EXHIBIT A
SCOPE OF SERVICES

SECTION I. DESCRIPTION OF THE PROJECT

1.1 The OWNER owns and operates Morris Sheppard Dam, which forms Possum Kingdom Lake. The dam is located at river mile 687.5 on the Brazos River in Palo Pinto County, approximately 11 miles southwest of Graford, Texas. Construction of the dam began in May 1938, and it was completed in March 1941. The dam was designed to raise the water surface elevation 130 feet from the original river level to a normal pool elevation of 1,000 feet. Possum Kingdom Lake is a water supply reservoir only; it was not designed for flood control. In 2014, the OWNER surrendered its Federal Energy Regulatory Commission (FERC) license to produce hydropower at Morris Sheppard Dam, and the dam reverted to the regulatory authority of the Texas Commission on Environmental Quality.

1.2 Morris Sheppard Dam consists of the following components constructed between May 1938 and March 1941:

i. An approximately 1,633-foot long, Ambursen slab and buttress section, constructed from reinforced concrete, at the north end, which consists of 40 buttresses on 40-foot centers, spanned by a flat upstream deck slab.

a. The north, non-overflow bulkhead (Buttresses 1 through 8) is approximately 326-foot long.
b. The ogee-shaped service spillway (Buttresses 8 through 26) is approximately 707-foot long.
c. The south, non-overflow bulkhead (Buttresses 26 through 40) is approximately 600-foot long.

ii. An approximately 100-foot wide, 5-foot thick, reinforced concrete, spillway hearth with deflector shield and toe wall.

iii. An approximately 420-foot long earthen embankment with a reinforced concrete core wall, which extends south from the south, non-overflow bulkhead to the emergency spillway, constructed in 1988.

iv. A reinforced concrete intake tower.

1.3 During the 1987 FERC Part 12D inspection, the independent consultant discovered that portions of the dam were sliding downstream due to (**i**) excessive uplift forces on the dam foundation, (**ii**) reduction in passive resistance due to erosion of the downstream channel, and (**iii**) probable damage to the shale foundation during construction. A 50-year movement of approximately 4.5 inches was measured at Buttress No. 20. Numerous cracks attributed to movement of the dam were observed in the

footings, downstream toe wall, buttress corbels, and transition beam. Additionally, the independent consultant determined that the spillway could not pass the probable maximum flood without overtopping the non-overflow portions of the dam. The following initiatives were undertaken to stabilize the dam.

i. In 1987, an eight-foot diameter passageway was drilled through the spillway buttresses to relieve differential tail water pressures on the buttresses and to access the lower level of the spillway. Approximately 66,000 cubic yards of gravel ballast were placed inside the spillway to increase resistance to sliding and to provide access for installation of instrumentation and relief wells. One hundred forty-six relief wells were installed to reduce piezometric pressures on the buttress footings, and grout was injected to seal a crack in the transition beam.

ii. Between 1988 and 1991, an approximately 1,400-foot long emergency spillway was constructed by excavating a portion of the original earthen embankment and the natural right abutment, in order to reduce the water surface elevation during the probable maximum flood. Also, upper sections of the upstream deck panels were reinforced with reinforced concrete overlays, and the natural river channel downstream of the hearth was reinforced with roller compacted concrete, dental concrete, and derrick stones in order to restore passive resistance to sliding, which had been reduced by erosion.

iii. Between 1990 and 1994, massive concrete ballast blocks were placed inside the spillway to further increase resistance to sliding. Additionally, an approximately 250-foot long, 30-inch thick, reinforced concrete stilling basin with a thickened end sill and toe key was constructed below Gates 6 through 9 on the south end of the spillway to prevent erosion of the channel downstream of the hearth.

Since 1988, the OWNER has performed extensive monitoring of the dam using piezometers, extensometers, inclinometers, crack monitors, flow measurement, precision surveys, and visual inspections. No significant dam safety issues have been identified during that time. However, recently, concrete spalling at several locations, particularly near buttress corbels, has prompted the OWNER to initiate a program to re-assess and remediate, if necessary, the reinforced concrete, structural elements of the dam in an effort to extend its service life

1.4 The OWNER seeks to develop a comprehensive reinforced concrete maintenance and repair program that will complement the monitoring, inspection, and mechanical equipment maintenance and repair programs currently in place. The Concrete Assessment and Service Life Extension (CAASLE) program at Morris Sheppard Dam must address surface defects in the reinforced concrete dam components as well as potential internal reinforced concrete deterioration.

1.5 This initial assessment phase of the CAASLE program must encompass all possible reinforced concrete defects. If a particular type of reinforced concrete defect is not present at the dam, then the initial assessment must document its absence based upon a review of available evidence by an expert in the field. At a minimum, the initial assessment shall address the following potential reinforced concrete defects:

- **i.** Alkali-aggregate reaction.
- **ii.** External sulfate attack.
- **iii.** Internal sulfate attack.
- **iv.** Freeze-thaw damage.
- **v.** Hydrogen sulfide induced concrete corrosion.
- **vi.** Reinforcing steel **c**orrosion induced by carbonation.
- **vii.** Reinforcing steel corrosion induced by acidification.
- **viii.** Reinforcing steel **c**orrosion induced by external chloride ions.
- **ix.** Reinforcing steel **c**orrosion induced by internal chloride ions.

1.6 Wherever deleterious constituents, typically limited by transport mechanisms, have been dispersed throughout massive, reinforced concrete, dam components, the actual rate-limiting mechanism must be identified and quantified in order to assess potential impacts on the dam's service life. Furthermore, potential impacts of concrete deterioration mechanisms within massive dam components must be properly quantified, albeit boundary conditions may differ from typical conditions near the concrete surface.

1.7 During this initial assessment, the ENGINEER shall locate, measure, analyze, categorize, prioritize, and catalogue concrete defects in a database, approved by OWNER, which can be readily searched, filtered, and updated by the OWNER. ENGINEER shall develop a database to operate on OWNER's computer system; populate the database with field measurements, laboratory data, photographs, coordinates, dimensions, risk classifications, and other data, as specified hereinafter; install the populated database on OWNER's computer; transfer any required software license(s) to OWNER, and train OWNER's personnel to operate and maintain the database.

1.8 The ENGINEER shall utilize the data collected during this initial assessment to provide quantitative likelihood estimates for potential failure modes related to reinforced concrete dam components. The ENGINEER shall develop event trees describing potential failure modes, estimate load and structural response probabilities, and perform nonlinear progressive collapse analyses using in situ material property distributions, whenever practicable, as specified hereinafter.

1.9 For all event sequences that lead to an uncontrolled reservoir release, the ENGINEER shall postulate the most probable breach parameters; calculate the subsequent discharge hydrograph, and route the discharge hydrograph downstream as necessary to ascertain the incremental population at risk in comparison to the probable maximum flood or fair weather condition, whichever is postulated for the failure mode.

The ENGINEER shall model loss of life and economic loss for each breach scenario using census data, real estate and construction cost data, and life loss estimation models as specified hereinafter.

1.10 The ENGINEER shall calculate the baseline residual service life and annualized failure probability as a function of time assuming that no repair or rehabilitation work transpires for the duration of the dam's service life. Additionally, the ENGINEER shall calculate the residual service life and annualized failure probabilities as a function of time for various risk reduction alternatives. The ENGINEER shall produce parametric cost estimates and timelines for implementation of risk reduction alternatives.

1.11 The ENGINEER shall assist the OWNER in the development of practicable and cost-effective procedures that OWNER's employees can utilize to monitor the condition of the reinforced concrete components of the dam, particularly inaccessible or low-light areas. Such procedures should allow the OWNER's employees to locate and to measure the extent and growth rate of a concrete defect with sufficient accuracy that OWNER can determine whether an immediate response is warranted and, if so, to provide sufficient information for a structural engineer to determine whether a dam safety threat exists.

SECTION II. BASIC SERVICES

2.1 The ENGINEER shall perform the SERVICES as described in this Exhibit for the PROJECT for the OWNER in Phases and/or parts only as authorized by the OWNER in subsequent written authorizations to proceed as described hereinafter:

i. Services Description: ENGINEER shall provide engineering assessment SERVICES associated with the PROJECT. Such SERVICES to be accomplished through the following tasks:

a. **TASK ONE**: Existing Data Review.
b. **TASK TWO**: Three Dimensional Lidar Modeling.
c. **TASK THREE**: Asset Management Database.
d. **TASK FOUR**: Reinforced Concrete Condition Survey.
e. **TASK FIVE**: Probable Failure Mode Analysis.
f. **TASK SIX**: Failure Consequence Analysis
g. **TASK SEVEN:** Risk Reduction Analysis.

ii. Basic Services Scope of Work: ENGINEER's Basic SERVICES scope of work generally includes the following:

a. ENGINEER shall perform a reinforced concrete assessment at Morris Sheppard Dam including, but not limited to, the following work:

1. Review applicable reports, drawings, specifications, construction records, photographs, videos and miscellaneous data.

2. Create a three-dimensional model of all interior and exterior surfaces of the reinforced concrete dam components using laser radar imagery (lidar) and optical imagery, supplemented by photogrammetry and record drawings as necessary. Show the location of all significant reinforced concrete defects on the three-dimensional model.

3. Develop and populate a database for reinforced concrete defects, approved by OWNER, which can be readily searched, filtered, and updated by OWNER.

4. Locate, measure, evaluate, categorize, prioritize, and catalogue existing external defects on all surfaces, including submerged and buried surfaces, of the reinforced concrete dam components stipulated hereinafter.

5. Sample, analyze, and investigate reinforced concrete dam components with different environmental exposures, in addition to critical structural locations, in order to ascertain presence, type and extent of internal defects and in situ material properties.

6. Develop quantitative likelihood estimates for potential failure modes related to reinforced concrete dam components, including failure modes that cause operator injury.

7. Evaluate demand/capacity ratios of critical structural components with various loads using in situ material properties or probable properties based upon age, construction materials, construction techniques, environmental exposure, and/or extent of deterioration.

8. Forecast the residual service life and annualized failure probability of the dam with and without risk reduction measures.

9. Recommend priority and sequence of repairs, based upon annualized life loss, annualized economic loss, and/or annualized probability of operator injury, for each type of reinforced concrete defect.

10. Prepare parametric cost estimates and timelines for implementation of risk reduction alternatives.

11. Assist OWNER in the development of practicable and cost-effective procedures that OWNER's employees can utilize to monitor the condition of the reinforced concrete dam components.

b. ENGINEER shall perform the SERVICES described herein as necessary for the following reinforced concrete dam components, hereinafter referred to as the PROJECT Area:

1. North, non-overflow bulkhead.
2. Service spillway with regulating piers and gate chambers.
3. South, non-overflow bulkhead.

4. Spillway hearth with deflector and toe wall.
5. Stilling basin with end sill and toe key.
6. Intake tower.

c. ENGINEER shall conduct meetings at the PROJECT site or OWNER's Central Office Facility, as specified hereinafter, to discuss investigation protocols and/or findings. For each meeting, ENGINEER shall perform the following tasks:

1. Prepare and distribute draft meeting minutes to OWNER's representative and the Peer Review Board for comments.
2. Following a two-week comment period, prepare and distribute the final meeting minutes.
3. Prepare or amend a list of issues discussed at the meeting.

a) Number each issue to indicate the meeting number and the issue number.
b) Include a description of the issue and the resolution of the issue or ENGINEER's rationale for not resolving the issue.
c) Old issues will remain on minutes of subsequent meetings until the issue has been resolved.

d. ENGINEER shall conduct telephone or video conferences with the OWNER at scheduled hold points and as necessary to accomplish the objectives of this PROJECT and to assure that recommendations from the OWNER are duly considered.
e. ENGINEER shall provide monthly progress reports, and ENGINEER's project manager shall participate in monthly conference calls with OWNER's project manager and project engineer.
f. ENGINEER shall perform site visits as necessary to accomplish the tasks described herein.
g. ENGINEER shall prepare reports, as specified hereinafter, to document investigation protocols and findings.

2.2 ENGINEER will protect OWNER in providing these SERVICES. ENGINEER shall not be responsible for the acts or omissions of any person (except its own employees or agents) at the PROJECT site or otherwise performing any of the work of the PROJECT.

SECTION III. TASK ONE: EXISTING DATA REVIEW

3.1 ENGINEER shall perform as necessary, but not be limited to, the following SERVICES under Task One:

i. Review available record documents and existing data on concrete defects, as necessary to become familiar with the dam's features, condition, and history, including, but not limited to, the following:

a. Ambursen Engineering Corporation, Plans and Specifications for Possum Kingdom Dam (1937).
b. Freese and Nichols, Inc., Breach Analysis for Morris Sheppard Dam (1986).
c. Freese and Nichols, Inc., Five-Year Inspection Preliminary Statement of Findings and Recommendations (1987).
d. Freese and Nichols, Inc., Report on Inspection of Morris Sheppard Dam (1987).
e. Freese and Nichols, Inc., Report on Structural Analysis of Morris Sheppard Dam (1988).
f. Freese and Nichols, Inc., Plans and Specifications for Improvements to Morris Sheppard Dam (1989).
g. Freese and Nichols, Inc., Plans and Specifications for Improvements to Morris Sheppard Dam (1990).
h. Freese and Nichols, Inc., Crack Survey Report for Morris Sheppard Dam (1992).
i. Freese and Nichols, Inc., Plans and Specifications for Stilling Basin Extension (1992).
j. Kam W. Wong, Analysis of 1992 Survey Data from Morris Sheppard Dam (1992).
k. Freese and Nichols, Inc., Report on Investigation, Correction, and Modification of Morris Sheppard Dam (1993).
l. Fugro-McClelland, Inc., Geotechnical Remedial Work: Stability Analyses Report (1993).
m. Freese and Nichols, Inc., Morris Sheppard Dam Breach Analysis (2001).
n. Freese and Nichols, Inc., Supporting Technical Information Document (2008).
o. Arcadis US, Inc., FERC Part 12D Dam Safety Inspection Report (2012).
p. Arcadis US, Inc., Morris Sheppard Dam 2012 Precision Survey (2012).
q. Fugro Consultants, Inc., Dam Safety, Surveillance and Monitoring Report (2013).
r. Arcadis US, Inc., Hydrographic Survey and Structural Analysis Review (2015).
s. Fugro Consultants, Inc., Annual Geotechnical Evaluation of 2014 Instrumentation Data (2015).
t. Brazos River Water Quality Data near Dam (1997 to 2015).
u. Miscellaneous Construction Records (1938 to 1941).

ii. Review high resolution photographs of the interior and exterior surfaces of the dam, provided by OWNER, in order to locate, measure, evaluate, categorize, prioritize, and catalogue existing reinforced concrete defects.

iii. Review existing underwater video of some submerged sections of upstream deck panels, provided by OWNER, in order to locate, measure, evaluate, categorize, prioritize, and catalogue existing reinforced concrete defects.

