STATE OF TEXAS

TWDB Contract No. 1800012283

COUNTY OF TRAVIS

General Revenue
LRE Water LLC

This Contract, (hereinafter "CONTRACT"), between the Texas Water Development Board (hereinafter "TWDB") and **LRE Water LLC** (hereinafter "CONTRACTOR"), is composed of two parts, SECTION I. SPECIFIC CONDITIONS AND EXCEPTIONS TO THE STANDARD AGREEMENT and SECTION II. STANDARD AGREEMENT. The terms and conditions set forth in SECTION I will take precedence over terms and conditions in SECTION II.

SECTION I. SPECIFIC CONDITIONS AND EXCEPTIONS TO STANDARD AGREEMENT

ARTICLE I. DEFINITIONS

For the purposes of this CONTRACT, the following terms or phrases shall have the meaning ascribed therewith:

1. TWDB – The Texas Water Development Board, or its designated representative

2. CONTRACTOR – LRE Water LLC

3. EXECUTIVE ADMINISTRATOR – The Executive Administrator of the TWDB or a designated representative

4. PARTICIPANT(S) – Jordan Furnans, Ph.D., P.E., P.G.

5. REQUIRED INTERLOCAL AGREEMENT(S) – None

6. RESEARCH PROJECT – Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin (Phase Two)

7. TWDB APPROVAL DATE – N/A

8. DEADLINE FOR CONTRACT EXECUTION – November 15, 2018

9. CONTRACT INITIATION DATE – October 1, 2018

10. STUDY COMPLETION DATE – June 30, 2019

11. CONTRACT EXPIRATION DATE – August 31, 2019

12. TOTAL STUDY COSTS – $75,000.00

13. TWDB SHARE OF THE TOTAL STUDY COSTS – the lesser of $75,000.00 or 100 percent of the total study costs or individual payment submission

14. LOCAL SHARE OF THE TOTAL STUDY COSTS – $000000.00 in cash or 00.00 percent of the total study costs or individual payment submission

15. PAYMENT SUBMISSION SCHEDULE – Quarterly

16. OTHER SPECIAL CONDITIONS AND EXCEPTIONS TO STANDARD AGREEMENT OF THIS CONTRACT – None

SECTION II. STANDARD AGREEMENT

ARTICLE I. RECITALS

Whereas, on TWDB APPROVAL DATE, the TWDB considered providing the CONTRACTOR a grant to conduct a RESEARCH PROJECT;

Whereas, the CONTRACTOR and PARTICIPANT will commit the LOCAL SHARE OF THE TOTAL STUDY COSTS, if applicable, in cash and/or in-kind services to pay for the LOCAL SHARE OF THE TOTAL STUDY COSTS of this RESEARCH PROJECT;

Whereas, the CONTRACTOR is the entity who will act as administrator of the TWDB's research grant and will be responsible for the execution of this contract;

Whereas, on the TWDB APPROVAL DATE, the TWDB approved a research grant to the CONTRACTOR;

Now, therefore, the TWDB and the CONTRACTOR, agree as follows:

ARTICLE II. PROJECT DESCRIPTION AND SERVICES TO BE PERFORMED

1. The TWDB enters into this CONTRACT pursuant to Water Code §16.012; Exhibit A, the Statement of Qualification, which is incorporated herein and made a permanent part of this CONTRACT; and this CONTRACT.

2. The CONTRACTOR will conduct a RESEARCH PROJECT, as delineated and described in Exhibit A, according to the Scope of Work contained in Exhibit B.

3. A progress report, including results to date, will be provided to the EXECUTIVE ADMINISTRATOR quarterly, based on the State's Fiscal Year, throughout the project. Special interim reports on special topics and/or results will be provided as appropriate. Instructions for the progress report are shown in Exhibit E, TWDB Guidelines for a Progress Report.

4. Within the first 60 days of the commencement of this CONTRACT, the CONTRACTOR will consult with TWDB staff to prepare a list of entities that potentially may be affected by the results of this RESEARCH PROJECT. On the STUDY COMPLETION DATE, this list will be reviewed and updated by the CONTRACTOR and submitted to the TWDB with the draft final report.

ARTICLE III. CONTRACT TERM, SCHEDULE, REPORTS, AND OTHER PRODUCTS

1. The CONTRACTOR has until the DEADLINE FOR CONTRACT EXECUTION to execute this CONTRACT and to provide acceptable evidence of any REQUIRED INTERLOCAL AGREEMENT(S) and the CONTRACTOR's ability to provide the LOCAL SHARE OF THE TOTAL STUDY COSTS, if applicable, to the EXECUTIVE ADMINISTRATOR for approval or the TWDB's SHARE OF THE TOTAL STUDY COSTS will be rescinded.

2. The term of this CONTRACT shall begin and the CONTRACTOR shall begin performing its obligations hereunder on the CONTRACT INITIATION DATE and shall expire on the CONTRACT EXPIRATION DATE. Delivery of an acceptable final report prior to the CONTRACT EXPIRATION DATE shall constitute completion of the terms of this CONTRACT.

3. The CONTRACTOR will complete the Scope of Work and will deliver seven (7) double-sided copies of a draft final report to the EXECUTIVE ADMINISTRATOR no later than the STUDY COMPLETION DATE. The draft final report will include the scope of work; a description of the research performed; the methodology and materials used; any diagrams or graphics used to explain the procedures related to the study; any data collected; an electronic copy of any computer programs, maps, or models along with an operations manual and any sample data set(s) developed under the terms of this CONTRACT; analysis of the research results; conclusions and recommendations; a list of references, a Table of Contents, List of Figures, List of Tables, an Executive Summary, and any other pertinent information. All final reports should be prepared according to Exhibit D, Guidelines for Authors Submitting Contract Reports to the Texas Water Development Board. After a 30-day review period, the EXECUTIVE ADMINISTRATOR will return review comments to the CONTRACTOR.

4. The CONTRACTOR will consider incorporating comments from the EXECUTIVE ADMINISTRATOR and other commentors on the draft final report into a final report. The CONTRACTOR will include a copy of the EXECUTIVE ADMINISTRATOR's comments in the final report. The CONTRACTOR will submit one (1) electronic copy of the entire final report in Portable Document Format (PDF) and seven (7) bound double-sided copies of the final report to the EXECUTIVE ADMINISTRATOR no later than the sixty (60) days after the STUDY COMPLETION DATE. The CONTRACTOR will submit one (1) electronic copy of any computer programs or models and an operations manual developed under the terms of this CONTRACT. In compliance with Texas Administrative Code Chapters 206 and 213 (related to Accessibility and Usability of State Web Sites), the digital copy of the final report will comply with the requirements and standards specified in statute. After a 30-day review period, the EXECUTIVE ADMINISTRATOR will either accept or reject the final report. If the final report is rejected, the rejection letter sent to the CONTRACTOR shall state the reasons for rejection and the steps the CONTRACTOR needs to take to have the final report accepted and the retainage released.

5. The CONTRACTOR will submit the most recent progress report with submittal of payments according to the PAYMENT SUBMISSION SCHEDULE. Progress reports shall be in written form and shall include a brief statement of the overall progress made since the last status report; a brief description of any problems that have been encountered during the previous reporting period that will affect the study, delay the timely completion of any portion of this CONTRACT, inhibit the completion of or cause a change in any of the study's products or objectives; and a description of any action the CONTRACTOR plans to take to correct any problems that have been encountered.

6. The EXECUTIVE ADMINISTRATOR can extend the STUDY COMPLETION DATE and the CONTRACT EXPIRATION DATE upon written approval. The CONTRACTOR should notify the EXECUTIVE ADMINISTRATOR in writing within ten (10) working days prior to the STUDY COMPLETION DATE or thirty (30) days prior to the CONTRACT EXPIRATION DATE that the CONTRACTOR is requesting an extension to the respective dates.

ARTICLE IV. COMPENSATION AND REIMBURSEMENT

1. The TWDB agrees to compensate and reimburse the CONTRACTOR in a total amount not to exceed the TWDB's SHARE OF THE TOTAL STUDY COSTS for costs incurred and paid by the CONTRACTOR pursuant to performance of this CONTRACT. The CONTRACTOR will contribute local matching funds, if applicable, in sources and amounts defined as the LOCAL SHARE OF THE TOTAL STUDY COSTS. The TWDB shall reimburse the CONTRACTOR for ninety percent (90%) of the TWDB's share of each invoice pending the CONTRACTOR's performance, completion of a Final Report, and written acceptance of said Final Report by the EXECUTIVE ADMINISTRATOR, at which time the TWDB shall pay the retained ten percent (10%) to the CONTRACTOR.

2. The CONTRACTOR shall submit payments and documentation for reimbursement billing according to the PAYMENT SUBMISSION SCHEDULE and in accordance with the approved task and expense budgets contained in Exhibit C to this CONTRACT. The CONTRACTOR has budget flexibility within task and expense budget categories to the extent that the resulting change in amount in any one task or expense category does not exceed 35% of the total authorized amount by this CONTRACT for the task or category. Larger deviations shall require approval by the EXECUTIVE ADMINISTRATOR or designee, which will be documented through an Approved Budget Memorandum to the TWDB contract file. The CONTRACTOR will be required to provide written explanation for the overage and reallocation of the task and expense amount.

   For all reimbursement billings including any subcontractor's expenses, the EXECUTIVE ADMINISTRATOR must have determined that the REQUIRED INTERLOCAL AGREEMENT(S) and contracts or agreements between the CONTRACTOR and the subcontractor are consistent with the terms of this

CONTRACT. The CONTRACTOR is fully responsible for paying all charges by subcontractors prior to reimbursement by the TWDB.

3. The CONTRACTOR and its subcontractors shall maintain satisfactory financial accounting documents and records, including copies of invoices and receipts, and shall make them available for examination and audit by the EXECUTIVE ADMINISTRATOR. Accounting by the CONTRACTOR and its subcontractors shall be in a manner consistent with Generally Accepted Accounting Principles.

4. By executing this CONTRACT, the CONTRACTOR accepts the authority of the State Auditor's Office, under direction of the legislative audit committee, to conduct audits and investigations in connection with any and all state funds received pursuant to this contract. The CONTRACTOR shall comply with and cooperate in any such investigation or audit. The CONTRACTOR agrees to provide the State Auditor with access to any information the State Auditor considers relevant to the investigation or audit. The CONTRACTOR also agrees to include a provision in any subcontract related to this contract that requires the subcontractor to submit to audits and investigation by the State Auditor's Office in connection with any and all state funds received pursuant to the subcontract.

5. The CONTRACTOR shall submit a signed and completed payment request using the current spreadsheet located at: http://www.twdb.texas.gov/about/contract_admin/index.asp. You can contact Contracts@twdb.texas.gov for a personalized payment request spreadsheet. The CONTRACTOR shall also submit a progress report as described in Article II, Item 3.

   In addition, the following documentation which documents the TOTAL STUDY COSTS for the reporting period even if the TOTAL STUDY COSTS are zero for reimbursement by the TWDB to the CONTRACTOR for the TWDB's SHARE OF THE TOTAL STUDY COSTS shall be submitted by the CONTRACTOR to the EXECUTIVE ADMINISTRATOR for reimbursement billing:

   A. A completed "Current Reimbursement Worksheet" Payment Request Checklist tab, or an invoice which includes the following information:
      (1) TWDB Contract Number;
      (2) Billing period; beginning (date) to ending (date);
      (3) Total Expenses for this period;
      (4) Total In-kind services, if applicable;
      (5) Less Local Share of the total study costs for the billing period, if applicable;
      (6) Total TWDB's share of the total study costs for the billing period;
      (7) Total costs to be reimbursed by the TWDB for the billing period; and
      (8) Certification, signed by the CONTRACTOR or authorized representative, that the expenses submitted for the billing period are

a true and correct representation of amounts paid for work performed directly related to this CONTRACT.

B. Using the "Current Reimbursement" Worksheet, post all expenses for the period on the Invoice Ledger tab and Task Ledger tab for direct expenses incurred by the CONTRACTOR.
   (1) Salaries and Wages, Fringe, Overhead, and Profit.
   (2) Other Expenses: Copies of detailed, itemized invoices/receipts for other expenses (credit card summary receipts or statements are not acceptable).
   (3) Travel Expenses: Names, dates, work locations, time periods at work locations, itemization of subsistence expenses of each employee, limited, however, to travel expenses authorized for state employees by the General Appropriations Act, Tex. Leg. Regular Session, 2015, Article IX, Part 5, as amended or superceded. Receipts required for lodging; as well as copies of invoices or tickets for transportation costs or, if not available, names, dates, and points of travel of individuals.

C. Using the "Current Reimbursement" Worksheet, post all expenses for the period on the Invoice Ledger tab and Task Ledger tab for direct expenses incurred by all subcontractors.
   (1) Salaries and Wages, Fringe, Overhead, and Profit.
   (2) Other Expenses: Copies of detailed, itemized invoices/receipts for other expenses (credit card summary receipts or statements are not acceptable).
   (3) Travel Expenses: Names, dates, work locations, time periods at work locations, itemization of subsistence expenses of each employee, limited, however, to travel expenses authorized for state employees by the General Appropriations Act, Tex. Leg. Regular Session, 2015, Article IX, Part 5, as amended or superceded. Receipts required for lodging; as well as copies of invoices or tickets for transportation costs or, if not available, names, dates, and points of travel of individuals.

6. Incomplete requests will be returned to the CONTRACTOR if deficiencies are not resolved within ten (10) business days.

7. If for some reason the reimbursement request cannot be processed due to the need for an amendment to the CONTRACT, the CONTRACTOR will be required to resubmit the Payment Request Checklist dated after the execution of the amendment.

8. The CONTRACTOR is responsible for any food or entertainment expenses incurred by its own organization or that of its subcontractors, outside that of the travel expenses authorized and approved by the State of Texas under this CONTRACT.

9. A compliance report in accordance with Texas Administrative Code (TAC) Title 1,

Part 5, Chapter 111, Subchapter B, Rule §111.14, The CONTRACTOR shall maintain business records documenting its compliance with the approved Historically Underutilized Business subcontracting plan in the format prescribed by the Texas Procurement and Support Services (Exhibit F). The compliance reports must include payment information on all HUB and non-HUB subcontractors. Submittal of these monthly compliance reports is required as a condition of payment.

The TWDB will monitor the HUB subcontracting plan monthly to ensure the value of the subcontracts meets or exceeds the HUB subcontracting provisions specified in the contract. The CONTRACTOR who fails to implement the HUB subcontracting plan in good faith will be reported to Texas Procurement and Support Services. The TWDB may revoke the contract for breach of contract and make a claim against the CONTRACTOR.

ARTICLE V. INTELLECTUAL PROPERTY: OWNERSHIP, PUBLICATION, AND ACKNOWLEGEMENT

1. "Use" of a work product, whether a the CONTRACTOR Works, a Subcontractor Works or otherwise, shall mean and include, without limitation hereby, any lawful use, copying or dissemination of the work product, or any lawful development, use, copying or dissemination of derivative works of the work product, in any media or forms, whether now known or later existing.

2. "No Compensation Obligation" shall mean there is no obligation on the part of one co-owner or licensee of a work, whether a the CONTRACTOR Works, a Subcontractor Works or otherwise, to compensate other co-owners, licensees or licensors of the work for any use of the work by the using co-owner or licensee, including but not limited to compensation for or in the form of: royalties; co-owner or licensee accounting; sharing of revenues or profits among co-owners, licensees or licensors; or any other form of compensation to the other co-owners, licensees or licensors on account of any use of the work.

3. "Dissemination" shall include, without limitation hereby, any and all manner of: physical distribution; publication; broadcast; electronic transmission; internet streaming; posting on the Internet or world wide web; or any other form of communication, transmission, distribution, sending or providing, in any forms or formats, and in or using any media, whether now known or later existing.

4. The TWDB shall have an unlimited, unrestricted, perpetual, irrevocable, non-exclusive royalty-free right to access and receive in usable form and format, and to use all technical or other data or information developed by the CONTRACTOR and Subcontractor in, or otherwise resulting from, the performance of services under this CONTRACT.

5. For purposes of this Article, "CONTRACTOR Works" are work products developed by the CONTRACTOR and Subcontractor using funds provided under this CONTRACT or

otherwise rendered in or related to the performance in whole or part of this CONTRACT, including but not limited to reports, drafts of reports, or other material, data, drawings, studies, analyses, notes, plans, computer programs and codes, or other work products, whether final or intermediate.

a. It is agreed that all CONTRACTOR Works shall be the joint property of the TWDB and the CONTRACTOR.

b. The parties hereby agree that, if recognized as such by applicable law, the CONTRACTOR Works are intended to and shall be works-made-for-hire with joint ownership between the TWDB and the CONTRACTOR as such works are created in whole or part.

c. If the CONTRACTOR Works do not qualify as works-made-for-hire under applicable law, the CONTRACTOR hereby conveys co-ownership of such works to the TWDB as they are created in whole or part. If present conveyance is ineffective under applicable law, the CONTRACTOR agrees to convey a co-ownership interest of the CONTRACTOR Works to the TWDB after creation in whole or part of such works, and to provide written documentation of such conveyance upon request by the TWDB.

d. The TWDB and the CONTRACTOR acknowledge that the copyright in and to a copyrightable CONTRACTOR Work subsists upon creation of the CONTRACTOR Works and its fixing in any tangible medium. The CONTRACTOR or the TWDB may register the copyrights to such Works jointly in the names of the CONTRACTOR and the TWDB.

e. The TWDB and the CONTRACTOR each shall have full and unrestricted rights to use a CONTRACTOR Works with No Compensation Obligation.

6. For purposes of this Article, "Subcontractor Works" include all work product developed in whole or part by or on behalf of Subcontractors engaged by the CONTRACTOR to perform work for or on behalf of any CONTRACTOR under this CONTRACT (or by the Subcontractors' Subcontractors hereunder, and so on). The CONTRACTOR shall secure in writing from any Subcontractors so engaged:

a. unlimited, unrestricted, perpetual, irrevocable, royalty-free rights of the TWDB (and, if desired, of the CONTRACTOR) to access and receive, and to use, any and all technical or other data or information developed in or resulting from the performance of services under such engagement, with No Compensation Obligation; and either

b. assignment by the Subcontractor to the TWDB (and, if desired by them, jointly to the CONTRACTOR) of ownership (or joint ownership with the Subcontractor) of all Subcontractor Works, with No Compensation Obligation; or

c. grant by Subcontractor of a non-exclusive, unrestricted, unlimited, perpetual, irrevocable, world-wide, royalty-free license to the TWDB (and, if desired by them, the CONTRACTOR) to use any and all Subcontractor Works, including the right to sublicense use to third parties, with No Compensation Obligation.

7. No unauthorized patents. The CONTRACTOR Works and Subcontractor Works or other work product developed or created in the performance of this CONTRACT or otherwise using funds provided hereunder shall not be patented by the CONTRACTOR or their Subcontractor unless the EXECUTIVE ADMINISTRATOR consents in writing to submission of an application for patent on such works; and provided that, unless otherwise agreed in writing, any application made for patent shall include and name the TWDB (and, as applicable and desired by them, the CONTRACTOR) as co-owners of the patented work:

   a. no patent granted shall in any way limit, or be used by the CONTRACTOR or Subcontractor to limit or bar the TWDB's rights hereunder to access and receive in useable form and format, and right to use, any and all technical or other data or information developed in or resulting from performance pursuant to this CONTRACT or the use of funds provided hereunder; and

   b. the TWDB (and, if applicable, the CONTRACTOR) shall have No Compensation Obligation to any other co-owners or licensees of any such patented work, unless otherwise expressly agreed in writing.

8. The CONTRACTOR shall include terms and conditions in all contracts or other engagement agreements with any Subcontractors as are necessary to secure these rights and protections for the TWDB; and shall require that their Subcontractors include similar such terms and conditions in any contracts or other engagements with their Subcontractors. For the purposes of this section, "Subcontractors" includes independent contractors (including consultants) and also employees working outside the course and scope of employment.

9. Any work products subject to a TWDB copyright or joint copyright and produced or developed by the CONTRACTOR or their Subcontractor pursuant to this CONTRACT or using any funding provided by the TWDB may be reproduced in any media, forms or formats by the TWDB or the CONTRACTOR at their own cost, and be disseminated in any medium, format or form by any party at its sole cost and in its sole discretion. The CONTRACTOR may utilize such work products as they may deem appropriate, including Dissemination of such work products or parts thereof under their own name, provided that any TWDB copyright is noted on the materials.

10. The CONTRACTOR agrees to acknowledge the TWDB in any news releases or other publications relating to the work performed under this CONTRACT.

ARTICLE VI. AMENDMENT, TERMINATION, AND STOP ORDERS

1. This CONTRACT may be altered or amended by mutual written consent or terminated by the EXECUTIVE ADMINISTRATOR at any time by written notice to the CONTRACTOR. Upon receipt of such termination notice, the CONTRACTOR shall, unless the notice directs otherwise, immediately discontinue all work in connection with the performance of this CONTRACT and shall proceed to cancel promptly all existing orders insofar as such orders are chargeable to this CONTRACT. The CONTRACTOR shall submit a statement showing in detail the work performed under this CONTRACT to the date of termination. The TWDB shall then pay the CONTRACTOR promptly that proportion of the prescribed fee, which applies to the work, actually performed under this CONTRACT, less all payments that have been previously made. Thereupon, copies of all work accomplished under this CONTRACT shall be delivered to the TWDB.

2. The EXECUTIVE ADMINISTRATOR may issue a Stop Work Order to the CONTRACTOR at any time. Upon receipt of such order, the CONTRACTOR shall discontinue all work under this CONTRACT and cancel all orders pursuant to this CONTRACT, unless the order directs otherwise. If the EXECUTIVE ADMINISTRATOR does not issue a Restart Order within 60 days after receipt by the CONTRACTOR of the Stop Work Order, the CONTRACTOR shall regard this CONTRACT terminated in accordance with the foregoing provisions.

ARTICLE VII. SUBCONTRACTS

Each Subcontract entered into to perform required work under this CONTRACT shall contain the following provisions:

a. This subcontract does not create any debt by or on behalf of the State of Texas and the TWDB. The TWDB's obligations under this CONTRACT are contingent upon the availability of appropriated funds and the continued legal authority of the TWDB to enter into this CONTRACT.

b. a detailed budget estimate with specific cost details for each task or specific item of work to be performed by the Subcontractor and for each category of reimbursable expenses;

c. a clause stating that the Subcontract is subject to audit by the Texas State Auditor's Office and requiring the Subcontractor to cooperate with any request for information from the Texas State Auditor, as further described in Article X, Section 1, Paragraph D hereof;

d. a clause stating that payments under the Subcontract are contingent upon the appropriation of funds by the Texas Legislature, as further described in Article X, Section 1, Paragraph A hereof;

e. a clause stating that ownership of data, materials and work papers, in any media, that is gathered, compiled, adapted for use, or generated by the Subcontractor or the CONTRACTOR shall become data, materials and work owned by the TWDB and that Subcontractor shall have no proprietary rights in such data, materials and work papers, except as further described in Article V hereof;

f. a clause stating that Subcontractor shall keep timely and accurate books and records of accounts according to generally acceptable accounting principles as further described in Article X, Section 2, Paragraph G;

g. a clause stating that Subcontractor is solely responsible for securing all required licenses and permits from local, state and federal governmental entities and that Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity; and

h. a clause stating that Subcontractor is an independent contractor and that the TWDB shall have no liability resulting from any failure of Subcontractor that results in breach of CONTRACT, property damage, personal injury or death.

