region and contribute to extensive flooding. Average annual flood damages in the Fargo-Moorhead metropolitan area are currently estimated at over $74 million.

The planning objectives of the study are to:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota)
- Provide additional wetland habitat in conjunction with other project features
- Provide recreational opportunities in conjunction with other project features.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the Fargo-Moorhead Metropolitan Feasibility Study in accordance with the Department of the Army, U.S. Army Corps of Engineers, Water Resources Policies and Authorities' *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010 and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the

hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

This purpose of the IEPR is to assess the adequacy and acceptability of economic, engineering, and environmental methods, models, and analyses used for the Fargo-Moorhead Metropolitan Feasibility Study. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) with extensive experience in engineering, economics, and environmental issues relevant to the project. They should also have experience applying their subject matter expertise to flood risk management.

The panel members will be "charged" with responding to specific technical questions as well as providing a broad technical evaluation of the overall project. Per EC 1165-2-209, Appendix D, reviews should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on assumptions, data, methods, and models. The Panel may offer its opinions as to whether there are sufficient analyses upon which to base a recommendation.

DOCUMENTS PROVIDED

The following is a list of documents and reference materials that will be provided for the review. **The documents and files presented in bold font are those which are to be reviewed.** All other documents are provided for reference.

- **Draft Feasibility Report and Environmental Impact Statement, Fargo-Moorhead Metropolitan Area Flood Risk Management**
  - **Appendix A: Hydrology**
  - **Appendix B: Hydraulics**
  - **Appendix C: Economics and Social**
  - **Appendix D: Other Social Effects**
  - **Appendix E: Cultural Resources**
  - **Appendix F: Environmental**
  - **Appendix G: Real Estate**
  - **Appendix H: Geotechnical Analysis: Credit to Existing Levees**
  - **Appendix I: Geotechnical Design and Geology**
  - **Appendix J: Structural**
  - **Appendix K: Civil Engineering**
  - **Appendix L: Cost**
  - **Appendix M: Recreation and Aesthetics**
  - **Appendix O: Plan Formulation**
  - **Appendix P: Non-Structural**
  - **Appendix Q: Public Involvement and Coordination**
  - **Plan Plates**

- Scoping Document, Fargo-Moorhead Metropolitan Area, Flood Risk Management, Environmental Impact Statement, September 2009 (Supporting document for information purposes only, not for review)
- Alternatives Screening Document, Fargo-Moorhead Metropolitan Area, Flood Risk Management, December 2009 (Supporting document for information purposes only, not for review)
- USACE guidance *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010;
- CECW-CP Memorandum dated March 31, 2007; and
- Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

SCHEDULE

TASK	ACTION	DUE DATE
Conduct Peer Review	Review documents sent to panel members	4/1/2010
	Battelle/panel Kick-off Meeting	4/2/2010
	USACE/Battelle/panel Kick-off Meeting with panel members	4/2/2010
	External panel members complete their review	4/22/2010
Prepare Final Panel Comments and Final IEPR Report	Battelle provides panel members merged individual comments and talking points for panel review teleconference	4/26/2010
	Convene panel review teleconference	4/26/2010
	Battelle provides final panel comment directive to panel	4/28/2010
	External panel members provide draft final panel comments to Battelle	5/3/2010
	Battelle provides feedback to panel members on draft final panel comments; panel provides revised draft final panel comments per Battelle feedback	5/4/2010 - 5/7/2010
	Final Panel Comments finalized	5/7/2010
	Battelle provides Final IEPR report to panel for review	5/10/2010
	Panel provides comments on Final IEPR report	5/12/2010
	*Submit Final IEPR Report	5/17/2010
Comment/ Response Process	Input final panel comments to DrChecks Battelle provides final panel comment response template to USACE	5/19/2010
	USACE PDT provides draft Evaluator responses and clarifying questions to Battelle	6/1/2010
	Battelle provides panel members the draft Evaluator responses and clarifying questions	6/3/2010
	Panel members provide Battelle with draft BackCheck responses	6/8/2010
	Teleconference with Battelle and panel members to discuss panel's draft Backcheck responses	6/11/2010
	Final Panel Comment Teleconference between Battelle, IEPR team, and PDT to discuss final panel comments, draft responses and clarifying questions	6/11/2010
	USACE inputs final Evaluator responses in DrChecks	6/22/2010
	Battelle provides Evaluator responses to panel members	6/25/2010
	Panel members provide Battelle with BackCheck responses	7/5/2010
	Battelle inputs BackCheck responses in DrChecks	7/6/2010
	*Battelle submits pdf printout of DrChecks project file	7/7/2010

CHARGE FOR PEER REVIEW

Members of this peer review panel are asked to determine whether the technical approach and scientific rationale presented in the Fargo-Moorhead Metropolitan Feasibility Study are credible and whether the conclusions are valid. The reviewers are asked to determine whether the technical work is adequate, competently performed, properly documented, satisfies established quality requirements, and yields scientifically credible conclusions. The Panel is being asked to provide feedback on the economic, engineering, environmental resources, and plan formulation. The reviewers are not being asked whether they would have conducted the work in a similar manner.

