US Army Corps of Engineers®

Prepared by:

SWF District

SWD Division

Benbrook Dam (TX00003)

Review Plan

ENDORSED BY:

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MSC Approval Date: ***27 NOV 18***

Last Revision Date:

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Section 1
Purpose and Requirements

1.1 Purpose

This Review Plan for Benbrook Dam Issue Evaluation Study (IES) (P2# 465894), (Dam NID # TX00003) will ensure a quality-engineering product is developed by the Corps of Engineers in accordance with EC 1165-2-217, “Review Policy for Civil Works”. The Review Plan shall layout a value added process and describe the scope of review for the IES.

1.2 References

- EC 1165-2-217, Review Policy For Civil Works, 20 February 2018
- ER 1110-1-12, Quality Management, 31 Mar 2011
- ER 1110-2-1156, Safety of Dams – Policy and Procedure, 31 Mar 2014
- Benbrook Dam Phase II Project Management Work Plan Documents, 15 Oct 2018
- Benbrook Dam Post-SQRA Memo, December 2017

1.3 Requirements

This RP was developed in accordance with EC 1165-2-217, which establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products. This RP will be provided to Project Delivery Team (PDT), District Quality Control (DQC), Hydrologic Hazards and Loading Curve Reviewer, Agency Technical Review (ATR), and Quality Control and Consistency Review (QCC) Teams.

1.4 Review Management Organization

The USACE Risk Management Center (RMC) is the Review Management Organization (RMO) for this project. This Review Plan will be updated for additional project phases.

Section 2
Project Background and Information

2.1 Project Background

Benbrook Lake is a multi-purpose reservoir operated for flood risk management, water supply, recreation, and environmental benefit. It is a unit of the Trinity River Basin System, which consists of eight Corps of Engineers lakes and various channel improvements and levees operated to provide flood protection along the Trinity River. Water supply contracts exist with the cities of Fort Worth and

Benbrook and the Tarrant Regional Water District. Construction of the project commenced in May 1947 and was substantially completed in February 1951. Deliberate impoundment began in September 1952 and conservation pool was attained in May 1957.

Benbrook Dam is a high hazard potential dam located on the Clear Fork of the Trinity River at river mile 15.0. The dam is located in North Central Texas approximately 17 miles southwest of the City of Fort Worth, Texas. The vertical control for dam design and construction was NGVD 29, and all elevations in this report has been converted to NAVD 88. The elevation conversion to NAVD 88 is -0.033 feet at the dam location which is less than half an inch difference. The dam consists of an embankment, an outlet works, and an uncontrolled spillway. The rolled earth fill embankment is 9,130 feet long, with a crest width of 20 feet, a crest elevation of 747.0 feet, and a maximum height of 130 feet above the streambed. The outlet works consists of an intake structure with upstream approach walls, a 13-foot diameter reinforced concrete conduit, and a stilling basin. A service bridge which has an 11-foot-wide clear roadway extends from the roadway on the top of the embankment to the top deck of the inlet tower. The spillway is located in a saddle at the north end of the dam, and consists of an approach channel, concrete ogee weir, discharge apron, and discharge channel all 500 feet in width. The concrete ogee weir has a crest elevation of 724.0 feet with the exception of a 100-foot wide notch down to elevation 710.0 feet located in the center of weir. Benbrook Dam location map are shown in Figure 1 below.

The primary consequence centers are Benbrook, Fort Worth and Dallas, Texas. Estimated population at risk (PAR) due to dam breach ranges from 244,000 (day) to 133,000 (night), and the non-breach PAR ranges from 152,000 (day) to 82,000 (night). Estimated incremental life loss for the risk-driver potential failure modes ranged from 644 (day) to 712 (night) for Overtopping. The estimated incremental life loss for concentrated leak erosion (CLE) in the embankment is between the maximum high pool estimate of 5,313 (day) to 2,437 (night) and the top of active storage estimate of 2,136 (day) and 1,057 (night).

Figure 1: Project Location

A Periodic Assessment (PA) of the project was performed and findings and recommendations were presented to the Dam Senior Oversight Group (DSOG) in January 2016. The DSOG assigned a Dam Safety Action

Classification (DSAC) 2 due primarily to incremental risk associated with the potential for erosion from overtopping and internal erosion along the conduit.

