Final Compiled Comments and Responses on the Independent External Peer Review of the Addicks and Barker Dams

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.

PDT Final Evaluator Response (FPC#1):

__Concur _X_Non-Concur

Explanation: The PDT acknowledges that there is limited piezometric data. However, the serviceability of the cutoff wall was the focus of PFM 17 – Foundation seepage and piping due to defects in cutoff wall. The reason for discounting was that seepage and piping analyses reflected that seepage due to any defects (if any exist) in the slurry wall are negligible. Foundation seepage, even at maximum pool, was shown to not be a factor through much of the alignments of the dams. This can be seen in the table of computed gradients relative to initiating piping in the memorandum dated 6 August 2009 (Revised 19 April 2011), Subject: Evaluation of Seepage and Piping Potential, Addicks and Barker Dams, Buffalo Bayou and Tributaries, Houston, Texas. This memorandum is presented in Appendix 11 of the DSM Report. These gradients were presented during the evaluation of PFM 17. Soils profiles (boring logs) of the embankments were reviewed relative to the composition of the earth embankments and soils profiles show that the earth embankments were constructed of low plasticity clay. With seepage through the foundations and through the embankments not issues for potential failures, PFM 17 was discounted. Data from decades of monitoring piezometers at both dams, the slurry cutoff was seen to be effective in restricting seepage through the foundations at both dams. In addition, any potential erosion through defects, if existed, in cutoff wall is expected to be minimal because there is not a permanent pool and thus the continuous hydraulic loading behind the embankment.

Nevertheless, although it is not an immediate concern because of the reasons described above, the PDT agrees to adopt the following recommendations to insure the continuous serviceability of the cutoff wall.

Recommendation #1: _X_Adopt __Not adopt
Explanation: Contemporary construction records were reevaluated by engineering consultants in the early eighties. The location and extent of "collapse zones" were detailed in "Slurry Trench Stability" (report) by National Soil Services, Inc., for USACE dated April 26, 1982. Based on the information provided in the report, the collapses were limited to the upper soil about 3 to 4 feet below the top of the slurry wall and on the downstream side of the slurry wall during the open trench period following excavation. The possible impact on the homogeneity and composition of the slurry wall should be minimal as the collapses occurred before the backfill completion of the slurry wall. The collapsed material in the slurry should have been displaced by the backfill. The District is reviewing additional construction records and reports to verify the displacement of the collapsed material during backfill. If supporting documentation is unavailable, investigations will be conducted during PED phase and the information gathered will be used in the next periodic assessment of Addicks and Barker Dams in 2017.

Recommendation #2: _X_Adopt __Not adopt
Explanation: The District has continuously monitored the performance of the slurry cut-off wall since its construction. Data is limited by infrequent pools of short duration and little reservoir rise. Additional piezometers have been installed since its construction and additional piezometers are planned and some of the piezometers are also being automated.

Recommendation #3: _X_Adopt __Not adopt
Explanation: The District will conduct a literature study relating to the desiccation (and increase in permeability) of the soil-bentonite walls installed and cured in dry ambient conditions in conjunction with the upcoming periodic assessments of Addicks and Barker Dams in 2017.

Recommendation #4: _X_Adopt __Not adopt
Explanation: The District will 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 conjunction with the upcoming periodic assessments of Addicks and Barker Dams in 2017.

Panel Final BackCheck Response (FPC#1):

__X_Concur __Non-Concur

The Panel recognizes that the PDT's opinion may change in light of the results from the studies recommended by the Panel and adopted by the PDT.

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.

PDT Final Evaluator Response (FPC#2):

__Concur __X_Non-Concur

Explanation:

The DSMS hydrology and hydraulics analyses including reservoir elevation-area-capacity ratings are based on 2002 LIDAR 2-foot resolution surveys (NAVD88 and NAD83) supplemented with gage datum adjustments by the USGS and field surveys conducted in 2010. The 2010 surveys consisted of confirming horizontal and vertical control, obtaining topographic cross sections and profile data of the Addicks and Barker Reservoir outfall channels and feeder ditches. Cross sections were generated and contours from existing LIDAR survey data and plan view drawings created utilizing NAIP (National Agriculture Imagery Program) aerial photographic imagery with their respective metadata files. Additionally LIDAR data was “ground proofed” with GPS RTK survey data shots to verify the accuracy of the LIDAR data used for the DSMS. Regional settlement/subsidence is accounted therefore variables for economics and loss of life are considered reliable and accurate for this study.