3.2 ENGINEER shall schedule and conduct a Project Kick-Off Meeting with OWNER's representative(s) and the Peer Review Board at the Possum Kingdom office to review the scope of work and to develop preliminary protocols for visual inspections, non-destructive tests, concrete coring, sample analyses, and electrochemical tests.

SECTION IV. TASK TWO: THREE DIMENSIONAL MODELING

4.1 Prior to commencement of the reinforced concrete condition survey, ENGINEER shall create a three-dimensional model of all interior and exterior surfaces within the PROJECT Area and exterior surfaces of the Power House plus a 300-foot buffer zone, using stationary lidar and color, optical imagery, supplemented by photogrammetry and record drawings as necessary. In performing these SERVICES, ENGINEER shall:

i. Reference northings, eastings, and elevations to the site-specific Morris Sheppard Dam coordinate system. Northings and eastings shall be established based on the fixed horizontal coordinates of Control Point 101, and the fixed bearing between Control Points 101 and 102. Elevations shall be established based on the fixed elevation of Benchmark 102. Provide units in U.S. Survey feet.

ii. Unless otherwise indicated hereinafter, data acquisition shall conform to applicable requirements of Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing (ASPRS), 2014) for non-vegetated areas.

iii. Acquire three-dimensional data using terrestrial lidar with color, optical imagery, wherever feasible, as specified below.

a. At a minimum, overall span distances shall be correct in the lidar scan and the model to an accuracy of ¼-inch over a 100-foot distance.

b. An integral color camera or an exterior color camera mounted to the lidar scanner shall be set up to correctly map color onto the laser scan point cloud.

c. Where scanning will be performed in dark or near-dark conditions, such as the interior of the dam away from the walkway lighting, ENGINEER shall provide lighting, conductors, generators, and miscellaneous electrical items as necessary to thoroughly photograph interior surfaces, as specified hereinafter. OWNER will provide limited electrical power as described below.

d. Scanning may be performed without obtaining color photographs only if authorized by OWNER.

e. Lidar scanning shall be performed at a resolution sufficient to produce viewer files for software such as Leica TruView 2.

iv. In areas with limited accessibility to suitable terrestrial lidar scanner locations, an unmanned aerial vehicle (UAV) and camera system may be used to supplement stationary lidar data acquisition with photogrammetric data, but the ¼-inch accuracy requirements shall be maintained.

a. Digital, aerial sensors for photogrammetry shall meet the following minimum requirements:

1. Focal length less than or equal to 153 mm.
2. Camera and boresight calibration not older than three years.
3. Multi-directional motion compensation and vibration isolation.
4. Gyro-stabilized camera mount with adaptive control.
5. Camera controller with embedded carrier phase differential Global Positioning System receiver and Inertial Measurement Unit and Integrated Inertial Navigation software.

b. UAV must be authorized by the Federal Aviation Administration in the form of a Section 333 exemption and a Certificate of Waiver or Authorization.
c. Maximum aerial photographic scale shall be 1:2400 unless otherwise approved by OWNER.
d. Average forward or endlap shall be 60 percent of the image frames; the allowable limits of deviation will be no less than 57 percent and no greater than 65 percent.
e. Average sidelap shall be no less than 35 percent; the allowable limit of deviation shall be no less than 25 percent.
f. If the endlap or sidelap differs from these percentages, the aerial photography shall be rejected. ENGINEER shall be responsible for re-acquiring any rejected images at no additional cost to OWNER.

v. Environmental conditions during data acquisition for external surfaces shall follow these guidelines:

a. Atmospheric conditions shall be fog and rain free.
b. Ground conditions shall be snow and ice free.
c. No water releases from the reservoir, except for low-flow gates, shall transpire during data acquisition.

Additionally, for photogrammetric data acquisition, the sun angle shall be greater than 30 degrees, allowing for enough reflective light to minimize the effects of long shadows, and wind speed shall be less than the maximum velocity recommended by the aerial vehicle manufacturer or 10 miles/hour, whichever is lesser.

vi. Data voids or gaps in the point cloud coverage are not acceptable except in the following circumstances:

a. Where caused by water bodies.
b. Where caused by areas of low near infrared reflectivity.
c. Where authorized by the OWNER's representative as a result of space constraints in tunnels or shafts or limited accessibility to suitable scanner locations.

vii. Prior to development of derivative products from the point cloud, the absolute and relative vertical accuracy of the point cloud shall be verified by comparing the coordinates of well-defined points in the data set with coordinates in the Morris Sheppard Dam 2012 Precision Survey. A minimum of 20 check points shall be used for field checking; check points shall be evenly distributed throughout the exterior and interior of the PROJECT Area including any area mapped with photogrammetry.

a. Northing and easting data shall be tested to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 0.63 (cm) $RMSE_x$/$RSME_y$ (Root Mean Square Area) Horizontal Accuracy Class.
b. Elevation data shall be tested to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 1-cm $RMSE_z$ Vertical Accuracy Class.

The horizontal and vertical accuracy of the data sets shall be documented in the metadata in the manner prescribed in ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014).

viii. Discrepancies between X, Y, or Z coordinates of the ground point check survey and the data set that exceed three times the limiting RMSE shall be interpreted as blunders and will be corrected prior to development of derivative products. Blunders may not be discarded without proper investigation and explanation in the metadata.

ix. All point deliverables shall be fully compliant with ASPRS LAS Specification, Version 1.4, using Point Data Record Format 6,7,8,9 or 10.

x. A single, non-overlapping PROJECT tiling scheme, agreed upon by the ENGINEER and the OWNER, shall be used for all tiled deliverables.

a. The tiling scheme shall use the same coordinate reference system as the data.
b. The tile size shall be an integer multiple of the cell size for raster deliverables.

c. The tiles shall be indexed in x and y to an integer multiple of the x and y dimensions of the tile.
d. The tiled deliverables shall edge-match seamlessly and without gaps or added overlap.

xi Prepare a three-dimensional model of all interior and exterior surfaces within the PROJECT Area and exterior surfaces of the Power House plus a 300-foot buffer zone using Autodesk Revit 2015 or approved equal software.

a. Beam, strut and other relatively small members shall have cross section dimensions modeled to an accuracy of ¼-inch.
b. The three-dimensional model's geometry shall be based on current conditions at the facility.
c. The three-dimensional model shall include the gravel and concrete ballast that has been installed inside the dam.
d. For buried or submerged surfaces, the model's geometry shall be based on existing, record drawings of the facility.
e. In addition to the surfaces described above, **t**he three-dimensional model shall include the following components:

1. Roof weir gates.
2. Mechanical equipment, including gate operators.
3. Light poles, electrical conduit, control panel boxes.
4. Pipes and conduit larger than ¾-inch diameter.
5. Floors including housekeeping pads and curbs.
6. Walls and ceilings inside the operating piers.
7. Handrail and guardrails.
8. Stairs, stair landings and ladders.
9. Fences and gates.

f. Bare-earth lidar points shall be classified in a manner that prevents unnatural surface artifacts from being created between mass points and break line vertices.

1. Water bodies shall be flattened.
2. The entire water surface edge shall be at or below the immediately surrounding terrain, no floating water bodies.

g. The three-dimensional model shall incorporate the following data points provided by OWNER.

1. Triangulated irregular network representing the top surface of the sediment accumulated upstream of the dam.
2. Bare earth digital terrain model (60 cm) of an approximately 5,000-foot x 10,000-foot area around Morris Sheppard Dam.

xii. Process the lidar point cloud to be viewable by the latest version of Leica TruView 2.

xiii. Show the approximate location and size of all significant reinforced concrete defects on the three-dimensional model.

4.2 ENGINEER shall transfer any required software license(s) to OWNER and assist with installation of the three-dimensional model on OWNER's computer networks at the Central Office and Possum Kingdom facilities including, at a minimum, the following data files:

i. Metadata including a survey report detailing check points used to validate the lidar point data, excluding data points provided by the OWNER, and explaining any blunders.
ii. Point cloud, fully calibrated, georeferenced, and adjusted to ground.
iii. Digital surface model including data points provided by the OWNER.

4.3 ENGINEER shall provide two four-hour training sessions, at a minimum, for OWNER's personnel, one training session at OWNER's Central Office facilities and one training session at OWNER's Possum Kingdom facilities, to demonstrate viewing, adding, and editing concrete defect data using Autodesk Revit 2015 and the latest version of Leica Truview2 or equal software approved by OWNER.

4.4 At least two weeks prior to the training sessions, ENGINEER shall submit one draft reference guide in .pdf format for approval by OWNER. Before each training session, ENGINEER shall produce ten (10) hard copies of the final reference guide and one copy in .pdf format, incorporating OWNER's comments, in accordance with the deliverable requirements hereinafter.

SECTION V. TASK THREE: ASSET MANAGEMENT DATABASE

5.1 ENGINEER shall develop an asset management database for reinforced concrete components within the PROJECT Area, as specified herein, to operate on OWNER's computer systems, using Microsoft SQL Server 2014 or approved equal; populate the database with field measurements, laboratory data, photographs, coordinates, dimensions, risk classifications, and other data, as specified hereinafter; install the database on OWNER's computer system(s); transfer any required software license(s) to OWNER, and train OWNER's personnel to operate and maintain the database.

5.2 The proposed database will provide a repository for data associated with each reinforced concrete defect including sketches (.pdf), laboratory reports (.pdf), and photographs (.jpg) as well as coordinates, dimensions, single-line descriptors, and multi-line descriptions as indicated in the following field descriptions. Terminology used to describe dam components shall generally conform to Crack Survey Report for Morris

Sheppard Dam (1992) except that each bay shall be referenced to the northernmost buttress. Terminology used to describe the condition of reinforced concrete shall generally conform to U.S. Army Corps of Engineers Evaluation and Repair of Concrete Structures (EM 1110-2-2002).

5.3 In accordance with Section 6.4, the database for each reinforced concrete defect shall include the following information if applicable:

- **i.** Identification Number
- **ii.** Centroid Coordinates
  - **a.** Northing
  - **b.** Easting
  - **c.** Elevation
- **iii.** Initial Observation Date
- **iv.** Significant (Y/N)
- **iv.** Structural Component
  - **a.** Buttress
  - **b.** Footing
  - **c.** Corbel
  - **d.** Transition Beam
  - **e.** Upstream Cut Off Wall
  - **f.** Upstream Deck Slab
  - **g.** Downstream Deck Slab
  - **h.** Apron
  - **i.** Hearth
  - **j.** Stilling Basin
  - **k.** Deflector Shield
  - **l.** Downstream Toe Wall
  - **m.** North Training Wall
  - **n.** South Training Wall
  - **o.** North Abutment
  - **p.** South Abutment
  - **q.** Strut
  - **r.** Counterfort
  - **s.** Intake Tower
  - **t.** Gate Chamber
  - **u.** Regulating Pier
- **v.** Defect Type(s)
  - **a.** Cracking
    - **1.** Checking or Crazing
    - **2.** D-Cracking
    - **3.** Map or Pattern
    - **4.** Random
    - **5.** Hairline
    - **6.** Longitudinal

7. Diagonal
8. Transverse
9. Vertical
10. Horizontal
11. Reflective
12. Isolated

b. Construction Fault
1. Bug Holes
2. Cold Joint
3. Exposed Reinforcing Steel
4. Honeycombing
5. Irregular Surface
6. Shrinkage Cracking

c. Spalling
1. Pop Out
2. Delaminated
3. Detached
4. Exposed Reinforcing Steel

d. Disintegration
1. Blistering
2. Chalking
3. Delamination
4. Dusting
5. Peeling
6. Scaling
7. Weathering

e. Joint Sealant Failure

f. Seepage
1. Corrosion
2. Discoloration
3. Exudation
4. Efflorescence
5. Encrustation

g. Movement
1. Buckling
2. Warping
3. Faulting
4. Settling
5. Tilting

vi. Environment
a. Internal
b. External
c. Continuously Wet
d. Continuously Dry
e. Intermittently Wet/Dry

- **f.** Hydrogen Sulfide
- **g.** North Exposure
- **h.** South Exposure

vii. Root Cause(s)