ARTICLE VIII. LICENSES, PERMIT, AND INSURANCE

1. For the purpose of this CONTRACT, the CONTRACTOR will be considered an independent contractor and therefore solely responsible for liability resulting from negligent acts or omissions. The CONTRACTOR shall obtain all necessary insurance, in the judgment of the CONTRACTOR, to protect themselves, the TWDB, and employees and officials of the TWDB from liability arising out of this CONTRACT.

2. The CONTRACTOR shall be solely and entirely responsible for procuring all appropriate licenses and permits, which may be required by any competent authority for the CONTRACTOR to perform the subject work.

3. Indemnification. The CONTRACTOR shall indemnify and hold the TWDB and the State of Texas harmless, to the extent the CONTRACTOR may do so in accordance with state law, from any and all losses, damages, liability, or claims therefore, on account of personal injury, death, or property damage of any nature whatsoever caused by the CONTRACTOR, arising out of the activities and work conducted pursuant to this CONTRACT. The CONTRACTOR is solely responsible for liability arising out of its negligent acts or omissions during the performance of this CONTRACT.

ARTICLE IX. SEVERANCE PROVISION

Should any one or more provisions of this CONTRACT be held to be null, void, voidable, or for any reason whatsoever, of no force and effect, such provision(s) shall be construed as severable from the remainder of this CONTRACT and shall not affect the validity of all other provisions of this CONTRACT which shall remain of full force and effect.

ARTICLE X. GENERAL TERMS AND CONDITIONS

1. GENERAL TERMS.

   a. No Debt Against the State. This CONTRACT does not create any debt by or on behalf of the State of Texas and the TWDB. The TWDB's obligations under this CONTRACT are contingent upon the availability of appropriated funds and the continued legal authority of the TWDB to enter into this CONTRACT.

   b. Independent Contractor. Both parties hereto, in the performance of this contract, shall act in an individual capacity and not as agents, employees, partners, joint ventures or associates of one another. The employees or agents of one party shall not be deemed or construed to be the employees or agents of the other party for any purposes whatsoever.

   c. Procurement Laws. The CONTRACTOR shall comply with applicable State of Texas procurement laws, rules and policies, including but not limited to competitive bidding and the Professional Services Procurement Act, Government Code, Chapter 2254, relating to contracting with persons whose services are within the scope of practice of: accountants, architects, landscape architects, land surveyors, medical doctors, optometrists, professional engineers, real estate appraisers, professional nurses, and certified public accountants.

   d. Right to Audit. The CONTRACTOR and its Subcontractors shall maintain all financial accounting documents and records, including copies of all invoices and receipts for expenditures, relating to the work under this CONTRACT. The CONTRACTOR shall make such documents and records available for examination and audit by the EXECUTIVE ADMINISTRATOR or any other authorized entity of the State of Texas. The CONTRACTOR'S financial accounting documents and records shall be kept and maintained in accordance with generally accepted accounting principles. By executing this CONTRACT, the CONTRACTOR accepts the authority of the Texas State Auditor's Office to conduct audits and investigations in connection with all state funds received pursuant to this CONTRACT. The CONTRACTOR shall

comply with directives from the Texas State Auditor and shall cooperate in any such investigation or audit. The CONTRACTOR agrees to provide the Texas State Auditor with access to any information the Texas State Auditor considers relevant to the investigation or audit. The CONTRACTOR also agrees to include a provision in any Subcontract related to this CONTRACT that requires the Subcontractor to submit to audits and investigation by the State Auditor's Office in connection with all state funds received pursuant to the Subcontract.

e. Force Majeure. Unless otherwise provided, neither the CONTRACTOR nor the TWDB nor any agency of the State of Texas, shall be liable to the other for any delay in, or failure of performance, of a requirement contained in this CONTRACT caused by force majeure. The existence of such causes of delay or failure shall extend the period of performance until after the causes of delay or failure have been removed provided the non-performing party exercises all reasonable due diligence to perform. Force majeure is defined as acts of God, war, strike, fires, explosions, or other causes that are beyond the reasonable control of either party and that by exercise of due foresight such party could not reasonably have been expected to avoid, and which, by the exercise of all reasonable due diligence, such party is unable to overcome. Each party must inform the other in writing with proof of receipt within two (2) business days of the existence of such force majeure or otherwise waive this right as a defense.

f. Does not Boycott Israel. As required by Texas Government Code section 2270.002, the CONTRACTOR certifies, by executing this CONTRACT, that the CONTRACTOR does not, and will not during the term of this CONTRACT, boycott Israel. The CONTRACTOR further certifies that no subcontractor of the CONTRACTOR boycotts Israel, or will boycott Israel during the term of this CONTRACT. The CONTRACTOR agrees to take all necessary steps to ensure this certification remains true during the term of this CONTRACT.

2. STANDARDS OF PERFORMANCE.

a. Personnel. The CONTRACTOR shall assign only qualified personnel to perform the services required under this CONTRACT. The CONTRACTOR shall be responsible for ensuring that any Subcontractor utilized shall also assign only qualified personnel. Qualified personnel are persons who are properly licensed to perform the work and who have sufficient knowledge, skills and ability to perform the tasks and services required herein according to the standards of performance and care for their trade or profession.

b. Professional Standards. The CONTRACTOR shall provide the services and deliverables in accordance with applicable professional standards. The CONTRACTOR represents and warrants that he is authorized to acquire Subcontractors with the requisite qualifications, experience, personnel and other resources to perform in the manner required by this CONTRACT.

c. Antitrust. The CONTRACTOR represents and warrants that neither the CONTRACTOR nor any firm, corporation, partnership, or institution represented by the CONTRACTOR, or anyone acting for such firm, corporation, partnership, or institution has (1) violated the antitrust laws of the State of Texas under the Texas Business & Commerce Code, Chapter 15, of the federal antitrust laws; or (2) communicated directly or indirectly the proposal resulting in this CONTRACT to any competitor or other person engaged in such line of business during the procurement process for this CONTRACT.

d. Conflict of Interest. The CONTRACTOR represents and warrants that the CONTRACTOR has no actual or potential conflicts of interest in providing the deliverables required by this CONTRACT to the State of Texas and the TWDB. The CONTRACTOR represents that the provision of services under this CONTRACT will not create an appearance of impropriety. The CONTRACTOR also represents and warrants that, during the term of this CONTRACT, the CONTRACTOR will immediately notify the TWDB, in writing, of any potential conflict of interest that could adversely affect the TWDB by creating the appearance of a conflict of interest.

CONTRACTOR represents and warrants that neither the CONTRACTOR nor any person or entity that will participate financially in this CONTRACT has received compensation from the TWDB or any agency of the State of Texas for participation in the preparation of specifications for this CONTRACT. The CONTRACTOR represents and warrants that he has not given, offered to give, and does not intend to give at any time hereafter, any economic opportunity, future employment, gift, loan, gratuity, special discount, trip, favor or service to any public servant in connection with this CONTRACT.

e. Proprietary and Confidential Information. The CONTRACTOR warrants and represents that any information that is proprietary or confidential, and is received by the CONTRACTOR from the TWDB or any governmental entity, shall not be disclosed to third parties without the written consent of the TWDB or applicable governmental entity, whose consent shall not be unreasonably withheld.

f. Public Information Act. The CONTRACTOR acknowledges and agrees that all documents, in any media, generated in the performance of work conducted under this CONTRACT are subject to public disclosure under the Public

Information Act, Government Code, Chapter 552. The CONTRACTOR shall produce all documents upon request of the TWDB within two (2) business days when the documents are required to comply with a request for information under the Public Information Act.

g. Accurate and Timely Record Keeping. The CONTRACTOR warrants and represents that he will keep timely, accurate and honest books and records relating to the work performed and the payments received under this CONTRACT according to generally accepted accounting standards. Further, the CONTRACTOR agrees that he will create such books and records at or about the time the transaction reflected in the books and records occurs.

h. Dispute Resolution. The CONTRACTOR and the TWDB agree to make a good faith effort to resolve any dispute relating to the work required under this CONTRACT through negotiation and mediation as provided by Government Code, Chapter 2260 relating to resolution of certain contract claims against the state. The CONTRACTOR and the TWDB further agree that they shall attempt to use any method of alternative dispute resolution mutually agreed upon to resolve any dispute arising under this CONTRACT if this CONTRACT is not subject to Chapter 2260.

i. Contract Administration. The TWDB shall designate a project manager for this CONTRACT. The project manager will serve as the point of contact between the TWDB and the CONTRACTOR. The TWDB's project manager shall supervise the TWDB's review of the CONTRACTOR's technical work, deliverables, draft reports, the final report, payment requests, schedules, financial and budget administration, and similar matters. The project manager does not have any express or implied authority to vary the terms of the CONTRACT, amend the CONTRACT in any way or waive strict performance of the terms or conditions of the CONTRACT.

ARTICLE XI. CORRESPONDENCE

All correspondence between the parties shall be made to the following addresses:

For the **TWDB:**

Contract Issues:
Texas Water Development Board
Attention: Contract Administration
P.O. Box 13231
Austin, Texas 78711-3231
Email: contracts@twdb.texas.gov

Payment Request Submission:
Texas Water Development Board
Attention: Accounts Payable
P.O. Box 13231
Austin, Texas 78711-3231
Email: invoice@twdb.texas.gov

Physical Address:
Stephen F. Austin State Office Building
1700 N. Congress Avenue
Austin, Texas 78701

For the **CONTRACTOR:**

Contract Issues:
Jordan Furnans, Ph.D., P.E., P.G.
Vice President & Manager – Texas Operations
LRE Water, LLC
1101 Satellite View #301
Round Rock, TX 78665
Email: Jordan.Furnans@LREWater.com

Payment Request Submission:
Jordan Furnans, Ph.D., P.E., P.G.
Vice President & Manager – Texas Operations
LRE Water, LLC
1101 Satellite View #301
Round Rock, TX 78665
Email: Jordan.Furnans@LREWater.com

Physical Address:
LRE Water, LLC
1101 Satellite View #301
Round Rock, TX 78665

IN WITNESS WHEREOF, the parties have caused this CONTRACT to be duly executed in multiple originals.

TEXAS WATER DEVELOPMENT BOARD

for Jeff Walker
Executive Administrator

Date: 10-16-18

LRE WATER LLC

Jordan Furnans, Ph.D., P.E., P.G.
Vice President & Manager – Texas Operations

Date: 10/15/18

EXHIBIT A

STATEMENT OF QUALIFICATION

July 9, 2017

Texas Water Development Board
PO Box 13231
Austin, TX 78711-3231
Contact: Phyllis Thomas
Phone: 512-463-7825
Email: Phyllis.Thomas@twdb.texas.gov

RE: RFQ #580-18-RFQ0070 – Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin (Phase Two)

Dear Ms. Thomas and Members of the Selection Committee:

On behalf of the LRE Water Team, I present you with our qualifications for the advertised project #580-18-RFQ0070 – Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin (Phase Two). **LRE Water, LLC** partnered with **Kennedy Resource Company** offers TWDB unrivaled knowledge and experience regarding the surface and groundwater hydrology of the Upper Colorado River Basin. We also offer innovative technological and analysis methods that will allow us to complete all project tasks on time and within budget. This is evidenced by our recent completion of a statewide subsidence risk assessment for TWDB (Contract #1648302062).

The LRE Water team offers unparalleled water right expertise and the passion to provide stellar service. Throughout the attached statement of qualifications, we have detailed our collective experience with regard hydrologic evaluations of the Upper Colorado River Basin. This experience includes' Kirk Kennedy's having successfully completed Phase 1 of this project effort, as well as my numerous studies of rainfall/runoff effects in the subject area on behalf of the Central Texas Water Coalition (CTWC) and other private clients. We plan to couple our wealth of experience with TWDB's well prescribed project Scope of Work to efficiently and effectively quantify causal relationships leading to the observed reduction in streamflow in the Upper Colorado River Basin.

It is our pleasure to submit these qualifications and we look forward to speaking with you in more detail about how the LRE Water team can support TWDB on this project effort.

Sincerely,

Jordan Furnans, PE, PhD, PG
Vice President – TX Operations & Project Manager
LRE Water, LLC.

1101 Satellite View | Suite #301 | Round Rock, Texas 78664 | 512-736-6485 | Jordan.Furnans@LREWater.com

PAGE INTENTIONALL LEFT BLANK

Texas Water Development Board
REQUEST FOR SOQ NO. 580-18-RFQ0070
Evaluation of Rainfall-Runoff Trends
in the Upper Colorado River Basin (Phase Two)

TABLE OF CONTENTS

CONTENT ITEM 1
EXECUTION OF SOQ
to the
REQUEST FOR QUALIFICATIONS

Company Name: LRE Water, LLC.

Address: 1101 Satellite View #301

Round Rock, TX 78665

Phone Number: 512-736-6485

Email: Jordan.Furnans@LREWater.com

I _____ , am the above-referenced company's representative and I am authorized to submit this response and sign future contract documents. By signing below, the representative certifies that if a Texas address is shown as the address, the respondent qualifies as a Texas Bidder as defined in 34 TAC Rule 20.32(68).

_____ _____
Authorized Signature Date

_____
Title

CONTENT ITEM 2
COMPANY PROFILE SUMMARY AND HISTORY

LRE Water, LLC is a subsidiary of Leonard Rice Engineers, Inc, who for 48 years, has provided engineering services throughout the US West related to planning, managing, and developing water resources. Lee Rice started the company in 1970, and the ownership has evolved from a single owner to an employee-owned corporation with multiple principal owners. We continue to invest in developing our next generation of engineers/geoscientists through leadership, project management, and technical training.

As a recognized leader in water resources engineering, we have continued to add to our expertise with water as the foundation. Our staff is comprised of Hydrogeologists, Water Resources Engineers, Water Rights Engineers, Regulatory Compliance and Environmental Permitting Specialists, Data Integration and Modeling Engineers, and Civil Engineers.

Company Legal Name: **LRE Water, LLC**

Parent Company: Leonard Rice Engineers, Inc.
Address: 1101 Satellite View #301, Round Rock TX 78665
Texas PE Firm: #14368
Texas PG Firm: #50516
Website: www.LREWater.com
Contact: Jordan Furnans, PhD, PE, PG, Vice President and Manager
Phone Number: 512-736-6485
Email: Jordan.Furnans@LREwater.com

For this effort, we expect project work to be conducted primarily from our Texas office by Texas-based staff Dr. Jordan Furnans, PE, PG and Mr. Mike Keester, PG. Supporting work will be undertaken by members of our Water Information Technology group based in Denver, CO, led by Ms. Katy Kaproth-Gerecht, PE. Although not anticipated, we request the ability to utilize staff as needed from our company offices in Denver (CO), Phoenix (AZ), and Lawrence (KS). We have also partnered with Kirk Kennedy of Kennedy Resource Company in order to benefit from the insights he developed during the completion of the first phase of this project effort.

One main asset of LRE Water, LLC is our demonstrated expertise in addressing Texas water resources issues involving both surface water and groundwater. Coupling this expertise with the innovative data visualization and analysis methods created by our CO-based Water Information Technology group serves to greatly enhance the services and products we offer to TWDB and other clients. This in-house expertise makes us uniquely qualified to perform the detailed hydrologic analyses requested in this RFQ, and will ensure our final project analyses properly synthesizes results from both disciplines.

Our LRE surface water team is led by Dr. Jordan Furnans, PE, PG who has been analyzing the hydrology of Texas continuously since 2003. Dr. Furnans earned a PhD in Civil Engineering from the University of Texas at Austin, where his dissertation research focused on improving numerical modeling methods of surface water movement. Dr. Furnans is a recognized testifying

expert on surface water availability, numerical modeling, open channel flow, and hydraulic engineering. He began his career as a hydrologist in the TWDB Surface Water division, assisting in developing instream flow requirements as part of the SB2 process. As a private consultant with INTERA and LRE Water, Dr. Furnans has assisted numerous clients (including wholesale water providers, municipalities, and industry) in assessing their water availability, obtaining additional water supplies, and improving water infrastructure to increase availability. His work that is most pertinent to this project effort stems from his ongoing work with the Central Texas Water Coalition (CTWC), a group of concerned citizens attempting to ensure that the Colorado Basin water supply is properly managed to ensure regional prosperity. In this regard, Dr. Furnans has performed numerous hydrologic studies of the Colorado River Basin, including a 2013 preliminary study to elucidate causes of decreased streamflow upstream of the Highland Lakes. This study was reviewed by Kirk Kennedy as part of the Phase 1 project work leading up to this Phase 2 RFQ. Dr. Furnans has also recently been retained to review hydrologic analyses in support of two EIS studies required by the USACE. Both of these studies required assessing the assumed stationarity of streamflow hydrology in the subject area, and Dr. Furnans utilized numerical and statistical techniques to discern whether past hydrologic records could reliably reflect expected future conditions.

Our LRE Groundwater Team has a long history serving our clients' needs for groundwater resource development and management. Led by Mike Keester, PG, our team's work ranges from groundwater supply planning to well design, construction, testing, repair and operational optimization. Mr. Keester routinely assists clients with all aspects of groundwater development, and has served as a testifying expert and support witness in legal proceedings concerning Texas groundwater. Mr. Keester recently led our technical analysis of state wide subsidence risk due to groundwater pumping under TWDB contract 1648302062. During this subsidence study, Mr. Keester developed automated methods to extract pertinent information from TWDB groundwater databases and Submitted Drillers Reports, allowing us to assess relative subsidence risk statewide using over 430,000 individual well records. We expect to parlay this experience and expertise in assessing trends in groundwater levels in the Upper Colorado watershed as part of this project.

Our LRE Water Information Technology team has, over the past 8 years, led the development of automated means for data retrieval, analysis, and web-based visualization of hydrologic data. Sample projects include the development of decision support systems for water master operations, development of web-based repositories for groundwater monitoring databases, and the development of online tools for visualizing hydrologic model results for public consumption. For this project, Ms. Katy Kaproth-Gerecht will lead efforts to utilize aerial imagery (through Google Earth Engine and other platforms) to rapidly assess watershed changes over time and to identify seasonal/perennial ponds and stock tanks.

Our project team is rounded out with Mr. Kirk Kennedy, PG of Kennedy Resource Company, who completed the Phase 1 evaluations of Colorado Basin rainfall runoff patterns that led directly to the effort requested in this RFQ. Mr. Kennedy will provide reference support during this project effort, and will be actively involved in reviewing project findings based on his intimate knowledge of the subject basin. Mr. Kennedy has been involved in Texas' surface water rights for 27 years, with experience ranging from Team Leader of the TCEQ's Surface Water

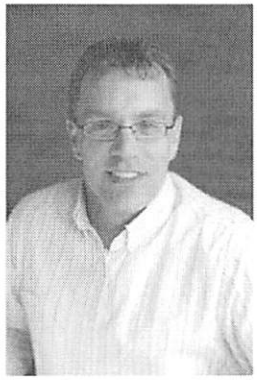
Rights Availability Team to Senior Scientist for R. J. Brandes Company. While with the TCEQ, Mr. Kennedy determined water availability for water right applications, represented Texas in River Compact issues with other states, testified as an expert witness for the TCEQ, determined impacts of environmental flow recommendations on proposed water right applications, and developed much of the process and guidance used by the TCEQ to bring about the construction of most of the WAM models under Senate Bill 1 (75th Legislature). After leaving the TCEQ, Mr. Kennedy has analyzed water projects using every WAM model in the state and was deeply involved with the construction of the Colorado, Rio Grande, and Nueces/Rio Grande Coastal WAM models as well as in the development of the naturalized flows that are used as inputs to these models and other WAM models. Over the past several years, Mr. Kennedy has been involved in the formulation and application of the state's Senate Bill 3 process (80th Legislature) in roles ranging from assisting the Science Advisory Committee's (SAC) efforts to provide guidance on the interpretation and model representation of many aspects of SB3, participating as a member of the Colorado Lavaca Basin Bay Expert Science Team (BBEST), and determining impacts of future eflow recommendations on possible new water supply projects for the Guadalupe and Colorado Basin Bay and Stakeholder Committees (BBASC).

CONTENT ITEM 3
Resumes of Individuals

Resumes are included for:

Jordan Furnans, PhD, PE, PG – LRE Water, LLC
Mike Keester, PG – LRE Water, LLC
Katy Kaproth-Gerecht, PE – LRE Water, LLC
Kirk Kennedy – Kennedy Resource Company

PROFESSIONAL SUMMARY



Jordan Furnans leads LRE Water, LLC in Round Rock, Texas. His 17 years of professional experience encompasses both field hydrologic data collection and analysis of data through the development and application of numerical models. He specializes in water availability modeling, water rights analysis & acquisition, hydrology & hydraulics, water supply planning/evaluation, water valuation, water right accounting; optimization, coupled field and model hydrodynamic investigations of estuaries, lakes, and rivers; linking water quality and hydrodynamics in natural systems; watershed hydrology planning and management; flood plain management; hydrographic and sedimentation survey methods; and freshwater inflow and instream flow requirements for ecosystem health. He regularly provides expert testimony and interacts with regulators at the Texas Commission on Environmental Quality.

PROFESSIONAL REGISTRATIONS

Professional Engineer

TX	(2006)	No. 97316
CO	(2010)	No. 44217
NM	(2010)	No. 19880
OK	(2012)	No. 26095
AZ	(2015)	No. 61061

Professional Geoscientist

TX	(2011)	No. 11002

NSPS Certified Hydrographer**

USA	(2011)	No. 268

***National Society of Professional Surveyors*

EDUCATION

PhD, 2005, Civil Engineering
The University of Texas at Austin

MSE, 2001, Environmental & Water Resources Engineering
The University of Texas at Austin

BSE, 1999, Civil/Geological Engineering,
Princeton University

US Fulbright Fellowship, 2002-2003,
Centre for Water Research
The University of Western Australia

EMPLOYMENT & GENERAL EXPERIENCE

LRE Water, LLC, Round Rock, TX 2015-present

Senior Project Manager, Vice President and Manager of the Leonard Rice Engineers, Inc. Texas office

Conducts and supervises water resource investigations, including watershed hydrology, surface water supply/analyses, groundwater availability assessments/modeling, support and review of environmental impact statement modeling, stormwater management planning, water availability modeling, reservoir and river operations modeling, water rights accounting, and hydrographic surveys of reservoir volumes and sedimentation.