The Harris-Galveston Subsidence District (HGSD) was established by the State of Texas in 1975 to regulate groundwater pumping in Harris and Galveston Counties. Ground water withdrawal and land subsidence has been decreasing significantly for Harris and Galveston Counties for the period after 1978 as indicated on Figure 17: Subsidence for the Period 1978-2000 of Section 1.7 of Appendix 11- Engineering. This decreased rate in subsidence provides a higher degree of confidence when adjusting elevations after 1980.

Harris and Galveston counties continue to work on regional projects to convert from ground water withdrawals to surface water supply. The Luce Bayou Interbasin Transfer Project (LBITP) is a regional water supply project proposed to be implemented by Coastal Water Authority (CWA) that would transfer raw water from the Trinity River Basin to Lake Houston, a major water supply reservoir for the City of Houston.

The need for the LBITP is to meet the projected water demand and to increase available water supplies to comply with contracted, future demands identified by the City of Houston. A secondary objective of the LBITP is to assist with the conversion of groundwater to surface water supply sources to control land subsidence that has occurred from excessive pumping of area groundwater aquifers. The LBITP is a cornerstone in satisfying the mandated groundwater-to-surface water conversion program designed to control subsidence in the Houston area. The conversion to surface water supplies is expected to slow subsidence by 2010. By 2020, subsidence is expected to be controlled and finally halted by 2030. Water levels within the Gulf Coast Aquifer are predicted to rebound by as much as 125 feet through the implementation of the HGSD’s groundwater withdrawal reduction plan. Therefore, the Addicks and Barker Dams project area is not expected to be affected in the future by regional subsidence due to aquifer pumping to the southeast.

Recommendation #1: _X_Adopt __Not adopt

Explanation: SWG is required to meet compliance with Vertical Datum Guidance ER 1110-2-8160. The ER recommends periods for assessment from 5 to 20 years. Accurate, detailed, and comprehensive topographical surveys using the state-of-art and compliance with the ER will be performed under post project conditions.

Recommendation #2: _X_Adopt __Not adopt

Explanation: Regional settlement/subsidence will be monitored for movements of the new and abandoned outlet structures, and adjacent dam sections. The initial assessment period determined by the PDT will take into account historical survey assessments. The period will be adjusted as necessary to maintain reasonably accurate survey data for future evaluations in dam safety performance.

Panel Final BackCheck Response (FPC#2):

__X_Concur __Non-Concur

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.

PDT Final Evaluator Response (FPC#3):

_X_ Concur __Non-Concur

Explanation: The design and constructability of the outlet works was developed to sufficient detail to understand the sequencing of these activities to enable development of accurate cost estimates, however, it was not presented in sufficient detail in the DSM Report.

Recommendation #1: _X_Adopt __Not adopt
Explanation: The construction effort in general is seemingly a straight-forward diversion-excavation-construction-backfill operation and to a large extent this is true. However, several significant design/construction elements are unique to the remediation of these two dams: (1) Voids and disturbances in the foundation soils at the bottom of the outlet works structures must be addressed to provide a remediated stable foundation for the abandoned outlet works; (2) tying the new cutoffs to the abandoned structures and the new cutoffs to the newly constructed outlet works structures are crucial to achieving a continuous cutoff through the embankment and foundation; (3) proper sequencing of the construction; and (4) construction of the slurry cutoff at the pipeline crossing of the dam.

The discussion of construction activities as presented in the DSM Report, which provided a general idea of the activities, will be revised to incorporate descriptions of methods to address the unique features. These construction activities will include filling voids beneath the conduits beneath the abandoned outlet works structures to provide satisfactory foundations for the increased weight of the grout-filled conduits; details of the interface/connection tying the new cutoffs to their respective structures; sequencing of the construction activities; and a discussion of the operations predicted for the pipeline crossing. This discussion will be inserted into the revised DSMR.

Recommendation #2: _X_Adopt __Not adopt
Explanation: Filling voids within the foundation soils beneath the abandoned outlet works structures to eliminate future settlements will be added to the project plans and specification during PED.

Recommendation #3: _X_Adopt __Not adopt
Explanation: Details of the contact between the abandoned/new outlet works structure and

the respective new cutoff wall to ensure satisfactory long-term performance at this critical interface will be developed during PED and the details will be incorporated in the project plans for construction.

