DEPARTMENT OF THE ARMY
US ARMY ENGINEER DIVISION, SOUTHWESTERN
1100 COMMERCE STREET, SUITE 831
DALLAS TX 75242-1317

REPLY TO
ATTENTION OF

CESWD-RBT-W

07 DEC 2012

MEMORANDUM FOR Commander, Tulsa District

SUBJECT: Keystone Dam, Oklahoma, Issue Evaluation Study Review Plan Approval

1. References:

a. EC 1165-2-209, Civil Works Review Policy, 31 Jan 2010; and Change 1, 31 January 2012.

b. Memorandum, CEIWR-RMC, 30 November 12, subject: Risk Management Center Endorsement – Keystone Dam, OK – IES Review Plan (Encl 1).

c. Final Review Plan (RP) for Keystone Dam Issue Evaluation Study (Encl 2).

2. In accordance with reference 1.a., I hereby approve the enclosed RP for the subject project study.

3. Please post the final approved RP with a copy of this memorandum to the District's public internet website. Prior to posting to the District website, the names of USACE employees should be removed.

4. The SWD point of contact for this action is Mr. Michael Southern, CESWD-RBT-W, at 918-669-7148.

Thomas W. Kula

THOMAS W. KULA
Brigadier General, USA
Commanding

2 Encls
as

CF:
CESWT-EC-S/ Locke (w/encls)

KEYSTONE DAM, *Tulsa, Oklahoma*

Issue Evaluation Study - *Review Plan*

For Implementation Documents and Other Work Products Southwestern Division (SWD)
Tulsa District, Southwestern Division
U.S. Army Corps of Engineers

19 November 2012

Lead Engineer: *Name Removed*
Review Plan POC: *Name Removed*

US Army Corps of Engineers ®

REVIEW PLAN

Keystone Dam, Oklahoma
Issue Evaluation Study

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1. PURPOSE AND REQUIREMENTS

a. Purpose. This Review Plan defines the scope and level of peer review for the Keystone Dam, Oklahoma, Issue Evaluation Study (IES) Report.

b. References:

(1) Engineering Circular (EC) 1165-2-209, Civil Works Review Policy, 31 Jan 2010
(2) EC 1105-2-412, Assuring Quality of Planning Models, 31 Mar 2011
(3) Engineering Regulation (ER) 1110-1-12, Quality Management, 30 Sep 2006
(4) ER 1105-2-100, Planning Guidance Notebook, Appendix H, Policy Compliance Review and Approval of Decision Documents, Amendment #1, 20 Nov 2007
(5) Keystone, Oklahoma, Interim Risk Reduction Measures Plan, 01 August 2008
(6) ER 1110-2-1156, Safety of Dams – Policy and Procedures, Chapter 9, 28 October 2011

c. Requirements. This review plan was developed in accordance with EC 1165-2-209, which establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products by providing a seamless process for review of all Civil Works projects from initial planning through design, construction, and operation, maintenance, repair, replacement and rehabilitation (OMRR&R). The EC outlines four general levels of review: District Quality Control/Quality Assurance (DQC), Agency Technical Review (ATR), Independent External Peer Review (IEPR), and Policy and Legal Compliance Review. In addition to these levels of review, decision documents are subject to cost engineering review and certification (per EC 1165-2-209) and planning model certification/ approval (per EC 1105-2-412).

d. Levels of Review.
This review plan was developed in accordance with EC 1165-2-209, which establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products by providing a seamless process for review of all Civil Works projects from initial planning through design, construction, and operation, maintenance, repair, replacement and rehabilitation (OMRR&R). The EC outlines four general levels of review:

(1) District Quality Control/Quality Assurance (DQC)
(2) Agency Technical Review (ATR)
(3) Independent External Peer Review (IEPR)
(4) Policy and Legal Compliance Review.

As per ER 110-2-1156, a Quality Control and Consistency (QCC) review will be conducted in conjunction with the ATR including the district, MSC, and RMC. The RMC will certify that the risk assessment was completed in accordance with the USACE current guidelines and best risk management practices. Independent External Peer Review (IEPR) is applied in cases that meet certain criteria. This IES is not a decision document and does not cover work requiring a Type I or Type II IEPR. Issue Evaluation Studies are used to justify Dam Safety Modification Studies. If this project requires a Dam Safety Modification Study, both Type I and Type II IEPR will be conducted.