The University of Texas at Austin, Austin TX 2016-present

Adjunct Faculty – Department of Civil, Architectural, and Environmental Engineering.

Teaching CE 356 – Fundamentals of Hydraulic Engineering

INTERA, Inc. Austin, TX 2009-2015

Senior Water Resources Engineer & Surface Water Team Manager

Provided water availability modeling (WAM) services for various clients in the Brazos River, Concho River, Colorado River and Guadalupe River Basins in Texas. Performed WAM analyses using State of Texas approved models, as well as developed detailed daily models for assessing individual client needs and for aquifer storage and recovery (ASR) development efforts. Developed RiverWare models for basins in CO, OK, and TX. Developed HEC-RAS models of client canal systems to assist in bridge re-design, culvert sizing, and operational methods review. Planned, executed, and completed hydrodynamic modeling for projects in WA, CO, TX, NM and OK. Modeled reservoir management options to increase water supplies. Provided Expert review of numerical groundwater, accounting and reservoir operations models. Served as a Hydrology & Hydraulics expert peer reviewer on USACE projects.

EXPERIENCE, continued

Provided litigation support for water right accounting and allocation matters in Texas. Served as testifying expert witness at the State of Texas Office of Administrative Hearings (cases regarding the Brazos Basin Watermaster Petition and Lower Colorado River Authority's Water Management Plan.

Texas Water Development Board. Austin, TX 2003-2009

Water Resources Engineer

Served as an engineering specialist assisting in State of Texas programs related to Instream Flow evaluation, Bays & Estuaries modeling, Water Availability Analyses, and Hydrographic Surveying.

Served as part of a team working toward developing the methodology used to determine instream flow requirements for Texas. Lead data collection efforts on the San Antonio, Colorado, Sabine, Brazos and Trinity Rivers. Data collection involved high precision elevation surveying using GPS, bathymetric data collection, ADCP usage, spot velocity measurements, and fish collection/identification. Developed hydrodynamic models linking flows to habitat availability for selected fish/invertebrate species in the Brazos, Sabine, and San Antonio River Basins.

Overhauled the surveying and data processing methodology of the hydrosurvey program in order to improve the accuracy of reservoir volume and sediment accumulation rate estimates. Developed a multi-function software package (HydroEdit) which processes, edits, interpolates and extrapolates survey data collected using various depth sounders and surveying equipment. Lead the program assessment project which involved a detailed survey of Lake Lyndon Baines Johnson, developed recommendations for improvements in study design, surveying methodology, data processing techniques and methods for comparing the results of repeated surveys. Performed field data collection on 12 hydrographic surveys in Texas; oversaw the completion of 23 survey reports, and developed methods for incorporating LiDAR and multibeam datasets into reservoir volumetric computations.

Planned and directed a field and modeling exercise aimed at determining the impact of a potential desalination brine discharge into the Corpus Christi Bay system. Lead 2-15 professionals on 4 field data collection trips, sampling water quality parameters and bathymetry in the Corpus Christi Bay system. Processed data to determine the cause of existing seasonal hypoxia and to determine the extent of the existing high-density underflow plumes affecting water quality. Directed the development of an EFDC model of the exchange flows between Oso Bay and Corpus Christi Bay.

Norwich University. Northfield, VT 2008-2011

Adjunct Professor – Civil Engineering

Developed online courses for graduate level classes in groundwater hydraulics, waste water engineering, and landfill design. Taught online courses in groundwater hydraulics and waste water engineering.

The University of Texas at Austin, Austin TX 1999-2005

Graduate Student – Department of Civil, Architectural, and Environmental Engineering.

Developed hydrodynamic models of Marmion Marine Park (Western Australia) and Lake Kinneret (Israel). Tracked GPS drifters and compared motion to model-predicted motion using ELCOM and customized drifter-modeling program. Developed ArcGIS tools for water resources research, implemented the Pfafstetter coding system into ArcGIS for watershed connectivity management.

PROJECT EXPERIENCE & DESCRIPTIONS

State of Texas Subsidence Risk Identification due to Groundwater Pumping, TWDB, 2017-2018. *Project Manager/Engineer.* Served as project manager for effort to assess subsidence risk in all major and minor aquifers across Texas, quantifying relative risk and developing mathematical tools to incorporate subsidence risk in groundwater permitting decisions. TWDB Contract Number 1648302062.

Surface water- groundwater linkage along the San Saba River, TX, TK Cattle Co., LLC, 2018. *Project Engineer.* Measured water levels in the San Saba River and adjacent groundwater wells to determine the likelihood that wells are pumping surface water without proper surface water permits. Performed evaluation in response to a TCEQ notice of violation. Working with landowners and attorneys at Terrill & Waldrop to ensure water usage conforms to all applicable laws.

Surface water pond evaluation, Uhl, Fitzsimons, Jewett, Burton & Wolff, PLCC, 2018. *Project Engineer.* Evaluated existing surface water ponds on private property in Karnes and Dimmit County, TX to determine if ponds capture State of Texas water and therefore require surface water permits prior to using the pond water for non-domestic and livestock purposes. Performed site visits and hydrologic/topographic data reviews, developed reports, obtained official rulings from regulators at the TCEQ.

Water Supply Options Assessment, City of Manvel, TX. 2015-Present. *Project Engineer.* Serving as lead engineer in providing technical expertise to the City of Manvel regarding future development options for a 105-acre sand pit which receives groundwater inflows. Responsible for quantifying water availability, water quality, water treatment options, and land-use options to support growth in the local area. Revised Brazos River Basin WAM model for a potential new water right application, developed local MODFLOW model of the sand pit replenishment. Developed rating curve using HEC-RAS for Mustang Bayou adjacent to the sand pit, and quantified bayou flows from 7/2017 to 7/2018 to assess viability of a water right application.

Water Rights Analyses and Litigation Support, Gulf Coast Water Authority, TX. 2010 – Present. *Project Engineer.* Serving as lead engineer in providing technical expertise to the Gulf Coast Water Authority (GCWA) to improve GCWA's ability to reliably supply water to clients within the Brazos River Basin, with specific focus on Fort Bend, Brazoria, and Galveston counties, TX. Supported GCWA in contested-case hearings and mediation efforts against the Brazos River Authority (TX), the City of Sugarland (TX), and Dow Chemical (TX). Ongoing work includes analyzing water usage patterns of GCWA customers, evaluating potential short-term water supply sources, developing a revised and more effective Drought Contingency Plan (through a WaterSMART grant from the US Bureau of Reclamation), developing a water accounting plan for GCWA Brazos River water rights, development of a canal-system conveyance model (water balance & HEC-RAS) for water operations planning, developing Version 7 of the GCWA Daily-Hydro Water Availability Model, and representing GCWA in public meetings regarding GCWA water reliability and supply commitments. Past tasks include: 1) Modeling support in the Brazos Basin watermaster contested case hearing, 2) development of the GCWA Daily-Hydro water accounting model (Versions 1-6), currently the only available daily model capable of assessing water availability in Texas, 3) quantifying GCWA's expected water shortages during 2011 (a year worse than the current Brazos Basin drought of record), 4) evaluating water availability modeling (WAM) in support of proposed and desired future water right permits in the Brazos basin, 5) identifying errors in WAM modeling efforts and the implications of such errors with respect to water availability resulting from the "granting" of pending water right permits applications, 6) review of the Lake Houston Water Accounting Plan, 7) performing a sedimentation survey of TX City Reservoir, 8) analysis of water availability from GCWA's Juliff Canal system & Chocolate Bayou water rights, 9) evaluating the impacts to GCWA of the proposed Brazos River Authority Water Management Plan, 10) performing hydrographic surveys of GCWA's Mustang Reservoir and Canal A1 system, and 11) conducting a flow gain-loss study of the GCWA canal system,.

Hydrologic and Engineering Support Services, Central Texas Water Coalition (CTWC), TX. 2012 – Present. *Project Engineer.* The CTWC is an organization representing the interests of land owners and businesses dependent on the recreational activities associated with the highland lakes of Central Texas. In developing the basin Water Management Plan, the Lower Colorado River Authority (LCRA) brought together stakeholder groups, including CTWC, to help determine the appropriate management of water in the basin, including conditions under which water for agricultural uses would be curtailed. Have and continue to provide hydrologic and engineering support services to assist the CTWC in evaluating proposed water management strategies for the LCRA Highland Lakes system in the Colorado River Basin (TX). Ongoing activities include developing alternative water accounting models (other than the TCEQ-approved WAM model) to simulate water ability through 2016 according to the Texas prior-appropriation system. Past activities have included: 1) investigating potential reasons for historically low lake inflows which are out-of-proportion to the relatively low rainfall totals in the watershed, 2) review of LCRA- and TCEQ-produced water availability models and results, 3) review of historical inflow data to the Highland Lakes, 4) assessing the impact of the Lake Buchanan-O.H. Ivie subordination agreement on Highland Lake water levels, 5) quantifying how recent TCEQ emergency orders have prevented drought-worse-than-drought-of-record (DWDOR) declarations, and 6) developed a forward-looking water balance model to demonstrate the impact of low lake inflows on water supply reliability.

Water Rights Litigation Support – South Texas Project Nuclear Operating Company, 2016-Present. *Lead Engineer, Project Manager.* Utilized WAM and Non-WAM based analysis techniques to advise client on the impact to their water supply of proposed changes to senior water rights ("Garwood" and "Gulf Coast") owned by the Lower Colorado River Authority. Provided engineering technical support to STPNOC staff and outside counsel. Developed the Wharton Water Balance model to quantify water availability for STPNOC both before and after LCRA completes construction of Arbuckle Reservoir.

Expert Peer Review – Cedar Ridge Reservoir EIS, Abilene, TX, 2018-Present. *Expert Reviewer – WAM Modeling.* As a subcontractor to Stantec, performed evaluation of the Cedar Ridge Reservior Purpose and Needs document, including supporting Water Availability Models (WAMs) used to demonstrate and quantify needs. WAM modeling focused on the Brazos and Colorado River basins.

Expert Peer Review – Little Colorado River EIS Review, Winslow, AZ, 2017-Present. *Expert Panel Reviewer – Hydrology & Hydraulics.* Was selected to participate in the independent external peer review panel for Little Colorado River EIS review as a subcontractor to Battelle.

Waller Creek Tunnel Hydraulic Review – SJ Louis Company, 2016-Present. *Lead Engineer.* Performed hydraulic calculations and reviewed expert documents provided by the City of Austin regarding the Waller Creek Tunnel. Demonstrated how calculations were initially improperly performed, and how when corrected they indicate that design objectives are maintained by the current state of tunnel construction.

Stormwater Pond Evaluation Survey – Brushy Creek Municipal Utility District, Round Rock, TX. 2017. *Lead Engineer.* Performed a multi-frequency hydrographic survey 24 stormwater ponds (wet & dry) to assess as-built/operated conditions and determine if ponds need rehabilitation to continue providing the level of stormwater runoff protection services expected by residents.

Northern Integrated Supply Project, City of Fort Collins, CO. 2015.
Project Engineer. Serving as expert reviewer for issues regarding treatment of total organic carbon (TOC) and trichloroethylene (TCE) as discussed in the Supplemental Draft Environmental Impact Statement (SDEIS) developed by the US Army Corps of Engineers. Reviewed CE-QUAL-W2 model of Horsetooth Reservoir, water quality modeling of the Cache de la Poudre River.

Watermaster Compliance Review & Evaluation: CiLI, 2015. *Lead Engineer, Project Manager.* Performed hydraulic modeling to develop a reference device for a water right holder to properly divert water from the North Bosque River according to permit conditions. Evaluated owner's water pump for compliance with Brazos River Watermaster regulations, recommended water management and operation alternatives to optimize water usage for client's pecan orchard.

Sedimentation Assessment on Morris Shepard Dam, Graford TX. 2014 *Lead Engineer.* For the Brazos River Authority, as a subcontractor to ARCADIS, performed a multi-frequency hydrographic survey of the area immediately upstream of Morris Sheppard Dam on Lake Possum Kingdom. Quantified the amount of sediment accumulation on the face of the dam, based on acoustic measurements of current water depths/bathymetry and sediment accumulation. Collected sediment core samples using a Vibracore system, and had samples analyzed for chemical content and density.

Water Management Plan Review and Litigation Support, NRG Texas Power LLC. 2014 *Lead Engineer, Project Manager.* Provided litigation support and review services regarding the Brazos River Authority's pending permit 5851 water right application, water management plan, and accompanying accounting plan. Assisted counsel in negotiations and analyses regarding NRG Texas Power LLC water rights and the impact of permit 5851 on those rights.

Creek Flow Measurements for Permitting Support, TX . 2014 *Lead Engineer, Project Manager.* On behalf of a confidential client, measured flow within an unclassified receiving waterbody for use in a pending Texas Pollutant Discharge Elimination System (TPDES) water discharge permit. Aided client in interpreting the impact of the flow measurements and computing the harmonic mean flow used in assessing surface water quality maintenance efforts. Will continue to support client in negotiations with the TCEQ regarding the pending discharge permit.

Water Availability Assessment: City of Houston, TX . 2014 *Lead Engineer, Project Manager.* On behalf of a confidential client, detailed the water availability and reliability for a potential new water customer relying upon supplies to be made available by the City of Houston. Analysis involved assessing City of Houston water rights using the WAM models, GIS analysis, review of water right permits and certificates of adjudication, and review of the Texas State Water Plan and Region H Regional Water Plan.

Water Reuse-Supply Feasibility Study, Houston Ship Channel, Confidential Client, TX. 2012 – 2013. *Lead Technical Engineer.* For a confidential client, reviewed water supplies and demands for Harris County, TX, and the neighboring region to assess the potential for tertiary water reuse projects in supporting industrial water needs. Analyses involved reviewing the state water plan and Region H water plans, City of Houston accounting plans, Texas Water Availability Models (WAMs), and existing water reuse applications and permits.

Review of Brazos River Authority Water Availability Modeling and Water-Management Plan for Pending Permit 5851, Possum Kingdom Lake Association, Graford, TX. 2013. *Lead Technical Engineer.* For the Possum Kingdom Lake Association (PKLA), reviewed water availability modeling (WAM) and water-management plan (WMP) documents submitted to the Texas Commission on Environmental Quality (TCEQ) in support of the Brazos River Authority's (BRA) pending water right permit 5851. Verified modeling claims made by BRA and concluded that the Brazos Basin WAM model does suggest sufficient water is available to meet the current permitted and pending permitted water needs in the Brazos Basin. Also identified areas of potential miscommunication of facts in BRA document regarding the pending 5851 permit and WMP, and clarified these points for PKLA.

Expert Peer Review – Hunting Bayou Flood Risk Management Study, Harris County Flood Control District, TX. 2013. *Expert Panel Reviewer – Hydrology & Hydraulics. Was selected to participate in the independent external peer review panel for Hunting Bayou Flood Risk Management Study as a subcontractor to Battelle.*

Water Supply Assessment, Barton Creek Lakeside Property Owners Association, TX. 2013. *Lead Engineer, Project Manager.* The Barton Creek Lakeside Property Owners Association (POA) is concerned about the future water supply for irrigation of their properties considering the low level of the Pedernales River during the central Texas drought. Oversaw the evaluation of the water supply systems for the POA, including the evaluation of existing infrastructure and the needs for improvement where the existing infrastructure was inadequate. Insured that the existing potable water supply company was meeting all Texas Commission on Environmental Quality (TCEQ) regulations. Oversaw compilation and analysis of water quality and water level data in the vicinity of wells serving the Barton Creek Lakeside community. Due to the proximity of the wells to nearby Lake Travis and water system failures in nearby communities, the POA was concerned about the reliability of their water supply. Available hydrologic data was evaluated to determine the source of water to the wells – whether groundwater from the Hosston unit of the Trinity Aquifer or intercepted surface water from Lake Travis – and the expected impacts to the water supply in an ongoing drought.

Waurika-Ellsworth System Evaporation Study, Waurika Lake Master Conservancy District, OK. 2013. *Lead Engineer.* Developed scientifically justified rules based on historical hydrology and climate to determine when water should be conveyed via pipeline to minimize combined storage losses due to evaporation. This was done to assist the Waurika Lake Master Conservancy District in managing its municipal water supply between its three reservoirs in Oklahoma. A daily decision making tool was developed in Microsoft Excel for water managers to evaluate the benefits/determents of transferring water given current conditions. Assessed the full range of possible relative conditions (using MATLAB) and developed guidelines for when transfers would most often yield water savings.

Water Reuse-Supply Feasibility Study, Confidential Client, TX and LA. 2013. *Lead Technical Engineer.* Identified potential sites for a confidential client to obtain municipal wastewater discharges, perform additional water treatment, and then sell the available treated water to nearby industries. This project involved using the 20 Water Availability Models (WAMs) for Texas and assessing each of the more than 10,000 water rights for use, suitability, and proximity to municipal and industrial centers in Texas. In Louisiana, identified petrochemical industry water needs and determining which might be sustained through reuse of nearby municipal wastewater.

Water Availability Assessment, Aquifer Storage and Recovery Applications, Naismith Engineering, Victoria, TX. 2013. *Principal Engineer.* Used the monthly WAM model to determine water availability for a proposed Aquifer Storage and Recovery (ASR) project. Developed a daily model which allocates water to water right holders in the Guadalupe River Basin (TX) and San Antonio River Basin (TX) in order to better quantify ASR water availability. The model determined the quantity and likelihood of water being available for ASR projects in the vicinity of Victoria, TX, and near facilities managed by the Guadalupe-Blanco River Authority near Port Lavaca, TX. The model simulates water allocation based on daily gauged flows, and follows the Texas prior-appropriation doctrine. The model also includes pumping limitations and treatment limitations dictated by the ASR-design constraints, and any special provisions dictated in existing Guadalupe and San Antonio Basin water right permits.

Bathymetric & Sedimentation Surveys - Gulf Coast Water Authority, TX. 2013. *Project Engineer.* Served as lead engineer in determining reservoir capacities and sediment accumulations rates in water supply reservoirs owned and managed by the Gulf Coast Water Authority (GCWA). Surveyed waterbodies include Mustang Reservoir (650 acres), TX City Reservoir (800 acres), and the A1 canal (35 miles), including lakes within the City of Sugarland. Demonstrated that sediment influx into the A1 canal has increased due to land management/construction practices within the ETJ of the City of Sugarland.

Baker-Martin Lake Impoundment Study, the Terrill Firm P.C., Menard County, TX. 2013. *Lead Technical Engineer.* Reviewed impoundment calculations for the Baker-Martin dam on the San Saba River, Menard County, TX, for the Terrill Firm P.C. Reviewed the data and volume calculations from TCEQ, and developed revised volume estimates using traditional hydrographic survey data processing techniques. Performed a detailed bathymetric survey of Baker-Martin lake to definitively quantify the impounded water volume and upstream boundary of the water body.

Expert Model Review – HEC-EFM and HEC-GeoEFM, U.S. Army Corps of Engineers (USACE). 2012. *Expert Model Reviewer – Hydrology & Hydraulics. Was selected to participate in the independent external peer review panel for the planning model quality assurance review of the* USACE Hydrologic Engineering Center Ecosystem Functions Model (HEC-EFM) and HEC-GeoEFM Spatial Accessory to HEC-EFM *as a subcontractor to Battelle.*

Water Availability Analysis, Bentwood County Club, San Angelo, TX. 2012. *Project Engineer.* Performed Water Availability Model (WAM) analyses to support water supply negotiations between the Bentwood County Club and the City of San Angelo. Reviewed all (135+) local Certificates of Adjudication, confirmed their representation in the state's WAM model, reviewed the water accounting plan for the Concho River system reservoirs, and assessed benefits to all parties resulting from numerous potential water supply agreements. Will provide as-needed support for ongoing negotiations and/or legal proceedings.

Water Availability Analysis and Salinity Study, Brazosport Water Authority, Brazoria County, TX. 2012. *Project Engineer.* Performed Water Availability Model (WAM) analyses for the Brazosport Water Authority (BWA), and assessed reliability of water rights within Brazoria County, TX. Compared the WAM-based reliability results to those generated by the INTERA-created GCWA Daily-Hydro

model, which uses data from 2011 (a a year worse than the current Brazos River Basin drought-of-record). Developed a relationship between Brazos River flow and salinity at the BWA intake location using measured field data, WRAP-SALT, and the TxBLEND and SELFE hydrodynamic models.

Water Availability Model-Based Hydrologic Analyses of Strategies to Meet SB3 Environmental Flow Standards for the Guadalupe Estuary, National Wildlife Federation, Austin, TX. 2011. *Lead Engineer.* Performed WAM-based hydrologic analyses to assess environmental flow strategies for the Guadalupe Estuary. Modified the Region L WAM to include increases in flow to the estuary due to 1) wastewater return flow dedications, 2) temporary dry year irrigation right transfers, and 3) the conversion of unused portions of senior firm water rights into permanent environmental flow water rights. Evaluated the effectiveness of each strategy to address environmental flow needs of the estuary. Reported modeling results to the National Wildlife Federation and the Guadalupe, San Antonio, Mission, and Aransas Rivers, and Mission, Copano, Aranasas, and San Antonio Bays Expert Science Team (GSA BBEST).

Bathymetric and Sedimentation Survey of Sunshine Lake, City of Weatherford, TX. 2011. *Lead Engineer, Project Manager.* To aid the City of Weatherford, TX, in assessing their surface water availability, planned and executed a multi-frequency bathymetric and sedimentation survey of Sunshine Lake. Data collection occurred along pre-planned survey lines spaced at 100-ft intervals covering the extent of the approximately 43 acre lake, with lines oriented in a grid pattern to achieve spatial coverage adequate per U.S. Army Corps of Engineers hydrographic standards. Interpreted multi-frequency acoustic sounding data and spud-bar measurements to estimate and map the thickness of the accumulated sediment layer along the lake bottom. Determined the lake has lost approximately 1/6th of its original capacity due to sediment accumulation.