The preliminary results from Semi-Quantitative Risk Assessment (SQRA) session for Benbrook Dam were presented to the Risk Management Center (RMC) on 01 December 2017. The MVS-2 District Cadre and SWF District completed the SQRA session in general accordance with ER 1110-2-1156. The incremental risks are primarily driven by the potential for overtopping and concentrated leak erosion of the embankment into the blanket drain. Seismic-related potential failure modes were judged to be non-risk drivers. The team has been instructed to complete an Issue Evaluation Study utilizing the Trinity River Basin H&H study and field investigations to re-evaluate the following potential failure modes:

PFM	Description	Failure Likelihood	Confidence	Consequence Level	Confidence
1	Overtopping	1x10-5 to 1x10-6	Low	100 to 1,000	Moderate
20	CLE of the embankment into the blanket drain	3x10-5 to 3x10-6	Moderate	300 to 3,000	Moderate

2.2 Project Sponsor

Products and analyses provided by non-Federal sponsors as in-kind services are subject to DQC, ATR, and policy and legal compliance reviews. Sponsor Peer Review of In-Kind Contributions - There will not be in-kind contributions for this effort.

Section 3
District Quality Control

3.1 Requirements

All work products (including supporting data, analyses, reports, etc.) shall undergo DQC in accordance with EC 1165-2-217. DQC is an internal review process of basic science and engineering work products focused on fulfilling the project quality requirements. All work products undergo DQC. Basic quality control tools include quality checks and reviews, supervisory reviews, and Project Delivery Team (PDT) reviews, etc. The home district will manage and document the DQC.

Quality checks and reviews occur during the development process and are carried out as a routine management practice. Quality checks may be performed by staff responsible for the work, such as supervisors, work leaders, team leaders, designated individuals from the senior staff, or other qualified personnel. However, they will not be performed by the same people who performed the original work, including managing/reviewing the work in the case of contracted efforts.

All DQC review comments and responses will be documented in accordance with the District's Quality Management Plan. Microsoft Word (using track changes) or Adobe Acrobat may be used to provide typographical comments and edits. The DQC comments and responses will be part of the DQC review documentation and provided to the ATR team to assess appropriateness and effectiveness of the DQC activities. A certification of DQC review will be completed by the home District.

As a part of DQC, the RMC Senior Advisor and Technical Advisor will review the IES report prior to submission for ATR to ensure completeness.

See Attachment 1, **Error! Reference source not found.**, for the DQC Lead, reviewers and reviewer's disciplines.

3.2 Documentation

Documentation of DQC activities is required and will be implemented by the process describes in paragraph DQC Schedule and Estimated Cost.

Although DQC is always seamless, Table 3.2-1 below denotes the scheduled review; DQC 29 APR 19-10 MAY 19 followed by comment resolution from 13-31 MAY 19. The cost for DQC is approximately $59,976.

Project Phase/Submittal	Review Start Date	Review End Date
DQC Review	29 APR 19	31 MAY 19

Table 1 DQC Schedule

Section 4
Agency Technical Review

4.1 Requirements

All civil works products (including supporting data, analyses, environmental compliance documents, water control manuals, etc.) shall undergo ATR in accordance with EC 1165-2-217. ATR reviews will occur seamlessly, including early involvement of the ATR team for key decisions, and at the scheduled milestones as shown in Table 2 ATR Schedule. ATR Reviews will be scaled to the appropriate level of technical effort required to evaluate the project findings and recommendations based on the complexity of the project and the level of risk assessment that was conducted. If needed, the District will conduct a site visit for the ATR Team. There will be an ATR pre-brief meeting scheduled prior to the start of the ATR review.

4.1.1 ATR Requirements for Hydrologic Hazards and Loading Curves

The Hydrologic Hazards Assessment and Loading Curve will undergo an Agency Technical Review by an RMC Hydrology and Hydraulic (H&H) Advisor or designated Alternate prior to the Risk Assessment Elicitation, or as directed by the RMC. The reviewer will provide advance review of this work product to avoid unnecessary delays to the completion of the risk analysis and IES report. Ideally, this reviewer will serve as the H&H ATR team member for the IES Report. The reviewer is shown in Attachment 1.

4.1.2 ATR Requirements for IES Phase I & II Reports

ATR for Issue Evaluation Studies conducted using quantitative risk methodology will consist of a review of the technical products by an independent ATR team of USACE dam safety professionals who have past experience with dam safety projects and work products. The ATR Team Lead and ATR team shall be selected by the RMO.

Due to the diverse backgrounds and levels of experience of the cadres and PDT's preparing these reports, and the scope of the ATR team to ensure the quality and credibility of the government's scientific information, an independent panel of senior-level, highly experienced experts from USACE, other agencies, and private industry, shall supplement the ATR by performing a quality and consistency review (QCC) of the risk

assessment findings for quantitative risk assessments. While the ATR Team is given wide latitude to confirm that the technical data, analysis, and methodology meets current agency and state of the practice standards, the scope of the QCC review is more focused and defined by providing written responses to very specific questions that convey the panels professional and technical opinions on the major findings and understandings, the estimated levels of risk and risk reduction, and the appropriateness of the recommendations. The QCC Review findings provide a technical basis to resolve differences of opinion between the PDT and ATR teams, and helps USACE ensure recommended actions are appropriate and applied consistently across the USACE national portfolio of dams. The ultimate decisions concerning the risks and appropriate actions remain with the USACE vertical team.