- **a.** Structural
  - **1.** Tension
  - **2.** Shear
  - **3.** Compression
- **b.** Construction Fault
- **c.** Dam Movement
- **d.** Chemical Reaction
  - **1.** Alkali-Silica Reaction
  - **2.** Alkali-Carbonate Reaction
  - **3.** Sulfate Reaction
    - **a)** Ettringite
    - **b)** Thaumasite
  - **4.** Hydrogen Sulfide Reaction
- **e.** Reinforcing Steel Corrosion
  - **1.** Carbonation
  - **2.** External Chloride Ion
  - **3.** Internal Chloride Ion
- **f.** Freeze-Thaw
- **g.** Erosion
  - **1.** Abrasion
  - **2.** Cavitation
- **h.** Thermal Expansion
- **i.** Settlement

viii. Priority Ranking

ix. Trigger Level

x. Observations

- **a.** Date
- **b.** Description
- **c.** Dimensions
  - **1.** Length
  - **2.** Width
  - **3.** Depth
- **d.** Active Growth (Y/N)
- **e.** Growth Description
- **f.** Repair Description
- **g.** Reservoir Elevation
- **h.** Tail Water Elevation
- **i.** Temperature
- **j.** Photographs
- **k.** Documents

xi. Remediation Strategy

xii. Remediation Status
- **a.** Proposed
- **b.** Budgeted
  - **1.** Fiscal Year
  - **2.** Amount
- **c.** Planning (%)
- **d.** Design (%)
- **e.** Construction (%)
- **f.** Completed
- **g.** None

xiii. Work Order
- **a.** Number
- **b.** Date Submitted
- **c.** Date Required
- **d.** Date Completed
- **e.** Action Required
  - **1.** Inspection
  - **2.** Repair
- **f.** Description

xiv. Repairs
- **a.** Date
- **b.** Engineer
- **c.** Contractor
- **d.** Description
- **e.** Cost
  - **1.** BRA Labor
  - **2.** Engineering
  - **3.** Construction
- **f.** Photographs
- **g.** Documents

5.4 Each defect in the database shall be labeled in the three-dimensional dam model using a unique identification number as specified below.

i. The first one or two letters of the defect identification number shall indicate the dam component and general location relative to the component as shown below:

- **a.** BN for Buttress, North Face.
- **b.** BS for Buttress, South Face.
- **c.** FN for Footing, North Side of Buttress.
- **d.** FS for Footing, South Side of Buttress.
- **e.** TB for Transition Beam.
- **f.** CO for Cutoff Wall.
- **g.** TW for Downstream Toe Wall.

h. ST for Strut.
i. CN for Counterfort, North Side of Buttress.
j. CS for Counterfort, South Side of Buttress.
k. H for Hearth.
l. DP for Deck Plate.
m. DS for Deflector Shield.
n. CW for Crest Walkway.
o. SB for Stilling Basin.
p. IN for Intake Tower, North Face.
q. IS for Intake Tower, South Face.
r. IW for Intake Tower, West Face.
s. IE for Intake Tower, East Face.
t. GC for Gate Chamber.
u. RP for Regulating Pier.
v. ST = South Training Wall.
w. NT = North Training Wall.
x. OP = Operating Pier.
y. M = Miscellaneous.

ii. Identification numbers for defects associated with a buttress (i.e., BN, BS, FN, FS, CN, CS, RP or OP) shall include the appropriate prefix above followed by two zeroes and then a two-digit buttress number (e.g. FN0009 for a defect in the footing on the north side of Buttress No. 9).

iii. Identification numbers for defects associated with a bay (i.e., TB, ST, H, DP, DS, CW, CO, and TW) shall include the appropriate prefix above followed by four numbers, indicating the two buttresses between which the defect is located (e.g, TB3334 for a defect in the transition beam between Buttresses Nos. 33 and 34).

iv. Identification numbers for defects associated with a gate chamber, including intake and discharge tunnels and shafts, shall include the appropriate prefix above followed by three zeroes and then a one-digit gate number (e.g. GC0001 for a defect in the gate chamber for Gate No. 1).

v. Identification numbers for defects associated with the intake tower shall include the appropriate prefix above followed by two or three zeroes and then a one- or two-digit number indicating whether the defect is located on the supporting members for a particular intake gate or the members between two gates (e.g. IW0012 for a defect in the supporting members between Intake Gates Nos. 1 and 2 on the west side of the intake tower).

vi. If more than one defect is located on the same structural component, each defect shall be designated by a prefix and four-digit number, followed by a decimal and a three-digit number. (e.g. BN0026.002 for the second defect on the north side of Buttress 26).

vii. If applicable, identification numbers for deck plates, buttresses, intake tower, and other components may have a suffix to provide more precise defect delineation:

a. D for Downstream.
b. U for Upstream.
c. I for Interior.
d. E for Exterior.
e. R for Reflective.
f. N for Non-reflective.
g. A for Above Normal Pool Elevation.
h. B for Below Normal Pool Elevation.

5.5 The label in the model shall provide direct linkage to the database using Revit DB Link or an Open Database Connectivity (ODBC) driver compatible with the SQL Server and Revit or approved equal software versions installed on OWNER's computer system.

5.6 The database shall be capable of sorting data and querying or filtering data by multiple fields simultaneously (e.g., all spalls caused by reinforcing steel corrosion on Buttress No. 26). Additionally, the database shall have the capability to edit, delete, and add fields and defects.

SECTION VI. TASK FOUR: REINFORCED CONCRETE CONDITION SURVEY

6.1 ENGINEER shall locate, measure, analyze, categorize, prioritize, and catalogue external defects in reinforced concrete components within the PROJECT Area, as specified herein, including but not limited to construction faults, cracking, disintegration, distortion, erosion, joint failure, seepage, spalling, and delamination. In performing these SERVICES, ENGINEER shall:

i. Assess, categorize, prioritize, and catalogue all reinforced concrete defects, identified in the 1992 Crack Survey Report for Morris Sheppard Dam (Volumes I, II, & III), in the asset management database, as specified herein.

a. Transfer all available information regarding defects, identified in the crack survey report, into the asset management database, including sketches and photographs if available.
b. Inspect each defect, located above the gravel ballast, as necessary to verify size, location, category, type, environment, root cause(s), priority, growth, and repair(s) and input up-to-date information in the asset management database.
c. To the greatest extent possible, determine the category, type, environment, root cause(s), priority, and repair(s) of any defect, buried by

ballast placement, and input the information into the asset management database.

d. Show the approximate size and location of all significant reinforced concrete defects, identified in the crack survey report, on the three-dimensional model and label the defects as specified herein.

e. To the greatest extent possible, assess the effectiveness of any repair procedures performed on concrete defects, identified in the crack survey report, including but not limited to, epoxy injection into the buttress footings and downstream toe wall.

ii. Assess, measure, categorize, prioritize, and catalogue all post-1992 reinforced concrete defects, identified by OWNER, in the asset management database as specified herein.

a. Ascertain whether each defect had been previously identified in the crack survey report.

b. Input all information, provided by OWNER, regarding post-1992 defects into the asset management database including photographs if available.

c. Inspect each post-1992 defect as necessary to verify size, location, category, type, environment, root cause(s), priority, growth, and repair(s) and input up-to-date information in the asset management database.

d. Show the approximate size and location of all significant post-1992 reinforced concrete defects on the three-dimensional model and label the defects as specified herein.

e. To the greatest extent possible, assess the effectiveness of any repair procedures performed on post-1992 reinforced concrete defects.

iii. Assess, measure, categorize, prioritize, and catalogue all reinforced concrete defects, observable in high resolution photographs of internal and external surfaces of dam components, provided by OWNER, in the asset management database as specified herein.

a. Ascertain whether each defect, visible in the photographs, had been previously identified in the crack survey report or the post-1992 defect data provided by OWNER.

1. If the defect had been previously identified, insert a link to the high resolution photograph into the database for that defect.

2. If not, inspect or otherwise evaluate the defect to verify size, location, type, environment, root cause(s), priority, growth, and repair(s) and input up-to-date information in the asset management database.

b. Show the approximate size and location of newly discovered, significant, reinforced concrete defects on the three-dimensional model and label the defects as specified herein.

iv. Locate, assess, measure, categorize, prioritize, and catalogue all reinforced concrete defects, observable in existing underwater video of submerged sections of the upstream deck panels, provided by OWNER, in the asset management database as specified herein.

a. Ascertain whether each defect, visible in the videos, had been previously identified in the crack survey report or the post-1992 defect data provided by OWNER.

b. Inspect the defect to verify size, location, type, environment, root cause(s), priority, growth, and repair(s) and input up-to-date information in the asset management database.

c. Show the approximate size and location of significant, reinforced concrete defects on the three-dimensional model and label the defects as specified herein.

v. Inspect visible, internal and external reinforced concrete dam components, including submerged components, in order to locate, assess, measure, categorize, prioritize, and catalogue any other external defects, not previously discovered in the crack survey report, inspections, photographs, or videos. In performing these SERVICES, ENGINEER shall:

a. Inspect all submerged portions of the upstream deck slab and intake tower, including joints, above the lake sediment using divers or a remotely operated vehicle (ROV) as necessary to detect surface cracking, spalling, concrete deterioration, or reinforcing steel exposure and/or corrosion up to 150-feet deep.

1. Perform underwater inspections by a certified commercial diving subcontractor with, at a minimum, 10 years of relevant experience in concrete dam inspections.

2. Provide closed circuit television (minimum D1 resolution), lighting, and communications equipment to transmit video and audio at the site in real time and to record underwater inspections.

3. Provide high resolution color still photograph(s) of each defect using a full-frame, digital, single lens reflex camera with minimum 10-megapixel resolution, 6-micron photosensor, ISO 800-1200, strobe light(s) and diffuser(s).

4. Provide equipment required to plot the three-dimensional position of all reinforced concrete defects within ±3 feet, referenced to the site-specific Morris Sheppard Dam coordinate system.

5. Provide underwater line lasers or other equipment, approved by OWNER, to measure or scale dimensions of defects within ± ¼-inch.

6. Extract concrete cores underwater at locations specified hereinafter. ENGINEER shall comply with all federal and state regulations and shall remediate any spills in accordance with Texas Commission on Environmental Quality requirements at no additional cost to OWNER.

7. Provide equipment and materials required to inject non-toxic, biodegradable dye, with approval of OWNER, underwater, as required to ascertain sources of leaks.

8. Collect water samples at approximately 25-foot depth intervals and temperature at each sampling location. Analyze water samples for chloride, sulfate/sulfide speciation, pH and oxidation/reduction potential.

9. In addition to cracks, spalls, corrosion and other surface defects, provide specific information on location, depth, and extent of any soft, friable, or mushy concrete.

10. Inspect and photograph, if feasible, the interior of the inlet for the controlled outlet conduit to identify possible symptoms of cavitation.

11. Inspect upstream location of Bay 9 potential rupture. If visible, provide high resolution color still photograph(s), as specified above, and measure dimensions of any defect(s).

12. Inspect upstream areas of dam for signs of funnel shapes or other indications of concentrated flow.

b. Ascertain whether each submerged defect had been previously identified in the crack survey report, the post-1992 defect data provided by OWNER, or the photographs or video provided by OWNER.

c. Evaluate the defect to determine size, location, type, environment, root cause(s), priority, growth, and repair(s) and input up-to-date information in the asset management database.

d. Show the approximate size and location of significant, reinforced concrete defects on the three-dimensional model and label the defects as specified herein.

vi. Provide on-site supervision of all inspections, including but not limited UAV, underwater, and rope access inspections, by a structural engineer (licensed in the State of Texas) capable of identifying significant reinforced concrete defects and assessing the root cause(s) of those defects.

a. The professional structural engineer, who performs this function, shall be subject to approval by OWNER, which shall not be unreasonably withheld.

b. ENGINEER shall provide closed circuit television (minimum D1 resolution), lighting, and communications equipment as required for the on-site structural engineer to view inspections in real time and to direct inspectors as necessary to acquire the information required for reinforced concrete assessment.

vii. Ascertain the approximate area and depth for each delamination, wherever feasible, by sounding, infrared thermography, or other methods approved by OWNER.

viii. At a minimum, in order to assess effectiveness of reinforced concrete repairs, ENGINEER shall:

a. Review all historical documentation and interview persons familiar with the repair work, if feasible, regarding the defect condition prior to repair, repair materials and procedures, and any changes in the defect subsequent to the repair.
b. Inspect the repair work in order to assess its current condition, including but not limited to repair mix bonding to original concrete and shrinkage or other cracking including cold joints, as well as the condition of the adjacent reinforced concrete, including but not limited to, presence or impending occurrence of anodic ring corrosion.
c. Perform half-cell potential or other testing as necessary to ascertain probability of anodic ring corrosion.
d. Ascertain whether the repair work fully remedied the root cause(s) of the original defect.

ix. ENGINEER shall provide lighting, conductors, generators, and miscellaneous electrical items as necessary to thoroughly inspect and photograph reinforced concrete defects within the service spillway. OWNER will provide single-phase, 110-volt, 20-amp electrical power at the Power House and the regulating piers at Buttresses Nos. 8, 14, and 20.

a. Temporary electrical power shall conform to applicable requirements of the National Fire Protection Association (NFPA) 70: National Electrical Code and the Occupational Safety and Health Administration (OSHA).
b. Temporary electrical power shall not interfere with routine duties concerning operation and maintenance of the facility.

6.2 ENGINEER shall locate, analyze, categorize, prioritize, and catalogue internal defects in reinforced concrete components within the PROJECT Area, as specified herein. In performing these SERVICES, ENGINEER shall:

i. Develop a sampling and analytical protocol to determine the presence or absence of internal concrete deterioration or corrosion of reinforcing steel including but not limited to the following mechanisms or some combination thereof:

a. Alkali-aggregate reaction.
b. External sulfate attack.
c. Internal sulfate attack.
d. Freeze-thaw damage.
e. Hydrogen sulfide induced concrete corrosion.
f. Reinforcing steel **c**orrosion induced by carbonation.
g. Reinforcing steel corrosion induced by acidification.
h. Reinforcing steel **c**orrosion induced by external chloride ions.
i. Reinforcing steel **c**orrosion induced by internal chloride ions.
j. Other cause(s) that ENGINEER deems appropriate.

ii. Develop representative sampling zones, suitable for testing by both non-destructive and destructive testing, in order to infer the extent of internal concrete deterioration and the distribution of in situ concrete and reinforcing steel properties. The sampling zones shall include, but not be limited to, the following:

a. Environmental zones:

1. Exterior, continuous submergence.
2. Exterior, intermittent submergence.
3. Exterior, non-submergence.
4. Exterior, wet-dry, horizontal, buttress construction joint.
5. Interior, continuous submergence, hydrogen sulfide.
6. Interior, intermittent submergence, hydrogen sulfide.
7. Interior, non-submergence, hydrogen sulfide.
8. Interior, continuous submergence, non-hydrogen sulfide.
9. Interior, intermittent submergence, non-hydrogen sulfide.
10. Interior, non-submergence, non-hydrogen sulfide.
11. Intermittent wet-dry, panel-panel or panel-buttress joint.
12. Intermittent wet-dry hearth.

b. Structural zones:

1. Strut.
2. Hearth.
3. Buttress
4. Buttress corbel.
5. Upstream deck panel.
6. Spillway deck panel.
7. Gate chamber end wall.
8. Bulkhead strut support socket.

c. Other zone(s) that ENGINEER deems appropriate.