Specific questions for the panel members (by report section or Appendix) are included in the general charge guidance, which is provided below.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the Fargo-Moorhead Metropolitan Feasibility Study. Please focus on your areas of expertise and technical knowledge. Even though there are some sections with no questions associated with them, that does not mean that you cannot comment on them. Please feel free to make any relevant and appropriate comment on any of the sections and appendices you were asked to review. In addition, please note the following guidance. Note that the panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-209; Appendix D).

1. Your response to the charge questions should not be limited to a "yes" or "no." Please provide complete answers to fully explain your response.
2. Assess the adequacy and acceptability of the economic and environmental assumptions and projections, project evaluation data, and any biological opinions of the project study.
3. Assess the adequacy and acceptability of the economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, and models used in evaluation of economic or environmental impacts of the proposed project.
4. If appropriate, offer opinions as to whether there are sufficient analyses upon which to base a recommendation.
5. Identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods.
6. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable.
7. Please focus the review on assumptions, data, methods, and models.

Please **do not** make recommendations on whether a particular alternative should be implemented, or whether you would have conducted the work in a similar manner. Also please **do not** comment on or make recommendations on policy issues and decision making.

Comments should be provided based on your professional judgment, **not** the legality of the document.

1. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the USACE Independent Technical Review.
2. Please contact the Battelle deputy project manager (Julian DiGialleonardo, digialleonardoj@battelle.org) or project manager (Karen Johnson-Young, johnson-youngk@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle project manager immediately.
4. Your name will appear as one of the panelists in the peer review. Your comments will be included in the Final IEPR Report, but will remain anonymous.

Please submit your comments in electronic form to Julian DiGialleonardo, digialleonardoj@battelle.org, no later than April 22, 2010, 10 pm EDT.

Independent External Peer Review
Fargo-Moorhead Metropolitan Flood Risk Management Feasibility Study,
North Dakota and Minnesota

Final Charge Questions

GENERAL QUESTIONS

1. Are the assumptions that underlie the economic, engineering and environmental analyses sound?

2. Comment on the adequacy and acceptability of the economic, engineering, and environmental methods, models and analyses used.

3. In general terms, are the planning methods sound?

4. Are the interpretations of analysis and conclusions based on the analysis reasonable?

SECTION 1 – STUDY INFORMATION

Section 1.1- Study Authority

No questions.

Section 1.2 Study Purpose and Scope

5. Comment on the comprehensiveness of the discussion of the project's purpose and scope.

Section 1.3 Location of the Study Area

6. Is the location of the project area clearly identified? If not, what additional information should be incorporated?

Section 1.4 History of the Investigation

7. Has sufficient information been included to fully understand the history of the investigation in the project area? What other information, if any, should be included in this section?

Section 1.5 Prior Reports and Existing Projects

8. Comment on breadth of information detailed in this section regarding prior and existing studies performed within the study area.

9. Comment on whether the relationship between on-going and planned projects and the proposed project alternatives has been clearly outlined.

Section 1.6 Planning Process and Report Organization

10. Comment on whether the report has described the planning process.

SECTION 2.0 – NEED FOR AND OBJECTIVES OF ACTION

Section 2.1 National Objectives

No Questions

Section 2.2 Public Concerns

No Questions

Section 2.3 Problems and Opportunities

11. Comment on the comprehensiveness of the list of opportunities that may arise from the execution of the project.

12. Are the problems and opportunities discussed in this section adequately described to make an informed decision regarding the project alternatives?

Section 2.4 Purpose and Need

13. Are the purpose and need adequately defined?

Section 2.5 Planning Objectives

14. Comment on whether the planning objectives are sufficient for achieving the national objectives, and for providing a sufficient focus to formulate alternatives.

Section 2.6 Planning Constraints

15. Comment on the comprehensiveness of the study-specific planning constraints considered, based on your understanding of current conditions and the planning process.

