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Final Independent External Peer Review Report Dam Safety Modification (DSM) Report for Addicks and Barker Dams, Texas

Prepared by
Battelle Memorial Institute

Prepared for
U.S. Army Corps of Engineers
Risk Management Center (RMC)
for the Galveston District

Contract No. W912HQ-10-D-0002
Task Order: 0029

Final Independent External Peer Review Report
Dam Safety Modification (DSM) Report for
Addicks and Barker Dams, Texas

by

Battelle
505 King Avenue
Columbus, OH 43201

for

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Dam Safety Modification (DSM) Report for Addicks and Barker Dams, Texas

EXECUTIVE SUMMARY

Project Background and Purpose

The Addicks and Barker Reservoirs are part of the Buffalo Bayou and Tributaries flood risk management system located on the west side of Houston, Texas. These reservoirs provide flood risk management benefits for the City of Houston, the fourth largest city in the United States. Over 4 million people live in, work in, and transit through the Buffalo Bayou watershed. Industrial, commercial, and residential development is located throughout the Buffalo Bayou corridor. In addition to commercial and residential structures, this development includes hospitals, highways, roads and utilities, oil industry infrastructure, and water and sewage treatment facilities.

The Addicks and Barker Reservoirs were constructed in the mid-1940s. The principal geomorphological feature is the relatively flat terrain, which exists across the Addicks and Barker reservoir areas. These reservoirs serve as detention basins designed to collect excessive amounts of rainfall during storm events. Following a storm event, the reservoirs release the collected rainfall down Buffalo Bayou at a controlled rate (not to exceed 2,000 cubic feet per second [cfs]) that prevents flooding in downtown Houston and the urban areas west of downtown. The Addicks and Barker Reservoirs were originally designed and constructed as stormwater detention systems that reduce the peaks of flood hydrographs by extending the duration flow. With increased development of lands downstream of the reservoirs forcing tighter regulation of the water releases, and with increased development of the watershed upstream of the reservoirs causing increased runoff into the projects, the value of the dams and reservoirs for flood damage reduction is ever increasing. Four of the ten highest pools at both the Addicks and Barker Dams have occurred in the past 10 years. However, these structures now essentially function as dams; thus, they are currently operating beyond the original design intent.

The Addicks Reservoir project features include an earthen dam, concrete outlet works, and uncontrolled spillways. The earthen dam consists of an unzoned, random-fill embankment that is 61,166 feet long and 48.5 feet above the original streambed. A 12-foot-wide gravel road extends along the top of the dam. The top of the dam elevation currently ranges from 117.4 to 121 feet North American Vertical Datum of 1988 (NAVD88), and the crest is 12 feet wide. Five gated concrete conduits, 8 feet wide by 6 feet high by 252 feet long, serve as the outlet works. The original intake structure design only gated the center conduit of the five conduits on the upstream side of the dam. Additional contracts added an open steel-frame intake structure service platform and gates on the four originally ungated conduits. The four outside conduits are controlled by rectangular, electrically operated 8-foot-wide by 10-foot-high sluice gates. The center conduit is

controlled by twin 3-foot-wide by 8-foot-high electrically operated sluice gates. A maximum design discharge of 7,900 cfs can pass through a 43.5-foot-long spillway into a 40-foot-long by 60-foot-wide stilling basin and then through a 150-foot, riprap-lined outlet channel emptying into the improved channel of South Mayde Creek. An auxiliary spillway approximately 8,400 feet long with an average crest elevation of 112.5 feet NAVD88 is at the north end of the dam. An auxiliary spillway approximately 10,500 feet long with an average crest elevation of 115.5 feet NAVD88 is on the south end of the dam. The north auxiliary spillway ties into natural ground at elevation 108 feet NAVD88, and the south auxiliary spillway ties into natural ground at elevation 111 feet NAVD88; water can therefore flank around them before the auxiliary spillway crest overtops. The auxiliary spillways are armored with roller-compacted concrete, and act as uncontrolled spillways.

The Barker Reservoir project features include an earthen dam, concrete outlet works, and uncontrolled spillways. The earthen dam consists of an unzoned, random-fill embankment that is 71,900 feet long with a maximum height of 42.9 feet at the outlet works. A 12-foot-wide gravel road extends along the top of the dam. The top of dam elevation ranges from 110.0 feet to 113.1 feet NAVD88. Five gated concrete conduits, 9 feet wide by 7 feet high by 190.5 feet long, serve as the outlet works. The original intake structure design only gated the center conduit of the five conduits on the upstream side of the dam. Additional contracts added an open steel-frame intake structure service platform and gates on the four originally ungated conduits. The four outside conduits are controlled by rectangular, electrically operated 9-foot-wide by 10-foot-high sluice gates. The center conduit is controlled by twin 9-foot-wide by 8-foot-high electrically operated sluice gates. A maximum design discharge of 8,730 cfs can pass through a 55.5-foot-long spillway into a 50-foot-long by 60-foot-wide stilling basin and then through a 160-foot, riprap-lined outlet channel emptying into the improved channel of Buffalo Bayou. An auxiliary spillway approximately 3,000 feet long with an average crest elevation of 105.5 feet NAVD88 is at the north end of the dam. An auxiliary spillway approximately 12,500 feet long with an average crest elevation of 106.7 feet NAVD88 is at the south end of the dam. The north and south auxiliary spillways tie into natural ground at elevation 104 feet NAVD88; water can therefore flank around them before the reservoir pool overtops the auxiliary spillway crest. The auxiliary spillways are armored with roller-compacted concrete, and act as uncontrolled spillways.

Seepage control measures were incorporated at both projects due to seepage concerns. Potential seepage and piping are associated with erodible foundation soils and soils surrounding the concrete conduits, exacerbated by increased storage durations caused by gated operation. These erodible foundation soils consist of mostly fine sand and silt layers randomly interbedded with discontinuous clay layers, pockets, and seams. The seepage control measures included the construction of a soil-bentonite slurry trench through a length of the embankment and pervious foundation, placement of a downstream berm to enhance slope stability, and placement of areas of clay blankets to thicken the impervious cover over pervious foundation materials. In some areas (or lengths of the dam), no improvements were considered necessary.

As a result of provisions contained in the Dam Safety Assurance Program, the Addicks and Barker Dams were modified to conform to updated design criteria. Remedial work consisted of two primary features. First, the crest elevation of major portions of the dam was raised to achieve

needed freeboard requirements. Second, erosion protection was added to the lower ends of the dams so the ends can serve as overflow spillways during storms greater than the Standard Project Flood (SPF), up to and including the Probable Maximum Flood (PMF). This work was accomplished between 1986 and 1989.

Several factors within and around the conduits have led to recent repairs. These factors include erodible foundation sands, 'window' areas of the soil-bentonite cutoff walls adjacent to the conduits, open conduit joints, cracks within the parabolic spillways, void formation beneath the conduits and spillway, and lack of engineered filters. Chemical grouting was undertaken in 2009 to fill large voids beneath the conduits at both Addicks and Barker Dams. Cementitious grouting was undertaken in 2010 beneath and adjacent to the entire outlet works structure at both dams.

Without intervention and with the occurrence of higher pools, the dams have a high likelihood of failure under normal operations. Furthermore, the estimated life loss due to dam failure is extremely high. Both of these are essential characteristics of Dam Safety Action Classification (DSAC) I (highest risk) dams that have been substantiated by Issue Evaluation Studies (IESs) completed in February 2011. The Addicks and Barker Dams are currently categorized as DSAC I (urgent and compelling: unsafe).

The current DSAC was determined from the following events:

- May 2007 – Screening for Portfolio Risk Analysis (SPRA) Team classified the dams as DSAC II.
- September 2009 – IES Team recommended the classification be changed to DSAC I.
- October 2009 – Senior Oversight Group (SOG) changed classification to DSAC I.
- March 2011 – SOG retained classification as DSAC I.

The Galveston District's Project Delivery Team (PDT) is preparing a decision document – the Dam Safety Modification (DSM) Report – for the remediation of the Addicks and Barker Dams. The DSM Report consists of the main report supported by technical appendices and other documents as needed for approval. The DSM Report documents the deficiency issues of seepage and piping beneath the outlet structures and embankment failure resulting from uncontrolled flow around the ends of the Addicks and Barker Dams. The report also describes recommended corrective actions to resolve these deficiencies. The DSM Report serves as the decision document allowing remediation of the related seepage and piping deficiencies in order for the project to function safely, effectively, and in compliance with U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1156, Safety of Dams - Policy and Procedures (USACE, 2011). The DSM Report describes the alternative risk management plans considered and the plan recommended for remediation of the seepage and piping deficiencies. Following Headquarters', United States Army Corps of Engineers (HQUSACE) approval of the DSM Report and appendices and approval of the Environmental Assessment (EA) with a signature of the Finding of No Significant Impact (FONSI), the PDT will proceed to preconstruction engineering and design activities for the Addicks and Barker DSM Project.

Due to the extremely high risk associated with seepage and piping beneath, around, and near the conduits, the Addicks and Barker DSM Study was completed to address the issues associated with the conduits as well as a portion of the embankment for Barker Dam. A Phase 2 study will

be completed to address the non-breach risk, risk exposure (both downstream and upstream), potential operational changes, and potential failure modes (PFMs) associated with auxiliary spillway flow and flow around the ends of the dams.

Independent External Peer Review Process

USACE is conducting an Independent External Peer Review (IEPR) of the DSM Report for Addicks and Barker Dams, Texas (hereinafter: Addicks and Barker Dams). As a 501(c)(3) non-profit science and technology organization, Battelle is independent, is free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2012a, 2012b). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate the IEPR of the Addicks and Barker Dams. 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 (2012a, 2012b) 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).

Based on the technical content of the Addicks and Barker Dams review documents and the overall scope of the project, Battelle identified candidates for the Panel in the following key technical areas: geotechnical engineering, engineering geology, civil/structural engineering, hydraulic/hydrology engineering, economics/planning, and environmental planner/National Environmental Policy Act (NEPA) impact assessment.[1]

Five panel members were selected for the IEPR from more than 25 candidates identified. USACE was given the list of candidate panel members, but Battelle made the final selection of the Panel.

The Panel received an electronic version of the Addicks and Barker Dams review documents (approximately 2,000 pages), along with a charge that solicited comments on specific sections of the documents to be reviewed. USACE prepared the charge questions following guidance provided in USACE (2012a) and OMB (2004); the charge questions were included in the draft and final Work Plans.

The USACE PDT briefed the Panel and Battelle during a kick-off meeting held via teleconference prior to the start of the review to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. In addition, an in-person meeting to discuss the Addicks and Barker Dams was held at the USACE Addicks Project Office in Houston, Texas, on January 31, 2013; all five panel members attended this meeting. As part of this meeting, USACE led Battelle and the Panel on a visit of the Addicks and Barker Reservoirs, including a tour of the earthen dams, concrete outlet works, uncontrolled spillways, and the intake structure service platform and gates for both dams. One week after the site visit, Battelle convened a teleconference with the economics panel member and USACE counterparts (who were unable to

[1] Battelle identified a candidate who served in a combined role in the disciplines of economics/planning and environmental planner/NEPA impact assessment for this IEPR.

attend the site visit) so that USACE could answer specific questions pertaining to economic aspects of the project. USACE was able to provide responses to all of the questions during the teleconference. Other than these teleconferences and the in-person site visit, there was no direct communication between the Panel and USACE during the peer review process. The Panel produced more than 130 individual comments in response to the 26 charge questions.

IEPR panel members reviewed the Addicks and Barker Dams 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, 13 Final Panel Comments were identified and documented. Of these, two were identified as having high significance, seven had medium significance, and four had low significance.

Results of the Independent External Peer Review

The panel members agreed between each other on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2012a and 2012b; p. D-4) in the Addicks and Barker Dams IEPR review documents. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Appendix A of this report. The following summarizes the Panel's findings.

Based on the Panel's review, the historical problems associated with erosion along the outlets are well-documented in the information provided, and the concern for potential failure along the outlets is well-substantiated. However, the complete list of PFMs and the reasons why some were dismissed have not been documented in the DSM Report. Including this information would provide more robust documentation that various modes of failure were considered.

The unacceptable risk associated with the current condition of the dams is clearly identified in the DSM Report. USACE provided an effective and comprehensive assessment of risk and uncertainty related to potential failure of the Addicks and Barker Dams. The Panel recognizes there is always uncertainty. However, the DSM Report makes an appropriate effort to identify and account for these uncertainties. The Panel believes that providing additional information on the significant flood risk that remains after post-Phase 1 construction would provide a more complete understanding of how the project will proceed into the second phase.

Table ES-1. Overview of 13 Final Panel Comments Identified by the Addicks and Barker Dams IEPR Panel

No.	Final Panel Comments
Significance – High	
1	The serviceability of the cutoff wall structure, now over 30 years old, has not been demonstrated and cannot be relied upon.
2	The elevation survey baseline has not been addressed and may impact several project variables, including loss of life and economic damage calculations.
Significance – Medium	
3	The description of the design and constructability of the outlet works was not presented in sufficient detail to understand the sequencing of these activities or the implementation of certain key elements.
4	Slope stability analyses, which confirm that the current and proposed embankment geometry provides required factors of safety, are not provided.
5	The complete list of potential failure modes (PFMs) and the reasons why some were dismissed have not been documented in the Dam Safety Modification (DSM) Report.
6	The discussion of seepage using the USACE-preferred methodologies of flow nets and computer analysis (SEEP-W) has not been sufficiently emphasized in the Dam Safety Modification (DSM) Report and related documents, which focus on the less rigorous Weighted Creep Path Method.
7	The residual risk associated with post-Phase 1 construction was not thoroughly described.
8	Land use controls to prohibit future development in the project pool and further encroachment into the Probable Maximum Flood (PMF) reservoir level have not been documented.
9	The origin and nature of the faults that intersect the embankments have not been adequately discussed.
Significance – Low	
10	The models used to determine economic consequences were not documented clearly.
11	The DSM Report does not account for population change over the 50-year period of economic analysis.
12	Documentation for the basis of the preliminary hydraulic and structural designs for the new outlet works intake, conduit, spillway, and stilling basin is not discussed in sufficient detail.
13	While it appears that the Recommended Alternative was logically formulated and selected to meet the study objectives, the study constraints were not defined in sufficient detail to determine if they were fully considered in the plan formulation.

Plan Formulation – The Panel found the DSM Study to be conducted in compliance with USACE ER 1110-2-1156 (USACE, 2011). The DSM Report and the supplemental information provided are generally adequate to evaluate the recommendations made as part of the DSM Study. The recommended plan has been properly and thoroughly documented and based on sound and reasonable technical analyses. The recommended plan will fully restore the structural integrity of the outlet works and will allow it to operate without unacceptable risk of failure to protect the City of Houston from flooding. The recommended plan also addresses all of the known deficiencies of the existing outlet and facilitates construction while maintaining the ability to provide interim flood protection through limited discharges.

However, additional information would enhance the completeness and readability of the document. Clearly identifying the constraints that guided the DSM Study would improve the technical clarity and completeness of the review documents. As noted in ER 1110-2-1156, "Problems and opportunities statements will generally encompass just current conditions, but in some instances, may need to encompass future conditions…". However, what appears to be missing in terms of "future conditions" is any accounting of population change over the 50-year period of economic analysis. The Panel is concerned that without incorporating the future conditions over the period of analysis, it is likely that the loss of life and economic consequences are underestimated, but the ranking of alternatives would not be affected.