ENGINEER shall identify specific representative concrete elements from each zone to be tested for the presence or absence of internal concrete deterioration or reinforcing steel corrosion, in particular, elements where internal reinforced concrete deterioration would jeopardize the service life and/or the safety of the dam.

iii. At least four weeks prior to commencement of destructive and non-destructive testing, submit detailed written procedures in Word format, for approval by OWNER, of the means and methods to sample and analyze each representative zone, ensuring that the testing results in no impact on the load bearing capability of the concrete element, including, at a minimum, the following:

a. Concrete Destructive Testing:

1. Rationales and objectives for samples.
2. Quantities, locations, diameters, and depths of samples.
3. Reinforcing steel location procedures.
4. Core logging procedures.
5. Sample preservation methods.
6. Analytical procedures.
7. Core repair procedures.

b. Concrete Non-Destructive Testing
c. Reinforcing Steel Corrosion Testing

At least one week prior to commencement of destructive and non-destructive testing, ENGINEER shall submit the final testing protocol, incorporating responses to OWNER's comments, in .pdf format.

iv. At each test location, determine cover depth and location of reinforcing steel or other embedded materials by non-destructive means using ground penetrating radar and pachometer (rebar locator). To calibrate and confirm these non-destructive techniques, measure cover directly by drilling into the concrete or by making exploratory openings at non-critical locations. Unless otherwise approved by OWNER, core drilling shall not damage or penetrate reinforcing steel or other embedded materials.

v. Unless otherwise approved by OWNER, extract concrete cores at approved locations in accordance with applicable procedures in ACI 207.3R, Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions, USACE EM 1110-2-2002, Evaluation and Repair of Concrete Structures, ASTM C42, Standard Test Method for Obtaining and Testing Drilled

Cores and Sawed Beams of Concrete, ASTM C823, Standard Practice for Examination and Sampling of Hardened Concrete in Constructions, and other appropriate industry standards.

a. All cores shall be extracted using diamond-impregnated core bits. If concrete cores are damaged by core drilling methods, ENGINEER shall revise drilling procedures and/or obtain equipment such as double-tube core barrels to reduce drilling-induced damage.

1. At a minimum, extract four-inch diameter cores from the deck slabs, intake structure, struts, walls and other reinforced concrete sections; extract minimum six-inch diameter cores from buttresses and footings.
2. Determine depth of carbonation at each non-submerged core location using phenolphthalein stain.
3. Locations of borings shall be permanently marked on the structure with a unique boring identification number.
4. Core samples shall be properly identified and oriented with permanent markings.
5. All cores shall be logged in accordance with EM 1110-2-2002.

b. Seal all cores in airtight packaging to preserve in situ moisture condition and transport them to a laboratory, which complies with minimum requirements of ASTM E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
c. Unless otherwise approved by OWNER, core samples shall represent both the concrete surface and the concrete at depth. If the concrete surface is too weak to be sampled by coring, obtain samples of surface concrete to be included with deeper cored samples.
d. Show each core location on a separate sample layer of the three-dimensional model and label each location with its unique identification number linked to a database that includes analytical results, photographs, core logs and other information pertinent to each core.
e. Borehole endoscopy or other techniques approved by OWNER shall be utilized to investigate in situ properties of the moment and shear bars in the buttress corbels, particularly cross-sectional area and corrosion product accumulation.

vi. Extract at least three concrete cores representative of Class A concrete and three cores representative of Class B concrete from dam components without known deterioration; these samples may also be representative of various structural zones. Additional samples may be warranted if the coefficient of variation in test results exceeds 14 percent.

vii. Extract at least three horizontal concrete cores from buttress horizontal construction joints to be analyzed for splitting tensile strength in accordance with ASTM C496, Test of Splitting Strength of Concrete.

viii. Unless otherwise approved by OWNER, analyze all concrete cores for physical properties by the following test procedures:

a. ASTM C39, Standard Test Method for the Compressive Strength of Cylindrical Concrete Specimens for compressive strength.
b. ASTM C42, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete for compressive strength and tensile strength.
c. ASTM C215, Test Method for Fundamental Transverse, Longitudinal and Torsional Frequencies of Concrete Specimens for dynamic modulus of elasticity (Young's Modulus).
e. ASTM C469, Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression for static modulus of elasticity and Poisson's ratio.
f. ASTM C496, Test of Splitting Strength of Concrete for tensile strength. All tensile splitting tests shall immediately be tested for depth of carbonation with phenolphthalein.
g. ASTM C642, Standard Test Method for Density, Absorption, and Voids in Hardened Concrete for density and porosity.
h. ASTM C900. Standard Test Method for Pullout Strength of Hardened Concrete at the discretion of OWNER for comparison to ASTM C496.

Estimate probable in situ concrete strength values from core samples using the statistical procedures and strength correction factors in FEMA 274, NEHRP Commentary on the Guidelines for Seismic Rehabilitation of Buildings. Compute the variability of in situ concrete strength values for each concrete class per FEMA 274 in order to:

a. Determine the overall quality of the concrete.
b. Determine whether additional samples are necessary.
c. Identify outlier values.

Outliers shall be dispositioned per ASTM E178, Standard Practice for Dealing with Outlying Observations. Appropriate values for other parameters shall be derived from the referenced ASTM standard and accepted statistical methods.

ix. Perform petrographic analyses on concrete cores from each environmental zone at frequencies and locations specified hereinafter in order to characterize composition and general quality of the concrete, as well as to identify the presence of potential distress mechanisms.

a. Unless otherwise indicated herein, petrographic examinations shall be performed in accordance with ASTM C856, Standard Practice for Petrographic Examination of Hardened Concrete, ASTM C457, Standard Test Method for the Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete, and A Code of Practice for the Petrographic Examination of Concrete (Applied Petrography Group, 2010) using, at a minimum, the following equipment:

1. Zoom stereo binocular microscope.
2. High quality petrological photomicroscope with digital camera.
3. Petrological microscope with point counting equipment.
4. Petrological microscope with filters and light source for fluorescence observations in reflected or transmitted light.
5. Scanning electron microscope with energy dispersive x-ray microanalysis equipment.
6. Polarized light microscope.

b. Petrographic analyses shall be performed by a person qualified by education and experience to operate the equipment used in the analysis and to record and interpret the results. At a minimum, the petrographer shall have five years of experience with concrete analysis.

c. Preliminary macroscopic examinations shall include the following observations at a minimum:

1. Presence and position of reinforcement.
2. Extent to which reinforcement is corroded.
3. Nature of the external surfaces of the concrete.
4. Features and distribution of macro and fine cracks.
5. Distribution, size range, and type of aggregate.
6. Type and condition of cement paste.
7. Superficial evidence of deleterious processes.

d. Large area polished surfaces shall be examined for the following features at a minimum:

1. Size, shape, and distribution of coarse and fine aggregates.
2. Coherence, color, and porosity of the cement paste.
3. Distribution, size, shape, and content of voids including estimated air content.
4. Volume proportions of coarse aggregate, fine aggregate, paste, and void.
5. Distribution and frequency of fine cracks and microcracks.
6. Relative abundance of rock types in the coarse aggregate.
7. Possible presence of gel or other exudations.

e. At a minimum, two thin sections shall be prepared from each environmental zone. Unless otherwise approved by OWNER, at least one thin section from each zone shall be made from a plate cut at right angles to the external surface of the concrete. Thin sections shall be examined for the following features at a minimum:

1. Presence of concrete deterioration reaction products, particularly, alkali-silica reaction gel, thaumasite, Friedel's salt, calcium carbonate, brucite, and ettringite or gypsum in excess of amounts expected from cement hydration.
2. Depth and extent of carbonation reactions, in conjunction with phenolphthalein stain to assess pH. Any variation in the depth of carbonation near cracks shall be noted.
3. Size, distribution, and abundance of phases in the cement paste.
4. Presence of supplementary cementitious materials, such as fly ash.
5. Original water-cement ratio of concrete and degree of hydration.
6. Composition of the concrete in terms of weight fractions.
7. Details of aggregate types and properties.

x. Perform ionic migration tests on concrete cores from each environmental zone, in order to determine the concrete's ability to resist chloride ion penetration and to provide an indication of its permeability, at frequencies and locations specified hereinafter, in accordance with ASTM C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

xi. Test cores from each environmental zone for acid-soluble chloride content using a modified version of ASTM C1152, Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete. Near-surface regions of each core shall be divided into 10 separate layers, spanning the nominal depth of the reinforcement as determined by the reinforcement cover survey. Deeper measurements shall also be performed to provide baseline chloride levels for the concrete at the time of original construction.

xii. Test cores from each environmental zone for concrete resistivity by ASTM WK37880, New Test Method for Measuring the Surface Resistivity of Hardened Concrete Using the Wenner Four-Electrode Method. Test concrete surfaces in situ by ASTM WK37880 at each non-submerged environmental zone.

xiii. Perform copper-copper sulfate half-cell potential testing, in general accordance with ASTM C876, Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete, for each non-submerged and

intermittently wet-dry environmental zone, in order to identify general areas of potential corrosion in the reinforcement.

xiv. Calculate corrosion rates from linear polarization resistance measurements, in accordance with ASTM G59, Standard Test Method for Conducting Potentiodynamic Polarization Resistance Measurements, for each non-submerged and intermittently wet-dry environmental zone.

xv. In addition to the test locations described above, perform up to eight additional random tests at readily accessible areas where no cracking or spalling is visually observed for depth of concrete cover and corrosion potential.

xvi. Sample hearth and apron concrete and concrete subject to wetting and drying, freezing and thawing, and abrasion-erosion for depth of deterioration relative to original construction.

xvii. Extract and analyze samples of reinforcing steel in locations of reduced stress as approved by OWNER.

a. At a minimum, three reinforcing steel samples shall be extracted for analysis; additional samples may be warranted if the coefficient of variation in test results exceeds 14 percent.

b. Sample sizes shall be determined in accordance with ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

c. Only one sample shall be taken at any one cross section location, and samples shall be separated by at least one development length.

d. Analyze samples for yield and ultimate tensile and bend strength and modulus of elasticity in accordance with applicable requirements of ASTM A370.

e. Assess metallurgical condition of the reinforcing steel samples including, but not limited to, carbon equivalent, presence of any degradation such as corrosion, bond with concrete, and chemical composition.

f. Unless otherwise approved by OWNER, repair sample areas to pre-existing condition or better by splicing replacement material to maintain continuity, installing cathodic protection as necessary to prevent corrosion, and replacing concrete as specified hereinafter.

xviii. Unless otherwise approved by OWNER, repair core holes and other sample areas within one week after testing, in accordance with the following minimum requirements:

a. Repair mix design and placement and curing procedures shall minimize shrinkage.

1. Water-cement ratio shall be less than or equal to 0.4.
2. Aggregate shall be well-graded; the largest aggregate dimension shall be approximately one third of the smallest dimension in the repair area.
3. Concrete surfaces receiving cementitious repair materials shall be saturated surface dry unless an epoxy bonding agent is applied to the existing concrete surface; in which case, the surface shall be dry.
4. Repair material shall be cured with a wet cloth and polyethylene sheet or a curing compound for a minimum of 7 days.
5. A shrinkage reducing and/or compensating admixture may be used with approval of OWNER.

b. Compressive strength shall be greater than the original concrete and shall not be less than 4,000 psi.
c. Repair materials shall be placed in a manner that ensures bonding with the original concrete surface.

1. Concrete surfaces receiving repair materials shall be free of dust or other bond-inhibiting materials.
2. Unless otherwise approved by OWNER, concrete surfaces receiving repair materials shall be coated with a bonding agent.
3. Consolidate the repair material into the cavity using a vibrator or other method approved by OWNER.

d. Repair material shall include an air entrainment admixture approved by OWNER.
e. Unless otherwise approved by OWNER, follow repair material manufacturer's recommendations.

xix. Evaluate historical water quality data provided by OWNER to assess potential effects of lake constituents on internal concrete deterioration mechanisms, particularly chloride and sulfate.

xx. Analyze atmospheric hydrogen sulfide concentrations within the dam as necessary to determine whether hydrogen sulfide release to the atmosphere is systemic (turbulence due to percolation through gravel ballast) or local (turbulence due to weir or excavations).

xxi. Collect and analyze water samples at a minimum of three locations within the dam to ascertain sulfate/sulfide speciation, pH and oxidation/reduction potential.

xxii. Provide northing, easting and elevation of each sample and/or test location referenced to the site-specific Morris Sheppard Dam coordinate system. Show

each sample and/or test location on the sample layer of the three-dimensional model.

xxiii. Extrapolate field measurements to other locations with similar environmental conditions in order to estimate the extent of various concrete deterioration mechanisms. Describe the rationale for each extrapolation in the condition survey report as specified hereinafter.

6.3 Categorize all reinforced concrete defects, including the defects identified in the crack survey report, using the following general categories:

i. Significant Dam Safety Issue, or

ii. Significant Operation & Maintenance Issue, or

iii. Insignificant.