Hydrodynamic Model Development, Mid-Columbia Fisheries Enhancement Group, WA. 2011 - 2014. *Lead Engineer,* Developed a hydrodynamic (EFDC) model to determine the likely impact of the removal of the Bateman Island Causeway on salmonid migration, dissolved oxygen (DO) levels, and water temperatures at the confluence between the Columbia and Yakima rivers in Richland, WA. Performed a bathymetric and sedimentation survey of the confluence area using multi-frequency depth sounders and survey-grade GPS equipment. Developed and validated EFDC models to describe both current water circulation patterns and those expected under four alternative causeway-breaching scenarios

Hydrologic Analysis of Climate Change Impacts on Water Availability, Albuquerque Bernalillo County Water Utility Authority (ABCWUA), NM, 2010 - 2012. *Project Engineer.* Served as technical lead in assisting the ABCWUA to understand how climate change may affect its future water supplies from the Rio Grande. Developed a statistical analysis algorithm/program to assess the impact of potential streamflow reductions and alterations to historical snowmelt runoff patterns in the Rio Grande Basin. Evaluated historical USGS gage records to determine whether any statistically significant changes to the timing, magnitude, and duration of snowmelt runoff have occurred over the period of record. Developed a graphically-based hydrograph-shifting program to assess the impact on water availability models if (due to climate change) snowmelt runoff were to occur earlier or later in the year and result in reduced (or increased) flow volumes. Implemented the hydrograph-shifting program into a Goldsim model provided to the ABCWUA.

Model Analysis and Litigation Support, Hays Caldwell Public Utility Agency, TX. 2011. *Project Engineer.* Assisted in preparation of engineering material for use in potential litigation hearings regarding groundwater availability and pending groundwater permit applications in Gonzalez County, TX. Analyzed MODFLOW model input and output files to assess consistency with material presented in permit applications and engineering reports by opposing parties.

Hydrographic Survey and Data Analysis, City of Santa Fe, NM. 2011. *Lead Engineer, Project Manager.* To assess available water supplies for the City of Santa Fe, planned & executed detailed bathymetric and sedimentation surveys of McClure and Nichols Reservoir, including review and analysis of previous survey data collected in 1995. Results from the current survey (undertaken in May 2011) were used to determine the current capacity of each reservoir, the original (pre-impoundment) capacity of each reservoir, and the amount of sediment/debris accumulated in the reservoir since impoundment. Based on the accumulated sediment/debris volumes, capacity loss rates due to reservoir infill were extremely small (<0.1% per year), with capacity lost both due to soft sediment influx and influx of hard sediment (rocks, trees, etc) due to mass wasting and erosional processes in the immediate vicinity of each reservoir. Project involved extensive field data collection and analysis using multi-frequency depth sounders and survey-grade GPS equipment (Trimble R6-R8 system and VX Scanner).

Stormwater Management Plan Update and Water Quality Analysis, City of Bonita Springs, FL. 2010 - 2011. *Project Engineer.* Served as technical lead in updating the stormwater management plan for the City of Bonita Springs, FL. Completed tasks include the development, calibration and validation of an ICPR model of runoff response to storm events, use of Florida State Emergency Response Team (SERT) LiDAR data in determining stormwater system watersheds, and creation of GIS data describing city stormwater infrastructure. Using ICPR, performed numerical modeling of flooding extent, channel conveyance, and detention basin performance under assumed design storm conditions. Revised Imperial River bathymetric survey data to improve model calibration results. Assisted in the identification and prioritization of potential stormwater system improvement projects. Aided in data collection and analysis for assessing stormwater quality concerns within the city limits, and developing an HSPF water quality model of the City of Bonita Springs watersheds. The HSPF model was used to determine the water quality impacts of proposed future land use and to identify needed water quality improvement projects.

PlumeCalc Model Review, Los Alamos National Laboratories, NM. 2010 - 2011. *Project Engineer.* Developed numerical models of groundwater flow and contaminant transport for use in assessing accuracy and numerical performance of the PlumeCalc

program developed by the Los Alamos National Laboratory. Models were developed using Groundwater Vistas, MODFLOW, and MT3DMS, with statistical and visual comparisons made with customized MATLAB scripts. Identified numerical instabilities and physical inconsistencies in the PlumeCalc code, leading to code revisions and program re-distribution.

Regional Water Plan, Choctaw and Chickasaw Indian Tribes, Southeast OK. 2010 – 2014. *Project Engineer.* The Choctaw and Chickasaw Nations are involved in a federal lawsuit over water rights within their jurisdictional boundaries. Provided expert modeling support for this effort, including hydrologic analyses of stream flow records, development of a Kiamichi Basin RiverWare accounting model, and development of the larger Red River Basin RiverWare accounting model. Development of the Red River Basin RiverWare model required detailed understanding of the Red River Compact dictating water management between Texas, Oklahoma, Arkansas, and Louisiana. Also developed innovative means for using RiverWare to assess prioritized diversions from subbasins, subject to applicable water management methods in each subbasin and state.

Water Availability Modeling and Irrigation Supply Assessment, Colorado Water Issues Committee, Wharton, TX. 2010. *Project Engineer.* Provided expert model review services for the Colorado Water Issues Committee (CWIC), an organization of rice farmers in the Lower Colorado River basin, in their effort to understand the modeling performed by the Lower Colorado River Authority (LCRA) as part of their 2010-2011 water management plan revision. Reviewed and assessed the LCRA's water availability model (WAM) for accuracy and conformity with established legal water priorities, and recommended policy initiatives CWIC should suggest to better ensure sufficient water supplies for irrigation purposes.

Water Use and Availability Analysis, Confidential Client, NM. 2009 – 2010. *Project Engineer.* Employed extensive numerical and analytical modeling techniques to assess water right allocations and water availability in New Mexico. Served as technical lead assessing alternative water usage scenarios for developing expert testimony (Confidential Clients). Using GIS techniques and MATLAB scripts, assessed the possibility of inter-basin transfers within New Mexico, considering both surface water and groundwater simulations. Reviewed the impact that climate change may have on future water availability, and assessed how groundwater use practices may alter historical streamflow patterns.

Developing Uncertainty Analysis Methodologies for the MikeSHE/Mike11 Modeling System, U.S. Army Corps of Engineers, Jacksonville, FL. 2009. *Project Engineer.* Organized the automatic modification of a coupled MikeSHE/Mike11 groundwater/surface water model of the Kissimmee Basin (FL) developed by the U.S. Army Corps of Engineers, using the mCalc Monte Carlo simulation program developed by INTERA. Developed the linkages between mCalc and the MikeSHE/Mike 11 model and extracted output metrics for use in a simplified, "proof of concept" uncertainty analysis of the Kissimmee Basin model. Developed the proof-of-concept analysis report for the U.S. Army Corps of Engineers.

Hydrographic Survey Program, Texas Water Development Board, TX. 2003 – 2009. *Project Engineer.* Overhauled the surveying and data processing methodology of the hydrosurvey program in order to improve the accuracy of reservoir volume and sediment accumulation rate estimates. Developed a multi-function software package (HydroEdit) which processes, edits, interpolates and extrapolates survey data collected using various depth sounders and surveying equipment. Lead the program assessment project which involved a detailed survey of Lake Lyndon Baines Johnson, developed recommendations for improvements in study design, surveying methodology, data processing techniques and methods for comparing the results of repeated surveys. Performed field data collection on 12 hydrographic surveys in Texas, oversaw the completion of 23 survey reports, and developed methods for incorporating LiDAR and multibeam datasets into reservoir volumetric computations. Work performed while employed by the Texas Water Development Board.

RiverWare Model Development for Water Accounting, CADSWES, CO. 2009 – Present. *Technical Lead.* Developed extensive expertise in developing both "simulation" and "rule-based simulations" within the RiverWare modeling system developed by CADSWES (University of Colorado). Completed the CADSWES RiverWare training courses "Introduction to Simulation Modeling in RiverWare," "Rulebased Simulation Modeling in RiverWare," and "Water Accounting In RiverWare." Currently LRE's lead technical engineer actively involved with applications of the RiverWare model on the Kiamichi River (OK), Pecos River (NM), the Upper Rio Grande River (NM), the Lower Colorado River (TX), the Red River Basin (TX/OK) and the Brazos River Basin (TX).

Instream Flow Program Development, Texas Water Development Board, TX. 2003 – 2006. *Project Engineer.* Served as part of a team working toward developing the methodology used to determine instream flow requirements for Texas. Lead data collection efforts on the Colorado, Sabine, Brazos and Trinity Rivers. Data collection involved high precision elevation surveying using GPS, bathymetric data collection, ADCP usage, spot velocity measurements, and fish collection/identification. Work performed while employed by the Texas Water Development Board.

Corpus Christi Bay Data Collection and Modeling, Texas Water Development Board, TX. 2005 – 2006. *Project Engineer/Team Leader.* Planned and directed a field and modeling exercise aimed at determining the impact of a potential desalination brine discharge into the Corpus Christi Bay system. Lead 2-15 professionals on 4 field data collection trips, sampling water quality parameters and bathymetry in the Corpus Christi Bay system. Processed data to determine the cause of existing seasonal hypoxia and to determine the extent of the existing high-density underflow plumes affecting water quality. Directed the development of an EFDC model of the exchange flows between Oso Bay and Corpus Christi Bay. Work performed while employed by the Texas Water Development Board.

Hydrodynamic Modeling of Water Currents, The University of Western Australia, Marmion Marine Park, Australia, and Lake Kinneret, Israel.
2002 - 2003. ***Project Engineer.*** While on a U.S. Fulbright Fellowship to Australia, studied at the Centre for Water Research under Stockholm Water Laureate Jörg Imberger. Performed field data collection and numerical modeling of observed surface currents near a wastewater treatment plant outfall within Marmion Marine Park, Australia. Circulation was predicted using the three-dimensional ELCOM model and validated using current data observed with GPS-tracked drifters. Developed advanced numerical methods to simulated the Lagrangian movement of drivers within the Eulerian velocity field predicted by ELCOM. Developed statistical techniques to assess ELCOM's ability to reproduce the observed drifter motion. Used the ELCOM model to predict surface circulation patterns in Lake Kinneret, Israel, with the circulation validated using drifters. Lake Kinneret experienced zones of low-dissolved oxygen interspersed with seasonal zones of high biological productivity. The numerical modeling indicated that internal waves produced the observed water quality conditions and were due to the diurnally and seasonally varying wind forcing from the eastern Mediterranean Sea.

EXPERT TESTIMONY & LITIGATION SUPPORT EXPERIENCE

Brazos River Authority Permit 5851 Contested Case Hearing, NRG Texas Power, LLC, 2014. - *Project Engineer.* Provided expert witness support to counsel for NRG Texas Power LLC (Joe Freeland, Freeland & Mathews). Reviewed permit 5851 and its associated accounting and water management plans, and detailed how Brazos River Authority operations could be detrimental to NRG Texas Power LLC. Suggested adjustments to Permit 5851 that would reduce the risk of harm to NRG Texas Power LLC should permit be issued and should Brazos Basin streamflows continue to be low based on the historical record. Legal action still being considered by NRG Texas Power, LLC.

Lower Colorado River Authority Emergency Order Hearing, Central Texas Water Coalition, TX. 2014. *Project Engineer.* Provided expert witness testimony to support the desire of the Central Texas Water Coalition (CTWC) to have the Texas Commission on Environmental Quality (TCEQ) grant an emergency order to the Lower Colorado River Authority (LCRA) to allow deviations from the 2010 LCRA water management plan (Texas State Office of Administrative Hearings (SOAH) Docket No. 582-14-2123; TCEQ Docket No. 2014-0124-WR Application of The Lower Colorado River Authority For Emergency Authorization). Services performed included: 1) development of litigation support material regarding the need for an emergency order and the appropriate "trigger" level at which to allow stored water releases for interruptible users, and 2) providing oral expert-witness testimony (direct and cross-examination by opposing counsel). The provided testimony led to the Proposal for Decision from the Administrative Law Judges favoring issuance of the emergency order at the 1.4 M acre-ft combined storage trigger level favored by CTWC. Assisted Legal Counsel (Cindy Smiley & Shana Horton, Smiley Law Firm PC; Frank Cooley, Independent) in developing all technical testimony.

Brazos River Watermaster Hearing, Gulf Coast Water Authority, TX. 2013. *Project Engineer.* Provided expert witness testimony to support the desire of the Gulf Coast Water Authority (GCWA) to have a watermaster control water diversions in the entire Brazos River Basin (Texas State Office of Administrative Hearings (SOAH) Docket No. 582-13-3040; TCEQ Docket No. 2013-0174-WR Petition for the Appointment of a Watermater in the Brazos River Basin). Services performed included: 1) development of litigation support material regarding the need for a watermaster and the appropriate jurisdiction for a watermaster in the Brazos Basin, 2) providing an oral deposition, 3) developing and providing written pre-file testimony, and 4) providing oral expert-witness testimony during cross-examination by opposing counsel. The provided testimony led to the Proposal for Decision from the Administrative Law Judges favoring creation of a Brazos Basin watermaster with jurisdiction over the entire river basin. Assisted Legal Counsel (Molly Cagle, Baker Botts LLC) in developing all technical testimony.

Brazos River Systems Operations Permit #4851, Gulf Coast Water Authority (GCWA), TX. 2012. *Project Engineer.* Provided engineering support to GCWA in negotiations and mediation efforts with the Brazos River Authority (BRA) in regard to pending permit #4851. Assisted Legal Counsel (Molly Cagle, Vinson & Elkins) in developing all technical material for negotiations.

City of Sugarland Mediation Efforts, Gulf Coast Water Authority, TX. 2012. *Project Engineer.* Provided engineering support to GCWA in negotiations and mediation efforts with the City of Sugarland in regard to water management issues in Fort Bend County, including water accounting concerns related to Certificate of Adjudication 11-5169. Assisted Legal Counsel (Molly Cagle, Vinson & Elkins) in developing all technical material for negotiations.

Streamflow Losses on the Concho River, Glenn Jarvis (Attorney), TX. 2010. *Project Engineer.* Assisted in providing technical support and developing expert testimony for the plaintiffs in a water right contested case. Calculated the conveyance losses involved in moving a point of diversion several miles downstream and through a large reservoir situated in semi-arid central Texas. The stream loses water to the underlying aquifer and as a result of evaporation. Reviewed Colorado River Water Availability Model (WAM) to assess evaporative losses through the Concho River system.

EXPERT REPORTS & PUBLICATIONS

- Furnans, J., 2015. "Gulf Coast Water Authority Water Reliability Assessment for Long-Term Planning." Gulf Coast Water Authority, July.
- Furnans, J., 2015. "**Managing Water Supplies in the Lower Colorado River Basin**." EWRI World Congress, Austin, TX May 2015.
- Furnans, J., 2015. "**Hydrologic Studies of the Highland Lakes Watershed – Part 1 – Why are the recent inflows so low?**" Central Texas Water Coalition. January
- Furnans, J., 2013. "**Evidence for the Need to Change the Approach to Water Planning in the Lower Colorado Basin." Parts 1, 2, and 3**. Central Texas Water Coalition. May, June.
- Chowdhury, A., T. Osting, J. Furnans, and R. Mathews, 2010. Groundwater-Surface Water Interaction in the Brazos River Basin: Evidence from Lake Connection History and Chemical and Isotopic Compositions. Texas Water Development Board Report #375.
- Furnans, J., D. Pothina, T. McEwen, and B. Austin, 2010. Hydrographic Survey Program Assessment. Final Report for the U.S. Army Corps of Engineers, Texas Water Development Board.
- Hodges, B., J. Furnans, and P. Kulis, 2010. Case Study: Thin Layer Gravity Current with Implications for Desalination Brine Disposal. Journal of Hydraulic Engineering, Vol. 137, Issue 3. http://dx.doi.org/10.1061/(ASCE)HY.1943-7900.0000310
- Furnans, J., and B. Austin, 2008. Hydrographic Survey Methods for Determining Reservoir Volume. Environmental Modeling & Software, Volume 23, Issue 2 doi:10.1016/j.envsoft.2007.05.011
- Furnans, J., J. Imberger, and B. Hodges, 2008. Including drag and inertia in drifter modelling. Environmental Modelling & Software, Volume 23, Issue 6. doi:10.1016/j.envsoft.2007.09.010
- Furnans, J., B. Hodges, J. Imberger, 2005. Drifter Modeling and Error Assessment in Wind Driven Currents. PhD Dissertation, The University of Texas at Austin. http://www.crwr.utexas.edu/reports/pdf/2005/rtp05-05.pdf
- Furnans, J., D. Maidment, and B. Hodges, 2002. Integrated Geospatial Database for Total Maximum Daily Load Modeling, Lavaca Bay – Matagorda Bay Coastal Area. The University of Texas at Austin. http://www.crwr.utexas.edu/reports/2002/rpt02-1.shtml
- Maidment, D., S. Morehouse, S. Grise, F. Olivera, D. Honeycutt, J. Furnans, D. Djokic, Z. Ye, N. Noman, J. Nelson, K. Davis, V. Samuels, K. Schneider, V. Merwade, T. Whiteaker, M. Blongewicz, D. Arctur, and B. Booth, 2002. Arc Hydro: GIS for Water Resources. ESRI, Inc. Press. ISBN: 978158940346
- Furnans, J., and D. Maidment, 2001. Topologic Navigation and the Pfafstetter System. The University of Texas at Austin. http://www.crwr.utexas.edu/reports/2001/rpt01-5.shtml

EXPERT REPORTS & PUBLICATIONS, Continued

LRE Water Hydrographic Survey Project Reports: Volumetric and/or Sedimentation Survey Reports
(Served as Primary Co-Author)
2017: Brushy Creek Municipal Utility District – 24 Stormwater ponds, Round Rock (TX)

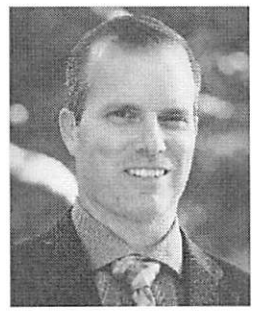
INTERA Hydrographic Survey Project Reports: Volumetric and/or Sedimentation Survey Reports
(Served as Primary Co-Author)

2014: Morris Sheppard Dam, Lake Possum Kingdom (TX)
2013: Baker-Martin Lake (TX), Mustang Reservoir (TX), TX City Reservoir (TX), Monsanto Reservoir (TX), GCWA Canal A1 (TX), Bonito Lake (NM)
2012: Yakima & Columbia River Confluence (WA)
2011: McClure Reservoir (NM), Nichols Reservoir (NM), Sunshine Lake (TX)

Texas Water Development Board Hydrographic Survey Project Reports: Volumetric and/or Sedimentation Survey Reports (Served as Primary Co-Author)

2010: Ray Roberts Lake (TX), Lake Bob Sandlin (TX), Lake Austin (TX)
2009: Richland-Chambers Reservoir (TX), Eagle Mountain Reservoir (TX), Gibbons Creek Reservoir (TX), Lake Mexia (TX), Navarro Mills Lake (TX), Lake Travis (TX), Lake Weatherford (TX), Granger Lake (TX), Lady Bird Lake (TX)
2008: Jim Chapman Lake (TX), Lake Palo Pinto (TX), Lake Cypress Springs (TX), Lake Lewisville (TX), Squaw Creek Reservoir (TX), Lake Arlington (TX), Lake Pat Cleburne (TX), Pat Mayse Lake (TX)
2007: Lake Buchanan (TX), Lake Marble Falls (TX), Inks Lake (TX), Lake LBJ (TX)
2006: Alan Henry Reservoir (TX), Eufaula Lake (OK), Sam Rayburn Reservoir (TX)
2005: GCWA Reservoirs A and B (TX), Possum Kingdom Reservoir (TX)

PROFESSIONAL SUMMARY



Mike began his experience conducting and supervising hydrogeologic investigations throughout Texas and Oklahoma in 2003. Mr. Keester focuses on groundwater flow and determination of availability with respect to quantity and quality as well as regulatory limitations. His work includes assessing and quantifying groundwater resource availability through the evaluation of the effects of groundwater production on aquifer water levels, spring and stream flows, and potential land surface subsidence. He specializes in applying numerical modeling and evaluation of aquifer hydraulics to these quantitative assessments of groundwater availability, flow, and transport including the determination of the statistical uncertainty associated with the assessments and model predictions to better inform clients and meet their project needs.

Mr. Keester has provided professional hydrogeologic consulting services to commercial entities, industrial operations, and governmental agencies. His experience includes the assessment of groundwater availability from karst, fractured, and porous media aquifers. In addition, through his evaluations he has worked closely with clients to develop optimal groundwater production plans for maximizing groundwater production to meet demands while minimizing the costs associated with well field development, production, and maintenance. He has also provided expert testimony on behalf of clients during regulatory hearings regarding hydrogeologic conditions and the potential effects of production from an aquifer.

EDUCATION

M.S., Hydrogeology
Oklahoma State University
2002

B.A., Philosophy & Religion
Oklahoma Baptist University
1996

PROFESSIONAL REGISTRATIONS

Professional Geoscientist
#10331, Texas

EXPERIENCE

LRE Water, LLC
2017 – Present

LBG-Guyton Associates
2014 – 2017

Thornhill Group, Inc.
2003 – 2014

FEATURED PROJECT EXPERIENCE

Clearwater Underground Water Conservation District – Bell County, Texas (while employed at LBG-Guyton Associates) – Provided professional hydrogeologic consulting services to the District. Work involved the evaluation of permit applications for drilling of wells and production of groundwater, providing analysis of the potential effects of production on the aquifers in the District, and scientific representation before other governmental and commercial entities. Performed numerical modeling to evaluate potential aquifer desired future conditions, impacts on permittees from hypothetical well fields, and effects on stream flow due to groundwater production through a capture analysis simulation. Developed tools for assessing Trinity aquifer status relative to the adopted desired future conditions compared to measured water levels. Modeling work for CUWCD included revising the adopted groundwater availability model for the Northern Trinity and Woodbine aquifers to better reflect hydraulic parameters obtained from wells completed in the Lower Trinity Aquifer in Bell County. Model simulations were then conducted to assess how changes in the aquifer properties in the model may affect adopted desired future conditions for the managed aquifers.

North Texas GCD – Groundwater Management Area 8 (while employed at LBG-Guyton Associates) – Performed modeling using the groundwater availability model for the Northern Trinity and Woodbine aquifers adopted by the Texas Water Development Board for evaluation of potential desired future conditions. Work involved modification of the distribution and amount of predicted groundwater pumping, evaluation of predicted changes in aquifer conditions due to pumping, and presentation of results before the member districts. Developed custom scripts using the Julia programming language to expedite model simulations and analysis of simulation results including transmissivity-weighted composite water levels, average drawdown for geographic areas, aquifer water budgets, and impacts on individual wells. Prepared technical memorandums for the GMA and member districts to present results of multiple simulations. Provided support related to explanation of modeling results, model conceptualization that may affect the results, and technical discussion of results relative to statutory considerations.

FEATURED PROJECT EXPERIENCE Continued ...

Texas Water Development Board – Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping – The objective of this project was to assess the subsidence risk due to groundwater pumping for every major and minor aquifer Texas. Work included conducting analysis of well log data, driller's reports, subsidence observations, pumping records, groundwater availability models, and other available data to quantitatively assess subsidence potential. Developed the tools and techniques used to evaluate the potential for subsidence based on clay thickness, clay type, aquifer lithology, pre-consolidation level, and future water level changes. Led the development of the subsidence prediction tool to estimate subsidence potential within any major or minor aquifer in Texas. Project deliverables included geodatabases of subsidence risk evaluations for each aquifer, a written report detailing findings, and an Excel-based application for stakeholder use in evaluating subsidence risk.