Engineering – The Panel believes that extensive engineering analyses were completed for the dams and outlet works to identify and characterize the hydrologic, hydraulic, geotechnical, and structural deficiencies and develop alternative risk management plans. In some cases, additional information may affect the implementation of the Recommended Alternative (Alternative 2). The Panel is concerned that the review documents contain very little information on the design, construction, or performance of the existing cutoff wall — a vital dam safety modification — and that there is no information about the wall's current condition or effectiveness, making it difficult for the Panel to confirm that the cutoff wall can and will perform as intended under flood conditions. At the request of panel members, USACE provided the slurry cutoff post-construction/as-built reports to Battelle, which provided ample information to assist the Panel in its review. The cutoff wall has been judged critical to the safety of sections of both dams since it was conceived to stop seepage and eliminate the potential for associated piping at elevated reservoir levels. Slope stability calculations for the current geometry have not been provided for either the upstream or downstream embankments. If the missing slope stability information yields incorrect results, improvements to the embankments may be required as part of the Recommended Alternative (Alternative 2). If the impacts of the faults beneath or through dams have not been fully and correctly considered, improvements may be required as part of the Recommended Alternative.

Additional information would also improve the understanding of the review documents. The Panel acknowledges that consideration of design and constructability of the outlet works, as outlined in the DSM Report, is at an early stage. However, these early concepts should explain the construction sequencing more clearly and address other issues (e.g., densifying basal soils) that have not been evaluated. Discussion of flow net and seepage analysis (SEEP-W) results and how those methods were used would increase the Panel's ability to draw conclusions based on those analyses. It has been clearly shown in the documentation that the Addicks and Barker

Dams project area has been, and will continue to be, affected by regional subsidence due to aquifer pumping. Accurate survey data are essential inputs for hydraulic and hydrologic calculations (including loss of life and economic damages), and for ongoing monitoring of the service performance of the dams and their appurtenant structures during and after remediation. Additional information on land use controls to prohibit future development in the project pool and further encroachment into the PMF reservoir level would improve the understanding of future escalation of flooding risk. Additional documentation of the hydraulic and structural engineering analyses used to develop the alternatives presented in the DSM Report will improve the technical quality of the report. Finally, The Panel acknowledges that the DSM Study is at the stage where conceptual or preliminary designs are being considered and costed and that estimated construction costs are not final. However, presenting the basis for the generation of these estimated costs for the remedial efforts as currently conceived would enhance the DSM Report.

Hydraulics and Hydrology – For the hydraulic models, the description of the methodology stated that the Hydrologic Engineering Center-River Analysis System (HEC-RAS) model used a starting downstream water surface based on normal depth. The Panel is concerned that the model may give unreliable tailwater depths for use in design of the outlet structure because the flow immediately downstream of the outlets is not steady, uniform flow, assuming normal depth to start. The Panel acknowledges this is not the final design, and that USACE will likely produce more accurate modeling of the tailwater during the final design.

Economics – The Panel found the economic analyses to be consistent with generally accepted methodologies. The population at risk and economic damages during a potential dam failure are clearly identified to support this project. Life safety risk and the annual probability of failure were given preference, as they should have been, with economic risk being given due consideration. The impact to the public is well-documented by the inundation maps and loss of life and economic impacts presented in the Baseline Consequences Analysis. For the economics analysis, damages were based on depth-damage probabilities and construction costs using Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) modeling software. However, the Panel is concerned that while the models used to determine economic consequence were cited, further explanations geared toward guiding the decision-making process are warranted. If models and their input are not thoroughly referenced or described and if modeling results are inconsistent with accepted guidance, the project's expected risk reduction benefits may be subject to misinterpretation.

Environmental – Environmental damages were minor for construction, with the greatest impact coming from borrow material obtained from wetland areas where standard USACE methods were used to determine mitigation. The destruction of wetlands by the "taking" of borrow material in the Barker Reservoir appears to be fully mitigated in kind and in place. Environmental consequences associated with either dam failing would be extensive, but due to the urgency of the DSM Study, the qualitative descriptions provided should suffice.

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LIST OF ACRONYMS

ASCE	American Society of Civil Engineers
ASDSO	Association of State Dam Safety Officials
ATR	Agency Technical Review
COI	Conflict of Interest
cfs	cubic feet per second
DAMBRK	Dam-Break (Flood Forecasting Model)
DrChecks	Design Review and Checking System
DSAC	Dam Safety Action Classification
DSAP	Dam Safety Assurance Policy
DSM	Dam Safety Modification
EA	Environmental Assessment
EC	Engineer Circular
EGM	Economic Guidance Memorandum
EIS	Environmental Impact Statement
EM	Engineer Manual
EP	Engineer Pamphlet
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
FERC	Federal Energy Regulatory Commission
FONSI	Finding of No Significant Impact
GDM	General Design Memorandum
HEC-DSS	Hydrologic Engineering Center-Data Storage System
HEC-FIA	Hydrologic Engineering Center-Flood Impact Analysis
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center-River Analysis System
HQUSACE	Headquarters, United States Army Corps of Engineers
HSDRRS	Hurricane and Storm Damage Risk Reduction System
ID/IQ	Indefinite Delivery/Indefinite Quantity
IEPR	Independent External Peer Review
IES	Issue Evaluation Study

IWR	Institute for Water Resources
LIDAR	Light Detection and Ranging
NAVD88	North American Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
PDT	Project Delivery Team
PFM	Potential Failure Mode
PFMA	Potential Failure Mode Assessment
PMF	Probable Maximum Flood
SEEP-W	Seepage Analysis (Software)
SOG	Senior Oversight Group
SPF	Standard Project Flood
SPRA	Screening for Portfolio Risk Analysis
USACE	United States Army Corps of Engineers
USSD	U.S. Society on Dams

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1. INTRODUCTION

The Addicks and Barker Reservoirs are part of the Buffalo Bayou and Tributaries flood risk management system located on the west side of Houston, Texas. These reservoirs provide flood risk management benefits for the City of Houston, the fourth largest city in the United States. Over 4 million people live in, work in, and transit through the Buffalo Bayou watershed. Industrial, commercial, and residential development is located throughout the Buffalo Bayou corridor. In addition to commercial and residential structures, this development includes hospitals, highways, roads and utilities, oil industry infrastructure, and water and sewage treatment facilities.

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- October 2009 – Senior Oversight Group (SOG) changed classification to DSAC I.
- March 2011 – SOG retained classification as DSAC I.

The Galveston District's Project Delivery Team (PDT) is preparing a decision document – the Dam Safety Modification (DSM) Report – for the remediation of the Addicks and Barker Dams. The DSM Report consists of the main report supported by technical appendices and other documents as needed for approval. The DSM Report documents the deficiency issues of seepage and piping beneath the outlet structures and embankment failure resulting from uncontrolled flow around the ends of the Addicks and Barker Dams. The report also describes recommended corrective actions to resolve these deficiencies. The DSM Report serves as the decision document allowing remediation of the related seepage and piping deficiencies in order for the project to function safely, effectively, and in compliance with U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1156, Safety of Dams - Policy and Procedures (USACE, 2011). The DSM Report describes the alternative risk management plans considered and the plan recommended for remediation of the seepage and piping deficiencies. Following Headquarters', United States Army Corps of Engineers (HQUSACE) approval of the DSM Report and appendices and approval of the Environmental Assessment (EA) with a signature of the Finding of No Significant Impact (FONSI), the PDT will proceed to preconstruction engineering and design activities for the Addicks and Barker DSM Project.

Due to the extremely high risk associated with seepage and piping beneath, around, and near the conduits, the Addicks and Barker DSM Study was completed to address the issues associated with the conduits as well as a portion of the embankment for Barker Dam. A Phase 2 study will be completed to address the non-breach risk, risk exposure (both downstream and upstream), potential operational changes, and potential failure modes (PFMs) associated with auxiliary spillway flow and flow around the ends of the dams.

The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the DSM Report for Addicks and Barker Dams, Texas (hereinafter: Addicks and Barker Dams) in accordance with procedures described in the Department of the Army, USACE

Engineer Circular (EC) *Civil Works Review Policy, Change 1* (EC 1165-2-209, Change 1) (USACE, 2012a), *Civil Works Review* (EC 1165-2-214) (USACE, 2012b), and Office of Management and Budget (OMB) bulletin *Final Information Quality Bulletin for Peer Review* (OMB, 2004).[2] 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 IEPR panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel on the existing environmental, economic, and engineering analyses contained in the Addicks and Barker Dams review documents. The full text of the Final Panel Comments is presented 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 (2012a, 2012b).

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. For the purpose of this IEPR, USACE has been directed by Congress to evaluate USACE dams for safety assurance and seepage/stability correction. 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 Addicks and Barker Dams was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC Nos. 1165-2-209, Change 1, and 1165-2-214) under Section 501(c)(3) of the U.S. Internal Revenue Code with experience conducting IEPRs for USACE. Battelle has been conducting IEPRs for USACE since 2005.

3. METHODS

This section describes the method 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 by USACE (2012a, 2012b) and OMB (2004) guidance. Supplemental guidance on evaluation for conflicts of interest (COIs) 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).

[2] On December 15, 2012, USACE issued *Civil Works Review* (EC 1165-2-214), which supersedes EC 1165-2-209. However, the contract for this IEPR was awarded on September 19, 2012, before EC 1165-2-214 took effect. Accordingly, all tasks under this contract, including development of this IEPR report, were performed under *Civil Works Review Policy* EC 1165-2-209.

3.1 Planning and Schedule

At the beginning of the Period of Performance, 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). After conducting some initial activities following the award of the project, the IEPR was placed on hold pending receipt of the review documents on January 23, 2013. Any revisions to the schedule were submitted as part of the final Work Plan. The Work Plan also consisted of a Communications Plan to ensure that the proper level, channel, and forms of communication were maintained between Battelle and USACE, and between Battelle and the panel members.

Table 1 presents the schedule followed in executing the IEPR. Due dates for milestones and deliverables are based on the award/effective date of September 19, 2012. The review documents were provided by USACE on January 23, 2013. Note that the work items listed in Task 7 occur after the submission of this report. Battelle will enter the 13 Final Panel Comments developed by the Panel 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 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. Battelle will provide USACE and the Panel a pdf printout of all DrChecks entries, through comment closeout, as a final deliverable and record of the IEPR results.

Table 1. Addicks and Barker Dams IEPR Schedule

Task	Action	Due Date
1	Award/Effective Date	9/19/2012
	Review documents available	1/23/2013
	Battelle submits draft Work Plan[a]	1/22/2013
	USACE provides comments on draft Work Plan	1/24/2013
	Battelle submits final Work Plan[a]	1/25/2013
2	Battelle requests input from USACE on the COI questionnaire	9/21/2012
	USACE provides comments on COI questionnaire	9/21/2012
	Battelle submits list of selected panel members[a]	10/2/2012
	USACE confirms the Panel has no COIs	10/4/2012
	Battelle completes subcontracts for panel members	1/23/2013
3	Battelle submits draft charge (combined with draft Work Plan in Task 1)	1/22/2013
4	Battelle convenes kick-off meeting with USACE	9/27/2012
	Battelle sends review documents to Panel	1/24/2013
	Battelle convenes Panel kick-off meeting	1/25/2013
	Battelle convenes USACE/Panel kick-off meeting	1/25/2013

Table1. Addicks and Barker Dams IEPR Schedule (Cont'd)

Task	Action	Due Date
4	USACE/Battelle convene site meeting with Panel	1/31/2013
	Battelle convenes teleconference with economics panel member and USACE counterparts	2/7/2013
	Battelle submits minutes of the kick-off and site visit meetings	3/7/2013
5	Panel members complete their individual reviews	2/11/2013
	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	2/14/2013
	Battelle convenes Panel Review Teleconference	2/15/2013
	Panel members provide draft Final Panel Comments to Battelle	2/21/2013
	Battelle finalizes Final Panel Comments	3/1/2013
6	Battelle submits Final IEPR Report to USACE[a]	3/7/2013
7[b]	Battelle convenes teleconference with USACE to review the Post-Final Panel Comment Response Process	3/11/2013
	USACE provides draft PDT Evaluator Responses to Battelle	3/15/2013
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments and draft responses	3/21/2013
	USACE inputs final PDT Evaluator Responses in DrChecks	3/25/2013
	Battelle inputs the Panel's BackCheck Responses in DrChecks	3/28/2013
	Battelle submits pdf printout of DrChecks project file[a]	3/29/2013
	Project Closeout	5/31/2013

a Deliverable.

b Task 7 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: geotechnical engineering, engineering geology, civil/structural engineering, hydraulic/hydrology engineering, economics/planning, and environmental planner/National Environmental Policy Act (NEPA) impact assessment.[3] These areas correspond to the technical content of the Addicks and Barker Dams IEPR and overall scope of the Addicks and Barker DSM Project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle initially identified more than 25 candidates for the Panel, evaluated their technical expertise, and inquired about potential COIs. Of these, Battelle chose the most qualified candidates and confirmed their interest and

[3] One candidate was selected for a dual role in economics/planning and environmental planner/NEPA impact assessment.

availability, and ultimately proposed five experts for the final Panel. Information about the candidate panel members, including brief biographical information, highest level of education attained, and years of experience, was provided to USACE for feedback. Battelle made the final selection of panel members according to the selection criteria described in the Work Plan.

The five proposed primary reviewers constituted the final Panel. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required.

The candidates were screened for the following potential exclusion criteria or COIs.[4] These COI questions were intended to serve as a means of disclosure and to better characterize a candidate's employment history and background. Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

- Previous and/or current involvement by you or your firm[5] in the Dam Safety Modification (DSM) Report for the Addicks and Barker Dams, Texas.
- Previous and/or current involvement by you or your firm[5] in flood risk management or dam safety projects in the greater Houston, Texas region.
- Previous and/or current involvement (conceptual or actual design, construction, or operations and maintenance) by you or your firm[5] in projects related to the DSM Report for the Addicks and Barker Dams, Texas.
- Current employment by the USACE.
- Previous and/or current involvement with paid or unpaid expert testimony related to the DSM Report for the Addicks and Barker Dams, Texas.
- Previous and/or current employment or affiliation with members of the cooperating agencies: the Harris County Flood Control District (for pay or pro bono).
- Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to the greater Houston, Texas, area.
- Current personal involvement with other USACE projects, including authorship of any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters,

[4] 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."

[5] Includes any joint ventures in which a panel member's firm is involved and if the firm serves as a prime or as a subcontractor to a prime.

Engineer Research and Development Center [ERDC], etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Galveston District.