Recommendation #4: _X_Adopt __Not adopt
Explanation: The top elevation of the cutoff wall at Noble Road section is expected to be below the level of the existing pipeline. Construction of this section of cutoff across the pipeline will be through coordination with the pipeline company to either temporarily detour the pipeline flow and/or casing off the pipeline during construction. Details of the design and construction will be added to the project plans and specifications during PED. This discussion will be inserted in the final DSMR.

Recommendation #5: _X_Adopt __Not adopt
Explanation: Plans of the connection details with the existing wall for each new section of cutoff will be developed during the PED and will be added to the project plans for construction.

Panel Final BackCheck Response (FPC#3):

__X__Concur __Non-Concur

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.

PDT Final Evaluator Response (FPC#4):

_X_Concur __Non-Concur

Explanation: The slope stability analyses were only referenced in the DSM Report and were not included because the computation sheets illustrating the stability analyses could not be found.

Recommendation #1: _X_Adopt __Not adopt
Explanation: The summary results from previous stability analyses presented adequate factors of safety in accordance with Corps of Engineers regulations and practice. The computation sheets from these previous slope stability analyses have not been recovered. A complete stability analyses in accordance with EM 111-0-2-1902 to confirm that all loading conditions, including rapid drawdown, meet the requirements of Table 3-1 in the referenced EM is underway by District geotechnical engineers and will be included in the final DSM Report.

Recommendation #2: _X_Adopt __Not adopt
Explanation: Slurry wall stability evaluation for the “collapse zones” during the slurry wall construction was provided in “Slurry Trench Stability” (report) by National Soil Services, Inc., for USACE dated April 26, 1982. The post-construction reports concerning the slurry trench collapses will be reviewed to evaluate this potential for input to the stability analyses. Review of the post-construction slurry trench reports is underway by District geotechnical engineers to provide potential reductions in strengths of the upstream embankment soils with completion during the concurrent stability analyses.

Recommendation #3: _X_Adopt __Not adopt
Explanation: A summary of the results of the stability analyses will be included in Section 2.6.7 of the final Dam Safety Modification Report.

Recommendation #4: _X_Adopt __Not adopt
Explanation: The results of the slope stability analyses will be discussed in Chapter 3 of Appendix 11 of the final Dam Safety Modification Report.

Panel Final BackCheck Response (FPC#4):

__X_Concur __Non-Concur

The Panel understands that the USACE is performing a complete stability analyses in accordance with EM 111-0-2-1902 to confirm that all loading conditions, including rapid drawdown, meet the requirements of Table 3-1 in the referenced EM and that the results will be included in the final DSM Report. It is further understood that if the analyses indicate inadequate factors of safety, that improvements will be included in the Plan such that slope stability requirements are achieved or exceeded.

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.

PDT Final Evaluator Response (FPC#5):

_X_Concur __Non-Concur

Explanation: A complete list of potential failure modes (PFMs) were developed as a part of the potential failure mode analyses (PFMA) and issue evaluation study (IES). This information was provided to the contractor but not documented in the DSM Report and Appendix 1.

Recommendation #1: _X_Adopt __Not adopt
Explanation: Section 3.1.1 of the DSM Report will be revised to include a brief discuss and will reference 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).

Recommendation #2: _X_Adopt __Not adopt
Explanation: 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 will be included in Appendix 1 of the DSM Report.

Panel Final BackCheck Response (FPC#5):

__X__Concur __Non-Concur

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).

PDT Final Evaluator Response (FPC#6):

_X_Concur __Non-Concur

Explanation: Neither flow nets nor SEEP-W was used to calculate exit gradients for backward erosion piping at the outlet works of Addicks & Barker dams. Early seepage analyses with flow nets indicated that seepage would occur along the horizontal sand layer within the dam foundations & that gradients in sections other than the outlet works were too low to initiate piping within the dam foundations. Therefore, these methodologies were not emphasized in the Dam Safety Modification (DSM) Report. It should be noted that the less rigorous Weighted Creep Path Method was used only as an indicator of potential seepage issues.

Recommendation #1: _X_Adopt __Not adopt
Explanation: The discussions of the seepage analyses will be expanded and revised in Section 2.7.9 and Section 3.1 of Appendix 11 including use of flow nets and SEEP-W. This new text will be included in the final DSM Report.

