



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

CECW-ZB

JUN 10 2013

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

SUBJECT: Buffalo Bayou and Tributaries, Texas, Addicks and Barker Dam Safety Modification Report and Environmental Assessment – Final USACE Response to Independent External Peer Review

1. Independent External Peer Review (IEPR) was conducted for the subject project in accordance with Section 2034 of the Water Resources Development Act of 2007, EC 1165-2-214, and the Office of Management and Budget's Final Information Quality Bulletin for Peer Review (2004).
2. The IEPR was conducted by Battelle Memorial Institute. The IEPR panel consisted of five members with technical expertise in economics, planning/environmental processes, geotechnical engineering, civil/structural engineering and hydraulic/hydrology engineering.
3. I approve the final written responses to the IEPR contained in the enclosed document. The IEPR Report and USACE responses have been coordinated with the vertical team, endorsed by the Risk Management Center, and will be posted on the Internet, as required in EC 1165-2-214.
4. If you have any questions on this matter, please contact me, or have a member of your staff contact Ms. Sandy Gore, Deputy Chief, Southwestern Division Regional Integration Team, at 202-761-5237.

STEVEN L. STOCKTON, P.E.
Director of Civil Works

Encl

**Buffalo Bayou and Tributaries, Texas
Addicks and Barker
Dam Safety Modification Report and Environmental Assessment**

**FINAL
U.S. Army Corps of Engineers Response to
Independent External Peer Review
May 2013**

Independent External Peer Review (IEPR) was conducted for the subject project in accordance with Section 2034 of WRDA 2007, EC 1165-2-214, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (2004).

The goal of the U.S. Army Corps of Engineers (USACE) Civil Works program is to always provide scientifically sound, sustainable water resources solutions for the nation. The USACE review processes are essential to ensuring project safety and quality of the products USACE provides to the American people. Battelle Memorial Institute (Battelle), a non-profit science and technology organization with experience in establishing and administering peer review panels for the USACE, was engaged to conduct the IEPR of the Buffalo Bayou and Tributaries, Texas Addicks and Barker Dams Draft Dam Safety Modification Report (DSMR) and Draft Environmental Assessment (EA).

The Battelle IEPR panel reviewed the Draft DSMR and Draft EA, as well as supporting documentation. The Final IEPR Battelle Report was issued on 7 March 2013.

Overall, thirteen comments were identified and documented; two were identified as having high significance, seven were identified as having medium significance and four were identified as having low significance. The following discussions present the USACE Final Response to the thirteen comments.

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 field of geotechnical engineering, engineering geology, civil/structural engineering, hydraulic/hydrology engineering, economics/planning, and environmental/NEPA impact assessment. Five panel members were selected for the IEPR from more than 25 candidates identified.

1. Comment – *High Significance*: The serviceability of the cutoff wall structure, now over 30 years old, has not been demonstrated and cannot be relied upon.