- Previous or current involvement with the development or testing of models that will be used for or in support of the DSM report for the Addicks and Barker Dams, Texas, including, but not limited to, HEC-1, HEC-HMS, HEC-2, HEC-RAS, FLO-2D, HEC-DSS, and HEC-FDA.
- Current firm[5] involvement with other USACE projects, specifically those projects/contracts that are with the Galveston District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the Galveston District. Please explain.
- Any previous employment by the USACE as a direct employee or contractor (either as an individual or through your firm[5]) within the last 10 years, notably if those projects/contracts are with the Galveston District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning dam safety or flood risk management and include the client/agency and duration of review (approximate dates).
- Pending, current, or future financial interests in the DSM Report for the Addicks and Barker Dams, Texas-related contracts/awards from USACE.
- A significant portion (i.e., greater than 50%) of personal or firm[5] revenues within the last 3 years from USACE contracts.
- A significant portion (i.e., greater than 50%) of personal or firm[5] revenues within the last 3 years from contracts with the cooperating agency (if applicable).
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the Addicks and Barker Dams.
- Participation in prior federal studies relevant to the Addicks and Barker Dams and/or the DSM Report for the Addicks and Barker Dams, Texas.
- Previous and/or current participation in prior non-federal studies relevant to the Addicks and Barker Dams and/or the DSM Report for the Addicks and Barker Dams, Texas.
- Any past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project.

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

absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle made the final selection of the Panel. 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 procedures, and other pertinent information for the Panel.

3.3 Preparation of the Charge and Conduct of the IEPR

Charge questions were provided by USACE and included in the draft and final Work Plans. In addition to a list of 26 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). Prior to the charge being finalized, Battelle reviewed the charge questions for inconsistencies, ambiguity, and wording that could bias the Panel.

Battelle planned and facilitated a 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 final charge as well as the Addicks and Barker Dams documents and reference materials listed below. The documents and files in bold font were provided for review; the other documents were provided for reference or supplemental information only. In addition, throughout the review period, USACE provided additional documents at the request of panel members. These documents were provided to Battelle and then disseminated to the Panel as additional information only and were not part of the official review. A list of these additional documents requested by the Panel is provided below.

Documents Reviewed (Approximately 2,000 pages)[6]

- **Addicks and Barker Dam Safety Modification Report (382 pages)**
- **Appendix 1 – Risk Assessment and Risk Management Alternative Formulation (898 pages)**
- **Appendix 2 - Addicks Dam Life Loss and Economic Evaluation and Economic Consequences (23 pages)**
- **Appendix 3 – Barker Dam Life Loss and Economic Evaluation and Economic Consequences (23 pages)**
- **Appendix 5 - Environmental Assessment (216 pages)**
- **Appendix 11 – Engineering (592 pages)**

[6] USACE provided review documents (file name: AddicksBarker_IEPR_Review_Documents_Portfolio_23Jan2013.pdf) to Battelle on January 23, 2013.

Supplemental Documents[7]

At the beginning of the review, USACE provided supplemental background information on the dams; however, these reference CD files were not part of the review.

1. Analysis of Design, Buffalo Bayou Flood Control Project, Addicks Dam, Sept. 1945
2. Construction of Granular Filter, Addicks Dam, April 2011
3. Construction of Granular Filter, Barker Dam, April 2011
4. Construction Photos, Barker Dam, 1942 – 1944
5. Definite Project Report, Bases of Design, Buffalo Bayou, June 1940
6. Emergency Operation Drawings for Foundation Observers, Addicks and Barker Dams
7. Plans for Construction of Embankment and Outlet Works, Addicks Dam, March 1946
8. Plans for Construction of Embankment and Outlet Works, Barker Dam, November 1941
9. Outlet Structure Walls, Summary of Stability Analyses, Aug 2012

Documents Requested by Panel

During the review process, the Panel requested the following additional information from USACE:

- Issue Evaluation Studies and Potential Failure Mode Assessment (PFMA) for both dams
- Addicks and Barker Dams slurry cutoff post construction/as-built reports
- Dam Safety Assurance - General Design Memorandum - June 1984 - Addicks and Barker Dams
- Dam Safety Assurance - Supplement No.1 to General Design Memorandum - December 1985 - Addicks and Barker Dams

Reference Documents

- Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

The following USACE regulations were followed in conducting the IEPR. The most recent Engineer Circulars (ECs), Engineer Manuals (EMs), Engineer Pamphlets (EPs), and Engineer Regulations (ERs) were used, which are available at: http://140.194.76.129/publications/ or http://www.hnd.usace.army.mil/techinfo/engpubs.htm.

General

- EC 1105-2-410, Review of Decision Documents, 22 August 2008
- EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011

[7] USACE also provided a portfolio file which contained reference CD files not part of the review, but for information only (file name: AddicksBarker_DSMR_References_CD_Portfolio_30Nov12_v1.pdf).

- EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy, Change 1, 31 January 2012
- EC 1165-2-214, Water Resources Policies and Authorities - Civil Works Review, 15 December 2012
- EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and Risk Reduction Measures for Dams, 9 April 2010
- EP 1110-2-13, Dam Safety Preparedness, 28 June 1996
- ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (Change 2)
- ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
- ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28 October 2011
- ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001.
- National Academy of Sciences, "Policy and Procedures on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports," May 2003 for General Scientific and Technical Studies and Assistance: General Scientific and Technical Studies and Assistance. Available at: http://www.nationalacademies.org/coi/index.html
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECW-P, 28 December 1990
- Council on Environmental Quality. 1978. Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR Parts 1500-1508. Washington, DC: U.S. Government Printing Office (November 29, 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECW-RE (now CECW-A), 4 March 1988

Engineering Geology

- EM 1110-1-1804, Engineering and Design - Geotechnical Investigations, 01 January 2001
- ER 1110-1-1807, Engineering and Design - Procedures for Drilling in Earth Embankments, 01 March 2006

- EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations, 31 August 1995

Geotechnical Engineering

- EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1902, Engineering and Design - Slope Stability, 31 October 2003
- EM 1110-2-2300, Engineering and Design - General Design and Construction Considerations For Earth and Rock-Fill Dams, 30 July 2004
- EM 1110-2-1908, Engineering and Design - Instrumentation of Embankment Dams and Levees, 30 June 1995
- ER 1110-2-110, Engineering and Design - Instrumentation for Safety Evaluations of Civil Works Projects, 8 July 1985

Materials Engineering

- ER 1110-1-1901, Project Geotechnical and Concrete Materials Completion Report for Major USACE Project, 22 February 1999
- EM 1110-2-1906, Laboratory Soils Testing, 20 August 1986
- ER 1110-2-1911, Engineering and Design - Construction Control for Earth and Rock-Fill Dams, 30 September 1995
- EM 1110-2-2000, Engineering and Design - Standard Practice for Concrete for Civil Works Structures, 31 March 2001

Structural Engineering

- EM 1110-2-2002, Evaluation and Repair of Concrete Structures, 30 June 1995
- EM 1110-2-2100, Engineering and Design - Stability Analysis of Concrete Structures, 1 December 2005
- EM 1110-2-2102, Waterstops and Other Preformed Joint Materials for Civil Works Structures, 30 September 1995
- EM 1110-2-2104, Engineering and Design - Strength Design for Reinforced-Concrete Hydraulic Structures, 20 August 2003
- EM 1110-2-2400, Engineering and Design - Structural Design and Evaluation of Outlet Works, 02 June 2003
- EM 1110-2-4300, Instrumentation for Concrete Structures, 30 November 1987
- ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 15 February 1995

Hydraulic Engineering

- EM 1110-2-1602, Engineering and Design - Hydraulic Design of Reservoir Outlet Works, 15 October 1980
- EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, 16 January 1990
- EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
- EM 1110-2-3600, Engineering and Design - Management of Water Control Systems, 30 November 1987
- ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
- ER 1110-2-240, Water Control Management, 8 October 1998
- ER 1130-2-530, Flood Control Operations and Maintenance Policies, 30 October 1996
- ER 1110-2-8156, Preparation of Water Control Manuals, 31 August 1995

3.4 Site Visit

An in-person meeting to discuss the Addicks and Barker Dams was held at the USACE Addicks Project Office in Houston, Texas, on January 31, 2013; all five panel members and the Battelle Project Manager attended this meeting. As part of this meeting, USACE led Battelle and the Panel on a visit of the Addicks and Barker Reservoirs, including a tour of the earthen dams, concrete outlet works, uncontrolled spillways, and the intake structure service platform and gates for both dams. USACE, Battelle, and panel members drove the length of the project boundary and stopped at various points to observe key structural components, including a tour inside the conduits to observe the grouting and conduit joints. Panel members also observed the parabolic spillway slab, stilling basin, and spillway training walls.

Throughout the site visit, USACE pointed out specific project features to help the panel members better comprehend the design and construction intent of the project and answered questions posed by the panel members. This tour provided an opportunity for the panel members to see the project area and project features, and to ask clarifying questions of the PDT.

Panel members identified and requested various technical project documents that would further assist in the peer review, such as the cutoff documentation for the Addicks and Barker Dams slurry wall (Section 3.3, Documents Requested by Panel, second bullet).

One week after the site visit, Battelle convened a teleconference with the economics panel member and USACE counterparts (who were unable to attend the site visit) so that USACE could answer specific questions pertaining to economic aspects of the project. USACE was able to provide responses to all of the questions during the teleconference.

3.5 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a comment-

response form provided by Battelle. At the end of the review period, the Panel produced 130 individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. As a result of the review, Battelle summarized the 130 comments into a preliminary list of 28 overall comments and discussion points. Each panel member's individual comments were shared with the full Panel in a merged individual comments table.

3.6 IEPR Panel Teleconference

Battelle facilitated a 4-hour teleconference with the Panel so that the panel members could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final IEPR Report and 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 positive and negative comments, added any missing issues of high-level importance to the findings, and merged any related individual comments. In addition, Battelle confirmed each Final Panel Comment's level of significance to the Panel.

The Panel also discussed responses to four 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, and all sets of comments were determined not to be conflicting. Each comment was either incorporated into a Final Panel Comment, determined to be consistent with other Final Panel Comments already developed, or determined to be a non-significant issue.

At the end of these discussions, the Panel identified 14 comments and discussion points that should be brought forward as Final Panel Comments.

3.7 Preparation of Final Panel Comments

Following the teleconference, Battelle prepared a summary memorandum for the Panel 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 Addicks and Barker Dams:

- 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 the merged individual comments table, a summary detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.
- Directive to the Lead: Each lead was encouraged to communicate directly with the other 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 Panel 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(s) for Resolution (see description below).
- Criteria for Significance: The following were used as criteria for assigning a significance level (the importance of the concern with regard to USACE's conclusions) to each Final Panel Comment:
  1. High: Describes a fundamental problem with the project that could affect the recommendation, success, or justification of the project. Comments rated as high indicate that the Panel analyzed or assessed the methods, models, and/or analyses and determined that there is a "showstopper" issue.
  2. Medium: Affects the completeness of the report in describing the project, but will not affect the recommendation or justification of the project. Comments rated as medium indicate that the Panel does not have sufficient information to analyze or assess the methods, models, or analyses.
  3. Low: Affects the understanding or accuracy of the project as described in the report, but will not affect the recommendation or justification of the project. Comments rated as low indicate that the Panel identified information (tables, figures, equations, discussions) that was mislabeled or incorrect or data or report sections that were not clearly described or presented.
- Guidance for Developing Recommendations: The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., description of additional research or analysis that would appreciably influence the conclusions, and, when appropriate, the actions necessary to resolve the concern, and 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, 14 Final Panel Comments were prepared and assembled. However, during the Final Panel Comment development process, the Panel felt that one of the Final Panel Comments no longer met the criteria for a high, medium, or low level significance; therefore, the total Final Panel Comment count was reduced to 13.

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 (who were screened for availability, technical background, and COIs), and provided it to USACE for feedback. Battelle made the final selection of panel members.

An overview of the credentials of the final five primary 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 area of technical expertise is presented in the text that follows the table.

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Geotechnical Engineering					
Minimum 15 years of demonstrated experience in dam engineering and in evaluating, designing, and constructing large embankment dams (>150 feet high) for water storage	X				
Recognized expert in cutoff wall design and various methods of cutoff wall construction and soil improvement, including experience with various methods of cutoff wall construction	X				
Knowledge and experience in the forensic investigation of seepage, settlement, stability, and deformation problems associated with embankments constructed on alluvial soils	X				
Minimum of 15 years of experience in the general field of geotechnical engineering, including subsurface investigations; field and laboratory testing and the determination of in situ material properties; soil compaction and earthwork construction; soil mechanics; seepage and piping; bearing capacity and settlement; dewatering; design and construction of foundations on alluvial soils; foundation inspection and assessment; foundation grouting and other foundation treatment methods, including construction of seepage barriers; the design, installation, and assessment of instrumentation; and preparation of plans and specifications for USACE projects.	X				
Knowledge of USACE design and construction procedures and policies	X				

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Familiar with USACE dam safety assurance policy and guidance	X				
Experience in evaluating risk reduction measures for dam safety assurance projects	X				
Active participation in related professional societies	X				
Registered professional engineer	X				
Minimum M.S. degree or higher in engineering	X				
Civil/Structural Engineering					
Recognized expert in the design and construction of hydraulic structures for large and complex Civil Works projects, including outlet works and spillways		X			
Recognized expert in the stability analysis and structural design of mass concrete scour protection and stilling features, including the design of baffles, end sills, and training walls		X			
Familiar with preparing plans and specifications for USACE projects		X			
Knowledge of USACE design and construction procedures and policies		X			
Knowledge of USACE dam safety assurance policy and guidance		X			
Demonstrated knowledge in a variety of construction-related activities, including site layout, surveying, 3-dimensional modeling, construction techniques, grading, hydraulic structures, erosion control, interior drainage, earthwork, concrete placement, design of access roads, retaining wall design, and relocation of underground utilities		X			
Experience in evaluating risk reduction measures for dam safety assurance projects		X			
Practical knowledge of construction methods and techniques as they relate to structural portions of projects		X			
Active participation in related professional engineering and scientific societies		X			
Registered professional engineer		X			
Minimum M.S. degree or higher in engineering		X			

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Hydraulic/Hydrologic Engineering					
Minimum 10 years of experience in hydraulic engineering with an emphasis on large public works projects			X		
Extensive background in hydraulic theory and practice and river geomorphology			X		
Experience associated with flood risk management projects and the analysis and design of hydraulic structures for flood control projects, including outlet works, spillways, stilling basins, flood control channels and levees, diversion channel design, and large river control structures.			X		
Performed work in hydrologic analysis, floodplain analysis, hydraulic design of channels and levees using various channel and bank protection works, and river sedimentation			X		
Knowledge of, and experience with, physical modeling and the application of data from physical model testing to the design of stilling basins and scour protection; ability to coordinate, interpret, and explain testing results with other engineering disciplines, particularly structural engineers, geotechnical engineers, and geologists			X		
Knowledge of, and experience with, the routing of inflow hydrographs through multipurpose flood control reservoirs utilizing multiple discharge devices, including gated sluiceways and gated spillways			X		
Familiar with USACE application of risk and uncertainty in flood damage reduction studies and experience in evaluating risk reduction measures for dam safety assurance projects			X		
Familiar with standard USACE hydrologic and hydraulic computer models used in drawdown studies, dam break inundation studies, hydrologic modeling, and analysis for dam safety investigations, including but not limited to HEC-1, HEC-HMS, HEC-2, HEC-RAS, FLO-2D, and HEC-DSS			X[a]		
Familiar with preparing plans and specifications for USACE projects			X		
Knowledge of USACE design and construction procedures and policies			X		
Knowledge of USACE dam safety assurance policy and guidance			X		
Active participation in related professional engineering and scientific societies			X		

