STATEMENT OF QUALIFICATIONS

Buchanan Dam Arch Study
Peer Review
Lower Colorado River Authority

January 21, 2009
January 21, 2009

Katherine Berbel
Senior Category Manager
Lower Colorado River Authority

Statement of Qualifications – Buchanan Dam Arch Study Peer Review

Dear Ms. Berbel:

LCRA’s Buchanan Dam is one of the largest and most recognized multiple arch and buttress dams in the United States. We fully recognize the importance of involving uniquely qualified engineers to conduct a peer review of URS’ Buchanan Dam Structural Analysis – 35-Foot and 70-Foot Multiple Arch Sections. Each of our project team members has participated in the engineering analysis and/or rehabilitation of concrete buttress dams. Our experience includes:

- Engineering for nearly 90 percent of the concrete buttress dams over 30 feet tall in Texas
- Analysis and rehabilitation for 16 large multiple arch and slab and buttress dams across the United States, and others throughout the world

Freese and Nichols has inspected, analyzed and designed more than 500 dams, mostly in Texas, during the past 10 years. We are confident that our team has the experience and technical capability to keep public safety in the forefront, safeguard LCRA’s interest, and complete the project within the required time period.

**Familiarity with LCRA and National Expertise**

In addition to Freese and Nichols’ dam engineering specialists – known by many of your staff from their involvement in LCRA’s Dam Modernization Program and the Engineering and Dam Safety Program – we have enlisted internationally recognized concrete buttress dam specialists Mete Sozen, Ph.D., S.E., and Eric Kollgaard, P.E. to help in the assessments and interpretation of the engineering code.

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Peer Review Goal: Code Compliance or Safety Issues
Our peer-review goal will be to carefully evaluate the analyses and failure modes identified in the URS report. Older structures like Buchanan Dam often will not be in compliance with current American Concrete Institute 318 codes, and we will evaluate whether the failure modes were defined simply by engineering code limitations or whether Buchanan Dam is at risk for brittle failure, potentially creating serious operational and safety issues. The team will use its combined experiences to evaluate the failure modes and, if required, recommend appropriate testing and remedies to strengthen Buchanan Dam.

Risk Management
LCRA is facing the risks of costly repairs at Buchanan Dam. Our project team has managed similar project risks on previous dam evaluations and rehabilitation projects. We fully understand the importance of due diligence in each segment of the evaluation and, if needed, the design of any necessary rehabilitation. A key factor in the overall peer review is related to unwarranted repairs. We will thoroughly review the Buchanan Dam analysis according to contemporary dam safety standards and engineering practices and provide recommendations in light of the peer review findings. We are experienced in presenting the results of our dam evaluations in a clear, concise manner to stakeholder groups and decision-making bodies.

Freese and Nichols has enjoyed the trust that LCRA has placed in our firm for nearly 20 years, and we appreciate your consideration of our qualifications for the peer review of Buchanan Dam Structural Analysis – 35-Foot and 70-Foot Multiple Arch Sections.

Thank you for this opportunity. Please feel free to contact me with any comments or questions.

Sincerely,

John S. Wolfhope, P.E.
Project Manager / Principal
(512) 617-3118; jsw@freese.com
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Section One – Qualifications in Structural Evaluation of Dam Structures

Slab-and-buttress dams and multiple-arch dams are both considered concrete buttress dams. The Freese and Nichols Team has unmatched experience in the analysis and rehabilitation of Concrete Buttress Dams, including both flat slab-and-buttress dams and multiple arch dams. Every member of the Freese and Nichols team has direct experience evaluating concrete buttress dams.

Project Team Experience
Freese and Nichols team members have analyzed and/or rehabilitated:

- Nearly 90 percent of the remaining concrete buttress dams over 30 feet in Texas (see map above)
- 16 high-hazard and large concrete buttress dams throughout the United States and others internationally

We also have enlisted two highly respected international experts on concrete buttress dams – Mete Sozen, Ph.D., P.E., and Eric Kollgaard, S.E. – to manage the Structural Assessment (Sozen) and Rehabilitation and Repairs (Kollgaard) functions of our project approach.

Freese and Nichols also has inspected, analyzed and designed more than 500 dams during the past 10 years.

Project Team

John Wolfhope, P.E. – Project Manager
John Wolfhope has been Project Manager and Engineer for the analysis of three concrete buttress dams, including the interpretation of Finite Element Modeling results for the rehabilitation of two flat slab-and-buttress dams. He has served as Project Manager or Lead Engineer for all of the dams rehabilitated as part of LCRA’s Dam Modernization Program.
Victor Vasquez, P.E. – Project Engineer
Victor Vasquez served as Project Engineer for the rehabilitation of Tom Miller Dam, including mapping of concrete cracks throughout the flat slab-and-buttress portions of the dam. He has significant experience supporting LCRA for its Dam Modernization Program and has substantial experience in construction management and inspection for reinforced concrete dams.

Les Boyd, P.E. – Structural Coordination and Stability
Les Boyd has more than 36 years experience in the engineering, construction, and rehabilitation of concrete dams. He has served as Project Engineer and Resident Inspector for the rehabilitation of two concrete buttress dams including the Brazos River Authority’s Morris Sheppard Dam, the tallest flat slab-and-buttress dam in the United States. Mr. Boyd has managed construction phase inspection programs for construction of repairs to all of the LCRA Highland Lakes Dams.

Brad Watson, P.E. – Structural Engineering
Brad Watson is Freese and Nichols’ Structural Group Manager and a firm Associate. He brings substantial experience in the Finite Element Modeling of reinforced concrete dams. He has provided structural engineering services to support LCRA’s Dam Safety Team and Engineering Program.

Antonio Diaz, P.E. – Quality Control and Review
Antonio Diaz is a firm Associate with more than 45 years experience in the structural engineering for reinforced concrete dams, including more than 30 large and high-hazard dams. He has been responsible for the technical oversight and interpretation of Finite Element Modeling of four concrete buttress dams.