SECTION 3.0 – ALTERNATIVES

Section 3.1 Plan Formulation Rationale

No Questions

Section 3.2 Management Measures and Preliminary Plans

16. Comment on whether the discussion of mitigation options is accurate, realistic, and comprehensive.

17. Comment on the extent to which the alternative plans and down-selection process are clearly presented.

18. Comment on the extent to which the screening criteria are justified and consistently applied in the screening process.

Section 3.3 Final Array of Alternatives

19. Comment on the extent to which the costs are consistent with and justified by the detailed analysis in Appendix C.

20. Comment on whether data gaps for each alternative and components of each alternative (diversion channel, hydraulic control structures, bridges, etc.) were identified in the report.

21. Comment on the completeness of the description of existing conditions provided in Section 4.0, the subsurface interpretation in Section 3.3, and those listed in Appendix I as input for selecting typical cross-sections.

22. Comment on the process used to evaluate and select the final array of alternatives.

23. Comment on the adequacy of the final array of alternatives in providing a comprehensive baseline to address the planning objectives.

24. Comment on the adequacy of the data to support the exclusion of the flood plain area outside of the Fargo-Moorhead area shown in Figures 5-8.

25. Comment on the adequacy of the data to support the selection and subsequent evaluation of a uniform diversion alignment.

26. Comment on the justification for the maximum channel excavation depth of 30 ft. Does the information support the capacities, and the reason behind the capacities, that were chosen for inclusion in the North Dakota east alignment alternatives?

27. Have the potential impacts of the drop structure on fish passage been adequately described and evaluated? If not please discuss.

Section 3.4 Comparison of Alternatives

28. Comment on the discussion of how the Environmental Quality Account was considered during the plan formulation process.

29. Comment on the discussion of how the Formulation Criteria (completeness, effectiveness, efficiency, & acceptability) were considered during the final array comparison process.

30. Comment on the clarity of the approach used to determine cost effectiveness and incremental costs and benefits.

31. Has the formulation criterion of efficiency been accurately evaluated? Why or why not?

32. Are the differences in the level of acceptability adequately characterized by the five "impacts"? Why or why not?

Section 3.5 Plan Selection

33. Comment on whether the recommended plan addresses the purpose and authority of the project as well as the project's problems, objectives, constraints, and criteria.

34. Comment on whether the conclusions drawn on the viability of each alternative are supported by the analysis.

35. Discuss whether the conclusions drawn on the viability of each alternative are supported by the presented analysis.

Section 3.6 Risk and Uncertainty

36. Comment on the use of non-standard hydrologic methods to account for climate change variability.

37. Comment on the extent to which the uncertainty in the economic analysis is sufficient, justified, and appropriate.

38. Comment whether the analysis of an emergency flood fighting and levee effort is adequately addressed.

39. Comment on the extent to which the costs are consistent with and justified by the detailed analysis in Appendix I (Structural) and Appendix P (Non-Structural).

Section 3.7 Description of the Tentatively Selected Plan

40. Comment on whether the component features are adequately designed and sufficient for satisfying the study objectives.

41. Comment on whether the discussion of mitigation options and environmental commitments is accurate, realistic, and comprehensive.

42. Comment on the extent to which the costs and benefits of recreational features are adequately summarized in this section and consistent with Appendix M.

43. Comment on the major assumptions used in the evaluation of the alternatives.

44. Comment if the engineering challenges associated with the tentatively recommended plan have been adequately assessed.

Section 3.8 Implementation Requirements

No Questions

SECTION 4.0 – AFFECTED ENVIRONMENT

Section 4.1 Environmental Setting of the Study Area

45. Does the information presented in this report support geographic scope of analysis? Why or why not?

Section 4.2 Significant Resources

46. Comment on the accuracy of the predictions for future wetland acreage under the baseline, or without project conditions relative to current laws, regulations and conditions.

Section 4.2.1 Natural Resources

47. Comment on the comprehensiveness of the variables incorporated into this section.

48. Comment on whether rainfall patterns and other climate change-related impacts have been considered thoroughly.

Section 4.2.2 Cultural Resources

49. Comment on the completeness of the historical conditions and cultural resources for this project. Take into account information in Sections 5.2.2 and Appendix E.

Section 4.2.3 Socioeconomic Resources

50. Comment on the accuracy of the demographic, employment, housing and overall socioeconomics descriptions.

SECTION 5.0 – ENVIRONMENTAL CONSEQUENCES

Section 5.1 Environmental Evaluation Methodology

No Questions

Section 5.2 Effects on Significant Resources

51. Comment on whether the direct, indirect, and cumulative effects are adequately evaluated and quantified in this section.