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Registered professional engineer			X		
Minimum M.S. degree or higher in engineering			X[a]		
Economics/Planning					
Minimum 10 years of experience in water resource economic evaluation and review				X	
Direct experience working for or with USACE				X	
Very familiar with the USACE plan formulation process, procedures, standards, guidance, and economic evaluation techniques				X	
Familiar with the USACE flood risk and hurricane/coastal damage risk reduction analysis and economic benefit calculations, including the use of standard USACE computer programs including HEC-FDA				X	
Experience with the National Economic Development (NED) analysis procedures, particularly as they relate to hurricane and coastal storm damage risk reduction				X	
Demonstrated experience in public works planning, working with project teams to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk				X	
Extensive experience in reviewing analyses used to evaluate measures and alternatives to ensure that they are sufficiently comprehensive and complete to result in approval of recommended alternative				X	
Minimum 5 years of experience directly dealing with the USACE six-step planning process governed by ER 1105-2-100, Planning Guidance Notebook				X	
Experience identifying and evaluating impacts to environmental resources from structural flood risk management and hurricane and coastal storm damage risk reduction projects				X	
Active participation in related professional societies				X	
Minimum B.S. degree or higher in economics				X[a]	

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Environmental Planning/NEPA Impact Assessment					
Minimum 10 years of experience in water resource environmental evaluation and review				X	
Minimum 10 years of experience in the implementation of the NEPA compliance process and Endangered Species Act requirements				X	
Demonstrated experience in the EA process with knowledge of the NEPA process, cultural surveys, biological assessments, endangered species, working with coastal and estuarine ecosystems, and evaluating and conducting NEPA impact assessments, including cumulative effects analysis for complex multi-objective public works projects with competing trade-offs				X	
Familiar with the USACE calculation and application of environmental impacts and benefits, determining the scope and appropriate methodologies for impact assessment and analyses for a variety of projects, potential project impacts to nearby sensitive habitats, and programs with high public and interagency interests				X	
Experience in the Gulf of Mexico coastal region				X	
Minimum M.S. degree or higher in a related field				X	
Engineering Geology					
Minimum 15 years of experience in engineering geology					X
Proficient in assessing seepage and piping through and beneath dams constructed on or within various geologic environments, including, but not limited to, alluvial soils and colluviums and other geological formations					X
Familiar with, and knowledgeable of, the identification of geologic hazards; exploration techniques, including soil and rock logging, geologic mapping, geophysical investigations and air photo interpretations; field and laboratory testing and the determination of in situ material properties; geomorphology; foundation inspection and assessment; foundation grouting and other foundation treatment methods, including construction of seepage barriers; and the design, installation, and assessment of instrumentation.					X[a]
Familiar with preparation of factual data and interpretative geology reports, including the preparation of Geotechnical Baseline Reports for USACE projects					X

Table 2. Addicks and Barker Dams IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Bjarngard	Hutton	Bakken	Bastian *(Dual Role)*	Bruce
Familiar with preparing plans and specifications for USACE projects					X
Knowledge of USACE design and construction procedures and policies					X
Knowledge of USACE dam safety assurance policy and guidance					X
Active participation in related professional engineering and scientific societies					X
Registered professional geologist					X

[a]*Waiver statement presented as part of Task 2 deliverable and approved by USACE.*

Anders B. Bjarngard, P.E.

Role: Geotechnical Engineer
Affiliation: GZA GeoEnvironmental, Inc.

Mr. Bjarngard is a principal at GZA GeoEnvironmental, Inc. and has 27 years of experience performing dam engineering on water supply embankment dams. He has an M.S. in civil engineering (geotechnical) from Tufts University and is a registered professional engineer in Massachusetts. His areas of expertise include dam safety inspections / investigations and subsurface investigations; foundation, lateral earth support, and dam rehabilitation; construction monitoring and documentation; slope stability and seepage and settlement analyses; preparation of plans, specifications, and contract documents; field investigations; and laboratory and technical analyses. He has worked on numerous dam projects, including large structures such as the Gilboa Dam, for which he performed the analysis and design of outlet works and spillway structures, including both uncontrolled and gated facilities. As project manager for the Geotechnical Indefinite Delivery/Indefinite Quantity (ID/IQ) contract with the USACE North Atlantic Division, Mr. Bjarngard is experienced in the use of embankment dams used for flood control. He has evaluated and developed repairs to seepage and piping problems at multiple embankment dams. He has provided expert witness and forensic engineering on two earth embankment dams that experienced deformation and internal erosion failures at the primary spillways. He is experienced with concrete and low-permeability soil cutoff walls, having published a paper on a grouted cutoff wall at Lovell Pond Dam in Massachusetts.

Mr. Bjarngard has been responsible for hundreds of subsurface investigation programs, including a multi-million dollar investigation for the New York City Department of Environmental Protection, and has experience with a range of geotechnical laboratory field and laboratory tests, having conducted hundreds of moisture/density tests during compacted soil placement, borehole permeability tests, and packer testing. He has experience with *in situ* soil shear strength determination and slope stability and settlement analyses. Mr. Bjarngard is experienced with

bearing capacity, has performed dewatering analyses to evaluate bottom stability and dewatering of braced and unbraced excavations, and has designed and monitored the construction of various foundation elements bearing on alluvial soils.

Mr. Bjarngard has prepared analyses and designs for both mass concrete and reinforced concrete structures, including scour protection and stilling features, and has designed interim spillway channel repairs at Gilboa Dam and a new spillway, weir, apron, channel, and other features for Morey's Bridge Dam Replacement in Massachusetts. He has inspected subgrades for various foundations, including evaluating long-term performance and settlement, and he is experienced with underpinning and grouting, having designed a grouting program for the repair of a concrete cutoff wall and foundation of a large embankment dam. He has designed, installed, and monitored instrumentation programs at several dams, including piezometers, observation wells, inclinometers, settlement platforms, multi-point extensometers, and horizontal settlement Micro Electronic Mechanical Systems arrays.

Mr. Bjarngard has experience in the construction of dam safety projects, including experience with earth fill placement and grouting, and with multiple construction techniques, including issues of water control and support of excavation. He has conducted grading for dams and other projects and is familiar with erosion control techniques, including riprap, concrete, and bioengineering methods. He is familiar with interior drainage (toe drains and drainage blankets) and hot and cold weather concrete placement, mass concrete, admixture use to facilitate placement, and formwork design. He is familiar with USACE EMs and other USACE technical guidance as the basis of design for dam safety repairs, including concrete, riprap, and other structures, and he is familiar with USACE dam safety assurance policy (DSAP) protocols. He is also experienced with general dam safety risk reduction measures and is a Federal Energy Regulatory Commission (FERC) PFMA Facilitator. He has prepared plans and specifications for numerous dam rehabilitation projects and is familiar with USACE requirements through his work as project manager for a geotechnical ID/IQ contract and periodic flood control inspections with the USACE New England District. Mr. Bjarngard is an active member of the U.S. Society on Dams (USSD), the Association of State Dam Safety Officials (ASDSO), and the American Society of Civil Engineers (ASCE) and has published numerous papers on dam safety with ASDSO and USSD.

Charles C. Hutton, P.E.

Role: Civil & Structural Engineer
Affiliation: GENTERRA Consultants, Inc.

Mr. Hutton is a principal engineer at GENTERRA Consultants, Inc. with 45 years of experience in the development of water resource projects involving dams, hydropower, pumping plants, and water conveyance systems. He earned his M.S. in structural engineering from Purdue University and is a registered professional civil engineer in Colorado and Wyoming. His expertise includes the design of dams (concrete, roller-compacted concrete, rockfill, and earthfill) and appurtenant structures for dams and reservoirs; dam safety inspections; condition assessments of existing dams, hydropower facilities, and canal systems; development of designs for rehabilitation; and project and construction management.

Mr. Hutton is a recognized expert in the design and construction of hydraulic structures. He has worked on numerous dam and hydropower projects in the United States and overseas that have involved large and complex dams, hydropower plants, outlet works, spillways, and stilling basins. He is currently the structural technical advisor and reviewer for the World Bank for the Trung Son Dam and Hydropower Project in Vietnam, and he served as the structural expert on the Bluestone Dam, Dover Dam, and Rough River Dam IEPRs for USACE. For these IEPRs, he was involved in the technical evaluation of the dam designs, which were intended to reduce the risk of potential failure during floods, particularly the PMF.

Mr. Hutton has performed stability analyses and prepared structural designs for mass concrete scour protection and stilling basin features for numerous dam projects. He was the Deputy Project Manager and Senior Technical Advisor and Reviewer for preparation of design, drawings, and specifications for the Fort Peck Dam Interim Spillway Repair Project for USACE, Omaha District, which involved (among other responsibilities) the evaluation of alternative designs for the repairs and the reduction of the risk of failure of the spillway cutoff structures. He was also the principal structural engineer for the design of the stilling basin for Rio Valenciano Dam in Puerto Rico, for which he prepared plans and specifications based on USACE dam safety assurance policy and guidance. Mr. Hutton has managed projects involving field investigations; site surveys; geotechnical and engineering geology investigations and analysis; hydrologic/hydraulic analysis; structural stability and stress analysis and design; mechanical engineering for gates and valves; electrical engineering for instrumentation and controls; and construction management.

Mr. Hutton has directed and participated in the preparation of designs, drawings, specifications, cost estimates, and economic and financial analyses for numerous dams, hydroelectric power plants, pumping plants, pipelines, canals, and hydraulic structures. He has specifically prepared and conducted stability analyses and structural designs and analyses for static, hydrodynamic, and seismic loadings for concrete gravity dams; spillway gate, chute, and stilling basin structures; outlet works intakes, conduits, and energy-dissipating structures; canals and related hydraulic structures; hydroelectric power plants; pumping plants; and retaining walls. He is very familiar with the various USACE EMs. He was recently the senior structural engineer and reviewer for the structural analysis and stability evaluation of the Isabella Dam outlet works exit portal structures and spillway crest structures for USACE. Mr Hutton is a member of the ASCE, USSD, and ASDSO.

James R. Bakken, P.E.

Role: Hydraulic and Hydrologic Engineer
Affiliation: Ayres Associates

Mr. Bakken is vice president and project engineer at Ayres Associates with 38 years of experience in planning, managing, designing, and inspecting a variety of water resource projects. He earned his B.S. in civil engineering in 1972 from the University of Minnesota and is a registered professional engineer in Wisconsin, Minnesota, and Michigan. His experience includes planning, managing, designing, and inspecting a variety of water resource projects, and he is knowledgeable in dam inspection and rehabilitation, hydraulic and hydrologic analyses, flood control projects, stormwater management, master planning, river sedimentation, and

erosion control design. Additional expertise is in project management; emergency action plans; dam inspection, design, and rehabilitation; FERC Part 12 inspections and licensing assistance; hydropower feasibility studies; spillway rehabilitation; floating bulkhead design; and construction observation. He has provided planning and design services for water resource projects for the St. Paul, Sacramento, Detroit, Rock Island, and Chicago USACE Districts.

Mr. Bakken has worked on over 225 dam rehabilitation and inspection projects involving design of spillways, stilling basins, scour protection, outlet works, diversion channel design, and large river control structures, with much of his dam work focusing on reservoir routing and water outflow management. Mr. Bakken conducted dam failure simulation modeling of the Lake Marion Dam in South Carolina, where he defined the inundation area of the 76-mile reach from the dam to the Atlantic Ocean. He has extensive experience characterizing surface water flows in a watershed, including the prediction of watershed runoff in developing Federal Emergency Management Agency flood hazard mapping, using USACE software HEC-1 (now Hydrologic Engineering Center-Hydrologic Modeling System [HEC-HMS]), HEC-2, Hydrologic Engineering Center-Data Storage System (HEC-DSS), and HEC-RAS and using dam failure models (Dam-Break [DAMBRK] Flood Forecasting) to develop inundation mapping or hydraulic shadow mapping. He has direct experience with dam rehabilitation design for many projects. For the Big Eau Pleine Reservoir Dam, Wisconsin, he was part of a team that designed a drainage blanket on the downstream slope of a 1-mile-long, 40-foot-high earthen embankment to control seepage as a risk reduction measure. His involvement in risk and uncertainty analysis includes a number of flood damage reduction studies for USACE, including the Mississippi River at Winona Flood Control, the State Road Coulee Flood Control Channel, and the Grand Forks/East Grand Forks Flood Control projects. For these projects, risk was assessed and related to residual flood damages and/or loss of life for various levels of protection in conjunction with determining benefit/cost ratios. Mr. Bakken has been a review expert on previous USACE IEPR dam studies, including Bluestone Dam, Dover Dam, Bolivar Dam, and components of the New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS).

David F. Bastian, P.E.

Role: Economics, Planning and Environmental Plan, and NEPA Impact Assessment
Affiliation: David Bastian Consulting

Mr. Bastian is an independent consultant and professional engineer for David Bastian Consulting in Annapolis, Maryland, specializing in USACE compliance and policy review, plan formulation and incremental cost analysis, dredging and flood risk reduction, and hydraulic and river engineering. He earned his B.S. in civil engineering from Georgia Institute of Technology and a M.S. in River Engineering from Delft University, Holland. He has over 35 years of experience with USACE and 10 years as contractor/consultant on USACE projects, with 30 years of demonstrated experience in public works planning, working with project teams to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk. In addition, he has extensive experience reviewing the analyses used to evaluate measures and alternatives and is able to determine whether they are sufficiently comprehensive and complete to result in approval of recommended alternatives. Mr. Bastian's previous employment at USACE included positions as Deputy Chief of Staff for Support, Office Chief of Engineers; Assistant Director of Civil Works, Office Chief of Engineers; technical and policy

compliance review expert, Washington Level Review Center; and navigation research, USACE Institute for Water Resources (IWR). He has served as a USACE Washington level technical and policy compliance review expert and managed interdisciplinary reviews of over 70 feasibility reports.

Mr. Bastian is proficient in the USACE plan formulation process, procedures, standards, guidance, and economic evaluation techniques and in the application of the USACE six-step process. He is also an expert on USACE policy, including ER 1105-2-100. His project history has resulted in his creation or creation of over 100 USACE reports evaluating and comparing alternative plans. He is familiar with the USACE flood risk and hurricane/coastal damage risk reduction analysis and economic benefit calculations, including the use of standard USACE computer programs such as HEC-FDA studies. He has 10 years of experience identifying and evaluating impacts to environmental resources from structural flood risk management and hurricane and coastal storm damage risk reduction projects. His experience in the Gulf of Mexico is reflected in his 5 years involvement with the review of decision documents involving environmental impact statement (EIS) and NEPA requirements as well as levee construction designs for New Orleans, Louisiana, post-Katrina projects.