4.2 Documentation of ATR

4.2.1 Documentation of Hydrologic Hazards Review

Hydrologic Hazards review comments are documented in the form of a Word document or DrChecks^{SM}, as specified below. After resolution of the comments, the reviewer will sign the ATR completion form and this is to be include in the Benbrook Dam IES review documentation. This signature will ensure all comments have been addressed during ATR and signify concurrence.

4.2.2 Documentation of IES Phase I and II ATR

Documentation of ATR for IES Phase I and Phase II studies will be performed using the requirements of EC 1165-2-217. This should include the four part comment structure and the use of DrChecks^{SM} for comment collaboration, response, and back checking.

The scope of the QCC Panel, if applicable, is to review the draft documents, submit written draft comments that address a series of charge questions, attend a panel discussion with the PDT and ATR Lead to collaborate their major findings and understandings of the project, and submit updated responses to the charge questions following the panel discussion as a deliverable. Documentation of the review findings shall be in written format and in accordance with the A-E contract or Agency Scope of Work. The Panel's responses to the charge questions will be included in the final ATR documentation of the IES Report.

4.3 Products to Undergo ATR

The ATR team will review the following products:

- Field Investigation Program Plan
- Field Investigation Report
- H&H Documentation
- Issue Evaluation Report

4.4 Required Team Expertise and Requirements

4.4.1 IES Phase I & II ATR Team

ATR teams will be established in accordance with EC 1165-2-217. The following disciplines will be required for ATR of the IES:

ATR Team Members/Disciplines	Expertise Required
ATR Lead	The ATR team lead is a senior professional outside the home MSC with extensive experience in preparing Civil Works documents and conducting ATRs. The lead has the necessary skills and experience to lead a virtual team through the ATR process.
Geotechnical Engineer	Reviewer shall have experience in the field of geotechnical engineering, analysis, design, potential failure mode analysis, dam safety risk analysis, and construction of earthen dams. The geotechnical engineer shall have experience in subsurface investigations, rock and soil mechanics, internal erosion (seepage and piping), slope stability evaluations, erosion protection design, and earthwork construction. The geotechnical engineer shall have knowledge and experience in the forensic investigation of seepage, settlement, stability, and deformation problems associated with high head dams and appurtenances constructed on rock and soil foundations.
Geologist Engineer	Reviewer shall have experience in assessing internal erosion (seepage and piping) beneath earthen dams constructed on alluvium and rock. The engineering geologist shall be familiar with identification of geological hazards, exploration techniques, field and laboratory testing, and instrumentation. The engineering geologist shall be experienced in the design of grout curtains and must be knowledgeable in grout theology, concrete mix designs, and other materials used in foundation seepage barriers.
Hydrology and Hydraulic Engineer	Reviewer shall have experience in the analysis and design of hydraulic structures related to dams including the design of hydraulic structures (e.g., spillways, outlet works, and stilling basins). The hydraulic engineer shall be knowledgeable and experienced with the routing of inflow hydrographs through multipurpose flood control reservoirs utilizing multiple discharge devices, Corps application of risk and uncertainty analyses in flood damage reduction studies, and standard Corps hydrologic and hydraulic computer models used in drawdown studies, dam break inundation studies, hydrologic modeling and analysis for dam safety investigations.
Construction Engineer	Reviewer should be a senior level, professionally registered engineer with extensive experience in the engineering construction field with particular emphasis on dam safety projects. The Construction reviewer should have a minimum of 10 years of experience.
Consequences (Economist)	The economist (or consequence specialist) will have experience evaluating flood risk management projects in accordance with ER 1105-2-100 and USACE models and techniques to estimate population at risk, life loss, and economic damages for dam safety risk analysis.
Structural Engineer	The structural engineer will have experience evaluating the design, construction, and evaluation of hydraulic structures for dams (including gates/closure structures and penetrations), potential failure mode analysis, and dam safety risk analysis.

If the IES is planned to proceed to DSMS, a Climate Change reviewer will be included.

4.4.2 IES Phase I and II QCC Panel

The panel will consist of Senior Technical Experts from A-E firms and/or Technical Specialists from USACE. It is anticipated that three to four panel members from any of these groups will be selected by the RMC to review each project report. The panel members selected for each specific project will be referred to as the QCC Panel for that project. The ATR Lead will be invited to attend the QCC review.

4.5 Statement of Technical Review Report

4.5.1 IES Phase I and II Review Report

At the conclusion of each ATR effort, the ATR team will prepare a Statement of Technical Review Report with a completion and certification memo. The report will be prepared in accordance with EC 1165-2-217. At the conclusion of the QCC, the review facilitator will prepare a memo for RMC Directors Signature that summarizes what issues must be addressed prior to presentation to DSOG.