2. REVIEW MANAGEMENT ORGANIZATION (RMO) COORDINATION

The RMO is responsible for managing the overall peer review effort described in this Review Plan. The RMO for this decision document is the Risk Management Center (RMC). The RMO POC for the peer review effort described in this Review Plan is Mr. Tom Bishop.

3. STUDY INFORMATION

a. Issue Evaluation Study. The intent of this document is approval to initiate risk reduction actions for the Keystone Dam. Keystone Dam was screened by a national risk cadre on June 1, 2006 as part of the FY06 Screening for Portfolio Risk Analysis (SPRA). Based on the results of this risk screening, the dam was categorized as Dam Safety Action Class (DSAC) II (unsafe or potentially unsafe).

Risk Cadre working in conjunction with the SWT District Program Manager will initiate Project Data Preparation (Any existing SPRA, PFMA, IRRM, PI, site investigations, Electrical/Mechanical assessments, seepage and/or stability analyses, modeling, preliminary risk evaluations, etc.) posted to RADS II. At the same time the District will be updating the IES Study/Review Plan to capture re-initiation of the IES Study as well as FY 13 Risk Cadre/PDT formulation. Once the data has been reviewed and the Study Review Plan has been completed; selected Cadre and PDT members will conduct a site visit and perform onsite PFMA/qualitative risk assessment of previously determined PFMA's to confirm validity. Upon completion of the qualitative risk assessment the Issue Evaluation Report will be initiated which will include Expert Opinion Elicitation (EOE) and DAMRAE Output.

When the IES report has been assembled and complete the review process will be coordinated to include DQC and ATR reviews including comments and resolutions. This will all culminate in final preparations for the Quality Control Center (QCC) review/presentation. Once the target date for the QCC presentation is identified; Cadre and PDT members will provide advanced copies of the IES Report to QCC members and provide any corrections and/or additional information requested. Based on the recommendations of the QCC; Senior Oversight Group (SOG) preparations/Target date will be initiated/ established.

b. Study/Project Description. Keystone Dam was authorized by the Flood Control Act by Congress in the Flood Control Act of May 17, 1950 (Project Document SD 107, 81st Congress, 1st Session). Construction of Keystone Dam began in January 1957 and the project was placed in operation in September 1964 for flood control. The two generating units for hydroelectric power became operational in May 1968. The power facility went on line in 1969. The authorized purposes of Keystone Dam are flood control, water supply, hydroelectric power, navigation, and fish and wildlife enhancement.

The Keystone Dam is located in Tulsa County, at mile 538.8 on the Arkansas River about 15 miles west of the City of Tulsa, Oklahoma. This site is about 2 miles downstream from the confluence of the Cimarron and Arkansas Rivers. The features comprising the dam include right and left embankment sections, right and left non-overflow sections, a gated spillway section, and a two-unit power plant.

The embankments are constructed of rolled earthfilled material. The right embankment section is 1,965 feet long, and the section to the left of the spillway is 1,023 feet long. The maximum height of the dam above the streambed is about 121 feet. The embankment is constructed with a centrally located impervious core flanked by random fill zones. Along the downstream slope of the

impervious zone, a 5-foot-thick filter zone was provided to prevent material loss and remove any seepage through the embankment. The upstream embankment slope is protected with a 2-foot layer of stone underlain with two bedding layers from elevation 740.0 up to elevation 769.0. Below elevation 740.0, the thickness of the protection stone layer is reduced to 18 inches. The downstream slope is protected with a grass cover. The wraparounds at the embankment-spillway contacts consist of an impervious core adjacent to the non-overflow sections, transitioned by bedding zones to an outer zone of compacted rockfill.

A cutoff trench was constructed into the bedrock beneath each embankment. The bottom of the cutoff trench for the right embankment was excavated into sandstone and shale bedrock, and the bottom of the cutoff trench for the left embankment is silty shale and shale bedrock. The cutoff trench was designed to be excavated to a vertical depth of 10 feet or to firm rock, whichever was deeper, in sandstone and limestone strata, 5 feet or firm rock in shale strata, and 1 foot or firm rock in the valley section. In the valley section, and through all strata up to the top of the upper Avant limestone member of the Iola formation, the cutoff trench was specified to be 25 feet wide. Above the Avant limestone, the cutoff trench was specified to be 15 feet wide.