Mr. Bastian is also familiar with USACE's dam safety assurance guidance and has reviewed project rehabilitation and dam safety studies for policy compliance for HQUSACE. He has evaluated and conducted NED analysis procedures, particularly as they relate to hurricane and coastal storm damage risk reduction. He authored the deep-draft and inland navigation sections of the IWR Planning Workshop manual, participated in the IEPR of the Delaware River Deepening Feasibility Study (2003-2004), and contributed to the Port Everglades channel relocation and enlargement (2012) economic evaluation. He has been involved with programs with high public and interagency interests such as the post-Katrina HSDRRS and is experienced with the USACE calculation and application of environmental impacts and benefits, determining the scope and appropriate methodologies for impact assessment and analyses for a variety of projects, and potential project impacts to nearby sensitive habitats.

Due to his substantial experience as a HQUSACE feasibility study/EIS reviewer, he is knowledgeable in water resource environmental evaluation and review, and in implementation of the NEPA compliance process and Endangered Species Act requirements. He has prepared feasibility reports and provided independent technical review of flood damage reduction, eco-system restoration, navigation, major rehabilitation, post authorization, and dam safety assurance for Alaska, Galveston, Huntington, Jacksonville, Kansas City, Little Rock, Mobile, New Orleans, Tulsa, Vicksburg, and Norfolk Districts. His experience with studies such as the New Orleans HSDRRS study and associated series of interim environmental reports (2010-2012), Louisiana Coastal Area and Louisiana Coastal Protection and Restoration studies (2006-2008), Texas City Container Terminal (2005), and Spavinaw Creek Basin (2006-2007) involving EIS and NEPA requirements reflects his knowledge of both the EA process and the NEPA process, including cultural surveys, biological assessments, endangered species, and coastal and estuarine ecosystems. He is experienced in evaluating and conducting NEPA impact assessments, including cumulative effects analysis for complex multi-objective public works projects with competing trade-offs. Mr. Bastian's participation in professional societies includes the Wetland and Sediment Management Committee of ASCE, the Permanent International Association of

Navigation Congresses, and the Western Dredging Association.

Donald A. Bruce, Ph.D., D.GE, C.Eng., L.G., L.E.G.

Role: Engineering Geologist
Affiliation: Geosystems, L.P.

Dr. Bruce is president of Geosystems, L.P. and earned degrees in geology and civil engineering from Aberdeen University, Scotland in 1973 and 1977, respectively. He is a Chartered Engineer in the United Kingdom and a Licensed Geologist and Engineering Geologist in the State of Washington. He has 39 years of experience in engineering geology and is familiar with large, complex Civil Works projects. He was a member of the six-person Peer Review Panel for USACE's new program conducting safety evaluations of all the dams in its purview. Dr. Bruce was primarily responsible for geological and rehabilitation constructability issues involved in the remediation efforts for these critical structures. Dr. Bruce has extensive experience with dam foundation engineering related to seepage concerns.

In 2005, Dr. Bruce was appointed a member of a panel of experts formed by the U.S. Government to review the Mosul Dam in Iraq. The 370-foot-high, 14,000-foot-long embankment dam is built on a largely carbonate foundation that contains highly erodible and soluble gypsum beds. Dr. Bruce's prime roles on this project were to review available geological, construction, and dam performance data in relation to seepage, liquefaction potential, and quality of construction; lead "technology transfer" efforts to Iraqi forces; and develop an implementation manual for the grouting works. Dr. Bruce has published multiple papers and made multiple presentations on seepage and seepage cutoffs. He also has seismic experience, serving from 2006 to 2009 as a consultant to the contractor on the seepage and seismic remediation of the Tuttle Creek Dam, Kansas. Dr. Bruce has also served as a consultant on seepage and seepage cutoff concerns on multiple USACE dam projects, including Patoka Dam, Indiana; Mississinewa Dam, Indiana; Center Hill Dam, Tennessee; Wolf Creek Dam, Kentucky; and Clearwater Dam, Missouri. His participation in multiple USACE dam projects and expert panels, including the Mohawk Dam IEPR, has provided him with further knowledge of the USACE design criteria. For many years he has served on the standing Independent Review Board for the Tennessee Valley Authority. He is a member of numerous national and international committees on dams, foundations, and grouting. He has co-authored three textbooks and over 275 technical papers on geosystems and geotechnical construction. He is the past Chairman of ASCE's Grouting Committee and the International Society for Micropiles and is the recipient of the 1998 ASCE Martin Kapp Award and the 2004 GeoInstitute Wallace Hayward Baker Award. He is a long-time instructor for the Colorado School of Mines Grouting Short Course.

5. SUMMARY OF FINAL PANEL COMMENTS

The panel members agreed between each other on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2012a and 2012b; p. D-4) in the Addicks and Barker Dams IEPR review documents. Table 3 lists the Final Panel Comment statements by level of significance. The full

Table 3. Overview of 13 Final Panel Comments Identified by the Addicks and Barker Dams IEPR Panel

No.	Final Panel Comment
Significance – High	
1	The serviceability of the cutoff wall structure, now over 30 years old, has not been demonstrated and cannot be relied upon.
2	The elevation survey baseline has not been addressed and may impact several project variables, including loss of life and economic damage calculations.
Significance – Medium	
3	The description of the design and constructability of the outlet works was not presented in sufficient detail to understand the sequencing of these activities or the implementation of certain key elements.
4	Slope stability analyses, which confirm that the current and proposed embankment geometry provides required factors of safety, are not provided.
5	The complete list of potential failure modes (PFMs) and the reasons why some were dismissed have not been documented in the Dam Safety Modification (DSM) Report.
6	The discussion of seepage using the USACE-preferred methodologies of flow nets and computer analysis (SEEP-W) has not been sufficiently emphasized in the Dam Safety Modification (DSM) Report and related documents, which focus on the less rigorous Weighted Creep Path Method.
7	The residual risk associated with post-Phase 1 construction was not thoroughly described.
8	Land use controls to prohibit future development in the project pool and further encroachment into the Probable Maximum Flood (PMF) reservoir level have not been documented.
9	The origin and nature of the faults that intersect the embankments have not been adequately discussed.
Significance – Low	
10	The models used to determine economic consequences were not documented clearly.
11	The DSM Report does not account for population change over the 50-year period of economic analysis.
12	Documentation for the basis of the preliminary hydraulic and structural designs for the new outlet works intake, conduit, spillway, and stilling basin is not discussed in sufficient detail.
13	While it appears that the Recommended Alternative was logically formulated and selected to meet the study objectives, the study constraints were not defined in sufficient detail to determine if they were fully considered in the plan formulation.

text of the Final Panel Comments is presented in Appendix A of this report. The following summarizes the Panel's findings.

Based on the Panel's review, the historical problems associated with erosion along the outlets are well-documented in the information provided, and the concern for potential failure along the outlets is well-substantiated. However, the complete list of PFMs and the reasons why some were dismissed have not been documented in the DSM Report. Including this information would provide more robust documentation that various modes of failure were considered.

The unacceptable risk associated with the current condition of the dams is clearly identified in the DSM Report. USACE provided an effective and comprehensive assessment of risk and uncertainty related to potential failure of the Addicks and Barker Dams. The Panel recognizes there is always uncertainty. However, the DSM Report makes an appropriate effort to identify and account for these uncertainties. The Panel believes that providing additional information on the significant flood risk that remains after post-Phase 1 construction would provide a more complete understanding of how the project will proceed into the second phase.

Plan Formulation – The Panel found the DSM Study to be conducted in compliance with USACE ER 1110-2-1156 (USACE, 2011). The DSM Report and the supplemental information provided are generally adequate to evaluate the recommendations made as part of the DSM Study. The recommended plan has been properly and thoroughly documented and based on sound and reasonable technical analyses. The recommended plan will fully restore the structural integrity of the outlet works and will allow it to operate without unacceptable risk of failure to protect the City of Houston from flooding. The recommended plan also addresses all of the known deficiencies of the existing outlet and facilitates construction while maintaining the ability to provide interim flood protection through limited discharges.

However, additional information would enhance the completeness and readability of the document. Clearly identifying the constraints that guided the DSM Study would improve the technical clarity and completeness of the review documents. As noted in ER 1110-2-1156, "Problems and opportunities statements will generally encompass just current conditions, but in some instances, may need to encompass future conditions…". However, what appears to be missing in terms of "future conditions" is any accounting of population change over the 50-year period of economic analysis. The Panel is concerned that without incorporating the future conditions over the period of analysis, it is likely that the loss of life and economic consequences are underestimated, but the ranking of alternatives would not be affected.

Engineering – The Panel believes that extensive engineering analyses were completed for the dams and outlet works to identify and characterize the hydrologic, hydraulic, geotechnical, and structural deficiencies and develop alternative risk management plans. In some cases, additional information may affect the implementation of the Recommended Alternative (Alternative 2). The Panel is concerned that the review documents contain very little information on the design, construction, or performance of the existing cutoff wall — a vital dam safety modification — and that there is no information about the wall's current condition or effectiveness, making it difficult for the Panel to confirm that the cutoff wall can and will perform as intended under flood conditions. At the request of panel members, USACE provided the slurry cutoff post-

construction/as-built reports to Battelle, which provided ample information to assist the Panel in its review. The cutoff wall has been judged critical to the safety of sections of both dams since it was conceived to stop seepage and eliminate the potential for associated piping at elevated reservoir levels. Slope stability calculations for the current geometry have not been provided for either the upstream or downstream embankments. If the missing slope stability information yields incorrect results, improvements to the embankments may be required as part of the Recommended Alternative (Alternative 2). If the impacts of the faults beneath or through dams have not been fully and correctly considered, improvements may be required as part of the Recommended Alternative.

Additional information would also improve the understanding of the review documents. The Panel acknowledges that consideration of design and constructability of the outlet works, as outlined in the DSM Report, is at an early stage. However, these early concepts should explain the construction sequencing more clearly and address other issues (e.g., densifying basal soils) that have not been evaluated. Discussion of flow net and seepage analysis (SEEP-W) results and how those methods were used would increase the Panel's ability to draw conclusions based on those analyses. It has been clearly shown in the documentation that the Addicks and Barker Dams project area has been, and will continue to be, affected by regional subsidence due to aquifer pumping. Accurate survey data are essential inputs for hydraulic and hydrologic calculations (including loss of life and economic damages), and for ongoing monitoring of the service performance of the dams and their appurtenant structures during and after remediation. Additional information on land use controls to prohibit future development in the project pool and further encroachment into the PMF reservoir level would improve the understanding of future escalation of flooding risk. Additional documentation of the hydraulic and structural engineering analyses used to develop the alternatives presented in the DSM Report will improve the technical quality of the report. Finally, The Panel acknowledges that the DSM Study is at the stage where conceptual or preliminary designs are being considered and costed and that estimated construction costs are not final. However, presenting the basis for the generation of these estimated costs for the remedial efforts as currently conceived would enhance the DSM Report.

Hydraulics and Hydrology – For the hydraulic models, the description of the methodology stated that the Hydrologic Engineering Center-River Analysis System (HEC-RAS) model used a starting downstream water surface based on normal depth. The Panel is concerned that the model may give unreliable tailwater depths for use in design of the outlet structure because the flow immediately downstream of the outlets is not steady, uniform flow, assuming normal depth to start. The Panel acknowledges this is not the final design, and that USACE will likely produce more accurate modeling of the tailwater during the final design.

Economics – The Panel found the economic analyses to be consistent with generally accepted methodologies. The population at risk and economic damages during a potential dam failure are clearly identified to support this project. Life safety risk and the annual probability of failure were given preference, as they should have been, with economic risk being given due consideration. The impact to the public is well-documented by the inundation maps and loss of life and economic impacts presented in the Baseline Consequences Analysis. For the economics analysis, damages were based on depth-damage probabilities and construction costs using

Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) modeling software. However, the Panel is concerned that while the models used to determine economic consequence were cited, further explanations geared toward guiding the decision-making process are warranted. If models and their input are not thoroughly referenced or described and if modeling results are inconsistent with accepted guidance, the project's expected risk reduction benefits may be subject to misinterpretation.

Environmental – Environmental damages were minor for construction, with the greatest impact coming from borrow material obtained from wetland areas where standard USACE methods were used to determine mitigation. The destruction of wetlands by the "taking" of borrow material in the Barker Reservoir appears to be fully mitigated in kind and in place. Environmental consequences associated with either dam failing would be extensive, but due to the urgency of the DSM Study, the qualitative descriptions provided should suffice.

6. REFERENCES

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USACE (2003b). Generic Depth-Damage Relationships for Residential Structures with Basements. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 04-01. October 10. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm04-01.pdf. Accessed February 28, 2013.

USACE (2000). Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1105-2-100. April 22.

USACE (1993). Engineering and Design - Seepage Analysis and Control for Dams. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Manual (EM) No. 1110-2-1901, Change 1. April 30.

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APPENDIX A

Final Panel Comments

on the

Addicks and Barker Dams IEPR

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Final Panel Comment 1

The serviceability of the cutoff wall structure, now over 30 years old, has not been demonstrated and cannot be relied upon.

Basis for Comment

The seepage cutoff wall was installed in several successive phases between 1978 and 1982 in sections of both dams that were deemed most at risk from seepage-induced, internal erosion and piping. As-built documents record major and recurrent quality control and trench stability problems during construction of the cutoff wall. More specifically, the as-built reports refer to quality control issues related to the batching and placement of the backfill and detail recurrent problems during construction with trench collapse prior to backfilling. The backfill material consisted of a soil-bentonite blend, of high moisture content, without the addition of cement. The wall was installed through embankment material described as “desiccated” and, for the greater part of its life and depth, the wall has been above the normal pool elevation. No in-situ testing of the cutoff wall was originally conducted (as quality assurance), while only very limited piezometer readings taken immediately after construction indicated the wall’s effectiveness at that time.

The Panel therefore observes the following:

(a) There are no data to confirm the quality and homogeneity of the cutoff wall, as originally constructed.
(b) There are very limited piezometric data to confirm the effectiveness of the cutoff wall over the 30-plus years of its service.
(c) No tests or investigations have been conducted to demonstrate the current in-situ condition of the wall, with particular regard to any desiccation and deterioration which may have progressively occurred.

Flaws in the original construction, and/or deterioration of the wall with time (leading to desiccation cracking), will reduce the hydraulic effectiveness of the wall and may reduce the level of reliability which can be placed upon it to satisfy its original design intent. Recent studies (Rice and Duncan, 2010a, 2010b) have confirmed that erosion through defects in cutoff walls (even those with cement) is a real phenomenon to be considered under certain conditions. Such progressive damage would occur much more rapidly in the case of cutoffs formulated without cement.

If indeed the existing wall is not serviceable, it will need to be replaced (as at Wolf Creek Dam, Kentucky), and current plans for its extension will have to be revised.

Significance – High

The lack of any analytical, experimental, or investigatory information about the current in-situ condition of the cutoff — a vital element of dam safety — means that there is no confirmation that the cutoff can and will perform as intended under flood conditions.