Central Texas WSC – Lower Trinity Aquifer – Bell County, Texas – Worked with Central Texas Water Supply Corporation to assist with obtaining a production permit for a recently completed Lower Trinity production well. Work on the project focused on developing an assessment of the potential future groundwater demands for CTWSC to fulfill permit application requirements for the Clearwater Underground Water Conservation District. Represented CTWSC at the production permit hearing before the District Board to discuss the analyses and information supplied in the permit application.

Moffat WSC – Lower Trinity Aquifer – Bell County, Texas – Conducted an aquifer evaluation related to a proposed new public water supply well to be completed in the Lower Trinity Aquifer. Work involved evaluating records for existing Moffat WSC wells and other nearby wells from public databases regarding depth to water, water quality, well construction, and local subsurface hydrogeologic conditions; evaluating the data available from local wells and groundwater models to determine the expected quality of the groundwater in the local aquifer, as well as the likely production characteristics for a new public supply well; and, preparing a summary of recommendations for well design based on the anticipated production capacity and with budget level cost estimates from drilling contractors. The evaluations indicated a new well could provide greater production rates than the existing wells if the additional capacity is needed.

Confidential Client – Near Monahans State Park, Texas – Conducted a preliminary evaluation of groundwater availability from the local aquifers. Objectives of the investigation were to identify existing water lines and water wells on and near the property that could be used for water supply, and to evaluate the potential groundwater availability from the aquifer(s) beneath the property and the anticipated capacity of wells completed in the aquifer(s). Work involved compiling local aquifer and well data, evaluating geophysical logs, conducting model simulations, and preparing a summary report addressing the objectives with recommendations for drilling and testing. Results indicated several relatively small capacity wells completed in the Dockum aquifer would likely meet the water resource demands though drilling and testing would be needed to verify actual well capacity.

Confidential Client – Brackish Groundwater Resources Evaluation – Ellis County, Oklahoma – Prepared an evaluation of potential brackish groundwater resources within Ellis County, Oklahoma. The goal of the project was to identify potential sources of brackish groundwater from which production would not adversely affect the fresh groundwater resources of the Ogallala aquifer. Work for the project involved quantifying the potential quantity and quality of brackish groundwater available from sub-surface formations within the county. Also, conducted evaluations of geophysical logs to identify the formation contacts, thicknesses, and likely water quality. Cross-sections of the geologic units were developed to illustrate the configuration of the sub-surface formations.

FEATURED PROJECT EXPERIENCE Continued ...

Jack Hilliard Materials – Bell County, Texas (while employed at Thornhill Group, Inc.) – Led a project to develop groundwater supplies for industrial use from the Lower Trinity Aquifer in Bell County. Work on the project included preparing permit applications to obtain drilling and operating permits from the Clearwater Underground Water Conservation District and providing expert testimony during permit proceedings before the District Board of Directors. Also supervised well design, drilling, completion, testing, and acceptance.

San Antonio Water System – Brackish Carrizo-Wilcox Aquifer – Bexar County, Texas (while employed at LBG-Guyton Associates) – Conducted modeling of production from the SAWS brackish well field using a version of the Southern Carrizo-Wilcox Groundwater Availability Model updated to better represent aquifer transmissivity values determined from local production testing. The modeling evaluated the projected aquifer water level decline associated with production from the SAWS brackish well field. Also assessed the amount of short-term drawdown in the production wells associated with the pumping rates that would be in addition to the aquifer water level declines and how the total decline in the wells may reduce long-term well production capacity.

Coastal Bend GCD – Wharton County, Texas (while employed at LBG-Guyton Associates) – Conducted an evaluation of the potential effects of production on shallow wells from deeper groundwater production in the Garwood irrigation area. Performed simulations of the Lower Colorado River Basin model using MODFLOW-SURFACT to assess multiple production scenarios. Considerations included how deeper production may affect vertical hydraulic gradients and cause water levels in the overlying aquifers to decline below shallow domestic wells.

City of Austin – Colorado River Alluvium – Travis County, Texas (while employed at LBG-Guyton Associates) – Developed a Monte Carlo analysis of the hydraulic properties applied in a local scale groundwater flow model. The model was designed to determine the potential infiltration through recharge ponds, residence time in the aquifer of infiltrating water, and the amount of capture of infiltrated water using horizontal wells. Used pilot points with PEST and related utilities to create multiple model realizations that were all equally calibrated then assessed the range of possible problem solutions based on those realizations.

Groundwater Management Area 12 Joint Planning Support – Carrizo-Wilcox, Queen City, Sparta, and Yegua-Jackson Aquifers (while employed at LBG-Guyton Associates) – Performed model simulations and development of results for presentation to Groundwater Management Area 12 in consideration of potential desired future conditions for the Carrizo-Wilcox and other aquifers. Work included development of pumping files for the Brazos Valley Groundwater Conservation District and assembling pumping data from other districts into a single well file to conduct simulations. Developed custom processing tools to efficiently summarize the model results relative to existing and potential aquifer desired future conditions. Modified groundwater availability model input files to allow simulations through the year 2070. Prepared presentations of groundwater availability model simulation results for comparison of various potential aquifer desired future conditions.

El Paso Water Utilities – Injection Well Modeling – El Paso County, Texas (while employed at LBG-Guyton Associates) – Updated an existing aquifer exemption model developed for the Fusselman Dolomite, Montoya Dolomite, and El Paso Group to reflect the hydraulic properties observed from falloff testing on completed injection wells. The update involved converting the model from MODFLOW-2000 to MODFLOW-NWT to eliminate simulation uncertainties associated with dry cells. Using the updated flow model, Mike performed simulations of various injection scenarios along with transport simulations using MT3D-USGS to assess the likely migration of the injection water plume. To develop a statistical certainty of the plume migration, Monte Carlo analysis was conducted to address variability in near well hydraulics, injection rates, and injection locations.

FEATURED PROJECT EXPERIENCE Continued ...

End Op, LP – Carrizo-Wilcox Aquifer – Bastrop and Lee Counties, Texas (while employed at Thornhill Group, Inc.) – Mr. Keester managed a multi-year project involving the assessment of groundwater availability from the Simsboro aquifer in Bastrop and Lee counties for the potential development of up to 56,000 acre-feet per year of production for public supply use. His work included the design, completion, and testing of four test wells, later converted to permanent monitoring wells, completed to depths up to 2,200 feet, evaluating geophysical logs to delineate aquifers and aquifer permeability, analysis of aquifer testing to determine local hydraulic properties, determination of water quality and its suitability for the intended use, and modeling of proposed production to assess impacts on the groundwater resource, other aquifer users, and surface water resources. He also provided support to attorneys during settlement agreement negotiations, and expert testimony during multiple permit proceedings before the District Board and the State Office of Administrative Hearings.

Confidential Client – Dallas County, Texas (while employed at Thornhill Group, Inc.) – Conducted evaluations of the potential groundwater production from the Paluxy aquifer for irrigation purposes. Assisted with development of well specifications to optimize production from the aquifer based on the evaluation results. Worked with qualified drilling contractors to obtain competitive bids on the project. Assisted with drilling, well completion, and testing oversight to document activities and ensure adherence with specifications.

Private Landowner – Gulf Coast Aquifer – Matagorda County, Texas (while employed at Thornhill Group, Inc.) – Prepared a hydrogeologic evaluation in support of obtaining a production permit for supplying groundwater for industrial use for a proposed power plant. Performed modeling of the proposed production to determine the potential effects of the production on the aquifer, other groundwater users, and surface water resources. In addition, due to the proximity of the proposed well to the Gulf of Mexico, work involved assessing the potential for salt water intrusion into the aquifer due to the proposed production. Provided expert testimony on behalf of the client before the Coastal Plains Groundwater Conservation District during permit hearings.

Quarry Operator – Trinity Aquifer – Hays County, Texas (while employed at Thornhill Group, Inc.) – Performed extensive evaluations of potentially available Middle Trinity Aquifer groundwater supplies for use in quarry operations. Conducted inspection of well drilling, completion, and testing to assess well and aquifer hydraulic properties. Worked directly with the Barton Springs/Edwards Aquifer Conservation District staff to ensure regulatory compliance and fulfill permitting requirements throughout the project.

Evaluation of Proposed ElectroPurification Project – Trinity Aquifer – Hays County, Texas (while employed at LBG-Guyton Associates) – Conducted evaluations of completed test wells and preliminary production testing data. Performed analytic element modeling of the proposed production to assess the potential effects on neighboring well owners. Modeling results were documented and used by attorneys during presentations before the Hays County Commissioners Court and other public forums to inform residents prior to annexation of the area into the Barton Springs/Edwards Aquifer Conservation District.

Xcel Energy – Lamb County, Texas (while employed at LBG-Guyton Associates) – To assess the potential effects from production of a proposed horizontal well and support permitting of the proposed well with the High Plains Water District, Mike converted a structured grid MODFLOW-NWT model to a quadtree refined unstructured grid MODFLOW-USG model. Prior to conversion, Mike updated and re-calibrated the existing model then performed a Monte Carlo analysis to develop 100 additional realizations of the model parameters that each resulted in a calibrated model. The realizations were incorporated into the simulations to provide a robust assessment of the likelihood for potential impacts due to production and of the anticipated longevity of the proposed horizontal well and existing well fields.

FEATURED PROJECT EXPERIENCE Continued ...

San Antonio Water System – Saline Edwards Aquifer – Bexar County, Texas (while employed at LBG-Guyton Associates) – Updated an existing model of the downdip saline Edwards aquifer to reflect the hydraulic properties determined from pressure testing using completed injection wells. Modified the existing model which simulated annual stresses on the system to account for potential monthly changes in injection rates. Performed simulations to evaluate the pressure build up in the formation associated with disposal wells and how the pressure increase, including those associated with variations in the monthly injection rate, could affect nearby artificial penetrations that are open to the formation.

Truckee Meadows Water Authority – Reno, Nevada (while employed at LBG-Guyton Associates) – Work performed included an update and recalibration of a MODFLOW-96 model to MODFLOW-NWT. The model implemented domestic and municipal pumping; distribution system leakage; recharge from mountain-fronts, precipitation, and irrigation; evapotranspiration; rivers and streams; and discharge from springs and man-made pits. The model was used to complete wellhead protection assessment and evaluate long-term effects of multiple production scenarios. Work on the project included application of the USGS Soil Water-Balance Model to determine potential recharge and evapotranspiration factors for the model. These estimates of potential recharge were included in a flow model with a robust implementation of the Truckee River and its tributaries which allowed assessment of the amount of recharge to the deeper aquifer and the amount discharge to surface water features.

City of Enid – Cimarron Terrace Aquifer – Northern Oklahoma (while employed at Thornhill Group, Inc.) - The City of Enid, Oklahoma operates groundwater well fields with over 160 individual water wells dedicated to public water supply use. Mike's work on this project provided support to the local engineering firm and involved evaluating the City's primary source aquifer (namely, the Cimarron Terrace Aquifer) to determine the long-term viability of the aquifer to meet projected demands and assess areas for potential well field expansion within the shallow alluvial system deposited by the Cimarron River. The project included the development of a MODFLOW-2005 model designed to evaluate the effects of production from the existing well field areas, assess the potential for developing additional well fields, and overall groundwater availability from the Cimarron Terrace Aquifer. In addition, surface geophysical surveys were utilized to evaluate the structure of the alluvial system in key areas and to provide a relative comparison of the groundwater flow potential. During the project, he also worked closely with the project engineer to identify target locations for obtaining additional groundwater rights necessary under the current equal proportionate share allocation.

Midland County Freshwater Supply District #1 – T-Bar Well Field – Pecos Valley Aquifer – Winkler County, Texas (while employed at LBG-Guyton Associates) – Prepared a local scale groundwater flow model for the T-Bar well field in northwest Winkler County. The purpose of the model was to help inform operators regarding the longevity of the well-field and how well yields may change with declining water levels. Due to the structure of the Pecos Valley Aquifer, MODFLOW-NWT was used to improve model stability as model cells would desaturate.

Fort Stockton Holdings – Edwards-Trinity (Plateau) Aquifer – Pecos County, Texas (while employed at Thornhill Group, Inc.) – Developed a MODFLOW model to evaluate the hydraulic properties and flow characteristics of the karst aquifer near Fort Stockton, Texas. Conducted analysis of aquifer testing performed utilizing high capacity production wells completed in the complex aquifer system. Co-authored a hydrogeologic report for the area documenting the results of the investigations. Provided support to attorneys preparing permit submittals the local regulatory agency. Presented expert testimony during hearings before the Middle Pecos Groundwater Conservation District with regard to Fort Stockton Holdings' permit applications.

FEATURED PROJECT EXPERIENCE Continued ...

Nestle Waters North America – Spring Water Source Assessment – Wood County, Texas – (while employed at Thornhill Group, Inc.) – Conducted and supervised extensive aquifer hydraulic testing and water quality sampling and testing to determine connection between boreholes and flowing springs for development of spring water supplies. Work involved proper collection, preservation, and delivery of water samples from wells and springs for analysis of inorganic, organic, and semi-volatile constituents; in addition, water samples were collected from wells for microparticulate analysis to determine the influence of surface water on groundwater resources. Aquifer testing involved drilling and completion of test and monitoring wells, multi-day pumping tests, and analyses of test results. Determined connection between pumping wells, monitoring wells, and flowing springs based on pumped water having the same hydrochemical properties as water discharging from springs and there being a measurable effect on spring flow rate while pumping the well(s). Prepared Spring Water Standards of Identity for submission to the FDA and State health departments for obtaining approval to label bottled water as "Spring Water."

Oklahoma Gas and Electric – Horseshoe Lake Power Plant – Central Oklahoma Aquifer – Oklahoma County, Oklahoma (while employed at Thornhill Group, Inc.) – Worked with a local engineering firm to evaluate the potential for developing groundwater supplies to supplement surface water supplies during drought. The project included evaluating the condition of existing wells on the property that are completed in the Central Oklahoma Aquifer to determine their efficiency at moving water from the aquifer to land surface. Work on the project involved evaluating pumping tests and geophysical logs to determine the characteristics of the local aquifer and its ability to supply needed groundwater supplies. Developed both analytical and numerical models to assess the effects of production on the local aquifer, including a detailed model of the shallow alluvium to evaluate the potential for capturing streamflow using a horizontal well. Worked with the project engineer to prepare recommended well designs and cost estimates for developing well fields capable of meeting projected demands. Also, conducted an evaluation of available groundwater rights to provide recommendations for obtaining the rights necessary under the current equal proportionate share allocation.

Confidential Client – Ogallala Aquifer – Andrews and Gaines Counties, Texas (while employed at LBG-Guyton Associates) – Updated an existing MODFLOW96 model to MODFLOW-USG. Following conversion of the model, performed re-calibration of the model using PEST and associated utilities. Model results were used to assess long-term well field reliability and potential effects of production on other nearby groundwater resource users.

Athens Municipal Water Authority – Carrizo-Wilcox Aquifer – Henderson County, Texas (while employed at Thornhill Group, Inc.) – Supervised and conducted a test drilling program to assess the potential for developing a well-field producing from the Carrizo-Wilcox aquifer in Henderson County. Work on the project included supervising drilling, logging, and completion of test wells to assess the production characteristics of the aquifer. Also prepared a project report documenting the results of the evaluation which included geophysical log interpretation, aquifer testing results, model simulations of potential production, and determination of long-term well field capacity.

City of Lawton – Arbuckle-Timbered Hills Aquifer – Comanche County, Oklahoma (while employed at LBG-Guyton Associates) Assisted a local engineering firm regarding the potential quantity and quality of groundwater available from the Arbuckle-Timbered Hills aquifer to supplement the City's existing surface water supplies. Work on the project included evaluating the structure and geometry of the aquifer along with the spatial variations in groundwater quality. Based on the evaluation results, developed recommendations for ten locations for conducting test drilling to verify the quantity and quality of groundwater in the Arbuckle-Timbered Hills aquifer.

PROFESSIONAL SUMMARY

Katy provides technical expertise on a diverse range of projects including data management, water resources code and tool development, and hydrologic modeling and analyses. She specializes in transforming water resources data into accessible and useful information for clients and public users. This includes hydrologic modeling for decision support as well as data integration, database design and management, and developing custom web-based user interfaces and tools. Her background in modeling includes rainfall-runoff models, water quality models, and watershed systems modeling. Prior to joining LRE, Katy worked as a National Science Foundation graduate fellow with research focused on surface water-groundwater interactions in large regulated rivers as well as in headwater streams, and wildfire impacts on infiltration

PROFESSIONAL REGISTRATIONS

Professional Engineer
CO (2015) No. 51809

EDUCATION

MSE, 2012, Civil Engineering
The Pennsylvania State University

BS, 2010, Engineering Science,
Smith College

EXPERIENCE

2014-Present
LRE Water, LLC – Denver, CO

PROFESSIONAL ACTIVITIES

CWC POND – Committee;
Water Resources Research Scientific Journal – Reviewer

TECHNICAL SKILLS

HEC-HMS, SAC-SMA, TSTool, MATLAB, SQL, PostgreSQL, Drupal, Wordpress, LAMP, Unix, ArcGIS

FEATURED PROJECT EXPERIENCE

Colorado Division of Water Resources (DWR), Arkansas Basin Operational Tools Pilot Katy has worked with Division 2 office staff to develop tools for efficient daily management of water, leveraging the Google Stack to streamline the request process, inform water users of daily river activities, and automate daily reporting to the State's central diversion records database. *www.cdwrdiv2.us*

Urban Drainage Flood Control District Web Data Access, Colorado Katy has worked with the UDFCD to provide flood managers and other interested public with online access to flood warning information and hydrologic modeling output through a set of non-proprietary (Drupal), intuitive, map-based web tools. *www.udfcd-alert.org*

Colorado Water Conservation Board, In-stream Flow Accounting System Katy has worked with the CWCB to develop a tool for in-stream flow accounting reports. The non-proprietary system will help CWCB staff meet stakeholder data sharing goals and obligations with an extendable Drupal + Google API web site that CWCB staff can use and maintain themselves, including the creation of new accounting reports for future water right acquisitions.

Eagle River Water and Sanitation District Katy has worked extensively for the ERWSD including database and website development for a Water Quality Data Portal, water quality standards exceedance and excursion analyses for a comprehensive stream temperature assessment, uncertainty and sensitivity analyses for a Qual2Kw water quality model, and assisting in a use attainability analysis for proposed site-specific temperature standards.

City and County of Broomfield Katy assisted in the creation of stage-discharge rating curves at locations along Big Dry Creek utilizing USGS flow gaging standards.

On Surveys, Ratings Curves, Time Series Katy has completed stream gaging and land surveying of cross-sections and channel morphology for multiple projects in Colorado, Texas and Pennsylvania. She assisted in the creation of stage-discharge rating curves at locations along Big Dry Creek utilizing USGS flow gaging standards for the City and County of Broomfield. She's also completed time series analysis of stage and rainfall data as part of development of HEC-HMS and SAC-SMA basin rainfall-runoff models. She has worked with the Urban Drainage Flood Control District (UDFCD) in updates to their hydromodels and the development of web-based tools providing online access to flood warning information and modeling output.

Impact of Wildfire Burning on Soil Hydrologic Properties at a Laboratory Scale Katy designed and conducted an investigation into the impacts of wildfire on soil and hydraulic properties including water repellency and hydraulic conductivity. The aim of this work was to analyze the effects of burning and rain under controlled laboratory conditions using undisturbed soil cores (8 inch diameter, 4 inch depth). Very few studies have previously used intact soil samples and maintained the natural soil structure that we believe is important in quantifying the impacts of burning on these parameters. Laboratory burning of the samples was designed to simulate the intensity and duration of low and high severity fires. This work was completed as part of a National Science Foundation Graduate Research Fellowship at the Colorado School of Mines.

Anomalous Stream Temperature Response to Storms in a Forested Headwater Stream Katy collected and analyzed stream temperature data from a forested headwater stream in central Pennsylvania that indicated an unexpected urban-like (intense and rapid stream heating) response to high intensity large storms. Stream temperature is an important water quality parameter, particularly in headwater streams where smaller discharges can lead to highly dynamic thermal patterns. Stream temperature increases were large (up to 3.8 °C) and rapid (within one hour of precipitation). She explored the possible mechanisms driving these unexpected stream temperature responses and proposed that this departure from the typical forested stream temperature cooling response to storms has potential implications for headwater stream quality and habitat conditions. This work was completed as part of a National Science Foundation Graduate Research Fellowship at the Pennsylvania State University.

Surface Water-Groundwater Interactions of a Large, Regulated River Katy investigated how large, daily stage fluctuations altered surface water-groundwater exchanges on the lower Colorado River, which runs through Austin, TX and is heavily regulated for hydropower generation. She determined that the river is altered from a regionally gaining river to a river that both gains and loses on a daily basis due to the dam-controlled 1.5 m stage fluctuations. She used both temperature (via thermistor arrays) and pressure measurements (via shallow piezometers) to map the vertical extent of the hyporheic zone and determine how it varied spatially and temporally. This work occurred as part of a NSF research experience supported by the University of Texas at Austin.

Kinematic Wave Modeling of Stream Flow in the McMurdo Dry Valleys of Antarctica Katy developed a model using the kinematic wave to better understand how melt is routed from the glaciers to the lakes. She also investigated the dependencies between stream temperature and flow regime in the ephemeral streams linking the glaciers and lakes of the Antarctic Dry Valleys. These meltwater streams are a critical source of recharge and nutrients for the permanently ice-covered valley lakes. This work was completed as part of a NSF research experience supported by the University of Colorado at Boulder

PROFESSIONAL RESUME - KIRK KENNEDY

Email: kkennedy@kennedyresource.com

Address: 1443 CR 204; Burnet, TX 78611
Telephone: 512 / 589-5109 [office and cell]

EDUCATION

B.S Geology, Tarleton State University, Stephenville, Texas 1984

REGISTRATION

Professional Geoscientist, State of Texas, No. 3130

BACKGROUND

Mr. Kennedy has been involved in Texas surface water right analysis for 28 years. His work has been in the fields of water rights modeling, interstate compacts, water rights permit analysis, drought water management/allocation, WAM model design and construction, and water supply determination such as firm yield analysis. Mr. Kennedy has a broad background in Texas water resources, particularly with respect to the TCEQ's regulatory activities, and those of its predecessor agencies. This experience includes the construction of the pre-SB1 water availability models, as well as the SB1 WAM models and their subsequent use for system operations to long term water planning. Mr. Kennedy was the team leader for the Surface Water Availability Team at the TNRCC (now TCEQ) and is familiar with the TCEQ's needs and uses of WAM models in the administration of the surface water rights program and is familiar with WAM models for every basin in Texas. In addition, Mr Kennedy was a member of the Colorado BBEST team and is familiar with typical uses of these models for determining feasibility of new projects, reliability and yield of specific water rights and reservoirs, quantifying impacts on downstream water rights due to changes proposed by upstream users, and impacts of special conditions being proposed by TCEQ or environmental groups on amendments to existing water rights.