A grout curtain was installed along the axis of the dam by pressure grouting into holes drilled into the floor of the cutoff trench. The grout curtain was installed below the floor of the cutoff trench prior to performing special excavation. Primary holes were drilled on 20 foot spacings, with occasional areas where one-foot centers were drilled before grout refusal.

Solution cavities were observed in exposed faces of the cutoff trench of the left abutment, where the trench was excavated through the upper Avant limestone and the underlying sandstone. Some of these features extended the full height of the excavated face, and were as much as four feet wide and three feet deep. In most cases the cavities were filled with clay. Joints were also observed along the floor of the left cutoff trench from Station 46+20B through 50+74B. Joints observed on the floor appear to be oriented perpendicular to the axis of the dam. The solution cavities and joints were cleaned by hand and filled with grout. While excavation of the cutoff trench progressed on the left embankment, six feet of sandstone was removed (due to the amount of jointing observed) prior to line drilling from Station 46+50B through 47+50B.

The foundation of the embankment, with the exception of the cutoff trenches and the right abutment, consists of overburden. The overburden varies in thickness from 10 to 25 feet under the riverbed, to as much as 40 feet in the floodplain. The overburden generally consists of silts and sands with scattered lenses of gravel and clay. On the north side of the floodplain, the embankment was built upon silt and sand deposited against the left abutment. On the upper part of the left abutment, the embankment is founded on a terrace deposit, consisting of 30 feet of silty sand. The overburden encountered at the right abutment was composed of talus and residual soil; these materials were removed to expose the bedrock surface in all areas prior to construction of the south (right) end of the embankment.

The concrete section of the dam is 1,590 feet long and includes the weir, two non-overflow sections, and power intake. The non-overflow sections were constructed utilizing 15 monoliths - six monoliths on the right (monoliths 1 through 6) and nine monoliths on the left (monoliths 25 through 33). The weir was constructed using 18 monoliths (monoliths 7 through 24). Flow over the weir is controlled by eighteen 40-foot wide by 35-foot high tainter gates. Low flows are regulated through nine 5-foot 8-inch by 10-foot sluice gates through the weir. The powerhouse and the power intake structure are located between the spillway and the left non-overflow sections and include two penstocks, each 27 feet in

diameter, controlled by two 14-foot by 30-foot gates.

A baseline risk estimate had not been developed for the project. A preliminary screening-level risk analysis was performed as part of the FY 2006 SPRA. Based on the results of this risk screening, the dam was categorized as Dam Safety Action Class (DSAC) II (unsafe or potentially unsafe) with respect to the following Potential Failure Modes (PFM's).

(1) Failure of the penstock joints could result in minor release, but would likely have devastating consequence for the powerhouse and workers. It is expected that the bulkhead could be placed to stop flow in an emergency.
(2) Erosion behind the training walls would result in erosion of the embankment. It is unlikely that overtopping would cause a release.
(3) Piping of embankment material into solution channels along the abutments could lead to a dam breach at the abutment contract.
(4) Piping of the core material into the pervious foundation sand could lead to a dam breach of the right embankment.

The objective of an IES is to evaluate risk at Keystone Dam in relation to the USACE tolerable risk guidelines by focusing on all significant potential failure modes related to the performance, maintenance, and operational concerns and determine if further action is justified either through interim measures, formal study, or both.

The estimated cost to evaluate risk at the Keystone Dam could be in the range of $500,000 to $750,000.

c. Factors Affecting the Scope and Level of Review.

(1) A Potential failure Modes Analyses (PFMA) was completed by a previous risk cadre. The following significant PFMs were identified with respect to the project condition and the potential downstream consequences.