Ron Lemons, P.E. – Principal-in-Charge
Ron Lemons is Freese and Nichols’ Chief Operating Officer, Senior Vice President and a Principal of the firm. He is former President of the U.S. Society on Dams and has served as Project Manager for the Trinity River Authority’s $65-million Richland Chambers Reservoir, the Colorado Municipal River Authority’s $30-million Simon W. Freese Dam, and the Palo Duro River Authority’s $13-million Palo Duro Dam and Reservoir.

Mete Sozen, Ph.D., P.E. – Structural Assessment
Mete Sozen has more than 50 years experience in the development of reinforced concrete engineering practices. He is an international expert in the analysis of concrete buttress dams and the interpretation of the American Concrete Institute (ACI) reinforced concrete code. His long-standing participation as an active member of the ACI 318 committee provides a thorough understanding of the intent of the design code, its limitations, and the ability to apply the code to unconventional structures including massive concrete dams.

REFERENCES
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Eric Kollgaard, P.E. – Rehabilitation and Repair

Eric Kollgaard has more than 50 years experience leading the engineering design and rehabilitation of concrete dams, including five concrete buttress dams. He has served on Freese and Nichols teams for 12 years, including the rehabilitation of two concrete buttress dams. Mr. Kollgaard is recognized as the leading expert in the analysis and rehabilitation of reinforced concrete dams throughout North America.

The Freese and Nichols Team’s Relevant Dam Experience

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Featured Projects

The following pages feature three major projects that demonstrate Freese and Nichols' experience with concrete buttress dams and with LCRA. See pages 21-23 for Dr. Sozen's and Mr. Kollgaard's resumes that feature their impressive lists of projects related to concrete buttress dams and corbel rehabilitation.
Morris Sheppard Dam Rehabilitation

Brazos River Authority

Freese and Nichols has continuously provided engineering services for the Brazos River Authority’s (BRA) Morris Sheppard Dam since 1987. It is a 188-foot-high, 1,655-foot-long concrete buttress dam built from 1938-41, and is the highest slab-and-butress dam in the United States.

1987 – Emergency Rehabilitation and Modifications

In 1987, Freese and Nichols discovered signs of movement and structural distress during a five-year Federal Energy Regulatory Commission (FERC) inspection. Buttresses along the spillway had moved downstream as much as 4.5 inches, enough to crack the hearth and its downstream deflector toe wall. Freese and Nichols recommended immediate corrective actions, which included stabilizing and strengthening the slab-and-butress section of the dam. The plan lowered the lake 13 feet to increase the factor of safety and drilling 145 relief wells to alleviate the hydrostatic pressure. Freese and Nichols also worked closely with BRA, FERC and the Texas Water Commission (now TCEQ) to quickly resolve the problem and significantly reduce the dam’s potential for disaster.

1993 – Stilling Basin Extension

In 1993, Freese and Nichols designed a stilling basin extension, which included construction of a Roller Compacted Concrete Wall and erosion protection around the basin.

1994 – Bear Trap Gates Replacement #1

In 1994, Freese and Nichols designed upgraded replacements for four of the nine, 50-year-old bear trap gates, using a dynamic wave model to more accurately simulate the actual PMF loading conditions. Freese and Nichols prepared plans and specifications for the installation, which the BRA staff managed. The replacement design also was less susceptible to corrosion and provided for easier maintenance.

1998 – Bear Trap Gates Replacement #2

In 1998, Freese and Nichols designed replacements for the remaining five bear trap gates, efficiently incorporating cost-saving measures from the initial gate replacement design and adapting the design to accommodate the capabilities of the BRA staff.


Wesley Seale Dam

City of Corpus Christi

Freese and Nichols has been the City of Corpus Christi’s trusted advisor for dam services for the Wesley Seale Dam since 1992. The 80-foot-high, 5,680-foot-long dam was completed in 1958. It has three earth embankment sections and two 40-foot-high Ambursen, flat-slab-and-buttress spillways that accommodate 60 gates.

Those services have included:

- Dam safety inspections
- Design of spillway stabilization for the slab-and-buttress structures
- Design for the rehabilitation of crest gates and sluice gates
- Update of the Probable Maximum Flood (PMF)
- Section 404 Permitting
- Breach analysis and inundation mapping
- Construction phase monitoring
- Instrumentation evaluation
- Design of a parapet wall

Freese and Nichols evaluated the dam in 1996 and found concrete bulges in the hearth slabs, cracking of buttresses and abutment members, and downstream offsets in alignment of the spillways of up to four inches.

Freese and Nichols studied failure modes to explain the observed movements in the structure, and developed advanced Finite Element Models to analyze the structural behavior of the concrete buttress dam.

The design stabilized the slab-and-buttress spillways with 70,520 cubic yards of concrete. It also included reference monuments and extensometers for precision monitoring of any future spillway movement.

Freese and Nichols’ $23-million rehabilitation design saved the City about $5 million and achieved a 50-percent increase in the sliding factor of safety. The project was completed one year ahead of schedule. One time-saving method involved filling the spillway with sand to provide temporary stabilization, allowing the contractor to use conventional drilling instead of a barge to more efficiently install drains in the spillway.

Freese and Nichols significantly reduced the cost of modifications by using a dynamic wave model to update the PMF, reducing the level of overtopping from more than 10 feet to less than four feet. The PMF was easily contained by the addition of a parapet wall on the embankment sections.

2002 Top Engineering Excellence Award (Water Resources), Consulting Engineers of Texas’; National Finalist

2001 National Rehabilitation Project of the Year, Association of Dam Safety Officials

2001 Award of Excellence, Texas Construction Best of 2001
**Dam Modernization Program**

**Lower Colorado River Authority**

Freese and Nichols provided engineering services for the Lower Colorado River Authority’s dam safety program since 1994. The three-phase dam modernization program has included comprehensive dam evaluation, hydraulic and structural analysis, design of modifications, and construction phase services for Buchanan, Inks, Starcke, Tom Miller and Wirtz Dams.