Recommendation #2: _X_Adopt __Not adopt
Explanation: Neither flow nets nor SEEP-W was used to calculate exit gradients for backward erosion piping at the outlet works of Addicks and Barker dams. Early seepage analyses with flow nets indicated 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 will also be included in Section 2.7.9 and Section 3.1 of Appendix 11. SEEP-W confirmed the findings of the flow nets. Beneath the outlet works at both Addicks and Barker Dams, seepage would occur along and beneath the conduits with entrance at the upstream ends of the conduits and with exit at the downstream ends of the conduits. The conduits were constructed at the bases of excavations that cut through the upper clay layer and into the foundation sand layer. Gradients were then simply calculated as reservoir elevation minus tailwater elevation over the length of the conduits. This will be discussed in greater detail and included in the appropriate sections. The weighted creep path method was used only to illustrate the potential for erosion beneath the conduit structures during early discussions and presentations of the ongoing study. The weighted creep path method is a very good way to compare the erosion potential beneath a given dam to the 255 dams in the study that established the weighted creep path method. The weighted creep path method was never used to calculate hydraulic gradients. The analyses will be discussed in the appropriate sections of the final DSM Report.

Panel Final BackCheck Response (FPC#6):

_X_Concur __Non-Concur

The benefits of using the weighted creep path method, particularly for the case of erosion along and beneath the conduits are not being questioned by the Panel. The Panel appreciates that the PDT has confirmed that Flow Net and SEEP-W Analyses have indicated exit gradients that are too small to initiate piping at other cross sections and that this will be presented in appropriate sections of the DSM Report.

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.

PDT Final Evaluator Response (FPC#7):

_X_ Concur __Non-Concur

Explanation: This dam safety modification study (Phase 1) would provide immediate risk reduction measures to address existing urgent and compelling deficiencies, whereas, the Phase 2 Study would take an unknown amount of additional time and funds to complete given the current and numerous uncertainties associated with fully addressing potential end-around flow and operational changes. The Corps is aware that some residual risk will remain upon completion of the Phase I efforts. However, it should be noted that the residual risk of failure after completion of the Alternative 2 measures would be below tolerable risk guidelines (TRG), however, the consequences would remain high. This is illustrated in

Tables 3-36 and 3-41 and Figures 3-68 and 3-73 of the DSM Report.

Recommendation #1: _X_ Adopt __Not adopt
Explanation:
The Corps will edit the first paragraph of section 4.1 of the Dam Safety Action Decision Summary (DSADS) as follows. A similar expanded narrative will also be provided within the DSM report as recommended.

first paragraph of section 4.1 in the DSADS

This dam safety modification study (DSMS) will be labeled as the "Phase 1" and will be the first of a two phase effort to fully address all potential failure modes associated with Addicks and Barker Dams. Due to the extremely high risk associated with seepage and piping beneath, around, and near the conduits, this study was completed to primarily address these issues associated with the conduits. A Phase 2 study will be conducted to address the non-breach risk, risk exposure (both downstream and upstream) and potential operational concerns at the ends of the dams. Phase 2 will involve a lengthy process of coordinating local, state and federal stakeholders to comprehensively evaluate the life safety, environmental, industrial and economic impacts of potential end-around flooding and land use. Phase 1 will provide immediate risk reduction measures to address existing urgent and compelling deficiencies.

Panel Final BackCheck Response (FPC#7):

__X_ Concur __Non-Concur

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.

PDT Final Evaluator Response (FPC#8):

_X_Concur ___Non-Concur

Explanation: 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 in the DSM Report as the US Army Corps of Engineers (USACE) is not a land use management authority for private development in Harris and Fort Bend Counties.

Recommendation #1: __Adopt _X_Not adopt

Explanation: 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.

Numerous schools, emergency support facilities, and utilities and communication facilities are located in the consequence area along Buffalo Bayou downstream of Addicks and Barker Dams and through the City of Houston and are documented on Figure 2-5 Schools in Houston, Texas, Figure 2-6 Emergency Support Facilities in Houston, Texas, and Figure 2-7 Utility and Communication Facilities in Houston, Texas of the DSM Report.

Shortly after receiving notification in 2010 from HQUSACE that the Addicks and Barker Dams were rated DSAC I, the District began implementing Interim Risk Reduction Measures while conducting the DSM study. Project improvements implemented between 2010 thru 2012 included updated the District's Emergency Action Plan for the Dams and coordinated the plan with local authorities, conducted Risk Communications with the Public and installing a reservoir regulator alarm system for stage and rainfall reporting as documented in paragraph 2.6.15. Interim Risk Reduction Measures, Addicks and Barker Dams of the DSM Report.