(a) PFM 3 - Piping of core material into pervious cohesionless foundation soil near the right embankment valley floor (Sta. 10+00 to monolith 1). At conservation pool or higher, sufficient gradients might develop to begin initiation of internal erosion in a poorly compacted layer of impervious core material and or along slaked shale layers at bottom of the cutoff trench. Hydraulic gradients are sufficient for internal erosion to continue leading to the eventual progression of piping toward the reservoir. Erosion accelerates and gross enlargement occurs causing massive crest deformation subsequent unraveling of the dam and uncontrolled release of the pool with downstream consequences.

(b) PFM#4 – Seepage and Piping of embankment material into the limestone formation (Elev. 670 to 680, lower Avant) at left abutment station 45+00 to 45+50. Under all pools, hydrologic load is placed on the rock defect network in lower limestone formation (EL 670 to 680) in left abutment near station 45+00 to 45+50. Erosion of embankment material from sufficiently high hydraulic gradients into open solution features initiates and continues due to unprotected and unfiltered exits. Lack of adequate grouting during construction allows for progression of embankment material into the open void network. As the embankment material erodes, internal erosion of core material and shell material with ability to hold a roof allows for progression to upstream face of dam with eventual gross enlargement, collapse of roof, and subsequent loss of crest/unraveling of dam if defection/intervention efforts are unsuccessful. Unraveling leads to a

breach of the dam at the left abutment that works toward concrete structure and results in downstream consequences.

(c) PFM#5 – Seepage and piping of the embankment material into the lower limestone/shale formation contact (EL 660 to 670) at the right abutment. Under all pools, hydrologic load is placed on the rock defect network in lower limestone formation (EL 660 to 670) in right abutment near station 5+10 to station 6+00. Erosion of embankment material from sufficiently high hydraulic gradients into open solution features initiates and continued due to unprotected and unfiltered exits. Lack of adequate grouting during construction allows for progression of embankment material into the open void network. As the embankment material erodes, internal erosion of core material and shell material with ability to hold a roof allows for progression to upstream face of dam with eventual gross enlargement, loss of collapse of roof and subsequent loss of crest/unraveling of dam if defection/intervention efforts are unsuccessful. Unraveling leads to a breach of the dam at the left abutment that works toward concrete structure and results in downstream consequences.

(d) PFM#6 Overtopping failure of the embankment from approximately a probable maximum flood (PMF) event. A significant storm will develop on top of the normal pool and fill the flood pool. Another storm event occurs within 5 days of the first storm event producing approximately 3 days of rainfall causing the reservoir to rise and overtop the dam by approximately 2.9 feet. Overtopping of the embankment section for up to 30 hours causes massive erosion of the downstream slope progressing to headcutting erosion through crest of dam resulting in breach of the dam and catastrophic uncontrolled release of the pool and downstream consequences.

(e) PFM#7. Seepage and piping of the embankment material into the upper sandstone (Iola)/shale formation contact (EL 718 to 750) at the left abutment. Pool rises and loads the (flaw) geologic defect located between elevation (718 to 750) which is an eroded shale seam or solution joints in the sandstone formation at the left abutment. Critical hydraulic gradients are exceeded and erosion in the geologic defect initiates and unprotected/unfiltered exit allows internal erosion to continue. A roof in the core or sandy silt material forms and progresses to the upstream face near abutment interface. Gross enlargement begins and continues near seam defect, intervention efforts fail if internal erosion is detected and dam breach occurs leading to downstream consequences.

(f) PFM#9. Sloughing/Internal erosion of the upper embankment crest above the impervious core material at high water events. Pool rises and to elevation(s) above select impervious embankment fill (759.6) and develops sufficient hydraulic gradients in a relatively poorly compacted soil layer that is discrete but continuous zone (upstream to downstream) in which internal erosion and/or downstream face sloughing begins. Embankment material continues to erode with sufficient hydraulic gradients and either SM material with fines holds a roof or the roadway serves as a roof for very high pool event; or sloughing continues to occur. Internal erosion/sloughing progresses to the upstream face and/or sloughing occurs near the crest leading to massive unraveling of the dam and subsequent breach with downstream consequences.