Freese and Nichols completed the following:

- Developed a new PMF for each dam based on the use of a state-of-the-art dynamic wave model
- Reduced flood levels at Buchanan and Inks Dams, using modeling, to save LCRA about $40 million in repairs
- Identified possibly significant structural and hydraulic inadequacies at Tom Miller, Wirtz and Buchanan Dams
- Performed structural analysis of non-overflow sections, parapet walls, core walls and various other sections of the dams using the following analytical methods: internal stress analysis, overturning stability analysis and sliding stability
- Identified minor problems at Inks and Starcke Dams
- Analyzed the strength and stability of Inks, Wirtz and Tom Miller Dams, using advanced Finite Element Models to predict the structural behavior under various loads
- Analyzed PMF at Buchanan and Inks Dams and determined the dams’ hydraulic adequacies

**Projects Summaries**

- Buchanan Dam – Stabilization of the gravity non-overflow sections and stabilization of the multiple-arch foundation and spillway structures
- Inks Dam – Stabilization of the gravity spillway section, stabilization and investigation of the gravity non-overflow section
- Wirtz Dam – Design of a soil-cement overlay for the embankment section and stabilization of the gravity non-overflow sections, spillway and powerhouse intake with post-tensioned anchors
- Starcke Dam – Foundation repair at the toe of the dam
- Tom Miller Dam – Stabilization of the masonry overflow section and powerhouse intake structure and structural strengthening of the flat slab-and-buttress sections
Section Two – Proposed Project Approach

This section will address:

- Project Approach
- Risks
- Statement of Work
- Deliverables

Project Approach
Freese and Nichols’ approach begins with the development of a clear understanding of the URS’ report for the Buchanan Dam Structural Analysis – 35-Foot and 70-Foot Multiple Arch Sections. We will evaluate the thought processes utilized in arriving at statements regarding “under-reinforced” corbels and possible “brittle failures.” This approach is based on the limited information currently available from the report’s executive summary.

Our peer review of the analysis report will include the following evaluations:

- Independent review of the structural analysis, findings, and recommendations contained in the report
- Review of corbel conditions and investigation of repair alternatives

Initial Review of Structural Analysis’ Executive Summary
Our project team has reviewed the structural analysis’ Executive Summary, incorporated our knowledge of the Buchanan Dam, our team’s extensive experience with similar concrete buttress dams, and published accounts of concrete buttress dam rehabilitation.

An Approach Built on the Freese and Nichols Team’s Experience with Concrete Buttress Dams

Multiple-arch dams are part of a class of structures known as concrete buttress dams. Less than 35 multiple-arch dams over 30 feet in height remain in service in the United States.

Flat slab-and-buttress dams are the other significant type of concrete buttress dams. Less than 70 flat slab-and-buttress dams over 30 feet in height remain in service in the U.S.

All concrete buttress dams are similar in that they consist of a structural element (flat slab or arch section) that retains the reservoir and is supported by a series of buttresses. Texas and California are the two states having the most concrete buttress dams over 30 feet in height remaining in service.

The Freese and Nichols Team has unmatched experience in the analysis and rehabilitation of concrete buttress dams, especially in Texas, including both flat slab-and-buttress dams and multiple arch dams.
According to the Executive Summary, URS indicates that the arches and buttresses (in their current condition), have adequate safety. Our team agrees with the first task expressed in the RFQ: perform a structural analysis review of the arch and buttress structure.

By fully understanding the behavior of the arches and the buttresses under the assumed loads, our team expects to verify, or nullify, any structural concerns and failure modes that can reasonable be identified. We will critically evaluate the failure modes that the analysis identifies.

Our initial assessment is that the concerns may be more related to URS’ interpretation of American Concrete Institute requirements outlined in ACI 318 – Building Code Requirements for Structural Concrete than to actual strength concerns.

**Current ACI Codes and Evaluation of Dam Safety**

Older structures often will not be in compliance with current code or design practices. As a result, we do not expect Buchanan Dam to meet all of the detailing requirements of the current ACI 318 codes, which have changed since the design and construction.

Changes to ACI design codes can be driven by the need for a correction to the design practice due to identified problems or simply by improved design practice and methodology. Our project team members have long tenures in applying ACI design codes to dam design and evaluation throughout Texas and across the United States. We also have a thorough understanding of what drivers have been behind changes in ACI 318 since the construction of Buchanan Dam.

Our approach will be to evaluate the dam in terms of safety with the benefit of understanding those code changes.

**Concrete Butress Dams: Service Issues**

Typical issues associated with concrete buttress dams during service include: inadequate spillway capacity, inability to withstand seismic events, leakage at the construction joints, and deterioration of the concrete due to freeze-thaw cycles or aggregate alkali reaction (AAR).

There are isolated cases in the literature where buttress heads have been locally repaired due to concrete deterioration, particularly in cold climate locations. There are no published cases of concrete buttress dams that have been rehabilitated due to inadequate shear capacity of the buttress heads, unless the repair was associated with other deficiencies such as seismic instability.
Initial Review of Corbels
Our initial review of available drawings for the 35-foot and 70-foot arches indicate that the corbels are not reinforced according to today’s standards, but are consistent with the standard practices of their design period. We also noted that the buttresses for the 70-foot arches widen in size as they approach the foundation. We believe any problems, if any exists, may be restricted to the upper portions of the corbels (see graphic at right).

Evaluation of the Need for Corbel Rehabilitation
The Executive Summary states that “the results for the corbels indicate that they are under-reinforced, and possibly subject to brittle failure.” We will evaluate two alternative possibilities for these findings:

1. **Insufficient Corbel Strength Independent Of Ductility**
   If the full report indicates that the corbels do not have sufficient strength independent of ductility, we will evaluate the corbels using the latest analysis techniques, including Finite Element Modeling (FEM) and strut-and-tie modeling.