52. Comment on the accuracy of the predictions for future wetland acreage under the baseline, or without project conditions relative to current laws, regulations and conditions.

53. Comment on the adequacy and appropriateness of the socioeconomic baseline conditions description.

54. Comment on the adequacy of the descriptions for the recreational opportunities presented by the alternatives.

55. Comment on the thoroughness of the transportation considerations described.

56. Comment on the suitability of the assumptions for the level and timeframe of benefits accruing to property values and tax revenues.

Section 5.2.1 Natural Resources

57. Comment on the predicted impacts of each alternative on the air quality of the project area.

58. Comment on the downstream water quantity impacts predicted for each of the alternatives.

59. Comment on the predicted impact of each alternative on wetland acreage in the project area.

60. Comment on the predicted impact of each alternative on groundwater, specifically the Buffalo Aquifer, in the project area.

61. Comment on whether all potential fisheries and aquatic habitat that may be impacted by each of the alternatives has been identified.

62. Comment on the predicted impact of each alternative on fish passage in the project area.

63. Comment on the predicted impacts of each alternative on the endangered species present in the project area.

Section 5.5

64. Comment on the accuracy of the assumed real estate prices presented.

65. Comment on the thoroughness and accuracy of the benefit and cost information presented for the alternatives

SECTION 6.0 – PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION

Section 6.1 Public Involvement Program

66. Comment on the public, stakeholder, and agency involvement throughout the process of determining and addressing issues of interest.

Section 6.2 Resource Agency Team

No Questions

Section 6.3 Institutional Involvement

No Questions

Section 6.4 Additional Required Coordination

No Questions

Section 6.5 Report Recipients

No Questions

Section 6.6 Public Views and Responses

No Questions

Section 6.7 Agency Correspondence

No Questions

SECTION 7.0 – LIST OF PREPARERS

No Questions

SECTION 8.0 – RECOMMENDATION

No Questions

APPENDIX A: HYDROLOGY

67. Comment on the validity of the methods used to estimate mean daily peaks and instantaneous peak flows.

68. Comment on the methods used to analyze the complexity associated with reservoirs, breakout flows and floodplain storage when developing frequency distributions.

69. Comment on the assumptions used in generating the balanced hydrographs and whether smoothing is necessary.

APPENDIX B: HYDRAULICS

70. Comment on the suitability of the method used to model flow breakouts.

71. Comment on the completeness of the risk and uncertainty analysis.

72. Comment on the suitability of the methods by which the initial Phase I diversion designs were adjusted to the Phase 2 Hydrology.

73. Do the modeling results support the conclusions of the initial screening? Why or why not?

74. Comment on adequacy of the information presented in supporting the requirement of a control structure to provide the needed water surface profile reduction and minimize the potential for erosion and sedimentation impacts.

75. Comment on the adequacy of the proposed Red River and Diversion structures to perform under varying ice and debris conditions.

APPENDIX C: ECONOMICS AND SOCIAL

76. Comment on the accuracy of the demographic, employment, housing and overall socioeconomics information.

77. Comment on the accuracy of the assumptions used to address real estate market conditions.

78. Comment on the suitability of the benefits and costs derivation method for each alternative.

79. Comment on the accuracy of the dollar figures and their genesis presented in this section.

80. Comment on the timing and consideration of project costs.

81. Comment on the items considered for each of the national accounts.

82. Comment on the adequacy of the sensitivity analysis used for capturing the economic uncertainty of the project.

APPENDIX D: OTHER SOCIAL EFFECTS

83. Comment on the adequacy and comprehensiveness of the other social effects analysis.

APPENDIX E: CULTURAL RESOURCES

No Questions

APPENDIX F: ENVIRONMENTAL

84. Comment on the accuracy and comprehensiveness of the analyses used to estimate the acreage of and types of impacts to wetlands.

85. Comment on the accuracy and comprehensiveness of the analyses used to determine the Farmland Conversion Impact Rating

APPENDIX G: REAL ESTATE

86. Comment on the adequacy of the description for the component costs of the alternatives.

87. Comment on the suitability of the takings analysis for the project.

APPENDIX H: GEOTECHNICAL ANALYSIS: CREDIT TO EXISTING LEVEES

88. Comment on whether the key hazards leading to levee failure have been identified and appropriately described.

89. Comment on whether there is sufficient existing condition information available to determine the levee stability under the five stated geotechnical performance modes.