Chapter 13 Communication Plan and Appendix F Public Outreach Data of the Addicks and Barker Appendix 7 PMP for Design Phase describe the efforts to communicate the risk to residents and local government agencies of flooding as a result of potential dam failure. Public meetings were conducted in FY2010 and FY2011 to inform the public of the issues identified with the dams as well as the efforts being undertaken by USACE to address these issues as noted in paragraph 13.6 Communications Timeline of the Communication Plan. Additional public meetings will be scheduled once the DSM Report is approved to inform the public of the recommended plan and the timeline for development of plans and specifications and contract award. A webpage, http://www.addicksandbarker.info/, has been set-up to keep the public informed of ongoing efforts between the public meetings.

Requirements for the inclusion of onsite detention for private development off Government owned lands surrounding the reservoirs is 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.

Panel Final BackCheck Response (FPC#8):

_X_ Concur __Non-Concur

The above explanation of efforts to communicate flooding risk to local governments and private developments is helpful in understanding the PDT's position on this issue. The

Panel commends the efforts described above to communicate the risk of flooding and loss of life as a result of a potential dam failure. Clearly, it is a local responsibility, not the PDT's responsibility, to control development in the floodplain outside of the government owned land. We concur with the decision to not attempt to describe the local land use controls (for lands outside the government owned area) in the DSM Report.

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.

PDT Final Evaluator Response (FPC#9):

_X_Concur __Non-Concur

Explanation: A detailed discuss of the origin and nature of the faults that intersect the embankments was not included in the DSM Report as they were not considered a concern to the integrity of the dams.

Recommendation #1: _X_Adopt __Not adopt

Explanation: Growth faults are gravity-driven faults that develop in conjunction with deposition of sediment on the surface (syndepositional) and grow with depth of burial. These growth faults are a consequence of regional depositional tectonics of the Gulf of Mexico Basin and have been developing for centuries. Growth faults in the Texas Gulf Coast may be caused by a number of processes, including a buoyant rise of salt or shale and differential sediment loading on underlying soft deposits. The increasing weight of deposited sediments become too much for the underlying soft muds and cause shearing of the subsurface to great depths. Acceleration of the movements of growth faults is generally believed to be caused by differential settlement due to the decrease in pore fluid pressure associated with the withdrawal of large amounts of groundwater and hydrocarbons. The growth faults cut the geopressured zone (soft muds at depth) and contain overpressured water. The presence of this water, along with the inherently low strength of the soft sedimentary deposits, may allow slow movement along the faults without strain accumulations and the sudden strain release that initiates an earthquake. There is no historical record of major earthquakes in this region. Growth faults have been identified and mapped within the City of Houston. A growth fault crossed the dam alignment of Addicks near the northeast end of dam alignment at approximately station 600+00, or about 7,000 feet north along the dam alignment from Clay Road; this corresponds to plane coordinates: 29°51' N, 95°35' W. This growth fault is the Brittmore Fault of the Addicks Fault System. Movement along the fault has been measured from 12.5 mm/year to 16.5 mm/year. The dip of the fault is 67 degrees. At the location of this fault the embankment is approximately 12 feet high with roller-compacted concrete 8 inches in thickness over the upstream slope from 10 feet along the slope from the crest to the crest, across the 15-foot wide dam crest, over the entire downstream slope, and extending 15 feet from the toe as an apron. Embankment side slopes are 1v-on-3h, upstream and downstream. No fault trace at or near Barker Dam has been identified. Fault traces of the Addicks Fault System have been identified within the Addicks reservoir area and within the Barker Reservoir. These fault traces are several hundred feet from the dam embankments. This information will be inserted in Section 2.5.4.2 of the revised DSM Report.

Recommendation #2: _X_Adopt __Not adopt

Explanation: The location and presence of the fault was not considered a significant potential failure mode. The USACE Dam Safety Program requires Periodic Assessments (Risk Assessments) on a 10-year cycle or an assessment can be initiated of an issue develops. Prior to the next Periodic Assessment, USACE Galveston District 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. The information gathered will be used in the next periodic assessment of Addicks Dam.