   Our experience in these analysis techniques, particularly on concrete buttress dams, will help select the most appropriate technique for Buchanan Dam.

2. **Insufficient Corbel Strength Based On Lack Of Ductility**
   If the report indicates that the corbels do not have sufficient strength based purely on the lack of ductility, we will investigate the necessity for the upgrade.

• **Incorporating Dam-Specific Evaluation Criteria**
   We understand the importance of applying the proper interpretation of corbels, corbel reinforcing and performance expectations to the structure.

   In order to provide increased ductility, the 1971 and subsequent editions of ACI 318 require a minimum amount of corbel web reinforcement to increase ductility.

   We have the expertise on our team to assess the issue from the perspective of the building codes and

   We want to be cautious in considering code provisions built on tests of precast concrete corbels, as commonly used in the building industry, and applying those standards to continuous corbels (buttress heads) used on concrete buttress dams. Please see Typical Corbel graphic at top of previous page for sample design differences.

Freese and Nichols has used Finite Element Modeling for evaluations of:

- Tom Miller Dam, Lower Colorado River Authority
- Wesley Seale Dam, City of Corpus Christi
- Morris Sheppard Dam, Brazos River Authority
dam-specific codes and that of academia. We also will look at other dams of similar construction to determine the consensus of the industry on this issue. We will review studies of similar structures in other low seismic areas to help evaluate the need to repair these corbels.

**Understanding Load Transfer from Arch to Buttress**

The geometry on each arch section is different, and the structural behavior under load will depend on the load path into the buttress. It should be noted that the load path for the 35-foot arches passes through the center of the buttress head (see graphic above).

**Team Experience to Cost-Effective Corbel Rehabilitation**

If rehabilitation of the corbels is required, our team has more than 250 years of experience working with dams (see resumes in Section Three). The team includes Eric Kollgard, P.E., and Mete Sozen, Ph.D., P.E., national experts with specific experience in rehabilitation of similar concrete buttress dams in low- and high-seismic areas. Our experience includes addressing the comprehensive challenges of concrete buttress dam design, monitoring and rehabilitation.

This broader perspective will guide us in developing a cost-effective rehabilitation design, if needed, that considers the entire life-cycle cost.

**Risks**

Our team has identified three major risks associated with this project:

- Design Risk
- Physical Risk
- Unwarranted Risk

**Design Risk**

Engineering design has the inherent risk of making overly conservative on unconservative assumptions to describe structural behavior. It is critical that the correct structure is modelled, load transfer mechanisms are properly evaluated, and design codes are correctly interpreted on unconventional structures.

**Freese and Nichols’ Approach and Lessons Learned**

Our team’s approach to this risk is to perform due diligence in every aspect of this evaluation and investigation. All of our conclusions must be based upon non-questionable methods, adequate research and test programs, if necessary.
Our experience has taught us that our findings should withstand the utmost scrutiny and that our team members should be able to convey these findings in a clear, concise manner to any group of relevant stakeholders.

Physical Risk
There also are three obvious physical risks if rehabilitation is required:
Accessibility, near-constant hydrostatic load and corbel failure.

- **Accessibility for Repairs and Long-term Maintenance**
  Repair alternatives will likely involve drilling or coring into the corbels at hard-to-reach locations, i.e. elevated positions that are not readily accessible for drilling, tensioning, and work in general. Accessibility also will be an issue if the corbel solution requires periodic inspections to assess performance or possible deterioration.

**Freese and Nichols’ Approach and Lessons Learned**
Our team’s approach to these issues will be to develop installation methods that will minimize potential damage to existing structural components including reinforcing and to keep in mind the development of a system which will be resistant to exposure conditions to minimize maintenance.

- **Near-Constant Load**
  Another physical risk can arise from the work on corbels that are under a near constant load, i.e., reservoir head.

**Freese and Nichols’ Approach and Lessons Learned**
Depending on the limits determined for corbel repairs, we will develop temporary bracing/shoring, etc., and evaluate this approach versus the benefits of either reducing reservoir pools or scheduling the repair work during periods of low reservoir levels. We also recognize the risk of starting work during low reservoir periods and not being able to complete the repairs before the reservoir rises.

Unwarranted Repairs
Unwarranted repair of the structure results in expending significant resources and potentially detrimental modifications to the structure.

**Freese and Nichols’ Approach and Lessons Learned**
Our first effort would be to identify a sound engineering basis for leaving the structure as is. If modifications are required, we would try to minimize the construction impact on the structure.

Statement of Work
1. Coordinate a kickoff meeting with LCRA and all team members to obtain relevant project information share ideas and concerns, and to discuss project expectations.
2. Disseminate documents to project team for Peer Review to begin.
3. Coordinate phone conferences to discuss evaluations and address any additional questions.
Research history and service performance of concrete buttress dams and remedies used on identified structural problems.

Determine need for additional evaluation models, analyses or physical tests.

Convene a team meeting to discuss the Peer Review findings and to develop summary report outline on the findings.

Assign team members to develop each report chapter.

Disseminate draft report to all team members for review and comment.

Incorporate comments, as appropriate, and prepare draft Peer Review Report for presentation to LCRA.

Await LCRA’s comments on draft report.

Finalize Peer Review Report after receipt of Owner’s comments.

Determine additional tasks to proceed to next level, if necessary.

If corbel repairs are deemed necessary, perform the following:

  a. Determine analyses to be performed or test programs.
  b. Develop list of similar structures to be observed or contacted.
  c. Develop up to three repair alternatives.
  d. Present alternatives to project team for discussion and concurrence of applicability.
  e. Develop preliminary details for corbel repairs.
  f. Develop cost opinions for each repair alternative.
  g. Prepare summary report presenting recommendations, costs and discussions of each proposed repair method.