Recommendations for Resolution

1. Reevaluate the contemporary construction records from 1978 to 1982 to (a) confirm the location and extent of "collapse zones," (b) assess the possible impact of quality control problems on homogeneity and composition, and (c) assess the adequacy of the design.
2. Investigate the performance over time of the wall as indicated by the piezometric performance data. In this regard, it is noted that (a) the piezometers are limited in number, in relation to the considerable length of the cutoff, and (b) little/minimal head has typically existed across the wall due to the low level of the storage pool.
3. Conduct literature studies relating to the desiccation (and increase in permeability) of the soil-bentonite walls installed and cured in dry ambient conditions.
4. Design and implement a field testing program to demonstrate the current in-situ condition of the cutoff, with particular emphasis on those stretches where construction/quality control problems were recorded. In compliance with the contemporary standard of care exercised by the U.S. Army Corps of Engineers (USACE) at Herbert Hoover Dike, Florida, as an example, the following tests should be conducted on the existing cutoff:
   - Exposure, by excavation, to as low an elevation as safely practical.
   - Coring of boreholes at regular longitudinal intervals.
   - Permeability testing of these boreholes.
   - Optical televiewer survey of these boreholes.

   This field testing program should also measure the moisture content of the embankment soils adjacent to the wall. Should highly permeable conditions be encountered in any given borehole, dye testing should be conducted to evaluate seepage paths, and extended pump-in tests should be conducted to evaluate internal erosion potential.

Literature Cited

Rice, J.D., and Duncan, M.J. (2010a). Deformation and Cracking of Seepage Barriers in Dams due to Changes in the Pore Pressure Regime. American Society of Civil Engineers (ASCE) J Geotech Geoenviron, 133(1): 2-15.

Rice, J.D., and Duncan, M.J. (2010b). Findings of Case Histories on the Long-Term Performance of Seepage Barriers in Dams. American Society of Civil Engineers (ASCE) J Geotech Geoenviron, 133(1): 16-25.

Final Panel Comment 2

The elevation survey baseline has not been addressed and may impact several project variables, including loss of life and economic damage calculations.

Basis for Comment

It has been clearly shown in the documentation that the Addicks and Barker Dams project area has been, and will continue to be, strongly affected by regional subsidence due to aquifer pumping to the southeast. The project area has extremely large and ongoing total and differential settlements, which directly impact the dams, their reservoirs, and the floodplain. The amount of settlement is, in relative terms, very large (several feet) at the site and, given the length and orientation of the dams, has resulted in longitudinal tilting of at least one of the dams. Natural post-construction consolidation settlements are superimposed upon these regional movements.

Accurate structural baseline surveys are necessary when designing and laying out the proposed new remedial works, and for correcting and calibrating historical and ongoing instrumentation readings (especially piezometers and crest settlement data). Equally, and especially on this project, accurate data are essential inputs into hydraulic and hydrogeological studies and models.

Survey data also should be considered as part of a reliable and responsive structural monitoring plan. Monitoring the performance of the dams and their appurtenant structures, especially during high flood situations, is an important element to consider during and after project remediation.

Significance – High

Accurate survey data are essential inputs for hydraulic and hydrologic calculations (including loss of life and economic damages), and for ongoing monitoring of the service performance of the dams and their appurtenant structures during and after remediation.

Recommendations for Resolution

1. Conduct an accurate, detailed, and comprehensive topographical survey of the dams, their reservoirs, and immediate floodplains. Contemporary state-of-practice techniques, including light detection and ranging (LIDAR), should be used to supplement classic survey methods. This baseline must be updated regularly (e.g., every 3 years).
2. Focus attention on monitoring the movements of the new and abandoned outlet structures, and the adjacent dam sections as part of the broader instrumentation and monitoring plan. Baselining of the existing structures should begin promptly.

Final Panel Comment 3

The description of the design and constructability of the outlet works was not presented in sufficient detail to understand the sequencing of these activities or the implementation of certain key elements.

Basis for Comment

The Panel concurs that the decision to abandon the existing outlet works and replace them with new structures is logical. The Panel also acknowledges that consideration of design and constructability of the outlet works, as outlined in the Dam Safety Modification (DSM) Report, is at an early stage. However, the Panel is of the opinion that these early concepts merit further discussion and consideration to (a) explain more clearly the construction sequencing, and (b) address issues which have not so far been evaluated. In particular, the Panel draws attention to the following issues:

- No allowance has been made for the need to conduct a compaction-grouting / void-filling operation under each concrete structure prior to its infilling with some type of concrete. Neither the previous polyurethane grouting nor the high mobility grouting operations would have had the ability to densify the basal soils. If the basal soils were not densified, the potential consequence could be appreciable total and/or differential settlements of the filled structures (due to their increased weights), leading to seepage gaps developing between these structures and the cutoff walls surrounding them.
- The nature of the cutoff wall segments around the existing (old) and foreseen (new) outlet works has not been defined. Measures needed to ensure the tightness of the contact between cutoff and outlet works have not been described. The material to be used to create these new cutoff wall segments has not been defined.
- The sequencing of the cutoff wall construction at the new outlet works locations has not been addressed, and a clear, logical decision has not been made as to whether the cutoff or the outlet works should be built first.
- Section 7.2.5.3 of Appendix 11 of the DSM Report states that the cutoff through Noble Road “is expected to be constructed without relocating, even temporarily, the pipeline” (which is a 20-inch diameter natural gas line). It is not clear to the Panel how this can be accomplished as stated.

Significance – Medium

Not addressing these issues may lead to construction delays and claims, and the possibility of unacceptable performance of the remediation after its completion.

Recommendations for Resolution

1. Prepare a clear statement of the construction means, methods, materials, and sequencing for each structure to be abandoned or built, to elucidate constructability and optimize the cost estimate.
2. Consider densifying the basal soils (with compaction grouting) to eliminate future settlements in service for each such structure.

3. Consider the details of each structure's contact with the cutoff wall, and ensure satisfactory long-term performance at this critical interface.
4. Explain how the Noble Road section of cutoff will be built without relocating the existing pipeline.
5. Explain the connection details with the existing wall (assuming it remains serviceable) for each new section of cutoff.

Final Panel Comment 4

Slope stability analyses, which confirm that the current and proposed embankment geometry provides required factors of safety, are not provided.

Basis for Comment

It is assumed that slope stability analyses of the upstream and downstream embankments (as built) have been performed in accordance with Engineer Manual (EM) 1110-2-1902 (USACE, 2003a) and that those results meet the requirements specified in Table 3-1 of that document. Appendix 11 Engineering Appendix (p. 3-9) of the review documents briefly states that the

> "…results from numerous stability analyses over the years has provided satisfactory factors of safety".

However, no summaries or calculations were provided in the review documents. If the missing slope stability information has led to incorrect results, improvements to the embankments may be required as part of the Recommended Alternative (Alternative 2). Of particular concern regarding this omission is upstream stability for steady-state and rapid-drawdown conditions. The potential impact of the trench collapses which occurred during construction of the cutoff wall should be considered, as they may have weakened the embankment.

Based on a request from the Panel for the slope stability calculations, the U.S. Army Corps of Engineers (USACE) provided the following two documents:

1) *Dam Safety Assurance General Design Memorandum (GDM) for the Buffalo Bayou and Tributaries, Texas, Addicks and Barker Dams* dated June 1984; and

2) *Dam Safety Assurance Supplement No.1 to General Design Memorandum* dated December 1985.

The GDM included detailed slope stability calculations associated with the proposed geometry to raise the dam crest by raising the upstream embankment. However, Supplement No. 1, which revised the proposed design by placing fill on the downstream embankment to raise the dam crest, did not include any slope stability calculations for the revised geometry. Therefore slope stability calculations for the current geometry have not been provided for either the upstream or downstream embankments.

Significance – Medium

For completeness, the review documents should demonstrate that the stability of the earth embankments meets EM 1110-2-1902.

Recommendations for Resolution

1. Locate the previous slope stability analyses for the existing condition of the upstream and downstream dam embankments. Confirm that the methods used are in

accordance with EM 1110-2-1902 and that the results for all applicable loading conditions (including rapid drawdown) meet the requirements in Table 3-1 of the referenced manual.

2. Consider the potential for weakened upstream embankment soils which may have resulted from the numerous trench collapses that occurred during construction of the cutoff wall.
3. Provide a summary of the upstream and downstream embankment slope stability results in Section 2.6.7 of the Dam Safety Modification (DSM) Report.
4. Discuss the embankment stability results and cite or append the document that contains the detailed slope stability analyses in Chapter 3 of Appendix 11.

Literature Cited

USACE (2003a). Engineering and Design - Slope Stability. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Manual (EM) No. 1110-2-1902. October 31.

Final Panel Comment 5

The complete list of potential failure modes (PFMs) and the reasons why some were dismissed have not been documented in the Dam Safety Modification (DSM) Report.

Basis for Comment

Chapter 3 and Appendix 1 of the DSM Report do not discuss or list all of the PFMs that were identified during the early risk assessment studies for the project. According to the DSM Report (p. 1-3), the risk cadre teams identified 22 PFMs for Addicks Dam and 23 PFMs for Barker Dam. Only the significant failure modes (a subset of the 22 and 23 PFMs) are included in the DSM Report and appendices.

In response to a request from the Panel, the U.S. Army Corps of Engineers (USACE) provided the Addicks Reservoir and Barker Reservoir Issue Evaluation Studies (IESs) along with other supporting information, including Potential Failure Mode Assessment (PFMA) analyses. The IESs and the other supporting information provide a complete list of the PFMs considered, along with a brief statement of why they were not considered significant.

Significance – Medium

Providing the complete list of failure modes, and the reasons why some were discounted or not developed, would provide more robust documentation that various modes of failure were considered.

Recommendations for Resolution

1. Briefly discuss and reference the complete list of PFMs identified and the reasons some failure modes were not considered significant in Section 3.1.3 of the DSM Report.
2. Include the full list of PFMs for each dam and the reasons some failure modes were not developed in Appendix 1 of the DSM Report.

Final Panel Comment 6

The discussion of seepage using the USACE-preferred methodologies of flow nets and computer analysis (SEEP-W) has not been sufficiently emphasized in the Dam Safety Modification (DSM) Report and related documents, which focus on the less rigorous Weighted Creep Path Method.

Basis for Comment

The DSM Report generally emphasizes the use of the "Weighted Creep Path Method" to evaluate seepage and potential piping as potential failure modes (PFMs) (refer to Sections 2.7.9, 3.1.3, and 3.1.4 as well as Chapter 3 in Appendix 11 of the DSM Report). This method is an approximate method based on empirical data from hundreds of dam case histories. The U.S. Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-1901 (USACE, 1993) and the state of standard practice generally require more rigorous analyses to evaluate seepage and exit gradients that may cause piping of foundation soils. It appears that flow nets and the finite element program SEEP-W were also used in the DSM Report to evaluate seepage (Appendix 11, Chapter 3.1) at critical/worst-case sections, and that the results generally agree with those of the Weighted Creep Path Method. In addition, the *Evaluation of Seepage and Piping Potential, Addicks and Barker Dams* memorandum included in Chapter 9 of Appendix 11 of the DSM Report presents the seepage results of both the flow nets and SEEP-W method (Section 6) and the Weighted Creep Path Method (Section 7). The discussion and presentation of the flow net and SEEP-W results in the referenced memorandum and in the DSM Report (Sections 2.7.9, 3.1.3, 3.1.4 and Chapter 3.1 of Appendix 11) are limited and difficult to follow. For example, the discussion does not describe how and at what locations the exit gradients were calculated, nor does it explain how, based on the calculated exit gradients, it was determined that adequate factors of safety were achieved. However, the analyses appear to support the conclusions presented in the overall DSM Report.

Significance – Medium

The presentation of the flow net and SEEP-W analyses results in a limited understanding of how those methods were used and limits confidence in the conclusions that may have been drawn based on those analyses.

Recommendations for Resolution

1. Expand and clarify the discussion of the flow net and SEEP-W analyses in Section 2.7.9 of the DSM Report and Section 3.1 of Appendix 11.
2. Confirm the use of the flow net or SEEP-W analyses to calculate exit gradients and, in turn, discuss these analyses in appropriate sections (e.g., PMF-6 in Section 3.1.3 and PFMs 7 and 8 in Section 3.1.4).

Literature Cited

USACE (1993). Engineering and Design - Seepage Analysis and Control for Dams. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Manual (EM) No. 1110-2-1901, Change 1. April 30.

Final Panel Comment 7

The residual risk associated with post-Phase 1 construction was not thoroughly described.

Basis for Comment

The IEPR Panel understands and concurs with the decision to split the Addicks and Barker Dam safety upgrade into two phases. As stated in the Dam Safety Modification (DSM) Report, “due to the extremely high risk associated with seepage and piping beneath, around, and near the conduits,” it was decided to proceed immediately with Phase 1, and Phase 2 will be completed at a later date.

In the event of very high floods, approximately 2.5 feet to 4.5 feet of water will be flowing around the ends of the dams when the reservoir levels reach the crests of their respective auxiliary spillways. A very large number of downstream structures will be impacted by the flow around the dam as in addition to the many structures upstream of the dams that would be flooded during the Probable Maximum Flood (PMF). This potential of “flanking flow” and of upstream and downstream flooding will continue to be significant issues after the main spillways are reconstructed in Phase 1. Therefore, the Panel believes that the DSM Report should clearly state the significant risk that will remain due to the potential of flow around the dams and flooding in the reservoir after Phase 1 is completed.

Significance – Medium

Additional information on the significant flood risk that remains after post-Phase 1 construction would provide a more complete understanding of how the project will proceed into the second phase.

Recommendations for Resolution

1. Expand the narrative in the DSM Report that describes the residual risk after Phase 1 construction is completed.

Final Panel Comment 8

Land use controls to prohibit future development in the project pool and further encroachment into the Probable Maximum Flood (PMF) reservoir level have not been documented.

Basis for Comment

Since the Addicks and Barker Dams were constructed, expansive development has occurred adjacent to the boundary of the federally owned land around the reservoirs. Much of the development has occurred below the PMF reservoir level for the dams and in the low elevation area at the end of the dams where water would flow around the dam in the event of an extreme flood. This extensive development has occurred in the downstream "hydraulic shadow," which has resulted in increased flood and loss-of-life risk to residents, private industry, and government agencies. The current risks of potential dam failure are well-outlined in the Dam Safety Modification (DSM) Report. Future development in the areas subject to flooding will increase the projected risk to inhabitants in the floodplain.

Land use controls that would prevent further development in the floodplain would serve to minimize potential flood damage and loss-of-life risk. Implementation of existing or planned land use controls (including zoning or mapping measures and communication of flood risks to area residents), with the goal of preventing additional development in the floodplain, would logically be a part of the flood damage reduction plan. Existing risk to property and life will be reduced after completion of Phase 1 construction; however, land use controls can control or prevent the escalation of future flooding risks, especially if development continues unrestricted.

Significance – Medium

Additional information on land use controls would improve the understanding of future escalation of flooding risk.

Recommendations for Resolution

1. In the DSM Report, describe the land use controls in place and efforts to communicate the risk to residents and local government agencies of flooding as a result of potential dam failure.

Final Panel Comment 9

The origin and nature of the faults that intersect the embankments have not been adequately discussed.

Basis for Comment

From a geotechnical perspective, faults crossing dams are of significant concern because they may lead to weakened planes or preferential seepage paths through the embankment and/or foundation. Two draft February 2011 Issue Evaluation Studies (IESs) prepared for the Dam Safety Modification (DSM) Report and provided to the Panel indicate that potential failure mode (PFM) 11 was identified by the risk cadre teams for both the Addicks and Barker Dams as "Regional faults crossing dam result in cracks in dam and/or foundation," so it appears that the geotechnical implications of the faults have been considered (Addicks Reservoir IES, p. B-14; Barker Reservoir IES, p. B-38). However, the faults and the associated potential dam safety considerations are not discussed in Section 2.5.4.2 (Damsite Geology) or elsewhere in the DSM Report.