4.6 ATR Schedule and Estimated Cost

The preliminary ATR schedule is denoted in Table 4.6-1 below; ATR 3-28 JUN 19 followed by comment resolution 1-19 JUL 19. The cost for the ATR is approximately $141,346.

Project Phase/Submittal	Review Start Date	Review End Date
ATR	3 JUN 19	19 JUL 19

Table 2 ATR Schedule

Section 5
DSOG Review

5.1 Requirements

All IES work products will undergo a review by the Dam Safety Senior Oversight Group (DSOG). The DSOG is provided an advanced copy of the final report approximately four weeks prior to the DSOG Panel Discussion, or as directed by the Program Manager. The PDT will prepare DSOG Briefing Slides summarizing the project Risk, the report findings and recommendations. These slides will be reviewed by the Program Manger prior to presentation to DSOG for clarity and conciseness.

5.2 Documentation

At the conclusion of the DSOG briefing, a memo will be prepared by the DSOG Chairperson that summarizes the risk characterization of the dam, confirms or adjusts the recommended DSAC, proposes Dam Safety and Operations and Maintenance (O&M) actions to reduce risk, and is signed by the Headquarters Dam Safety Officer.

Section 6

Policy and Legal Compliance Review

All IES products will be reviewed throughout the study process for their compliance with law and policy. Guidance for policy and legal compliance reviews is addressed in Appendix H, ER 1105-2-100 and Chapter 8 of ER 1110-2-1156. These reviews culminate in determinations that the recommendations in the reports and the supporting analyses and coordination comply with law and policy, and warrant approval or further recommendation to higher authority by the home MSC Commander. DQC and ATR augment and complement the policy review processes by addressing compliance with pertinent published Army policies, particularly policies on analytical methods and the presentation of findings in decision documents. Initial and final policy compliance reviews will be conducted concurrently by the MSC and HQUSACE.

Section 7

Public Posting of Review Plan

As required by EC 1165-2-217, the approved Review Plan will be posted on the District public website (http://www.swf.usace.army.mil/About/Organization/PPMD/Peer-Review-Plans/). This is not a formal comment period and there is no set timeframe for the opportunity for public comment. If and when comments are received, the PDT will consider them and decide if revisions to the Review Plan are necessary.

Section 8

Review Plan Approval and Updates

The MSC Commander, or delegated official, is responsible for approving this RP. The Commander's approval reflects vertical team input (involving the District, MSC, and RMC) as to the appropriate scope, level of review, and endorsement by the RMC. The RP is a living document, all changes made to the approved RP will be documented in Attachment 3, Table 4 RP Revisions. Re-approval of review plans by the MSC, with re-endorsement by the RMO, will be required when there are significant changes, such as when the project advances from an SQRA to an IES Phase I and/or Phase II. Some projects with small changes will not require re-approval and re-endorsement. The latest version of the RP, along with the Commanders' approval memorandum, will be posted on the District's webpage and linked to the HQUSACE webpage. The approved RP should be provided to the RMO.

Section 9

Engineering Model Certification and Approval

The use of certified or approved engineering models is required for all activities to ensure the models are technically and theoretically sound, compliant with USACE policy, computationally accurate, and based on reasonable assumptions. The responsible use of well-known and proven USACE developed and commercial engineering software will continue and the professional practice of documenting the application of the software and modeling results will be followed. The selection and application of the model and the input and output data is still the responsibility of the users and is subject to DQC and ATR. Where such validations have not been

completed, appropriate independent checks of critical calculations will be performed and documented as part of DQC. The following engineering models, software, and tools are anticipated to be used:

Model Name	Version	Validation Date
HEC-LifeSim	HEC-LifeSim1.0.1	Approved
HEC-HMS	HEC-HMS 4.3	In progress, Preferred model
HEC-ResSim	HEC-ResSim 3.4	In progress, Preferred model
HEC-RAS	HEC-RAS 5.0.5	Approved
GeoStudio SlopeW	2018	Approved
GeoStudio SeepW	2018	Approved
WinDAM C	WinDAM C	Approved
Precipitation Watershed Analysis Tool (WAT)	HEC-WAT 2.0	In Progress, Preferred model
RiverWare	RiverWare 7.0.4	In Progress, Preferred model

Table 3 Models and Status

Section 10

Review Plan Points of Contact

Due to FOUO content this information will not be posted on the District Website.

ATTACHMENT 1

Team Rosters

Due to FOUO content attachment will not be posted on the District Website.

ATTACHMENT 2

Project Risk Information

Due to FOUO content attachment will not be posted on the District Website.

ATTACHMENT 3

Review Plan Revisions

Revision Date	Description of Change	Page/Paragraph Number

Table 4 RP Revisions