WAM EXPERIENCE

Mr. Kennedy was part of the team that completed the naturalized flow for the Rio Grande and Colorado River basins pursuant to legislative requirements in 1999 and 2001. In addition, Mr. Kennedy has extended the naturalized flow period numerous times in the Colorado River basin for LCRA, consistent with TCEQ direction, with the most recent effort extending the period of record through 2016, Mr Kennedy is also familiar with the naturalized flow files and process used in the Sulphur Basin and also has extensive knowledge and experience with WRAP and the WAM models used by the TCEQ to analyze water right permits, management plans, and is familiar with the use of these models use in TWDB's regional planning process. Mr. Kennedy has created numerous complex modifications of the TCEQ WAM models for specific analysis including the permitting and implementation of the most recent LCRA Water Management Plan which

utilized numerous operational concepts and priority assumptions which more closely reflect actual operations by using accounting procedures within WAM to better represent actual release operations with regard to travel time and future inflows downstream of LCRA's Highland Lakes. In addition, Mr. Kennedy developed the WRAP input files to accomplish representation of the TCEQ's drought definitions in the Colorado basin and created the WAM logic that simulates interruptible demand curtailments necessary to protect municipal and industrial users. Mr. Kennedy has altered the TCEQ WAM models for numerous clients to accurately represent new water right applications and amendment applications for the purposes of pursuing new water right authorizations from TCEQ.

PROJECT EXPERENCE

TEXAS WATER DEVELOPMENT BOARD, Austin Texas: Evaluation of Rainfall/Runoff Patters in the Upper Colorado River Basin

- Performed phase 1 of a study to evaluate historical streamflow conditions in the upper Colorado River basin in Texas. This analysis involved the use of USGS streamflow records, TCEQ naturalized flow information, historical precipitation, temperature, and evaporation information as well as numerous published documents to gain insight as to whether observed stream flows have declined over the long term. For sights that showed declines that could not be explained by available information, the study assessed other factors that might be contributing to declines and culminated in a final report documenting all of the phase 1 analysis which summarized possible activities that should be further explored.

TEXAS WATER DEVELOPMENT BOARD, Austin Texas: WAM / RiverWare Modeling

- Determined the increase in the Firm Annual Yield of Lake Kemp attributable to raising the conservation pool for various existing and future sedimentation conditions using TCEQ's monthly WAM and COE's daily RiverWare models. Made numerous modifications to TCEQ's WAM model to more closely reflect operational parameters in the COE's daily model and reviewed inflow development approach for both models. Noted yield differences between model results and explored/quantified differences for each inflow and outflow component. Wrote report detailing differences and furnished to TWDB staff.

TEXAS WATER DEVELOPMENT BOARD, Austin Texas: GSA BBEST / SB3 Modeling

- Applied the Guadalupe / San Antonio BBEST's proposed environmental recommendations to two large conceptual water supply projects in the Guadalupe/San Antonio River Basin to assess impacts of projects' depletions on river flows. Analysis included the refinement of TCEQ's WAM model to make more consistent with Region L modeling assumptions and the development of numerous basin wide model conditions such as natural and present conditions. Project involved use of the various WAM model's monthly flows, disaggregated to daily flows, for use in FRAT spreadsheet model to represent specific

parameters of water supply projects and environmental flow requirements on a daily basis. Prepared numerous graphs and tables depicting flows before and after projects for use by GSA BBEST to evaluate effectiveness of their recommendations with regard to protecting flows in the various water courses. Presented findings of analysis to GSA BBEST team.

SAWS / GBRA, San Antonio and Seguin Texas; WAM Modeling

- Participated in process with SAWS and GBRA staff to develop meaningful discussion of each party's interest in SAWS return flows for future water development in the basin. Developed necessary model approach to provide answers using TCEQ's WAM model of the basin and created a list of return flow/reuse scenarios to provide basis for discussion. This involved review of reported water use information from South Texas Watermaster, historical SAWS discharges from each of their WWTP's, water right documents for specific large water rights, and channel loss factors used in past and present TCEQ models. Created numerous presentations detailing this information and model results to facilitate meaningful discussions. Used the daily timestep process created by Region L's consultants to determine the firm annual yield of GBRA's proposed lower basin project using WAM model monthly timestep outputs as inputs for the daily process. Provided detailed simulation results including reliability impacts on GBRA's water rights and the associated lower basin yield as well as flow to the Bay for each return flow/reuse scenario.

LOWER COLORADO RIVER AUTHORITY, Austin Texas: WAM / RiverWare / Other

- Used TCEQ's Colorado WAM model to create a monthly operational model to assess impacts of LCRA's Water Management Plan update process. This operational WAM model utilizes a priority assumption which more closely reflects actual operations and also uses accounting procedures within WAM to better represent actual release operations with regard to travel time and future inflows downstream of LCRA's Highland Lakes. Created the WAM code that simulates complex interactions in the LCRA's 2015 Water Management including the drought definitions proposed by TCEQ. Made numerous advanced WAM model logic refinements in response to stakeholders, LCRA management, and TCEQ staff. Currently perfoming similar work for the ongoing 2018 update of the LCRA WMP.

- Created the WAM model used to represent the LCRA's lower basin off-channel project and determined the increase in LCRA System yield using a modified version of the Colorado WAM model. This modified version of the WAM model uses accounting processes to keep track of the numerous run-or-river components of the LCRA's lower basin water rights to ensure that the full use of these water rights is made while limiting the sum of all diversions to the limits in the water authorized water rights.

- Used TCEQ's Colorado Basin WAM model to represent the LSWP (LCRA-SAWS Water Project). Calculated instream flow requirements for the proposed new diversion point using the Lyons Method, Consensus Planning Criteria, as well as new storage trigger based environmental standards that were derived from the basin specific detailed instream flow and bay and estuary inflow studies. Developed daily spreadsheet model that used WAM output as input to better understand pump rate requirements and other project operations dependant on daily timestep detail. Manipulated WAM operating rule features to determine sensitivity of system yield by changing the release requirements between Lakes Buchanan and Travis. Developed WAM logic to represent freshet based Matagorda Bay inflow requirements and determined impacts of various Bay compliance requirements on the LSWP, Highland Lakes, and irrigation users in the lower basin. Explored numerous operational changes to optimize passes/releases of water for the environment from the Highland Lakes and determined yield impact of same.

- Participated in the Texas Water Development Board's Regional Water Planning Process for Region K. Implemented changes to the Colorado WAM model input files to represent reasonable planning conditions for determining supply estimates and coded/developed many of the code changes to represent the various strategies modeled by Region K.

- Participated in LCRA's efforts developing a Water Supply Resource Plan which enabled LCRA staff to compare the water supply value of numerous complex water supply strategies for decades 2010 to 2100. This activity required numerous modifications of the TCEQ's WAM model to simulate LCRA's existing surface water supplies/system along with the development of new water supplies from numerous strategies which included the amendment of large senior irrigation water rights located in the lower basin to municipal use in the Austin area of the basin, conjunctive use of groundwater, aquifer storage and recovery; desalination of sea water; the construction of large off-channel reservoirs located in the lower basin, and various levels municipal, industrial, and irrigation conservation.

CONTENT ITEM 4
Ownership of Business Entity

Names(s) and Social Security Number(s) of Each Person with at least 25 Percent Ownership of the Business Entity Submitting the RFQ

Name(s) and Social Security Number(s) of Each Pers ership of
the Business Entity Submitting

Name _____

Social Security Number _____

Name _____

Social Security Num _____

Name _____

Soci _____

Na _____

Social Sec ber _____

Not Applicable

**LRE Water, LLC is a subsidiary of Leonard Rice Engineers, Inc., which is an employee-owned company where no single employee currently owns more than 25% of the outstanding company shares.

CONTENT ITEM 5
Technical Approach

The LRE Water Team (LRE) believes that the RFQ for this Phase 2 project contains a very detailed and academic list of project tasks included in the Scope of Work. LRE will execute the tasks outlined in the Scope of Work, and has provided (below) preliminary ideas regarding each required task. The first task to be undertaken by LRE is to review the academic publications cited in the Scope of Work, and to incorporate their ideas into a revised project plan. LRE did not, while preparing this response, review the cited publications in a detailed manner, yet skimmed them only to understand their basic content. One question raised in our cursory review (and that will be answered during our detailed review upon project commencement) is whether the ideas and methods contained in the publications are applicable to the smaller watersheds and creeks making up the Upper Colorado River Basin (as opposed to the large subject rivers and watersheds utilized in the publications). LRE will also utilize access to the University of Texas at Austin library system in order to obtain and review other pertinent studies that might help further guide this project effort. Library access is available based on Dr. Furnans' status as an adjunct faculty member at the University of Texas at Austin.

LRE is concerned that the level of analyses, required detail for each analysis, and large number of required analyses and meetings stipulated within the RFQ makes the project difficult to complete for the $75,000 maximum budget offered. To increase project funds, LRE has reached out to both the Lower Colorado River Authority (LCRA) and Central Texas Water Coalition (CTWC); both entities are active stakeholders in the Colorado River Basin, and are interested in the outcome of this project. At the time of this submission, LRE has not heard from either entity with regard to their interest in contributing additional funds. LRE is willing, however, to donate $10,000 of in-kind services toward this project effort, increasing the project budget to $85,000. In offering in-kind services, LRE will not charge a portion of this effort to TWDB, yet will report to TWDB the project hours spent so that the in-kind services are documented.

Revising TCEQ Environmental Flow Standards – Required Information

With the exception of Kirk Kennedy, the LRE Project team has not been actively involved in SB3 Environmental Flow studies since 2009. As such, our knowledge of program methods and requirements stems from internet research and a review of TCEQ rules. Based on TCEQ rules TAC §298.25, revisions to established environmental flow standards may be made based on a petition from the TCEQ Executive Director. After allowing for public comment, the petition may be granted or denied without public hearings, yet TCEQ petition decisions may be challenged in potential contested case hearings. The Colorado-Lavaca BBASC is required, through its accepted work plan, to continually study the validity and effectiveness of its environmental flow standards, and it is likely based on these studies that the TCEQ Executive Director may petition for standards alteration.

Environmental flow standards are designed to maintain a sound ecological environment, and are typically implemented only in new or amended water right applications. LRE is unclear how results from this study, specifically obtaining a greater understanding of what is causing changes to the rainfall/runoff response in the Upper Colorado River Basin, will be used to suggest new environmental flow standards or validate existing standards. For example, if results

from this study were to quantifiably show that increases in the number of exempt watershed ponds directly reduces the amount of streamflow resulting from storm events, the only solution to increase the streamflow is to remove some or all watershed ponds. This action would not be related specifically to water rights issued in the Colorado River Basin. Hence LRE is unsure how the results to be obtained from this study effort are to be best utilized in aiding the environmental flows determination process. LRE is sure, however, that this study is necessary in guiding water management practices in Texas, and that study results can guide water management policy under and outside of the environmental flows umbrella. LRE also expects to obtain a better understanding of the relationship between this project and the revision/validation of environmental flow standards throughout the duration of the project effort.

Hydroclimatology Knowledge – Upper Colorado River Basin

The LRE Water team is highly familiar with the hydroclimatological characteristics of the Upper Colorado River Basin, based on our combined 60+ years of consulting investigation experience in the region. Kirk Kennedy has studied the hydroclimatology of the region nearly continuously for 27 years, and has been responsible for the development of the basin water availability models and naturalized streamflow datasets used to run the models. Mr. Kennedy also performed the Phase 1 study of the rainfall/runoff response within this watershed, and the knowledge he obtained during that project effort will greatly enhance our ability to efficiently complete Phase 2 project efforts without having to re-learn watershed characteristics known and reported by others.

In general, the Upper Colorado River basin watershed is largely rural, consisting mainly of agricultural and ranch land while supporting small to medium-sized communities/cities. The watershed extends north-westerly from Lake Travis, and average annual rainfall decreases westerly from the lake. Therefore the upper reaches of the Upper Colorado River basin typically receive less rainfall than the lower reaches located closer to the Highland Lakes. As such, changes to the rainfall/runoff response in the upper basin may lead to drastically reduced streamflow in an already typical low-streamflow environment.

Project Tasks Required per the RFQ Scope of Work

In general, the project tasks stipulated in Section 2.2 of the RFQ clearly dictate actions and methods to be used by LRE in completing all project tasks. LRE accepts the methods and tasks dictated and below provides our insight into the required tasks.

Task A – Summarize Existing Studies

For this task effort, LRE will review and summarize any pertinent studies identified by TWDB or LRE. The studies will detail temperature and precipitation changes and how they may impact naturalized streamflow, water use, and soil moisture. Studies will be reviewed for content and insight into processes likely to be at play in the Upper Colorado River Basin. LRE will utilize the University of Texas at Austin library system in order to access study reports, as well as utilize internet searches and possibly purchases of study reports from online vendors.

Task B – Remote Sensing Analysis

For this task, LRE will utilize remote sensing and GIS analysis methods to track the time-history of both noxious brush infestations and domestic & livestock reservoirs within the study area. We propose to investigate both items using available aerial imagery from TNRIS, as well

as through the use of customized programs within the Google Earth Engine (GEE) programming environment. GEE provides means for large-scale geospatial analysis of numerous geographic datasets maintained by Google and made available for public consumption. In 2014, LRE staff investigated using GEE to identify stock ponds and small reservoirs that were not included in existing datasets (such as the NHD or Texas Inventory of Dams). We also developed techniques for processing historical satellite imagery to determine crop density based on irrigation practices. Similar techniques will be utilized to quantify noxious brush extents over time, and to determine when individual reservoirs or stock tanks were constructed. With regard to stock tanks and reservoirs, LRE will be able to use the remote sensing data to determine the surface areas of each tank/reservoir, and as shown in Figure 1 we may be able to identify the relative date when ponds were constructed. Determining the volume of each tank or reservoir will only be possible if LiDAR elevation data is available for the subject area, and if the LiDAR data was collected at a time when the reservoir was empty. Otherwise, LRE will estimate water depth and volume based on professional judgement. LRE will be able to quantify, however, the average annual volume of water lost to evaporation from such tanks/reservoirs, based on the measured surface area and TWDB published evaporation depths.

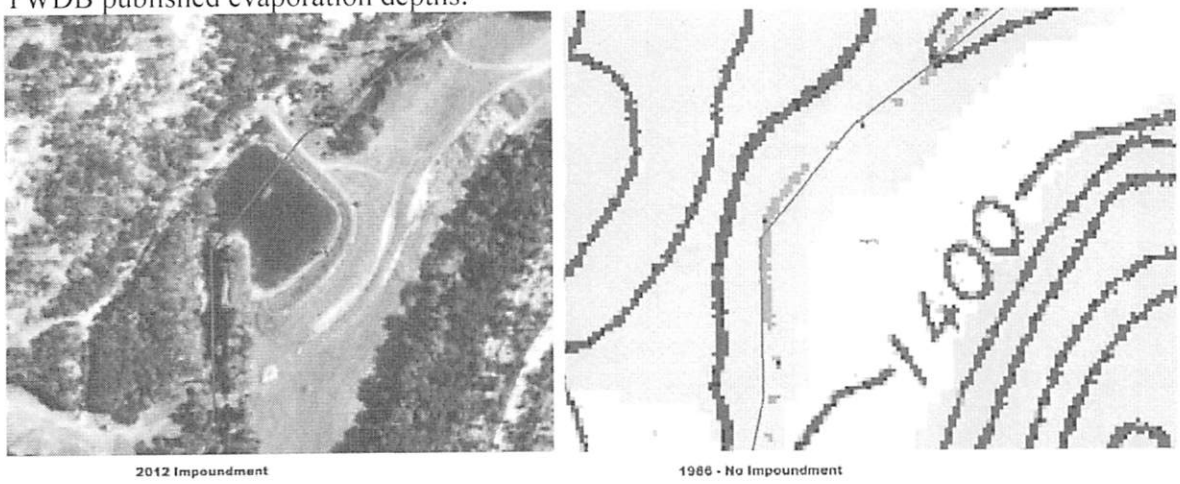


Figure 1 – Pond on Onion Creek that exists after 2012 yet was not retaining water in 1986.

Task C– Temperature Trend Analysis

For this task, LRE will use the Mann-Kendall statistical analysis technique (or an alternative technique identified through the research conducted under Task A) to determine trends and trend significances for long-term temperature datasets from the study area. Analyses will include assessments of means, minimums and maximums on a daily, monthly, and seasonal basis, and will also assess trends in the total number of days for which the maximum temperature exceeds a certain target temperature (e.g. 100 °F). All analyses will be reported along with station metadata, which will also be reviewed to ensure properties of the station will not unknowingly contribute to the observed trends in station data.

Figure 2 demonstrates the Mann-Kendall technique applied to LRE-compiled inflows to the Highland Lakes, with an apparent increase in the percentage of inflows derived from baseflows over time. Under the Mann-Kendall analysis, trends (S-values) are positive or negative, and are significant if the computed "Significance" parameter exceeds 1.0. In Figure 2, there is a statistically significant positive trend between inflows from baseflow and time.

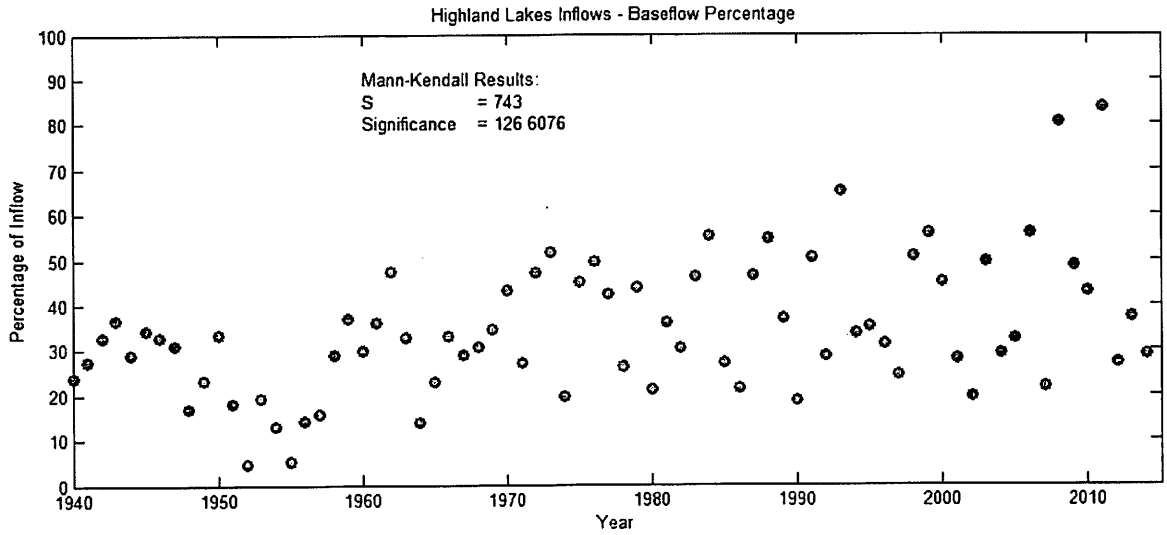


Figure 2- Statistical Trend Analysis for the percentage of Highland Lakes inflow derived from base flows

Task D– Streamflow Trends in Sub-Watersheds

For this task, LRE will utilize standard statistical techniques (including those identified under Task A to assess streamflow trends in the following subwatersheds within the study area:

North Concho River at Carlsbad
South Concho River
Elm Creek near Ballinger
San Saba River

For each watershed, streamflow records will be evaluated by season and month, as well as by any other pertinent period suggested from summarized literature. All statistical methods and analyses will be approved by TWDB prior to LRE's undertaking of the analysis. Statistical methods will be selected to determine non-stationarity and to identify change-points in the periods of record. LRE has previously performed such analyses using the Mann-Kendall equations, using the IHA software from The Nature Conservancy, and in customized analyses performed for clients in the Colorado and Brazos River basins.

Task E & F– Trends in Precipitation

For these tasks, LRE will identify and map long-term precipitation measurement stations located within the four subject watersheds identified in Task D. We will fill-in any data gaps using standard hydrologic methods approved by TWDB, and will document our gap-filling methods. We may consider purchasing weather data from companies such as Weather Analytics, which provide compiled, gap-filled weather datasets for commercial use. Using the complete datasets, we will analyze trends in 5-day, 10-day, monthly, and seasonal rainfall, including the duration of the dry periods and the onset of wet periods within the calendar year. We will also quantify the duration of seasonal rainfall, and the date at which identified wet seasons end. Further investigations may be warranted based on the results of the preliminary investigations, and in each case LRE will discuss potential analyses with TWDB prior to initiation of the analyses. A sample analysis is provided in Figure 3, showing the time-history of recorded rainfall in the study area near Winchell, TX. We will statistically analyze both rainfall intensity, duration, frequency, and timing using data/images such as Figure 3 as a reference. Figure 3 is especially useful for discerning the standard duration of dry periods between significant rainfall events.

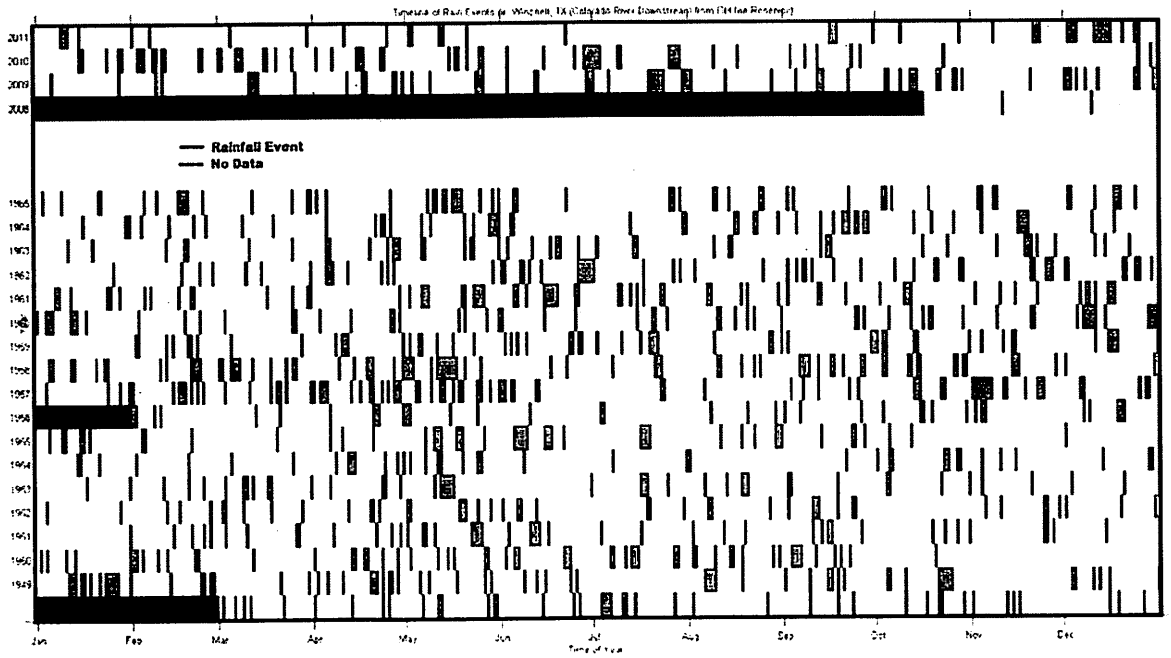


Figure 3 – Rainfall Calendar for the area near Winchell, TX (1948-1965, 2008-2011), showing longer dry periods between rain events in 2008-2011 compared to the 1948-1965 period.