(g) PFM#15. Seepage and piping of the embankment material into the upper sandstone (Iola)/shale formation contact at the right abutment. Pool rises and loads the (flaw) geologic defect located between elevation (710 to 730) which is an eroded shale seam or solution joints in the sandstone formation at the right abutment. Critical hydraulic gradients are

exceeded and erosion in the geologic defect initiates and unprotected/unfiltered exit allows internal erosion to continue. A roof in the core or sandy silt material forms and progresses to the upstream face near abutment interface. Gross enlargement begins and continues near seam defect, intervention efforts fail if internal erosion is detected and dam breach occurs leading to downstream consequences.

(h) # PFM17. Sliding instability of all concrete monoliths at foundation contact at higher pools. A flood event occurs that brings the water surface elevation above 755.0 (10-yr event). The reservoir load overcomes the strength of the weak shale layers in the foundation; several monoliths become unstable and begin moving downstream. The monoliths move far enough downstream to breach the dam and cause an uncontrolled release of the reservoir and downstream consequences.

(2) The following factors will affect the project study and level of review

(a) Hydrology/Hydraulics

(b) Soil Properties

(c) Development of Remedial Measures

(d) Probabilistic versus Deterministic Design

(e) Non-Failure Risks

(3) Environmental, health and safety, economic, societal and recreational impacts, while expected to be minimal, are yet to be determined pending decision on the nature and scope of the modification. This review plan is a living document and will be updated whenever possible throughout the decision document cycle.

(4) The study has local, state and Federal interest. The reservoir is owned and managed by the Fort Worth District of the Corps of Engineers.

(5) The project presents a threat to human life/safety because of its high risk of failure under an extreme event and the population downstream.

d. In-Kind Contributions. Products and analyses provided by non-Federal sponsors as in-kind services are subject to DQC, ATR, and IEPR. No in-kind products or analyses will be provided by the non-Federal sponsor(s) in preparation of IES.

4. DISTRICT QUALITY CONTROL (DQC)

All decision documents (including supporting data, analyses, environmental compliance documents, etc.) shall undergo DQC. DQC is an internal review process of basic science and engineering work products focused on fulfilling the project quality requirements defined in the Project Management Plan (PMP). The home district shall manage DQC. Documentation of DQC activities is required and shall be in accordance with the Quality Manual of the District and the Southwestern Division.

a. Documentation of DQC. The DQC will be managed by the Tulsa District in accordance with ER 1110-1-12 and the Southwestern Division/Tulsa District Quality Management Plans. The DQC will be documented using Dr Checks.

b. Products to undergo DQC. All work products, reports, evaluations, and assessments.

c. Required DQC Expertise. The DQC roster is provided in Attachment 1. The DQC team members represent the following disciplines: Geotechnical Engineering, Hydraulic and Hydrology Engineering, Structural and Civil Engineering, , Planning and Economics,

5. AGENCY TECHNICAL REVIEW (ATR)

ATR is mandatory for all decision documents (including supporting data, analyses, environmental compliance documents, etc.). The objective of ATR is to ensure consistency with established criteria, guidance, procedures, and policy. The ATR will assess whether the analyses presented are technically correct and comply with published USACE guidance, and that the document explains the analyses and results in a reasonably clear manner for the public and decision makers. ATR is managed within USACE by the designated RMO and is conducted by a qualified team from outside the Tulsa district that is not involved in the day-to-day production of the project/product. ATR teams will be comprised of senior USACE personnel and may be supplemented by outside experts as appropriate. The ATR team lead will be from outside the Southwestern Division MSC.

a. Products to undergo ATR. Issue Evaluation Study

b. Required ATR Team Expertise.

ATR Team Members/Disciplines	Expertise Required
ATR Lead	The ATR lead should be a senior professional with extensive experience in preparing Civil Works decision documents and conducting ATR. The lead should also have the necessary skills and experience to lead a virtual team through the ATR process. The ATR lead may also serve as a reviewer for a specific discipline (such as planning, economics, environmental resources, etc).
Geotechnical Engineering	The Geotechnical engineer should Licensed w /10-15 years of experience or equivalent education in soils engineering or related field; dam safety experience through participation in dam safety expert panels, risk evaluation/mitigation studies or similar experience with geotechnical evaluation of flood risk management structures such as static and dynamic slope stability evaluation, evaluation of the seepage through earthen embankments and underseepage through the foundation of the flood risk management structures, including dam and levee embankments, floodwalls, closure structures and other pertinent features, and as well as erosion evaluation of the structures.
Engineering Geologist	Team member should have at least 10 years of experience and expertise in the design and construction of large civil works projects founded on relatively soft Clay Shales.