Present summary report to LCRA for comment and guidance.

Meet with LCRA to task the next phase of work as appropriate.

**Deliverables**

1. Minutes of kickoff meeting
2. Monthly Progress Report (Updates)
3. Draft Peer Review Report
4. Final Peer Review Report
5. Summary Report of Corbel Repair Alternatives
Proposed Project Team

- **Principal-in-Charge**
  - Ron Lemons, P.E.

- **Project Manager**
  - John Wolfhope, P.E.

- **Quality Review**
  - Antonio Diaz, P.E.

- **Project Engineer**
  - Victor Vasquez, P.E.

  - **Structural Coordination and Constructability**
    - Les Boyd, P.E.

  - **Structural Engineering**
    - Brad Watson, P.E.

  - **Structural Assessment**
    - Mete Sozen, Ph.D., S.E.

  - **Evaluation and Repair**
    - Eric Kollgaard, P.E.
Project Manager

JOHN WOLFHOPE, P.E.

John Wolfhope is a Principal of Freese and Nichols and is the firm’s Central Division Water Resources Group Manager. His 20-year career has focused on the planning, design, and construction of significant water resources projects including dams, hydraulic structures, and water supply systems. Mr. Wolfhope has substantial experience in the design, rehabilitation, stabilization, and replacement of concrete dams, including gated spillways, gravity dams, flat slab and buttress spillways, multiple arch dams and labyrinth spillways. He has broad experience in dam assessments including dam safety inspections, structural assessments, geotechnical investigations, physical and numerical hydraulic modeling, development of risk assessments, emergency action planning, and vulnerability assessments.

He was Project Manager for the Lake Brazos Dam Replacement Project which received the USSD’s 2008 Award of Excellence in the Constructed Project. His work also has been recognized through awards that include the 2006 ASDSO Regional Award of Merit, Texas Section ASCE Outstanding Civil Engineering Achievement Award, Texas Chapter of APWA Public Works Project of the Year, Texas Council of Engineering Companies Gold Medal for Engineering Excellence, and USACE’s Safe Contractor of the Year.

Relevant Project Experience

- Engineering and Dam Safety Team and Peer Review, Lower Colorado River Authority (LCRA) – Project Manager for technical support of the Highland Lakes Dams and Dam Safety Team. Provided peer review of reports prepared by other consultants, including the Buchanan Dam Radial Gate Inspection and Analysis and the Buchanan Dam Comprehensive Facility Review.

- Dam Modernization Program, LCRA – Project Manager for the rehabilitation of four of the Highland Lakes Dams, including Wirtz Dam, Buchanan Dam, Inks Dam, and Tom Miller Dam. Project included structural strengthening of the 500-foot-long, gated flat slab-and-buttress spillway, and involved three-dimensional Finite Element Modeling, modeling of crack propagation, hydraulic model studies, detail geotechnical investigation program, geologic mapping, destructive and non-destructive structural testing program.

- Mansfield Dam Comprehensive Facility Review, Lower Colorado River Authority – Project Manager for a Comprehensive Facility Review Report of the conditions and operations of Mansfield Dam to evaluate the adequacy of the dam’s design, construction and performance; determine the likely modes of dam failure, related risks and consequences; and identify needed improvements for on-going performance monitoring of the dam.
Project Manager
JOHN WOLFHOPE, P.E. continued

- **Choke Canyon Dam Rehabilitation and Site Improvements, City of Corpus Christi** – Project Manager for rehabilitation and upgrades to spillway and inlet/outlet works at a three-mile long high-hazard dam. Improvements included rehabilitation and replacement of protective coatings for spillway tainter gates, stoplogs systems, gate hoists and intake trash racks.

- **Lake Brazos Dam Replacement Project, City of Waco** – Project Manager for the design and construction of the 3,000-foot labyrinth spillway, retaining walls, and outlet works. Project included the development and interpretation of finite element models to analyze the reinforced concrete structures for all hydraulic loading scenarios.

- **Wesley E. Seale Dam Gates and Spillway Rehabilitation, City of Corpus Christi** – Design Engineer for the stabilization of the two 1200-feet long flat slab and buttress spillway structures. Project included 3-D finite element modeling of the reinforced concrete buttress dam, including strengthening and stabilization of the structures. Project received ASDSO Outstanding Project of the Year Award in 2001.

- **Olmos Dam Rehabilitation, Bexar County** – Technical Leader on the evaluation of existing post-tensioned anchors as part of an overall dam assessment for Olmos Dam. The project included geotechnical investigations, dam stability analysis, hydraulic and hydrologic analysis, and evaluation on existing anchor test data.

- **City Lake Dam, City of Temple** – Project Manager for the inspection and rehabilitation of a 90-year old concrete channel dam. Project included hydraulic modeling, analysis of foundation erodability, scour analysis, spillway rehabilitation and undermining repairs.
Project Engineer

VICTOR VASQUEZ, P.E.

Victor Vasquez’s experience includes the design, rehabilitation, expansion and replacement of dams and hydraulic structures. He specializes in the development of construction documents and bid packages for the evaluation, rehabilitation, and design of dams including channel dams, concrete spillways and earthen embankments. He has considerable experience leading dam inspections involving structural assessment, geotechnical investigation programs and foundation scour analysis.

Relevant Project Experience

• Mansfield Dam Comprehensive Facility Review, Lower Colorado River Authority (LCRA) – Project Engineer for a Comprehensive Facility Review Report of the conditions and operations of Mansfield Dam to evaluate the adequacy of the dam’s design, construction and performance; determine the likely modes of dam failure, related risks and consequences; and identify needed improvements for on-going performance monitoring of the dam.

• Tom Miller Dam Modernization Project, LCRA – Project Engineer for program to modernize the 105-year old dam. Project included stabilization of concrete overflow spillway and structural strengthening of 500-foot-long gated flat-slab and buttress spillway. Tasks involved a detailed geotechnical investigation program, geologic mapping, a destructive and non-destructive structural testing program, three-dimensional finite element analyses, modeling of crack propagation and hydraulic model studies.