The regional faults at the dams show clear evidence of vertical movement and an orientation that appears to be generally transverse to the embankments; therefore, a preferential seepage path may potentially exist in the desiccated portion of the embankments associated with the movement along the fault.

Significance – Medium

Faults beneath or through dams warrant discussion and geotechnical consideration. If the impacts of the faults have not been fully and adequately evaluated (particularly with respect to a preferential seepage path or a weakened sliding surface) improvements may be required as part of the Recommended Alternative (Alternative 2).

Recommendations for Resolution

1. Discuss the origin, nature, and location of the faults in Section 2.5.4.2 of the DSM Report.
2. Consider field investigation such as test pitting where the fault crossed the embankments to evaluate the condition of the embankment along the fault.
3. Discuss the impacts of the faults in Chapter 3 (Static Stability) of Appendix 11.

Final Panel Comment 10

The models used to determine economic consequences were not documented clearly.

Basis for Comment

Application of models and their input is the basis for the Addicks and Barker Dam Safety Modification (DSM) study results. The DSM Report provides minimal explanation of how specific models, such as LIFESim and Hydrologic Engineering Center-Flood Impact Analysis [HEC-FIA], work and what their inputs are. For example, the *LIFESim* model was used to determine loss of life. While population at risk was calculated (using HEC-FIA) to be greatest at night for both Addicks and Barker Dams (pp. 3-107 and 3-108 of the DSM Report), the loss of life is greater during the day-time for Addicks, but greater at night-time for Barker, with no explanation given.

Furthermore, property damages computed for discrete pool elevation failures (using HEC-FIA) were based on depth-damage input data that are seemingly inconsistent with U.S. Army Corps of Engineers (USACE) guidance (USACE, 2003b; 2009). This inconsistency can be seen when comparing Figure 4-2 on p. 2-18 in Appendix 2 (Addicks) and, similarly, Figure 4-2 on p. 3-18 in Appendix 3 (Barker) with the table in USACE (2003b). This sample graphic implies that the damage estimates could vary considerably from what was reported. Figure 4-2 is a sample graphic (the only graphic provided) for an atypical house type in the Houston area; as such, it underestimates the structure damages by depth for both Addicks and Barker Dams in comparison with USACE (2003b). It also significantly overestimates the content damage for that category structure, but truncates the damage at a depth of 11 feet for a two-story residential structure. Similarly, the vehicle damage-damage curve data points (p. 2-19) do not match those of USACE (2009).

Significance – Low

If models and their input are not thoroughly referenced or described and if modeling results are inconsistent with accepted guidance, the project's expected risk reduction benefits may be subject to misinterpretation. Nonetheless, it appears that the overwhelming potential loss of life and damage output data would not be impacted to the extent that it would change the order of alternative ranking.

Recommendations for Resolution

1. Provide a concise description of how the models employed to analyze potential economic consequences work, discuss the models' input data, and explain the uncertainties associated with the input data and output data.
2. Reference pertinent 2003b and 2009 USACE guidance in the DSM Report.
3. Discuss and, if necessary, correct the anomaly between the dams and their comparative day versus night loss of life.

Literature Cited

USACE (2003b). Generic Depth-Damage Relationships for Residential Structures with Basements. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 04-01. October 10. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm04-01.pdf. Accessed February 28, 2013.

USACE (2009). Generic Depth-Damage Relationships for Vehicles. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 09-04. June 22. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm09-04.pdf. Accessed February 28, 2013.

Final Panel Comment 11

The DSM Report does not account for population change over the 50-year period of economic analysis.

Basis for Comment

While the primary concern of the Addicks and Barker Dams is the overwhelming potential for loss of life, the potential direct and indirect economic consequences for the existing conditions is also considerable. However, the economic analysis (Appendix 2, Sections 2.2, 2.2.8.1-2, and 3) does not appear to account for assumed population growth and the attendant property, content, and infrastructure over the 50-year period of economic analysis as required by Sections 9.5.2 and Q5.2.4.2 of Engineer Regulation (ER) 1110-2-1156 (USACE, 2011). In fact, direct damage estimates are stated to result from the application of the Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) model to specific pool elevation events based on the current population and existing conditions. However, these numbers do not appear to be used to estimate economic benefits. Project benefits (column 2 of Table 7-1, Appendix 2) are based on an unspecified deterministic rather than probabilistic accounting of flood risk management benefits from 1947 to 2011 for the historic conditions for each of those years.

Significance – Low

Without incorporating the future conditions over the 50-year period of economic analysis, it is likely that the loss of life and economic consequences are underestimated, but would not affect the ranking of alternatives.

Recommendations for Resolution

1. Either forecast a future without-project condition or provide clear and concise reasoning for using a surrogate of historic damages avoided as a basis for benefit analysis.

Literature Cited

USACE (2011). Safety of Dams – Policies and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

Final Panel Comment 12

Documentation for the basis of the preliminary hydraulic and structural designs for the new outlet works intake, conduit, spillway, and stilling basin is not discussed in sufficient detail.

Basis for Comment

The engineering analyses that were completed to prepare the alternative development plans are not described or referenced in the Dam Safety Modification (DSM) Report. Specifically, the basis for development of the preliminary hydraulic and structural designs shown on the drawings for the alternatives is not discussed in the DSM Report.
Section 3.4.1 of the DSM Report briefly discusses the hydrologic analysis and the system response curves for each alternative for the significant failure modes. In addition, the basis for development of the preliminary hydraulic and structural designs for the alternatives (shown on the drawings in Chapter 8 of Appendix 11) is not discussed in the DSM Report.

Appendix 11 contains documentation of hydraulic evaluations that were performed for the preliminary design of the new outlet works, but there is no reference in the DSM Report to this analysis.

The drawings of the alternatives for the new outlet works indicate that defensive structural design measures are to be included for the conduit, spillway, and stilling basin structures to prevent failure from seepage and piping. The details and basis of the new structural designs are not discussed in the DSM Report or appendices.

Significance – Low

Additional documentation of the hydraulic and structural engineering analyses used to develop the alternatives presented in the DSM Report will improve the technical quality of the report.

Recommendations for Resolution

1. Provide additional discussion in Section 3.4.1 of the DSM Report on the basis for the hydraulic designs, including what is already provided in the appendices for the hydrologic and hydraulic analyses conducted.
2. Provide details and basis of the new structural designs in the DSM Report or appendices.

Final Panel Comment 13

While it appears that the Recommended Alternative was logically formulated and selected to meet the study objectives, the study constraints were not defined in sufficient detail to determine if they were fully considered in the plan formulation.

Basis for Comment

As required by Step 1 of the U.S. Army Corps of Engineers (USACE) plan formulation process (USACE, 2000 [Section E.3]; USACE, 2011 [Section 9.5.1]), "the planning team develops objectives and constraints based on those problems and opportunities." The constraints were not clearly identified in the context of the planning process. It appears that staying within the project authorization and limiting downstream discharges to 2,000 cubic feet per second (cfs) are planning constraints. Because these constraints, in part, guide the study process, they should be clearly identified along with any other constraints developed by the planning team.

As it is presented now, constraints are mentioned on pp. 1-5 and 5-1 in the Dam Safety Modification (DSM) Report but are never really defined.

Significance – Low

Clearly identifying the constraints that guided the Addicks and Barker DSM Study would improve the technical clarity and completeness of the review documents.

Recommendations for Resolution

1. Clearly describe in the DSM Report the constraints for the overall DSM Study and in the formulation of the Recommended Alternative.

Literature Cited

USACE (2000). Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1105-2-100. April 22.

USACE (2011). Safety of Dams – Policies and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

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APPENDIX B

Final Charge to the Independent External Peer Review Panel as Submitted to USACE on January 25, 2013

on the

Addicks and Barker Dams IEPR

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Charge Questions and Guidance to the Peer Reviewers for the Independent External Peer Review of the Dam Safety Modification (DSM) Report for Addicks and Barker Dams, Texas

BACKGROUND

The Galveston District's PDT is preparing a decision document, the DSM report, for the remediation of the Addicks and Barker Dams. The DSM report will be comprised of the main report and supported by technical appendices and other documents as needed for approval. The DSM report documents the deficiency issues of seepage and piping beneath the outlet structures and embankment failure resulting from uncontrolled flow around the ends of the Addicks and Barker Dams and the recommended corrective actions to resolve these deficiencies. The DSM report serves as the decision document authorizing remediation of the related seepage and piping deficiencies in order for the project to function safely and effectively and in compliance with the USACE Engineering Regulation, ER 1110-2-1156, Dam Safety Policy and Procedures. The DSM report describes the alternative risk management plans considered and the plan recommended for remediation of the seepage and piping deficiencies. Following HQUSACE approval of the DSM report and Appendices and the Environmental Assessment (EA) with a signature of the Finding of No Significant Impact (FONSI), the Project Delivery Team (PDT) will proceed into preconstruction engineering and design activities for the Addicks and Barker Dam Safety Modification Project.

Study Description.
Note: Due to the extremely high risk associated with seepage and piping beneath, around, and near the conduits, this study was completed to address the issues associated with the conduits. A Phase 2 study will be completed to address the non-breach risk, risk exposure (both downstream and upstream), potential operational changes, and potential failure modes associated with auxiliary spillway flow and flow around the ends of the dams.

The Addicks and Barker Reservoirs are part of the Buffalo Bayou and Tributaries flood risk management system located on the west side of Houston, Texas. This system provides flood risk management benefits for the City of Houston, the fourth largest city in the United States. Over 4 million people live and work in and transit through the Buffalo Bayou watershed. Industrial, commercial, and residential development is located throughout the Buffalo Bayou corridor. In addition to commercial and residential structures, this development includes hospitals, highways, roads and utilities, oil industry infrastructure and water and sewerage treatment facilities. The Addicks and Baker Reservoirs were constructed in the mid-1940s, and the principal structural feature is the relatively flat terrain, which exists across the Addicks and Barker reservoir areas. These reservoirs serve as detention basins designed to collect excessive amounts of rainfall during storm events. Following a storm event, the reservoirs release the collected rainfall down Buffalo Bayou at a controlled rate (not to exceed 2,000 cfs) which prevents flooding in downtown Houston and the urban areas west of downtown. The Addicks and Barker Reservoirs were originally designed and constructed as storm water detention systems that reduce the peaks of flood hydrographs by extending the duration flow. With the increased development of lands downstream of the reservoirs forcing the tighter regulation of the water releases and the

increased development of the watershed upstream of the reservoirs causing increased runoff into the projects, the value of the dams and reservoirs for flood damage reduction is ever increasing. Four of the top ten pools at both the Addicks and Barker dams have occurred in the past 10 years. However, these structures now essentially function as dams and thus they are currently operating beyond the original design intent.

The Addicks Reservoir project features include an earthen dam, concrete outlet works, and uncontrolled spillways. The earthen dam consists of an unzoned, random fill embankment that is 61,166-feet long with a maximum height of 53.5-feet above the streambed. A 12-foot wide gravel road extends along the top of the dam. Top of dam elevation ranges from 117.4-ft to 121-ft NAVD88 (01adj). Five gated concrete conduits, 8-feet wide by 6-feet high by 252-feet long, serve as the outlet works. The original intake structure design only gated the center conduit of the five conduits on the upstream side of the dam. Additional contracts added the open steel frame intake structure service platform and gates on the four originally ungated conduits. The four outside conduits are controlled by means of rectangular electrically operated 8-foot wide by 10-foot high sluice gates. The center conduit is controlled by twin 3-foot wide by 8-foot high electrically operated sluice gates. A maximum design discharge of 7900-cfs passes through a 43.5-foot long spillway into a 40-foot long by 60-foot wide stilling basin then through a 150 feet riprap lined outlet channel emptying into the improved channel of South Mayde Creek. An auxiliary spillway approximately 8400-ft long with an average crest elevation of 112.5-ft NAVD88 is at the north end of the dam. An auxiliary spillway approximately 10,500-ft long with an average crest elevation of 115.5-ft NAVD88 is on the south end of the dam. The north and south auxiliary spillways tie into natural ground at elevation 108-ft NAVD88 and 111-ft NAVD88, respectively, and water flanks around them before the auxiliary spillway crest overtops. The auxiliary spillways are armored with roller-compacted concrete that serve as uncontrolled spillways.

The Barker Reservoir project features include an earthen dam, concrete outlet works, and uncontrolled spillways. The earthen dam consists of an unzoned, random fill embankment that is 71,900-feet long with a maximum height of 42.9-feet above the streambed. A 12-foot wide gravel road extends along the top of the dam. Top of dam elevation ranges from 110.0-ft to 113.1-ft NAVD88 (01adj). Five gated concrete conduits, 9-feet wide by 7-feet high by 190.5-feet long, serve as the outlet works. The original intake structure design only gated the center conduit of the five conduits on the upstream side of the dam. Additional contracts added the open steel frame intake structure service platform and gates on the four originally ungated conduits. The four outside conduits are controlled by means of rectangular electrically operated 9-foot wide by 10-foot high sluice gates. The center conduit is controlled by twin 9-foot wide by 8-foot high electrically operated sluice gates. A maximum design discharge of 8730-cfs passes through a 55.5-foot long spillway into 50-foot long by 60-foot wide stilling basin then through a 160 feet riprap lined outlet channel emptying into the improved channel of Buffalo Bayou. An auxiliary spillway approximately 3000-ft long with an average crest elevation of 105.5-ft NAVD88 is at the north end of the dam. An auxiliary spillway approximately 12,500-ft long with an average crest elevation of 106.7-ft NAVD88 is at the south end of the dam. The north and south auxiliary spillways tie into natural ground at elevation 104-ft NAVD88 and water flanks around them before the reservoir pool overtops the auxiliary spillway crest. The auxiliary spillways are armored with roller-compacted concrete that serve as uncontrolled spillways. Seepage control

measures were incorporated at both projects due to seepage concerns. Potential seepage and piping is associated with erodible foundation soils and increased storage durations caused by gated operation. These erodible foundation soils consist of mostly fine sand and silt layers randomly interbedded with discontinuous clay layers, pockets, and seams. The seepage control measures included the construction of a soil bentonite slurry trench through the embankment and pervious foundation, placement of a downstream berm to enhance slope stability, and placement of clay blankets to thicken the impervious cover over pervious foundation materials. This work was accomplished between 1977 and 1982.

As a result of provisions contained in the Dam Safety Assurance Program, the Addicks and Barker Dams were modified to conform to updated design criteria. Remedial work consisted of two primary features. First, the crest elevation of major portions of the dam was raised to achieve needed freeboard requirements. Second, erosion protection was added to the lower ends of the dams so the ends can serve as overflow spillways during storms greater than the Standard Project Flood (SPF), up to and including the Probable Maximum Flood (PMF). This work was accomplished between 1986 and 1989.

Several factors within and around the conduits have led to recent repairs. These include: erodible foundation sands, 'window' areas of the bentonite cutoff walls adjacent to the conduits, open conduit joints, cracks within the parabolic spillways, void formation beneath the conduits and spillway and lack of engineered filters. Chemical grouting was undertaken in 2009 to fill large voids beneath the conduits at Addicks and Barker Dams.