This comment includes four recommendations for resolution, all of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR panel recommended (1) reevaluation of 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. In response, construction records and reports were reviewed to verify the displacement of the collapsed material during backfill of the cutoff wall structure. Construction records were reevaluated by engineering consultants in the early 1980’s and the location and extent of the “collapse zones” were detailed in the “Slurry Trench Stability Report” prepared by the National Soil Services, Inc., dated April 26, 1982. Based on the information provided in the Slurry Trench Stability Report, the collapses were limited to the upper soil about 3 to 4 feet below the top of the cutoff wall and on the downstream side of the cutoff wall during the open trench period following excavation. The possible impact on the homogeneity and composition of the cutoff wall was minimal as the collapses occurred before the backfill completion of the cutoff wall. The collapsed material in the slurry of the cutoff wall was displaced by the backfill. Additional investigations will be conducted during the Preconstruction, Engineering and Design (PED) phase and the information gathered will be used in the next periodic assessment scheduled for 2017. The IEPR Panel recommended (2) investigating the performance of the cutoff wall over time using the data from the piezometers. In response, USACE will continue to monitor the performance of the cutoff wall using the data from the piezometers as it has since construction of the cutoff wall. Additional piezometers have been installed since the original construction of the cutoff wall and some of them were automated to facilitate the gathering of data for evaluating the performance of the cutoff wall. The recommended risk management plan includes the installation of additional piezometers which will increase the available data for evaluating the performance of the cutoff wall. The IEPR Panel recommended (3) conducting literature studies relating to the desiccation (and increase in permeability) of the soil-bentonite cutoff walls installed and cured in dry ambient conditions. In response, USACE will conduct the literature study in conjunction with the upcoming periodic assessments of the Addicks and Barker Dams scheduled for 2017. The IEPR Panel recommended (4) the design and implementation of a field testing program to demonstrate the current in-situ condition of the cutoff wall, with particular emphasis on those stretches where construction/quality control problems were recorded. In response, USACE will design and implement a field testing program as recommended in conjunction with the upcoming periodic assessments of Addicks and Barker Dams in 2017.

2. Comment – *High Significance*: The elevation survey baseline has not been addressed and may impact several project variables, including loss of life and economic damage calculations.

This comment includes two recommendations for resolution, both of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) that an accurate, detailed, and comprehensive topographical survey of the dams, reservoirs, and immediate floodplains be conducted using contemporary state-of-practice techniques, including light detection and ranging (LIDAR) to supplement classic survey methods and that the baseline be updated regularly. In response, USACE is using an elevation survey baseline that is accurate, detailed and comprehensive developed from 2002 LIDAR 2-foot resolution surveys which were supplemented with gage datum adjustments by the USGS and field surveys conducted in 2010. Additionally, the LIDAR data was “ground proofed” with GPS RTK survey data shots to verify the accuracy of the LIDAR data used for the Dam Safety Modification Study. This survey will be updated after construction of the new outlet works structures scheduled for completion in 2018. Post construction periodic assessments of the project survey datum will be included as an assessment item of the periodic inspections of the Addicks and Barker Dams. The IEPR Panel recommended (2) focusing attention on monitoring the movements of the new and abandoned outlet work structures, and the adjacent dam sections as part of the broader instrumentation and monitoring plan. In response, USACE will monitor regional settlement/subsidence for movements of the new and abandoned outlet structures, and adjacent dam sections. The initial assessment period determined by the USACE will take into account historical survey assessments. The period will be adjusted as necessary to maintain accurate survey data for future evaluations in dam safety performance.

3. Comment – *Medium Significance*: 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.

This comment includes five recommendations for resolution, all of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) preparing 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. In response, these items are

further documented in Chapter 7 Development of Quantities and Construction Sequencing for Cost Estimates of the revised Appendix 11 Engineering. The IEPR Panel recommended (2) considering densifying the basal soils (with compaction grouting) to eliminate future settlements in service for each such structure. In response, the design for filling voids within the foundation basal soils beneath the abandoned outlet works structures to eliminate future settlements will be developed during PED and the details will be incorporated in the project plans and specifications for construction. The IEPR Panel recommended (3) considering the details of each structure's contact with the cutoff wall to ensure satisfactory long-term performance at this critical interface. In response, USACE will ensure that the details of the contact between the abandoned/new outlet works structure and the respective new cutoff wall ensure satisfactory long-term performance at this critical interface. The details will be developed during PED and the details will be incorporated in the project plans for construction. The IEPR Panel recommended (4) explaining how the Noble Road section of cutoff will be built without relocating the existing pipeline. In response, an explanation is provided in Chapter 7 Development of Quantities and Construction Sequencing for Cost Estimates of the revised Appendix 11 Engineering. The design details will be developed during PED and the details will be incorporated in the project plans for construction. The IEPR Panel recommended (5) providing details of the connection details with the existing cutoff wall for each new section of cutoff wall. In response, USACE will ensure that the design of the connection details with the existing cutoff wall for each new section of cutoff wall will be developed during PED and the details will be incorporated in the project plans for construction.