• Engineering and Dam Safety Team and Peer Review, LCRA – Engineer for technical support of the Highland Lakes Dams and Dam Safety Team. Provided peer review of reports prepared by other consultants, including the Buchanan Dam Radial Gate Inspection and Analysis and the Buchanan Dam Comprehensive Facility Review.

• Lake Brazos Dam Replacement Project, City of Waco – Lead Engineer for the design and construction of the 3,000-foot labyrinth spillway, retaining walls, and outlet works. Project included in-depth hydraulic and hydrodynamic modeling, and finite-element modeling of foundation and reinforced concrete structures.

• Olmos Dam Rehabilitation, Bexar County – Project Engineer on the geotechnical investigation, post-tensioned anchor evaluation, and stability analysis of Olmos Dam. The project included geotechnical investigations, dam stability analysis, hydraulic and hydrologic analysis, and evaluation on existing anchor test data.

• Inks Dam Modernization Project, LCRA – Engineer for geotechnical investigation, hydraulic analyses and design for modernization of 1,800-foot-long concrete dam. Project involved demolition, stabilization and replacement of the concrete spillway, while maintaining the pool at normal operating elevation.

Experience
• 11 years

Education
• M.S., Civil Engineering, University of Texas at Austin
• B.S., Civil Engineering, University of Texas at Austin

Registration
• Professional Engineer, Texas #93564

Location
• Austin

Availability
• 50%
Structural Coordination and Constructability

LES BOYD, P. E.

Les Boyd is a Senior Structural Design Engineer and a firm Associate with more than 36 years experience in design and evaluation of new and existing reinforced concrete dams. He also is Freese and Nichols Central Division technical leader for constructability reviews and construction support.

Mr. Boyd has served the LCRA for 15 years in the repair and strengthening of LCRA’s dams. He served as the chief construction representative for the modernization of Wirtz Dam, Buchanan Dam, Inks Dam, and Tom Miller Dam. He specializes in analyzing the behavior of hydraulic structures including concrete buttress dams. He lead the rehabilitation of Morris Sheppard Dam (the tallest flat slab and buttress dam in the United States). His is often recognized by his clients for his practical solutions and innovative approaches in dam rehabilitation and strengthening.

Relevant Project Experience

- **Murphy Dam Repairs, City of Taylor** – Structural Engineer for repairs to a multiple arch dam. Project included evaluation of the dam, replacement of training walls, and grouting of voids beneath the buttresses and apron slab.

- **Dam Modernization Program, LCRA** – Lead Engineer and Resident Construction Representative for the rehabilitation of four of the highland Lakes Dams, including Wirtz Dam, Buchanan Dam, Inks Dam, and Tom Miller Dam. Project included structural strengthening of the 500-feet long gated flat-slab and buttress spillway. Project included three-dimensional finite element analyses, modeling of crack propagation, hydraulic model studies, detail geotechnical investigation program, geologic mapping, destructive and non-destructive structural testing program.

- **Gilboa Dam Emergency Stabilization (New York), Dvirka and Bartilucci** – Assistant Resident Representative for emergency dam stabilization.

- **Morris Sheppard Dam, Brazos River Authority** – Resident Engineer for rehabilitation of Morris Sheppard Dam. Project included three separate contracts for construction of an emergency spillway, modifications to primary spillway, stabilization of the dam and rehabilitation of spillway gates.

- **Spillway Gate Rehabilitation, Wesley E. Seale Dam, City of Corpus Christi** – Lead Engineer for rehabilitation of 60 spillway gates for slab and buttress spillways. Included structural modifications for safely passing the probable maximum flood and replacement of protective coatings and side seals.

- **Lake Brazos Dam Replacement Project, City of Waco** – Structural Engineer for the design and construction replacement of 3,000-foot labyrinth spillway, retaining walls, and outlet works. Project included in-depth hydraulic and hydro-dynamic modeling, and finite-element modeling of foundation and reinforced concrete structures.

**Experience**

- 36 years

**Education**

- M.S., Civil Engineering, Vanderbilt University
- B.S., Civil Engineering, University of Texas at Arlington

**Registration**

- Professional Engineer, Texas #39453

**Location**

- Austin

**Availability**

- 50%
Structural Engineering

BRAD WATSON, P.E.

Brad Watson is Freese and Nichols’ Structural Group Manager. He has significant experience in the design and evaluation of new and existing dams. He manages the group of structural engineers responsible for the development and finite element analysis of reinforced concrete dams. He has managed the structural analysis of concrete buttress dams over the past 10 years. He has consulted with the USACE regarding corbel repairs for their reinforced concrete structures.

Relevant Project Experience

- **Engineering and Dam Safety Team and Peer Review, LCRA** – Structural Engineer for technical support of the Highland Lakes Dams and Dam Safety Team. Provided peer review of reports prepared by other consultants, including the Buchanan Dam Radial Gate Inspection and Analysis and the Buchanan Dam Comprehensive Facility Review.
- **Tom Miller Dam Modernization Project, Lower Colorado River Authority (LCRA)** – Structural Engineer providing oversight of the 3-D finite element modeling of the concrete buttress sections and the gravity overflow sections.
- **Lake Brazos Dam Replacement Project, City of Waco** – Lead Structural Engineer for the design replacement of 3000-feet labyrinth spillway, retaining walls, and outlet works. Lead the development and interpretation of finite element models to analyze the reinforced concrete structures for all hydraulic loading scenarios.
- **Lake Livingston Dam Evaluation, Trinity River Authority** – Structural Engineer for comprehensive inspection and evaluation of 14,000-foot-long Lake Livingston Dam, including the general condition of the gated spillway structure and the service outlet.
- **Richland Chambers Seawall Improvements, Tarrant Regional Water District** – Project Manager for construction of seawall and associated landscape improvements along 700 feet of Richland Chambers Reservoir.
- **Olmos Dam Rehabilitation, Bexar County** – Lead Structural Engineer for the stabilization and Finite Element Modeling of reinforced concrete structures.
- **Dam Modernization Program, Upper Brushy Creek Water Control and Improvement District** – Structural Engineer for evaluation and modernization of 23 Upper Brushy Creek WCID dams, including 21 high-hazard dams.
- **Wells Branch Regional Erosion/Flood Control Pond, City of Austin** – Structural Engineer for preparation of structural construction documents for a 30-foot tall concrete flood wall and weir basin. Stability was provided by a combination of gravity design and rock anchors.