ENGINEER shall categorize defects as insignificant only if the defect is not indicative of any chemical reaction including corrosion of reinforcing steel, structural overload, dam movement including settlement, freeze-thaw, abrasion, cavitation, or thermal expansion and the defect will not cause or contribute to any future concrete deterioration in the best professional judgment of ENGINEER

6.4 Catalogue concrete defects, which ENGINEER considers to be insignificant, as specified above, in the asset management database as specified herein, including, at a minimum, the following information:

i. Individual identification number as specified above.

ii. Category as specified above.

iii. Rationale for categorizing the defect as insignificant.

iv. Description with photograph(s) such that inspectors can ascertain whether the defect changes over time.

6.5 Catalogue concrete defects, which ENGINEER considers to be significant for dam safety or operation and maintenance, in the asset management database as specified herein, including, at a minimum, the following information:

i. Individual identification number as specified above.

ii. Three dimensional coordinates, referenced to the site-specific Morris Sheppard Dam coordinate system, within ± 6 inches for non-submerged locations, within ±3 feet for submerged locations.

iii. Length, width, and depth of the defect.

iv. Initial observation date.

v. Category as specified above.

vi. Structural component(s) known to be impacted by the defect.

vii. All physical descriptors applicable to the defect.

viii. All environmental descriptors applicable to the defect.

ix. Probable root cause(s) of the defect.

x. Priority of repair referenced to probability of loss of life, economic loss, or operator injury.

xi. Trigger levels (e.g., growth in length, width or depth) to initiate remedial actions by OWNER.

xii. Initial observation including qualitative description such that inspectors can ascertain whether the defect has changed over time, estimated age of defect if reasonably discernible, potential rate of deterioration, previous observations, photograph(s), and sketches, if applicable.

xiii. Description(s) of repair(s) previously implemented to remedy the defect including ENGINEER's opinion regarding the effectiveness of the repair(s) and the likelihood of anodic ring corrosion or other impacts on adjacent reinforced concrete.

6.6 ENGINEER shall drill one (1) vertical borehole with 4-inch core through the concrete and continuing into rock with HQ-core boring near Piezometer No. 22-1, as directed by OWNER, to approximately elevation 840.0, as specified hereinafter. The boring shall penetrate all zones suspected of slide surfaces; it will be located on the hearth above normal tail water elevation. Surface elevation at this location is approximately 893 feet. The hearth is constructed from reinforced concrete approximately 4-feet thick. Beneath the hearth at this location lies the Wolf Mountain member of the Canyon group, which consists of moderately hard, argillaceous sandstone underlain by stiff to moderately hard shale.

i. ENGINEER shall provide all labor, supervision, vehicles, equipment, tools, consumables, mileage, per diem, lodging, and miscellaneous items required to collect subsurface geotechnical information including samples, to analyze

samples, and to install an inclinometer casing. In performing these SERVICES, ENGINEER shall:

a. Determine cover depth and location of reinforcing steel or other embedded materials at the boring location by non-destructive means. Extract a 4-inch diameter core from the hearth to be analyzed as specified above.

b. Continuously core and log the boring. Retrieve rock samples using double- or triple-tube core barrels as necessary to recover soft or broken and fractured zones.

1. Mark the core to preserve its orientation such that dip and strike of any joint, bedding plane, or other planar surface can be ascertained.

2. After classifying, logging, and photographing cores, wrap them to preserve the natural moisture condition until laboratory tests can be performed.

3. Provide, high resolution (minimum 12 megapixel), digital color photographs of all cores that clearly show the core interval.

c. Provide continuous, on-site supervision of the boring by a licensed professional geologist or geotechnical engineer, qualified to perform the work. The on-site geologist or geotechnical engineer shall log each lithologic unit in the boring in general accordance with USACE EM 1110-1-1804, Geotechnical Investigations including, at a minimum, the following information:

1. Northing, easting and elevation of the bore hole referenced to the site-specific Morris Sheppard Dam coordinate system.

2. Driller contact information and Texas Department of Licensing and Regulation Water Well Driller's License Number.

3. Method and equipment used to advance the boring.

4. Type, intervals, and method of casing.

5. Type, intervals, and method of grouting.

6. Laboratory test data.

7. Flow information.

8. Completion date.

9. Completion depth.

10. Driller's comments.

11. Unit designation.

12. Rock type and lithology.

13. Hardness, relative strength, or induration.

14. Degree of weathering.

15. Texture and structure.

17. Faults, fractures, joints, shear zones, or other discontinuities.

18. Orientation with respect to core axis.
19. Surface roughness.
20. Grain size and tightness.
21. Color and staining.
22. Solution and void conditions.
23. Swelling and slaking properties.
24. Mineralization, inclusions, and fossils.
25. Percent core recovery.
26. Sample depths.

c. Select at least three (3) **s**amples of the of the concrete core to be tested as specified herein and at least three (3) samples of the rock cores, particularly, shear zones, fractures, or other discontinuities in the shale member. Wrap the samples in airtight packaging to preserve in situ moisture condition, and transport the samples to a laboratory, which complies with minimum requirements of ASTM E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection and ASTM D3740, Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction, to be analyzed for the following parameters at a minimum:

1. Liquid limit and plastic limit shall be analyzed in accordance with ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils on shale samples prepared using the blenderizing procedure in USACE EM 1110-2-1906, Laboratory Soils Testing, Appendix III.

2. Natural water content of all samples shall be analyzed by ASTM D2216, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass**.**

3. Unit dry weight of all samples shall be analyzed by ASTM D7263, Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens.

4. Unconfined compressive strength, elastic moduli, and Poisson's ratio of all samples shall be analyzed by ASTM D7012, Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures**.** Failure strain and normalized stress-strain curves shall be included in the results.

5. Unless otherwise directed by OWNER, all samples shall be analyzed using multi-stage, drained, direct shear tests in accordance with Method 203 of the USACE Rock Testing Handbook. Sample selection for direct shear testing as well as test parameters, such as drainage conditions, shall be subject to approval by OWNER's representatives. Relationships derived from the test data shall

include shear strength versus normal stress and shear stress versus shear displacement.

d. Record optical (minimum D1 resolution) and acoustic imagery of the entire surface of the borehole. Optical and acoustic imagery shall be witnessed by an OWNER's representative at the site in real time. Notify OWNER, at a minimum, one week prior to conducting borehole televiewer logging. Provide virtual acoustic and optical cores with directional data.

e. Wrap all cores, except laboratory samples, in airtight packaging, pack them in cardboard core boxes, and transport them to a location, designated by OWNER, at Possum Kingdom for storage.

f. Install DGSI Slope Indicator 70 mm CPI inclinometer casing for the full depth of the borehole. Align one set of grooves perpendicular to the dam axis. Grout the casing into the borehole, complete installation below the concrete surface, and install a protective cap, approved by OWNER, flush with the concrete surface.

g. Provide northing, easting and elevation of the inclinometer referenced to the site-specific Morris Sheppard Dam coordinate system. Provide a diagram that shows precise orientation of the inclinometer casing grooves relative to the dam axis. Show the boring location on the sample layer of the three-dimensional model.

h. Unless otherwise authorized by OWNER, legally dispose of all waste materials off-site. ENGINEER shall be fully responsible for containment of all waste materials. ENGINEER shall remove any spills in accordance with Texas Commission on Environmental Quality requirements at no additional cost to OWNER.

ii. OWNER will furnish and operate a crane to place drilling equipment, up to 38,000 pounds per load, onto the hearth from the south river bank and remove it following completion of the geotechnical work, provided that ENGINEER executes a crane liability waiver on a form provided by OWNER.

6.7 ENGINEER shall acquire additional high resolution photography with an UAV and camera system, which ENGINEER deems necessary for the reinforced concrete assessment, as an Additional SERVICE, as specified hereinafter, only if authorized by OWNER.

6.8 ENGINEER shall perform inspections using rope access, which ENGINEER deems necessary for the reinforced concrete assessment, as an Additional SERVICE, as specified hereinafter, only if authorized by OWNER.

6.9 ENGINEER shall perform additional sample collection and/or analysis as an Additional SERVICE, as specified hereinafter, only if authorized by OWNER.

6.10 ENGINEER shall perform additional optical or acoustic imagery including virtual acoustic and optical cores as an Additional SERVICE, as specified hereinafter, only if authorized by OWNER.

6.11 At least two weeks prior to the Data Assessment Review Meeting specified hereinafter, ENGINEER shall submit a draft Reinforced Concrete Condition Survey Report in Word format for review by OWNER and the Peer Review Board summarizing findings of the survey including, but not limited to, the following information:

i. Summary of crack and spall observations including, at a minimum, the following:

a. Probable roots cause(s) of significant cracks and spalls including, but not limited to, patterns of distress indicative of dam movement, internal concrete deterioration reactions, carbonation-induced corrosion, chloride-induced corrosion, or inferior concrete quality.
b. Listing of defects that constitute dam safety or operation and maintenance issues.
c. Possible acceleration of concrete or reinforcing steel deterioration caused by cracks or spalls.

ii. Summary of sample collection and analytical procedures including any deviations from the sampling protocol submitted previously.

iii. Summary of in situ concrete and reinforcing steel material properties including coefficient of variation for material properties of different concrete classes.

iv. Summary of observations regarding the presence or absence of each type of internal concrete deterioration including, at a minimum, the following:

a. Evidence to support elimination of any internal concrete deterioration reaction(s), which ENGINEER considers improbable in his/her best professional judgment.
b. Probable extent of internal concrete deterioration reactions based on analogous environmental conditions.

v. Summary of reinforcing steel corrosion data including, at a minimum, the following:

a. Chloride concentration profiles including estimated chloride concentrations at the depth of reinforcement and probable onset of chloride-induced corrosion.
b. Probability of reinforcing steel **c**orrosion induced by internal chloride ions including rate of reaction and impacts.

c. Carbonation depth profiles including estimated pH at the depth of reinforcement and probable onset of corrosion.

d. Rationale for constants, coefficients, and assumptions, particularly steel surface area, assumed for electrochemical characteristics of steel in concrete.

e. Interpretation of half-cell equipotential contour maps and linear polarization resistance or resistivity measurements, particularly in cases of carbonation or chloride contamination.

f. Comparisons between corrosion rates at different locations and exposure conditions within the dam.

g. Electrical resistivity of water-saturated concrete and significance for the corrosion process.

h. Probable extent of reinforcing steel corrosion based on analogous environmental conditions.

i. Impacts of corrosion on allowable tensile stress and bond stress of reinforcing steel, particularly square bars with small deformations.

j. Impacts of reinforcing steel corrosion on structural stability of the dam, particularly corrosion of deeply embedded reinforcing steel.

vi. Summary of observations regarding the extent of hydrogen sulfide reactions including, at a minimum, the following:

a. Location, surface area, and depth of unsound concrete in Bay 9 and other locations.

b. Extent and severity of reinforcing steel corrosion induced by acidification.

c. Results of underwater inspection upstream of Bay 9, in particular, probable source of leakage into Bay 9.

d. ENGINEER's opinion regarding probable extent and severity of hydrogen sulfide induced concrete corrosion within the dam including reinforced concrete components buried beneath gravel ballast.

vi. Recommendations for appropriate material properties, based upon field data or literature values, particularly in areas where concrete or steel properties may have been altered by deleterious reactions.

vii. Assessment of petrographic, chemical, electrochemical and materials data quality and completeness and adequacy of the dataset regarding decisions inferred from it,

viii. Summary of proposed additional sample collection and/or analyses, which ENGINEER deems necessary to attain program objectives, including but not limited to, objectives, locations, depths, quantities, and number and types of analyses.

ix. A DVD of each inspection video with clear audio. DVDs of each inspection shall be neatly labeled and bound into each report in clear, poly safety sleeves.

6.12 ENGINEER shall schedule and conduct a Data Assessment Review Meeting with OWNER's representative(s) and the Peer Review Board at the Central Office in Waco to review results of the field investigations and analyses. ENGINEER shall coordinate with OWNER and dependent upon the findings and OWNER's concurrence, if necessary, develop an additional program of testing to be performed in order to provide data required for the Probable Failure Mode Analysis (PFMA) of reinforced concrete elements.

6.13 Following the Data Assessment Review Meeting, ENGINEER shall submit ten hard copies and one copy in .pdf format of the final Reinforced Concrete Condition Survey Report, incorporating comments from the OWNER.

6.14 ENGINEER shall provide one eight-hour training course on crack and spall identification for OWNER's personnel at the Possum Kingdom Lake office including, at a minimum, the following:

i. Instruction on identification and categorization of cracks and spalls.
ii. Proper techniques for mapping, measuring and assessing concrete defects.
Iii. Examples with photographs of insignificant cracks and spalls, which can be safely ignored in future inspections and monitoring programs.
iv. Thorough documentation, which will allow future personnel to perform crack and spall identification without additional training, in an electronic format acceptable to OWNER.