Cementitious grouting was undertaken in 2010 beneath and adjacent to the entire outlet works structure at both dams. Without intervention and with the occurrence of enough higher pools, the dams have a high likelihood of failure under normal operations. Furthermore, the estimated life loss due to dam failure is extremely high. Both of these are essential characteristics of DSAC I dams that have been substantiated by the IES Studies completed in February 2011. The Addicks and Barker Dams are currently categorized as Dam Safety Action Classification (DSAC) I (urgent and compelling: unsafe). The current DSAC was determined from the following events:

- May 2007 – Screening for Portfolio Risk Analysis (SPRA) Team classified Dam as DSAC II.
- September 2009 – IES Team recommended the classification be changed to DSAC I.
- October 2009 – Senior Oversight Group (SOG) changed classification to DSAC I. March 2011 – SOG retained classification as DSAC I.

The Dam Safety Modification Report (DSMR) serves as the Decision Document.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the technical basis for the economic, engineering, and environmental methods, models, data and analyses, and assumptions supporting the DSM report on Remediation of the Addicks and Barker Dams, Texas. An IEPR is one of the important procedures used to ensure the quality of published information meets the standards of the scientific and technical community. This peer review typically evaluates the clarity of hypotheses, the validity of the research and design, the quality

of data collection procedures, the robustness of the methods employed, the appropriateness of the methods for the hypotheses being tested, the extent to which the conclusions follow from the analysis, and the strengths and limitations of the overall products.

The purpose of the IEPR portion of the scope is to analyze the adequacy and acceptability of economic, engineering, and environmental methods, models, data and analyses, and assumptions performed for the DSM report, EA, and technical appendices. The IEPR will be limited to technical review and will not involve policy review. This review will be conducted by subject matter experts with extensive experience in engineering, economic, and environmental issues associated with dam safety considerations. The subject matter experts will be "charged" with responding to specific technical questions, as well as providing a broad technical (engineering, economic, and environmental) evaluation of the overall project. The review panel shall focus on answering the general questions listed in Appendix B for each phase of the project. The review panel shall not make a recommendation on whether a particular alternative should be implemented, as the Chief of Engineers is ultimately responsible for the final decision on USACE work products.

The IEPR panel members (i.e., reviewers) will identify, recommend, and comment upon the assumptions underlying the analyses, as well as evaluate the soundness of models, and the design and analytical methods used. The reviewers should be able to evaluate whether the interpretations of analyses and conclusions are technically sound and reasonable, provide effective review in terms of both usefulness of results and of credibility, and have the flexibility to bring important issues to the attention of decision makers. The reviewers may offer opinions as to whether there are sufficient technical analyses upon which to base the ability to implement the recommendations of the DSM report. The independent reviewers will address factual inputs, data, the use geotechnical, structural, hydrologic, and hydraulic models, analyses, assumptions, and other scientific and engineering tools/methodologies to inform the decision-making process. This work will be conducted in accordance with procedures described in the Department of the Army, U.S. Army Corps of Engineers, Engineer Circular (EC) 1165-2-214, *Civil Works Review* (15 December 2012), and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (16 December 2004).

USACE officials may attend panel meetings, but may not participate in the management or control of the group. USACE cannot be a voting member of the group, may not direct activities at the meetings, and may not develop the agenda for the meetings. USACE officials must refrain from participating in the development of any reports or final work product of the group.

DOCUMENTS PROVIDED

The following is a list of documents, supporting information, and reference materials that will be provided for the review.

Documents for Review

The review documents will be provided by USACE on January 23, 2013.

Title	Approx. No. of Pages	Required Disciplines
Dam Safety Report	382	All Disciplines
Appendix 1 – Risk Assessment and Risk Management Alternative Formulation	898	Geotechnical engineer, engineering geologist, civil/structural engineer, hydraulic and hydrologic engineer
Appendix 2 - Addicks Dam Life Loss and Economic Evaluation and Economic Consequences	23	Economist/planner and environmental planner/NEPA impact assessment expert
Appendix 3 – Barker Dam Life Loss and Economic Evaluation and Economic Consequences	23	Economist/planner and environmental planner/NEPA impact assessment expert
Appendix 5 - Environmental Assessment	216	Economist/planner and environmental planner/NEPA impact assessment expert
Appendix 11 - Engineering	592	Geotechnical engineer, engineering geologist, civil/structural engineer, hydraulic and hydrologic engineer

Supporting Documents

No supporting documents have been identified.

Documents for Reference

The following USACE regulations shall be followed in conducting the IEPR. The most recent Engineer Circulars (EC), Manuals (EM), Pamphlets (EP), and Regulations (ER) shall be used, which are available at: http://140.194.76.129/publications/ or http://www.hnd.usace.army.mil/techinfo/engpubs.htm.

General

- EC 1105-2-410, Review of Decision Documents, 22 August 2008
- EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
- EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy, Change 1, 31 January 2012

- EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and Risk Reduction Measures for Dams, 9 April 2010
- EP 1110-2-13, Dam Safety Preparedness, 28 June 1996
- ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (change 2)
- ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
- ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28 October 2011
- ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001.
- National Academy of Sciences, "Policy and Procedures on Committee Composition and
- Balance and Conflicts of Interest for Committees Used in the Development of Reports," May 2003 for General Scientific and Technical Studies and Assistance: General Scientific and Technical Studies and Assistance. Available at: http://www.nationalacademies.org/coi/index.html
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended.

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECW-P, 28 December 1990
- Council on Environmental Quality. 1978. Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR Parts 1500-1508. Washington, DC: U.S. Government Printing Office (November 29, 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988.

Engineering Geology

- EM 1110-1-1804, Engineering and Design - Geotechnical Investigations, 01 January 2001
- ER 1110-1-1807, Engineering and Design - Procedures for Drilling in Earth Embankments, 01 March 2006
- EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations, 31 August 1995.

Geotechnical Engineering

- EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1902, Engineering and Design - Slope Stability, 31 October 2003

- EM 1110-2-2300, Engineering and Design - General Design and Construction Considerations For Earth and Rock-Fill Dams, 30 July 2004
- EM 1110-2-1908, Engineering and Design - Instrumentation of Embankment Dams and Levees, 30 June 1995
- ER 1110-2-110, Engineering and Design - Instrumentation for Safety Evaluations of Civil Works Projects, 8 July 1985.

Materials Engineering

- ER 1110-1-1901, Project Geotechnical and Concrete Materials Completion Report for Major USACE Project, 22 February 1999
- EM 1110-2-1906, Laboratory Soils Testing, 20 August 1986
- ER 1110-2-1911, Engineering and Design - Construction Control for Earth and Rock-Fill Dams, 30 September 1995
- EM 1110-2-2000, Engineering and Design - Standard Practice for Concrete for Civil Works Structures, 31 March 2001.

Structural Engineering

- EM 1110-2-2002, Evaluation and Repair of Concrete Structures, 30 June 1995
- EM 1110-2-2100, Engineering and Design - Stability Analysis of Concrete Structures, 1 December 2005
- EM 1110-2-2102, Waterstops and Other Preformed Joint Materials for Civil Works Structures, 30 September 1995
- EM 1110-2-2104, Engineering and Design - Strength Design for Reinforced-Concrete Hydraulic Structures, 20 August 2003
- EM 1110-2-2400, Engineering and Design - Structural Design and Evaluation of Outlet Works, 02 June 2003
- EM 1110-2-4300, Instrumentation for Concrete Structures, 30 November 1987
- ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 15 February 1995.

Hydraulic Engineering

- EM 1110-2-1602, Engineering and Design - Hydraulic Design of Reservoir Outlet Works, 15 October 1980
- EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, 16 January 1990
- EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
- EM 1110-2-3600, Engineering and Design - Management of Water Control Systems, 30 November 1987
- ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
- ER 1110-2-240, Water Control Management, 8 October 1998

- ER 1130-2-530, Flood Control Operations and Maintenance Policies, 30 October 1996
- ER 1110-2-8156, Preparation of Water Control Manuals, 31 August 1995.

SCHEDULE

This final schedule is based on the January 23, 2013 receipt of the final review documents.

Task	Action	Days to Complete Action	Due Date
Conduct Peer Review	Battelle sends Review documents to Panel	Within 1 day of completing subcontracts for panel members	1/24/2013
	Battelle convenes kickoff meeting with Panel	Within 2 days of Panel being under subcontract	1/25/2013
	USACE/Battelle convenes kickoff/site meeting with Panel (3 days: 1 day travel/1 day site visit/1 day travel)	Within 6 days of Panel being under subcontract	1/31/2013
	Panel members complete their review of documents	Within 12 days of Panel receiving review documents	2/11/2013
Prepare Final Panel Comments and Final IEPR Report	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	Within 3 days of panel members completing their review	2/14/2013
	Battelle convenes Panel Review Teleconference	Within 1 day of panel members receiving merged comments	2/15/2013
	Battelle finalizes Final Panel Comments	Within 6 days of receipt of draft-final Final Panel Comments	3/1/2013
	Battelle provides Final IEPR Report to Panel for review	Within 1 day Final Panel Comments being finalized	3/4/2013
	Panel provides comments on Final IEPR Report	Within 1 day of receipt of Final IEPR Report	3/5/2013
	*Battelle submits Final IEPR Report to USACE	Within 4 days of the Final Panel Comments being finalized	3/7/2013
Comment/ Response Process	Battelle convenes teleconference with Panel to review the Post-Final Panel Comment Response Process (if necessary)	Within 1 day of submittal of Final IEPR Report	3/8/2013
	USACE provides draft PDT Evaluator Responses to Battelle	Within 6 days of receipt of Final IEPR Report	3/15/2013
	Battelle provides the Panel the draft PDT Evaluator Responses	Within 0 days of receipt of draft PDT Evaluator Responses	3/15/2013
	Panel members provide Battelle with draft BackCheck Responses	Within 2 days of receipt of draft PDT Evaluator Responses from Battelle	3/19/2013

Task	Action	Days to Complete Action	Due Date
Comment/ Response Process, continued	Battelle convenes teleconference with Panel to discuss draft BackCheck Responses	Within 1 day of receipt of draft BackCheck Responses	3/20/2013
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments and draft responses	Within 4 days of USACE providing draft Evaluator Responses	3/21/2013
	USACE inputs final PDT Evaluator Responses in DrChecks	Within 2 days of Final Panel Teleconference	3/25/2013
	Battelle provides PDT Evaluator Responses to Panel	Within 0 days of final PDT Evaluator Responses being available	3/25/2013
	Panel members provide Battelle with final BackCheck Responses	Within 2 days of receipt of final PDT Evaluator Responses	3/27/2013
	Battelle inputs the Panel's BackCheck Responses in DrChecks	Within 3 days of notification that USACE final PDT Evaluator Responses have been posted in DrChecks	3/28/2013
	*Battelle submits pdf printout of DrChecks project file	Within 1 day of DrChecks closeout	3/29/2013

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the Addicks and Barker Dams IEPR documents are credible and whether the conclusions are valid. The Panel is 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 asked to provide feedback on the economic, engineering, environmental resources, and plan formulation. The panel members are not being asked whether they would have conducted the work in a similar manner.

Specific questions for the Panel (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 Addicks and Barker Dams IEPR documents. Please focus your review on the review materials assigned to your discipline/area 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 1165-2-214; 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 engineering, 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 evaluating 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 Agency Technical Review (ATR).
2. Please contact the Battelle Project Manager Rachel Sell (sellr@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle Program Manager, Karen Johnson-Young (johnson-youngk@battelle.org) immediately.
4. Your name will appear as one of the panel members 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 Rachel Sell (sellr@battelle.org)**, no later than February 11, 2013, COB ET.**

Independent External Peer Review of the Independent External Peer Review of the Dam Safety Modification (DSM) Report for Addicks and Barker Dams, Texas

Charge Questions and Relevant Sections As Supplied By USACE

General (3)

1. Were risk and uncertainty sufficiently considered?
2. Are potential life safety issues accurately and adequately described under existing, future without project, and future with project conditions?
3. In your opinion, are there sufficient analyses upon which to base the recommendation?

Problem, Needs, Constraints, and Opportunities (1)

4. Are the problems, needs, constraints, and opportunities adequately and correctly defined?

Existing and Future without Project Resources (3)

5. Do you agree with the general analyses of the existing social, financial, and natural resources within the study area?
6. Was the hydrology discussion sufficient to characterize current baseline conditions and to allow for evaluation of how forecasted conditions (with and without proposed actions) are likely to affect hydrologic conditions. Please comment on the completeness of the discussion of the relationship between subsurface hydrology and the hydrodynamics of the project area.
7. Are the future conditions expected to exist in the absence of a Federal project logical and adequately described and documented?

Plan Formulation / Evaluation (4)

8. Was a reasonably complete array of possible measures considered in the development of alternatives?
9. Are future Operation, Maintenance, Repair, Replacement, and Rehabilitation efforts adequately described and are the estimated cost of those efforts reasonable for each alternative?
10. Please comment on the screening of the proposed alternatives. Are the screening criteria appropriate? In your professional opinion, are the results of the screening acceptable? Were any measures or alternatives screened out too early?
11. Were the engineering, economic, and environmental analyses used for this study consistent with generally accepted methodologies? Why or why not?

Recommended Plan (2)

12. Comment on whether you agree or disagree with how the selected alternative was formulated and selected. Comment on the plan formulation. Does it meet the study objectives and avoid violating the study constraints?
13. Please comment on the completeness of the recommended plan, i.e. will any additional efforts, measures, or projects be needed to realize the expected benefits?

Dam Safety (5)

14. Has the condition of the dam, including the design and construction of the dam and appurtenant features, project maintenance, previous major rehabilitations and dam safety modifications, and the dam's performance over time, been clearly described?
15. Is there sufficient information presented to identify, explain, and comment on assumptions that underlie engineering analyses. Why or why not?
16. Were the characteristics, conditions, and scenarios leading to failure, along with the potential consequences adequately identified? Were pertinent factors, including population at risk, considered in the estimation of risk for the baseline condition? Were all the dam safety issues and opportunities identified?
17. Have all alternatives received sufficient consideration, including those involving repairing, replacing, or removing the dam?
18. Have the potential impacts of each alternative been clearly and adequately presented?

Project Specific Questions (3)

19. Are the methods used to evaluate the condition of Addicks Dam and Barker Dam adequate and appropriate given the circumstances?
20. Have the hazards that affect the structure been adequately described for Addicks Dam and Barker Dam?
21. Has anything significant been overlooked in the development of the assessment of Addicks Dam and Barker Dam or the alternatives?

Environmental Assessment Questions (4)

22. Has the affected environment and environmental consequences of all alternatives been adequately described? If not, please elaborate.
23. Should any other resources be considered for the affected environment? If yes, please elaborate.
24. Does the mitigation result in the project meeting the threshold of negligible adverse impact on significant environmental resources? If not, please elaborate.
25. Have all pertinent Federal Acts, Regulations, and Executive Orders been considered and compliance demonstrated? If not, please elaborate.

FINAL OVERVIEW QUESTION (1)

26. 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?