Experience

- **18 years**

Education

- M.S., Structural Engineering, University of Texas at Austin
- B.S., Civil Engineering, Texas Tech University

Registration

- Professional Engineer, Texas #80318 (two states total)

Location

- Fort Worth

Availability

- 25%
Quality Reviews

ANTONIO DIAZ, P.E.

Antonio Diaz is Freese and Nichols’ most experienced senior structural engineer and serves as technical advisor for the analysis and design of reinforced concrete structures. He has 45 years experience in the structural design and construction of hydraulic structures including concrete buttress dams. He oversees the development, interpretation, and peer review of finite element models to analyze complex reinforced concrete structures. He is recognized for his practical solutions for stabilizing and strengthening existing concrete structures.

Relevant Project Experience

- Morris Sheppard Dam FERC Part 12 Inspection, Brazos River Authority
- Lake Houston Comprehensive Dam Evaluation, Coastal Water Authority
- Wesley Seale Dam Spillway Stability Rehabilitation, City of Corpus Christi
- Engineering and Dam Safety Team and Peer Review, Lower Colorado River Authority
- Dam Rehabilitations and Modernizations for Buchanan, Inks Lake, Starke, Tom Miller and Wirtz Dams, Lower Colorado River Authority
- Comal Dam Rehabilitation, Lower Colorado River Authority
- Richland Chambers Reservoir and Dam Design, Tarrant Regional Water District
- Lake Livingston Dam Condition Assessment, Trinity River Authority
- Morris Sheppard Dam Rehabilitation, Brazos River Authority
- Alan Henry Dam Miscellaneous Engineering Services, Brazos River Authority
- DeCordova Bend Dam Investigation and Repairs, Brazos River Authority
- Choke Canyon Dam Improvements, City of Corpus Christi
- Lake Brazos Rehabilitation, City of Waco
- Mountain Creek Dam Inspections and Repairs, TXU
- Squaw and SSI Dam Inspections, TXU
- Lake Creek Dam Spillway Assessment, TXU
- Trinidad Dam Gate Rehabilitation, TXU
- Lake Conroe Dam Gate Overtopping and Extension, San Jacinto River Authority
- Lake Conroe Dam Rock Riprap Damage Repairs, San Jacinto River Authority
- Hubbard Creek Dam Rehabilitation, West Central Texas Municipal Water District

Experience
- 45 years

Education
- B.S., Civil Engineering, Arlington State College

Registration
- Professional Engineer, Texas #32713

Location
- Fort Worth

Availability
- 10%
Principal-in-Charge

RON LEMONS, P.E.

Ron Lemons is Freese and Nichols’ Chief Operating Officer, Senior Vice President and a Principal of the firm. Mr. Lemons understands Freese and Nichols’ clients’ needs and has spent his entire career working on large projects requiring close coordination with water districts, TRA, TxDOT, EPA, NCTCOG, TCEQ, U.S. Army Corps of Engineers and various other regulatory agencies. The majority of Mr. Lemons’ engineering experience is in the planning, design and construction administration of major water supply facilities. He specializes in the design of water retaining/storage structures such as reservoirs, dams, levees and canals, and has considerable experience in the rehabilitation of concrete and earthen dams.

Mr. Lemons has provided Principal-In-Charge and QC/QA direction to a wide range of Freese and Nichols’ projects, mentoring both experienced and younger engineers to encourage outstanding client service and top quality workmanship. He also is an experienced Project Manager, having led the firm’s efforts for many large-scale projects such as the Texas Water Development Board’s Senate Bill 1 Comprehensive State Water Plan (the firm developed seven of the state’s 16 regional water plans).

Mr. Lemons is also heavily involved in several professional societies in his field for which he currently holds and has held significant leadership positions. Mr. Lemons has served as President of the U.S. Society on Dams and was elected chairman of the Committee on Global Climate Change and Dams, Reservoirs and the Associated Water Resources for the International Commission on Large Dams.

Mr. Lemons has served as Project Manager for the Trinity River Authority’s $65-million Richland Chambers Reservoir, the Colorado Municipal River Authority’s $30-million Simon W. Freese Dam, and the Palo Duro River Authority’s $13-million Palo Duro Dam and Reservoir.
Structural Assessment

METE SOZEN, PH.D., S.E.

Dr. Mete Sozen has over 50 years experience in the development of reinforced concrete engineering practice. He is recognized as an expert in the structural analysis of concrete buttress dams and hydraulic structures. His research focus is on the behavior of building, transportation, and hydraulic structures under static and dynamic loads. Through his research and professional committee leadership, he has contributed to the development of the current design procedures used in the ACI Building Code for Structural Concrete and the European Concrete Committee model code for flexural and shear strength of prestressed concrete and reinforced concrete slabs. His long-standing participation as an active member of the ACI 318 committee provides a thorough understanding of the intent of the design code, its limitations, and the ability to apply the code to unconventional structures including massive concrete dams.

Dr. Sozen is a tenured professor at Purdue University and teaches courses in behavior of reinforced concrete structures. He received the National Science Foundation Award in 1998 for his research titled, “Performance in Shear of Concrete Bridges.”