SECTION VII. TASK FIVE: PROBABLE FAILURE MODE ANALYSES

7.1 ENGINEER shall perform a PFMA for only reinforced concrete dam components as a supplement to the PFMA performed as part of recent FERC inspections. As a minimum, risk trees shall be provided using Precision Tree from Palisade Corporation or approved equal decision analysis software. In performing these SERVICES, ENGINEER shall:

i. Unless otherwise approved by OWNER, perform the PFMA in general accordance with USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis and FERC Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 14. The PFMA shall generally conform to FERC guidelines, but Morris Sheppard Dam is not regulated by FERC; no FERC inspector will be involved in the PFMA, and the PFMA may deviate from FERC procedures at OWNER's discretion.

ii. Function as the Independent Consultant for purposes of the PFMA. OWNER will assign the Team Leader from its staff. OWNER will contract separately with the Facilitator. The Core Team will include the Peer Review Board,

contracted separately by OWNER, as well as operational staff assigned by OWNER. The Core Team may also include a geotechnical engineer, contracted separately by OWNER.

iii. At a minimum, re-analyze and produce risk analyses for the following failure modes included in the 2012 FERC Part 12D Dam Safety Inspection Report based on findings from the reinforced concrete condition survey and recent changes in environmental conditions:

a. PFM No. 1.1: Sliding failure of the concrete dam.
b. PFM No. 1.2: Failure of an upstream deck slab, downstream spillway slab, or supporting corbel due to structural inadequacy, cracking, corrosion of reinforcement or other structural mechanisms.
c. PFM No. 1.4: Sliding failure along the concrete-rock interface occurs at one or more buttresses.
d. PFM No. 3.1: Spillway deck panels collapse.
e. PFM No. 3.2: Erosion of the service spillway channel.
f. PFM No. 4.3: Structural failure of the dam due to earthquake loading.

iv. Additionally, analyze the following failure modes related to operation and maintenance and operator safety, at a minimum:

a. Gate failure due to excessive seal leakage caused by concrete deterioration or reinforcing steel corrosion reactions.
b. Operator injury due to spalling concrete.

v. Provide structural modeling SERVICES performed by a Professional Structural Engineer licensed in the state of Texas and knowledgeable in the basic theory of structural dynamics, materials, seismology, and finite-element analysis. At a minimum, the structural modeler shall have 10 years of relevant experience with finite element analysis of concrete dams.

vi. Per FERC Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 10, use the working stress method in ACI 318-95 Appendix A, “Alternate Design Method” for analysis of reinforced concrete wherever square, un-deformed reinforcing bars were used in the original construction. Also, per FERC’s guidelines, buttresses with longitudinal joints, such as the contraction joints in Morris Sheppard Dam, may not act monolithically; in which case, the buttresses must be analyzed as independent columns separated by the joints.

vii. Perform static, linear, three-dimensional finite element analyses, in order to estimate stresses induced by dam movement, by changing the dam alignment in the model to simulate deflection at various time periods. Indications of high stress or strain shall be analyzed with nonlinear materials. At a minimum, finite element

analyses shall be performed to simulate stress conditions for dam alignments under the usual loading combination, specified hereinafter, at the following intervals:

a. 1941 – Dam alignment at initial filling.
b. 1987 – Dam alignment prior to remediation.
c. 1989 – Dam alignment following relief well installation.
d. 1992 – Dam alignment following grouting and ballast blocks.
e. 1997 – Dam alignment at maximum downstream deflection.

Compare patterns of distress found in the condition survey to stress concentrations at each time period in order to ascertain whether defects were caused by dam movement. Additionally, evaluate locations and magnitudes of tension-compression cycles due to dam movement.

viii. Develop event trees to represent sequences or progressions of events that could result in adverse consequences when the dam responds to various loading conditions. Event tress shall be populated with load and structural response probabilities as specified hereinafter.

a. In accordance with USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis, Chapter 14, calculate capacity of reinforced concrete components without strength reduction factors, and calculate demands without load factors. Appropriate strength reduction factors shall be ascertained during the condition survey based on severity of reinforcing steel corrosion and concrete deterioration.
b. Whenever in situ material property distributions cannot reasonably be estimated based upon findings from the field investigation, ENGINEER shall utilize material properties, consistent with the construction materials, environmental exposure, and age of Morris Sheppard Dam, from the Bureau of Reclamation Aging Concrete Information System or similar resources.
c. Response (fragility) curves from USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis, Chapter 14 or other industry standards shall be used to determine probability of failure based on demand/capacity ratio where applicable. ENGINEER shall develop response curves if none are available in the USBR/USACE guidelines based on ACI 318, Building Code Requirements for Structural Concrete or other appropriate industry standards.
d. Response curves shall account for parallel versus series failure mechanisms as described in FERC Engineering Guidelines: Risk-Informed Decision Making, Chapter R5, particularly regarding corbel shear and tension failure.
e. Unless otherwise approved by OWNER, allowable stresses in reinforcing steel shall conform to recommended values in Concrete

Reinforcing Steel Institute (CRSI), Engineering Data Report No. 48: Evaluation of Reinforcing Bars in Old Reinforced Concrete Structures and FERC Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 10.

f. Only if quantitative probabilities cannot be reasonably ascertained for an event, ENGINEER shall utilize the verbal mapping scheme, described in USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis, Chapter 13, to develop qualitative probabilities based upon input from the Core Team and others.

g. Assess uncertainty by estimating the range or distribution of values associated with each node in the event trees.

ix. At a minimum, perform static, linear, three-dimensional finite element analyses for the 2012 dam configuration in order to ascertain the probability of failure under the loading combinations specified hereinafter. Indications of high stress or strain shall be analyzed with nonlinear materials. Plot location and magnitude of stress concentrations for all analyses.

a. Usual Loading Combination: Normal Operating Condition + Silt Pressure + Ballast Lateral Pressure + Concrete Overlay Pressure.

b. Unusual Loading Combination: Probable Maximum Flood Condition + Silt Pressure + Ballast Lateral Pressure + Concrete Overlay Pressure + Internal Air Pressure + Spillway Negative Pressure + Hydrodynamic Bucket Pressure.

c. Static analysis for the unusual loading combination shall include any uplift force caused by internal air pressure on the downstream deck slabs, as described in FERC Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 10, as well as hydrodynamic forces on the downstream deck panels, apron, and bucket.

d. Static analyses for both loading combinations shall include the lateral pressure caused by the ballast blocks on the deck slabs as well as the additional weight of the concrete overlays on the upstream deck panels and uplift pressures and/or piezometric pressures from the foundation.

e. Temperature effects shall be included if the condition survey provides any evidence of overstressing from temperature loads, such as buttress cracks perpendicular to the deck panels.

f. Evaluate capability of joints between deck panels and corbels and between struts and buttresses to move as designed. If joint movement may be restricted, include effects of joint restraint as appropriate in the structural analyses.

g. At a minimum, provide one copy of input files for each analysis to OWNER in text or other format that can be edited.

x. Perform a site-specific, probabilistic seismic hazard evaluation consistent with the latest revisions of USGS Incorporating Induced Seismicity in the 2014

United States National Seismic Hazard Model – Results of 2014 Workshop and Sensitivity Studies and FERC Evaluation of Earthquake Ground Motions. In performing these SERVICES, ENGINEER shall:

a. Perform seismologic SERVICES by a Professional Geoscientist licensed in the state of Texas and qualified to perform the work. At a minimum, the seismologist shall have 10 years of relevant experience.

b. Ascertain seismologic and geologic data pertinent to each induced seismic zone identified in USGS Incorporating Induced Seismicity in the 2014 United States National Seismic Hazard Model – Results of 2014 Workshop and Sensitivity Studies in order to establish the appropriate recurrence relationship for each source.

c. Determine the probability that rupture surfaces associated with each potential seismic zone will be located at a specific distance from Morris Sheppard Dam.

d. Determine the probability that ground motions from an earthquake of a certain magnitude occurring at a certain distance will exceed a specific level at Morris Sheppard Dam based on selected attenuation relationship(s).

e. Compute the annual probability of exceeding a specified level of ground motion at the dam by combining the probability functions for each potential source. Sum the contributions from all potential sources to obtain the total seismic hazard at the dam.

f. Provide site-specific mean and fractile hazard curves and uniform hazard response spectra for 10%, 5%, 2%, and 0.5% probability of exceedance in 50 years, including natural periods for all buttress, pier, intake tower, and elevator shaft dimensions.

g. Provide at least three (3), three-component acceleration time histories for 10%, 5%, 2%, and 0.5% probability of exceedance in 50 years, based upon recorded motions for induced earthquakes in seismic zones, delineated by the USGS, near Morris Sheppard Dam. Accelerograms shall be selected, in particular, for pulse sequencing characteristics.

h. Plot the site-specific rate of occurrence of earthquakes per annum versus magnitude for Morris Sheppard Dam.

i. Evaluate potential impacts of seiches on the dam and appurtenant equipment, particularly gates.

xi. Based on seismologic characteristics of induced earthquakes in known seismic zones near Morris Sheppard Dam, particularly Azle, as well as the two 3.7-magnitude earthquakes south of Perrin, TX in 2013, and site-specific geologic characteristics, particularly the Mineral Wells Newark East fault system and the Bend Arch, estimate the probability of occurrence and magnitude of earthquakes potentially induced by injection well activities within a fifteen-mile radius of the dam; if practicable, estimate response spectra for a hypothetical earthquake induced by injection activity near the dam.

xii. Perform non-linear, time-history, three-dimensional, dynamic finite element analyses with the following loading condition in order to estimate the probability of failure due to earthquake damage in both upstream-downstream and cross-canyon directions. Analyses shall generally conform to Safety Assessment of Existing Dams for Earthquake Conditions (Canadian Electrical Association, 1990) and USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis, Chapter 19. Initial conditions shall be utilized from the previous analyses creating the stress state from the initial geometry to 2012.

a. Extreme Loading Combination: Normal Operating Condition + Silt Pressure + Ballast Lateral Pressure + Concrete Overlay Pressure + Maximum Credible Earthquake.

b. Separate analyses shall be performed with horizontal accelerations in the upstream-downstream and cross-canyon directions. Vertical acceleration shall be included in both simulations, particularly hydrodynamic forces on the upstream deck panels per USBR, Hydrodynamic Pressures on Dams Due to Earthquake Effects.

c. Model all of the buttresses of the dam in order to properly capture the cross-canyon loads. The dynamic analysis shall specifically address cross-canyon, earthquake-induced compressive loads.

1. After an initial model run, evaluate compressive forces in the struts relative to both compressive strength capacity and potential for buckling.

2. Remove any strut with demand in excess of capacity from subsequent model runs; repeat until no additional struts fail.

3. Additionally, evaluate unseating of struts due to horizontal displacements. Remove any unseated struts from subsequent model runs.

4. Evaluate cross-canyon compressive forces in the deck panels relative to both compressive strength capacity and potential for buckling. Evaluate tension and shear in the deck panels relative to tensile and shear strength capacity.

5. After loss of strut and slab lateral support has been assessed, evaluate buttress capacity in both horizontal and vertical directions.

6. If the dynamic analysis indicates failure of one or more buttresses, evaluate impacts of breach outflow on adjacent buttresses including, but not limited to, lateral, hydrodynamic pressures on adjacent buttresses.

d. Non-linear analysis shall account for loss of structural stiffness as a result of concrete cracking, yielding of steel, opening of contraction joints, slippage across construction joints (particularly shear strength and height of the keys in the horizontal construction joints of the buttresses), foundation

displacements, non-linear material behavior (particularly concrete cracking and load transfer to the steel reinforcement), and other sources of non-linearity.

e. Dam and foundation shall be analyzed together in a coupled analysis. Dynamic strength of intact rock and concrete shall be included in the analysis. Concrete properties shall account for, as nearly as practicable, the effects of aging and existing cracks and the expected rate of loading. Sensitivity studies using variations in material properties shall be performed where appropriate.

1. Analysis must include dynamic loads from the dam acting on the foundation blocks as well as the inertial loads from the foundation blocks.

2. If the analysis indicates that sliding stresses exceed the frictional resistance plus intact rock cohesion at some point during the earthquake loading, then reduction or elimination of cohesion shall be necessary as well as residual values for frictional resistance.

3. Deformations shall be computed for the foundation blocks by a Newmark-type rigid block sliding analysis, and the dam's performance shall be evaluated by a comparison with acceptable deformation criteria. Foundation compressibility shall include both elastic and inelastic deformations.

7.2 At least two weeks prior to the Potential Failure Modes Analysis meeting specified hereinafter, ENGINEER shall submit a draft Potential Failure Modes Analysis Report for review by OWNER and the Peer Review Board summarizing findings of the structural modeling and risk analyses including, but not limited to, the following:

i. Stress histories that show maximum values, number and duration of excursions beyond the tension or compression limits, and the areal distribution of stresses in the dam.

ii. Statistics on the number of stress cycles exceeding the allowable values and the corresponding excursions of these stress cycles beyond the specified limits.

iii. Graphical depictions showing the extent of deformation of the dam components in three dimensions with appropriate scaling to visualize deformations.

iv. Risk analyses for all failure modes related to reinforced concrete dam components, including probability of occurrence and potential for change over time.

7.3 ENGINEER shall participate in a Potential Failure Modes Analysis meeting at the Possum Kingdom office with OWNER's representative(s) and the Peer Review Board. ENGINEER shall present findings of the structural modeling and risk analyses and assist in formulating potential failure modes and populating event trees.

7.4 ENGINEER shall categorize failure modes and document the major findings and understandings of the PFMA for review by the Facilitator and other Core Team members. Following review and comment by the Core Team, ENGINEER shall finalize the supplemental PFMA report within 60 days of the PFMA session and update any relevant documents in a manner consistent with the existing Supporting Technical Information Document and FERC Part 12D inspection reports. ENGINEER shall submit ten hard copies and one copy in .pdf format of the final PFMA report, incorporating comments from the OWNER.

SECTION VIII. TASK SIX: FAILURE CONSEQUENCE ANALYSIS

8.1 ENGINEER shall evaluate life loss and economic consequences for all event sequences that lead to an uncontrolled reservoir release or operator hazard. In performing these SERVICES, ENGINEER shall:

i. For all event sequences that lead to an uncontrolled reservoir release, postulate the most probable breach parameters; calculate the subsequent discharge hydrograph, and route the discharge hydrograph downstream as necessary to ascertain the incremental population at risk, loss of life, and economic damage in comparison to the probable maximum flood or fair weather condition, whichever is postulated for the failure mode.

a. Breach parameters shall include dam breach location and elevation, breach geometry and rate of development, and reservoir elevation at the initiation of failure. Rate of breach development shall account for size and location of concrete ballast at the breach location, volume of gravel ballast at the breach location, shear stress from flow through the breach per USBR/USACE Best Practices in Dam and Levee Safety Risk Analysis, Chapter 15, and the critical shear stress of the ballast or foundation material.

b. Route the flood wave resulting from each breach scenario using HEC-RAS 4.1 or approved equal, one-dimensional, unsteady flow routing software, at a minimum, including hydrographs representing runoff upstream of the reservoir as well as lateral inflows for areas downstream of the dam. Map floodplain inundation resulting from each breach scenario with the HEC-GeoRAS program or approved equal.

c. For fair weather conditions, dam breach flood routing shall continue to the point where the breach flood no longer poses a risk to life and property damage based on the following criteria:

1. There are no habitable structures in the dam breach inundation zone and anticipated future development in the floodplain is limited.