Task G & H– Availability and Trends in Soil Moisture Data

For these tasks, LRE will identify and map soil moisture monitoring stations located within the study area, identified within State of Texas, Federal, or private databases including the North American Land Data Assimilation System. We will also obtain and document soil moisture data from the GRACE satellite mission, which estimates soil moisture changes by measuring changes in the gravitational field above the earth's surface. Soil moisture data may also be purchased from companies such as Weather Analytics, and LRE will investigate the utility and benefits of such a purchase should freely-available data not provide sufficient coverage of the study area. Should sufficient data be available, LRE will perform trend analyses using the techniques developed for previous parts of this project.

Task I – Groundwater Level Evaluations

For this Task, LRE will build upon the expertise developed during our recent TWDB subsidence project (Contract #1648302062) where we evaluated all wells listed in TWDB databases and statewide driller's reports to determine clay layer thickness and historical water levels/elevations. During the subsidence effort, we evaluated over 430,000 well reports, extracted water level information, and mapped data within ArcGIS. Our analysis included data from the Lipan-Kickapoo, Plateau, and Menard Groundwater Conservation Districts – therefore LRE will be able to efficiently rehash our previous analysis for use in assessing groundwater influences on streamflow. Analyses undertaken during this task will include: 1) mapping wells in the study area, including possible 3-D mapping of the wells, water levels, and terrain/surface water features, 2) Documenting well properties, water level elevations, and trends, and 3) compiling available data on historical and permitted pumping quantities (under the theory that increasing groundwater pumping over time will reduce flows to creeks, thereby reducing baseflows and possibly reducing the streamflow response to rainfall events. Efforts under this

task may also be used to address the extent to which surface water and groundwater systems are connected within the study are watershed; LRE has recently performed such analyses for property owners on the San Saba River, who are in dispute with regulators at the TCEQ.

Task J – Demonstrating Cause and Effect Regarding Rainfall/Runoff Response

The goal of this entire project is encapsulated within this task – namely to demonstrate how observed trends in watershed characteristics (rainfall, land use, groundwater usage, storage tank construction, etc.) have led to the observed alteration on the rainfall/runoff response within the study area. At this time, without first having synthesized and analyzed project data, LRE is unable to state unequivocally how we will demonstrate any causal relationships related to rainfall/runoff responses. This task will be undertaken toward the middle and end of the project duration, after we have developed initial analysis methodologies and compiled needed data. We suspect to apply some form of water balance approach to quantifying streamflow response over time – first looking at 1940s'-1950's conditions and then comparing the response derived from more recent time periods. This approach will likely involve SCS curve number analyses, soil-moisture budgets, and assumptions regarding the methods with which water moves through the hydrologic cycle from precipitation to streamflow.

Project Meetings and Timeline

As stipulated in the RFQ, we will have a minimum of 3 meetings at which LRE will coordinate project efforts with TWDB staff and members of the Colorad0-Lavaca BBASC. We propose having the first meeting immediately after contract execution, in order to discuss preliminary ideas to analyses methodologies and the initial data collection efforts. LRE then suggests a 2-week "research period" where LRE and possibly TWDB staff independently undertake the research efforts and data collection described above in order to better formulate the analysis methodology to be employed during the project effort. After the research period, LRE will meet with TWDB staff (and BBASC member, if they are interested) to discuss findings and identify the appropriate analysis methodologies to be incorporated into the remainder of the project efforts. The second RFQ-required meeting will occur approximately 2/3 of the way through the project duration, as which time LRE will present to TWDB and BBASC preliminary project results and our outline for project completion. The final meeting will be a formal presentation of the project results, delivered by LRE to TWDB, BBASC members, and interested project stakeholders. Such a meeting could be held in collaboration with the Region F and Region K water planning group meetings.

The RFQ requires quarterly progress reports to be submitted by LRE to TWDB – we will follow this schedule, but we recommend shorter weekly or bi-weekly reports be submitted to the TWDB project manager to ensure the project remains on track in terms of content and budget. LRE recommends such frequent reporting to the TWDB project manager so that all work can be performed to the expectations of all parties, without unforeseen surprises arising toward the end of the project. This is standard operations for LRE as dictated in our project management plans (PMPs), which we create internally and use to ensure efficient project operations.

LRE recognizes that the expected project start date is August 7, 2018, and that all work is to be completed by August 31, 2018. LRE recently successfully completed the larger TWDB subsidence risk evaluation project (contract #1648302062) under a similar timeframe, and we are 100% confident we can complete this project effort per the RFQ requirements.

Exhibit B
Scope of Work

Evaluation of Rainfall-Runoff Trends
in the Upper Colorado River Basin (Phase Two)

Project Goal

The goal of this project is to demonstrate and quantify the causal factors for observed changes in the rainfall-streamflow response in four regions in the Upper Colorado River Basin upstream of the Highland Lakes.

Tasks

LRE Water (LRE) will address all project tasks as listed in Section 2.2 of RFQ 580-18-0070. Additional details on how each task will be addressed is listed below.

Task 1 – Literature Review and Development of Detailed Project Plan

For this task effort, LRE will review and summarize pertinent studies detailing temperature and precipitation changes and how they may impact naturalized streamflow, water use, and soil moisture. Studies will be reviewed for content and insight into processes likely to be at play in the Upper Colorado River Basin.

Based on the review, LRE will develop a detailed project plan outlining the investigations and steps to be undertaken to complete this project. LRE will present the plan to TWDB for review and approval prior to undertaking remaining project tasks. LRE will present the project plan and review summaries to TWDB at the planned "Project Initiation" meeting.

Task 2 – Remote Sensing Analysis

For this task, LRE will utilize remote sensing and GIS analysis methods to track the time-history of both noxious brush infestations and domestic and livestock reservoirs within the study area. This will be done using available aerial imagery from TNRIS, as well as through the use of customized programs within the Google Earth Engine (GEE) programming environment, should GEE be identified as an appropriate mechanism for use in this endeavor. GEE provides means for large-scale geospatial analysis of numerous geographic datasets maintained by Google and made available for public consumption. In 2014, LRE staff investigated using GEE to identify stock ponds and small reservoirs that were not included in existing datasets (such as the National Hydrography Dataset (NHD) or Texas Inventory of Dams). LRE also developed techniques for processing historical satellite imagery to determine crop density based on irrigation practices. Similar techniques will be utilized to quantify noxious brush extents over time, and to determine when individual reservoirs or stock tanks were constructed. With regard to stock tanks and reservoirs, LRE will be able to use the remote sensing data to determine the surface areas of each tank/reservoir. As shown in Figure 1, LRE may be able to identify the relative date when ponds were constructed. Determining the volume of each tank or reservoir will only be possible if LiDAR elevation data is available for the subject area, and if the LiDAR data was collected at a time when the reservoir was empty. Otherwise, LRE will estimate water depth and volume based on professional judgement. LRE will be able to quantify, however, the average annual volume of water lost to evaporation from such tanks/reservoirs, based

on the measured surface area and TWDB published evaporation depths. Explicit analysis methods will be detailed within the draft project plan submitted for TWDB approval at the project initiation meeting.

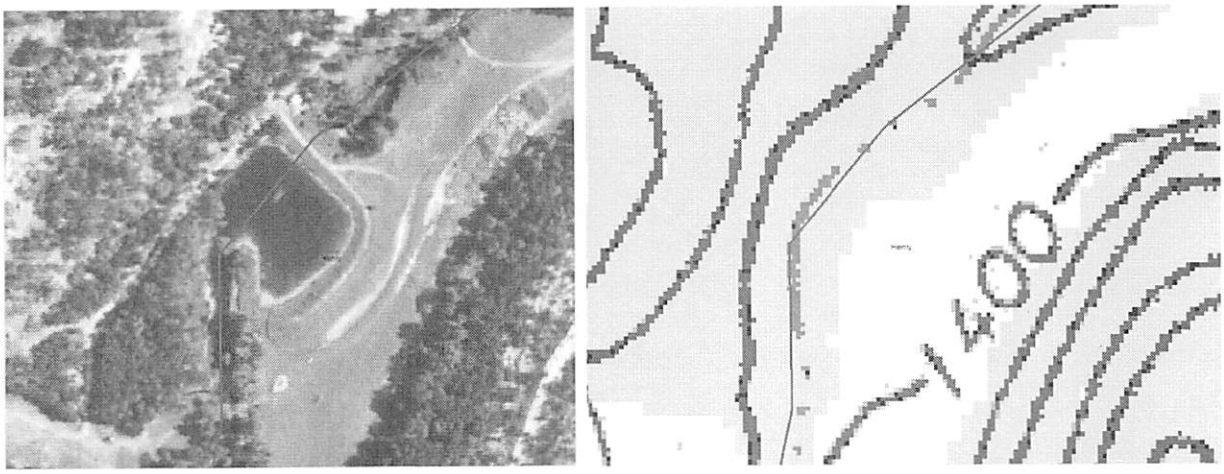


Figure 1 – Pond on Onion Creek that exists after 2012 yet was not retaining water in 1986.

Task 3– Temperature Trend Analysis

For this task, LRE will use the Mann-Kendall statistical analysis technique (or an alternative technique identified through the research conducted under Task 1) to determine trends and trend significances for long-term temperature datasets from the study area. Analyses will include assessments of means, minimums and maximums on a daily, monthly, and seasonal basis, and will also assess trends in the total number of days for which the maximum temperature exceeds a certain target temperature (e.g. 100 °F). All analyses will be reported along with station metadata, which will also be reviewed to ensure properties of the station will not unknowingly contribute to the observed trends in station data. Figure 2 demonstrates the Mann-Kendall technique applied to LRE-compiled inflows to the Highland Lakes, with an apparent increase in the percentage of inflows derived from baseflows over time. Under the Mann-Kendall analysis, trends (S-values) are positive or negative and are significant if the computed "Significance" parameter exceeds 1.0. In Figure 2, there is a statistically significant positive trend between inflows from baseflow and time.

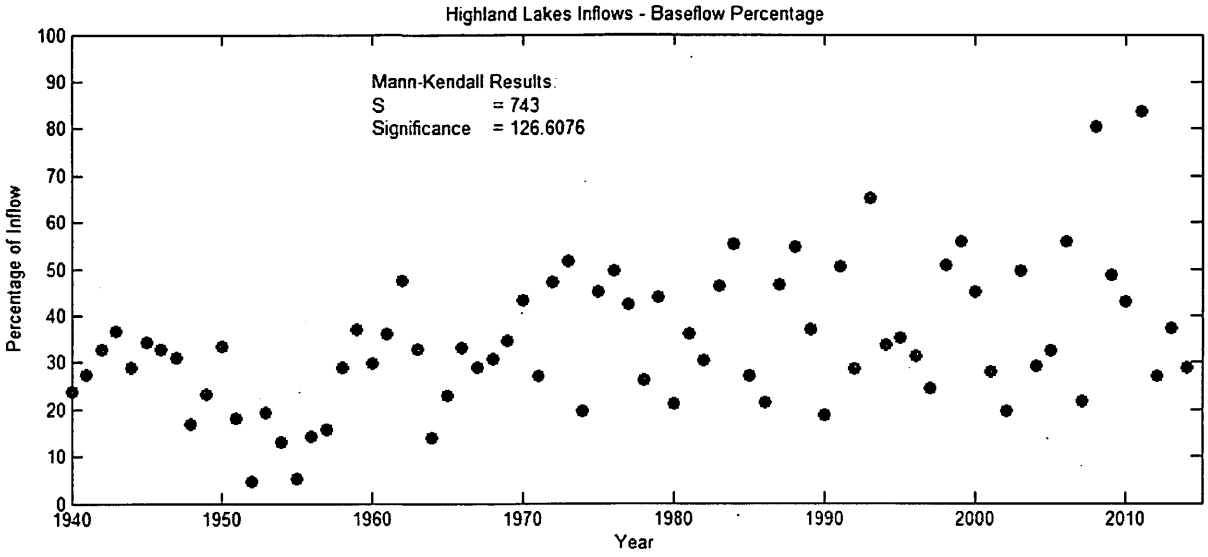


Figure 2- Statistical Trend Analysis for the percentage of Highland Lakes inflow derived from base flows

Task 4- Streamflow Trend Analysis for Select Sub-Watersheds

For this task, LRE will utilize standard statistical techniques (including those identified under Task 1 to assess streamflow trends in the following sub-watersheds within the study area:

North Concho River at Carlsbad
South Concho River
Elm Creek near Ballinger
San Saba River

For each watershed, streamflow records will be evaluated by season and month, as well as by any other pertinent period suggested from summarized literature. All statistical methods and analyses will be approved by TWDB prior to LRE's undertaking of the analysis. Statistical methods will be selected to determine non-stationarity and to identify change-points in the periods of record. LRE has previously performed such analyses using the Mann-Kendall equations, using the Indicators of Hydrologic Alteration (IHA) software from The Nature Conservancy, and in customized analyses performed for clients in the Colorado and Brazos River basins.

Task 5- Precipitation Trend Analysis

For this task, LRE will identify and map long-term precipitation measurement stations located within the four subject watersheds identified in Task 4. Any data gaps will be in-filled using standard hydrologic methods approved by TWDB. These infilling methodologies will be documented. LRE may consider purchasing weather data from companies such as Weather Analytics, which provide compiled, gap-filled weather datasets for commercial use. Using the complete datasets, LRE will analyze trends in 5-day, 10-day, monthly, and seasonal rainfall, including the duration of the dry periods and the onset of wet periods within the calendar year. LRE will also quantify the duration of seasonal rainfall, and the date at which identified wet seasons end. Further investigations may be warranted based on the results of the preliminary investigations, and in each case LRE will discuss potential analyses with TWDB prior to initiation of the analyses. A sample analysis is provided in Figure 3, showing the time-history of recorded rainfall in the study area near

Winchell, TX. LRE will statistically analyze both rainfall intensity, duration, frequency, and timing using data/images such as Figure 3 as a reference. Figure 3 is especially useful for discerning the standard duration of dry periods between significant rainfall events.

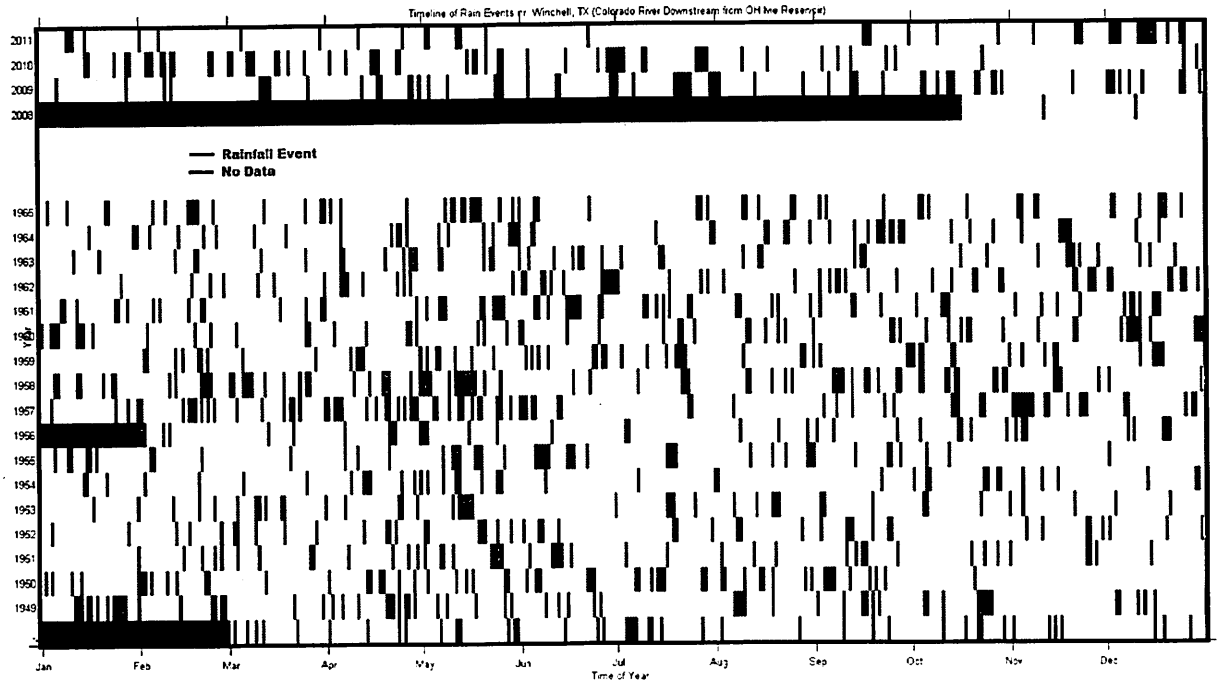


Figure 3 – Rainfall Calendar for the area near Winchell, TX (1948-1965, 2008-2011), showing longer dry periods between rain events in 2008-2011 compared to the 1948-1965 period.

Task 6– Soil Moisture Data Analysis

For this task, LRE will identify and map soil moisture monitoring stations located within the study area, identified within State of Texas, Federal, or private databases, including but not limited to the Lower Colorado River Authority (LCRA) and University of Texas Bureau of Economic Geology (UTBEG) TxSON sites, the TWDB TexMesonet stations, and the North American Land Data Assimilation System (NLDAS). LRE will also obtain and document soil moisture data from the GRACE satellite mission, which estimates soil moisture changes by measuring changes in the gravitational field above the earth's surface. Soil moisture data may also be purchased from companies such as Weather Analytics, and LRE will investigate the utility and benefits of such a purchase should freely-available data not provide sufficient temporal and spatial coverage of the study area. LRE recognizes that some data sources (such as NLDAS) provide modeled rather than measured soil moisture data, and other sources (such as GRACE) provide estimated rather than measured soil moisture data. LRE will fully document the source of all soil moisture data used in this assessment, and will preferentially use measured data over modeled or estimated data. Should sufficient data be available, LRE will perform trend analyses using the techniques developed for previous parts of this project.

Task 7 – Groundwater Level Evaluations

For this Task, LRE will perform the following analyses, using available TWDB databases including submitted drillers reports. Activities will include: 1) mapping wells in the study area, including possible 3-D mapping of the wells, water levels, and terrain/surface water

features, 2) Documenting well properties, water level elevations, and trends, and 3) compiling available data on historical and permitted pumping quantities. Efforts under this task may also be used to address the extent to which surface water and groundwater systems are connected within the study are watershed.

Task 8 – Demonstrating Cause and Effect Regarding Rainfall/Runoff Response

The goal of this entire project is encapsulated within this task – namely to demonstrate how observed trends in watershed characteristics (rainfall, land use, groundwater usage, storage tank construction, etc.) have led to the observed alteration on the rainfall/runoff response within the study area. This task will be undertaken after the development of initial analysis methodologies and the compilation of long-term data sets. It may be necessary to apply a form of a water balance approach to quantify streamflow response over time – first looking at 1940s'-1950's conditions and then comparing the response derived from more recent time periods. This approach will likely involve soil conservation service (SCS) curve number analyses, soil-moisture budgets, and assumptions regarding methods by which water moves through the hydrologic cycle from precipitation to streamflow.

Task 9 – Project Report Preparation

Under this task, LRE will fully document all project analyses in a draft report to be submitted for TWDB review by June 30, 2019. LRE will incorporate any TWDB comments on the draft report into a revised final report, to be submitted within 30 days of receipt of comments from TWDB. The final report will meet TWDB required formatting guidelines.

Task 10 – Project Management and Quarterly Reporting

Under this task, LRE will perform administrative duties regarding the completion of this project, including compiling and formatting invoices, coordinating meetings, and attending project meetings. The RFQ requires quarterly progress reports to be submitted by LRE to TWDB. LRE will follow this schedule and also anticipates providing weekly or bi-weekly updates to the TWDB project manager to ensure the project remains on track in terms of content and budget. LRE recommends such frequent reporting to the TWDB project manager so that all work can be performed to the expectations of all parties, without unforeseen surprises arising toward the end of the project.

Project Meetings and Timeline

As stipulated in the RFQ, a minimum of three meetings will be conducted at which LRE will coordinate project efforts with TWDB staff and members of the Colorado-Lavaca Basin and Bay Area Stakeholder Committee (BBASC). An initial informal meeting will be held immediately after contract execution to discuss preliminary ideas on analysis methodologies and the initial data collection efforts. After reviewing literature and honing in on suitable analysis techniques, the first official project meeting will be held with TWDB staff (and BBASC members, if they are interested) to discuss findings and agree on the appropriate analysis methodologies to be adopted for the project. The second project meeting will occur approximately 2/3 of the way through the project duration, as which time LRE will present to TWDB and BBASC preliminary project results and our outline for project completion. The final meeting will be a formal presentation of the project results, delivered by LRE to TWDB, BBASC members, and interested project stakeholders. Such a

meeting could be held in collaboration with the Region F and Region K water planning group meetings.