See Appendix for Dr. Sozen’s selected publications.

Multiple Arch and Slab-and-Buttress Dams

- Florence Lake Dam, Fresno County, California – Structural evaluation of multiple arch dam in south fork of the San Joaquin River. 149-ft high dam was constructed in 1926 and owned by Southern California Edison Company.

- PIT4 Dam, Shasta County, California – Structural evaluation of flat slab dam in the Pit River. 74-ft high dam was constructed in 1927 and is owned by Pacific Gas and Electric Company.

- Mountain Dell Dam, Salt Lake County, Utah – Structural evaluation of high hazard multiple arch and flat slab-and-buttress dam in Parleys Creek. 105-ft high dam was constructed in 1916 and is owned by Salt Lake City Corporation.

- Crane Valley Dam, Madera County, California – Structural evaluation of flat slab and buttress dam in the north fork of the Willow Creek. 145-ft high hydropower dam was constructed in 1910 and is owned by Pacific Gas and Electric Company.

Other Dam Evaluation Experience

- Middle Fork Dam
- Bradbury Dam
- Urra Dam (Colombia)
- Lake Almanor Dam
Evaluation and Repair

ERIC KOLLGAARD, P.E.

Eric Kollgaard is recognized through the international dam engineering community as an expert in the design, evaluation, and construction of arch dams, multiple arch dams, and slab and buttress dams. He has 54 years experience in safety and rehabilitation evaluations of dams and hydraulic structures including, stress and stability analysis, structural and hydraulic model testing and geotechnical and foundations investigations.

Specific Project Experience in Corbel and Buttress Strengthening and Reinforcement

- **River Mill Dam, Oregon** – Project included infilling for stability, spillway slab strengthening, corbel post-tensioned anchor bolting, and structural lateral bracing
- **Pacoima Dam, California** – Project included finite element analysis, abutment stabilization, and post-earthquake concrete crack repair
- **Cushman Dam Nos. 1 & 2, Washington** - Project included Finite Element Modeling of abutment deformation, strengthening for seismic stability, concrete buttressing, and foundation remediation
- **Seymour Falls Dam, Washington** - Strengthening of buttresses by structural plates, static stability strengthening, and post-tensioning for spillway gate trunions
- **Tom Miller Dam, Austin, Texas** - Spillway slab concrete strengthening and infilling to strengthen areas of buttresses and provide support for upstream structural elements

Mr. Kollgaard has completed Finite Element Modeling and analysis, rehabilitation, and FERC safety evaluations for the following dams:

Multiple Arch - Stability Evaluation
- Bartlett Dam, USBR, Arizona (287 feet high)
- Rock Creek Diversion Dam and Pitt Dam No. 3, PGE, California
- Murray Dam and Lake Hodge Dam, City of San Diego, California

Slab-and-Buttress Dams
- Wesley Seale Dam, City of Corpus Christi, Texas
- River Mill Dam, Portland General Electric, Oregon
- Tom Miller Dam, LCRA, Texas
- Pit Dam 4, PGE, California
- Seymour Falls Dam, Greater Vancouver Water Department, Washington

Single Arch – Final Design
- Amaluza Dam, ENECEL, Ecuador (558-foot high arch dam)
- Ross High Dam, Seattle City Light, Washington (121-foot raise of 540-foot high dam)
Evaluation and Repair

ERIC KOLLGAARD, P.E. continued

Single Arch – Stress Analyses, Rehabilitation and/or FERC Part 12 Safety Evaluations

- Diablo Dam, Boundary Dam, Ross Dam and Gorge Dam, Seattle City Light, Washington
- Alder Dam, Tacoma Light and Water, Washington
- Cushman Dam No 1 and Cushman Dam No. 2, Tacoma Light and Water, Washington
- Mossyrock Dam, Tacoma Light and Water, Washington
- Mayfield Dam, Tacoma Light and Water, Washington
- Pacoima Dam, LA Flood Control District, California
- Matilija Dam, Ventura County, California
- Sweetwater Dam, Southern California
- Spaulding Dam, PGE, California
- Roosevelt Dam, USBR, Arizona
- Auburn Dam Design Review, USBR, Sacramento, California
- Karapiro Dam, New Zealand, Electric Corporation of New Zealand
- McKay’s Point Dam, Northern California Power Association, California
- Casad Arch Dam, City of Bremerton, Washington
- Big Box Canyon Dam, Washington
Section Four – Proposed Schedule

Our proposed schedule demonstrates that the project can be completed prior to LCRA’s deadline due to the working knowledge experience that we have with Buchanan Dam and other multiple arch dams, as well as the unique team of professionals assembled for this important project.

However, completing the project by May 5, 2009 assumes that LCRA provides Freese and Nichols with a Notice to Proceed during the first week of February.

Please see the following page for Freese and Nichols proposed schedule.
### Project: Peer Review of Buchanan Dam Arch

**Date:** Tue 1/20/09

#### Section Four – Schedule

<table>
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<th>ID</th>
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Appendix – Selected Publications

Selected Publications – Mete Sozen, Ph.D., P.E.


3. M. A. Sozen, “Multiple-Panel Reinforced Concrete Floor Slabs: Design Methods—Their Evolution an Comparison,” Journal of the American Concrete Institute, No. 8, August 1963, pp. 99-1028.


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<tr>
<td>D. Wolfgram, D. Rothe, P. Wilson and M. Sozen, “Earthquake Simulation Tests of Three One-Tenth Scale Models,” Earthquake Effects on Reinforced Concrete Structures, U.S.-Japan Research, American Concrete Institute, SP-84, 1985</td>
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P. E. Mlakar, D. O. Dusenberry, J. R. Harris, G. F. Haynes, L. T. Phan, and M. A.


Selected Publications – Eric Kollgaard, P.E.


Brazos River Authority’s Morris Sheppard Dam, the tallest concrete slab-and-buttress dam in the United States.