4. Comment – *Medium Significance*: Slope stability analyses, which confirm that the current and proposed embankment geometry provides required factors of safety, are not provided.

This comment includes four recommendations for resolution, all of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) locating the previous slope stability analyses for the existing condition of the upstream and downstream dam embankments and confirming 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. In response, the USACE located the summary results from previous slope stability analyses and confirmed that the factors of safety are adequate. The computation sheets from these previous slope stability analyses were not recovered, consequently, a complete slope stability analyses in accordance with EM 111-0-2-1902 was conducted which confirmed that all loading conditions, including rapid drawdown, met the requirements of Table 3-1 of EM 111-0-

2-1902 and are presented in the revised Appendix 11 Engineering. The IEPR Panel recommended (2) considering the potential for weakened upstream embankment soils which may have resulted from the numerous trench collapses that occurred during construction of the cutoff wall. In response, the Slurry Trench Stability Report prepared by the National Soil Services, Inc. dated April 26, 1982 was reviewed, as well as the post-construction reports concerning the cut-off wall slurry trench collapses to evaluate the potential for weakened upstream embankment soils as input to the slope stability analyses. Based on these reviews it was determined that the slopes for both the Addicks and Barker dams are adequately designed and are stable for its current configurations. The detailed analysis and results of all cases are presented in Appendix 11 Engineering. The IEPR Panel recommended (3) a summary of the upstream and downstream embankment slope stability results be added to Section 2.6.7 of the Dam Safety Modification Report. In response, a summary of the upstream and downstream embankment slope stability results was added to Section 2.6.7 of the Dam Safety Modification Report. The IEPR Panel recommended (4) that a discussion of the embankment stability results and the detailed slope stability analyses be included in Chapter 3 of Appendix 11 Engineering. In response, the discussion has been added to Chapter 3 of Appendix 11 Engineering.

5. Comment – *Medium Significance*: 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.

This comment includes two recommendations for resolution, both of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) including a brief discussion and reference of the complete list of PFMs identified and the reasons some failure modes were not considered significant in Section 3.1.3 of the Dam Safety Modification Report. In response, Section 3.1.1 of the DSM Report was revised to include a brief discussion and reference of the complete list of PFMs identified and the reasons why some failure modes were not considered significant as prepared for the Potential Failure Mode Analyses (PFMA) and Issue Evaluation Study (IES). The IEPR Panel recommended (2) including the full list of PFMs for each dam and the reasons some failure modes were not developed in Appendix 1 of the DSM Report. In response, a full list of PFMs for each dam and the reasons some failure modes were not developed were prepared as part of the potential failure mode analyses (PFMA) and Issue Evaluation Study (IES) and have been included in Appendix 1 of the DSM Report.

6. Comment – *Medium Significance*: 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.

This comment includes two recommendations for resolution, both of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) expanding and clarifying 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. In response, the discussions of the seepage analyses were expanded and revised in Section 2.7.9 of the DSM Report and Section 3.1 of Appendix 11 to include the use of flow nets and SEEP-W. The IEPR Panel recommended (2) confirmation of 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). In response, the appropriate sections of the DSM Report were revised to discuss the methodology used to calculate the exit gradients and to clarify that analyses were conducted using flow net and SEEP-W which yielded the same results that seepage would occur along the horizontal sand layer within the dam foundations and that gradients in sections other than the outlet works were too low to initiate piping within the dam foundations. These findings for sections other than the outlet works are included in the revised Section 2.7.9 of the DSM Report and Section 3.1 of Appendix 11.

7. Comment – *Medium Significance*: The residual risk associated with post-Phase 1 construction was not thoroughly described.