ATR Team Members/Disciplines	Expertise Required
Structural Engineering	Team member should be Licensed with least 10 years of experience and expertise in the design and construction of large civil works projects utilizing steel, concrete and composite materials utilizing state of the art Computer modeling of both static and dynamic loading.
Hydrology	The Hydrologist should have 10 years experience in water management especially with managing reservoir water outflows. Will also have experience with characterizing surface water flows in a watershed using inundation mapping software, HEC-HMS, HEC-ResSim, and other water-flow scenario development techniques.
Hydraulic Engineering	The Hydraulic engineer should have 10 years experience or equivalent education assessing hydraulic retention structures. Will also have direct design or experience with dam rehabilitation projects especially with regard to spillways, stilling basins and drainage pipes. Shall also have modeling experience with Flo-2D models and HECRAS
Consequences and Economics	The Economist should have at least 10 years of extensive experience working with risk models and disaster scenarios with regard to economic impacts for flood risk management projects.
Real Estate	The Real Estate reviewer should have 10-15 years experience in reviewing dam/reservoir projects. The Panel member should hold at minimum, a B.S. degree.

c. Documentation of ATR. Dr. Checks review software will be used to document all ATR comments, responses and associated resolutions accomplished throughout the review process.

(1) Comments should be limited to those that are required to ensure adequacy of the product. The four key parts of a quality review comment will normally include:

(a) The review concern – identify the product's information deficiency or incorrect application of policy, guidance, or procedures;

(b) The basis for the concern – cite the appropriate law, policy, guidance, or procedure that has not been properly followed;

(c) The significance of the concern – indicate the importance of the concern with regard to its potential impact on the plan selection, recommended plan components, efficiency (cost), effectiveness (function/outputs), implementation responsibilities, safety, Federal interest, or public acceptability; and

(d) The probable specific action needed to resolve the concern – identify the action(s) that the reporting officers must take to resolve the concern.

(2) In some situations, especially addressing incomplete or unclear information, comments may seek clarification in order to then assess whether further specific concerns may exist.

(3) The ATR documentation in DrChecks will include the text of each ATR concern, the PDT response, a brief summary of the pertinent points in any discussion, including any vertical team coordination (the vertical team includes the Tulsa district, RMO, Southwestern MSC, and HQUSACE), and the agreed upon resolution. If an ATR concern cannot be satisfactorily resolved between the ATR team and the PDT, it will be elevated to the vertical team for further resolution in accordance with the policy issue resolution process described in either ER 1110-1-12 or ER 1105-2-100, Appendix H, as appropriate.

Unresolved concerns can be closed in DrChecks with a notation that the concern has been elevated to the vertical team for resolution.

(4) At the conclusion of each ATR effort, the ATR team will prepare a Review Report summarizing the review. Review Reports will be considered an integral part of the ATR documentation and shall:

(a) Identify the document(s) reviewed and the purpose of the review;

(b) Disclose the names of the reviewers, their organizational affiliations, and include a short paragraph on both the credentials and relevant experiences of each reviewer;

(c) Include the charge to the reviewers;

(d) Describe the nature of their review and their findings and conclusions;

(e) Identify and summarize each unresolved issue (if any); and

(5) Include a verbatim copy of each reviewer's comments (either with or without specific attributions), or represent the views of the group as a whole, including any disparate and dissenting views.

(6) ATR will be certified when all ATR concerns are either resolved or referred to the vertical team for resolution and the ATR documentation is complete. The ATR Lead will prepare a Statement of Technical Review certifying that the issues raised by the ATR team have been resolved (or elevated to the vertical team). A Statement of Technical Review should be completed, based on work reviewed to date, for the AFB, draft report, and final report. A sample Statement of Technical Review is included in Attachment 2.