2. Dam breach flood flows are contained within a large downstream reservoir.

3. Dam breach flood flows are confined within the downstream channel.

d. For probable maximum flood conditions, dam breach flood routing shall continue to the point where the flood elevations resulting from the breach converge to the flood elevations for the same precipitation event without the breach within 1 foot or less.

1. Probable maximum precipitation values shall be derived from NOAA, Hydrometeorological Report No. 51: Probable Maximum Precipitation Estimates, United States East of the 105th Meridian and NOAA, Hydrometeorological Report No. 52: Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian.

2. Spatially center the probable maximum precipitation event over the main river watershed with and without the failure of the dam.

3. Temporal distribution of the probable maximum precipitation event shall be consistent with the National Weather Service Hydrometeorological Report No. 51.

e. OWNER will provide approximately 50 cross sections representing the river channel from Morris Sheppard Dam to approximately 30 miles below DeCordova Bend Dam as well as bathymetric data for Possum Kingdom Lake. ENGINEER shall provide any additional cross sections required to route the dam breach flood wave and estimate roughness coefficients based on water surface elevation for the channel and the overbanks.

ii. Model loss of life and economic loss for each breach scenario with LIFESim or approved equal simulation software using population and building structural inventory data from the Census Bureau and FEMA HAZUS-MH and road and rail network data. Provide estimates of life loss and other output variables as probability distributions. For each breach scenario, provide simulation results for three dam breach time-of-day scenarios: 02:00, 10:00, and 18:00.

iii. For each breach scenario, plot the peak water surface elevation with and without dam breach and time to peak elevation with dam breach at each cross section on the Brazos River downstream from the dam. Also, for each breach scenario, show the flood inundation area with and without dam breach and cross section locations on a plan view of the river.

8.2 Hydraulic modeling SERVICES shall only be performed by a Professional Engineer licensed in the state of Texas and qualified to perform the work. At a minimum,

the hydraulic modeler shall have 10 years of relevant experience with HEC-RAS, LIFESim, or approved equal software.

8.3 ENGINEER shall schedule and conduct an Emergency Action meeting with OWNER's representative(s) and local, emergency response personnel at the Possum Kingdom office prior to the flood inundation simulations in order to review existing and proposed emergency action plans and appropriate simulation inputs regarding safe zones and warning dissemination, mobilization, and evacuation-transportation processes.

8.4 ENGINEER shall install flood routing and simulation models on OWNER's computer system(s); transfer any required software license(s) to OWNER, and train OWNER's personnel to use and maintain the models. ENGINEER shall provide one four-hour training session, at a minimum, for OWNER's personnel, at OWNER's Central Office facilities to demonstrate viewing, adding, and editing dam breach scenarios using Autodesk HEC-RAS, HEC-GeoRAS, and LIFESim, or equal software approved by OWNER.

8.5 ENGINEER shall submit a draft Failure Consequence Analysis Report in Word format for review by OWNER and the Peer Review Board summarizing findings of the hydraulic modeling and flood simulations including, but not limited to, the following:

i. For each breach scenario, plot the peak water surface elevation with and without dam breach and time to peak elevation with dam breach at each cross section on the Brazos River downstream from the dam.
ii. For each breach scenario, show the flood inundation area with and without dam breach and cross section locations on a plan view of the river.
iii. Show life loss probability distributions and probable economic loss for each breach scenario.

8.6 ENGINEER shall participate in a Remediation Strategy meeting at the Possum Kingdom office with OWNER's representative(s) and the Peer Review Board. ENGINEER shall present findings of the consequence analysis, assist in populating event trees, and recommend appropriate actions to remedy the root cause of structural deficiencies.

i. Examine baseline risk for components that contribute the highest risk and brainstorm structural and non-structural alternatives to economically reduce risk.

ii. Revise previously developed event trees to quantify the effects of the alternatives on the components of risk.

Following the Remediation Strategy Meeting, ENGINEER shall submit ten hard copies and one copy in .pdf format of the final Failure Consequence Analysis Report, incorporating comments from the OWNER.

SECTION IX. TASK SEVEN: RISK REDUCTION ANALYSIS.

9.1 ENGINEER shall calculate the baseline residual service life and annualized failure probability as a function of time assuming that no repair or rehabilitation work transpires for the duration of the dam's service life.

9.2 ENGINEER shall recommend priority and sequence of repairs, based upon annualized life loss, annualized economic loss, and/or annualized probability of operator injury, for each type of reinforced concrete defect.

9.3 ENGINEER shall forecast the residual service life of the concrete structural components of the dam and intake and annualized failure probabilities as a function of time for various risk reduction alternatives.

i. Risk shall be computed by finding the product of probabilities and consequences for each path in an event tree. Total risk shall be calculated by summing the values from all paths.
ii. Monte Carlo simulations may be performed to combine the variations in estimates and to portray the range in final results.
iii. Residual service life calculations shall account for carbonation and chloride-induced corrosion, particularly impacts of the following on service life:

a. crack density and width.
b. chloride in excess of the threshold limit for corrosion in proximity to deeply embedded reinforcing steel.
c. appropriate transport and reaction coefficients including atypical constituents and pathways.

iv. Unless otherwise approved by OWNER, ENGINEER shall evaluate the following risk reduction alternatives at a minimum:

a. Repair of concrete spalling at the buttress corbels including methods to minimize reinforcing steel corrosion at the spall and anodic ring corrosion as well as methods to enhance corbel strength.
b. Repair of concrete spalling at the bulkhead strut support sockets including methods to minimize reinforcing steel corrosion at the spall and anodic ring corrosion.
c. Repair of hydrogen sulfide induced concrete corrosion near observed leakage in Bay 9.
d. Repair of observed leakage into Bay 9 or methods to remove water from Bay 9 without releasing hydrogen sulfide gas.
e. Repair or replacement of the flow measurement device in Bay 9 in a manner that minimizes release of hydrogen sulfide gas.
f. Repair of panel-panel and panel-buttress joints including submerged joints.

g. Method(s) to reduce rate of reinforcing steel corrosion induced by carbonation, acidification, and/or chloride ions.
h. Repair of buttress footings to increase shear capacity.
i. Repair of upstream deck panels at or below elevation 885.
j. Repair of freeze-thaw damage.
k. Others that ENGINEER deems appropriate.

9.4 Unless otherwise approved by OWNER, ENGINEER shall evaluate feasibility and cost of converting the slab and buttress dam into a gravity dam including at a minimum the following:

i. Effect of the upstream deck slab slope on the stability of the proposed gravity dam.
ii. Method to transfer loads between the concrete fill, existing ballast, and existing buttresses in order to prevent differential movement of gravity dam segments.
iii. Effect of existing gravel and concrete ballast on placement of concrete fill, differential settlement of dam components, and lateral pressure on the deck slabs.
iv. Additional drains if necessary to relief foundation pressure or pressure between the deck slabs and the concrete fill.
v. Access for maintenance of existing pressure relief wells.

9.5 ENGINEER shall produce parametric cost estimates and timelines for implementation of risk reduction alternatives. ENGINEER shall perform preliminary engineering of risk reduction alternatives as necessary to estimate costs and identify risks posed by the potential construction activities.

9.6 ENGINEER shall schedule and conduct a two-hour (minimum) workshop with OWNER's staff in the Central Office facilities to present results of the reinforced concrete assessment including, at a minimum, the following topics.

i. Summary of probable failure mode and failure consequence analyses including comparison of risks at Morris Sheppard Dam to risks at similar facilities as well as life loss risks from ordinary activities.

ii. Cost, annualized life loss and economic risk, and residual service life for each risk reduction alternative including the do-nothing alternative.

iii. Recommended programmatic approach for the OWNER to consider for accomplishing the repair of concrete deterioration identified during the inspection.

iv. Operations and maintenance activities that OWNER may initiate to prevent future deterioration.

9.7 Following the workshop, ENGINEER shall submit ten hard copies and one copy in .pdf format of the final Risk Reduction Alternatives Report, incorporating comments from the OWNER.

SECTION X. ADDITIONAL SERVICES OF THE ENGINEER

10.1 If authorized in writing by the OWNER, the ENGINEER shall furnish or obtain from others Additional Services of the following types, which are not considered normal or customary Basic Services under this AGREEMENT; these will be paid for by the OWNER at the unit rates stipulated in "Exhibit C":

i. Appearances before regulatory agencies or other public meetings other than those provided as a Basic PROJECT Services.

ii. Field layouts or the furnishing of construction line and grade surveys.

iii. Making property, boundary and right-of-way surveys, preparation of easement and deed descriptions, including title search and examination of deed records.

iv. Providing environmental support SERVICES including the design and implementation of ecological baseline studies, environmental monitoring, impact assessment and analyses, permitting assistance, and other assistance required to address environmental issues.

v. Making revisions to drawings, specifications or other documents when such revisions are 1) consistent with approvals or instructions previously given by OWNER or 2) due to other causes not solely within the control of ENGINEER.

vi. Services required to resolve bid protests or to rebid the projects.

vii. Any additional SERVICES required as a result of default of the Contractor or the failure, for any reason, of the Contractor to complete the work.

viii. Revision of PROJECT deliverables requested by OWNER after OWNER'S written approval of same unless such revision is required for the correction of ENGINEER'S work products containing errors/omissions or other faults.

ix. Providing consultation concerning the replacement of any work damaged by fire or other cause during the construction, and providing SERVICES as may be required in connection with the replacement of such work.

x. Copies of PROJECT documents in excess of number provided as a Basic PROJECT service.

xi. Providing SERVICES after the completion of all TASKS set forth above not specifically listed in the Basic Services.

xii. Providing SERVICES made necessary due to the presence of hazardous substances in any form.

xiii. Design, contract modifications, studies or analysis required to comply with local, State, Federal or other regulatory agencies that become effective after the date of this agreement.

xiv. Industrial rope access by SPRAT/IRATA certified technicians in conformance with applicable OSHA regulations.

SECTION XI. DELIVERABLE REQUIREMENTS

11.1 Drawings, specifications, and related documents shall only be acceptable if they have been prepared under the direction of a Professional Engineer licensed in the State of Texas and qualified to perform the Work. All engineering documents must have an engineering seal, signature, firm registration name and number and dates affixed in accordance with the rules of the Texas Board of Professional Engineers.

11.2 Drawings shall be scaled such that all dimensions, details, or other information relevant to construction are legible within the 19” x 32” title block when reduced to half-scale. Drawings intended for review, bidding, construction, or record purposes shall be printed on 22” x 34” sheets unless otherwise directed by the OWNER.

11.3 All drawings, except one-line and control diagrams and details, shall be drawn to standard engineering or architectural scales or a multiple of 10 times a standard engineering scale. The scale shall be clearly shown on the drawing using a graphic scale.

11.4 Reports or specifications shall be printed on heavy, first quality 8-1/2" X 11" paper. Reduce drawings and diagrams to 8-1/2" X 11" or 11" by 17" paper size. Text and drawings shall be legible and reproducible by standard copy machines. Marking out with ink shall not be acceptable. Do not use "highlighting". Hard copy reports shall be bound in three-ring binders.

11.5 All drawings shall be drawn within the PROJECT-specific OWNER title block. All abbreviations and symbols used on the drawings must be defined.

11.6 Drawings shall have consistent graphics and fonts. The fonts shall be similar to AutoCAD, 1/8-inch Romanesque.

11.7 Plan views shall include a north arrow similar to the OWNER standard arrow. The arrow shall be oriented either toward the top or toward the right.

11.8 Existing facilities and utilities shall be clearly shown on drawings using a reproducible color (gray) and line weight that can be easily differentiated from proposed facilities and utilities (black).

11.9 Products may be specified as notes on the drawings whenever feasible without affecting the quality or cost of the completed work.

11.10 Products may be specified by manufacturer and model; however, each reference to a specific product must include the phrase "or approved equal" unless OWNER authorizes sole source procurement in writing.

11.11 Specifications shall conform to the Construction Specifications Institute format and the OWNER standard font style and size.

11.12 All submittals shall include PROJECT-specific header and footer information that matches the OWNER standard for this PROJECT. The footer of each page of any report produced for this PROJECT shall contain the following phrase in red, italic font: "Contains Critical Energy Infrastructure Information – Do Not Release".

11.13 References to Division 0 and Division 1 documents shall match OWNER standard section numbers.

11.14 Drawing cover sheets and manual covers shall include a logo approved by the OWNER.

11.15 Video of each inspection shall be submitted on a DVD. All inspection videos shall be clearly audible. DVDs of each inspection shall be neatly labeled and bound into each report in clear, poly safety sleeves.

SECTION XII. HEALTH & SAFETY REQUIREMENTS

12.1 ENGINEER understands and acknowledges that ENGINEER and ENGINEER's employees, sub-contractors and sub-consultants may encounter potentially hazardous conditions while performing activities on or within the OWNER's facility.