This comment includes one recommendation for resolution which has been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended expanding the narrative in the DSM Report that describes the residual risk after Phase 1 construction is completed. In response, the discussion in the DSM Report and Section 4.1 of the Dam Safety Action Decision Summary were revised to describe the residual risk that will remain after construction of Phase 1 is complete, which calls for a follow on Phase 2 study that will address the risk associated with the potential flow around the ends of the dams during the Probability Maximum Flood (PMF) and/or when the reservoir level reaches the crests of their respective auxiliary spillways, non-breach risk, and potential

operational concerns. Additionally, Harris County Flood Control District continues to study and manage the non-breach flood risk upstream and downstream of Addicks and Barker Dams.

8. Comment – *Medium Significance*: 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.

This comment includes one recommendation for resolution which has not been adopted as discussed below.

USACE Response: Not Adopted.

The IEPR Panel recommended that the DSM Report describe and implement land use controls and efforts to communicate the risk to residents and local government agencies of flooding as a result of potential dam failure in order to prevent a projected increase of risk to inhabitants in the floodplain. Land use controls to prohibit future development into the project pool and further encroachment into the Probable Maximum Flood (PMF) reservoir level have not been documented in the DSM Report as the USACE does not have the authority to restrict development on non-Government owned lands. Extensive communications have occurred since 2010 with local authorities, governments, and the public. Additional public meetings are scheduled at the end of the DSM phase, and a website is available with updated information.

Requirements for the inclusion of onsite detention for private development off Government owned lands surrounding the reservoirs are enforced by local flood control entities in both Harris and Fort Bend counties. The Harris County Flood Control District is actively implementing flood control measures to upstream and downstream tributaries of the Buffalo Bayou which include detention, channel rectification and channel enlargement. These floodplain management practices are considered in the hydrological analysis for the Addicks and Barker Reservoirs.

The land use controls in place for development within the government owned lands of the Addicks and Barker Reservoirs and the current use of the project and its projected future use are documented in paragraphs 2.3.3 and 2.4 of the DSM Report, respectively.

9. Comment – *Medium Significance*: The origin and nature of the faults that intersect the embankments have not been adequately discussed.

This comment includes three recommendations for resolution, all of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) a discussion of the origin, nature, and location of the faults be included in Section 2.5.4.2 of the DSM Report. In response, a discussion that notes that there is no historical record of major earthquakes in this region and that describes the origin and nature of the Brittmore fault that crosses the embankment of Addicks Dam and that no fault is known to cross the embankment of Barker Dam was added to the revised Section 2.5.4.2 of the DSM Report. The discussion also includes details on fault traces of the Addicks Fault System that have been identified within the Addicks Reservoir area and within the Barker Reservoir which are several hundred feet from the dam embankments. The IEPR Panel recommended (2) considering field investigations such as test pitting where the fault crossed the embankment to evaluate the condition of the embankment along the fault. In response, the USACE will excavate a test pit near the upstream toe of the dam embankment to inspect and evaluate the fault and possible impact of the fault on the dam embankment and foundation prior to the next periodic assessment. The information gathered will be used in the next periodic assessment of Addicks Dam scheduled for 2017. The IEPR Panel recommended (3) a discussion of the impacts of the faults be added to Chapter 3 (Static Stability) of Appendix 11. In response, Chapter 3 (Static Stability) of Appendix 11 was revised. Chapter 3 documents that the Brittmore fault that crosses the embankment of Addicks Dam does not impact the stability of the dam embankment and includes details on how the risk analysis team arrived at this conclusion.

10. Comment – *Low Significance*: The models used to determine economic consequences were not documented clearly.

This comment includes three recommendations for resolution, of which one has been adopted and two which were not adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) discussing and, if necessary, correcting the anomaly between the dams and their comparative day versus night loss of life. In response, Section 3.2 of Appendix 2 has been revised to discuss the location of seven commercial, industrial and hotel structures between Interstate 10 and the toe of Addicks Dam that account for a large number of daytime life loss in the Addicks Dam failure analysis, but are not affected by a failure of Barker Dam. This is the primary reason for the day versus night difference in the life loss between the two dams.