6. Review Schedule

Project Phase / Submittal	Review Start	Review Complete
DQC Review	January 2014	February 2014
ATR Review	February 2014	February 2014
Report Revisions and Backcheck	February 2014	March 2014
Submit Report to QCC	March 2014	April 2014
QCC Review	March 2014	April 2014
Report Revisions	March 2014	April 2014
Submit Report to SOG	April 2014	May 2014
SOG Review	April 2014	May 2014
Report Revisions	May 2014	June 2014

7. POLICY AND LEGAL COMPLIANCE REVIEW

Not-Applicable. There is no policy or legal compliance review required as this is not a decision document nor is there any policy or legal compliance issues to address.

8. MODEL CERTIFICATION AND APPROVAL

The following models are anticipated to be used in the development of the decision document:

Model Name	Model Description	Model Type
HEC-FIA	Economic model used to calculate estimated economic damages and loss of life corresponding to floodplain mapping.	Planning
HEC-HMS By applying this model the PDT is able to:	a. Define the watersheds' physical features b. Describe the metrological conditions c. Estimate parameters d. Analyze simulations e. Obtain GIS connectivity	Engineering
HEC-ResSim	This model predicts the behavior of reservoirs and to help reservoir operators plan releases in real-time during day-to-day and emergency operations. The following describes the major features of HEC-ResSim a. Graphical User Interface b. Map-Based Schematic c. Rule-Based Operations	Engineering
HEC-RAS	Unsteady 1-dimensional flow model used to simulate the channel hydraulics	Engineering
FLO-2D	Unsteady 2-dimensional flow model used to simulate wide alluvial fan floodplain inundation, and produce corresponding floodplain mapping.	Engineering

9. REVIEW SCHEDULES AND COSTS

Task Description	Review Start	Review Cost
DQC Review	January 2014	$33,000
ATR Review	February 2014	$30,000
QCC Review	March 2014	$35,000
SOG Review	April 2014	$25,000

10. PUBLIC PARTICIPATION

Not Applicable. This is not a decision or public document and therefore, no public participation is needed or required.

11. REVIEW PLAN APPROVAL AND UPDATES

The Southwestern Division Commander is responsible for approving this Review Plan. The Commander's approval reflects vertical team input (involving Tulsa district, Southwestern MSC, RMO, and HQUSACE members) as to the appropriate scope and level of review for the decision document. Like the PMP, the Review Plan is a living document and may change as the study progresses. The Tulsa district is responsible for keeping the Review Plan up to date. Minor changes to the review plan since the last Southwestern MSC Commander approval are documented in Attachment 3. Significant changes to the Review Plan (such as changes to the scope and/or level of review) should be re-approved by the Southwestern MSC Commander following the process used for initially approving the plan. The latest version of the Review Plan, along with the Commanders' approval memorandum, should be posted on the Tulsa District's webpage. The latest Review Plan should also be provided to the RMO and Southwestern MSC.

12. REVIEW PLAN POINTS OF CONTACT

Public questions and/or comments on this review plan can be directed to the following point of contact:

- Lisa Lawson, Project Manager, Tulsa District, Lisa.Lawson@usace.army.mil , (918) 669-7551.

ATTACHMENT 1: TEAM ROSTERS

1. **Keystone Dam Product Delivery Team (PDT)** The current risk assessment teams conducting the base line risk assessment at the dams include:

Project Title	Name	Organization
Dam Safety Program Manager	*Name Removed*	SWT
Lead Project Engineer	*Name Removed*	SWT
Lead Structural	*Name Removed*	SWT
Lead H&H	*Name Removed*	SWT
Lead Planner/Economist	*Name Removed*	SWT
Project Manager	*Name Removed*	SWT
Geotechnical Engineer	*Name Removed*	SWT
Engineering Geologist	*Name Removed*	SWT
GIS	*Name Removed*	SWT

2. **Keystone Dam Risk Cadre to evaluate the current risk assessment at the dam includes**

Project Title	Name	Organization
Cadre Lead	*Name Removed*	RMC
Geotechnical Engineer	*Name Removed*	RMC
Geotechnical Engineer	*Name Removed*	RMC
Structural Engineer	*Name Removed*	RMC
H&H Engineer	*Name Removed*	RMC
H&H Engineer	*Name Removed*	RMC
Economist	*Name Removed*	RMC
Economist	*Name Removed*	RMC
Engineering Geologist	*Name Removed*	RMC