12.2 ENGINEER understands and acknowledges that ENGINEER shall be solely responsible for the Health and Safety of ENGINEER'S employees, sub-contractors and sub-consultants while they are at OWNER's facilities, including, but not limited to the responsibility of fully:

i. evaluating the potential hazards at the OWNER site, whether inherent to the site and its normal operation, or resulting from ENGINEER's activities and practice;

ii. implementing any and all safety procedures and requirements for ENGINEER's employees, sub-contractors and sub-consultants; and

iii. complying with health and safety-related state and federal requirements as applicable, including but not limited to the Federal Occupational Safety and Health Act of 1970, and associated regulations.

12.3 ENGINEER shall notify OWNER in advance of any activities or practices that have the potential to add to or exacerbate hazards inherent to the site and its normal operation. Such activities or practices shall not commence until OWNER has prepared OWNER personnel to operate and maintain the facility while such activities or practices are underway by ENGINEER.

12.4 OWNER's documents regarding known hazards and hazard mitigation have been developed by the OWNER solely to meet the needs of OWNER's personnel performing routine duties concerning operation and maintenance of the facility. ENGINEER may, on request, receive a copy of the OWNER's known hazards and hazard mitigation plan. Such documents shall be provided for ENGINEER's information only, and shall in no way constitute any, all or part of ENGINEER's hazard assessment.

12.5 ENGINEER may utilize existing, permanent, engineered control measures within OWNER's facilities for work related to this PROJECT, such as ventilation and lighting systems, if available, subject to the limitations stipulated hereinafter:

i. OWNER reserves the right to schedule use of such systems by ENGINEER at its sole discretion. ENGINEER shall make no claim to increase the PROJECT fee or schedule based upon availability of such systems.

ii. ENGINEER shall notify the OWNER at least two (2) business days prior to the date that utilization of such systems are requested.

iii. ENGINEER shall be fully responsible for assessing the adequacy of engineered control measures for work to be performed by ENGINEER's employees, sub-contractors, or sub-consultants.

iv. ENGINEER shall be fully responsible for ensuring the Health and Safety of ENGINEER's employees, sub-contractors, and sub-consultants should OWNER's facilities or equipment fail or malfunction during work being performed by ENGINEER.

v. OWNER shall not be obligated under any circumstances to provide personal protective equipment or monitoring equipment for ENGINEER.

vi. Underwater diving work shall be performed by qualified personnel in compliance with applicable provisions of 40 CFR 1910 Subpart T and 40 CFR 1926 Subpart Y.

vii. THE ENGINEER HEREBY EXPRESSLY AGREES TO INDEMNIFY AND HOLD HARMLESS THE OWNER AND THE OWNER'S OFFICERS, AGENTS AND EMPLOYEES, FROM AND AGAINST ALL CLAIMS, DEMANDS, COSTS, CAUSES OF ACTION, AND LIABILITY OF EVERY KIND AND NATURE, INCLUDING REASONABLE ATTORNEY'S FEES FOR THE DEFENSE OF SUCH CLAIMS AND DEMANDS, ARISING OUT OF OR ATTRIBUTED, DIRECTLY OR INDIRECTLY, TO ENGINEER'S UTILIZATION OF ENGINEERED CONTROL MEASURES WITHIN FACILITIES OWNED BY OWNER.

SECTION XIII. SECURITY REQUIREMENTS

13.1 ENGINEER shall establish and enforce security procedures at the PROJECT site that minimize the potential for property damage; danger to facility personnel; danger to ENGINEER's employees, sub-contractors, or sub-consultants; danger to the public and operational problems due to unauthorized entry to and/or activities at the PROJECT site. ENGINEER shall be responsible for implementing procedures that provide secure conditions associated with PROJECT activities, whether within controlled access areas or public access areas. ENGINEER shall ensure that the requirements contained within this section are contained within contractual documents between the ENGINEER and sub-contractors or sub-consultants.

13.2 ENGINEER shall abide by all security procedures in effect at OWNER's facilities. ENGINEER shall keep all gates closed to control access to the PROJECT site. Under no circumstances shall the ENGINEER allow controlled access areas to be left open unattended. The controlled access area must be secured properly prior to leaving the site unattended. Whenever OWNER's personnel provide an access code for security gate(s), ENGINEER shall not divulge the code to any personnel without a security clearance.

13.3 Unless otherwise approved by the OWNER, normal working hours shall be limited to 8:00 a.m. to 4:00 p.m. Monday through Friday. When facility access is required during times other than normal working hours, the ENGINEER shall coordinate with the OWNER regarding access. ENGINEER shall provide at least two (2) business days notice when site access will be required during non-working hours.

13.4 ENGINEER's employees, sub-contractors, or sub-consultants, or others working at the PROJECT site, who want unescorted access to OWNER's facilities, must submit personal and vehicle identification information as stipulated hereinafter to the OWNER's Chief Lake Ranger or Security Program Manager in writing seventy-two (72) hours or three (3) working days prior to required PROJECT site access. The purpose of this information is to issue personnel access badges and vehicle access placards.

i. OWNER's security personnel must review and approve a background check on anyone, who will be allowed unescorted access into controlled access areas. Personnel cleared for access to secure areas shall be issued a badge that shall be displayed and clearly visible on their person at all times. Persons not displaying authorized access badges within controlled access areas shall be removed immediately.

a. ENGINEER shall submit a certified copy of a background check on all employees, sub-contractors, or sub-consultants for whom ENGINEER requests unescorted access to controlled access areas. The background check(s) shall be conducted by a security contractor approved by the Texas Department of Public Safety, not more than one (1) year prior to required site access.

b. The OWNER reserves the right to refuse entry to anyone who fails the background check or anyone who refuses to provide required information. Factors that may disqualify personnel for access into the PROJECT site include, but are not limited to the following:

1. Murder conviction.
2. Any terroristic act or threat.
3. Any registered sex offender.
4. Any conviction for violence that causes serious bodily injury within past five years.
5. Felony theft conviction within past ten years.
6. Felony burglary conviction within past ten years.
7. Presence on any International, Federal, or State watch list.
8. Workplace violence (to include communicated threats) within the PROJECT site.
9. Vandalism or theft within the PROJECT site.
10. Determination that the person is in the country illegally.

c. The OWNER's Chief Lake Ranger or Security Program Manager may withdraw badges from ENGINEER's employees, sub-contractors, or sub-consultants due to changes in their background, their conduct on the PROJECT, or any other activities deemed detrimental to the PROJECT, to OWNER's facilities, or resulting in danger to other personnel.

ii. OWNER's security personnel will issue access placards for any vehicles that need to enter a controlled access area. This placard must be positioned in or on each vehicle such that it is clearly visible upon exterior inspection of the vehicle. Only vehicles displaying access placards issued by OWNER are allowed to enter controlled access areas.

a. ENGINEER's employees, sub-contractors, or sub-consultants requesting vehicle access into controlled access areas shall submit the year, make, model and license plate number or vehicle identification number for each vehicle.

b. Any vehicle within the PROJECT site is subject to search by OWNER's security personnel without notice. Vehicles found inside a controlled access area without a valid access placard shall vacate the PROJECT site immediately.

c. Vehicles found to contain prohibited items will be escorted out of the controlled access area by a Lake Ranger. The vehicle will be allowed back into the controlled access area after the items have been removed. Prohibited items include:

1. Firearms.
2. Fireworks.
3. Alcoholic beverages.
4. Video recording devices.
5. Cameras unless required by the Contract.

d. Contraband found in violation of any State, Federal or Local laws will be seized as evidence. The person or persons involved will be escorted out of the controlled access area, and the person or persons found in violation will be processed accordingly.

e. The OWNER reserves the right to inspect vehicle(s) prior to entry into and upon departure from the PROJECT site.

13.5 ENGINEER shall work with OWNER's security personnel to ensure rigid compliance. OWNER's security personnel shall be notified immediately by ENGINEER upon termination of any employee, sub-contractor, or sub-consultant, and ENGINEER shall immediately retrieve access badges and vehicle placards.

13.6 OWNER's security personnel will conduct random checks in the PROJECT site to assure all persons and vehicles are in compliance with the requirements set forth herein. Personnel inside the PROJECT site shall provide photographic identification that matches the personnel access badge issued for the PROJECT whenever requested by OWNER's security personnel.

13.7 ENGINEER shall coordinate all photography through the Chief Lake Ranger. No unauthorized photography will be allowed within the PROJECT Site. All photographs taken within the PROJECT site shall become the property of the OWNER.

13.8 Cell phones are not prohibited, but use of the video and camera function will only be allowed for authorized photography.

13.9 ENGINEER shall not permit any alcoholic beverages or illegal substances on the PROJECT site at any time.

13.10 ENGINEER shall not permit any concealed or illegal weapons on the PROJECT site at any time.

SECTION XIV. ADDITIONAL SERVICES OF THE OWNER

14.1 In addition to general responsibilities of the OWNER enumerated in the AGREEMENT, OWNER shall provide the following PROJECT-specific services subject to the limitations stipulated hereinafter:

i. Furnish one (1) 24-foot wide x 30-foot long, 30,000-pound capacity barge equipped with a work platform, one (1) crew boat with push knees and personnel to operate the work boat in order to access upstream surfaces of the dam or intake not otherwise accessible, subject to the following limitations:

a. OWNER reserves the right to schedule such services at its sole discretion. ENGINEER shall make no claim to increase the PROJECT fee or schedule based upon availability of the barge, crew boat or operational personnel.
b. ENGINEER shall notify the OWNER at least two (2) weeks or ten (10) business days prior to the date that boat services are requested.
c. ENGINEER's employees, sub-contractors, and sub-consultants shall comply with OWNER's safety requirements during boat operations.
d. OWNER will furnish flotation devices for ENGINEER's employees, sub-contractors, and sub-consultants. ENGINEER shall furnish any additional safety equipment required by OWNER during boat operations.

ii. Excavate gravel ballast at three locations within the dam, subject to the following limitations:

a. OWNER reserves the right to schedule such services at its sole discretion. ENGINEER shall make no claim to increase the PROJECT fee or schedule based upon availability of personnel or equipment to perform excavation services.
b. ENGINEER shall notify the OWNER at least two (2) weeks or ten (10) business days prior to the date that excavation services are requested.
c. Excavation services shall be limited to the following locations within the dam:

1. Bays 9, 10, 13, and 15.
2. Bays 5 through 7 and 16 tunnel area only.

d. Locations for excavations shall be marked by the ENGINEER. OWNER may reject any location at its sole discretion.

e. Unless otherwise approved by OWNER, depths of excavations shall not exceed twelve (12) feet below existing grade at any location within the dam. If an excavation does not yield sufficient water for sampling at that depth, ENGINEER may select one alternative excavation location, but no more than four locations shall be excavated.

f. OWNER may cease excavation operations if, in the sole opinion of OWNER's site safety supervisor, further excavation activities would require continuous supplied air.

g. ENGINEER's employees, sub-contractors, and sub-consultants shall comply with OWNER's safety requirements during excavation operations.

iii. Furnish available historical water quality data for Possum Kingdom Lake near the dam.

iv. Furnish available surveying data for benchmarks at the PROJECT site.

v. Furnish electrical power subject to limitations stipulated above.

14.2 THE ENGINEER HEREBY EXPRESSLY AGREES TO INDEMNIFY AND HOLD HARMLESS THE OWNER AND THE OWNER'S OFFICERS, AGENTS AND EMPLOYEES, FROM AND AGAINST ALL CLAIMS, DEMANDS, COSTS, CAUSES OF ACTION, AND LIABILITY OF EVERY KIND AND NATURE, INCLUDING REASONABLE ATTORNEY'S FEES FOR THE DEFENSE OF SUCH CLAIMS AND DEMANDS, ARISING OUT OF OR ATTRIBUTED, DIRECTLY OR INDIRECTLY, TO THESE ADDITIONAL SERVICES TO BE PERFORMED BY THE OWNER, ITS OFFICERS, AGENTS, EMPLOYEES AND PARTIES WITH WHOM IT CONTRACTS.

SECTION XV. ENGINEER'S QC/QA PLAN

15.1 ENGINEER shall implement and maintain a Quality Control/Quality Assurance ("QC/QA") plan that incorporates QC/QA for ENGINEER and all sub-consultants.

15.2 The QC/QA plan ("Plan") shall be a comprehensive, well-defined, written set of procedures and activities carried out by the ENGINEER aimed at delivering products that meet the BRA's expectations and contractual requirements. The ENGINEER'S Plan shall identify the organization or individuals responsible for Quality Control and the specific procedures used to ensure delivery of a quality product. The Plan shall also detail Quality Assurance measures and the method of accountability and required documentation.

15.3 The QC/QA Plan shall at a minimum include the following:

i. Organizational chart showing responsibilities for engineering or construction services and QC/QA checks.

ii. Project schedule including deliverables and milestone
iii. Project QC/QA requirements and milestones

a. Scoping Phase: All necessary disciplines shall be included when scoping a project.
b. Design Phase: provide QC/QA reviews at every contractual milestone, within all necessary disciplines, and regarding any modifications or additions to the design.
c. Construction Phase: The QC/QA Plan shall incorporate engineering during construction, contract administration, and resident project representative duties as set forth in the Contract.

15.4 QC/QA checks shall be conducted by an independent person, well qualified in the specific scientific or technical area of review, that is not directly associated with the development of the project.

15.5 Communications plan that outlines the protocol for all communications related to the QC/QA Plan.

15.6 Format and schedule for checking design reports, calculations, plans and specifications, and construction work. The QC/QA Plan shall make provisions for review of reports, plans, specifications, estimates and construction work provided by sub-consultants.

15.7 Format and procedure for documenting all comments, issues, and responses provided as part of the review process and coordinating this information with the BRA. Where appropriate, established BRA forms shall be provided and used for coordinating this information with the BRA.

15.8 Format and procedure for providing written certification that all of the requirements of the QC/QA Plan have been met and that all comments and issues have been resolved to the satisfaction of the review team.

15.9 Check all documents for accuracy and completeness by using prescribed checklists, standards, policies, and procedures.