90. Comment on the adequacy of the analysis to develop conclusions and recommendations regarding levee performance.

APPENDIX I: GEOTECHNICAL DESIGN AND GEOLOGY

91. Comment on the quality and utility of data presented for the Phase 2 geotechnical investigation used to screen down alternatives.

92. Comment on whether the observed foundation conditions meet those encountered as part of the Phase 2 geotechnical study.

93. Comment on the scope of the subsurface investigation and any implications these data might have on project pre-design considerations.

94. Comment on the adequacy of the information obtained from the subsurface investigation to determine the impact of groundwater at the pre-design phase.

95. Comment on the utilization of the subsurface investigation and geotechnical analysis results in a) the selection of design parameters or b) the preliminary design of levee and channel diversion alternatives.

96. Comment on the clarity and appropriateness of the approach used to estimate project earthwork volumes and associated costs for the excavation and construction of the main diversion channel

    a. Is the proposed borrow material is well-suited for levee material from an engineering, economic and environmental standpoint?

97. Comment on the overall degree of conservatism employed in the seepage and slope stability analyses.

APPENDIX J: STRUCTURAL

98. Comment on the suitability and thoroughness of the technical assumptions used to recommend proposed bridge and hydraulic control structures placement.

99. Comment on the basic investigative techniques and interpretive methodologies used in the engineering feasibility analysis.

100. Comment on the precision and comprehensiveness of the design assumptions used to develop the cost estimates and preliminary bridge layout drawings.

101. Comment on the appropriateness and sufficiency of the assumptions included in the $50M estimate to relocate the Dilworth Rail Yard.

102. Comment on the overall degree of conservatism employed in the consideration of ice conditions and/or ice and flooding conditions within the conceptual level analyses.

103. Comment on the precision and comprehensiveness of the design assumptions and parameters used to develop the concept level design for the hydraulic structures.

APPENDIX K: CIVIL ENGINEERING

104. Comment on the soundness and thoroughness of the engineering calculations and modeling utilized.

105. Comment on the validity of the technical assumptions used to recommend the alignment of the low flow, diversion flow, and tributary channels.

APPENDIX L: COST

106. Comment on whether this appendix adequately describes the methods for estimating the costs associated with project alternatives.

107. Comment on level of detail provided for and utility of the key cost assumptions outlined in Section L.2.

108. Comment on the clarity and appropriateness of the approach used to estimate project costs associated with

    a. the excavation and construction of the main diversion channel;

    b. individual hydraulic structures, including ice handling and fish passage systems;

    c. new bridges and existing bridge upgrade;

    d. ecological mitigation and enhancement;

    e. fish and wildlife facilities

109. Comment on the clarity and appropriateness of the approach used to estimate construction costs associated with major hydraulic structures including the Red River Control Structure, the Red River Outlet Structure, and the hydraulic structures located on the Wild Rice River, Sheyenne River, Maple River, and Lower Rush River.

110. Comment on the extent to which the summary of project unknowns presented in Section L11.0: Contingency is consistent with and justified by the analyses included in the Draft Feasibility Report and appendices.

111. Comment on the extent to which the total project cost summary is consistent with and supported by the cost and risk analysis presented in the Draft Feasibility Report.

112. Comment on the level of detail presented in the cost rationale presented in Part E of this appendix for the proposed new highway (20) and rail (4) bridge structures.

113. Comment on the comprehensiveness of the information presented in the Project Cost Summary Sheets for the Channel Diversion Alternatives.

APPENDIX M: RECREATION AND AESTHETICS

114. Comment on the completeness of the quantification and evaluation of the recreational resources available to the residents of Fargo, North Dakota, and Moorhead, Minnesota.

APPENDIX O: PLAN FORMULATION

115. Comment on the completeness of the criteria used in the comparison of alternatives.

APPENDIX P: NON-STRUCTURAL

116. Comment on the comprehensiveness of the non-structural flood reduction measures.

117. Comment on the clarity and appropriateness of the approach used to estimate project costs associated with the non-structural flood reduction techniques.

118. Comment on the extent to which the non-structural project unknowns effect the cost estimates presented in Tables 15 – 33 for the 100-year and 500-year flood risk reduction measures

119. Comment on the completeness of the residential- and commercial-specific non-structural measures evaluated in this appendix.

APPENDIX Q: PUBLIC INVOLVEMENT AND COORDINATION

No Questions

PLAN PLATES

120. Please describe whether the utility of the channel diversion and levee profiles is clearly stated and supported and if the profiles are fit-for-purpose in terms of content and level of detail.

FINAL OVERVIEW QUESTION

121. What is the most important concern you have with the document or its appendices that was not covered in your answers to the questions above?