3. **District Quality Control (DQC) Team Roster**

Project Title	Name	Organization
Geotechnical Engineer	*Name Removed*	SWT
Structural Engineer	*Name Removed*	SWT
H&H Engineer	*Name Removed*	SWT
Economist	*Name Removed*	SWT
Engineering Geologist	*Name Removed*	SWT
Real Estate Specialist	*Name Removed*	SWT

4. **Agency Technical Review (ATR) Team Roster**

Position	Name	Organization
Geotechnical Engineer	*Name Removed*	TBD
Structural Engineer	*Name Removed*	TBD
Geologist	*Name Removed*	TBD
H&H Engineer	*Name Removed*	TBD
Planning Specialist	*Name Removed*	TBD
Engineering Geologist	*Name Removed*	TBD
Economics Specialist	*Name Removed*	TBD
Real Estate Specialist	*Name Removed*	TBD

ATTACHMENT 2: SAMPLE STATEMENT OF TECHNICAL REVIEW FOR DECISION DOCUMENTS

COMPLETION OF AGENCY TECHNICAL REVIEW

The Agency Technical Review (ATR) has been completed for the Issue Evaluation Study for Keystone Dam, Tulsa, Oklahoma. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-209. During the ATR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The ATR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the ATR have been resolved and the comments have been closed in DrChecks[sm].

SIGNATURE _____ _____

Name Removed Date
ATR Team Leader
Office Symbol/Company

SIGNATURE _____ _____

Name Removed Date
Project Manager
CESWT-PP-PM

SIGNATURE _____ _____

Name Date
Architect Engineer Project Manager[1]
Company, location

SIGNATURE _____ _____

Name Removed Date
Director, RMC

CERTIFICATION OF AGENCY TECHNICAL REVIEW

Significant concerns and the explanation of the resolution are as follows: *Describe the major technical concerns and their resolution.* As noted above, all concerns resulting from the ATR of the project have been fully resolved.

SIGNATURE _____ _____

Name Removed Date
Chief, Engineering & Construction Division
CESWT-EC

SIGNATURE _____ _____

Name Removed. Date
Dam Safety Officer[2]
CESWT-EC-SD

[1] Only needed if some portion of the ATR was contracted
[2] Only needed if different from the Chief, Engineering Division.

ATTACHMENT 3: REVIEW PLAN REVISIONS

Revision Date	Description of Change	Page / Paragraph Number

ATTACHMENT 4: ACRONYMS AND ABBREVIATIONS

Term	Definition	Term	Definition
AFB	Alternative Formulation Briefing	NED	National Economic Development
ASA(CW)	Assistant Secretary of the Army for Civil Works	NER	National Ecosystem Restoration
ATR	Agency Technical Review	NEPA	National Environmental Policy Act
CSDR	Coastal Storm Damage Reduction	O&M	Operation and maintenance
DPR	Detailed Project Report	OMB	Office and Management and Budget
DQC	District Quality Control/Quality Assurance	OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
DX	Directory of Expertise	OEO	Outside Eligible Organization
EA	Environmental Assessment	OSE	Other Social Effects
EC	Engineer Circular	PCX	Planning Center of Expertise
EIS	Environmental Impact Statement	PDT	Project Delivery Team
EO	Executive Order	PAC	Post Authorization Change
ER	Ecosystem Restoration	PMP	Project Management Plan
FDR	Flood Damage Reduction	PL	Public Law
FEMA	Federal Emergency Management Agency	QMP	Quality Management Plan
FRM	Flood Risk Management	QA	Quality Assurance
FSM	Feasibility Scoping Meeting	QC	Quality Control
GRR	General Reevaluation Report	RED	Regional Economic Development
Home District/MSC	The District or MSC responsible for the preparation of the decision document	RMC	Risk Management Center
HQUSACE	Headquarters, U.S. Army Corps of Engineers	RMO	Review Management Organization
IEPR	Independent External Peer Review	RTS	Regional Technical Specialist
ITR	Independent Technical Review	SAR	Safety Assurance Review
LRR	Limited Reevaluation Report	USACE	U.S. Army Corps of Engineers
MSC	Major Subordinate Command	WRDA	Water Resources Development Act