Exhibit C
Task and Expense Budgets

TASK BUDGET

TASK	DESCRIPTION	AMOUNT
1	Existing Study Analysis & Project Plan Development	$ 3,000.00
2	Remote Sensing Analysis	$ 15,000.00
3	Temperature Trend Analysis	$ 7,500.00
4	Streamflow Trends in Sub watersheds	$ 7,500.00
5	Precipitation Trend Analyses	$ 6,000.00
6	Soil Moisture Evaluations	$ 6,000.00
7	Groundwater Level Evaluations	$ 7,500.00
8	Demonstrating Cause and Effect	$ 12,500.00
9	Project Report Preparation	$ 7,500.00
10	Project Management & Quarterly Reporting	$ 2,500.00
TOTAL		**$75,000.00**

EXPENSE BUDGET

CATEGORY	AMOUNT
Salaries & Wages[1]	$24,000.00
Fringe[2]	$6,500.00
Travel[3]	$0.00
Other Expenses[4]	$1,250.00
Subcontract Services	$5,000.00
Overhead[5]	$22,500.00
Profit	$15,750.00
TOTAL	**$75,000.00**

[1] Salaries and Wages is defined as the cost of salaries of engineers, draftsmen, stenographers, survey men, clerks, laborers, etc., for time directly chargeable to this CONTRACT.
[2] Fringe is defined as the cost of social security contributions, unemployment, excise, and payroll taxes, workers' compensation insurance, retirement benefits, medical and insurance benefits, sick leave, vacation, and holiday pay applicable thereto.
[3] Travel is limited to the maximum amounts authorized for state employees by the General Appropriations Act, Tex. Leg. Regular Session, 2017, Article IX, Part 5, as amended or superseded
[4] Other Expenses is defined to include expendable supplies, communications, reproduction, postage, and costs of public meetings directly chargeable to this CONTRACT.
[5] Overhead is defined as the costs incurred in maintaining a place of business and performing professional services similar to those specified in this CONTRACT. NOTE; Overhead/Indirect will not be reimbursed when a CONTRACT is awarded in a non-competitive process.

EXHIBIT D

GUIDELINES FOR AUTHORS SUBMITTING CONTRACT REPORTS TO THE TEXAS WATER DEVELOPMENT BOARD

1.0 Introduction

The purpose of this document is to describe the required format of contract reports submitted to the Texas Water Development Board (TWDB). Our reason for standardizing the format of contract reports is to provide our customers a consistent, and therefore familiar, format for contract reports (which we post online for public access). Another reason for standardizing the format is so that we can more easily turn a contract report into a TWDB numbered report if we so choose. Remember that your report will not only be seen by TWDB staff, but also by any person interested in the results of your study. A professional and high quality report will reflect well on you, your employer, and the TWDB.

Available upon request, we will provide a Microsoft Word template (used to write these instructions) that gives the fonts, spacing, and other specifications for the headings and text of the report. Please follow this template as closely as possible.

2.0 Formatting your report

The TWDB format is designed for simplicity. For example, we use Times New Roman for all text. We use 12 point, single-spaced text, left justification for paragraph text, 18 points bold for first-level headings, and 14 points bold for second-level headings. Page numbers are centered at the bottom of the page. Other than page numbers, please refrain from adding content to the document header or footer. Page setup should use one-inch margins on all four sides.

2.1 Text

The best way to format your document is to use the styles described and embedded in the template document (Authors_Template.dot) that is available on request from the TWDB. To use the Authors_Template.dot file, open it in Word (make sure *.dot is listed under Files of type) and save it as a .doc file. Advanced users can add the .dot file to their computers as a template. Make sure the formatting bar is on the desktop (to open, go to View→Toolbars→Formatting) or, to view all of the formatting at once, go to Format→Styles and Formatting and select Available Styles from the dropdown box at the bottom of the window. The formatting in the template document provides styles (such as font type, spacing, and indents) for each piece of your report. Each style is named to describe what it should be used for (for example, style names include Chapter Title, Body Text, Heading 1, References, and Figure or Table Caption). As you add to your report, use the dropdown list on the Formatting Toolbar or the list in the Styles and Formatting window to adjust the text to the correct style. The Authors_Template.dot file shows and lists the specifications for each style.

2.1.1 Title

Give your report a title that gives the reader an idea of the topic of your report but is not terribly long. In addition to the general subject (for example, "Droughts"), you may include a few additional

words to describe a place, methodology, or other detail focused on throughout the paper (for example, "Droughts in the High Plains of Texas" or "Evaluating the effects of drought using groundwater flow modeling"). Please capitalize only the first letter of each word except 'minor' words such as 'and' and 'of'. Never use all caps.

Use headings to help the reader follow you through the main sections of your report and to make it easier for readers to skim through your report to find sections that might be the most interesting or useful to them. The text of the report should include an executive summary and sections outlined in 4.4 of Attachment 1. Headings for up to five levels of subdivision are provided in the template; however, we suggest not using more than three or four levels of subdivision except where absolutely necessary. Please avoid stacked headings (for example, a Heading 1 followed immediately by a Heading 2), and capitalize only the first letter of headings or words where appropriate—never use all caps.

2.2 Figures and photographs

To publish professional-looking graphics, **we need all originals to be saved at 300 dots-per-inch** (dpi) and in grayscale, if possible, or in the CMYK color format if color is necessary. Excessive use of color, especially color graphics that do not also work in grayscale, will prevent us from publishing your report as a TWDB numbered report (color reproduction costs can be prohibitive). Preferred file formats for your original graphics are Adobe Illustrator (.ai), Photoshop (.psd), EPS with .tiff preview, .jpg, .png, or .tiff files. Refrain from using low resolution .jpg or .gif files. Internet images at 72 dpi are unacceptable for use in reports.
All graphics shall be submitted in two forms:

1. Inserted into the Microsoft Word document before you submit your report. Ideally, inserted graphics should be centered on the page. Format the picture to downsize to 6 inches wide if necessary. Please do not upsize a graphic in Word.
2. Saved in one of the formats listed above.

2.2.1 Other graphics specifications

It is easiest to design your figures separately and add them in after the text of your report is more or less complete. Graphics should remain within the 1-inch page margins of the template (6.5 inches maximum graphic width). Be sure that the graphics (as well as tables) are numbered in the same order that they are mentioned in the text. Figures should appear embedded in the report after being called out in the text. Also, remember to include a caption for each graphic in Word, not as part of the graphic. We are not able to edit or format figure captions that are part of the figure. For figures and photographs, the caption should appear below the graphic. For tables, the caption should appear above.

2.2.2 Creating publication-quality graphics

When designing a graphic, make sure that the graphic (1) emphasizes the important information and does not show unnecessary data, lines, or labels; (2) includes the needed support material for the reader to understand what you are showing; and (3) is readable (see Figures 1 and 2 for examples). Edward R. Tufte's books on presenting information (Tufte, 1983; 1990; 1997) are great references on good graphic design. Figures 1 through 3 are examples of properly formatted, easy to understand graphics. Do not include fonts that are less than 6 points.

For good-looking graphics, the resolution needs to be high enough to provide a clear image at the size you make them within the report. In general, 300 dpi will make a clear image—200 dpi is a minimum. Try to create your figures at the same size they will be in the report, as resizing them in Word greatly reduces image quality. Photographs taken with at least a two-megapixel camera (if using digital) and with good contrast will make the best images. Save the original, and then adjust color levels and size in a renamed image copy. Print a draft copy of your report to double-check that your figures and photographs have clear lines and show all the features that you want them to have.

Figures and photographs should be in grayscale. Color greatly adds to the cost of printing, so we are trying to keep it to a minimum. Also remember that your report may be photocopied, scanned, or downloaded and printed in black and white. For this reason, you should use symbols or patterns, or make sure that colors print as different shades in black and white. All interval or ratio data (data measuring continuous phenomena, with each color representing an equal interval) need to be displayed in a graded scale of a single color (Figure 3). This way your figures will be useful even as a photocopy.

If you need help with your graphics or have questions, please contact the TWDB graphics department at (512) 936-0129.

2.2.3 Using other people's graphics

Figures and photographs (and tables) need to be your own unless you have written permission from the publisher that allows us to reprint them (we will need a copy of this permission for our records). Avoid using any figures or photographs taken off the Internet or from newspapers or magazines—these sources are difficult to cite, and it is often time-consuming and expensive to gain permission to reproduce them.

2.3 Tables

Tables should be created in Microsoft Word (see Table 1). Tables should include a minimal amount of outlining or bold font to emphasize headings, totals, or other important points. Tables should be numbered separately from figures, and captions should appear above the text of the table.

Table 1: A sample table. Note caption above table.

	Table text heading*							
Table text	1940	1950	1960	1970	1980	1990	2000	%GW
Table text	15	441	340	926	196	522	83	97.4
Table text	64	944	626	173	356	171	516	99.9
Total	79	1385	966	1099	552	693	599	

* A footnote should look like this using 10 point Times New Roman.
%GW = percent groundwater
Be sure to describe any abbreviations or symbols, and, unlike in this table, be sure to note the units!

3.0 Units

Measurements should be in English units. Metric units may be included in parentheses after the English units.

All units of geologic time should conform to the most recent geologic timescale (Gradstein and others, 2004). A summary of this timescale is available from the International Commission on Stratigraphy's website at http://stratigraphy.org/chus.pdf.

4.0 Citations and references

It is important to give credit where credit is due. Therefore, be sure to use the appropriate citations and include references in your paper.

4.1 In-text citations

Each piece of information you use in your report that comes from an outside source must be cited within the text using the author's last name and the year of publication. If there are two authors, list the last name of each followed by the year, and if there are more than two authors, list the last name of the first author followed by "and others" and the year. For example: the end of the Jurassic Period occurred approximately 145.5 million years ago (Gradstein and others, 2004).

4.2 References

All sources that are cited within the report should be listed at the end of the paper under the heading References. The references should follow the guidelines in "Suggestions to Authors of the Reports of the United States Geological Survey" (Hansen, 1991). These are available online at http://www.nwrc.usgs.gov/lib/lib_sta.html (a link to the chapter "Preparing references for Survey reports," p. 234-241, is found here). Several examples of complete reference citations are listed at the end of these guidelines. Be sure that any citations that appear in tables or figures are included in the reference list. Also, before submitting the report, please check that all the citations in the report are included in the reference list and all references in the reference list are cited in the report. If at all possible, avoid web-based citations. These materials are often transient and therefore useless to future readers.

5.0 Submitting your report

Before you submit your report, proofread it. Look for spelling and grammatical errors. Also, check to see that you have structured the headings, paragraphs, and sentences in your paper so that it is easy to follow and understand (imagine you are a reader who does not already know the information you are presenting!).

6.0 Conclusions

Following the instructions above and providing accurate and readable text, tables, figures, and citations will help to make your report useful to readers. Scientists may read your report, as well as water planners, utility providers, and interested citizens. If your report successfully conveys accurate scientific information and explanations to these readers, we can help to create more informed decisions about the use, development, and management of water in the state.

7.0 Acknowledgments

Be sure to acknowledge the people and entities that assisted you in your study and report. For example:
We would like to thank the Keck Geology Consortium, the American Society of Civil Engineers, and the Texas Bar CLE for providing examples to use in developing these guidelines. In addition, we appreciate Mike Parcher for providing information on how to create publication-quality graphics, Shirley Wade for creating the data used in sample Figure 1, and Ian Jones for providing sample Figure 3.

8.0 References

Gradstein, F.M., J.G. Ogg, and A.G. Smith, eds., 2005, A geologic time scale 2004: Cambridge, Cambridge University Press, 610 p.

Hansen, W.R., ed., 1991, Suggestions to authors of the reports of the United States Geological Survey (7th ed.): Washington, D.C., U.S. Government Printing Office, 289 p.

Tufte, E. R., 1983, The visual display of quantitative information: Cheshire, C.T., Graphics Press, 197 p.

Tufte, E. R., 1990, Envisioning information: Cheshire, C.T., Graphics Press, 126 p.

Tufte, E. R., 1997, Visual explanations: Cheshire, C.T., Graphics Press, 156 p.

9.0 Examples of references

Arroyo, J. A., and Mullican, III, W. F., 2004, Desalination: *in* Mace, R. E., Angle, E. S., and Mullican, W. F., III, editors, Aquifers of the Edwards Plateau: Texas Water Development Board Report 360, p. 293-302.

Bates, R. L., and Jackson, J. A., 1984, Dictionary of geological terms: Anchor Press/Doubleday, Garden City, New York, 571 p.

Blandford, T. N., Blazer, D. J., Calhoun, K. C., Dutton, A. R., Naing, T., Reedy, R. C., and Scanlon, B. R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico–Numerical simulations through 2050: contract report by Daniel B. Stephens and Associates, Inc., and the Bureau of Economic Geology, The University of Texas at Austin to the Texas Water Development Board, variably paginated.

Fenneman, N. M., 1931, Physiography of Western United States (1st edition): New York, McGraw-Hill, 534 p.

Hubert, M., 1999, Senate Bill 1–The first big bold step toward meeting Texas's future water needs: Texas Tech Law Review, v. 30, no. 1, p. 53-70.

Kunianski, E. L., 1989, Precipitation, streamflow, and baseflow in West-Central Texas, December 1974 through March 1977: U. S. Geological Survey Water-Resources Investigations Report 89-4208, 2 sheets.

Mace, R. E., Chowdhury, A. H., Anaya, R., and Way, S.-C., 2000, A numerical groundwater flow model of the Upper and Middle Trinity aquifer, Hill Country area: Texas Water Development Board Open File Report 00-02, 62 p.

Maclay, R. W., and Land, L. F., 1988, Simulation of flow in the Edwards aquifer, San Antonio Region, Texas, and refinements of storage and flow concepts: U. S. Geological Survey Water-Supply Paper 2336, 48 p.

For more examples of references, see p. 239-241 of "Suggestions to Authors of the Reports of the United States Geological Survey" at http://www.nwrc.usgs.gov/lib/lib_sta.html.

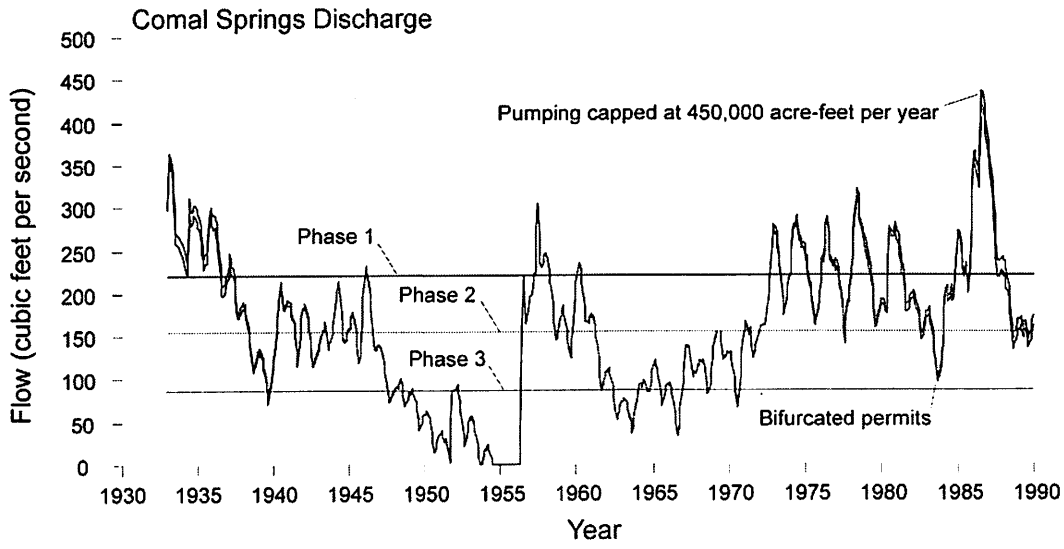


Figure 1. A sample figure showing only the information needed to help the reader understand the data. Font size for figure callouts or labels should never be less than 6 point.

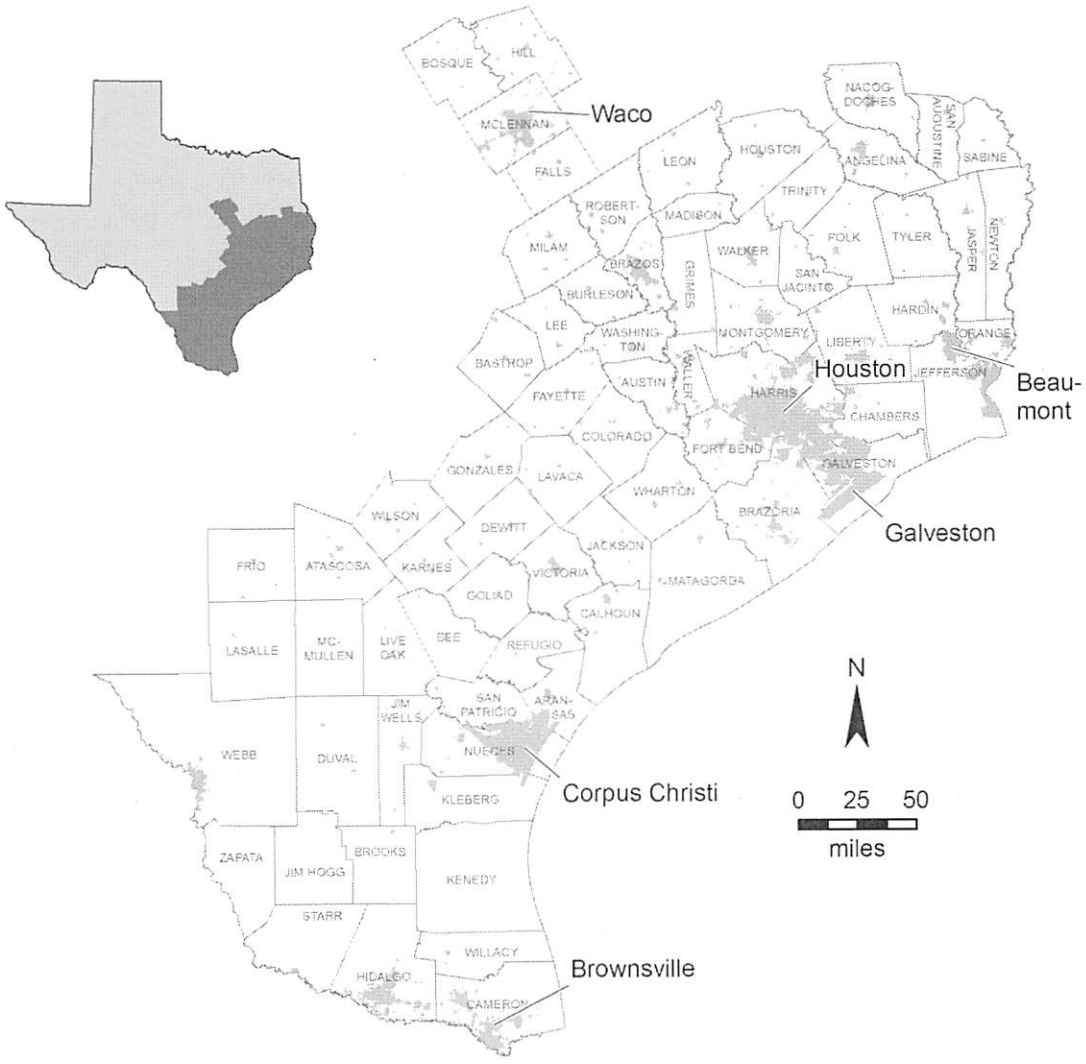


Figure 2. A sample subject area map, giving the reader enough information to understand the location being discussed in this conference. For map figures, be sure to include a north arrow to orient the reader, a scale, and, if needed, a submap that places the figure in greater geographic context. Be sure that text is readable and that any citations listed on the figure or in the figure caption are included in the reference list. Font size should never be less than 6 pt.

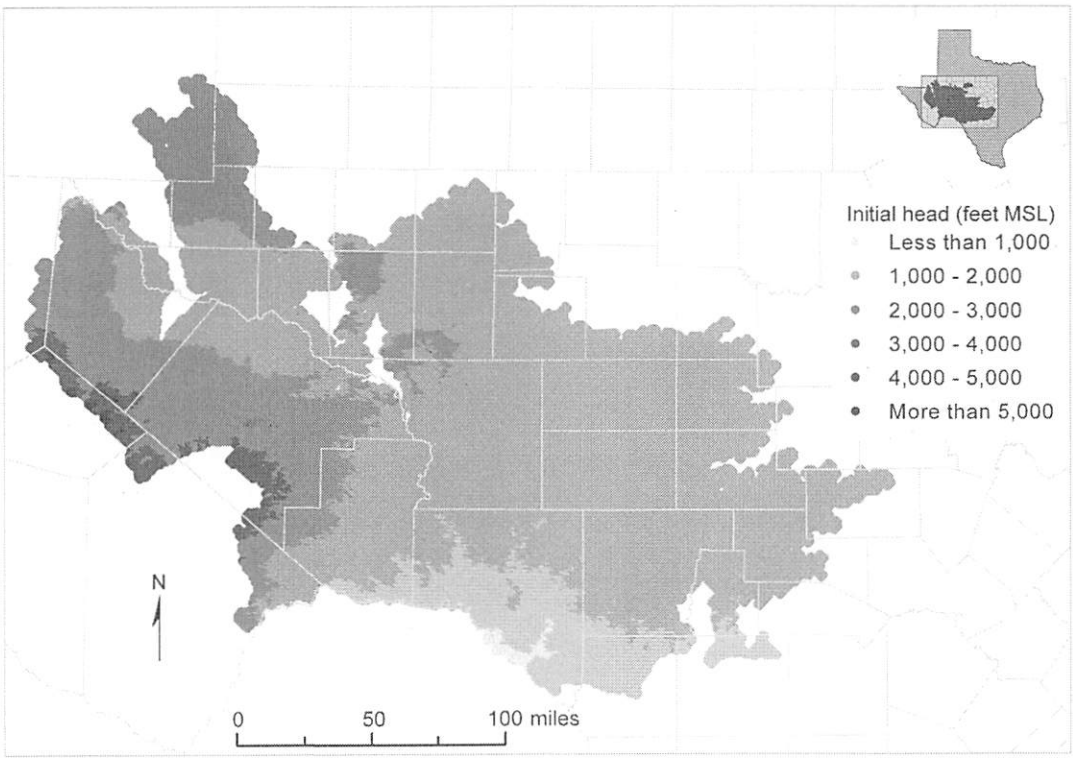


Figure 3. **Initial hydraulic heads used in model simulations for layer 1. Note the use of grayscale shading to show differences.**

EXHIBIT E

TWDB Guidelines for a Progress Report

Texas Water Development Board Contractors are required by their contracts to provide Progress Reports usually with the submission of an invoice/payment request.

The progress report should contain the following standard elements:

- Date: Date the memo is sent
- To: Name and position of the reader
- From: Name and position of the writer
- Subject: TWDB Contract Number and a clear phrase that focuses the reader's attention on the subject of the memo

Work Completed: *(The next section of a progress report explains what work has been done during the reporting period. Specify the dates of the reporting period and use active voice verbs to give the impression that you or you and your team have been busy). For Example:*

Task 1: Completed 3 draft chapters and all appendices. Met with sub consultants on their chapters.
Task 2: Completed sample collection throughout river reach.
Task 3: No work completed in reporting period.

Problems:
If the reader is likely to be interested in the glitches you have encountered along the way, mention the problems you have encountered and explain how you have solved them. If there are problems you have not yet been able to solve, explain your strategy for solving them and give tell the reader when you think you will have them solved.

EXHIBIT F

HUB SUBCONRACTING PLAN PROGRESS ASSESSMENT REPORT

(Use current form located at:
http://www.window.state.tx.us/procurement/prog/hub/hub-forms/)