USACE Response: Not Adopted.

The IEPR Panel recommended (2) referencing USACE EGM No 04-01 and EGM No 09-04 in the DSM Report. The USACE concurred that had those damage curves been used, they would

be referenced. However, in the Dam Safety Modification Study, the HAZUS dataset was used, including occupancy type and redefined depth damage curves for different structure occupancy types. The depth damage functions for structures, contents and vehicles are sufficient to capture the estimated economic consequences resulting from dam failure. Additional information and refinement of the economic information would not result in a different recommendation.

The IEPR Panel recommended (3) providing 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. In response, it was explained to the IEPR panel that the recommended information is contained in the Dam Safety Modification Report, Appendix 2 Addicks Dam Life Loss Consequences and Economic Evaluation and Economic Consequences and Appendix 3 Barker Dam Life Loss Consequences and Economic Evaluation and Economic Consequences, and further documentation is not necessary. Specifically, Section 2.2 of Appendices 2 and 3 provides a concise description of the Life Loss methodology of the HEC-FIA model and its use of the simplified LifeSim Model. Section 4.1 of Appendices 2 and 3 explains how the model employed the Economic Consequences and how the HEC-FIA uses HAZUS (hazard US data) as input for the model. The uncertainty in the model, in regards to life loss, is in the assumptions of the model parameters. This is explained in Section 2.2.8 of Appendices 2 and 3. The primary economic consequence uncertainty (dollar damages) is due to the uncertainty of the hydrology (i.e. inundation and depths of flooding) which is accounted for in the hydrologic model and documented in Section 1 of Appendix 11 Engineering.

11. Comment – *Low Significance*: The DSM Report does not account for population change over the 50-year period of economic analysis.

This comment includes one recommendation for resolution which has not been adopted as discussed below.

USACE Response: Not Adopted.

The IEPR Panel recommended either forecasting a future without-project condition or providing clear and concise reasoning for using a surrogate of historic damages avoided as a basis for benefit analysis. The life and economic consequences are most likely understated equally for all alternatives and would not affect the ranking of alternatives. The primary decision metric is life-safety, so gathering additional information for the economic analysis would not have added additional significant decision information. The study did include information about historic flood damages prevented as existing information and adequate for the identified decision. The flood benefits foregone in the event of dam failure are a very small percentage of the overall cost of failure, and therefore, more refined information would not change the ranking of alternatives.

Additionally, future with and without project economic damages are limited from inclusion in the economic analysis due to Section 308 of WRDA 1990.

12. Comment – *Low Significance*: 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.

This comment includes two recommendations for resolution, both of which have been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended (1) providing 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. In response, Section 3.4.1 of the DSM Report has been revised to include additional discussion on the basis for the hydraulic designs, including what is already provided in Chapter 1 of Appendix 11 – Engineering. Additional descriptions, basis, and more detail analyses will also be developed during the PED phase of the project. These include descriptions for hydraulic and structural analyses and design criteria. The IEPR Panel recommended (2) providing the details and basis of the new structural designs in the DSM Report or appendices. In response, Chapter 5 of Appendix 11 Engineering was revised to include some details and basis of the structural designs. The final structural design and development of all details will be completed during final design (PED) of the selected alternative.

13. Comment – *Low Significance*: 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.

This comment includes one recommendation for resolution which has been adopted as discussed below.

USACE Response: Adopted.

Action Taken: The IEPR Panel recommended clearly describing in the DSM Report the constraints for the overall DSM Study and in the formulation of the Recommended Alternative. In response, Section 3.1. Dam Safety Issues and Opportunities of the DSM Report was revised to clearly describe the study constraints for the overall DSM Study and in the formulation of the Recommended Alternative which consisted of technical, environmental, economic, regional, social, and institutional constraints.