Recommendation #3: _X_Adopt __Not adopt

Explanation: The fault crossing Addicks Dam at Station 600+00 does not impact the stability of the dam embankment. The embankment and foundation soils are low plasticity clay (CL) and low plasticity clay does not undergo a significant reduction in strength as a result of remolding along a fault. With no significant reduction in strengths of the embankment and foundation soils, and with an embankment height of 12 feet, the stability of the dam embankment at the location of the fault will remain satisfactory. Also, with the slow rate of movement along the fault, the clay embankment and clay foundation are expected to remold plastically and not result in a distinct crack that would exacerbate seepage through the embankment and foundation. This was the conclusions of the risk analysis team that was convened in May 2010 to develop potential failure modes (PFM), evaluate the risk of dam failure under static and hydrologic loadings, and rank the potential failure modes of greatest concern. PFM 11 accounted for regional faults crossing the dam that could result in cracks in the dam and/or the foundation and was discounted for the reason discussed. This will be inserted into Chapter 3 (Static Stability) of Appendix 11-Engineering.

Panel Final BackCheck Response (FPC#9):

_X_ Concur ___Non-Concur

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.

PDT Final Evaluator Response (FPC#10):

_X_Concur __Non-Concur

Explanation: The models used to determine economic consequences were not documented clearly in the body of the DSM report. The reason is the DSM report contains and discusses the results of the modeling and not the model itself. The Documentation and the Methodology of the models and how it works are contained in the respective Appendices (i.e. Appendix 2 for Addicks Dam and Appendix 3 for Barker Dam).

Recommendation #1: __Adopt _X_Not adopt

Explanation: The recommendation is to provide a concise description of how the models employed to analyze potential economic consequence work, discuss the models' input data and explained uncertainties associated with input and output data. If the concern is the minimal explanation of LifeSim and HEC-FIA in the DSM Report itself, this can answered by seeing the Appendices for the respective Dam (i.e. Appendix 2 and 3, section 2.2 of each Appendix). This section in each respective Appendices gives in detail (but yet in a concise format) the Life Loss methodology of the HEC-FIA model and its use of the simplified LifeSim Model.

Moreover, section 4.1 of each respective Appendices (Appendix 2 and 3), explains how the model employed the Economic Consequences ; it reads, "The program [in HEC-FIA] uses mathematical formulas and information about building stock, geology, economic data, and other information to estimate losses. The program generates economic and population data for the study area using census blocks and computes urban and agricultural flood damages based on the input event. Property damage assessment includes structure, content, and automobile damages…" The section goes on to explain how the Model 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. And this is explained in section 2.2.8 of each of Appendix 2 and 3. Since the input for structures is from Census data, the uncertainty in regards to Economic Consequences (dollar damages) would be mostly due to the accuracy of the hydrology (i.e. inundation and depths of flooding) that is modeled for each event but this uncertainty is covered in the hydrology sections of the report.

Recommendation #2: _X_Adopt __Not adopt
Explanation: 2. The recommendation to reference pertinent 2003b and 2009 USACE guidance in the DSM Report could potentially be adopted in the future if a planning study is needed (e.g. during PED) to justify project alternatives with a benefit-cost analysis, but currently it is not adopted. USACE EGM No. 04-01 (Generic Depth-Damage (2003b)) and EGM No. 09-04 (2009)) are guidance for studies dealing in Flood Risk Management (i.e Flood damage reduction studies). These studies deal with justifying the level of protection for a storm event (e.g. 100 year and 500 year event or 1% and .2% exceedance event) and these curves would be used in a flood damage reduction analysis model such as HEC-FDA. The DSM report is not a flood reduction study where the project alternatives are assessed on the level of protection it provides. The DSM project alternatives are rather

assessed on how they lower the probability of failure of the dam. Therefore, in the without project condition the assumption is a failure at a certain pool level and the consequence of it (i.e. a singular event). However, it could be said that the generic curves could still be used. In this case it was not used; therefore, the 2003b and 2009 guidance were not referenced. The reason is the HAZUS dataset that the HEC-FIA model used had its own specific occupancy type with predefine depth damage curves for the different types of structures. These depth damage curves for structure, content, and vehicle were assumed to be sufficient to capture the estimated economic consequence resulting from a dam failure which is a singular event (i.e. not trying to capture the 1% and .02% event over the life of the project, which is the basis for modeling in a flood damage reduction studies).

Recommendation #3: _X_Adopt __Not adopt
Explanation: The recommendation to discuss the anomaly between the dams and their comparative day versus night loss of life will be adopted. A paragraph in Section 3.2 will be added to explain this difference. Based on HEC-FIA modeling, a failure at Addicks Dam outlet works, would have a greater loss of life during the day or night, compared to an outlet works failure at Baker Dam. One contributing factor is that Addicks Dam has a greater flooding inundation extent from a dam failure compared to a failure at Barker Dam. A major contributing factor to the Addicks daytime life loss is 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 that is not affected by a failure of Barker Dam. This is the main reason for the day versus night anomaly in the LOL in the comparison between the two dams.

Panel Final BackCheck Response (FPC#10):

_X_Concur __Non-Concur

The PDT has used appropriate and accepted models with brief descriptions of model input. Furthermore, it confirms that the application of the models and their input described in the DSM Report was sufficient to derive a reasonable quantification of economic consequences.

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.

PDT Final Evaluator Response (FPC#11):

_X_Concur __Non-Concur

Explanation: The DSM report does not account for population change over the 50-year period of economic analysis. The reason is there is not a significant need to forecast a population change for benefit analysis.

Recommendation #1: __Adopt _X_Not adopt

Explanation: The recommendation to forecast a future without project condition (in regards to FRM benefits for the 50 year period of economic analysis) was not adopted. The reasoning is the DSM report attempts to estimate the consequences (both the economic and life loss) of a dam failure at a certain pool elevation (i.e. a singular event). In regards to Flood Risk Management (FRM) Benefits, the assumption is a failure of the dam would be loss of the dam; therefore, a loss of FRM benefits. In Appendix 2 and 3, FRM benefits are assumed to be lost until the Dam is rebuilt as shown in section 5 and are presented as annualized FRM benefits, discounted to present value, and based on historical data because that is the best available information at the time the report was written. The FRM benefits can be considered conservative and maybe understated but there is historical support for it. ER 110-2-21156 (notably Q.5.2.4.2) states that discounted present value of project future economic benefits should be included in the baseline economic consequence. Assuming a population increase would most likely overstate FRM benefits without much support. Also, because the DSM report isn't a flood damage reduction study, there is not a significant need to forecast a future without project condition for benefit analysis. The project alternatives are rated on how they will reduce the probability of failure over the 50 year period of analysis. Since this is the case, forecasting populations over the 50 year period of economic analysis is not significant in evaluating the alternatives nor does it affect the rankings.

Panel Final BackCheck Response (FPC#11):

__X_Concur __Non-Concur

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.

PDT Final Evaluator Response (FPC#12):

_X_Concur __Non-Concur

Explanation: The basis of the preliminary hydraulic and structural designs for the new outlet works intake, conduit, spillway, and stilling basin were not discussed in sufficient detail in the DSM Report. The reason being that the DSM Report contains the drawings of the alternatives and not the details for the basis of these designs which are contained in Appendix 11 Engineering and the Reference CD to the DSM Report.

Recommendation #1: _X_Adopt __Not adopt
Explanation: For this phase of the study, the structural conduit alternative variation was constrained by the necessity to maintain similar reservoir elevation-discharge ratings and operation regulations including emergency release criteria. The preliminary basis is therefore very similar as the existing outlet works with the major change being from rectangular conduits to circular conduits. Section 3.4.1 of the DSM Report will be 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.

Recommendation #2: _X_Adopt __Not adopt
Explanation: Chapter 5 of Appendix 11 Engineering will be revised to include some details and basis of the structural designs. Final structural design and development of all details will be completed during final design (PED) of the selected alternative.

Panel Final BackCheck Response (FPC#12):

__X_Concur __Non-Concur

The Panel assumes that the additional detailed hydraulic and structural analyses and designs developed during the PED phase of the project will follow the procedures in the USACE Engineering Manuals and current practice for the design of outlet works through embankments.

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.

PDT Final Evaluator Response (FPC#13):

_X_Concur __Non-Concur

Explanation: The Recommended Alternative was logically formulated and selected to meet the study objectives. Although, the study constraints were fully considered in the plan formulation the constraints as mentioned on pp. 1-5 and 5-1 of the DSM Report were not well defined.

Recommendation #1: _X_Adopt __Not adopt
Explanation: Section 3.1. Dam Safety Issues and Opportunities of the DSM Report will be 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.

Panel Final BackCheck Response (FPC#13):

__X_Concur __Non-Concur

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.